

→ AGRICULTURE

### Advances in EO Technologies for Agricultural Monitoring

Waldner F., Defourny P., Bontemps S., Arias M., Bellemans N., Cara C., Dedieu G., Guzzonato E., Hagolle O., Inglada J., Morin D., Rabaute T., Savinaud M., Udroiu C., Valero S., Koetz B. & 12 benchmarking & demonstration site partnerS









· eesa

# Unique momentum for satellite remote sensing in agriculture



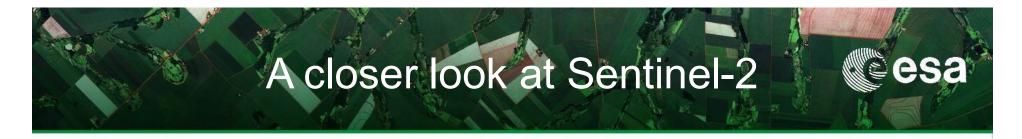
EO response to operational agricultural applications:

- Emerging collaborative initiatives endorsed by G20 in the context of GEO (AMIS, GEOGLAM)
   GEOGLAM
- JECAM initiative opening the door to move from local experiments to global solutions
   JECAM
- CEOS support to global agriculture users requirements
- US and Chinese efforts on 30-m global croplands mapping
- Sentinel-2a&b mission to finally reach agric. Application requirements, jointly with Landsat-8 and Sentinel-1a&b

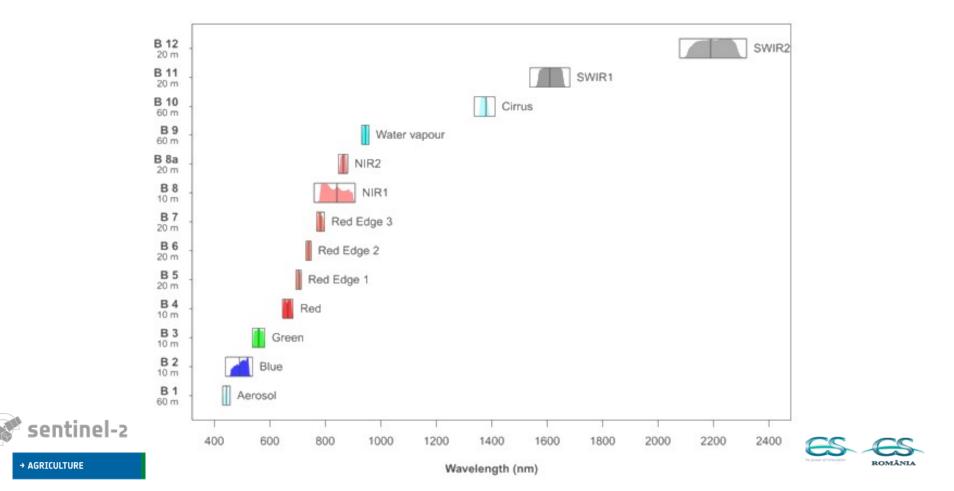




periment for Crop Assessment and Monitoring



# 10-day revisit cycle with Sentinel-2A, 5-day revisit cycle with Sentinel-2A and -B



# Sentinel-2 for Agriculture Objectives esa

# Preparation for national to regional agricultural monitoring based on Sentinel-2

• R&D for full exploitation of temporal & spatial resolution of S2

### **Consolidate Best Practices for EO agricultural monitoring**

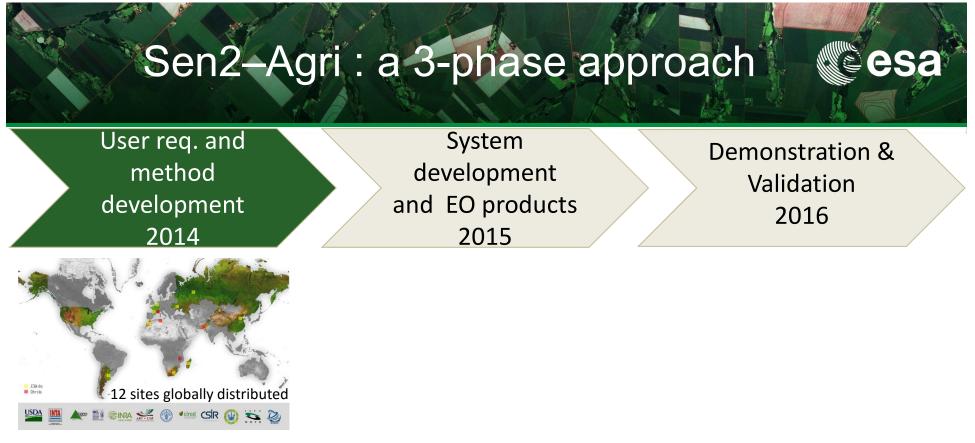
- Benchmarking & validation of algorithms for 4 EO products
- Testing products over a wide range of conditions (globally distributed JECAM network)

### **Strengthening National Capacity for Agricultural Monitoring**

- Open source system for **national reporting & food security**
- Transfer to users including local system installation & training
- Demonstration of agricultural EO products at national scale







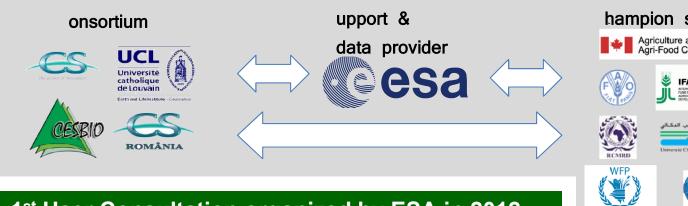


- ✓ User Requirements
- ✓ Products specification
- ✓ Methods development





### **User-driven** approach

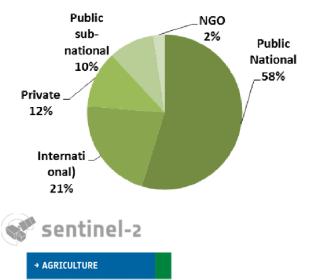


### 1<sup>st</sup> User Consultation organized by ESA in 2012 2<sup>nd</sup> User Consultation through surveys in 2014



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Survey filed up by 42 institutions





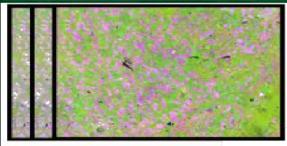
1<sup>st</sup> Sen2-Agri Users Workshop – FAO May 2014 2<sup>nd</sup> Sen2-Agri Users Workshop – EU Nov.2015

## System to deliver 4 Sen2-Agri products

### in line with the GEOGLAM core products

### Monthly cloud free surface reflectance composite at 10-20 m

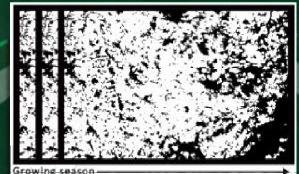
#### **CLOUD FREE SURFACE** REFLECTANCE COMPOSITES



Growing season (monthly updates)

> **Vegetation status map** at 20 m delivered every week (NDVI, LAI, pheno index)

#### DYNAMIC CROPLAND MASK

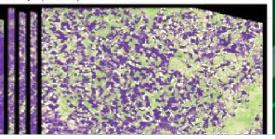


(monthly updates)

Open source toolbox Capacity building and training

#### VEGETATION STATUS

Growing season (weekly updates)

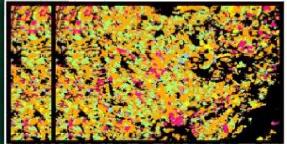


identifying annually cultivated land at 10m updated every month

#### CULTIVATED CROP TYPE MAP

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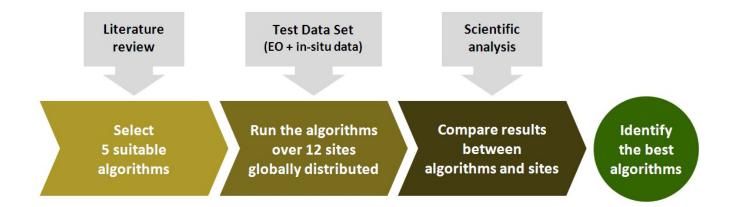
Growing season-(first half and end of the season)



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

**Binary map** 

# Benchmarking for selecting the best algorithms for each product



12 test sites, relying on JECAM network, spread over the world, which represent more than 17 major crop types

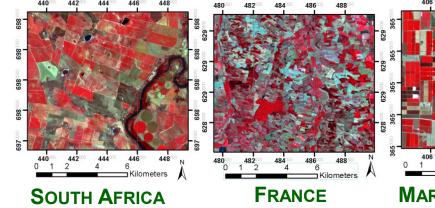
Joint Experiment for Crop Assessment and Monitoring

sentinel-2

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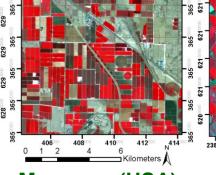


# Benchmarking for selecting the best algorithms for each product

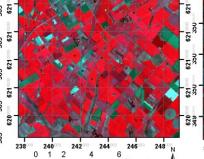


### 4 scientific papers published

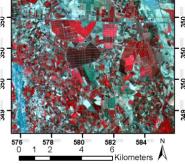
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### MARICOPA (USA)



**A**RGENTINA



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### Morocco



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# Current Sen2–Agri Achievements

Users req. and methods development 2014



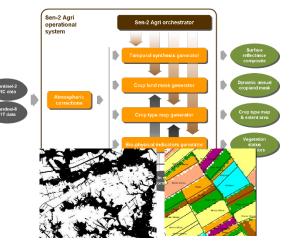
JECAN Joint Experiment for Crop Assessment and Monitoring

- ✓ User Requirements
- ✓ **Products specification**
- ✓ Methods development



System development and EO products 2015

Demonstration & Validation 2016-2017



- ✓ 4 agriculture products
- ✓ Open source system
- Prototypes & validation based on SPOT 4/5 Take 5 & Landsat-8



# 5 main Sen2-Agri Challenges

- Portable open-source solution for operational production
- Timeliness of EO products from Sentinel-2 large volume
- Algorithm selection and system development before S-2
- **EO products validation** by users and external partners
- > Addressing the **large diversity** of agricultural systems





### Sen2-Agri system : design and development

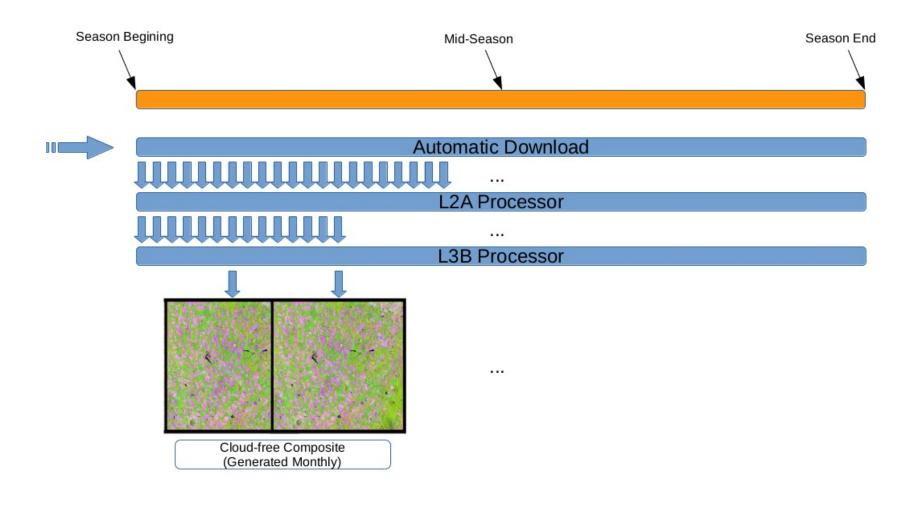
A system designed to run in an automated/off line mode and deliver agric. products as the satellite images are ingested

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#### Sen-2 Agri Sen-2 Agri orchestrator operational system Surface Temporal synthesis generator reflectance composite **Dynamic annual** Crop land mask generator cropland mask Atmospheric L1 time L2A time corrections series series Crop type map Crop type map generator & extent area Vegetation **Bio-physical indicators generator** status indicators sentinel-2 UCL Université catholique de Louvain In situ *System Acceptance Review on 3 March* information ROMÂNL → AGRICULTURE

### => Orchestrator concept

# Automatic production of monthly cloud-free composite

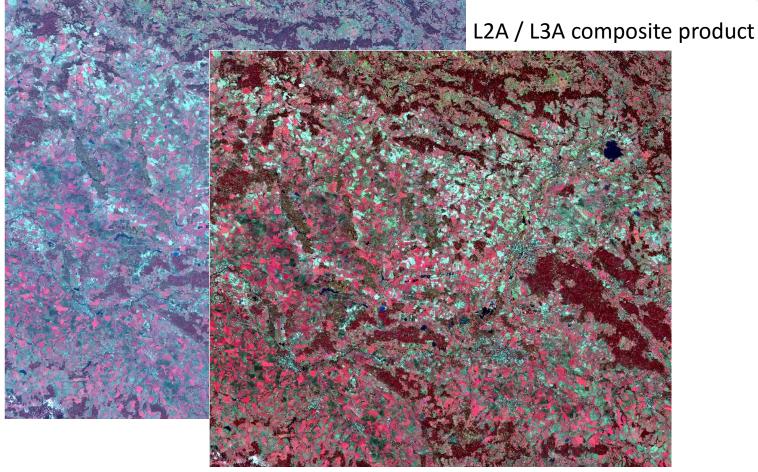


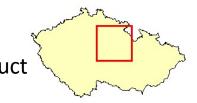




# Cloud-free surface reflectance composite Cesa

### L1C product – as downloaded from ESA hub







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Sentinel-2 image acquired on 17 March 2016 Czech Republic





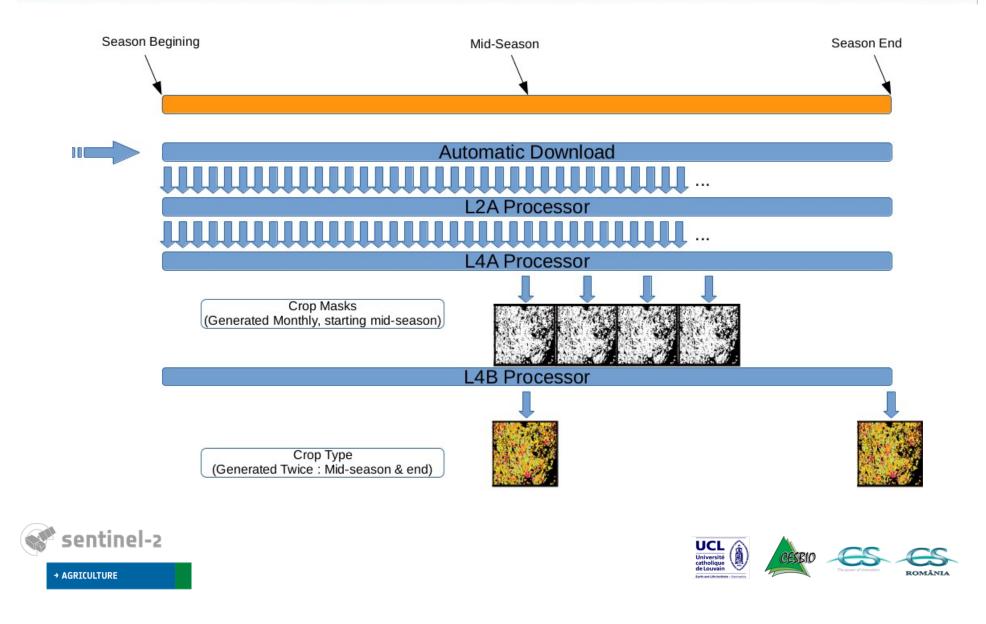






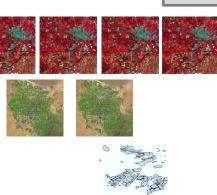
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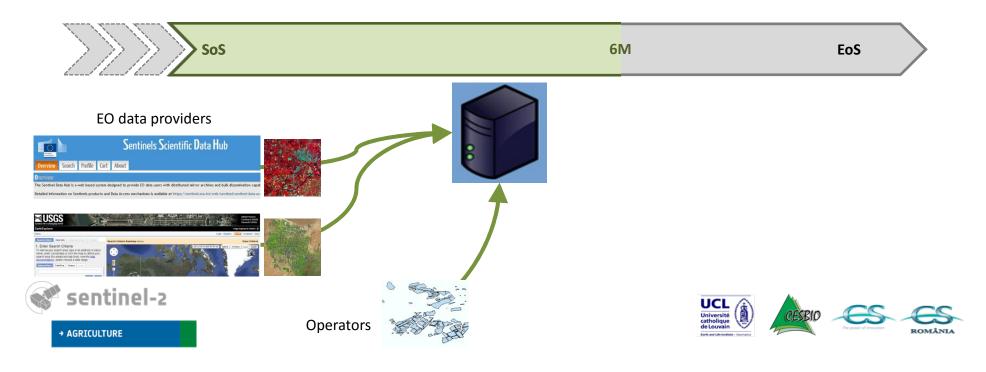
# Production of Crop Mask & Crop Type esa (machine learning and unsupervised processor) esa

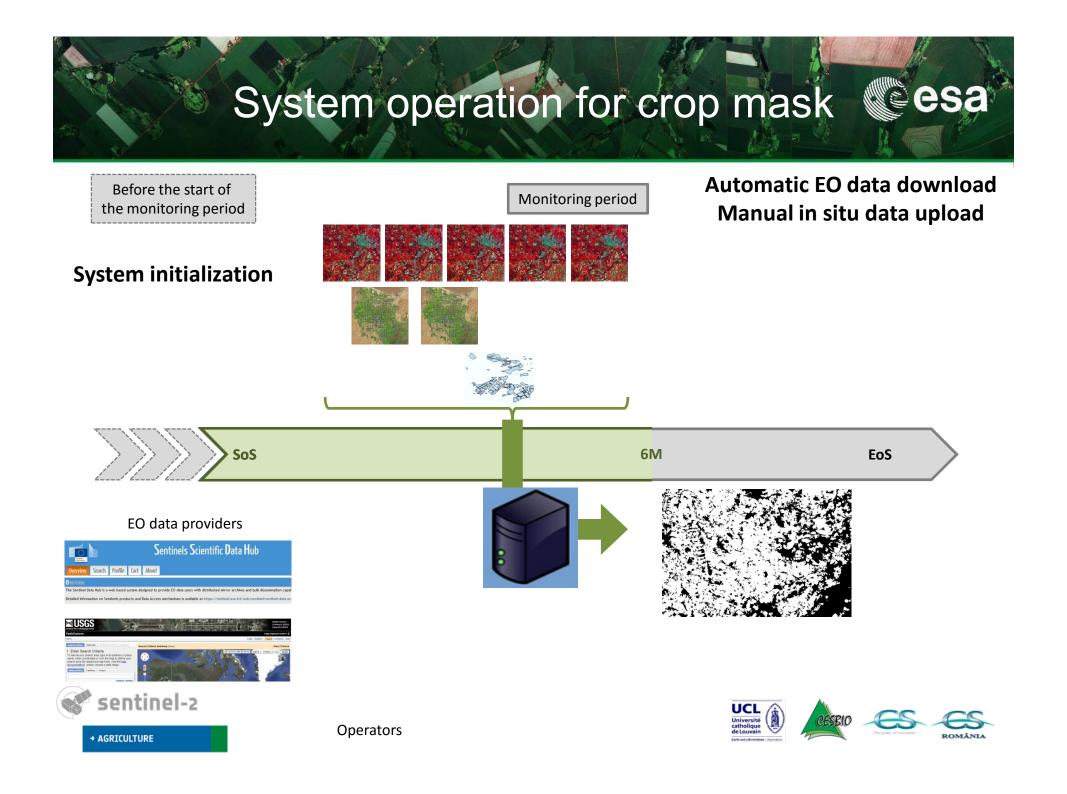


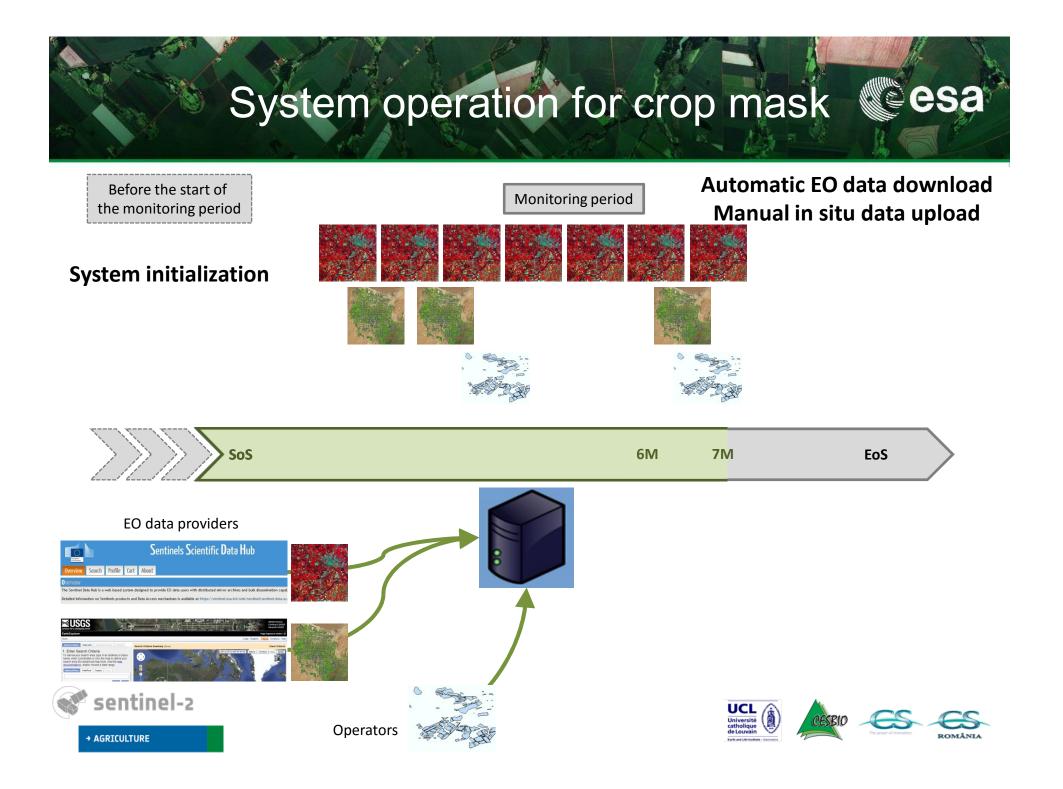
# Before the start of the monitoring period Monitoring period

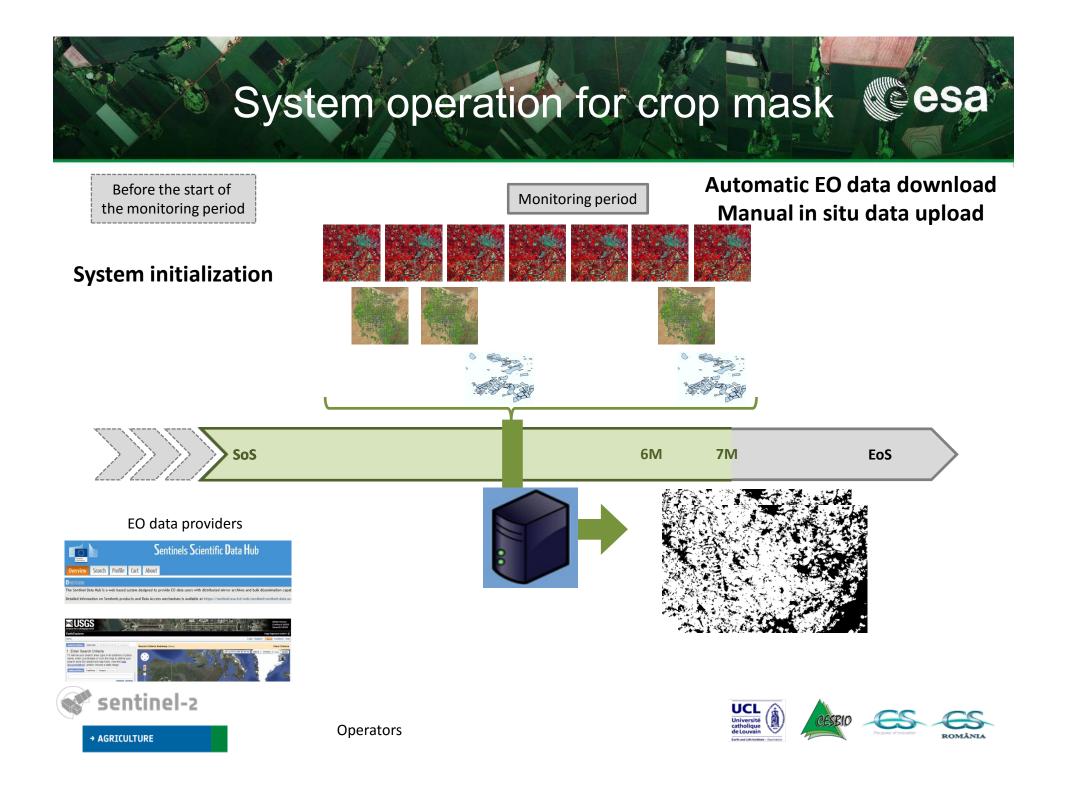


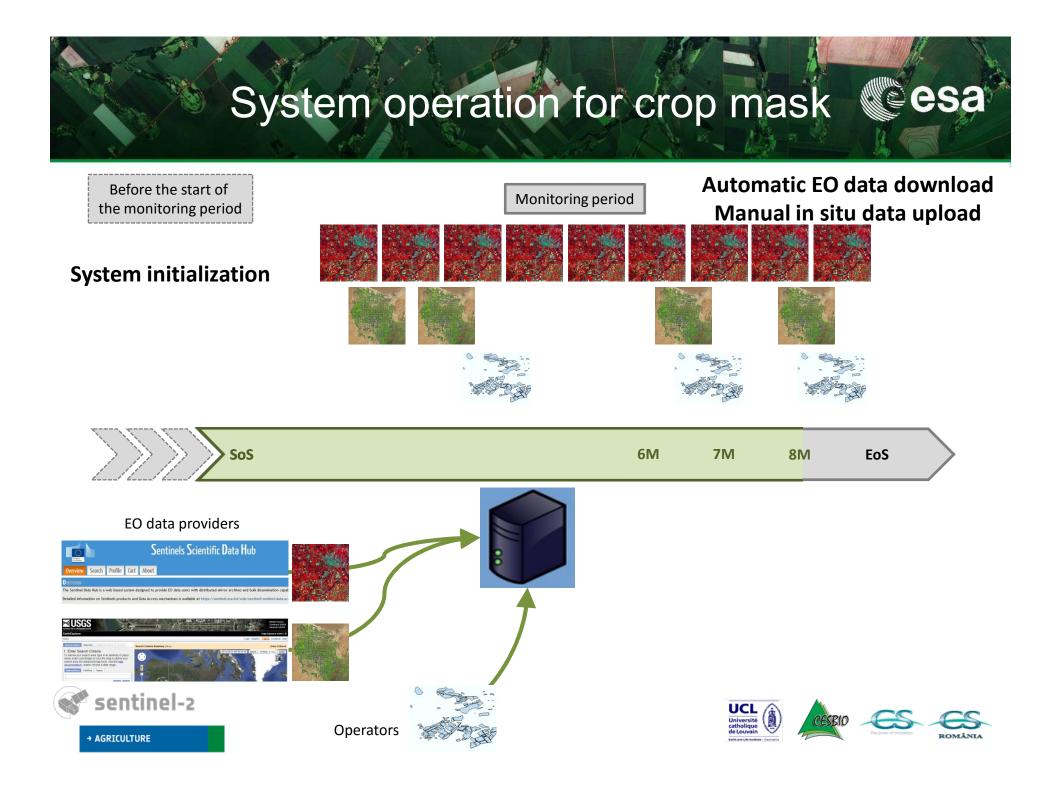


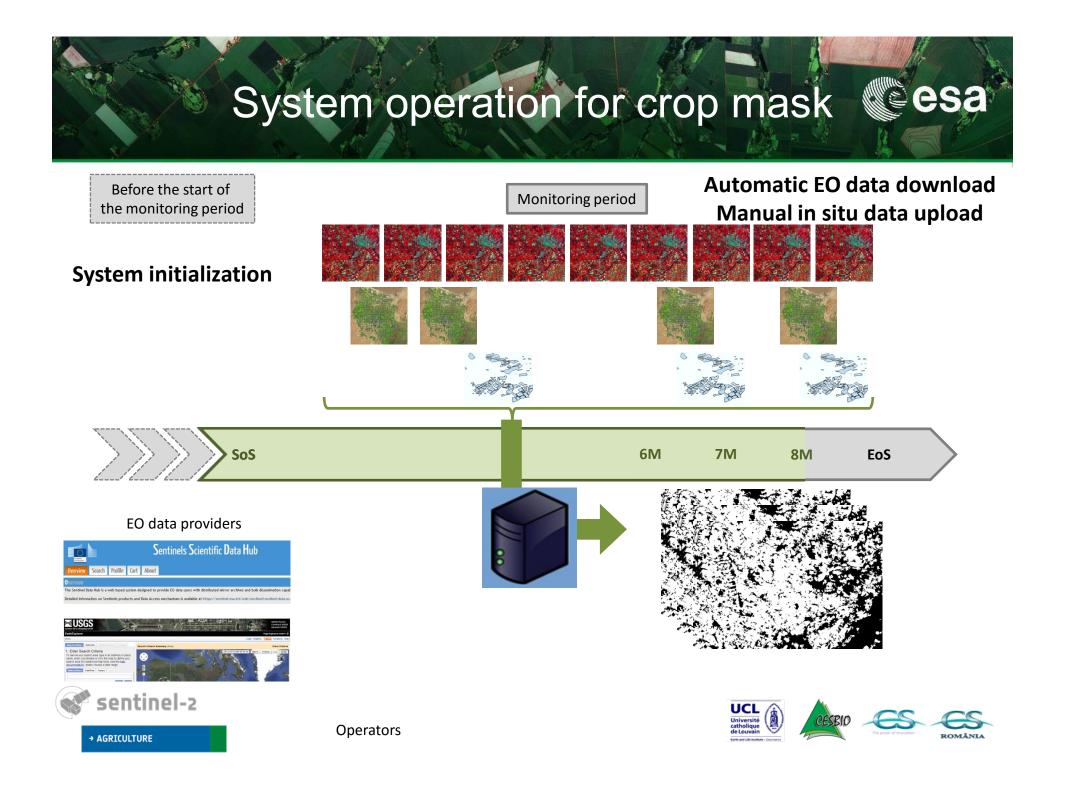


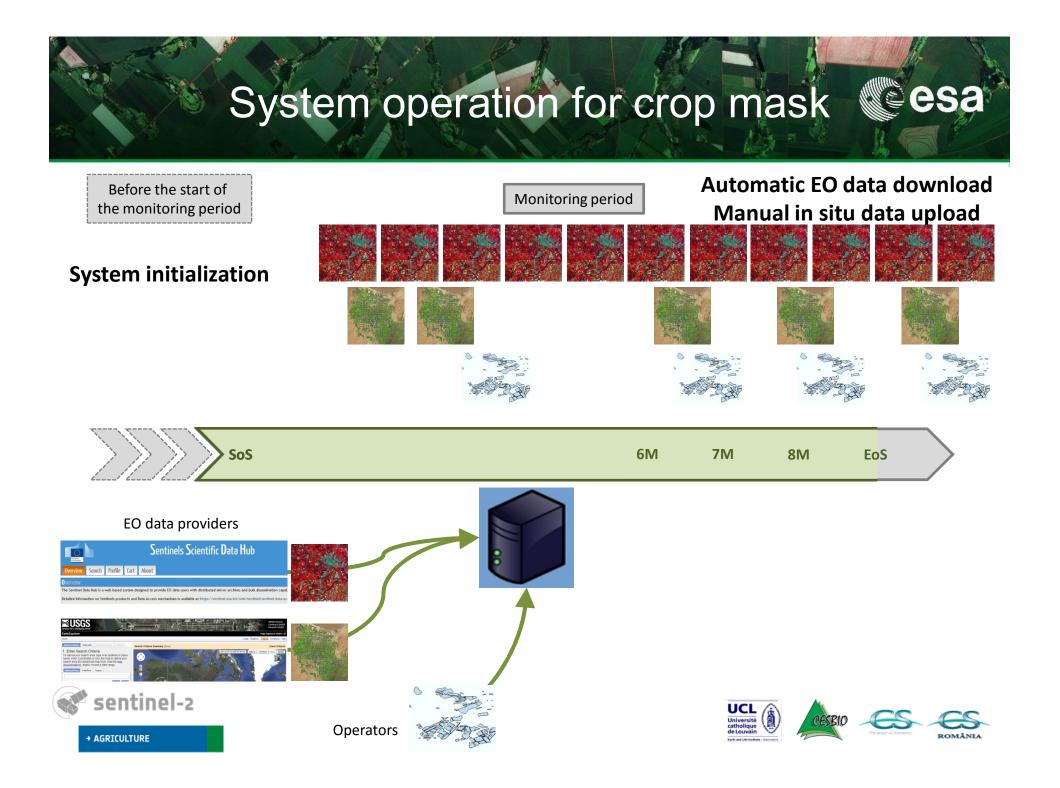


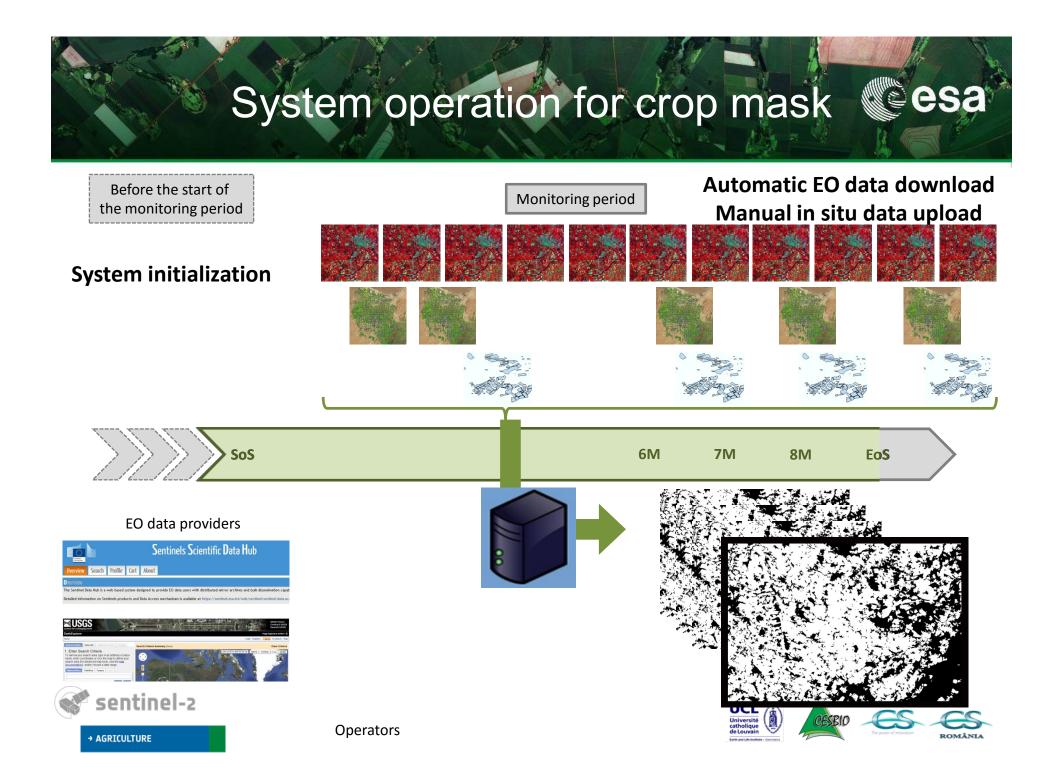






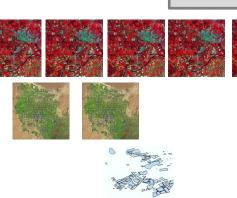


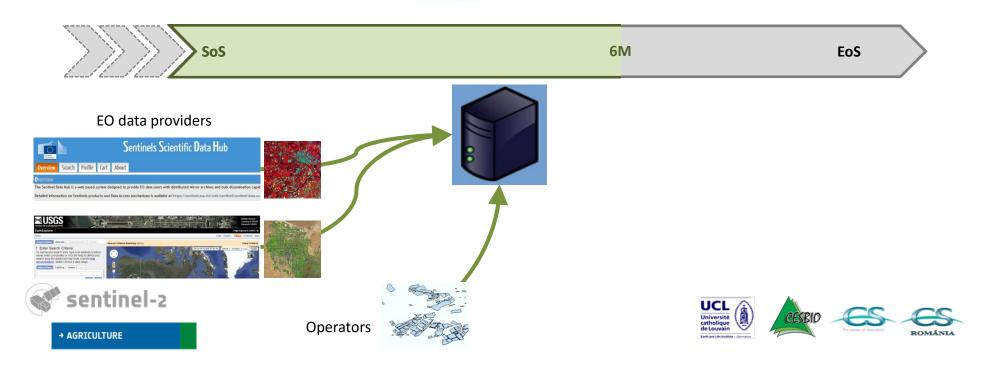


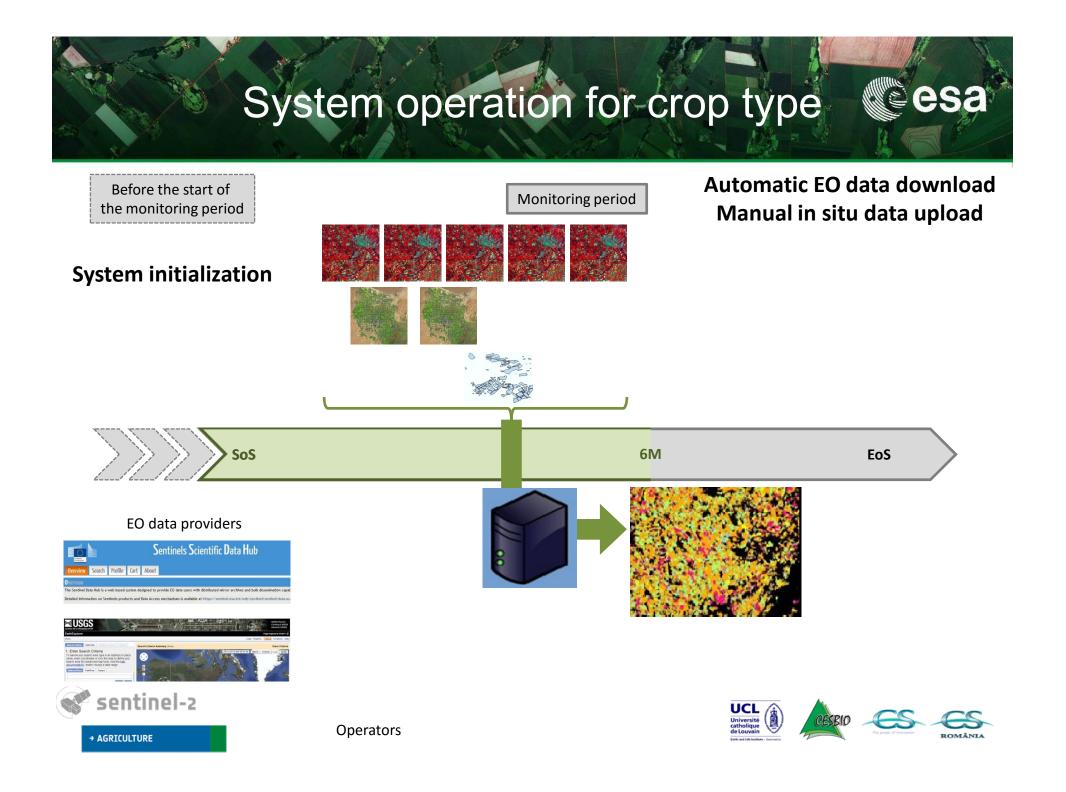


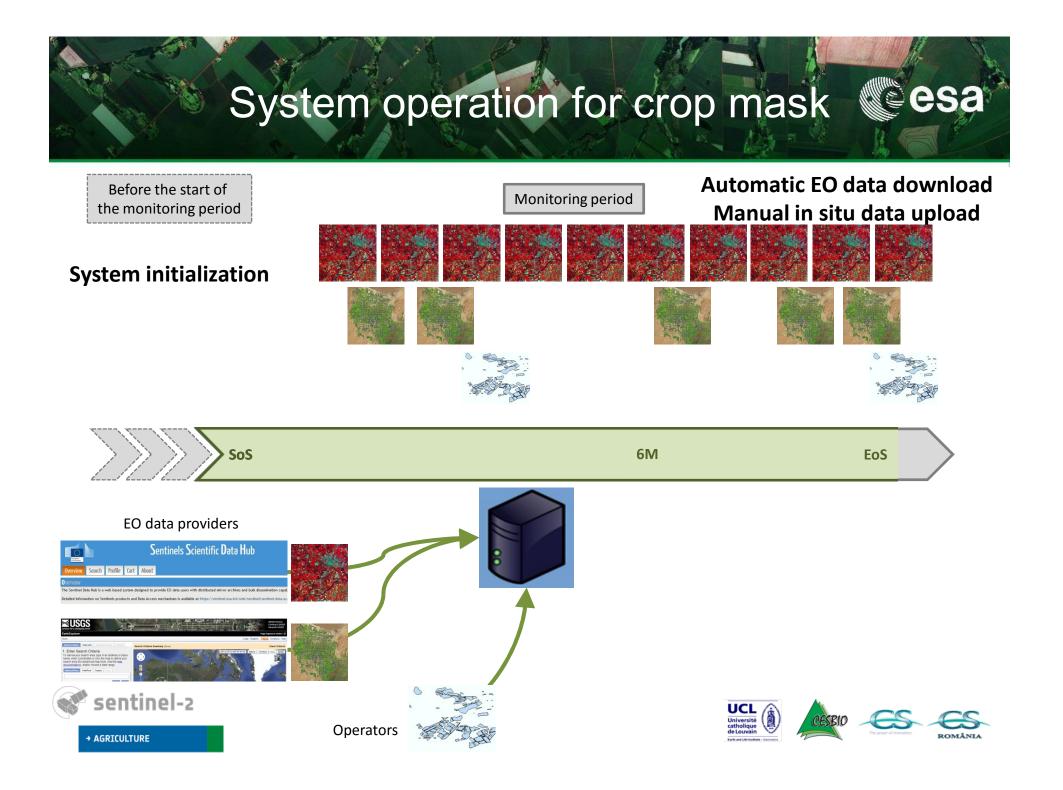
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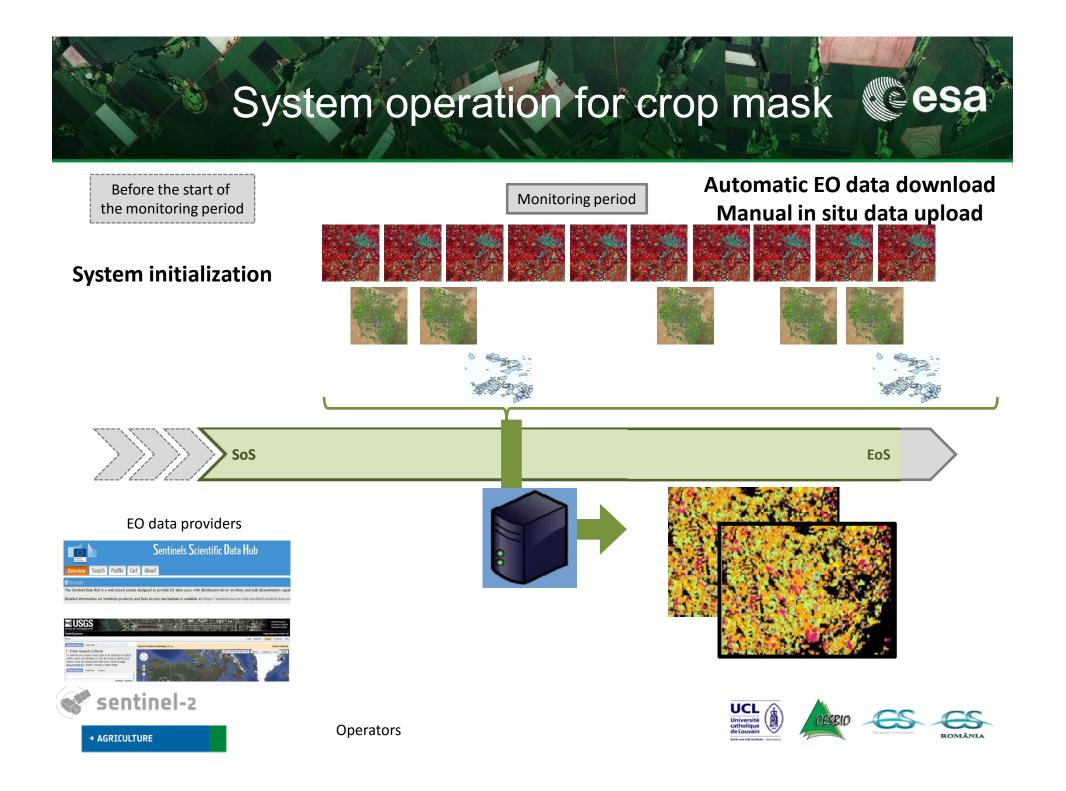




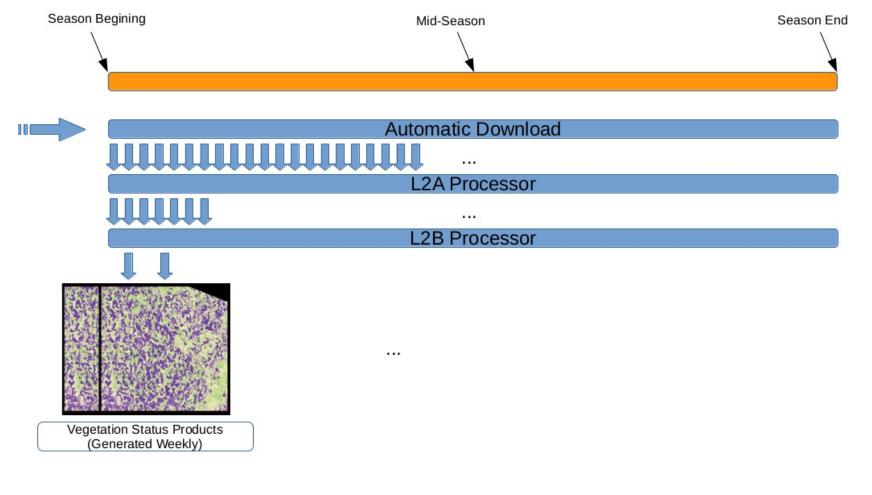






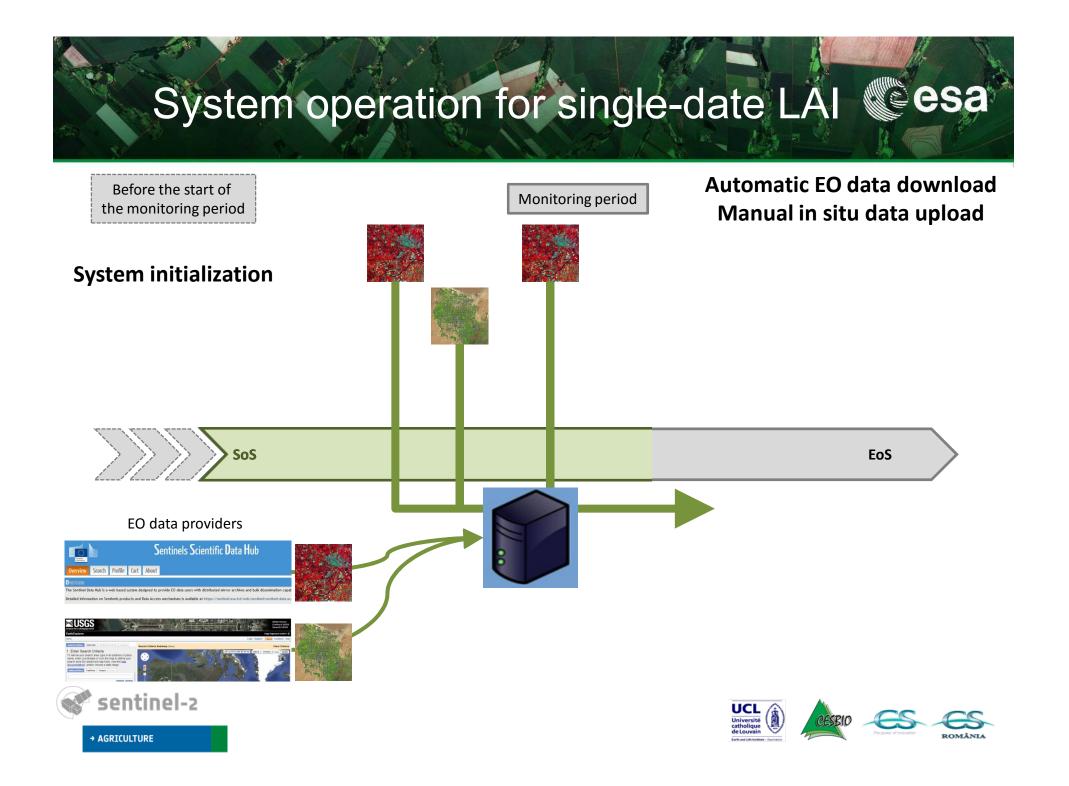


# Automatic production of Vegetation Status on weekly basis (LAI, NDVI)

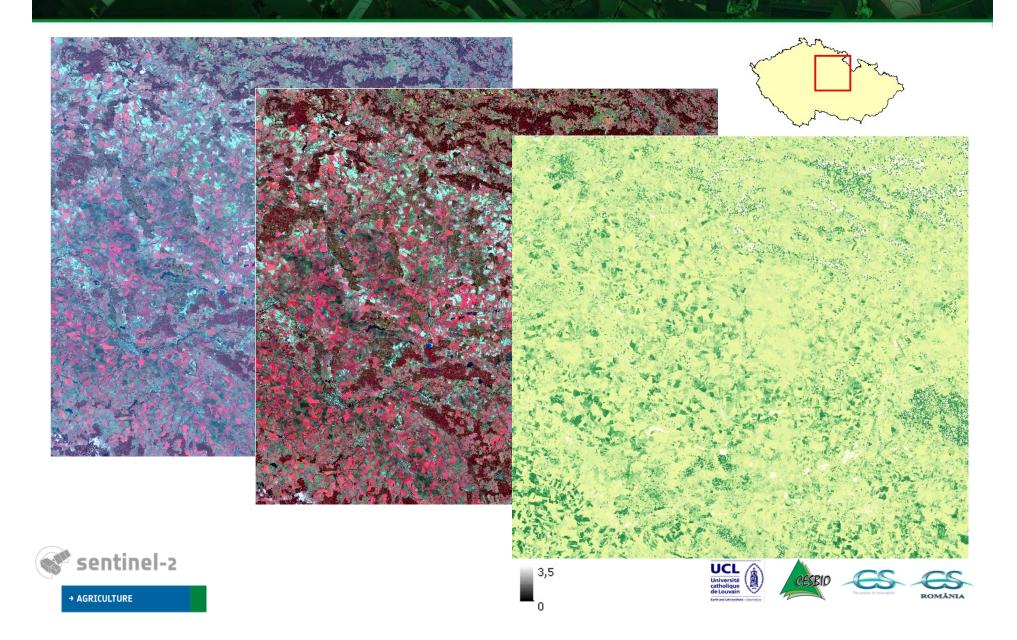




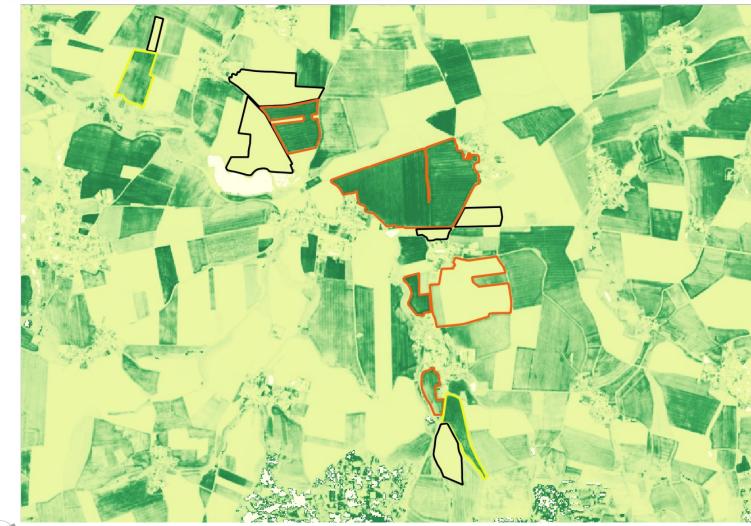




# Sen2-Agri single date LAI map



# Sen2-Agri single date LAI map from Sentinel-2 Casa



### Leaf Area Index 17 March 2016

winter rapeseed
winter cereals
fodder crops
no vegetation

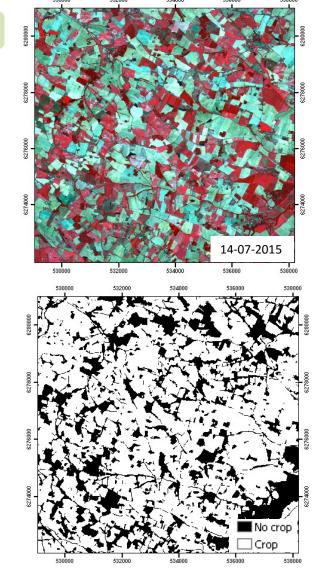


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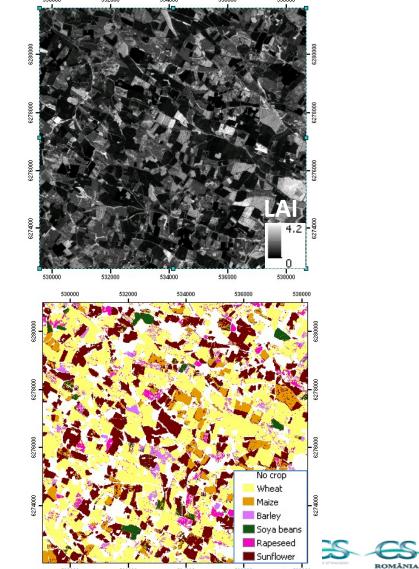




### France



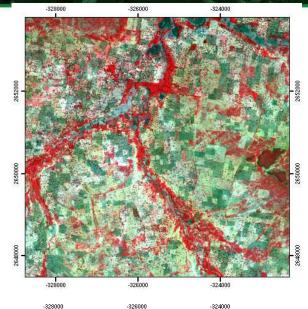


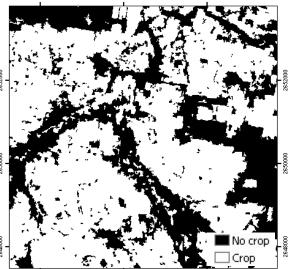


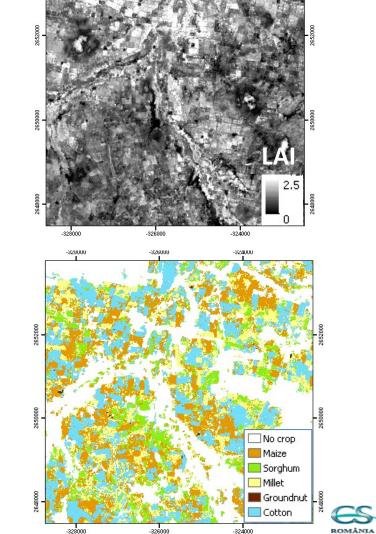
### Prototype products in Mali site (SPOT 5 Take 5 - 2015)

### Mali (JECAM)



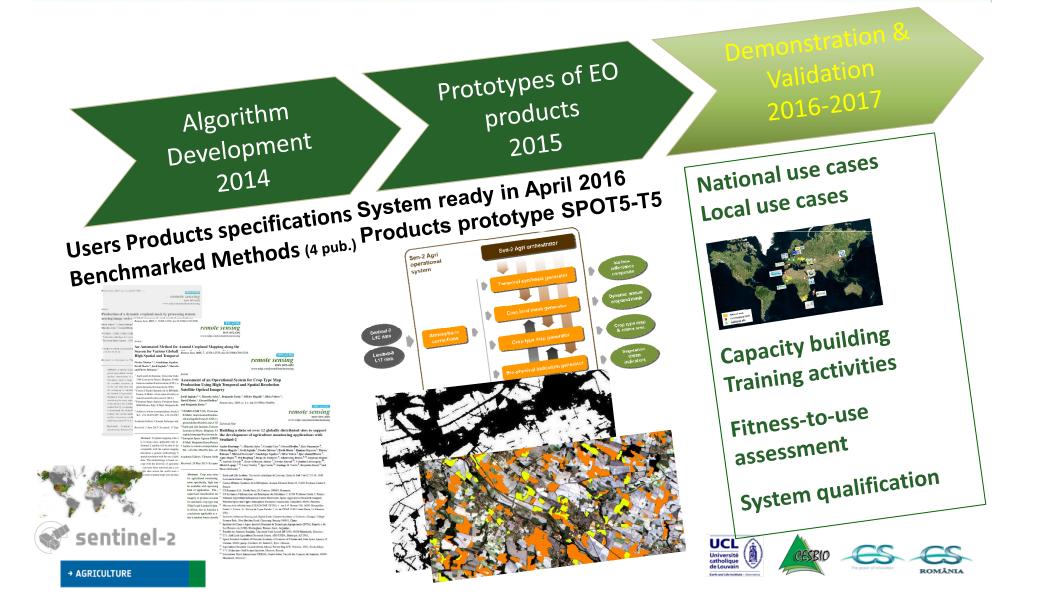


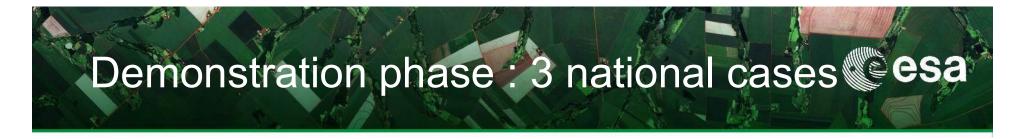






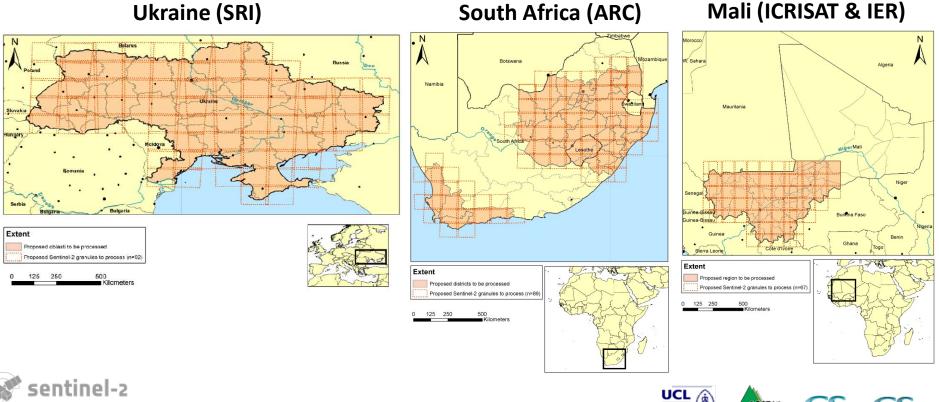
# Sen2-Agri System ready for demonstration esa





To demonstrate the Sen2-Agri system and NRT products using Sentinel-2a & Landsat 8 (but without Sentinel-2b) at national scale with *in situ* system implementation :

Ukraine (SRI)



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# Demonstration phase : 7 local cases esa

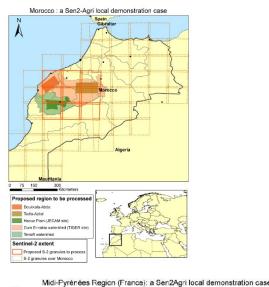
### To demonstrate NRT products using Sentinel-2 & Landsat 8

### at local scale (~ 300 x 300 km):

Site ID	Site name and localization		
Sen2-Agri supported sites			
1	France, Midi-Pyrénées		
2	Morocco, Tensift		
3	China, Shandong		
4	Madagascar, Antsirabe		
5	Sudan, White Nile /South-Sudan		
Additional demonstration sites			
6	Czech sites , Czech (CCN2)		
7	Belgium, Belgium		
sentinel-2			



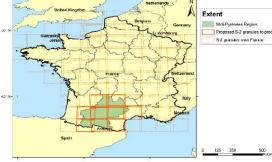
osed region to be processed Sentinel-2 extent Part of Upper Nile - South Sudar Proposed S-2 granules to pro White Nile - Sudan S-2 granules over Sudan and S-Suda 125 250





Sentinel-2 extent











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### Crop mapping in South Africa with Landsat-8 and Sentinel-2

F. Waldner and Pierre Defourny (UCLouvain, Belgium)

M. Hansen (UMD, USA)

T. Newby (ARC, South Africa)

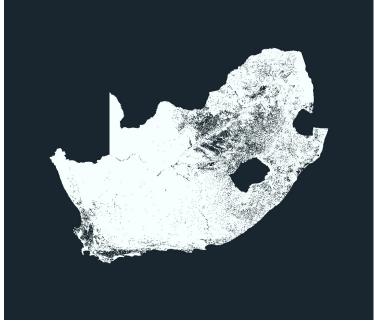




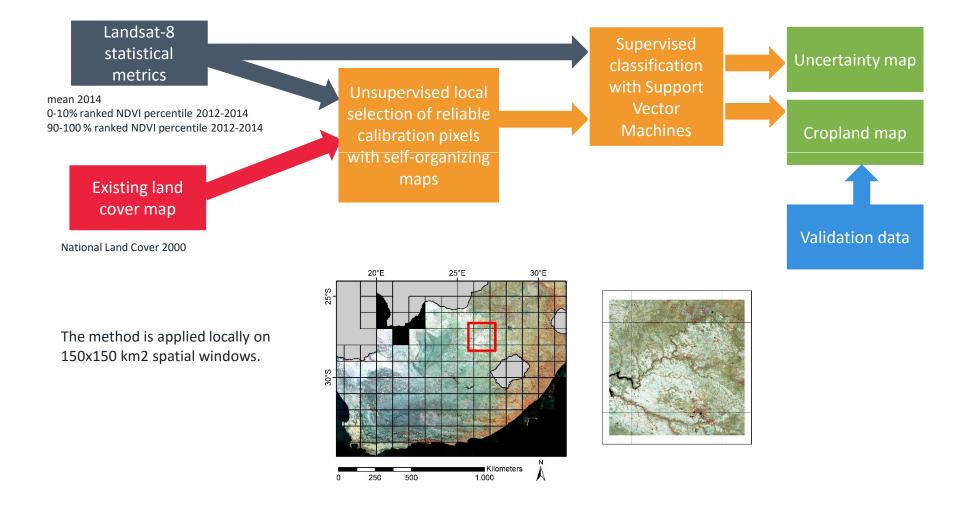






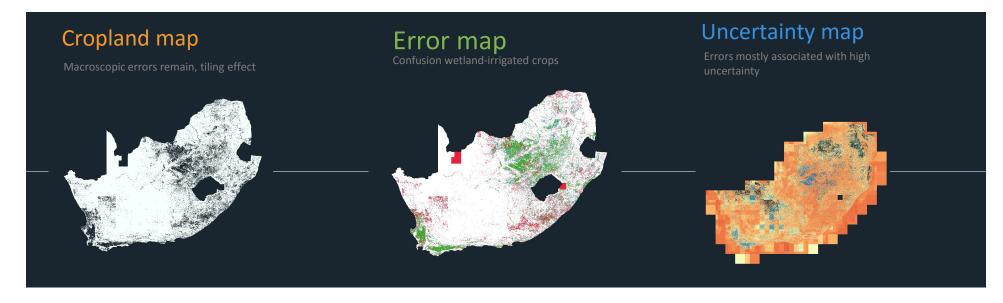


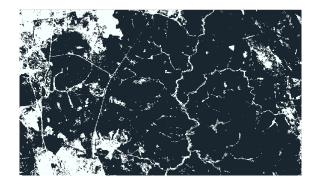
# Fully automated cropland classification based on Landsat-8 metrics and existing land cover information

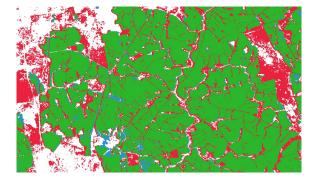


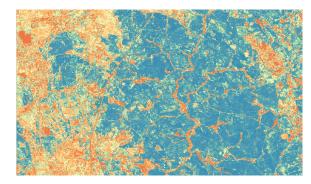
### Wall-to-wall classification and validation

Preliminary results: overall accuracy 87.33%







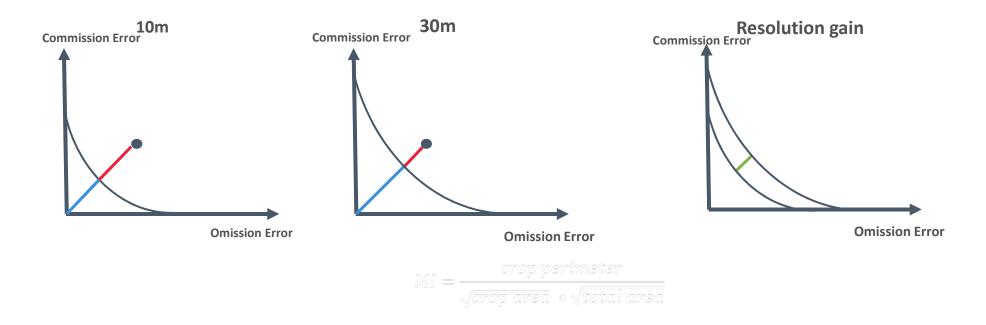


Defining the spatial resolution gain... ... predicting the added value of Sentinel-2

### CLASSIFICATION ERROR = SPATIAL RESOLUTION BIAS + CLASSIFIER ERROR

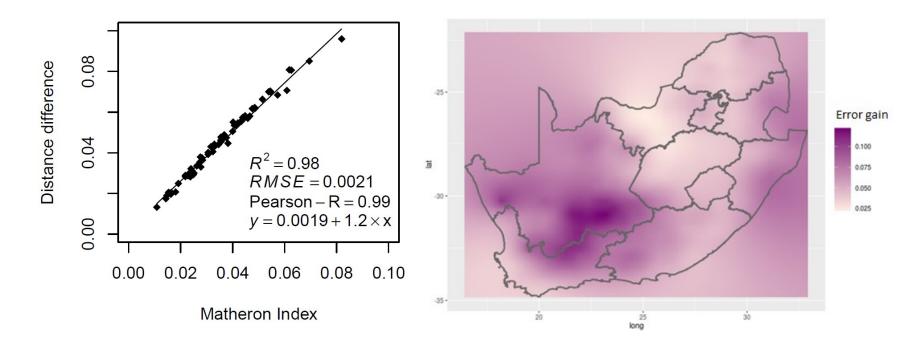
(Boschetti et al., 2004)

#### **RESOLUTION GAIN = SPATIAL RESOLUTION BIAS at 30m – Spatial RESOLUTION BIAS at 10m**



# Can we predict the resolution bias based on landscape fragmentation metrics?

Calibration of a linear regression with a landscape fragmentation metric and application countrywide



The Matheron index measures the ratio between the total outer perimeter of crop patches and the product between the area of crop and the total area

$$MI = \frac{crop \ perimeter}{\sqrt{crop \ area} \ * \sqrt{total \ area}}$$

# Conclusions

- Unique momentum in ag. Monitoring with satellite remote sensing
- For the first time, the combination of current HR sensors is able to meet the requirements for ag. monitoring.
- Remote sensing methods need to be combined with local knowledge, expertise and field observations to achieve accurate results.

 $\rightarrow$  open source toolbox can be locally adapted

Sen2Agri toolbox alleviates the (pre)processing time
 → more time to focus on the interpretation of the RS products





## Thank you for your attention

...and let's learn from the diversity of agrosystems

