Sentinel-2 for Agriculture Project

Take 5 Data Set to Anticipate Sentinel-2 Exploitation for Agriculture Monitoring Applications

Bellemans N., Arias M., Bontemps S., Dedieu G., Guzzonato E., Hagolle O., Inglada J., Matton N., Morin D., Rabaute T., Savinaud M., Sepulcre G., Valero S., Defourny P., Koetz B.

Sentinel-2 for Agriculture

Launched by ESA in Feb. 2014

Objective:

- **Preparation for national to regional agricultural monitoring based on Sentinel-2**
- **Consolidate best practices for EO agricultural monitoring**
- **Strengthening national capacity for agricultural monitoring**

3-phases project over 3 years

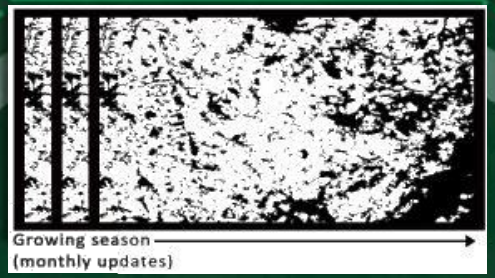
Algorithm Development 2014	System development and EO prototype products 2015	Demonstration & Validation 2016

User-driven approach (DUE programme)

18 Champion Users + 13 Sites Managers

Toolbox for 4 S2-based products in line with the GEOGLAM core products

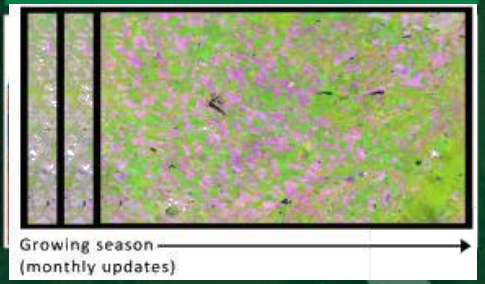
DYNAMIC CROPLAND MASK



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

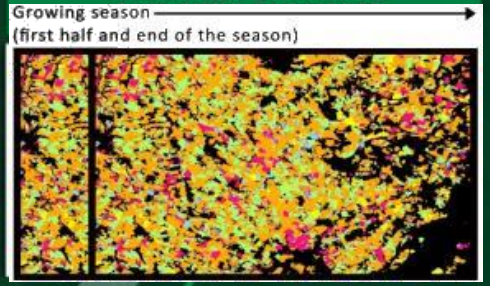
Monthly cloud free surface reflectance composite at 10-20m

CLOUD FREE SURFACE REFLECTANCE COMPOSITES



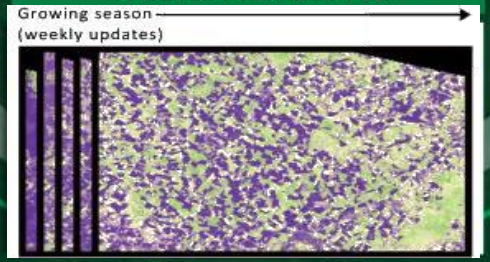
Open source toolbox
Capacity building and training

CULTIVATED CROP TYPE MAP



Crop type map at 10m for the main regional crops (twice during the season)

VEGETATION STATUS



Vegetation status maps delivered every 10 days (NDVI, LAI, pheno index)

A unique dataset made of Sentinel-2 like EO time series …

12 sites globally distributed to develop algorithms where EO dataset mainly made of **SPOT4- Take 5**

(Bontemps et al., RS2015)

A unique dataset made of Sentinel-2 like EO time series …

12 sites globally distributed to develop algorithms where EO dataset mainly made of **SPOT4- Take 5**

(Bontemps et al., RS2015)

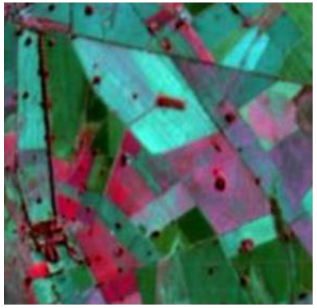
8 sites to repeat the experience and test the robustness of the selected algorithms with dataset mainly made of **SPOT5-Take 5**

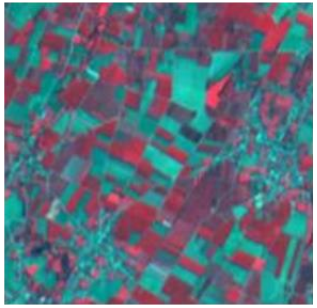
… and globally spread in-situ data set

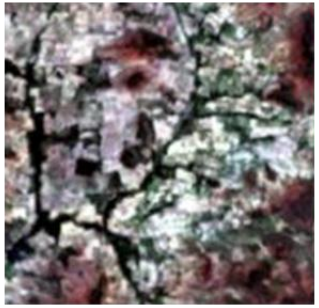
Site	2013	2015
Argentina	Crop (108) – No crop (39)	X
Belgium	Crop (31244)-No crop (78156) GAI, PAI, FAPAR, FCOVER	Crop (41) – No crop (68594) GAI
Burkina Faso	Crop (496) – No crop (101)	Crop (611) – No crop (141)
China	Crop (54) - No crop (22)	Crop (142) – No crop (20)
France	Crop (1500) - No crop (7659) GAI, PAI, FAPAR, FCOVER	Crop (985) – No crop (809) GAI, PAI, FAPAR, FCOVER
Mali	X	Crop (497) – No crop (80)
Morocco	Crop (636) - No crop (500) LAI	X
Pakistan	Crop (228) – No crop (54)	X
Russia	Crop (205) - No crop (56)	Crop (85) – No crop (44) GAI, PAI, FAPAR, FCOVER
South Africa	Crop (120) - No crop (44)	Crop (182) – No crop (599)
Ukraine	Crop (221) - No crop (56) GAI, PAI, FAPAR, FCOVER	Crop (70) – No crop (69)
Maricopa (USA)	Crop (4907) – No crop (11351)	X

Successful development thanks to JECAM collaborative network

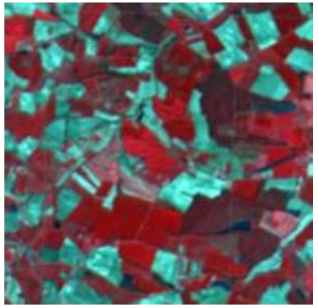
Wide range of agricultural systems

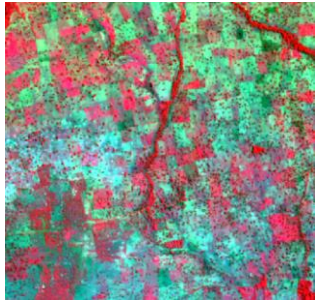

Argentina

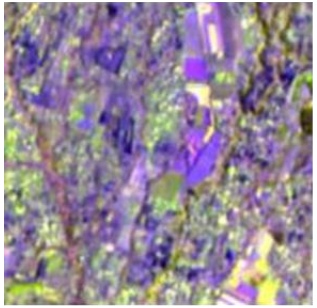

Belgium

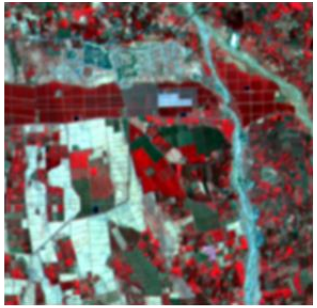

Burkina Faso


China

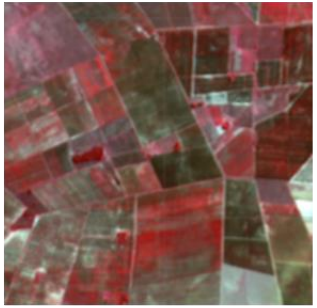

France

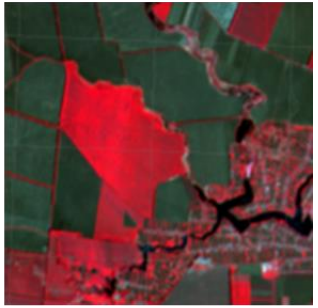

Mali


Madagascar


Morocco


Russia


South Africa


Ukraine


Maricopa

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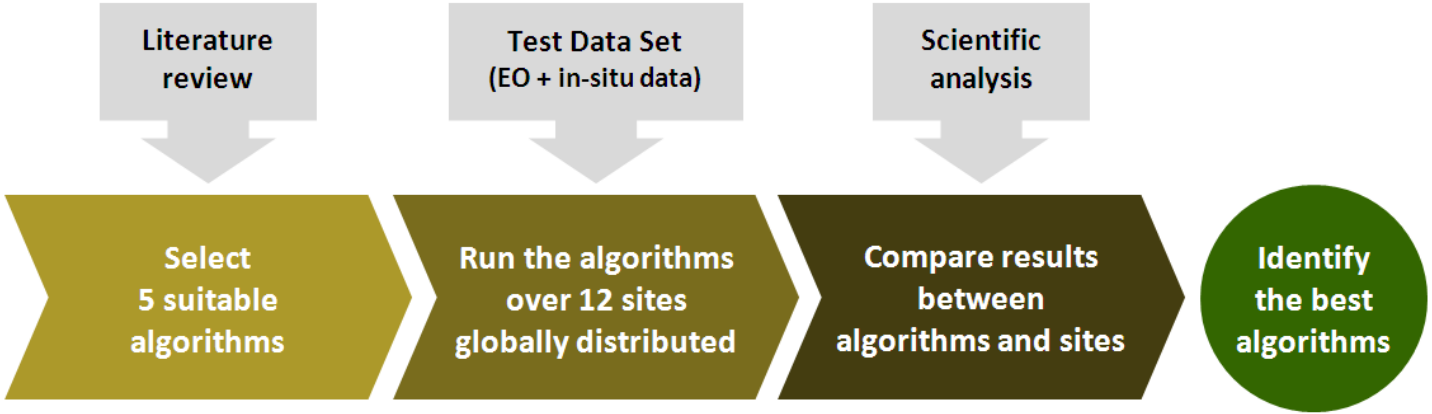
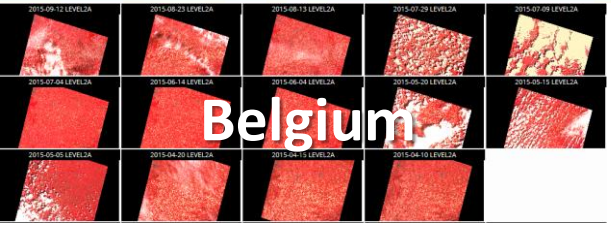
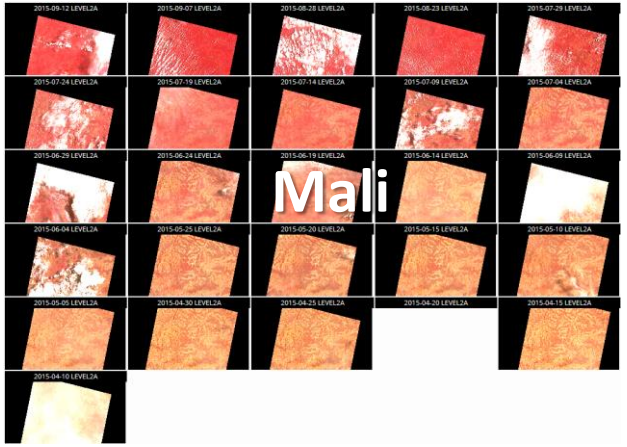
→ AGRICULTURE

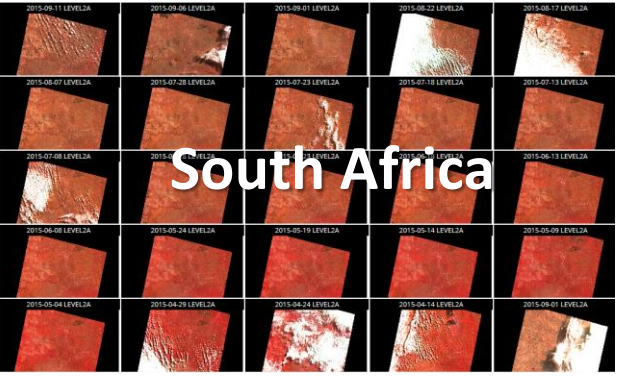
Benchmarking for a transparent and objective algorithms selection using SPOT4Take5 data

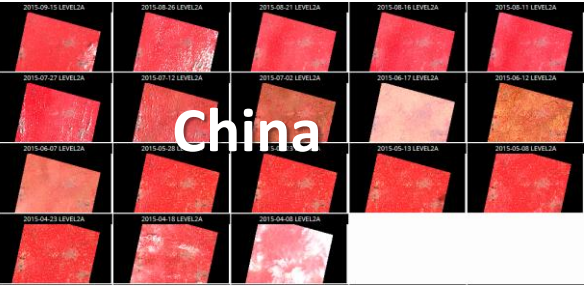


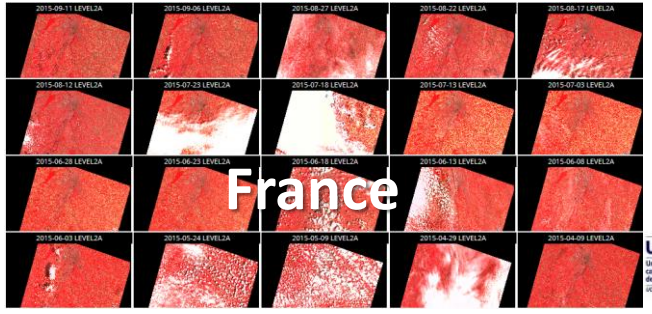
Repeating and testing the robustness with SPOT5-Take5 dataset











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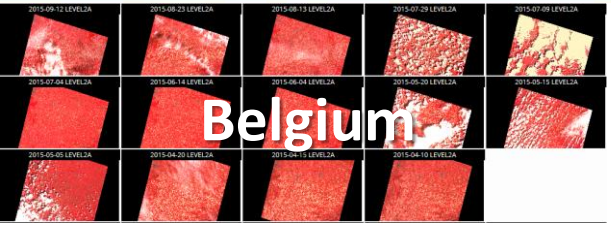
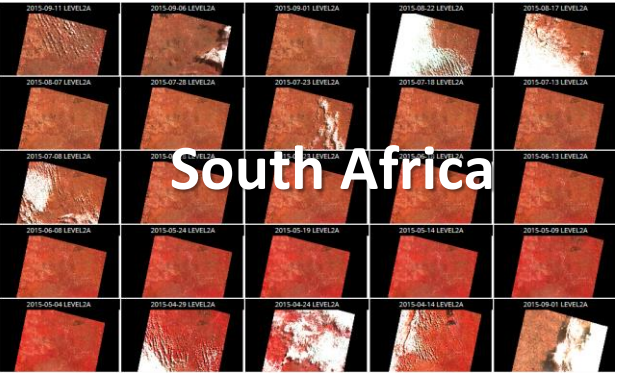
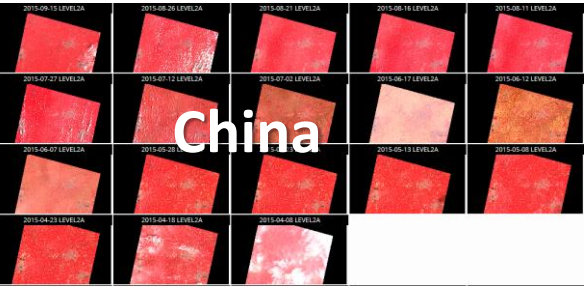
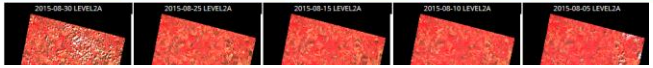
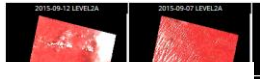
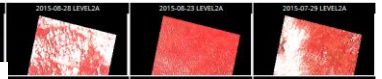




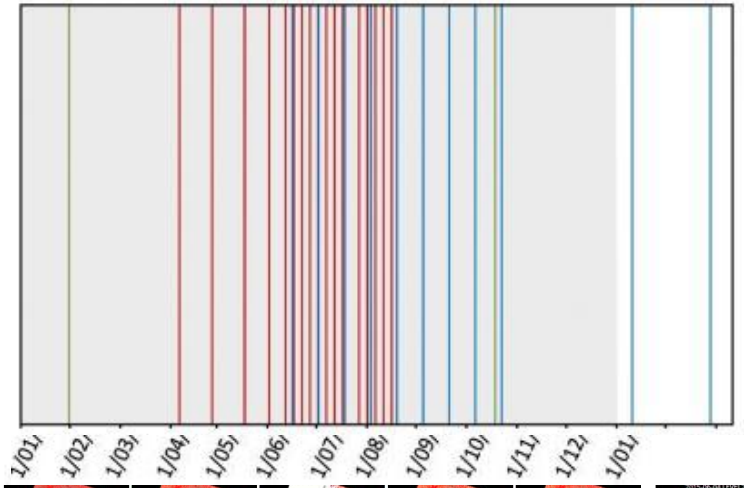


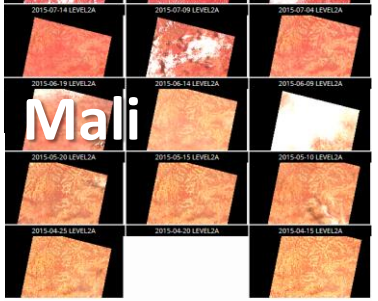


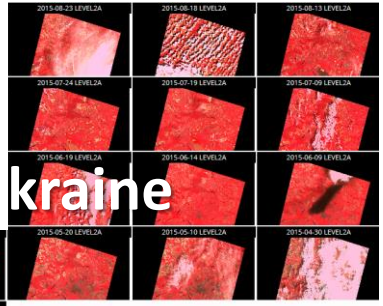


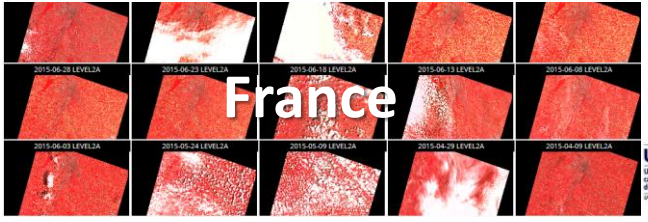


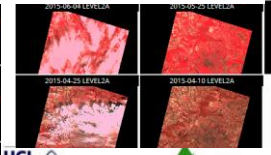
Landsat 8 and some RE acquisitions to complete the dataset when needed



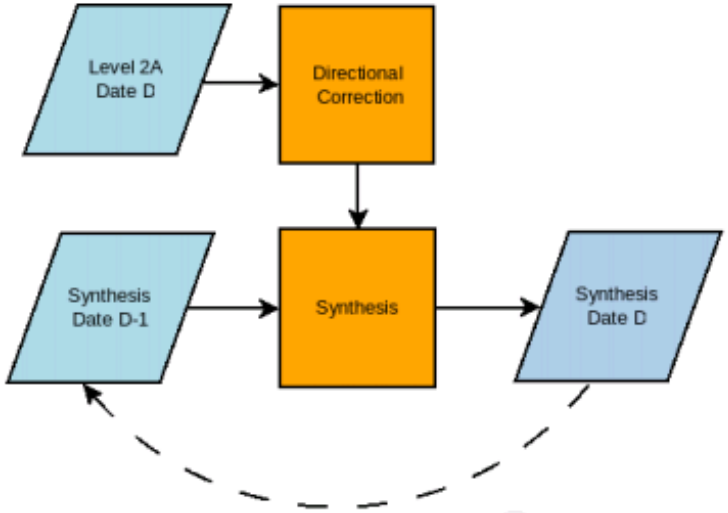








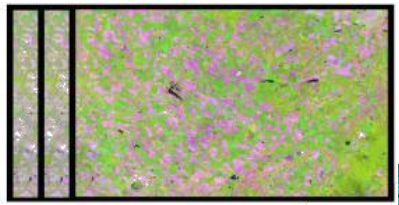
Monthly cloud-free composite



Benchmarking conclusions

- Weighted average approach
- Compositing period can vary between 30 to 50 days window
- Implements a directional correction for seamless composites
- Recurrent implementation : L3A product updated with each new L2A product

  To limit the data volume to keep on-line in Sen2Agri system



sentinel-2

→ AGRICULTURE

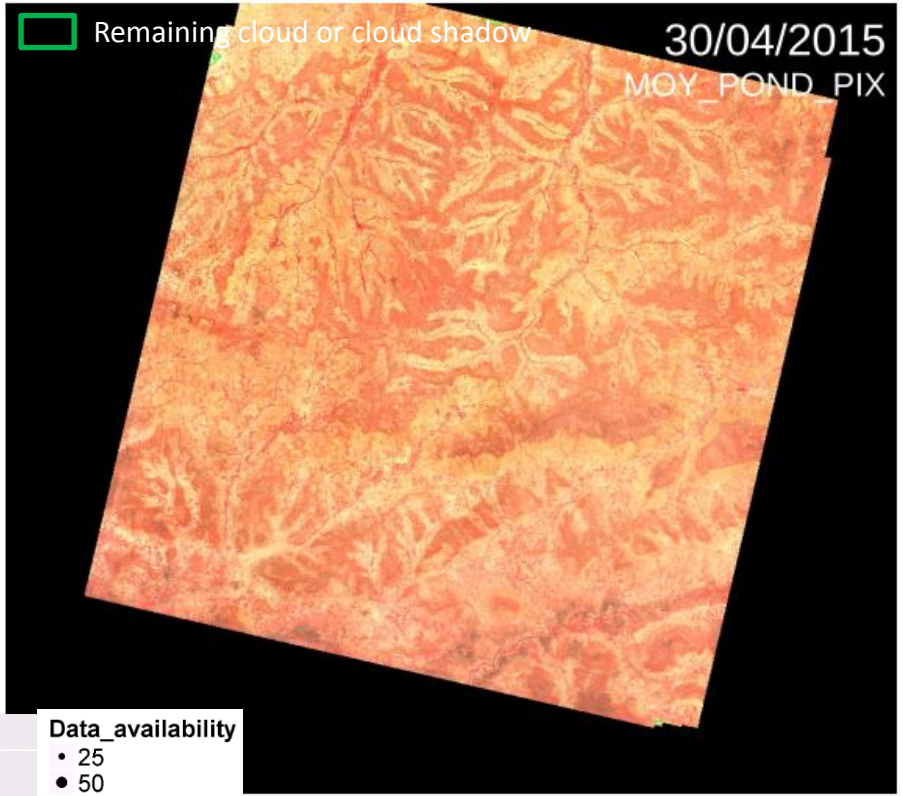
Glimpse of 2015 results on Mali site

Site : **Ourikela-Mali**

From 2015-04-10 to 2015-09-12

5 monthly composites

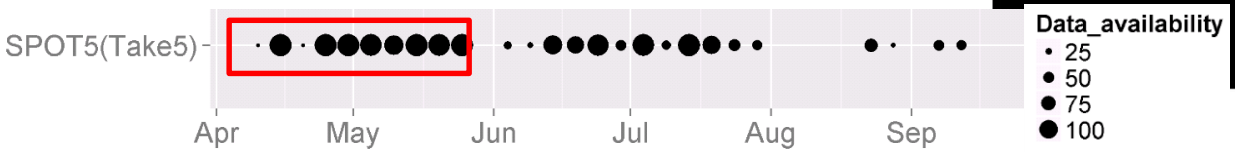
Compositing period: 50 days



- Artefacts and higher proportion of remaining gaps on the edges due to SPOT5 footprint instability

- Even with a temporal period of 50 days for compositing, there are still gaps in rainfall season. (~25 % of soil is not visible from 07-20 to 09-10)

Composite period w/r to the data availability



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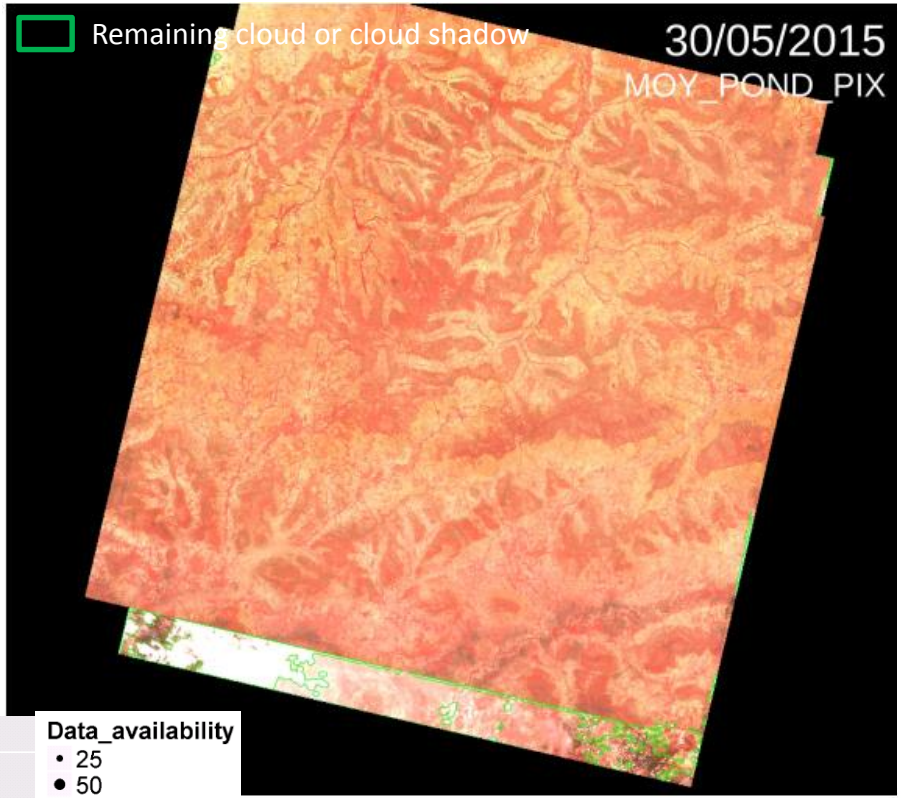

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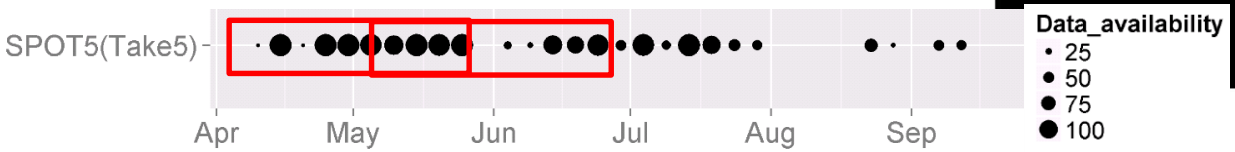

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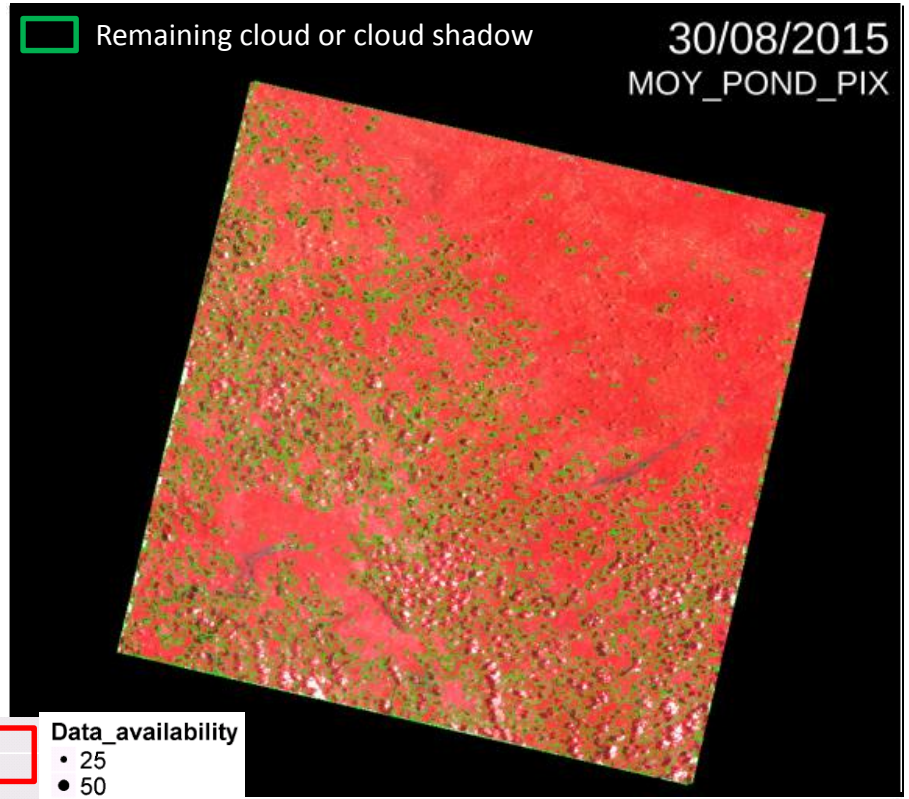

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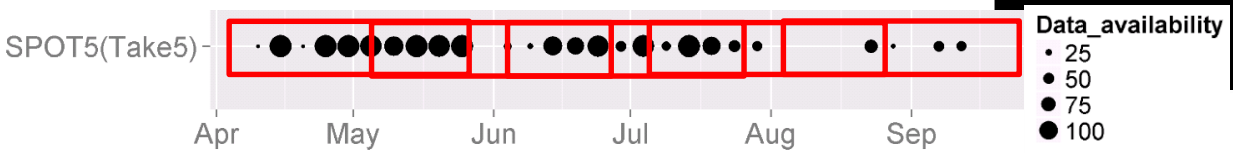
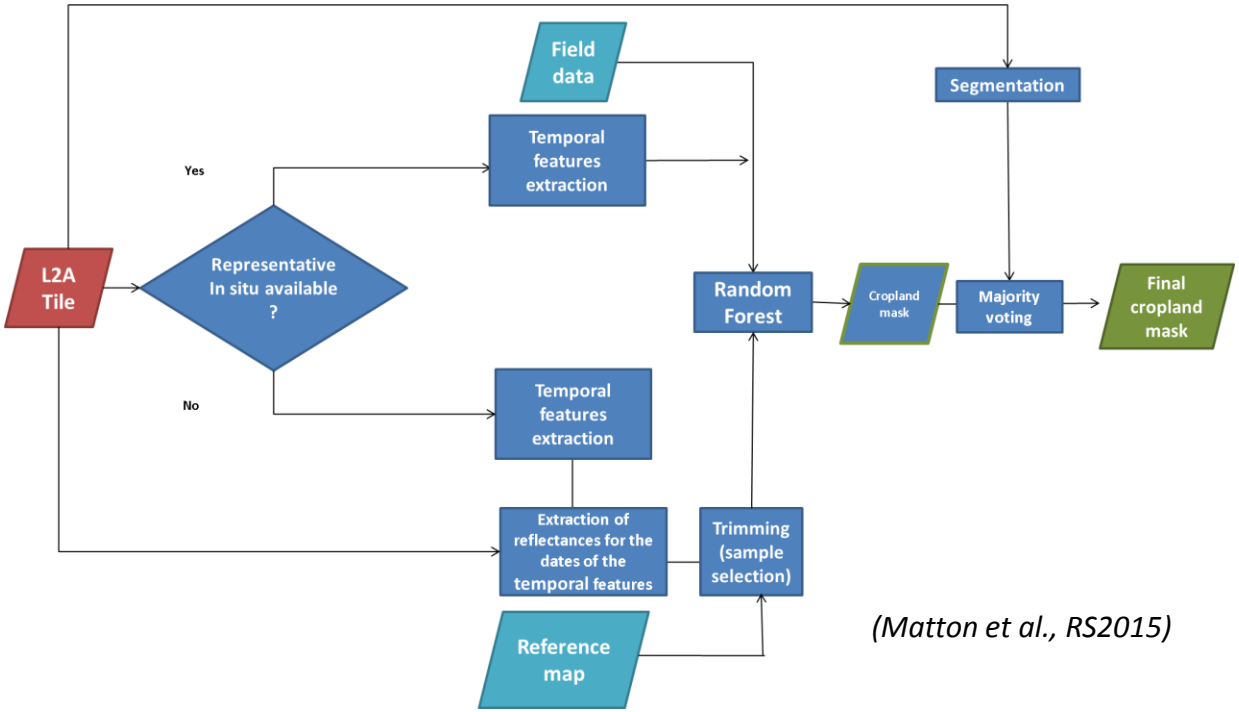


Dynamic cropland mask

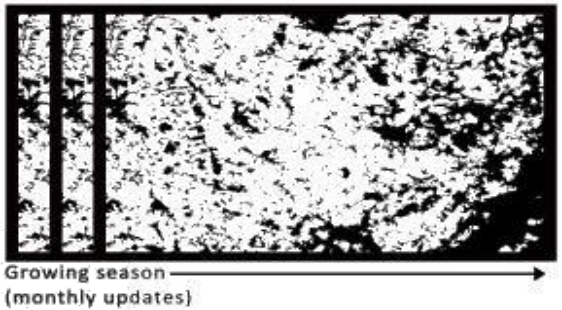
(Valero S. et al., RS2016)



(Matton et al., RS2015)

Benchmarking conclusions

- 2 chains implemented to deal with presence/absence of in-situ data
- RF supervised algorithm
- Trimming to clean an reference map
- A posteriori smoothing based on a per-object approach



sentinel-2

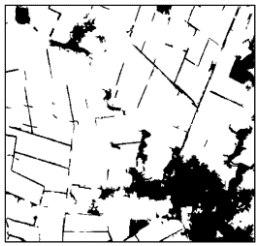
→ AGRICULTURE

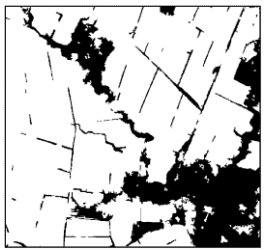
Exemples on few SPOT4 sites

Ukraine

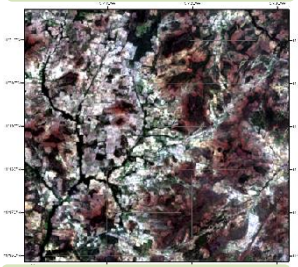
Without in situ

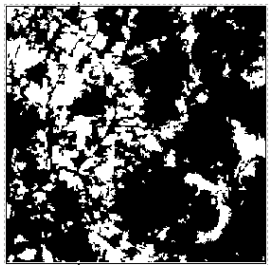
With in situ

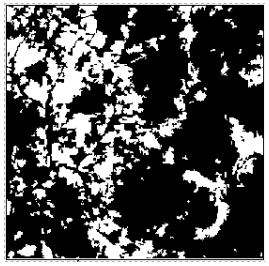




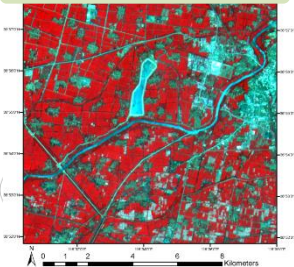
Burkina Faso

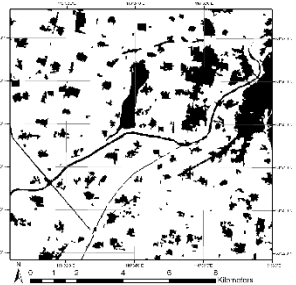






China

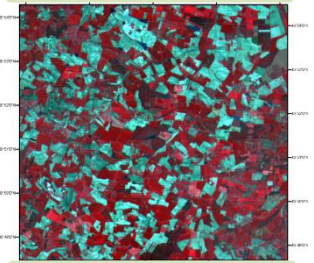


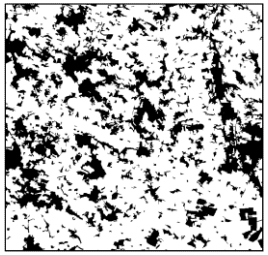


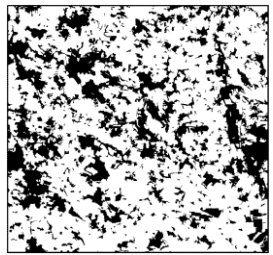
France

Without in situ

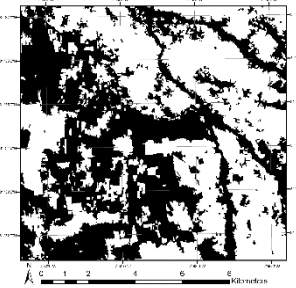
With in situ

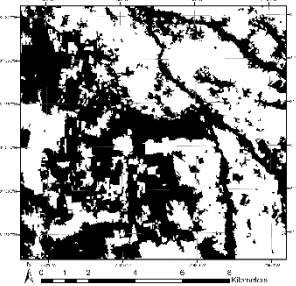




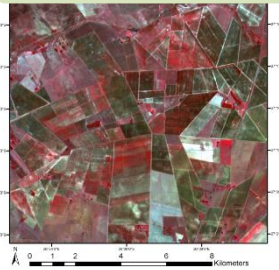


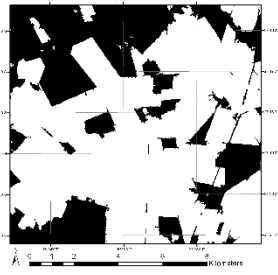
Madagascar

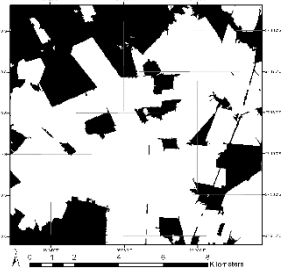




Morocco

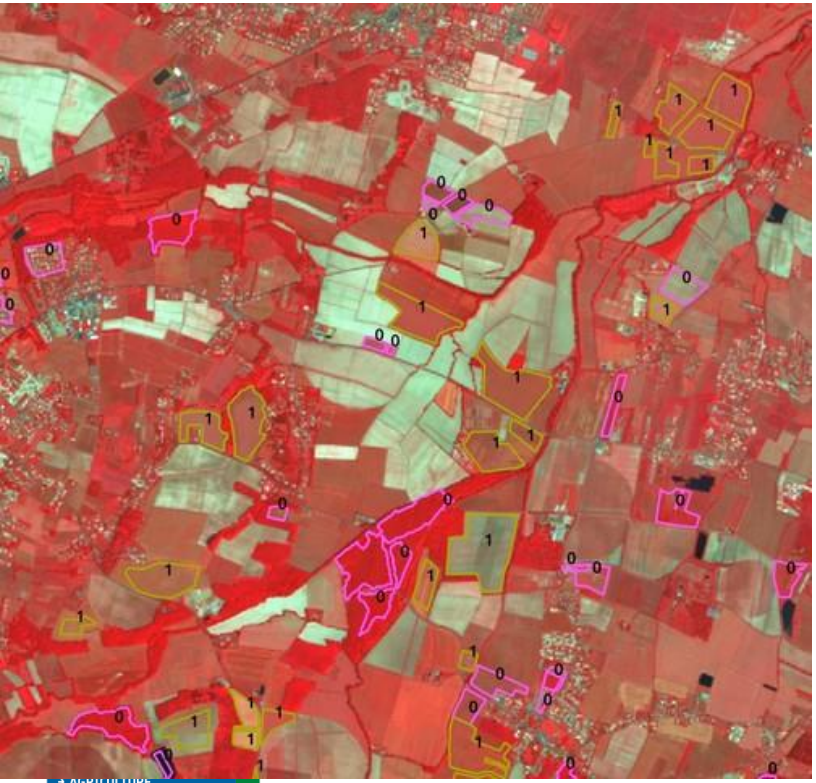






2015 Crop mask – Using in situ data
Auch-France

SPOT5 30/05/2015 - False colors composite



Crop mask legend

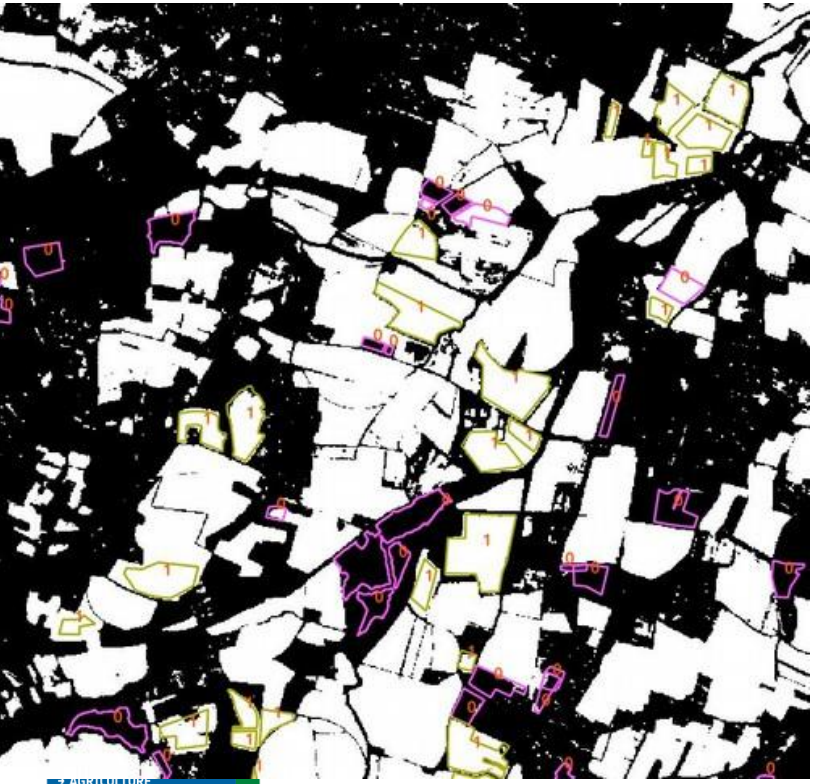
- No crop
- Crop

Validation data

- No crop
- Crop

2015 Crop mask – Using in situ data
Auch-France

Crop mask pixel



Crop mask legend

- No crop
- Crop

Validation data

- No crop
- Crop

2015 Crop mask – Using in situ data
Auch-France

Crop mask pixel → Majority vote with segmentation

9 month

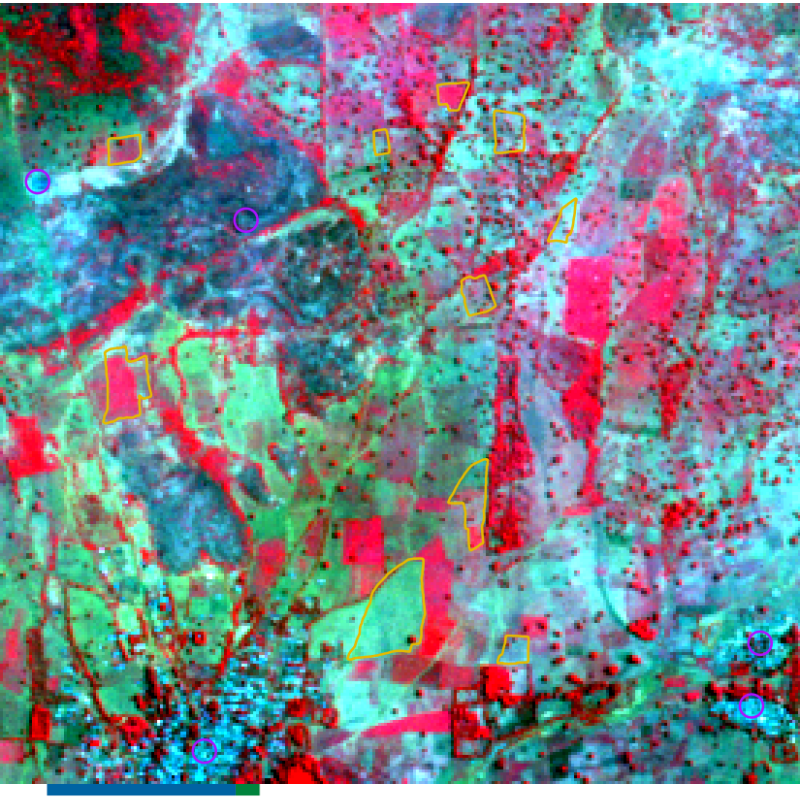
	Fscore_noCrop	Fscore_Crop	Kappa	OverallAccuracy
Mean	0.873	0.939	0.812	0.918
CI-95	0.007	0.003	0.007	0.003

9 month with post-processing

	Fscore_noCrop	Fscore_Crop	Kappa	OverallAccuracy
Mean	0.885	0.945	0.829	0.925
CI-95	0.005	0.003	0.006	0.003

2015 Crop mask – Using in situ data
Mali - Ourekila

SPOT5 30/07/2015 - False colors composite



Validation data

- No crop
- Crop

2015 Crop mask – Using in situ data
Mali - Ourekila

Crop mask pixel → Majority vote with segmentation

6 month

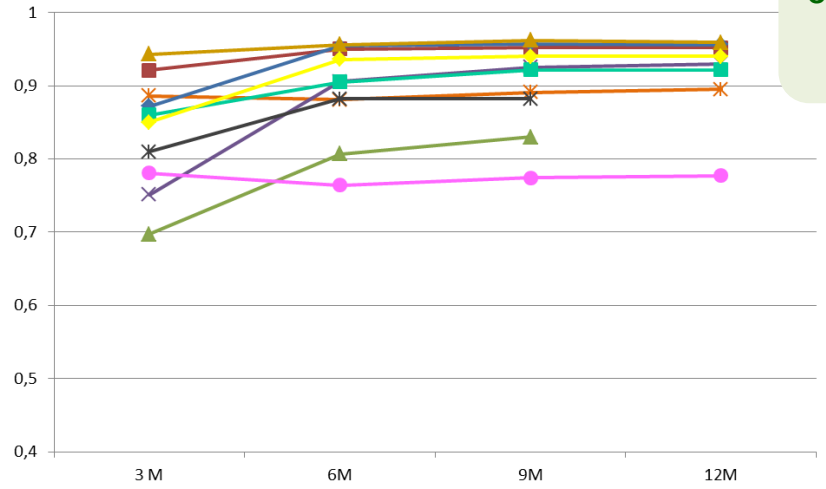
	Fscore_noCrop	Fscore_Crop	Kappa	OverallAccuracy
Mean	0.834	0.922	0.756	0.894
CI-95	0.011	0.009	0.018	0.010

6 month with post-processing

	Fscore_noCrop	Fscore_Crop	Kappa	OverallAccuracy
Mean	0.869	0.940	0.809	0.918
CI-95	0.010	0.007	0.016	0.009

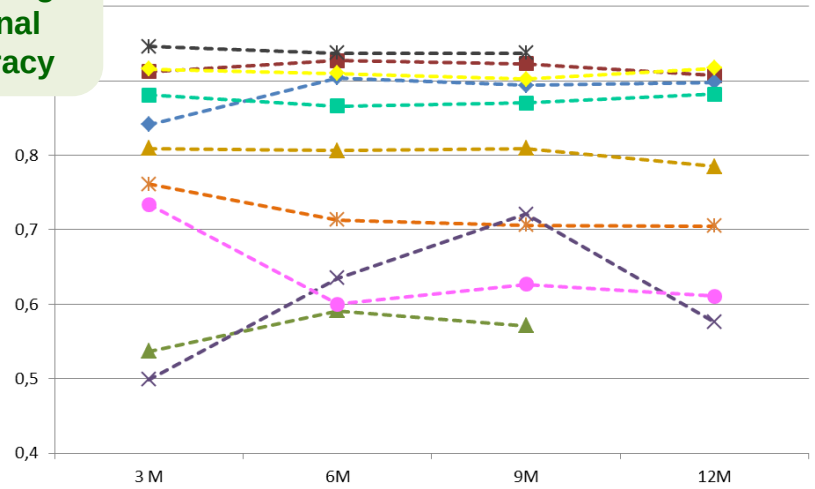
Efficient annual cropland mapping along the season

Overall accuracy – With in situ



6 months of observations enough to reach the final cropland accuracy

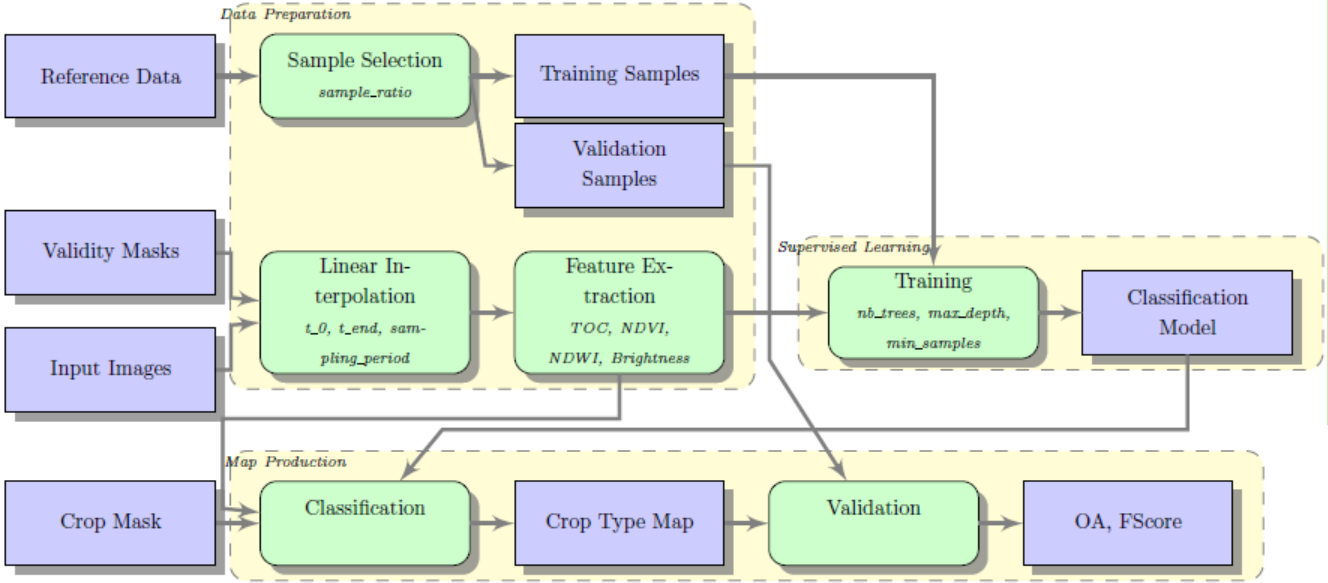
Overall accuracy – Without in situ



Approach using in situ better than without in situ one.

Without in situ method reachs the OA targets => also interesting as many situations where field campaigns are not ensured (e.g. 1st year of activity, food insecure countries, political instabilities, etc.)

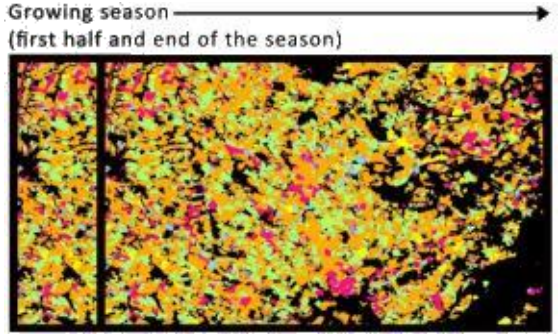
Crop type map



(Inglada et al., RS2015)

Benchmarking conclusions

- Based on the crop mask previously generated
- Random forest classifier
- Classifier applied on features :
  - Surface reflectance
  - NDVI
  - NDWI
  - Brightness



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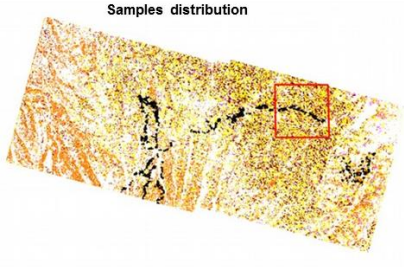
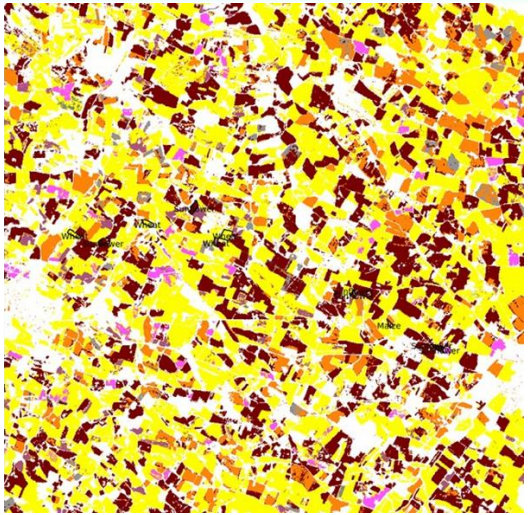
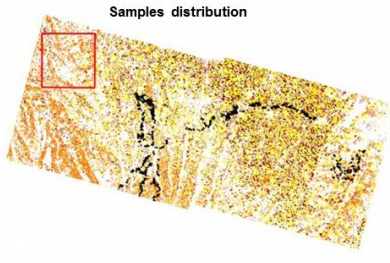
2015 Crop type over Toulouse region (France)







No crop/No data
Wheat
Maize
Barley
Rapeseed
Sunflower
Other annual crops

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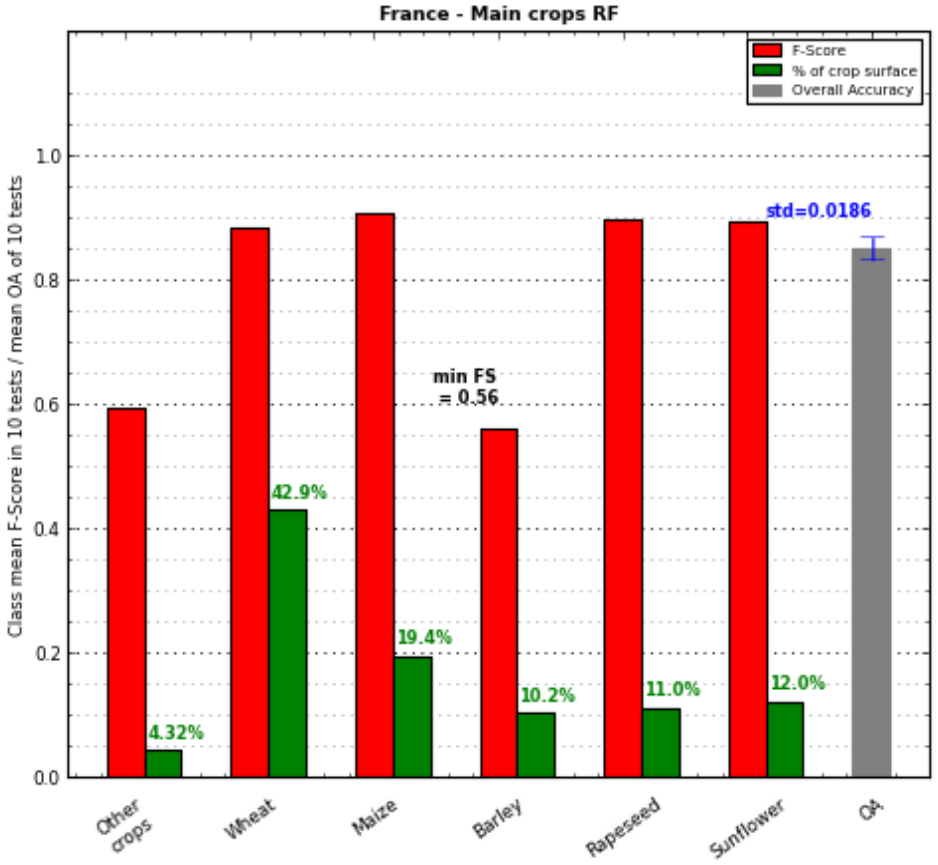
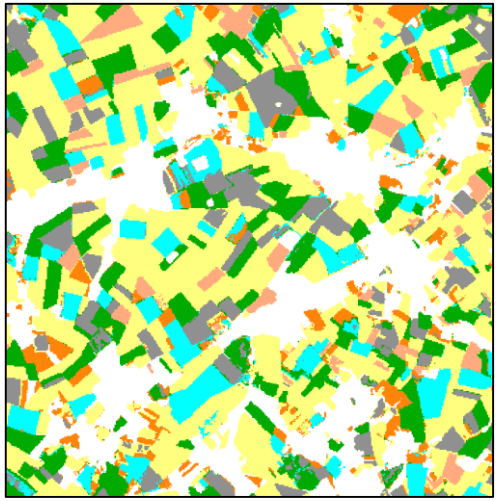
Crop type (Auch - France)



* Overall Accuracy : 0,8512
* 4 main crops F-Score > 0,80
* Barley : confusion with wheat

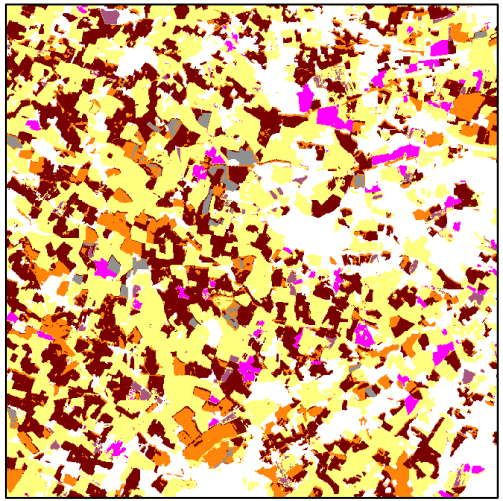
Argentina

- Maize
- Soybeans



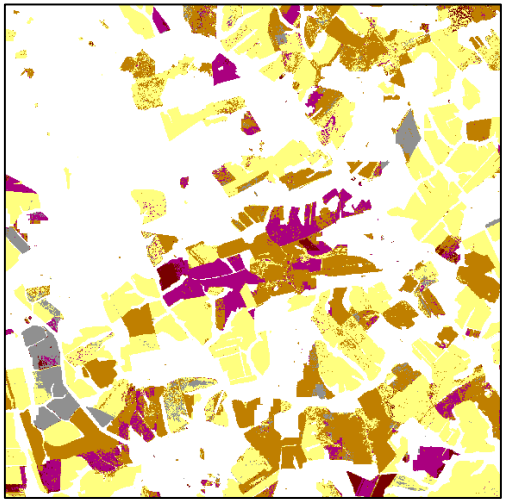
Belgium

- Maize
- Potatoes
- Sugar beet
- Winter wheat
- Winter barley
- Other annual crops



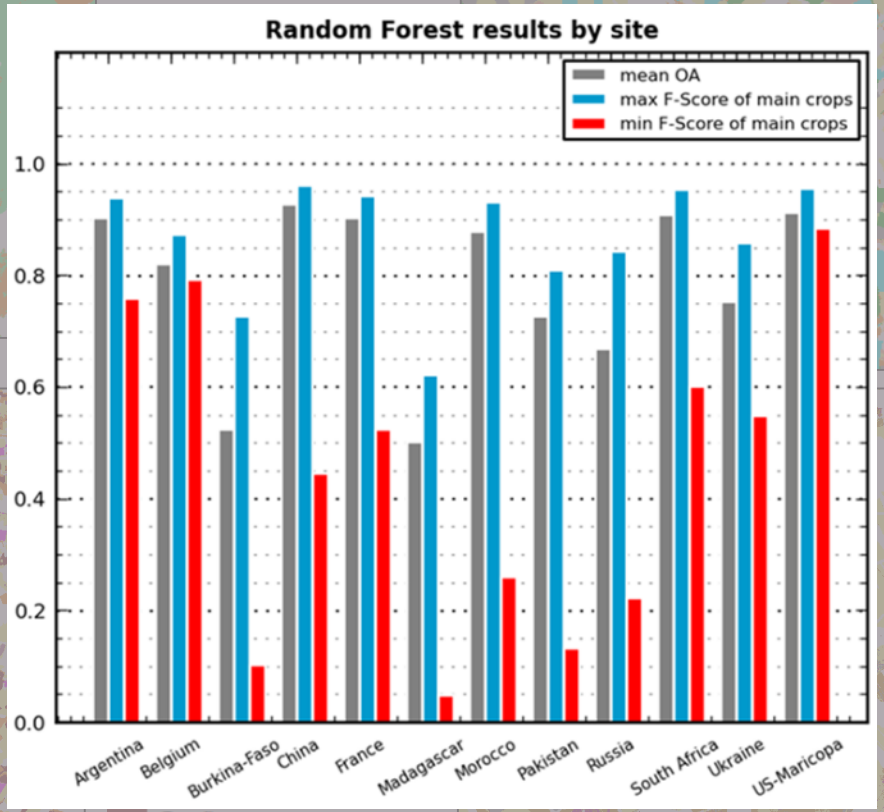
France

- Wheat
- Maize
- Barley
- Rapeseed
- Sunflower
- Other annual crops



Russia

- Winter wheat
- Spring barley
- Rapeseed
- Sunflower
- Other annual crops



Argentina

Belgium

Maize
Potatoes
Sugar beet
Winter wheat
Winter barley
Other annual crops

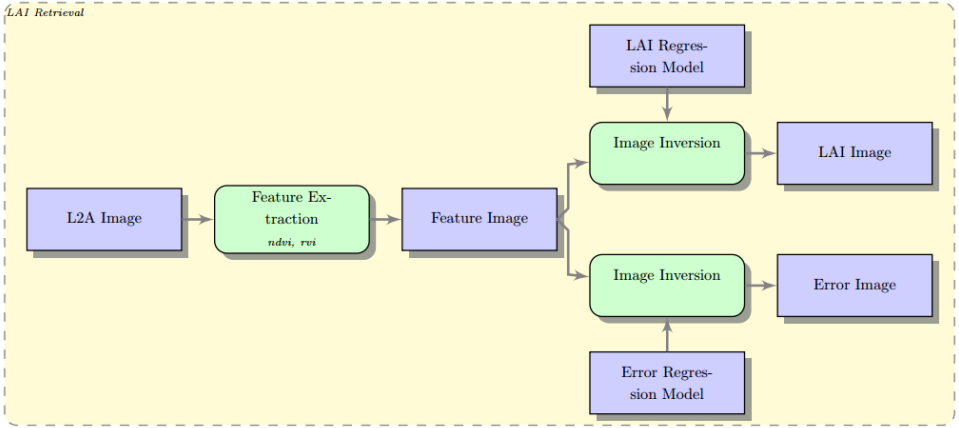
Russia

Winter wheat
Spring barley
Rapeseed
Sunflower
Other annual crops

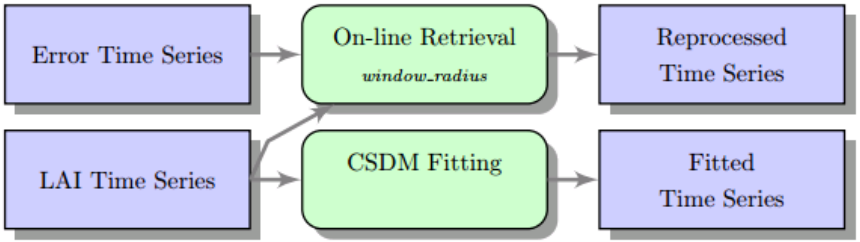
Sunflower
Other annual crops

3 LAI products

- Mono-date LAI estimation



- Multi-date and fitted LAI reprocessing



Benchmarking conclusions

- Non-linear regression model
- Reflectance are simuated using the ProSail model
- 2 reprocessing options :
  - Weighted average using the n last LAI value
  - Fitting a phenological model on the full time series

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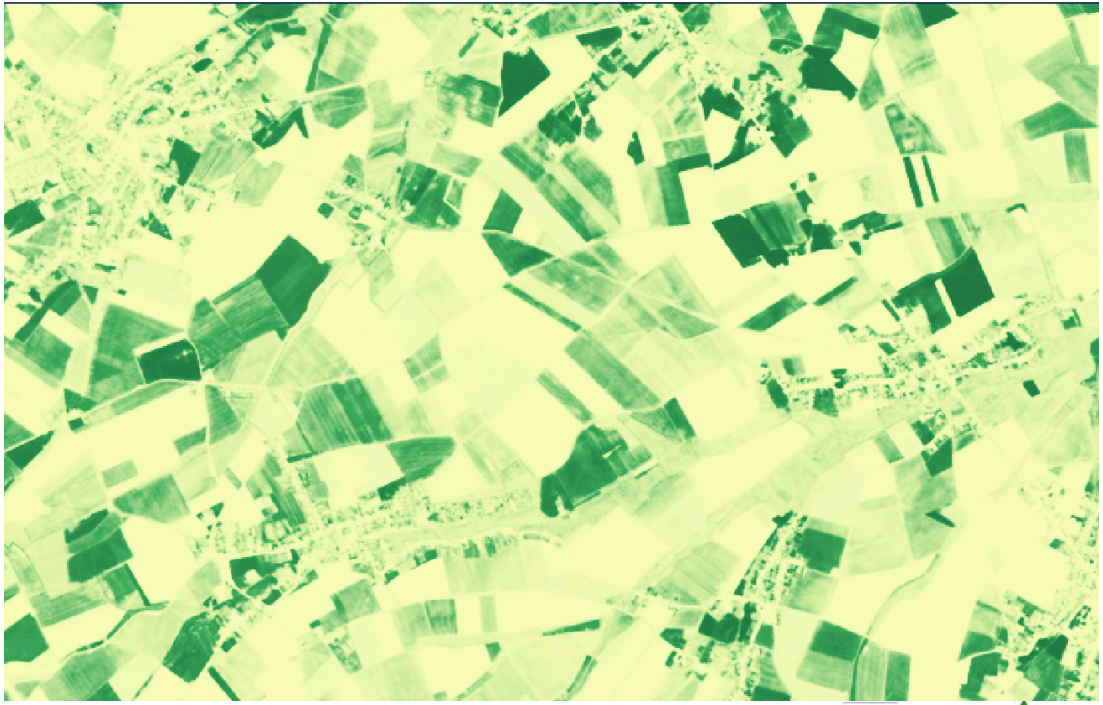
2015 monodate LAI series over Belgium

2016 Growing season

10-04-2015



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2015 monodate LAI series over Belgium

20-04-2015

2016 Growing season

10-04-2015

sentinel-2

→ AGRICULTURE

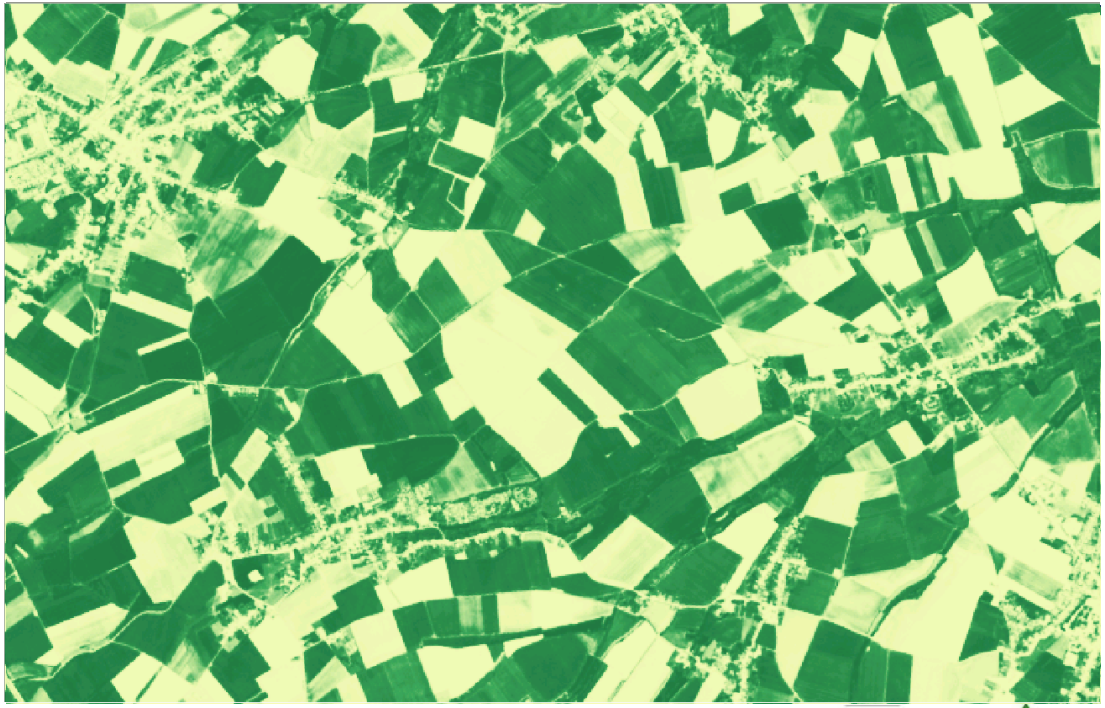
2015 monodate LAI series over Belgium

20-04-2015

2016 Growing season

10-04-2015

04-06-2015



LAI value

5

2

0.5

0.25

0

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2015 monodate LAI series over Belgium

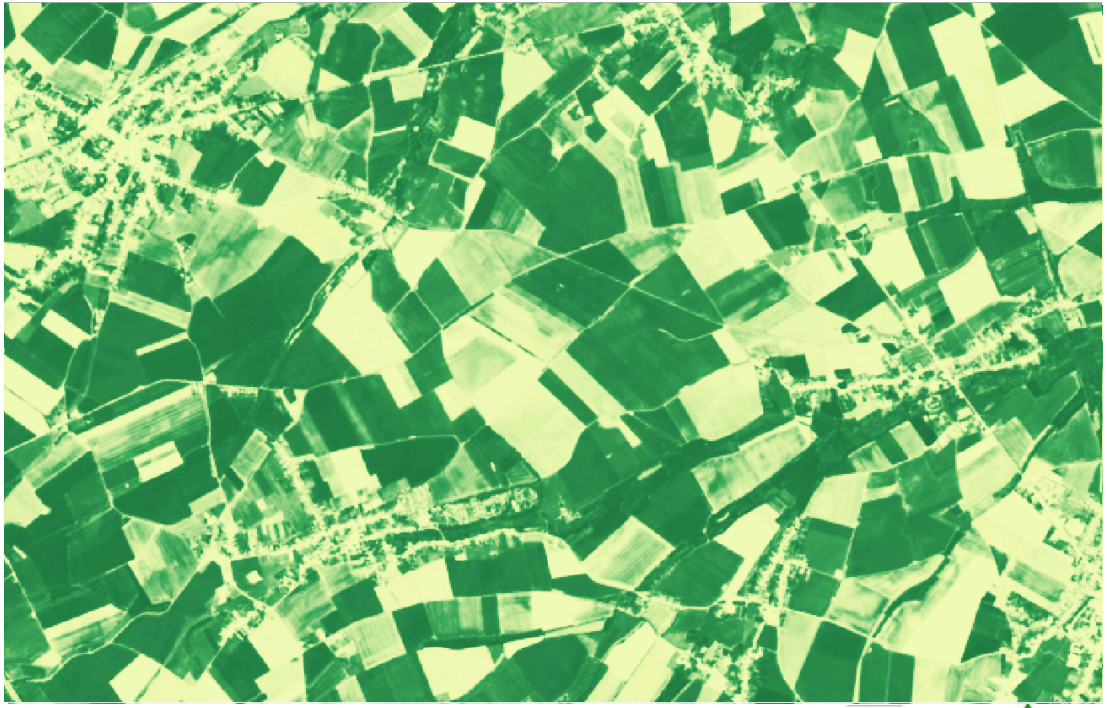
20-04-2015

14-06-2015

2016 Growing season

10-04-2015

04-06-2015



LAI value

5

2

0.5

0.25

0

sentinel-2

→ AGRICULTURE

2015 monodate LAI series over Belgium

20-04-2015

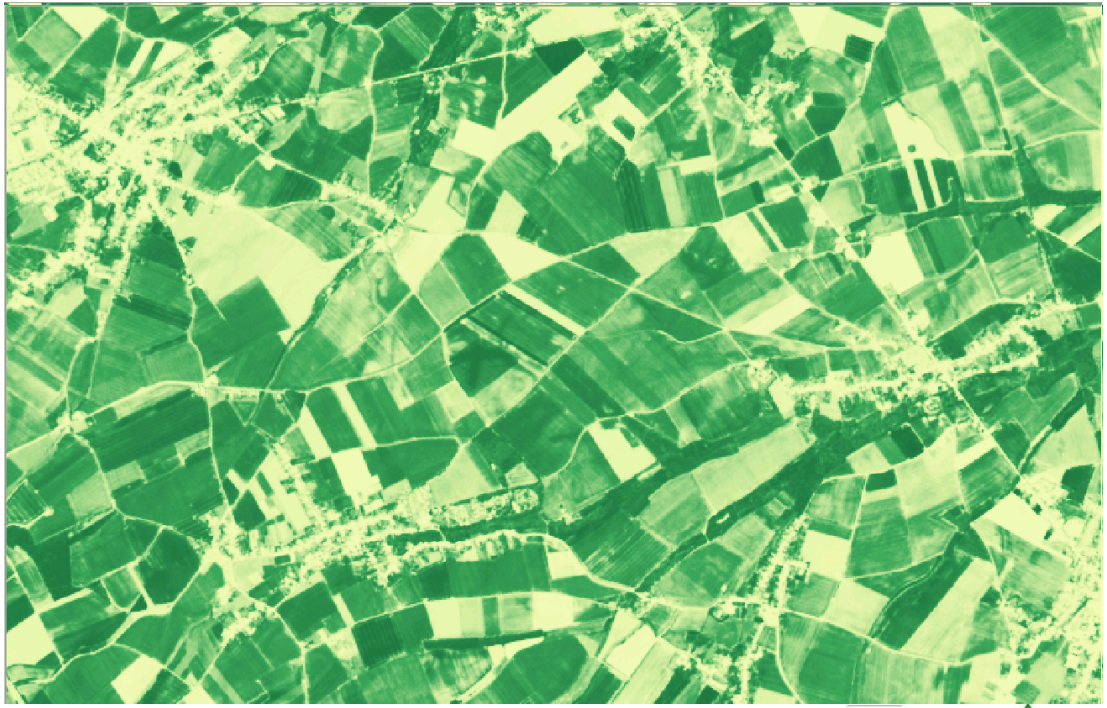
14-06-2015

2016 Growing season

10-04-2015

04-06-2015

04-07-2015



LAI value

5

2

0.5

0.25

0

sentinel-2

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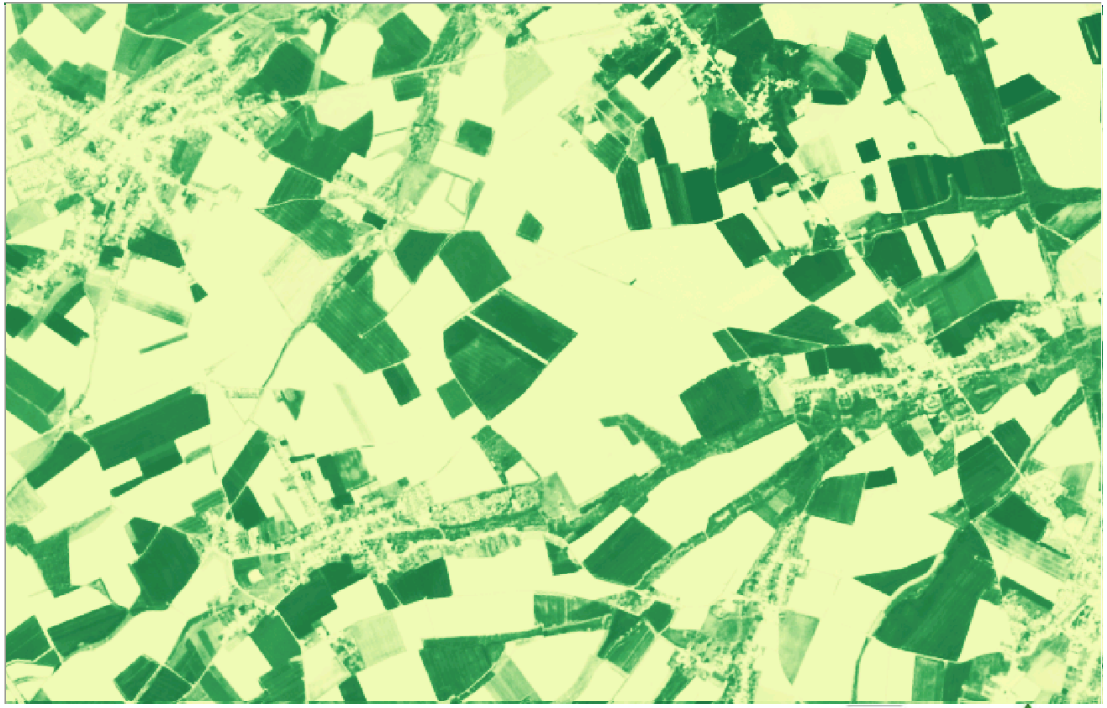
2015 monodate LAI series over Belgium

20-04-2015 14-06-2015 23-08-2015

2016 Growing season

10-04-2015 04-06-2015 04-07-2015



LAI value

5
2
0.5
0.25
0

sentinel-2

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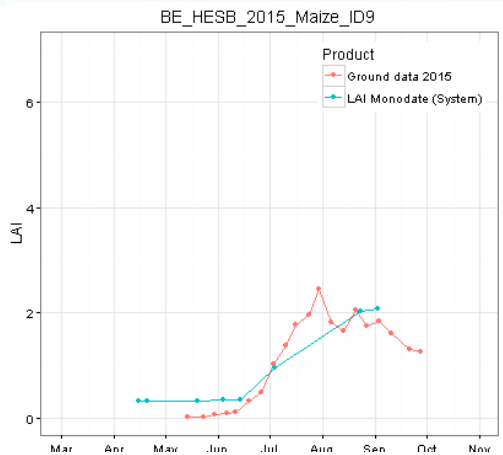
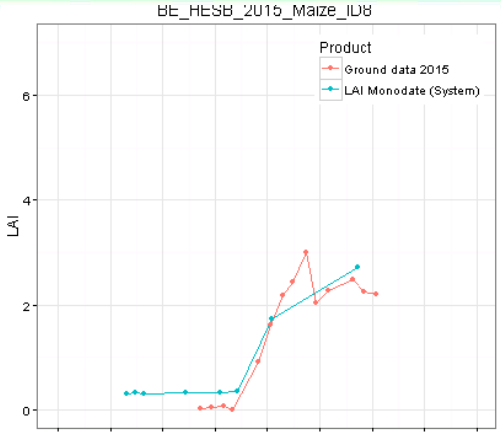
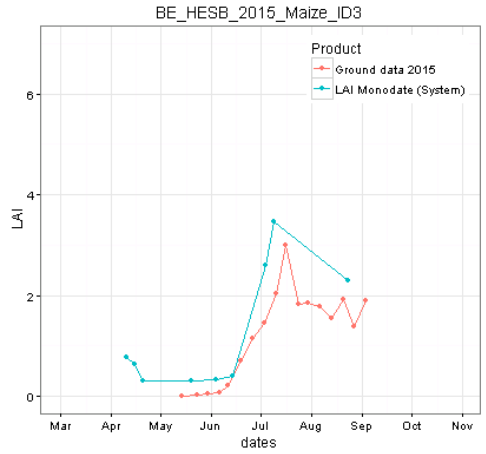
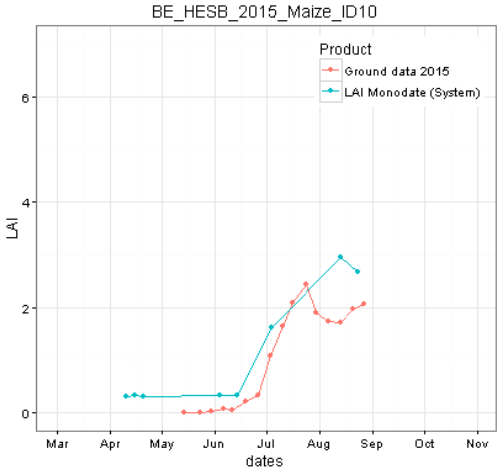
2015 monodate LAI profiles over Belgium





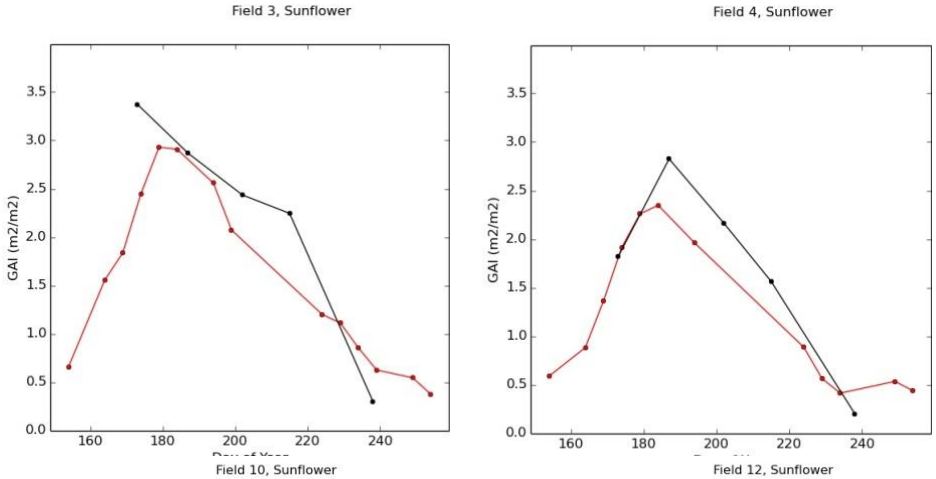




Ground data

LAI SPOT5

2015 monodate LAI profiles over France



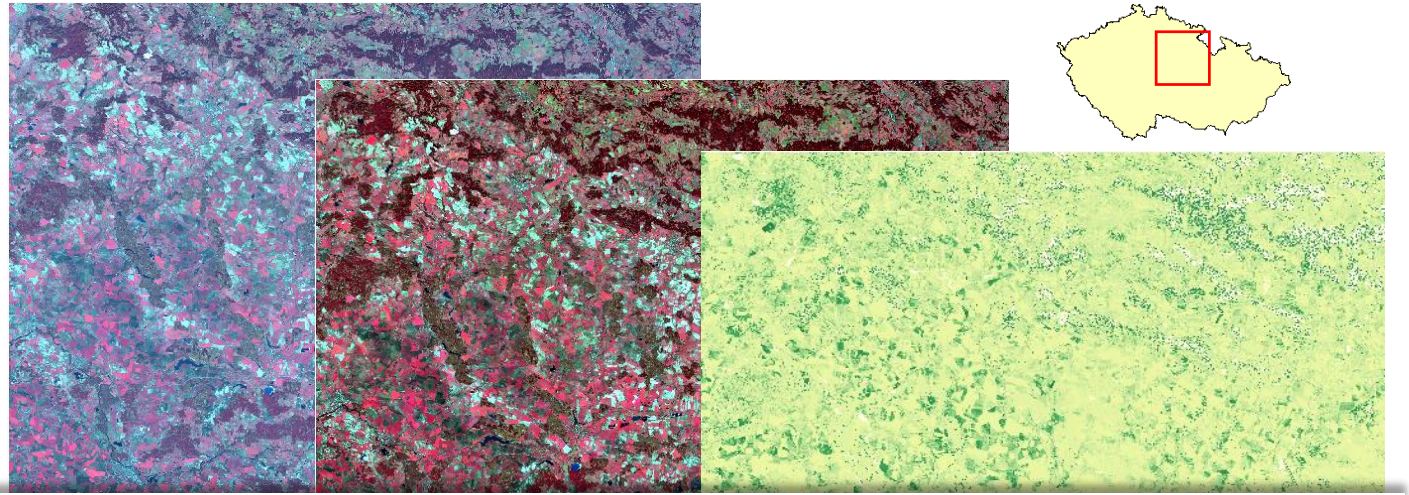
Ground data

LAI SPOT5

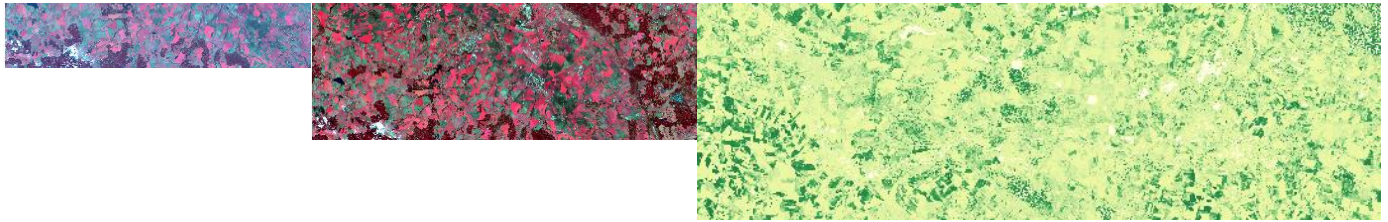
Conclusions

- SPOT4 (Take5) enabled to test methods in conditions similar to Sentinel-2
- Repeated experiment with SPOT5 (Take5) allows obtaining the same encouraging results
- With both experiments the project is now able to provide a strong scientific contribution to the JECAM network and GEOGLAM initiatives
- Contribute to fill the gap between operational systems and state-of-the-art
- Ready for demonstration phase allowing to test Sentinel-2 data in real conditions
- Many thanks to CNES and ESA for making this unique dataset available
- Successful development thanks to JECAM collaborative network

Thank you for your attention



Early results from Sen2-Agri system using S-2 over Czech Republic



sentinel-2

→ AGRICULTURE