EU GLOBAL ACTION ON SPACE

Harvesting from Space: EU Space Programme Benefits for Agriculture in Brazil

14 September 2023

Session 1: The EU Space Programme and the EU Global Action on Space

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European Commission – DG DEFIS
Global Action on Space leader

Funded by the European Union

Promoting the European Union Space Programme

EU GLOBAL ACTION ON SPACE

The EU Space Programme

- Has positioned the EU at the **forefront of satellite technology**
- Provides unique **services** that **address climate change, support disaster relief, and boost economic activity and innovation**
- Is a **key enabler of the digital economy**
- Generates a very important **downstream industry** (services and applications)
- Contributes to **fulfil EU key policy goals** and priorities.

Budget for EU Space programme (2021-2027)

€14.88bn

>300.000

Jobs supported by EU Space

Flagship components

GALILEO

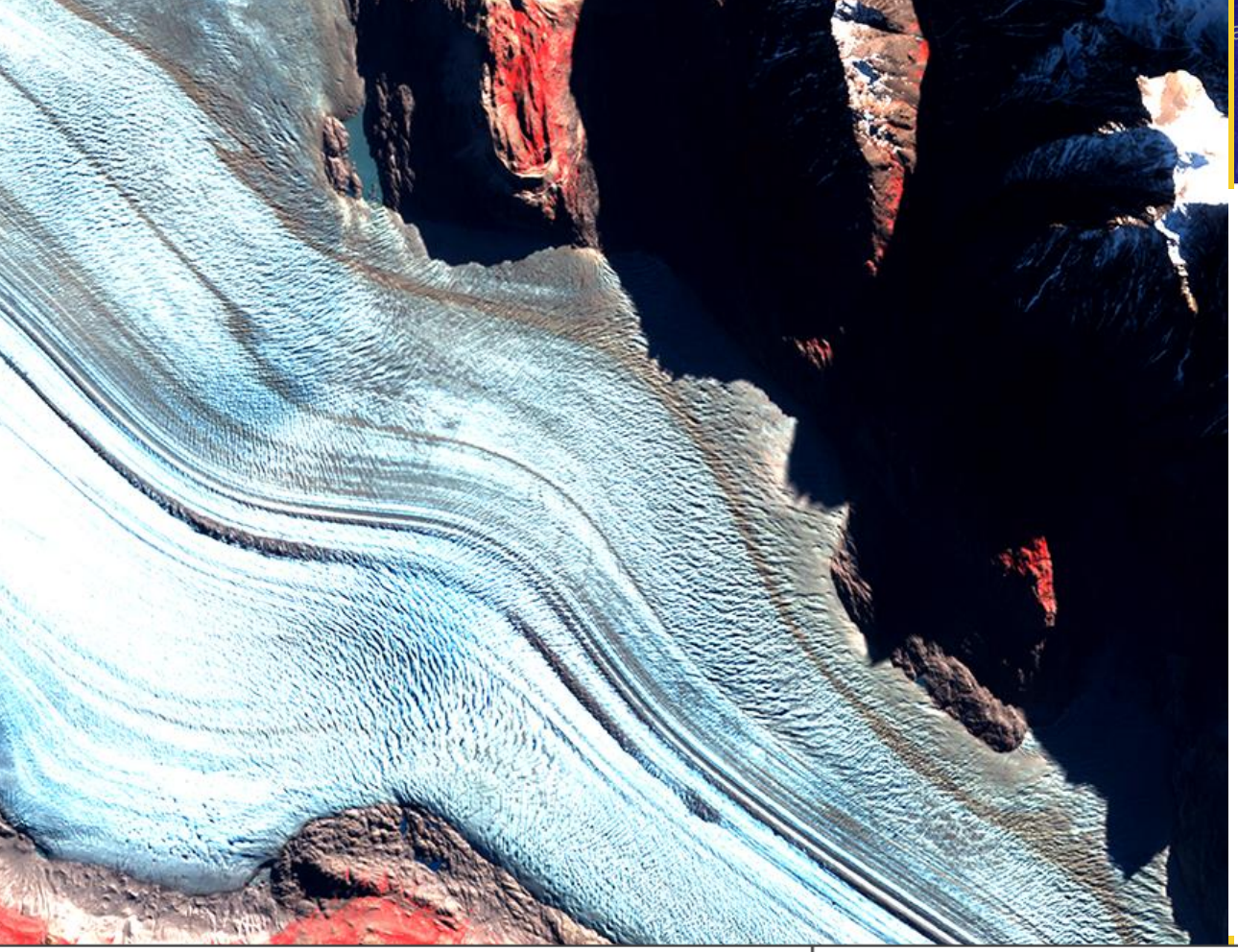
11% of the EU GDP is enabled by satellite navigation

EGNOS

Operational in 500+ airports & helipads in 23 countries

Copernicus Europe's eyes on Earth

No.1 global provider of space data and information



Copernicus – Europe's Eyes on Earth

- Copernicus is the **largest space data provider in the world**. It builds upon a space component (observation satellites) and an in-situ component (ground, airborne and seaborne stations).
- **Free, full and open data access** policy.
- Information **services in six areas**: land monitoring, marine environment monitoring, atmosphere monitoring, climate change, emergency management and security.

Cumulative economic value generated	Earth Observation Companies in Europe exploiting Copernicus Data	Volumes of downloads from Data Access Systems
€16.2 – 21.3 billion	72%	16 TB of data daily

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Galileo

- High-quality GNSS services
- Offers precise timing, positioning and emergency services to citizens, private companies and public authorities.
- Provides up to 20cm high accuracy positioning and a Search & Rescue service to assist individuals in distress and
- Almost **2.5 billion users; 11% of the EU's GDP**.

Number of satellites, control centres and sensor stations	Value of the Global GNSS market	Estimated revenue from services relying on GNSS technology by 2029
30	**€175 billion**	**€166 billion**

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EGNOS

GALILEO

Egnos - The European Geostationary Navigation Overlay Service

EGNOS is a **satellite-based augmentation** system which covers the EU + hinterland.

- Currently **improves the accuracy and reliability of GPS positioning**. In the future it will improve the performance of Galileo.

- Provides **safety-critical navigation services to aviation, maritime and land-based users**.

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EGNOS

GALILEO

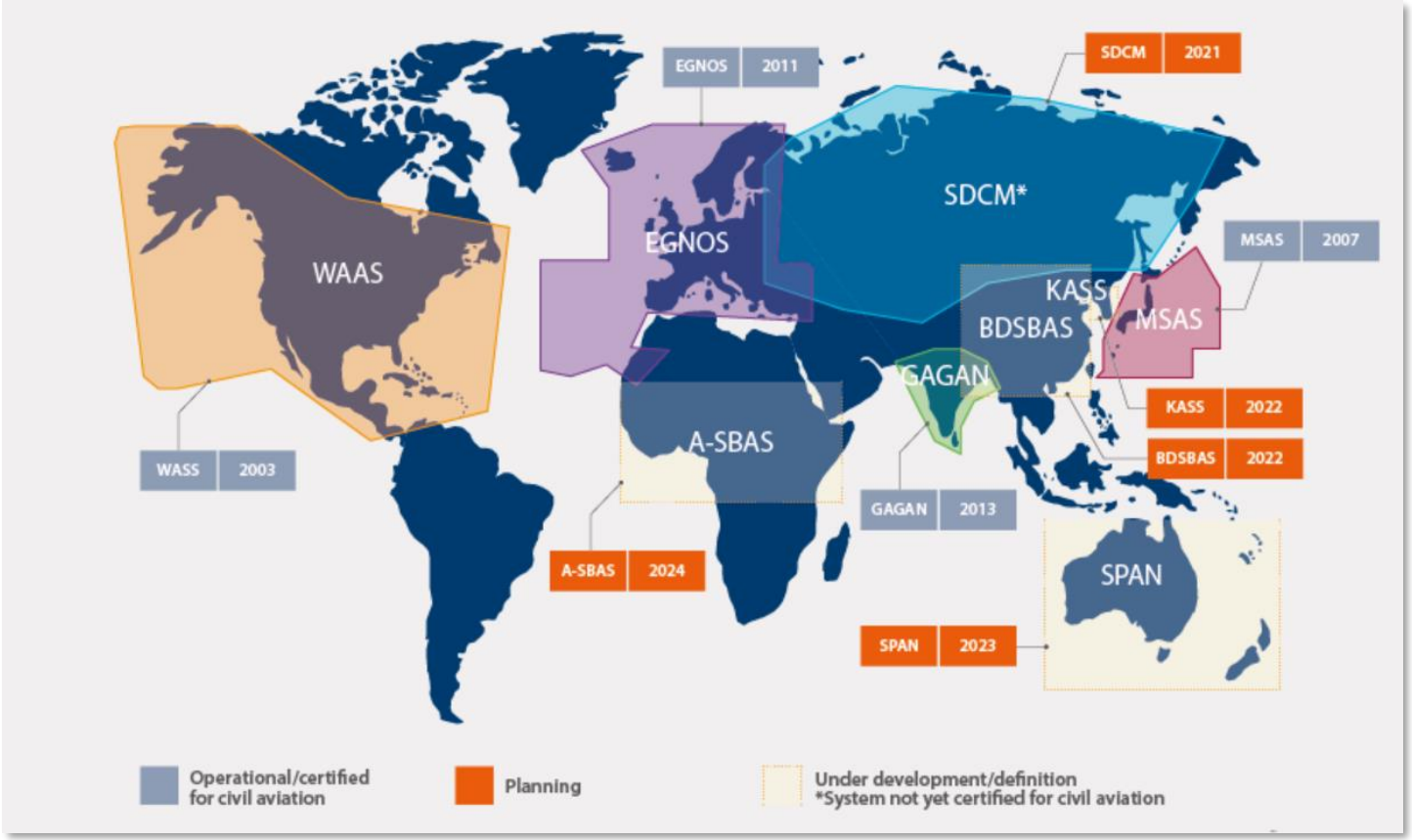
Existing SBAS in the World

Interoperable: the SBAS equipment will work:

- in any of the regions where there is a SBAS service
- With other GNSS source

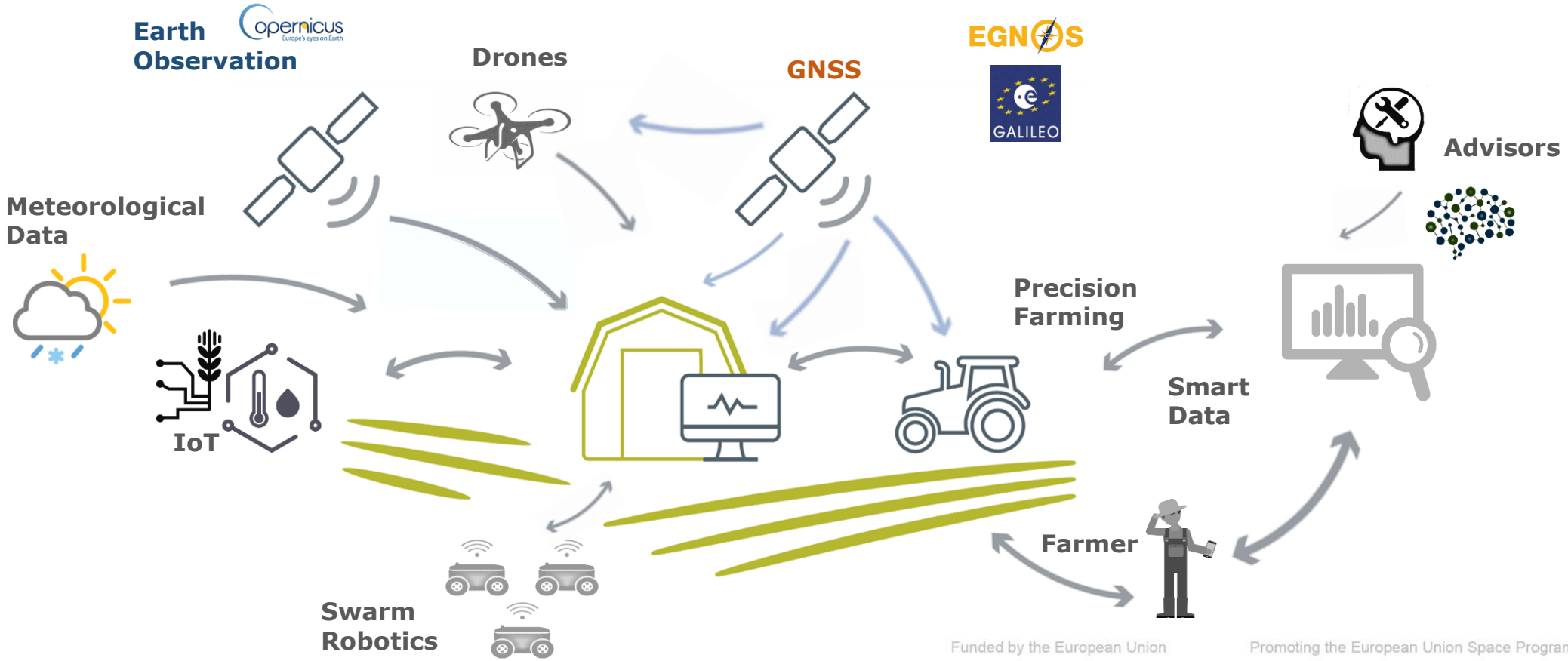
In the future (>2026):

- **EGNOS** will augment also **Galileo**
- **EGNOS** will broadcast dual-frequency corrections

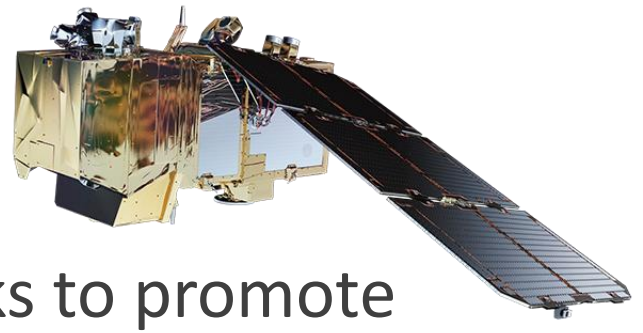


EU Space Programme Synergies

GNSS and Copernicus are core components in digital farming



A vision on the EU Global Action on Space



Through the 'Global Action', the European Commission seeks to promote cooperation with the EU on space, namely by:

- Promoting understanding of EU Space capabilities worldwide.
- Relaying information on specific opportunities for space cooperation in more than 40 markets worldwide, including Brazil.
- Providing tailor-made coaching services for companies wishing to do business based on EU space capabilities (including agriculture)

Contacts

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EGNOS

GALILEO

Copernicus

Brasilia, 14.09.23

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Europe's eyes on Earth

Space

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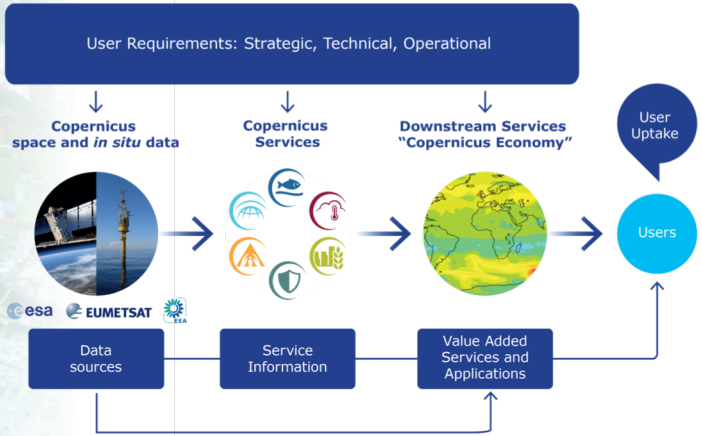
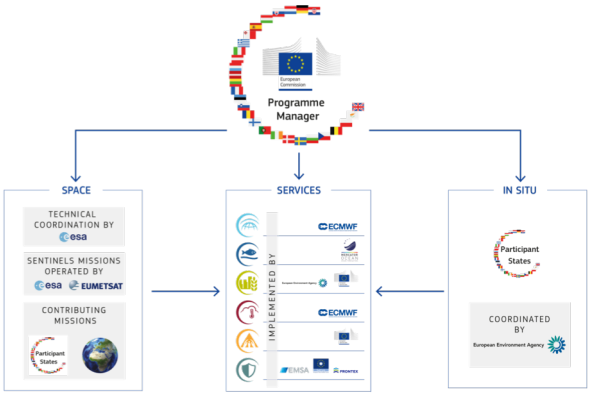
Copernicus

- **Copernicus, the Earth Observation and Monitoring flagship programme** of the European Union
- **Monitors the Earth,** its environment and ecosystems
- **Full, free and open data policy**
- **Operational** and long term **Sustainability**
- Coordination by **European Commission DG DEFIS** & implemented by **Delegated Entities**





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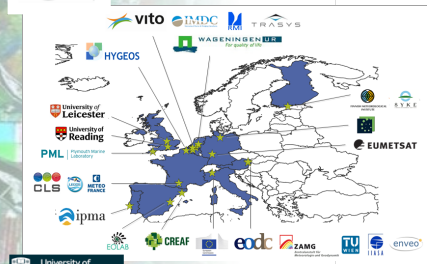
Building on existing expertise

CLMS : 65+ industry partners / 350+ experts



SYKE · enveo · HYGEOS · IMDC · University of Reading · LEGOS · TU WIEN GEO · EOXPLORE to observe, to explore, to protect · GISBOX · SINERGISE · Universitat de València · TerraSphere · ZAMG Zentralanstalt für Meteorologie und Geodynamik · CREAF · ipma · IGN · Societe · EUMETSAT · TRASYS · eodc · TU WIEN · IIASA · WAGENINGEN UNIVERSITY · JOANNEUM RESEARCH · IGN France International · ONF International · space 4 environment · GISBOX · EOXPLORE · RMI · EOLAB · METEO FRANCE · University of Leicester · CLS COLLECTE LOCALISATION SATELLITES · SPACEBEL · Université de Liège · Informus GmbH Observing the natural environment · University of Southampton · FINNISH METEOROLOGICAL INSTITUTE · vito · PML Plymouth Marine Laboratory · BROCKMANN CONSULT GMBH · e-geos UNA SOCIETÀ ASI/TELESPAZIO · EXELIS Visual Information Solutions · ISPRA · Telespazio · LUND UNIVERSITY · Starlab® STARLAB LIVING SCIENCE · IMDC · EXELIS · UCLC · ITHACA · National Research Council of Italy · ONF International · JOANNEUM RESEARCH · GEOFIT · space 4 environment · adwäisEO · BROCKMANN CONSULT GMBH · SINERGISE · GeoVille · ACRI ST · LuxCarta · adwäisEO · UCLC · iLab · Copernicus Europe's eyes on Earth · European Commission

The current Sentinel missions

FULL, FREE AND OPEN

Sentinel Mission and Status		Key Features
 SENTINEL-1: 4-40m resolution, 6 days revisit at equator	*2 Sats in orbit (-1)*	Polar-orbiting, all-weather, day-and-night radar imaging
 SENTINEL-2: 10-60m resolution, 5 days revisit time	*2 Sats in Orbit*	Polar-orbiting, multispectral optical, high-res imaging
 SENTINEL-3: 300-1200m resolution, <2 days revisit	*2 Sats in Orbit*	Optical, thermal and altimeter mission monitoring sea and land parameters
 SENTINEL-4: 8km resolution, 60 min revisit time	*1st Launch in 2023*	Payload for atmosphere chemistry monitoring on MTG-S
 SENTINEL-5p: 7-68km resolution, 1 day revisit	*1 Sat in Orbit*	Mission to reduce data gaps between Envisat, and S-5
 SENTINEL-5: 7.5-50km resolution, 1 day revisit	*1st Launch in 2023*	Payload for atmosphere chemistry monitoring on MetOp 2nd Gen
 SENTINEL-6 Michael Freilich: 10 day revisit time	*1 Sat in Orbit*	Radar altimeter to measure sea-surface height globally

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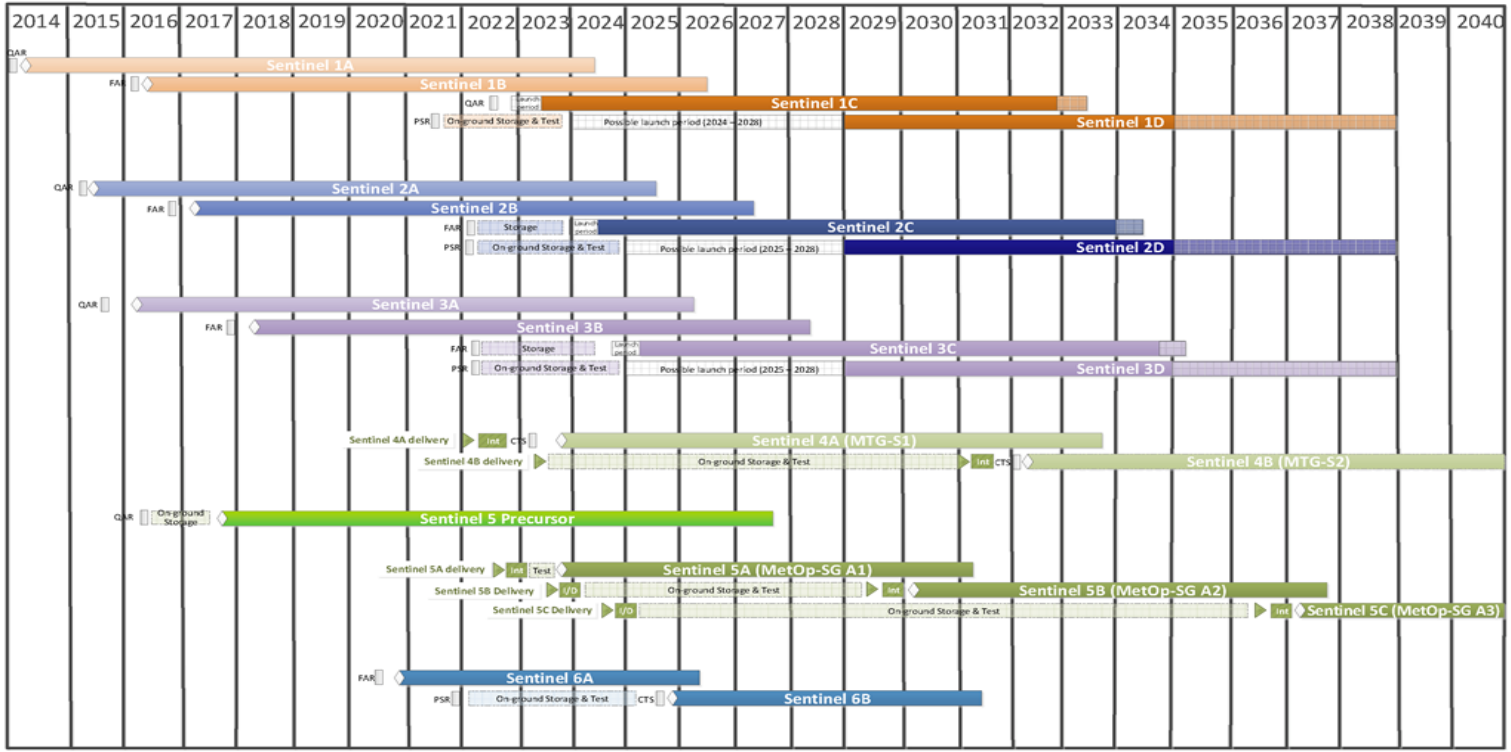
European Commission

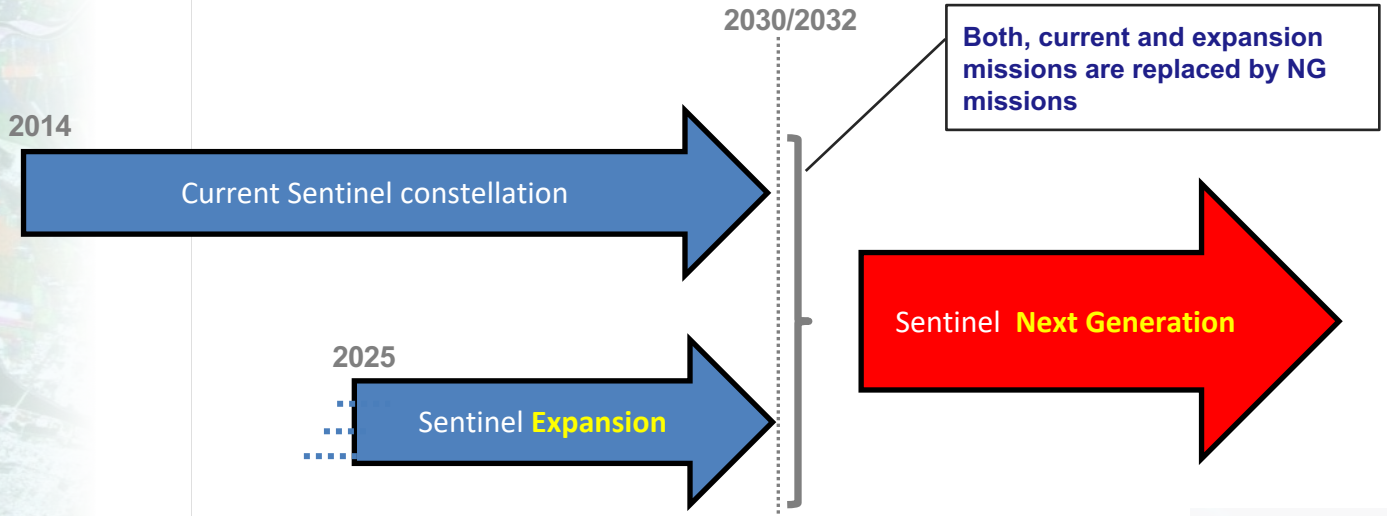
Sentinel Satellite Deployment

Indicative Copernicus Constellation Deployment Schedule

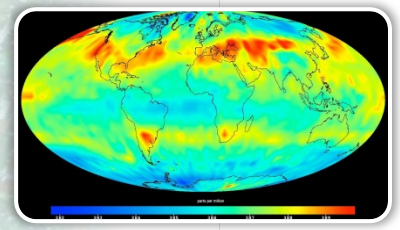


Status and Planned launches

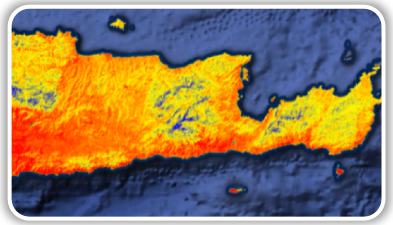
- Space Strategy orientation (2016)
- User Requirement Survey (2015-2018) – Identify Space Segment Gaps and Improvements
- Two steps approach
  - Next Generation Sentinel (Technical specifications under preparation)
  - Expansion Missions complementing the current Sentinel



Priority Challenges for Expansion missions

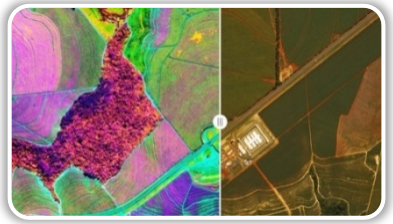


Causes Climate Change

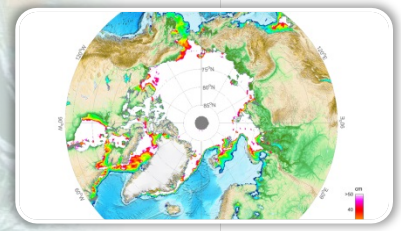


Agriculture & Urban Monitoring

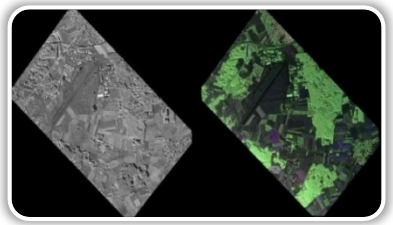
Effects Climate Change



Food Security, Soil & Minerals



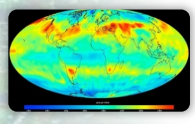
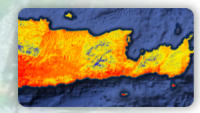
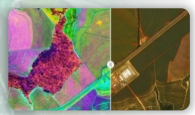
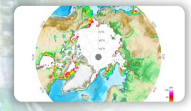
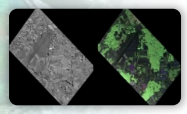
Sea Ice & Hydrology



Soil, Vegetation & Ground Motion

The Expansion missions post 2025

FULL, FREE AND OPEN

	Expansion Mission and Status		Key Objectives
	CO2M: Near and shortwave infrared spectrometer	*1st Launch in 2025*	Mission to measure and monitor anthropogenic CO2 emissions
	LSTM: High spatio-temporal thermal infrared	*1st Launch in 2028*	Mission for agriculture, water productivity, urban heat
	CRISTAL: Altimeter & microwave radiometer	*1st Launch in 2028*	Mission for polar sea-ice & snow thickness, and ice-sheet elevations
	CHIME: Hyperspectral Imaging mission	*1st Launch in 2028*	Mission for agriculture nutrients, Soil, Minerals, Biodiversity
	CIMR: Passive microwave radiometer	*1st Launch in 2029*	Mission for Sea Surface Temperature & Ice concentration
	ROSE-L: L Band SAR mission	*1st Launch in 2028*	Mission for Vegetation, Ground Motion and Soil Moisture

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COPERNICUS SERVICES

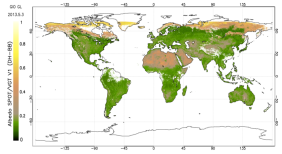
Monitoring the State of the Earth System Environment …

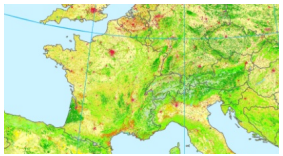
… Six cross-cutting Thematic Services

Land Monitoring

LAND / Benefit areas and products examples

- Ecosystems
- Biodiversity
- Agriculture
- Forestry
- Energy
- Natural Resources
- Water
- Urban planning





- Global Systematic Monitoring
- Global Hot Spot
- Pan-European land cover mapping and systematic monitoring
- EU Local component
- Reference Data & SENTINEL 2 Mosaic

COPERNICUS Services – Current Status

Land Monitoring

Portfolio of the Biophysical Variables:
From **9** NRT variables to now
21 type products
3 resolutions (1km, 300m, 100m)
80+ data collections

Variable	*Temporal Coverage*				
LAI/FAPAR/FCover	*1999 – present*				
NDVI/VCI/VPI	*1999 – present*				
Dry Matter Productivity	*2009 – present*				
Burnt Area	*1998 – present*				
TOC Reflectance	*2013 – present*				
Surface Albedo	*1999 – present*				
Land Surface Temperature	*2009 – present*				
Soil Water Index	*2007 – present*	*1 day*	*l*	*0.1*	*Metop / ASCAT*
Water bodies	*1999 – present*	*10 days*	*Globa l**	*1km*	*SPOT/PROBA V*

From medium to high resolution

Theme	Variable	Spatial Resolution Moderate 100m
Vegetation	Land Cover	In production

From coarse to medium resolution

Theme	Variable	Spatial Resolution Coarse >=1km	Medium 300m
Vegetation	Fraction of photosynthetically active radiation absorbed by the vegetation	In production	In production
	Fraction of green vegetation cover	In production	In production
	Leaf Area index	In production	In production
	Normalized Difference Vegetation Index	In production	In production
	Vegetation Condition Index	In production	
	Vegetation Productivity Index	In production	
	Dry Matter Productivity	In production	In production
	Burnt Area	In production	In production
	Soil Water Index	In production	
	Surface Soil Moisture	In production	
Energy	Land Surface Temperature	In production	
	Top Of Canopy Reflectance	In production	
	Surface Albedo	In production	
Water	Water Bodies	In production	In production
	Lake Surface Water Temperature	In production	
	Lake Water Quality	In production	
Cryosphere	Lake Ice Extent	In production	
	Snow Cover Extent	In production	
	Snow Water Equivalent	In production	

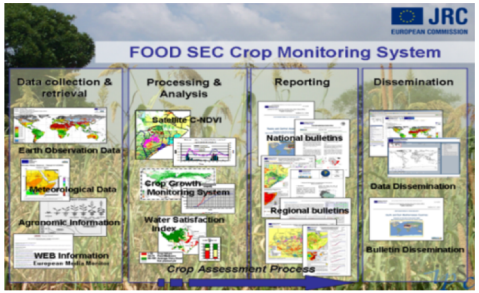
Non-gridded products

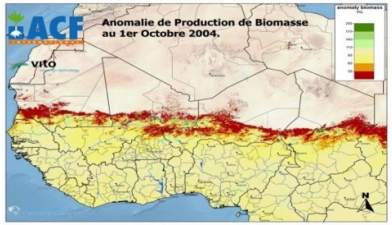
Theme	Variable	Rivers and Lakes
Water	Water Level	In production

Land Monitoring

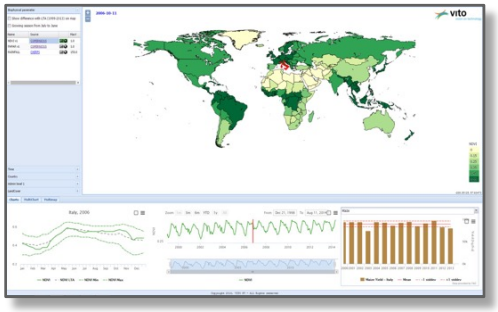
Application domains

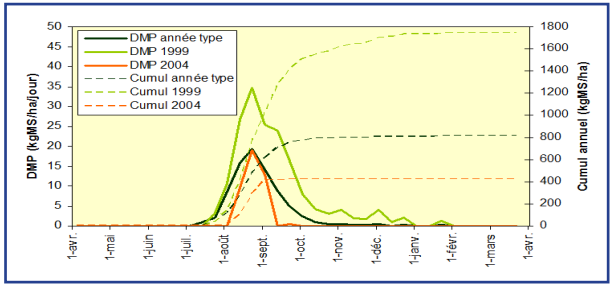
- Climate change
  - Carbon flux forecast
- Agriculture – Food Security
  - Crop monitoring
  - Yield forecasting
  - Biomass conditions
- Monitoring extreme events
  - Droughts
  - Frost conditions
  - Heat waves
- Hydrology
  - Water management
  - River discharge





- Monitoring of fires and burned areas on a daily basis
- Development of indices of fire management and efficiency
- Bulletins developed at national and PA level



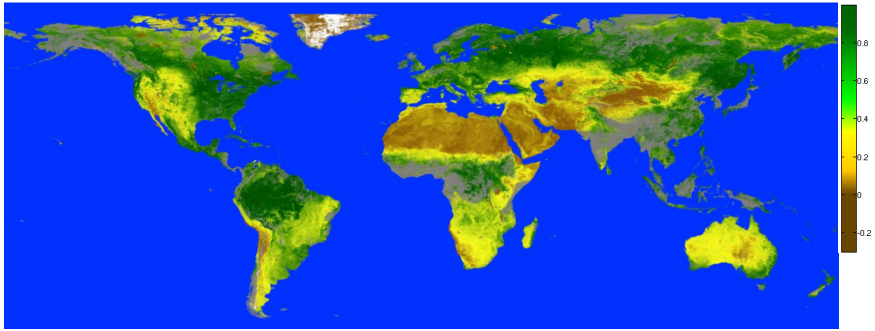


Land Monitoring

Vegetation Dynamic

Product: NDVI , VCI/VPI
Status: Operational

- Description:
  - Normalized Difference Vegetation Index is an indicator of greenness of the biomes
  - Vegetation Condition Index and Vegetation Productivity Index assess the vegetation by referencing the current value to long-term statistics
- Product Specifications:
  - Sensor SPOT-VGT, PROBA-V, Sentinel-3
  - Collection 1km V2 1999-NRT
    - Method max_NDVI 10 days
  - Collection 300m V1 2014-NRT
    - Method max_NDVI 10 days
  - On going: 1km V3, 300m V2
    - Method ANT (angular normalization) 10 days
- Accuracy:
  - 0.05: not possible to assess

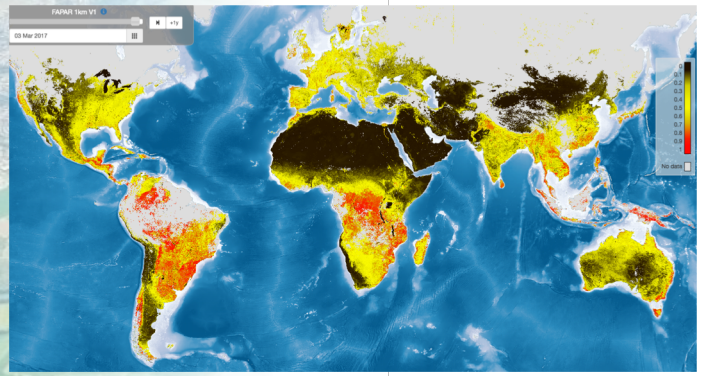


Vegetation status (NDVI)
1st decade March 2022

Land Monitoring

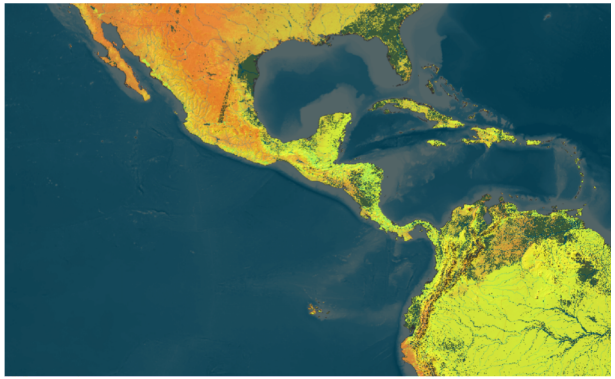
BIOPHYSICAL PRODUCTS

Vegetation status (**FAPAR**)



Vegetation status (**LAI**)
Leaf Area Index
1st decade March 2022

Vegetation status (**DMP**)
Dry Matter Production
1st decade March 2022



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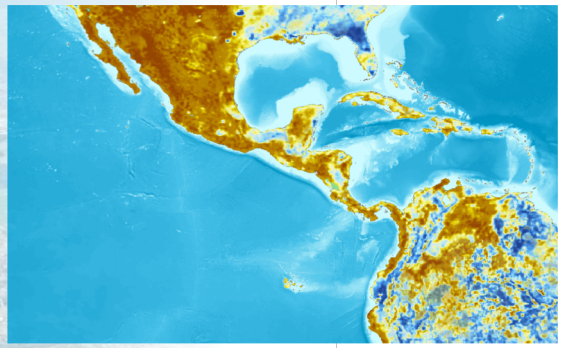
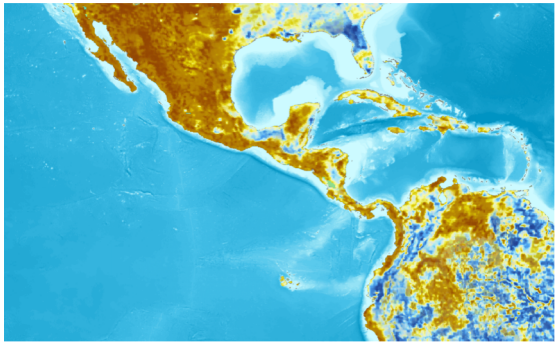
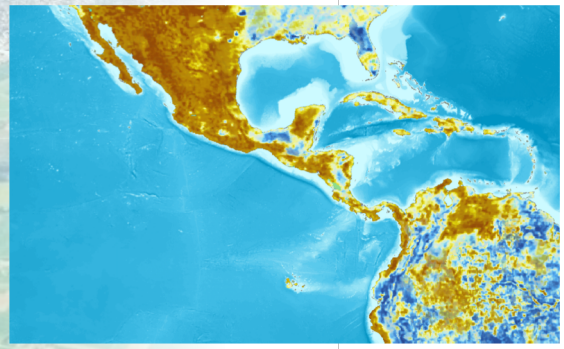
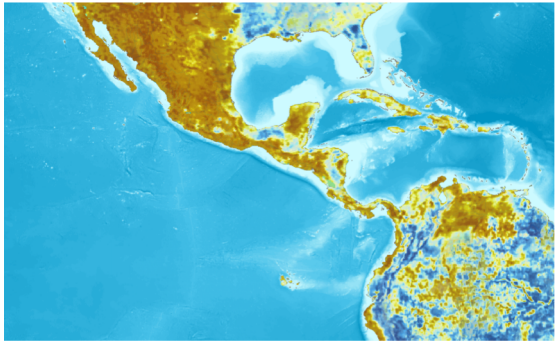
Land Monitoring

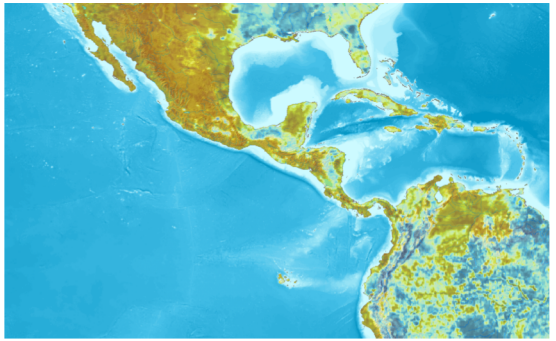
Soil Water Index







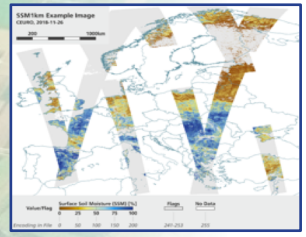




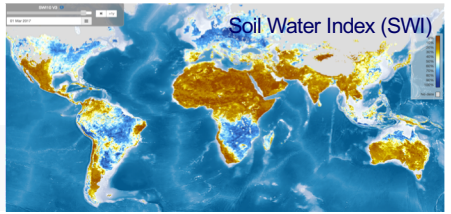
Soil Water Index / Soil Moisture

The SWI quantifies the amount of water (m^3/m^3) in soil layers at various depths

Global
Daily
1 km (with Sentinel 1) – 10 km (Metop ASCAT)

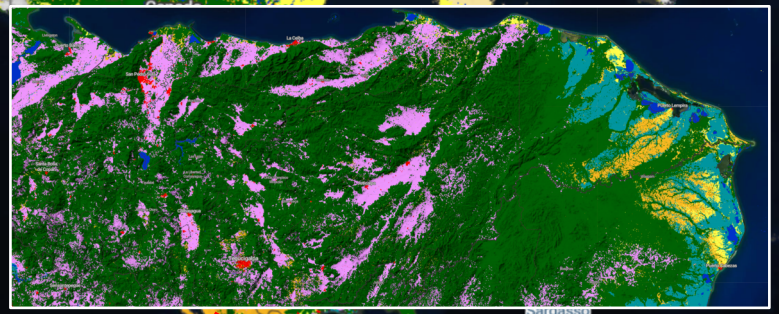


Sequence of 5 days of SWI in March 2022 (10 km)



Land Cover Map

100m, 2015-2019,
80,6% Global accuracy



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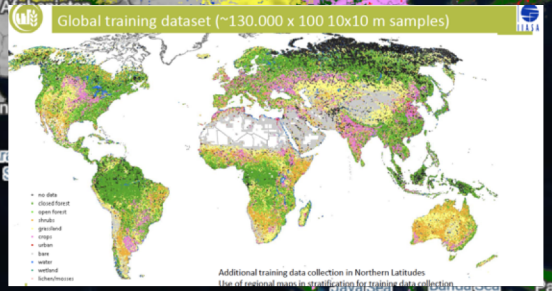
LAND MONITORING
SERVICE
Europe's eyes on the terrestrial environment
land.copernicus.eu

Global Activities



remote sensing

Communication

Copernicus Global Land Cover Layers—Collection 2

Marcel Buchhorn 1,*, Myroslava Lesiv [2], Nandin-Erdene Tsendbazar [2], Martin Herold [3], Luc Bertels [1] and Bruno Smets [1]

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2 Ecosystems Services and Management, International Institute for Applied Systems Analysis (IIASA), A-2361 Laxenburg, Austria; lesiv@iiasa.ac.at
3 Laboratory of Geo-Information Science and Remote Sensing, Wageningen University & Research, NL-6708 Wageningen, The Netherlands; martin.herold@wur.nl (M.H.); marlus.kruijt@wur.nl (M.K.)
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Received: 19 February 2020; Accepted: 12 March 2020; Published: 18 March 2020

Abstract: In May 2019, Collection 2 of the Copernicus Global Land Cover layers was released. Next to a global discrete land cover map at 100 m resolution, a set of cover fraction layers is provided depicting the percentual cover of the main land cover types in a pixel. This additional continuous classification scheme represents areas of heterogeneous land cover better than the standard discrete classification scheme. Overall, 20 layers are provided which allow customization of land cover maps to specific user needs or applications (e.g., forest monitoring, crop monitoring, biodiversity and conservation, climate modeling, etc.). However, Collection 2 was not just a global up-scaling, but also includes major improvements in the map quality, reaching around 80% or more overall accuracy. The processing system went into operational status allowing annual updates on a global scale with an additional implemented training and validation data collection system. In this paper, we provide an overview of the major changes in the production of the land cover maps, that have led to this increased accuracy including aligning with the Sentinel 2 satellite system in the grid and coordinate system, improving the metric extraction, adding better auxiliary data, improving the biome delineations, as well as enhancing the expert rules. An independent validation exercise confirmed the improved classification results. In addition to the methodological improvements, this paper also provides an overview of where the different resources can be found, including access channels to the product layer as well as the detailed peer-review product documentation.

Keywords: Copernicus; land cover; land cover classification; cover fractions; remote sensing; global land cover mapping; random forest; time series analysis

1. Introduction

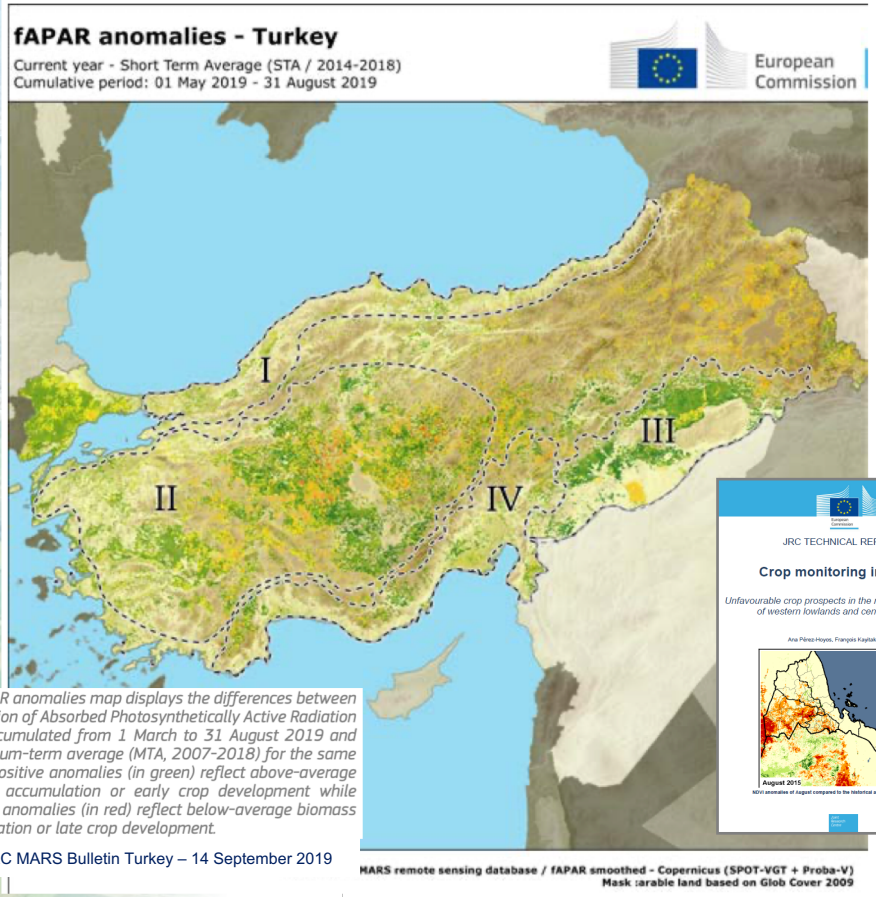
Land is an important asset for human beings. The globalization of the world's economy and the increase of its population, however, have large environmental consequences and put unprecedented pressure on land management [1–3]. To understand these consequences and to act upon them, accurate characterization of land cover and land-use change is essential. This also means records of vegetation characteristics and land cover (LC) need to be available. While long-term consistent to ultra-observations for large areas remain scarce, satellite remote sensing has become a major source of information for the monitoring of vegetation dynamics since the 70s [4]. Satellite systems like Landsat, National Oceanic and Atmospheric Administration's (NOAA) AVHRR, and MODIS, among others, provide long-term records of reflectance data on a global scale [5–7]. These datasets have been used to generate state-of-the-art global discrete LC maps at low to medium resolution [8,9] like the GlobCover [10], LC-CCI [11], and MODIS [12] products. Georg et al. [13] produced the first

2019
2018
2017
2016
2015

- Forests
- Shrubland
- Herbaceous vegetation
- Herbaceous wetland
- Moss & lichen
- Bare / sparse vegetation
- Cropland
- Built-up
- Snow & ice
- Permanent water bodies

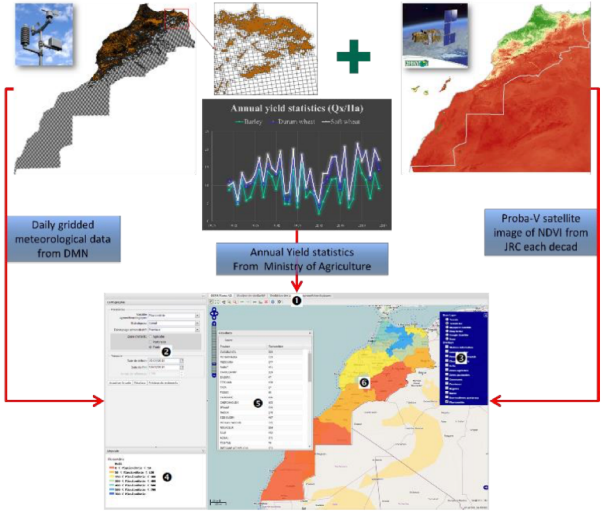
Land Monitoring

Agriculture monitoring for food security



The fAPAR anomalies map displays the differences between the fraction of Absorbed Photosynthetically Active Radiation (fAPAR) cumulated from 1 March to 31 August 2019 and the medium-term average (MTA, 2007-2018) for the same period. Positive anomalies (in green) reflect above-average biomass accumulation or early crop development while negative anomalies (in red) reflect below-average biomass accumulation or late crop development.

DG JRC MARS Bulletin Turkey – 14 September 2019



CGMS-Maroc: mapping system

Data sources used

From the service

- NDVI
- FAPAR
- FCOVER
- LAI

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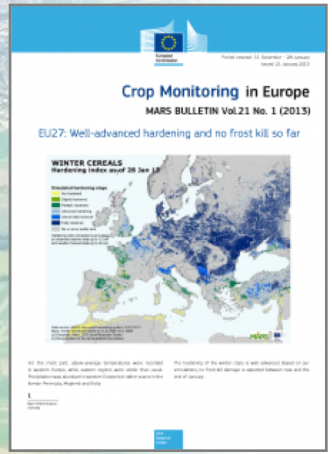
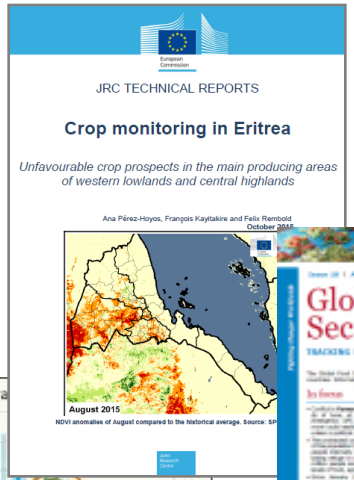
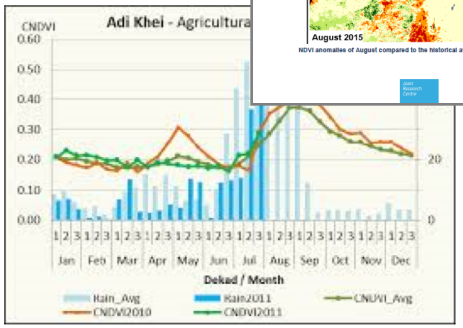
GLOBAL LAND Systematic Monitoring Agriculture applications

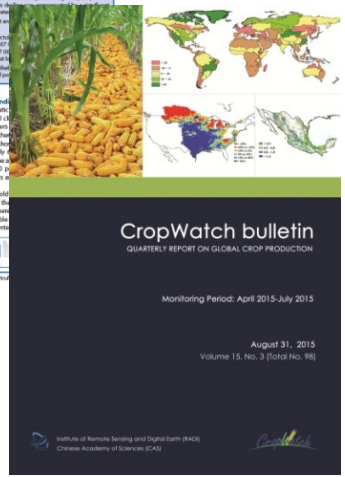
Land Monitoring

- Agriculture
  - Crop monitoring
  - Yield forecasting
  - Biomass conditions









Some agriculture users (from our download records) : INRA France, FAO, WFP, MESA (AUC-Africa), Action Contre la Faim (NGO), MARS JRC, Chinese Academy of Agricultural Sciences, INRA Morocco, SRI Ukraine, Wageningen University, ISRO India, ARC South Africa, CIRAD France …

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European Commission

Coffee, Biodiversity (Guatemala)

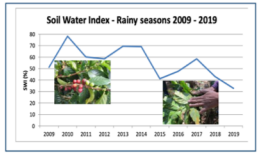
Land Monitoring

Copernicus Global Land Service
Use Case

Coffee, biodiversity & health

User's reference: Quantic Statistics
https://quanticstats.blogspot.com/

Activity domain: Agriculture & Biodiversity
Geographic area: Guatemala



Average Soil Water Index during rainy seasons from 2009 to 2019 in Alta-Verapaz, one of the coffee growing regions of Guatemala. The region suffers a continuous decrease of soil moisture from 2014, with a devastating El Niño event in 2014-2015, contributing to making healthy and sane coffee plants infected by rust. Although a partial recovery in 2017, the crisis continued in 2018 and 2019.

Overview

Across the "dry corridor", a region which stretches from southern Guatemala into northern Honduras and El Salvador, communities rely on subsistence farming for survival. This part of Guatemala, covering the coffee growing areas, has experienced since 2014 severe drought and irregular rainfall that has allowed the rust, a pernicious fungus, spreading across the coffee plantations causing a heavy drop in grain production. Indeed, the coffee flower blossom needs high moisture in May-June at the beginning of the rainy season (May to October). High temperatures, below-average rainfall and extended dry spells resulted in severe soil moisture deficits which also affected major crops like maize and beans. The time series of the Soil Water Index (SWI) and the Normalized Difference Vegetation Index (NDVI) are used to monitor the impact of dry soils on coffee plant growth and health.

Benefits for the user

- Measure the droughts in focalized regions across Guatemala.
- Coffee ecosystem biodiversity and health indicator with NDVI.
- Timely information to take early-stage countermeasures against coffee plant infection

Data sources used

From the service:

- NDVI 1km version 2.2
- Daily and 10-daily Soil Water Index 0.1° V3

Other sources:

- U.S. drought monitor
- NOAA NCDC Sea Surface Temperature

Facts & key numbers

According to the Guatemalan national organization of coffee growers, more than half a million Guatemalans rely directly on the coffee harvest for employment.

As of June 2016, the United Nations estimated 3.5 million people -- a third of the dry corridor's population -- required humanitarian assistance as a result of crop losses.

Tragedy of the hungry problem forced young Guatemalans to flee to the United States. The U.S. Customs and Border Protection apprehended nearly 75,000 Guatemalan migrants along the southern border between October 2015 and September 2016, compared to under 17,000 in 2010.

According to GEOGLAM, 2019 is the second consecutive year of poor and failure harvests across the Dry Corridor.

About the user

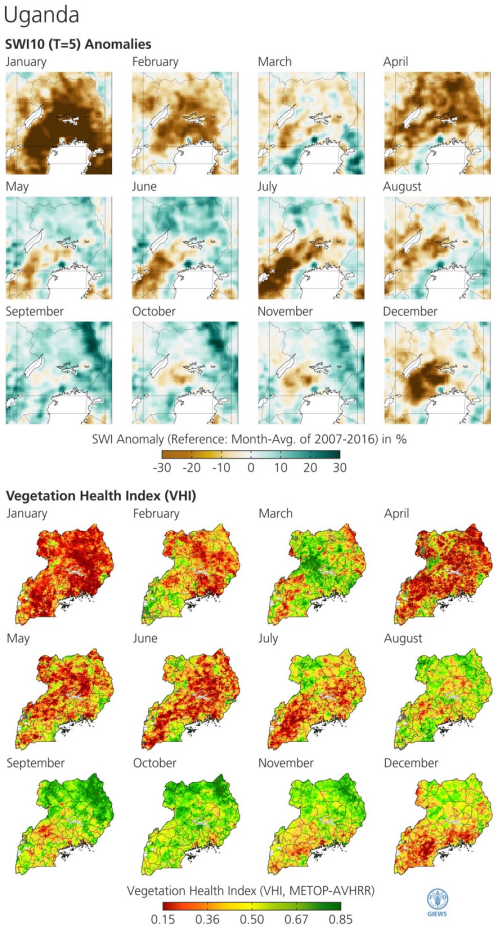
Organization type: Private Company
Web site: https://quanticstats.blogspot.com/
Contact: Fernando Roque, Managing director
fmroque10@gmail.com

land.copernicus.eu/global/ land.copernicus.eu/global/contact Published: 2020-05-07

Surface Soil Moisture
Surface Soil Moisture (SSM) is the relative water content of the top few centimetres soil

Soil Water Index
The SWI quantifies the amount of water (m3/m3) in soil layers at various depths and is derived from the SSM

Europe
Global
Daily
1km – 10km



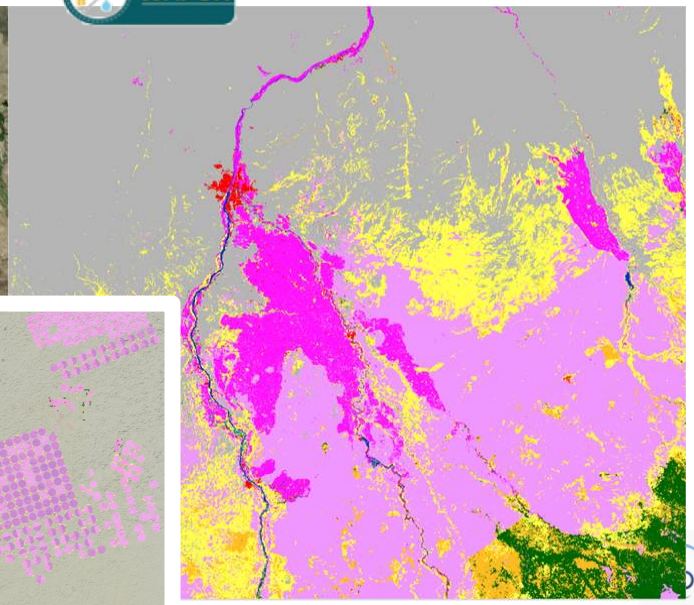
Land Monitoring

FAO uses the CLMS Global land Cover map

WaPOR

The FAO portal to monitor WAter Productivity through Open access of Remotely sensed derived data

FAO WAPOR USES OUR LAYERS & ALGORITHM TO MONITOR WATER PRODUCTIVITY AND EVEN ADD OWN DATA FOR IRRIGATION MAPPING



Khartoum Sudan

- Forest
- Shrubs
- Herbaceous vegetation
- Cropland rainfed
- Cropland irrigated
- Built-up
- Bare / sparse vegetation
- Snow & ice
- Permanent Water Bodies
- Herbaceous Wetland
- Sea
- Unknown (no data)

http://wapor.apps.fao.org

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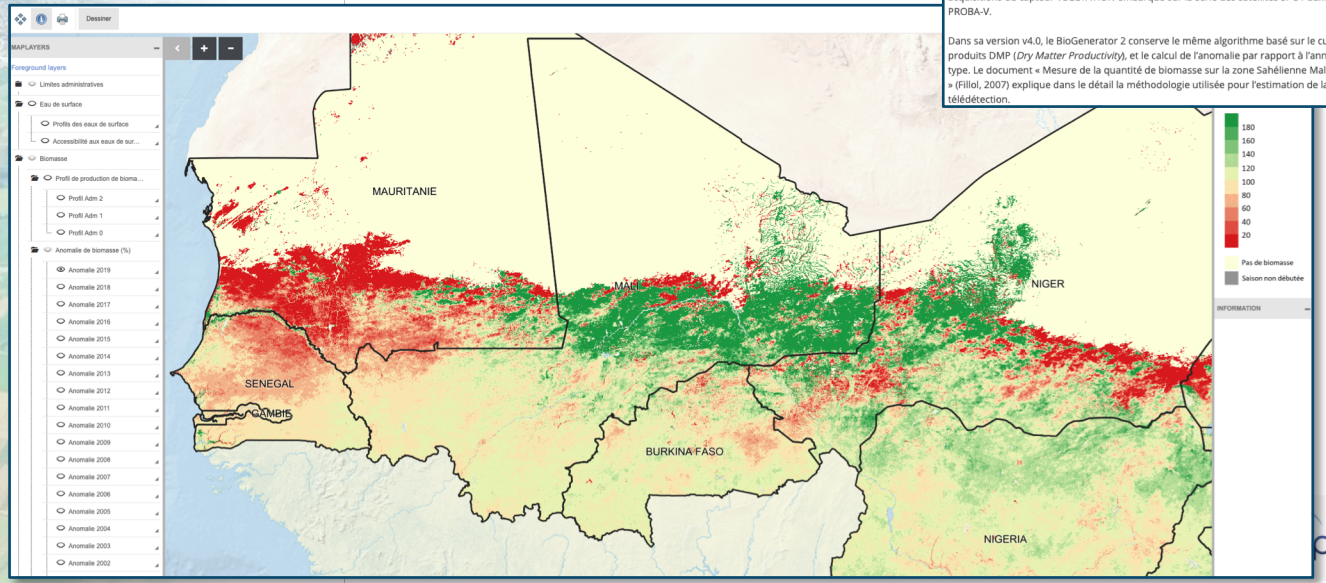
Agriculture monitoring for food security

Land Monitoring



Dry Matter Productivity
Amount (weight) of dry matter (DM) produced per surface unit and per time unit expressed in kilograms of dry matter per hectare per day (kgDM/ha/day). Derived from FAPAR.

Global
Ten day (from 1999)
1km - 300m

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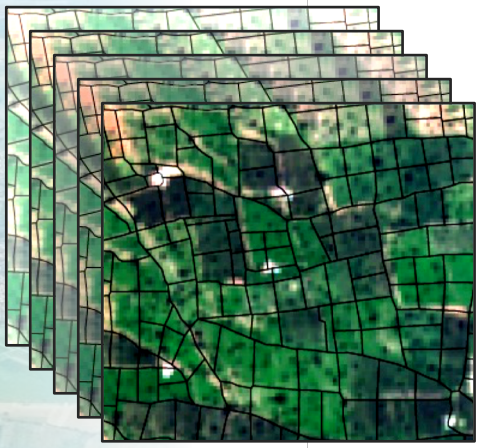
European Commission

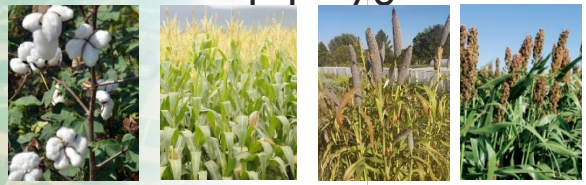
GLOBAL Hot Spot component – Agriculture capacity

Land Monitoring

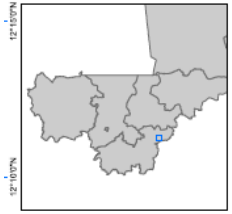
Sentinel-2 time series (5-day revisit)



500 crop polygons in situ



Cotton Maize Mil Sorgho

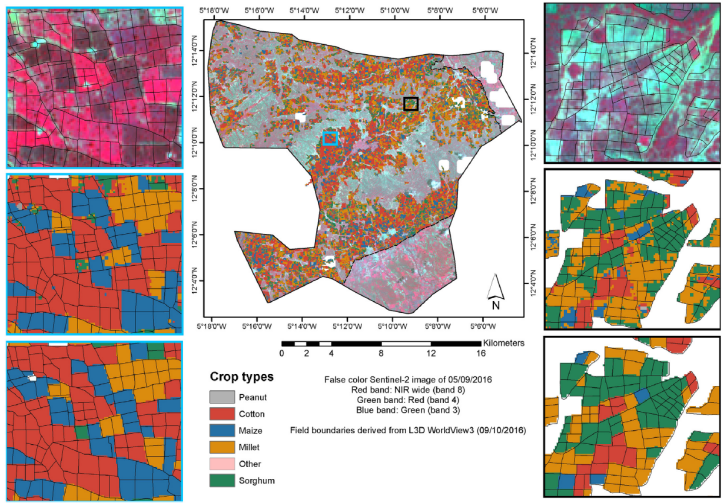


Digital Globe Sentinel-2 PROBA-V

Machine learning

Accuracy (F1-score)	
Coton	0,93
Maïs	0,87
Mil	0,82
Sorghum	0.45
Overall acc. = 85.5 %	

(Lambert et al., RSE2018)



sen4cap common agricultural policy

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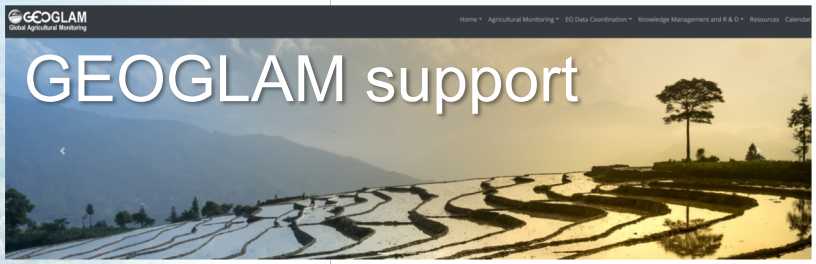
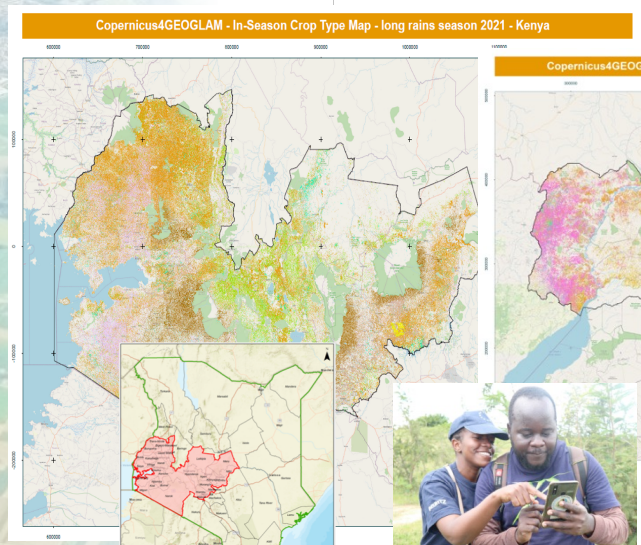
Land Monitoring

GLOBAL Hot Spot component - Agriculture



Country	Field campaign	In-season mapping	End-of-season mapping
Tanzania	First - completed Second – to start	Completed	Completed
Kenya	First – completed Second – to start	Completed	Completed
Uganda	First – completed Second – to start	Completed	Completed

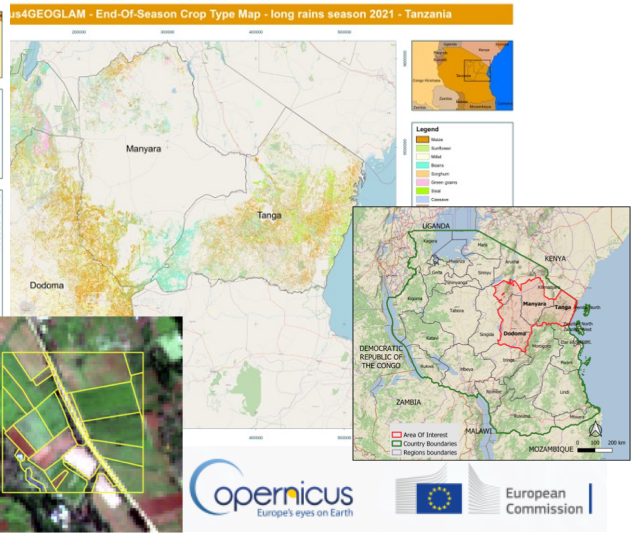
Crop Mapping



Kenya (98 687 km²)

Uganda (89 296 km²)

Tanzania (116 190 km²)



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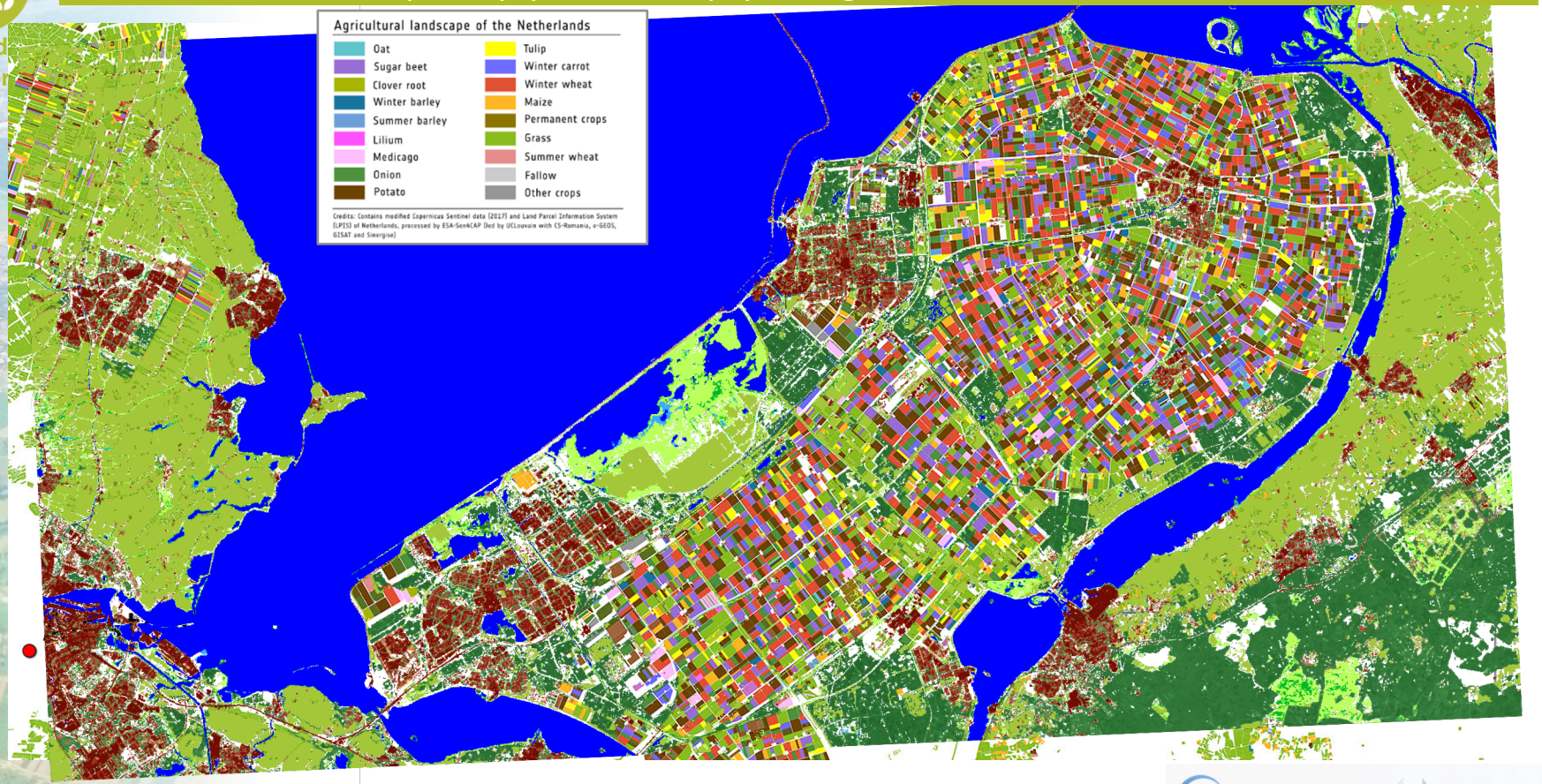
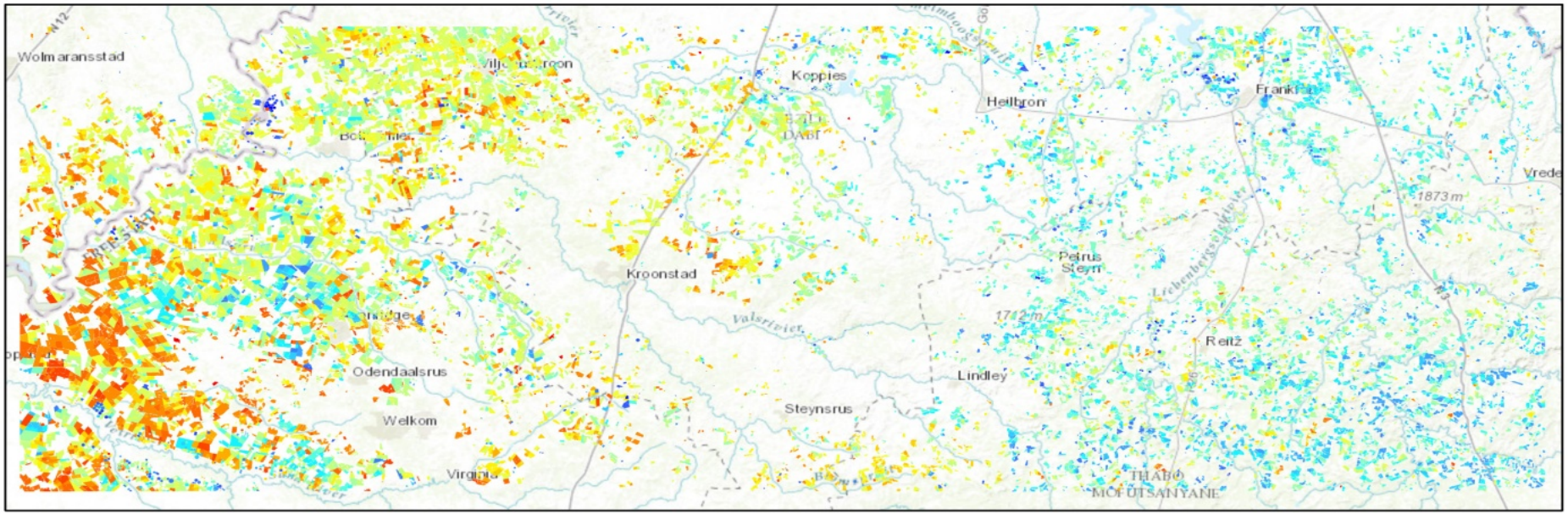
Annual crop type mapping



Land Monitoring

Maize emergence date map at field level, Free State, South-Africa

H2020 ECoLaSS project



UCL Université catholique de Louvain

ARC • LNR

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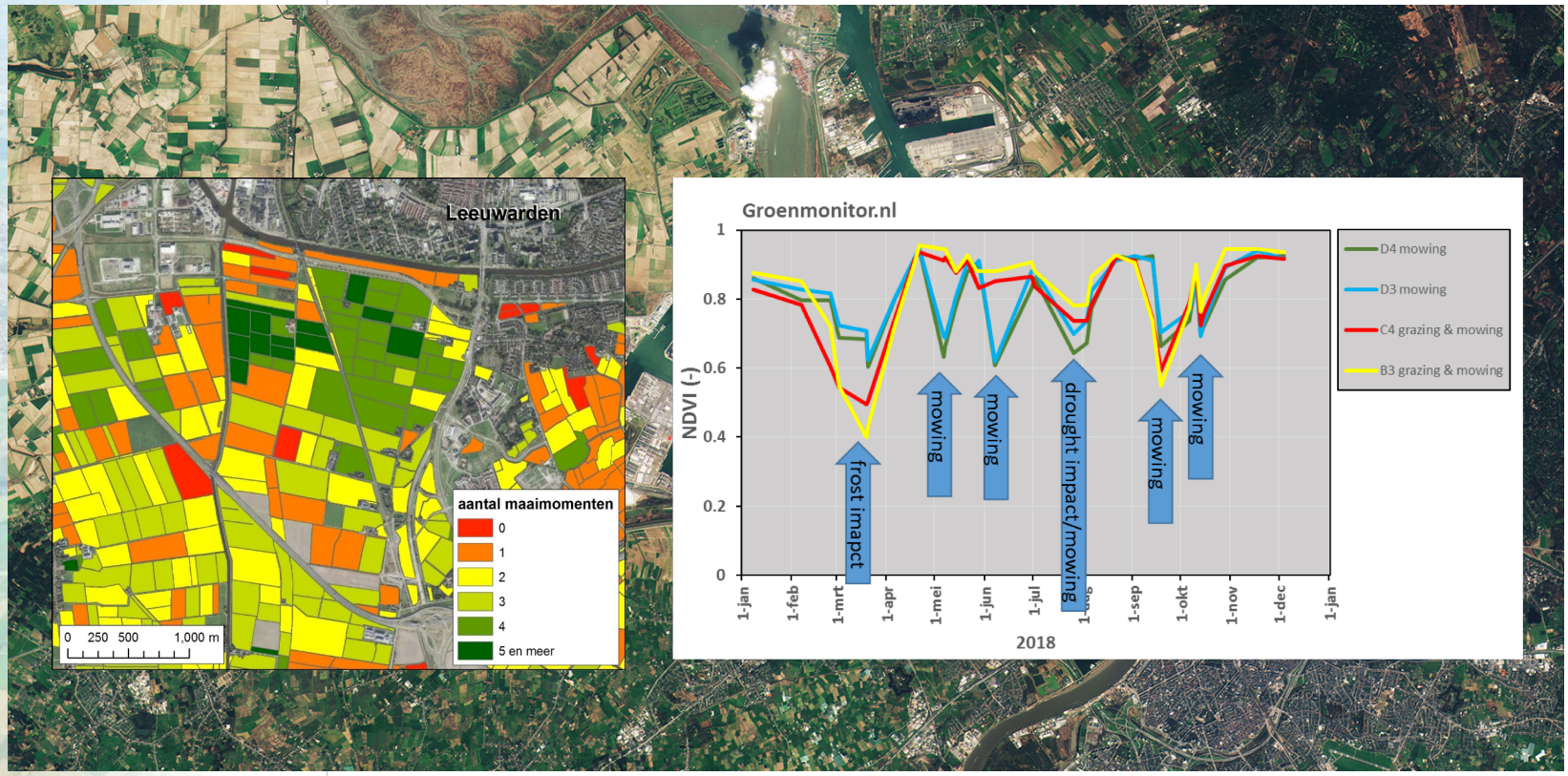
European Commission

Land Monitoring

Grassland and mowing cycles



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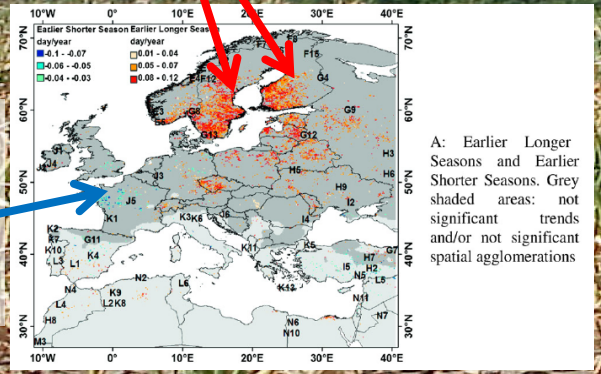
Land Monitoring

Monitoring phenological events and climatic variation

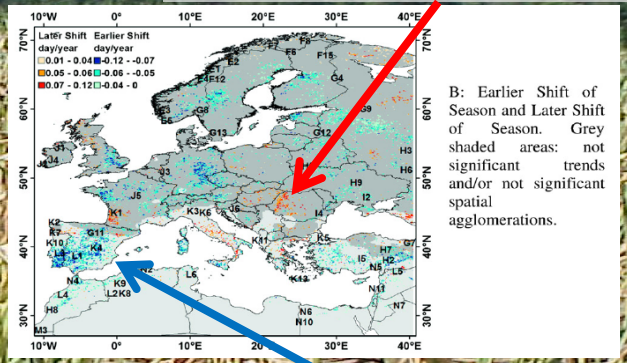
Earlier and longer season

Earlier and shorter season

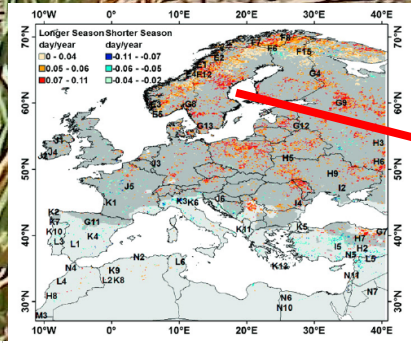


A: Earlier Longer Seasons and Earlier Shorter Seasons. Grey shaded areas: not significant trends and/or not significant spatial agglomerations

Season length unchanged entire season shifts later



B: Earlier Shift of Season and Later Shift of Season. Grey shaded areas: not significant trends and/or not significant spatial agglomerations.



C: Longer Seasons and Shorter Seasons. Grey shaded areas: not significant trends and/or not significant spatial agglomerations.

Season length unchanged entire season shifts earlier

Start of season unchanged the growing season is longer

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European Commission

CLIMATE CHANGE / Benefit areas and products examples

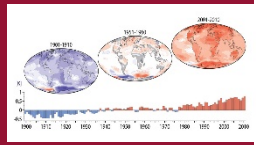
Climate Change

- Climate change
- Mitigation and adaptation
- Weather forecast
- Pollution
- Environment
- Health

Consistent Estimates of the Essential Climate Variables (ECVs)

Support to Mitigation and Adaptation Strategies

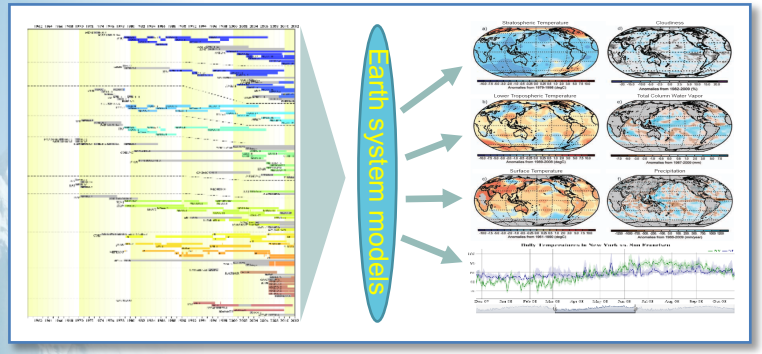
Global and Regional Reanalyses



Seasonal Forecasts And Climate Projections

Climate Change

C3S / Access to past, present and future climate information

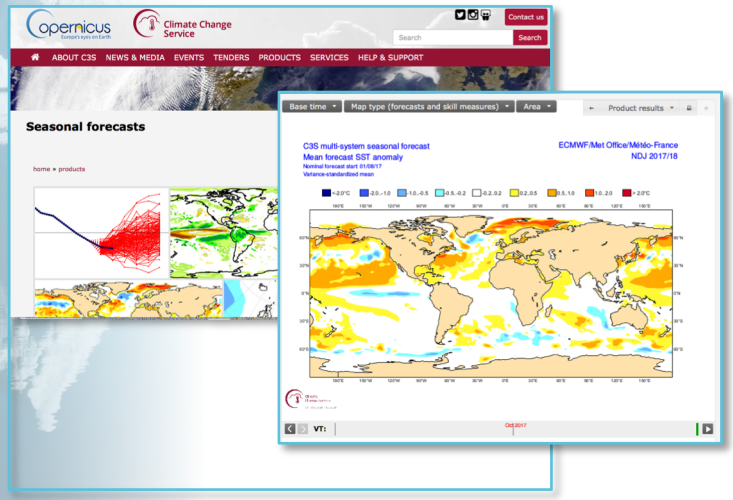


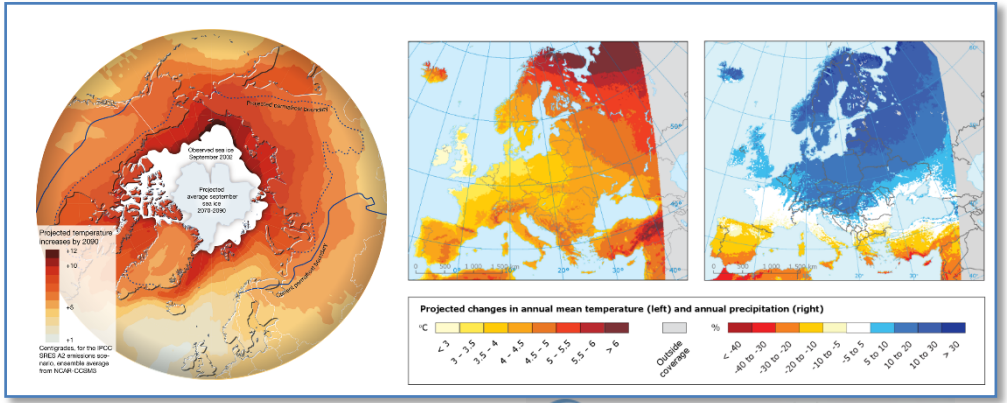
Observations and climate re-analyses

Seasonal forecast data and products

Climate model simulations

Sectoral Impact Assessment





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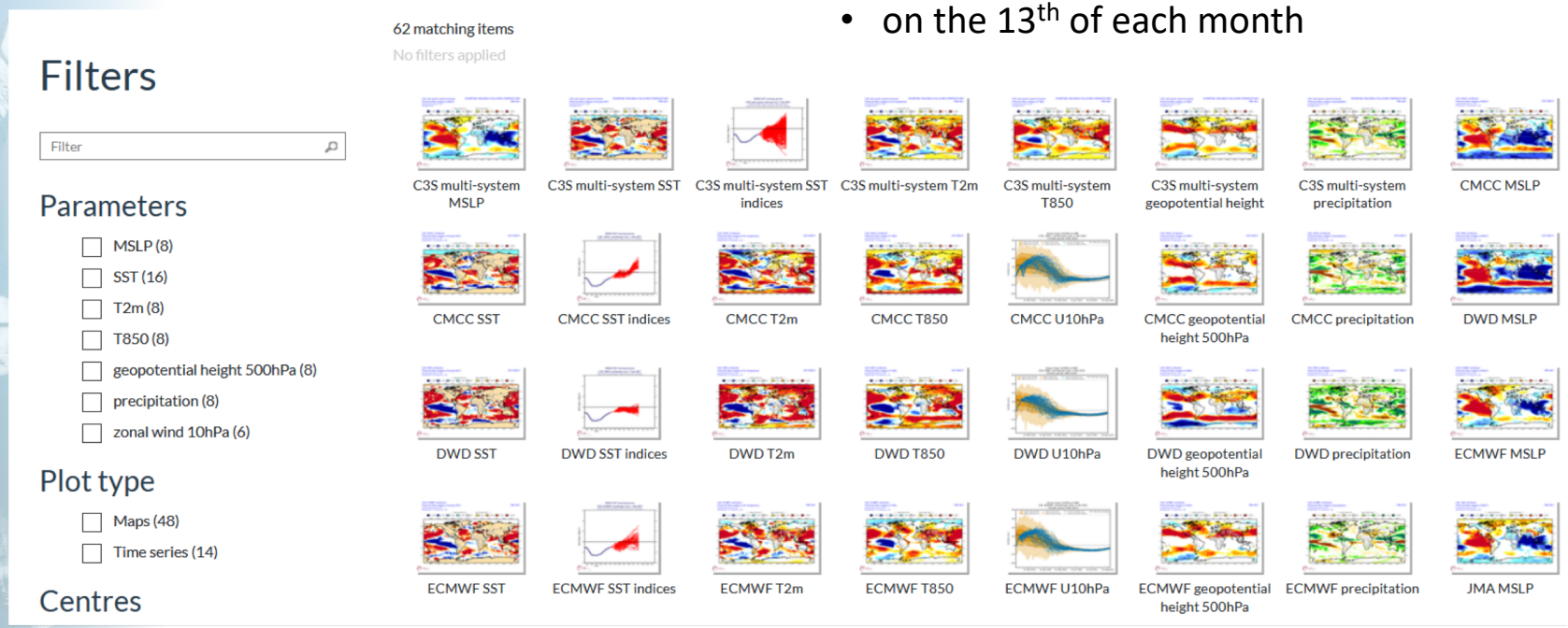
Seasonal Forecast – Graphical products

Climate Change

Publication schedule:

- monthly updates
- on the 13th of each month

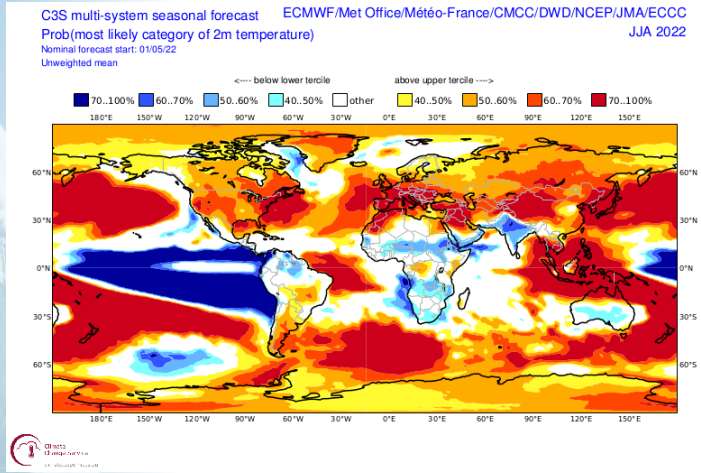


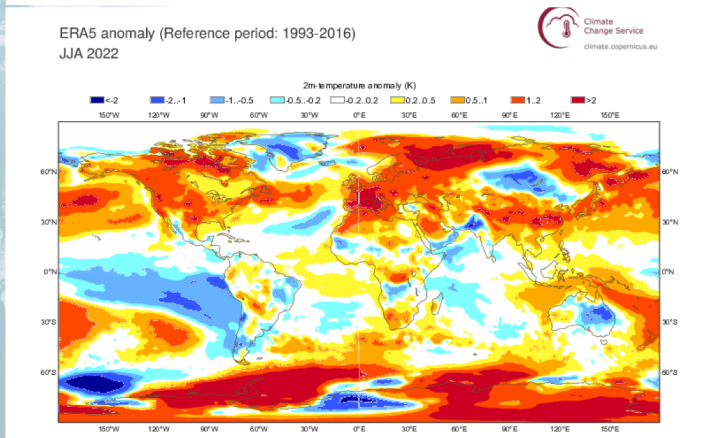
http://climate.copernicus.eu/charts/c3s_seasonal/

IMPLEMENTED BY ECMWF Copernicus Europe's eyes on Earth European Commission

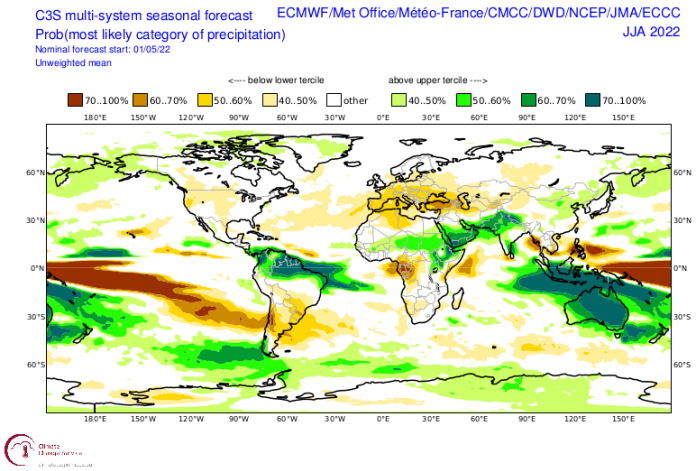
May forecast for June-August 2022

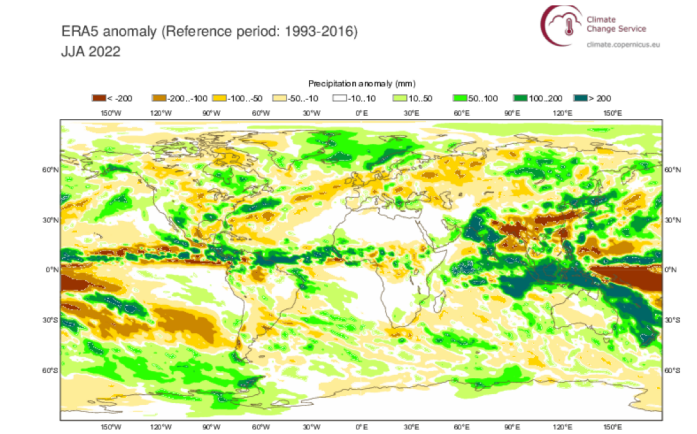
Climate Change





Risk of high temperature (left) and below average rain (right) predicted in areas where hot and dry conditions (bottom row) were observed





Climate Change

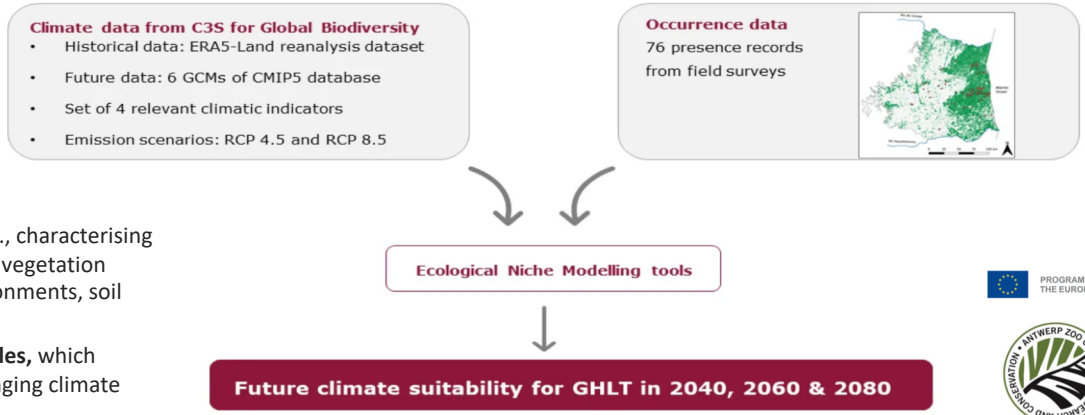
Use of C3S data products to support the conservation of the Golden-Headed Lion Tamarin in Brazil

- Climate change will dramatically reduce the distribution of **golden headed-lion tamarin**, which habitat found only in the south of the Brazilian state of Bahia in the Atlantic Forest
- Protected areas are unlikely to remain climatically suitable if the global average temperature increase is not kept well below 2°C.

➔ **Need for investigating which regions will still have a suitable climate in the future**

➔ **Whether current protected areas in Brazil will remain climatically suitable**

- Field observations of tamarin populations are combined with tailored climate data from C3S, in **Ecological Niche Modelling tools** to map areas with suitable climates for tamarin



- C3S products used
  - **Bioclimatic variables:** i.e., characterising surface energy, drought, vegetation sensitivity, marine environments, soil moisture and wind
  - **Essential Climate Variables,** which describe the Earth's changing climate

Emergency Management

EMERGENCY / Benefit Areas

The Emergency Management Service supports actors (e.g. civil protection, insurance companies, risk evaluation and humanitarian aid sectors) dealing with:

Emergency Response

Natural Disasters

Man-made Emergency Situations

Humanitarian Crises

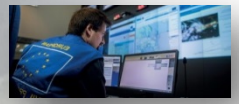
Preparedness and Recovery Activities

CEMS / Service Overview

Emergency Management

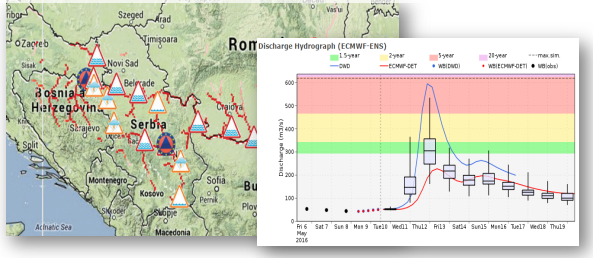
Scope

- Complementary to national efforts
- Supporting the EC's Emergency Response and Coordination Centre (ERCC)
- Focus on Europe but available globally



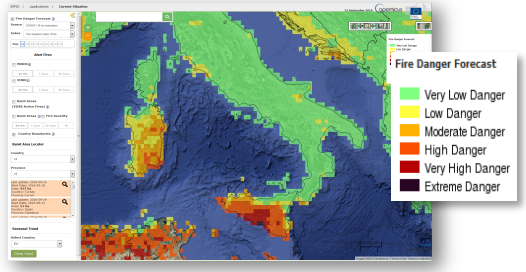
Flood Awareness System (EFAS - GLOFAS)

Flood monitoring and forecasting across Europe and Global



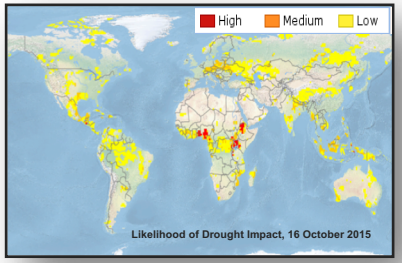
European Forest Fire Information System (EFFIS)

Near real-time & historical information on forest fires in the European, Middle Eastern & N-African regions



Drought Observatory (EDO – GDO)

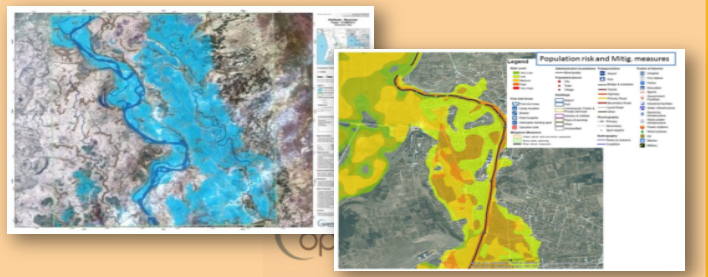
Early warning, monitoring & forecasting of droughts & their impacts



On-demand Mapping

Any disaster

On-demand provision of geospatial information in support of preparedness, emergency response, recovery for any type of disaster

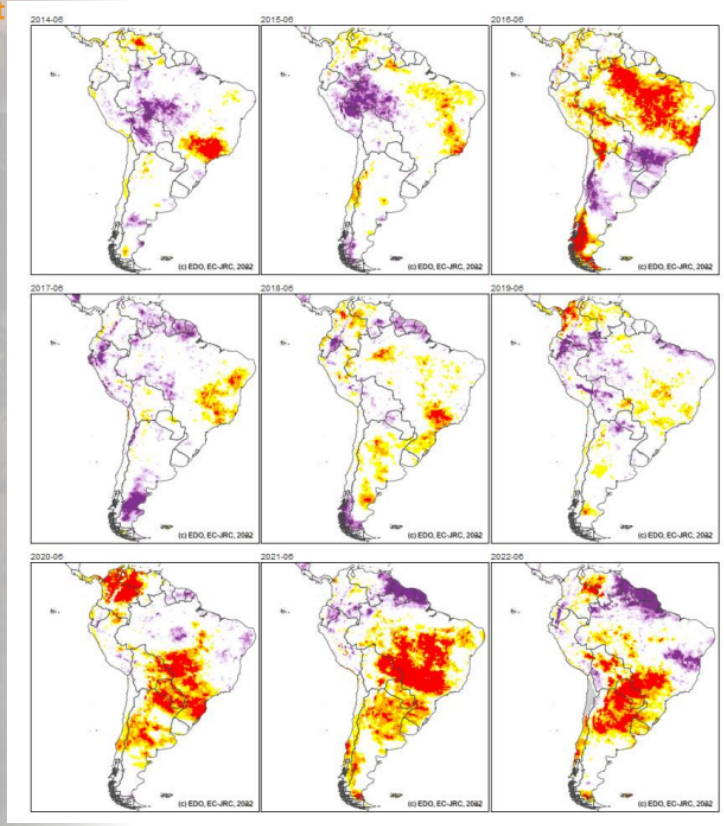


Drought Monitoring Observatory

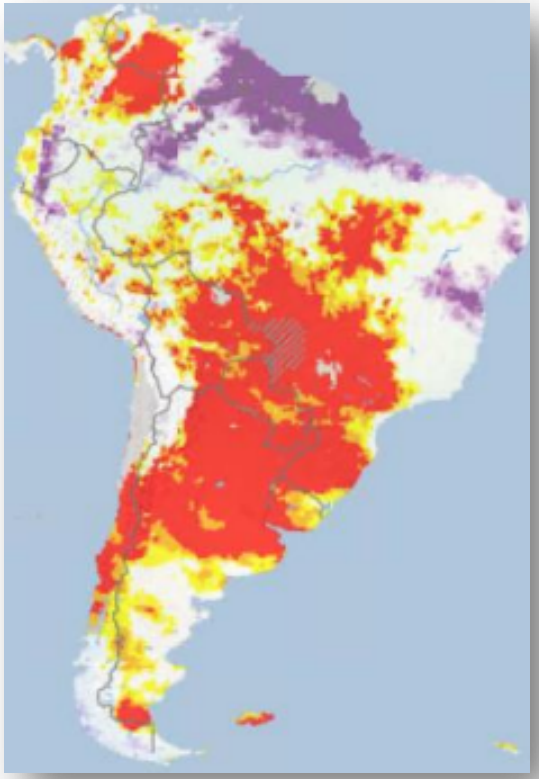
Emergency Management

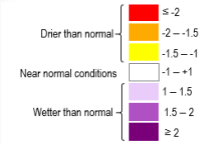
2014

2022



June SPI-12 from 2014 to 2022. Source: Drought in South America April 2023. GDO report





March 2023 SPI-48. Source: Drought in South America April 2023. GDO report

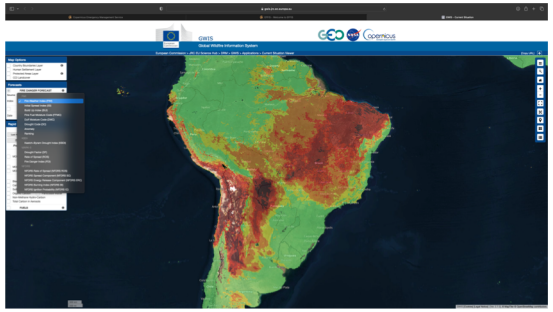
Copernicus Europe's eyes on Earth

European Commission

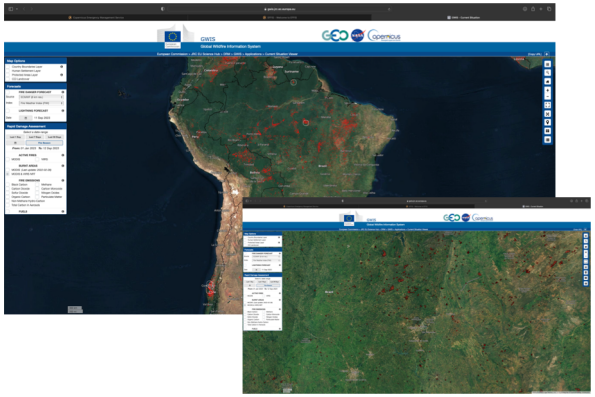
Forest Fire Information System

Emergency Management

https://gwis.jrc.ec.europa.eu



Fire Risk Forecast



Burnt Areas Mapping

Active Fire (Current season)

Fire Emissions (ex. Carbon Dioxide)

Copernicus Europe's eyes on Earth

European Commission

Thank you

Michel F. Massart
Earth Observation unit
Directorate-General for Defence, Industry and Space
European Commission

Email: Michel.Massart@ec.europa.eu

Copernicus
Europe's eyes on Earth

Space

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#EUSpace

EGNOS and Galileo Contribution to Agriculture

Brasilia, 14 September 2023 - Harvesting from Space: EU Space Programme Benefits for Agriculture in Brazil

Reinhard Blasi, Market Downstream & Innovation Manager

EUSPA
European Union Agency for the Space Programme

A new EU Space Programme has brought EU space activities under one umbrella

#EUSpace

EUSPA
European Union Agency for the Space Programme

Newly IRIS2
the new EU Secure Satellite Constellation

EGNOS

EGNOS "Makes navigation signals more accurate and trustable for Safety-critical applications"

Operational in **400+ airports** & helipads in 23 countries

Galileo

Global satellite navigation and positioning system (GNSS)

More than **3 billion Galileo receivers** worldwide

Copernicus

Earth Observation (EO) and monitoring based on satellite & non-space data

Nr.1 world provider of space data and information (>20TB/day)

GOVSATCOM

Secure satellite communications for EU governmental actors

Rapid support over crisis areas

Space Situational Awareness (SSA)

Space Surveillance and Tracking (SST)

Space Weather Events (SWE)

Near-Earth Objects (NEO)

Others

Access to Space

Research & Innovation

Entrepreneurship

Certification & standardisation

Capacity Building

Galileo OS and HAS are the most relevant EGNSS services for agricultural applications in Brazil

Galileo Initial Services are provided to worldwide users **since December 2016**

Open Service (OS)	Freely accessible service for positioning and timing and navigation message authentication
Public Regulated Service (PRS) – **Governmental Service**	Encrypted service designed for greater robustness and higher availability – secure satellite communication
Search and Rescue Service (SAR)	Locates people in distress and acknowledges that the distress signal has been received
High Accuracy Service (HAS)	Delivers global high accuracy service, freely accessible
Under preparation	
Commercial Service Authentication (CS)	Delivers authentication services for commercial applications

* OS Navigation Message Authentication (OSNMA) on the horizon

EGNOS services are provided to users since **October 2009**

Open Service (OS)	Improving GNSS accuracy, intended mainly for high-volume satellite navigation applications for use by consumers
Safety of Life Service (SoL)	Providing a high level of integrity for users for whom safety is essential (e.g. civil aviation, in accordance with ICAO standards)
Data Access Service (EDAS)	Offering EGNOS data with greater added value through internet, intended mainly for professional or commercial use

Relevant -global and open- EU Space services available for agriculture and precision farming

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GALILEO

OPEN SERVICE

Freely accessible and global service for **positioning, timing** and **navigation message authenticatic**

HIGH ACCURACY SERVICE

Freely accessible and global high accuracy positioning service (20 cm accuracy)

Copernicus

Land Monitoring

Climate Change

Copernicus Marine Service

Atmosphere Monitoring

Emergency Management

Today's way of life is transforming agriculture needs

World **population** is **growing**

Climate change

Impact of **urbanisation** on rural labour

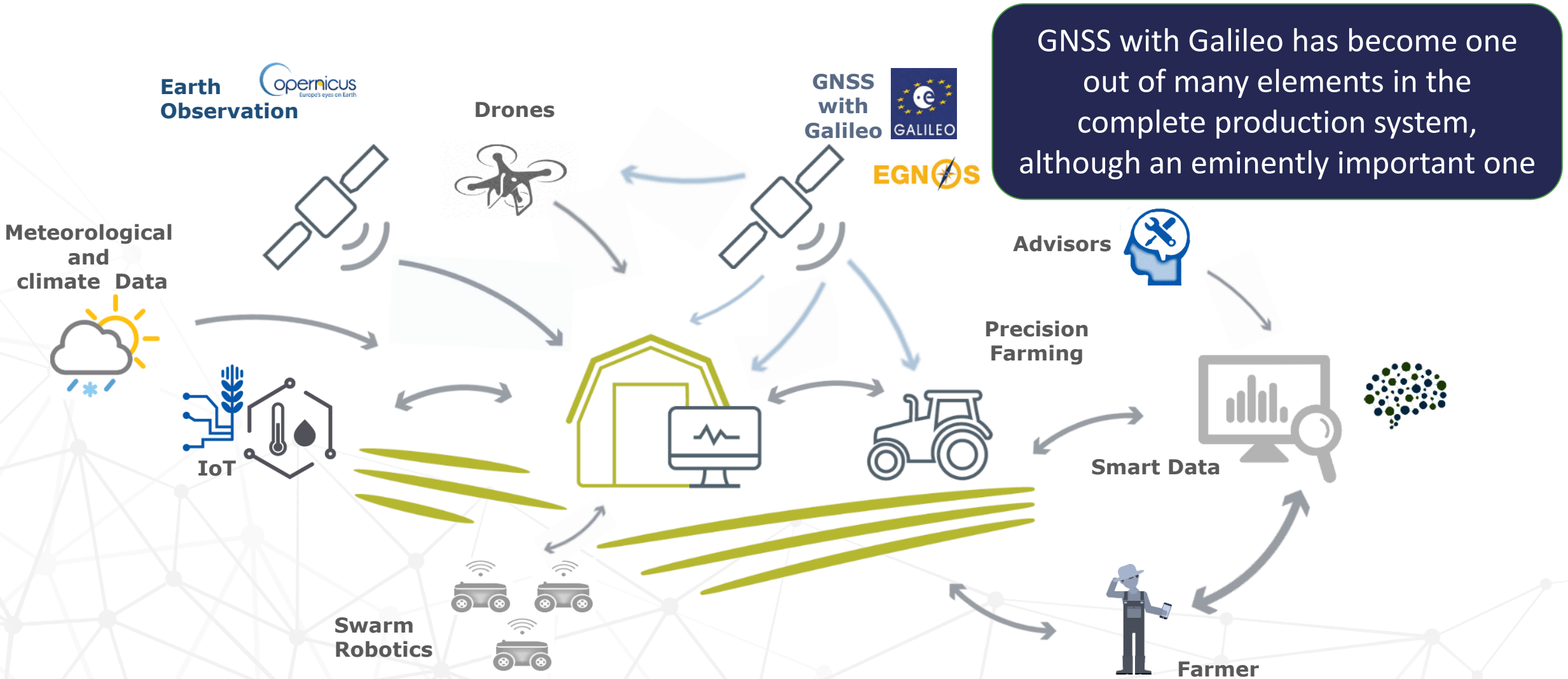
Eating habits and **consumption patterns** are **changing**

Shrinking of **arable land**

Price and **availability of energy**

Precision Farming and Smart Forestry helps to cope with the food and climate challenges

Galileo and Copernicus are at the core of precision farming



….supporting a myriad of applications

Legend

EO application

GNSS application

Synergetic application (combined use of EO and GNSS)

Today’s precision farming offers more possibilities with increased efficiency and sustainability

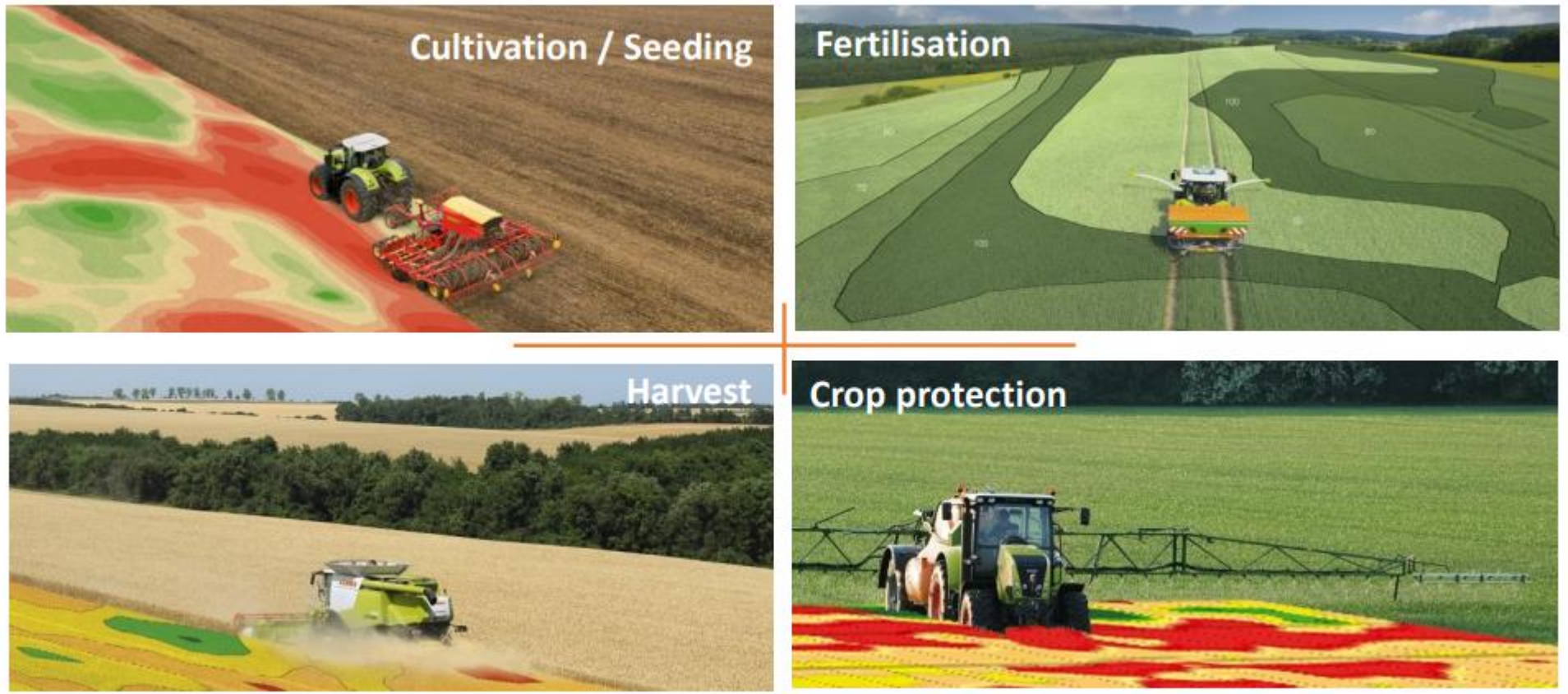


Image courtesy CLAAS

…benefiting from synergies of Galileo-Copernicus

#EUSpace

Example

Variable Rate Applications

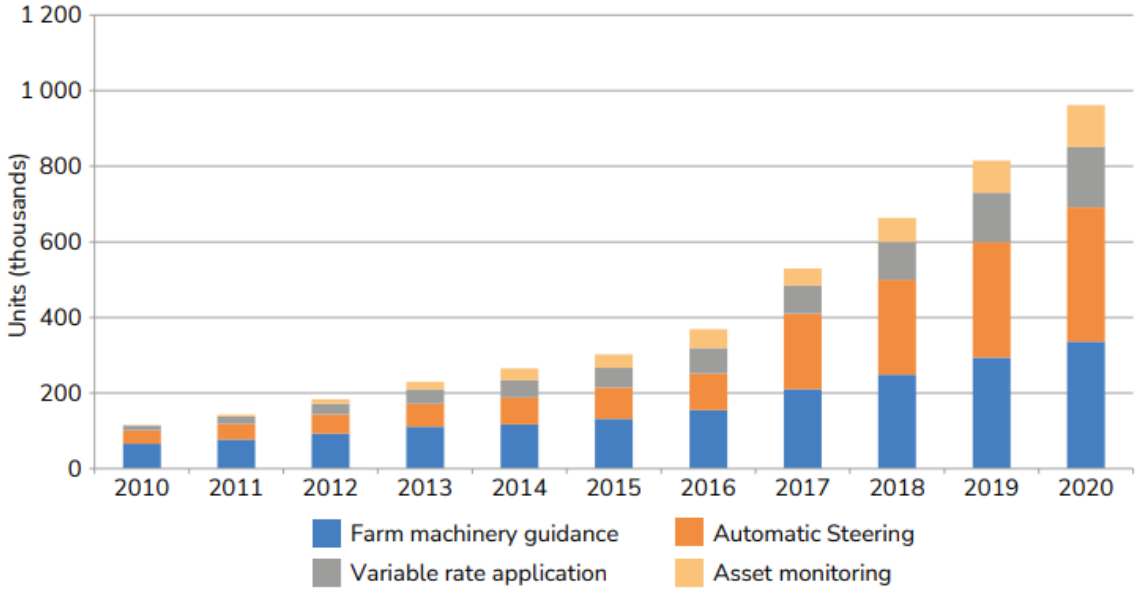
Prescription map: A geo-referenced map which contains rate information controllers shall apply (NDVI index, health of crops, soil moisture, etc.)

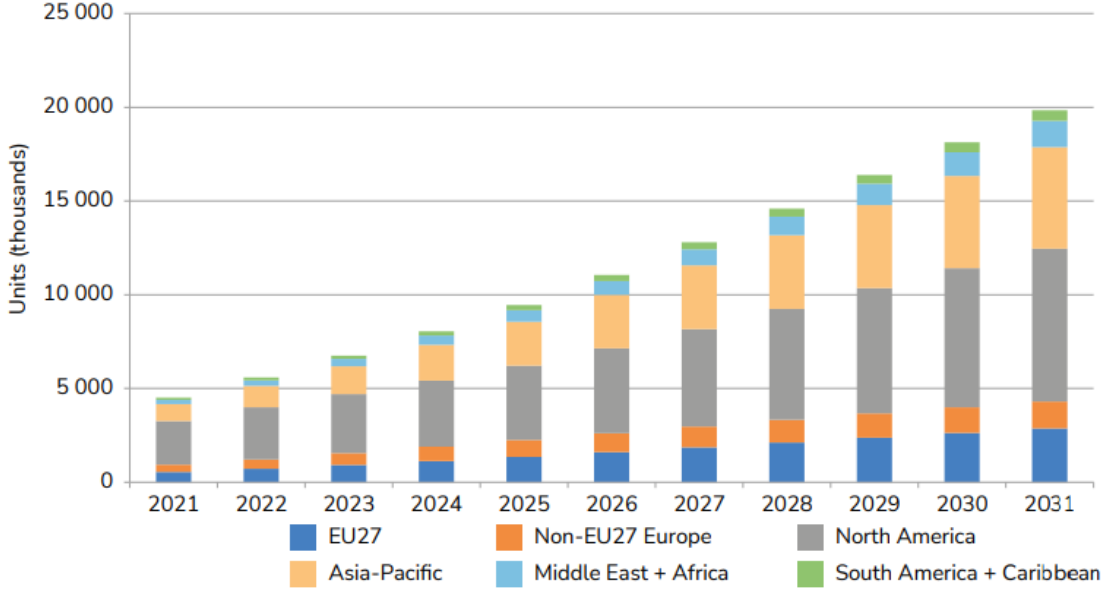
+

Highly accurate positioning of the machinery that show where fertiliser/ pesticides should be applied

- **Precise application of the fertilisers and pesticides** where and when they are most necessary
- **Lower environmental footprint**
- **More efficient use of manpower**
- Higher productivity and profitability

Shipments of GNSS receivers over the past decade have exhibited a very strong growth trend





However, the uptake of Precision Farming is still low, varying from country to country

Image courtesy Aerovision

Precision agriculture without GNSS

….looking ahead to agriculture 5.0

Below story is not really the case for Brazil

1.0: Year 1900

Mechanisation

Introduction of tractors

Increasing efficiency

Manual labour required

Low production, family needs

2.0: Year 1950

Green Revolution

New agronomical practices

Use of fertilizer and pesticides

Improvement of quality seed

Increasing the yield

3.0: Year 1990

Precision Agriculture

Guidance Systems

Yield Monitoring

Variable Application

Data Management

4.0: Year 2010

Digital Farming

Cloud based ICT systems

''Connectivity''

Big data Analytics

Drones, IoT…

Smart control devices

Resources optimisation

5.0: Year 2020+

Unmanned operations and autonomous decision support systems (robotics)

Artificial Intelligence

Sustainable Land Management

Environmental Optimization

What will the future bring?

EGNSS is key to exploiting the full potential of future evolution in agriculture

5G and IoT

Inter-cropping

Big Data from Space

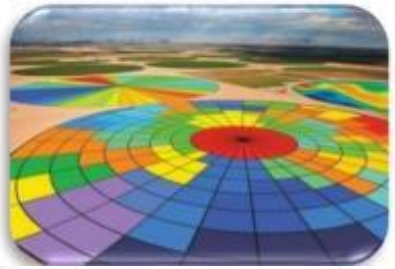
Smart Applications

Vertical Farming

Autonomous machinery

Interoperability

Increased Accuracy



Sustainability

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Linking space to user needs

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www.euspa.europa.eu

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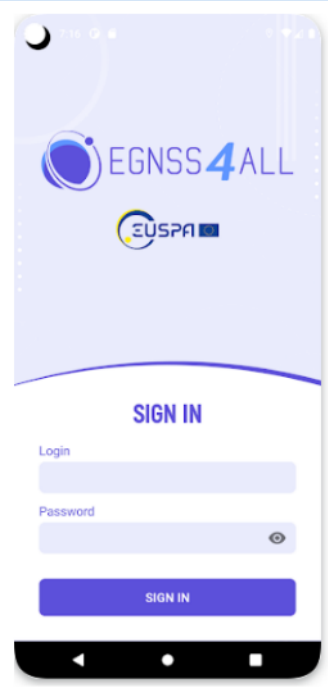
The European Union Agency for the Space Programme is hiring!

Apply today and help shape the future of **#EUSpace!**

Galileo-based geo-tagged photo with increased accuracy and trustworthiness

- EUSPA demonstrator for **collecting coordinates and geotagged photo by mobile phone application**
- Leveraging Galileo and OSNMA
  - **Increased accuracy and trustworthiness**
- Is widely used in EU's CAP and has been piloted in the context of the EUDR



European GNSS and Copernicus is powering cutting-edge and innovative solutions – from R&D to the market

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METEOROLOGICAL ASSIMILATION FROM GALILEO and DRONES for AGRICULTURE

The MAGDA project aims at developing a toolchain for atmosphere monitoring, weather forecasting, and severe weather/irrigation/crop monitoring advisory, with GNSS (including Galileo) at its core, to provide useful information to agricultural operators.

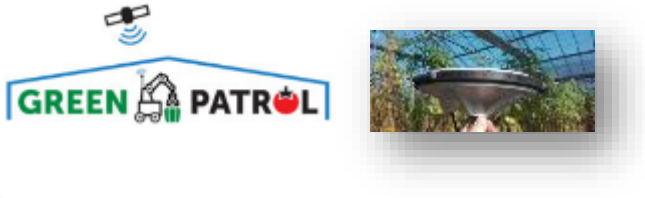
SPACE4GREEN

SPACE4GREEN propose a technological solution that enables a trusted platform among agricultural stakeholders of different natures for the automated certification that activity occurs or a thing is in a location at a certain point in time, without requiring a third-party human certification

Artificial intelliGence applied to pRecision farmIng By the use of GNSS and Integrated Technologies

AgriBIT aims to increase the precision, accuracy and continuity of services to deliver improved Precision Agriculture services to farmers, leading to a reduction in costs through decreased use of inputs (water, energy, fertilisers, pesticides), lower environmental impacts and increased production yields, combining augmented GNSS and EO information with on-field and on-machine sensors and actuators

European GNSS is powering cutting-edge and innovative solutions – from R&D to the market

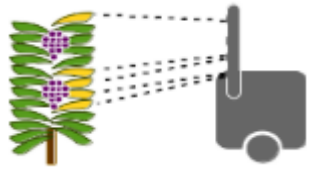


The GreenPatrol project makes direct use of the added value provided by European GNSS to develop an innovative robotic solution for Integrated Pest Management in greenhouses

It allows a sustainable business model, increasing productivity, reducing losses caused by pests and reducing the use of pesticides

The Galirumi builds a robot for herbicide-free weed control in dairy farming

Will reduce the environmental impact of dairy farming by eliminating herbicide use and reducing exposure of farm workers to herbicides.



The Scorpion project develops a safe, cos-effective and autonomous precision spraying tool integrated into a modular unmanned tractor (robotics platform).

Will be used on steep slope vineyards and other high-value permanent crops, reducing the fertiliser usage in agriculture and increasing air quality

Sentinel-2 application on Precision Agriculture: On-farm experimentation

Colheita do Espaço: Benefício do Programa Espacial da UE para a Agricultura do Brasil - September 2023

João de Mendonça Naime

Embrapa 50 ANOS

MINISTÉRIO DA AGRICULTURA E PECUÁRIA

GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

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[5]Grupo Scheffer, Sapezal, MT
[6]Instituto Matogrossense do Algodão, Cuiabá, MT

Partners

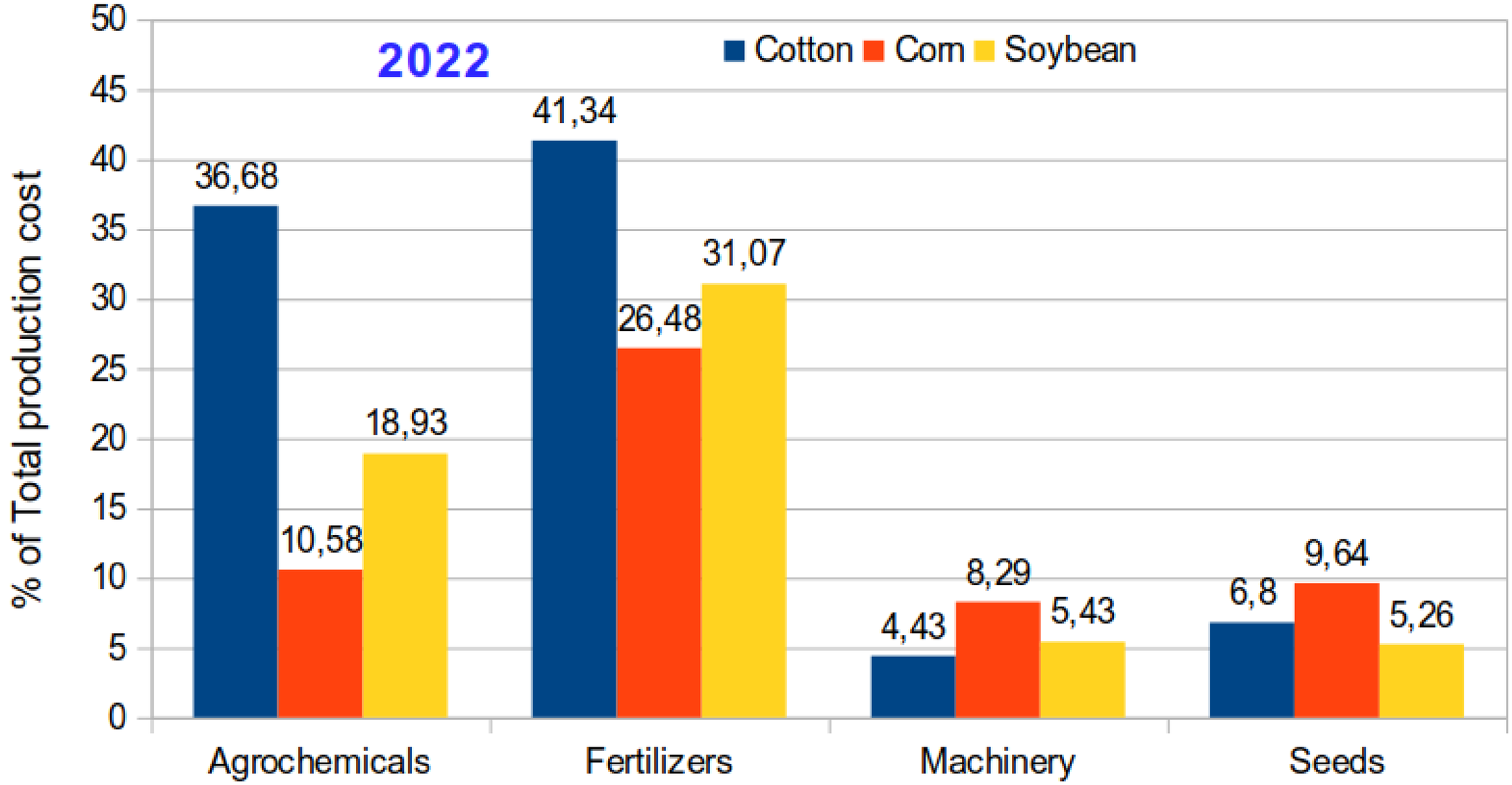
IMA-MT
Group Scheffer
Group Amaggi

Objective

Increase of cotton productivity by variable rate application of the inputs: seeds, nitrogen, and plant growth regulator (PGR).

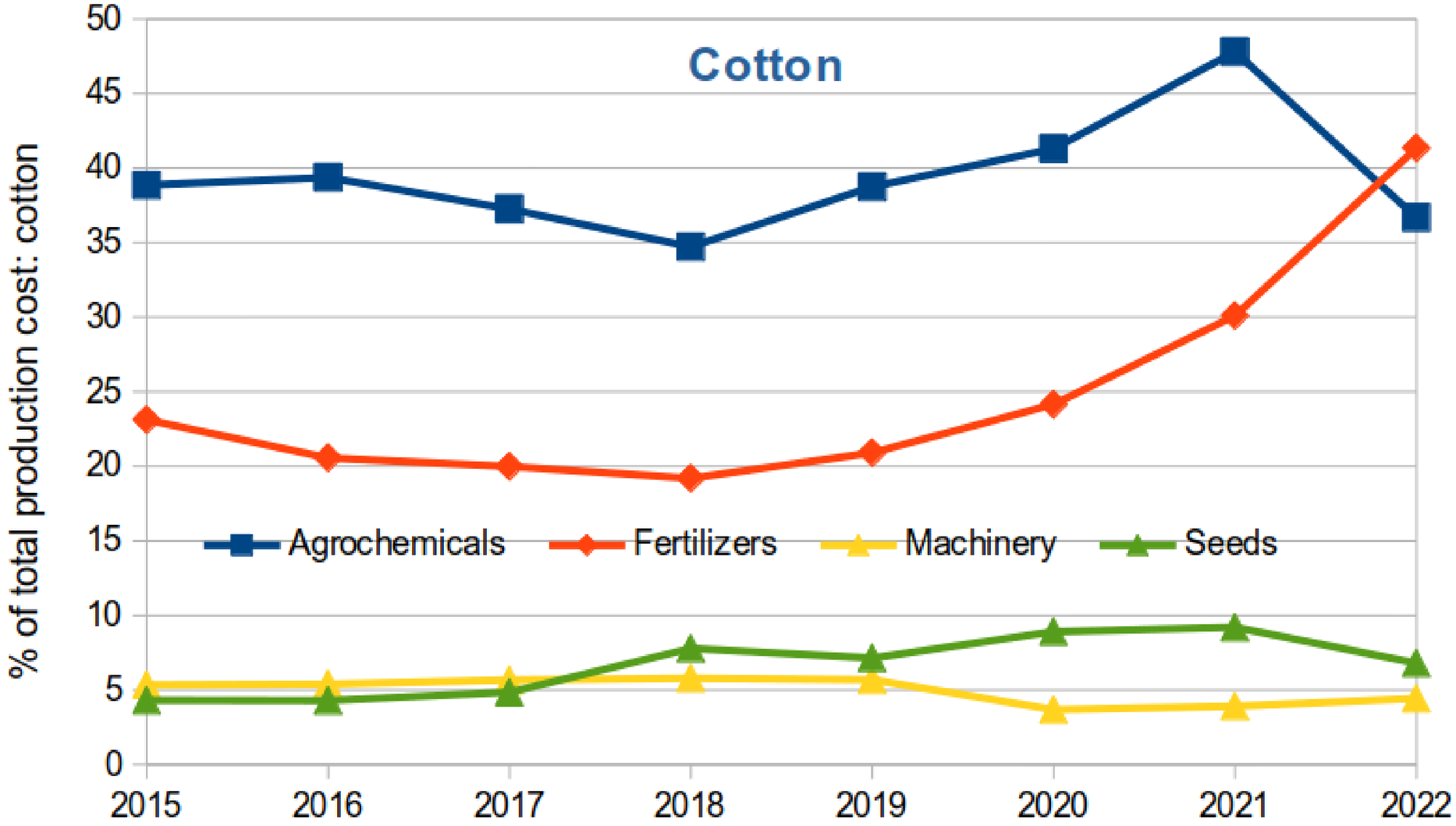
Sapezal city in Mato Grosso

Farm Três Lagoas (Grupo Scheffer) – Plots A e B
Farm Tucunaré (Grupo Amaggi) – Plot C



Cotton: Agrochemicals + Fertilizers + Seeds = **84,8%**

Source: CONAB (region of Sapezal/MT)

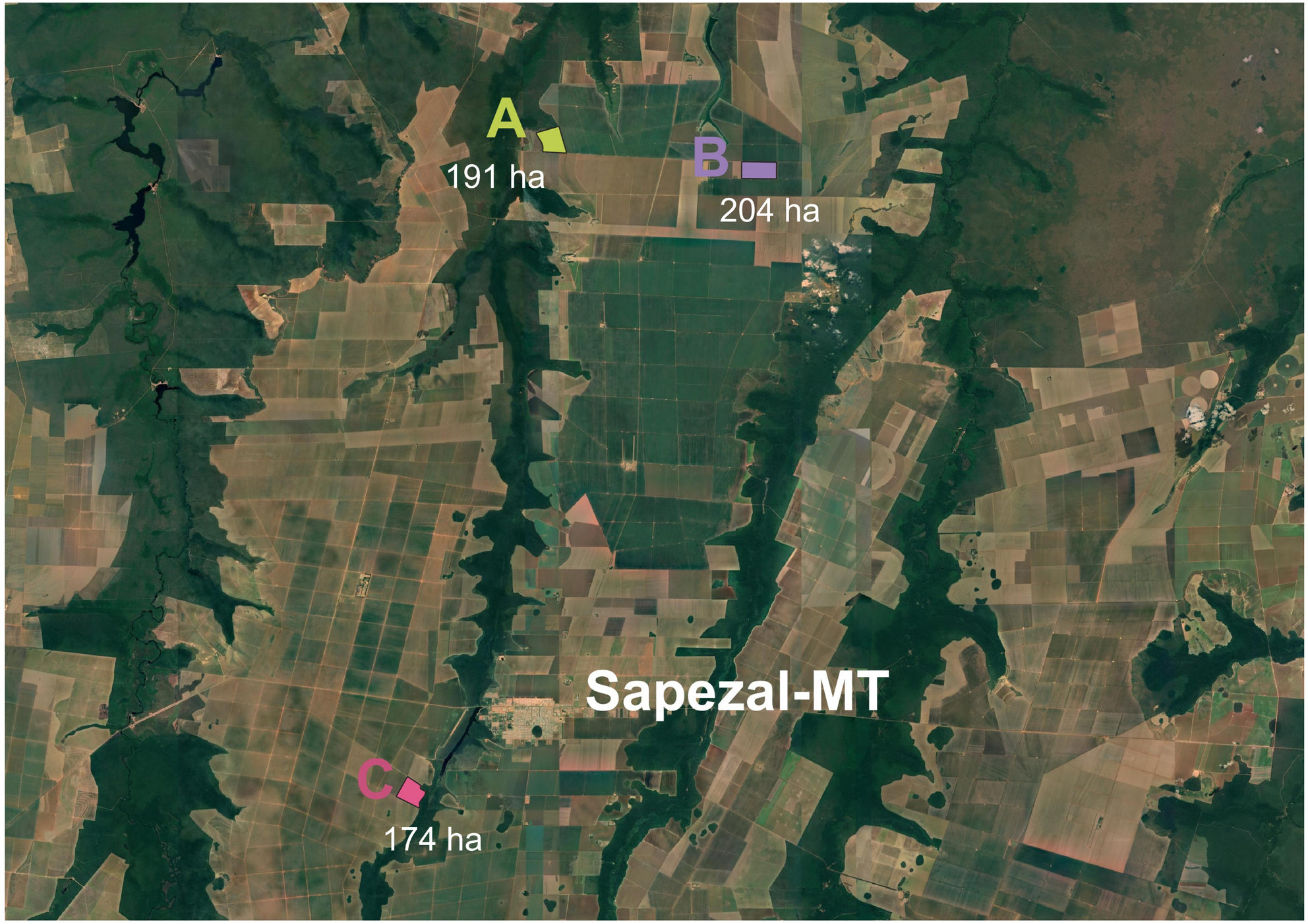


Cotton: Agrochemicals + Fertilizers + Seeds = **84,8%**

Source: CONAB (region of Sapezal/MT)

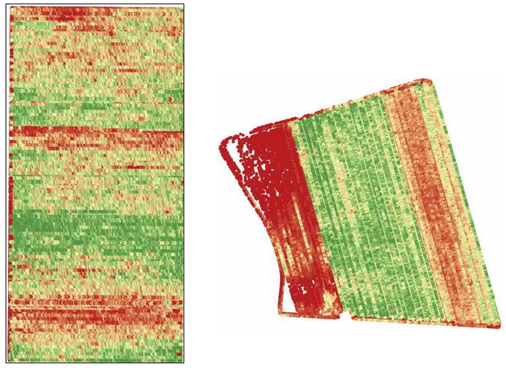
Three fields where the on-farm experimentation were carried out during 2019/2020 cotton crop

Field	Grupo	Area	Coordinates		Date		Cultivar	Productivity
		ha	Lat	Long	Seeding	Harvest		arrobas ha^{-1}
A	Scheffer	191	-13,243	-58,809	02/02/20	13/08/20	FM 954 GLT	258,4
B	Scheffer	204	-13,258	-58,704	30/01/20	08/08/20	FM 944 GL	300,4
C	Amaggi	174	-13,584	-58,884	27/12/19	13/07/20	TMG 81WS	285,3

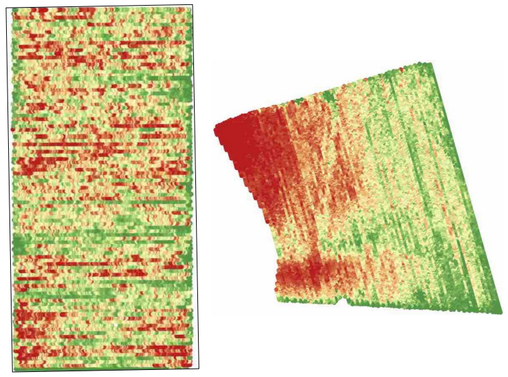

A
191 ha
B
204 ha
Sapezal-MT
C
174 ha

Sensing technologies

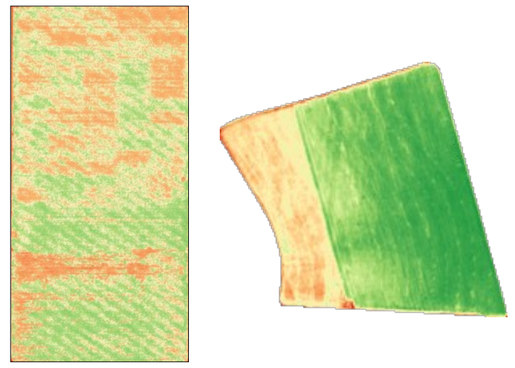
Yield map



Electric conductivity



Sentinel-2 Level-2A

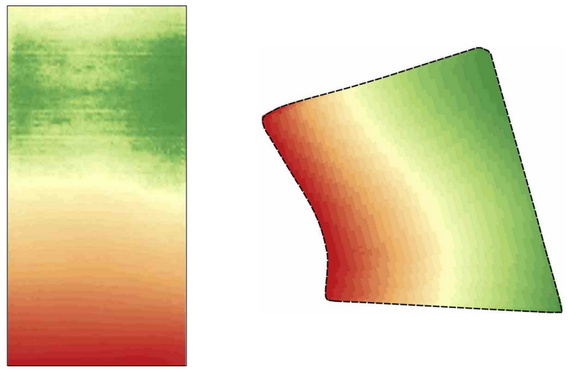


Vegetation Indices

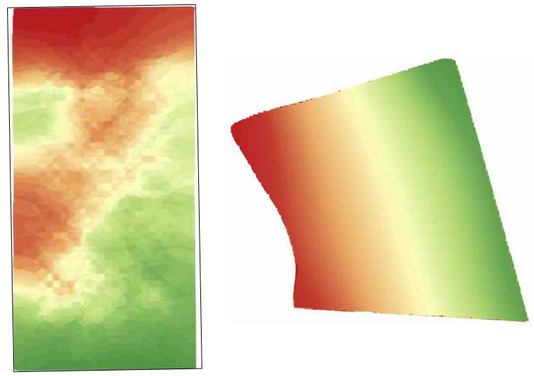
Acronym	Name	Formula *
NDVI	Normalized Difference Vegetation Index	$(NIR - R)/(NIR+R)$
RVI	Ratio Vegetation Index	NIR/R
PSRI	Plant Senescence Reflectance Index	$(R - G)/RE$
GNDVI	Green Normalized Difference Vegetation Index	$(NIR - G)/(NIR+G)$
TVI	Triangular Vegetation Index	$0.5 \times (120 \times (NIR - G) - 200 \times (R - G))$
CVI	Chlorophyll Vegetation Index	$(NIR \times R)/(G^2)$
CIG	Chlorophyll Index—Green	$(NIR/G) - 1$
CIRE	Chlorophyll Index—Red Edge	$(NIR/RE) - 1$
DVI	Difference Vegetation Index	NIR-RE
NDRE	Normalized Difference Red Edge Index	$(NIR-RE)/(NIR+RE)$
EVI	Enhanced Vegetation Index	$2.5 \times (NIR - R)/(NIR+6 \times R - 7.5 \times B+1)$
SAVI	Soil-Adjusted Vegetation Index	$(NIR - R)/(NIR+R+0.428) \times (1.428)$

Sensing technologies

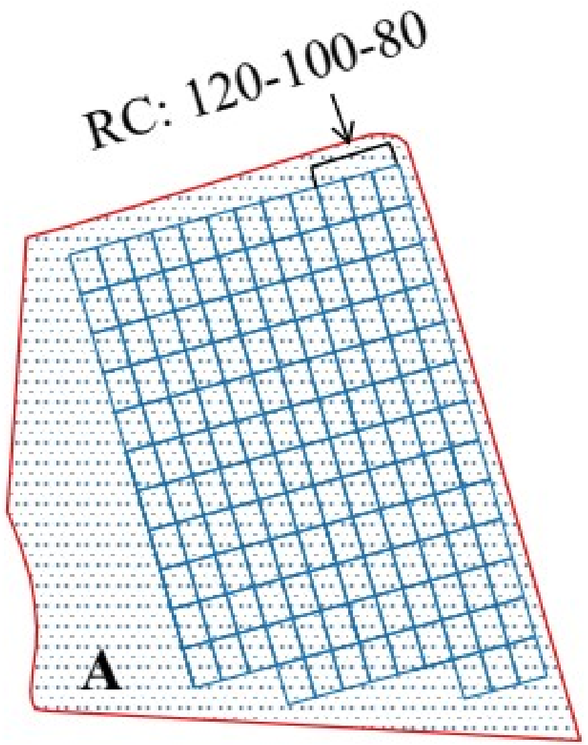
Altimetry/slope



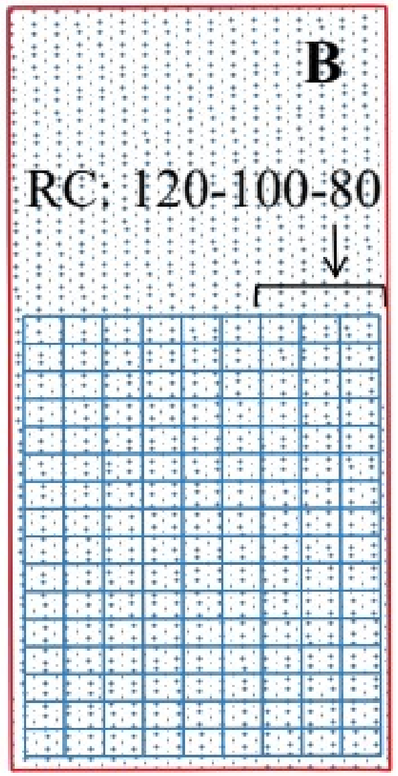
Soil texture



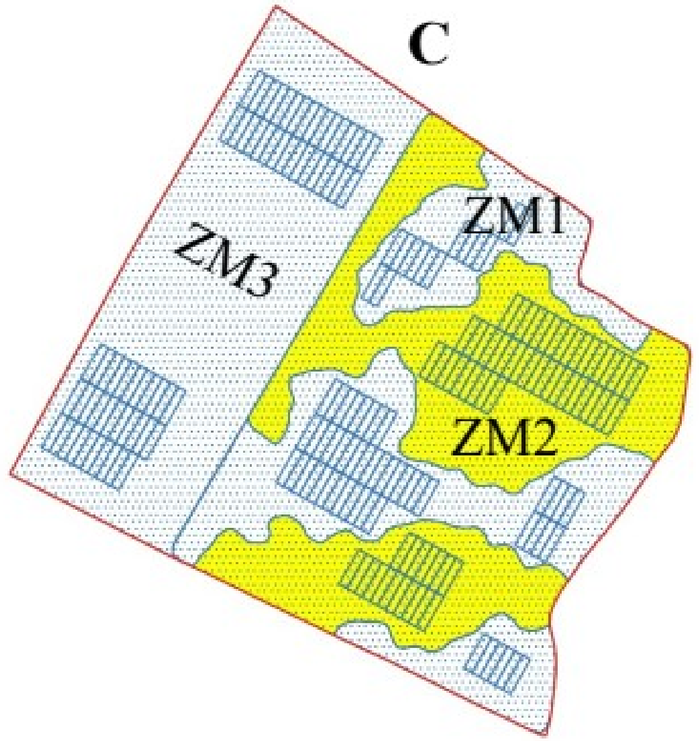
Virtual plots at different treatments
4 repetitions



144 plots 0,8 ha



144 plots 0,8 ha



192 plots 0,2 ha

0,8 ha: 74mx106m

0,2 ha: 22mx100m

Virtual plots and treatments of the on-farm experimentation of fields A, B and C. Cotton crop 2019/2020

Fields		Plots on-farm		Treatment			
		no.	Area(ha)	Nitrogen (kg/ha)	Seed pop.(seed/m)	PGR	Rep.
A		144	0,8	53-102-148-192	6-9,5-13	80-100-120*	4
B		144	0,8	45-99-158-196	6-9,5-13	80-100-120*	4
C	MZ1	64	0,2	140-200-250-300	7,7-9,9-12-14,2	160**	4
	MZ2	64			7,7-8,8-9,9-12	220**	4
	MZ3	64			7,7-8,8-9,9-11	130**	4

PGR: plant growth regulator

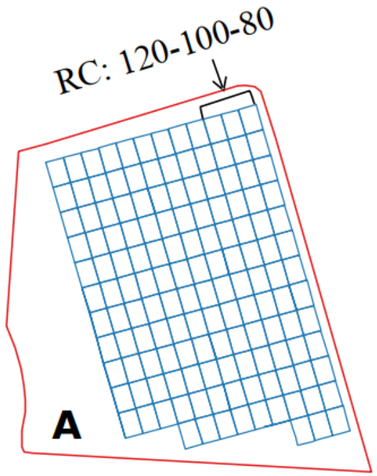
*Percentage relative to the usual dose in the farm

** Total dose applied in MZ1, MZ2, and MZ3.

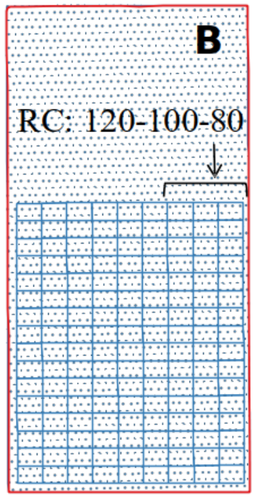
A (100%) = 403 mL/ha, B (100%) = 705 ml/ha

Fields A e B (Três Lagoas farm)

- 4 doses of N broadcasting
- 3 seed densities
- 3 doses of plant growth regulator (PGR)
- 4 repetitions
- 144 virtual plots 0,8 ha(74 m x 106 m)



144 parcelas 0,8 ha



144 parcelas 0,8 ha

PGR* applied in tracks, the width of the sprayers.
A (100%) = 403 mL/ha, 3 applications; B (100%) = 705 mL/ha, 5 applications*
Seed population and doses of N: randomly distributed.

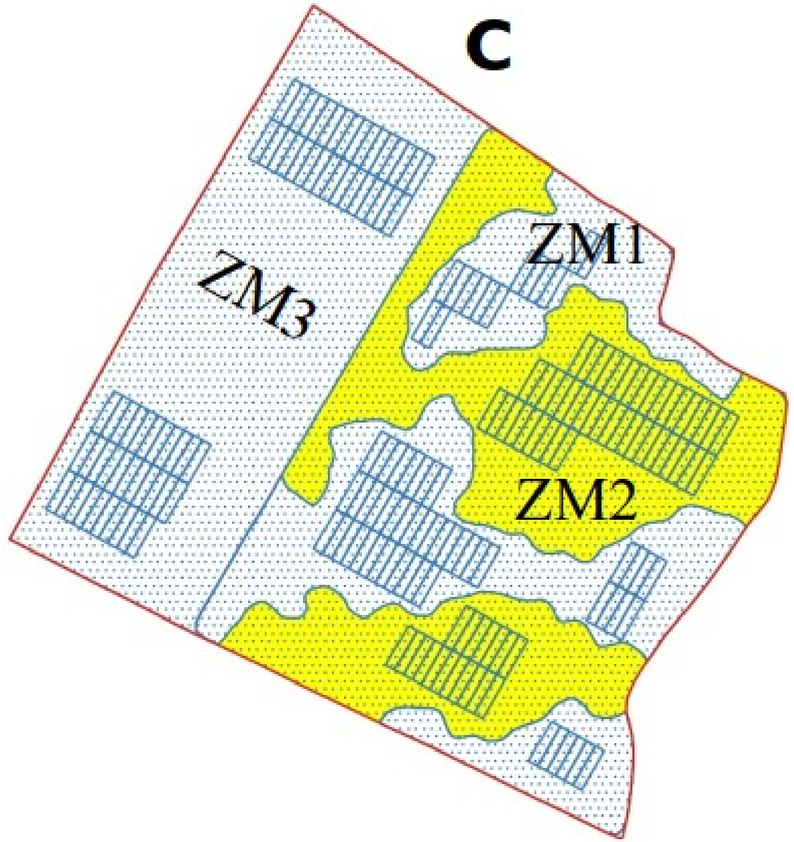
Seeding and N at variable rate: planter John Deere DB74
PGR in tracks: self-propelled sprayer John Deere PV4730
Yield maps from cotton pickers John Deere CP690

*Mepiquat chloride

Field C (Tucunaré farm)

- 4 doses of N
- 4 seed populations
- GPR applied in specific dose for each MZ
- 4 repetitions in each 3 management zones

192 virtual plots of 0,2 ha (22 m x 100 m)



RC applied with sprayer Uniport 3030 Jacto
N applied with broadcaster Hercules 10000
Seeder John Deere DB74
Yield Map: cotton picker John Deere CP690

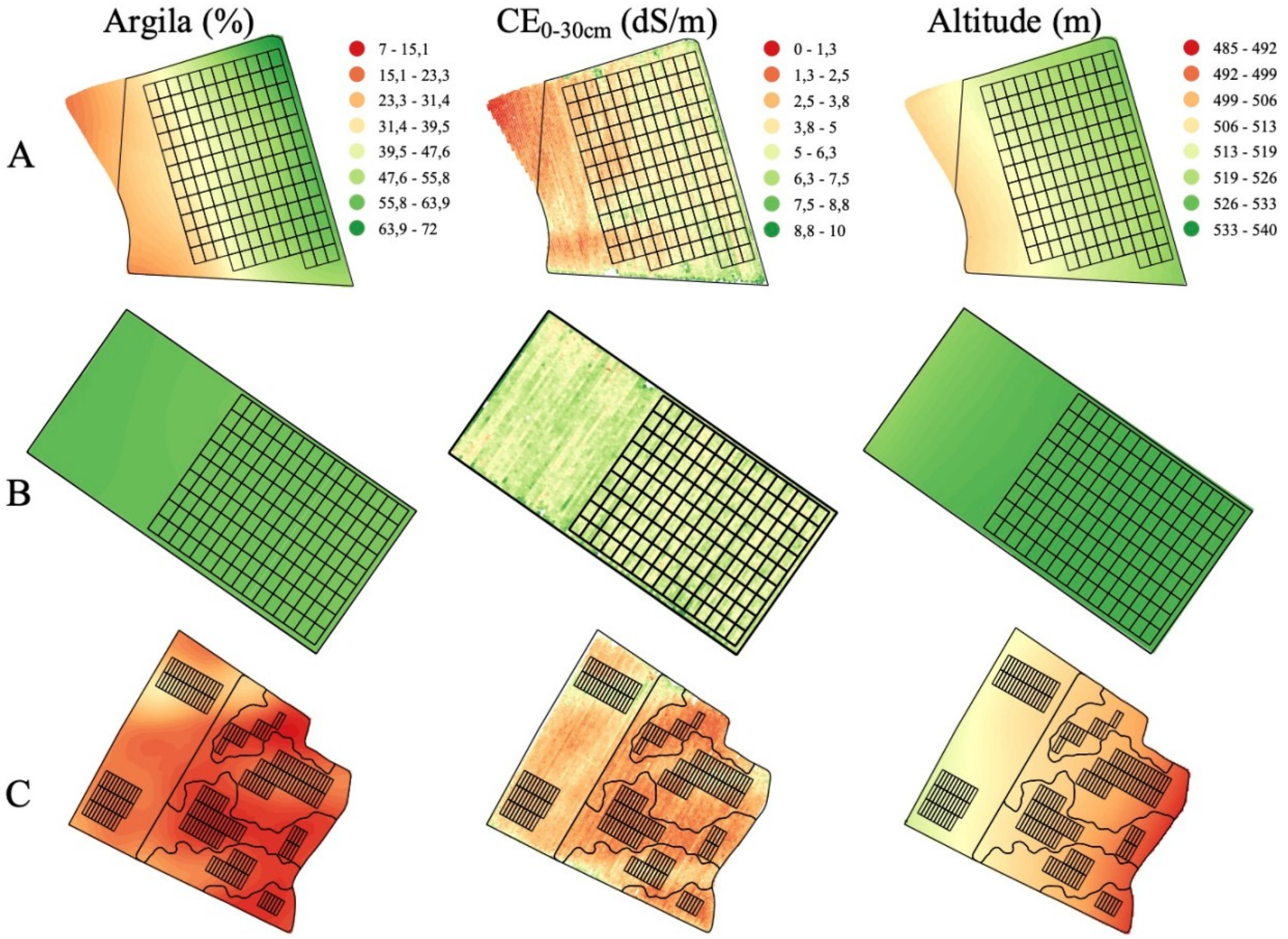
Characterization of field spatial variability

- Aparent soil electric conductivity (ECa): 0-30 cm e 0-90 cm Veris3100.
- Soil clay content: samples A (20), B (135) e C (170), regular grid, kriging and semivariogram
- Topography (altitude and slope): RTK GNSS of cotton picker
- Vegetation indices (Sentinel2): NDVI e NDRE

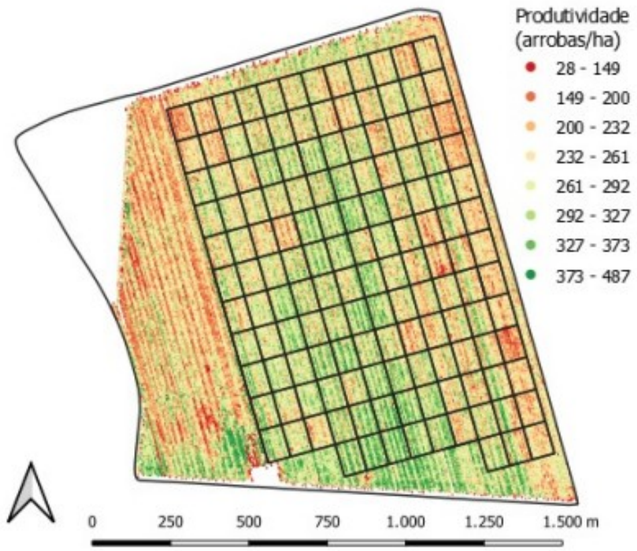
Management zones of field C defined from 7 layers of information:

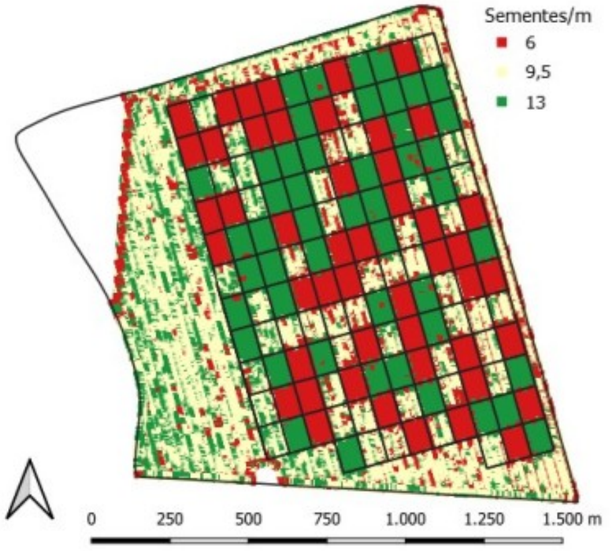
- NDVI and NDRE from may to june, 2019
- Productivity in 2019 harvest
- ECa (0-30cm) e ECa (0-90cm)

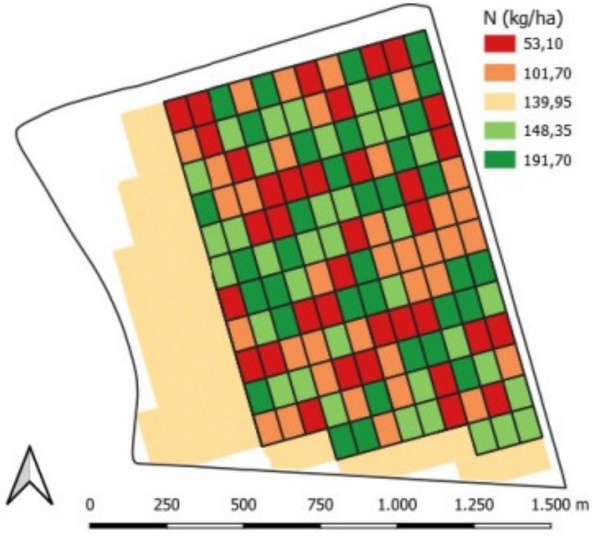
Clay, EC and altitude in the 3 fields

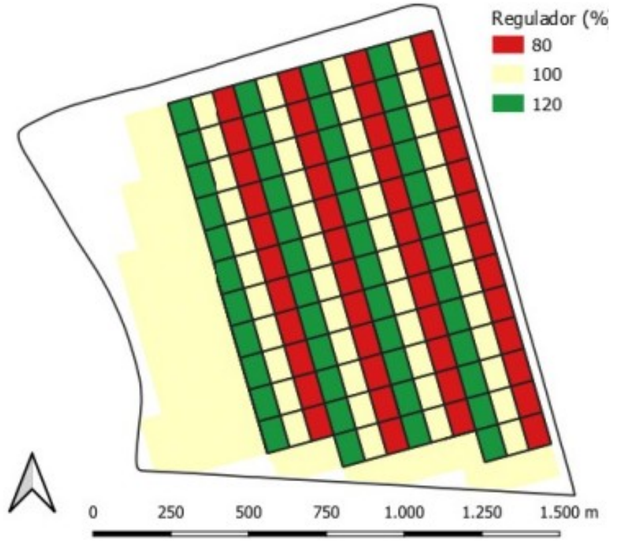


Productivity x Inputs in field A



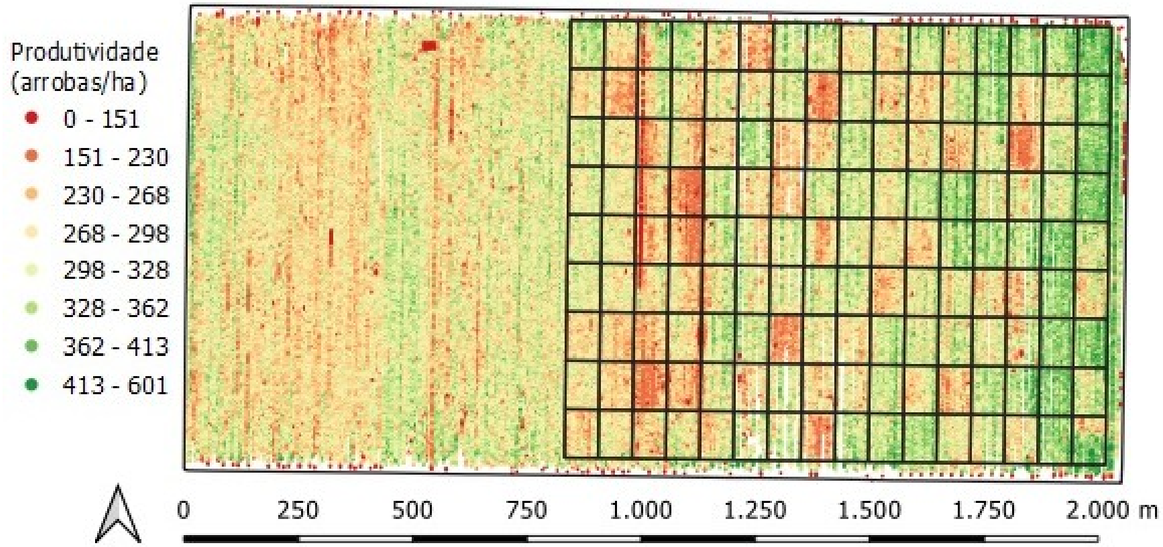


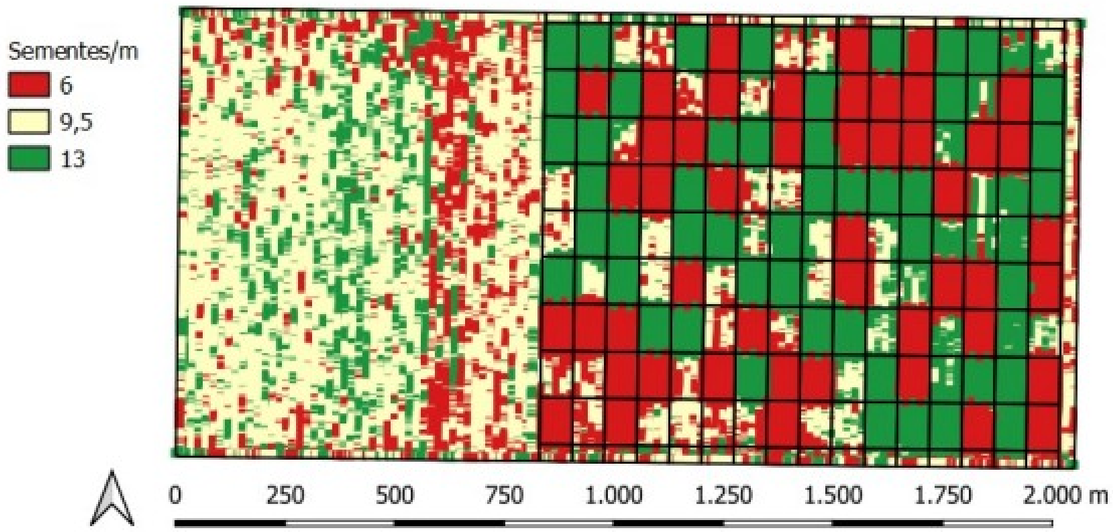




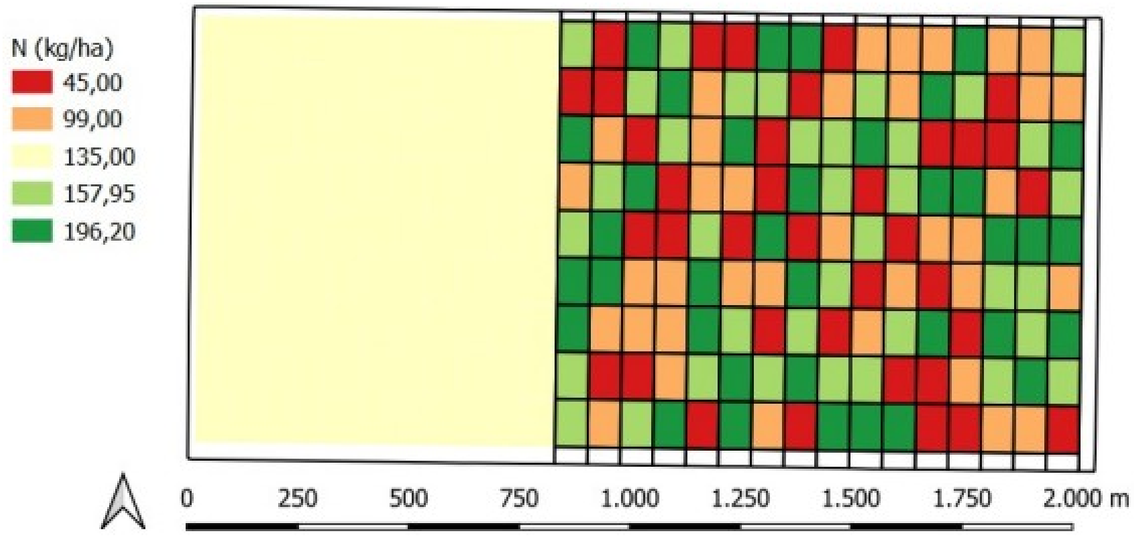
Cotton harvest
2019/2020

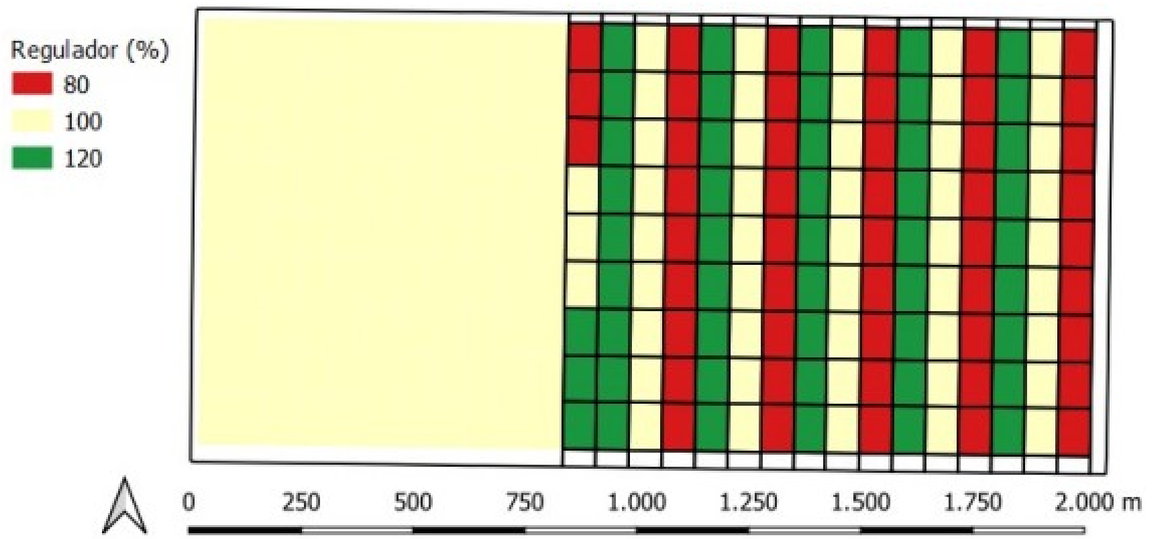
Productivity x Inputs in field B





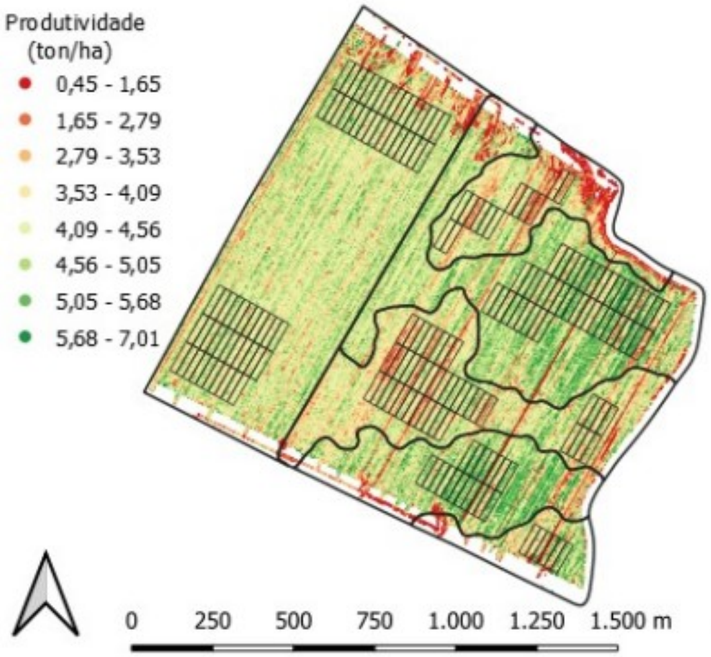
Cotton harvest 2019/2020

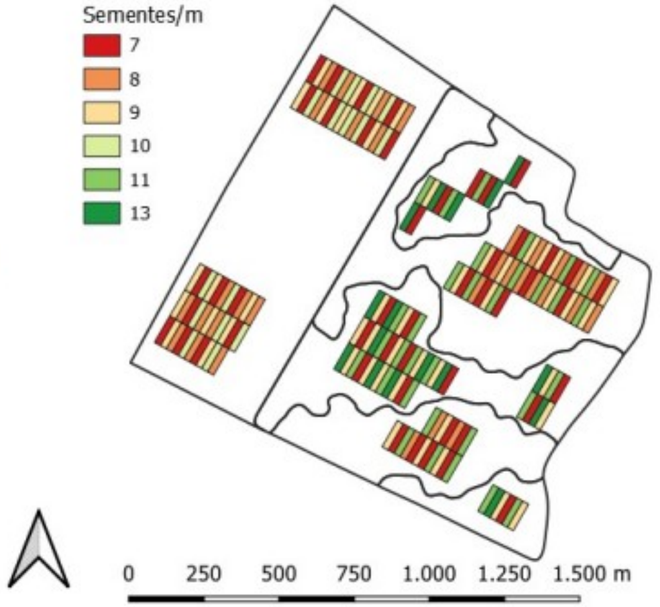


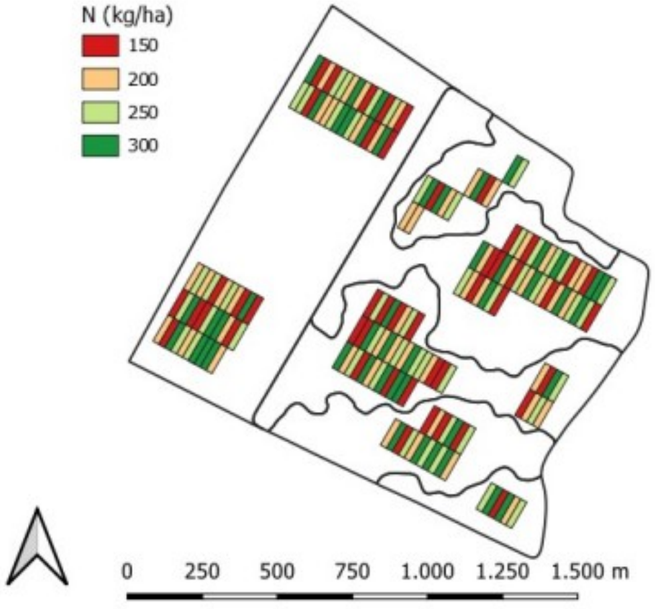


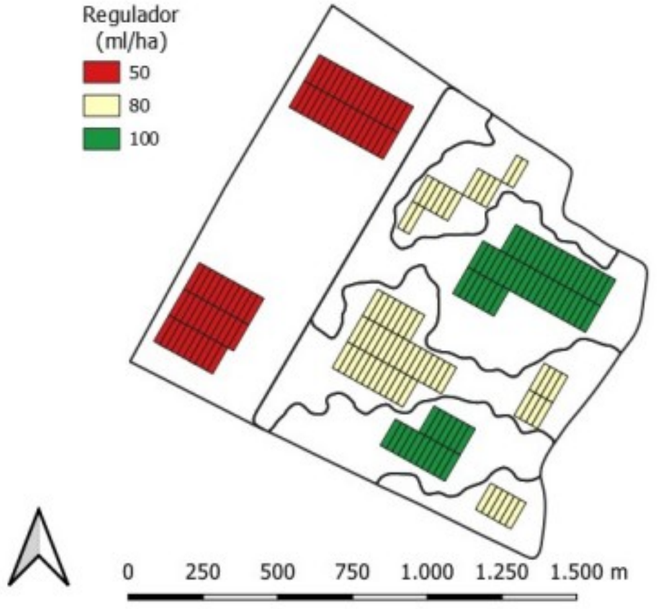
Productivity X Inputs in field C

Cotton harvest
2019/2020









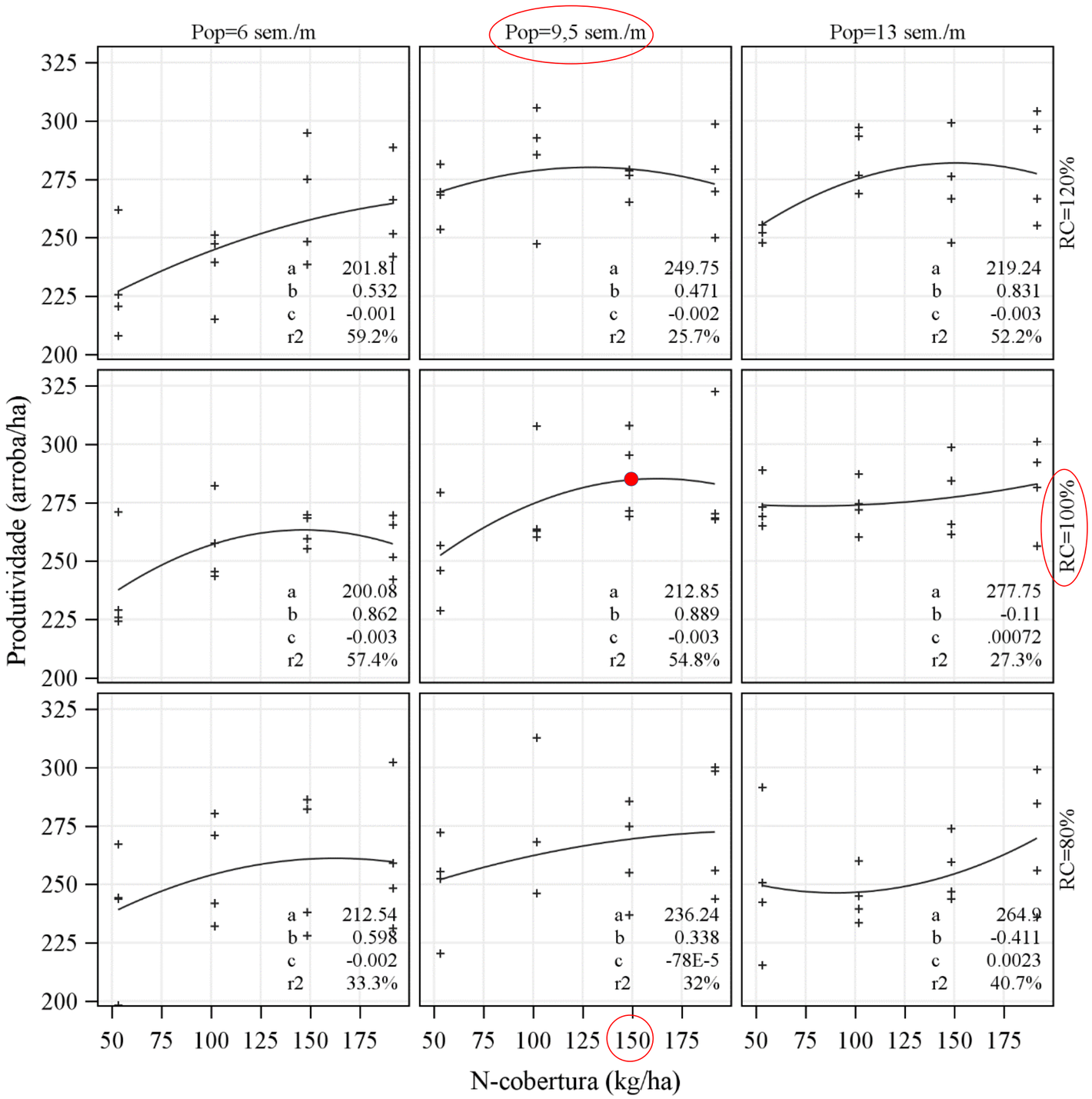
Field A

Productivity response curves

286,1 @/ha: 11% productivity gain, above the field average (258,4 @/ha)

Recommendation:
Pop.: 9.5 seeds/m
PGR: 100% farm reference* dose
N: 148 kg/ha

* 403 mL/ha



Field B

Productivity response curves

343,4 @/ha: 13% gain in productivity, above the field average (303,4 @/ha)

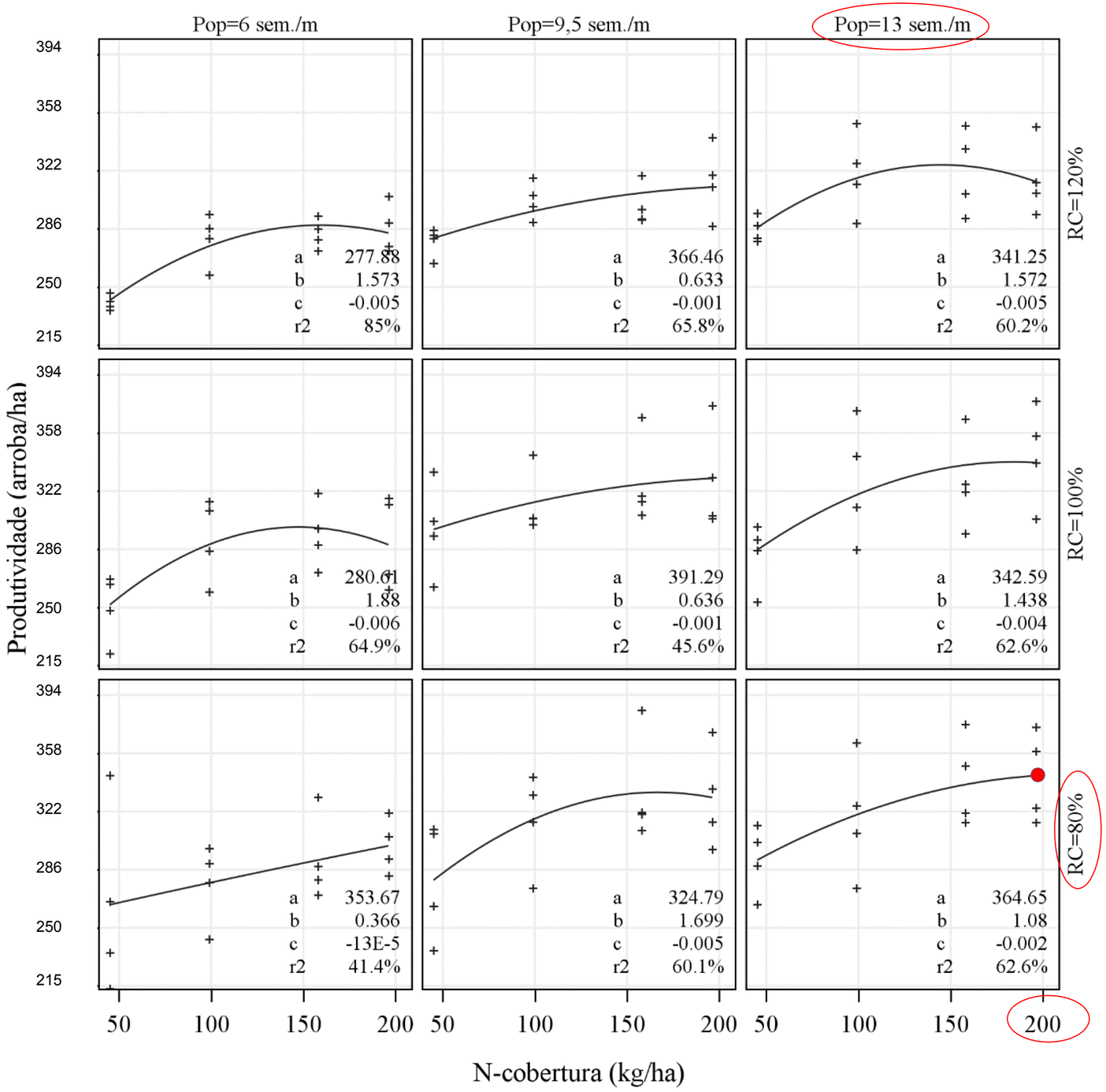
Recommendation:

Pop.: 13 seeds/m

RC: 80% of farm reference* dose

N: 196 kg/ha

*80% de 705 mL/ha: 564 mL/ha



Field C

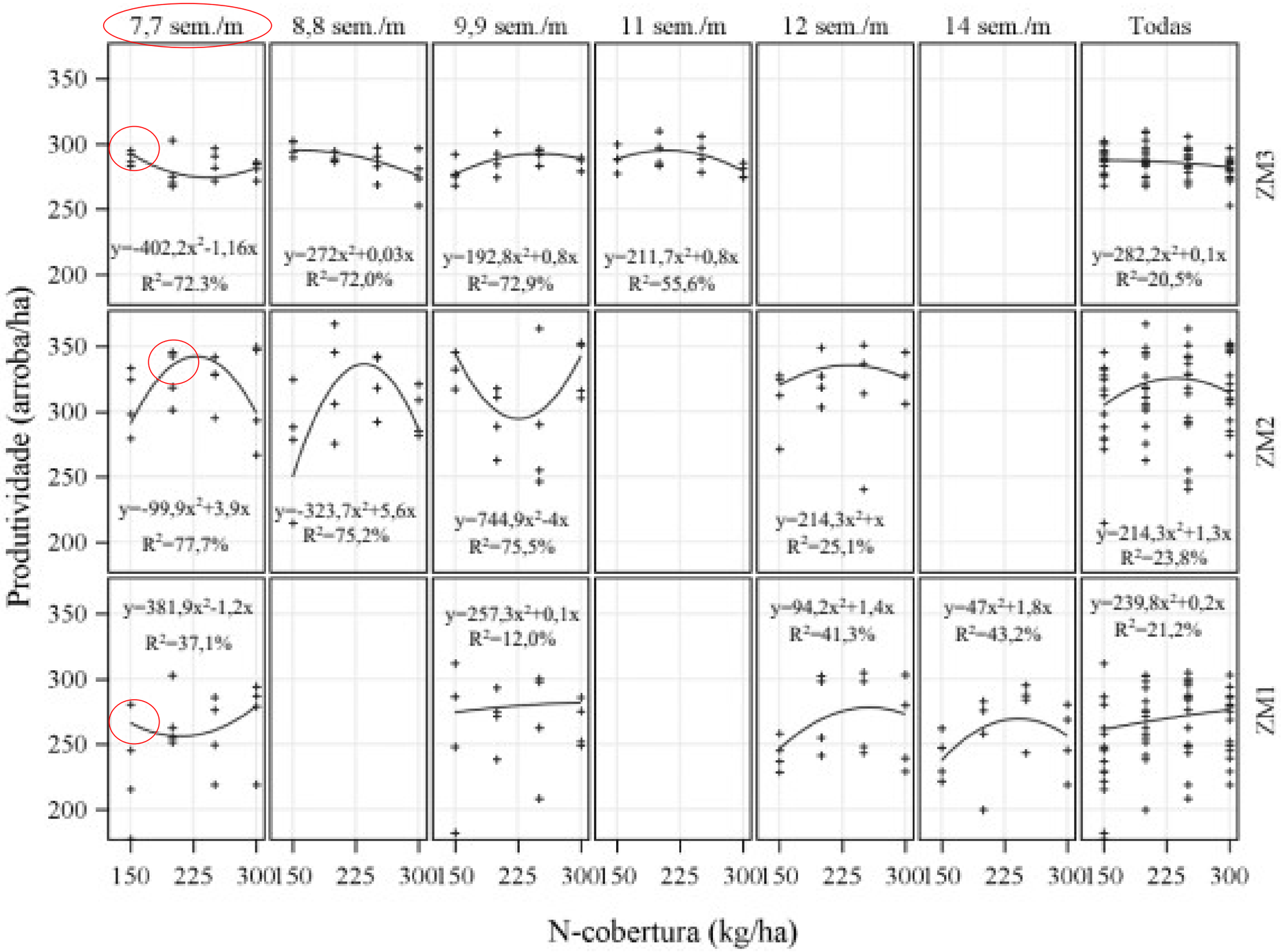
Productivity response curves

Productivities
MZ1=260 @/ha: -8,9%
MZ2=313 @/ha: +0,7%
MZ3=286 @/ha: +0,2%
Field average: 285,3 @/ha

Recommendation
Seed density = 7,7 seeds/m in the 3 Mzs.

N: MZ1 = 150 kg/ha
MZ2 = 200 kg/ha
MZ3 = 150 kg/ha

GPR: MZ1=160 mL/ha
MZ2 = 220 mL/ha
MZ3 = 130 mL/ha



Conclusions

On-farm experimentation is very interesting because as the trial evolves, the farmer can see the effectiveness of Precision Agriculture. In the majority of cases, using the data sources that are already available in the farm or in the cooperative such as: remote and proximal sensing, machinery, IT resources, and qualified personnel.

*Minimal interference in the farming operations routine.

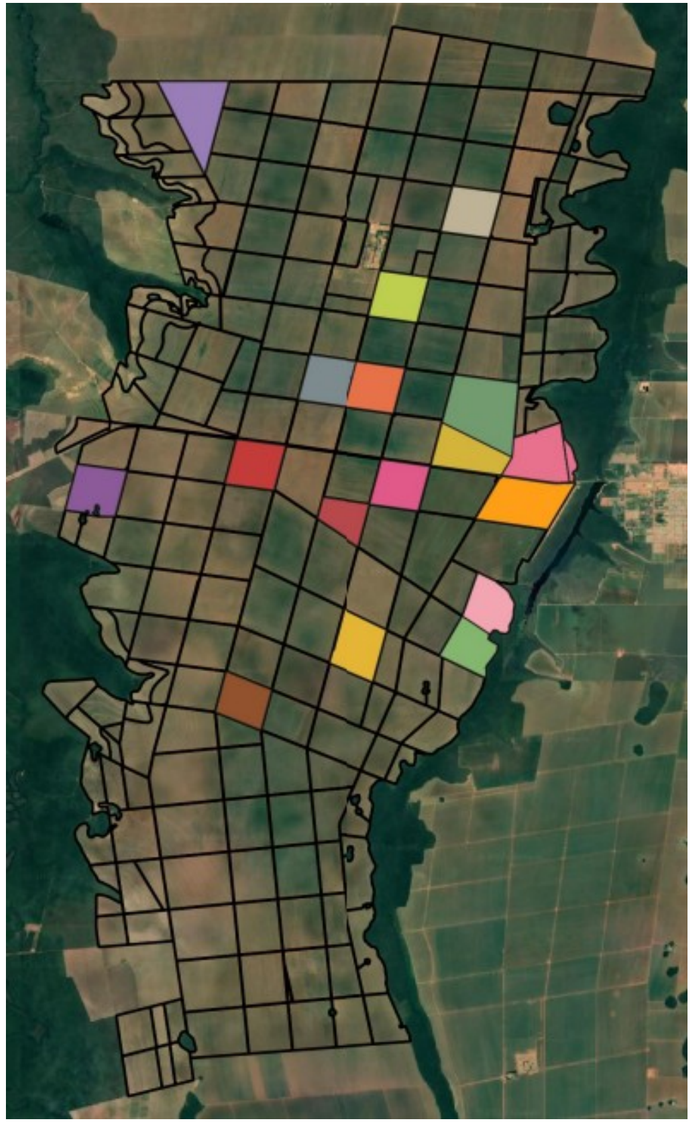
Knowledge and technology transfer occur along the research process.

On-farm experiments have minimal interference with field operations.

The productivity analysis enables to determine the most profitable dose for the producer.

Sentinel-2 MSI level-2A (surface reflectance) is very useful to determine spatial variability in crops and to compose a dataset to delineate management zones for Precision Agriculture.

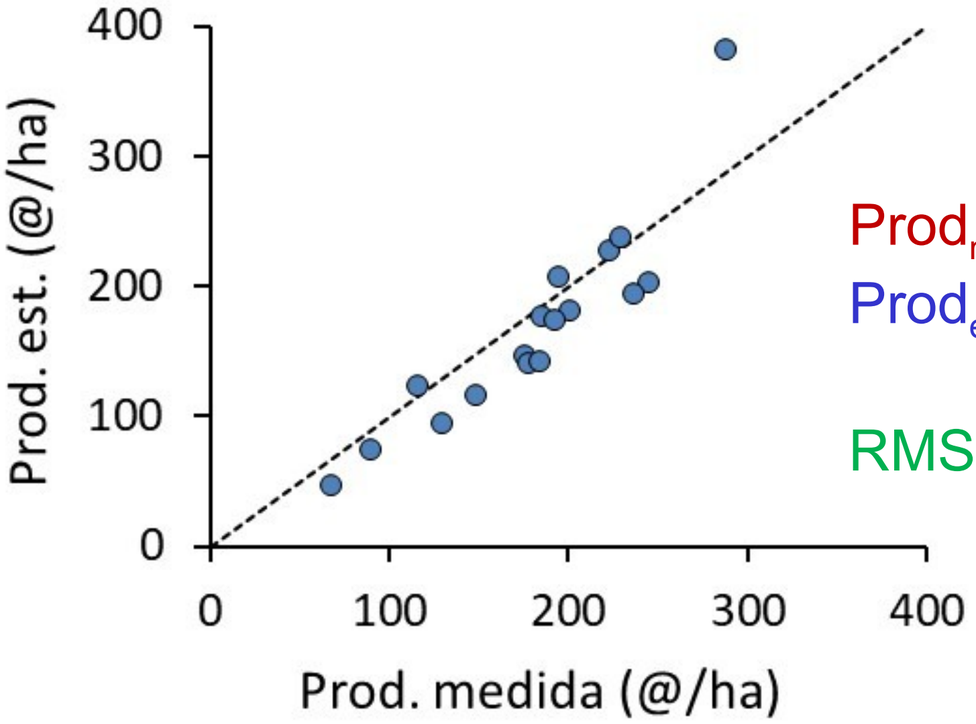
Other applications of satellite remote sensing



Yield forecast

Farm Tucunaré – Sapezal/MT

18 fields – soybean crop 2021-2022



$Prod_{measured}$ = 182@/ha

$Prod_{estimated}$ = 169 @/ha

RMSE = 34 @/ha

Other applications of satellite remote sensing in Precision Agriculture

- Identification of areas with high infestation of cotton nematodes (worm)

- Soil clay content prediction

Obrigado!

joao.naime@embrapa.br

Informações complementares

Embrapa 50 ANOS

MINISTÉRIO DA AGRICULTURA E PECUÁRIA

GOVERNO FEDERAL
BRASIL
UNIÃO E RECONSTRUÇÃO

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
INSTITUTO NACIONAL DE PESQUISAS ESPACIAIS

Colheita do Espaço: Benefícios do Programa Espacial da UE para a Agricultura no Brasil

Marcos Adami
Divisão de Observação da Terra e Geoinformática – DIOTG
Coordenação-Geral de Observação da Terra – CGOBT
marcos.adami@inpe.br

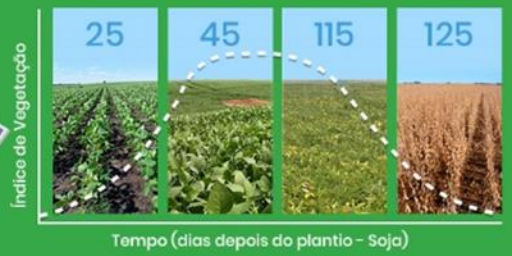
Brasília, DF, 14 de setembro de 2023

MINISTÉRIO DA CIÊNCIA, TECNOLOGIA E INOVAÇÃO
GOVERNO FEDERAL BRASIL UNIÃO E RECONSTRUÇÃO

INPE

PESQUISAS, PRODUTOS E SERVIÇOS DO INPE APLICADOS A AGROPECUÁRIA

Fenologia obtida por satélite



Mapa de uso e cobertura da terra - Cerrado

- MAPEAMENTO DAS ÁREAS AGRÍCOLAS
- ACOMPANHAMENTO DO DESENVOLVIMENTO DAS LAVOURAS
- MODELAGEM PARA MONITORAMENTO E PREVISÃO DE EVENTOS METEOROLÓGICOS EXTREMOS
- PREVISÃO DE SAFRAS ESTIMATIVA DE ÁREA ESTIMATIVA DE PRODUTIVIDADE
- MONITORAMENTO DAS LAVOURAS PARA FINS DE CRÉDITO E SEGURO AGRICOLA
- APOIO Á CERTIFICAÇÃO DA PRODUÇÃO AGRICOLA

INPE
UNIDADE DE PESQUISA DO MCTI

Monitoramento e Previsão de Eventos Meteorológicos Extremos

Acompanhamento do desenvolvimento de lavouras

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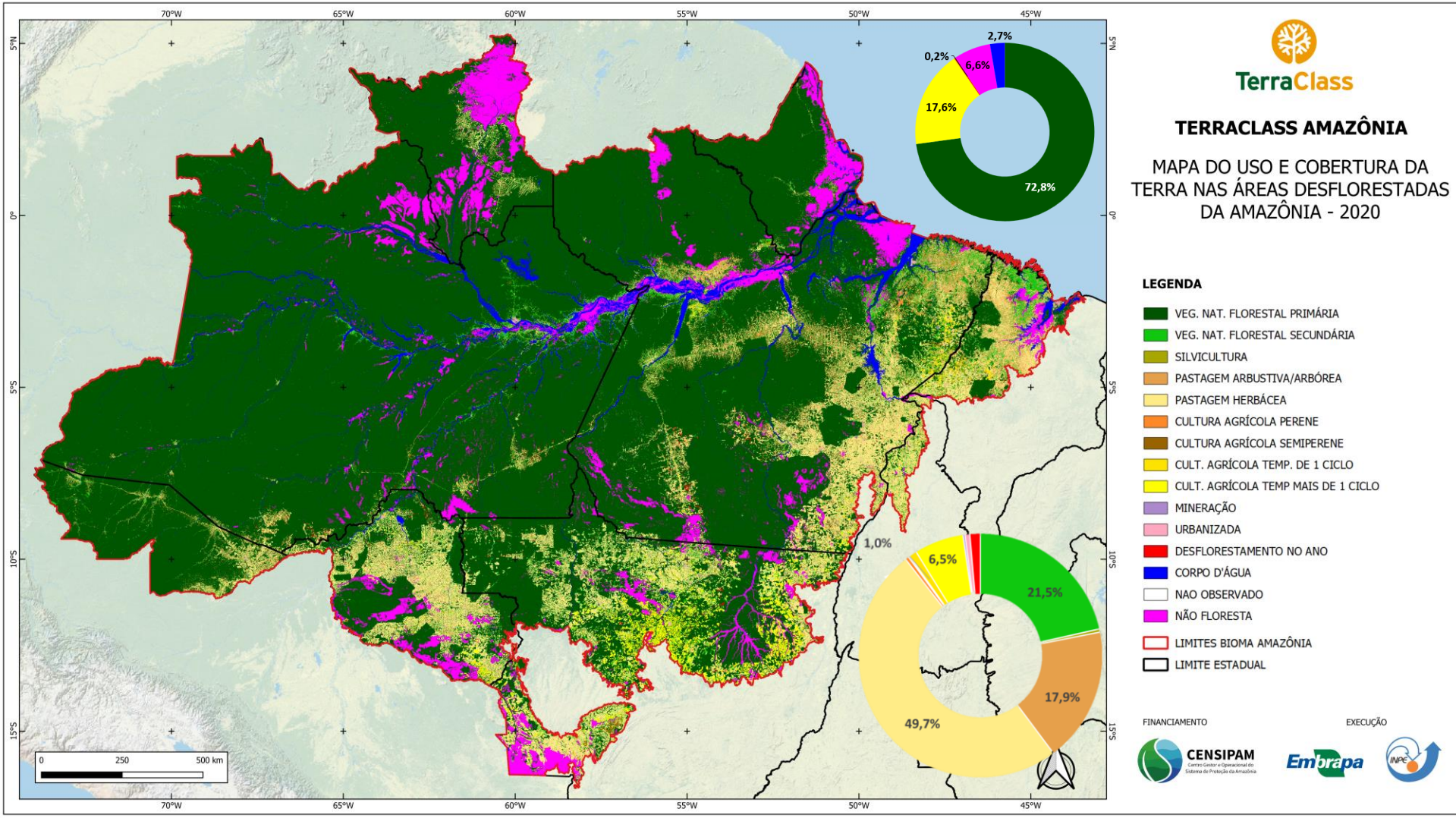
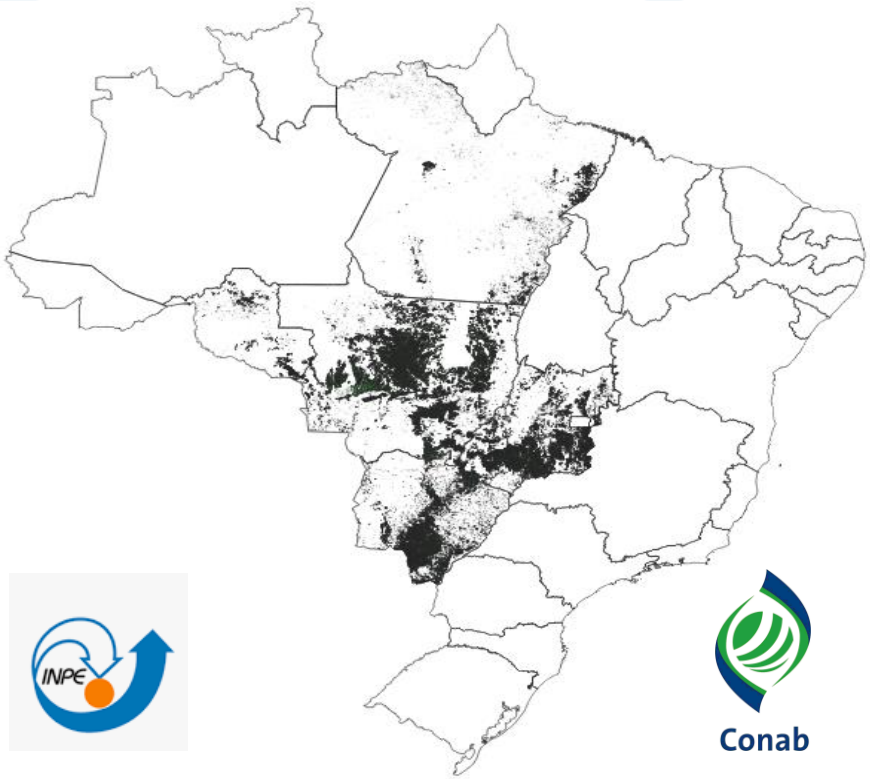
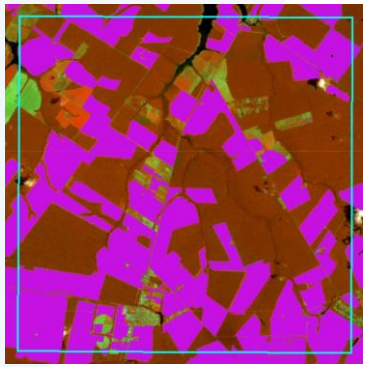
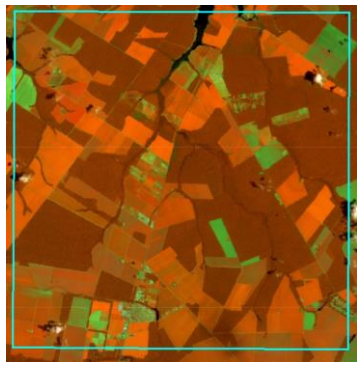
Mapeamento de áreas agrícolas



Mapeamento de áreas agrícolas

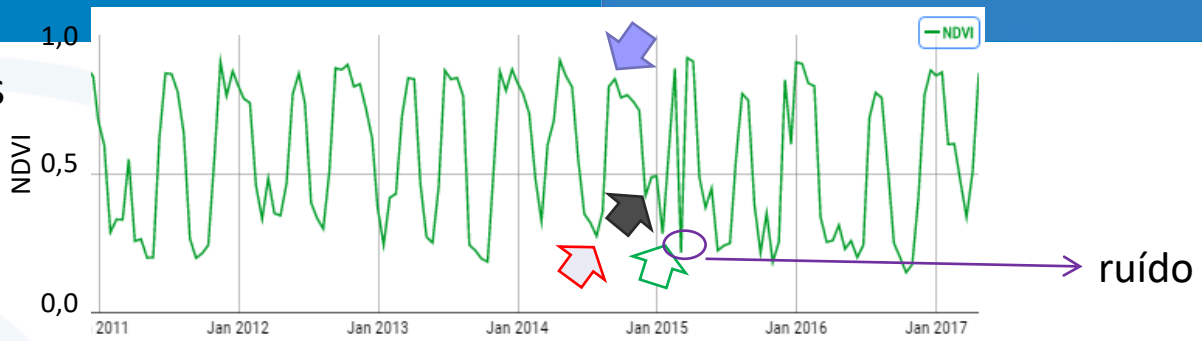


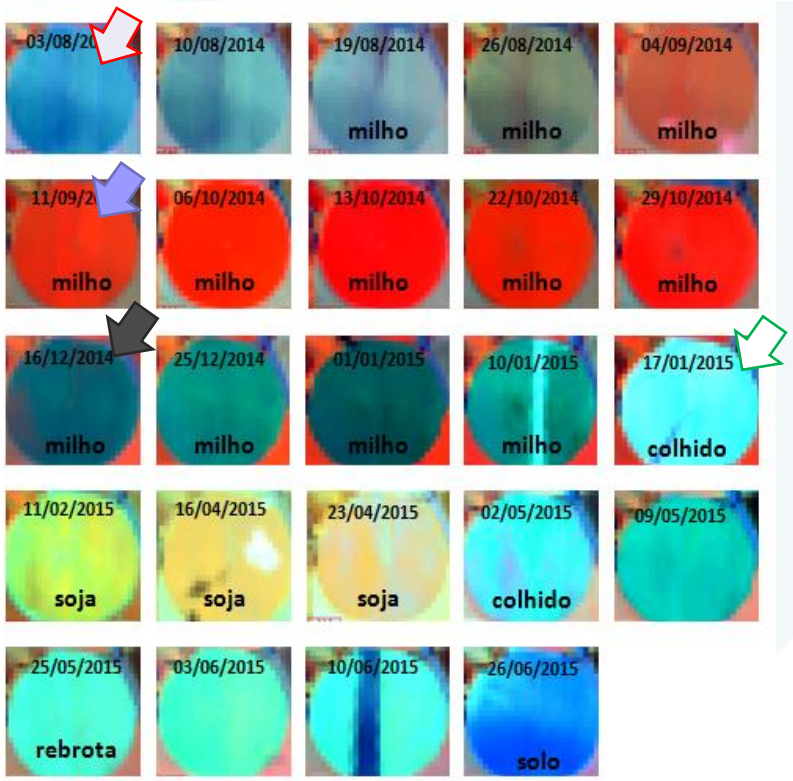




Identificação de culturas agrícolas

Rotação de culturas
Milho - Soja





Landsat-8/OLI – RGB 564 (NIR-SWIR1-Red)

Formaggio
& Sanches (2017)

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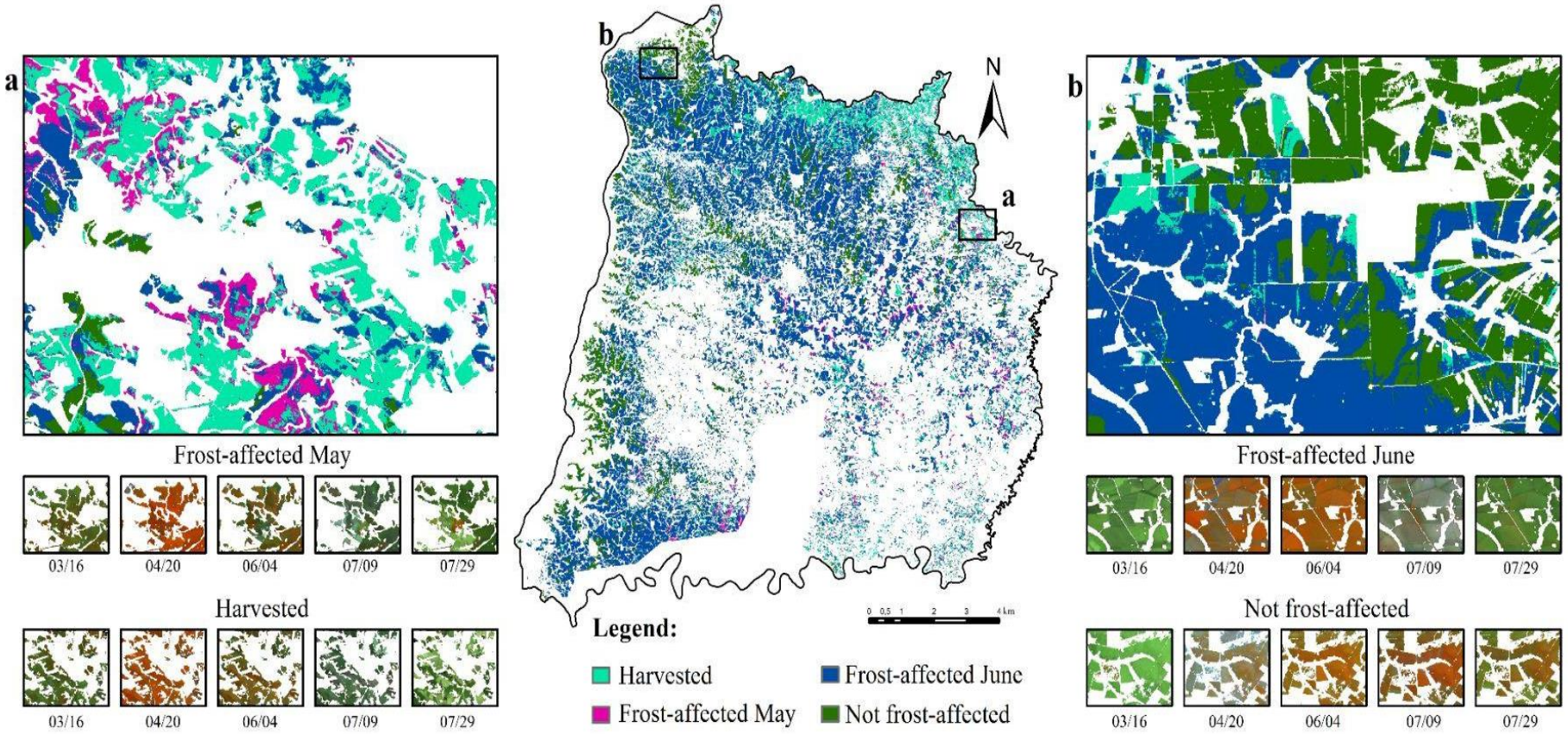
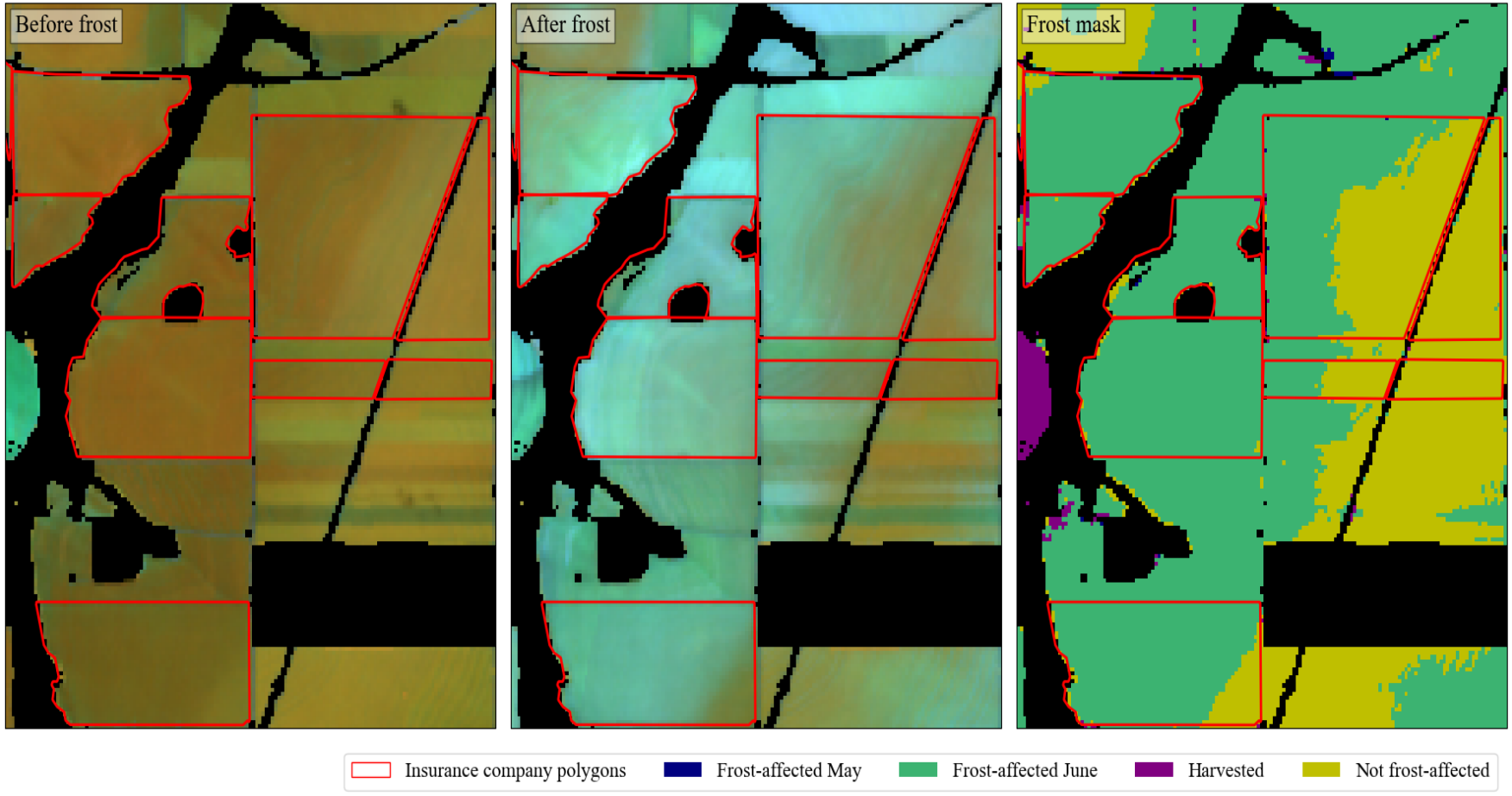
Eventos extremos



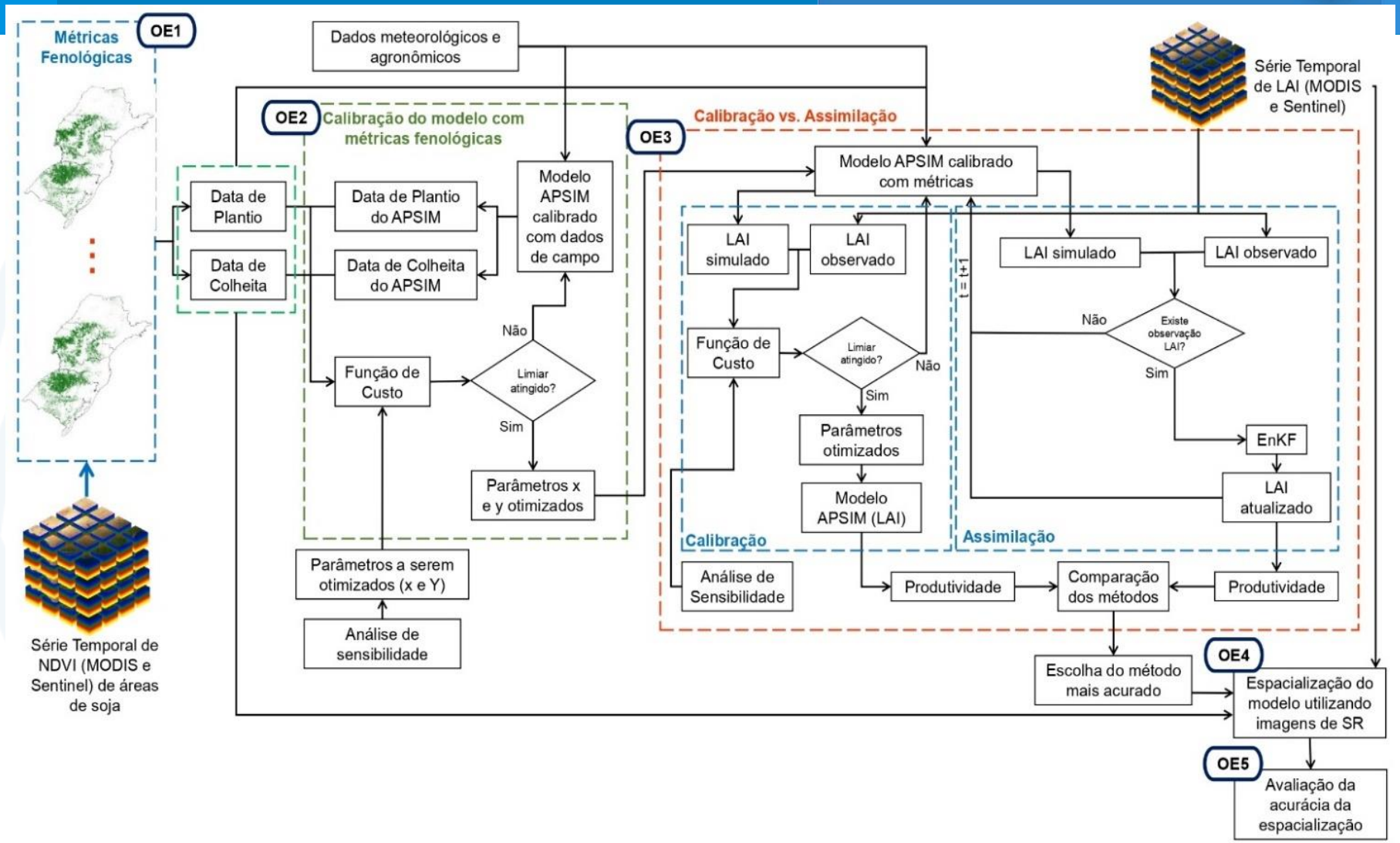
Chaves, submetido

Eventos extremos



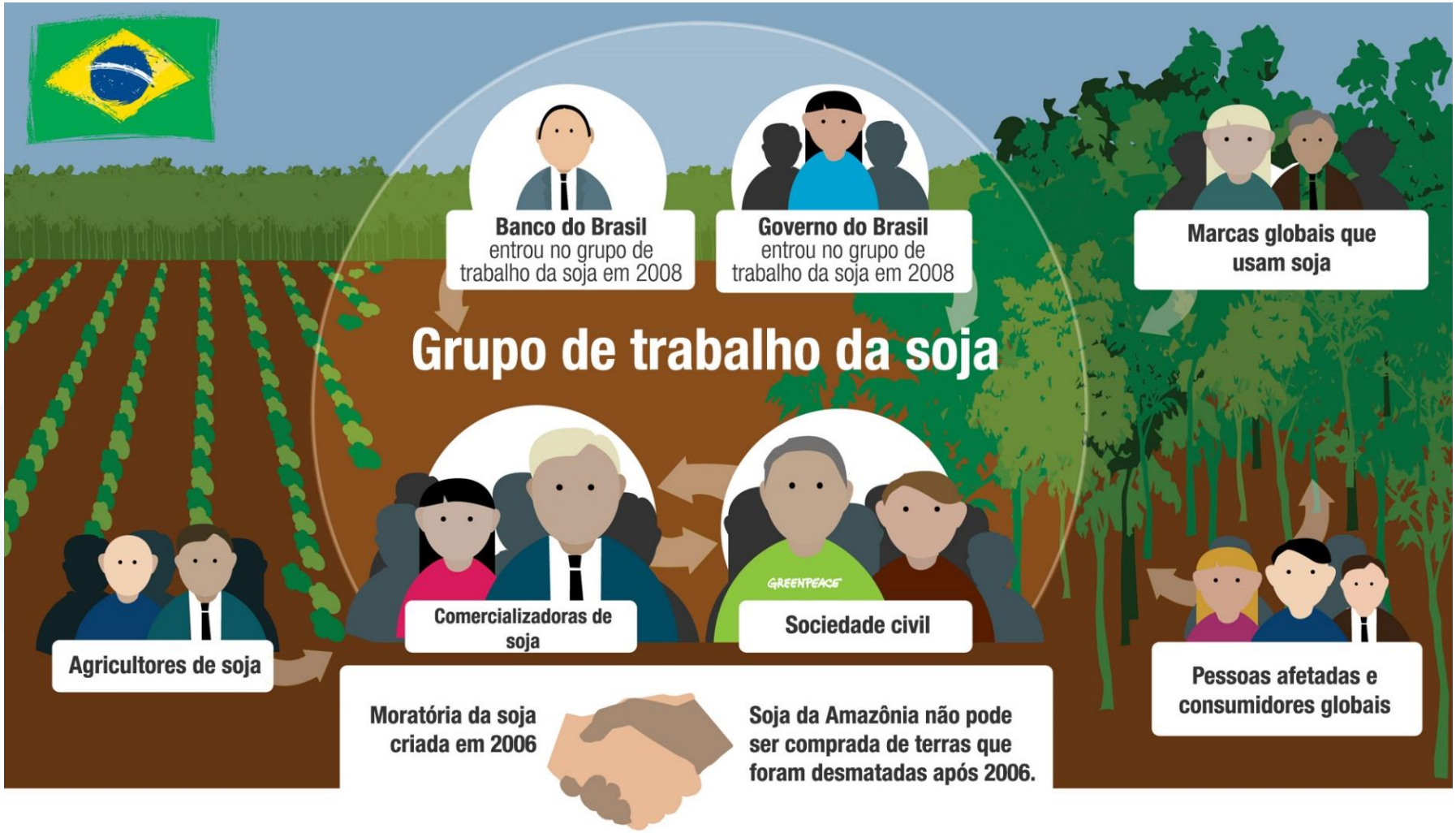
Chaves, submetido

Previsão e estimativa de produtividade

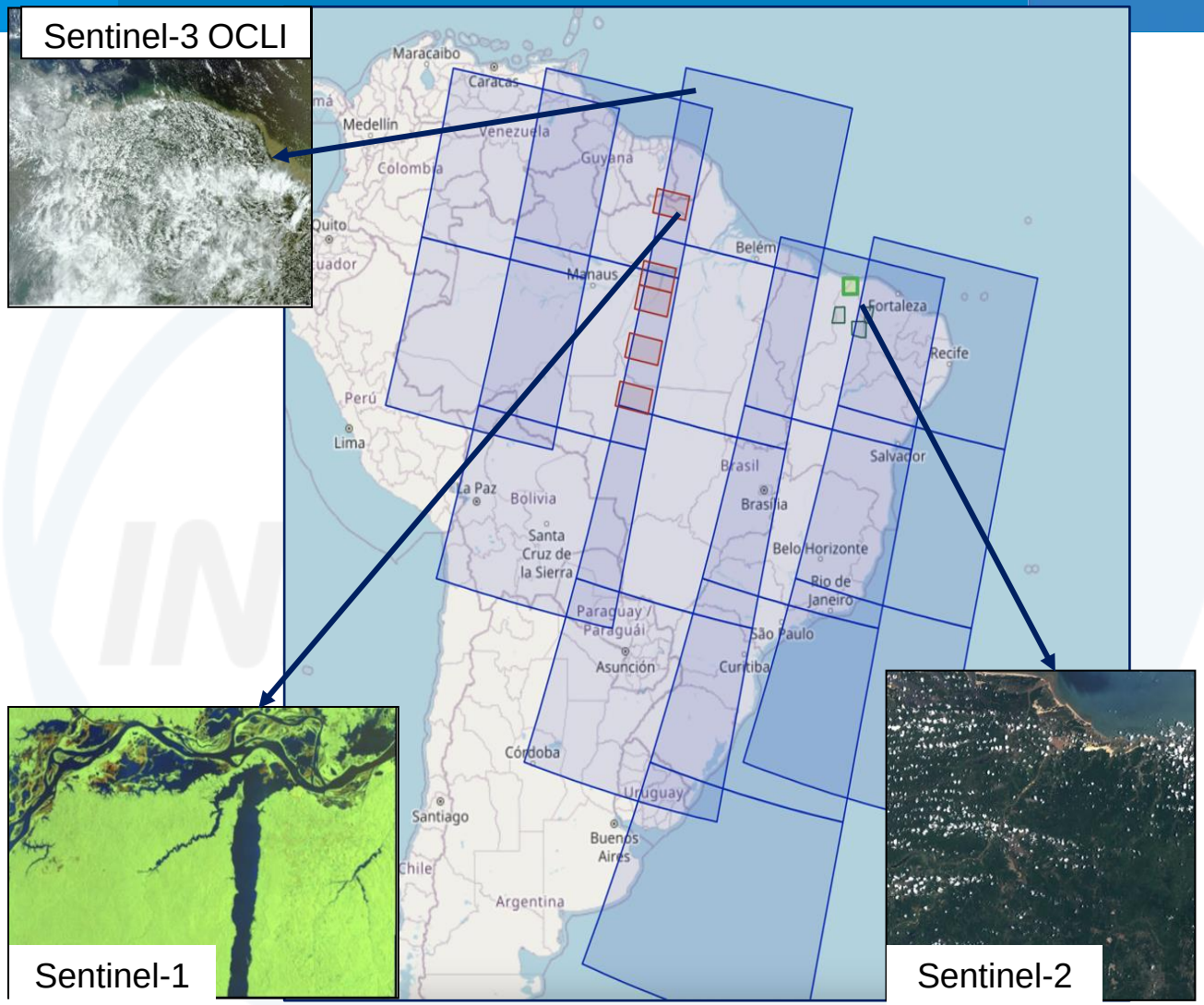


Rodigheri (2022)

Apoio a certificação
Moratória da soja



Base de Informações Georreferenciadas (BIG)



INPE Sentinel Mirror Site

https://data.inpe.br/sentinel-hub/

Since January 2022, INPE has transferred over 200 TB of Sentinel data from ESA International Hub, to its premises

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Brazil Data Cube

Big data of remote sensing images modeled as multidimensional data cubes

Land use and cover mapping

BRAZIL
DATA CUBE

Image time series analysis

Big data technologies and machine learning

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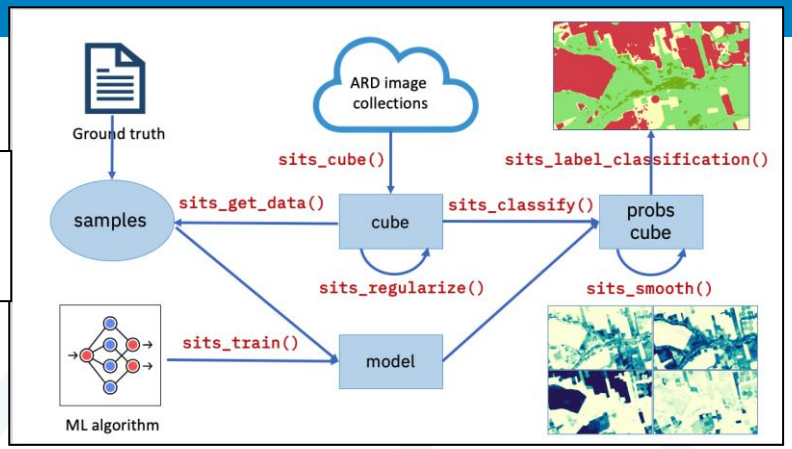
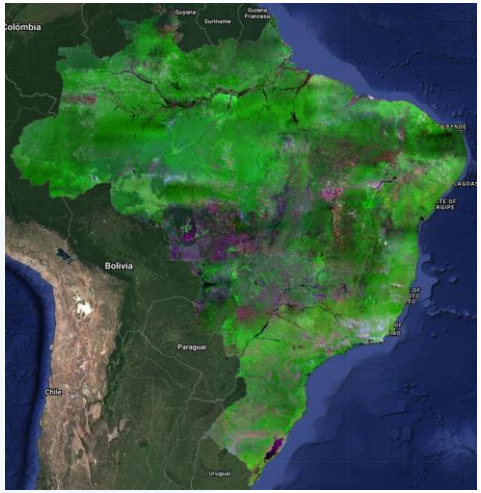
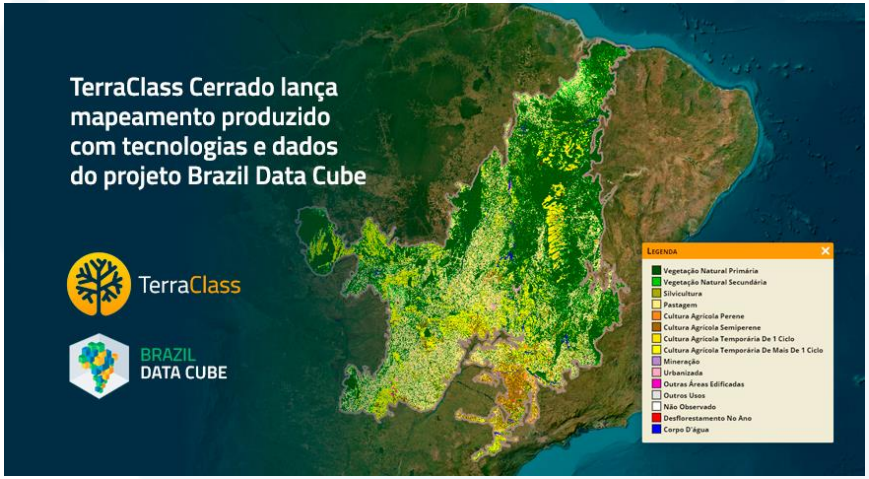


https://e-sensing.github.io/sitsbook/

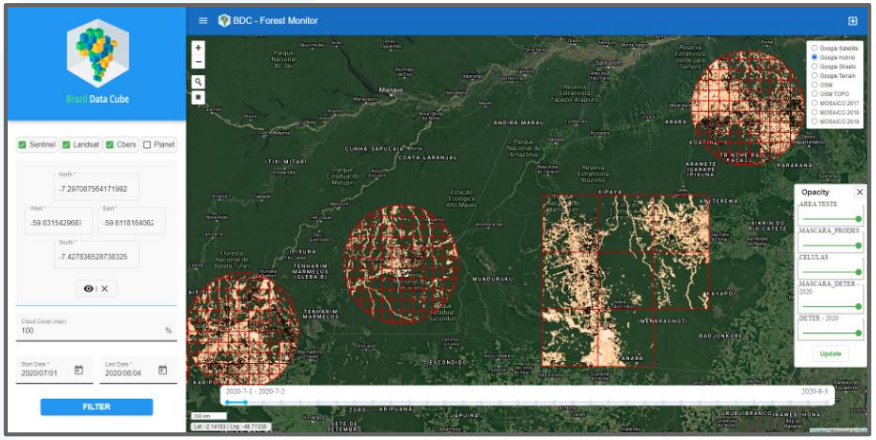


Mosaics – selection of the best pixels (free of clouds or cloud shadow) for periods.



Forest Monitor - **DETER Intenso**

Service to visualize big Earth observation data on AWS



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Muito obrigado!

Contato

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Coordenação-Geral de Observação da Terra – CGOBT
www.inpe.br

#EUSpace

Drones in agriculture

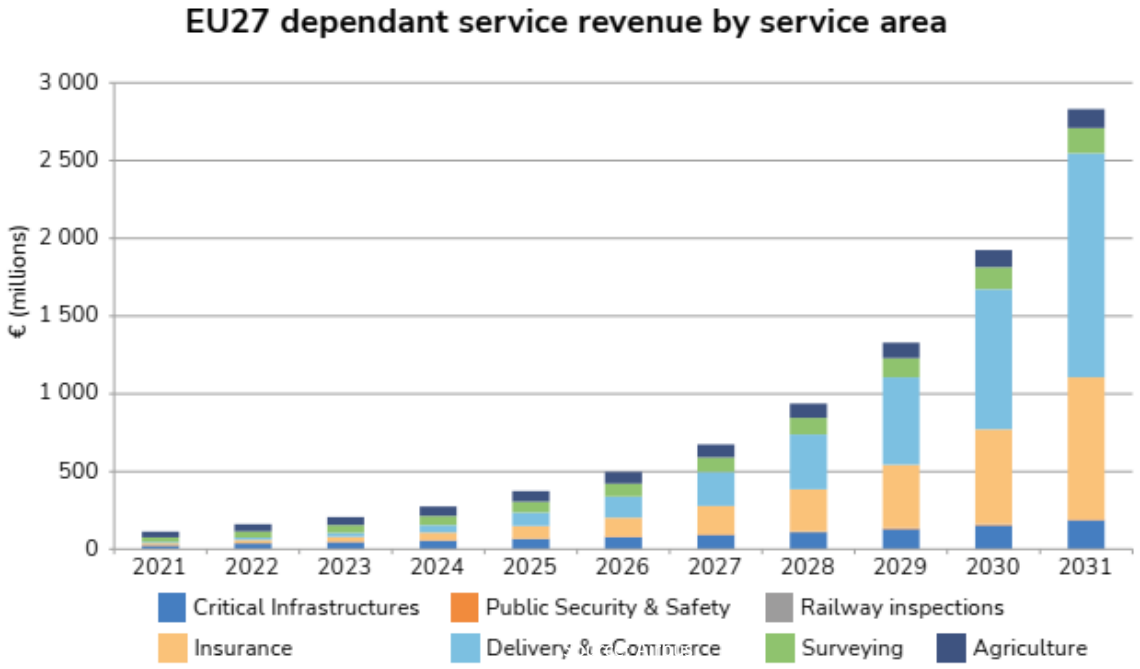
14 September 2023, Brasilia

Harvesting from Space: EU Space Programme Benefits for Agriculture in Brazil

Stefan Schneider, Space Downstream Entrepreneurship Officer

EUSPA
European Union Agency for the Space Programme

Drone technology is enabling a booming market in many domains, with agriculture projected to grow strongly



- **Delivery & eCommerce** is set to become the **largest market** by 2030
- **EGNSS** is essential for new applications demanding high navigation performances
- The majority of drone receiver models are **Galileo/EGNOS capable**

DRONES for AGRICULTURE

- The agriculture drone market is estimated at 4.5 billion USD in 2023 and is projected to grow at a **CAGR of 31.5%** by 2028 ($ 17.9 B)*
- The usage of drone technology in agriculture will be steadily growing in the EU in the next years. The other regions will follow a similar pattern
- A widespread usage of drones is expected at both large and small farms, ranging from scouting to enhancing security measures

* source: https://www.marketsandmarkets.com/Market-Reports/agriculture-drones-market-23709764.html

Drone Tech transforming agriculture

Why drones for agriculture?

Enabling Precision Farming
Cost Efficiency
Time Savings
Enhanced Crop Management
Improved Resource Allocation
Environmental Benefit
Increased Yield
Risk Mitigation
Livestock Monitoring
Security
Data Analytics
Remote Accessibility
Scalability
Decisions per individual plant
(as opposed to per area)

Drones used in agriculture are equipped with various types of sensors

RGB cameras

Visual inspection of crops (plant accounting, weed detection…)
Aerial mapping

Multispectral and hyperspectral cameras

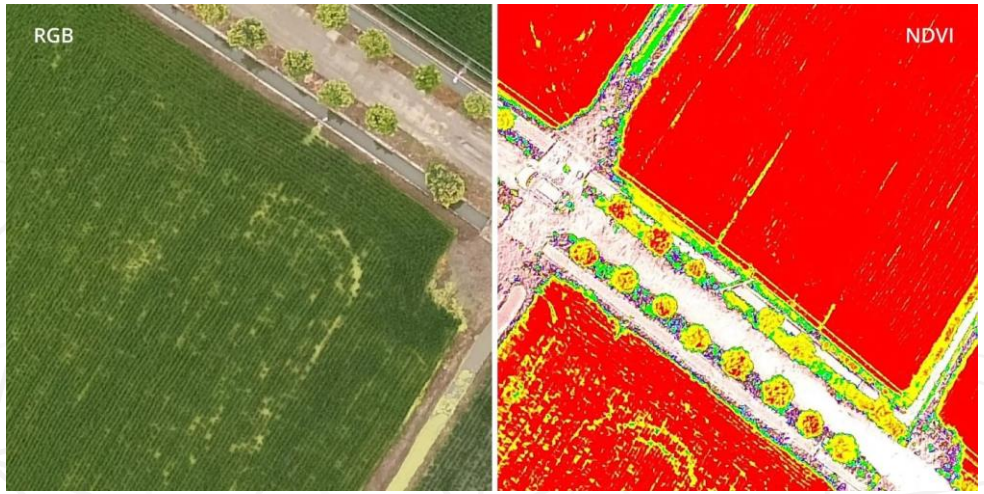
They can detect variations in crop health, identify diseases, assess nutrient levels in plants, water quality, etc.

Thermal cameras

They can capture heat signatures, allowing farmers to identify temperature variations in fields. This is valuable for detecting stress in crops, irrigation issues, and even livestock monitoring

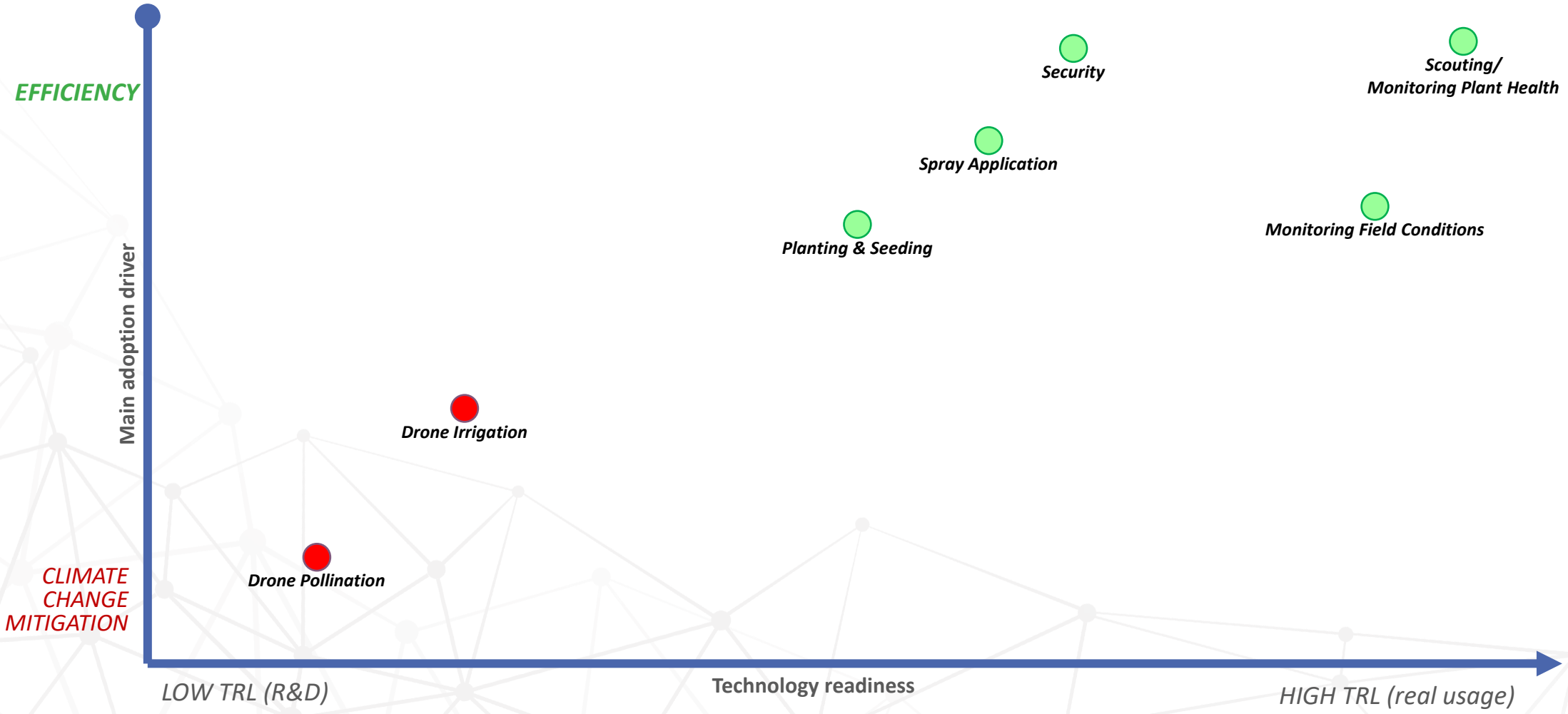
LIDAR

Create highly accurate 3D models of terrain and objects. In agriculture, LiDAR can be used to create detailed topographic maps for precision farming applications



*Microwave imaging systems have also attracted the attention. Compared with visible light and infrared imaging systems, microwave imaging is not susceptible to weather

Efficiency and the capability to mitigate climate change effects are the main adoption drivers



Scouting/Monitoring Plant Health

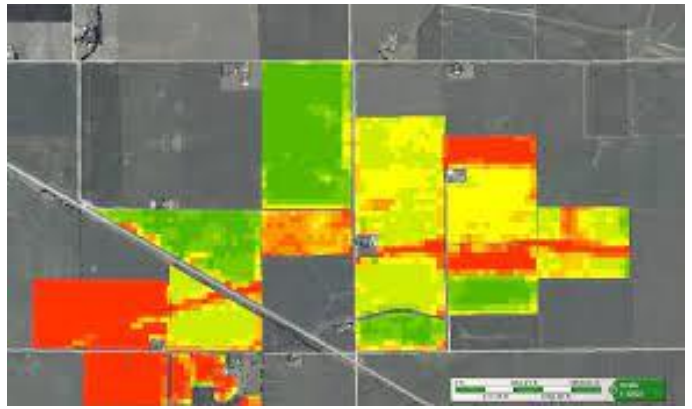
EFFICIENCY

Main adoption driver

CLIMATE CHANGE MITIGATION

Scouting/ Monitoring Plant Health

- Drones equipped with special imaging equipment (i.e. Normalized Difference Vegetation Index) use detailed colour information to indicate plant health
- Farmers can monitor crops as they grow so that any occurring problem can be fixed quickly
- It represents one of the most widespread usage of drones in agriculture



LOW TRL (R&D)

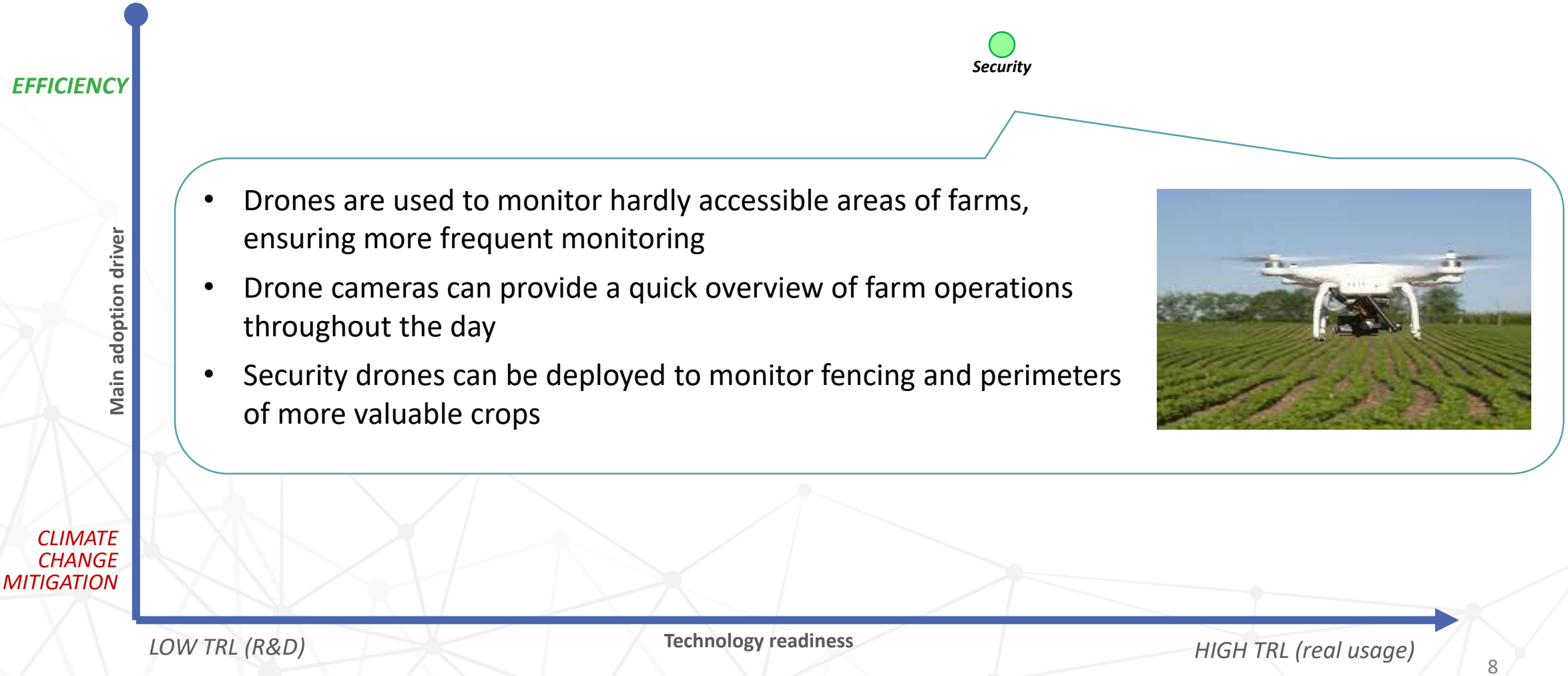
Technology readiness

HIGH TRL (real usage)

Monitoring Field Conditions

- Drones quickly provide accurate field mapping
- Such information is then used to determine drainage patterns and wet/dry spots, representing a key enabled of precision farming

Security



- Drones are used to monitor hardly accessible areas of farms, ensuring more frequent monitoring
- Drone cameras can provide a quick overview of farm operations throughout the day
- Security drones can be deployed to monitor fencing and perimeters of more valuable crops

Spray Application

EFFICIENCY

Main adoption driver

CLIMATE CHANGE MITIGATION

Spray Application

- Crop spraying drones can carry large liquid storage reservoirs
- Way more efficient than crop dusters, they ensuring safety (e.g. easy access to remote locations and precise targets, while avoiding workers exposure to hazardous liquids)
- Already widespread usage in south-east Asia, (e.g. Japan aSouth Korea)
- Still not legal everywhere due to the need to understand the impact of spray drift

LOW TRL (R&D)

Technology readiness

HIGH TRL (real usage)

Planting & Seeding

EFFICIENCY

Main adoption driver

CLIMATE CHANGE MITIGATION

Planting & Seeding

- Mostly used in forestry, they allow the access to remote areas without endangering workers
- Drones can be extremely more efficient than manual work and finally ensure quick reforestation

LOW TRL (R&D)

Technology readiness

HIGH TRL (real usage)

Drone Irrigation

- Using microwave sensing, drones are able to capture very accurate soil health information including moisture levels without the plants getting in the way
- This allows water to be distributed in the field a really efficient way, enabling precise irrigation

Drone Pollination

- Miniature drones are being used to pollinate crops as part of research looking at alternatives to honey bee pollination
- Research and tests are being carried out in the Netherland, Japan and Australia

Pros and cons of using drones in agriculture

Enabling Precision Agriculture

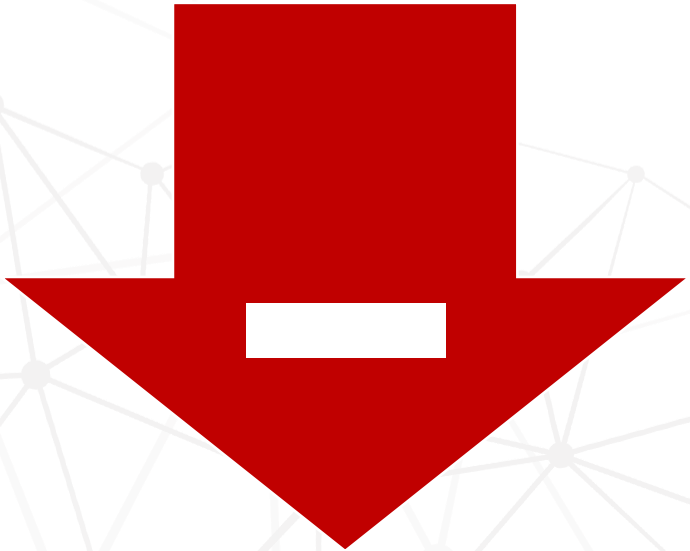
Efficiency

Cost-Effective

Safety

Environmental Benefits

Data Analytics



Initial Investment

Regulations

Limited Payload Capacity

Weather Dependency

Data Management

Battery Life

Skill and Training (license)

EGNOS and Galileo differentiators support drone operations and implementation of U-Space

Availability

PVT available in challenging environments

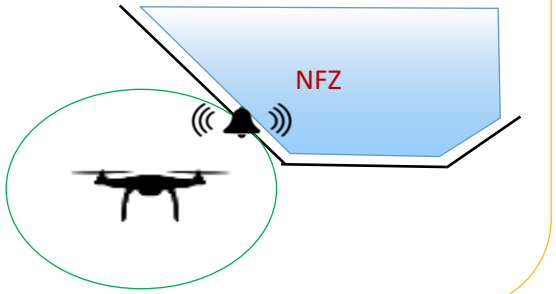
Integrity

Reliable PVT performance for the intended operation

- performance monitoring and alerting -

Detect and Avoid

Geo-fencing/caging

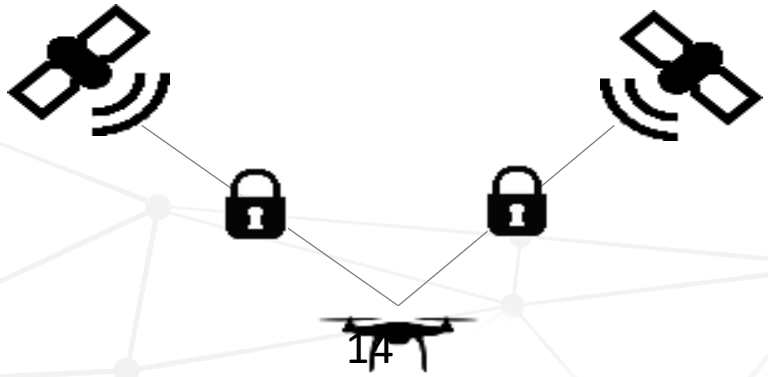


Accuracy

Unprecedented high accuracy for demanding applications also in the vertical axis, supporting integration in the airspace

Authentication

Embedded cybersecurity features



Copernicus contribution to drones operations

Pre-flight risk assessment for specific category

(e.g. beyond visual line of sight)

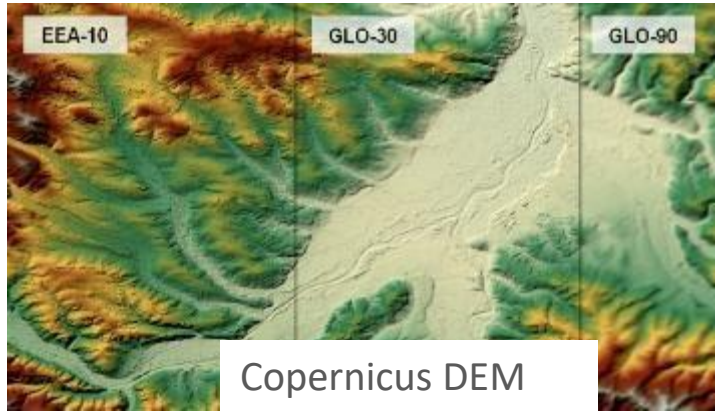
Copernicus human settlement layer (population density) can be used to assess how many people are exposed to risk from the drone

Copernicus DEM for flight planning

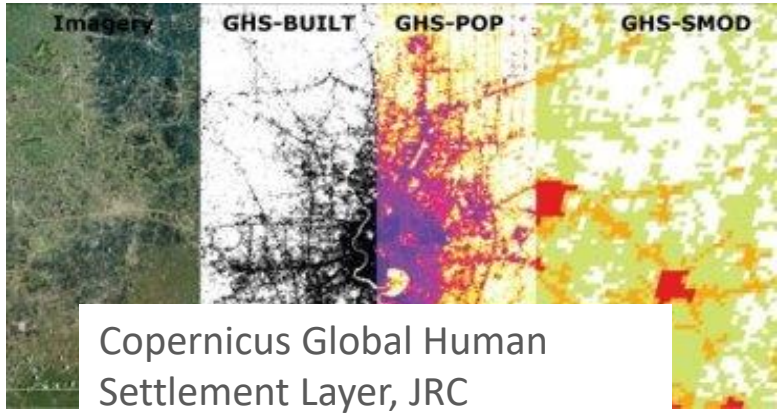
Relevant for flight planning in missions where terrain following is important
(limited resolution for the global product)

Tip and cue approach

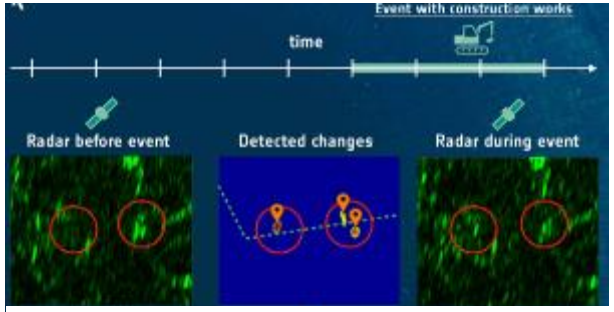
Copernicus-based large scale monitoring is used to trigger/prioritize more detailed surveys



Copernicus DEM



Copernicus Global Human Settlement Layer, JRC



Copernicus SAR change detection to trigger drone survey

EGNOS and Galileo differentiators support drone operations and implementation of U-Space

Availability

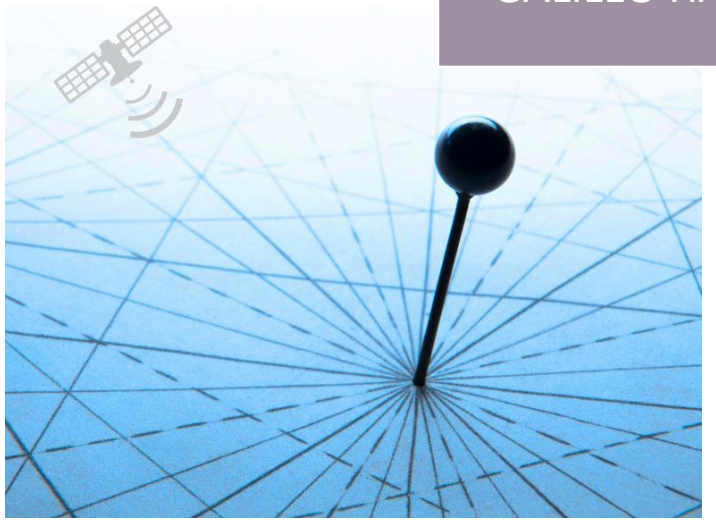
PVT available in challenging environments

Accuracy

Unprecedented high accuracy for demanding applications also in the vertical axis, supporting integration in the airspace

New Galileo service

GALILEO HAS



Delivers global high accuracy service

< 20 cm

Freely accessible

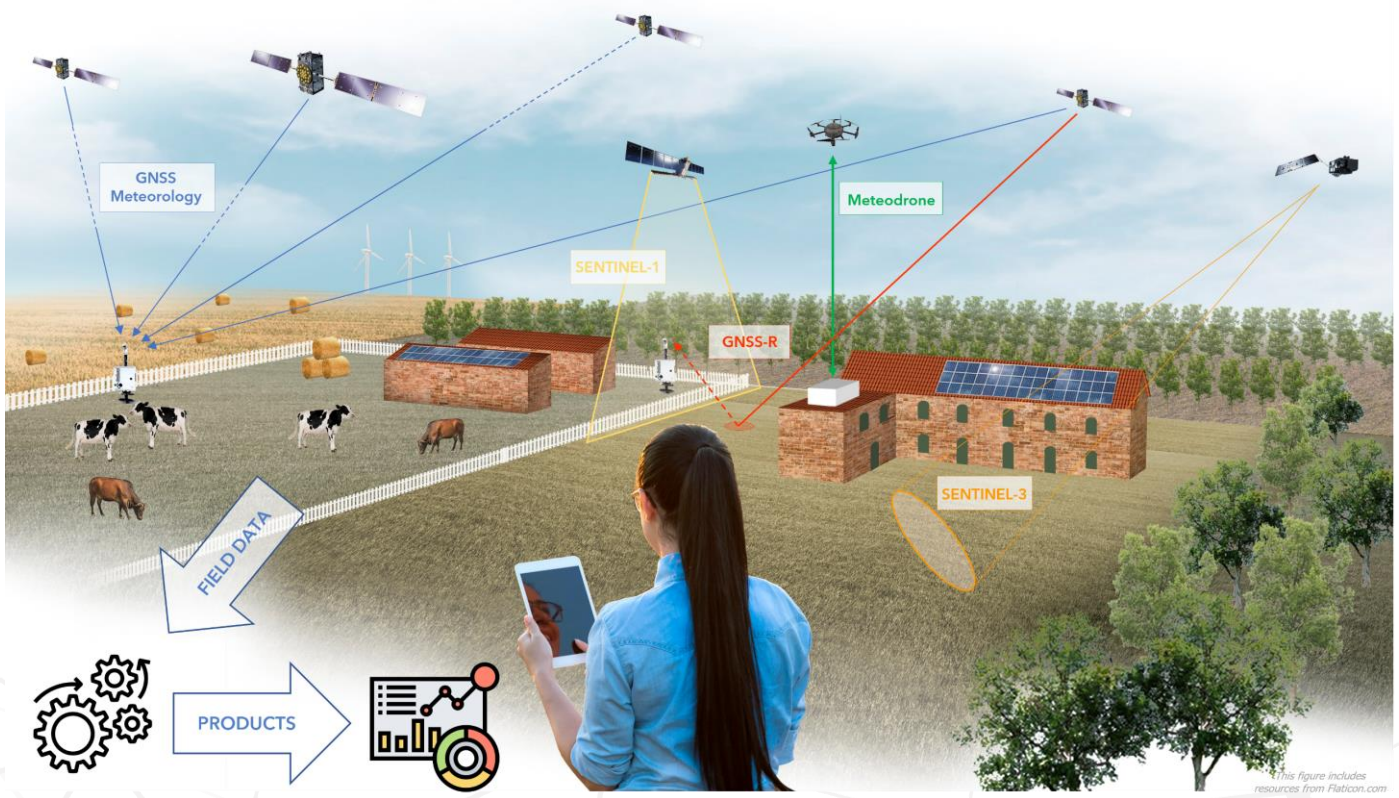
No need for internet connection

European GNSS and Copernicus is powering cutting-edge and innovative solutions – from R&D to the market

MAGDA

METEOROLOGICAL ASSIMILATION FROM GALILEO and DRONES for AGRICULTURE

The MAGDA project aims at developing a toolchain for atmosphere monitoring, weather forecasting, and severe weather/irrigation/crop monitoring advisory, with GNSS (including Galileo) at its core, to provide useful information to agricultural operators



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