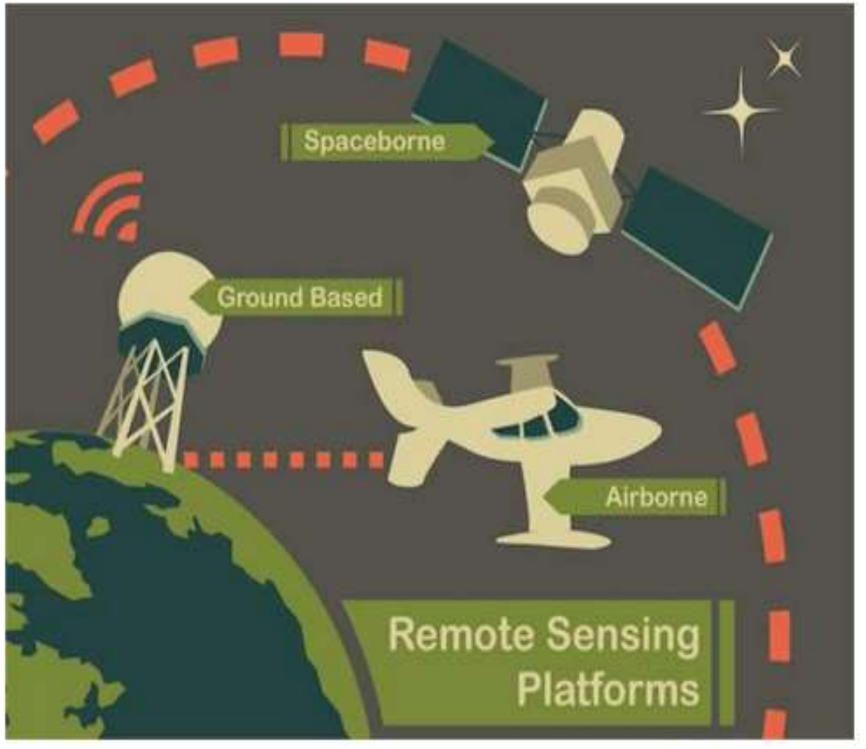
What is Remote Sensing?



Remote sensing is obtaining information about an object from a distance.

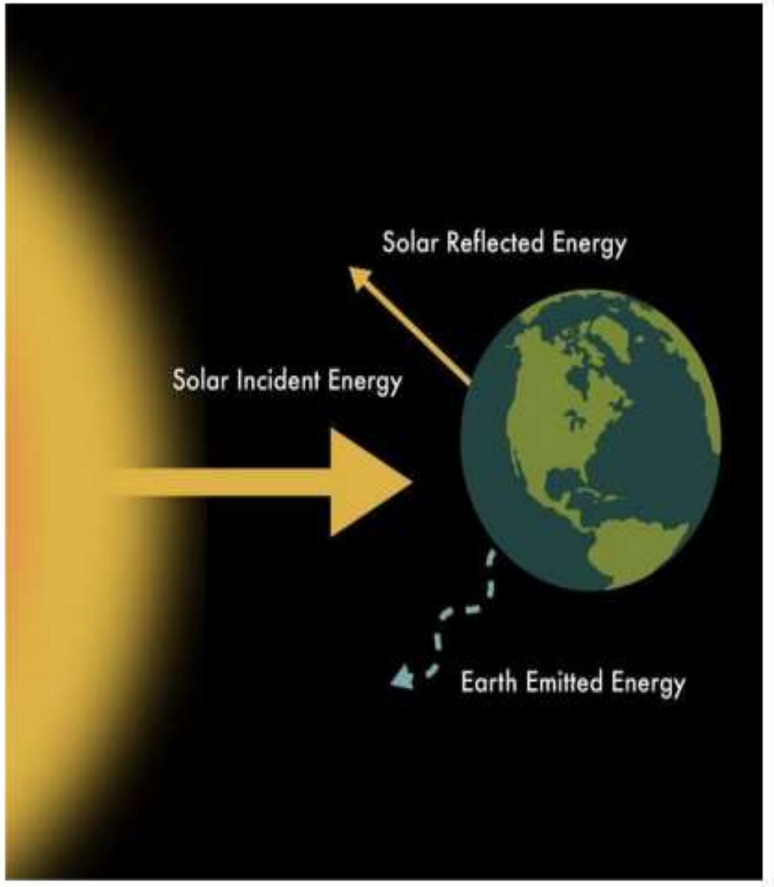
Photography is a very common form of remote sensing.

There are different ways to collect data, and different sensors are used depending on the application.

Some methods collect ground-based data, others airborne or spaceborne.

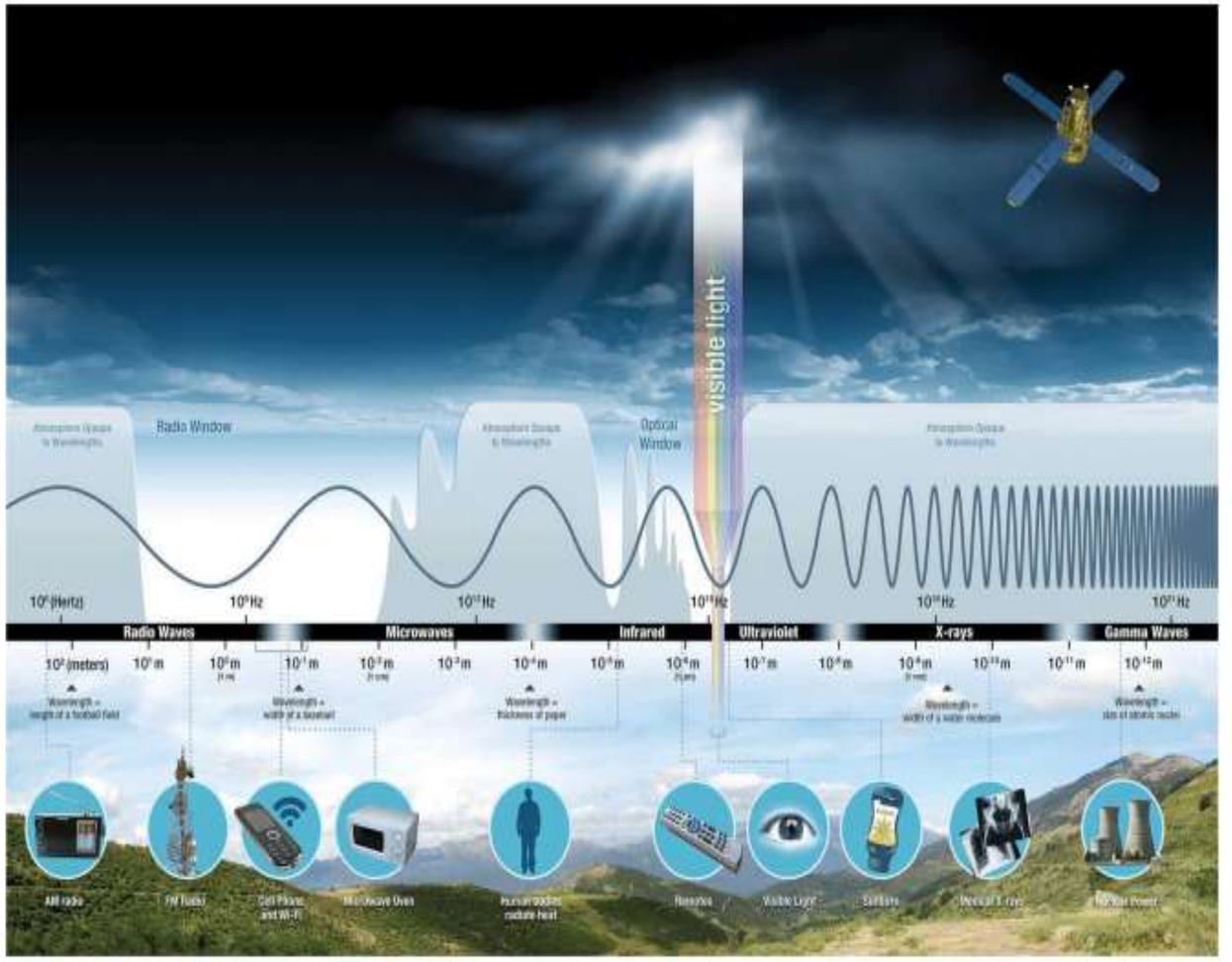
- What information do you need?
- How much detail?
- How frequently do you need the data?

What is Remote Sensing?



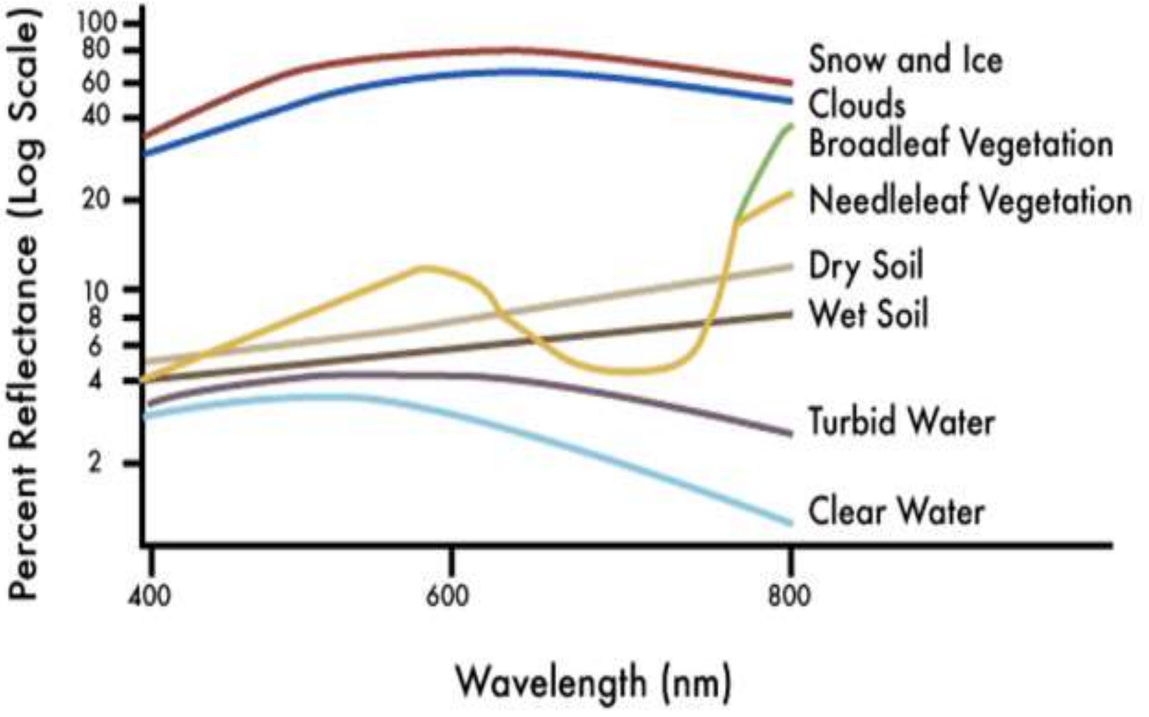
- The energy Earth receives from the sun is called **electromagnetic radiation**.
- Radiation is reflected, absorbed, and emitted by the Earth's atmosphere or surface, as shown by the figure on the left.
- Satellites carry instruments or sensors that measure electromagnetic radiation reflected or emitted from both terrestrial and atmospheric sources.
- With calibrated instruments, scientists can measure the height, temperature, moisture content (and more) for nearly every feature of the Earth's atmosphere, hydrosphere, lithosphere, and biosphere.

What is Remote Sensing?



- The electromagnetic spectrum is simply the full range of **wave frequencies** that characterizes solar radiation.
- Although we are talking about light, most of the electromagnetic spectrum cannot be detected by the human eye. Even satellite detectors only capture a small portion of the entire electromagnetic spectrum.

What is Remote Sensing?



- Different materials reflect and absorb different wavelengths of electromagnetic radiation.
- You can look at the reflected wavelengths detected by a sensor and determine the type of material it reflected from. This is known as a **spectral signature**.
- In the graph on the left, compare the relationship between percent reflectance and the reflective wavelengths of different components of the Earth's surface.

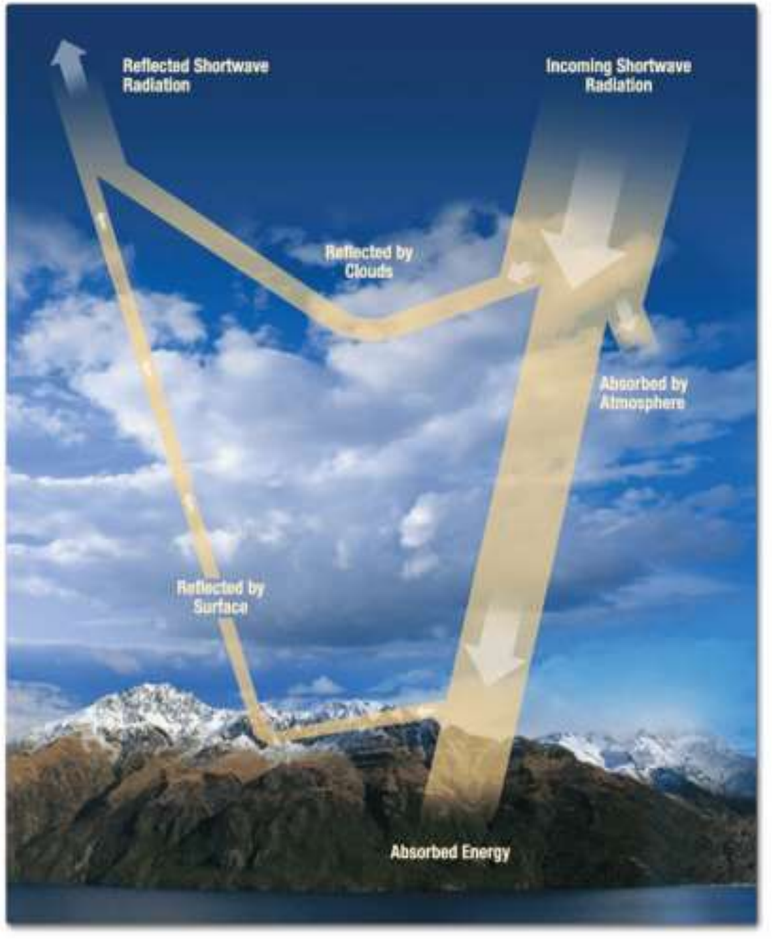
What is Remote Sensing?

Image Credit: NASA Earth Observatory, using Landsat data courtesy of USGS.

Water

- Longer visible wavelengths (green and red) and near-infrared radiation are absorbed more by water than shorter visible wavelengths (blue) – so water usually looks blue or blue-green.
- Satellites provide the capability to map optically active components of upper water column in inland and near-shore waters.

What is Remote Sensing?



Atmosphere

- From the sun to the Earth and back to the sensor, electromagnetic energy passes through the atmosphere twice.
- Much of the incident energy is absorbed and scattered by gases and aerosols in the atmosphere before reaching the Earth's surface.
- Atmospheric correction removes the scattering and absorption effects from the atmosphere to obtain the surface reflectance characterizing surface properties.

Satellites and Sensors

Satellites carry sensors or instruments. The names of sensors are usually acronyms that can include the name of the satellite.

Image Credit: NASA

Advantages of Remote Sensing

- Provides information where there are no ground-based measurements.
- Provides globally consistent observations.
- Provides continuous monitoring of our planet.
- Earth systems models integrate surface-based and remote sensing observations and provide uniformly gridded, frequent information of water resources data parameters.
- Data are freely available and there are web-based tools for data analysis.

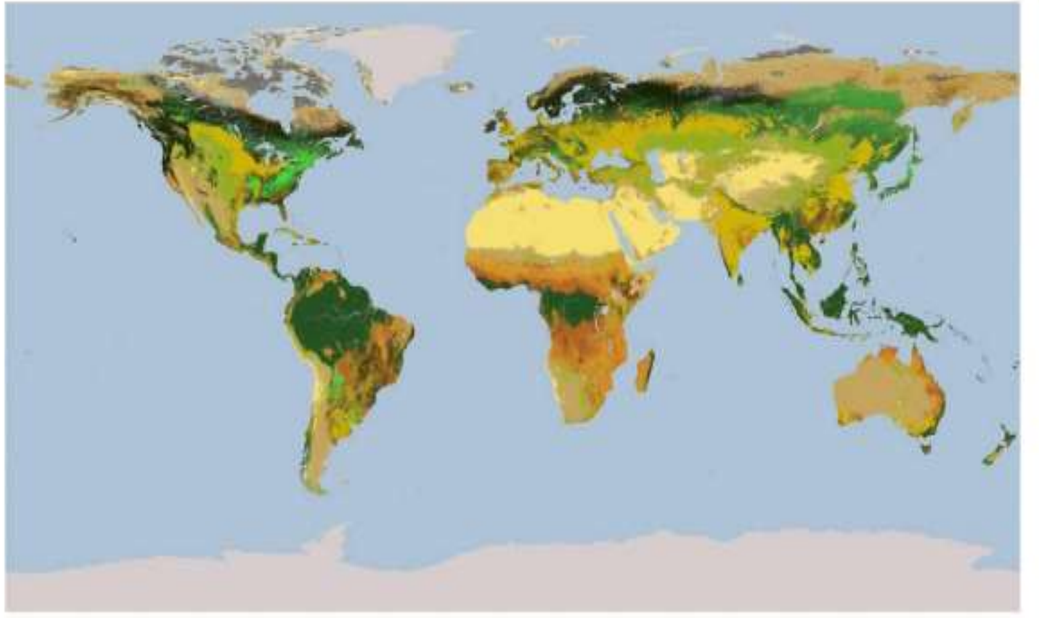


Image Credit: NASA GSFC

Disadvantages of Remote Sensing

- It is very difficult to obtain high spectral, spatial, temporal, and radiometric resolution all at the same time.
- Large amounts of data in a variety of formats can lead to more time and processing.
- Applying satellite data may require additional processing, visualization, and other tools.
- While the data are generally validated with selected surface measurements, regional and local assessment is recommended.

Image Credit: NOAA

Remote Sensing Terminology

Amplitude: The "height" of a wave or its maximum displacement from equilibrium.

Coordinate Reference System: A coordinate-based local, regional, or global system used to locate geographical entities.

Datum: A known point that can be used as a reference point for all other locations.

Electromagnetic Radiation: The energy the Earth receives from the Sun.

Frequency: The number of cycles of a wave passing a fixed point per unit of time.

Geodesy: The science of accurately measuring and understanding three fundamental properties of the Earth: its geometric shape, its orientation in space, and its gravity field.

Geodetic: Relating to geodesy.

Geoid: The hypothetical shape of the Earth, coinciding with mean sea level and its imagined extension under (or over) land areas.

Georeference: To link spatial data to its correct location.

Geostationary: Remaining fixed over a specific location on Earth's surface.

Gridded: Spatial data displayed over a uniform grid, often tied to specific locations.

Nadir: The point on the Earth's surface directly below the observing satellite.

Polar: A type of orbit that crosses the poles.

Polarization: The orientation of an electromagnetic wave.

Projection: The means by which you display the coordinate system and your data on a flat surface.

Radiometric Resolution: Describes a sensor's ability to discriminate differences in energy (or radiance).

Spatial Extent: The overall surface area covered by a given dataset.

Spatial Resolution: The ground surface area that forms one pixel in the image.

Spectral Resolution: The number and width of spectral bands of the sensor. The higher the spectral resolution, the narrower the wavelength range for a given channel or band.

Sun-Synchronous: The satellite always visits the same spot at the same local time.

Temporal Resolution: The time it takes for a satellite to complete one orbit cycle—also called "revisit time."

What Is Earth Observation and Remote Sensing?

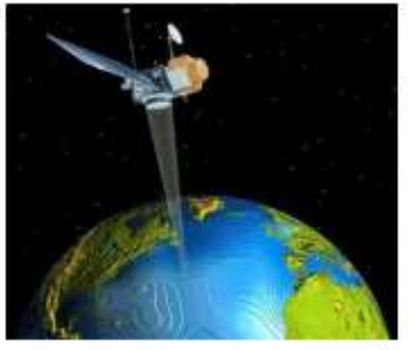
- "Obtaining information from an object without being in direct contact with it."
- More specifically, "obtaining information from the land surface through sensors mounted on aerial or satellite platforms."

Balloon photography (1858)

Pigeon cameras (1903)

Aircraft (WWI and WWII)

Space (1947)



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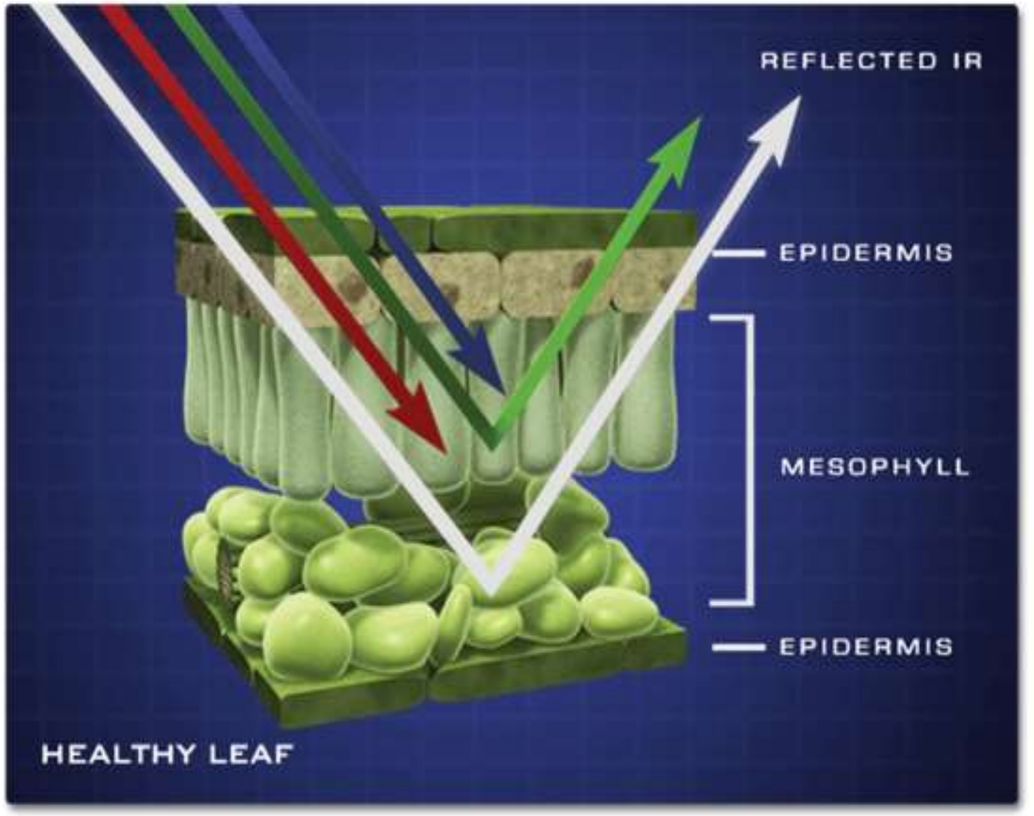
What is Remote Sensing?



Vegetation

- Certain pigments in plant leaves strongly absorb wavelengths of visible (red) light.
- The leaves themselves strongly reflect wavelengths of near-infrared light, which is invisible to human eyes.
- As a plant canopy changes from early spring growth to late-season maturity and senescence, these reflectance properties also change.
- Since we can't see infrared radiation, we see healthy vegetation as green.

Earth Observation Data and Tools Are Used to:

- Monitor change
- Alert to threats
- Inform land management decisions
- Track progress towards goals (such as REDD+, the UN's Sustainable Development Goals (SDGs), etc.)

Significance of Earth Observation

Improving sustainable land management using Earth Observation is critical for:

- Monitoring ecological threats (deforestation & fires) to territories
- Mapping & resolving land tenure conflicts
- Increasing knowledge about land use and dynamics
- Mapping indigenous land boundaries and understanding their context within surrounding areas
- Monitoring biodiversity

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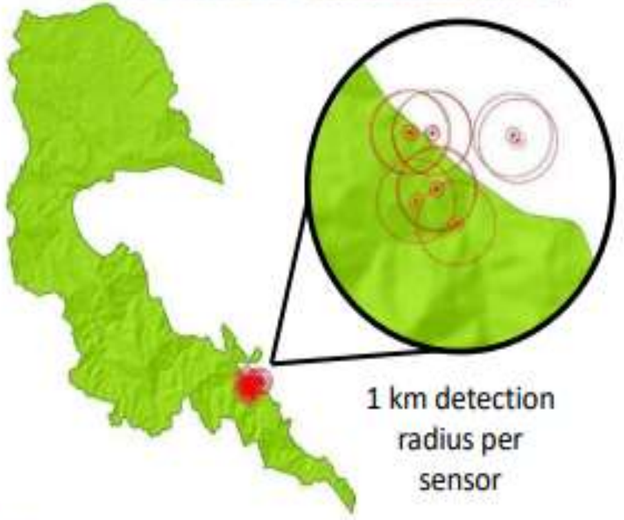
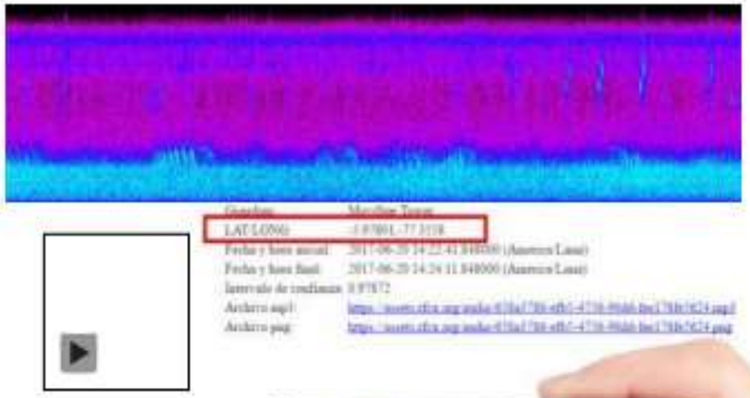
Monitoring Illegal Logging with Acoustic Alerts

1) Chainsaw noise is detected by acoustic sensors



2) Acoustic sensors send alerts via e-mail



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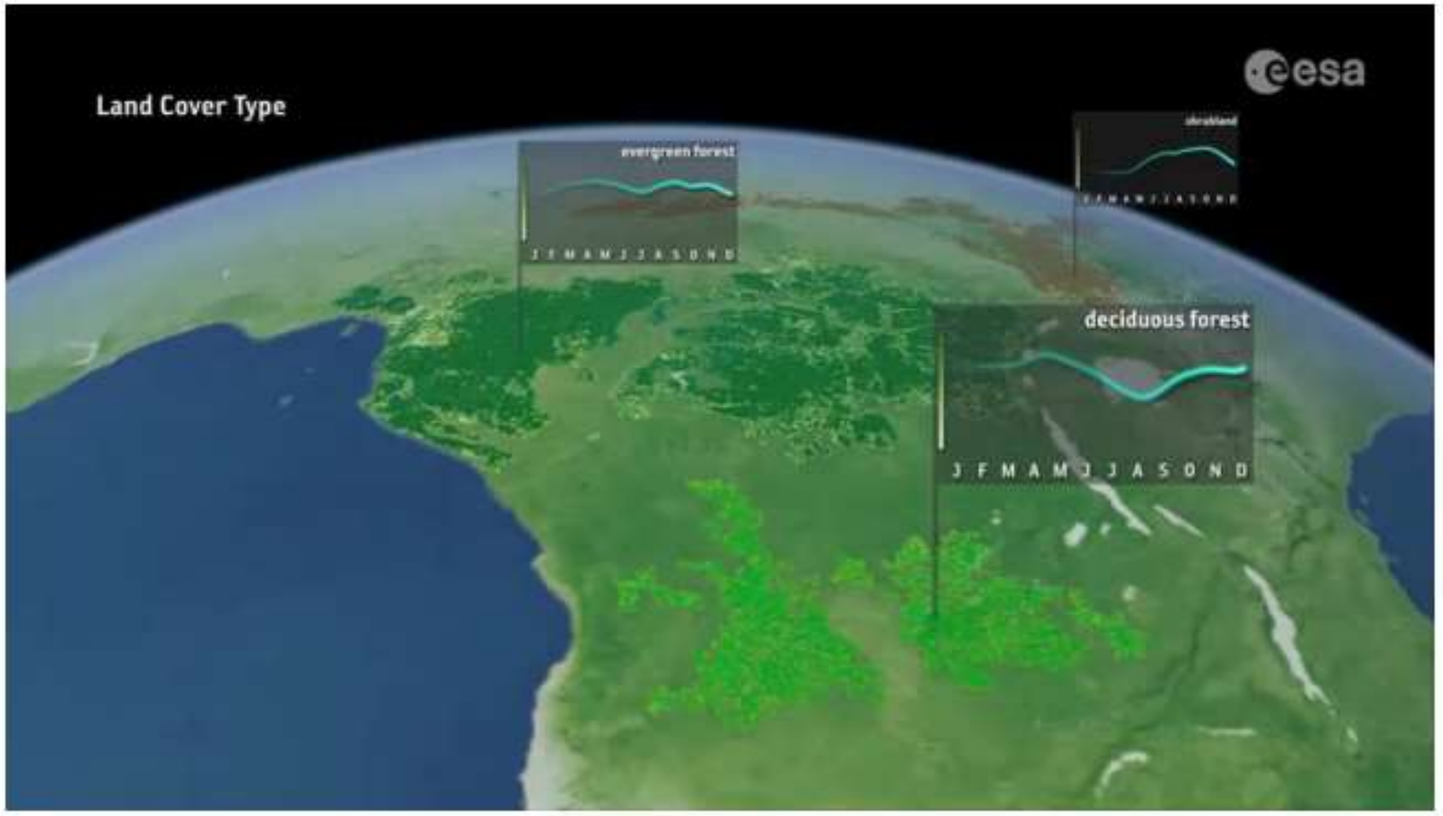
Monitoring Biodiversity with Camera Traps

- Identify and track species
- Discover trends of how populations are changing
- Use in ecotourism to raise awareness of conservation
- https://www.wildlifeinsights.org/

Land cover Dynamics



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What Are the Components of a Remote Sensing Stream?

1. Energy source or illumination (A)
2. Radiation and the atmosphere (B)
3. Interaction with the target (C)
4. Energy recording by sensor (D)
5. Transmission, receiving, processing (E)
6. Interpretation and analysis (f)
7. Application (G)

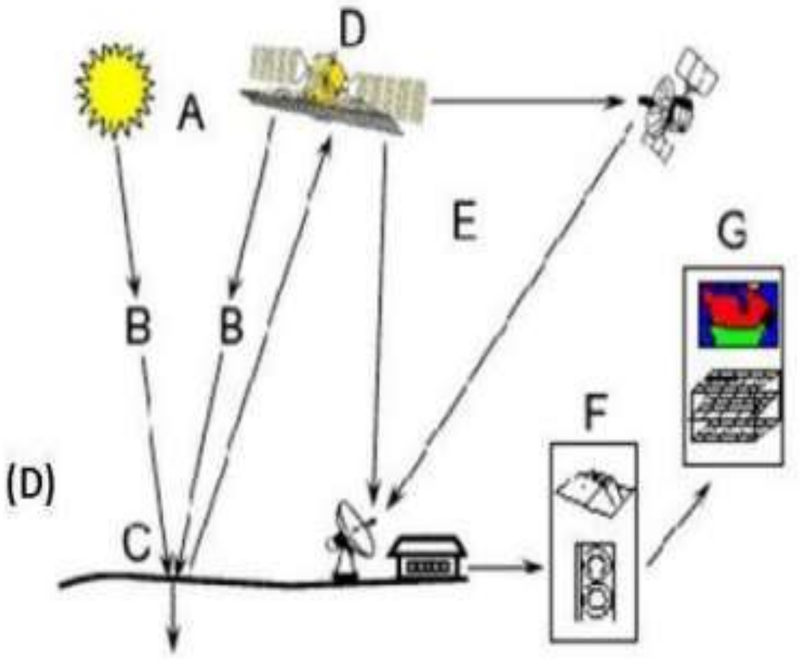
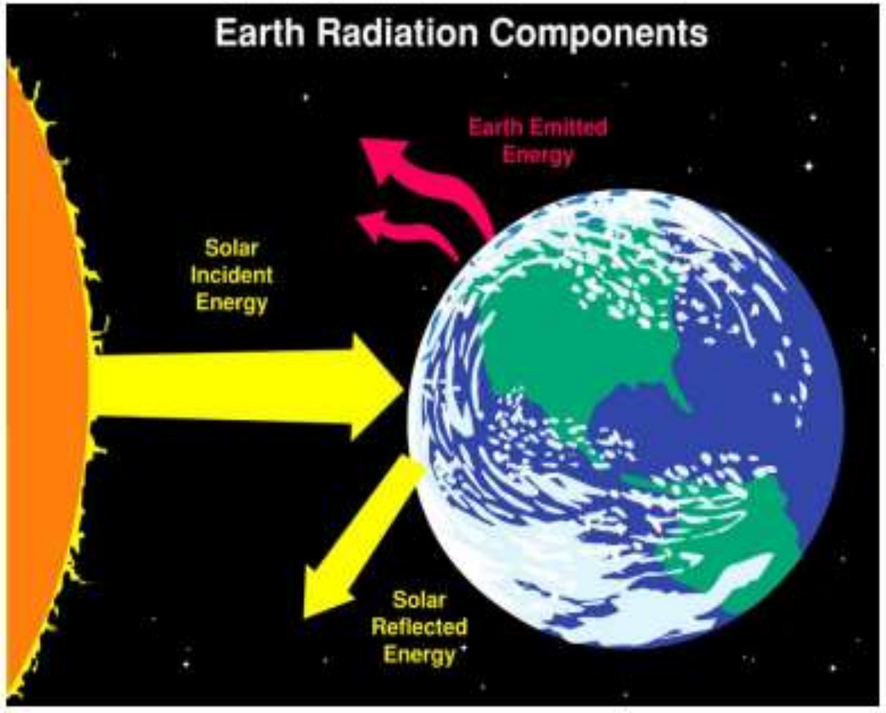


Image Credit: Dipen Sahajanani, M.Tech Geomatics & Remote Sensing, Center for Environmental Planning and Technology University(2019)
https://www.quora.com/Whatare-thecomponents-of-a-remotesensing-satellite

1. Energy Source or Illumination

Earth Radiation Components

- Incident energy from the sun is:
  - Reflected (Solar Reflected Energy)
  - Transmitted
  - Absorbed



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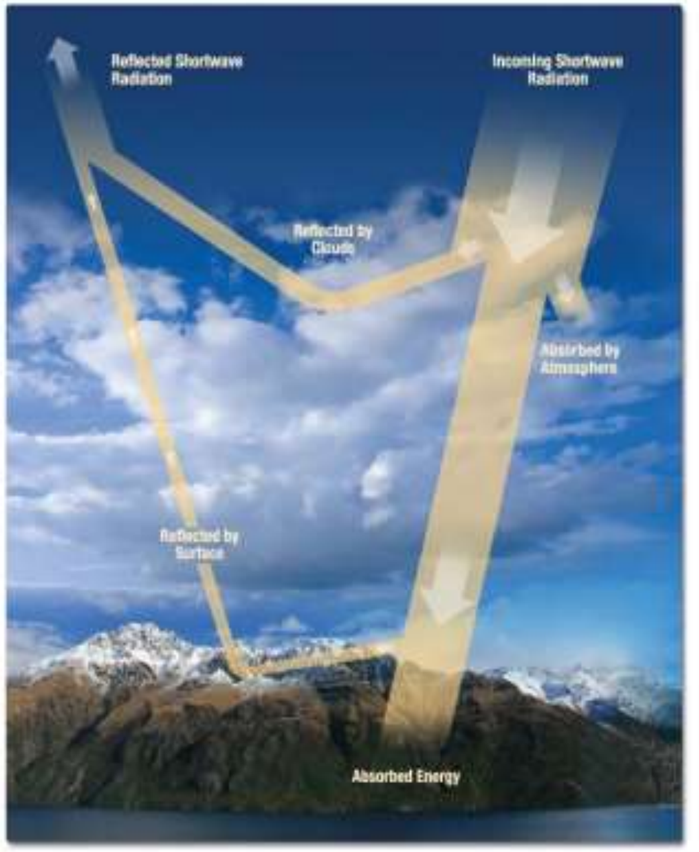
2. Radiation and the Atmosphere

Atmosphere

- Clouds reflect visible solar radiation and emit infrared radiation into space and provide an indirect measure of precipitation
- Microwave frequencies are used to observe precipitation



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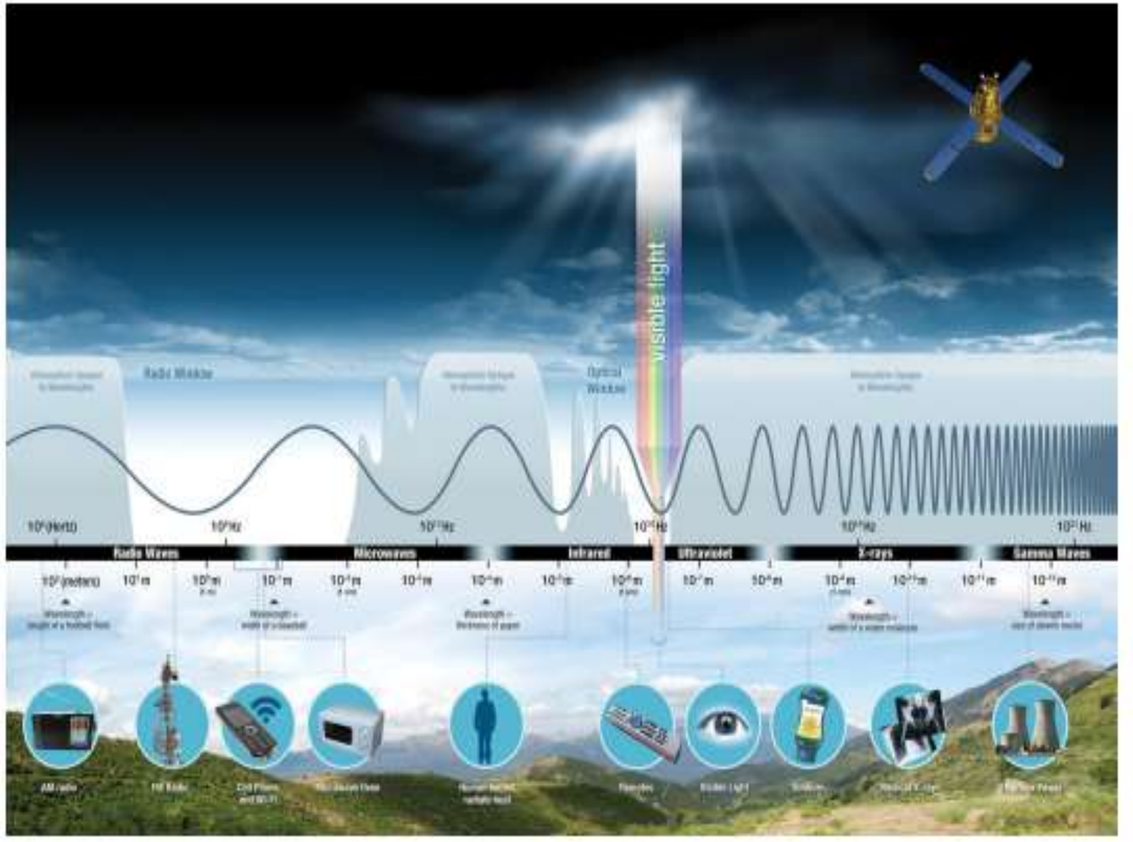
3. Interaction with the Target

Electromagnetic Spectrum

- Orbiting satellites carry sensors or instruments
- Sensors are calibrated to detect various wavelengths along the electromagnetic spectrum, often including visible light



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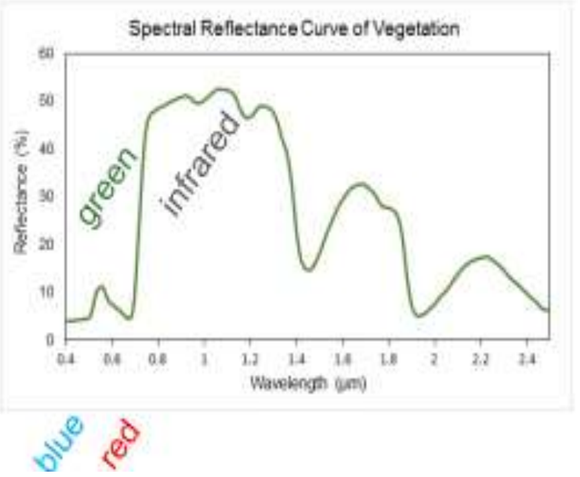
3. Interaction with the Target

Vegetation

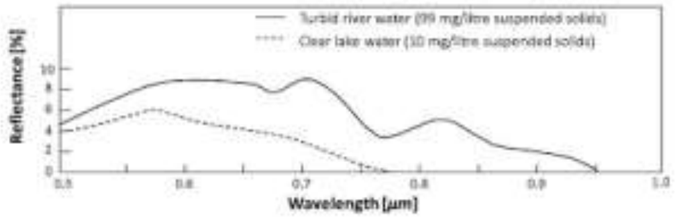
- Healthy vegetation absorbs blue and red wavelengths but reflects green and infrared
- Since we can't see infrared radiation, we see healthy vegetation as green



3. Interaction with the Target

Water

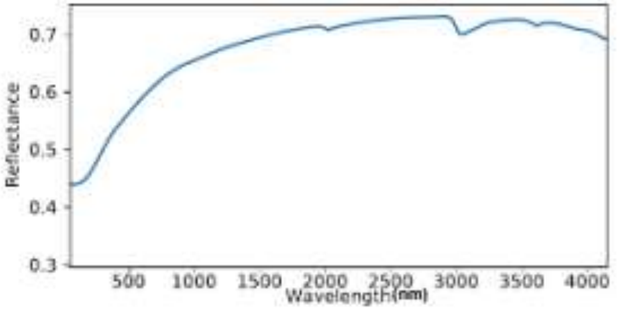
- Longer visible wavelengths (green and red) and near-IR radiation are absorbed more by water than shorter visible wavelengths (blue)
- Water usually looks blue or blue-green
- Sediment in the upper layers of water will cause more reflectance and the water will appear brighter



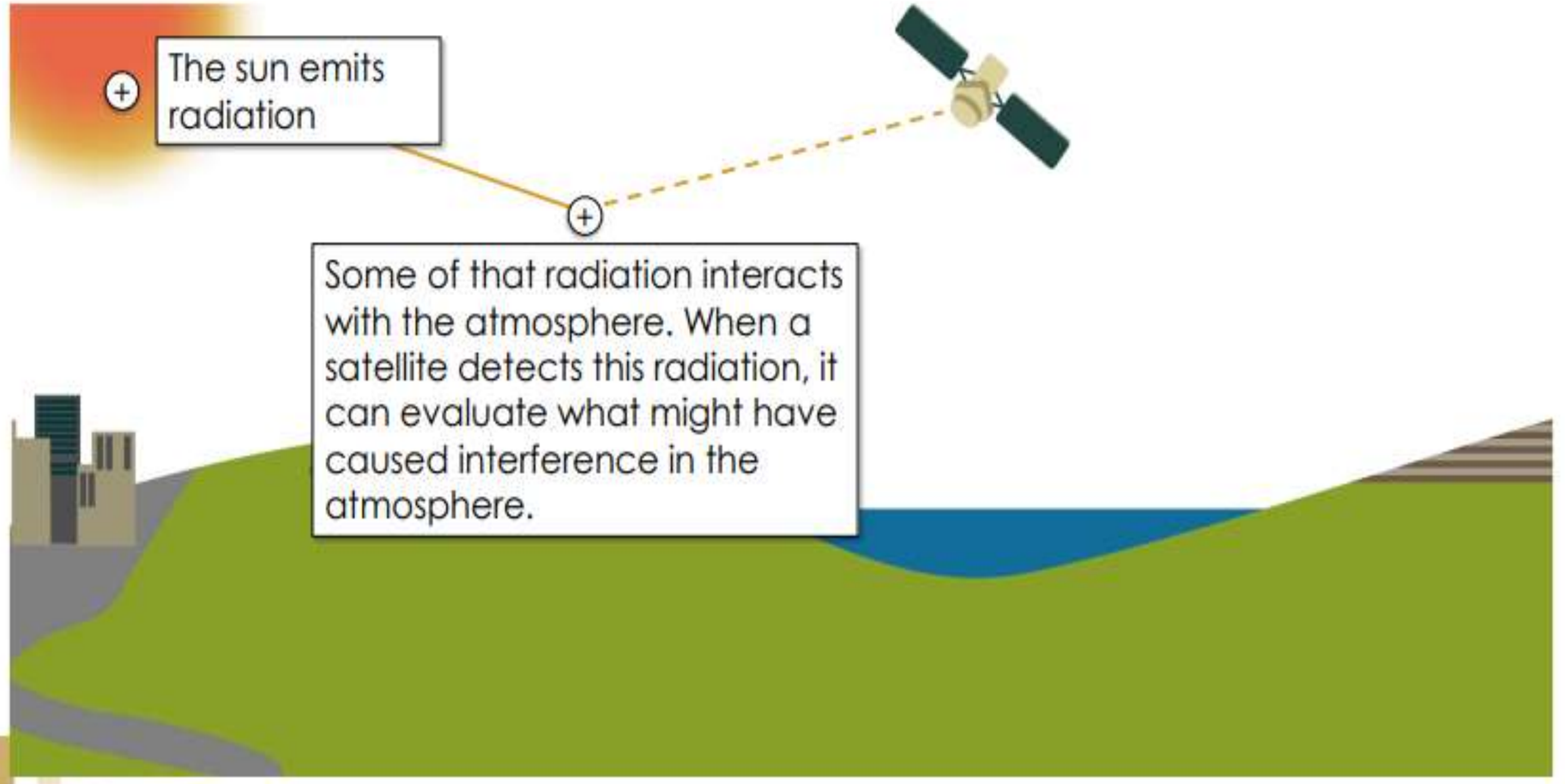
3. Interaction with the Target

Soil

- The spectral signature of soil is fairly constant over the range of wavelengths
- Reflectance is affected by moisture, texture, and mineral content



4. Energy Recording by Sensor



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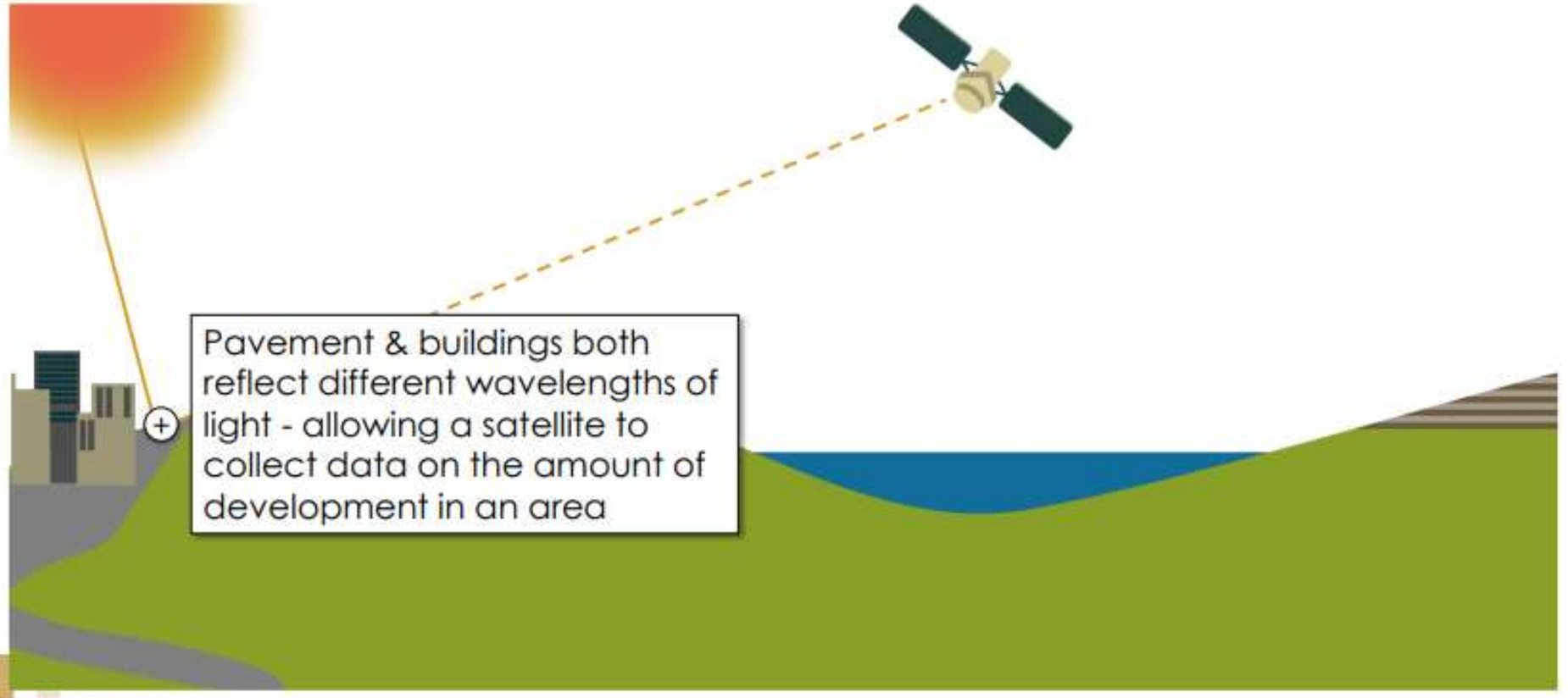

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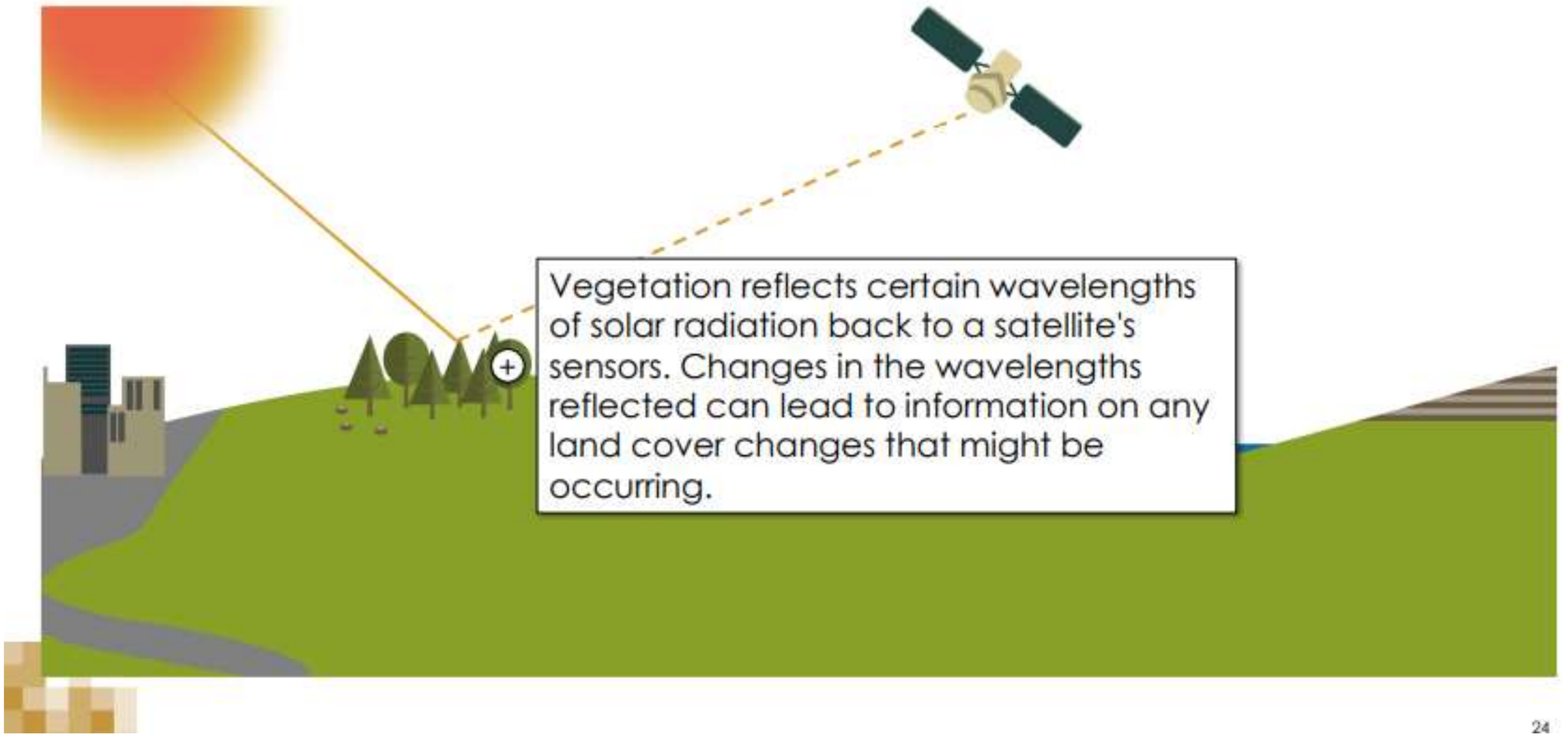

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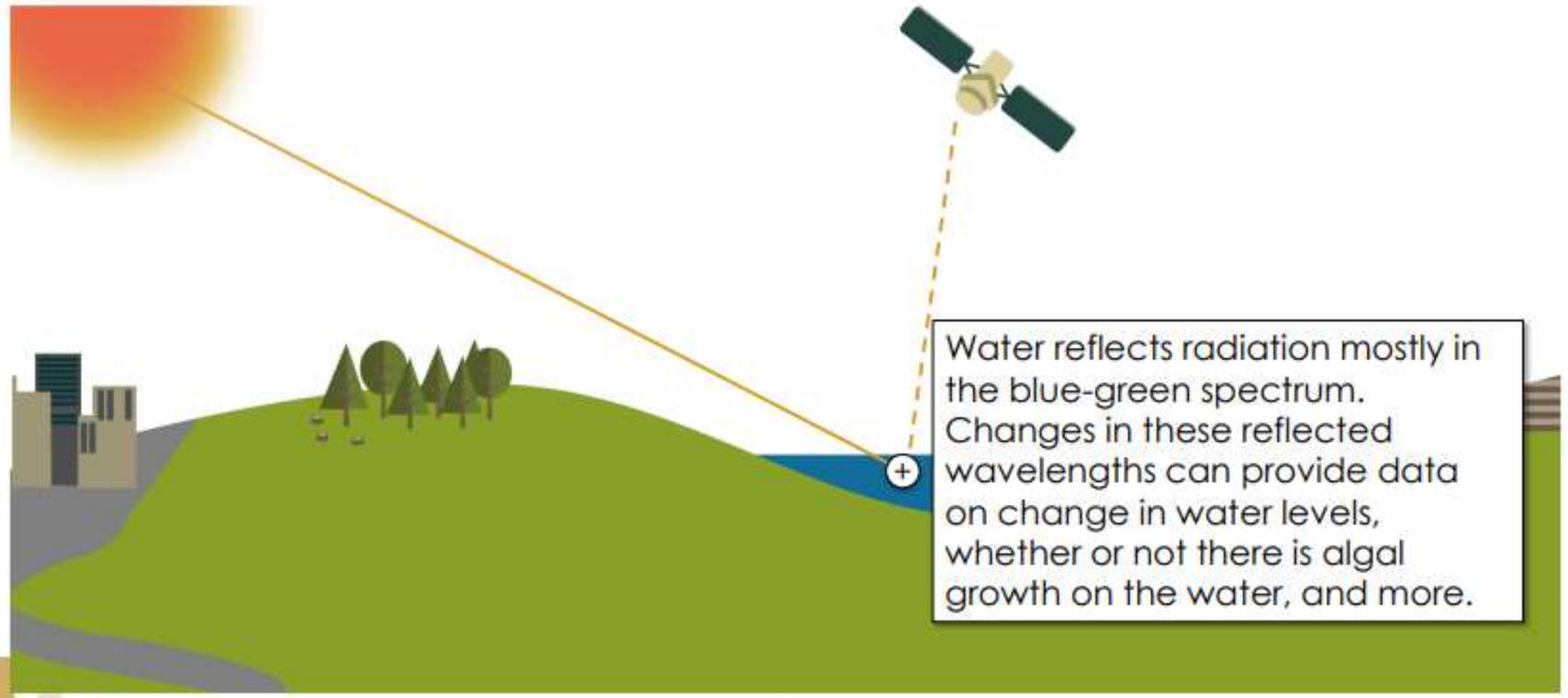

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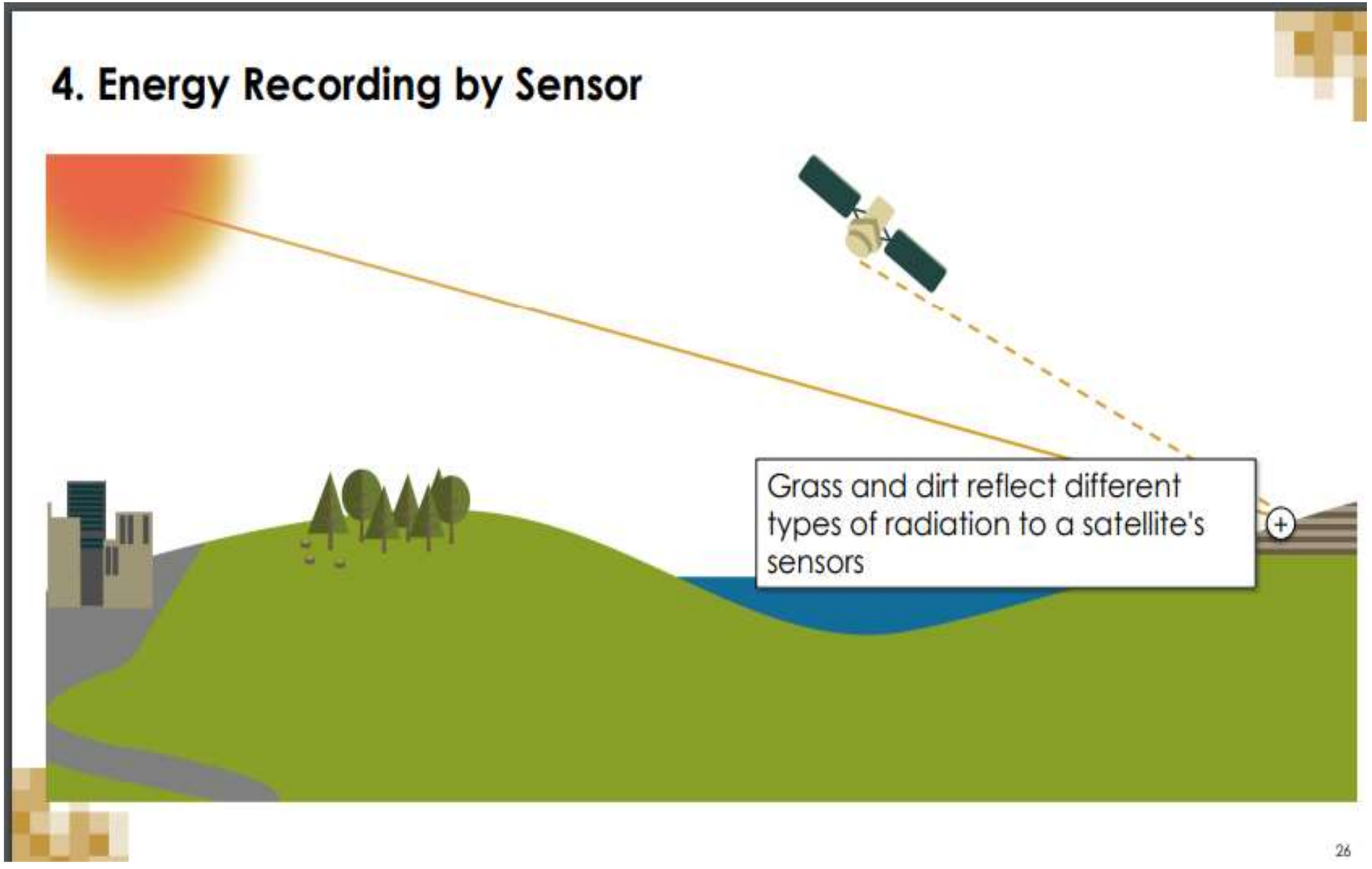
4. Energy Recording by Sensor



Types of Remote Sensing

Passive: source of energy is either the Sun or Earth/atmosphere

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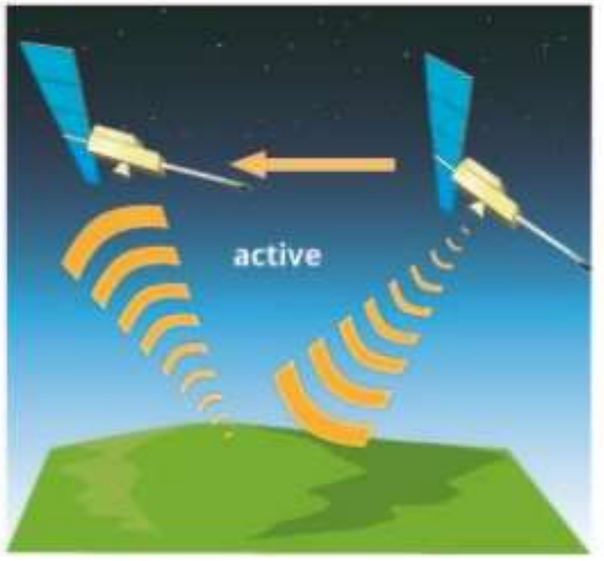
Active: source of energy is part of the remote sensor system



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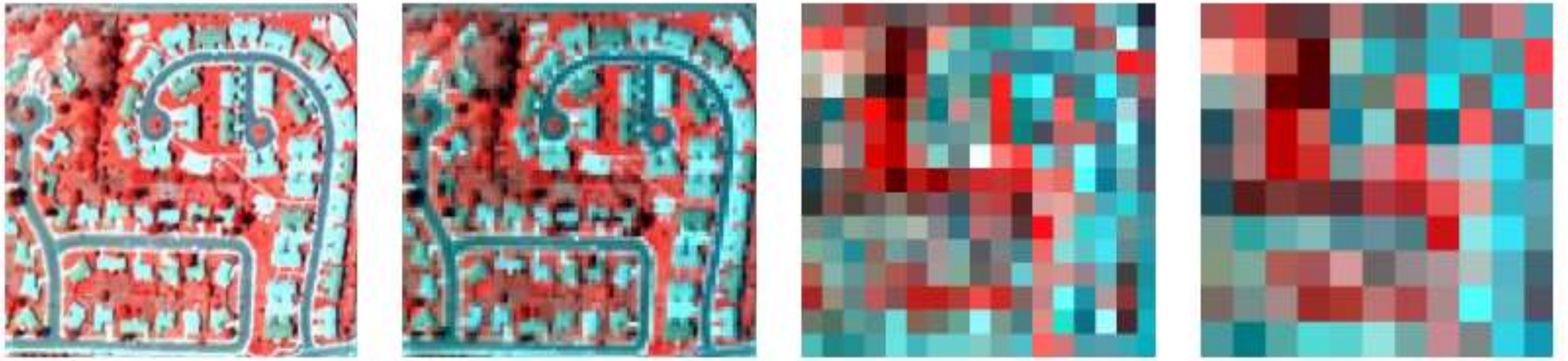
Types of Resolution

Spatial Resolution

- Spatial resolution refers to the size of the pixels that make up the remote sensing image
- Images with smaller pixels are said to have a higher spatial resolution, leading to clearer scenes, while images with smaller pixels have a lower spatial resolution



1 x 1 m | 4 x 4 m | 20 x 20 m (SPOT) | 30 x 30 m (Landsat TM)

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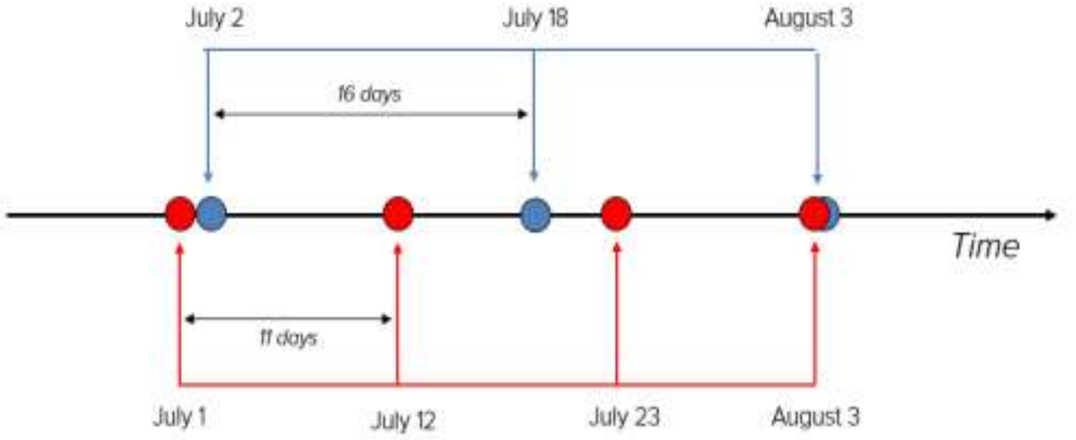
Types of Resolution

Temporal Resolution

- Frequency at which images are recorded/ captured in a specific place on the Earth.
- The more frequently it is captured, the better or finer the temporal resolution is said to be.
  - **High temporal resolution**: < 24 hours - 3 days
  - **Medium temporal resolution**: 4 - 16 days
  - **Low temporal resolution**: > 16 days



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Resolution of Orbiting Satellites

Satellite	Spatial Resolution	Temporal Resolution
Landsat 8	30m	16 days
MODIS (Terra + Aqua)	250m, 500m, 1000m	1 to 2 days
VIIRS	375-m	12 hours
AVHRR	1100m	<1 day
Sentinel-2	10m, 20, 60m	5 days
Ikonos	0.8m, 3.2m	< 3 days
SPOT-7	1.5m, 6m	As low as 1 day

Current NASA Constellation

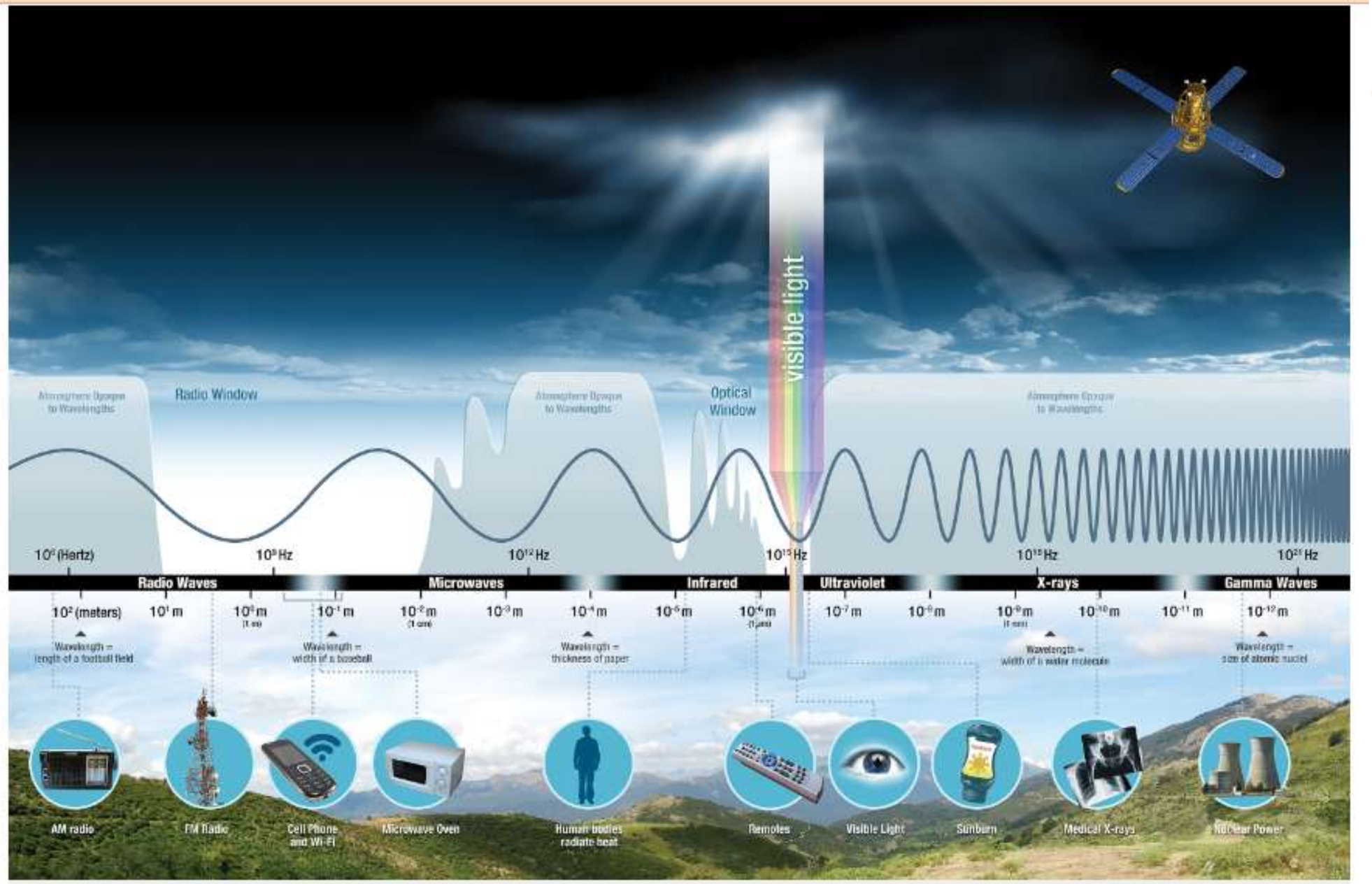

Diagram of the Electromagnetic Spectrum. Credit: NASA Science.