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Accelerating circular bio-based solutions integration in European rural areas

Satellite monitoring for agricultural drought

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The *Copernicus programme* is a long-term European Union Earth observation and monitoring program. Currently, the program has launched seven dedicated families, the so-called Sentinels.

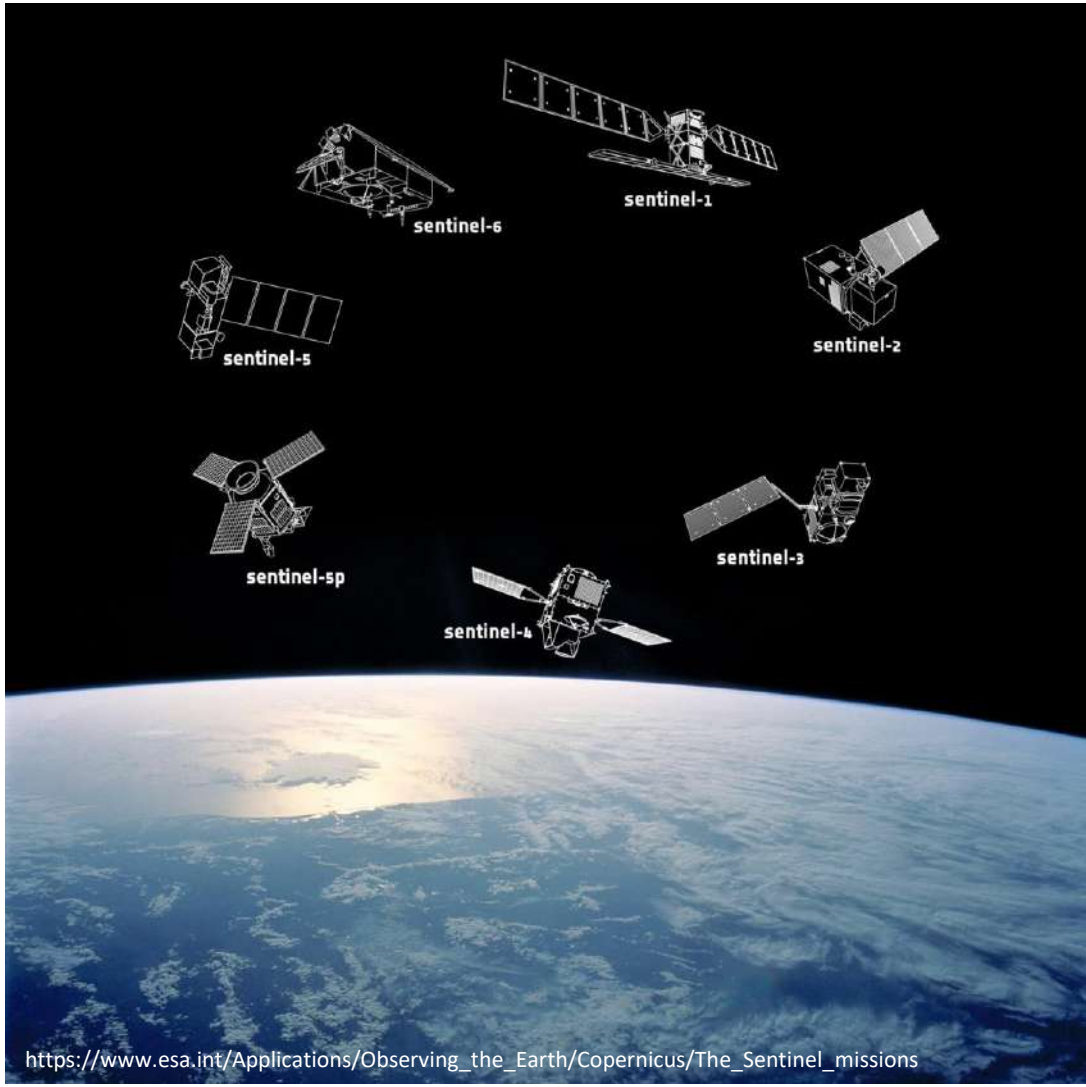
- *Sentinel-1:* high-resolution land and ocean monitoring
- *Sentinel-2:* high-resolution land and ocean monitoring
- *Sentinel-3:* ocean and global land monitoring
- *Sentinel-4:* atmospheric composition monitoring
- *Sentinel-5 Sentinel-5P:* atmospheric composition monitoring
- *Sentinel-6:* sea level monitoring

now in orbit - 7 satellites: Sentinel-1A, Sentinel-2A, Sentinel-2B, Sentinel-3A, Sentinel-3B, Sentinel-5P, Sentinel-6A

approved to launch – 12 satellites: *Sentinel-1C, Sentinel-1D, Sentinel-2C, Sentinel-2D, Sentinel-3C, Sentinel-3D, Sentinel-4A, Sentinel-4B, Sentinel-5A, Sentinel-5B, Sentinel-5C, Sentinel-6B*

In preparation are six high priority candidate "expansion" missions.

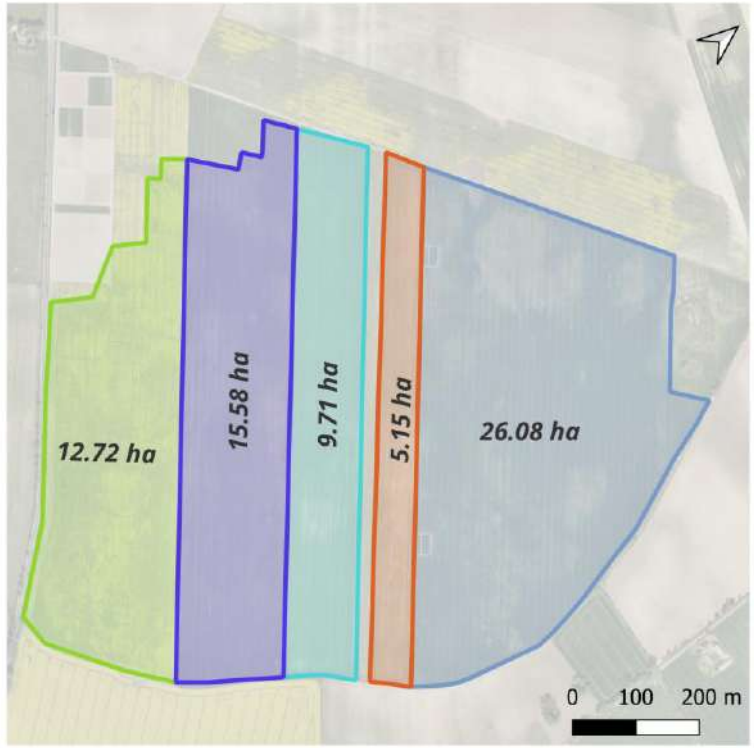
- *Sentinel-7:* Anthropogenic CO_2 emissions monitoring
- *Sentinel-8:* High Spatio-temporal resolution Land Surface Temperature
- *Sentinel-9:* Copernicus Polar Ice and Snow Topography Altimeter
- *Sentinel-10:* Copernicus Hyperspectral Imaging Mission for the Environment
- *Sentinel-11:* Copernicus Imaging Microwave Radiometer
- *Sentinel-12:* Radar Observing System for Europe - L-band SAR

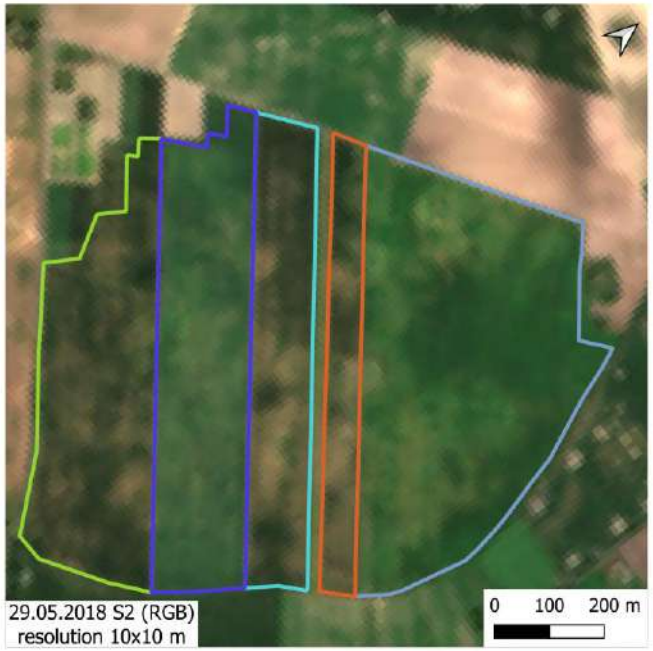


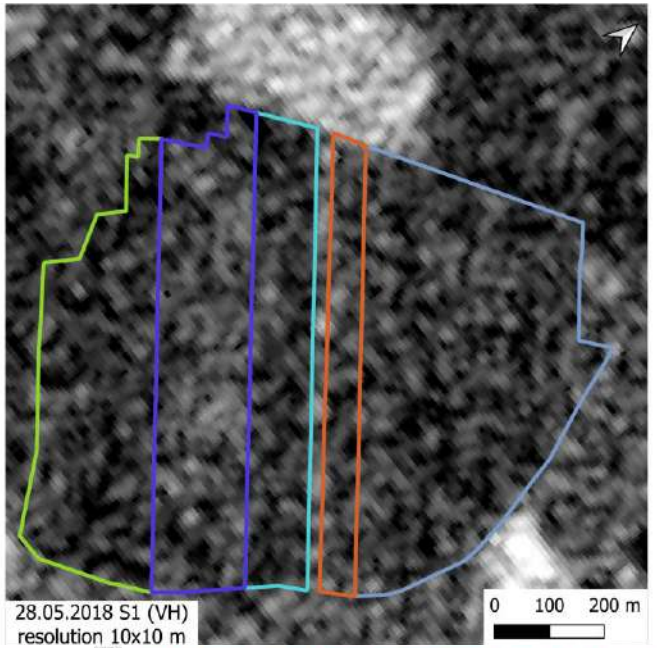
https://www.esa.int/Applications/Observing_the_Earth/Copernicus/The_Sentinel_missions

HIGH-RESOLUTION SATELLITE IMAGERY

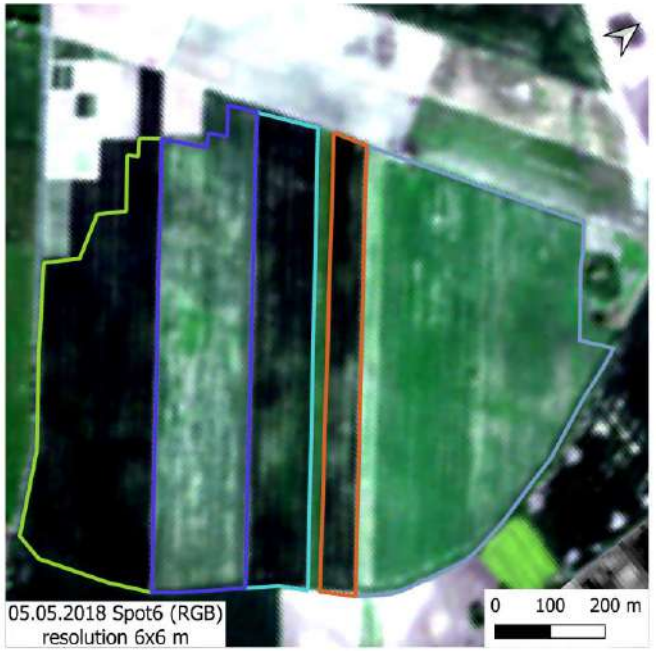
Sentinel-1 & Sentinel-2
public satellite imagery

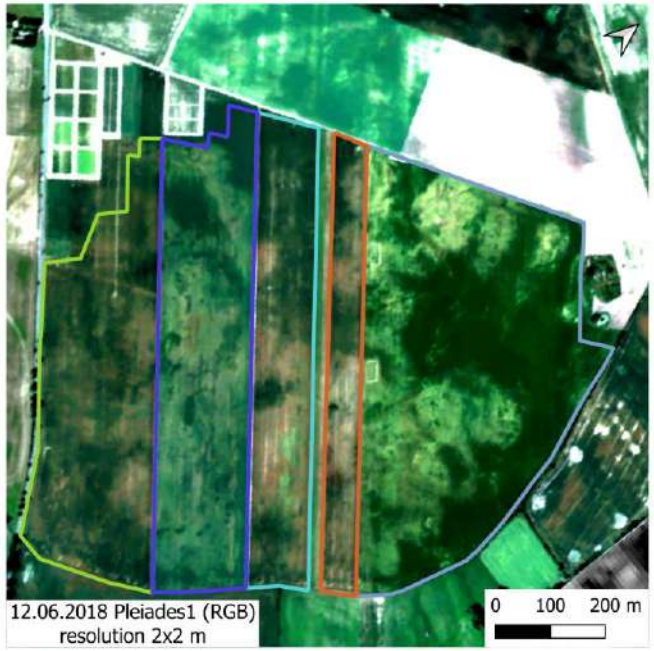






Spot6 & Pleiades-1
commercial satellite imagery





SENTINEL-2 multi-spectral imaging mission

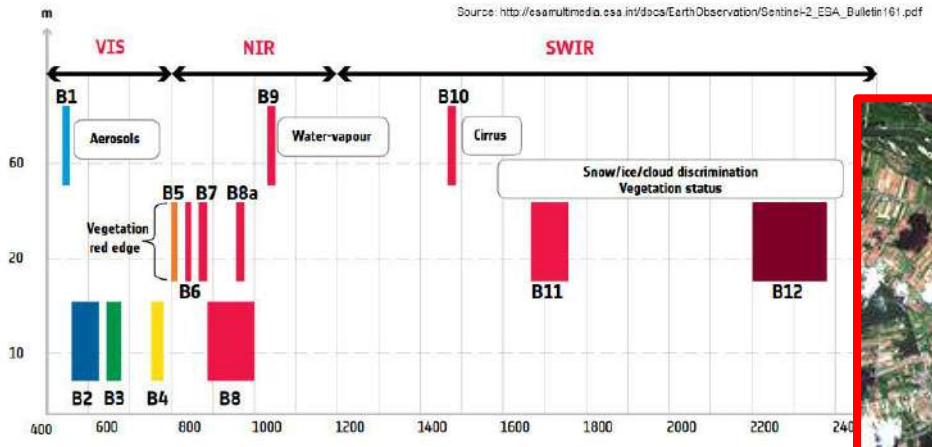
Sentinel-2A - launched - 23.06.2015

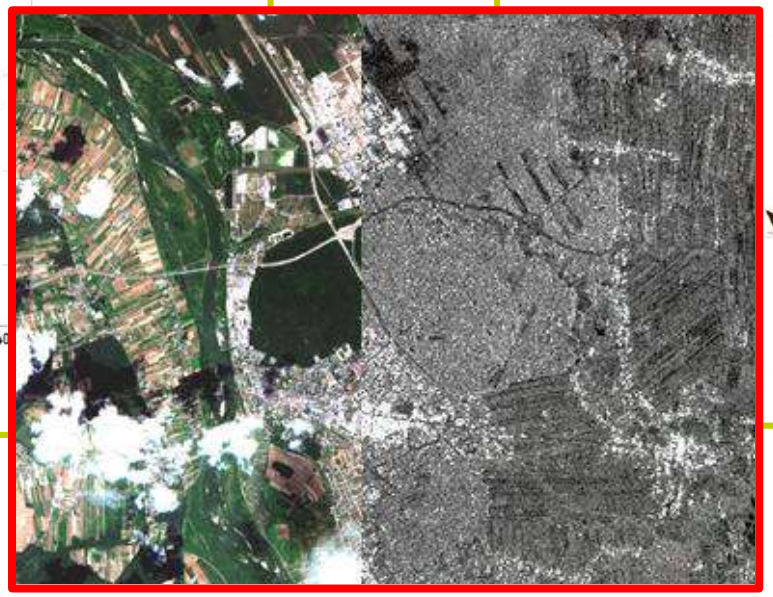
Sentinel-2B - launched - 07.03.2017

sensor - **13-bands multispectral scanner instrument (MSI)**

revisit time (one satellite) - **10 days**

spatial resolution - **10 m, 20 m and 60 m**





SENTINEL-1 radar imaging mission

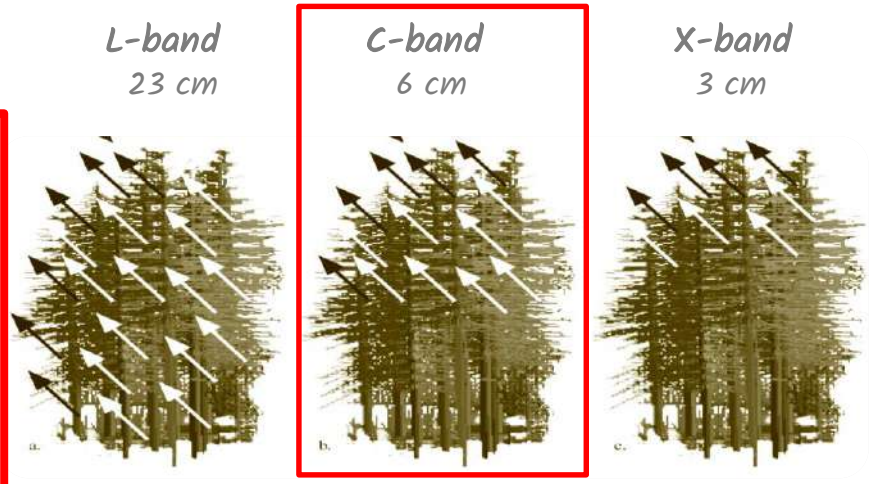
Sentinel-1A - launched - 03.04.2014

Sentinel-1B - launched - 25.04.2016 (ended 3.08.2022)

sensor - **C-band Synthetic Aperture Radar (SAR)**

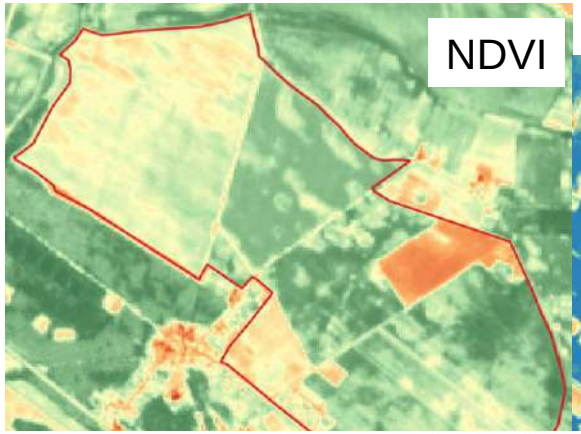
revisit time (one satellite) - **12 days**

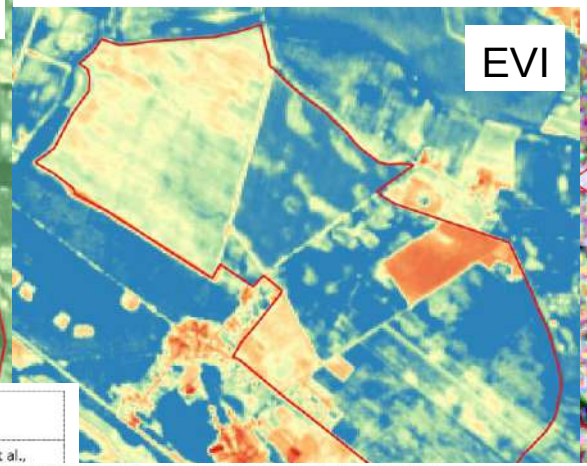
spatial resolution

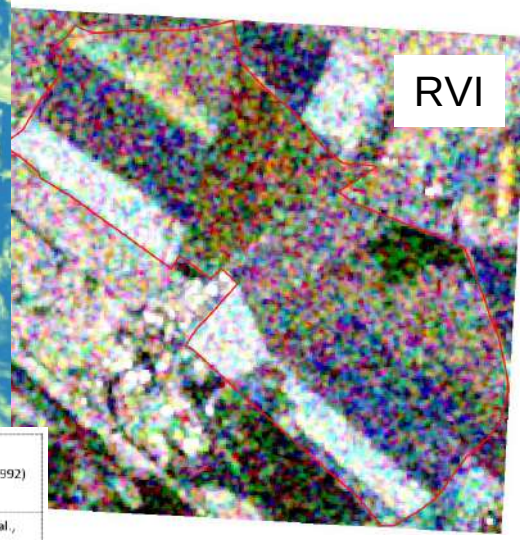


Missions comprises a constellation of two polar-orbiting satellites placed in the same sun-synchronous orbit, phased at 180° to each other.

VEGETATION INDICES FOR AGRICULTURAL MONITORING







Vegetation Index	Name / Description	Sentinel bands and constants used	Source
ARI1	Anthocyanin Reflectance Index 1	$\left(\frac{1}{B3}\right)-\left(\frac{1}{B5}\right)$	(Gitelson et al., 2001, pp. 4
ARI2	Anthocyanin Reflectance Index 2	$\left(\frac{B8}{B2}\right)-\left(\frac{B8}{B3}\right)$	(Kaufman 1992)
CHL-RED-EDGE	Chlorophyll Red-Edge	$\frac{B5}{B8}$	(LGIS, 2018
CRI1	Carotenoid Reflectance Index 1	$\left(\frac{1}{B2}\right)-\left(\frac{1}{B3}\right)$	(LGIS, 2018
CRI_{700}	**Carotenoid Reflectance Index at 700nm**	$\left(\frac{1}{B2}\right)-\left(\frac{1}{B5}\right)$	(Gitelson e 2002, p. 27
EVI	Enhanced Vegetation Index	$2.5\cdot\frac{B8-B4}{B8+(6\cdot B4-7.5\cdot B2)+1}$	(JIANG et a p. 2)
	Enhanced Vegetation Index 2	$2.5\cdot\frac{B8-B4}{B8+2.4\cdot B4+1}$	(JIANG et a p. 4)

GEMI	Global Environmental Monitoring Index	$e\cdot(1-0.25\cdot e)-\left(\frac{B4-0.125}{1-B4}\right)$ With: $e=\frac{2\cdot(B8^2-B4^2)+1.5\cdot B11+0.5\cdot B4}{B8+B4+0.5}$	(Pinty et al., 1992)
GLI	Green Leaf Index	$\frac{(B3-B4)+(B3-B2)}{B2+2\cdot B3+B4}$	(Louhaichi et al., 2008)
GNDVI	Green Normalized Difference Vegetation Index	$\frac{B8-B3}{B8+B3}$	(Gitelson et al., 1996)
GRVI	**Green-red Vegetation Index**	$\frac{B3-B4}{B4+B3}$	(Motohka et al., 2010, p. 2370)
GRVI1	Green Ratio Vegetation Index 1	$\frac{B8}{B3}$	(Sripada et al., 2007, p. 1425)
GSAVI	Green Soil Adjusted Vegetation Index	$(1+L)\cdot\frac{B8-B3}{B8+B3+0.5}$ with: L =0.5	(Harris Geospatial Solutions, Inc., 2018)
IRECI	Inverted Red-Edge Chlorophyll Index	$(B7-B4)\cdot\frac{B6}{B5}$	(Frampton et al., 2013, p. 84)
LAI-SAVI	Leaf Area Index - Soil Adjusted Vegetation Index	$-\frac{\log\left(0.371+1.5\cdot\frac{B8-B4}{B8+B4+0.5}\right)}{2.4}$	(LGIS, 2018)

Radar Vegetation Index

$$RVI=\frac{4VH}{VH+VV}$$

NDVI (Normalized Difference Vegetation Index)

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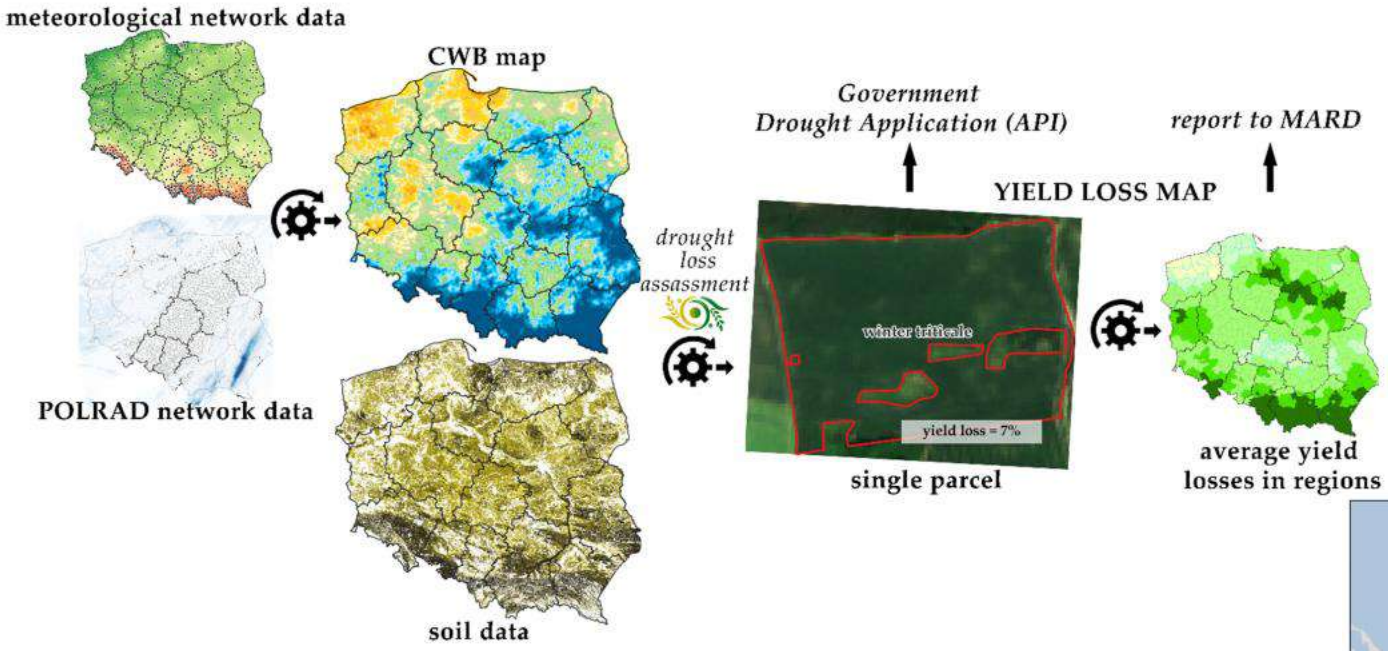
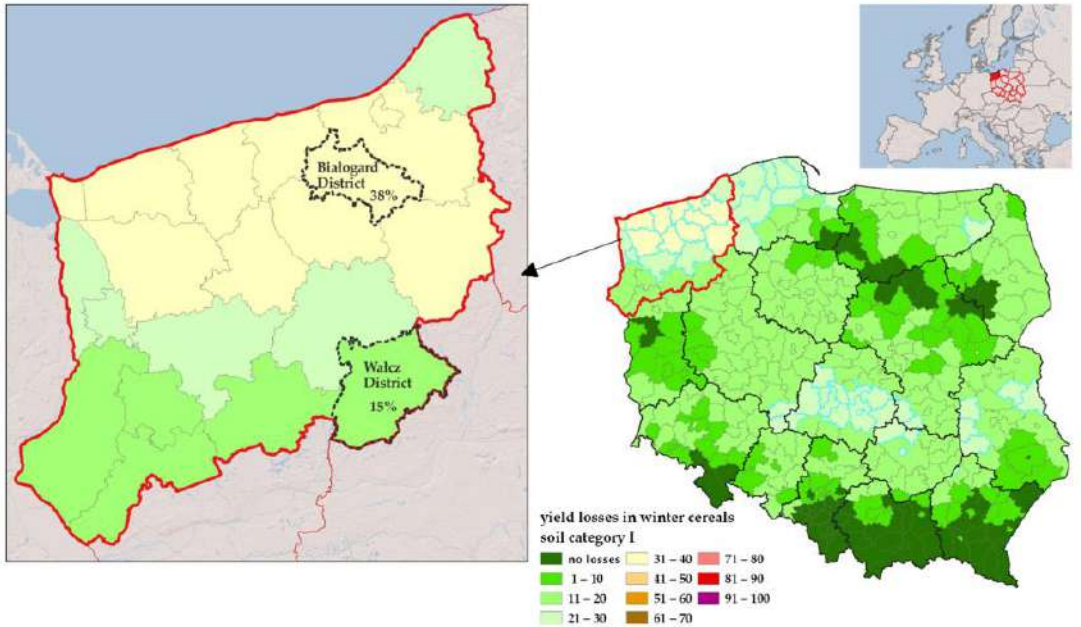
Agricultural Drought Monitoring System in Poland—Farmers' Assessments vs. Monitoring Results (2021)

Agriculture **2022**, *12*(4), 536; https://doi.org/10.3390/agriculture12040536





Description of soil drought vulnerability categories use in ADMS

Name	Description	Available Water Capacity (AWC)
Category I	Highly sensitive to drought	<127.5 mm
Category II	Sensitive to drought	127.5–169.9 mm
Category III	Moderately sensitive to drought	170.0–202.5 mm
Category IV	Slightly sensitive to drought	>202.5 mm

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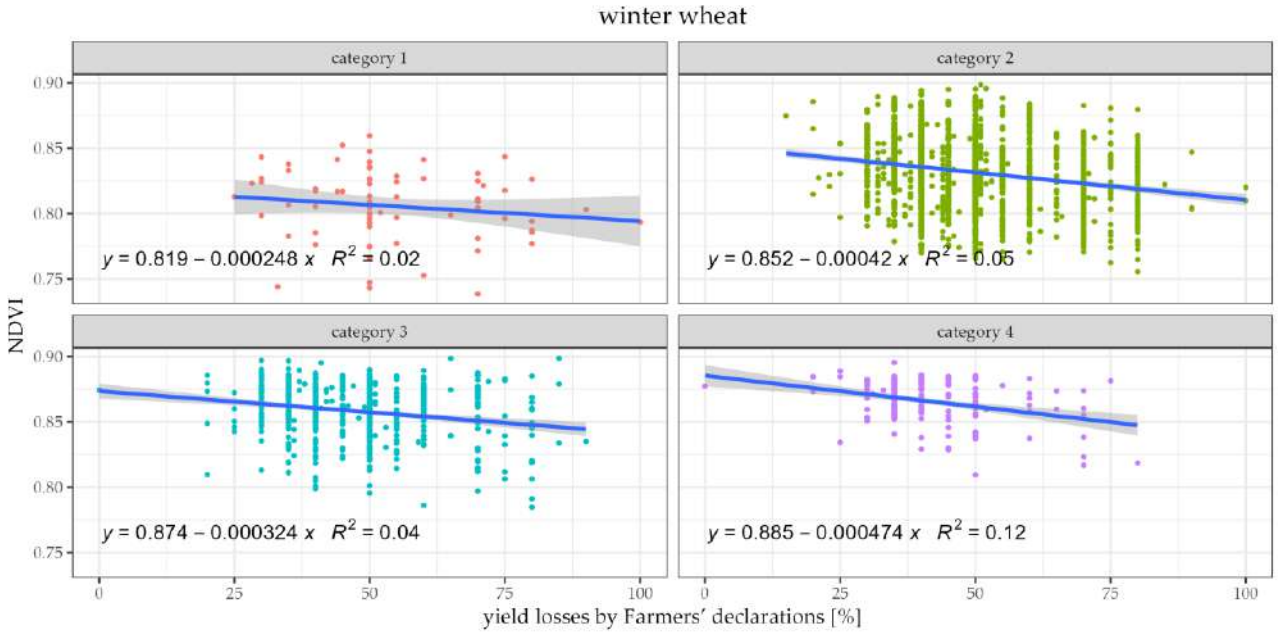

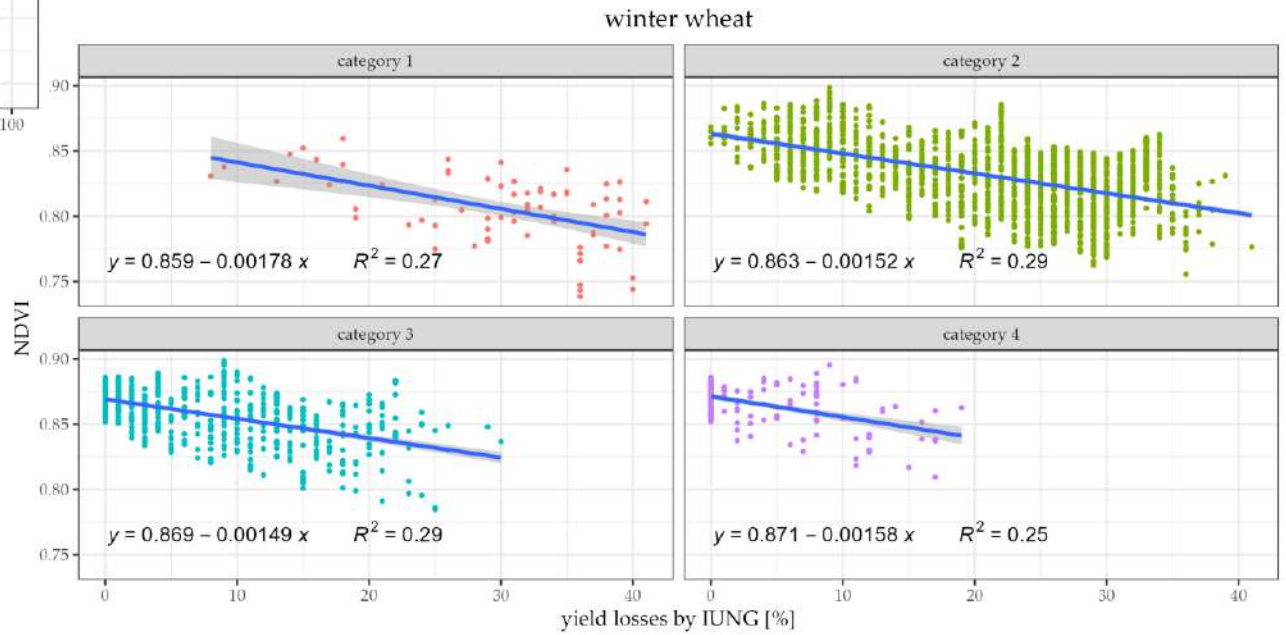

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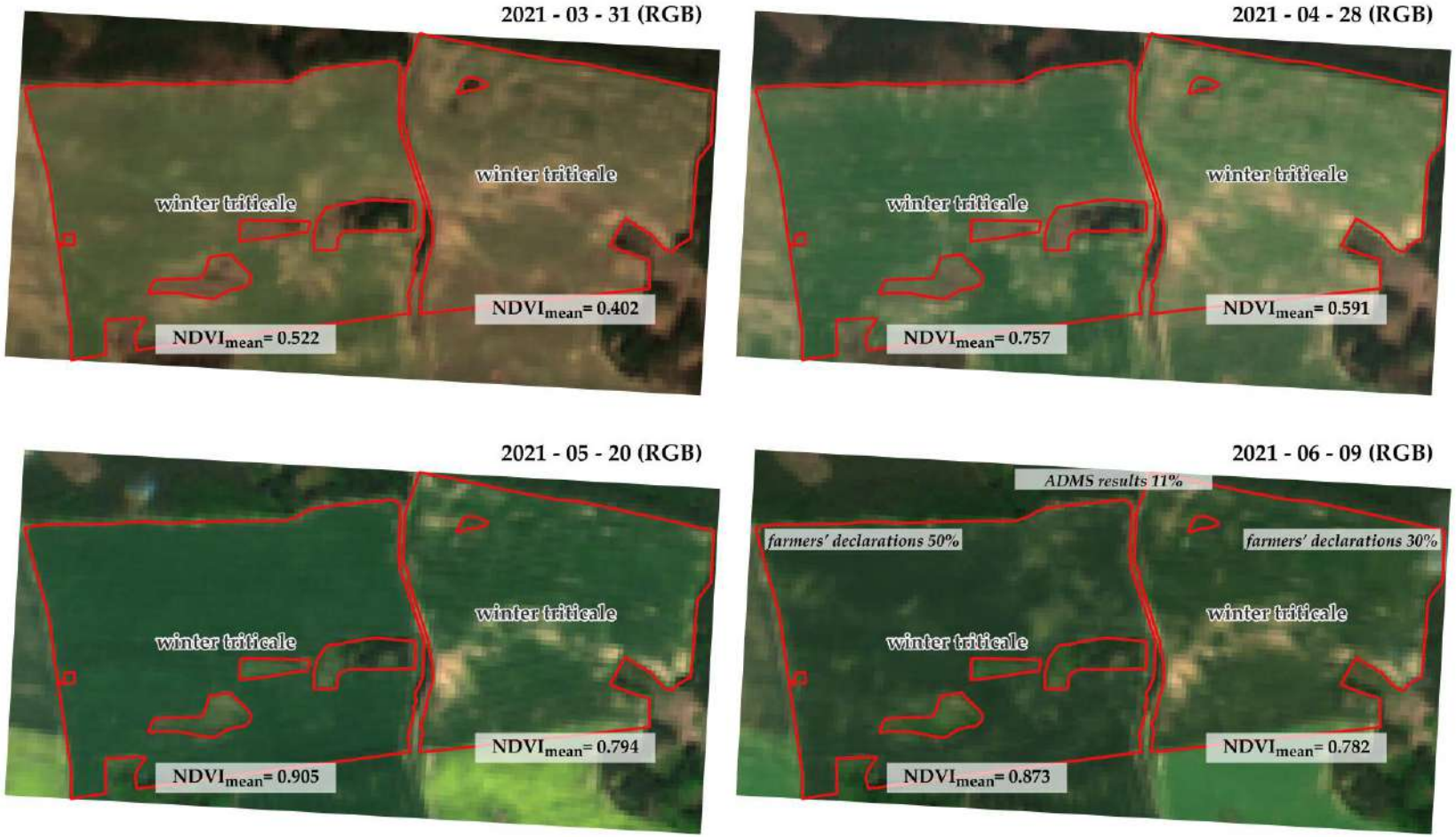

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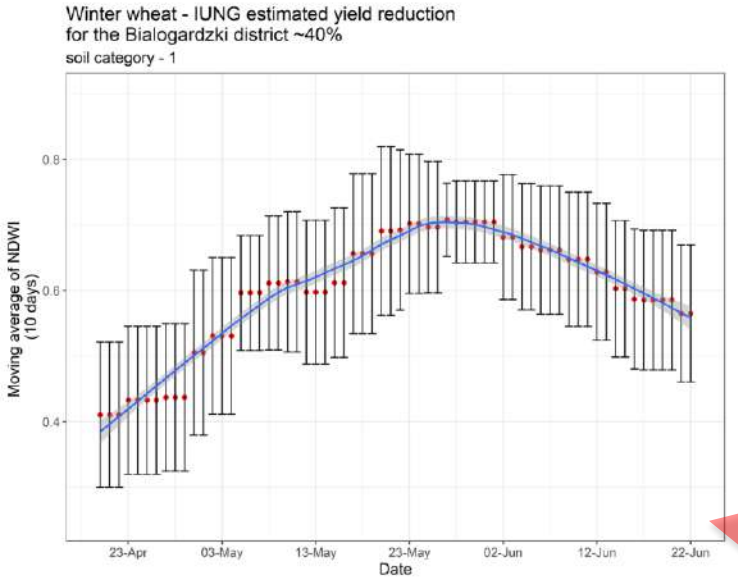

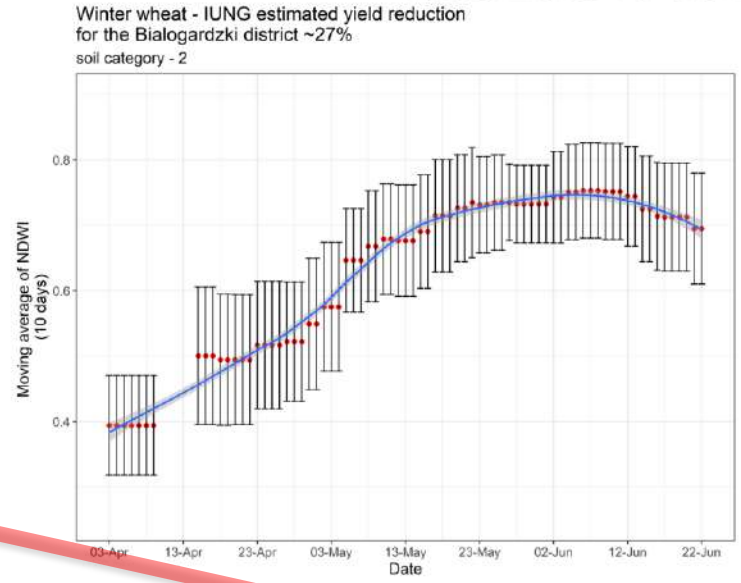

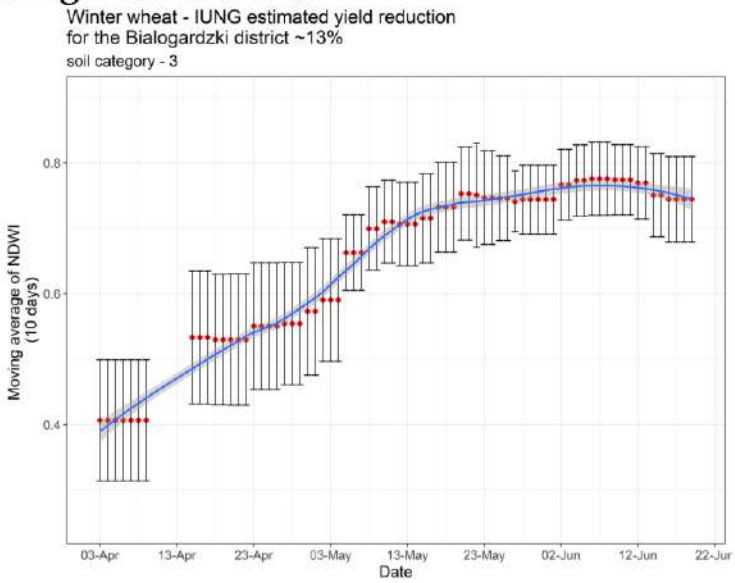

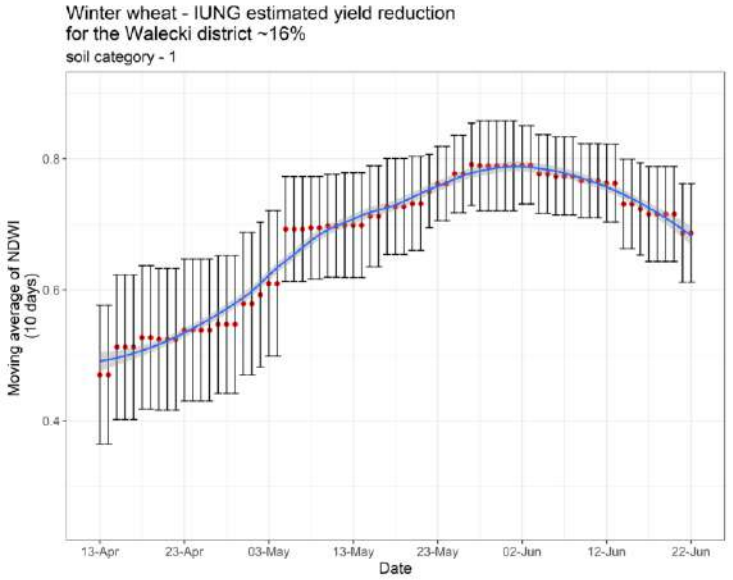

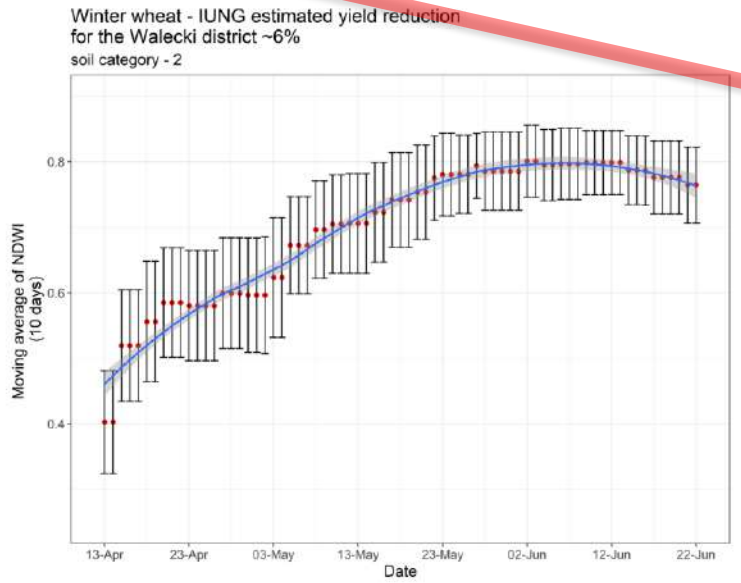

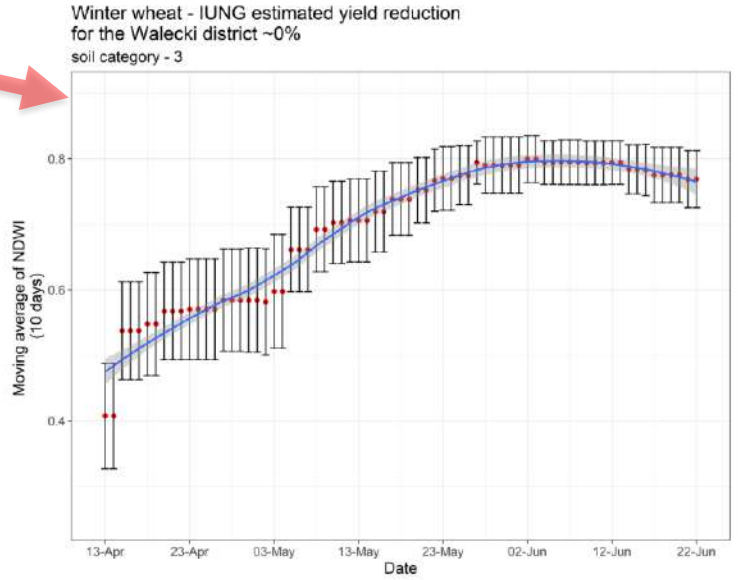

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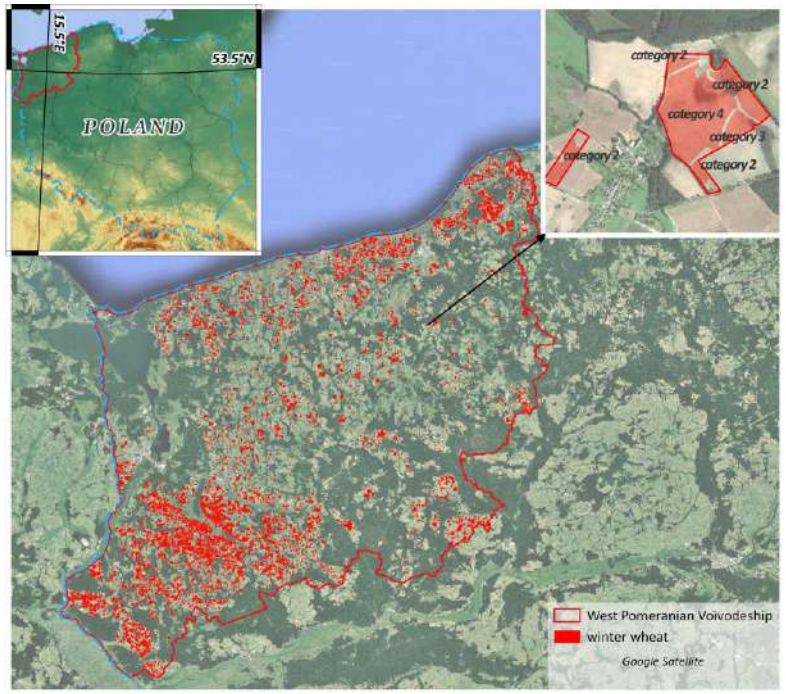
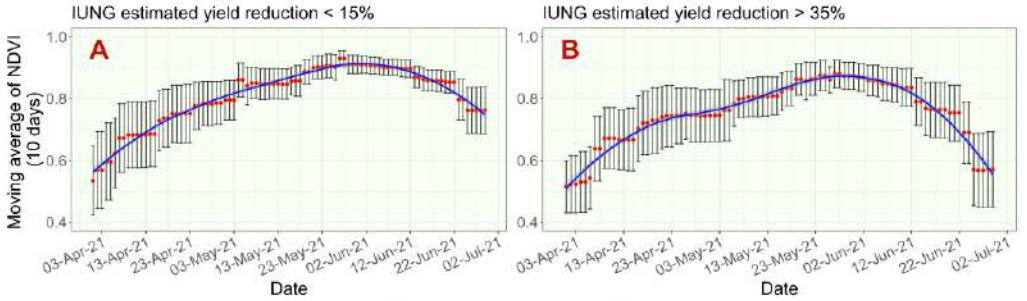
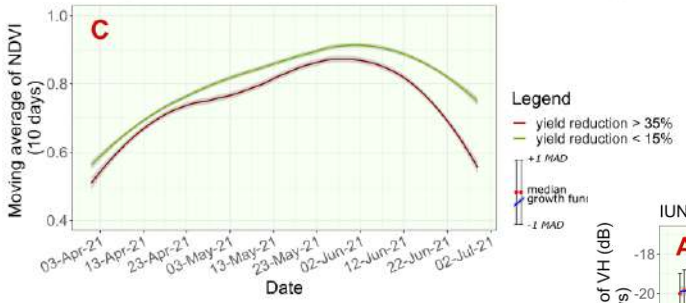
Exploring the Potential Use of Sentinel-1 and 2 Satellite Imagery for Monitoring Winter Wheat Growth under Agricultural Drought Conditions in North-Western Poland

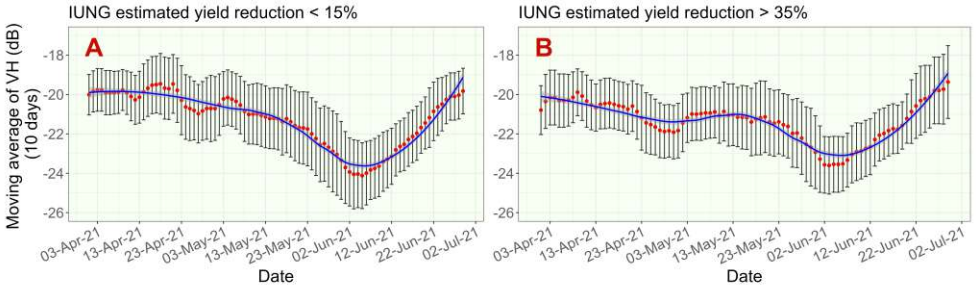
S-2 NDVI, NDWI

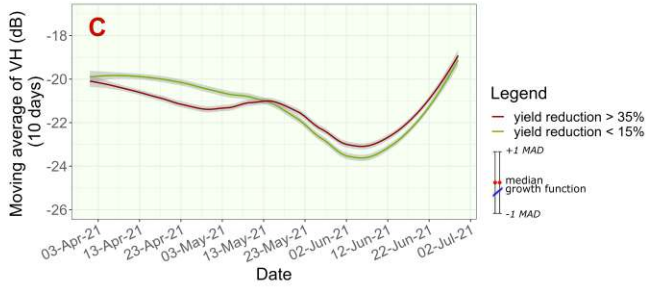
S-1 VV, VH, VV/VH

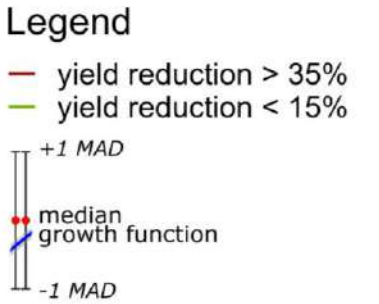












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Thank you for your attention

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