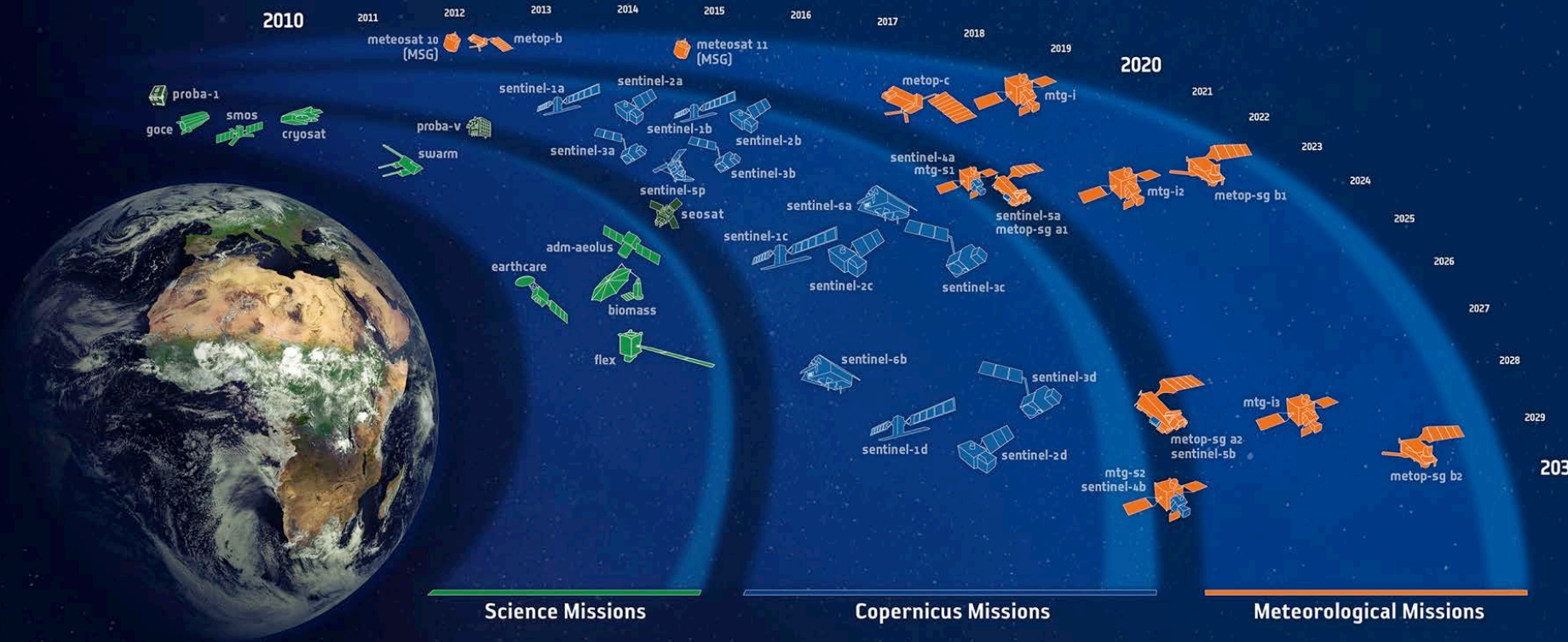
New Capabilities in Earth Observation for Agriculture

Training course on the use of satellite products for drought monitoring and agro-meteorological applications

Budapest, 25 April 2017

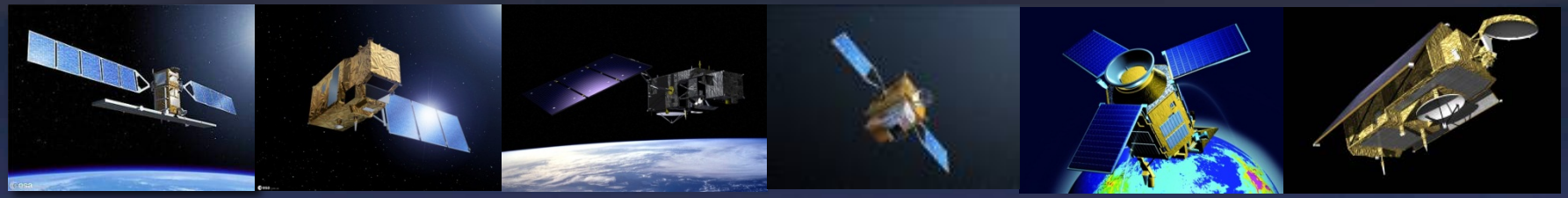
Espen Volden, ESA

→ ESA–DEVELOPED EARTH OBSERVATION MISSIONS



Copernicus: A New Generation of Data Sources

Sent-1A/B | Sent-2A/B | Sent-3A/B | Sent-4A/B | Sent-5/5P | Sent-6A/B

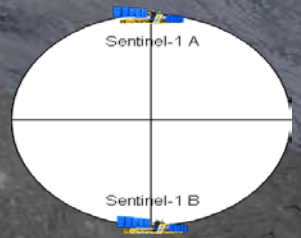


- Copernicus - European space flagship programme, led by the EU
- ESA is responsible for space component, Sentinel development, operation of some Sentinels, data buy from other partners, system evolution
- Sentinels – most comprehensive EO system world-wide for environmental monitoring
- Free and open data policy
- Ensured continuity 2030+

Sentinel-1

Copernicus radar imaging mission for ocean, land, emergency

- Mission based on 2 identical satellite units (S1A & S1B)
- C-band Radar instrument
- 6-day repeat cycle at Equator (1 satellite = 12 days)
- Instrument operations based on a predefined observation scenario



Sentinel-1: Rice Monitoring
Monitoring of Crop Stages

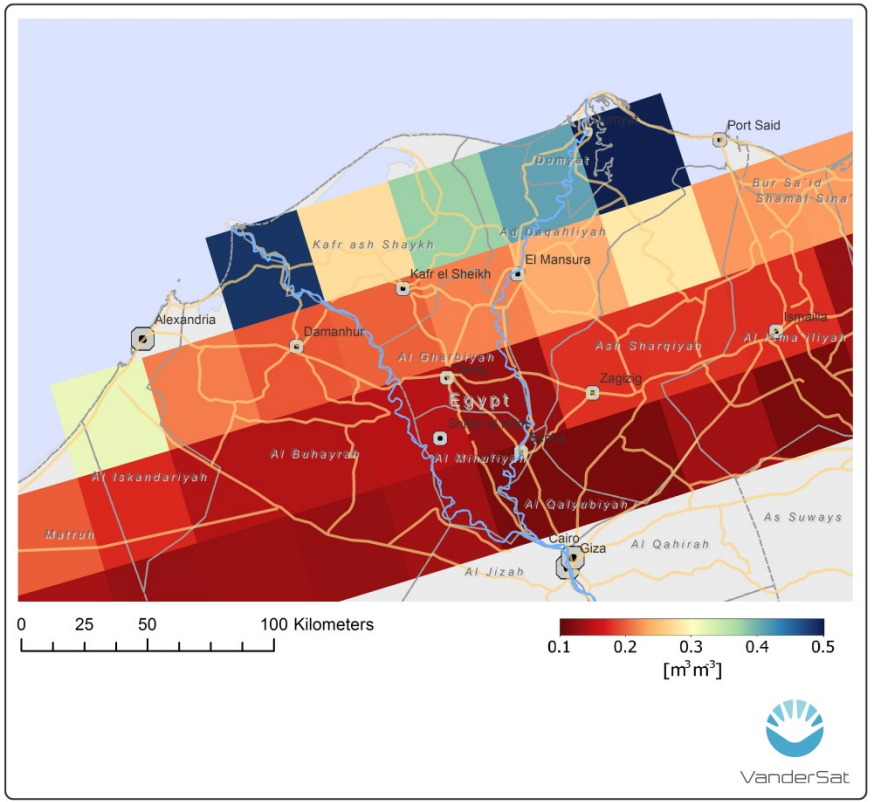
Winter-Spring Rice 2015/16

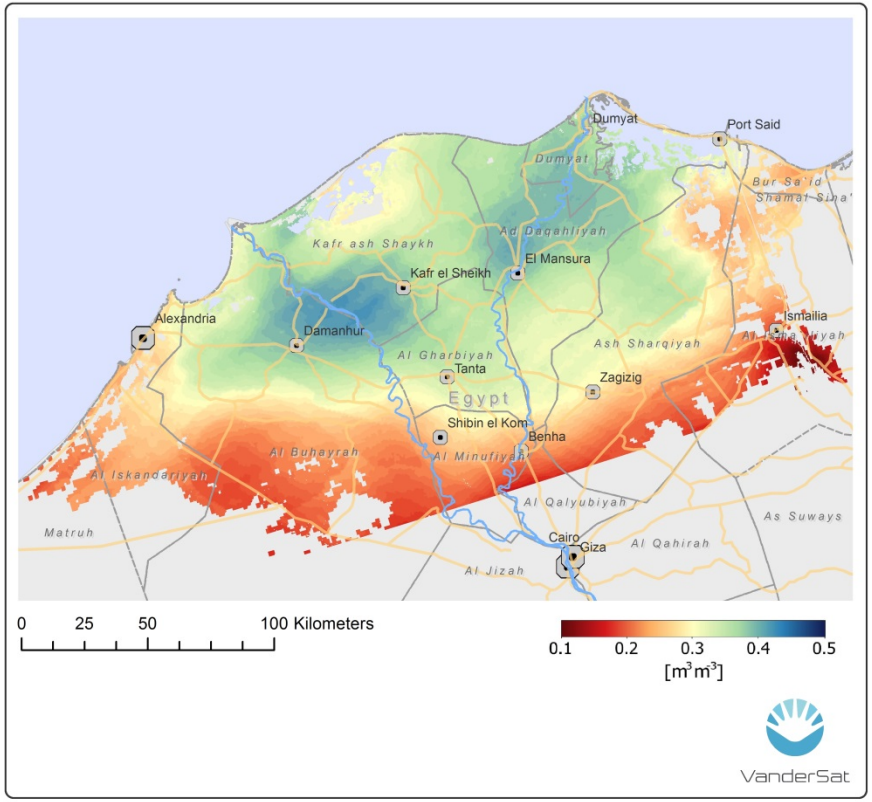
- March 2016: 1.4 Million ha rice
- March 2015: 1.7 Million ha rice
- 16.5% loss in rice area due to drought and salt water intrusion caused by El Nino
- 976.000 people affected, 67 Mil. $ estimated damage

- Based on unprecedented S1 timeseries

The Mekong Delta, Vietnam
300 km x 300 km, 20 m resolution

Zooming in on Soil Moisture (SMAP+Sentinel-1)





GAME CHANGER: SENTINEL-2

Land and coastal zones are in focus, emphasis is on vegetation

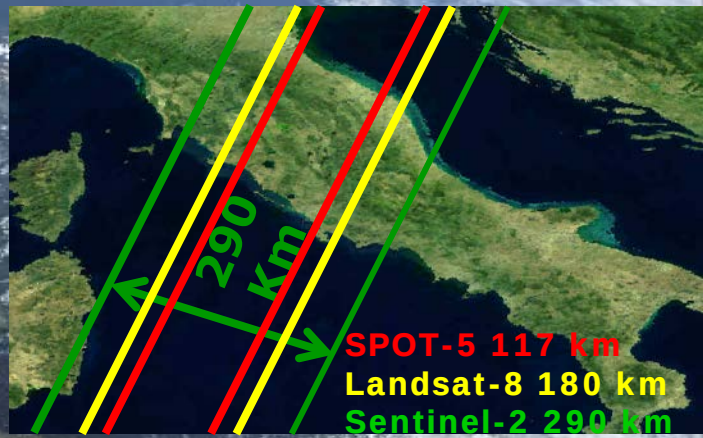
Global & systematic observations with unprecedented swath width & spectral richness

5 days revisit at equator

Spatial resolution: 10m / 20m (60 m for atmosphere calibration)

Long term data distribution and archiving beyond 2030

Best radiometric, geometric and spectral performance in its category

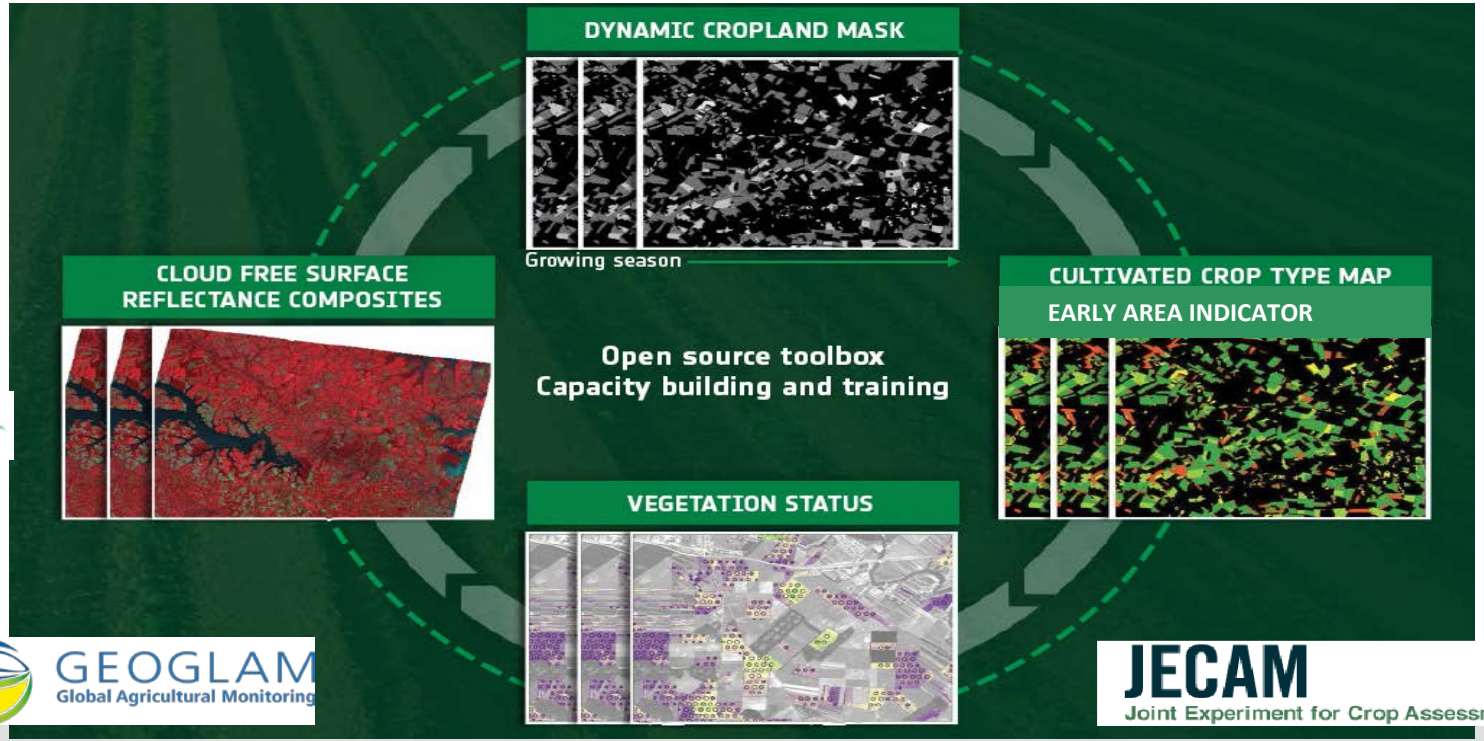


sentinel-2

→ AGRICULTURE

Sentinel-2 for Agriculture

Towards exploitation of Sentinel-2 for local to global agricultural monitoring - contribution to GEOGLAM



Project

UCL Université catholique de Louvain

CESBIO

CS

CS ROMÂNIA

Key Users

FAO

WFP

IFAD Enabling poor rural people to overcome poverty

JRC EUROPEAN COMMISSION

cirad AGRICULTURAL RESEARCH FOR DEVELOPMENT

FEWS NET

RCMRD

GEOGLAM Global Agricultural Monitoring

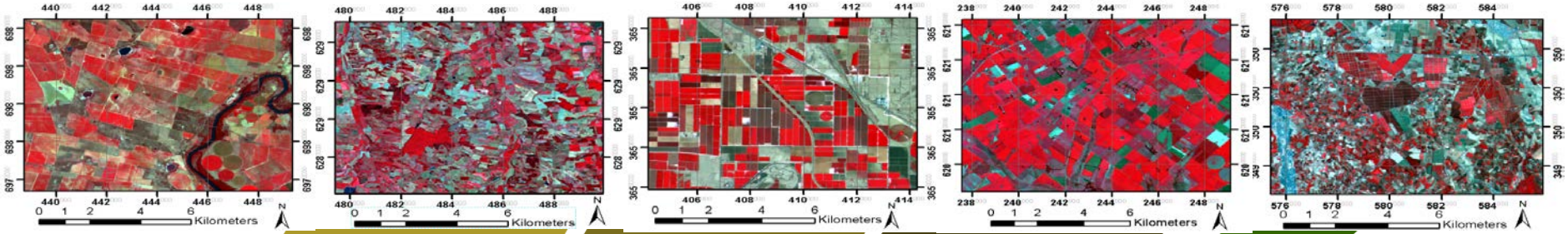
JECAM Joint Experiment for Crop Assessment and Monitoring

sentinel-2

→ AGRICULTURE

Algorithm Benchmarking for global product development

esa



JECAM

Joint Experiment for Crop Assessment and Monitoring

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

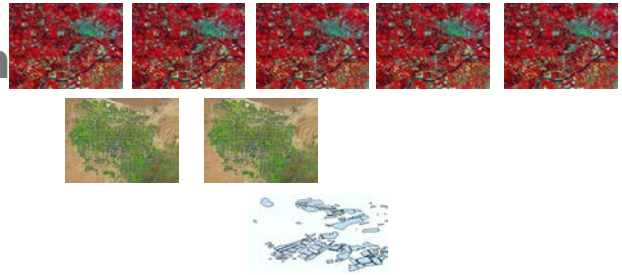
*Results published in peer-reviewed journal

System operation for crop mask

Before the start of the monitoring period

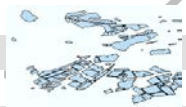
System initialization

Monitoring period



Automatic EO data download
Manual in situ data upload

EO data providers



Operators

System operation for crop mask

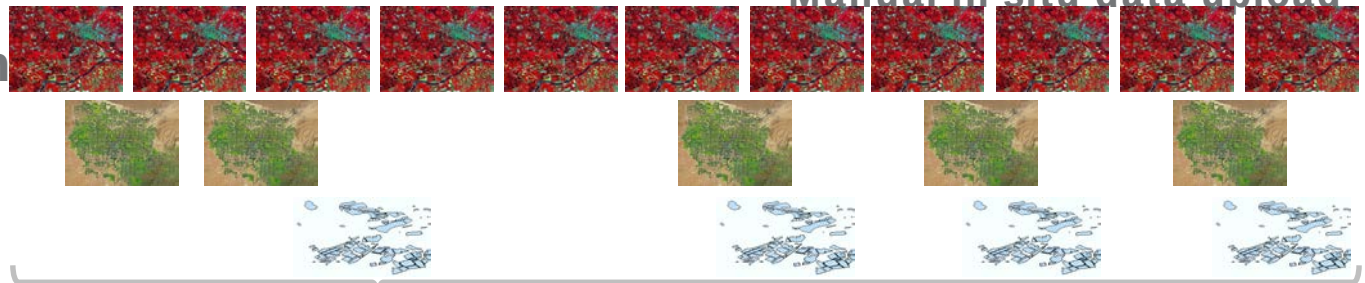
→ AGRICULTURE

Before the start of the monitoring period

System initialization

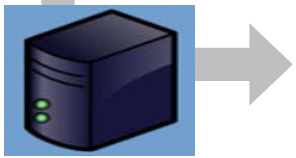
Monitoring period

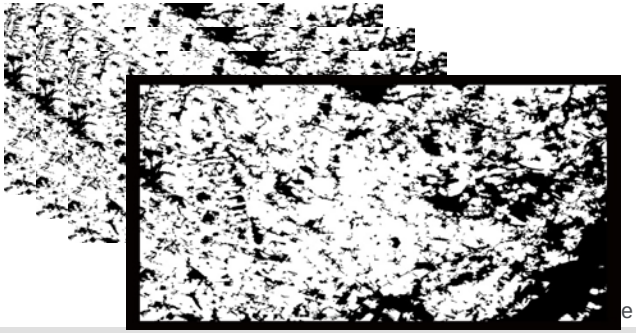
Automatic EO data download
Manual in situ data upload



SoS 6M 7M 8M EoS

EO data providers





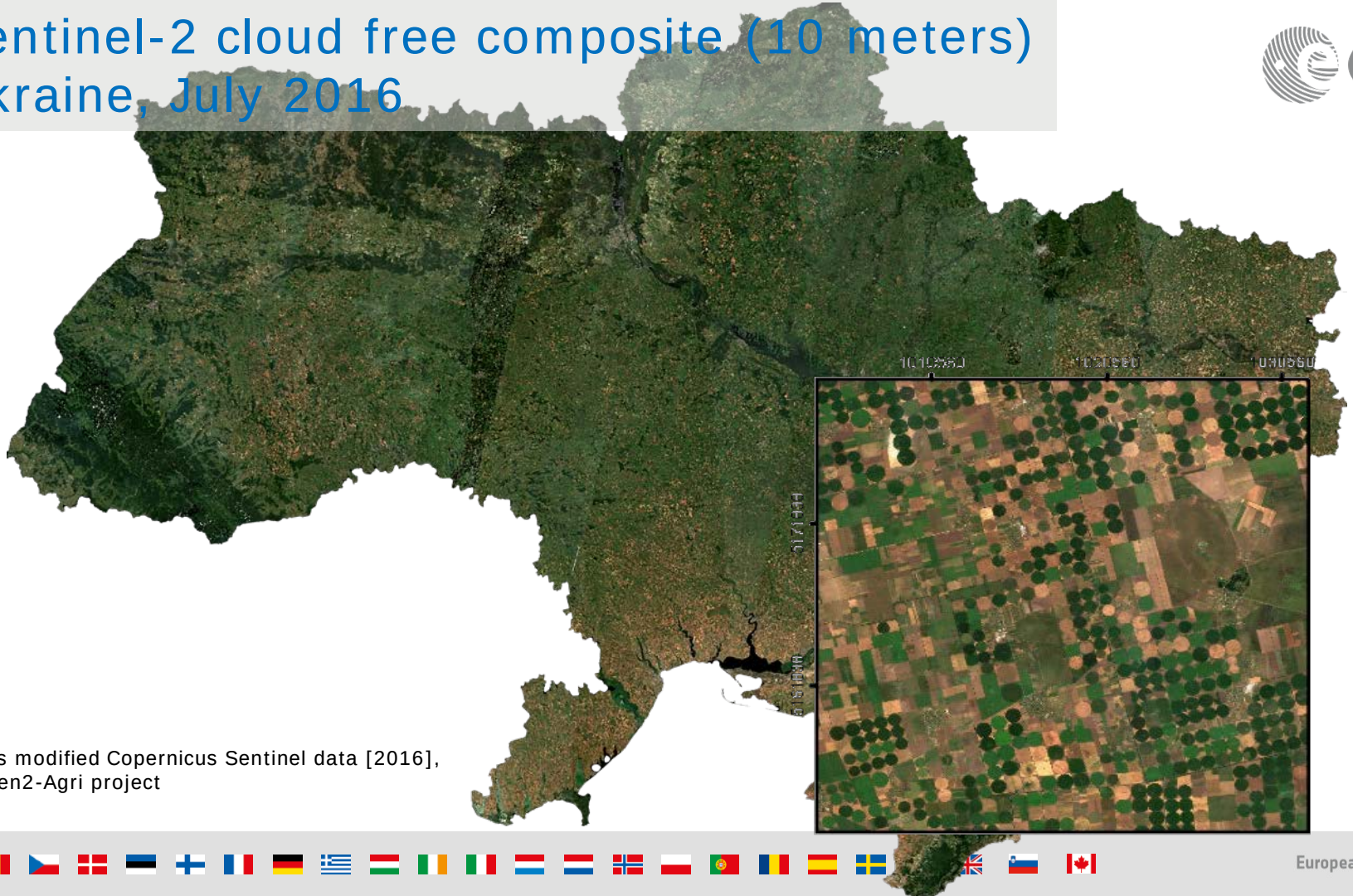
Operators

Demonstration & Transfer Local to National

Demonstrate products and system using Sentinel-2 over :

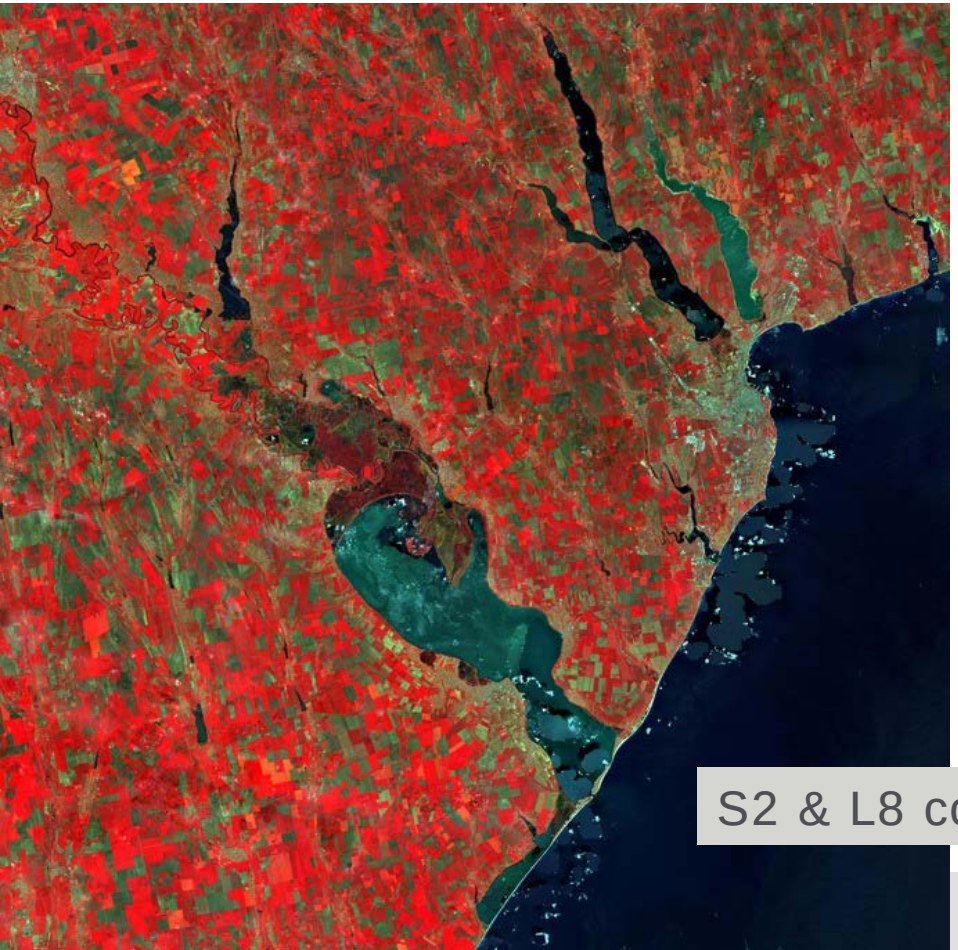
- 3 countries: Ukraine, South Africa, Mali
- 5 local cases (290*290 km)
- Engagement of mandated national/local authorithies (national Agricultural ministries, WFP,CGIAR)

Sentinel-2 cloud free composite (10 meters) Ukraine, July 2016

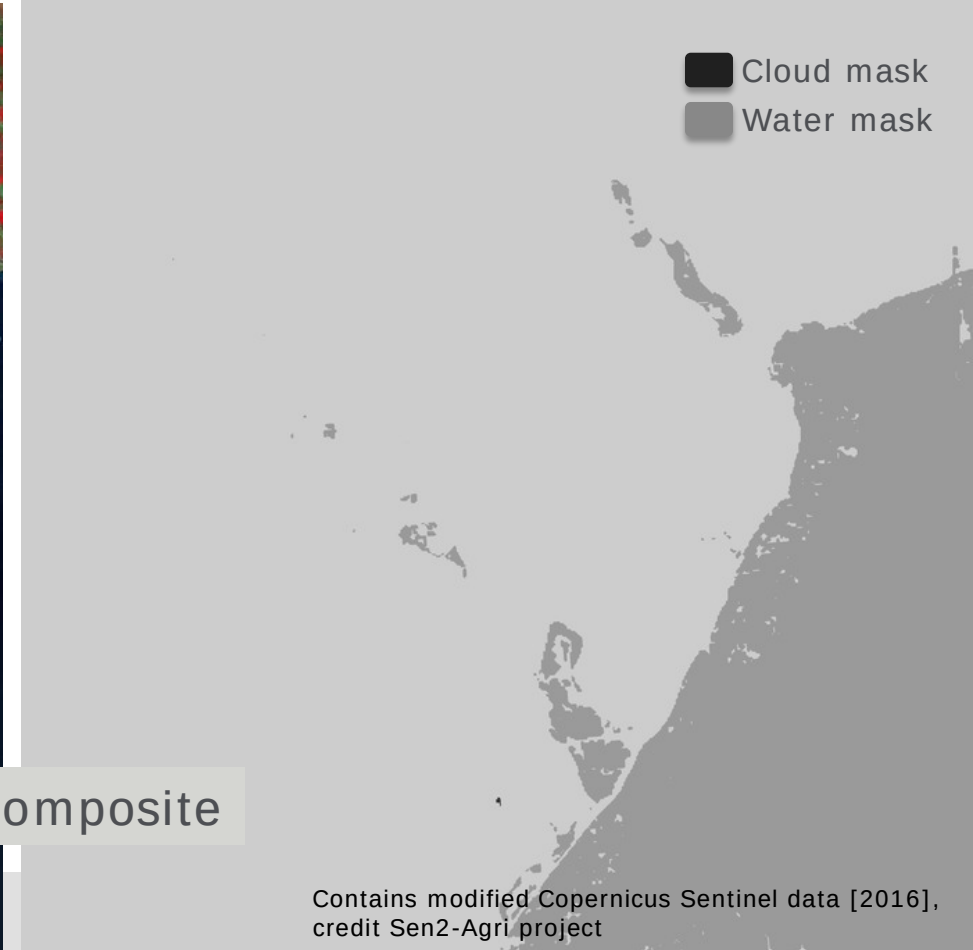


Contains modified Copernicus Sentinel data [2016], credit Sen2-Agri project

S2 & L8 cloud free composite – improved coverage

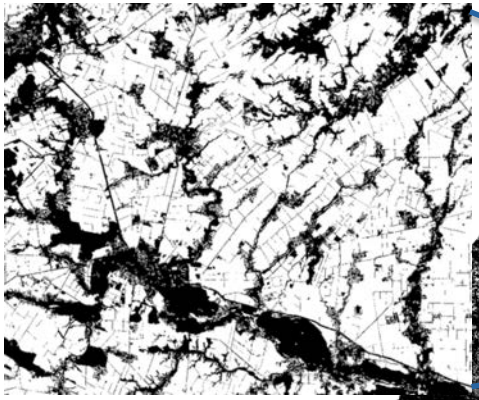


S2 & L8 composite



Contains modified Copernicus Sentinel data [2016], credit Sen2-Agri project

Ukraine – 2016 Crop Mask

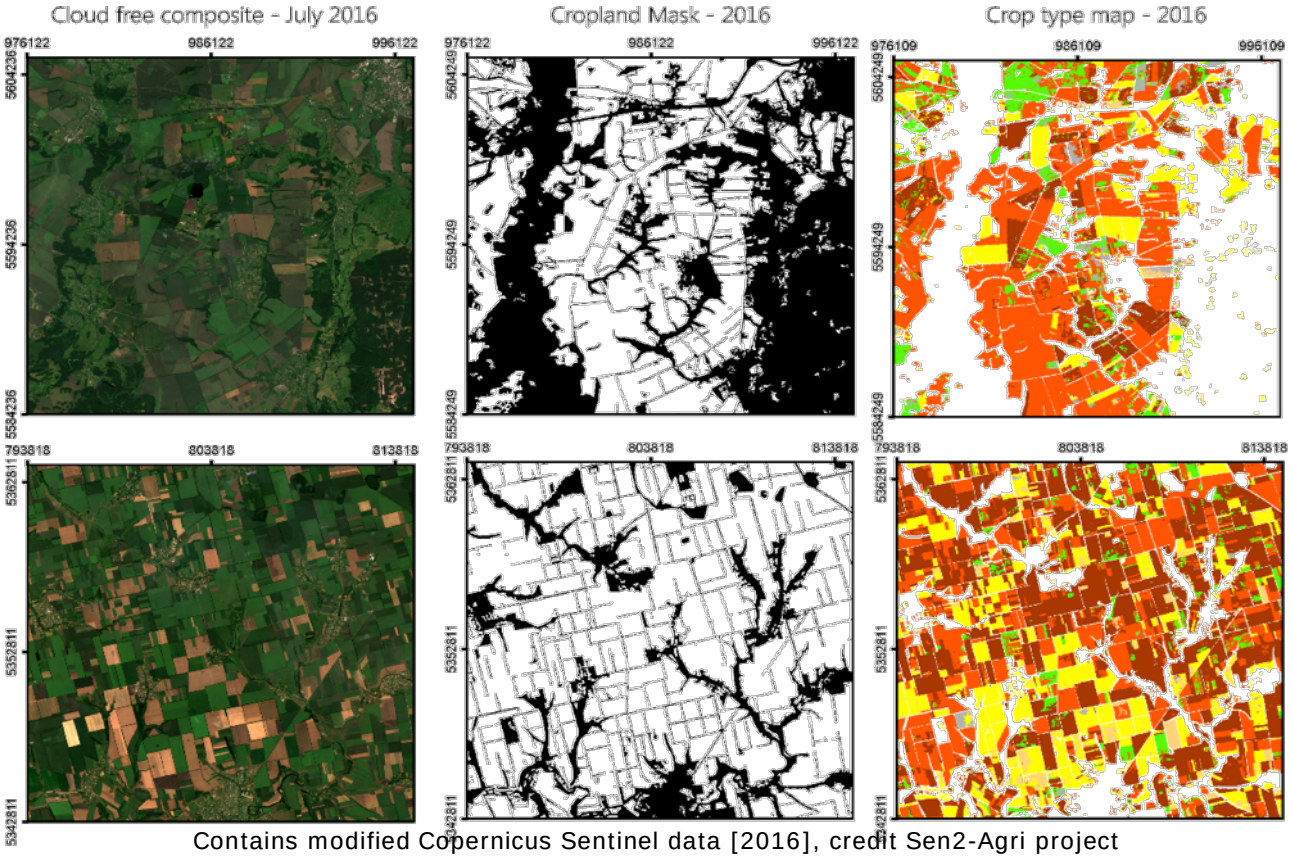


- National Coverage: 603.500 km^2
- Field Scale: 10 meter resolution
- Overall Accuracy: 96%

Cropland
Non-Cropland

Contains modified Copernicus Sentinel data [2016],
credit Sen2-Agri project

National Crop mask and type mapping at field scale Ukraine 2016



sentinel-2

→ AGRICULTURE

Contains modified Copernicus Sentinel data [2016], credit Sen2-Agri project

Crop Status Monitoring over the Season
Ukraine 2016

18 Feb. 16

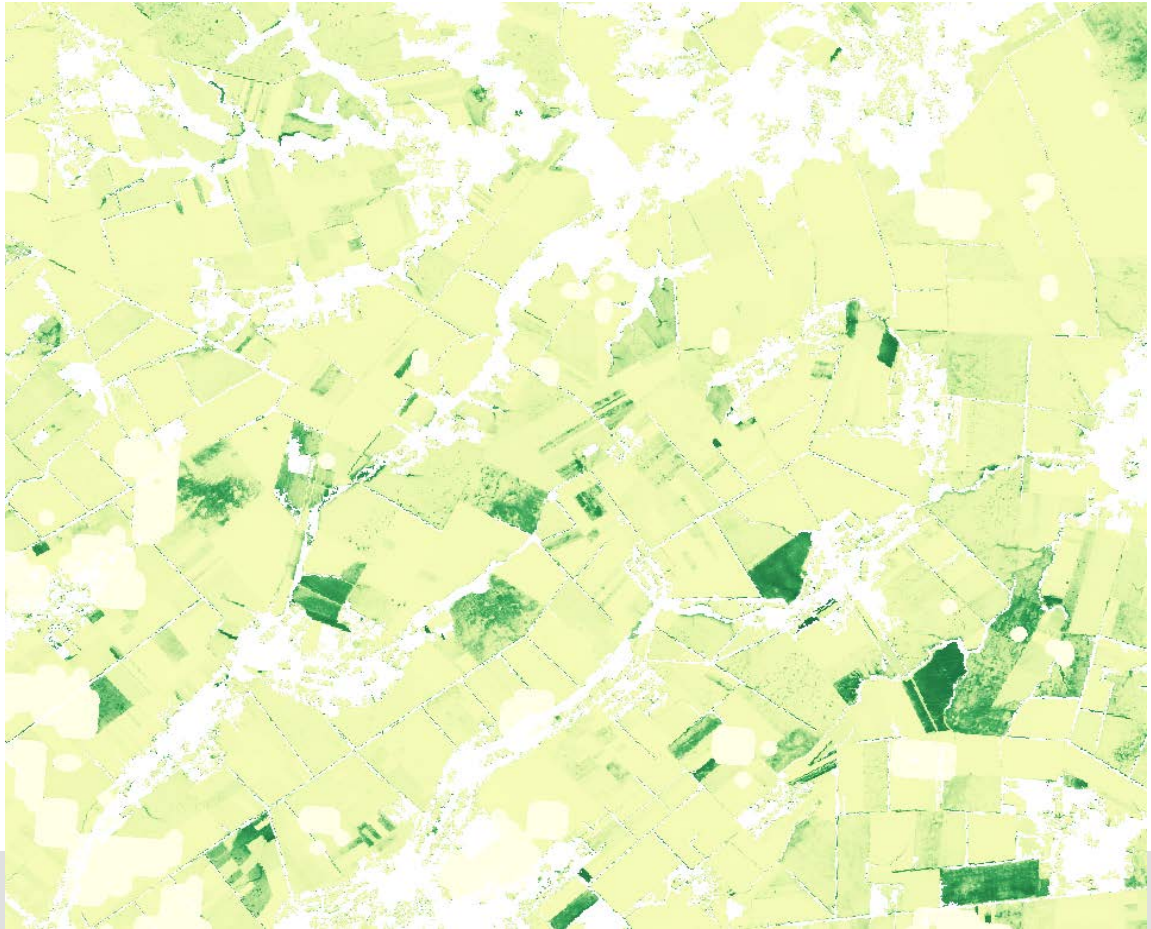
18 Apr. 16

28 Apr. 16

17 Jun. 16

17 Jul. 16

8 Sept. 16



Leaf Area Index values

5
4
3
2
1
0

sentinel-2 → AGRICULTURE

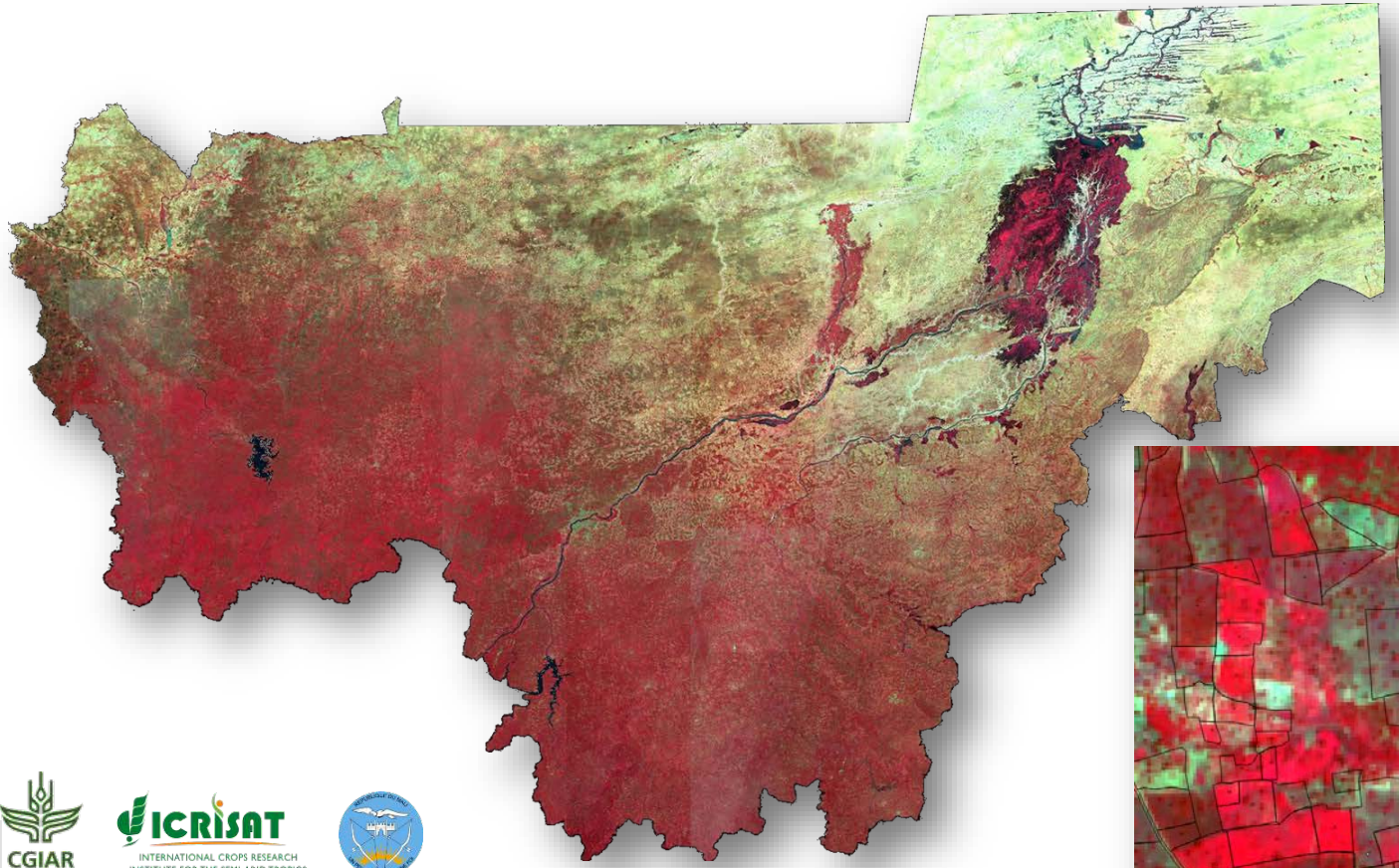
Contains modified Copernicus Sentinel data [2016], credit Sen2-Agri project

sentinel-2

→ AGRICULTURE

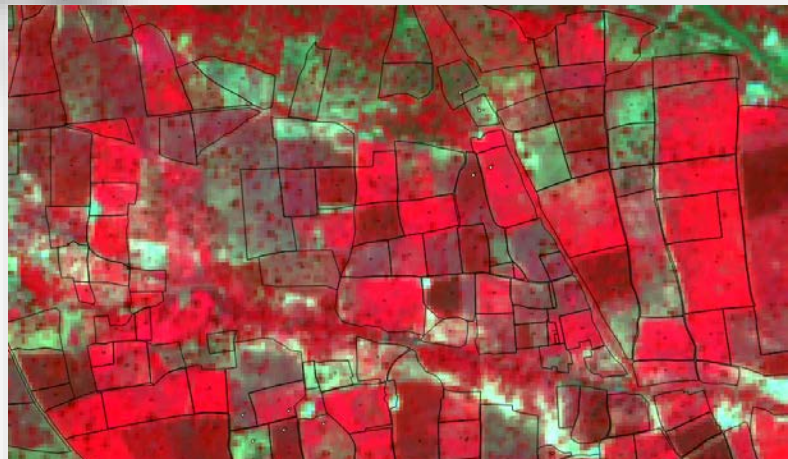
Mali: Food Insecure Country national statistics, crop damage

esa



November 2016

5/10/2016-25/11/2016



CGIAR

ICRISAT
INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

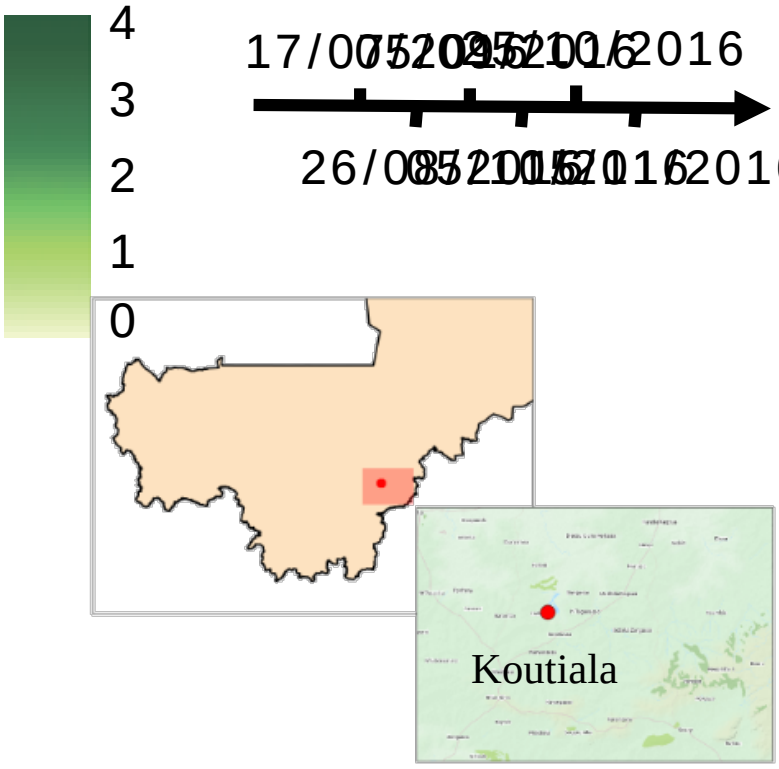
sentinel-2

→ AGRICULTURE

Mali: Crop Mask over Smallholder Farming

esa

Growth Monitoring of Cotton



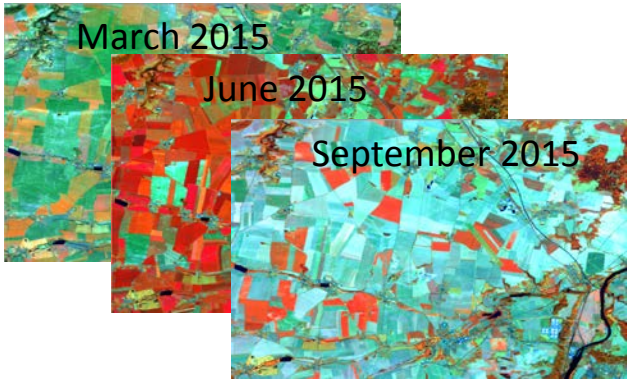
sentinel-2

→ AGRICULTURE

Czech-Agri: National Demonstration

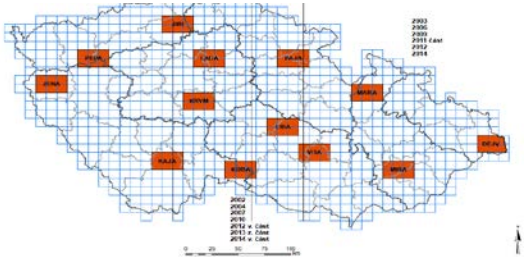
esa

Landsat & Sentinel-2 time series

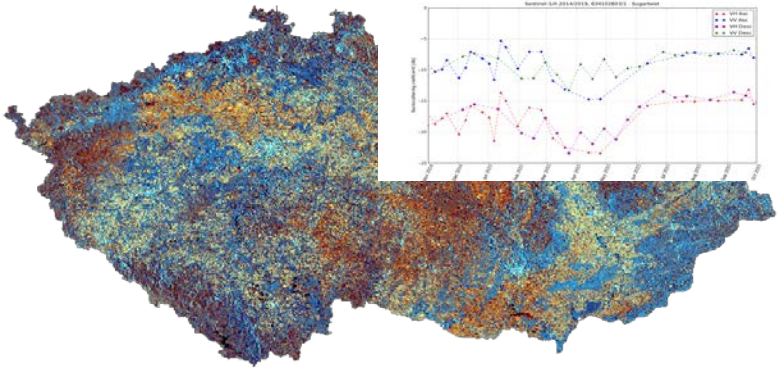


Land Parcel Identification System

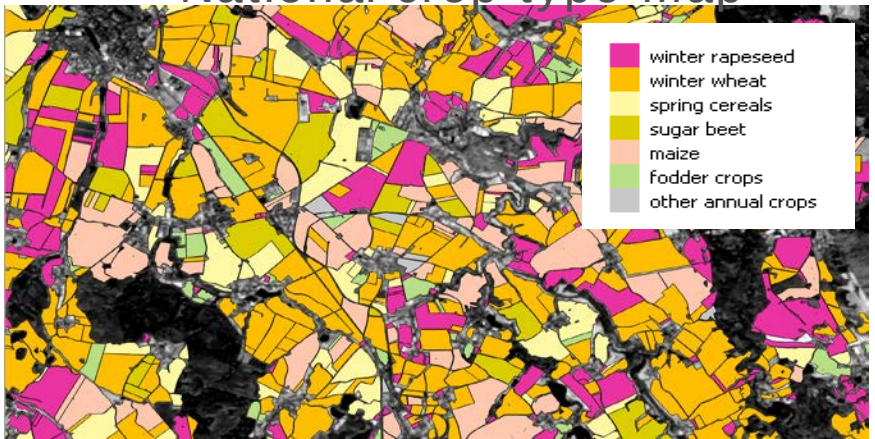
(2300 parcels for calibration & validation



Sentinel-1 time series



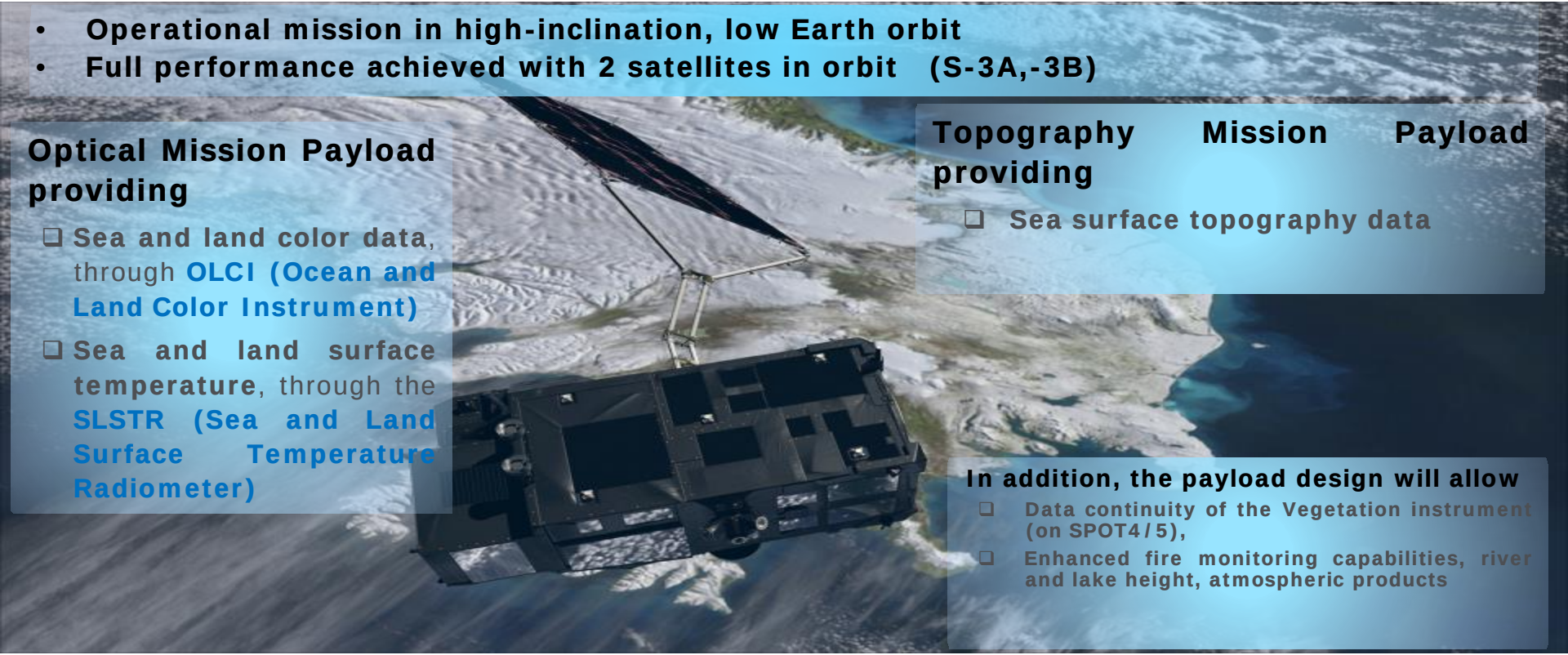
National crop type map



First Image of Sentinel-2B: Brindisi, Italy

SENTINEL-3 MISSION OVERVIEW

- **Operational mission in high-inclination, low Earth orbit**
- **Full performance achieved with 2 satellites in orbit (S-3A,-3B)**



Optical Mission Payload providing

- **Sea and land color data**, through **OLCI (Ocean and Land Color Instrument)**
- **Sea and land surface temperature**, through the **SLSTR (Sea and Land Surface Temperature Radiometer)**

Topography Mission Payload providing

- **Sea surface topography data**

In addition, the payload design will allow

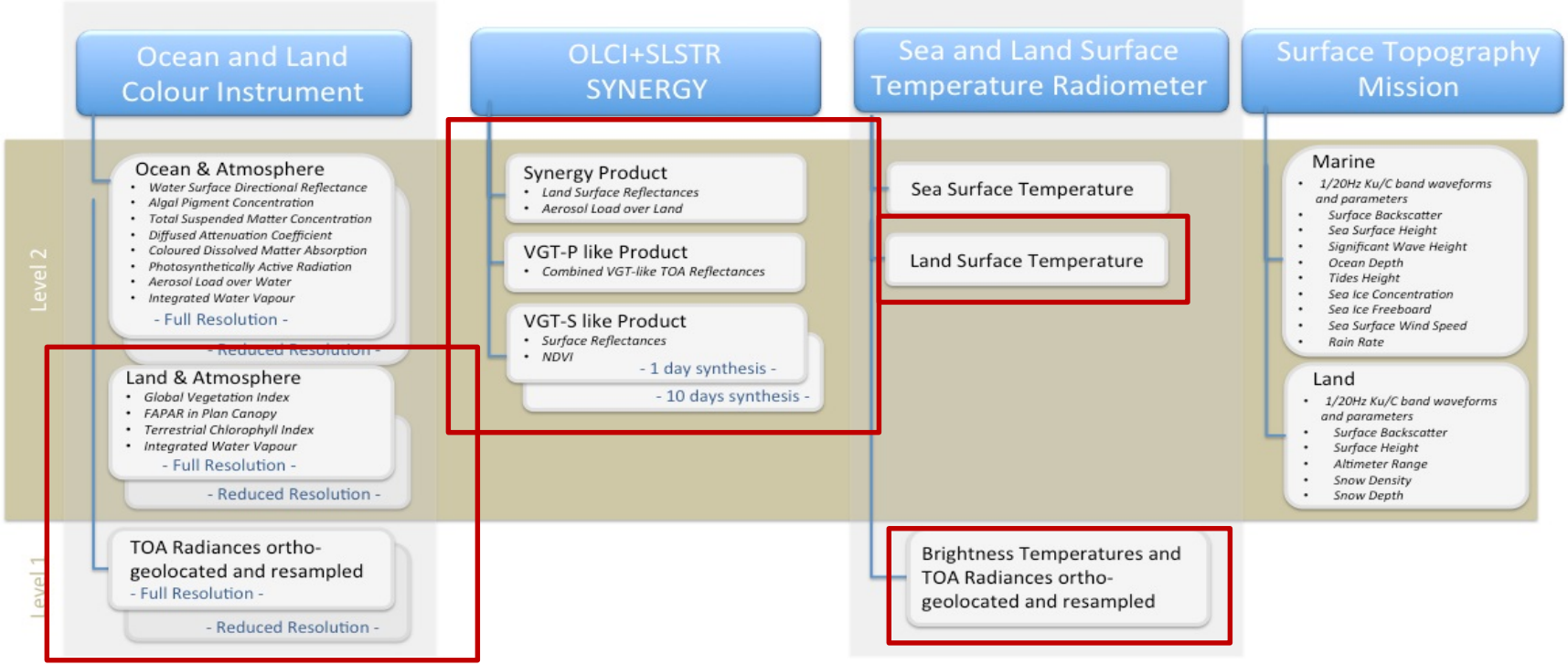
- **Data continuity of the Vegetation instrument (on SPOT4/5),**
- **Enhanced fire monitoring capabilities, river and lake height, atmospheric products**

NEW FEATURES - optical payload

- **100% overlap** between SLSTR and OLCI
- **Increased number of bands**
- **Broader swath**
- Optical payload **< 2 days global coverage** (with 2 Satellites)
- **Increased spatial resolution**:
  - OLCI: 300m for land and ocean
  - SLSTR: 500m for VIS-SWIR, 1km for IR-Fire
- **Mitigation of sun glint** by tilting cameras 12.5 deg in westerly direction
- **Near-Real Time** (< 3 hr) availability of L2 core products

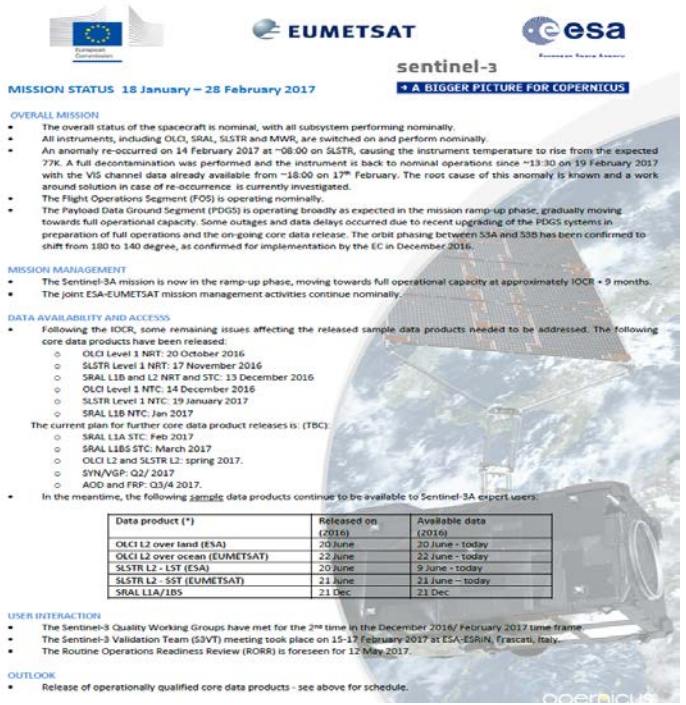
Instrument Swath

Sentinel-3: core data products



Sentinel-3 Status

- S-3A in ramp-up phase
- All instruments switched on and working well
- **Official data release**
  - OLCI Level 1 NRT: 20 October 2016
  - SLSTR Level 1 NRT: 17 November 2016
  - OLCI Level 1 NTC: 14 December 2016
  - SLSTR Level 1 NTC: 19 January 2017
  - OLCI L2 and SLSTR L2: spring 2017.
  - SYN/VGP: Q2/ 2017
- **Product evolution**
  - Land product harmonisation/synergy (Proba-V, S3, S2)
  - Improvements to vegetation products
  - Snow cover: SEOM project
- **Data access in operations**
  - **L1/L2 LAND**: ESA through the Sentinel Data Hub, Copernicus Services Hub, Collab Hub etc
  - **L1/L2 MARINE:** EUMETSAT's Earth Observation Portal (EUMETSAT's ODA, Data Centre, EUMETCast)
- **Sentinel-3B launch planned for end 2017**



sentinel-3

+ A BIGGER PICTURE FOR COPERNICUS

MISSION STATUS 18 January – 28 February 2017

OVERALL MISSION

- The overall status of the spacecraft is nominal, with all subsystem performing nominally.
- All instruments, including OLCI, SRAL, SLSTR and MWR, are switched on and perform nominally.
- An anomaly re-occurred on 14 February 2017 at ~08:00 on SLSTR, causing the instrument temperature to rise from the expected 77K. A full decontamination was performed and the instrument is back to nominal operations since ~13:30 on 19 February 2017 with the VIS channel data already available from ~18:00 on 17th February. The root cause of this anomaly is known and a work around solution in case of re-occurrence is currently investigated.
- The Flight Operations Segment (FOS) is operating nominally.
- The Payload Data Ground Segment (PDGS) is operating broadly as expected in the mission ramp-up phase, gradually moving towards full operational capacity. Some outages and data delays occurred due to recent upgrading of the PDGS systems in preparation of full operations and the on-going core data release. The orbit phasing between S3A and S3B has been confirmed to shift from 180 to 140 degree, as confirmed for implementation by the EC in December 2016.

MISSION MANAGEMENT

- The Sentinel-3A mission is now in the ramp-up phase, moving towards full operational capacity at approximately IOCR + 9 months.
- The joint ESA-EUMETSAT mission management activities continue nominally.

DATA AVAILABILITY AND ACCESS

- Following the IOCR, some remaining issues affecting the released sample data products needed to be addressed. The following core data products have been released:
  - OLCI Level 1 NRT: 20 October 2016
  - SLSTR Level 1 NRT: 17 November 2016
  - SRAL L1B and L2 NRT and STC: 13 December 2016
  - OLCI Level 1 NTC: 14 December 2016
  - SLSTR Level 1 NTC: 19 January 2017
  - SRAL L1B NTC: Jan 2017

The current plan for further core data product releases is: (TBC):

  - SRAL L1A STC: Feb 2017
  - SRAL L1BS STC: March 2017
  - OLCI L2 and SLSTR L2: spring 2017.
  - SYN/VGP: Q2/ 2017
  - AOD and FRP: Q3/4 2017.
- In the meantime, the following sample data products continue to be available to Sentinel-3A expert users:

Data product (*)	Released on (2016)	Available data (2016)
OLCI L2 over land (ESA)	20 June	20 June - today
OLCI L2 over ocean (EUMETSAT)	22 June	22 June - today
SLSTR L2 - LST (ESA)	20 June	9 June - today
SLSTR L2 - SST (EUMETSAT)	21 June	21 June – today
SRAL L1A/1BS	21 Dec	21 Dec

USER INTERACTION

- The Sentinel-3 Quality Working Groups have met for the 2nd time in the December 2016/ February 2017 time frame.
- The Sentinel-3 Validation Team (S3VT) meeting took place on 15-17 February 2017 at ESA-ESRIN, Frascati, Italy.
- The Routine Operations Readiness Review (RORR) is foreseen for 12 May 2017.

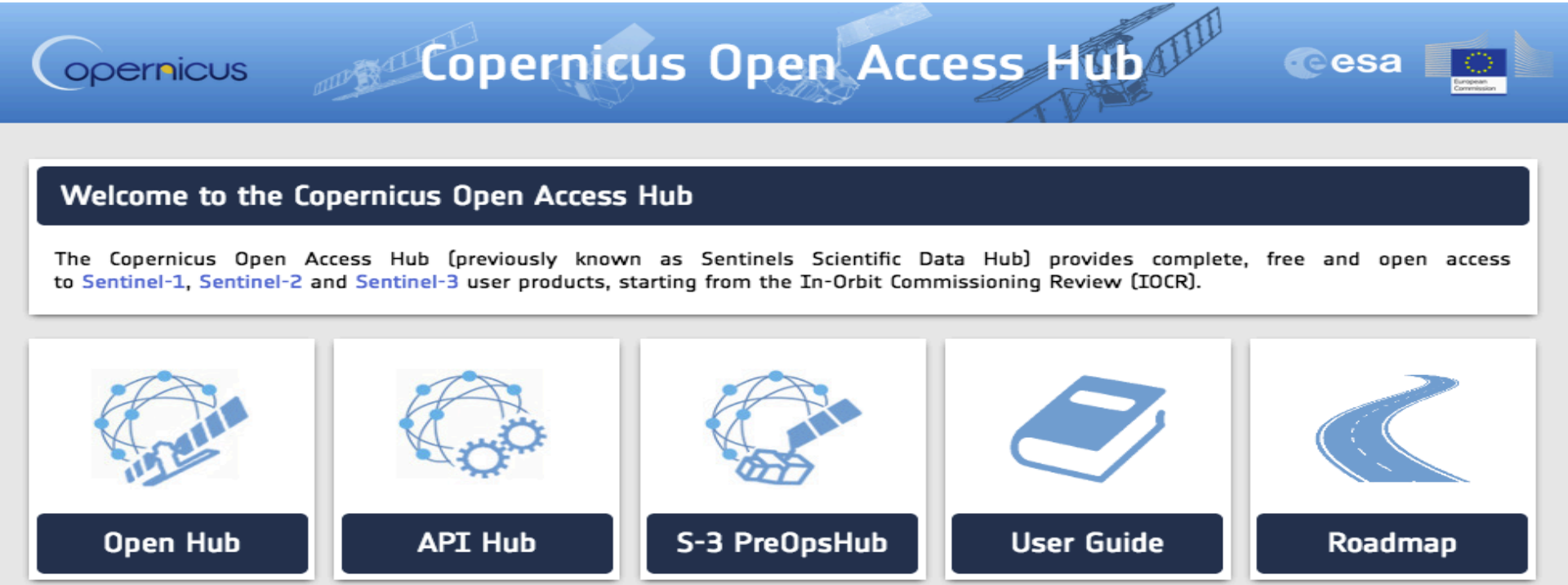
OUTLOOK

- Release of operationally qualified core data products - see above for schedule.

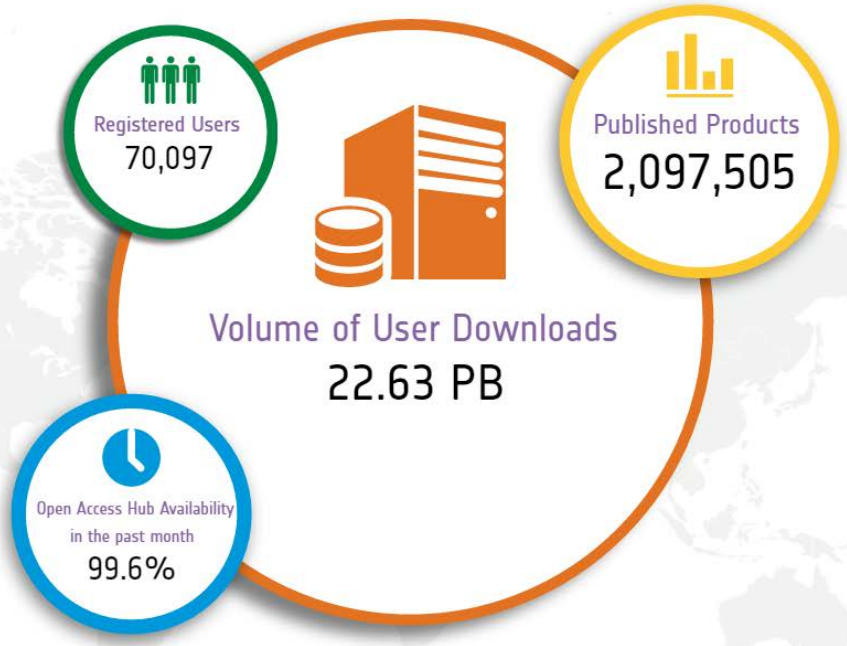
Weekly mission status on https://sentinel.esa.int/web/sentinel/missions/sentinel-3/mission-status

Sentinel Data Dashboard

https://scihub.copernicus.eu/

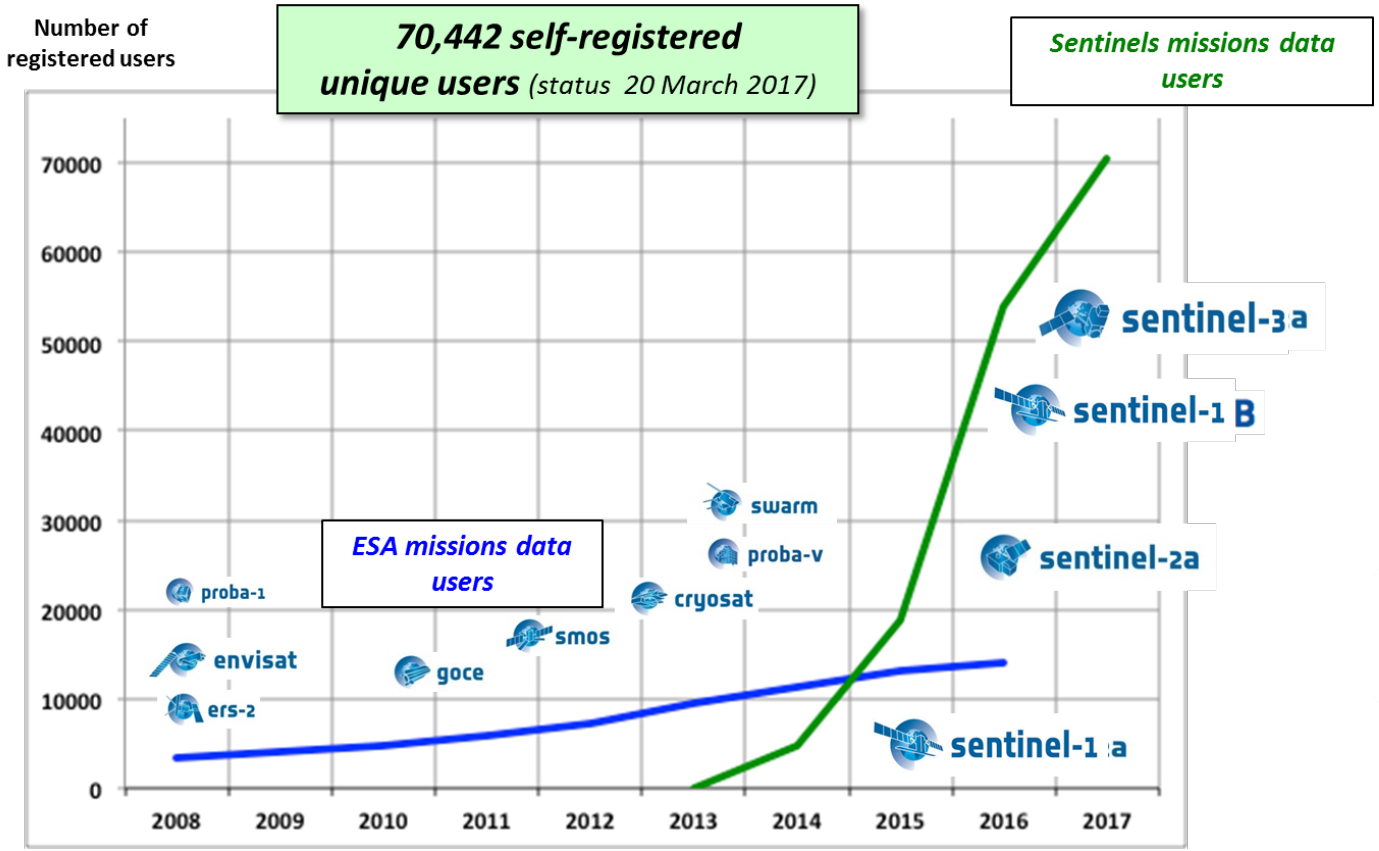


Copernicus: A Success Story



status as of
17 March 2017

Copernicus: User Uptake



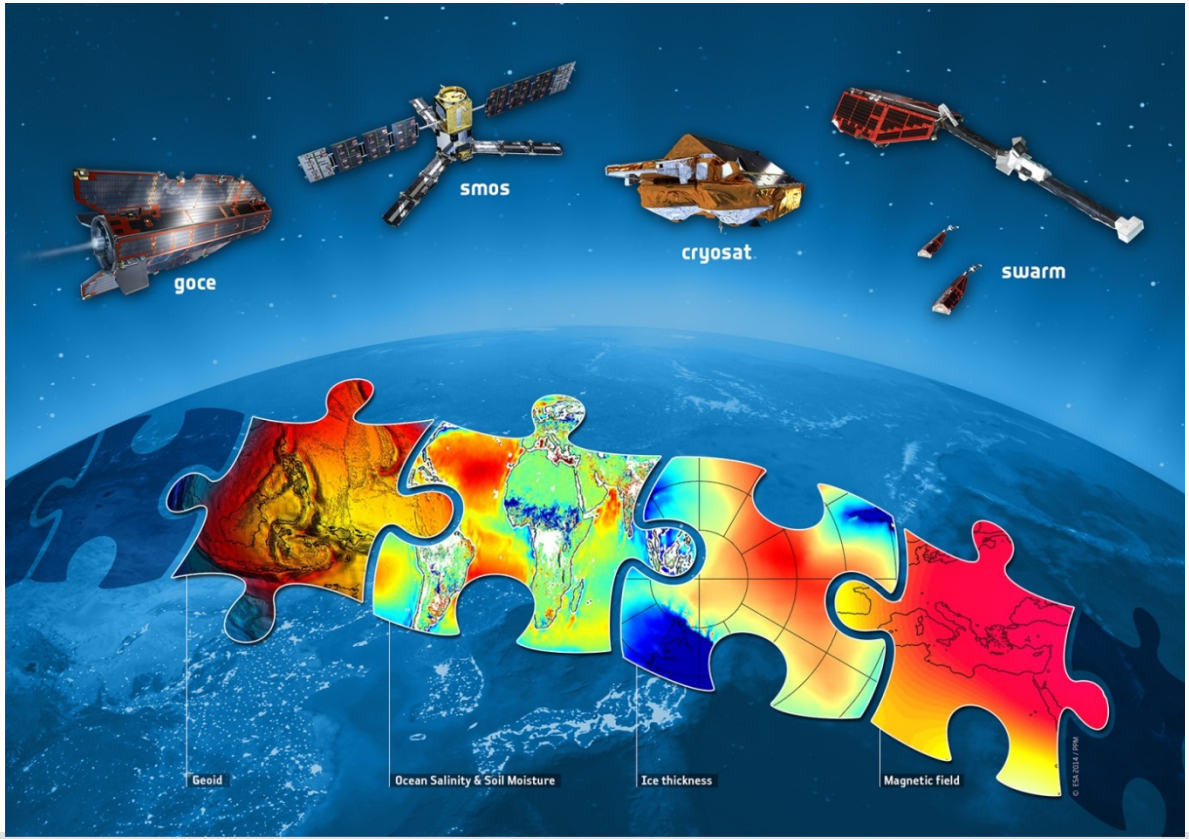
Sentinel Expansion

Candidates to be verified through requirements process !

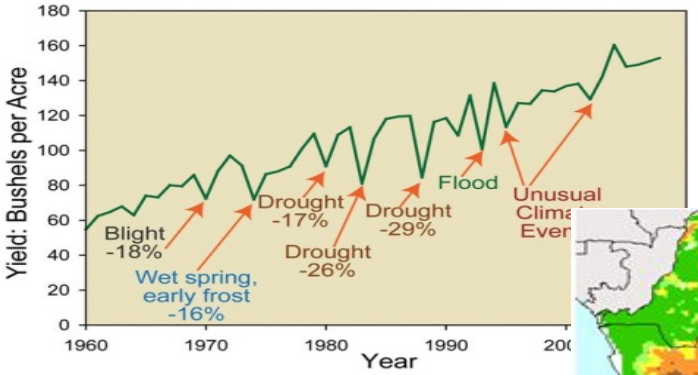
It is assumed that the following Sentinels are confirmed as a result of the user consultation process and following a gap analysis :

- Sentinel-7: a anthropogenic CO_2 monitoring mission
- Sentinel-8: a Thermal Infrared Imager (companion to Sentinel-2 C/D)
- Sentinel-9: components:
  - S-9 ICE: Enhanced Ice and Snow Continuity mission
  - S-9 HEO: Polar Weather Payload on a Highly Elliptical Orbit
- Sentinel-10: a Hyper-spectral mission

Science missions: Earth Explorers

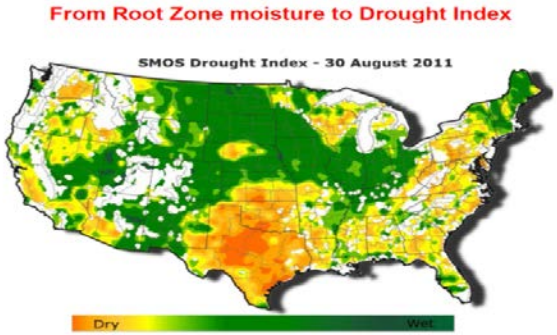


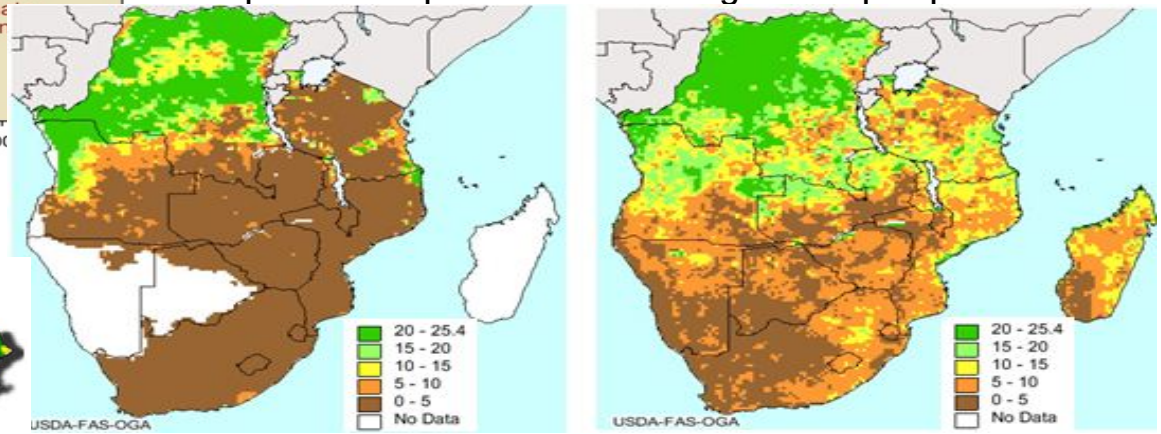
Using SMOS soil moisture for food security



Credit: USDA FAS

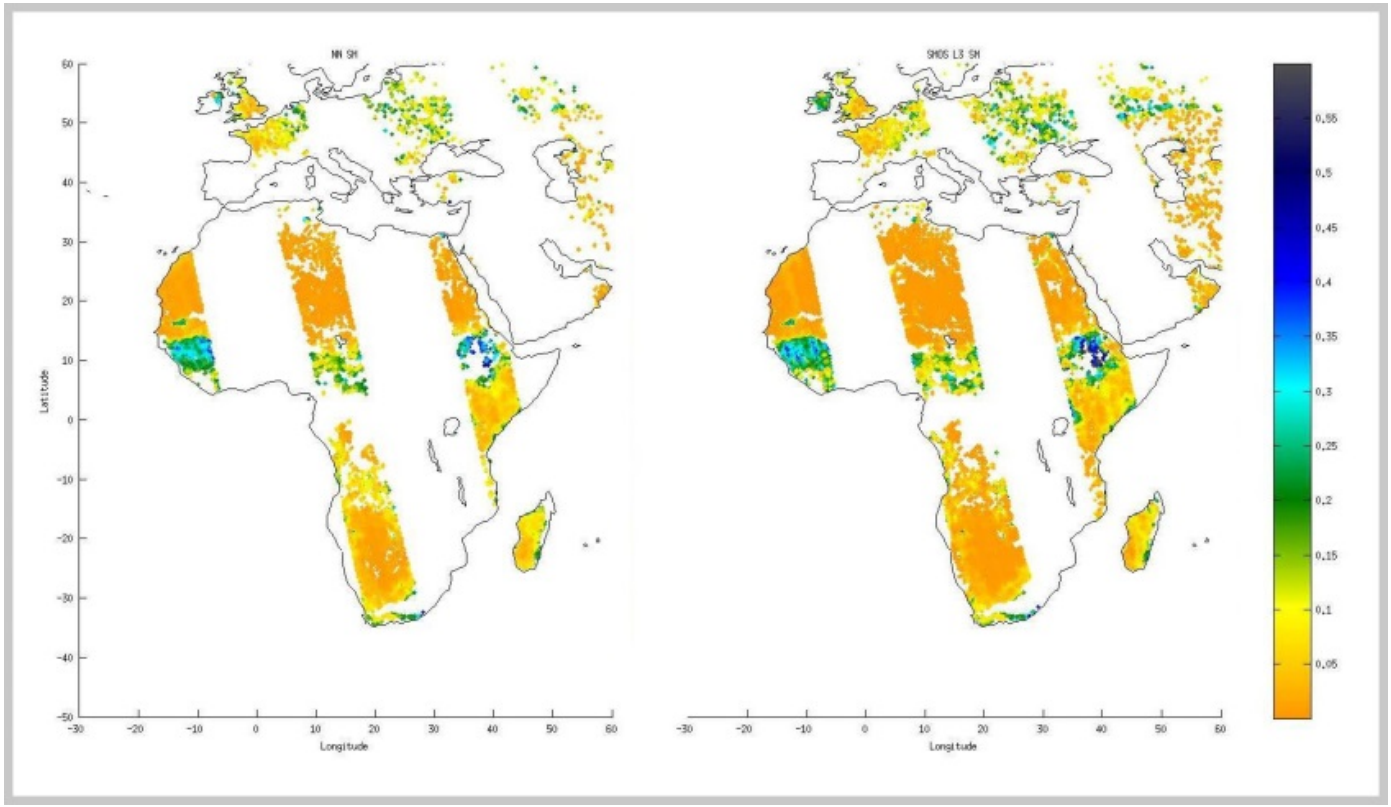
SMOS data used to predict drought and improve crop yield by US Department of Agriculture, Crop Explorer website: http://www.pecad.fas.usda.gov/cropexplorer/





Credit: USDA FAS, Soil moisture in southern Africa in mid-April 2014.

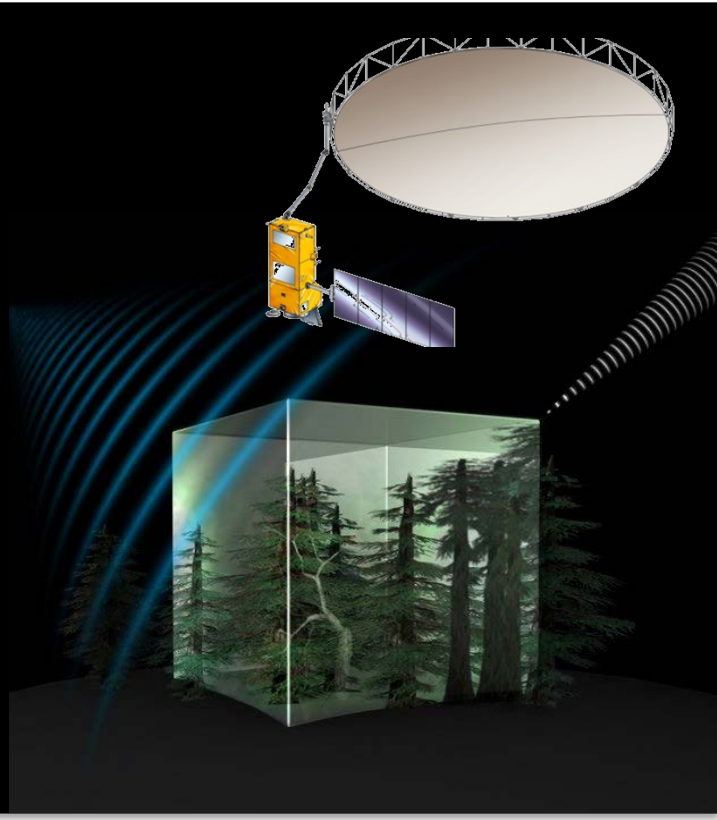
SMOS: Soil Moisture processed in two ways



Further Earth Explorer Missions

- 7th Earth Explorer: Biomass
  - Biomass estimates based on global interferometric and polarimetric P-Band Radar observations

- 8th Earth Explorer: FLEX
  - global maps of vegetation fluorescence, which can be converted into an indicator of photosynthetic activity



FLuorescence EXplorer FLEX

Scientific Objectives:

- FLEX will quantify **actual photosynthetic activity** of terrestrial ecosystems
- FLEX will provide **physiological indicators** for vegetation health status
- by direct measurements of **vegetation fluorescence** at relevant spatial scales

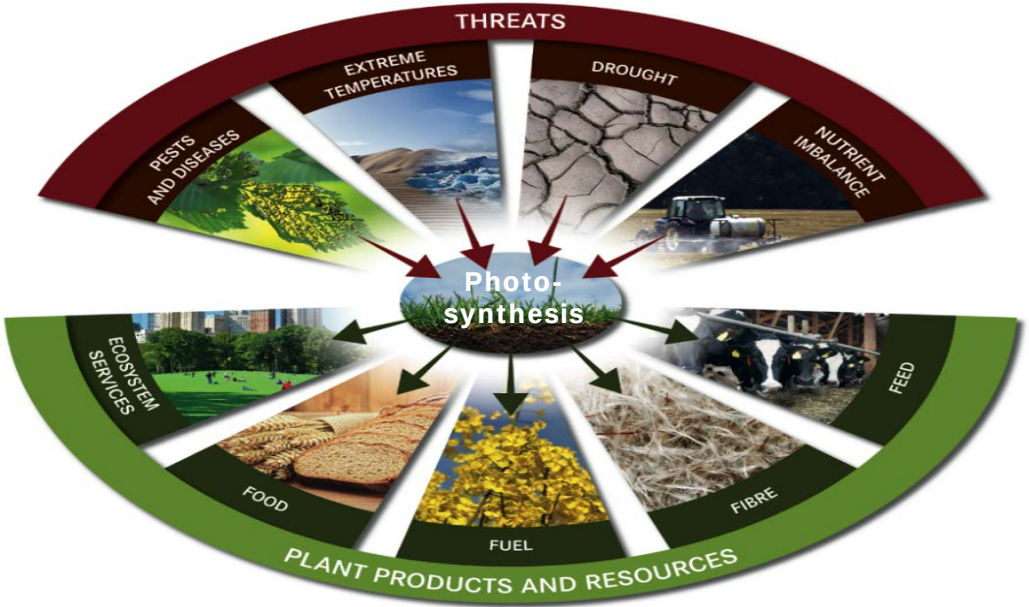
Key Mission Characteristics:

- Safe formation flying with Sentinel-3
- Launch in 2022
- Single imaging spectrometer
  - Swath of ~ 150 km
  - Pixel size of 0.3 x 0.3 km^2

Photosynthesis is the central metabolic process that determines plant productivity

Photosynthesis dynamically adapts to environmental stress

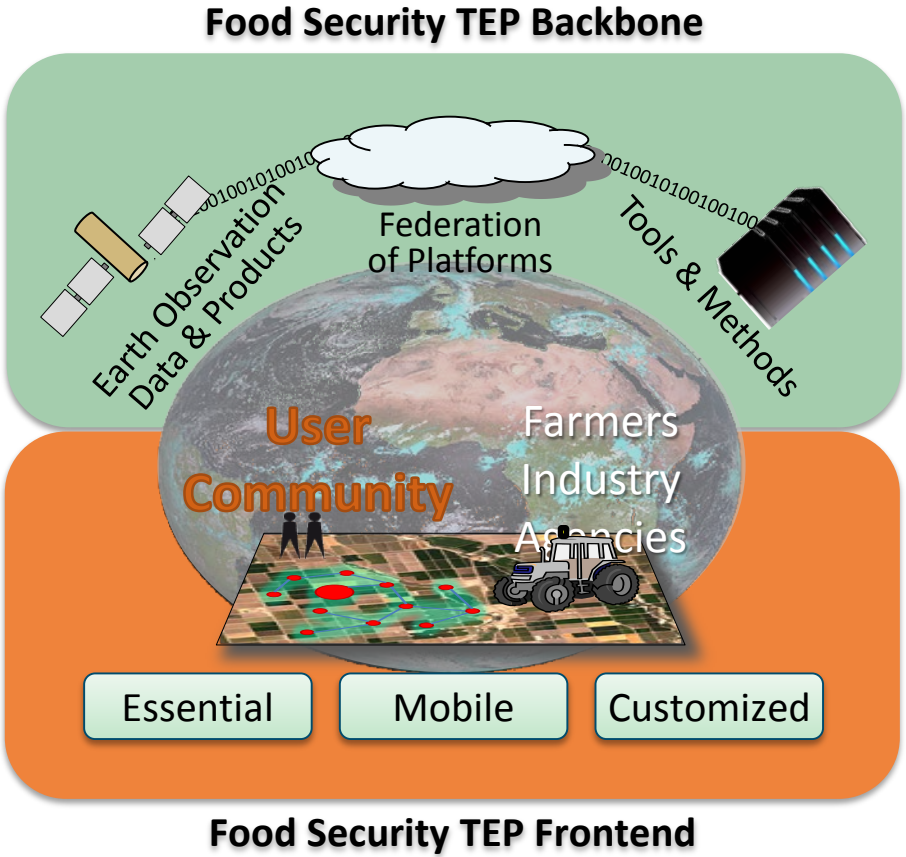
Could potentially help farmers detect disease, droughts and other problems before crops are heavily impacted



Food Security

Thematic Exploitation Platform

Food Security Thematical Exploitation Platform



tep thematic exploitation platform

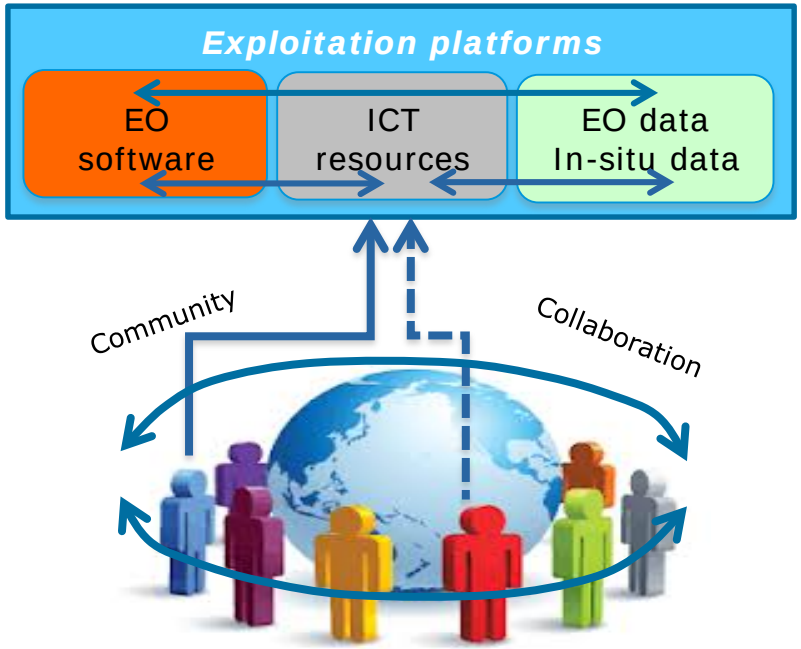
food security tep

"Bringing the people to the data"

The innovative virtual platform builds on existing infrastructure and aims at simplifying the extraction of information from Earth Observation data for the advancement of data-intensive services in the food security sector mainly in Europe and Africa

Food Security Platform - Concept

“*Bringing the User to the Data*” and **“*Connecting the Users*”**



An innovative operations concept: users access a work environment containing the data and resources required, as opposed to downloading and replicating the data ‘at home’

→ *An R&D scenario for data intensive exploration gradually complementing the traditional operations concept for the ground segment*

Community platform:

A virtual, open and collaborative environment

bringing together:

- data access (EO and other)
- computing resources and hosted processing
- collaborative tools (processing, data mining, user tools, …)
- application shops and market place functionalities
- communication tools (social network) & documentation
- accounting tools to manage resource utilisation

Food Security Platform – Scope

Crop monitoring, yield forecasting, livestock management
Monitoring of land use and agricultural soils status
Support to sustainable fisheries & aquaculture production
Support to capacity building

TARGET USERS

- ✓ R&D communities: Agriculture, Aquaculture, Fisheries, EO applications
- ✓ Food producers: Farmers and cooperatives, aquaculture industry, fisheries, agro-industry
- ✓ Service providers and facilitators: Consultants, extension services, EO value-adding industry
- ✓ Policy and financing: EC, ministries, development agencies, development banks, insurance

International cooperation: EC, GEOGLAM/JECAM, FAO, IFAD, WFP, …

- Interoperable with existing Food Security info systems and services
- Integrating EO (Sentinels 1-2-3, Proba-V, Landsat, SMOS, …), in-situ, administrative and other data, as well as models

FS- TEP Structure

FS-TEP GUI

FS-TEP Customised – InaaS
restricted data and services, commercial

FS-TEP Mobile – InaaS
free, easy, but limited

FS-TEP Basic – Paas & SaaS
free, for advanced users (Science)

EO4Food user comm.

FS-TEP Backbone

FS-TEP InaaS

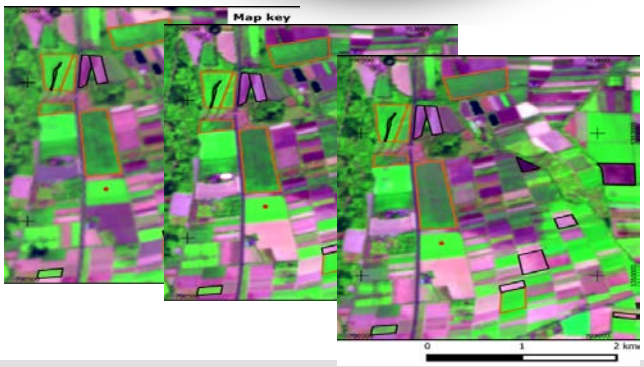
FS-TEP PaaS & SaaS

PaaS & InaaS Proba-V MEP

SaaS F-TEP

InaaS other activities

DaaS & IaaS
CloudFerro or Code-DE



PARTNERSHIP FOR GROWTH & SUSTAINABILITY

- Bringing together diversity of actors *(farmers and cooperatives associations, main international food security organisations, other UN, NGOs, scientists, insurance, development aid, agro-industry, App developers, commercial service providers, international initiatives)*
- Improved understanding of challenges of actors in food security
- Improved understanding of EO potential to support Food Security
- Defining user needs
  incl. cap. build.
- Lessons learnt
- Preparing activities

User consultation Workshop 11-12 April 2016 in ESRIN

Thank you for your attention!

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