The EC-JRC's agriculture monitoring: European and global systems

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Principles of crop monitoring systems

1. Alert warning on crop development	2. Qualitative analysis of crop development	3. Quantitative forecast of crop yield
Detection of **major issues** concerning possible crop abiotic stress **with high reliability in near-real time.**	Able to **rank the current season with high reliability** in the actual quartile distribution	Yield forecasts with **significantly better accuracy than the average inter-annual variability**, both at national and sub-national levels.
Detection of **major issues** concerning possible crop abiotic stress **with medium reliability in near-real time**.	Able to rank the current season with **medium reliability** in the actual quartile distribution.	Yield forecasts with **significantly better accuracy than the average inter-annual variability at national level**
Detection of **extreme events that will produce severe damages on crop yield**/development with **high reliability**.	Able to place the current season with **high reliability below or above the actual average season.**	Able to estimate the inter-annual changes of crop yields, with accuracy **comparable to the average inter-annual variability at national level.**
Detection of only **extreme events that would produce severe damages on crop yield**/development with **medium reliability.**	Able to place the current **season with medium reliability below or above the average season.**	Forecasts able to provide **indications about major changes** in crop yields.

Technical complexity – team skills – costs

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EC-JRC-D.5 agriculture monitoring systems

1. Alert warning on crop development		3. Quantitative forecast of crop yield
Detection of **major issues** concerning possible crop abiotic stress **with high reliability** **in near-real time.**		
		Yield forecasts with **significantly better accuracy than the average inter-annual variability at national level**

ASAP (Anomaly hot Spots of Agricultural Production)

Early warning systems of global food production problems with focus on countries with high risk of food insecurities

MCYFS (MARS Crop Yield Forecast System)

Yield forecasts at national level for the most relevant crops in EU28 + neighbors

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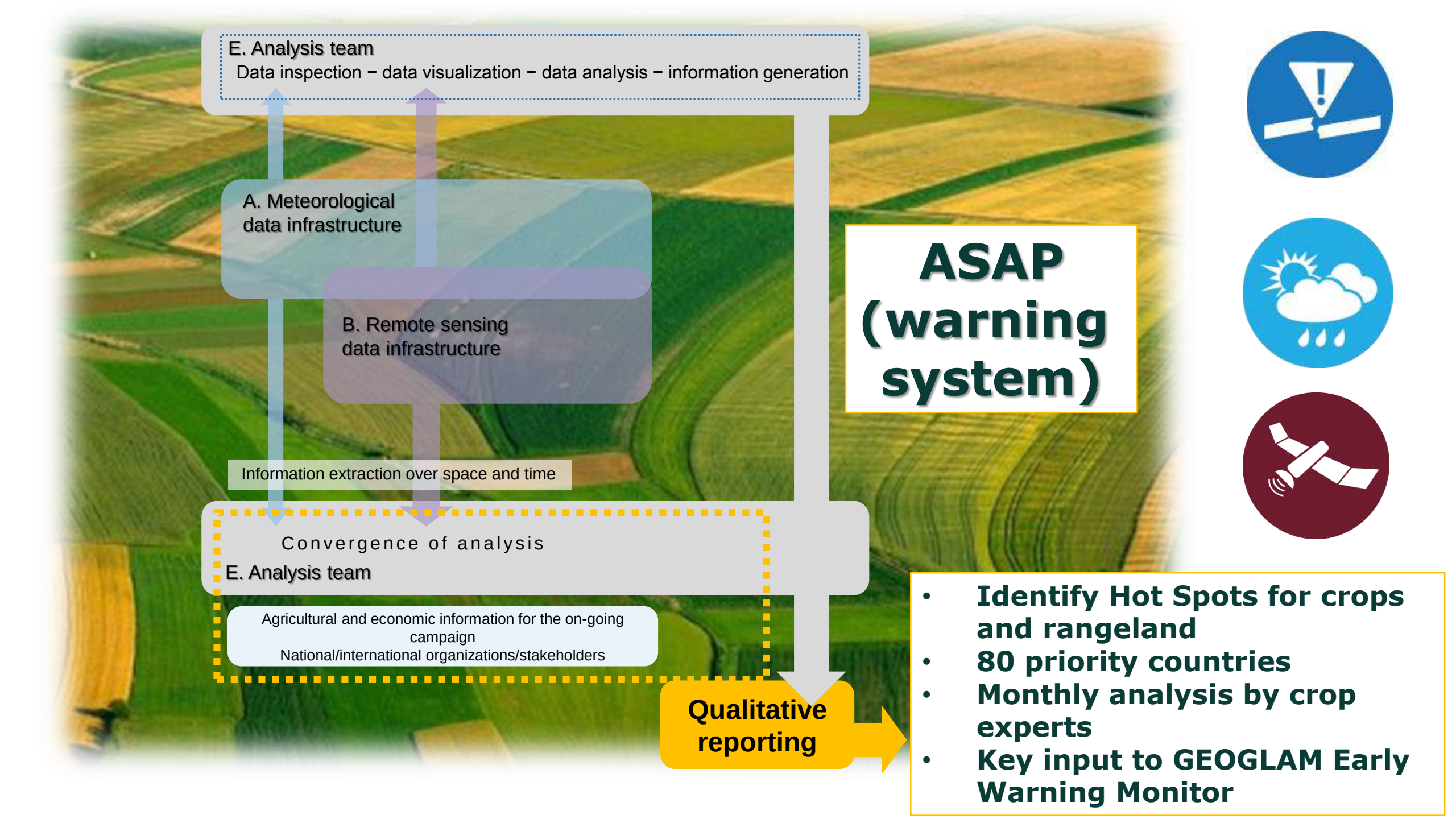


ASAP (warning system)

- **Identify Hot Spots for crops and rangeland**
- **80 priority countries**
- **Monthly analysis by crop experts**
- **Key input to GEOGLAM Early Warning Monitor**

ASAP – Data

Automatic warning classification system, every 10 - days

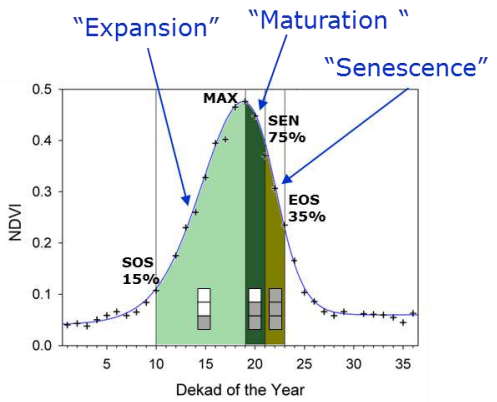
MODIS
ECMWF

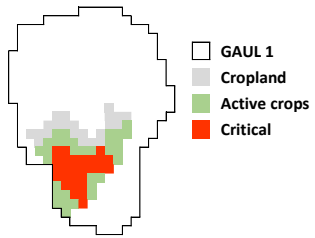
Detect active crop season based on satellite imagery

Flag areas where precipitation or biomass deficit is observed

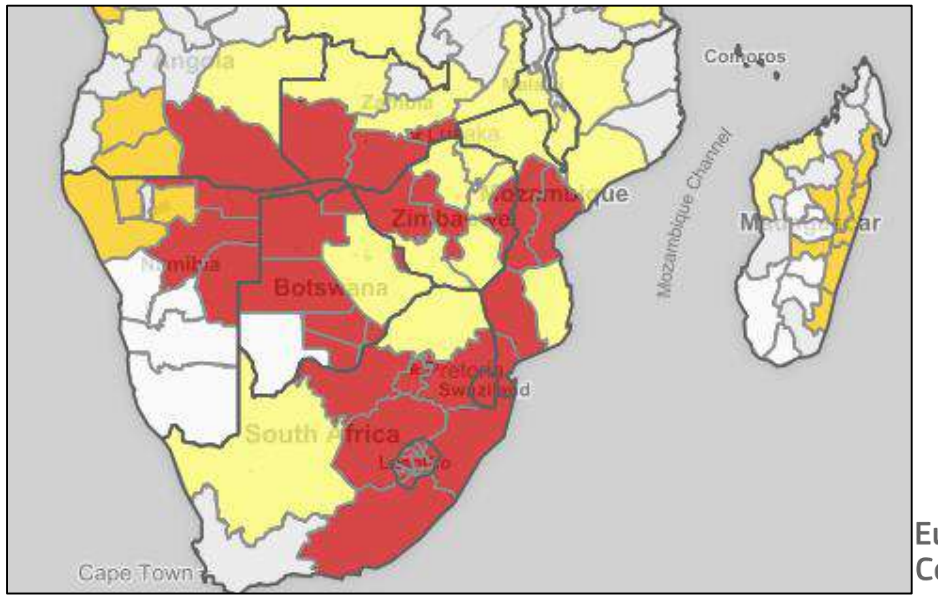
Determine area affected at sub-national admin. level

Classify type of warning





Level	Indicators concerned
1	Poor precipitation
2	Poor biomass
3	Poor biomass & prec.
4	Poor biomass @ end of seas.



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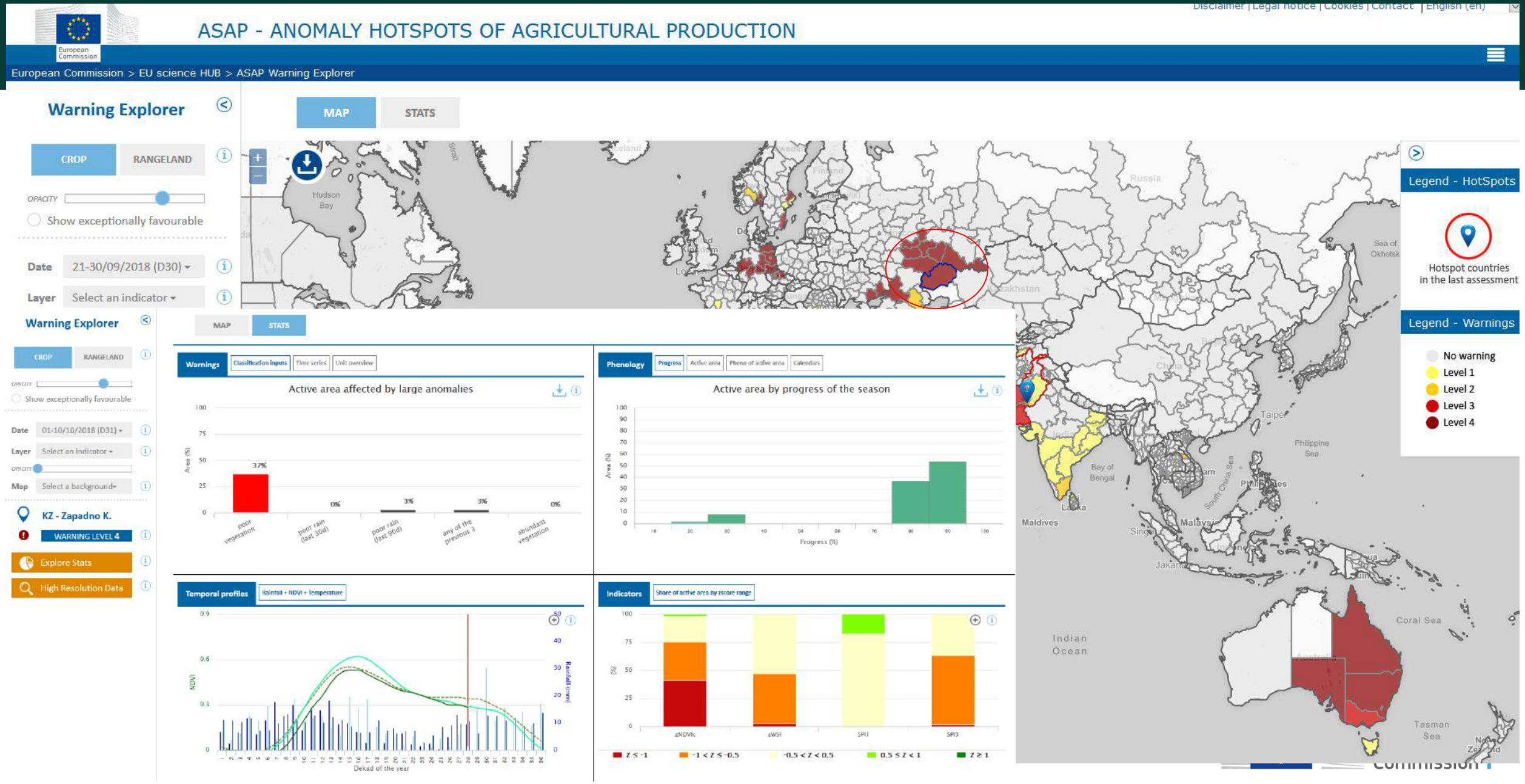
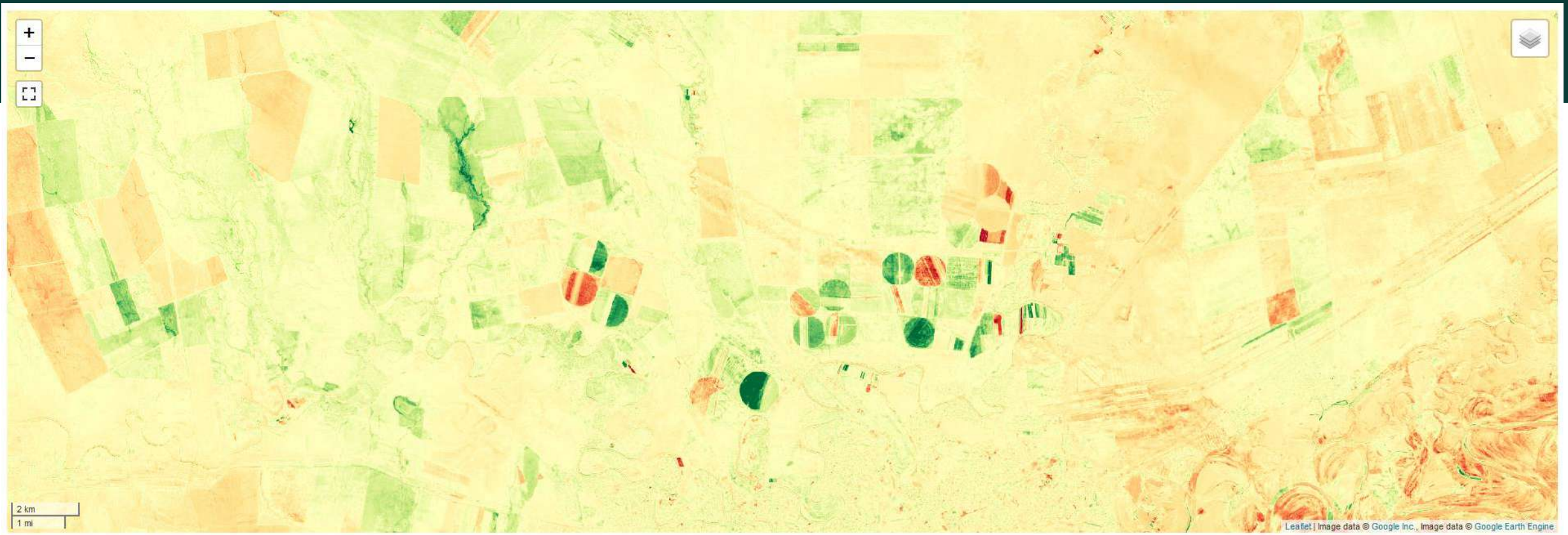
The warning Explorer



ASAP high resolution viewer



GAUL 1 district: **Zapadno-kazachstanskaya** (Kazakhstan)
Analysis end : 09 / 20 / 2018 Period (days): 32 Max. cloud %age: 10 Retrieve imagery

NDVI anomaly (2018 vs 2017)

- Retrieves high resolution imagery (Sentinel 1,2 and Landsat) for the selected GAUL1 level for any period and comparison year, different band combinations, crop mask overlay
- Challenge: TOC, cloud filtering and time series compositing for enhanced quality of the maps

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ASAP – Expert analysis

Hotspot analysis at country level, monthly

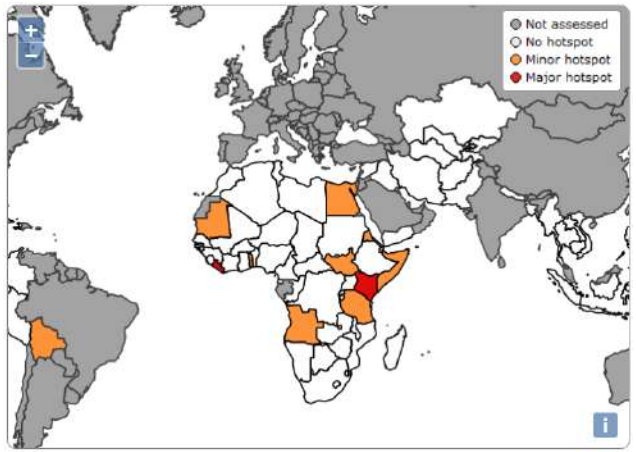
Analyse warnings and auxiliary information and assign hotspot status at national level

Publish hotspots on the home page and write a short narrative

- ***Warning Explorer maps and graphs***
- ***High resolution analysis***

- *European Media Monitor (EMM)*

- *Other sources*



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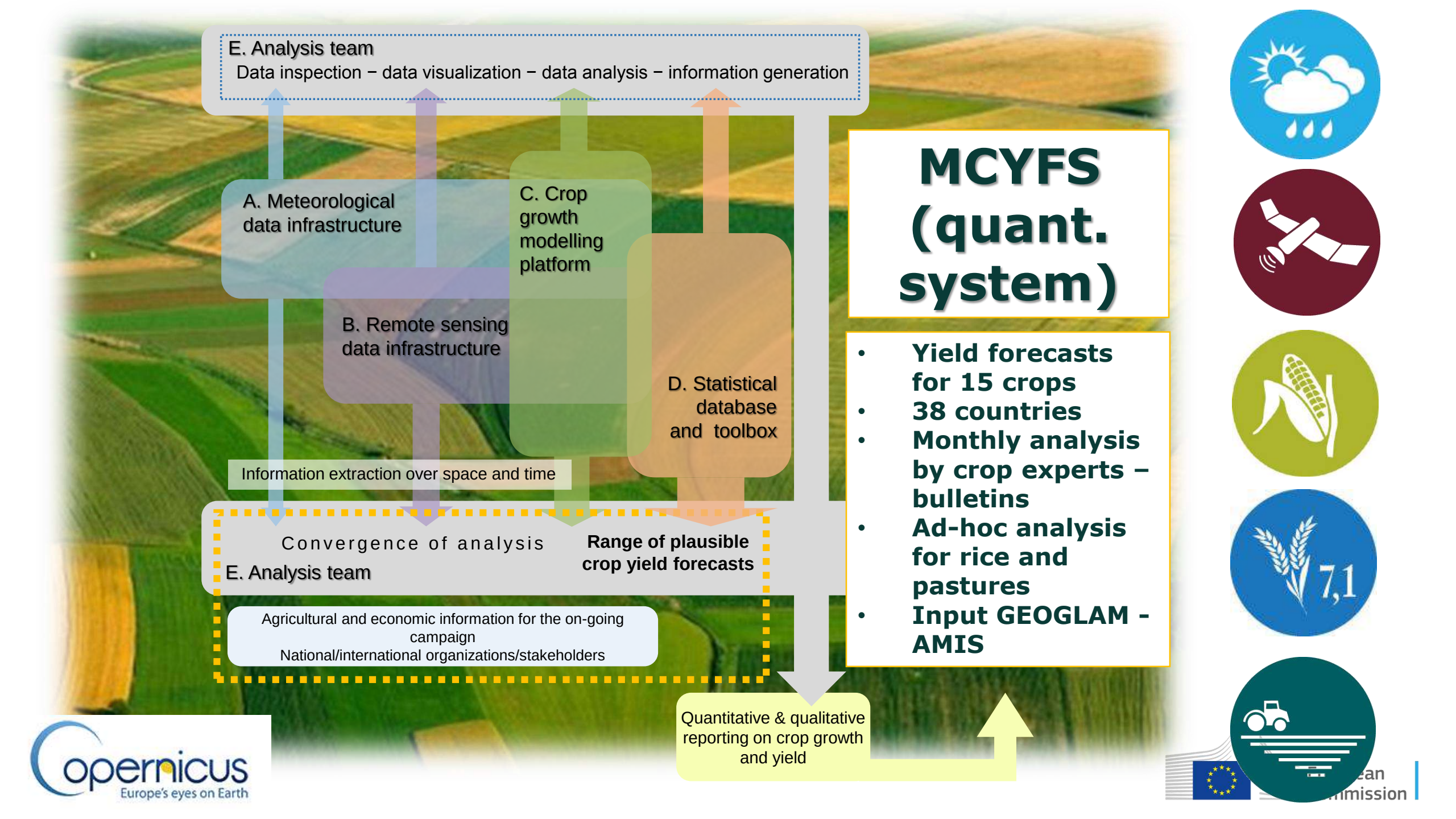
ASAP

TIME SERIES ANALYSIS - ANOMALY ANALYSIS

BASED ON:

- **Ancillary data among which tailored land use masks**
- **ECMWF ERA interim + HiRes**
- **MODIS 1KM NDVI – 10 day composite – filtering – no BRDF – 18 years**
- **SENTINEL 2 TOA – 2 years**


E. Analysis team
Data inspection − data visualization − data analysis − information generation
A. Meteorological data infrastructure
B. Remote sensing data infrastructure
C. Crop growth modelling platform
D. Statistical database and toolbox
Information extraction over space and time
Convergence of analysis
E. Analysis team
Range of plausible crop yield forecasts
Agricultural and economic information for the on-going campaign
National/international organizations/stakeholders
Quantitative & qualitative reporting on crop growth and yield
MCYFS (quant. system)
Yield forecasts for 15 crops
38 countries
Monthly analysis by crop experts – bulletins
Ad-hoc analysis for rice and pastures
Input GEOGLAM - AMIS
7,1
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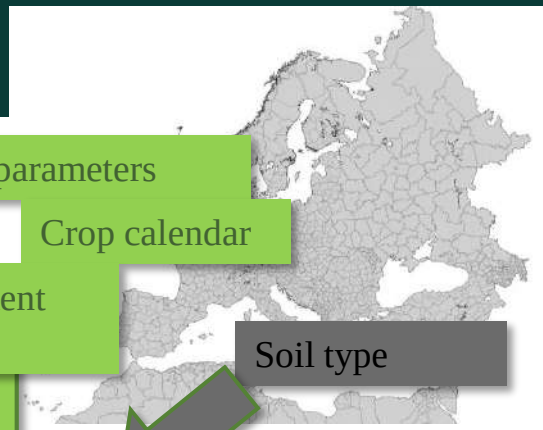
Meteo and model

Incoming Solar Radiation

Mean Daily Temperature

Precipitation



Crop variety parameters

Crop calendar

Management practices

Soil type

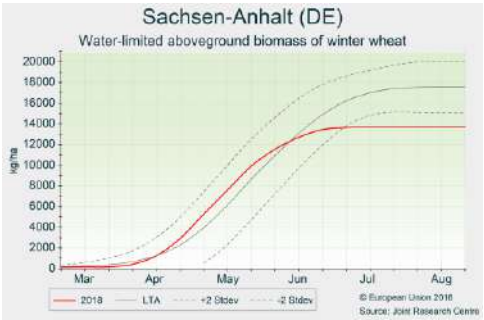
CROP GROWTH MODEL (WOFOST - WARM)

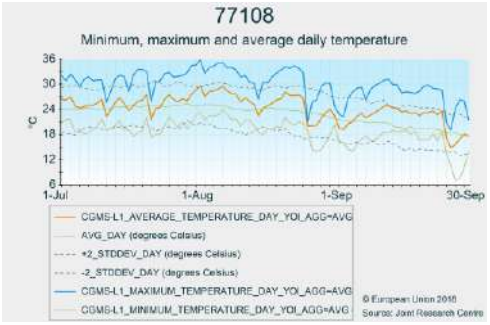
BioMA

Biomass

LAI

Yield





Spatial aggregation (to GRID/NUTS according to land cover)

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Remote Sensing

- **Non crop specific analysis**
  - **Arable land monitoring**
  - **Pasture / grassland monitoring**

- **Independent analysis for crops and pastures – qualitative**
  - **Independent source of measured biomass activity**
  - **Convergence of results**
- **Independent analysis for crops – quantitative**
  - **Crop yield forecasts based on RS derived vegetation state parameters only**

- **Improvements meteorological infrastructure – quantitative**
  - **Snow cover**
  - **Radiation / MSG / station co-efficients**

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Remote Sensing products

Metop 1km back-up chain

Copernicus biophysical p.

Basic req.

Atmospheric correction

Geo-referencing

10-day compositing

Input

Vegetation Index (NDVI)

Copernicus biophsycal p. (fAPAR, LAI)

Temporal Gap-filling / Smoothing

RUM algorithm (Regiona Unmixed Mean, from Genovese, 2001)

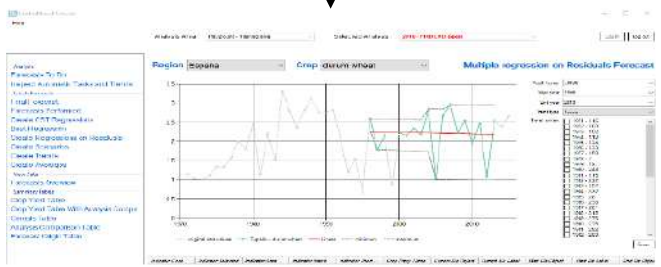
Spatial aggregation (land cover)

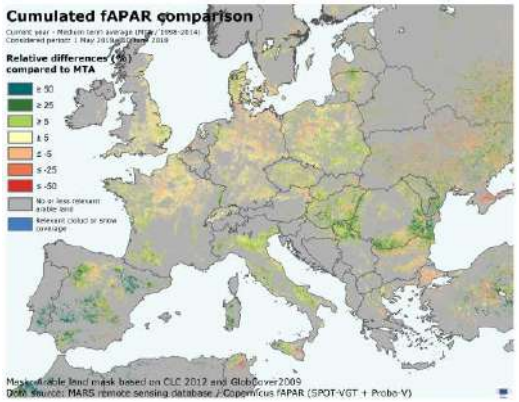
Yield predictor

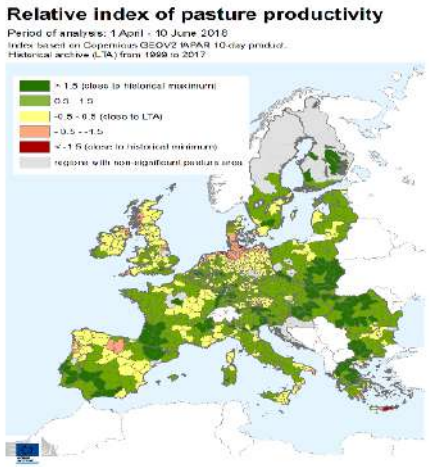
Anomaly maps

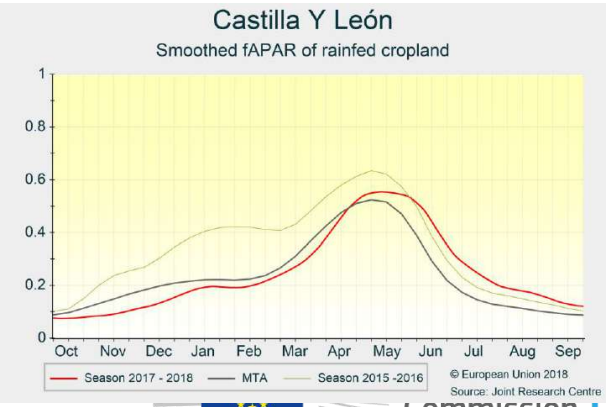
Pasture productivity index

Admin. units time-series









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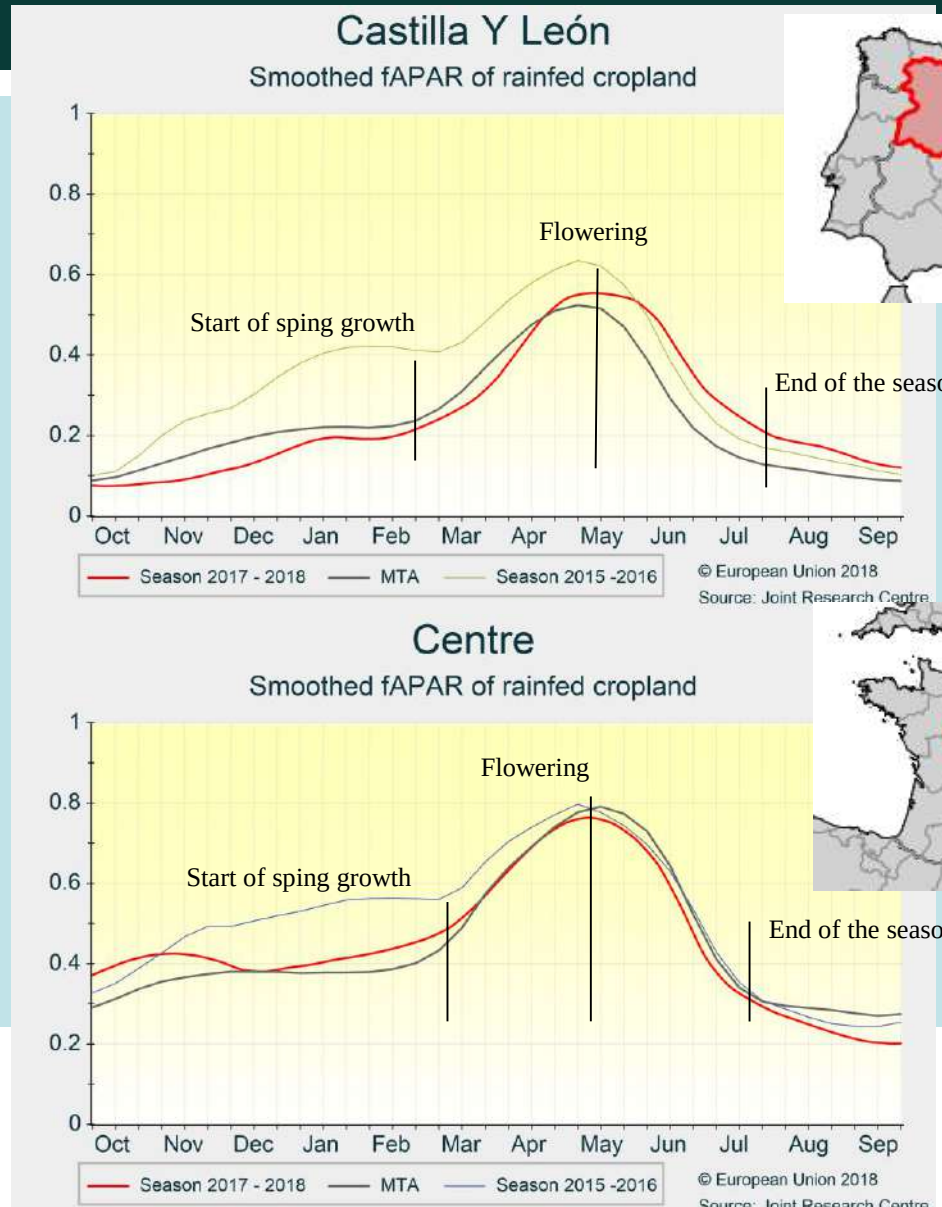
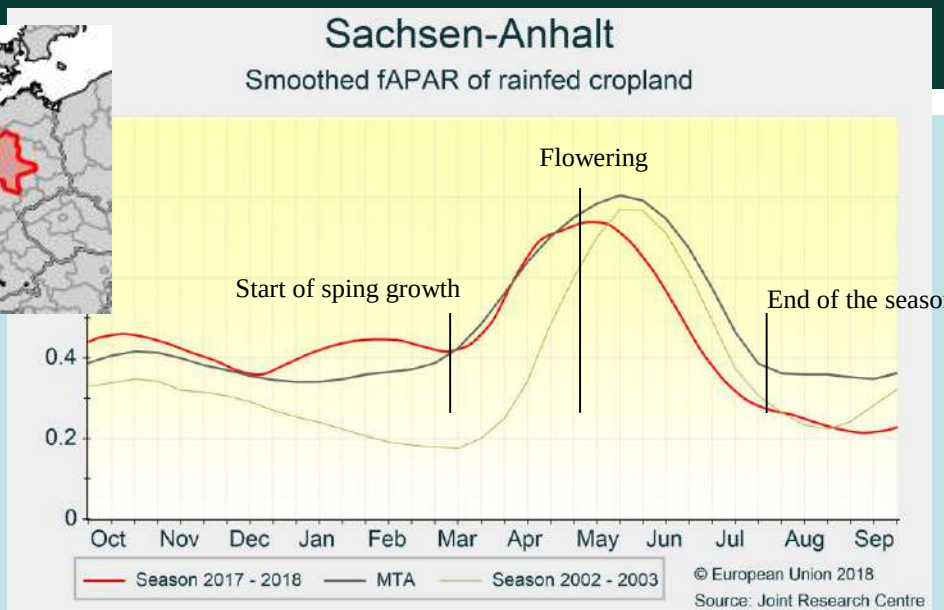
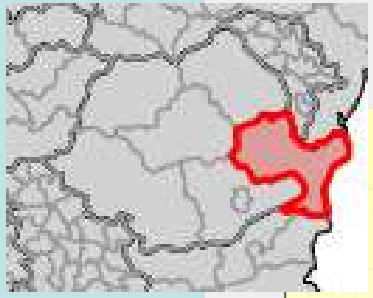
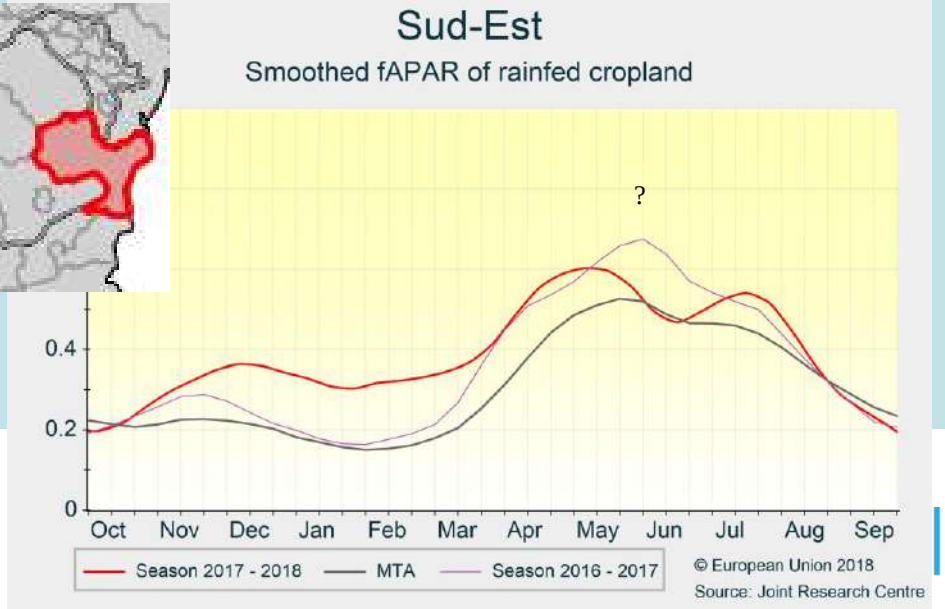
Qualitative information - examples

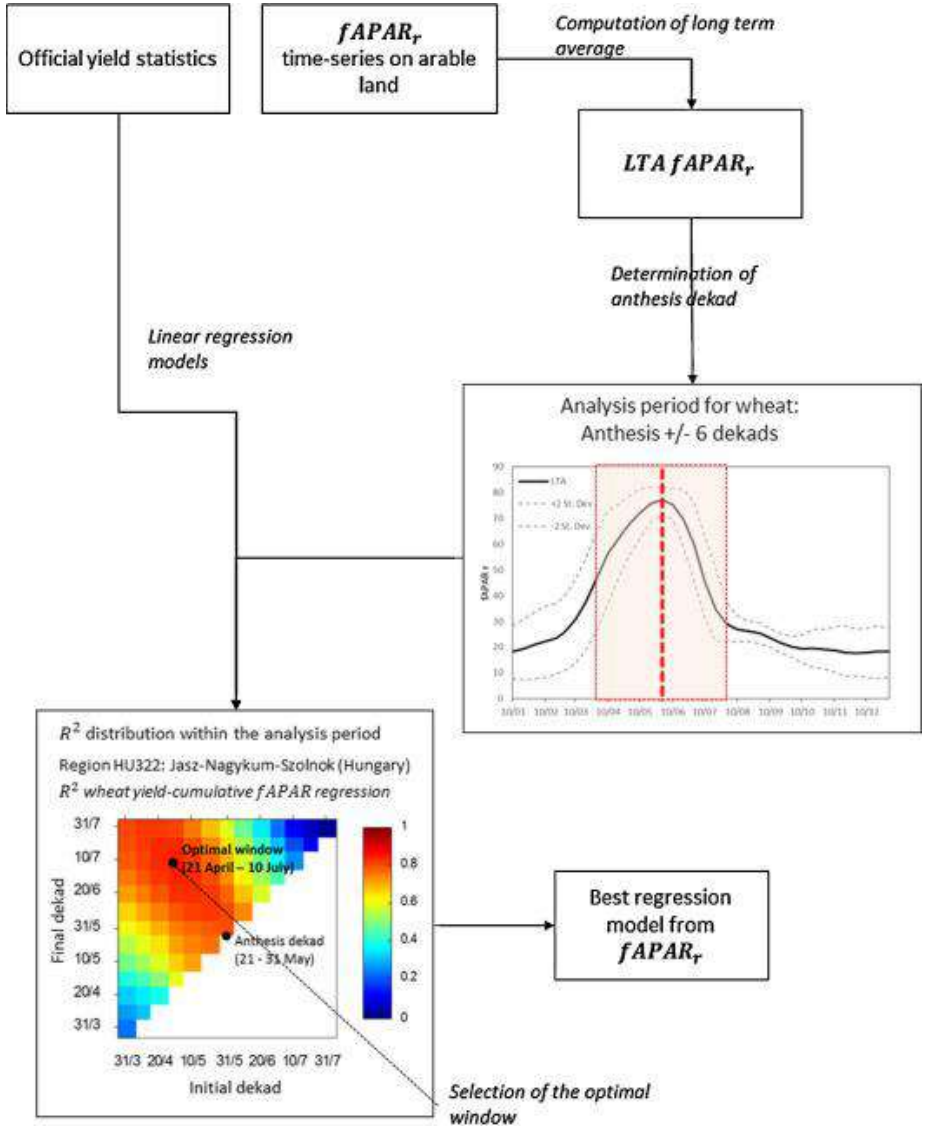








Quantitative analysis



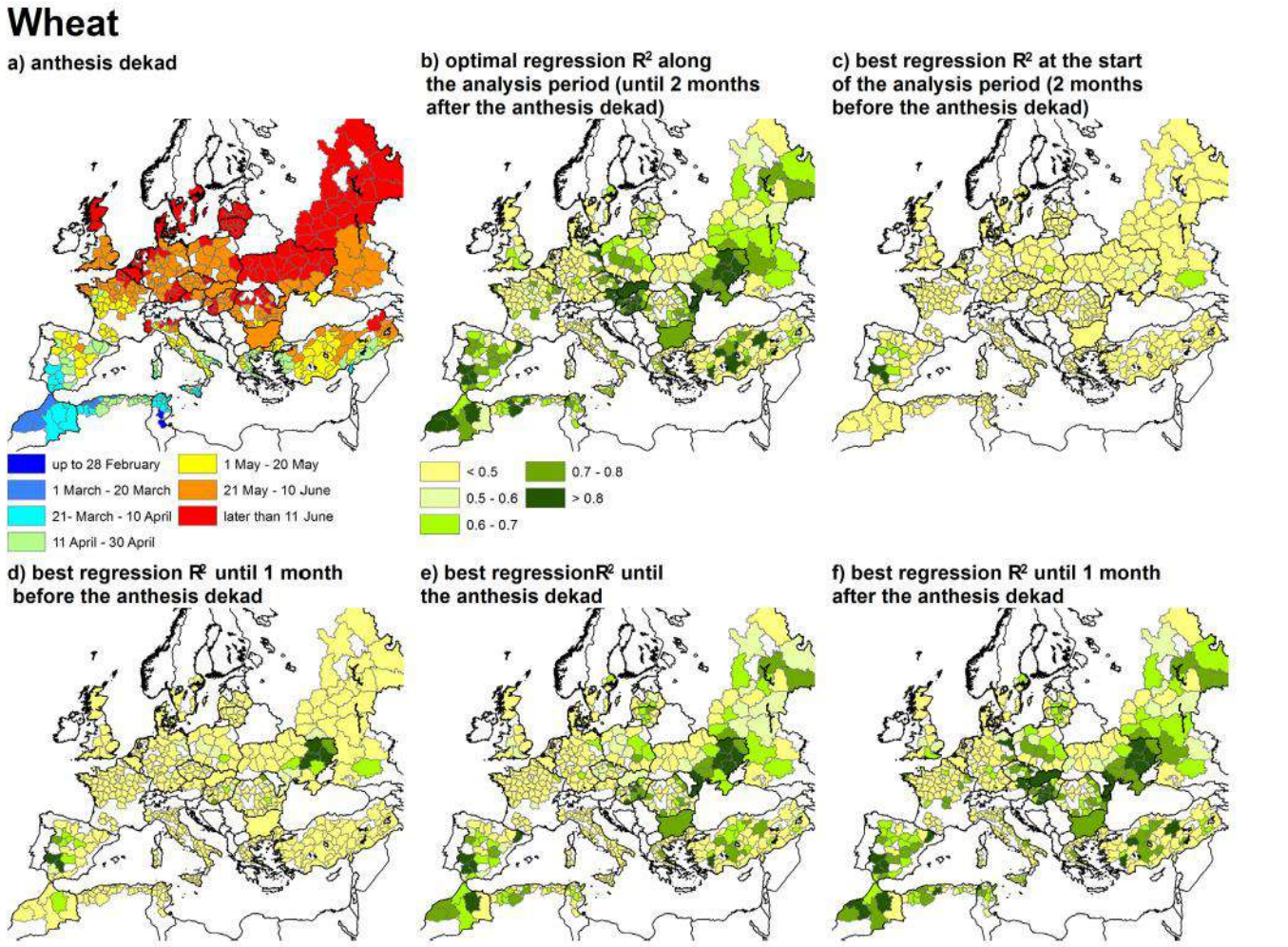


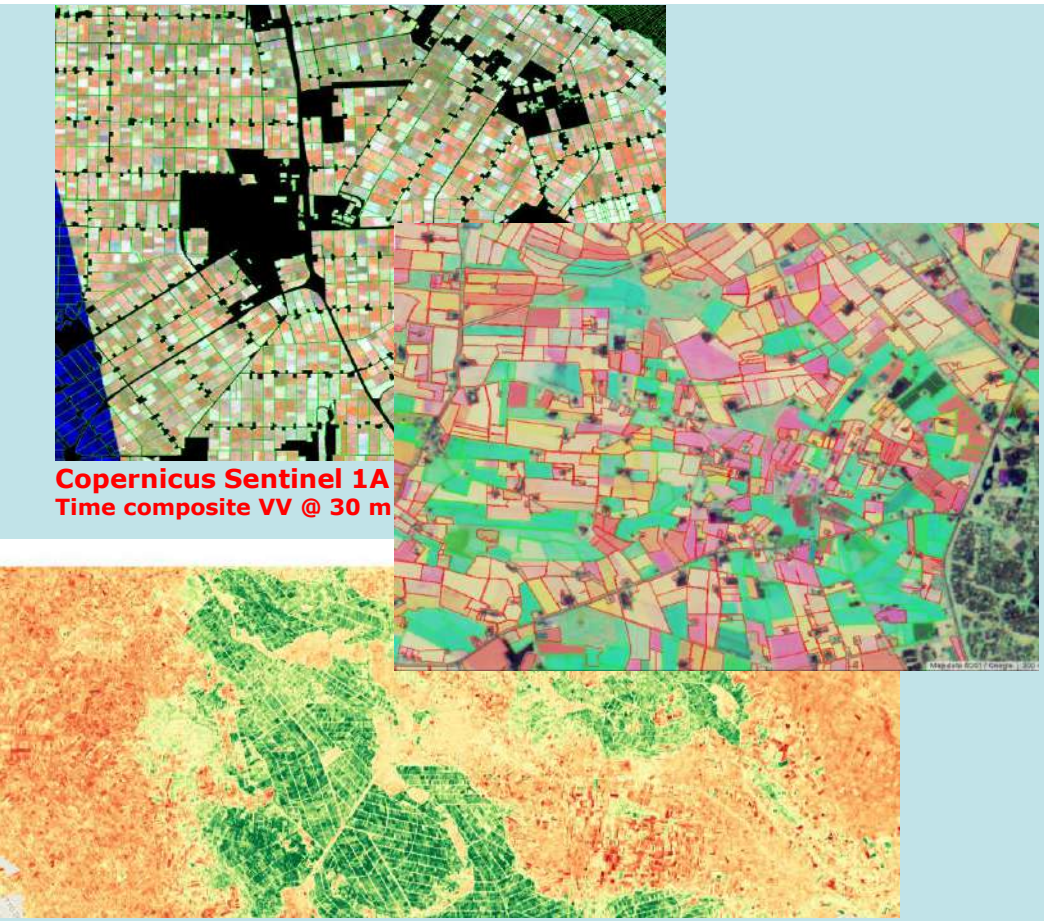
Fig. 3. (a) Dekad of anthesis computed from $fAPAR_r$ LTA (Section 2.4.1); and (b)–(f), coefficient of determination R^2 of the best regression models (Section 2.4.2) between cumulated $fAPAR_r$ and official wheat yields at administrative unit level on different moments of the analysis period.

MCYFS

TIME SERIES ANALYSIS - ANOMALY ANALYSIS - YIELD FORECASTING:

- **Ancillary data among which land use masks**
- **Meteo stations network**
- **Crop model**
- **REMOTE SENSING DATA:**
  - **1km time series (Copernicus biophysical products) – 10days NRT filtering/smoothing - BRDF correction**
  - **1km backup time series based on NDVI MetOP (A + B) – 10days NRT – filtering/smoothing – no BRDF**

Data requirements



Large increase in the last 5 years of high resolution optical and SAR data with enormous potential for agricultural monitoring

BUT ALSO NEED FOR:

1.) big data analysis approach and infrastructure

2.) quality as low/medium resolution (atm.correction, reflectances, compositing, BRDF...)

3.) Long time series (continuity of main missions and inter-calibration with new ones, data fusion…)

4.) data validation/ against other satellite sources and ground control points

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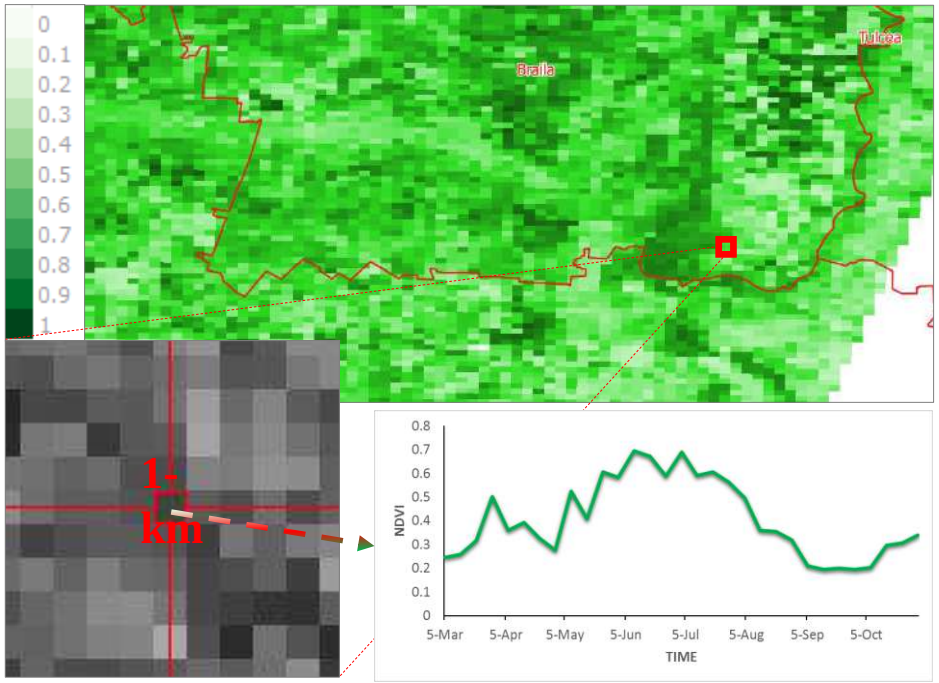
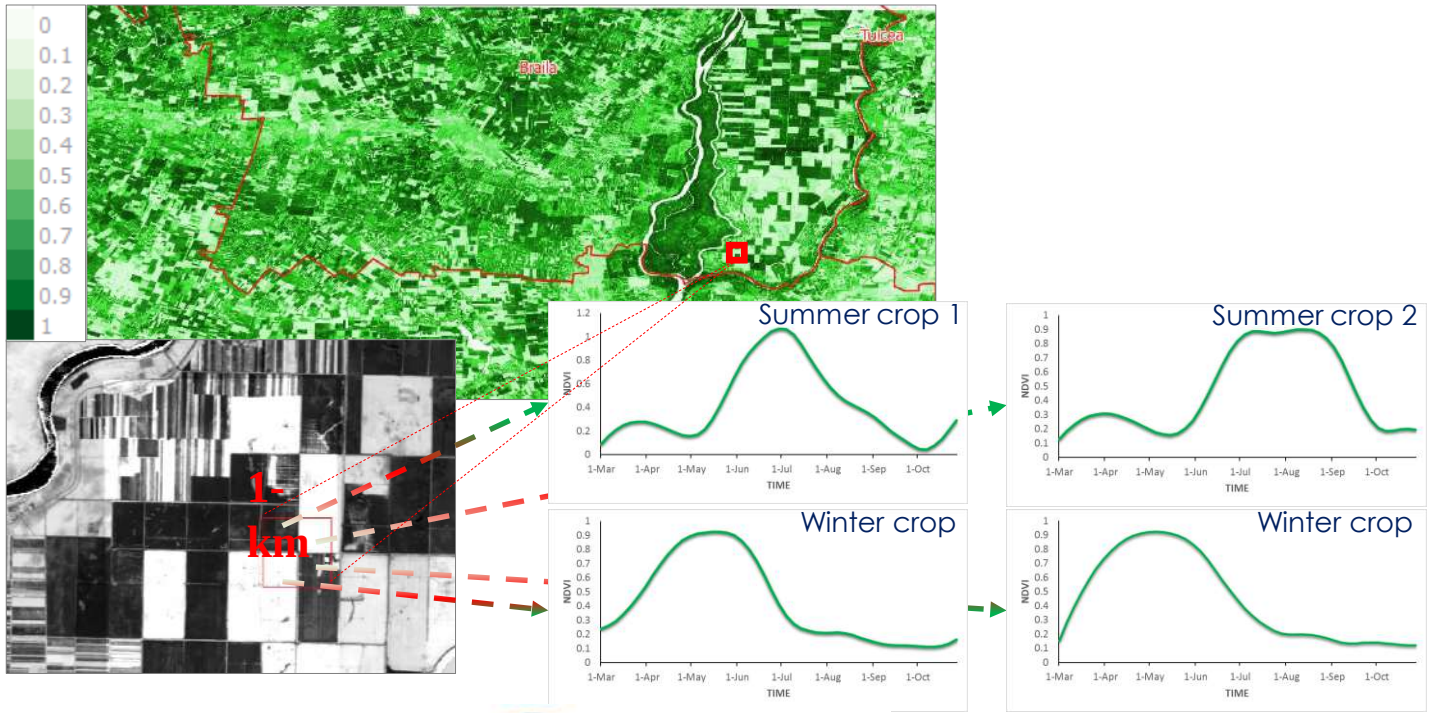
1. PROVIDE CROP SPECIFIC OBSERVATIONS

- **High spatial resolution data permits to overcame Low Resolution (LR) limitations in providing crop specific information.**
- **This represents a big step in improving different components of our system, permitting to reach crop-specific monitoring at regional level.**



(Lat. 44 48' 21.29" Lon. 27 58' 57.59")



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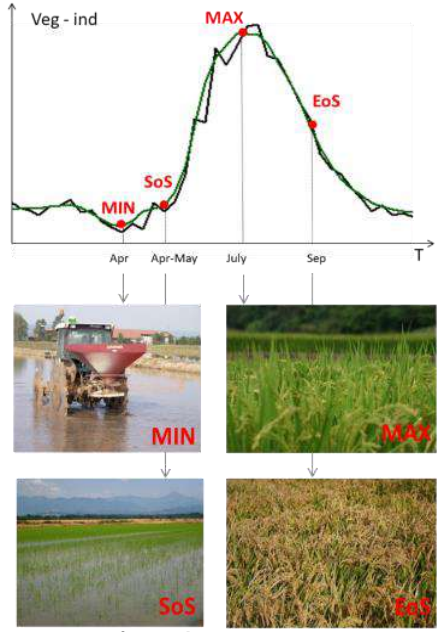
2. IMPROVE OF MODEL'S ACCURACY

- **High temporal and crop-specific indicators (e.g. NDVI, fAPAR, LAI) from Sentinel 2 would contribute to improve the crop modelling component of the MCYFS by:**

  i. **Assimilating them into the models (e.g. forcing, parameter optimization) in order to improve the reliability of crop growth models.**

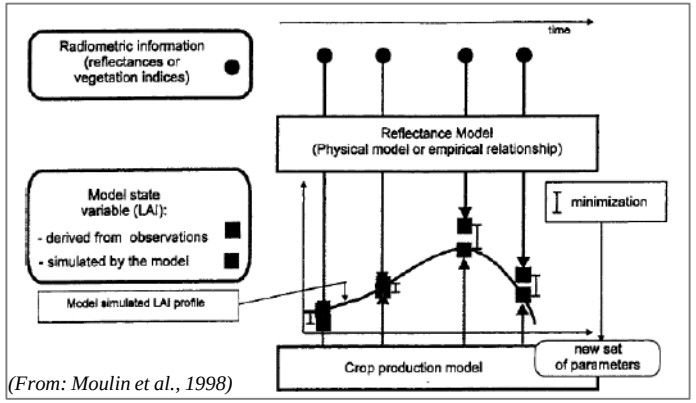
  ii. **Spatializing model parameters in order to set up regional based model calibrations.**



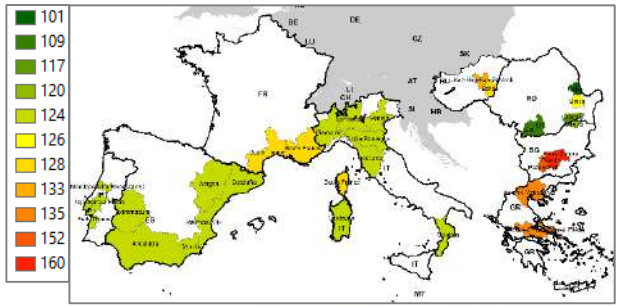
(From: Manfron et al., 2012)

Crop model forcing

Param. spatialization



(From: Moulin et al., 1998)



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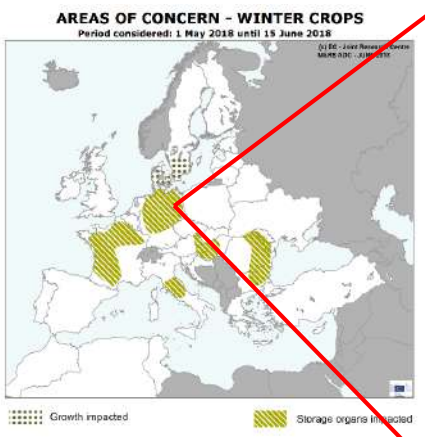
3. MONITORING of EXTREME EVENTS

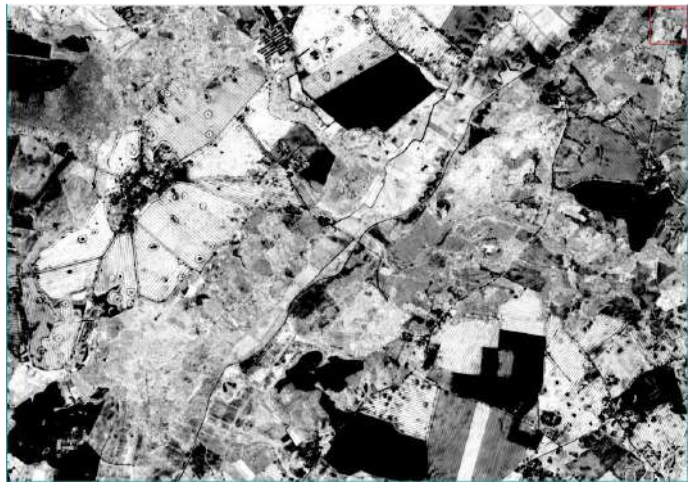
- **ASAP / MCYFS can benefit of high resolution satellite images during the analyses of specific areas of concern, to provide a better assessment of the damage intensity but also to derive insights on the affected areas.**

Area Of Concern

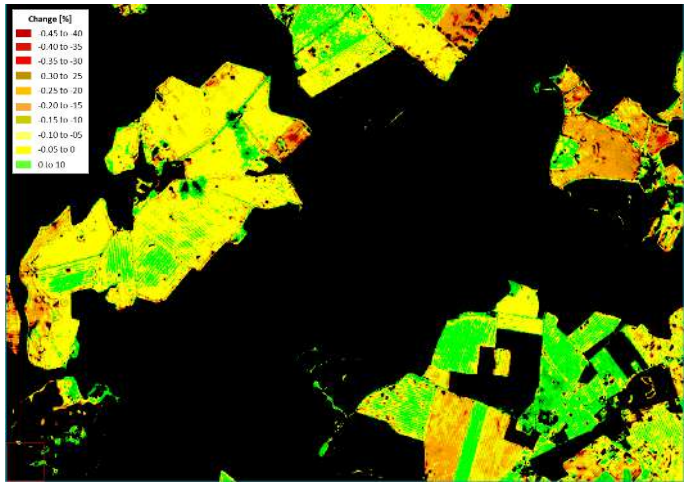


2017 Vegetation index

2018 Vegetation index



HR Vegetation index changes



(Cammin, Germany. Lat. 53 59' 23.13" Lon. 12 21' 25.48")

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Expected future improvements

- Crop specific observations (area and yield)
- Improve reliability of the crop models
  - Calibration
  - Estimation of crop specific parameters to run the model
  - Simulate correctly responses of the crop to abiotic stresses
- Monitoring with higher precision impact of extreme events

- and we will continue to rely on low resolution data as well……

Thank you

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