

# Ten Years to Cross the Threshold: When Sentinel-2 Finally Enabled Crop-Specific Monitoring

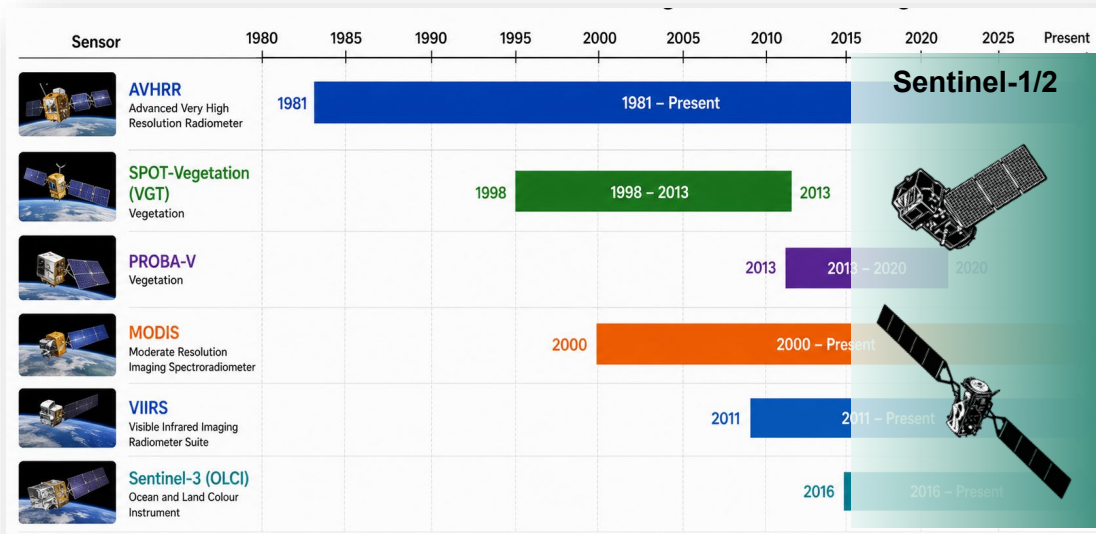
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Aouf<sup>1</sup>, Lorenzo Seguí<sup>1</sup>, Guido Lemoine<sup>1</sup>, Marijn Van der Veld<sup>1</sup>, Stefan Niemeijer<sup>1</sup>*

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# Crop monitoring: a core use case for Earth Observation

- Earth Observation has been widely used for many crop monitoring systems
- They all rely on coarse-resolution systems (500m-1km), providing overall cropland condition
- Mixed pixels prevent crop-specific interpretation
- Sentinel-1/2 = parcel-level observation (10–20 m)




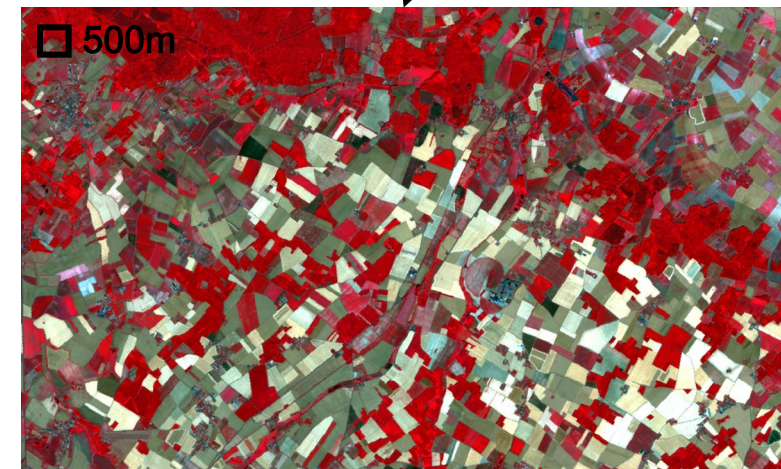
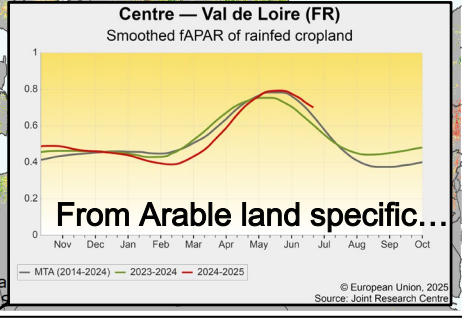
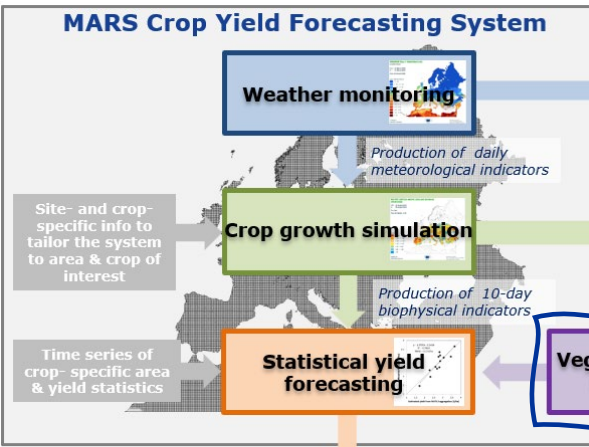
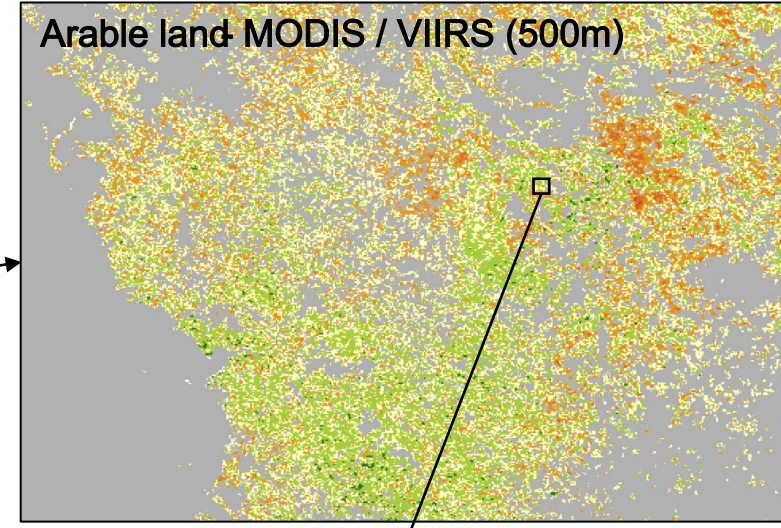
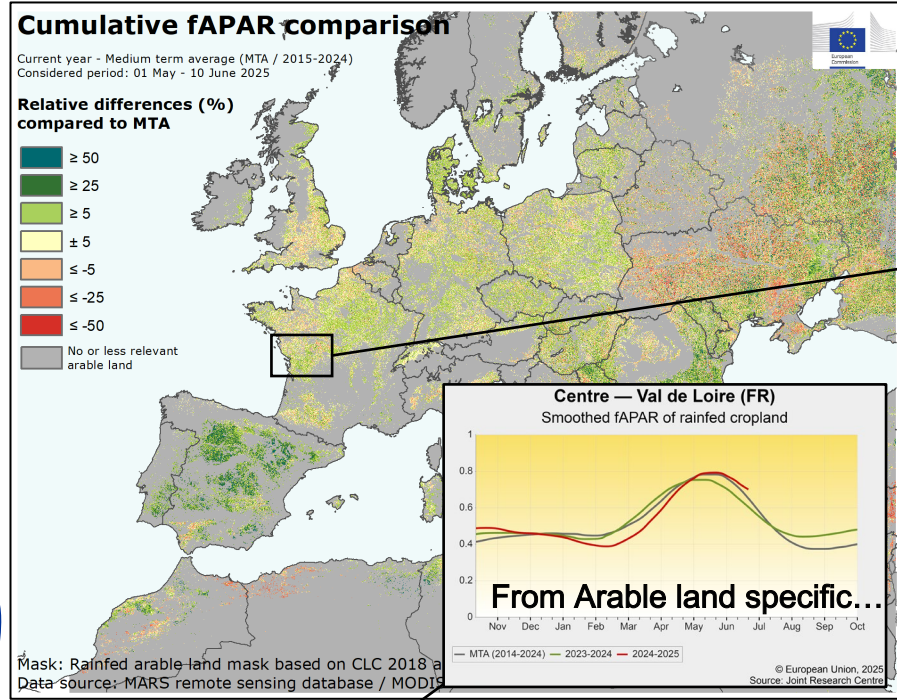
The collage includes several key components:

- FAO Agricultural Stress Index (ASI):** A world map showing the percentage of cropland area affected by severe drought per GAUL 2 region. Legend: < 10, 10-25, 25-40, 40-55, 55-70, 70-85, > 85. Legend also includes off season, no data, no seasons, and no cropland.
- JRC ASAP:** A dashboard for 'Warning Explorer' showing 'ASAP units', 'Date' (11-20/04/2026), 'Warning layer' (CRDP - RANGELAND), and 'MAP LAYERS'. It features a 'Time series' plot and a 'Share of active area by zscore range' bar chart.
- NASA / USDA GIMMS Global Agricultural Monitoring:** A dashboard showing 'GIMMS Global Agricultural Monitoring' with a map of the USA and a 'Seasonal Time Series for S-NPP VIIRS 8-day NDVI / Copine 2018 Dryland / Vienne, Pottou...' plot.
- GEOGLAM:** A dashboard for 'Central Region (Central Region, Malawi) Phase 2024' showing 'Cumulative Precipitation (in 5 year mean)', 'Mean 5 Year NDVI Comparison', 'Precipitation (Daily)', 'Disjunctive Storm Index', and 'Temperature (Daily mean)'. It includes logos for MARYLAND, GEOGLAM, and Crop Monitor.
- JRC MARS Bulletin:** A report titled 'Favourable crop conditions across Europe, with emerging water deficits' and 'Turkey: Overall fair yield perspectives despite challenges'. It includes a table of contents and a map of Europe.

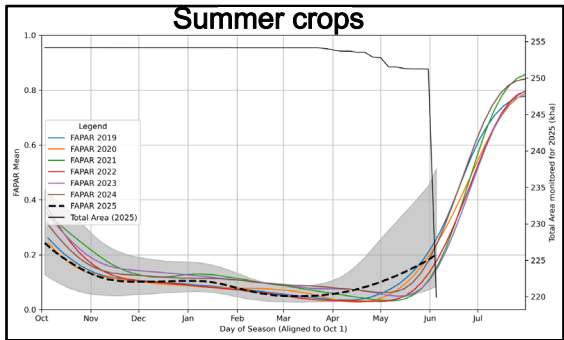
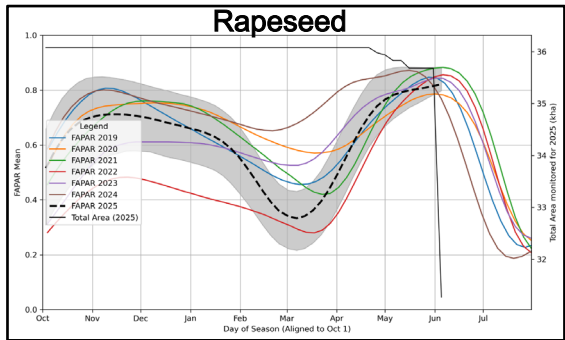
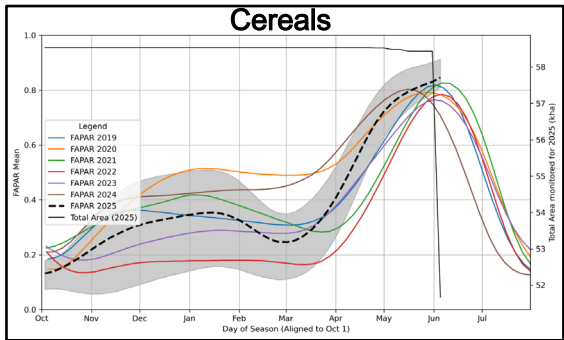


# The Remote Sensing component of MARS JRC in


 European Commission  
 Joint Research Centre  
 Issued 23 March 2026, JRC MARS Bulletin Vol. 34 No. 2  
 JRC MARS Bulletin  
 Crop monitoring in Europe – March 2026  
 Crops exit from winter dormancy in favourable conditions



... to Crop specific

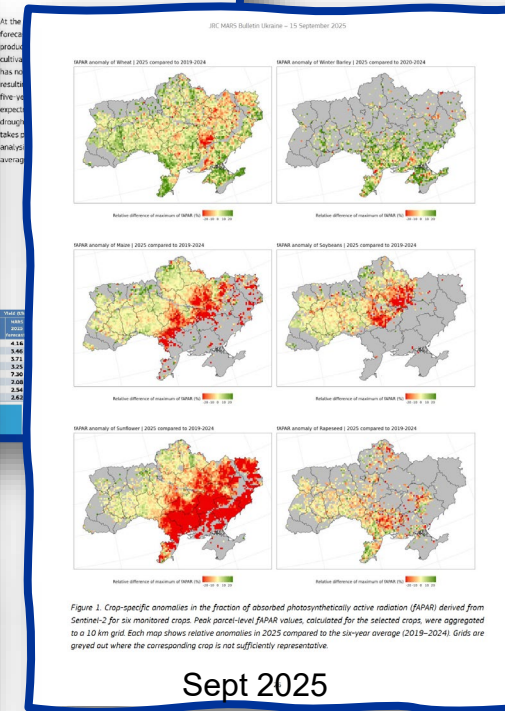
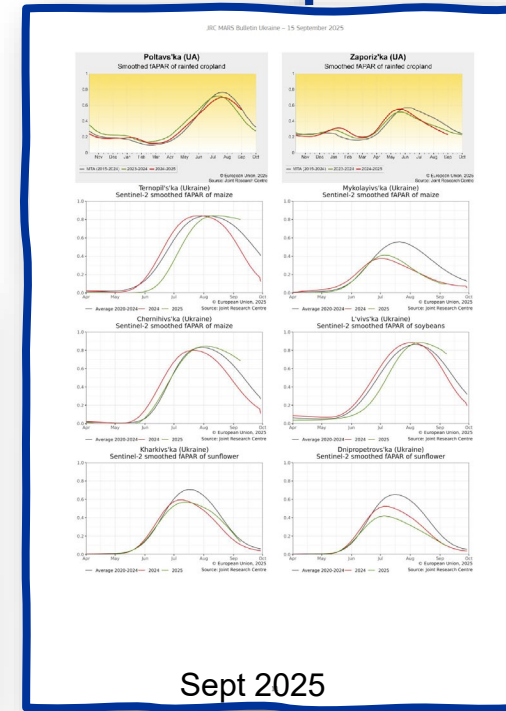
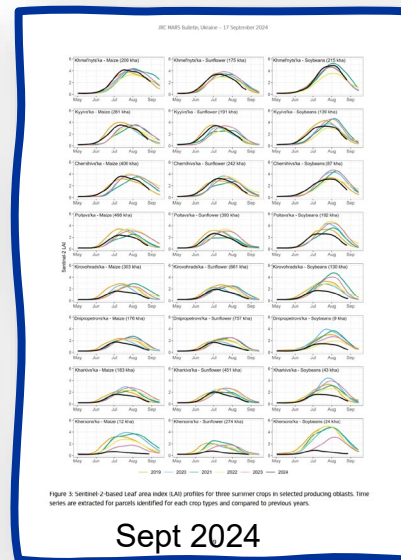
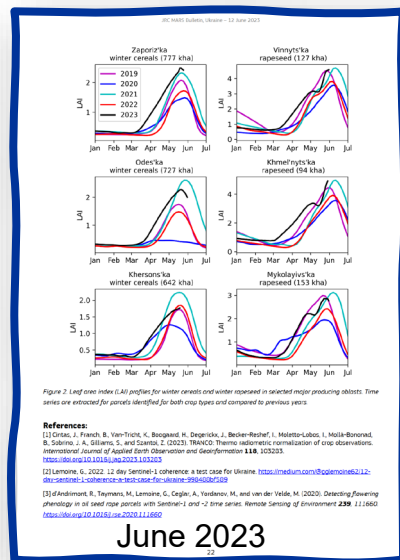
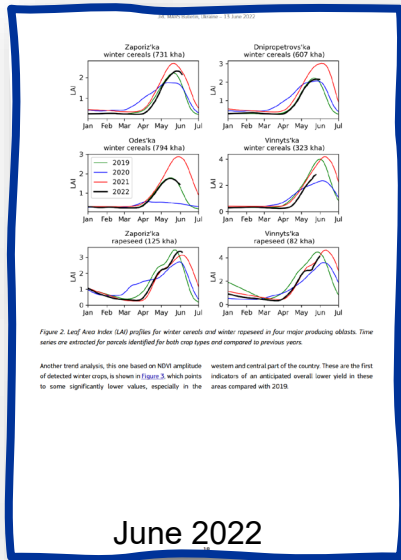
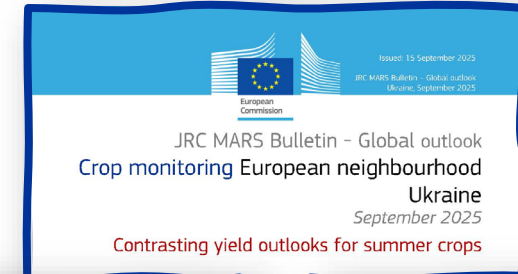


Crop specific Sentinel2 (10m)



# Sentinel opened a new era of crop monitoring

- As of 2026: ~10 years of Sentinel-2 observations available
- No systematic integration in operational monitoring systems
- Current use remains largely ad hoc
- Since 2022: JRC MARS Ukraine analyses as a flagship application with the support of the Kyiv Polytechnic Institute



# Toward an operational system for full Europe

*It comes with two major challenges:*

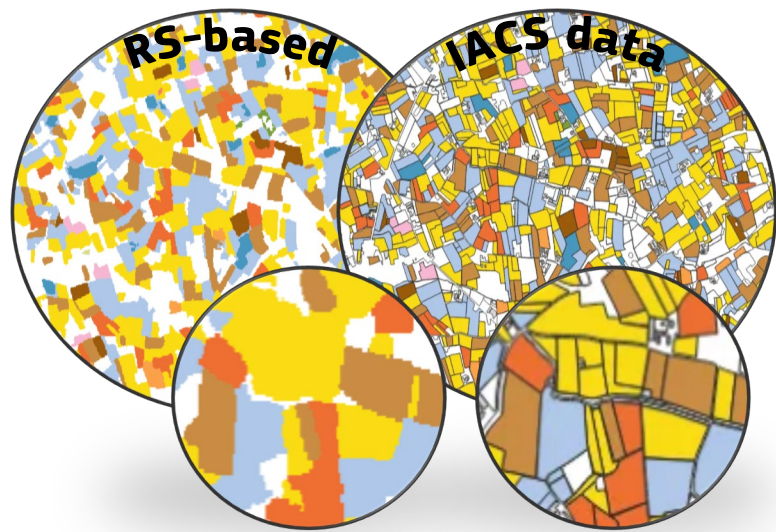
- *#1 Yearly updated crop type map*
- *#2 Very large processing*

# Challenge #1: where are the crops?

- Most Crop type changes yearly

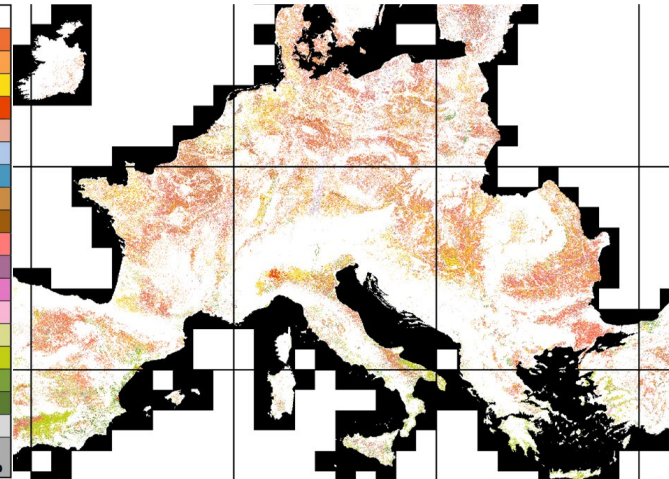


- Two main sources of data:

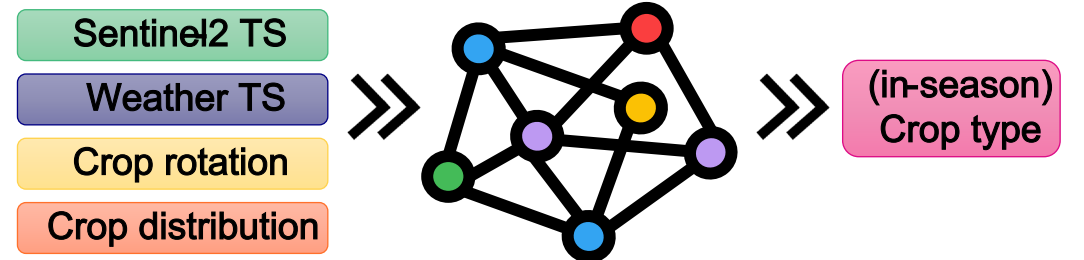


- HRL VLCC CTY is a pan-European yearly RS-based product for 2017-2024

Code	Crop type
1110	Wheat
1120	Barley
1130	Maize
1140	Rice
1150	Other cereals
1210	Fresh Vegetables
1220	Dry pulses
1310	Potatoes
1320	Sugar Beet
1410	Sunflower
1420	Soybeans
1430	Rapeseed
1440	Flax, cotton and hemp
2100	Grapes
2200	Olives
2310	Fruits
2320	Nuts
3100	Unclassified arable crop
3200	Unclassified permanent crop



- For in-season, we rely on RS-based classification system (like a HRL-NRT product)



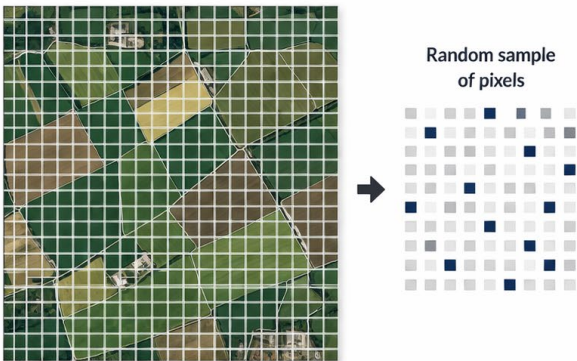
Crop rotation = temporal sequence of crop types  
 Crop distribution = 2020-2024 average spatial distribution of crops - 10km radius




# Challenge #2: Very large processing

- ~150 million ha of arable land in Europe
- ~15 billion @10m pixels (vs 6 million @500m)
- Two approaches to reduce the data space:
- Our approach: HRL-VLCC to create proxy of parcel

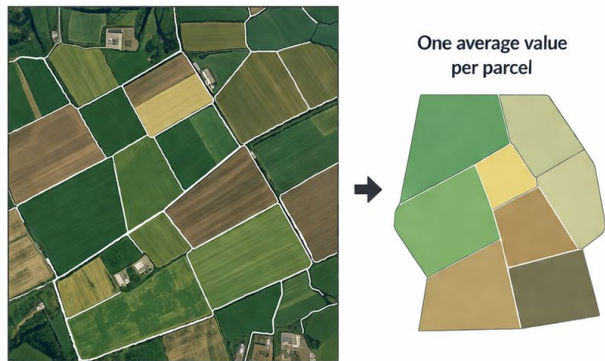
## 1 Sampling some pixels Random sample of pixels to process




- All pixels (original data)
- Sampled pixels (subset to process)

 Data space reduced by using a random sample of pixels.

## 2 Using parcels to average the pixels Average all pixels within each parcel



- Parcels (field boundaries)
- Average value of pixels within each parcel

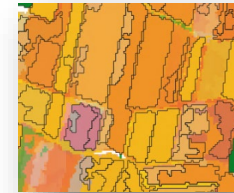
 Data space reduced by summarizing pixels within parcels (one value per parcel).





# The first PoC of a Europe crop-specific monitoring system

- Dataset size: 46M polygons, covering 150 million ha
- Crop Rotation: 2017-2024 crop sequence
- S2 time series: decadal TS from October 2016 to present  
→ 15+ billion data points per variable (LAI, FAPAR, spectral bands,...)
- Crop distribution: 2020-2024 average spatial distribution
- Weather: decadal TS from October 2016 to present per variable (Temp, precip, ET0)
- All features stored in DuckDB / parquet



Crop rotation

cropfield int32	c2017 int16	c2018 int16	c2019 int16	c2020 int16	c2021 int16	c2022 int16	c2023 int16	c2024 int16	npix int16
51318	1220	1120	1220	1120	0	1120	1120	0	223
52968	1120	1220	1120	1220	1120	1220	1120	1120	246
54621	1220	1110	1220	1220	1120	1220	1220	1110	294
56851	1220	1120	1110	1120	0	1120	1220	1120	358
57168	1110	1220	1110	1120	1110	0	1110	1120	232
59835	1120	1110	1110	1120	1440	1440	1110	1440	214
60136	1440	1440	3100	1140	1130	1440	1440	1210	581
60956	1140	1130	1140	1140	1440	1140	1140	1120	216
61963	1120	1110	1130	1140	1110	1110	1110	1110	275
62437	1220	1110	1220	1110	1120	1220	1110	1120	640

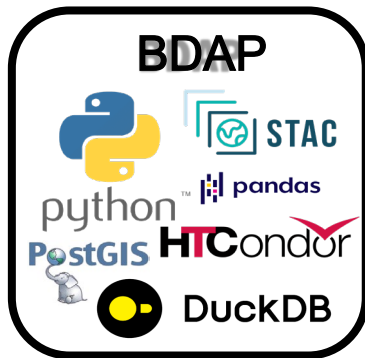
10 rows 10 columns

S2 time series

```
D select * from smooth_all limit 10 ;
```

cropfield int64	doe uint16	b04_mean int16	b08_mean int16	b12_mean int16	lai_mean int16	fapar_mean int16	fapar_std int16	ndyi_mean int16	ndre_mean int16
10003927	1607	59	427	106	2047	696	45	305	473
10003927	1608	50	438	94	2726	744	39	317	528
10003927	1609	40	451	80	3486	798	32	329	590
10003927	1610	31	465	68	4217	849	26	337	644
10003927	1611	25	488	58	5004	897	20	331	685
10003927	1612	27	523	55	5785	929	16	302	698
10003927	1613	40	556	65	6279	923	15	259	673
10003927	1614	65	568	91	6089	853	17	226	613
10003927	1615	103	553	137	5125	712	23	209	518
10003927	1616	141	528	185	3949	558	29	202	422

10 rows 10 columns



Weather

cropfield int32	rdekad int16	temp float	rain float	rad float	et0 float
11867336	15	26.9	0.5	28548.4	60.0
17184758	10	11.7	11.9	15960.4	28.5
17184726	10	11.7	11.9	15960.4	28.5
17184830	10	11.7	11.9	15960.4	28.5
17184802	10	11.7	11.9	15960.4	28.5
17184894	10	11.7	11.9	15960.4	28.5
17184979	10	11.7	11.9	15960.4	28.5
17185057	10	11.7	11.9	15960.4	28.5
17185192	10	11.7	11.9	15960.4	28.5
17185117	10	11.7	11.9	15960.4	28.5

10 rows 6 columns

Crop distribution

cropfield int32	cropcode int32	area ha int32
11516491	4100	946
11516491	4200	6929
11459649	0	12
11459649	1110	49
11459649	1120	49
11459649	1130	125
11459649	1150	57
11459649	1210	0
11459649	1220	1
11459649	1410	2

10 rows 3 columns

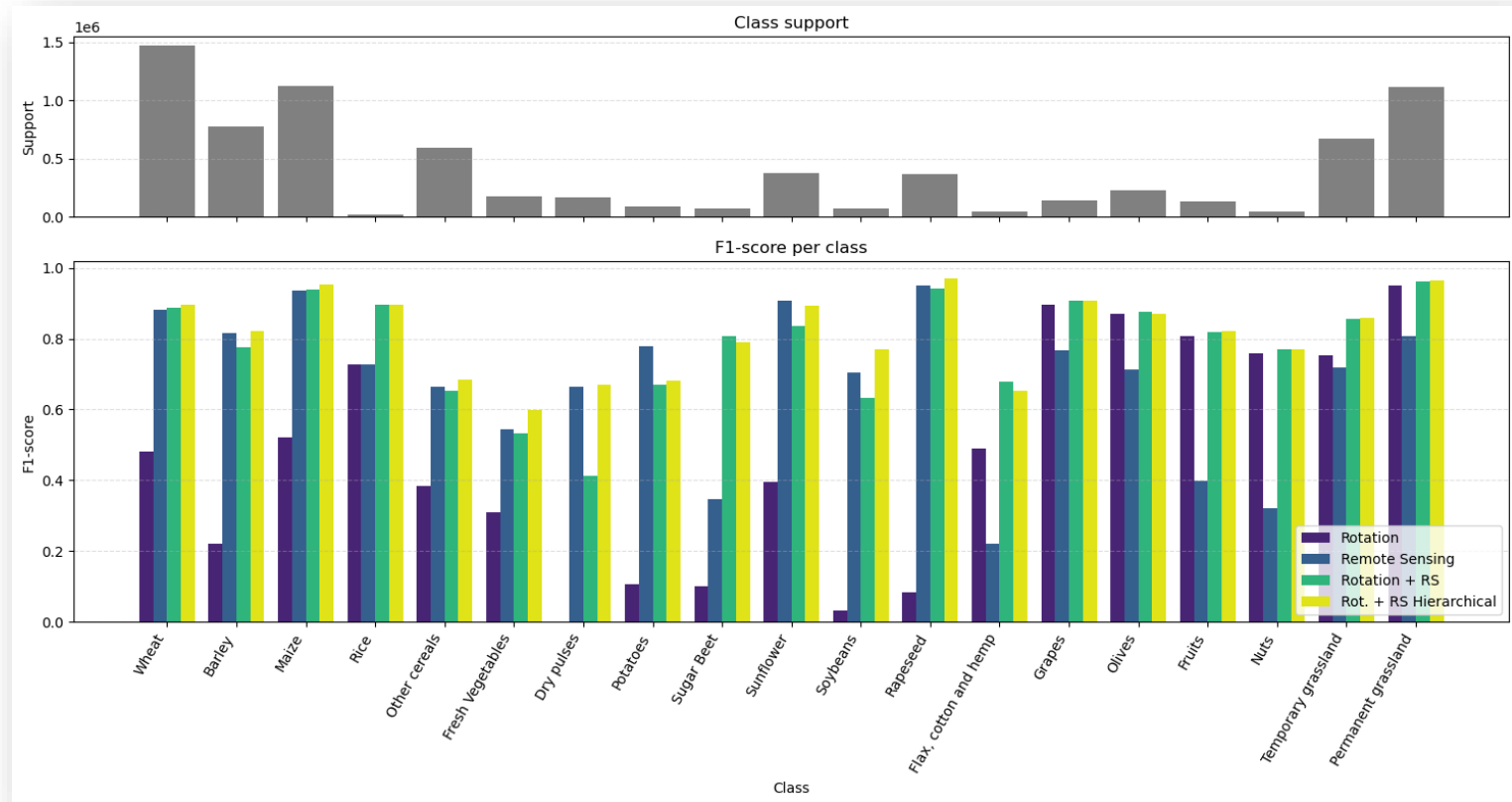


# Some Early results: crop mapping

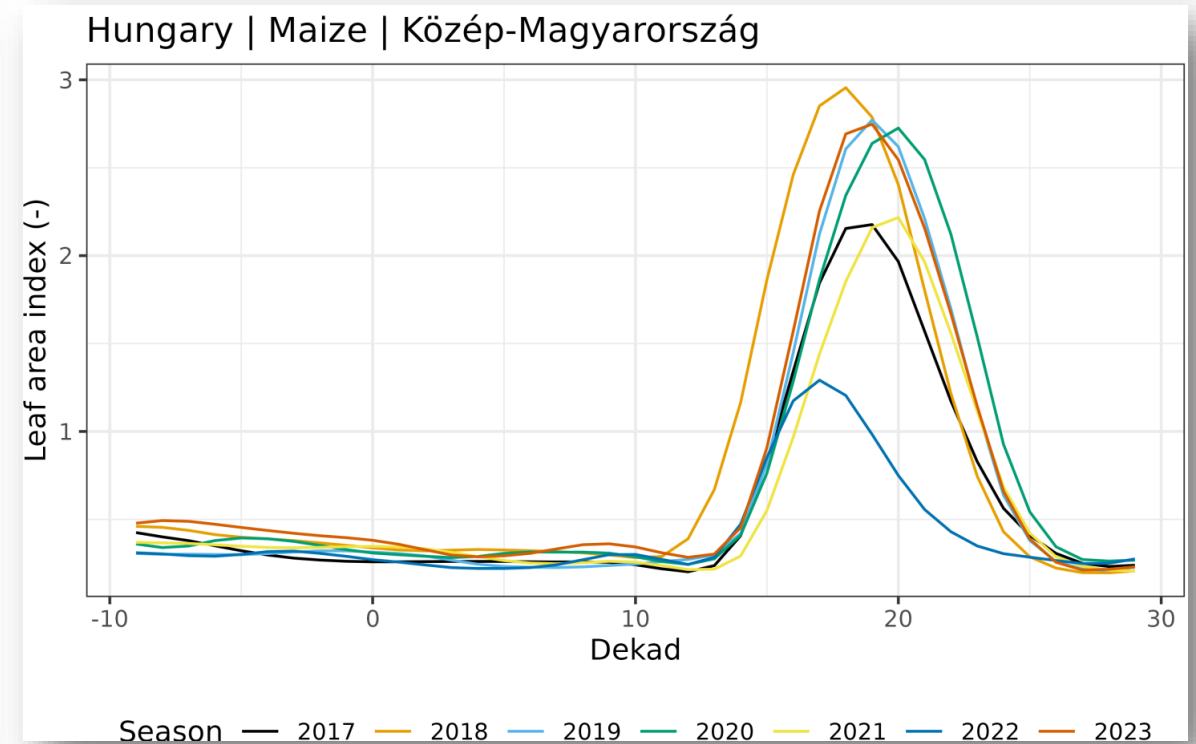
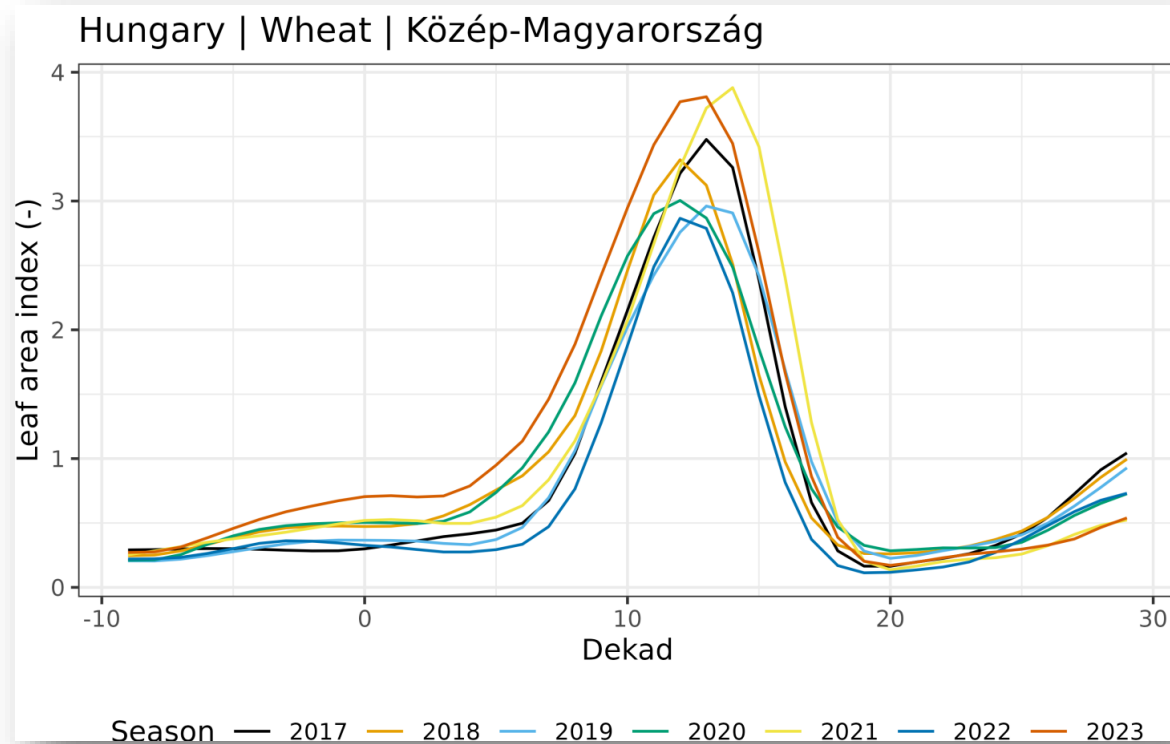
- Experiment based on a 7M sampling stratified over countries and crops

Training set	2017-2022
Validation set	2023
Test set	2024

- Three models evaluated:
  - Crop rotation only
  - Remote sensing only
  - Crop rotation + RS
  - Hierarchical model

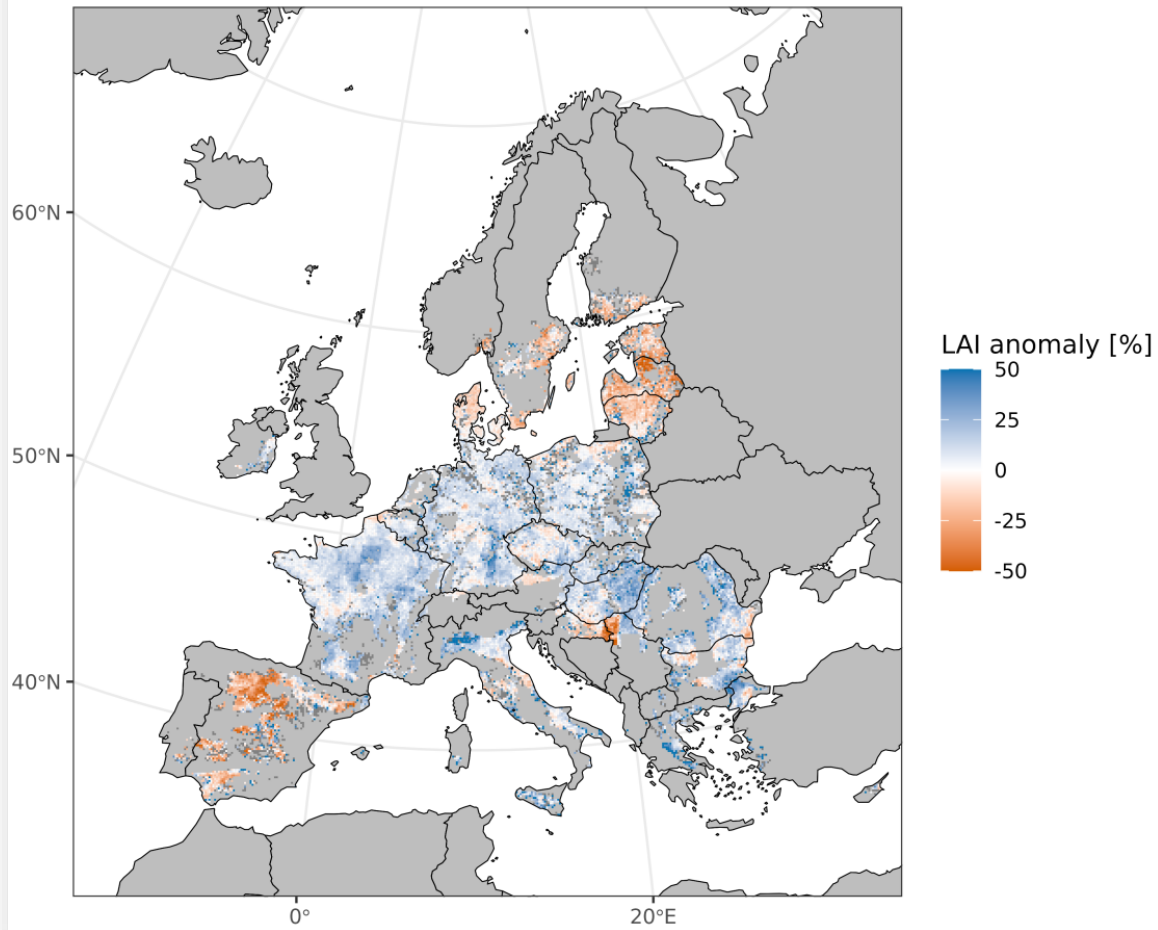


# Crop-specific time series at administrative level

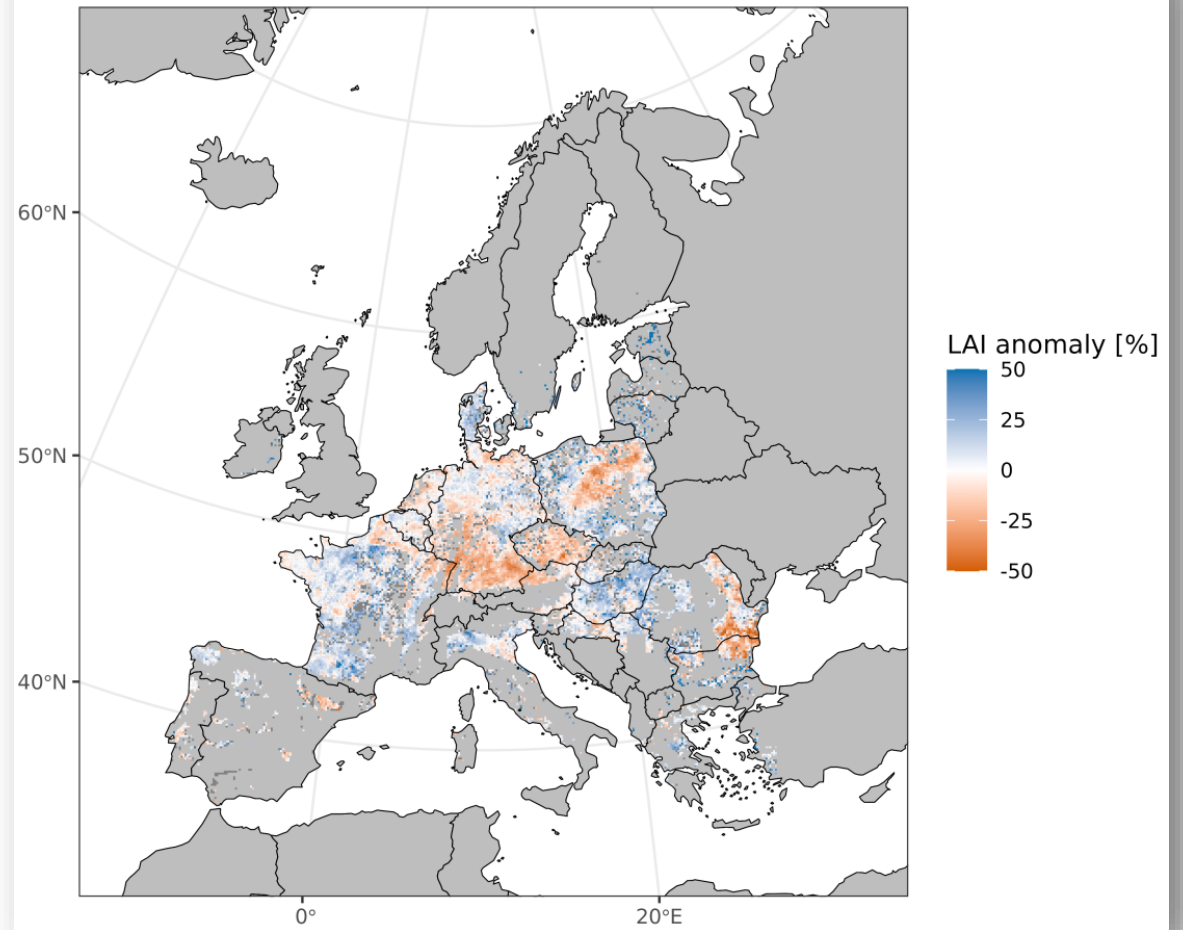


# Cropspecific maps at 10km grid level

Anomaly of maximum LAI | Wheat | 2023

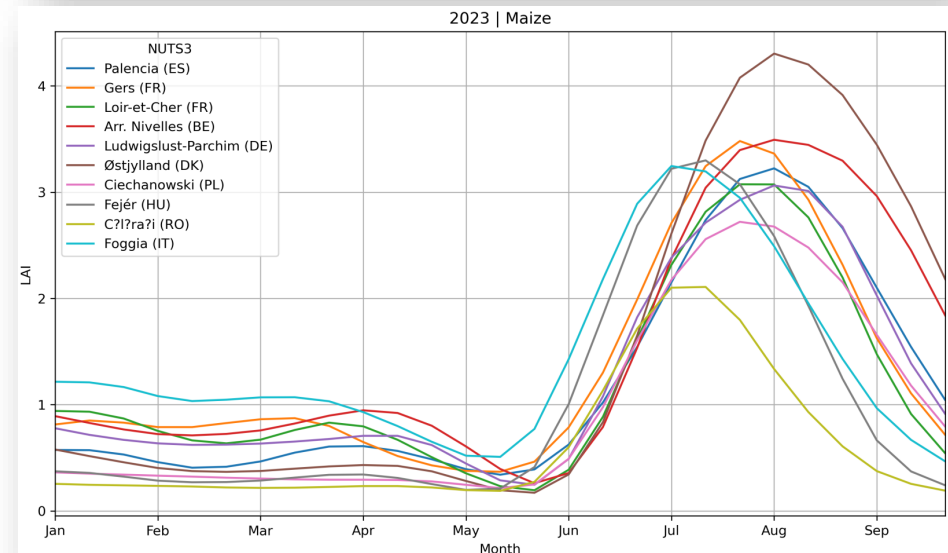
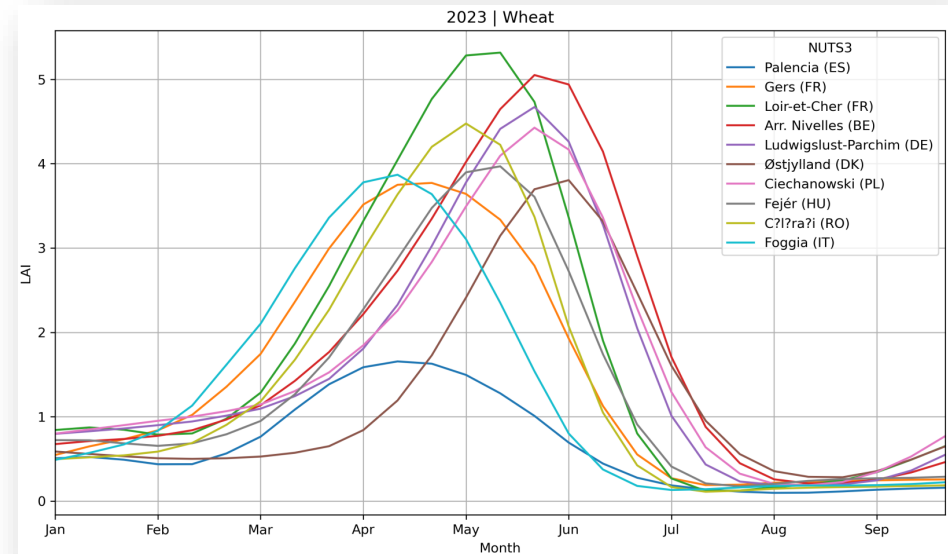


Anomaly of maximum LAI | Maize | 2023



# From Sentinel-2 Capability to Operational Crop Monitoring

- ~10 years of Sentinel-2 observation  
→ Time to move toward institutional operationalization
- First near-real-time, full EU27 Sentinel-2 processing
- In-season crop type mapping is the main technical and scientific challenge
- Quantification of added value vs legacy systems (MODIS / VIIRS) is still required
- Accumulated EO time series = high-value asset for multiple policy applications



# Thank you



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