Earth Observations for Informing Disaster Risk and Response to Drought, Wildfire, and Flooding in Mexico

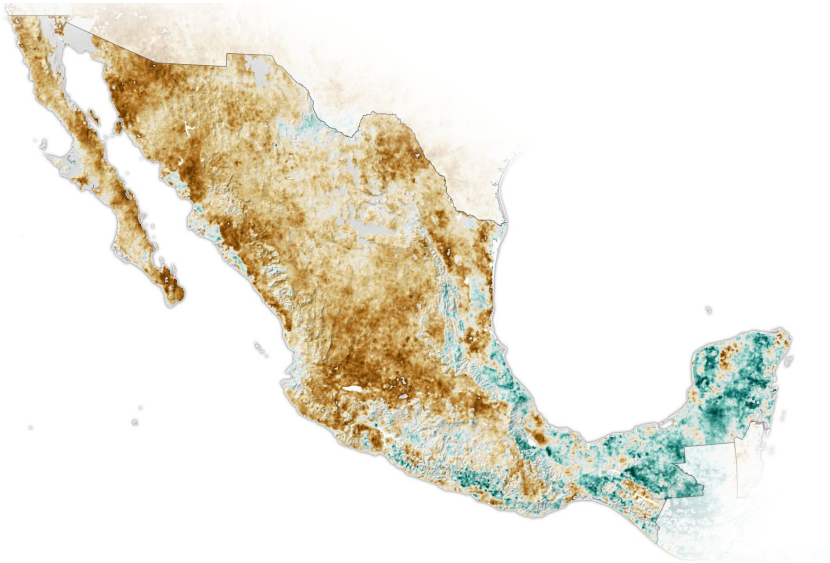
Overview of Data Sets for Floods, Droughts, and Wildfires

May 8, 2023

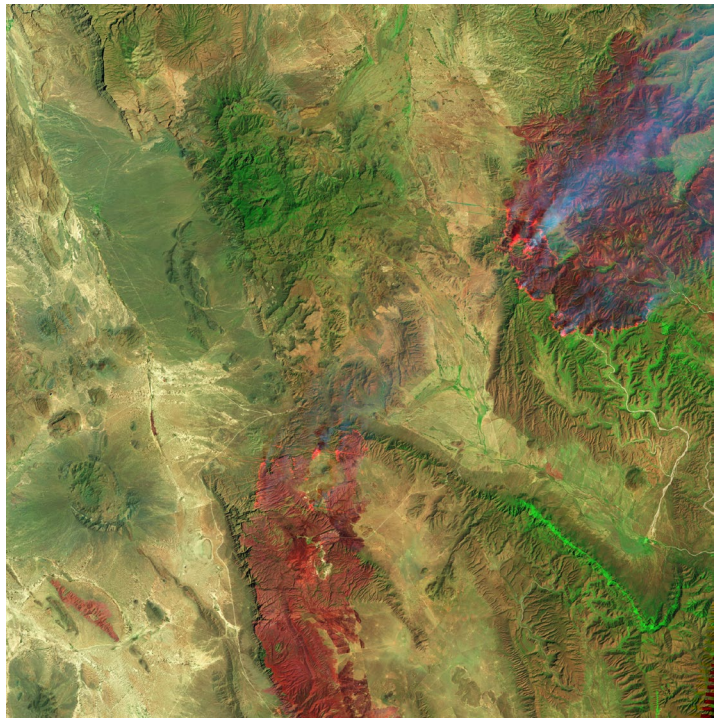
Objective:

- By the end of this presentation, you will have comprehensive information about Earth observations useful for monitoring flood, drought, and wildfire risks and impacts used in this training.

Credit: Earth Observatory



Credit: Earth Observatory



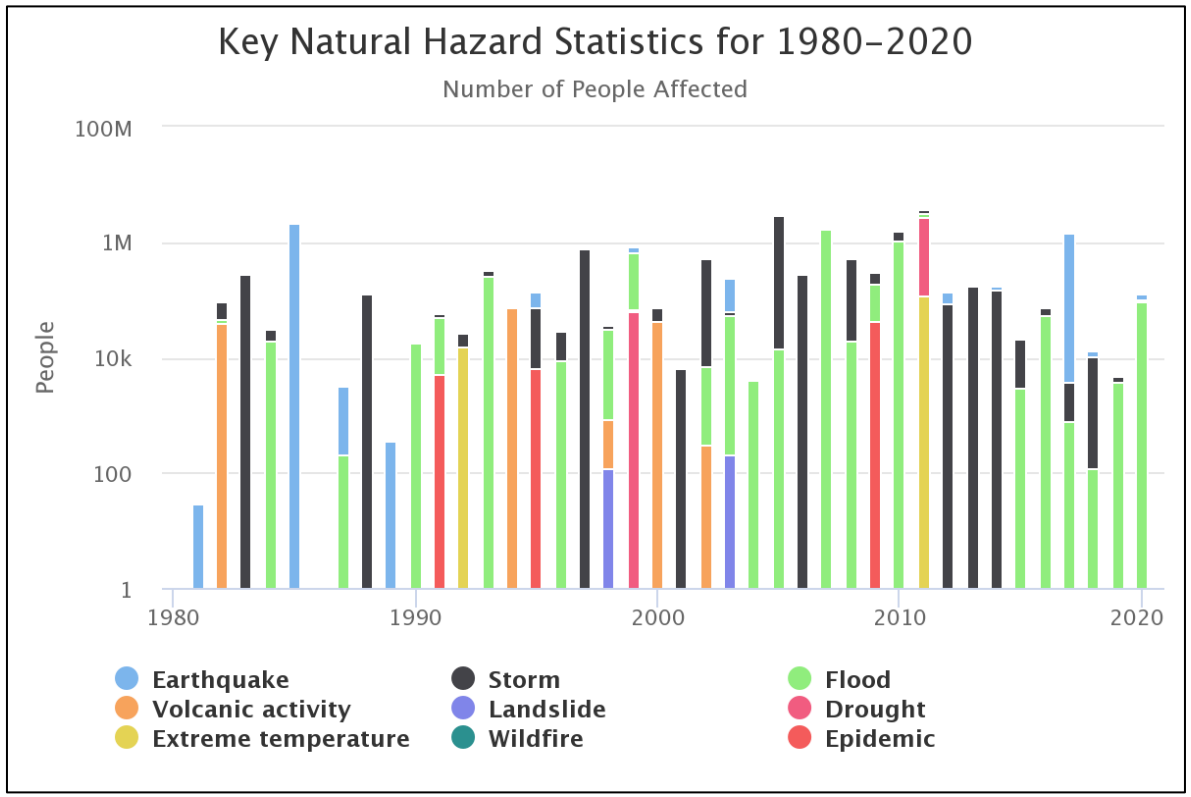
Credit: Earth Observatory

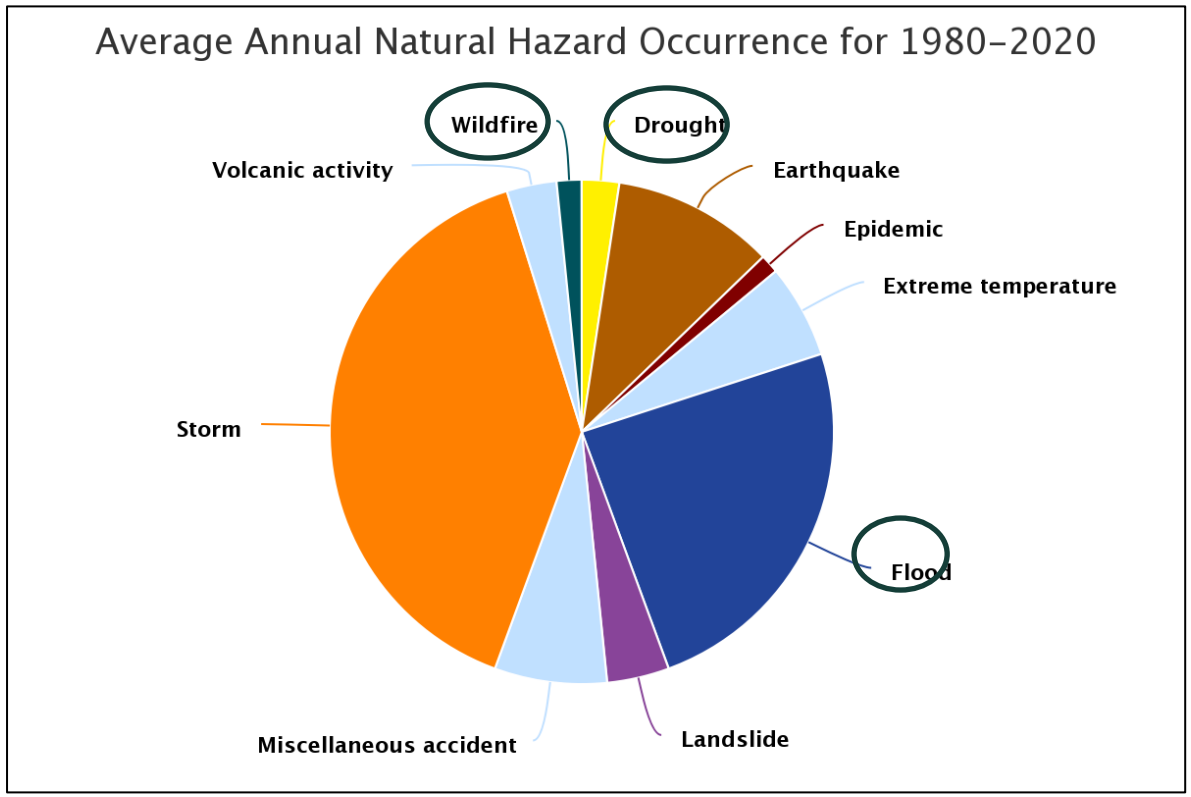
Outline

- Atmospheric and land parameters relevant for assessing flood, drought, and wildfire conditions.
- Satellites and sensors relevant for observing floods, droughts, and wildfires conditions.
- Brief review of remote sensing concepts.

Natural Hazards in Mexico

https://climateknowledgeportal.worldbank.org/country/mexico/vulnerability

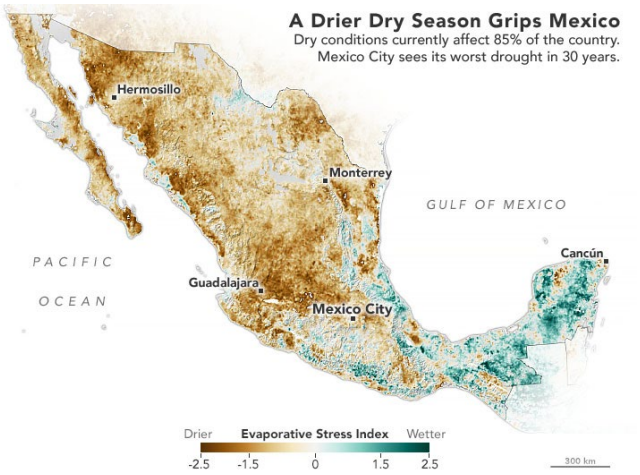




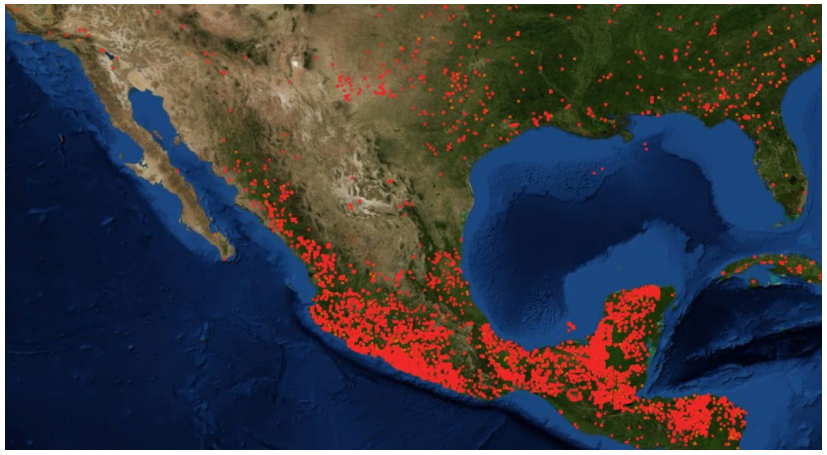
Floods, Droughts, and Fires

- How to assess risk of these disasters?
- How to plan post-disaster impacts and response strategy?

Flood rescue in San Juan del Río, Querétaro, Mexico October 2021. Photo; Municipal de San Juan del Río

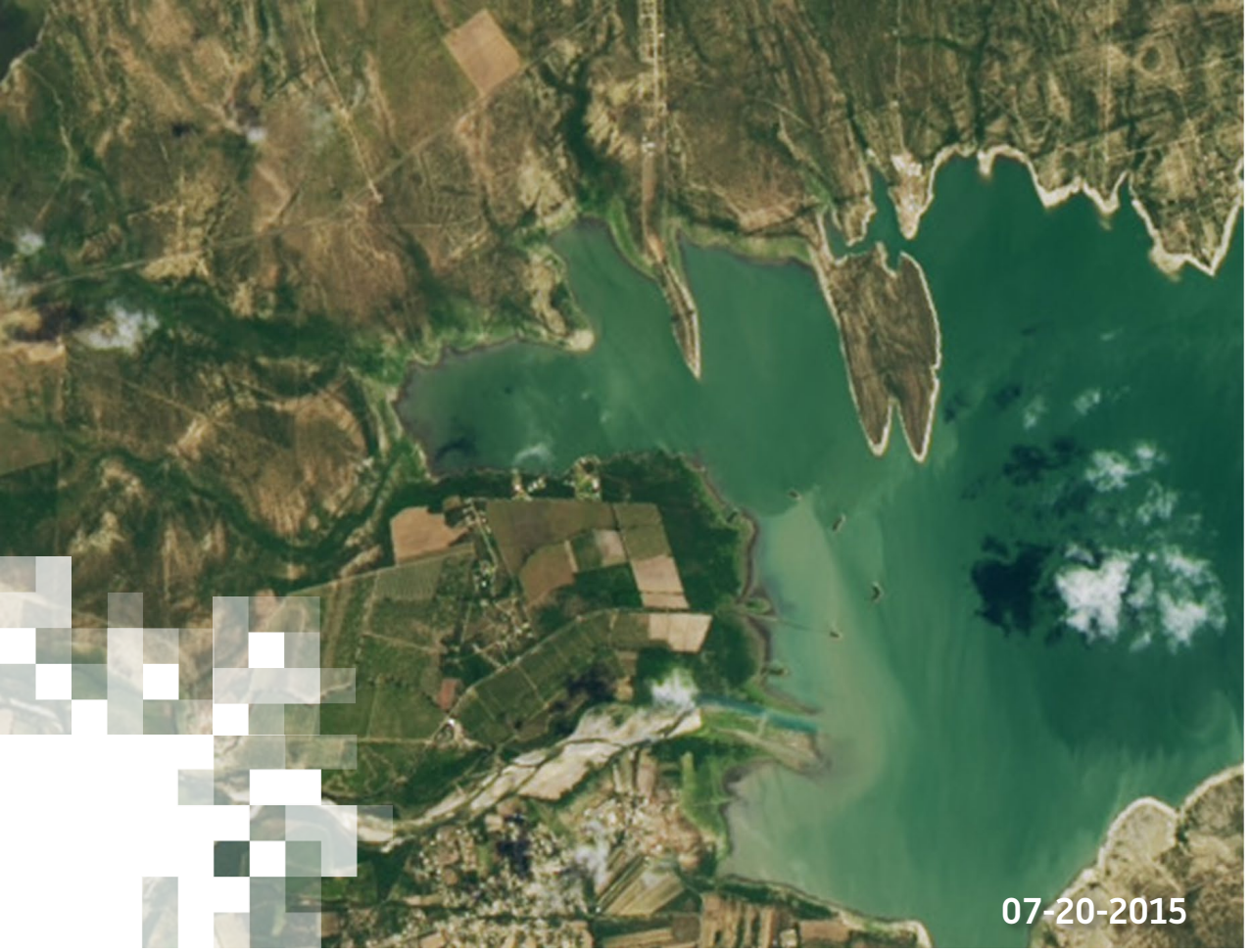


From NASA Earth observatory



Red dots represent severe fires, which are intense in Mexico's south and in most parts of Central America. NASA

Reliable observations of land and atmosphere are crucial for disaster risk and response assessment.



Atmospheric and Land Parameters Relevant for Assessing Flood, Drought, and Wildfire Conditions

Observations Relevant for Flood, Drought, Wildfire

Flood

- Precipitation
- Soil Moisture
  - soil characteristics
- Terrain & Slope
- Landcover
  - e.g., vegetation, urban
- Drainage Capacity (for urban areas)

Drought

- Precipitation
- Soil Moisture
- Land Surface Temperatures
- Evapotranspiration

Wildfire

- Dry Vegetation
- Soil Moisture
- Atmospheric Conditions
  - Precipitation
  - Humidity
  - Lightning conditions

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Wildfire

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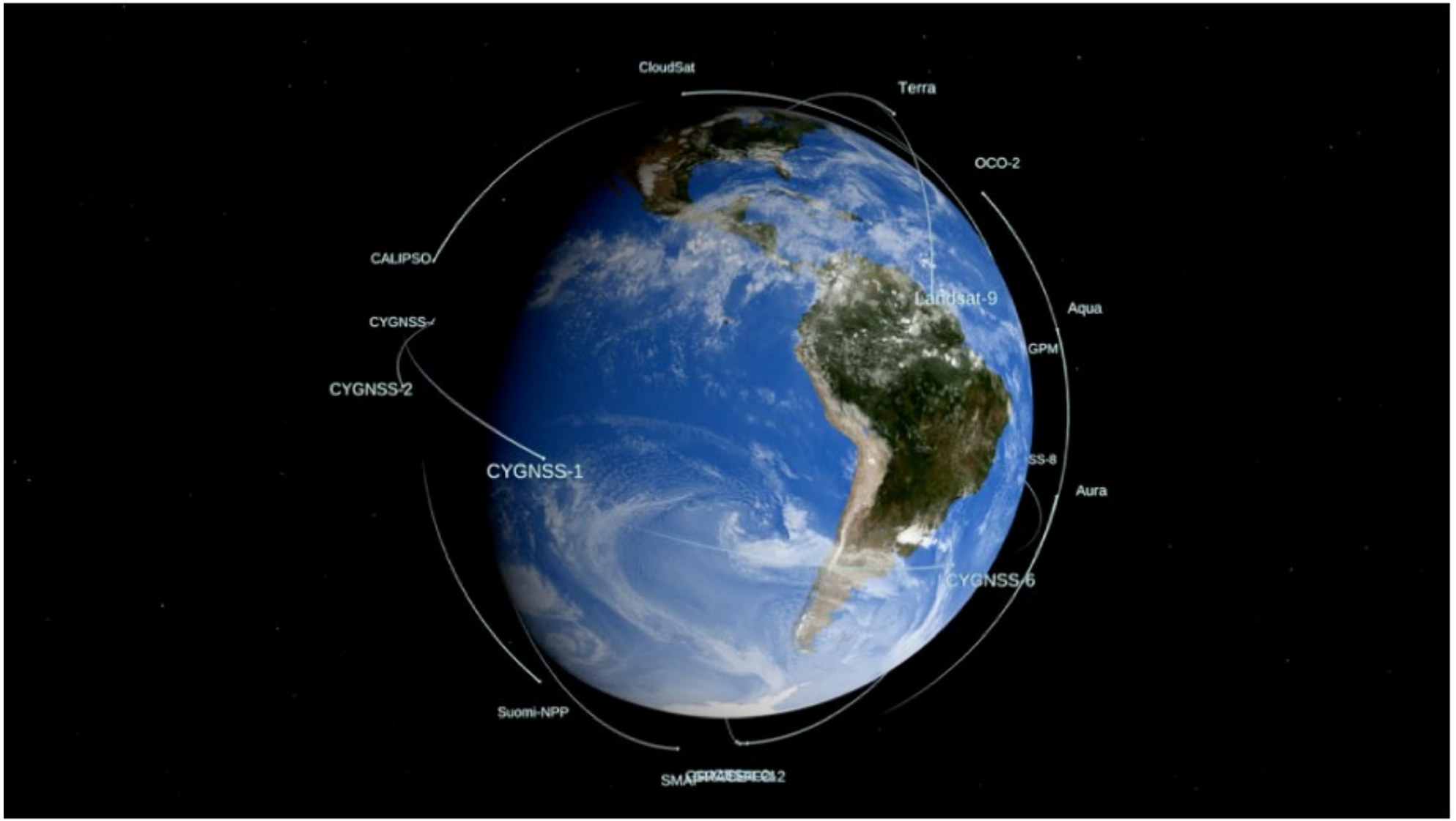
  - Humidity
  - **Lightning conditions**

Satellite remote sensing is very useful to obtain these parameters.

NASA Earth Observing Satellites

NASA Scientific Visualization Studio (SVS)



Satellites and Sensors Used in this Training

Parameters	Satellites	Sensors	Spectral Measurements
Precipitation	TRMM & GPM	TMI, PR GMI, DPR	TMI: 10-85 GHz GMI: 10-183 GHz PR and DPR (Ku and Ka)
Soil Moisture	SMAP	Microwave Radiometer	1.41 GHz
Land Cover, Land Surface Temperatures Evapotranspiration	Landsat 8,9	OLI, OLI2 TIRS, TIRS2	Visible, Near IR, Middle IR, Thermal IR
Land Cover, Land Surface Temperatures Evapotranspiration	Terra & Aqua	MODIS	Visible, Near IR, Middle IR, Thermal IR
Day/Night Imagery	SNPP JPSS	VIIRS	

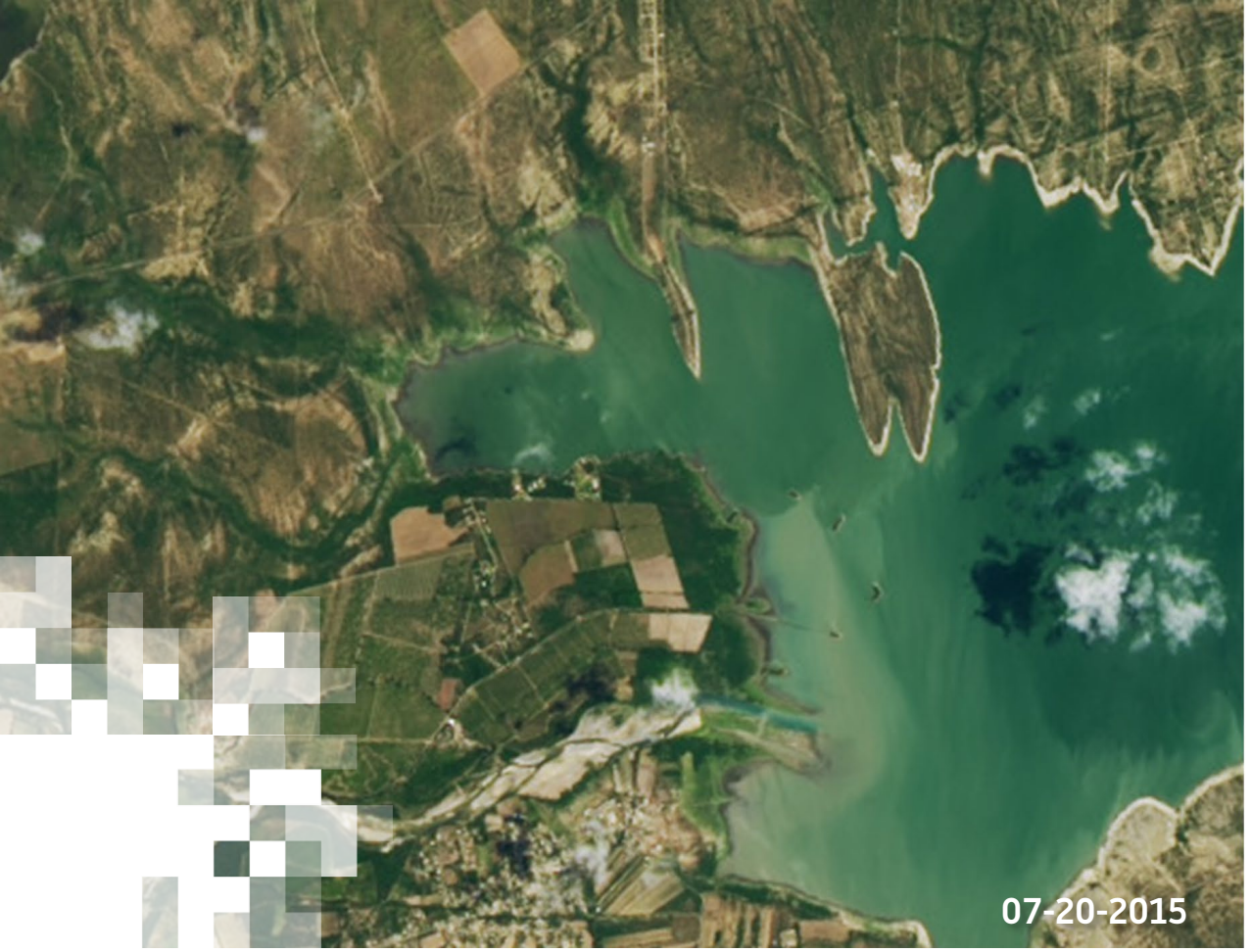
Acronyms are given on the next slide.

Satellites and Sensors Used in this Training

Parameters	Satellites	Sensors	Spectral Measurements
Land Cover	Sentinel 1A and 1B	Synthetic Aperture Radar (SAR)	C-Band
Terrain	Space Shuttle Endeavour	SRTM	C-Band

DPR	Dual-frequency Precipitation Radar
GPM	Global Precipitation Measurements
GMI	GPM Microwave Imager
IR	Infrared
JPSS	Joint Polar Satellite System
MODIS	MODerate-resolution Imaging Spectroradiometer
OLI	Operational Land Imager
PR	Precipitation Radar

SMAP	Soil Moisture Active Passive
SNPP	Suomi National Polar Partnership
SAR	Synthetic Aperture Radar
SRTM	Shuttle Radar Topography Mission
TRMM	Tropical Rainfall Measuring Mission
TMI	TRMM Microwave Imager
TIRS	Thermal Infrared Sensor
VIIRS	Visible Infrared Imaging Radiometer Suite

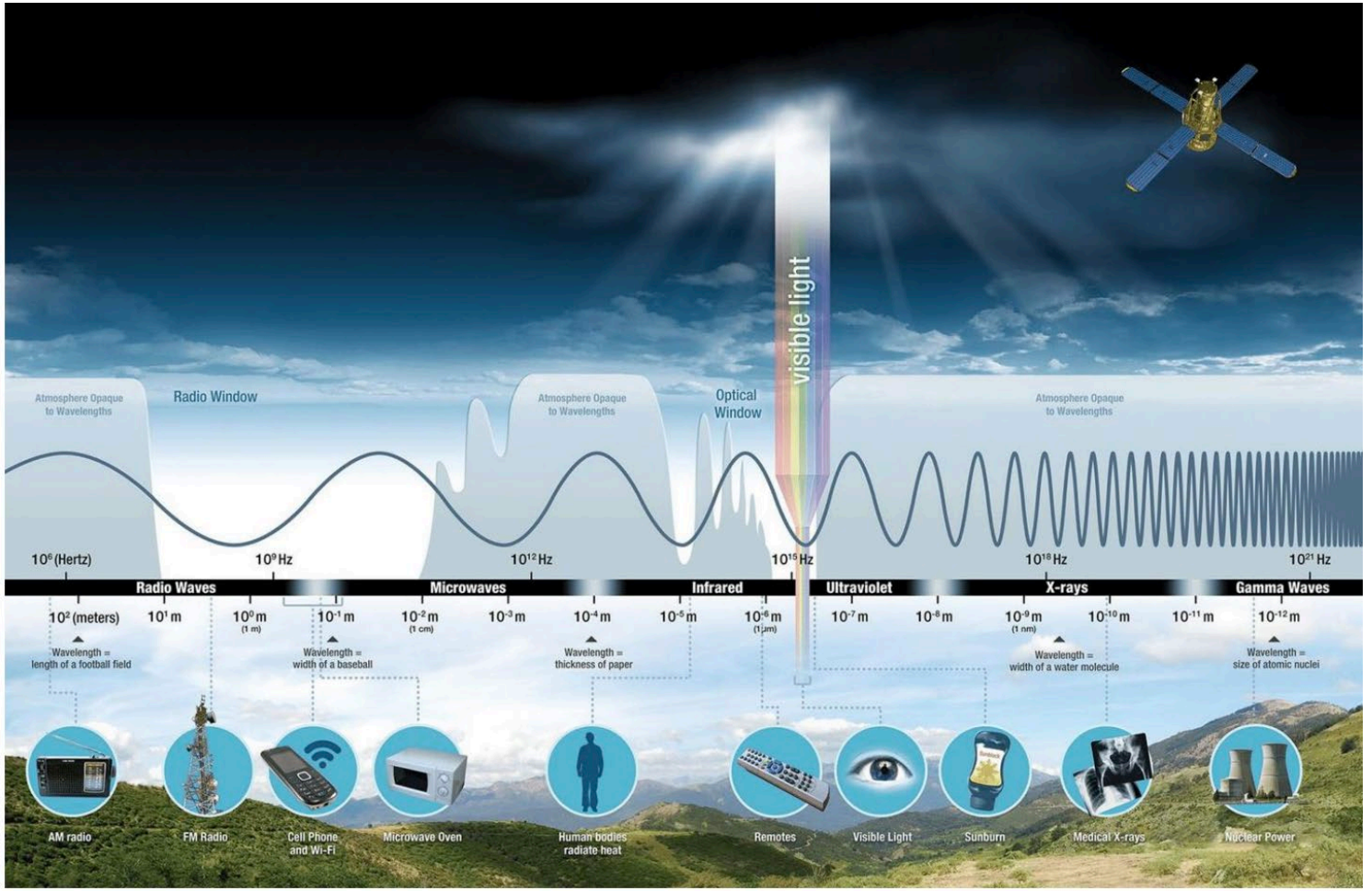


Brief Review of Remote Sensing Concepts

Satellite Sensors

- Satellites carry one or multiple sensors or instruments.
- Sensors measure electromagnetic radiation
  - reflected solar radiation
  - emitted infrared and/or microwave
  - radiation by the earth-atmosphere system

Electromagnetic Spectrum



appliedsciences.nasa.gov/join-mission/training/english/arset-fundamentals-remote-sensing

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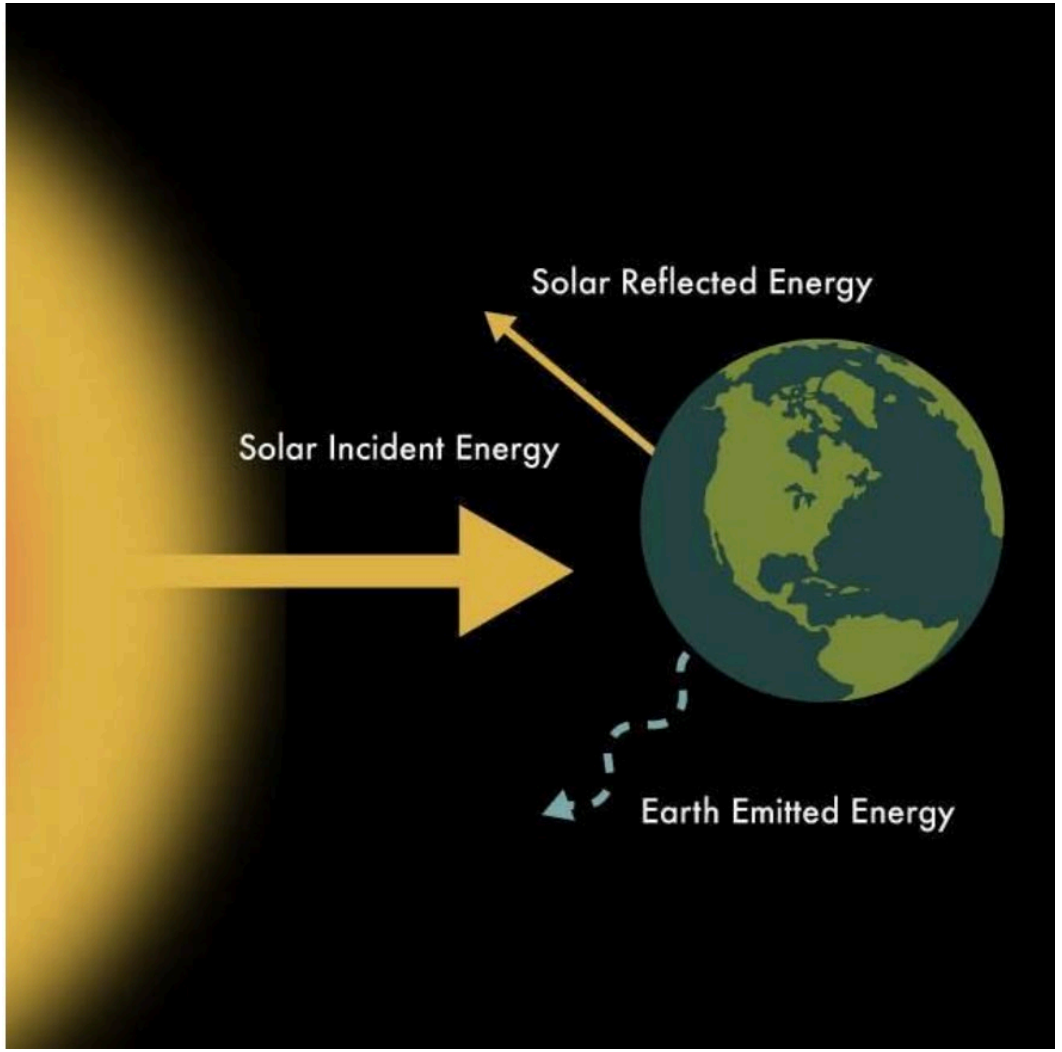

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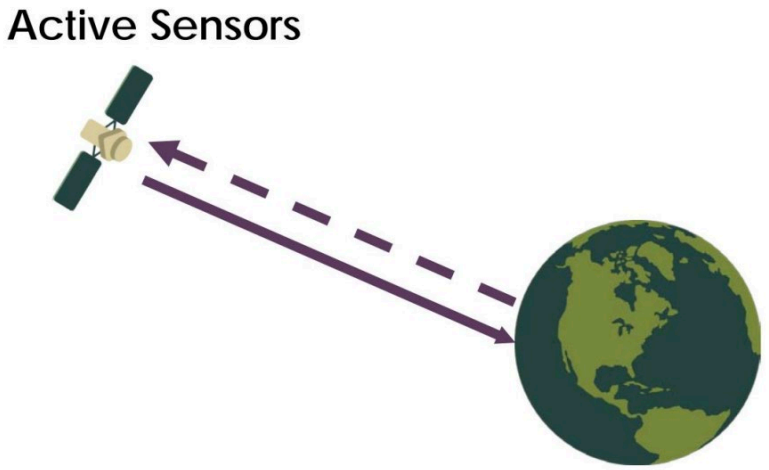
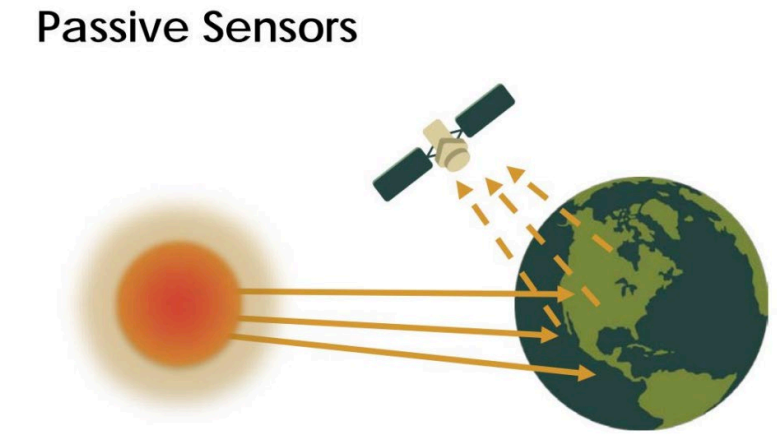
Satellite Sensors

- There are two types of sensors, active and passive.
- An active sensor has is own source of electromagnetic radiation that is sent to the earth system and backscattered radiation is then received by the sensor – e.g., radar.
- A passive remote sensor measures radiant energy reflected or emitted by the Earth-atmosphere system or changes in gravity from the Earth – e.g., radiometer, imager.





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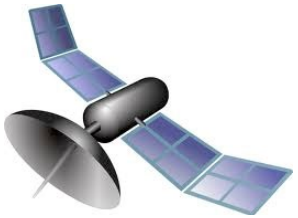
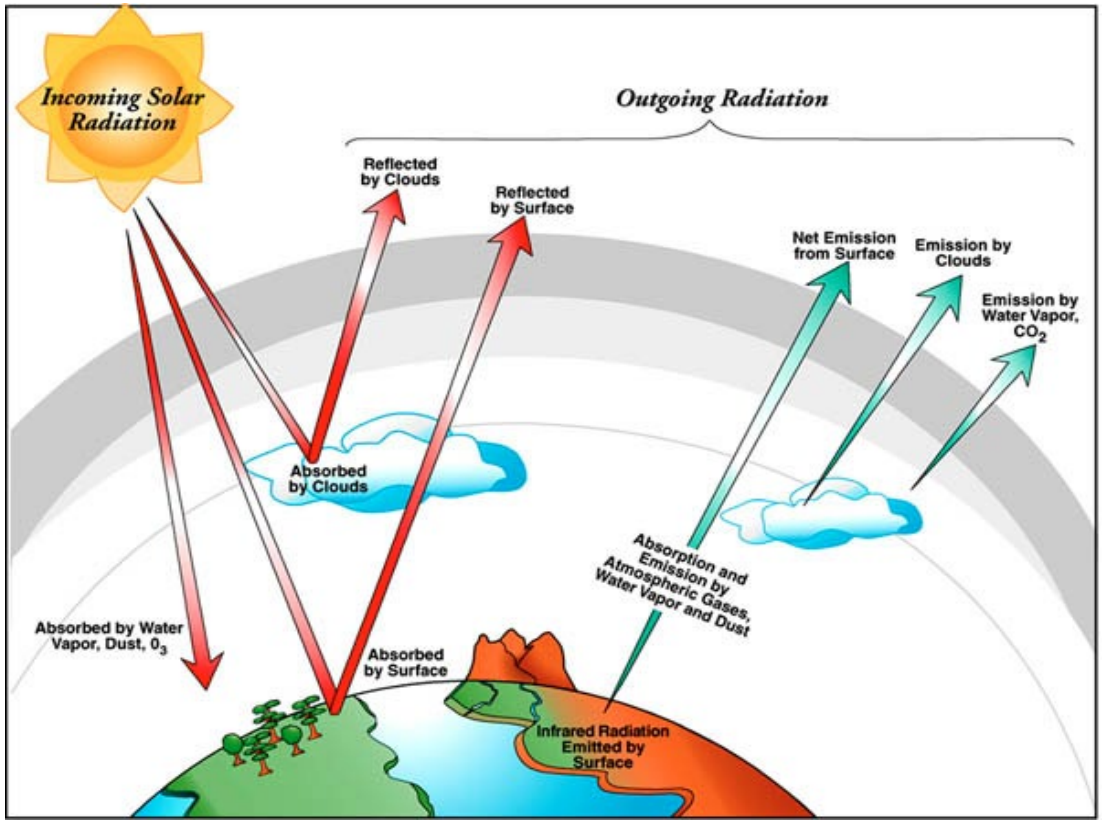
Satellite Remote Sensing of Physical Parameters

- Complex methodologies are developed using sensor measurements of radiation from the earth-atmosphere system, along with ground-based measurements and model-based data to obtain physical parameters such as temperature, precipitation, soil moisture, land cover.





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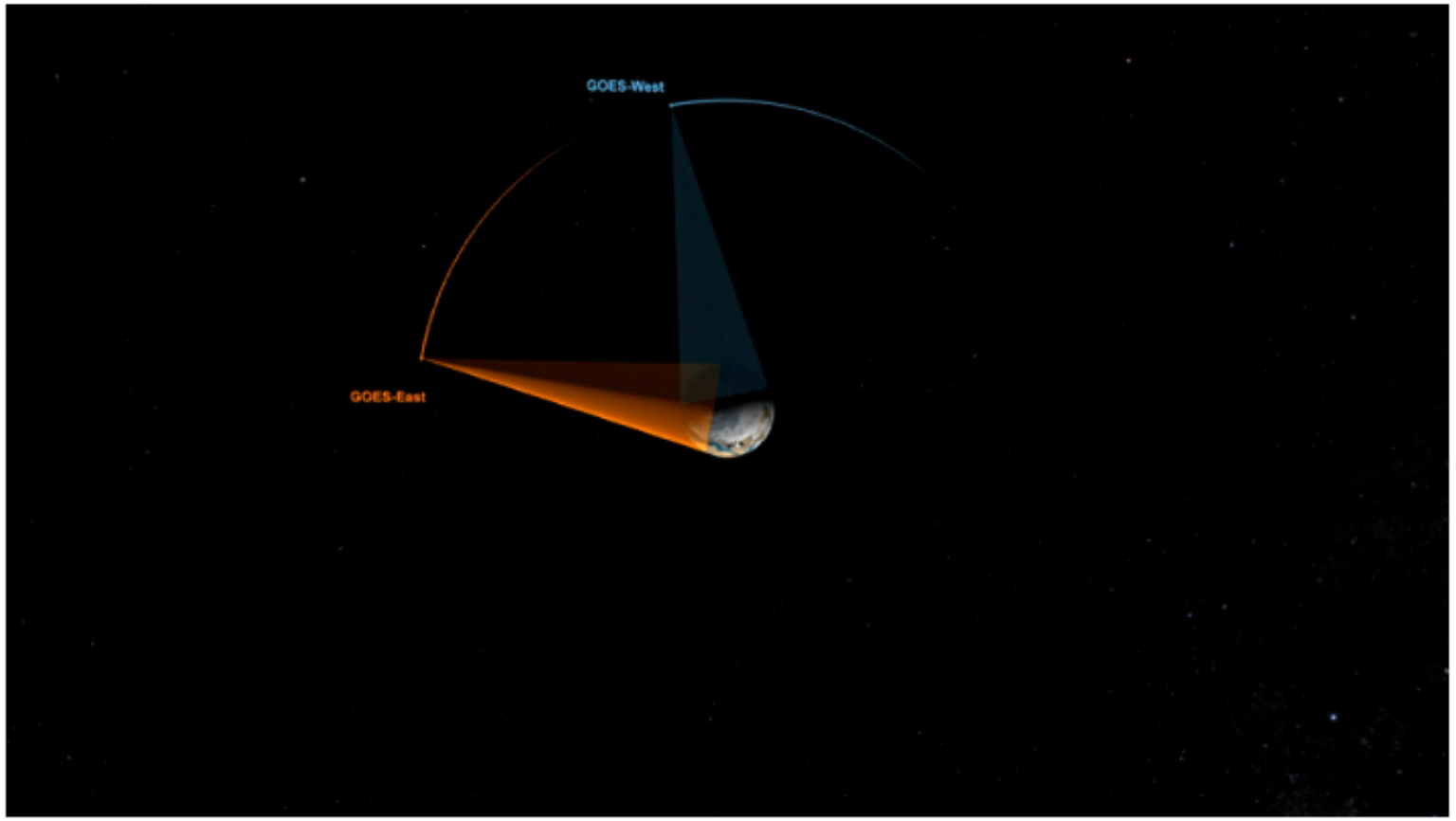
Satellite Orbits and Spatial and Temporal Coverage

Geostationary Orbit

- Typically orbit ~36,000 km over the equator with the same rotation period as Earth
- Multiple observations/day
- Limited spatial coverage—observations are always of the same area



Credit: NASA Science and Visualization Studio (SVS)

Satellite Orbits and Spatial and Temporal Coverage

Polar or Sun-synchronous Orbit

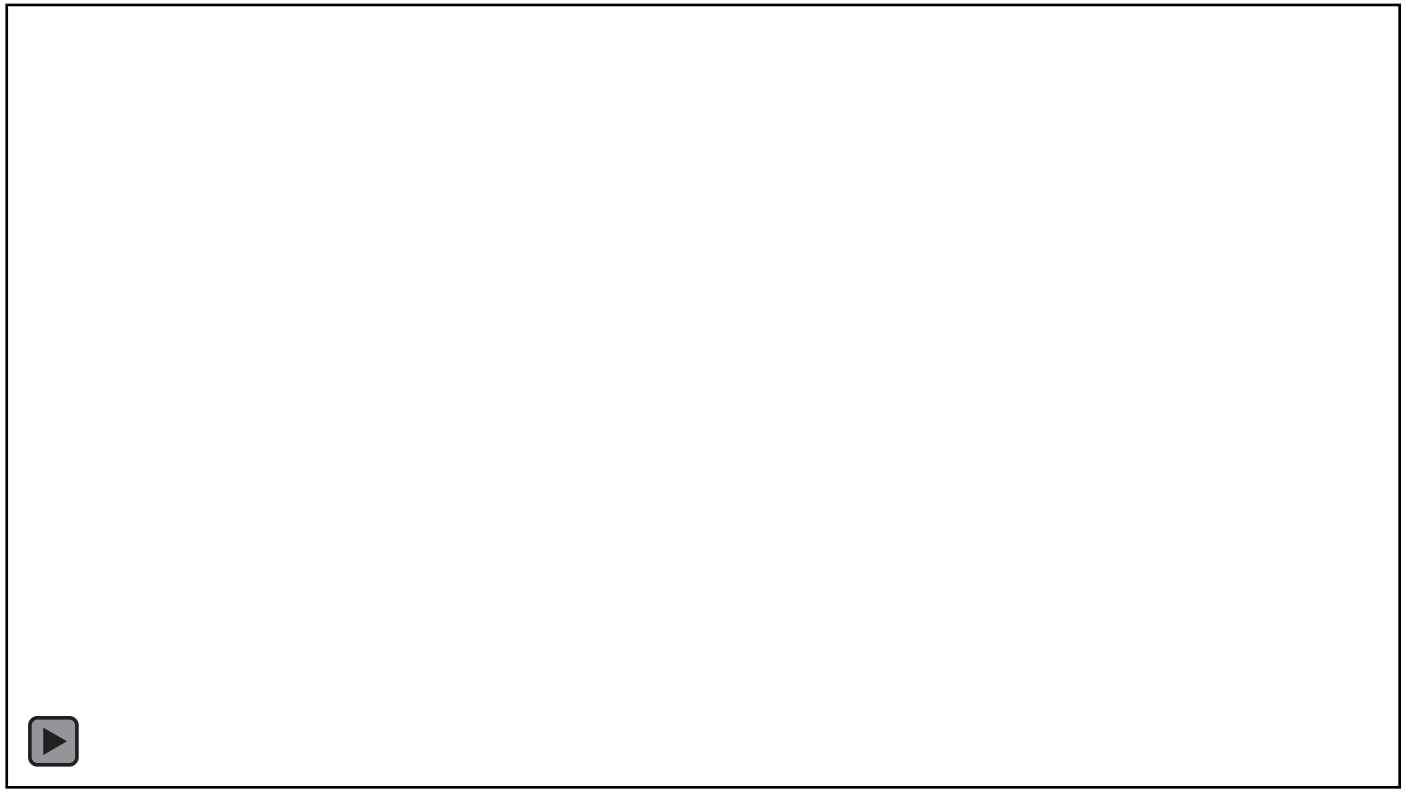
- Global coverage.
- Varied measurement frequency (once per day to once per month).
- Satellites travel over the polar regions synchronous with the sun—this means that the satellite always visits the same spot at the same local time on Earth.

Credit: NASA SVS

Satellite Orbits and Spatial and Temporal Coverage

Low-inclination Orbit

- Orbit moving relative to Earth–can be polar or nonpolar
- Less frequent measurements
- Global or near-global spatial coverage



Credit: NASA SVS

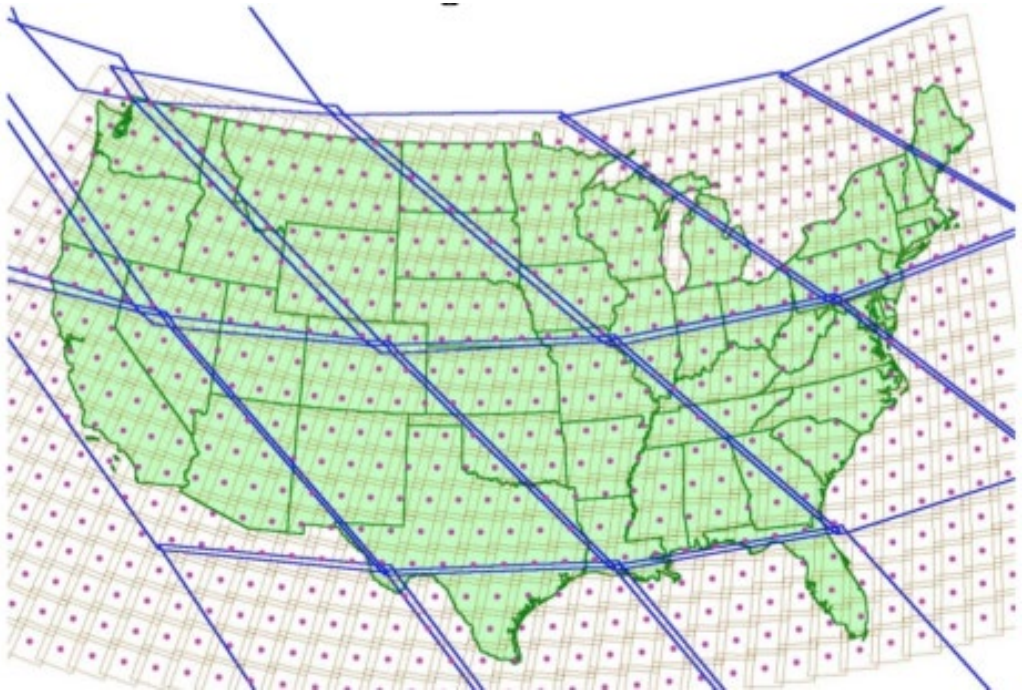
Satellite Observations: Spatial Resolution

- Spatial Resolution depends upon satellite orbit configuration and sensor design.
- Different sensors have different resolutions.
- Signifies the smallest ground surface area that forms one picture element or pixel in the image.
- The higher the spatial resolution, the less area is covered by a single pixel.

Landsat 8 image of Reykjavik, Iceland, acquired July 7, 2019, illustrating different pixel resolutions
Credit: NASA Earth Observatory.

Satellite Observations: Temporal Resolution

- Temporal resolution is the time elapsed between observations of the same point on Earth by a satellite—also called "revisit time."
- Depends on satellite/sensor capabilities, swath (area observed by a sensor as it moves in the orbit) overlap, and latitude
- Some satellites have greater temporal resolution because:
  - they can maneuver their sensors
  - they have increasing overlap at higher latitudes.



Orbital swath of MODIS (blue boxes) versus the orbital swath of the OLI aboard Landsat 8 (boxes with red dots). Due to its much wider imaging swath, MODIS provides global coverage every 1-2 days versus 16 days for the OLI. Red dots indicate the center point of each Landsat tile.

Credit: NASA Earth Observatory

Satellite Observations: Spectral Resolution

- Spectral resolution is the ability of a sensor to discern finer wavelengths, that is, having more and narrower bands.
- Sensors that we will use in this training are are multispectral, having 3–36 spectral bands in the wavelength range of visible (red, blue green), near-infrared (NIR), and microwave (MW).
- We will use spectral bands or spectral channels with wavelengths in units of nanometer (nm) or frequency in units of gigahertz (GHz).

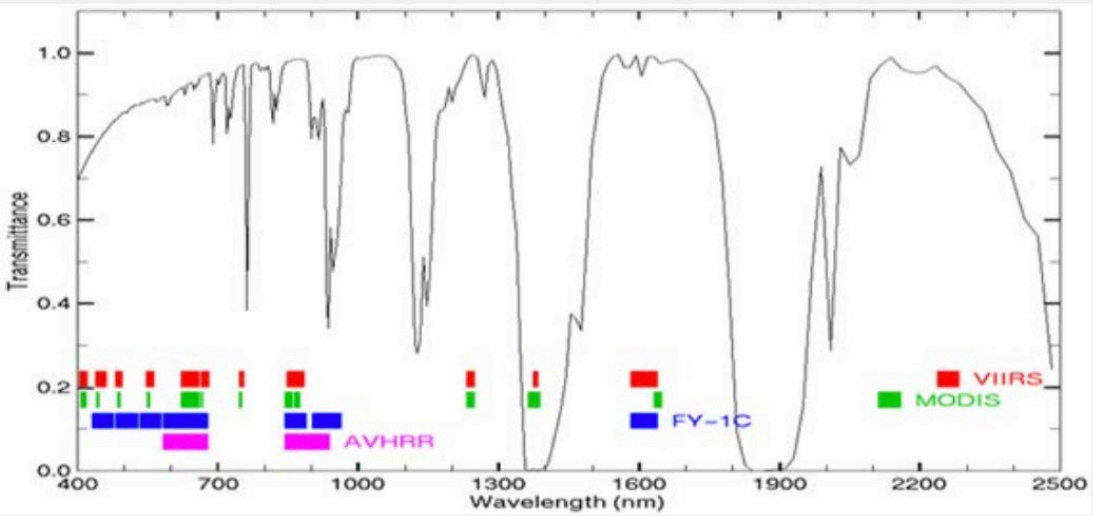


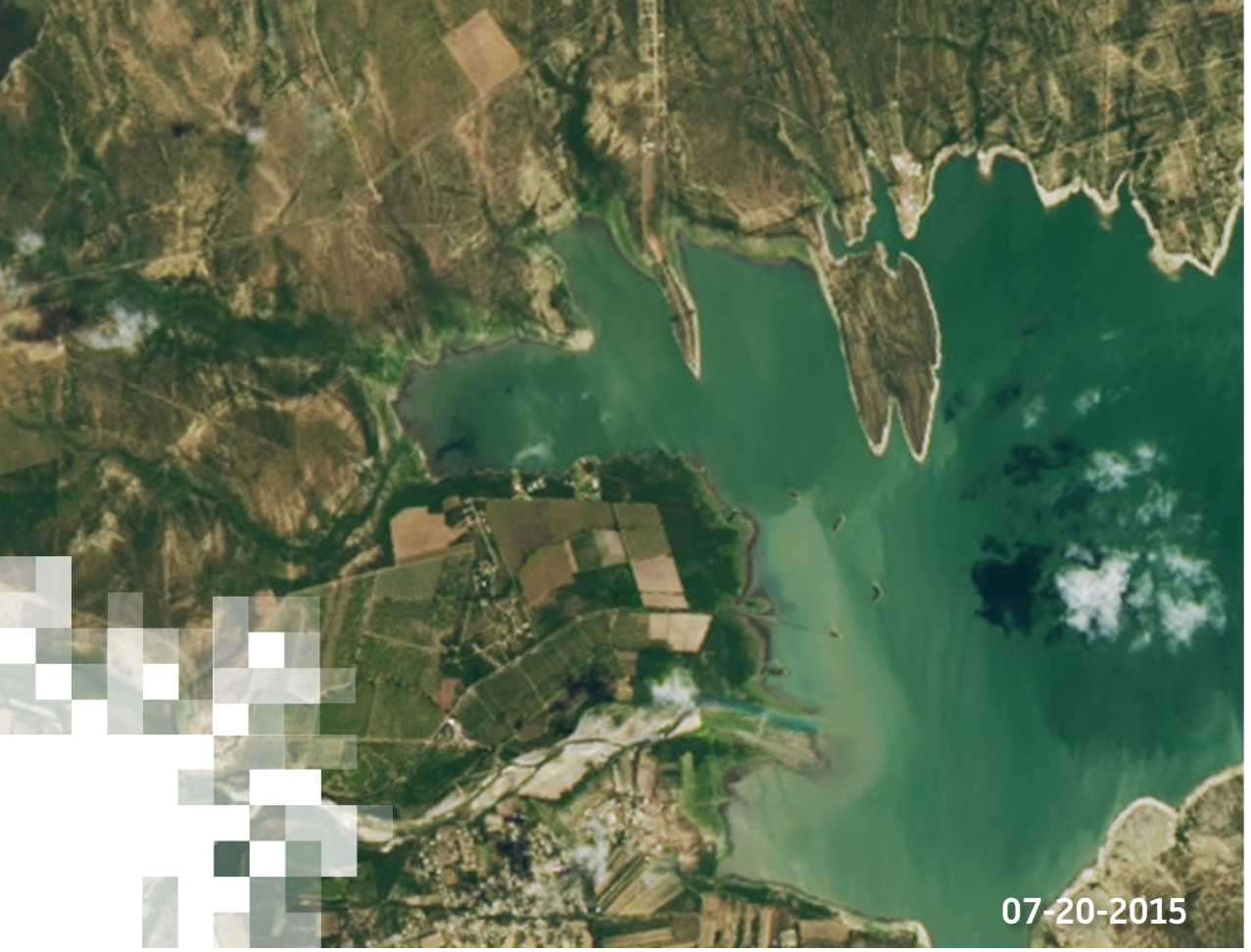
Image Credit: http://cimss.ssec.wisc.edu/

Summary

- For assessing risk and impacts of floods, droughts, and fires, we will use parameters derived from:
  - GPM-multi satellite constellation (microwave radar and radiometers)
  - Landsat-8 and Landsat-9 (OLI, TIRS)
  - Aqua & Terra (MODIS)
  - NPP & JPSS (VIIRS)
  - SMAP (microwave radiometer)
  - Sentinel-1 (microwave radar)
- We will access the data available from Google Earth Engine (GEE) (https://earthengine.google.com/)

Summary

- We will use ancillary data from GEE:
  - Terrain (SRTM)
  - Night Light Imagery (VIIRS)
  - Winds (MERRA2, NASA atmospheric model)
  - Population Density
  - Impervious Surface



Next: Remote Sensing of Precipitation