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Remote sensing and deep learning for environmental policy support

vito remote sensing

Swin Transformers and U-Net for remote sensing based surface water monitoring

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fwo

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remote sensing based surface water monitoring

- Water monitoring from space
  - U-Net
  - Sentinel-2 and Sentinel-1 as inputs
  - Focus on temporal dimension

- Water monitoring airborne
  - Swin-Transformer + UPerNEt
  - RGB+NIR orthophoto (@25cm) as inputs
  - Focus in spatial dimension

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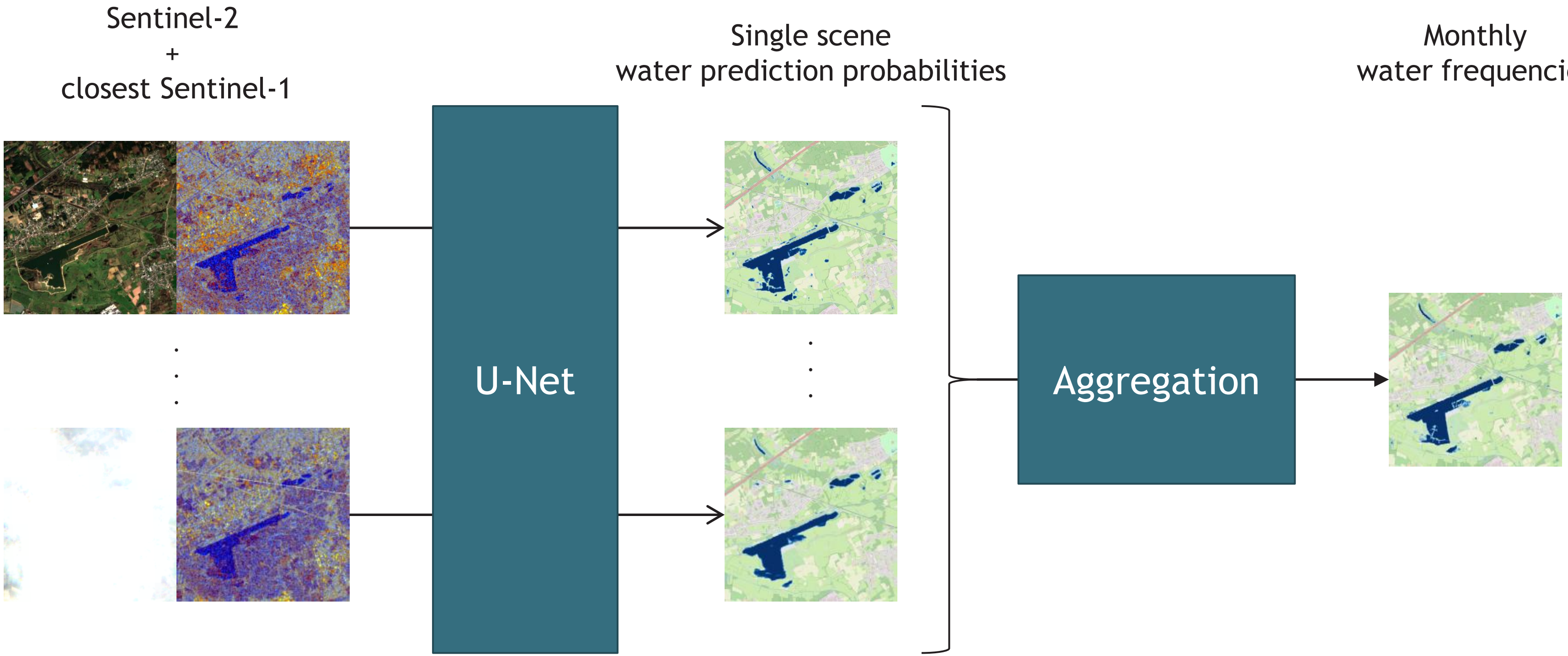
Water monitoring from space

Water monitoring from space

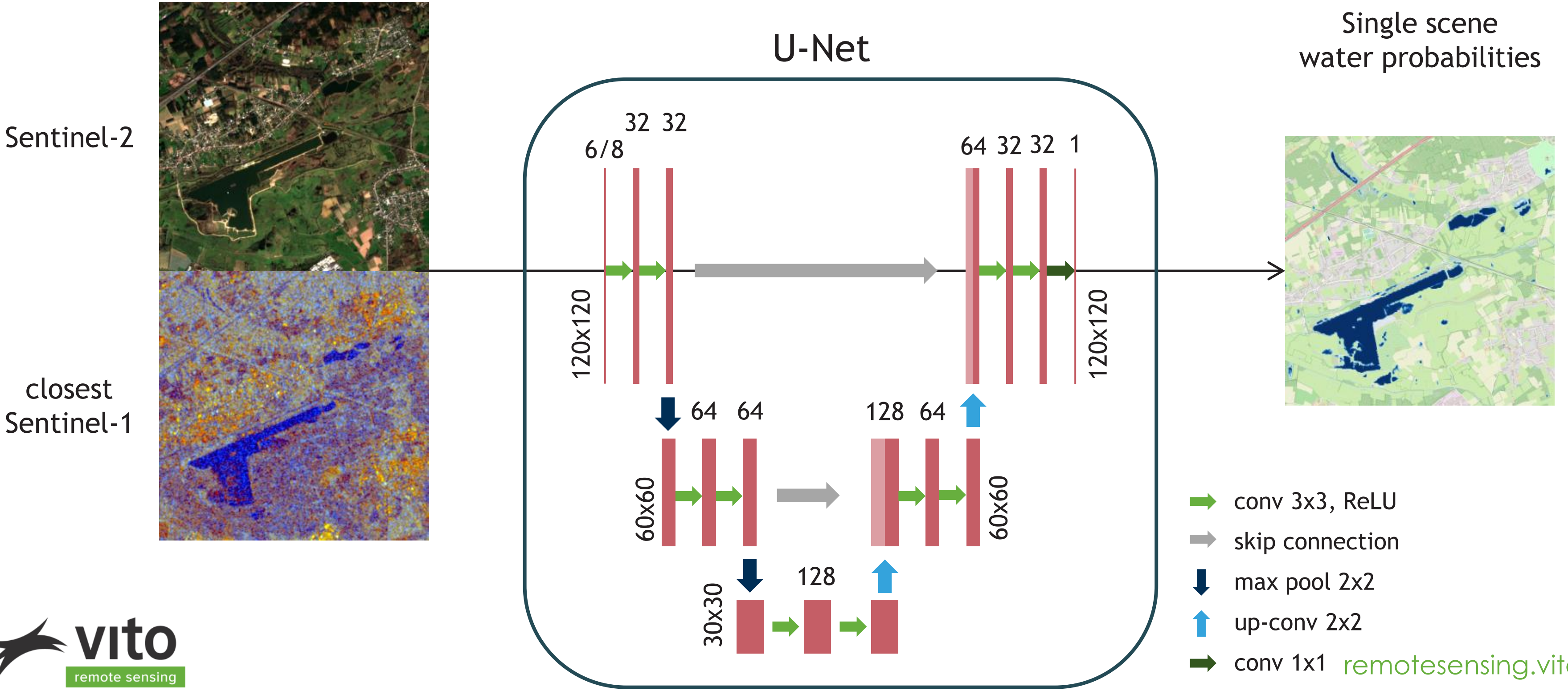
Sentinel-2	Sentinel-1
+ clear water pattern	– many confusing factors
+ high resolution	– moderate resolution
– moderate revisit time	+ high revisit time
– unreliable observation frequency	+ cloud independent

→ combine complementary strengths

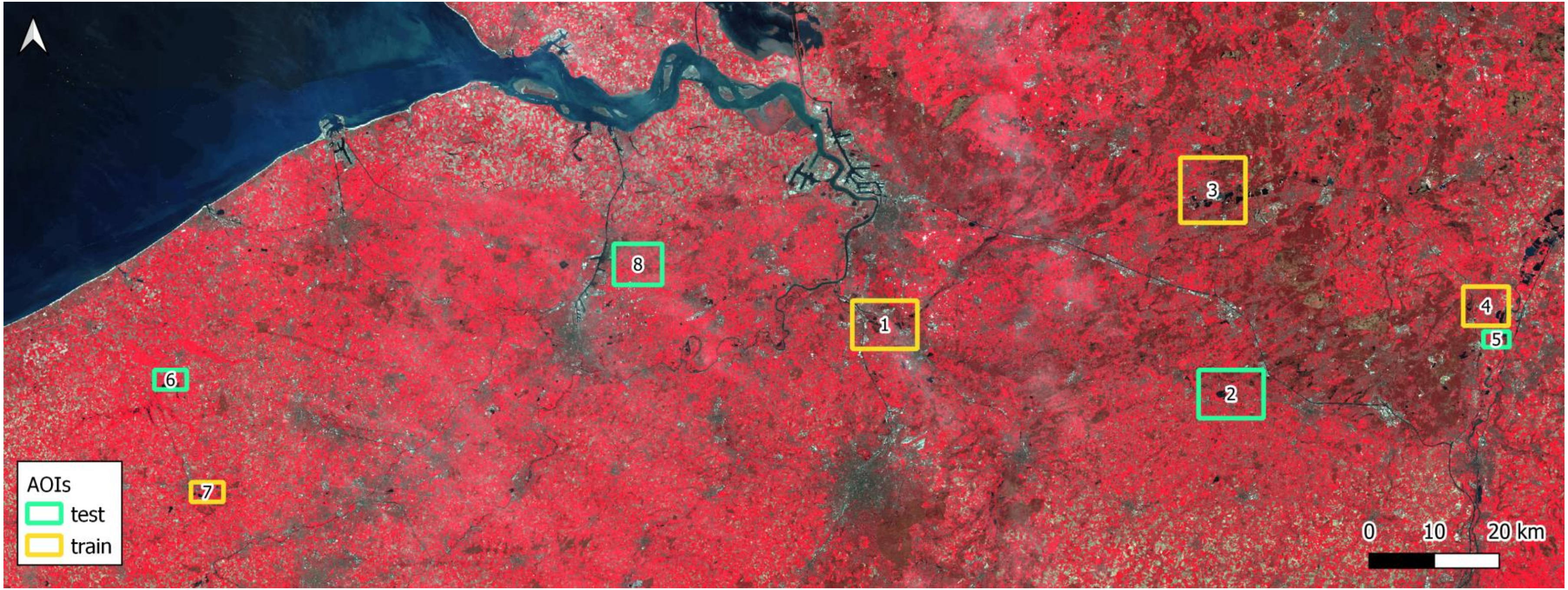
Setup


Sentinel-2
+
closest Sentinel-1
U-Net
Single scene
water prediction probabilities
Aggregation
Monthly
water frequencies

Setup


Sentinel-2
closest
Sentinel-1
U-Net
6/8
32 32
120x120
64 64
60x60
30x30
128
128 64
60x60
64 32 32 1
120x120
Single scene
water probabilities
conv 3x3, ReLU
skip connection
max pool 2x2
up-conv 2x2
conv 1x1

Training setup: AOIs



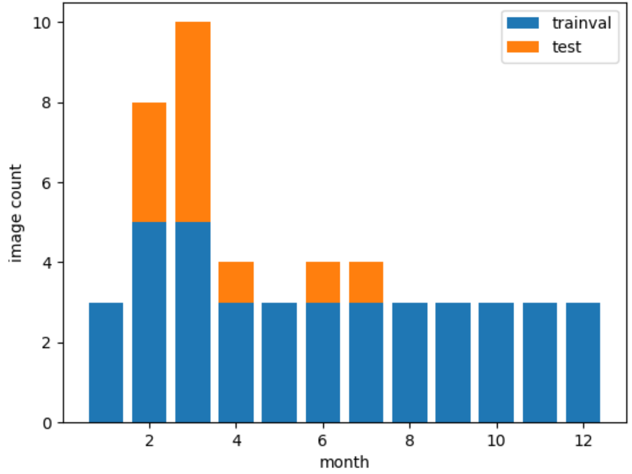
Training setup: inputs

- Sentinel-2 / Sentinel-1 pairs with $\Delta t < 24h$

  2018 - 2021

- Training: uniform spread across year
- Testing: matchup with yearly orthophotos

- Cloud-free + cloudy dataset



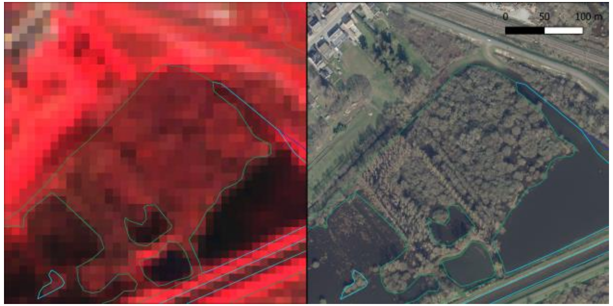
Training setup: labels

- Manual annotations starting from static INBO dataset
- Reference: 25cm yearly orthophotos + Sentinel-2
- Subclass labels

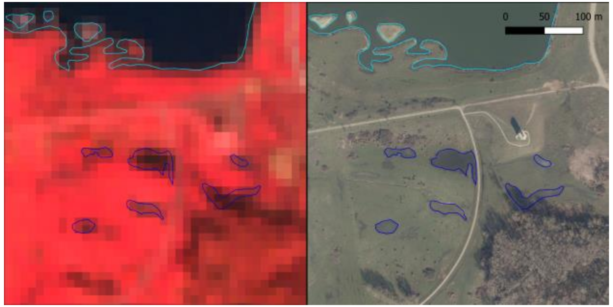
  shallow, saturation, vegetation, trees, invisible

Vegetation

Trees

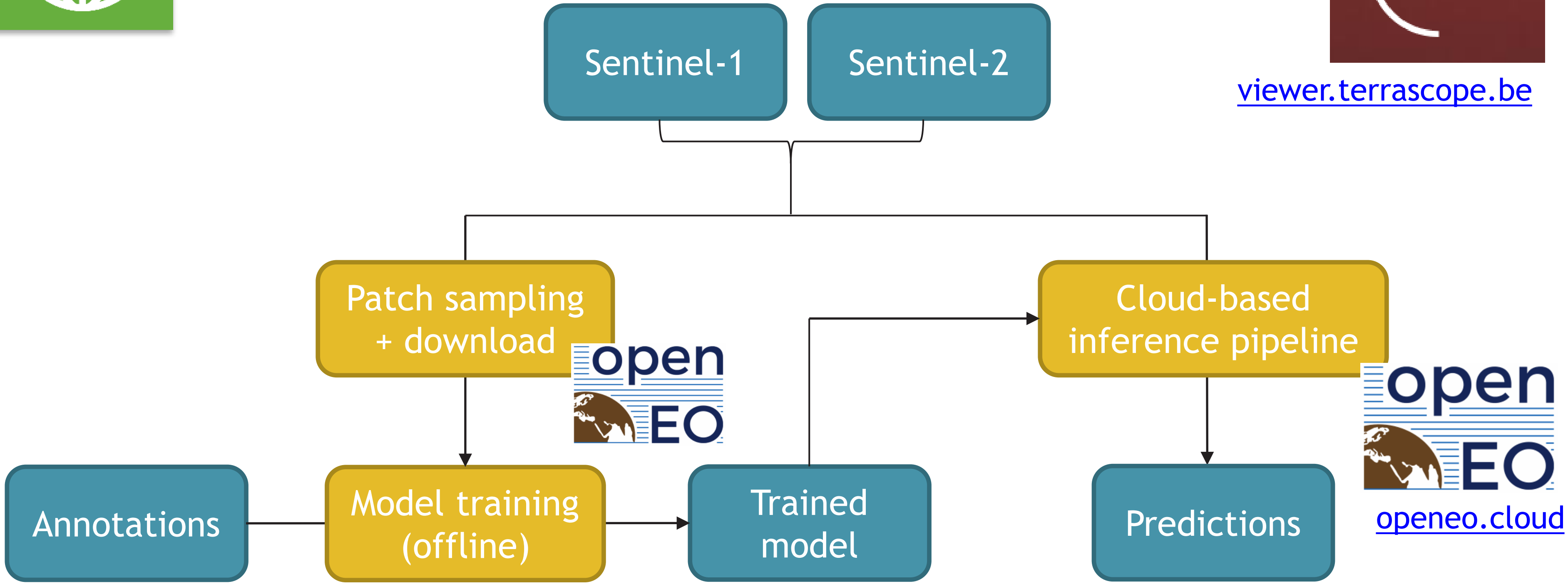


Shallow water



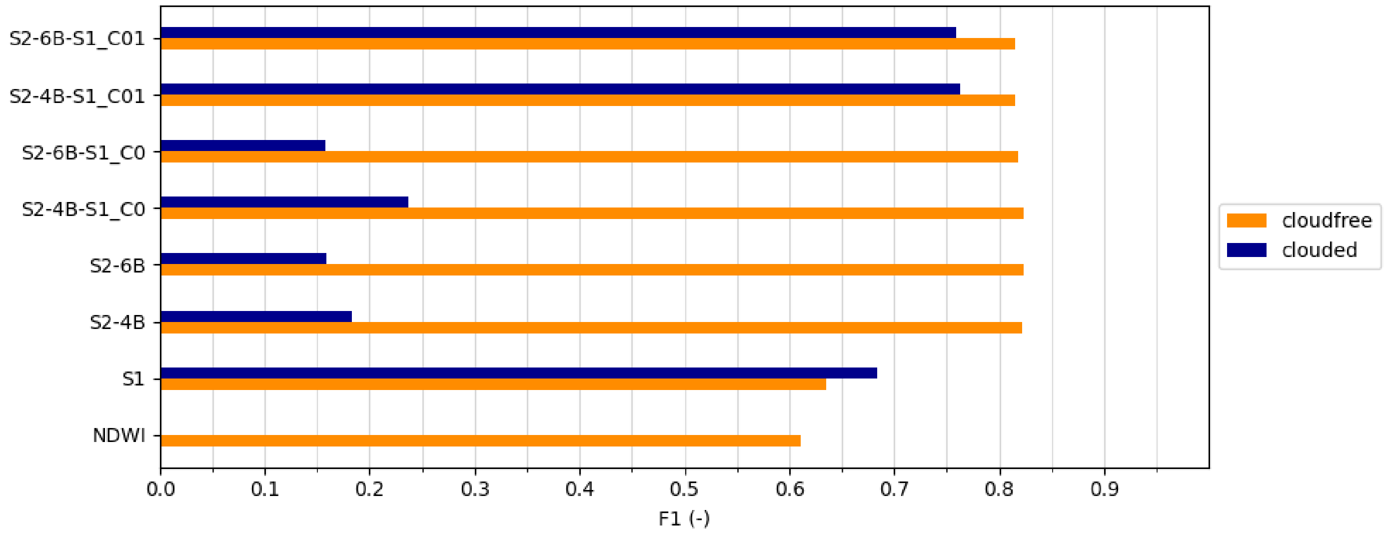
Workflow

viewer.terrascope.be



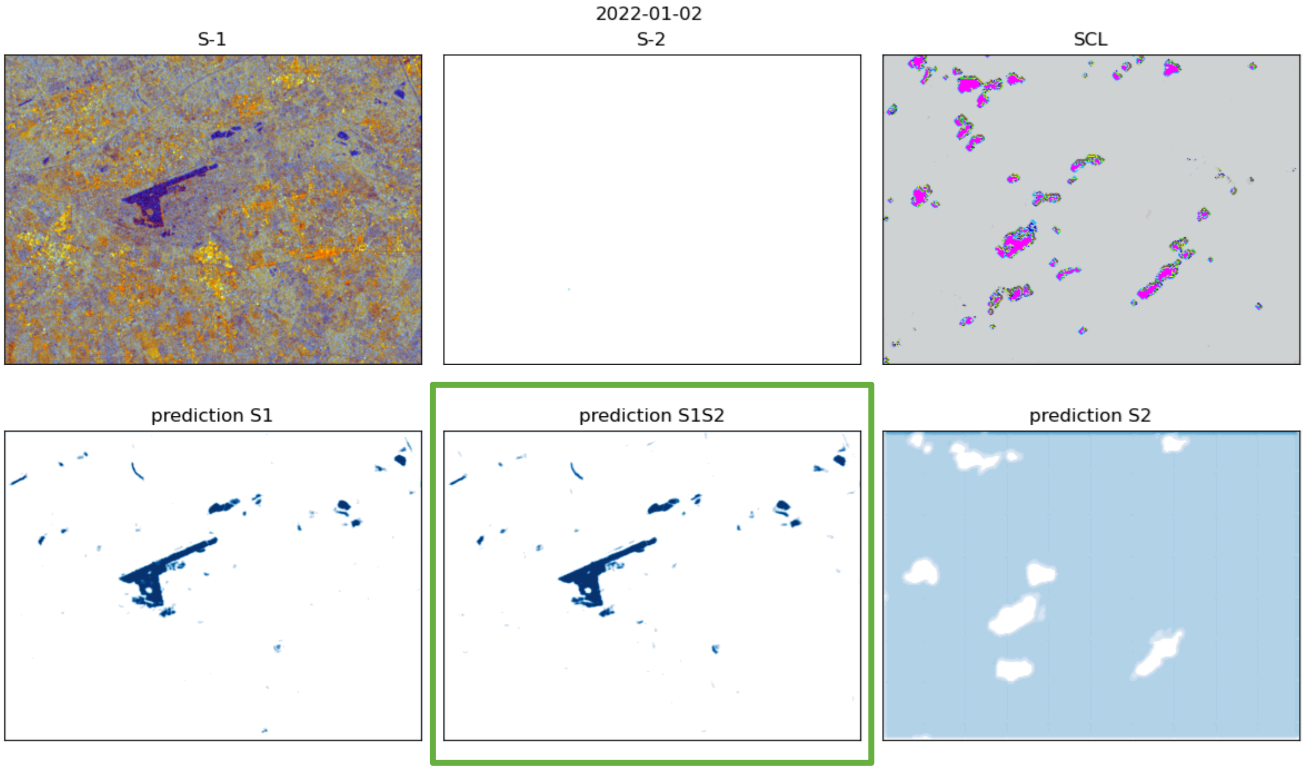
TensorFlow
Adam optimizer, binary cross entropy
50 epochs + early stopping
Variable learning rate starting at 0.001

Results: single scenes

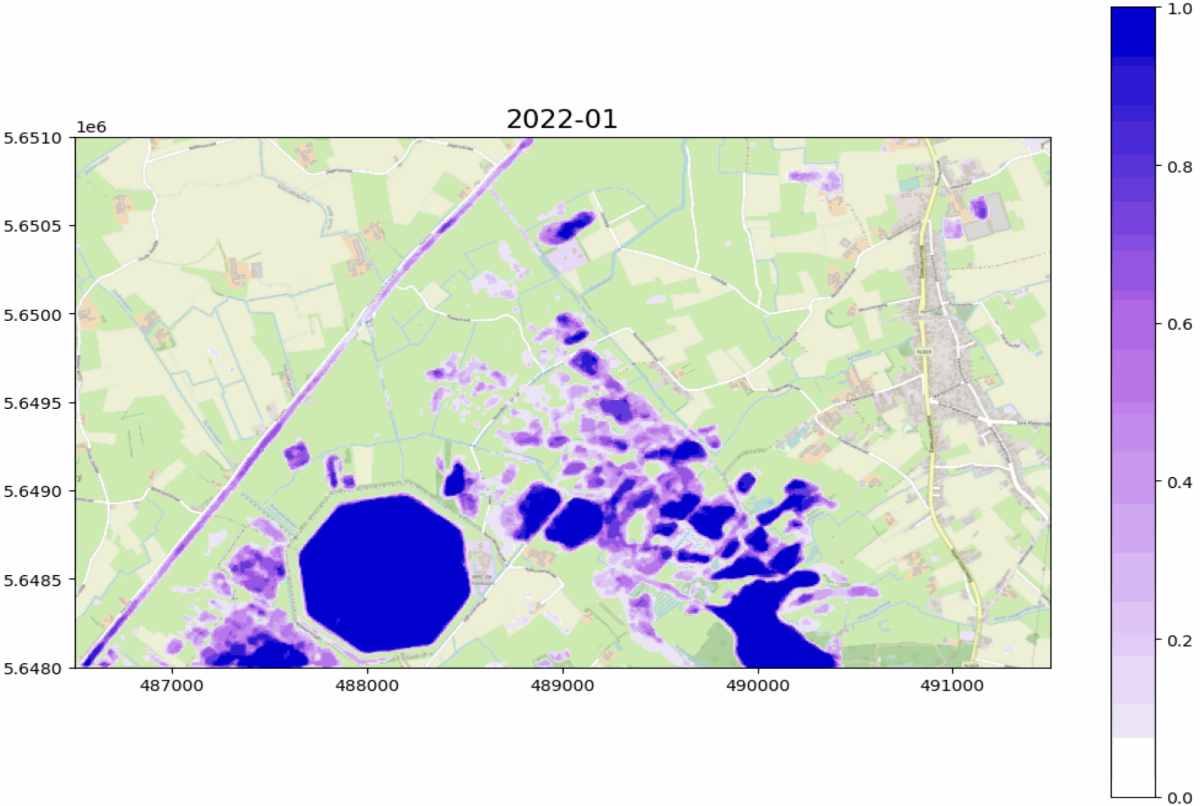


S1: VV, VH
S2-4B: B2, B3, B4, B8
S2-6B: B2; B3, B4, B8, B11, B12

Results: single scenes



Results: time series



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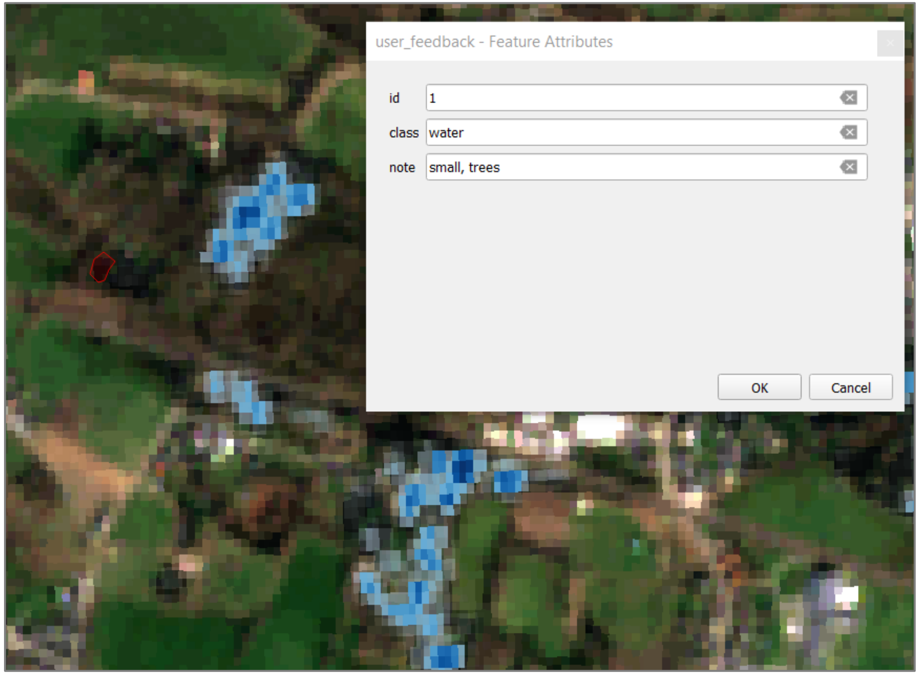
User interaction

- Visualization
- Feedback for active learning



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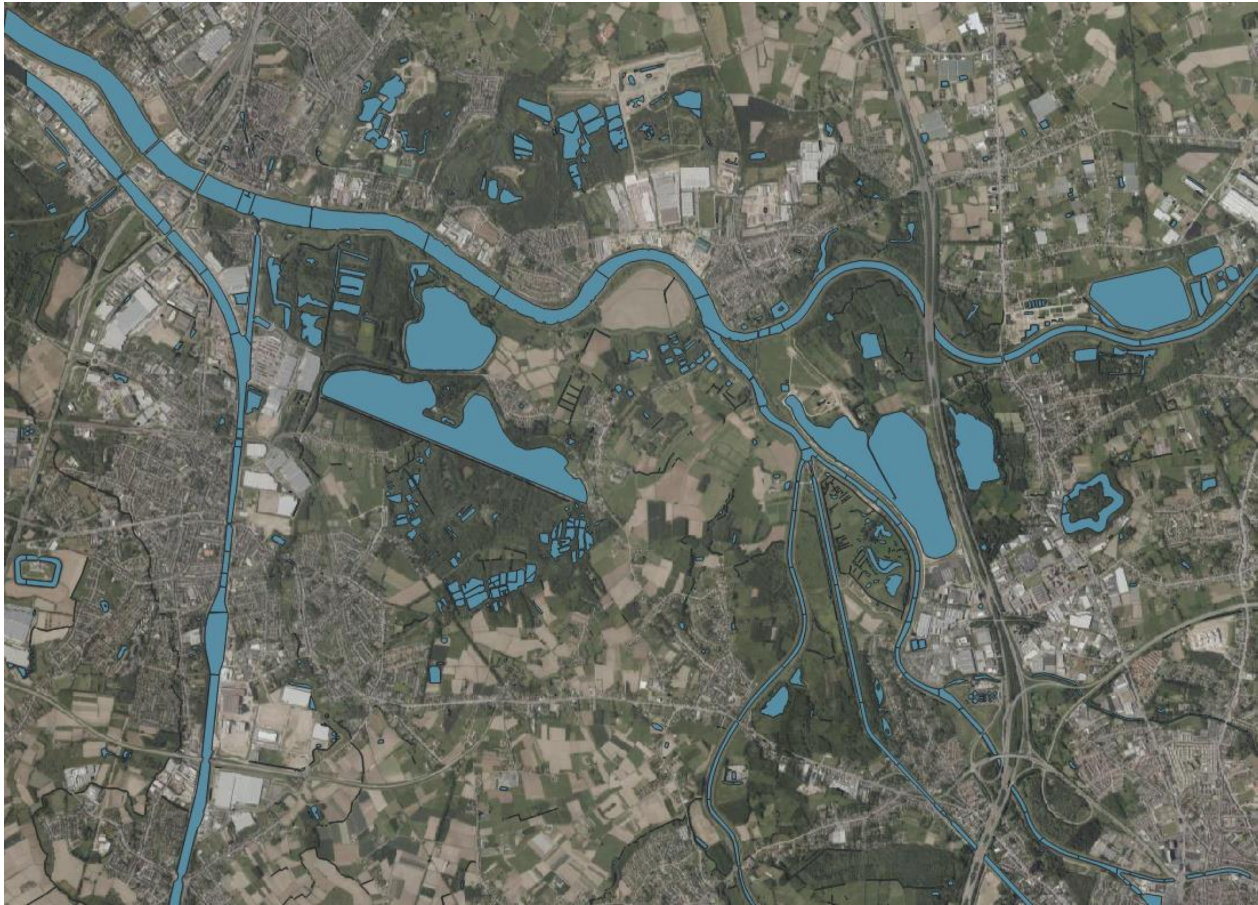
PICTURE

Water monitoring from the air

remote sensing

Water monitoring airborne

- RGB-NIR
- 25cm GSD
- AOI 1, 2 and extra AOI8



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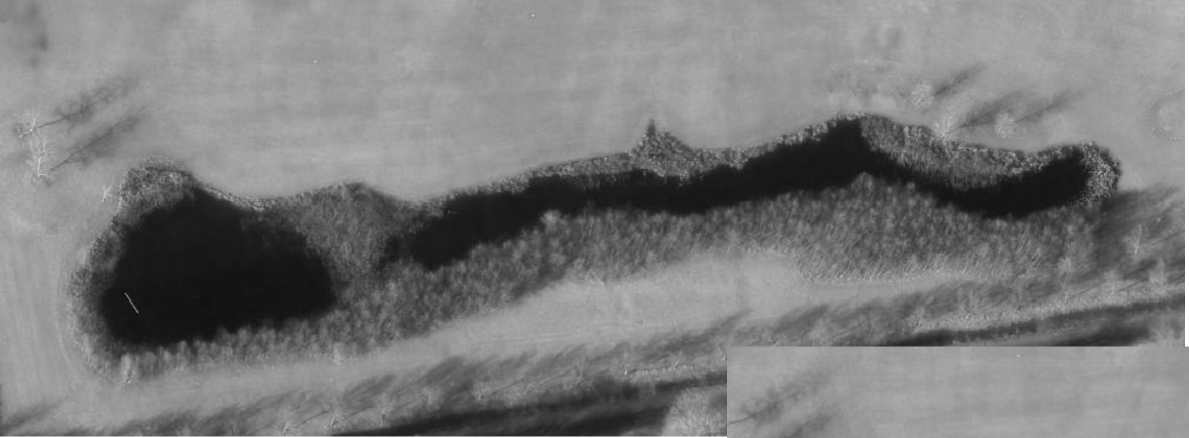
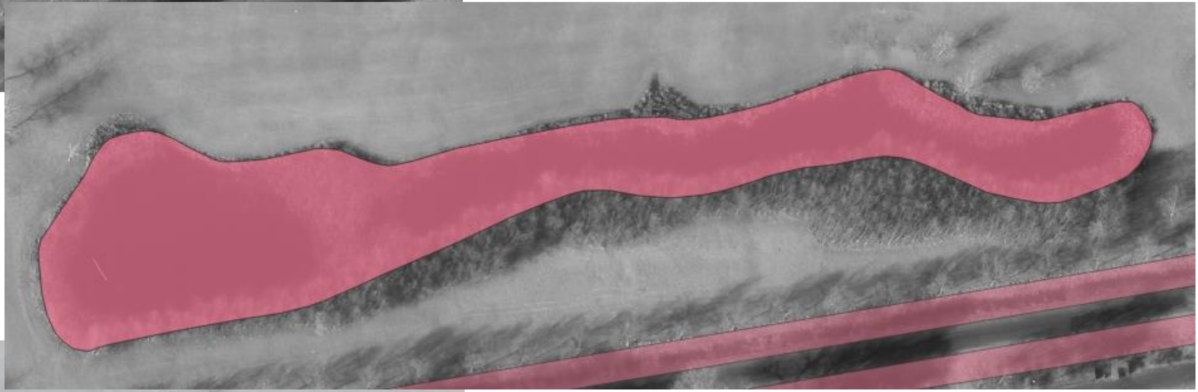
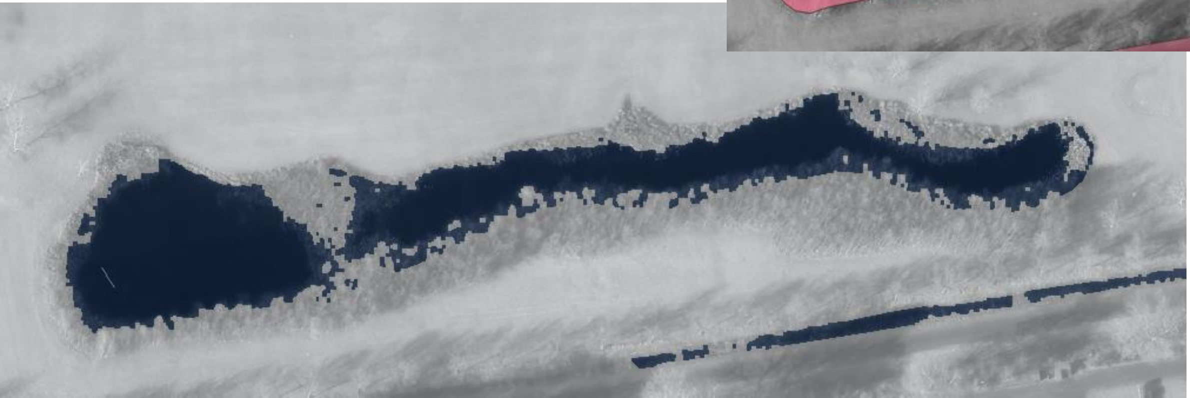


NIR image

Manual annotation

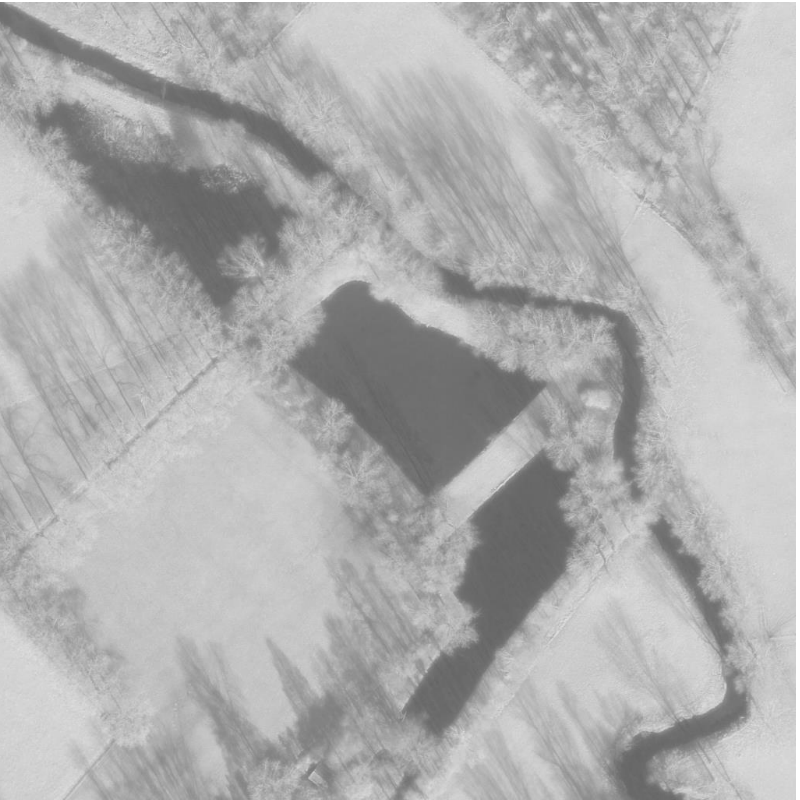


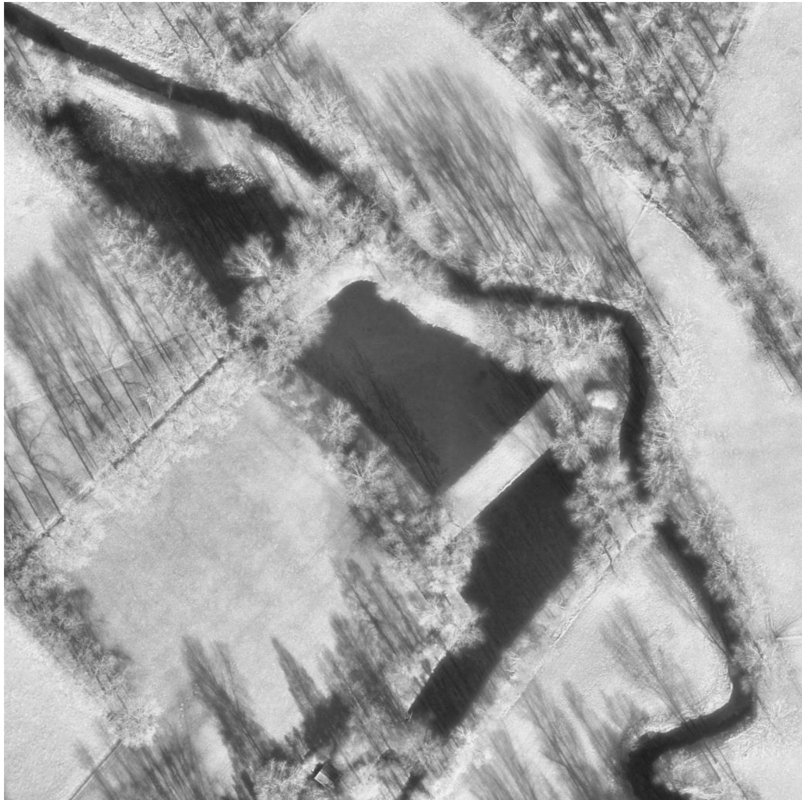


Thresholded annotation

remotesensing.vito.be

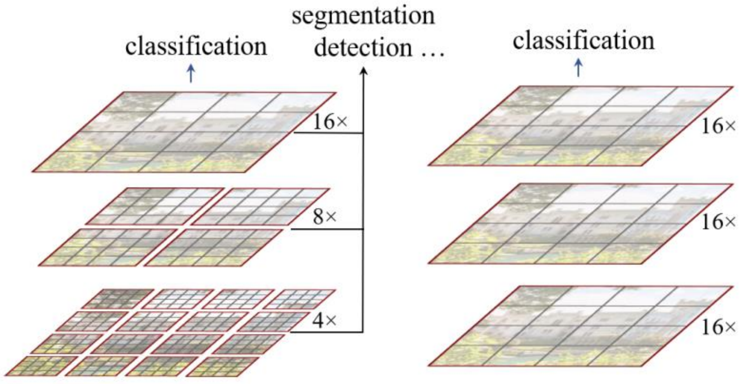
NIR preprocessing: CLAHE





AI detection model: SWIN backbone + UPerNet

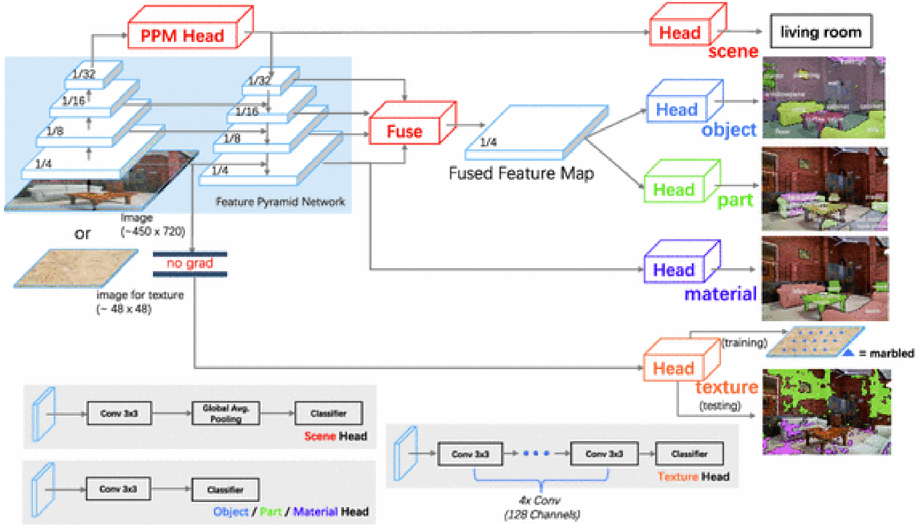
Swin Transformer backbone



(a) Swin Transformer (ours)

(b) ViT

Unified Perceptual Parsing for Scene Understanding



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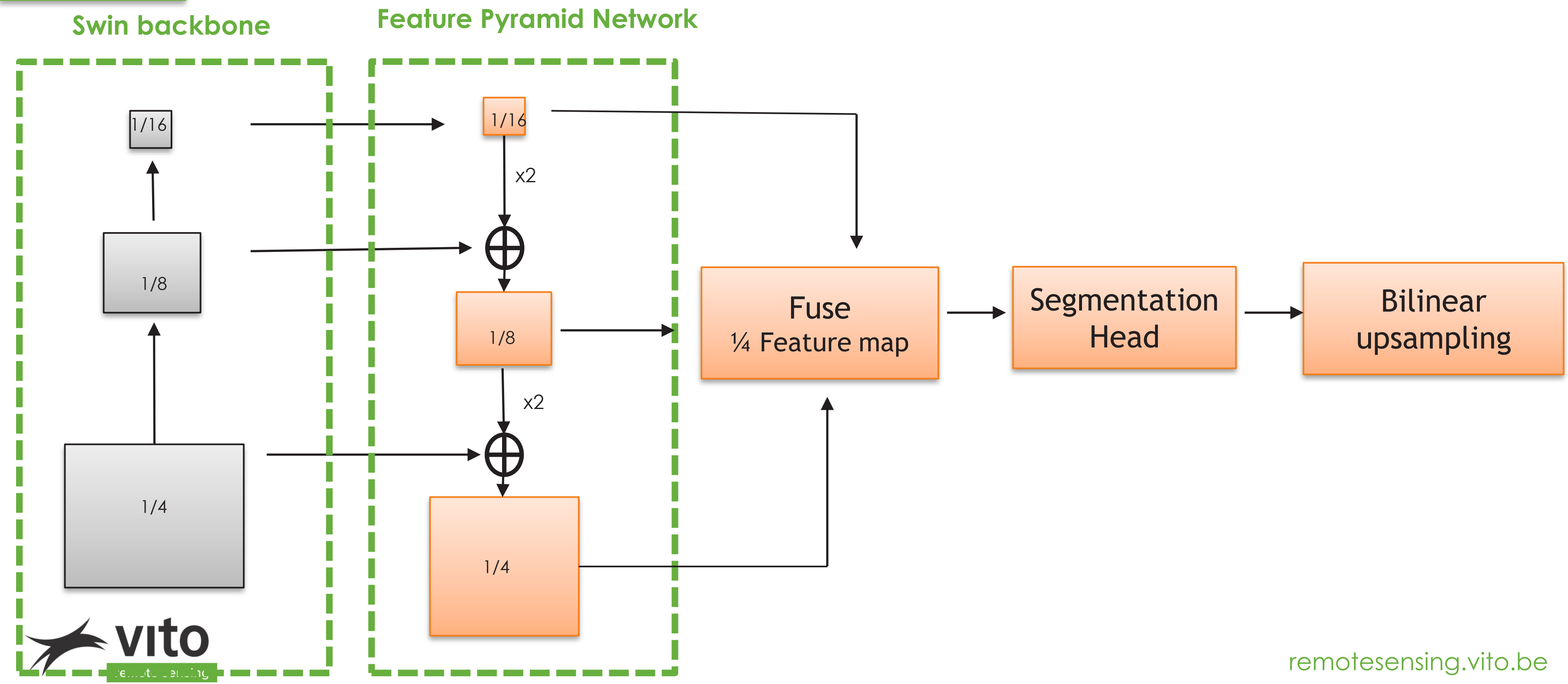
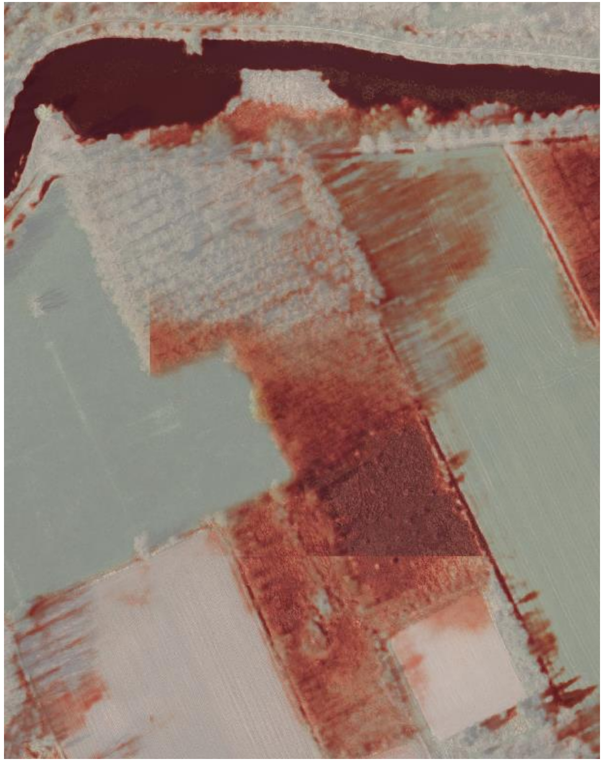
AI detection model: SWIN backbone + UPerNet



Water monitoring airborne: results

No CLAHE, training set v1



CLAHE, training set including shaded areas

Water monitoring airborne: results

Conclusion & future perspectives

- Spaceborne:
  - S-1 & S-2 successfully combined
  - Good results for open water, narrow & shallow water more challenging
  - Main remaining error: S-1 "water-a-likes"
- Airborne:
  - Good results for different NIR quality inputs
- Iterative training:
  - improve cloudy predictions for spaceborne
  - Update training dataset for airborne with client feedback

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THANK YOU

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Sentinel-2 image Copernicus Sentinel data (2016)