WELCOME TO NASA APPLIED REMOTE SENSING TRAINING (ARSET) WEBINAR SERIES

INTRODUCTION TO REMOTE SENSING FOR CONSERVATION MANAGEMENT

COURSE DATES: EVERY TUESDAY, MAY 5 – JUNE 2
TIME: 12:00 – 1:00 PM EDT
OR
10:00 – 11:00 PM EDT

Course Structure

- One lecture per week – every Tuesday May 5 to June 2
  - 12:00 – 1:00 PM EDT (Session 1)
  - 10:00 – 11:00 PM EDT (Session 2)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET Conservation Management webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

ARSET Conservation Management

https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

Course Objectives

- Provide overview of NASA Earth Observation resources available for conservation management including:
  - A basic understanding of remote sensing
  - How to access and visualize NASA Earth science data
  - How to use NASA Earth science data, tools, and products for conservation issues


USFWS

Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Guest Speakers:
  - Walter Jetz – Yale University (week 3)
  - Jeff Cavner –University of Kansas (week 4)
  - Karyn Tabor – Conservation International (week 5)

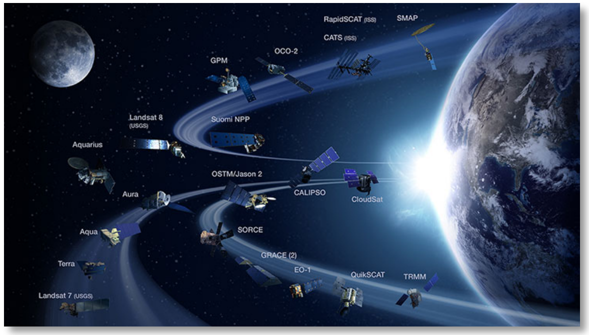
General inquiries about ARSET: Ana Prados (ARSET) aprados@umbc.edu

Course Outline

Week 1

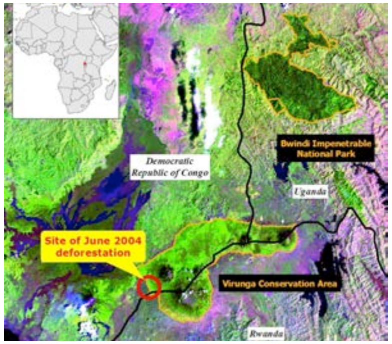
Overview of satellite remote sensing

Week 2



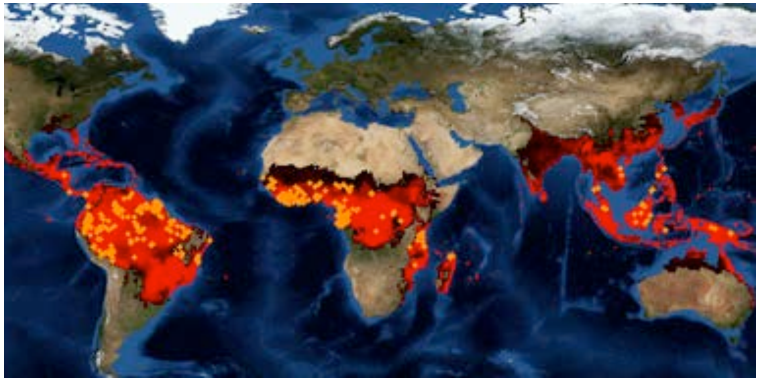
Platforms and sensors for conservation

Week 3



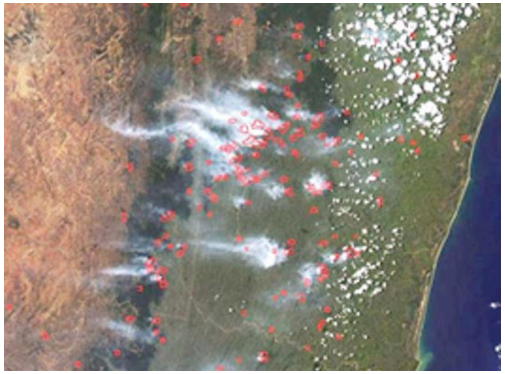
Habitat monitoring

Week 4



Animal movement

Week 5



Near-real time data

Week 1 Agenda

- Course structure and objectives
- Overview of ARSET
- Global conservation issues that can be addressed with remote sensing
- Fundamentals of remote sensing

Applied Remote SEnsing Training (ARSET)

NASA Applied Sciences Capacity Building Program

- **GOAL**: Increase utilization of NASA observational and model data for decision-support through training activities for environmental professionals.
- **Online Trainings**: Live and recorded, 4-6 weeks in length. Include demos on data access
- **In person Trainings**: In a computer lab, 2- 4 days. Large focus on data access
- **Train the Trainers**: Courses and training manuals for those interested in conducting their own remote sensing training.
- **Application Areas:** water resources, disasters, health/air quality, and land management
- http://arset.gsfc.nasa.gov

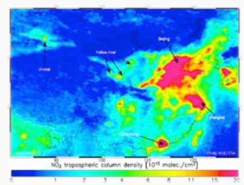
Accomplishments (2008 – 2014)

- 46 trainings completed
- 2300+ participants worldwide
- 700+ Organizations

ARSET: Training Focus Areas

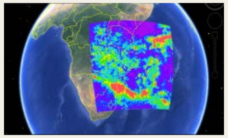
Health (Air Quality)

- 2008 – present
- 33 Trainings
- 1000+ end-users
- Analysis of dust, fires and urban air pollution.
- Long range transport of pollutants
- Satellite and regional air quality model inter-comparisons.
- Support for air quality forecasting and exceptional event analysis



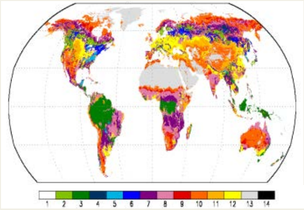
Water Resources and Flood Monitoring

- April 2011 – present
- 11 Trainings
- 1000+ end-users
- Flood/Drought monitoring
- Severe weather and precipitation
- Watershed management
- Climate impacts on water resources
- Snow/ice monitoring
- Evapotranspiration (ET), ground water, soil moisture, and runoff.



Land Management

- Launched in 2014
- 2 Trainings, +300 end-users
- GIS Applications
- Vegetation indices
- Wildfire Applications



Train the Trainers (Starting in 2015)

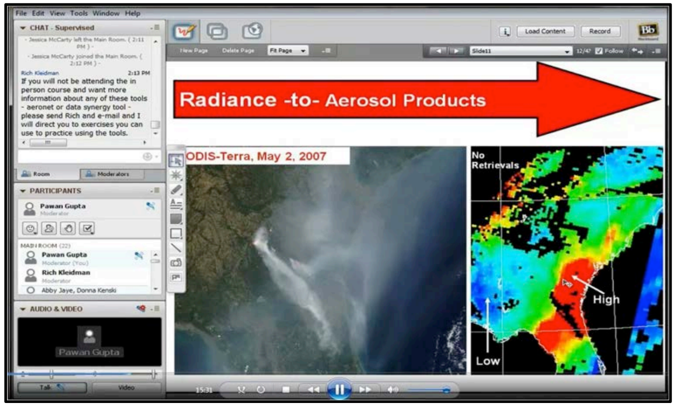
- Courses and guidance on how to design and develop, *YOUR OWN* online and/or computer based remote sensing training
- How to develop effective presentations and exercises.

ARSET: Gradual Learning Approach

Basic Training
Webinars
Hands-on
Assumes no prior knowledge of RS

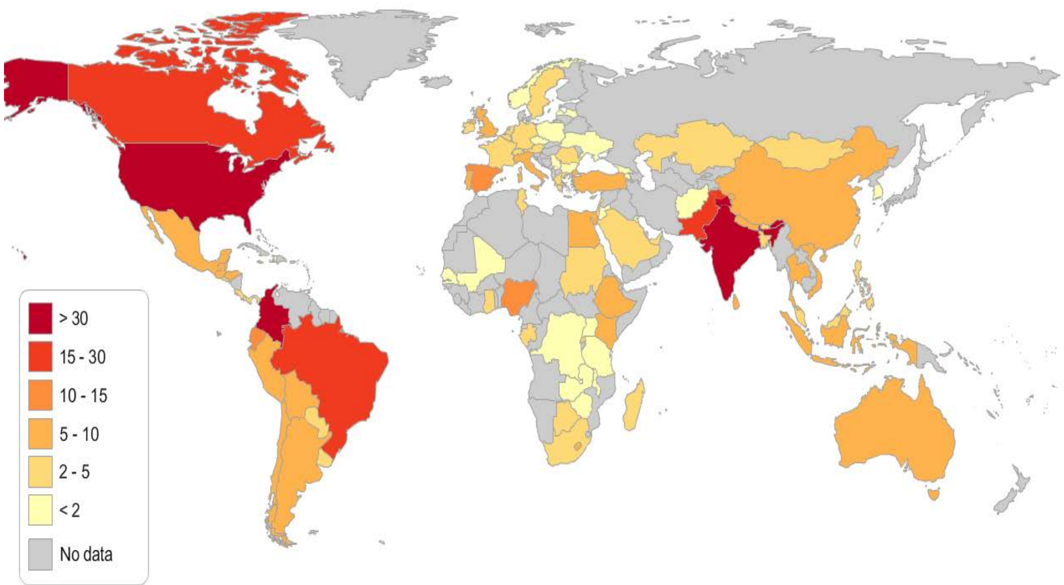
Advanced Training
Hands-on
Webinar course generally required
Focused on a specific application/ problem/Data: for example dust or smoke monitoring in a specific country or region

Online Training



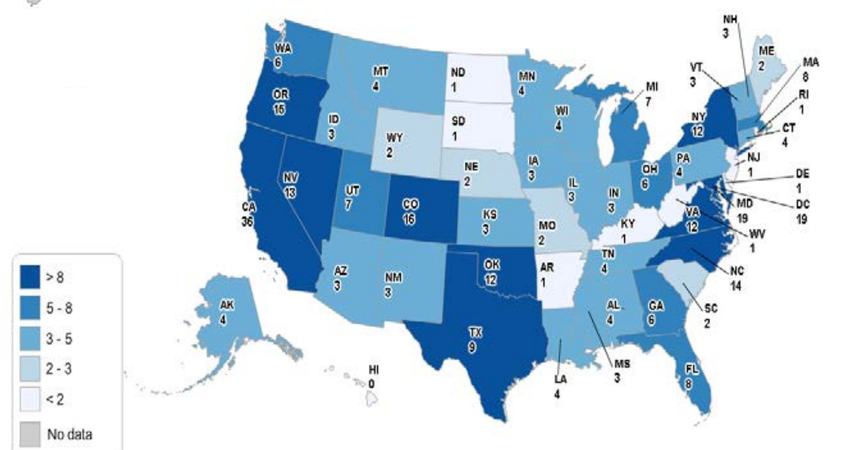
In-Person Training

ARSET: Capacity Building



- 2008 – 2014
  - 46 trainings
  - 2300+ End-users
  - 700+ Organizations

Number of participating organizations per country (above) and per US state (right): Air Quality, Water, Flood, and Land management



Remote Sensing Applications for Conservation Management

How Remote Sensing Can Contribute to Conservation

- Conservation Biology paper (Rose, et al 2014) that identified ten topics
  - Species distributions and abundances
  - Species movements and life stages
  - Ecosystem processes
  - Climate change
  - Rapid response
  - Protected areas
  - Ecosystem services
  - Conservation effectiveness
  - Agriculture and aquacultural expansions and changes in land use land cover (LULC)
  - Degradation and disturbance regimes

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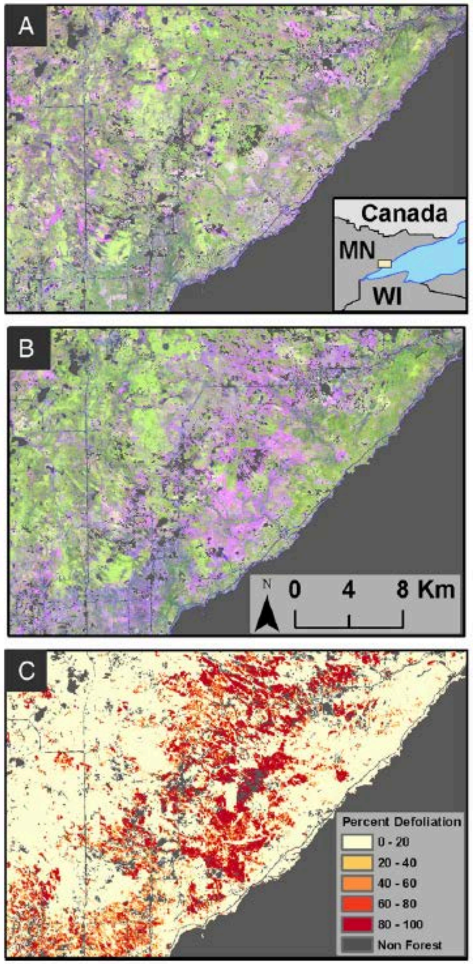
WEEK 3: Habitat Monitoring

How Remote Sensing Can Contribute to Conservation

- Ecosystem Processes and Disturbance Regimes:
  - Example: Townsend et al, 2012
  - Use of Landsat model to predict canopy defoliation in deciduous forests in northern Minnesota
  - Focused on two outbreaks of gypsy moth defoliation in two predominantly oak forested study areas
  - Field data used in conjunction with vegetation indices to map defoliation events
  - Maps provide percent defoliation



(Townsend et al, 2012)

Fig. 7. Defoliation by the forest tent caterpillar in northern Minnesota in 2001: (A) Base image from DD Month 2002, (B) Target defoliation image from DD July 2001, (C) Mapped defoliation using the global model presented in Table 4. Color scheme is same as Figs. 2 and 5.

How Remote Sensing Can Contribute to Conservation

- Land Use Changes and Conservation Effectiveness:
  - Example: Sieber et al, 2013
  - Goal was to map changes in forest cover from 1984-2010 in two protected areas in Russia to assess the effectiveness of conservation in this region.
  - Used Landsat imagery and conducted change detection methods
  - Found disturbances in 5% of lands and 39% of abandoned agricultural land that lead to forest regrowth

A. Sieber et al. / Remote Sensing of Environment 133 (2013) 38–51 43

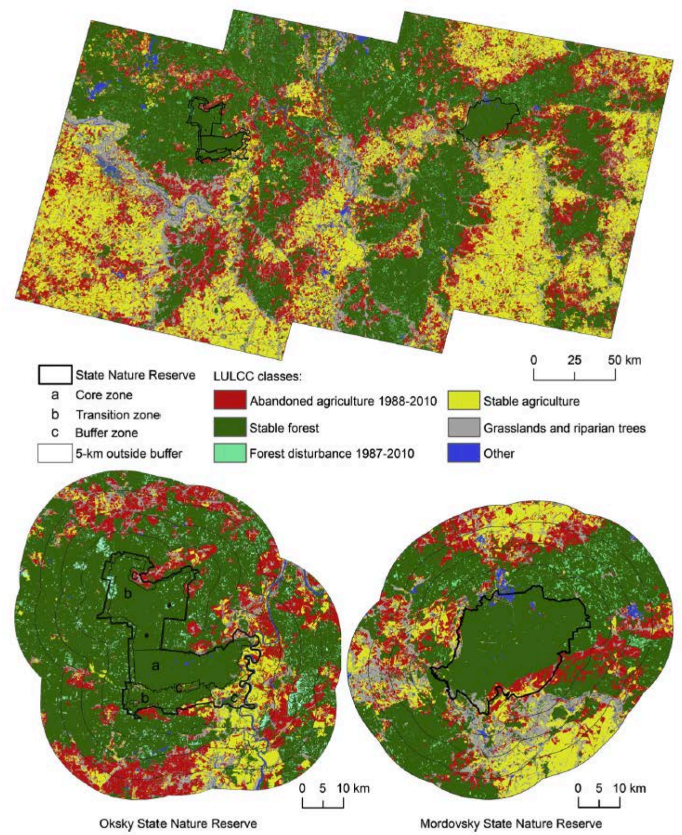


Fig. 4. Post-Soviet land-use and land-cover change (LULCC) within the study area and Oksky and Mordovsky State Nature Reserves with their surrounding ring-shaped buffers within 0–5, 5–10, 10–15, and 15–20 km of the outermost boundary of the protected areas.

(Seiber et al, 2012)

How Remote Sensing Can Contribute to Conservation

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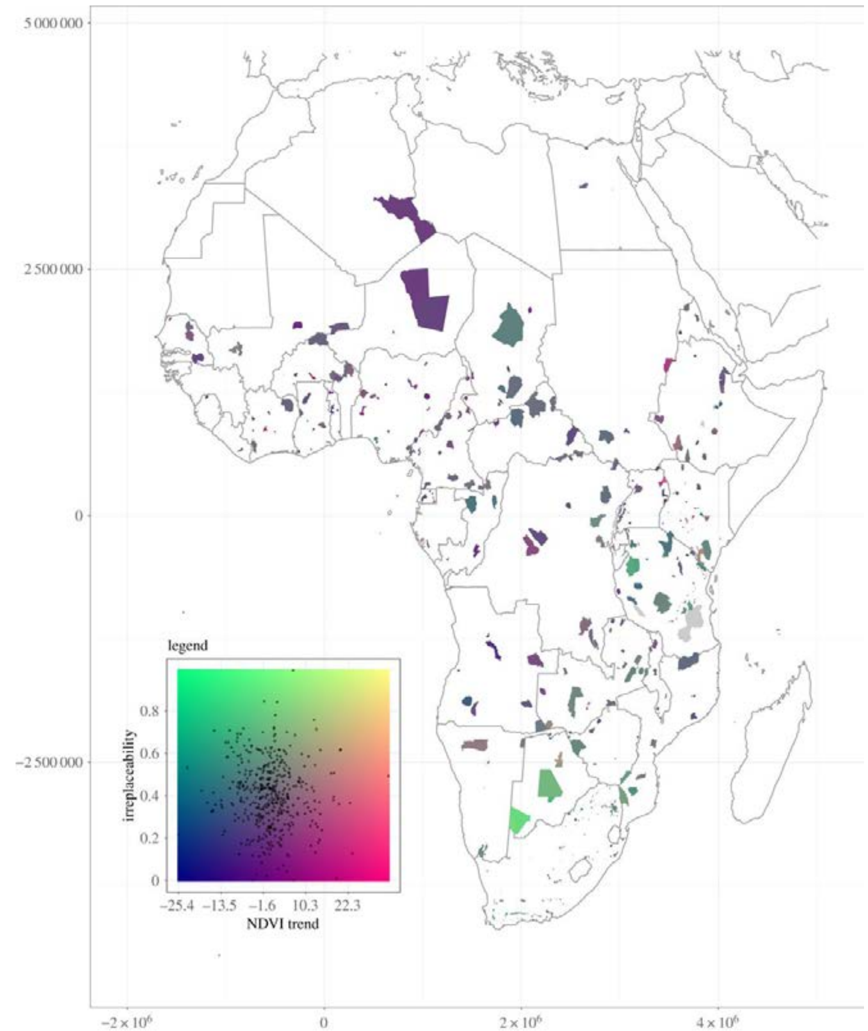
WEEK 4: Animal Movement

How Remote Sensing Can Contribute to Conservation

- Animal Movement: network connectivity of suitable habitat
  - Example: Wegmann et al, 2014
  - Studied African protected areas (PAs) and measured network connectivity (irreplaceability) for large carnivores based on 30-year trend in remotely sensed vegetation cover
  - Also related to disturbance regimes, land cover change, etc.



(Wegmann et al, 2014)

How Remote Sensing Can Contribute to Conservation

- Animal Movement: Migration paths and topography
  - Example: Katzner et al, 2012
  - This study used migratory flight data of golden eagles in conjunction with terrain data to determine potential implications for wind-energy development

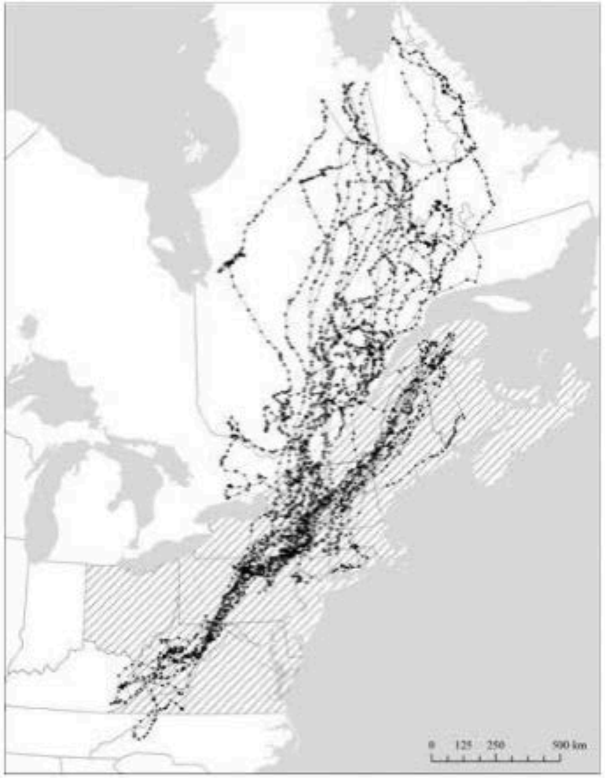


Fig. 1. Large scale movements of eight satellite-tagged golden eagles migrating through eastern North America. Data for this study were collected along these migratory tracks in all types of landform. Movement tracks are overlaid on cross hatching showing the extent of The Nature Conservancy's (TNC) Ecological Landform Units (ELUs) considered (Anderson *et al.* 2006). Details on data coverage are provided in the methods section.

(Katzner et al, 2012)

How Remote Sensing Can Contribute to Conservation

- Conservation Biology paper (Rose, et al 2014) that identified ten topics
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WEEK 5: Near-real time monitoring

How Remote Sensing Can Contribute to Conservation

- Rapid Response: Near-real time monitoring
  - Example: Fire Information for Resource Management System (FIRMS)
  - Web Fire Mapper provides Wildfire data available nearly 3 hours after a satellite overpass and can be viewed on 24, 48, and 72 hour timeframes
  - Can be used for identifying important habitat at risk

NASA FIRMS website

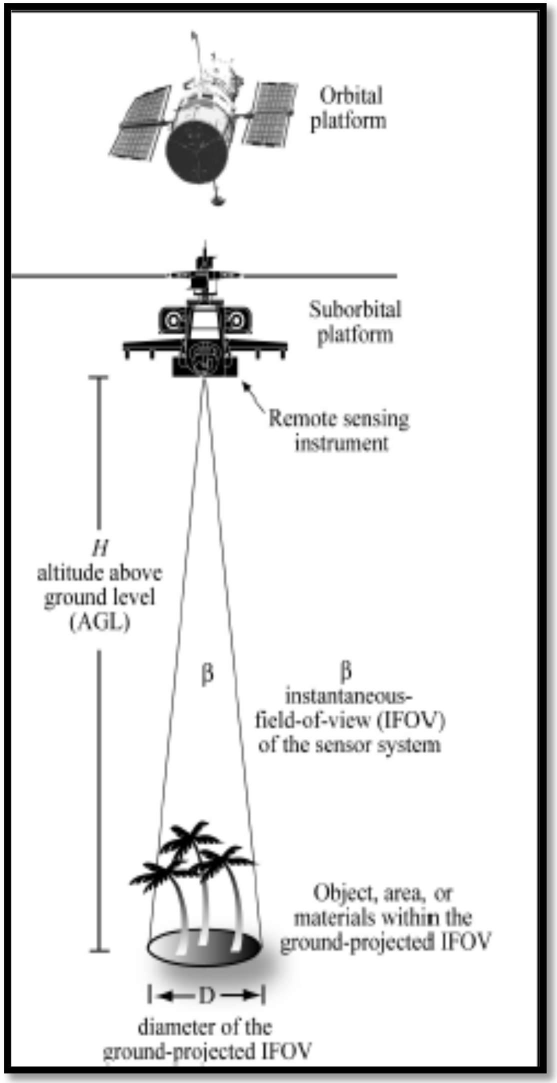
Fundamentals of Remote Sensing

What is Remote Sensing?

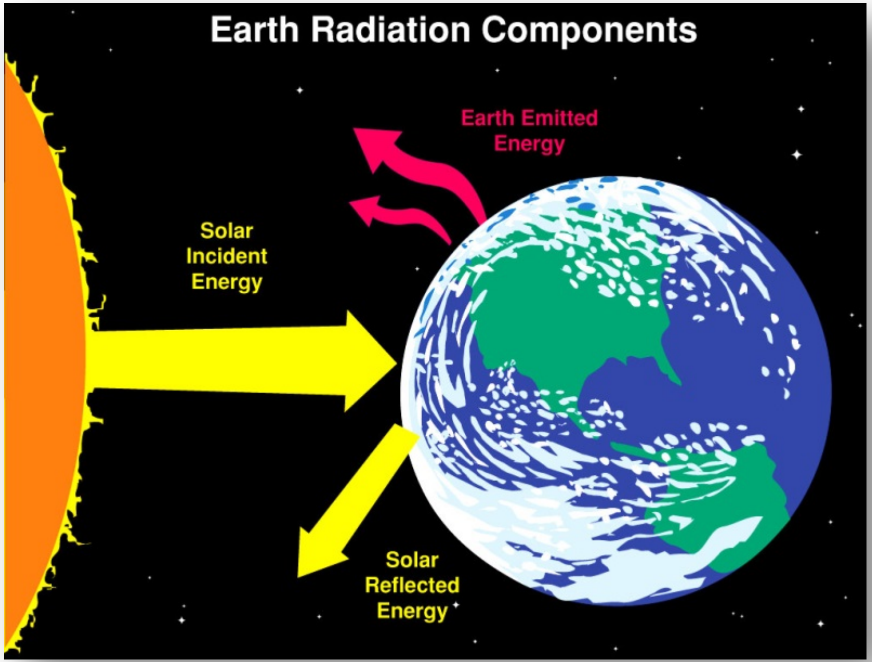
Measurement of a quantity associated with an object by a device not in direct contact with the object

- The most useful platform depends on the application.
- What information? How much detail?
- How frequent?

Satellite Remote Sensing



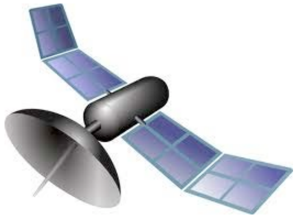
Satellites carry instruments or sensors which **measure electromagnetic radiation** coming from the earth-atmosphere system

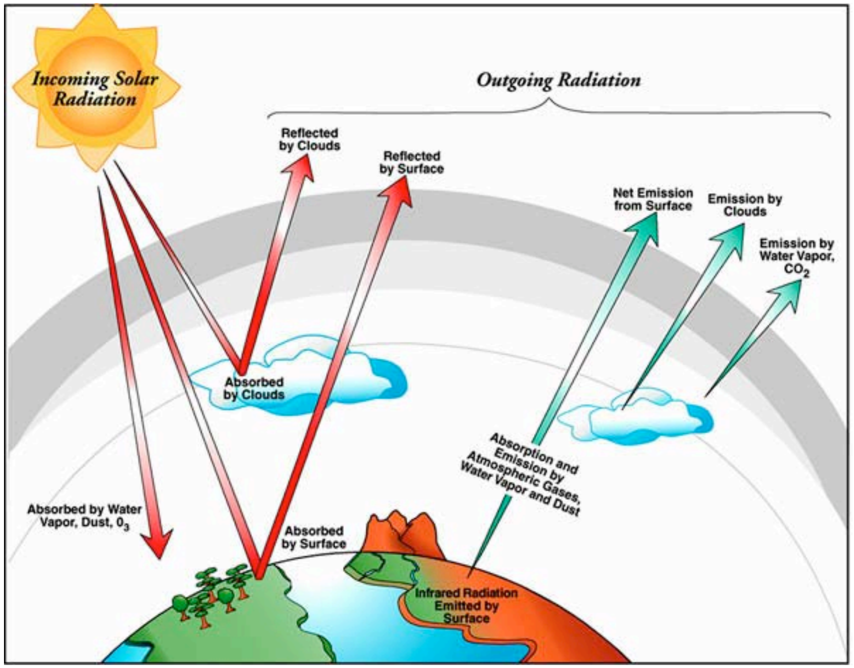


Satellite Remote Sensing

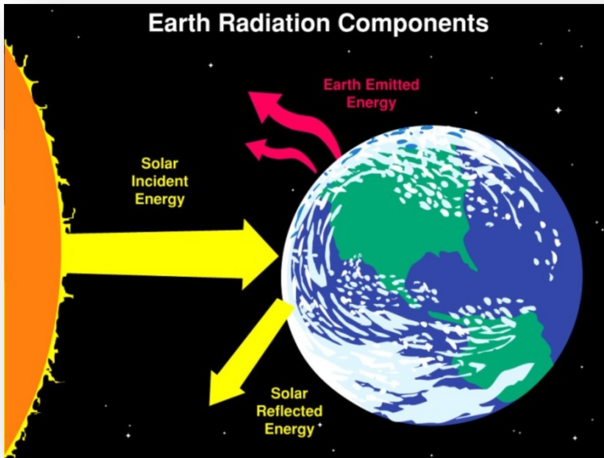
- The intensity of reflected and emitted radiation to space is influenced by the surface and atmospheric conditions.

- Thus, satellite measurements contain information about the surface and atmospheric conditions.



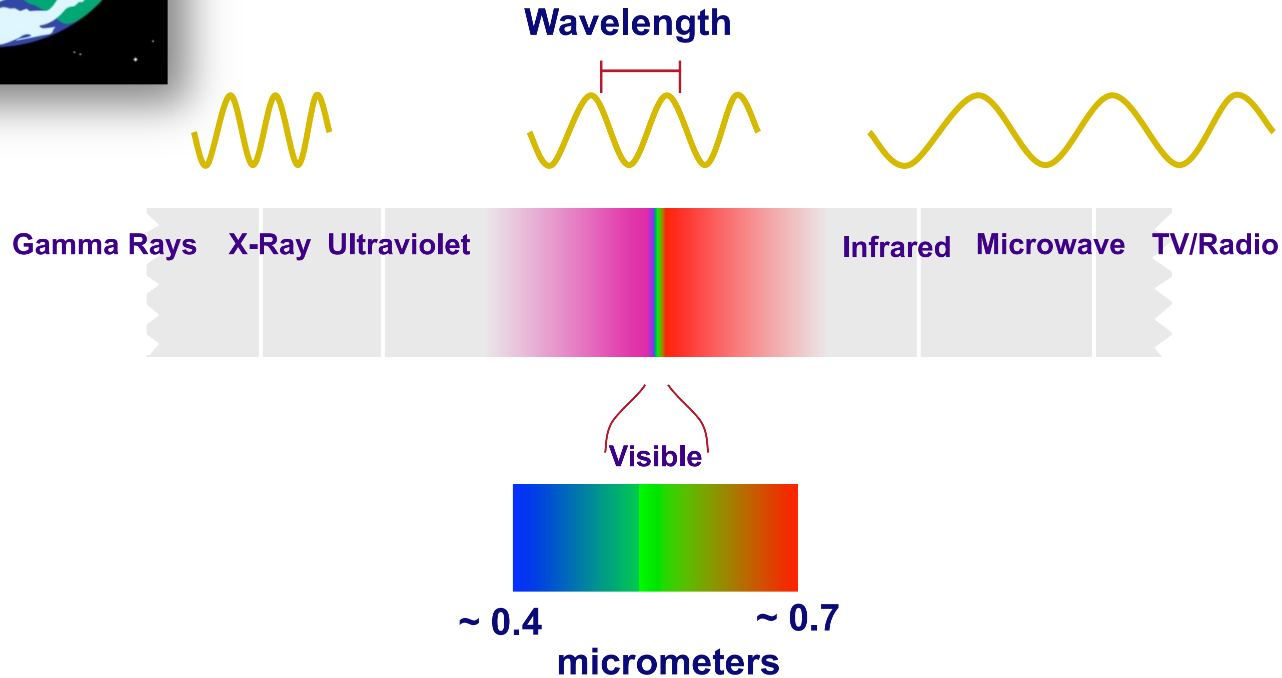


Electromagnetic Radiation

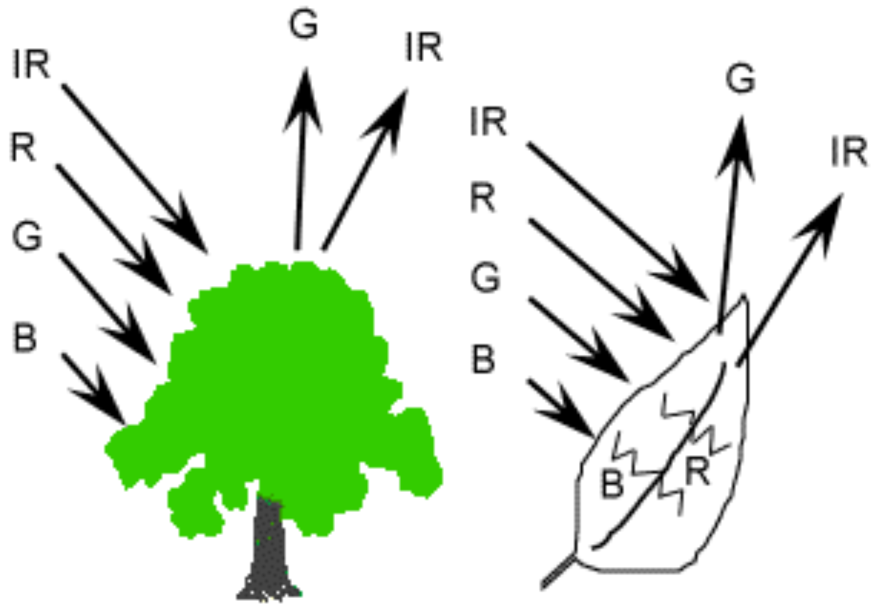


Earth-Ocean-Land-Atmosphere System :
- Reflects solar radiation back to space
- Emits Infrared and Microwave radiation to space

Electromagnetic Spectrum



Electromagnetic Energy

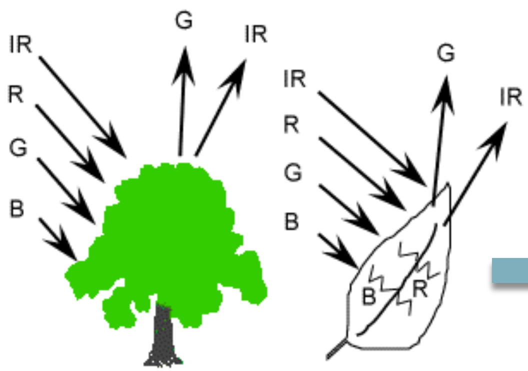


Example: Healthy, green vegetation absorbs Blue and Red wavelengths and reflects Green and Infrared

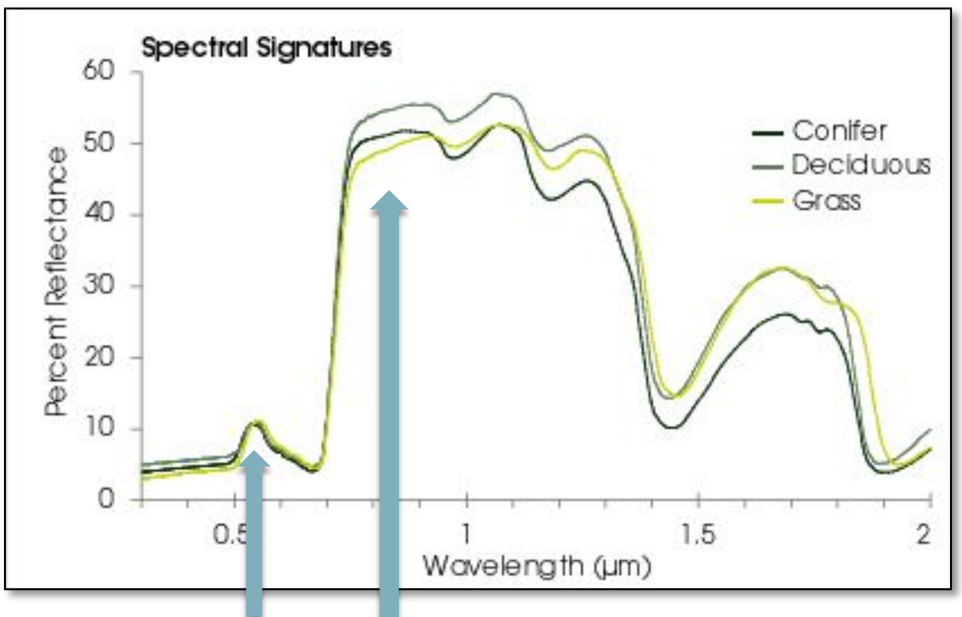
That's why we see healthy vegetation as green

Spectral Signatures

- Every kind of surface has it’s own spectral signature
- Going back to the healthy vegetation example….

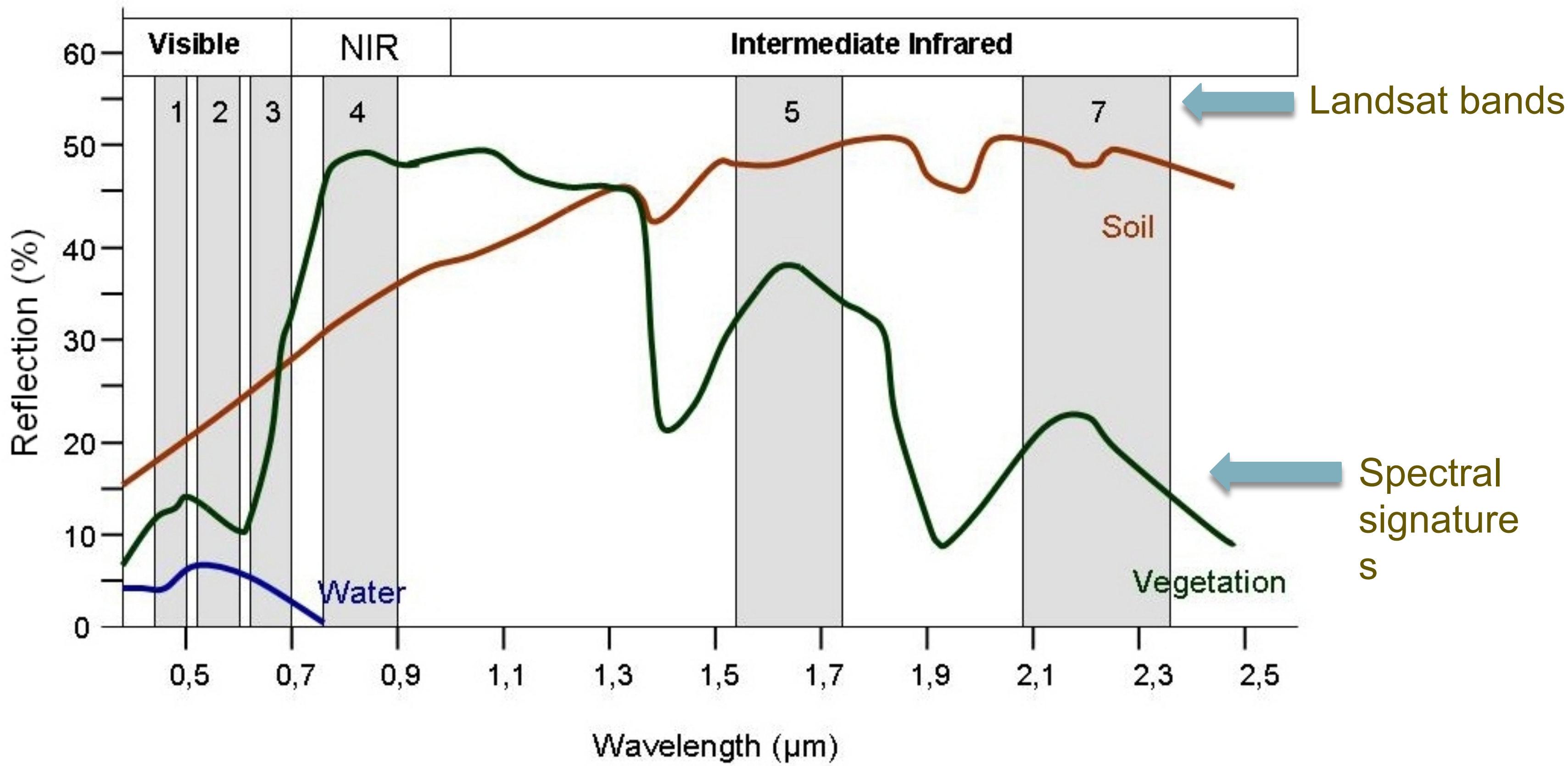


Spectral Signature



Spectral Signatures in Imagery

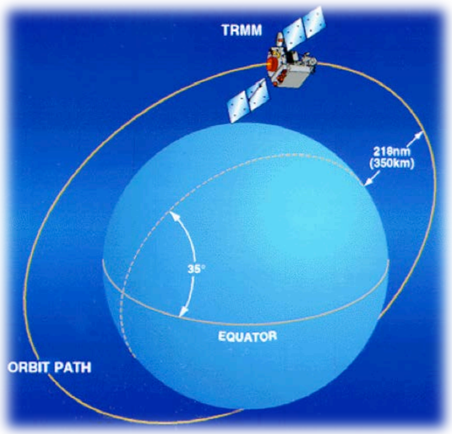
- Remotely sensed imagery acquires information in different wavelengths, representing different parts of the Electromagnetic Spectrum

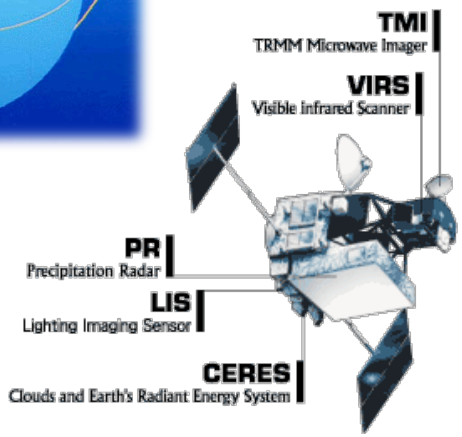


Satellite Remote Sensing Observations: What to Know

- Instruments/sensors and types
- Types of satellite orbits around the Earth
- Spatial and temporal coverage
- Geophysical quantities derived from the measurements
- Quality and accuracy of the retrieved quantity
  - Availability, access, format
  - Applications and usage

These affect the spatial resolution, the temporal resolution, and the spatial coverage

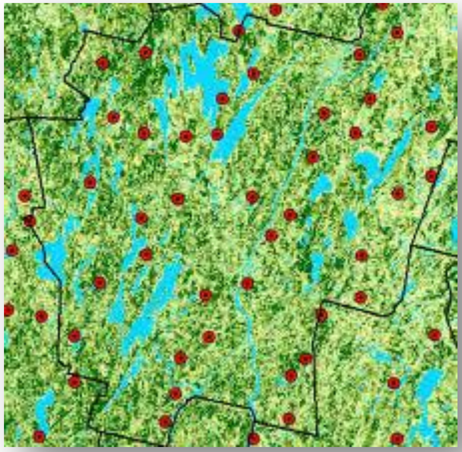




Advantages and Disadvantages of Remote Sensing Observations

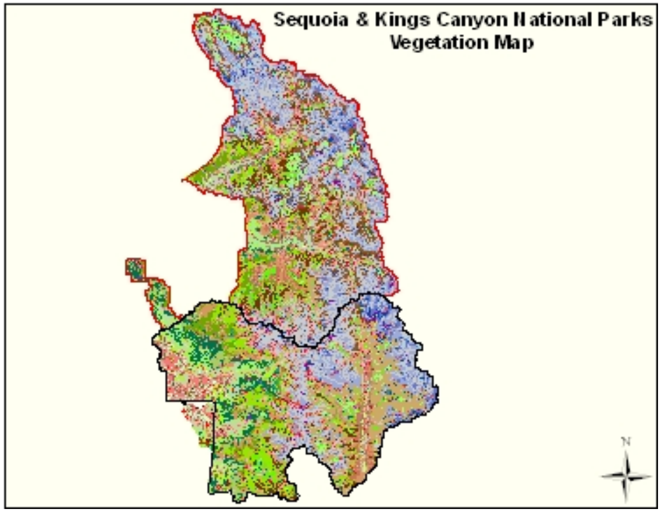
Ground-based Measurements

- Example: US Forest Service Forest Inventory Analysis (FIA)
  - Very detailed information for each plot
  - Non-uniform spatial and temporal coverage
  - Cannot get exact locations of plots



Remote Sensing Observations

- Provide information where there are no ground-based measurements
- Provide globally consistent observations
- Disadvantages:
  - Does not provide high level of detail at the ground level
  - Cannot detect landcover under canopy



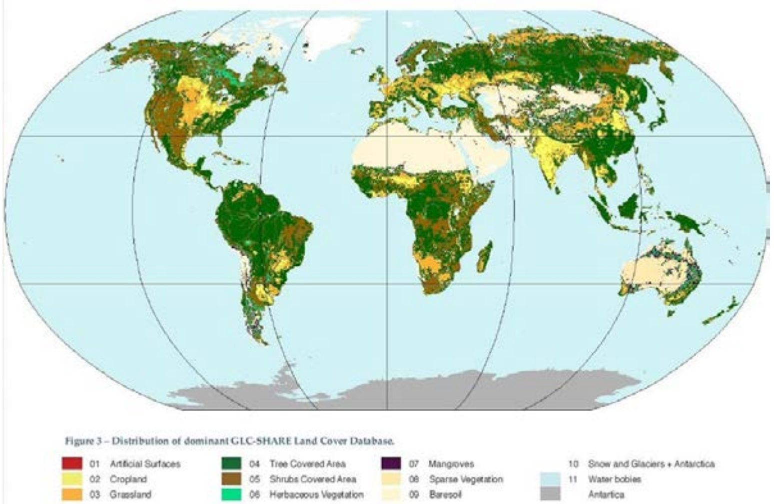


Figure 3 – Distribution of dominant GLC-SHARE Land Cover Database.

Satellite Sensors

Satellite Sensors

Type of Sensors

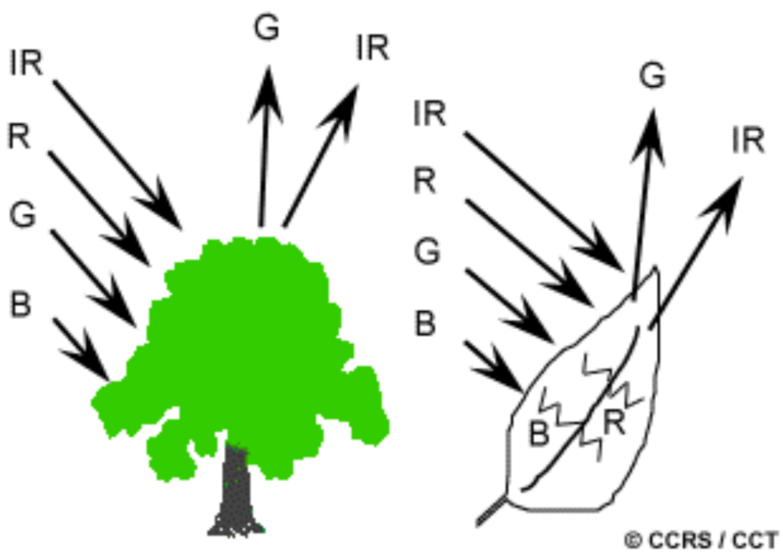
Spectral Resolution

Temporal Resolution

Spatial Resolution

Satellite Sensors

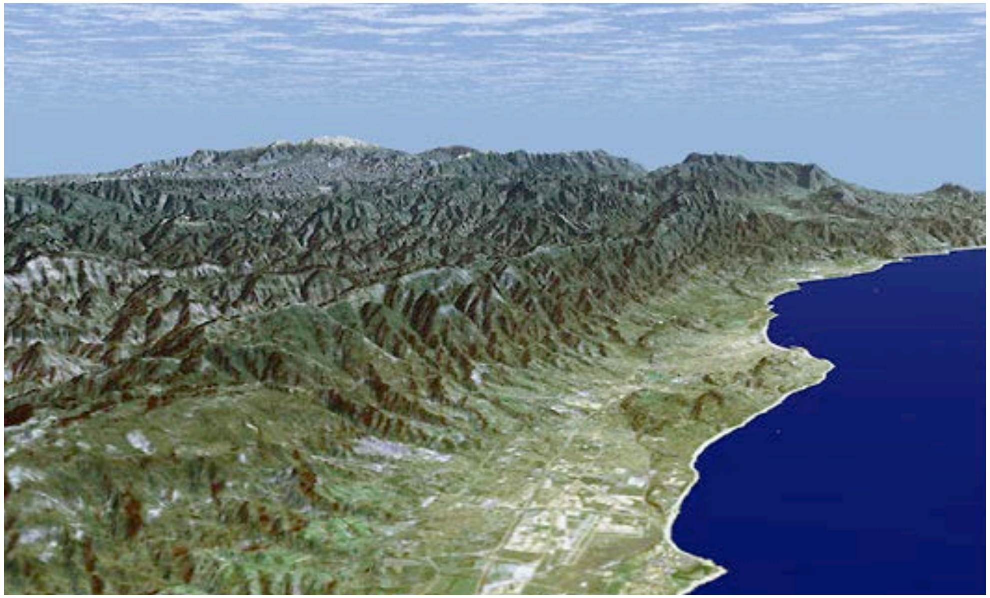
- **Passive** remote sensors measure radiant energy reflected or emitted by the Earth-atmosphere system
  - Examples: Landsat, MODIS



Landsat image of San Francisco Bay Area

Satellite Sensors

- **Active** remote sensors 'throw' beams of radiation on the earth-atmosphere system and measure 'back-scattered' radiation
  - The back-scattered radiation is converted to geophysical quantities
- Advantages:
  - Can be used day or night
  - Can penetrate cloud cover
- Disadvantages:
  - Challenging to process
  - Some available only from aircraft
- Examples: Radar, LIDAR



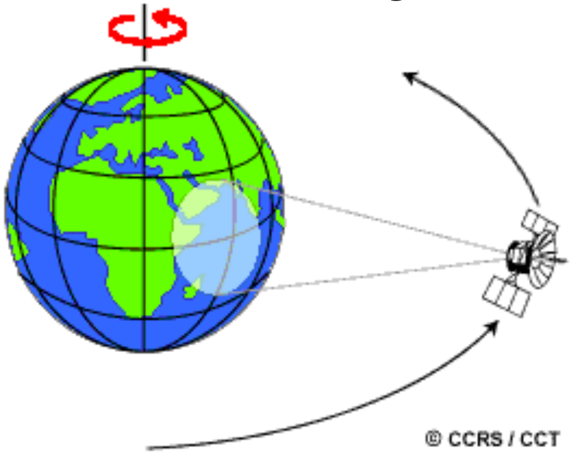
This perspective view of the Santa Barbara region was generated using data from the Shuttle Radar Topography Mission (SRTM) and an enhanced Landsat satellite image in February 2000.

Spatial and Temporal Resolution of Satellite Measurements

- **Temporal resolution:**
  - How frequently a satellite observes the same area of the earth
- **Spatial Resolution:**
  - Decided by its pixel size -- pixel is the smallest unit measured by a sensor
- Depends on the satellite orbit configuration and sensor design

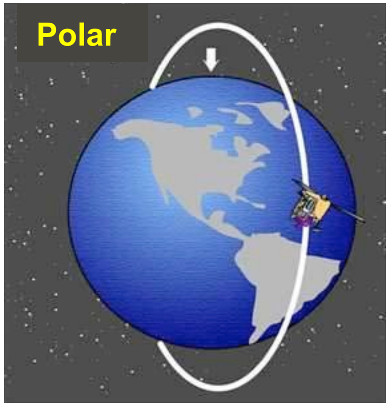
Types of Satellite Orbits

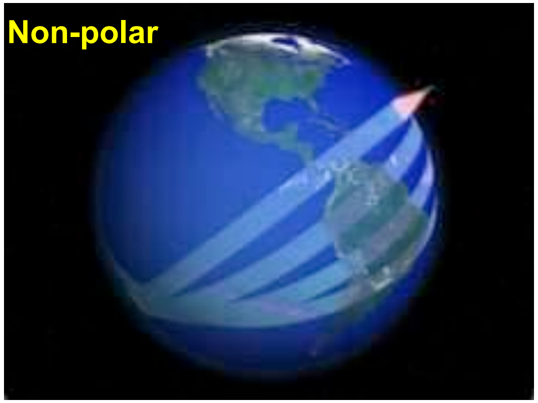
Geostationary orbit



- Satellite is at ~36,000 km above earth at equator. Same rotation period as earth's. Appears 'fixed' in space.
  - Frequent measurements
  - Limited spatial coverage
- Examples:
  - Weather or communications satellites

Low Earth Orbit (LEO)





- Circular orbit constantly moving relative to the Earth at 160-2000 km. Can be in Polar or non-polar orbit
  - Less frequent measurements
  - Large (global) spatial coverage
- Polar orbit examples: Landsat or Terra satellites

Spatial Resolution

- Spatial resolution refers to the detail discernable in an image by a pixel

Sensor	Spatial Resolution
Digital Globe (and others)	1-4 m
Landsat	30 m
MODIS	250 m-1km

Spatial Resolution

1 meter 10 meter 30 meter

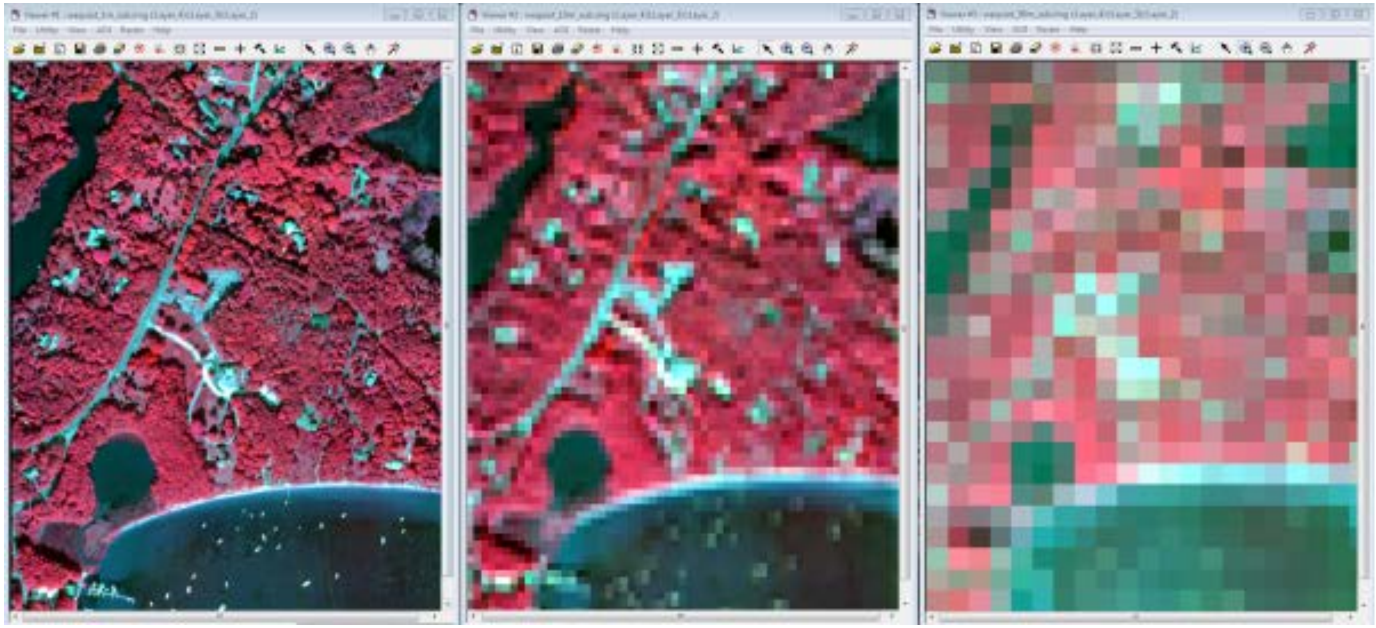
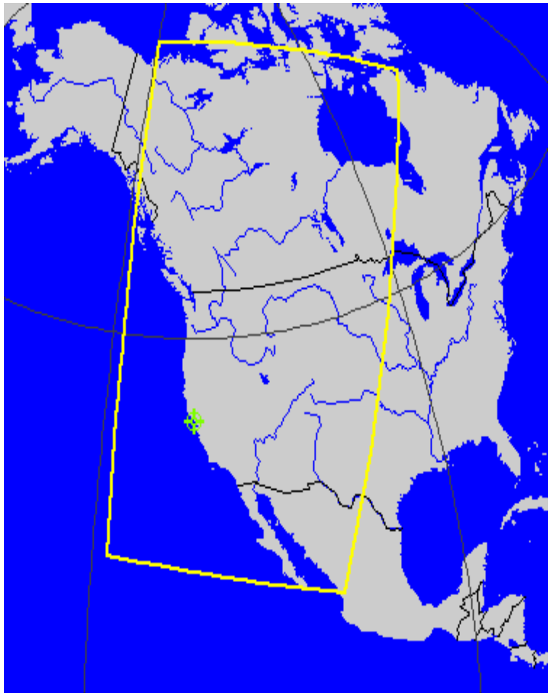


Image courtesy of www.csc.noaa.gov

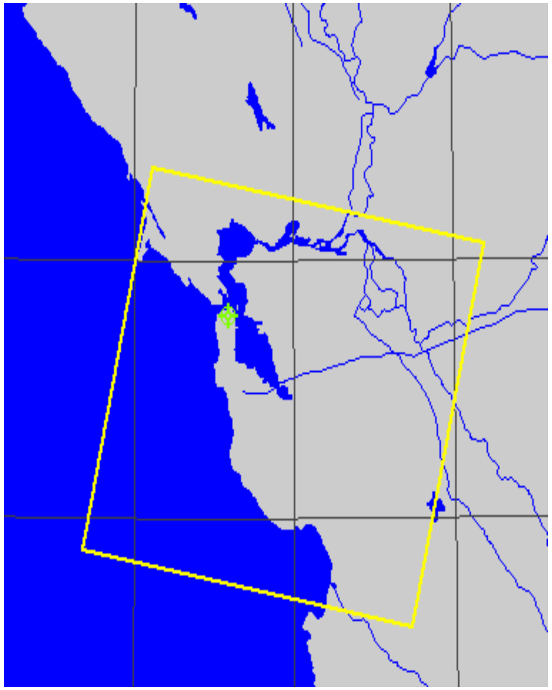
- BUT….there is a tradeoff between spatial resolution and spatial extent!

Spatial Extent

- Generally, the higher the spatial resolution the less area is covered by a single image



MODIS (1 km)



Landsat (30 m)

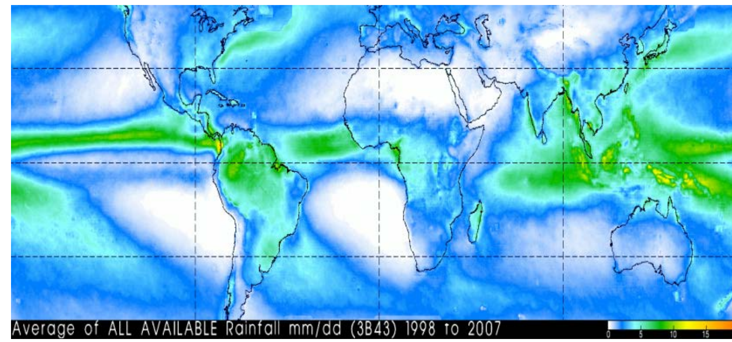
NASA Satellite Measurements with Different Spatial Resolutions

Landsat Image of Philadelphia

Spatial resolution: 30 m

Rain Rate from TRMM

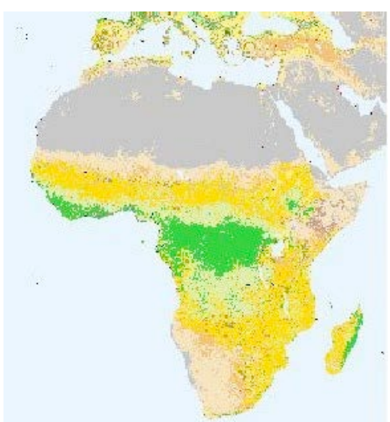
Spatial resolution: 25 km²



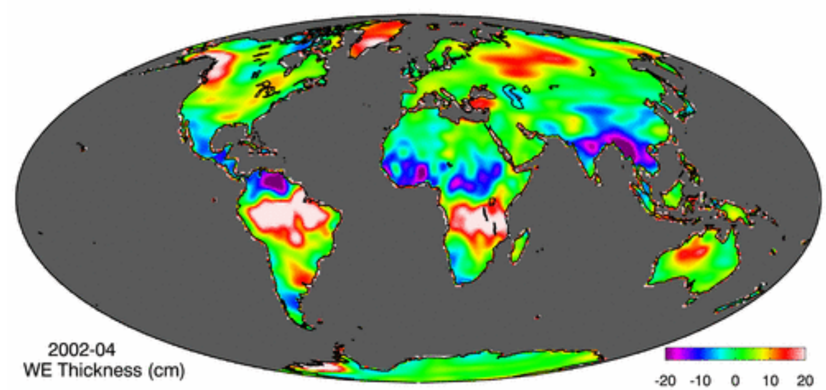
Land Cover from Terra/MODIS:

Spatial resolution: 1 km²

(From: http://gislab.jhsph.edu/)

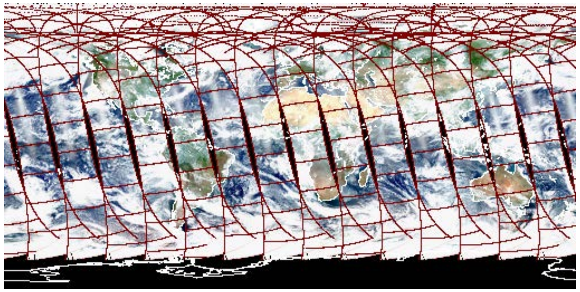


Terrestrial Water Storage Variations from GRACE: Spatial resolution: 150,000 km² or coarser (Courtesy: Matt Rodell, NASA-GSFC)

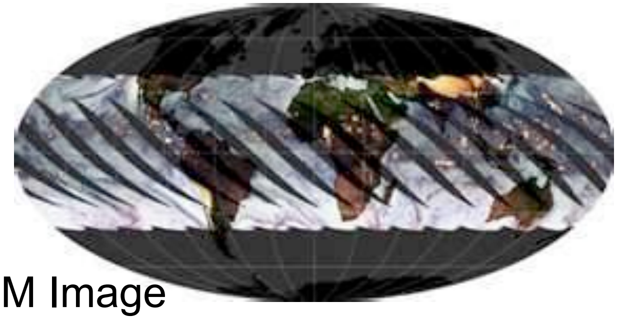


Spatial Coverage and Temporal Resolution

- **Polar orbiting satellites:**
  - Global coverage
  - Temporal resolution: 1 to ≥16 days depending on swath size
  - Orbital gaps often present.
- **Non-Polar orbiting satellites:**
  - Non-global coverage.
  - Temporal resolution: < 1 day – monthly depending on swath size
  - Orbital gaps present.
- **Geostationary satellites:**
  - Non global coverage (more than one satellite needed for global coverage
  - Multiple observations per day



Aqua ("ascending" orbit) day time

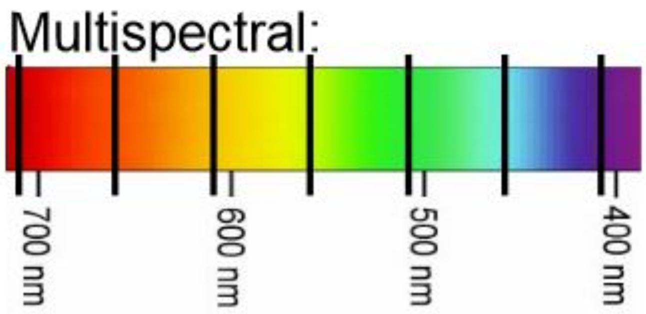


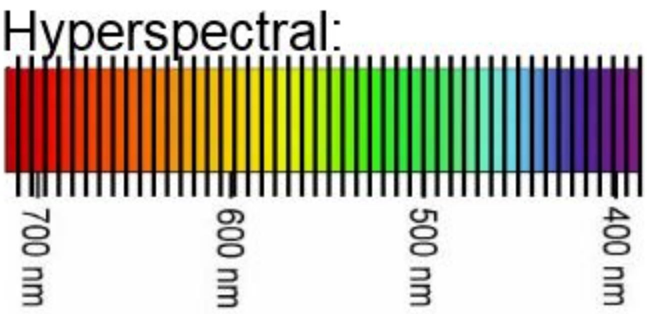
TRMM Image

GOES Image

Spectral Resolution

- **Spectral Resolution:** The number and width of spectral channels. More and finer spectral channels enable remote sensing of different parts of the Earth's surface





Example: Landsat (7-11bands)

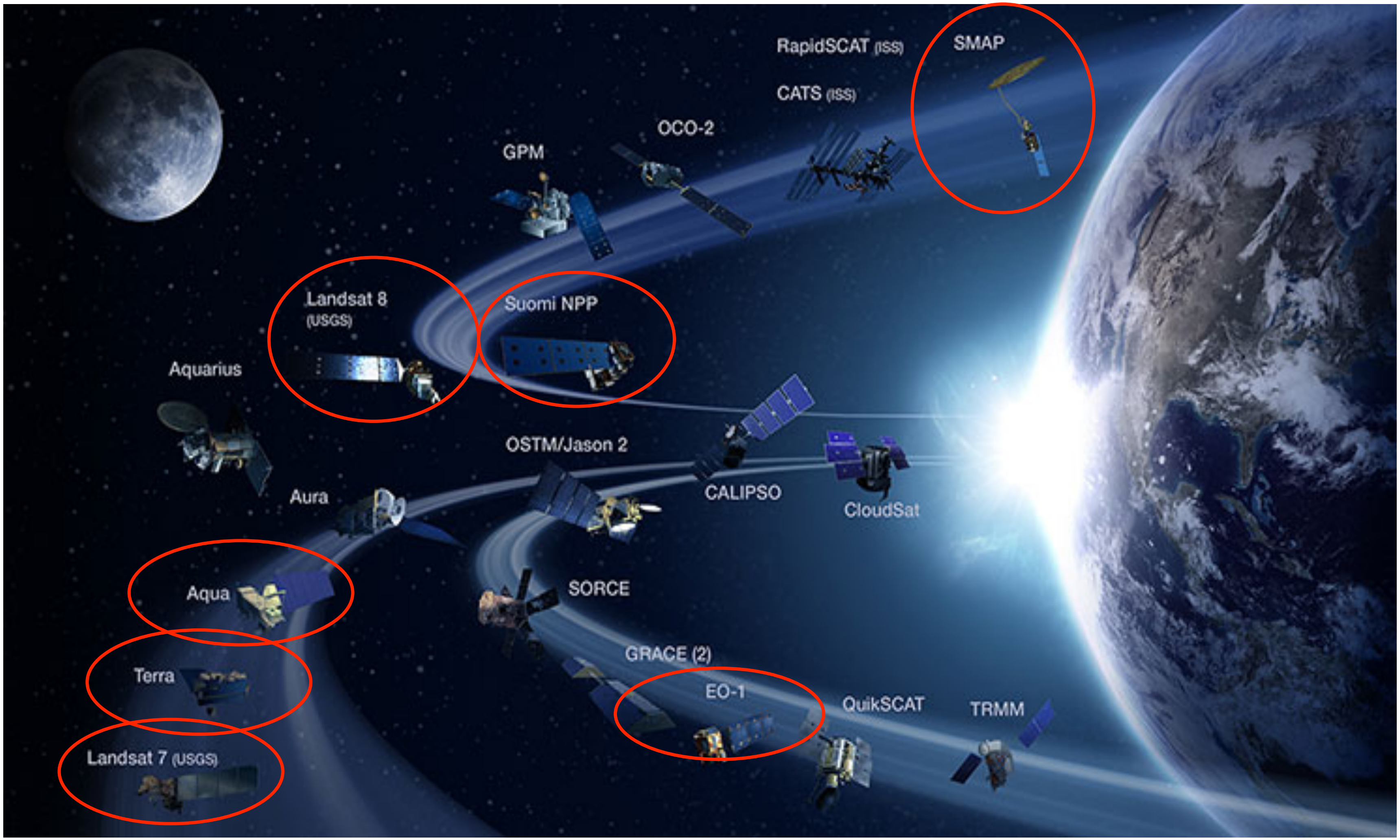
Example: AVIRIS (256 bands)

Remote Sensing Observations: Trade-Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal resolution at the same time
- Several sensors can obtain global coverage every one – two days because of their wide swath width
- Higher spatial resolution polar/non-polar orbiting satellites may take 8 – 16 days to attain global coverage
- Geostationary satellites obtain much more frequent observations but at lower resolution due to the much greater orbital distance
- Large amount of data with varying formats
- Data applications may require additional processing, visualization and other tools

NASA Satellites and Sensors for Conservation Management

NASA Satellites for Conservation Management



NASA Satellites for Conservation Management

Satellite	Sensor(s)	Dates	Spatial Resolution
Landsat 1-3	MSS	1972 - 1983	80 meter
Landsat 4 and 5	Landsat TM	1982 - 2013	30 m (120 m thermal band)
Landsat 7	Landsat ETM+	1999 - present	15 m panchromatic, 30 m multispectral, 60 m thermal
Landsat 8 (LDCM)	Operational Land Imager (OLI), Thermal Infrared Sensor (TIRS)	2013 - present	15m panchromatic; 30m multispectral; 100m thermal
Terra, Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS)	2000 - present	250 – 5600 meter
Terra	ASTER	2000 - present	15-90 meter
EO-1	Hyperion, Advanced Land Imager (ALI)	2000 - present	10-30 meter
Suomi NPP	Visible Infrared Imager Radiometer Suite (VIIRS)	2013 - present	375-750 meter
SMAP	Soil Moisture Active Passive	2015 - present	3 km

Products Derived from NASA Satellites for Conservation Management

- **Land cover maps**
  - Many different sources: regional, national and global
  - Single snapshot in time
  - Land cover classification varies
- **Vegetation Indices (NDVI, EVI, SAVI, etc.)**
  - Many different sources at different spatial resolutions
  - Can get time series
- **Other (Fire perimeters, burn severity)**
  - A few sources at different spatial resolutions
- **Change Detection**
  - New methods are using the freely available Landsat time series to get annual (or monthly) change

Coming up next week!

Week 2: Satellite platforms and sensors for conservation applications

Important Information

- One lecture per week – every Tuesday May 5 to June 2
  - 12:00 – 1:00 PM EDT (Session 1)
  - 10:00 – 11:00 PM EDT (Session 2)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET Conservation Management webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

Landsat 5 Image showing deforestation due to conversion to cropland and pasture.

Image Credit: USGS Earthshots, 2001.

Thank You!!

Cindy Schmidt

Cynthia.L.Schmidt@nasa.gov