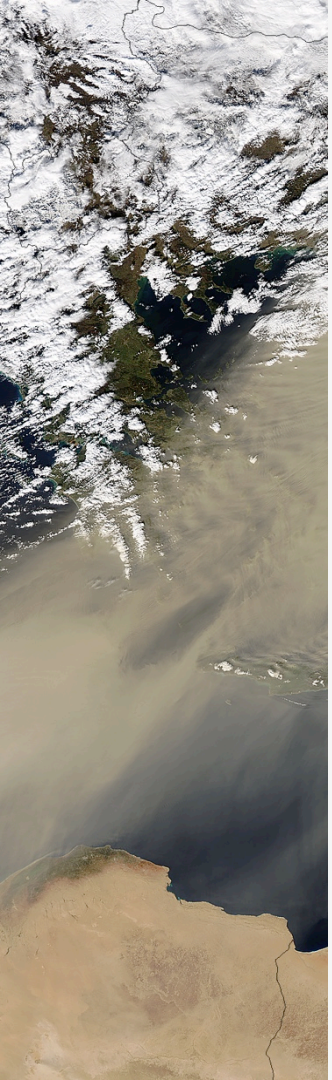


National Aeronautics and Space Administration

ARSET

Applied Remote Sensing Training

http://arset.gsfc.nasa.gov

@NASAARSET

Fundamentals of Remote Sensing for Public Health Applications

Webinar Session 1

Level 1 Webinar Series

5 Weeks

- Dates:
  – Thursday, June 2, 2016 to Thursday, June 30, 2016
- Times
  – 10:00-11:30 a.m. and 3:00-4:30 p.m. EDT (UTC-4)

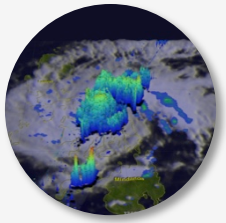
Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov

Provide online and on-site trainings tailored to:

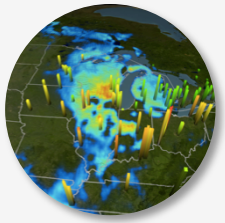
- policy makers
- regulatory agencies
- applied environmental professionals

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

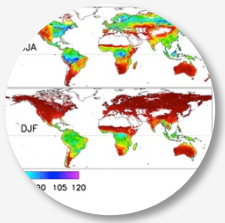


Disasters

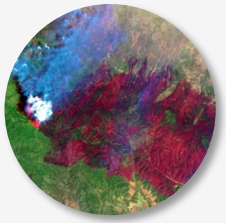
Ecoforecasting



Health & Air Quality



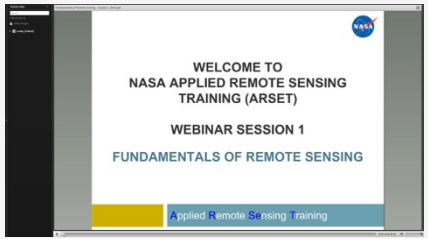
Water Resources



Wildfires

Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov



Online Webinars

- 1 hr a week, 4-6 weeks
- Live & recorded
- Include demos on data access
- *New: advanced webinars*

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

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

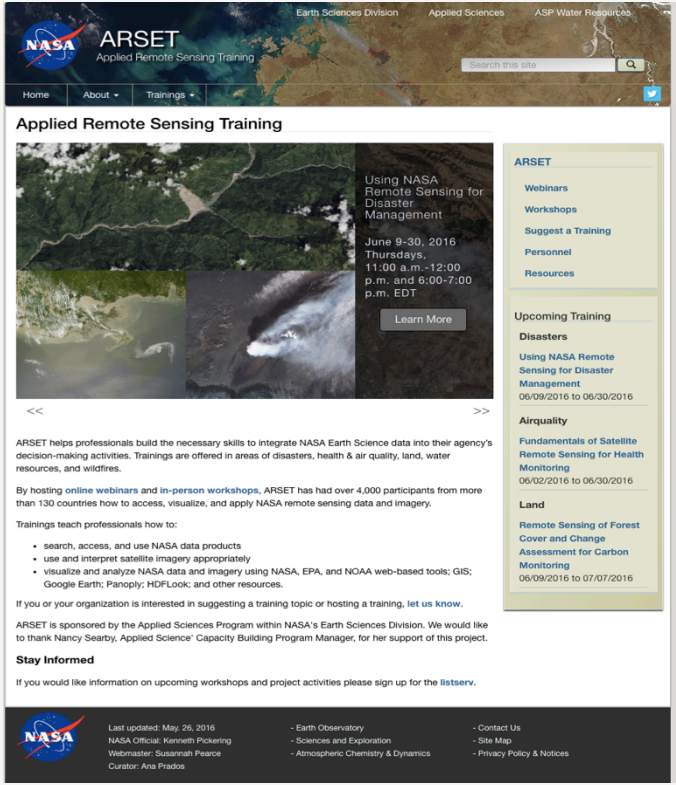
Example: Satellite Remote Sensing of Particulate Matter Air Quality

Applied Remote Sensing Training Program (ARSET)

http://arset.gsfc.nasa.gov

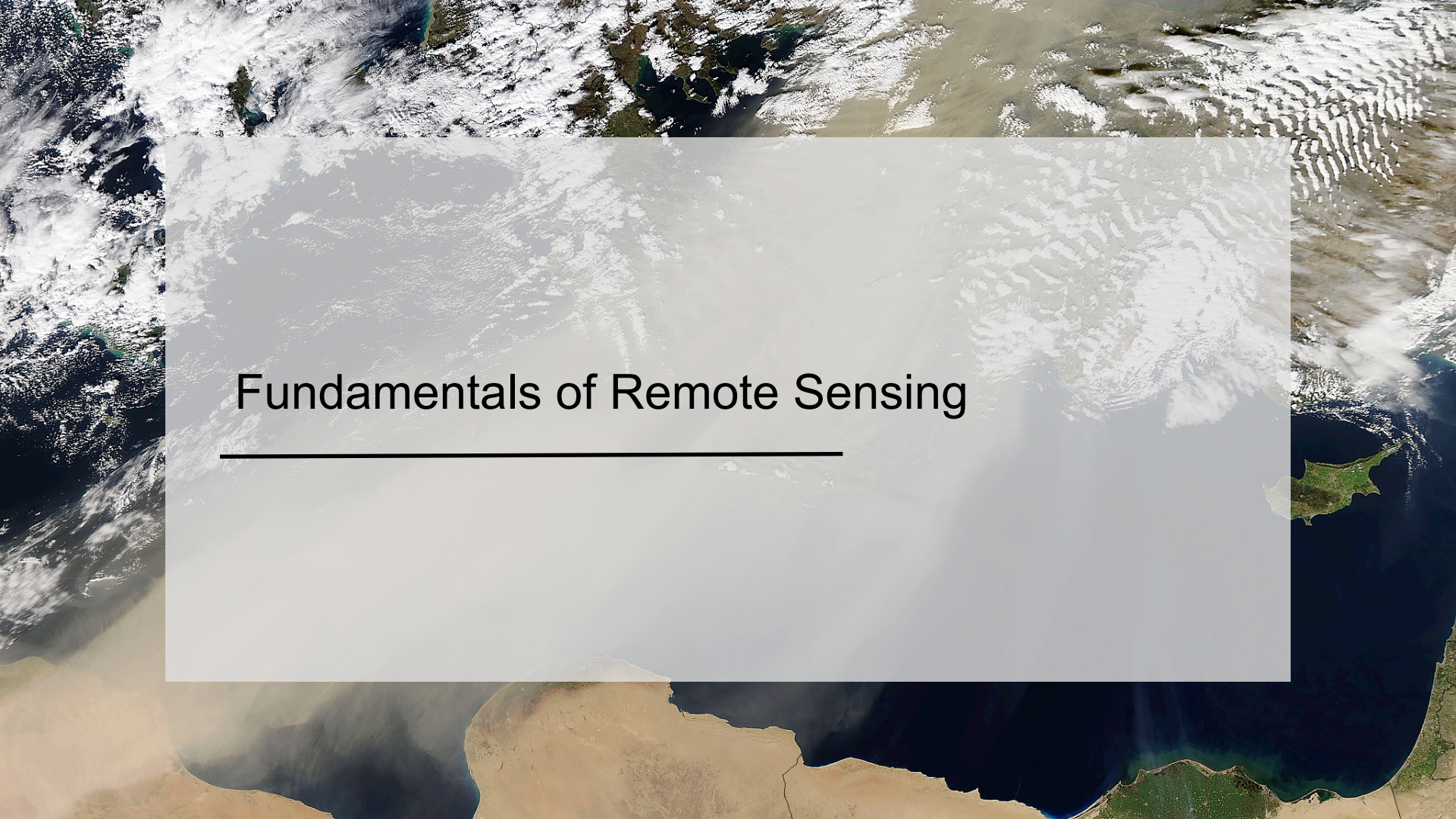
Fundamentals of Satellite Remote Sensing for Health Monitoring

http://arset.gsfc.nasa.gov/airquality/webinars/health-applications-2016



Outline

- Fundamentals of Remote Sensing
- Satellites and Sensors
  - Types
  - Resolutions
- Advantages/Disadvantages of Remote Sensing
- Satellite Data Processing Levels
- Observations to Applications

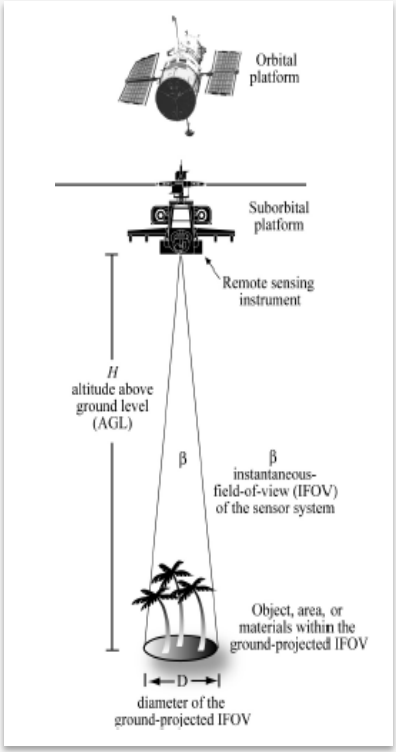


Fundamentals of Remote Sensing

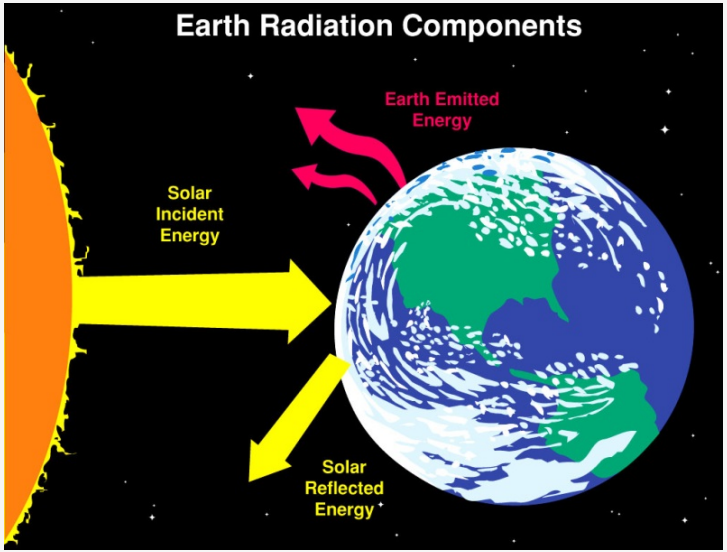
What is Remote Sensing?

- 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

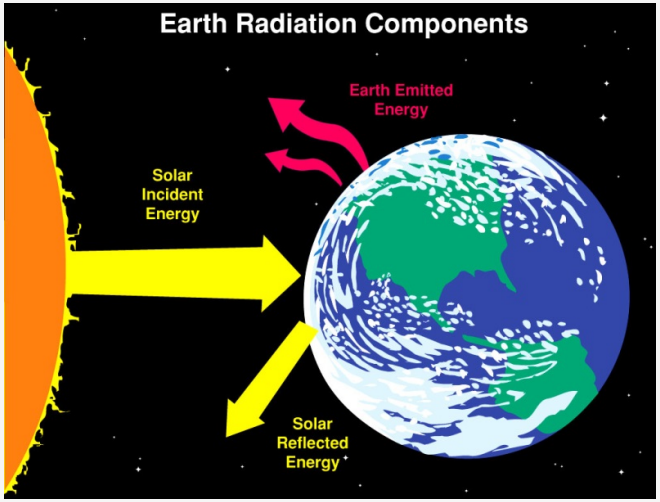


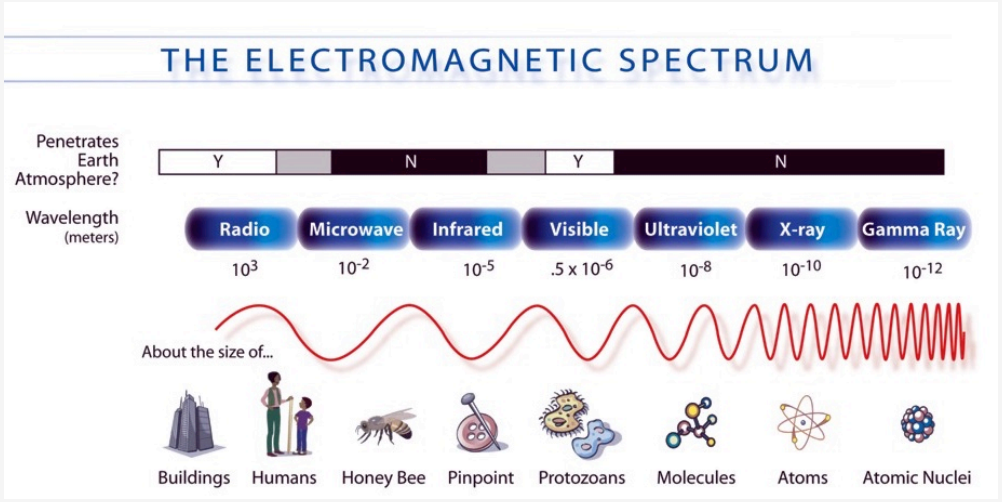
- Satellites carry instruments or sensors that measure **electromagnetic radiation** coming from the earth-atmosphere system



Electromagnetic Radiation

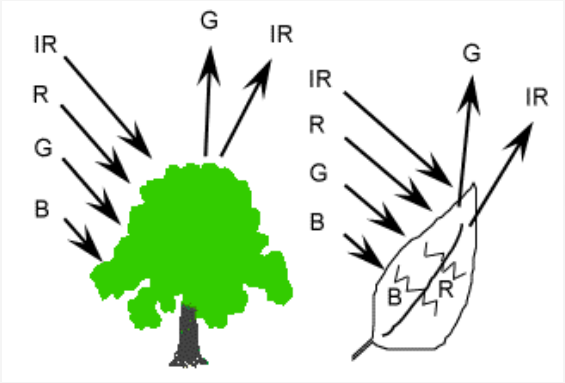
- Earth-Ocean-Land-Atmosphere System:
  - Reflects solar radiation back to space
  - Emits infrared and microwave radiation to space



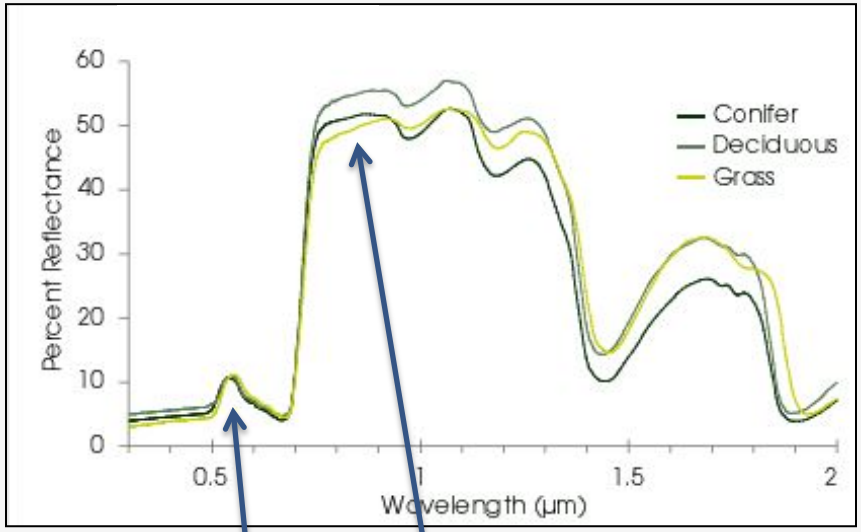


Spectral Signatures

Every kind of surface has its own spectral signature



Spectral Signature



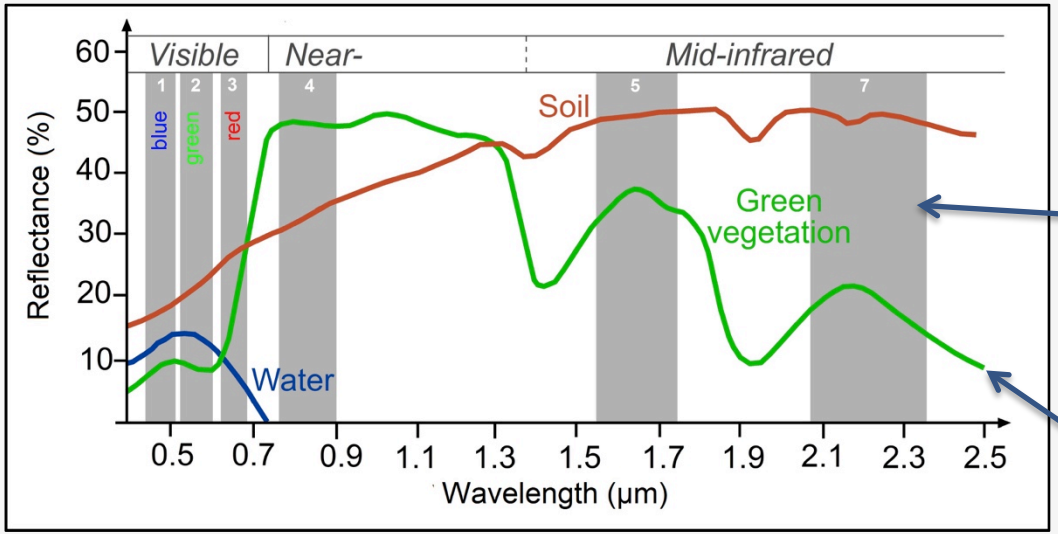
Green

Near-Infrared (IR)

Spectral Signatures

In Imagery

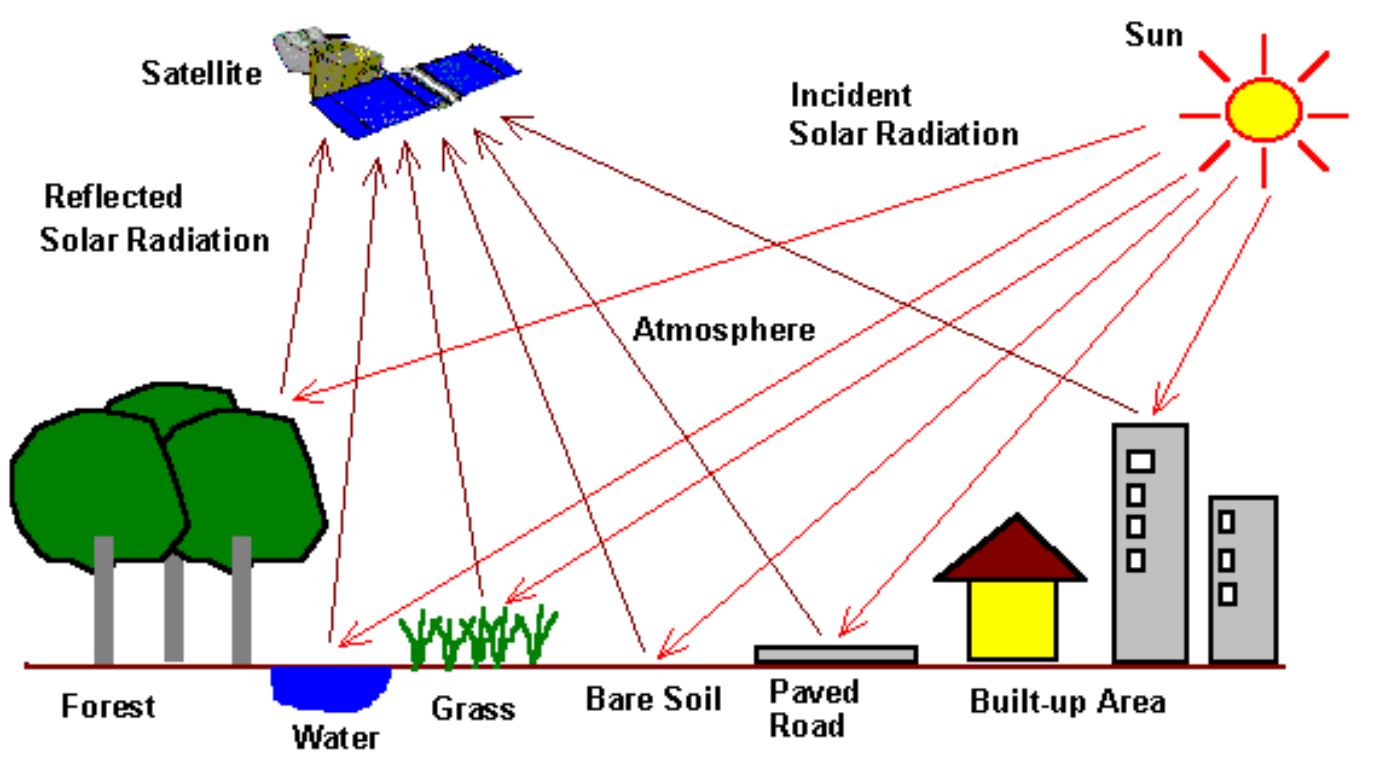
- Remotely sensed imagery acquires information in different wavelengths, representing different parts of the electromagnetic spectrum.

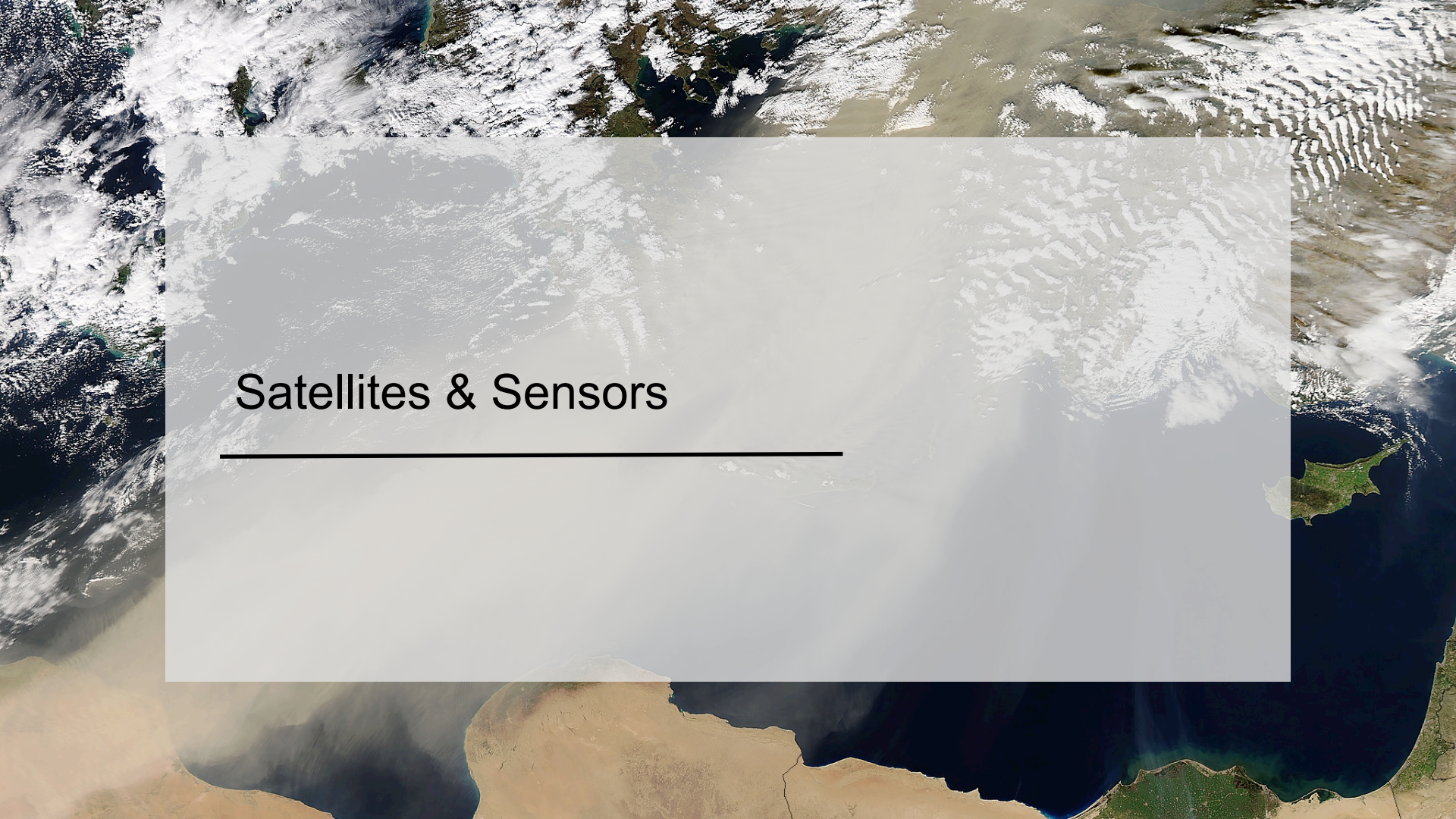


Landsat bands

Spectral signatures

How Satellites Collect Data





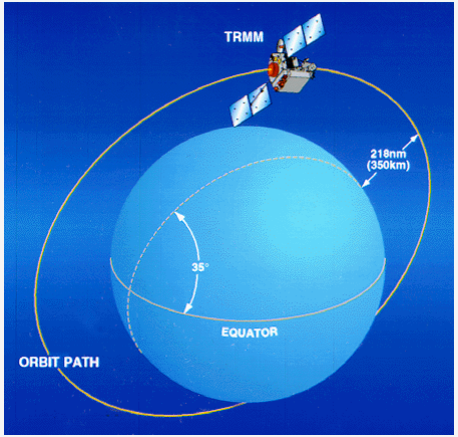
Satellites & Sensors

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
  - Applications and usage
  - Availability, access, format

These affect spatial and temporal resolutions



Satellite & Sensor Characteristics

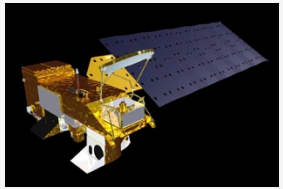
- Satellites vs. Sensors
- Satellite Orbits
- Spectral Resolution
- Spatial Resolution
- Temporal Resolution
- Radiometric Resolution

Satellites vs. Sensors

Satellites carry sensors or instruments

- Earth-observing satellite remote sensing instruments are named according to
  - the satellite (also called the platform)
  - the instrument (also called the sensor)

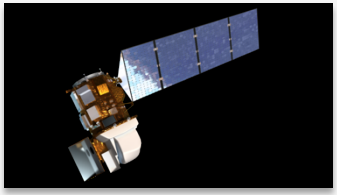
Aqua Satellite



Instruments (sensors):

- MODIS
- CERES
- AIRS
- AMSU-A
- AMSR-E
- HSB

Landsat 8



Instruments (Sensors):

- OLI
- TIRS

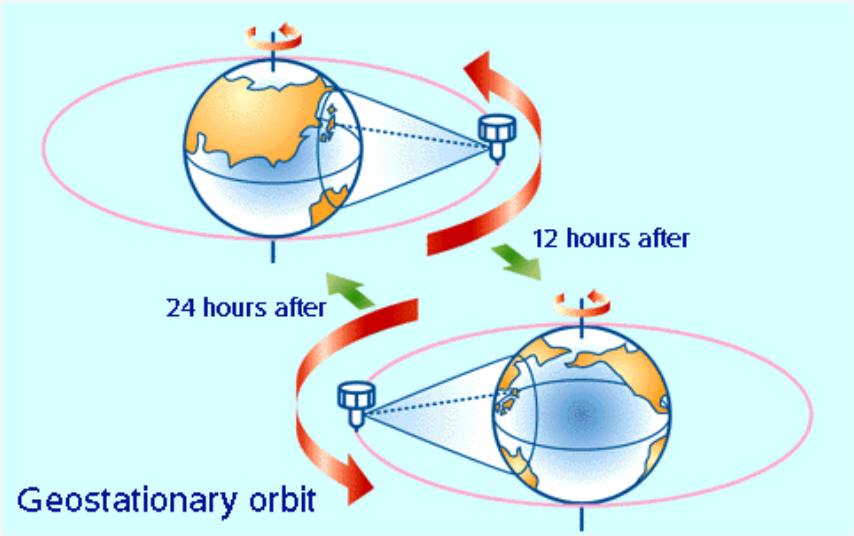
Satellites and Sensors

Characterization

- Orbit
  - Polar vs. Geostationary
- Energy Source
  - Passive vs. Active
- Solar and Terrestrial Spectra
  - Visible, UV, IR, Microwave…
- Measurement Technique
  - Scanning
  - Non-Scanning
  - Imager
  - Sounders
- Resolution (Spatial, Temporal, Spectral, Radiometric)
  - Low vs. High
- Applications
  - Weather
  - Ocean Colors
  - Land Mapping
  - Atmospheric Physics
  - Atmospheric Chemistry
  - Air Quality
  - Radiation Budget
  - Water Cycle
  - Etc.

Satellite Orbits

Two Primary Types: Geostationary and Low Earth Orbit

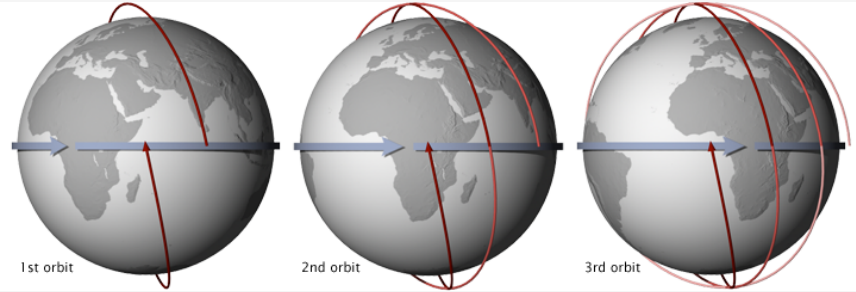


Geostationary Orbit

- 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



Low Earth Orbit

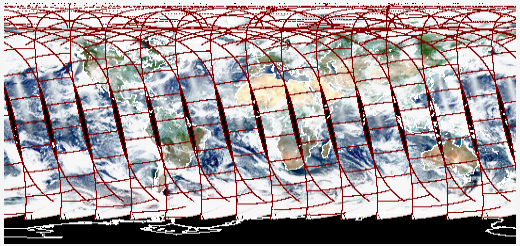
- Circular orbit constantly moving relative to the Earth at 160-2,000 km - can be in polar or non-polar orbit
  - Less frequent measurements
  - Large (global) spatial coverage
- Examples (polar):
  - Landsat or Terra

Satellite Orbits

Spatial Coverage and Temporal Resolution

Polar Orbiting

- Global coverage
- Varied measurement frequency
- Larger swath size means higher temporal resolution



Aqua “ascending” orbit

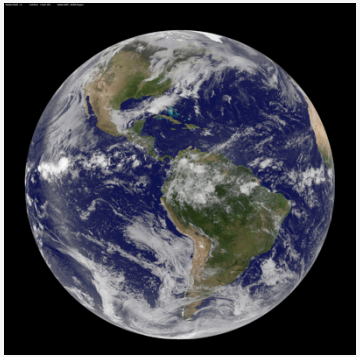
Non-Polar Orbiting

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

TRMM Image

Geostationary

- Limited spatial coverage
- Multiple observations per day

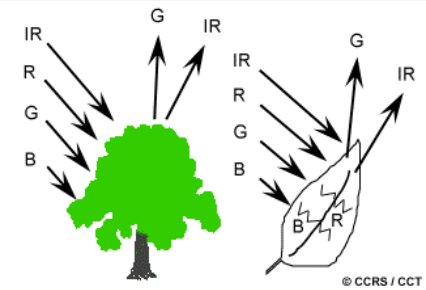


GOES Image

Satellite Sensors

Passive

- Measure radiant energy reflected or emitted by the Earth-atmosphere system
  - Radiant energy is converted to bio-geophysical such as: temperature, precipitation, soil moisture, chlorophyll-a
  - Examples: Landsat, MODIS, TRMM Microwave Imager, AIRS

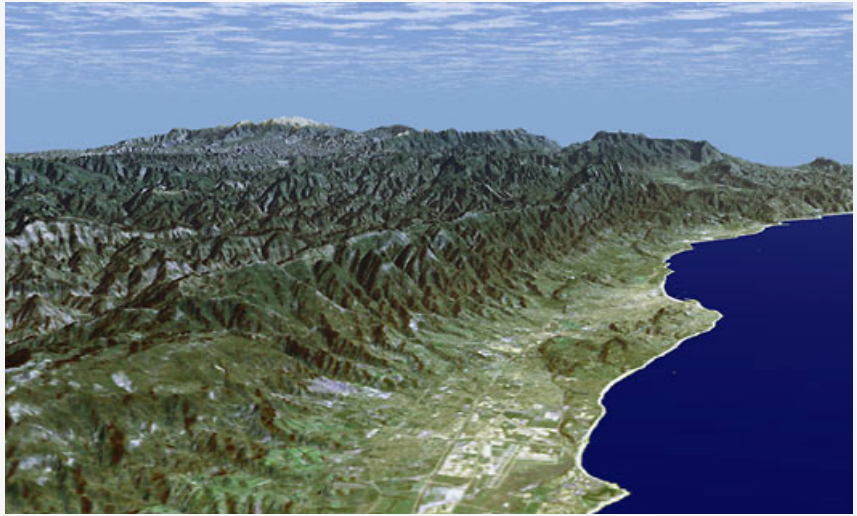


Landsat image of San Francisco Bay Area

Satellite Sensors

Active

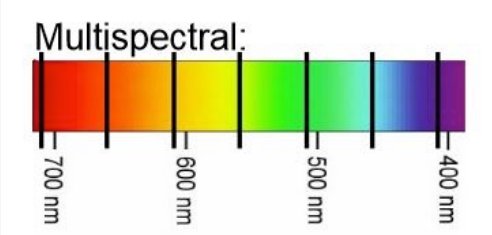
- Send beams of radiation on the Earth-atmosphere system; measures ‘back-scattered’ radiation
  - converted to geophysical quantities
- Advantages
  - Can be used day or night
  - Can penetrate cloud cover
- Disadvantages
  - Challenging to process
  - Some available only from aircraft
- Examples: Radar, LIDAR



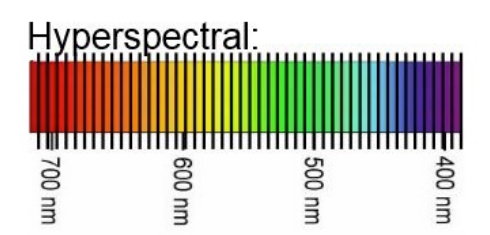
This perspective view of the Santa Barbara region was generated using data from the Shuttle Radar Topography Mission (SRTM) and an enhanced Landsat satellite image in Feb 2000.

Spectral Resolution

- Describes the ability of a sensor to define fine wavelength intervals
- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band
- More and finer spectral challenges enable remote sensing of different parts of the Earth's surface



Example:
Landsat (7-11 bands) & MODIS (36 bands)



Example:
AVIRIS (256 bands)

Spatial Resolution

Decided by its pixel size: pixel is the smallest unit measured by a sensor

Sensor	Spatial Resolution
Digital Globe (and others)	< 1 - 4 m
Landsat	30 m
MODIS	250 m – 1km
Global Precipitation Mission (GPM) Dual Frequency Radar	5 km

Spatial Resolution

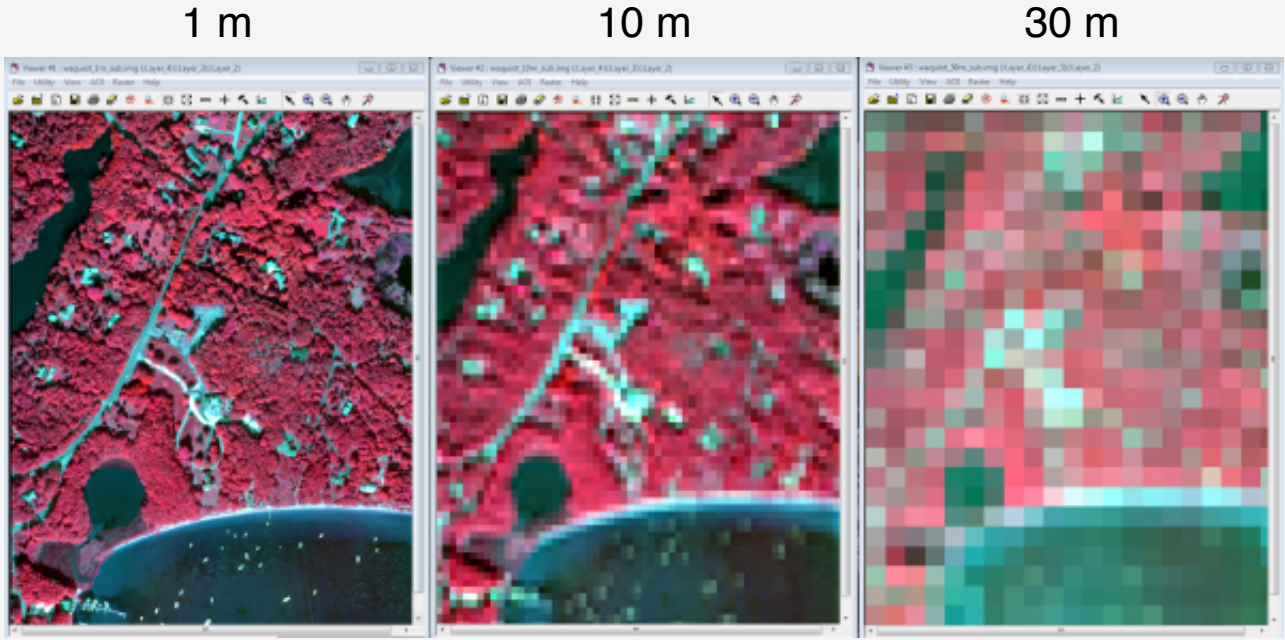


Image courtesy of www.csc.noaa.gov

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

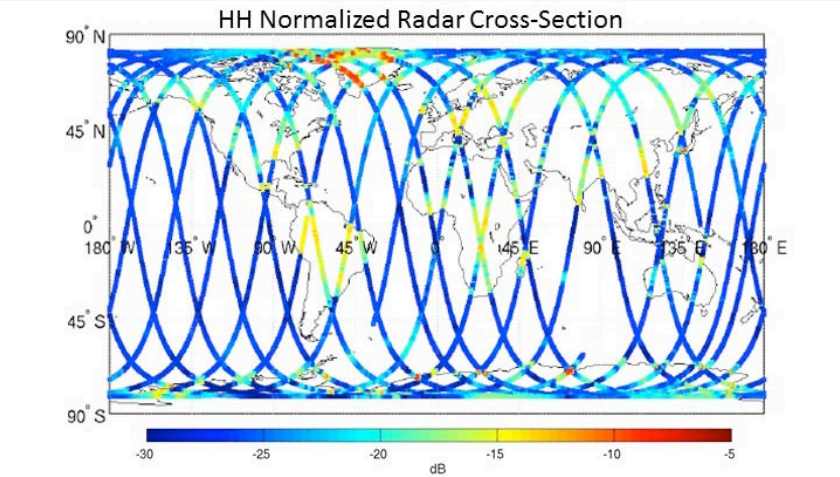
Temporal Resolution

- The time it takes for a satellite to complete one orbit cycle – also called “revisit time”
- Depends on satellite and sensor capabilities, swath overlap, and latitude

Sensor	Revisit Time
Landsat	16 days
MODIS	2 days
Commercial (OrbView)	1-2 days

Temporal Resolution

- Some satellites may have greater temporal resolution
  - Some satellites are able to point their sensors
  - Some satellites have increasing overlap at higher latitudes so many have a greater repeat time



- A radar image path from NASA's Soil Moisture Active Passive satellite
- Areas at high latitudes will be imaged more frequently due to increasing overlap

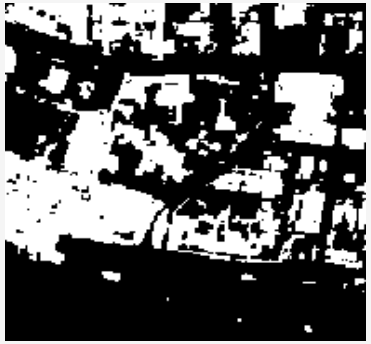
Radiometric Resolution

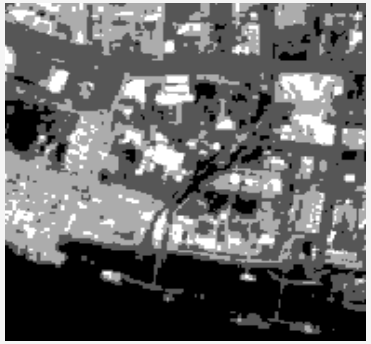
- The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded
- The larger this number, the higher the radiometric resolution, and the sharper the imagery
- Represented by positive digital numbers that very from zero to (one less than) a selected power of two
  - 12 bit sensor (MODIS, MISR): 2^{12} or 4,096 levels
  - 10 bit sensor (AVHRR): 2^{10} or 1,024 levels
  - 8 bit sensor (Landsat TM): 2^{8} or 256 levels (0-255)
  - 6 bit sensor (Landsat MSS): 2^{6} or 64 levels (0-63)

Radiometric Resolution

Different classes are more precisely identified if radiometric precision is high

2 - levels





4 - levels

8 - levels

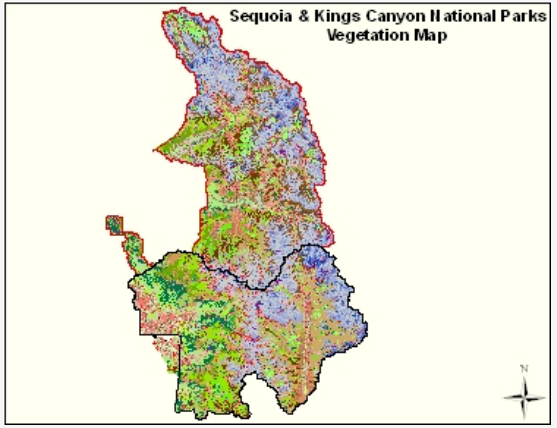
16 - levels

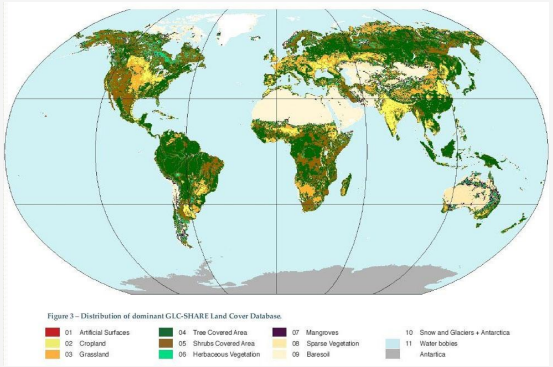
Advantages and Disadvantages of Remote Sensing Observations

Remote Sensing Observations

Advantages and Disadvantages

- Advantages:
  - Provides information where there are no ground-based measurements
  - Provides globally consistent observations
- Disadvantages:
  - Does not provide high level of detail at ground level
  - Cannot detect land cover under canopy
  - Cannot detect much under water





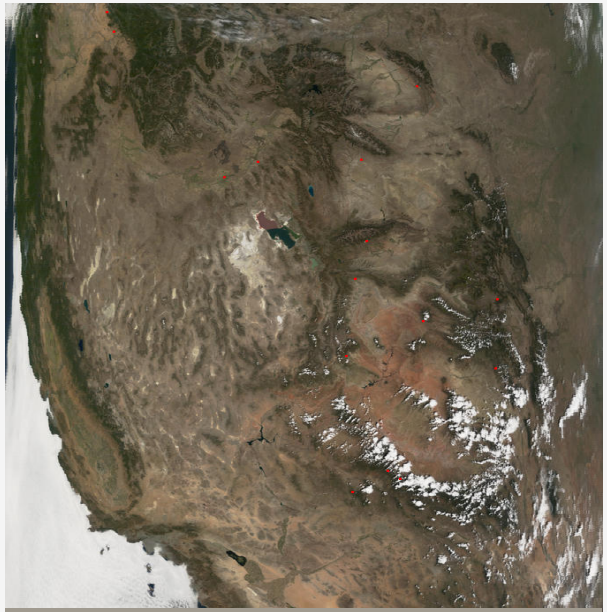
Remote Sensing Observations

Trade-Offs

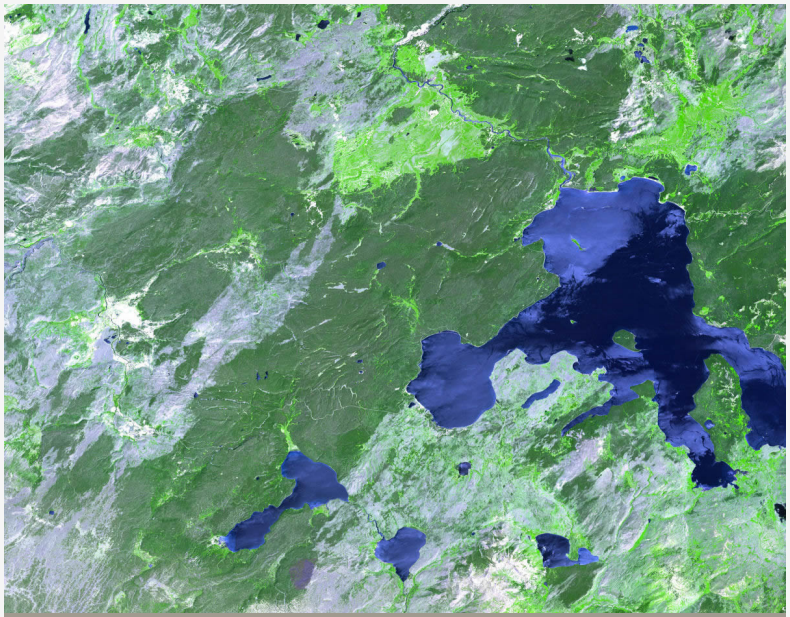
- It's very difficult to obtain extremely high spectral, spatial, temporal, and radiometric resolution at the same time
  - Several sensors can obtain global coverage every 1-2 days because of their wide swath width
  - Higher spatial resolution polar/non-polar orbiting satellites may take 8-16 days to attain global coverage
  - Geostationary satellites obtain much more frequent observations but at lower resolution due to the much greater orbital distance, and only cover a fraction of the earth
- Large amounts of data with varying formats
- Data applications may require additional processing, visualization, and other tools

Remote Sensing Observations

Trade-Offs



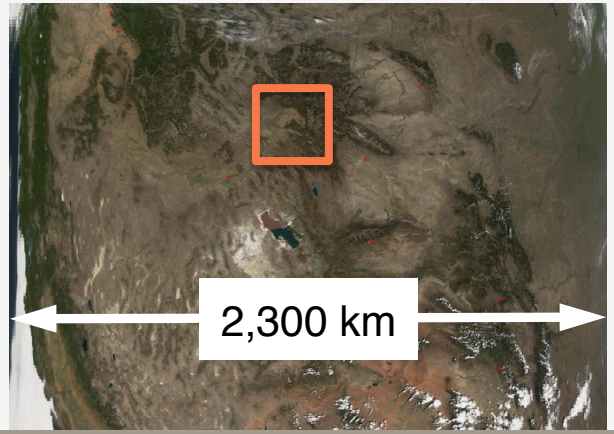
MODIS 500m
True Color Image

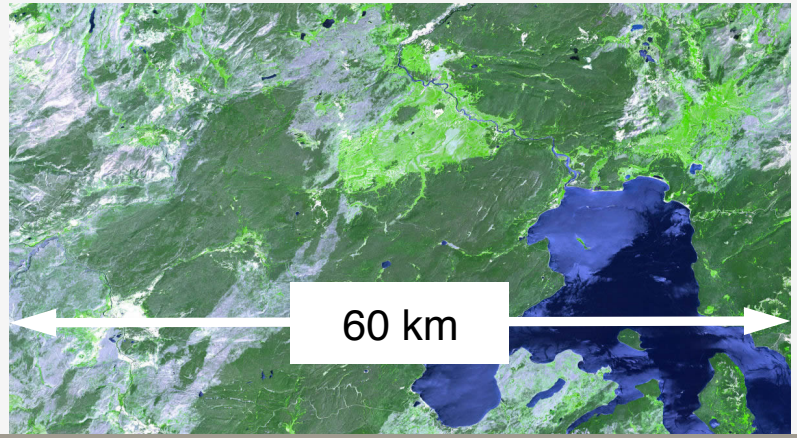


ASTER Image
15m Resolution

Remote Sensing Observations

Trade-Offs

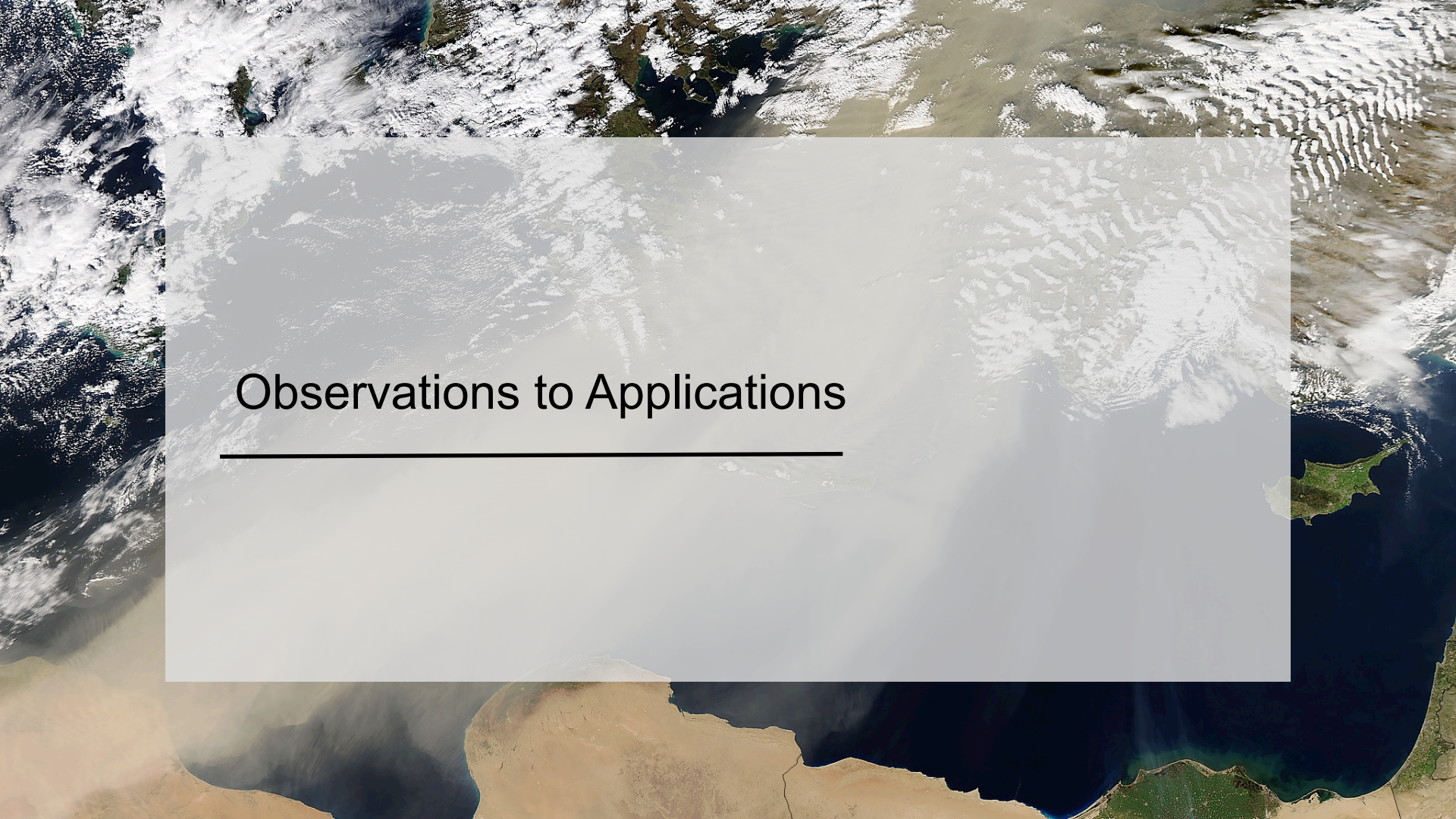




- The different resolutions are the limiting factor for the utilization of the remote sensing data for different applications. The trade-off is because of technical constraints.
- Larger swatch size is associated with low spatial resolution and vice versa.
- Often satellite designs are application oriented

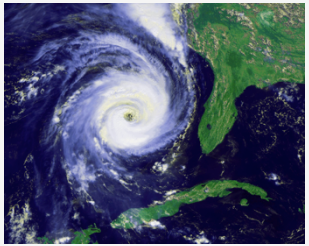
Challenges Working with the Environmental Public Health Community

- Sharing data between agencies with different missions and mindsets
- Protecting confidentiality of information
- Ensuring high quality geocoded data
- Ensuring appropriate spatial and temporal resolution of environmental data
- Developing sound resources and methods for conducting data linkages and data analysis



Observations to Applications

Observations to Applications



Flash Flood Warning

Satellite Measurements

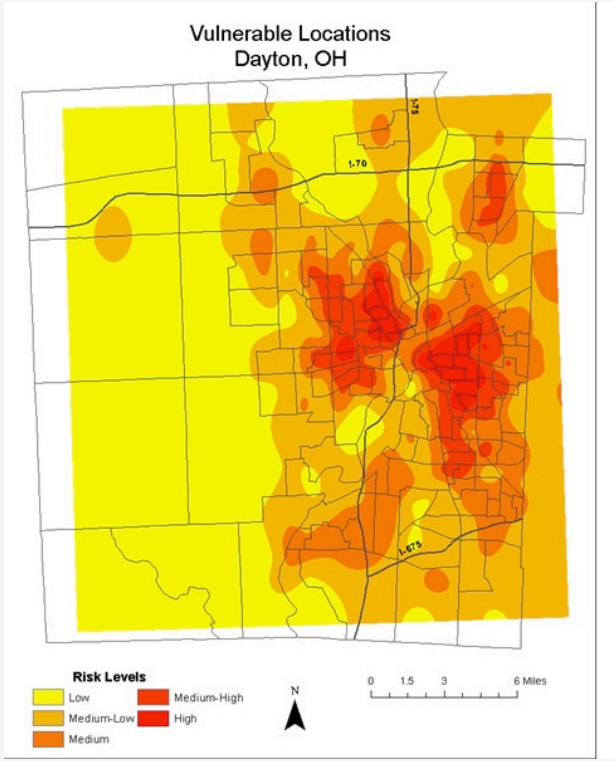
Satellite Products

Environmental Applications

Examples of Data Applications

Environmental Public Health

- Remote sensing and modeling data, along with other sources of data, are used for a variety of applications, either:
  - directly
  - in statistical or physical modeling tools
- Remotely sensed data can be used:
  - to identify the hottest areas
  - improve identification of locations most vulnerable during extreme heat events

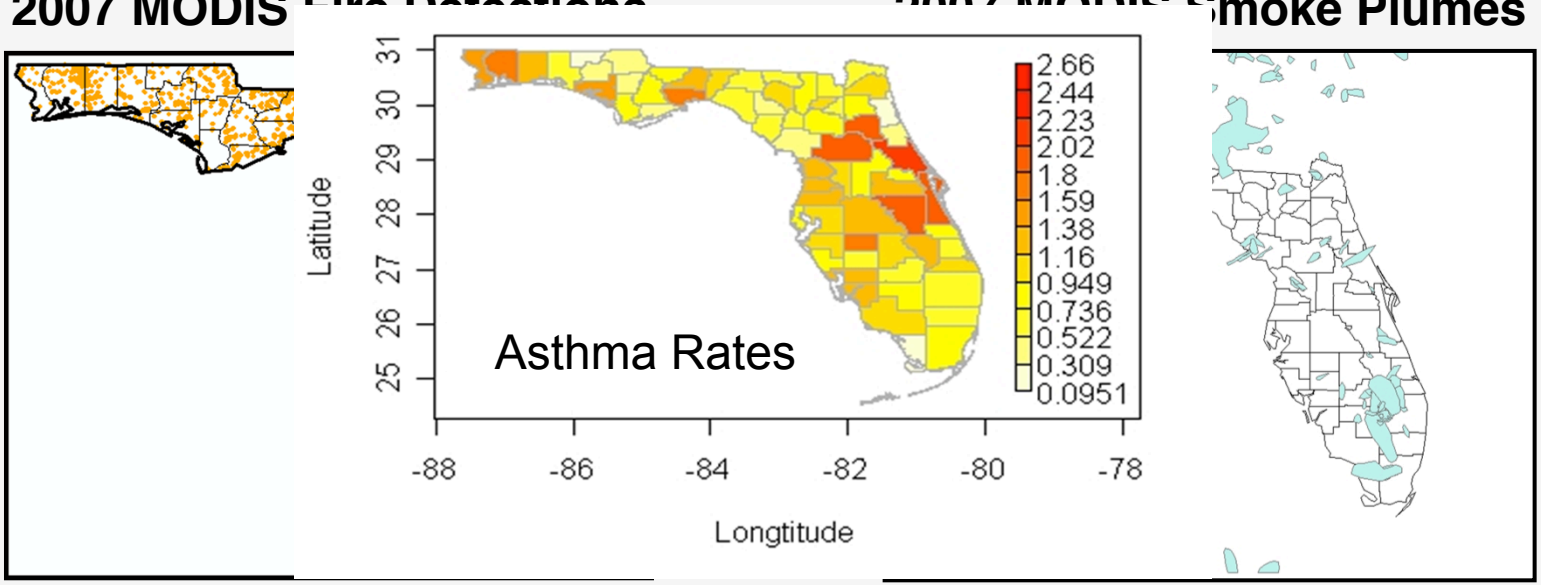


Examples of Data Applications

Fires, Smoke, and Public Health

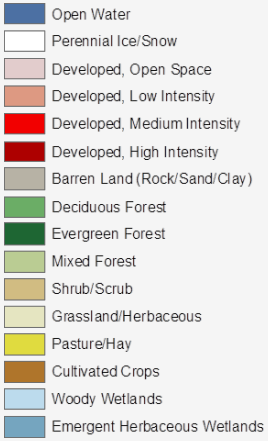
This environmental data can be combined with public health data to evaluate the effect of fires and smoke on Asthma in Florida or other U.S. regions

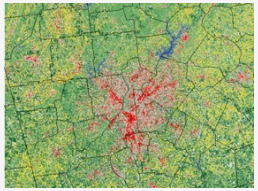
2007 MODIS Fire Detections **2007 MODIS Smoke Plumes**



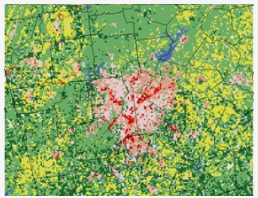
Examples of Data Applications

Relationship Between Living Environment and Blood Pressure

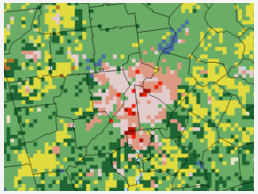




Landsat 30 m

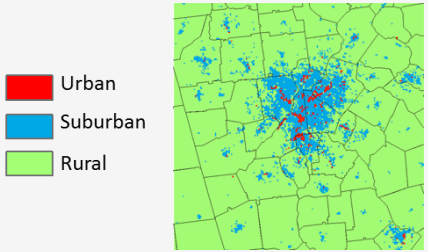


Landsat 1km



Landsat 3km

Landsat data was used at the native resolution of 30m and resampled at other resolutions to determine the optimal scale to distinguish urban, suburban, and rural living environments in the metropolitan Atlanta region.



Living Environment	Mean SBP	Mean DBP
Urban	131±0.54	78±0.31
Suburban	127±0.42	77±0.24
Rural	127±0.76	76±0.44
p-Value	*<0.0001*	*>0.0001*

Source: Environmental Health Perspectives, 117 (12), 2009

Future Public Health Webinars

- This concludes Session 1 of the “Fundamentals of Remote Sensing” ARSET webinar
- Additional sessions will be offered focusing on the topic areas of:
  - Overview of the Public Health Applications Program
  - Centers for Disease Control & NASA collaboration and usage of remotely sensed data
  - Use of remotely sensed data for study of the West Nile Virus and public health applications
  - Use of remotely sensed data for study of harmful algal blooms and implications for public health

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