COURSE: SATELLITE IMAGE PROCESSING

LECTURE 1 – Satellite and Airborne Remote Sensing

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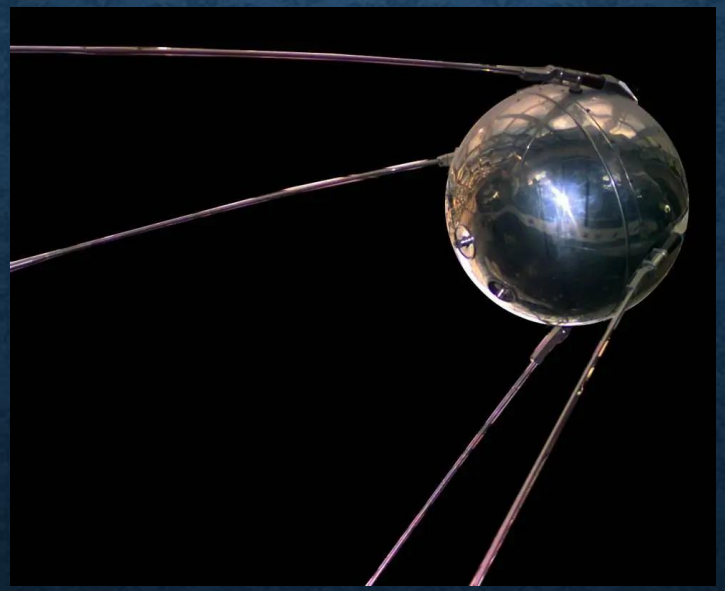
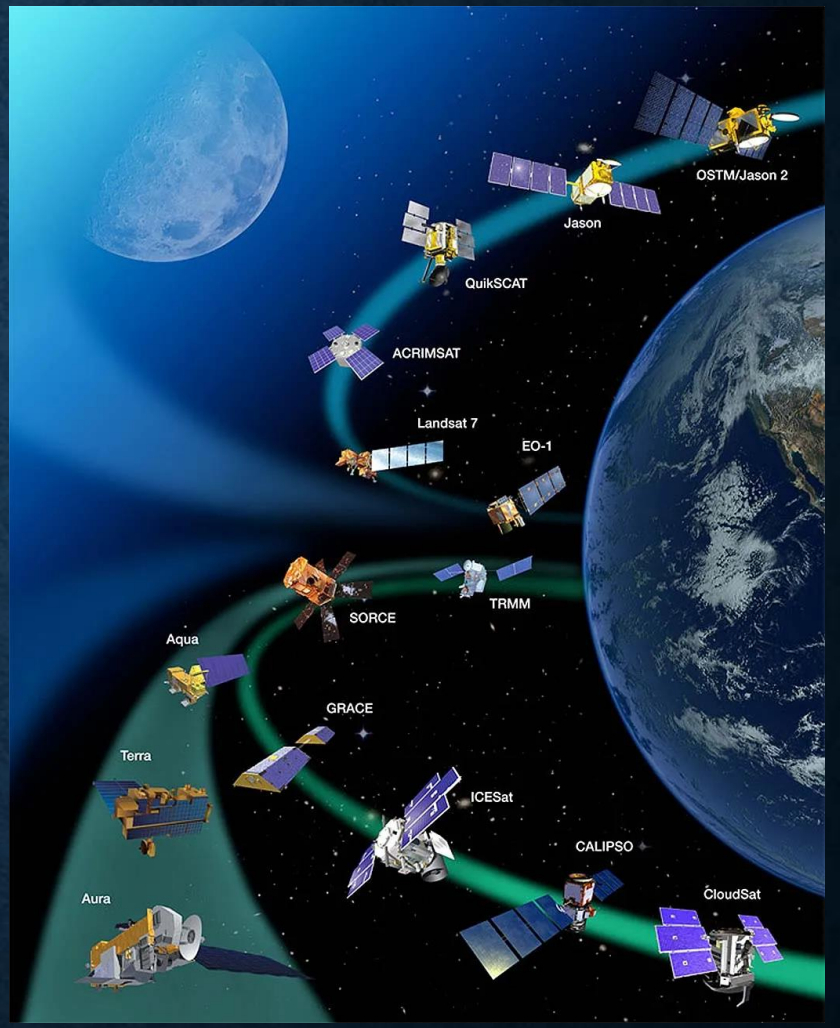
What is satellite

- In the context of space exploration and technology, a satellite typically refers to an artificial object placed into orbit around the Earth or another celestial body.
- It is a Platform that carries various sensors

The Jason-2 satellite orbits Earth



The satellite Sputnik 1



Dozens of Satellite in the Orbit

Source: NASA, 2024, Retrieve online: https://www.nasa.gov/learning-resources/for-kids-and-students/what-is-a-satellite-grades-k-4/

Types of satellite

There are different types of Satellites and serves various purposes:

- Communication Satellite,
- Navigation Satellite,
- Earth observation Satellite (Satellite Remote sensing),
- Scientific research Satellite
- Military Satellite.

Navigation Satellites

These satellites form systems like GPS (Global Positioning System), GLONASS, and Galileo, providing precise location and timing information for navigation on Earth.

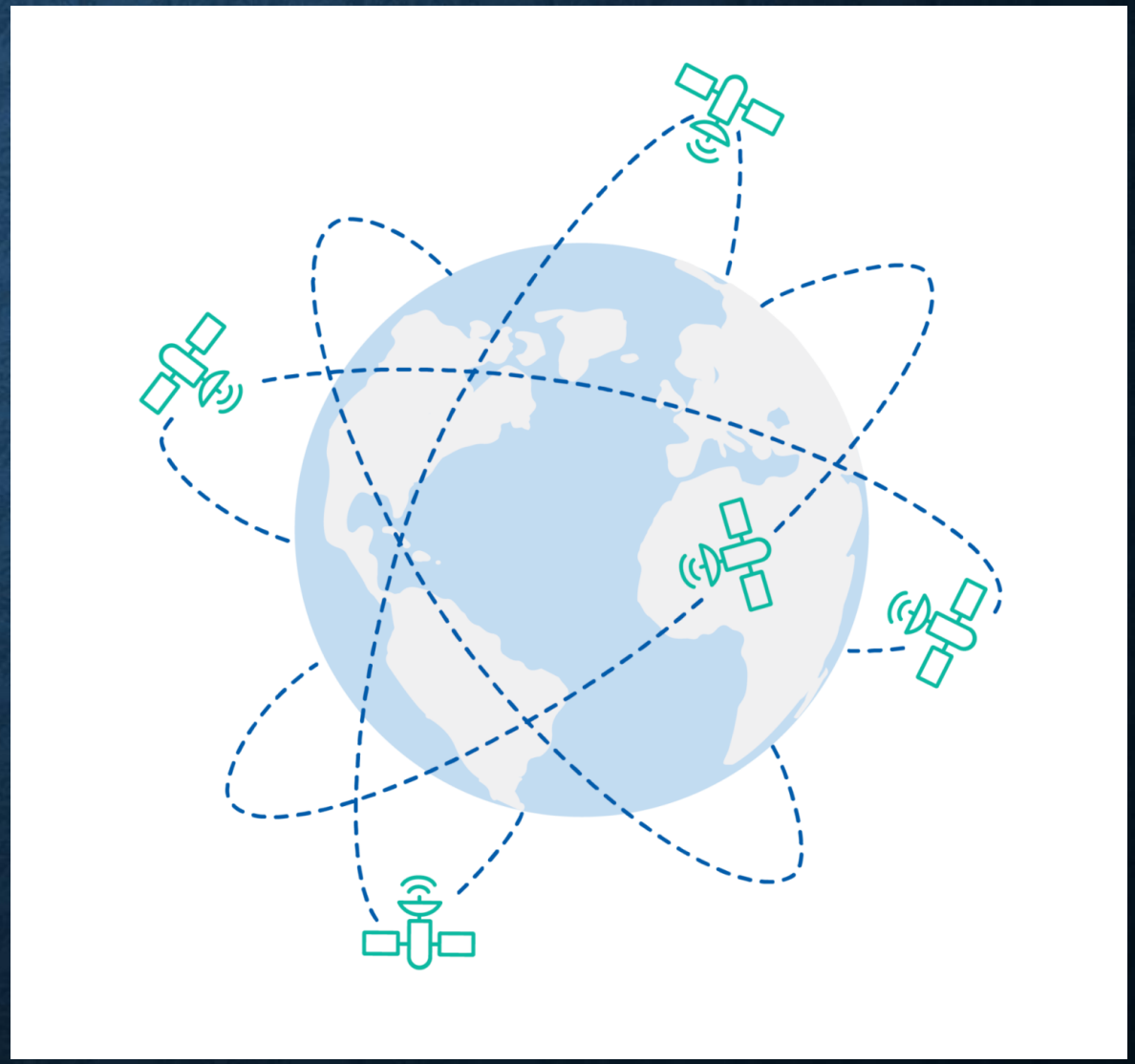


Image Source: Advanced Navigation, 2024; Retrieved: https://www.advancednavigation.com/tech-articles/global-navigation-satellite-system-gnss-and-satellite-navigation-explained/

Navigation Satellites

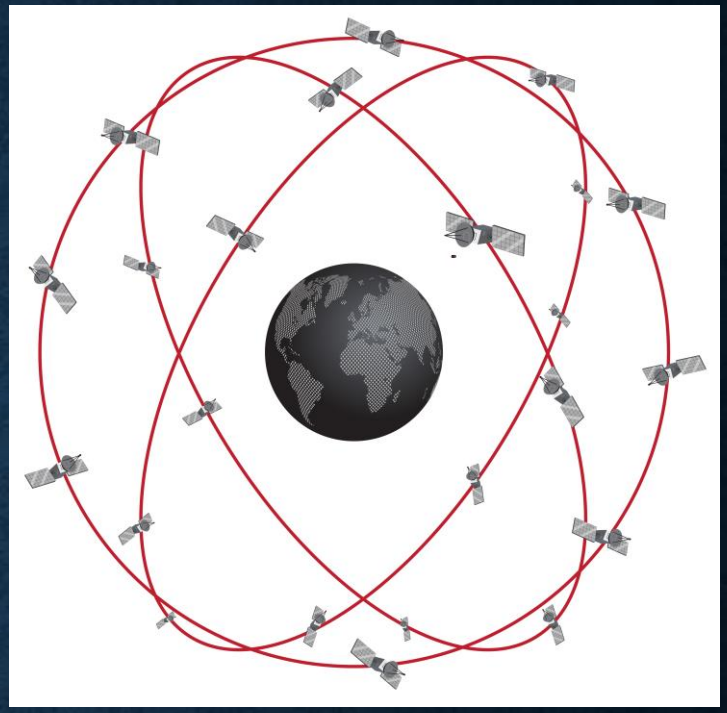
- GNSS is often generically referred to as GPS (Global Positioning System)
- There are several GNSS satellite constellations orbiting the Earth.
- Each providing data for positioning in various continental areas.

Image Source: Advanced Navigation, 2024; Retrieved: https://www.advancednavigation.com/tech-articles/global-navigation-satellite-system-gnss-and-satellite-navigation-explained/

Navigation Satellites

GNSS Satellite Constellation

- BeiDou-china
- Galileo-European Union
- GLONASS-Russia
- GPS (originally Navstar GPS)- United States



Source: VECTORNAV, 2024; Retrieved from: https://www.vectornav.com/resources/inertial-navigation-primer/theory-of-operation/theory-gnss#:~:text=A%20Global%20Navigation%20Satellite%20System,position%2C%20velocity%2C%20and%20time.

Satellite and Airborne Remote Sensing in Earth Observation

- Earth observation satellites utilize remote sensing technologies to gather data about the Earth's surface features, atmosphere and ocean from space and it is term as Satellite Remote Sensing.

- Airborne remote sensing involves using sensors mounted on airborne platforms to capture imagery and data of the Earth's surface.

Satellite and Airborne Remote Sensing in Earth Observation

Satellite and Airborne platform are equipped with various sensors and instruments that capture;

- images,
- measure environmental parameters,
- Capture weather and climate information
- monitor changes over time
- Topography
- other

Remote Sensing Instruments

Instruments are flown;

1. Onboard satellites (Space borne)

2. Suborbital aircraft (Airborne) such as;

- airplanes,
- helicopters,
- Unmanned Aerial Vehicles (UAVs).

3. Sound Navigation and Ranging (SONAR) sensors;

- placed onboard ships and submarines to map the bathymetry of subsurface terrain.

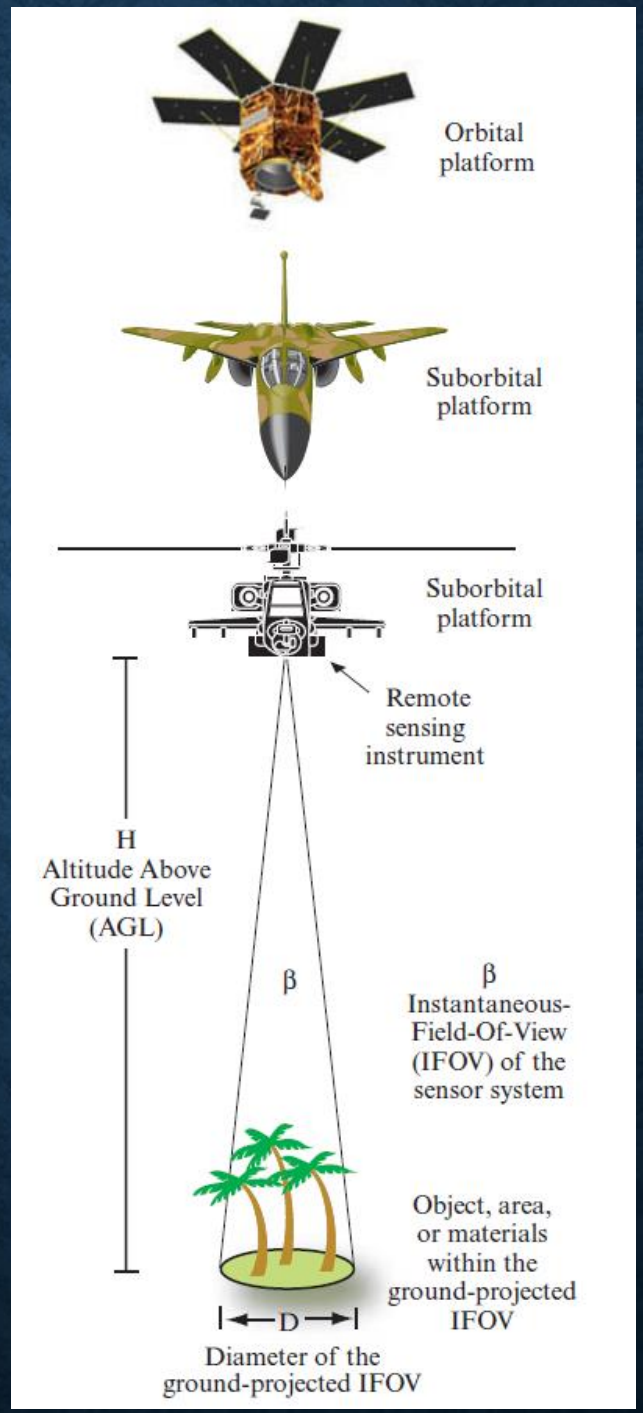
Remote Sensing Instruments

Remote sensing Instructions and technologies for Data collection and processing:

- Cameras,
- Multispectral and hyperspectral sensors,
- Thermal-infrared detectors,
- Radio Detection and Ranging (RADAR) sensors,
- Light Detection and Ranging (LiDAR)

Remote Sensing

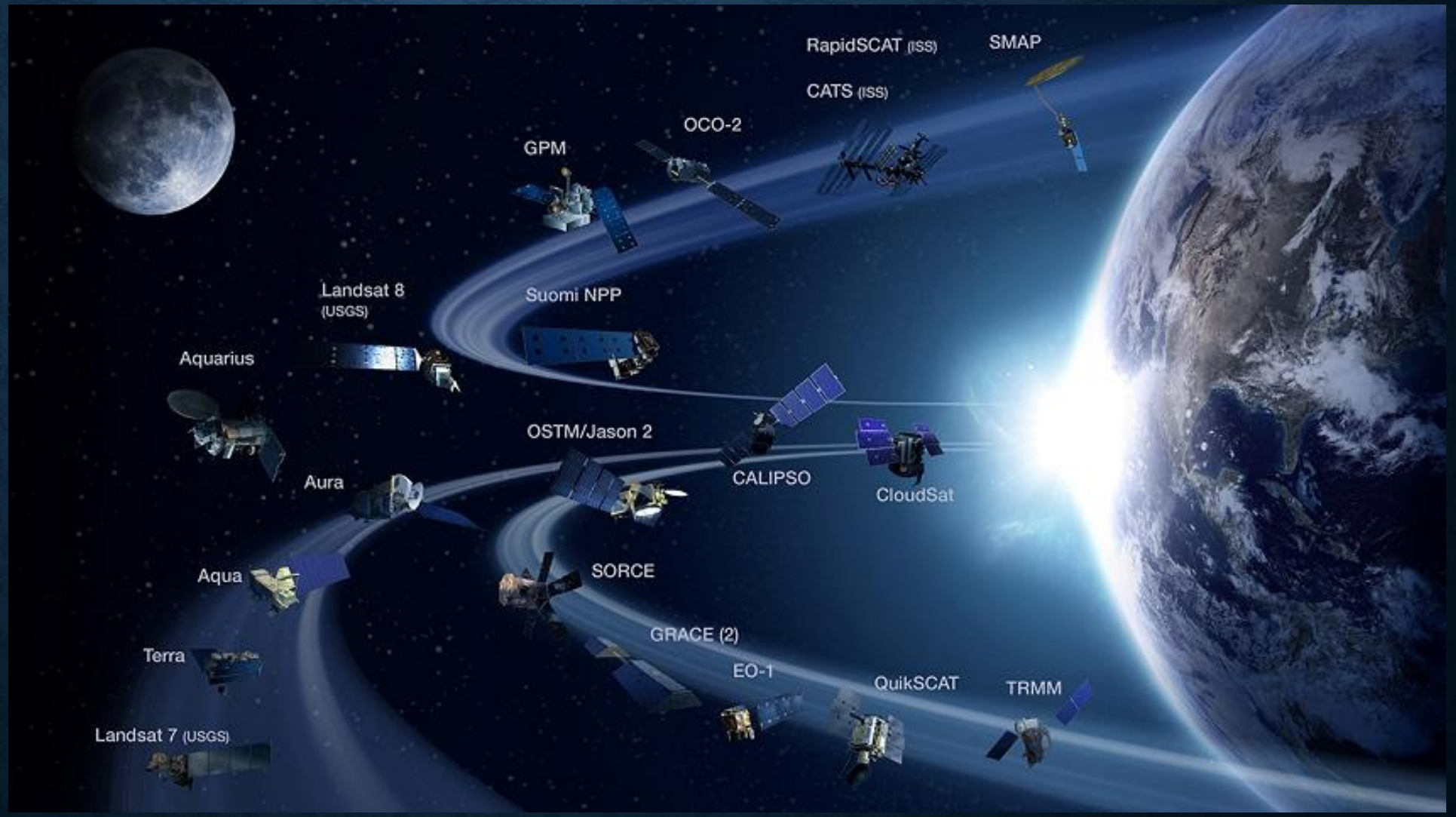
- Using sensors to gather information about objects or areas from a distance without being in direct contact.



Source: John R. Jesen, 4th Ed, 2015

Remote Sensing – Space borne

NASA's Earth Observing Satellites (EOS) and their Mission Descriptions



Source: Yanow, K. (2018). 4th Quarter 2018 Edition), John P. Wilson (Ed.).

Remote Sensing – Space-borne

Space borne platform orbiting earth

The satellites can be placed in different types of orbits, such as;

- polar orbits,
- geostationary orbits, or
- sun-synchronous orbits,

The reason is to cover specific areas with varying temporal and spatial resolutions.

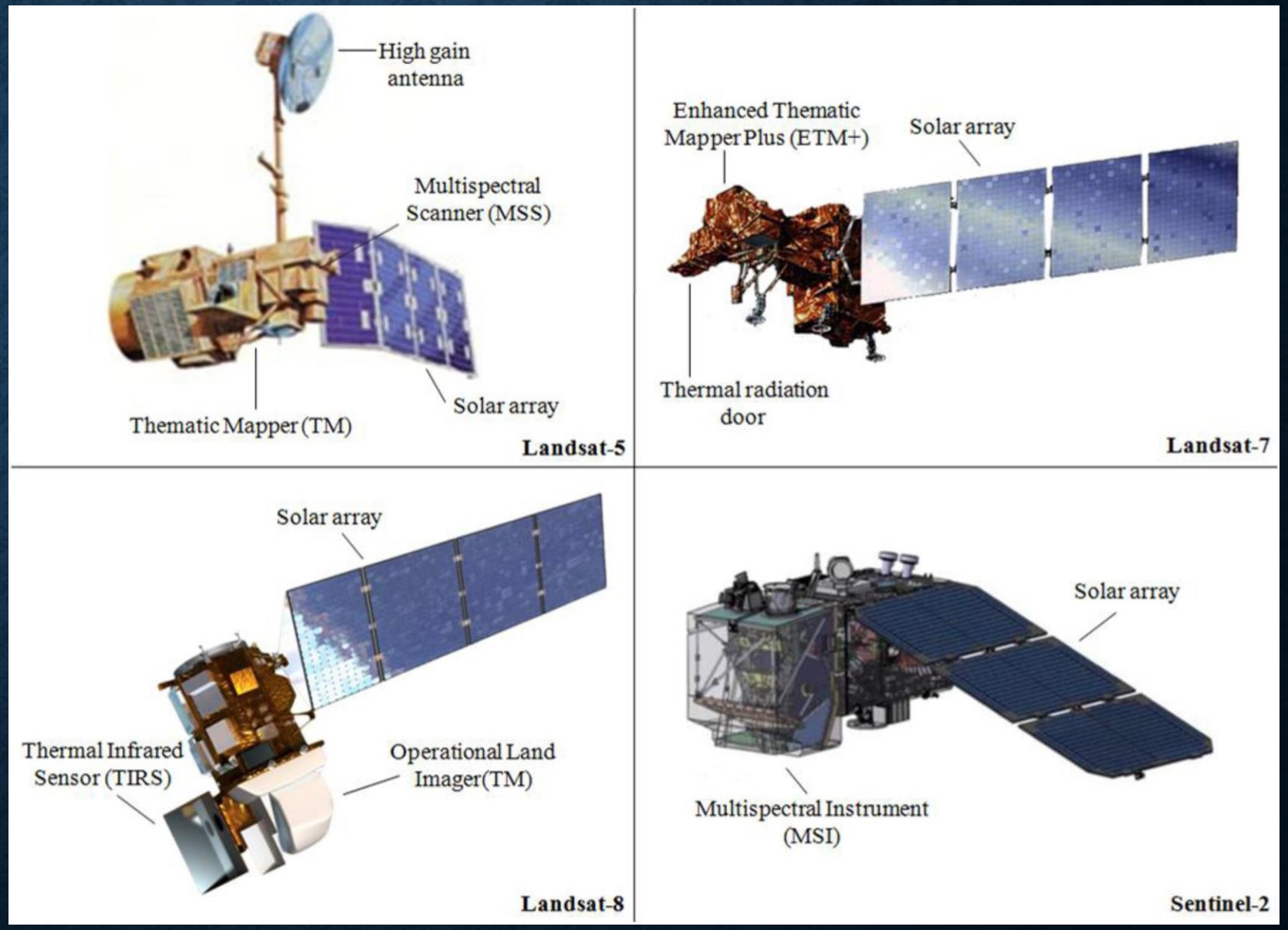
Source: Pixalytics, Retrieve from: https://gistbok.ucgis.org/bok-topics/remote-sensing-platforms

Remote Sensing – Space-borne

Space borne platform orbiting earth

Examples of satellite missions include;

- Landsat,
- Sentinel,
- MODIS, and
- NOAA's GOES series,



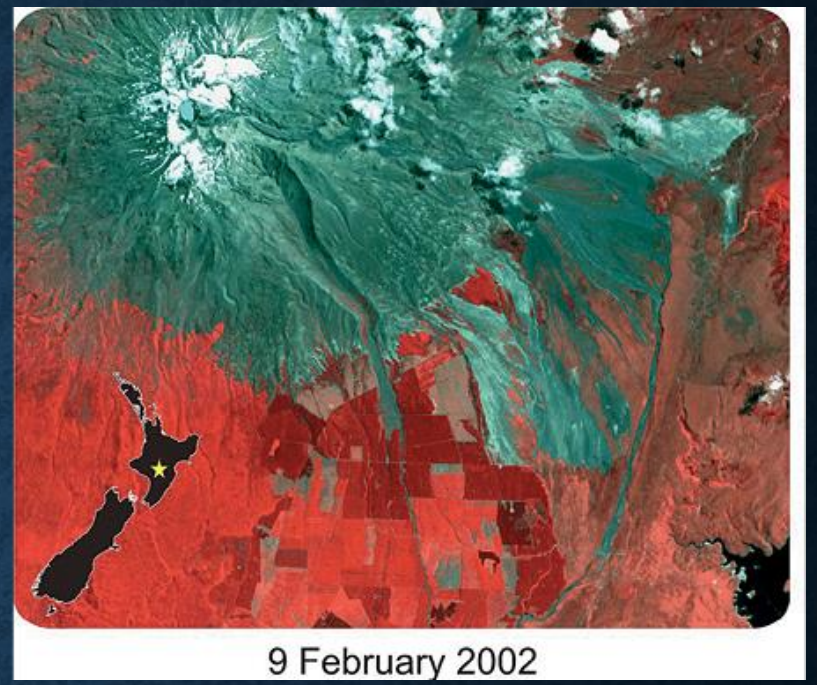
Source: Adiri. Z, et al. 2020; Sentinel-2 User Handbook (2015), Landsat 8 Data Users Handbook (2019),

Remote Sensing – Space Borne and Airborne

Application:

The satellites provide valuable data for applications such as;

- environmental monitoring,
- land use planning,
- disaster management,
- Topography
- scientific research.



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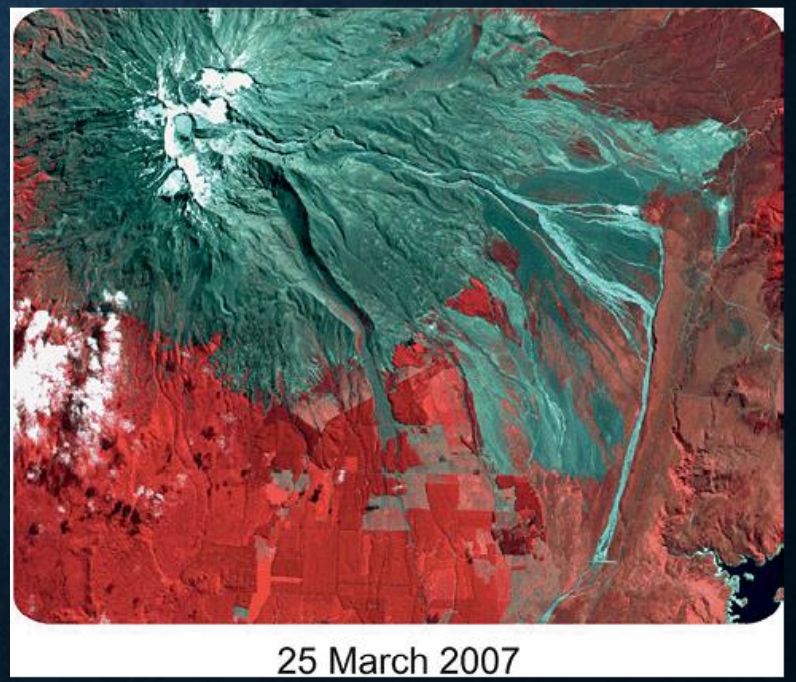
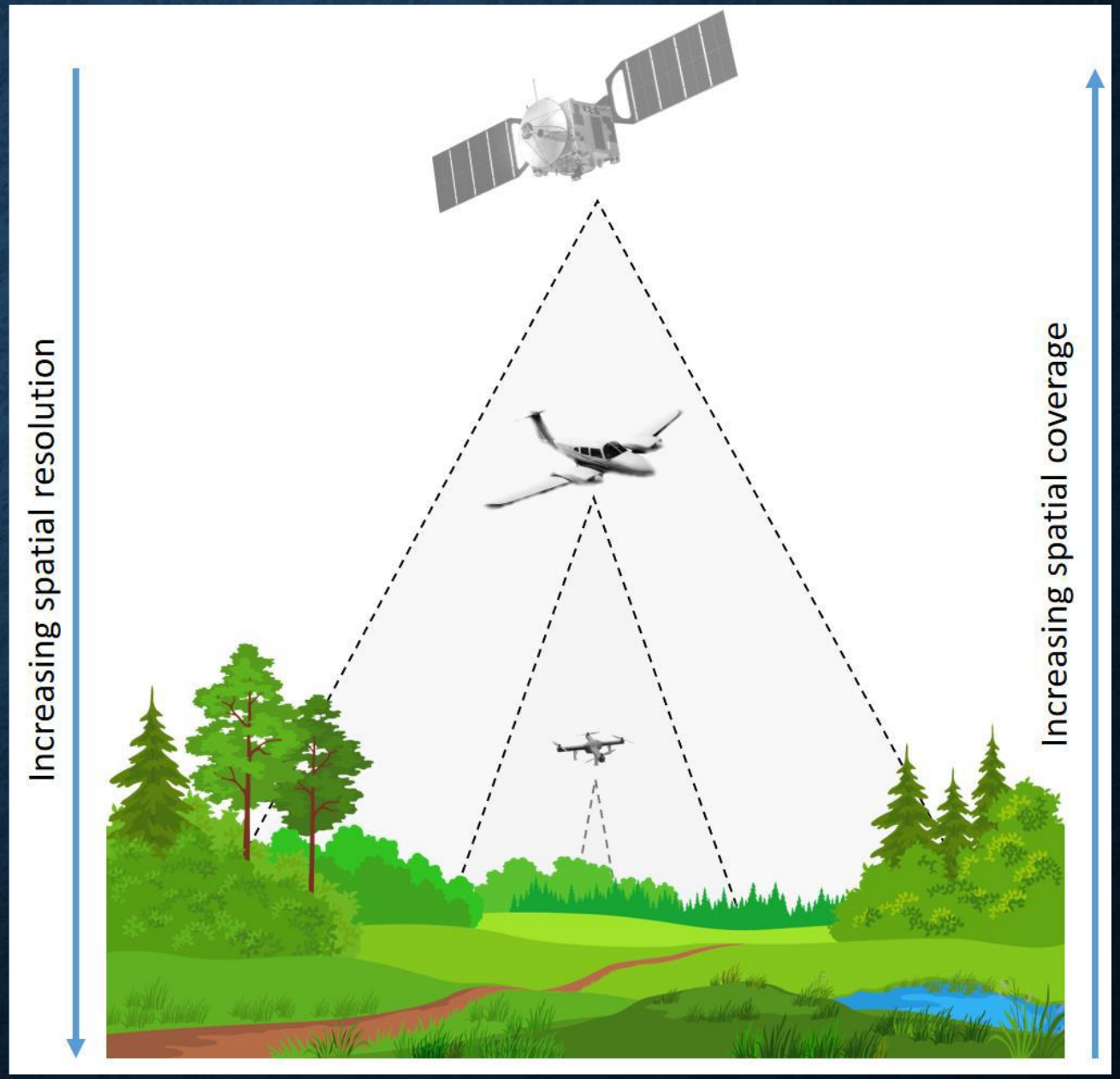


25 March 2007

Image Source: Joyce. K et al, 2010, Retrieve from ; https://knowledge.aidr.org.au/resources/ajem-oct-2010-incorporating-remote-sensing-into-emergency-management/

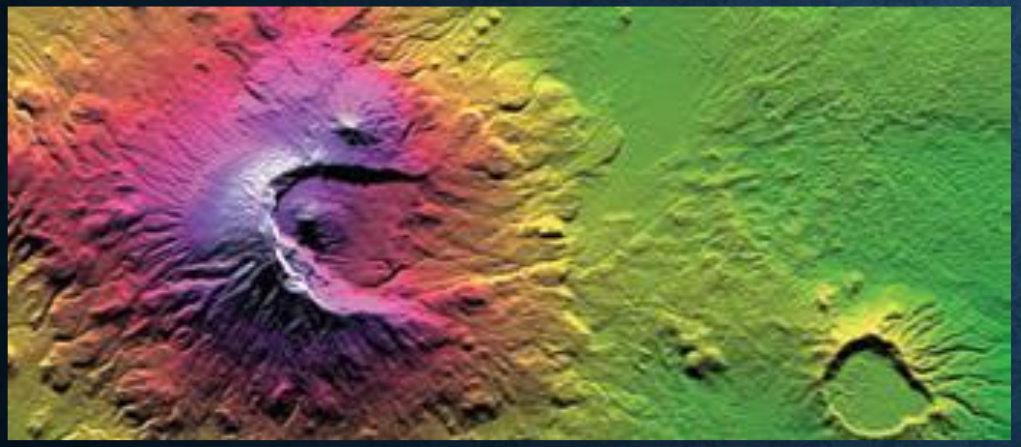
Remote Sensing – Scale and Resolution of Mapping/Data Collection

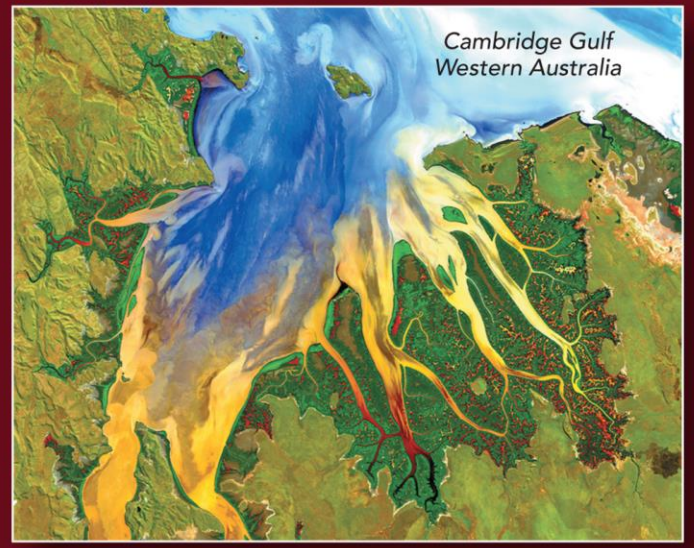
The scale of data collection and mapping varies based on platform type and flight altitude.



Source: Liao et al. (2018)

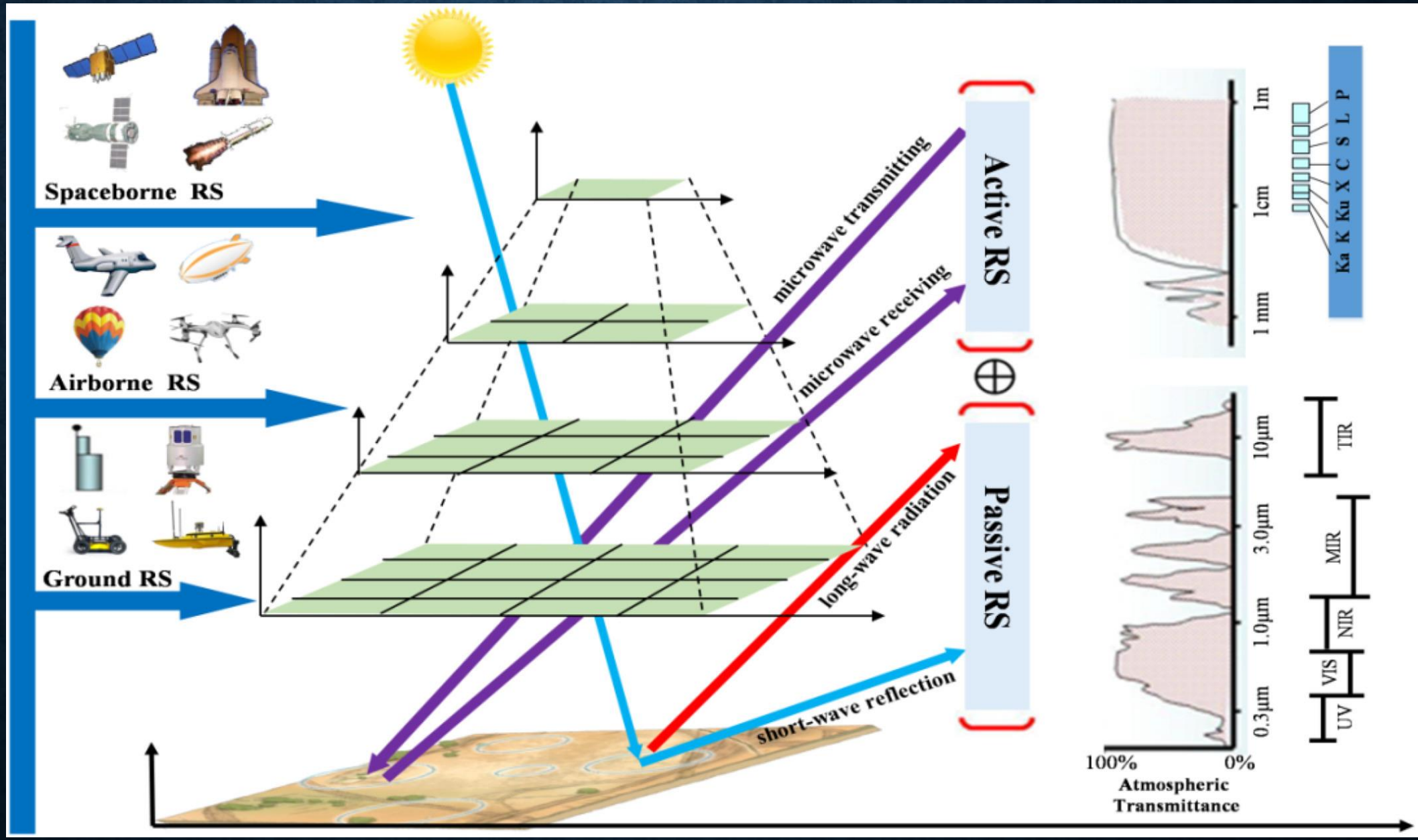
Remote Sensing data





Source: John R. Jesen, 4th Ed, Landsat 8 artist rendition: NASA, 2014

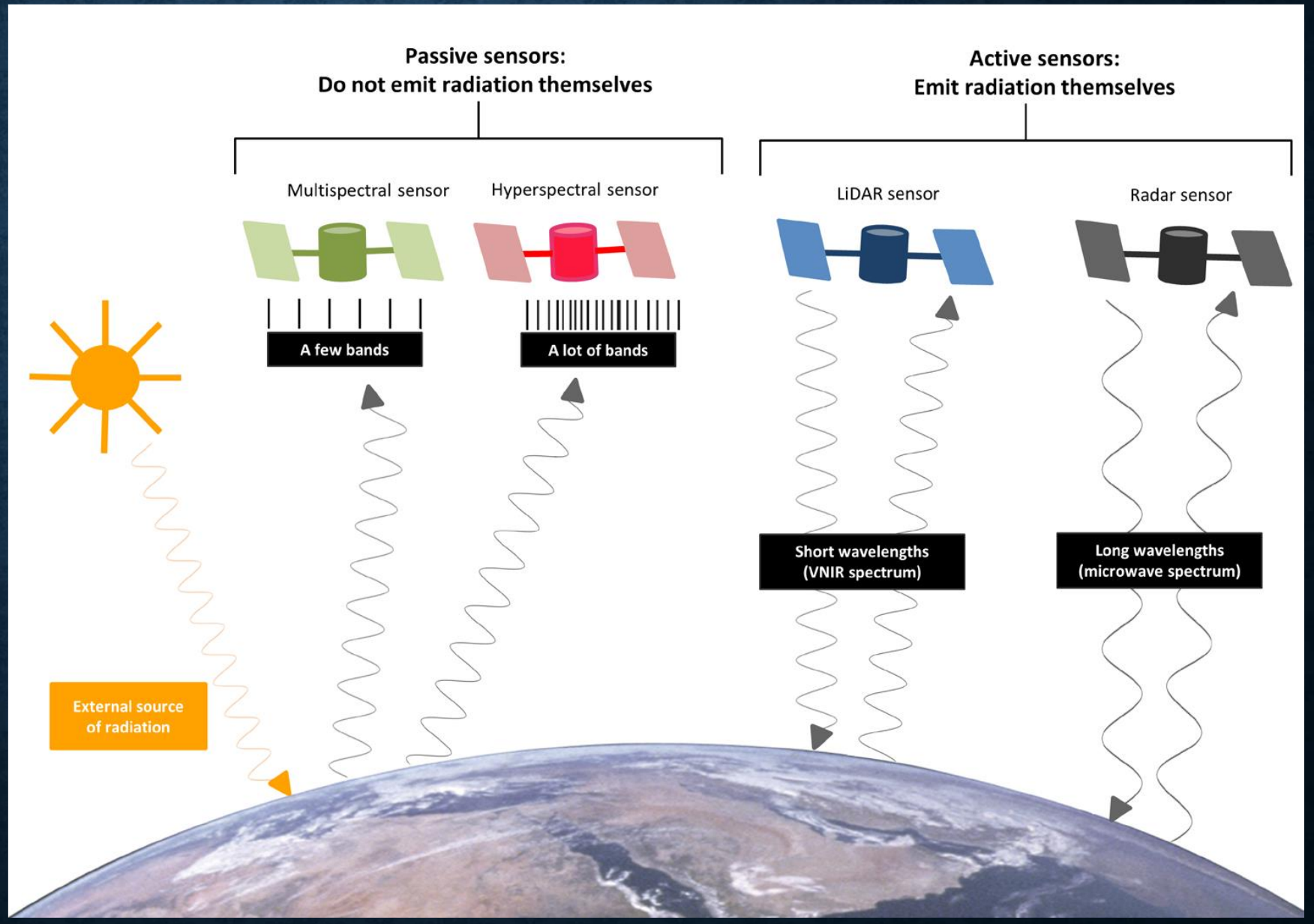
Remote Sensing – Space borne and Airborne



Source: Luo et al, 2019, https://doi.org/10.1016/j.rse.2019.111280

Passive and active Remote Sensing

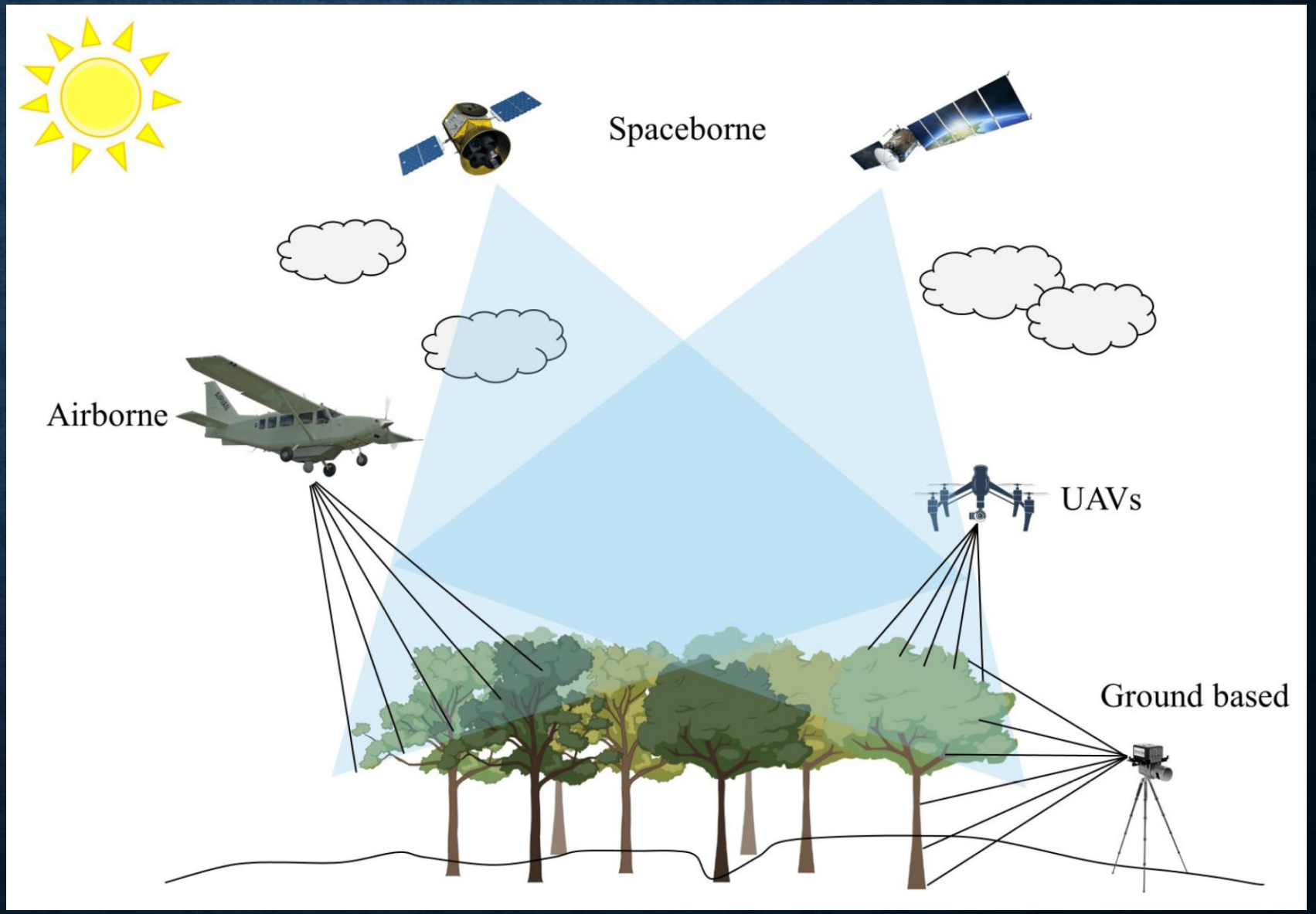
- Passive remote sensing involves detecting natural radiation emitted or reflected by objects on Earth's surface without direct interaction.
- Active remote sensing involves emitting energy and measuring the response to gather information about surface characteristics.



Source: Pettorelli, N., et al. 2018.

Remote Sensing – Space borne, Airborne and Ground Base

Illustration of forest aboveground biomass estimation using remote sensing techniques.

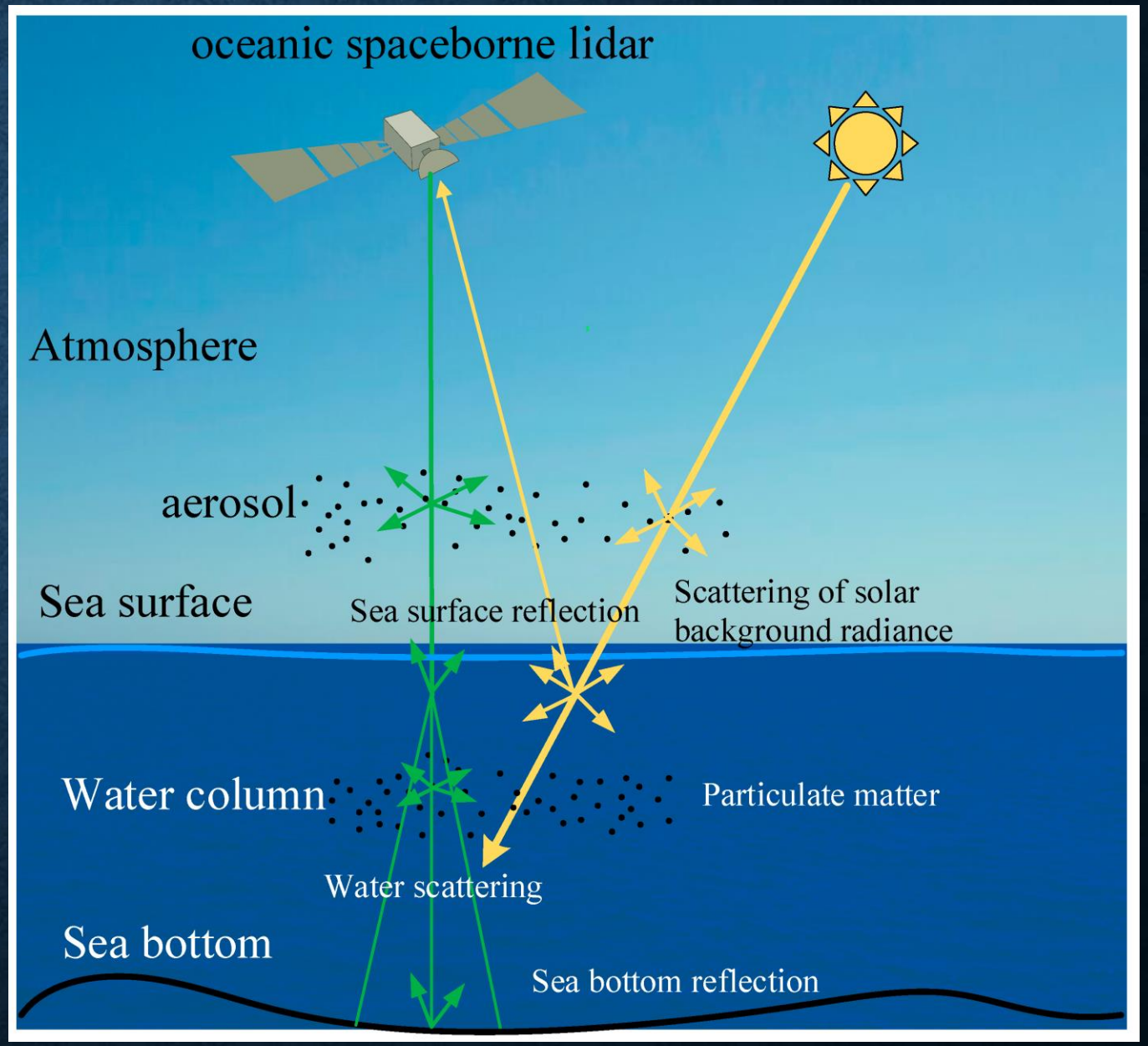


Source: Lei, et al. 2023.
https://doi.org/10.3390/f14061086

Remote Sensing – Space borne

Space borne oceanic lidar system, a laser emits a short pulse toward the atmosphere and ocean;

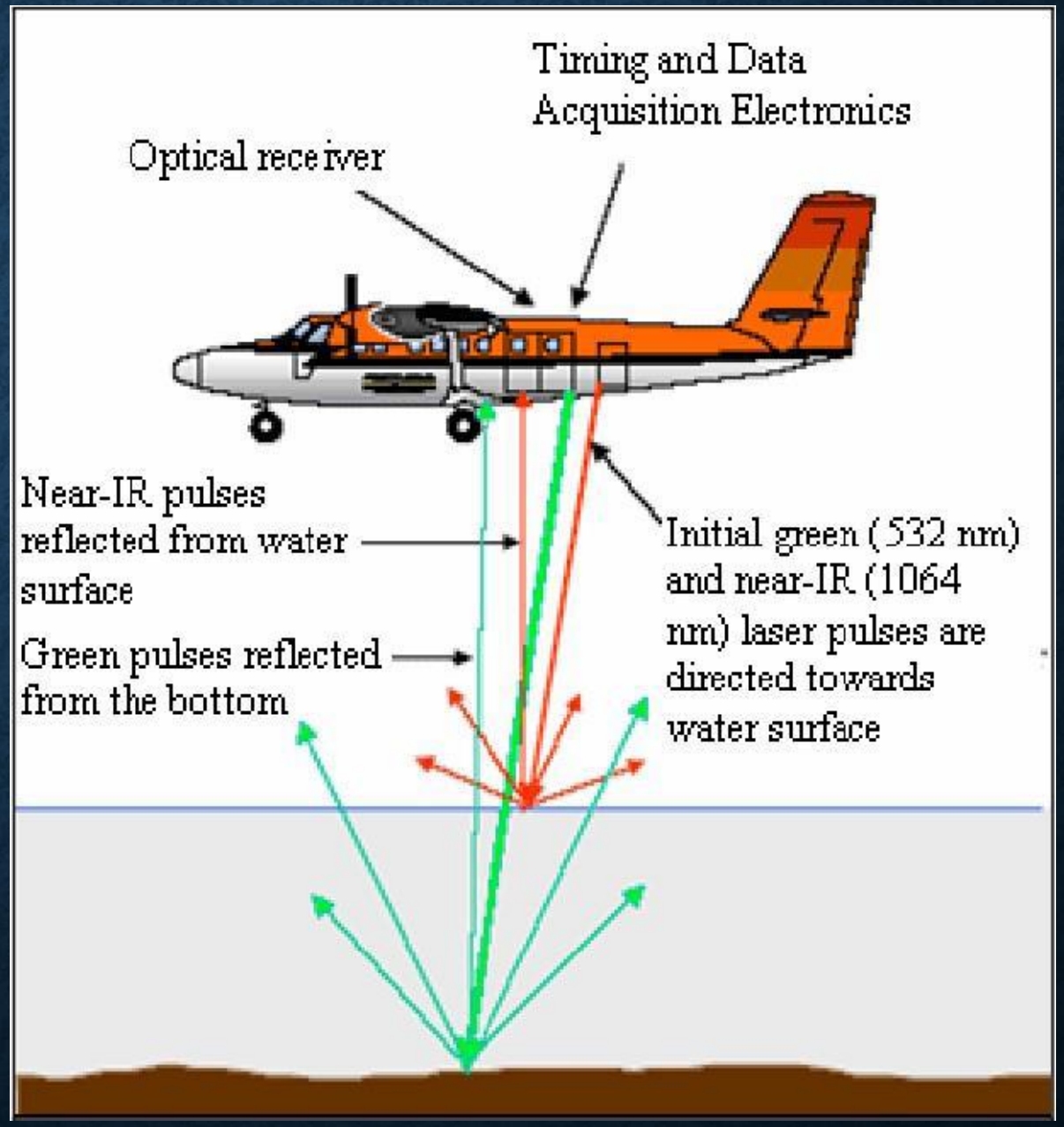
then a telescope is pointed in the same direction as the laser beam and collects the backscattered light from particles and molecules.



Source: Zhenhua. Z et al 2022. https://doi.org/10.3390/rs14081849

Remote Sensing – Airborne

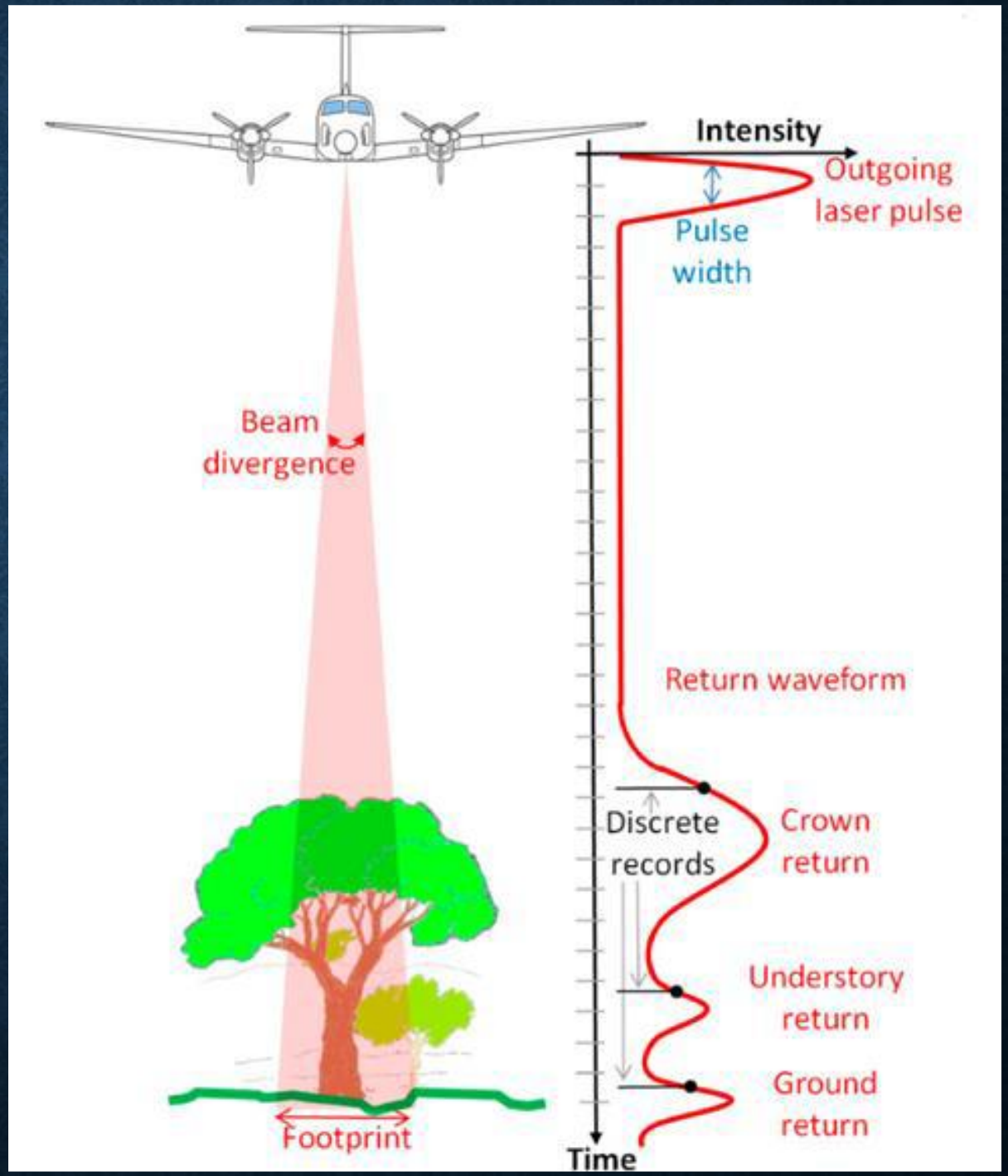
Bathymetric LiDAR System.



Source: LaRocque and West, 1990

Remote Sensing – Airborne

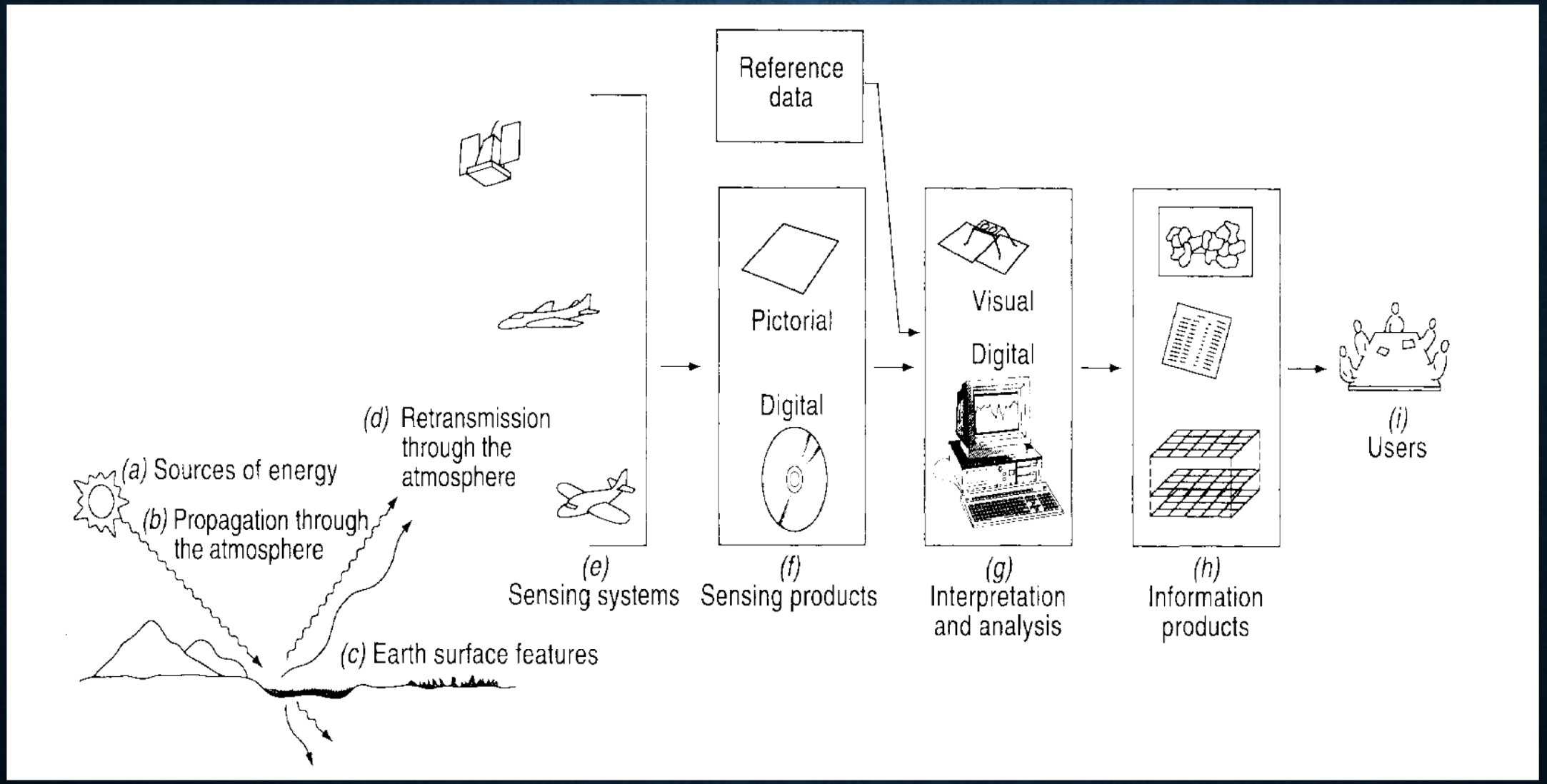
Forest canopy mapping.



source: Fernandez-Diaz et al., (2014

Remote Sensing Processes

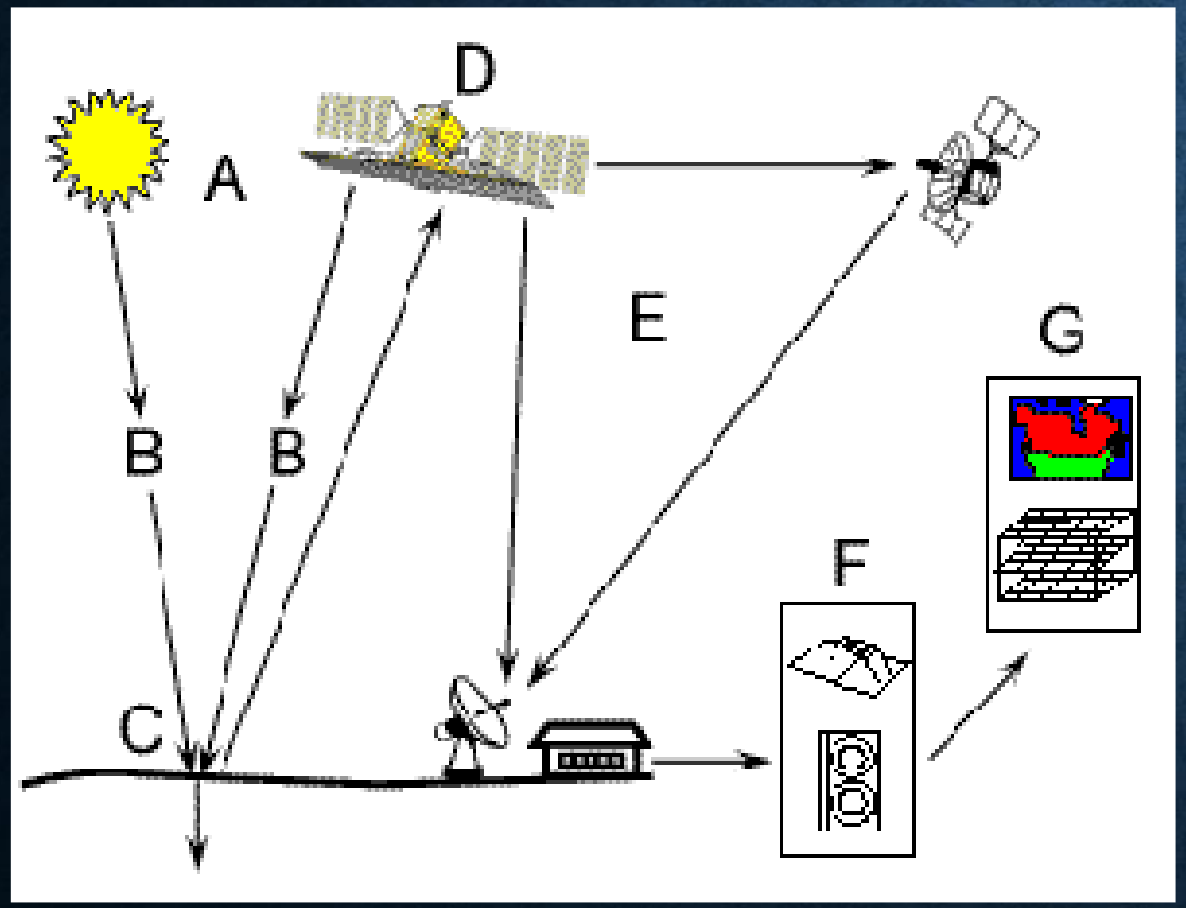
Data Acquisition to Analysis



Source: Thomas M. Lillesand, Ralph W. Kiefer and Jonathan W. Chipman, 2004, fifth ed.

Remote Sensing Processes

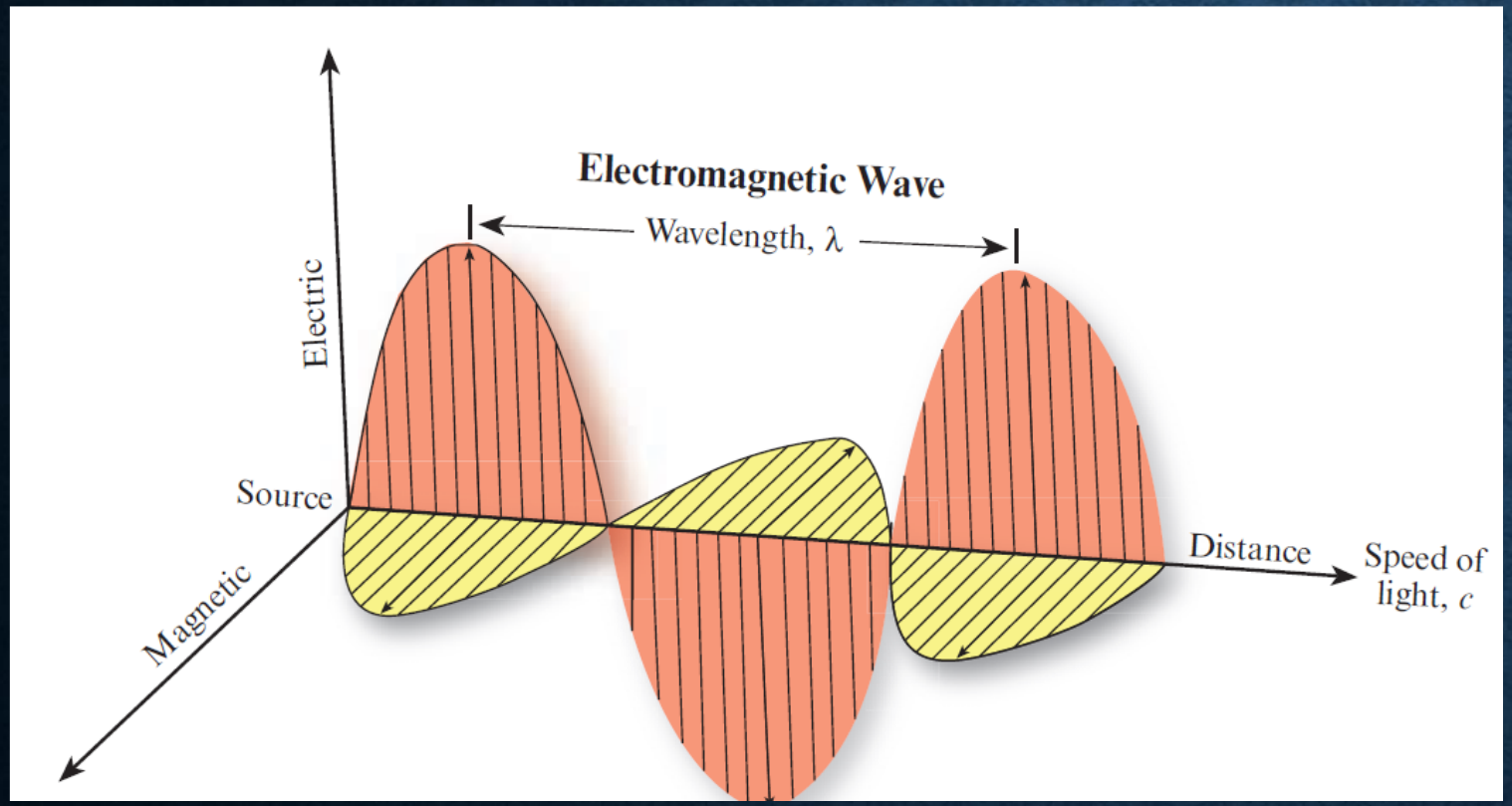
Data Acquisition to Analysis



- Energy Source or Illumination (A)
- Radiation and the Atmosphere (B)
- Interaction with the Target (C)
- Recording of Energy by the Sensor (D)
- Transmission, Reception, and Processing (E)
- Interpretation and Analysis (F)
- Application (G)

Source: CCRS/CCT

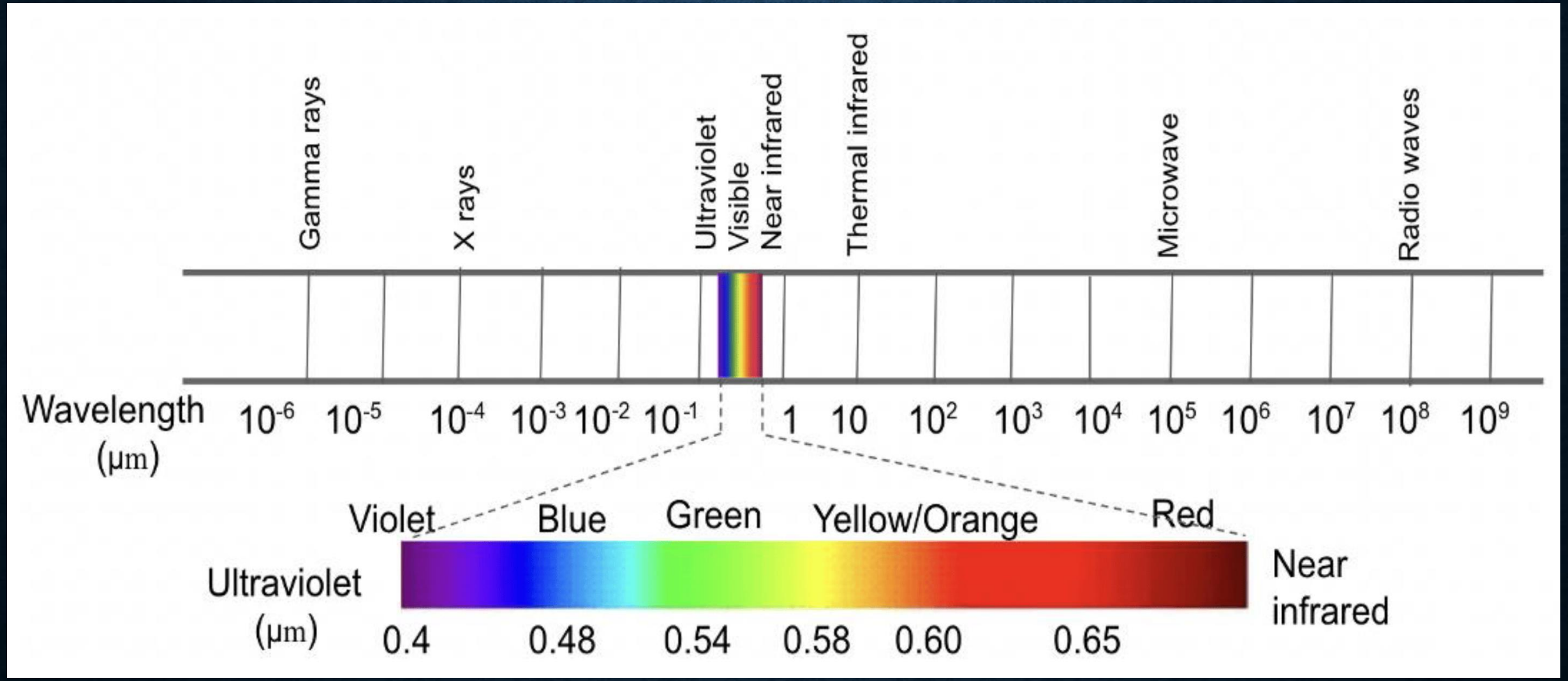
Electromagnetic Radiation



- Electrical Field.
- Magnetic field.
- Travel at the speed of light

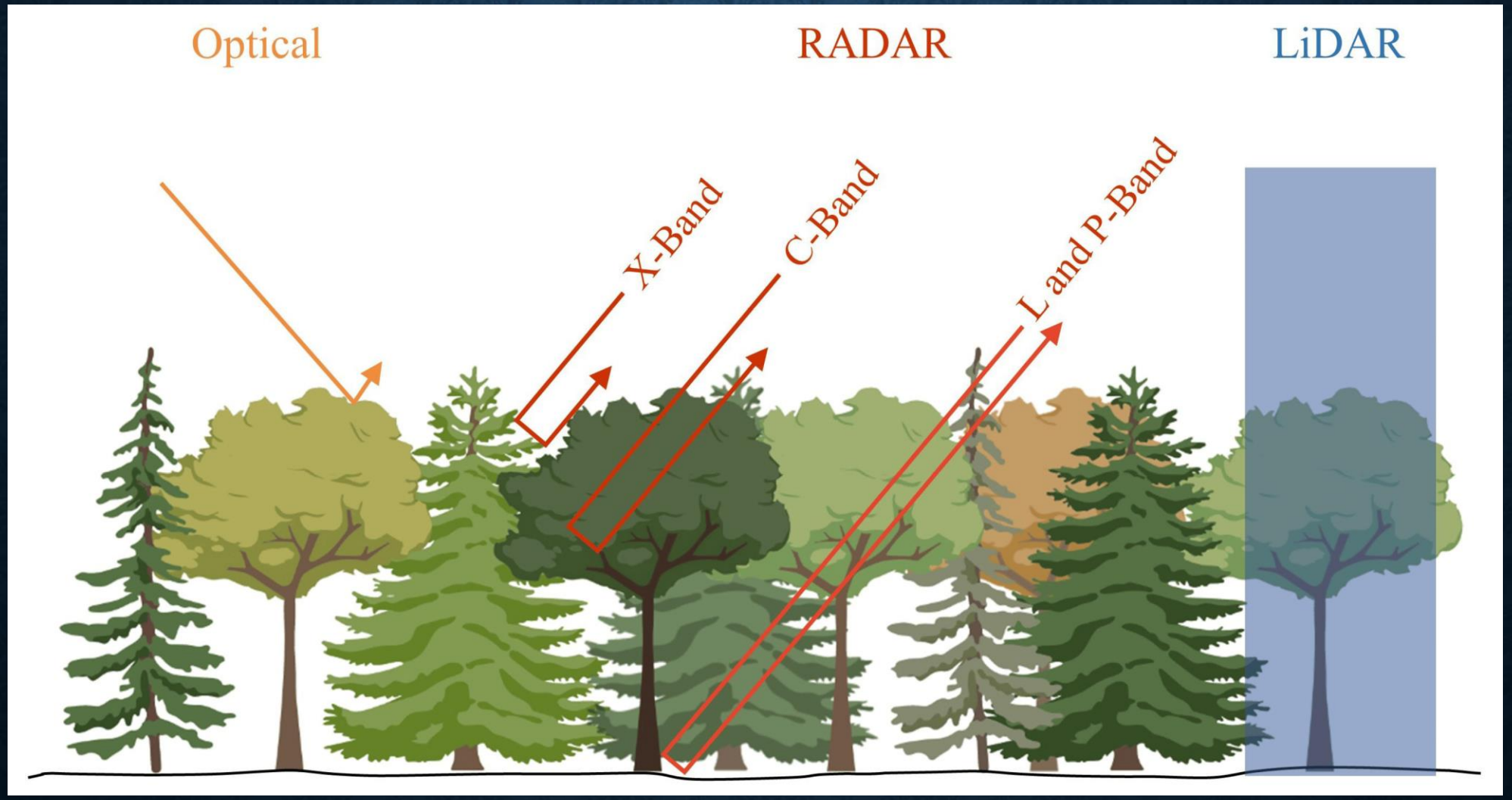
Source: John R. Jesen, 4th Ed, 2015

Electromagnetic Radiation



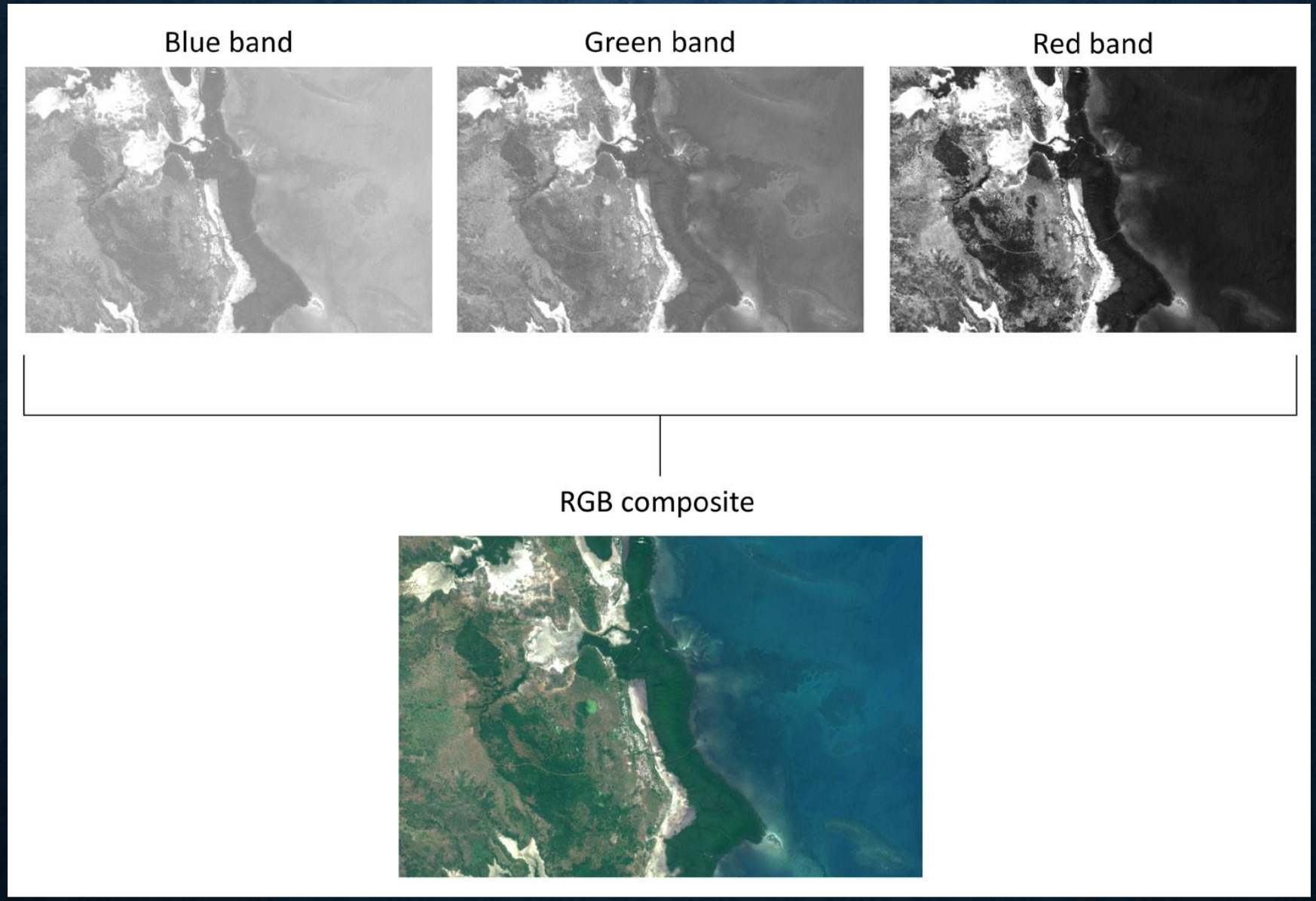
Source: Janga B, et al. https://doi.org/10.3390/rs15164112

Electromagnetic Radiation and Advantages of Data Capture



Source: Lei, et al. 2023. https://doi.org/10.3390/f14061086

Electromagnetic Radiation to Image



Source: Pettorelli, N., et al. 2018.

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