SESSION #2

Introduction to Remote Sensing

Presenters: David Hunt and Jenny Hewson

Session #2 Outline

- Overview of remote sensing concepts
- History of remote sensing
- Current remote sensing technologies for land management

What Is Earth Observation and Remote Sensing?

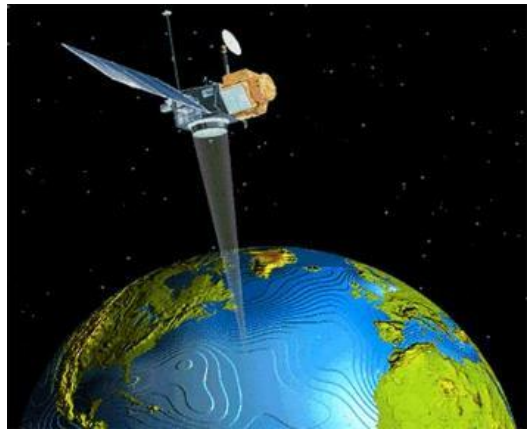
- "Obtaining information from an object without being in direct contact with it."
- More specifically, "obtaining information from the land surface through sensors mounted on aerial or satellite platforms."

Balloon photography (1858)

Pigeon cameras (1903)

Aircraft (WWI and WWII)

Space (1947)



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

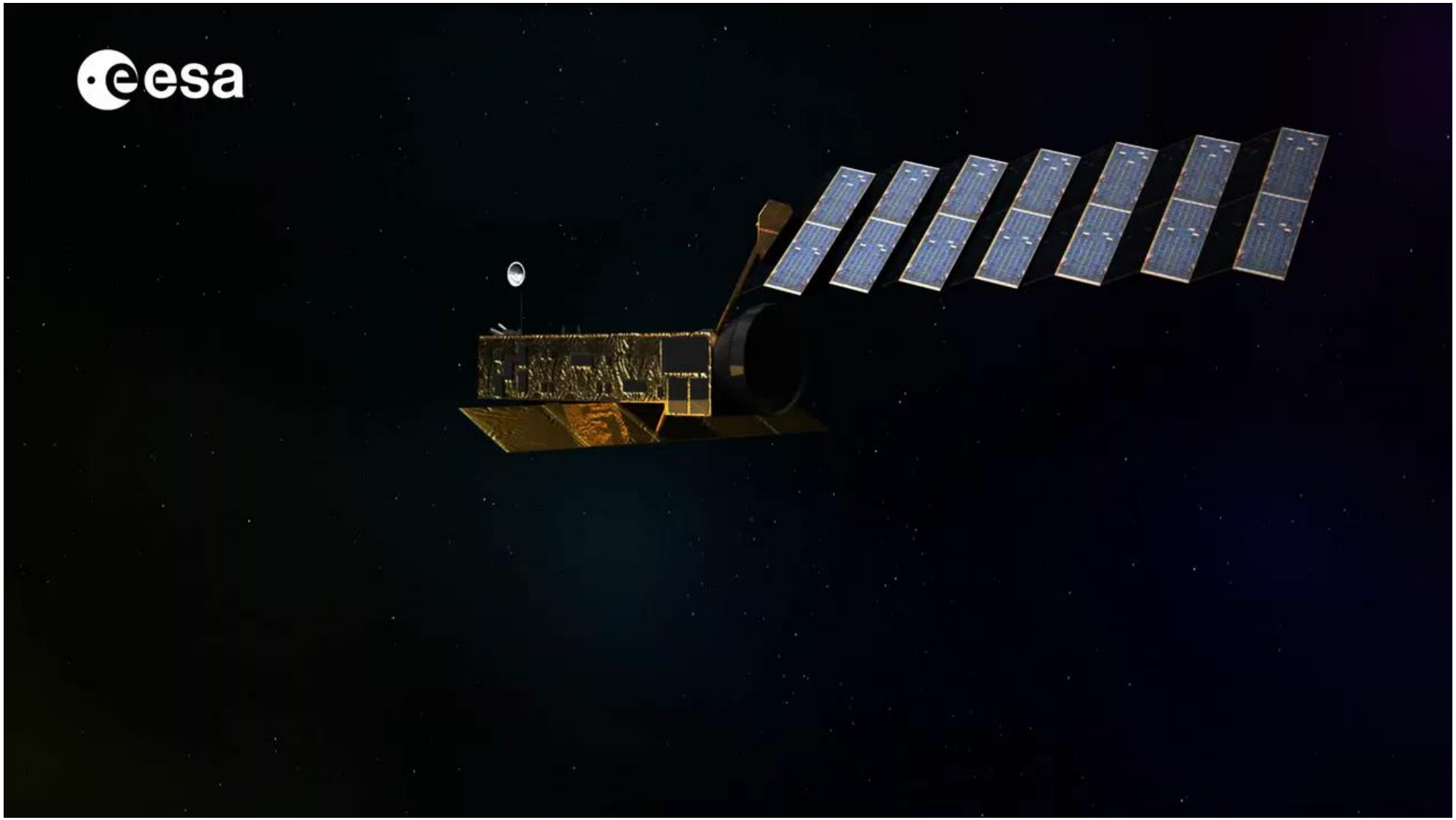
Improving sustainable land management using Earth Observation is critical for:

- 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

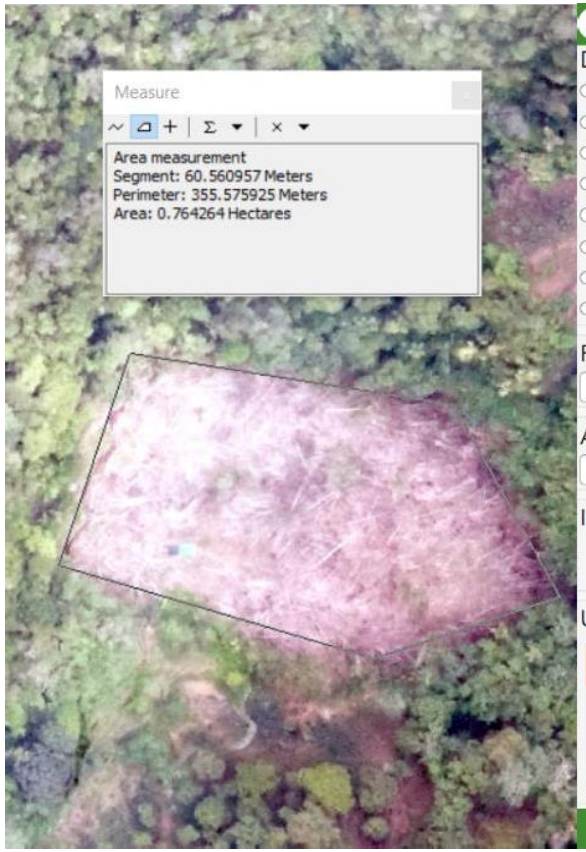
Deforestation Monitoring

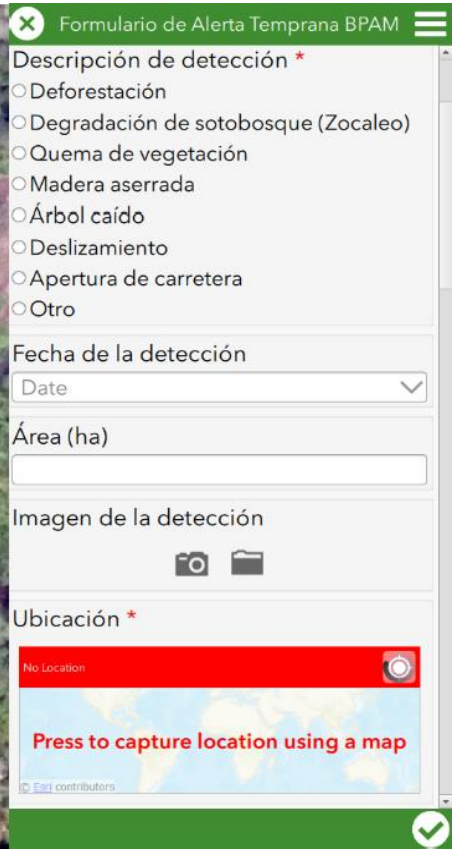
ESA video showing deforestation in Rondonia, Brazil from 1986 to 2010

Forest Fire Monitoring



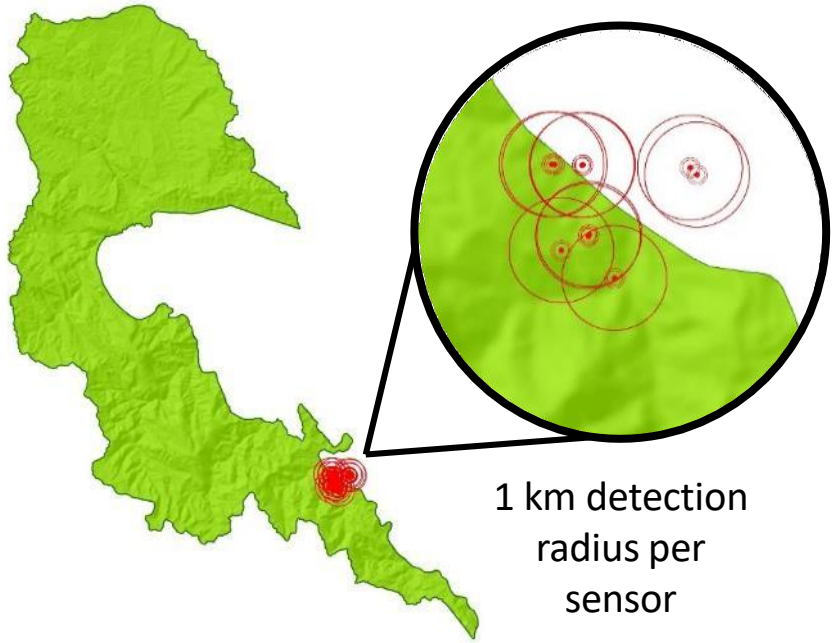
Monitoring Land Use Changes





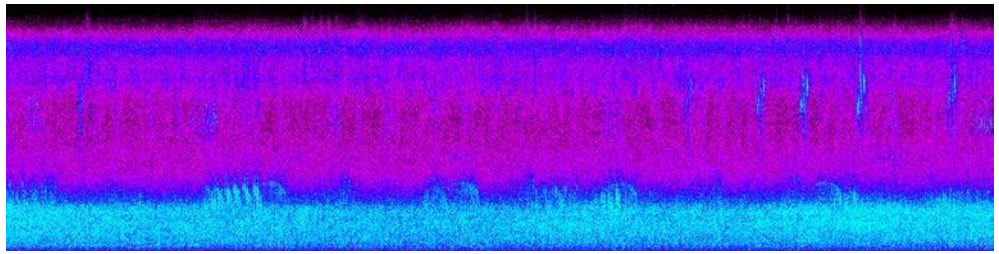
Monitoring Illegal Logging with Acoustic Alerts

1) Chainsaw noise is detected by acoustic sensors



1 km detection radius per sensor

2) Acoustic sensors send alerts via e-mail

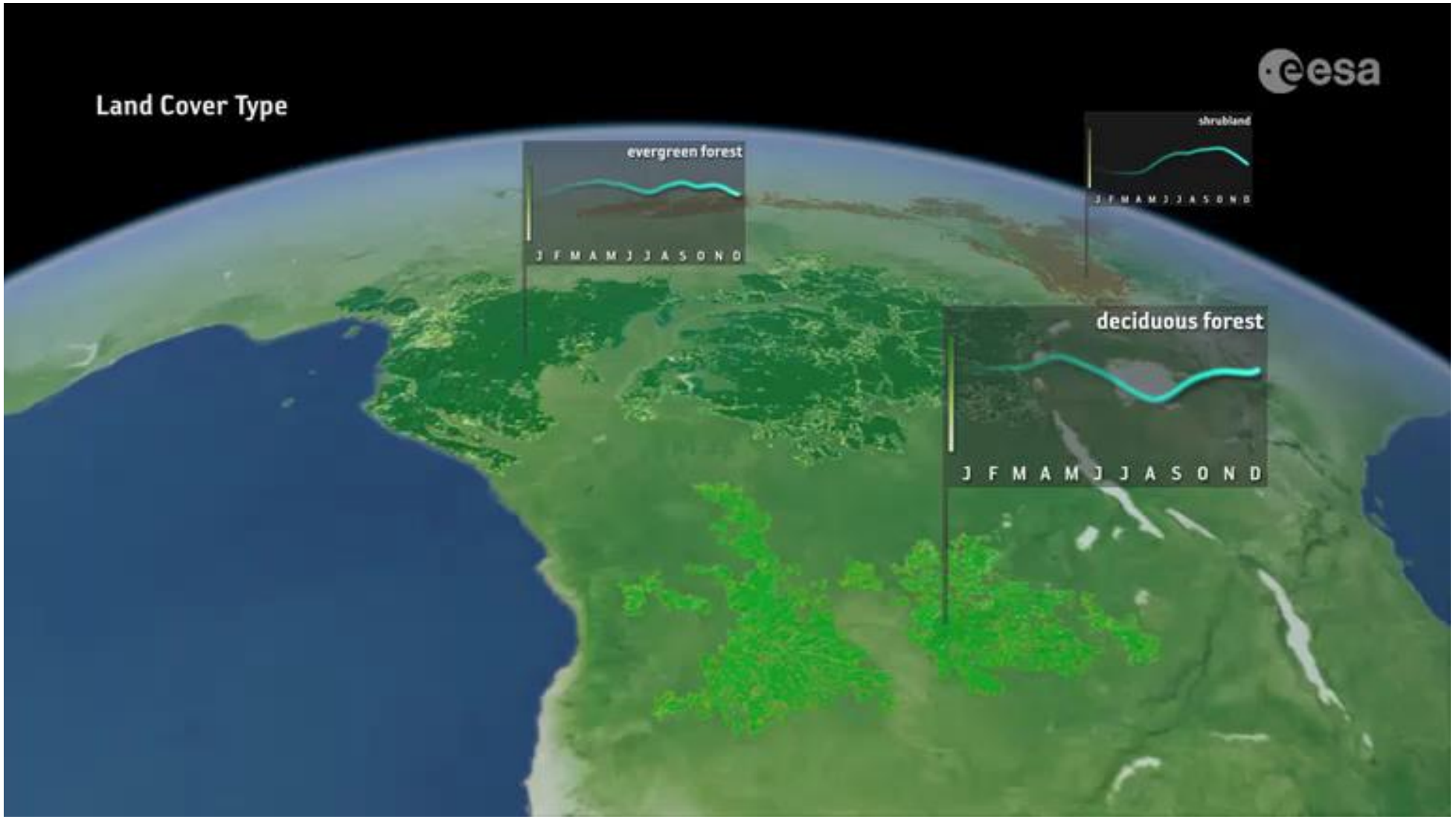


Guardian:	MoviStar Tower
LAT/LONG:	-5.97801,-77.3558
Fecha y hora inicial:	2017-06-20 14:22:41.848000 (America/Lima)
Fecha y hora final:	2017-06-20 14:24:11.848000 (America/Lima)
Intervalo de confianza:	0.97872
Archivo mp3:	https://assets.rfcx.org/audio/658a3786-efb5-4756-96dd-fae176fe5624.mp3
Archivo png:	https://assets.rfcx.org/audio/658a3786-efb5-4756-96dd-fae176fe5624.png

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



Mapping Land Boundaries

- Participatory Mapping using Satellite imagery
- Example from session #1 with the COMUNIDAD NATIVA ALTO MAYO

Satellite Remote Sensing

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)

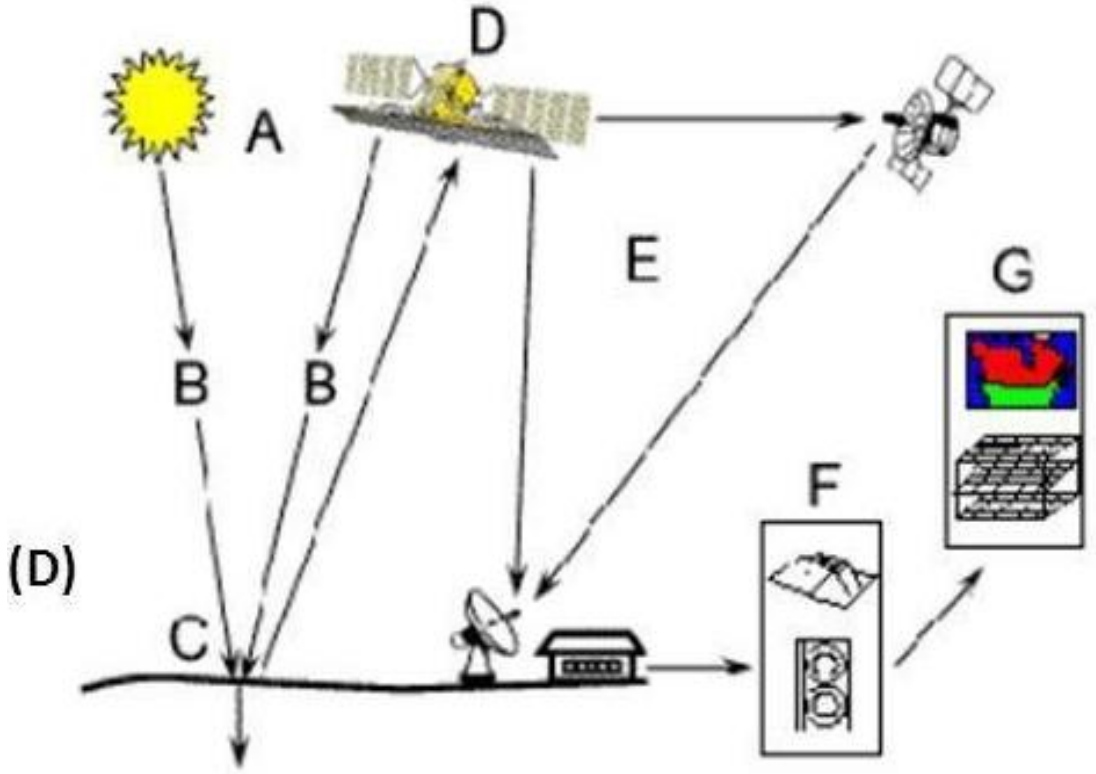
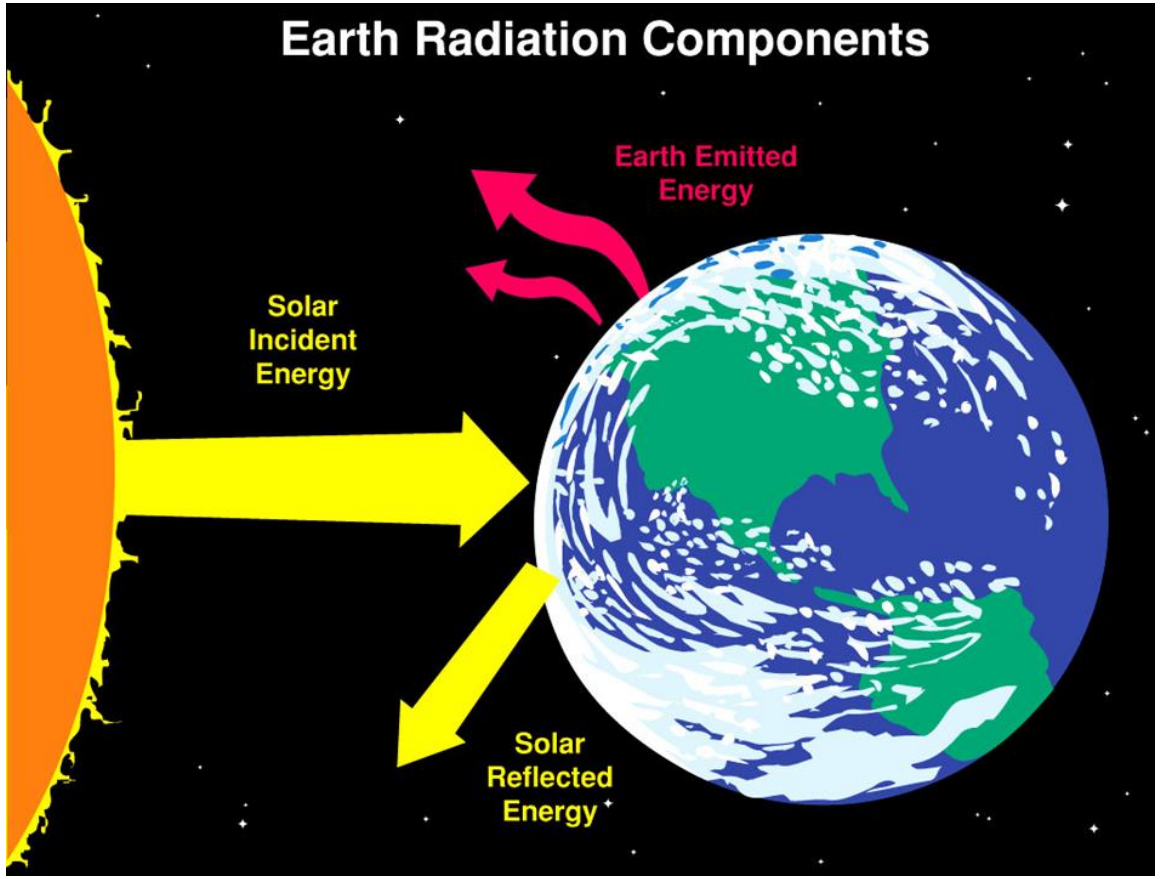


Image Credit: Dipen Sahajramani, M.Tech Geomatics & Remote Sensing, Center for Environmental Planning and Technology University (2019)
https://www.quora.com/What-are-the-components-of-a-remote-sensing-satellite

1. Energy Source or Illumination

Earth Radiation Components

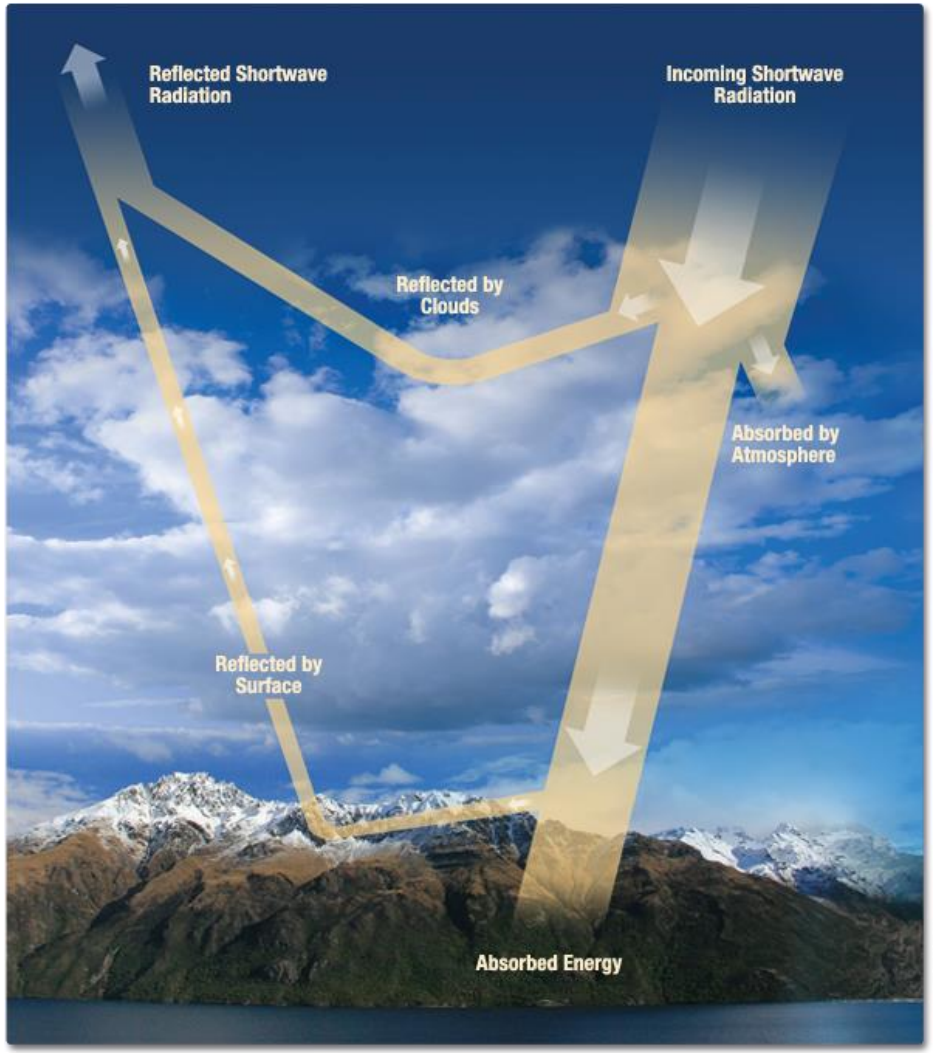
- Incident energy from the sun is:
  - Reflected (Solar Reflected Energy)
  - Transmitted
  - Absorbed



2. Radiation and the Atmosphere

Atmosphere

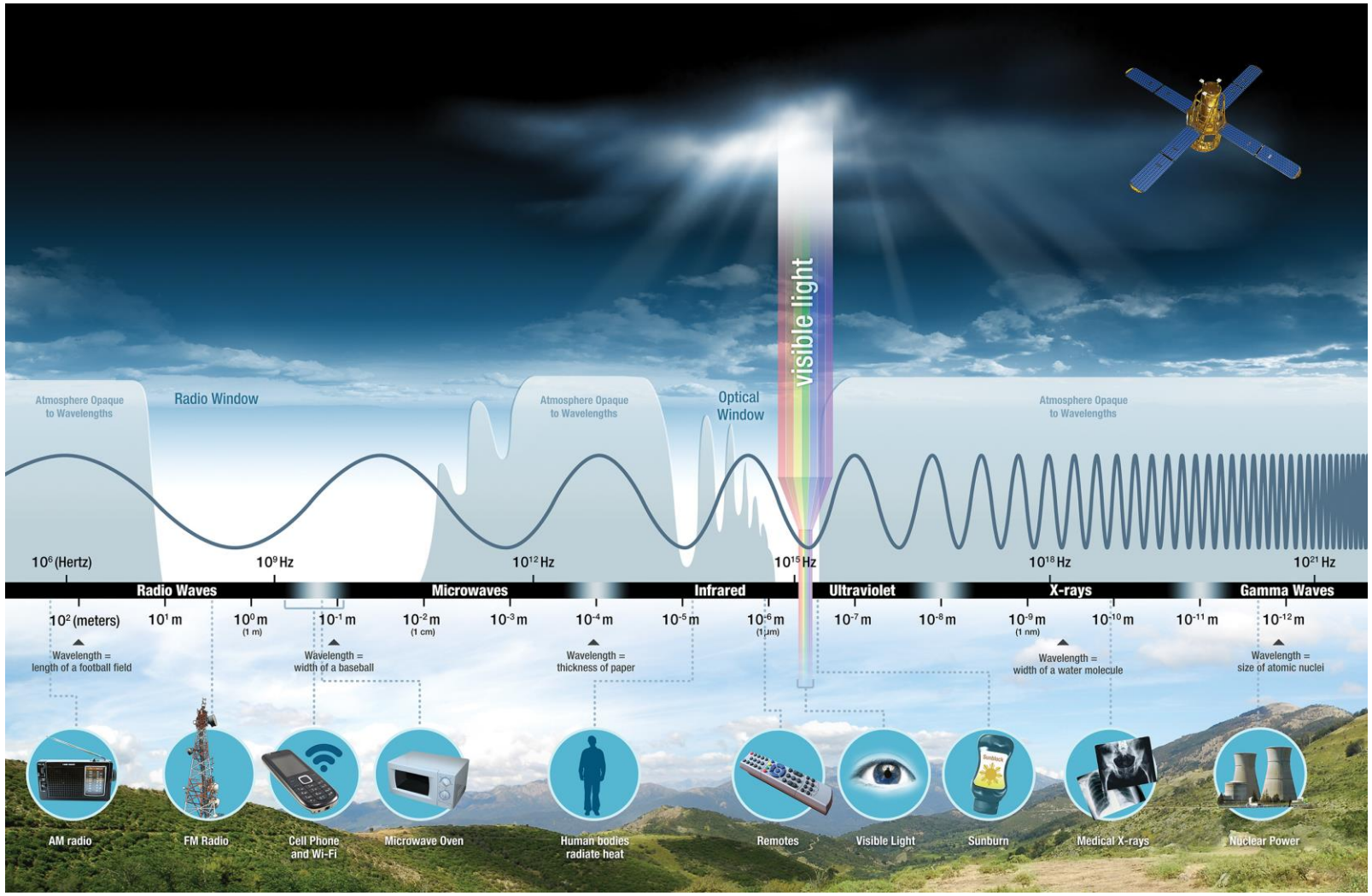
- Clouds reflect visible solar radiation and emit infrared radiation into space and provide an indirect measure of precipitation
- Microwave frequencies are used to observe precipitation



3. Interaction with the Target

Electromagnetic Spectrum

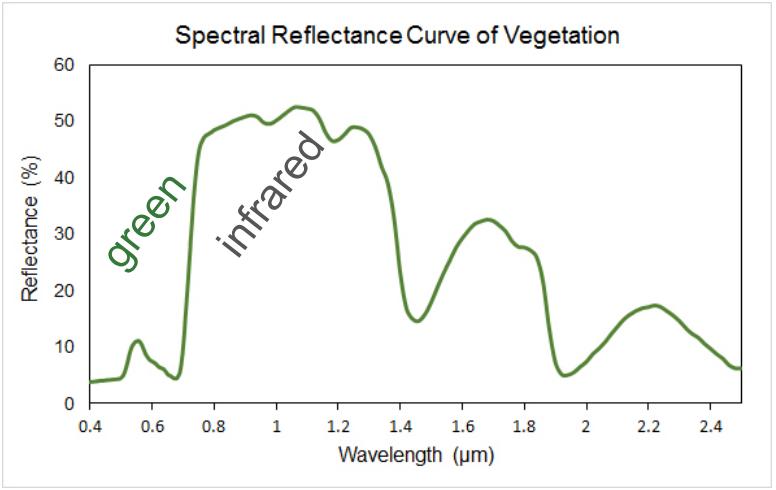
- Orbiting satellites carry sensors or instruments
- Sensors are calibrated to detect various wavelengths along the electromagnetic spectrum, often including visible light



3. Interaction with the Target

Vegetation

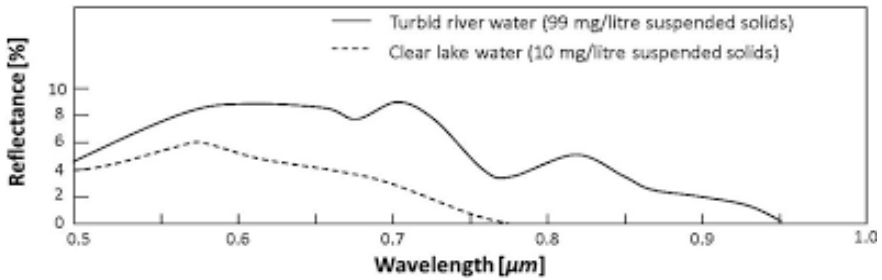
- Healthy vegetation absorbs blue and red wavelengths but reflects green and infrared
- Since we can't see infrared radiation, we see healthy vegetation as green



3. Interaction with the Target

Water

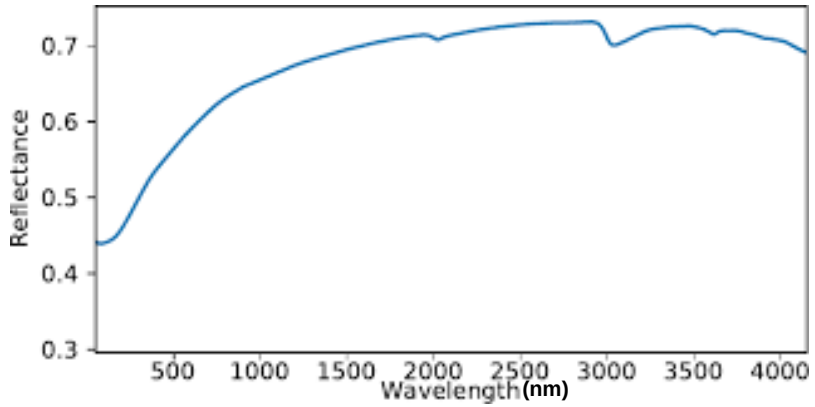
- Longer visible wavelengths (green and red) and near-IR radiation are absorbed more by water than shorter visible wavelengths (blue)
- Water usually looks blue or blue-green
- Sediment in the upper layers of water will cause more reflectance and the water will appear brighter



3. Interaction with the Target

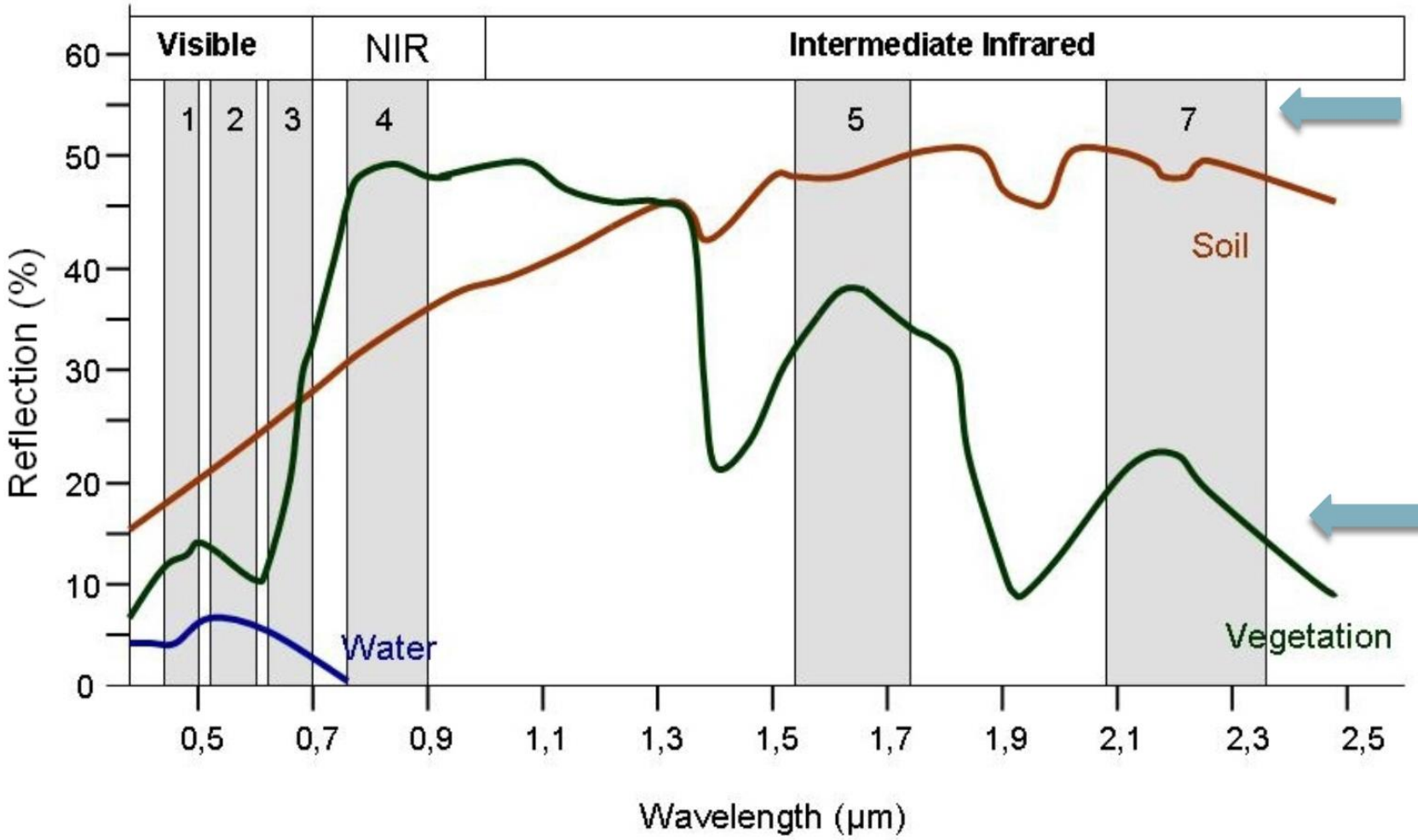
Soil

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



3. Interaction with the Target

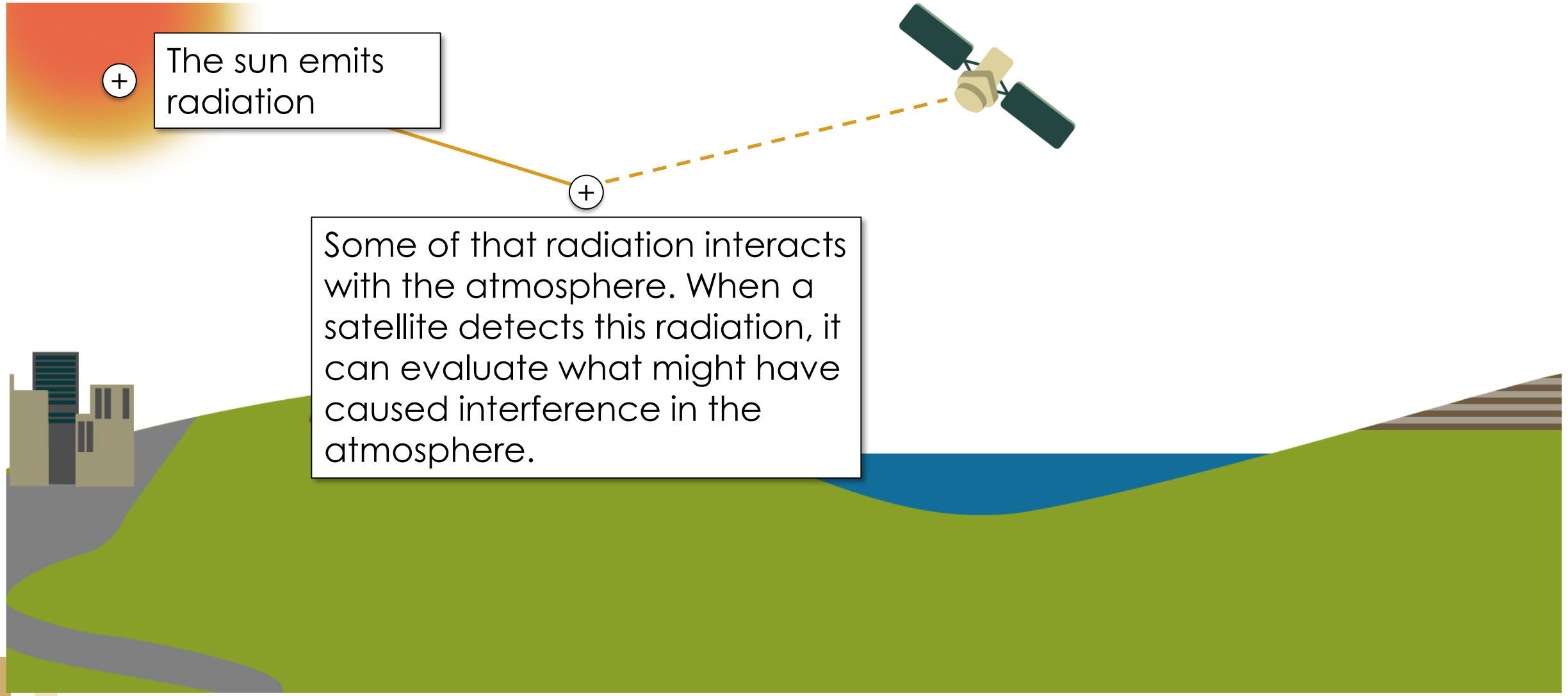
Spectral Signatures



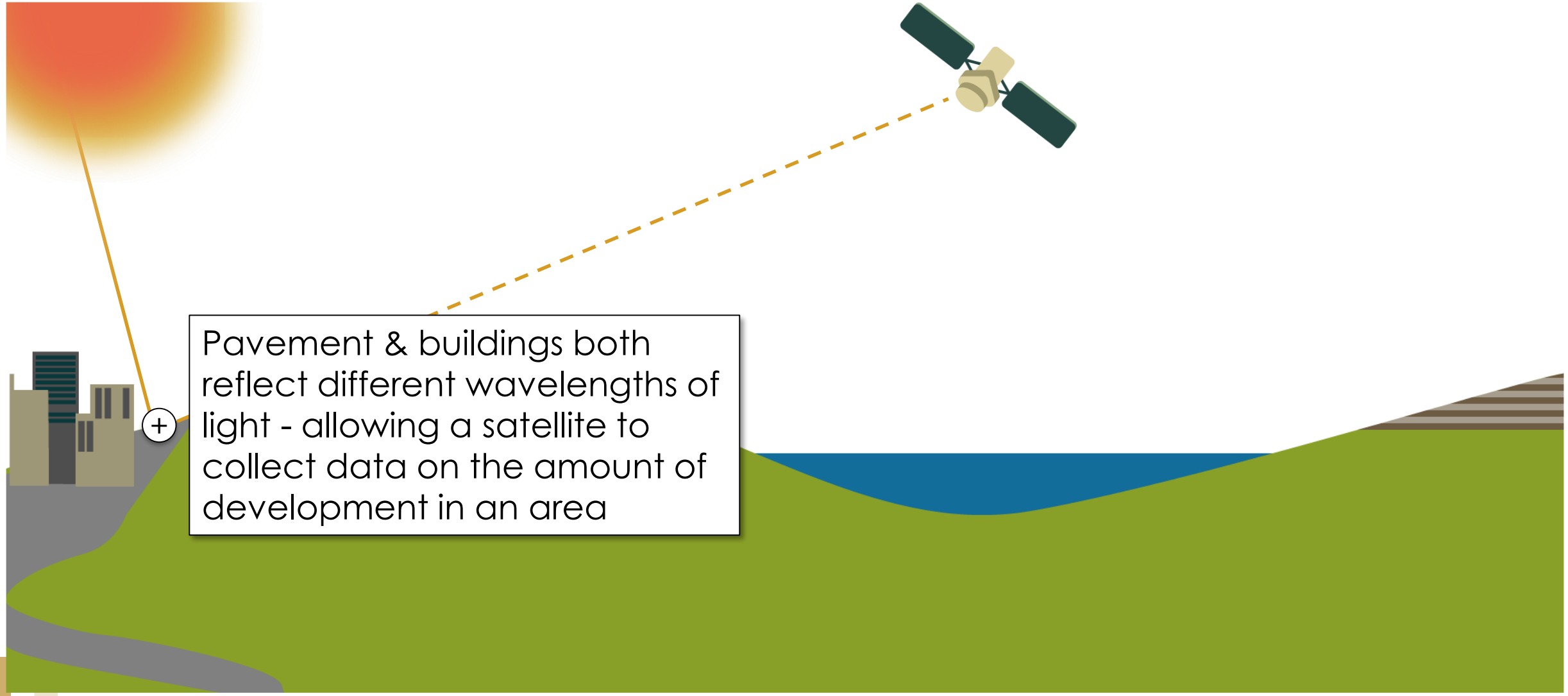
Landsat bands

Spectral signatures

4. Energy Recording by Sensor

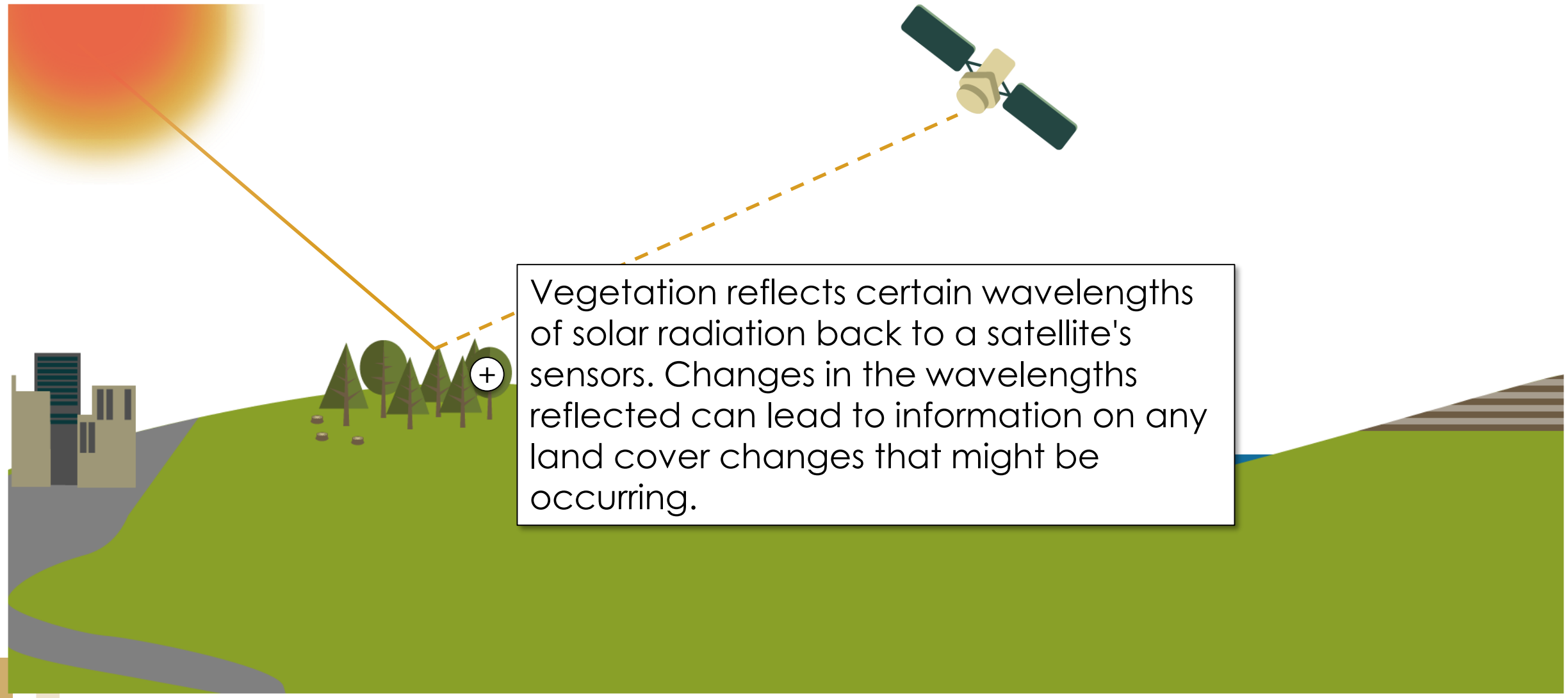


4. Energy Recording by Sensor



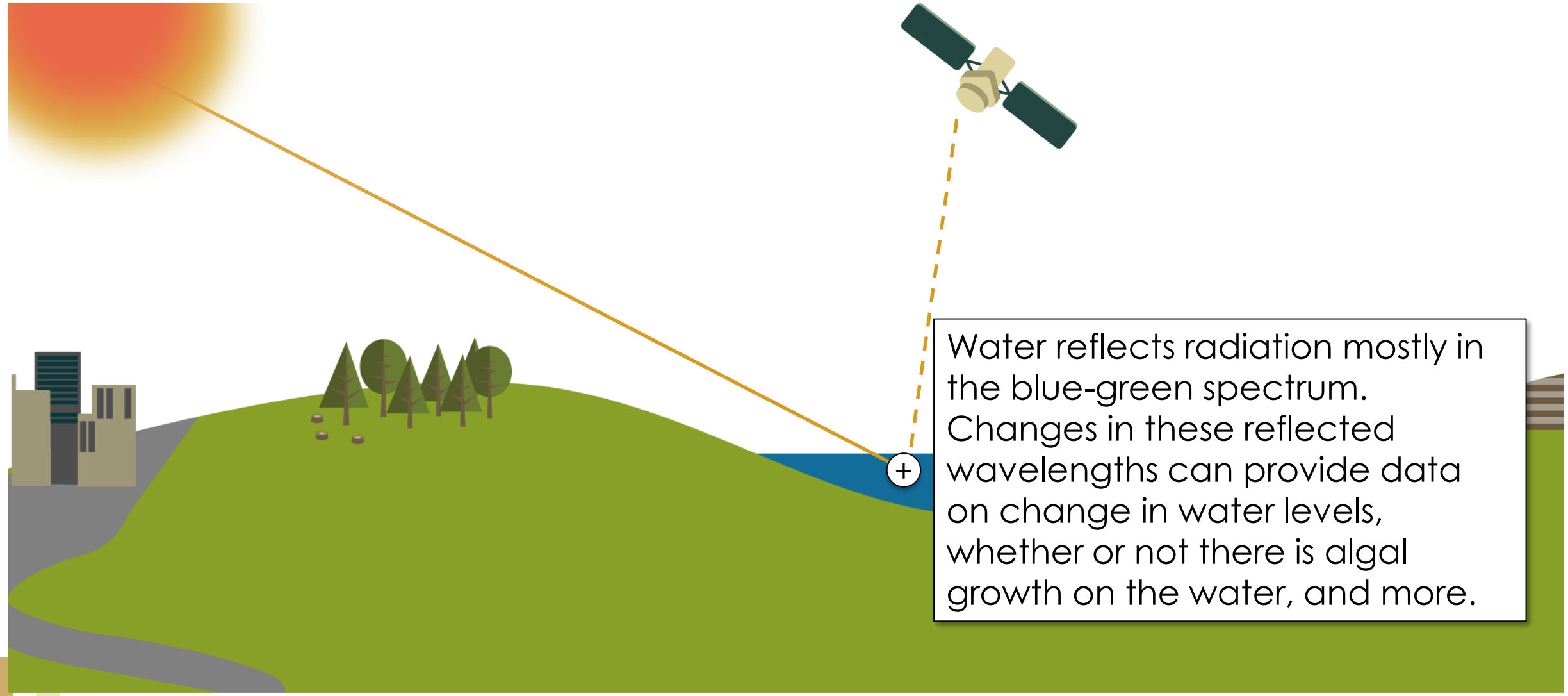
Pavement & buildings both reflect different wavelengths of light - allowing a satellite to collect data on the amount of development in an area

4. Energy Recording by Sensor



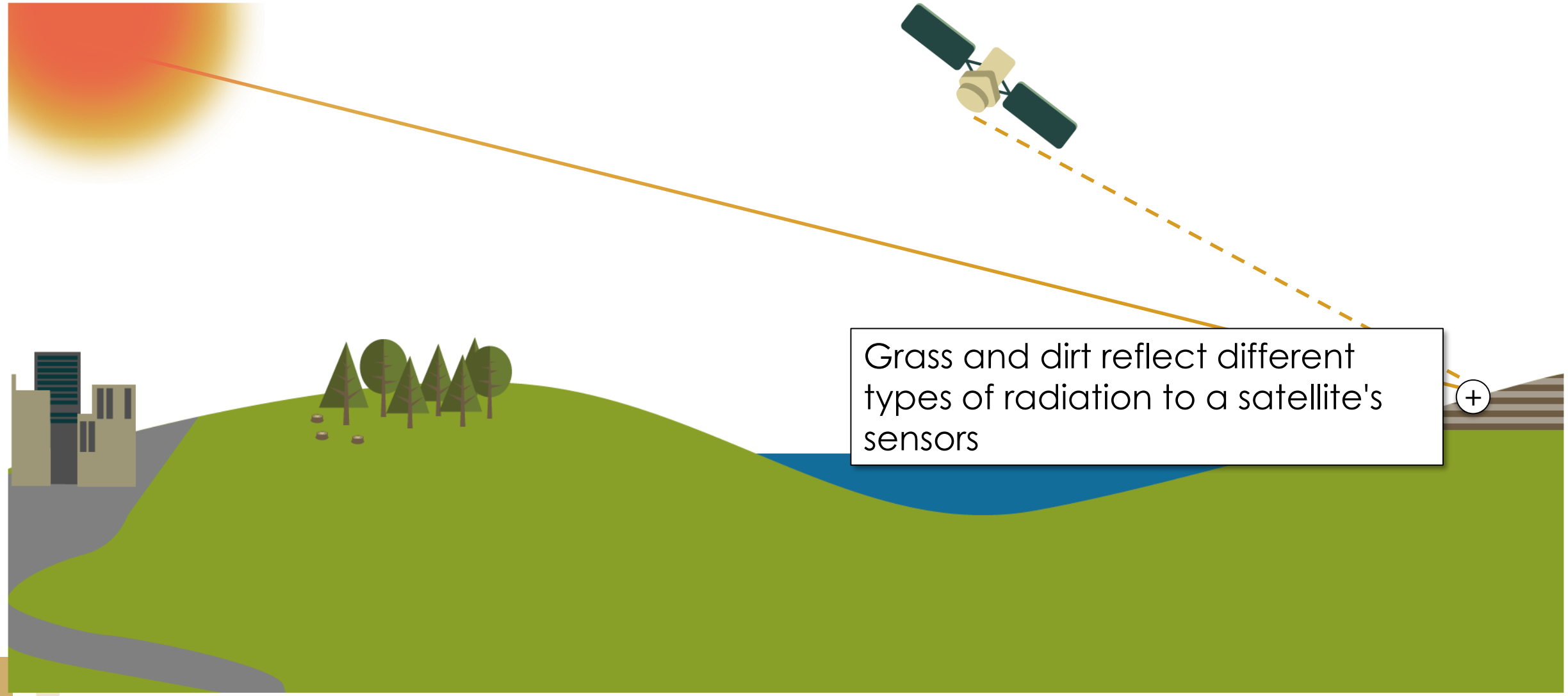
Vegetation reflects certain wavelengths of solar radiation back to a satellite's sensors. Changes in the wavelengths reflected can lead to information on any land cover changes that might be occurring.

4. Energy Recording by Sensor



Water reflects radiation mostly in the blue-green spectrum. Changes in these reflected wavelengths can provide data on change in water levels, whether or not there is algal growth on the water, and more.

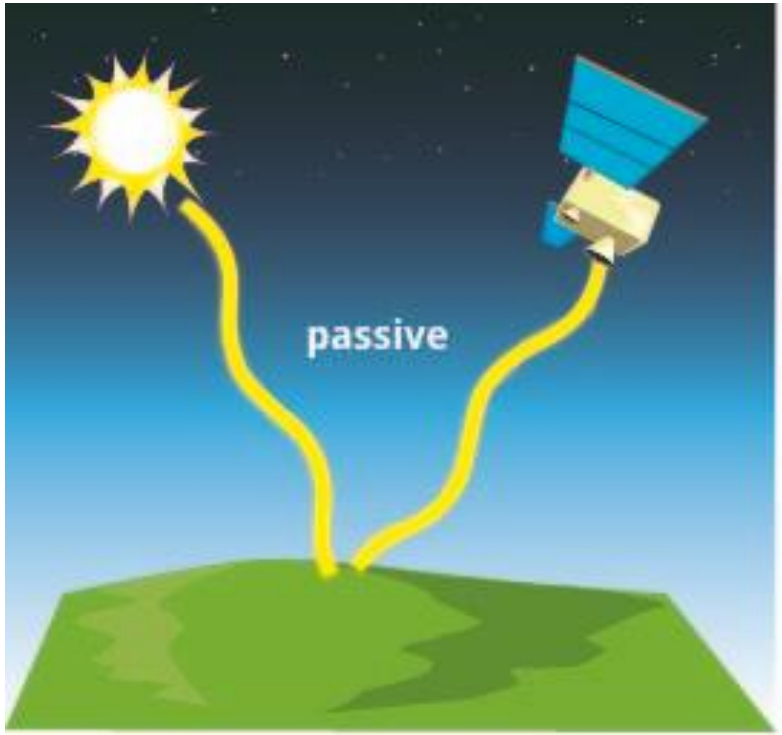
4. Energy Recording by Sensor



Sentinel-2B

Types of Remote Sensing

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



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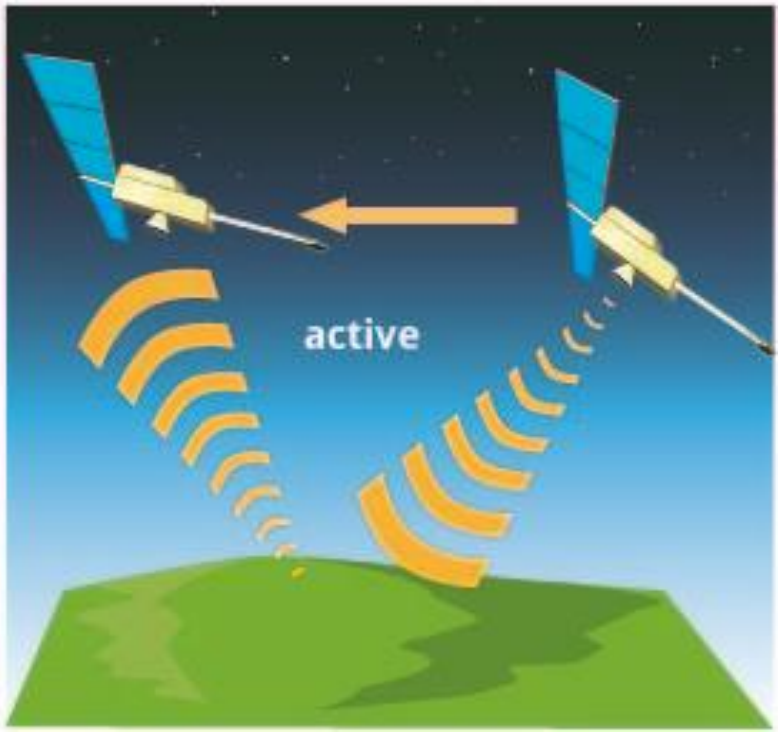
Active: source of energy is part of the remote sensor system



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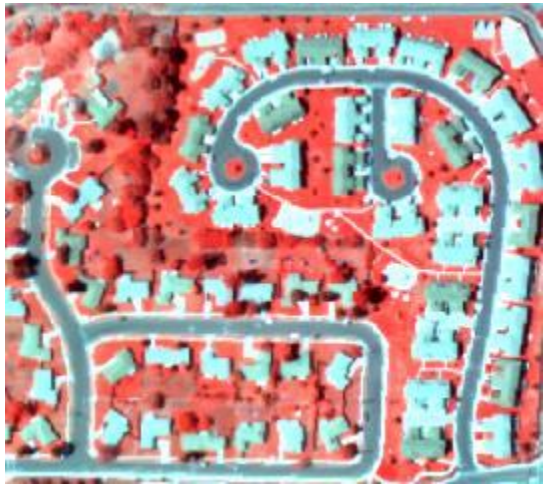
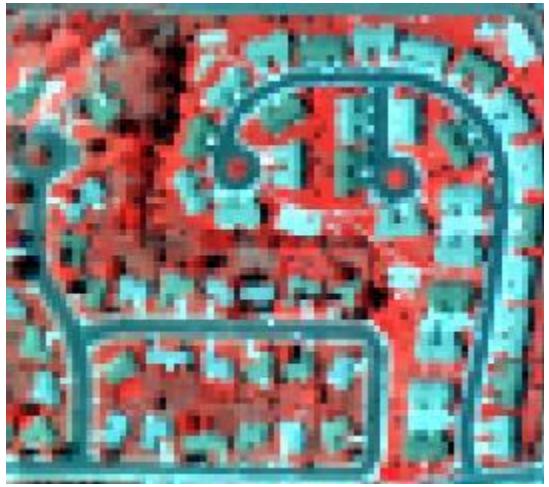
Types of Resolution

Spatial Resolution

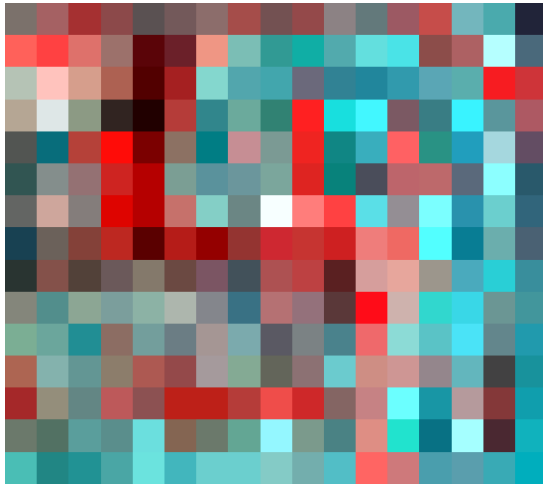
- Spatial resolution refers to the size of the pixels that make up the remote sensing image
- Images with smaller pixels are said to have a higher spatial resolution, leading to clearer scenes, while images with smaller pixels have a lower spatial resolution



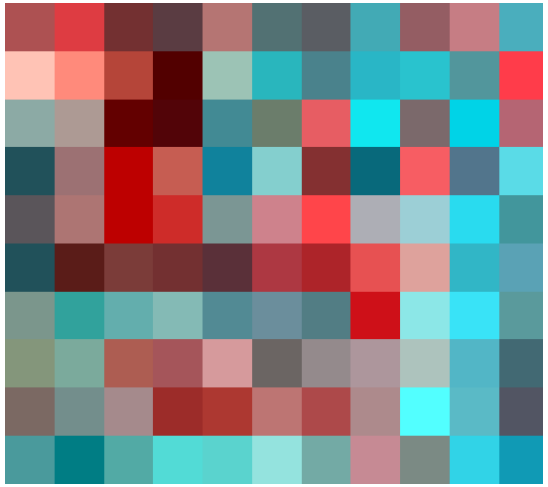
1 x 1 m



4 x 4 m



20 x 20 m
(SPOT)

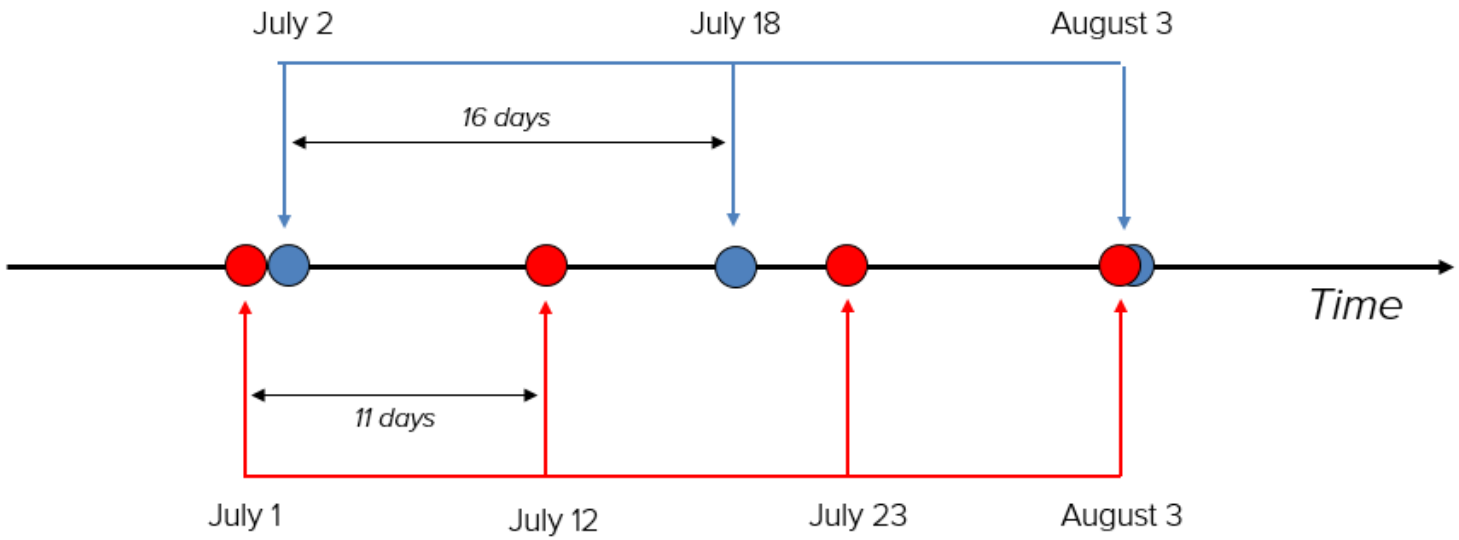


30 x 30 m
(Landsat TM)

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



Resolution of Orbiting Satellites

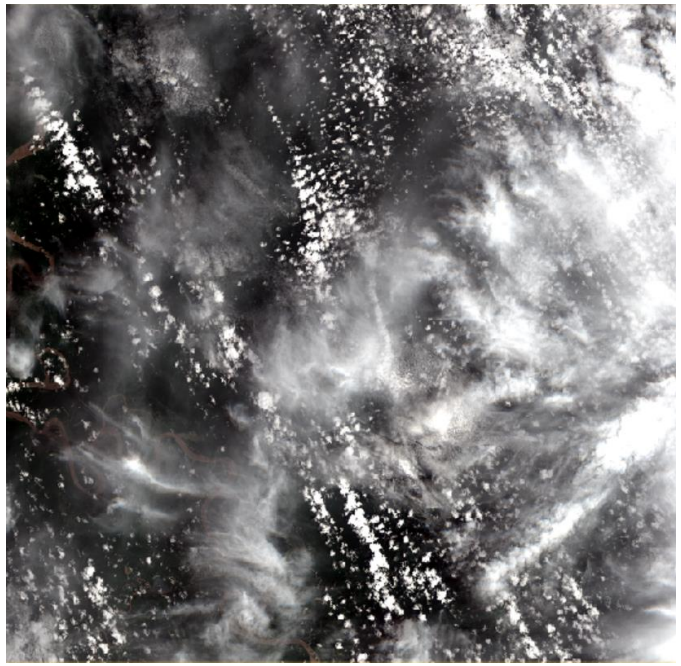
Satellite	Spatial Resolution	Temporal Resolution
Landsat 8	30m	16 days
MODIS (Terra + Aqua)	250m, 500m, 1000m	1 to 2 days
VIIRS	375-m	12 hours
AVHRR	1100m	<1 day
Sentinel-2	10m, 20, 60m	5 days
Ikonos	0.8m, 3.2m	< 3 days
SPOT-7	1.5m, 6m	As low as 1 day

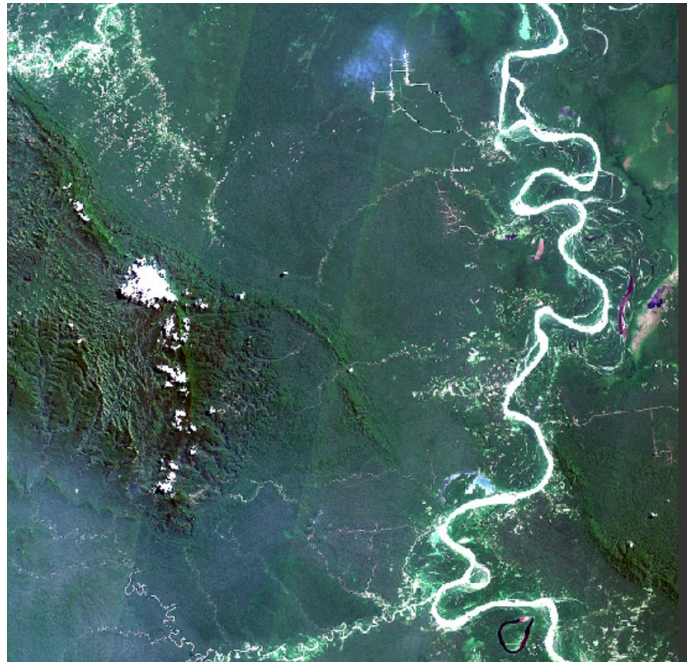
Choosing Resolution

- Resolutions are the limiting factor in utilizing remote sensing data
- A high spatial resolution tends to be accompanied by a low temporal resolution and vice versa
- For example, Landsat 8 has a spatial resolution of 30 m and a temporal resolution of 16 days, while MODIS has a spatial resolution of 250 m to 1 km and a temporal resolution of 1 to 2 days
- Fortunately, with emerging technologies, trade-offs between the spatial and temporal resolutions are becoming less of an issue

Choosing Resolution

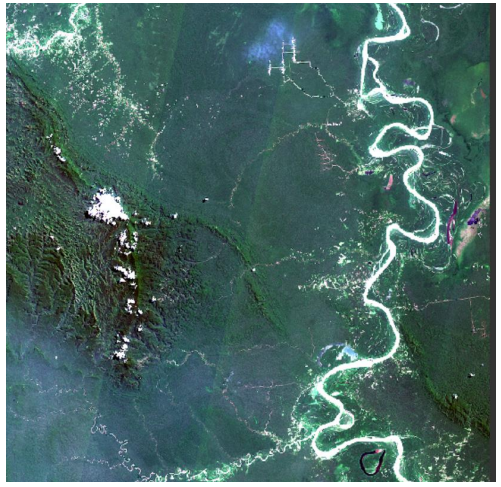
- It is important to pick the most useful resolutions for your specific project
- High spatial resolutions are useful for small study areas or examining an area in fine detail
- High temporal resolutions are useful in dynamic, frequently changing environments and areas with high levels of cloud cover

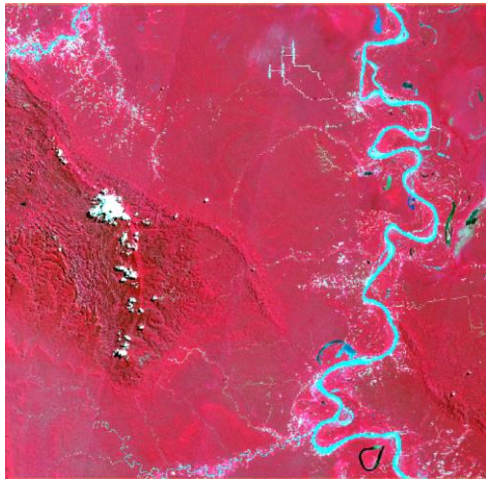




Remote Sensing Interpretation

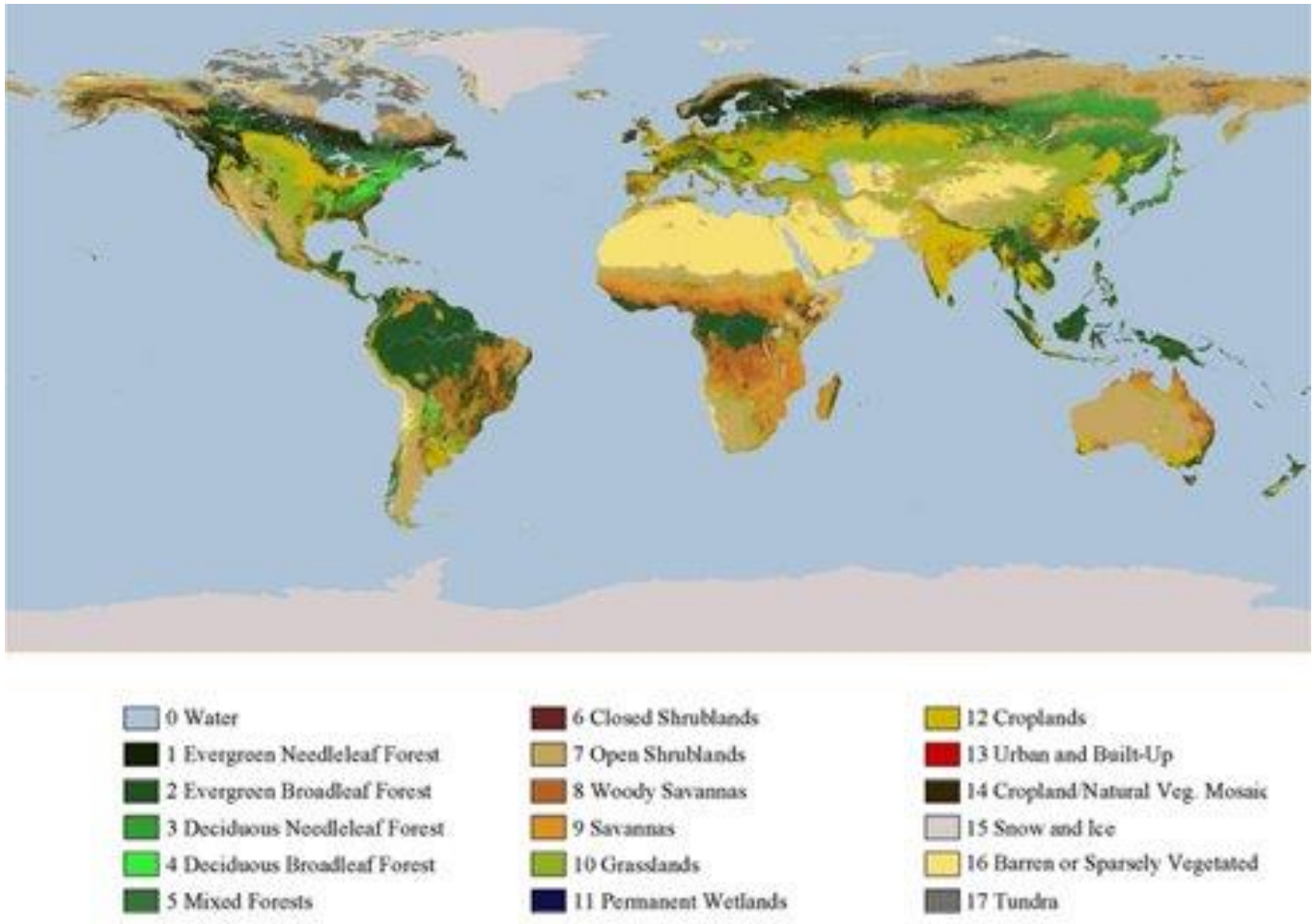
- Remote sensing data comes in multiple images, each representing a different range, or band, of wavelengths
- The pixel values of the images represent the intensity of the energy from the source
- Multiple band images can be stacked and viewed at once
- The image on the left is a true color composite (colors on the image match real world colors and are the colors our eyes would see) and is created by stacking the red, green, and blue bands
- The image on the right is a false color composite (colors on the image do not match real world colors) and is created by stacking the near-infrared, red, and green bands





Classification

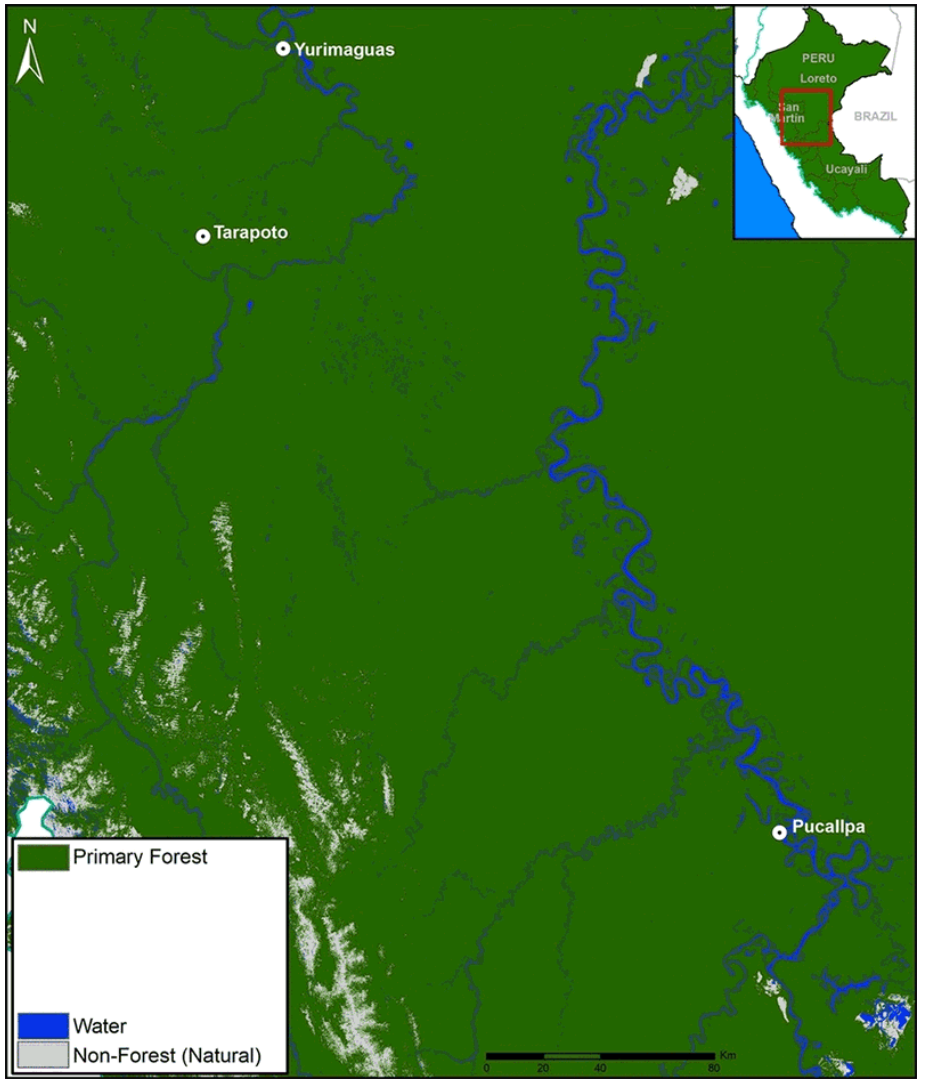
- Images can be classified into groups of similar pixel values
- These groups can represent certain land cover types or phenomena on the earth's surface



NASA Global Landcover Classification

Applications of Classification

- Classified images can be used to map landcover type
- Time-series of classified images can effectively highlight changes in the landscape, such as deforestation and land degradation

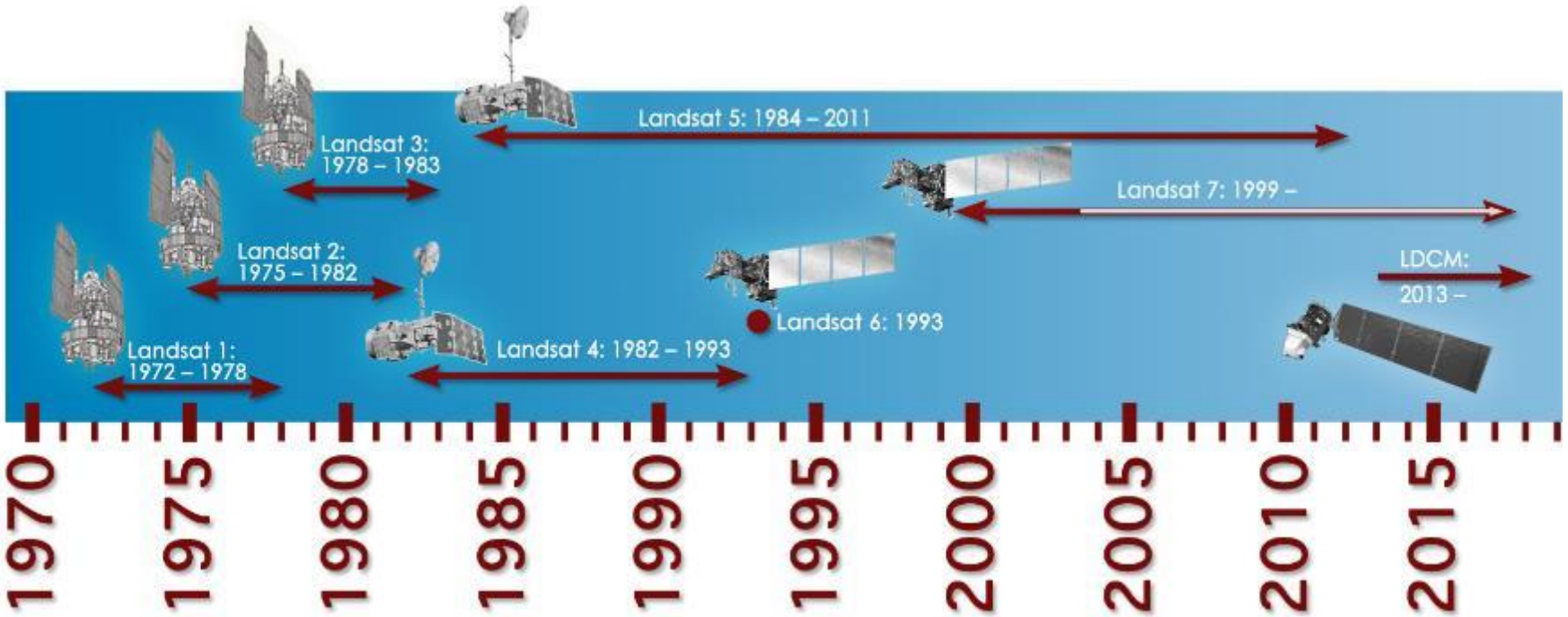


MAAP GIF of deforestation classification in the central Peruvian Amazon

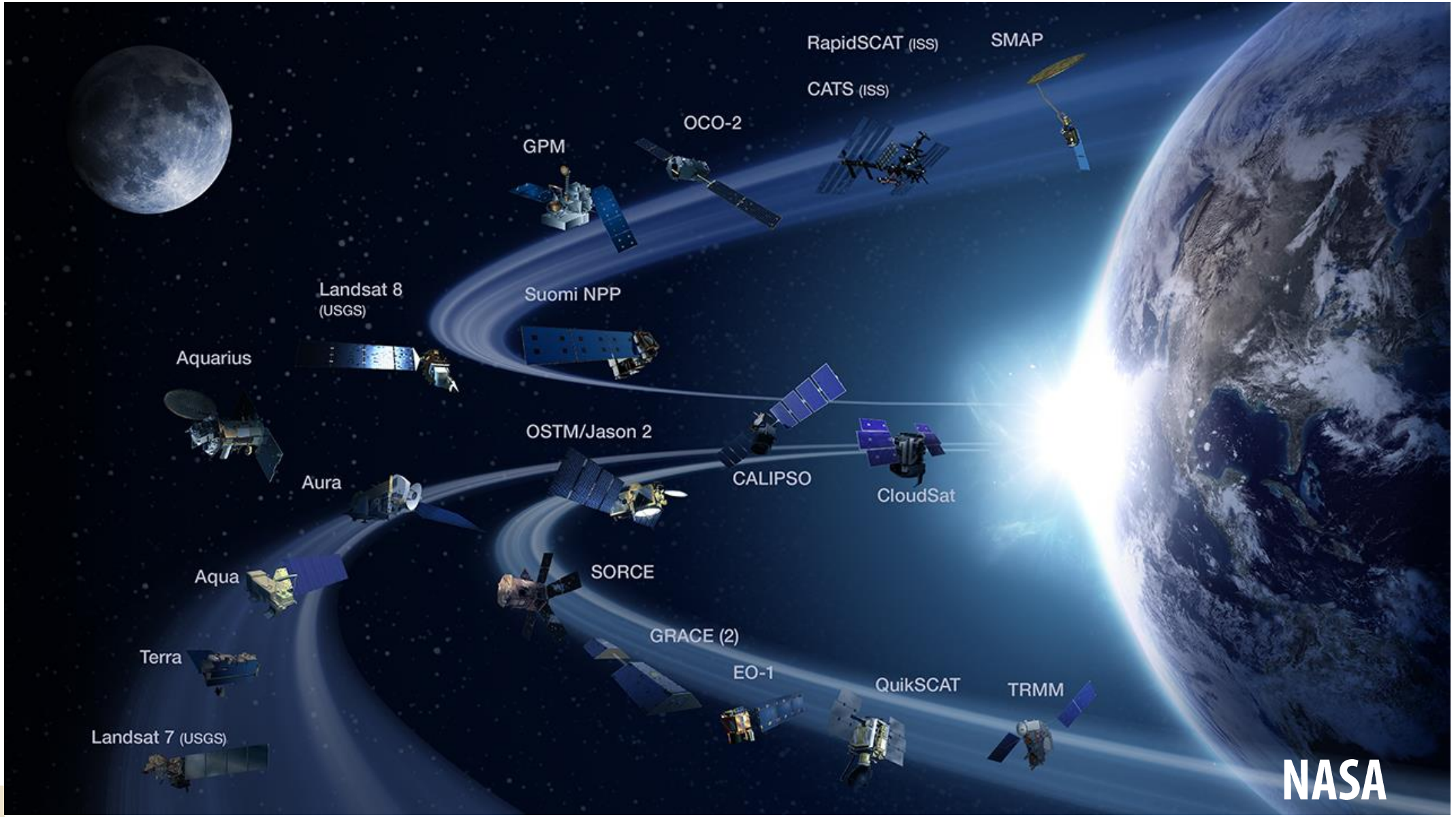
Forest Monitoring

Current and Emerging Remote Sensing Technologies

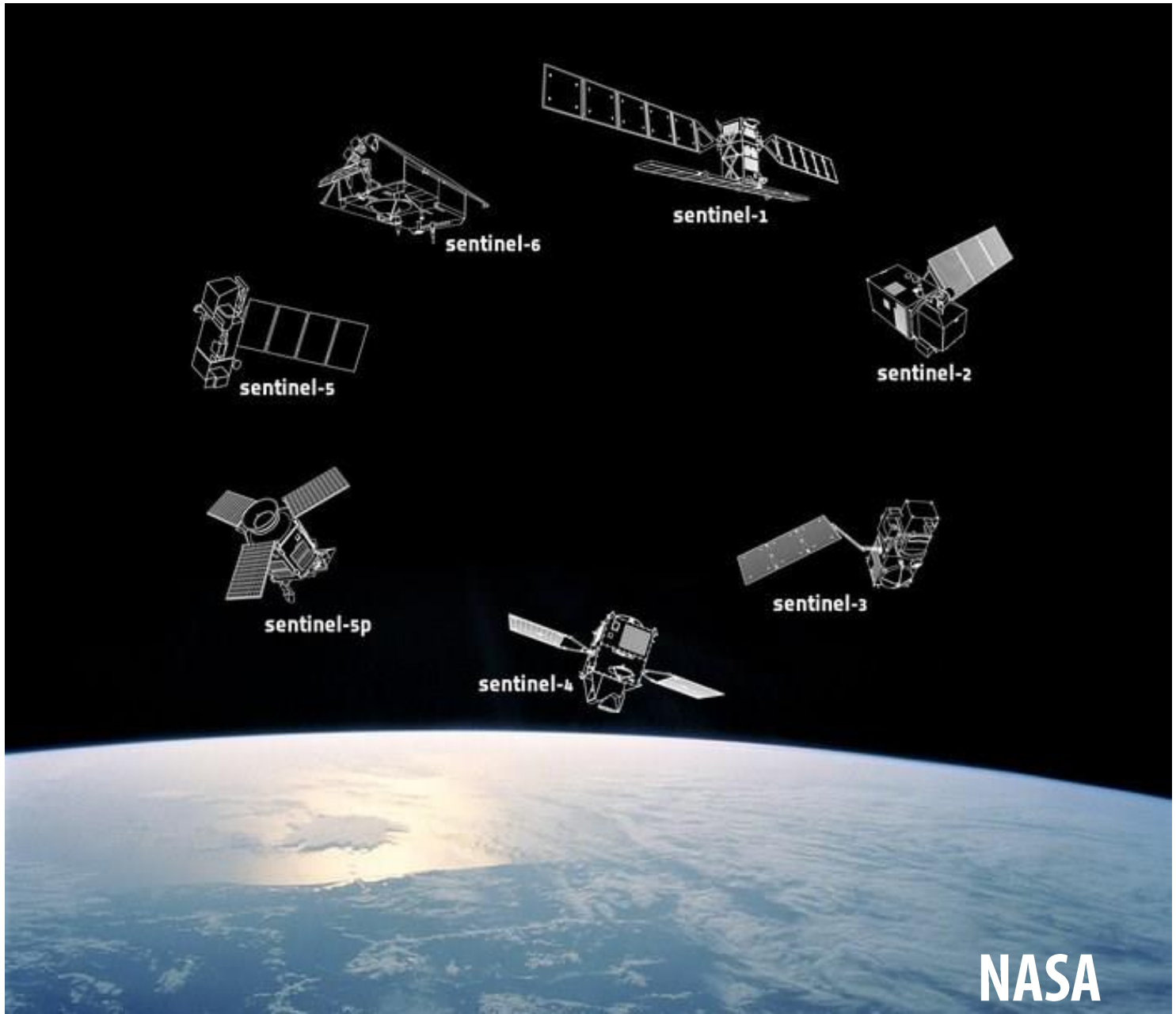
Landsat History



Current NASA Constellation

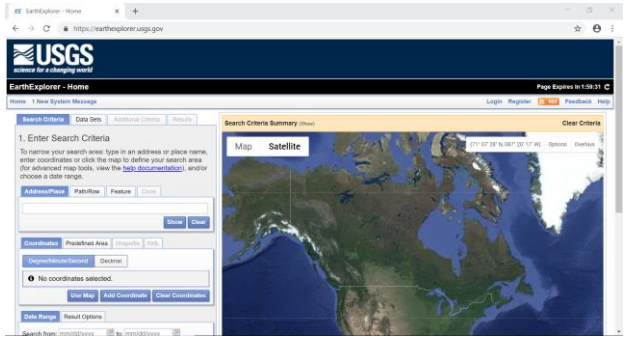


ESA Sentinel Missions

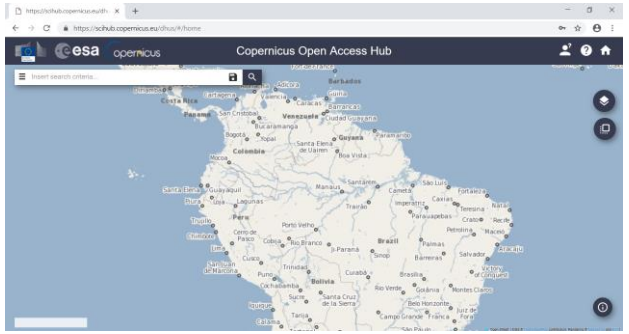


Data Portals

- USGS Earth Explorer – Landsat, Sentinel, MODIS, etc.
  - https://earthexplorer.usgs.gov/
- ESA Sentinel Hub – Sentinel-1, 2, 3 and 5P
  - https://scihub.copernicus.eu/
- FIRMS – global fire data
  - https://earthdata.nasa.gov/earth-observation-data/near-real-time/firms
- University of Maryland – Global Forest Change data (produced by Hansen et al. 2013)
  - https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html



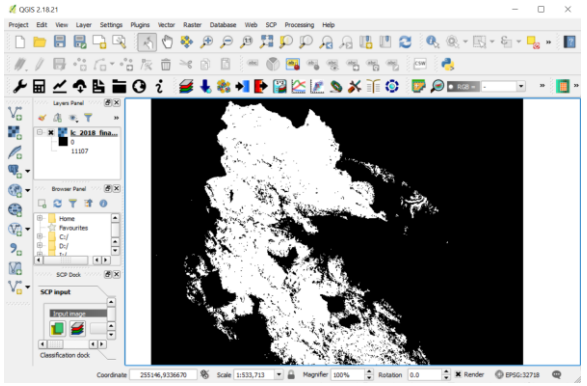
Earth Explorer



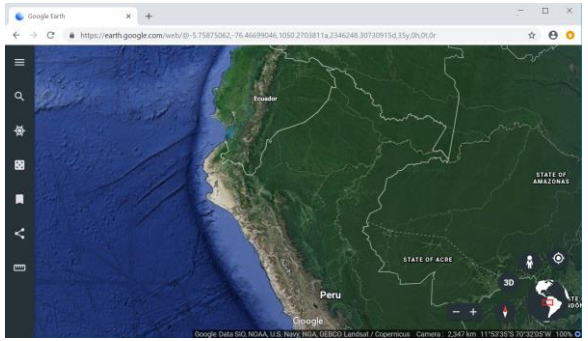
Sentinel Data Hub

Open Source Software/Tools for Image Analysis

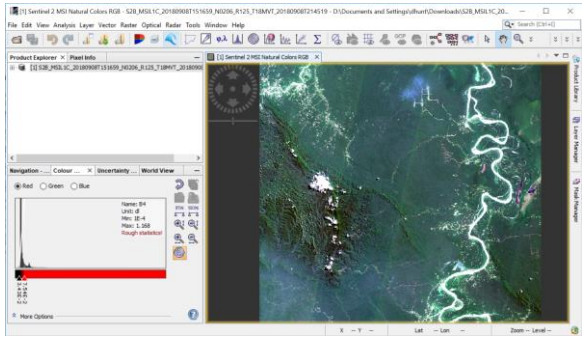
- QGIS
  - https://qgis.org/en/site/forusers/download.html
- Google Earth – visualizations
  - https://earth.google.com/web/
- SNAP – for ESA data and radar
  - http://step.esa.int/main/toolboxes/snap/
- Landsat explorer app
  - http://landsatexplorer.esri.com/
- Advanced ARSET training
  - https://arset.gsfc.nasa.gov/



QGIS



Google Earth



SNAP

Drone Remote Sensing

Introduction to Drones

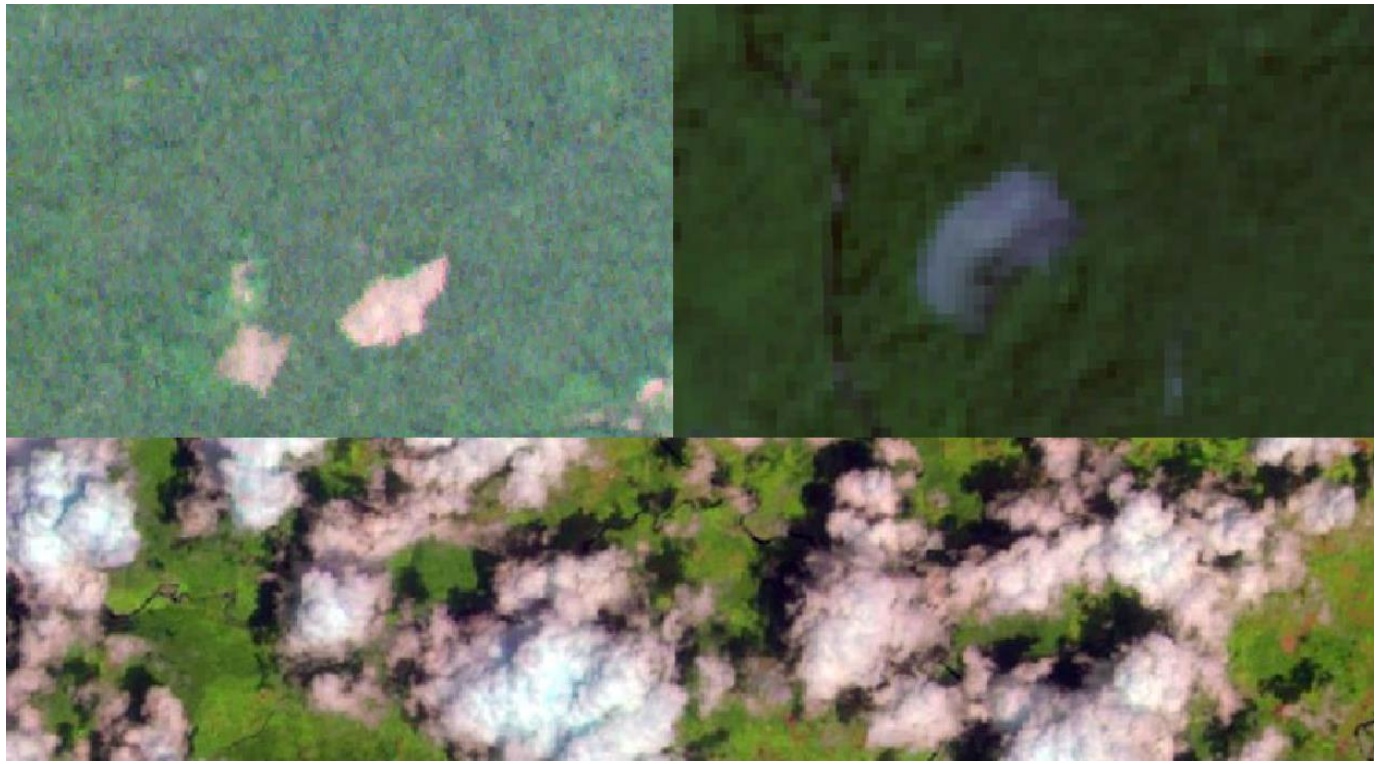
- Drones provide an additional tool to collect and view high resolution imagery
- They are relatively cheap (as little as $1000) and easily deployable
- Two main types of drones are multi-rotor and fixed-wing
- Multi-rotor provide more control and can do more complex missions
- Fixed-wing have longer flight time and larger range
- Recent advances in drone technology have reduced cost of aircraft sensors and drone imagery processing software

Deforestation Alert System with Remotely Piloted Aircraft (Drones)

CONSERVACIÓN INTERNACIONAL Perú

What Do We Need for the Monitoring Process?

- To detect deforestation and selective cutting
- To generate rapid responses to protect areas of interest
- Useful in areas permanently covered by clouds

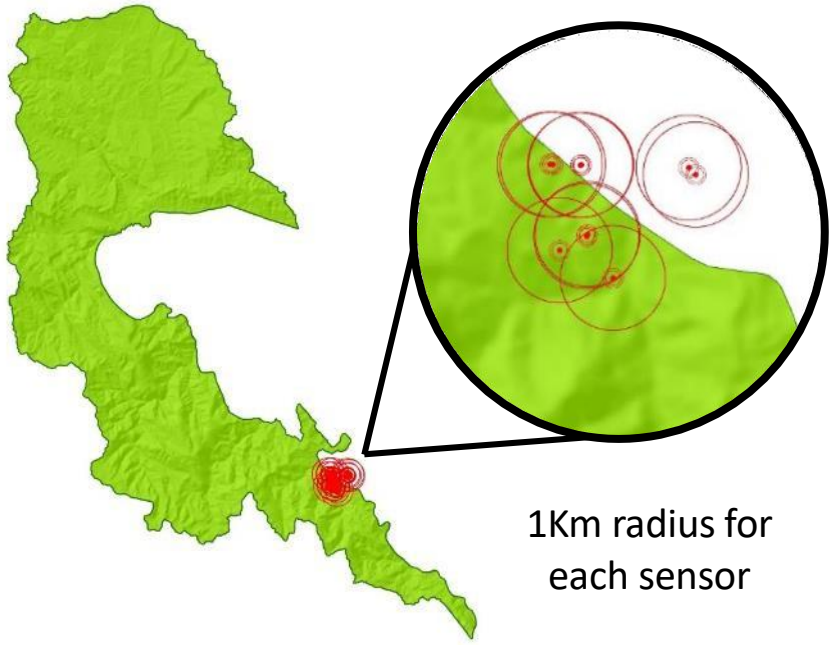


Main Advantages

- Low cost in the medium and long term.
- Use whenever and however often required
- No inconvenience caused by the presence of clouds
- Produces highly accurate results with high spatial resolution imagery

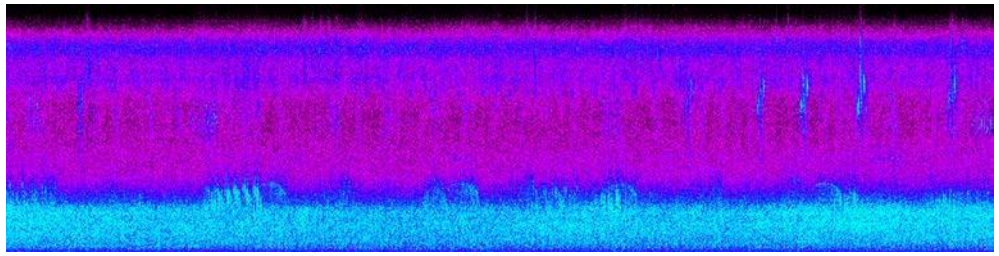
How Does the System Work?

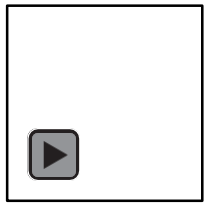
1. Chainsaw sounds are detected by acoustic sensors throughout the area



1Km radius for each sensor

2. Activity near the acoustic sensors triggers an alert that is relayed by email





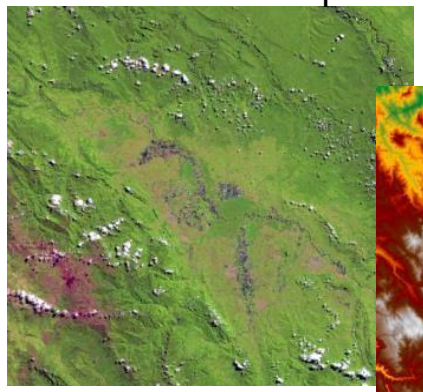
Guardian:	MoviStar Tower
LAT/LONG:	-5.97801,-77.3558
Fecha y hora inicial:	2017-06-20 14:22:41.848000 (America/Lima)
Fecha y hora final:	2017-06-20 14:24:11.848000 (America/Lima)
Intervalo de confianza:	0.97872
Archivo mp3:	https://assets.rfcx.org/audio/658a3786-efb5-4756-96dd-fae176fe5624.mp3
Archivo png:	https://assets.rfcx.org/audio/658a3786-efb5-4756-96dd-fae176fe5624.png

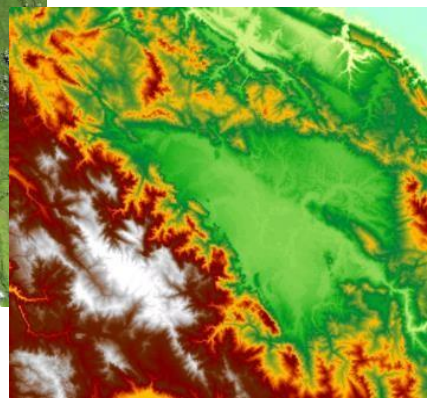
How Does the System Work?

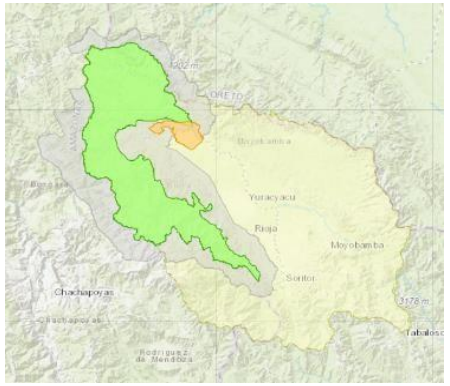
3. Flight mission planning

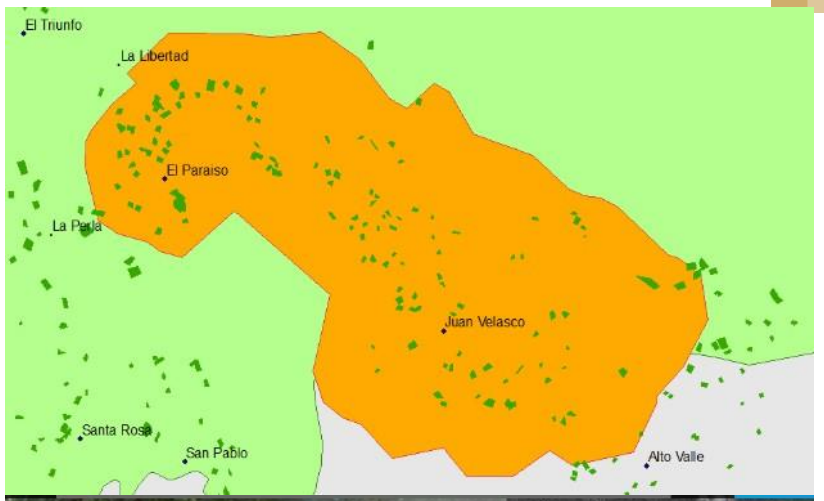
- Set the flight planner
- Locate the study area
- Geoprocessing with ArcToolbox (Visual basins, raster reclassification, distance calculations, vector analysis, etc.).
- Calculate and set flight parameters

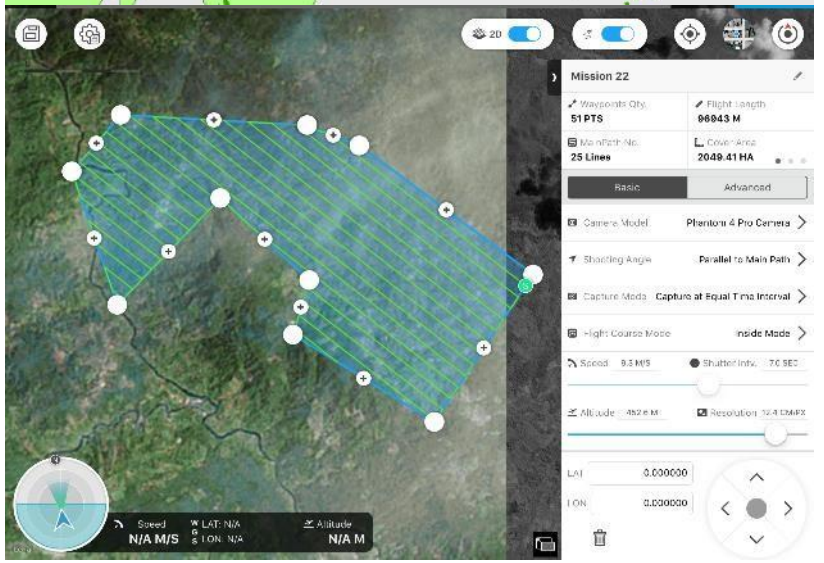
(Longitudinal overlap, lateral overlap, flight altitude, horizontal speed, time interval between captures)







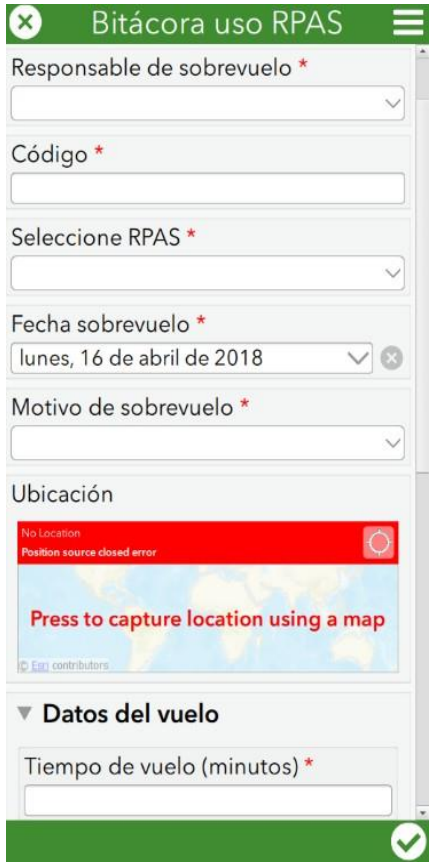


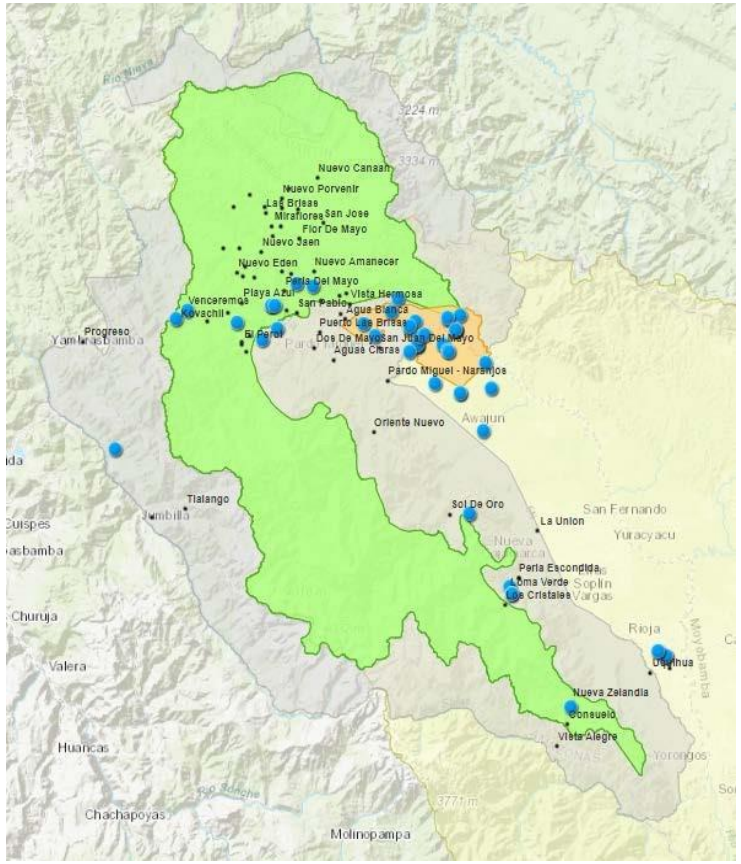


How Does the System Work? (Flight)

4. The drone is sent to verify the first alerts.

5. We record take-off spots using SURVEY123.



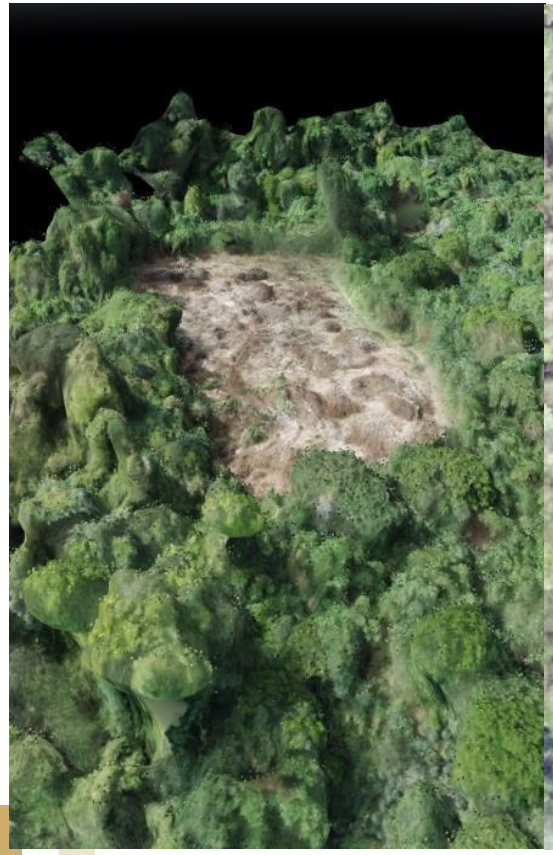


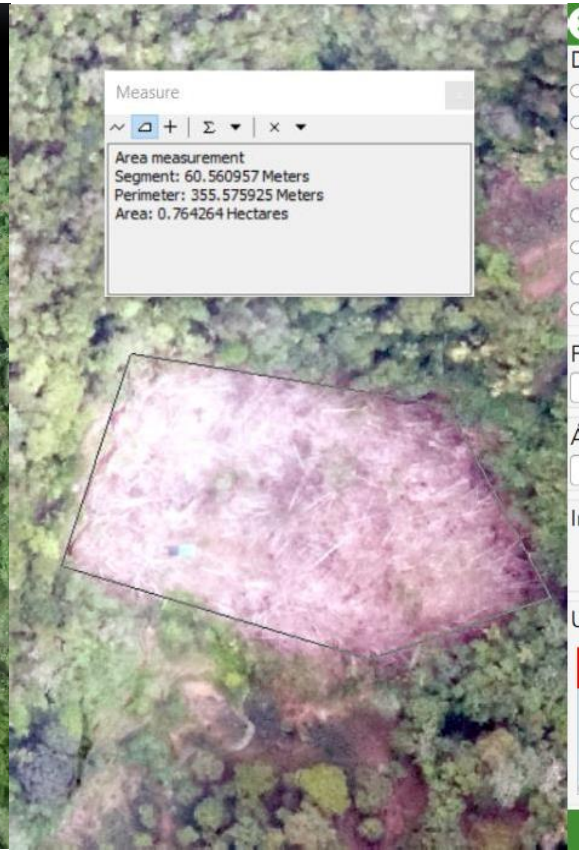
https://survey123.arcgis.com/share/fad0a26486ed45d085b9352cdfb69450

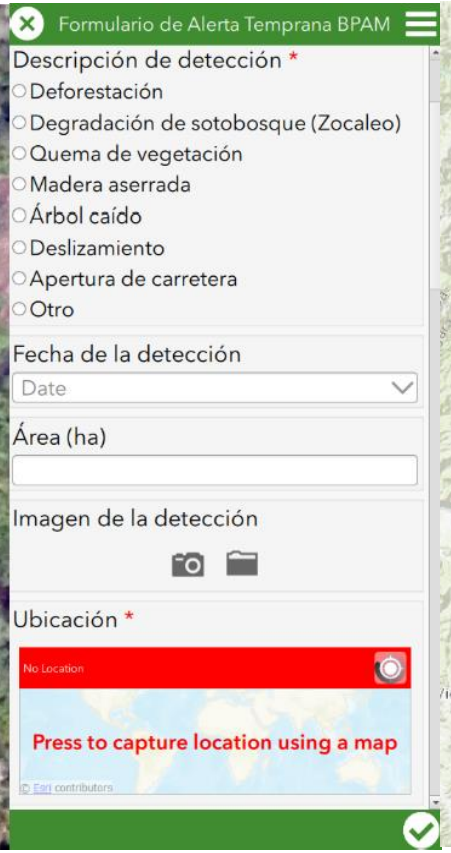
How Does the System Work?

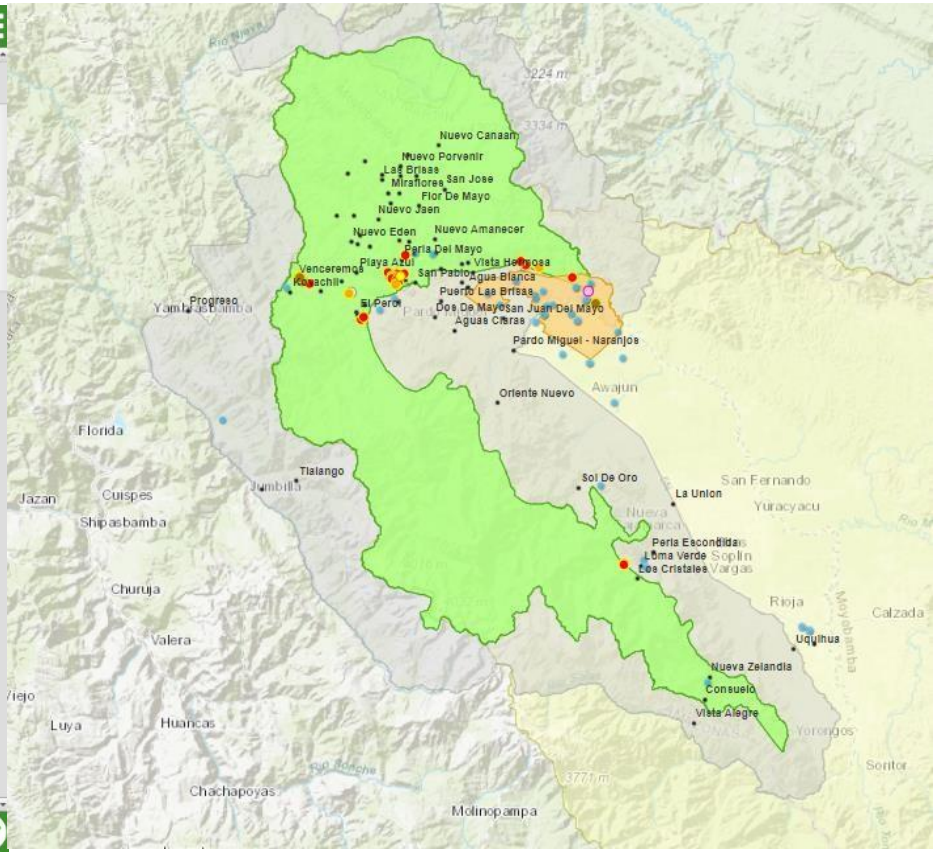
6. The images captured by the drone are analyzed and processed.

7. Detections are recorded with SURVEY123 for subsequent analysis, display and decision-making.



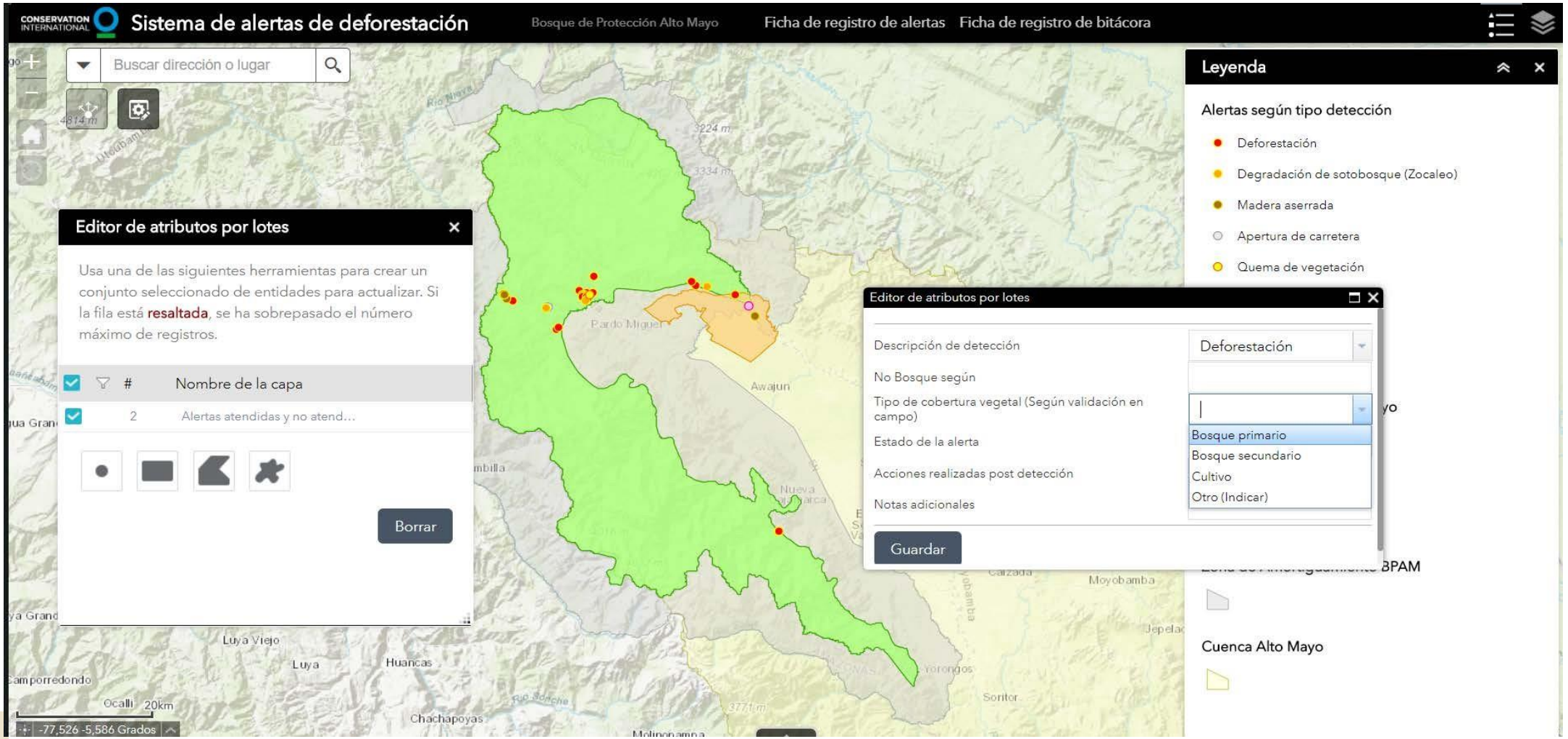






Result: Publication

8. The images captured by the drone are analyzed, processed, and published using ArcGIS online

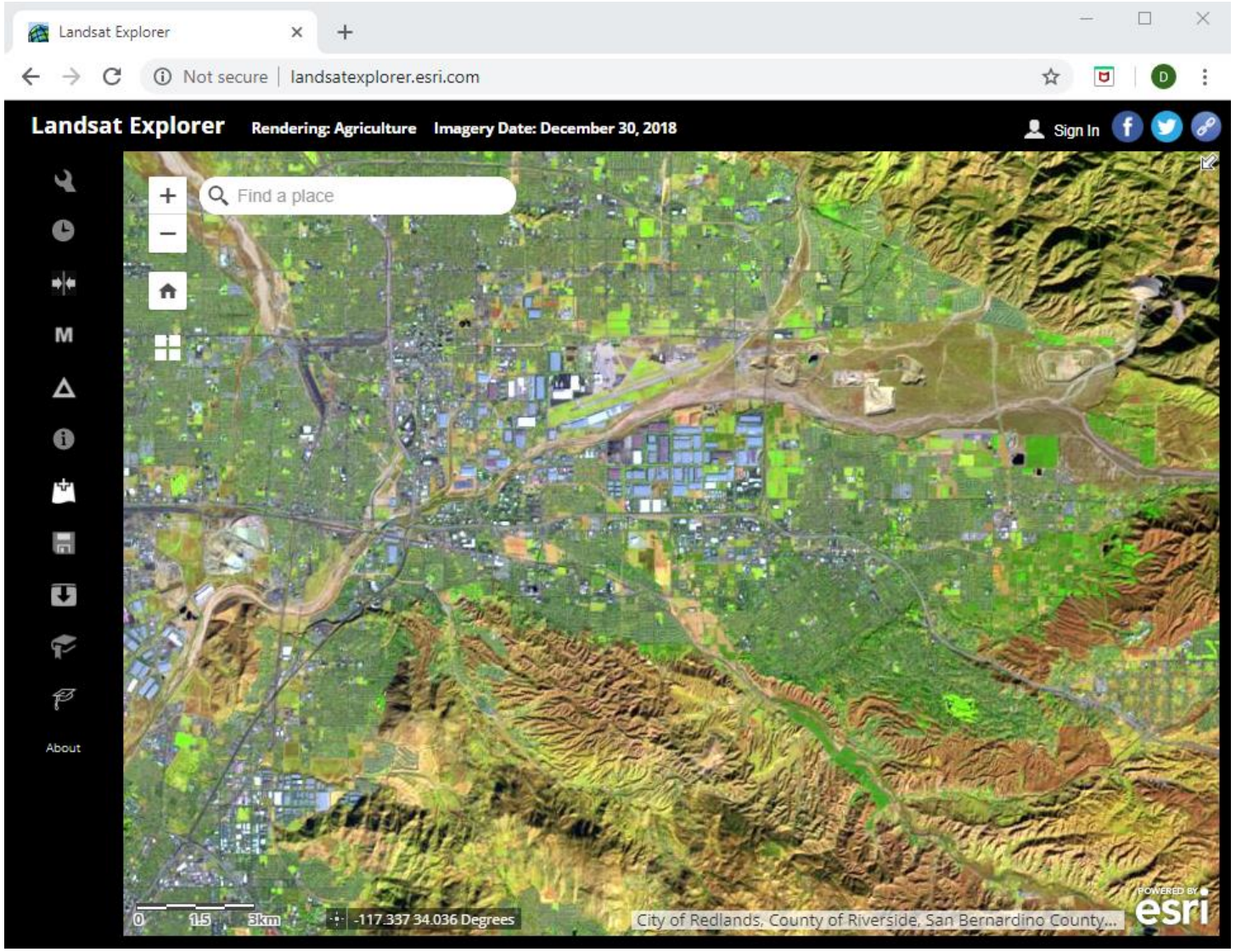


Result: Participation with Park Rangers and the Population

- Special patrols
- Offenders reported and investigations launched
- Identification of areas where intervention is easier
- Greater surveillance of the area
- Deforestation and other unlawful activities reduced

Landsat Explorer Application

http://landsatexplorer.esri.com/



Demonstration of Landsat Explorer App

- Navigate to Limoncocha, Shushufindi, ECU, and examine multiple dates to view different cloud cover levels. Try 10% cloud cover and compare 28/10/2016 and 2/9/2013.
- Experiment with different renderings, particularly natural color, color infrared, and vegetation index. Use the custom bands setting to change band combinations. Select the swipe icon to compare the remote sensing data to the basemap.
- Click the time selector and navigate to 25/5/2009 and select "Set Current as Secondary Layer". Then drag the slider to 2/9/2013 for the comparison date. Click the change detection icon to view the change in the Vegetation Index between these two dates.

Summary of Session #2

- Defining Earth observation and remote sensing
- The uses and significance of Earth observation and remote sensing
- Principles of satellite remote sensing and data analysis
- Drone remote sensing and its emerging uses
- Introduction and demonstration of Landsat Explorer

Homework #2

- This assignment helps participants become familiar with the Landsat Explorer remote sensing web application
  - Tasks include exploring band combinations, exploring spectral signatures, masking, and change detection
- This assignment can be found in the handout section and the materials webpage
- All of the instructions for completing this assignment can be found in the homework document
- Please complete this homework by the beginning of next week's webinar session

Session 3: Applications for Sustainable Land Management Decisions and Early Warning and Alert Systems

Preview of Next Session

- Using near real-time data for tracking global change
- Discussion of the top five applications of early warning systems
- Introduction to important web-based and mobile applications