Remote Sensing for Weather and Marine Applications

الاستشعار عن بعد لتطبيقات الطقس والبحرية

Lecturer: Manal Al Hashmi

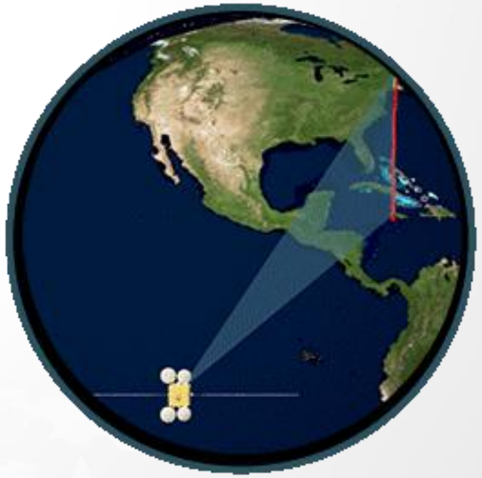
DGMET – Research & Development Department – Research & Remote Sensing section

30 Sep 2024

Remote Sensing: Definition

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

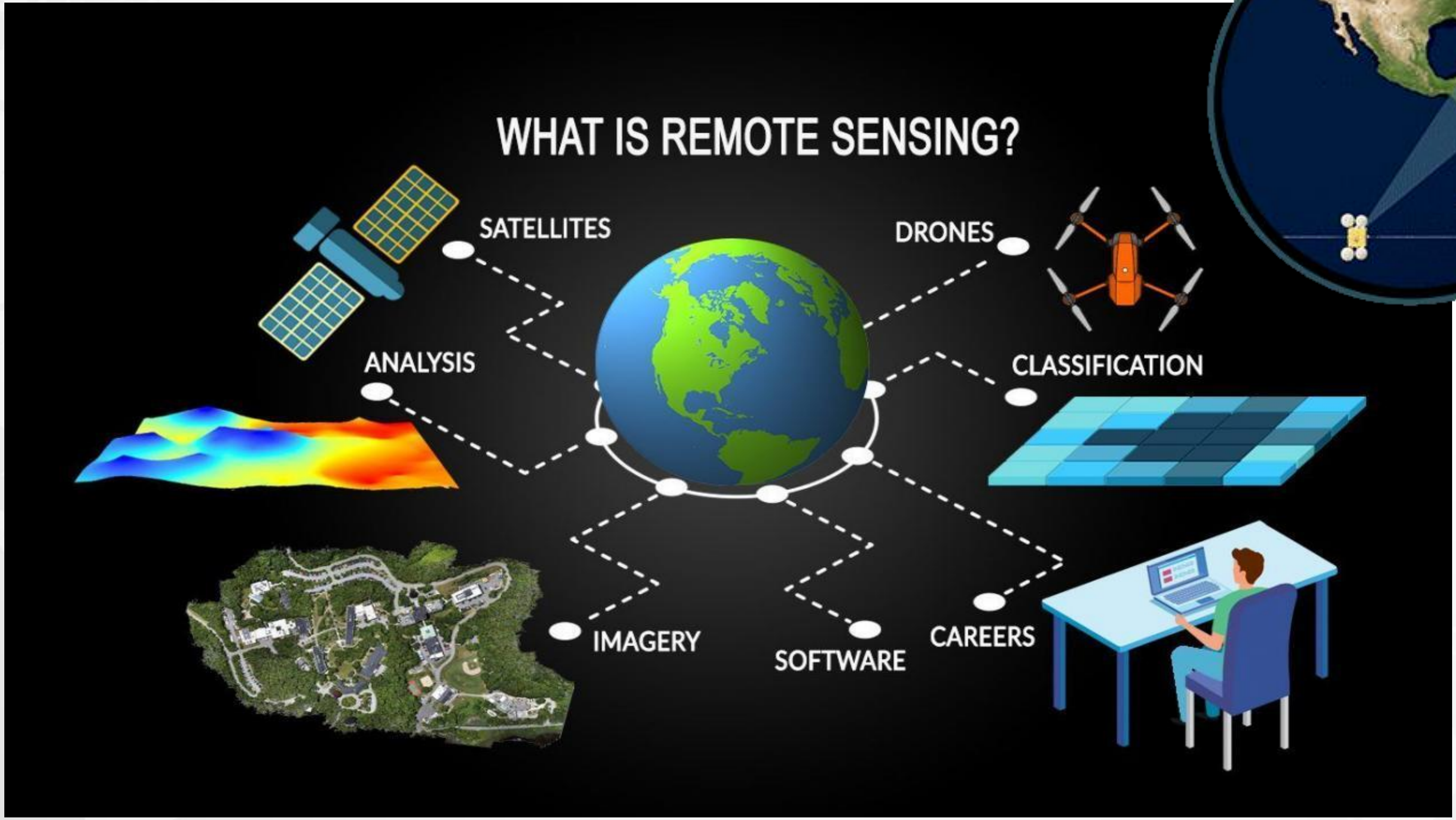
- **Sensing:** Refers to the act of collecting data or information, whether it be temperature, pressure, or images.



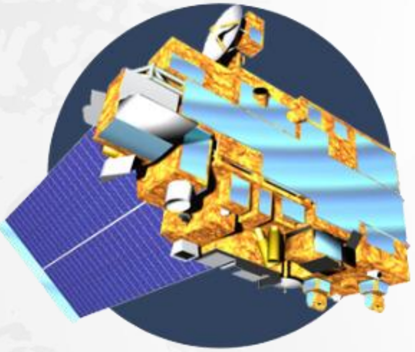
Remote Sensing

- 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.

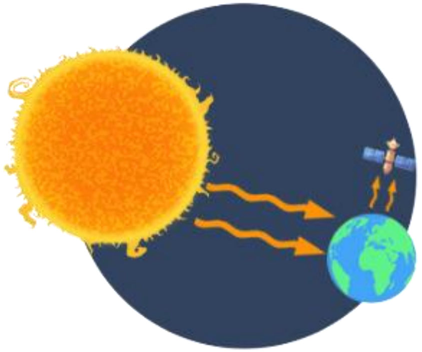
Remote Sensing: Definition



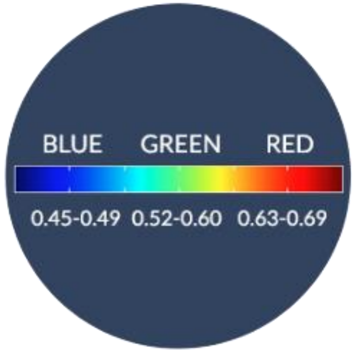
Content



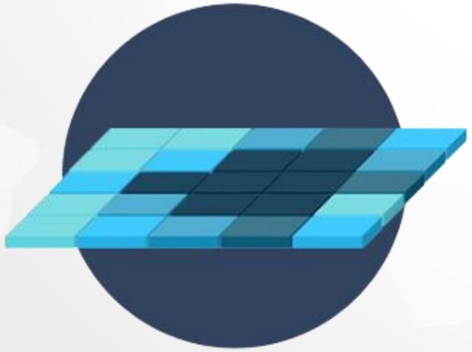
Sensor Types



Types of Remote Sensing



Channels and RGBs



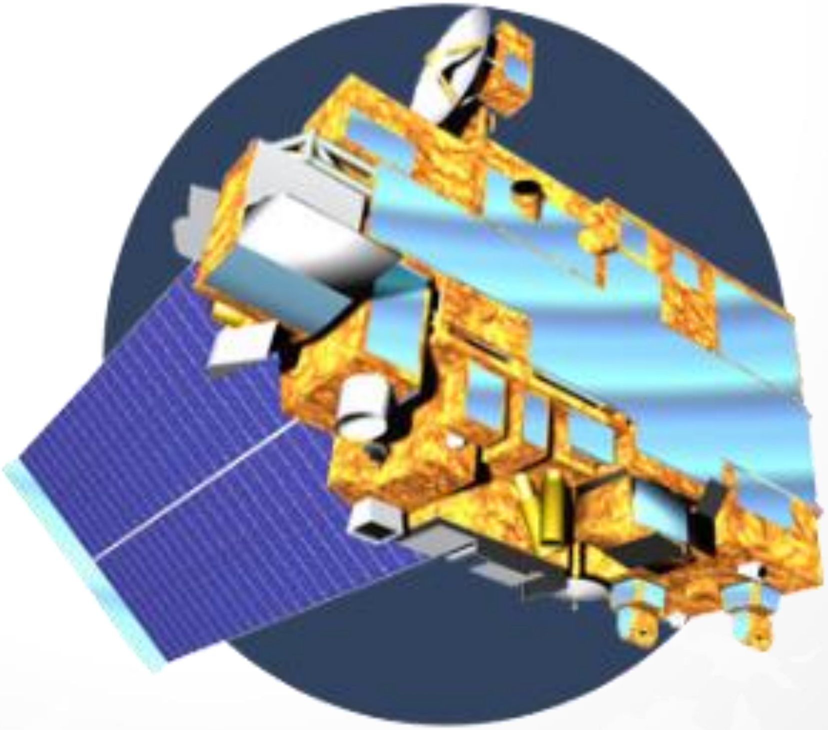
Sensors - Applications

Applications and Uses

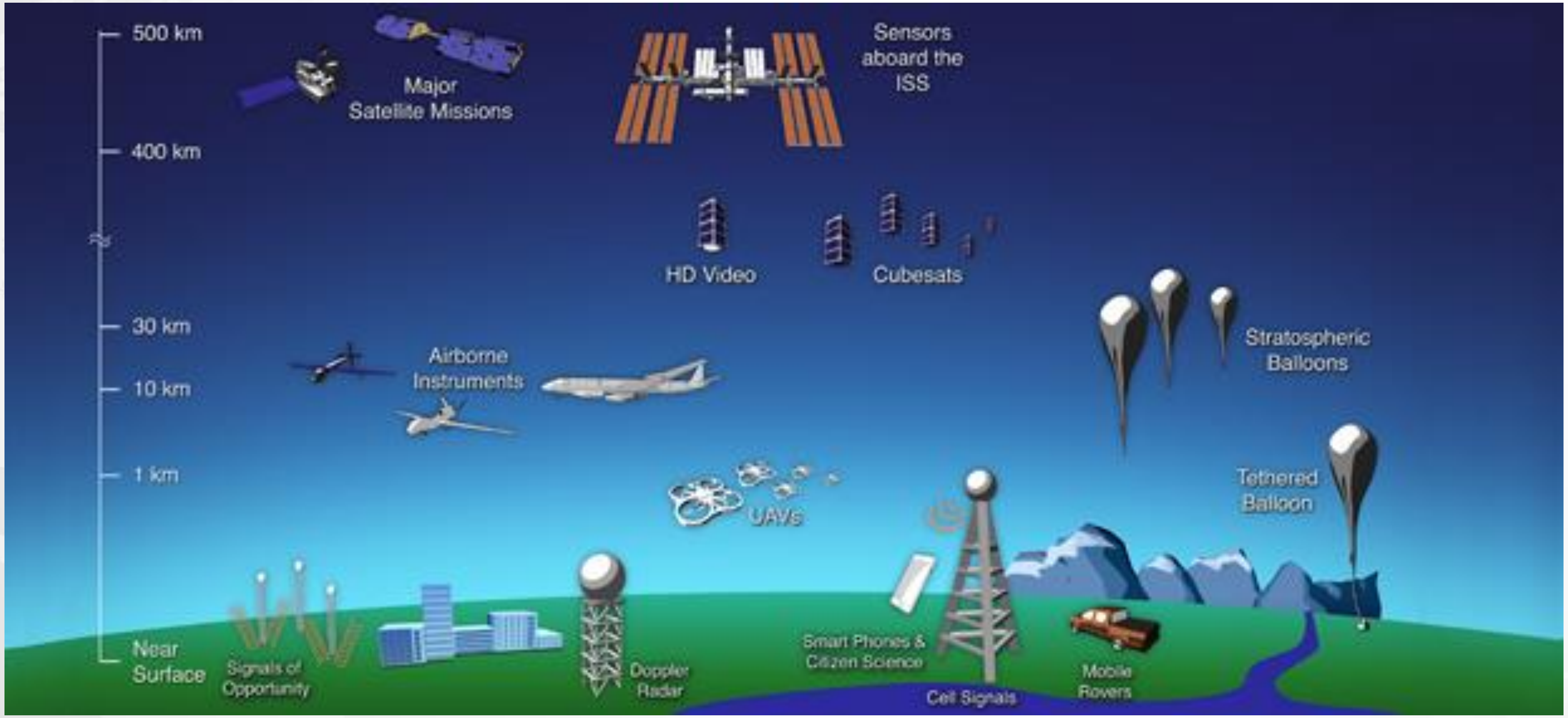
Sensor Types

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

هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

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

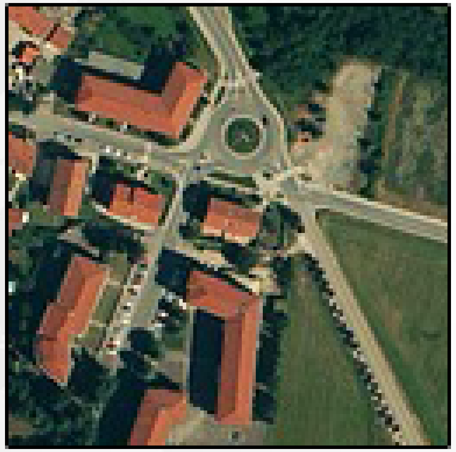
Remote Sensing: Image Resolution

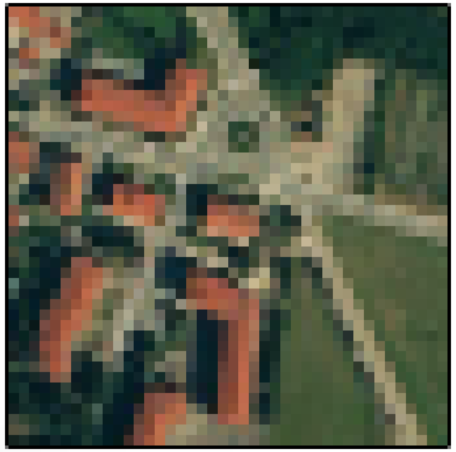
Remote sensing divides image resolution into FOUR different types:

- 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.

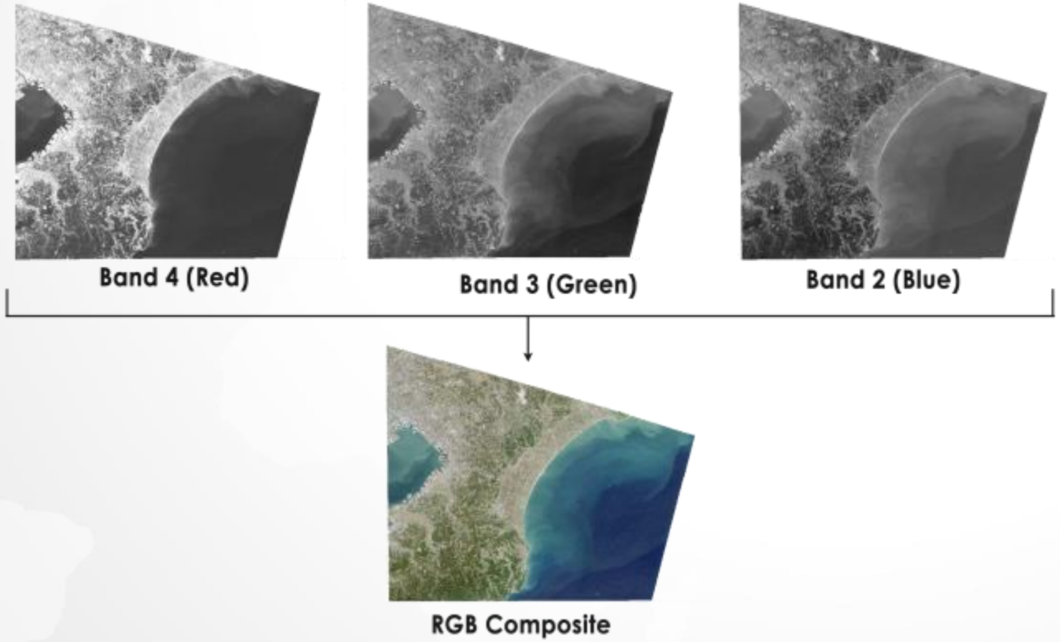

High Spatial Resolution


Medium Spatial Resolution


Low Spatial Resolution

Remote Sensing: SPECTRAL RESOLUTION

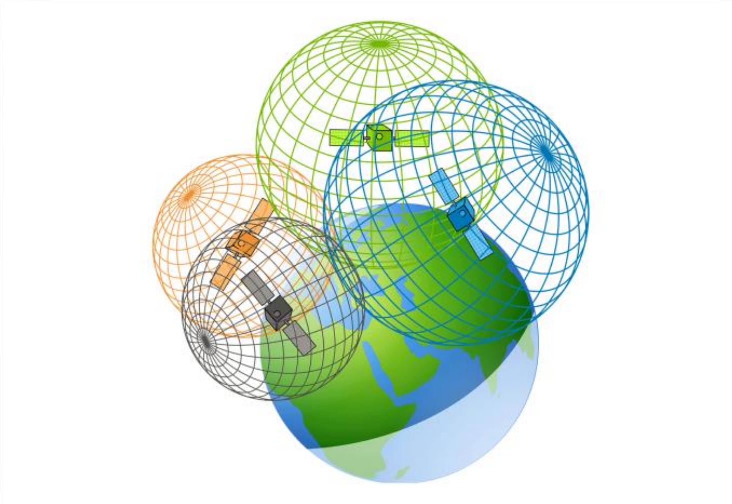
Spectral Resolution is the amount of spectral detail in a band. High spectral resolution means its bands are more narrow. Whereas low spectral resolution has broader bands covering more of the spectrum.



Remote Sensing: TEMPORAL RESOLUTION

Temporal Resolution is the time 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: TYPES OF ORBITS

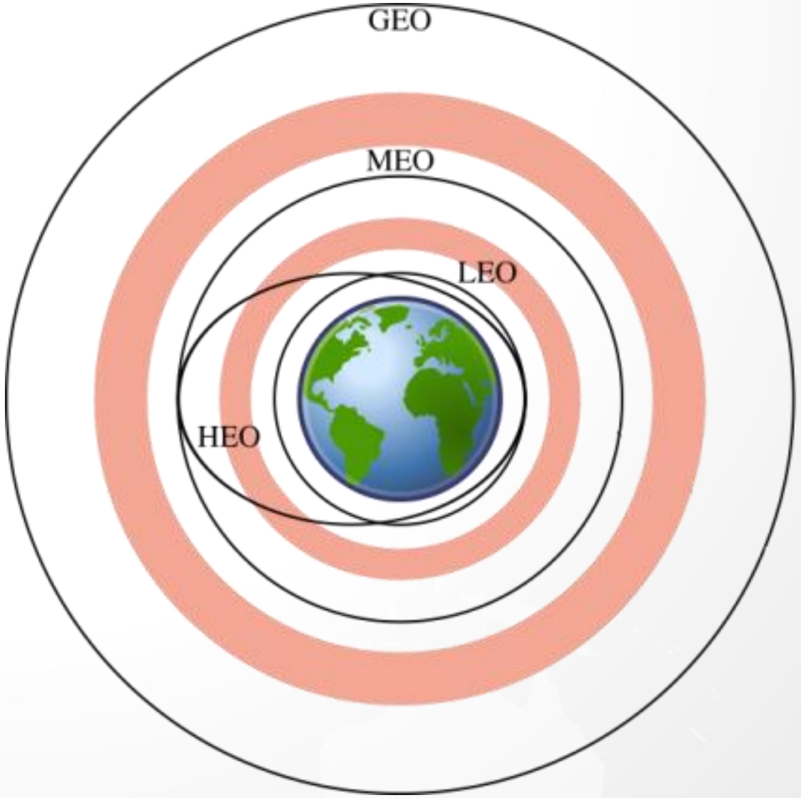
CAA
هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

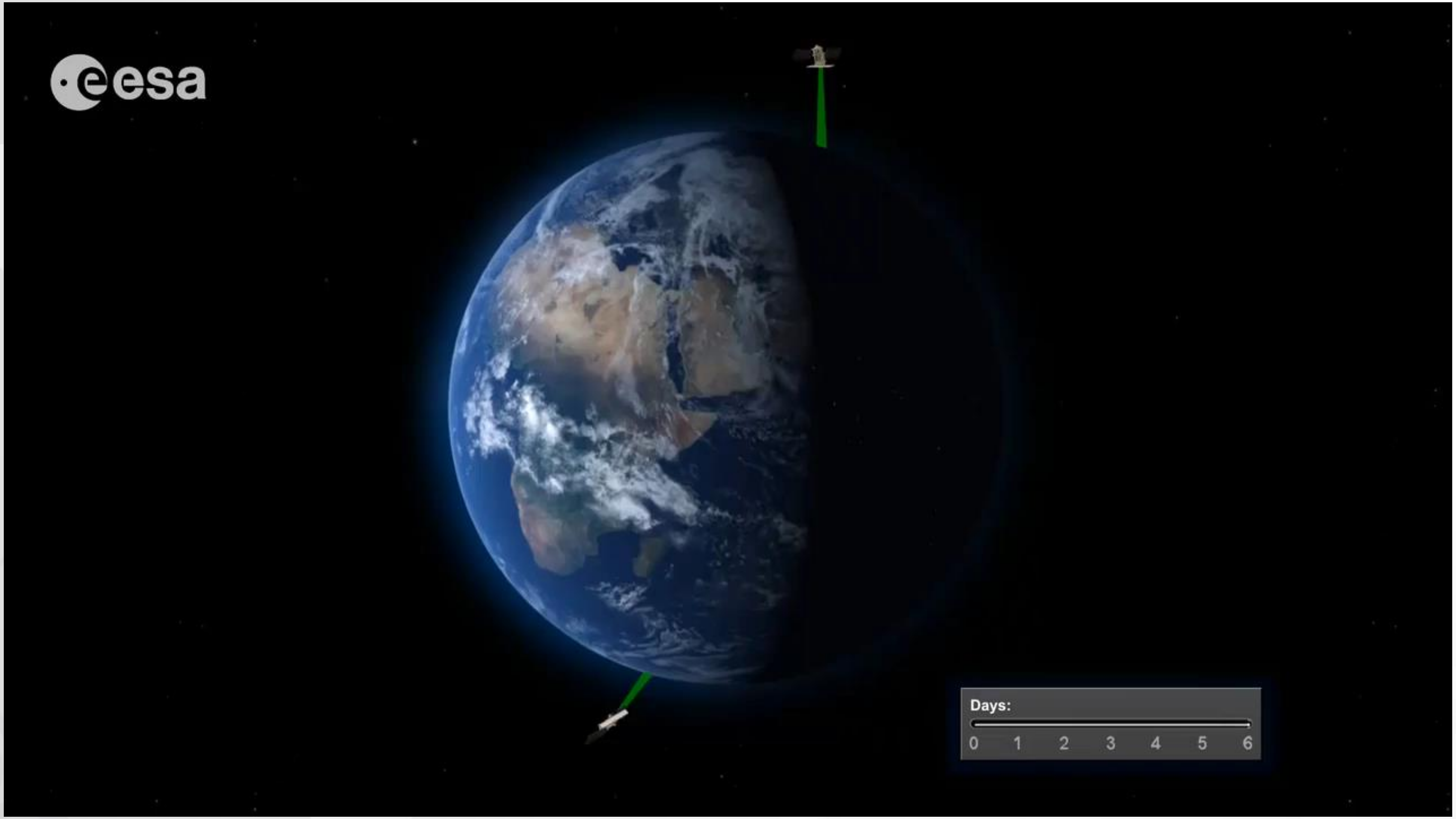
The types of orbits are:

- 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:

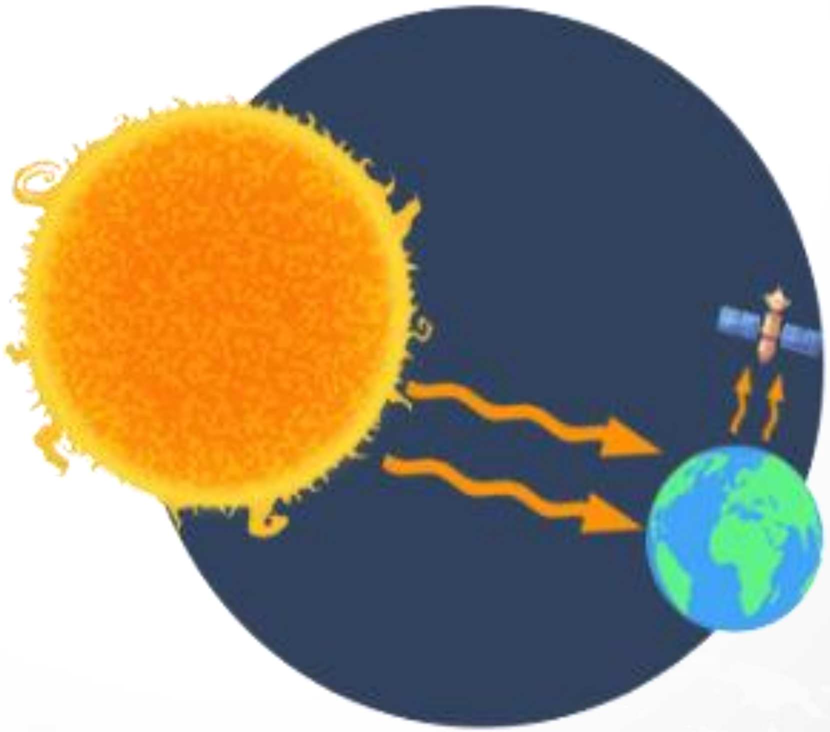
- Low Earth Orbit (LEO)
- Medium Earth Orbit (MEO)
- High Earth Orbit (HEO)





هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

Types of Remote Sensing



Remote Sensing: Types of Remote Sensing

The two types of remote sensing sensors are:

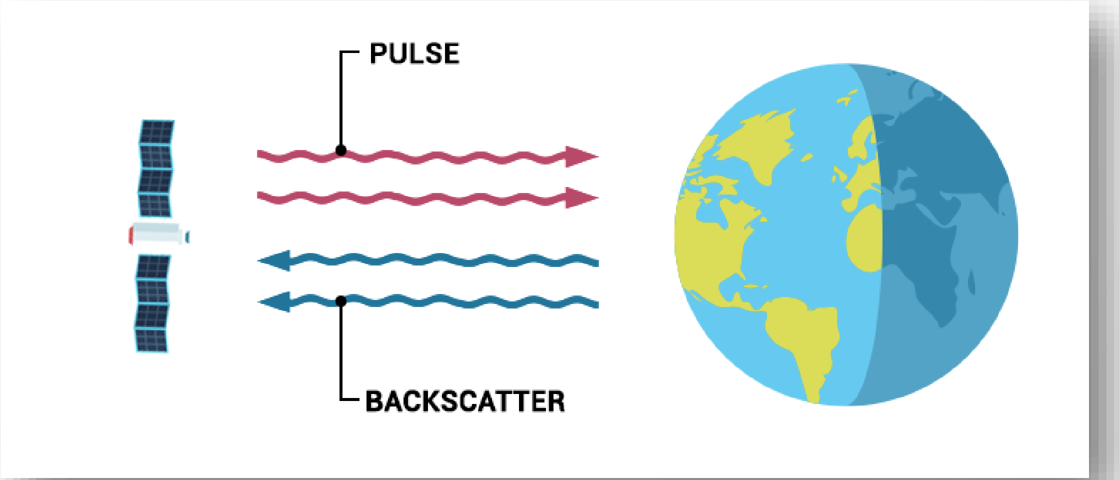
Active sensors

Passive sensors

Remote Sensing: ACTIVE SENSORS

CAA
هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

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**.



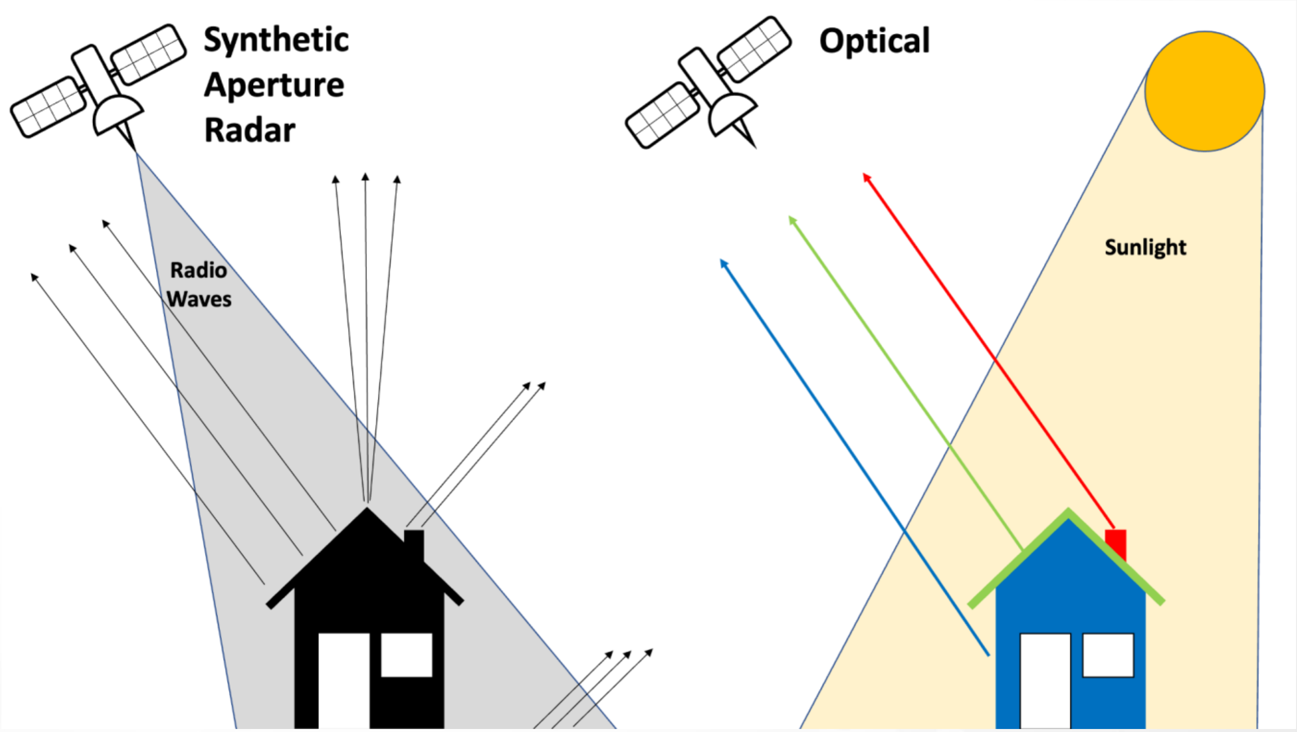
Imagine the flash of a camera. It brightens its target. Next, it captures the return light. This is the same principle of how active sensors work.

IS SAR sensor an Active Sensor?

A Synthetic Aperture Radar (SAR) sensor is classified as an **active** sensor

because it transmits its own microwave signals towards the Earth and measures the signals that are reflected back.

This capability enables SAR sensors to operate effectively during both day and night and under all weather conditions, including heavy cloud cover.

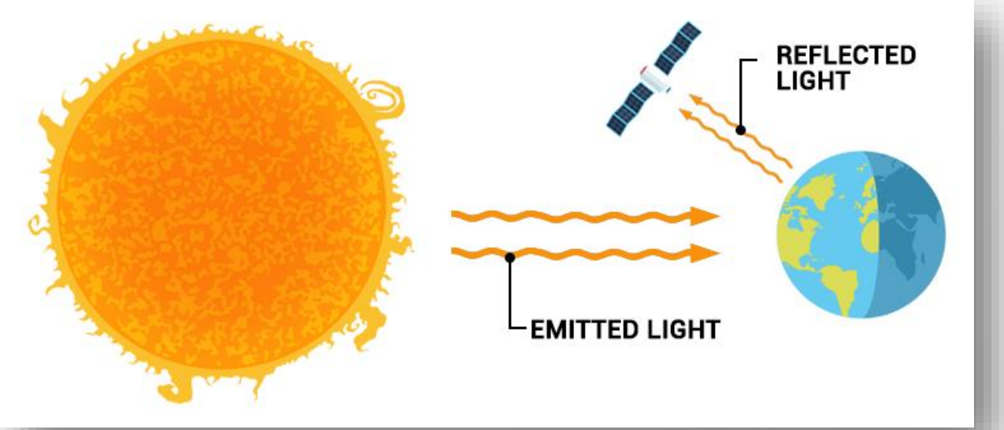


Remote Sensing: PASSIVE SENSORS

هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

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.

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

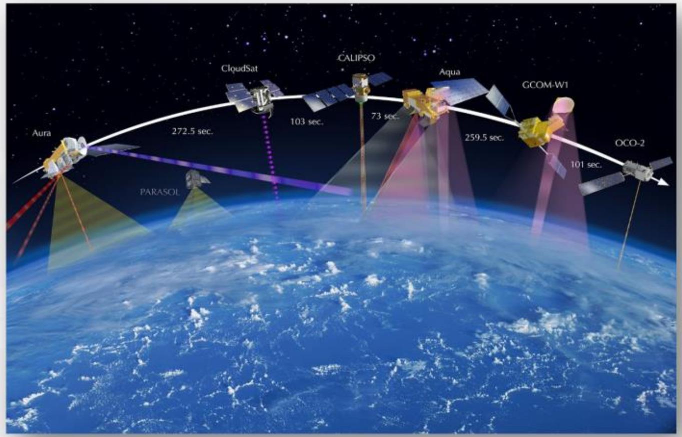
Active | Instruments emit their own signal and the sensor measures what is reflected back. Sonar and radar are examples of active sensors.

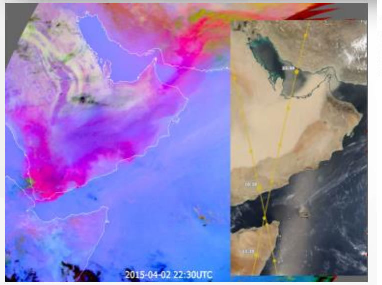
Channels and RGBs

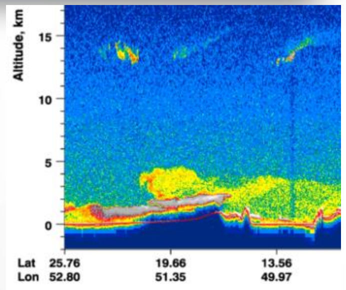
Many products and large amounts of data.

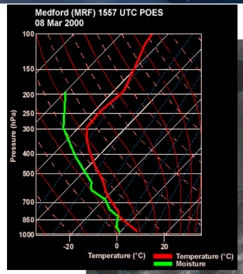
MSG

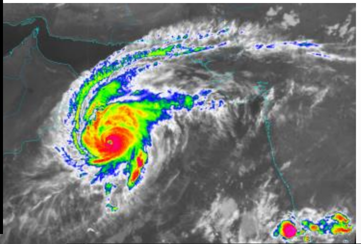
MTG

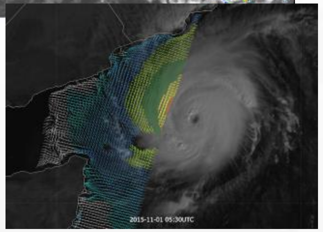


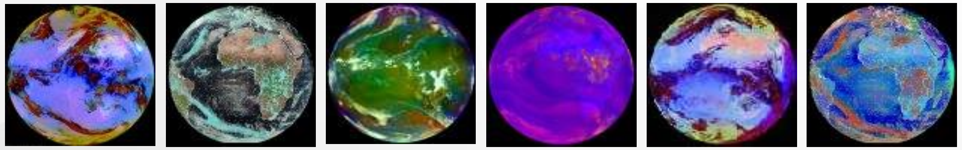




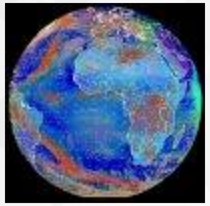




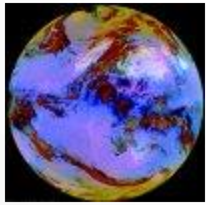




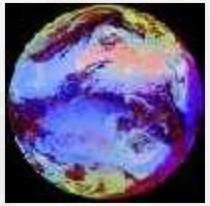
الصور المركبة (RGB)



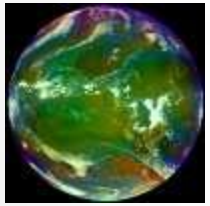
Day Microphysics RGB



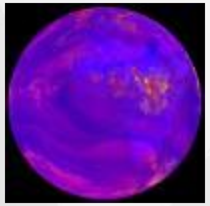
Dust RGB



Fog / Low Clouds RGB

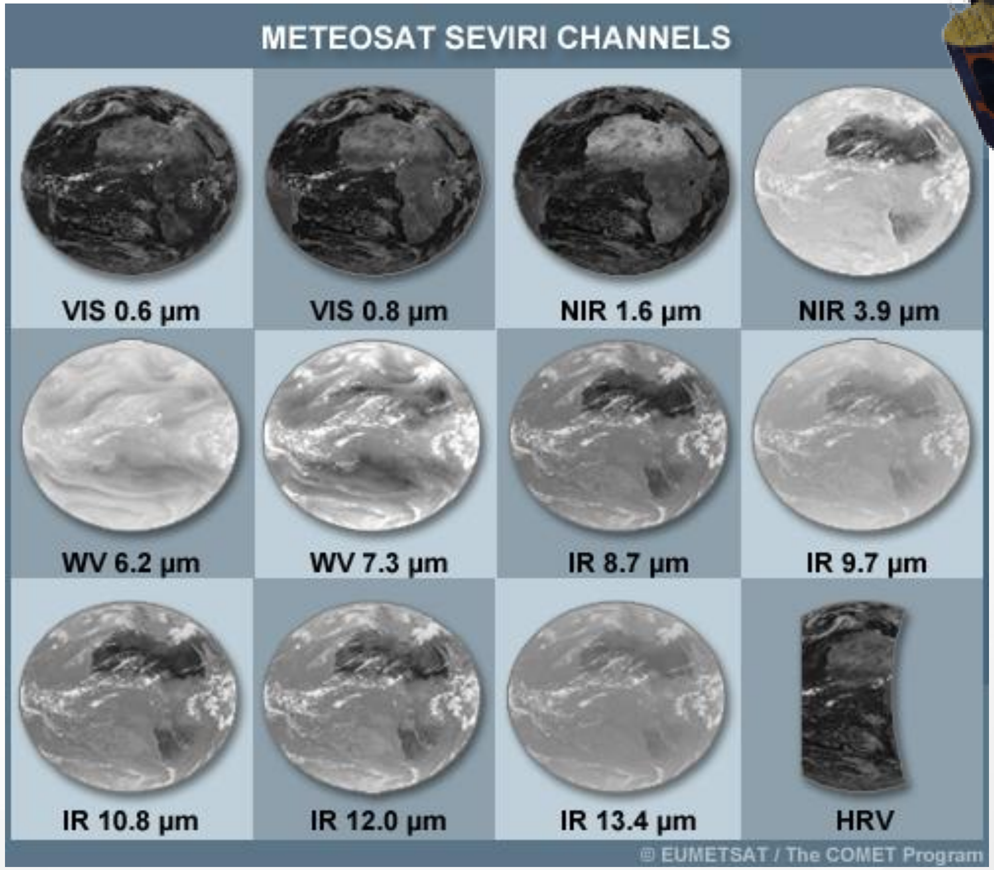


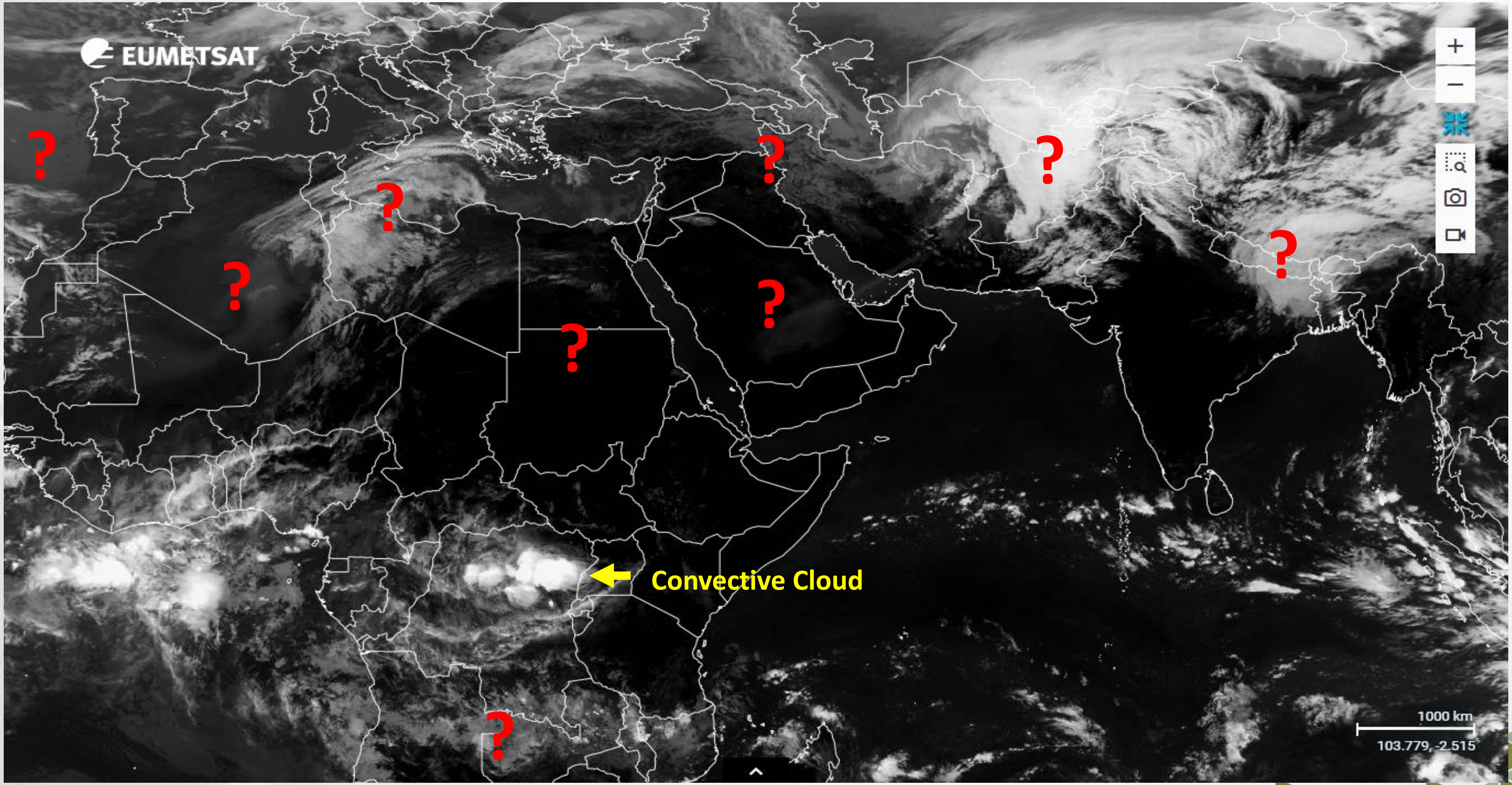
Airmass RGB

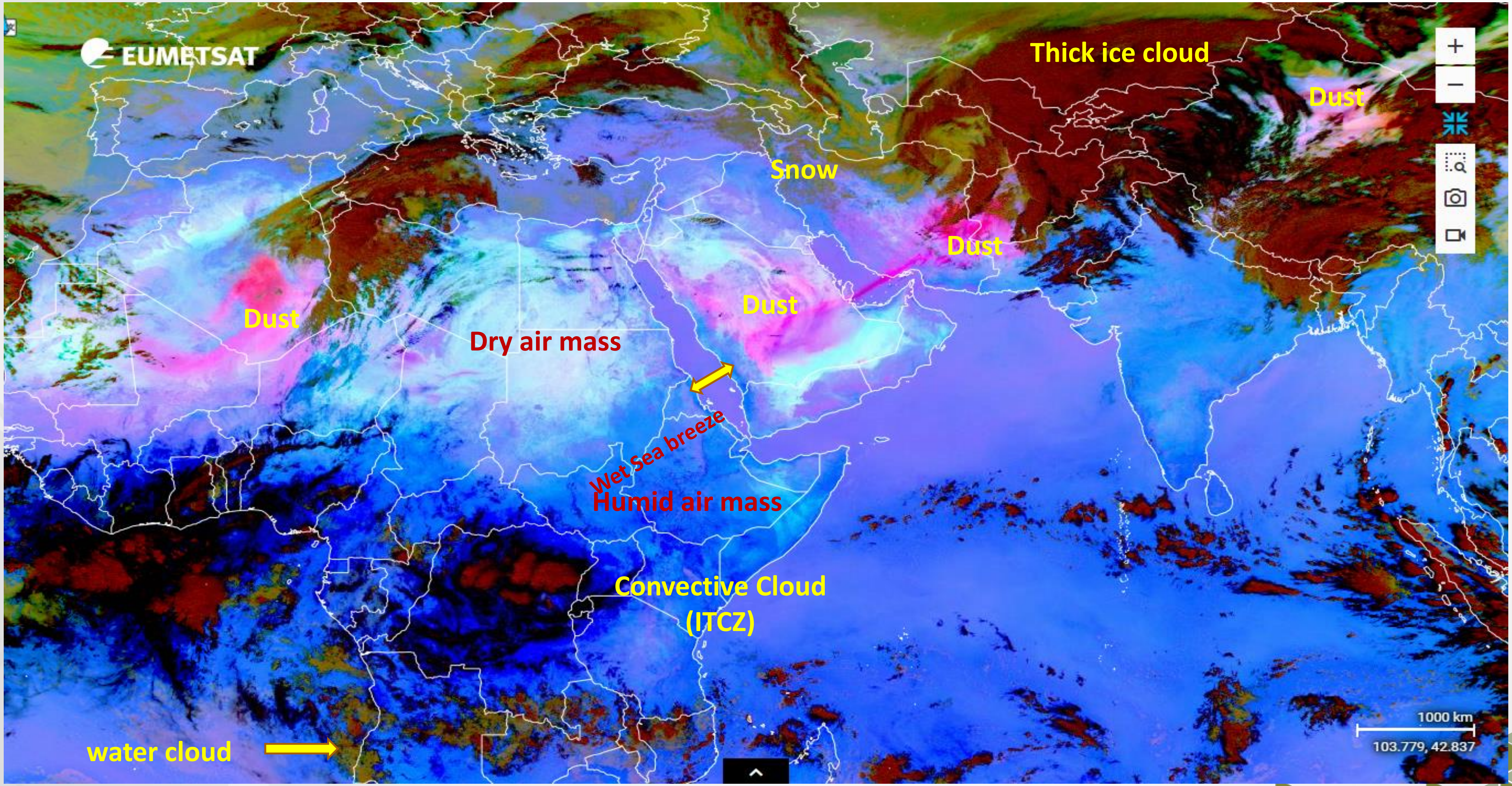


Convection RGB

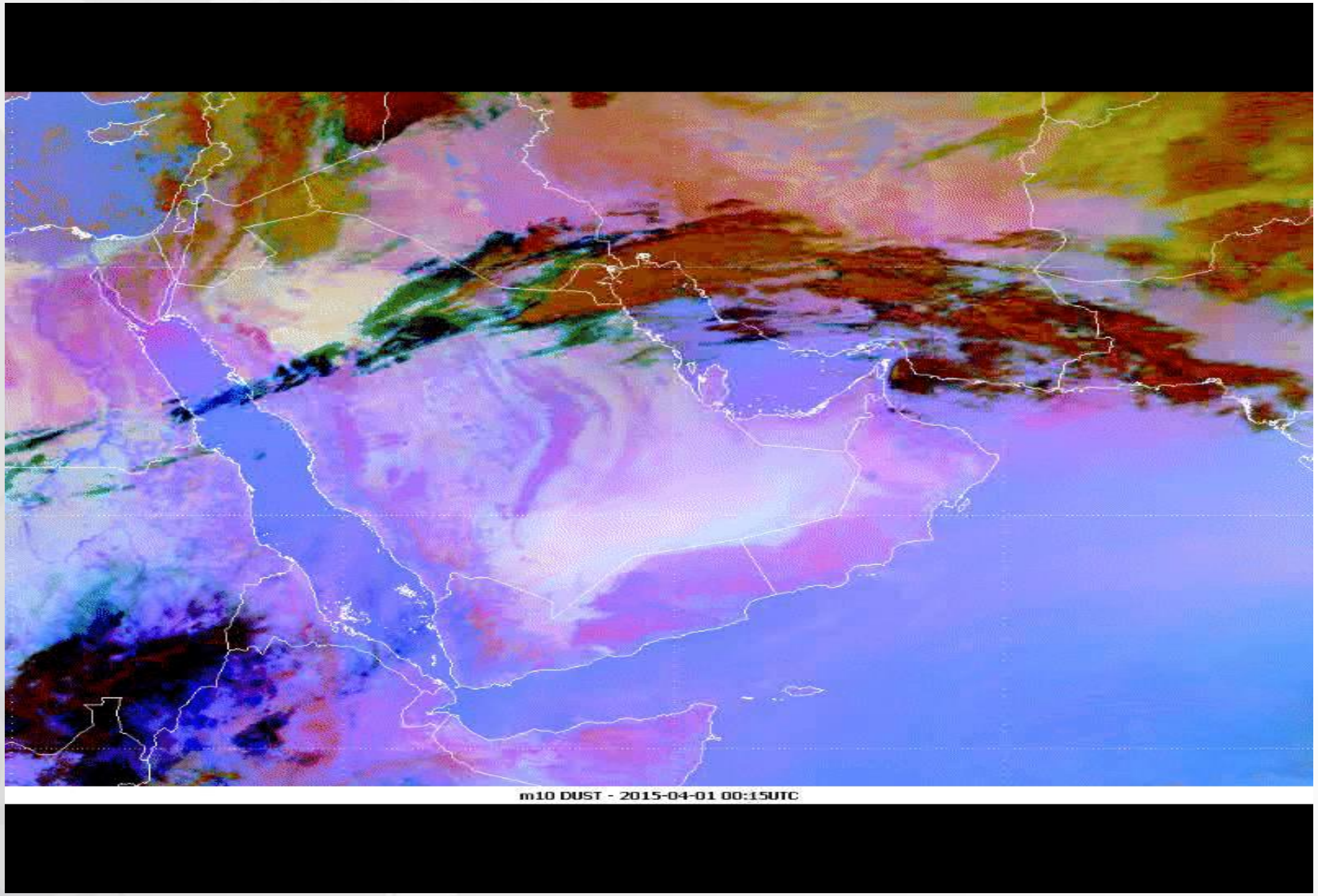
Natural Color RGB



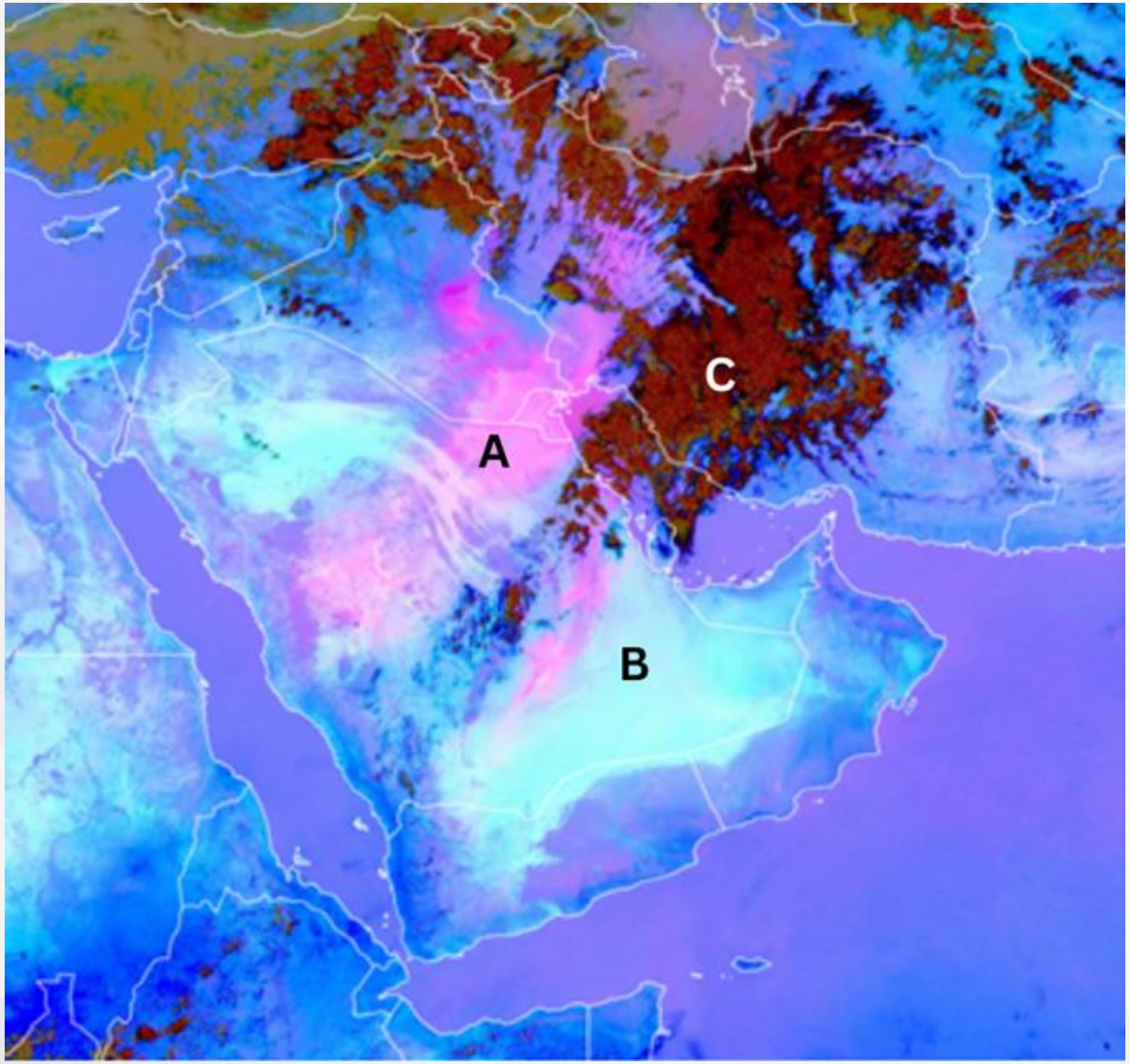

EUMETSAT
?
?
?
?
?
?
?
?
?
Convective Cloud
1000 km
103.779, -2.515


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 !

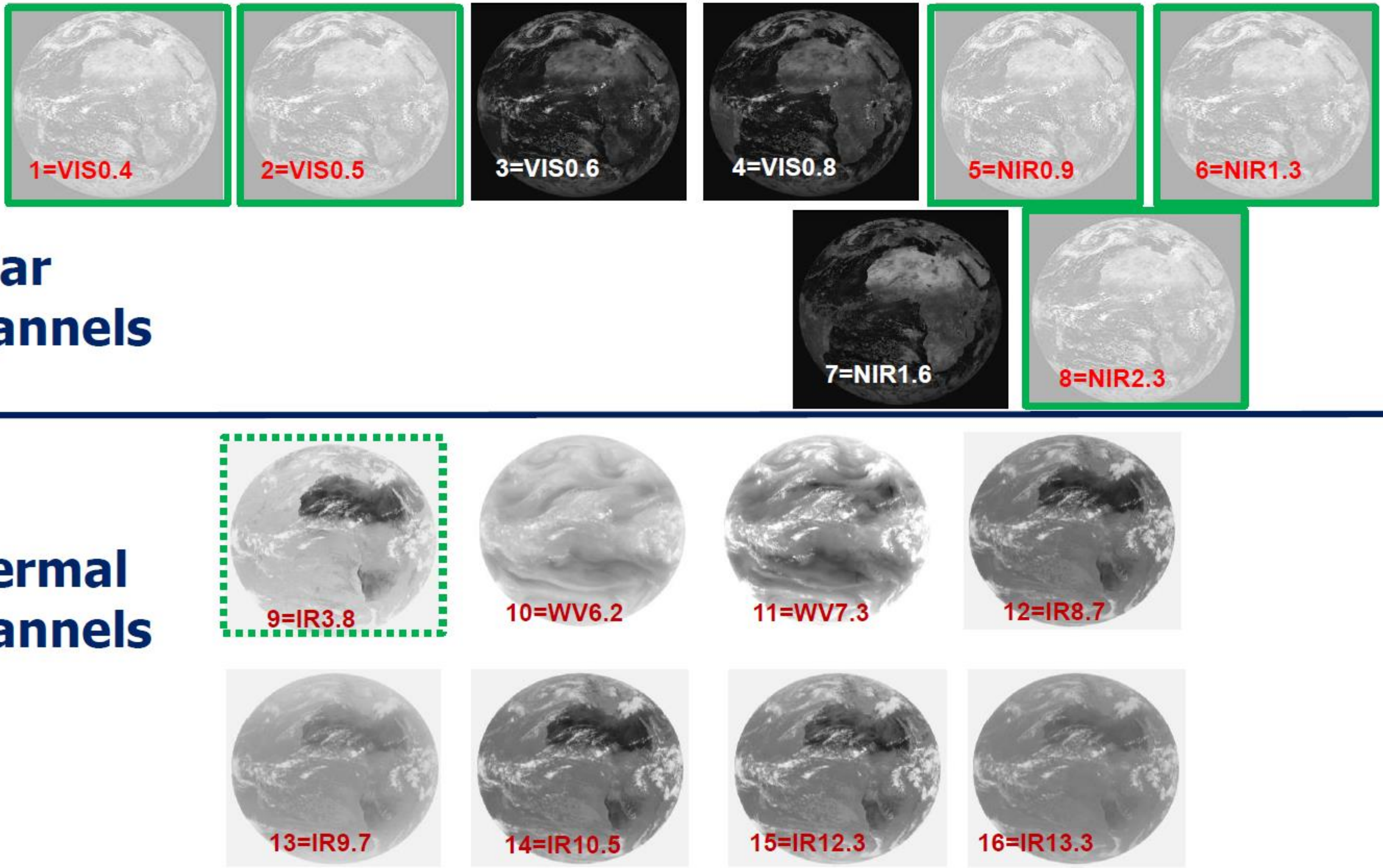

C
A
B

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

SEVIRI (FCI) spectral channels

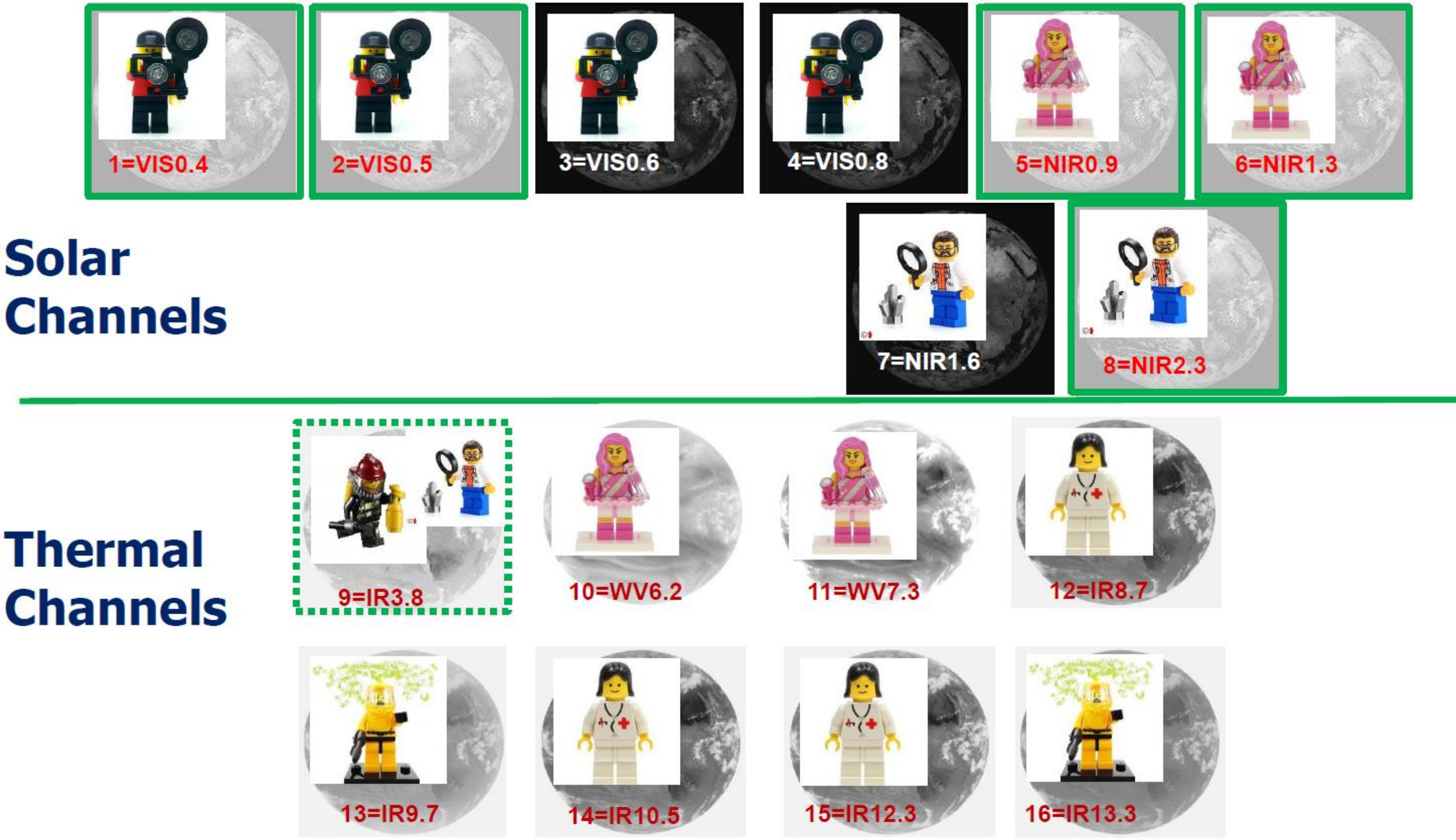
Solar Channels

Thermal Channels



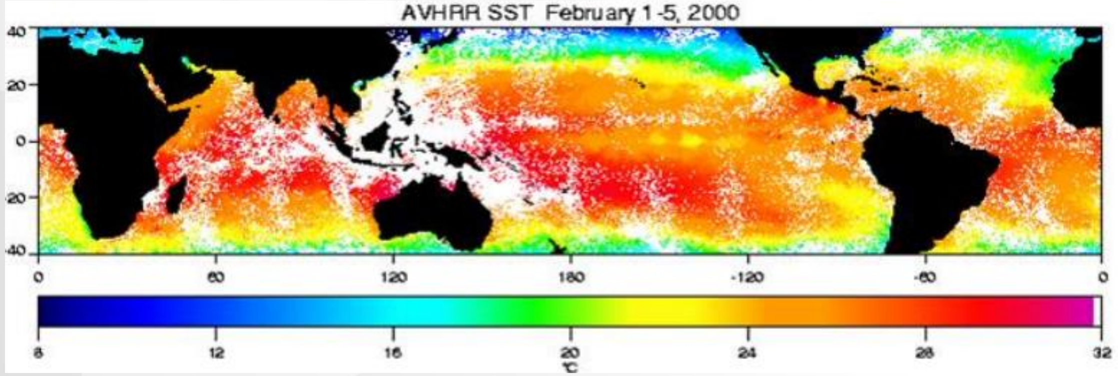
SEVIRI (FCI) spectral channels

"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

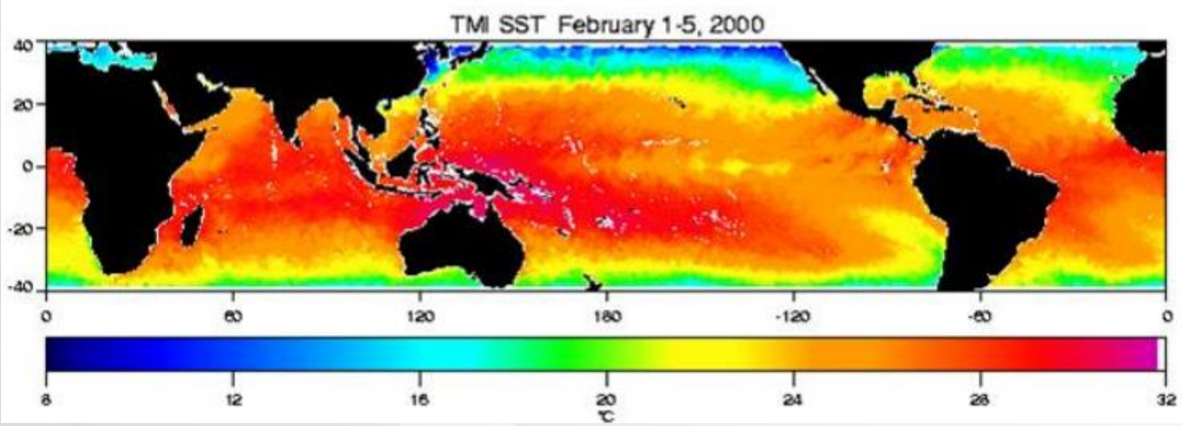


Remote Sensing:

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.

Sensors - Applications

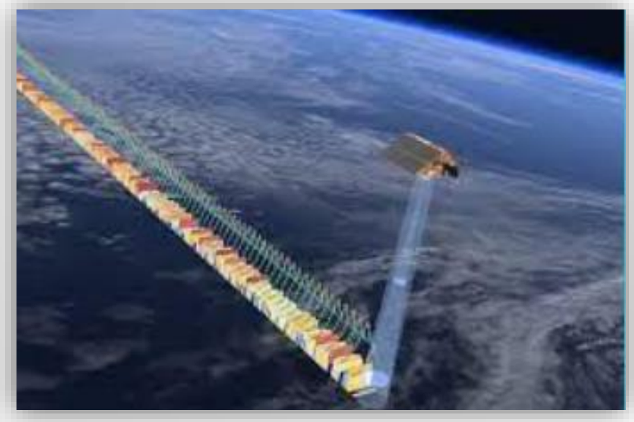
Remote Sensing: sensors - Applications

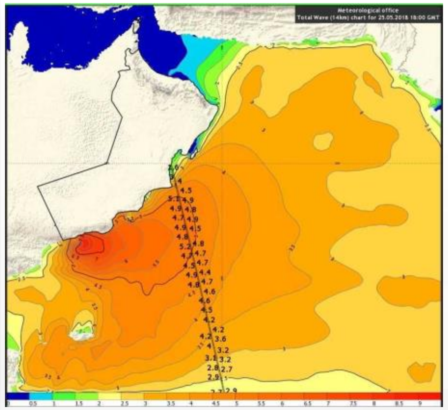
1. Satellite Altimeter

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

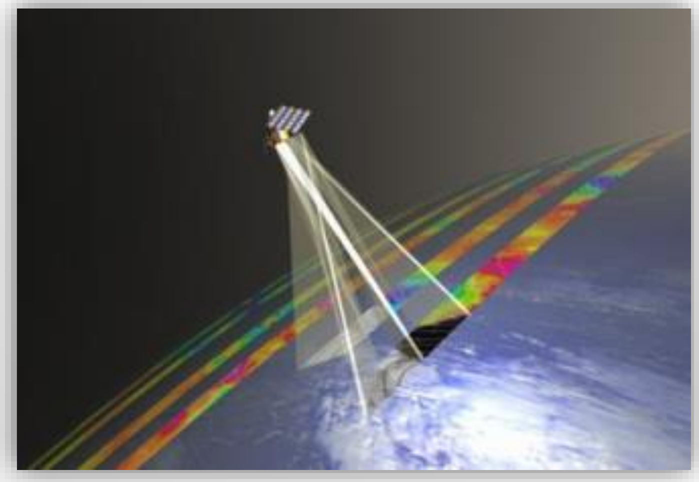
Remote Sensing: sensors - Applications

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

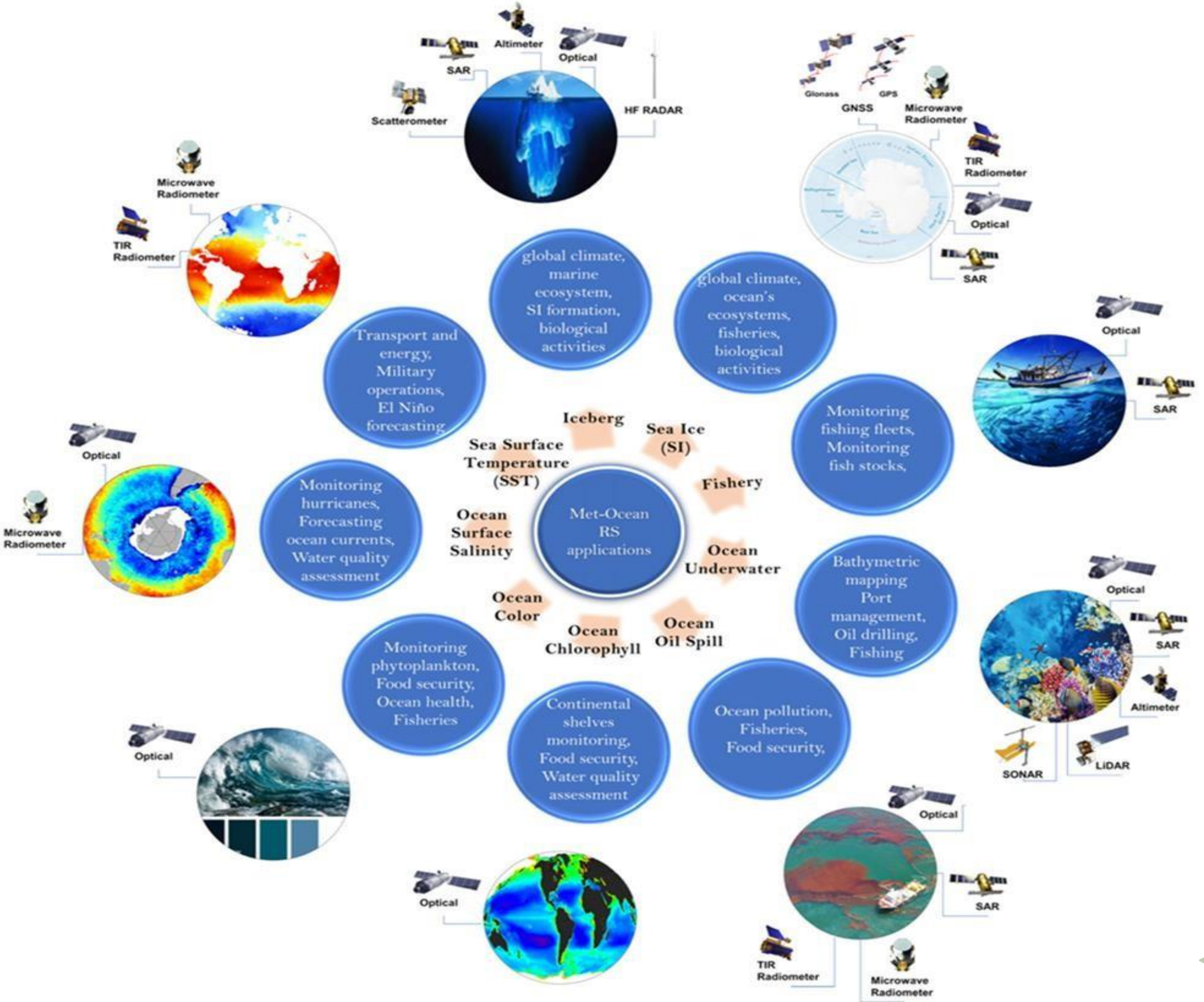
Purpose: Measures infrared radiation to determine the temperature of the sea surface.

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

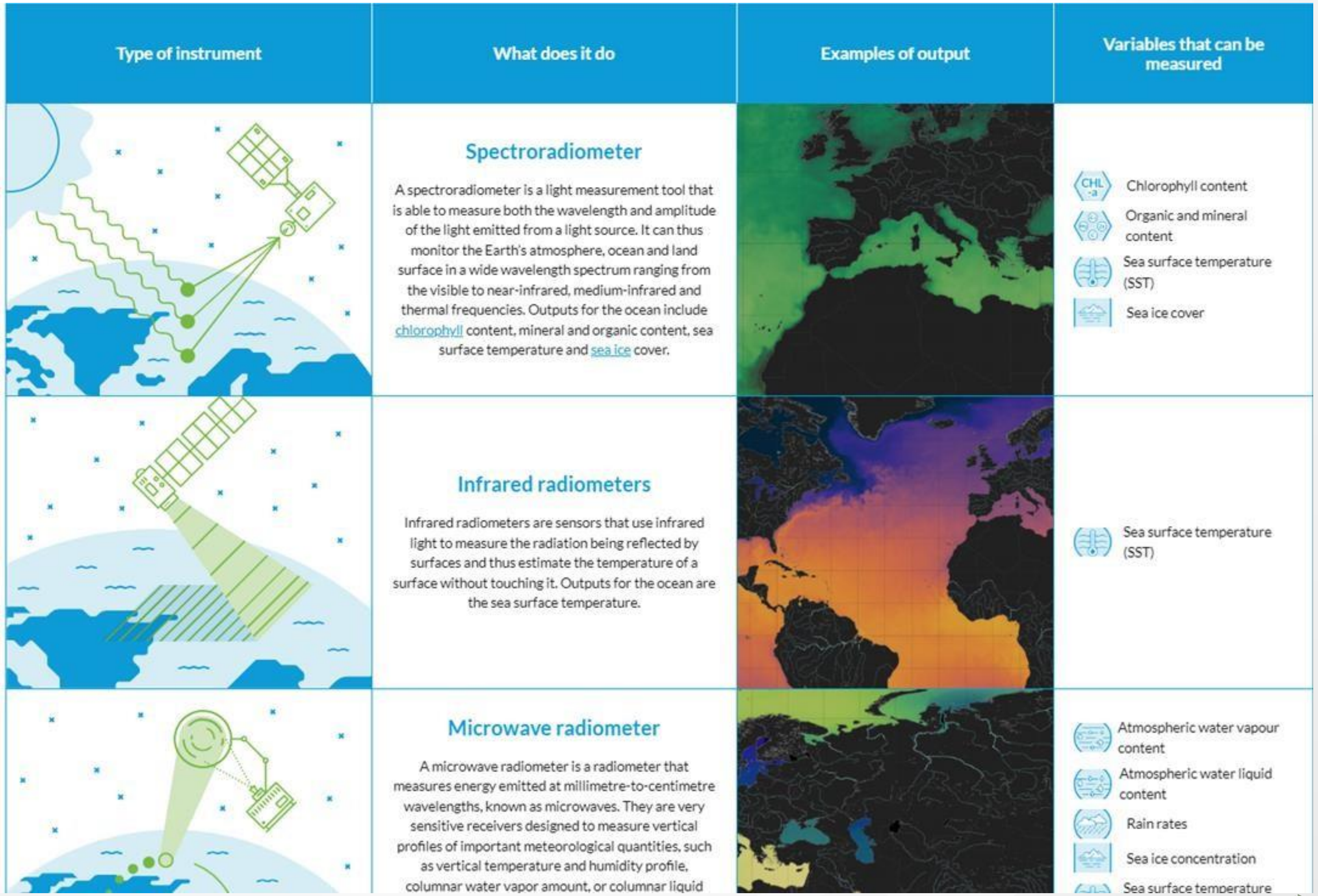
Applications and Uses



Marine Satellite Applications

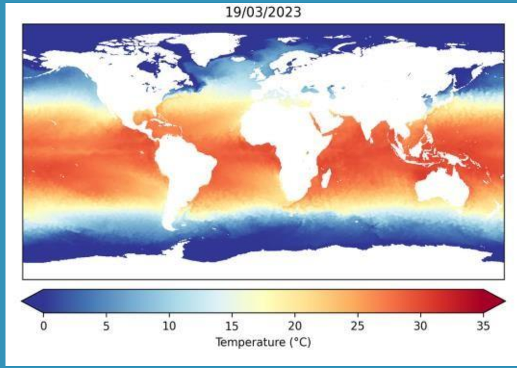
Observing the Ocean with Satellite

https://marine.copernicus.eu/explainers/operational-oceanography/monitoring-forecasting/satellites

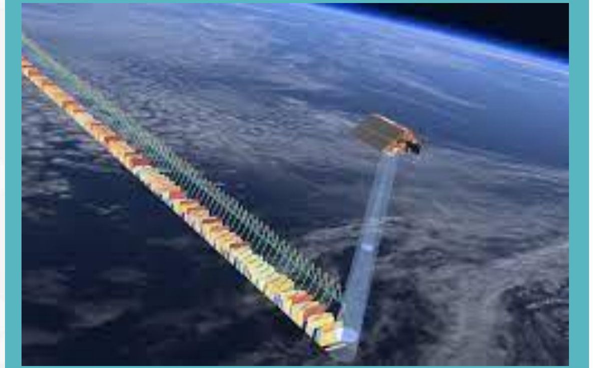


Type of instrument	What does it do	Examples of output	Variables that can be measured
	Spectroradiometer A spectroradiometer is a light measurement tool that is able to measure both the wavelength and amplitude of the light emitted from a light source. It can thus monitor the Earth's atmosphere, ocean and land surface in a wide wavelength spectrum ranging from the visible to near-infrared, medium-infrared and thermal frequencies. Outputs for the ocean include chlorophyll content, mineral and organic content, sea surface temperature and sea ice cover.		Chlorophyll content; Organic and mineral content; Sea surface temperature (SST); Sea ice cover
	Infrared radiometers Infrared radiometers are sensors that use infrared light to measure the radiation being reflected by surfaces and thus estimate the temperature of a surface without touching it. Outputs for the ocean are the sea surface temperature.		Sea surface temperature (SST)
	Microwave radiometer A microwave radiometer is a radiometer that measures energy emitted at millimetre-to-centimetre wavelengths, known as microwaves. They are very sensitive receivers designed to measure vertical profiles of important meteorological quantities, such as vertical temperature and humidity profile, columnar water vapor amount, or columnar liquid		Atmospheric water vapour content; Atmospheric water liquid content; Rain rates; Sea ice concentration; Sea surface temperature

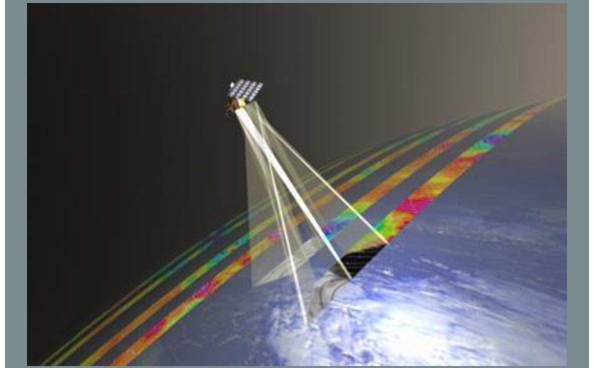
Main Ocean Properties derived from satellite



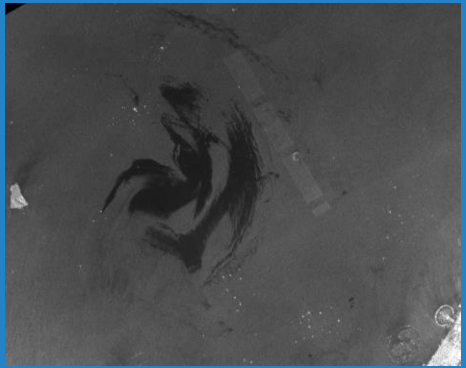
Sea Surface Temperature



Significant Wave Hight



Sea Surface Wind Speed



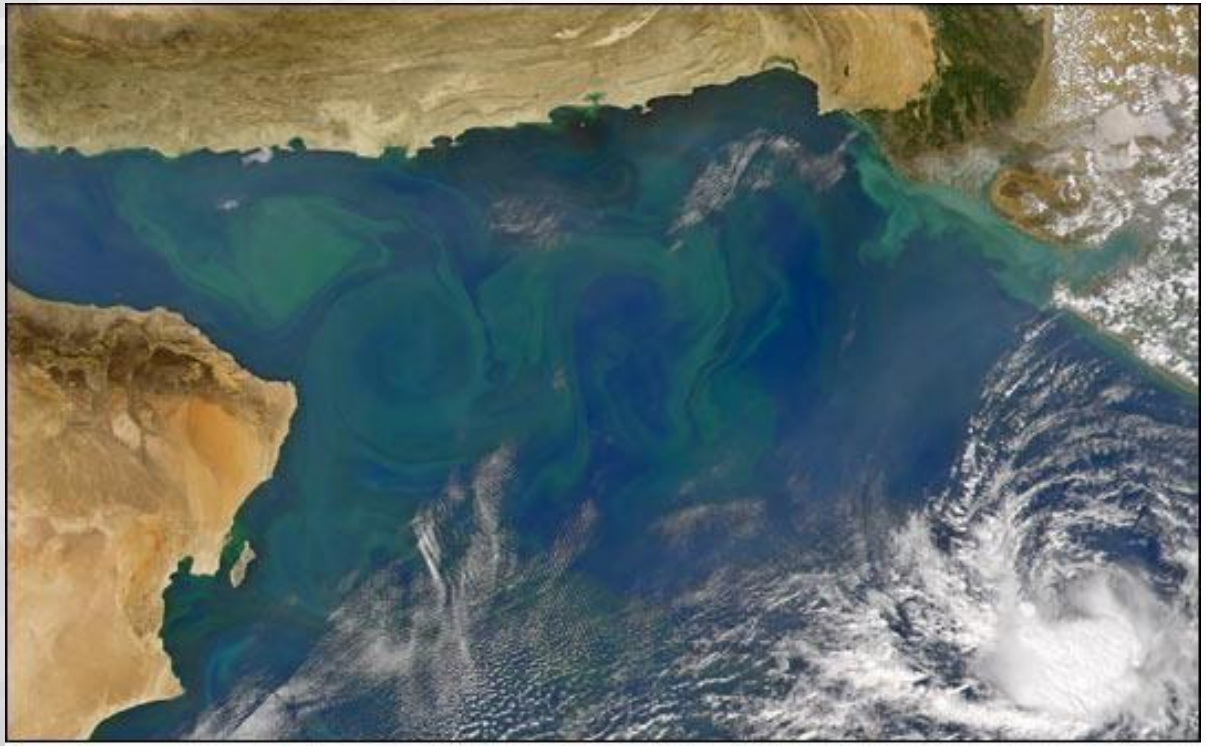
Water Quality

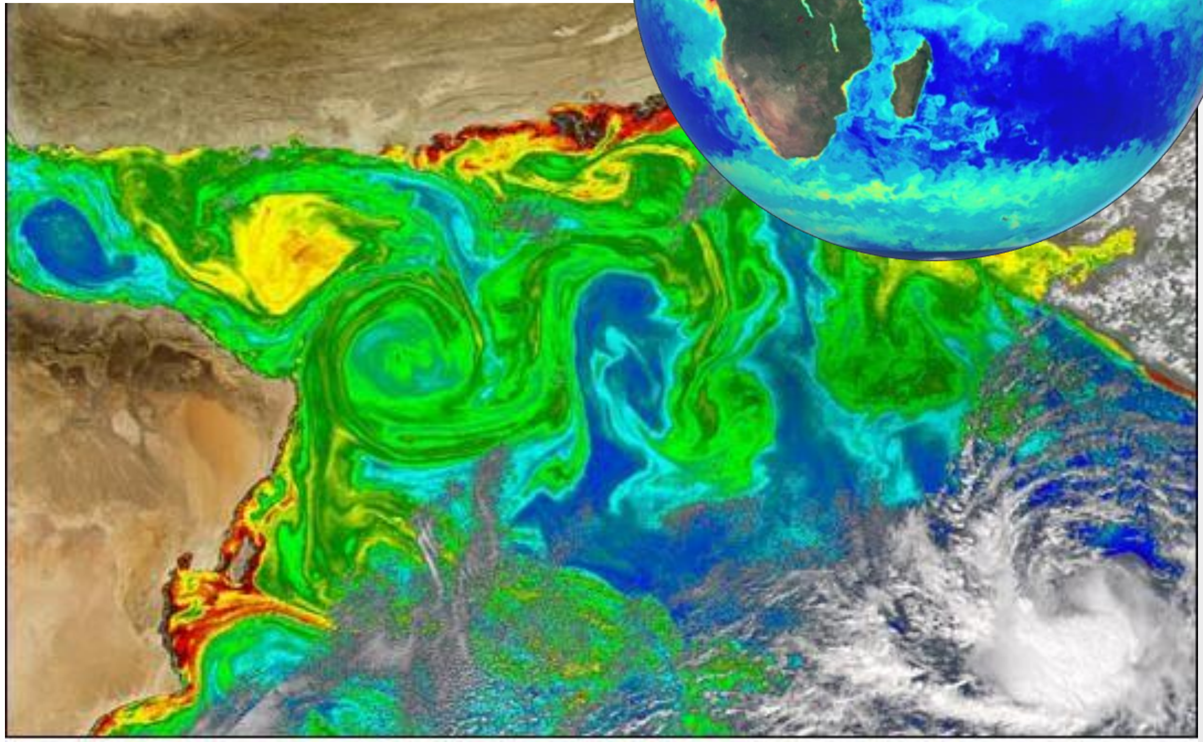
Chlorophyll

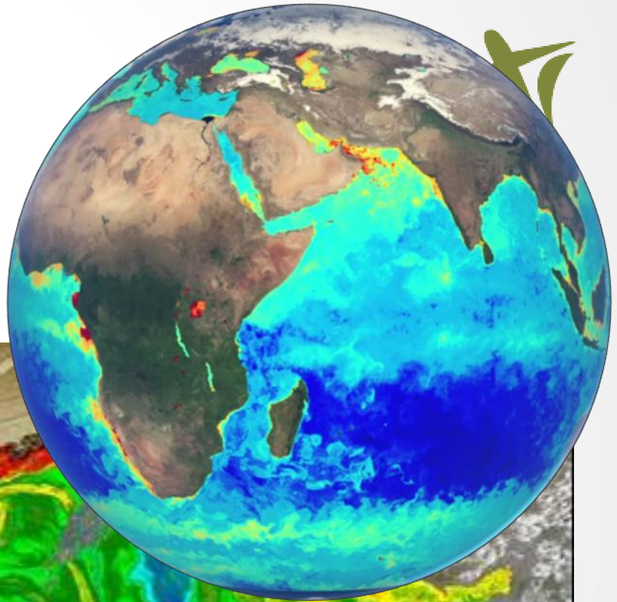
Salinity

Oil spill

Water Quality/algal bloom


Natural Color


Chlorophyll Concentration



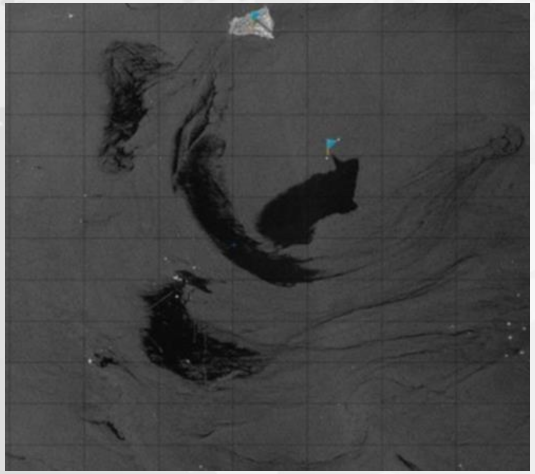
[Eumetview /Case]

Water Quality/ Oil Spill Detection

Link

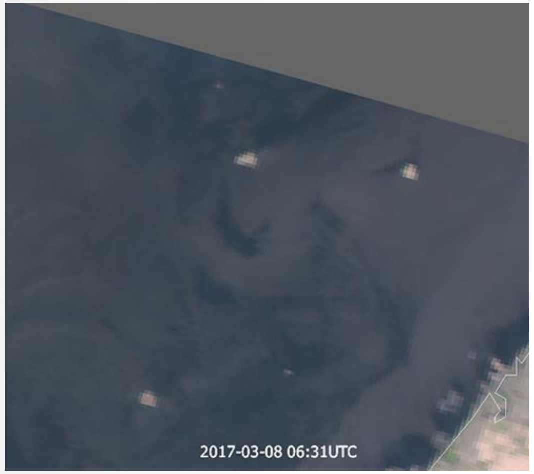
CAA
هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

Why SAR data??

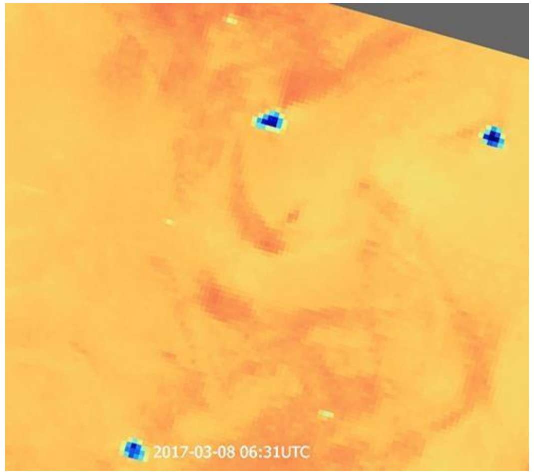


SAR/ Sentinel-1

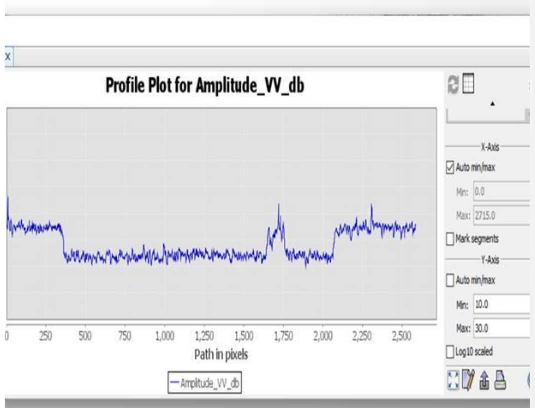
8 March 2017



Natural RGB/Metop-A



Difference Vis0.6 & NIR1.6 /Metop-A

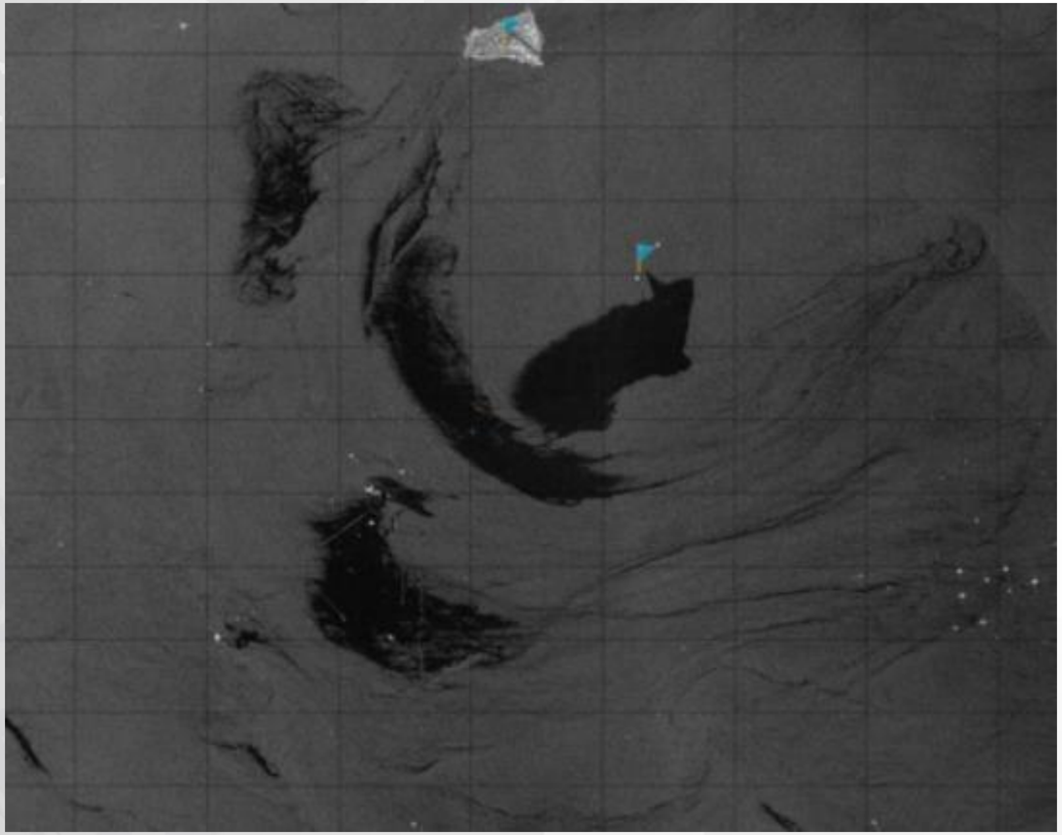


Reflectivity Analysis SAR

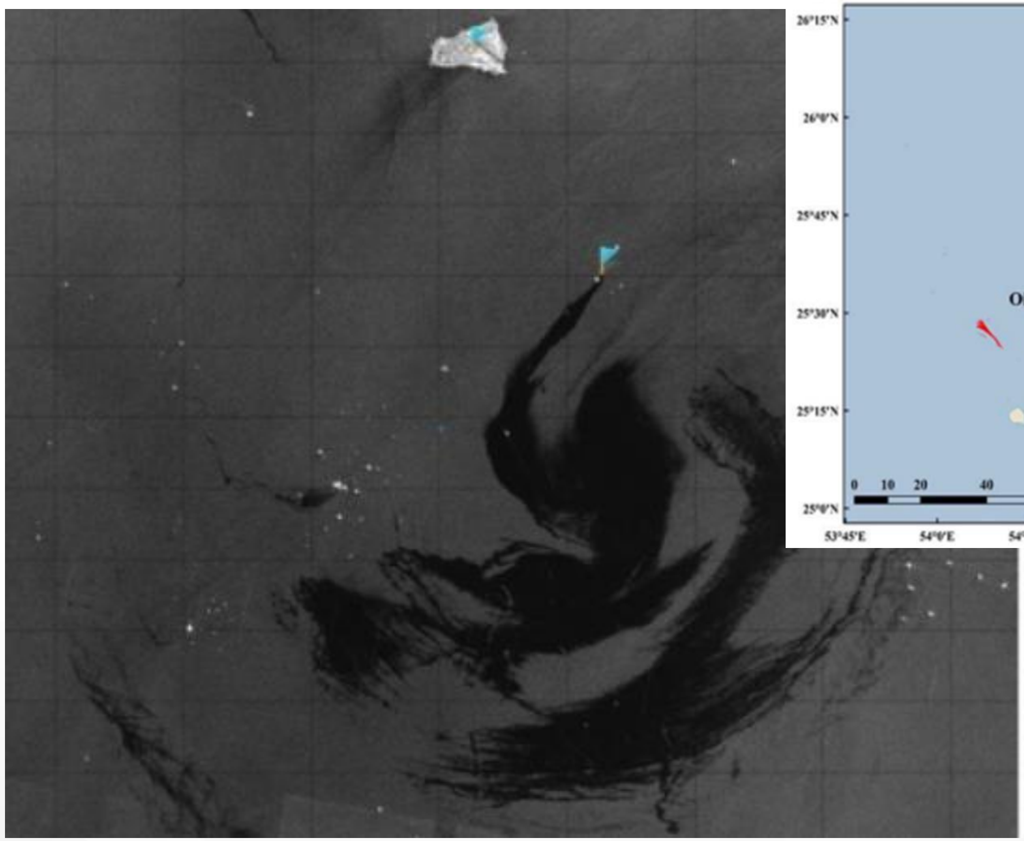
- Oil spill appear dark (smooth surface) , lower reflectivity, back scattered comparable with the sea surface that appears bright due to its high reflectivity and natural roughness.
- See through cloud.
- Large Swath
- Day and Night

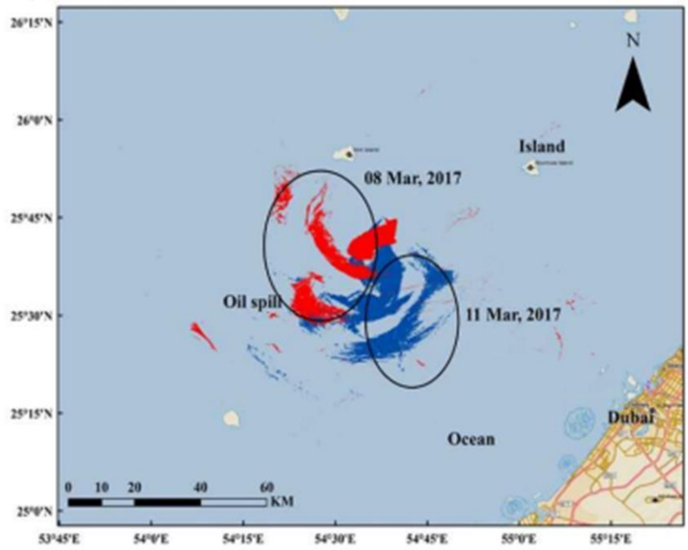
Water Quality/ Oil Spill Detection

- 8 March 2017



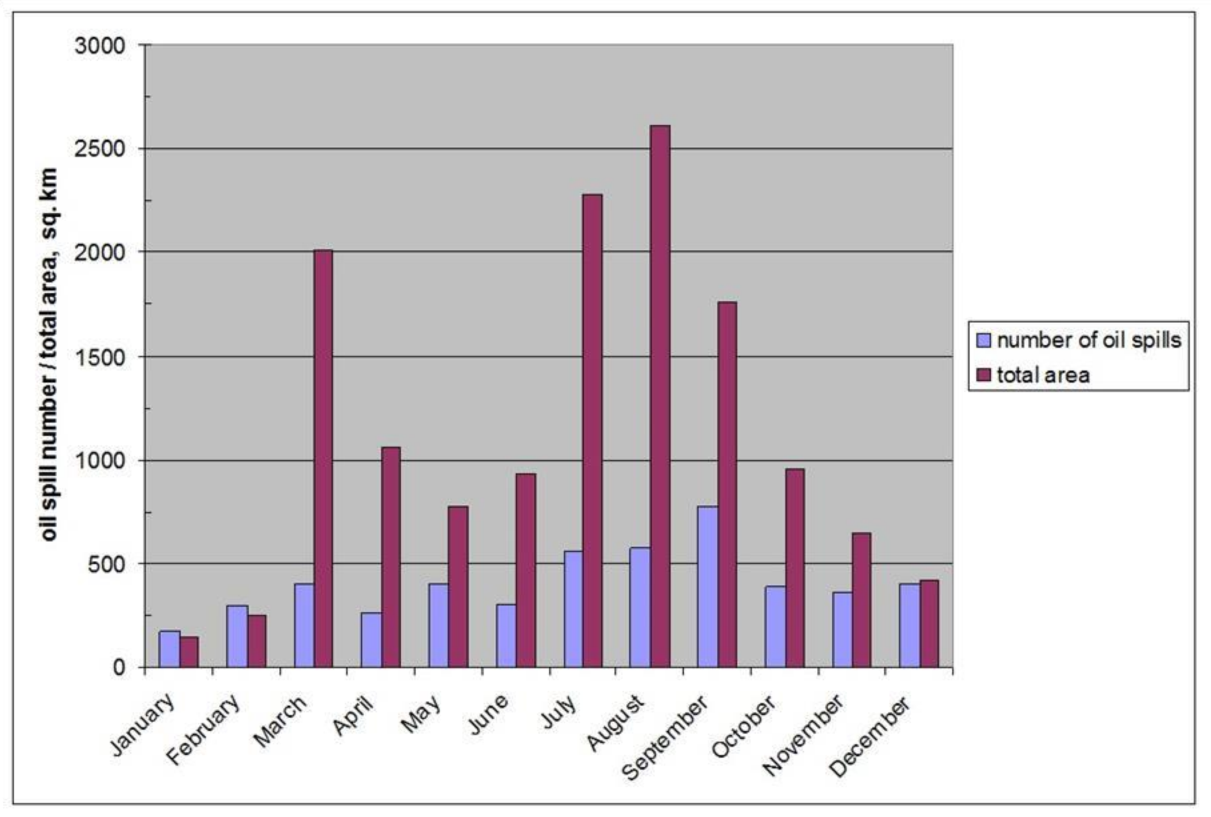
- 11 March 2017



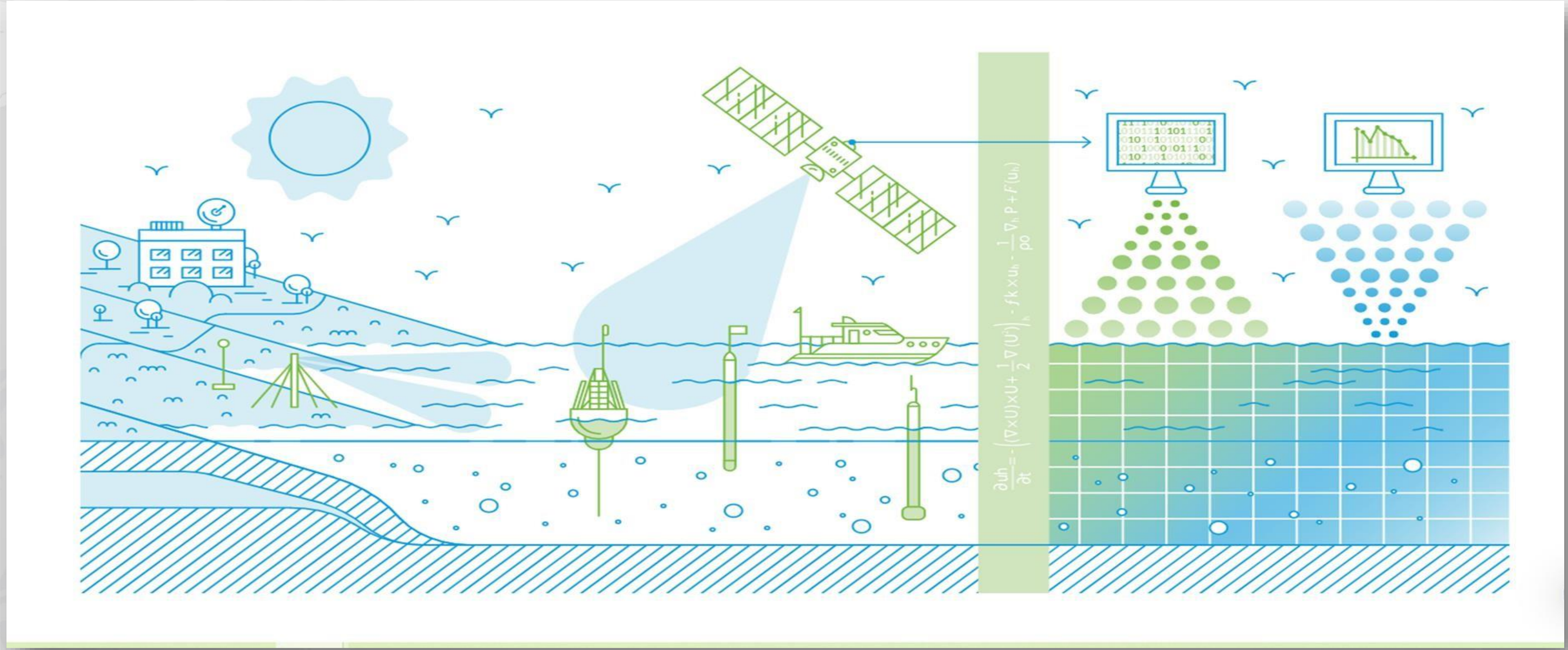


Statistical Analysis of Satellite data

Month of 2017	Number of detected oil spills	Total area of all detected oil spills, km^2
January	176	143
February	297	246
March	399	2011
April	265	1061
May	403	775
June	306	932
July	564	2279
August	575	2612
September	773	1759
October	390	954
November	358	643
December	399	420
Total	**4905**	**13835**



Ocean Monitoring & Forecasting System



سنبحث هنا عن حالة جوية مميزه

CHRS RainSphere
An Integrated System for Global Satellite Precipitation Data and Information

نستكشف الحالة عن طريق أقمار

EUMETSAT
USER PORTAL

نبحث عن دقه مكانية أعلى

NASA WORLDVIEW

المزيد من الدقة المكانية

EO Browser

Thanks