Training Overview and Introduction to Satellite Remote Sensing

Pawan Gupta

Spring 2015

ARSET - AQ

Applied Remote Sensing Education and Training – Air Quality

A project of NASA Applied Sciences
Outline

- Introduction to ARSET
- Training overview
- Fundamentals of Satellite Remote Sensing
- Tour to ARSET webpage
National and international activities to engage and train users applying NASA Earth Science satellites and modeling data in their decision making activities

Applied Remote SEnsing Training (ARSET) Program

On-line and hands on basic/advanced trainings tailored to end-users & organizations
GOAL:
Increase utilization of satellite observational and model data for decision-support

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 satellite images for decision-support.

NASA Training for California Air Resources Board, Sacramento
NASA Earth Science
Applied Sciences Program

Applications to Decision Making: Thematic Areas

- Agricultural Efficiency
- Air Quality
- Climate
- Disaster Management
- Ecological Forecasting
- Public Health
- Water Resources
- Weather
For more information about ARSET visit http://arset.gsfc.nasa.gov/
ARSET Contact Information

(Any individual or organization can contact us for more advance training in the area of satellite remote sensing and its applications. ARSET provide trainings to public, private and non-profit organizations around the world.)

• Overall program information
  Ana Prados: aprados@umbc.edu

• Air Quality
  Pawan Gupta: pawan.gupta@nasa.gov

More details are available at
http://arset.gsfc.nasa.gov/
Questions?

Poll # 1

Brief tour to ARSET page
http://arset.gsfc.nasa.gov
Fundamentals of Satellite Remote Sensing
Instruments and Applications
Basics of Satellite Remote Sensing

Collecting information about an object without being in direct physical contact with it.
Remote Sensing ...

- **Orbital platform**
- **Suborbital platform**
- **Remote sensing instrument**

- **H**: altitude above ground level (AGL)
- **β**: instantaneous-field-of-view (IFOV) of the sensor system

Object, area, or materials within the ground-projected IFOV:

- **D**: diameter of the ground-projected IFOV
Remote Sensing: Platforms

- Platform depends on application
  - What information do we want?
  - How much detail?
  - What type of detail?
  - How frequent?
Number of Satellites making daily observations of Earth-Atmosphere and Ocean Globally
What you get from satellite?

Day Time

Night Time
What does satellite measures?
Remote Sensing Process

Satellite measured spectral Radiance

A priority information & Radiative Transfer Theory

Retrieval Algorithm

Geophysical Parameters → Applications
Remote Sensing Process

Energy Source or Illumination (A)

Recording of Energy by the Sensor (D)

Transmission, Reception, and Processing (E)

Interpretation and Analysis (F)

Application (G)

Radiation and the Atmosphere (B)

Interaction with the Target (C)

Reference: CCRS/CCT
Questions?

Poll # 2
Earth-observing satellite remote sensing instruments are named according to:

1) the satellite (also called platform)
2) the instrument (also called sensor)

**Satellites Vs Sensors**

**Aqua Satellite**
- Six Instruments:
  - MODIS
  - CERES
  - AIRS
  - AMSU-A
  - AMSR-E
  - HSB

**Aura Satellite**
- Four Instruments:
  - OMI
  - TES
  - HIRDLS
  - MLS
Satellite/Sensor Classifications

Some of the ways satellites/sensor can be classified

• **Orbits**
  – Polar vs Geostationary

• **Energy source**
  – Passive vs Active …

• **Solar spectrum**
  – Visible, UV, IR, Microwave …

• **Measurement Technique**
  – Scanning, non-scanning, imager, sounders …

• **Resolution (spatial, temporal, spectral, radiometric)**
  – Low vs high (any of the kind)

• **Applications**
  – Weather, Ocean colors, Land mapping, Atmospheric Physics, Atmospheric Chemistry, Air quality, radiation budget, water cycle, coastal management …
Common types of orbits

Geostationary orbit
An orbit that has the same Earth’s rotational period
Appears ‘fixed’ above earth
Satellite on equator at ~36,000km

Polar orbiting orbit
fixed circular orbit above the earth,
~600-1000km in sun
synchronous orbit with
orbital pass at about same local solar time each day
Observation Frequency

Polar orbiting satellites – 1 - 2 observations per day per sensor

Geostationary satellites – Future satellites - TEMPO, GEMS, Sentinel-4
Ascending vs Descending

Path of Satellite

Ascending Orbit:
The satellite is moving South to North when that portion of the orbit track crosses the equator.

Descending Orbit:
The satellite is moving North to South when that portion of the orbit track crosses the equator.

Polar Orbits
MODIS-Aqua ("ascending" orbit)

Approximately 1:30 PM local overpass time
Afternoon Satellite

MODIS-Terra ("descending")

Approximately 10:30 AM local overpass time
Morning Satellite
Satellite Coverage

- MODIS: 2300 Km
- VIIRS: 3000 Km
- Calipso Space Borne Lidar: 380 Km
- MISR: 1 Km
Satellite Coverage

MODIS

VIIRS

MISR
Remote Sensing ... Sensors

**Passive Sensors:** Remote sensing systems which measure energy that is naturally available are called passive sensors.

MODIS, MISR, OMI

**Active Sensors:** The sensor emits radiation which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor.

CALIPSO
Remote Sensing – Resolutions

– Spatial resolution
  The smallest spatial measurement.

– Temporal resolution
  Frequency of measurement.

– Spectral resolution
  The number of independent channels.

– Radiometric resolution
  The sensitivity of the detectors.
Pixel

pixels - the **smallest units of an image**.

Image pixels are normally regular shape (but not necessary) and represent a certain area on an image/Earth.
Why is spatial resolution important?
Spectral Resolution

- 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.

- **multi-spectral sensors** - MODIS
- **hyper spectral sensors** - OMI, AIRS
In order to capture information contained in a narrow spectral region – hyper spectral instruments such as OMI, or AIRS are required
Radiometric Resolution

• Imagery data are represented by positive digital numbers which vary from 0 to (one less than) a selected power of 2.

• The maximum number of brightness levels available depends on the number of bits used in representing the energy recorded.

  - 12 bit sensor (MODIS, MISR) – $2^{12}$ or 4096 levels
  - 10 bit sensor (AVHRR) – $2^{10}$ or 1024 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

In classifying a scene, different classes are more precisely identified if radiometric precision is high.
Temporal Resolution

• How frequently a satellite can provide observation of same area on the earth
• It mostly depends on swath width of the satellite – larger the swath – higher the temporal resolution

• MODIS – 1-2 days – 16 day repeat cycle
• OMI – 1-2 days
• MISR – 6-8 days
• Geostationary – 15 min to 1 hour
  (but limited to one specific area of the globe)
Remote Sensing – Trade offs

MODIS 500 Meter True color image

Aster Image 15 M Resolution
The different resolutions are the limiting factor for the utilization of the remote sensing data for different applications. Trade off is because of technical constraints.

Larger swath is associated with low spatial resolution and vice versa.

Therefore, often satellites designs are applications oriented.
Trade Offs

- It is very difficult to obtain extremely high spectral, spatial, temporal and radiometric resolutions at the same time.

- MODIS, OMI and several other sensors can obtain global coverage every one – two days because of their wide swath width.

- Higher resolution polar orbiting satellites may take 8 – 16 days for global coverage or may never provide full coverage of the globe.

- Geostationary satellites obtain much more frequent observations but at lower resolution due to the much greater orbital distance.
Limitations of Satellite Data for Air Quality Applications

- Most of the satellite sensors are passive sensors.
- Most Passive sensors measure the entire column.
- Column measurements may or may not reflect what is happening at ground level.
- This is true whether we are measuring aerosols or trace gases.

*But new methods and algorithms have been developed (and developing) to convert column measurement for the surface monitoring.*
*to learn attend rest of the webinar*
Questions?

Poll # 3
Next Week

- Visible satellite imagery and air quality applications
- Image information content, feature identification, and image archives
- Virtual tour of Earth observatory
Assignment Week - 1

http://goo.gl/forms/XjhzniWcZR

Material and Recording will be available at

http://arset.gsfc.nasa.gov/airquality/webinars/observations-tools-south-east-asia