



The LifeWatch ERIC Biodiversity
& Ecosystem eScience Conference
PLOVDIV, BULGARIA 7-10 JULY 2026

Introduction and hands-on Earth Observation for Biodiversity Monitoring

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08 July 2026

We engage with a wide range of stakeholder communities to understand how EO data and services can help address their real needs, and to provide them with practical support for uptake.

- Promote available tools and products
- Organise training and capacity building
- Provide bespoke support as needed

EO based
tools and
services



Stakeholder
communities

- Understand needs and working practices
- Capture and analyse requirements
- Collect feedback on the practical use of EO



Food Systems



Ecosystems and Biodiversity



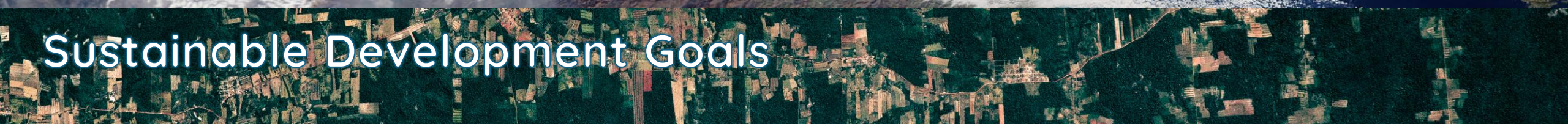
Urban Environments



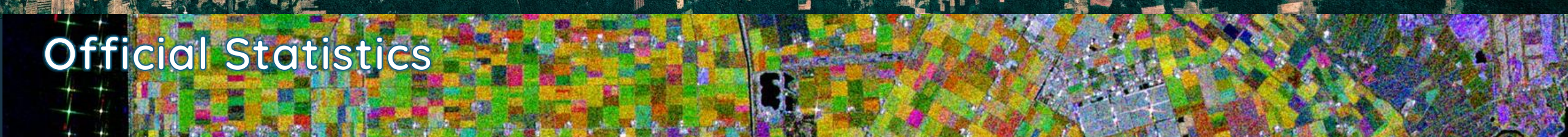
Renewable Energy



Carbon and Air Quality



Sustainable Development Goals

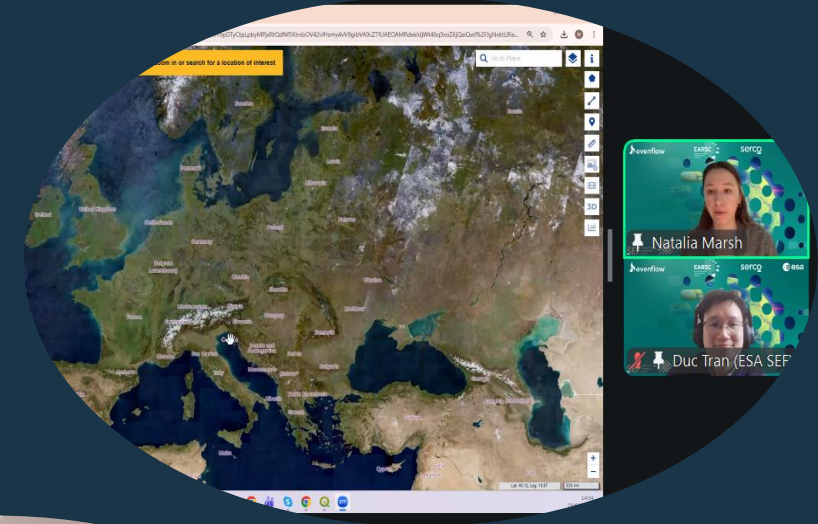


Official Statistics

Presentations, demonstrations and exhibitions at user community events



Organise webinars, workshops and training courses



Deep dives and case studies with individual users and stakeholder groups



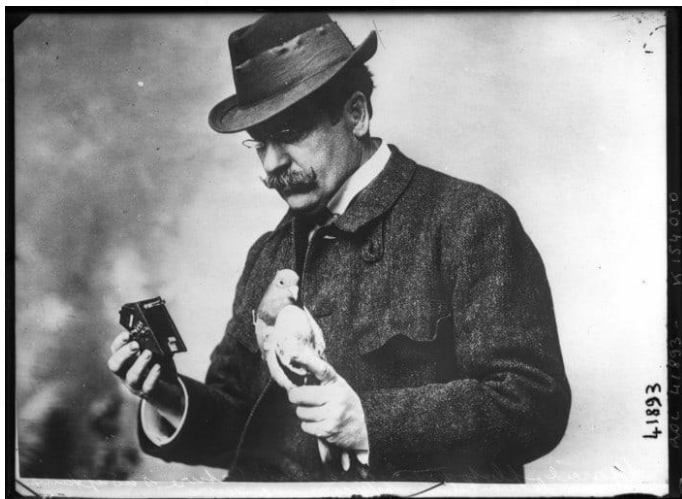
What is Earth Observation (EO)?



Remote Sensing (RS) is the science of obtaining information about objects or areas **from a distance**, typically from aircrafts or satellites,

whereas **Earth Observation (EO)** refers to the **use of remote sensing technologies** to monitor land, marine areas (seas, rivers, lakes) and the atmosphere.

History of Earth Observation



Julius Neubronner holding a homing pigeon and one of his cameras, 1914.

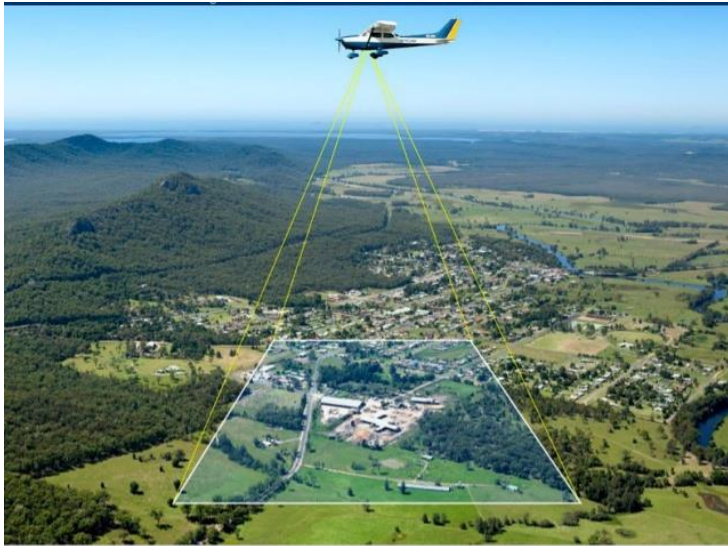


Homing pigeons strapped with Neubronner's cameras.



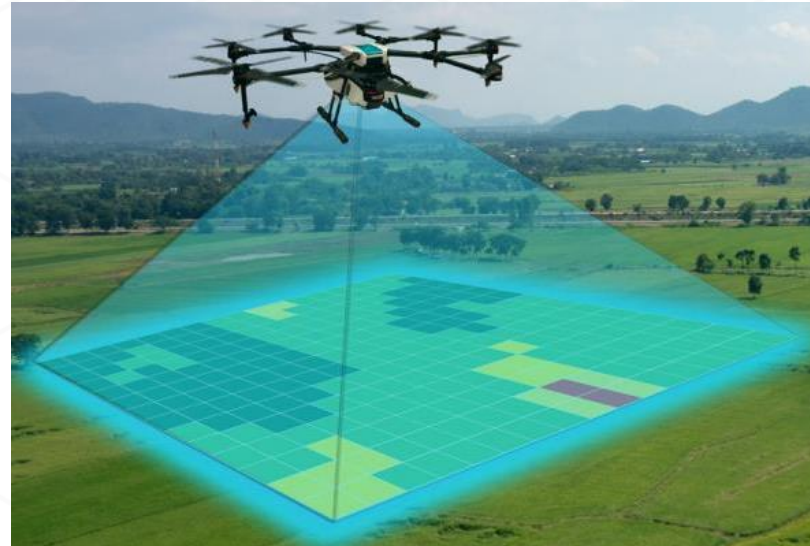
Modern Remote Sensing Sensors Carriers

Airplanes



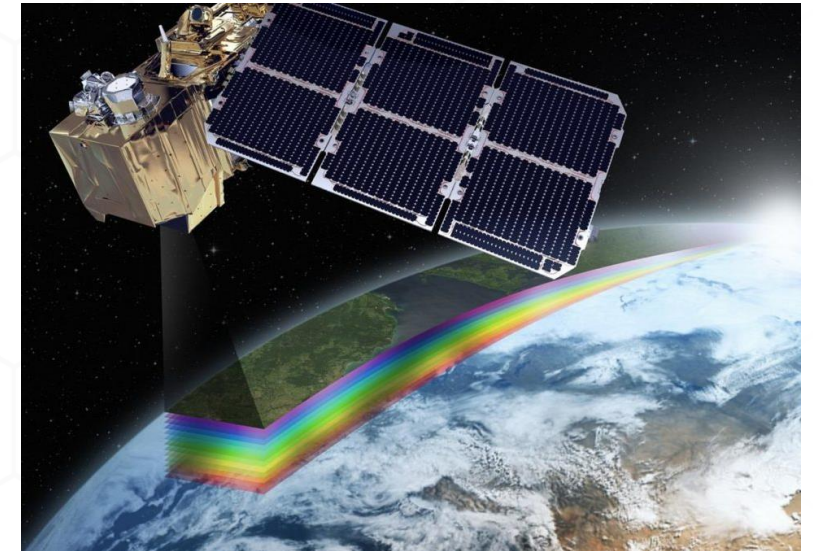
Source: <https://www.slideshare.net/saislideshere/remote-sensing-sainath-aher>

UAVs



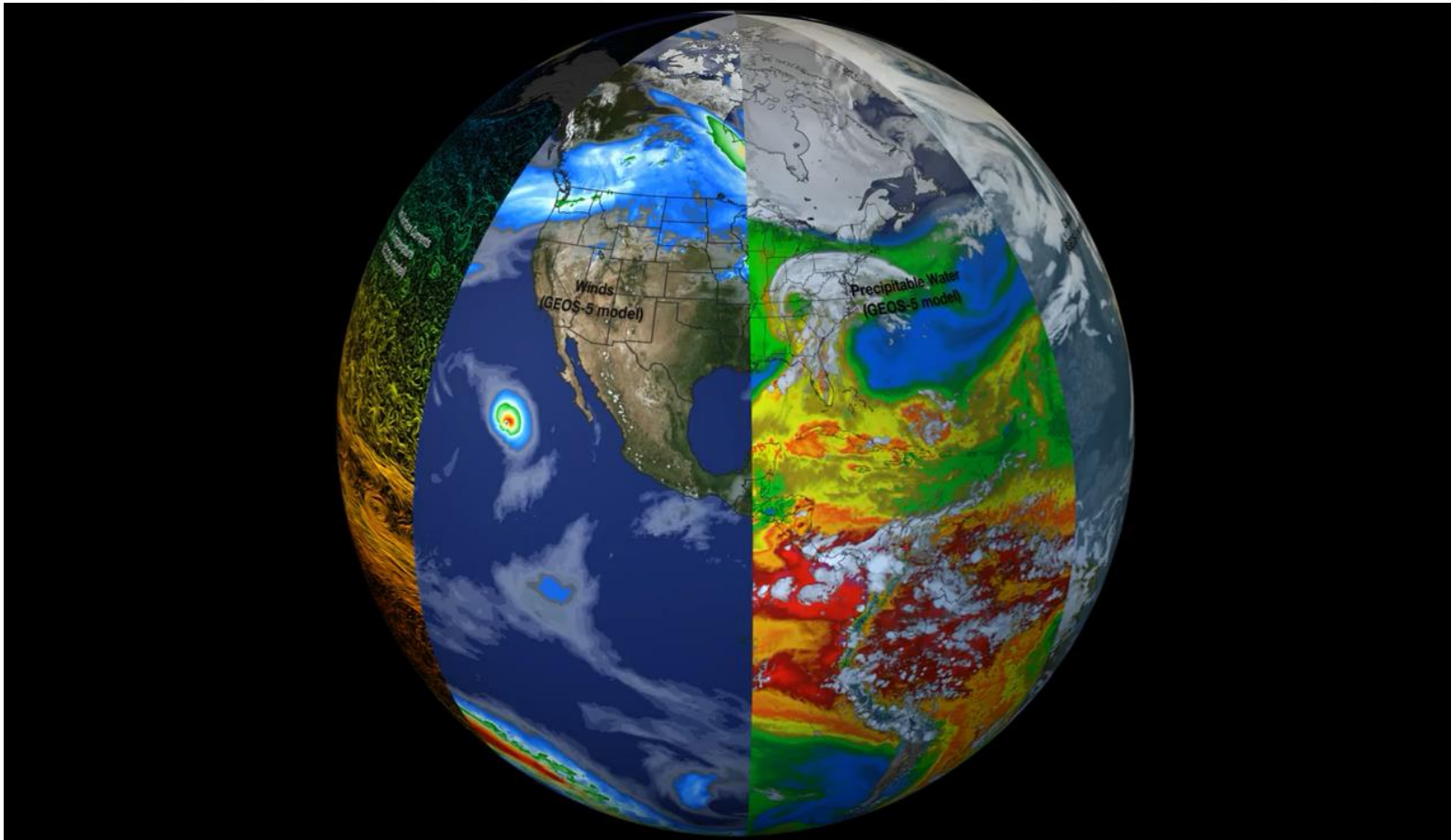
Source: <https://www.inrae.fr/en/news/remote-sensing-dossier>

Satellites



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

Earth is a System of Systems



Earth is the planet ESA studies more than any other.

Like our own bodies, the Earth is made up of connected, but different systems that interact in complex ways.

A change in one system can result in changes in one or more other systems.

Satellites study the entire Earth System to not only observe what is changing but also understand how changes in one of these systems impact all the others.

ESA Developed Earth Observation Missions





PROGRAMME OF THE
EUROPEAN UNION



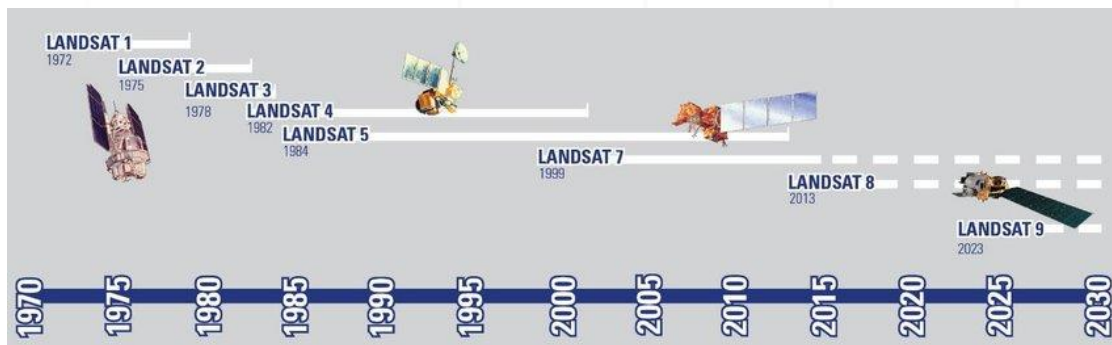
co-funded with



Copernicus

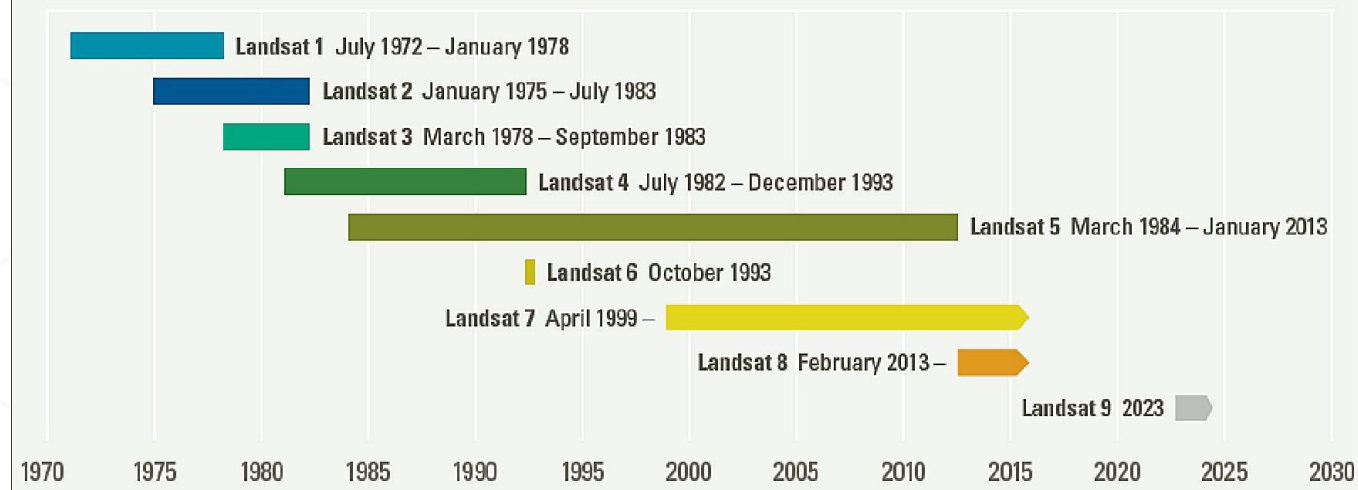


Landsat Mission of the NASA



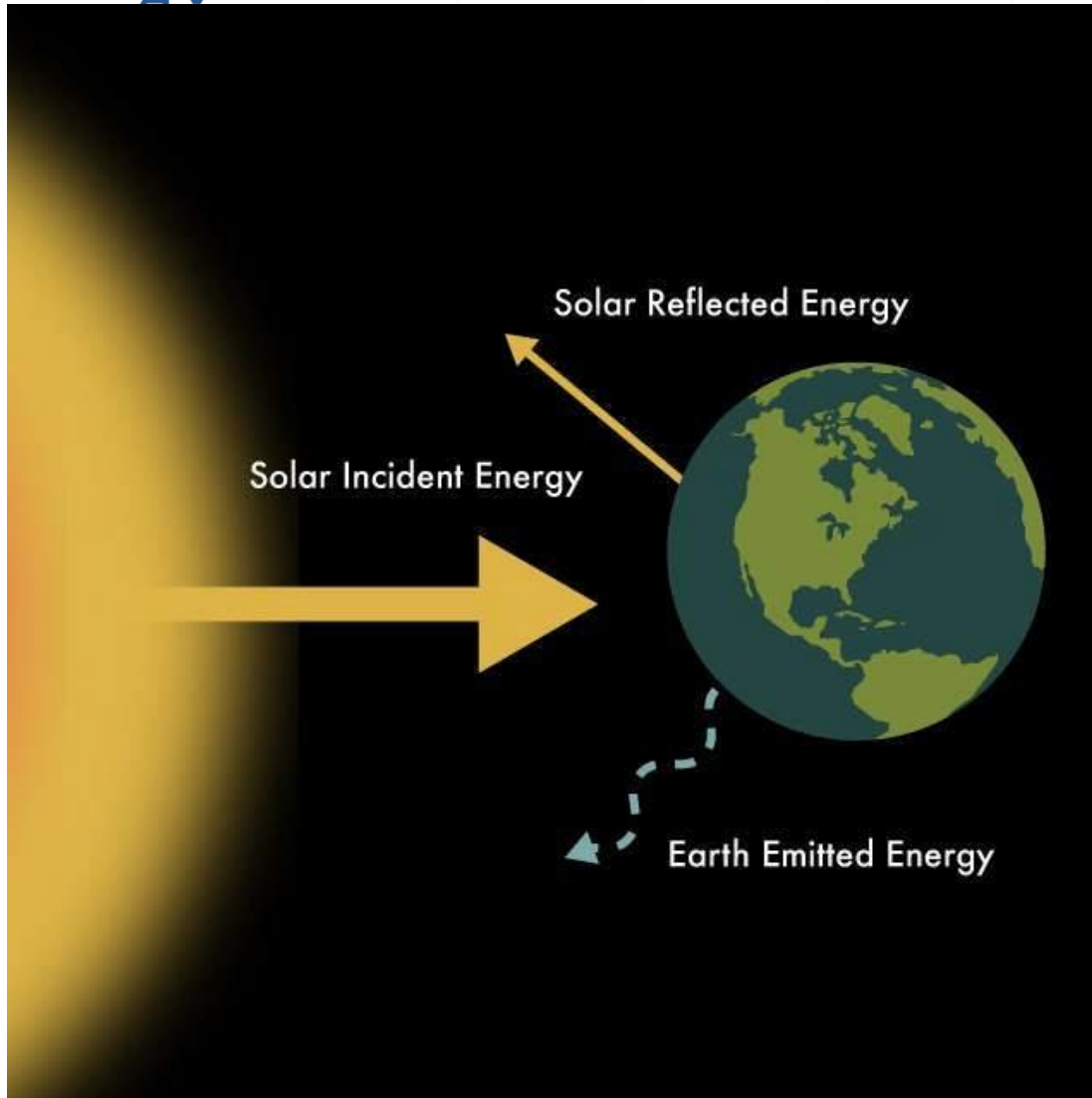
Landsat 9 was launched on September 27, 2021 at 1:12PM CST from Vandenberg Air Force Base, California

Landsat Missions: Imaging the Earth Since 1972



The Main Source of Energy

Electromagnetic radiation

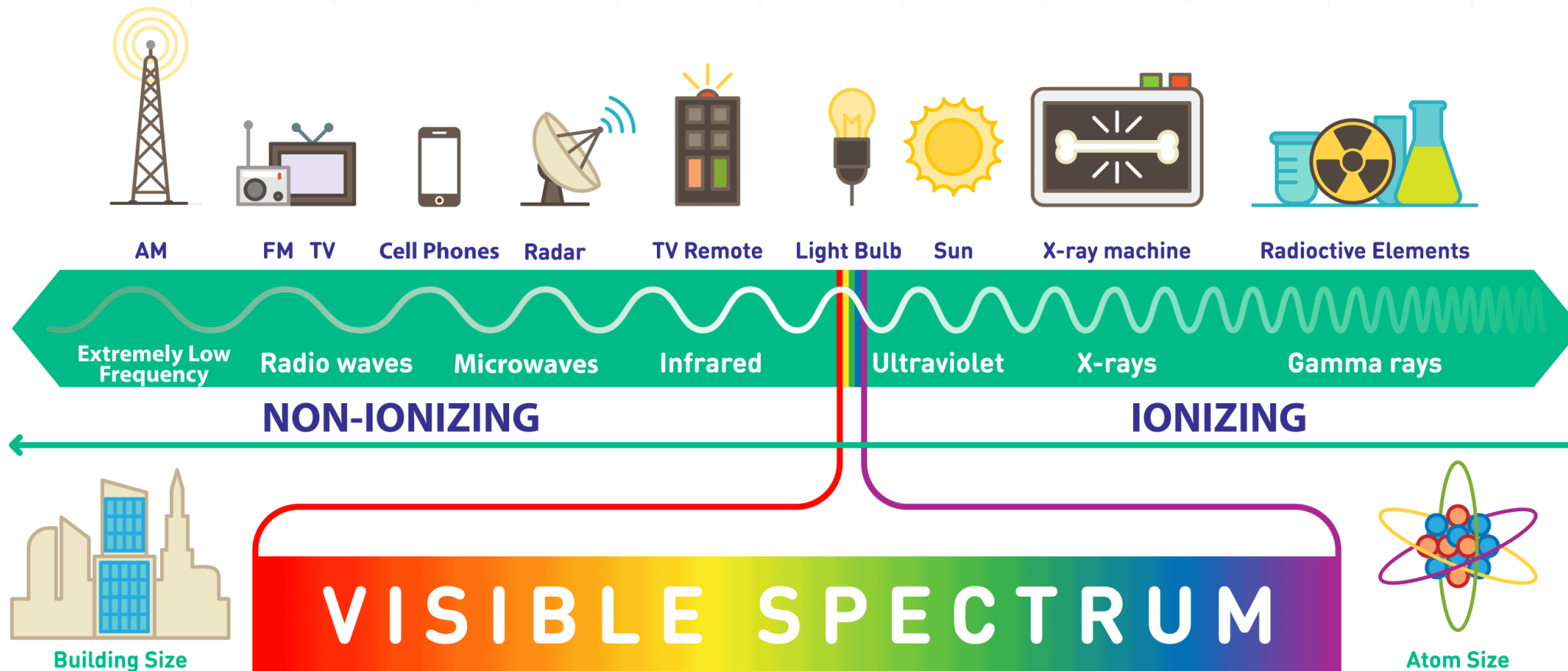


Incident Solar Energy is the radiant **solar energy** that hits the earth's surface and is referred as “global radiation” on a surface.

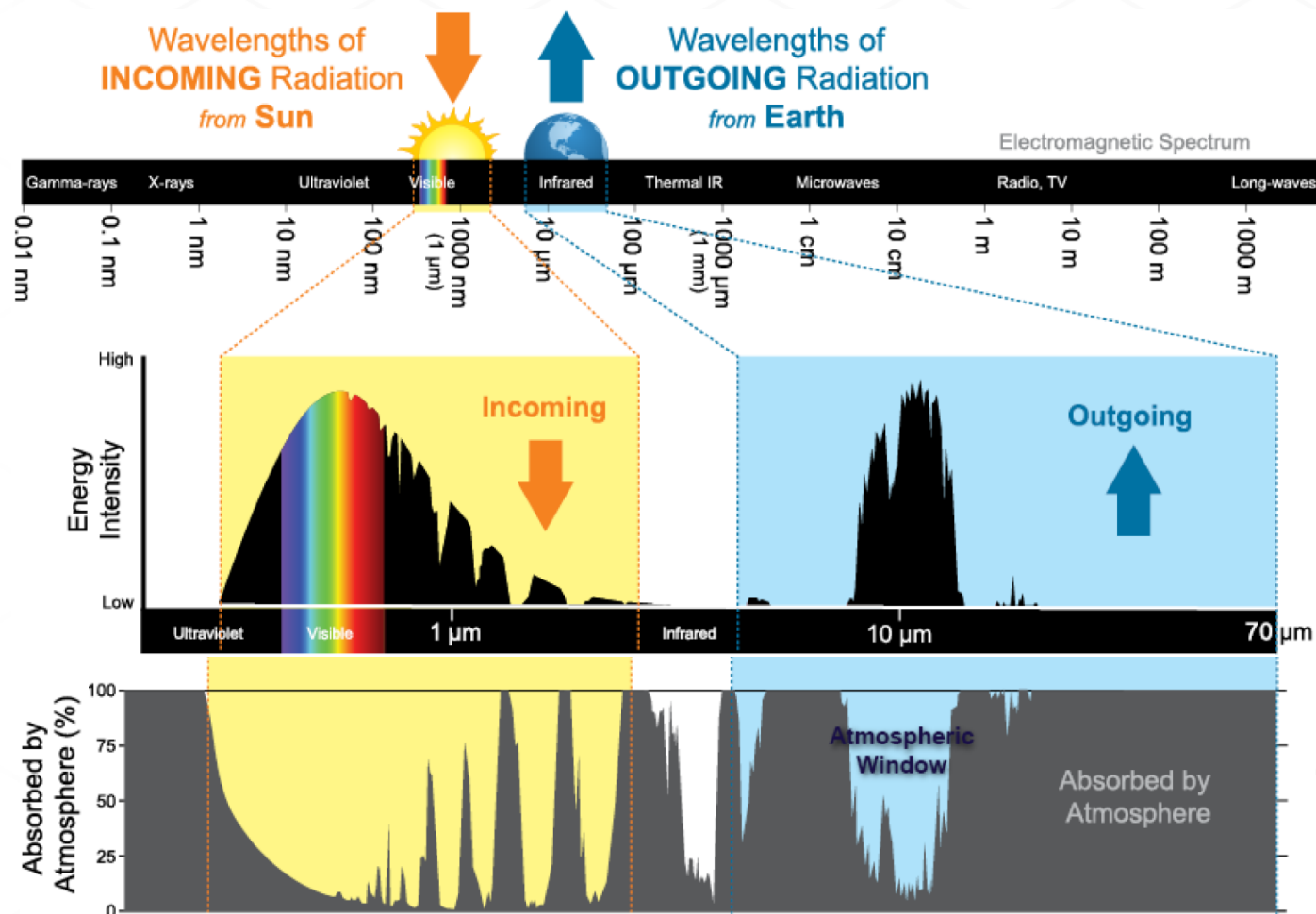
Reflected Solar Energy describes sunlight that has been **reflected** off of non-atmospheric things such as the Earth's surface.

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

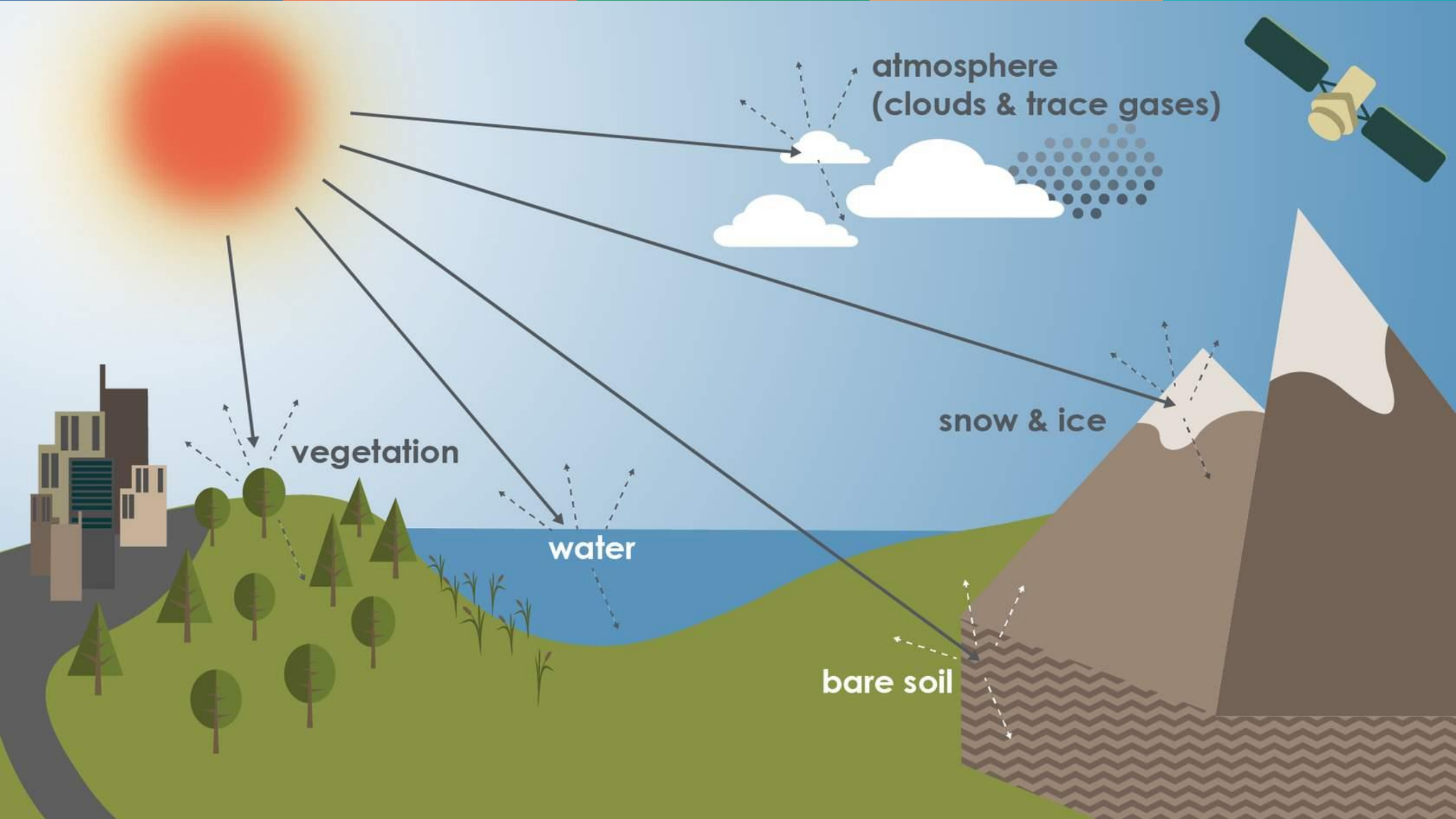
Electromagnetic Spectrum

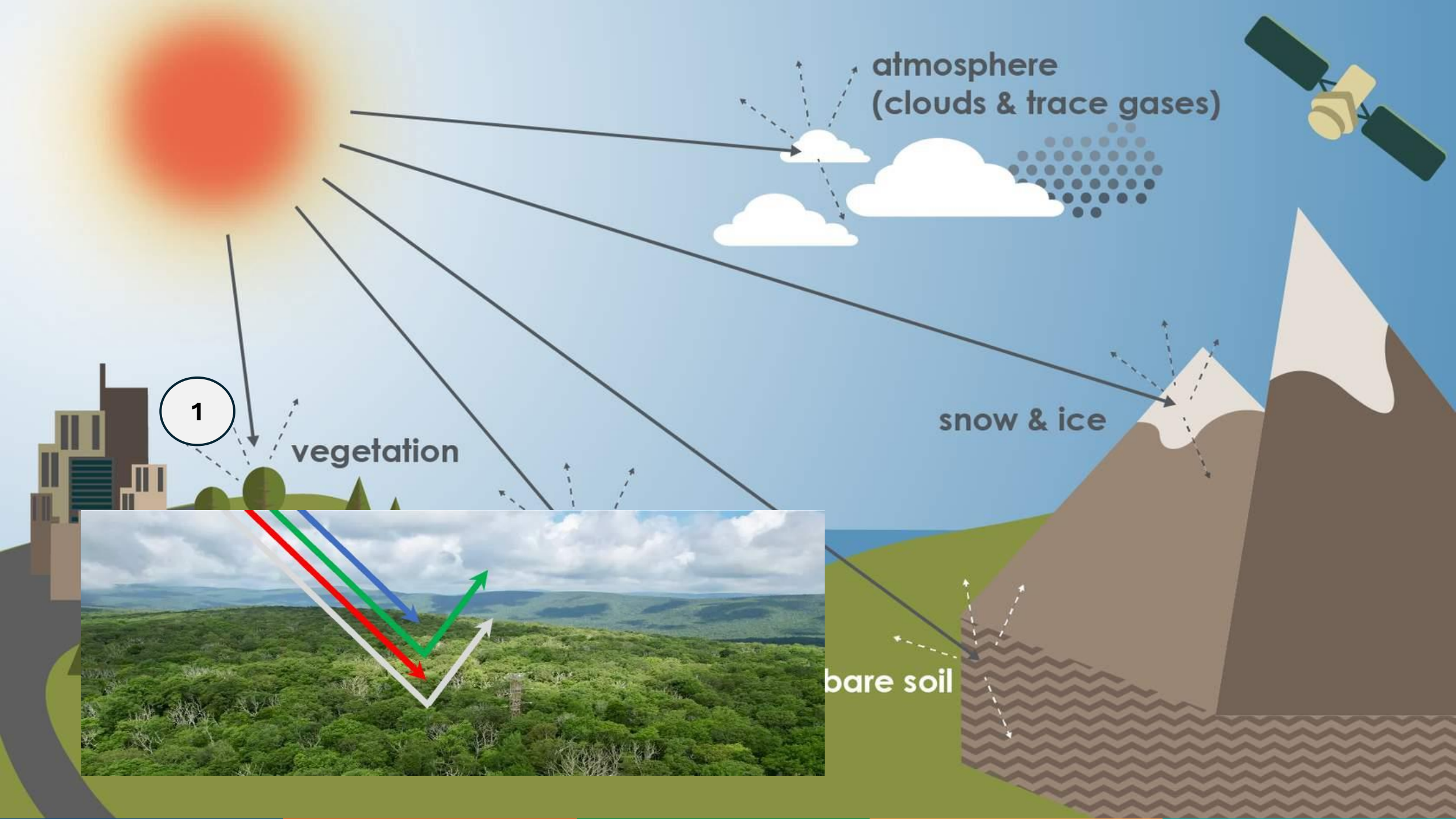


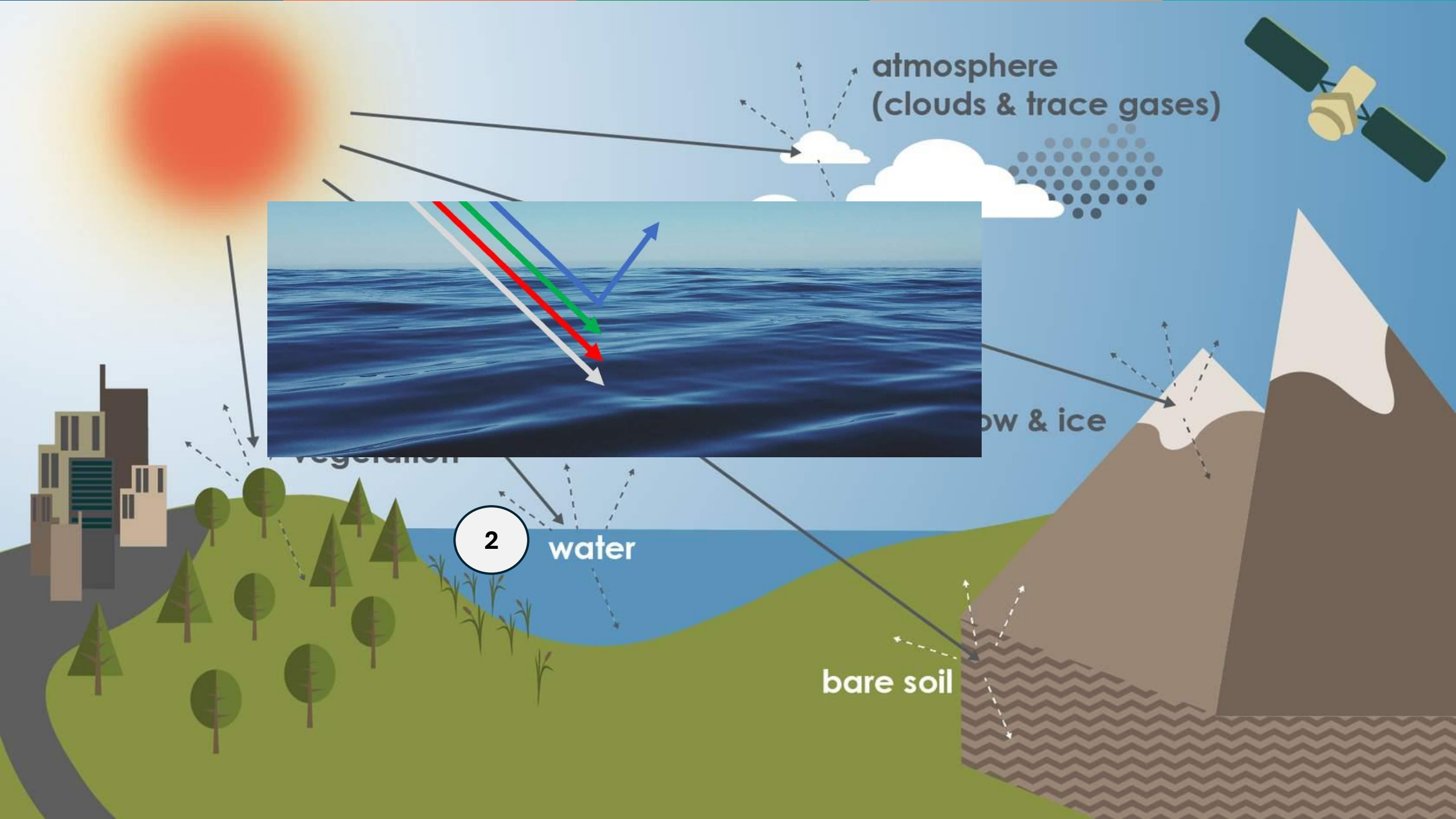
Atmospheric Windows

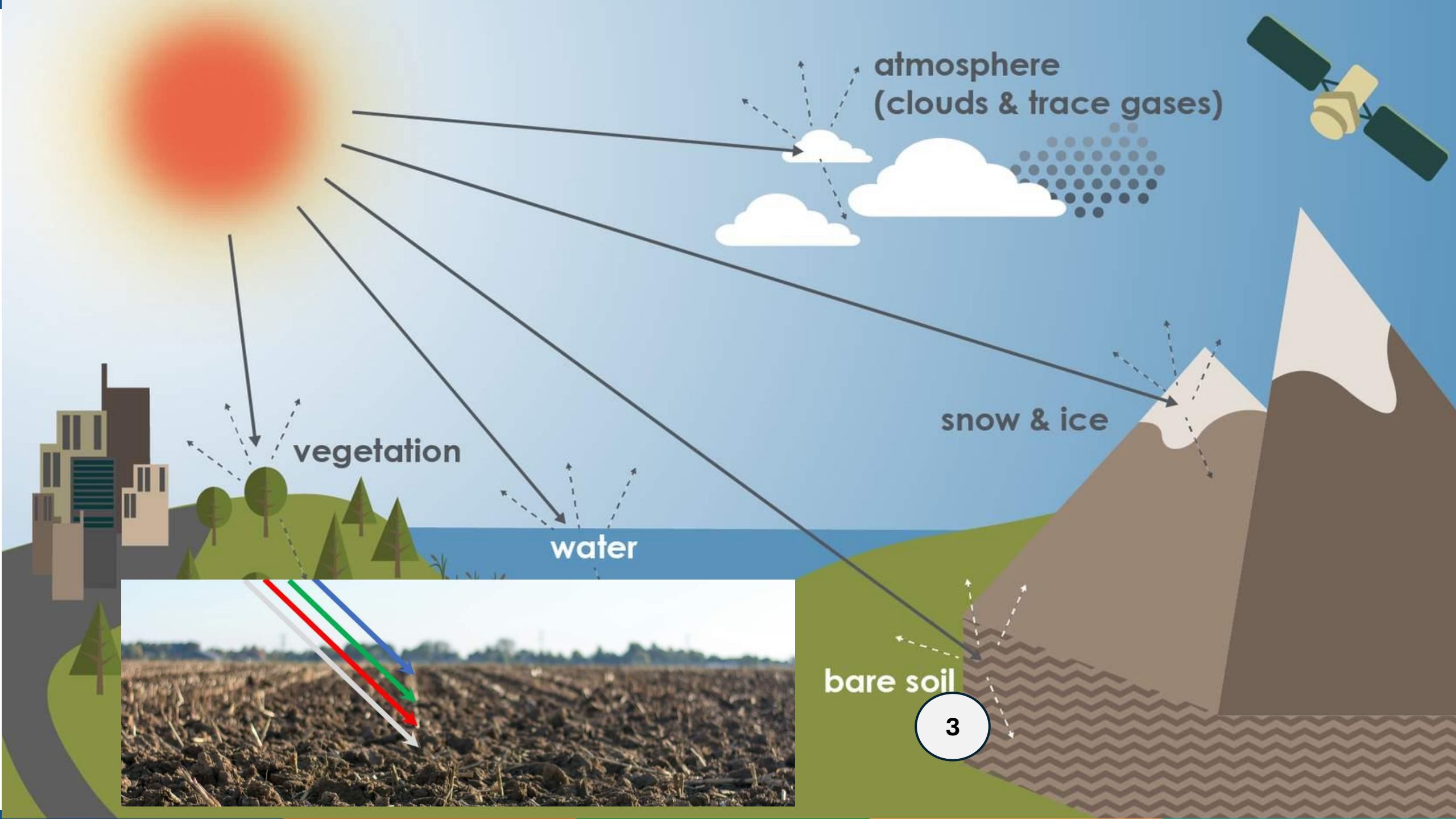


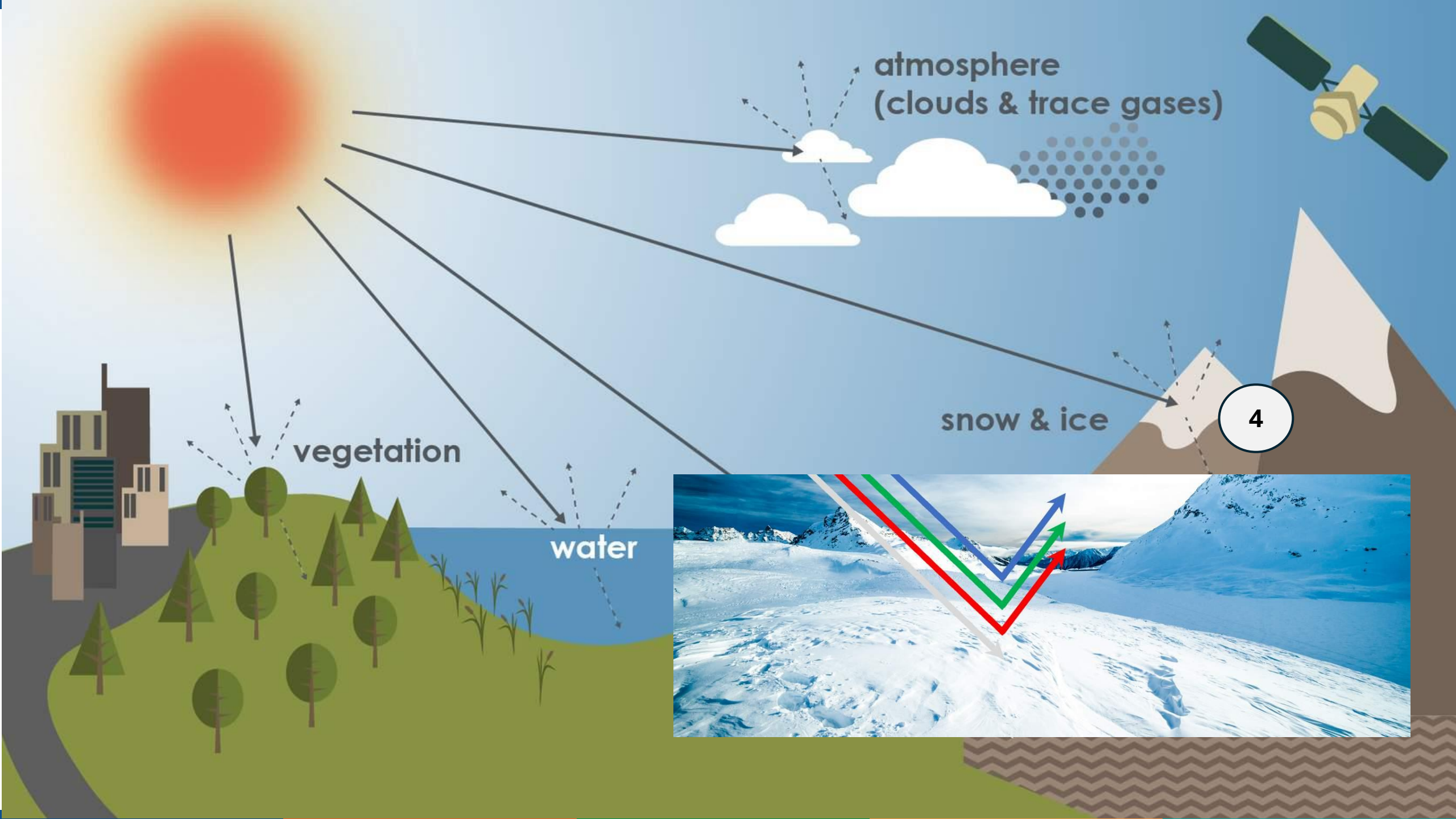
These are wavelength ranges where the Earth's atmosphere is transparent, allowing radiation to pass through. Earth observation sensors are designed to use these windows (e.g., visible light, some infrared, and microwave).

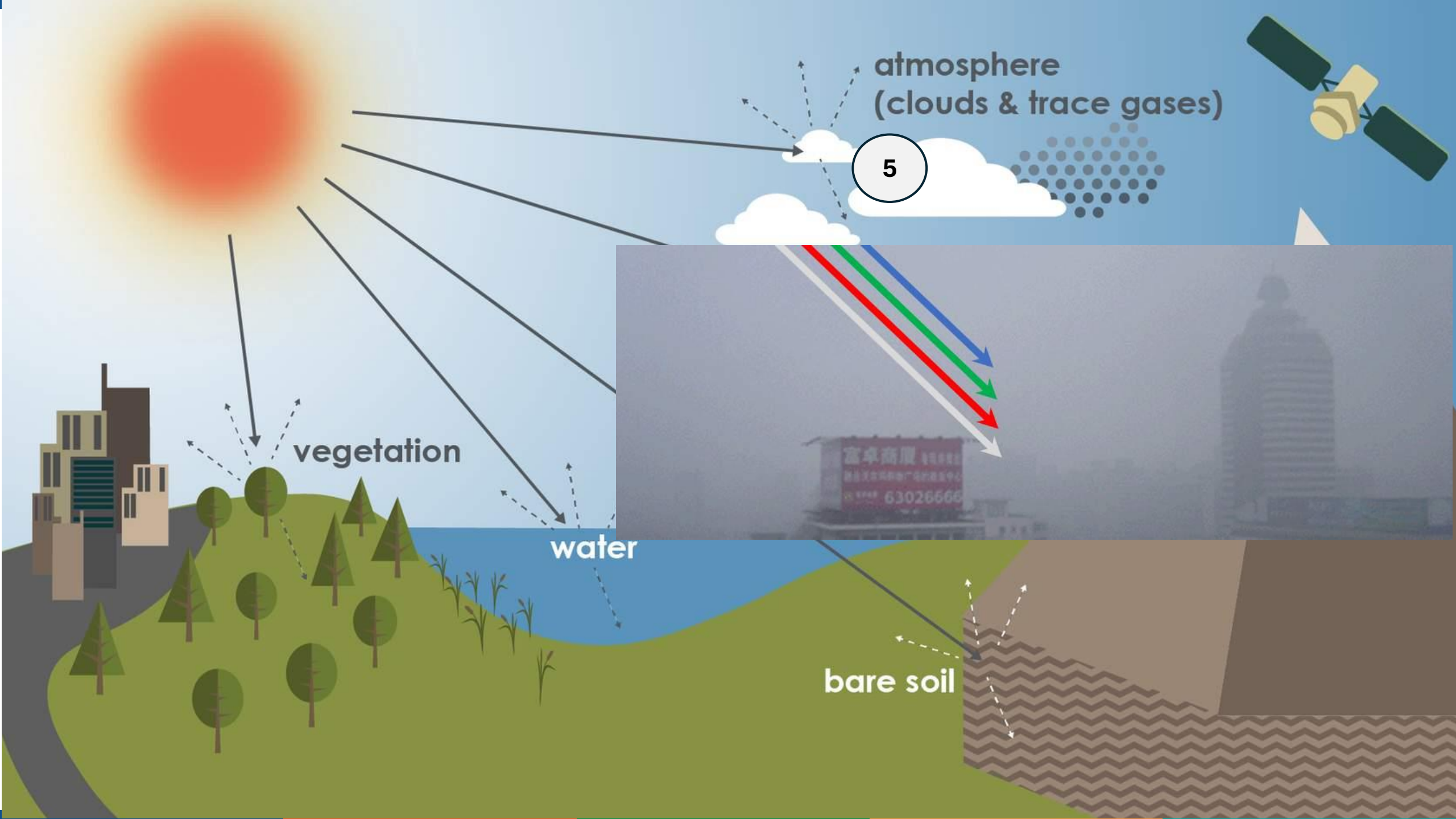




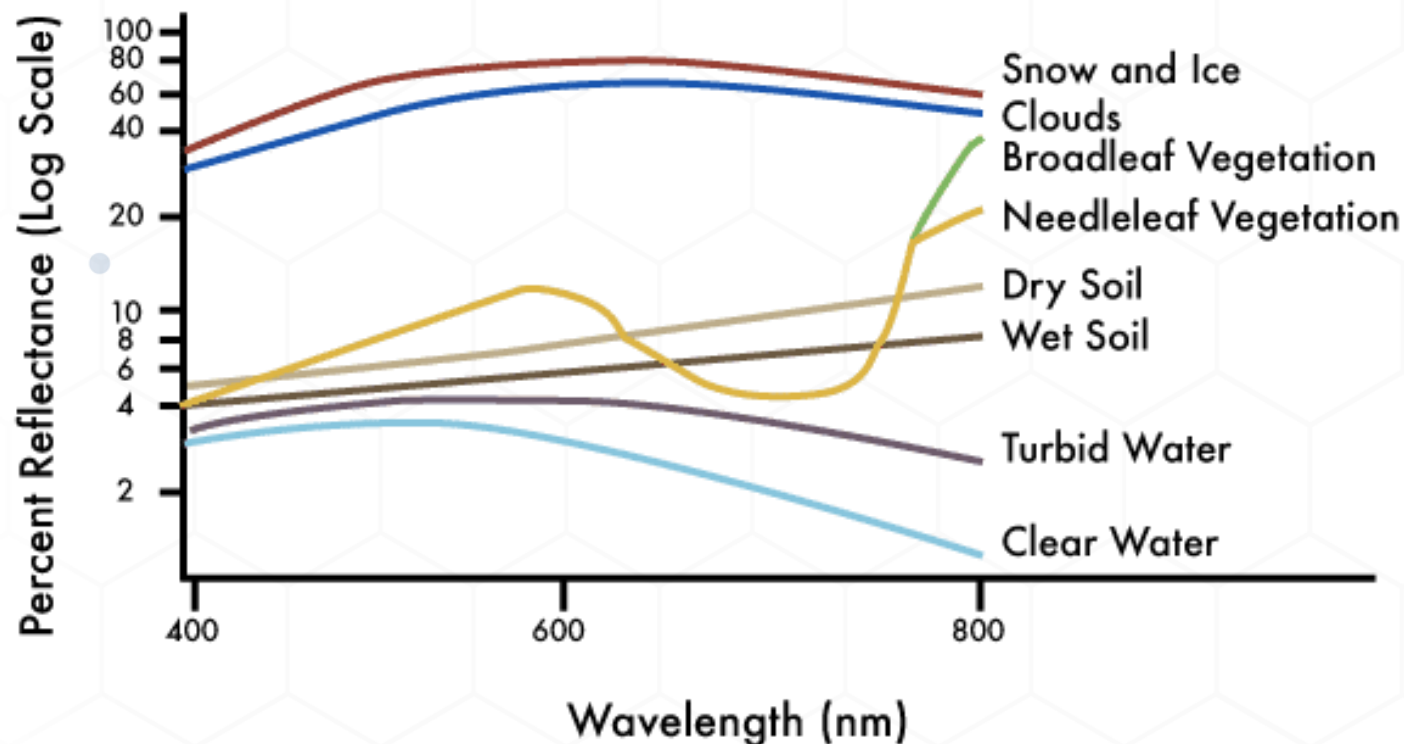






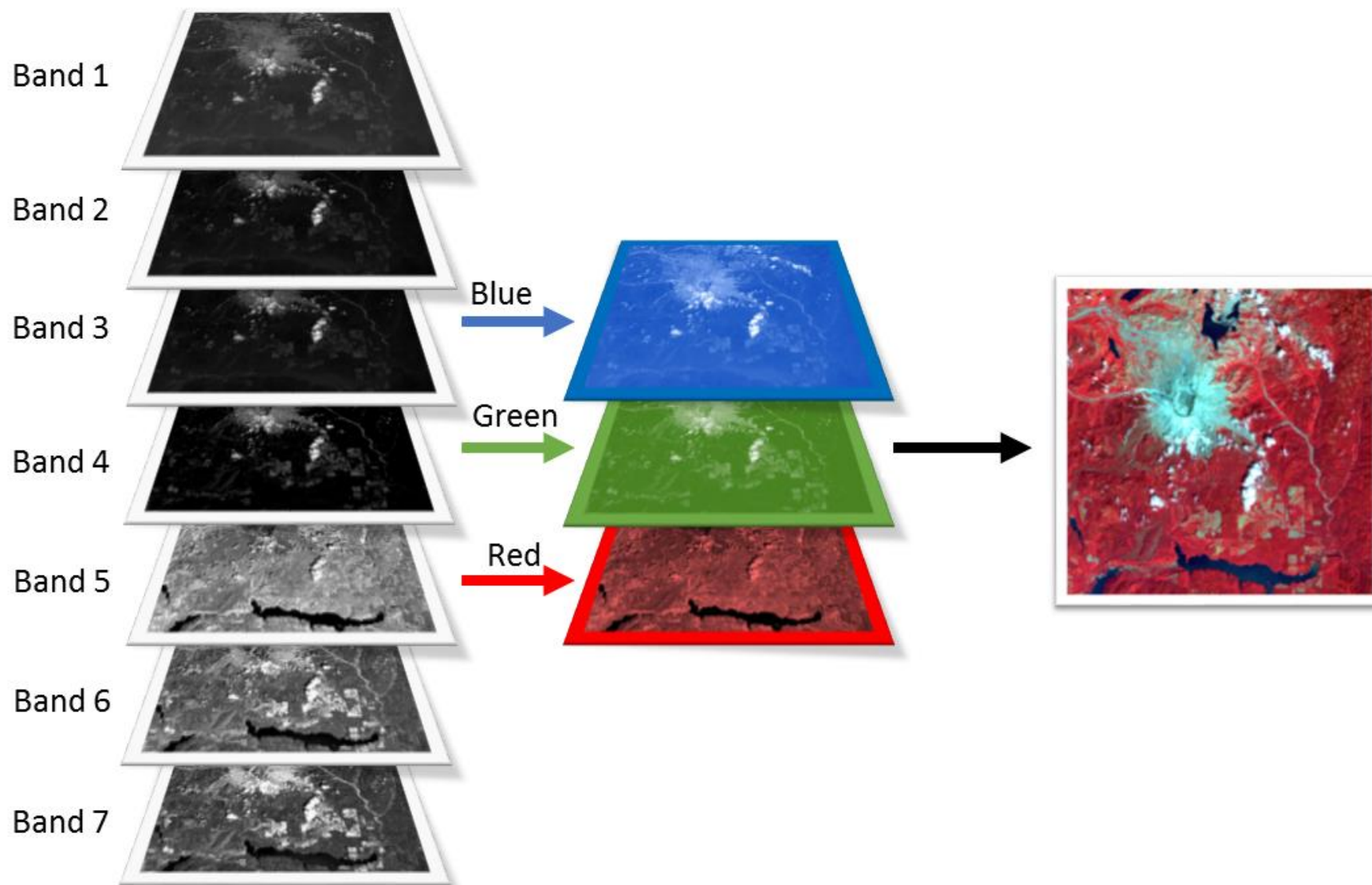


Spectral Signatures

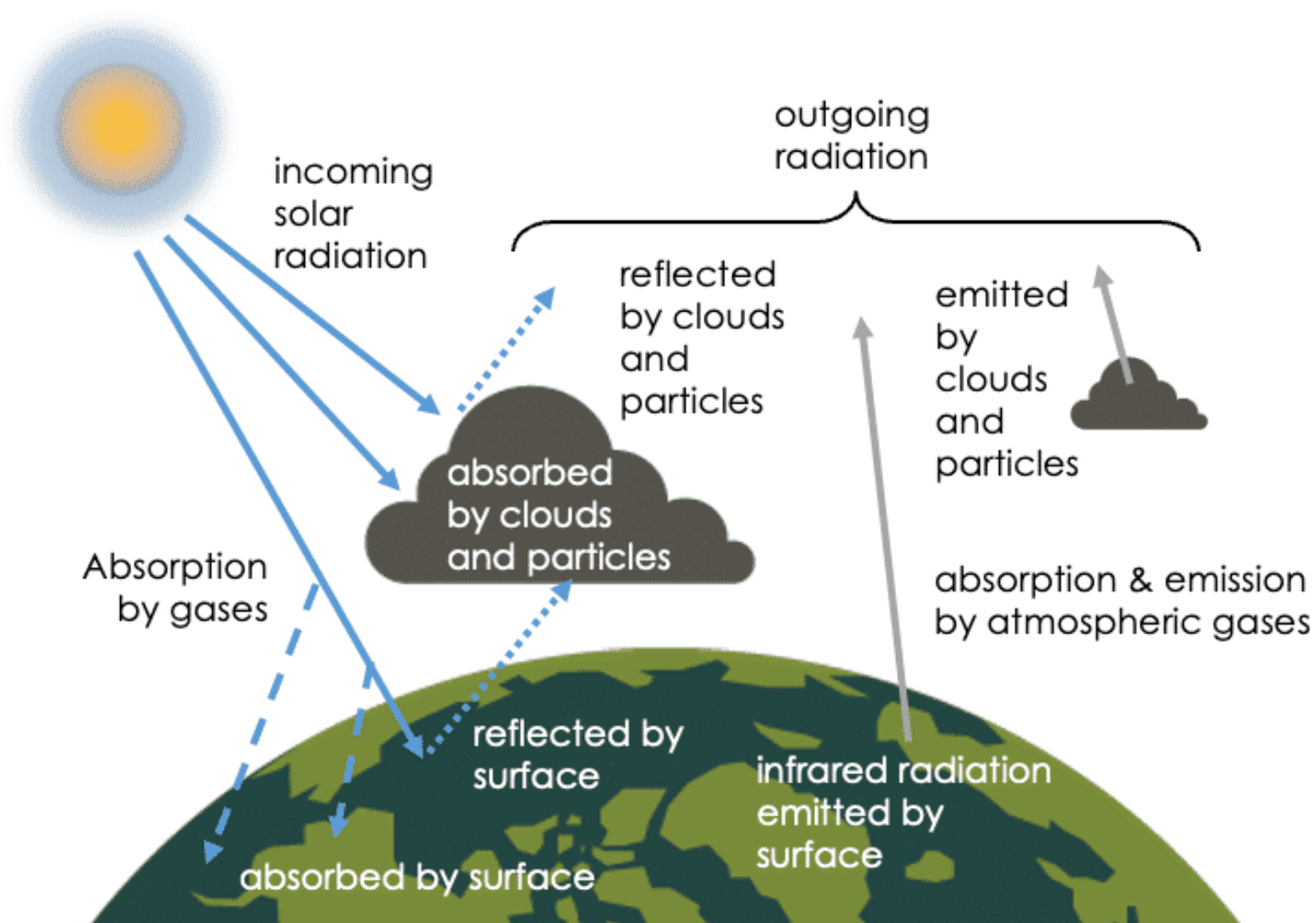


Different materials reflect and absorb different wavelengths of electromagnetic radiation. Because of this, you can look at the reflected wavelengths detected by a sensor and determine the type of material it reflected off of. This is known as a spectral signature. In the graph on the left you can see the relationship between percent reflectance and the reflective wavelengths of different components of the Earth's surface.

Bands of a Satellite Image



Atmospheric Interference



Processing Levels of Satellite Data

Level-0
Raw Instrument Data

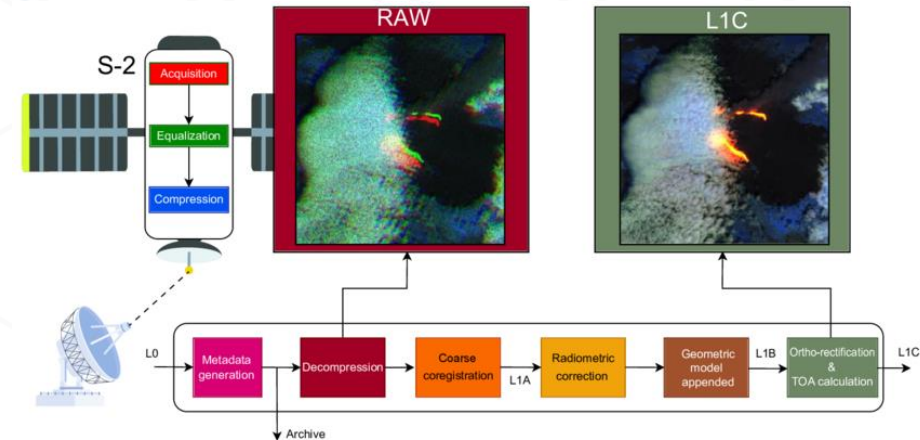
Level-1A
Georeferenced,
Radiometrically
Corrected, but Not
Orthorectified

Level-2A
Bottom-of-
Atmosphere
Reflectance =
“Surface Reflectance”

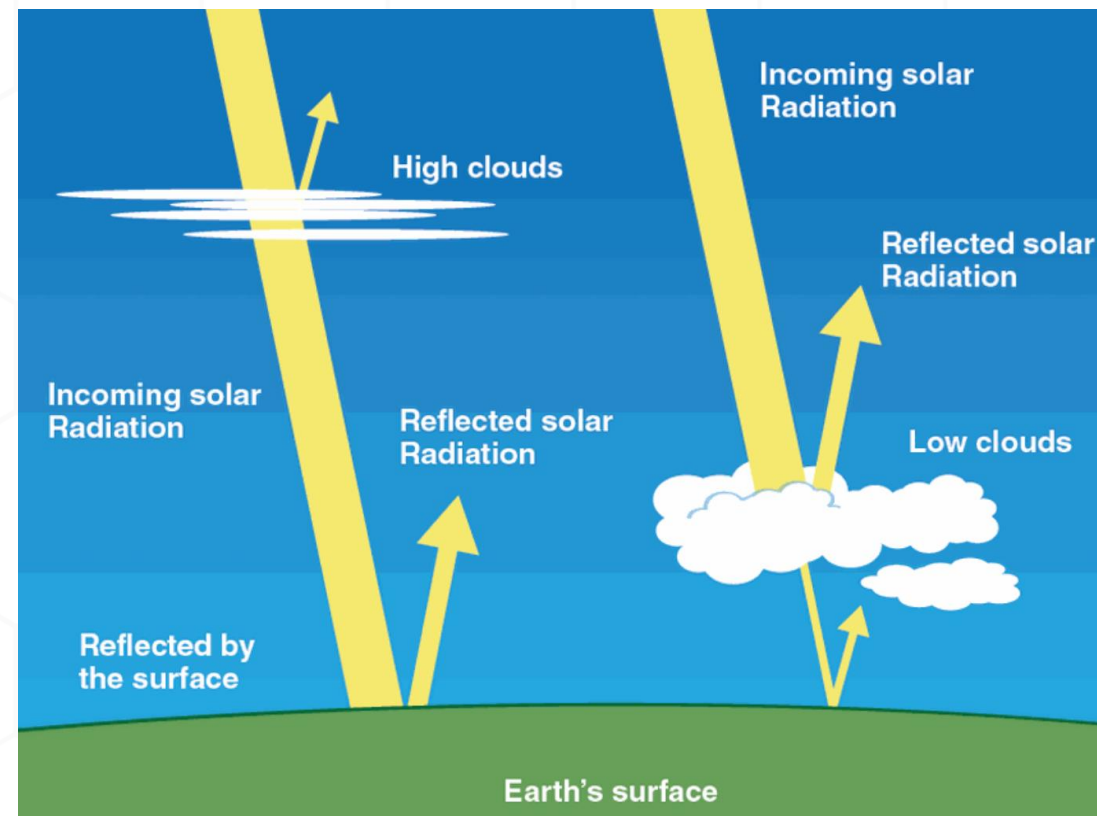
Level-1B
Top-of-Atmosphere
Radiance

Level-1C
Top-of-Atmosphere
Reflectance,
Orthorectified

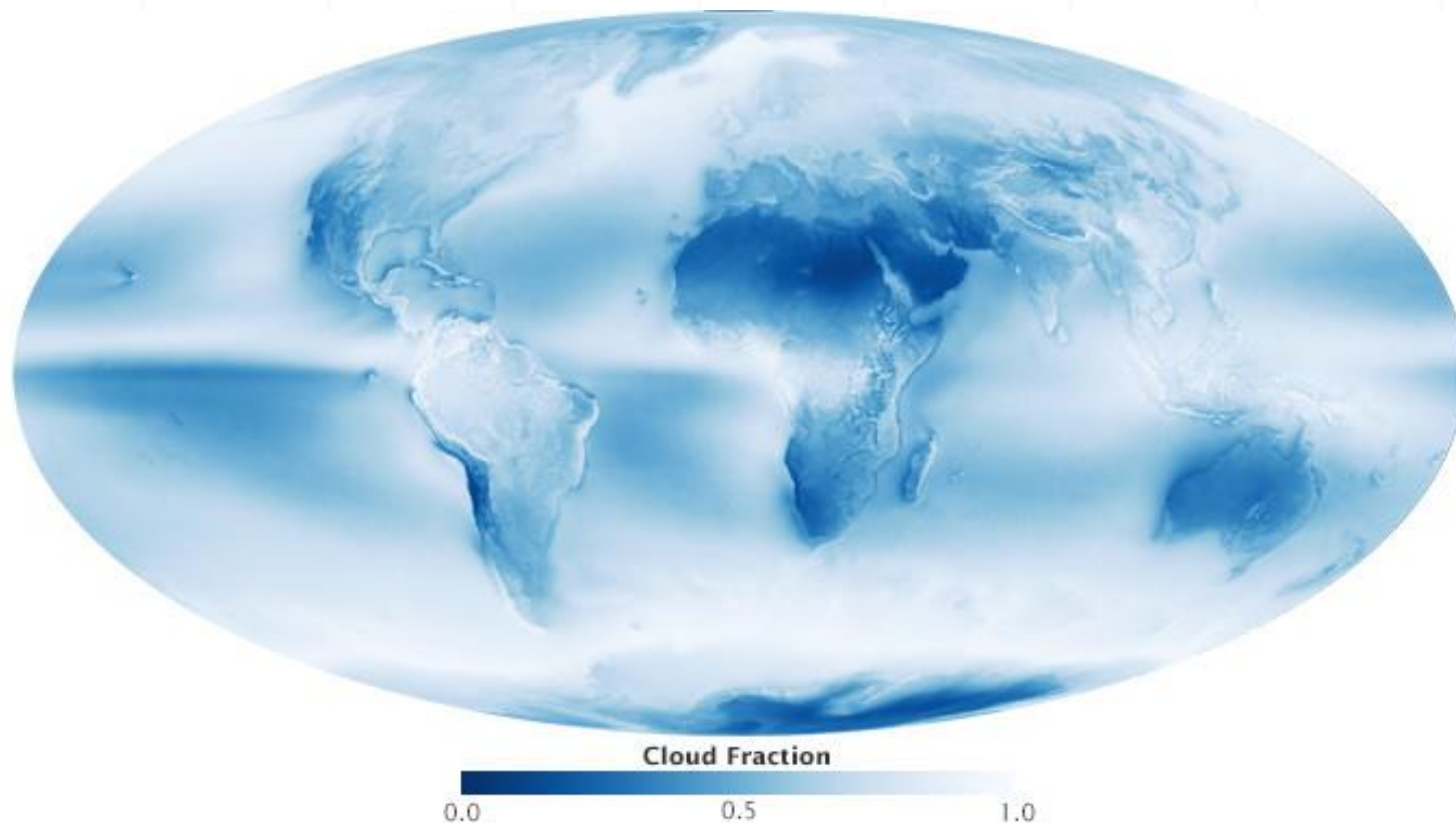
Higher-Level Products (Derived / Thematic) Top-of-Atmosphere Radiance
Mosaics or temporal composites (e.g., monthly NDVI averages).
Biophysical variables (Leaf Area Index, Fraction of Absorbed
Photosynthetically Active Radiation, etc.) — e.g., Copernicus Global Land
Service products.



Cloud Cover and Optical Satellite Sensors



Cloudy Earth

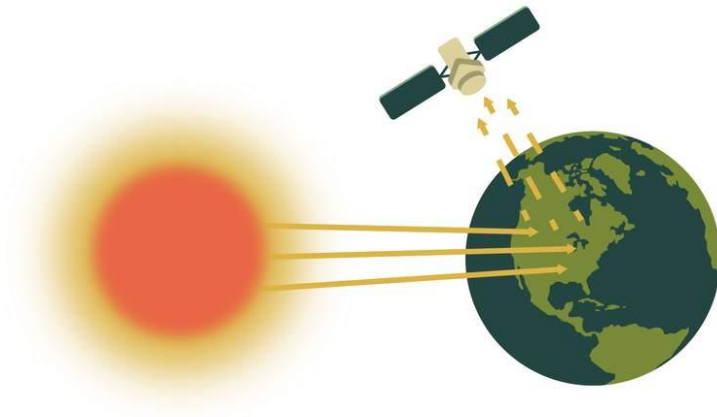


Earth's cloudy nature is unmistakable in **this global cloud fraction map**, based on data collected by the **Moderate Resolution Imaging Spectroradiometer (MODIS)** on the Aqua satellite.

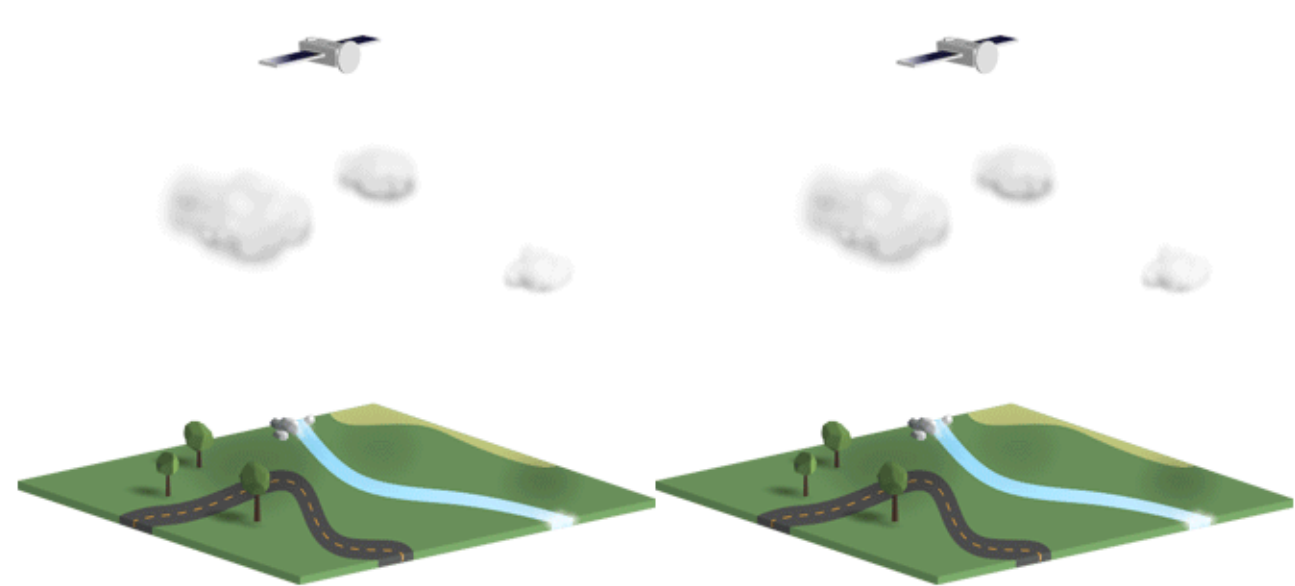
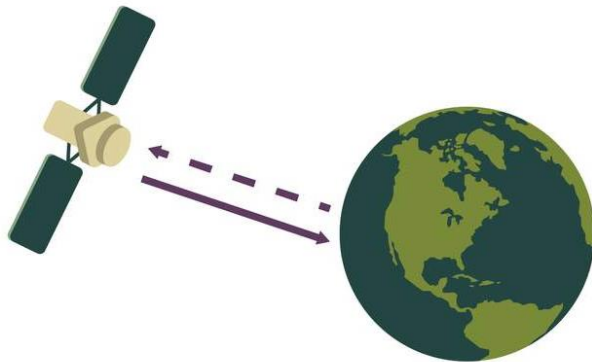
While MODIS collects enough data to make a new global map of cloudiness every day, this version of the map shows an **average of all of the satellite's cloud observations between July 2002 and April 2015**. Colors range from **dark blue (no clouds) to light blue (some clouds) to white (frequent clouds)**.

Passive vs Active Sensors

Passive Sensors



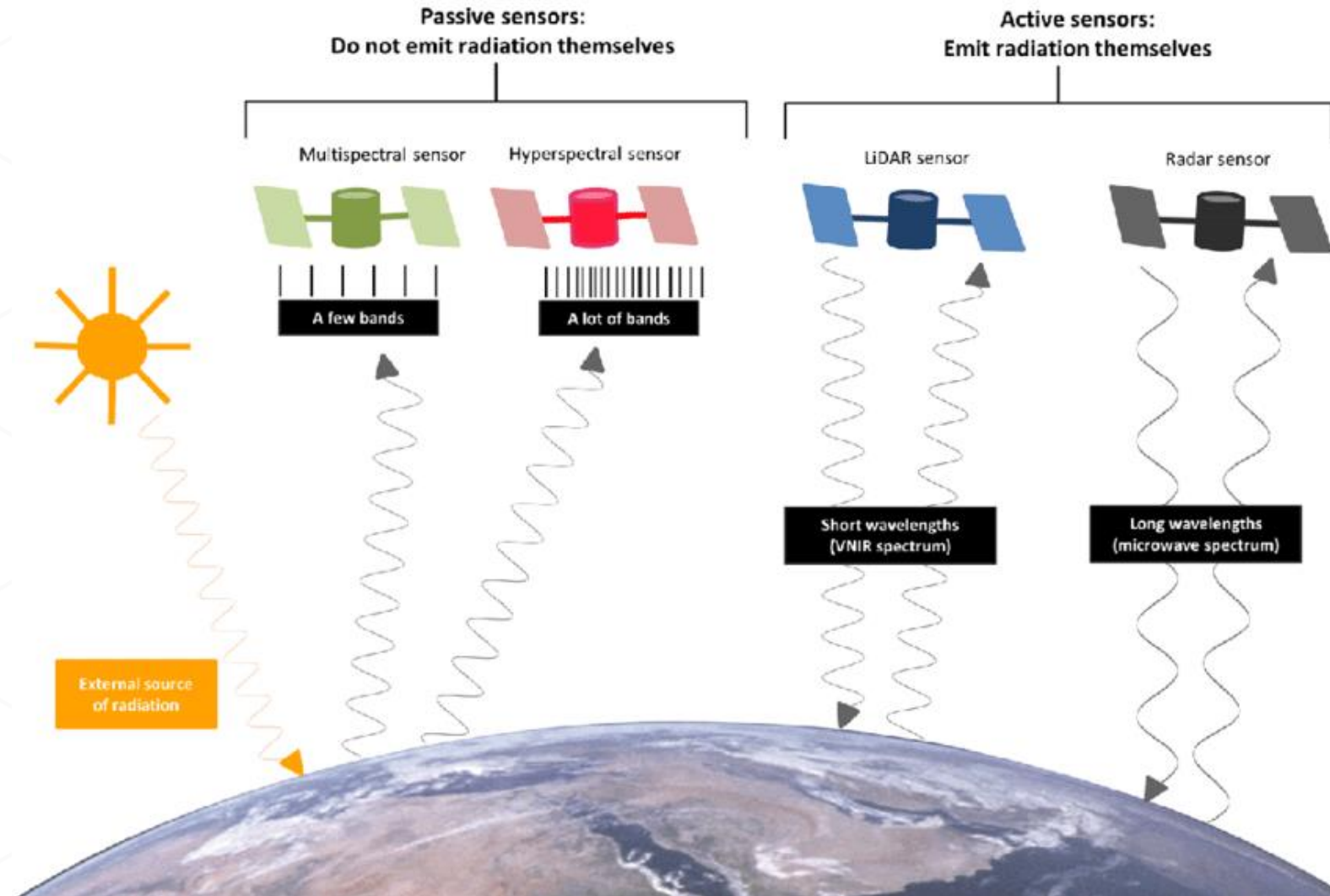
Active Sensors



Passive | Sensors detect only what is emitted from the landscape, or reflected from another source (e.g., light reflected from the sun).

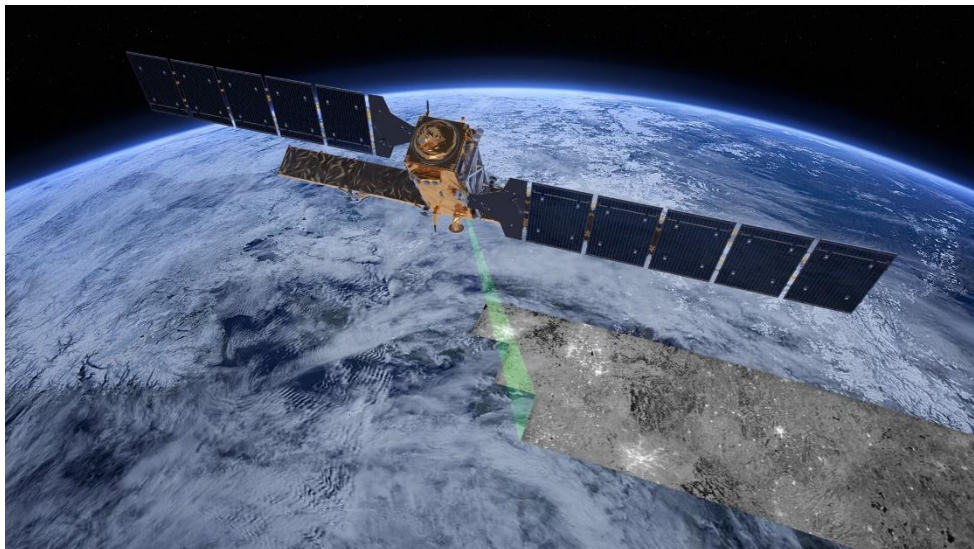
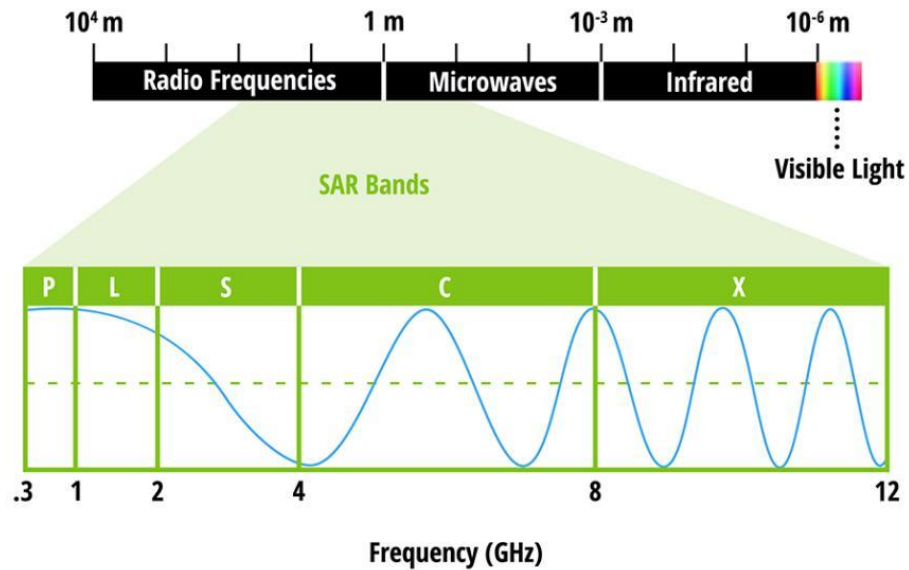
Active | Instruments emit their own signal and the sensor measures what is reflected back. Sonar and radar are examples of active sensors.

Passive VS Active Remote Sensing

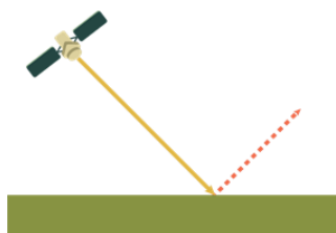




Synthetic Aperture Radar (SAR)



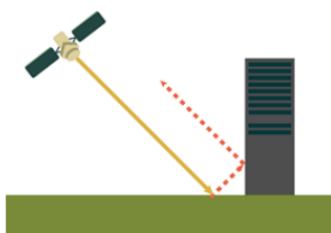
Band	Frequency	Wavelength	Typical Application
Ka	27–40 GHz	1.1–0.8 cm	Rarely used
K	18–27 GHz	1.7–1.1 cm	Rarely used
Ku	12–18 GHz	2.4–1.7 cm	Rarely used
X	8–12 GHz	3.8–2.4 cm	High resolution SAR (urban monitoring, ice and snow, little penetration into vegetation cover; fast coherence decay in vegetated areas)
C	4–8 GHz	7.5–3.8 cm	SAR Workhorse (global mapping, change detection, monitoring of areas with low to moderate penetration, higher coherence); ice, ocean, maritime navigation
S	2–4 GHz	15–7.5 cm	Increasing use for SAR-based Earth observation and agriculture monitoring (NISAR will carry an S-band channel; expands C-band applications to higher vegetation density)
L	1–2 GHz	30–15 cm	Medium resolution SAR (geophysical monitoring, biomass and vegetation mapping, high penetration, interferometric SAR [InSAR])
P	0.3–1 GHz	100–30 cm	Biomass, vegetation mapping, and assessment. Experimental SAR band.



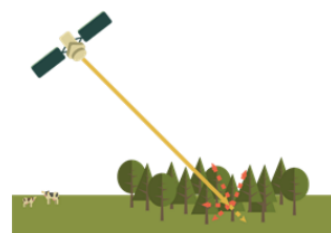
Smooth Surface
(specular Reflector)



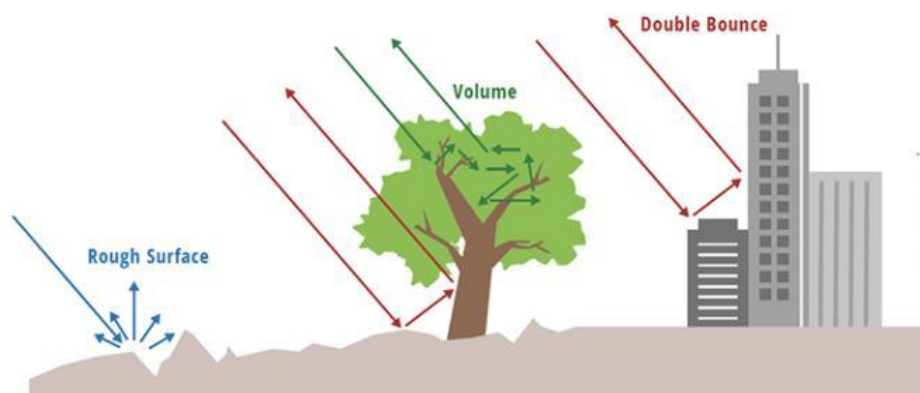
Rough Surface



Double Bounce

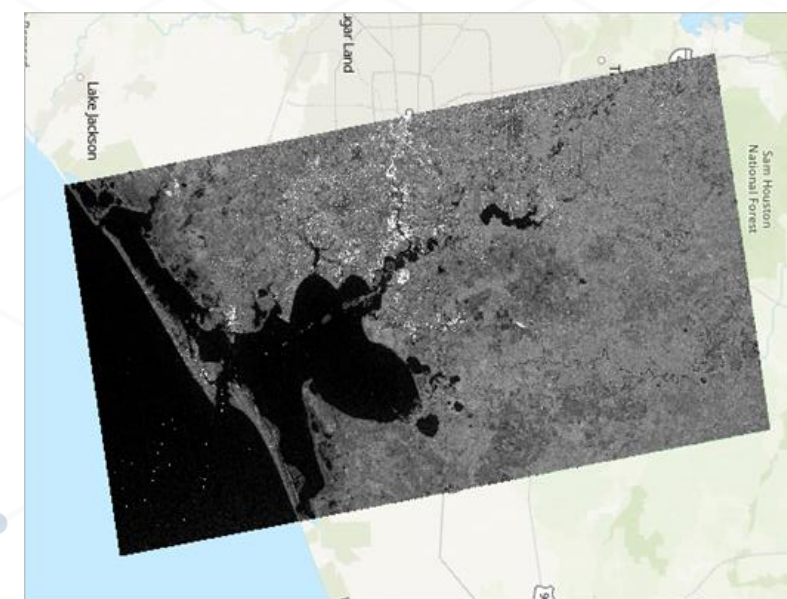
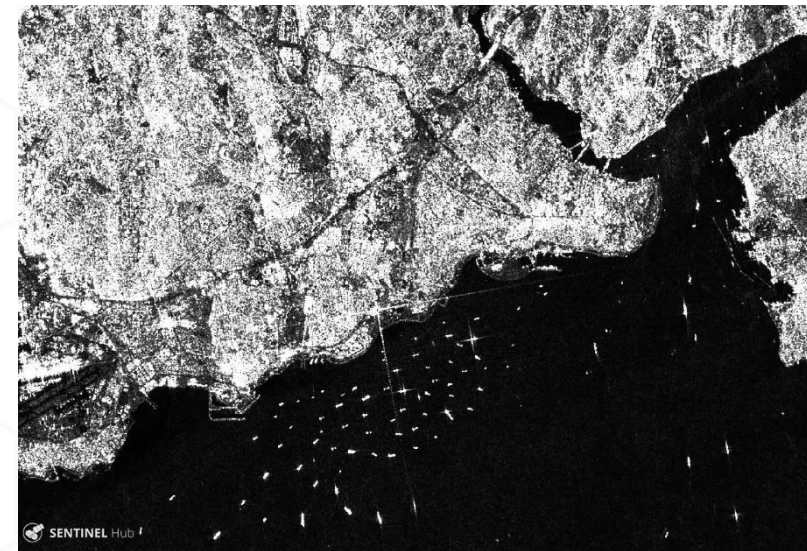


Volumetric



RELATIVE SCATTERING STRENGTH BY POLARIZATION:

Rough Surface Scattering	$ S_{VV} > S_{HH} > S_{VH} $ or $ S_{HV} $
Double Bounce Scattering	$ S_{HH} > S_{VV} > S_{VH} $ or $ S_{HV} $
Volume Scattering	Main source of $ S_{VH} $ and $ S_{HV} $





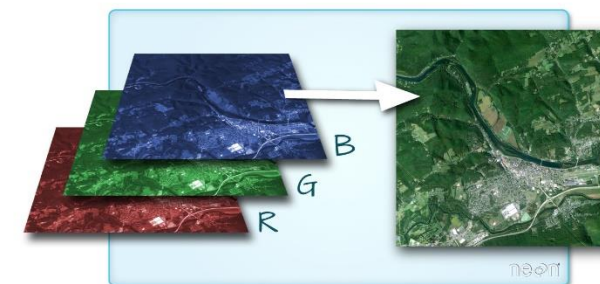
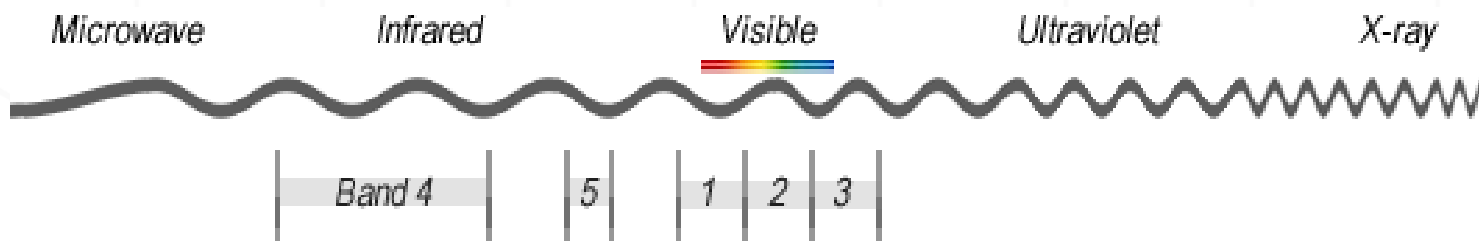
Sentinel 2



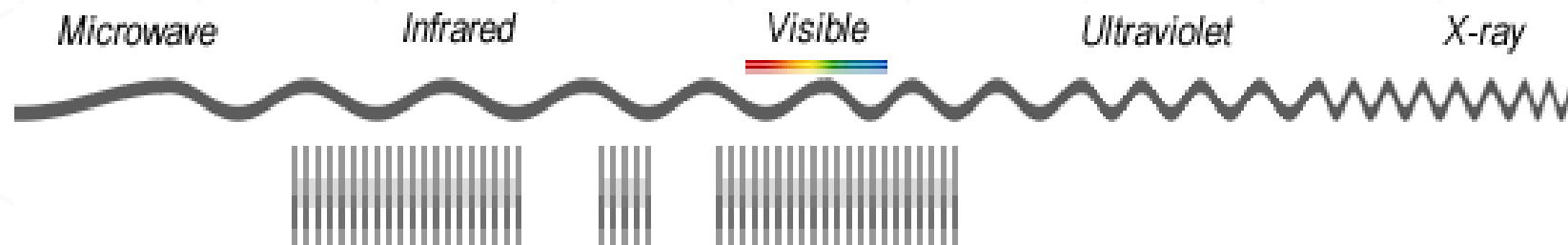
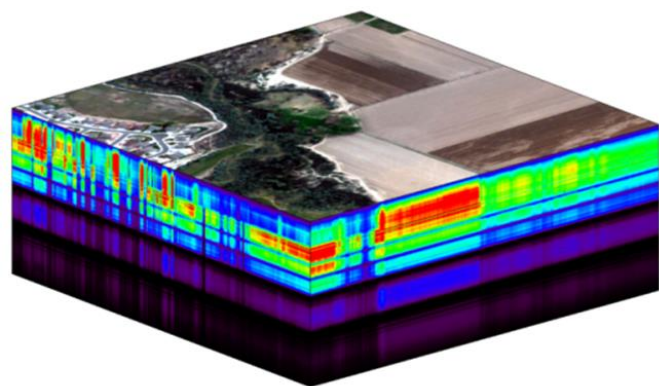
Sentinel 1

Multispectral VS Hyperspectral

Multispectral

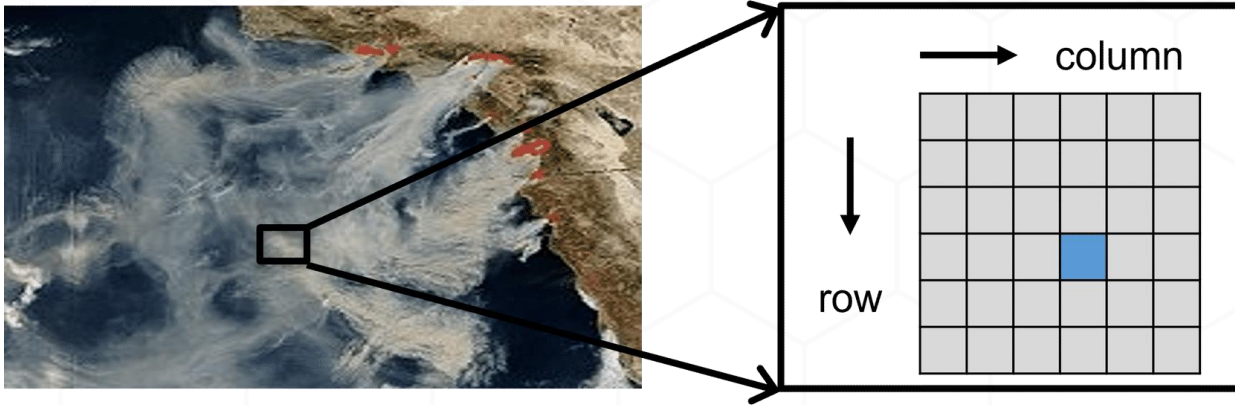


Hyperspectral

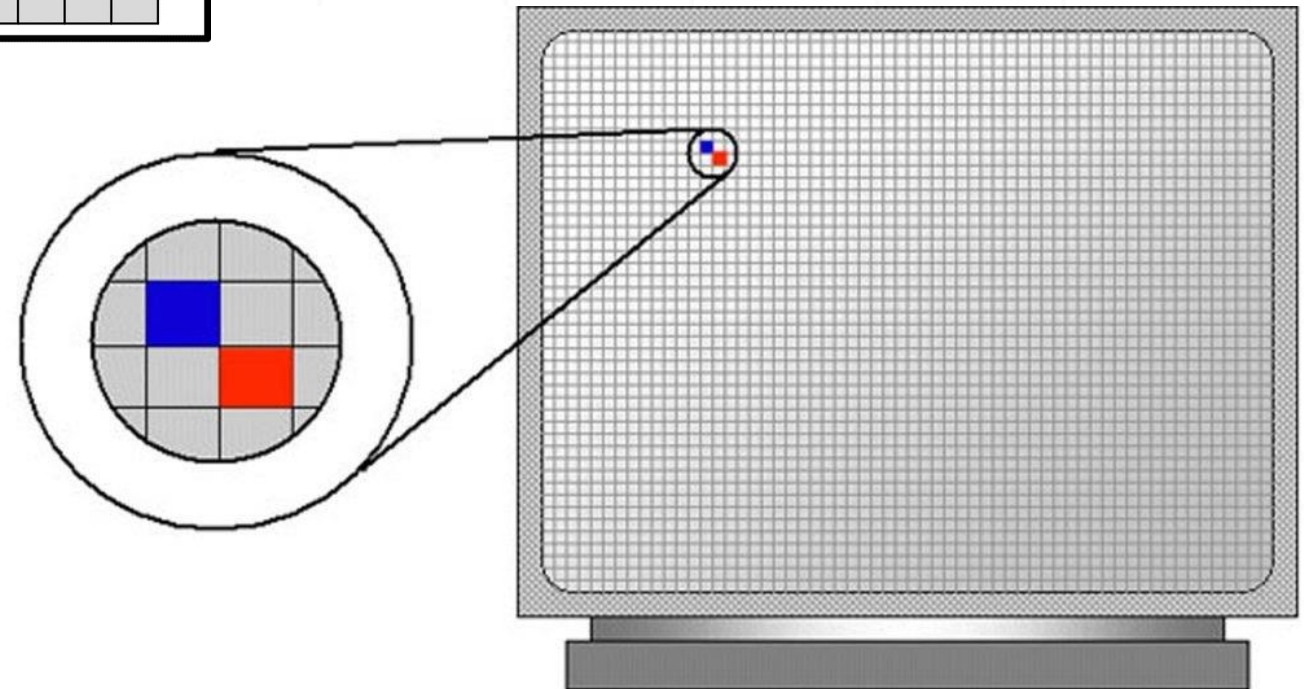


Types of Resolution

Structural Unit of an Image



The **pixel** (a word invented from the "picture element") is the basic unit of programmable color on a computer display or in a computer image.



Spatial Resolution

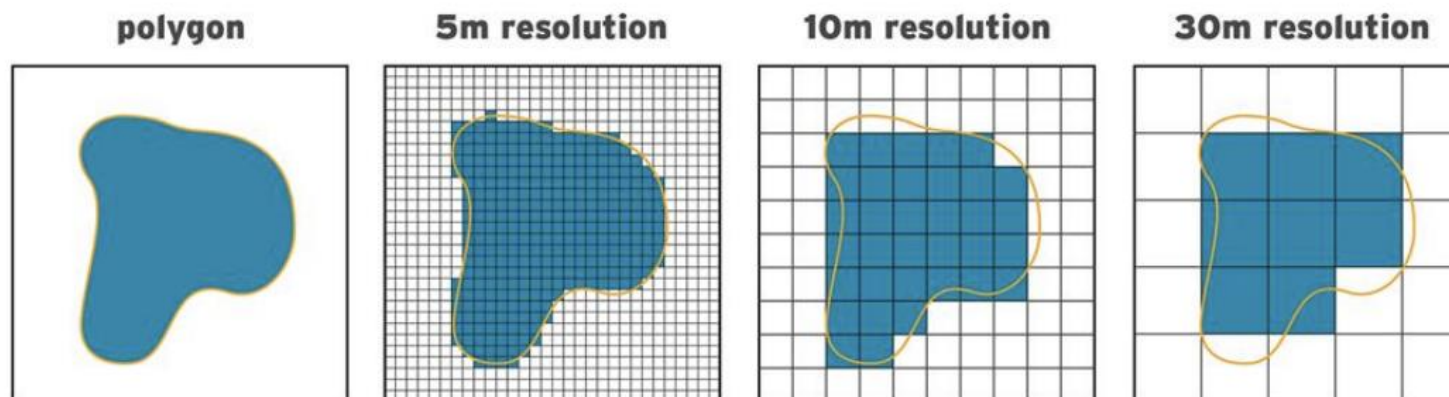


1 m.

10 m.

30 m.

Spatial resolution is the geographical area covered by a pixel in a satellite's image. Generally, the higher the spatial resolution, the less area is covered by a single pixel.



**Smaller cell size
Higher resolution**

**Larger cell size
Lower resolution**



**High Spatial
Resolution**

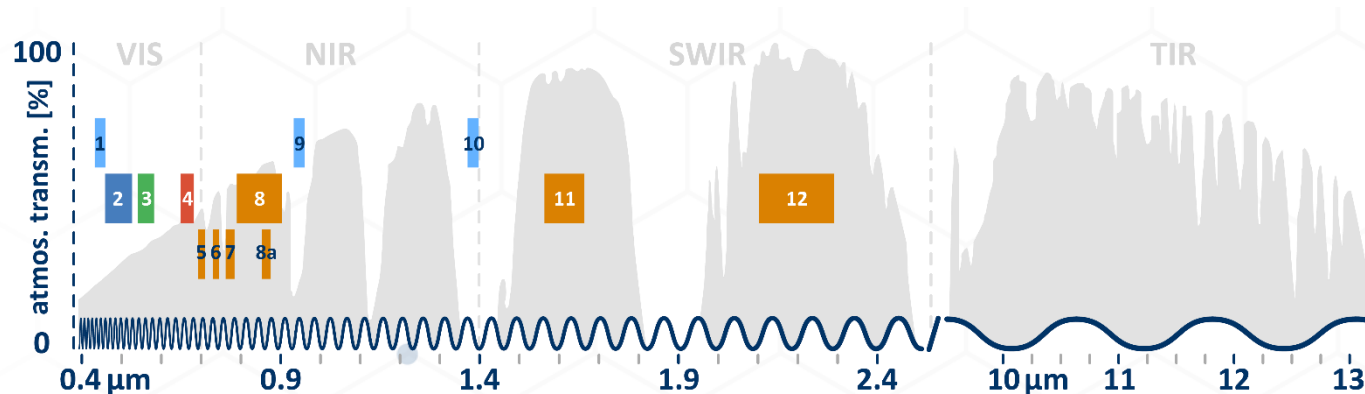
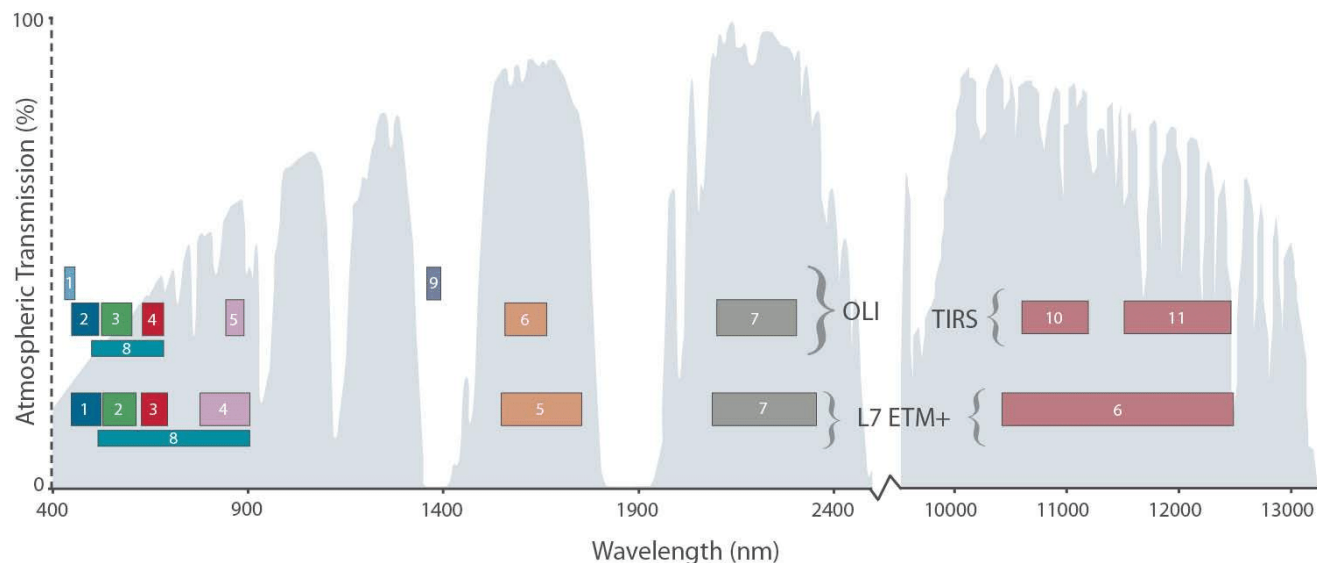


**Medium Spatial
Resolution**



**Low Spatial
Resolution**

Spectral Resolution



Spectral resolution describes the ability of a sensor to detect fine wavelength intervals. Instruments detect different ranges of wavelengths along the electromagnetic spectrum, referred to as bands. The narrower a wavelength range is, the finer the spectral resolution is. More and finer spectral channels enable remote sensing of different parts of the Earth's surface.

Examples:

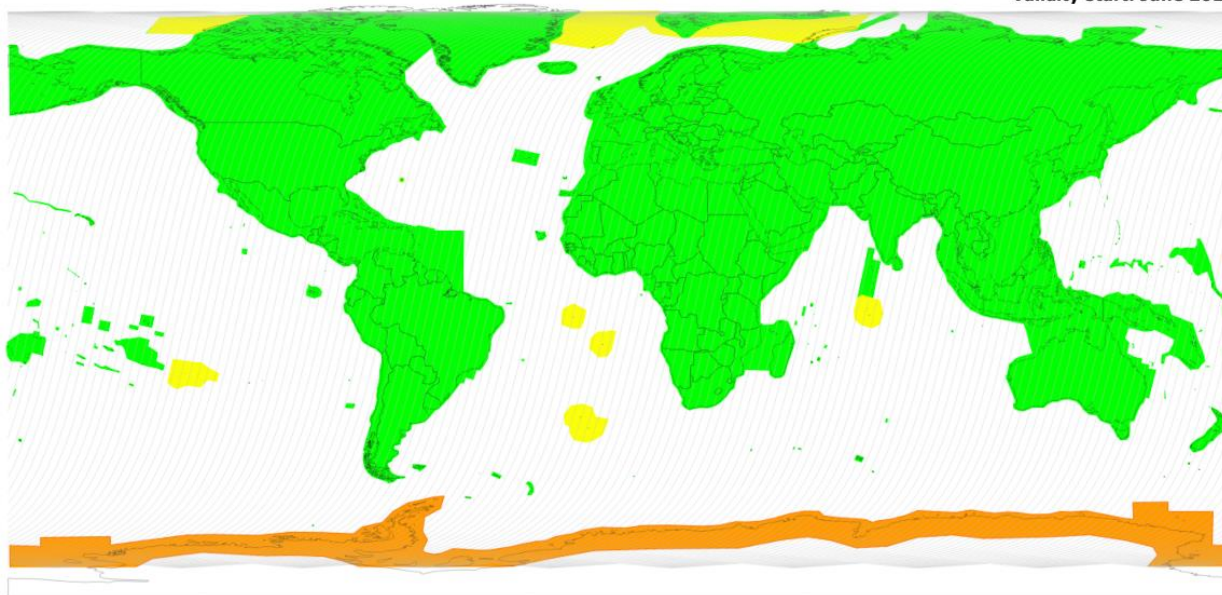
- Landsat (7-11 bands)
- Sentinel 3(11 bands)

Temporal Resolution

Sentinel-2 Constellation Observation Scenario: Revisit Frequency



Validity start: June 2022



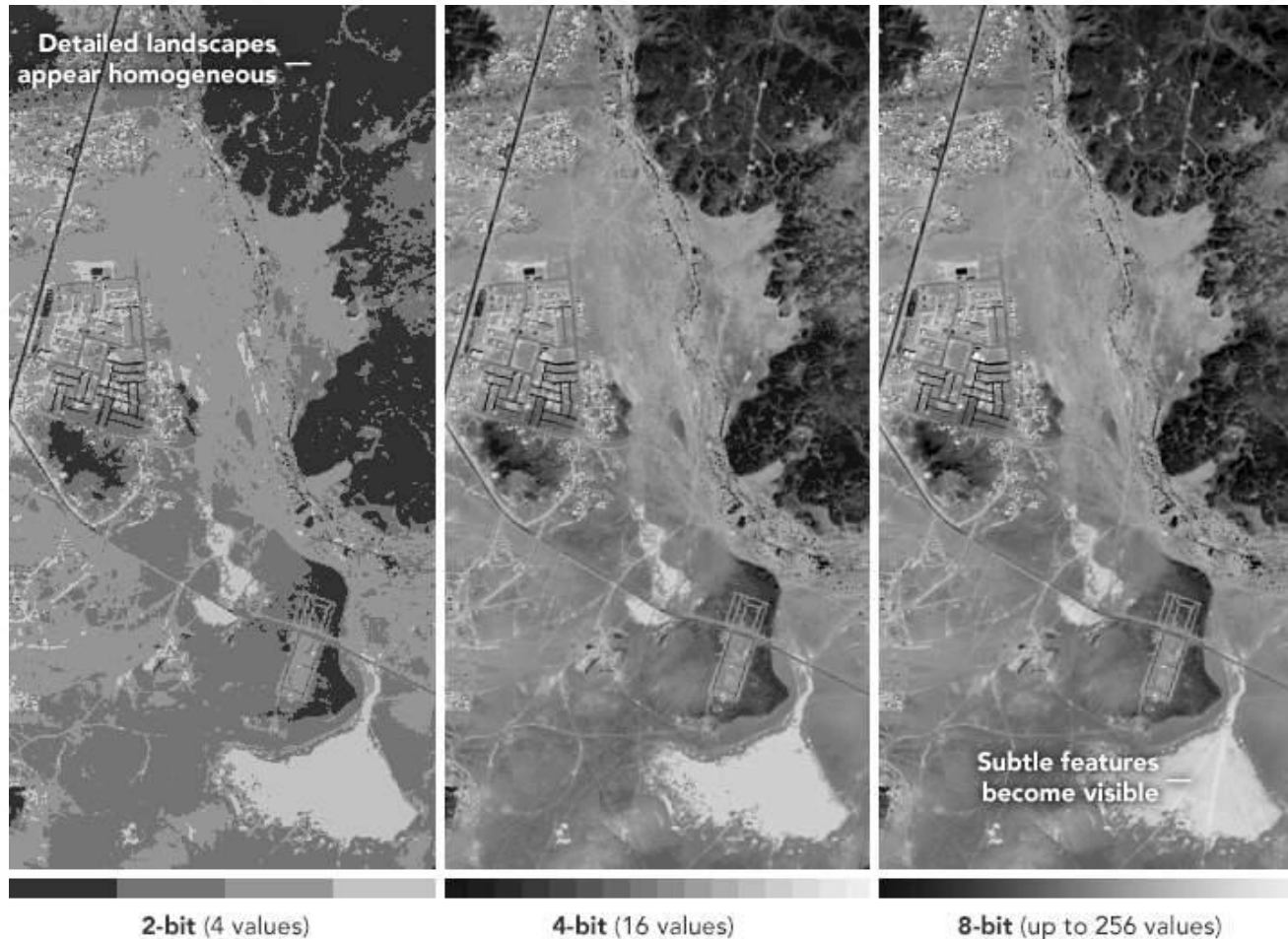
5 days
10 days
10 days access from alternated tracks

Temporal resolution is the revisit period of a satellite. It is the time it takes for a satellite to image the same area at the same viewing angle a second time. It depends on the satellite and sensor capabilities, the overlap of the satellite's path, and latitude of the satellite.

Some satellites have greater temporal resolution because:

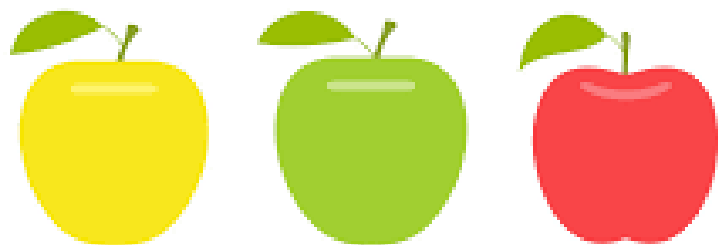
- they are able to maneuver their sensors
- they have increasing overlap at higher latitudes

Radiometric Resolution



Radiometric resolution describes a sensor's ability to discriminate differences in energy (or radiance). The better the radiometric resolution, the more sensitive the sensor is to small differences in energy. It is determined by multiple factors, chief among these are the saturation radiance - the "brightest" thing detectors can measure - and how the radiance measurements are quantized (turned into a digital bit stream).

- 12 bit sensor, 4,096 levels: Landsat 2
- 10 bit sensor, 1,024 levels: AVHRR
- 8 bit sensor, 256 levels: Landsat TM
- 6 bit sensor, 64 levels: Landsat MSS

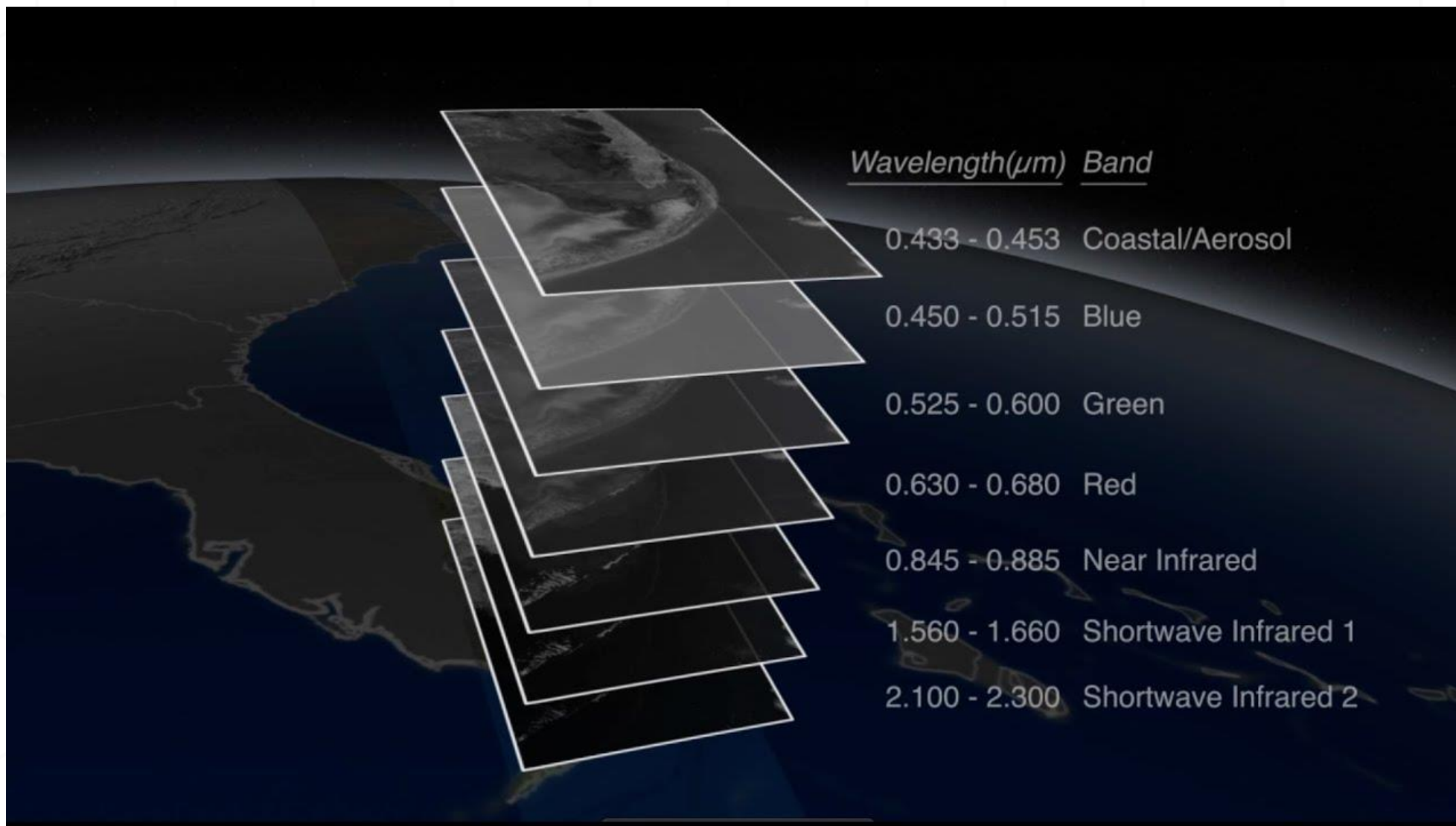


VS



Basic Analysis Techniques

Satellite Image Bands



Sentinel 2 Bands

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



Band 1 - Coastal Aerosol – central wavelength
443 nm – spatial resolution 60m





Band 2 – Blue – central wavelength
490 nm – spatial resolution 10 m





Band 3 - Green – central wavelength
560 nm – spatial resolution 10m





Band 4 – Red – central wavelength 665 nm
– spatial resolution 10m





Band 5 – Vegetation red edge – central wavelength 705 nm – spatial resolution 20 m





Band 6 – Vegetation red edge – central wavelength 740 nm – spatial resolution 20 m





Band 7 – Vegetation red edge – central wavelength 783 nm – spatial resolution 20 m





Band 8 – Near Infra-Red– central wavelength
842 nm – spatial resolution 10 m



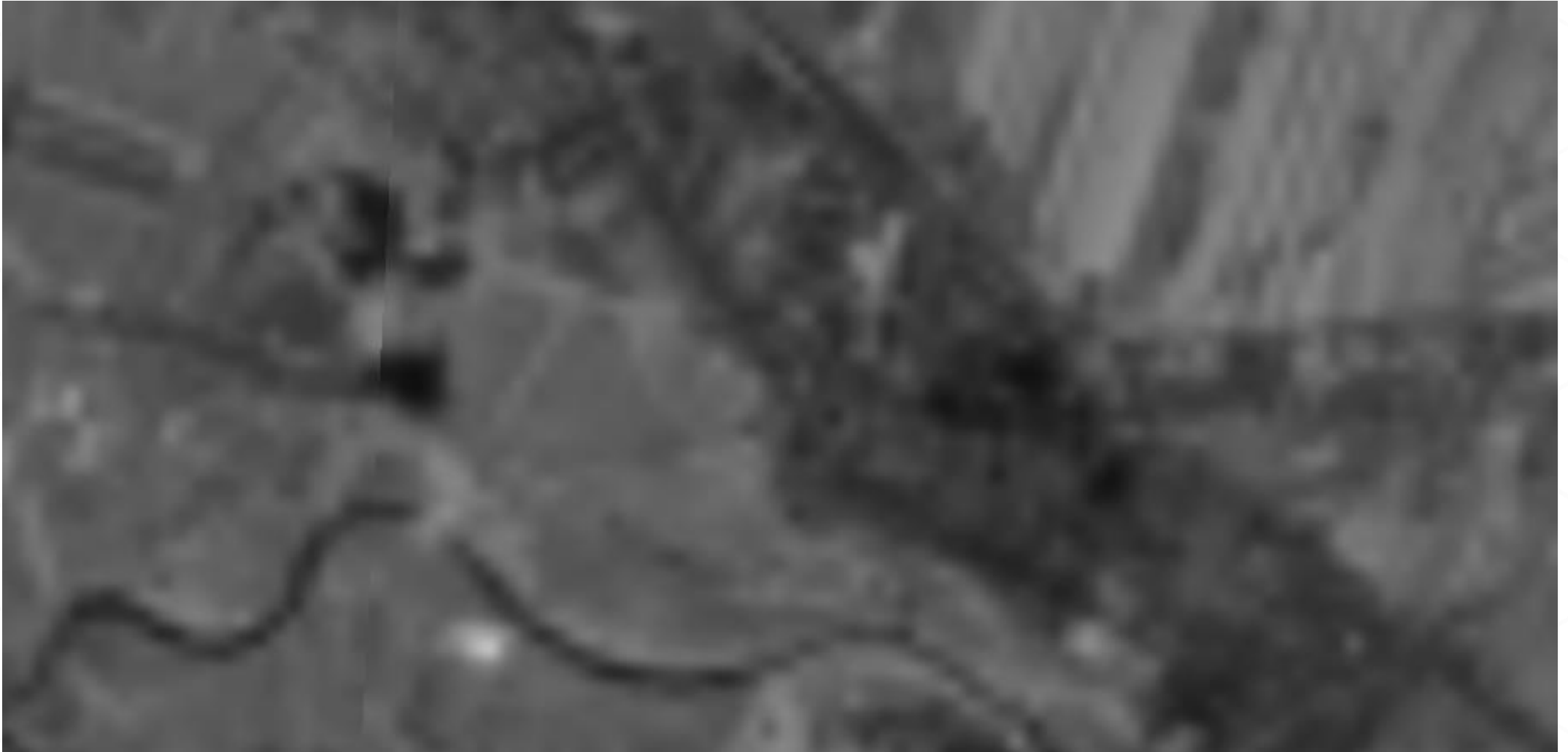


Band 8A – Vegetation red edge– central wavelength 865 nm – spatial resolution 20 m





Band 9 – Water Vapour – central wavelength
945 nm – spatial resolution 60 m





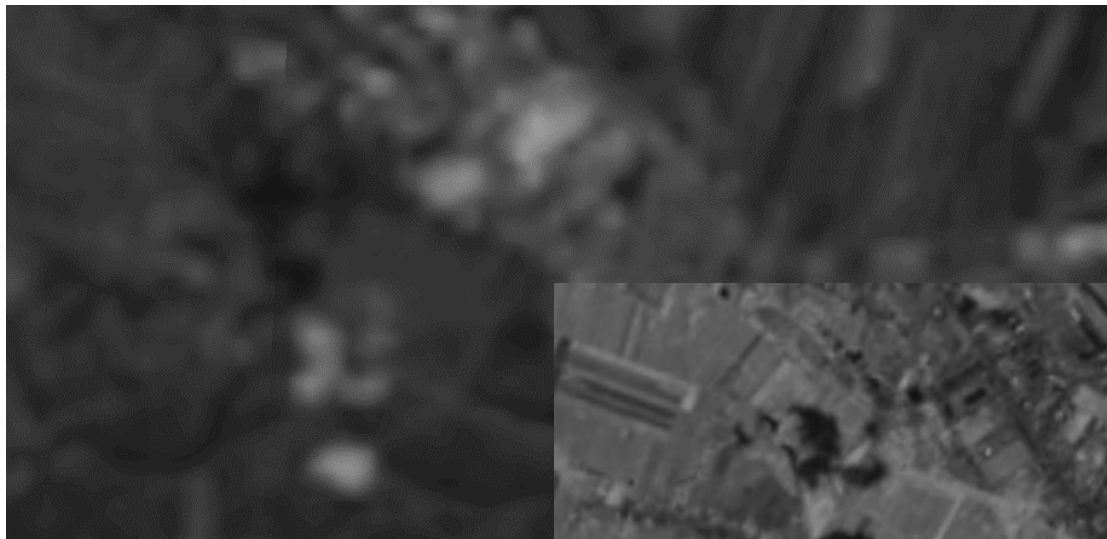
Band 10 – SWIR – Cirrius– central wavelength
1375 nm – spatial resolution 60 m





Band 11 – SWIR– central wavelength 1610 nm – spatial resolution 20 m





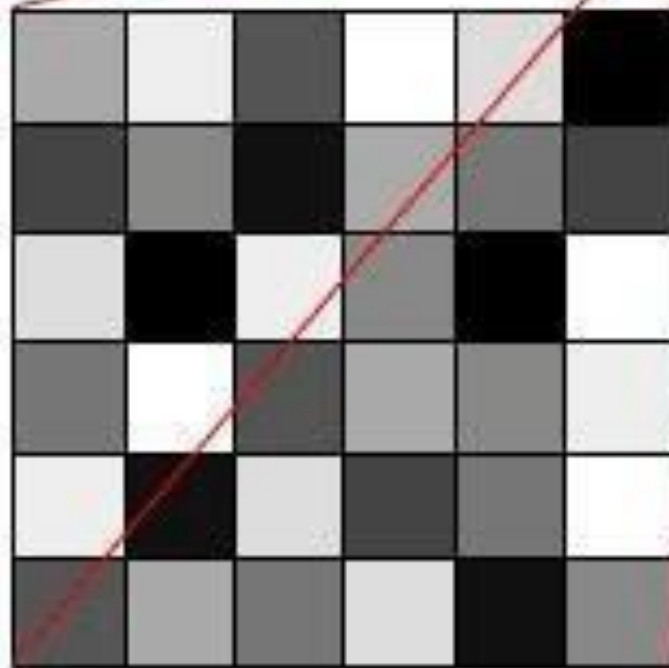
60 m



20 m



10 m



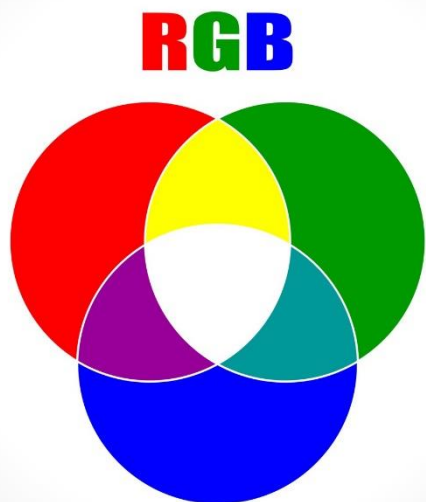
170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

DarkSalmon	Brown	DarkOrange1	Red
R=0.91 G=0.59 B=0.48	R=0.64 G=0.16 B=0.16	R=1.00 G=0.50 B=0.00	R=1.00 G=0.00 B=0.00
Yellow	Green	ForestGreen	Cyan
R=1.00 G=1.00 B=0.00	R=0.00 G=1.00 B=0.00	R=0.13 G=0.55 B=0.13	R=0.00 G=1.00 B=1.00
Blue	DarkViolet	Magenta	
R=0.00 G=0.00 B=1.00	R=0.58 G=0.00 B=0.83	R=1.00 G=0.00 B=1.00	
Gray60	Gray40	Black	
R=0.60 G=0.60 B=0.60	R=0.40 G=0.40 B=0.40	R=0.00 G=0.00 B=0.00	

box indicate Red, Green, and Blue intensity values.

100/000/000	90%	80%	70%	60%	50%	40%
100/050/000	90%	80%	70%	60%	50%	40%
100/100/000	90%	80%	70%	60%	50%	40%
050/100/000	90%	80%	70%	60%	50%	40%
000/100/000	90%	80%	70%	60%	50%	40%
000/100/050	90%	80%	70%	60%	50%	40%
000/100/100	90%	80%	70%	60%	50%	40%
000/050/100	90%	80%	70%	60%	50%	40%
000/000/100	90%	80%	70%	60%	50%	40%
050/000/100	90%	80%	70%	60%	50%	40%
100/000/100	90%	80%	70%	60%	50%	40%
100/000/050	90%	80%	70%	60%	50%	40%

100/000/000	90%	80%
100/050/000	90%	80%
100/100/000	90%	80%
050/100/000	90%	80%
000/100/000	90%	80%
000/100/050	90%	80%
000/100/100	90%	80%



8 Bit

Possible shade values per channel

256 x 256 x 256



16,777,216
Possible Colors



10 Bit

Possible shade values per channel

1,024 x 1,024 x 1,024



1,073,741,824
Possible Colors



12 Bit

Possible shade values per channel

4,096 x 4,096 x 4,096



Over 68 Billion
Possible Colors



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.

False Color (Urban)



This composite is used to visualize urbanized areas more clearly. Vegetation is visible in shades of green, while urbanized areas are represented by white, grey, or purple. Soils, sand, and minerals are shown in a variety of colors. Snow and ice appear as dark blue, and water as black or blue. Flooded areas are very dark blue and almost black. The composite is useful for detecting wildfires and calderas of volcanoes, as they are displayed in shades of red and yellow

Sentinel Bands

And their combinations

Visual

(B4, B3, B2)

Bathymetric

(B4, B3, B1)

Color Infrared

(B8, B4, B3)

NDMI

$(B8A - B11) / (B8A + B11)$

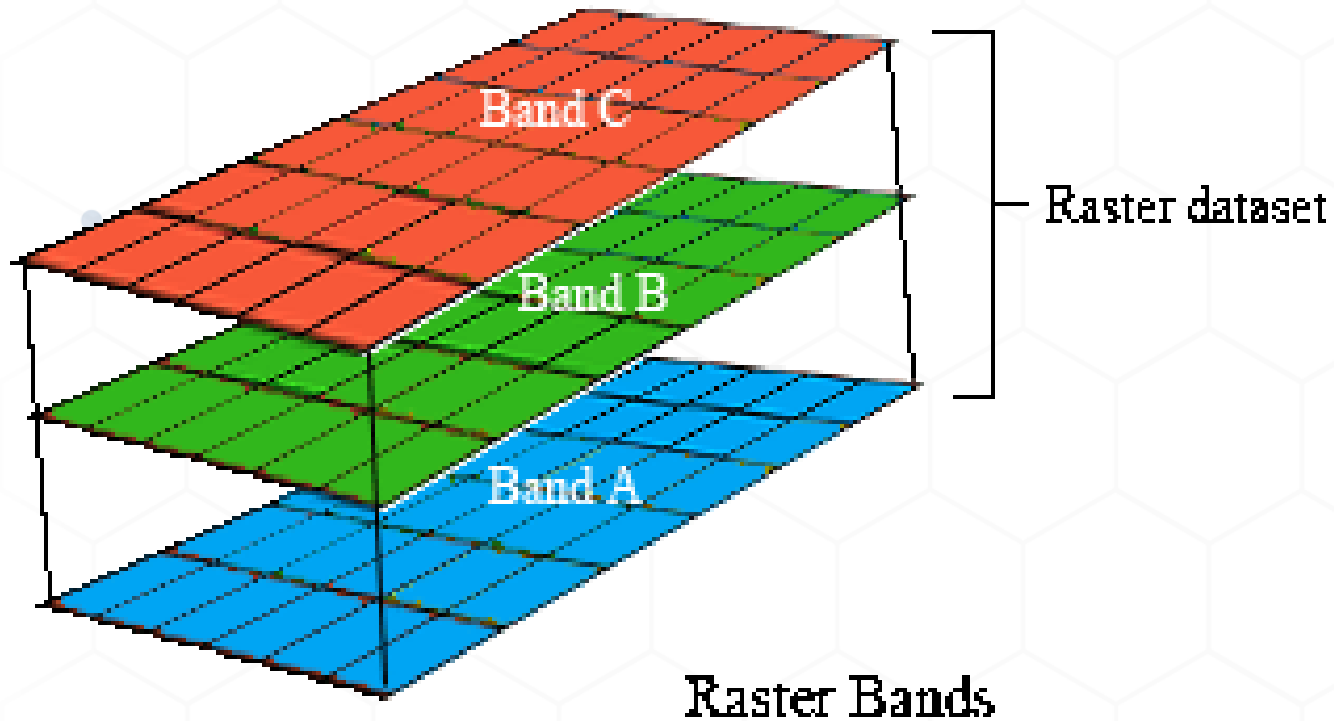
Geology

(B12, B11, B2)

NDVI

$(B8 - B4) / (B8 + B4)$

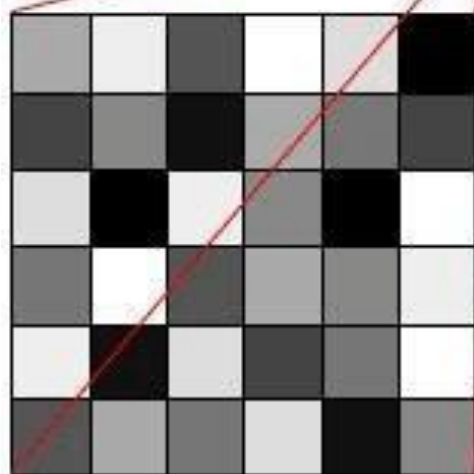
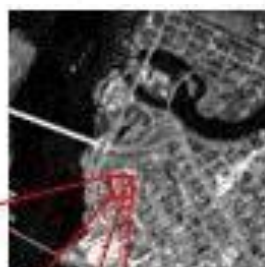
Spectral Indices



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.

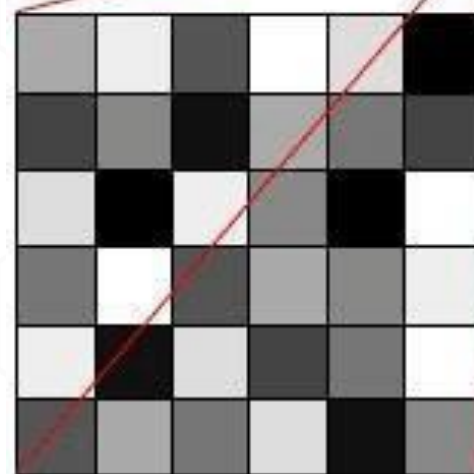
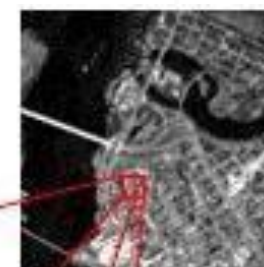
$$\frac{A-B}{B-A} = D$$

Band A



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

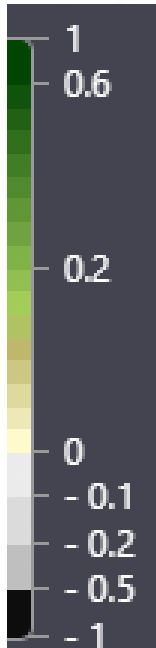
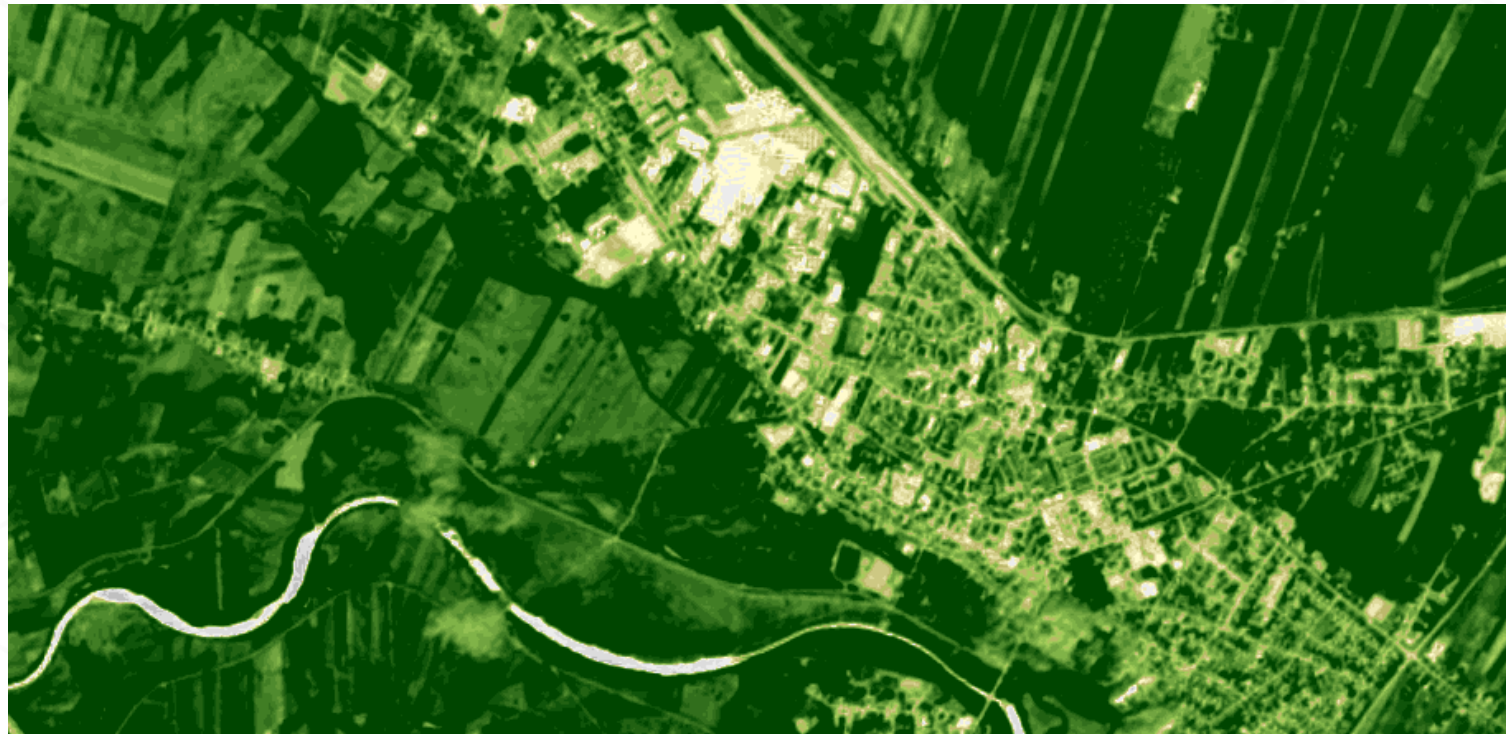
Band B



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

Normalized Difference Vegetation Index (NDVI)

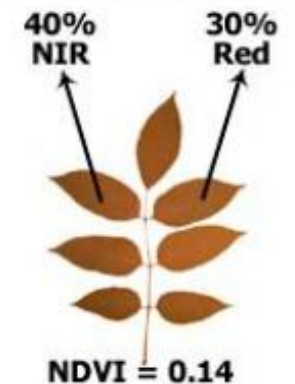
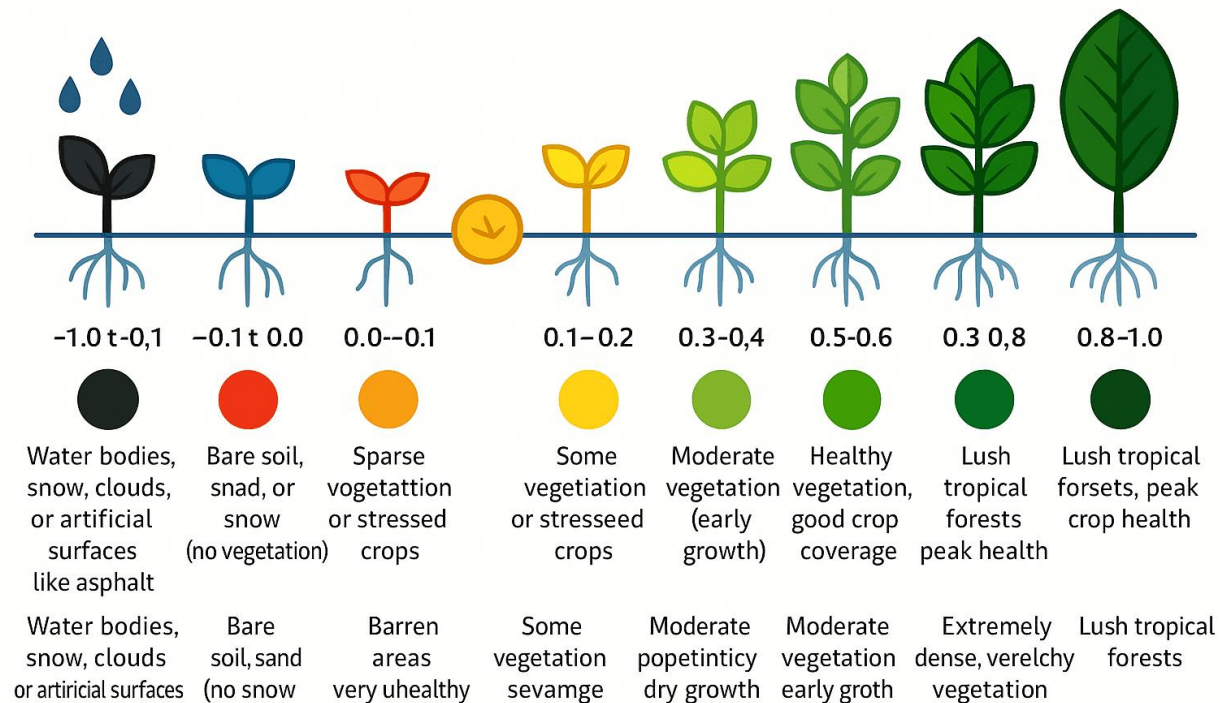
The normalized difference vegetation index is a simple, but effective index for quantifying green vegetation. It is a measure of the state of vegetation health based on how plants reflect light at certain wavelengths. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -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).



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

NDVI Values Interpretation

NDVI Value Range



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

Let's try to calculate NDVI!

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

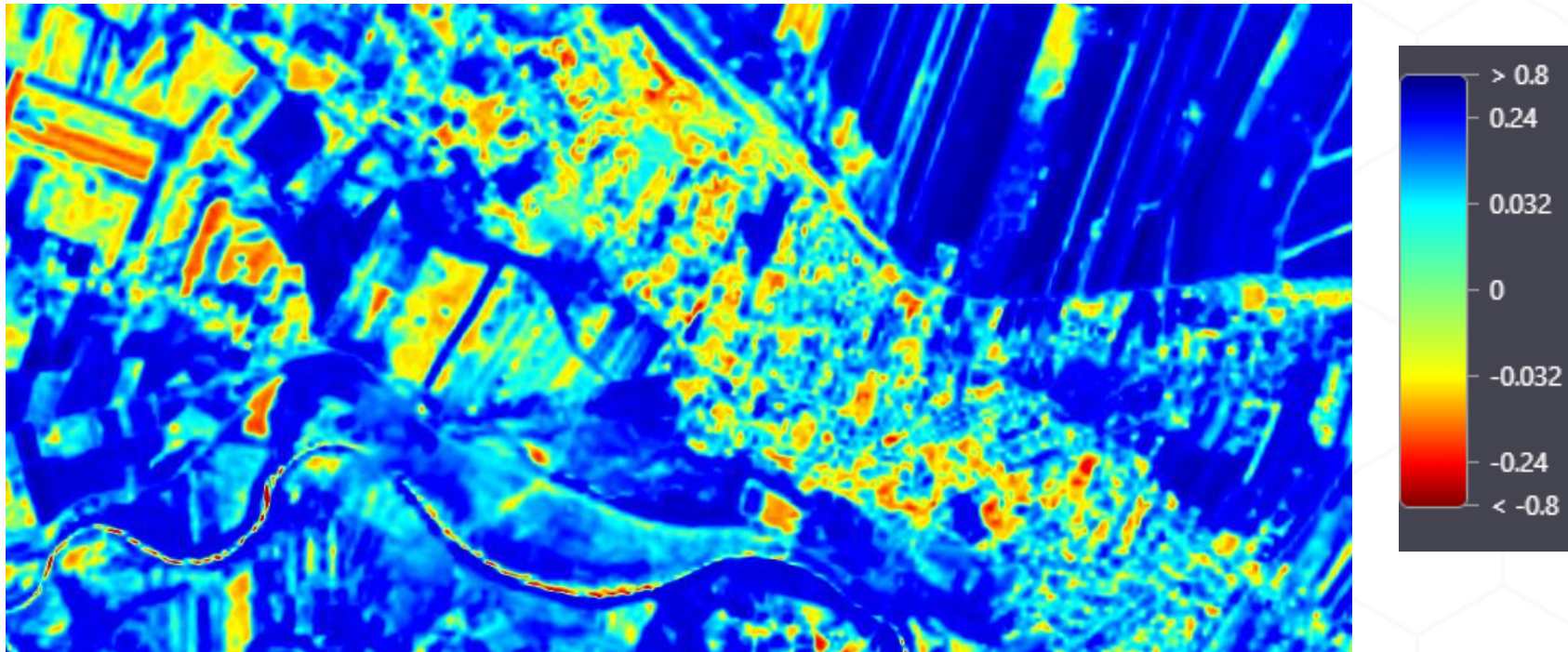
11	24	18	21	21	22
24	58	17	14	10	0
12	34	43	12	7	8
31	26	17	14	12	76
34	9	13	16	34	16
18	23	5	6	7	14

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

-0.46	-0.65	-0.24	-0.24	-0.10	-0.42
-0.77	0	0.24	0.25	0.7	0.16
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...

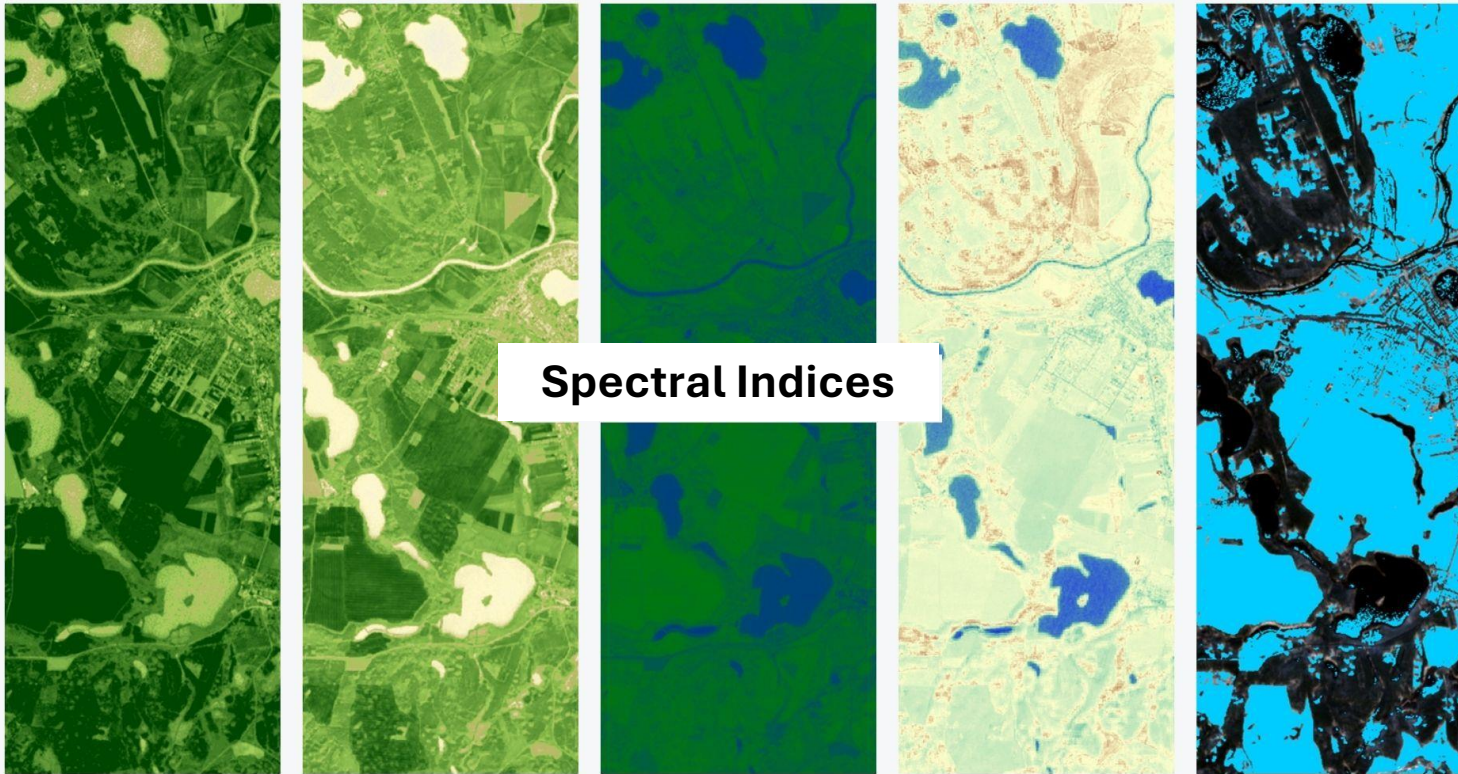
Normalized Difference Moisture Index

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



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).

Other Popular Spectral Indices



SAVI – Soil-Adjusted Vegetation Index

NDWI – Normalized Difference Water Index

NDSI – Normalized Difference Snow Index

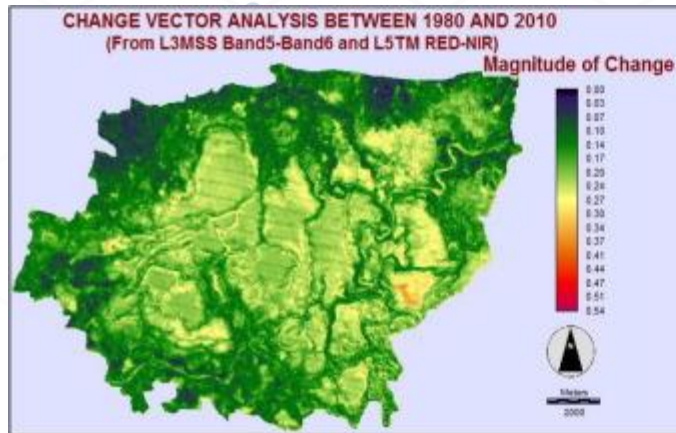
BSI – Bare Soil Index

MNDBI – Modified Normalized Difference Built-up

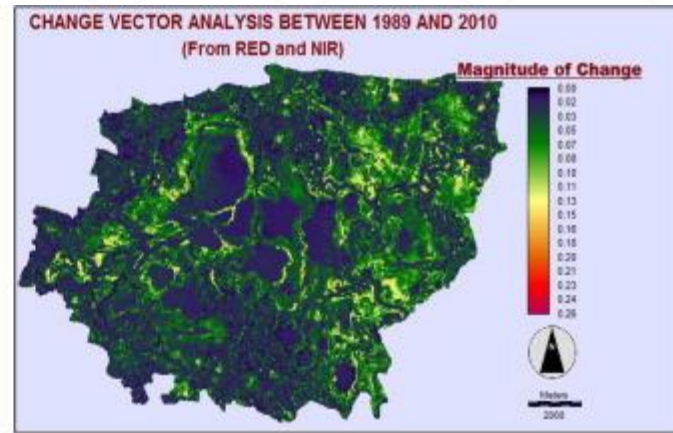
BAEI – Built-up Area Extraction Index

<https://ongeo-intelligence.com/blog/spectral-bands-list-of-formulas-for-the-most-popular-spectral-indices>

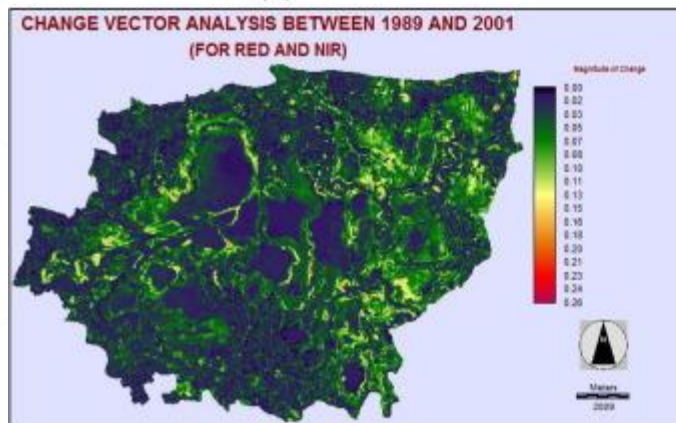
Change Detection



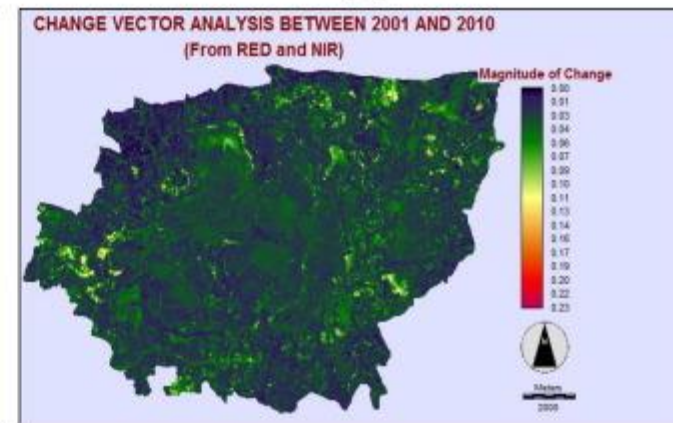
(a)



(b)



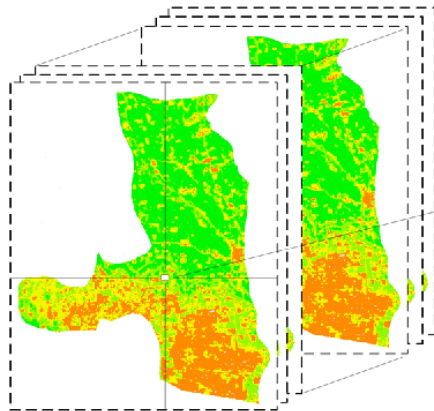
(c)



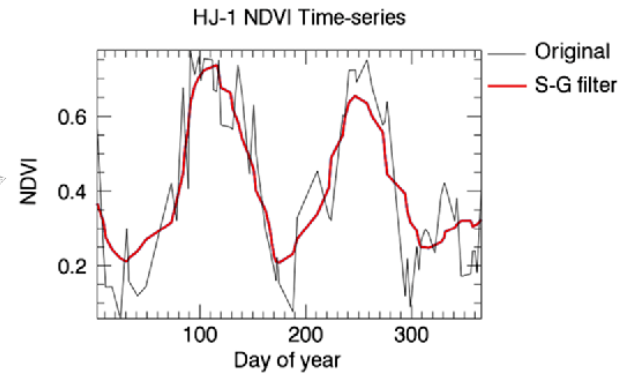
(d)

Change detection is the process of identifying changes between scenes of the same location acquired at different times.

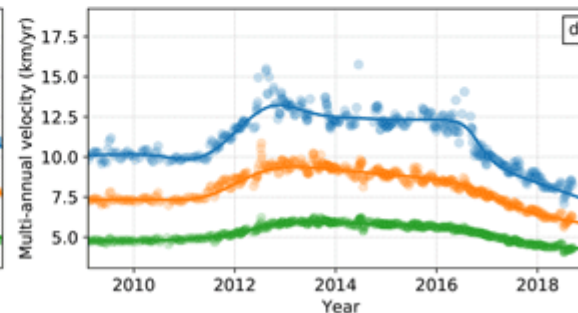
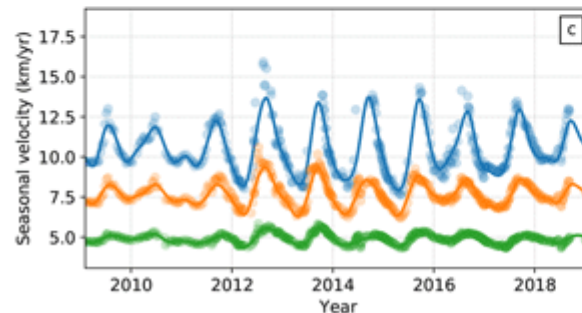
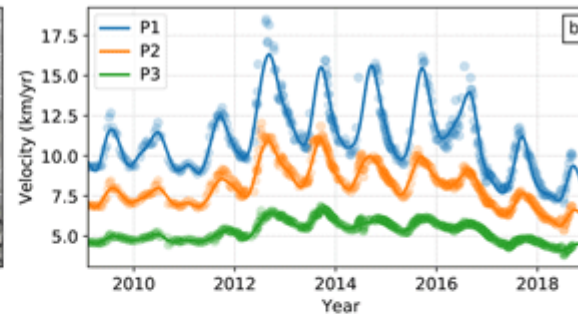
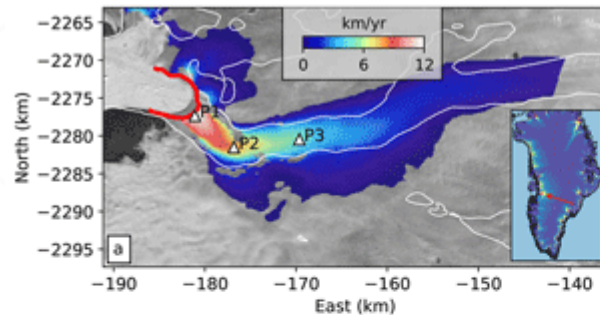
Satellite Image Time Series



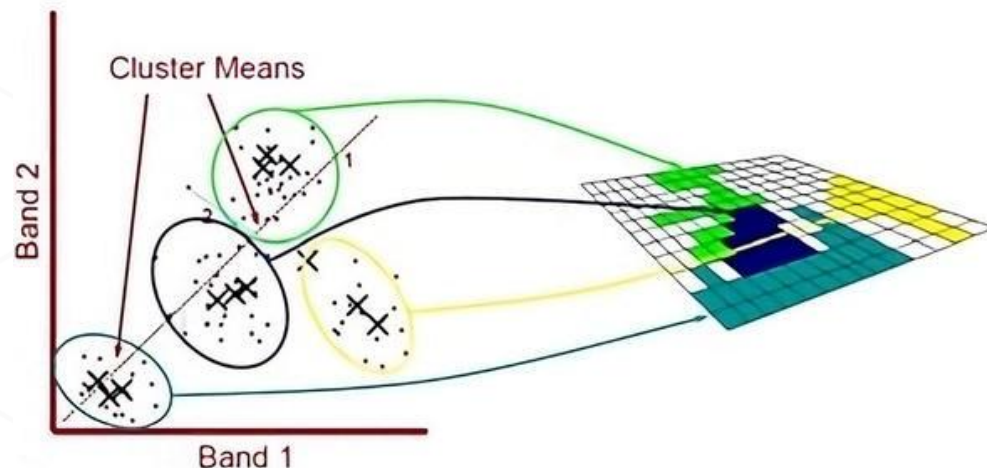
Interpolation



A **Satellite Image Time Series (SITS)** is a set of satellite images taken from the same scene at different times. A SITS makes use of different satellite sources to obtain a larger data series with short time interval between two images. In this case, it is fundamental to observe the spatial resolution and registration constraints.



Segmentation and Classification



Segmentation

Segmentation is the process of dividing an image into smaller, meaningful units (pixels or groups of pixels) that share similar characteristics such as color, texture, or spectral values.

Classification

Classification goes one step further: it assigns each pixel or segment to a predefined category (class) based on its spectral signature or other features. For example, classes might include “water,” “forest,” “urban area,” or “agriculture.” In Earth Observation, classification is used to create land cover maps, detect changes, and monitor ecosystems.

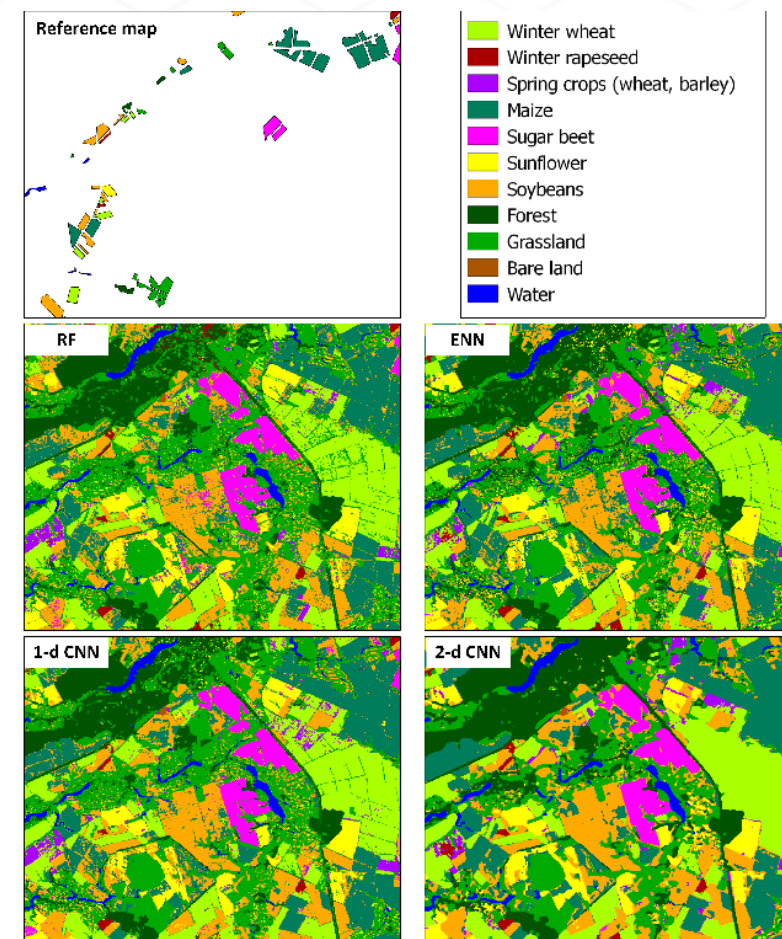


Fig. 3. Example of classification result for the Kviv region for 2015 based

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THANK YOU!

Questions?

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