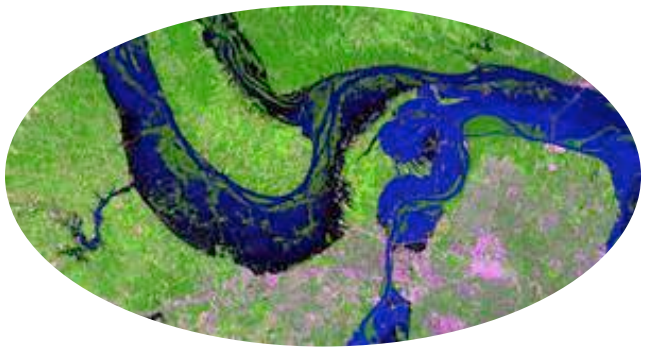
WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

NASA REMOTE SENSING OBSERVATIONS FOR FLOOD MANAGEMENT

COURSE DATES: EVERY MONDAY, JUNE 8, 15, 22, 29
TIME: 8 TO 9 AM AND 1 TO 2 PM EDT



Applied Remote Sensing Training

Objective

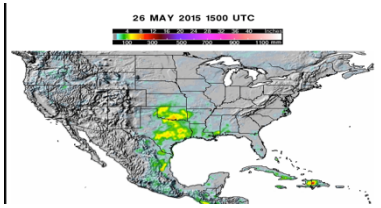
To provide a basic understanding of satellite remote sensing observations relevant for flood monitoring and web-based flood tools useful for flood management

Webinar Outline

Week 1

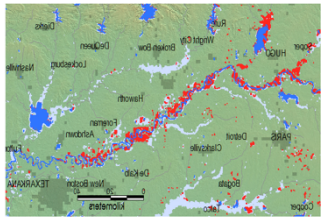
NASA Remote Sensing Data for Flood Management, Introduction to Flood Monitoring Tools

Week 2



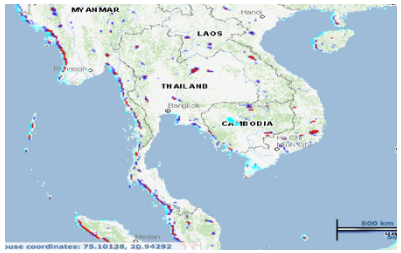
TRMM-based Flood Monitoring Web-tools

Week 3



Regional Flood Management over Africa, Demonstration of the MODIS-based Inundation Mapping

Week 4



Floodplain Management of the Mekong River, Demonstration of Selected Flooding Cases using Multiple Web-Tools and GIS

Training Team

Instructors:

- Amita Mehta (ARSET): amita.v.mehta@nasa.gov
- Brock Blevins (ARSET): bblevins37@gmail.com

Guest Speakers:

- Ashutosh Limaye (NASA): ashutosh.limaye@nasa.gov (Week-3)
- John Bolten (NASA): john.bolten@nasa.gov (Week-4)

Spanish Translation:

- David Barbato (ARSET): barbato1@umbc.edu

General inquiries about ARSET:

- Brock Blevins (ARSET) bblevins37@gmail.com
- Ana Prados (ARSET) aprados@umbc.edu

Important Information

Certificate of Completion (upon request):

You must attend all 4 live sessions

You must submit the homework assignment

(homework assignment link will be provided after Week-4)

Contact : Marines Martins

Email: marines.martins@ssaihq.com

Agenda for Week-1

NASA Remote Sensing Data for Flood Management, Introduction to Flood Monitoring Tools

- About Applied Remote Sensing Training (ARSET) Program
- Advantages of Remote Sensing Observations
- Fundamentals of Remote Sensing
- Overview of i) Remote Sensing Observations for Flood Monitoring and ii) Flood Monitoring Tools

About ARSET

NASA Applied Sciences Themes

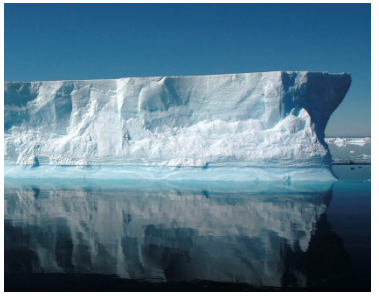
Disasters

Ecological forecasting

Health and Air Quality

Water Resources

Agriculture



Climate

Energy

Oceans

Meteorology

NASA Applied Sciences Themes

ARSET Capacity Building Training Areas

Disasters

Ecological forecasting

Health and Air Quality

Water Resources

Agriculture

Climate

Energy

Oceans

Meteorology

NASA Applied Remote Sensing Training (ARSET)

http://arset.gsfc.nasa.gov

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, wildfires, and land management.

Accomplishments (2009 – 2014)

- 50+ trainings completed
- 2500+ participants worldwide
- 800+ Organizations

ARSET

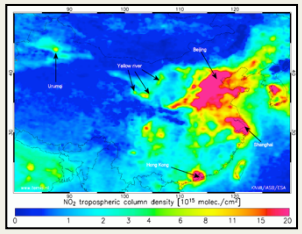
Online and Hands-on Trainings:

- **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

Applied Remote Sensing Training (ARSET)

Health (Air Quality)

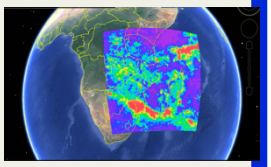


- 2008 – present
- 33 Trainings
- 1000+ end-users
- Analysis of dust, fires and urban air pollution.
- Long range transport of pollutants
- Satellite and regional air quality model inter-comparisons.
- Support for air quality forecasting and exceptional event analysis

Water Resources and Flood Monitoring

- April 2011 – present
- 11 Trainings
- 1200+ 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.

Satellite derived precipitation

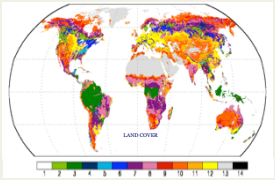


Inundation mapping

Land Management

- Launched in 2014
- 2 Trainings, +300 end-users
- GIS Applications
- Vegetation indices
- Fire products (beginning in 2015)

Land Cover



Train the Trainers (Starting in 2015)

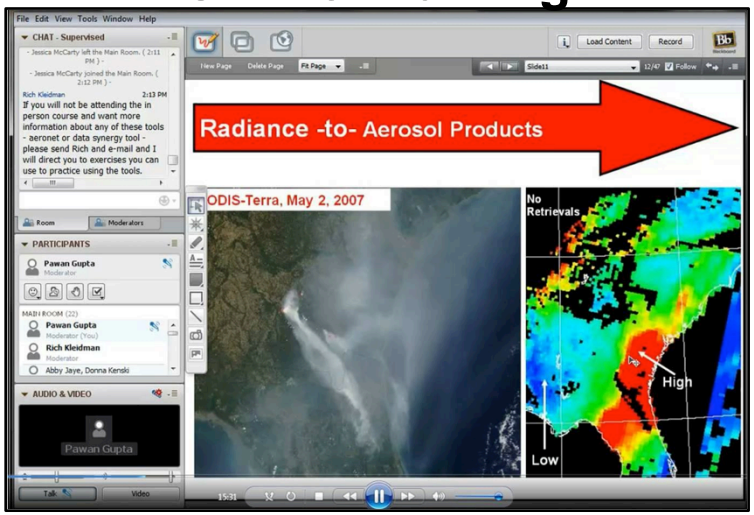
- Courses and guidance on how to design and develop, *YOUR OWN* online and/or computer based remote sensing training
- How to develop effective presentations and exercises.

Gradual Learning Approach

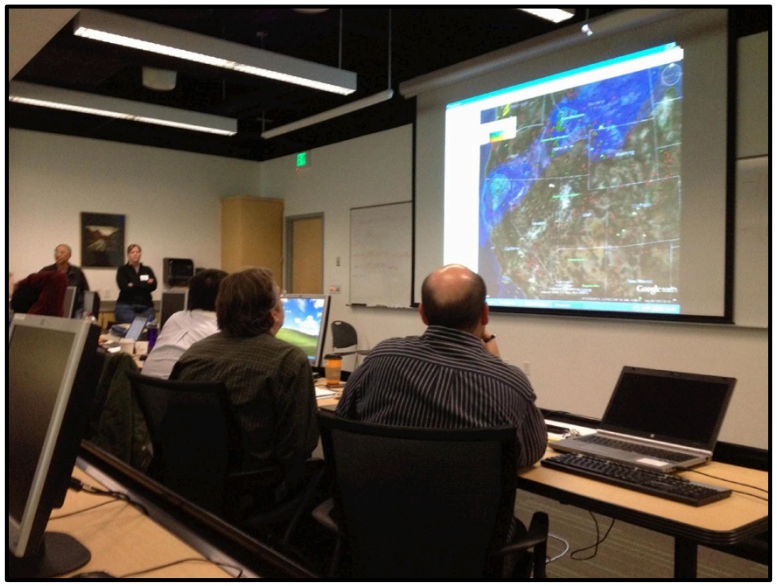
Basic Training
Webinars
Hands-on
Assumes no prior knowledge of RS

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

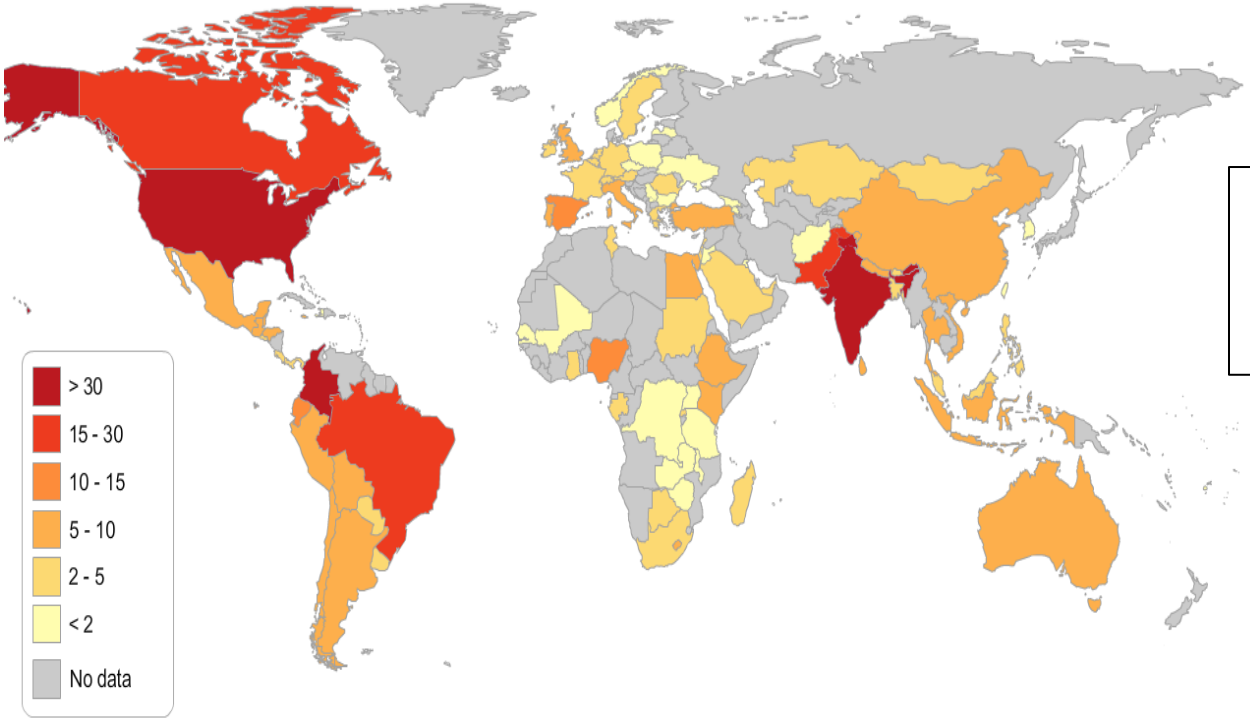
Online Training



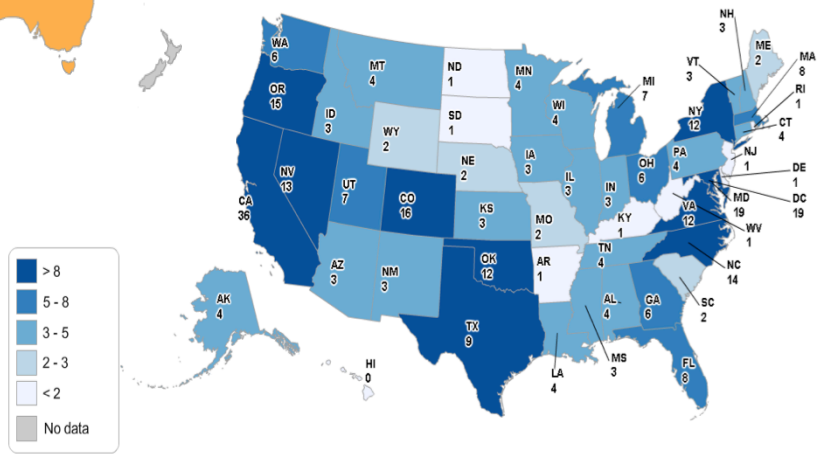
In-Person Training



ARSET: 2009 – 2015



52 Trainings
3000+ End-users
800+ Organizations



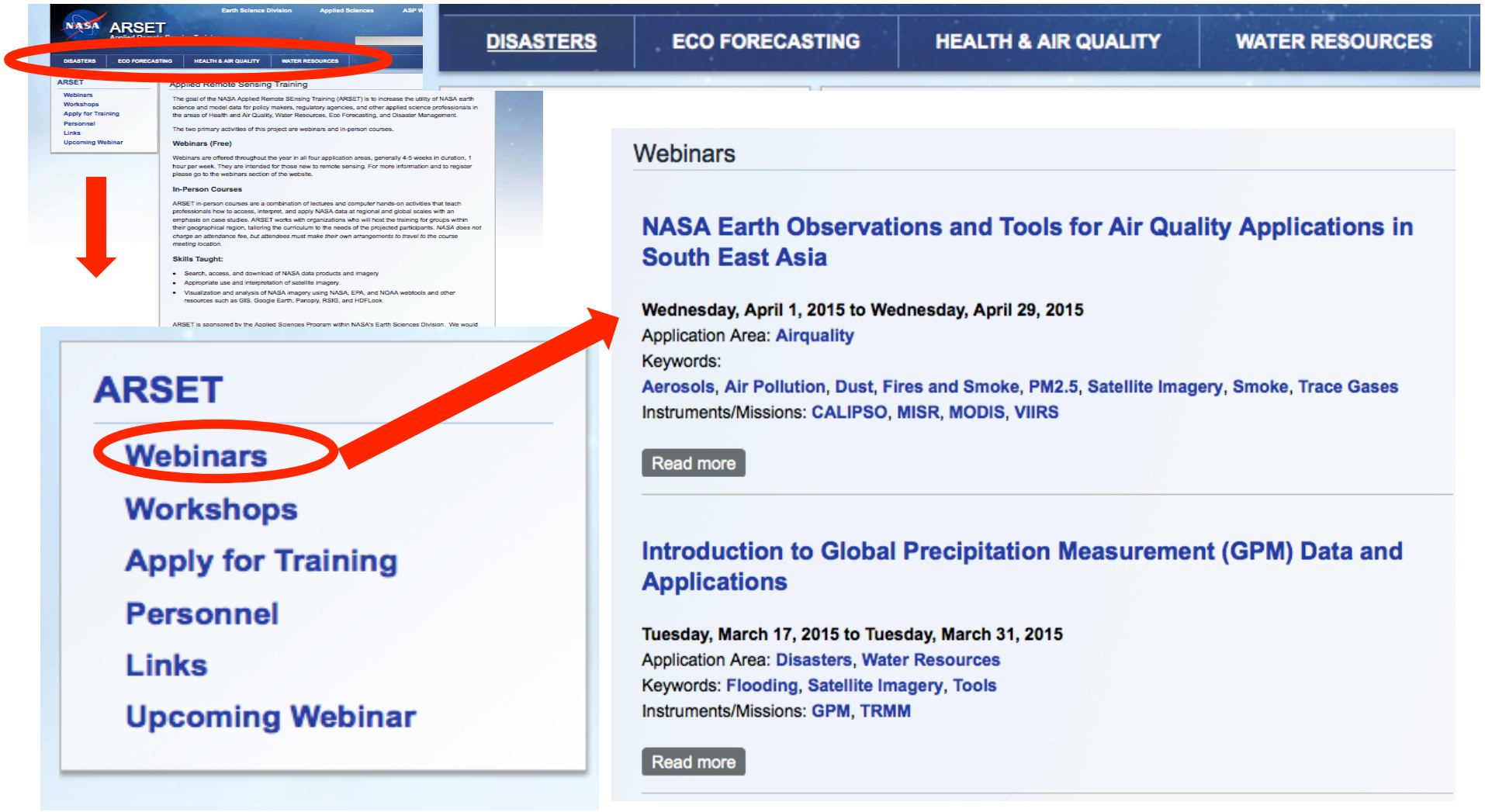
Number of participating organizations per country (above) and U.S State (right) : Air Quality, Water, Flood, and Land management

ARSET Website

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

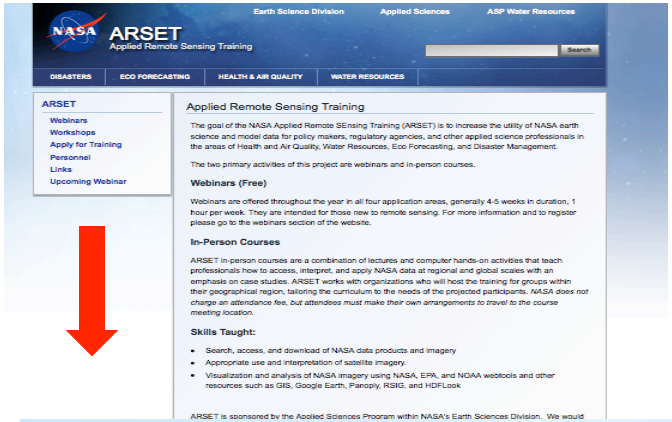
Access to ARSET Trainings

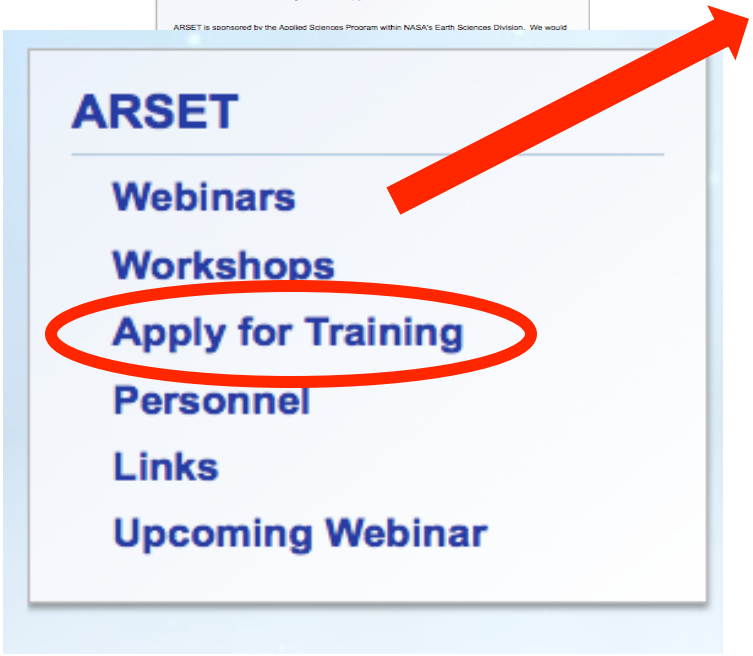
http://arset.gsfc.nasa.gov



Request a Training

http://arset.gsfc.nasa.gov





Apply for Training

The NASA Applied Remote Sensing Training Program provides webinars and in-person courses. The goal of these training activities is to build the capability and skills to utilize NASA earth science observations and model data for environmental management and decision-support. Courses are primarily intended for applied science professionals and decision makders from local, state, federal agencies, NGOS, and the private sector. ARSET also offers a Train the Trainers program, which is recommended for establishing or growing your organizations' capacity in applied remote sensing.

ARSET trainings are NOT designed for research but for operational and application driven organizations.

To apply for a training email Ana Prados at **Ana.I.Prados@nasa.gov**

The program offers four types of courses. For in-person courses, applicants must provide a computer laboratory or similar facility.

1. Overview webinar course: held over a period of 4-5 weeks, 1 hour per week
2. Basic hands-on: In person applied remote sensing course for those new to remote sensing. Generally 2-3 days in length held. It is highly recommended that attendees first take the webinar course.
3. Advanced hands-on: In person applied remote sensing course that builds the skills to use NASA data for a specific environmental management problem. Intended for those who have already taken the basic course or have previous experience using NASA data and resources. Generally 1-2 days in length.
4. Train the Trainers: In person applied remote sensing course intended for existing remote sensing/geospatial trainers within the organization/institution/agency.

ARSET ListServ

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

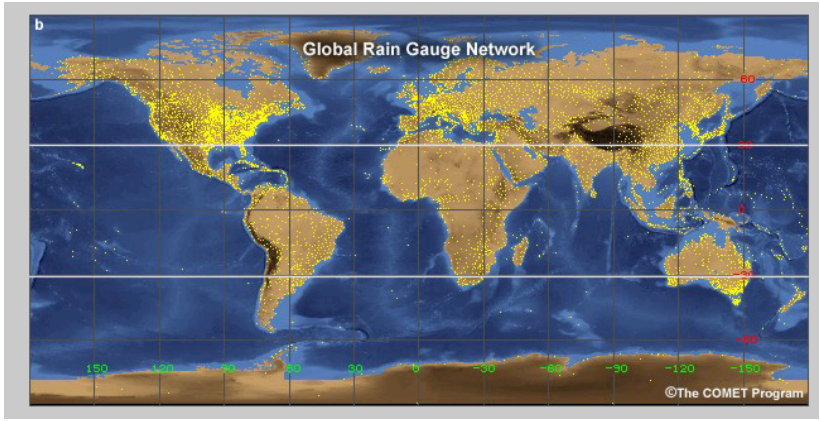
https://lists.nasa.gov/mailman/listinfo/arset

Advantages of Remote Sensing Observations

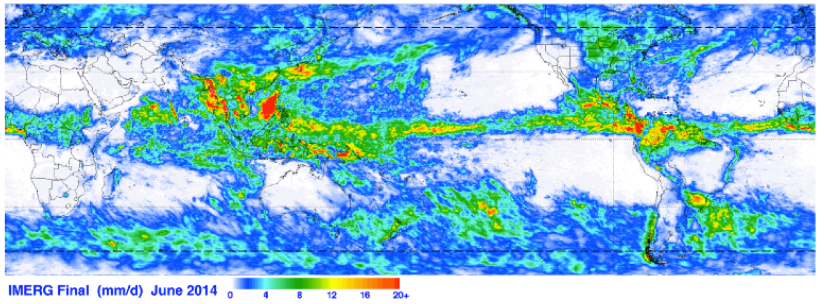
Remote Sensing Observations Augment Surface Observations

- Provide information where surface-based measurements are not available and augment existing measurements
- Provide global/near-global coverage with consistent observations

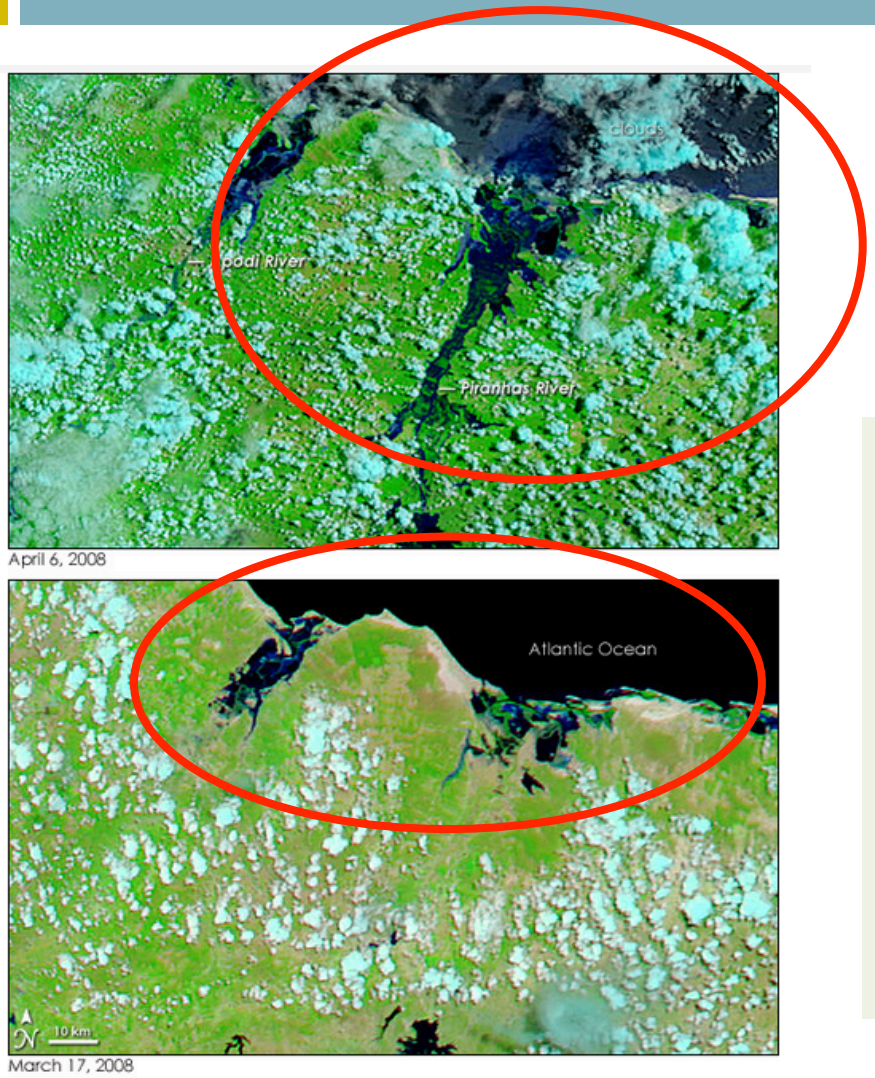
Non-uniform Coverage
of Surface Measurements



Continuous Coverage
From TRMM Multi-satellite Precipitation



Remote Sensing observations provide continuous, large-scale coverage compared to point measurements



From NASA Earth Observatory

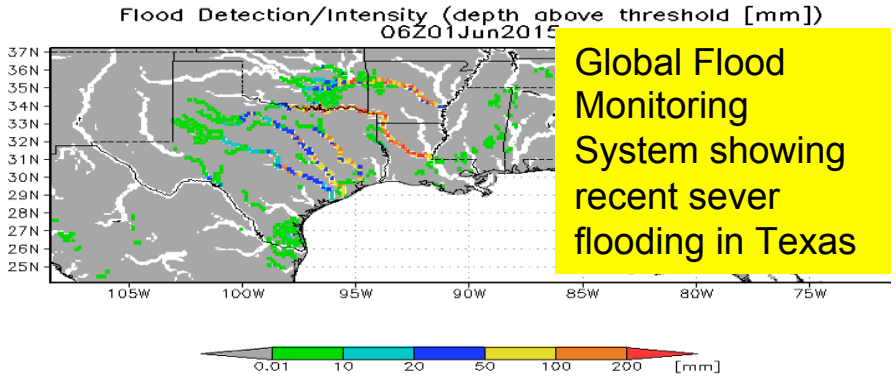
http://earthobservatory.nasa.gov/IOTD/view.php?id=8641

These images are from the Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on NASA's Terra and Aqua satellites.

The images show flooding conditions in Piranhas and the Apodi Rivers in Brazil. The rivers are much wider on April 6, 2008 (upper image) than on March 17, 2008 (lower image).

Remote Sensing Observations Can be Used in Flood Modeling

- NASA Remote Sensing-based precipitation, surface temperature, winds, terrain, and land-cover are used to model flood intensity



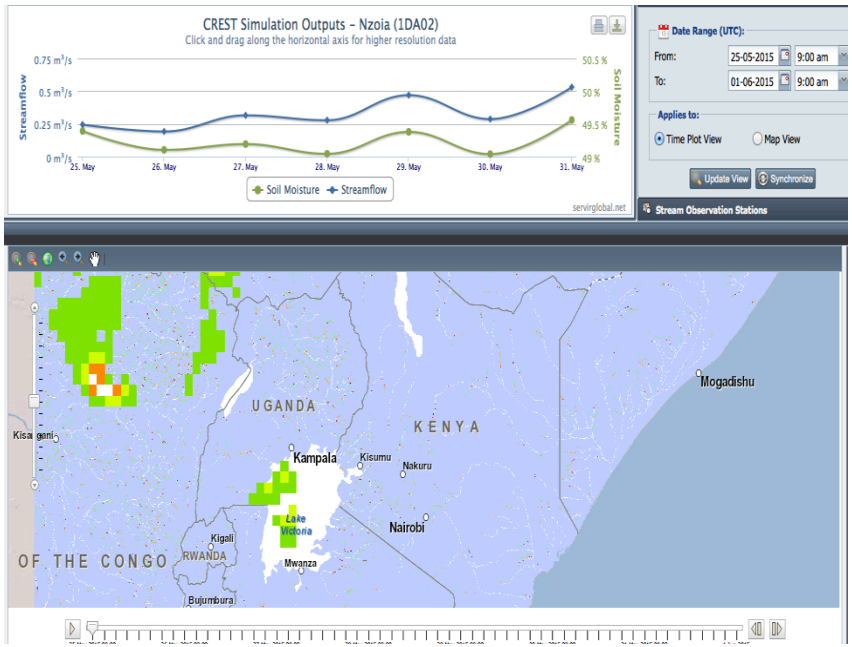
Global Flood Monitoring System showing recent sever flooding in Texas

http://flood.umd.edu/

Satellite-based rainfall observations used in a flood model based on the University of Washington Variable Infiltration Capacity (VIC) land surface model coupled with the University of Maryland Dominant River Tracing Routing (DRTR) model

Satellite-based Rainfall Observations Used in the CREST Hydrology Model to Monitor Flooding Over East Africa

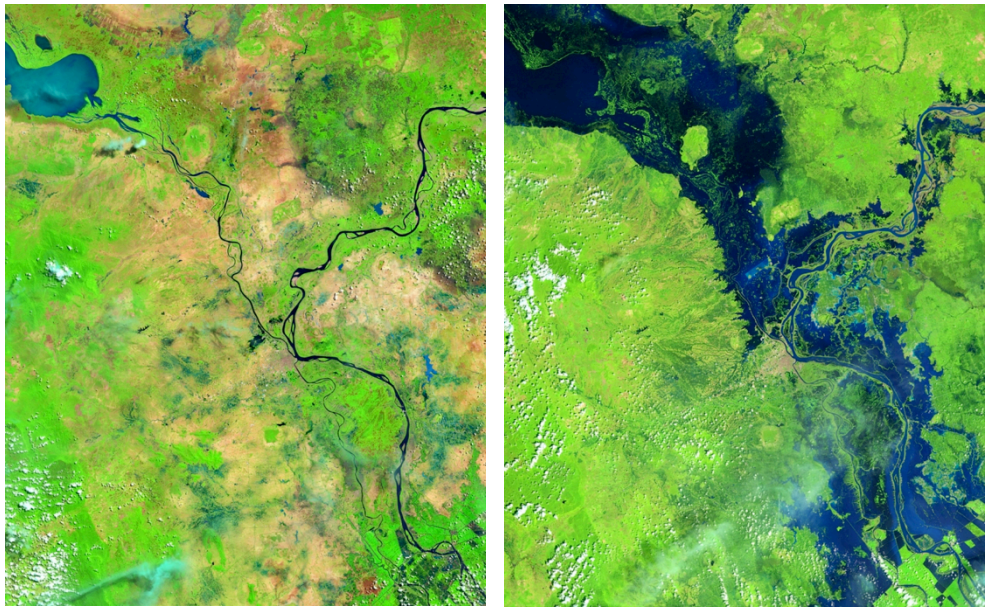
http://ags.servirlabs.net/crestviewer/



NASA Remote Sensing Data Used for Flood Relief

http://www.nasa.gov/content/goddard/when-waters-rise-nasa-improves-flood-safety/#.VWx36qbWq1l

Before and After Images:



In October 2013, Typhoon Nari followed heavy seasonal rains to create substantial flooding along the Mekong and Tonlé Sap rivers in Cambodia. The flood affected more than a half-million people, and more than 300,000 hectares (about three-quarters of a million acres) of rice fields are believed to have been destroyed. Both images were taken by the Operational Land Imager aboard Landsat 8.

The United Nations World Food Programme, which delivers food relief to inundated areas, uses NASA Earth science satellite-based flood maps to locate floods and map delivery routes to affected areas.

Contractors with the U.S. Federal Emergency Management Agency (FEMA) also use Landsat imagery to track urban development, which can affect an area's flood risk.

Fundamentals of Remote Sensing

- *What is Remote Sensing?*
- *Types of Satellite Sensors*
- *Satellite Remote Sensing Attributes : Spatial and temporal Resolution and Coverage*

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?

What is Satellite Remote Sensing?

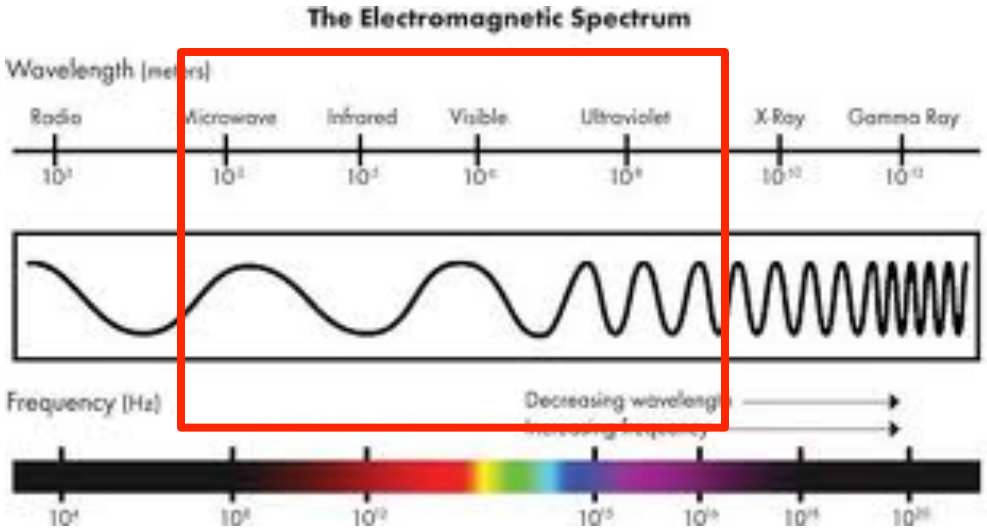
Measuring properties of the earth-atmosphere system from space

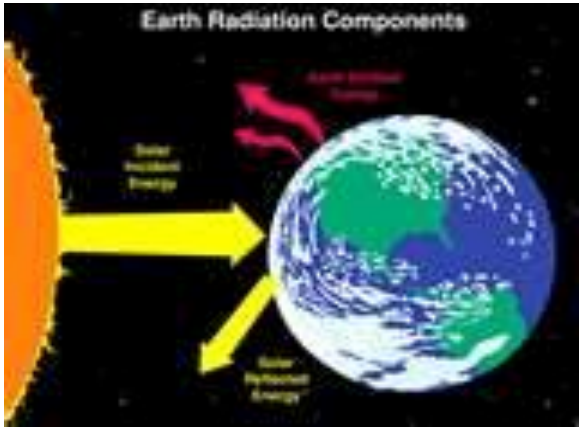
Earth-Ocean-Land-Atmosphere System :

- reflects solar radiation back to space
- emits infrared radiation and microwave radiation to space

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

The Electromagnetic Spectrum

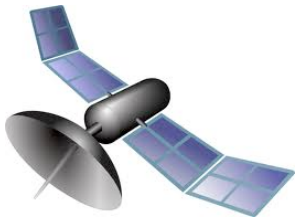


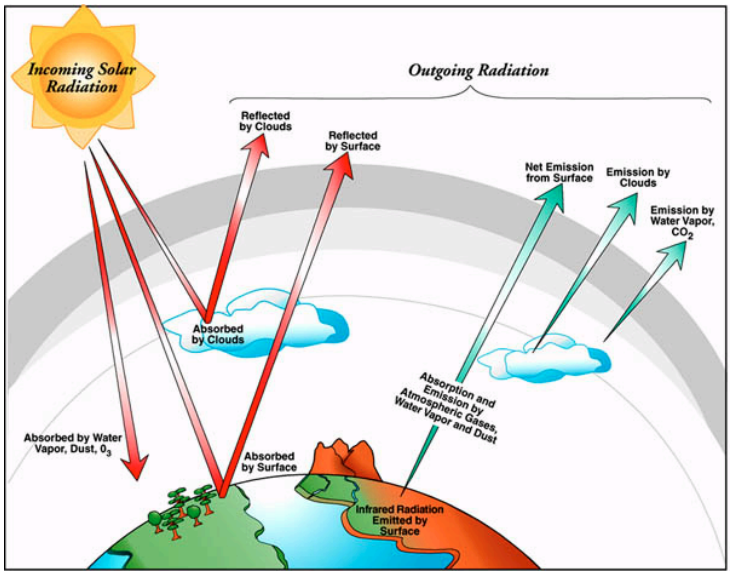


Measuring Properties of the Earth-Atmosphere System from Space

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

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





Satellite Sensors

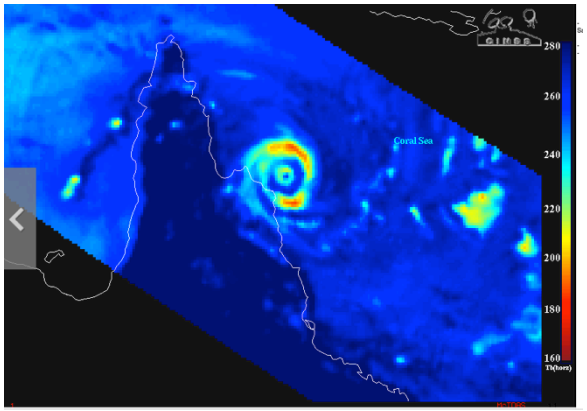
Passive remote sensors

measure radiant energy
reflected or emitted by the
earth-atmosphere System

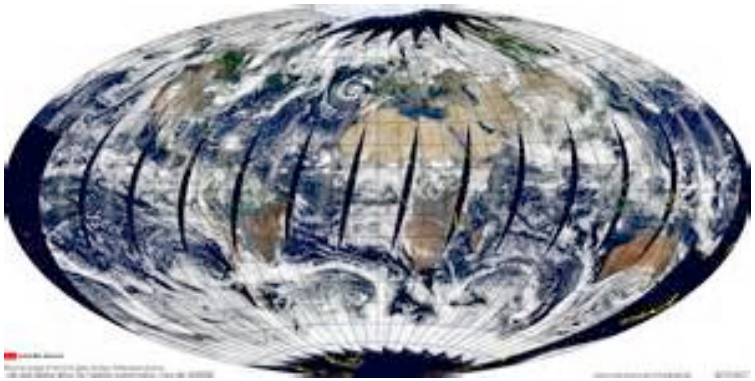
Radiant energy is converted to
bio-geophysical quantities
such as temperature,
precipitation, soil moisture,
chlorophyll-a

Examples: TRMM Microwave
Imager, MODIS, AIRS

TRMM TMI 85 GHz Microwave Image
cimss.ssec.wisc.edu



MODIS Reflectance Image
earthobservatory.nasa.gov

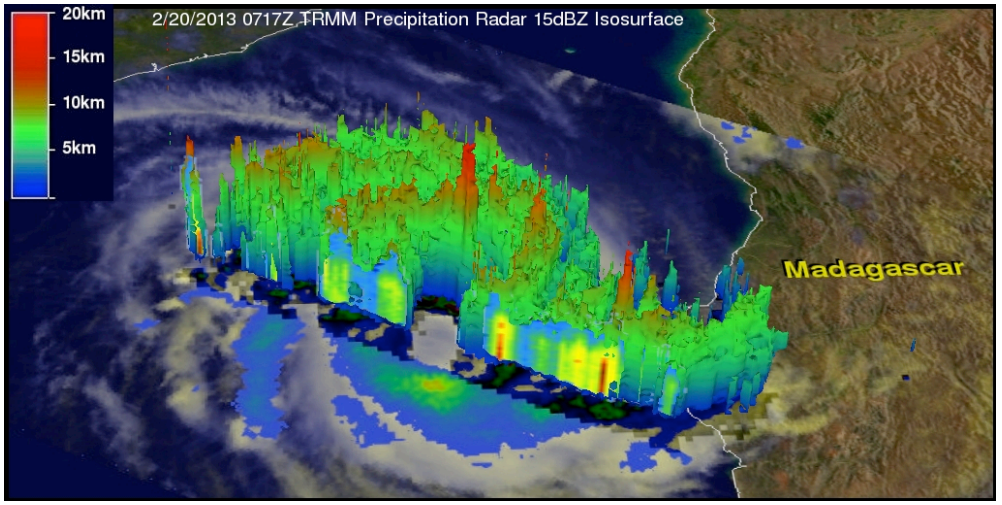


Satellite Sensors

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

Examples: Radar, LIDAR



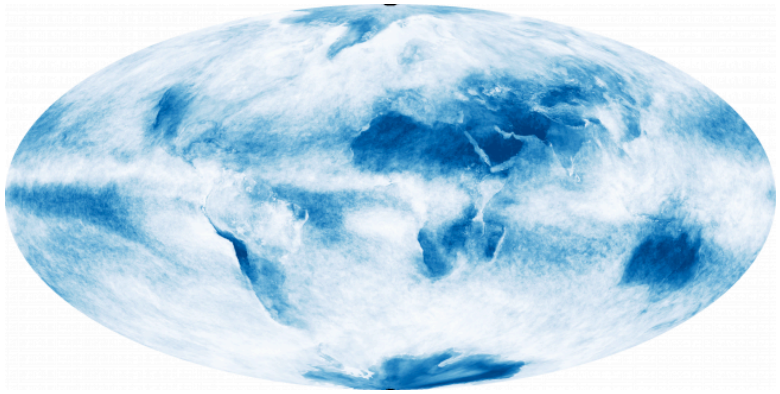
The 3-D image was derived from a TRMM Precipitation Radar (PR) slice through tropical storm Haruna's center pmm.nasa.gov

Satellite Sensors

Imagers: Create Images

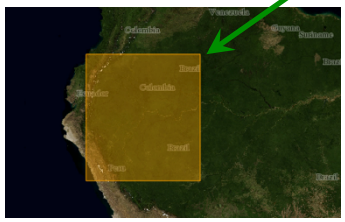
Examples: MODIS, TMI

Cloud Image from MODIS

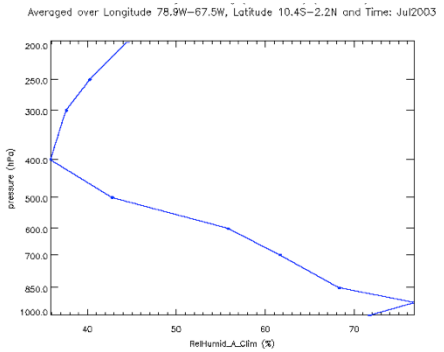


Sounders: Provide vertical profiles

Examples: AIRS



Regional Relative Humidity Profile from AIRS



Spatial and Temporal Resolutions of Satellite Measurements

Depend on the satellite orbital configuration and sensor design

- **Spatial Resolution:**

  Determined by its pixel size -- pixel is the smallest unit measured by a sensor

- **Spatial Coverage:**

  The geographical area covered by a satellite

- **Temporal resolution:**

  How frequently a satellite observes the same area of the earth

- **Temporal Coverage:**

  Time span or life-time of a satellite for which measurements are available

Spatial and Temporal Resolutions of Satellite Measurements

Depend on the satellite orbital configuration and sensor design

- **Spatial Resolution:**

  Determined by its pixel size -- pixel is the smallest unit measured by a sensor

- **Spatial Coverage:**

  The geographical area covered by a satellite

- **Temporal resolution:**

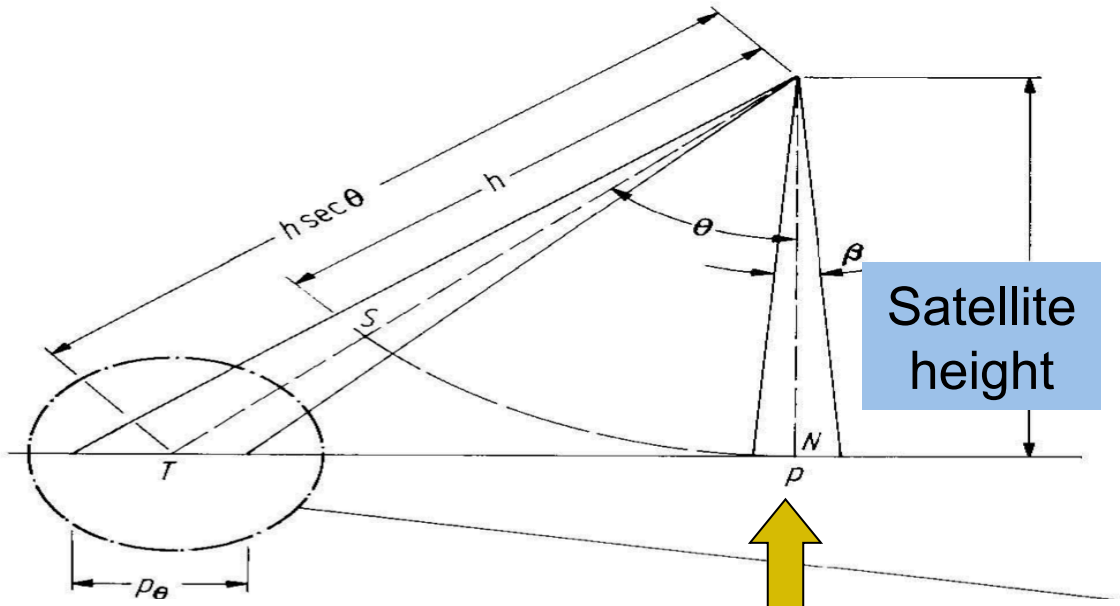
  How frequently a satellite observes the same area of the earth

- **Temporal Coverage:**

  Time span or life-time of a satellite for which measurements are available

Spatial Resolution

- A simple definition is the pixel size - smallest size - that satellite images cover
- Satellite images are organized in rows and columns called raster imagery and each pixel has a certain spatial size

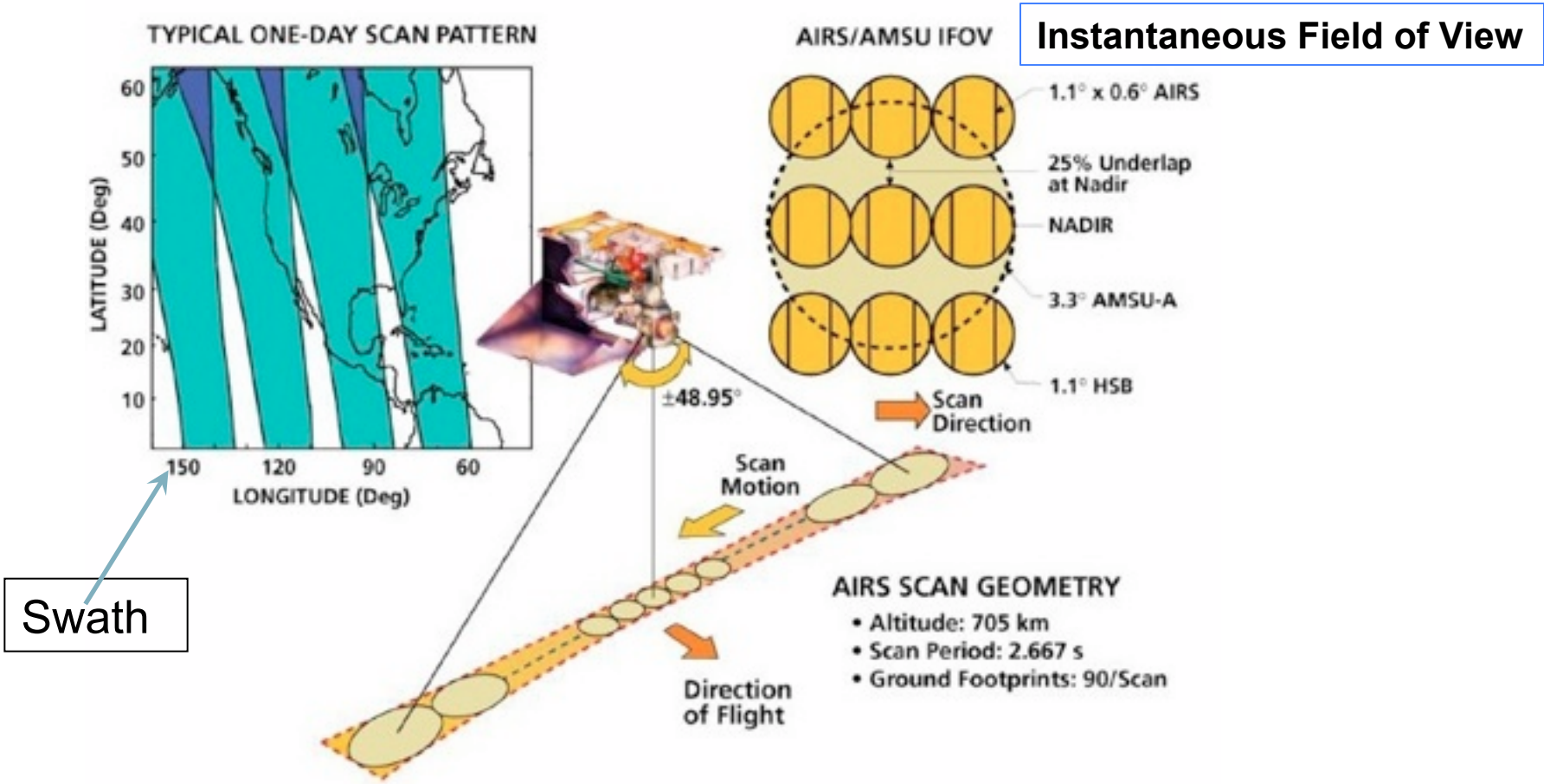


Off-nadir pixel size

Nadir pixel size

Spatial resolution

Example (AIRS -- Atmospheric Infrared Sounder)



AIRS is flying aboard NASA's Aqua satellite

Spatial Resolution

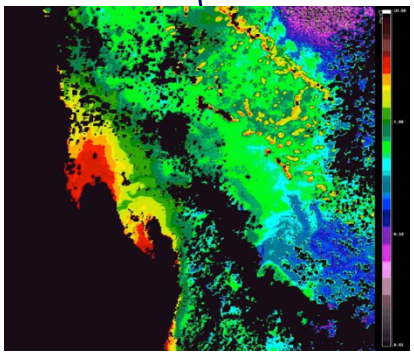
Varies with satellite/sensor

Landsat-7 Image of Niger River Delta

Spatial resolution: 30 m

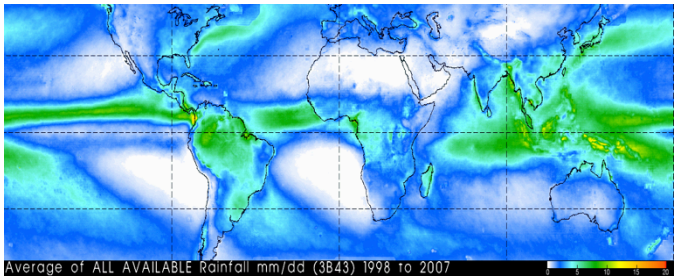
Chlorophyll from Terra/MODIS:

Spatial resolution: 1 km

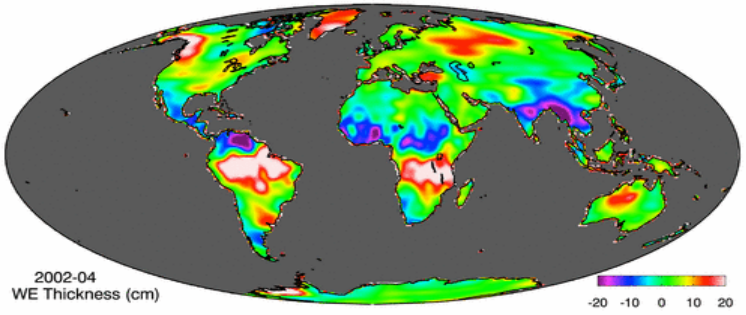


TRMM and Multi-satellite Rain Rate

Spatial resolution: 25 km



Terrestrial Water Storage Variations from GRACE: Spatial resolution: ~100 km or coarser (Courtesy: Matt Rodell, NASA-GSFC)



Spatial Coverage and Temporal Resolution of Satellite Measurements

Depend on the satellite orbit configuration and sensor design

- **Spatial Resolution:**

  Determined by its pixel size -- pixel is the smallest unit measured by a sensor

- **Spatial Coverage:**

  The geographical area covered by a satellite

- **Temporal resolution:**

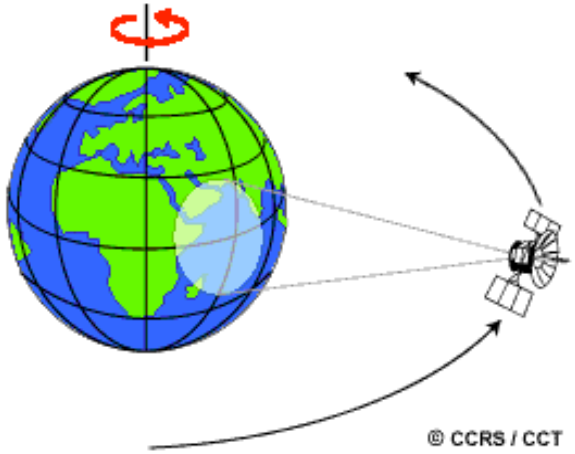
  How frequently a satellite observes the same area of the earth

- **Temporal Coverage:**

  Time span or life-time of a satellite for which measurements are available

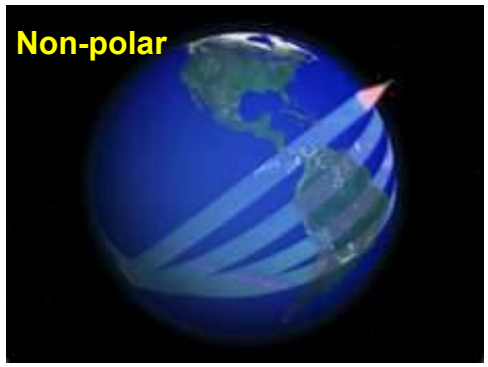
Types of Satellite Orbits

Geostationary orbit

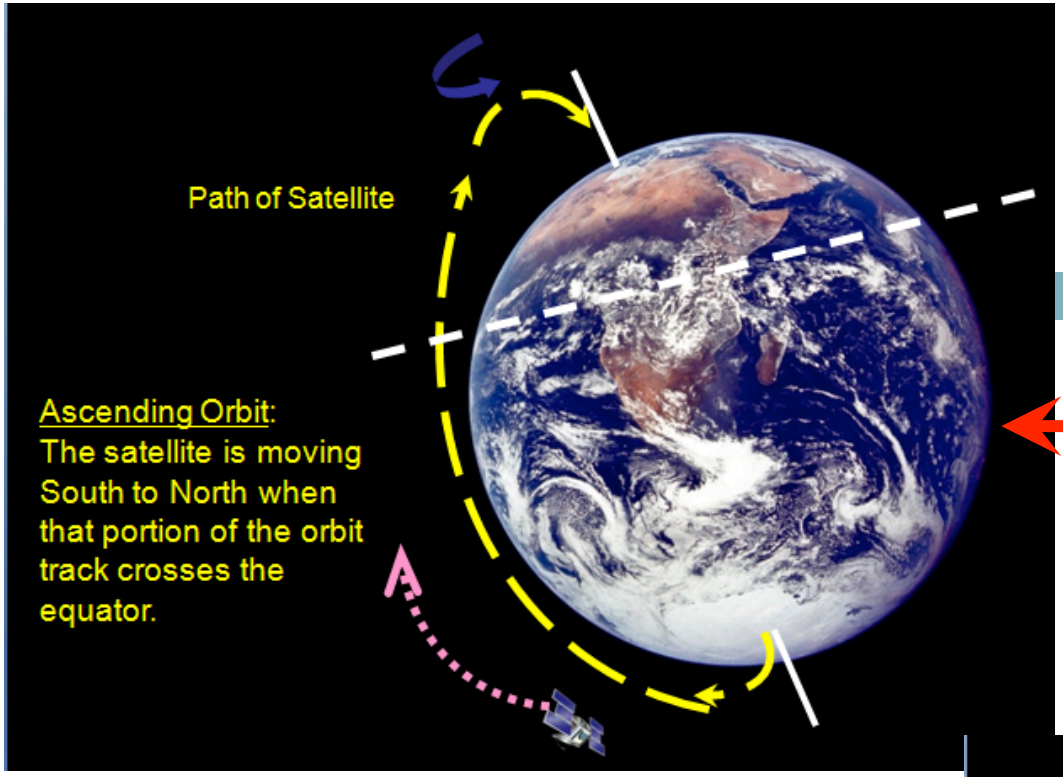


Satellite is ~36,000 km above earth the equator. Same rotation period as earth's. Appears 'fixed' in space.

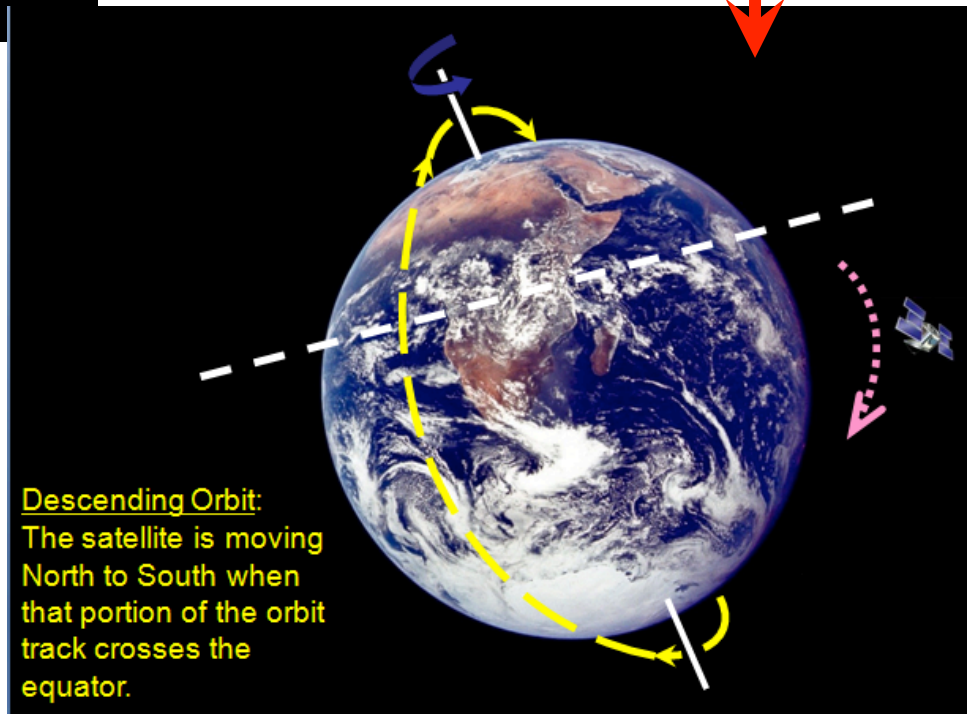
Low Earth Orbit (LEO)



Circular orbit constantly moving relative to the Earth at 160-2000 km. Can be in Polar or non-polar orbit



Ascending vs Descending



Polar Orbits

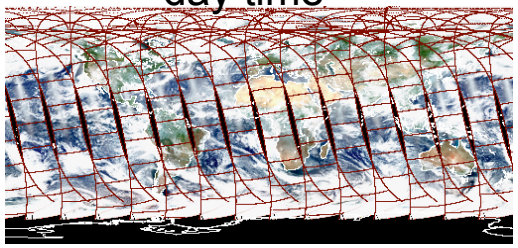
Spatial Coverage and Temporal Resolution of Satellite Measurements

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

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

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

Aqua ("ascending" orbit) day time



TRMM Image

GOES Image

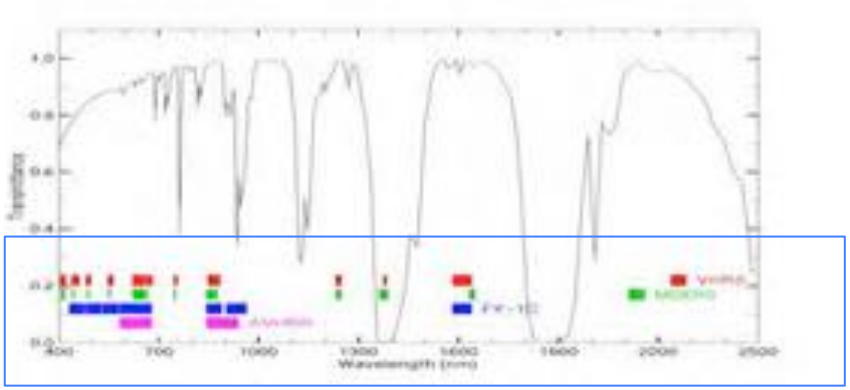
Spectral and Radiometric Resolutions

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



Spectral Bands and Resolution for various sensors
cimss.ssec.wisc.edu

Overview of Remote Sensing Observations for Flood Monitoring

Primary Uses of Remote Sensing Observations for Flood Monitoring

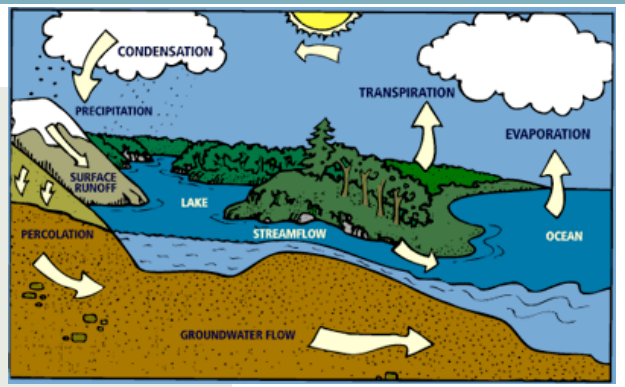
There are three primary uses of remote sensing observations for flood monitoring

1) To infer flooding conditions by using satellite-derived precipitation

2) To derive streamflow and runoff to monitor flooding conditions by using rainfall and surface weather data in a hydrology model

3) To detect flood water on previously dry land surface by using satellite-derived land-cover observations

Hydrological Information Crucial for Flood Monitoring



- Rain Rate and Accumulated Rain Amount
- Snow Melt Rate
- Soil Condition: soil moisture, temperature, land cover
- Reservoir/River Level
- Storm Water Drainage System (urban floods)
- Terrain

NASA Satellites and Atmosphere-land Models for Flood Monitoring

- Rain
- Surface Temperature
- Soil Moisture
- Snow/Ice
- Clouds
- Terrain*
- Ground Water
- **Land Cover***
- Evapotranspiration
- Run off

Useful for direct observations of flooding conditions and/or for inputs to hydrology models

*Terrain Data are available from the Shuttle Radar Topography Mission

*Land Cover is used for detecting inundated surface surface

All these quantities are available from satellite observations as well as from models
Quantities in green are derived from satellite observations
Quantities in red are from land and atmosphere-land models in which satellite observations are assimilated

NASA Satellites for Flood Monitoring

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

Landsat (07/1972-present)

TRMM (11/1997-04/2015)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

NASA Satellites for Flood Monitoring

- The focus of this webinar will be on TRMM/GPM and Terra/Aqua Data Used for Flood Monitoring
- The webinar will include web-based tools that provide access to TRMM and Terra/Aqua observations for near-real time flood monitoring and inundation mapping

TRMM: Tropical Rainfall Measuring Mission
GRACE: Gravity Recovery and Climate Experiment
GPM: Global Precipitation Measurements
SMAP: Soil Moisture Active Passive

Landsat (07/1972-present)

TRMM (11/1997-04/2015)

GPM (2/27/2014-present)

Terra (12/1999-present)

Aqua (5/2002-present)

SMAP (1/31/2015-present)

GRACE (3/2002-present)

Hydrological and Land Parameters from TRMM, GPM, Terra & Aqua/MODIS used for Flood Monitoring

Satellite	Sensors	Quantities
TRMM	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS)	Rain Rate, Vertical Rain Rate Profile,
GPM	Dual-frequency Precipitation Radar (DPR) GPM Microwave Imager (GMI)	Rain Rate, Vertical Rain Rate Profile,
Terra and Aqua	MODerate Resolution Imaging Spectroradiometer (MODIS) (Note: MOIDS is one of several sensors flying on these satellites)	Snow Cover, Vegetation Index, Leaf Area Index, Land Cover, Cloud Cover

Products useful for Flood Monitoring

Details of the satellites/sensors/quantities will be provided in the subsequent webinar sessions

Overview of Flood Monitoring Tools

Flood Monitoring: TRMM/GPM
Inundation Mapping: Terra & Aqua/MODIS

TRMM/GPM provide direct observations of surface rainfall. The rainfall data:

i) are used to infer flooding conditions

ii) are used in conjunction with a hydrology model to derive streamflow or runoff

MODIS provides observations of land-surface characteristics. MODIS reflectance from various bands indicates the presence of water on land surface.

TRMM-based Flooding Tools

- TRMM Current Heavy Rain, Flood and Landslide EstimatesTool
  http://trmm.gsfc.nasa.gov/publications_dir/potential_flood_hydro.html

- Extreme Rainfall Detection System – Version 2 **(ERDS2)**
  http://playground.ithacaweb.org/apps/world/leaflet/erds2.html#layers

- Dartmouth Flood Observatory and Global Disaster Alert and Coordination System (GDACS) : *Experimental River Discharge Data using TRMM Imager*
  http://floodobservatory.colorado.edu/ http://www.gdacs.org/flooddetection/

- Global Flood Monitoring System (http://flood.umd.edu/)

(GPM data will replace the TRMM data)

Details of these web-tools will be provided in the next webinar session on 15th June

MODIS-based Inundation Mapping Tools

- MODIS NRT Global Flood Mapping (*http://oas.gsfc.nasa.gov/floodmap/*)
- Dartmouth Flood Observatory (http://floodobservatory.colorado.edu/)

Coming Up Next Week

- Overview of TRMM and GPM Precipitation Data
- TRMM-based Flood Monitoring Tools:
  - TRMM Current Heavy Rain, Flood and Landslide Estimates Tool
  - Extreme Rainfall Detection System – Version 2 **(ERDS2)**
  - Dartmouth Flood Observatory **AND**
    Global Disaster Alert and Coordination System (GDACS)/Global Flood Detection System *Experimental River Discharge Data using Microwave Imager*
  - Global Flood Monitoring System (Live Demo)

Thank You!

Amita Mehta

email: amita.v.mehta@nasa.gov