WHAT IS REMOTE SENSING?

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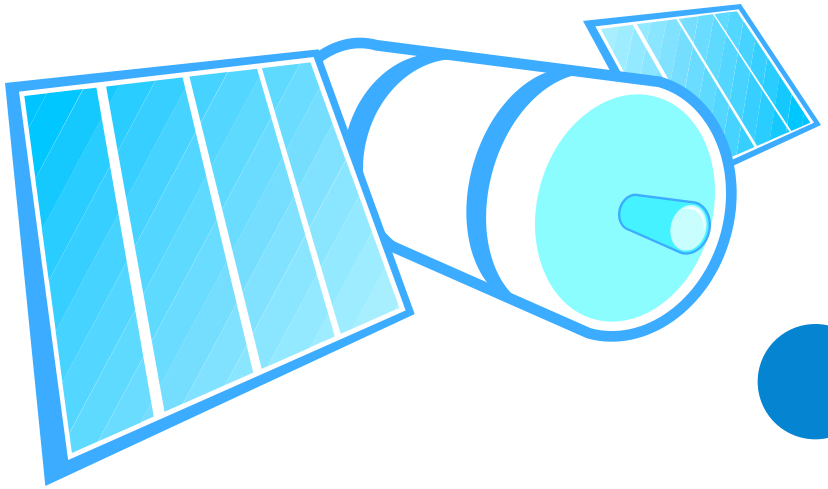
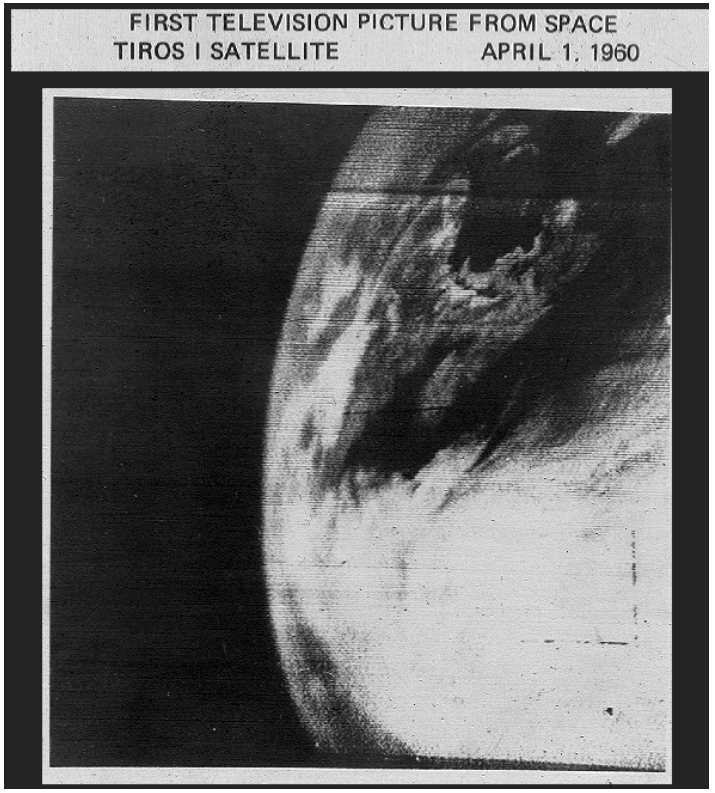
Collection of information about an object without being in direct contact with the object



Remote Sensing: A Limited Definition

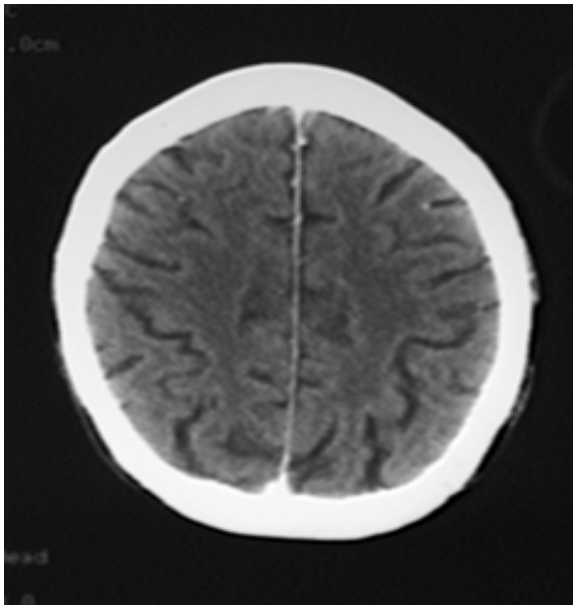
Remote sensing is the science of acquiring information about the Earth's surface without actual physical contact.

This is done by measuring and recording reflected or emitted electromagnetic energy.



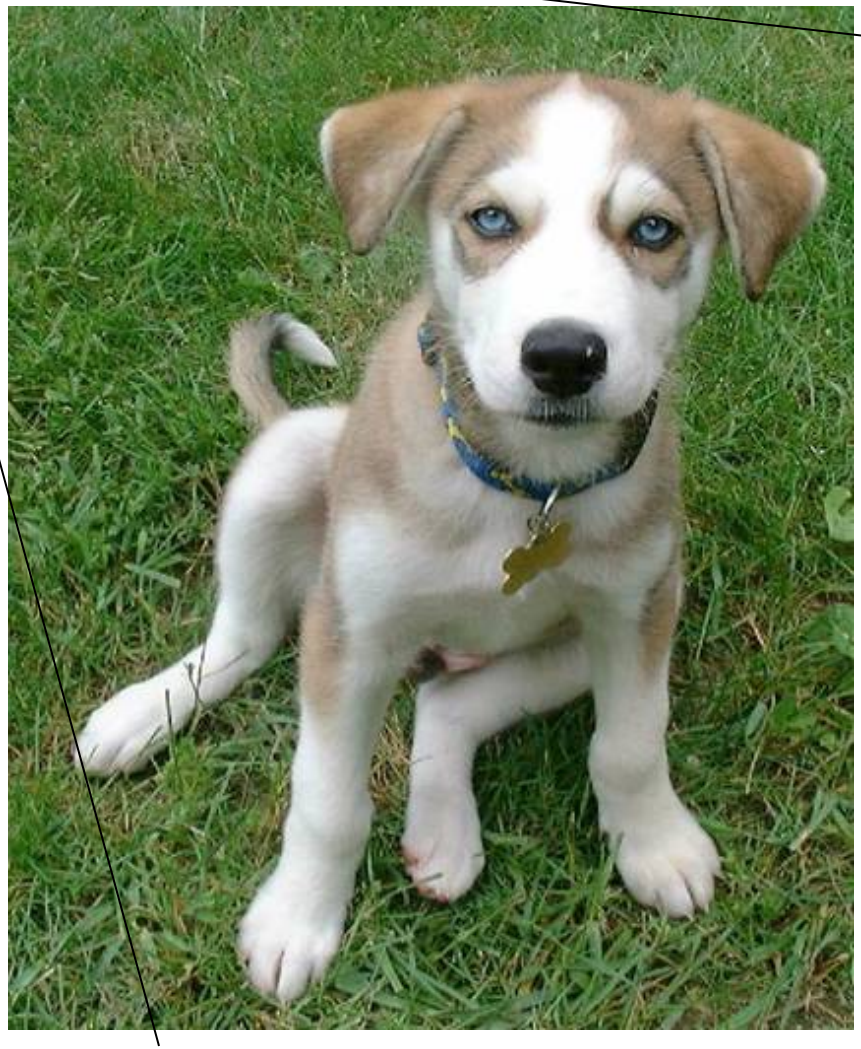
Medical examples

X-rays

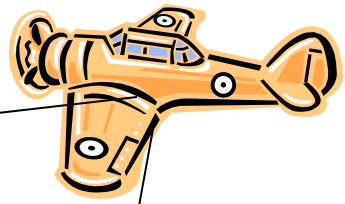


Cat-scans

A PHOTOGRAPH



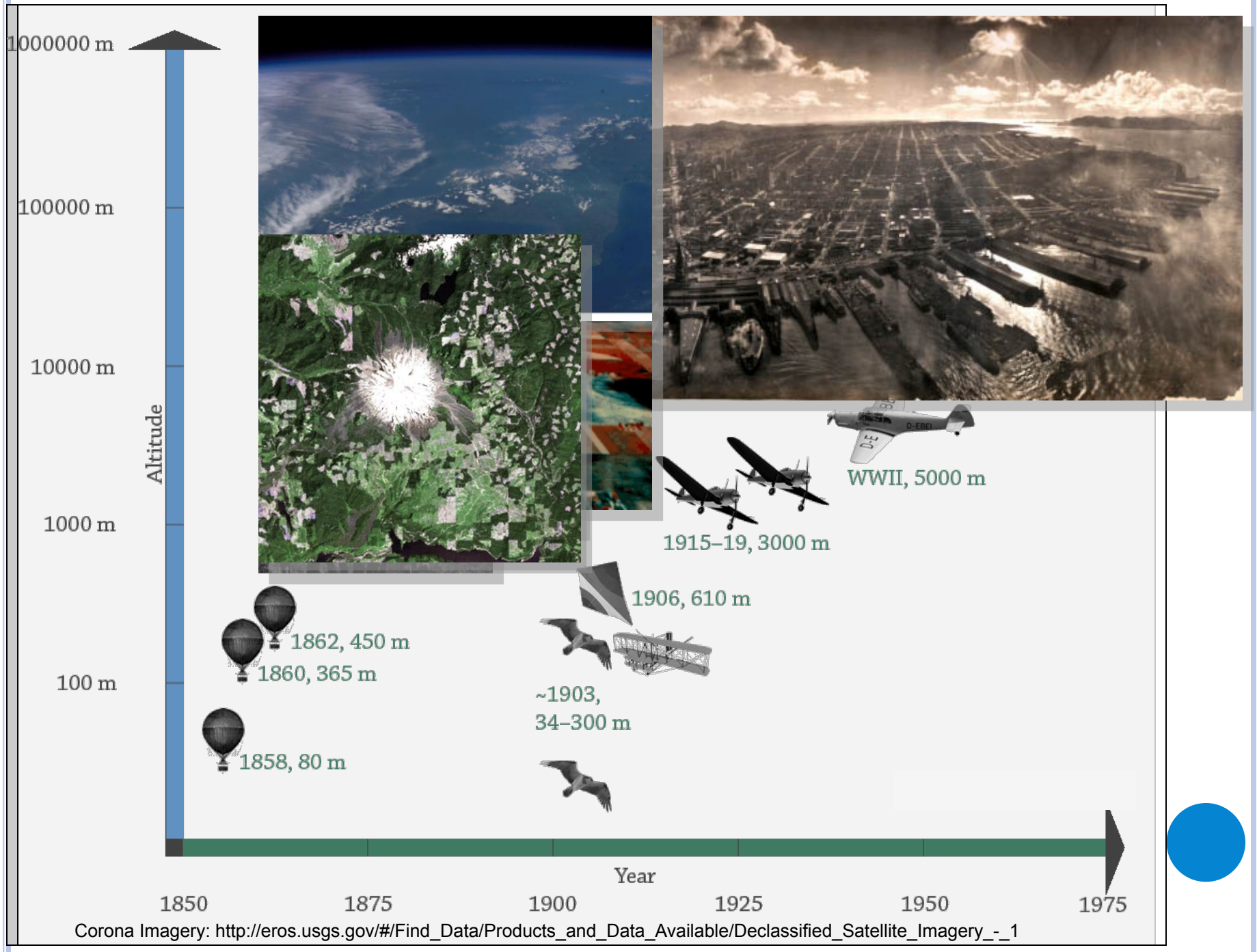
An aerial photograph



A SATELLITE IMAGE

Lake Erie

Cleveland International Airport



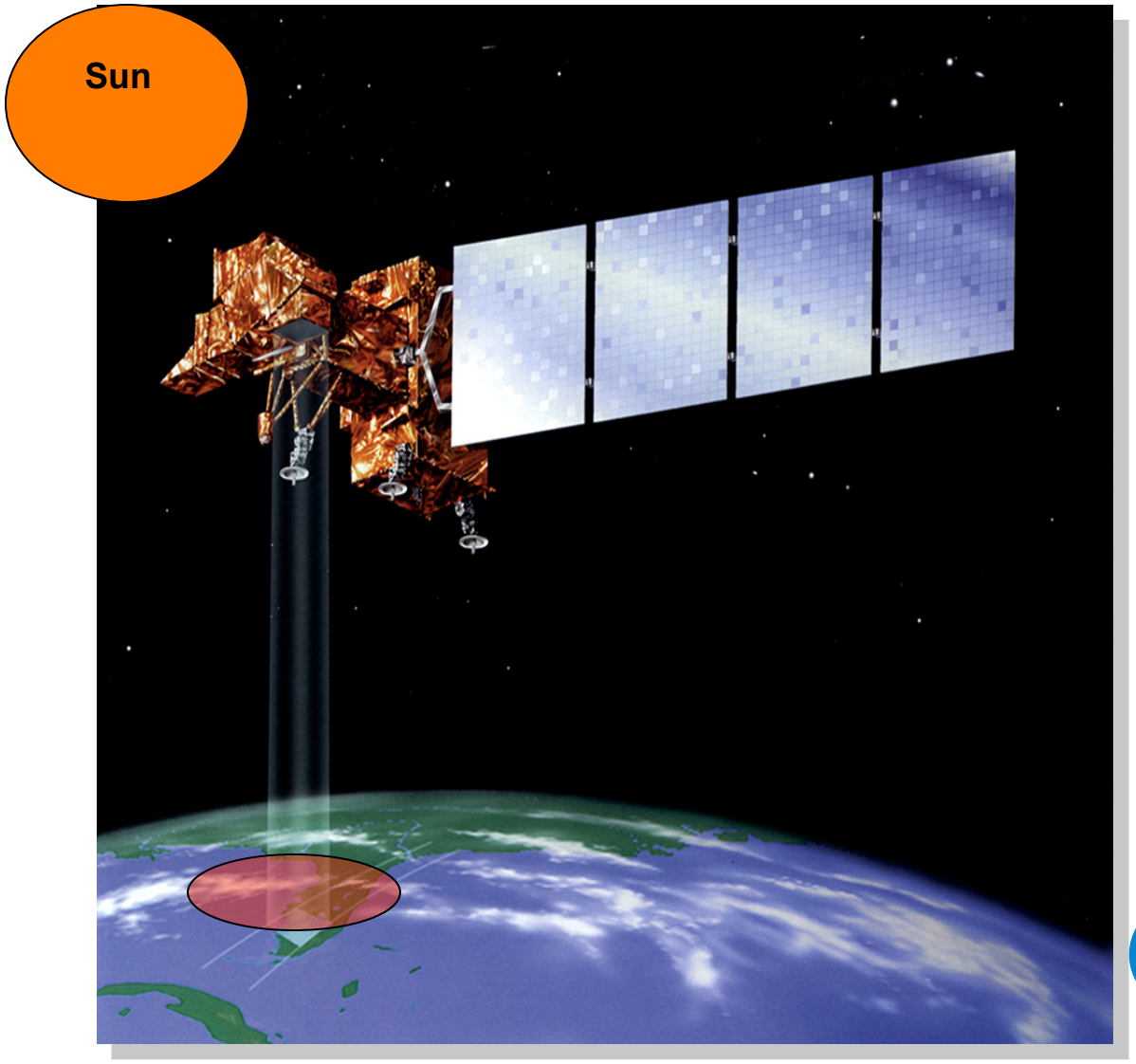
Corona Imagery: http://eros.usgs.gov/#/Find_Data/Products_and_Data_Available/Declassified_Satellite_Imagery_-_1

Three Major Components

1. Energy Source

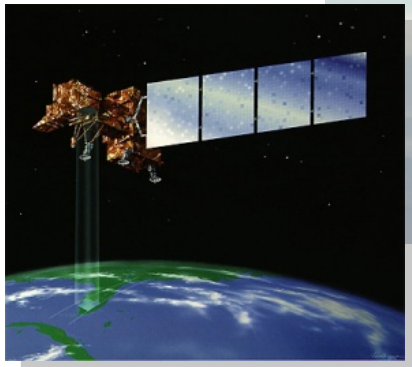
2. Instrument (Ex. Satellite) with Sensor onboard

3. Object to be measured (i.e., target material)



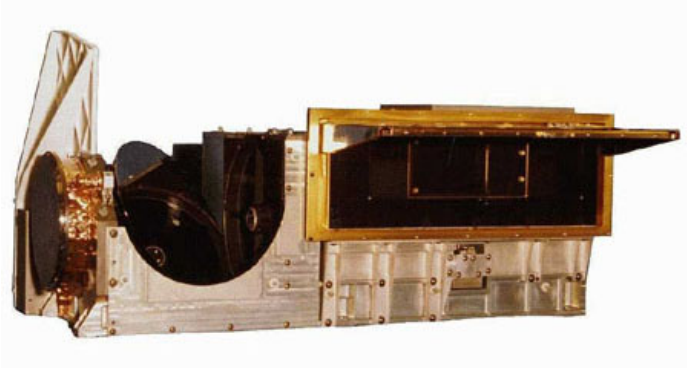
Development of Platforms

- Balloons
- Airplanes
- Unmanned aerial vehicles (UAV)
- Satellites



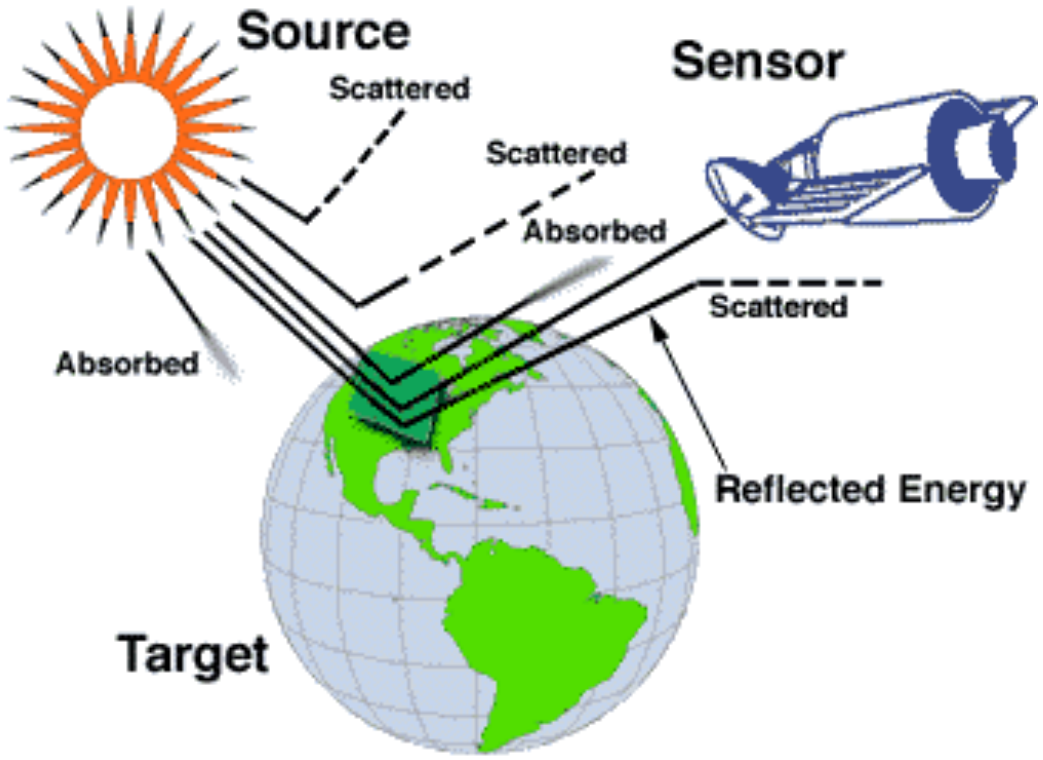
SENSORS

- **Sensors**: Detect the energy reflecting off of a target
- Two types
  - Active – the energy that is measured is produced by the instrument (i.e., RADAR or LIDAR or SONAR)
  - Passive - the energy that is measured comes from a source other than the instrument, most often the sun (i.e., cameras and imaging sensors) or from thermal emissions
- Atached to a platform



The AVHRR sensor that is attached to many NOAA satellites

How do imaging satellites work?



Satellite sensors "see" reflected and emitted radiation

SATELLITES

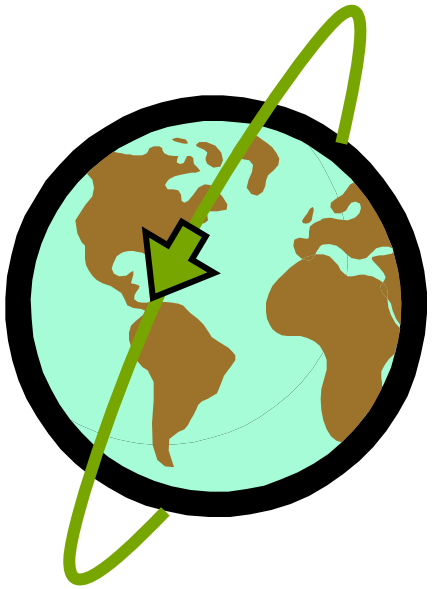
- Satellites are man-made vehicles that orbit the earth and possess sensors that detect energy that is emitted from the Earth
  - Geostationary satellites
    - Orbit at 35,784 km above the Earth's surface with an orbit time of 23 hours, 56 minutes, and 4 seconds
    - Includes TV satellites, communications satellites, and some weather satellites
  - Low Earth Orbit (LEO) satellites
    - Orbit at lower altitudes typically between ~700 km and 3,000 km
    - Includes GPS satellites, pole to pole orbiting satellites

GEOSTATIONARY SATELLITES

- Move in-sync with the Earth's movements
  - TV satellites
  - Weather satellites

Low Earth Orbit Satellites

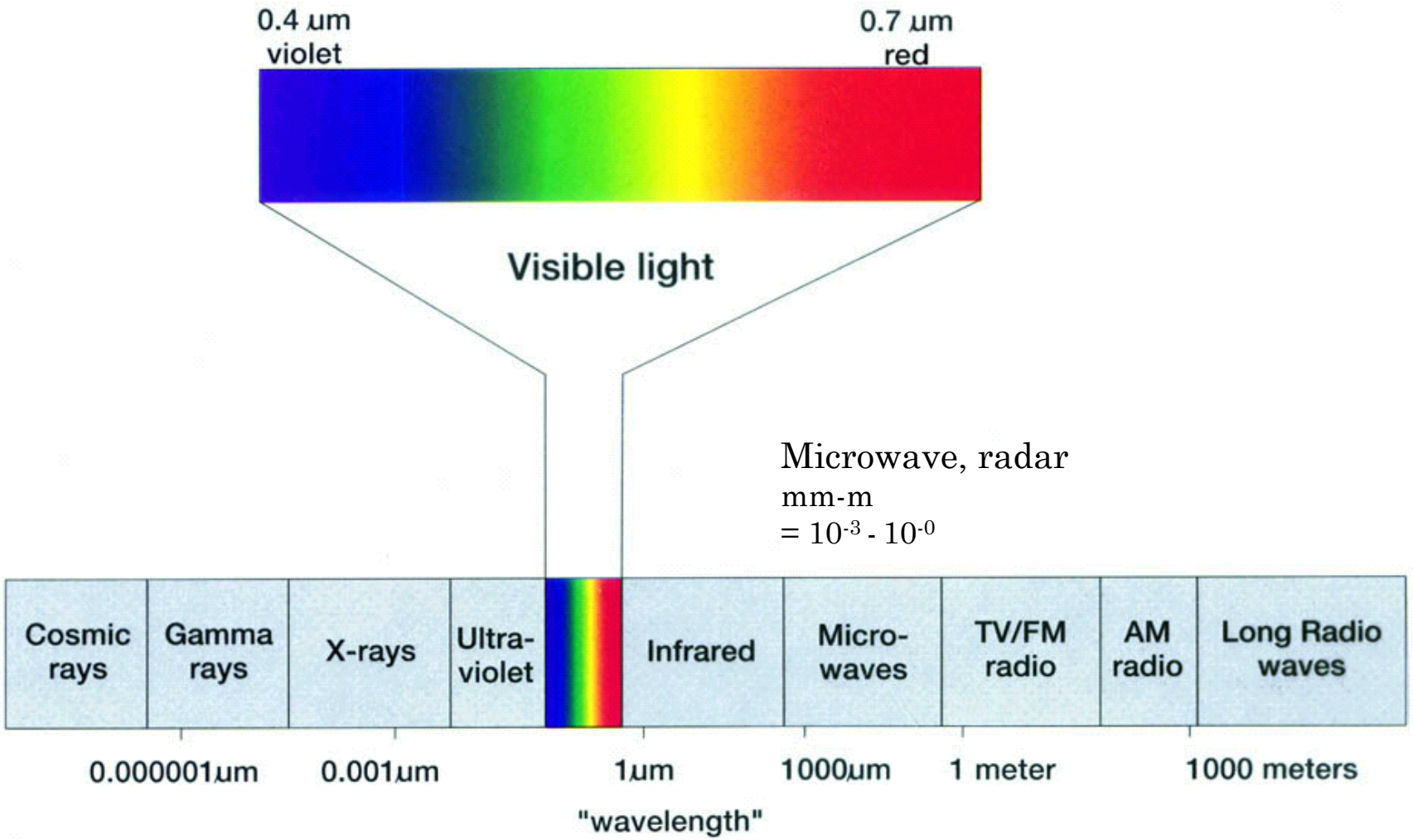
- Includes pole to pole orbiting satellites
- Earth spins under the orbiting satellite
- Satellites typically sun-synchronous
  - Orbit southward in daylight
    - Illuminated zone of Earth



PRINCIPLES OF REMOTE SENSING

- Energy is detected by a sensor
- All sensors are sensitive to specific areas of the *electromagnetic spectrum*
  - The spectrum consists of *electromagnetic radiation* that occurs in various *wavelengths*
- Areas of the electromagnetic spectrum can be sensed = *bands*
  - *Broad bands*
  - *Narrow bands*

THE ELECTROMAGNETIC SPECTRUM



UNITS

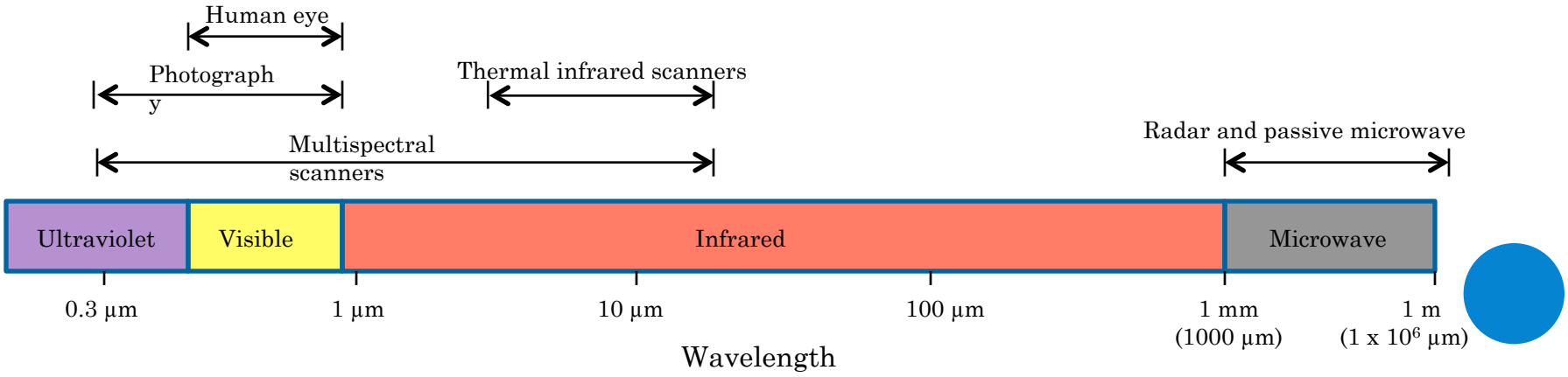
- Meter (m) = 1.0 m
- Centimeter (cm) = 0.01 m or 10^{-2} m
- Millimeter (mm) = 0.001 m or 10^{-3} m
- Micrometer (μm) = 0.000001 or 10^{-6} m
- Nanometer (nm) = 0.000000001 or 10^{-9} m

If you want to "see" these sizes, look at this video in order to better visualize these scales of measurement:

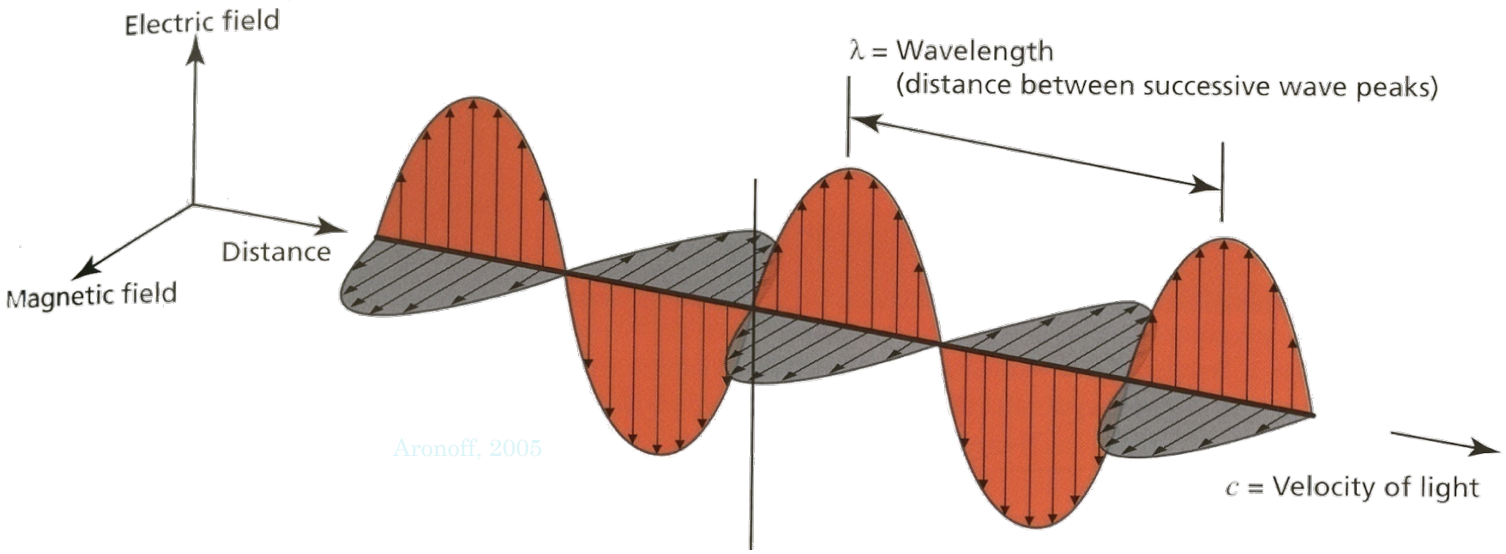
http://htwins.net/scale2/

EMR Regions Important to Remote Sensing

- Visible light (VIS): 0.4 - 0.7 µm
  - Blue: 0.4 - 0.5 µm
  - Green: 0.5 - 0.6 µm
  - Red: 0.6 - 0.7 µm
- Near infrared (NIR): 0.7 - 1.3 µm
- Middle infrared (MIR) / Shortwave infrared (SWIR): 1.3 - 3.0 µm
- Thermal infrared (TIR): 3.0 - 5.0 µm and 8.0 - 14.0 µm
- Microwave and radio waves (radar): 1mm to 10 m
- **Recall we are limiting our scope to 0.4 µm to 15 µm**



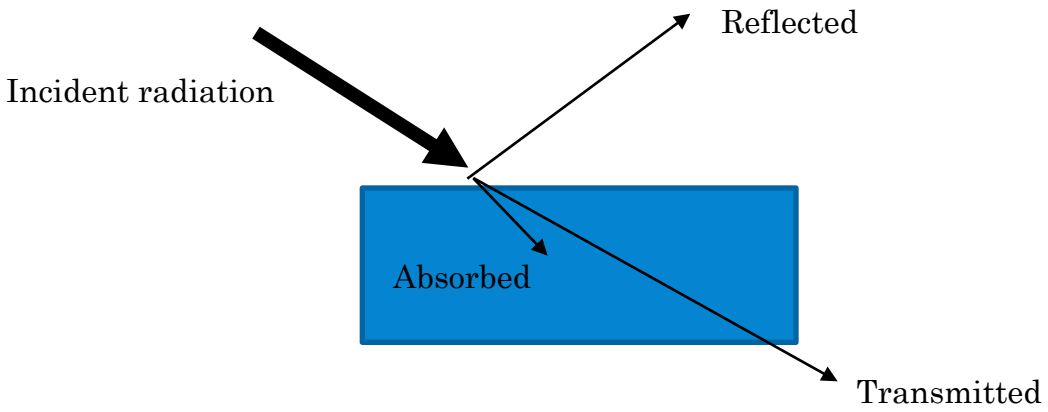
Remote Sensing Physics Fundamentals



- **Radiation**: the process by which electromagnetic energy is propagated through free space by virtue of joint undulatory variations in the electric and magnetic fields in space
- Electromagnetic radiation (EMR) acts as both a particle and a wave
  - It needs no transport medium
  - It travels at the speed of light
  - It is described by frequency and wavelength

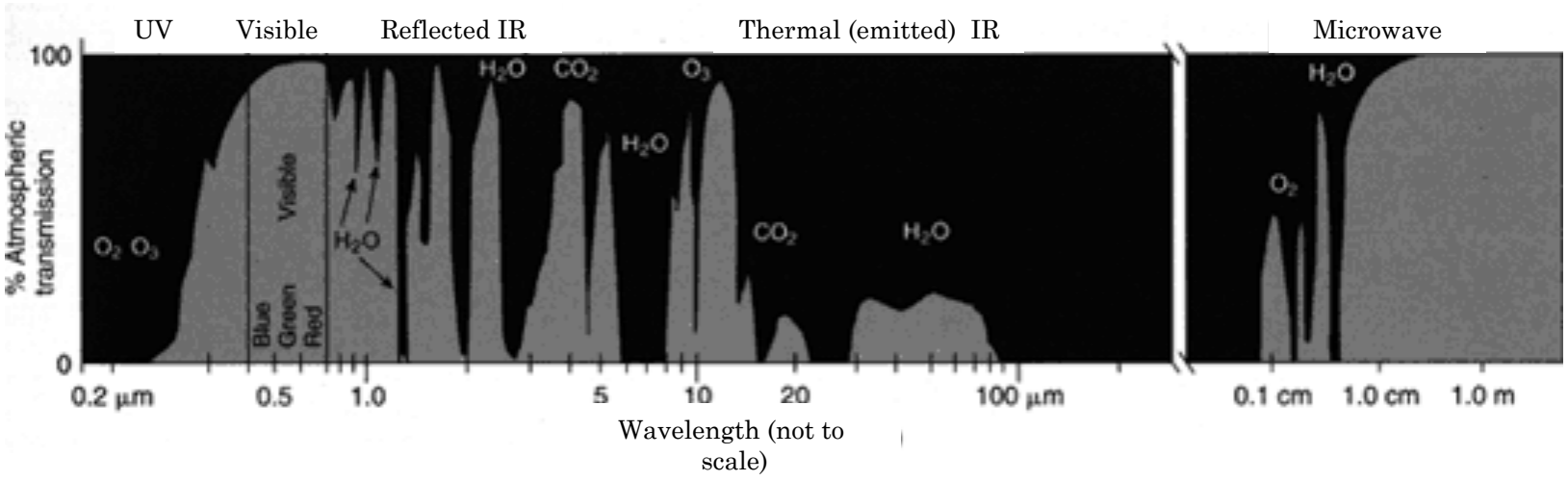
Energy Interaction with Target

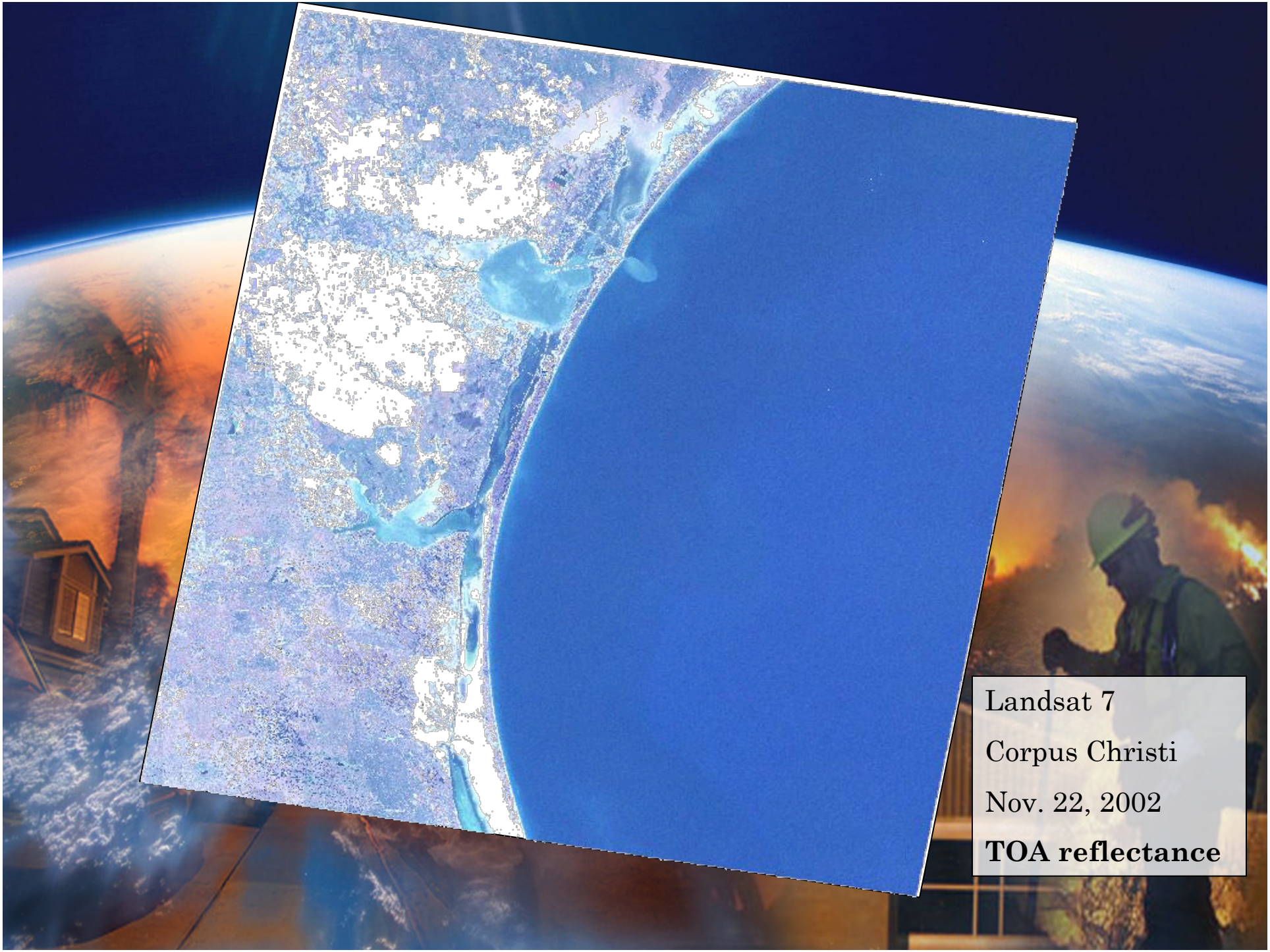
- A fundamental aspect of remote sensing is monitoring how incoming (incident) radiation in selected wavelengths interacts with a target (e.g., Earth)
- When energy comes into contact with a target it can be:
  (1) **Transmitted:** Radiation passes through the target
  (2) **Absorbed:** Radiation is absorbed by the target and later emitted as thermal infrared energy
  (3) **Reflected:** Radiation bounces off of target



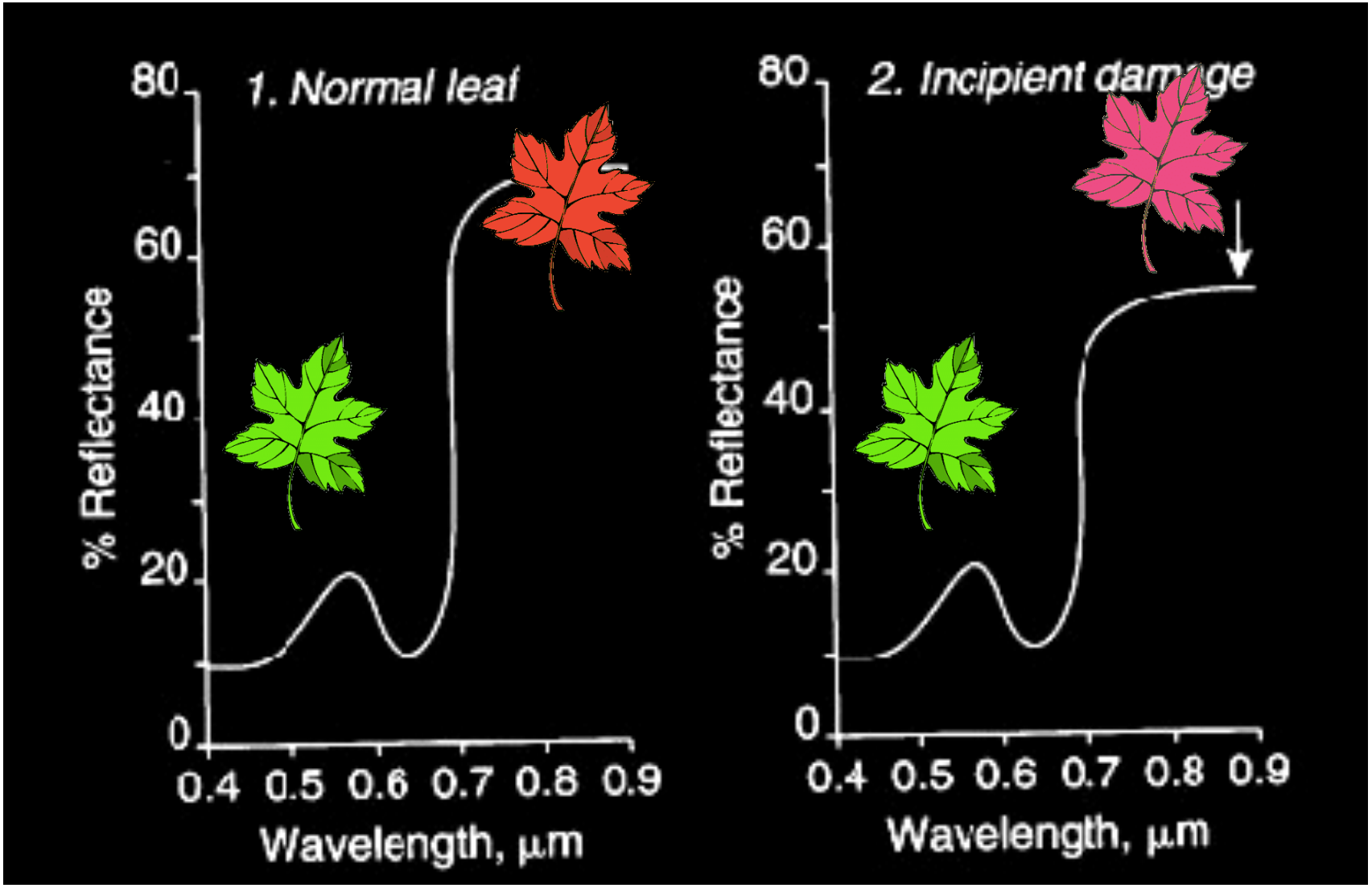
Atmospheric Windows

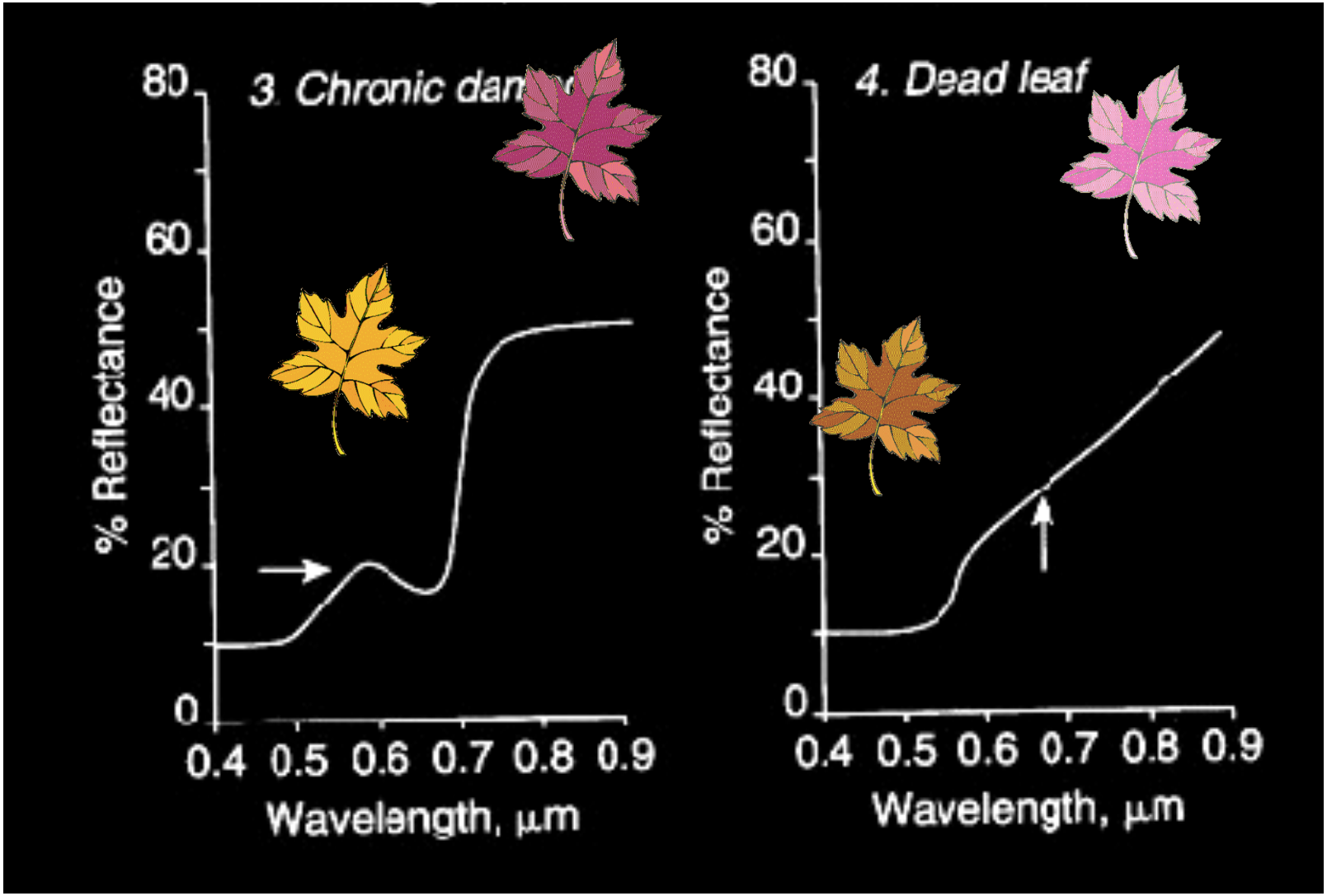
- "What are the spectral windows one is peaking through?"
- The regions of the EMR spectrum that transmit energy effectively are called *Atmospheric Windows*
- The visible portion of the spectrum (0.4 to 0.7 μm) is an atmospheric window as it transmits all of the incident energy

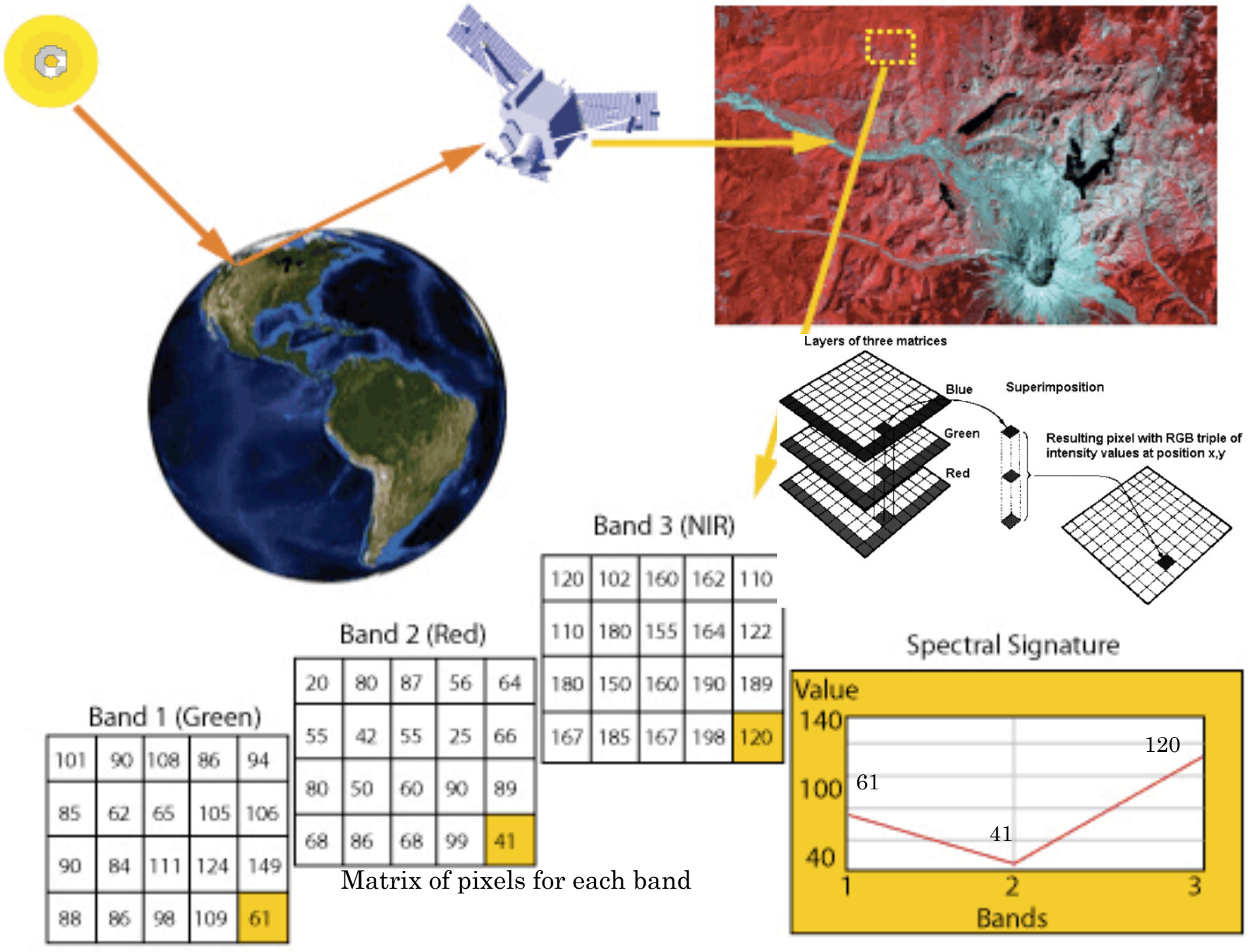



Landsat 7
Corpus Christi
Nov. 22, 2002
TOA reflectance


Landsat 7
Corpus Christi
Nov. 22, 2002
Surface reflectance

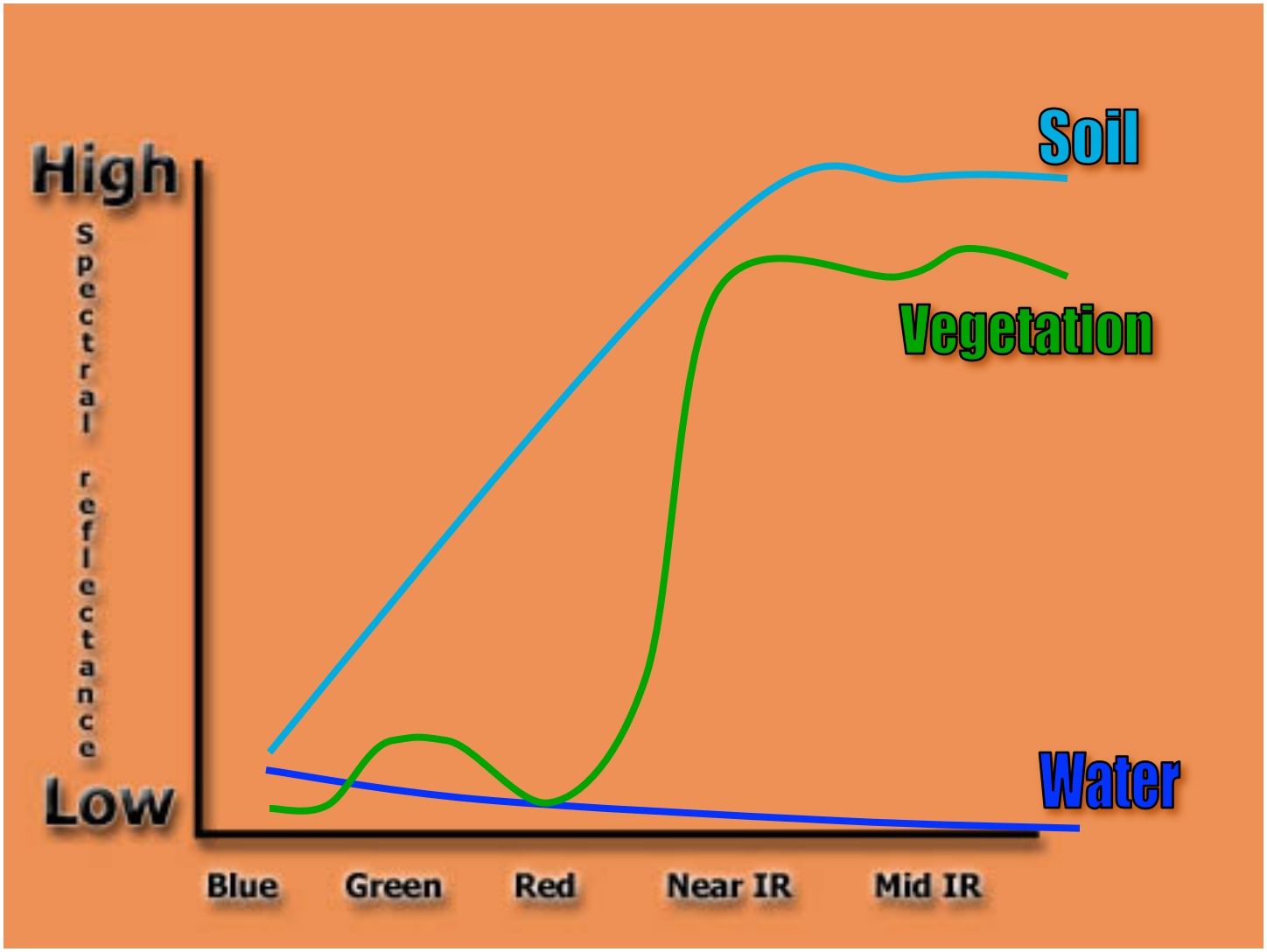

1. Normal leaf
2. Incipient damage
% Reflectance
80
60
40
20
0
0.4 0.5 0.6 0.7 0.8 0.9
Wavelength, µm


3. Chronic dam
4. Dead leaf
% Reflectance
80
60
40
20
0
0.4 0.5 0.6 0.7 0.8 0.9
Wavelength, µm

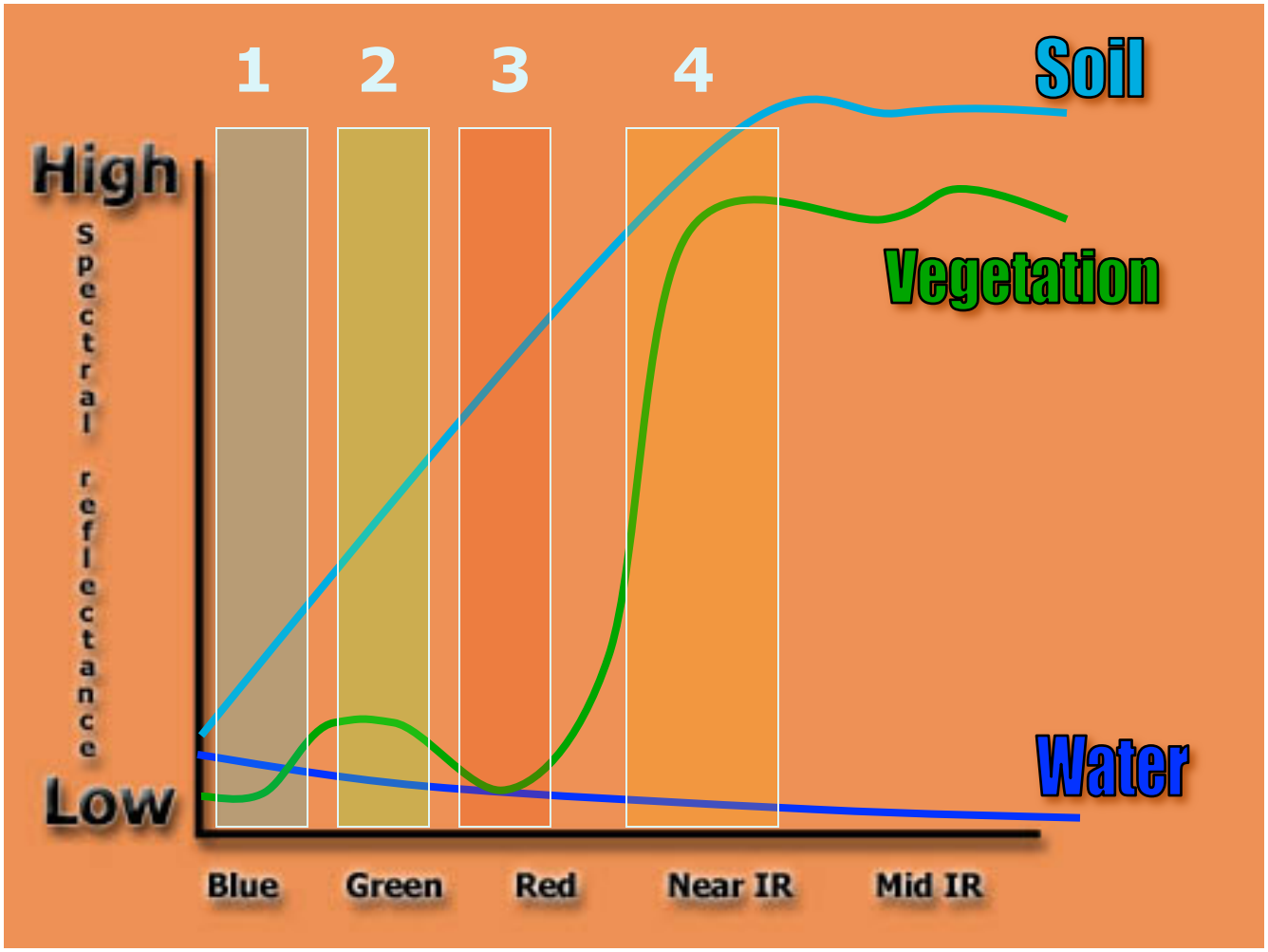


Matrix of pixels for each band

Spectral curves of Earth materials

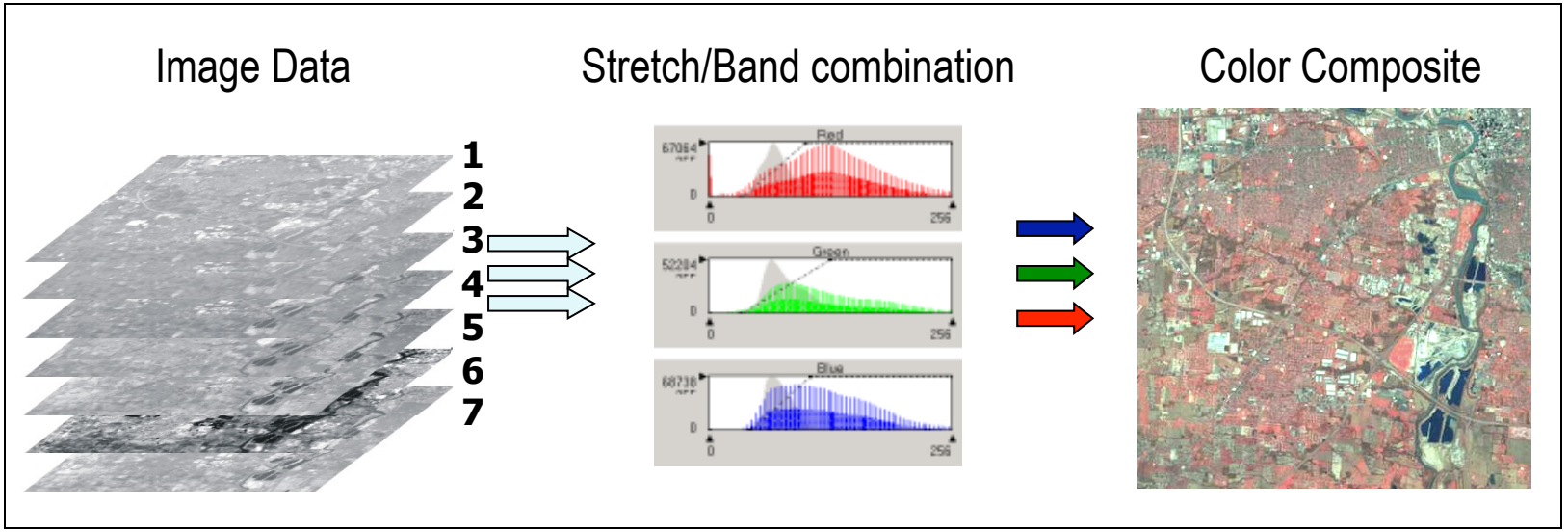


Landsat bands 1-4 and spectral curves



Displaying Multiple Band Data

- Steps for generating a color composite:
  - Each pixel is assigned a brightness value
  - Color guns are used to display pixels in varying degrees of red, green and blue
  - Each pixel is displayed by combining values for each of the red, green and blue color intensities
- Only three bands can be displayed at a time



Natural color composite
3,2,1

False color composite
4,3,2

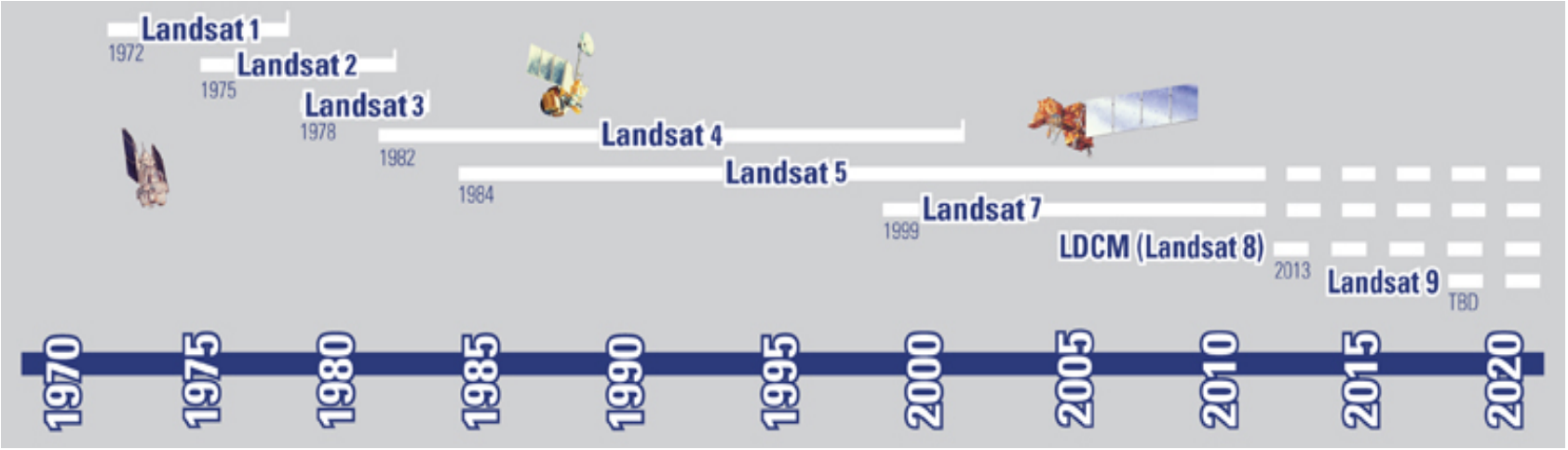
EOS: Land Observations

- The Earth Observing System (EOS) is a system of satellites and instruments designed to "monitor and understand key components of the climate system and their interactions through long-term global observations"
- Consists of three separate platforms
  - Terra – launched on Dec. 18, 1999
  - Aqua – launched on May 4, 2002
  - Aura – launched on July 15, 2004
- The two main land-observing instruments on EOS are:
  - MODIS
    - Flown on Terra and Aqua platforms
  - ASTER
    - Flown on Terra platform

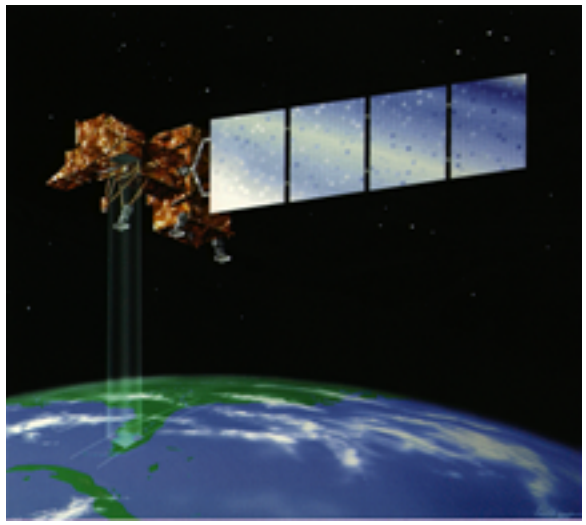
Learn More
http://modis.gsfc.nasa.gov/
http://asterweb.jpl.nasa.gov/

LANDSAT' S HISTORY

- Program launched on July 23, 1972
- Six satellites have been in operation
- Currently Landsat 5 failed in spring 2012 and only 7 is in operation
- The next-generation Landsat satellite, the Landsat Data Continuity Mission, is scheduled to be launched on January 24, 2013



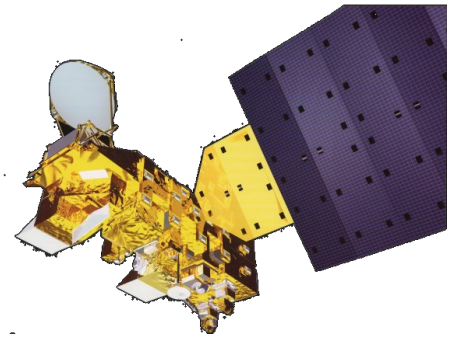
Pole to pole orbiting satellite Landsats 5 & 7



- 705-km altitude
- 16-day repeat cycle
- 185 km swath width
- Pixel resolution 30 m
- 8 bands

POLE TO POLE ORBITING SATELLITE MODIS

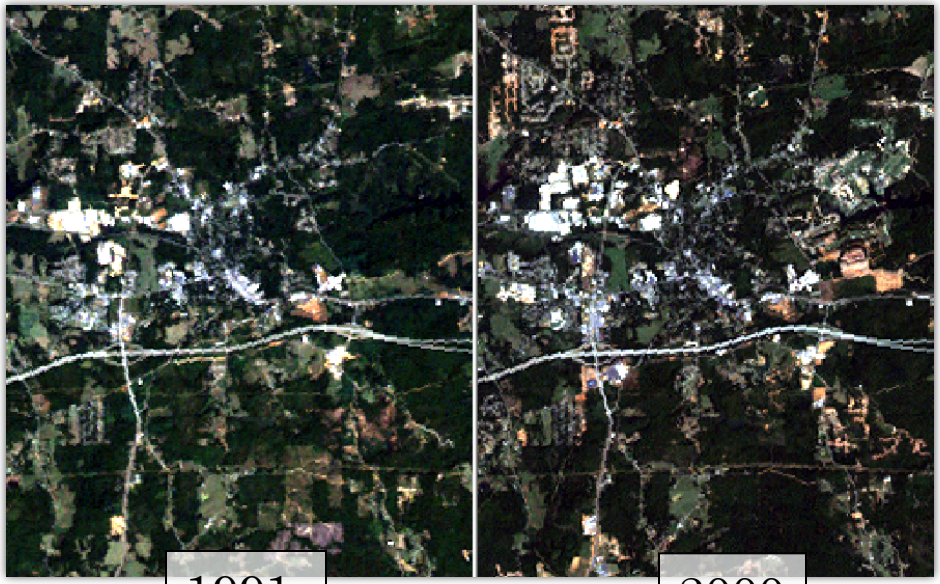
- Moderate Resolution Imagaing Spectroradiometer



  - 692 km altitude
  - 16-day repeat cycle
  - 2,330 km swath width
  - Pixel resolution 250m
  - 36 bands

CHANGE?

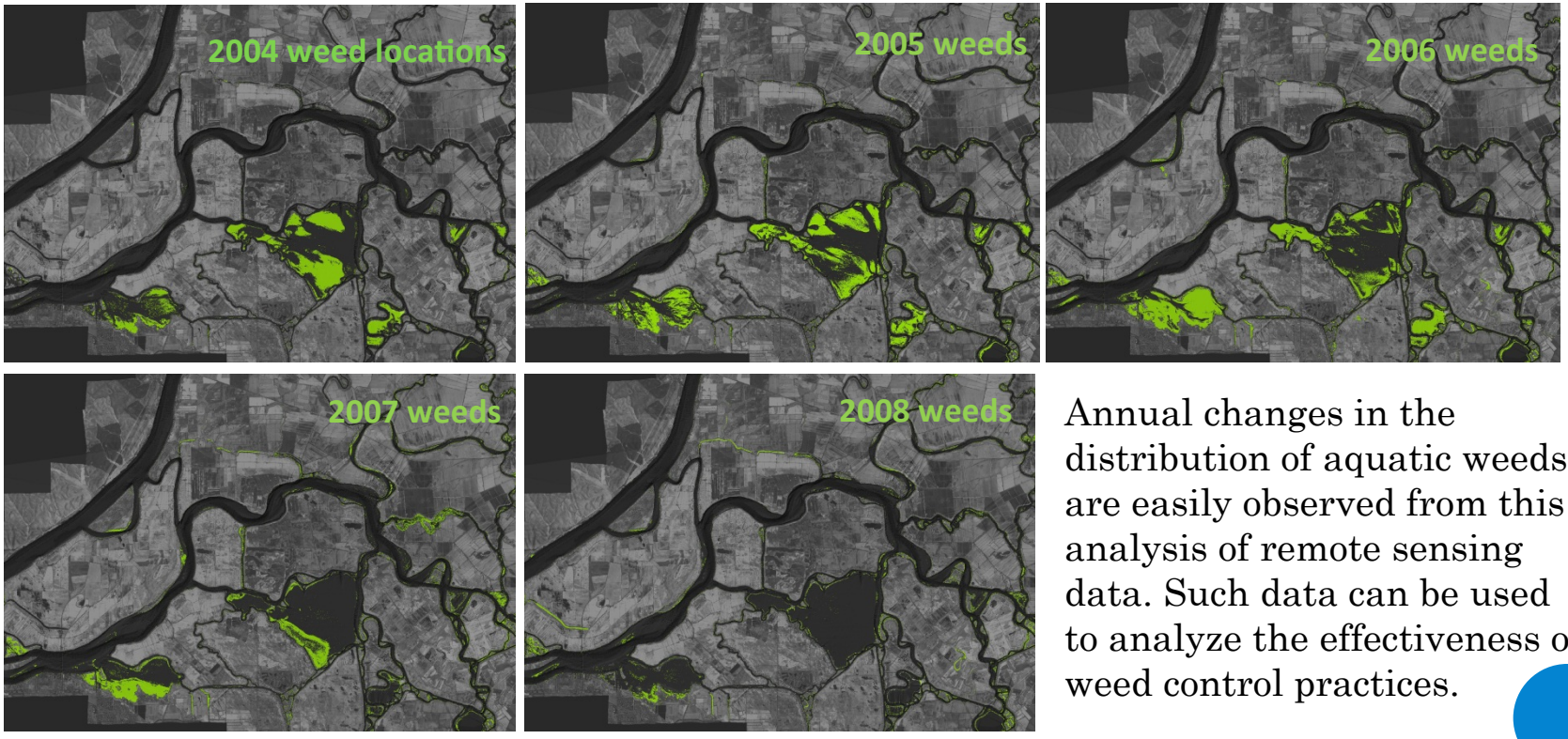
- Short term phenomena
  - Ex. Water level change, plant growth, etc.
- Long term phenomena
  - Ex. Urban development, etc.



GOVERNMENT AGENCIES : CASE STUDY

- Natural resources management & change monitoring

Monitoring changes in submerged aquatic weeds



Annual changes in the distribution of aquatic weeds are easily observed from this analysis of remote sensing data. Such data can be used to analyze the effectiveness of weed control practices.

Resources

- http://www.gpem.uq.edu.au/cser-rstoolkit

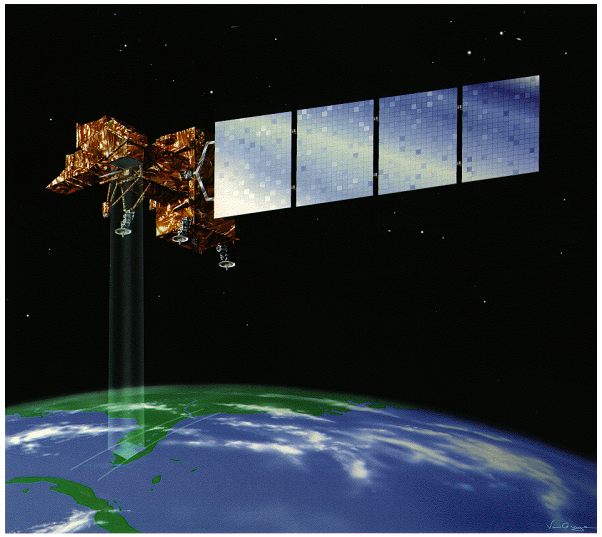
- Remote Sensing Toolkit

- http://www.nrcan.gc.ca/earth-sciences/geography-boundary/remote-sensing/fundamentals/1430
  Canada remote sensing tutorial

On-line tutorials in remote sensing

- Fundamentals of Remote Sensing - CCRS
  - http://www.ccrs.nrcan.gc.ca/resource/tutor/fundam/index_e.php
- NASA Remote Sensing Tutorial
  - http://rst.gsfc.nasa.gov/
- Remote Sensing Core Curriculum – J. Jensen, Introductory Digital Image Processing
  - http://www.cla.sc.edu/geog/rslab/Rscc/index.html
- Other Landsat-7 data sets:
  - http://l7downloads.gsfc.nasa.gov/index.htm

Landsat Web Sites



- http://geo.arc.nasa.gov/sge/landsat/landsat.html
- http://landsat.gsfc.nasa.gov/
- http://landsat.usgs.gov/
- http://earthexplorer.usgs.gov
- http://glovis.usgs.gov
- http://www.ohioview.org/