



EARTH & LIFE INSTITUTE
EnGE

Crop monitoring along the seasons with the Sentinels

The on-going BELCAM, Sen2-Agri, LifeWatch experiences

C. Delloye, G. Chomé, M.J. Lambert, S. Bontemps, N. Bellemans, J.
Radoux, F. Hawotte, P. Defourny

GTEO – Agriculture 13th of June 2017

L'agriculture à l'échelle nationale

La Belgique



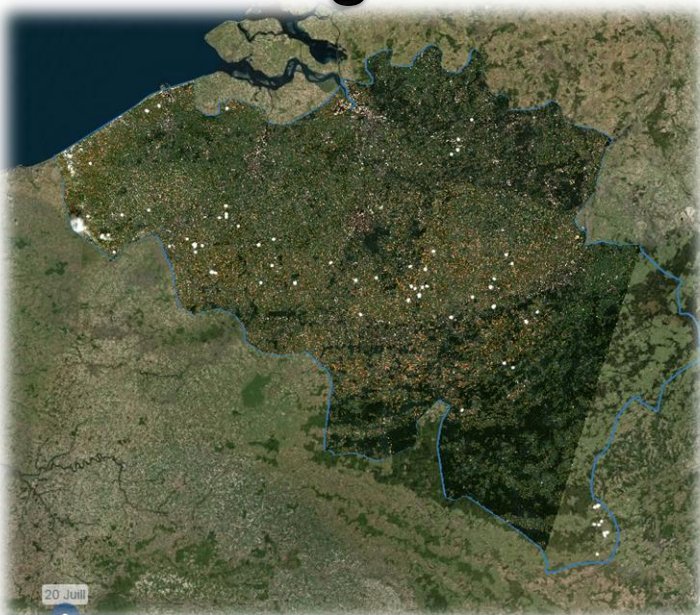


BELCAM



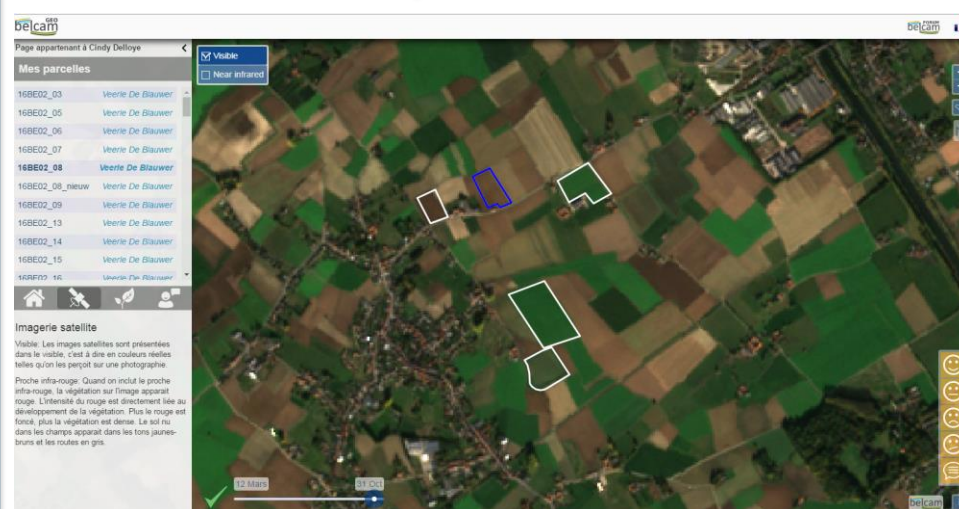
5 scientific partners led by UCL and 8 pilot/technical centers

Belgian



Product at the belgian scale

Collaborative IT platform



Pilot & Technical Centers

Pionneers farmers

Agriculture Monitoring parcel level



3 crops: wheat, potato, maize

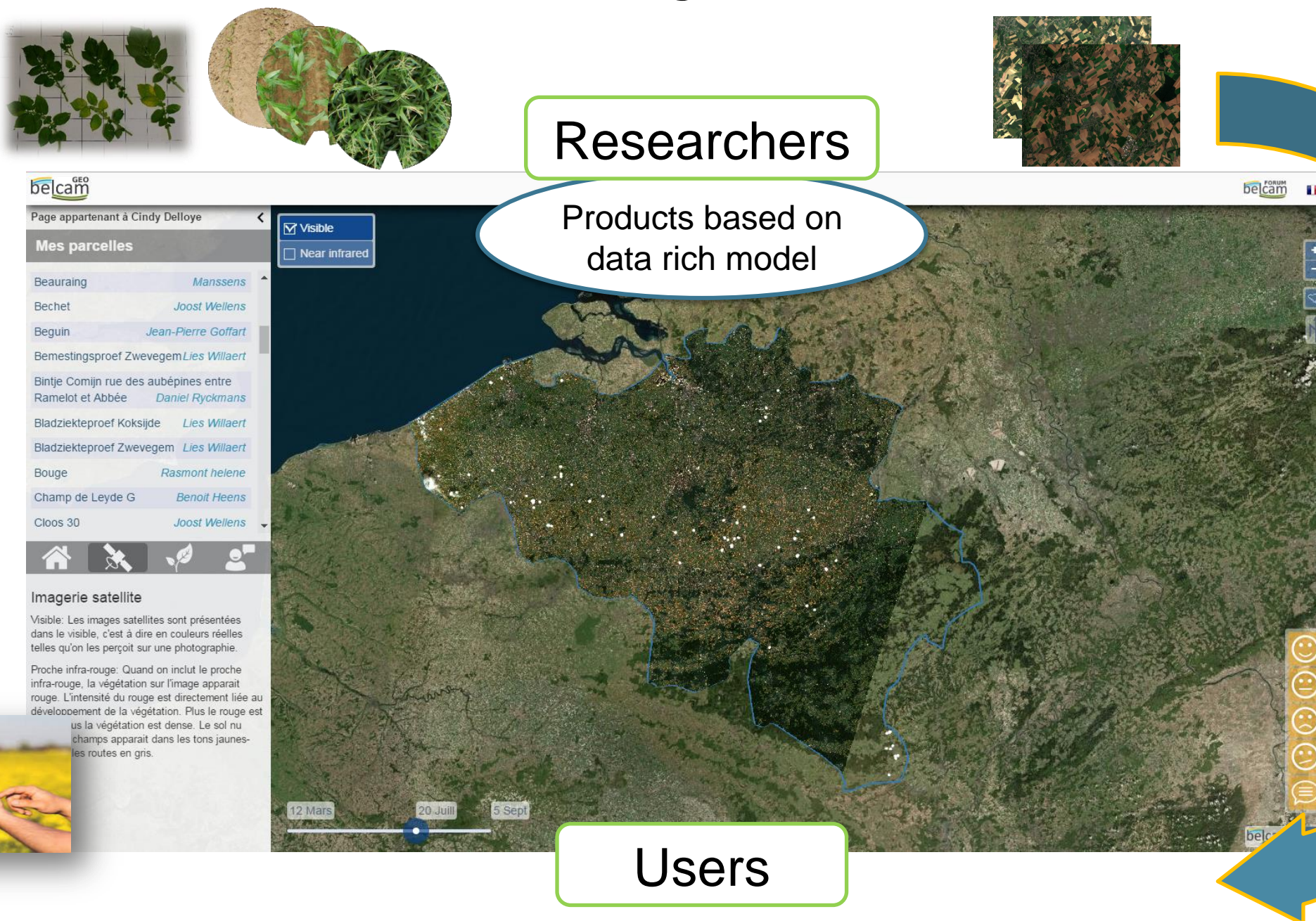


<http://maps.elie.ucl.ac.be/belcam/>



Partnership and collaborative system

Learning phase





Partnership and collaborative system

Farm sourcing



Users



Researchers

Products based on data rich model

Feedback & Field data





BELCAM Objectives

- ✓ Speed up information loop
- ✓ Develop products corresponding to the user's needs (farmers vs. CP)
- ✓ Products available in NRT via ITplatform



BELCAM Products

Free Sentinel time series

Sowing

Harvest

Development monitoring
&
anomalies detection

Nitrogen
advice

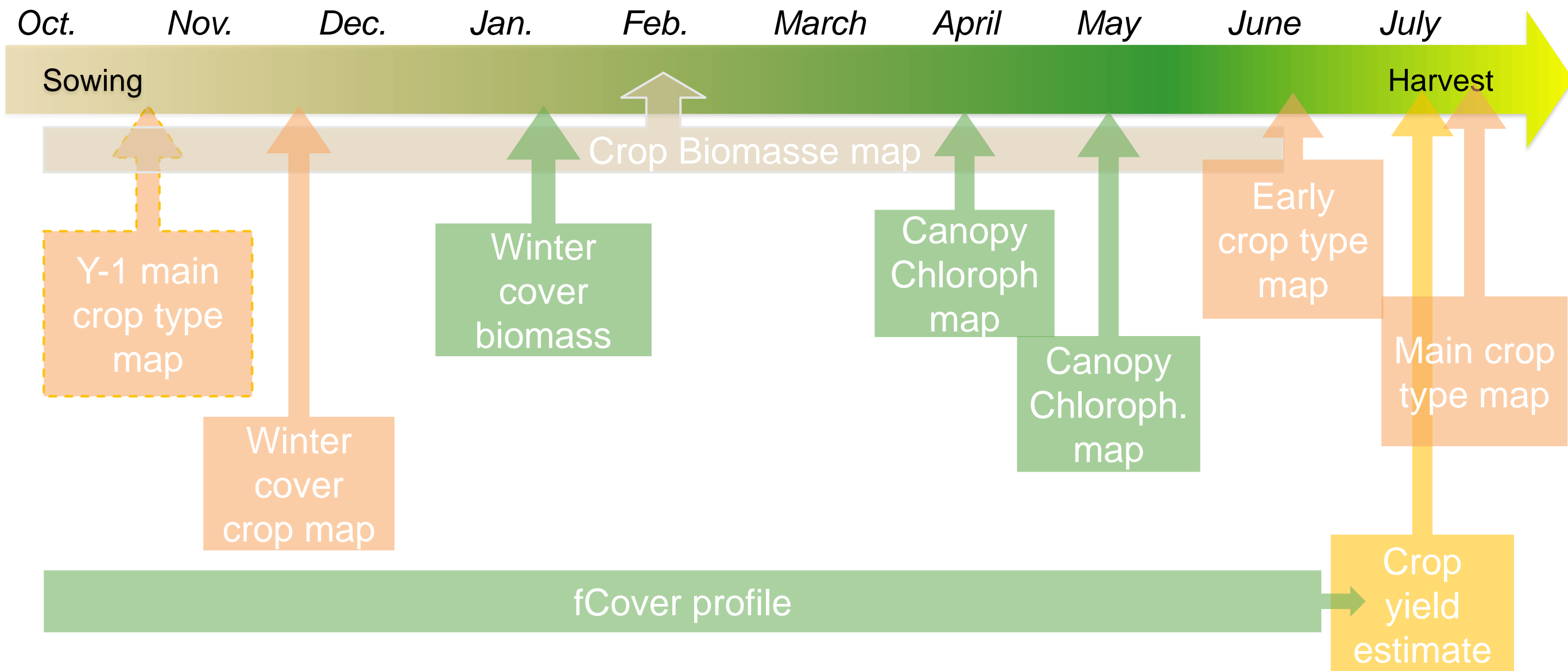
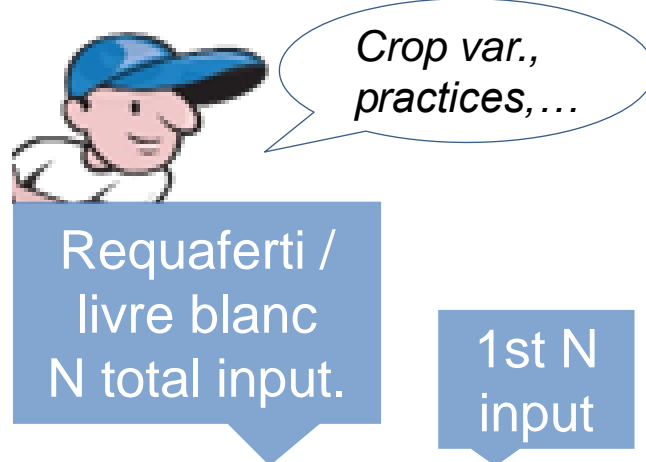
Yield
prediction

Heterogeneity map



BELCAM Calendar - NRT

Winter wheat



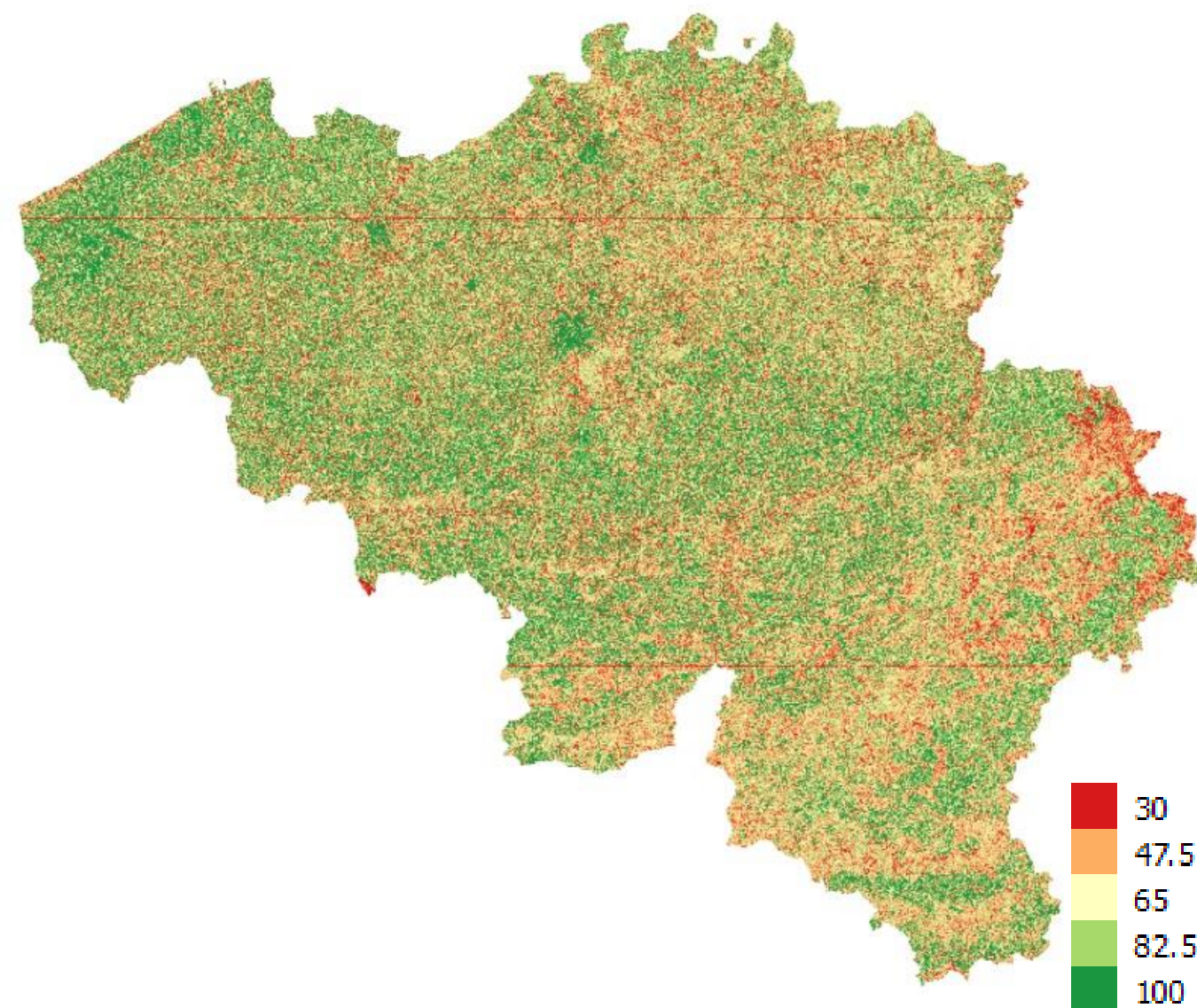
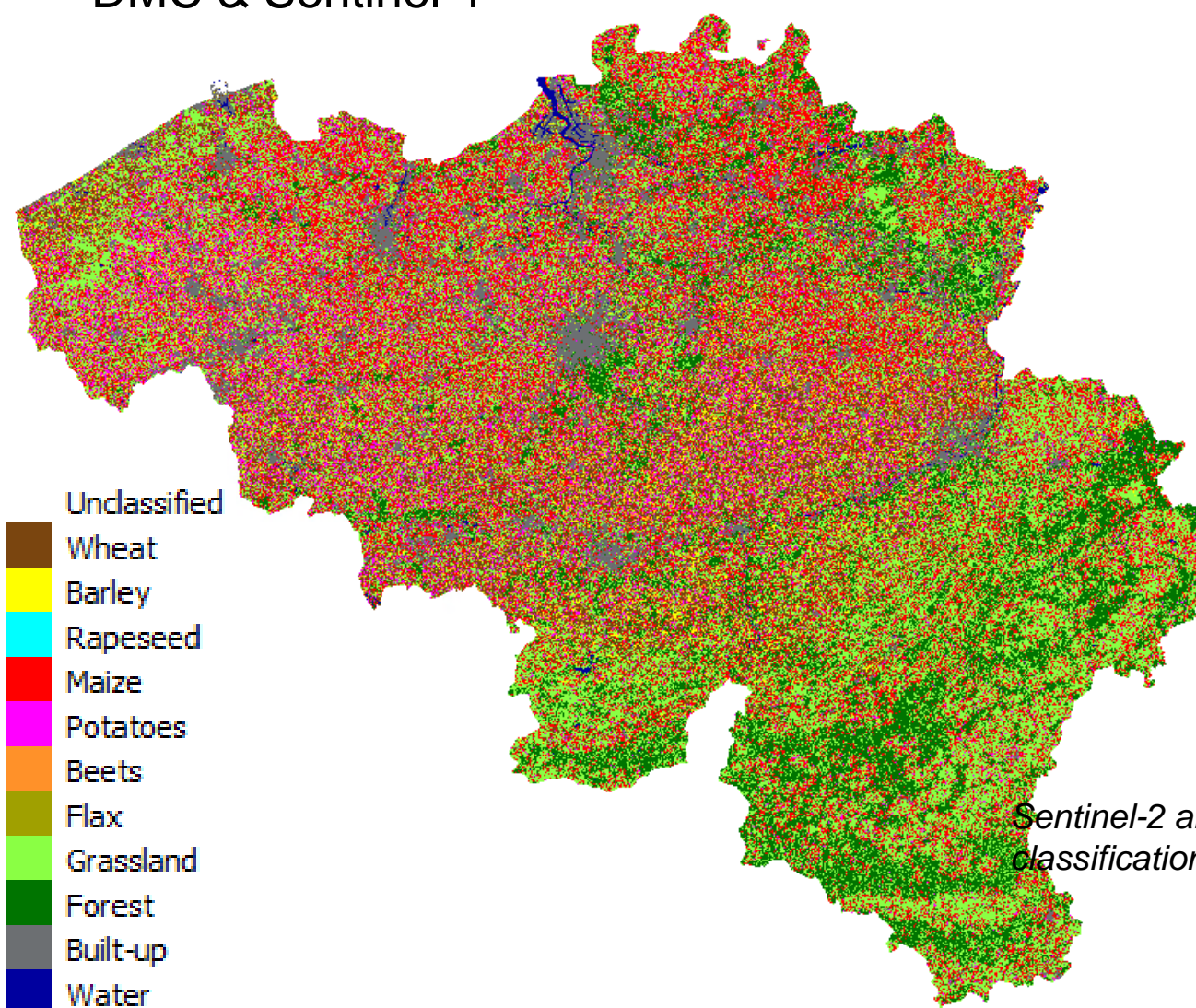
EO researchers, crop researchers, and model researchers for a partnerships with farmers along the info chain



Previous crop (Requaferi input) Crop type map 2016

Classification
DMC & Sentinel-1

Combined confidence (%)
(RF probability X valid data %)



	Wheat	Barley	Rape seed	Maize	Potatoes	Beets	Flax	Grass land	Forest	Built-up	Water
Confidence	82%	66%	55%	66%	62%	69%	69%	71%	60%	73%	54%
Accuracy	99%	92%	57%	94%	93%	86%	85%	94%	70%	79%	72%



Winter cover and tillage detection

- S1 time series to map bare soil and detect tillage

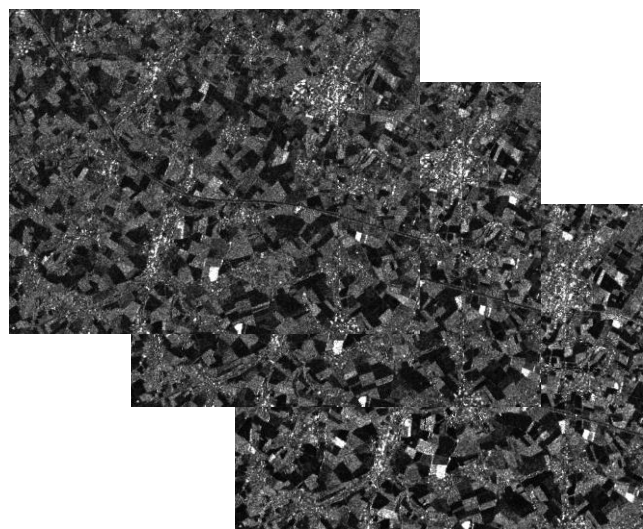
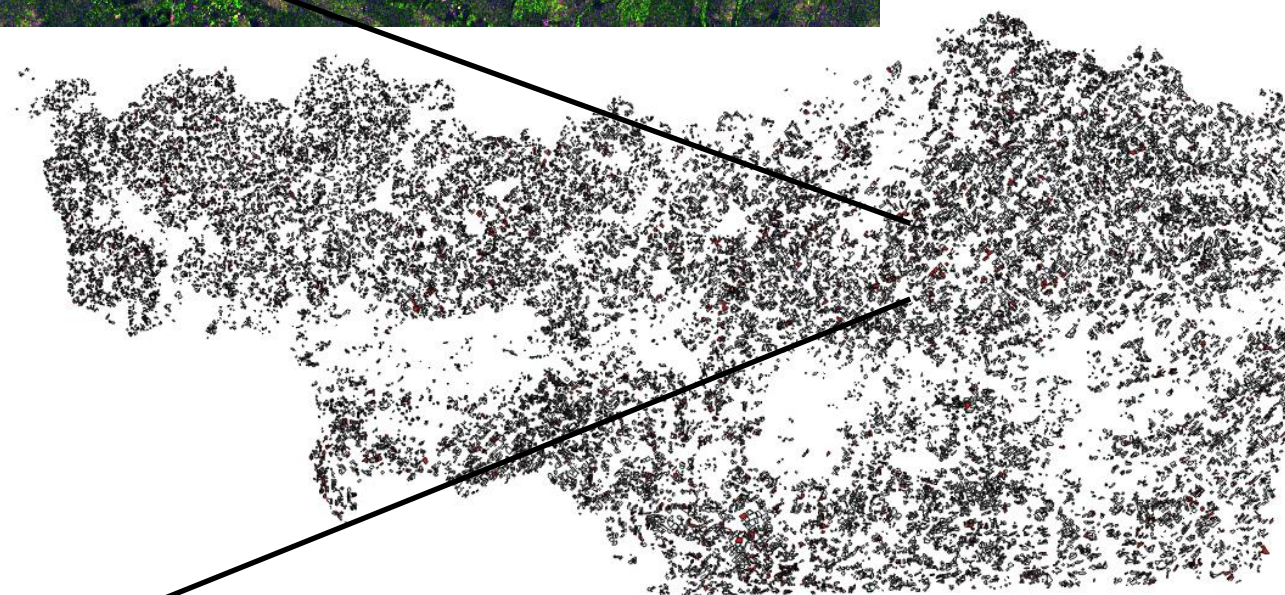
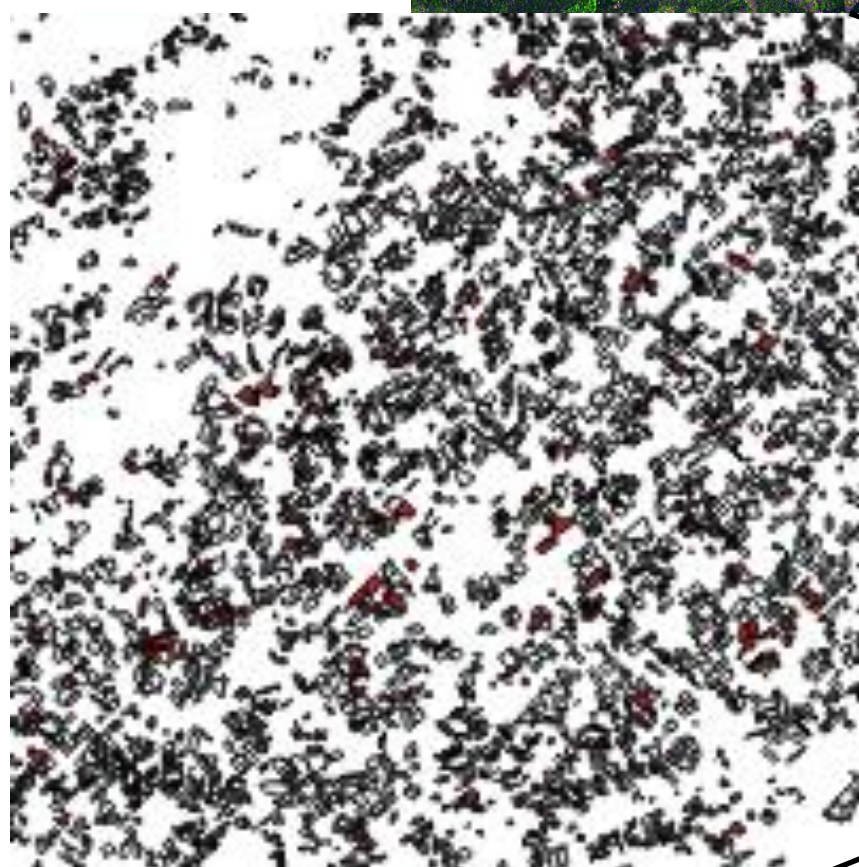
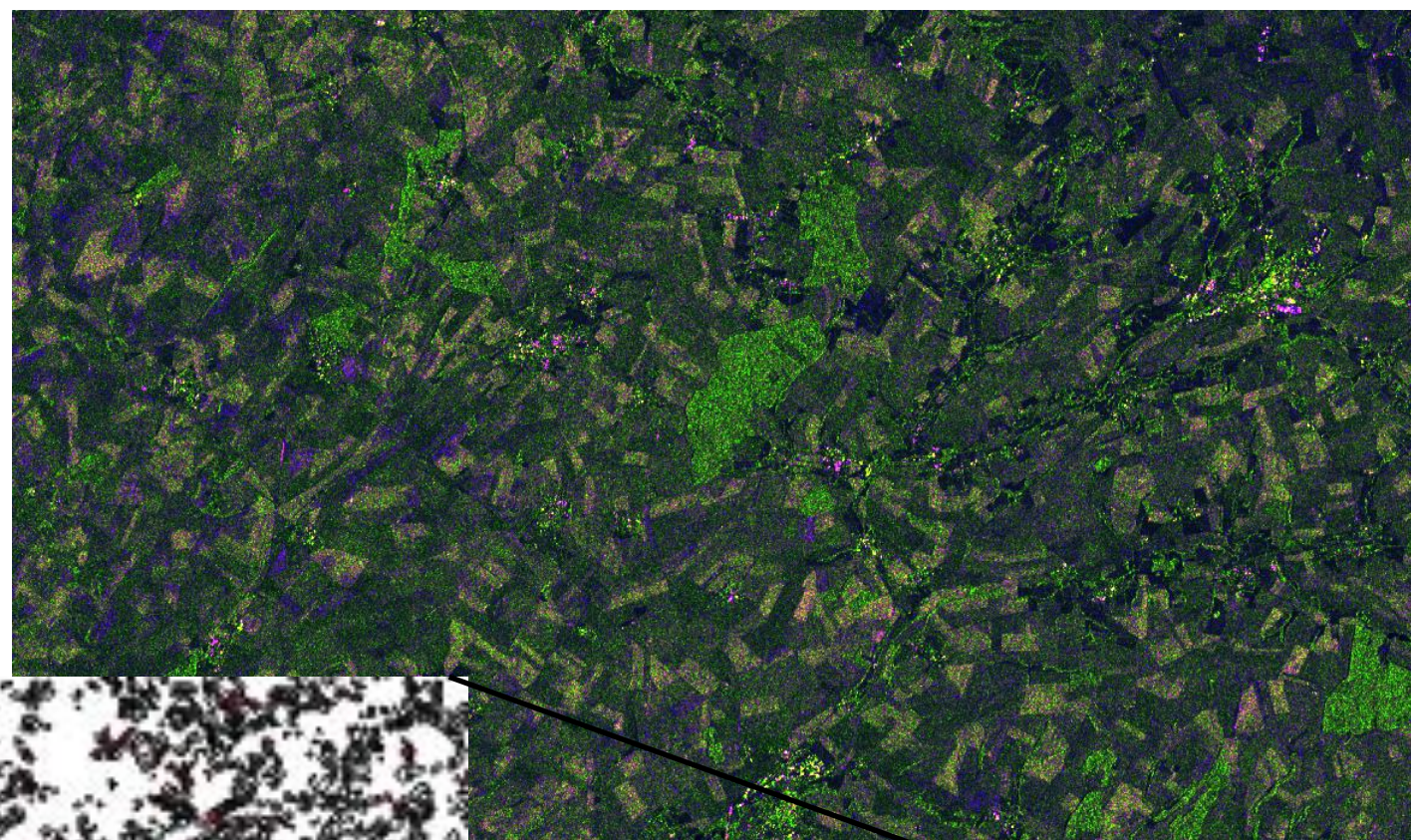


Figure 1: non-filtered Gamma0 VV - Sentinel-1A temporal series example in three vignettes.

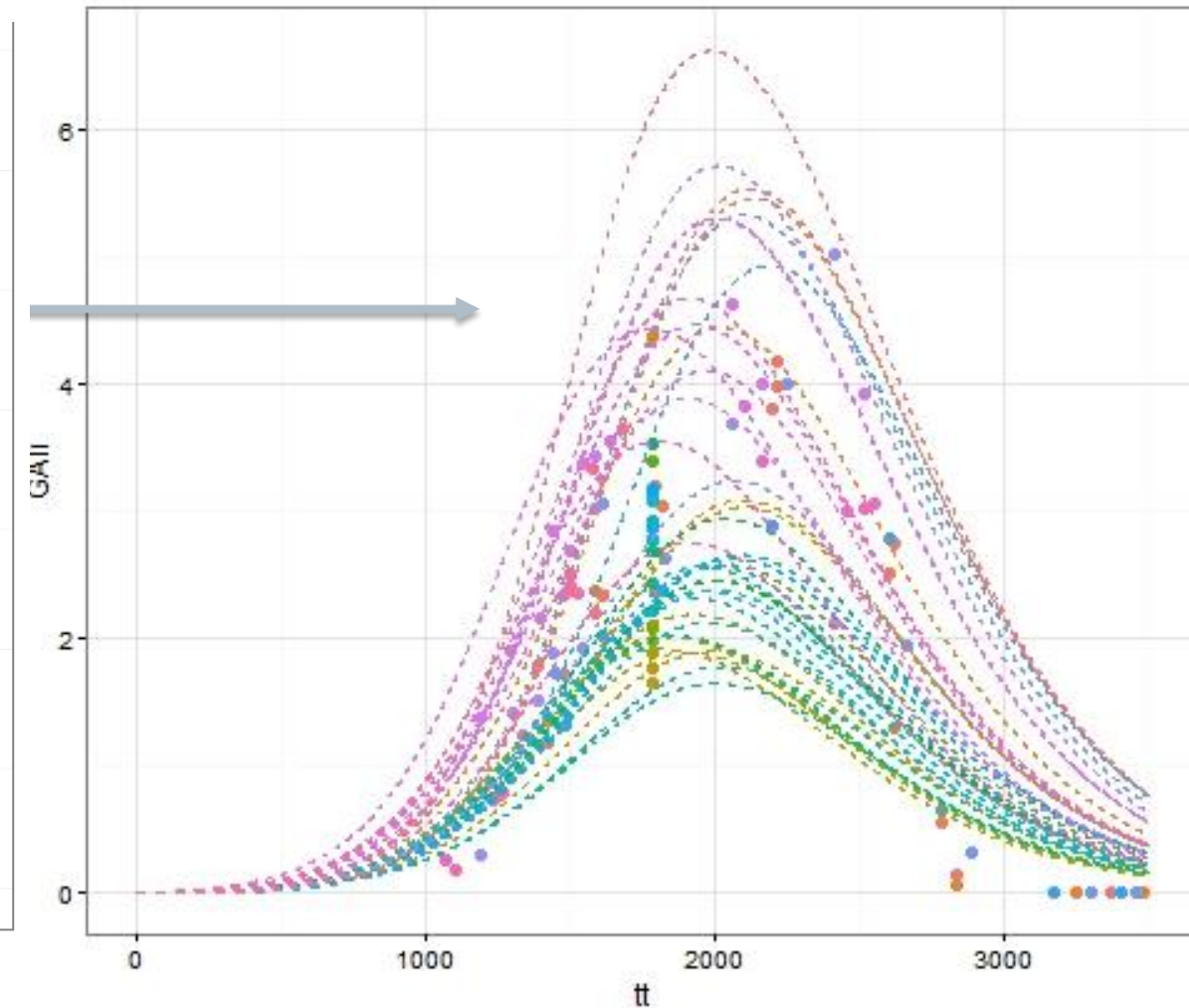
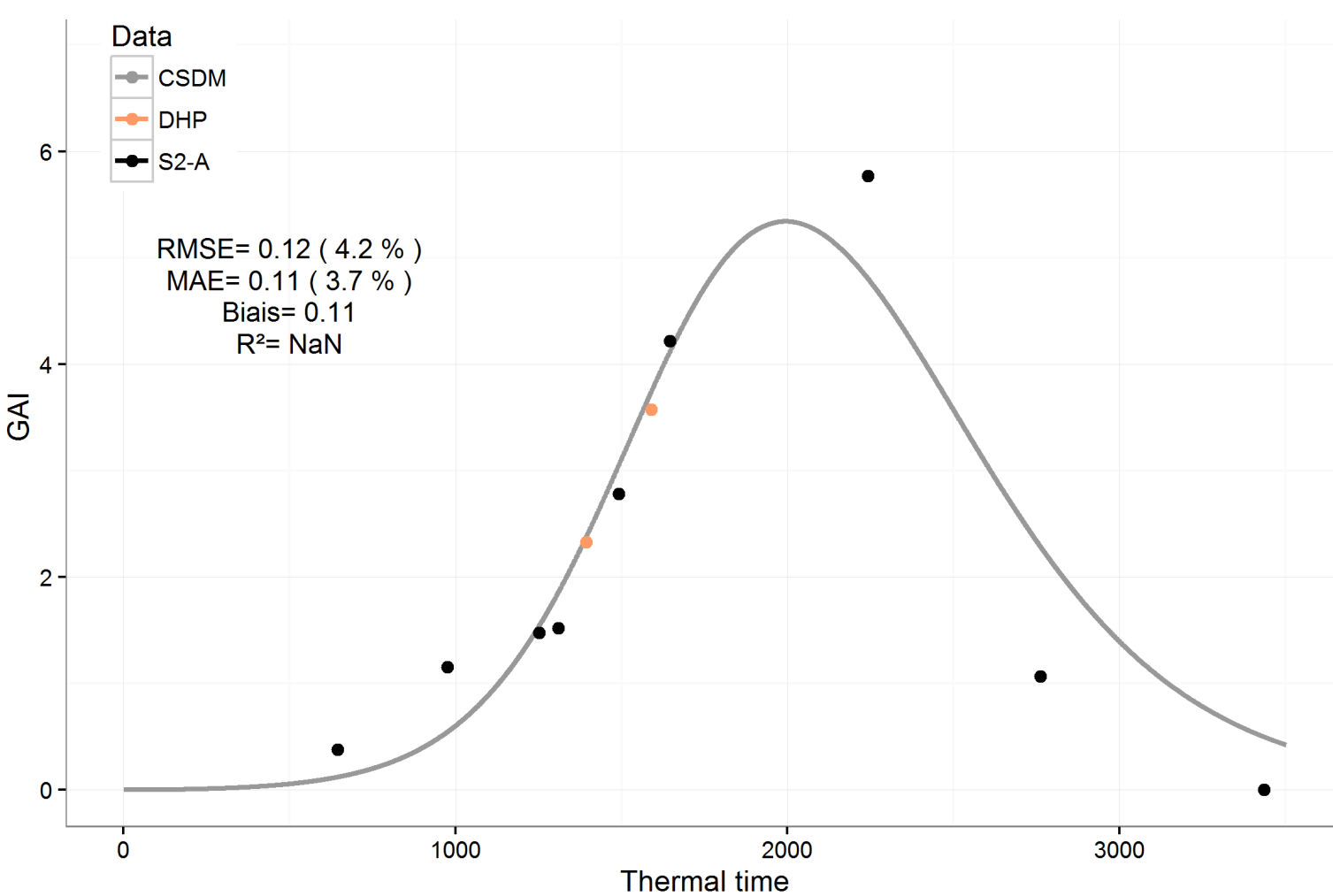


0 10 20 30 40 km



Development monitoring

Model - Meteo data



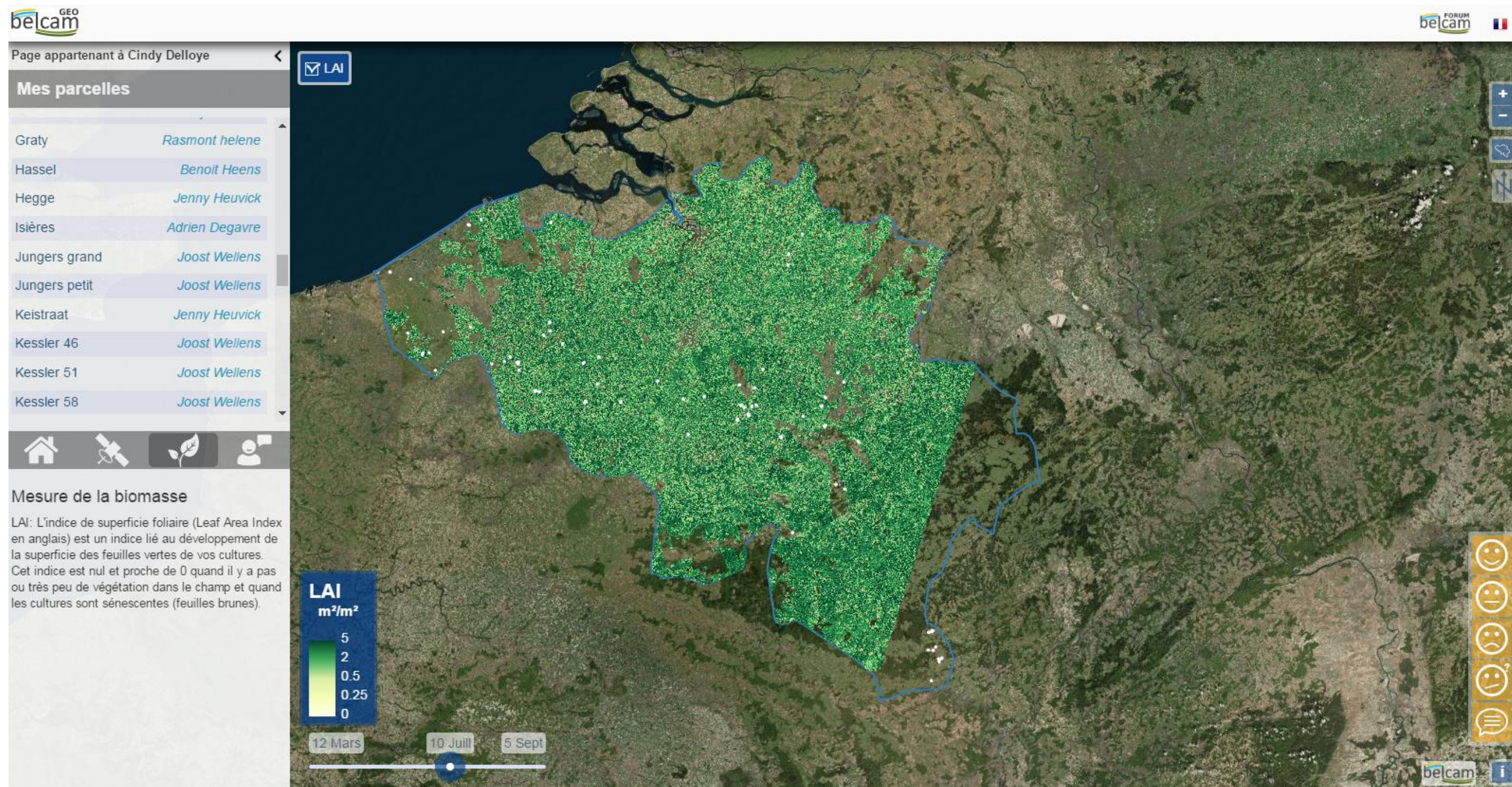
Crop GAI map





Green area index - Biomass

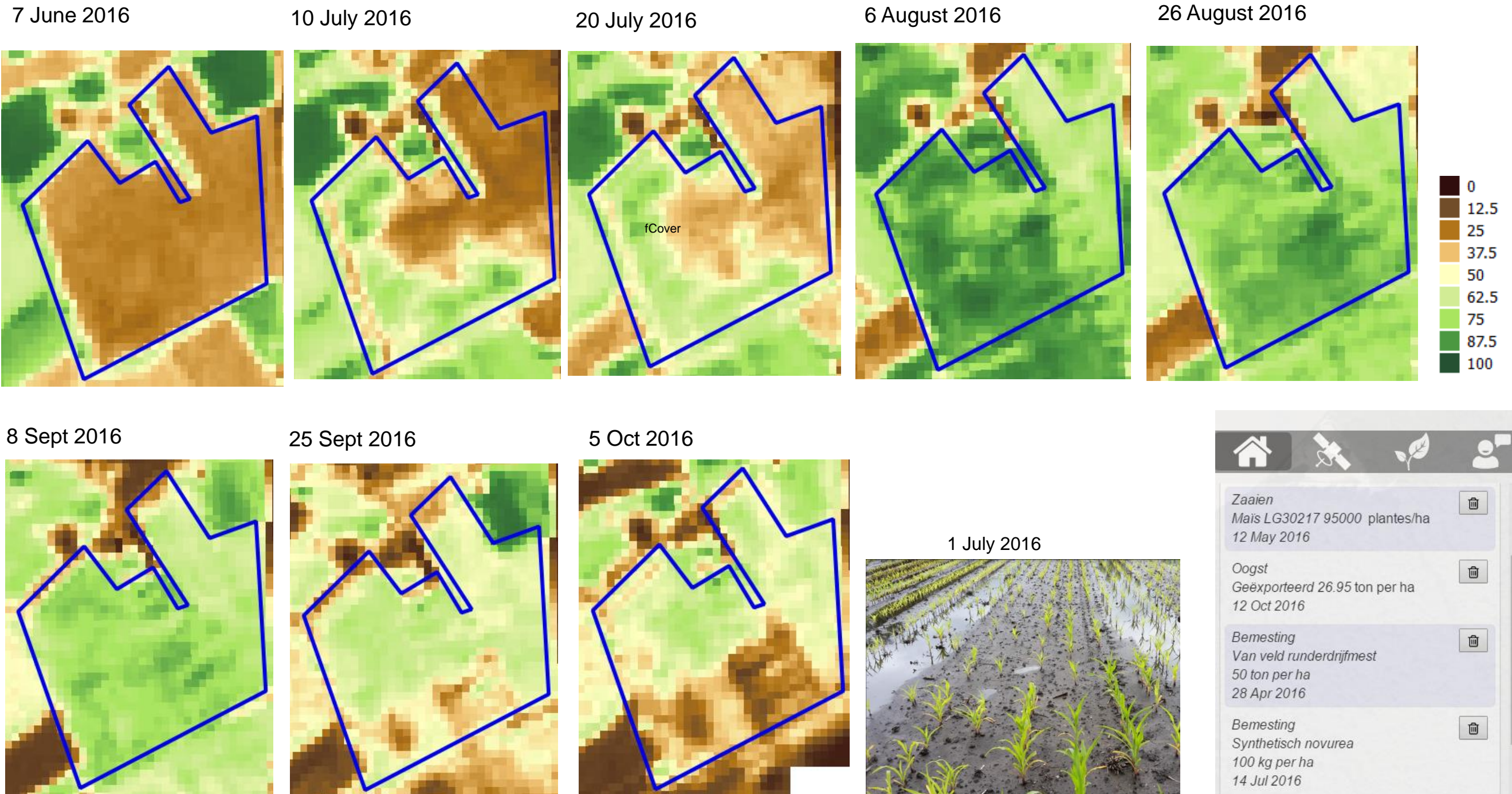
At the Belgian level available for farmers





Anomalies detection

- Example on the maize (Hooibeeekhoeve “Tolhuis Tongerlo”): heterogeneity due to water excess is clearly visible on Sentinel-2 fCover image time series



Zaaien
Maïs LG30217 95000 plantes/ha
12 May 2016

Oogst
Geëxporteerd 26.95 ton per ha
12 Oct 2016

Bemesting
Van veld runderdrijfmest
50 ton per ha
28 Apr 2016

Bemesting
Synthetisch novurea
100 kg per ha
14 Jul 2016

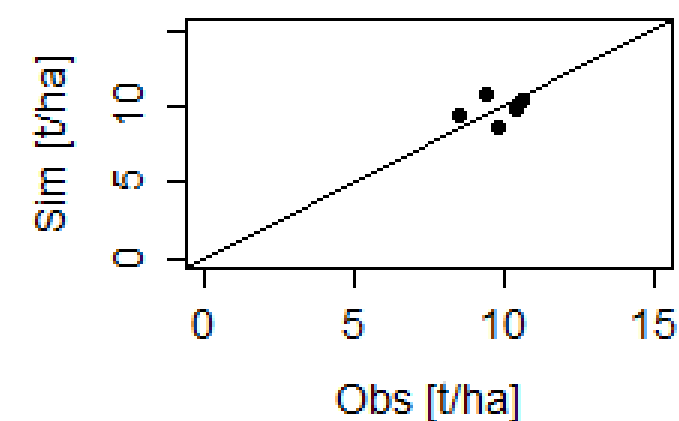
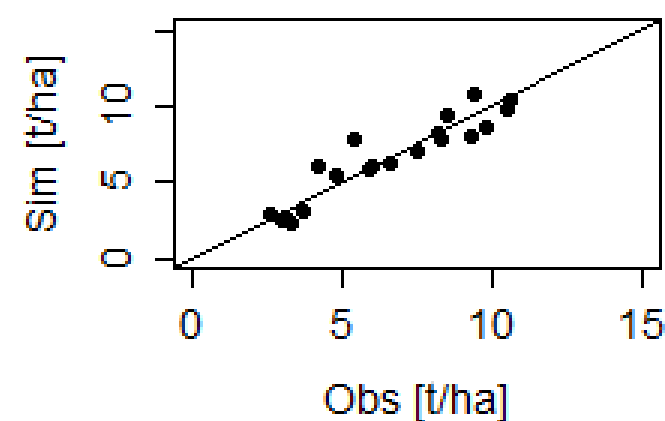
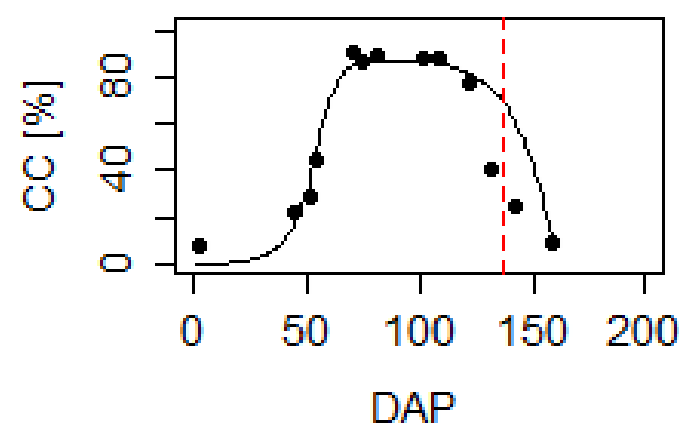
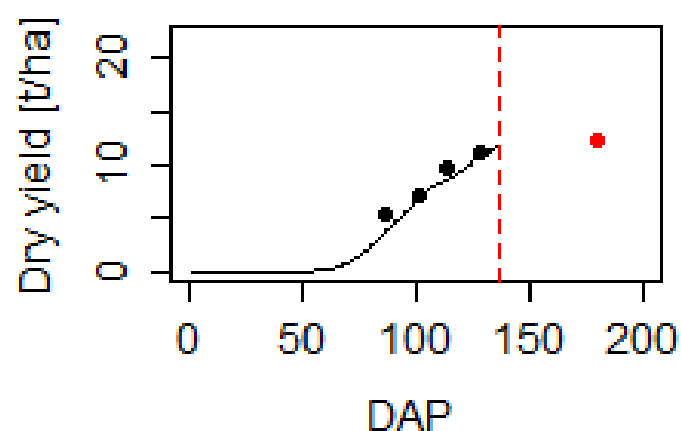
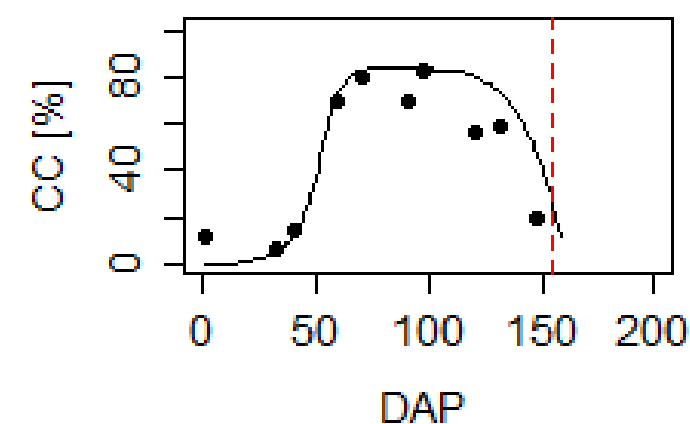
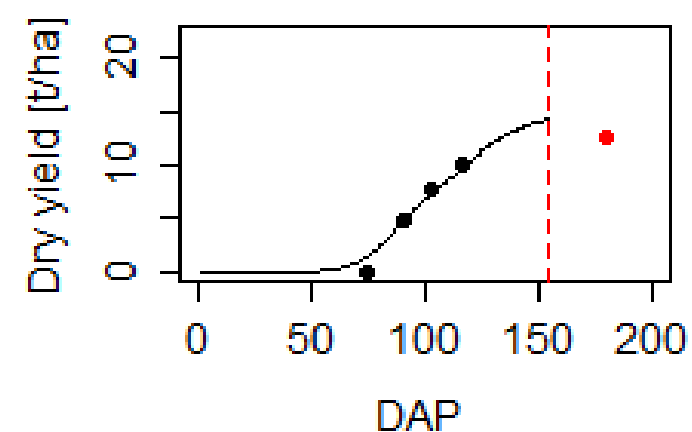
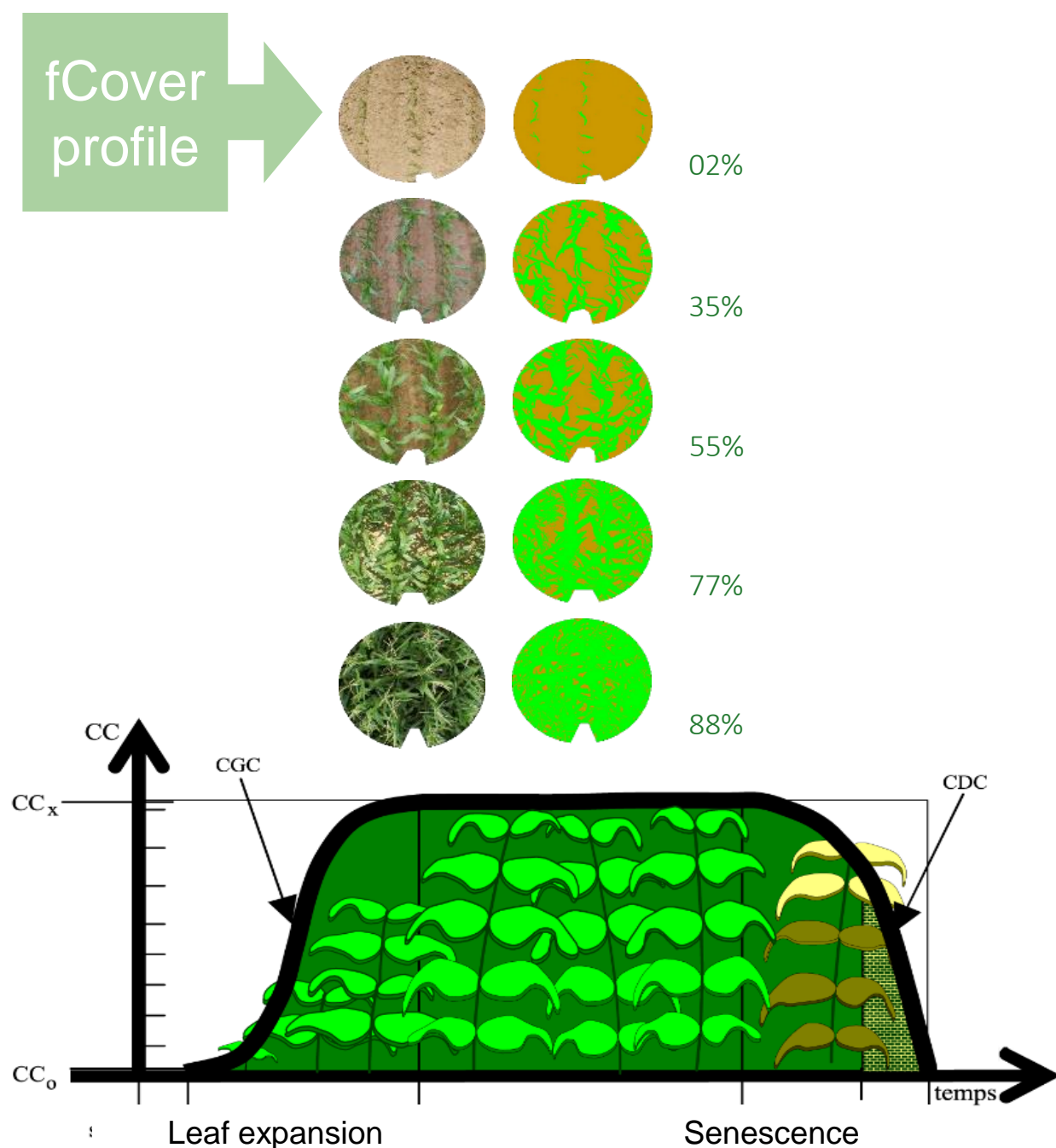
Activiteit (0)



Yield estimate

- Based on **Aquacrop** with integration of fCover from S2, meteo data

Potato



Accuracy= 0,9 ton/ha

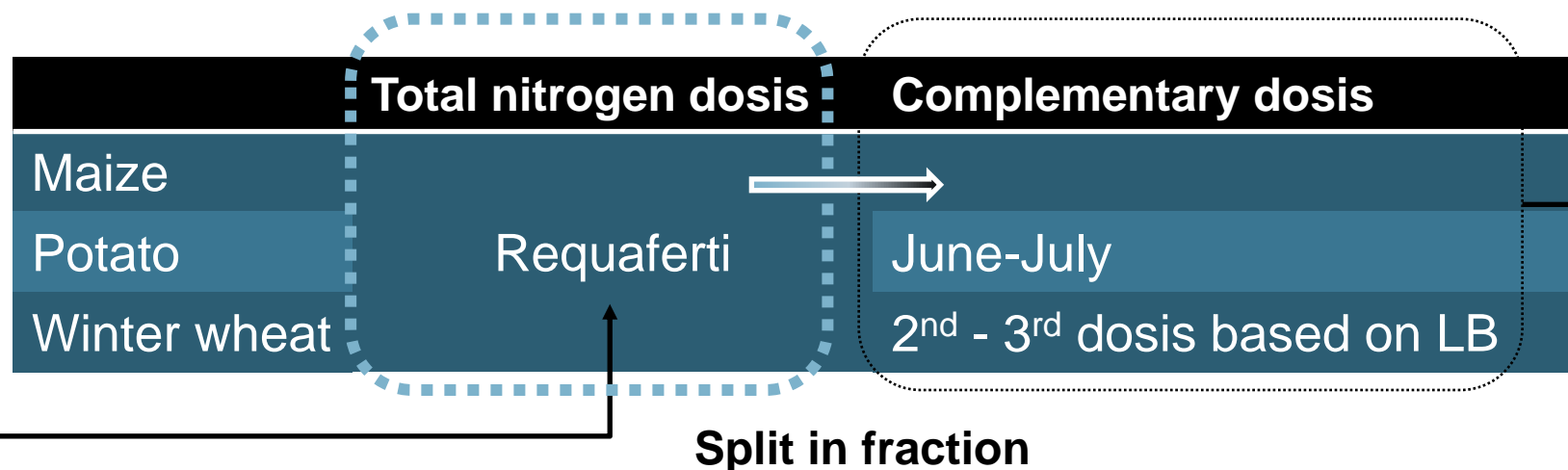


Nitrogen advice

Sentinel data to improve the N recommendation



Source: Scientific American



Input data

- Crop type & variety
- Soil characteristics
- Crop residues use
- Manure application frequency
- Previous crop (type, yield)
- Cover crop type
- Cover crop biomass
- Cover crop ploughed/not ploughed
- ...

Sentinel-2

Sentinel-1

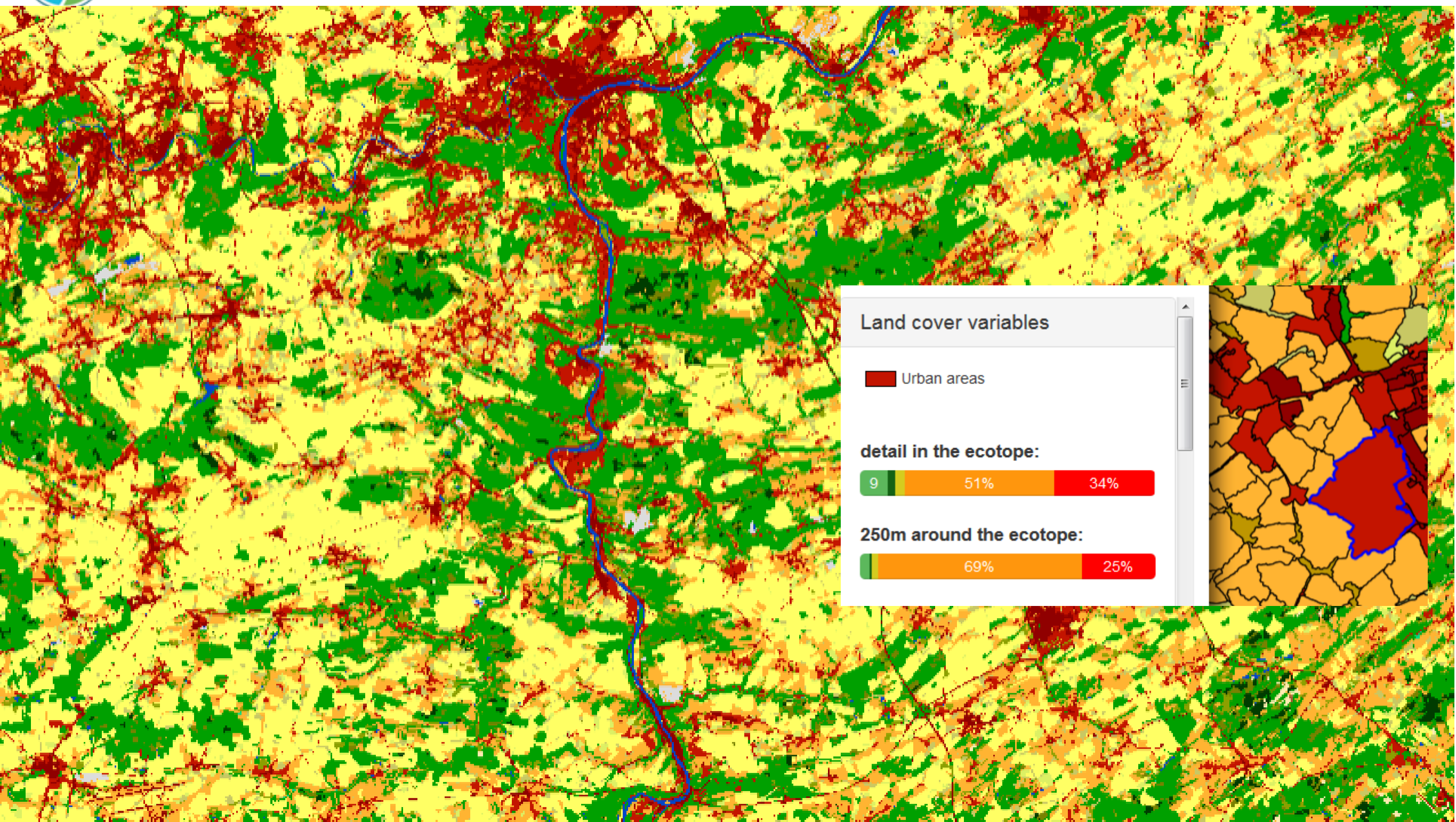


L'agriculture à l'échelle européenne





Annual update of the crop map

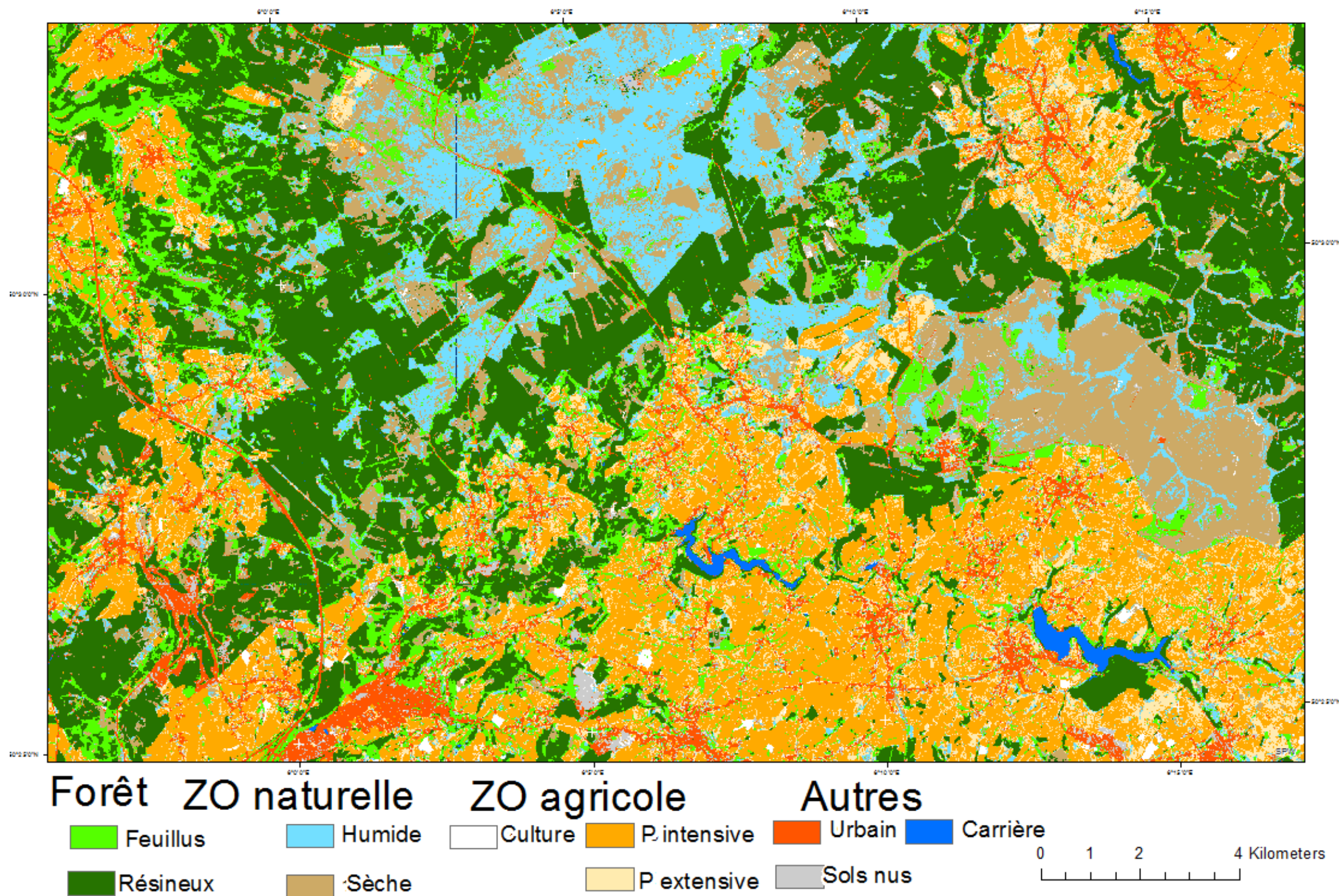


Distinction grassland – crop in the ecotopes GDB



Open environment: finest classification

- Combination S2 – S1 2016



L'agriculture à l'échelle internationale

Mali

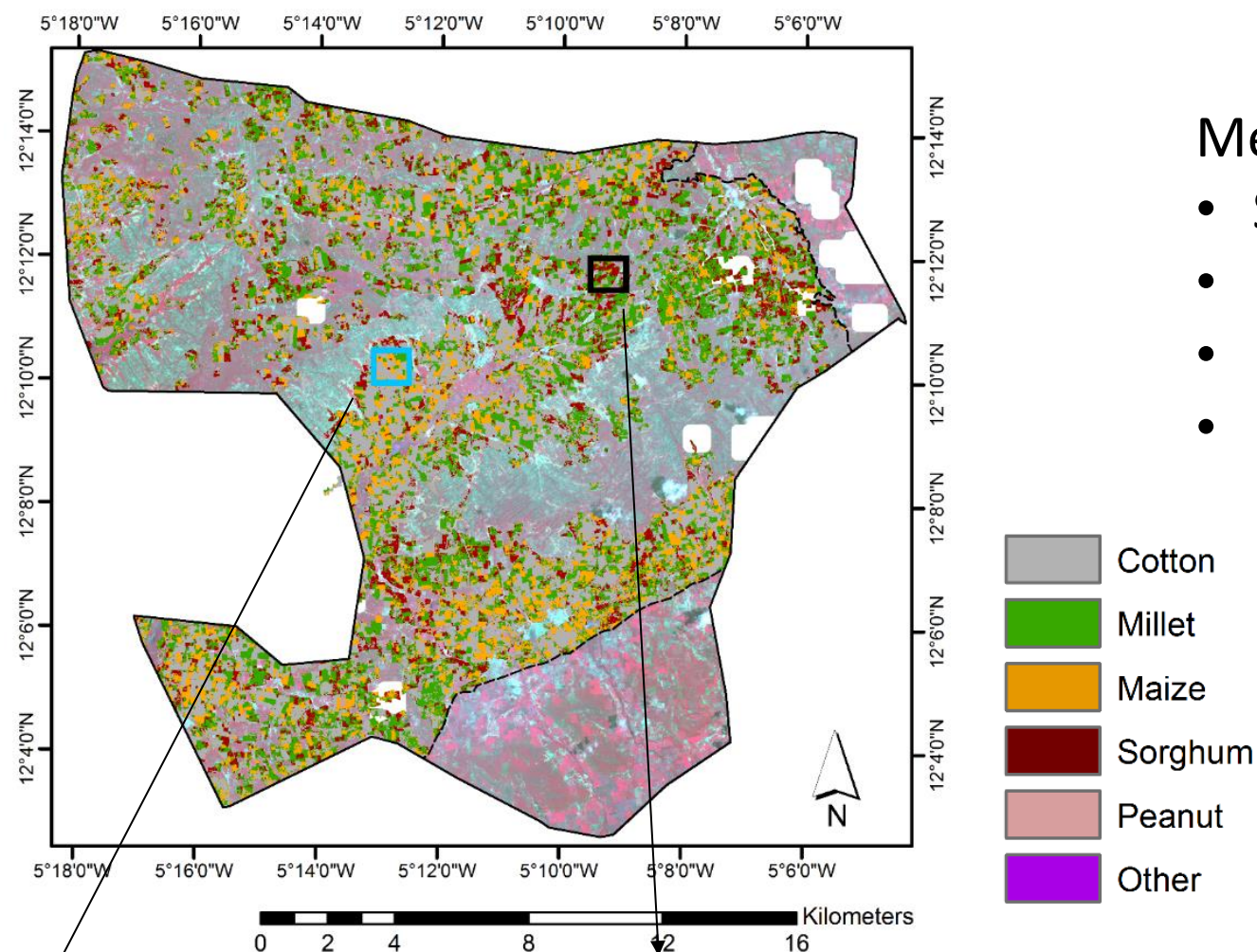




Estimate yield at parcel level

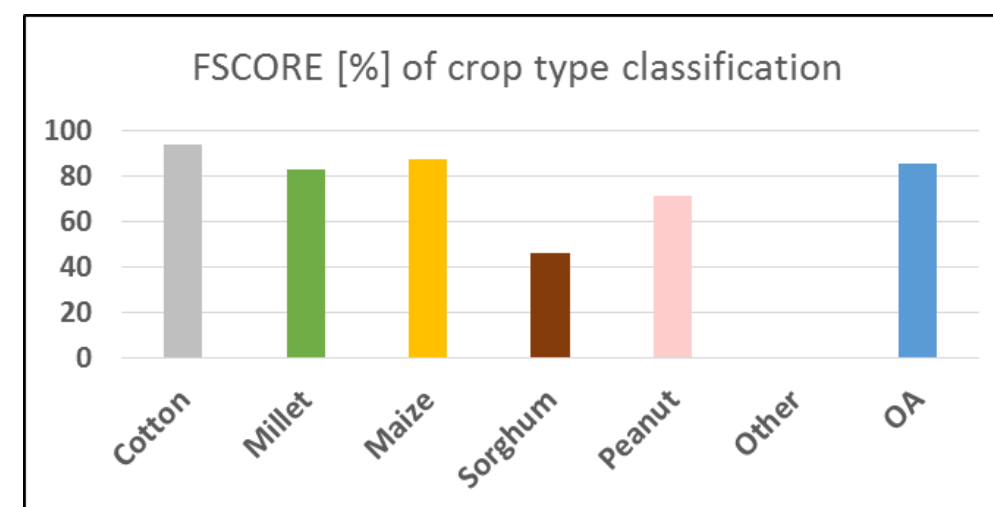
Sub-saharan smallholder farming systems

Lambert Marie-Julie (PhD researcher)



Method

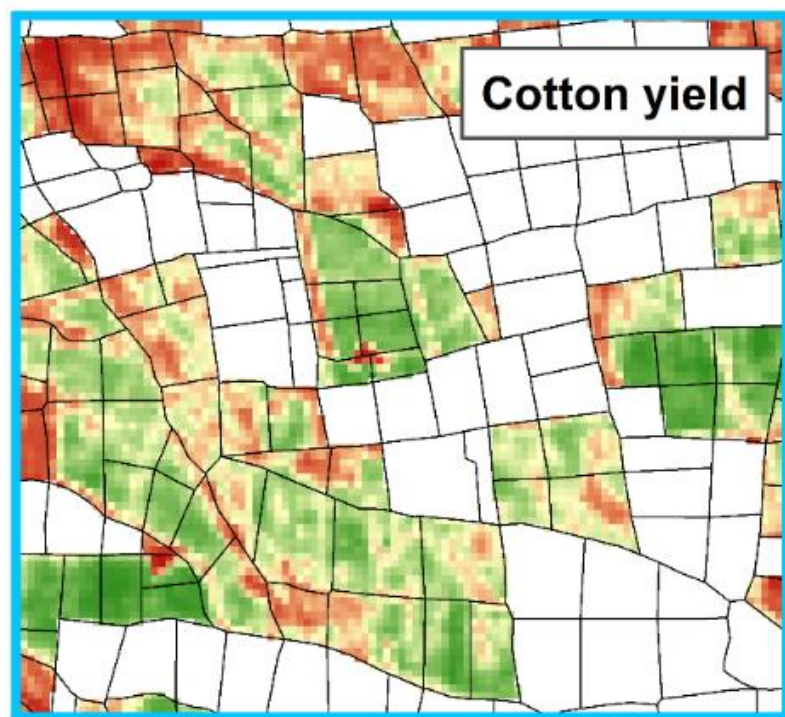
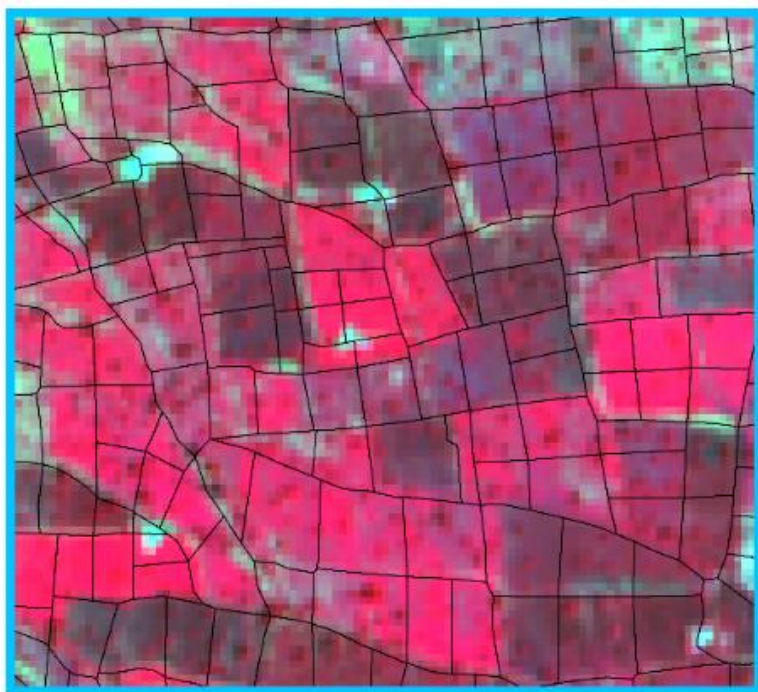
- Sentinel 2: 10m and 20m bands
- Random Forest classifier trained with field data
- Under the cropland mask
- Majority filter with cadastral parcels



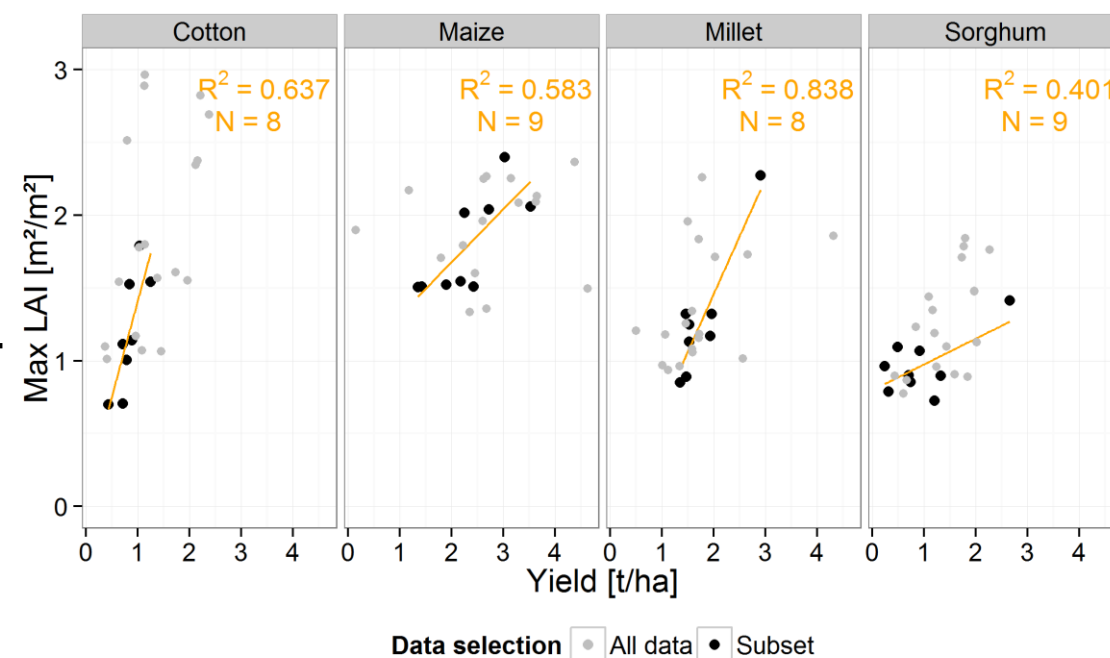
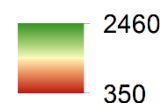


Mapping yield by combining crop type map and yield estimation

- High intra and inter field heterogeneity



Yield [kg/ha]

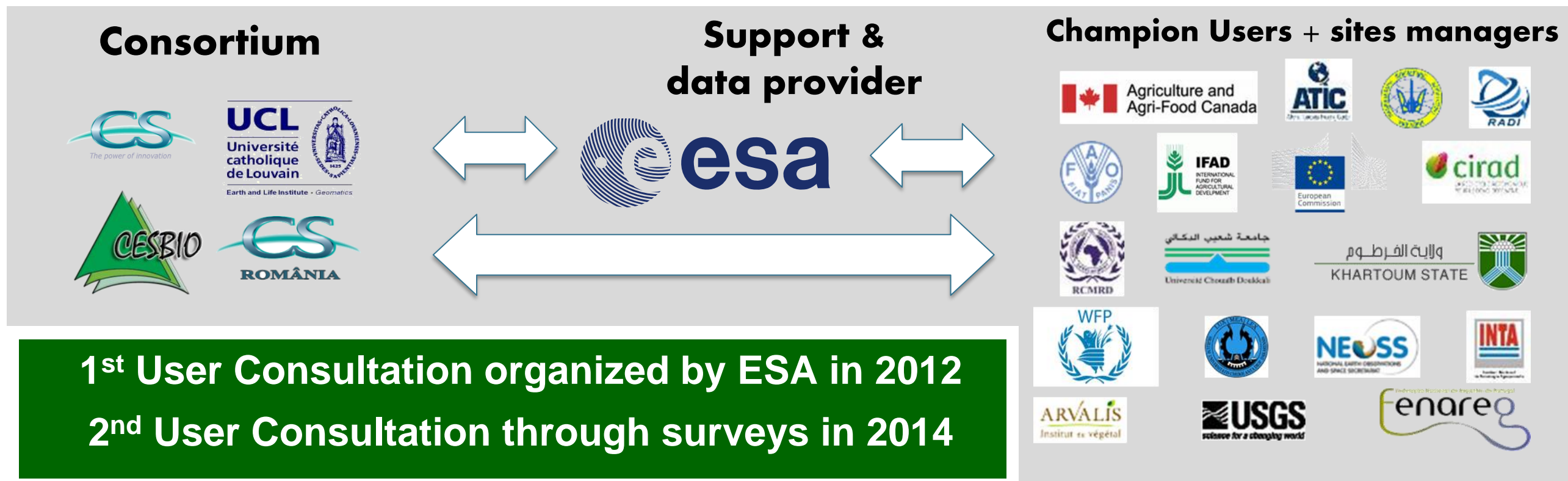


L'agriculture à l'échelle mondiale

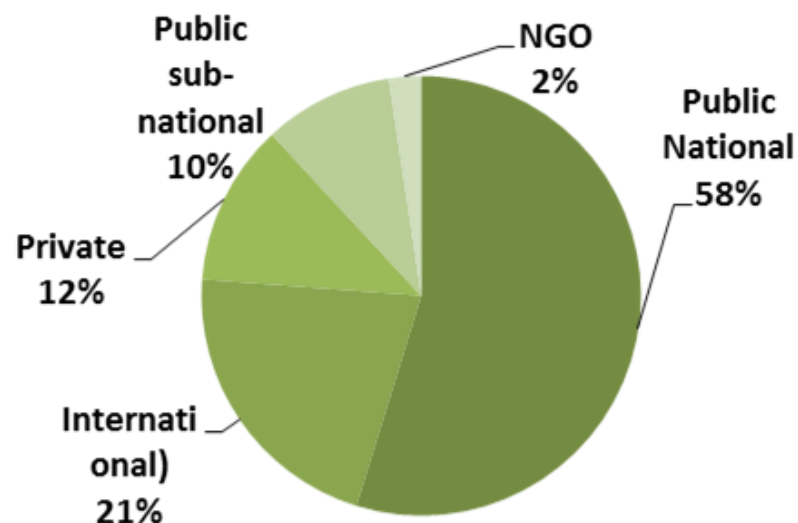




Sentinel-2 for Agriculture



Survey filed up by 42 institutions



1st Sen2-Agri Users Workshop – FAO May 2014

2nd Sen2-Agri Users Workshop – EU Nov. 2015

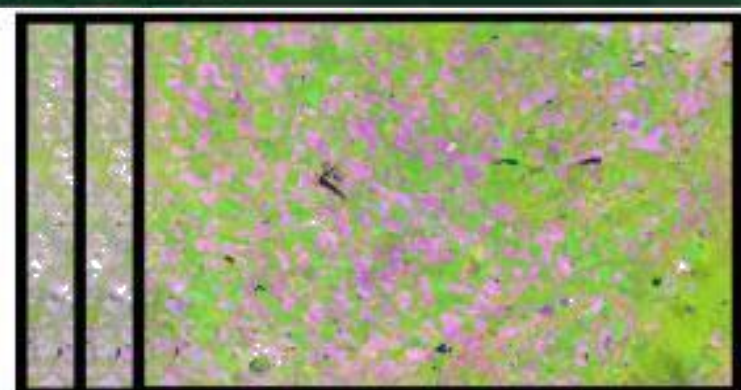


Open source System to deliver 4 products along the growing season

In line with the GEOGLAM core products

Monthly cloud free surface
reflectance composite at 10-
20 m

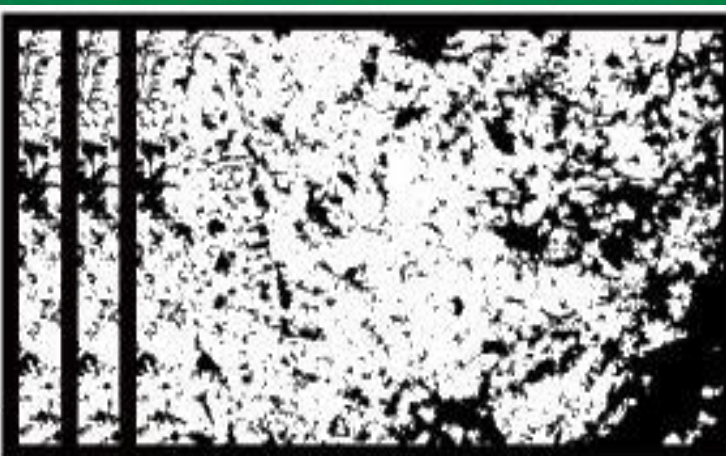
CLOUD FREE SURFACE
REFLECTANCE COMPOSITES



Growing season
(monthly updates)

Vegetation status map at
20 m delivered every week
(NDVI, GAI, pheno index)

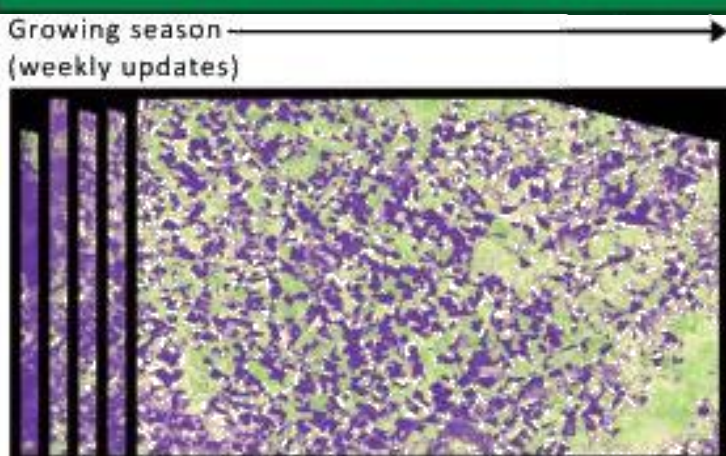
DYNAMIC CROPLAND MASK



Growing season
(monthly updates)

Open source toolbox
Capacity building and training

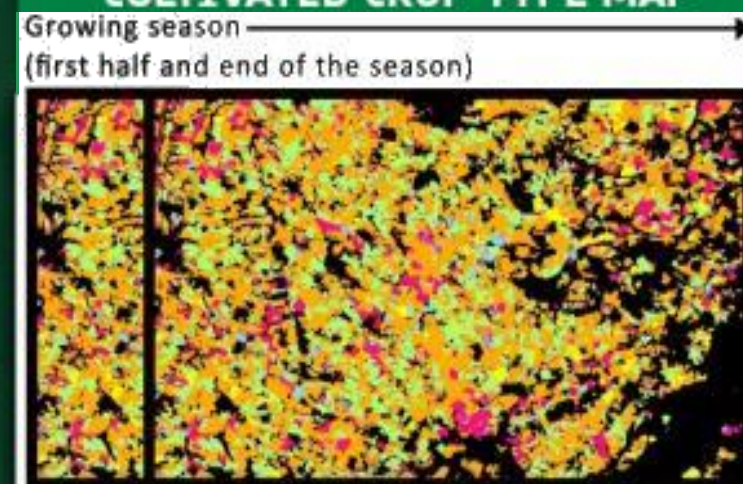
VEGETATION STATUS



Growing season
(weekly updates)

Binary map identifying
annually cultivated land at
10m updated every month

CULTIVATED CROP TYPE MAP



Growing season
(first half and end of the season)

Crop type map at 10 m for the
main regional crops including
irrigated/rainfed
discrimination



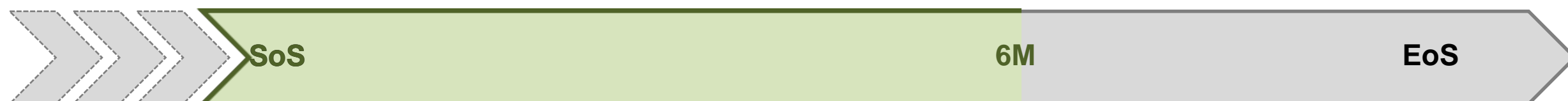
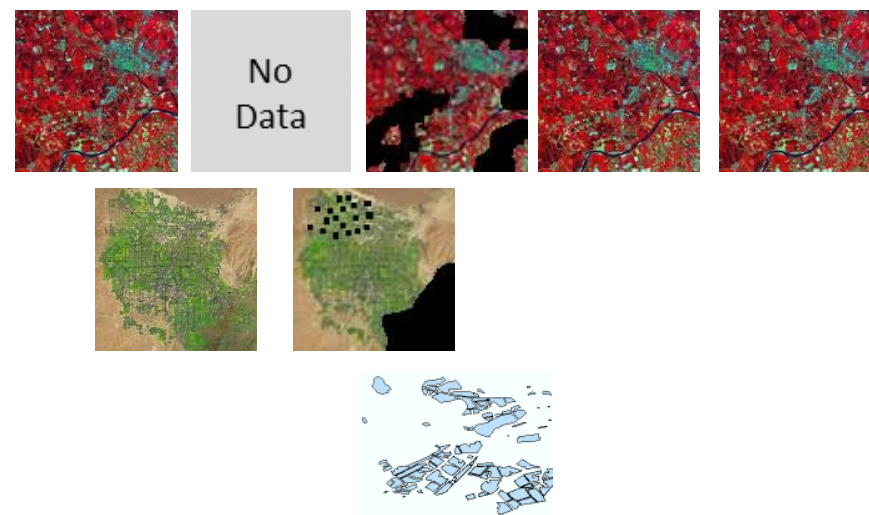
System operation for crop type

Before the start of the monitoring period

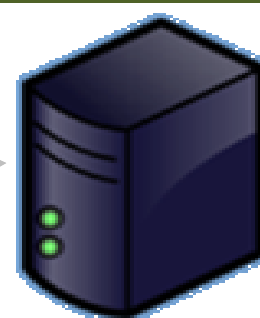
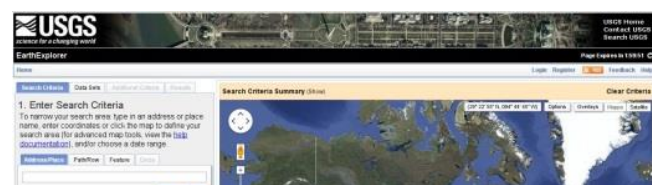
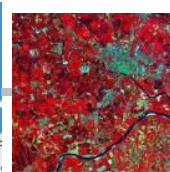
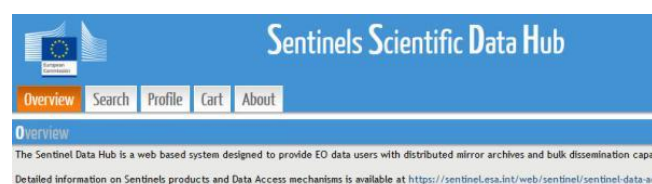
Monitoring period

Automatic EO data download
Manual in situ data upload

System initialization



EO data providers



Operators





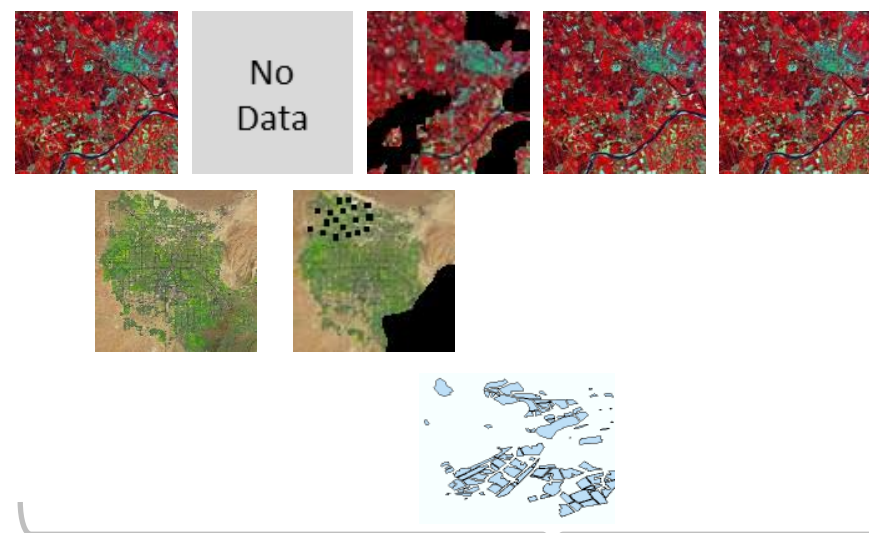
System operation for crop type

Before the start of the monitoring period

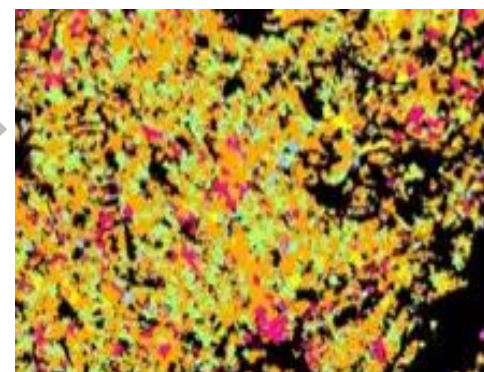
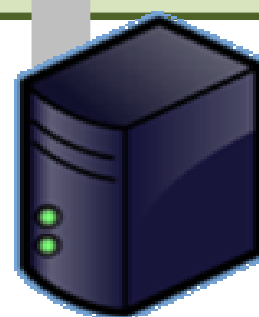
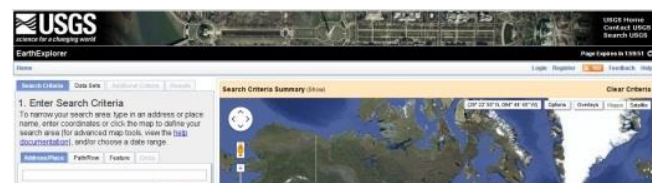
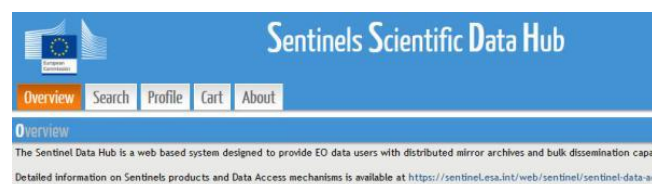
Monitoring period

Automatic EO data download
Manual in situ data upload

System initialization



EO data providers



Operators



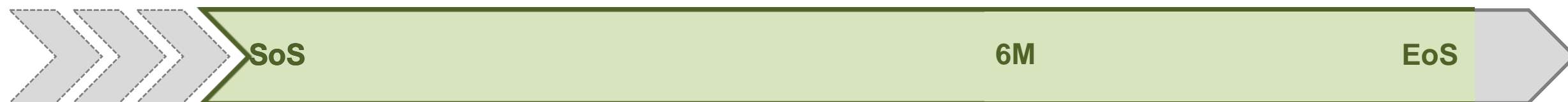
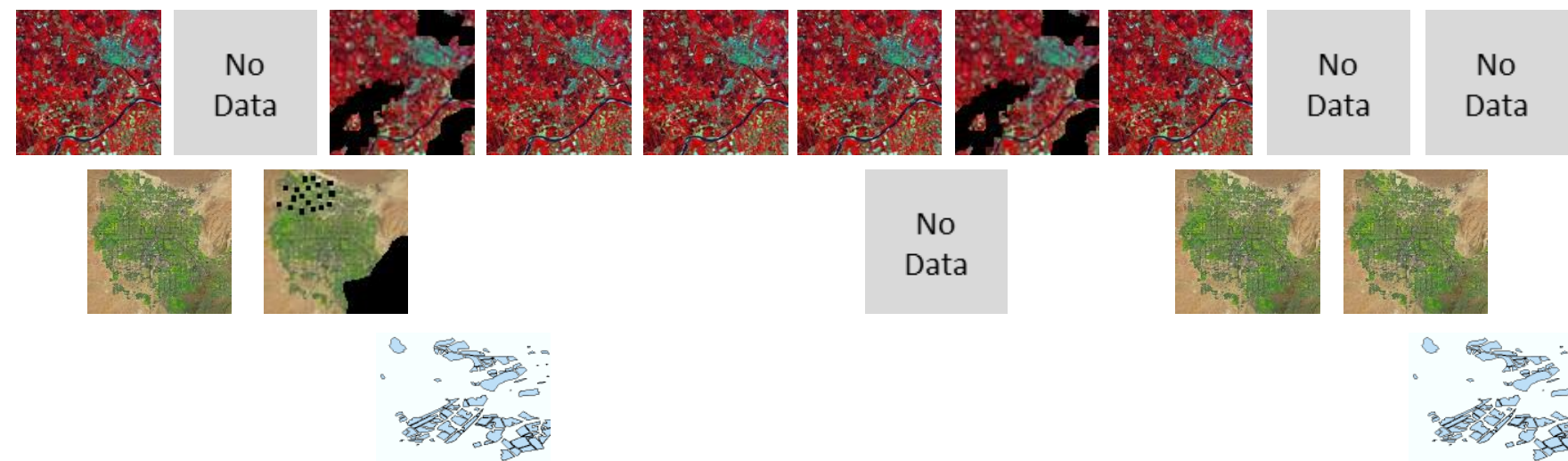
System operation for crop type

Before the start of the monitoring period

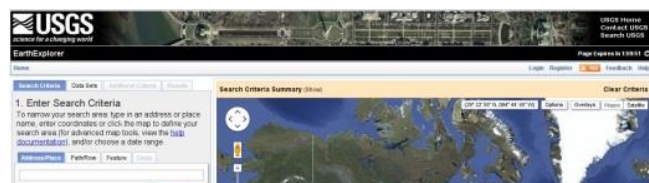
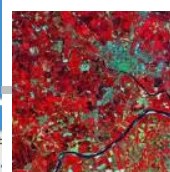
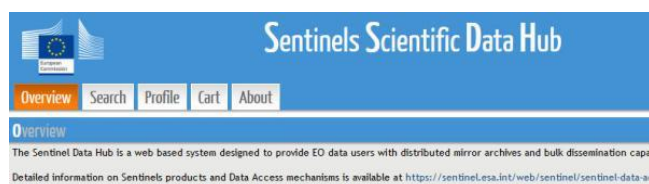
Monitoring period

Automatic EO data download
Manual in situ data upload

System initialization



EO data providers



Operators





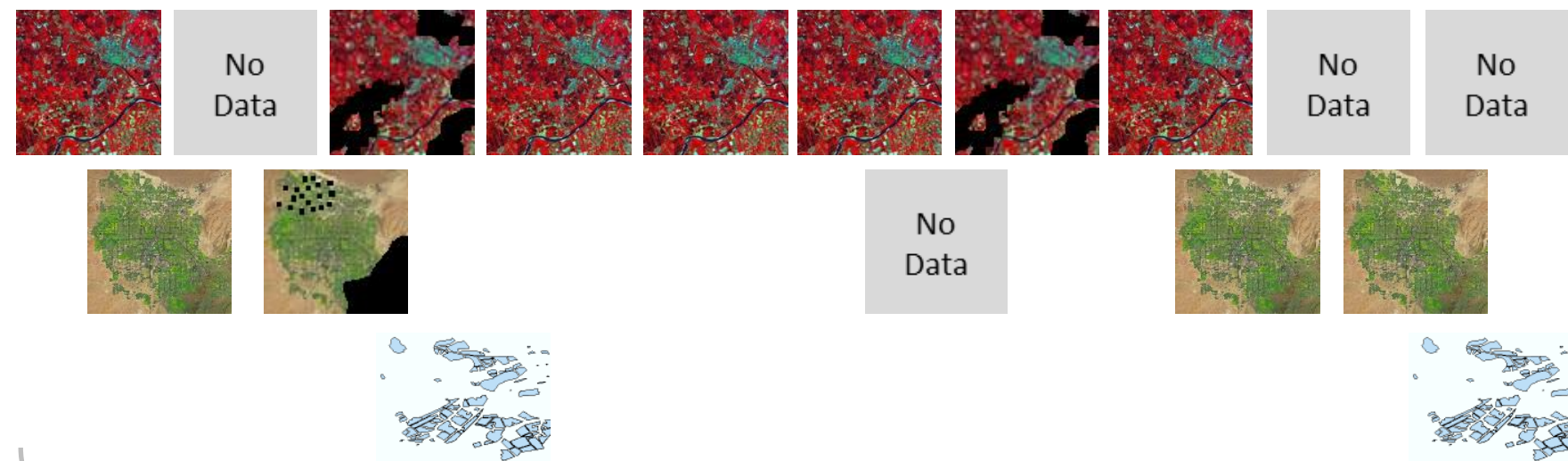
System operation for crop type

Before the start of the monitoring period

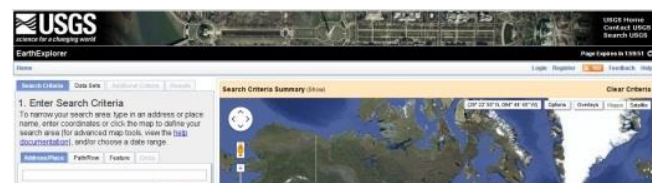
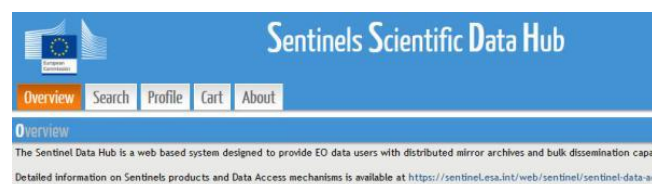
Monitoring period

Automatic EO data download
Manual in situ data upload

System initialization



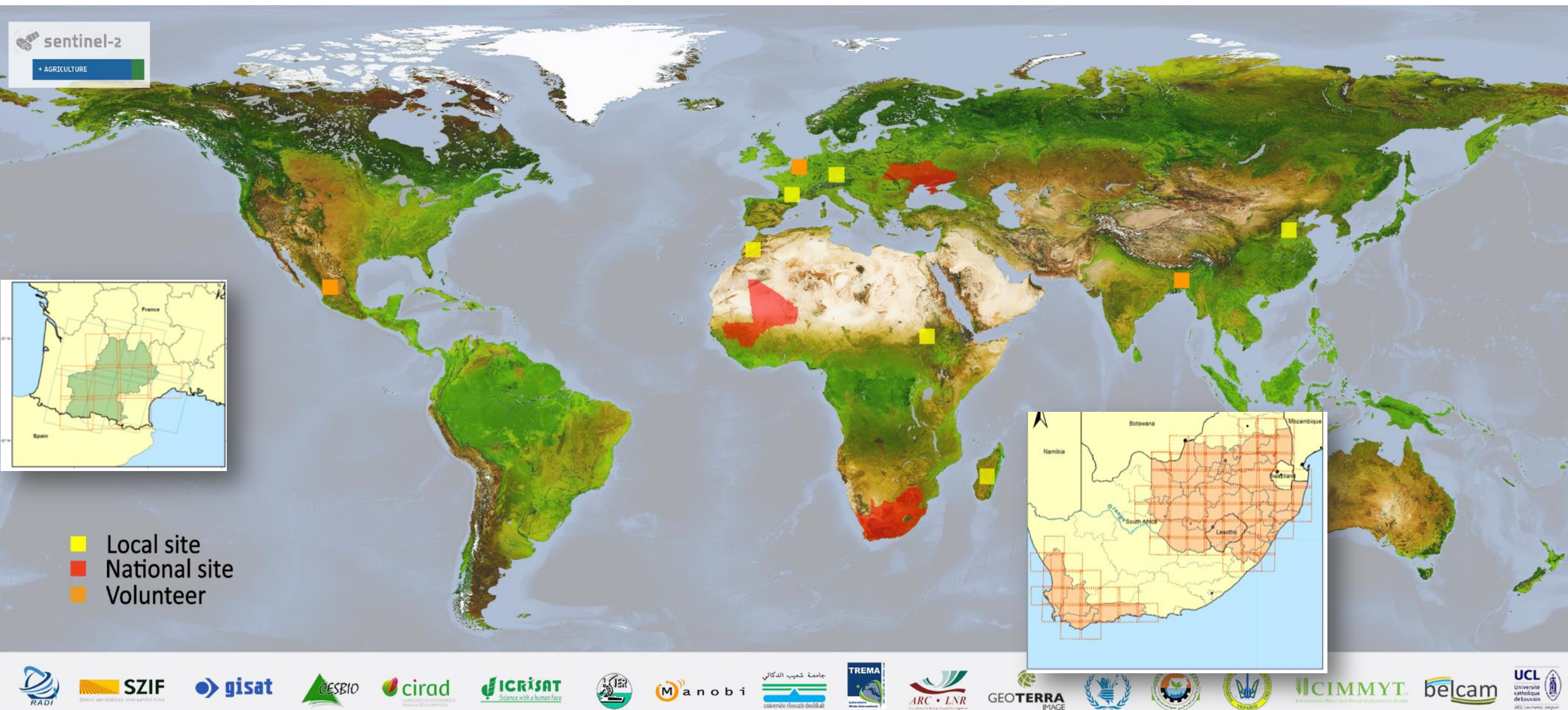
EO data providers



Operators



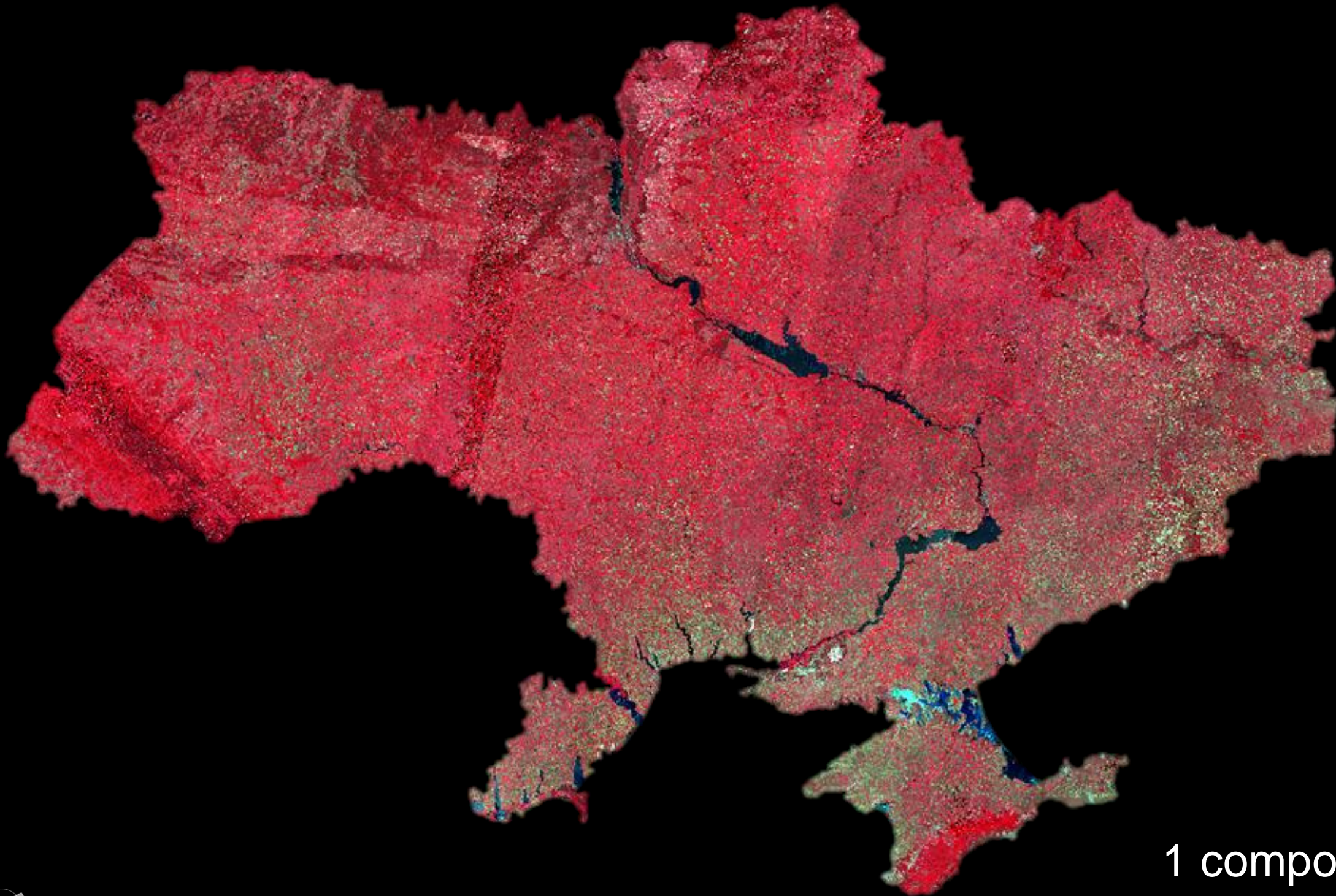
A great network of active partners !



■ Local site
■ National site
■ Volunteer

3 national sites: development at large scale
8 local sites + volunteers: exhaustiveness of agrosystems

Ukraine: first nationwide cloud free composite at 10m resolution from 92 Sentinel-2 tiles



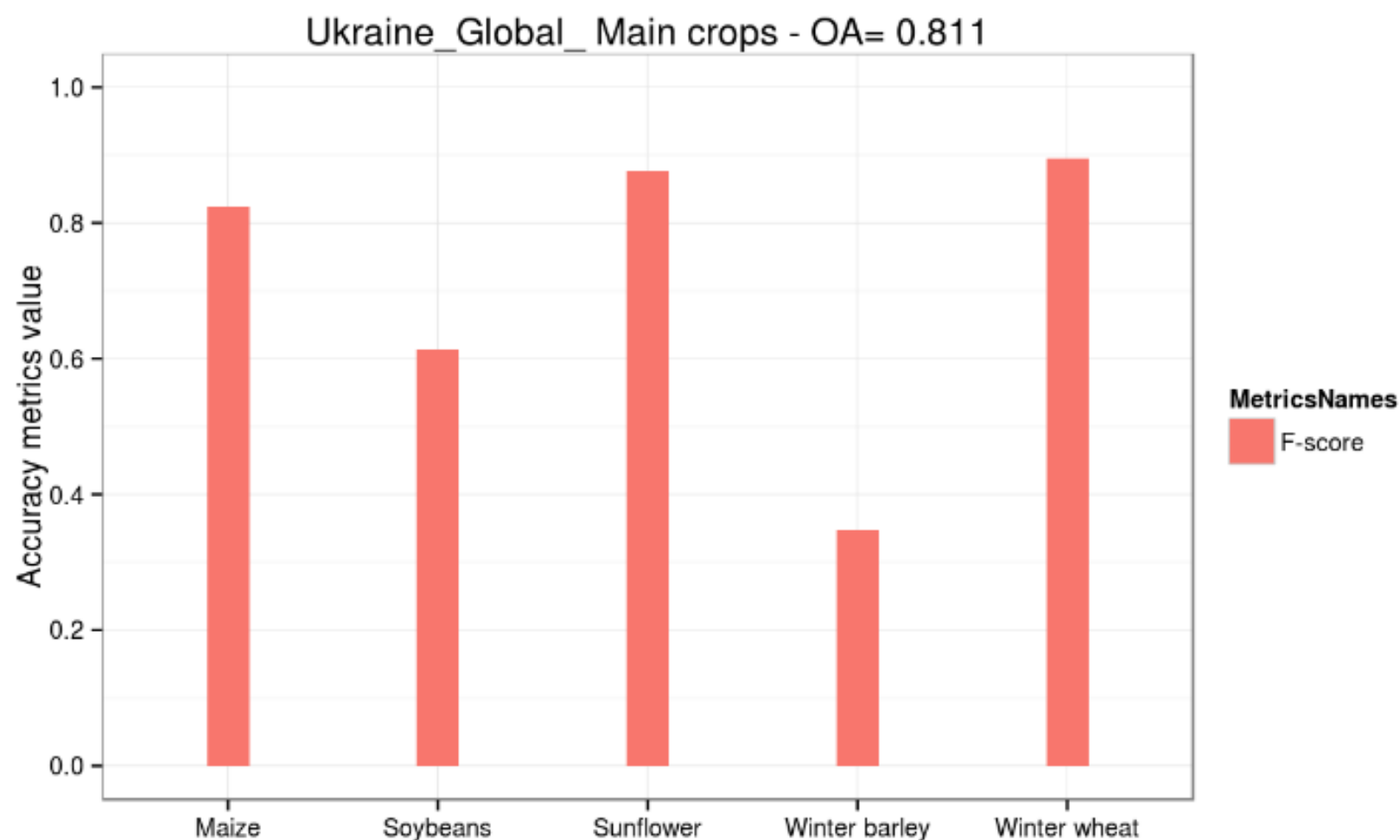
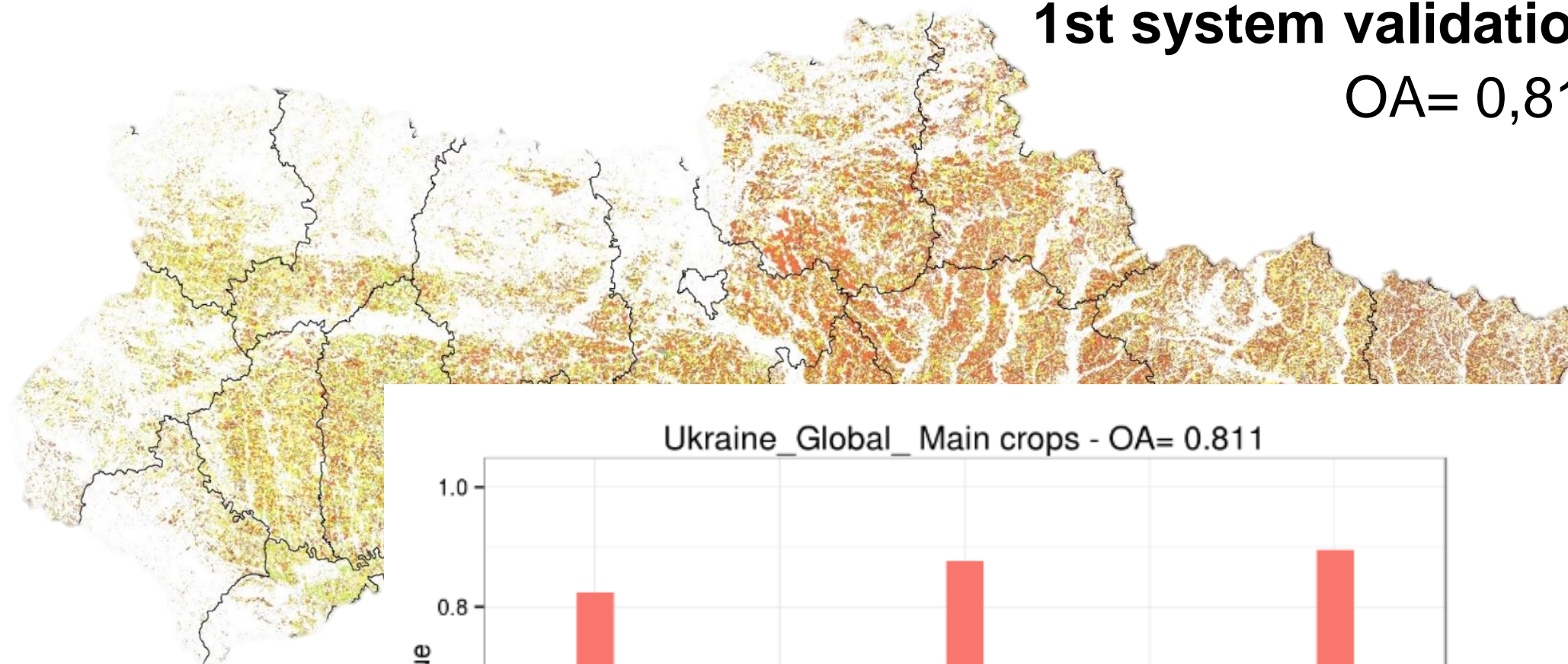
1 composite per month
Based on 50 days of data



First nationwide croptype map at 10m resolution from Sentinel-2

Crop mask
OA= 0,96

1st system validation:
OA= 0,81





Vegetation status map

GAI series over cropland

18/02/2016

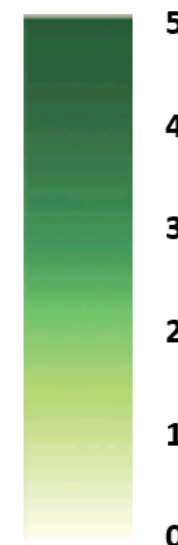
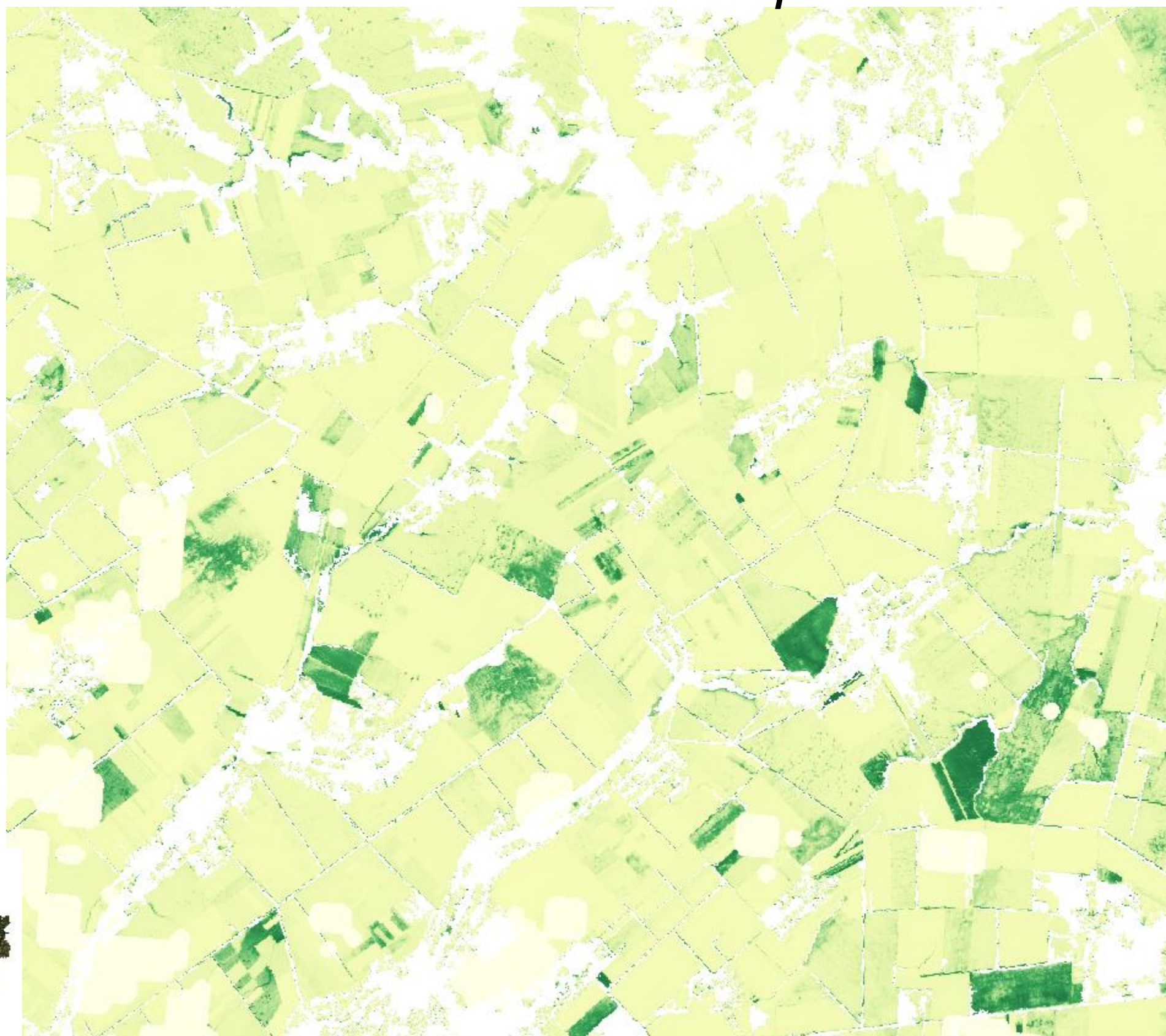
18/04/2016

28/04/2016

17/06/2016

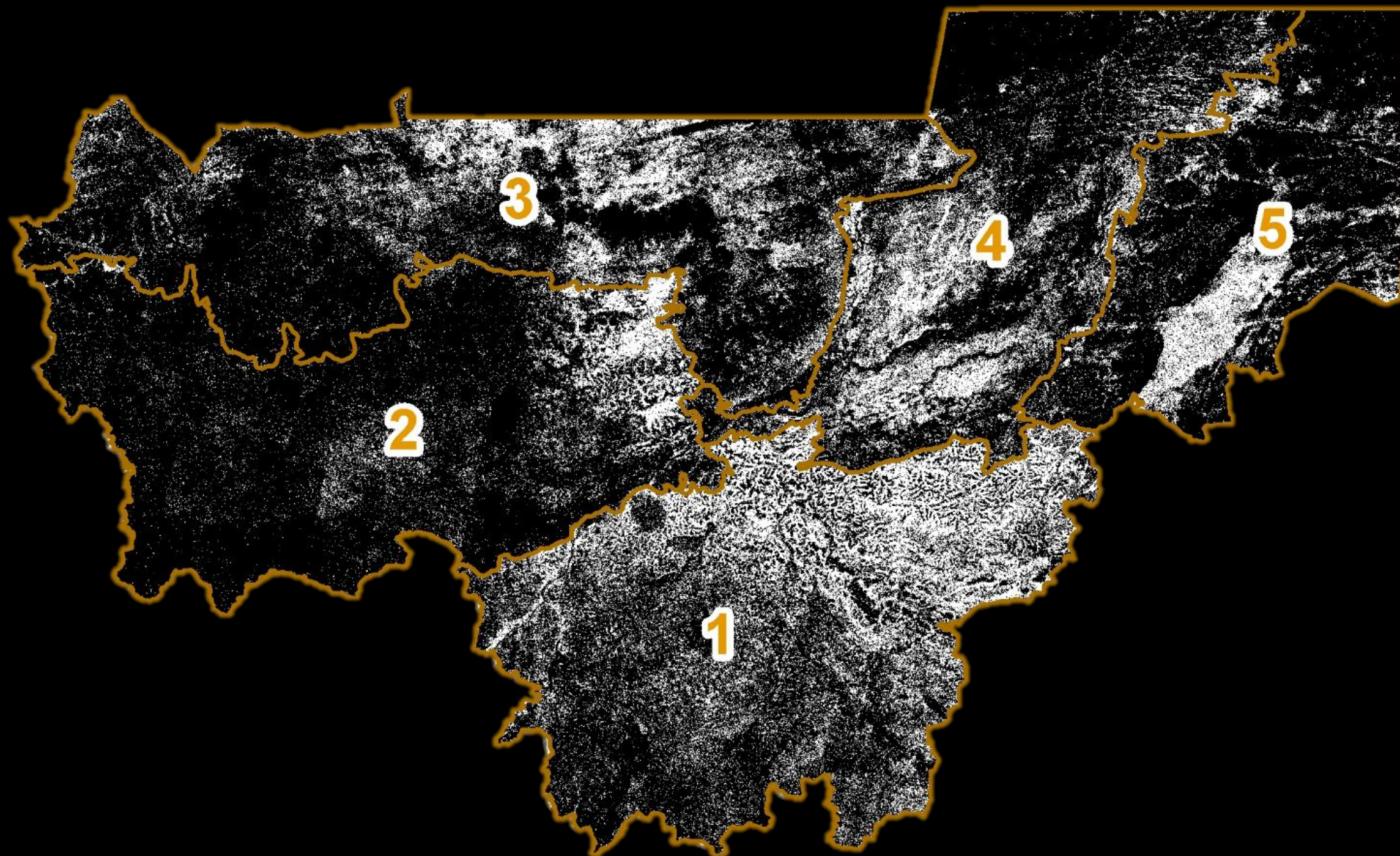
17/07/2016

09/08/2016



Mali Crop mask

Most difficult site - data collection

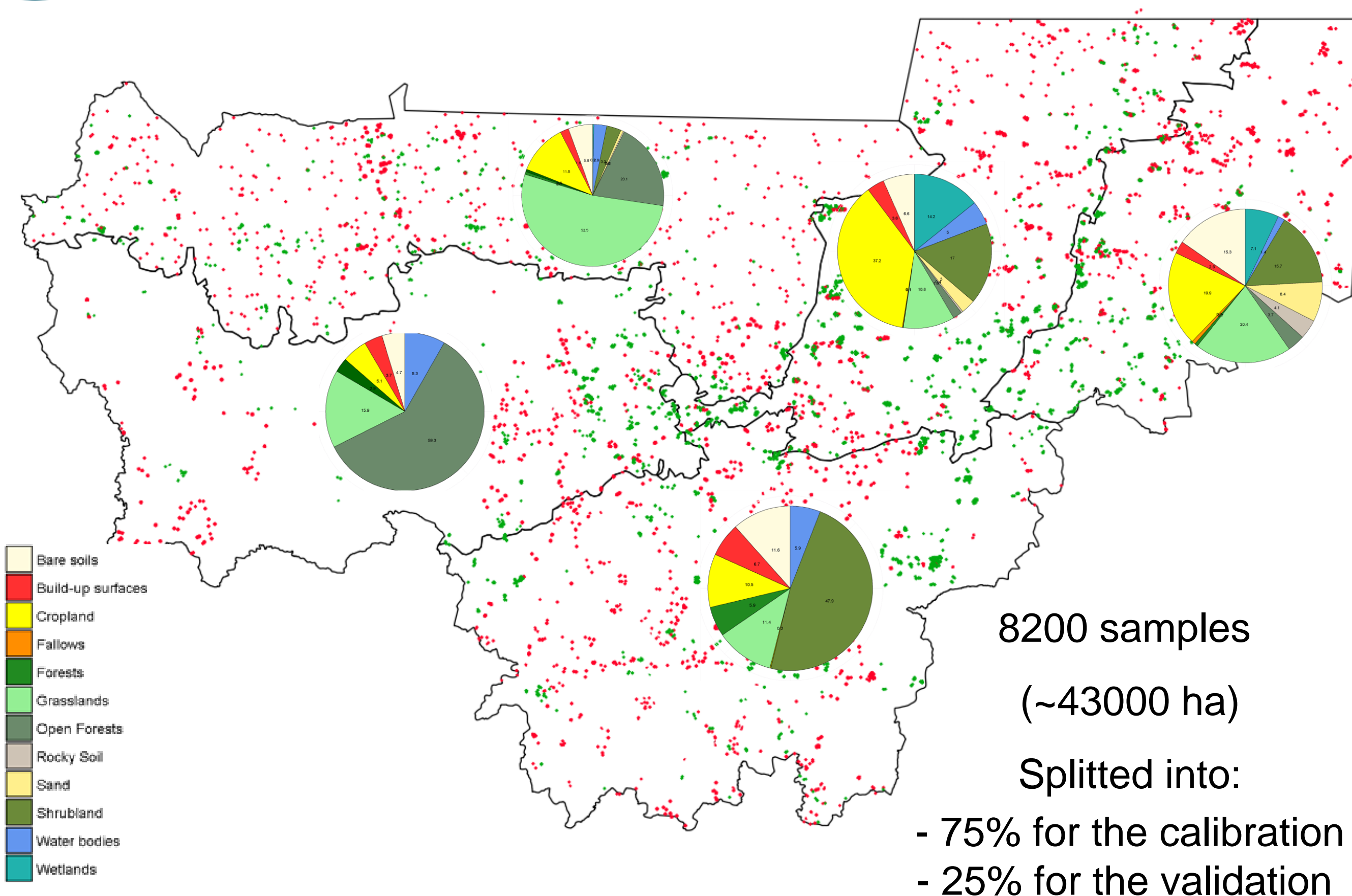


OA: 81%

Mali



Nonetheless, data were collected...

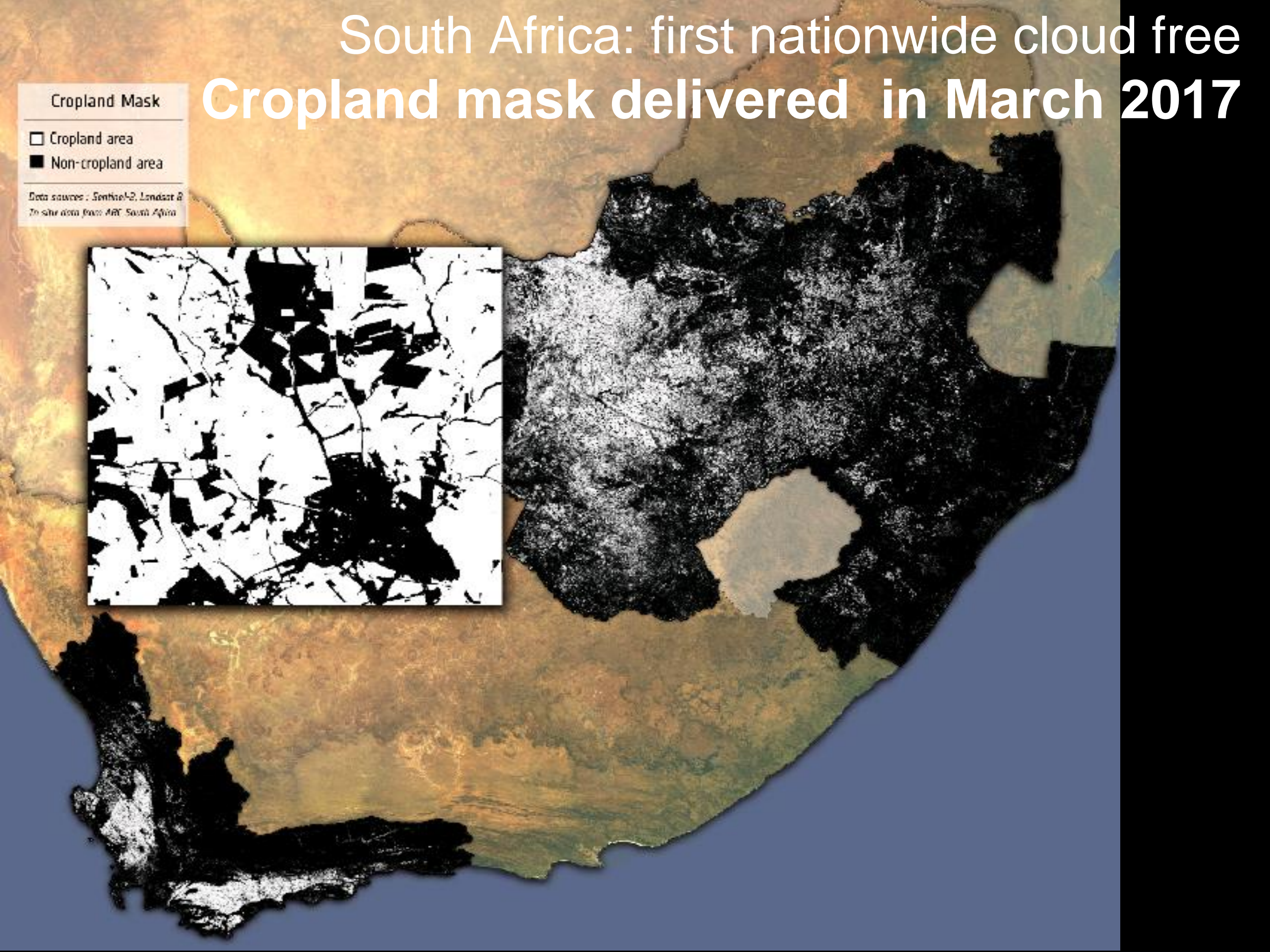


South Africa: first nationwide cloud free Cropland mask delivered in March 2017

Cropland Mask

- ☐ Cropland area
- ☒ Non-cropland area

Data sources : Sentinel-2, Landsat 8
In situ data from ARC South Africa



NRT
demand to
localise
mobile grain
silo

Overall Accuracy 81 %

Main Crops	F1-Score
Wheat	82%
Barley	68%
Oilseed crops	92%
Fodder crops	89%

Cape Town

sentinel-2

→ AGRICULTURE

Winter grain production region

Western Cape Province monitored by Sentinel 2 in 2016



3 days to convert ~7 TB of images into a cropland mask of 6,6 Gb !

Data volume

- ◆ **Cropland mask : 6,6 Gb** for a national Ukraine coverage, i.e. an area of ~600 000 km²
- ◆ **Crop Type map : 2,7 Gb** for a national Ukraine coverage, i.e. an area of ~600 000 km²
- ◆ Amount of L1C Sentinel-2 and L1T Landsat 8 data downloaded : **2,16 TB**
- ◆ Amount of L2A generated : **6,86 TB**

System performance

- ◆ **Cropland mask** : about 3 days for the raw crop mask, about 5 days for the post filtering step
- ◆ **Crop Type map** : about 2 days
- ◆ **Atmospheric Correction** : 30min / tile

Hardware specification: 2 x Intel(R) Xeon(R) CPU E5-2650 v3 @ 2.30GHz (20 cores total, 40 threads), 128 GB RAM (26 TB disk space)



Availability of the system

- Free, open access and fully documented from 28 June 2017
<http://www.esa-sen2agri.org/>
- Open meeting FAO (Rome) : champion users product's feedback
- Operational system: GNU/Linux

The system interface for Sentinel-2 for Agriculture monitoring is shown. The main dashboard includes a navigation bar with links to sites, products, system overview, dashboard, custom jobs, and monitoring. A 'Create new site' button is present. The 'Add New Site' modal window shows fields for Site name (Test Site), Seasons, Upload site shape file, and an Enable site toggle (ON). The 'Edit Site' modal window displays a table of seasons and active processors.

Season name	Season start	Season mid	Season end	Enabled	Active processors	Action
Summer	2017-04-21	2017-04-30	2017-05-31	ON	<input checked="" type="checkbox"/> L2A <input checked="" type="checkbox"/> L3A <input checked="" type="checkbox"/> L3B <input checked="" type="checkbox"/> L4A <input type="checkbox"/> L4B	

Merci pour votre attention



Contact: cindy.delloye@uclouvain.be

