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

INTRODUCTION TO GLOBAL PRECIPITATION MEASUREMENTS (GPM) DATA AND APPLICATIONS

WEBINAR DATES: EVERY TUESDAY, MARCH 17, 24, 31
TIME: 8 TO 9 AM AND 1 TO 2 PM EDT

Outline

- About Applied Remote Sensing Training (ARSET) Program
- About This Webinar
- Week 1 : Precipitation Remote Sensing
  NASA Precipitation Missions TRMM* and GPM
  Precipitation Data Applications

*TRMM: Tropical Rainfall Measuring Mission

About ARSET

ARSET

NASA Applied Sciences Capacity Building Program

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

NASA Earth Science
Applied Sciences Program Thematic Areas

Agricultural Efficiency

Air Quality

Climate

Disaster Management

Ecological Forecasting

Public Health

Water Resources

Weather

Applied Remote Sensing Training (ARSET)

NASA Applied Sciences Capacity Building Program

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, and land management.

Accomplishments (2008 – 2014)

- 46 trainings completed
- 2300+ participants worldwide
- 700+ Organizations

ARSET: 2009 – 2013

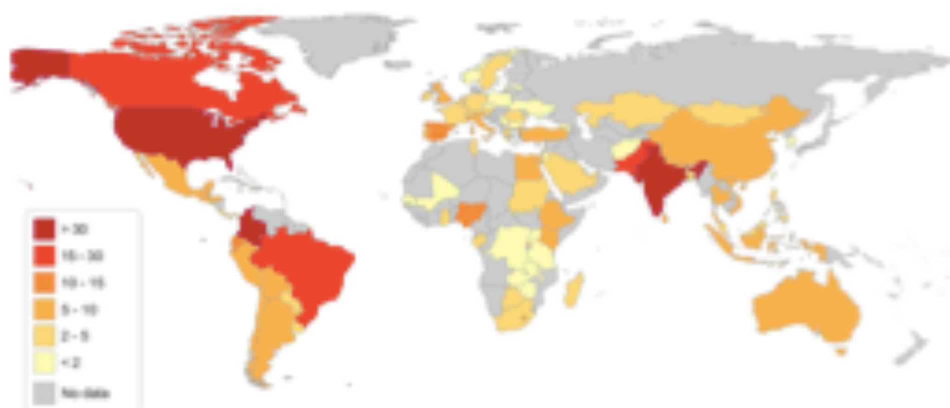
Number of participating organizations per country: Air Quality, Water Resources, Flood Monitoring.

46 courses

2300+ end-users

700+ organizations

Number of participating organizations per state (US) or country



ARSET Trainings on Water Resources/Flooding

Hands-on Trainings:

- University of Oklahoma, National Weather Center, June 2012, Water Resources
- World Bank, DC, March 2013, Flooding Applications
- Cartagena, Colombia, May 2015, Climate Variability and Flooding

Online Trainings:

Fall 2012 : Precipitation/Flooding/Drought

Spring 2013 and Winter 2014: Snow Products

Fall 2013: Water Resources Management

Fall 2013: Flood Monitoring

Fall 2014: Water Quality Monitoring

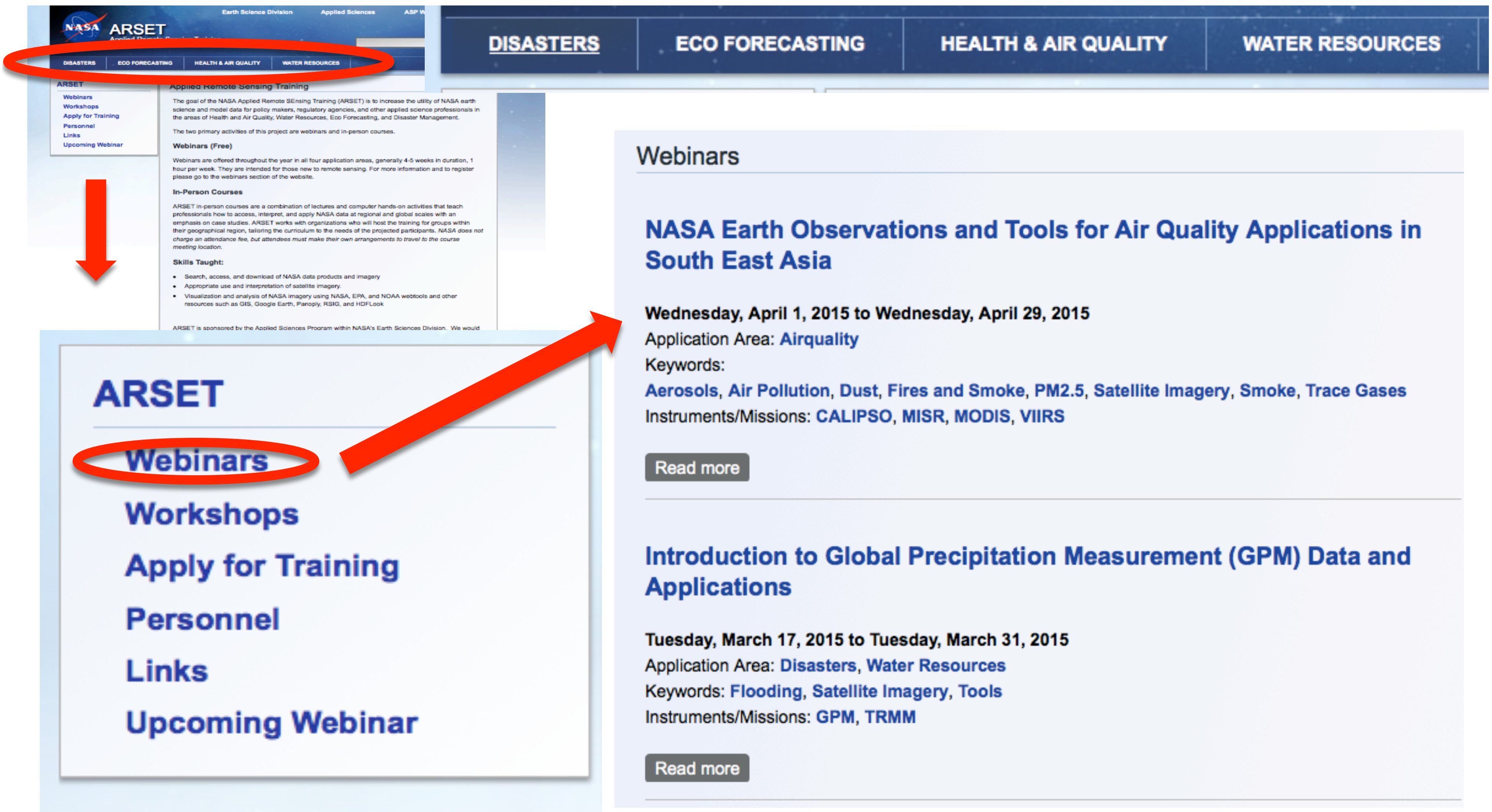
Presentation and Data Demonstration:

- USAID GeoCenter, Va, February 16, 2014, NASA Data for Water Resources and Disaster Management

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

ARSET Webinars Website

http://arset.gsfc.nasa.gov



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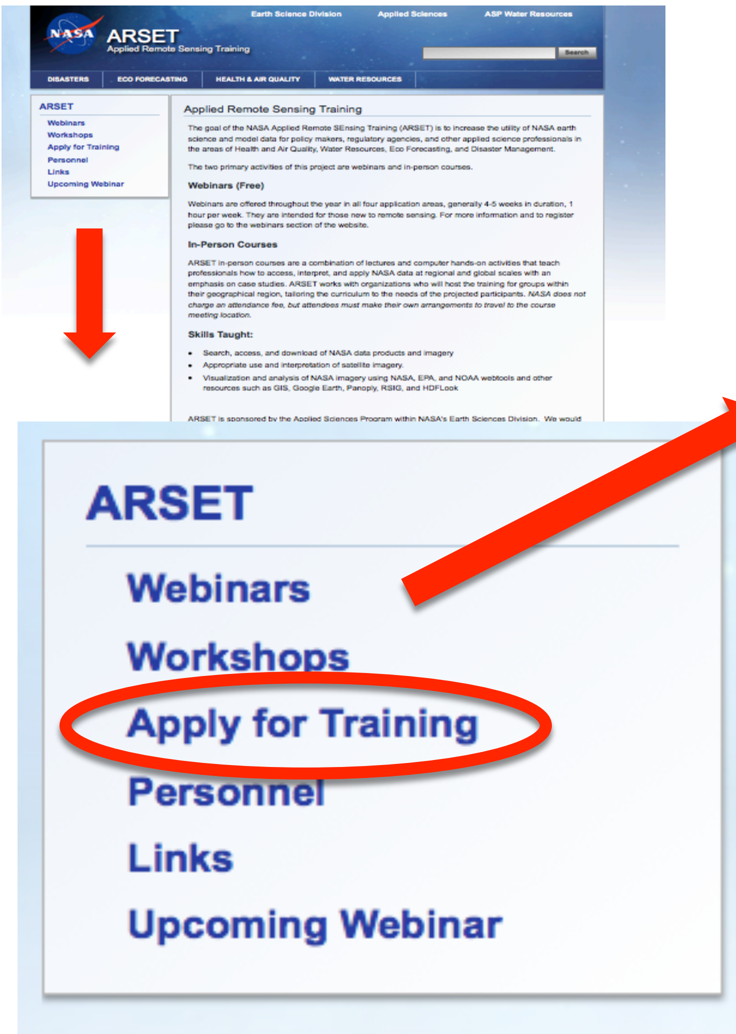


Apply for Training

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

About This Webinar

Why This Webinar Training?

- **Precipitation is the most important source of freshwater :** *Accurate measurements are crucial in planning water resources for drinking water, agriculture, hydro-power, health, ecosystems, and flood management*

- A NASA satellite, Tropical Rainfall Measuring Mission (TRMM), designed specifically for precipitation remote sensing, combined with data from other national and international satellites provide near-real time as well as ~15 years of high quality measurements which are used for a variety of societal applications

- NASA launched the Global Precipitation Measurement (GPM) Mission in February 2014 to ensure continued availability of improved quality, near-global precipitation data for societal applications and environmental decision support

Training Objectives

- Provide overview of TRMM and GPM missions and data with examples of precipitation data for environmental applications
- Introduce web-tools for access and analysis of GPM data
- Demonstrate GIS Applications of GPM data

Training Instructors

- Amita Mehta (ARSET): amita.v.mehta@nasa.gov
- Brock Blevins (ARSET): bblevins37@gmail.com
- George Huffman (week 3): (NASA-GSFC): george.j.huffman@nasa.gov

General inquiries about ARSET:
Brock Blevins (ARSET) bblevins37@gmail.com
Ana Prados (ARSET) aprados@umbc.edu

Webinar Schedule

- Three sessions, one lecture per week – every Tuesday (March 17, 24, and 31, 2015)

  8-9 AM and 1-2 PM Eastern US time

- Q/A: 15 minutes following each lecture

- One on-line assignment at the end of Week-3

- Webinar presentations can be found at: http://arset.gsfc.nasa.gov/water

Important Information

Certificate of Completion (upon request):

You must attend all 3 live sessions

You must submit the homework assignment

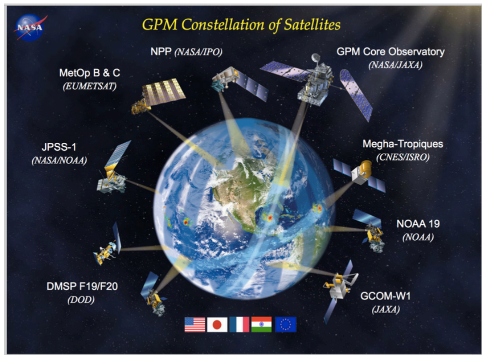
(homework assignment link will be provided after Week-3)

Contact : Marines Martins

Email: marines.martins@ssaiha.com

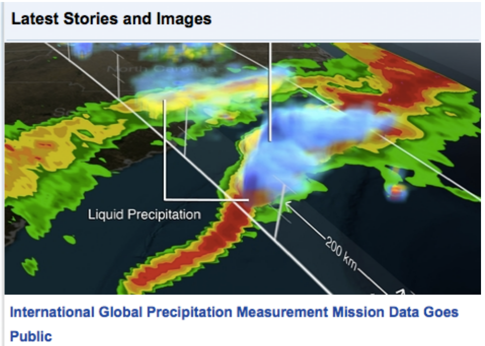
Webinar Outline

Week 1



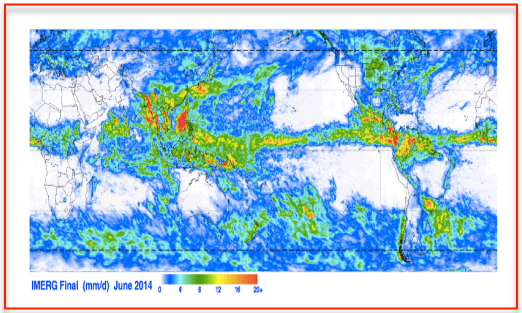
Precipitation Remote Sensing Overview of TRMM and GPM

Week 2



TRMM/GPM Data Products and Data Access Tools

Week 3



GPM-IMERG Data Demonstration of Data Access and GIS Applications

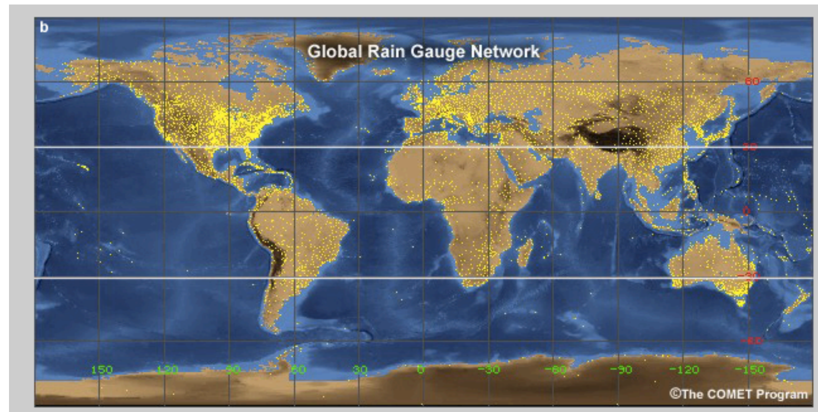
Week 1 Agenda

- Advantages of Precipitation Remote Sensing
- Fundamentals of Remote Sensing
- Overview of TRMM and GPM Missions and Sensors
- Examples of Precipitation Data Applications

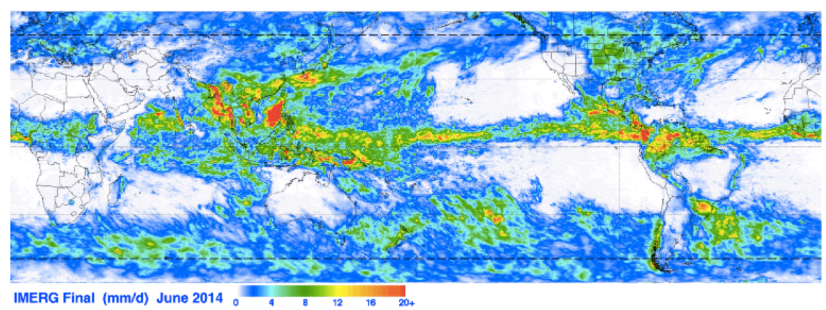
Advantages of Remote Sensing

- Provides information where there are no surface-based measurements available and augments existing measurements
- Provides global/near-global coverage with consistent observations
- Provides continuous, large-scale coverage compared to point measurements

Non-uniform Coverage
of Surface Measurements



Continuous Coverage
From TRMM Multi-satellite Precipitation



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

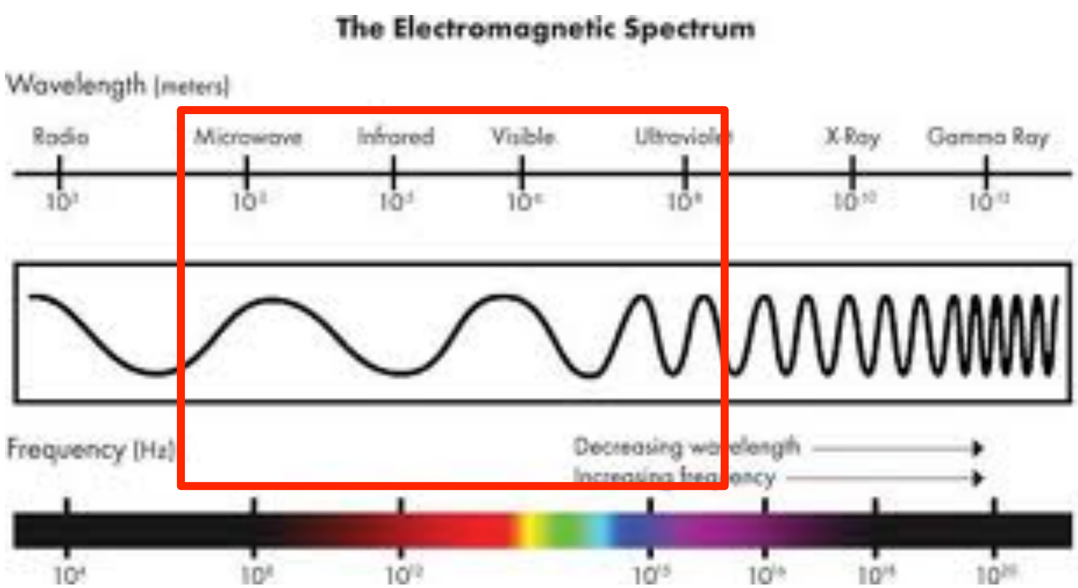
What is Satellite Remote Sensing?

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

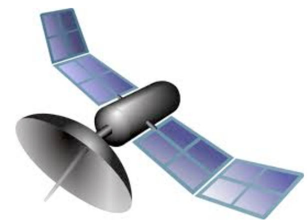
- ❑ Satellites carry **instruments or sensors which measure electromagnetic radiation** coming from the earth-atmosphere system

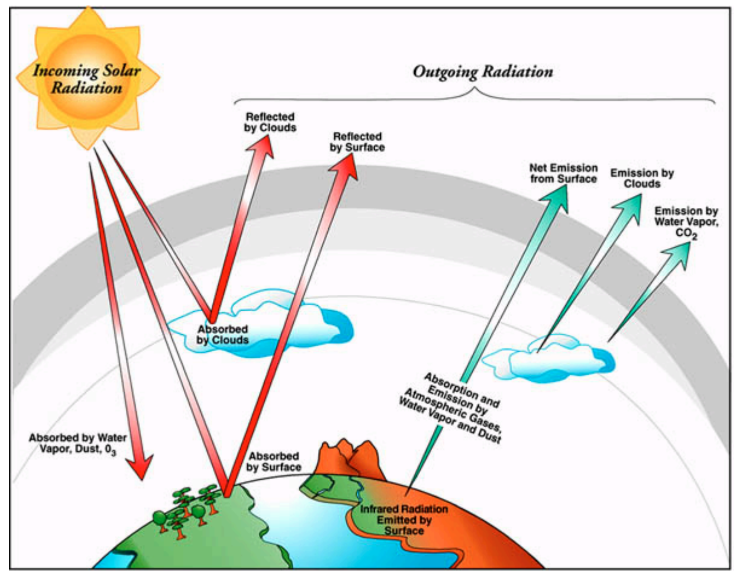


Measuring Properties of the Earth-Atmosphere System from Space

- 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





Satellite Sensors

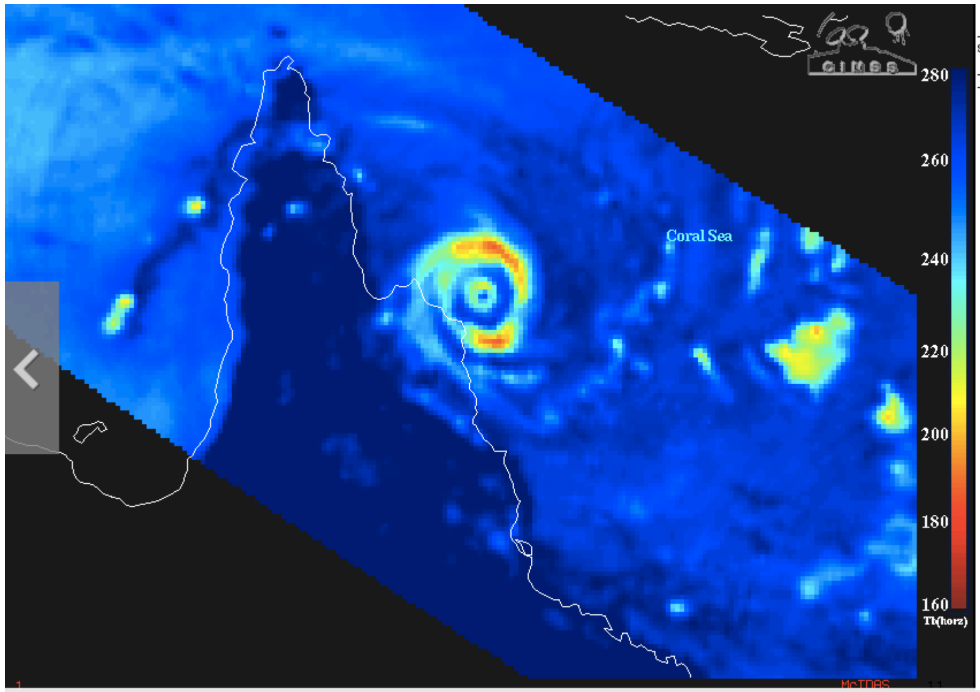
Passive remote sensors

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

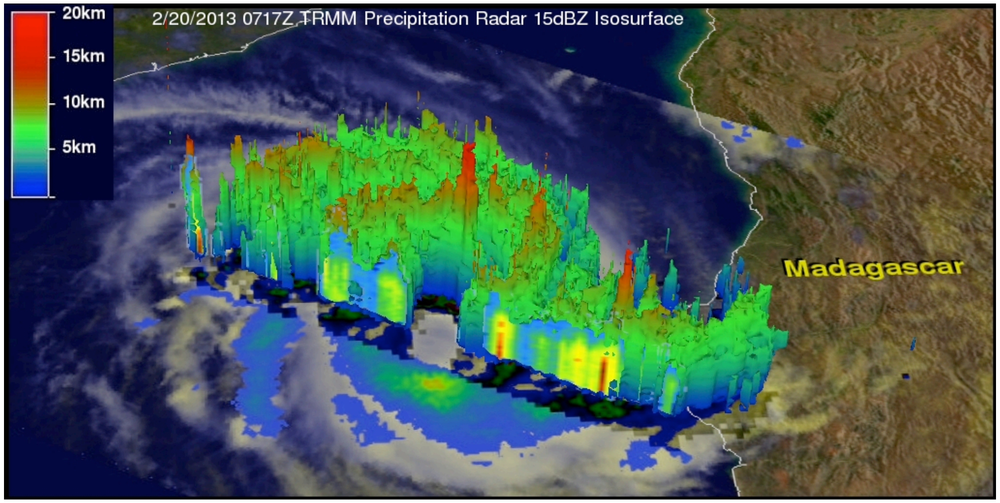
Satellite Sensors

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

The Spatial and Temporal Resolution of Satellite Measurements

Depends on the satellite orbit configuration and sensor design

- **Spatial Resolution:**

  Decided 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

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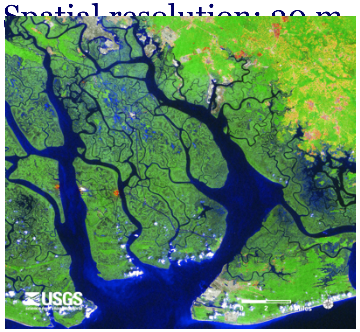
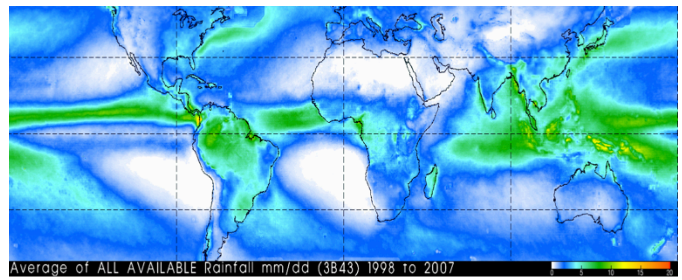
The Spatial Resolution

Varies with satellite/sensor

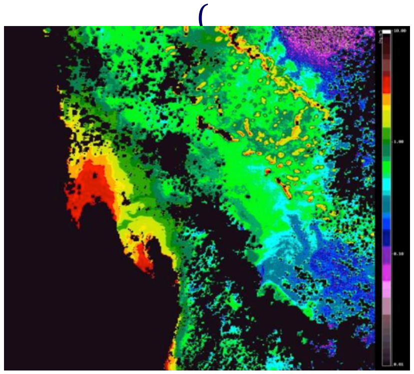
Landsat-7 Image of Niger River Delta
Spatial resolution: 30 m



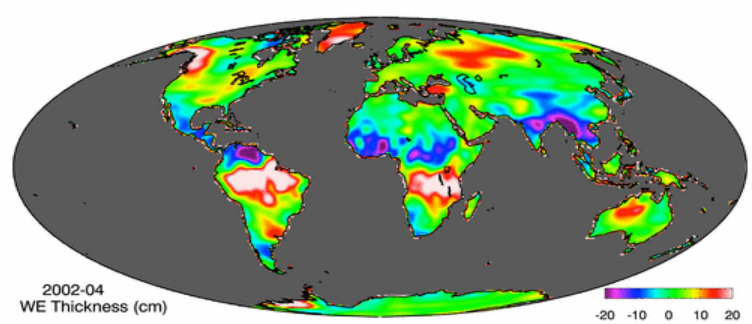
TRMM and Multi-satellite Rain Rate
Spatial resolution: 25 km



Chlorophyll from Terra/MODIS:
Spatial resolution: 1 km



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



The Spatial Coverage and Temporal Resolution of Satellite Measurements

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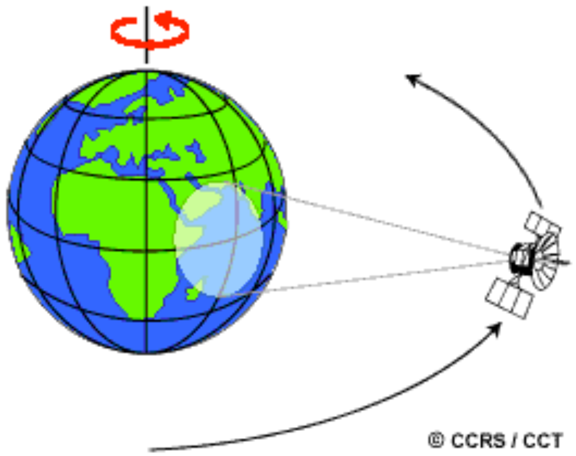
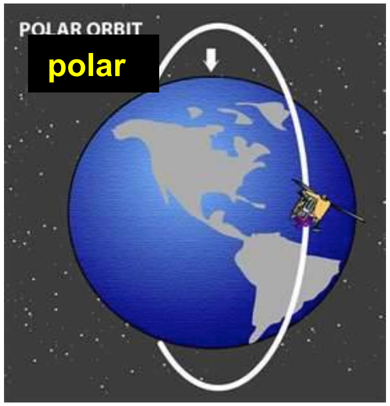
Types of Satellite Orbits

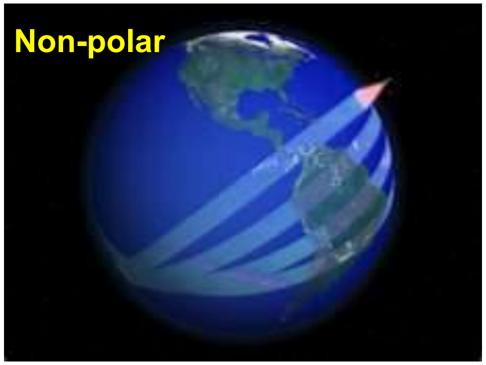
Geostationary orbit



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

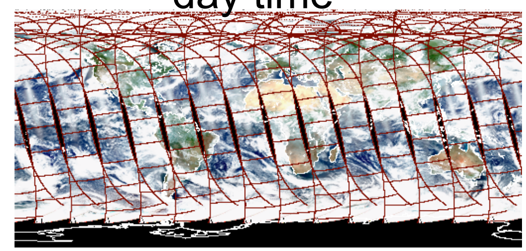
Spatial Coverage and Temporal Resolution of Satellite Measurements

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.

Non-Polar orbiting satellites: Less than one per day. Non-global coverage. Orbital gaps present. Larger 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:

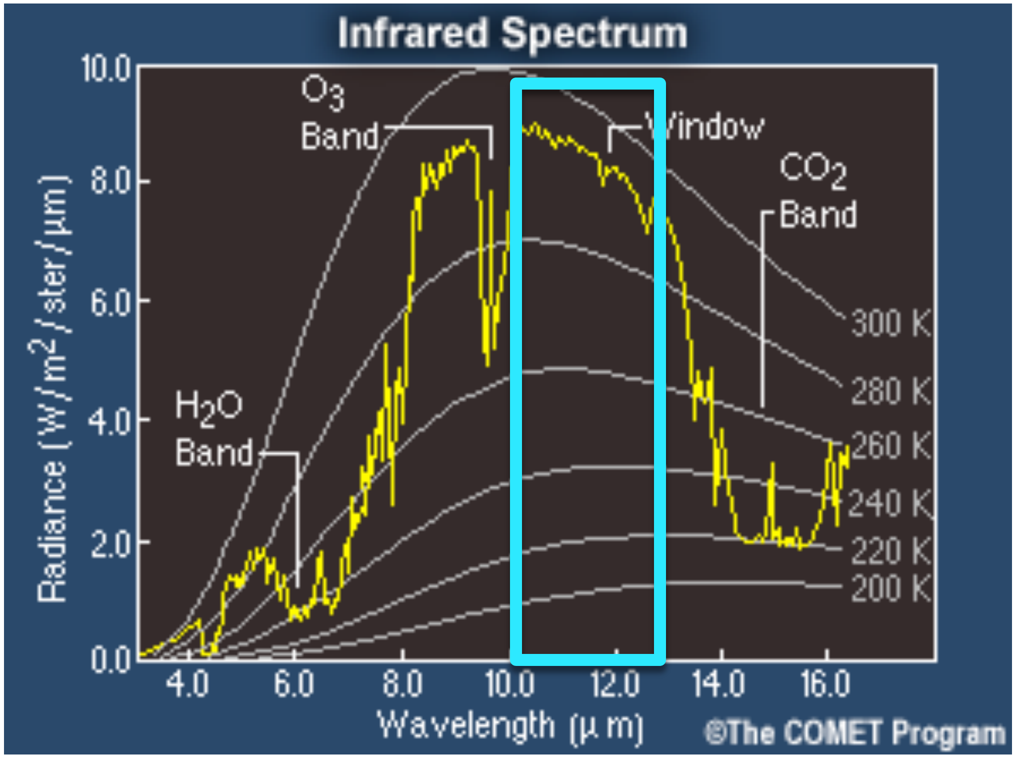
The number and width of spectral channels. More and finer spectral channels enable remote sensing of different parts of the atmosphere

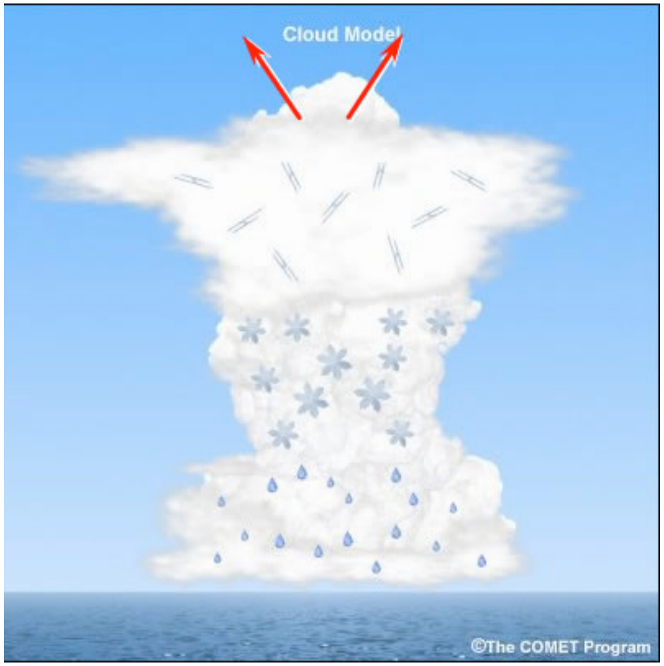
Radiometric Resolution:

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

Remote Sensing of Precipitation

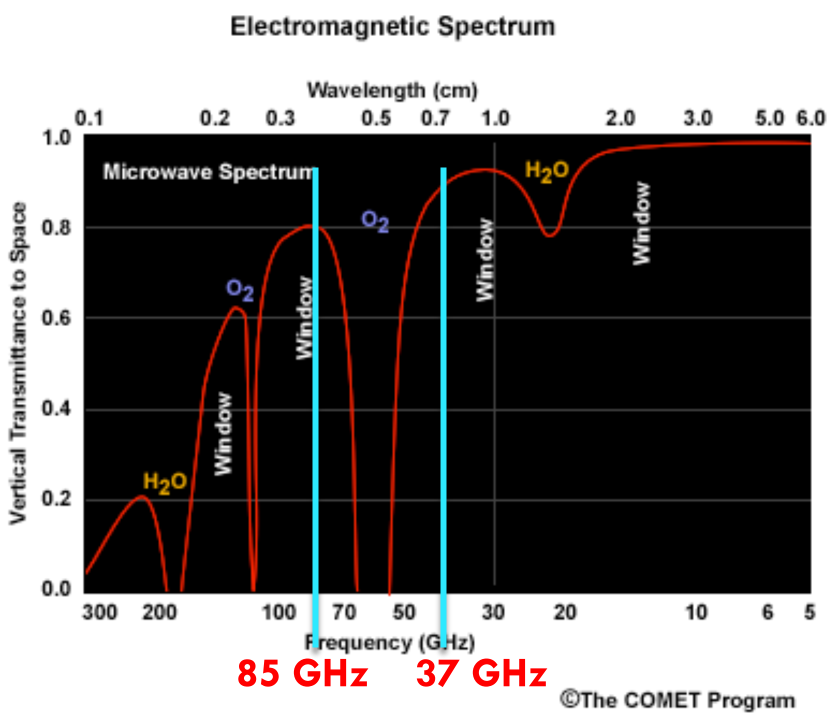
- Inferred indirectly from reflected solar radiation and emitted Infrared radiation by clouds **(Passive Remote Sensing)**





Remote Sensing of Precipitation

- Estimated from microwave radiation emitted or scattered by precipitation particles **(Passive Remote Sensing)**



From http://comet.ucar.edu

The lower frequencies, referred to as "emission channels," measure precipitation mainly from energy emitted by raindrops (37 GHz)

The higher frequencies, or "scattering channels," gather energy scattered by ice particles above the freezing level (85 GHz)

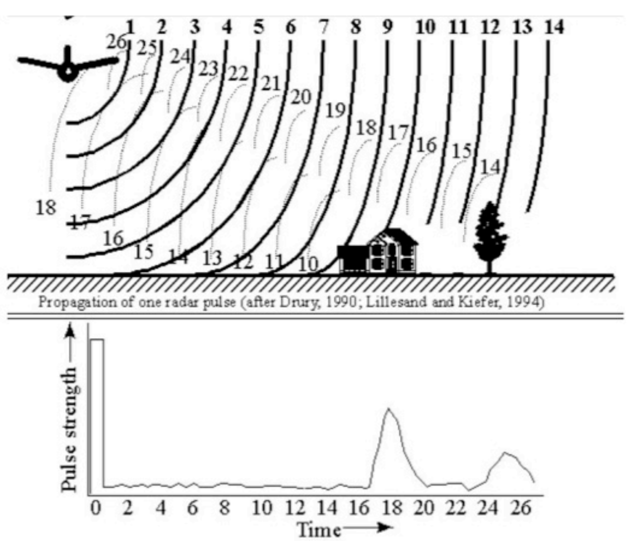
NASA Satellites TRMM and GPM include these frequencies

Remote Sensing of Precipitation

- Estimated from back-scattered microwave radiation transmitted by radars **(Active Remote Sensing)**

Active Remote Sensing

Source: Instrument pulse
Needs power to operate



From http://pmm.nasa.gov/

NASA Satellites TRMM and GPM use K-band Radar

K-band generally have frequency range within 27-40 GHz and 12-18 GHz

Overview of TRMM

A joint mission between NASA and the Japan Aerospace Exploration Agency (JAXA)

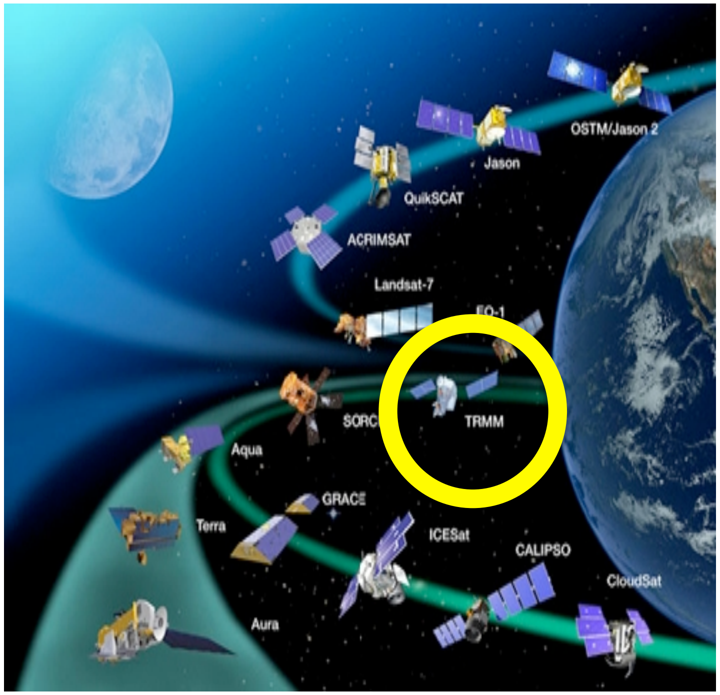
TRMM: Tropical Rainfall Measuring Mission

http://trmm.gsfc.nasa.gov

- The first satellite mission **dedicated to measuring tropical and subtropical rainfall** - Launched on 27 November 1997

- **First satellite to carry a microwave Precipitation Radar**

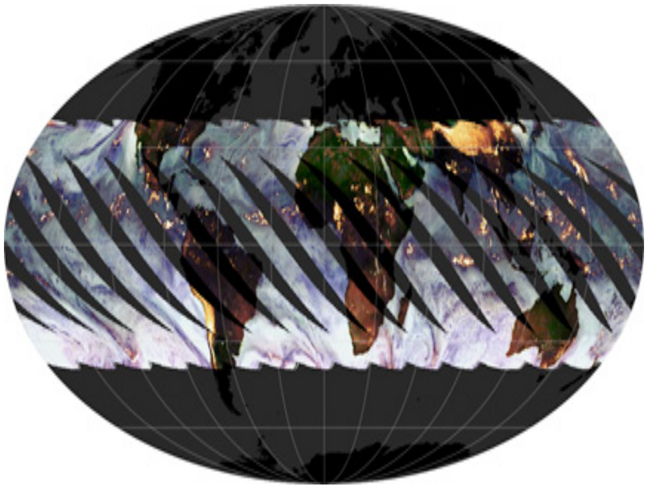
- Predecessor to Global Precipitation Measurement (GPM)



TRMM

http://trmm.gsfc.nasa.gov

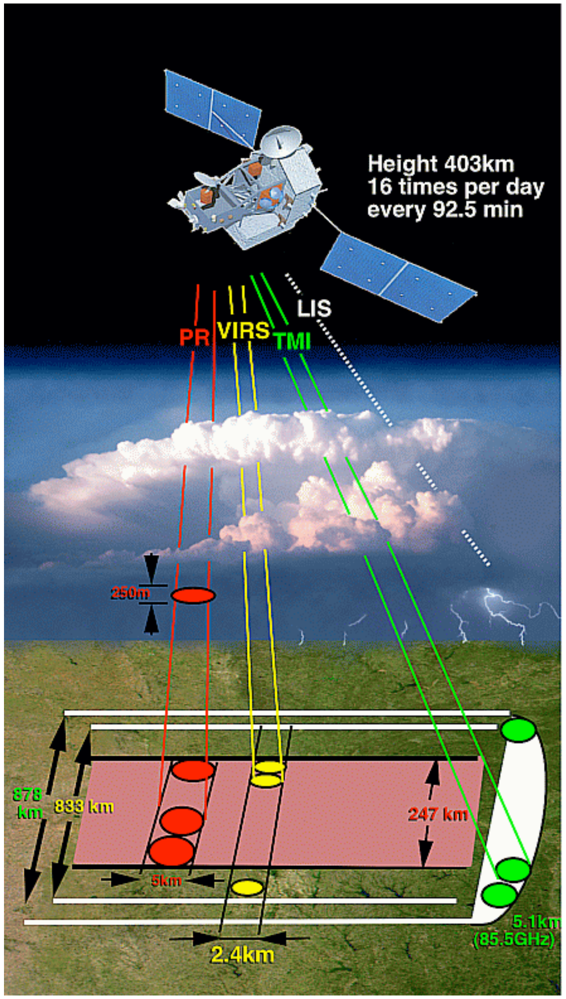
- **A non-polar, low inclination orbit** Revisit time ~11-12 hours, but time of the observation changes daily
- There are 16 TRMM orbits a day **covering global tropics between 35° S to 35°N latitudes**
- Altitude - of approximately 350 Km, raised to 403 Km after 23 August 2001



TRMM

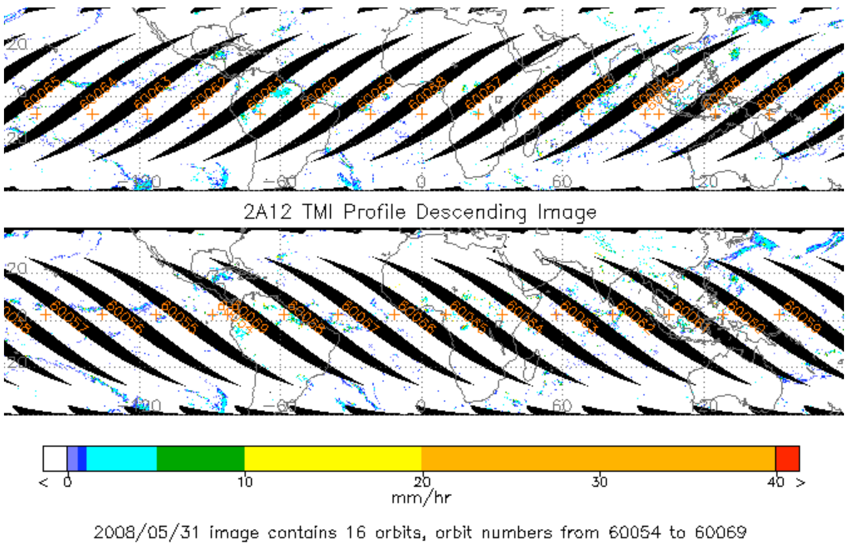
http://trmm.gsfc.nasa.gov

- Multiple sensors
- One active and two passive rain sensors
  *Precipitation Radar (**PR**)*
  *TRMM Microwave Imager (**TMI**)*
  *Visible and Infrared Scanner (**VIRS**)*
- Multiple rain products available from individual sensors, at varying spatial resolutions (details will be covered in Week-2)

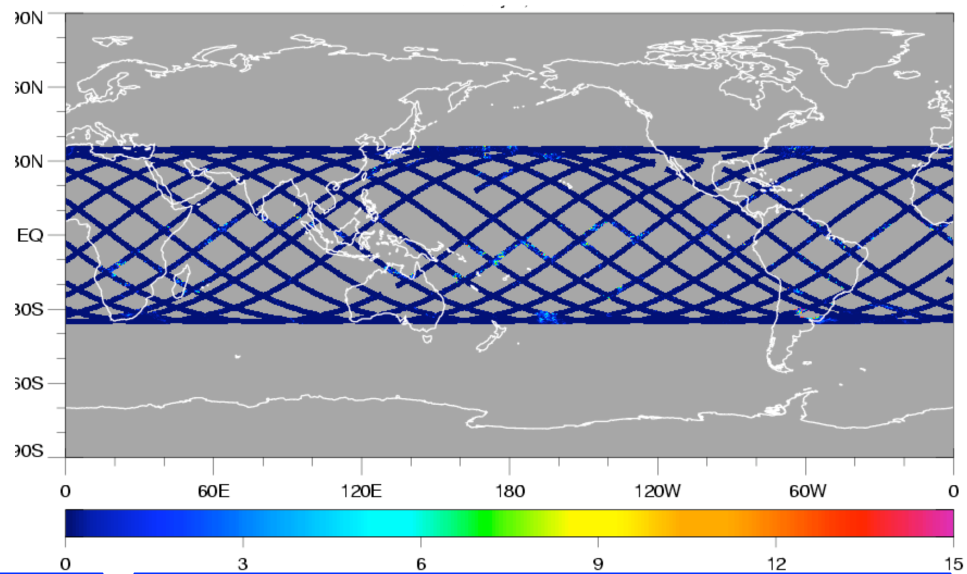


TRMM TMI and PR Measurements

TMI



PR+



Frequencies:	10.7, 19.4, 21.3, 37, 85.5 GH
Swath:	760 km (870* km)
Resolution:	5 to 45 km (channel-dependent)

Frequencies:	13.6 GHz
Swath:	220 km (247* km)
Resolution:	5 km

* After the orbit was raised in August 2001 +Stopped after October 7, 2014

Strength: High pixel resolution, Accurate measurements

Limitation: **No global, diurnal coverage on daily basis**

TRMM Multi-satellite Precipitation Analysis (TMPA)

(Widely used in Environmental Applications)

Also referred to as TRMM 3B42 combines data from TRMM and several other satellites to get improved spatial/temporal coverage:

- Combines PR and TMI rain rates
- Inter-calibrates passive microwave rain rates from other satellite sensors
  SSM/II, AMSR and **AMSU-B**
- Inter-calibrates with national and international **geostationary and NOAA low earth orbiting satellites infrared measurements** by using **VIRS**
- Final rain product is calibrated with rain gauge analyses on monthly time scale.

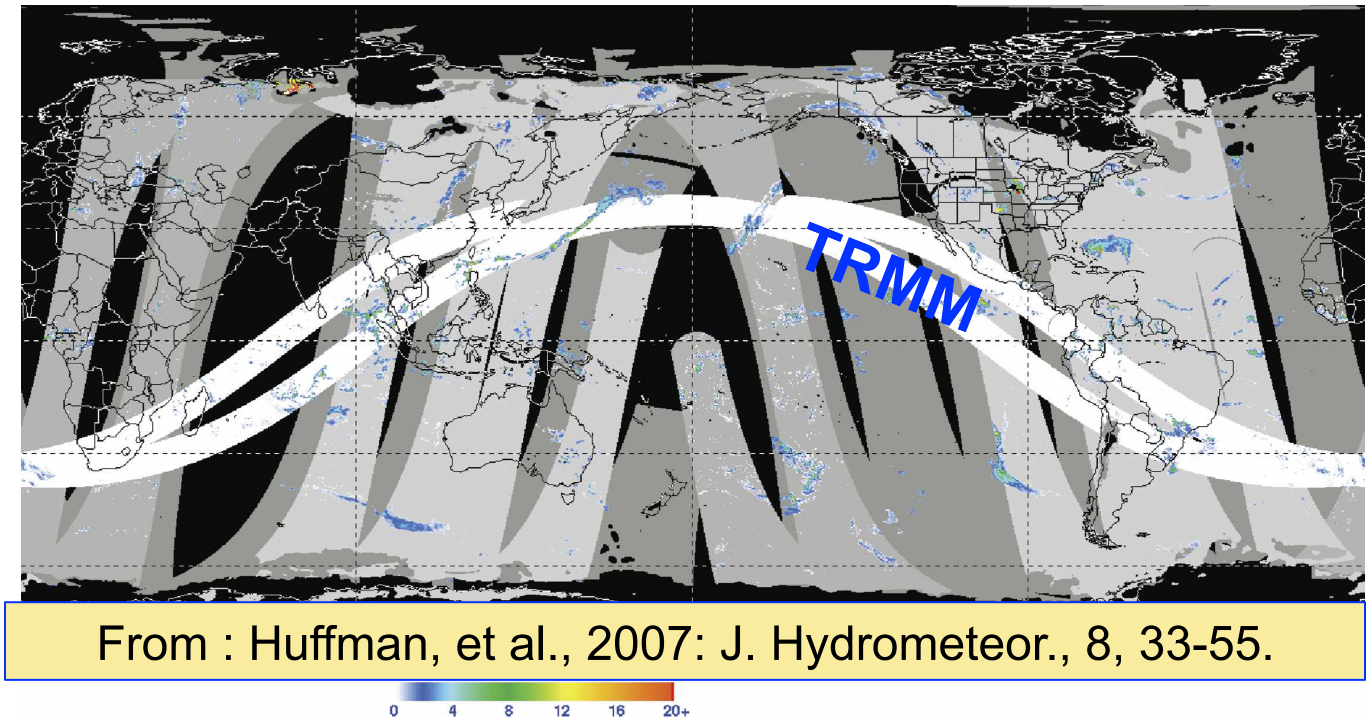
Temporal Resolution :
3-hourly

Spatial Resolution:
0.25°x0.25°

Spatial Coverage:
Global 50°S to 50°N

SSM/I: Special Sensor Microwave Imager – sensor on Defense Meteorology Satellite Project
AMSR: Advanced Microwave Scanning Radiometer – a sensor on NASA Aqua satellite
AMSU:Advanced Microwave Sounding Unit – a sensor on NOAA operational satellite

The TRMM Multi-satellite Precipitation Analysis



From : Huffman, et al., 2007: J. Hydrometeor., 8, 33-55.

Microwave Measurements in TMPA for y=the 3-hour period at 0 UTC on 25th May 2004

TMI (white), SSM/I (light gray), AMSR-E (medium gray), and AMSU-B (dark gray). (In the TMPA the TMI, SSM/I, and AMSR-E are averaged where overlaps occur.) Blacked-out areas denote regions that lack reliable estimates

TRMM Multi-satellite Precipitation Analysis (TMPA)

(Widely used in Environmental Applications)

Combination of TRMM - TMI, PR, VIRS with passive microwave, infrared and visible measurements available from national and international satellites provides rainfall data with --

Temporal Resolution :	3-hourly
Spatial Resolution:	0.25°x0.25°
Spatial Coverage:	Global 50°S to 50°N

Global Precipitation Measurement Mission (GPM) Designed to extend, enhance, and improve TRMM Precipitation Data

TRMM Data Limitations:

Does not provide measurements beyond 35°S-35°N

TRMM sampling frequency is 15 hours to 4 days at any point which introduces substantial uncertainties in rain estimates

TRMM provides rain measurements but not frozen precipitation, also can not detect light rain (<0.5 mm/hr)

GPM was designed to obtain measurements over tropics and higher latitudes, with advancement of observing light rain and snow

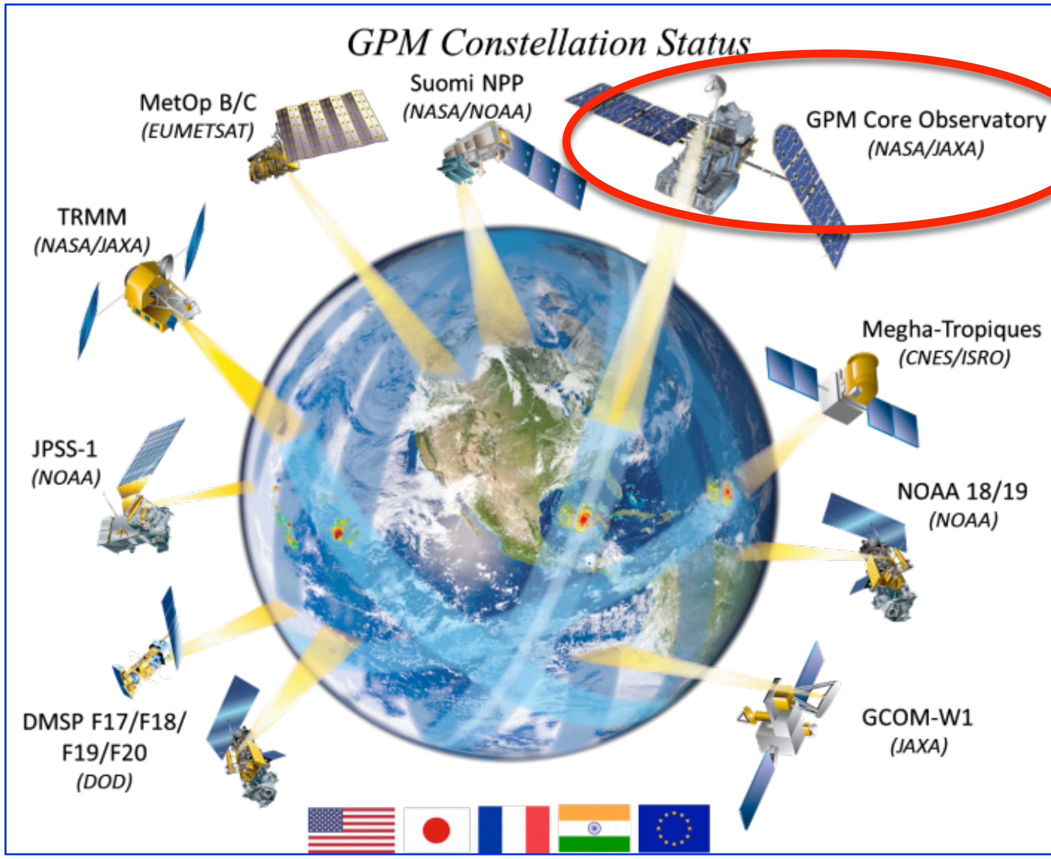
Overview of GPM

Global Precipitation Measurement (GPM)

http://pmm.nasa.gov/GPM

- An international network of satellites with GPM Core satellite designed to provide global observations of rain and snow
- Initiated by NASA and the JAXA as a successor to TRMM

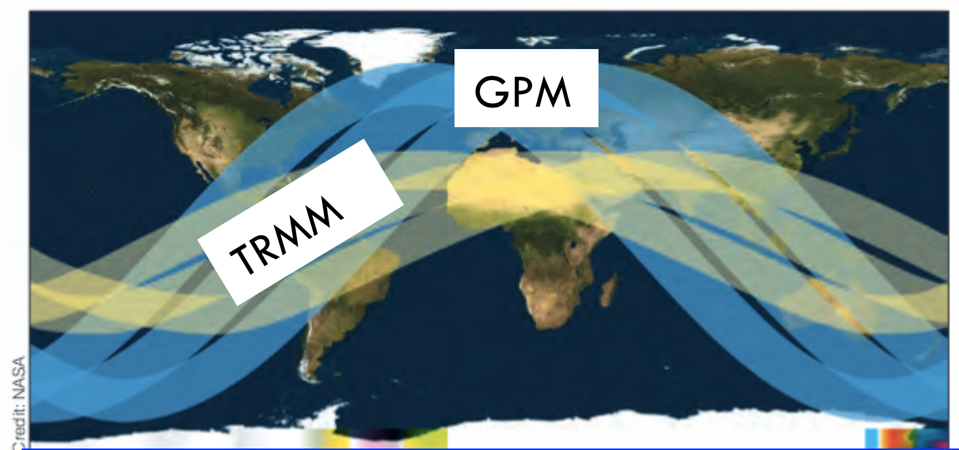
GPM Core satellite was launched on February 27th, 2014



GPM

http://pmm.nasa.gov/GPM

- GPM Core satellite **in a non-polar orbit,** but along with the constellation satellites has revisit time of 1-2 hours over land
- There are 16 orbits per day **covering region between 65° S to 65°N latitudes**
- Altitude – 407 km



the area covered by three TRMM orbits [yellow] versus orbits of the GPM Core Observatory [blue]

GPM measurements span middle and high latitudes

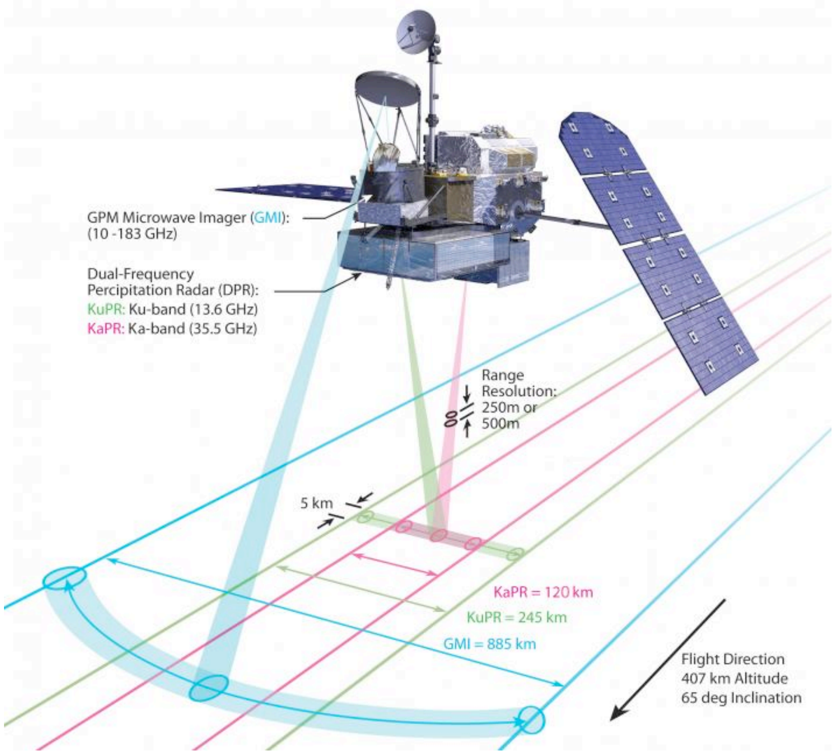
GPM

http://pmm.nasa.gov/GPM

- Multiple Sensors
- One active and one passive rain sensors

  Dual-frequency *Precipitation Radar (**DPR**)*

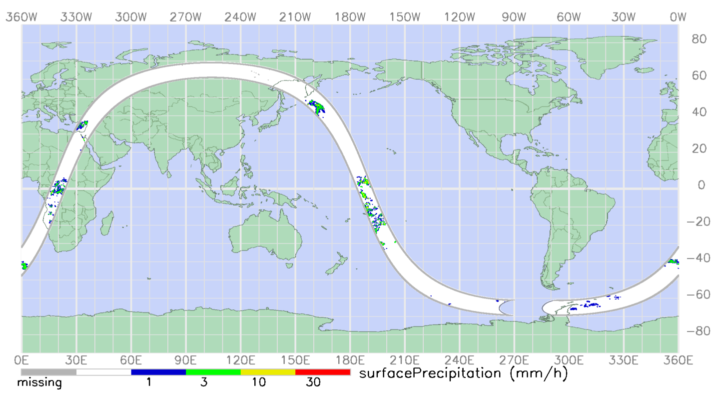
  *GPM Microwave Imager (**GMI**)*
- DPR and GMI – improvement over TRMM PR and TMI



GPM GMI and DPR Measurements

http://pmm.nasa.gov/GPM

GMI



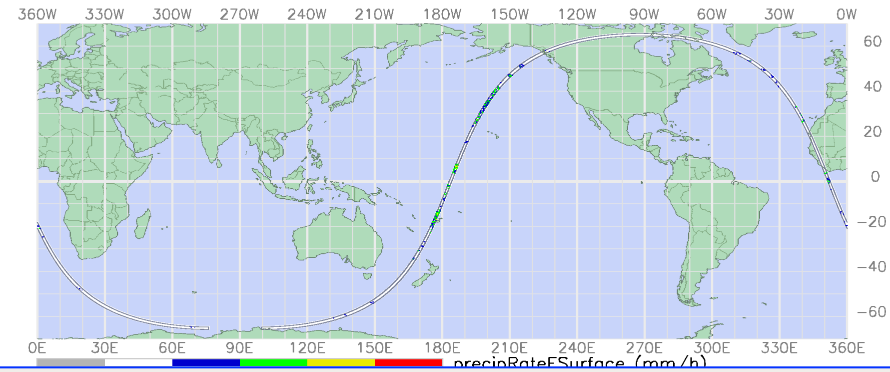
GMI Frequencies:
10.6,18.7,23.8,36.5,89,166 & 183 GHz

Swath width 885 km

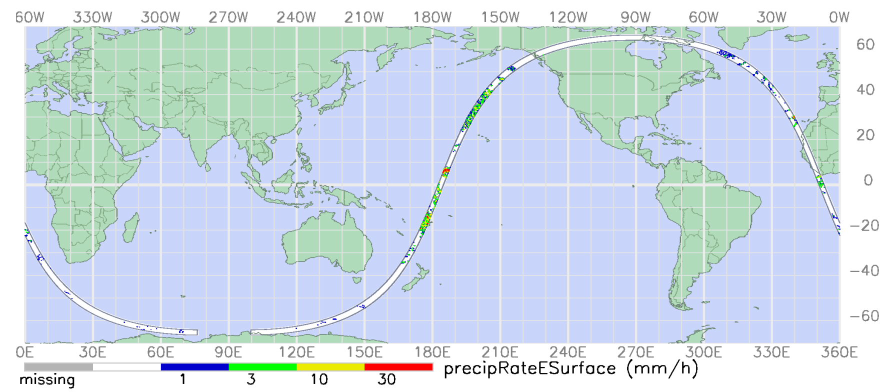
Resolution: 19.4km x 32.2km (10 GHz)
to 4.4km x 7.3km (183 GHz)

Higher spatial resolutions than TMI
High frequencies help measure snow

DPR



Ka 35.5 GHz, Swath Width 120 km, Resolution 5.2 km



Ku 13.6 GHZ, Swath Width 245 km, Resolution 5.2 km

GPM GMI and DPR Measurements

http://pmm.nasa.gov/GPM

GMI

Compared to TRMM TMI:

- Higher spatial resolutions
- Improved light rain and snow detection
- Reference for constellation radiometers calibration

DPR

Compared to TRMM PR:

- Higher sensitivity to light rain and snow
- Better accuracy of measurements
- Better identification of liquid, ice, mixed-phase precipitation particles
- Reference standard for inter-calibration of constellation precipitation measurements

IMERG: Integrated Multi-satellitE Retrievals for GPM

Conceptually similar to TRMM TMPA, combines GPM GMI/DPR data with the GPM constellation satellites to yield improved spatial/temporal precipitation estimates:

	IMERG	TMPA
Temporal Resolution :	30-minutes	3 hours
Spatial Resolution:	0.1°x0.1°	0.25°x0.25°
Spatial Coverage:	Global	Global
	60°S to 60°N	50°S to 50°N

Week-3 will focus on IMERG Data, Access, and GIS Analysis

Constellation Satellites:
GCOM-W, DMSP, Megha-Tropiques, MetOp-B, NOAA-N', NPP, NPOESS

Precipitation Data Applications

TRMM data are used for a variety of applications, these applications will continue using improved GPM data

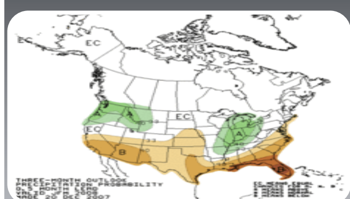
Societal Benefit Areas of TRMM and GPM Precipitation

Extreme Events and Disasters

- Landslides
- Floods
- Tropical cyclones
- Re-insurance

Water Resources and Agriculture

- Famine Early Warning System
- Drought
- Water Resource management
- Agriculture



Weather, Climate & Land Surface Modeling

- Numerical Weather Prediction
- Land System Modeling
- Global ClimateModeling

Public Health and Ecology

- Disease tracking
- Animal migration
- Food Security

Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*

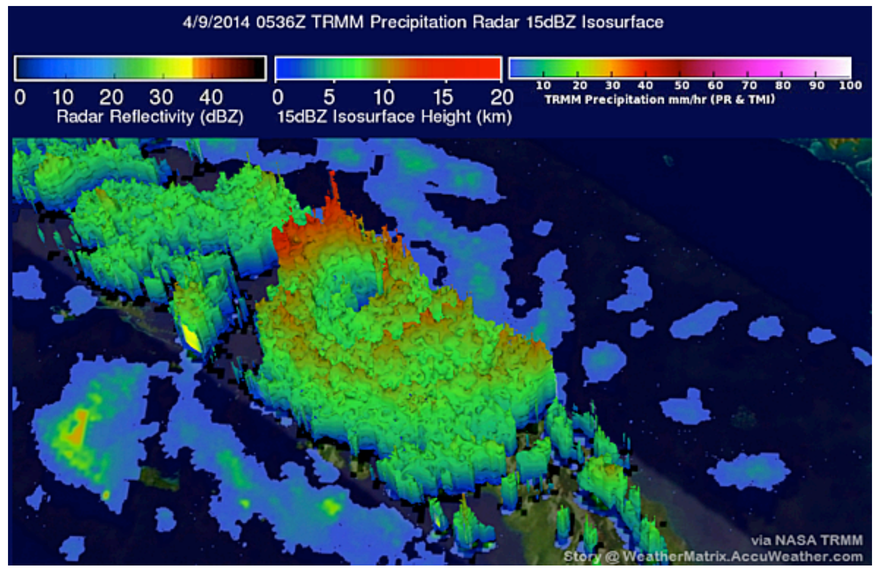
TRMM Data Are Used in Weather Monitoring

Used by AccuWeather (http://www.accuweather.com)
to monitor storms and heavy rainfall

Monster Australia Cyclone Ita, April 9 & 10, 2014

- GPM data will be used by tropical cyclone forecasting centers worldwide to detect the location and intensity of tropical cyclones.

- GPM's orbit (unlike TRMM's) will enable observation of tropical cyclones as they progress from tropical to mid-latitude systems



TRMM PR and TMI showing heavy rainfall within the storm

TRMM Data Are Used to Provide Early Warning of Extreme Rainfall and Flooding For Developing Countries

GPM-IMERG will be used for extreme rainfall detection by ITHACA)

Used by Information Technology for Humanitarian Assistance, Cooperation, and Action (ITHACA) www.ithacaweb.org

- Extreme Rainfall Detection System – Version 2 **(ERDS2)** uses near-real time **3-hourly TMPA** (http://www.ithacaweb.org/projects/erds/)

- **ERDS2** is a strategic tool, providing immediate information about potential flood events, used by the **UN World Food Programme (WFP)** Emergency Preparedness Unit

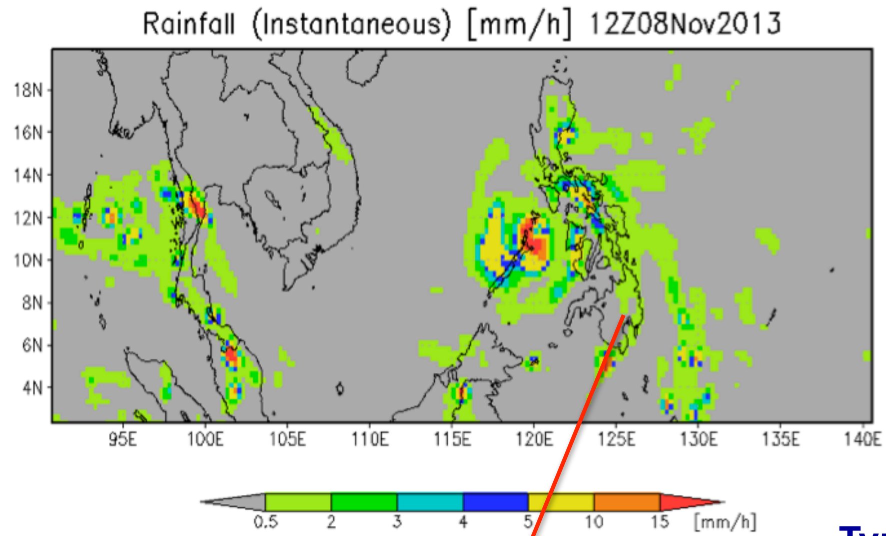
ITHACA provides trainings to government staff in developing countries on how to use ERDS2 and remote sensing data for flood hazard assessment http://www.ithacaweb.org/news/

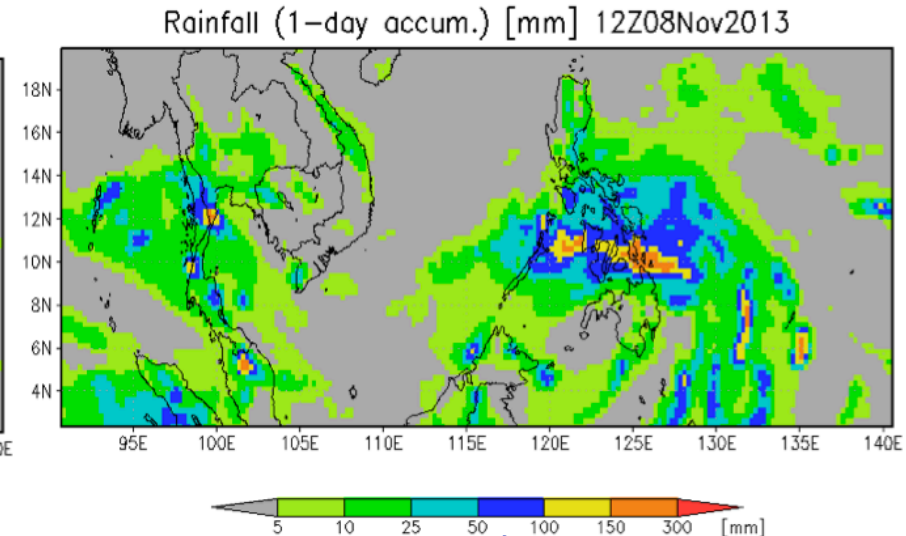
ITHACA delivers technical training to Malawi Gov't staff
Fri 16 Jan 2015
Within the World Bank financed project MASDAP, ITHACA held a technical training session on the use of satellite data for vulnerability assessment in Blantyre from December 15 to 19, 2014.
Read more.

ITHACA hosts 3 Ethiopian interns for technical training on GIS and GPS systems
Mon 20 Oct 2014
On October 20 ITHACA started a 3-week specialization module on GIS and GPS systems for 3 Ethiopian trainees in the framework of the WATSAM project, coordinated by Hydroaid - Water for Development Management Institute.
Read more.

Satellite-based Rapid Mapping training in Lilongwe (September 29 – October 1, 2014)
Wed 15 Oct 2014

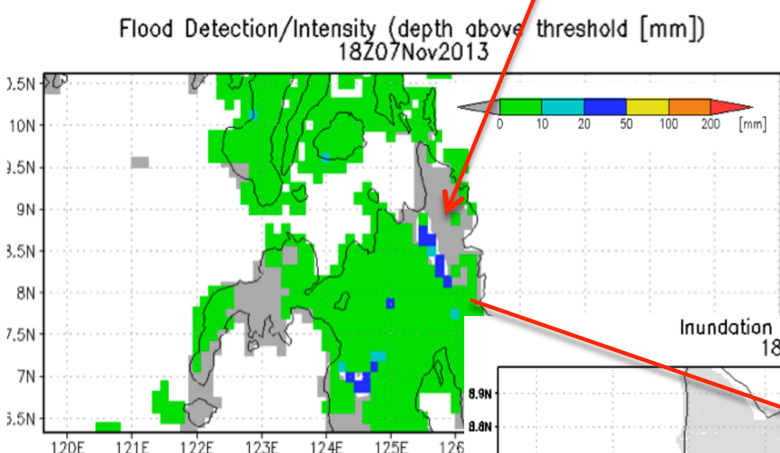
TRMM Data Are Used for Flooding Estimates

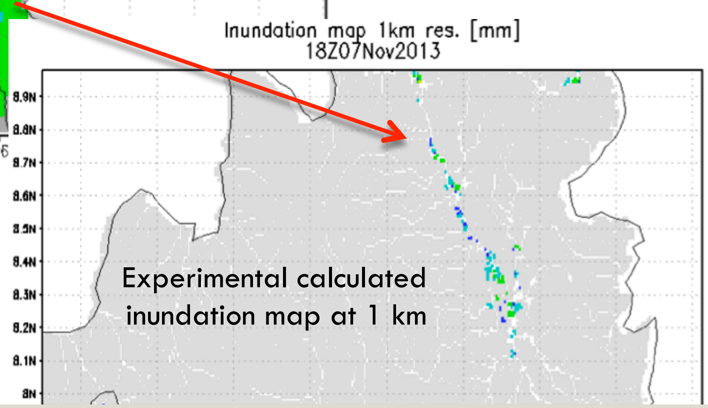


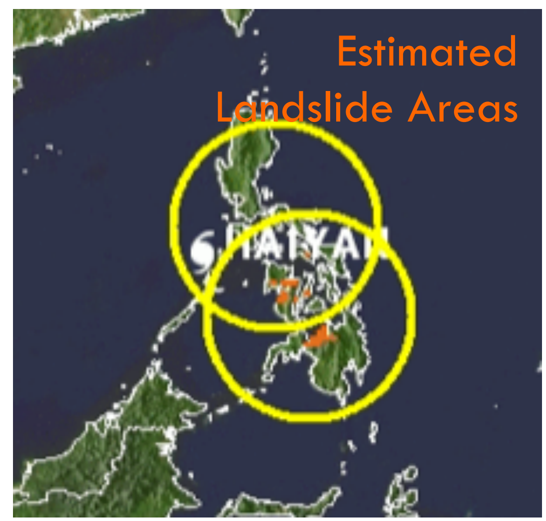


Typhoon Haiyan produced rainfall up to about 300 mm.

Flooding estimated from Haiyan and previous rainfall along with landslides. **GPM will enable high resolution (compared to TRMM) flood detection and mapping**.







flood.umd.edu

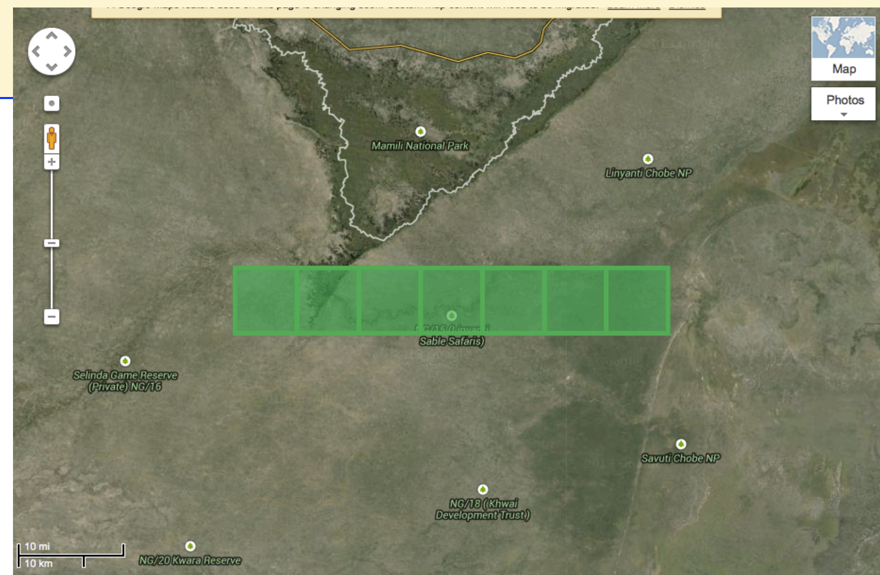
Adler/Wu
U. of Maryland

Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*

TRMM Data Are Used by Global Disaster Alert and Coordination System (GDACs)

GDACS, managed by the United Nations and European Commission, provides disaster alerts and river watch that is used by many governments and about 14,000 disaster response and non-governmental organizations for their national disaster response plans. (http://www.gdacs.org)

One of the data sources used by GDACS is river run off derived from TRMM-TMI data by Dartmouth Flood Observatory (http://www.dartmouth.edu)

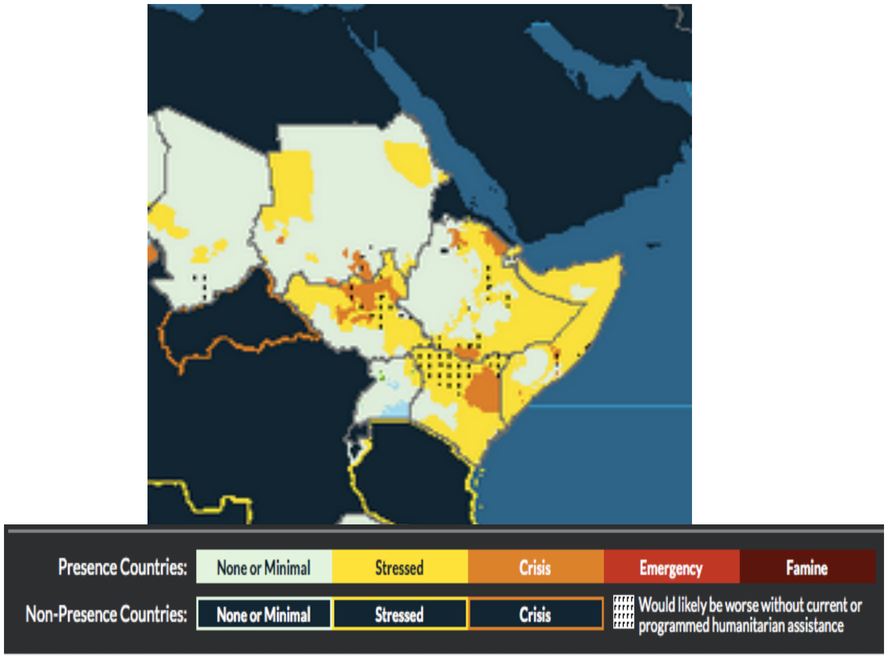


Flooding alert in Botswana on 15th December 2014

Higher resolution and extended spatial coverage by GPM-GMI will provide improved river-run off estimates

TRMM Data Are Used in Agricultural Forecasting

January 2015 Report



http://www.fews.net

Famine Early Warning System (FEWS) relies on TRMM and other satellite estimates for anticipating poor growing seasons. GPM will improve these estimates.

FEWS NET Data Portal

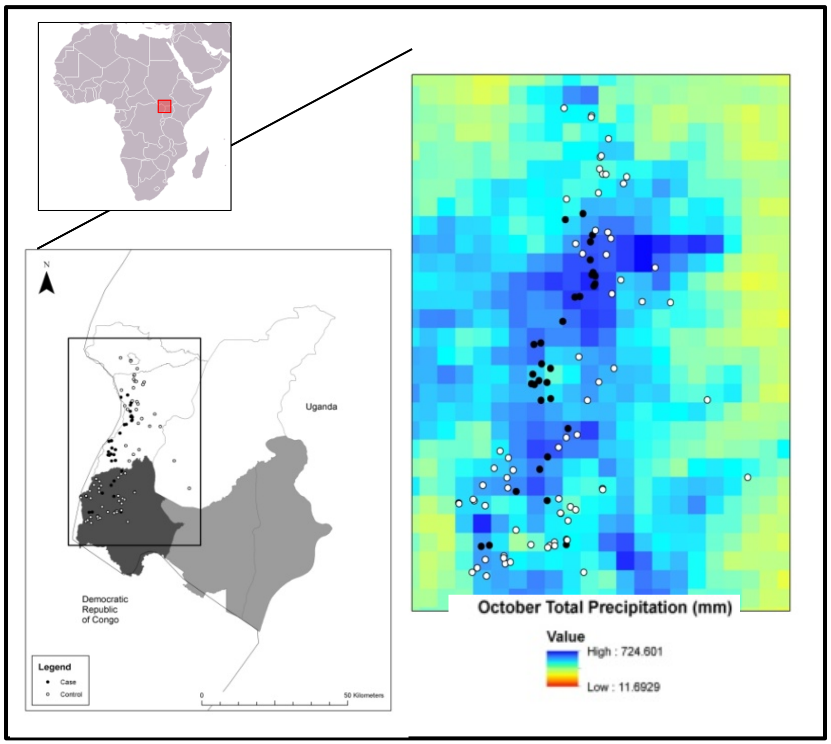
http://earlywarning.usgs.gov/fews

USGS science for a changing world | USAID FROM THE AMERICAN PEOPLE | FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

TRMM Data Are Used in Disease Tracking

TRMM data has been used to estimate and trace the source areas of vector and river-borne diseases around the world. GPM will enable higher resolution evaluation of these disease source areas.

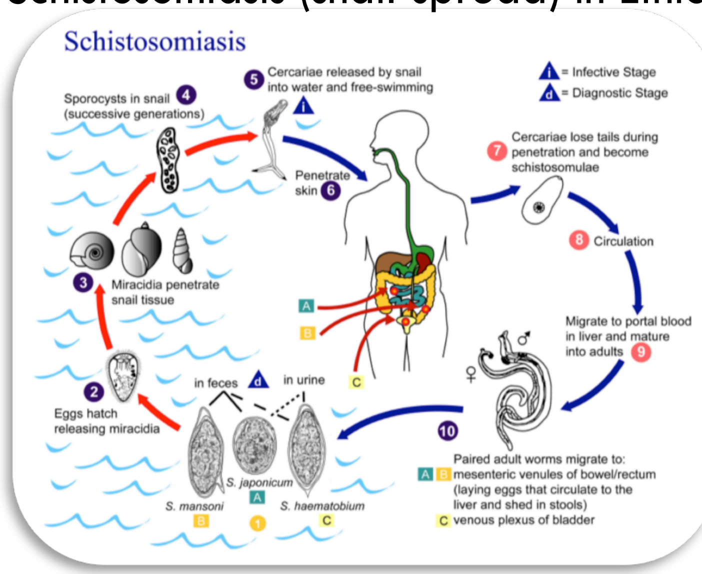
Observed Plague Cases in Uganda



Cases are associated with wetter, cooler regions

Monaghan et al. 2012; MacMillan et al., 2012

Schistosomiasis (snail-spread) in Ethiopia



Courtesy of Bitew and Gebremichael

Studies have found a relationship between TRMM rain and the onset of this disease in local populations due to contact with snails in irrigation channels

Courtesy: Dalia Kirschbaum, *GPM Applications Science Lead*

Coming up next week!

Week 2: GPM/TRMM Data Products
Data Validation
Data Access Tools
Remote Sensing Data Trade-offs

Thank You!

Amita Mehta **email: amita.v.mehta@nasa.gov**

TRMM PR and TMI Measurements

Characteristic	Visible Infrared Scanner	TRMM Microwave Imager	Precipitation Radar
Frequency/ Wavelength	0.63, 1.6, 3.75, 10.8, 12 µm	10.65, 19.35, 37.0, 85.5 GHz dual polarization, 22.235 GHz vertical polarization	13.8 GHz horizontal polarization
Scanning Mode	Cross track	Conical	Cross track
Ground Resolution	2.1 km	Ranges from 5 km at 85.5 GHz to 45 km at 10.65 GHz	4.3 km at nadir
Swath Width	720 km	760 km	220 km

Measurements are converted to Brightness Temperatures and Radar Reflectivity – which are converted to rain rate via complex algorithms

GPM DPR Measurements

Item	KuPR	KaPR
Swath Width	245 kilometers (km)	120 kilometers (km)
Range Resolution	250 meters (m)	250/500 meters (m)
Spatial Resolution	5 km (Nadir)	5 km (Nadir)

http://pmm.nasa.gov/GPM/flight-project/DPR

GPM GMI Measurements

Channel No	Center frequency (GHz)	Ctr. freq. stabilization (±MHz)	Bandwidth (MHz)	Polarization
1	10.65	10	100	V
2	10.65	10	100	H
3	18.70	20	200	V
4	18.70	20	200	H
5	23.80	20	400	V
6	36.50	50	1000	V
7	36.50	50	1000	H
8	89.00	200	6000	V
9	89.00	200	6000	H
10	165.5	200	4000	V
11	165.5	200	4000	H
12	183.31±3	200	2000	V
13	183.31±7	200	2000	V

https://directory.eoportal.org/web/eoportal/satellite-missions/g/gpm