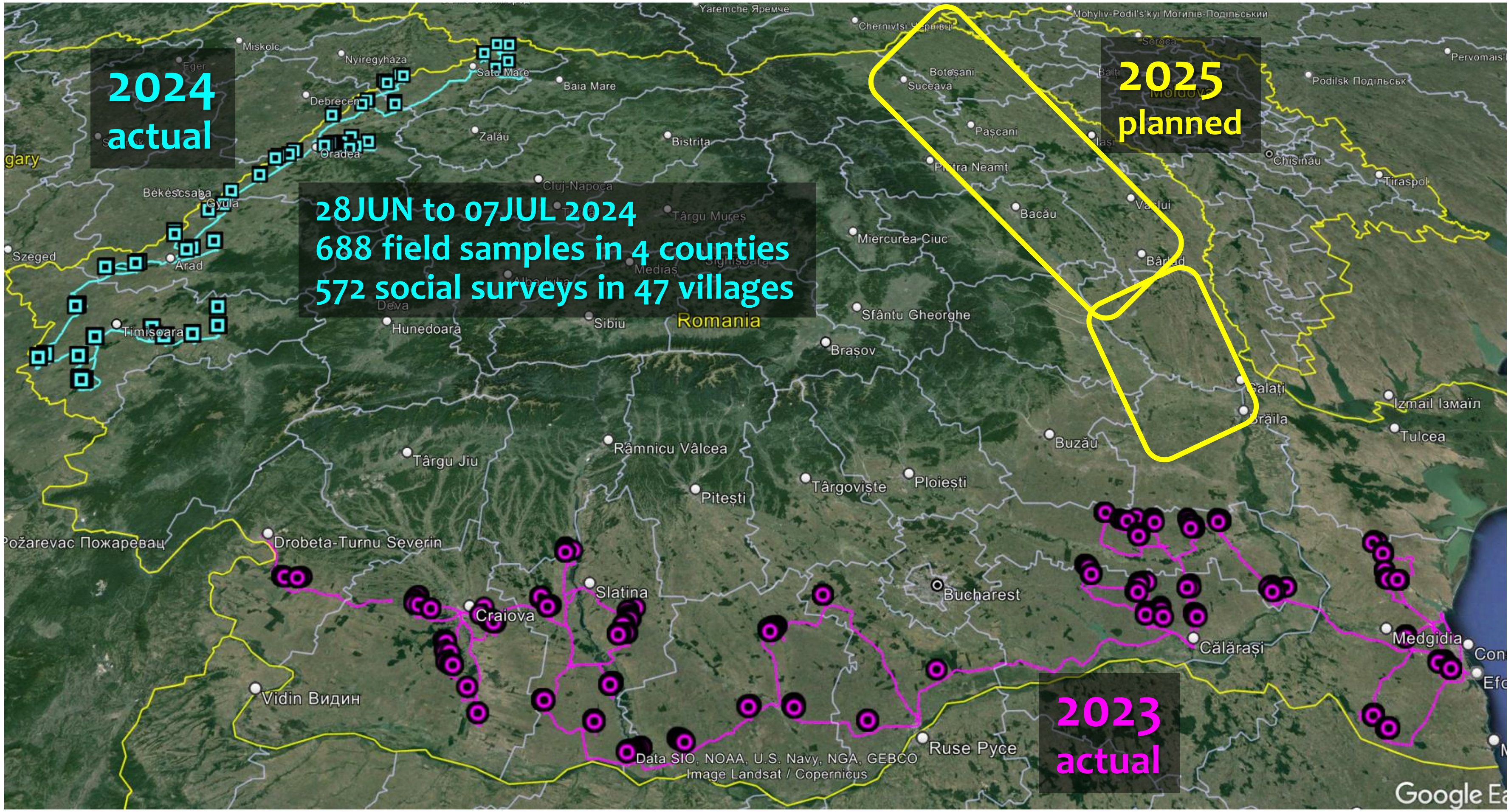
Agricultural Landscape Dynamics in Post-Socialist Romania: Diachronic Hotspot Analysis 2002-2024



NASA LCLUC
LAND-COVER AND LAND-USE CHANGE

A NASA Land Use Land Cover Change project funded for 2023-2025

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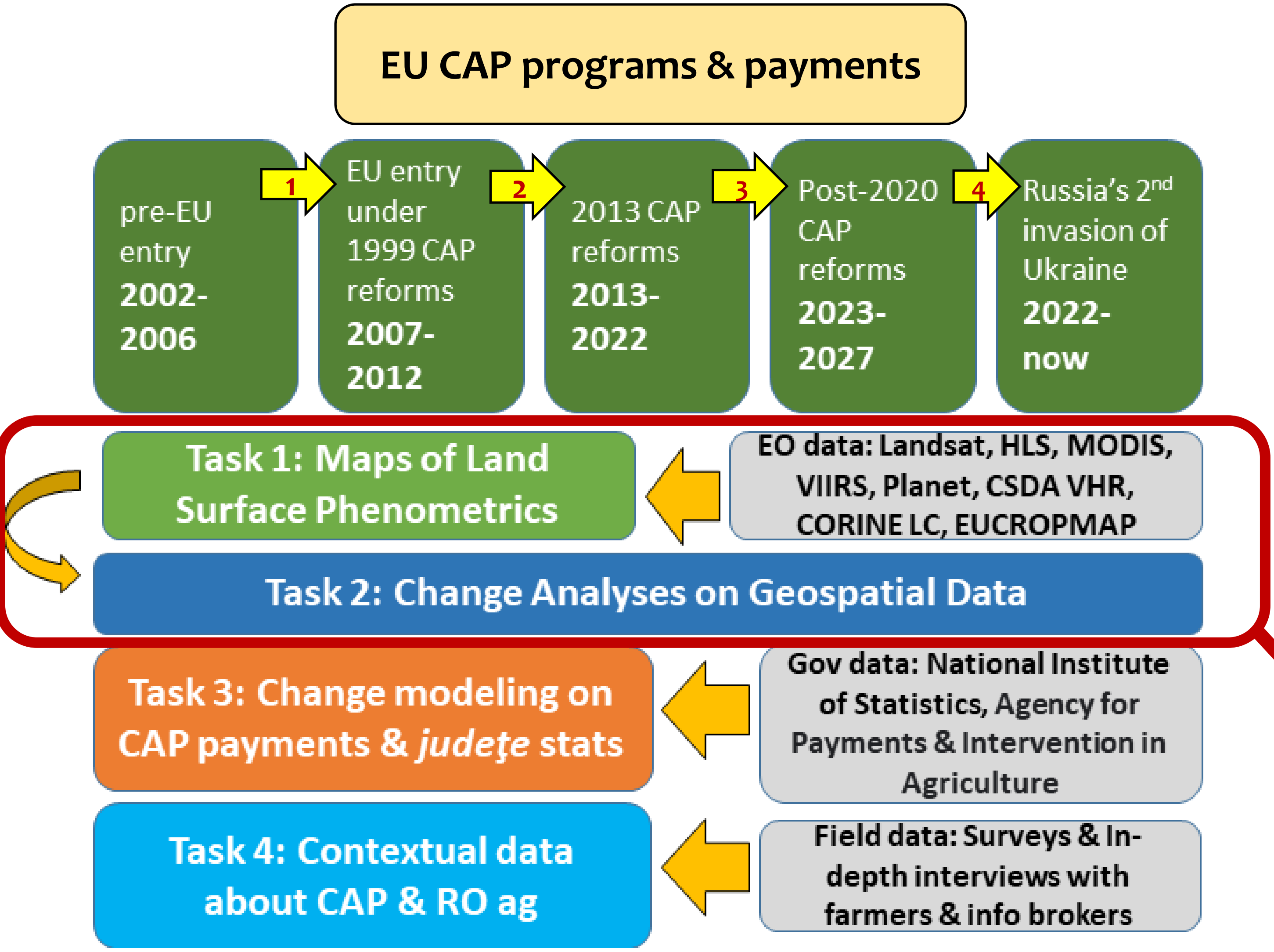
UNIVERSITATEA OVIDIUS DIN CONSTANȚA

UNIVERSITY OF BUCHAREST
VIRTUTE ET SAPIENTIA

Institutional Forcings on Agricultural Landscapes in Post-Socialist Europe:

Diachronic Hotspot Analysis of CAP Influences on Agricultural Land Use in Romania 2002-2024

Overview of the project concept & workflow



The Common Agricultural Policy (CAP) is a very large and complicated suite of policy instruments that influences agricultural activities across the EU.

CAP programs include livelihood payments to farmers, environmental protections, rural development projects, and other incentives.

We seek to understand how the diffusion of innovation—here CAP program enrollments and payments—work to influence land use change.

We propose a diachronic hotspot analysis for Romania that focuses attention on agricultural land use changes following four triggering events:

1. **Romania's entry into the EU and the CAP in 2007;**
2. **the 2013 CAP reforms;**
3. **the "post-2020" CAP reforms, which are necessarily convolved during the duration of this project with**
4. **the manifold repercussions of the Russian invasion of Ukraine starting in February 2022.**

Today I will touch briefly on our work to date addressing these two tasks

- Neither Romania nor Europe has an annual cropland data layer
- Attempts at European crop layers have been sporadic & incomplete
- We seek to use Harmonized Landsat Sentinel-2 (HLS) together with our field sampling to characterize crop phenologies to reconstruct basic agricultural land cover dynamics in Romania 2002-2024
- Earlier approaches to LSP modeling and analysis assumed temporal sparsity due to limited acquisitions and/or limited budget
- Implications of sparsity: need lots of data smoothing or gap-filling before curve-fitting
- **Working with HLS and other high cadence image time series, we have developed a simple, novel, and powerful approach to characterizing seasonality in land cover dynamics**

A *non-parametric* approach to characterizing seasonality in high cadence, high spatial resolution time series:

Tomochronographic Imaging

from Greek roots: τομος "slice" + χρονος "time" + γραφειν "to write"

Monika, my collaborator, was not enthused by this tongue-twister of a phrase, so I decided to use a name that is both easier to say and to remember:

Vegetation Seasonality Indicators (VSIs)

Vegetation Seasonality Indicators (VSIs)

A simple idea…leverage dense image time series using non-parametric statistics to compose characteristic seasonal *slices*: **maxima, medians, *and* the differences between them**

Maximum Value Composites (MVCs) are also tomochronographic images, but used for a different purpose

In the following false color composites, for each year we separately computed 10 VSIs (or tomochronographic images):

1. Annual median
2. Spring maximum
3. Summer maximum
4. Fall maximum
5. Spring max minus Annual median
6. Summer max minus Annual median
7. Fall max minus Annual median
8. Summer max minus Spring max
9. Summer max minus Fall max
10. Spring max minus Fall max

Illustrate the utility of VSIs using examples from our work on agricultural land cover dynamics in southern Romania

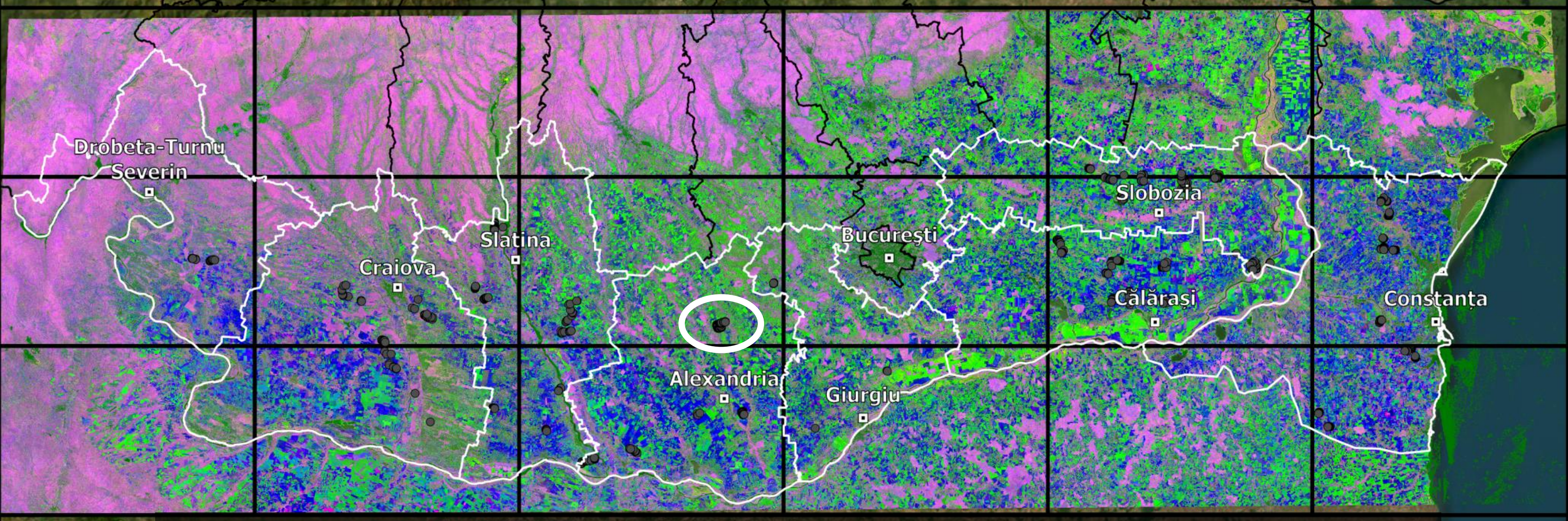
We calculated EVI2 from complementary products:

i. NASA's Harmonized Landsat Sentinel-2 (HLS) product at 30 m

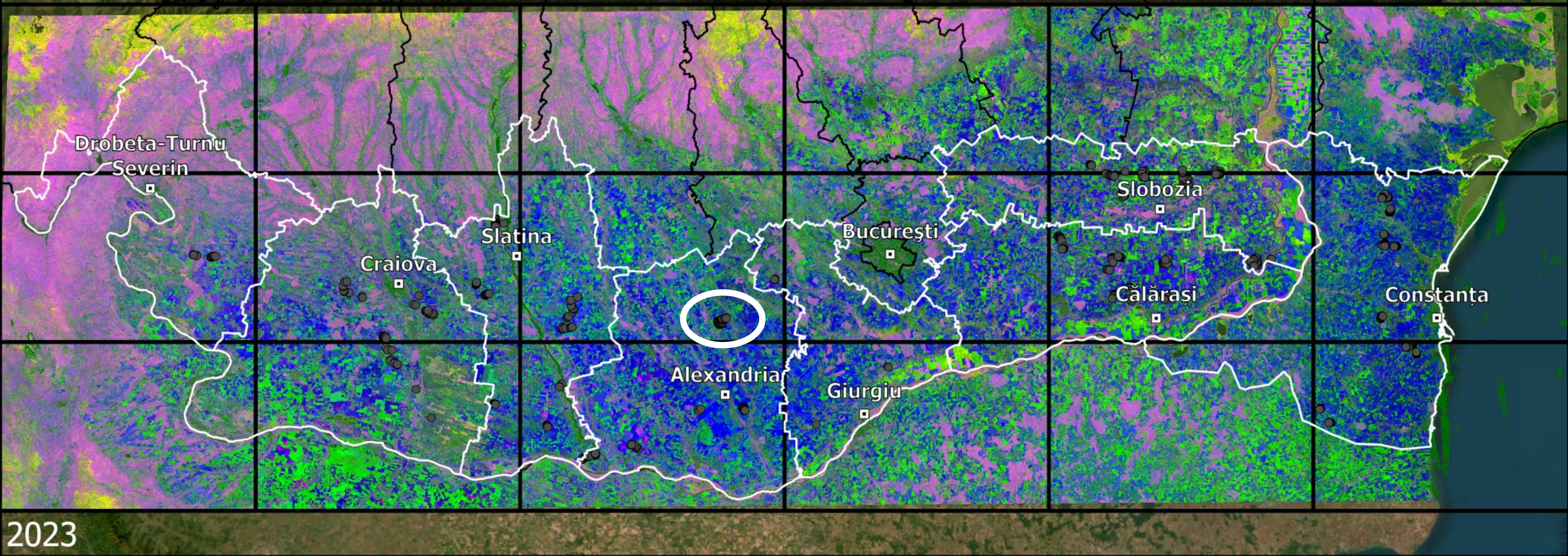
ii. ESA's Sentinel-2 surface reflectance product (SEN2A) at 10 m

We assessed maxima and medians from pixel-centric distributions of positive EVI2 values

The following illustrations are false color composites of EVI2 values, *not classified maps*



winter/spring crops more prevalent in 2023 than 2018



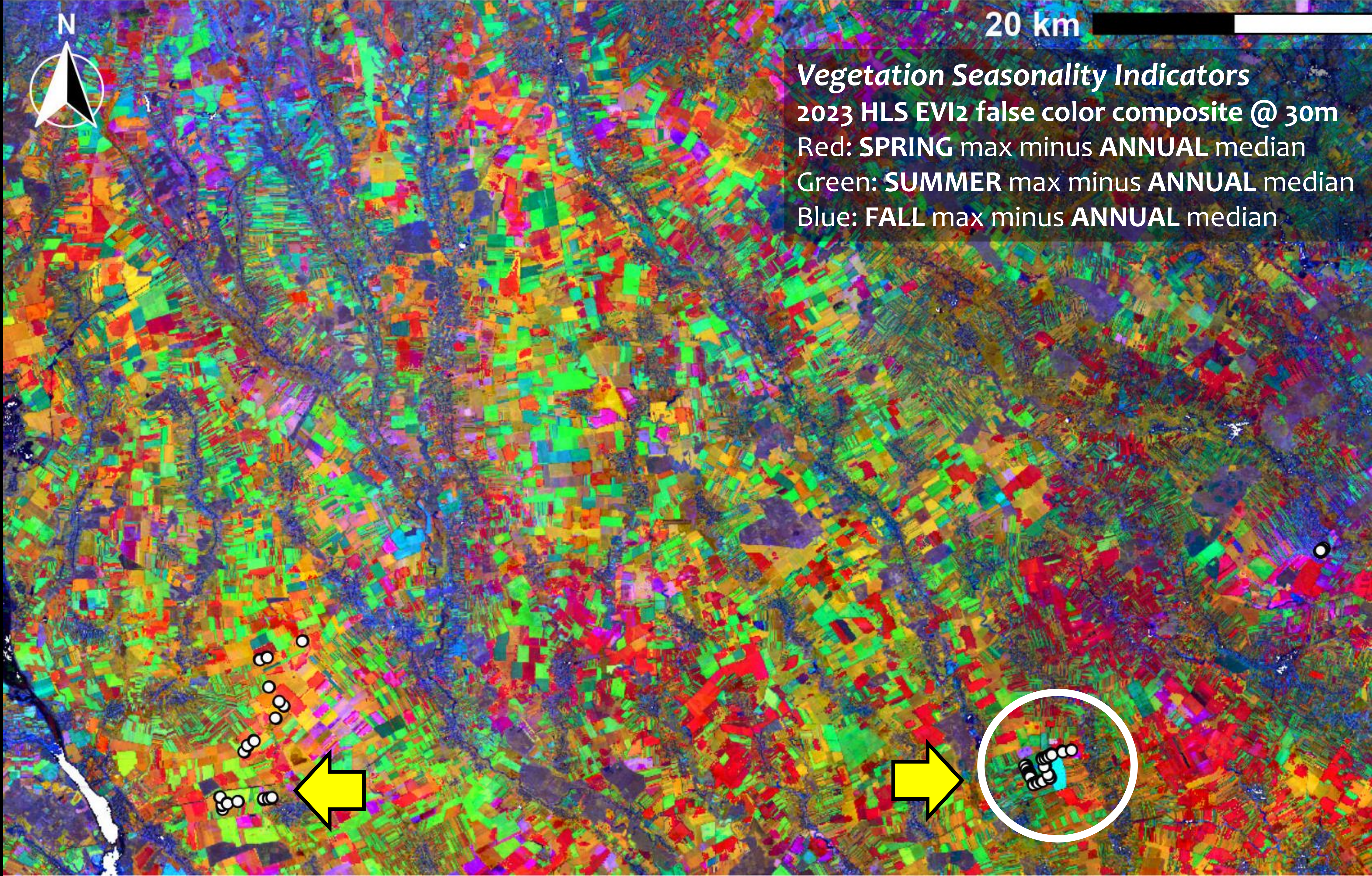
VSIs computed from dense time series of HLS @ 30m reveal crops across southern Romania in 2018 & 2023

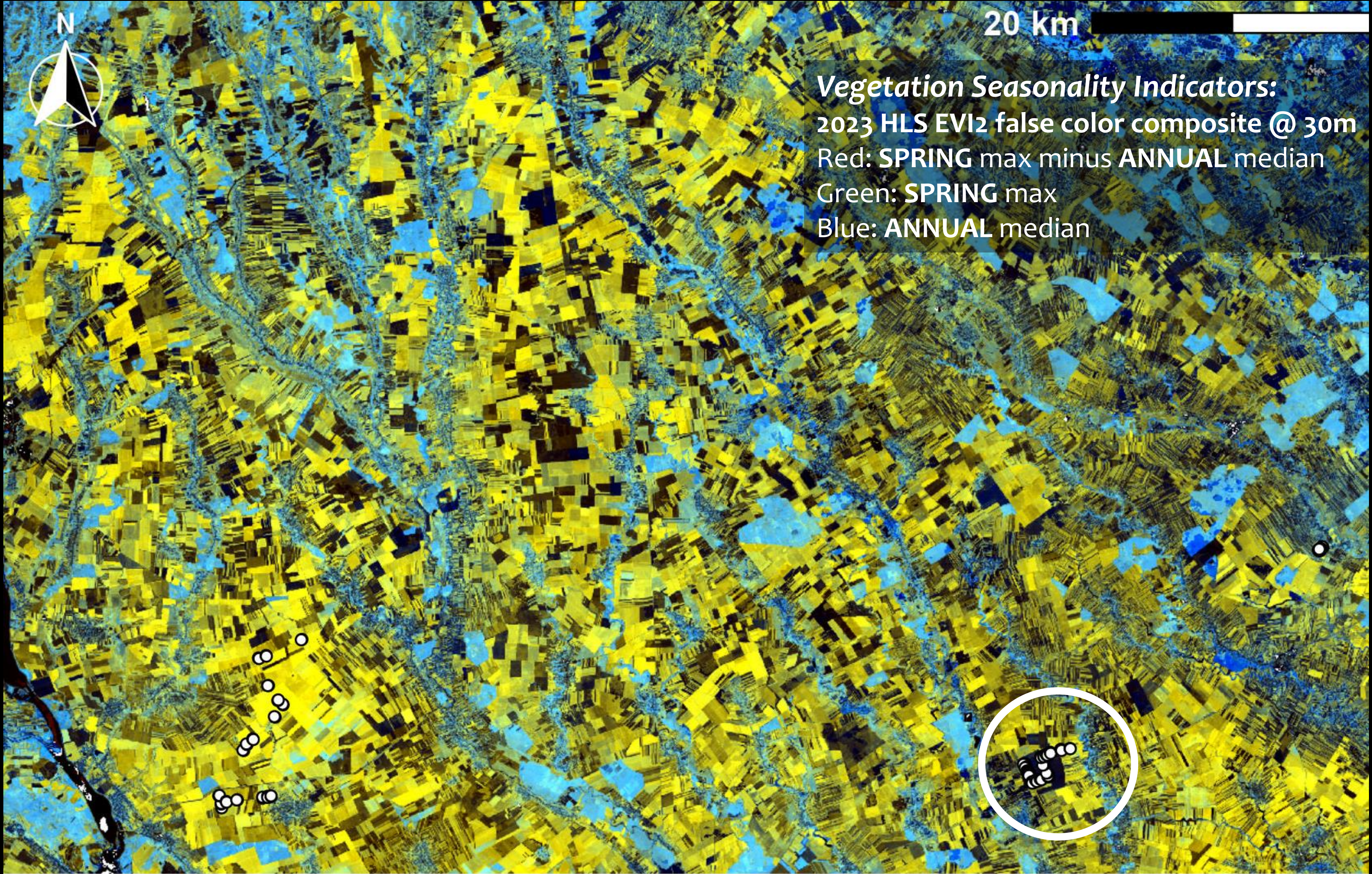
Magentas indicate perennial vegetation (forests, pastures, grasslands)

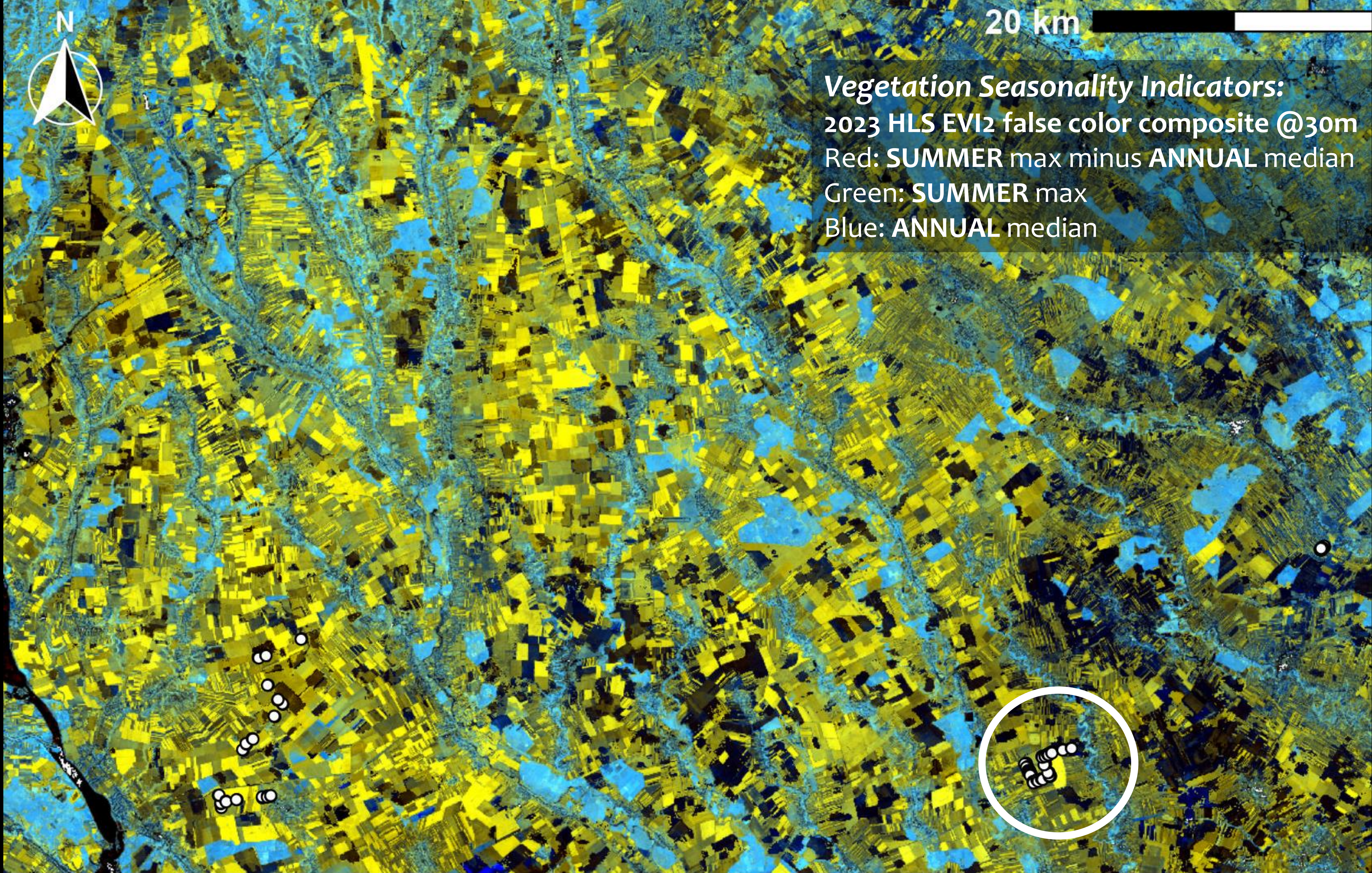
Greens indicate summer crops (maize, beans, sunflowers)

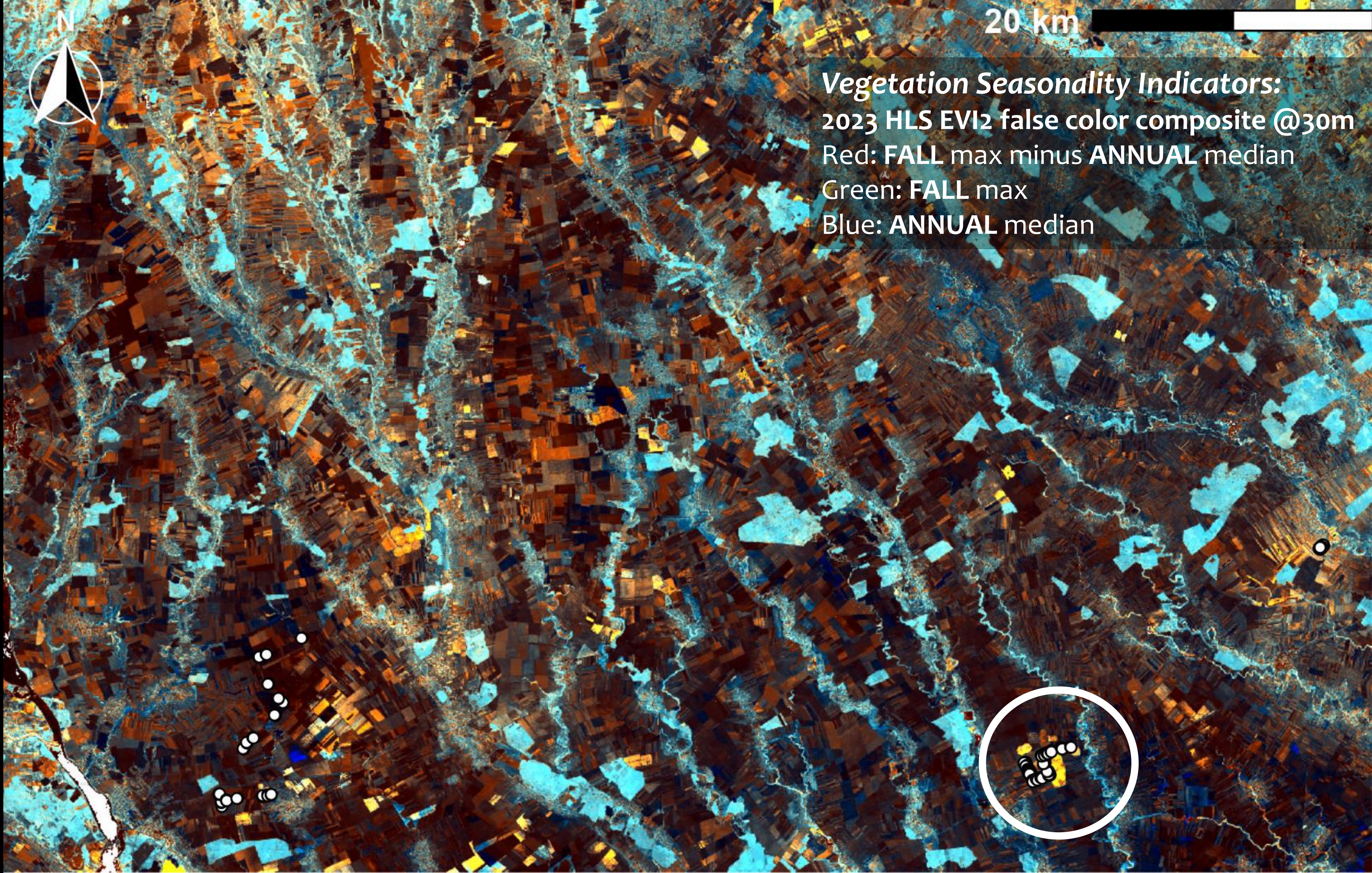
Blues indicate winter/spring crops (wheat, barley, rye, rapeseed)

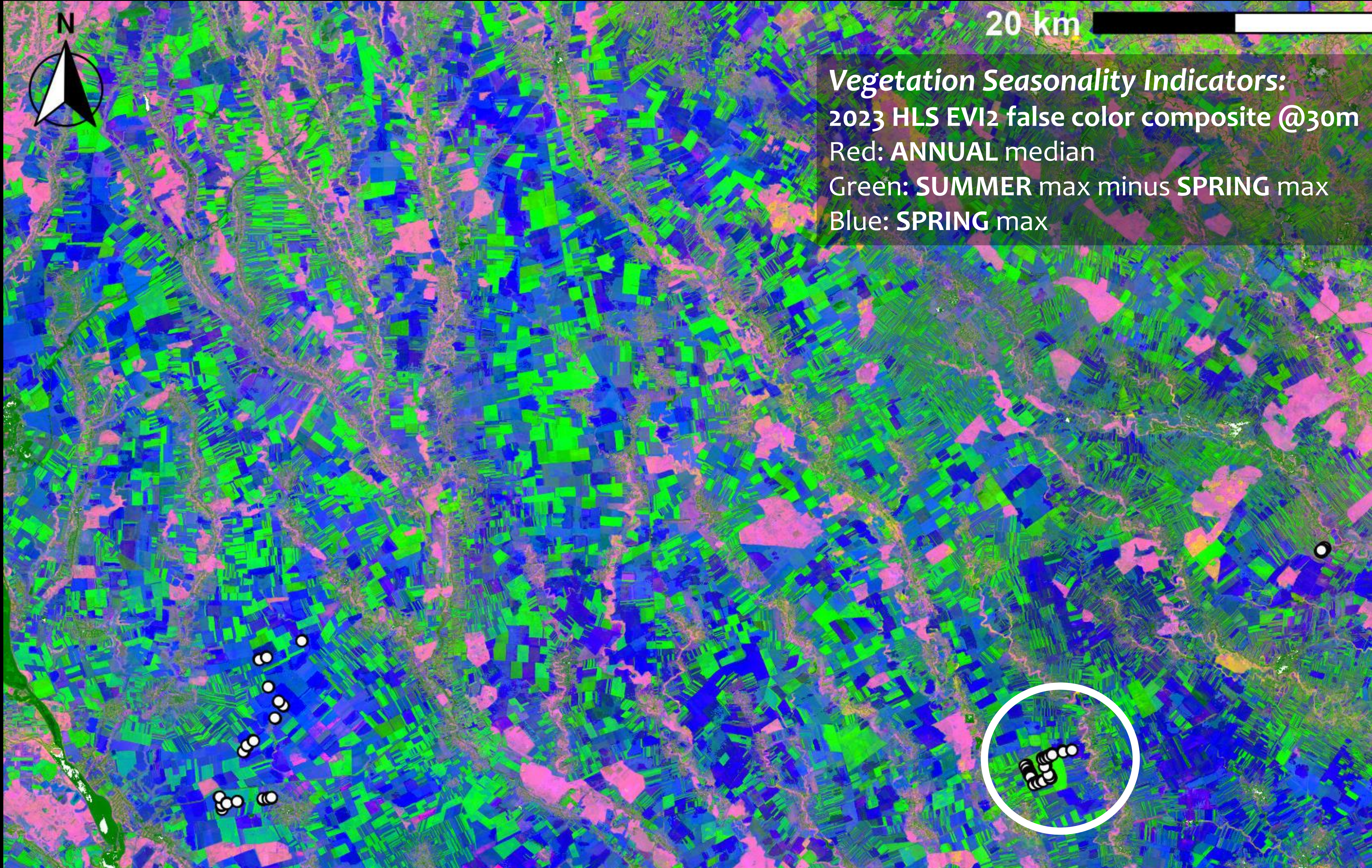
Yellows indicate very low spring EVI2 due to snow or persistent clouds at higher elevations

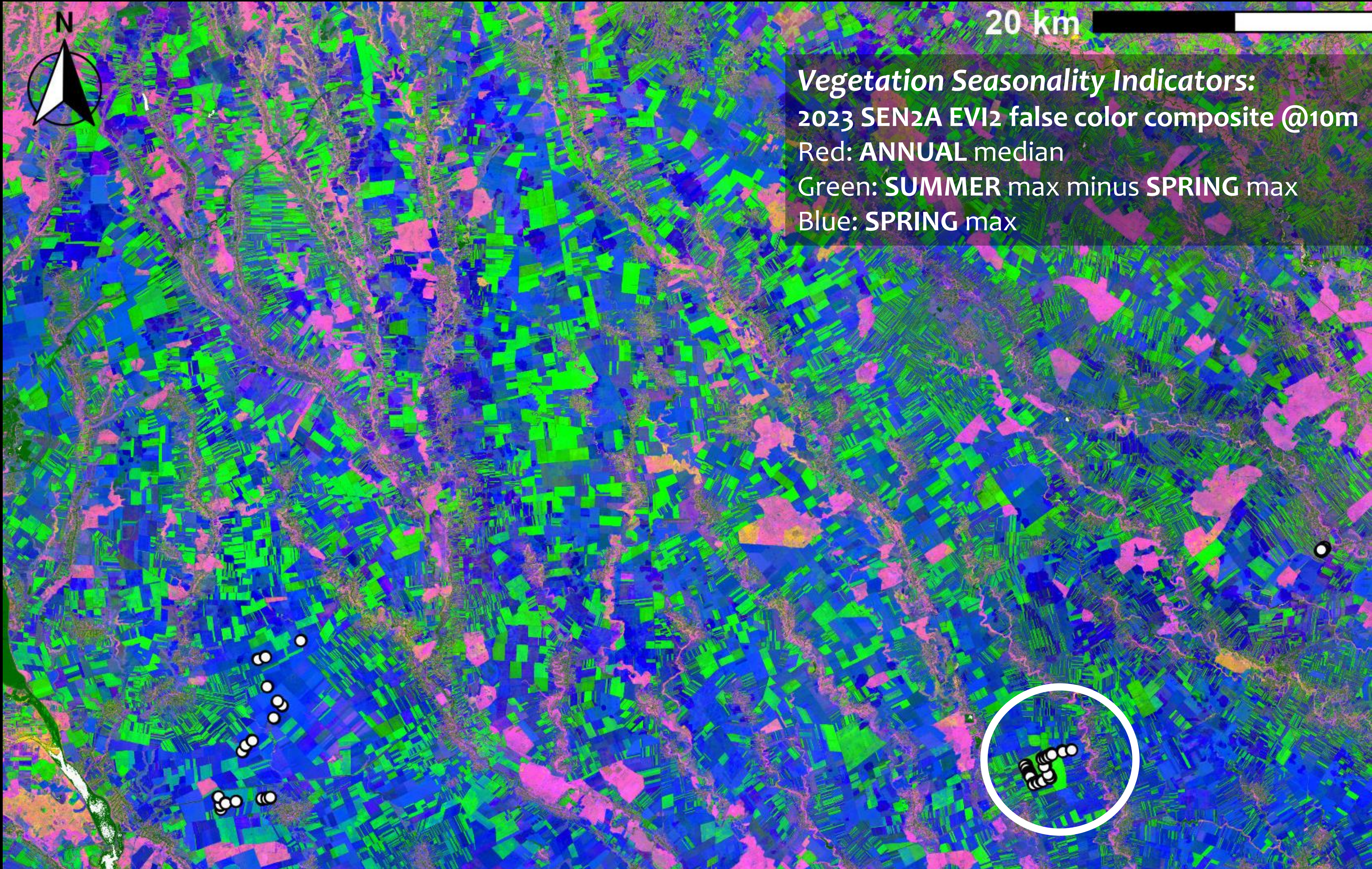

N
20 km
Vegetation Seasonality Indicators
2023 HLS EVI2 false color composite @ 30m
Red: **SPRING** max minus **ANNUAL** median
Green: **SUMMER** max minus **ANNUAL** median
Blue: **FALL** max minus **ANNUAL** median

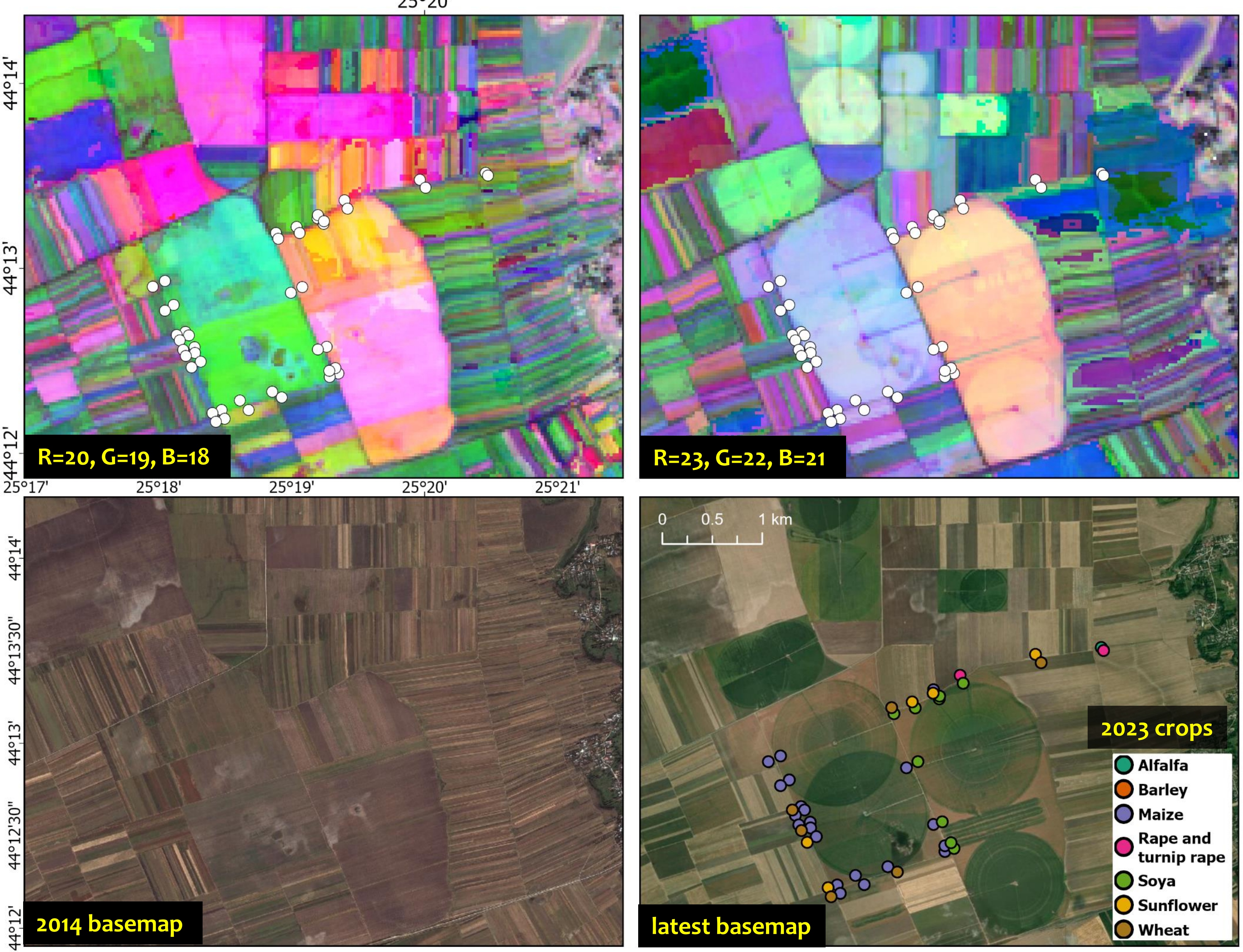

N
20 km
Vegetation Seasonality Indicators:
2023 HLS EVI2 false color composite @ 30m
Red: SPRING max minus ANNUAL median
Green: SPRING max
Blue: ANNUAL median


N
20 km
Vegetation Seasonality Indicators:
2023 HLS EVI2 false color composite @30m
Red: SUMMER max minus ANNUAL median
Green: SUMMER max
Blue: ANNUAL median


N
20 km
Vegetation Seasonality Indicators:
2023 HLS EVI2 false color composite @30m
Red: FALL max minus ANNUAL median
Green: FALL max
Blue: ANNUAL median


N
20 km
Vegetation Seasonality Indicators:
2023 HLS EVI2 false color composite @30m
Red: **ANNUAL** median
Green: **SUMMER** max minus **SPRING** max
Blue: **SPRING** max


N
20 km
Vegetation Seasonality Indicators:
2023 SEN2A EVI2 false color composite @10m
Red: ANNUAL median
Green: SUMMER max minus SPRING max
Blue: SPRING max



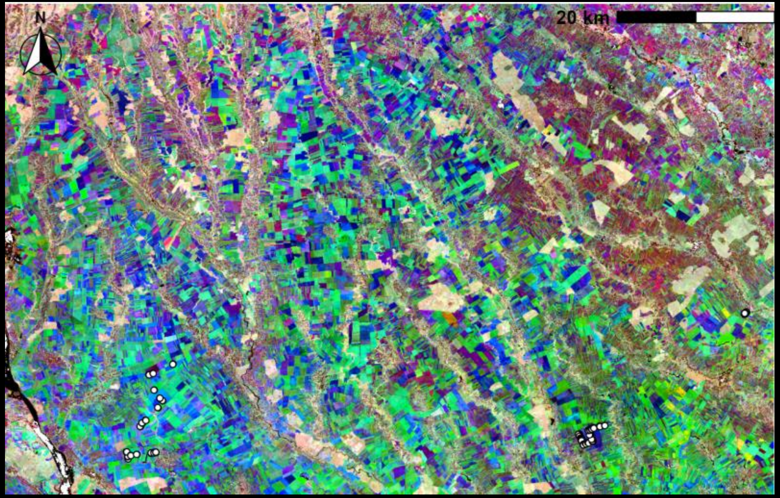
Hotspot of change in space & time

Recent field consolidation and installation in northern Teleorman county of center pivot irrigation systems for cultivation of maize and soy – facilitated through Common Agricultural Policy (CAP) funding

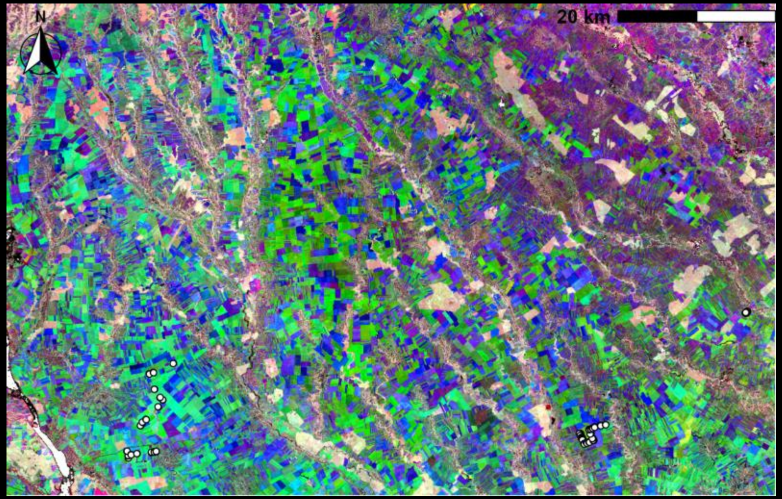
VSIs *for* dense HLS EVI2 time series @ 30m reveals high cropland heterogeneity of winter/spring crops (greens), summer crops (cyans & blues), cover & forage crops (yellows & magentas), and perennial vegetation (tans & greys)

Note: the association of colors with cover types depends on VSI combination ***and the weather!***

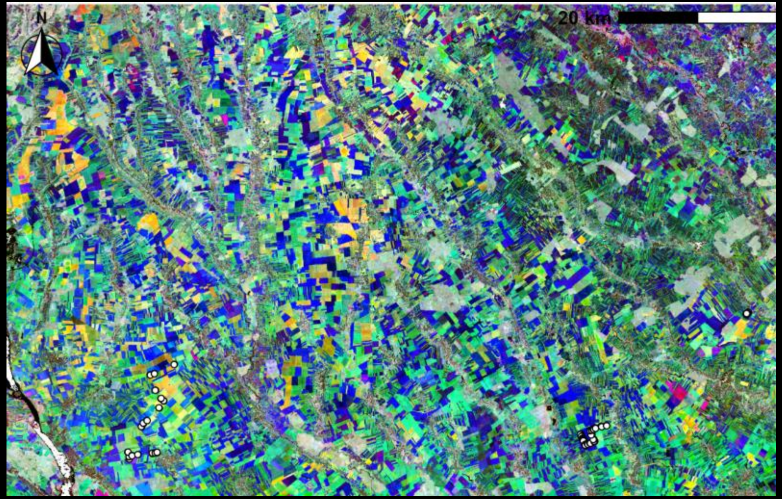
R: Fall 2018 + G: Spring 2019 + B: Summer 2019



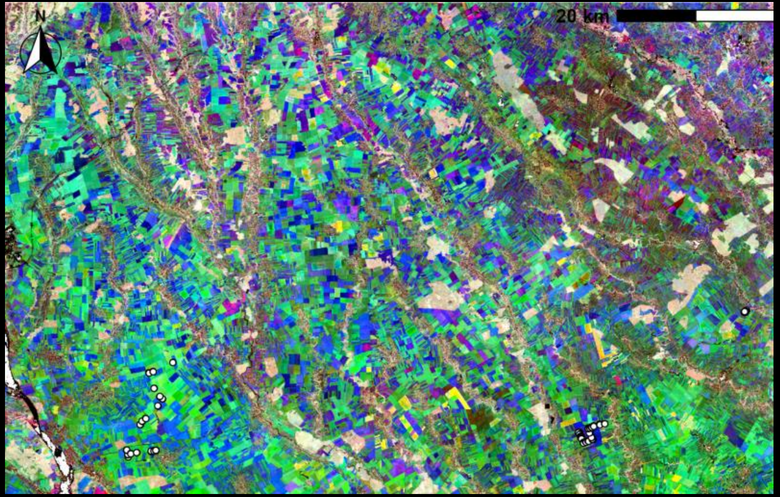
R: Fall 2019 + G: Spring 2020 + B: Summer 2020



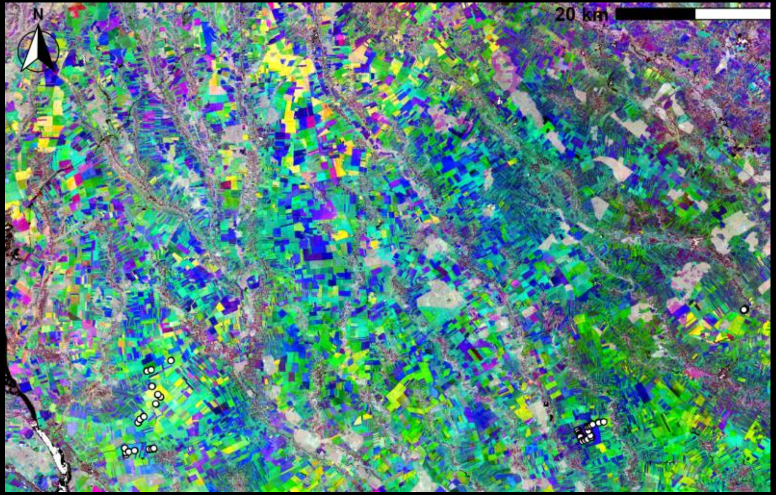
R: Fall 2020 + G: Spring 2021 + B: Summer 2021



R: Fall 2021 + G: Spring 2022 + B: Summer 2022



R: Fall 2022 + G: Spring 2023 + B: Summer 2023



The suite of VSIs I have just shown is one of several possible configurations

- Variable definitions of seasons (*e.g.*, precipitation-centric seasonality)
- Alternative vegetation indices
- Other false color composites of VSIs to emphasize different temporal phenomena

Possible VSI applications include

- Diachronic hotspot analysis/change analysis
- Interannual comparisons, including trends
- Preprocessing ahead of classification and ML/DL algorithms
- and many more – I invite you to think about the possibilities!

VSIs require some rethinking to interpret the tomochronographic images correctly

- VI values are spatially composited within season/year – not simple EVI2 "snapshots"
- Need some prior conception of what LSP types compose the vegetated land surfaces
- Need to appreciate the impact of weather on cloudiness (*e.g.*, climate oscillation modes)
- Need to parse compositing artifacts from within-field spatial heterogeneity

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Thanks!

Questions?

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← 07JUL24 after final field sample, south of Timişoara