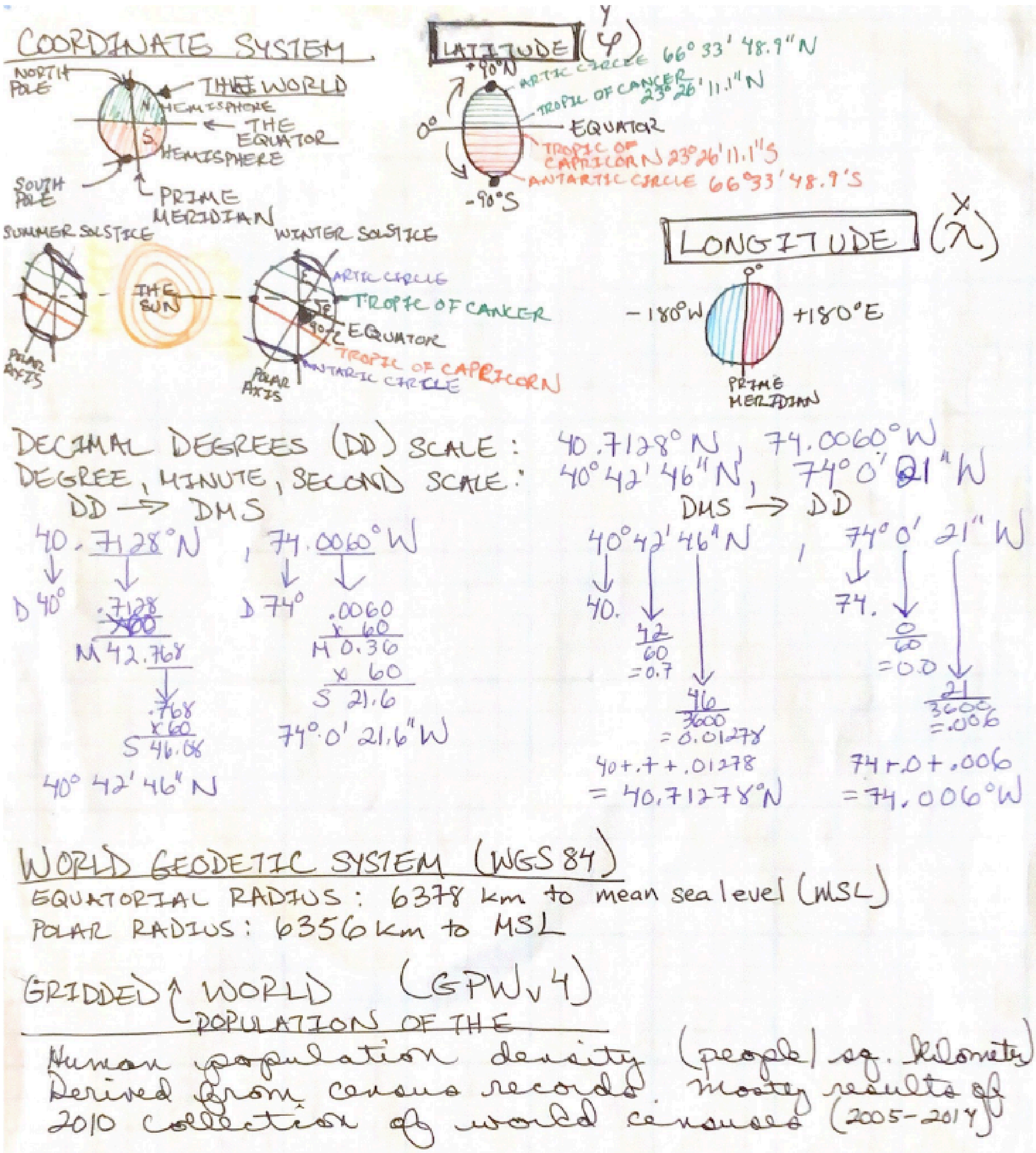
Coordinate Systems



Latitudes - lines that run East-West parallel to each other and perpendicular to the longitude.

- The **equator (0 degrees)** is the latitude that divides the Earth into the Northern and Southern Hemispheres.
- Latitudes north of the equator increase in number from 1 to 90 degrees NORTH until they read the north pole.

- Latitudes south of the equator decrease from -1 to -90 degrees until they reach the south pole.
- **Tropic of Cancer, Tropic of Capricorn, Arctic Circle, and Antarctic Circle** are significant latitudes to consider because they define climate zones based on the amount of sunlight each region receives. The area between the two tropics is called the **Tropical Zone** and gets the most direct sunlight year-round. The climate here tends to be warm and humid with lots of rain.
- The area between the tropics and the polar (i.e., the Tropic of Cancer and the Arctic Circle, and the Tropic of Capricorn and the Antarctic Circle, respectively) is called the temperate zone. It generally experiences all four seasons throughout the year. The area beyond the polar circles is called the polar zone. It receives the least amount of sunlight throughout the year and is typically cold and full of ice.

Longitudes - lines that run North-South parallel to each other and perpendicular to latitude.

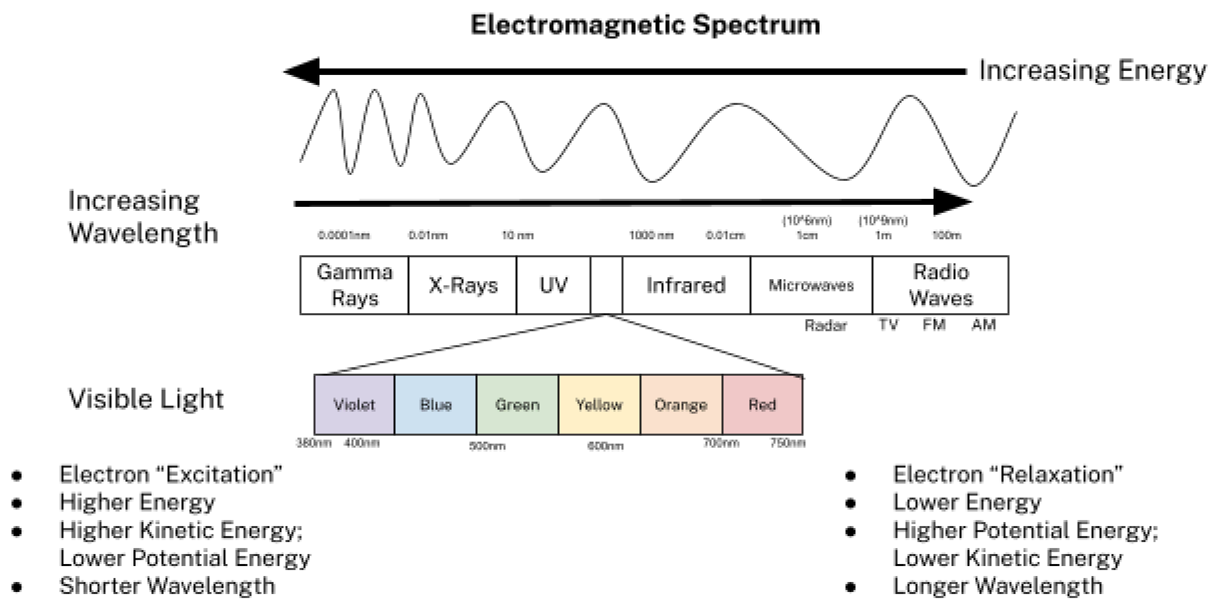
- The central longitude is the Prime Meridian and divides the Earth into Eastern and Western Hemispheres.
- Longitudes east of the Prime Meridian go up in number from 1 to 180 degrees East. Longitudes west of the Prime Meridian go down in number from -1 to -180 degrees West.
- Lines of longitude mark **time zones**.
    - To tell the difference between two times in the world, you just need to count the lines of longitude between them (15 deg = 1 hour, 30 deg = 2 hours, 45 deg = 3 hours, 60 deg = 4 hours).

Fundamentals of Remote Sensing

Remote Sensing - Data collection and analysis about an object, area, or phenomenon via a device not <u>in contact</u> with the object, area, or phenomenon under investigation.

- Remote sensing indices database: https://www.indexdatabase.de/db/i.php

Electromagnetic Radiation (EM) - is a form of energy that is all around us and takes many forms, such as radio waves, microwaves, X-rays, and gamma rays. Sunlight is also a form of EM, but visible light is only a small portion of the EM spectrum, which contains a broad range of EM wavelengths.



<u>Properties of Electromagnetic Radiation</u>

- Wave & particle-like
- Photon is the physical form of a quantum (quantum is a packet of energy)
- Wavelength is the distance from crest to crest
- Frequency is the number of occurrences
- Increase frequency = shorter wavelength
- *Amplitude = height of wave*

<u>Electromagnetic Radiation Interaction (Energy recorded by remote sensor undergoes a number of interactions)</u>

1. Radiated by atomic particles at the source
2. Propagates through the vacuum of space at the speed of light
3. Interacts with Earth’s atmosphere
4. Interacts with Earth’s surface
5. Interacts with Earth’s atmosphere once again
6. Reaches remote sensor (e.g., Satellite)

Passive Sensing [Visible and IR] - *Record* electromagnetic radiation reflected or emitted from terrain (optical and thermal sensors).

Active Sensing [Sensor emits a signal] - *Send* and *record* EM from the terrain. (Radar, LidDAR: Microwave, vis-NIR).

With visible light:

HIGHER ENERGY; SHORTER WAVELENGTH (electron excitation, high kinetic energy, low potential energy)

↓↓

LOWER ENERGY; LONGER WAVELENGTH (electron “relaxation,” low kinetic energy, high potential energy)

Levels of Spectral Info	Visible Light	Wavelength (nm)	Uses
Reflective	Violet	400-450	Illuminates material in shadows; water penetration for bathymetry.
	Blue	446-500	
	Green	500-578	Water penetration for bathymetry; discriminates oil on water.
	Yellow	578-592	
	Orange	592-620	Vegetation differentiation
	Red	620-700	
Emissive	NIR	700-1100	Camouflage detection; shoreline mapping; vegetation analysis
	SWIR	1100-3000	Discrimination of oil on water; snow/cloud differentiation; change detection; camouflage detection; plume detection; explosion detection
	MWIR	3000-5000	Nighttime target detection; ocean temperature analysis; daytime reflected/emitted analysis; thermal analysis; nighttime thermal analysis; smoke penetration
	LWIR	5000-14,000	Thermal analysis; vegetation density and ***; mineral & soils

Infrared (IR)

- Reflected IR: 0.7-3.0um
- Thermal Bands at 3-5um & 8-14um

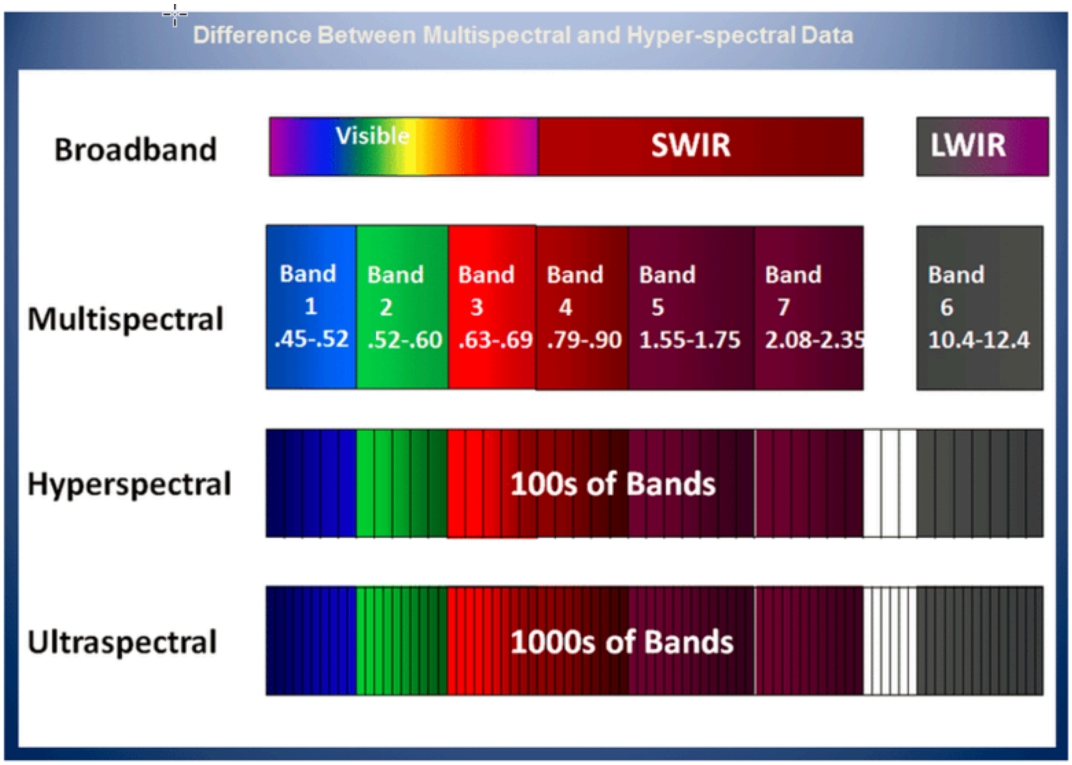
Spectral Signatures - Patterns for a particular material in the form of a graph showing the percentage of radiation of different wavelengths reflected from an object.

Multispectral

- Collection of reflected, emitted, or backscattered energy from an object or area of interest in multiple bands (regions) of the electromagnetic spectrum.
- Each pixel has several "large" discrete spectral bands.

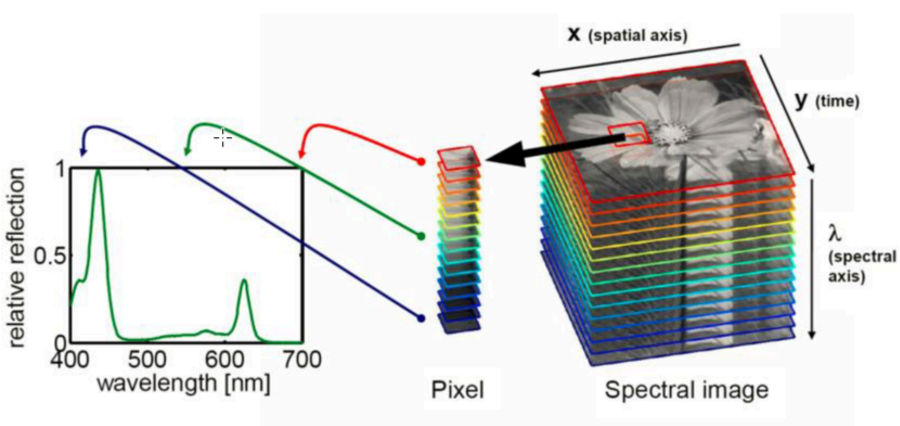
Hyperspectral

- Data collection in hundreds of bands
- Each pixel has many "small" continuous spectral bands

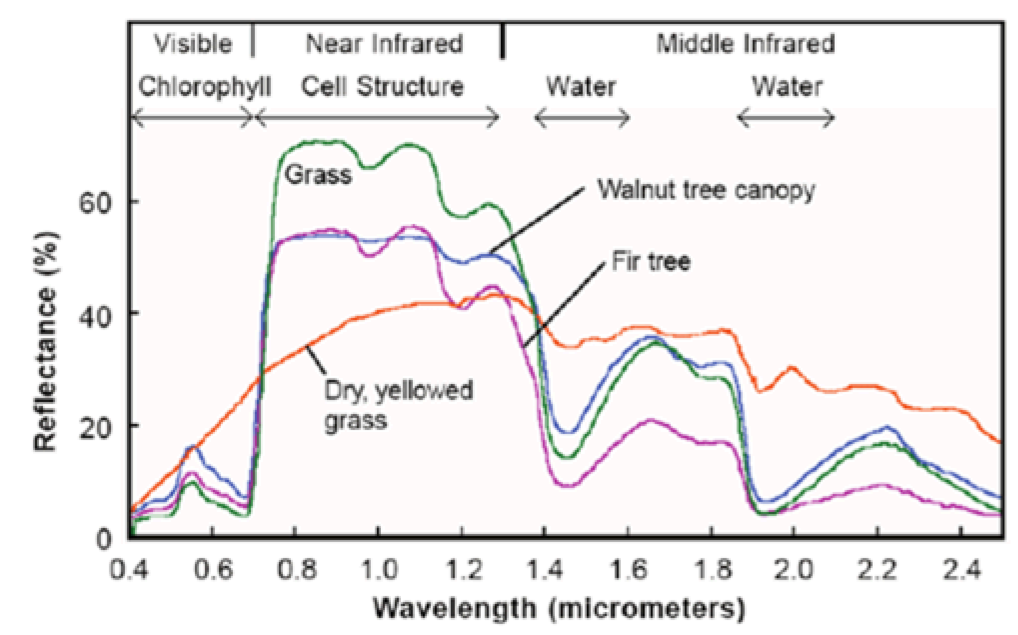


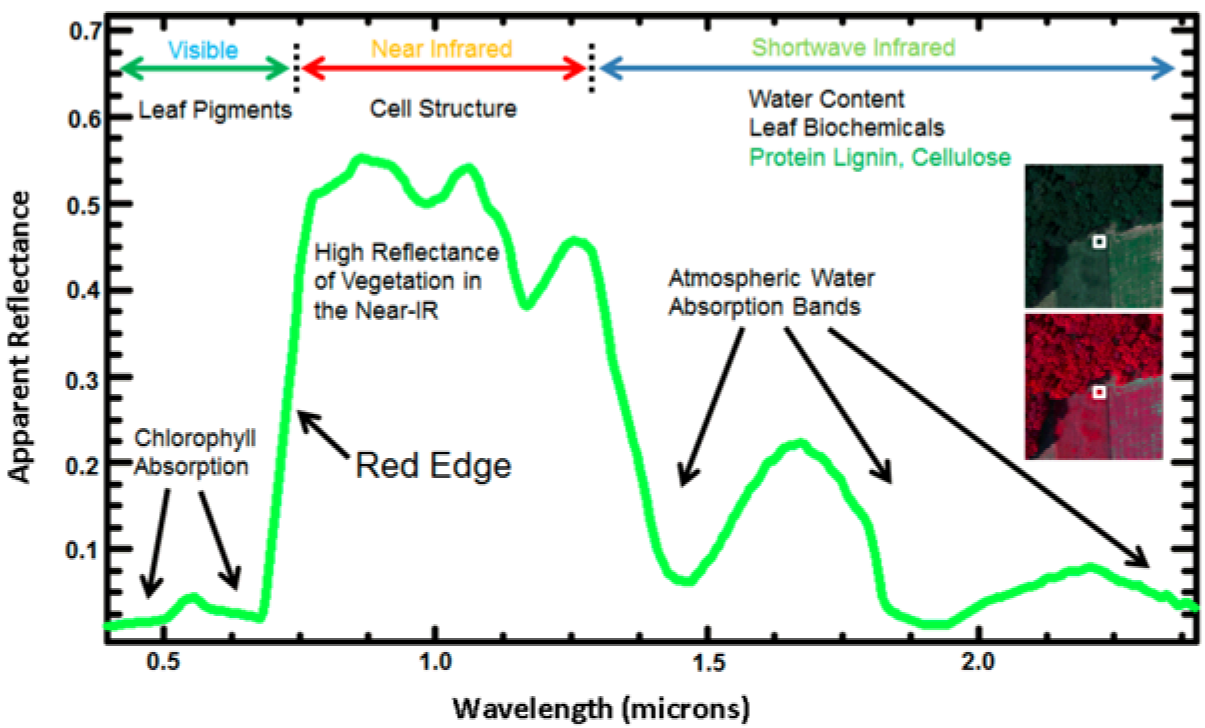
Hyperspectral Cube

- 224 bands (images), each of the 224 sensors collects the same area, a series of sensor frames



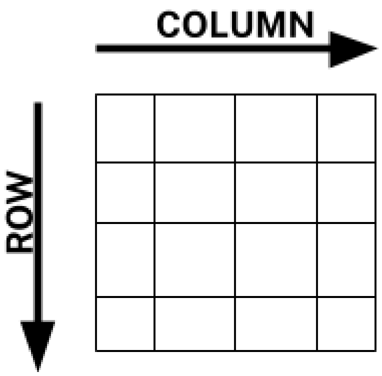
Sample Spectral Signatures





Instantaneous Field of View (IFOV) -the maximum angle of view in which the sensor can effectively see EM radiation.

Image - is a 2D representation of objects in a real scene
Analog Images - are aerial photographs from an airplane using a normal camera
Digital Images - are satellite images acquired using electronic sensors (2D array of pixels)



Digital Number (DN) Pixels & their latitude (Y) and longitude (X)

- Also called Brightness Value or intensity Value
- Represents measures solar radiance in a given wavelength band reflected from the ground, emitted infrared radiation, or backscattered rada intensity
- Each pixel in an image has its own digital number
- Example: 8-bit image
  - DN values range from 0-255
  - 0 = dark pixel/black
  - 255 = light pixel/white
- Greyscale represents a single-band
- RGB images can display three bands
- A computer can only display a multilayer image (Red+Green+Blue) for a combination of 3 bands.
- Each band can be assigned a color.
- The color chosen for a band (RGB) does not indicate the band wavelength. Any color can be assigned to a band.
- Colors on a computer for an 8-bit image
  - Red - 256 shades
  - Green-256 shades
  - Blue-256 shades
- You need to know the number of bits to calculate the number of shades or DN values in a satellite image.
  - The number of Shades = $2^{\text{bit depth}}$ (e.g., $2^8 = 256$)

BIT DEPTH OF IMAGE	DN VALUES	NUMBER OF SHADES
8-bit	0-255	256
12-bit	0-4095	4096

Data Visualization

- A DN has no intrinsic visual display meaning to the computer
- Lower pixel values are displayed as dark, and higher pixel values are displayed as bright.
- The number of image bands is unlimited, but the number a monitor can display at once is limited.
- Histogram - a diagram showing the distribution of the number of pixels, or frequency, with DN in an image

Stretching DN Values

- Enhancement, altering DN values to show better variation in the image
- Features will not be lost but amplified
- No Stretch → Keeps DN values the same between 0-255
- Linear Stretch → Sets the data min and max to values of 0 and 255 and stretches all other values between linearly
- Linear 5% Stretch → lowest and highest 5% DN values set to 0 and 255, stretches values between linearly
- Equalization Stretch → Emphasizing and stretching the larger part of the histogram. May condense values that are not as important

Three Color Composite

- It uses the visible red band, visible green band, and visible blue band channels to create an image that is very close to what a person would expect to see in a photograph.
    - Red Band → displayed as Red
    - Green Band → displayed as Green
    - Blue Band → displayed as Blue

Near-Infrared Composite

- Eliminates the blue band and uses a NIR band to produce an image
    - Red Band → displayed as Red
    - Green Band → displayed as Green
    - NIR Band → displayed as Blue

Sensor Resolution

- *Pixel Band*
    - Spatial Resolution - the size of the field of view or pixel size (e.g., 10x10m, 30x30m)
        - High Spatial Resolution = Small Pixel Size (1cm, 1m) = More detail
        - Low Spatial Resolution = Large Pixel Size (30m, 5m) = Less detail
    - Spectral Resolution-number and size of spectral regions the sensor records data in (e.g., 4 band sensor, each band has a 20nm width vs. 6 band sensor at 2nm width)
        - Higher Spectral Resolution = Means band only covers a few nanometers
- *Time Sensitivity*
    - Temporal Resolution - how often the sensor acquires data (e.g., Every 16 days.)
- *Radiometric Resolution*
    - The sensitivity of detectors to small differences in electromagnetic energy. (In other words, how many different grey levels there are.)
    - The smallest change in intensity level that can be detected by the sensing system.
        - E.g., A 12-bit sensor has a higher radiometric resolution than an 8-bit (256 pixels) sensor. 12-bit (4096 pixels) has more “color shades.”

Energy

How Energy is Transferred

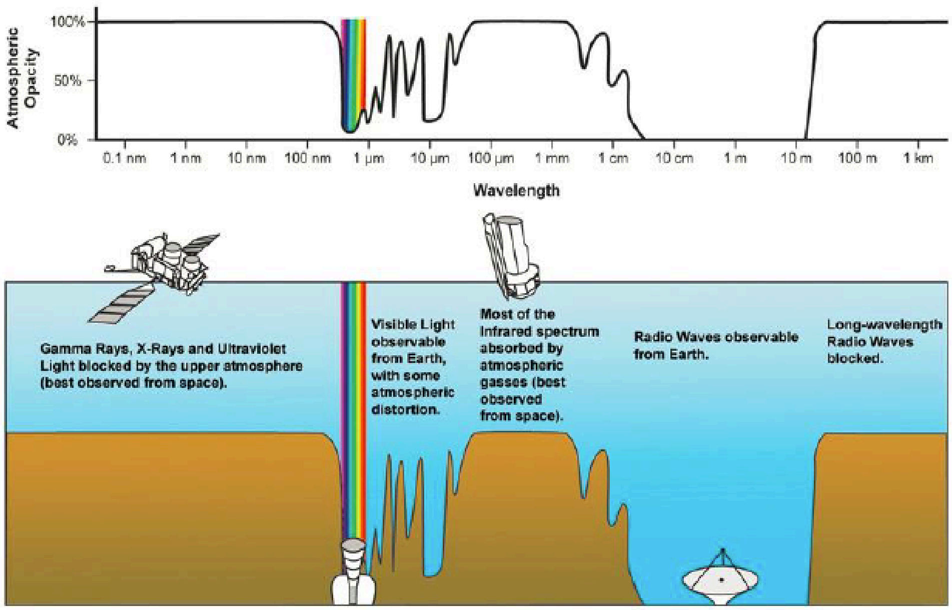
- Conduction (Direct Contact): Collisions between atoms and molecules
- Convection (Vapor): When a portion of a fluid is less dense, it rises due to gravity
- Radiation: Emission of energy in the form of waves or particles

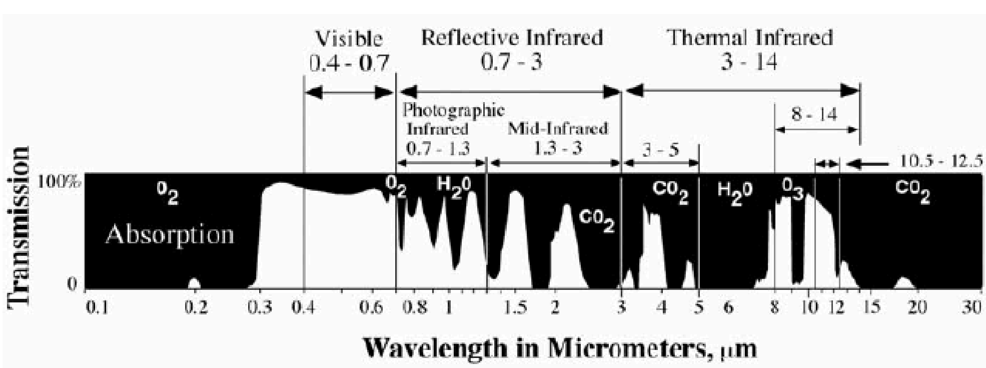
Atmospheric Windows

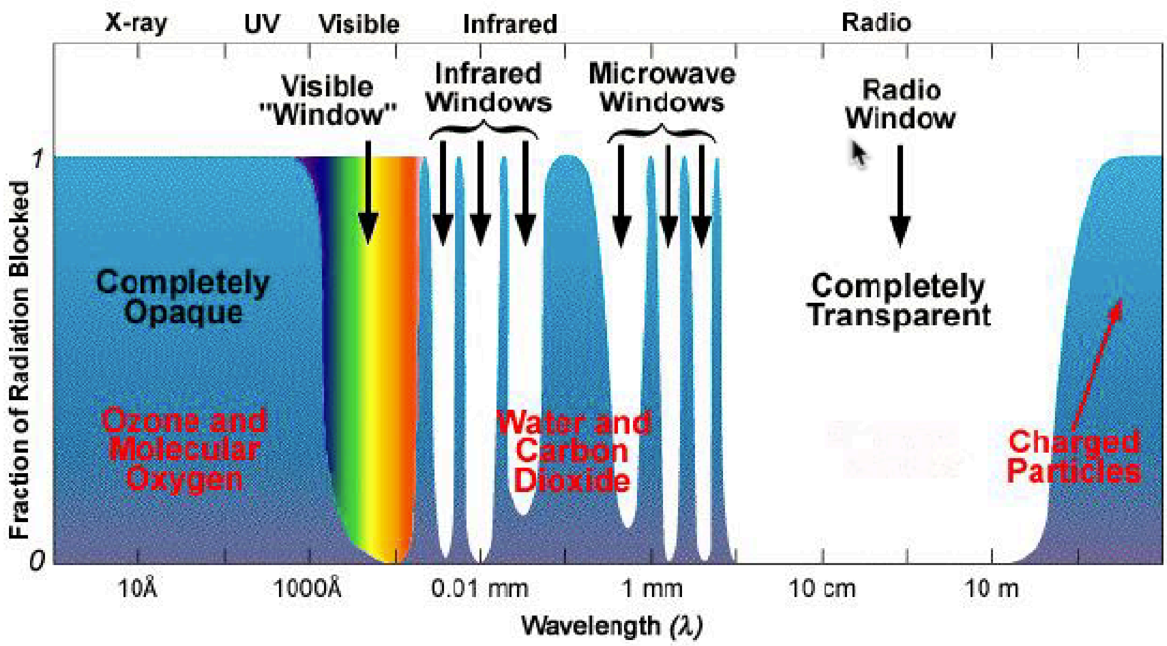
- Wavelengths that do not get absorbed by particles
- Particles don't absorb every wavelength
- These wavelengths can make it to sensors

Absorption

- Occurs when energy of the same frequency as the resonant frequency of an atom or molecule is absorbed, producing an excited state
- If instead of re-radiation a photon of the same wavelength, energy is turned into heat







Scattering - The direction of EM radiation is unpredictable, whereas the direction of reflection is predictable. Type of scattering is a function of

- Wavelength of incident radiant energy
- Size of the gas molecule/dust particle

Types of Scattering:

1. **Rayleigh**
    a. Specks of dust, N_2, and O_2 molecules
    b. Strongly wavelength-dependent (Shorter wavelengths are more affected.)
    c. The diameter of the matter is many times smaller than the wavelength of incident EM radiation.
2. **Mie** (White glare around the sun)
    a. Dust, pollen, smoke, and water droplets, lower 4.5km of the atmosphere
    b. Weakly wavelength-dependent
    c. Spherical particles with diameters about equal to the size of the wavelength of incident energy
3. **Non-Selective**
    a. Larger water droplets, large particles of airborne dust, >10 times the diameter of wavelength
    b. Wavelength-independent

Rayleigh Scattering - The amount of scattering is inversely related to the 4th power of the radiation's wavelength.

- Responsible for the blue sky (Blue light (0.4um) is scattered 16x more than NIR light (0.8um)
- Short violet and blue wavelengths are more efficiently scattered than the longer orange and red wavelengths.

- Responsible for red sunsets
    - Sunlight must pass through a longer slant path of air at sunset or sunrise than at noon.

Transmittance-Ratio of light energy falling on a body to that transmitted through it.

Absorption
- The process by which radiant energy is absorbed and converted into other forms of energy.
- That energy can then be emitted.

Reflectance
- Process whereby radiation “bounces off” an object like the top of a cloud, waterbody, or terrestrial Earth.
- Re-radiation of photons in unison by atoms or molecules in a layer of approximately one-half wavelength deep

Specular Reflection
- When the surface from which the radiation is reflected is essentially smooth (e.g., Calm waterbodies)
- Mirror type surface

Diffuse Reflection
- Reflected rays go in many directions.
- The surface has a large surface height relative to the size of the wavelength of the incident energy.
- Produces diffused radiation
- Lambertian Surface - radiant flux leaving the surface is constant for any angle of reflectance.

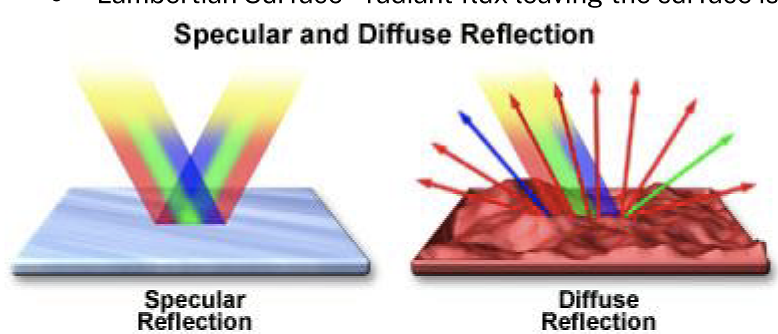
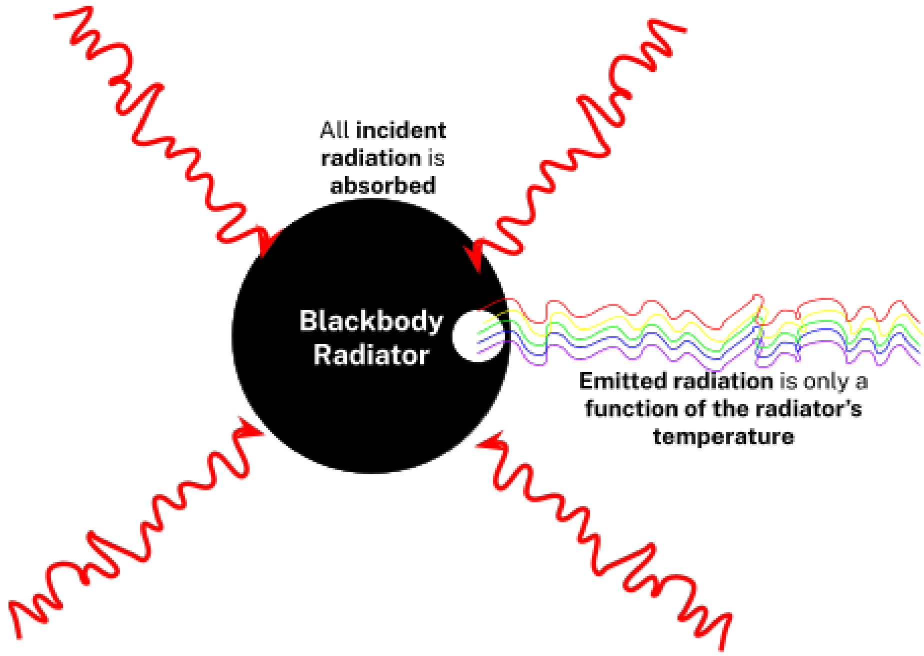


Figure 1

Bidirectional Reflectance Distribution Function (BRDF) - One direction comes in, but different directions can come out

Blackbody Radiation



- A theoretical construct that absorbs and radiates energy at the maximum possible rate per unit area at each wavelength per given temperature.
- The amount of energy emitted by an object, such as the Sun or Earth, is a function of its temperature. The greater the temperature, the greater the amount of radiant energy exiting the object.
- Absorption and emission in balance.
- As the temperature of an object increases, its dominant wavelength shifts toward the shorter wavelengths of the spectrum.

Plank's Law

- Describes the electromagnetic radiation emitted by a blackbody in thermal equilibrium at a definite temperature.
- The SI unit B(v, T) is $W \cdot sr^{-1} \cdot m^{-2} \cdot Hz^{-1}$

$$B(\nu, T) = \frac{2h\nu^3}{c^2} \frac{1}{e^{\frac{h\nu}{k_B T}} - 1}$$

c = speed of light (3×10^8 m/s)
v = frequency (wavelength of radiation)
T = Temperature
h = Plank's Constant (6.67×10^{-34} J s)
K = Boltzmann Constant ($1.3806503 \times 10^{-23}$ m^2 kg s^{-2} K^{-1})
B = emitted monochromatic intensity in a cavity with a temp T (spectral radiance)

Wien's Law or Wien's Law of Displacement

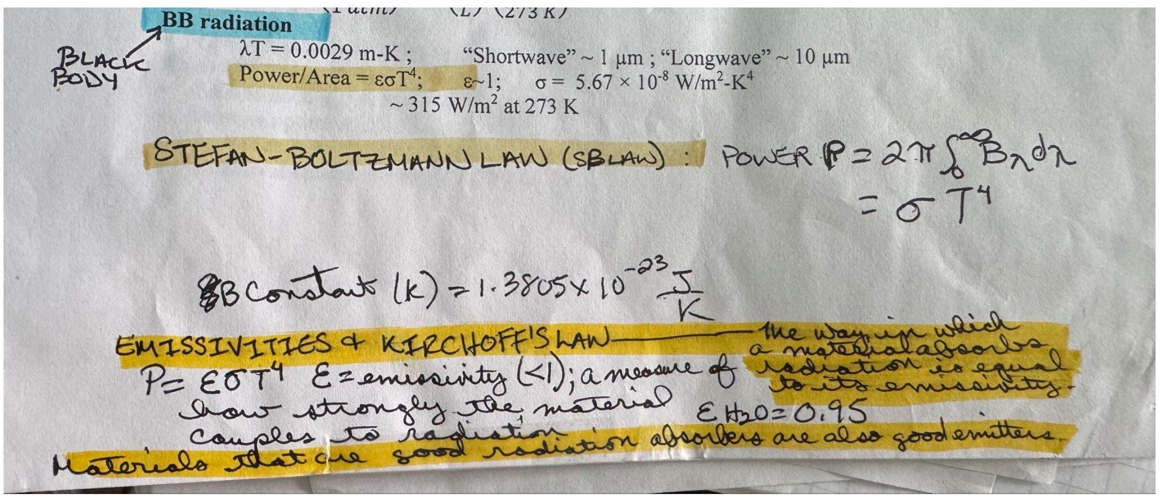
- States that the blackbody radiation curve for different temperatures peaks at a wavelength inversely proportional to the temperature.
- As objects become hotter, the wavelength of maximum emittance (emitted radiance) shifts to shorter wavelengths.
- Wien's constant b = 2.8978 x10^{-3} m K

$$\lambda = \frac{b}{T}$$

λ = wavelength (μm) at which radiance is maximum
T = Absolute Temperature in Kelvin

Stefan-Boltzmann's Law

- The total radiant heat energy emitted from a surface is proportional to the 4th power of its absolute temperature.
- Hot blackbodies emit more energy per unit area than cold blackbodies do.



Kirchoff's Law

- Blackbody–object that absorbs all incident radiation. None is reflected.

$$\varepsilon = \frac{M}{M_b}$$

ε = emissivity → measure of the effectiveness of an object as a radiator of EM energy
M = emittance of a given object (emitted irradiance)
M_b = emittance of a blackbody

Radiant Energy Conservation Law: Absorption + Reflection + Transmission = Incoming Radiation

Cosine's Law

- The amount of energy in direct beam of irradiance is strongly affected by the angle between the surface and the beam.
- Angle of energy coming in affects the energy coming out.

Radiant Energy - Total radiation energy
Radiant Flux - Radiant energy per unit time
Radiant Flux Density - Radiant flux per unit surface area
Irradiance - Radiant flux density refers to fluxes to or from (exitance) a flat surface in all directions
Radiance - Radiant flux density per unit solid angle. Refers to fluxes to or from a surface in a specific direction
Spectral Reflectance - Radiant flux per unit wavelength

Vegetation

$$6\ CO_2 + 6\ H_2O \xrightarrow{sunlight} C_6H_{12}O_6 + 6\ O_2$$

Carbon Dioxide   Water   Glucose (Energy)   Oxygen

Structure of a Leaf
- Red and blue light largely absorbed for use in photosynthesis
- Green is reflected
- High reflectance of infrared (NIR) light
- Water in the atmosphere and water in the leaf can cause dips in reflectance in IR region
- Lake water absorbs a lot of NIR
- Water in the leaf absorbs NIR

Species Identification
- Spectral reflectance differs between plants due to:
    - Cellular differences (protein, cellulose, lignin, water, pigments)
    - Leaf Area Index (LAI), leaf angle, leaf shape differences
    - Trunk, stem, and branch differences
    - Crown size and shape

Red Edge Shift (see charts on page 6 for more details)
- Shift in the location of a turning point on the red edge feature in the spectral signature, which is characteristic of vegetation canopies that can be related to leaf stress.

Vegetation Indices
- Reduction in the BRDF effect
- Generally, a ration (Band A / Band B)
- The inverse relationship between vegetation brightness in the red and NIR regions. The NIR/Red ratio is important.
- Indices are dimensionless, radiometric measures that indicate relative abundance and activity of green vegetation, including LAI, and % green color.

Ratio Based Indices - vegetation indices based on the ratio of two or more radiance, reflectance, or DN values.

Difference Indices

- Vegetation indices based on the difference between the spectral response of vegetation and the soil background.

Simple Ratio (SR)

- Ratio of red spectral band to NIR band
- $SR = \frac{Red}{NIR}$

NDVI

- Normalized Difference Vegetation Index
- $NDVI = \frac{NIR - Red}{NIR + Red}$
- Serves as a measure of greenness
- Unitless
- Values range from -1 to 1 (-1 meaning poor health, 1 meaning good vegetation health)
- Dense vegetation cover: absorption in red increases and reflectance decreases (NDVI close to 1)
- Lower NDVI: degraded vegetation cover
- Used as a method of estimating net primary production

Advantages of Vegetation Indices

- Maintains a proportional relationship to LAI, canopy cover, and biomass.
- Simplicity of implementation.
- Low computational cost.
- Reduction in data volume.
- Fast estimate.

Disadvantages of the Classical Vegetation Index

- Sensitivity to the particular sensor used.
- Not a measurable geophysical product.
- There is no clear definite meaning of interpretation.
- The values are difficult to compare if locations are separated by large distances.

Leaf Area Index (LAI)

- The total one-sided green leaf area per unit ground surface area.

Net Primary Productivity

- Used to quantify the net carbon absorption rate by living plants.
- Photosynthesis Rate - Respiration Rate
- Measure of plant growth

Boreal Ecosystem Productivity Simulator - Developed to mimic plant growth.

Histogram - A diagram showing the distribution of the number of pixels, or frequency, with a digital number in an image.

Additional Vegetation Indices

Vegetation Indices	
DVI, Difference Vegetation Index (Tucker, 1979)	NIR - red
GDVI, Green Difference Vegetation Index (Sripada et al., 2006)	NIR - green
GNDVI, Green Normalized Difference Vegetation Index (Buschmann and Nagel, 1993)	(NIR - green) / (NIR + green)
NDVI, Normalized Difference Vegetation Index (Rouse, 1973)	(NIR - red) / (NIR + red)
NG, Normalized Green (Sripada et al., 2006)	Green / (NIR + red + green)
NR, Normalized Red (Sripada et al., 2006)	Red / (NIR + red + green)
NNIR, Normalized Near Infrared (Sripada et al., 2006)	NIR / (NIR + red + green)
RVI, Ratio Vegetation Index (also known as the Simple Ratio) (Birth and McVey, 1968)	NIR / red
GRVI, Green Ratio Vegetation Index (Sripada et al., 2006)	NIR / green
Atmospherically Resilient Vegetation Indices	
GARI, Green Atmospherically Resilient Index (Gitelson et al., 2002)	NIR - [green-(blue-red)] / NIR[green-(blue-red)]
GEMI, Global Environmental Monitoring Index (Pinty and Verstraete, 1992)	$\eta \times (1 - 0.25 \times \eta) - [(red - 0.125) / (1 - red)]$, where $\eta = [2 \times (NIR^2 - red^2) + 1.5 \times NIR + 0.5 \times red] / (NIR + red + 0.5)$
VIgreen (VIg), Vegetation Index Green (Gitelson et al., 2002)	(green - red) / (green+red)

VARIgreen (VARIg), Vegetation Index Green (Gitelson et al., 2002)	(green - red) / (green+red - blue)
Soil-Adjusted Vegetation Indices	
EVI, Enhance Vegetation Index (Liu and Huete, 1995)	$G \times [(NIR - red)/(NIR + C1 \times red - C2 \times blue + L)]$, where G = 2.5, C1 = 6, C2 = 7.5, L=1
MSAVI2, Modified Soil Adjusted Vegetation Spectral Index (Equation 19 in Qi et al., 1994)	$[2 \times NIR + 1 - \sqrt{(2 \times NIR + 1)^2 - 8 \times (NIR - red)}]/2$
OSAVI, Optimized Soil Adjusted Vegetation Index (Rondeaux et al., 1996)	$[(NIR - red)/(NIR + red + L) \times (1 + L)$, where L is a correction factor that equals 0.16 (the same equation as SAVI but with a correction factor of 0.16 instead of 0.5)
SAVI, Soil Adjusted Vegetation Index (Huete, 1988)	$[(NIR - red)/(NIR + red + L) \times (1 + L)$, where L= 0.5, a correction factor which ranges from 0 for very high vegetation cover to 1 for very low vegetation cover. The most typically used value is 0.5, which is for intermediate vegetation cover, and that is the value used here.
GSAVI, Green Soil Adjusted Vegetation Index (Sripada et al., 2006)	$[(NIR - green)/(NIR + green + L)] \times (1 + L)$, where L=0.5
TSAVI, Transformed Soil Adjusted Vegetation Index (Baret et al., 1989)	$[a(NIR - a \times red - b)]/[a \times NIR + red - (a \times b) + X(1 + a^2)]$, where a = slope of the soil line, b = intercept of the soil line, X = 0.8 (adjustment factor with this value is in the original paper); the median soil line values reported in (Baret and Guyot, 1991) are a=1.2 and b=0.04

Remote Sensing Indices Database https://www.indexdatabase.de/db/i.php
Includes vegetation, minerals, and more.

Earth Observation (EO)

Earth's Radius = 6000 km

Satellite Platforms:

- 100s to 10s of thousands of kilometers from the earth's surface.
- Traveling at 10s of thousands of km/hr.
- Cover swaths of 100s to 1000s of kilometers.
- Earth observations: temperature, vegetation, lights, topography, oceans, atmosphere

Low Earth Orbit (LEO)	180-2000km	Observations
Medium Earth Orbit (MEO)	2000-35,786km	Navigation
Geosynchronous Earth Orbit (GEO)	35,786km	
High Earth Orbit (HEO)	>35,786km	Weather & Communications
Sun Synchronous (SS)		

Orbit	**Satellite (Year)**	**Active or Passive**	**Spectral Bands (Wavelength)**	**Resolution (Spatial | Temporal)**	**Purpose**
233 km (LEO)	Shuttle Radar Topography Mission, USA SRTM (2000)	Active	Band for A: C+X C (5.6 cm) X (3.1 cm)	Spatial: 30 m plan, 10 m vertical Temporal: 12-day mission	Digital Terrain Model (DEM)
514 km (LEO/SS)	TerraSAR-X, German Aerospace Center (DLR) (Launched 2007, Data 2014)	Active	31 mm Band for A: X	Spatial: 1m -(10)30,90m Temporal: 11 days	Digital Surface Model (DSM) Change Detection
514 km (LEO/SS)	National Agricultural Imagery (NAIP)	Passive	31 mm	Spatial: 1m Temporal: every 3-5 days	NDVI
622 km (LEO/SS)	World View 3, USA (Launched 2014, Data 2015)	Passive	0.4-1.0 nm	Spatial: 1.24 m Panchromatic: 0.34m	Settlement
692 km (LEO/SS)	Advanced Land Observation Satellite, Japan ALOS (2006-11)	Active	Panchromatic (0.52-0.77nm) Band for A: L	Spatial: 2-30 m plan, 5 m vertical	Digital Surface Model (DSM)
693 km (LEO/SS)	Sentinel-1 (Copernicus, European Space	Active	3.75-7.5 cm Band for A: C	Spatial: 10 m Temporal: 12 days	Digital Surface Model (DSM)

Orbit	Satellite (Year)	Active or Passive	Spectral Bands (Wavelength)	Resolution (Spatial | Temporal)	Purpose
	Agency) (Launched & Data 2014)				
693 km (LEO/SS)	LIDAR USGS	Active	3.75-7.5 cm	Spatial: 10 m	Digital Terrain Model (DEM)
694 km (LEO/SS)	SPOT-7 (Launched & Data 2014)	Passive	0.45-0.9 um	Spatial: 6 m Panchromatic: 1.5 m	Settlement, Change
701 km (LEO/SS)	Landsat 8/OLI +TIRS, USA (Launched & Data 2014)	Passive	0.4-12.5 um (9 spectral bands)	Spatial: 30 m Temporal: 16 days	Surface Temperature
705 km (LEO/SS)	Moderate Resolution Imaging Spectroradiometer, USA Terra/MODIS (1999-)	Passive	Thermal (31, 32 nm) 10.78-12.2 um	Spatial: 1000m (1 km) Temporal: 2 days	Temperature
786 km (LEO/SS)	Sentinel–2 European Space Agency (Launched 2015, Data 2017)	Passive	0.443-2.19 um	Spatial: 10 m (RGB) Temporal: 5 days; A+B 10 days	Flood, Settlement
800 km (LEO/SS-Polar Orbit)	Defense Meteorological Satellite Program/Operation al Line Scanner, DMSP/OLS (1626-2014)	Passive	Vis: 0.47-1.1 TIR: 10-13.4	Nighttime Lights 2.7 km Spatial: 1 km Temporal: Daily DN: 6-bit (0-64)	Weather Night Lights
833 km (LEO/SS)	Suomi National Polar-orbiting Partnership Satellite, USA/Visible Infrared Imaging Radiometer Suite (Suomi NPP/VIIRS) (Launched 2011, Data 2012)	Passive	DNB band: 0.5-0.9 um	Spatial: 0.5 km Temporal: Daily DNB band: 750 m	Night Lights
35,786 km (GEO)	GOES-16 Geostationary Operational Environmental		0.47-13.3 um	Spatial: 2000 m (2 km) Temporal: Raw Images-5 minutes;	Surface Temperature

Orbit	**Satellite (Year)**	**Active or Passive**	**Spectral Bands (Wavelength)**	**Resolution (Spatial | Temporal)**	**Purpose**
	Satellite, USA			Processed Images-hourly	