# Tracking the effects of extreme water conditions with Earth Observation

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LECHNER
TUDÁSKÖZPONT

FÖLDMEGFIGYELÉSI
OPERATÍV KÖZPONT

EuroGeographics webinar, 18.09.2025
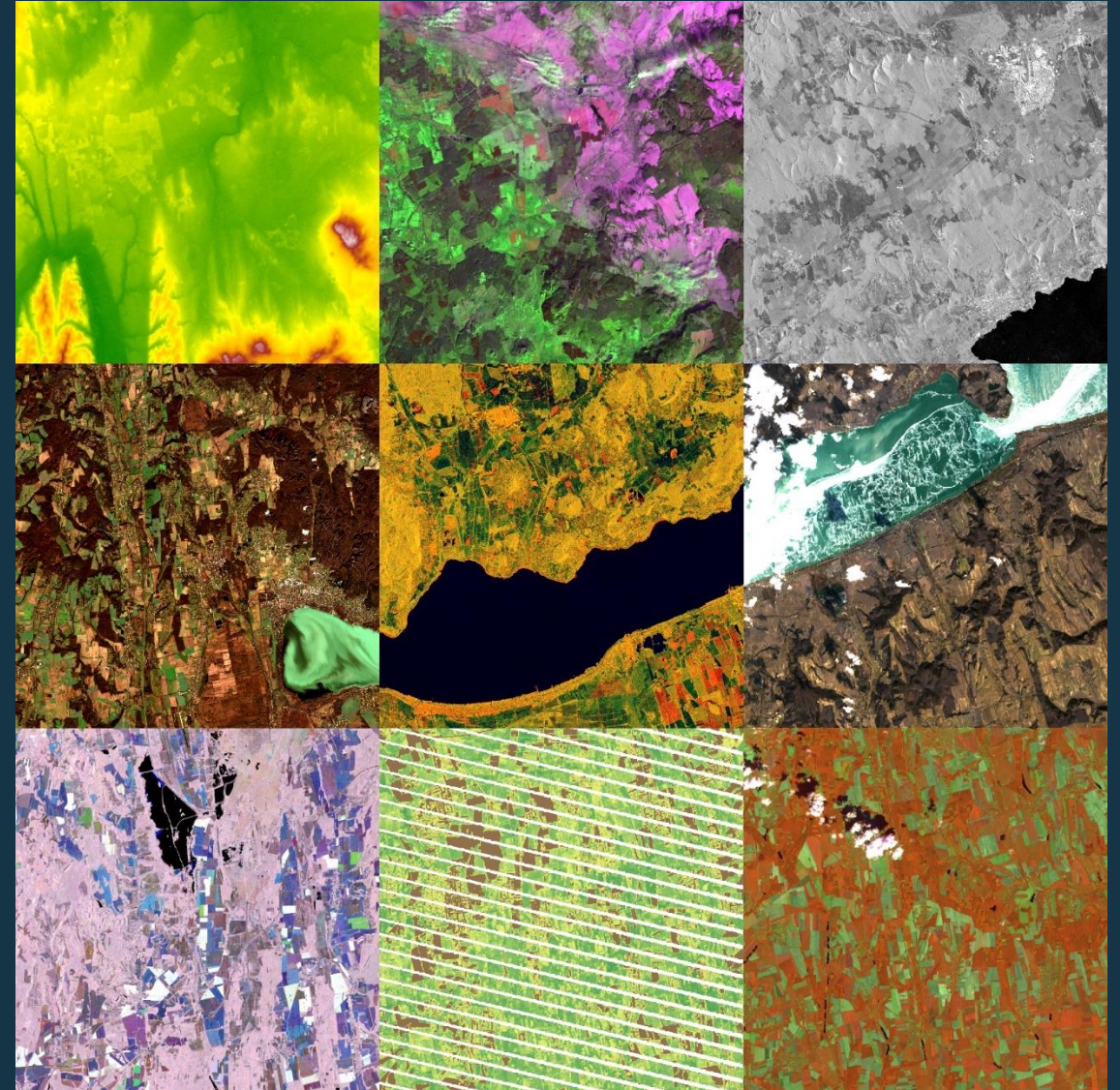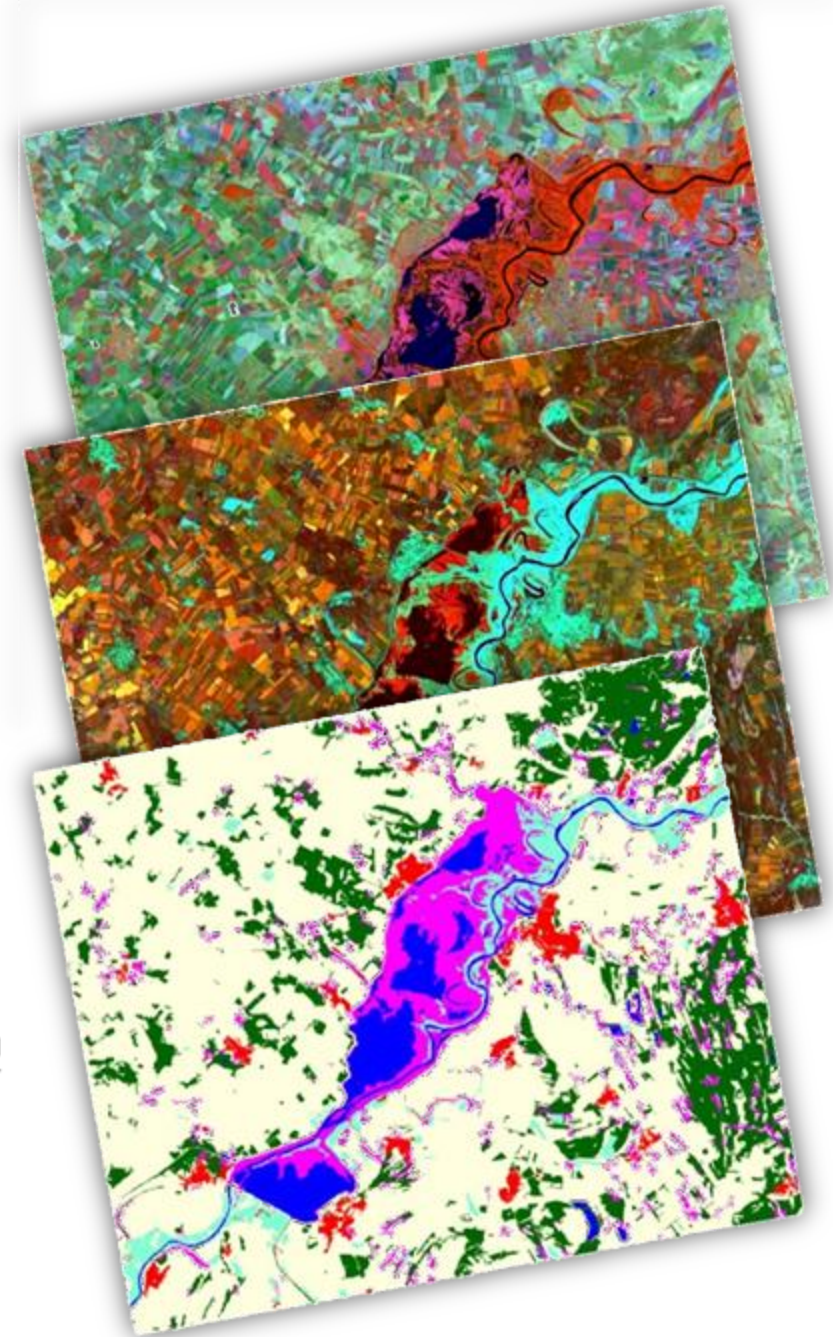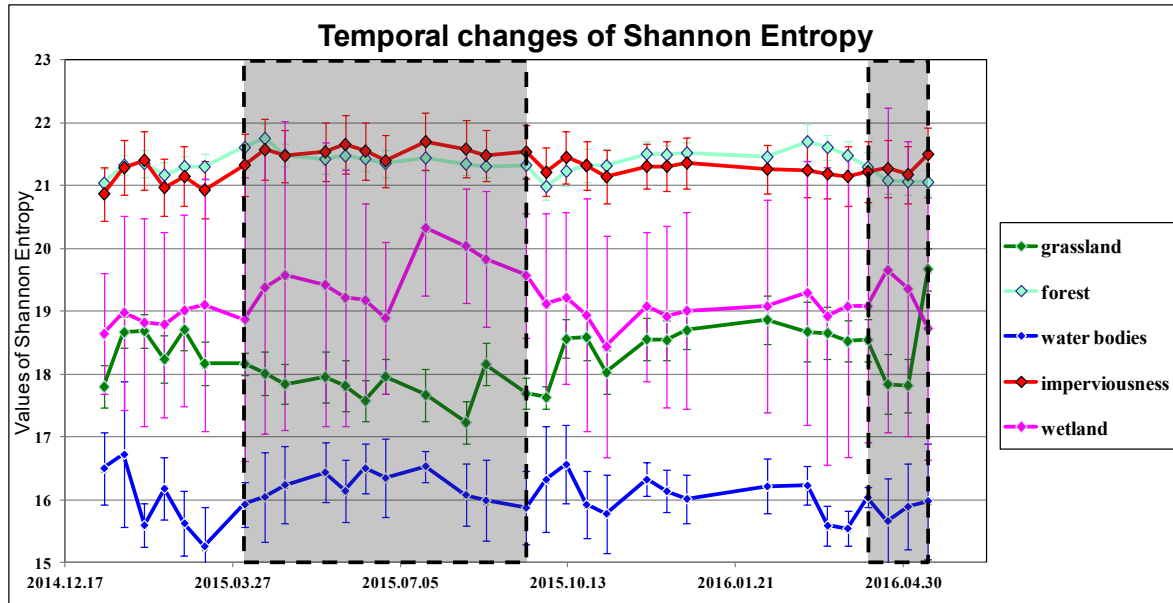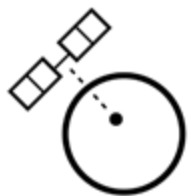
Lechner Knowledge Centre (LTK)

- **state-owned** not-for-profit company

- fulfilling **NMCA roles** since 2019 (integration of FÖMI)

- managing the largest and **most complete collection of spatial data** sets in Hungary

- spatial data related to the **natural environment**

- official records related to the **built environment**

- specific **processing, analysis and IT development** skills and activities in-house

- up-to-date **geospatial solutions** supporting government, authorities and the public

- **sharing** and **dissemination** of **knowledge**
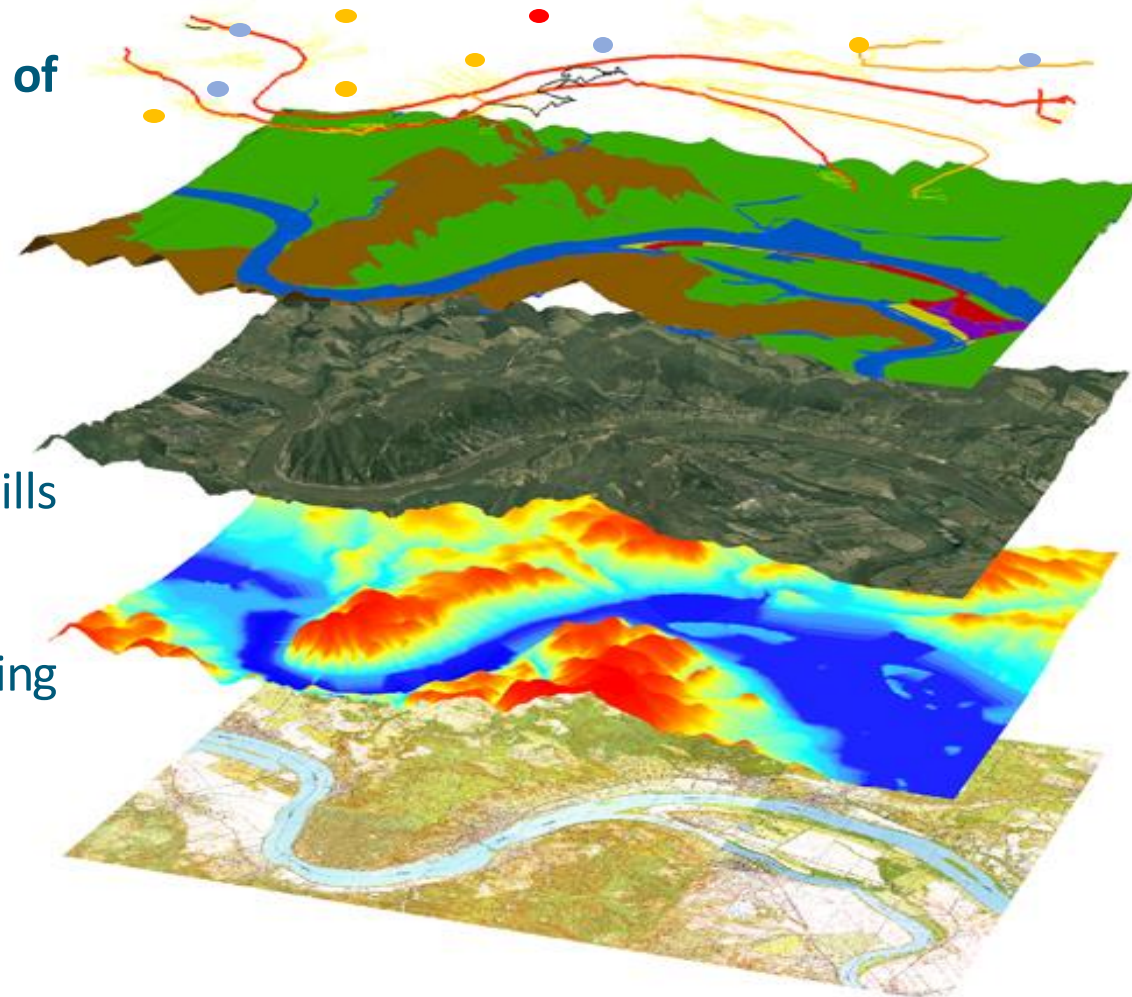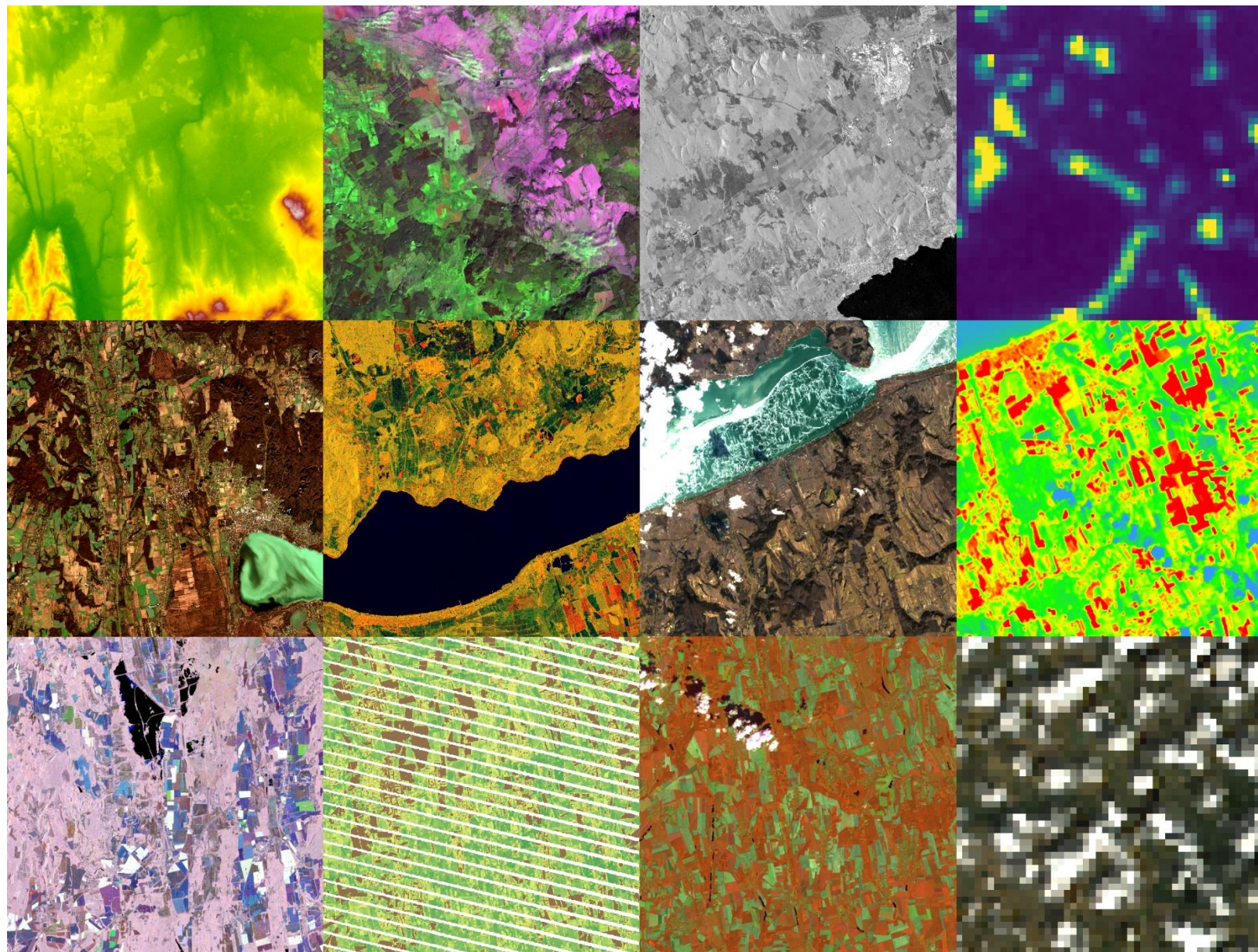
Remote Sensing capabilities

- Balanced use of computational and visual methods
- Combined use of different data sources
  - RS:
    - airborne/space-borne
    - optical and radar
  - Field surveys
  - Official data: LPIS, cadastre, topography
- Processing of big geospatial data (national, EU)

Temporal changes of Shannon Entropy

grassland
forest
water bodies
imperviousness
wetland

FÖLDMEGFIGYELÉSI
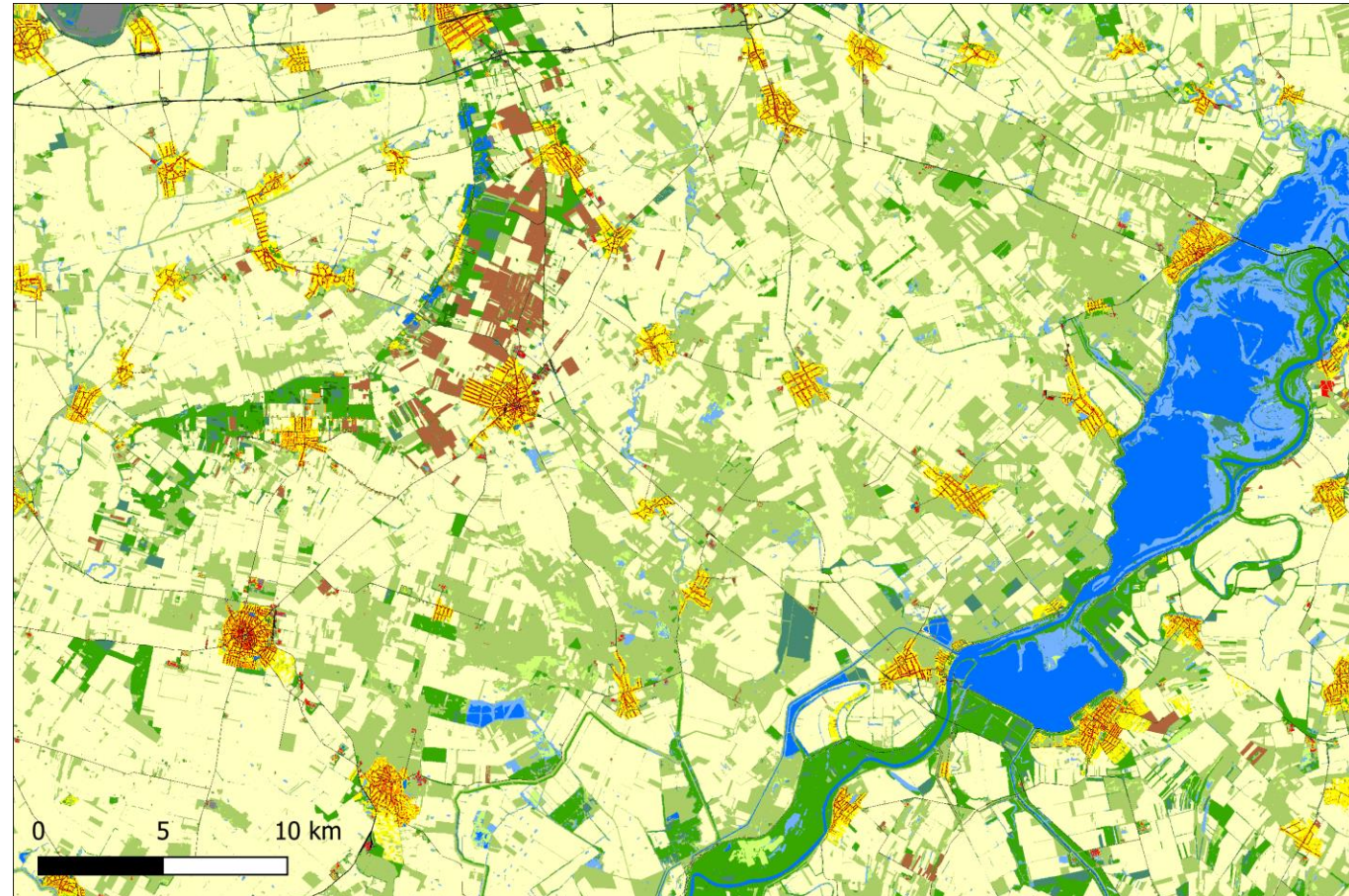OPERATÍV KÖZPONT

Land cover, land use

# Harmonized National High-Resolution Land Cover (hNHRL)

- Land Cover and Land Cover change mapping

- 23-14 classes, depending on processing level (HNRL-hNHRL)

- Country-wide

- Yearly between 2016-2023

- Combined method of machine learning, visual photo interpretation and data integration

- Sentinel-1-2 imagery, DEM, DSM, Soil information

Categories

- Artificial areas without buildings
- Roads and railways
- Arable land
- Grassland (dry)
- Orchards
- Vineyards
- Allotment gardens / complex cultivation
- Shrubland
- Broadleaved trees
- Coniferous trees
- Wet grassland
- Wetlands
- Water surfaces
- Buildings

0   5   10 km

Production of Harmonized National High-Resolution Land Cover (hNHRL)
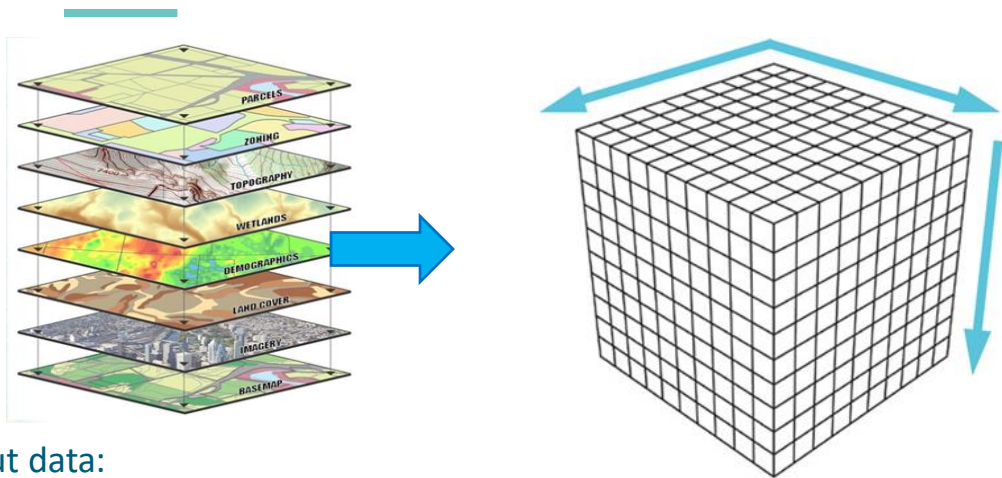
Input data:

Sentinel-2 optical satellite imagery,

Sentinel-1 radar imagery mosaics,

Digital Elevation and Surface Model,

Soil information

Reference data:

Previous NHRL layers, LPIS and SAPS data,

National Forest Database (NFD), road and rail network, buildings

- Uniform geometry and resolution (EOV 10m)
- Random Forest classifier
- Data integration, data cleaning
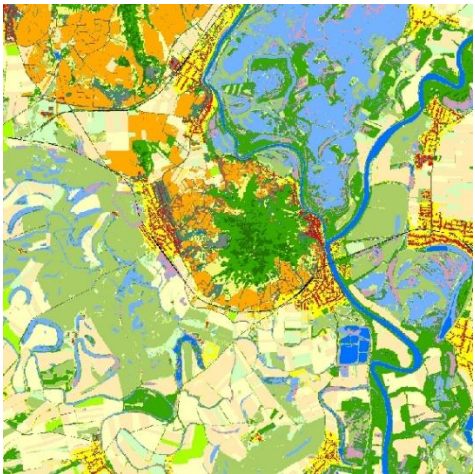
Raw NHRL

Available in Copernicus map browser with view and download service:
https://raster.lechnerkozpont.hu/apps/copernicus/
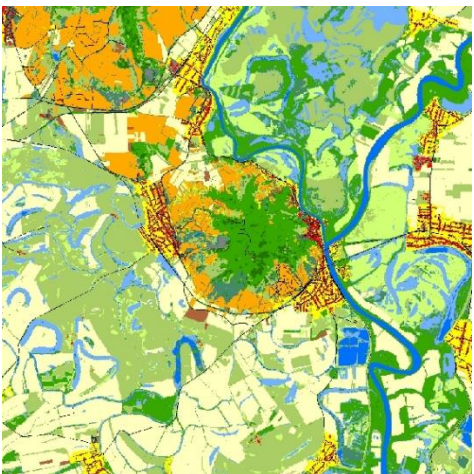
- 23 LC classes

Enhanced NHRL

Harmonized National High Resolution Land Cover, HNHRL

Value-added product

Visual control and correction

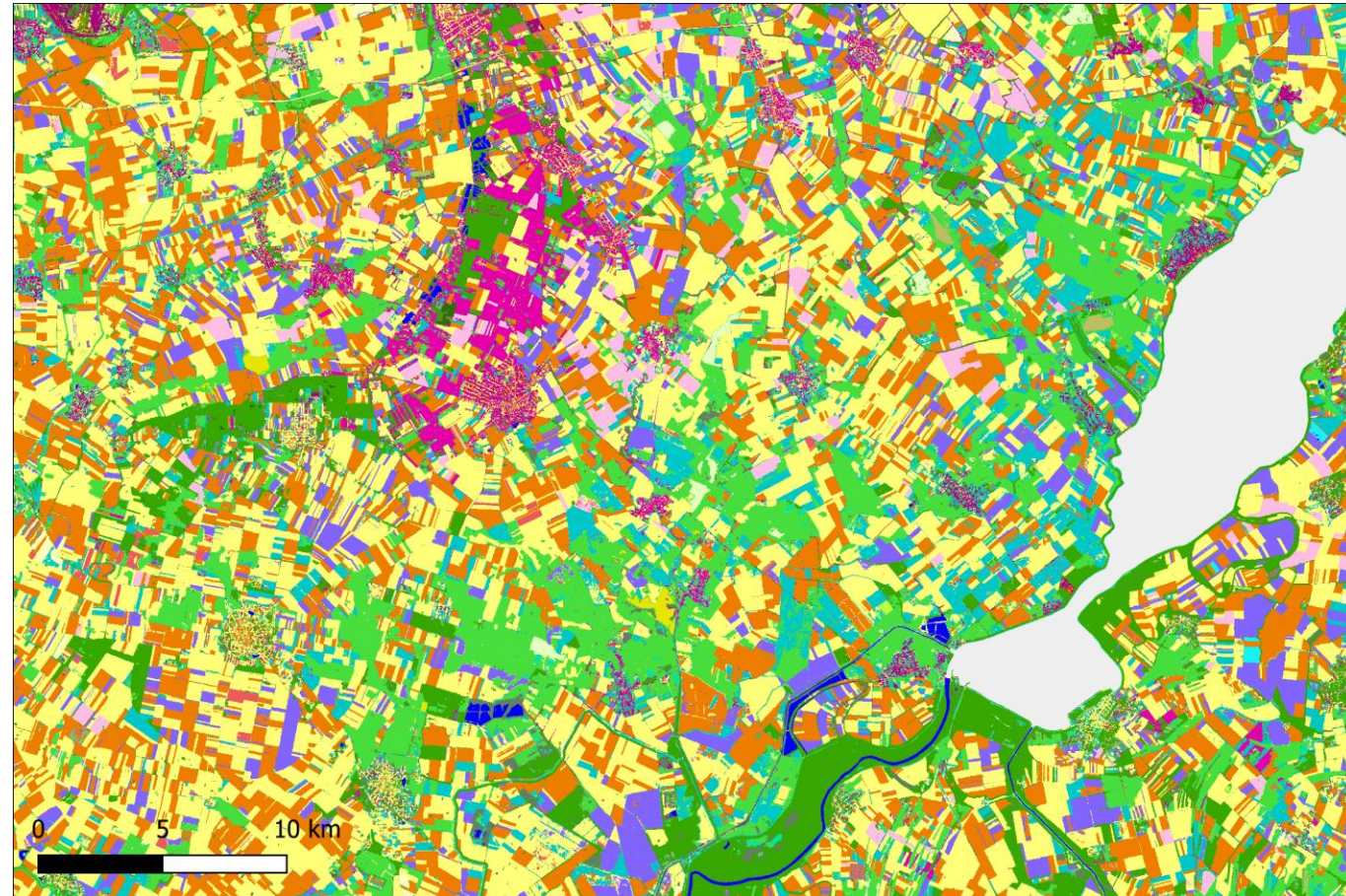Thematic aggregation

- 14 LC classes

Crop and Grassland Maps

- Annual crops, permanent crops and grasslands → agriculture, ecosystems or spatial planning

- 16-24 categories, depending on the year

- **Countrywide**, but parcel boundaries and ineligible territories are masked

- Yearly between 2013-2024

- Random Forest classification in Python

- Sentinel-2 reflectances and indices 6-8 dates between March and October

- Sentinel-1 temporal integrals from H/A/alpha polarimetric decomposition

- Reference from Anonymised Database of Subsidies

Categories

- Winter cereals
- Spring cereals
- Maize
- Sunflower
- Sugarbeet
- Alfalfa
- Peas
- Potato
- Rape
- Vineyard
- Orchard
- Grassland
- Soy bean
- Deciduous forest
- Coniferous forest
- Water
- Tobacco
- Oil pumpkin
- No-tilled grassland
- Weet grassland
- Saline grassland
- Grassland with herbaceous weed
- Grassland with woody weed
- Reed
- Non-classified areas


0   5   10 km

Lechner Knowledge Centre

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- Grassland with woody weed
- Reed
- Parcel bounds and ineligible area
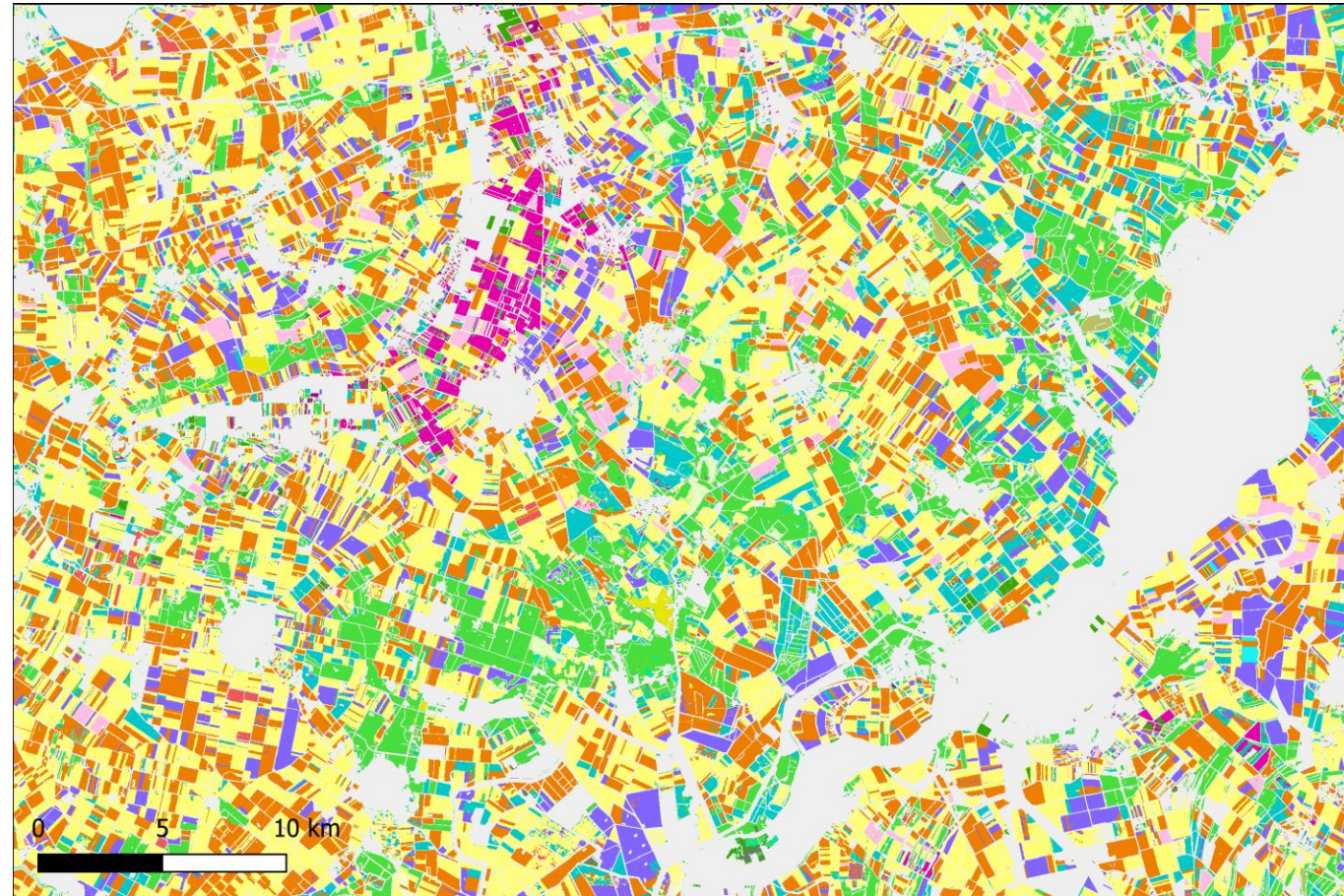
# Crop mapping developments using deep learning

- Annual crops, permanent crops grasslands and forests → agriculture, ecosystems or spatial planning

- Main categories (8-16)

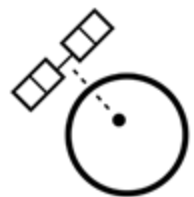- Reference from Anonymised Database of Subsidies

Experiments:

- *Data*: Sentinel-2 reflectances, Sentinel-1 backscatter, Sentinel-1 polarimetry

- *Algorithm*: 1D-CNN, LSTM, Transformer + autoregressive pretraining

- ***Aim*: spatially and temporally transferable pretrained model**
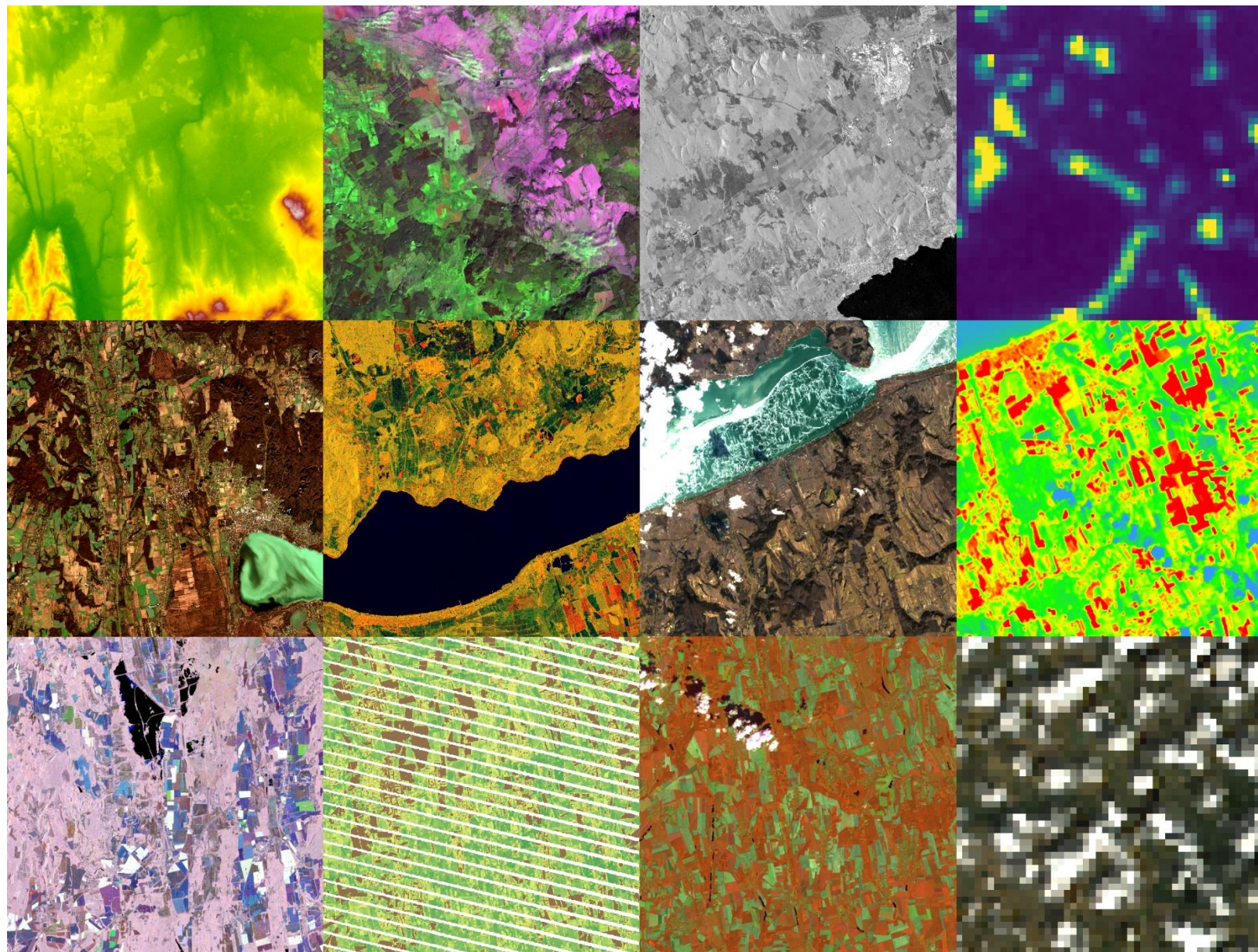
Categories

⬜	Outside the boundary of the study
🟨	Cereals
🟫	Maize
🟧	Sunflower
🟨	Rapeseed
🟥	Orchard
🟩	Perennial herbs (Grassland & Alfalfa)
🟩	Forest
🟦	Water

0   5   10 km
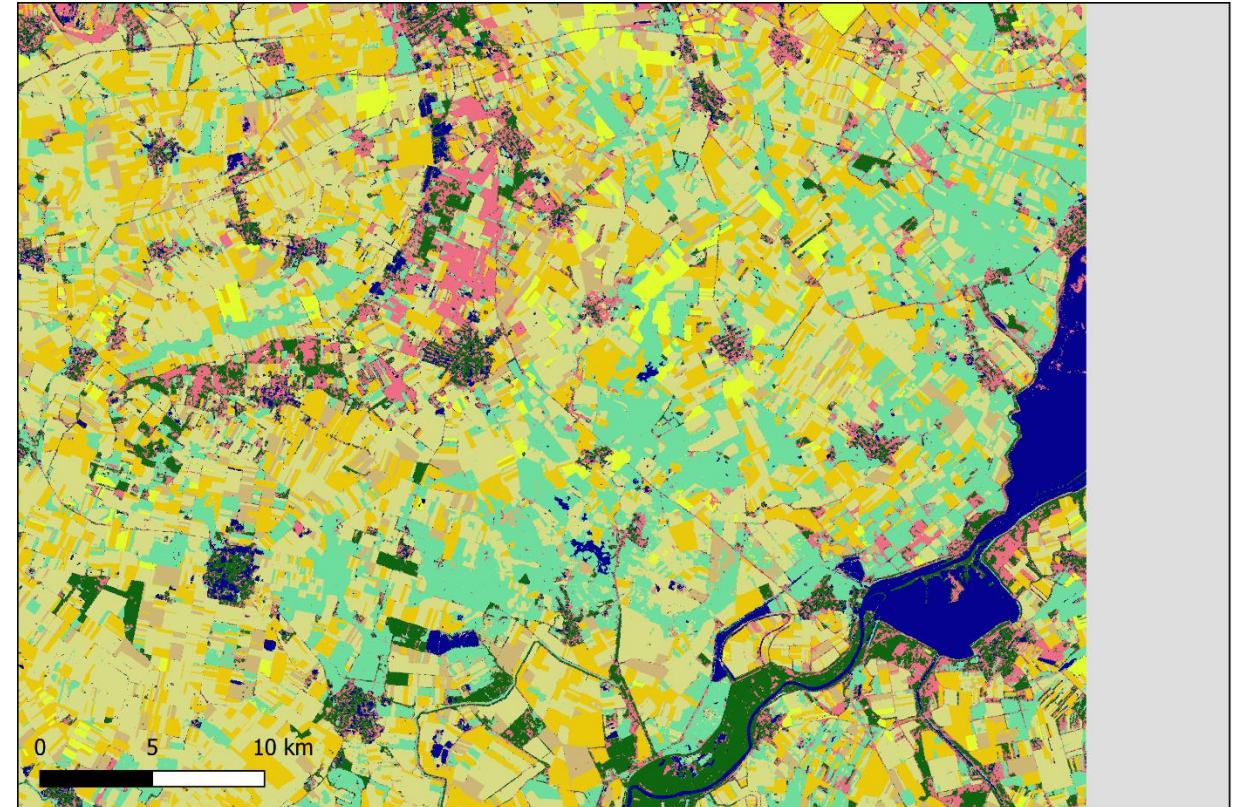
Extreme water conditions
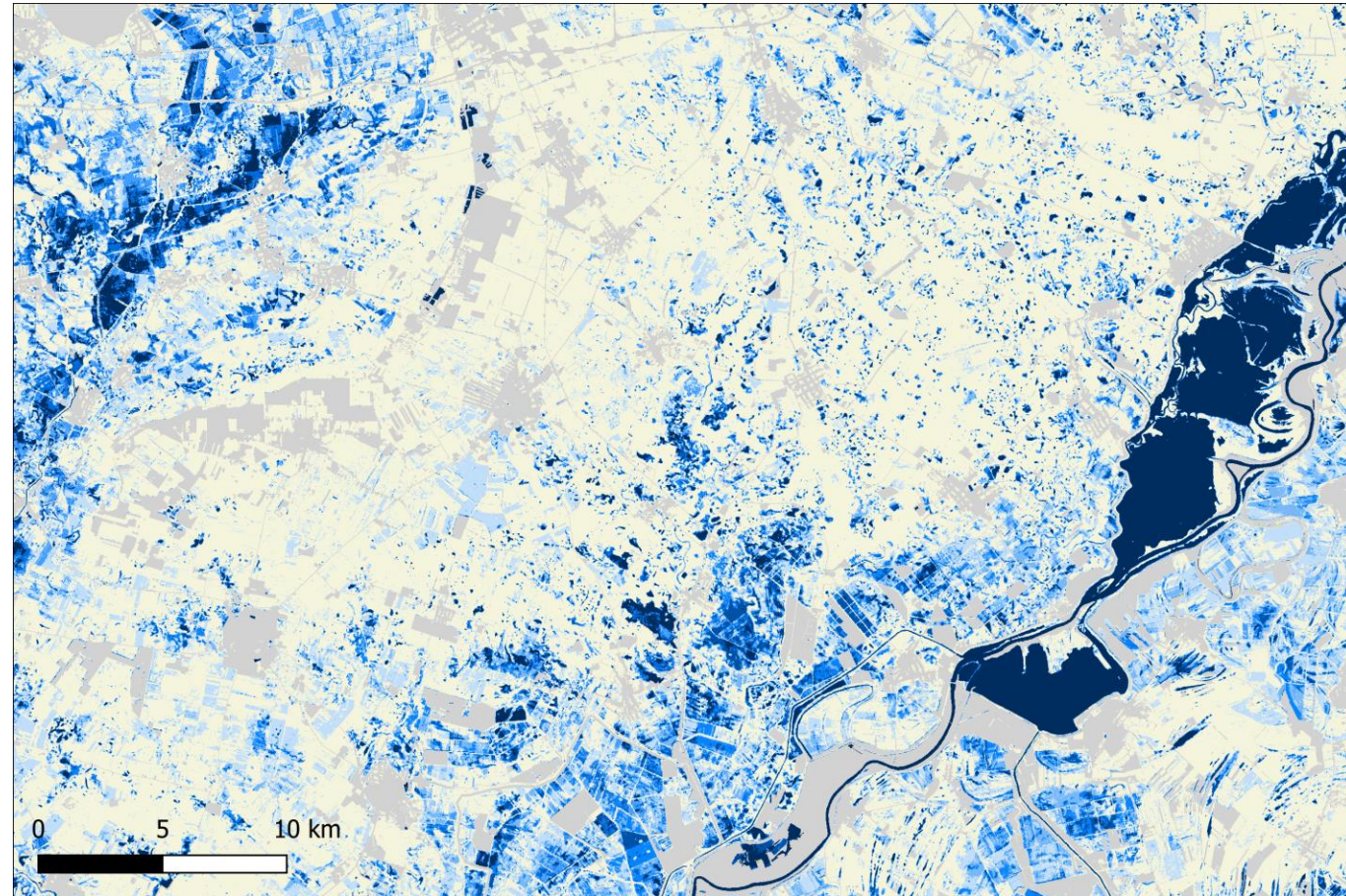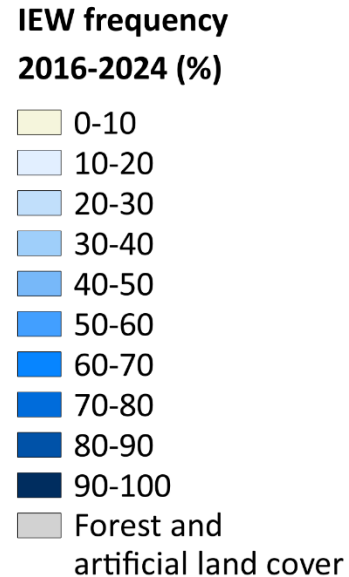
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Introduction

- Increase in the frequency and severity of extreme weather and water conditions

- The Carpathian Basin is among the regions most heavily affected

- Agricultural Risk Management System
  - To compensate the farmers for crop yield loss
  - Since 2012
  - 9 damage types icluding drought and excess water
  - Lechner Knowledge Center involved in decision support
  - Number and area of damage claims increasing, reaching all-time record in 2022

- Planning more efficient water management, water retention and conservation is a must

Forrás: ChatGPT

Flood and excess water maps based on optical imagery

- Based on Sentinel-2

- **<u>Countrywide</u>**

- Study years between 2016-2024

- Based on visually-assited single-date thresholding (bands and indices)

- Time series reaching back to 1998 available, based on Landsat and other optical data and similar methodology

IEW frequency 2016-2024 (%)

- 0-10
- 10-20
- 20-30
- 30-40
- 40-50
- 50-60
- 60-70
- 70-80
- 80-90
- 90-100
- Forest and artificial land cover

0   5   10 km

Radar-based flood and excess water maps

- Based on Sentinel-1A

- The sample area covers the most affected areas in **eastern Hungary**.

- Study years between 2020-2023

- VV thresholding

- Enhanced Edge Otsu method

- Filtering out drought periods based on SMAP anomalies
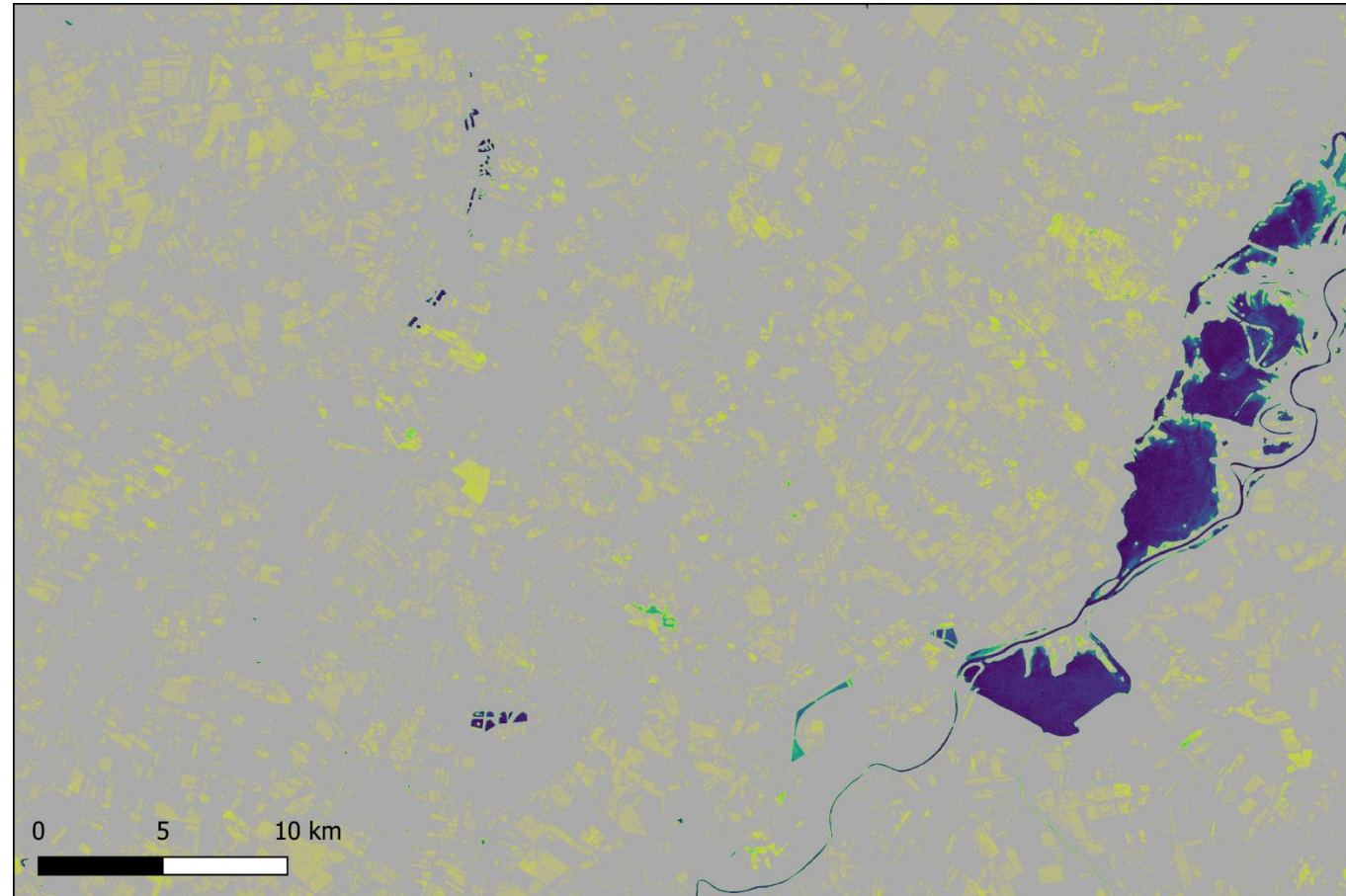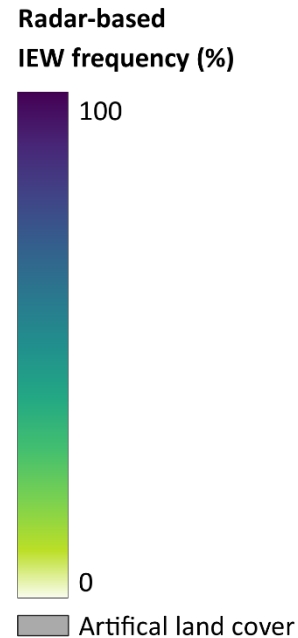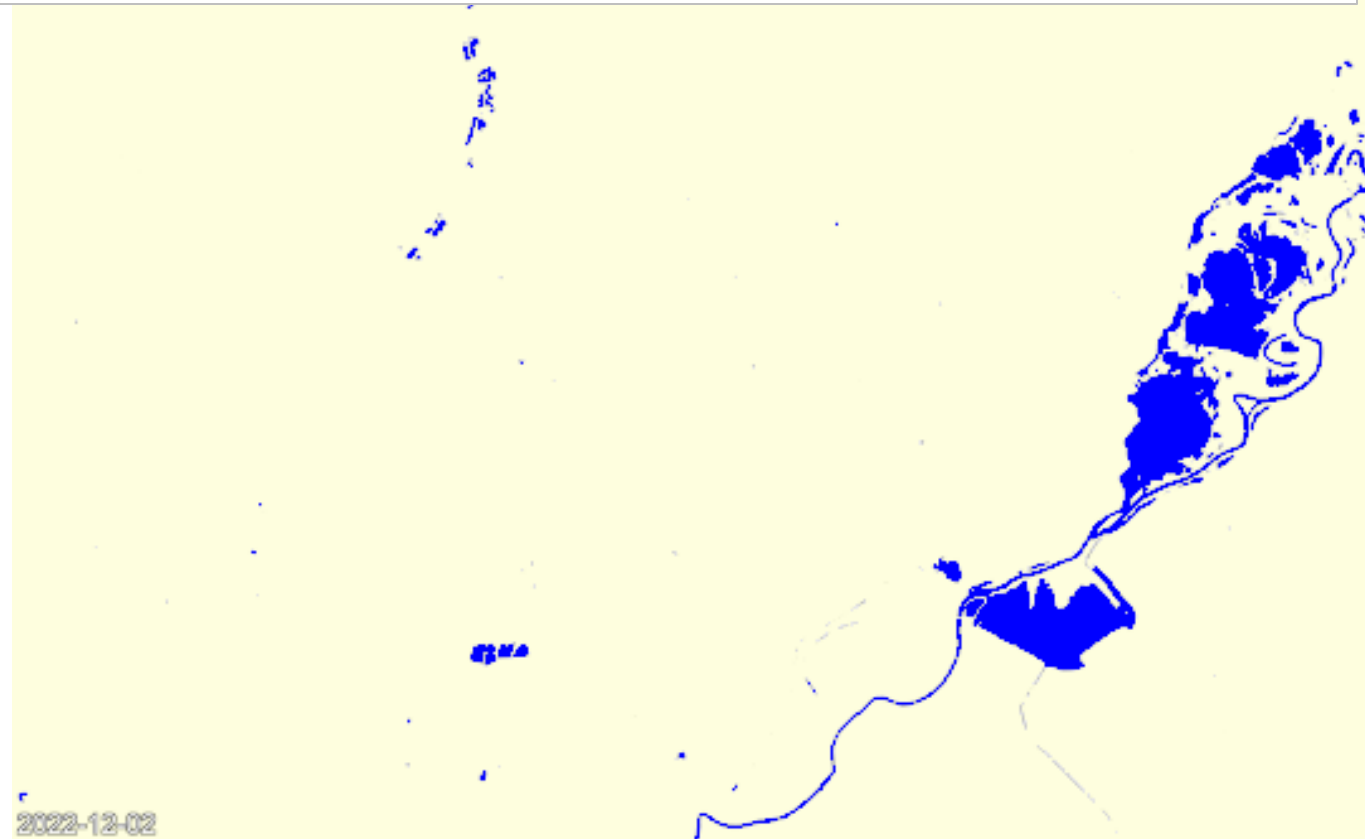
Deep Learning-based water detection (ESA RFP/3-18201/23/I-DT-bgh)

- AI based Fusion of Satellite /Airborne data for Biodiversity Change Characterization

- Objectives: mapping areas effected by water to support water-retention and water-buffer oriented land management efforts

- Members: HUN-REN Institute for Computer Science / Lechner Knowledge Center

- Period: 2023.10.15 – 2025.08.31

- Deep Neural Network based solution, using long time series of Sentinel-2 reflectance and derived indices, Sentinel-1 Sigma-0 backscatter coefficients (VV, VH, and their ratio), soil, DEM and morphometry data

- Two test areas

- Reference from field data and existing IEW maps

Categories

- ■ Open water surfaces
- ■ Soil seriously affected by water
- ■ Soil moderately affected by water
- ■ Soil slightly affected by water
- ■ Vegetation standing in water
- ■ Areas not affected
- ■ Cloud
- ■ Cloud shadow
- ■ Snow

Sentinel-1 classification, time series (December 1, 2022 – December 31, 2023)

2022-12-02

Deep Learning-based water detection (ESA RFP/3-18201/23/I-DT-bgh)

- Frequency map based on equal interval time series of integrated S2 and S1 classification results

- Applied to categories:
  - open water
  - soils seriously affected by water
  - vegetation standing in water.

IEW frequency 2021-2024 (%)

100

0

0   5   10 km
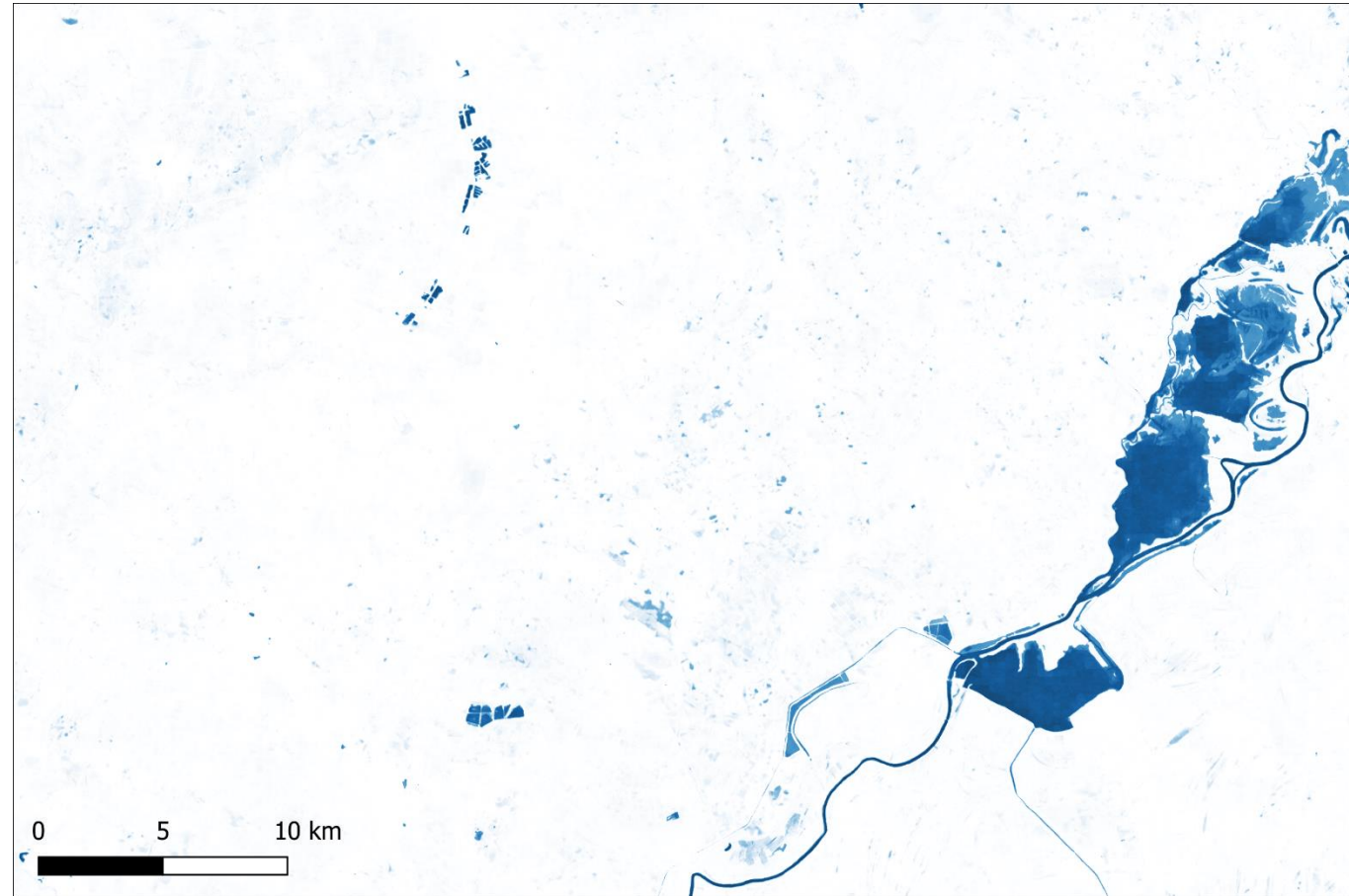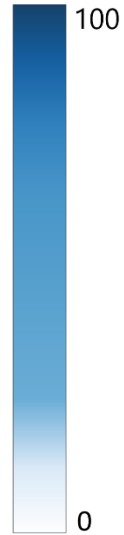
Drought maps based on optical imagery

- Based on MODIS NDVI

- **Countrywide**

- Reference period 2000-2023

- Mostly mapping during the Summer months

- 250 meters spatial resolution

Drought categories

- Severely drought
- Moderately drought
- Moderately drought
- Slightly drought
- Average
- Slightly better than average
- Much better than average
- Non-arable
- Cereal crops mask
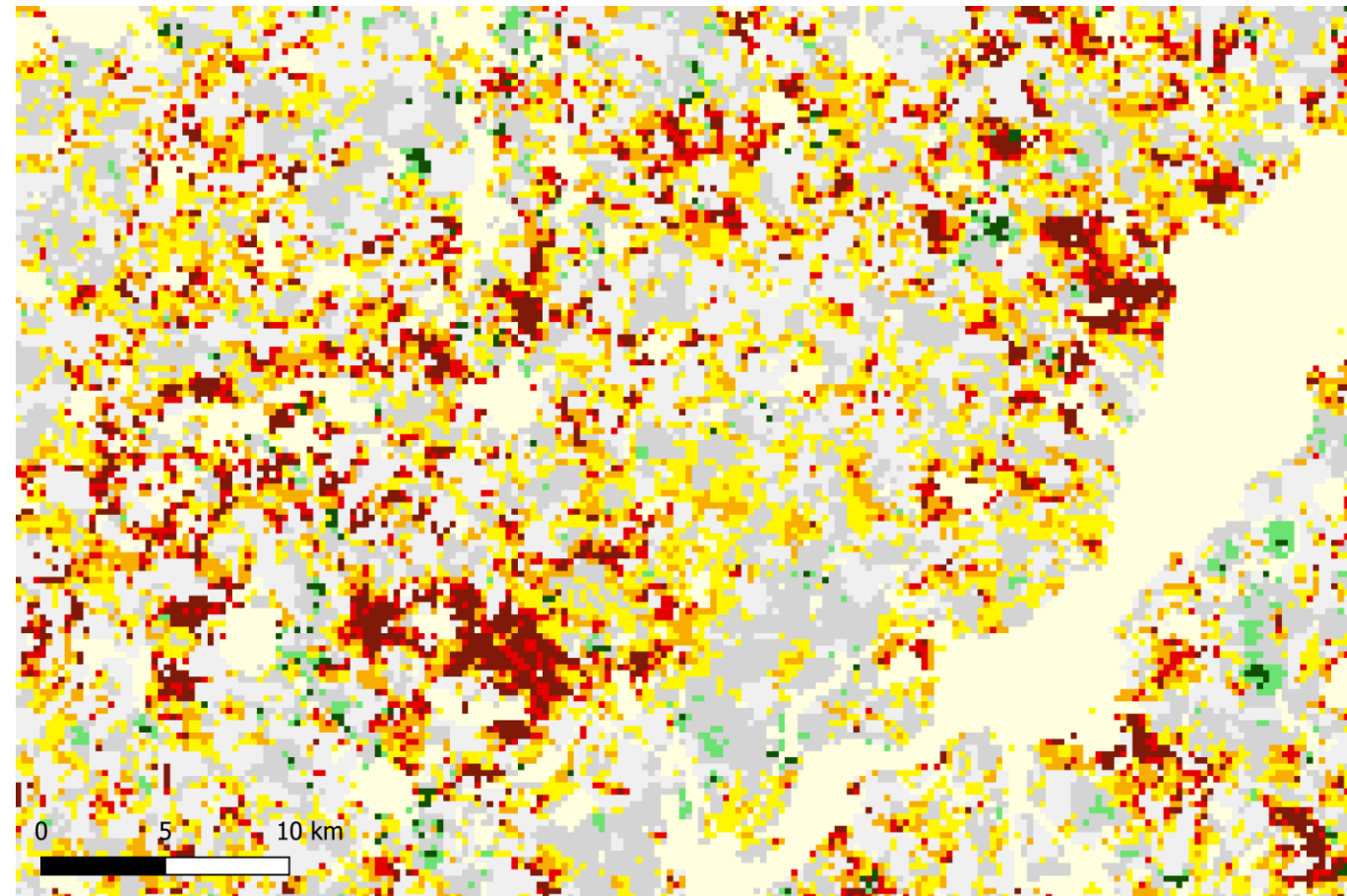
Crop Condition Maps

- Robust crop condition maps for maize and sunflower

- 6 categories: how many indices showed wrong condition?

- **Countrywide**, but based on data take

- Reference years between 2018-2023

- Crop rotation taken into account

- Sentinel-2 kNDVI, NDVI, EVI, NDMI and PSRI

- Strong, monotonic relationship between crop condition and damage claims from the Hungarian Agricultural Risk Management System

Crop condition

- Good condition according to all tested indices
- Bad condition according to one tested index
- Bad condition according to two tested indices
- Bad condition according to three tested indices
- Bad condition according to four tested indices
- Bad condition according to all tested indices
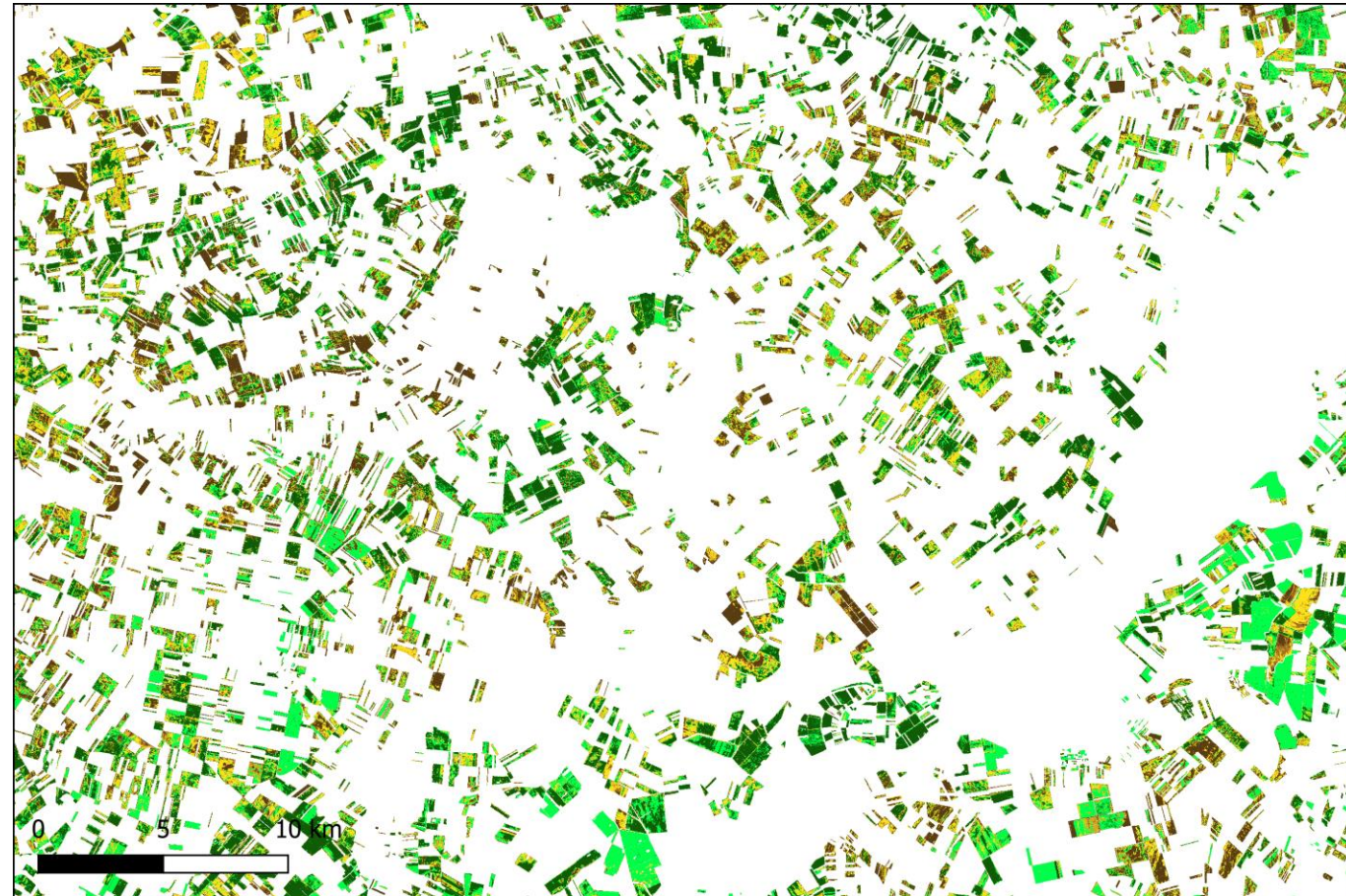
Row Crop-specific Drought Sensitivity Map

- Based on MODIS NDVI

- **Countrywide**

- For the period 2000-2024, all Augusts were mapped.

- 250-meter spatial resolution

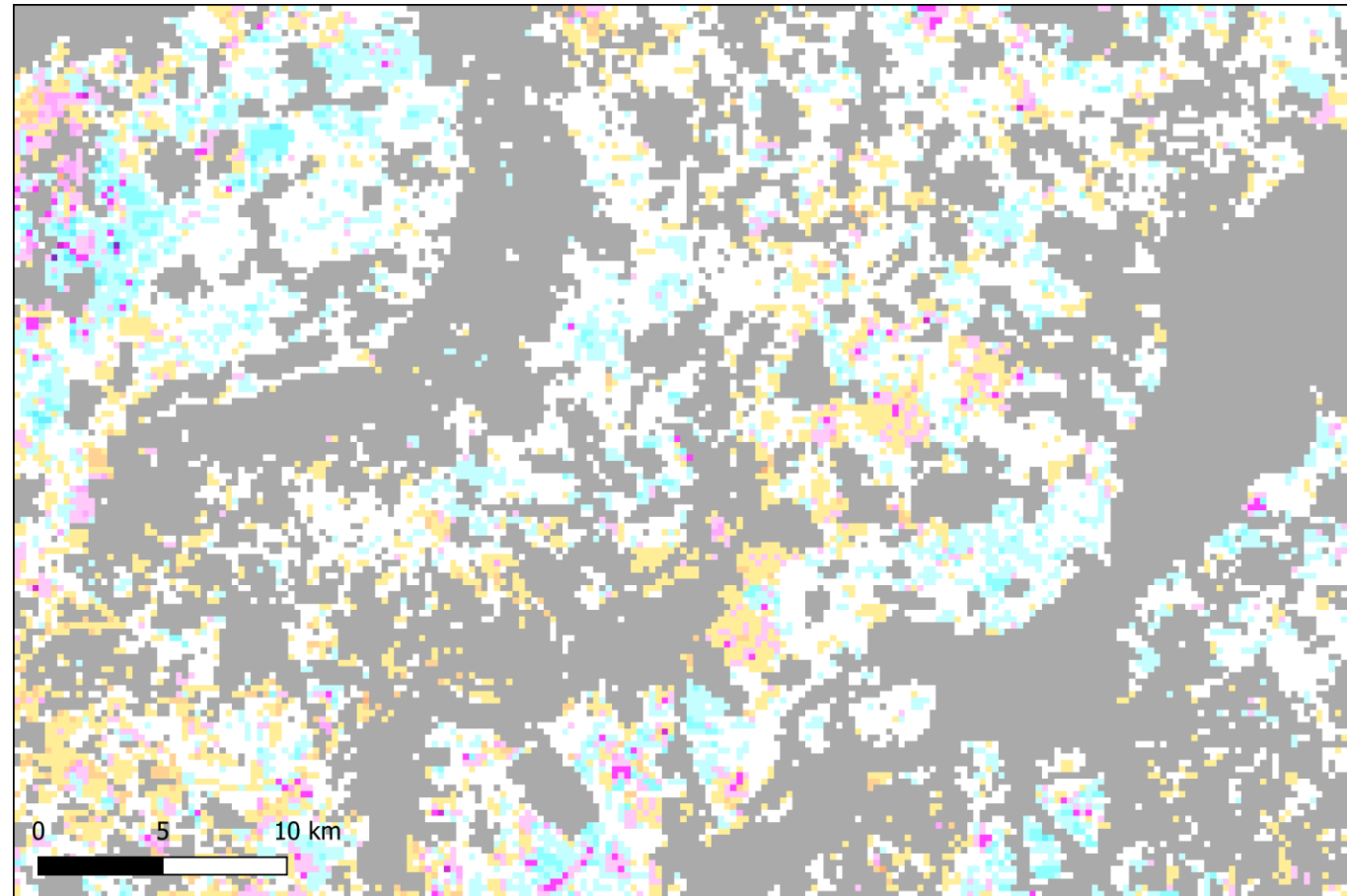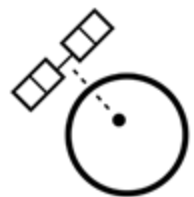Average "VCI" based on three vegetation indices

80

35

Non-arable dominant area

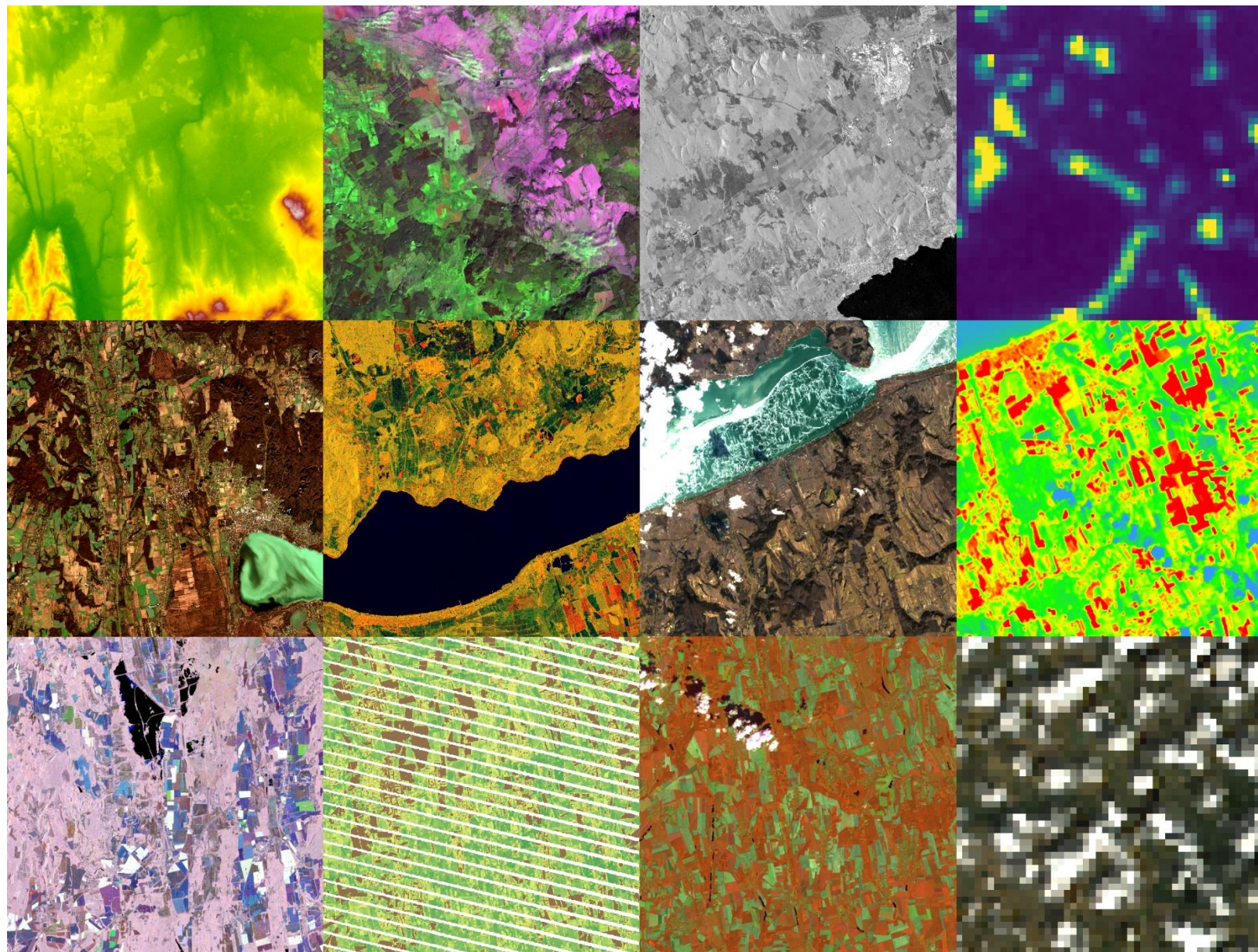0   5   10 km
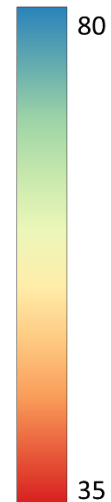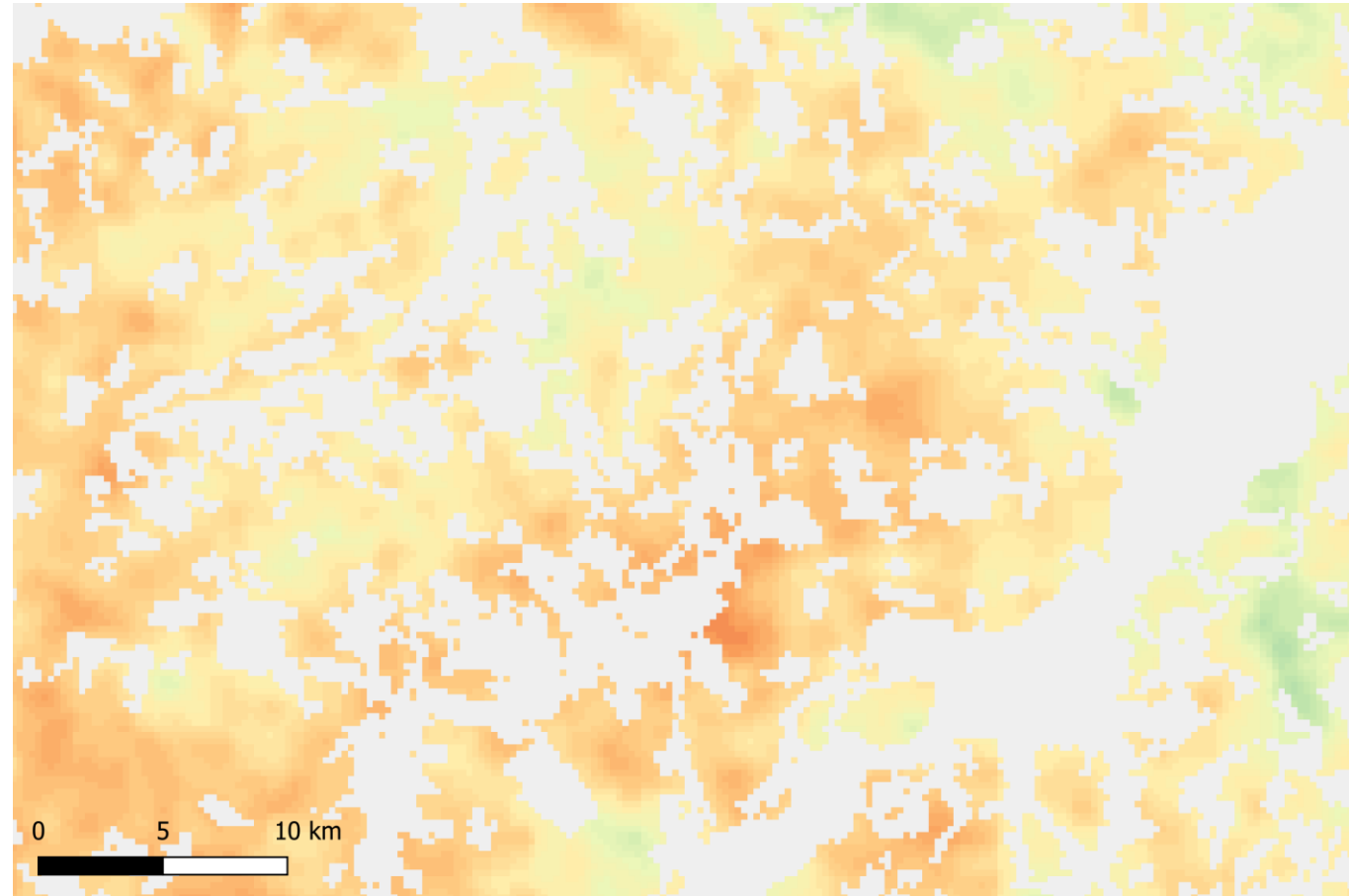
Integrated Extreme Water Events Maps

- Based on three IEW maps and three drought maps
  - Optical-based IEW frequency map
  - Radar-based IEW frequency map
  - Optical-based drought frequency map
  - Row crop-specific drought sensitivity map
  - Claims for drought
  - Claims for IEW

- The sample area covers the most affected areas in **eastern Hungary**.

- 15 categories: how many maps showed vulnerability?

- 250 meters spatial resolution

Categories

First digit - inland excess water/pounding

Second digit - drought

- 00
- 01
- 02
- 03
- 10
- 11
- 12
- 13
- 20
- 21
- 22
- 23
- 30
- 31
- 32
- Non-arable dominant area

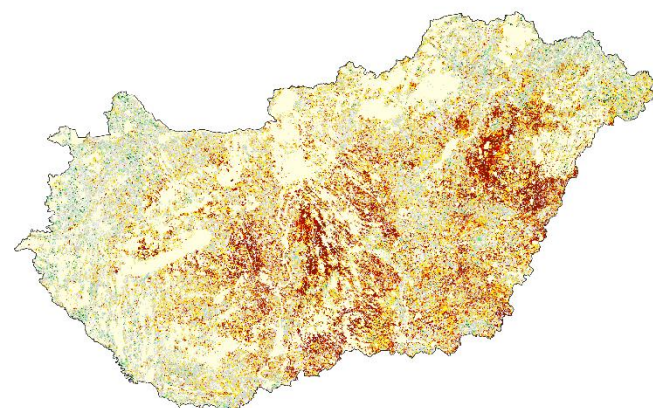Data integration and services
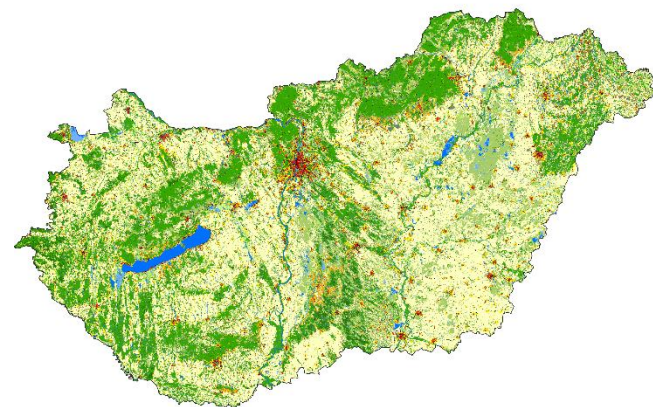
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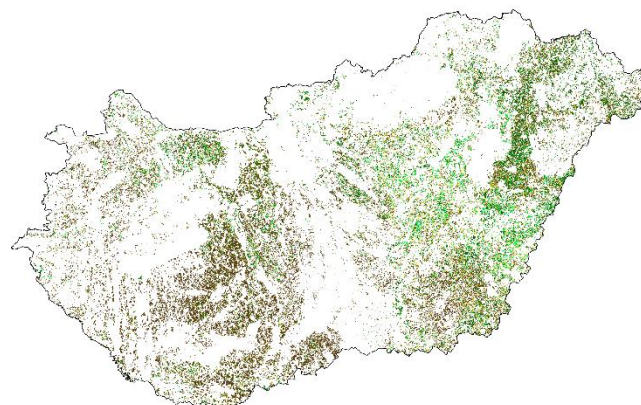- Wetlands
- Water surfaces
- Buildings
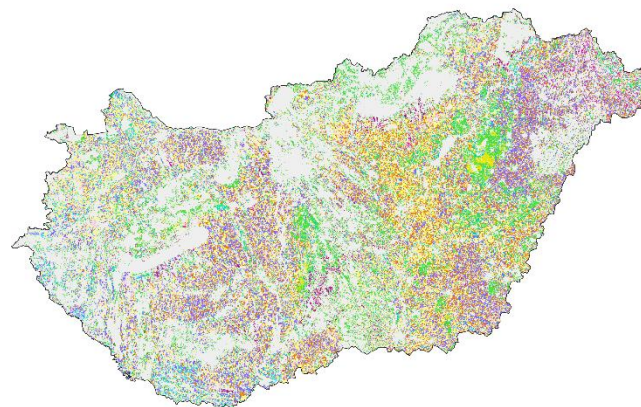
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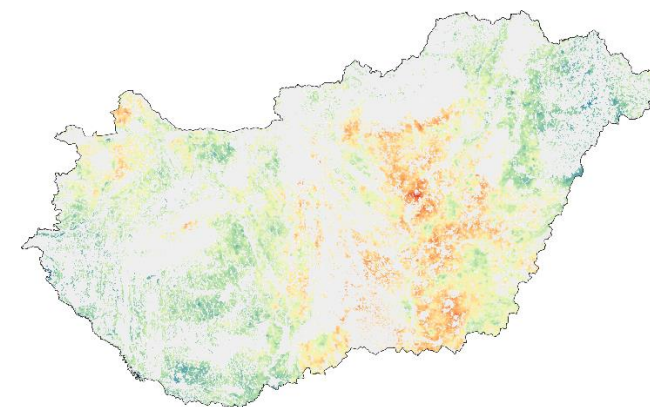- Grassland with woody weed
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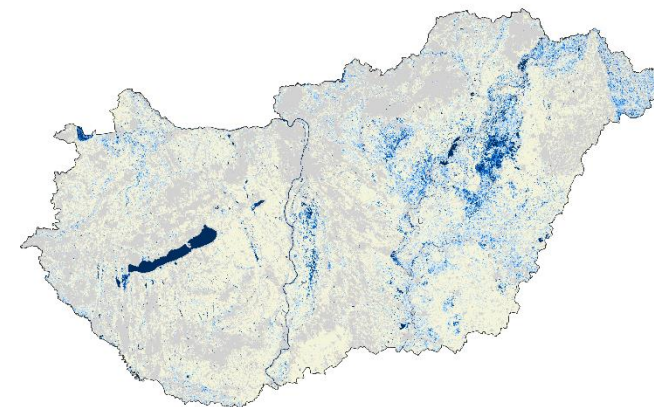
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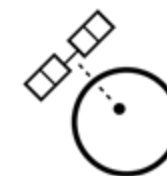- Much better than average
- Non-arable
- Cereal crops mask

Crop condition
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Average "VCI" based on three vegetation indices
- 80
- 35
- Non-arable dominant area
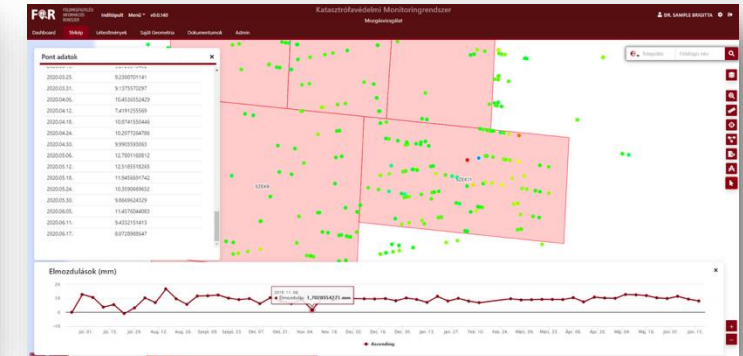
Radar-based IEW frequency (%)
- 100
- 0
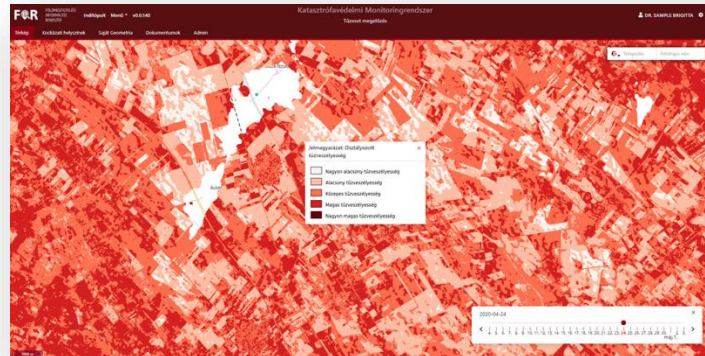- Artificial land cover
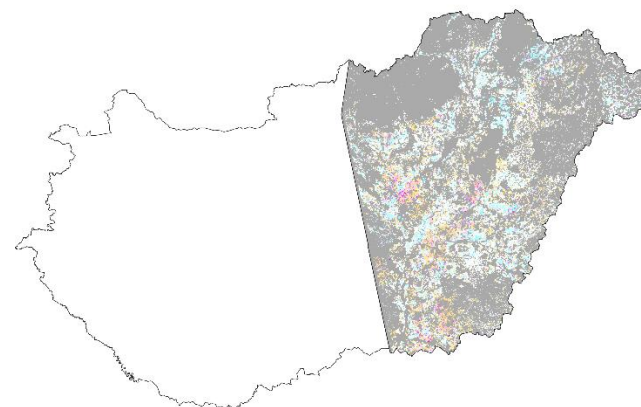
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Earth Observation Information System (FIR)

- KÖFOP-1.0.0-VEKOP-15-2017-00050 project (KIFÜ-LTK-NISZ)
- ESA Collaborative Ground segment node, public access
- Hardware and software infrastructure for NRT access, processing and archiving of Sentinel data over Hungary
- Earth Observation Operations Centre at LTK
- Automated processing chains to support governmental processes, specific modules:
  - Civil protection
    - Fire risk assessment
    - Monitoring of critical water infrastructure (InSAR)
  - Water authorities
    - Monitoring of inland excess water
  - Forestry
  - Agriculture

Agricultural Risk Management System (MKR)

Operational since 2014
Governmental system integrating the Ministry of Agriculture, the Paying Agency, Governmental Offices and supporting entities for the efficient assessment of yield loss compensation requests

The role of LTK: operationally provide thematic maps based on satellite data:
- Waterlogging/inundation maps (individual dates/certain periods, relative frequency map)
- Drought maps (certain periods, frequency map)
- High-resolution crop condition maps (new achievements from 2022)

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Copernicus browser: http://www.copernicusbongeszo.hu

THANK YOU

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