National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Water Resource Management Using NASA Earth Science Data

Course Objective

- Provide information about availability and access to global freshwater data from NASA remote sensing observations and land-atmosphere models

- Facilitate applications and decision support activities in planning
  - water allocation
  - flood and drought management
  - agricultural management
  - reservoir/dam management

Outline

- About ARSET
- Fundamentals of Remote Sensing
- Remote Sensing Data Levels and Formats
- Advantages and Limitations of Remote Sensing

Applied Remote Sensing Training Program (ARSET)

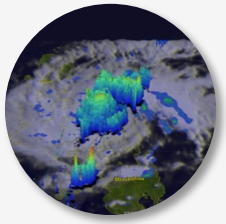
Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov

Provide online and on-site trainings tailored to:

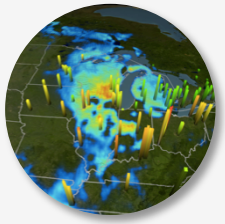
- policy makers
- regulatory agencies
- applied environmental professionals

to increase the use of NASA Earth Science models & data for environmental applications:

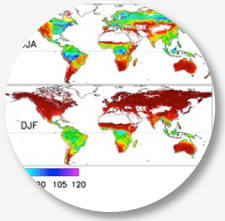


Disasters

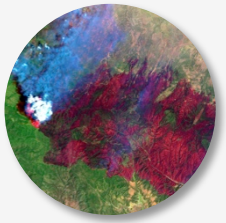
Ecoforecasting



Health & Air Quality



Water Resources



Wildfires

ARSET Team

Water Resources

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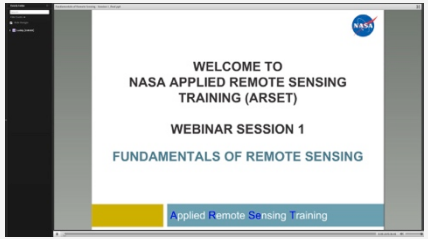
Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov

Training activities for environmental professionals to increase usage of NASA observational and modeling data for decision-making support.



Online Webinars

- 1 hr a week, 4-6 weeks
- Live & recorded
- Include demos on data access

In-person Workshops

- Held in a computer lab for 2 - 4 days
- Focus on data access
- Locally relevant case studies

Train the Trainers

- Courses & training manuals for those interested in doing their own remote sensing trainings

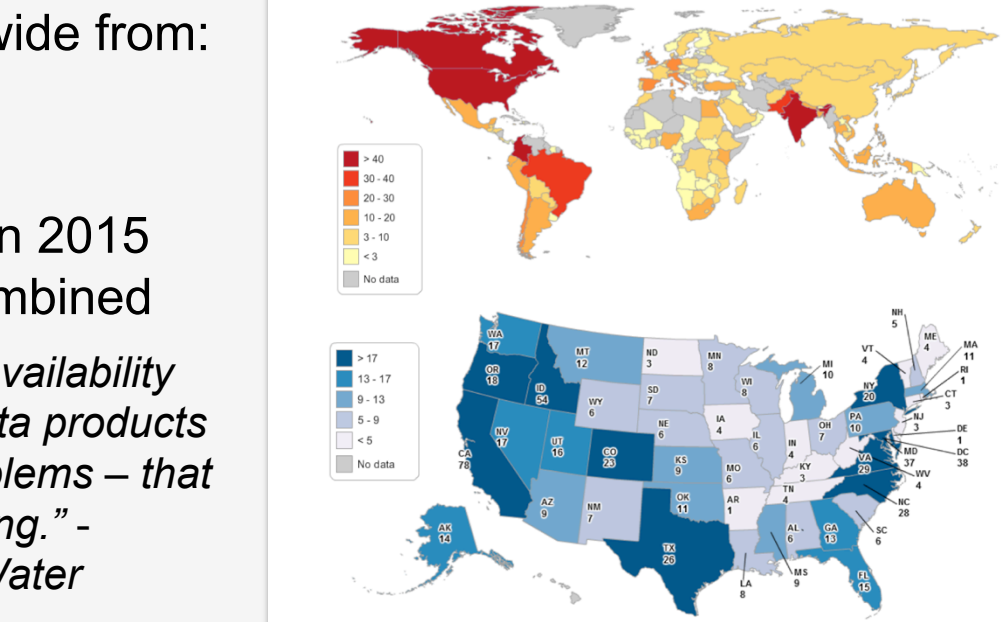
ARSET Trainings

Impact & Accomplishments

- 68 Trainings Completed
- 4,900+ participants worldwide from:
  - 1,600+ organizations
  - 130+ countries
- More participants trained in 2015 than all previous years combined

"The biggest benefit of training is availability and access of various data and data products for understanding and solving problems – that was not possible without this training." - Training Participant, *Nepal 2015 Water Resources Management webinar*

Number of Participating Organizations by Country & U.S. States (2008-2015)



ARSET Trainings

A gradual learning approach

Basic Trainings

- Webinars & Workshops
- Assumes no prior RS knowledge

Examples: Fundamentals of Remote Sensing; Introduction to Remote Sensing

Advanced Trainings

- Webinars & Workshops
- Requires basic training
- Focuses on specific applications

Example: Creating and Using NDVI from Satellite Imagery

ARSET Listserv

For information on upcoming courses and program updates, please sign up to the listserv

https://lists.nasa.gov/mailman/listinfo/arset

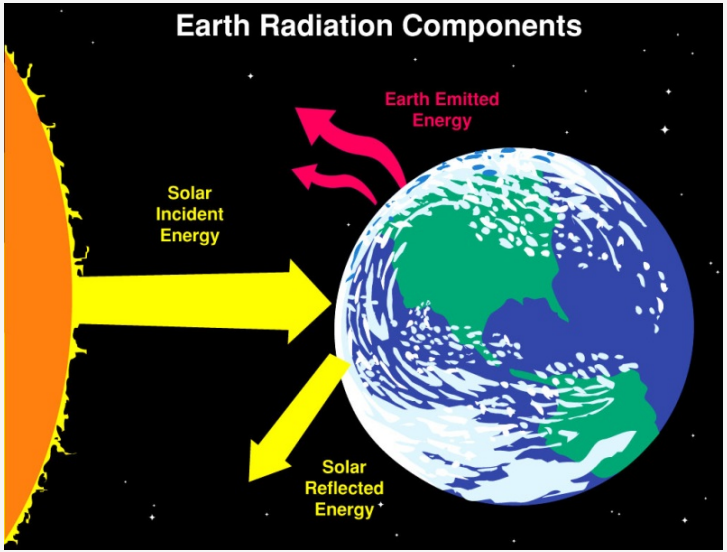
Fundamentals of Remote Sensing

What is Remote Sensing?

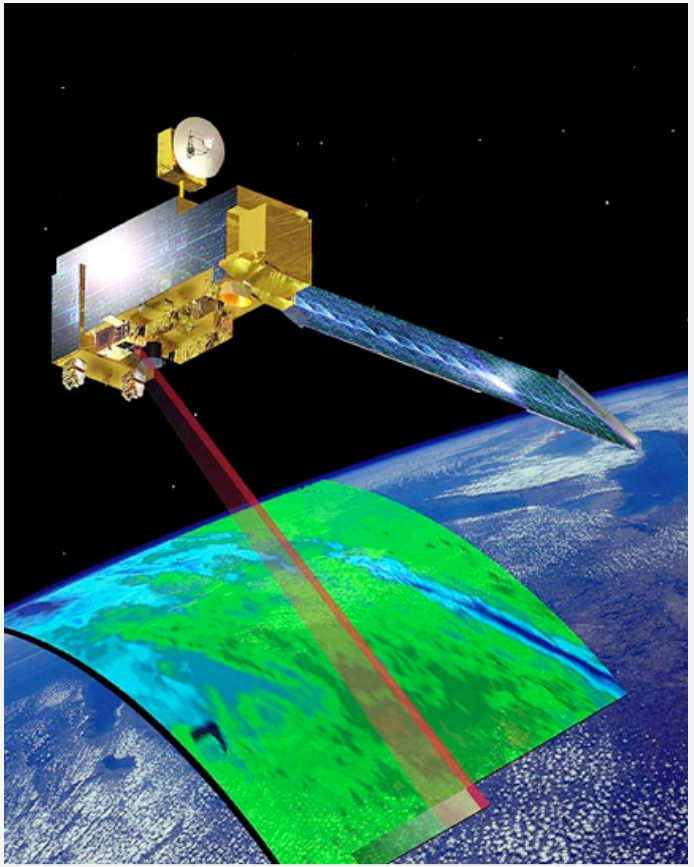
- Measurement of a quantity associated with an object by a device not in direct contact
- The most useful platform depends on the application
- What information? How much detail?
- How frequent?

Satellite Remote Sensing

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



mynasadata.larc.nasa.gov

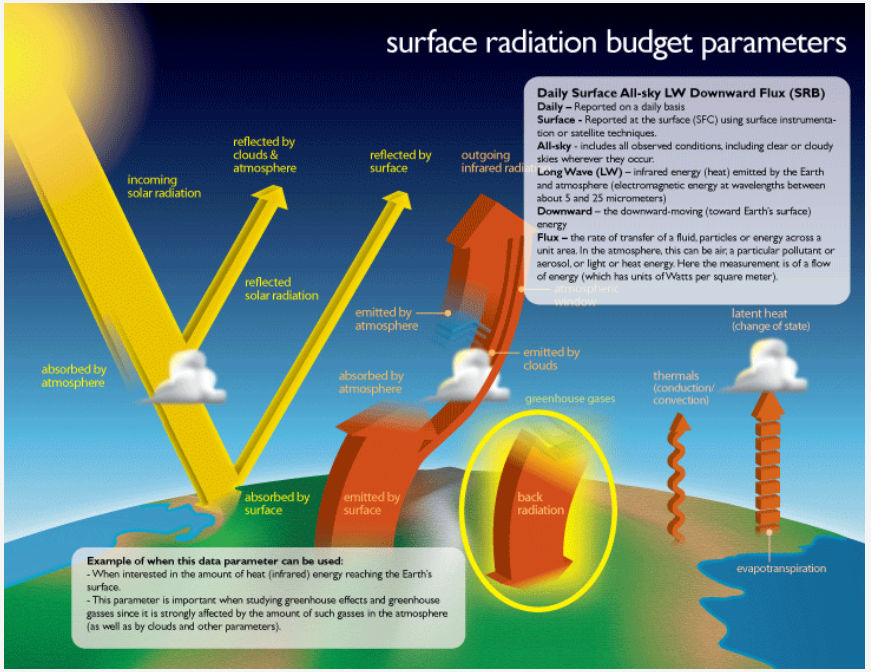


podacc.jpl.nasa.gov/terra

Measuring Properties of the Earth-Atmosphere System from Space

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

- Satellite measurements contain information about both the surface and atmospheric conditions



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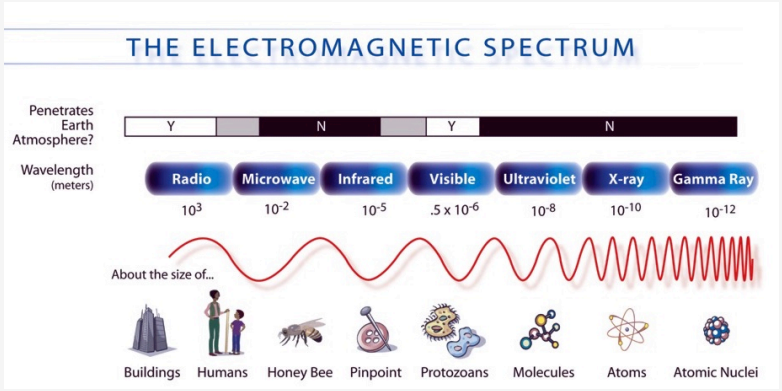
Electromagnetic Spectrum

- Earth-Ocean-Land-Atmosphere System:
  - Reflects solar radiation back to space
  - Emits infrared and microwave radiation to space



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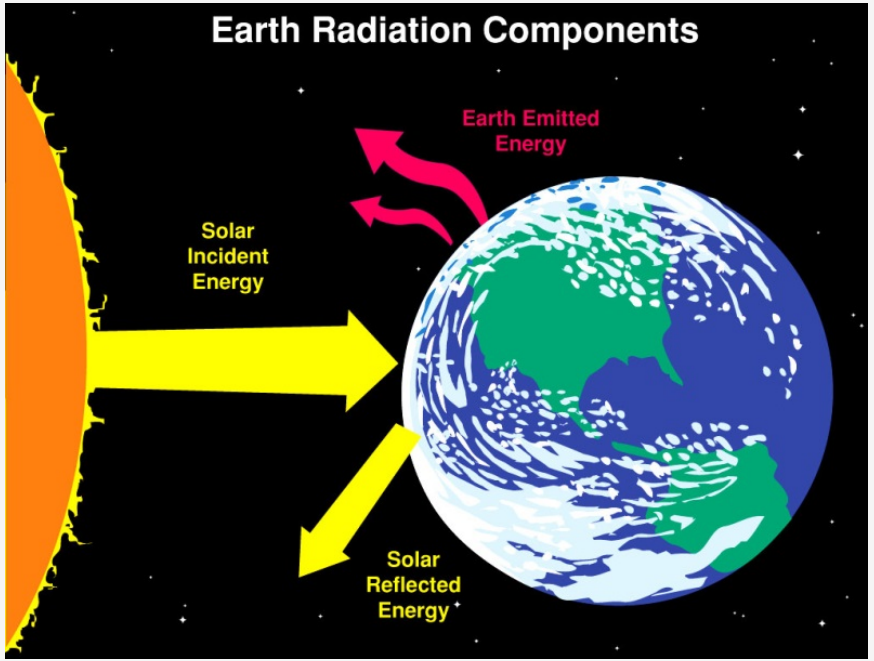

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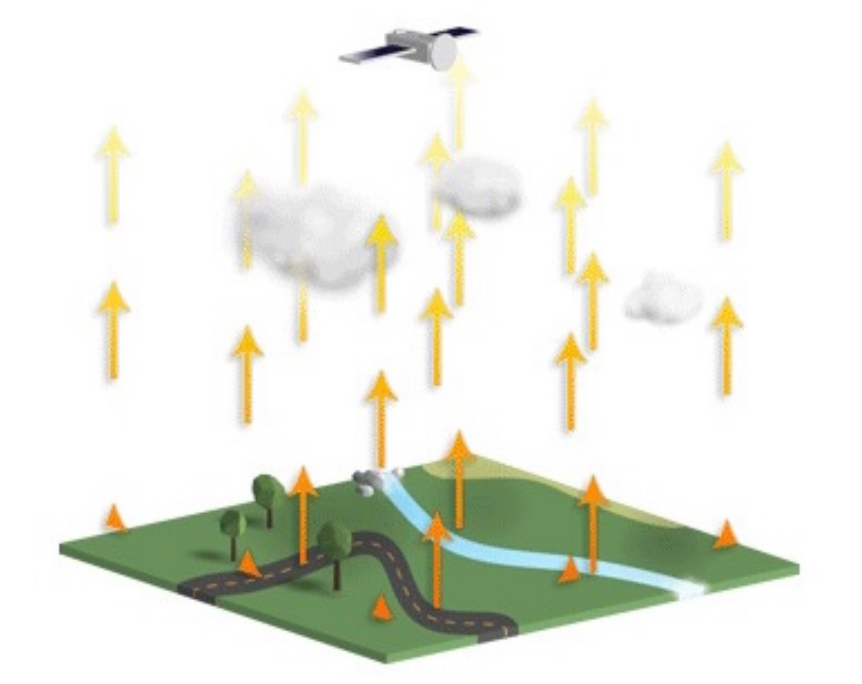
Satellite Sensors

Passive

- Passive remote sensors measure radiant energy reflected or emitted by the Earth-atmosphere system
- Radiant energy is converted to **bio-geophysical quantitates** such as:
  - temperature
  - precipitation
  - soil moisture
  - chlorophyll-a
- Examples:
  - Landsat Operational Land Imager, MODIS, TRMM Microwave Imager

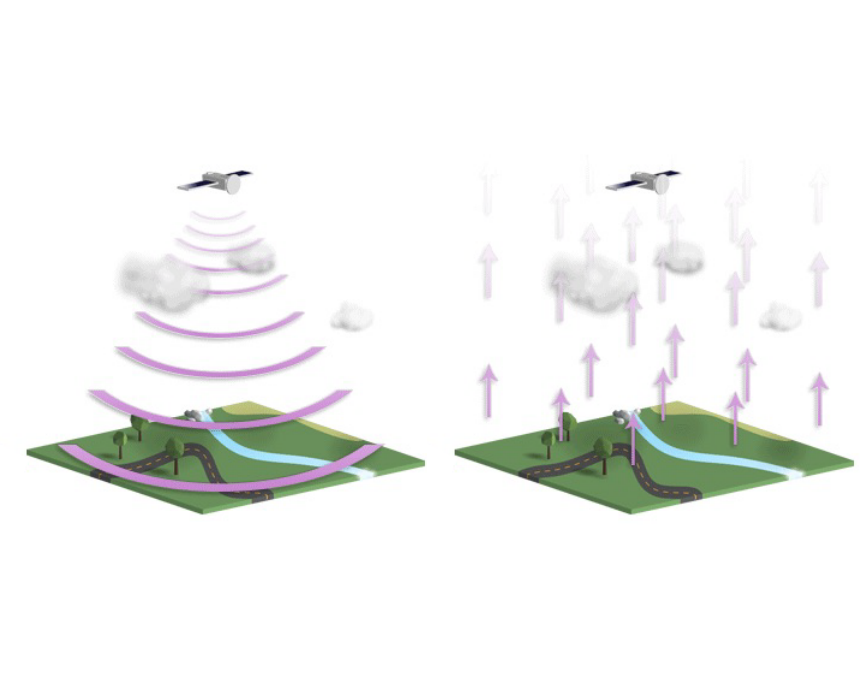


earthobservatory.nasa.gov

Satellite Sensors

Active

- Emit beams of radiation and measures ‘back-scattered’ radiation
  - The back-scattered radiation is converted to geophysical quantities
- Challenging to process
- Some available only from aircraft
- Examples:
  - Radar, LIDAR



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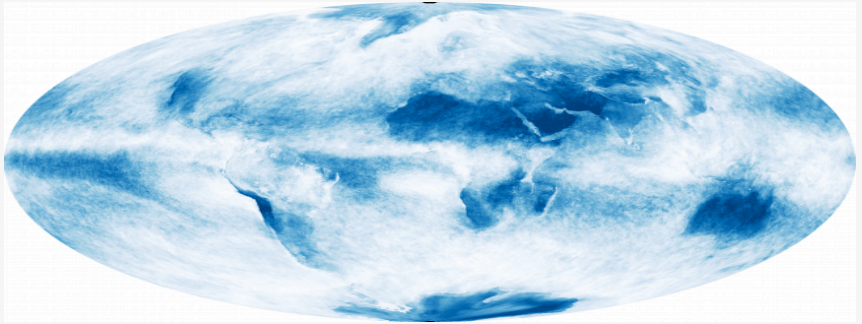
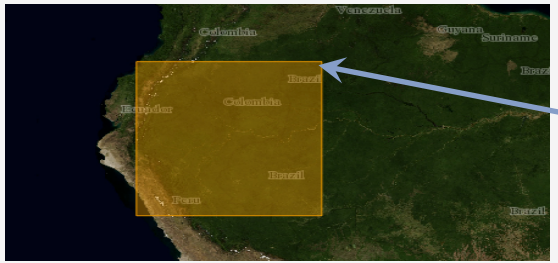
Satellite Sensors

Imagers & Sounders

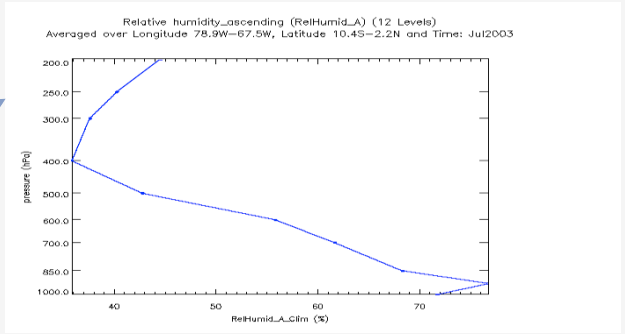
- Imagers:
  - Create images
  - Examples: MODIS, TMI
- Sounders
  - Provide vertical profiles
  - Examples: AIRS



Cloud images from MODIS



Regional Relative Humidity Profile from AIRS



Spatial & Temporal Resolution

- Depends on the satellite orbit configuration and sensor design

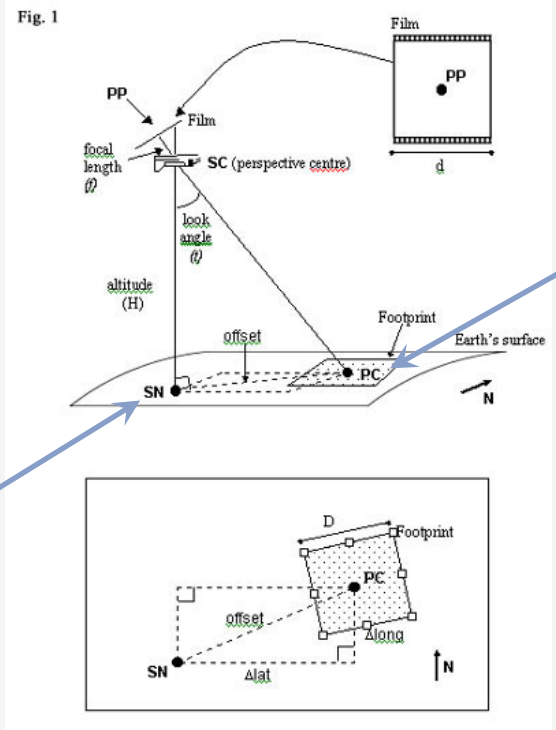
- Spatial Resolution
  – Decided by its pixel size
  – A pixel is the smallest unit measured by a sensor

- Temporal Resolution
  – How frequently a satellite observes the same area of the Earth

  Note: this is different from the *time span or life-time of a satellite for which measurements are available*

Spatial Resolution

- Simple definition: pixel size – smallest size – that satellite images cover
- Satellite images are organized into rows and columns called raster imagery
- Each pixel has a certain spatial size



Off-nadir pixel size

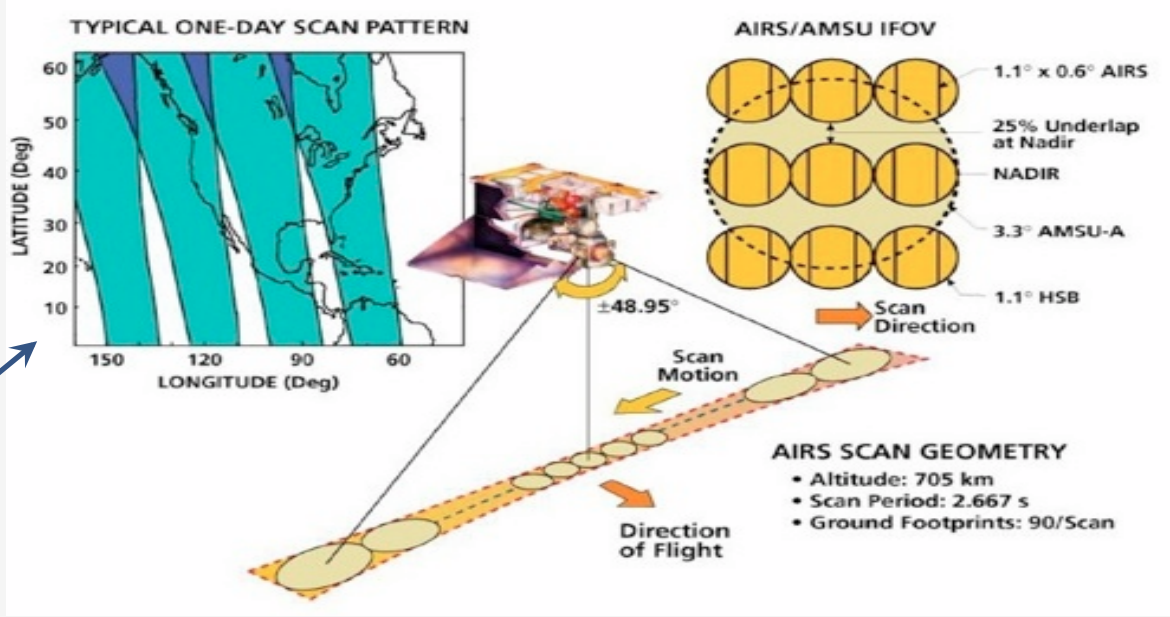
Nadir pixel size

Image Credit: J.A. Robinson; http://eol.jsc.nasa.gov/FAQ/

Spatial Resolution

Example: Atmospheric Infrared Sounder (AIRS), NASA Aqua

Instantaneous Field of View



Swath

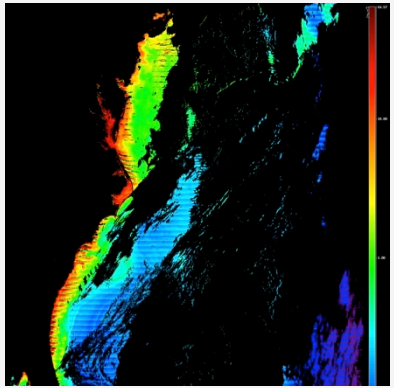
http://disc.sci.gsfc.nasa.gov/AIRS/documentation/airs_instrument_guide.shtml

NASA Satellite Measurements

Different Spatial Resolutions

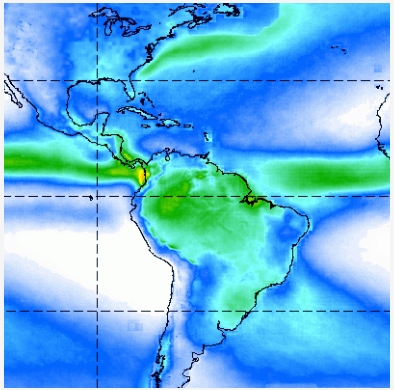
visibleearth.nasa.gov

Landsat 8 OLI
30m resolution



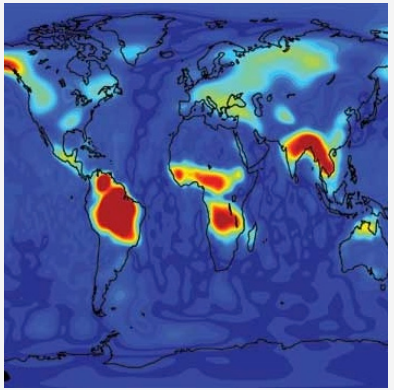
oceancolor.gsfc.nasa.gov

Terra MODIS
1km^2 resolution



pmm.nasa.gov

TRMM
25km^2 resolution

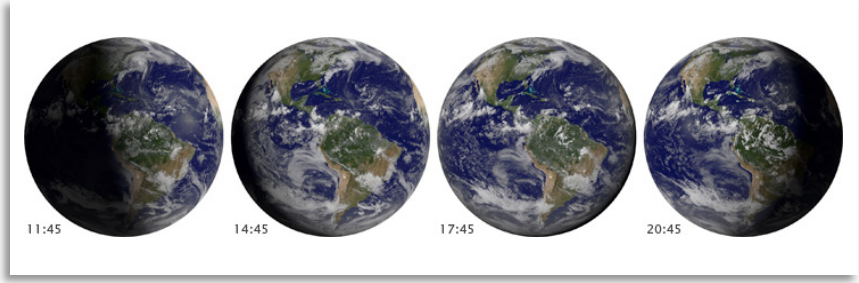


grace.jpl.nasa.gov

GRACE
150,000 km^2
resolution or coarser

Satellite Orbits

Two Primary Types: Geostationary and Low Earth Orbit



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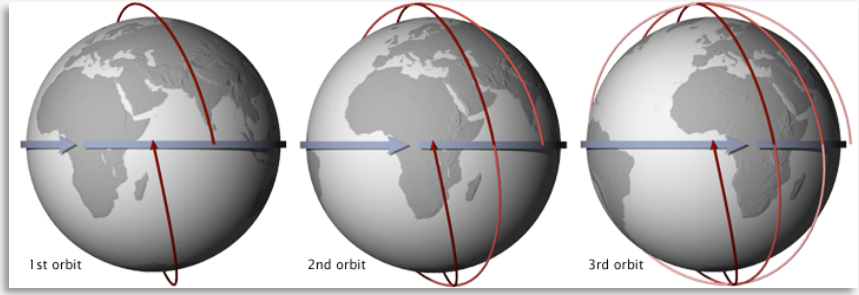
Spatial Coverage: the Geographical area covered by a satellite

Geostationary Orbit

- Satellite is ~36,000 km over the equator with same rotation period as the Earth's
  - Frequent measurements
  - Limited spatial coverage
- Examples:
  - Weather or Communications Satellites

Satellite Orbits

Two Primary Types: Geostationary and Low Earth Orbit



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Low Earth Orbit (LEO)

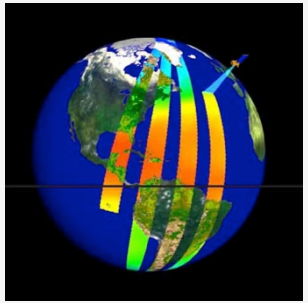
- Circular orbit constantly moving relative to the Earth at 160-2,000 km - can be in polar or non-polar orbit
  - Less frequent measurements
  - Large (global) spatial coverage
- Examples (polar):
  - Landsat or Terra

Satellite Orbits

Spatial Coverage and Temporal Resolution

Polar Orbiting

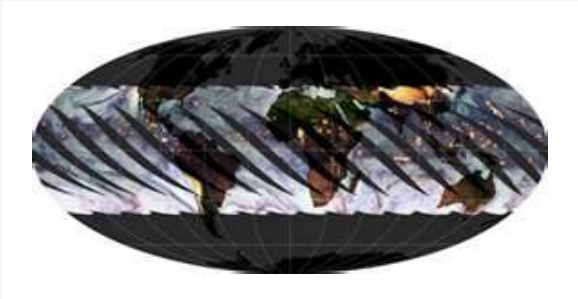
- Global coverage
- Varied measurement frequency (1 per day – 1 per month)
- Larger swath size means higher temporal resolution



history.nasa.gov

Non-Polar Orbiting

- Non-Global coverage
- Varied measurement frequency (less than 1 per day)
- Larger swath size means higher temporal resolution



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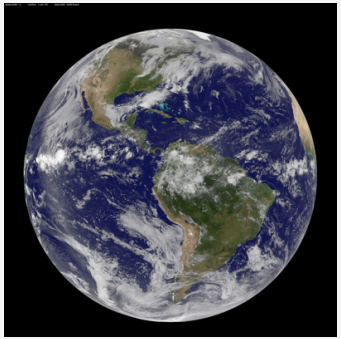
Geostationary

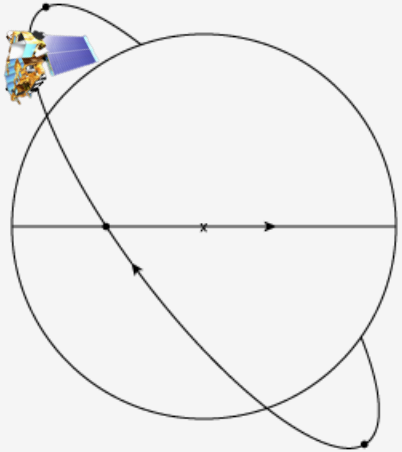
- Limited spatial coverage – more than one satellite needed for global coverage
- Multiple observations per day

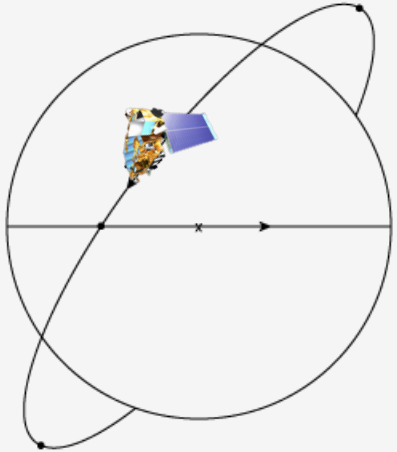


svs.gsfc.nasa.gov

Satellite Orbits

Ascending vs. Descending

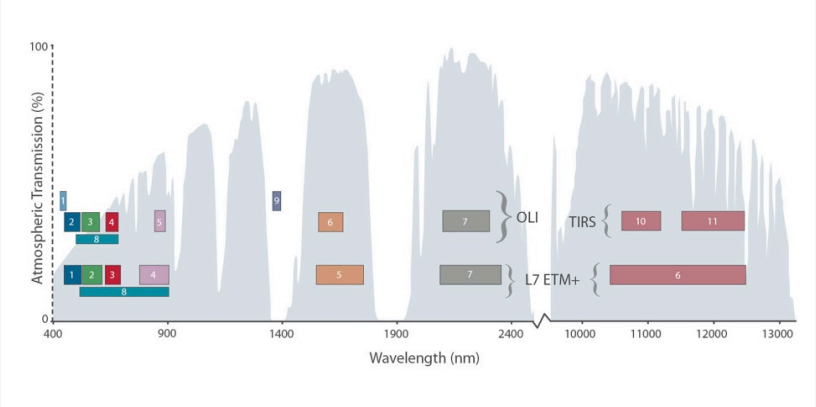




Images based on 1991 MODIS Science Team Meeting attachment. Terra not to scale.

Spectral & Radiometric Resolutions

- **Spectral Resolution**
  - 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



Landsat 8 bands. Graphic created by L. Rocchio & J. Barsi.
http://landsat.gsfc.nasa.gov/

Remote Sensing Data Levels and Formats

Data Processing Levels

L0: Raw Instrument Data

L1: Geolocated & calibrated

L2: Products derived from L1B

L3: Gridded & quality controlled

L4: Model output: derived variables

Harder to Use

Easier to Use

Data Levels

Orbital Data (Levels 0, 1, 2)

- More user control
- Highest spatial/temporal resolution
- Harder to use

Gridded Data Products (Levels 3, 4)

- Less user control
- Lower spatial/temporal resolution, but gridded
- May be available at multiple spatial/ temporal resolutions
- More web tools available for analysis and access
- Easier to use

Data Formats

Text/ASCII

- Pros: easy to read and examine data right away
- Cons: large data files, not always available

Binary: HDF, NetCDF, OpenDAP

- Pros: less space, more information (metadata, SDS)
- Cons: Needs specific tools or code to read the data

KML or KMZ (zipped KML)

- Pros: easy 2D & 3D visualization of data through free tools; data files are smaller in size and easier to download

Shapefiles/Geotiff

- GIS applications
- May or may not work with open source

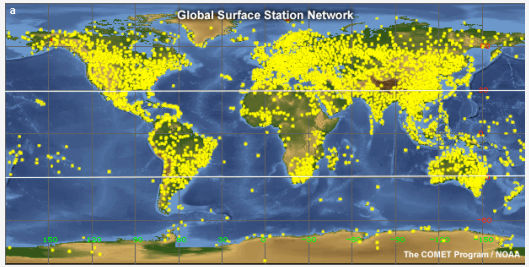
Advantages and Limitations of Remote Sensing

Remote Sensing Augments Surface Observations

- Provides information where surface-based measurements are not available and augments existing measurements

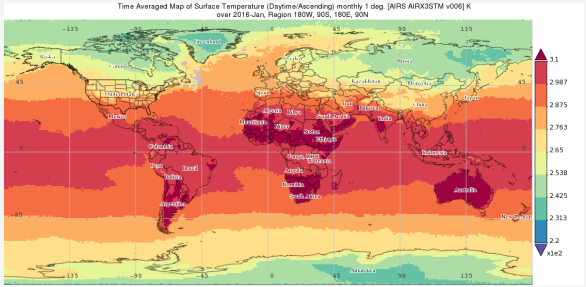
- Provides global/near-global coverage with consistent observations

Non-Uniform Coverage of Surface Measurements



http://www.goes-r.gov/users/comet/tropical/textbook_2nd_edition/print_2.htm#page_1.1.0

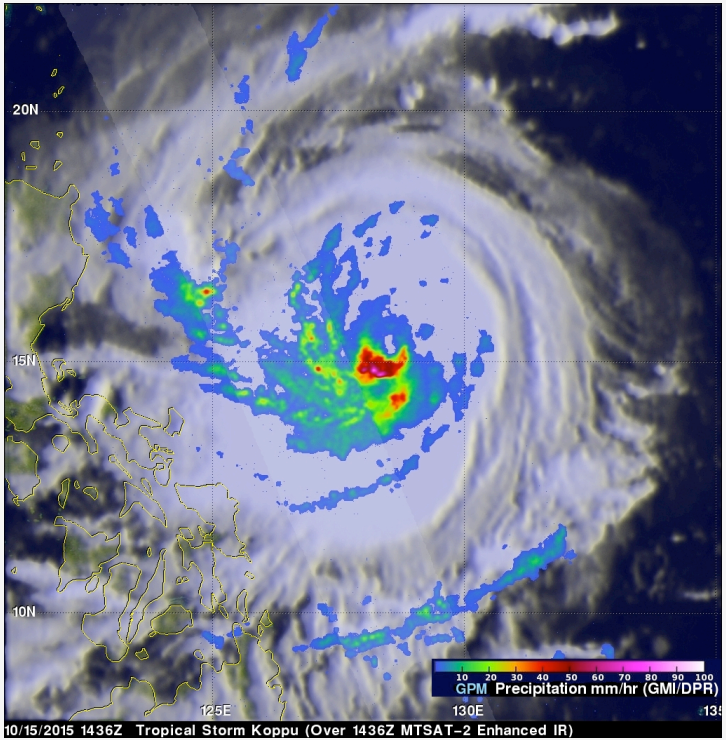
Uniform Global/Near-global Coverage



Surface Temperature for January 2016 from Atmospheric Infrared Sounder

Remote Sensing Observations

- Provide Continuous, Large-scale Coverage Compared to Point Measurements
- GPM Sees Tropical Storm Koppu Menacing The Philippines on 10/15/2015



https://pmm.nasa.gov/index.php?q=extreme-weather/gpm-sees-tropical-storm-koppu-menacing-philippines

Observations to Applications

Satellite Measurements → Satellite Products → Environmental Applications

earthobservatory.nasa.gov

earthobservatory.nasa.gov

(Top) Credits: UNDP/George Ntonya
(Bottom) Credits: UNDP/Arjan van de Merwe

Limitations

- Very difficult to obtain extremely high spectral, spatial, temporal, and radiometric resolution at the same time
- Some can obtain global coverage every 1-3 days depending on swath width
- Higher spatial resolution polar/non-polar orbiting may take 8-16 days to attain global coverage
- Geostationary satellites obtain more frequent observations but due to the greater orbital distance they only cover a fraction of the earth (less spatial coverage).
- Large amount of data with varying formats
- Data applications may require additional processing, visualization, & other tools
- Some sensors can’t observe through clouds

Questions

1. What is the difference between spatial resolution and spatial coverage ?

2. What is approximately TRMM’s spatial coverage ?

3. List one benefit of a polar orbiting satellite compared to a geostationary satellite

4. List one benefit a gridded data product compared to an orbital data product

5. List one disadvantage a gridded data product compared to an orbital data product

Next Presentation:
NASA Satellites and Earth System Models for Water Resources Management