Week – 1 – April 01, 2015

Training Overview and Introduction to Satellite Remote Sensing

Pawan Gupta

Spring 2015

ARSET - AQ

Applied Remote Sensing Education and Training – Air Quality

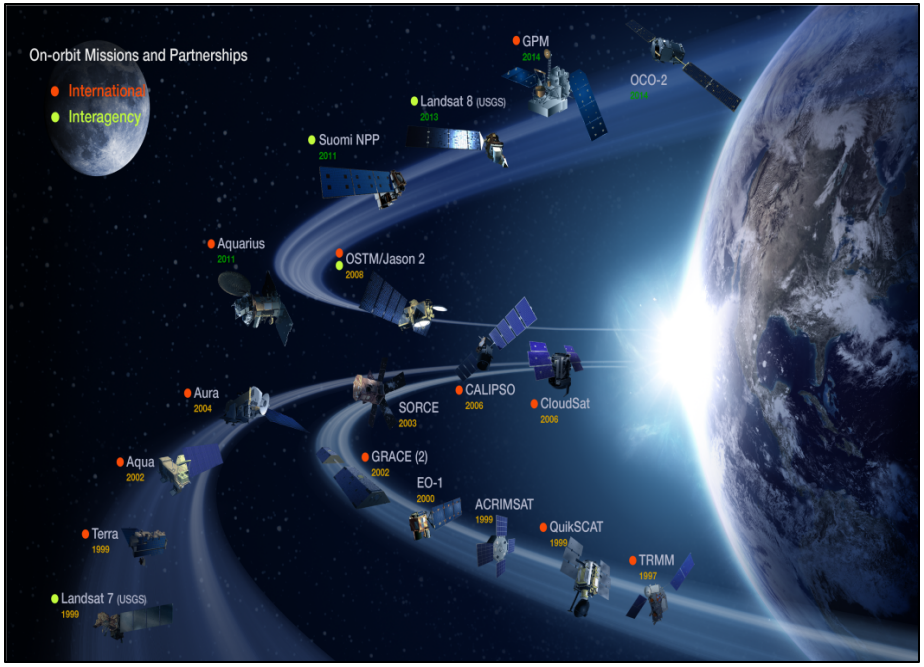
A project of NASA Applied Sciences

Outline

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

NASA Applied Sciences and Capacity Building

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



Applied Remote SEnsing Training (ARSET) Program

On-line and hands on basic/ advanced trainings tailored to end-users & organizations

Applied Remote Sensing Training Program (ARSET)

GOAL:

Increase utilization of satellite observational and model data for decision-support

Online and hands-on courses:

- **Who:** policy makers, environmental managers, modelers and other professionals in the public and private sectors.

  Where: U.S and internationally
- **When**: throughout the year. Check websites.
- Do NOT require prior remote- sensing background.
- Presentations and hands-on guided computer exercises on how to access, interpret and use satellite images for decision-support.

NASA Training for California Air Resources Board, Sacramento

NASA Earth Science
Applied Sciences Program

Applications to Decision Making: Thematic Areas

Agricultural Efficiency

Air Quality

Climate

Disaster Management

Ecological Forecasting

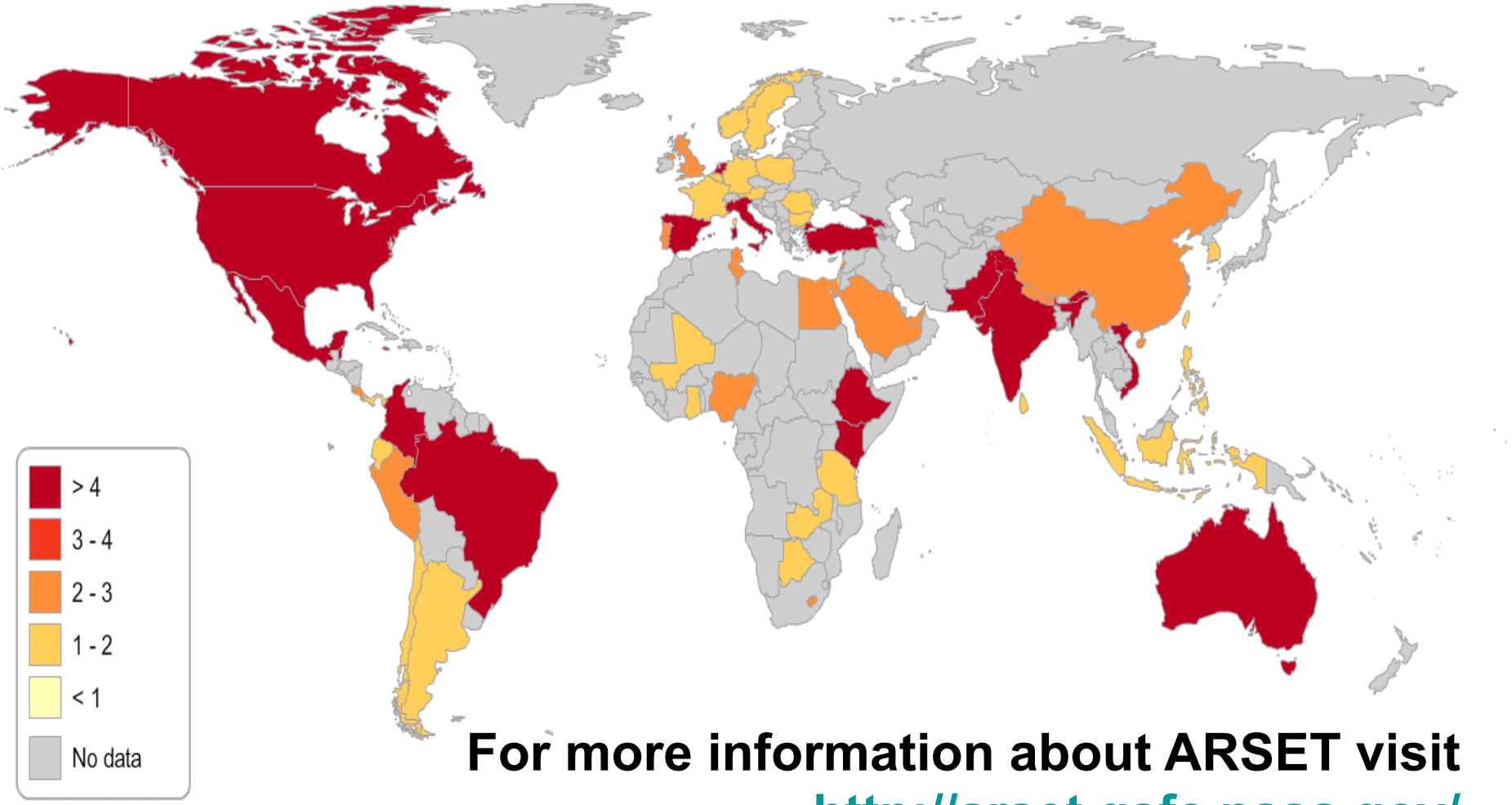
Public Health

Water Resources

Weather

ARSET: 2008 – 2014
+1600 End-users Reached

Number of participating organizations per country



For more information about ARSET visit

http://arset.gsfc.nasa.gov/

ARSET Contact Information

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

- Overall program information

  Ana Prados: aprados@umbc.edu

- Air Quality

  Pawan Gupta: pawan.gupta@nasa.gov

More details are available at

http://arset.gsfc.nasa.gov/

Questions ?

Poll # 1

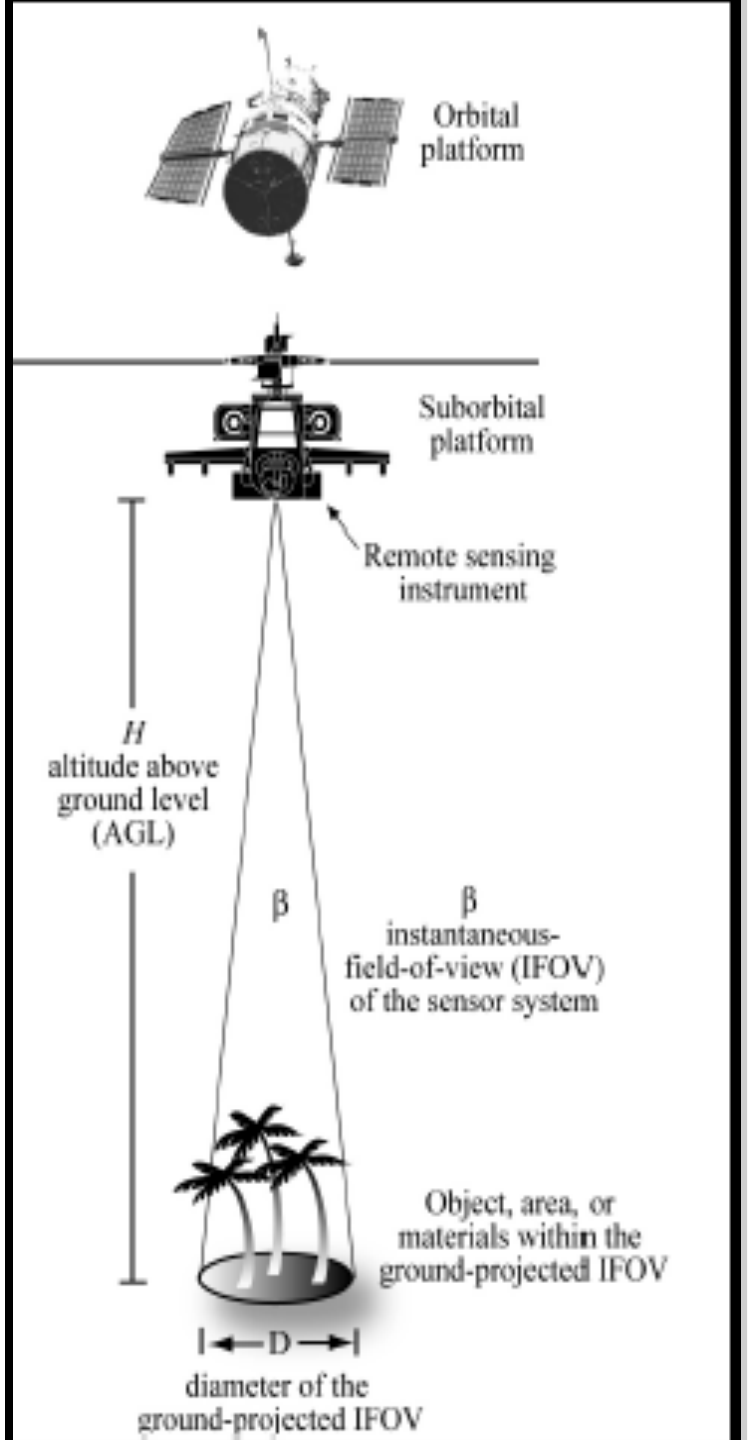
Brief tour to ARSET page
http://arset.gsfc.nasa.gov

Fundamentals of Satellite Remote Sensing Instruments and Applications

Basics of Satellite Remote Sensing

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

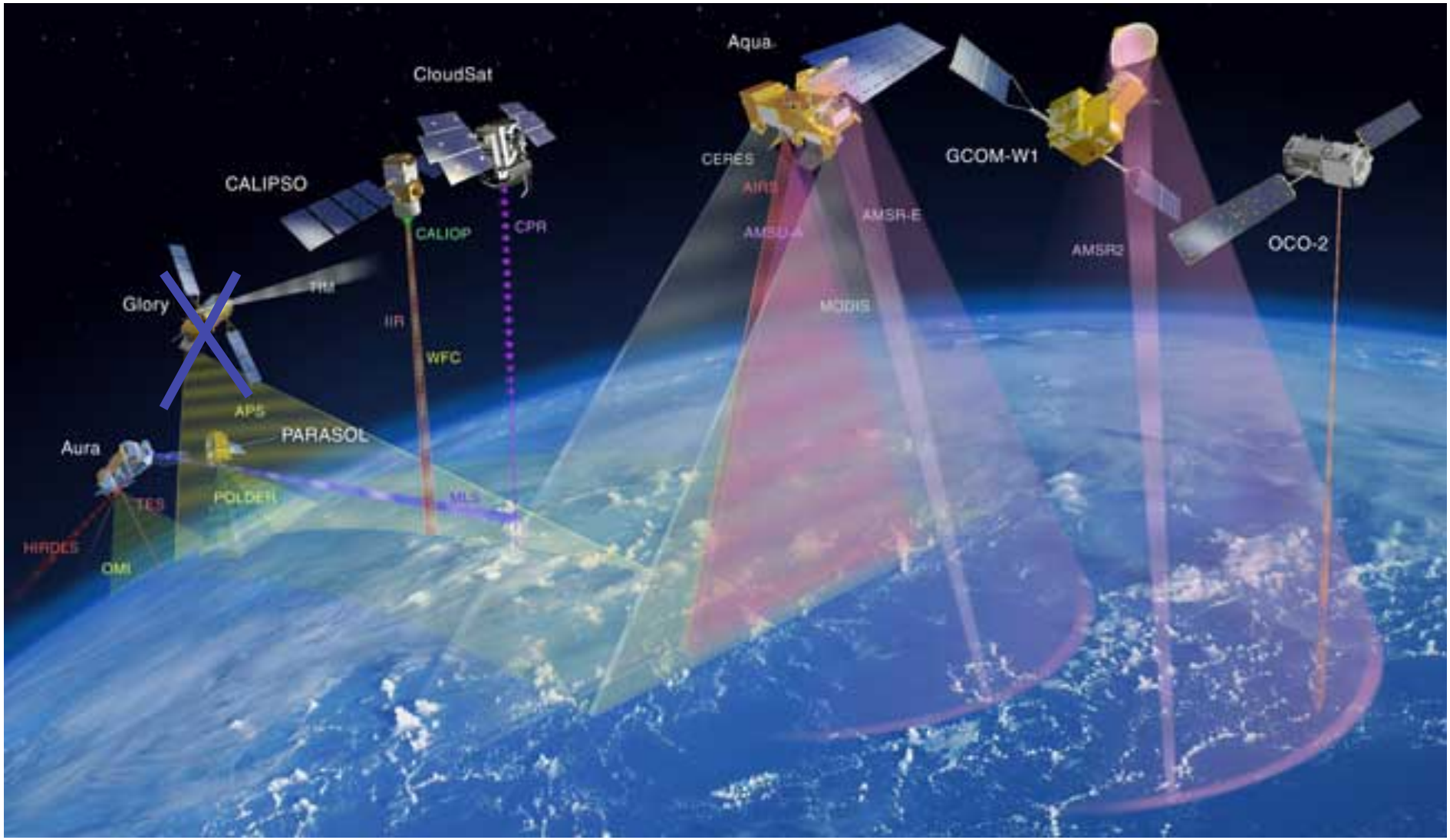
Remote Sensing …



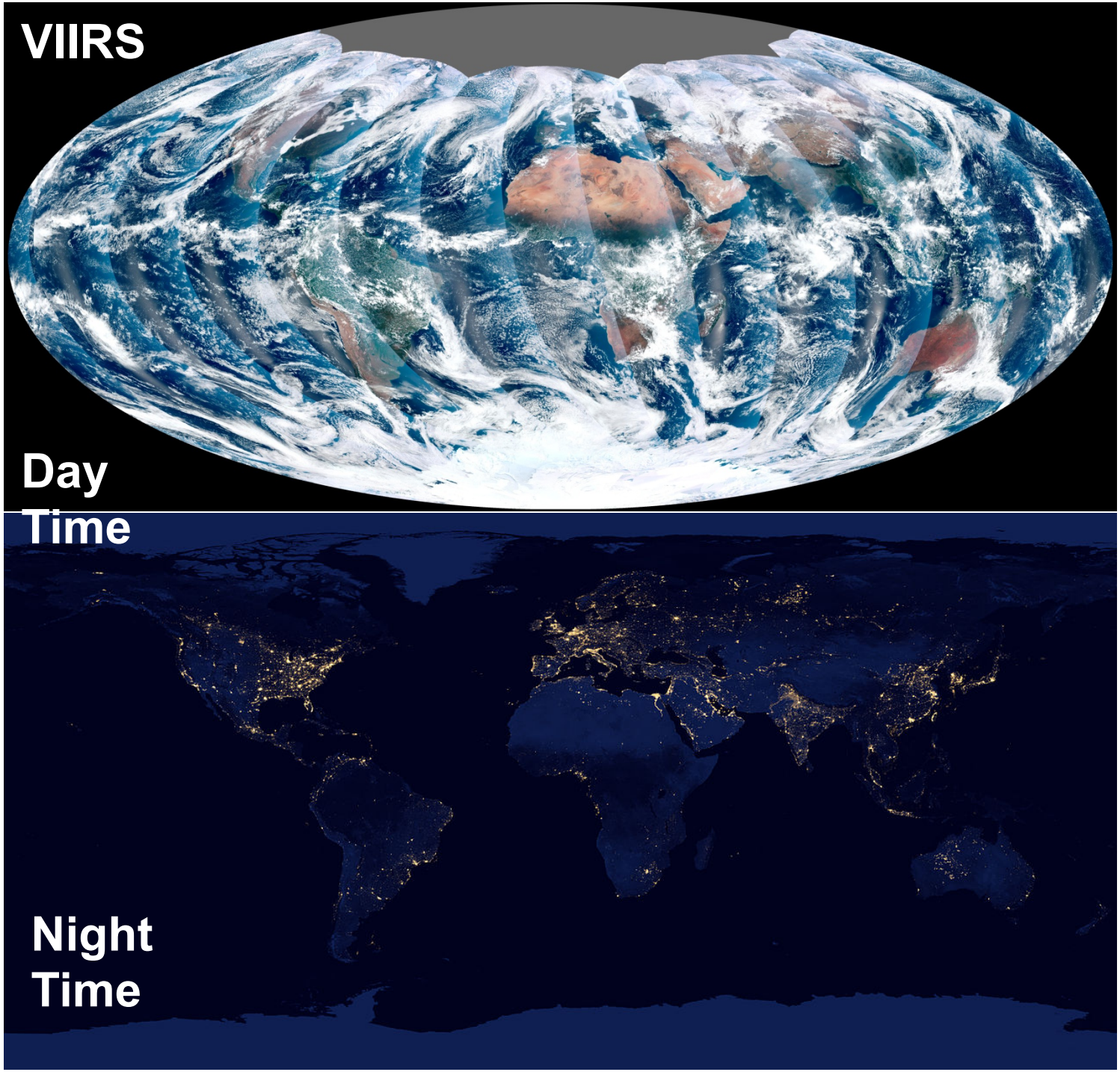
Remote Sensing: Platforms

- Platform depends on application
  - What information do we want?
  - How much detail?
  - What type of detail?
  - How frequent?

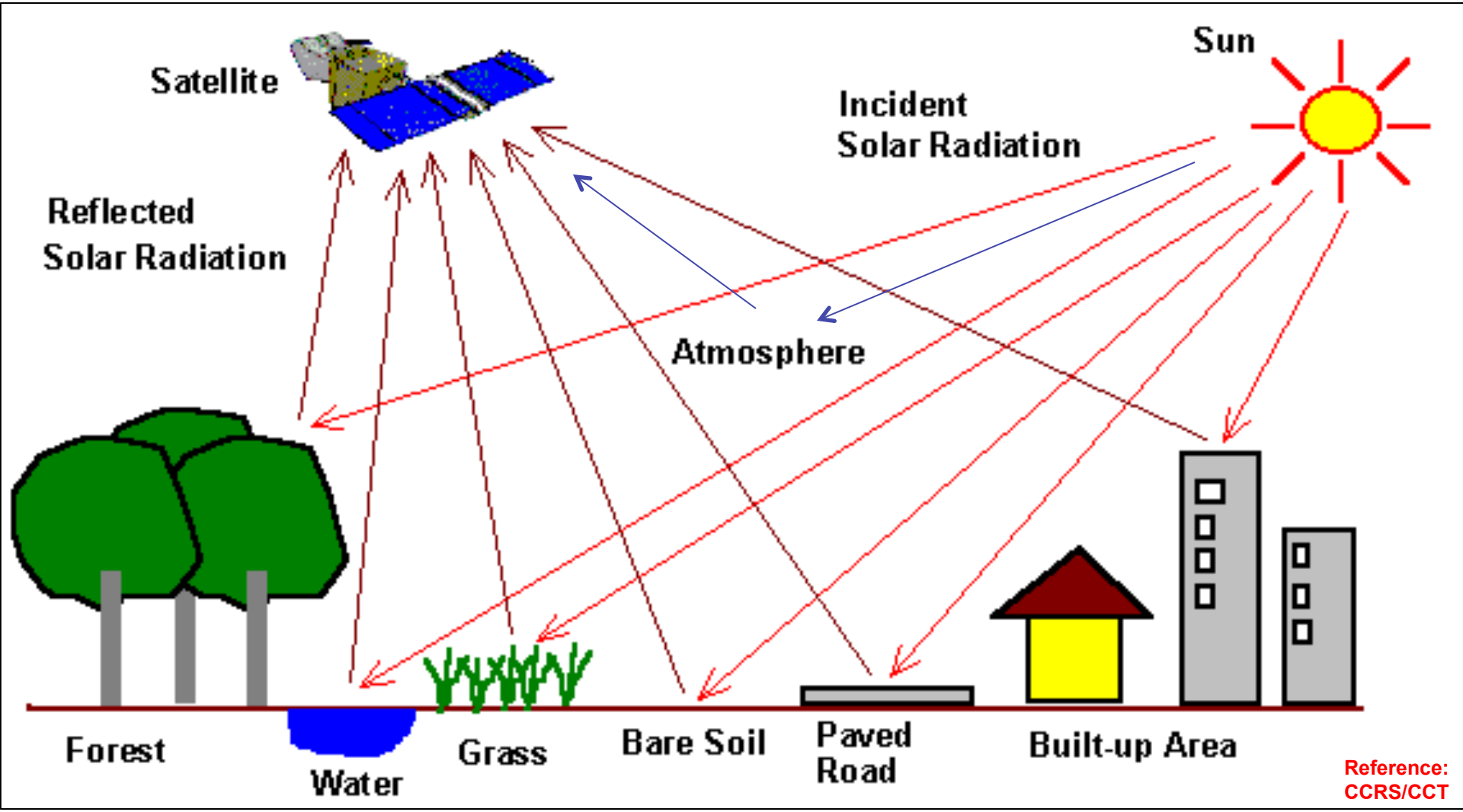
Number of Satellites making daily observations of Earth-Atmosphere and Ocean Globally



What you get from satellite ?

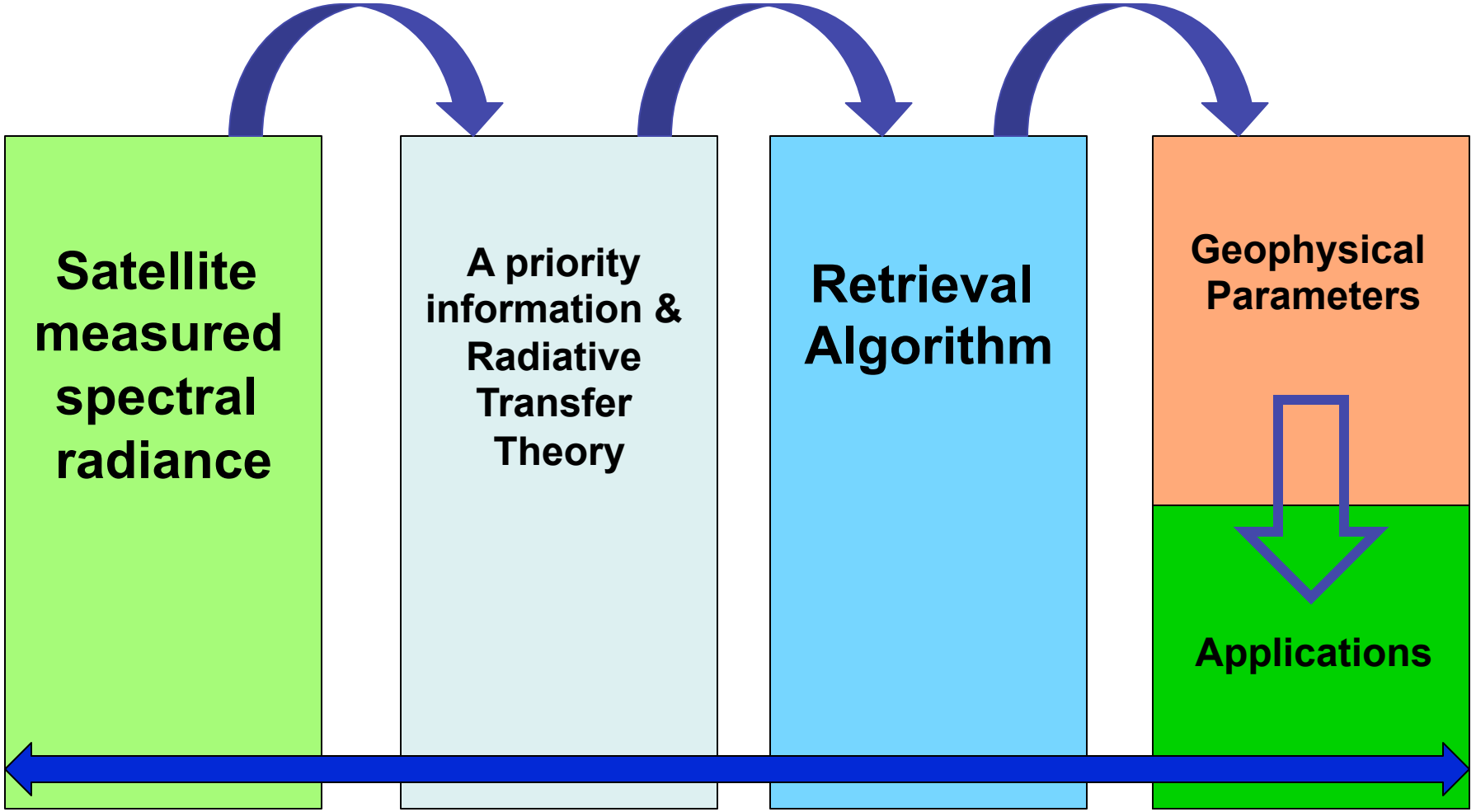


What does satellite measures ?

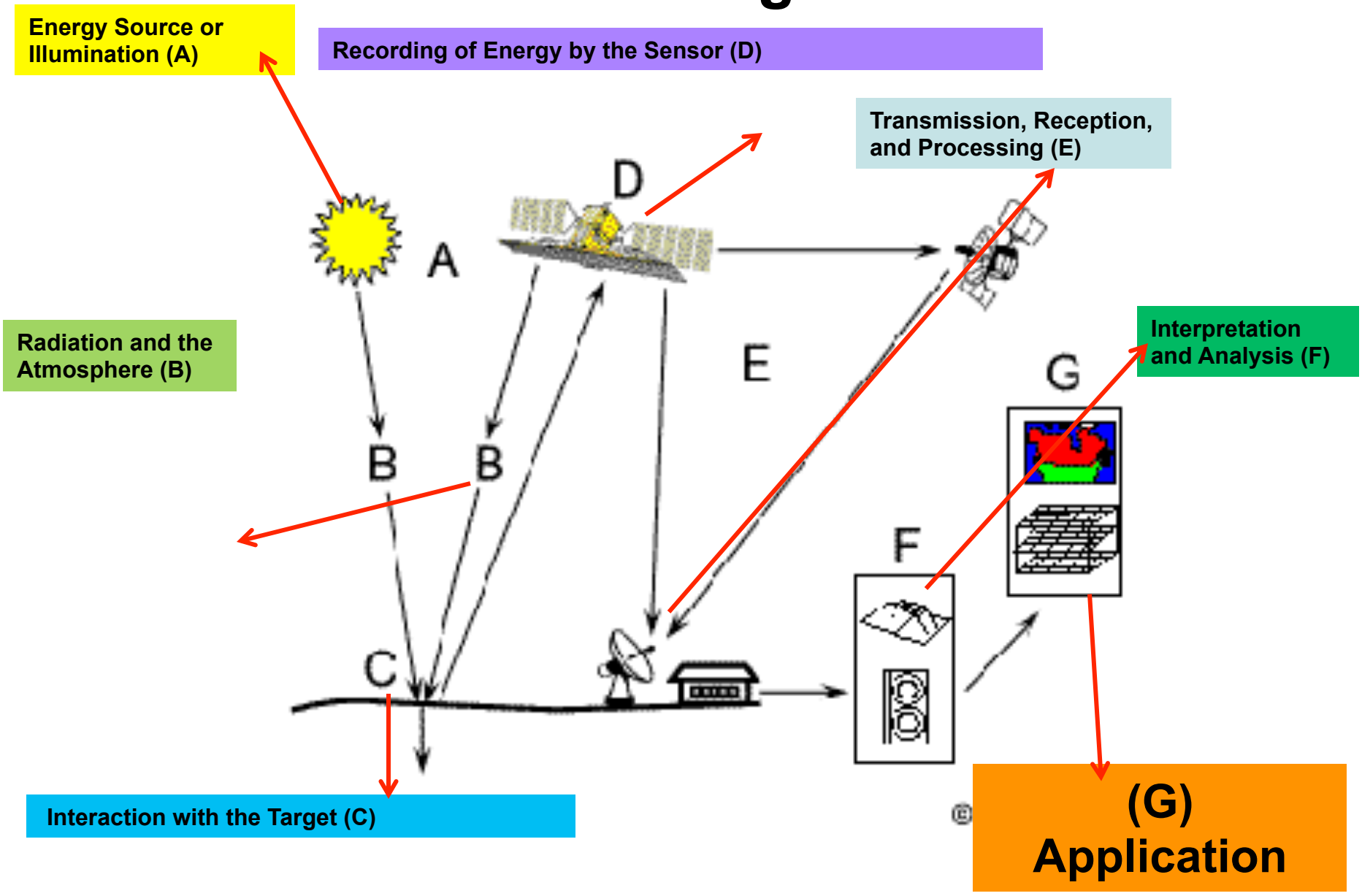


Reference:
CCRS/CCT

Remote Sensing Process



Remote Sensing Process



Reference: CCRS/CCT

Questions ?

Poll # 2

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

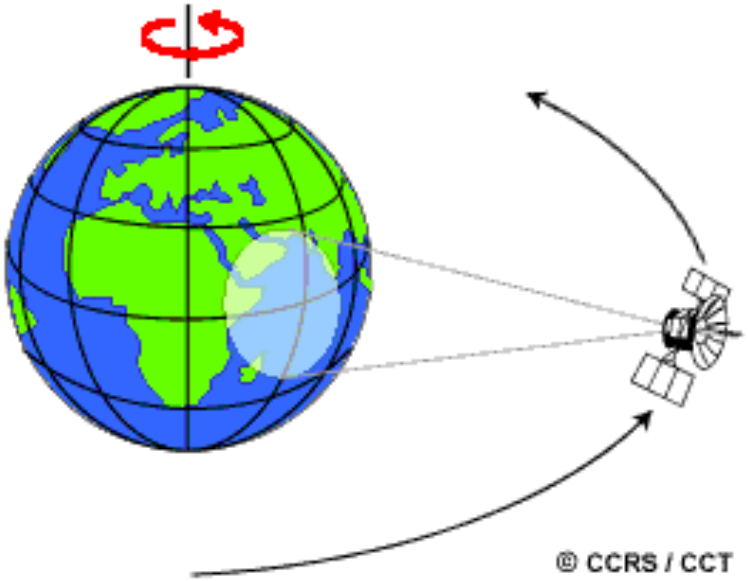
Satellite/Sensor Classifications

Some of the ways satellites/sensor can be classified

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

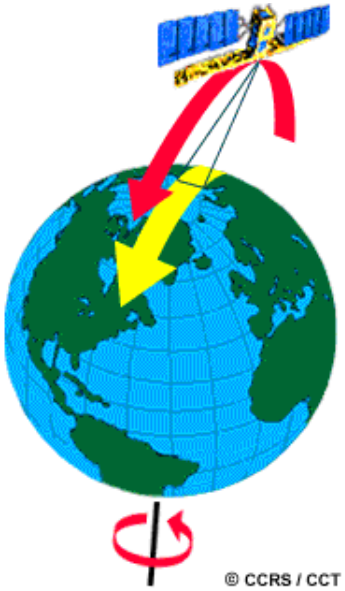
Common types of orbits

Geostationary



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

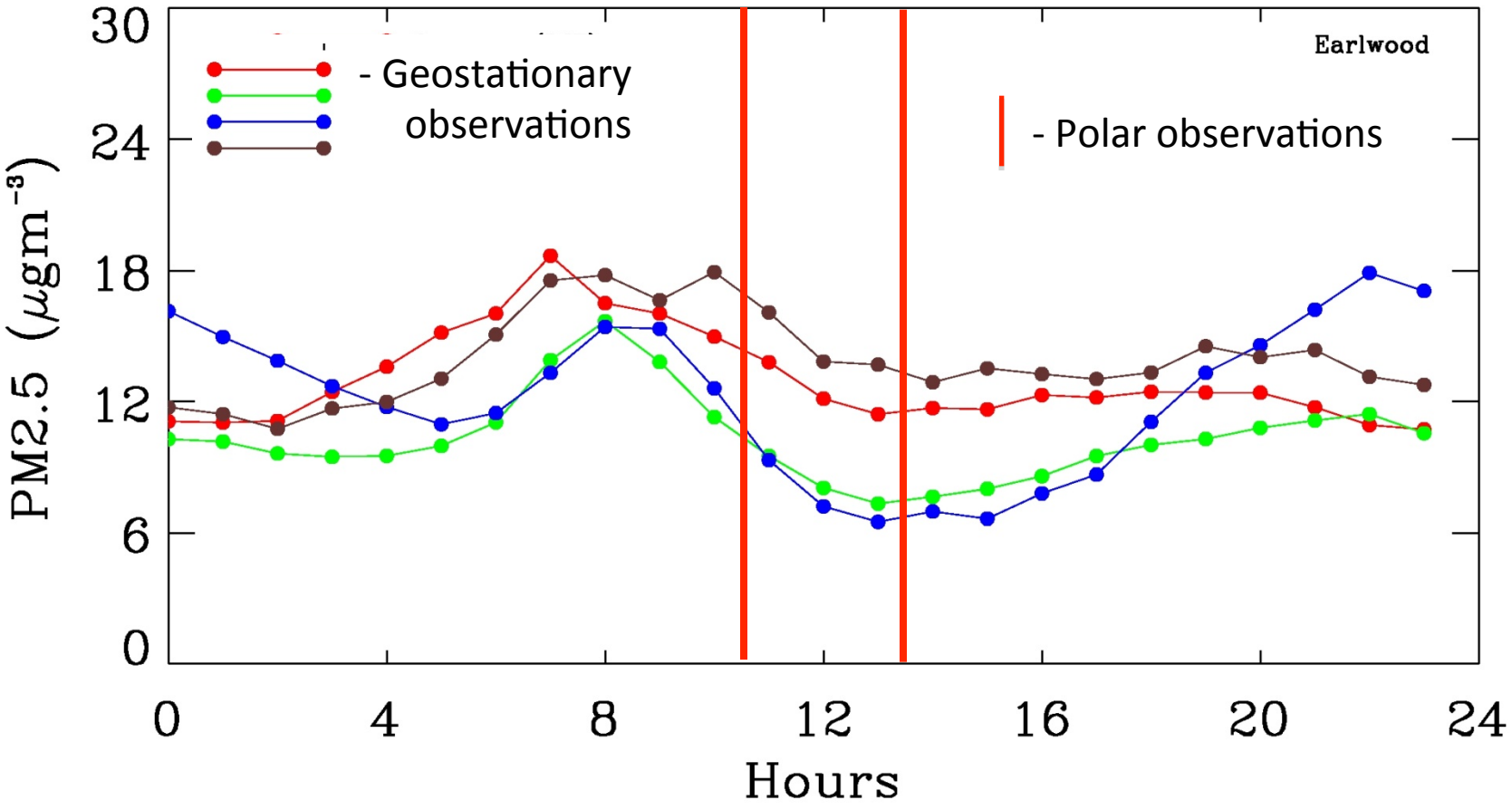
Polar



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

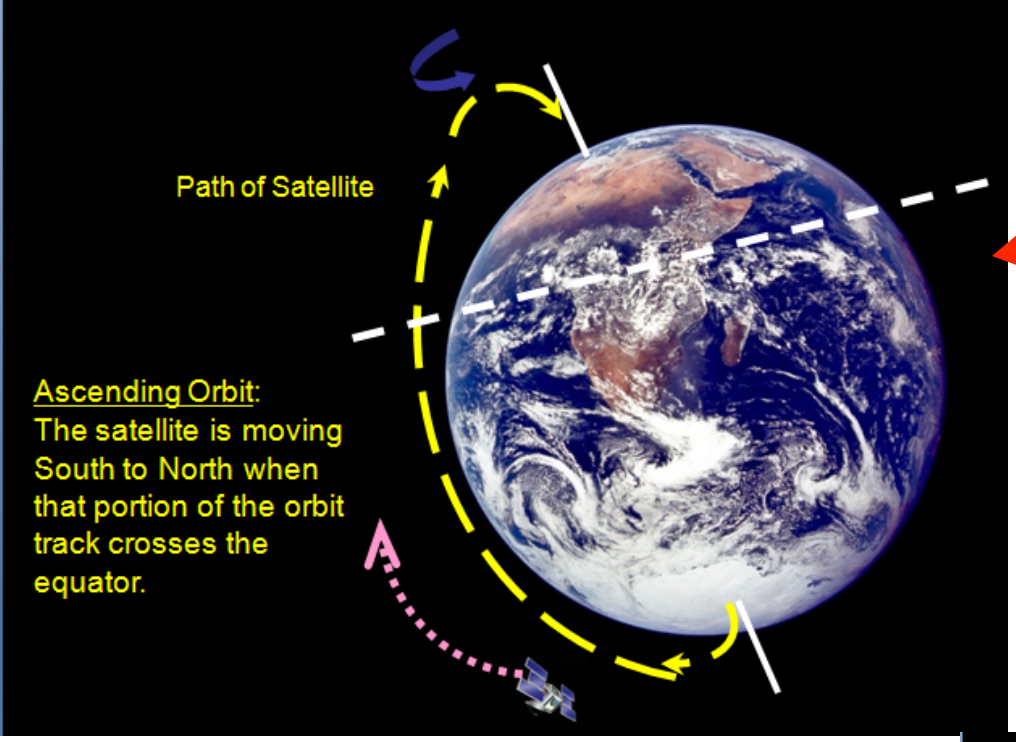
Observation Frequency

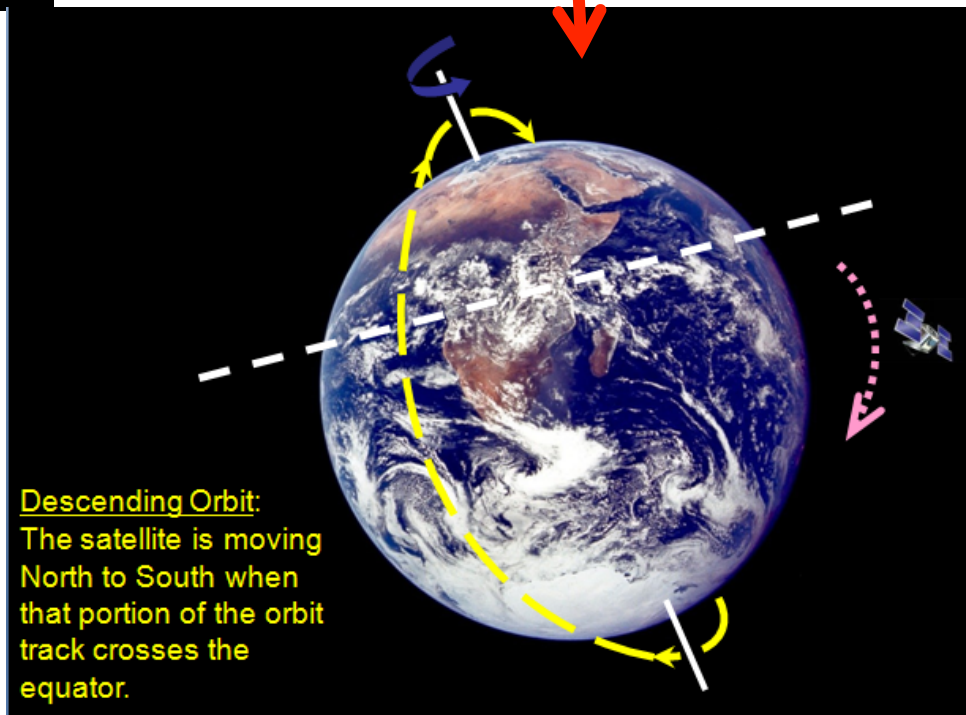
Polar orbiting satellites – 1 - 2 observations per day per sensor



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

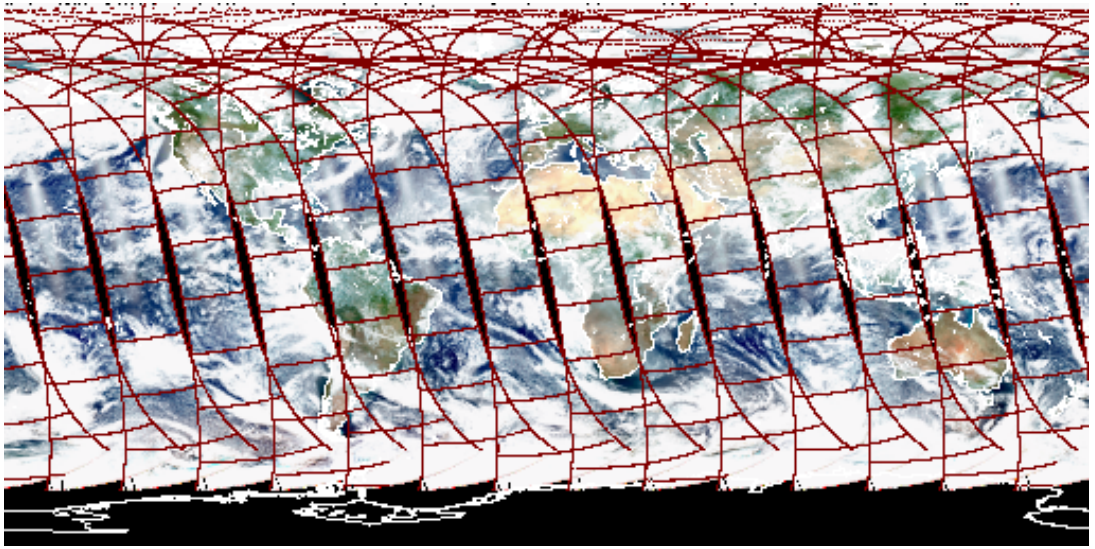
Ascending vs Descending





Polar Orbits

MODIS-Aqua ("ascending" orbit)



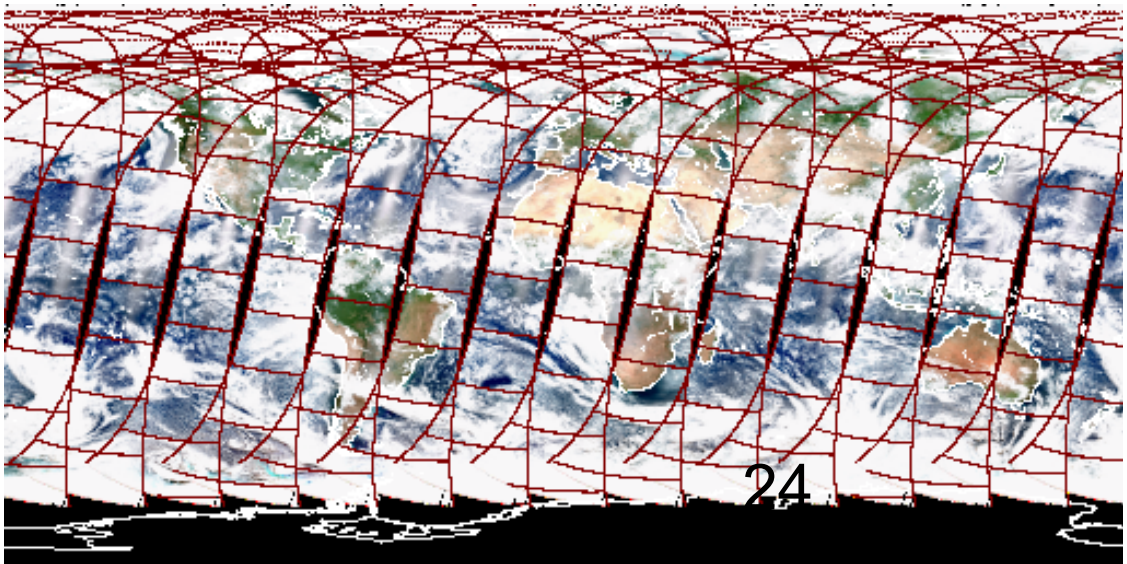
Approximately 1:30 PM local overpass time

Afternoon Satellite

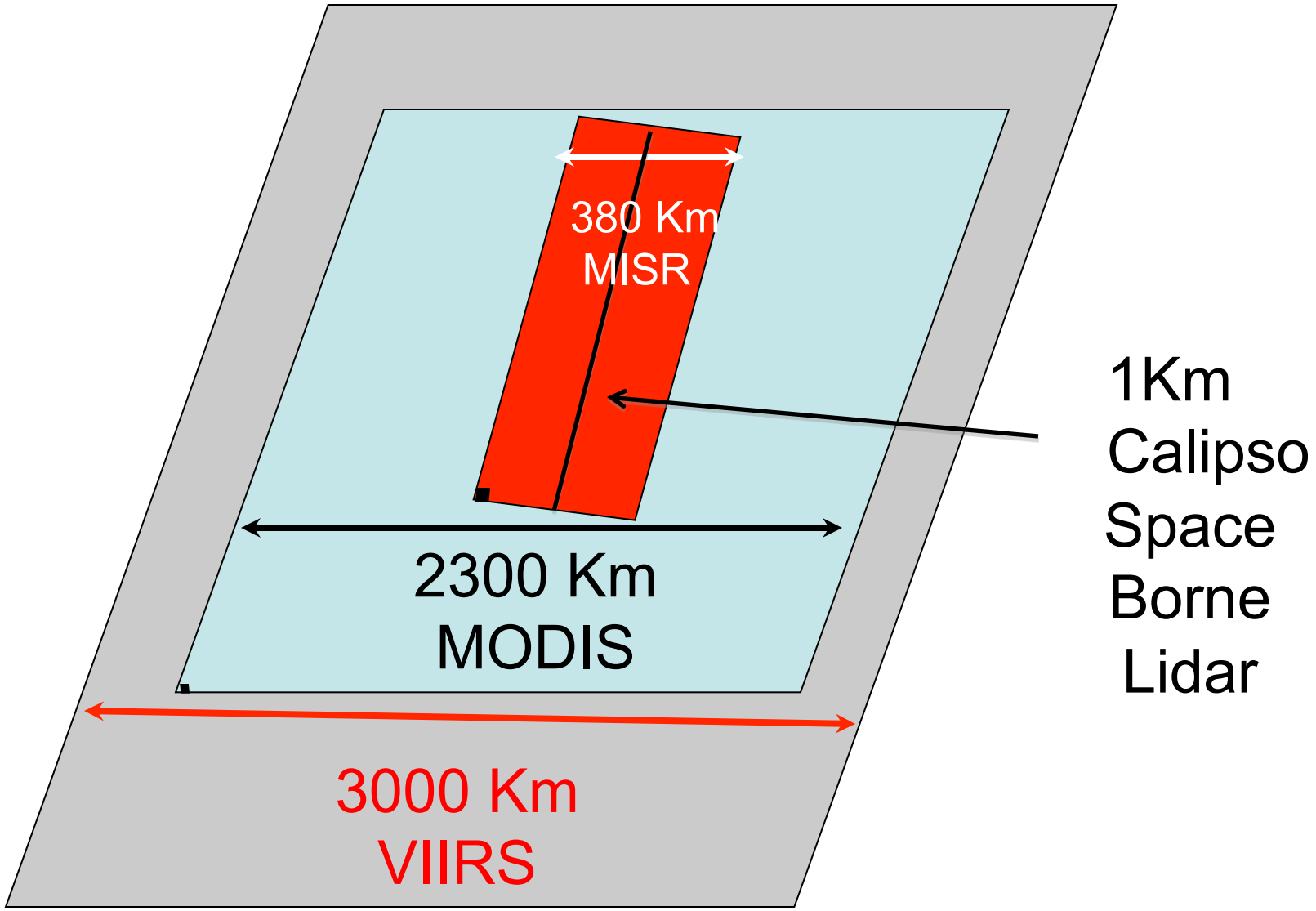
MODIS-Terra ("descending")

Approximately 10:30 AM local overpass time

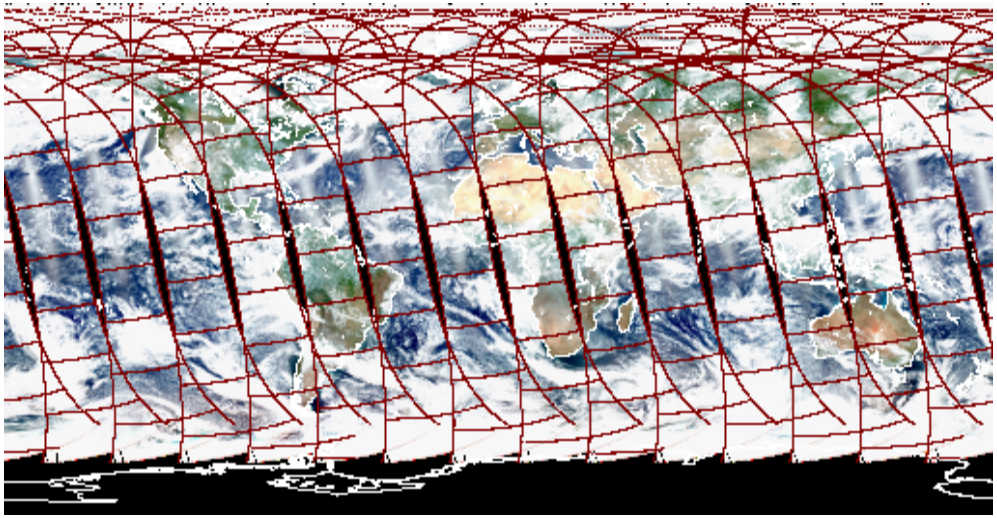
Morning Satellite



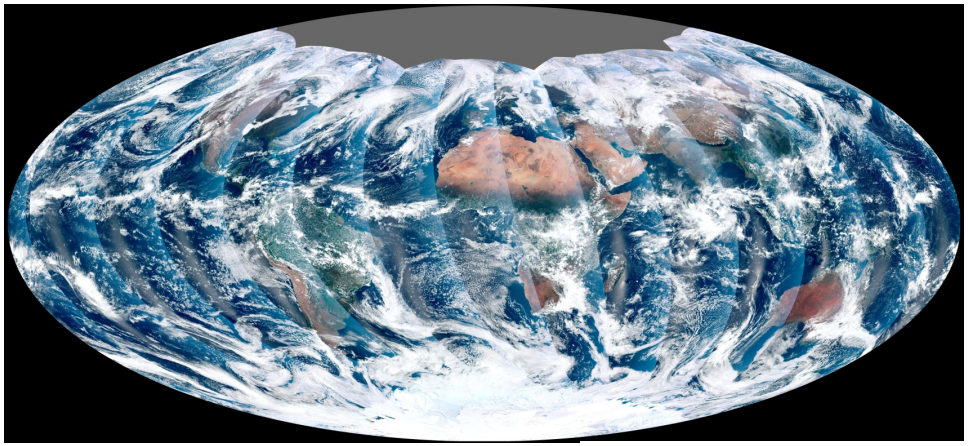
Satellite Coverage



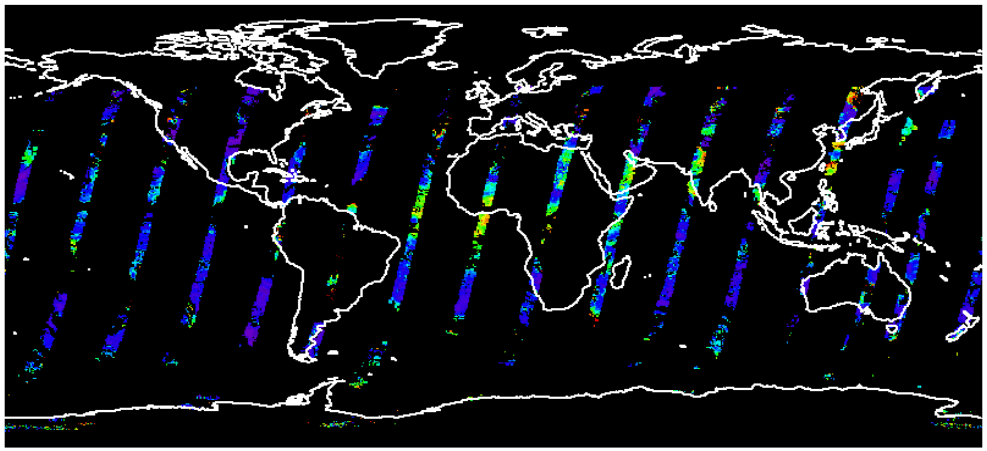
Satellite Coverage



MODIS



VIIRS



MISR

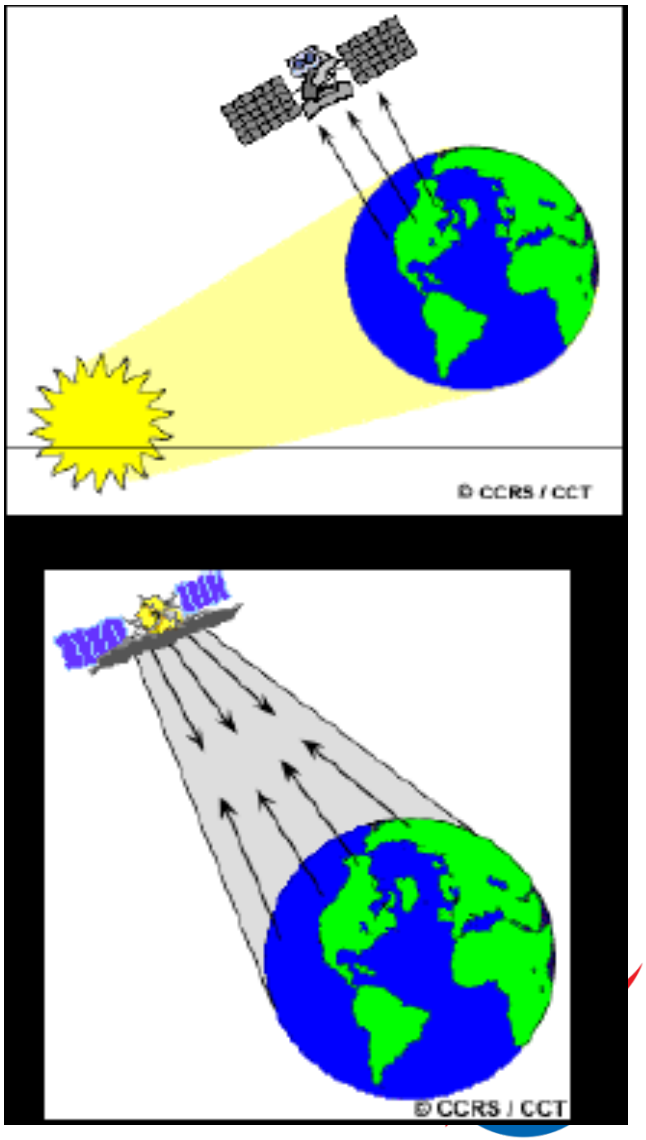
Remote Sensing …Sensors

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

MODIS, MISR, OMI

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

CALIPSO



Remote Sensing – Resolutions

- **Spatial resolution**

  The smallest spatial measurement.

- **Temporal resolution**

  Frequency of measurement.

- **Spectral resolution**

  The number of independent channels.

- **Radiometric resolution**

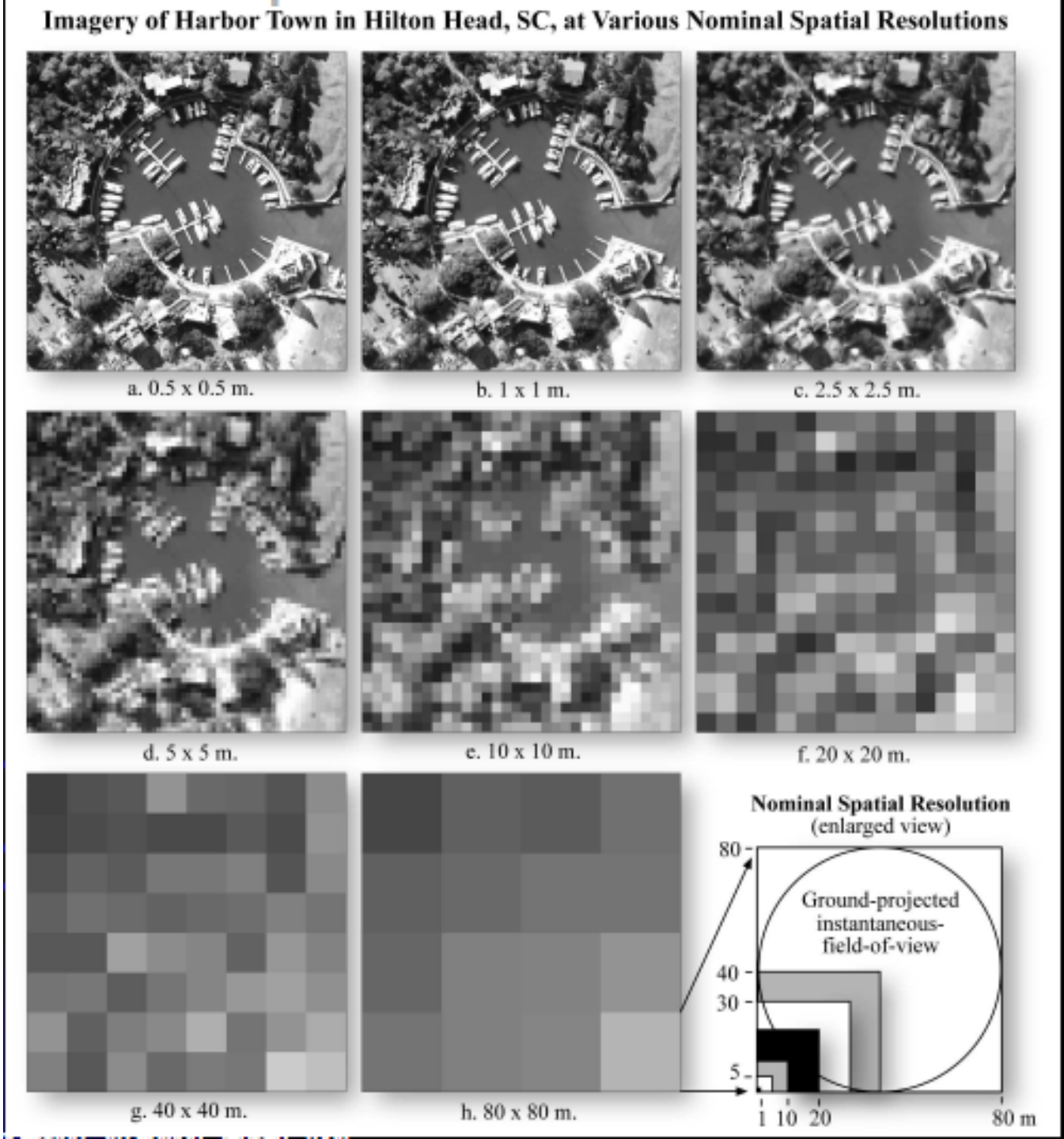
  The sensitivity of the detectors.

Pixel

pixels - the **smallest units of an image**.

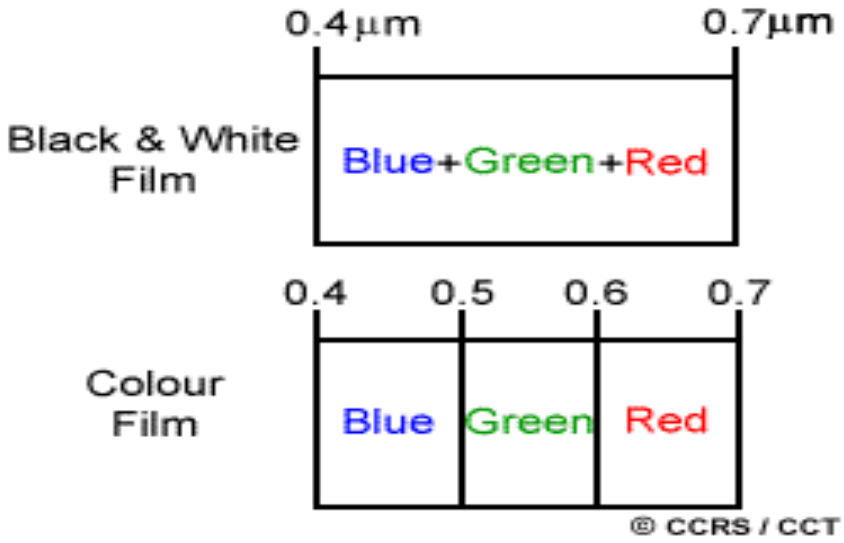
Image pixels are normally regular shape (but not necessary) and represent a certain area on an image/Earth.

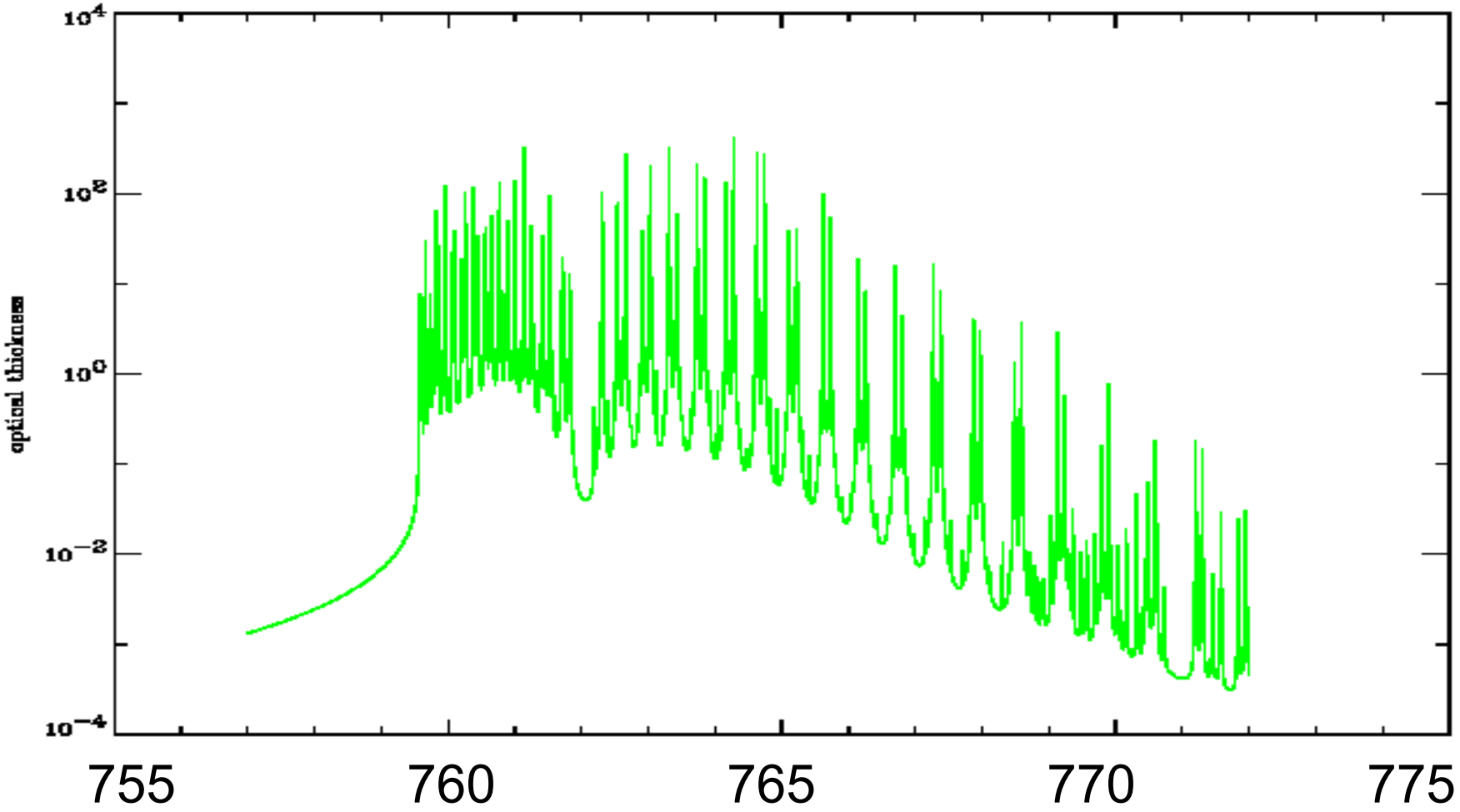
Why is spatial resolution important ?



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**
- **hyper spectral sensors - OMI, AIRS**





In order to capture information contained in a narrow spectral region – hyper spectral instruments such as OMI, or AIRS are required

Radiometric Resolution

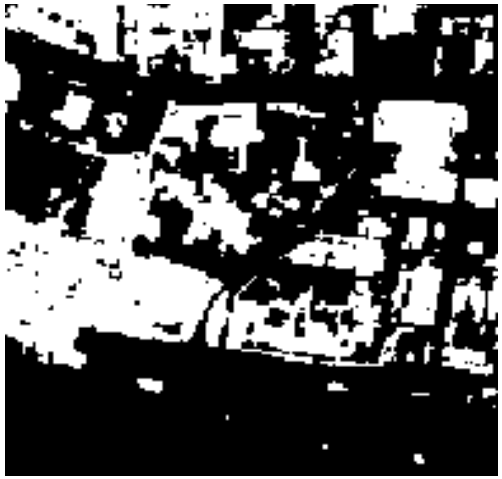
•Imagery data are represented by positive digital numbers which vary from 0 to (one less than) a selected power of 2.

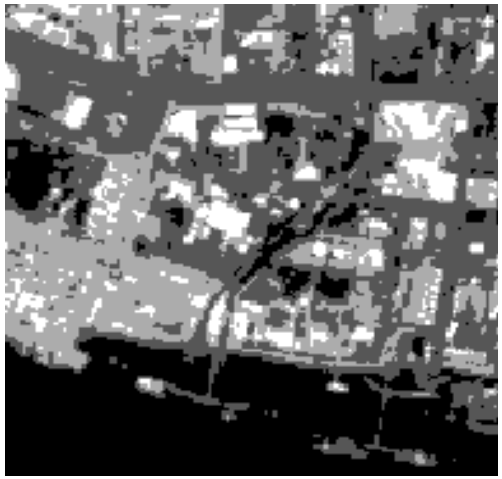
•The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded.

- **12 bit sensor (MODIS, MISR) – 2^{12} or 4096 levels**
- **10 bit sensor (AVHRR) – 2^{10} or 1024 levels**
- **8 bit sensor (Landsat TM) – 2^8 or 256 levels (0-255)**
- **6 bit sensor (Landsat MSS) – 2^6 or 64 levels (0-63)**

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

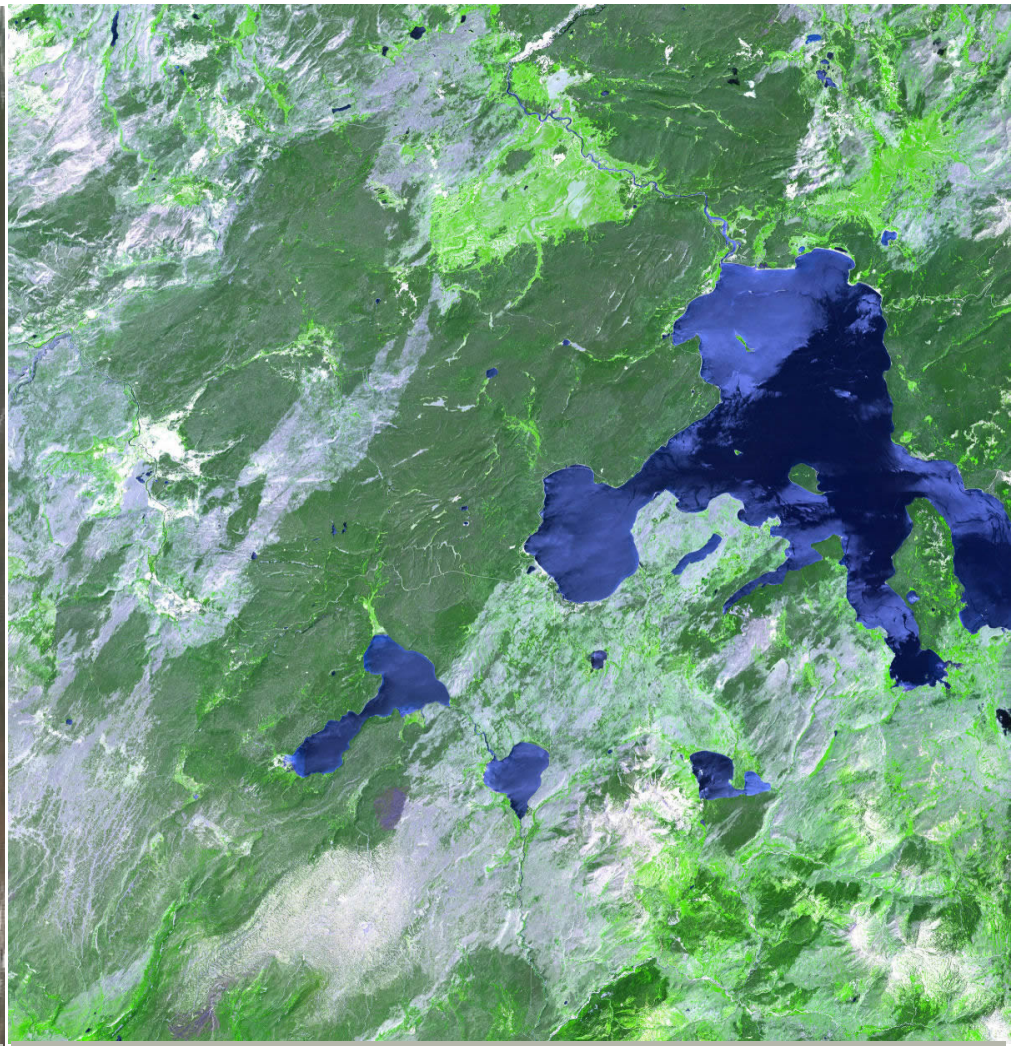
- How frequently a satellite can provide observation of same area on the earth
- It mostly depends on swath width of the satellite – larger the swath – higher the temporal resolution

- **MODIS – 1-2 days – 16 day repeat cycle**
- **OMI – 1-2 days**
- **MISR – 6-8 days**
- **Geostationary – 15 min to 1 hour**

  (but limited to one specific area of the globe)

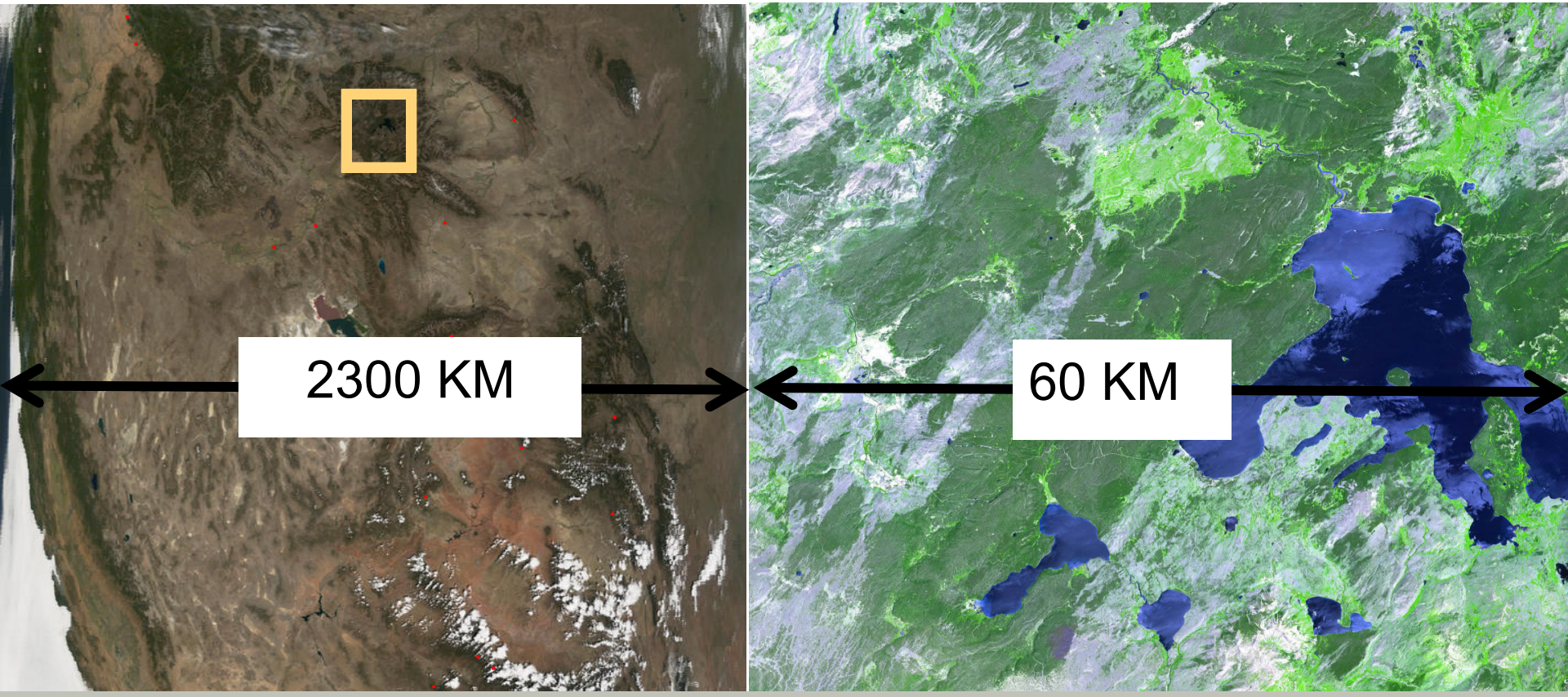
Remote Sensing – Trade offs

MODIS 500 Meter
True color image



Aster Image
15 M Resolution

Remote Sensing – Trade offs



•The different resolutions are the limiting factor for the utilization of the remote sensing data for different applications. Trade off is because of technical constraints.

•Larger swath is associated with low spatial resolution and vice versa

•Therefore, often satellites designs are applications oriented

Trade Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric resolutions at the same time
- MODIS, OMI and several other sensors can obtain global coverage every one – two days because of their wide swath width
- Higher resolution polar orbiting satellites may take 8 – 16 days for global coverage or may never provide full coverage of the globe.
- Geostationary satellites obtain much more frequent observations but at lower resolution due to the much greater orbital distance.

Limitations of Satellite Data for Air Quality Applications

- Most of the satellite sensors are passive sensors.
- Most Passive sensors measure the entire column.
- Column measurements may or may not reflect what is happening at ground level.
- This is true whether we are measuring aerosols or trace gasses.

But new methods and algorithms have been developed (and developing) to convert column measurement for the surface monitoring ..to learn attend rest of the webinar

Questions ?

Poll # 3

Next Week

- Visible satellite imagery and air quality applications
- Image information content, feature identification, and image archives
- Virtual tour of Earth observatory

Assignment Week - 1

http://goo.gl/forms/XjhzniWcZR

Material and Recording will be available at

http://arset.gsfc.nasa.gov/airquality/webinars/observations-tools-south-east-asia