



ČVUT

ČESKÉ VYSOKÉ
UČENÍ TECHNICKÉ
V PRAZE

155DPRZ

Practical lesson

Lesson 1 - Introduction

→ WHAT IS REMOTE SENSING?

Remote Sensing is the principle of measuring information about an object without being in physical contact with it.

The instruments that are used in remote sensing are called sensors. They measure the electromagnetic radiation of objects and convert it into data that a computer can interpret.

Remote sensing can be done from the ground, from an aircraft or from space. In remote sensing from space, the sensors are mounted on a satellite and are oriented towards the Earth so that the atmosphere, ocean, land and objects such as trees, crops, buildings, rivers can be observed.

Remote sensing sensors are grouped into two categories: passive and active.



PASSIVE SENSORS

Passive sensors measure the radiation coming from a source external to the sensor, such as the sunlight reflected by objects on the Earth or the thermal infrared radiation emitted by the Earth itself. Passive sensors cannot detect sunlight during the night. If they are optical, they also cannot see through clouds.



ACTIVE SENSORS

Active sensors use their own source of radiation. In this case, the sensor emits radiation towards objects on the Earth and measures the amount of radiation reflected back. In contrast to passive sensors, active sensors can measure by day and by night. If they are radar, they also can see through clouds.



Find out more at: www.esa.int/eduspace

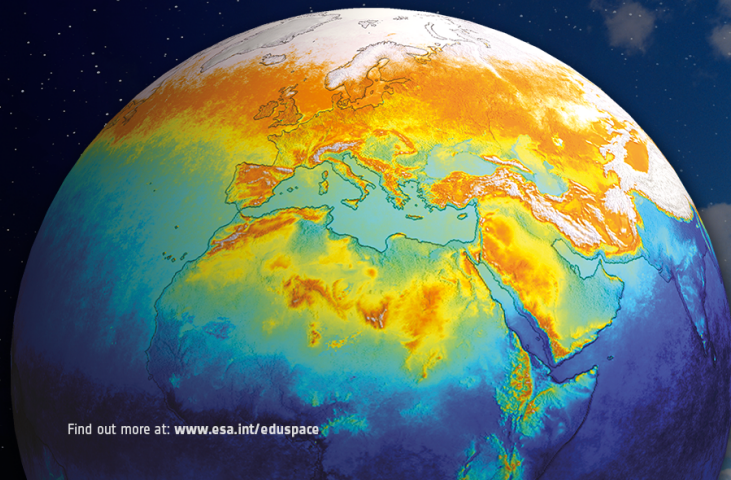
European Space Agency

In which fields is remote sensing commonly used?

→ ATMOSPHERE APPLICATIONS

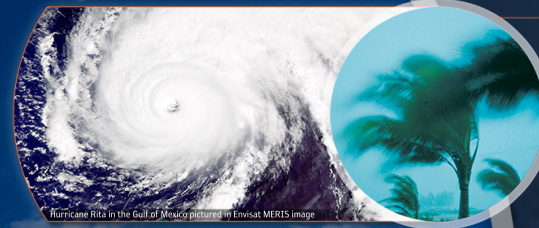
The Earth's atmosphere is the mixture of gases that surrounds our planet. It is of fundamental importance to life on Earth. Among other things, it provides living organisms air to breathe, protects us from the sun's ultraviolet radiation and regulates the Earth's temperature to keep it habitable. Monitoring the properties of the atmosphere is therefore essential.

Sensors on board satellites offer new capabilities to support atmospheric applications. For example, they provide profiles of wind and measurements of clouds distribution to improve weather models and forecast. They also monitor changes in atmospheric composition, useful to control air quality and refine climate models. They provide detailed views of phenomena such as hurricanes, eruptions of volcanic ash and urban heat islands.



HURRICANE

Optical imagers from space provide detailed views of cloud structures associated with the convection of wind. This information is useful to support the monitoring of hurricanes and improve weather forecasting.



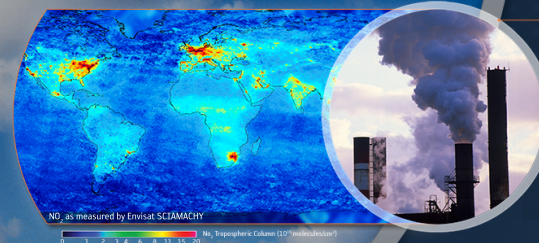
WIND

Imaging radar instruments are sensitive to water surface roughness such as waves produced by wind on open oceans or lakes. This information is used to retrieve wind estimates which are essential to the management of wind farms and to weather forecasting.



NITROGEN DIOXIDE (NO₂)

Optical spectrometers measure the light reflected from the atmosphere and reveal absorption lines, which correspond to certain gases such as Nitrogen dioxide (NO₂). This information is vital to assess air quality and to support the prediction of climate change.



What is the name of a satellite that we see every day in weather forecast on CT? Is it an active or passive sensor?

→ LAND APPLICATIONS

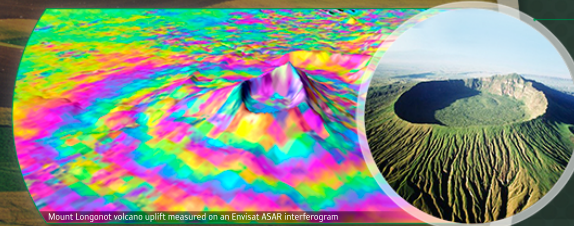
Land covers 30% of the Earth's surface. This area supports the vast majority of human activity and provides habitats to living beings. It also plays a prominent role in the Earth's climate, due to its direct interaction with the atmosphere and the hydrosphere. These elements make the monitoring of Land a key component for humankind and the biosphere.

Remote sensing has become today an invaluable tool in the assessment of land resources. Satellites support for example land cover mapping, urban planning, forest fires detection, soil moisture and erosion assessment, forest biomass estimation, Earth's topography measurement, volcano monitoring and earthquake modelling.



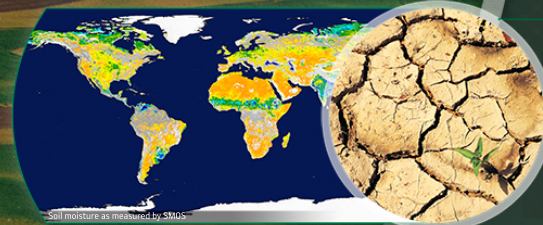
AGRICULTURE

Optical imagers are capable of providing periodic and fine detailed images of agricultural fields. This allows mapping crops and assessing their health and growth on a frequent basis.



VOLCANOES

Applications of radar imagers include measuring the inflation or deflation of a volcano with millimetric precision, using SAR Interferometry. This can provide information on volcanic activity, which can improve models for the prediction of future eruptions.



SOIL MOISTURE

Imaging radiometers, such as on ESA's SMOS satellite, produce global maps of surface soil moisture, an important parameter for vegetation and agriculture monitoring, water management, weather and climate forecasting.

Find out more at: www.esa.int/earthspace

European Space Agency

**What remote sensing data outcome we use on a daily basis?
Is it an active or passive sensor? Why?**

→ ICE APPLICATIONS

About 10% of the Earth's surface is permanently covered by glaciers, ice caps and ice sheets, collectively referred to as the cryosphere. These different forms of ice, mainly found in polar and high-altitude regions, play a critical role in regulating the Earth's climate and sea level. Recent observations point to rapid, possibly irreversible changes of the cryosphere. The monitoring of ice is therefore imperative for the future of our planet.

Remote sensing offers a new and valuable tool for ice monitoring and a variety of ice applications. For example, it supports ship routing and offshore operations in polar areas by mapping ice cover and tracking icebergs. It provides also measurements of essential ice variables such as sea-ice thickness and continental ice topography to monitor climate change. It allows the characterisation of sea-ice drift and the determination of glacier flow velocities.

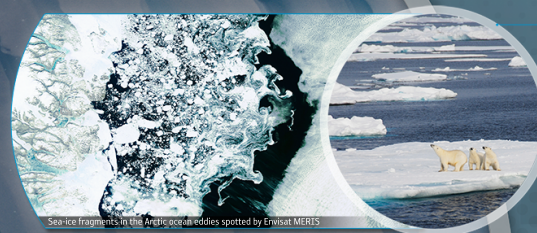
Find out more at: www.esa.int/eduspace

• Cryosat mapping changes in ice thickness, September 2007



ICE COVER

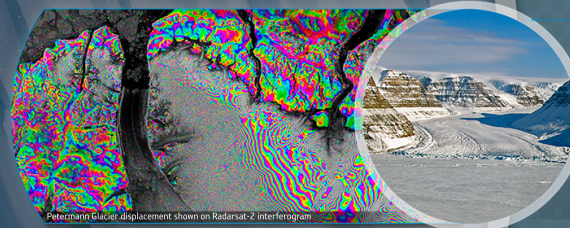
Optical imagers, as well as radar imagers, measure the ice cover extent and track drifting icebergs in ocean currents. These are important indicators for the monitoring of Climate Change and can support maritime navigation in our increasingly busy Arctic waters.



Sea ice fragments in the Arctic, ocean eddies spotted by Envisat MERIS

GLACIER FLOW VELOCITY

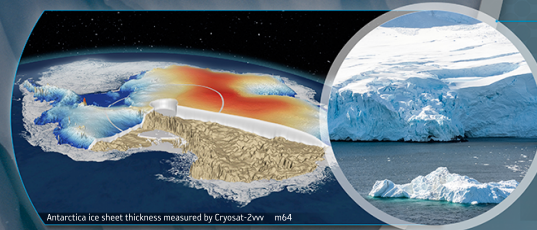
Using advanced techniques such as SAR Interferometry, radar instruments allow the measurement of glacier flow velocity. This information is used to infer glaciers' mass balance which is a sensitive indicator of the Earth's climate.



Petermann Glacier displacement shown on Radarsat-2 interferogram

SEA-ICE THICKNESS

Radar altimeters, such as the one on board ESA's CryoSat-2 satellite, measure with centimetre precision the ice sheet and sea-ice thickness. This enables quantification of the amount of ice melting in polar regions and its contribution to global sea level rise.



Antarctica ice sheet thickness measured by Cryosat-2wv m44

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What would be the rise of a ocean level (in meters) if all ice would melt?
The biggest ammount of ice was detected in Peistocen, do you know how may %?

→ OCEAN APPLICATIONS

The oceans cover more than 70% of the Earth's surface. These vast areas have a great influence on weather and climate regionally and worldwide, for this reason ocean monitoring is very important for our planet and for human well-being.

Nowadays, satellites measure a variety of ocean parameters at global, regional and local scales. These measurements support a wide range of applications such as climate change monitoring, weather forecasting, wind and waves monitoring, algae blooms, fishery, ship routing, search & rescue, oil spill detection, and water quality assessment.

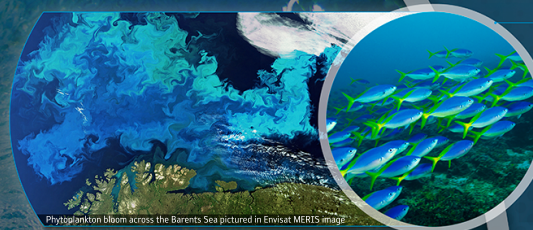
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Sea Surface Temperature



OCEAN COLOR

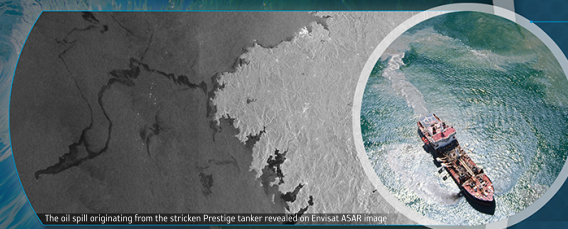
Optical instruments are capable of observing the colour of the oceans, revealing the presence of algae and plankton which is a good indicator of global ocean health and helps to determine the most suitable locations for productive fisheries.



Phytoplankton bloom across the Barents Sea pictured in Envisat MERIS image

OIL SPILL

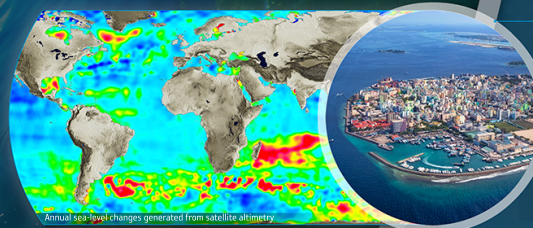
Imaging radar instruments are sensitive to surface roughness. This characteristic enables them to detect oil spills, as oil floating on the surface has the effect of smoothing the waves produced by the wind on the water.



The oil spill originating from the stricken Prestige tanker revealed on Envisat ASAR image

SEA-LEVEL

Radar altimeters measure the height of the sea surface. This information is vital to monitor sea level rise in coastal areas and to understand the global ocean circulation.



Annual sea level changes generated from satellite altimetry

Do you know what is an approximate rise of the ocean level every year?

Term explanation

PIXEL

Basic image element

Shortcut of „picture element“

Place where one measured information is detected

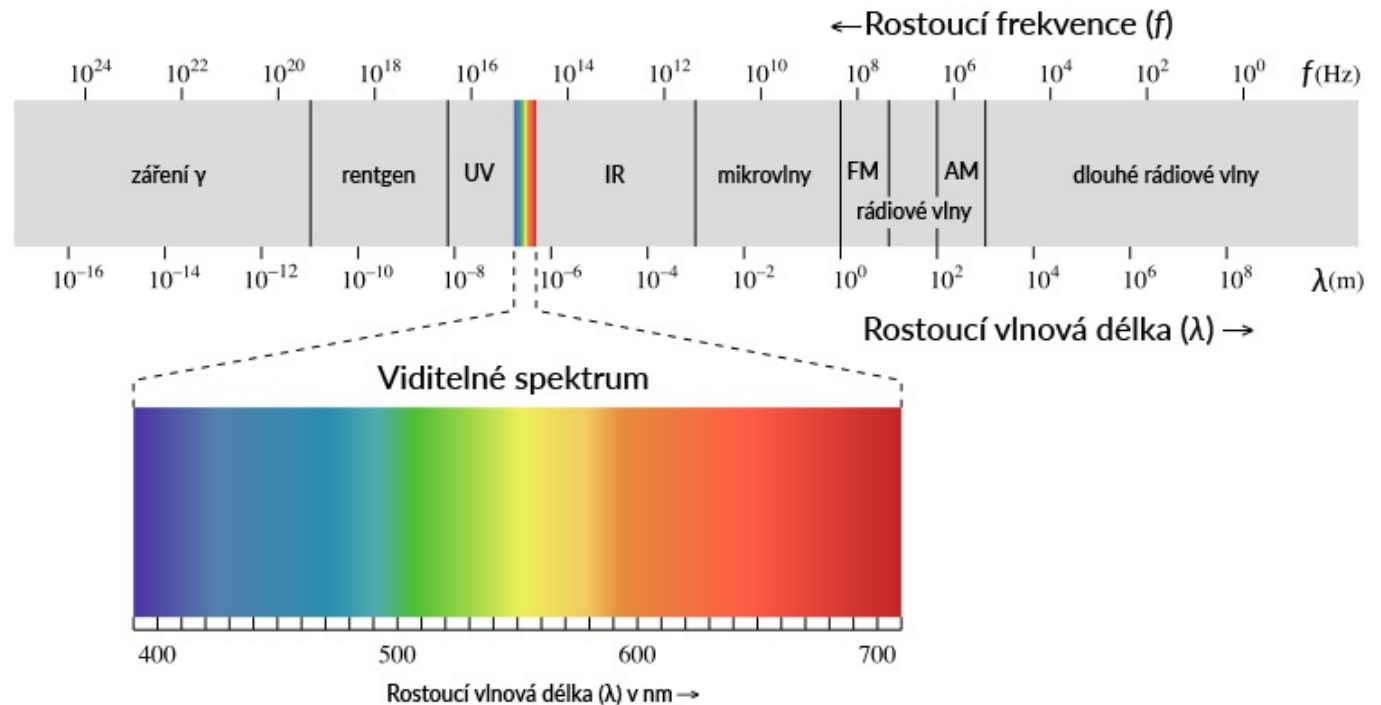
Defined spacial coordinates in raster

Term explanation

BAND

Is part of an
electromagnet
ic spectrum
defined by
boundary
wave lengths

Number of
bands and
their width
defines the
data
characteristics



Term explanation

RESOLUTION

Spatial – size of one point (pixel) – Low and middle, High, Very high

Spectral – Panchromatic (1 band), Multispectral, Hyperspectral (tens to hundreds of bands)

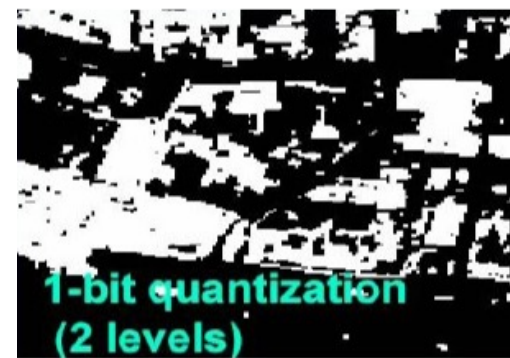
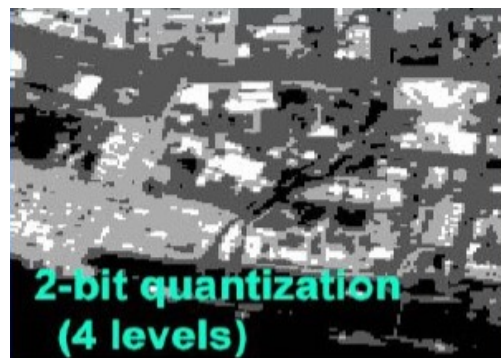
Temporal – revisit frequency of a defined area

Radiometric – pixel depth – smallest change in radiance intensity that can be detected (in bits)

Polarimetric – for radar data – better distinguishing between land cover types, improves object detection

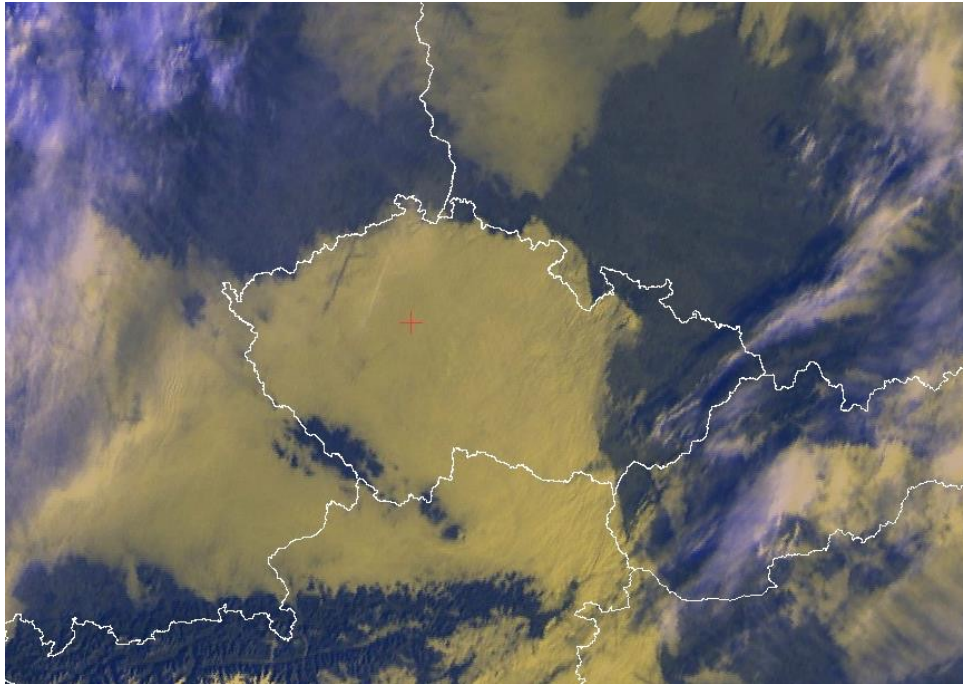
Examples

RESOLUTION

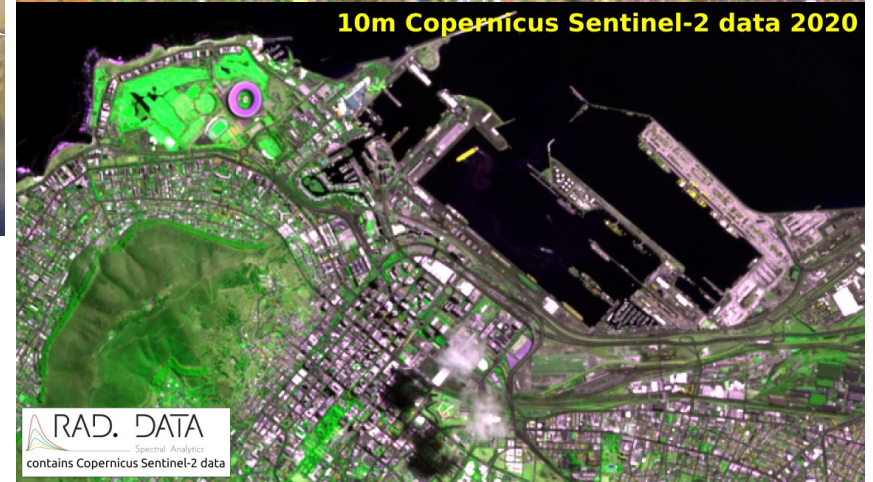
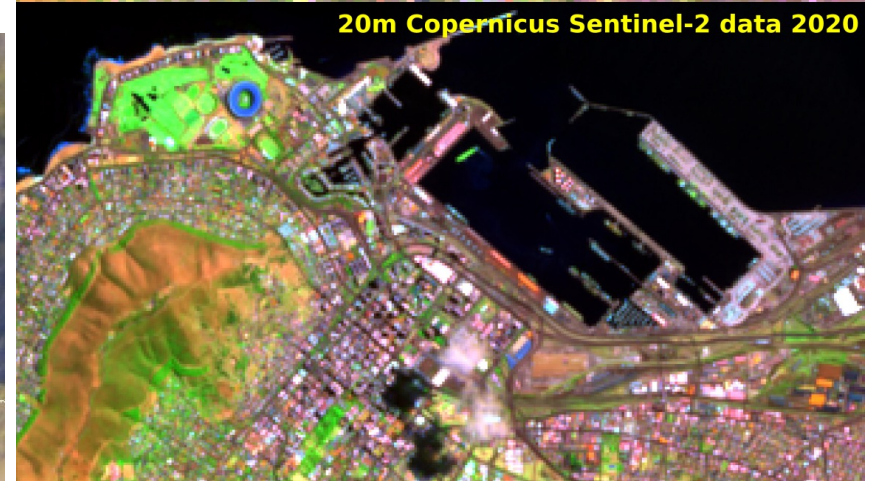
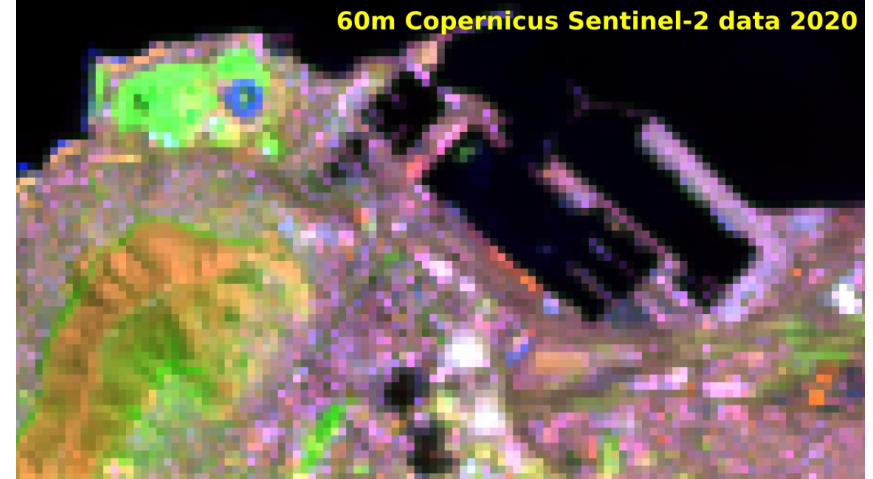


Examples

RESOLUTION



Low to middle- Meteosat MSG (km)
High - Sentinel 2 sensor MSI (tens of m)



**Very high
resolution**

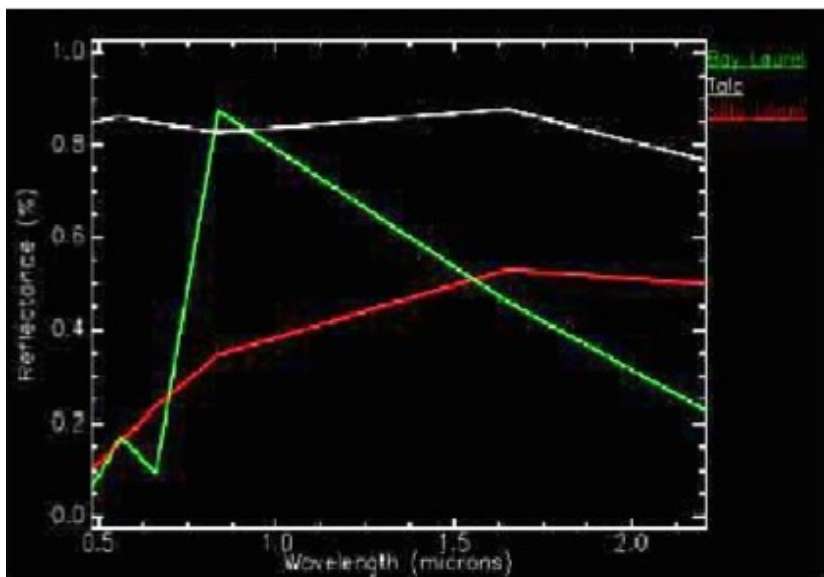
**Pleiádes-NEO
MS 1,2m
PAN 0,3m**

**Can you
recognize the
city?**

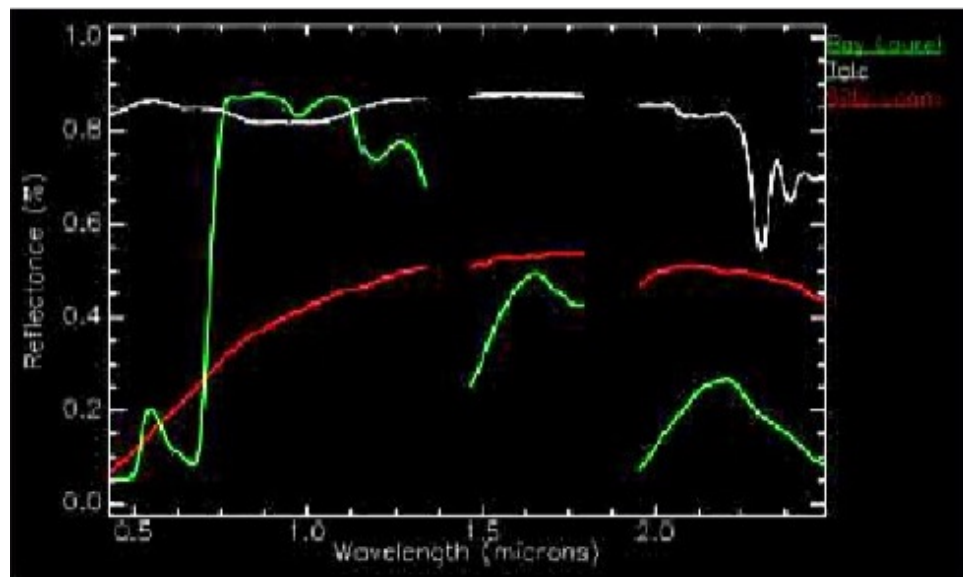


Examples

RESOLUTION



Landsat 7 - ETM 7 bands



Letecké - AVIRIS, 224 bands, absorption bands

Panchromatic band – Pan (all) Chroma (color) = 1 band in a spectral range of visible and VNIR, black and white picture in grey scale

Data processing types

Unprocessed („raw“) data

Processed (“system corrected“) data

By „processing“ we mean implementation of basic radiometric (sensor calibration), geometric (position) and atmospheric corrections.

→ SATELLITE ORBITS

In Earth Observation, the satellites follow trajectories around the Earth called orbits.

The shape of these orbits depends on three principal factors. The first factor is the gravity of the Earth, the second factor is the velocity of the satellite and the third factor is the position of the satellite. The closer the satellite is to the Earth, the higher is its velocity.

Scientists select the orbits according to what the satellites need to observe.

In general, two types of orbits are used for Earth observation satellites:

Near Polar Sun-synchronous and Geostationary orbits.



GEOSTATIONARY ORBITS "LOCKED WITH THE EARTH"

Geostationary orbits are described by a circular trajectory approximately 36,000 km above the Earth's equator. Satellites on these orbits travel around the Earth at the same angular velocity as the Earth. In this way, they appear constantly at the same position above the Earth's surface and can provide a continuous service. Most meteorological and telecommunication satellites are placed in geostationary orbits.



NEAR POLAR SUN-SYNCHRONOUS ORBITS "LOCKED WITH THE SUN"

Near polar Sun-synchronous orbits are described by a roughly circular trajectory approximately 800 km above the Earth's surface. Satellites on these orbits ascend or descend nearly crossing the poles as the Earth rotates, in such a way that they can observe every part of the Earth at the same local time and with the same sun illumination each day. Earth observation satellites needing to cover the planet globally are placed in these orbits.

European Space Agency

What satellites are commonly used for Earth observation?
What trajectory has the previously mentioned Meteosat MSG (CHMI weather forecast)?

Data portals

ESA Portal - Data and processed outcome examples for public

<https://apps.sentinel-hub.com/eo-browser>

Profesional data portals

Downloading and further processing of data

Are not so visually attractive

Data availability – commercial vs. open

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

NASA - <https://search.earthdata.nasa.gov>

Paid providers (AWS - Amazon, Google Earth Engine) – easier access when processing large amounts of data

Next lesson task

Be able to download data

CZ

Copernicus hub na CESNET (<https://www.cesnet.cz>)

Create account at <https://dhr1.cesnet.cz/#/home>

Others

ESA Scihub

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