



UNIVERSITÀ
DEGLI STUDI
FIRENZE



POLITÉCNICA

u é v o r a
UNIVERSITY OF EVORA

ERREQUADRO
Research and Practice



CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

ValueD

MAZZEI
1435

REZOS
BRANDS
Delivering Value



Satellite Imagery for SPA

Area 2 – Technologies

Lesson 5 – Remote Sensing

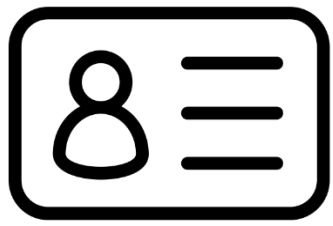
Sequence ID – 17

Agrosap



Co-funded by the
Erasmus+ Programme
of the European Union

The European Commission support for the production of this publication does not constitute endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.



Our team of experts



Manuel Pérez
Universidad de Sevilla



Salvador Correa
Agricultural Engineer and
MBA
Director & Sales
Manager



Francisco López
Technician
Administration,
logistics &
Communications



Alberto Jardúo
Technical Agricultural Engineer
Senior Installer; Ag Software
Autopilot & flow controls
Info Management & SIS
Water management & IQ



Juan Jesús Acosta
Technician
Senior Installer



Juan Carlos García
Technician
Junior Installer



Jorge Martínez
Ph. D Agricultural Engineer
Data Management
R&D department
UAVs & Imagery



Juan Agüera
Universidad de Córdoba
Ph.D Agricultural Engineer
R&D Managers
Precision farming
Institutional Relations



Javier Rodríguez
Technical Agricultural
Engineer
Sales & Ag Software



Miguel A. Polo
Technical Agricultural
Engineer
Communication &
Marketing



Pablo Agüera
Technician
Info Management
R&D department
UAVs & Imagery

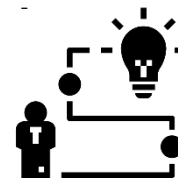


Joao Rucha
Technician
Portugal Sales

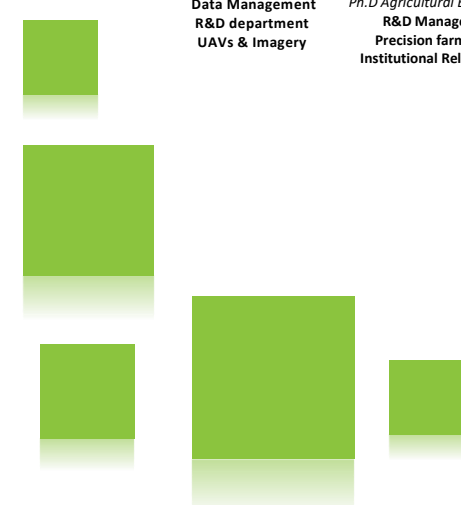
AGROSAP (R&D department)



Passionate about research & digital
skills in agriculture



+12 years experience on PA hardware,
sensors & development





DISCLAIMER

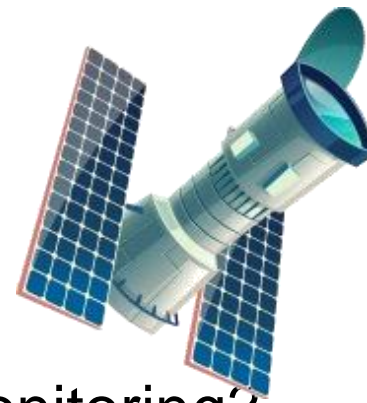
A2.L5.T1 Satellite imagery for SPA

Manuel Perez Ruiz, manuelperez@us.es, Agrosap, Spain, [0000-0002-3681-1572](https://doi.org/10.36253/978-88-5518-044-3.17)

Jorge Martinez Guanter, martinezj@us.es, Agrosap, Spain

Manuel Perez Ruiz, Jorge Martinez Guanter, *Satellite imagery for SPA*, © 2020 Author(s), [CC BY-SA 4.0 International](https://creativecommons.org/licenses/by-sa/4.0/), [DOI 10.36253/978-88-5518-044-3.17](https://doi.org/10.36253/978-88-5518-044-3.17), in Marco Vieri (edited by), *SPARKLE - Entrepreneurship for Sustainable Precision Agriculture*, © 2020 Author(s), [content CC BY-SA 4.0 International](https://creativecommons.org/licenses/by-sa/4.0/), [metadata CCO 1.0 Universal](https://creativecommons.org/licenses/by-sa/4.0/), published by [Firenze University Press](https://www.firenzeuniversitypress.it/), ISSN 2704-6095 (online), eISBN 978-88-5518-042-9, [DOI 10.36253/978-88-5518-044-3](https://doi.org/10.36253/978-88-5518-044-3)

Table of Contents



1. Why to use satellite imagery for crop monitoring?
2. Use of satellite imagery for SPA. Advantages and disadvantages
3. LANDSAT program constellation
 1. Instruments
 2. Bands
 3. Products
4. Sentinel program constellation
 1. Instruments
 2. Bands
 3. Products
5. Where to find free satellite images?
6. Are there other (paid) services?

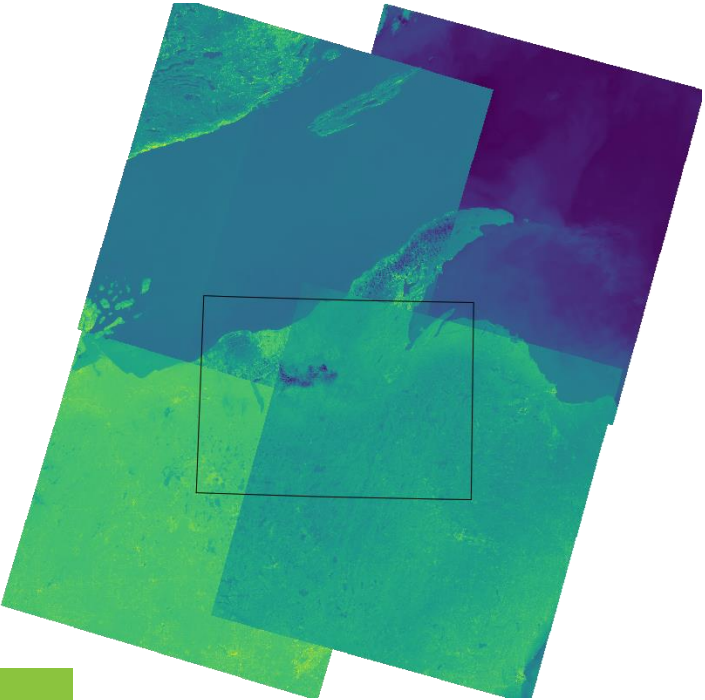


Why to use satellite imagery for crop monitoring?



- Advanced remote management of a large number of hectares
- Allows expert field visits
- Free availability of information at reasonable resolution
- Support tool for technicians
- Simple
- Scalability

Use of satellite imagery for SPA



Advantages

- Covers large areas
- Cost effective
- Time efficient
- Multi-temporal
- Multi-sensor
- Multi-spectral
- Overcomes inaccessibility
- Faster extraction of GIS-ready data

Disadvantages

- Needs ground verification
- Doesn't offer details
- Not the best tool for small areas
- Needs expert system to extract data



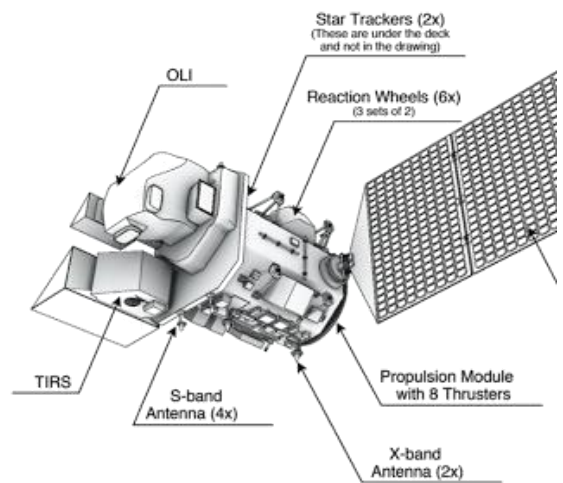


Main Satellite remote sensing platforms

LANDSAT program constellation

Managed by NASA and USGS
 7 missions since 1972
 More than 2 million images

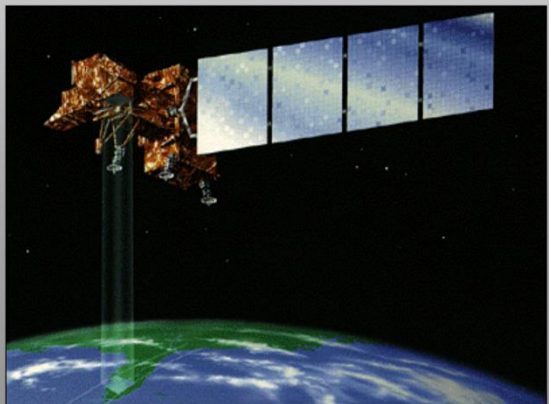
Landsat 1 a 3



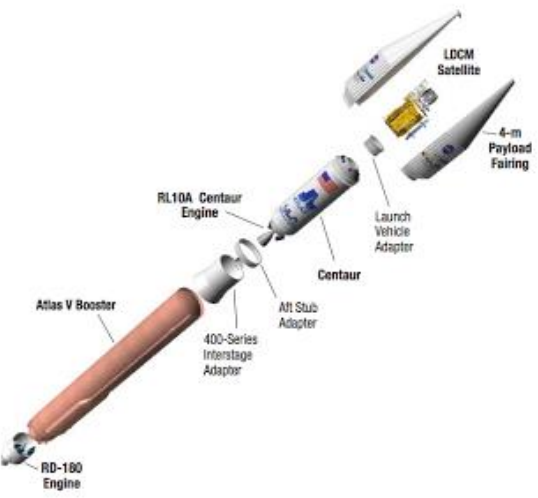
Landsat 8



Landsat 4 y 5



Landsat 7



Did you know that...?

The Landsat 8 was launched by the NASA organisation in 2013 using an Atlas V rocket. This magnificent rocket has a height of 58.3 m and has an impressive weight of 546 700 kg.

Landsat 8 Instruments



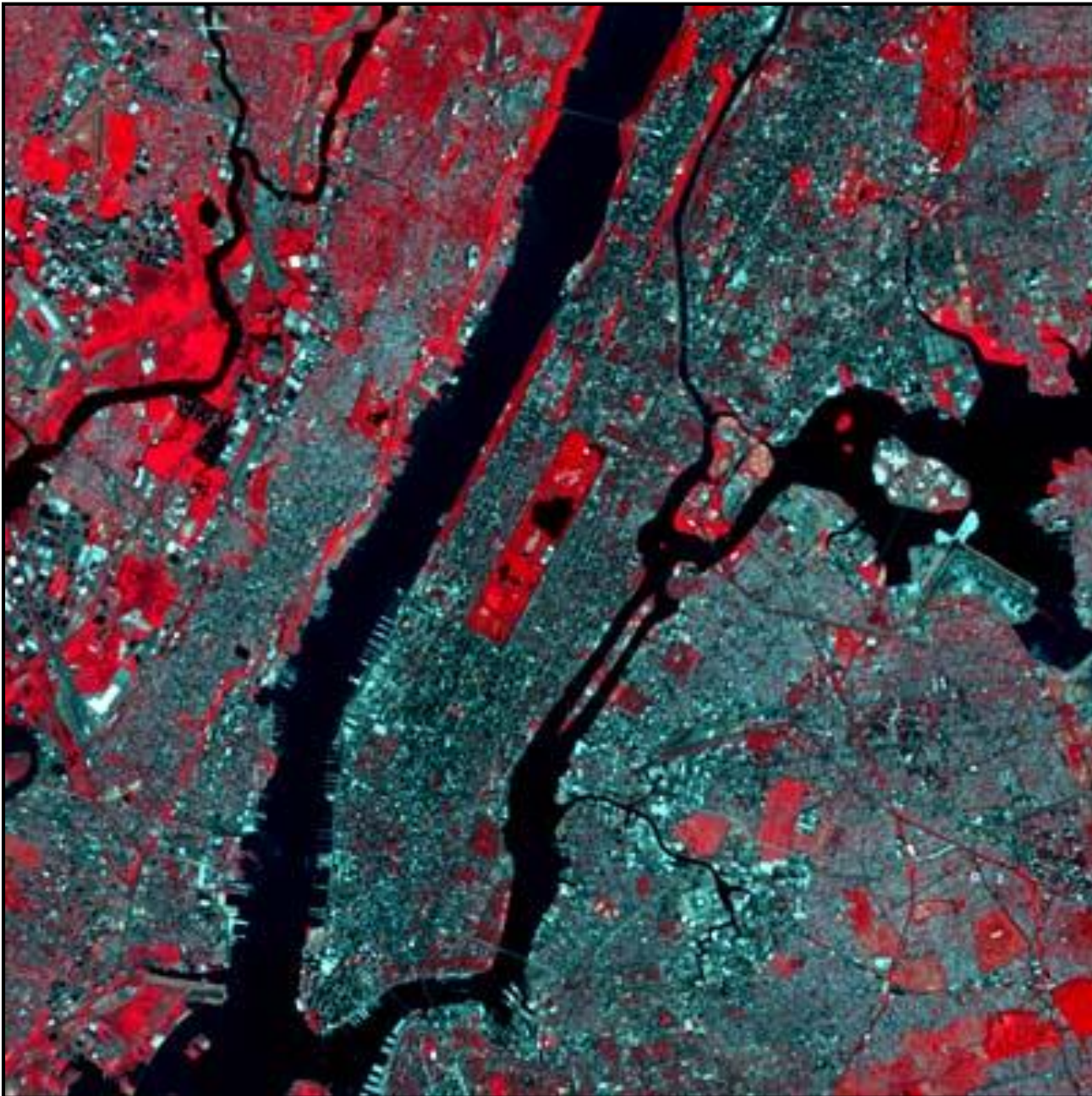
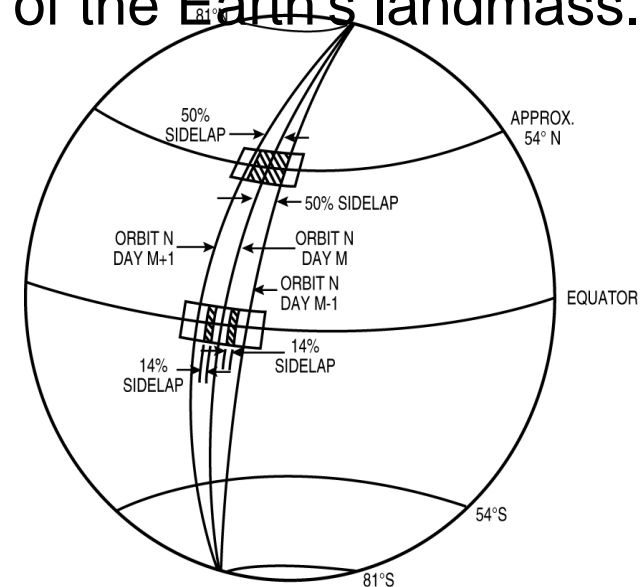
OLI (Operational Land Imager):
Is a camera for observing the Earth at eight visible and near-infrared wavelengths. It has a resolution of 15 meters in panchromatic mode and 30 meters in multispectral mode.



TIRS (Thermal Infrared Sensor):
Is an infrared camera to measure and quantify the management of water resources in agriculture. It has a resolution of 100 meters and the images obtained have a width of 185 kilometers.



- **Mission Continuity:** Landsat 8- latest in long history of land remote sensing spacecraft, spanning 40 years of multispectral imaging.
- **Global Mission:** data acquired systematically to build and periodically refresh a global archive of sun-lit, substantially cloud-free images of the Earth's landmass.



Landsat 8 bands

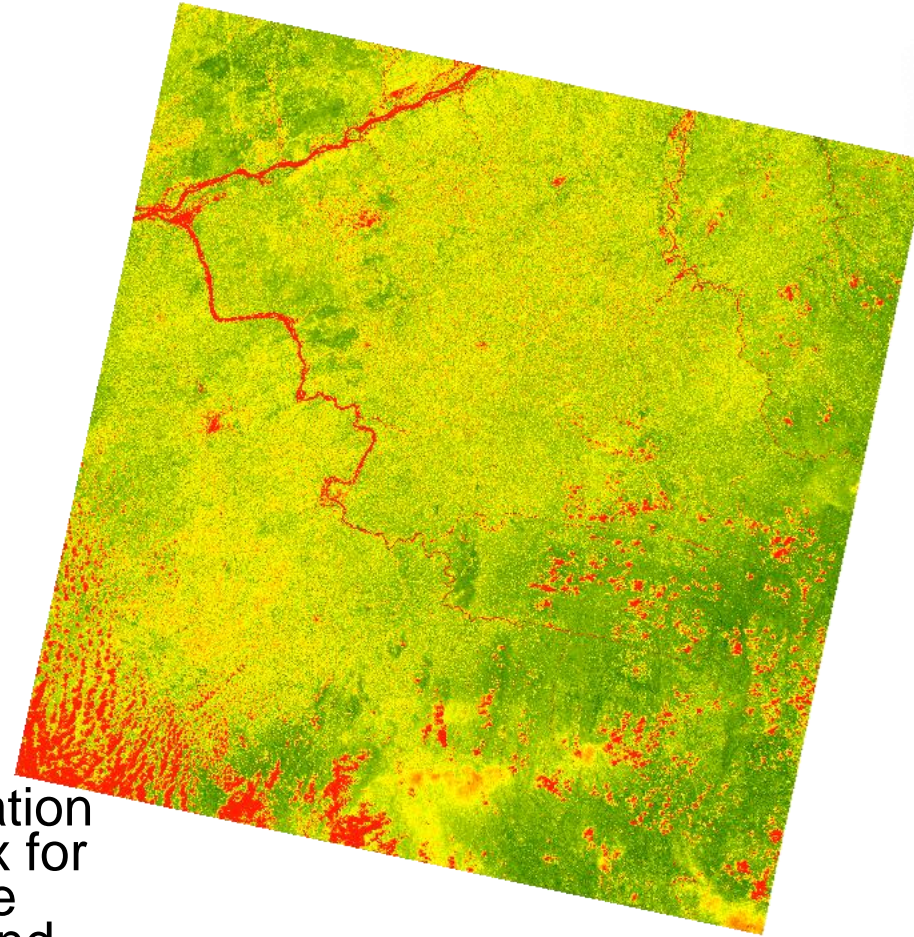
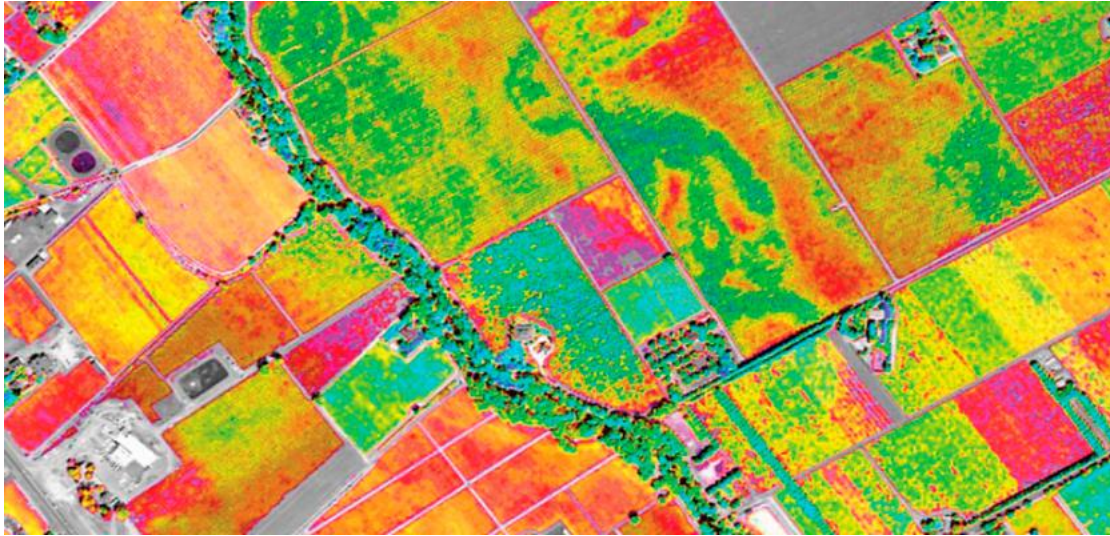


Landsat 8 Operational Land Image (OLI) and Thermal Infrared Sensor (TIRS)

Band	Wavelength	Useful for mapping
Band 1 - coastal aerosol	0.43-0.45	Coastal and aerosol studies
Band 2 - blue	0.45-0.51	Bathymetric mapping, distinguishing soil from vegetation and deciduous from coniferous vegetation
Band 3 - green	0.53-0.59	Emphasizes peak vegetation, which is useful for assessing plant vigor
Band 4 - red	0.64-0.67	Discriminates vegetation slopes
Band 5 - Near Infrared (NIR)	0.85-0.88	Emphasizes biomass content and shorelines
Band 6 - Short-wave Infrared (SWIR) 1	1.57-1.65	Discriminates moisture content of soil and vegetation; penetrates thin clouds
Band 7 - Short-wave Infrared (SWIR) 2	2.11-2.29	Improved moisture content of soil and vegetation; penetrates thin clouds
Band 8 - Panchromatic	0.50-0.68	15 meter resolution, sharper image definition
Band 9 - Cirrus	1.36-1.38	Improved detection of cirrus cloud contamination
Band 10 - TIRS 1	10.60-11.19	100 meter resolution, thermal mapping and estimated soil moisture
Band 11 - TIRS 2	11.50-12.51	100 meter resolution, improved thermal mapping and estimated soil moisture

*Wavelength unit = μm

Landsat 8 products

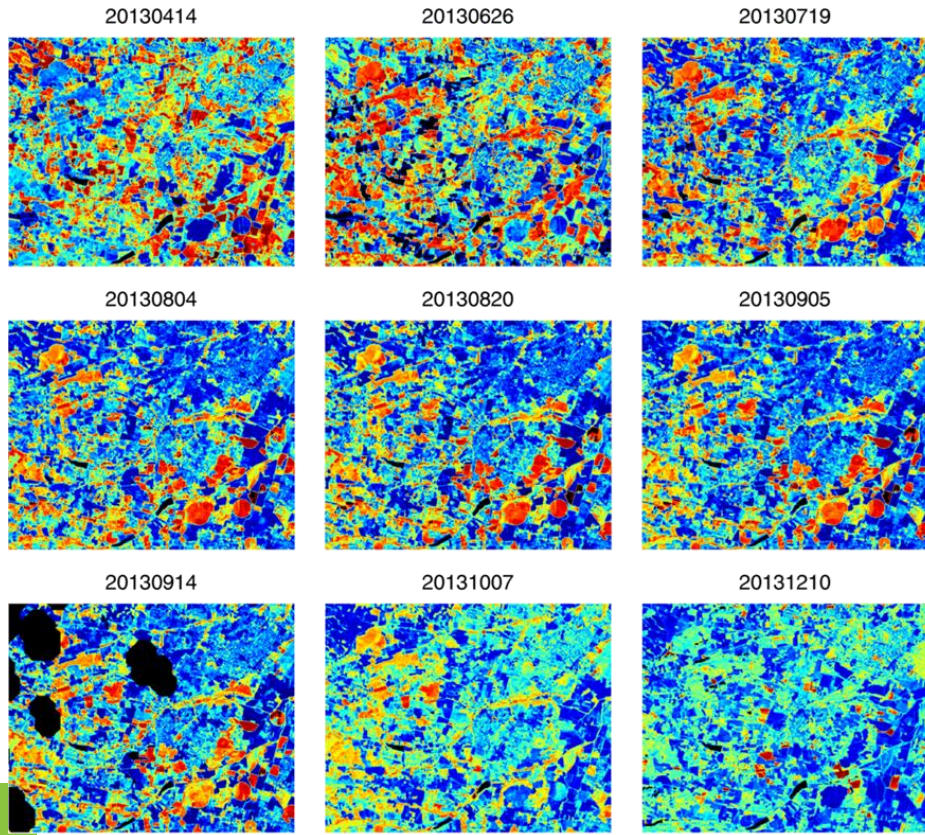


NDWI and NDVI indexes

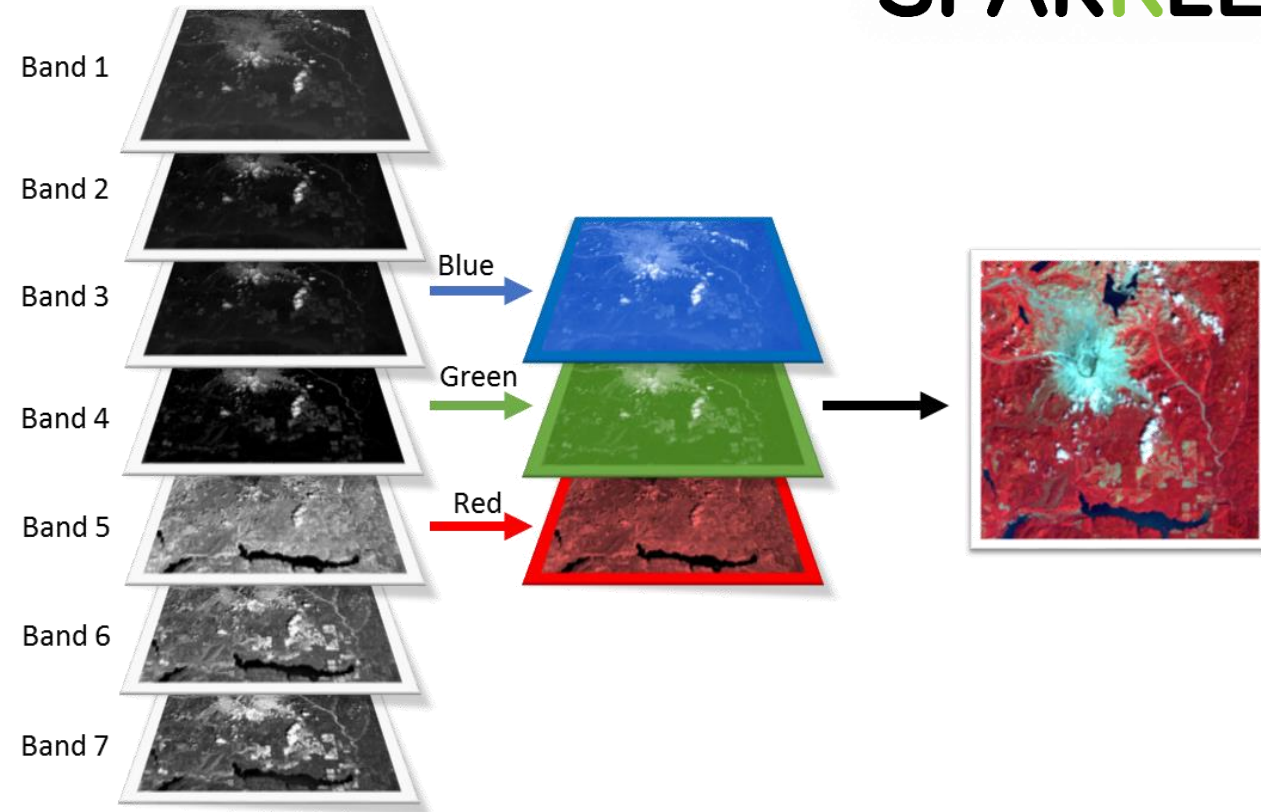
The NDVI (Normalized Difference Vegetation Index) is a very versatile vegetation index for vegetation assessment and cover change dynamics. This index has been studied and evaluated with a series of satellites for many years, changing its method of calculation with respect to the number and type of satellite bands.

$$NDVI = \frac{NIR - R}{NIR + R}$$

Landsat 8 products



Fractional Vegetation Cover



Panchromatic composition based on bands combination

DIFFERENTIAL MANAGEMENT AREAS

More info: <https://bit.ly/3aVky6Q>



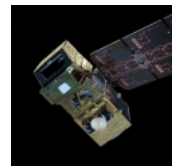
Main Satellite remote sensing platforms Sentinel program constellation

Managed by the European Union together with the European Space Agency (ESA)

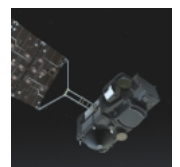
6 Sentinel missions



SENTINEL-1
With the objectives of Land and Ocean monitoring. A RADAR imaging instrument is mounted on it.



SENTINEL-2
For land monitoring, with High Resolution optical Instruments for imagery. Sentinel 2 A and B.



SENTINEL-3
For marine observation and sea-surface study. With a radar altimeter and optical imagers



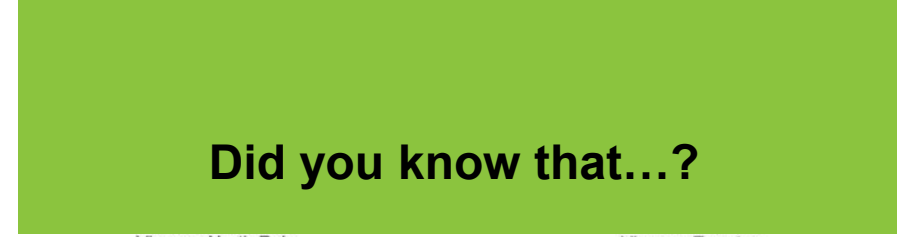
SENTINEL-4
For air-quality monitoring
Mounting an UVN spectrometer.



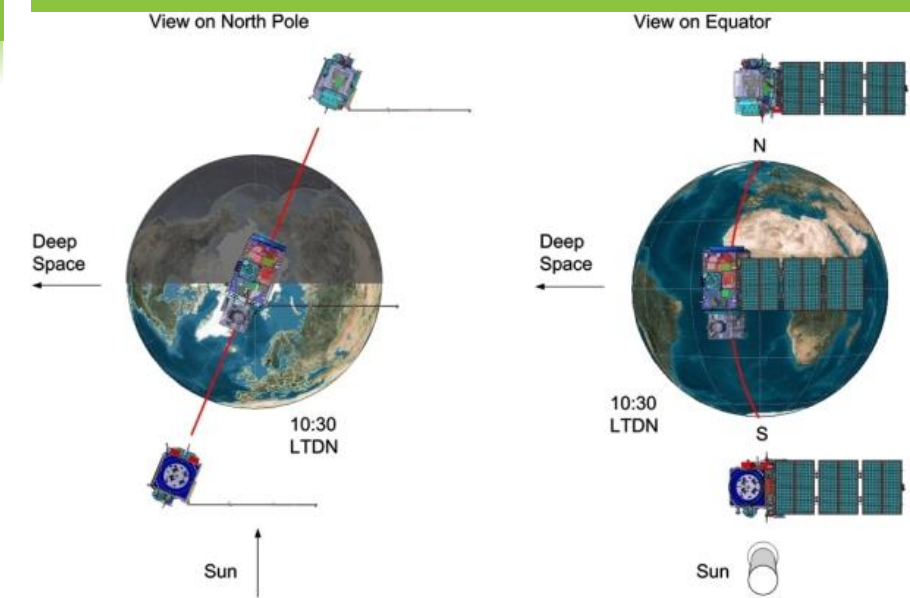
SENTINEL-5
For air-quality monitoring
Mounting a second generation UVNS spectrometer.



SENTINEL-5P
Atmospheric measurements relating to air quality, climate forcing
Ozone and UV radiation



Did you know that...?



Two identical SENTINEL-2 satellites operate simultaneously, phased at 180° to each other, in a sun-synchronous orbit at a mean altitude of 786 km. The position of each SENTINEL-2 satellite in its orbit is measured by a dual-frequency Global Navigation Satellite System (GNSS) receiver.



Main Satellite remote sensing platforms

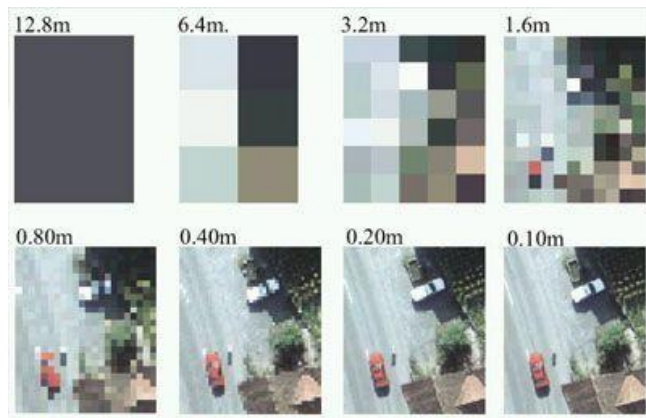
Sentinel program constellation

Sentinel 2 mission

Free images with:

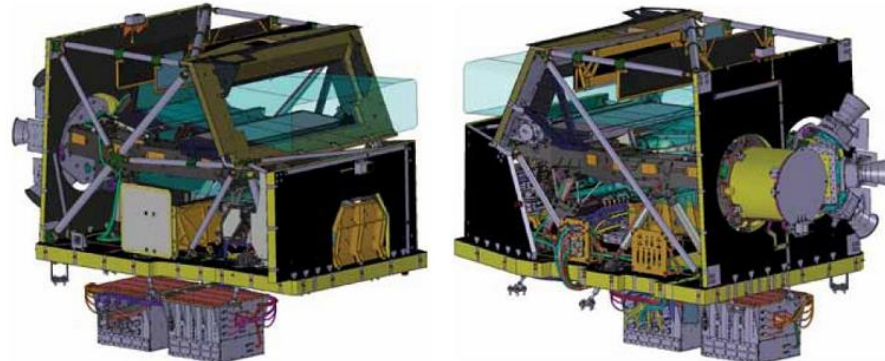
Temporal resolution: 4/5 days

Spatial resolution: 10 m



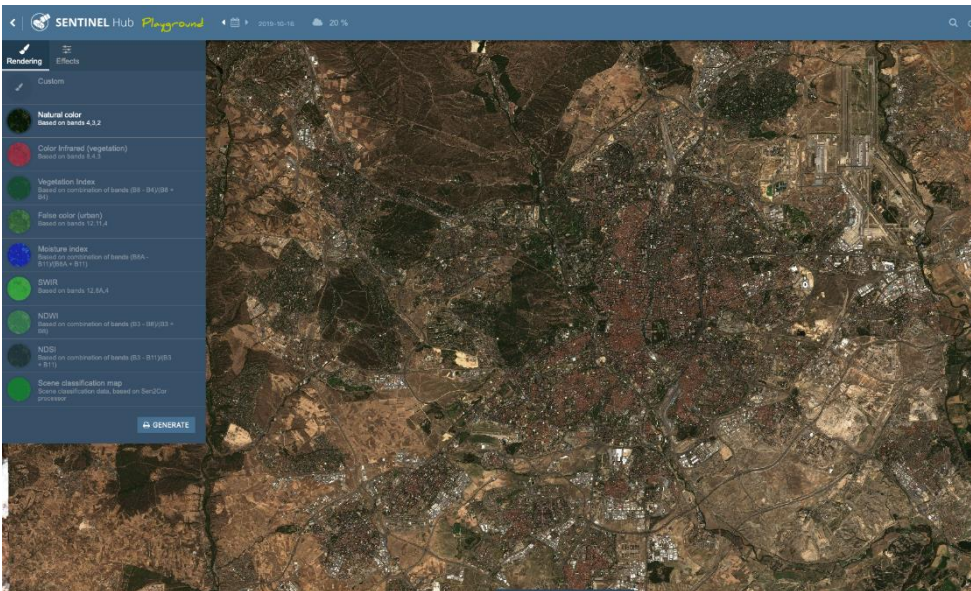
Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

Did you know that...?

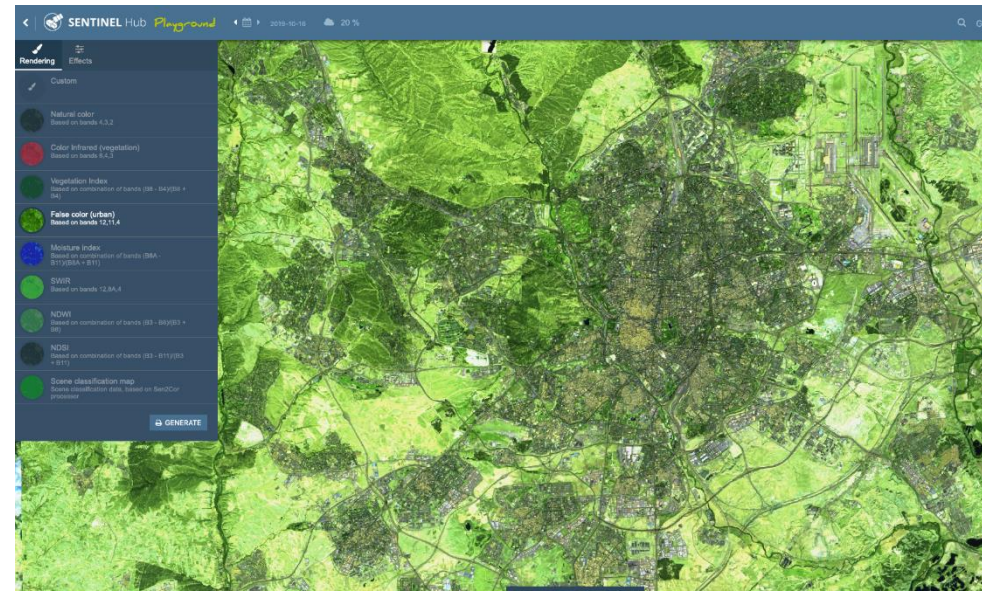


The MultiSpectral Instrument on board the Sentinel 2 satellites weighs 230 Kg and has a power consumption of 200W when it is in Imaging mode.

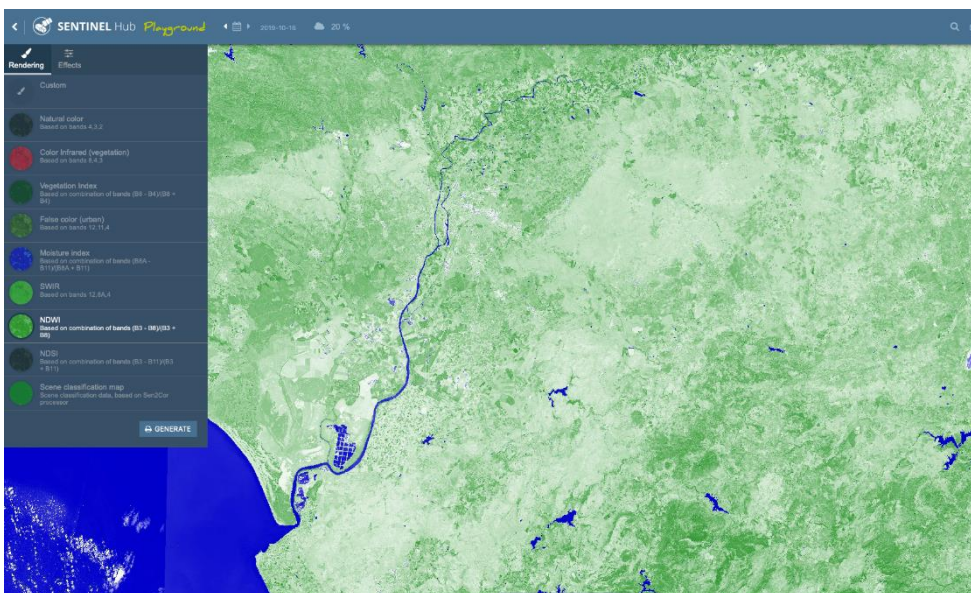
The MSI measures the Earth's reflected radiance in 13 spectral bands from VNIR to SWIR



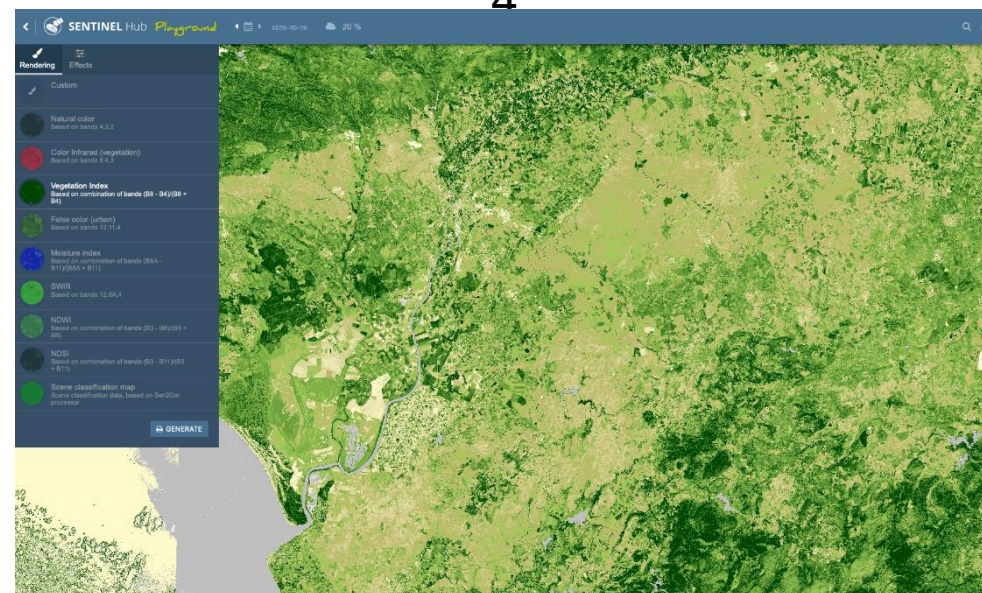
Natural RGB Colour. Bands 4, 3, 2



False Colour for urban areas. Bands 12, 11, 4



Normalized Difference Water Index (NDWI)
 $(B3-B8)/(B3+B8)$



Normalized Difference Vegetation Index (NDVI)

Band Combination

Spectral Indices

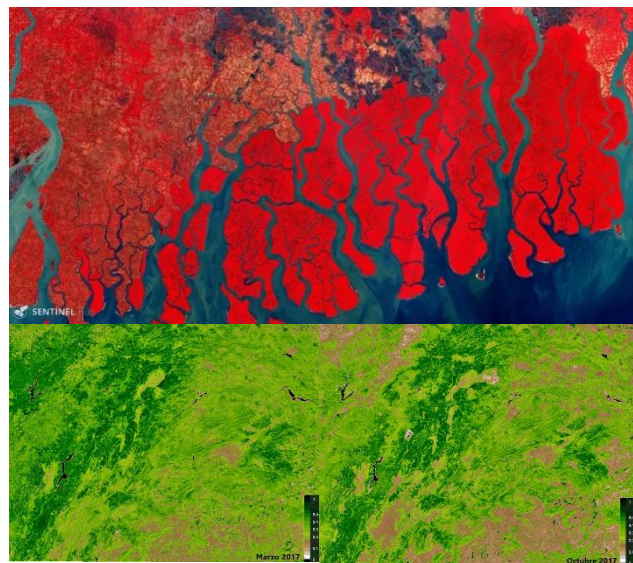


Multi-spectral remote sensing from satellites is linked to crop growth and condition through such canopy parameters as the leaf area index (LAI), which measures two basic physiological processes, photosynthesis and evapotranspiration, most dependent on solar radiation.

Measurements from Remote Sensing data:

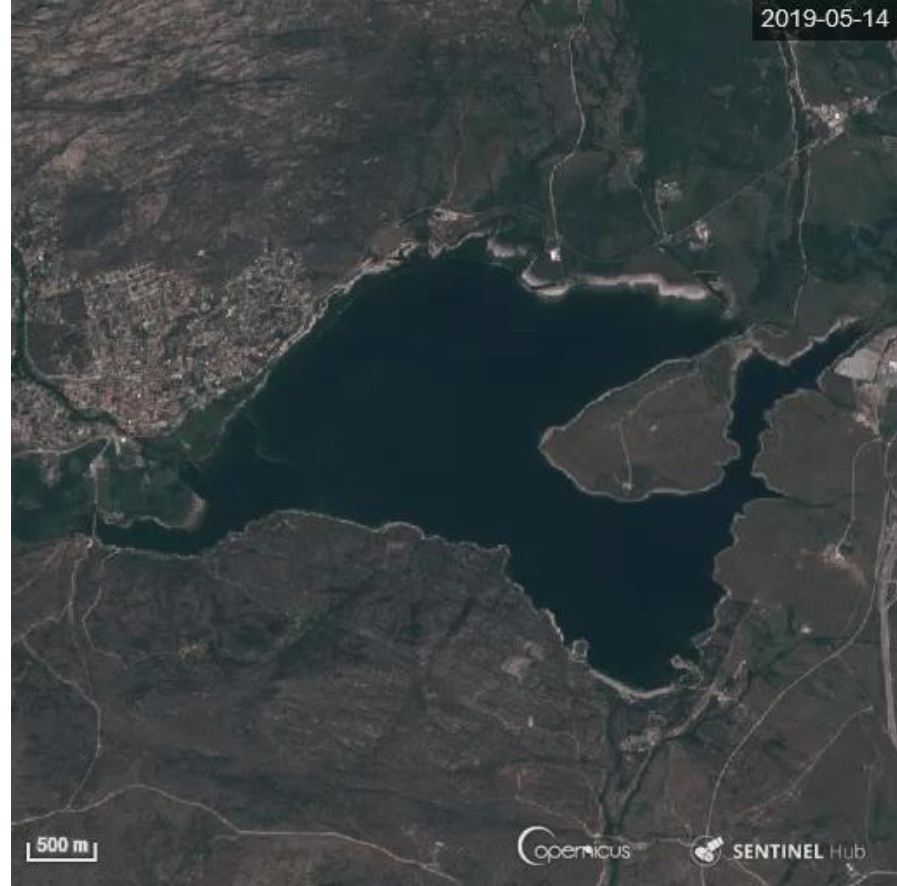
- surface soil properties
- nitrogen content
- water stress
- vegetation cover
- above ground biomass
- crop species
- crop height
- crop yield
- weed extent



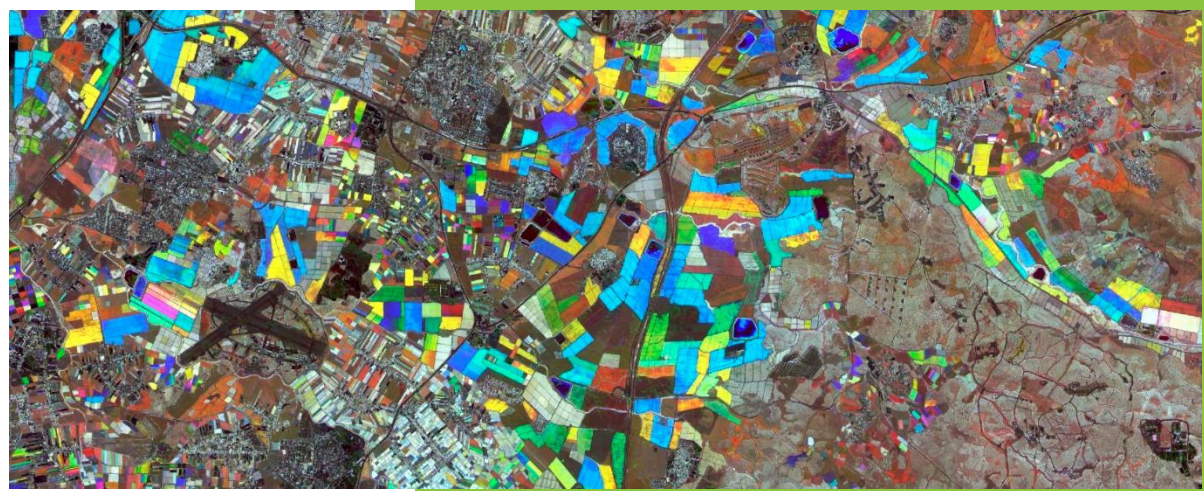


earth observation

earth observation & hydrological evolution



Crop monitoring through spectral indexes





Where to find free satellite images?

For Sentinel Images:

<https://scihub.copernicus.eu/dhus/#/home>

For Landsat Images:

<https://landsatapp.s3-website-us-west-2.amazonaws.com/>

Google Earth Engine: earthengine.google.com





Are there other (paid) services?

Yes, there are on-demand satellite imagery services with much higher spatial resolutions than the free Sentinel and Landsat services.

- RAPIDEYE offers 5 meters resolution imagery with 1 day temporal resolution.
- DigitalGlobe with the WorldView3 and 4 offers up to 0.5 m of spatial resolution.
- SPOT constellation offers 1.5 m color images and 6 m multispectral imagery.
- Hexagon Geosystems offer 30 cm resolution imagery in USA and EU and 15 cm in USA cities