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

INTRODUCTION TO REMOTE SENSING DATA FOR LAND MANAGEMENT

COURSE DATES: EVERY MONDAY, NOVEMBER 3- DECEMBER 1
TIME: 12PM-1PM EDT

Applied Remote Sensing Training

Important Information

Presentations URL:

http://arset.gsfc.nasa.gov/webinar

Contact for requesting recorded link for the webinars:

Marines Martins: marines.martins@ssaihq.com

Outline

- About ARSET
- ARSET Course Structure and Objectives
- Global Land Management Issues
- Overview of NASA Remote Sensing Data for Land Resources Management

NASA Earth Science
Applied Sciences Program

Applications to Decision Making: 4 Focus Areas

Health and Air Quality

Disaster Management

Ecological Forecasting

Water Resources

Applied Remote SEnsing Training Program (ARSET)

Online and hands-on courses:

- **Who**: policy makers, environmental managers, modelers and other professionals in the public and private sectors.
- **Where**: U.S and internationally
- **When**: throughout the year. Check websites.
- **Do NOT require prior remote-sensing background.**
- Presentations and hands-on guided computer exercises on how to access, interpret and use NASA satellite images for decision-support.

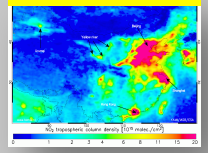
NASA Training for California Air Resources Board, Sacramento

ARSET Training Topics

Health (Air Quality)

- Analysis of dust, fires, & urban air pollution
- Satellite and regional air quality model comparisons
- Support for air quality forecasting and exceptional event analysis

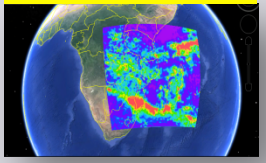
Nitrogen Dioxide over China



Water Resources & Flood

- Flood/drought monitoring
- Severe weather and precipitation
- Watershed mgmt
- Snow/ice monitoring
- Evapotranspiration, ground water, soil moisture, runoff

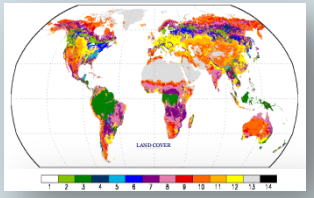
Satellite derived precipitation



Land Use/Change and Ecology

- Land cover and change
- Vegetation amount and health
- Fire products

Land Cover



Who Can Benefit from ARSET Courses?

- **Public Sector:** Local, state, federal, international regulatory agencies; project managers; health and disaster management agencies; World Bank; United Nations
- **Private Sector:** Tribal nations, NGOs, consultants, industry, and other organizations involved in capacity building
- **Scientists/Technical Experts:** Ecologists, geologists, modelers, biologists, etc..

ARSET Land Resource Management

http://arset.gsfc.nasa.gov/eco/webinars/

Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Lindsey Harriman - Land Processes DAAC (week 3)

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

Course Structure

Course Objectives

- Provide overview of land management issues
- Introduce web-tools for data access, analysis and imaging
- Show examples of data applications
- Prerequisite for advanced ARSET trainings

Webinar Course Structure

- One lecture per week – every Monday from 3 November to 1 December (12-1 PM EDT)
- Webinar presentations can be found at: http://arset.gsfc.nasa.gov/eco/webinars/land-management
- Two assignments (after Week 2 and Week 4)
- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

More Important Information

Certificate of Completion (upon request):
You must attend all 5 live sessions
You must submit 2 homework assignments

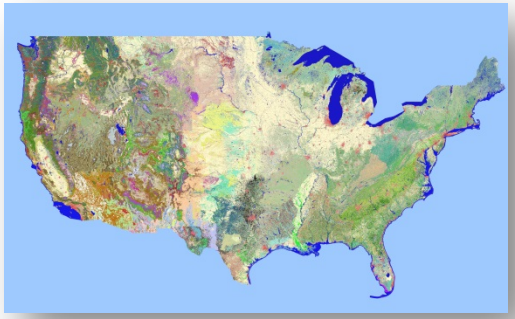
For Webinar Recording Link:
Contact: Marines Martins
Email: marines.martins@ssaiha.com

Course Outline

Week 1

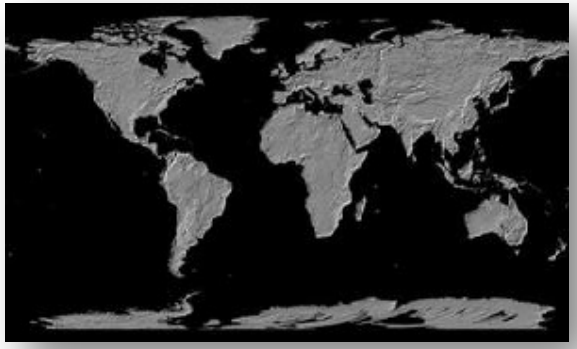
Intro. & Background: Satellite Remote Sensing

Week 2



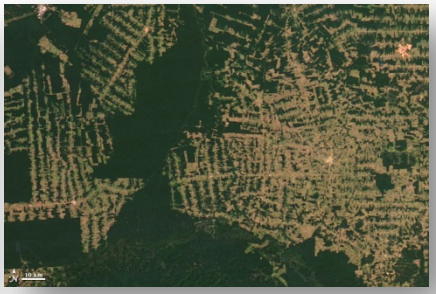
Land Cover Mapping/ Web tools for data access

Week 3



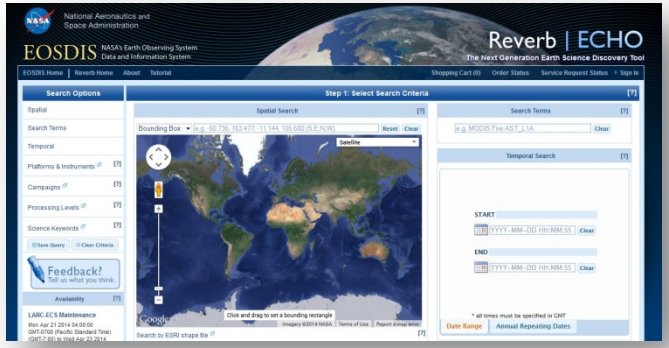
Terrain

Week 4



Change Detection

Week 5



Web tools for data access/ Integration with GIS

Week 1 Agenda

- Global land resources and land management issues
- NASA Earth science research questions and monitoring ecosystem change
- Advantages and disadvantages of remote sensing
- Fundamentals of remote sensing
- NASA satellites and sensors for land management

Global Land Resources

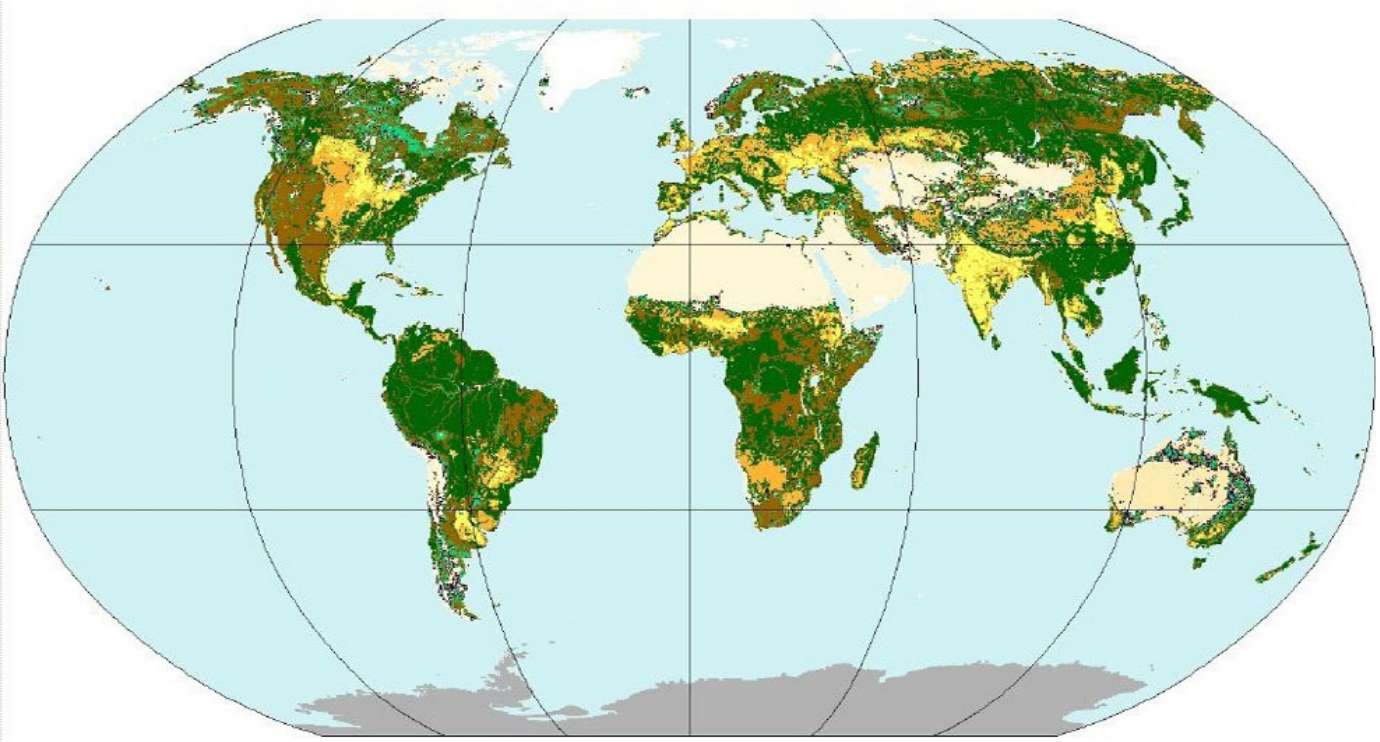


Figure 3 – Distribution of dominant GLC-SHARE Land Cover Database.

01 Artificial Surfaces	04 Tree Covered Area	07 Mangroves	10 Snow and Glaciers + Antarctica
02 Cropland	05 Shrubs Covered Area	08 Sparse Vegetation	11 Water bobies
03 Grassland	06 Herbaceous Vegetation	09 Baresoil	Antartica

Land Cover	%
Tree cover	27.7
Bare soils	15.2
Grasslands	13
Croplands	12.6
Snow and glaciers	9.7
Shrub-covered	9.5
Sparse vegetation	7.7
Inland water bodies	2.6
Herbaceous vegetation	1.3
Artificial surfaces	0.6
Mangroves	0.1

Source: FAO Global Land Cover SHARE database
http://www.glcn.org/databases/lc_glcshare_en.jsp:

Global Land Resources: Critical Issues

- Food production
  - Growing populations
  - Less natural resources
  - Changing climate

Source: www.icid.org

- Plant and animal species
  - Habitat loss
  - Declining biodiversity
  - Changing climate

Source: polarbearsinternational.org

Source: naturemappingfoundation.org

Land Management Issues

- Treeline/ecotone changes
- Invasive species
- Desertification
- Deforestation
- Urban growth
- Crop management
- Wildfire
- Loss of biodiversity
- Habitat loss

Source: nps.gov

Yellow star thistle

Source: NASA Earth Observatory

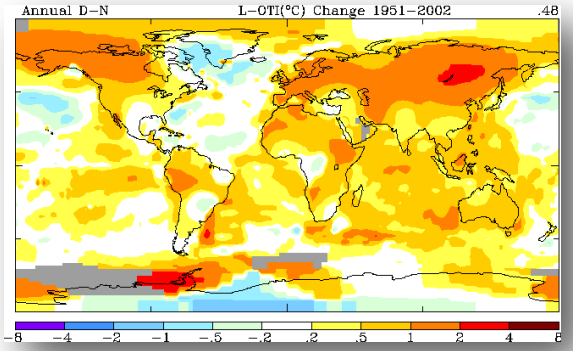
MODIS images of Rondonia in western Brazil.

NASA's Earth Science Research Questions

- How is the global Earth system changing?
- What are the primary causes of change in the Earth System?
- How does the Earth system respond to natural and human-induced changes?
- What are the consequences of changes in the Earth system for human civilization?
- How well can we predict future changes to the Earth system?

Monitoring Ecosystem Change

- NASA Earth science questions with respect to ecosystems:
  - How are global ecosystems changing?
  - How do ecosystems respond to and affect global environmental change and the carbon cycle?

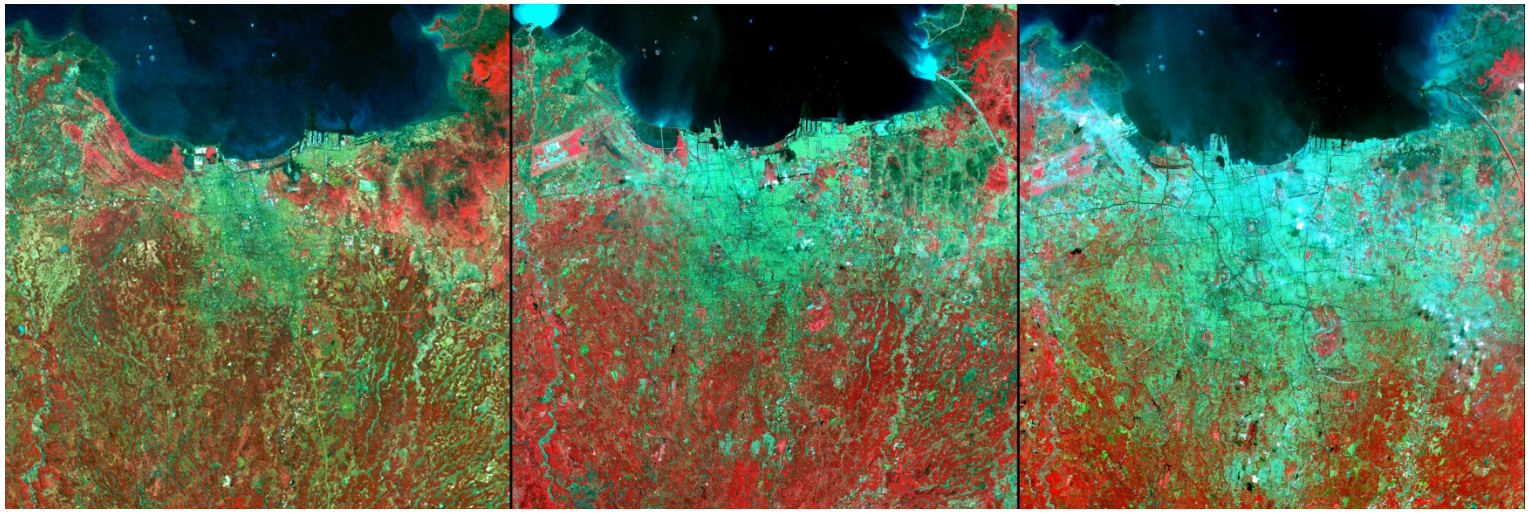


- Climate change:
  - Although climate change is a global phenomenon….
  - The effects of climate change on ecosystems are local and heterogeneous

Monitoring Ecosystem Change with Satellite Imagery

- Identify land cover
- Monitor change over time

While land cover can be observed on the ground or by airplane, the most efficient way to map it is from space.



Source: NASA Earth Observatory

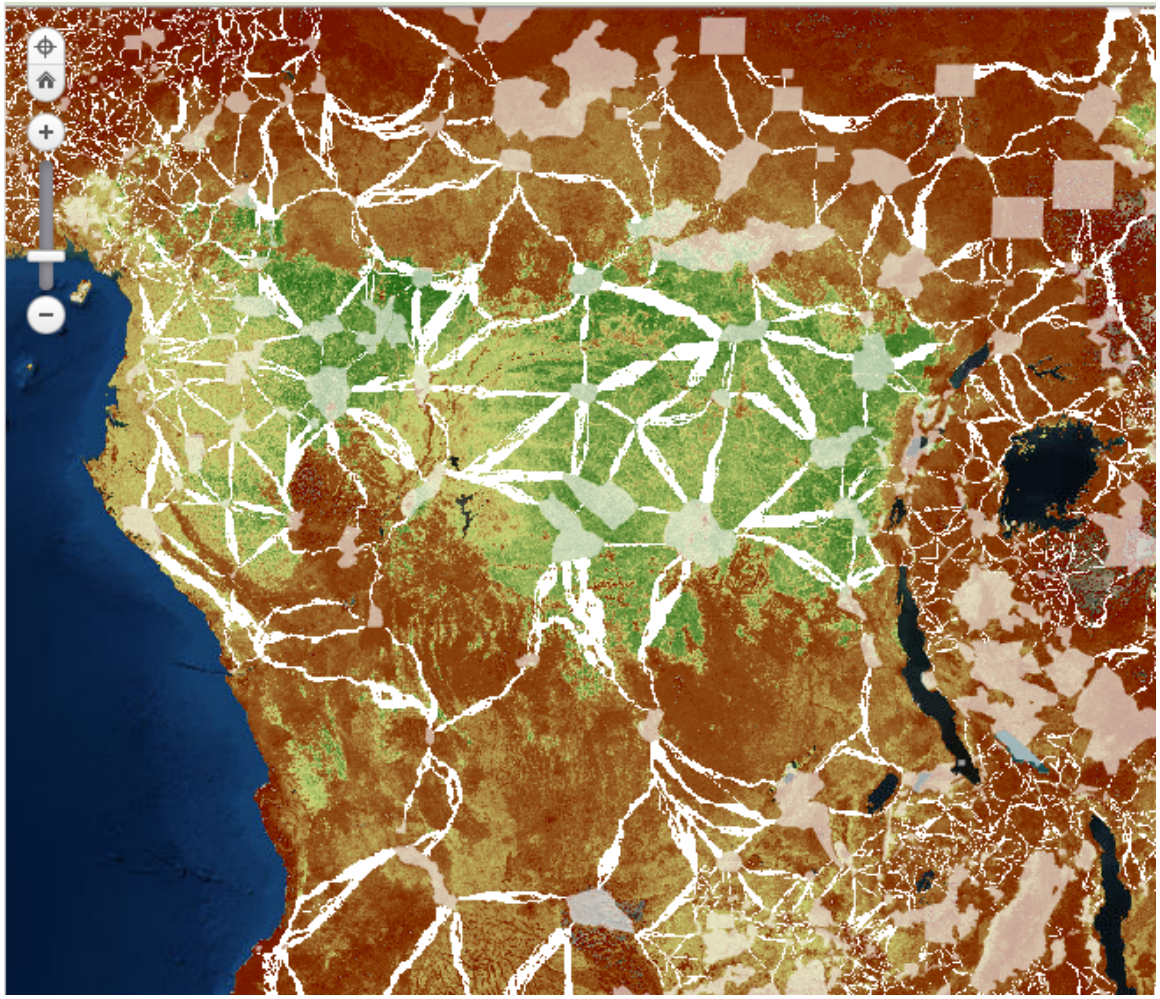
Urban growth from 1976, 1989 to 2004 in Jakarta, Indonesia

Example: Use of Satellite Imagery for Biodiverstiy and Carbon Assessment

Corridors optimizing pathways between tropical protected areas via high vegetation carbon stock areas are mapped in this image. This may help avoid deforestation in these areas.

For more information:

http://whrc.org/mapping/pantropical/habitatcorridors/index.html

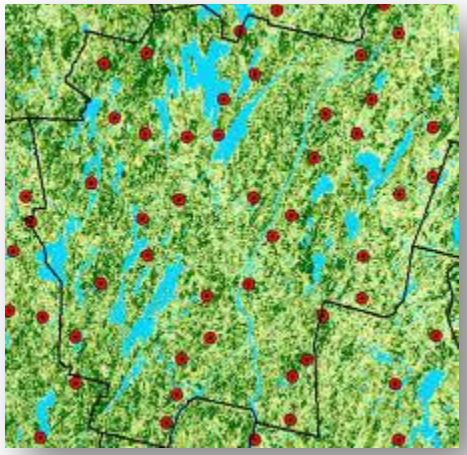


Jantz, P., et al. , (2014) Nature Climate Change

Advantages and Disadvantages of Remote Sensing Observations

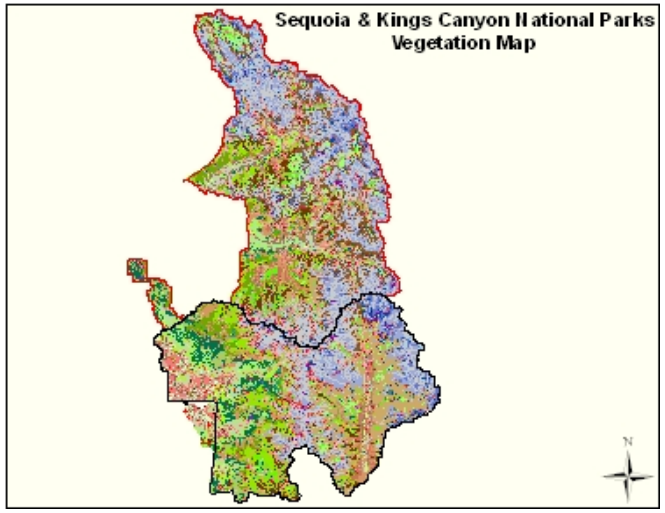
Plot-based Measurements

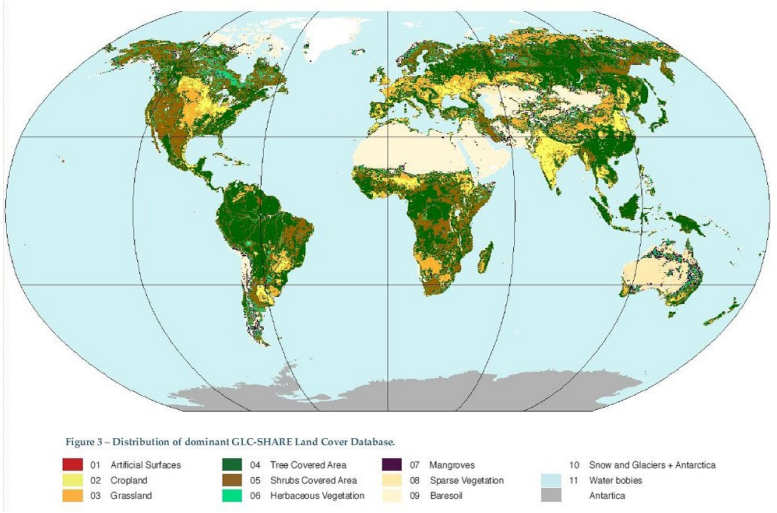
- Example: US Forest Service Forest Inventory Analysis (FIA)
  - Very detailed information for each plot
  - Non-uniform spatial and temporal coverage
  - Cannot get exact locations of plots



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

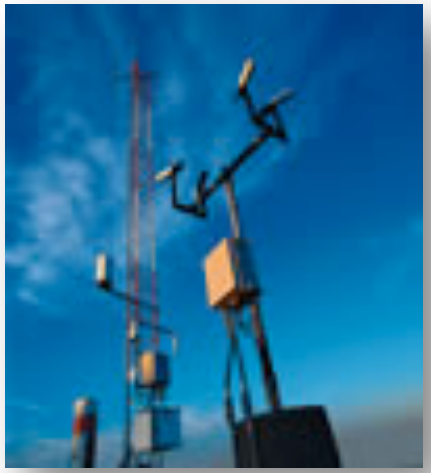




Fundamentals of Remote Sensing

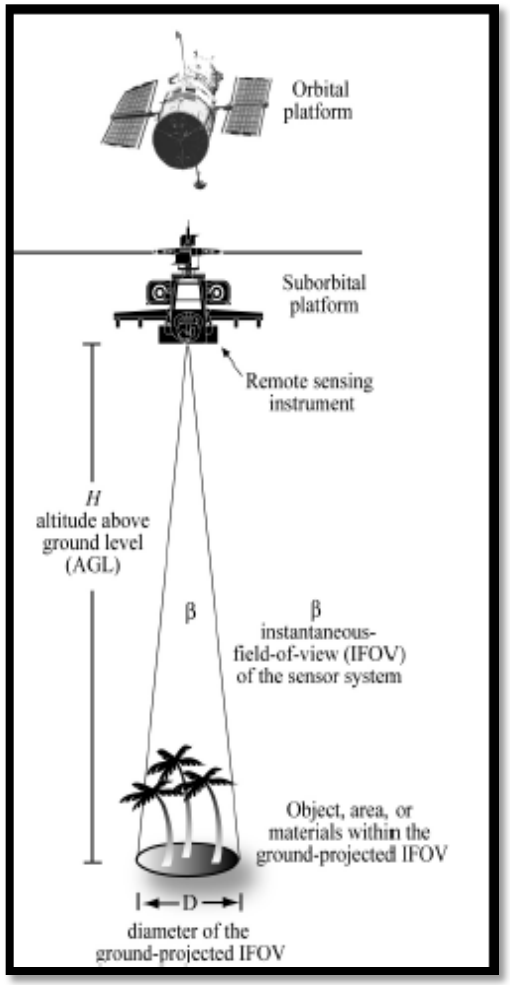
What is Remote Sensing?

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

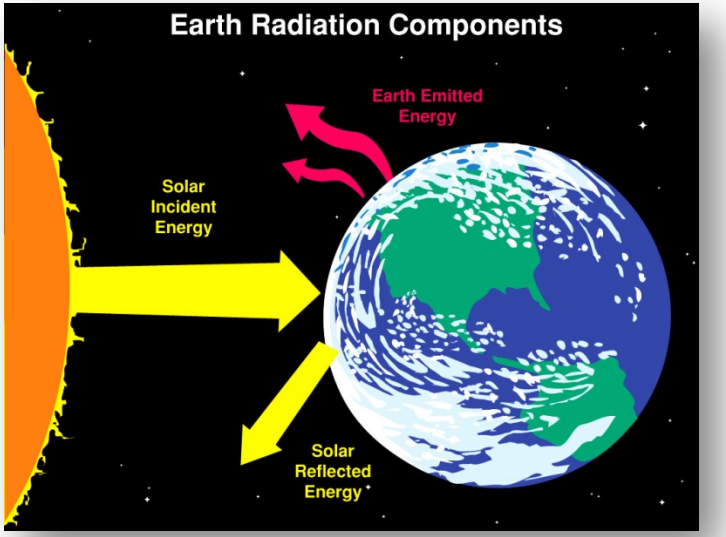


- Platform depends on application
- What information? how much detail?
- How frequent?

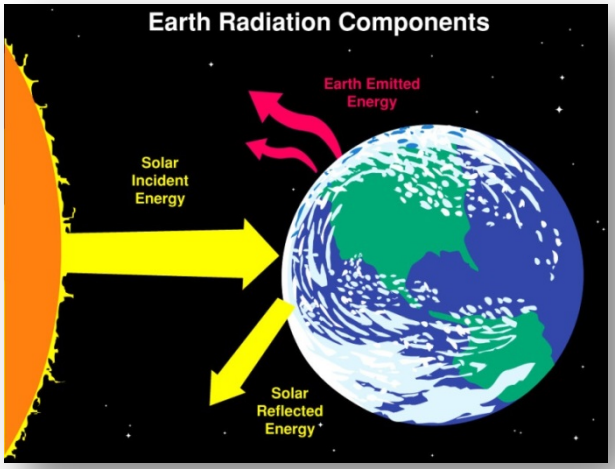
Measuring properties of the Earth-Atmosphere system from space



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



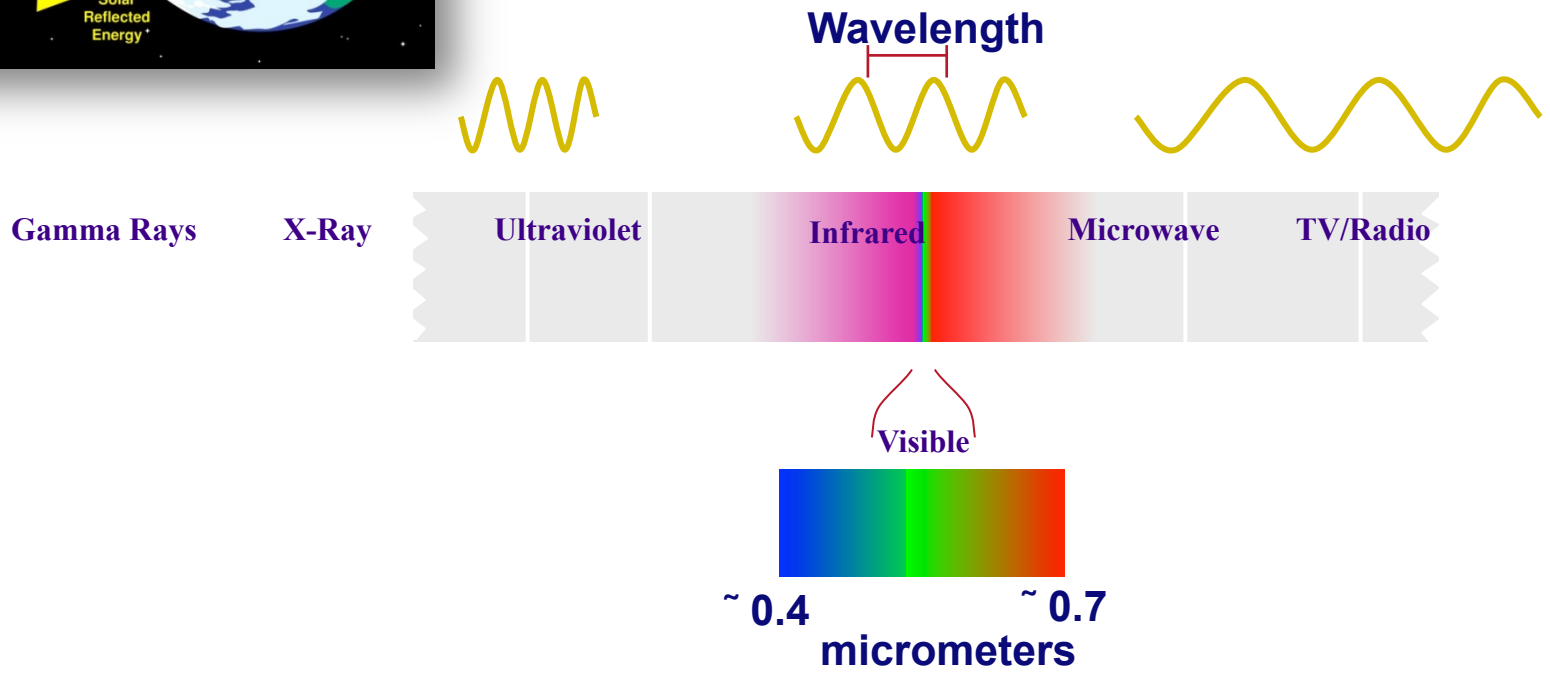
Electromagnetic Radiation



Earth-Ocean-Land-Atmosphere System :

- reflects solar radiation back to space
- emits Infrared radiation and Microwave radiation to space

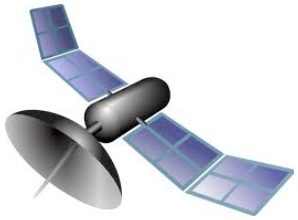
Electromagnetic Spectrum

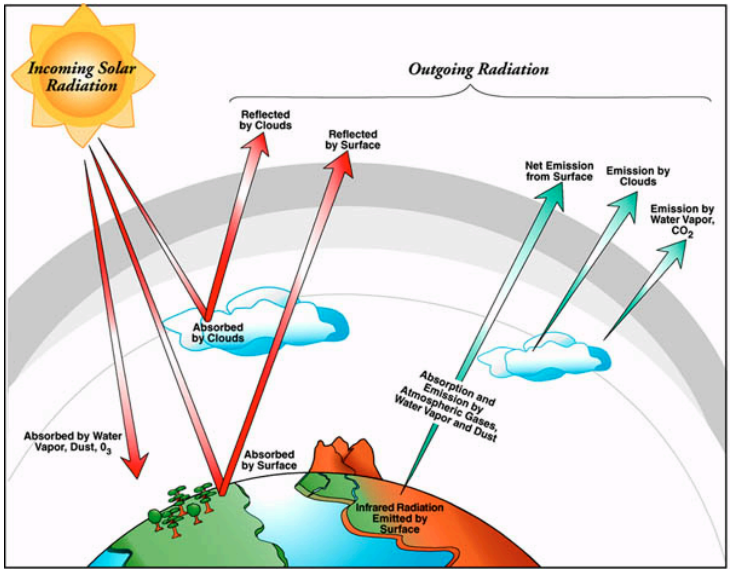


Measuring Properties of Earth-Atmosphere System from Space

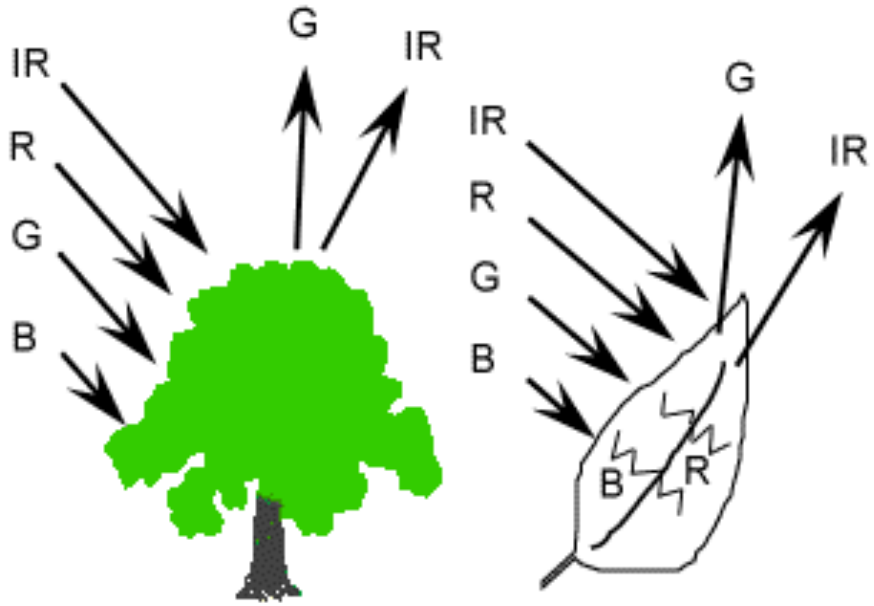
- The intensity of reflected and emitted radiation to space is influenced by the surface and atmospheric conditions

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





Electromagnetic Energy: Example

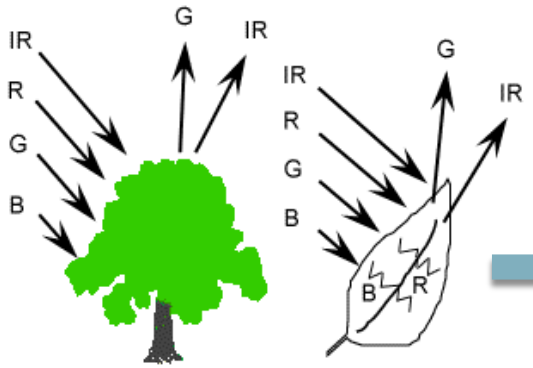


Example: Healthy, green vegetation absorbs Blue and Red wavelengths and reflects Green and Infrared

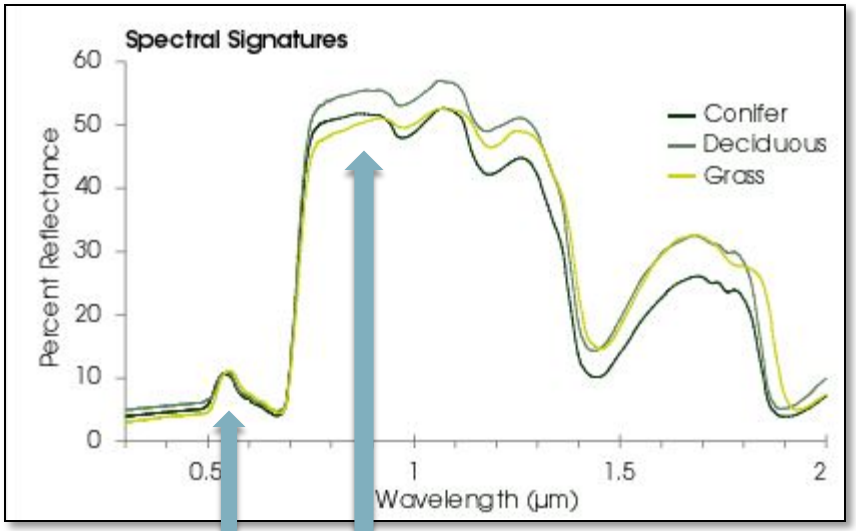
That's why we see healthy vegetation as green

Spectral Signatures

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



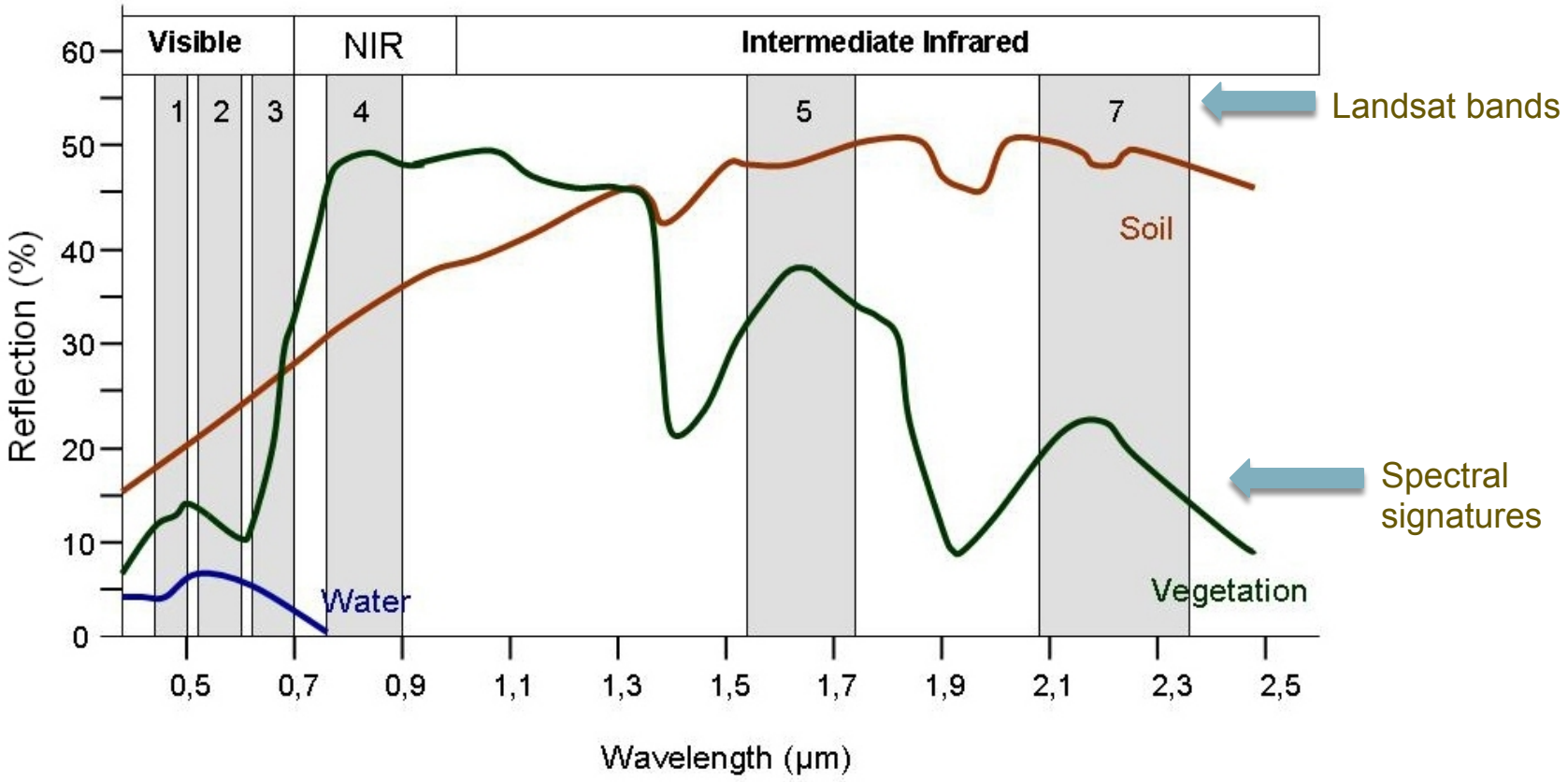
Spectral Signature



Green Near-Infrared (IR)

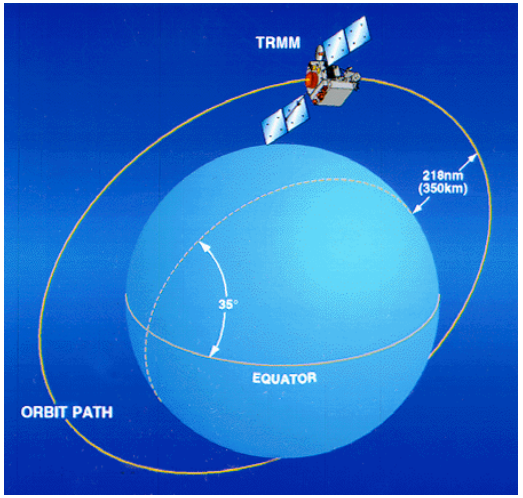
Now to include the imagery….

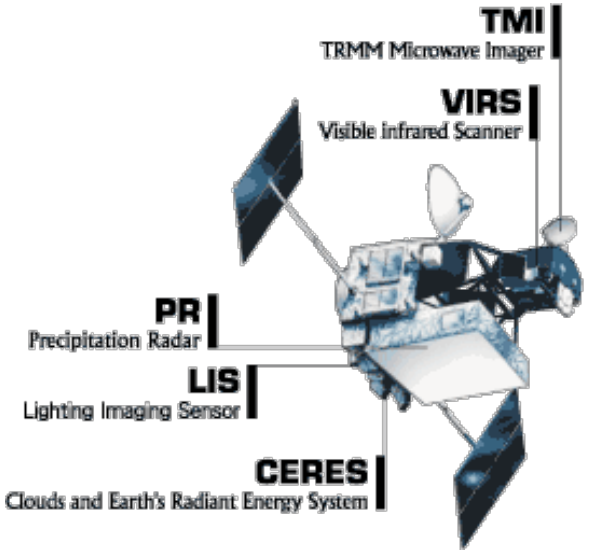
Remotely sensed imagery acquires information in different wavelengths, representing different parts of the Electromagnetic Spectrum



What we need to know about Satellite Remote Sensing Observations

1. Instruments/sensors and types of measurements
2. Types of satellite orbits around the earth
3. Spatial and Temporal Resolution and Spatial Coverage
4. Geophysical quantities derived from the measurements
5. Quality and accuracy of the retrieved quantities





Satellite Sensors

Type of Sensors

Spectral Resolution

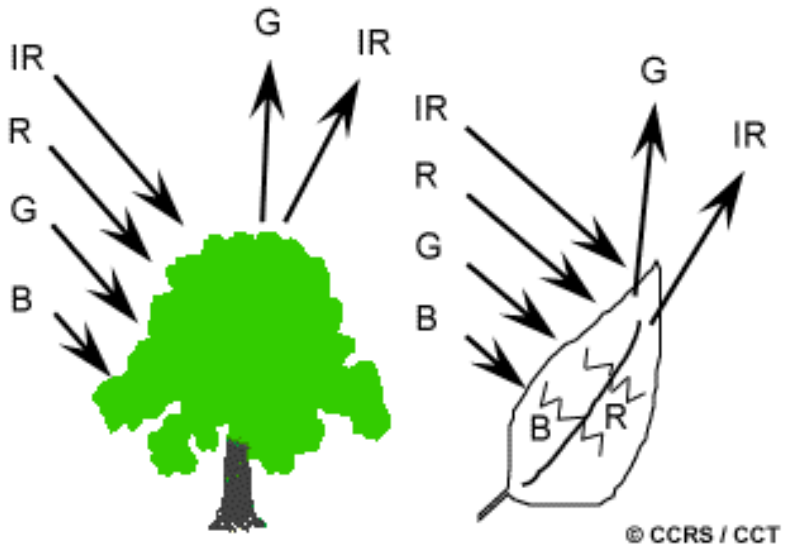
Radiometric Resolution

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

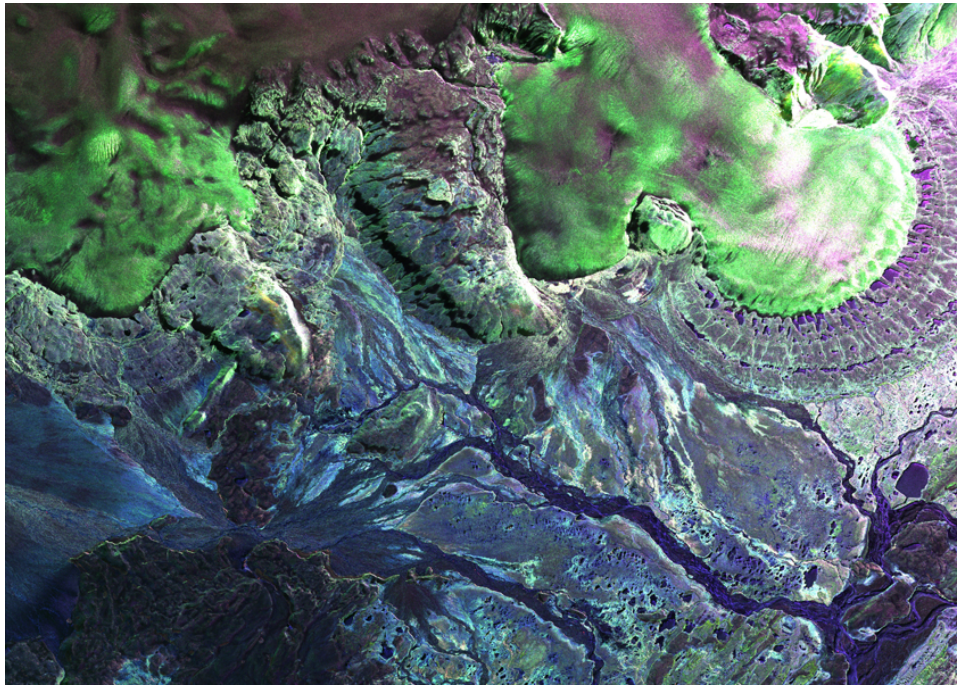


Image courtesy of uavsar.jpl.nasa.gov

UAV SAR image of a glacier in Hofsjokull, Iceland (June 12,2009). The blue areas are bare ground surfaces and the green areas are ice.

Spatial and Temporal Resolution of Satellite Measurements

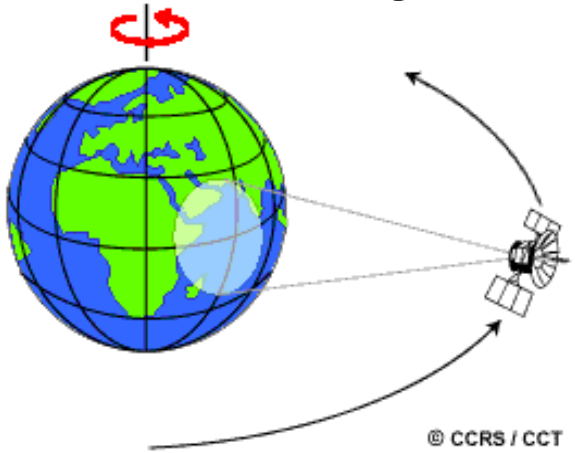
- Depends on the satellite orbit configuration and sensor design

- 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

Types of Satellite Orbits

Geostationary orbit

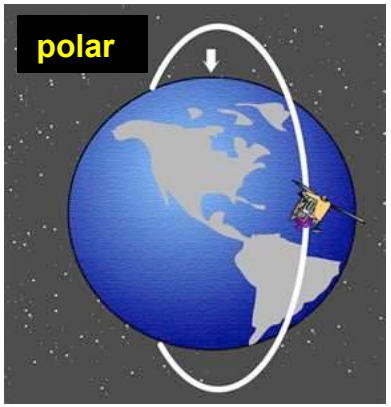


Satellite is at ~36,000 km above earth at equator. Same rotation period as earth's. Appears 'fixed' in space.

- 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

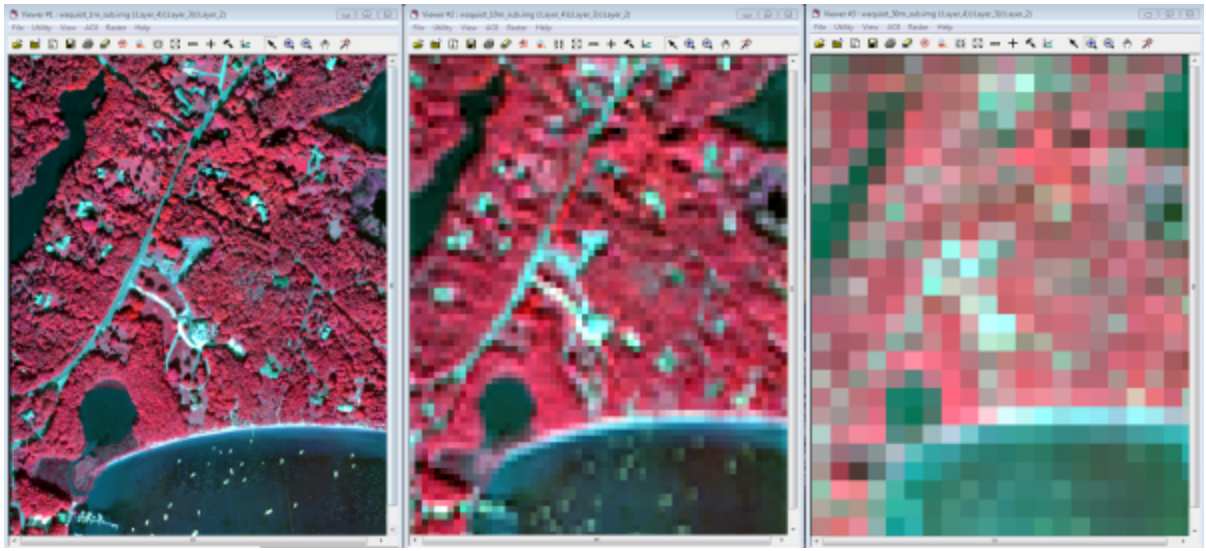
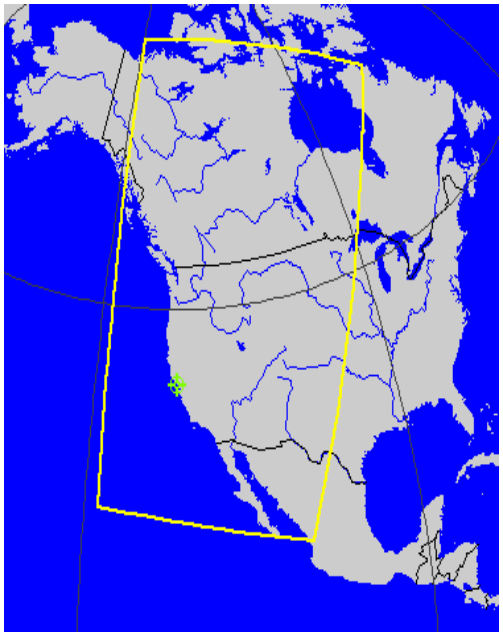


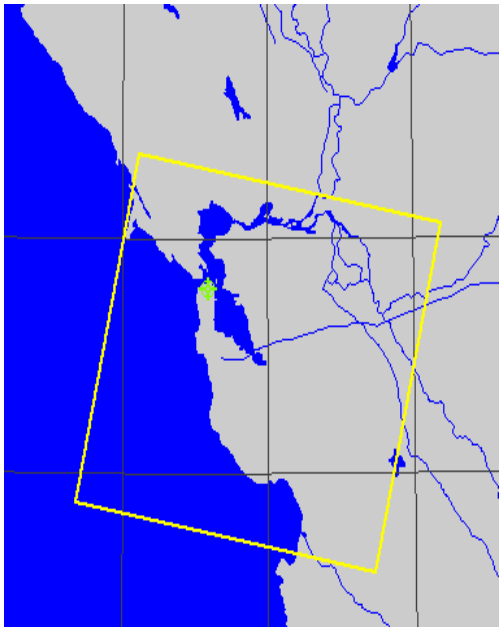
Image courtesy of www.csc.noaa.gov

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

Spatial Extent



MODIS (1 km)



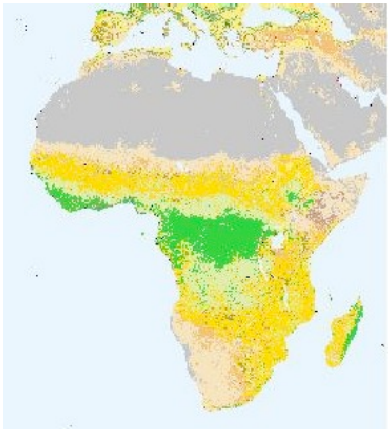
Landsat (30 m)

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

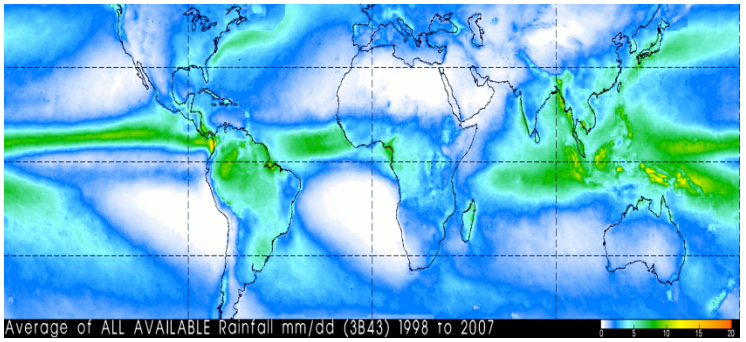
NASA Satellite Measurements with Different Spatial Resolution

Landsat Image of Philadelphia
Spatial resolution: 30 m

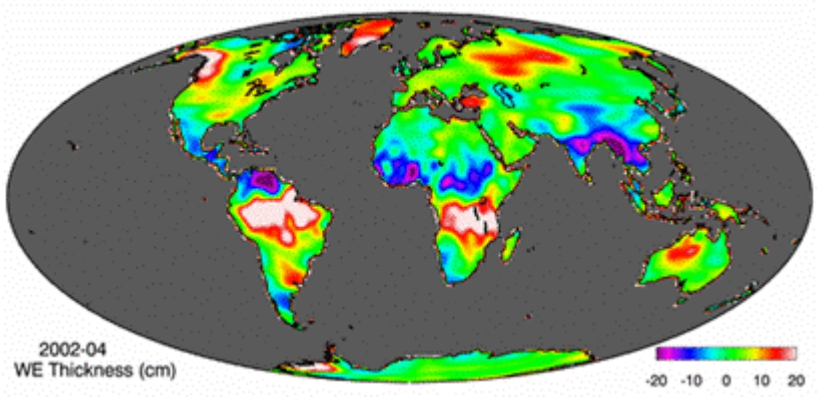
Land Cover from Terra/MODIS:
Spatial resolution: 1 km^2
(From: http://gislab.jhsph.edu/)



Rain Rate from TRMM
Spatial resolution: 25 km^2

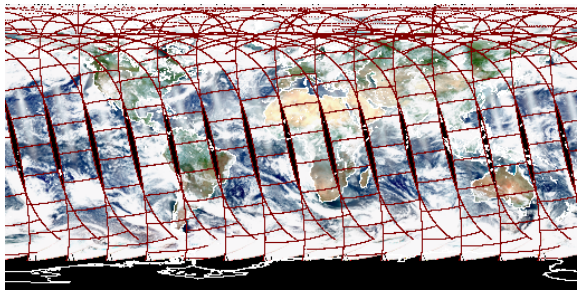


Terrestrial Water Storage Variations from GRACE: Spatial resolution: 150,000 km^2 or coarser
(Courtesy: Matt Rodell, NASA-GSFC)



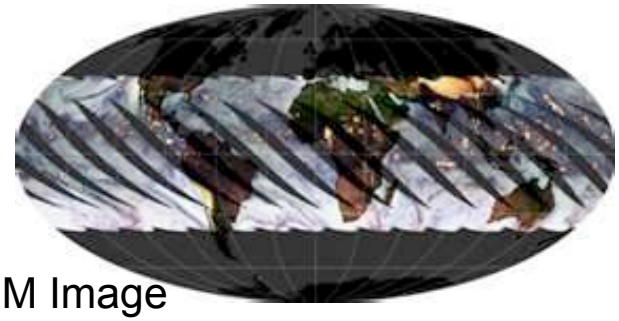
Spatial Coverage and Temporal Resolution

Polar orbiting satellites: global coverage - but one to two or less measurements per day per sensor. Orbital gaps present. Larger Swath size, higher the temporal resolution.



Aqua (“ascending” orbit) day time

Non-Polar orbiting satellites: Less than one per day. Non-global coverage. Orbital gaps present. Larger Swath size, higher the temporal resolution.



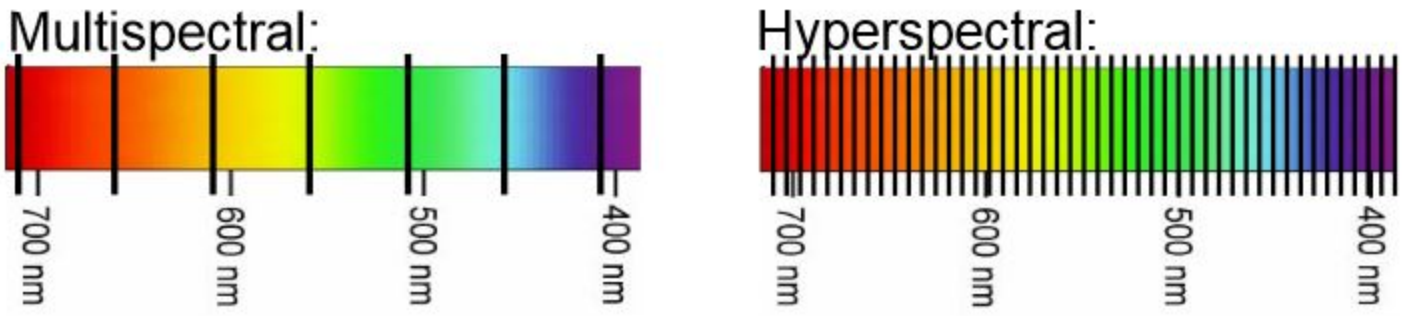
TRMM Image

Geostationary satellites: multiple observations per day, but limited spatial coverage, more than one satellite needed for global coverage.

GOES Image

Spectral and Radiometric Resolution

Spectral Resolution: The number and width of spectral channels. More and finer spectral channels enable remote sensing of different parts of the atmosphere



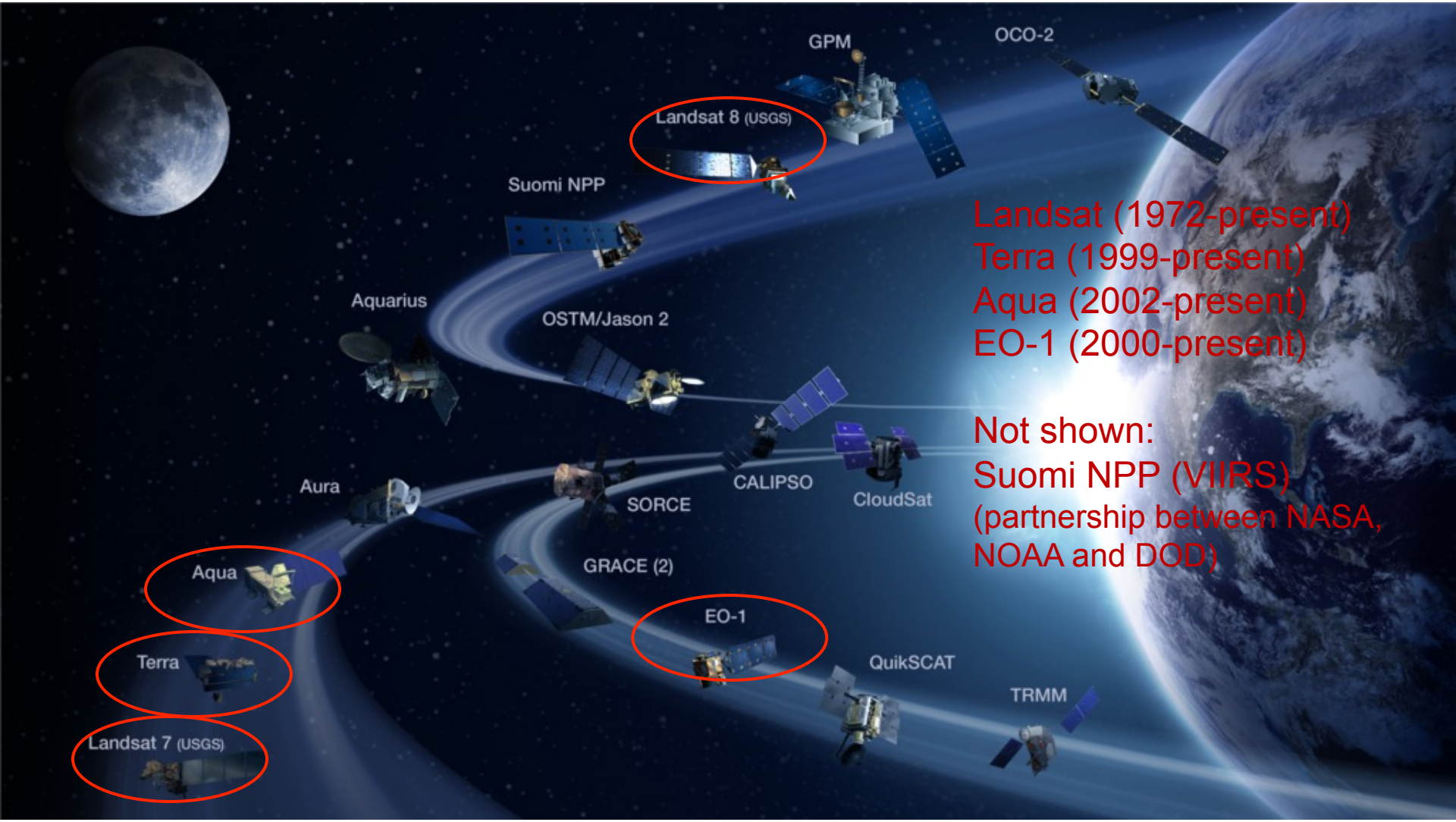
Radiometric Resolution: Remote sensing measurements represented as a series of digital numbers – the larger this number, the higher the radiometric resolution, and the sharper the imagery.

Remote Sensing Observations : Trade Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric 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 Land Management

NASA Satellites for Land Management



NASA Satellite Instruments for Land Resources 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

Products Derived from NASA Satellites for Land Resource 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: Overview of Land Cover Mapping

Thank You!

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