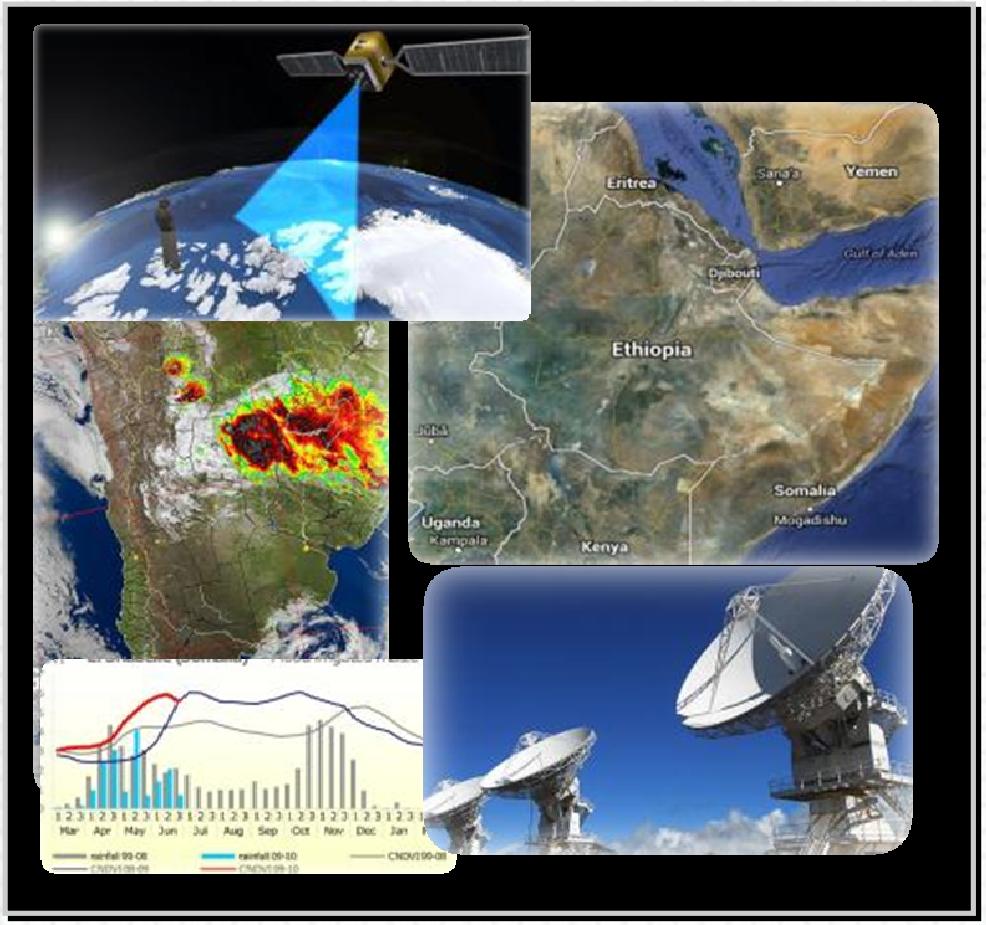
LEARNING OBJECTIVES

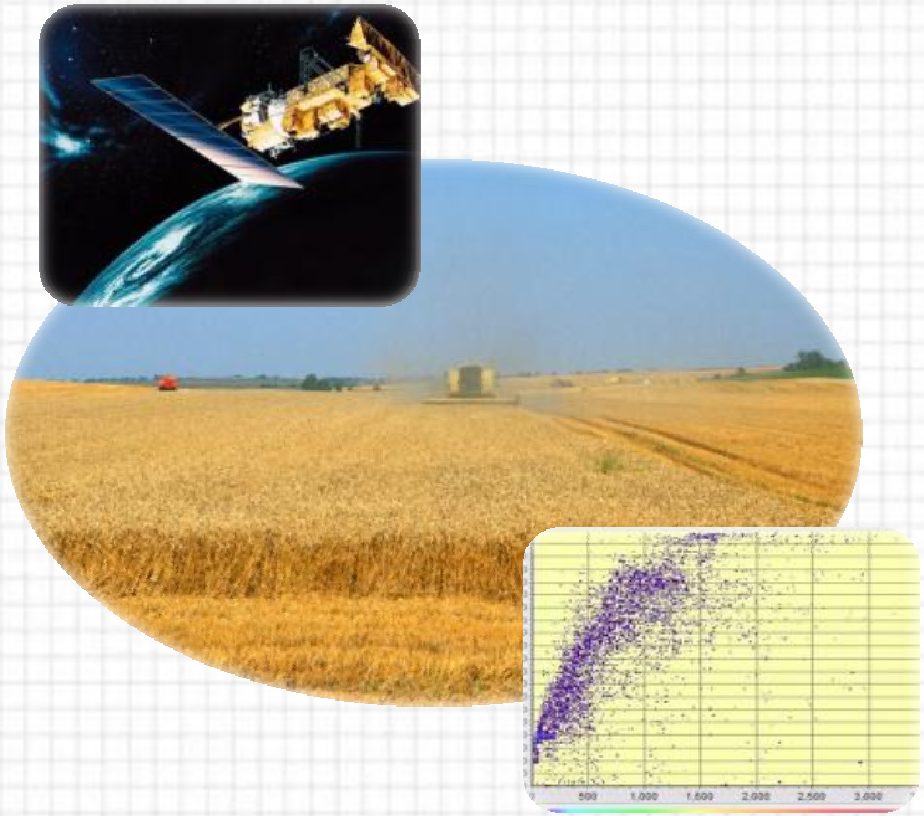
Lesson 2
Commonly Used Remote Sensing Data

At the end of the lesson, you will be able to:

- recognize the types of **data most commonly used** in remote sensing analysis of **crop monitoring**; and
- list a number of institutions making available remote sensing data for crop monitoring.



INTRODUCTION



This lesson presents the most important **data commonly used** for remote sensing analysis of **crop monitoring**.

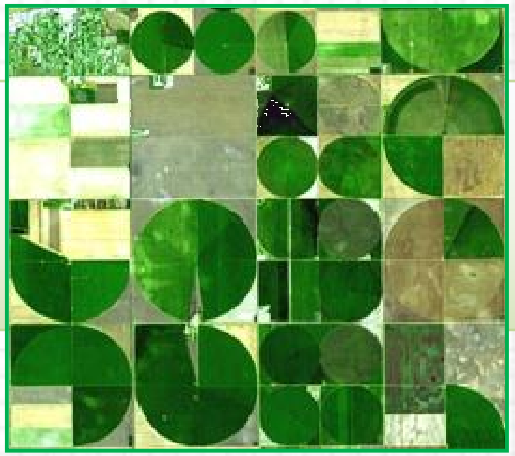
In particular, this lesson will illustrate through concrete examples the need and the potential uses for those kind of data.

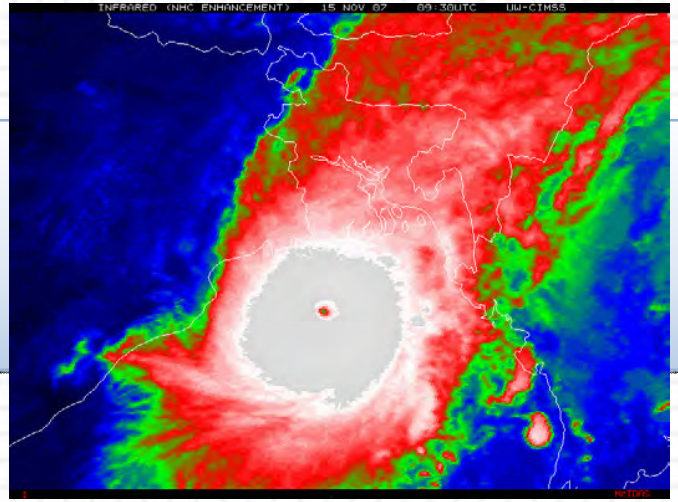
Furthermore, this lessons will provide some **links to** several **data repositories**.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

Satellite images can play a role in providing:

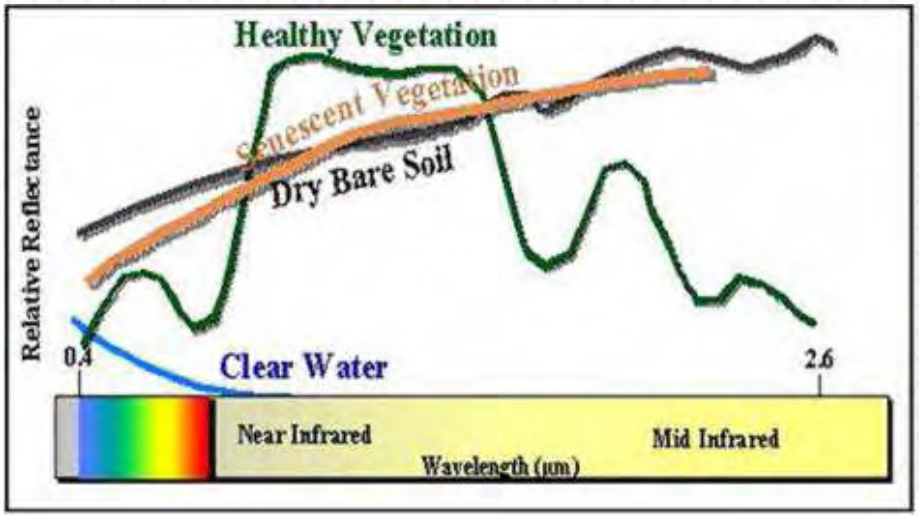
1. **direct information about crop** stage, conditions and health by **observing the spectral properties** of green vegetation and analysing their relationship with biomass/yield; and





2. **estimates of the meteorological variables** that drive crop development such as temperatures and rainfall, in those areas which are not sufficiently covered by meteorological stations.

Introduction: Crop monitoring using remote sensing



Spectral response of green & dry, vegetation, bare soil, water -> "**spectral signature**"

-> Interest to observe vegetation from distance (remote sensing / télédétection) -> using satellites, airplanes, now unmanned airborne vehicles (depending on the revisit frequency and resolution needed)

Let us look at the satellites used for crop monitoring

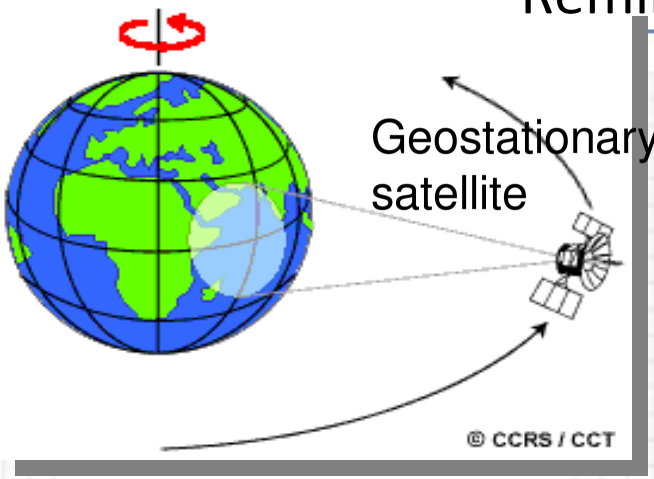
USING SATELLITE IMAGES FOR VEGETATION MONITORING

Let's see a short history of the use of satellite imagery for monitoring crop development….

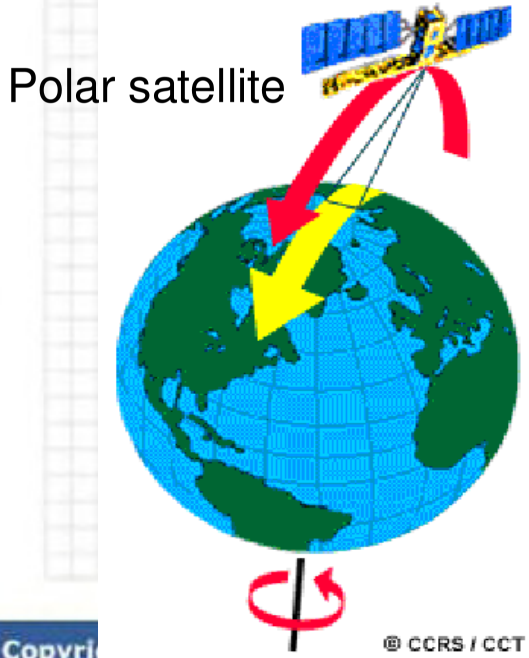
1. spectral properties

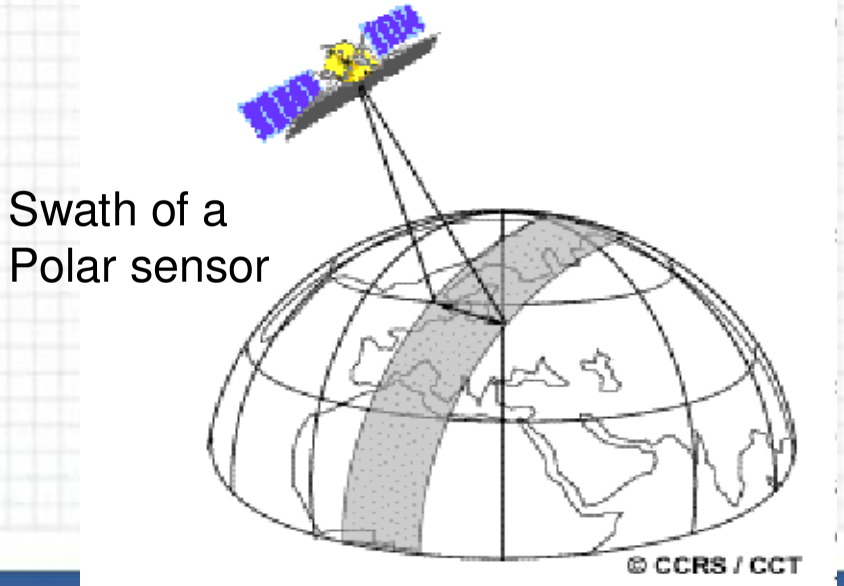
'70s - Landsat | '80s - AVHHR NOAA | '90s - VEGETATION SPOT | 2000s – MODIS/MERIS

Reminder on some satellite characteristics

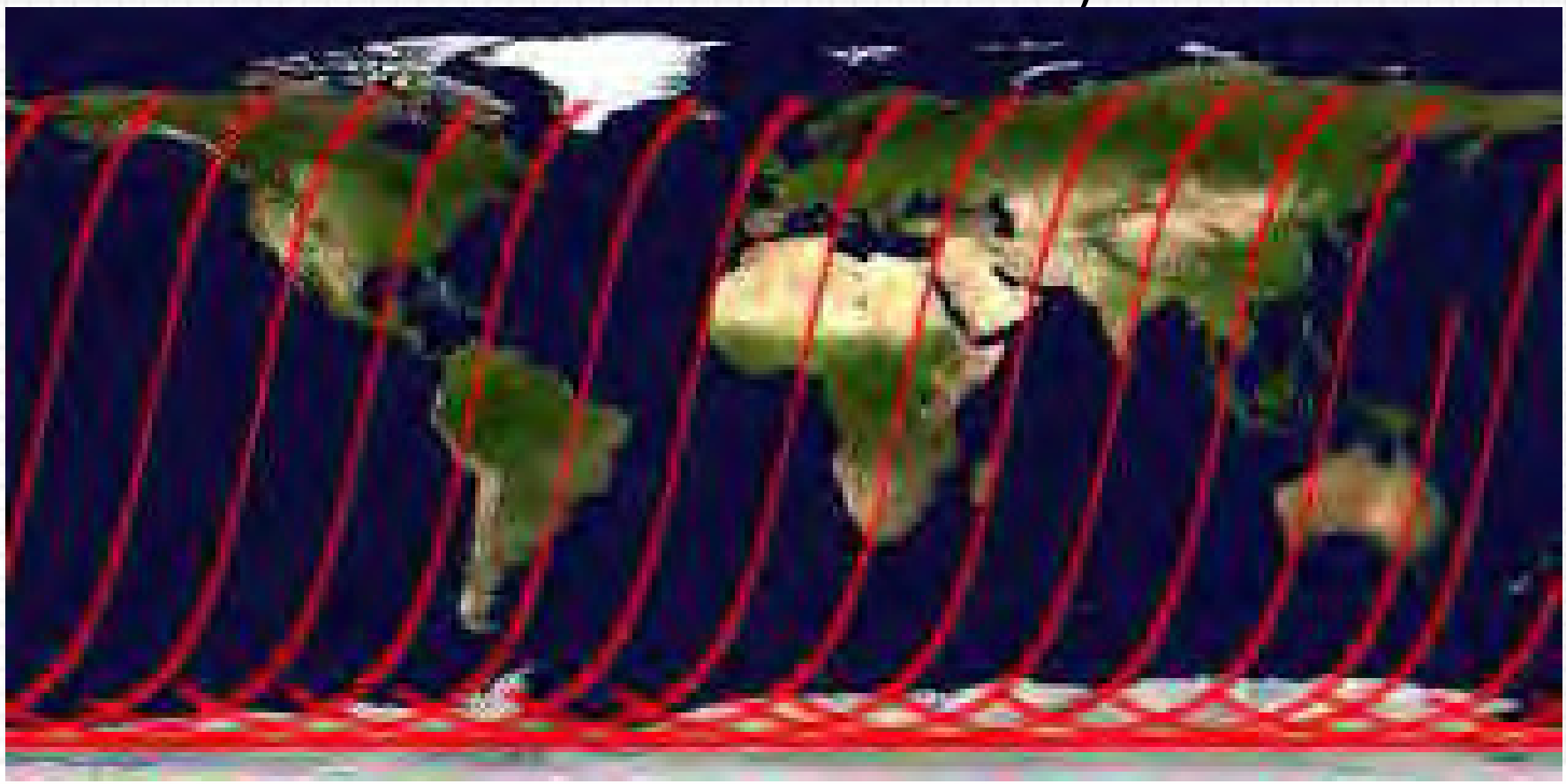


- **Orbit**: geostationary versus near-polar, sun synchronous (the satellite covers a given area of the world at a constant local solar time)
- **Orbit cycle**: time for the satellite to pass over the same point on the Earth's surface directly below the satellite (called the nadir point)
- **Swath**: portion of the Earth's surface seen by the satellite -> determines the revisit period



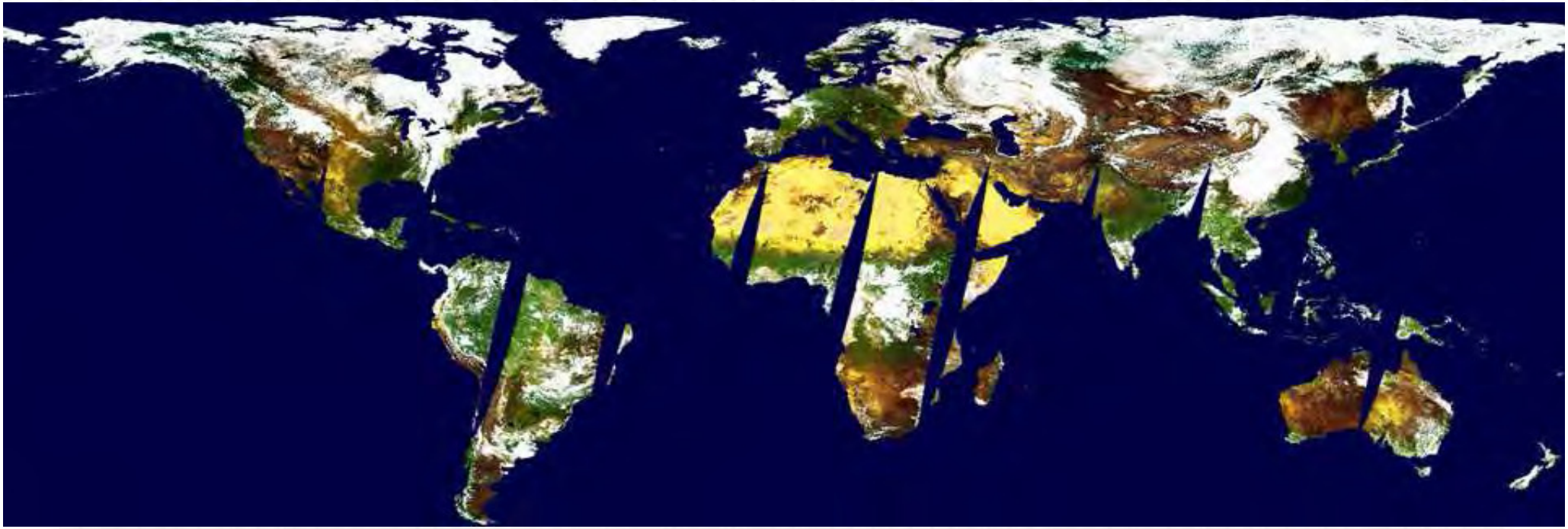


Adjacent swaths (ascending orbits of Landsat8 in 1 day, swath width 185 km)



Adjacent swaths (VEGETATION)

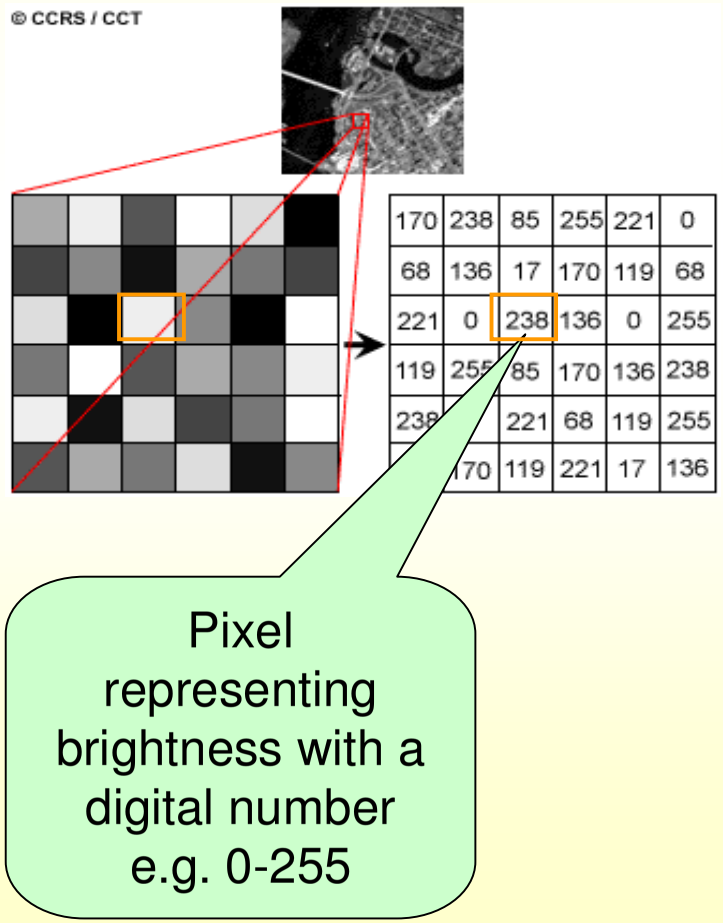
S1- product (daily synthesis), swath width 2200 km



Adjacent swaths (VEGETATION)

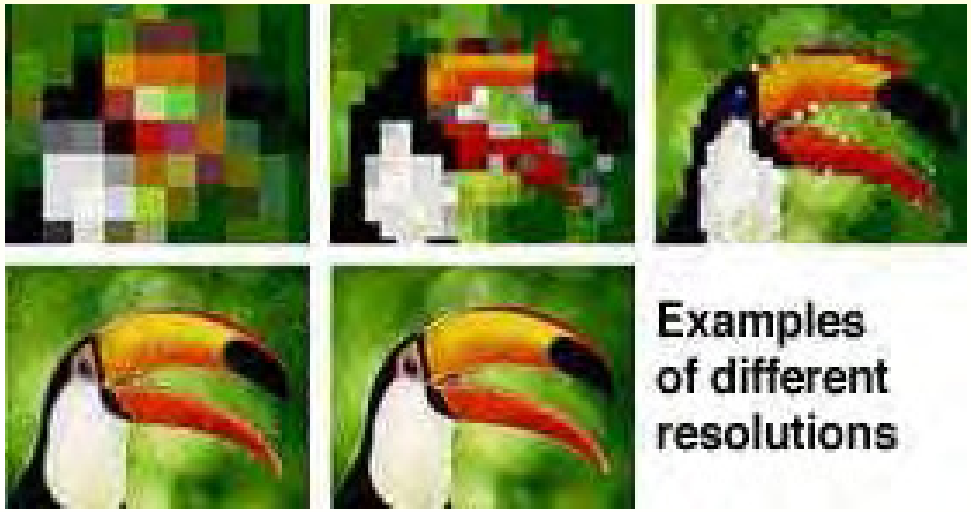
S10-product (10-daily synthesis)

Characteristics of images



- Electromagnetic energy may be detected:
  - **photographically** (chemical reactions on the surface of light-sensitive film to detect and record energy variations)
  - electronically / **digital** (subdividing the image into small equal-sized and shaped areas, called picture elements or pixels, and representing the brightness of each area with a numeric value or digital number)

Fine and coarse resolution



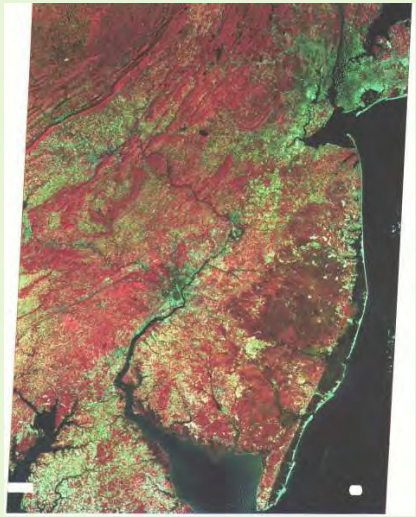
Examples of different resolutions

• Images where only large features are visible are said to have **coarse or low resolution** whereas images with fine or **high resolution** allow detecting smaller objects.

• Generally speaking, the finer the resolution, the smaller the image frame / area seen. There is a **trade-off between coverage and detail / data volume** (Earth's surface = 500 10^6 km^2 -> 500 MB/band with 1 km data and 1 byte/pixel; volume x 100^2 with 10m data, 1000^2 with 1m data…)

USING SATELLITE IMAGES FOR VEGETATION MONITORING

'70s - Landsat | '80s - AVHHR NOAA | '90s - VEGETATION SPOT | 2000s – MODIS/MERIS



A Landsat full image, from October 1972, shown as a false color composite.

The use of **spectral data** was studied extensively by using satellite imagery after the launch of the first civil Earth observation satellite (Landsat1) in 1972.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

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Landsat

Landsat imagery is available since 1972 from seven satellites with 4-5 sensors evolving over thirty years: **MSS** (Multi-Spectral Scanner, 4 bands) on Landsat 1-3 (1972-93), **TM** (Thematic Mapper, 7 bands) on Landsat 4 & 5 (1982-2013), **ETM+** (Enhanced Thematic Mapper Plus, 8 bands) on Landsat 7 (1999-), **OLI** (Operational Land Imager, 9 bands) & **TIRS** (Thermal InfraRed Sensor, 2 bands) on LDMC/Landsat 8 (2013-).

Landsat supplies high resolution visible and infrared imagery (MSS: 79m, TM 30m) with thermal imagery (120m on L4 & 5, 100m on L7, 60m on L8) and a panchromatic image (15m) also available from the ETM+ and OLI sensors.

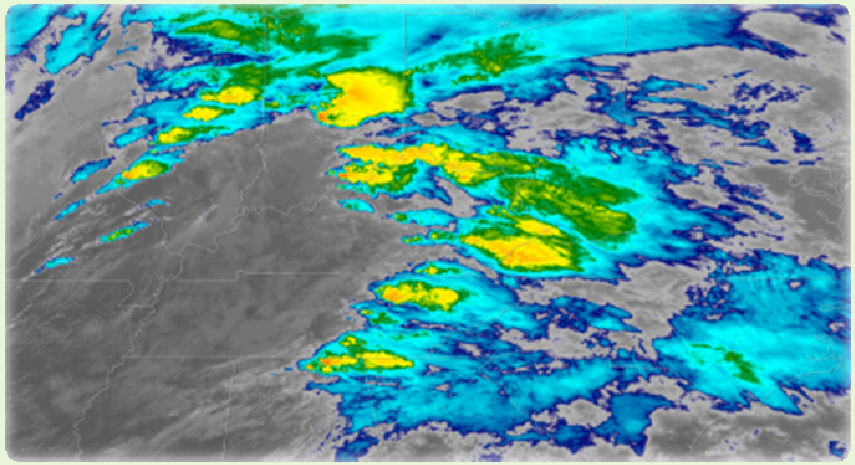
(Source: http://glcf.umd.edu/data/landsat)

For more information visit: http://www.landsat.org

Landsat-7 on orbit.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

'70s - Landsat | '80s - AVHHR NOAA | '90s - VEGETATION SPOT | 2000s – MODIS/MERIS



It is only with the growing availability of **low resolution multi-spectral satellite images** from the meteorological satellite series NOAA AVHRR in the early 80's, that similar analyses are extended to large areas, including many countries in arid and semiarid climates.

Image of a tornado outbreak taken by the NOAA AVHRR sensor.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

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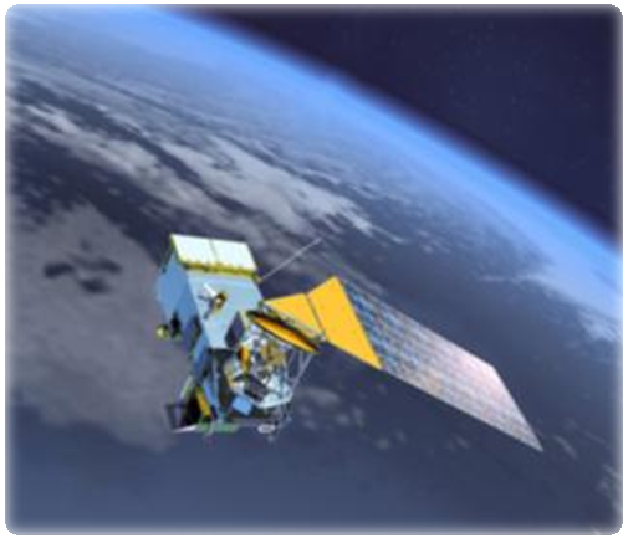
NOAA AVHRR



An artist's rendering of the NOAA POES.

AVHRR (Advanced Very High Resolution Radiometer) is a broad-band scanner, sensing in the visible (red), near-infrared, mid infrared and thermal infrared portions of the electromagnetic spectrum, carried on **NOAA**'s (National Oceanic Atmospheric Administration) Polar Orbiting Environmental Satellites (**POES**) and more recently also on the European **MetOp** satellite.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

'70s - Landsat | '80s - AVHHR NOAA | **'90s - VEGETATION SPOT** | 2000s – MODIS/MERIS

Most of the early studies (e.g. from the80's and the 90's) relate to the use of different sensors of the NOAA AVHRR series. These images were typically available at the national and multinational level with a 1km resolution (LAC) and at the continental and global level with a 4,6 km resolution (GAC) or below.
It is only at the end of the 90's that the French-Belgian-Swedish **satellite SPOT** is equipped with a **1km resolution sensor** (with B, R, NIR and SWIR bands) for **vegetation monitoring** at global scale called **VEGETATION**.

Athens (Greece) as seen by the Spot-5 satellite in 2002.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

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SPOT SATELLITE

Spot-5 Satellite.

The SPOT (Satellites Pour l'Observation de la Terre or Earth-observing Satellites) is a **high-resolution** (10-20m resolution, 60 km swath), optical imaging Earth observation satellite system operating from space, which was set up in 1978 by France in partnership with Belgium and Sweden.

The SPOT system includes a series of satellites and ground control resources for satellite control and programming, image production, and distribution. The company SPOT Image is marketing the high-resolution images, which SPOT can take from every corner of the Earth.

The first **VEGETATION** sensor (**1km** resolution, 2200 km swath) was launched on SPOT 4 in April 1998.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

'70s - Landsat | '80s - AVHHR NOAA | '90s - VEGETATION SPOT | 2000s – MODIS/MERIS

Several so called **medium resolution sensors** (maximum 250 - 300 m) are operational since the year 2000.

Amongst the best known are the **MODIS** and **MERIS** sensors belonging to the TERRA/AQUA and ENVISAT platforms respectively.

Envisat view of Europe as a whole, using the wide angle capability of MERIS.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

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MODIS and MERIS

MODIS and MERIS sensors can potentially observe the Earth's surface in **1-3 days** (similar to the 1 day of NOAA/AVHHR and SPOT VEGETATION), but their **spatial resolution** increases from 1km to **250 m** (MODIS) and **300 m** (MERIS) respectively.

The higher spatial resolution means that they include more topographic detail on ground features and for example rivers, small lakes, or irrigated areas are much better visible than with NOAA AVHRR or SPOT VEGETATION. On the other hand the **data volume** as compared to the other sensors **increases by a factor 16** (ca. 4*4 pixels corresponding to each 1km pixel).

In practice they provide spatially more detailed information and are typically used at national or regional scale, while NOAA AVHRR and SPOT VEGETATION images remain the most common at continental and global level.

Popup Window

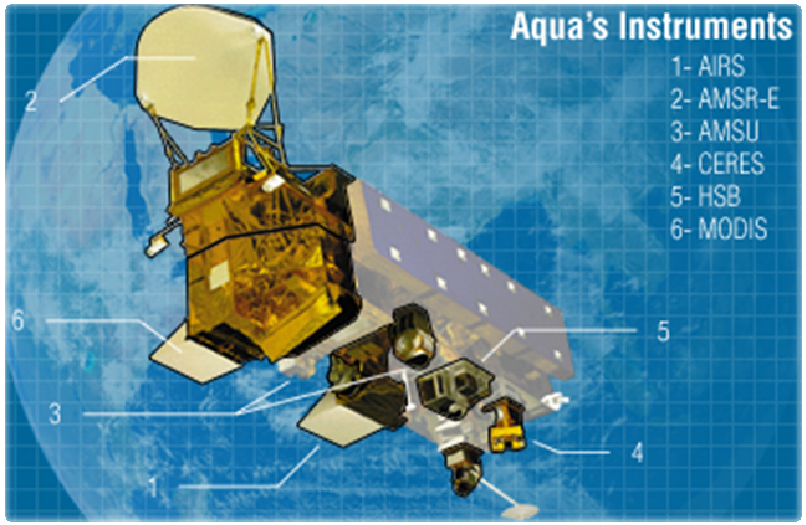
Terra and Aqua satellites

Terra and Aqua are multi-national NASA scientific research satellite.

Terra was launched on December 1999. It is the flagship of the Earth Observing System (EOS). The name "Terra" comes from the Latin word for Earth. Terra crosses the equator at 10:30 am.

Aqua was launched on 2002 and studies the precipitation, evaporation, and cycling of water. The name "Aqua" comes from the Latin word for water. Acqua crosses the equator at 1:30 pm.

Artist's rendering of the Terra spacecraft.



Aqua satellite and its instruments.

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Envisat

Envisat ("Environmental Satellite") was a large multi-sensor Earth-observing satellite which was launched on 2002 and was operational until April 2012.

This European Space Agency (ESA) satellite is the most advanced environmental spacecraft ever built and the largest civilian Earth observation satellite put into space.

Its objective was to service the continuity of European Remote-Sensing Satellite missions, providing additional observational parameters to improve environmental studies.

Model of Envisat in original size.

USING SATELLITE IMAGES FOR VEGETATION MONITORING

This table resumes the properties of the most common sensors used for vegetation monitoring.

1. spectral properties 

Properties of the most common optical low and medium resolution sensors

Sensor	Platform	Spectral range	Number of bands	Resolution	Swath width	Repeat coverage	Launch
AVHHR	NOAA POES 6-19	VIS, NIR, MIR, TIR	5	1100m	2400km	12 hours	1978
AVHRR	METOP	VIS, NIR, MIR, TIR	5	1100m	2400km	12 hours	2007
SEAWIFS	Orbview-2	VIS, NIR	8	1100m 4500m	1500km 2800km	1day	1997
VEGETATION	SPOT 4, 5	VIS, NIR, SWIR	4	1100m	2200km	1day	1998
MODIS	EOS AM1/PM1	VIS, NIR, SWIR, TIR	36	250-1000m	2330km	<2days	1999
MERIS	ENVISAT	VIS, NIR	15	300m (1200m)	1150km	<3days	2000
PROBA-V	PROBA-V	VIS, NIR, SWIR	4	300m (1000m)	2250km	1 day	2013
SENTINEL 3	SENTINEL	VIS, NIR, SWIR	21	300m	1270km	<2 days	Foreseen 2014