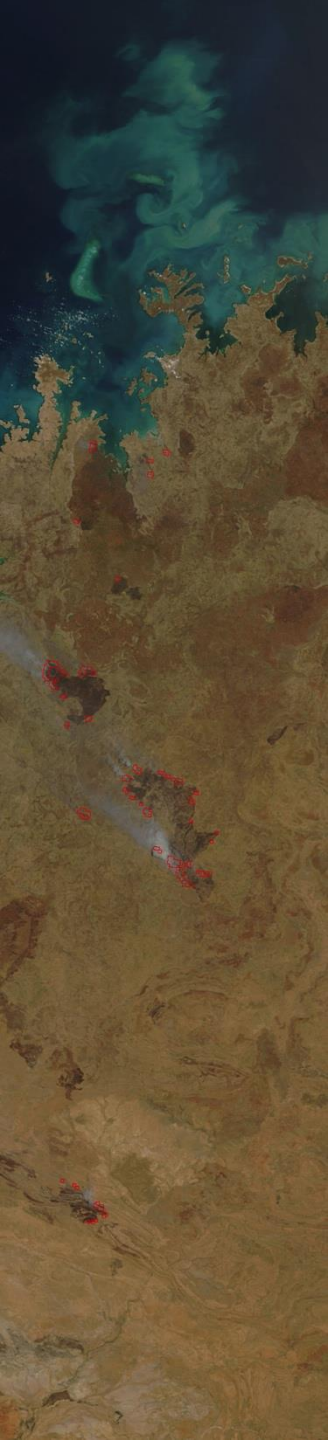

National Aeronautics and Space Administration

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Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

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Introduction to Satellite Remote Sensing for Air Quality Applications

Webinar Session 1 – July 6, 2016

Training Overview and Introduction to Satellite Remote Sensing

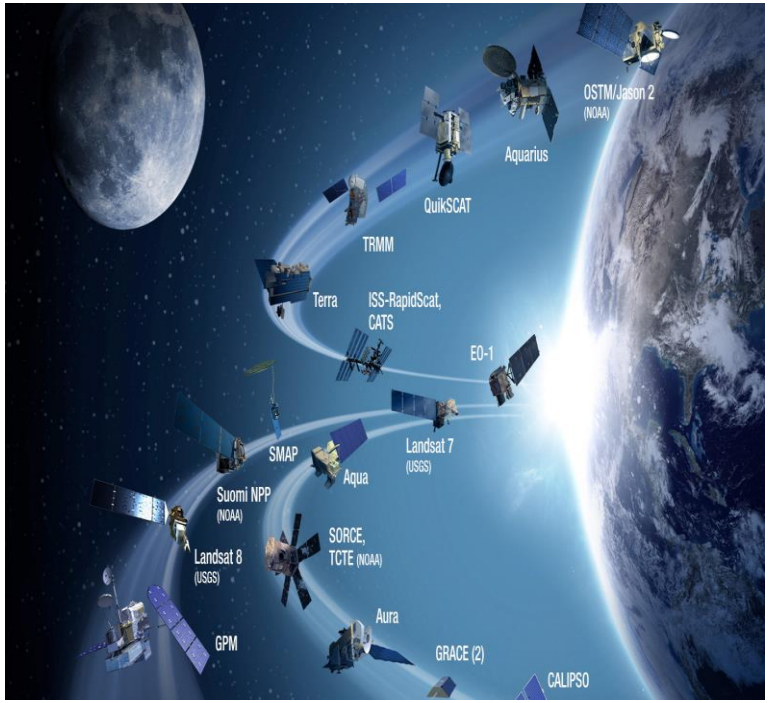
Outline

- ✓**Introduction to ARSET**
- ✓**Tour of the ARSET webpage**
- ✓**Training overview**
- ✓**Fundamentals of Satellite Remote Sensing**

Today's Instructor: **Pawan Gupta**
GESTAR/USRA, Code 614
NASA Goddard Space Flight Center
Greenbelt, MD 20771, USA
pawan.gupta@nasa.gov
http://arset.gsfc.nasa.gov/people/pawan-gupta-0

NASA Applied Sciences: Capacity Building

National and international activities to engage and train users applying NASA Earth Science satellites and modeling data in their decision making activities.



ARSET

Increasing the utilization of NASA Earth science and model data through online webinars and hands-on trainings.

Register to participate in courses or review past recorded webinars
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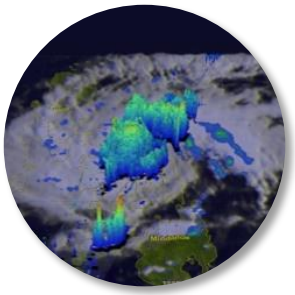
Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov

Provide online and on-site trainings tailored to:

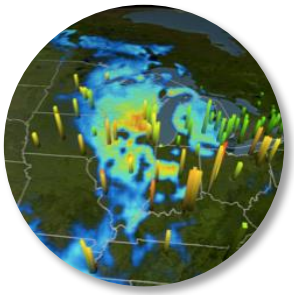
- policy makers
- regulatory agencies
- applied environmental professionals

to increase the use of NASA Earth Science models & data for environmental applications:

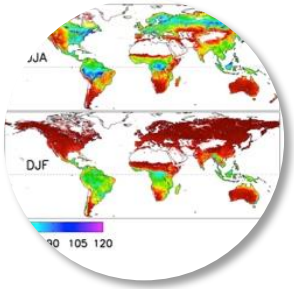


Disasters

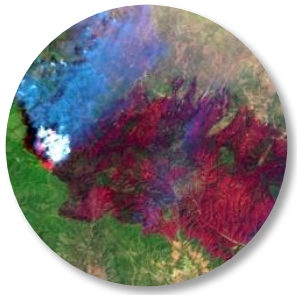
Ecoforecasting



Health & Air Quality



Water Resources



Wildfires

ARSET Trainings

A gradual learning approach

Basic Trainings

- Webinars & Workshops
- Assumes no prior RS knowledge

Examples: Fundamentals of Remote Sensing; Introduction to Remote Sensing

Advanced Trainings

- Webinars & Workshops
- Requires basic training
- Focuses on specific applications

Example: Satellite Remote Sensing of Particulate Matter Air Quality

Upcoming ARSET AQ Training at

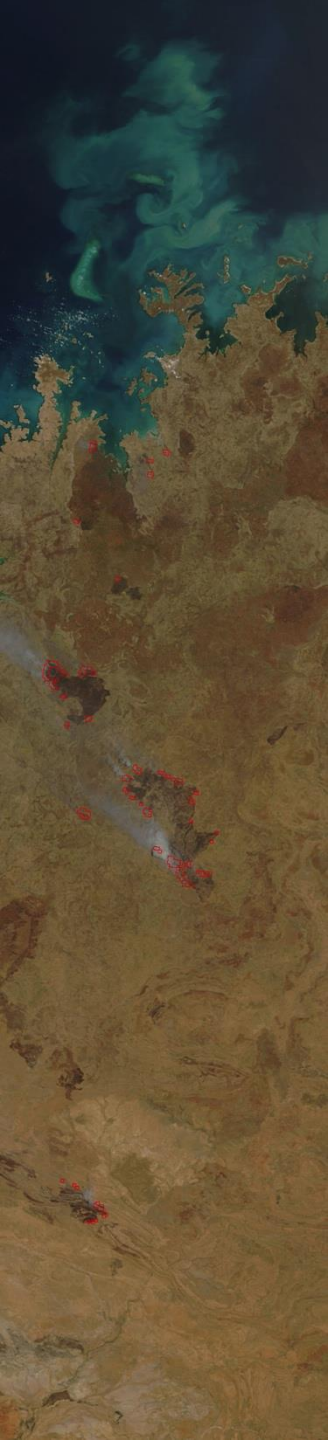
17th IUAPPA World Clean Air Congress and 9th CAA Better Air Quality Conference

29 August – 2 September 2016 | Busan, S. Korea

ARSET Contact Information

(Any individual or organization can contact us for more advanced training in the area of satellite remote sensing and its applications. ARSET provides trainings to public, private and non-profit organizations around the world.)

- **Overall program information**
  - **Ana Prados (aprados@umbc.edu)**
- **Training Request**
  - **Brock Blevins (brockbl1@umbc.edu)**
- **Air Quality**
  - **Pawan Gupta (pawan.gupta@nasa.gov)**



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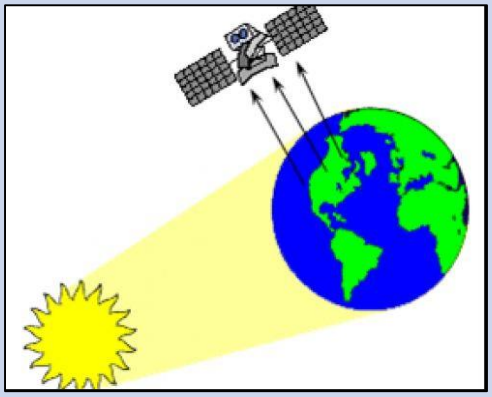
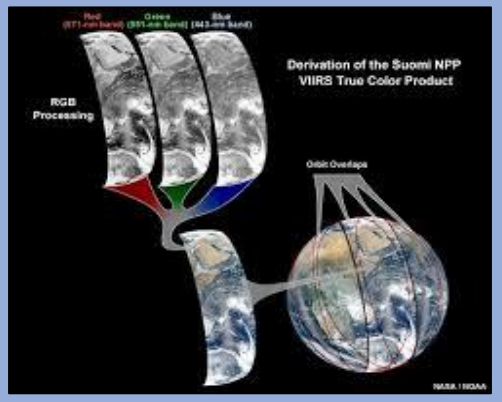
Brief tour of the ARSET page

http://arset.gsfc.nasa.gov

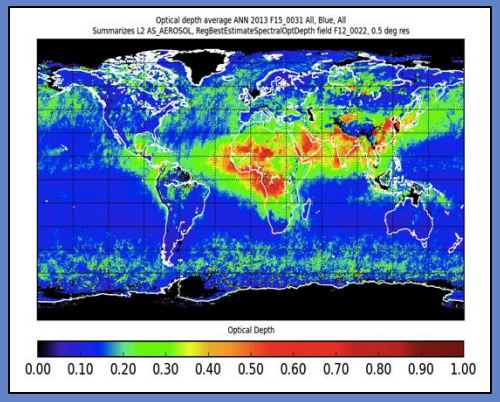
5 Weeks Webinar Series: Agenda



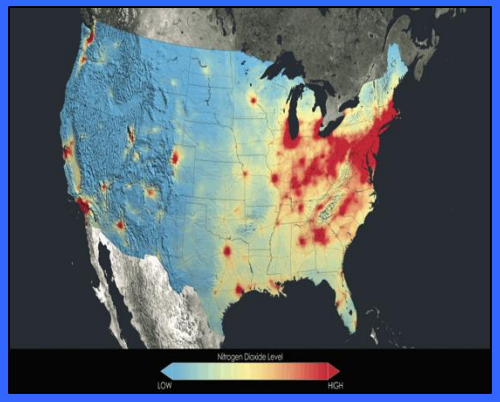
Week 1: Fundamental of Remote Sensing



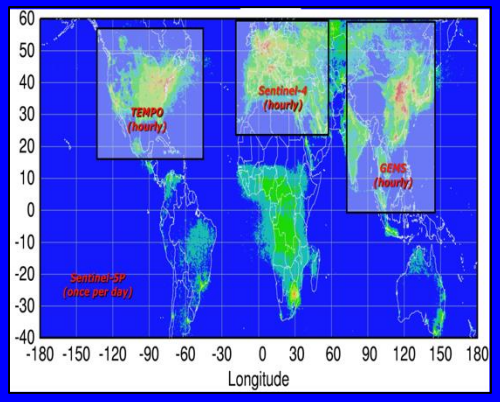
Week 2: Satellite Imagery



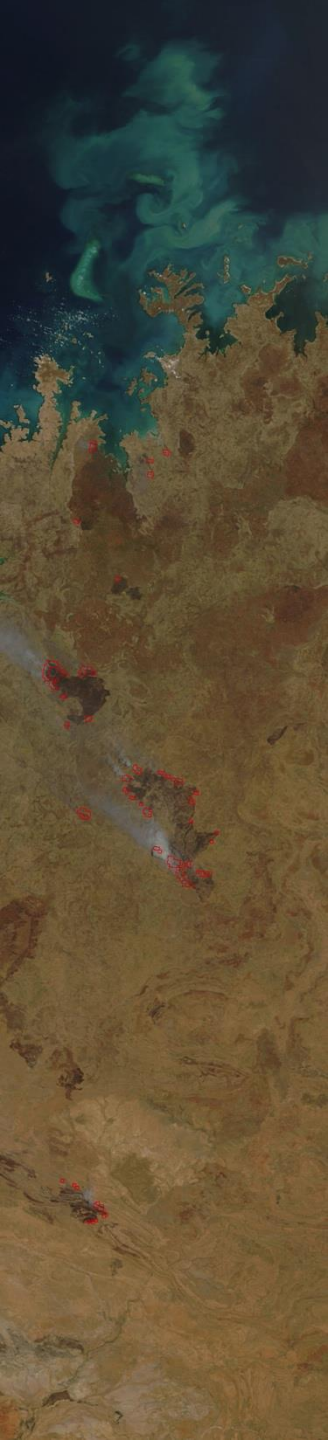
Week 3: Aerosol Data



Week 4: Trace Gas Data



Week 5: Future Capabilities



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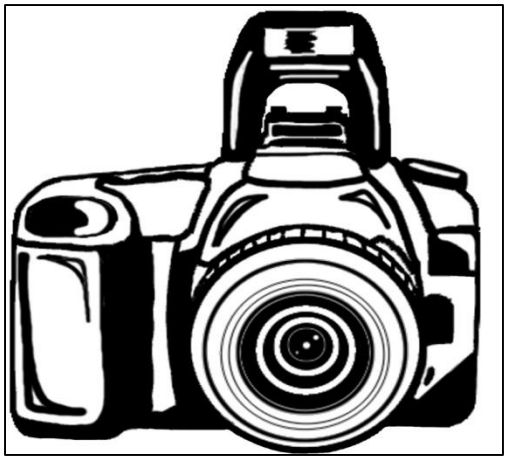
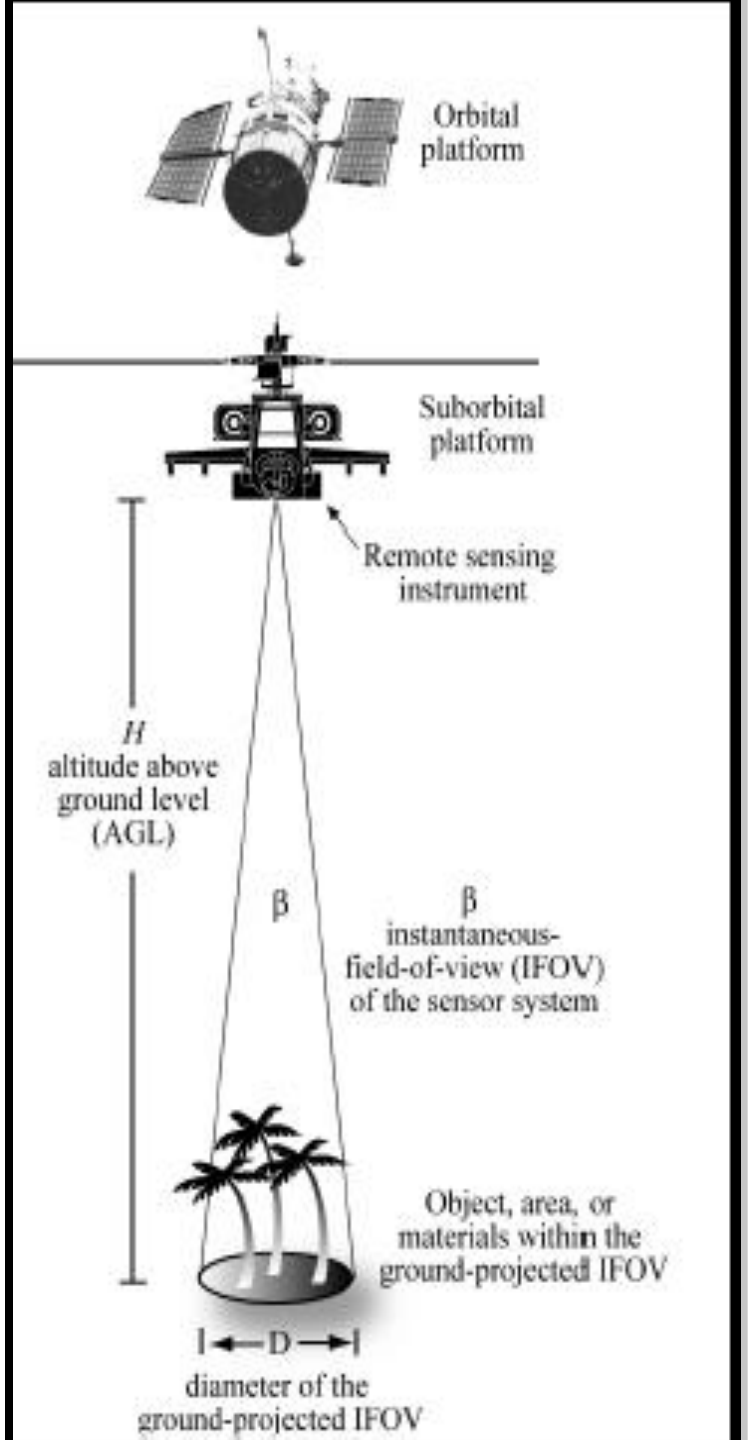
Fundamentals of Satellite Remote Sensing

What is Remote Sensing ?

Collecting information about an object without being in direct physical contact with it.



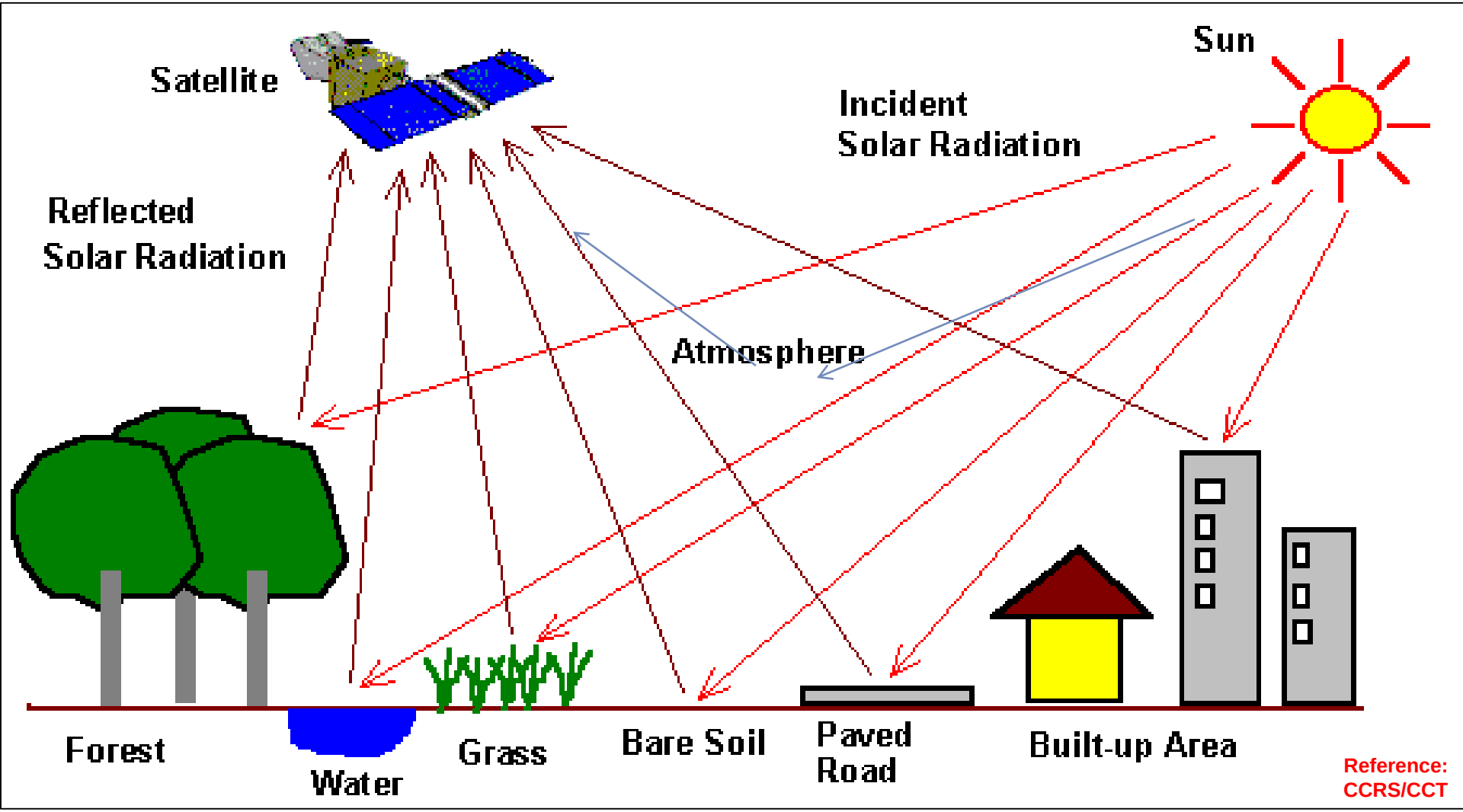
Remote Sensing …



Remote Sensing: Platforms

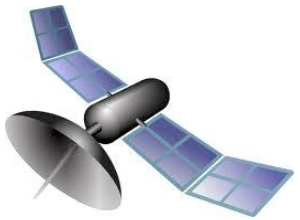
- **The platform depends on the end application**
- **What information do you want?**
- **How much detail do you need?**
- **What type of detail?**
- **How frequently do you need the data?**

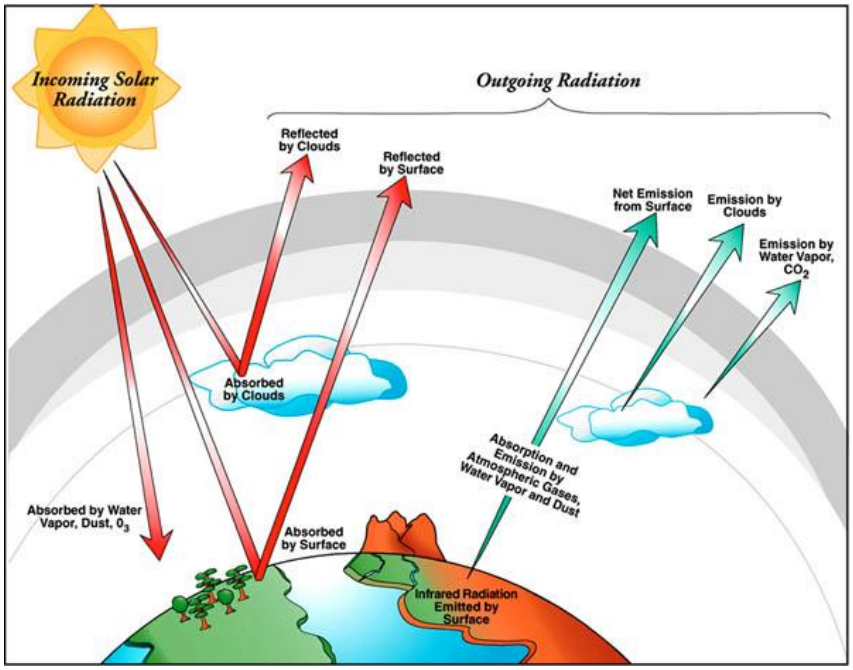
What do satellites measure ?



Measuring Properties of the Earth-Atmosphere System from Space

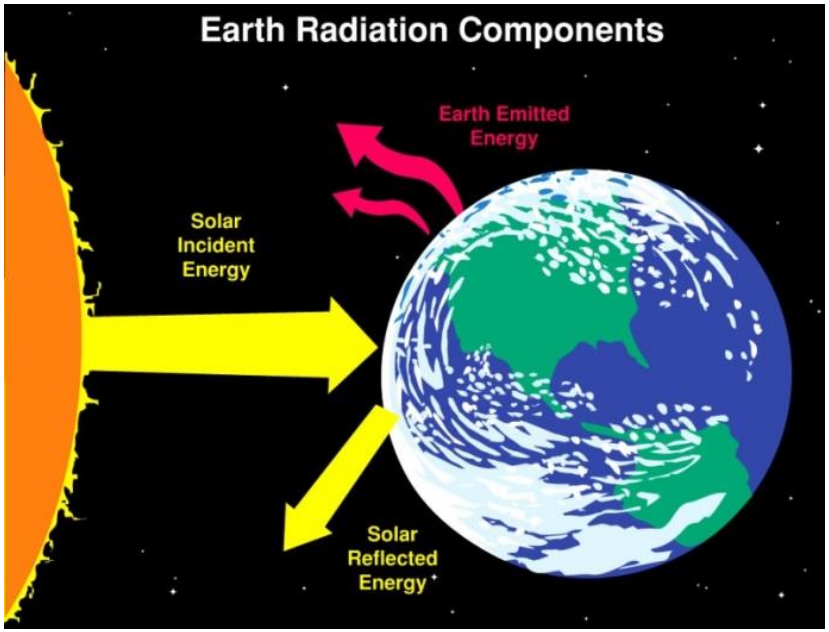
- The intensity of reflected and emitted radiation to space is influenced by the surface and atmospheric conditions.
- Thus, satellite measurements contain information about the surface and atmospheric conditions.

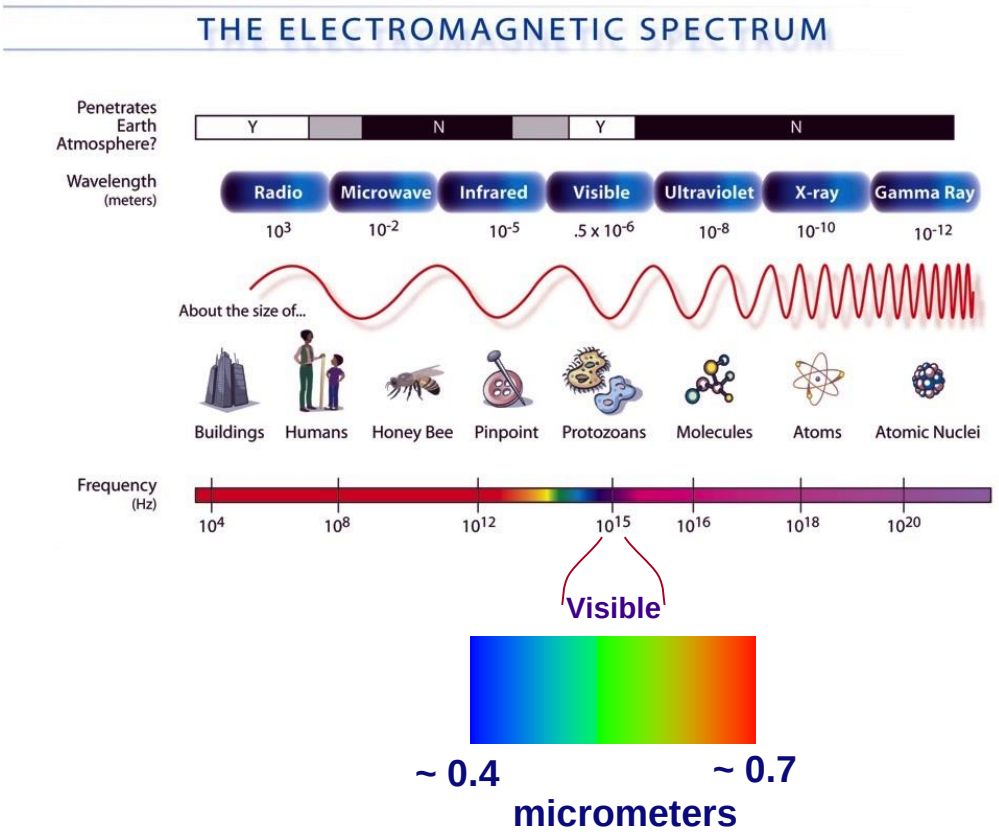




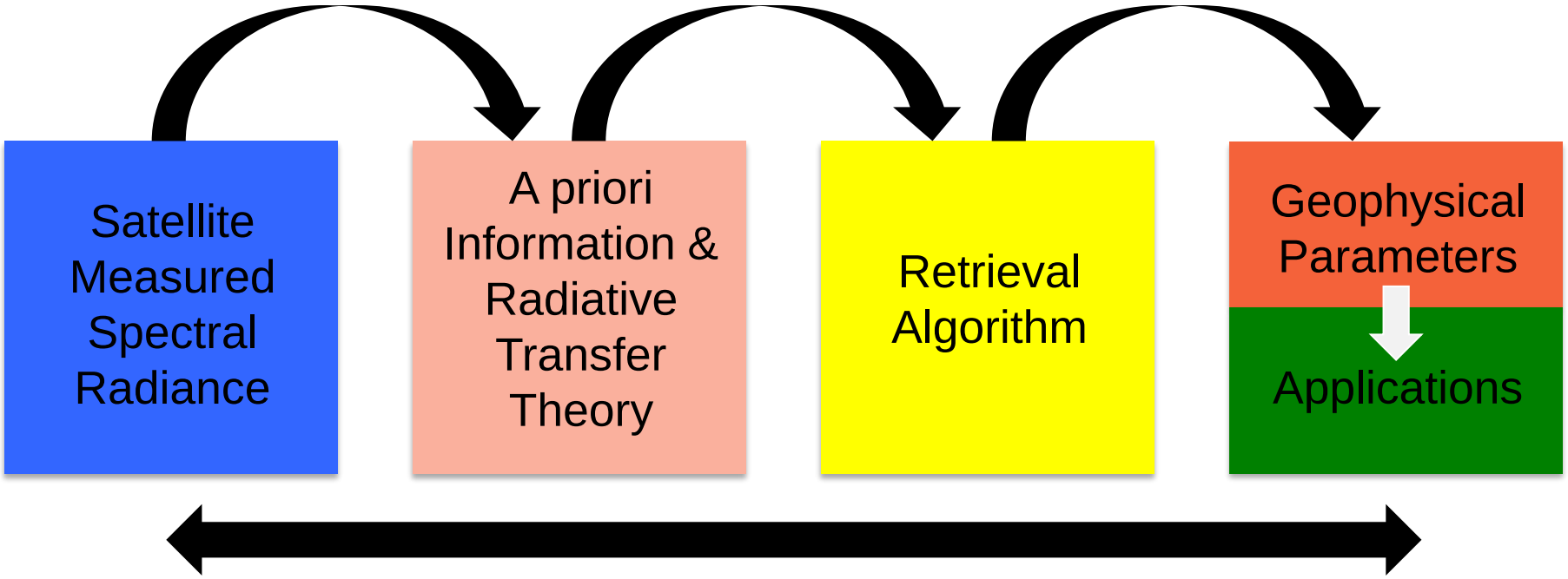
Electromagnetic Radiation

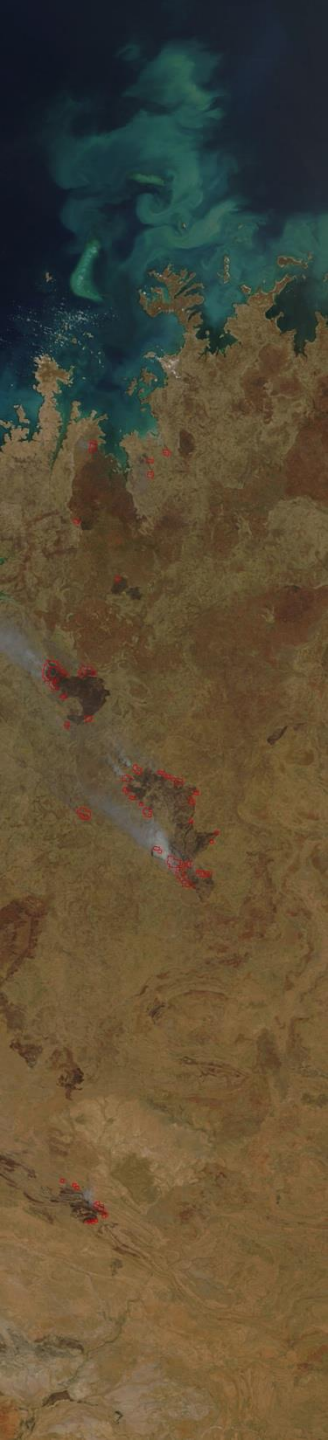
- Earth-Ocean-Land-Atmosphere System
  - Reflects solar radiation back into space
  - Emits infrared and microwave radiation into space





The Remote Sensing Process





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Satellites, Sensors, and Orbits

Satellites Vs Sensors

Earth-observing satellite remote sensing instruments are named according to

1) the satellite (also called platform)

2) the instrument (also called sensor)

Aqua Satellite

Six Instruments:

- MODIS
- CERES
- AIRS
- AMSU-A
- AMSR-E
- HSB

Aura Satellite

Four Instruments:

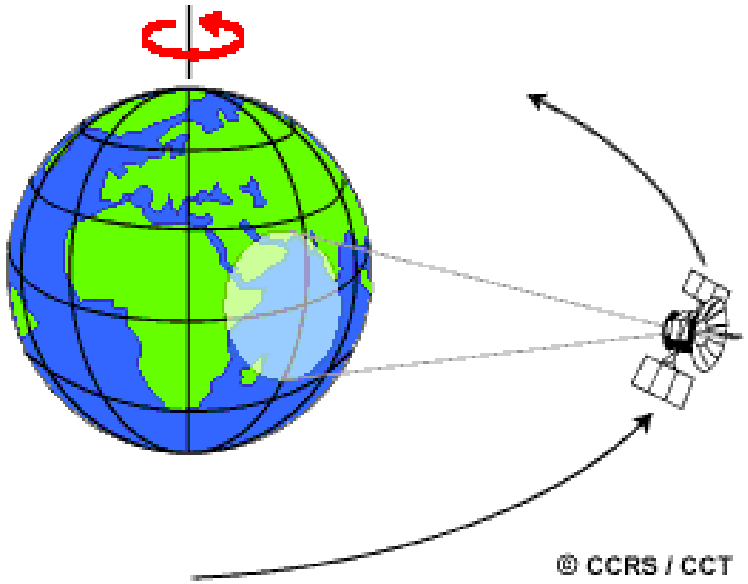
- OMI
- TES
- HIRDLS
- MLS

Characterizing Satellites and Sensors

- **Orbits**
  - Polar vs Geostationary
- **Energy source**
  - Passive vs Active …
- **Solar and Terrestrial Spectra**
  - Visible, UV, IR, Microwave …
- **Measurement Technique**
  - Scanning, non-scanning, imager, sounders …
- **Resolution (spatial, temporal, spectral, radiometric)**
  - Low vs high
- **Applications**
  - Weather, Ocean colors, Land mapping, Atmospheric Physics, Atmospheric Chemistry, Air quality, radiation budget, water cycle, coastal management …

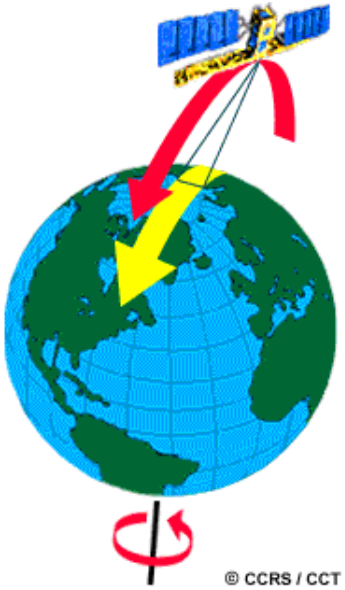
Common types of orbits

Geostationary



Geostationary orbit
An orbit that has the same Earth's rotational period
Appears 'fixed' above earth
Satellite on equator at ~36,000km

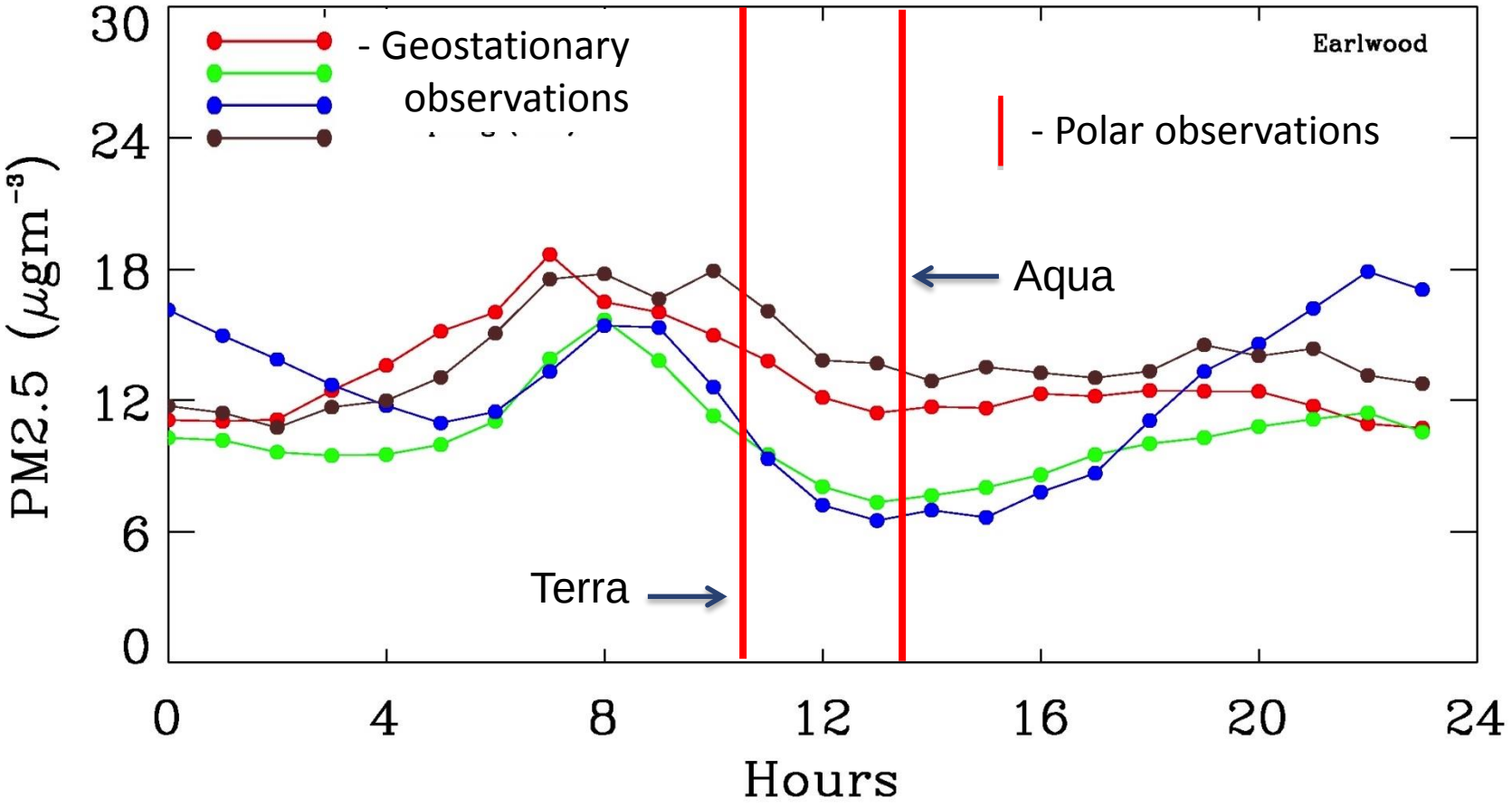
Polar



Polar orbiting orbit
fixed circular orbit above the earth, ~600-1000km
in sun synchronous orbit with orbital pass at about same **local solar time** each day

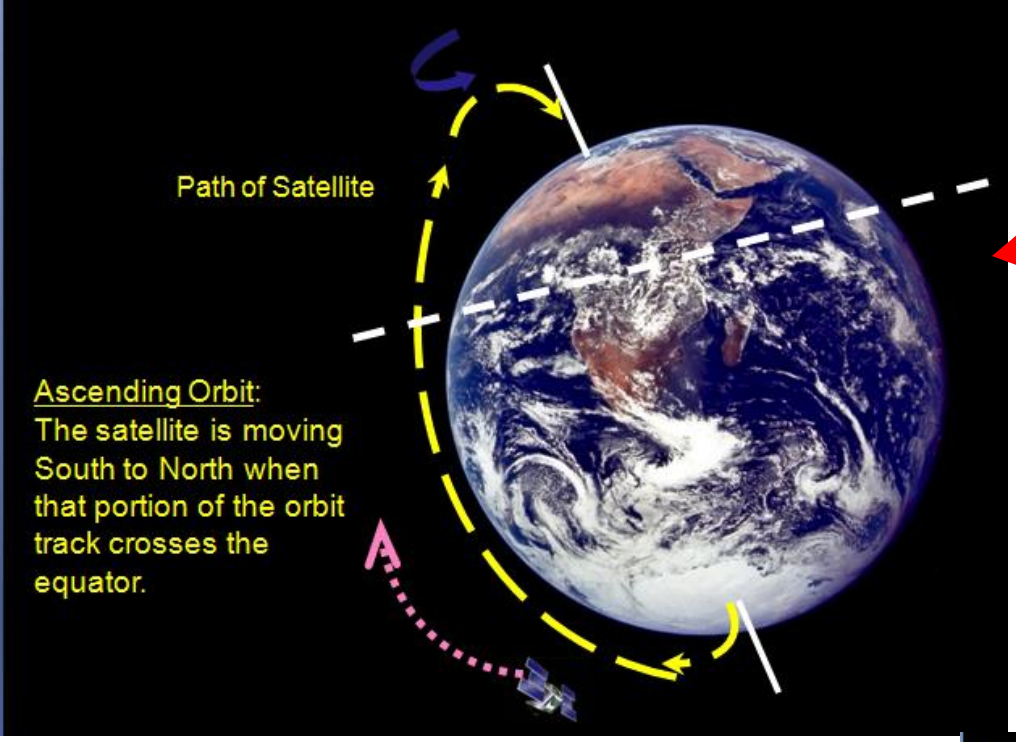
Observation Frequency

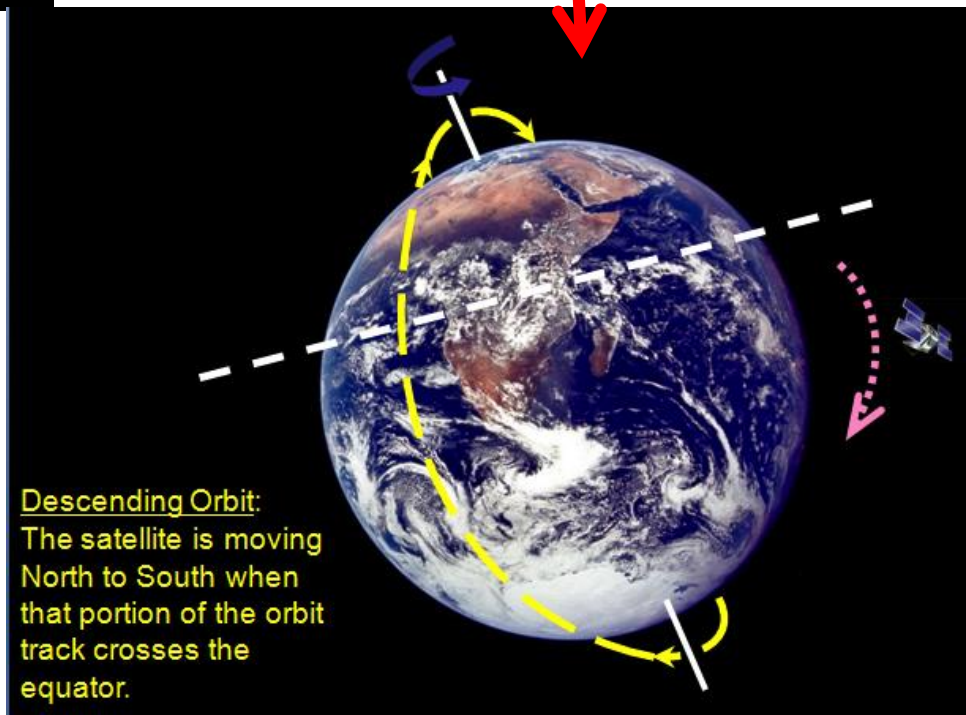
Polar orbiting satellites – 1 - 2 observations per day per sensor



Geostationary satellites – Future satellites - TEMPO, GEMS, Sentinel-4

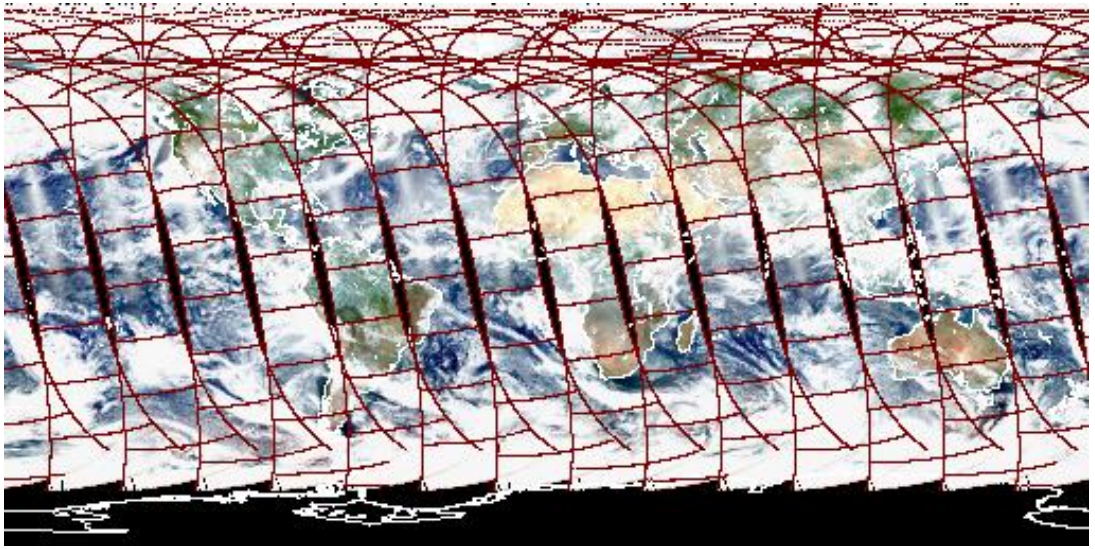
Ascending vs Descending





Polar Orbits

MODIS-Aqua ("ascending" orbit)



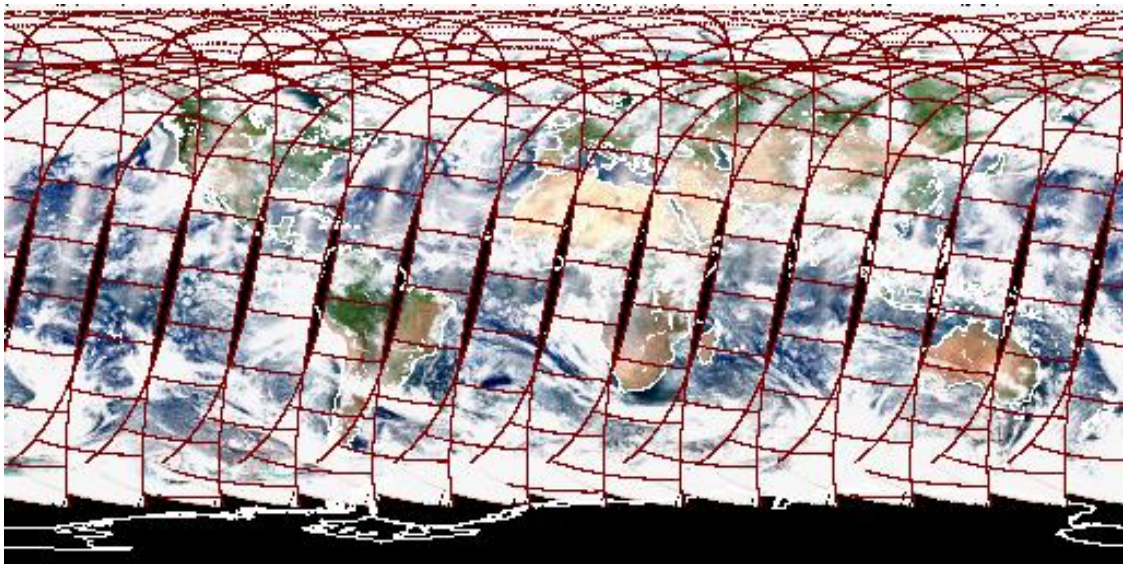
Approximately 1:30 PM local overpass time

Afternoon Satellite

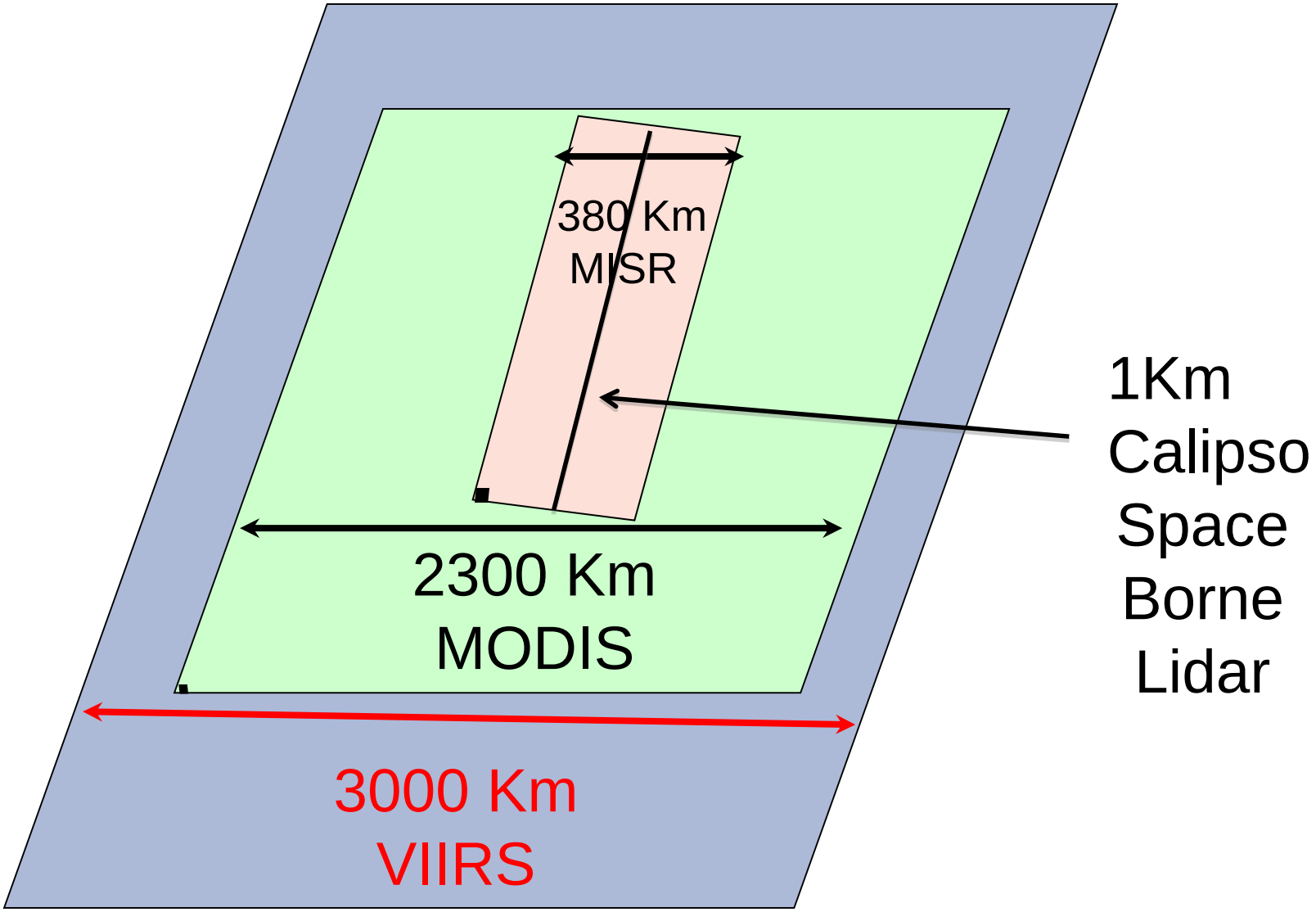
MODIS-Terra ("descending")

Approximately 10:30 AM local overpass time

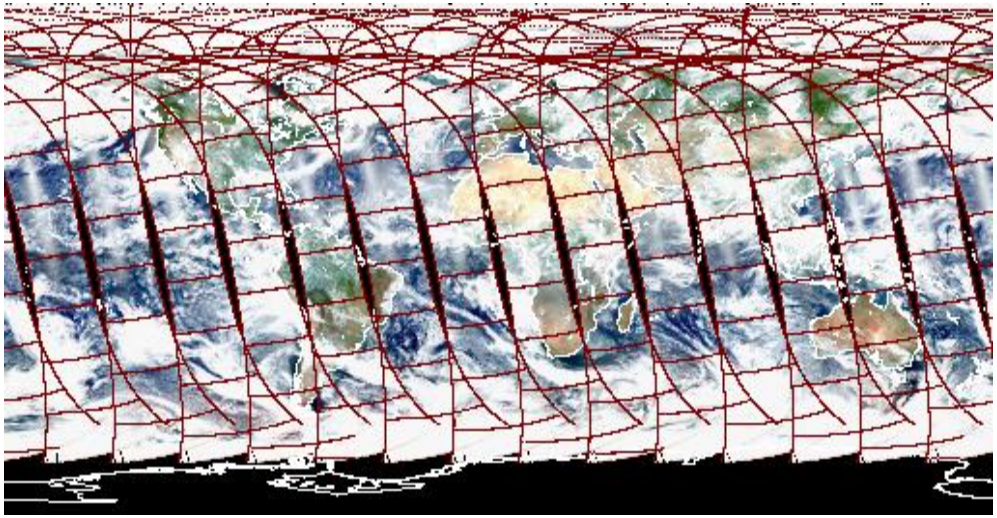
Morning Satellite



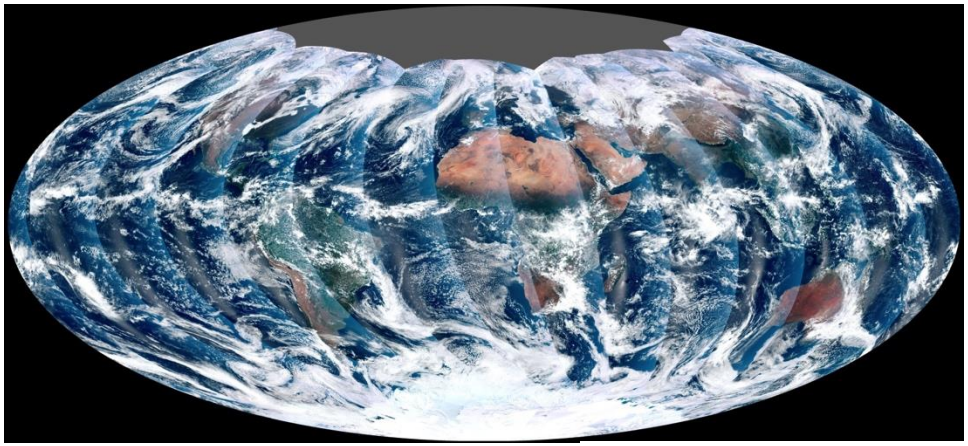
Satellite Coverage



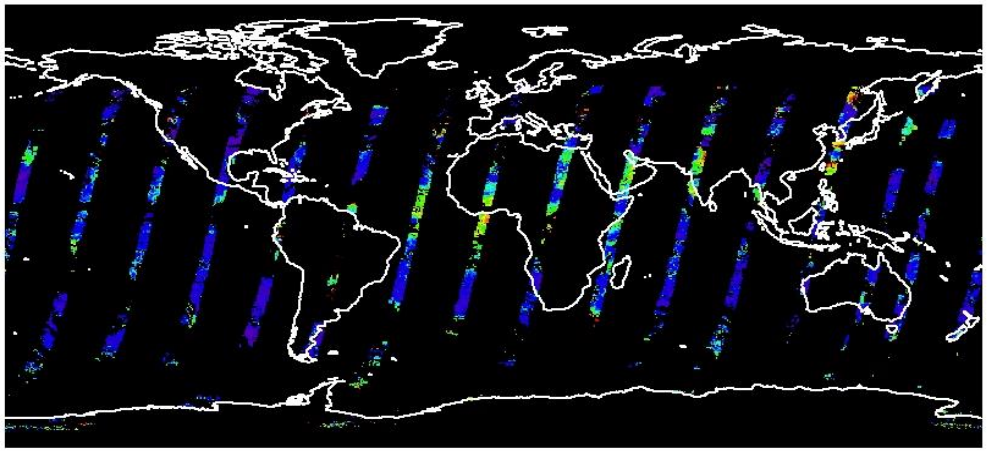
Satellite Coverage



MODIS



VIIRS



MISR

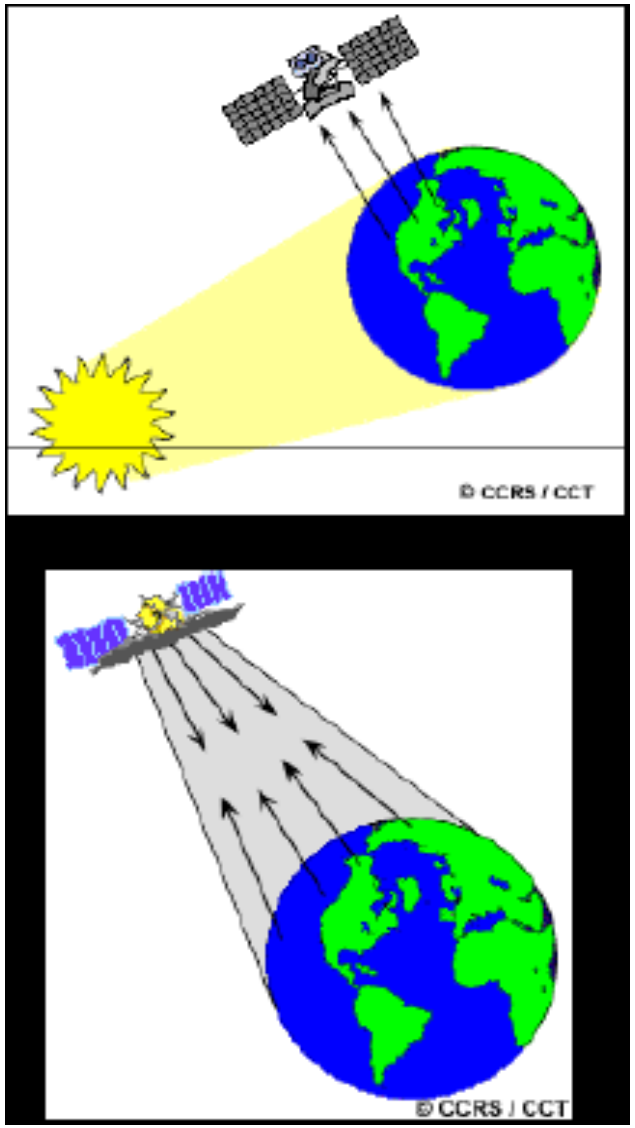
Remote Sensing: Active and Passive Sensors

Passive Sensors: Remote sensing systems that measure naturally available energy are called passive sensors.

MODIS, MISR, OMI, VIIRS

Active Sensors: The sensor emits radiation that is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor.

CALIPSO



Resolution

Remote Sensing – Types of Resolution

- **Spatial resolution**

  The smallest spatial measurement.

- **Temporal resolution**

  Frequency of measurement.

- **Spectral resolution**

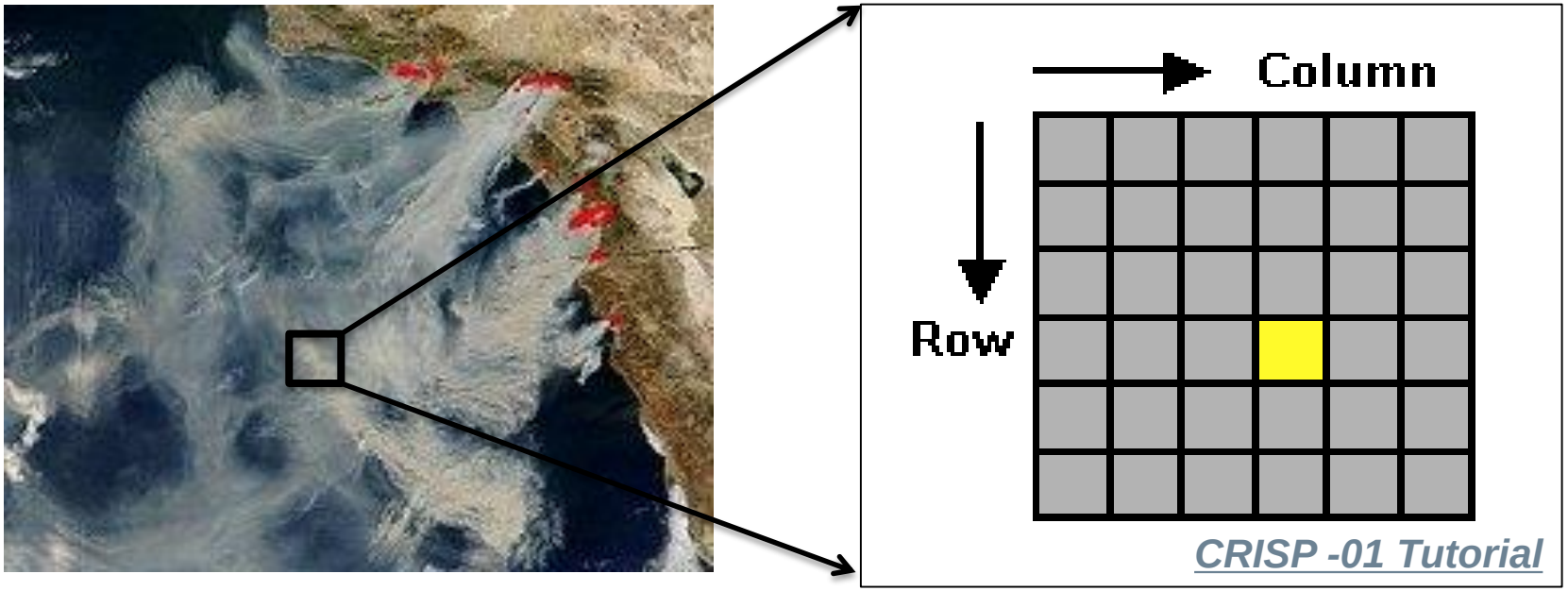
  The number of independent channels.

- **Radiometric resolution**

  The sensitivity of the detectors.

Depends on the satellite orbit configuration and sensor design. Resolutions are different for different sensors

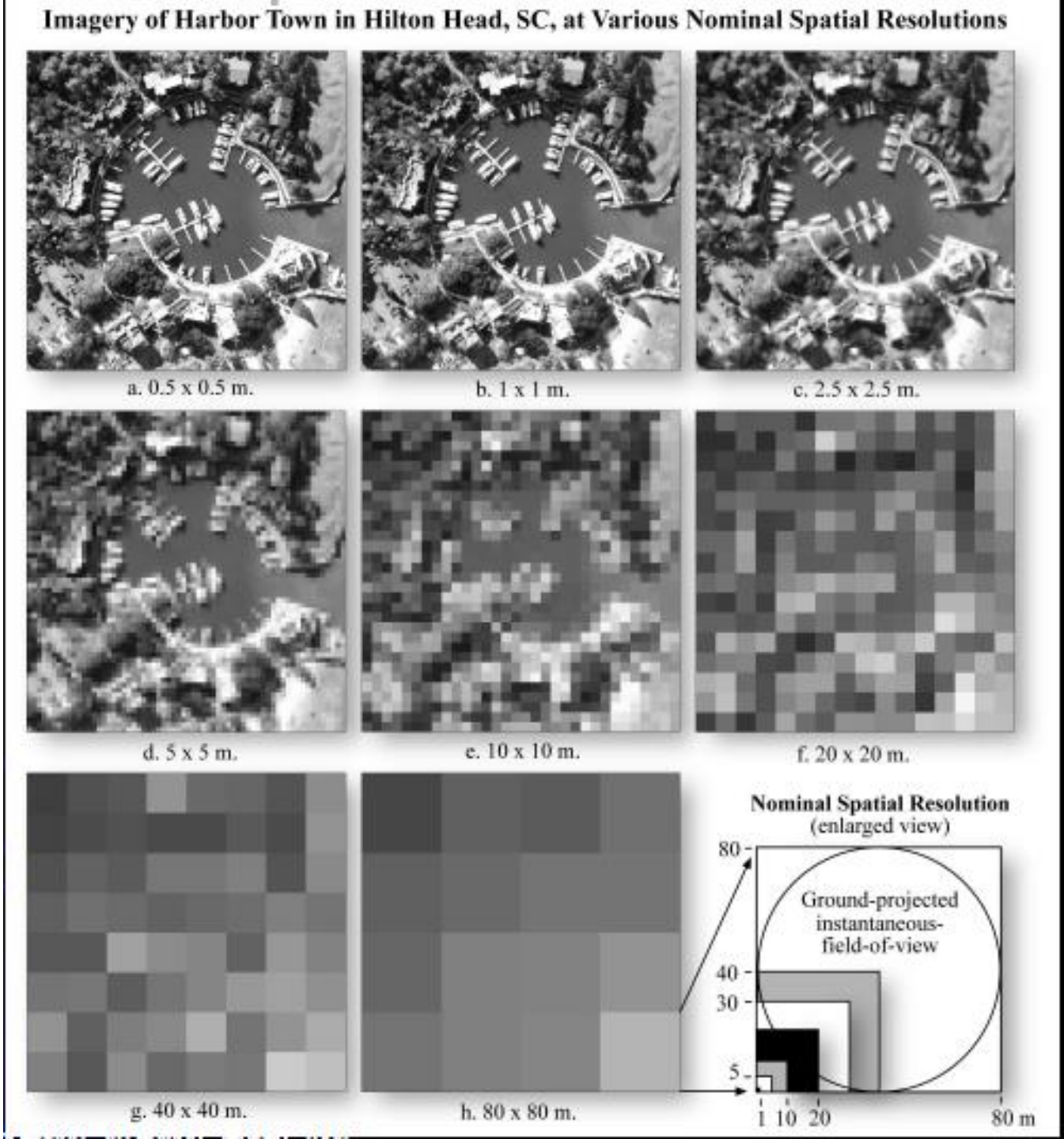
Pixel - the smallest unit of an image



- ✓ **A digital image is comprised of a two dimensional array of individual picture elements – called pixels – arranged in columns and rows.**
- ✓ **Each pixel represents an area on the Earth's surface.**
- ✓ **A pixel has an intensity value and a location address in the two dimensional image.**
- ✓ **Spatial resolution is defined by the size of pixel**

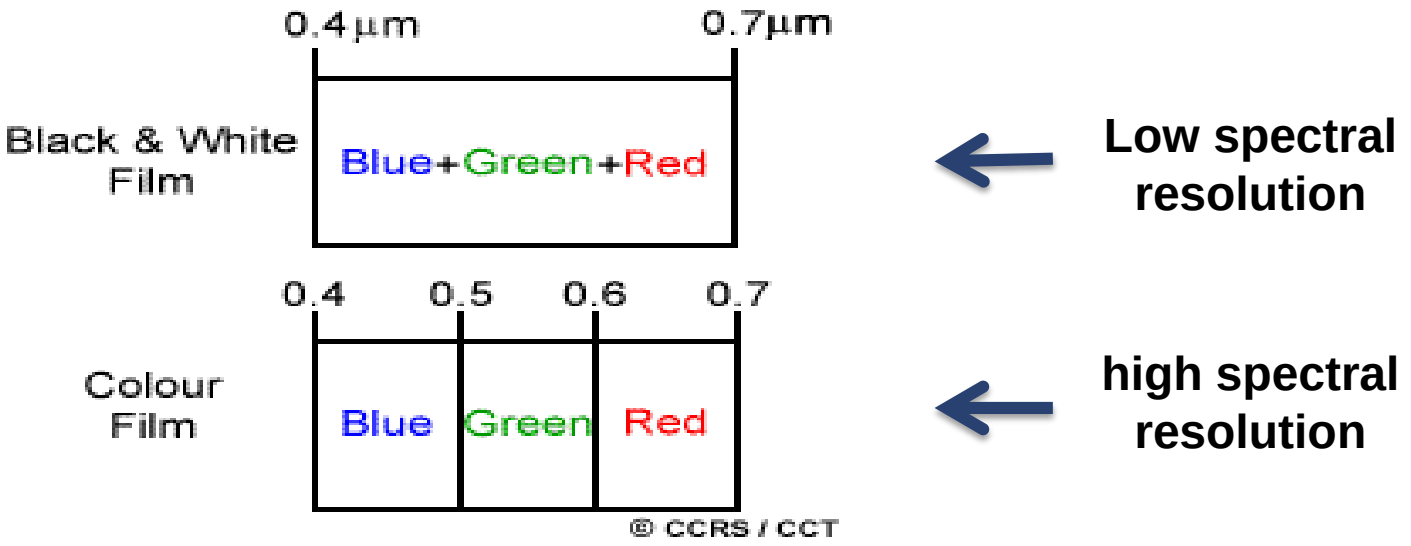
Why is spatial resolution important ?

- MODIS
  - 250 m to 1 km
- MISR
  - 275 m to 1.1 km
- OMI
  - 13x24 km
- VIIRS
  - 375 m

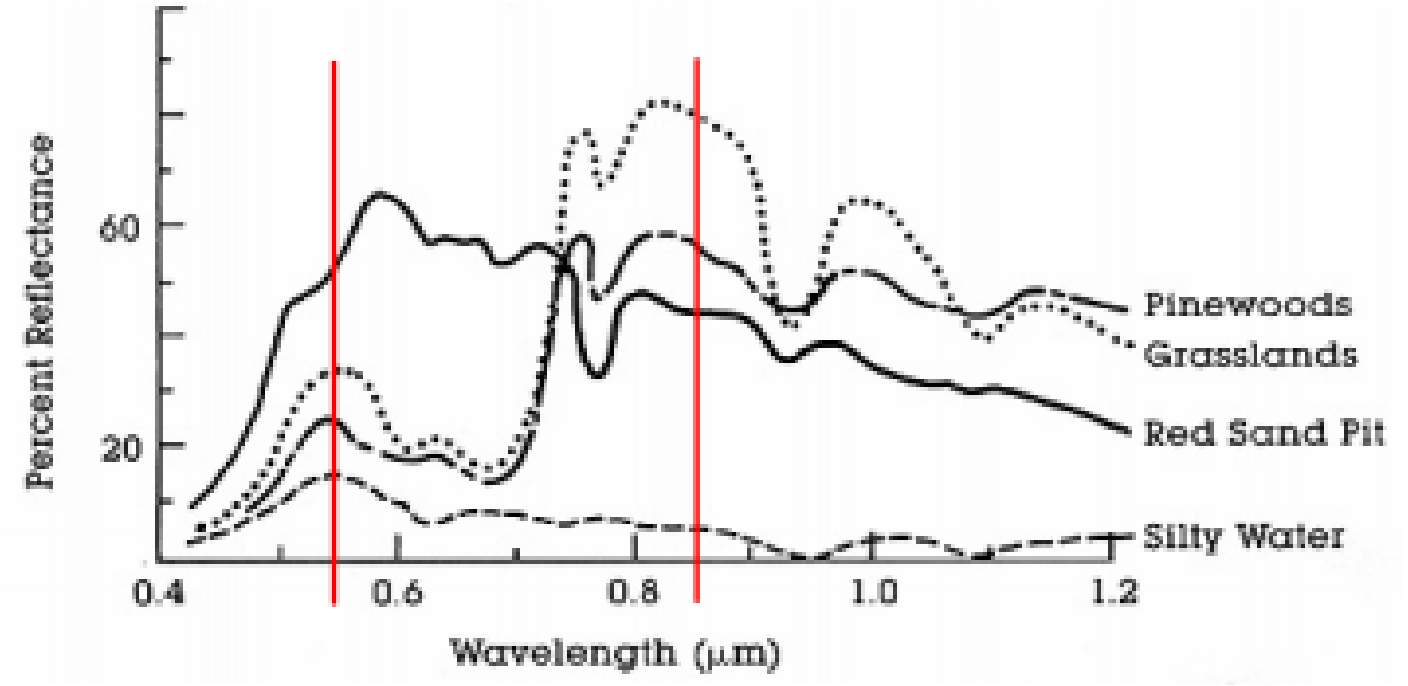


Spectral Resolution

- Spectral resolution describes the ability of a sensor to define fine wavelength intervals. The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.
- **multi-spectral sensors - MODIS – low spectral resolution**
- **hyperspectral sensors - OMI, AIRS – high spectral resolution**



Why is spectral resolution important ?

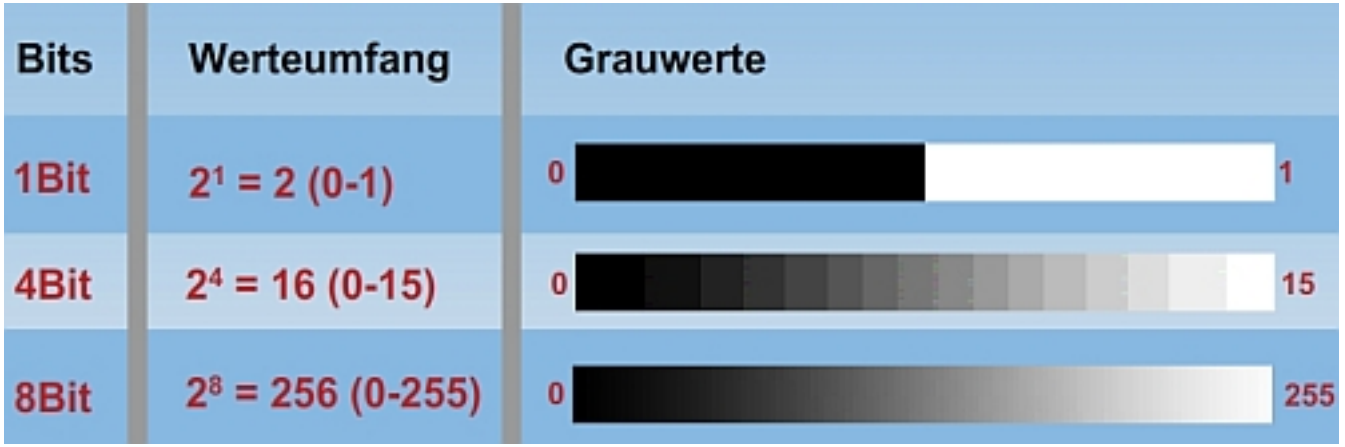


Radiometric Resolution

•Imagery data are represented by positive digital numbers that vary from 0 to (one less than) a selected power of 2.

•The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded.

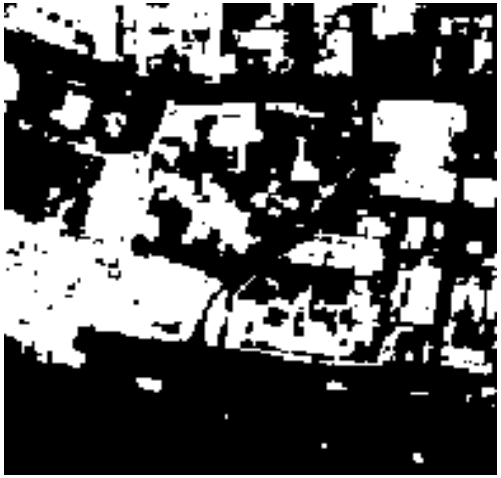
• The larger this number, the higher the radiometric resolution, and the sharper the imagery

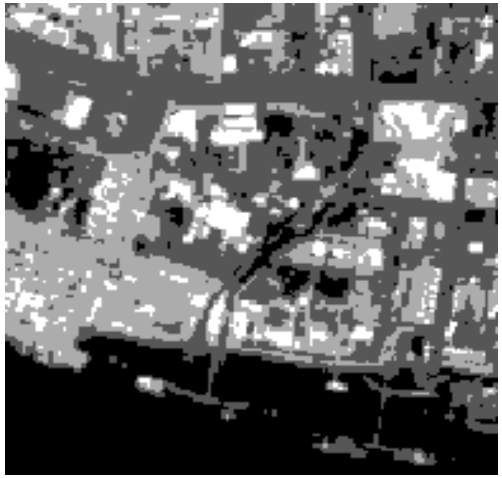


- **12 bit sensor (MODIS, MISR) – 2^{12} or 4096 levels**
- **10 bit sensor (AVHRR) – 2^{10} or 1024 levels**
- **8 bit sensor (Landsat 7 TM) – 2^8 or 256 levels (0-255)**

Radiometric Resolution

2 - levels





4 - levels

8 - levels

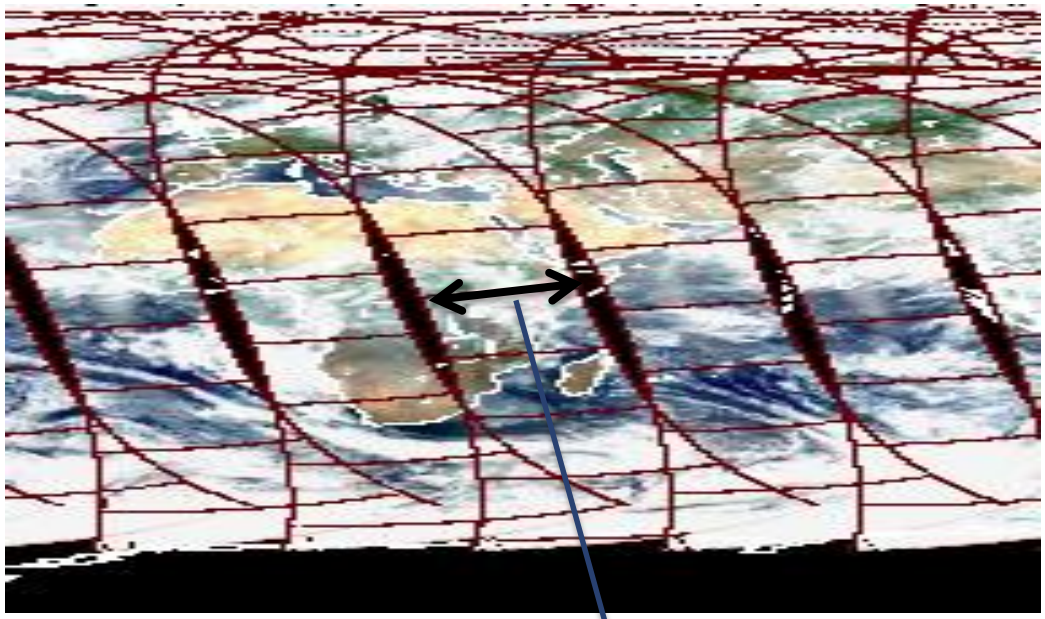
16 - levels

(MODIS 4096 levels)

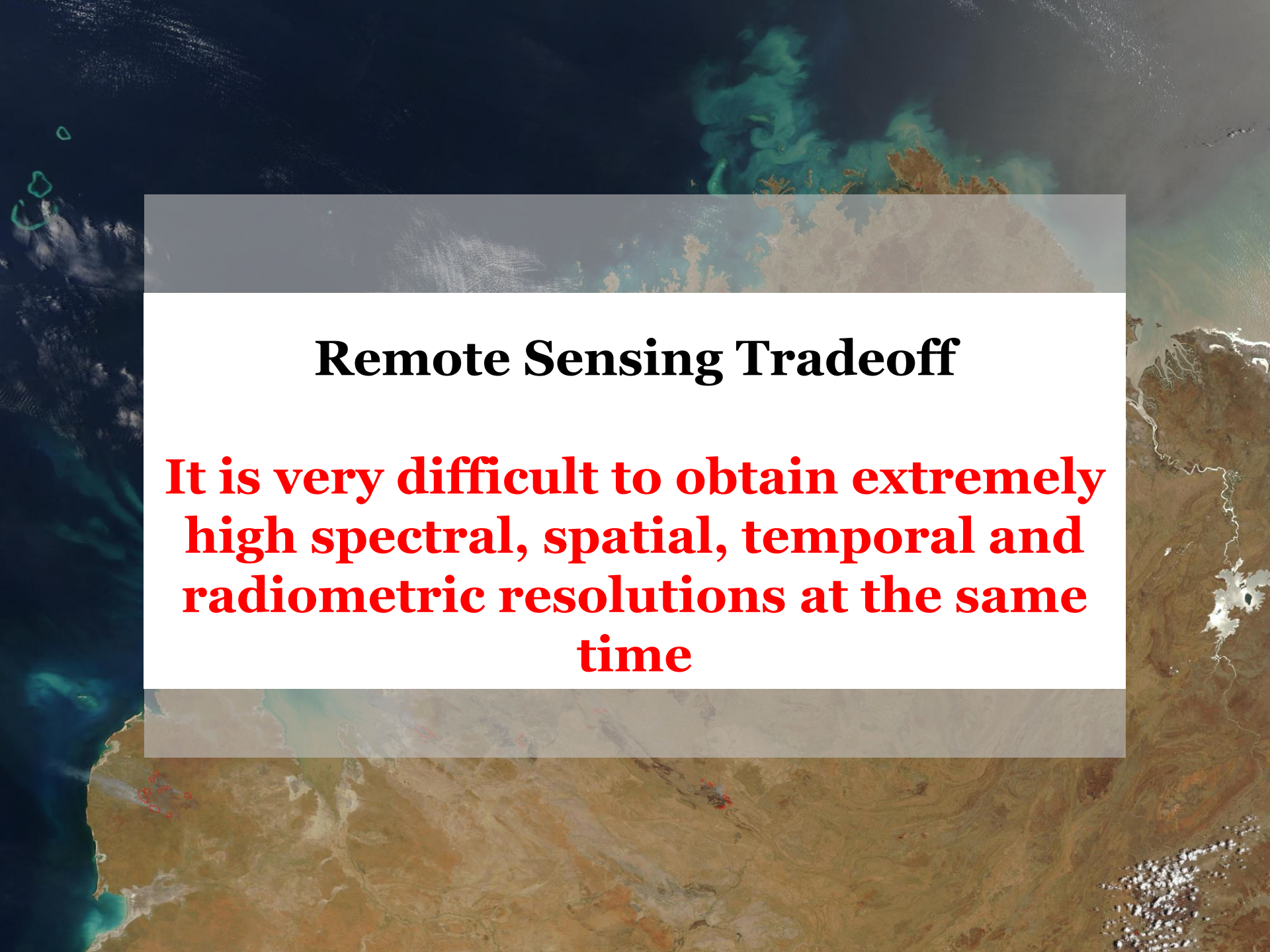
In classifying a scene, different classes are more precisely identified if radiometric precision is high.

Temporal Resolution

- How frequently a satellite can provide observation of the same area on the earth
- It mostly depends on swath width of the satellite – larger the swath – higher the temporal resolution



MODIS
-1-2 days
OMI
-1-2 days
MISR
-6-8 days
VIIRS
- 1 day
Geostationary
-10 min to 1 hour

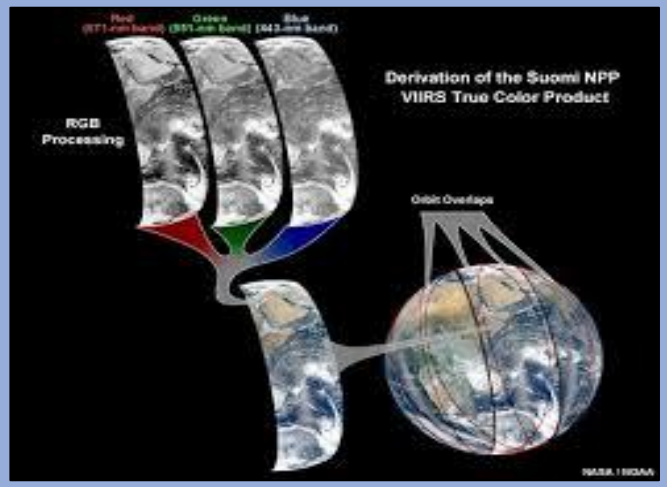


Remote Sensing Tradeoff

It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric resolutions at the same time

Next Week

- **Visible satellite imagery and air quality applications**
- **Image information content, feature identification, and image archives**
- **Near Real-Time Image Access Exercise**



Week 2: Satellite Imagery

References and Further Reading

- Natural Resources Canada

http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/satellite-imagery-products/educational-resources/9309

- Center for Remote Imaging, Sensing and Processing

http://www.crisp.nus.edu.sg/~research/tutorial/image.htm

- Earth Observatory
  http://earthobservatory.nasa.gov/Features/RemoteSensing/remote_06.php
- EOS-Goddard

http://fas.org/irp/imint/docs/rst/Front/tofc.html

- Spectral Resolution
  http://web.pdx.edu/~jduh/courses/Archive/geog481w07/Students/Cody_SpectralResolution.pdf


NO ASSIGNMENTS

Attending all sessions (live or recording) required for the certificate

All the materials and recordings will be available at

http://arset.gsfc.nasa.gov/airquality/webinars/introduction-satellite-remote-sensing-air-quality-applications

Contact

- Pawan Gupta (pawan.gupta@nasa.gov) for the technical questions
- Brock Blevins (brockbl1@umbc.edu) for material access, future trainings, and other logistic