Observing the Earth: Resolutions Part 1

First: Quick Review from last class

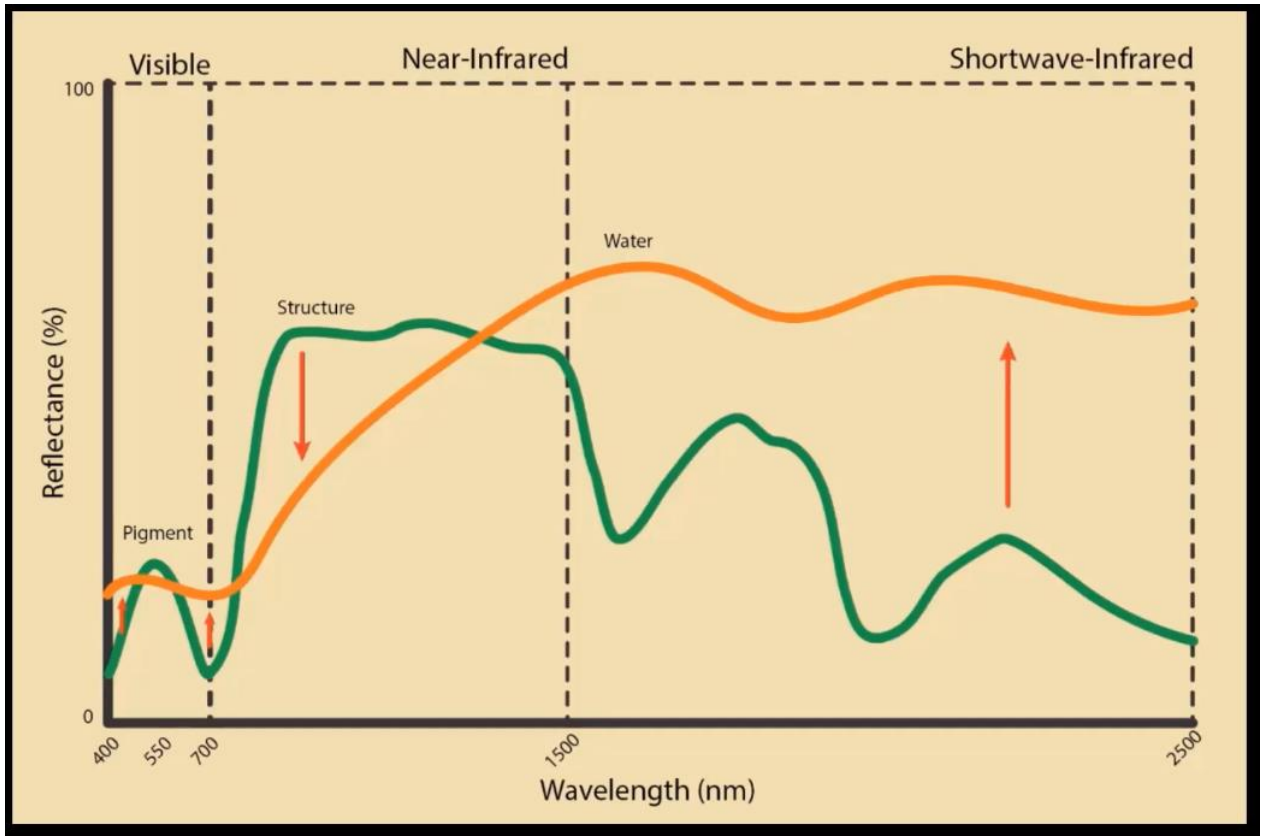
- We rushed a little bit at the end of lecture so let's just quickly review:
  - NIR to Red Simple Ratio (SR)
    - First spectral/remote sensing derived vegetation index
    - Larger SR = Healthier vegetation
  - Normalized Difference Vegetation Index (NDVI)
    - The standard today for spectral/remote sensing derived vegetation indeces
    - Ranges from -1 – 1 (but vegetation never below 0 in general)
      - Closer to 1 = Healthier vegetation

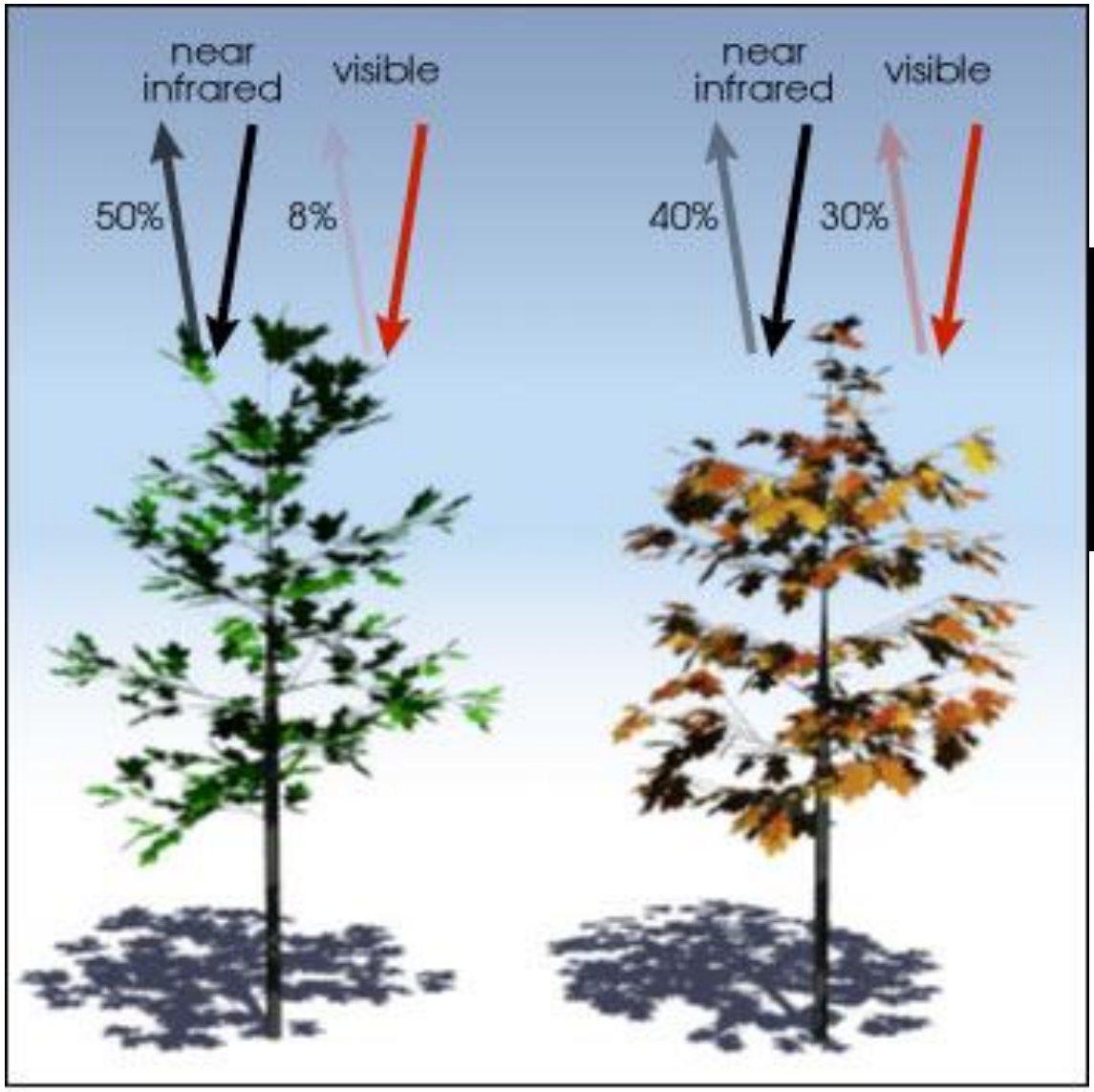
Vegetation Metrics

- Both metrics take advantage of the same process:
  - Healthier vegetation will have
    - Higher NIR reflectance
    - And lower VIS red reflectance
  - Unhealthier vegetation will have
    - Lower NIR reflectance
    - And higher VIS red reflectance

$$SR = \frac{NIR}{red}$$

$$NDVI = \frac{NIR - red}{NIR + red}$$





$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72$$

$$\frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Learning Objectives:

In this lecture you will learn about:

- What resolutions are important to consider in Earth Observation
- Understand why they are important to consider when imaging the Earth
- What is a definition of spatial resolution?
- What is a definition of spectral resolution?
- What is a definition of temporal resolution?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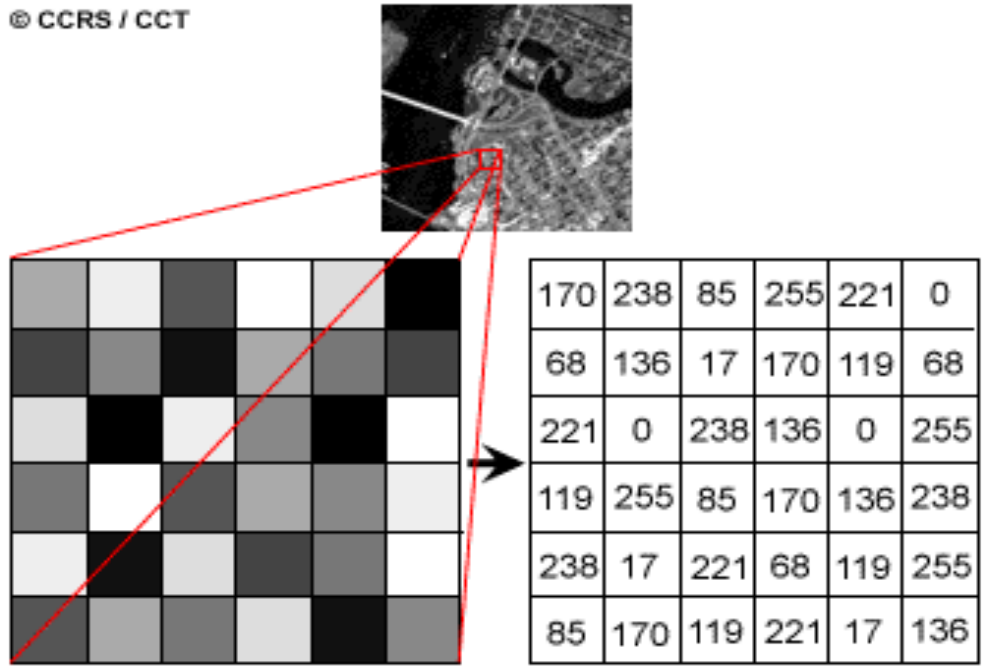
The Resolutions:

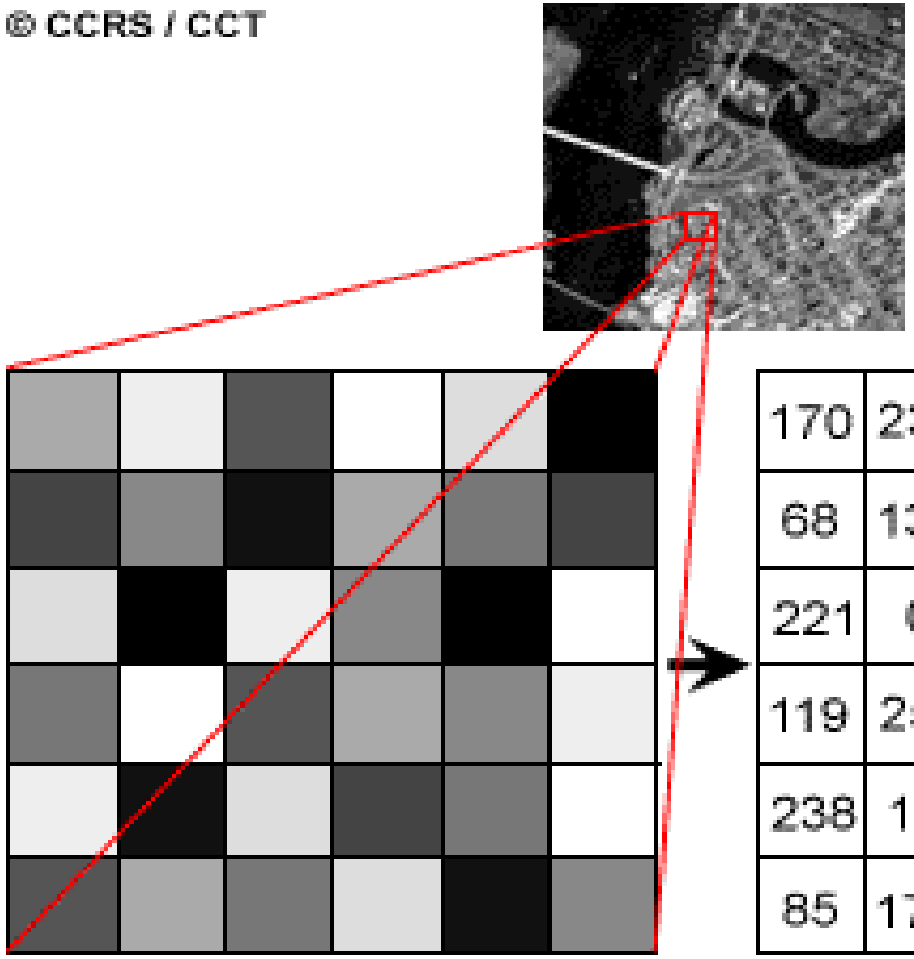
- Spatial Resolution
- Spectral Resolution
- Temporal Resolution

Spatial Resolution

- Smallest possible feature/object that can be detected
- Digital imagery:
  - Minimum area that can be resolved by the sensor
  - Ex: 30 x 30m area
  - Each pixel possesses a reflectance value
- Satellites:
  - Resolution is fixed
- Arial
  - Resolution is variable



Spatial Resolution



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

What Can I see? The Resolutions

What Can I see? The Resolutions

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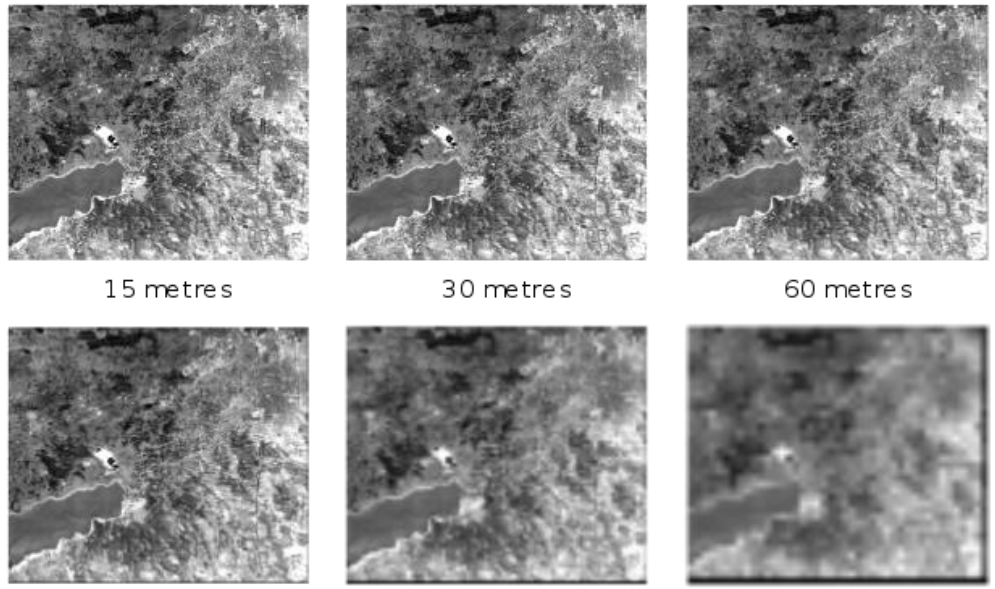
Spatial Resolution

- Impacts level of detail/information
- Coarser resolution = less detail/information



Spatial Resolution

Spatial resolution is typically defined by the pixel size

- Which is a function of platform and sensor specifications and geometry

Other considerations:

- Spatial arrangement of targets
- Data quality

Spatial Resolution

- Spatial resolution of this image = 60cm
- Tennis court line widths are < 20cm

- Why are we still able to see the lines?

a

b

Figure 4.4 Poor atmospheric and light conditions can dramatically reduce the effective spatial resolution of a remote sensing system. These images of the same scene were taken by the same sensor system under good (a) and poor (b) atmospheric conditions.

Source: Courtesy of Imagery Resolution Assessments and Reporting Standards Committee.

- Poor atmospheric & light conditions can reduce effective spatial resolution
  - The pixel size is the same, but the poor conditions increase the size of the smallest detectable object/feature

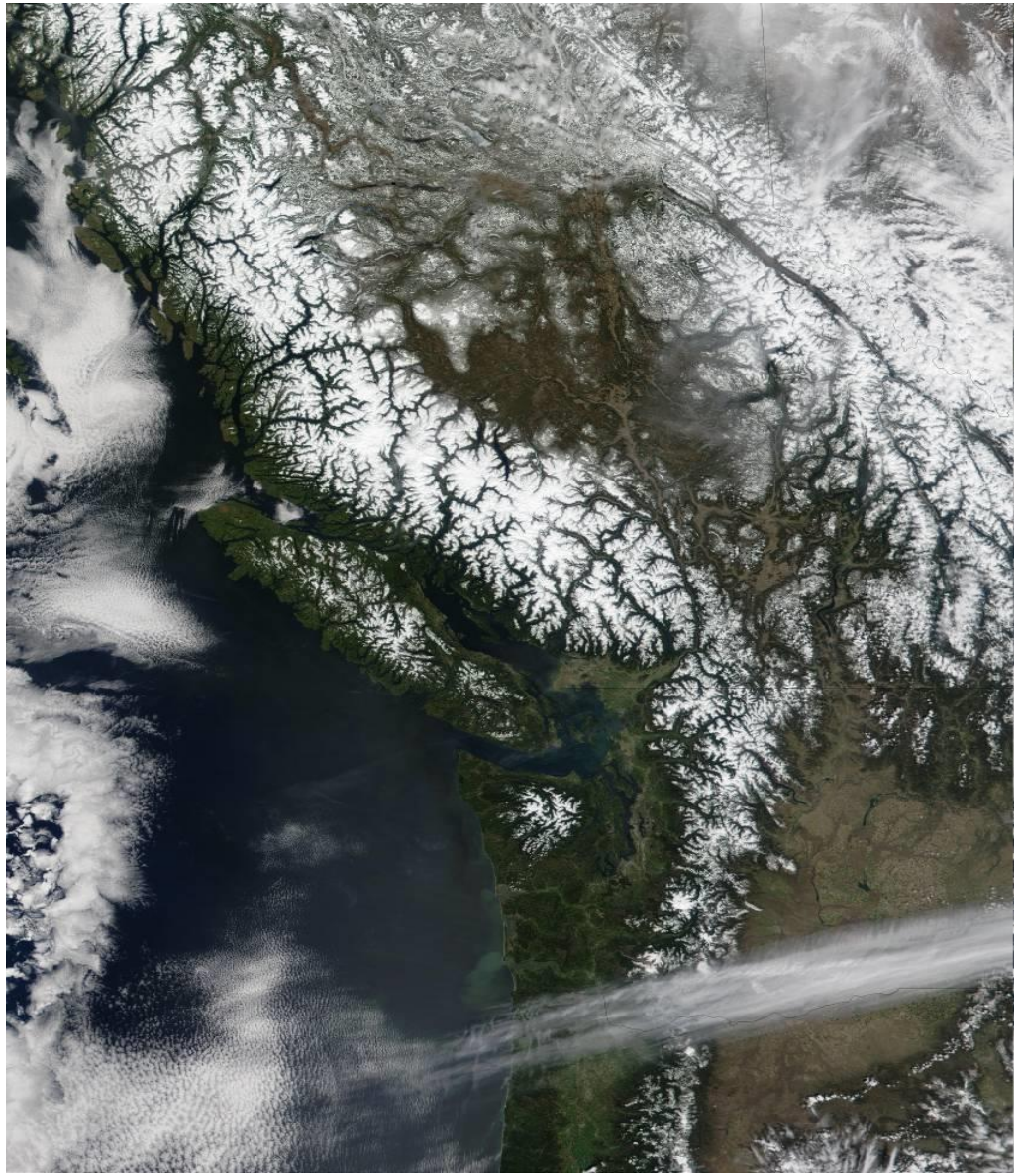
Low Spatial Resolution (>100m)

Platform: Terra; Aqua
Sensor: MODIS

Spatial resolution:
250m – 1km

Applications:
- Land cover type
- Snow cover extent
- Vegetation phenology
- Canopy cover
- Sea surface temp.

Acquisition cost:
- Free
- Typically government



Moderate Spatial Resolution (<100m)

Platform: Landsat

Sensor: Thematic Mapper and OLI

Spatial resolution:

30m

Applications:

- Forest cover
- Insect infestation
- Crop forecasting
- Land cover use/change

Acquisition cost:

- Free
- Typically government

High Spatial Resolution (<5m)

Platform: IKONOS

Sensor: IKONOS

Spatial resolution:

4m

Applications:

- Urban mapping
- Road mapping

Acquisition cost:

- Not free
- Private

Very High Spatial Resolution

Platform: airplane/drone

Sensor: digital camera

Spatial resolution:

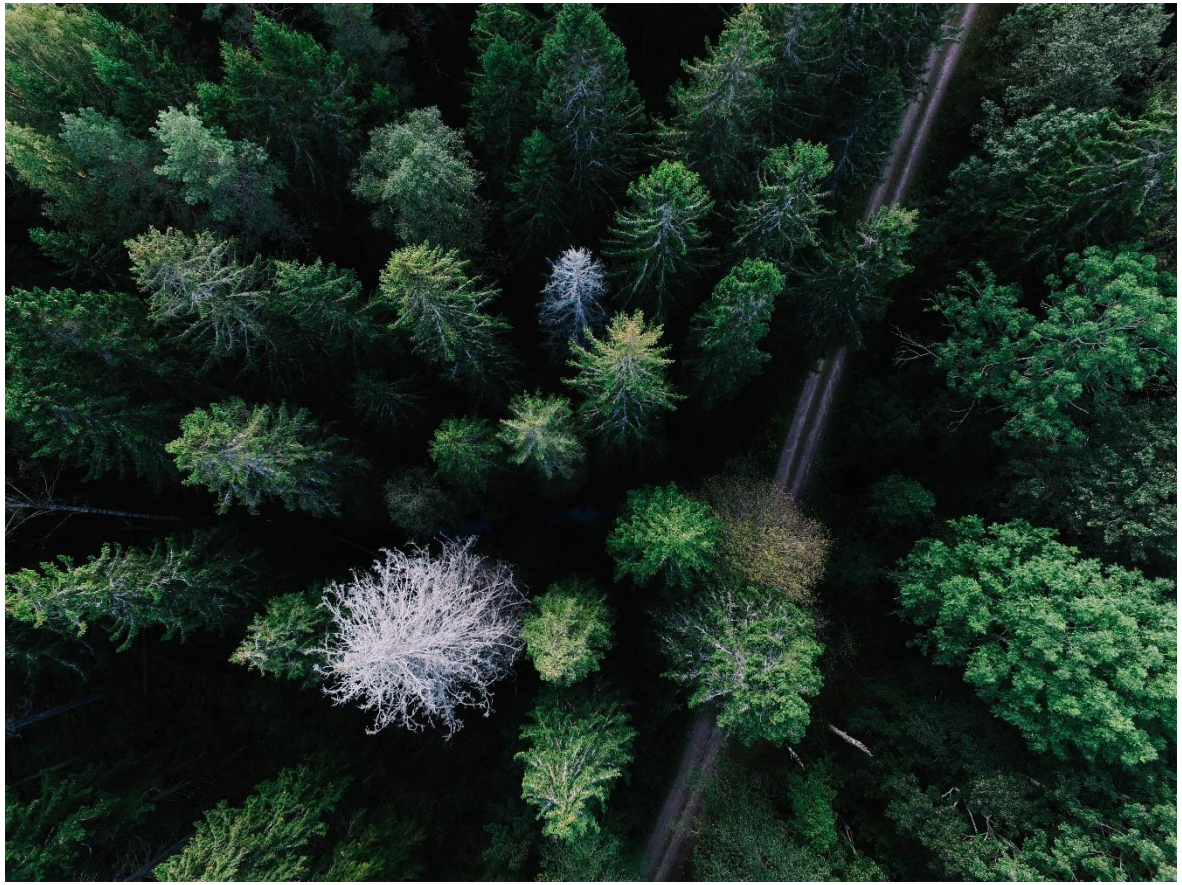
Variable (ex. 0.1m)

Applications:

- Individual trees
  - Health (insect infestation)
  - Crown size and shape

Acquisition cost:

- Not free
- Private or government



The Resolutions:

- Spectral Resolution

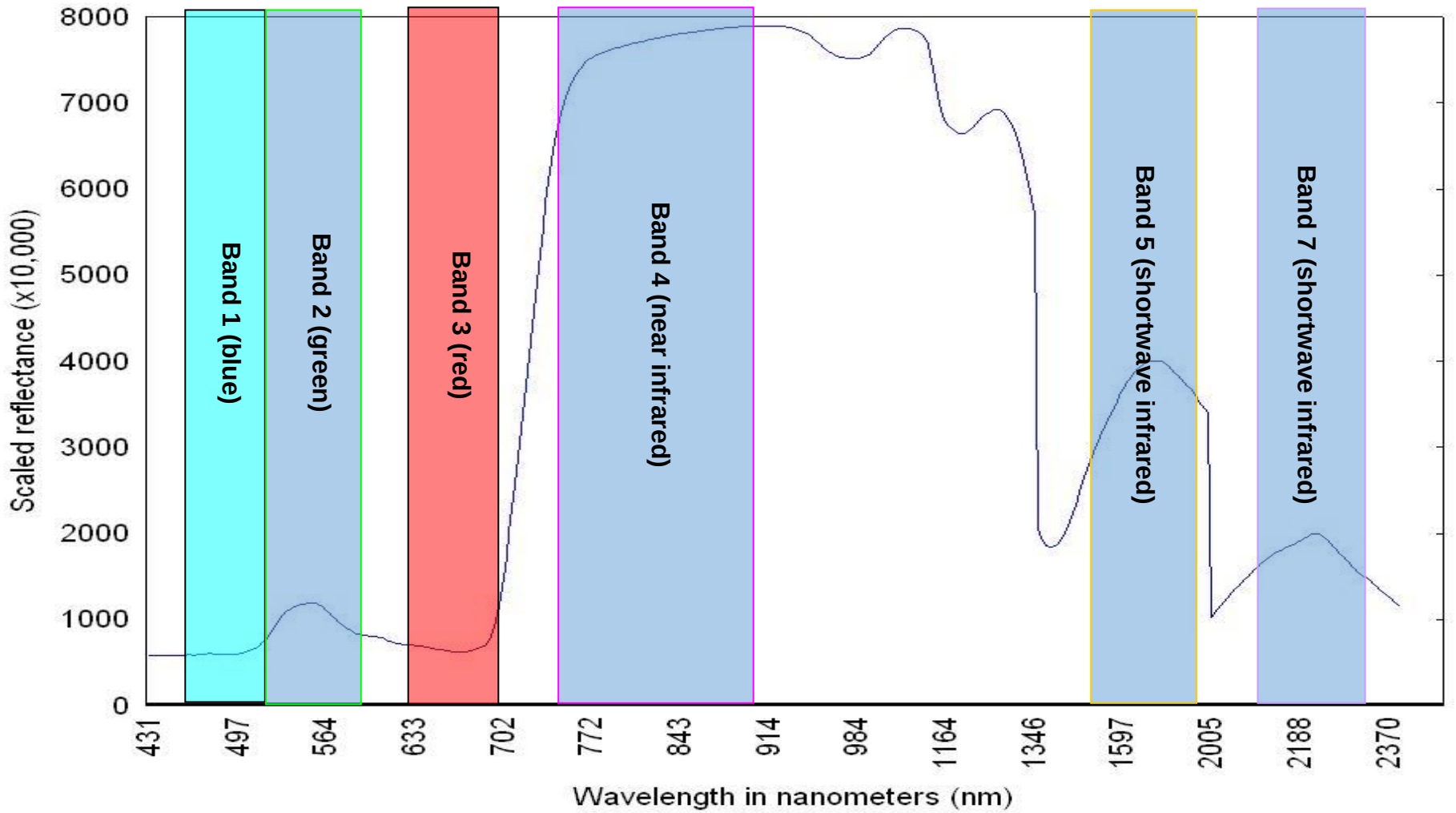
Spectral Resolution

The number and dimension of specific wavelength intervals in the electromagnetic spectrum to which a remote sensing instrument is sensitive…

OR

- **the # of spectral channels/bands used**
- **their location in the electromagnetic spectrum**
- **the bandwidth of each channel/band**

Spectral Resolution



Spectral Resolution

Spatial Resolution	30 x 30 m	
Bandwidth (in nanometers)	nm	
Band numbers	1 (Blue)	450 – 520
	2 (Green)	520 – 600
	3 (Red)	630 – 690
	4 (NIR)	760 – 900
	5 (SWIR)	1550 – 1750
	6 (Thermal)	10400 – 12600
	7 (SWIR)	2080 – 2350

Landsat Thematic Mapper
- 7 channels
- located in visible; NIR; mid-IR; and Thermal
- bandwidths ranging from: 60-270 nm (+ thermal is 2,200nm)

The Resolutions:

- Temporal Resolution

Temporal Resolution

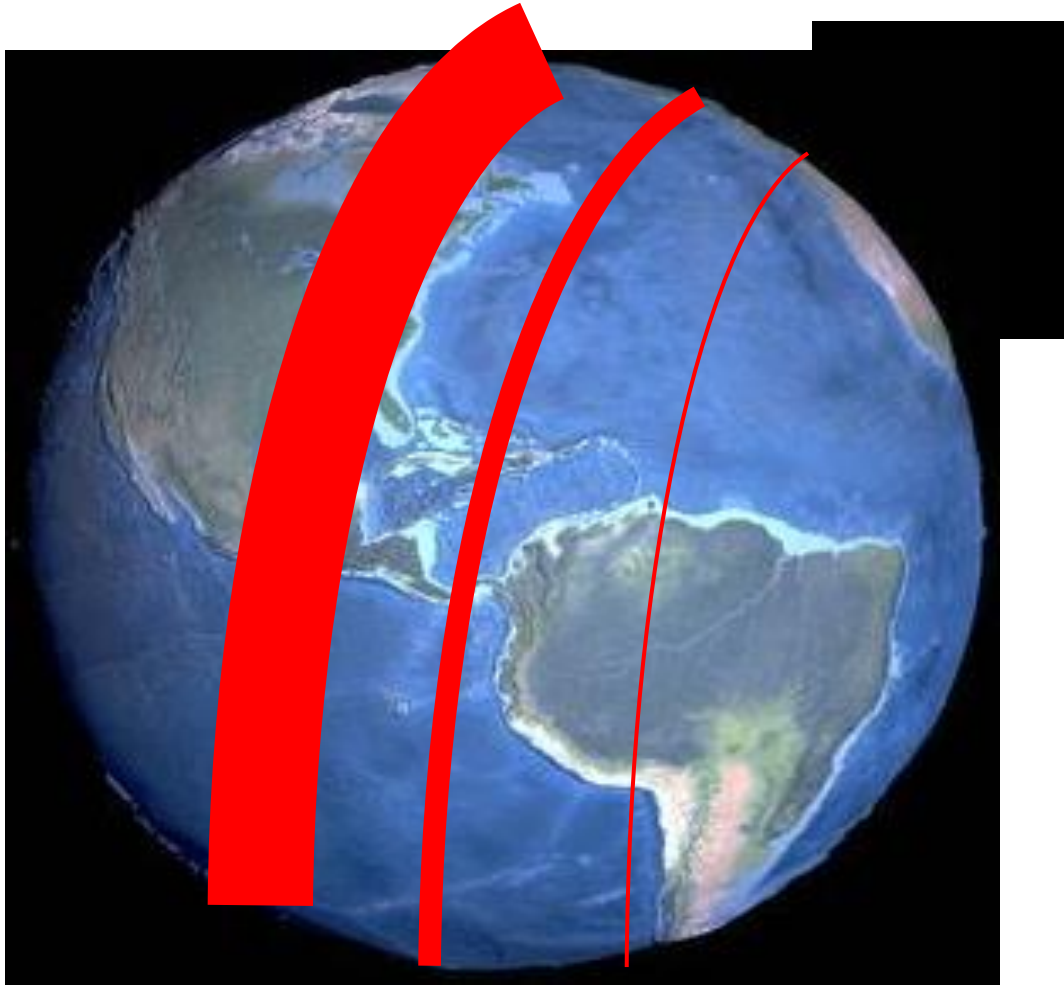
- Amount of time it takes to revisit same place on Earth

- Why does it matter?
  - Coarse vs. fine scale time change analysis
  - Seasonal differences vs. daily differences

Temporal Resolution

Depends on:

- **Orbit**
  - **Close elliptical vs. geostationary**
- **Swath width**



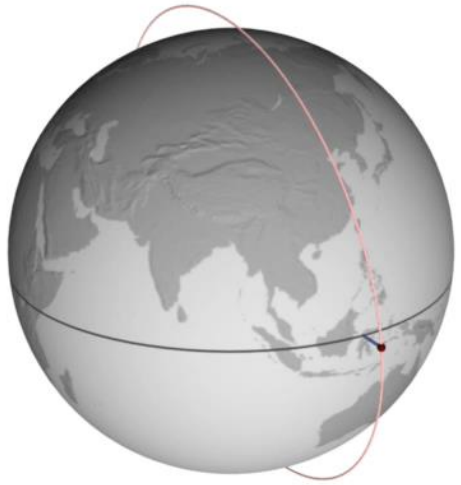
Temporal Resolution

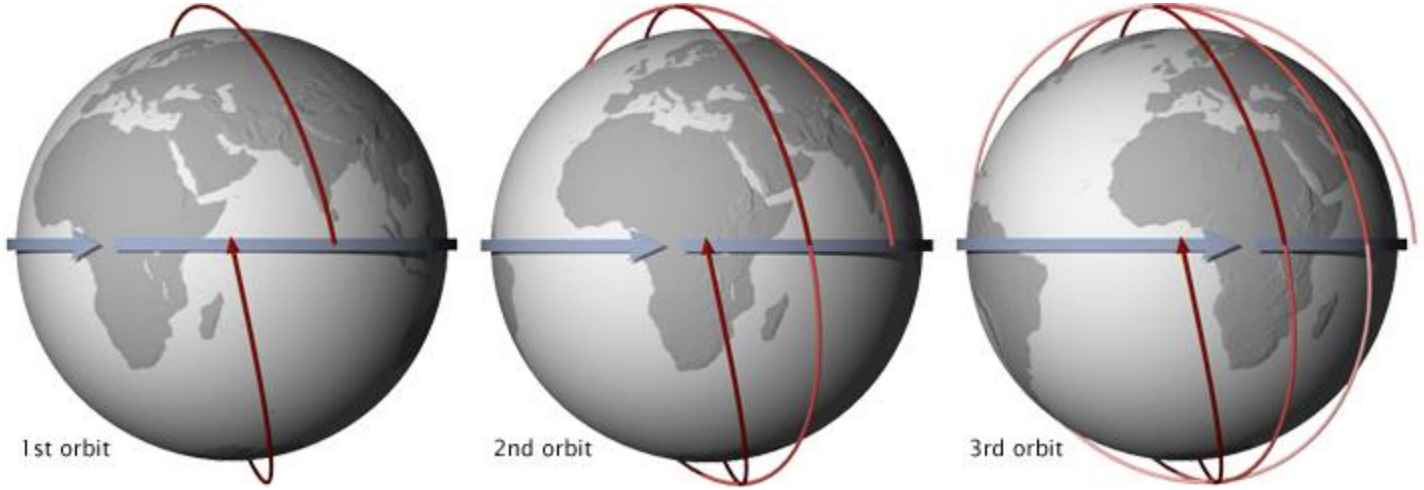
Orbits used in Earth Observation

- Close Elliptical orbits (700-2000km altitude)
  - Polar or near polar orbit
  - Sun synchronous orbit

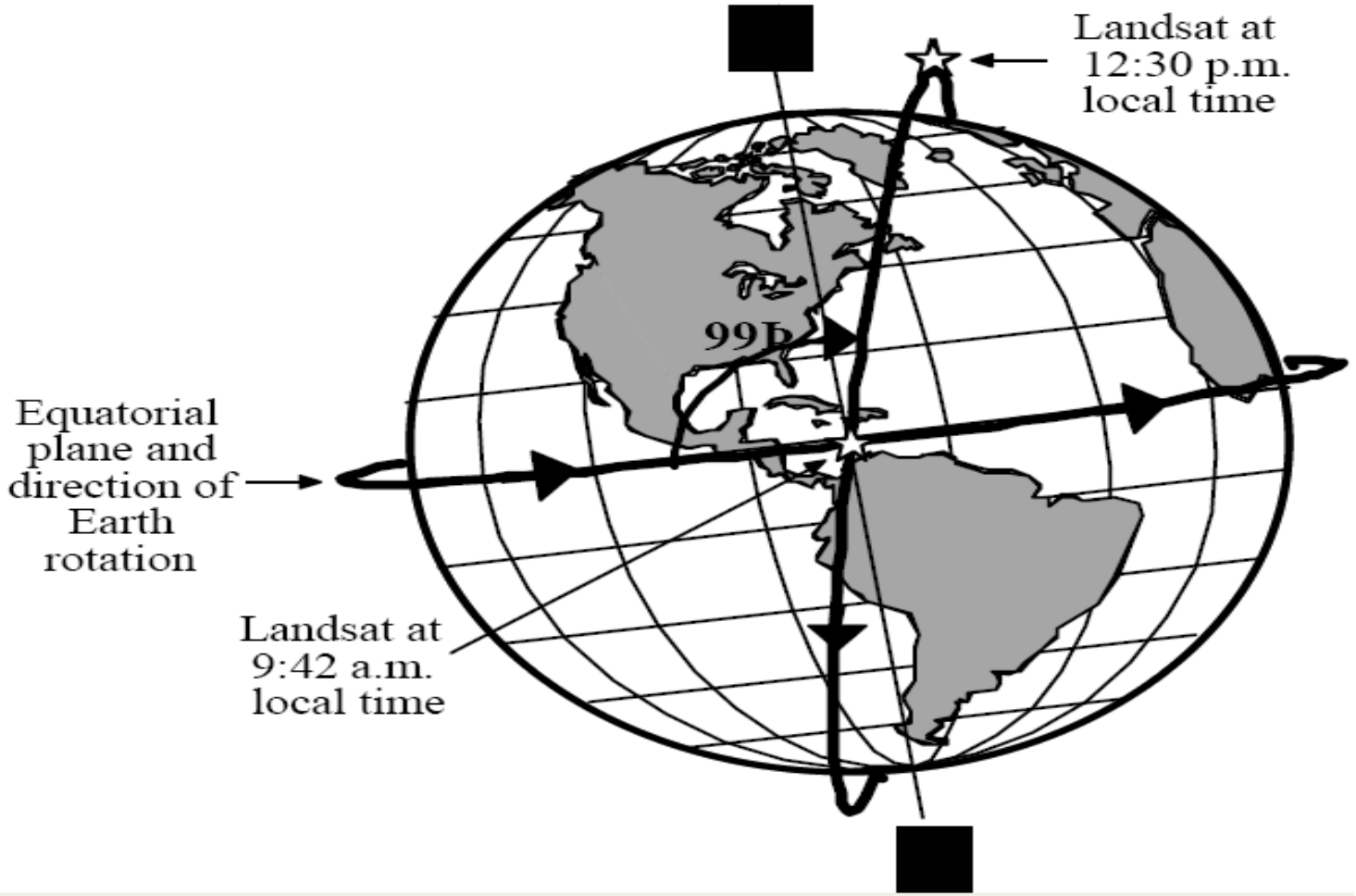
- Geo-stationary
  - Orbit speed matched to rotation of Earth
  - Location static above a geographic location
  - Altitude is 36,000 km above equator

Polar Orbit

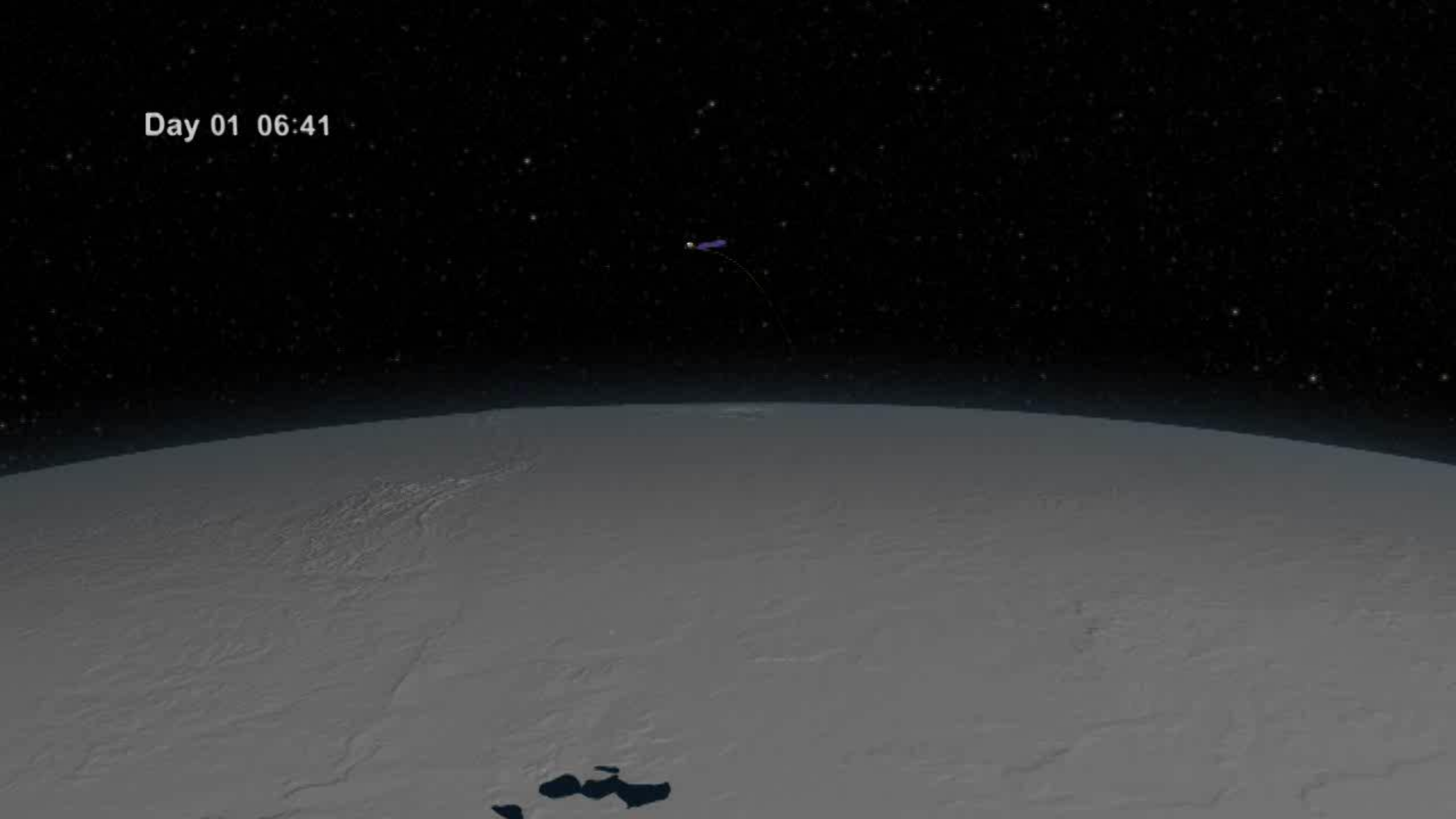




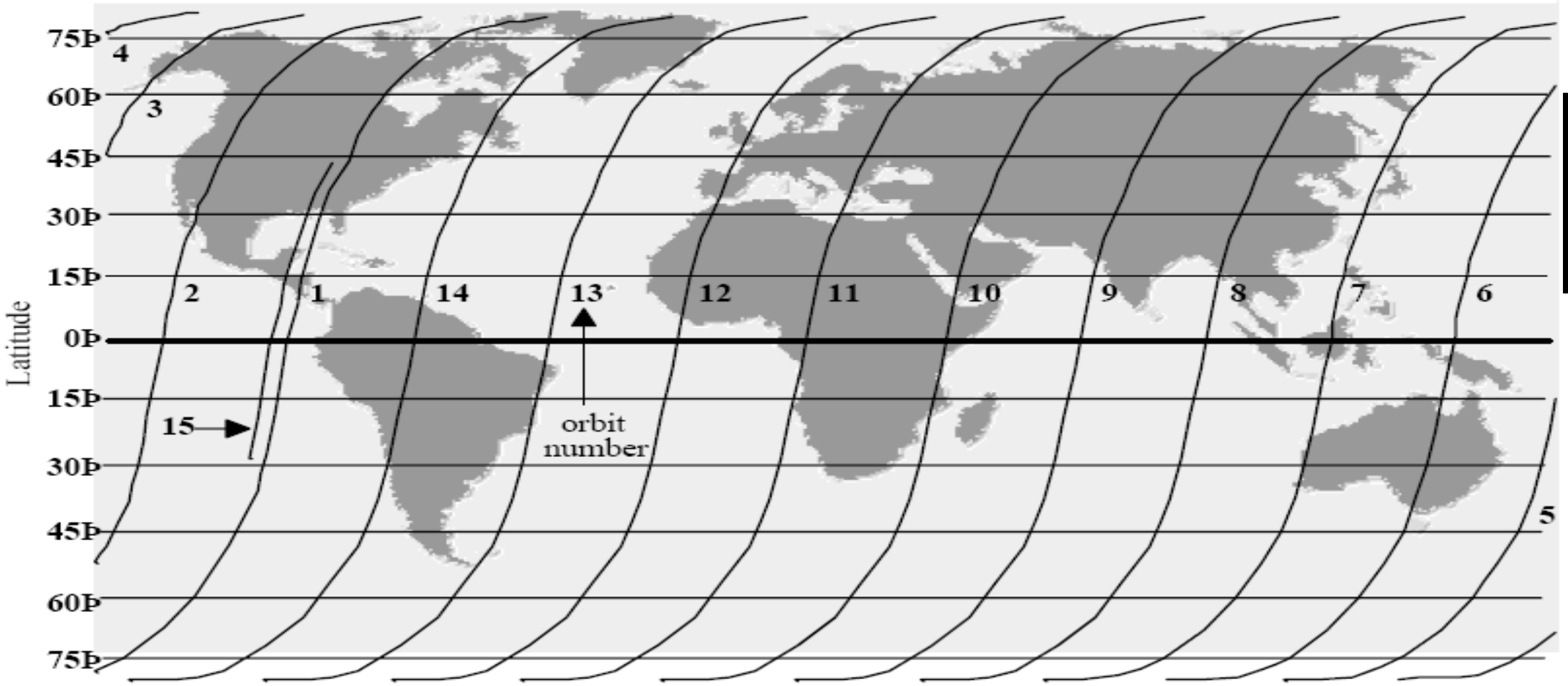
Temporal Resolution



(Jensen 2004)


Day 01 06:41

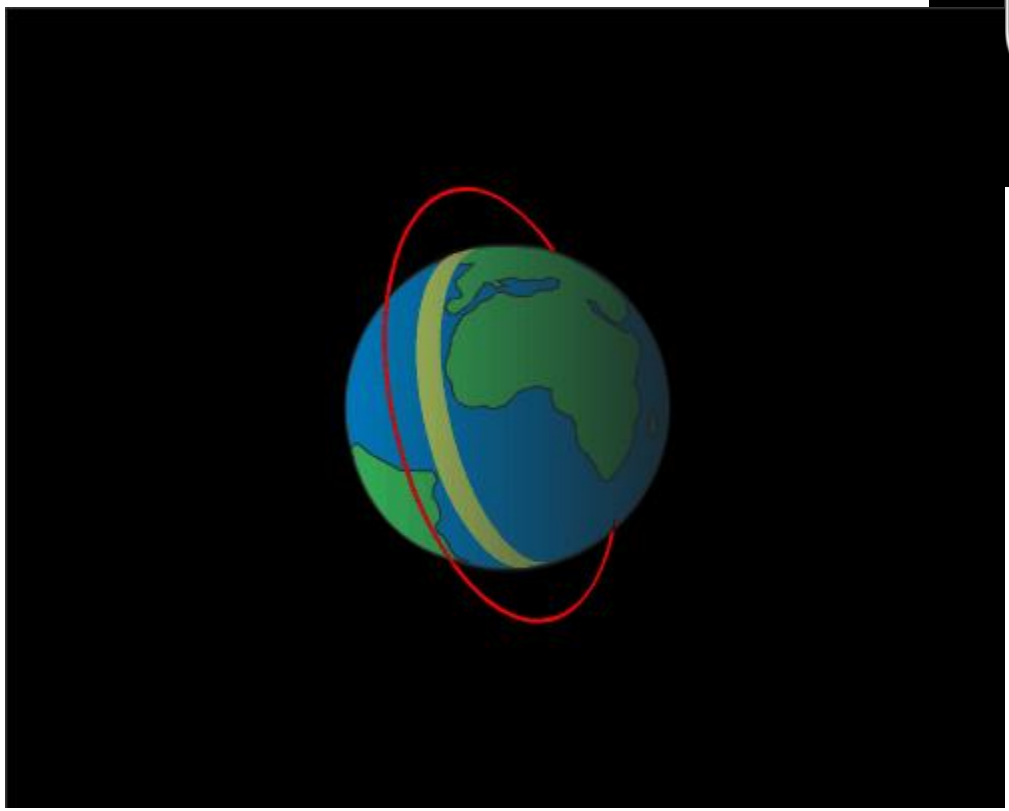
Temporal Resolution



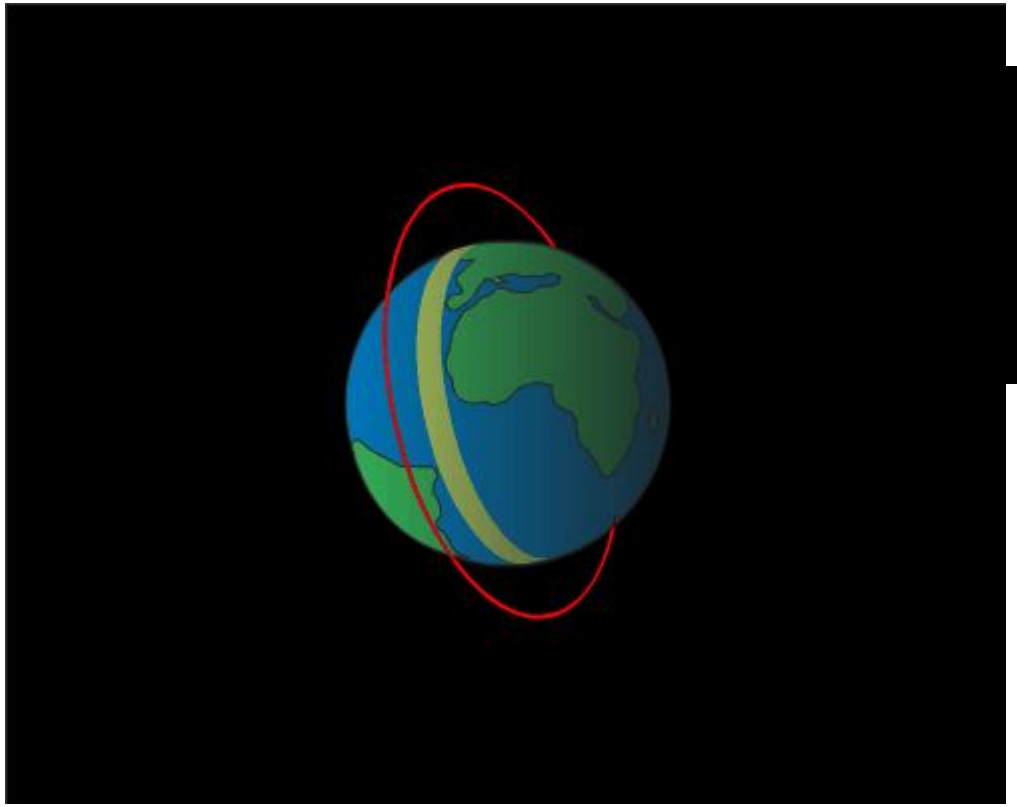
(Jensen 2004)

Sun-synchronous Orbits

- What is the difference between:
  - Close-elliptical orbit
  - Polar orbit
  - Sun-synchronous orbit



Sun-synchronous Orbits



- What is the difference between:
  - Close-elliptical orbit
    - Defined by altitude
    - 700 - 2000km
  - Polar orbit
    - Defined by orientation of orbit
    - Orbit passes over the pole
    - Is near perpendicular to equator
  - Sun-synchronous orbit
    - Passes over the equator the same time each day
      - Landsat passes over the equator between 10-10:30am
    - Passes over any same point on the earth at the same local time

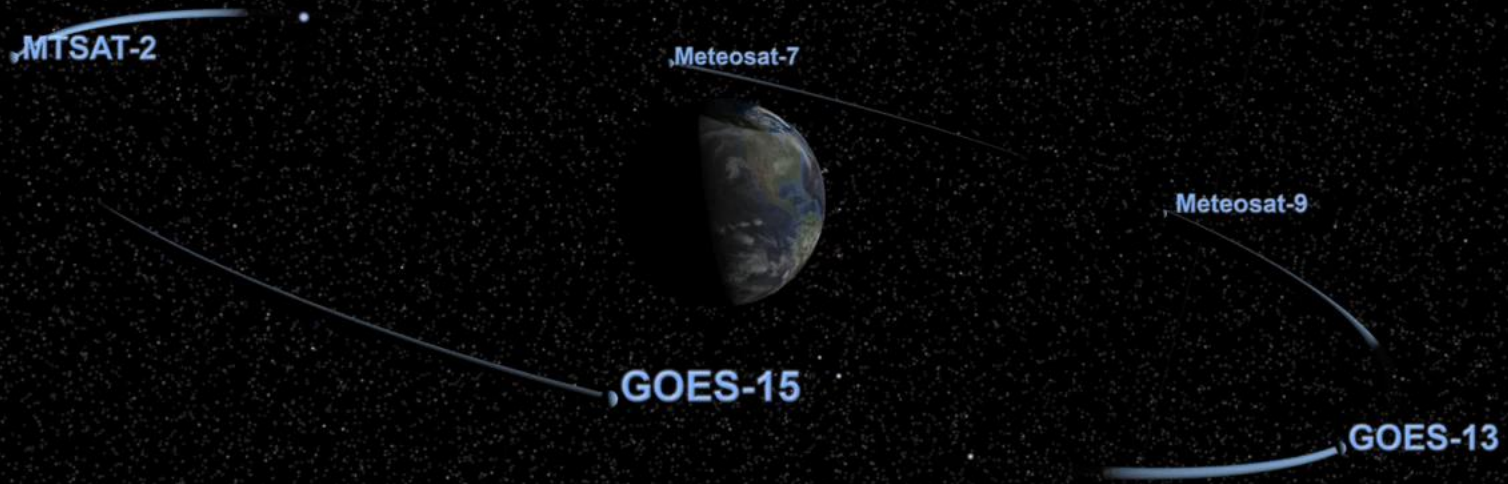
Why a Sun Synchronous Orbit?

Temporal Resolution

Geostationary Orbits

- Weather satellites (ex. GOES)
- Telephone and television relay satellites
- Constant contact w/ground stations
- Limited spatial coverage
  - Each satellite can only cover about 25-30% of the Earth's surface
  - Coverage extends only to the mid-latitudes, no more than about 55 degrees

Temporal Resolution



Important Topics

- What are the three resolutions we discussed that are important in earth observation?
- What are the 3 aspects that we use to describe the spectral resolution of a satellite?
- Describe a sun synchronous orbit:
  - Is a sun synchronous orbit a close-elliptical orbit?
  - Is it a polar/near polar orbit?
  - And ultimately how is it defined?
  - Why is it useful?
- What is the temporal resolution of a satellite in geostationary orbit?