

Remote Sensing Data showing Climate Change Consequences



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Presentation supported by Miroslav Havranek and Natalia Kobliuk

Aims of the workshop

- to motivate teachers and students to use remote sensing data and applications in GLOBE research and studying
- to show opportunities to observe and evaluate climate change using open remote sensing data
- to present hands-on applications implemented into GLOBE



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Charles University, Faculty of Science, Prague

The Department of Applied Geoinformatics and Cartography

Research and Education in the fields of:

- GIS a geodatabases
- Remote sensing and photogrammetry
- Cartography
- Computational geometry, algorithm development & programming
- Geodetic and surveying methods of data collection

EO4Landscape research team

eo4landscape.natur.cuni.cz

EO4Landscape



- Earth Observation (EO)**

Advanced classification methods using remote sensing data, Time Series, Normalization methods of remote sensing data, Big Data, Cloud computing and satellite data - Google Earth Engine, Sentinel Hub

- Land Use/Land Cover (LUCC)**

Long-term Land Use/Land Cover Change, Driving forces of LUCC,

- 3D**

Vizualization of the dynamic landscape changes in 3D,

- Web GIS technologies and maps services**

vizualization of landscape changes, in-situ data colection

- Capacity building and education in GIS and EO**

<https://www.linkedin.com/company/eo4landscape-research-group>

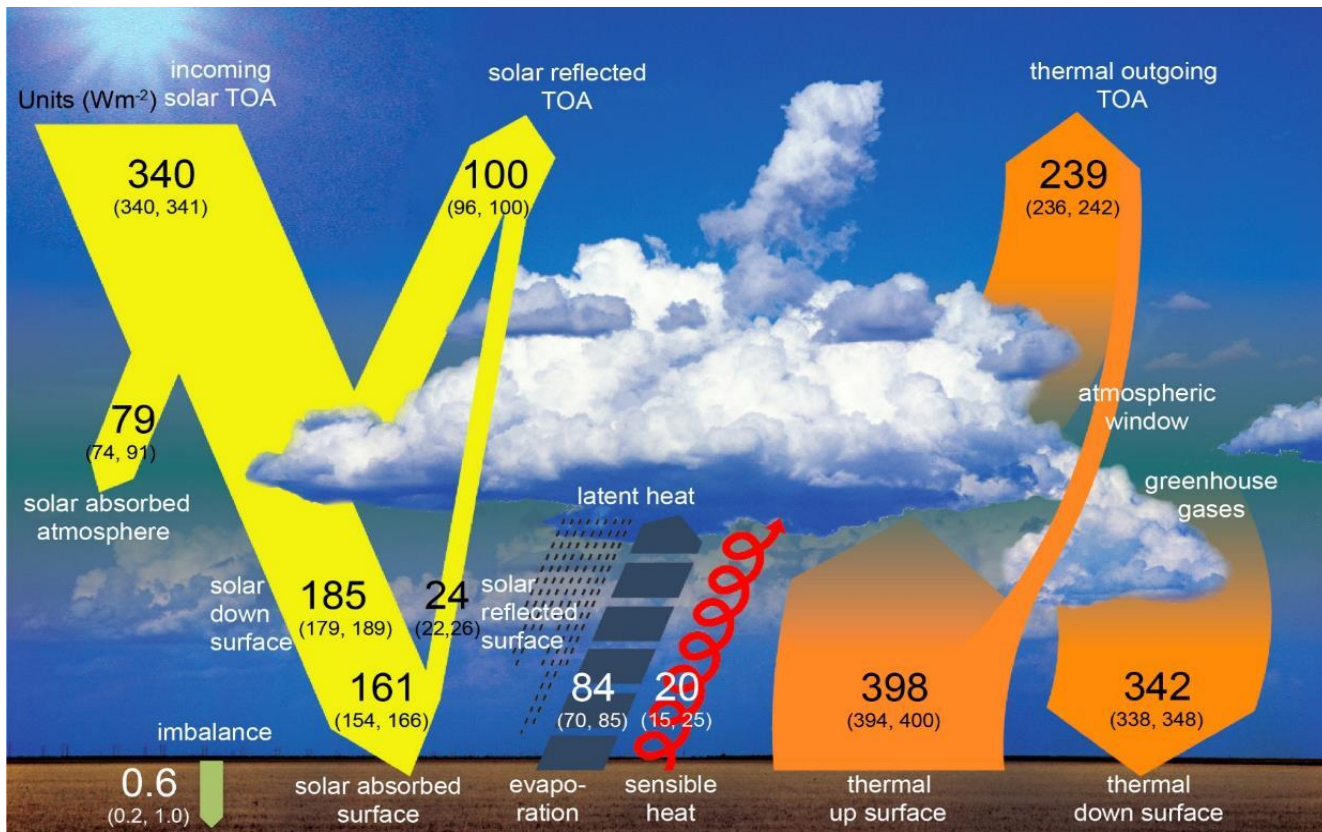
What is Remote Sensing?



Remote Sensing is studying the objects without touching them.

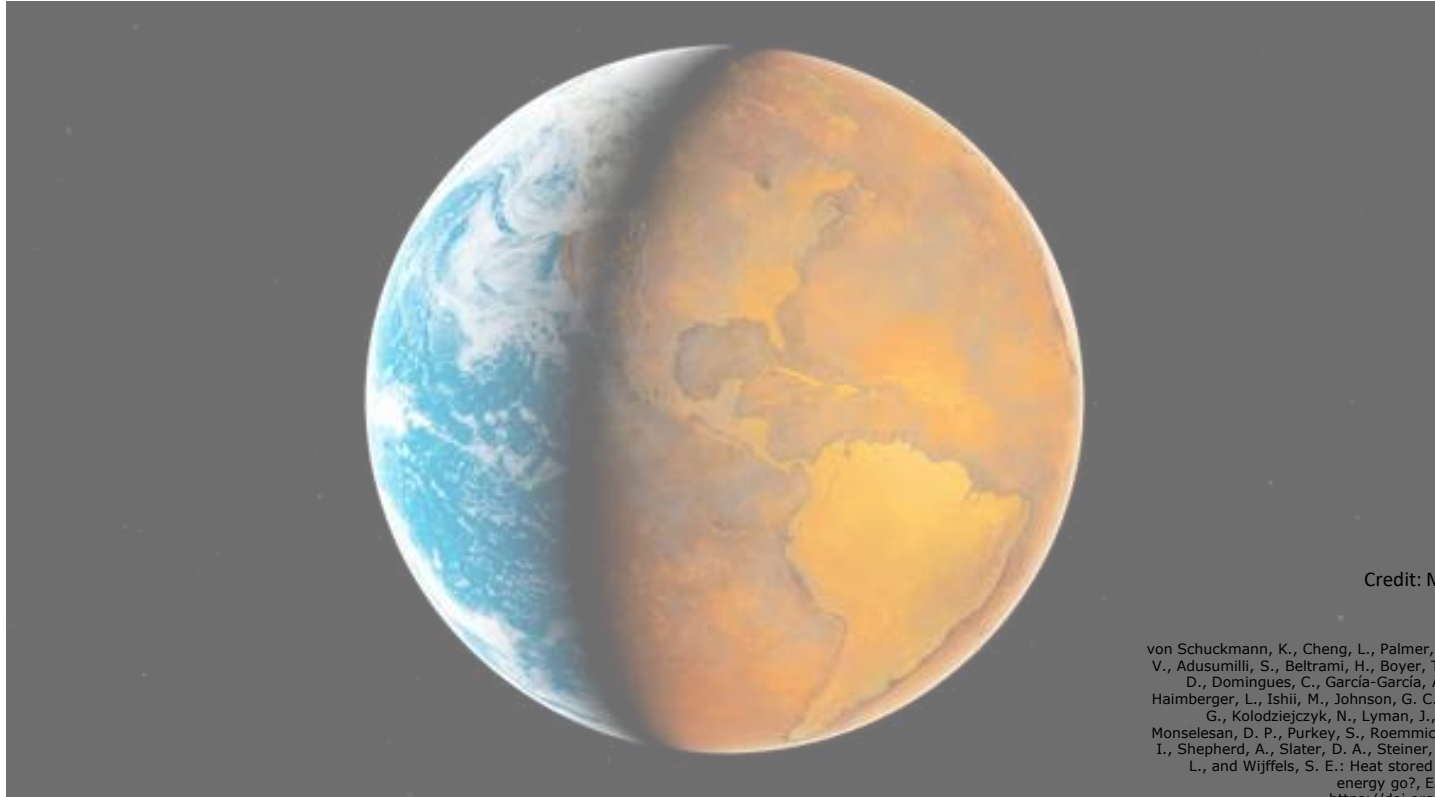
Why remote sensing and climate change?

Energy balance of the planet



(source: IPCC, 2013)

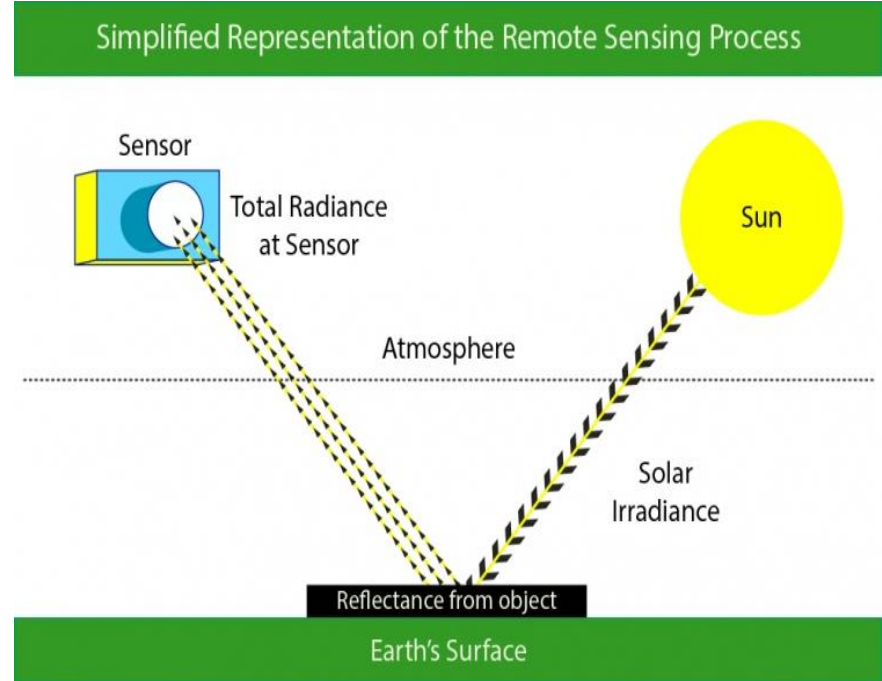
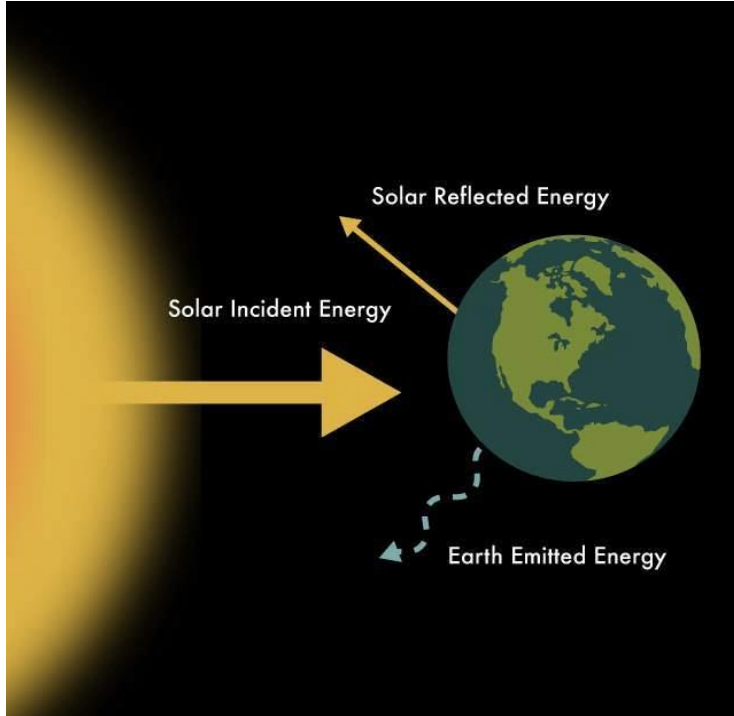
Climate change is a consequence of the disturbed energy balance of the planet



Credit: Mark Garlick Getty Images

von Schuckmann, K., Cheng, L., Palmer, M. D., Hansen, J., Tassone, C., Aich, V., Adusumilli, S., Beltrami, H., Boyer, T., Cuesta-Valero, F. J., Desbruyères, D., Domingues, C., García-García, A., Gentile, P., Gilson, J., Gorfer, M., Haimberger, L., Ishii, M., Johnson, G. C., Killick, R., King, B. A., Kirchengast, G., Kolodziejczyk, N., Lyman, J., Marzeion, B., Mayer, M., Monier, M., Monselesan, D. P., Purkey, S., Roemmich, D., Schweiger, A., Seneviratne, S. I., Shepherd, A., Slater, D. A., Steiner, A. K., Straneo, F., Timmermans, M.-L., and Wjffels, S. E.: Heat stored in the Earth system: where does the energy go?, *Earth Syst. Sci. Data*, 12, 2013–2041, <https://doi.org/10.5194/essd-12-2013-2020>, 2020.

The Remote Sensing



Global Temperature

↑ **1.2** °C above pre-industrial level
[More](#)

European Temperature

↑ **2.2** °C above pre-industrial level
[More](#)

Arctic Temperature

↑ **3** °C above pre-industrial level
[More](#)

Carbon Dioxide (CO₂)

↑ **417** ppm, annual average level
[More](#)

Carbon Dioxide (CO₂) Increase

↑ **2.4** ppm per year, since 2010
[More](#)

Methane (CH₄)

↑ **1894** ppb, annual average level
[More](#)

Global Glaciers

↓ **8600** km³, ice loss since 1997
[More](#)

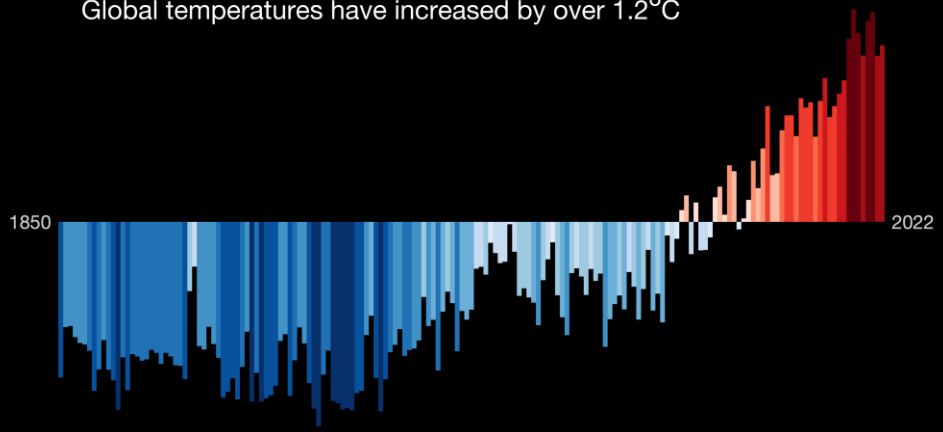
European Glaciers

↓ **960** km³, ice loss since 1997
[More](#)

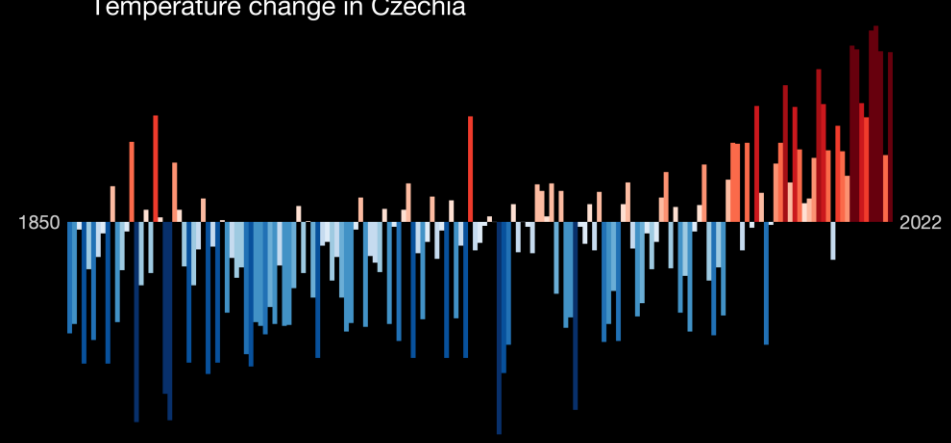
Greenland Ice Sheet

↓ **5850** km³, ice loss 1992-2020
[More](#)

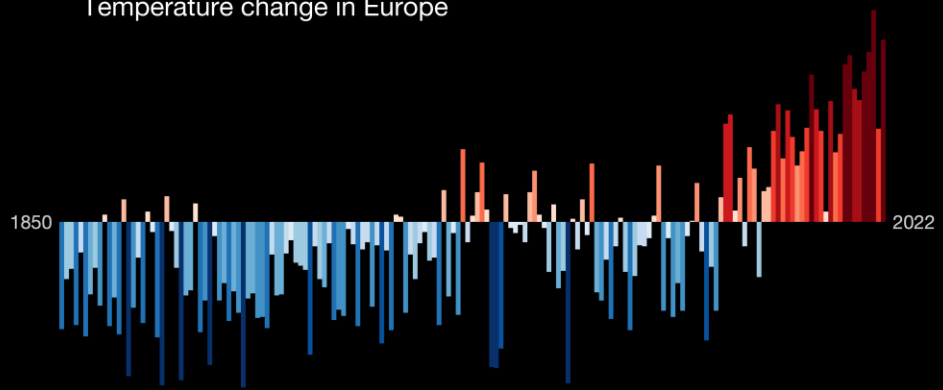
Global temperatures have increased by over 1.2°C



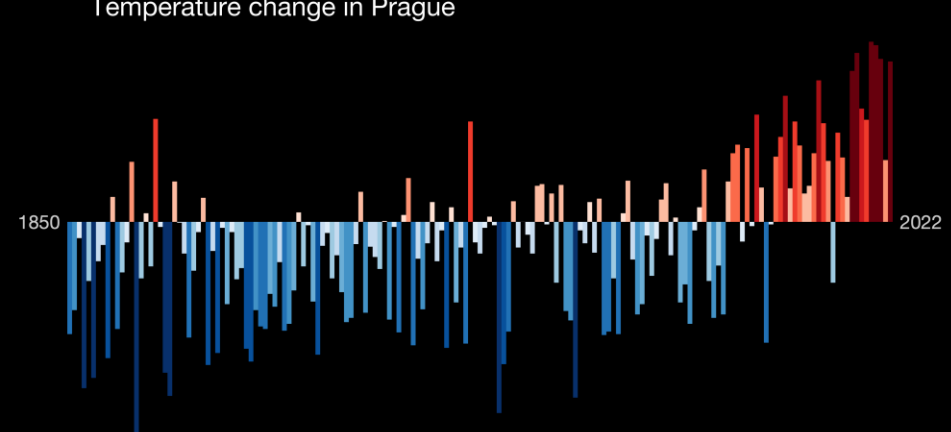
Temperature change in Czechia



Temperature change in Europe



Temperature change in Prague



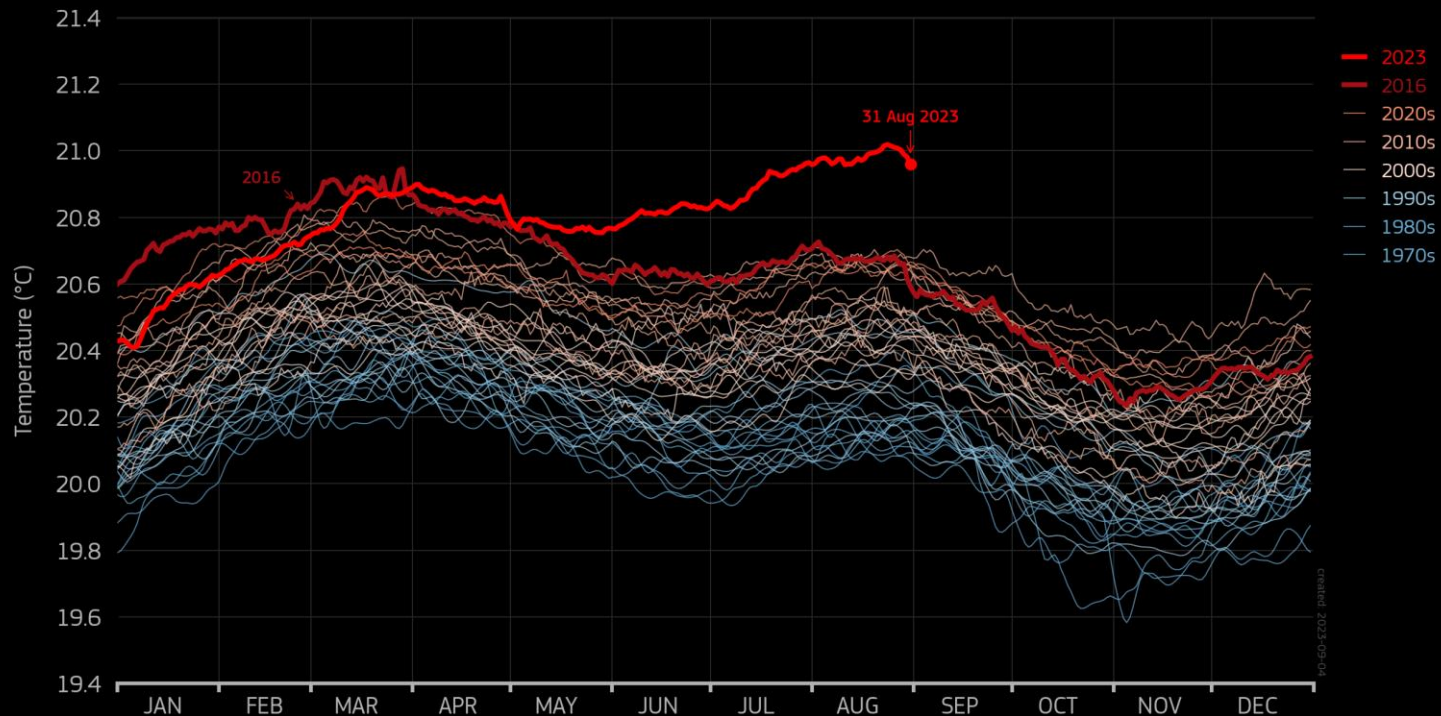
DAILY SEA SURFACE TEMPERATURE 60°S–60°N

Data: ERA5 1979–2023 • Credit: C3S/ECMWF



Climate
Change Service

climate.copernicus.eu



PROGRAMME OF
THE EUROPEAN UNION



IMPLEMENTED BY
ECMWF

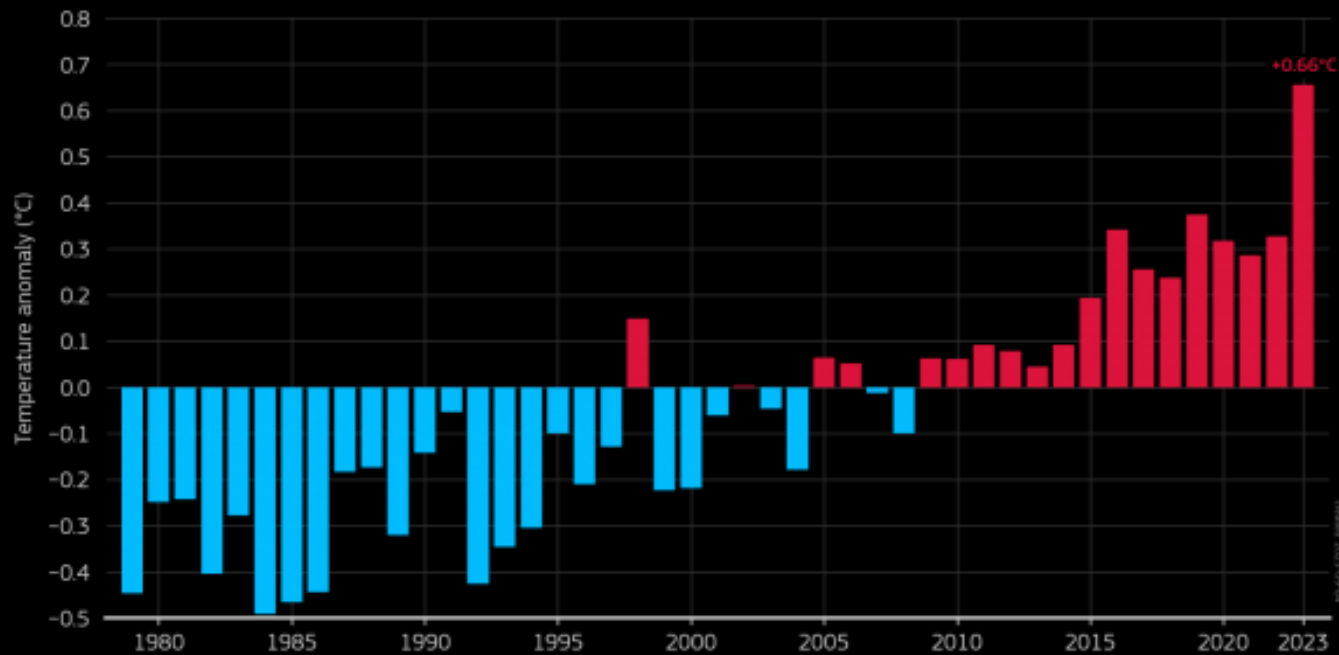
SURFACE AIR TEMPERATURE ANOMALIES • JUNE–AUGUST

Data: ERA5 • Reference period: 1991–2020 • Credit: C3S/ECMWF



Climate
Change Service

climate.copernicus.eu

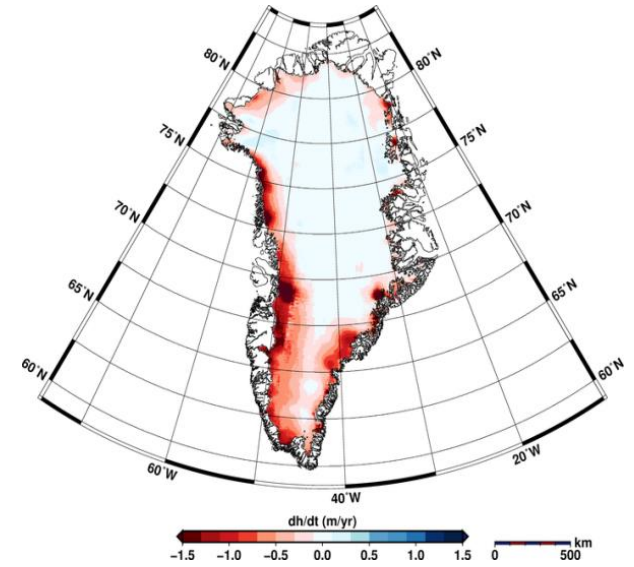
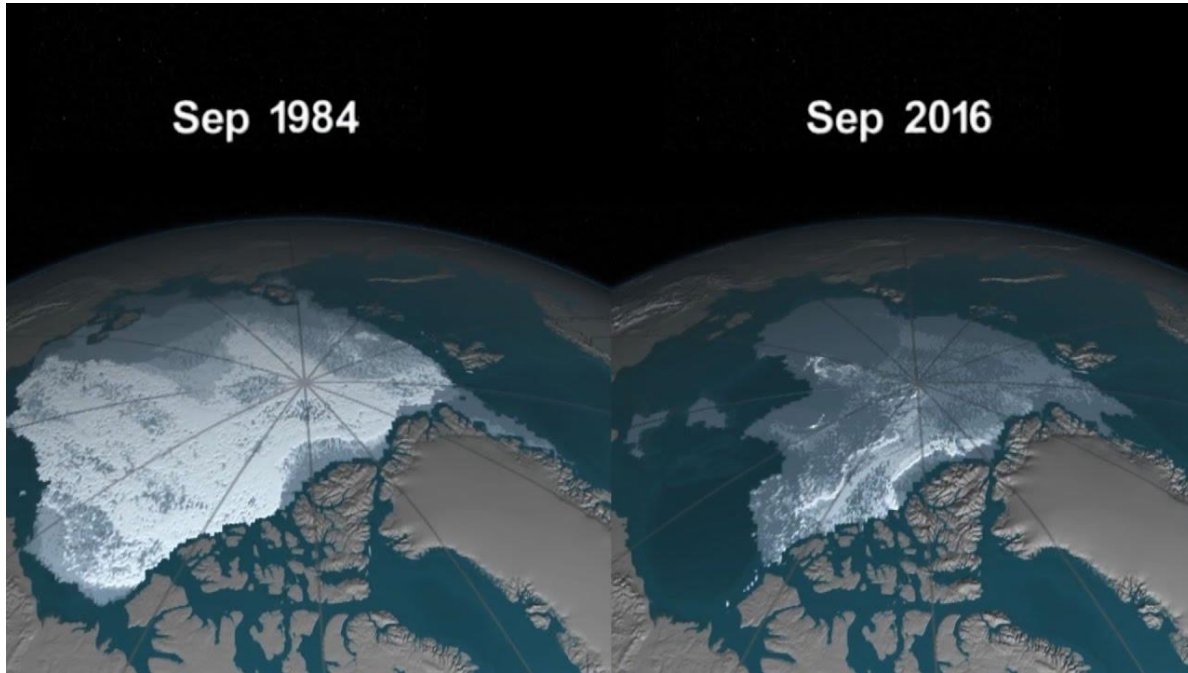


PROGRAMME OF
THE EUROPEAN UNION



19-10-1-2023 - 10:00 AM

The Cryosphere





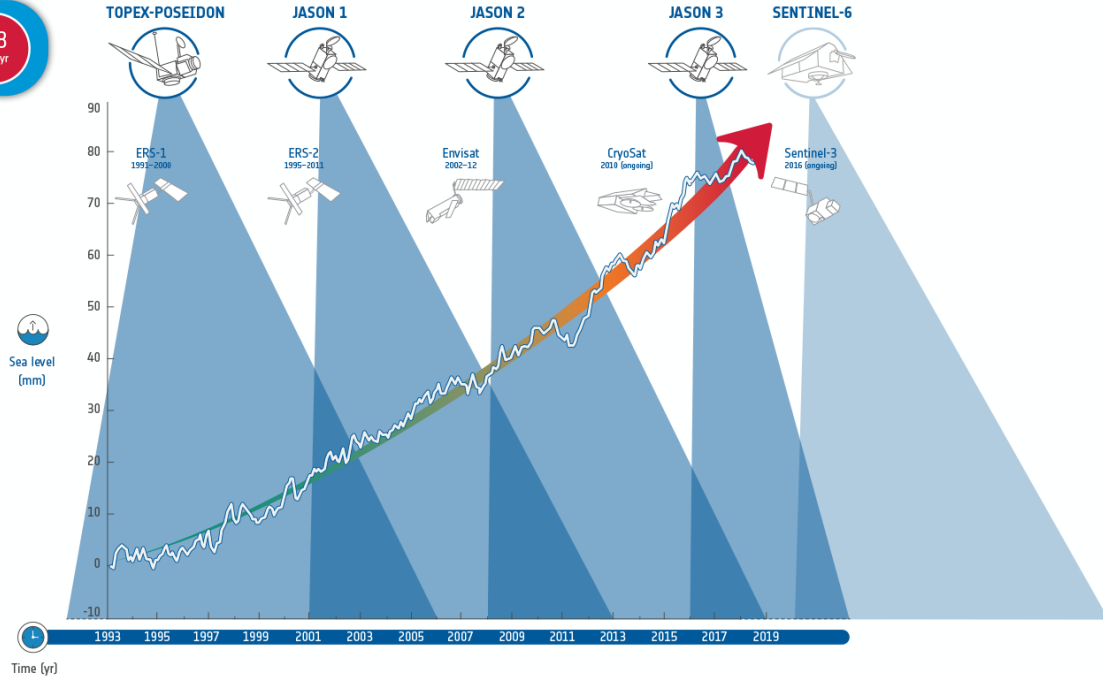
Ice



Warming



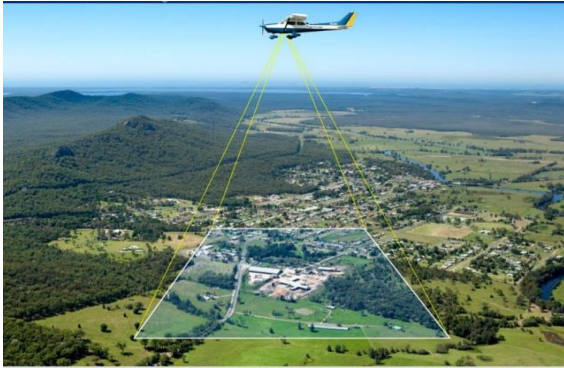
Thermal expansion



Introduction to Remote Sensing

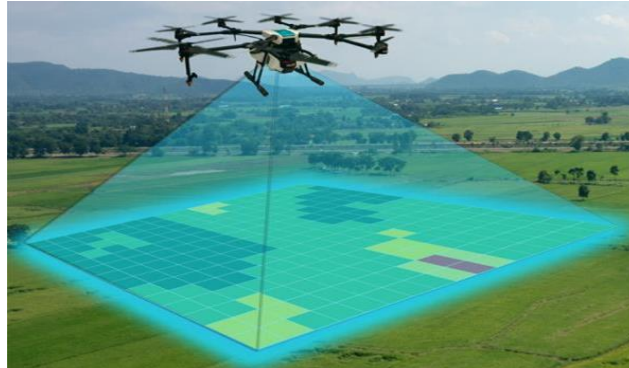
Modern Remote Sensing Platforms

Airplanes



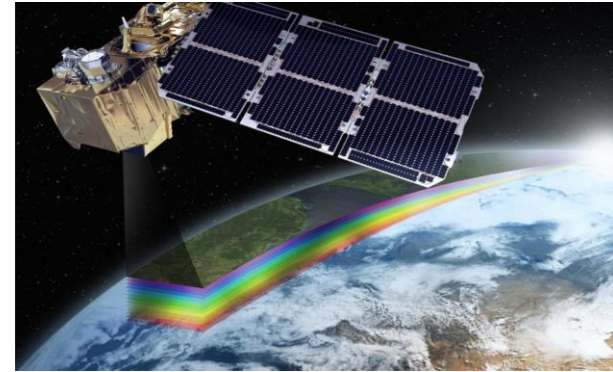
Source:
<https://www.slideshare.net/saislideshere/remotesensing-sainath-aher>

UAVs



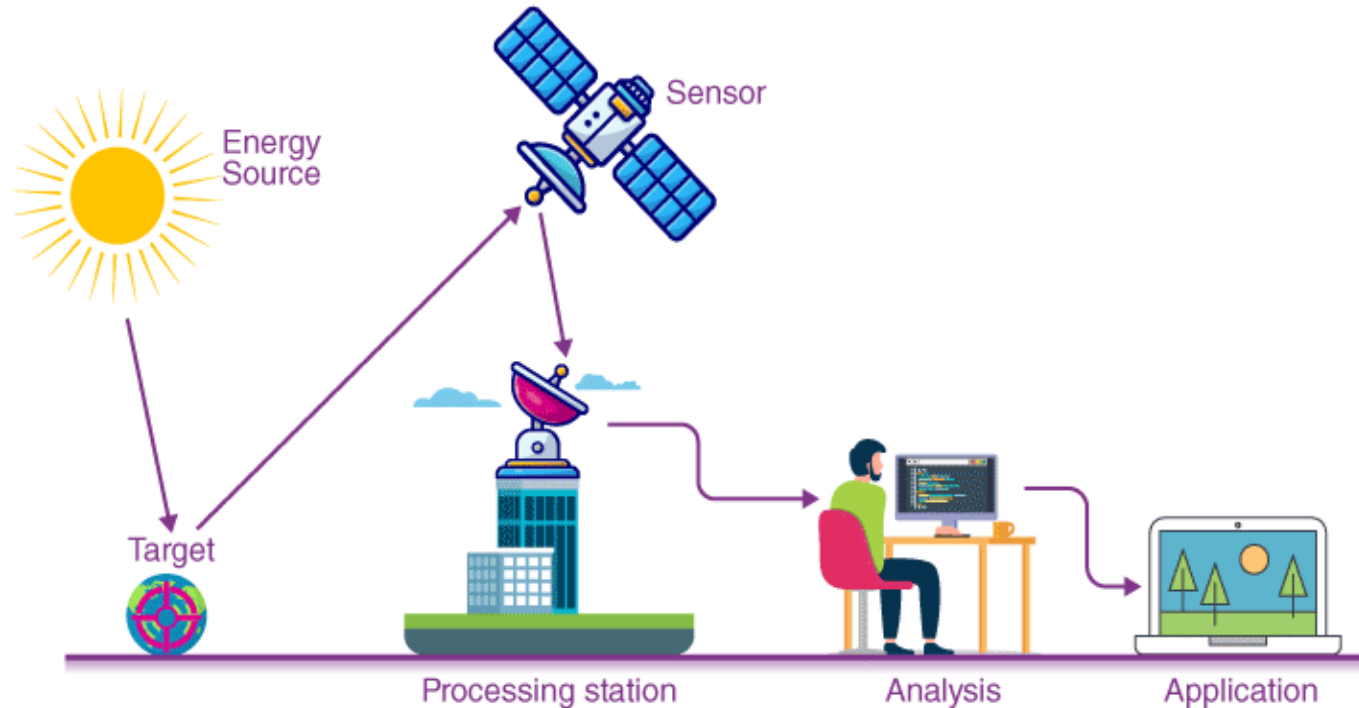
Source: <https://www.inrae.fr/en/news/remotesensing-dossier>

Satellites

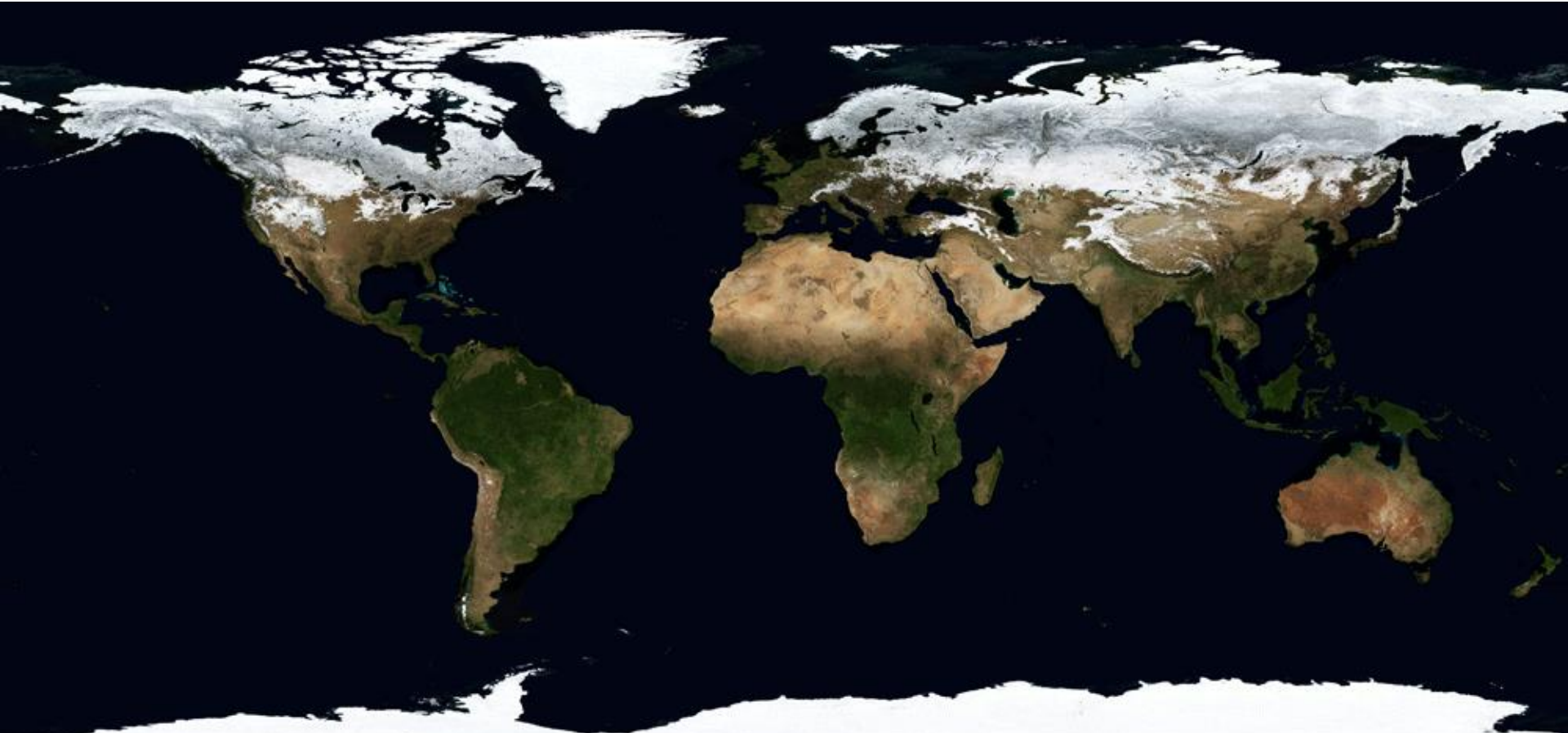


Source: <https://cervest.earth/remotesensing-of-planet-earth-part-1-introduction-to-satellite-imagery/>

The Remote Sensing Process



Google Earth Timelapse



<https://earthengine.google.com/timelapse/>

LEGEND **ANALYSIS**

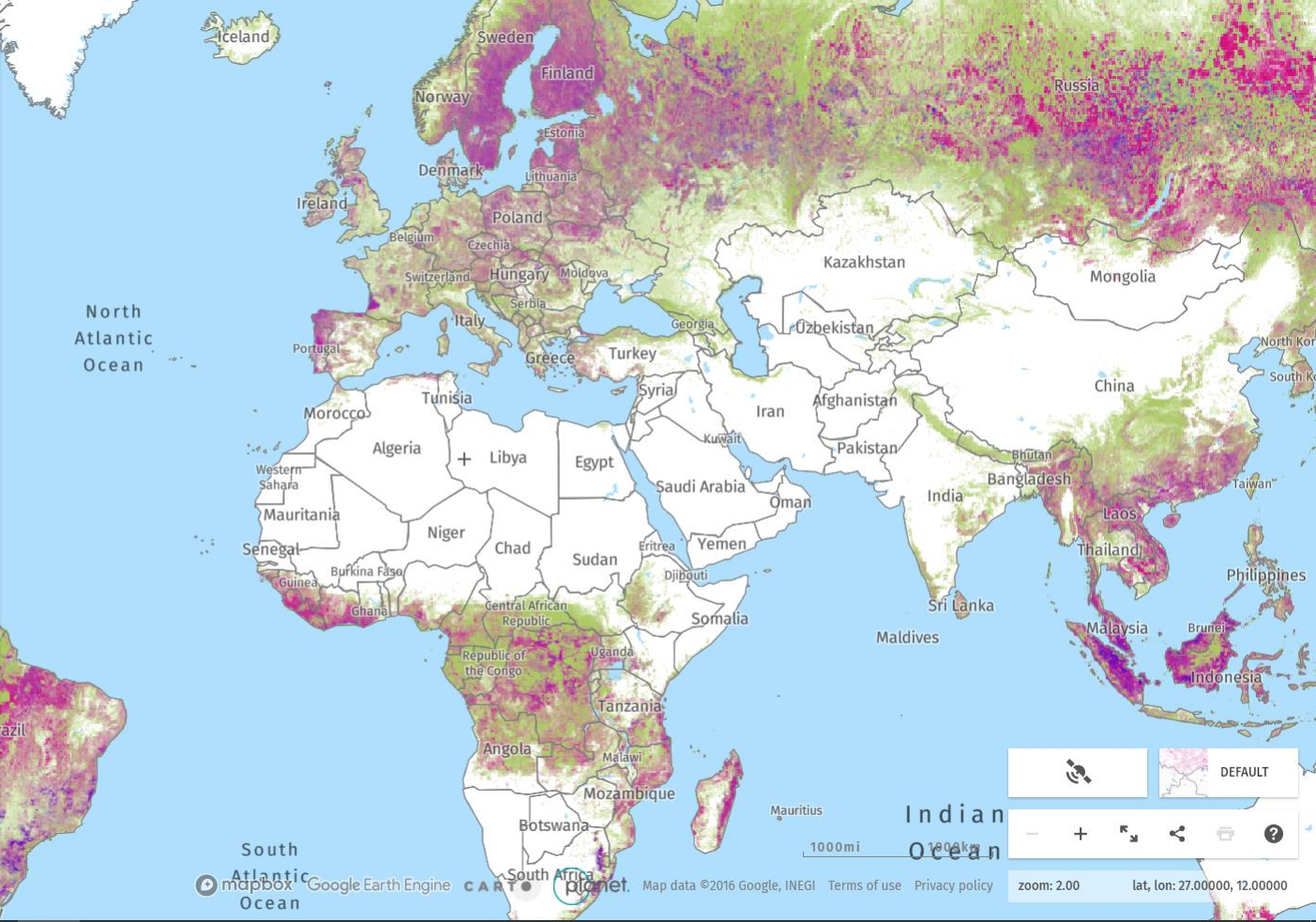
Tree cover gain - 2001-2012
 Tree cover gain

Tree cover loss - 2001-2019
 Tree cover loss
 Tree cover loss is not always deforestation.
 Displaying Tree cover loss with canopy density > 30%

2001 2004 2007 2010 2013 2016 2019

Tree cover - 2010
 Tree cover
 Displaying Tree cover with canopy density > 30%

Displaying Tree cover for 2010



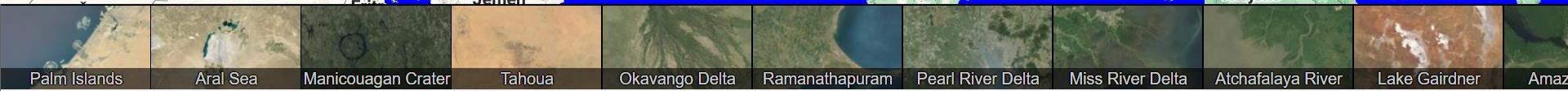
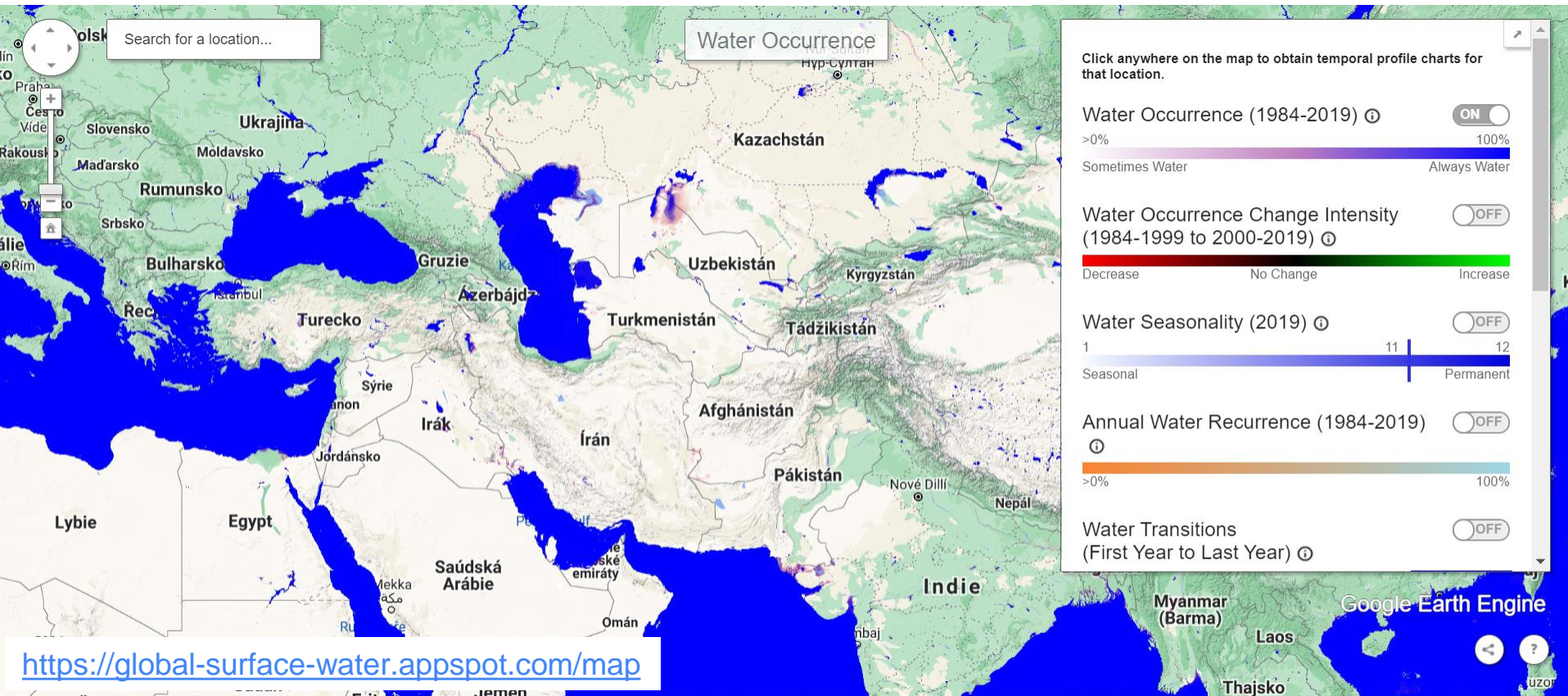
mapbox Google Earth Engine CARTO planet

Map data ©2016 Google, INEGI Terms of use Privacy policy

zoom: 2.00 lat, lon: 27.00000, 12.00000

DEFAULT

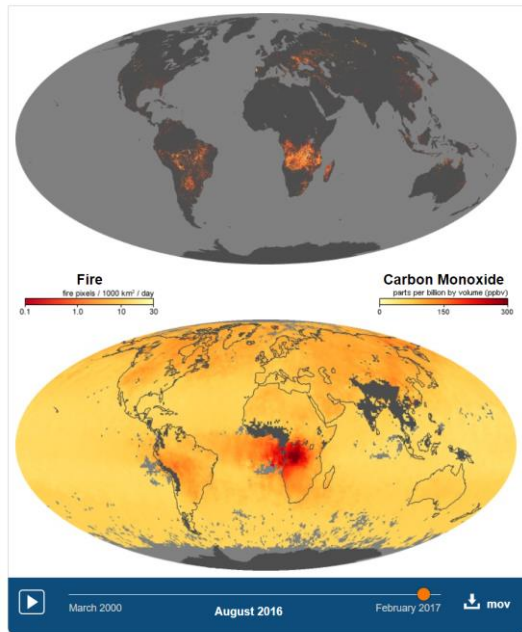
1000mi 1600km





<https://earthobservatory.nasa.gov/global-maps>

Fire & Carbon Monoxide



Select and Compare

Aerosol Optical Depth

Show All Maps

Land Atmosphere

Global Maps

Mar 2000 – Mar 2022

Snow Cover

Snow and ice influence climate by reflecting sunlight back into space. When it melts, snow is a source of water for drinking and vegetation; too much snowmelt can lead to floods. These maps show average snow cover by month.

Snow and Ice

Global Maps

Jul 2002 – Mar 2022

Chlorophyll

Chlorophyll is used by algae and other phytoplankton—the grass of the sea—to convert sunlight and carbon dioxide into sugars. These maps show chlorophyll concentrations in the ocean, revealing where phytoplankton are thriving.

Life Water

Global Maps

Jul 2006 – Mar 2022

Net Radiation

Net radiation is the balance between incoming and outgoing energy at the top of the atmosphere. It is the total energy available to influence climate after light and heat are reflected, absorbed, or emitted by clouds and land.

Heat

Global Maps

Feb 2000 – Mar 2022

Cloud Fraction

In addition to making rain and snow, clouds can have a warming or cooling influence depending on their altitude, type, and when they form. These maps show what fraction of an area was cloudy each month.

Atmosphere

Global Maps

Mar 2000 – Mar 2022

Aerosol Optical Depth

Airborne aerosols can cause or prevent cloud formation and harm human health. These maps depict aerosol concentrations in the air based on how the tiny particles reflect or absorb visible and infrared light.

Atmosphere

Global Maps

Mar 2000 – Mar 2022

Vegetation

Greenness is an important indicator of health for forests, grasslands, and farms. The greenness of a landscape, or vegetation index, depends on the number and type of plants, how leafy they are, and how healthy they are.

Land Life

Global Maps

Feb 2000 – Mar 2022

Land Surface Temperature

Land surface temperatures rise and fall with the heat of the Sun, and they represent how hot or cold the surface would feel to touch. These maps show daytime land temperatures as measured from space.

Heat Land

Global Maps

Mar 2000 – Mar 2022

Fire

Whether started by humans (farming, logging, or accidents) or by nature (lightning), fires are always burning somewhere on Earth. These maps show the locations of fires burning around the world each month.

Land

Global Maps

Feb 2000 – Mar 2022

Land Surface Temperature Anomaly

These maps depict anomalies in land surface temperatures.

Global Maps

Jul 2002 – Feb 2022

Sea Surface Temperature

Ocean temperatures can influence weather, such as

Global Maps

Mar 2000 – Feb 2017

Carbon Monoxide

When fuels such as coal, wood, and oil burn

Global Maps

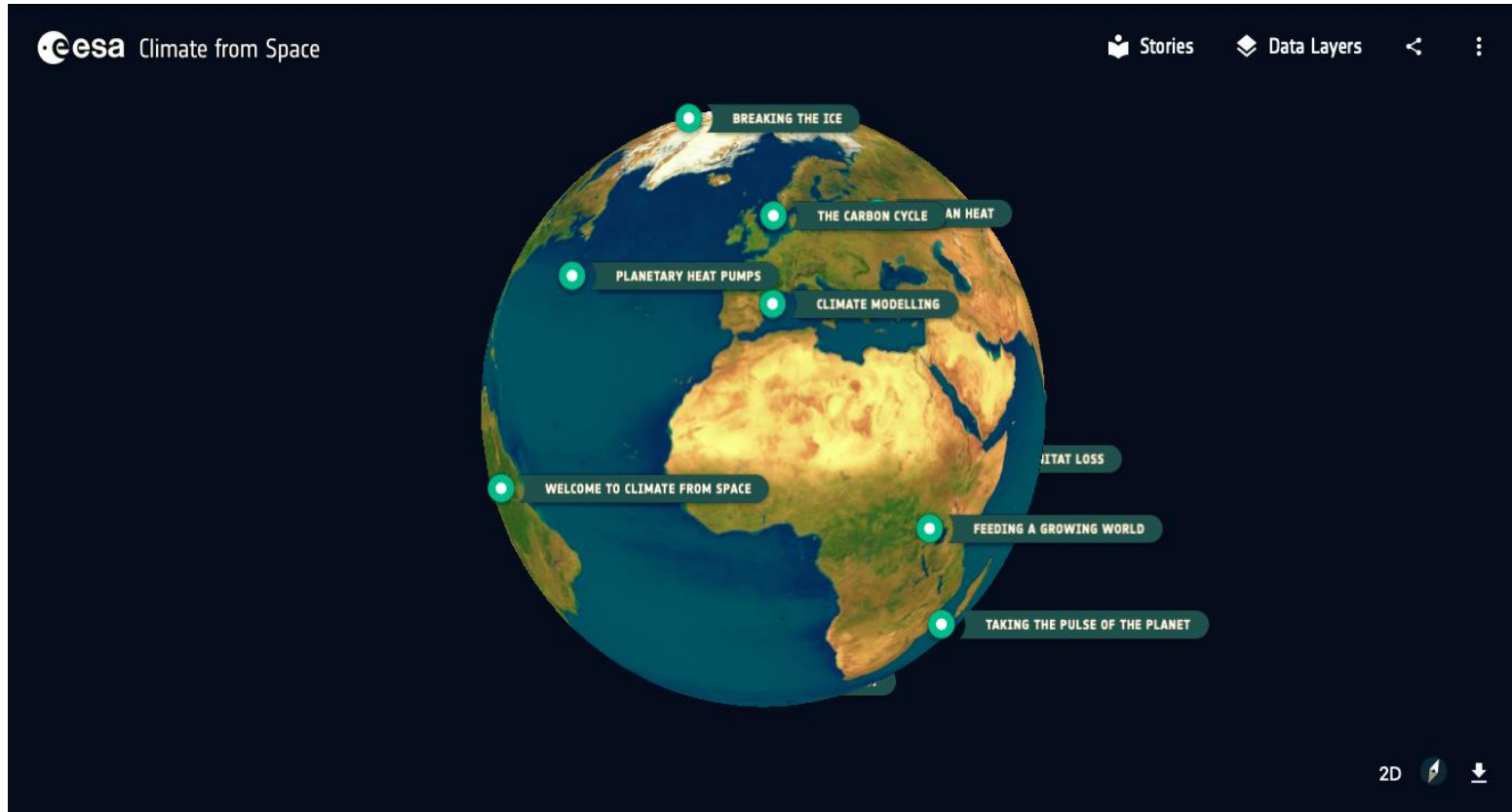
Jul 2002 – Feb 2022

Water Vapor

These maps show the average amount of water vapor in a column of atmosphere by

ESA Climate from Space

<https://cfs.climate.esa.int>






EARTHMAP

The power of Google Earth
Engine without coding.

A user friendly tool for complex
land monitoring

 Sign in with Google

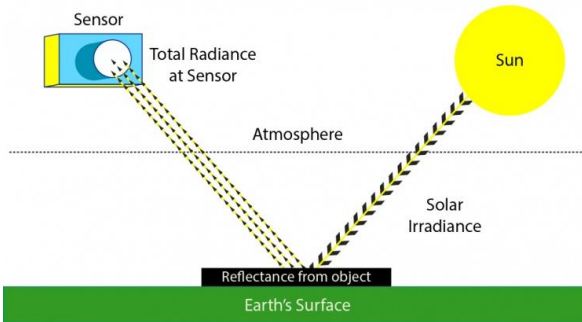
 Sign in with email

 Continue as guest

By continuing, you are indicating that you accept our [Terms of Service](#) and [Privacy Policy](#).

Basic principles of Remote Sensing

Simplified Representation of the Remote Sensing Process

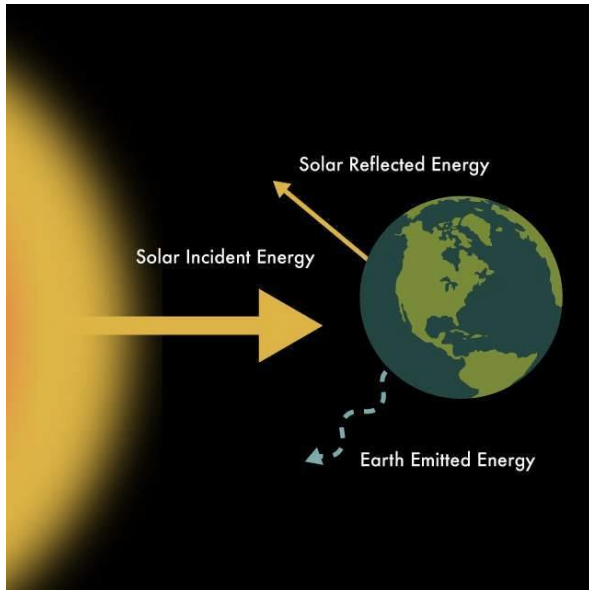


Solar radiation

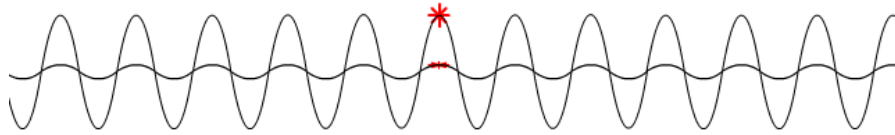
Incident Solar Energy is the radiant **solar energy** that hits the earth's surface and is referred to as “global radiation” on a surface.

Reflected Solar Energy describes sunlight that has been **reflected** off of non-atmospheric things such as the earth's surface.

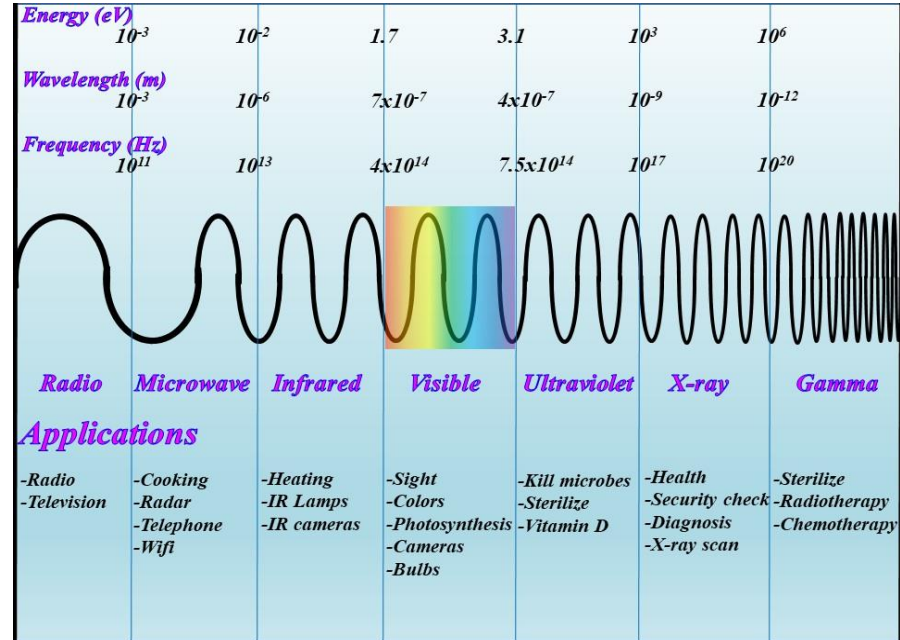
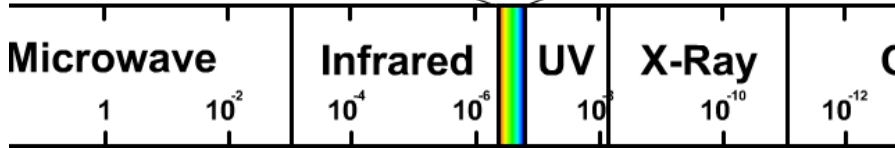
Earth Emitted Energy is the earth's own radiation emitted into atmosphere.



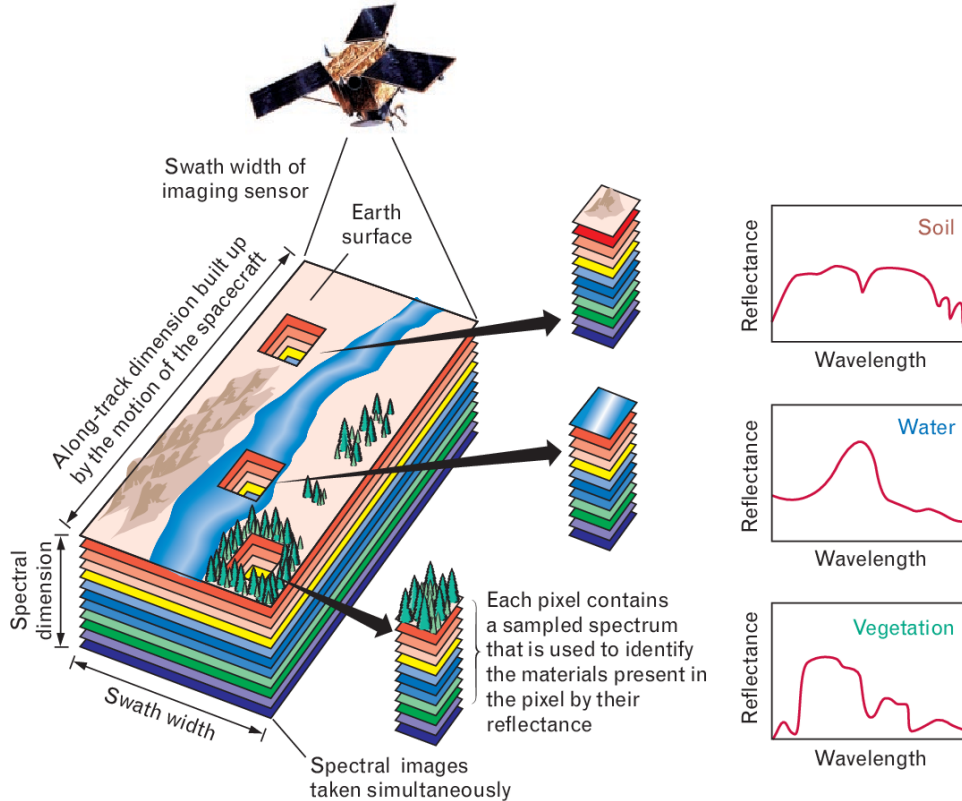
Electromagnetic spectrum



Visible



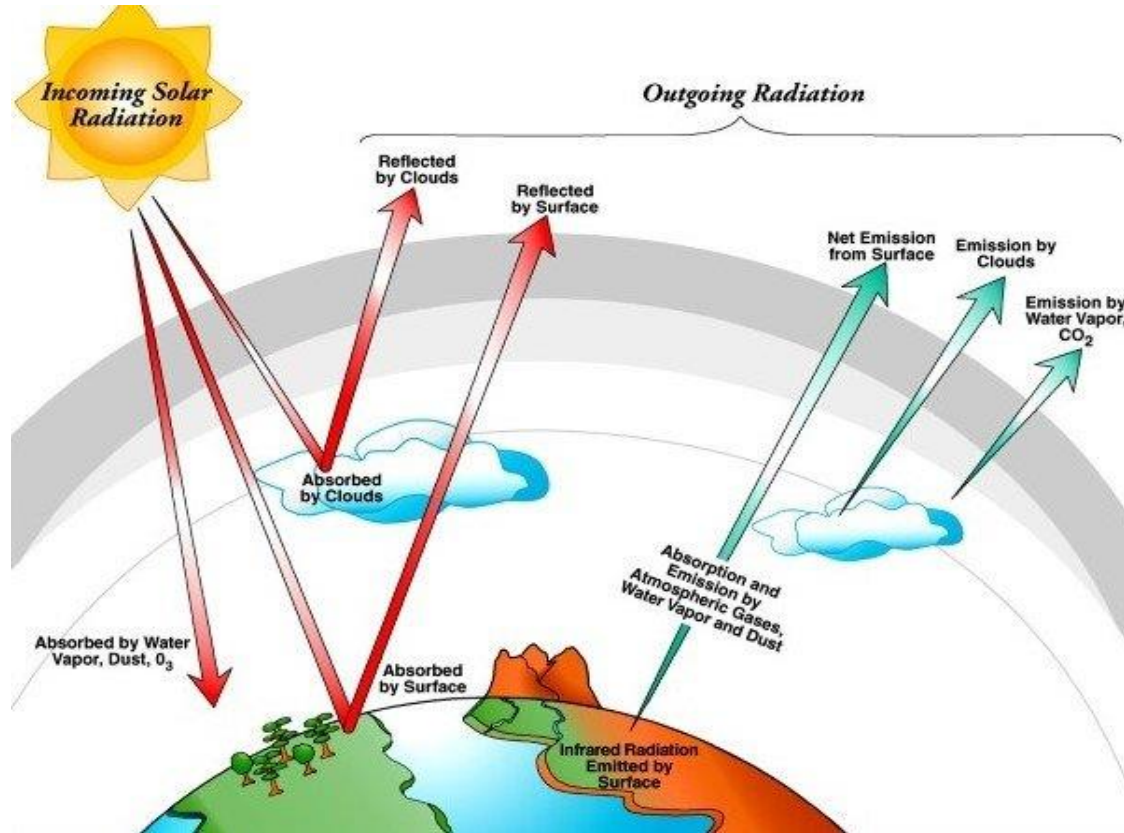
Spectrums of RS data



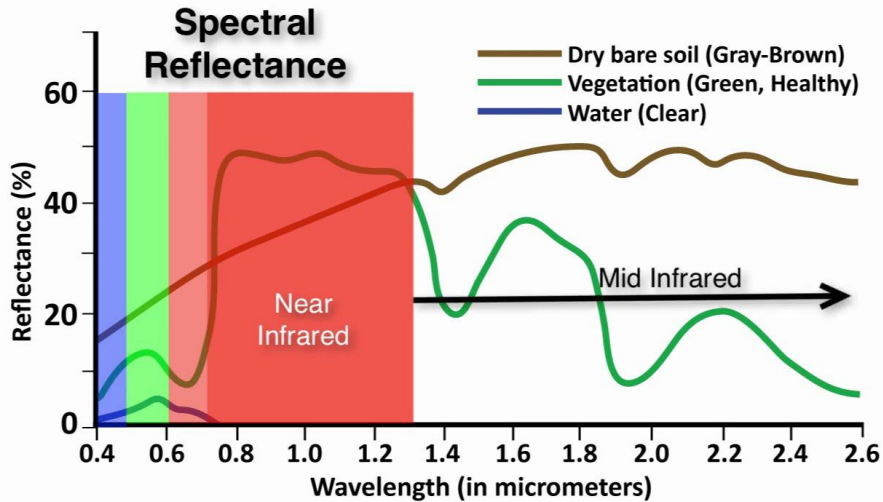
Satellite images often consist of **several bands** because they capture different portions of the electromagnetic spectrum.

The reason for having multiple bands is that different wavelengths of light interact differently with the Earth's surface and atmosphere. By capturing information across various bands, satellite images provide valuable insights into different aspects of the Earth's features and phenomena.

Interaction with the Earth Surface



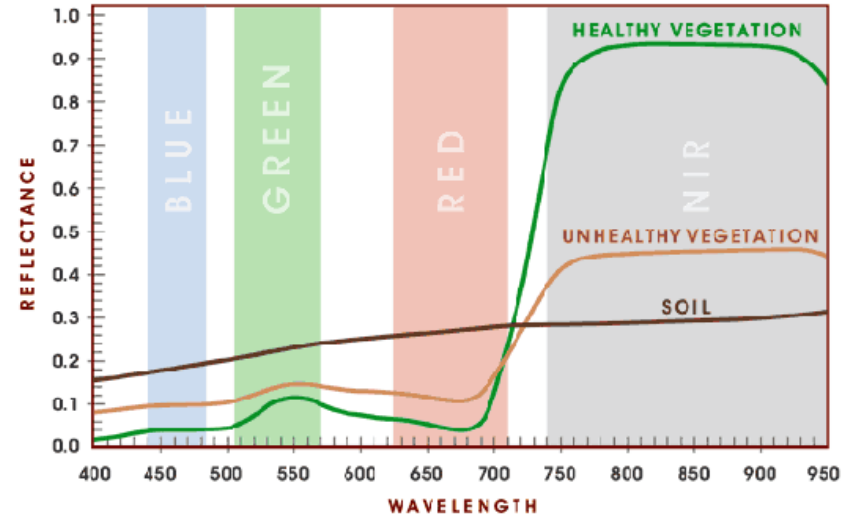
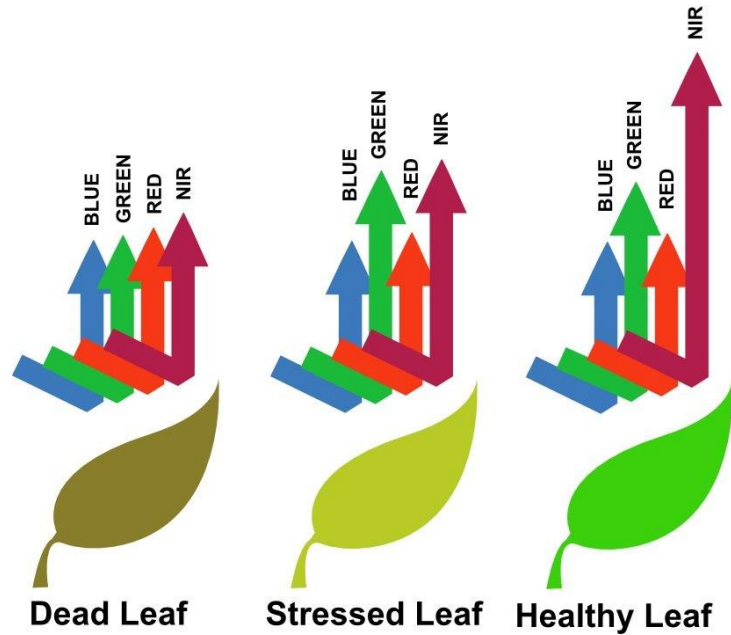
What is spectral signatures?



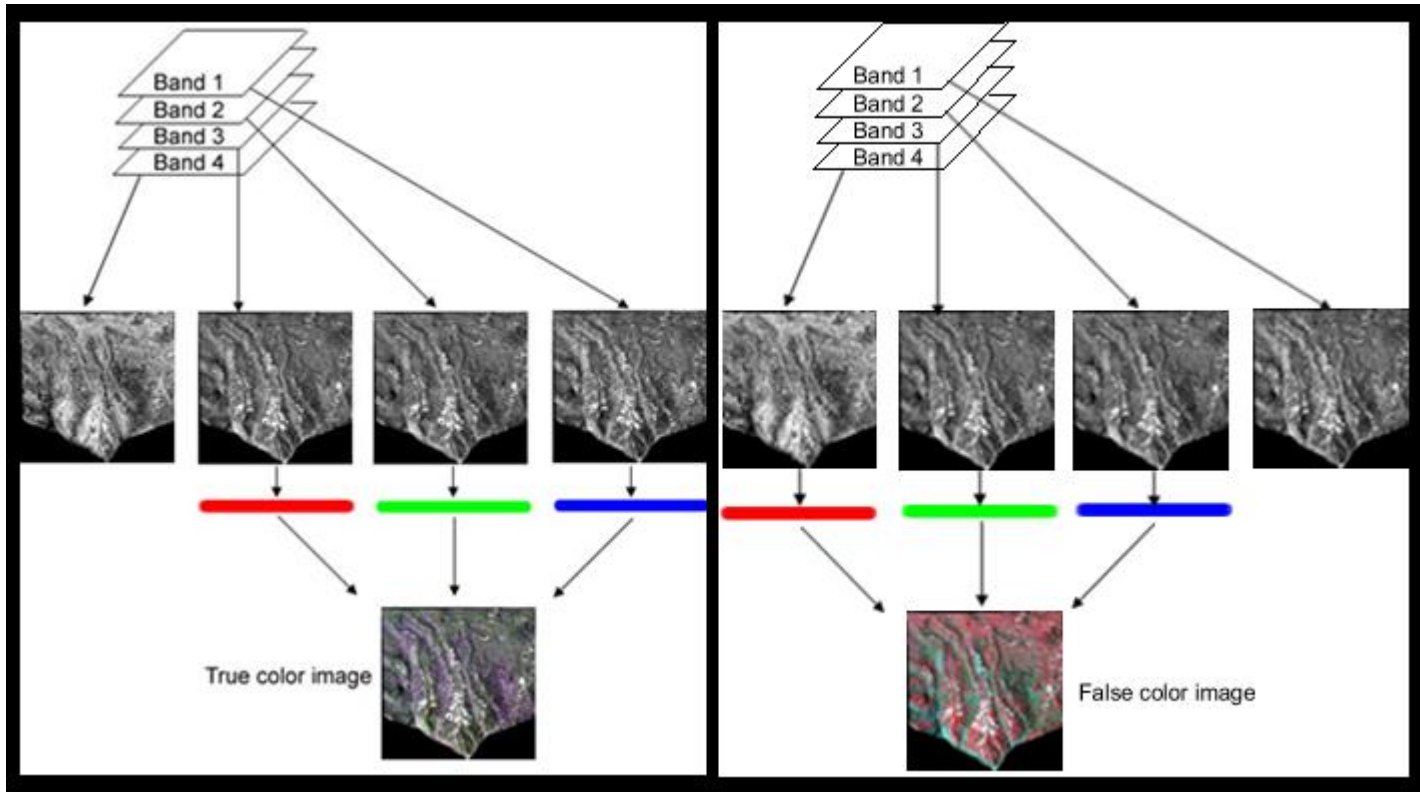
The **spectral signature** refers to the unique pattern of light or electromagnetic radiation that is reflected, emitted, or transmitted by an object or substance at different wavelengths. It is essentially a graph or plot that shows how an object interacts with light across a range of wavelengths.

Every material or object has its own distinctive spectral signature, similar to a fingerprint. This signature is determined by the way the material absorbs, reflects, or emits light at different wavelengths within the electromagnetic spectrum, which includes visible light as well as other forms of radiation like infrared and ultraviolet.

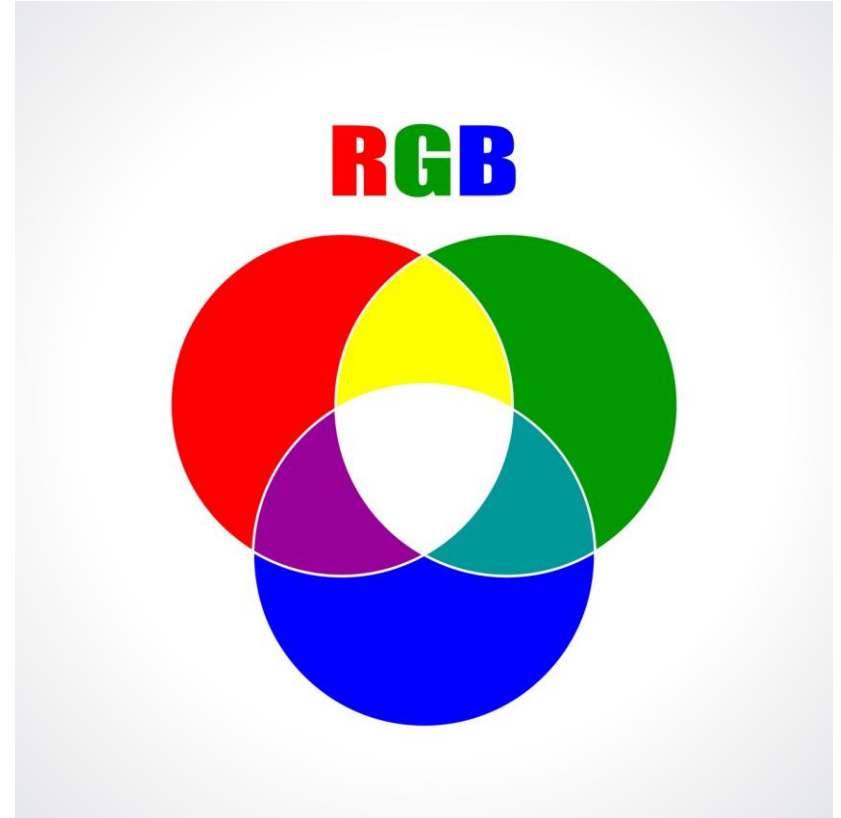
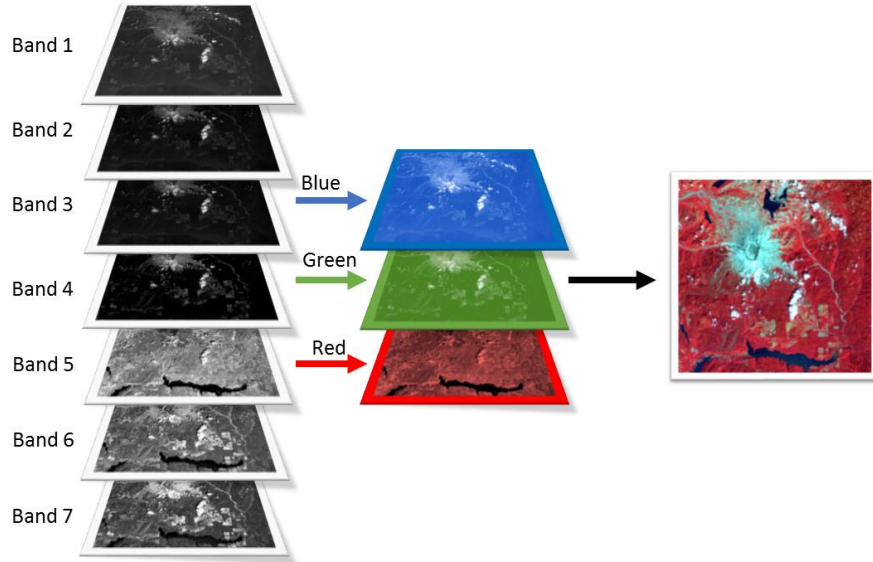
Spectral characteristics of vegetation



Combining bands of a satellite image



Band Combinations



True Color



True color composite uses visible light bands red, green and blue in the corresponding red, green and blue color channels, resulting in a natural colored product, that is a good representation of the Earth as humans would see it naturally.

False Color



A false color composite uses at least one non-visible wavelength to image Earth. The false color composite using near infrared, red and green bands is very popular (a band is a region of the electromagnetic spectrum; a satellite sensor can image Earth in different bands). The false colour composite is most commonly used to assess plant density and health, since plants reflect near infrared and green light, while they absorb red. Cities and exposed ground are grey or tan, and water appears blue or black.

Copernicus

www.copernicus.eu

Copernicus – a new Phase in EO



European Earth Observation System

- Led by the EU
- EU-ESA Collaboration

European response to global needs:

- to manage the environment
- to mitigate the effects of climate change
- to ensure civil security

European independence, contribution to global system (GEOSS)



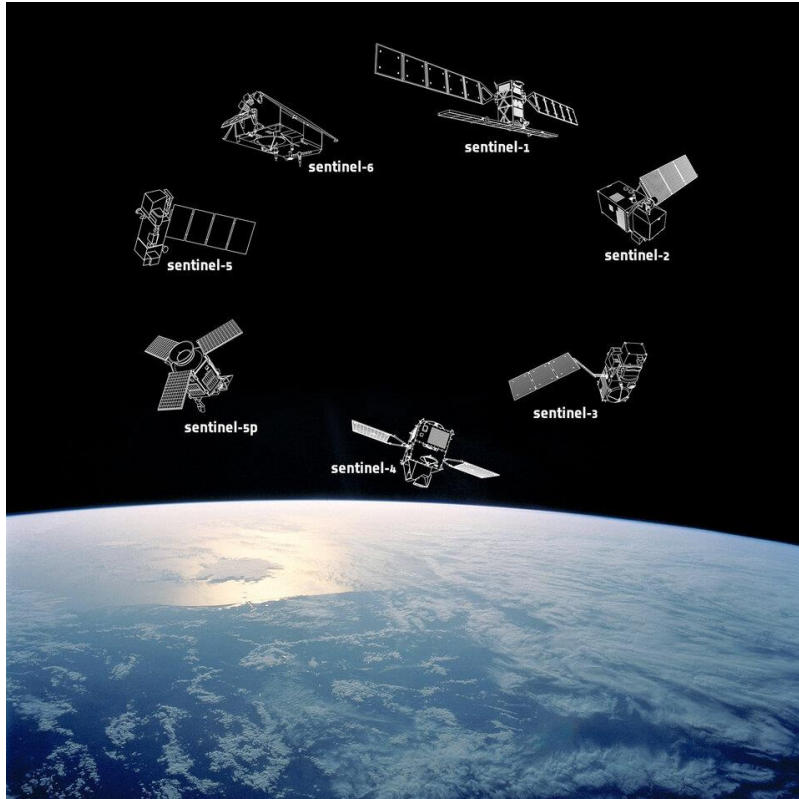
FULL, FREE AND OPEN
ACCESS TO DATA



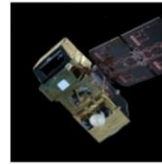
- ATMOSPHERE MONITORING
- MARINE ENVIRONMENT MONITORING
- LAND MONITORING
- CLIMATE CHANGE
- EMERGENCY MANAGEMENT
- SÉCURITÉ



Copernicus Program



With the objectives of Land and Ocean monitoring, **Sentinel-1** will be composed of two polar-orbiting satellites operating day and night, and will perform Radar imaging, enabling them to acquire imagery regardless of the weather. The first Sentinel-1 satellite was launched in April 2014.



The objective of **Sentinel-2** is land monitoring, and the mission will be composed of two polar-orbiting satellites providing high-resolution optical imagery. Vegetation, soil and coastal areas are among the monitoring objectives. The first Sentinel-2 satellite was launched in June 2015.

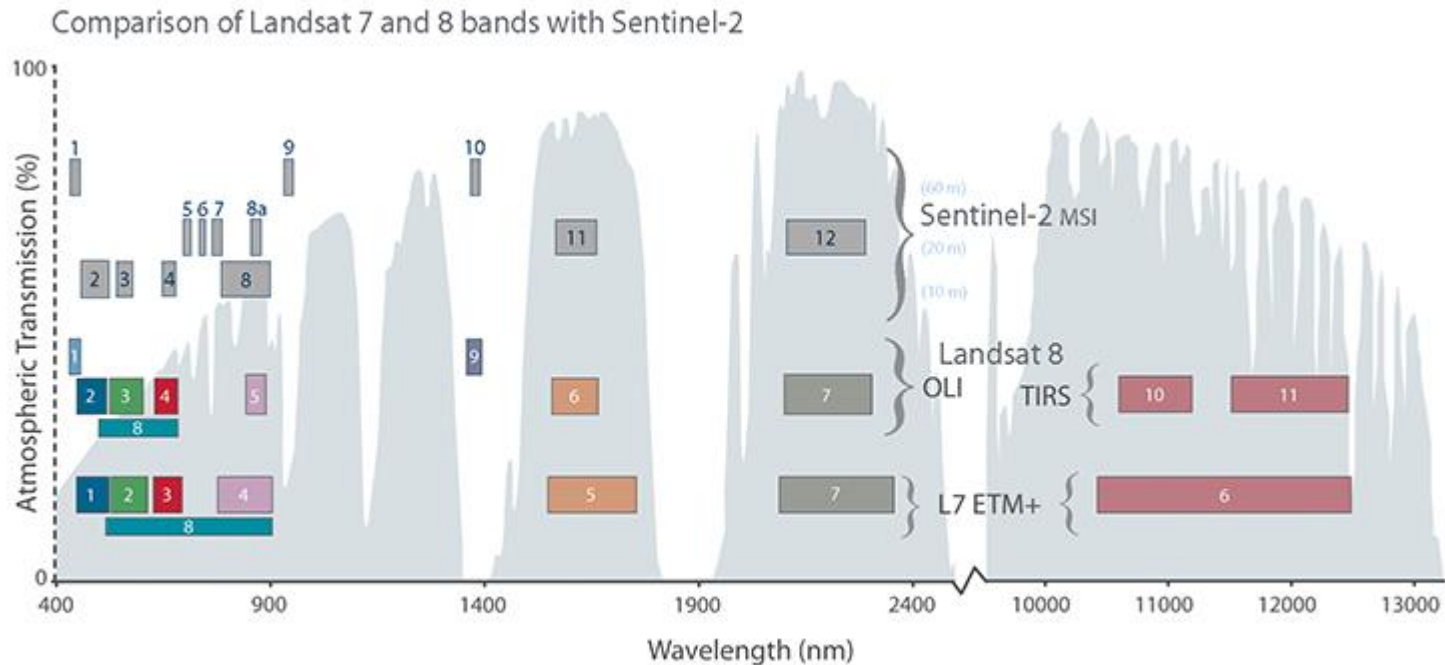


The primary objective of **Sentinel-3** is marine observation, and it will study sea-surface topography, sea and land surface temperature, ocean and land colour. Composed of three satellites, the mission's primary instrument is a radar altimeter, but the polar-orbiting satellites will carry multiple instruments, including optical imagers.



The main objective of the **Sentinel-5P** mission is to perform atmospheric measurements, with high spatio-temporal resolution, relating to air quality, climate forcing, ozone and UV radiation.

Sentinel-2 & Landsat 7,8 bands comparison



Landsat VS Sentinel 2

Landsat

Data availability: from 1972

Spatial resolution: 30, 100 m

Temporal resolution: 16 days

Has thermal bands!



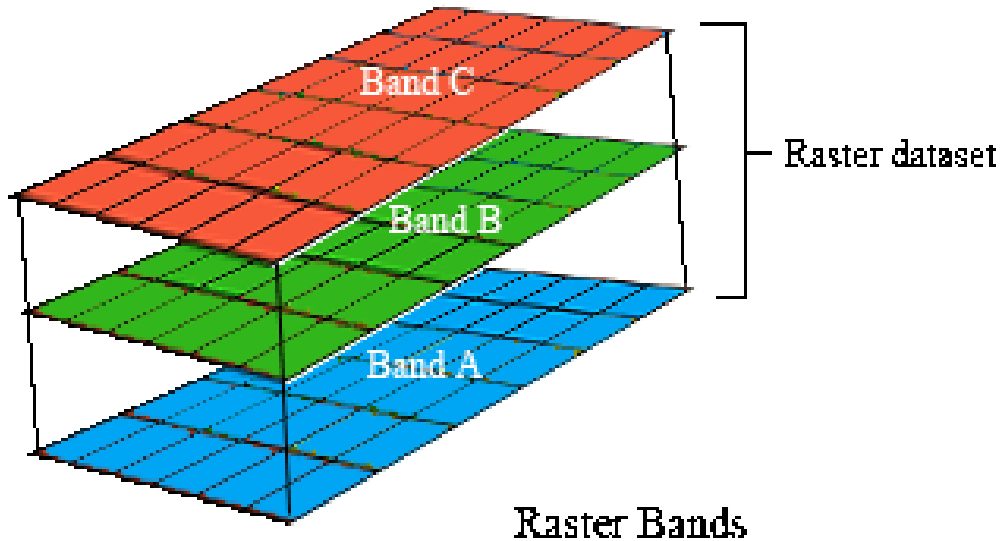
Sentinel 2

Data availability: from 2015

Spatial resolution: 10, 20, 60 m

Temporal resolution: 4-7 days

Spectral Indices



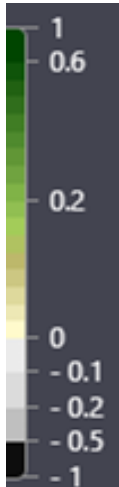
Spectral indices are combinations of **spectral** reflectance from two or more wavelengths that indicate the relative abundance of features of interest. Vegetation **indices** are the most popular type, but other **indices** are available for burned areas, man-made (built-up) features, water, and geologic features.

$$\frac{A-B}{B-A} = D$$

Normalized Difference Vegetation Index (NDVI)

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$

The normalized difference vegetation index is a simple, but effective index for quantifying green vegetation. It is a measure of the state of vegetation health based on how plants reflect light at certain wavelengths. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1 to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (values approaching 1).



Let's try to calculate NDVI

$$\text{NDVI} = \frac{(\text{NIR} - \text{Red})}{(\text{NIR} + \text{Red})}$$

NIR

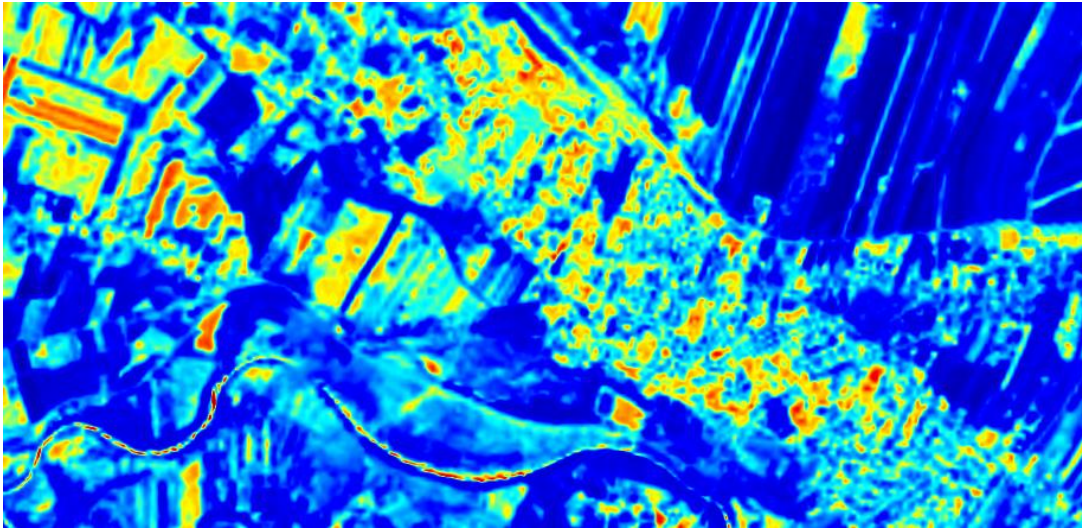
4	5	11	13	17	9
3	57	56	56	4	6
12	43	45	12	12	8
13	5	7	8	21	19
5	7	11	6	7	5
23	3	12	8	2	2

RED

11	24	18	21	21	22
24	58	17	14	10	0
12	34	43	12	7	8
31	26	17	14	12	76
34	9	13	16	34	16
18	23	5	6	7	14

<i>-0.46</i>	<i>-0.65</i>	<i>-0.24</i>	<i>-0.24</i>	<i>-0.10</i>	<i>-0.42</i>
<i>-0.77</i>	<i>0</i>	<i>0.24</i>	<i>0.25</i>	<i>0.7</i>	<i>0.16</i>
...
...
...
...
...

Normalized Difference Moisture Index (NDMI)

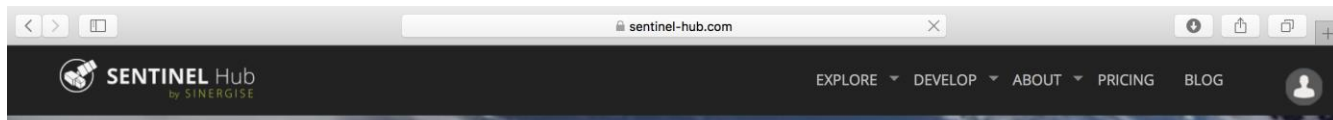


$$NDMI = \frac{NIR - SWIR}{NIR + SWIR}$$

The normalized difference moisture Index (NDMI) is used to determine vegetation water content and monitor droughts. The value range of the NDMI is -1 to 1. Negative values of NDMI (values approaching -1) correspond to barren soil. Values around zero (-0.2 to 0.4) generally correspond to water stress. High, positive values represent high canopy without water stress (approximately 0.4 to 1).



Sentinel Hub practice



sentinel hub



Vše

Obrázky

Mapy

Videa

Zprávy

Více

Nastavení

Nástroje

Přibližný počet výsledků: 6 070 000 (0,32 s)

Sentinel Hub

<https://www.sentinel-hub.com/> ▼ Přeložit tuto stránku

Sentinel Hub is a cloud based GIS platform for distribution, management and analysis of satellite data.

[Playground](#) · [EO Browser](#) · [Explore](#) · [Sentinel WMS services](#)





Thank you for your attention



Acknowledgments: to thank for the support of the European Union's Caroline Herschel Framework Partnership Agreement on Copernicus User Uptake under grant agreement No. FPA 275/G/GRO/COPE/17/10042, project FPCUP (Framework Partnership Agreement on Copernicus User Uptake).