Vessel detection from spaceborn optical and SAR images

Interim review presentation

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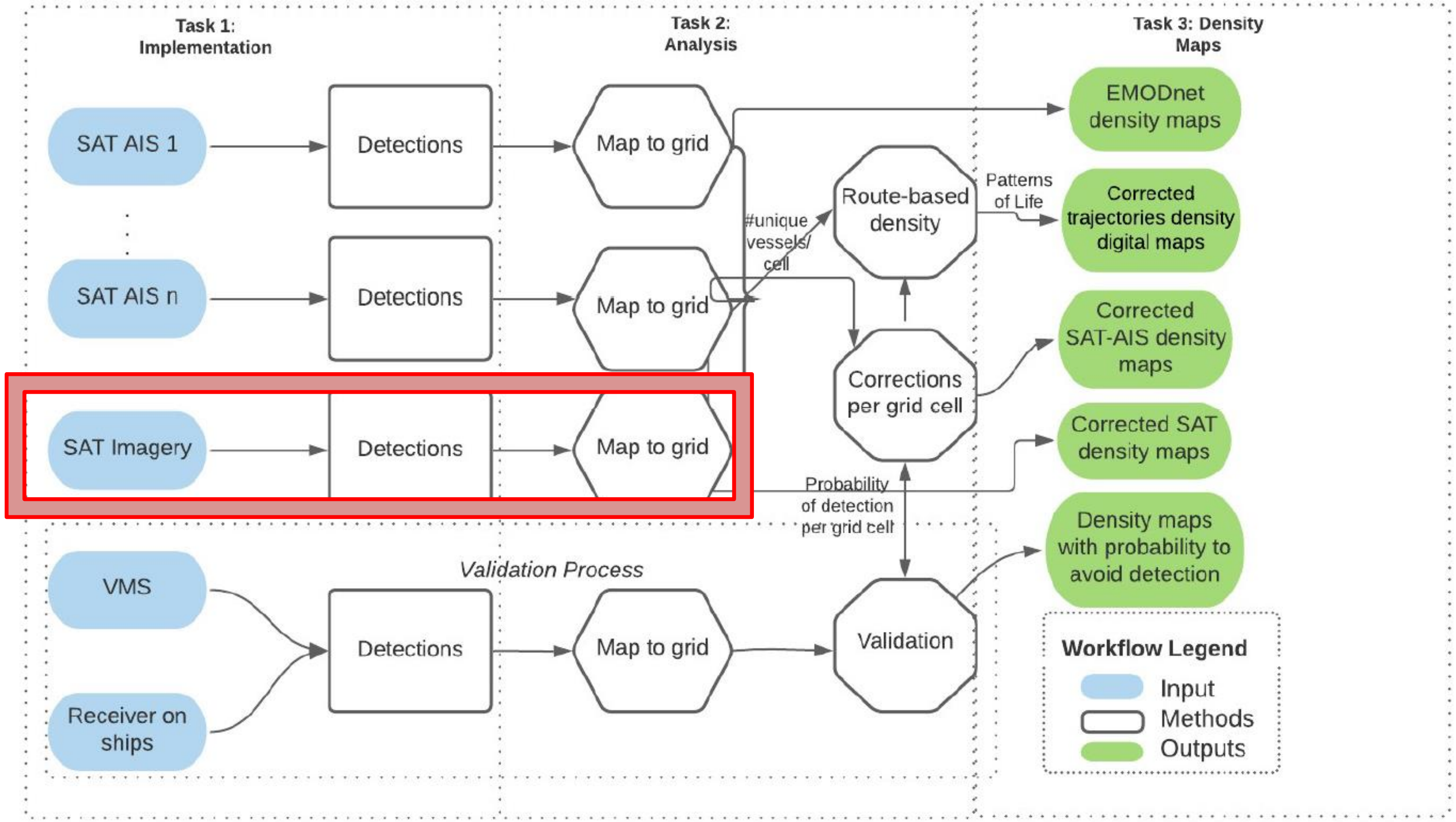
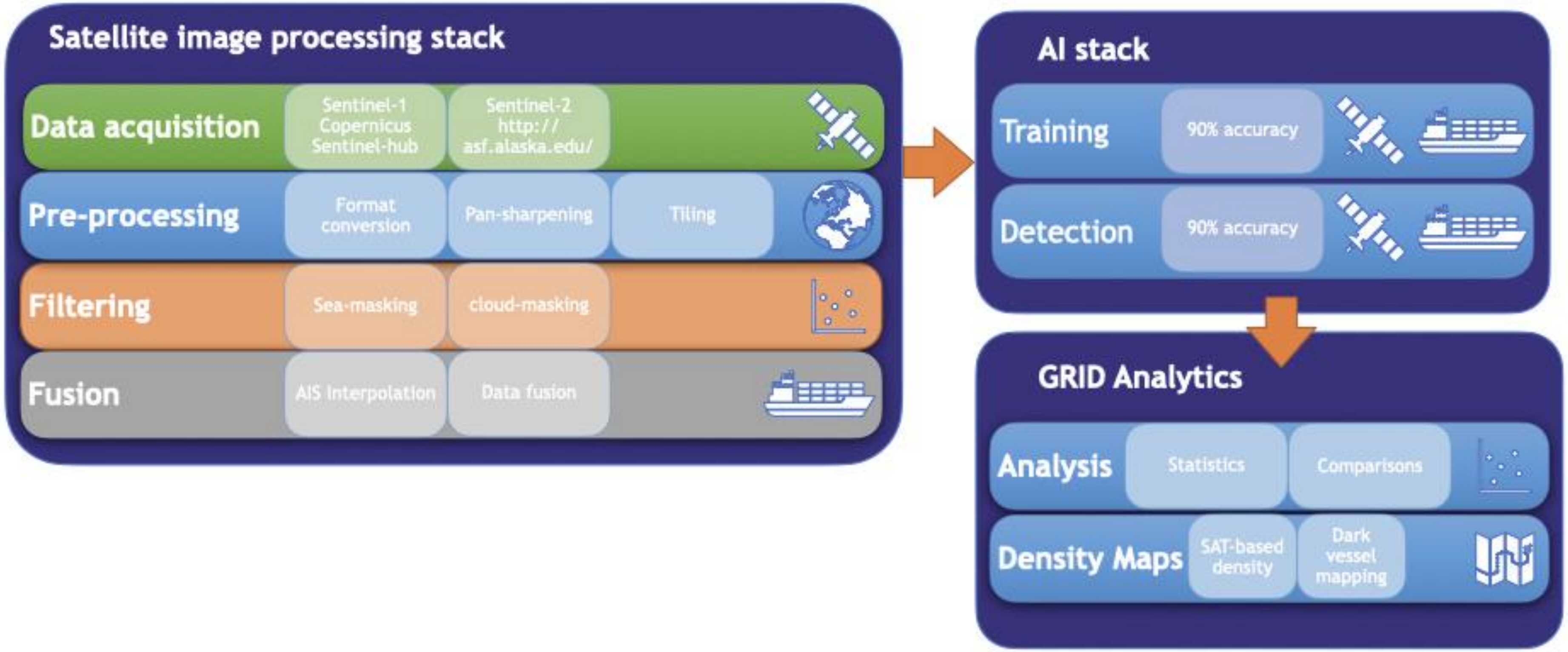
Overall workflow



Satellite image detection architecture



Data acquisition

- **Sentinel-1 SAR data**
  - 5000 images in OCT 2021 (1000 for MED)
  - GRD IW products
- **Sentinel-2 Optical data**, (cloud coverage up to 10%)
  - 10m TCI images (bit), IR, RGB bands (16-bit)
  - Volume:
  - OCT21: 5.25 TB, 5895 images
  - NOV21: 2.08 TB, 3501 images
  - DEC21: 2.20, 3616 images

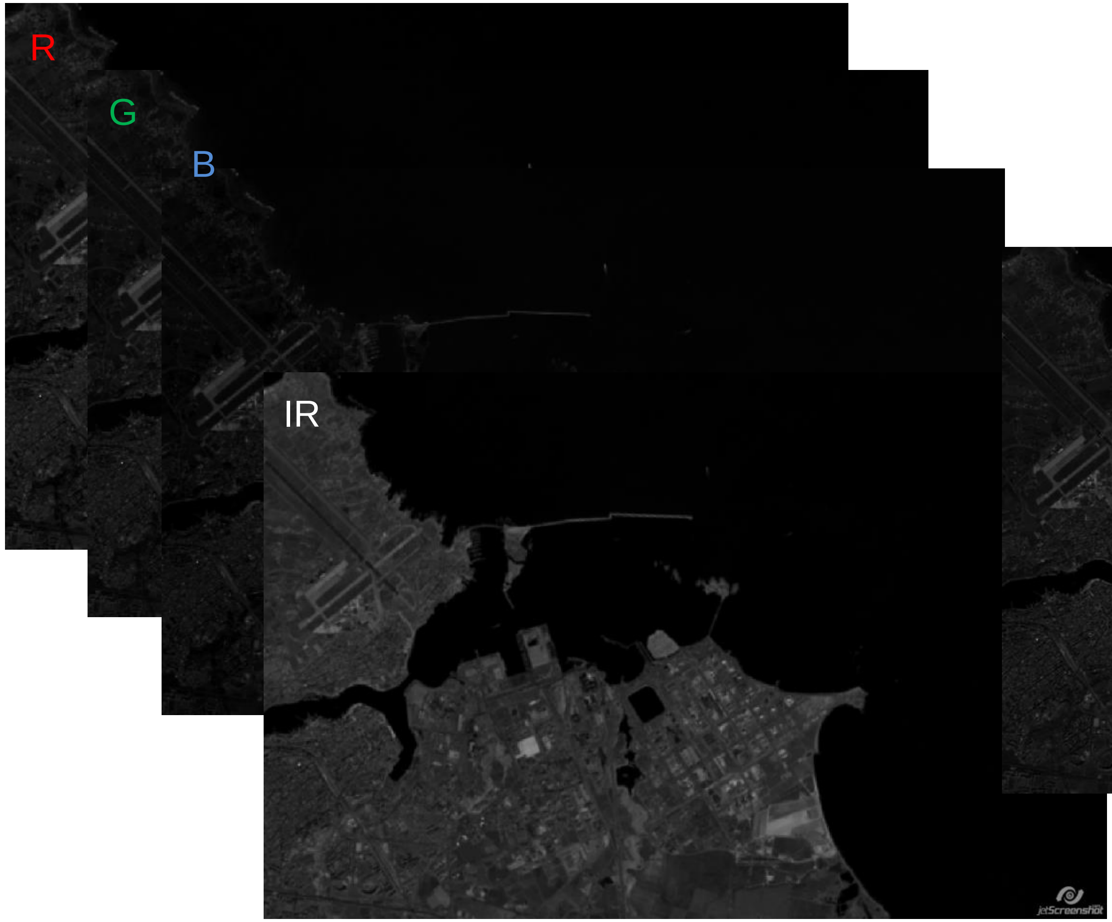
- **Repositories**:
  - https://scihub.copernicus.eu/
  - https://asf.alaska.edu/ (for archived S1 images)

Pre-processing

- **Pre-processing operations**
  - Geocoding
  - Transformation to another CRS
  - Transformation to another format (e.g., JP2 to GeoTIFF)
  - Panchromatic image composition (S2)
  - Pan-sharpening

Constructing a pan-chromatic image

- **Computing the average of RGB + NIR 10m**



Panchromatic

Pan-sharpening

- **Fuse the higher spatial information from the panchromatic image and the spectral information from a lower spatial information multispectral image. (20 MS (RGB, SWIR) + Panchromatic = 10m RGB + SWIR)**

20m

10m & SWIR

Problem: Deep Learning can be a bottleneck for large data volumes

Solution: Use image processing before NN detection to reduce the number of image tiles

Filtering: From TBs to GBs

- Most tiles do not contain vessels
- We use image processing to prune tiles that do not contain vessel
- **Sentinel 1**: we maintain statistics per tile (e.g., white/black pixels), thresholding
- **Sentinel 2**:
  - SCL band (clouds, sea, land)
  - Cloud masking, land masking
  - **R,SWIR** for filtering (thresholding)

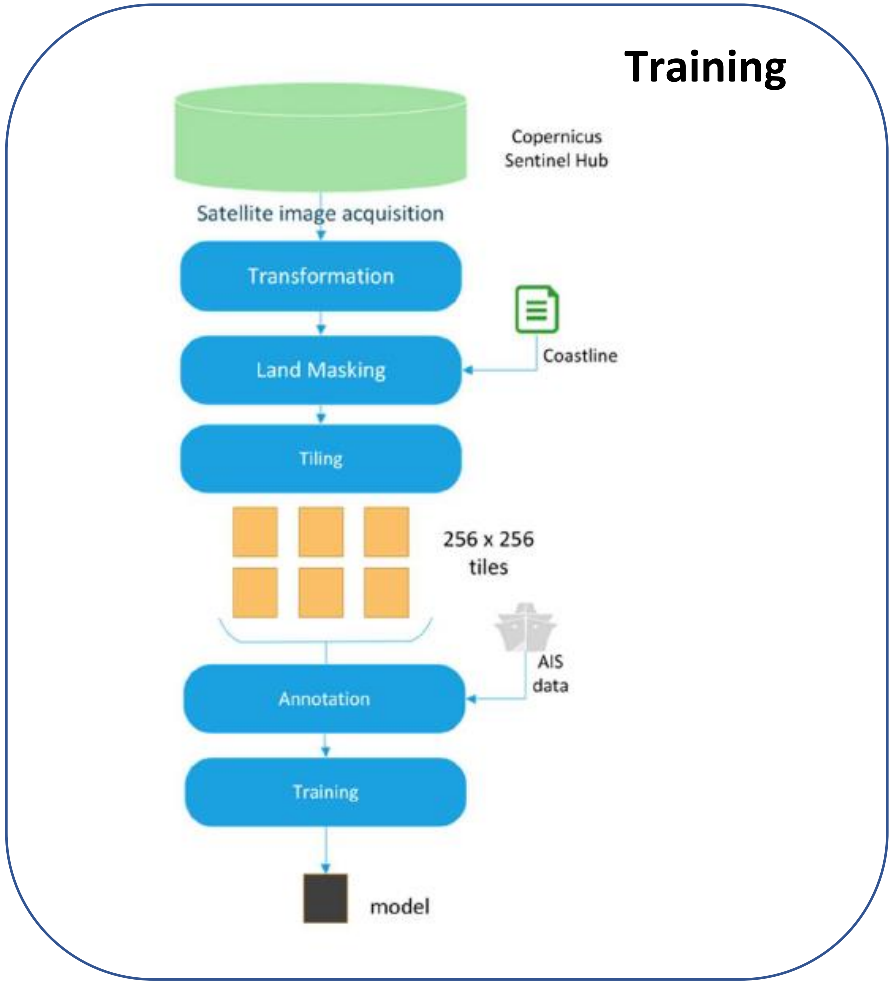
AI tasks: Training and Detection

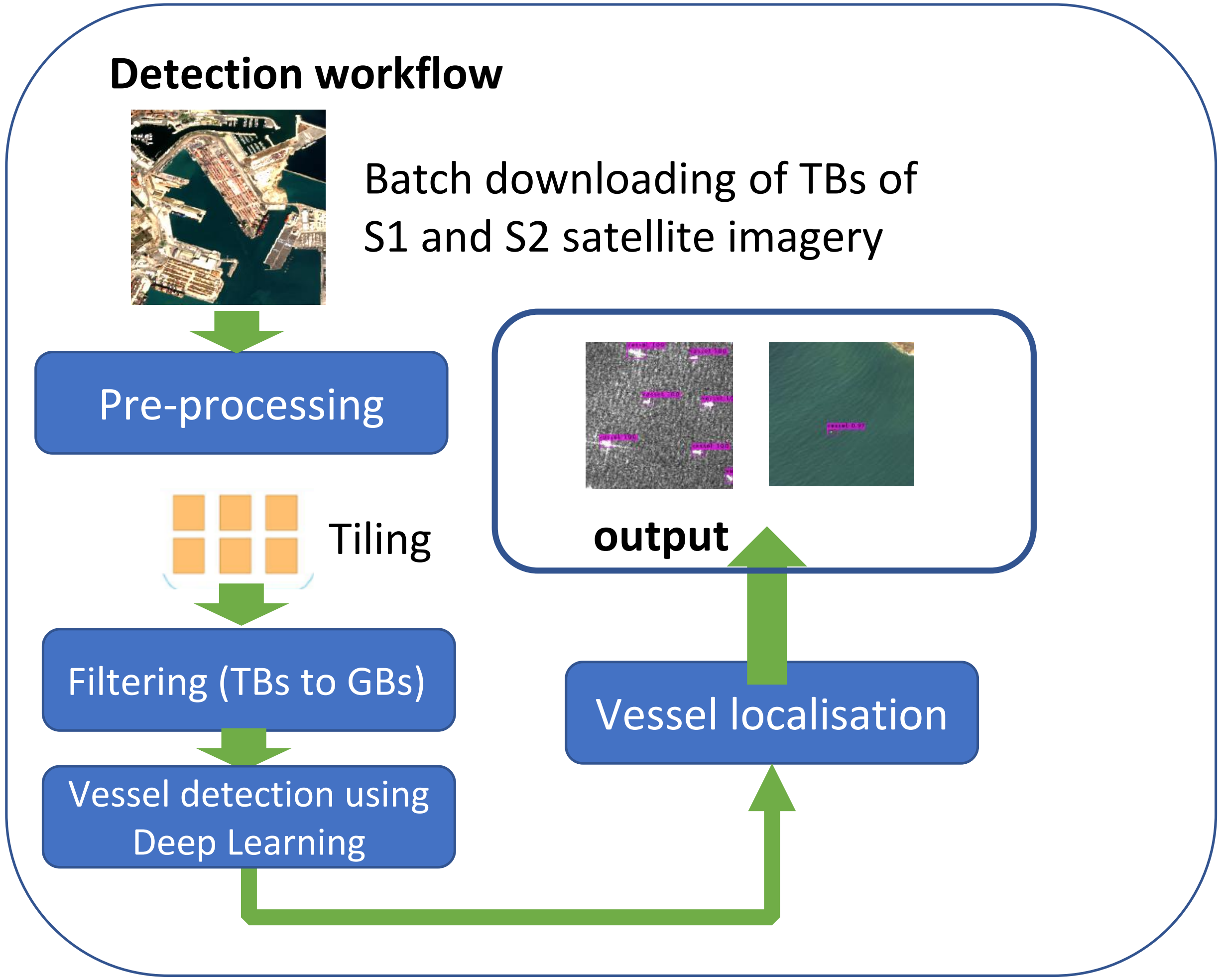
- We have trained a CNN-based object detection framework for vessel detection and localisation
- We use 2 models for vessel detection, one for S1 and another for S2 imagery (using the same network)
- We are training 2 respective models for vessel type classification
- Experiments

  Sentinel-1: precision = 0.92, recall = 0.93, F1-score = **0.92** (TP = 80, FP = 7, FN = 6)

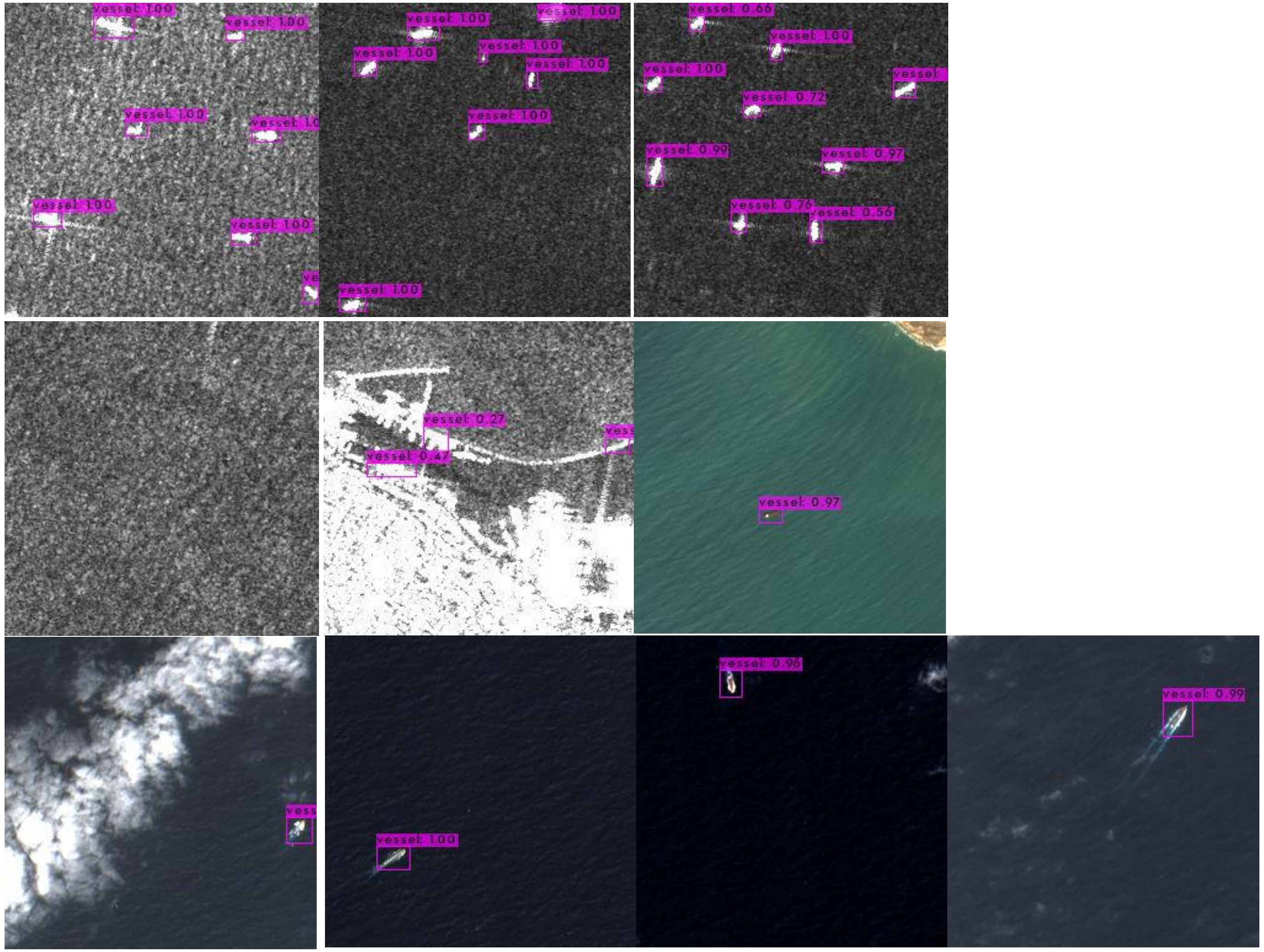
  Sentinel-2: precision = 0.90, recall = 0.88, F1-score = **0.89** (TP = 60, FP = 7, FN = 8)

AI vessel detection tasks: training and detection

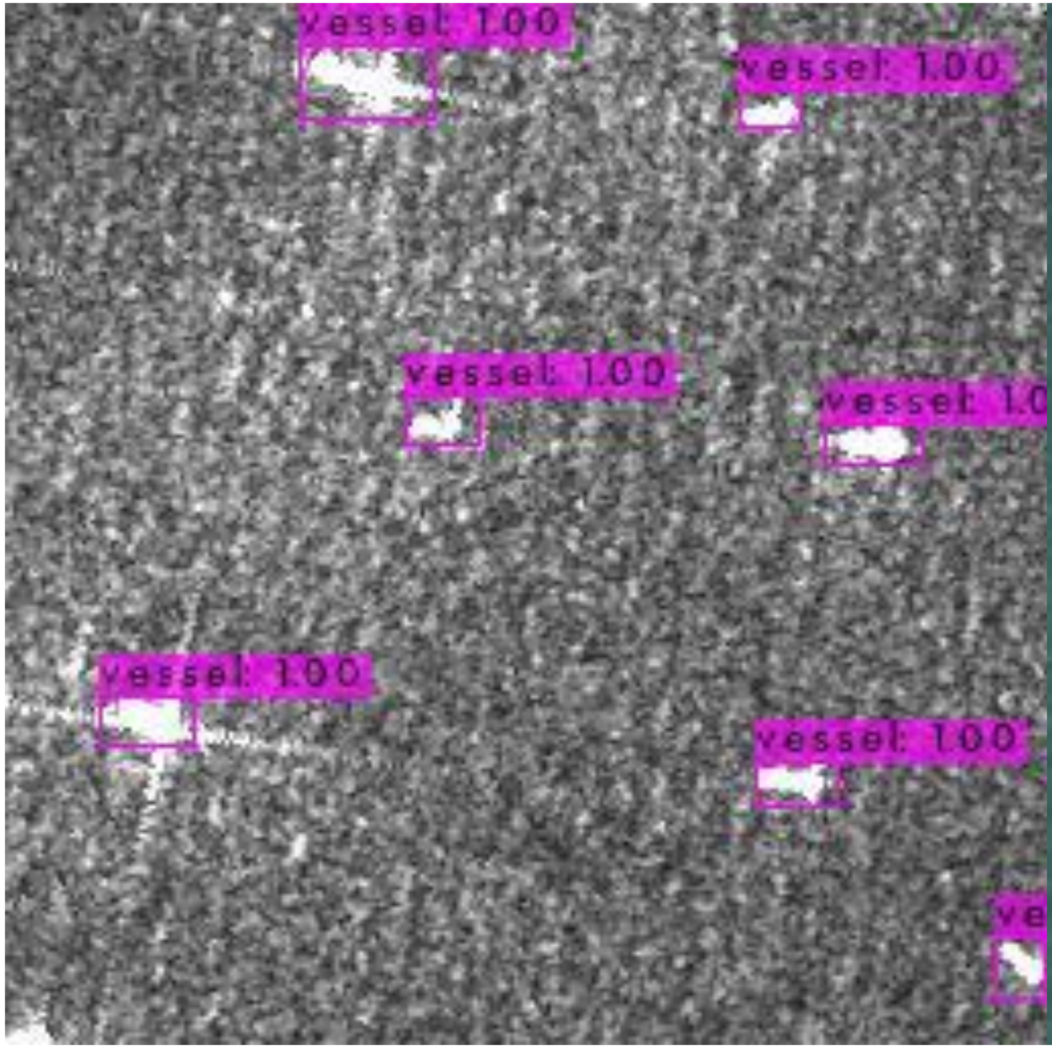




Examples of vessel detection



Examples

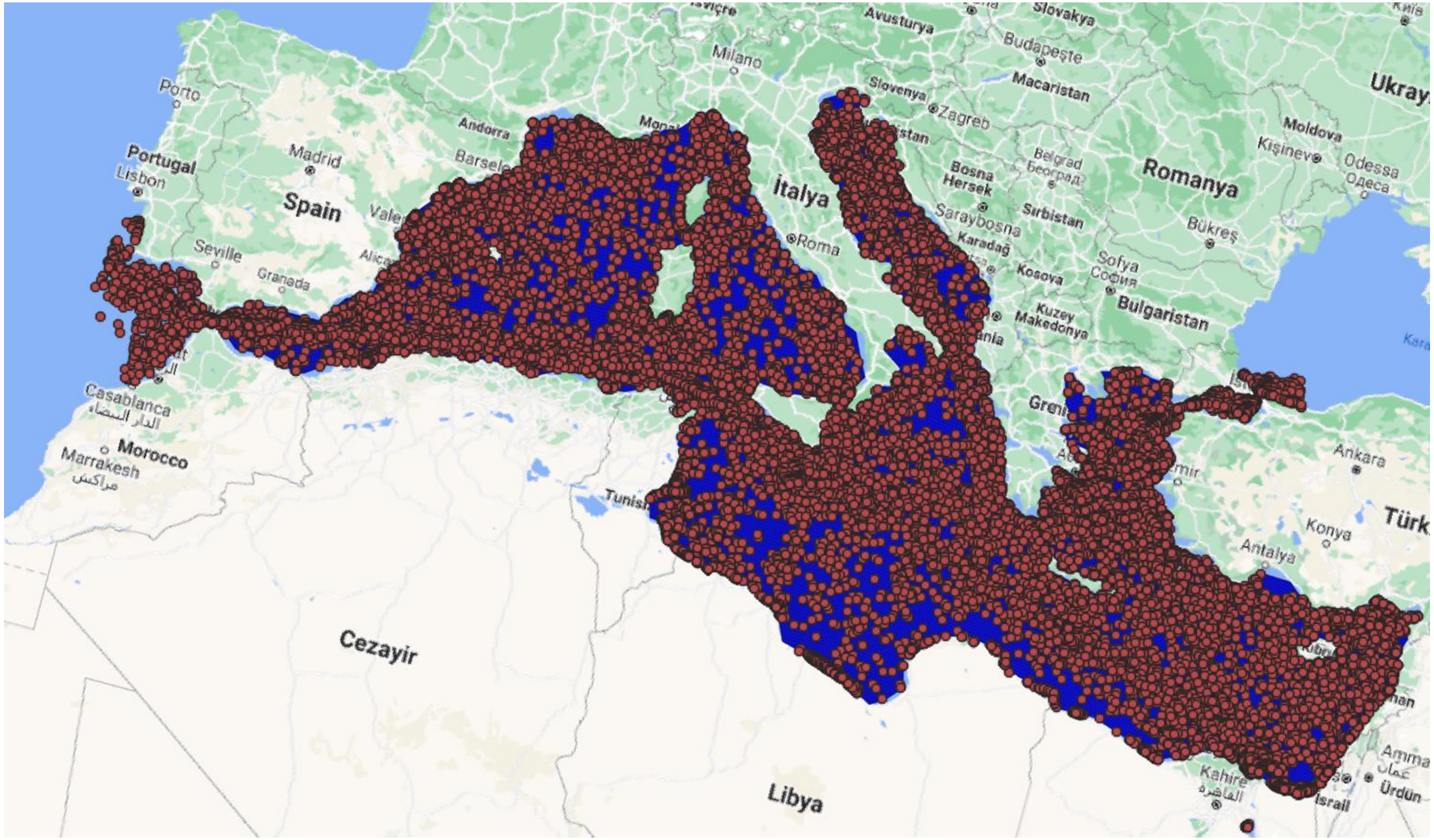

vessel: 1.00
vessel: 1.00
vessel: 1.00
vessel: 1.00
vessel: 1.00


vessel: 0.97

Post-processing

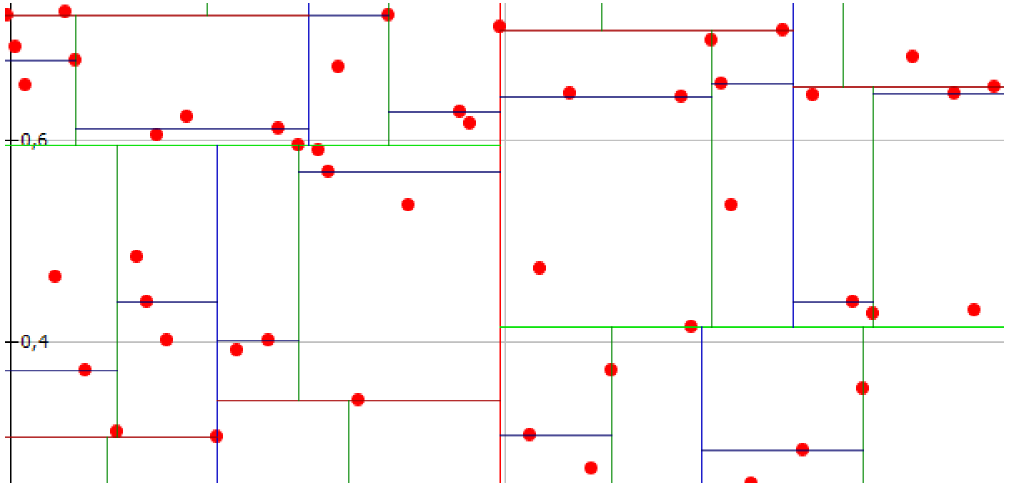
- Vessel detections with>0.5 confidence level are discarded.
- Image coordinates are translated into geographic coordinates
- Final output: CSV containing the location of vessels detected in a satellite image

Vessels detected in S1 images in MED (OCT21)



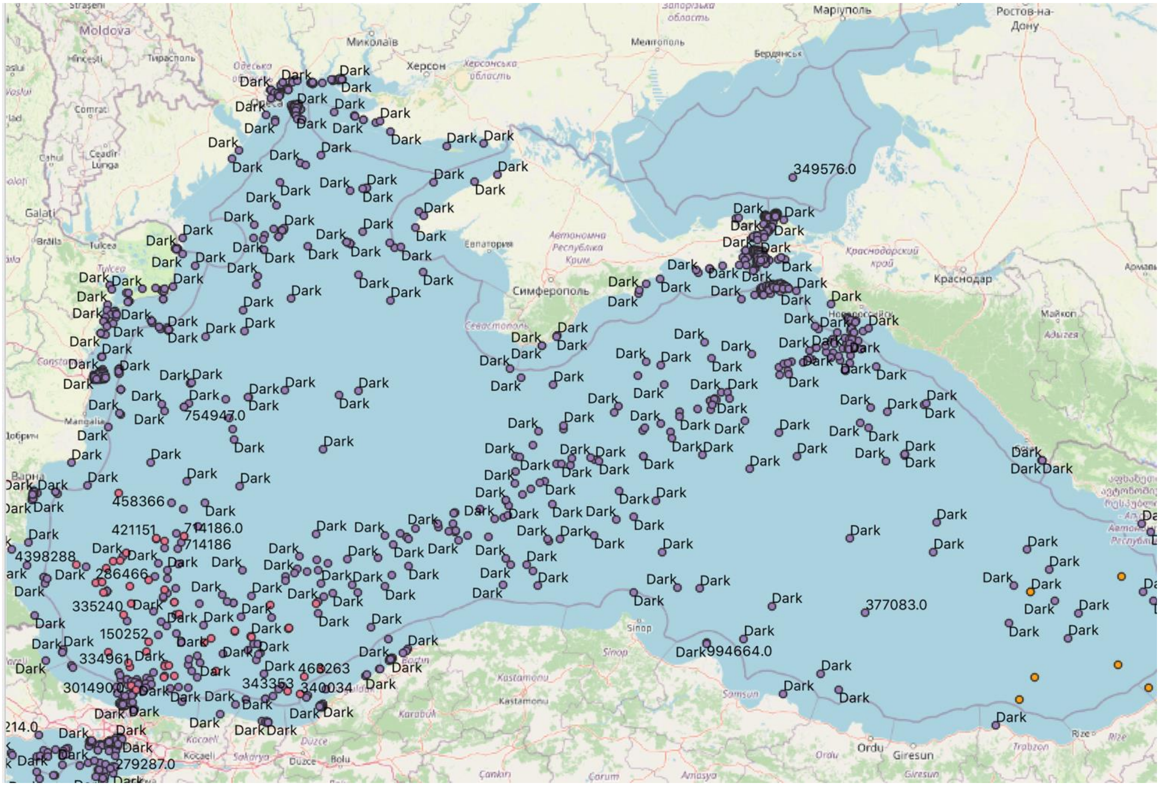
Fusion

- Correlation of AIS data with sat-imagery detections
- Data partitioned per image footprint
- Time window (30 mins +- acquisition time
- KNN-join using KD-index



Fusion

- Correlation of AIS data with sat-imagery detections
- Un-correlated vessels: Dark



Future work

- Sentinel-2 workflow execution in progress
- Sentinel-1 execution for the other seas and the rest of the time period
- Classification by vessel type
- *Konstantina Bereta, Ioannis Karantaidis, Dimitris Zissis. Vessel Traffic Density Maps based on Vessel Detection in Satellite Imagery. Submitted to IGARSS 2022.*