أساسيات الاستشعار عن بعد

تقديم: منال الهاشمية

2-10 ديسمبر 2024م (عن بعد)
26 - 30 يناير 2025م (حضوري)

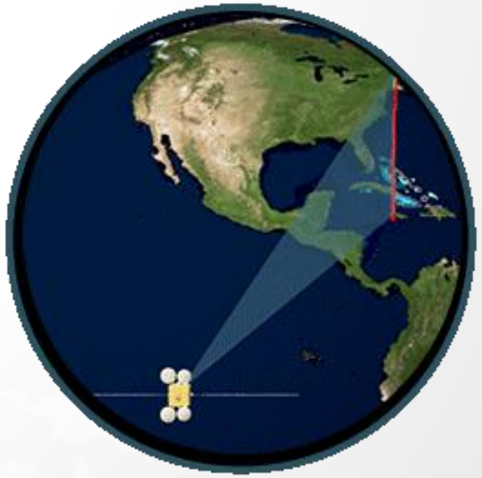
مسقط - سلطنة عمان

ورشة عمل باللغة العربية عن الجيل الثالث من سواتل الأرصاد الجوية: تعزيز التنبؤ بالطقس بإستخدام تكنولوجيا الجيل التالي من السواتل

Remote Sensing: Definition

- **Remote:** Refers to something that is not in direct physical contact. can vary from being slightly apart to extremely far

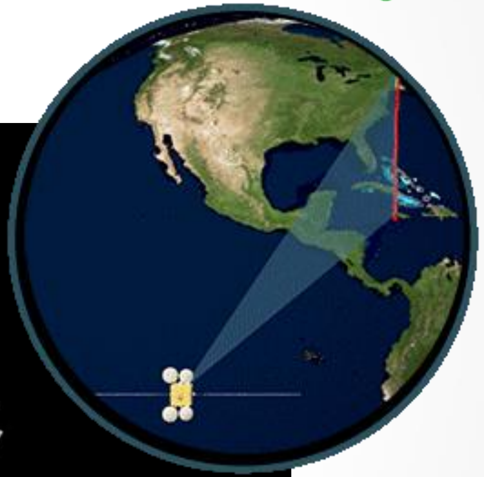
- **Sensing:** Refers to the act of collecting data or information, whether it be temperature, pressure, or images.

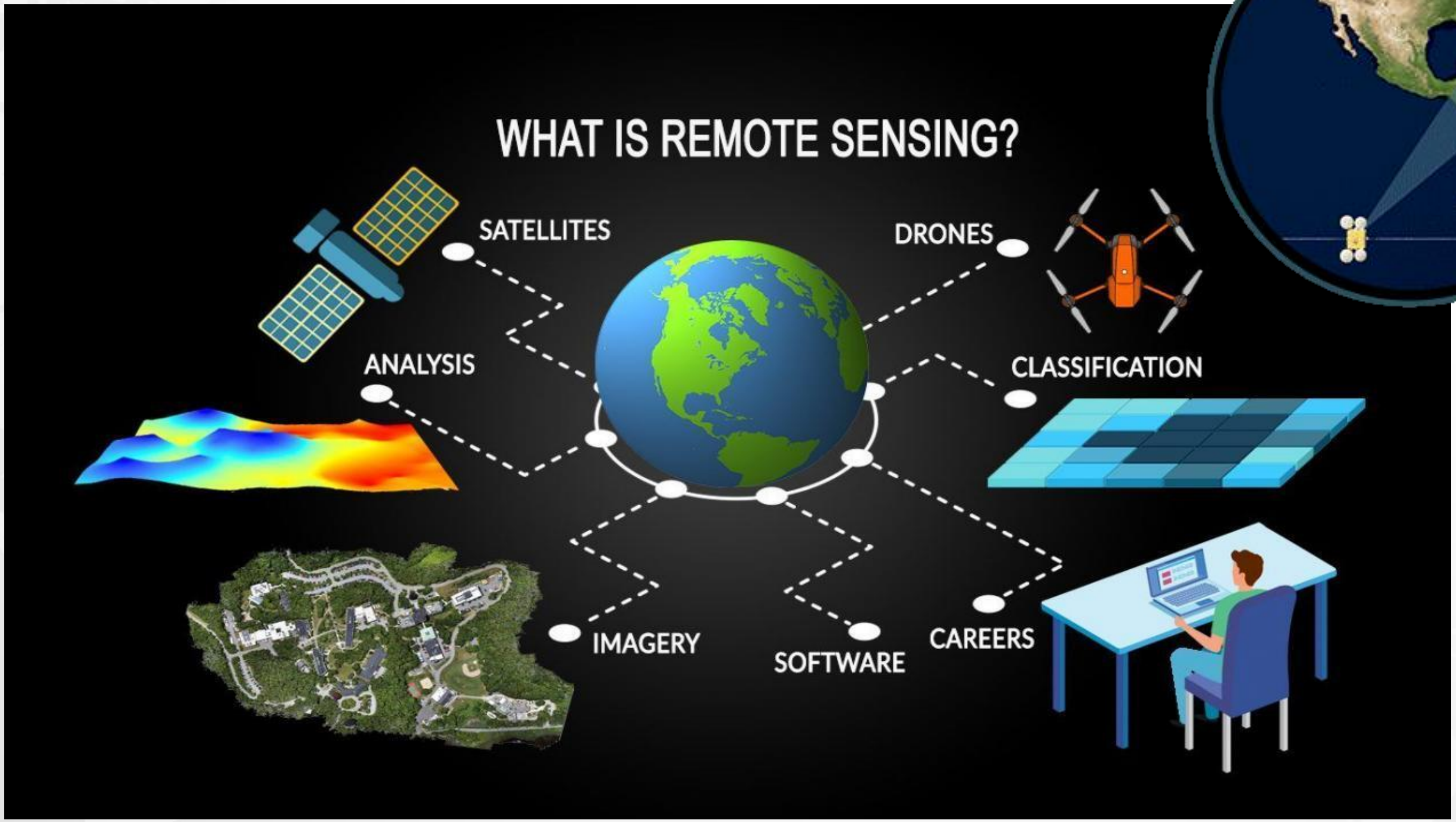


Remote Sensing

- The **science** of obtaining the physical properties of an area without being there.
- It allows users to **capture, visualize, and analyze** objects and features on the Earth's surface.

Remote Sensing: Definition





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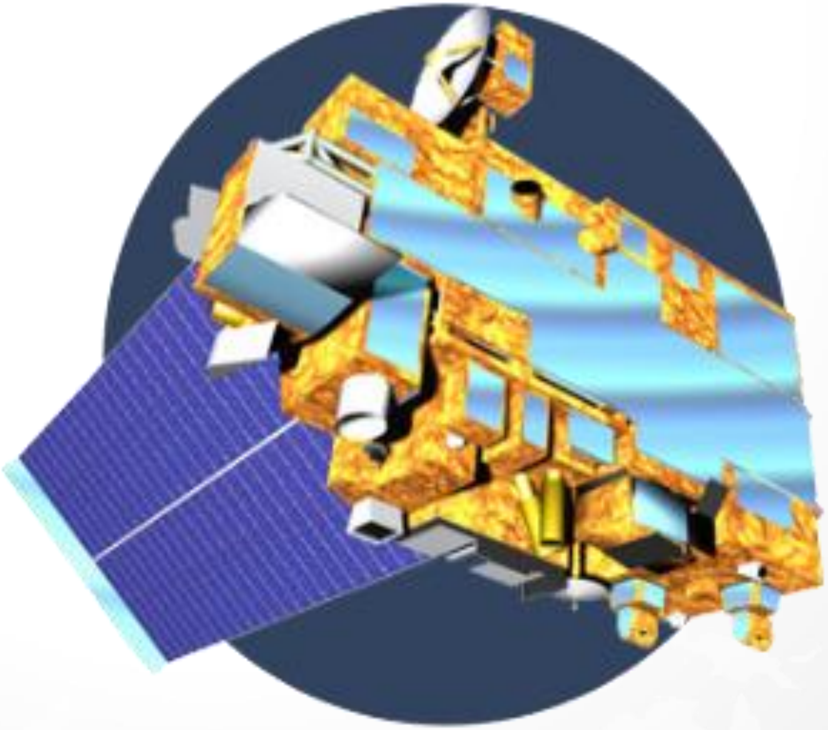
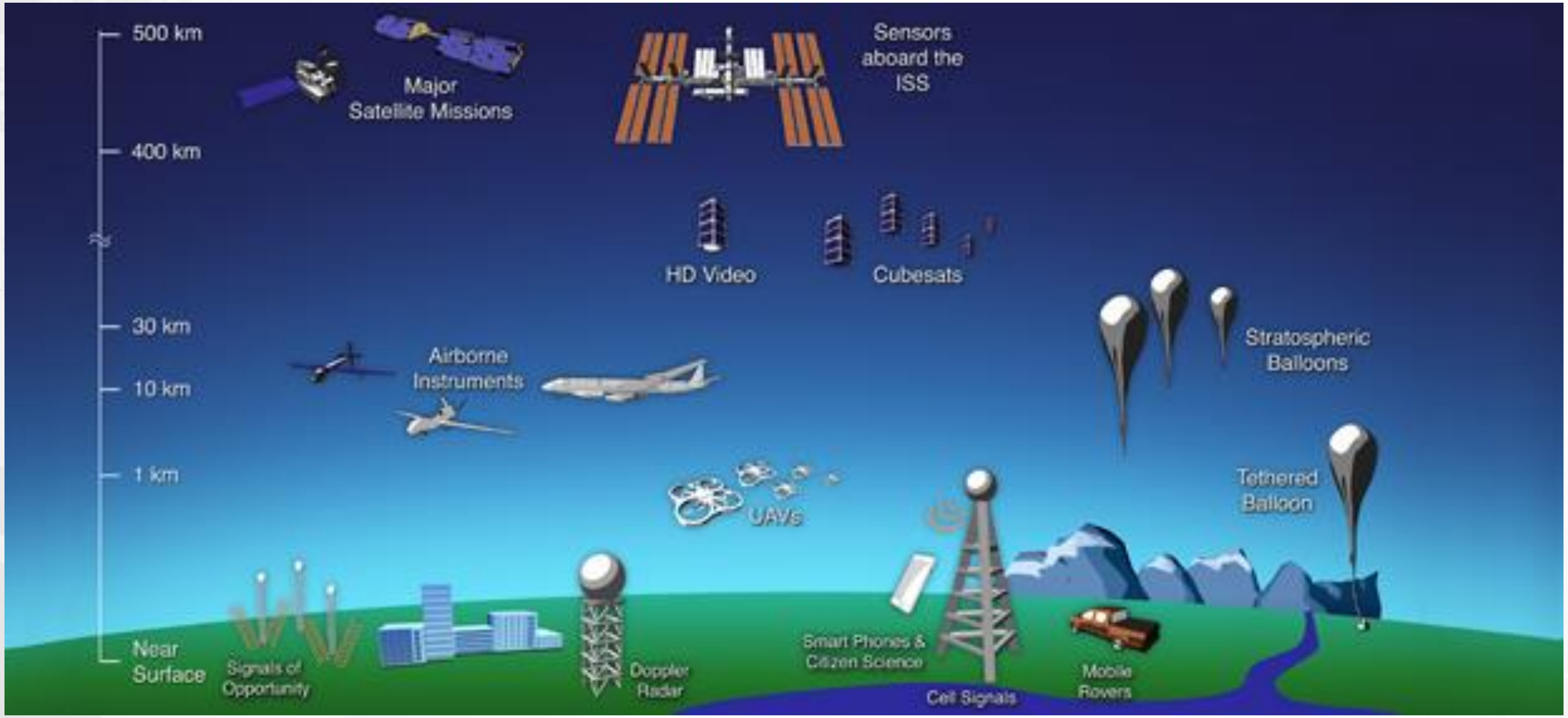
Sensor Types

Image Resolution &

TYPES OF ORBITS



Remote Sensing: Sensor Types



Remote sensing uses a sensor to capture an image.
For example, airplanes, satellites, and UAVs have specialized platforms that carry sensors.

Remote Sensing: Sensor Types

UAVs and Drones

ADVANTAGES
-Very high resolution imagery
-Programmable flight paths
-LiDAR capabilities

DISADVANTAGES
-Very small coverage extent
-Visual line of sight

Airplanes and Helicopters

ADVANTAGES
-High resolution imagery
-Pilot-flown flight paths
-LiDAR capabilities

DISADVANTAGES
-Small coverage extent
-Flight operation

Low Earth Orbit Satellites

ADVANTAGES
-High to coarse resolution imagery
-Large coverage extent

DISADVANTAGES
-Coverage limited to orbital path
-Cloud obstructions

Remote Sensing: Image Resolution

Remote sensing divides image resolution into FOUR different types:

- Spatial resolution
- Spectral resolution
- Temporal resolution
- Radiometric resolution

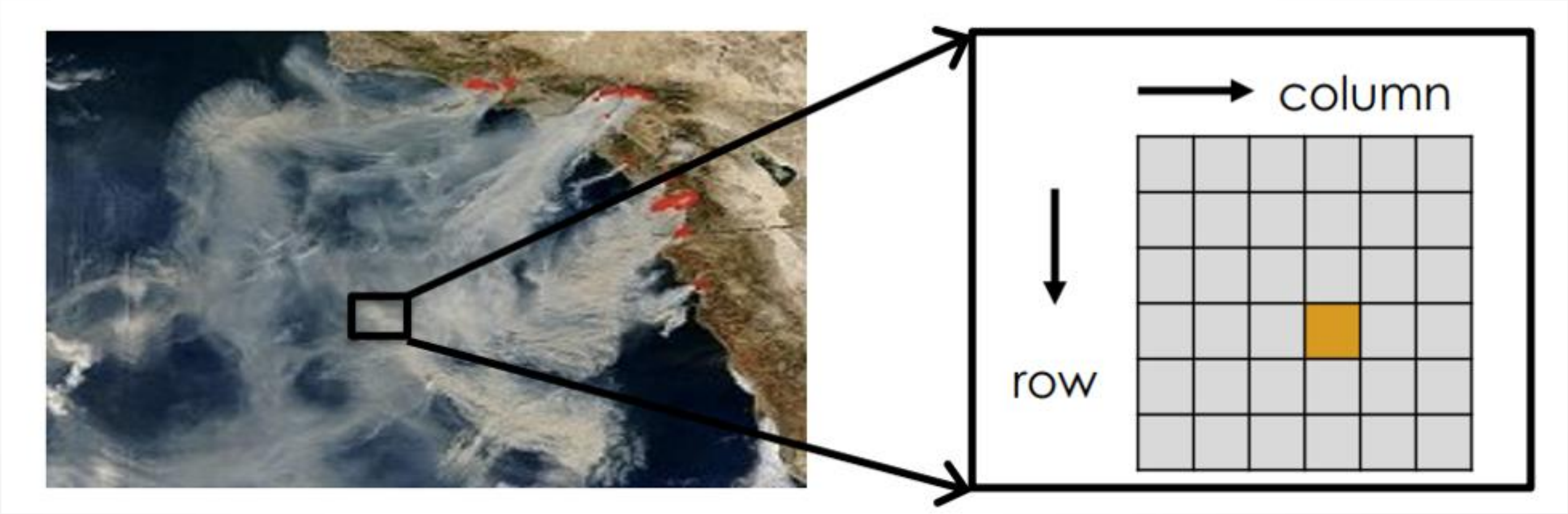
Remote Sensing: SPATIAL RESOLUTION

Spatial resolution is the detail in pixels of an image. High spatial resolution means more detail and smaller pixel size. Whereas, lower spatial resolution means less detail and larger pixel size.

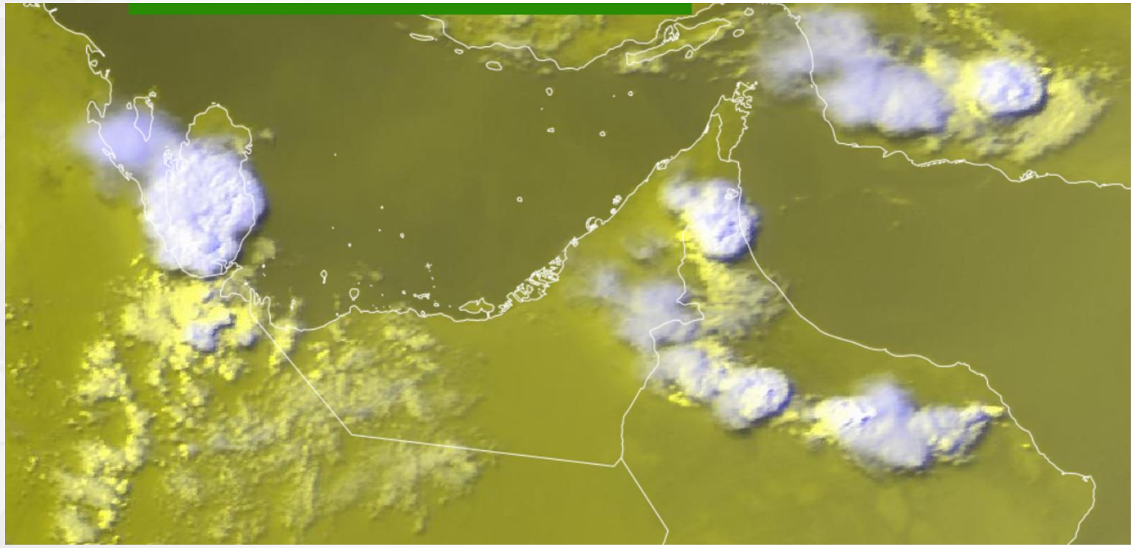
Remote Sensing: SPATIAL RESOLUTION

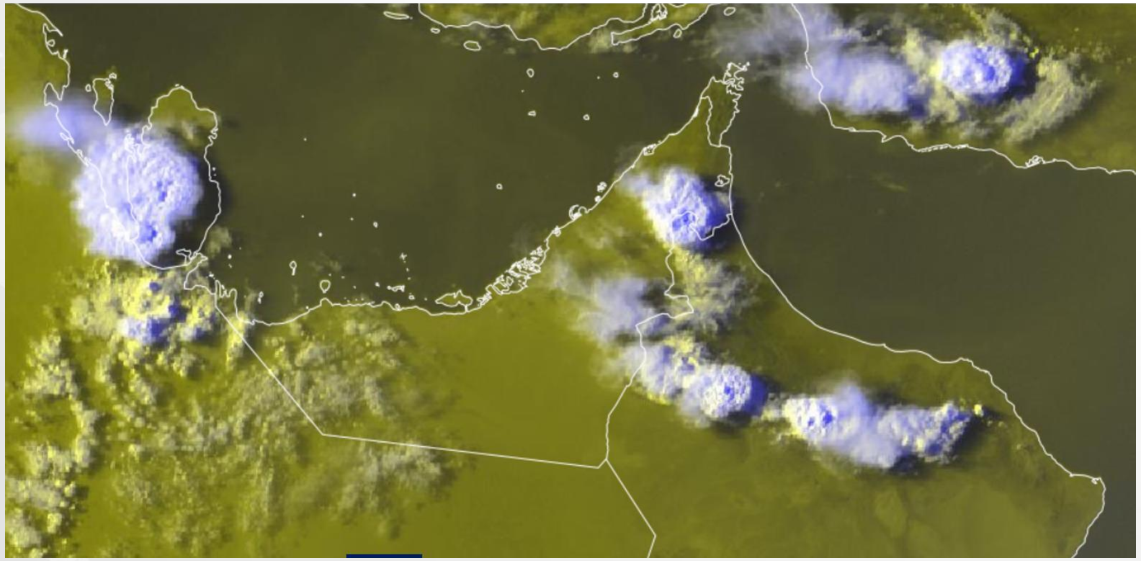
The spatial resolution is defined by the smallest Unit of an image (pixel): the Size of a pixel
The spatial resolution of the satellite image varies depending on the sensor type and the distance of the feature from the satellite and sensor used for observation.

The spatial Resolution is the best at the center of the image (near the satellite) and decreases as you move toward the edges of the observed area.



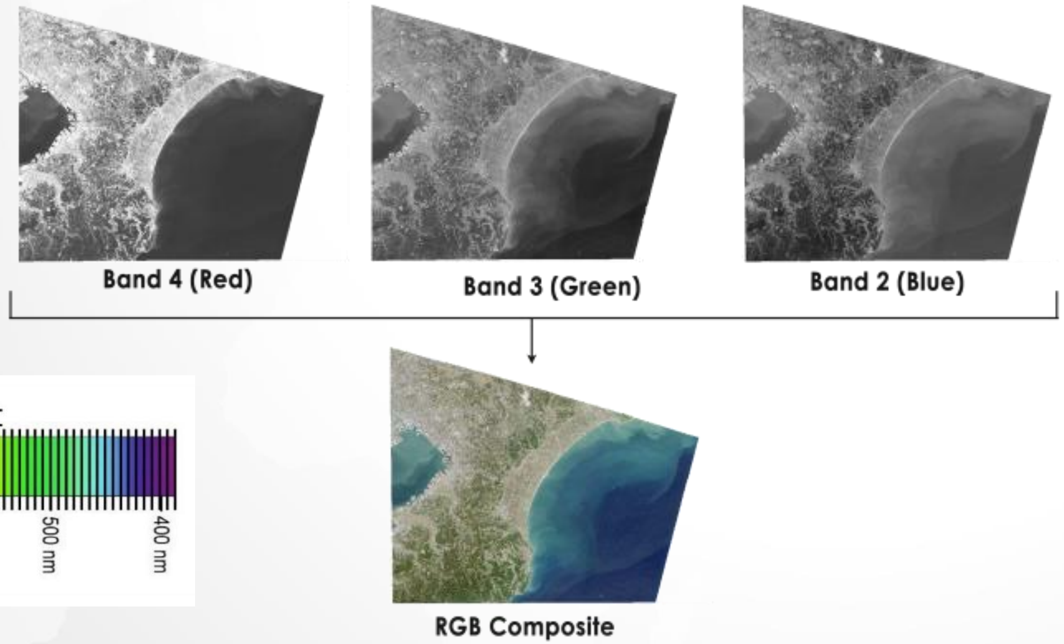
Remote Sensing: SPATIAL RESOLUTION

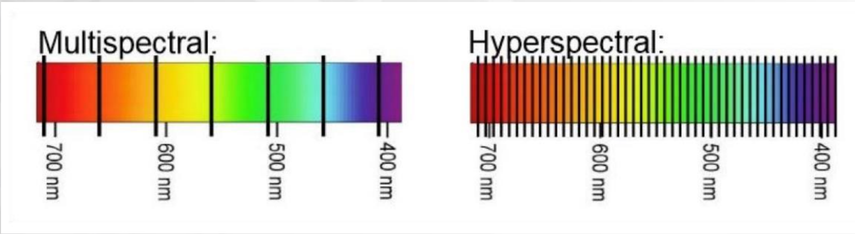




Remote Sensing: SPECTRAL RESOLUTION

Spectral Resolution is the amount of spectral detail in a band. High spectral resolution means its bands are more narrow. Whereas low spectral resolution has broader bands covering more of the spectrum.





Remote Sensing: TEMPORAL RESOLUTION

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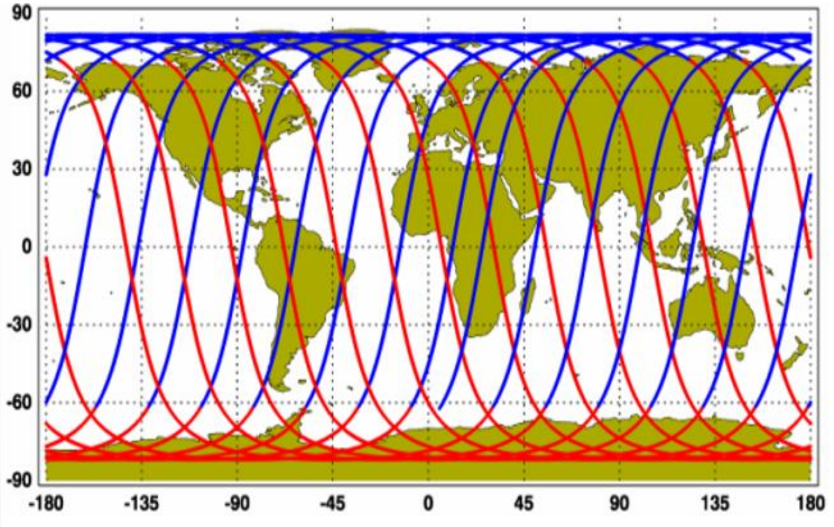
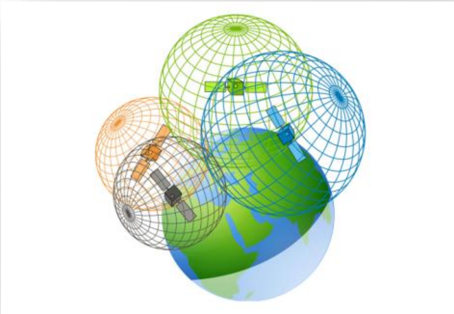
Temporal Resolution is the <u>time</u> it takes for a satellite to complete a full orbit.

UAVs, airplanes, and helicopters are completely flexible. But satellites orbit the Earth in set paths.



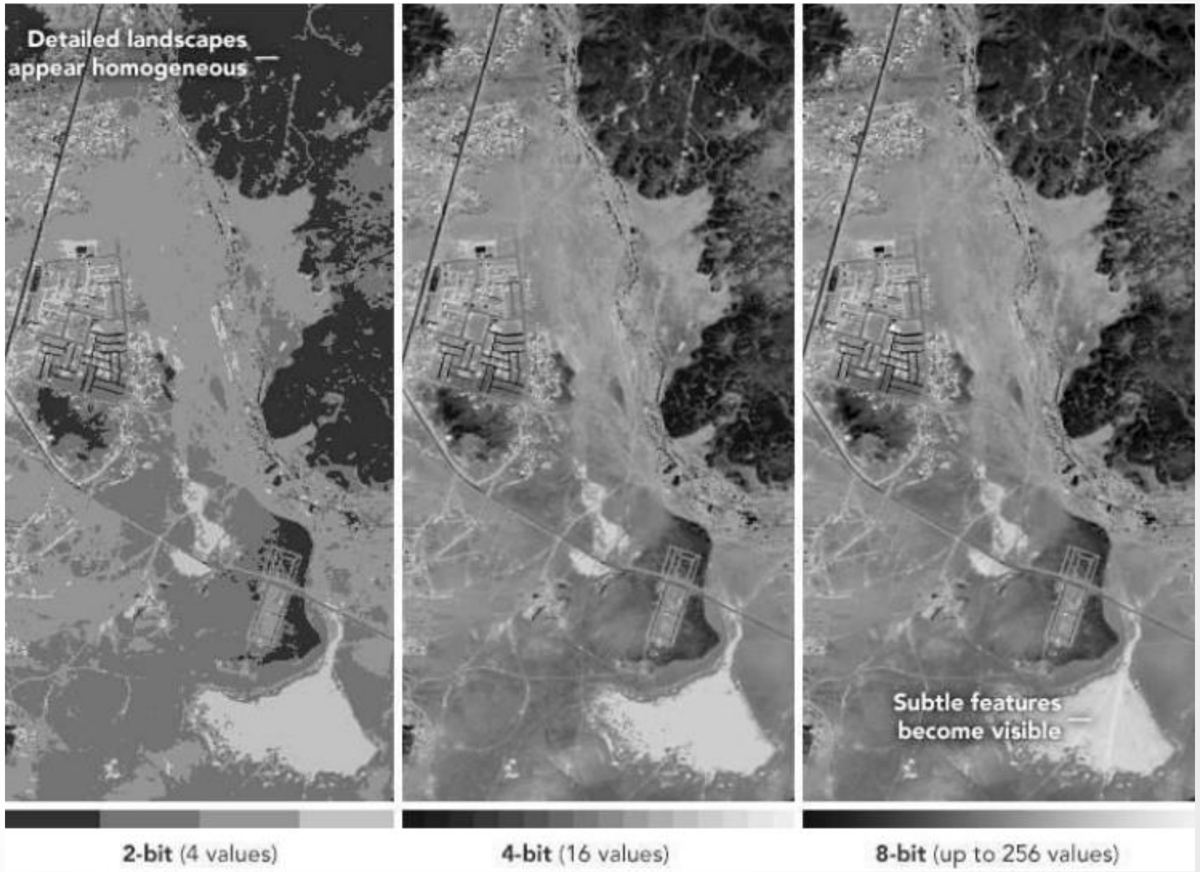


Remote Sensing: Radiometric resolution

The sensitivity of detectors to small differences in electromagnetic energy.

The better the radiometric resolution, the more sensitive the sensor is to small differences in energy.

The larger this number, the higher the radiometric resolution, and the sharper the imagery.



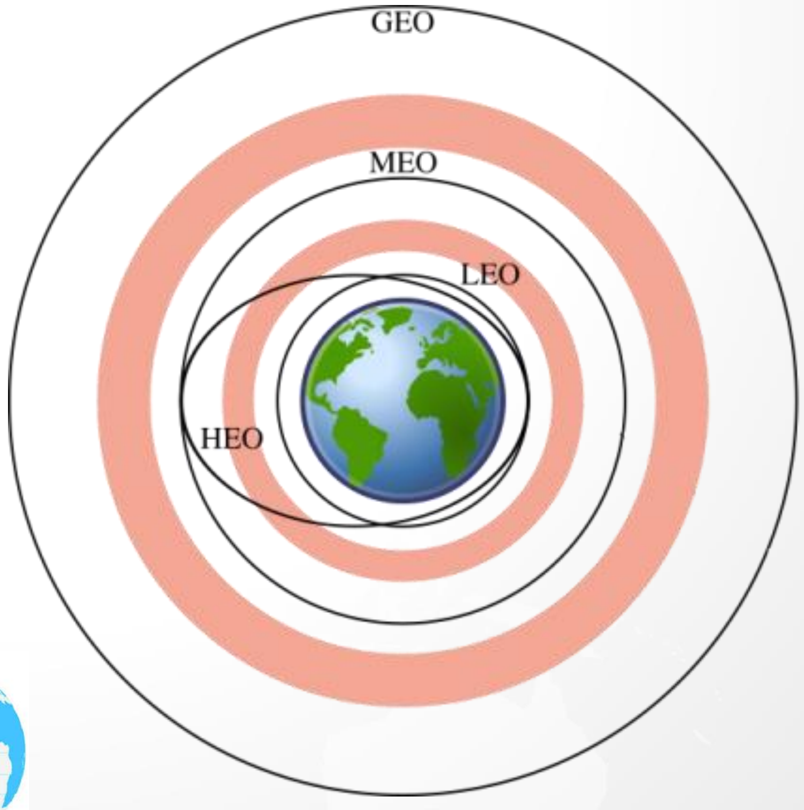
Remote Sensing: TYPES OF ORBITS

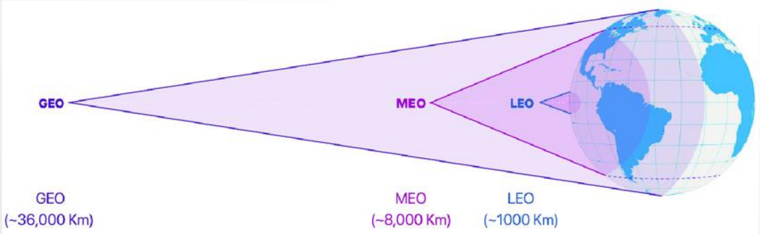
The types of orbits are:

- Geostationary orbits match the Earth's rate of rotation.
- Polar orbits pass above or nearly above both poles of Earth.

We categorize orbits by their altitude:

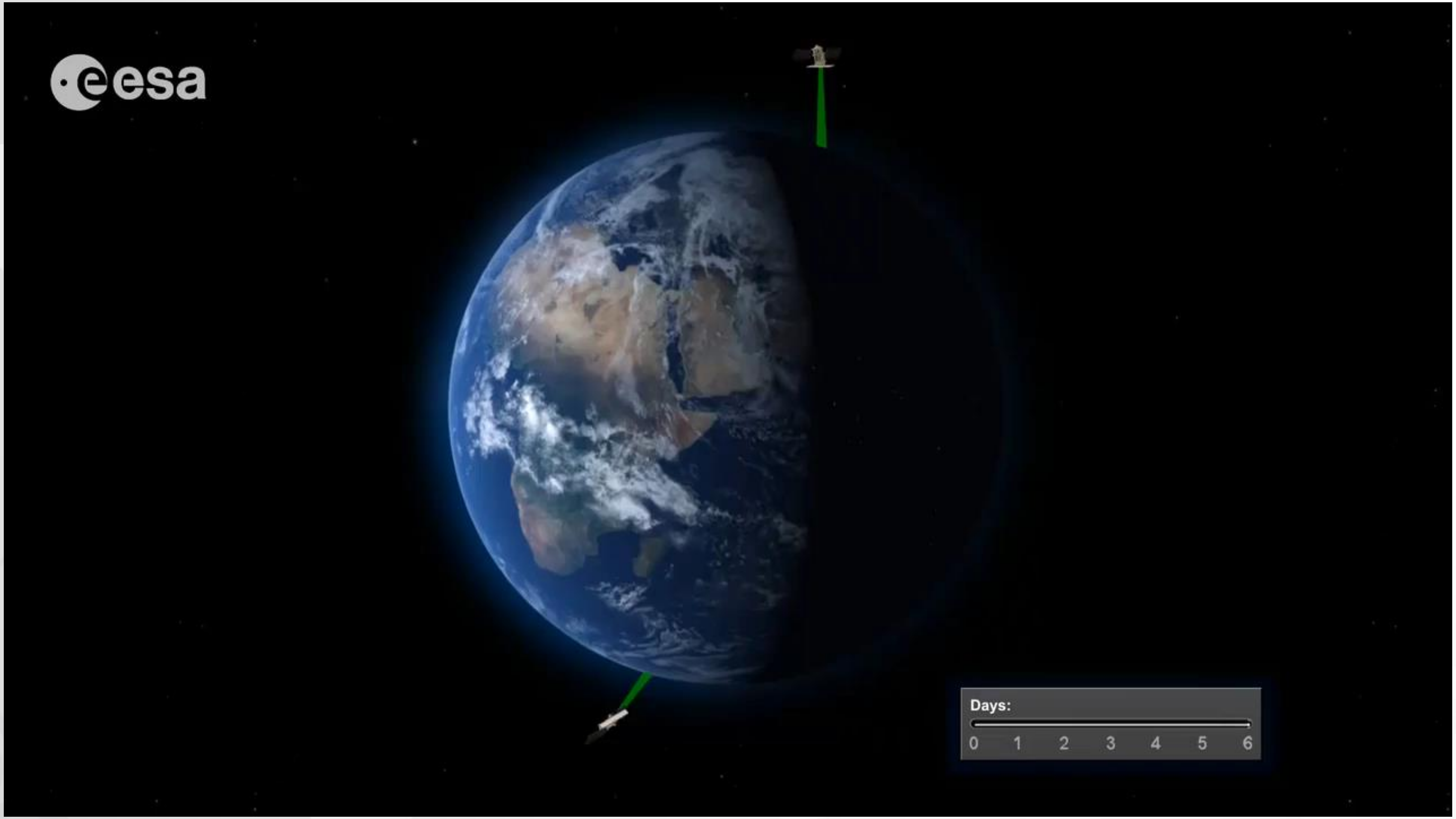
- Low Earth Orbit (LEO)
- Medium Earth Orbit (MEO)
- High Earth Orbit (HEO)

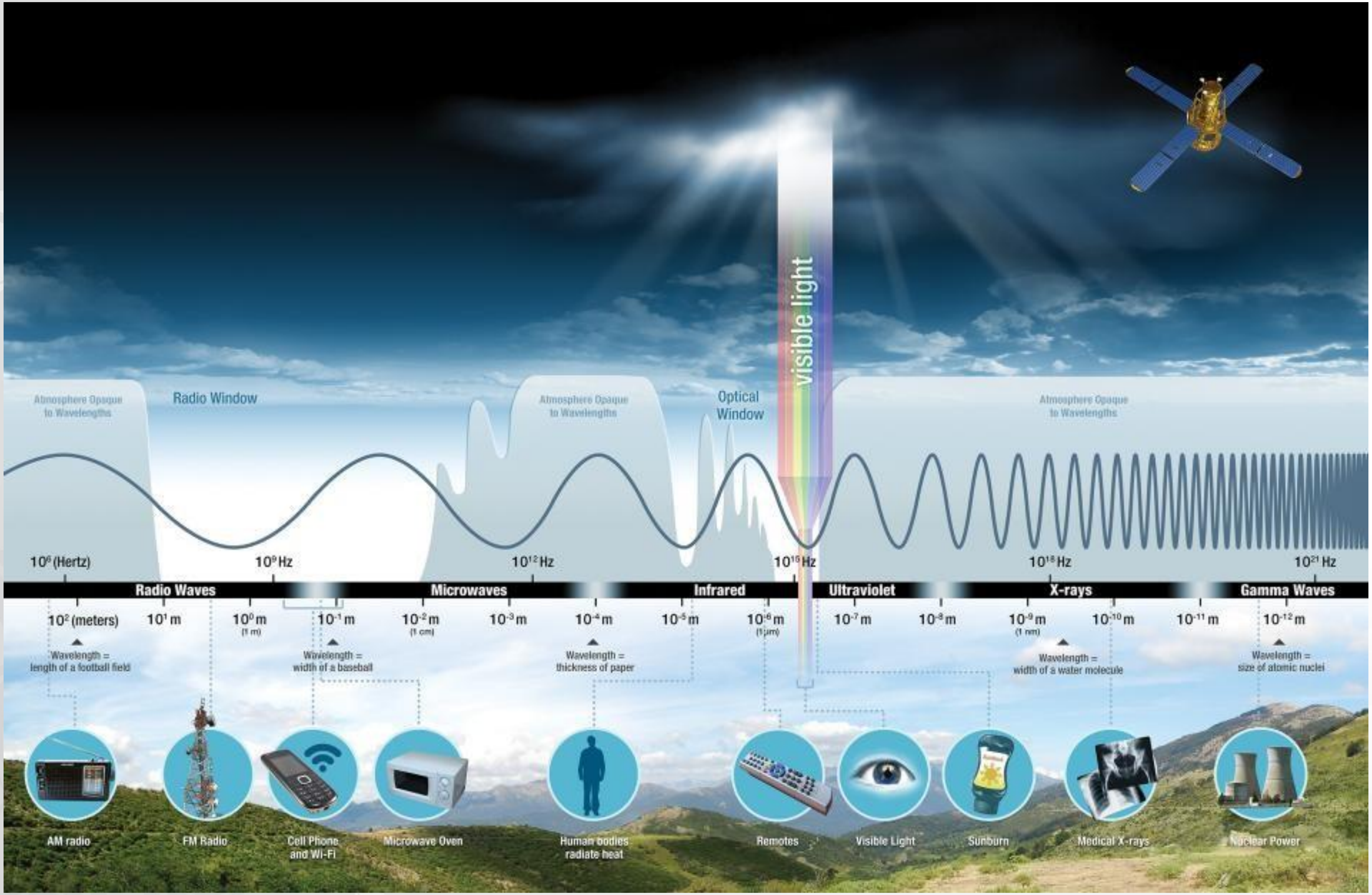




Remote Sensing: TYPES OF ORBITS

Geostationary Satellite	Low Orbiting Satellite
Continuous coverage of the same area	Global Coverage over time
Orbits ~36,000 km above the equator	Sun synchronous orbit ~600-1,000 km
lower resolution	Higher Resolution
Continuous Observation (every 5 -15 min)	only once every several hours


esa
Days:
0 1 2 3 4 5 6



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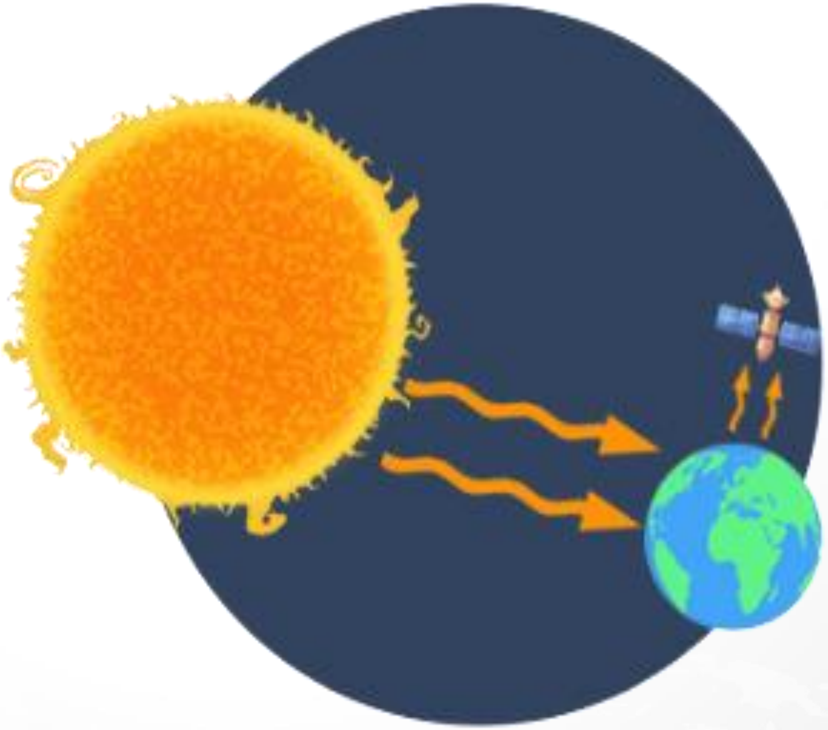
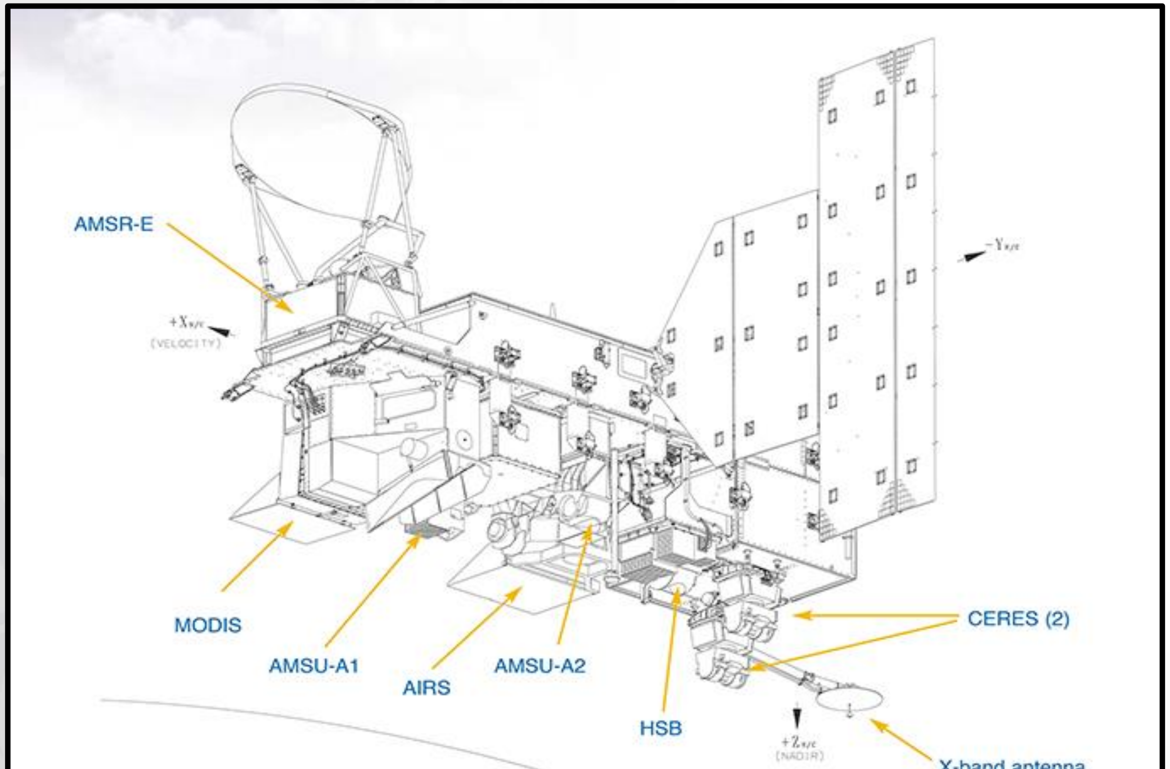
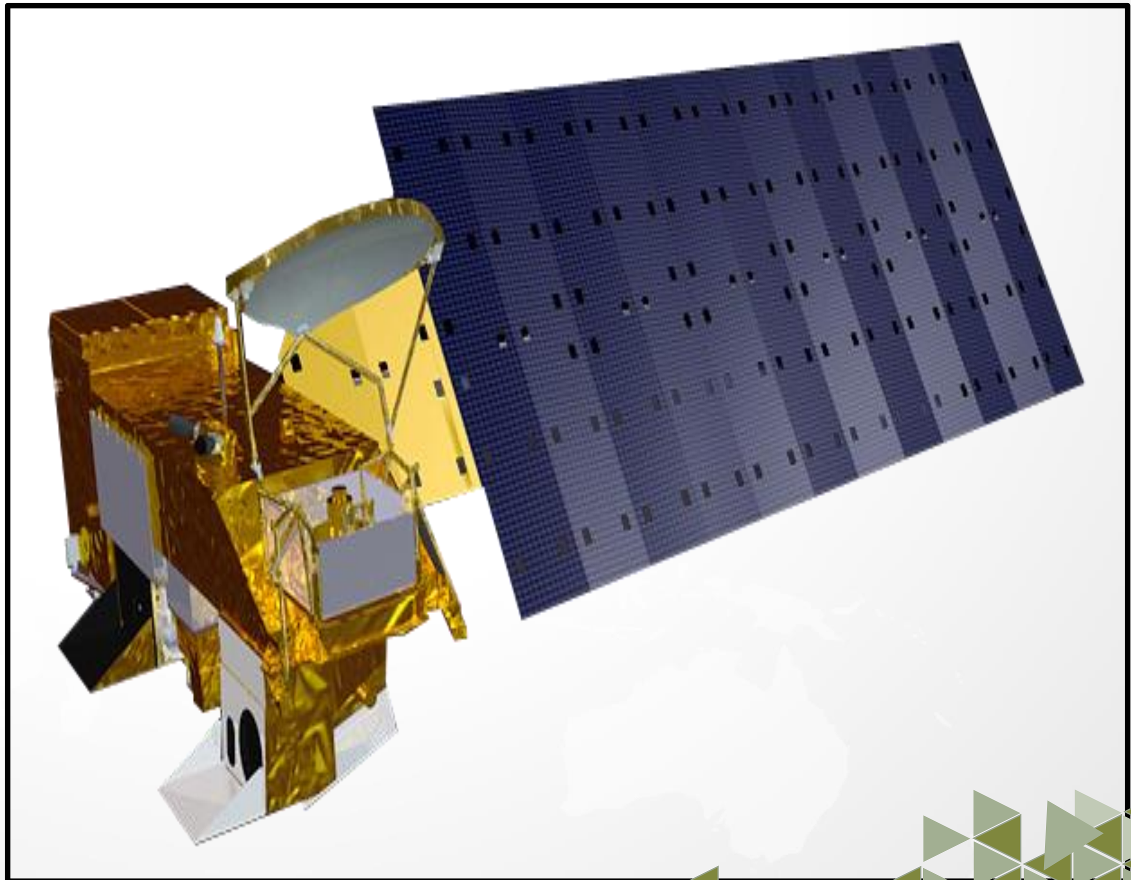
Types of Remote Sensing



Types of Satellite Instruments



36 channels



Remote Sensing: Types of Remote Sensing

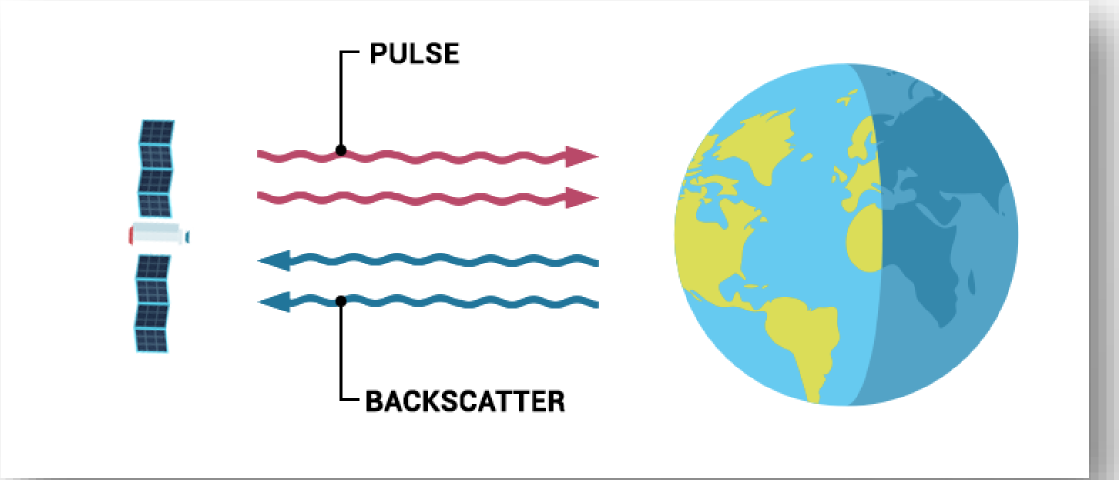
The two types of remote sensing sensors are:

Active sensors

Passive sensors

Remote Sensing: ACTIVE SENSORS

The main difference between active sensors is that this type of sensor illuminates its target. Then, active sensors measure the reflected light. For example, **Radarsat-2** is an active sensor that uses **synthetic aperture radar**.

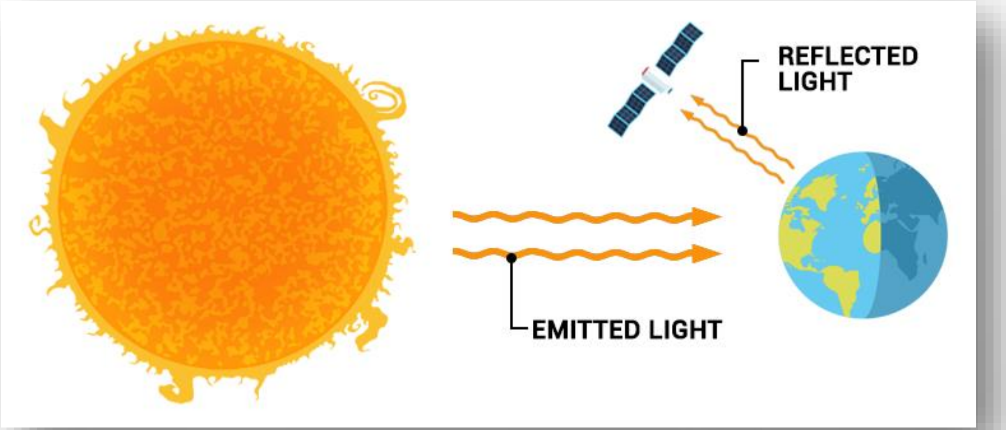


Imagine the flash of a camera. It brightens its target. Next, it captures the return light. This is the same principle of how active sensors work.

Remote Sensing: PASSIVE SENSORS

Passive sensors measure reflected light emitted from the sun. When sunlight reflects off the Earth's surface, passive sensors capture that light.

For example, **Landsat** and **Sentinel** are passive sensors. They capture images by sensing reflected sunlight in the electromagnetic spectrum.



Passive remote sensing measures reflected energy emitted from the sun.

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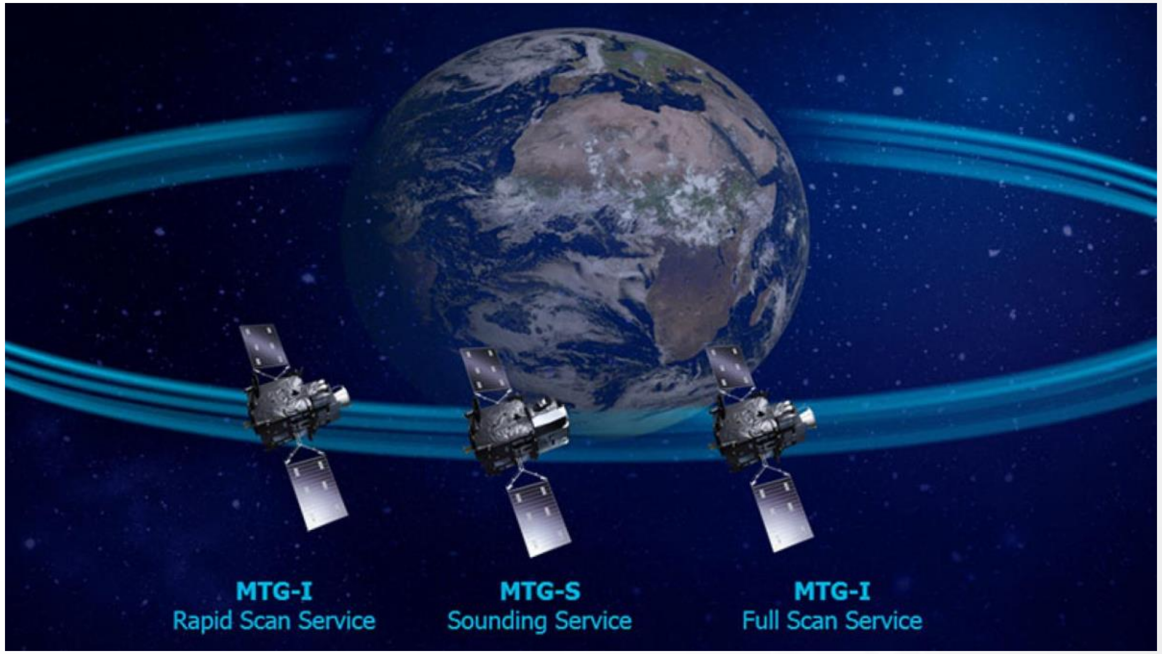
Passive | Sensors detect only what is emitted from the landscape, or reflected from another source (e.g., light reflected from the sun).

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

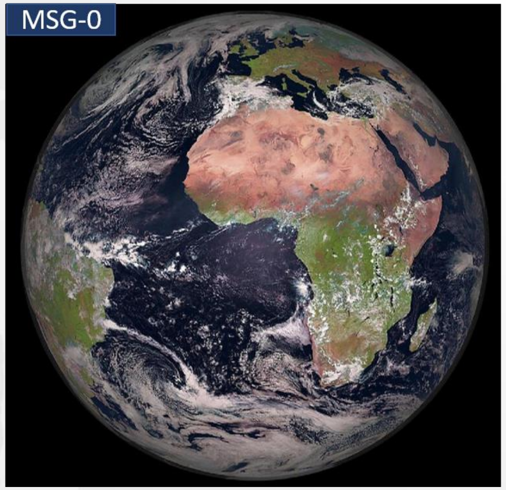
Operational EUMETSAT Geostationary Satellite

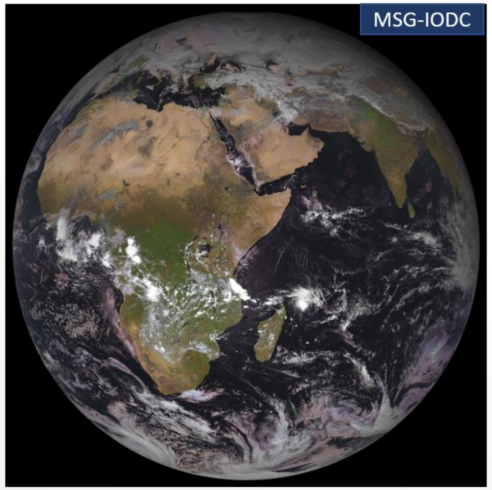


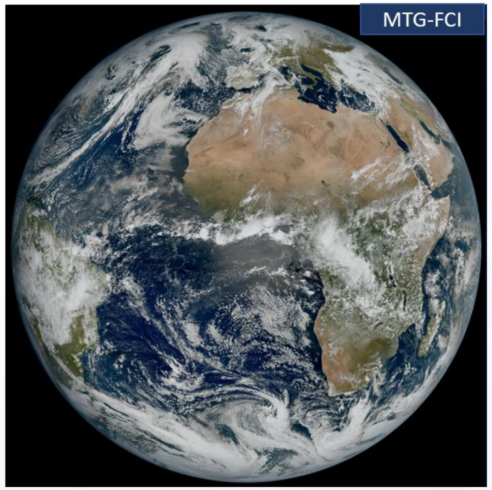
Remote Sensing: Operational EUMETSAT Geostationary Satellite

EUMETSAT currently operates:

- Three satellites from the Meteosat Second Generation (MSG), Meteosat-9, -10 and -11 over Europe, Africa and part of the Indian Ocean.
- Since December 2022, it has been operating the first satellite of the Meteosat Third Generation series, MTG-I1.







Channels and RGBs

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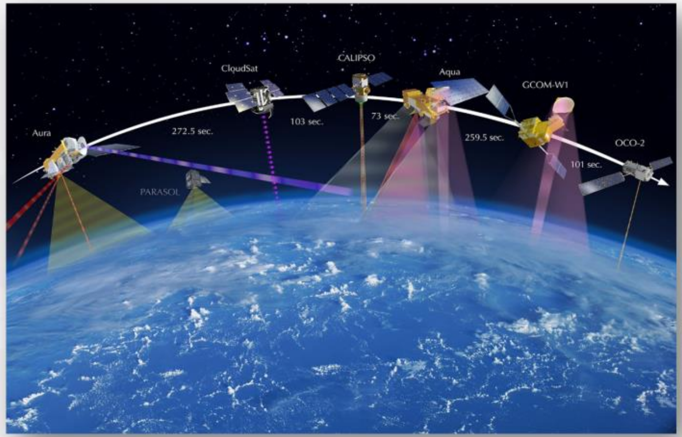
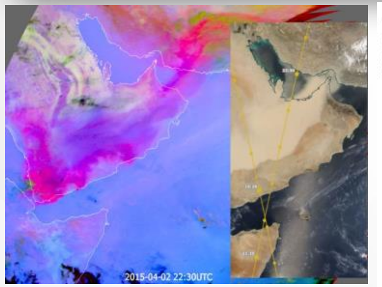
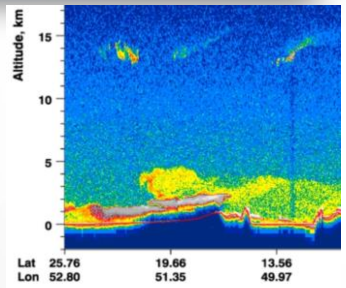
Many products and large amounts of data.

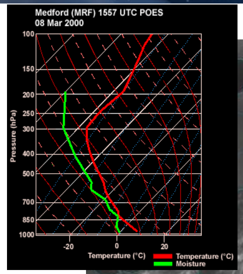
MSG

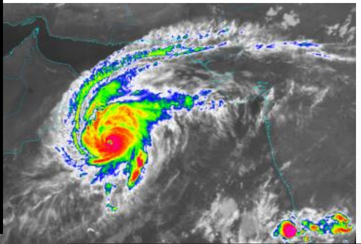
MTG

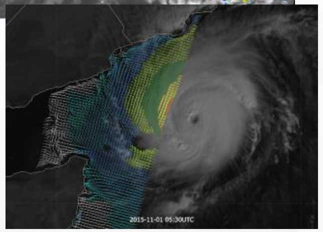


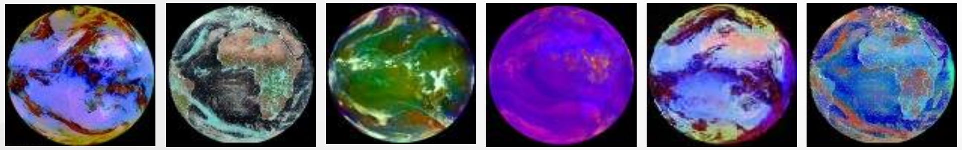




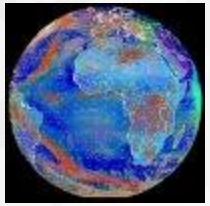




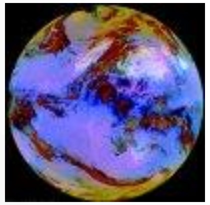




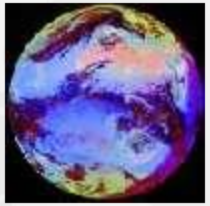
الصور المركبة (RGB)



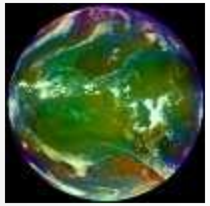
Day Microphysics RGB



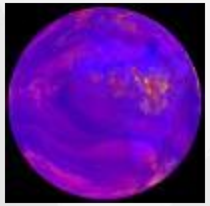
Dust RGB



Fog / Low Clouds RGB

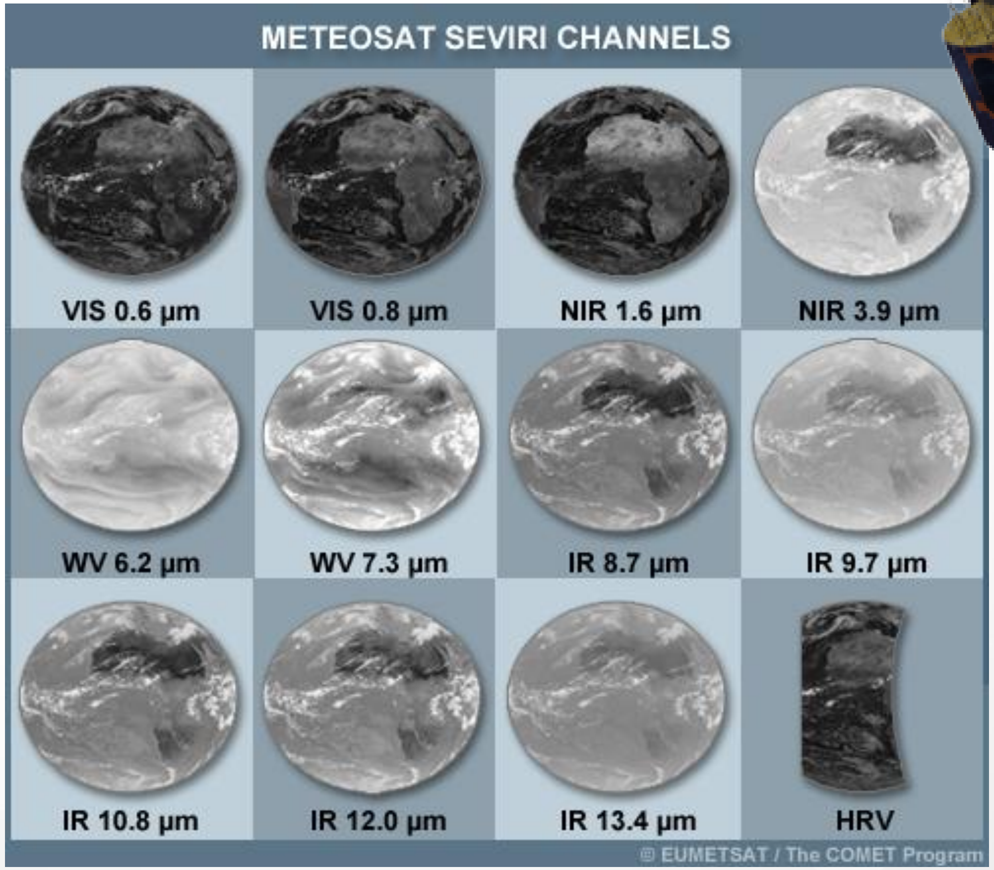


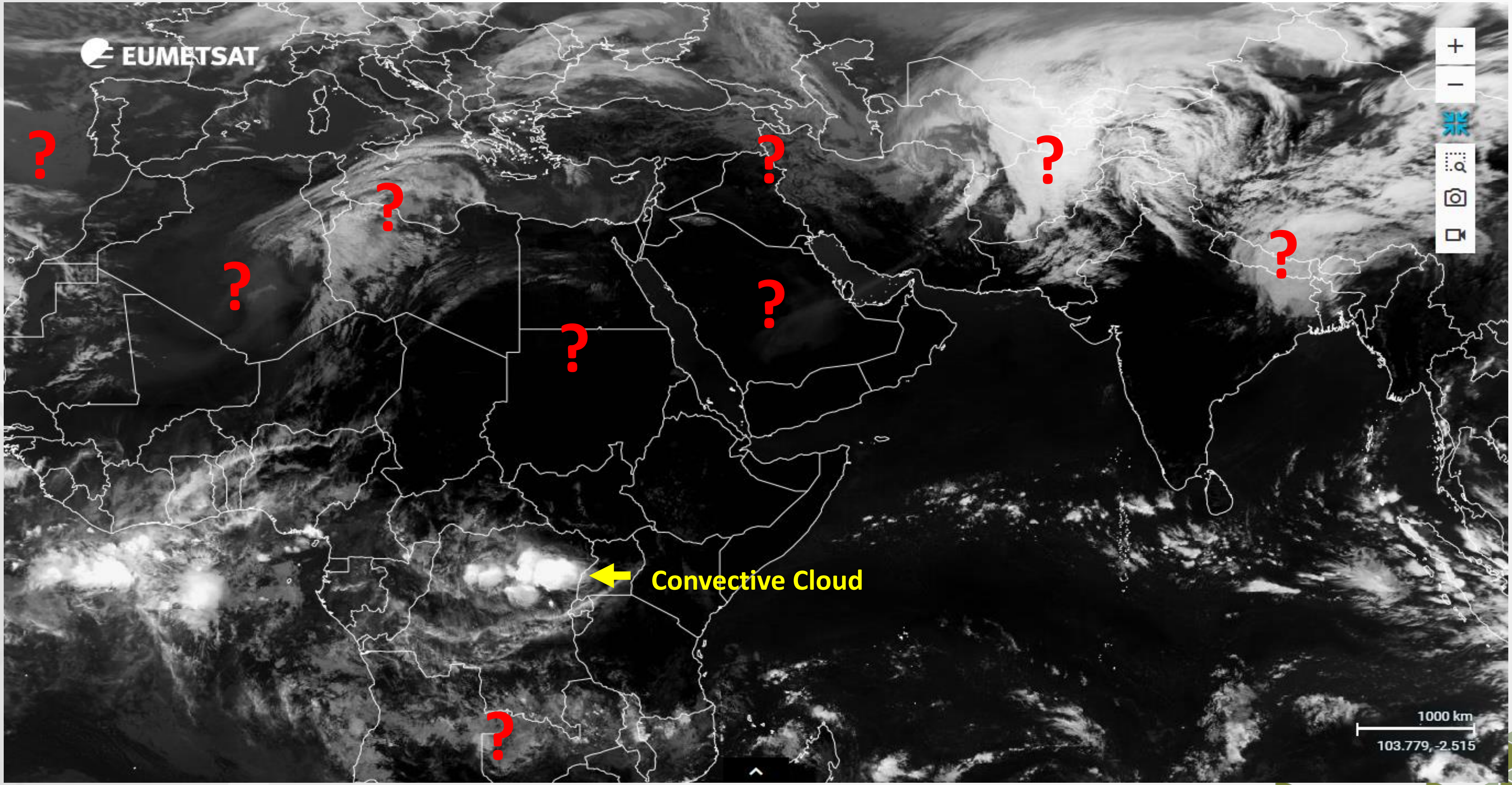
Airmass RGB

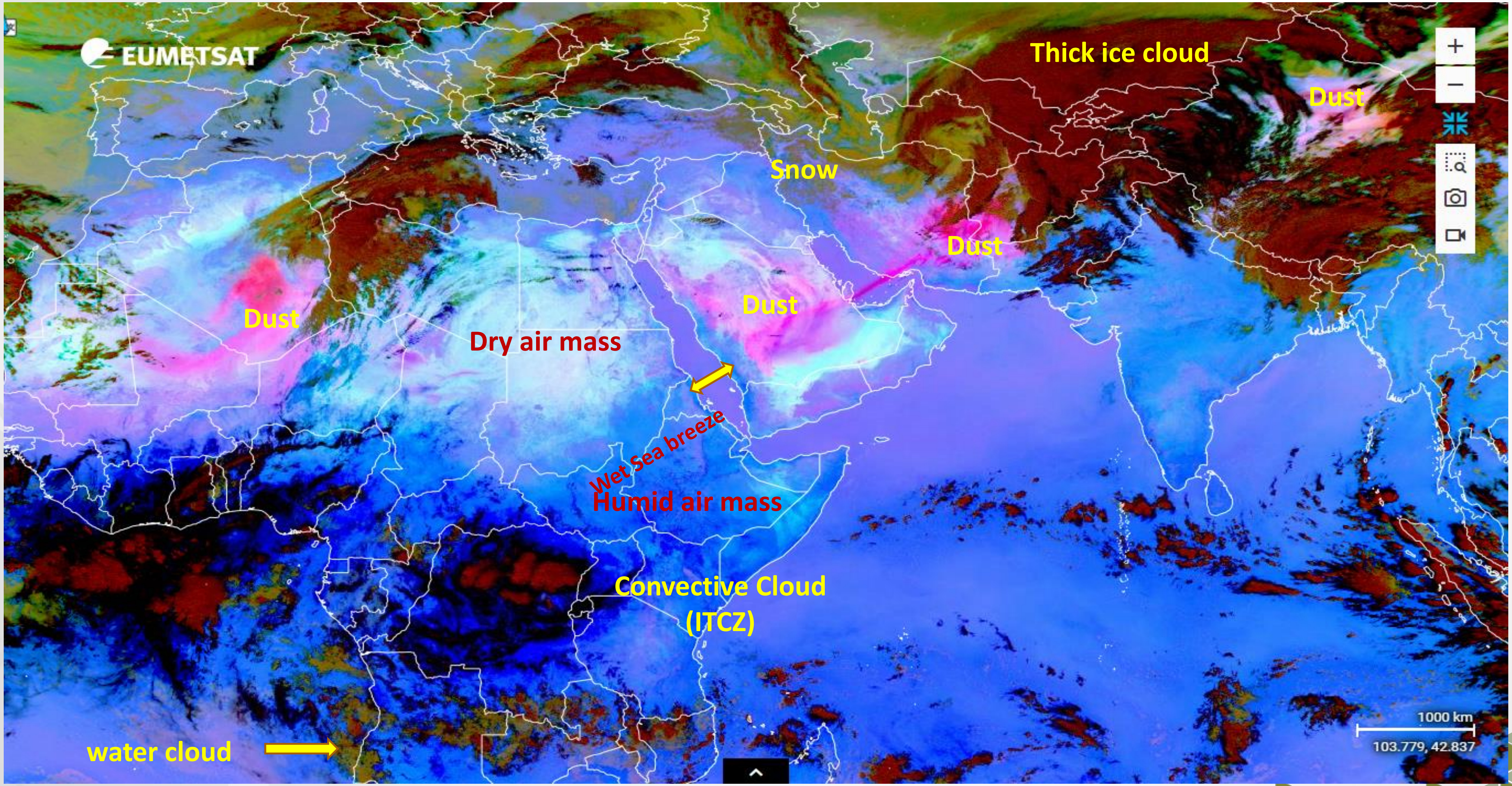


Convection RGB

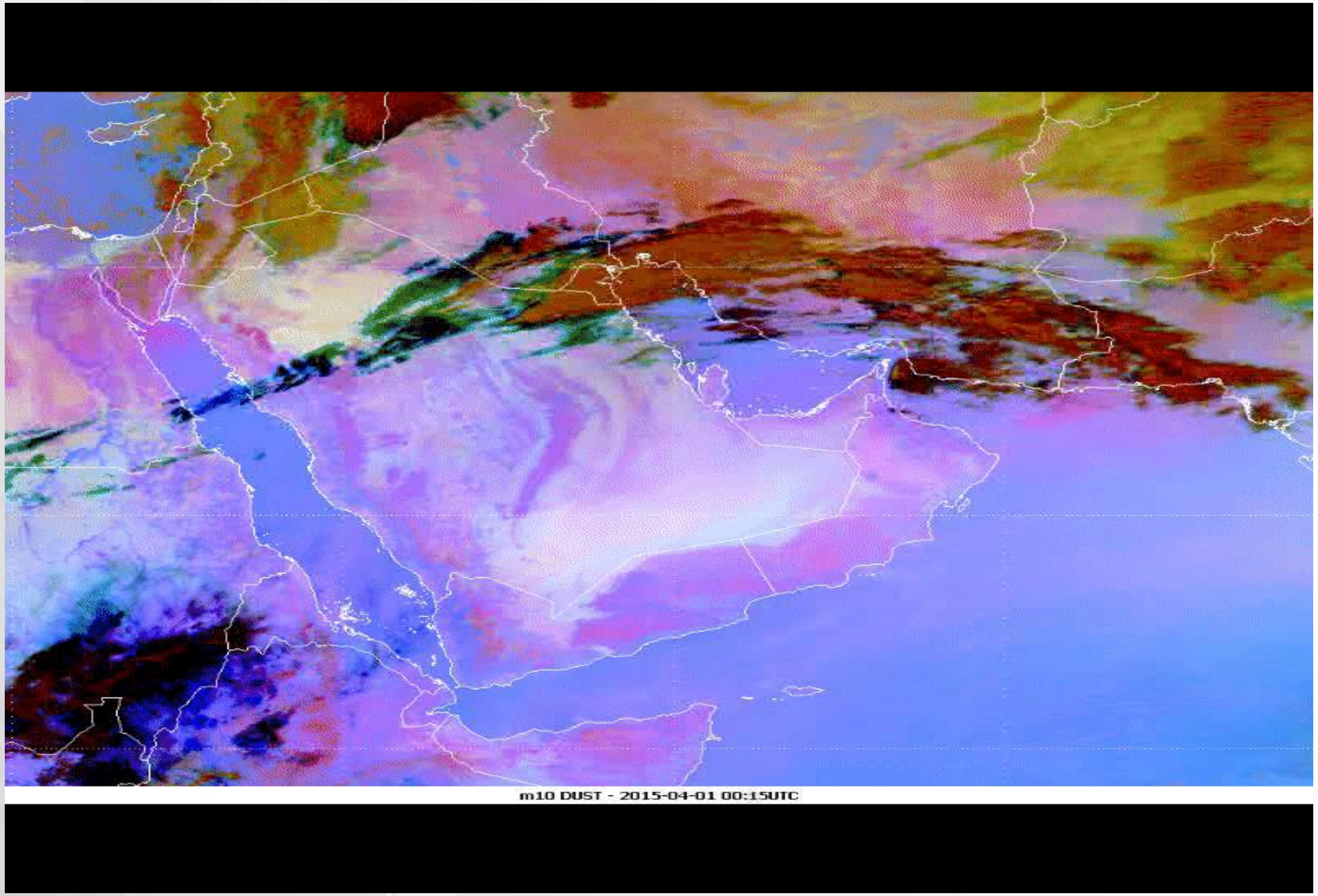
Natural Color RGB




EUMETSAT
?
Convective Cloud
1000 km
103.779, -2.515


EUMETSAT
Thick ice cloud
Dust
Snow
Dust
Dust
Dust
Dry air mass
Wet Sea breeze
Humid air mass
Convective Cloud
(ITCZ)
water cloud
1000 km
103.779, 42.837

Dust RGB/ Dust Storm 2015

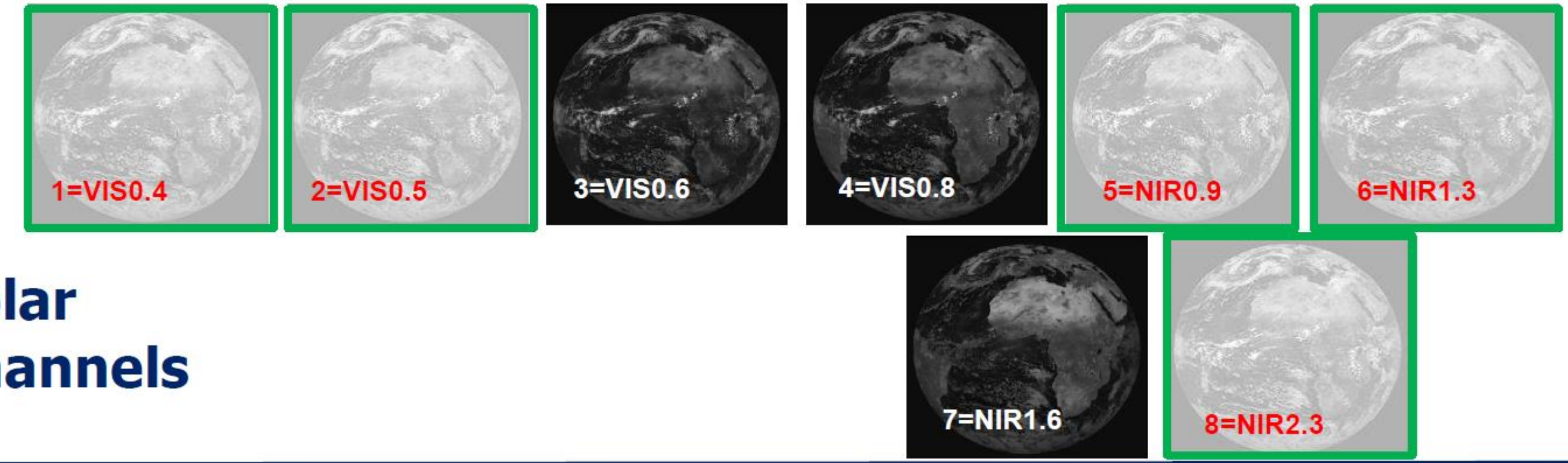


صورة واحدة لا تكفي !

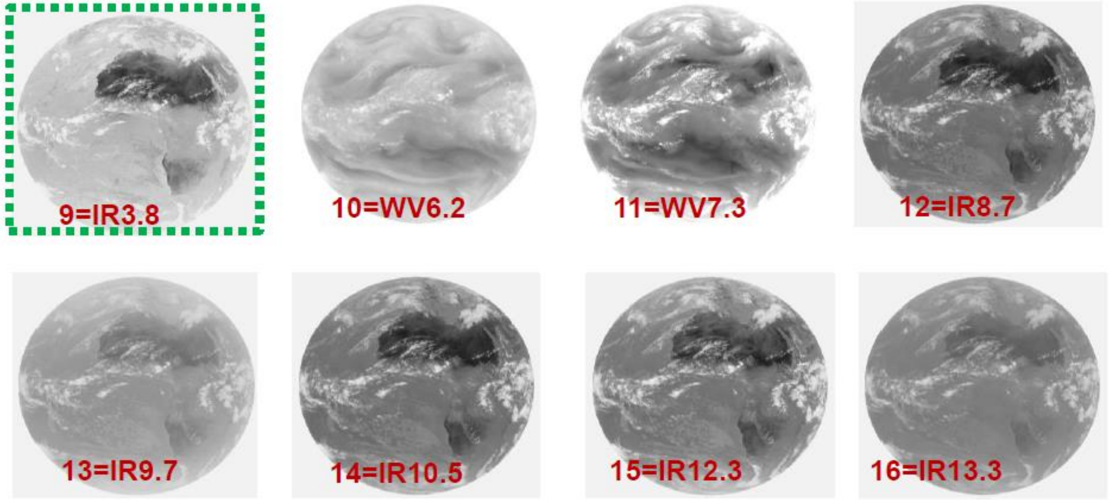
Channel Type	Used to Estimate
Solar Channels	Vegetation health, water quality, soil properties, reflected solar radiation
Thermal Channels	Surface temperatures (land and sea), cloud top temperatures, thermal properties of the Earth's surface
Microwaves Channels	Precipitation, soil moisture, sea state (wave height), wind speed over oceans

SEVIRI (FCI) spectral channels

Solar Channels



Thermal Channels

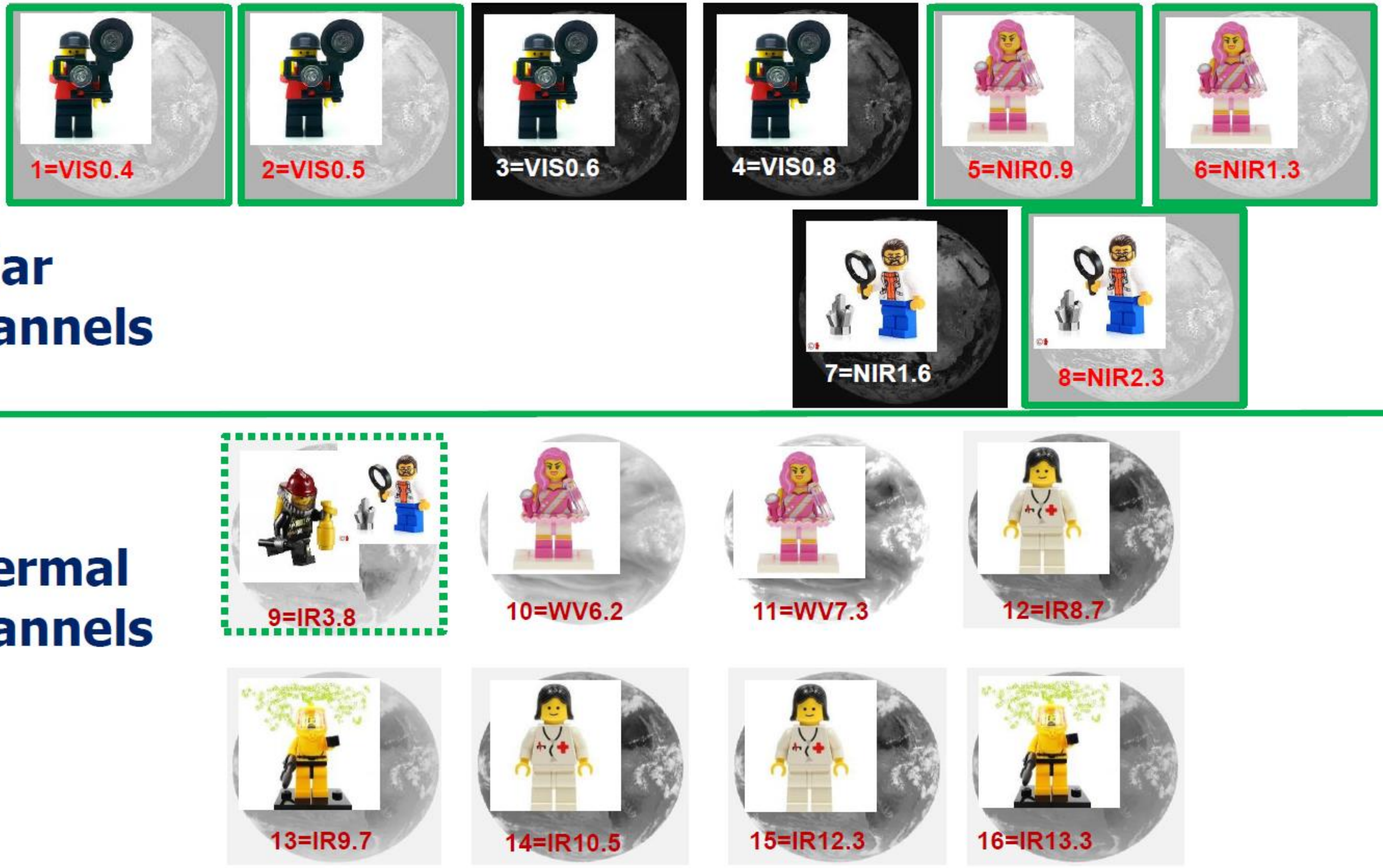


SEVIRI (FCI) spectral channels

"Colloquial" channel name	Applications
Blue	aerosol, surface features
Green	aerosol, vegetation
Red	fog, insolation, winds
Veggie	vegetation, winds
Low-Level WV	water vapour, winds
Cirrus	thin cirrus
NIR Phase	cloud phase, snow/ice
Particle Size	particle size, vegetation
Fire	microphysics, fires
Upper-Level WV	WV, winds, rainfall
Lower-Level WV	WV, winds, SO2
Cloud-Top Phase	cloud phase, SO2
Ozone	total O3, turbulence
Clean IR	SST, clouds temp
IR Longwave	SST, clouds temp, rainfall
Dirty IR	TPW, dust, ash
CO2	air temp, cloud height

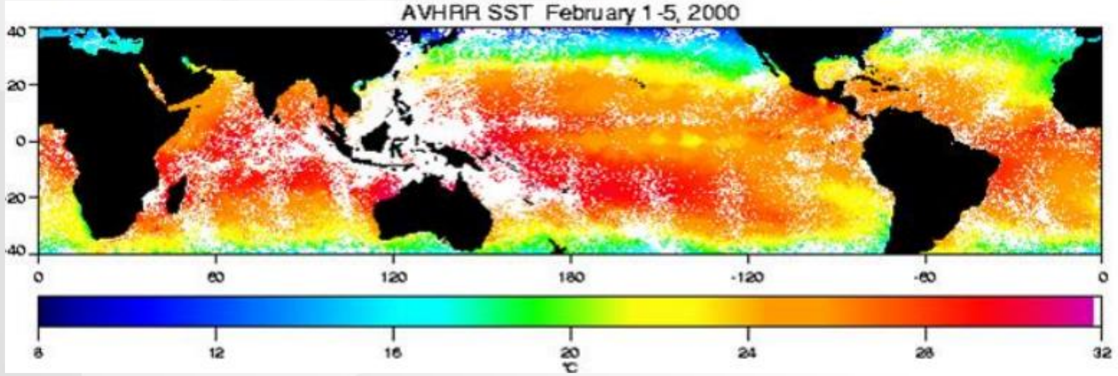
Solar Channels

Thermal Channels

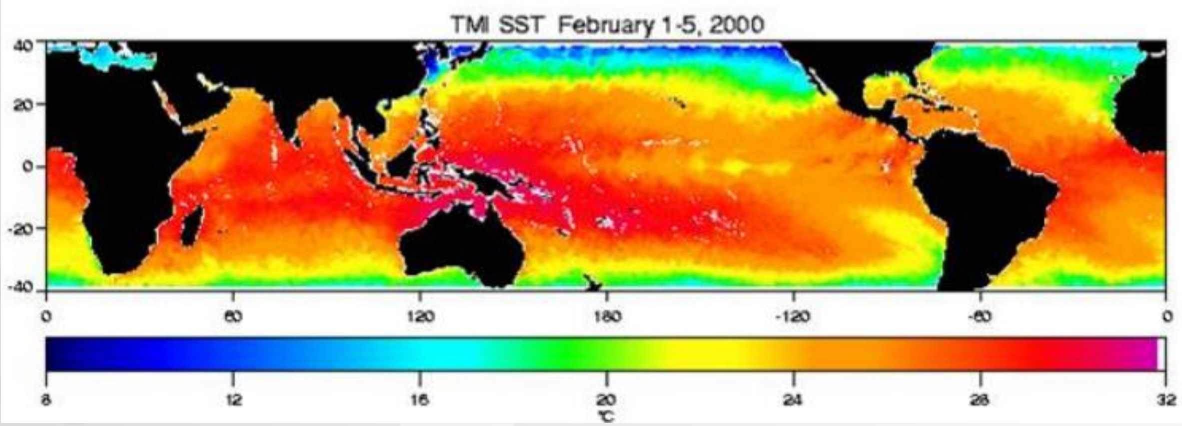


Remote Sensing:

The channels used for the Sea Surface Temperature (SST) maps shown



AVHRR SST
•**Channel Used:** Thermal band
•**Explanation:** This image uses thermal infrared channels from the Advanced Very High Resolution Radiometer (AVHRR) to measure sea surface temperature.



TM (Thematic Mapper) **SST**
•**Channel Used:** Microwave band
•**Explanation:** Microwave sensors can also be used to measure sea surface temperature by detecting emitted radiation in the microwave spectrum, which can penetrate clouds better than infrared, providing SST information even under cloudy conditions.

Some advantages of microwave satellite images not found in infrared images.

a. Can see during day and night time

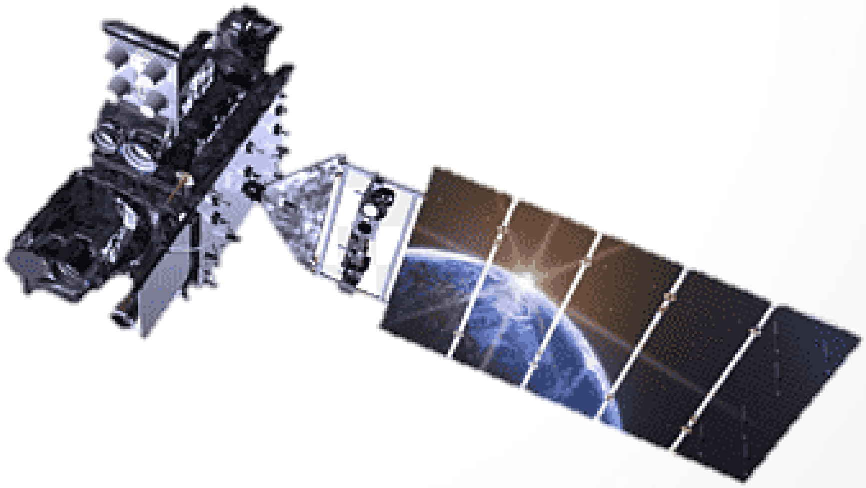
•**Explanation:** Microwave sensors do not rely on solar illumination, unlike some infrared sensors. They can collect data both during the day and at night because they are sensitive to the radiation emitted or reflected from Earth's surfaces and atmosphere regardless of sunlight.

b. Can see inner cloud features

•**Explanation:** Microwaves have longer wavelengths that can penetrate through clouds, allowing them to observe features below the cloud tops. This capability is crucial for studying meteorological phenomena such as the internal structure of storms and precipitation, which are not visible with infrared sensors that only detect surface thermal radiation blocked by clouds.

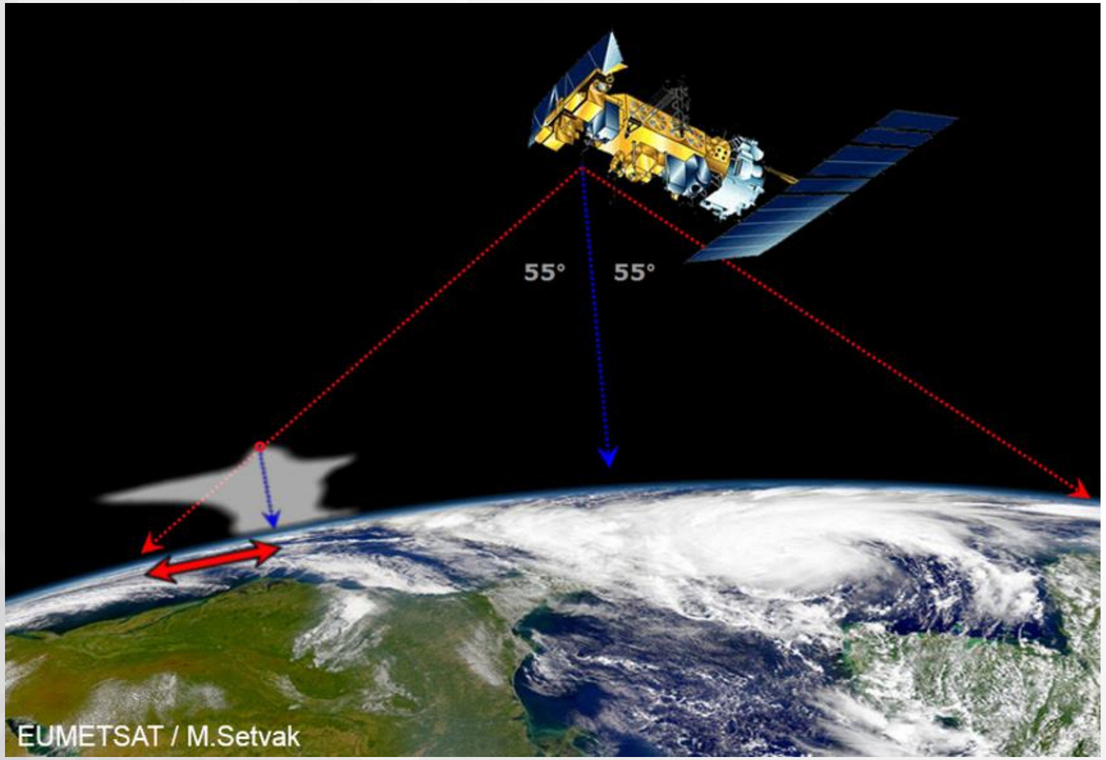
These characteristics make microwave imaging particularly valuable for continuous monitoring and studying atmospheric and surface conditions under all weather conditions, enhancing our understanding and forecasting of weather and climate phenomena.

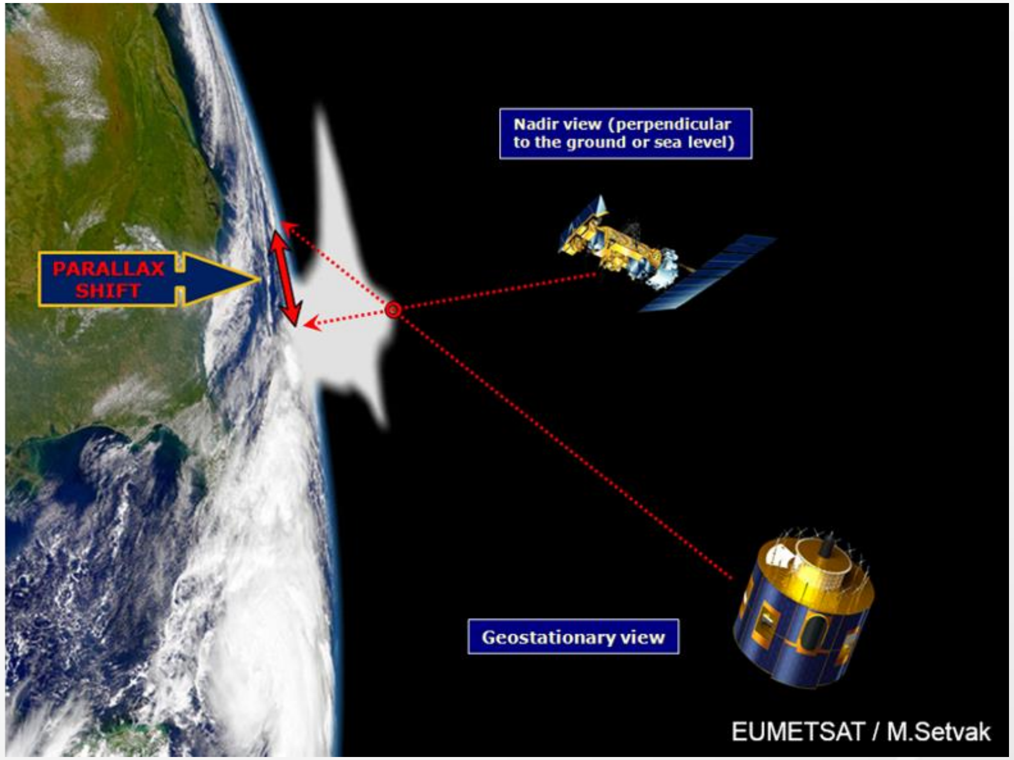
Satellite Limitations



Remote Sensing: Parallax Shift

When the satellite viewing angle is away from the sub-satellite point , an object's (cloud) position is shifted. Displacement grows more quickly with increasing distance from the satellite. At large viewing angles, high clouds move further than low clouds, and the distortion of the shape of the original feature is also greater.



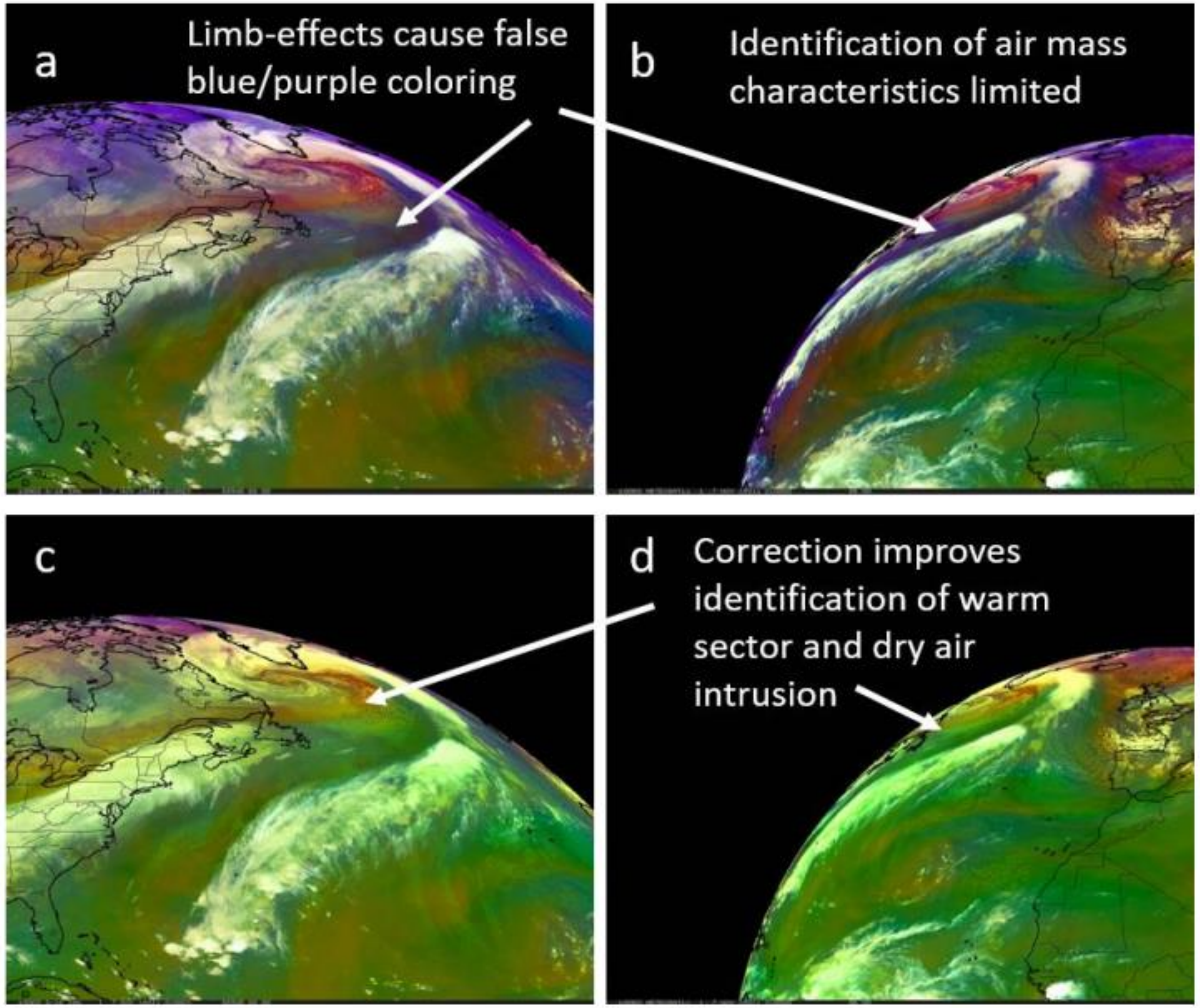


The image shows the parallax shift for satellite at polar orbit and Geostationary Satellite.

Remote Sensing: Limb Cooling

The limb-cooling is a result of an increase in measurement (optical) path length of the absorbing atmosphere, as viewing angle increases.

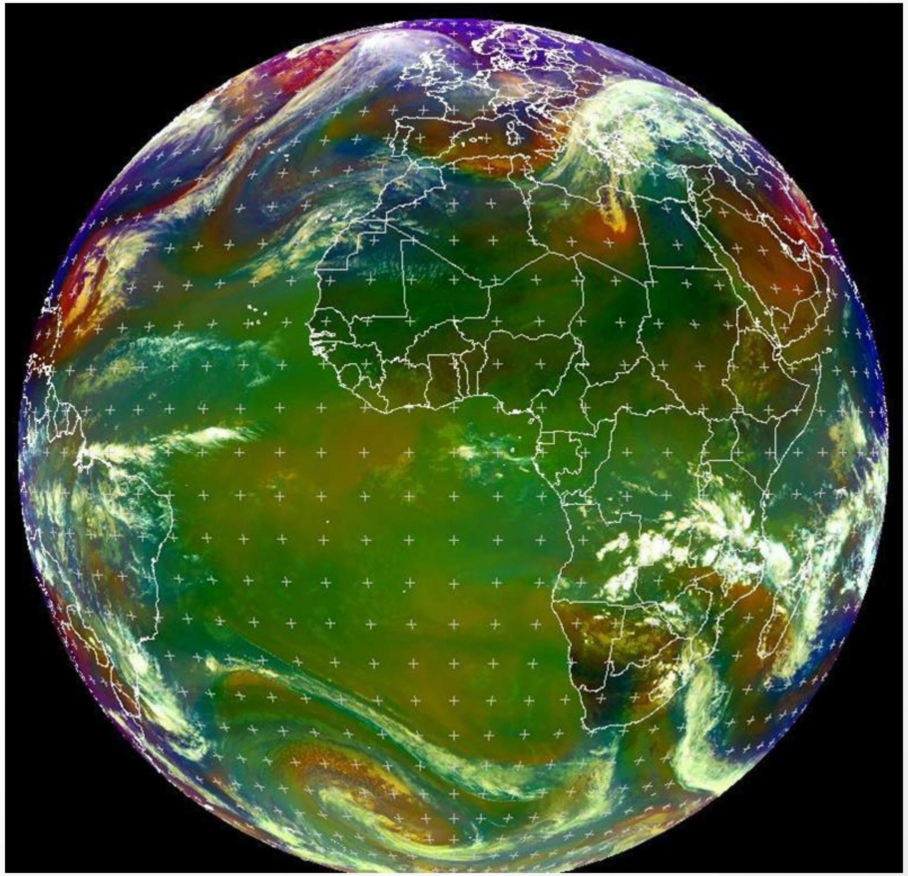
Major absorbing variables are water vapour, ozone and carbon dioxide. Satellite instrument IR measurements are colder at locations that are far from sub-satellite point.



7 Nov. 2019 2100 UTC Air Mass RGB (a) GOES-16, (b) SEVIRI, (c) GOES-16 limb-corrected, (d) SEVIRI limb-corrected

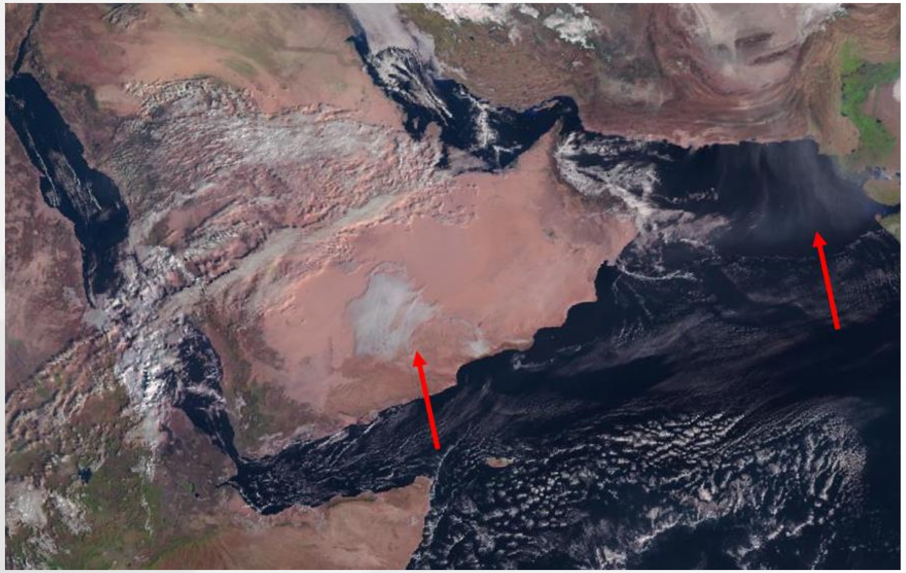
Remote Sensing: Limb Cooling

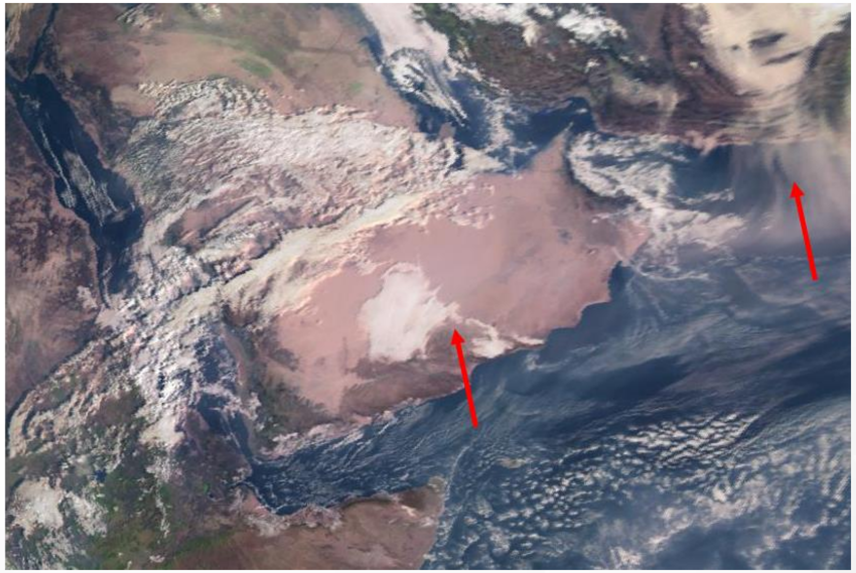
The blue colour in the Airmass RGB stems from the so-called "limb cooling effect". If the whole disk of the Airmass RGB is plotted, one sees that the blue colour prevails at the image edge even in the tropical regions. Radiation from the image edge (full disk image) traverses a longer path through the troposphere until it reaches the satellite instrument. Therefore, the measured radiances, especially in the WV bands, are far smaller than from regions near the sub-satellite point (see image below).



Remote Sensing: Limb Cooling

The higher viewing angle of the satellite also offers a positive advantage in detecting low-level features such as fog or thin dust. This is because the radiation passes through more of the atmosphere, allowing for better detection of these features.





The satellite images above were captured by SEVIRI instruments. In the image on the right, taken by MSG at 0°, the fog over the Arabian Peninsula and the dust over the Arabian Sea are more clearly visible compared to the left image, which was captured by MSG (IODC at 41.5°E) due to the higher viewing angle.

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Sensors - Applications

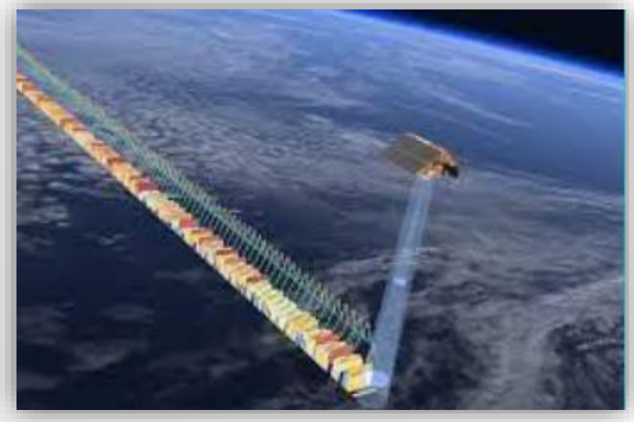
Remote Sensing: sensors - Applications

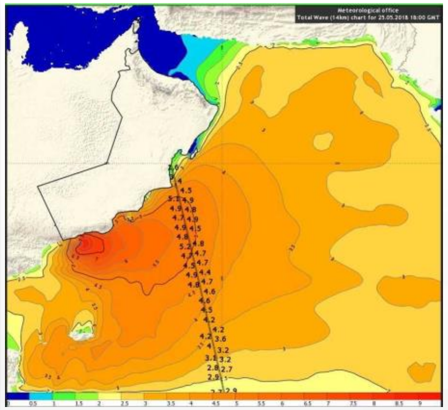
1. Satellite Altimeter

Purpose: Primarily measures sea level and significant wave height, providing crucial data for oceanography and climate studies.

Applications: Used to determine ocean circulation patterns, sea level rise, and wave heights.

Example: The satellite altimeter works by emitting radar pulses towards the ocean surface and measuring the time it takes for the signals to return. This allows it to determine the height of the sea surface and the height of the waves, offering comprehensive data over global scales.





Parameter Measured: Sea Level, Significant Wave Height

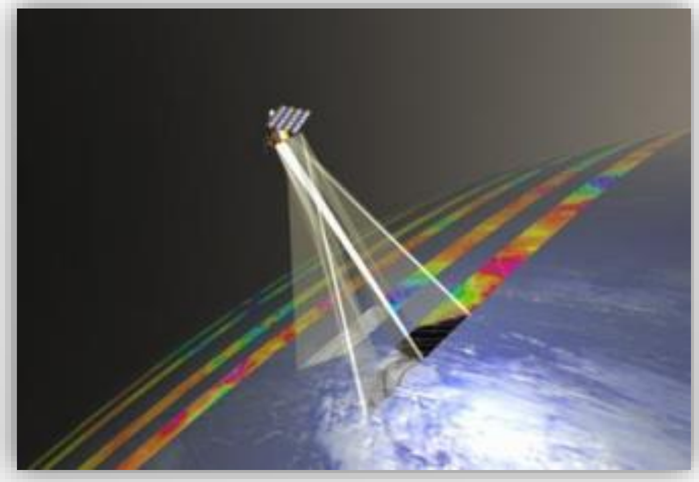
Remote Sensing: sensors - Applications

2. Satellite Scatterometer

Purpose: Captures wind vectors over the ocean surface.

Applications: Essential for weather forecasting, tracking hurricanes, and marine navigation.

Example: The depicted sensor emits microwave radar pulses towards the Earth's surface and measures the radiation scattered back to the satellite, which is analyzed to derive wind speeds and directions.



Parameter Measured: Wind Speed and Direction at the Ocean Surface

Remote Sensing: sensors - Applications

3. Infrared Radiometer
Purpose: Measures infrared radiation to determine the temperature of the sea surface.
Applications: Vital for monitoring ocean currents, climate patterns, and marine ecosystems.

Example: This sensor detects infrared energy emitted from the ocean surface, which is directly related to temperature, providing continuous and global observations of sea surface temperatures.

Parameter Measured: Sea Surface Temperature

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Thanks