Water emergent and floating aquatic vegetation mapping using Earth Observation data: An example at the Dniester Delta in Ukraine

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Acknowledgments

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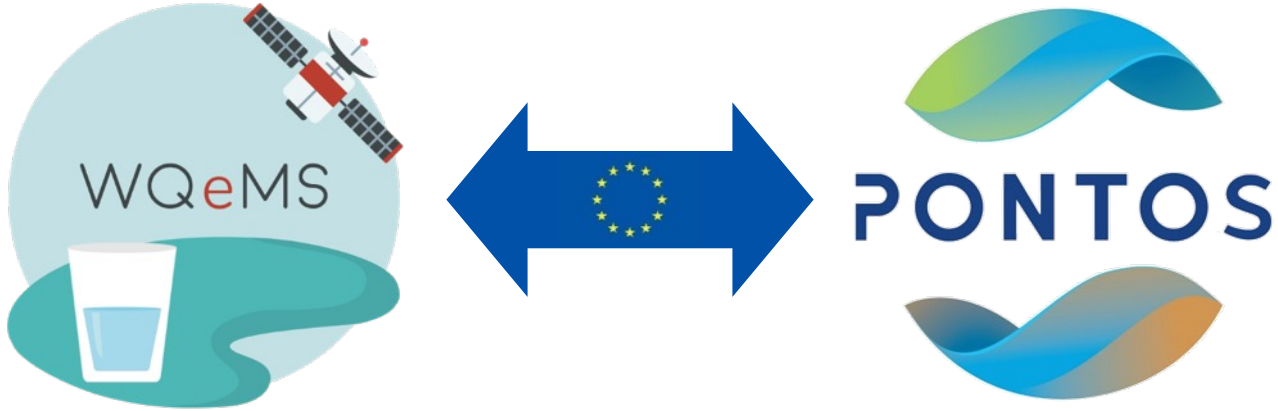

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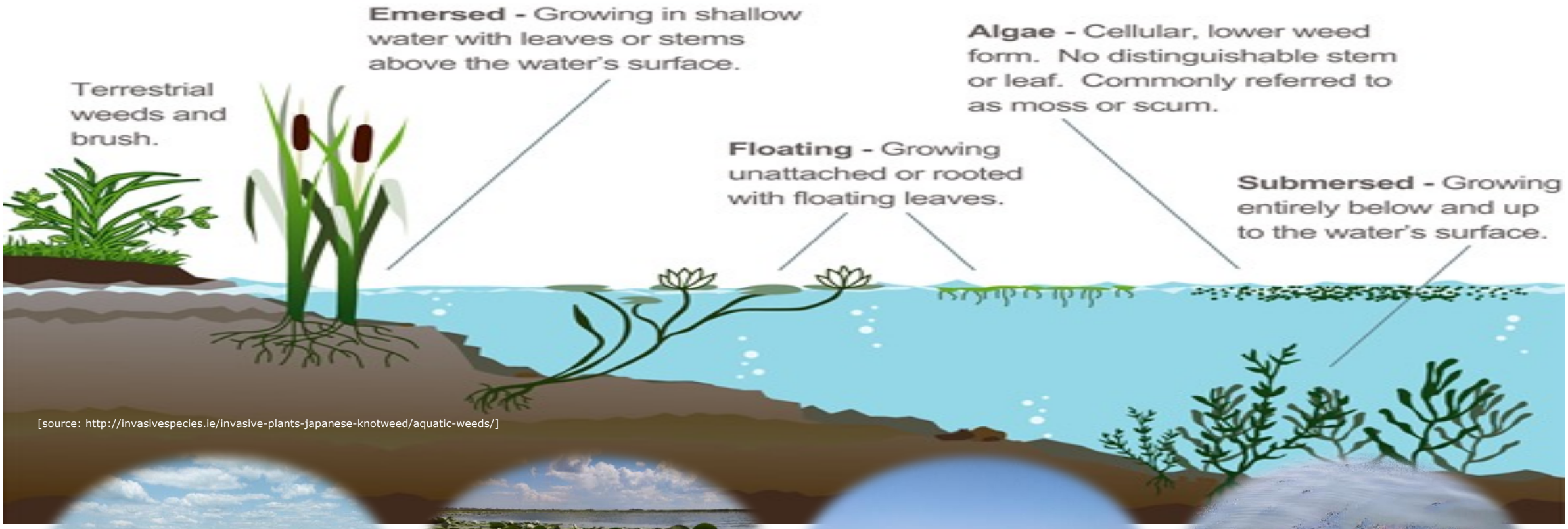
Thriving on the edge of the water
Aquatic vegetation – wetland ecosystems



[source: http://invasivespecies.ie/invasive-plants-japanese-knotweed/aquatic-weeds/]

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Aquatic vegetation excessive presence –> impacts

The aquatic vegetation affects to the water quality, biodiversity, ecosystems via

- decreasing dissolved oxygen level,
- increasing pH,
- reducing light penetration, slowing water velocity (while increasing water temperature),
- increasing siltation rates (in slow streams),
- clogging or hampering navigation channels/ areas used for fishing and touristic purposes,
- losing touristic attractiveness.

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Aim of this study is to produce inundation maps including information about emergent and floating vegetation

→ WITHOUT user input

→ with spaceborne data use ONLY

→ compatible with existing applied international workflows and norms

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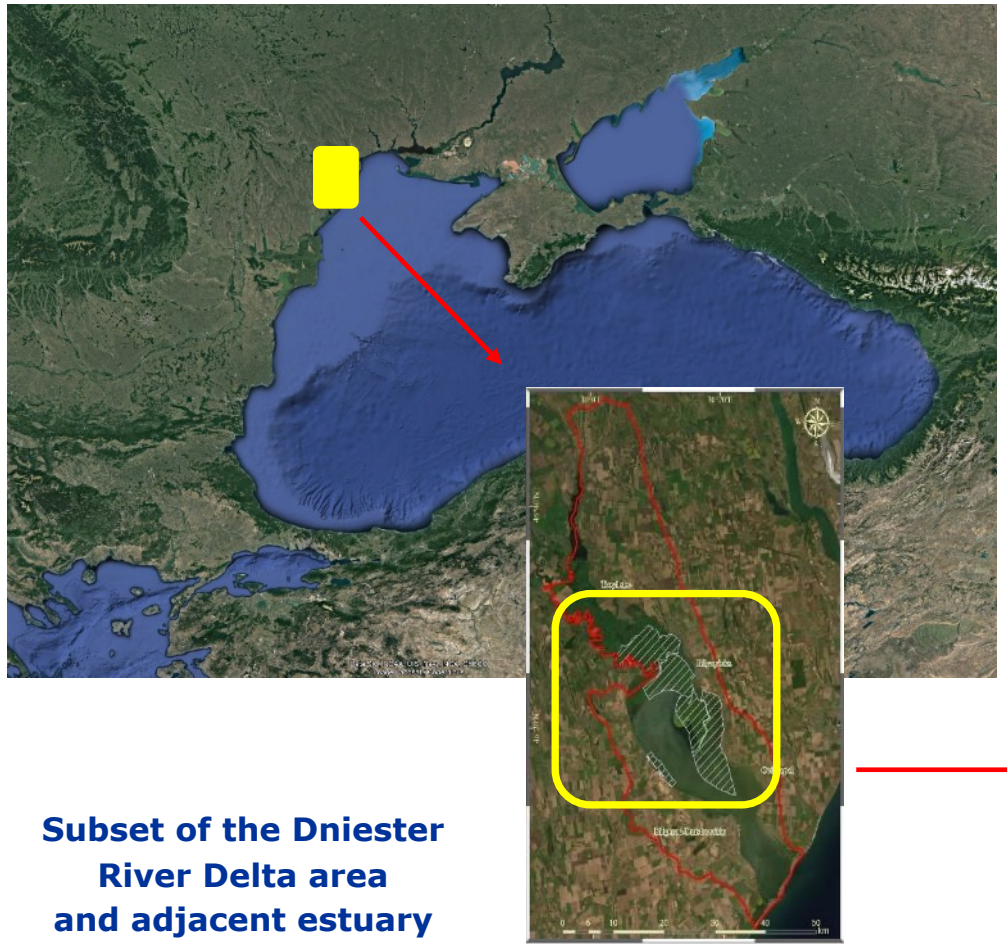
Location and surface cover synthesis of the study site: a puzzle for automated processes



Subset of the Dniester River Delta area and adjacent estuary (ca. 1800 km^2)

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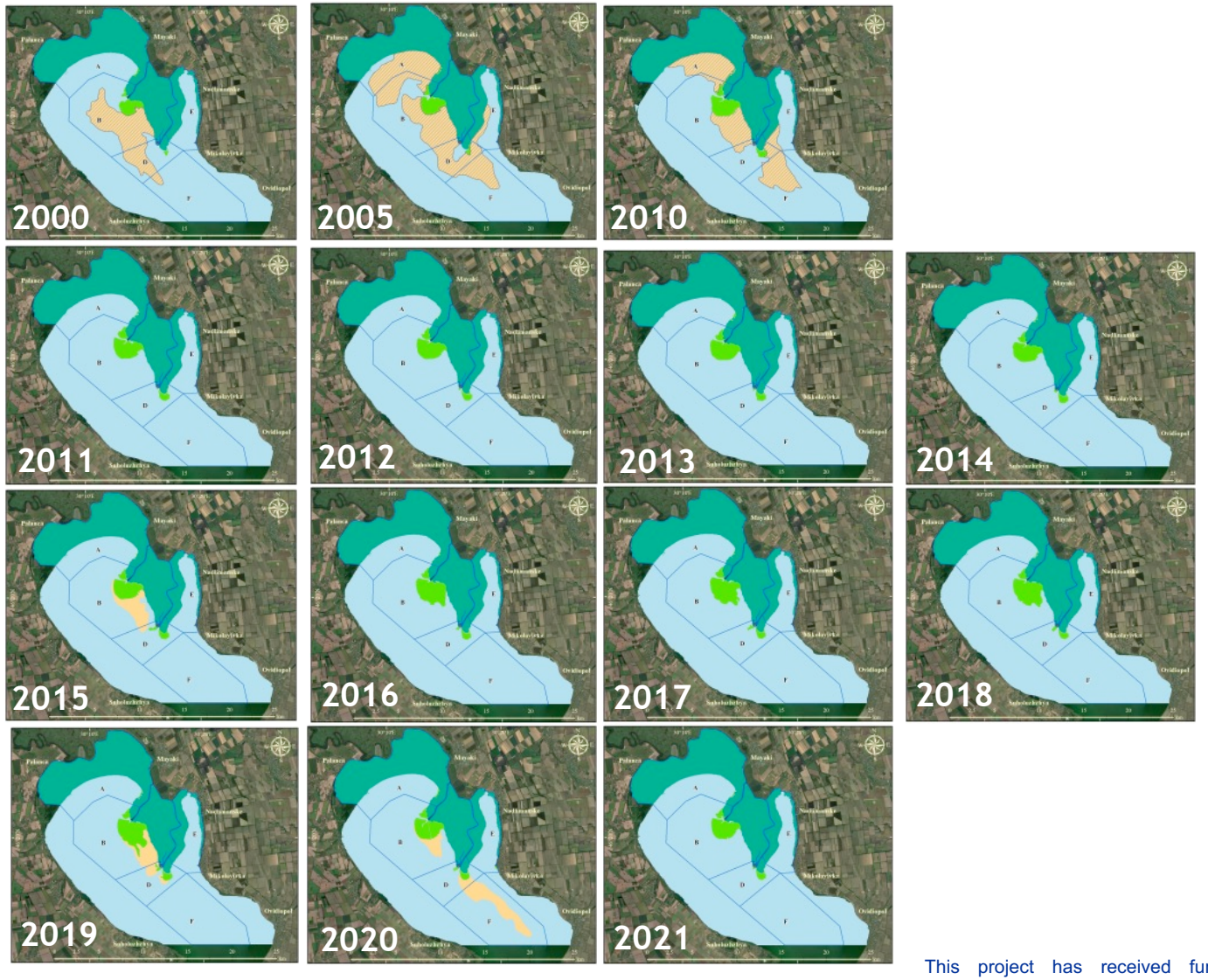
In situ monitoring through time: a resource demanding activity

Historical
Field data

Satellite estimates (2005-2010)
GPS-tracking (2011-2021)

Areas of
- Emergent
- Floating
- Floating with partially dense (semi)-submerged)

vegetation in the Dniester estuary in summer period of 2000-2021



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Field data acquisition

The historical data for 2011-2021 (Ukrainian pilot case) acquired by:

- Tracking of the boundaries of emergent and floating (+dense semi-submerged) vegetation with the boat-mounted GPS device of Eagle SeaCharter 640CDF GPS with horizontal accuracy of 3-5 meters (WAAS)
- Visual assessment of emergent and floating vegetation, its types and areas covered with a photo report
- Processing of the results of field tracking with GIS software, production of vegetation maps, and chronological analysis of changes

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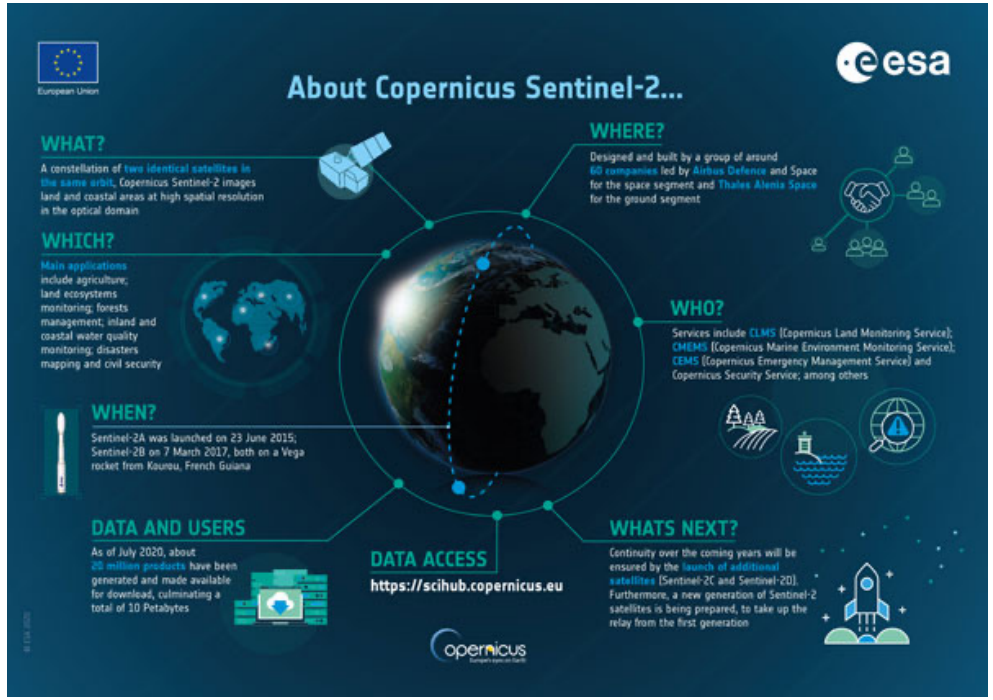
Spaceborne data

The methodology implemented using the available cloud-free Sentinel-2 (product 2A) data and specifically the:

- B05 band (Visible and Near Infrared, 705 nm)
- B11 band (Short Wave Infrared, 1610 nm)
- B12 band (Short Wave Infrared, 2190 nm)
- NDVI (Normalized Difference Vegetation Index)
- NDWI (Normalized Difference Water Index)



source: https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2

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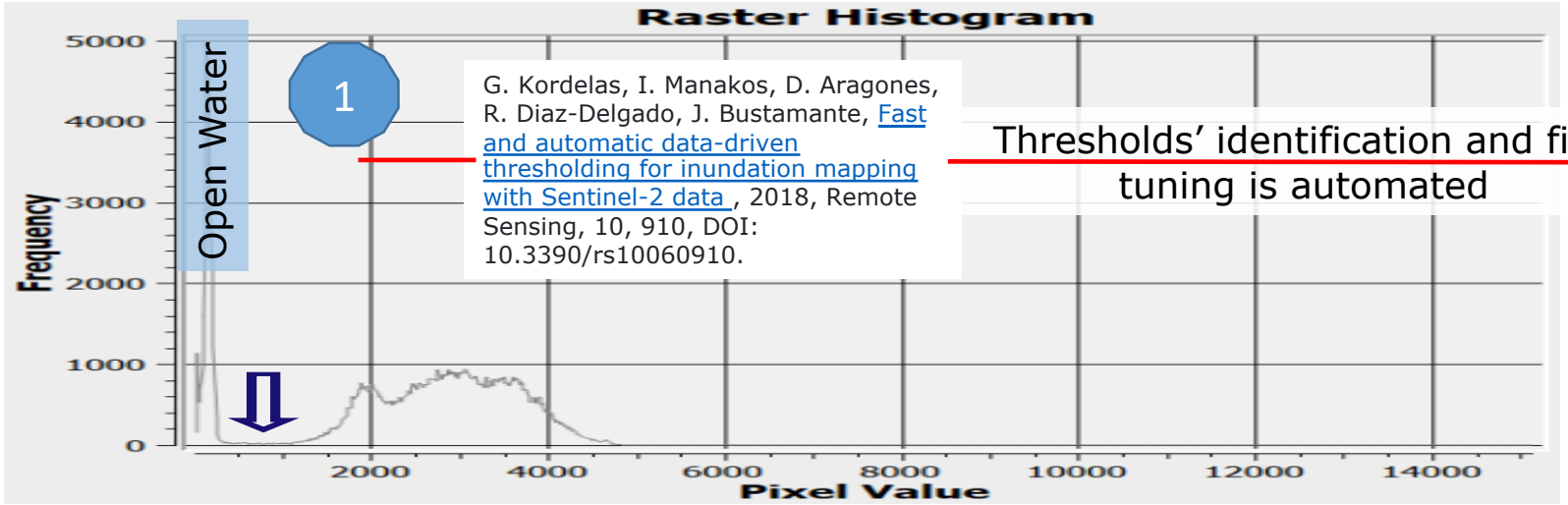
Towards solving the puzzle – Phase I

SWIR (B11) histogram

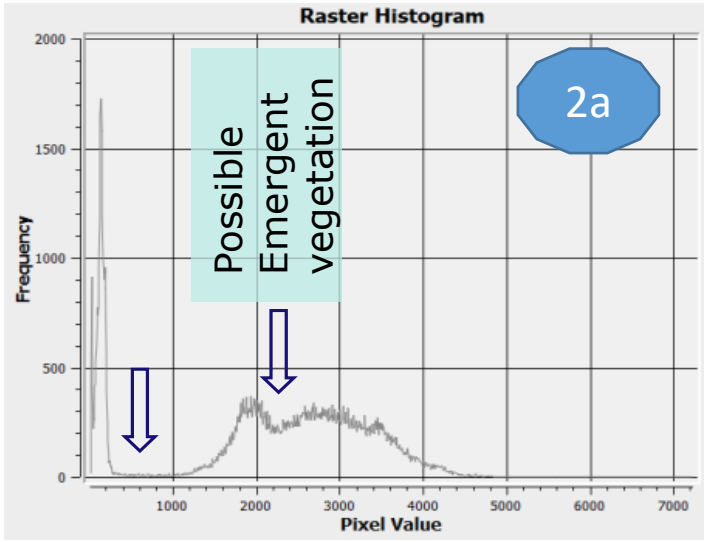


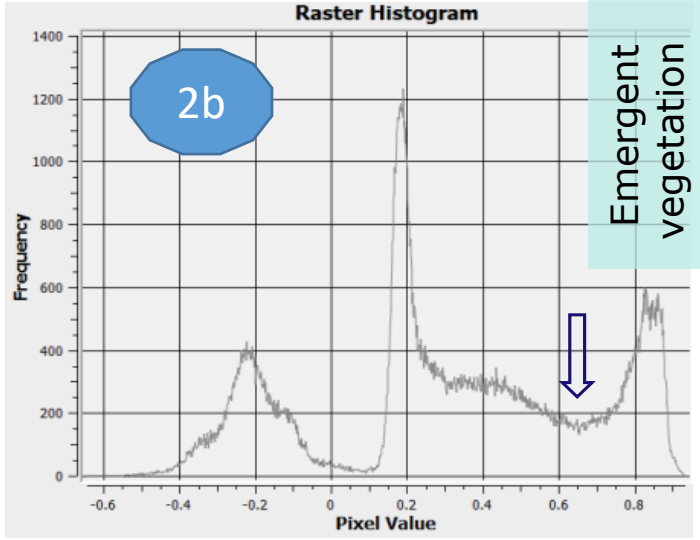
G. Kordelas, I. Manakos, D. Aragones, R. Diaz-Delgado, J. Bustamante, Fast and automatic data-driven thresholding for inundation mapping with Sentinel-2 data , 2018, Remote Sensing, 10, 910, DOI: 10.3390/rs10060910.

Thresholds' identification and fine tuning is automated

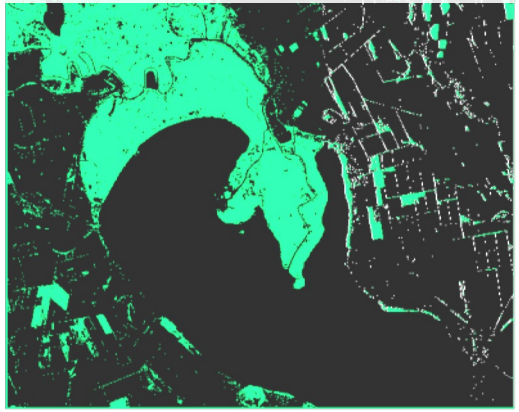
Open water, including floating vegetation

NDVI histogram





Emergent Vegetation, including floating vegetation



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Towards solving the puzzle – Phase II

3

Conditions:

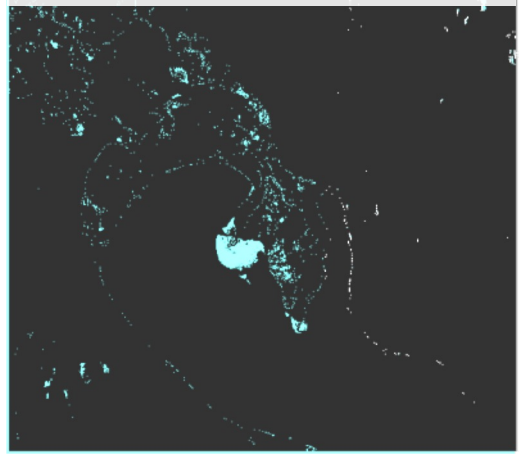
$B05/B11 \in (0.6, 1.5)$

$NDWI \in (0.2, 0.45)$

$B12 \in (100, 900)$

Thresholds' identification could become automated

Floating vegetation

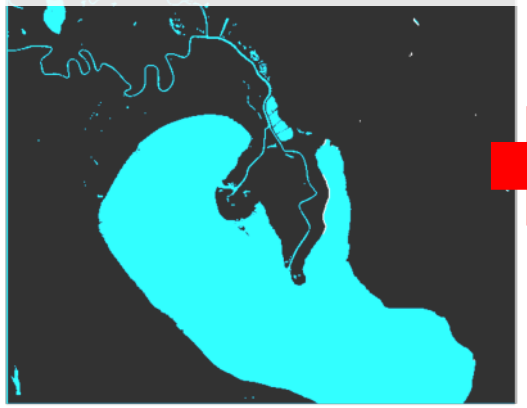


4

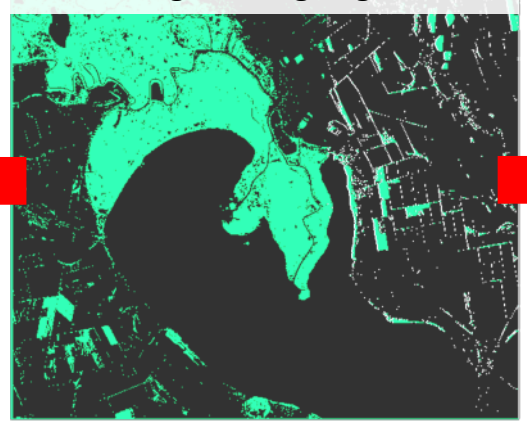
Combine the 1,2 &3

1. Where is Open water is Open water
2. Where is Emergent vegetation is Emergent vegetation
3. Where is Floating vegetation, keep it & overwrite pixels of (1.) & (2.)

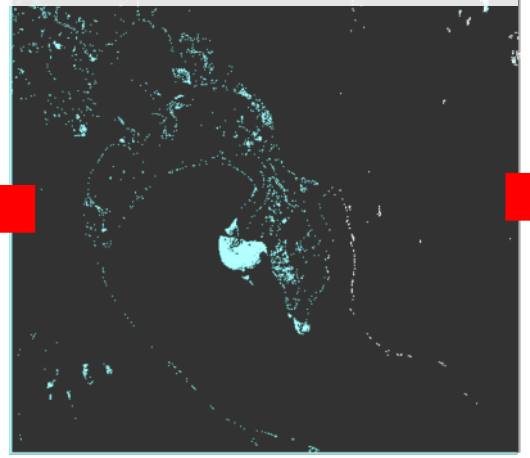
Open water, including floating vegetation



Emergent Vegetation, including floating vegetation



Floating vegetation



Area of interest boundaries:
the more specific the better the result as land cover synthesis influences thresholds' identification

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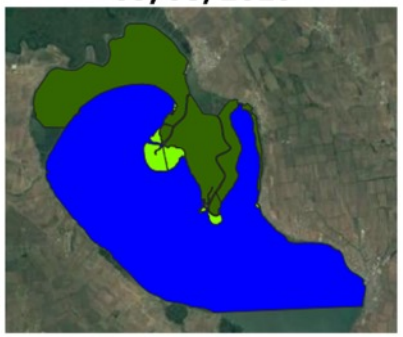
Results visualization

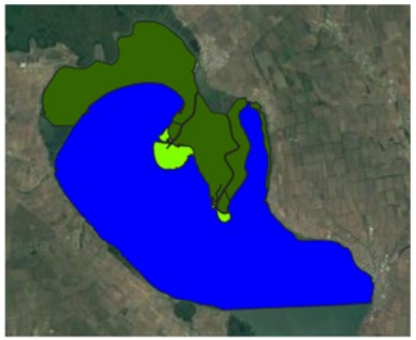
Classified image
05/08/2020

Ground reference data
05/08/2020



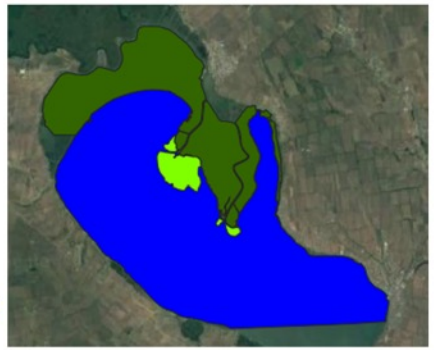
Classified image
05/08/2021

Ground reference data
26/07/2021



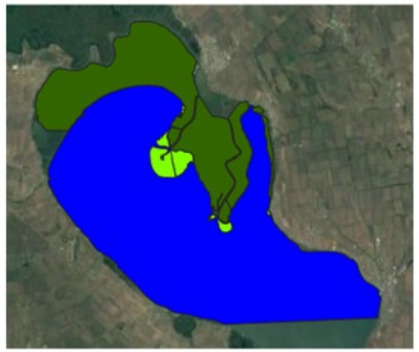
Classified image
11/08/2018

Ground reference data
22/07/2018



Classified image
30/08/2020

Ground reference data
05/08/2020



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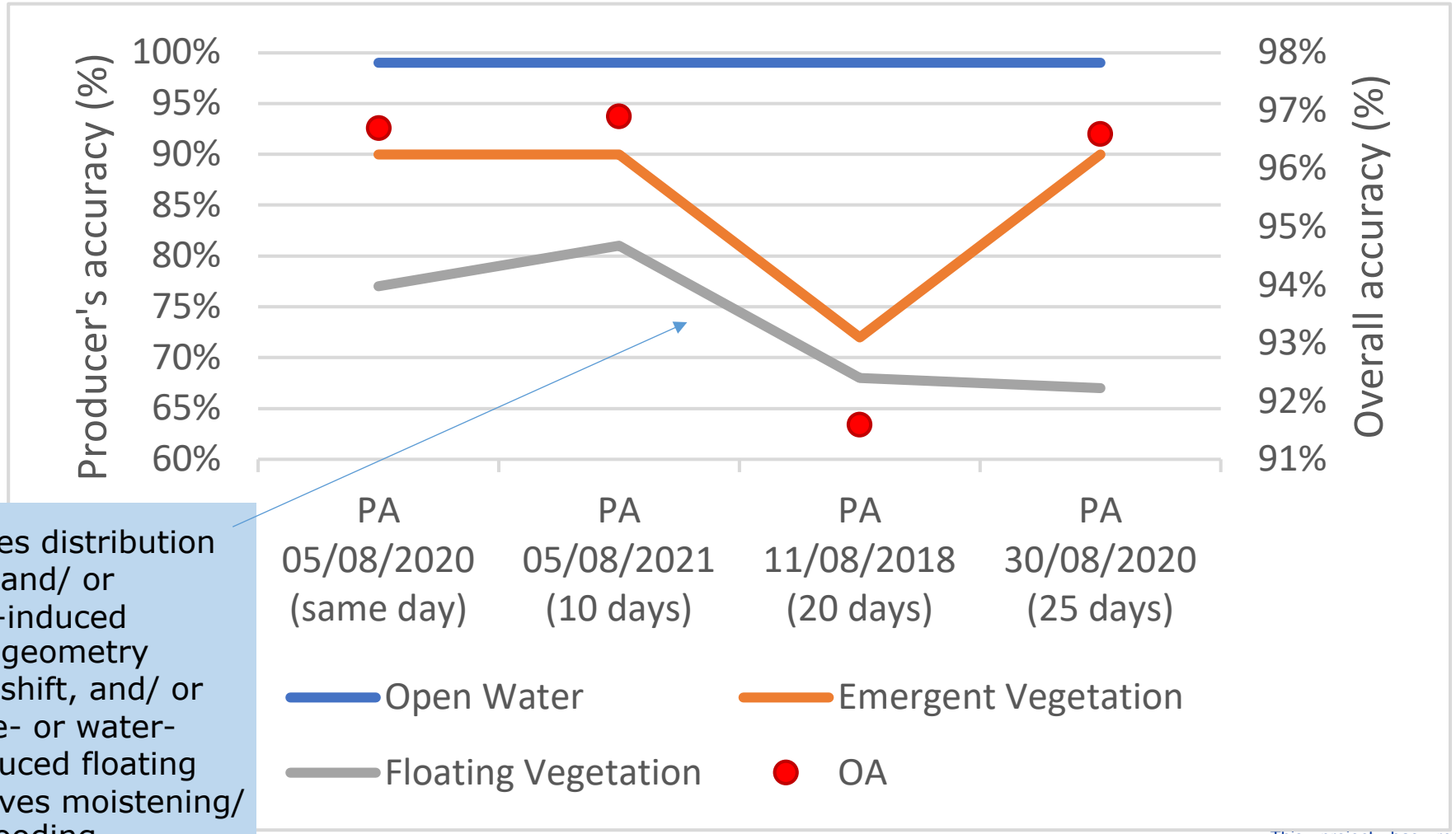
Statistics (…)

Overall high OA (> 91%) at all dates is in this case misleading for the performance of the approach in each class, as the assessed dataset is imbalanced (surface extent per class).



(i) Patches distribution change; and/ or
(ii) wind-induced density/ geometry change/ shift, and/ or
(iii) wave- or water-level-induced floating plant leaves moistening/ partial flooding

The PA shows the false negative predictions and compares the classified map with the producers' expectations: (correctly classified pixels/ total classified pixels for the class incl. wrong classifications)

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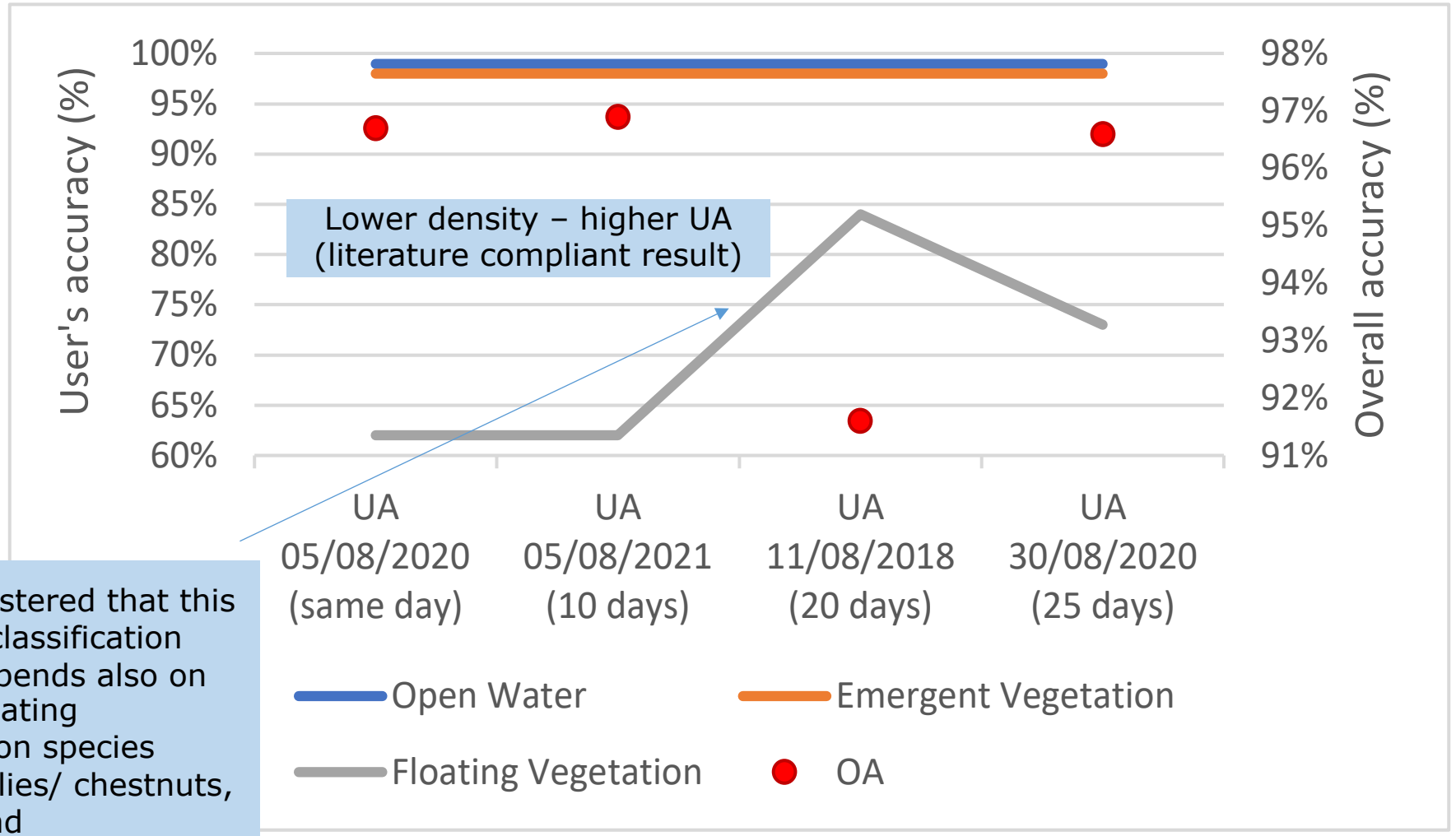
Statistics (…)



It is registered that this type of classification error depends also on
i) the floating vegetation species (water lilies/ chestnuts, else), and
ii) the density-level

The UA is the probability that a value predicted to be in a certain class really is that class, i.e., the user's certainty: (classified pixels of a class/ pixels that truly - per-in-situ-reference belong in this class)

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Conditions on the ground support findings

In July/August (until there is no strong flooding) wind may substantially change the geometry and density of floating vegetation appearance within hours-to-days, as well as even move the water lilies and water chestnut formations (polygons).

High waves (occurring in large-scale shallow water bodies) may also break the polygons, by uprooting floating rooted plant and move them.

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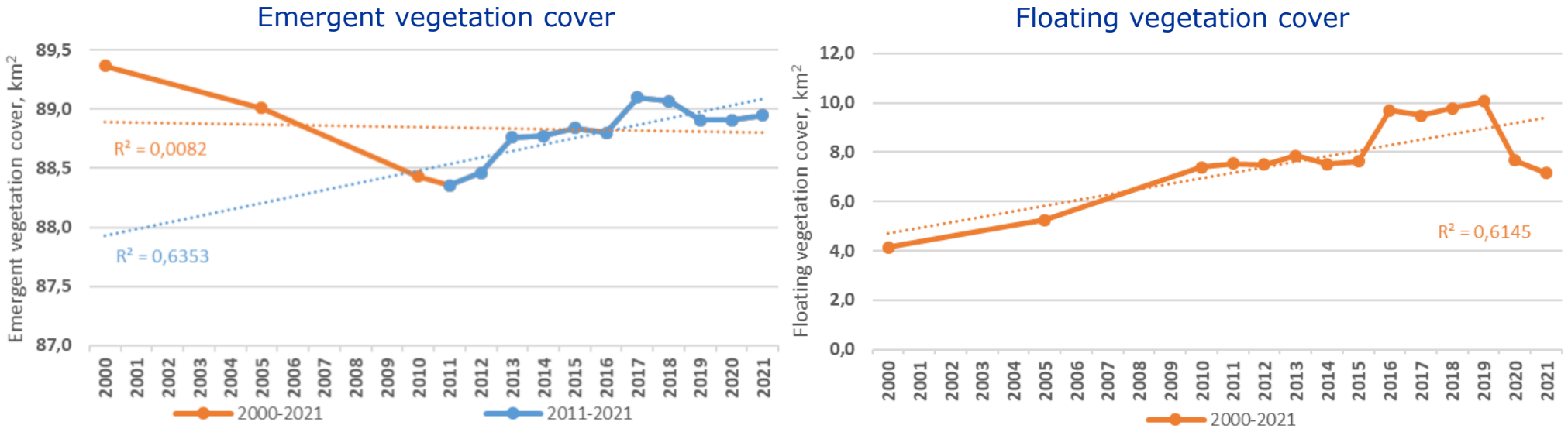
Way forward – transferability

Further experimentation is required, where ground reference data allow, to enhance the transferability of the approach through time, turbidity conditions, and neighbourhood land cover synthesis.



Inter-annual changes of emergent (left) and floating (right) vegetation cover (km2)
in the studied polygons (A, B, D, E) within Dniester estuary in mid-summer periods of 2000-2021

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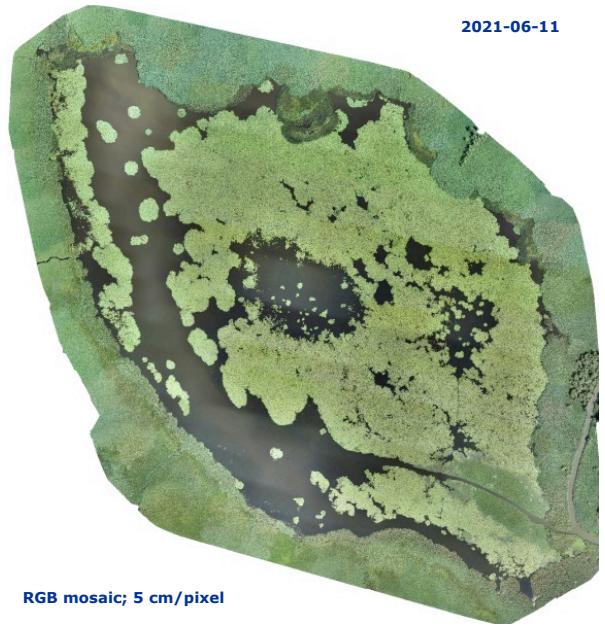
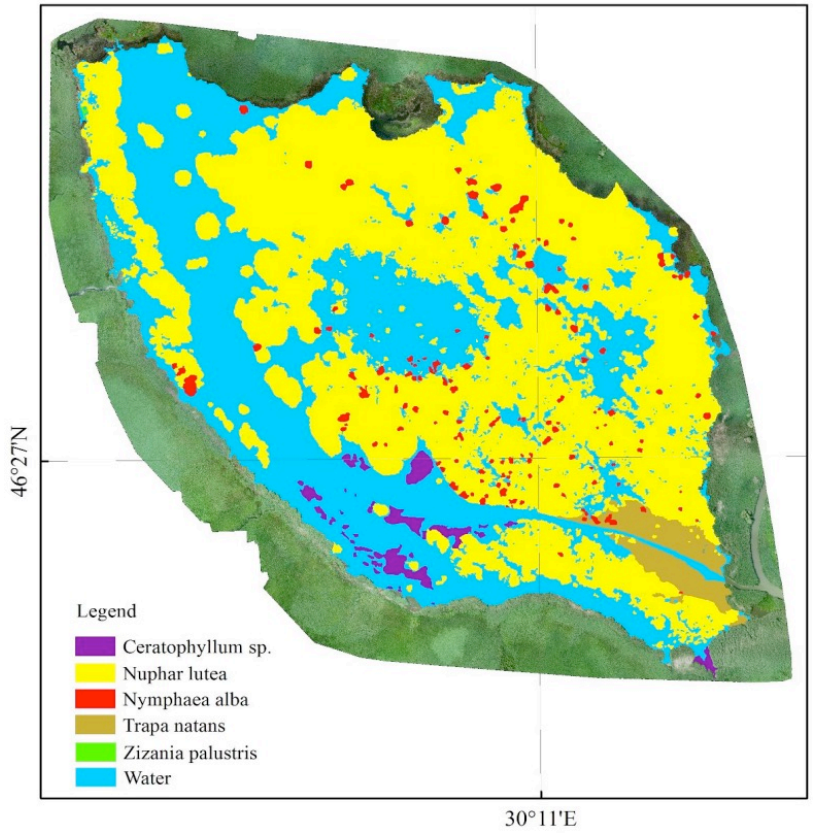
Way forward – automatization & reaching out to biologists

Reference data acquisition across additional sites may allow testing strict thresholding performance and possibly evolving adaptive thresholding techniques; thus, leading to generalization of the approach towards utilizing further sensors, and identifying species distributions.





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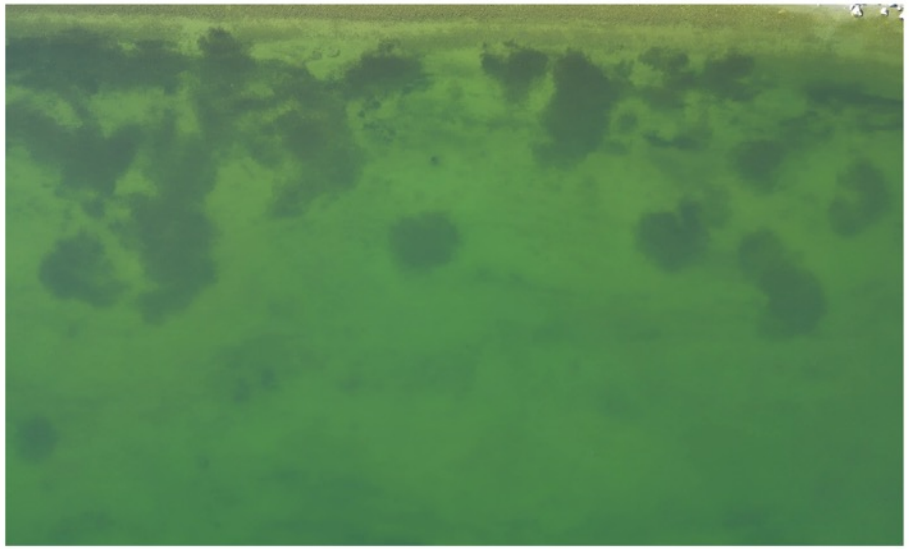
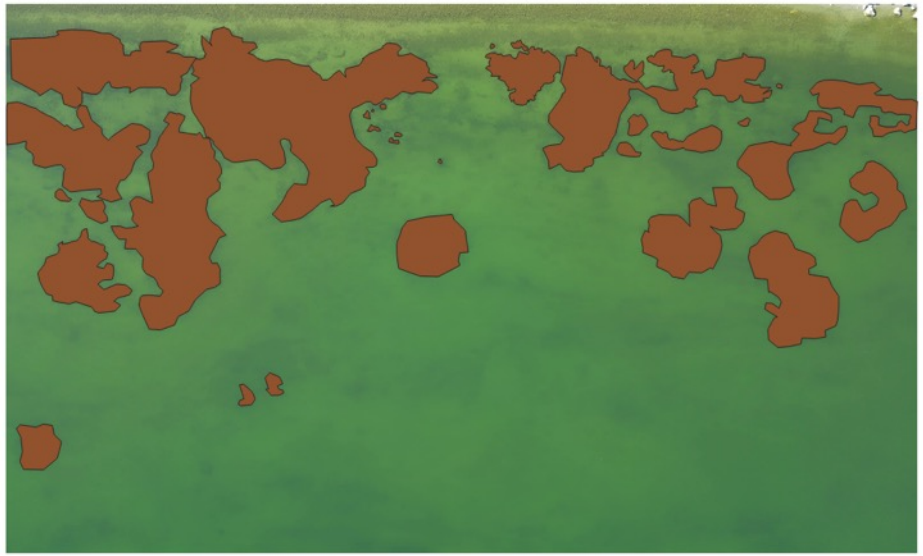
Way forward – the last piece of the aquatic vegetation occurrences

Ground data may also support augmenting the suggested approach by encompassing submerged aquatic vegetation mapping. This is still a challenge for Earth Observation due to the influence of the water column on the reflected signal.





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Thank you for your attention

On behalf of our Ukrainian colleagues and the CERTH team

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