Global Precipitation Measurement (GPM) Mission

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17th Annual GLOBE Partner Meeting: From Space to Place

August 14th, 2013

Guiding Questions

- Why do we need to measure rain and snow globally?
- What do we have now?
- What is the Global Precipitation Measurement (GPM) Mission?
- How do we connect the dots between satellite observations and what we measure at the surface?
- How can we use the data?
- Resources available to you!

Educational Themes

Water Cycle

The continuous movement of water on, above and below Earth's surface.

Weather & Climate

The atmospheric conditions that lead to our daily weather and global climate.

Technology

The spacecraft, instruments and people that study Earth systems.

Societal Applications

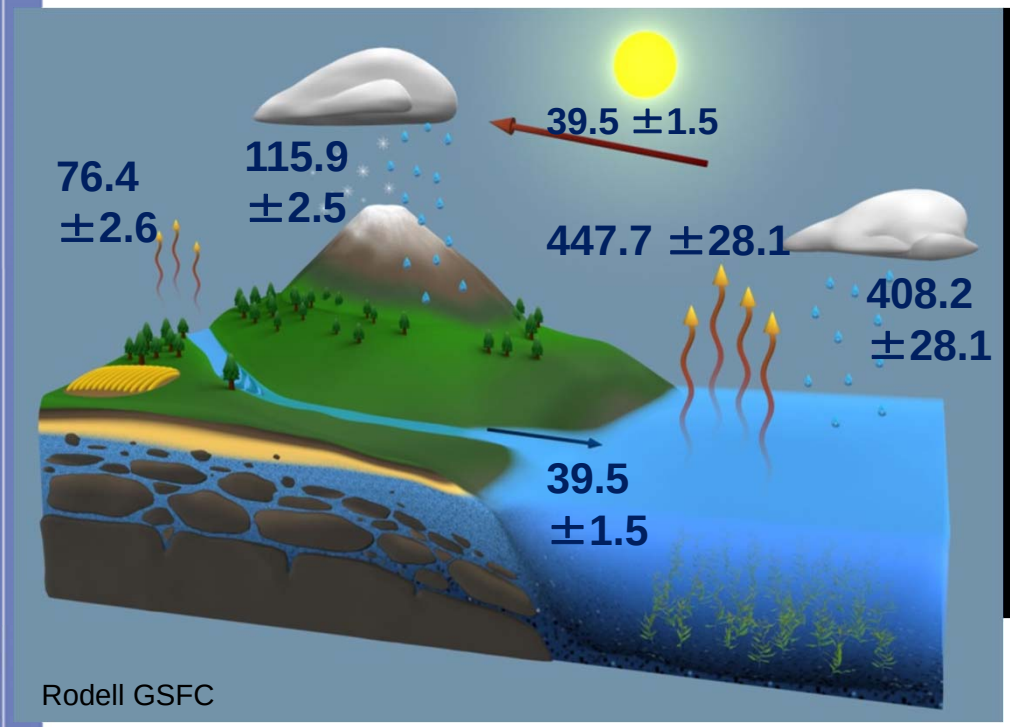
How studying our planet's rain and snowfall makes the world a better place.

The Freshwater Connection

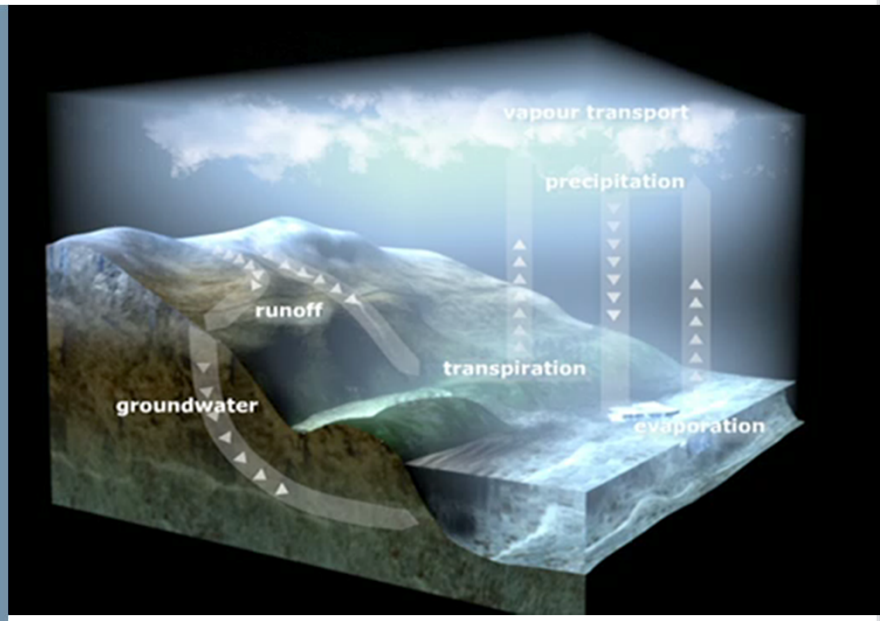
http://pmm.nasa.gov/education/videos/gpm-freshwater-connection

Why measure GLOBAL precipitation (rain, snow, ice)?

Precipitation is a key component of the water cycle and an important contributor of freshwater around the planet. We need to quantify all inputs to the water cycle in order to better understand how water is moving through the earth system and model how it may behave in the future.



Rodell GSFC



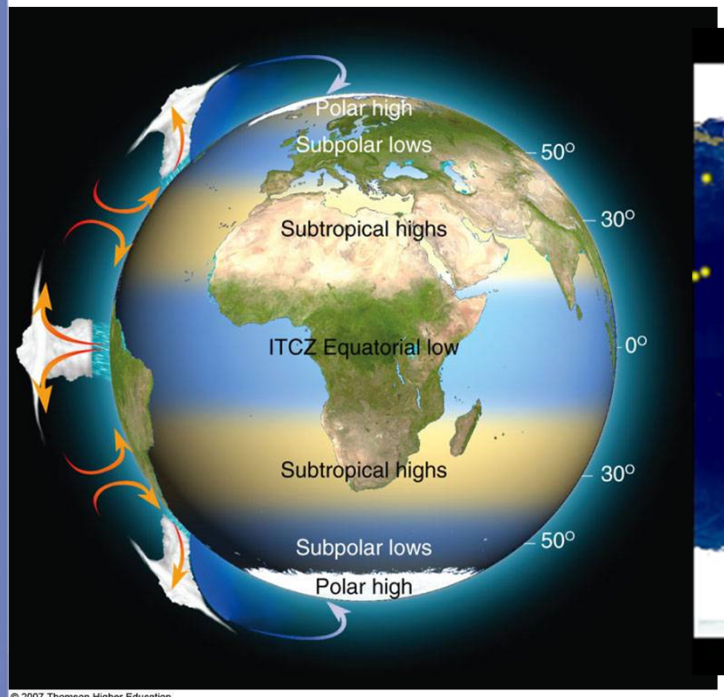
Global mean water fluxes (1,000 km^3/yr) at the start of the 21st century, based on satellite and ground-based observations and data integrating models.

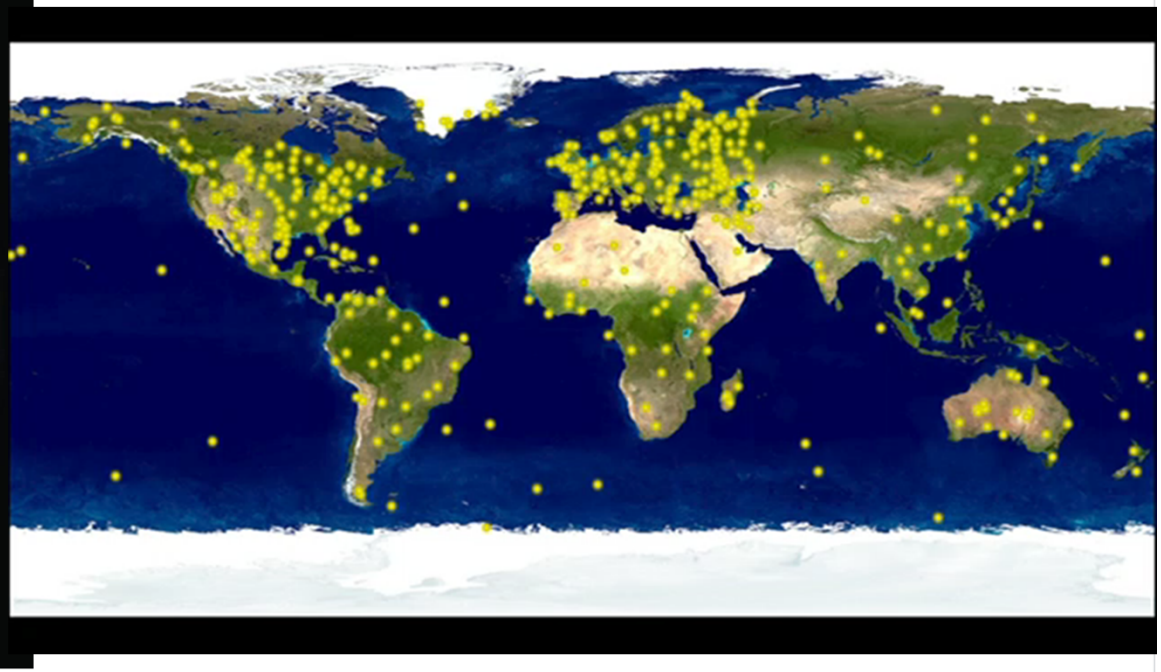
The most noticeable impacts of climate change will be changes in the water cycle

GLOBAL PRECIPITATION MEASUREMENT

Why look from space?

Precipitation is felt locally, but interacts with large-scale circulation patterns. Precipitation links the Earth's **ENERGY** and **WATER** cycles. 70% of the earth is covered by water where radar and gauges are very sparse. Even the coverage of gauges on land is quite small!





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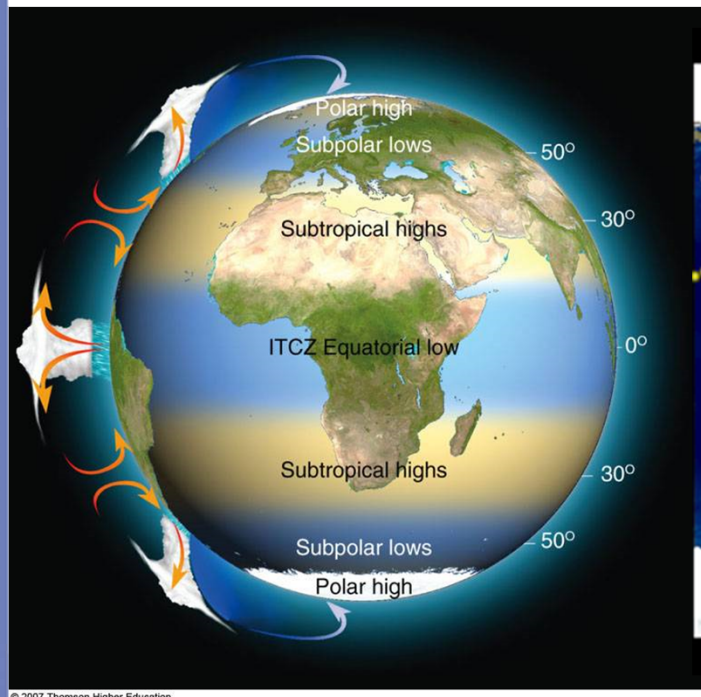
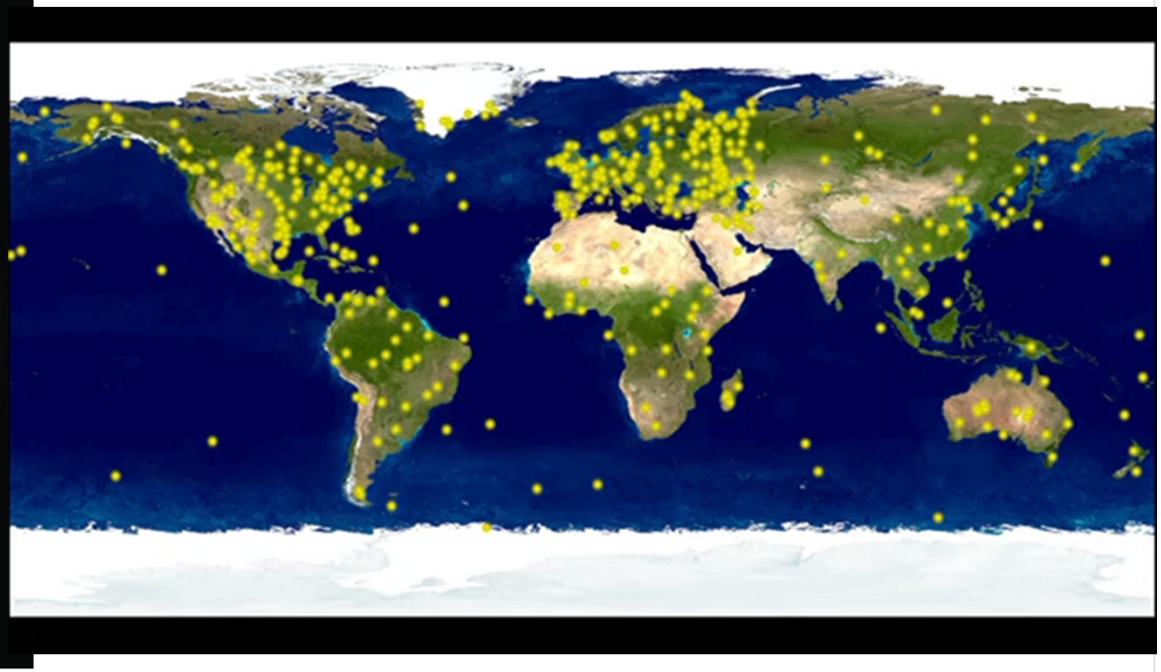
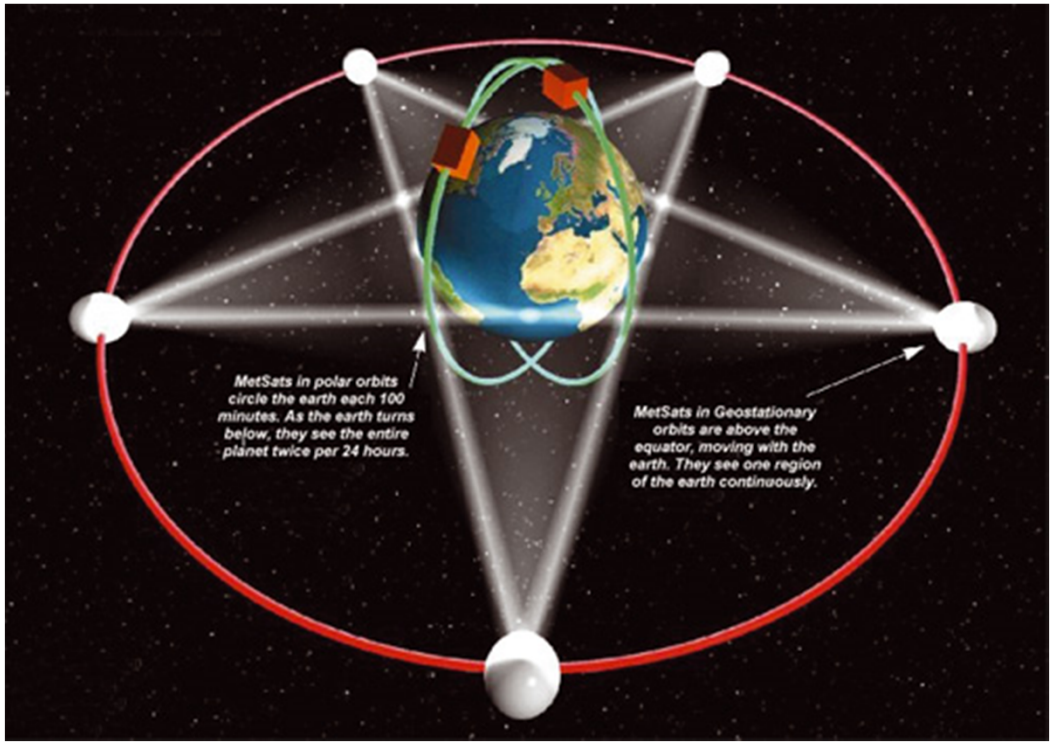




Space-borne remote sensing can provide both the **space** and **time** coverage needed for measuring and evaluating precipitation across the globe, particularly in areas without ground-based instruments (e.g. rain gauges, radar).

What do we have now?

- Traditional infrared weather satellites orbit the Earth ~20,000 miles above the surface, providing a continuous picture of one slice of the earth
- Polar orbiting satellites cross at the same time of day
- Non-sun-synchronous satellites can view the earth at the same point at different times of a day



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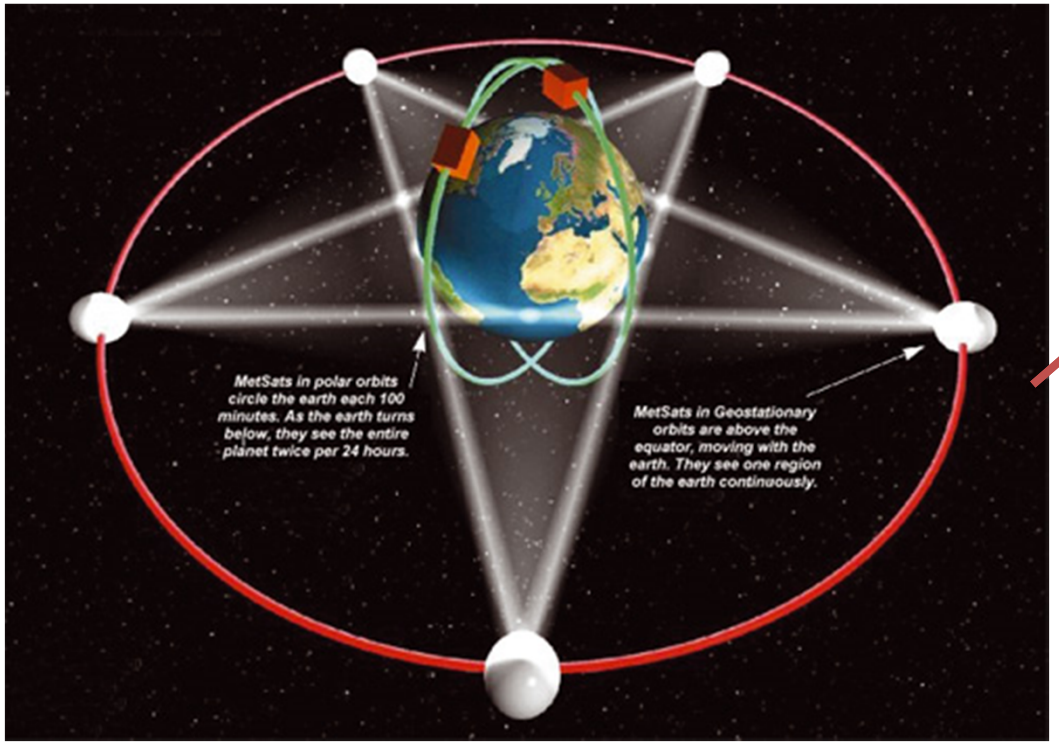
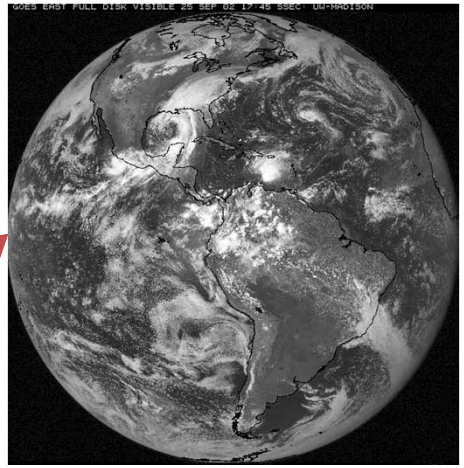


GOES Image
(Geostationary orbit)



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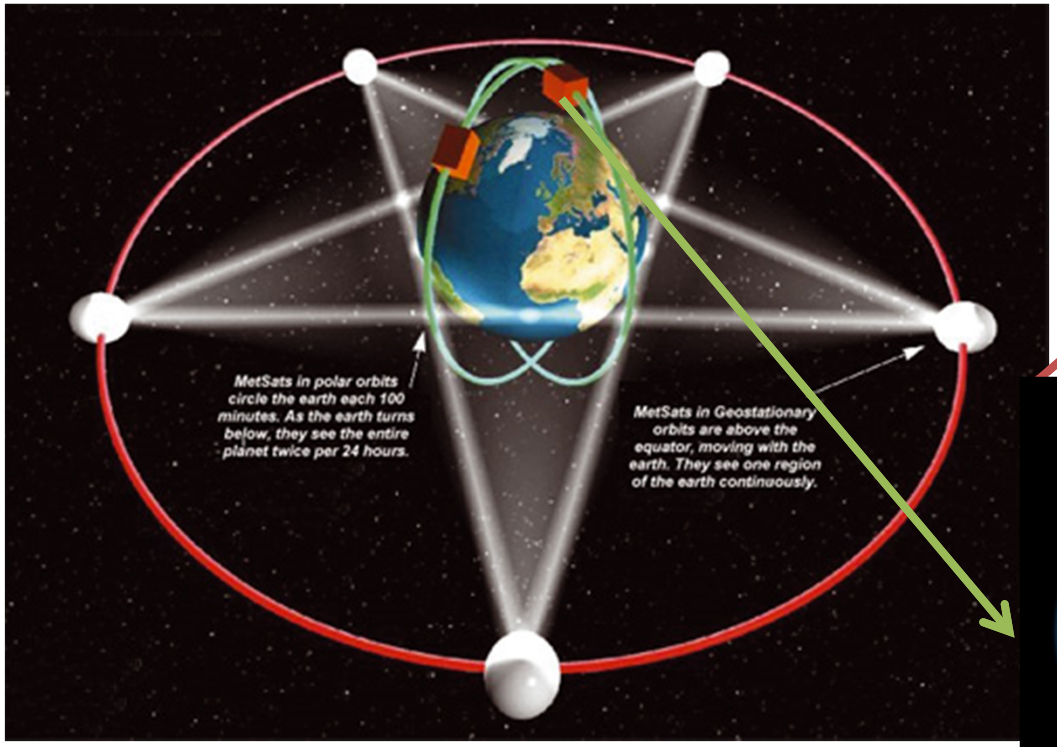

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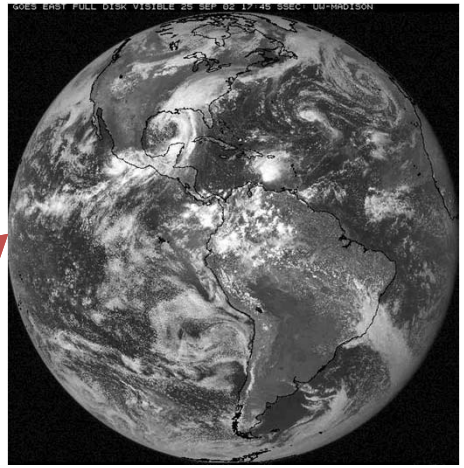

Suomi NPP composite image
(Polar orbit)

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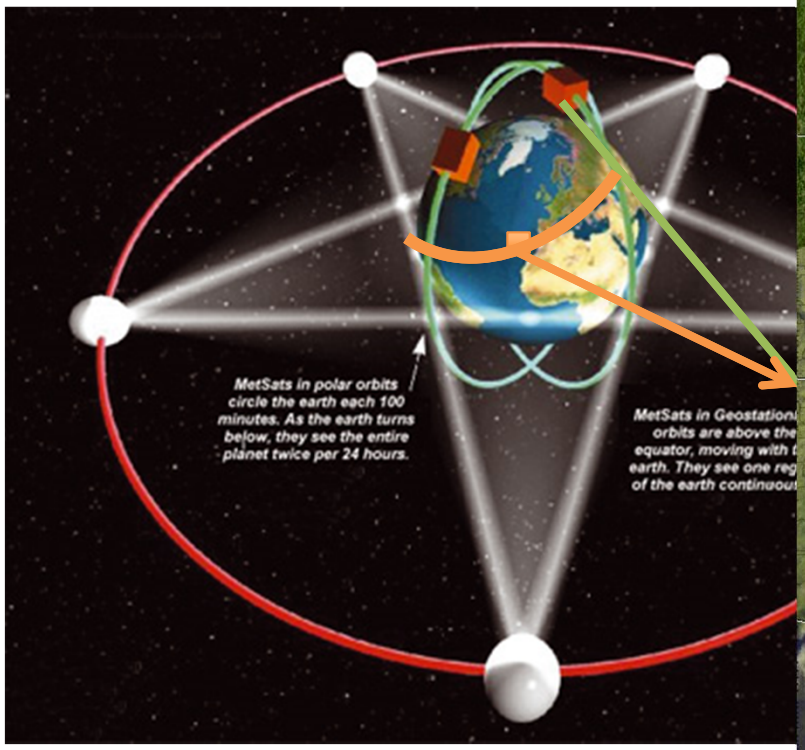
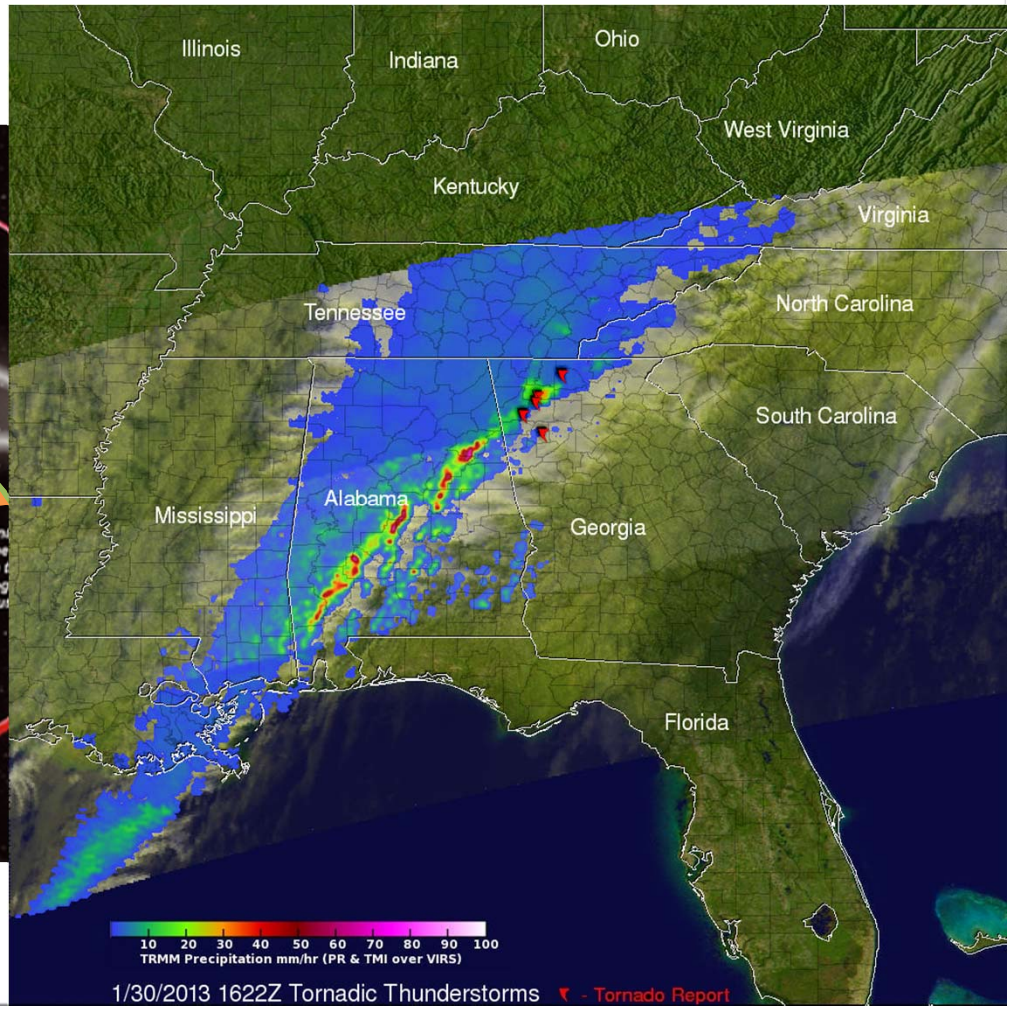




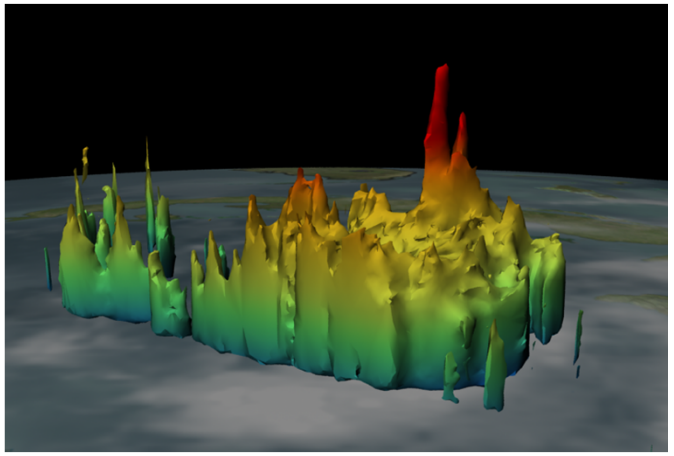
TRMM pass over Southeast US
(non-sun-synchronous orbit)

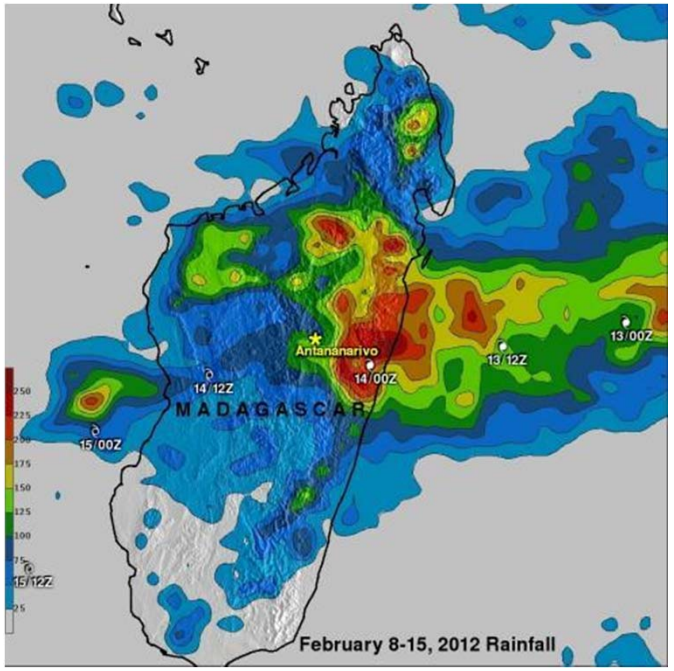
Tropical Rainfall Measuring Mission

GLOBAL PRECIPITATION MEASUREMENT

- Launched in 1997 to measure tropical rainfall
- Currently has a 15-year record of precipitation from ~35° North to 35° South
- Partnership between NASA and the Japan Aerospace Exploration Agency (JAXA)
- Data at http://trmm.gsfc.nasa.gov

Hot Towers observed in Hurricane Wilma





Rainfall Accumulation from Tropical Cyclone Giovanna, triggering deadly floods in Madagascar

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We need better instruments and improved models to identify light rainfall and snow in higher latitudes

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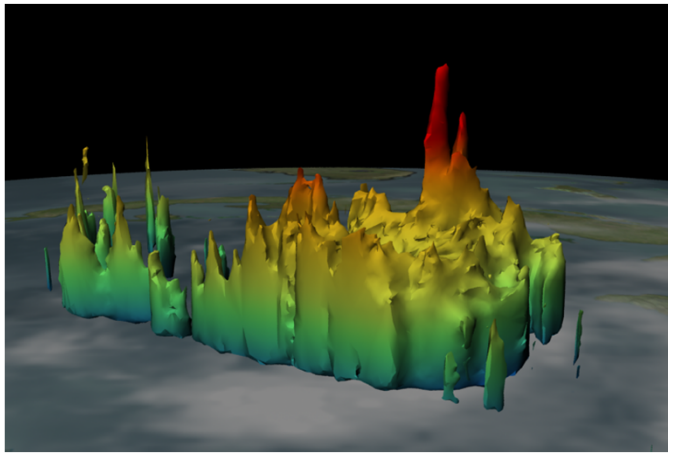

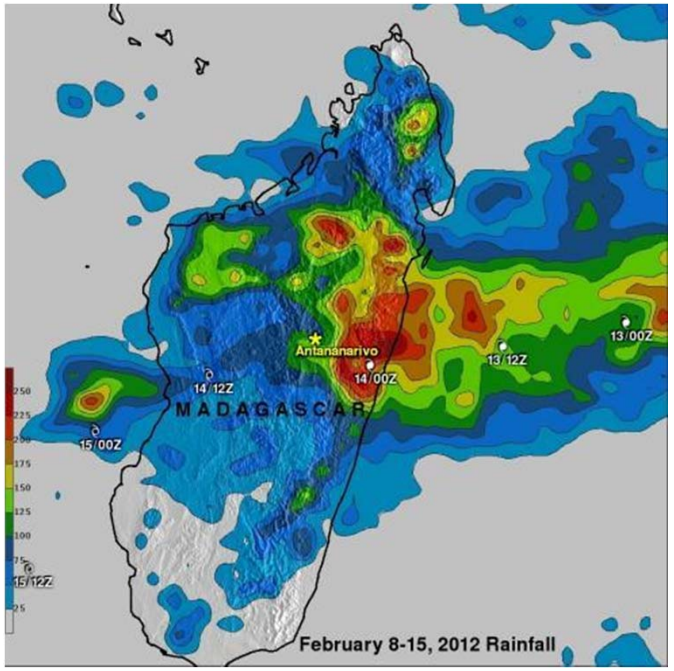

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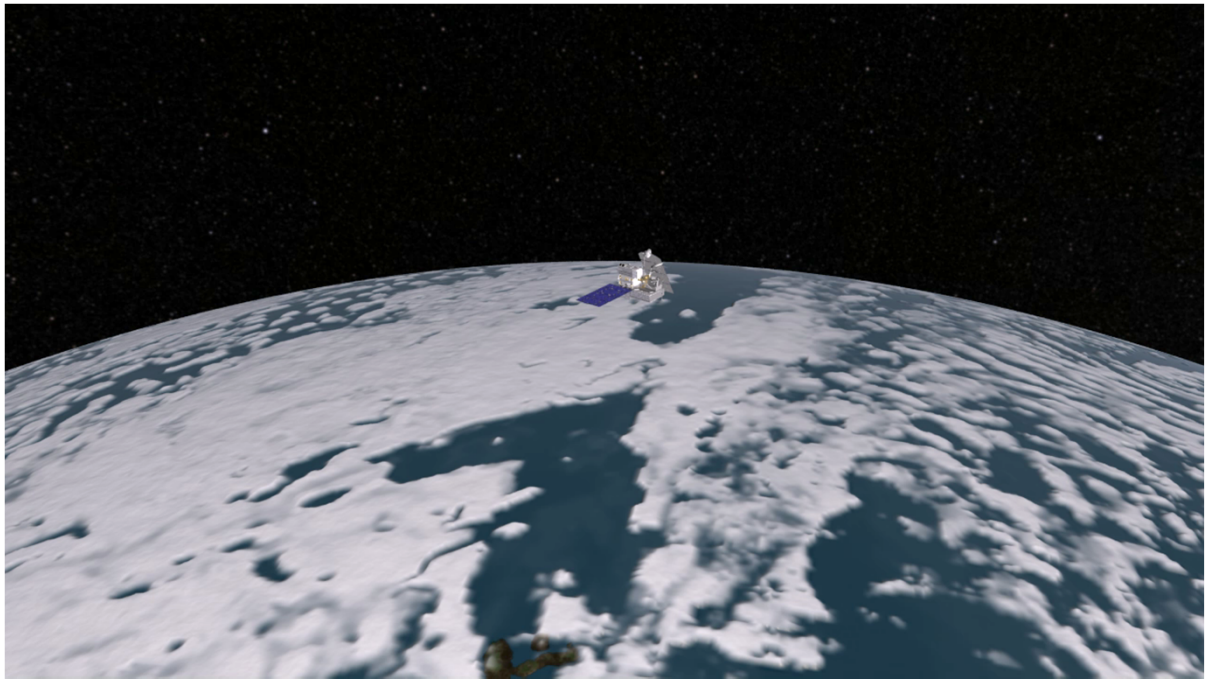
Introduction to GPM

GPM is an international mission which will use inputs from an international constellation of satellites to provide improved space and time coverage of precipitation (rain, snow) over the globe

GLOBAL PRECIPITATION MEASUREMENT

The GPM Core Observatory

The GPM Core Observatory will carry two advanced instruments that allow us to view precipitation (rain, snow, ice) in new ways and serve as a connector between the GPM Core and measurements taken on other partner satellites



Non-Sun-Synchronous orbit at 65^{o} inclination (Arctic to the Antarctic Circle) at 407 km

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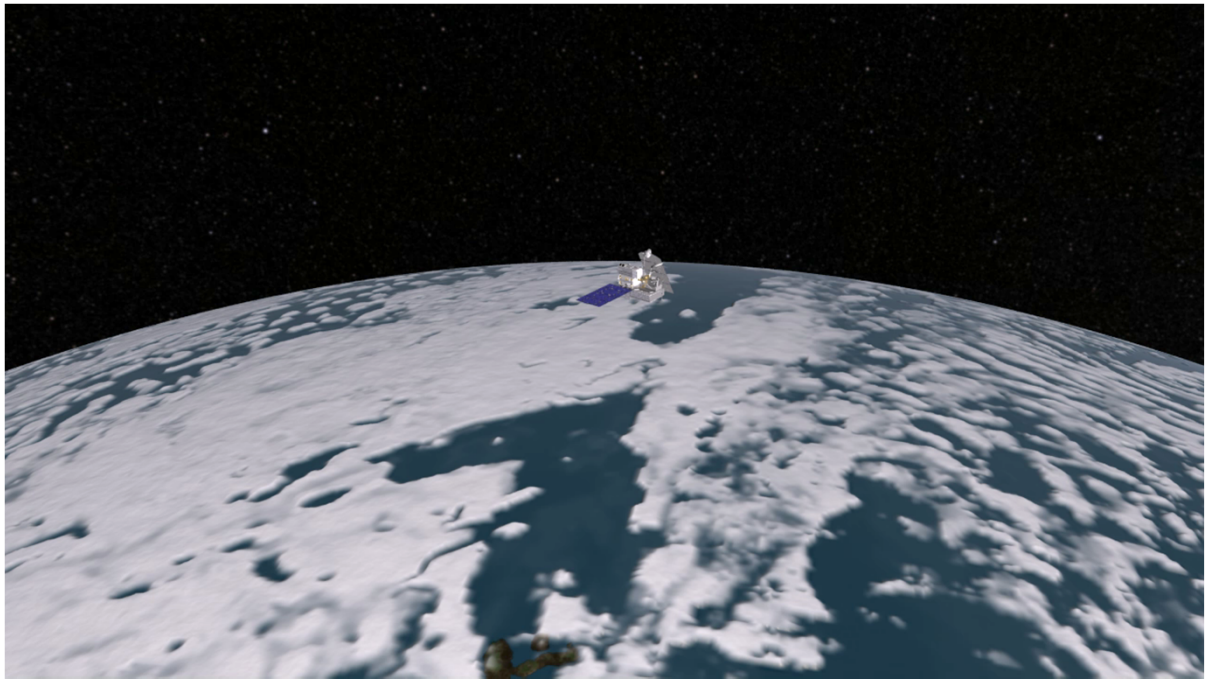

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Dual-frequency Precipitation Radar (DPR): Ku-Ka bands
Two different radar frequencies that can look at precipitation in 3-D throughout the atmospheric column.

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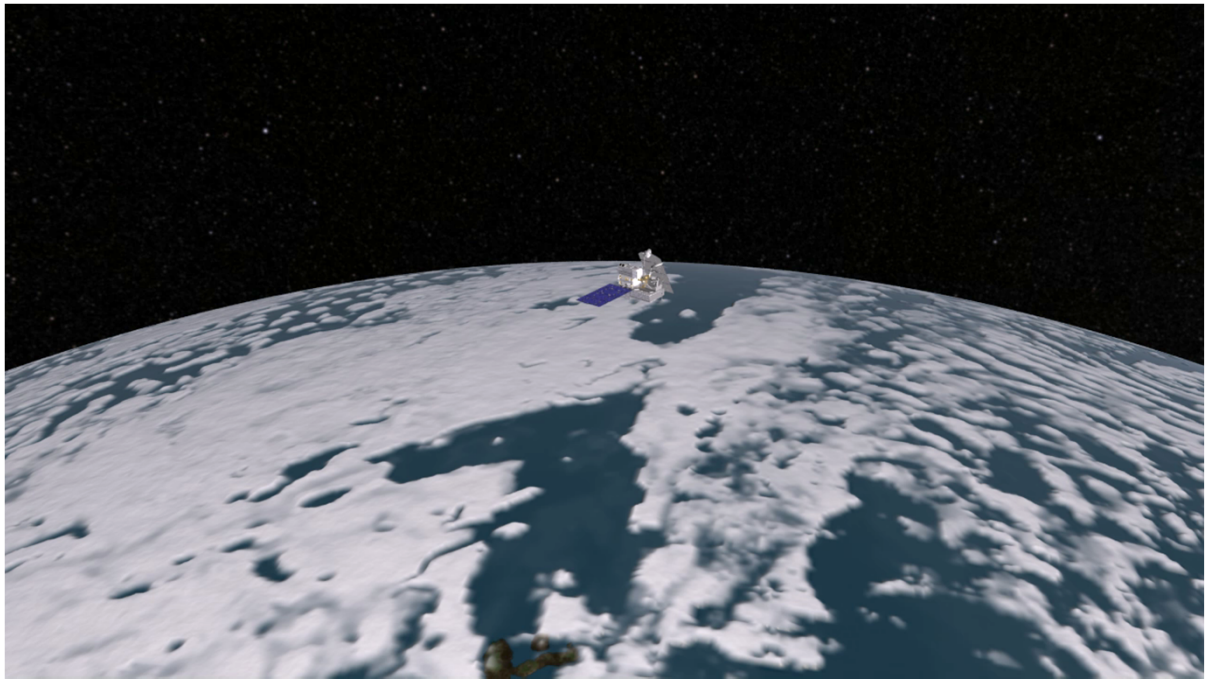

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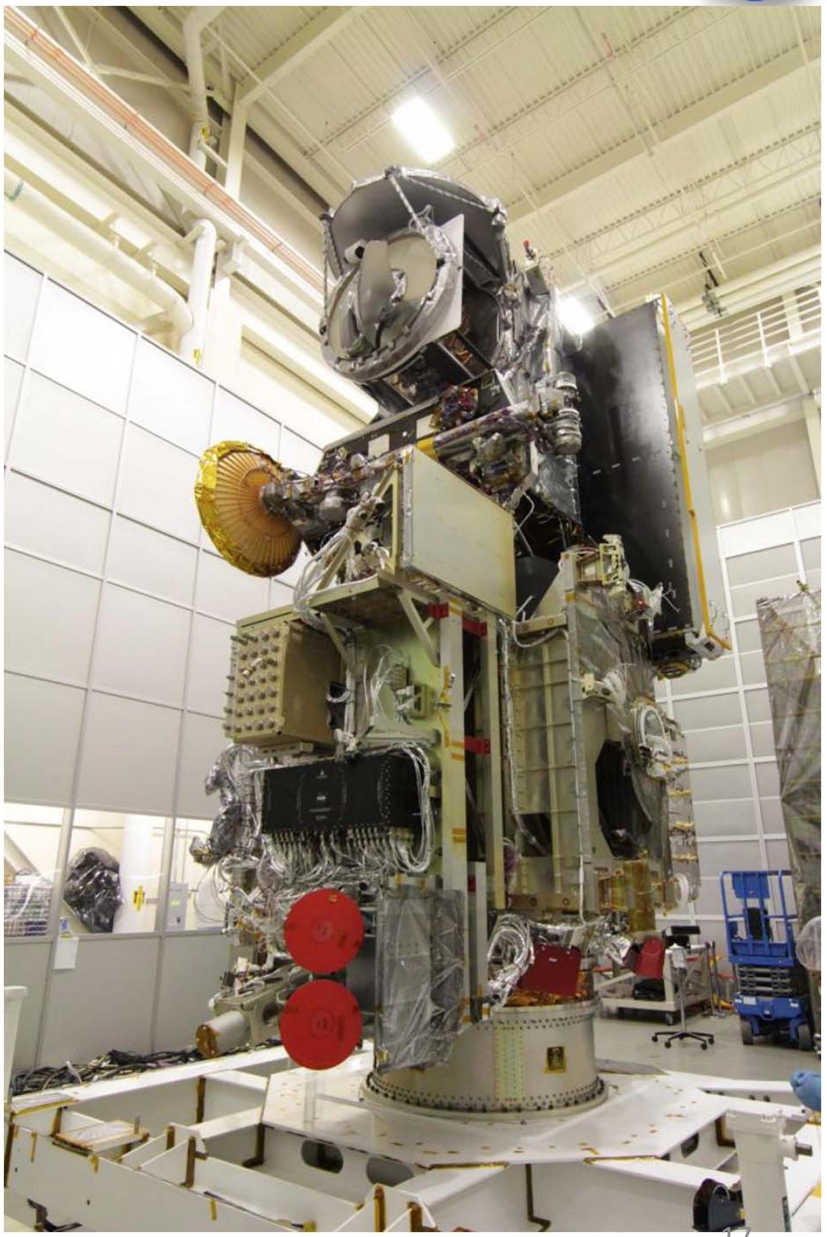
GPM Microwave Imager (GMI): 10-183 GHz

13 channels which provide an integrated picture of the energy emitted by precipitation, including light rain to heavy rain to falling snow

Testing at NASA Goddard!

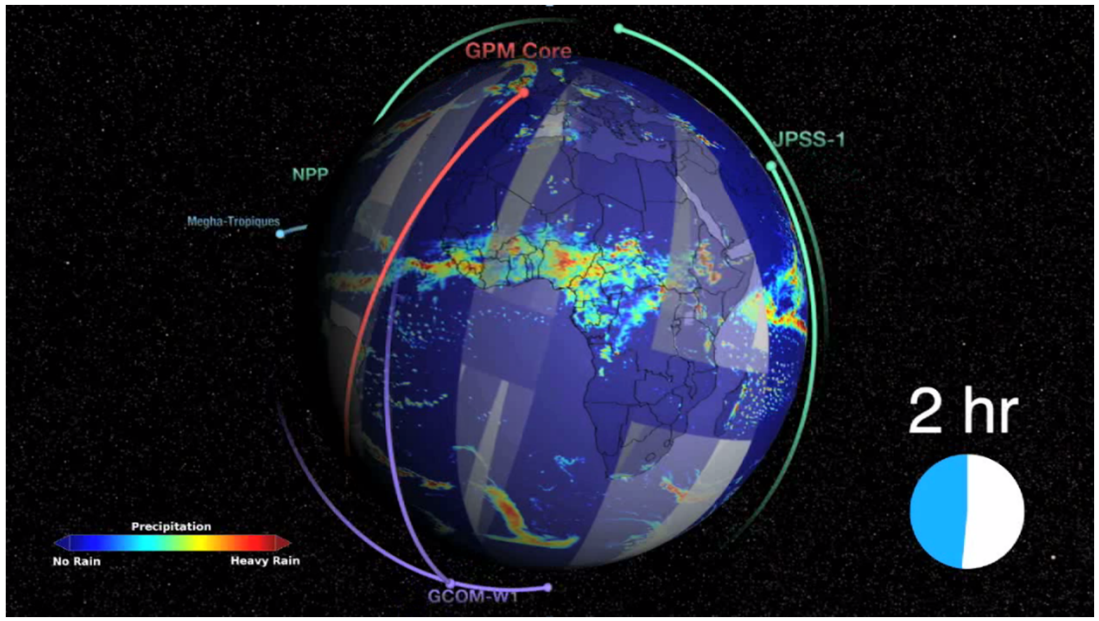
- Core Observatory satellite is being built and tested at GSFC.
  - May 2011 – Centrifuge testing
  - May 2012 – Completed instrument integration
  - August 2012 – Solar array vibration and acoustic testing
  - December 2012 – Thermal Vacuum Testing
  - March 2013 – Electromagnetic Interference Testing
  - June 2013 – Solar Array Deployment testing
- Early November, 2013 - GPM Core shipped to Tanegashima Island, Japan
- February, 2014 – GPM Launch!

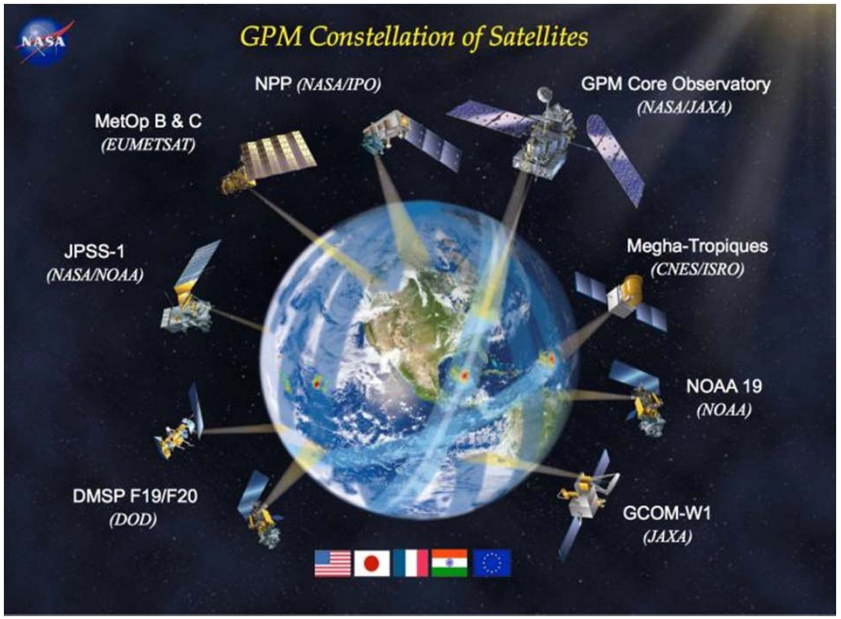


GPM at the clean room at NASA GSFC

Accurate and timely precipitation measurements

- GPM is an international mission which will use inputs from a constellation of satellites to provide improved space and time coverage of precipitation (rain, snow) over the globe
- The GPM Core Observatory will connect all of the data from partner satellites to provide precipitation information every 3 hours around the world





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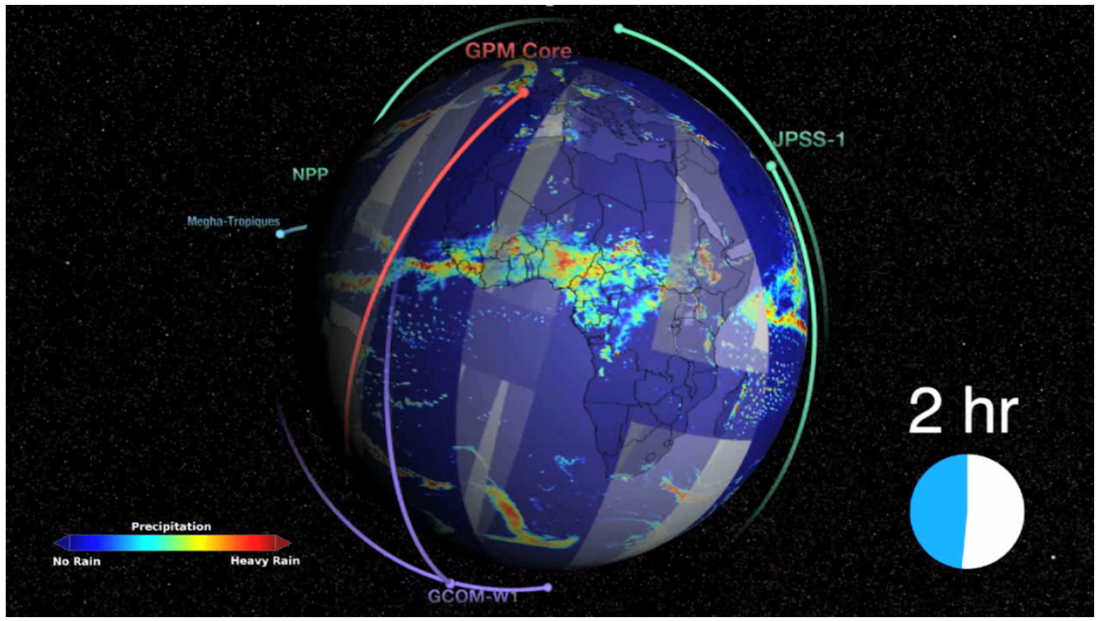
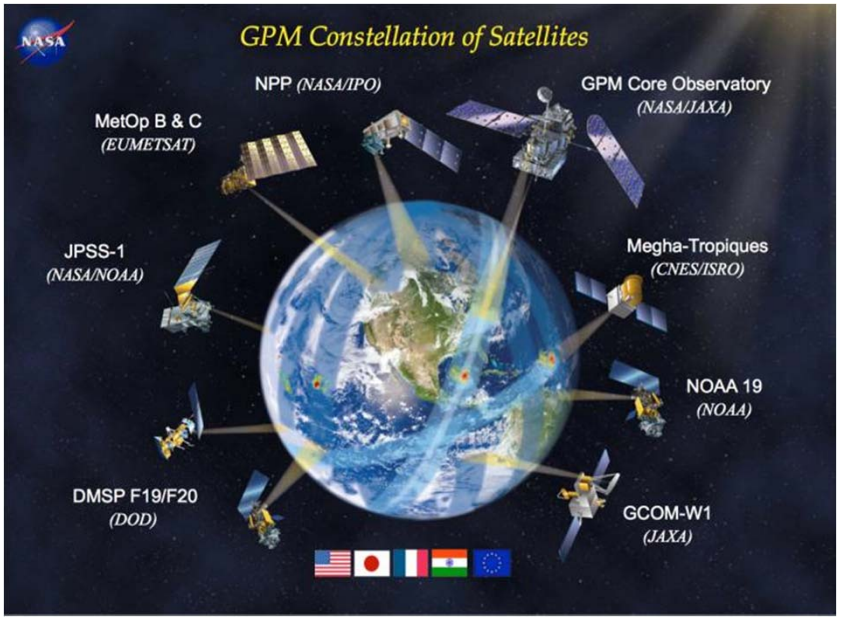


- Partner satellites will come from:
  - NOAA
  - DOD
  - EUMETSAT
  - ISRO/CNES (India/France)

Active Joint Projects (19 PI's from 13 countries)



Ground Validation and Field Campaigns

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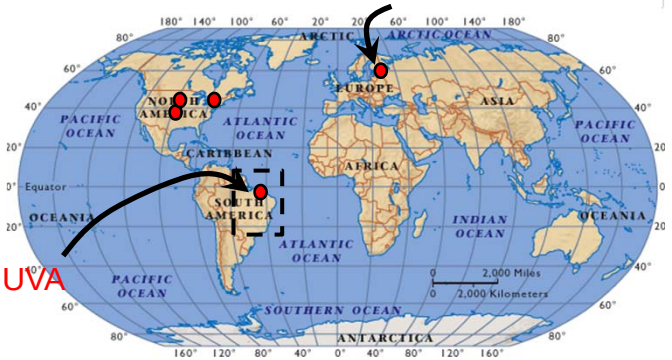

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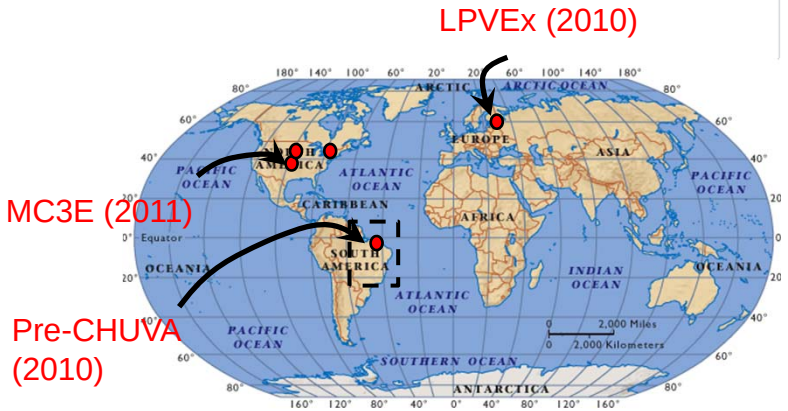

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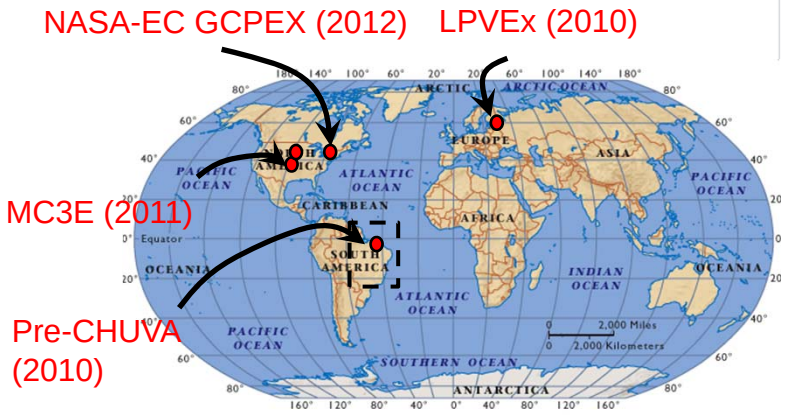

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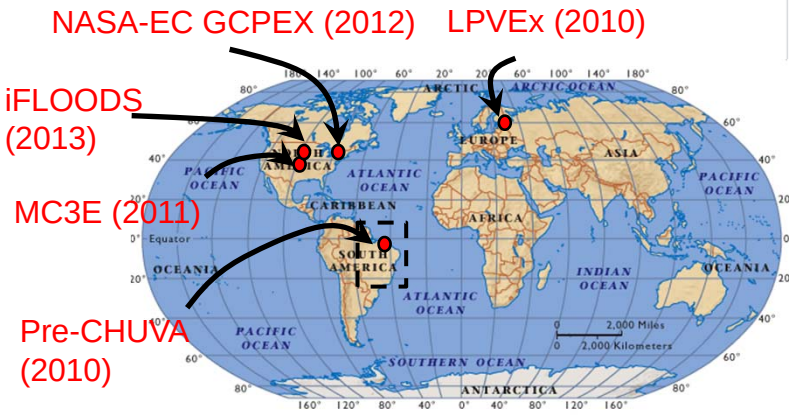

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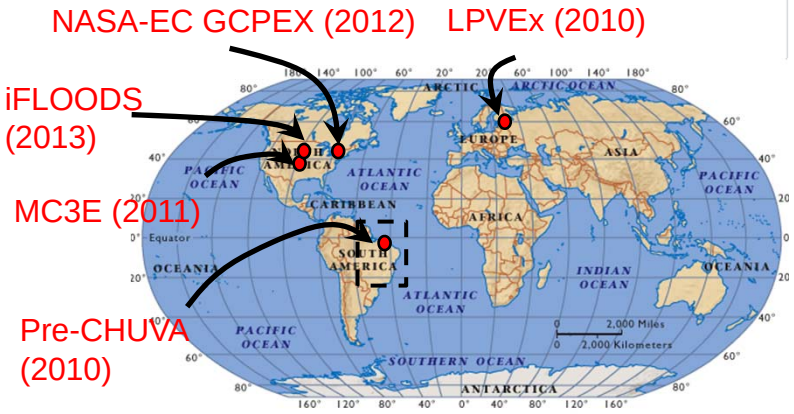
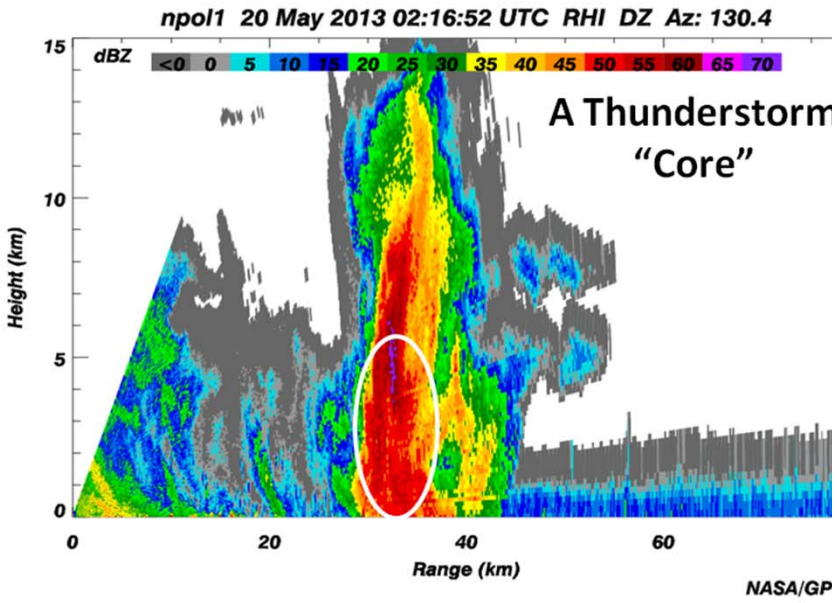


Defining what satellites are "seeing"

Example from 5/20/2013

NPOL –Diagnosed Cross-Sections of the Precipitation Process

Radar Reflectivity (returned power)



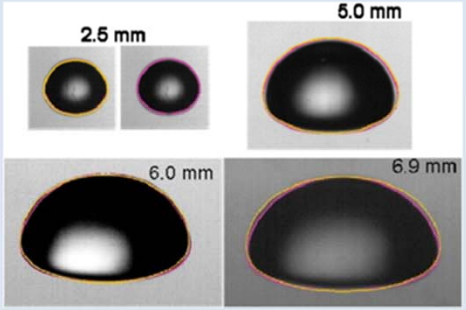
The "process" : Ice to Rain

Snow rimes

Graupel is formed

Graupel becomes *hail* and/or rain freezes and rimes to become hail

Rain drops (melting snow, hail, graupel)



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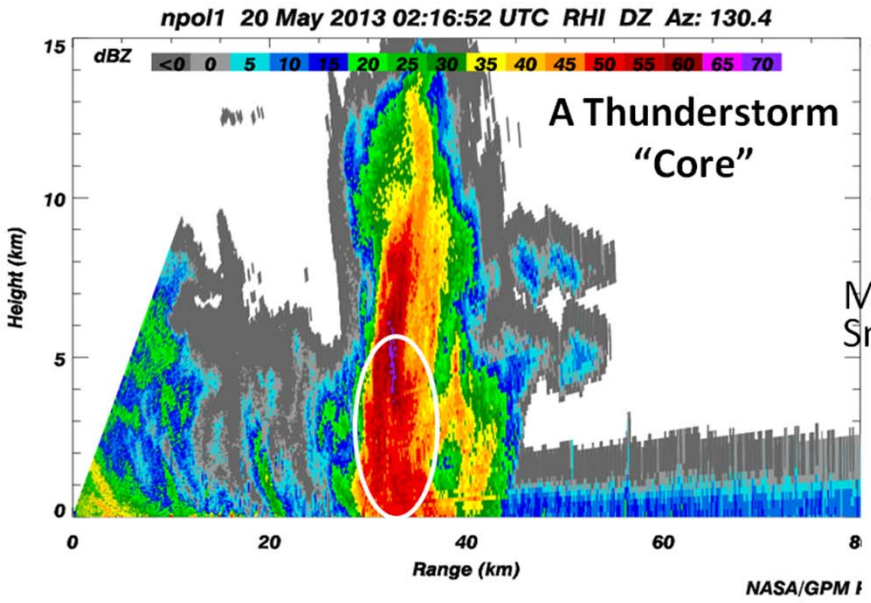
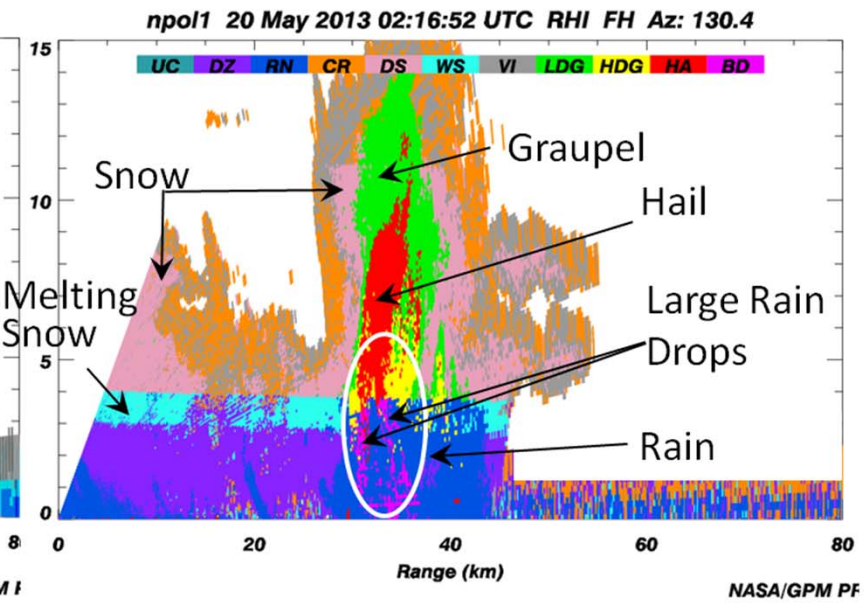


Diagnosed Precipitation Types



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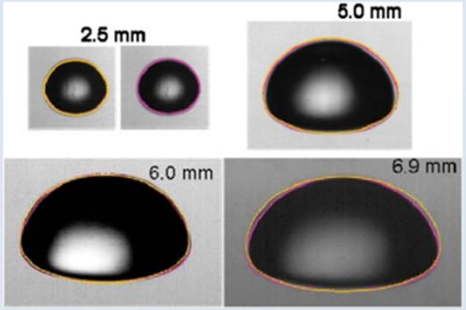
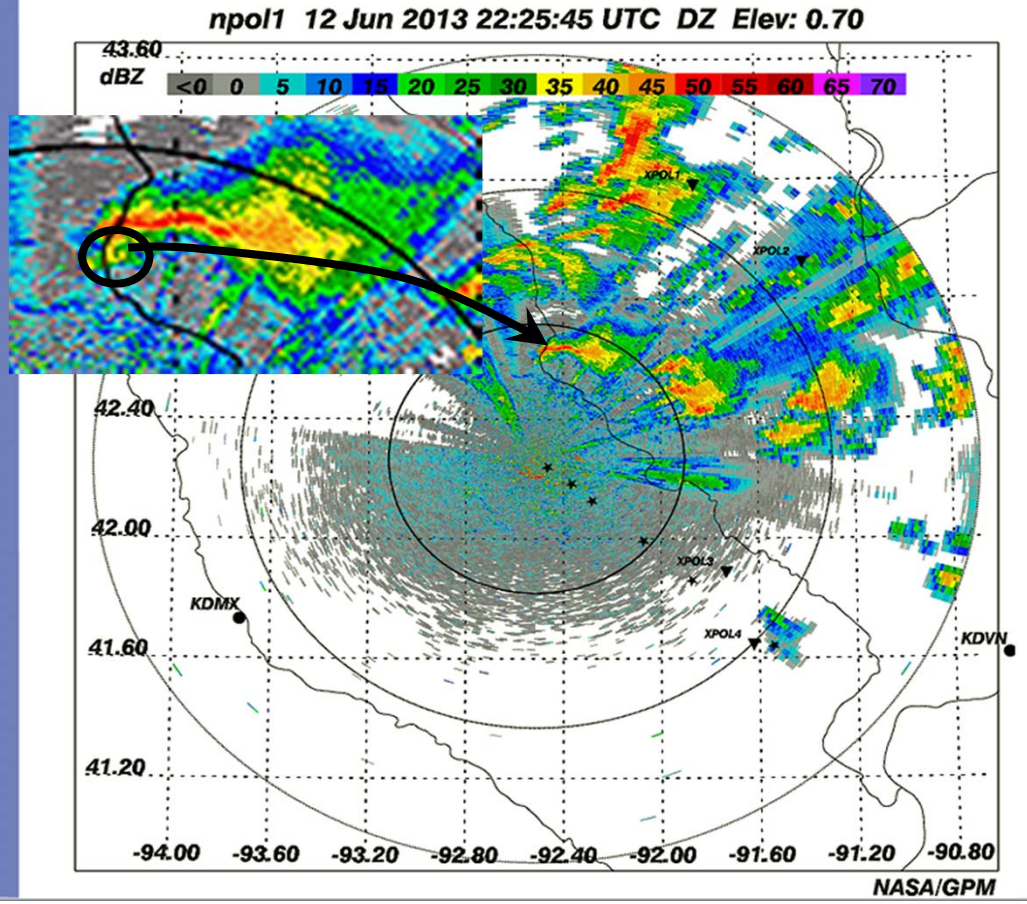
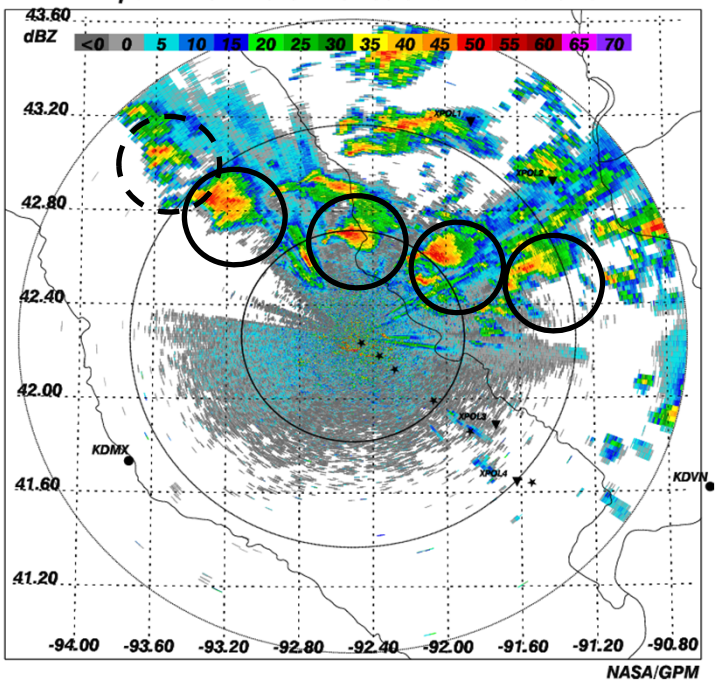


IFloodS: June 12, 2013 Severe Storm Outbreak

On Wednesday afternoon, June 12th there was a severe storm outbreak that developed and moved across central and eastern Iowa, spawning several tornadoes and huge thunderstorms.

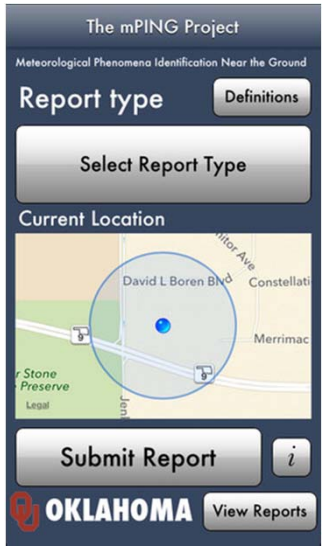
The NPOL radar was able to observe a Hook echo in a supercell only 40 km north of the radar. Images show convective Boundary Layer Development over NPOL and D3R on 6/12/2013 at ~1700 UTC. NPOL capturing line of multiple supercells, some tornadic moving across Iowa on June 12th at 21:57 UTC

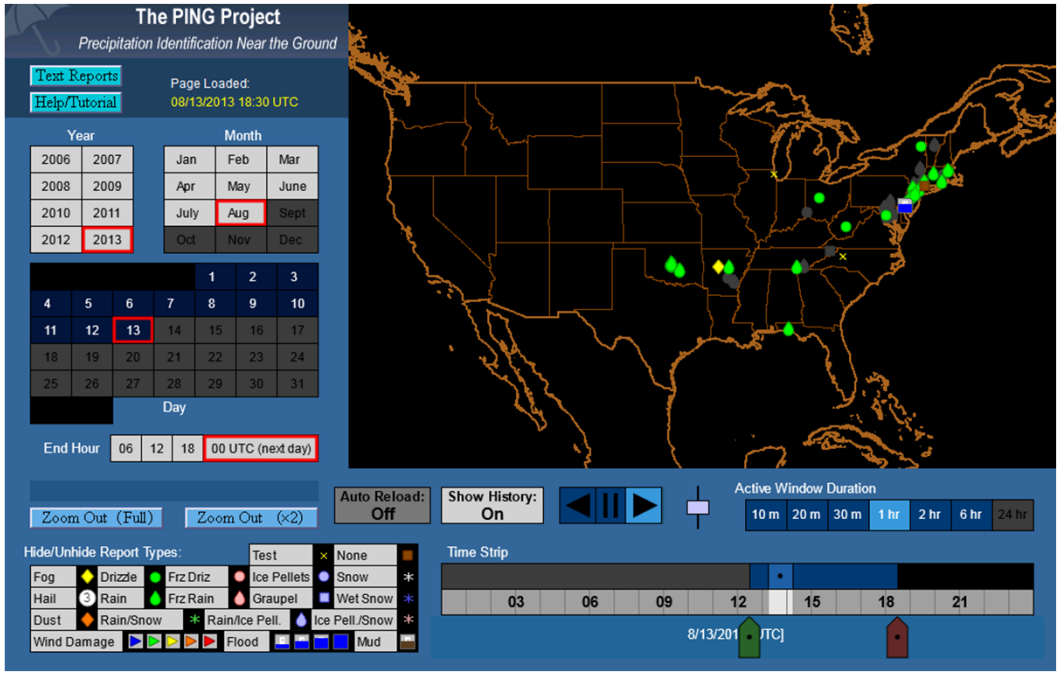




Citizen Science

- Meteorological Phenomena Identification Near the Ground (mPING) – Partnership with University of Oklahmoa, NOAA and NASA
- Report precipitation in your area with a click of a button!
- Going international by September





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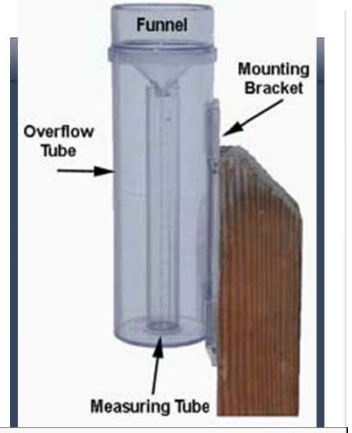
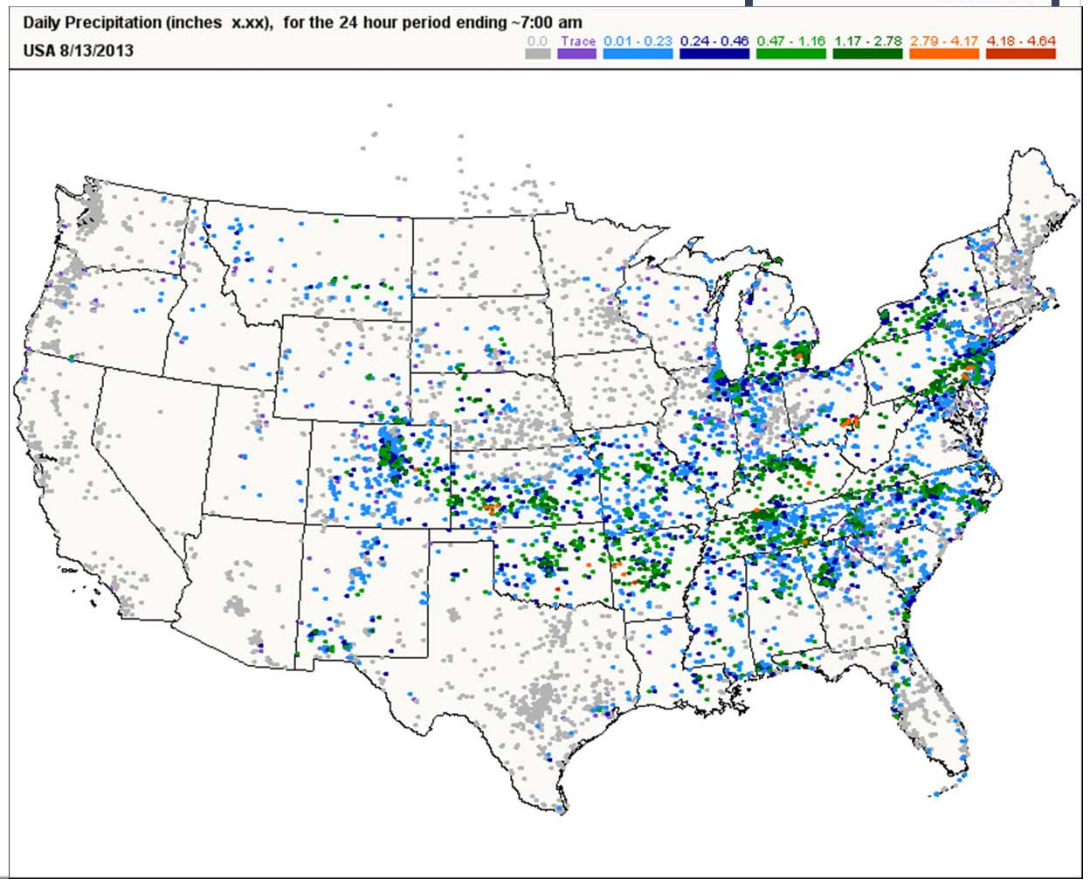


CoCoRaHS - Community Collaborative Rain, Hail and Snow Network; www.cocorahs.org)

- Network of individuals that take daily measurements of precipitation from rain gauges at their houses or other facilities

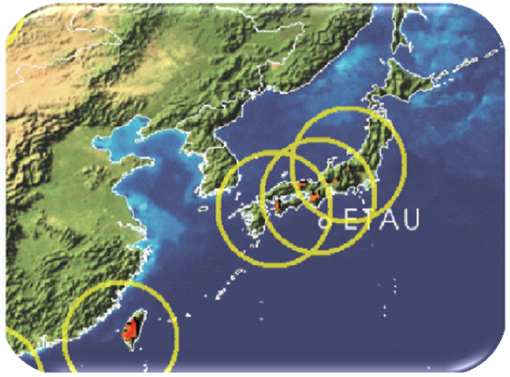


What can we do with the data?

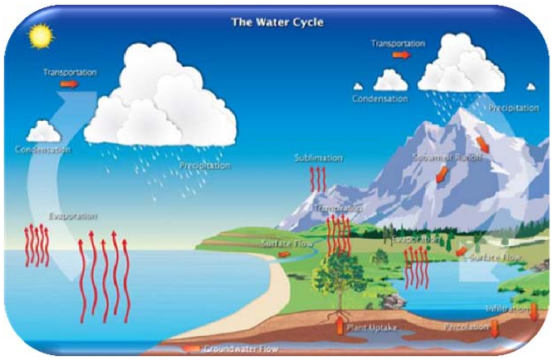
GLOBAL PRECIPITATION MEASUREMENT

Flooding

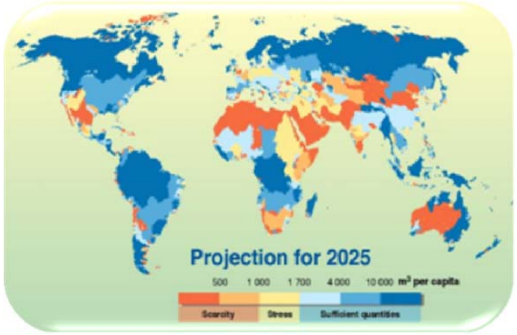
Landslides



Land surface and climate modeling



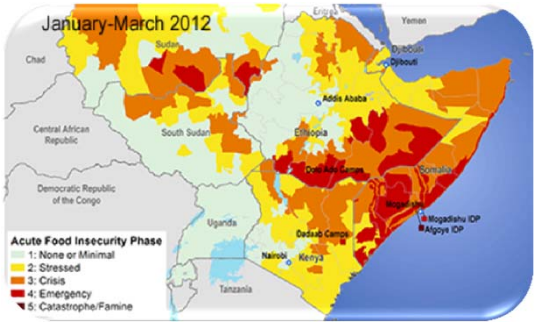
Freshwater Availability



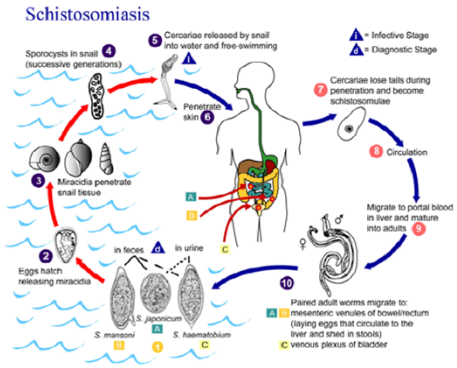
The rain and snow data gathered from the TRMM and GPM missions already provide and will extend our capabilities to study a wide range of applications for scientific research and societal benefit.

Extreme Events

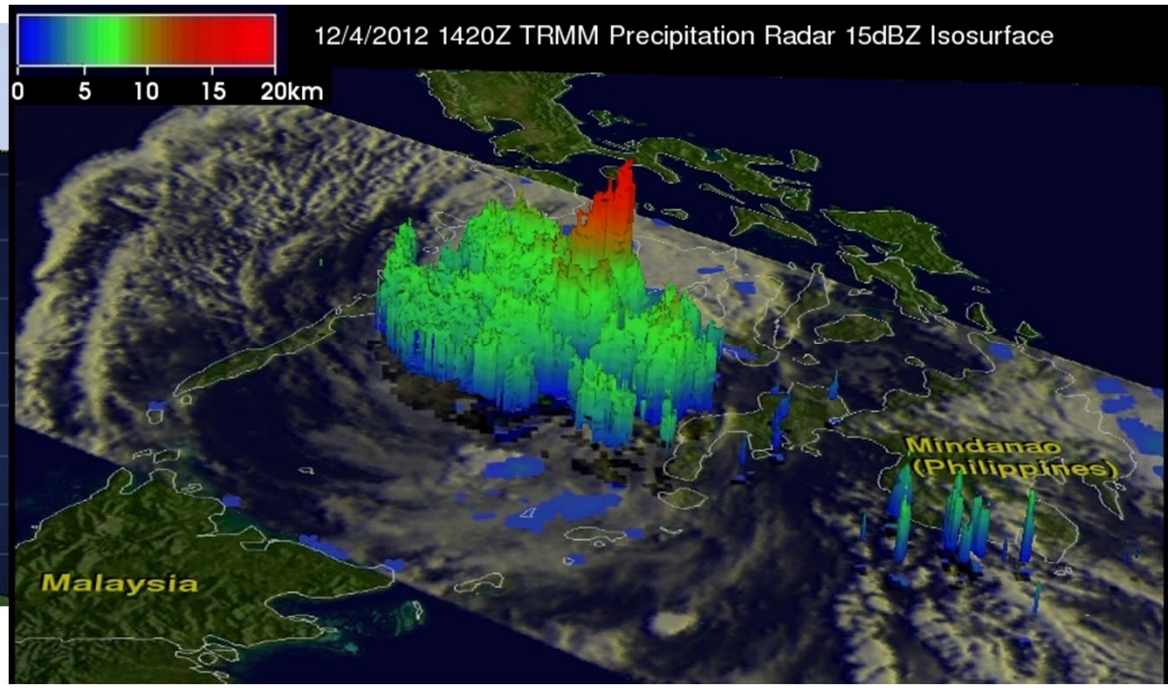
Agriculture/Famine Early Warning



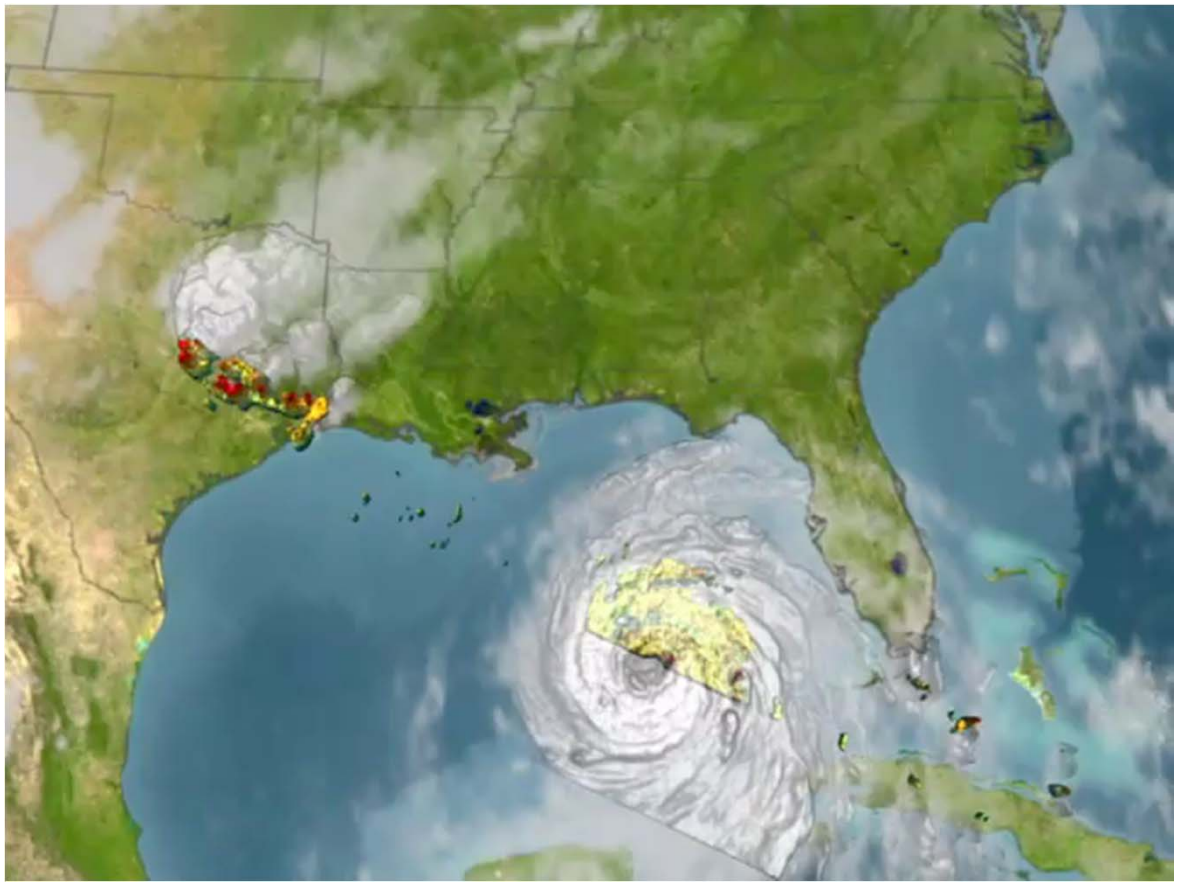
World Health



Typhoon Bopha, Dec. 4th, 2012



TRMM data are used by many tropical cyclone forecasting centers worldwide to detect the location and intensity of tropical cyclones. In 2004, more than 600 tropical cyclone fixes were made using TRMM.



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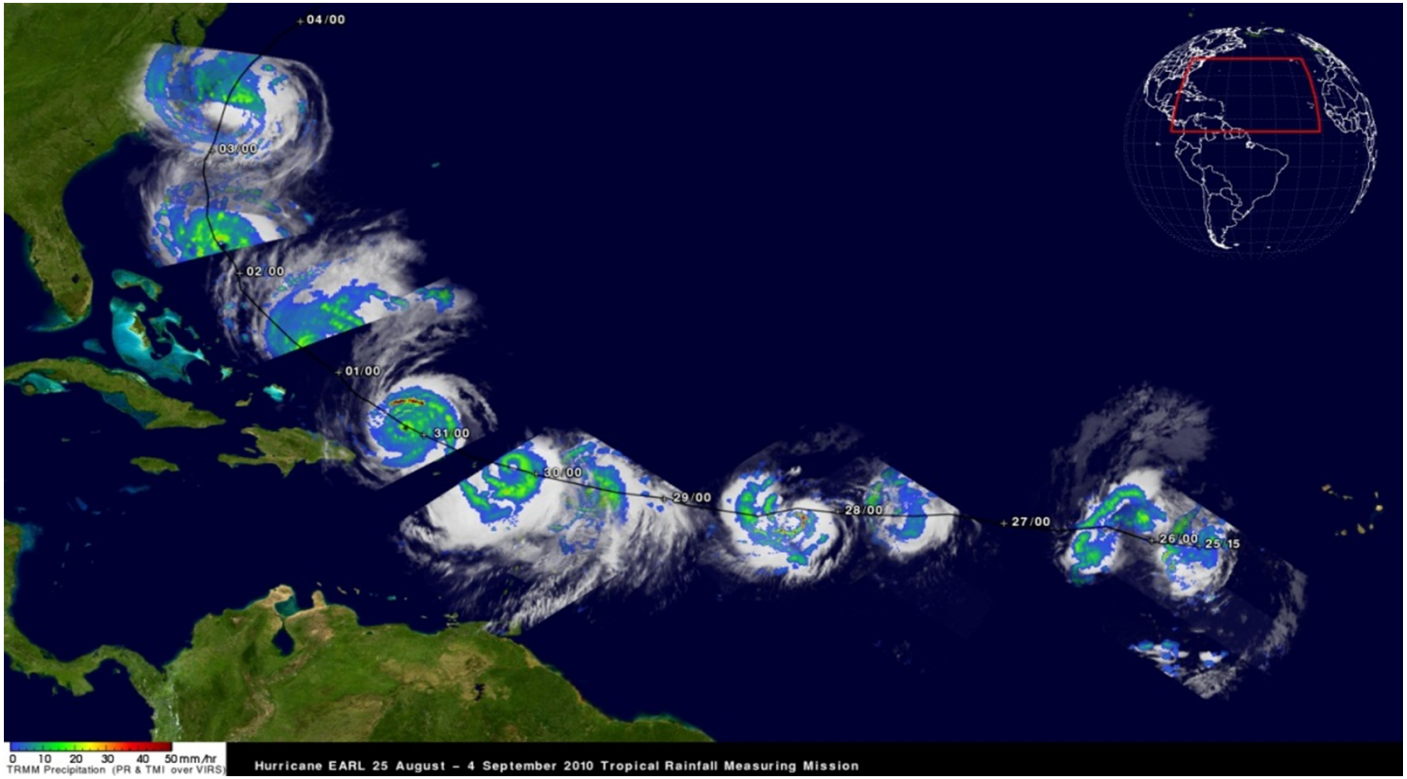
GPM's orbit will enable observation of tropical cyclones as they progress from tropical to mid-latitude systems



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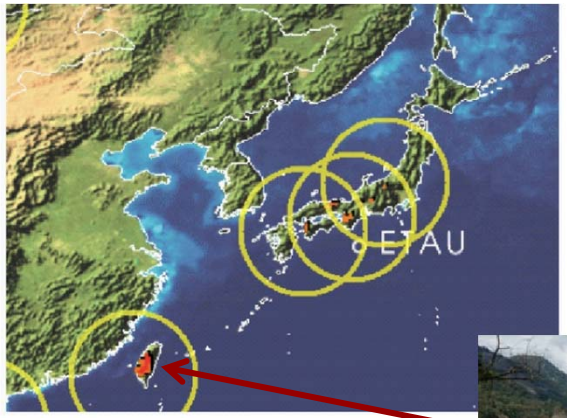
Landslides and flooding

GPM will provide rain accumulation and distribution data at high resolution to advance predictions of high-impact natural hazard events

Landslides and flooding

GPM will provide rain accumulation and distribution data at high resolution to advance predictions of high-impact natural hazard events

Landslide Hazard Forecasting



Typhoon Morakot (Etau) August 8th, 2009

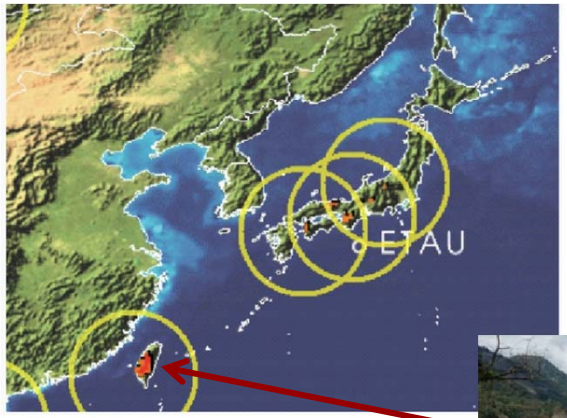
Over 500 people killed in Shiao Lin, triggered numerous and massive landslides throughout Southern and Central Taiwan

GPM will enhance modeling capabilities to estimate potentially susceptible areas to rainfall-triggered landslides.

Landslides and flooding

GPM will provide rain accumulation and distribution data at high resolution to advance predictions of high-impact natural hazard events

Landslide Hazard Forecasting



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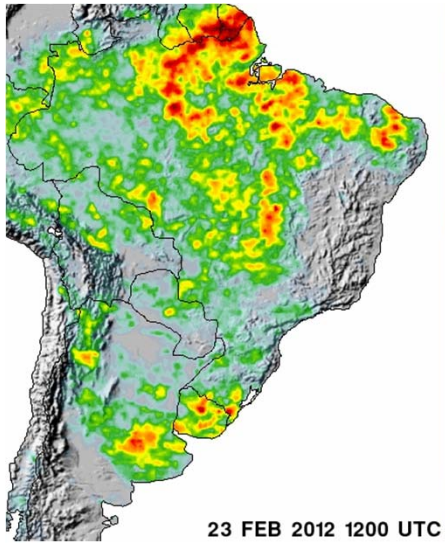
Global Flood Modeling

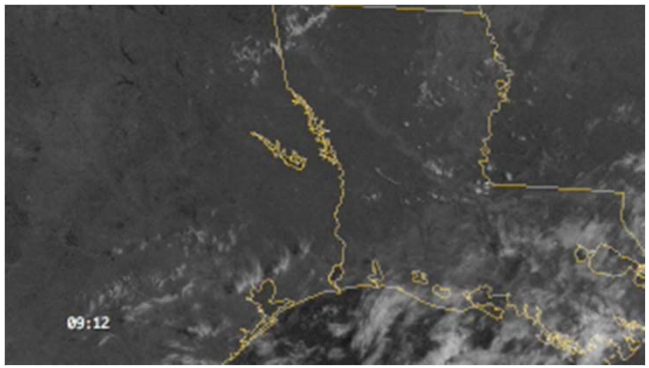


Real-time estimates of flood areas using satellite rainfall and a hydrological model updated globally, every 3 hrs

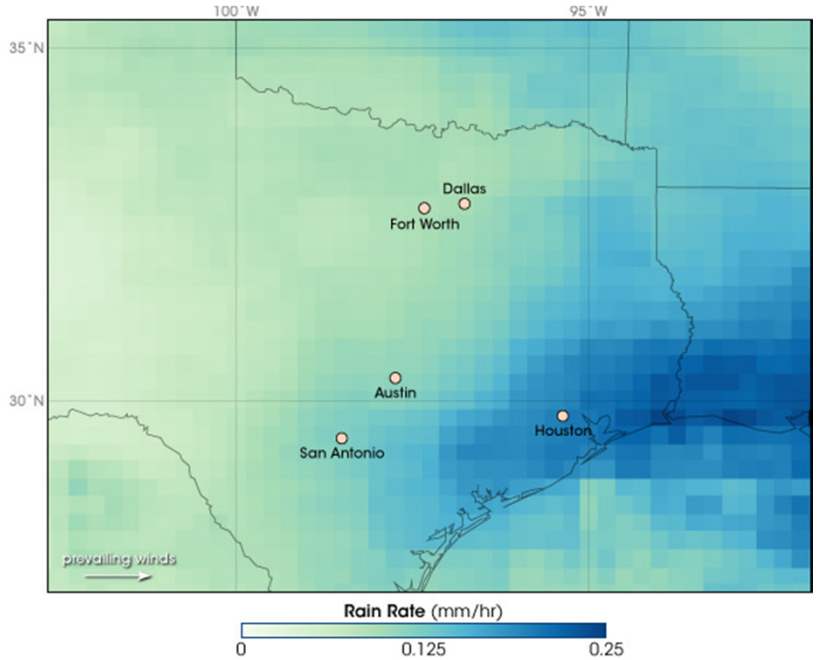
Estimating Urban Impacts

Measurements from TRMM revealed **elevated rain rates** downwind of urban areas in Texas. The heaviest rain (blue) occurred downwind of Houston.

"I started noticing that around some of the cities, there seemed to be these anomalies in rainfall downwind," Marshall Shepherd, current AMS president, University of Georgia, PMM Science Team Member



GOES imagery: Summer afternoon thunderstorms that sprang up along the border between Texas and Louisiana on September 6, 2006.



http://earthobservatory.nasa.gov/Features/UrbanRain/

GLOBAL PRECIPITATION MEASUREMENT

Estimating Urban Impacts

GLOBAL PRECIPITATION MEASUREMENT

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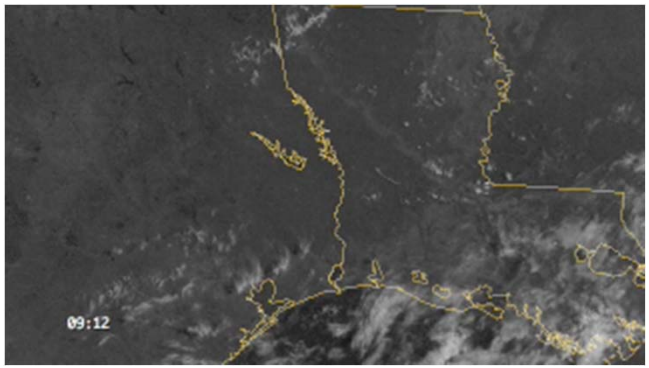

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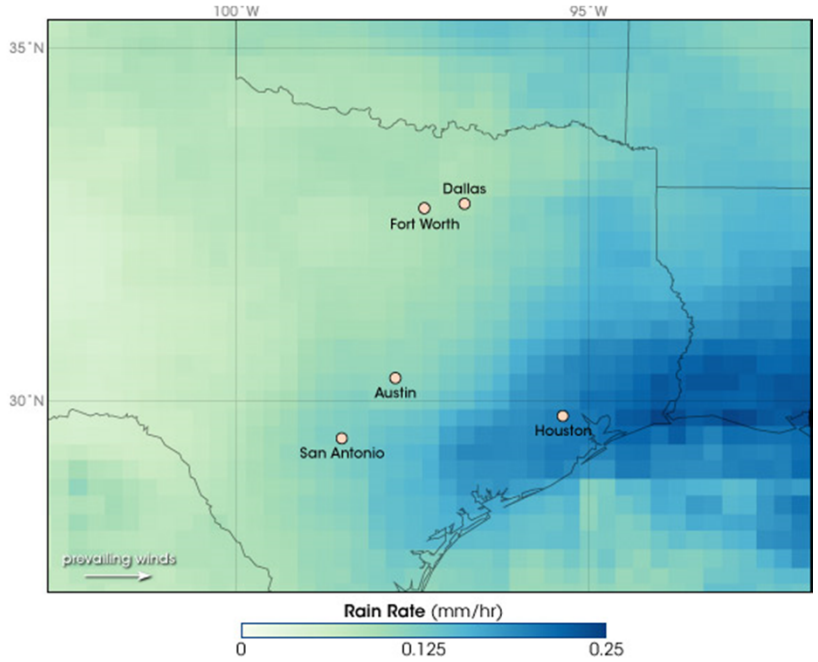

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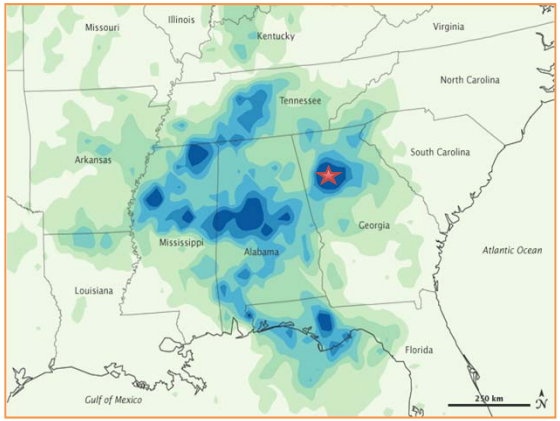
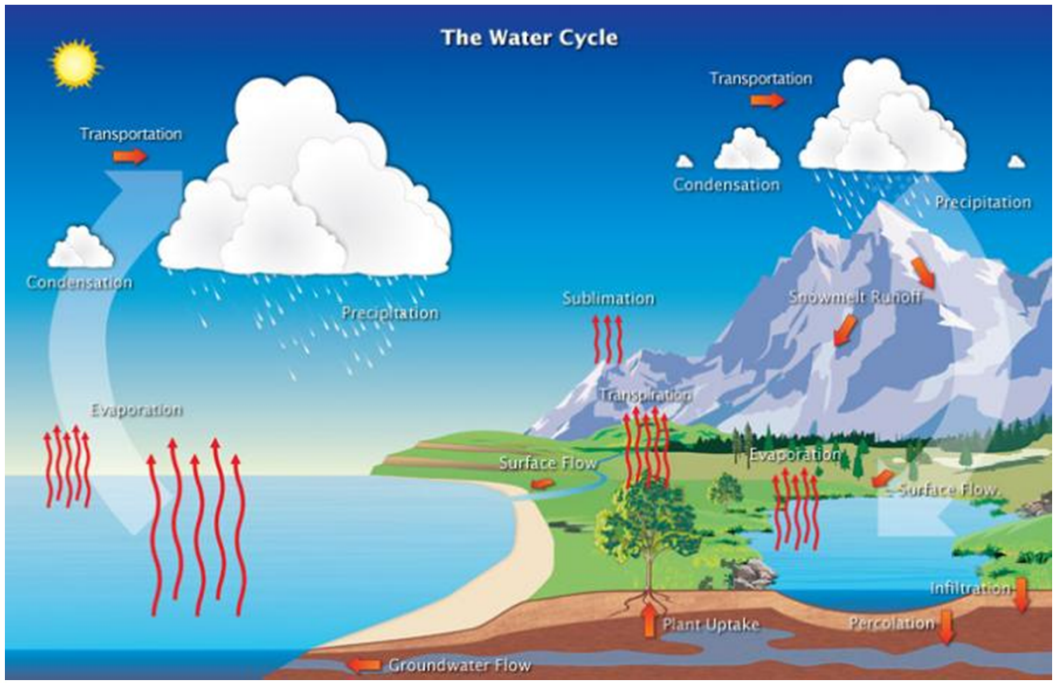


Rainfall (Atlanta floods) as acquired by multiple satellites, are calibrated with rainfall measurements from NASA's TRMM satellite. The highest rainfall amounts—more than 300 millimeters (11.8 inches)—appear in blue. Credit: NASA/Jesse Allen

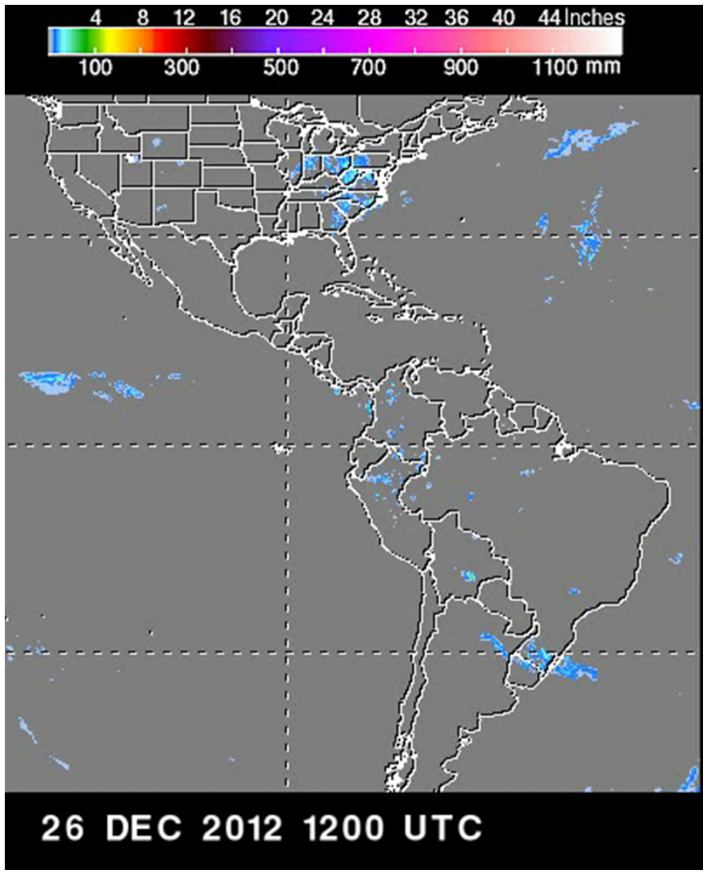
New research by *University of Georgia, University of Oklahoma, and the National Weather Service* has revealed **potentially predictive relationships between precipitable water (PW) distributions and urban flooding**

Climate Modeling and Numerical Weather Prediction (NWP)

Modeling short and long-term fluctuations in climate and the water cycle

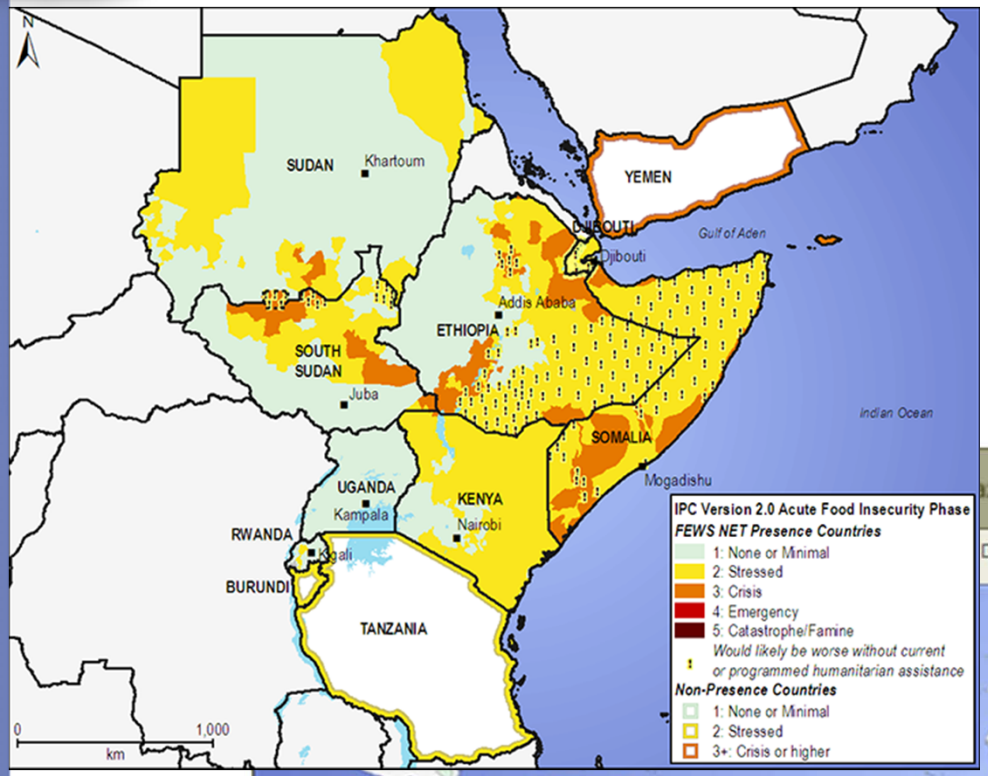


Rainfall accumulation for NWP

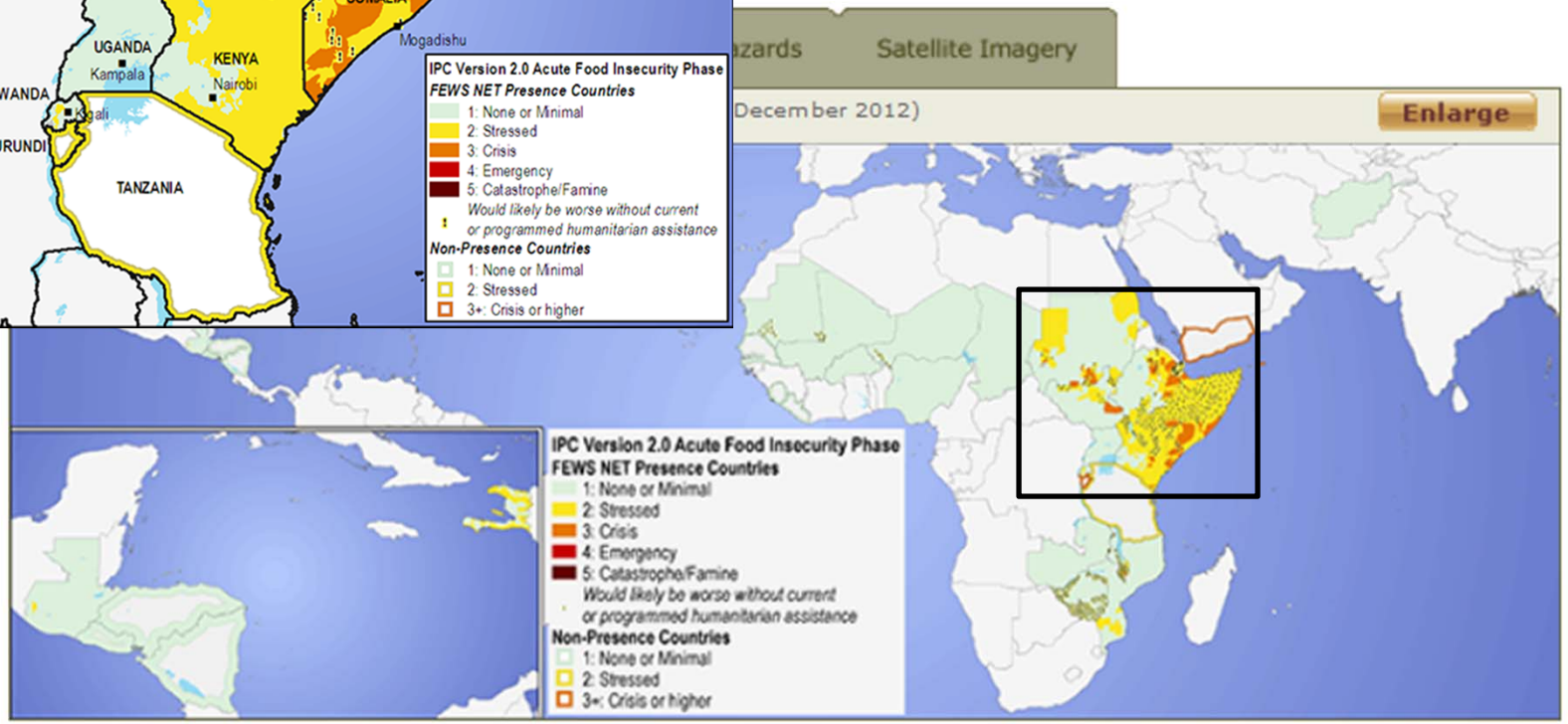


Precipitation observations are in use at ECMWF, NCEP, JMA, and other NWP centers to improve weather forecasting.

Freshwater availability and agriculture



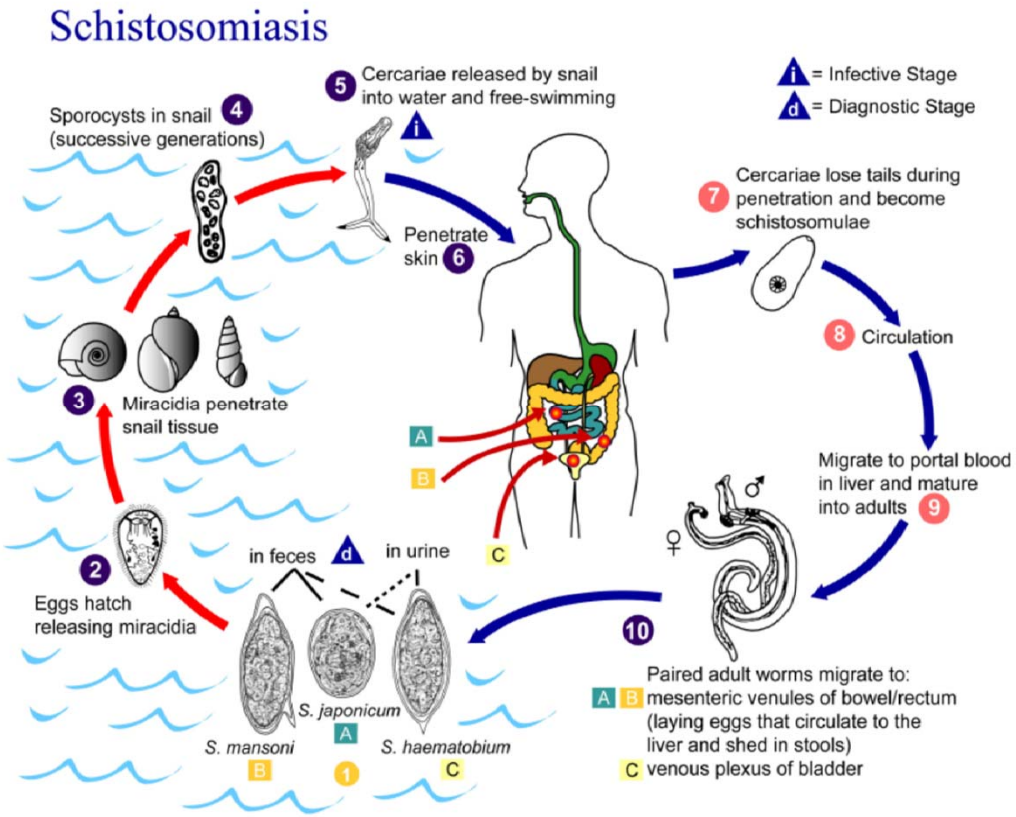
Accurate satellite precipitation estimates are critical to crop forecasts. Famine Earth Warning System (FEWS) relies on TRMM and other satellite estimates for anticipating poor growing seasons.



http://www.fews.net

World Health & Disease Outbreak

TRMM data has been used to estimate and trace the source areas of vector and river-borne diseases in Africa and Western Australia. Examples include Schistosomiasis (snail-spread) in Ethiopia.



Courtesy of Bitew and Gebremichael

Schuster et al. (2011), International Journal of Health Geographics, Vol. 10: 8, 1-14.

Educational resources

- Follow us on Twitter: @NASA_Rain
- "Like" us on Facebook: https://www.facebook.com/NASA.Rain
- Precipitation Education Website: www.pmm.nasa.gov/education

GPM Anime Challenge:

NASA and JAXA challenged people from around the world to design an anime character to help demonstrate GPM educational science themes of the water cycle, weather and climate, and technology. We received over 40 submissions from around the world. We are planning to develop a comic series with our grand prize winning characters

GPM Education and Public Outreach

- Formal Education:
  - Master Teachers: Developing materials with GPM themes to be taught in middle school Earth Science classes
  - Outdoor Education: “Survivor Module” based on measuring water in different environments
    - GLOBE Protocols: Precipitation and atmospheric measurements – Training sessions Tuesday and Thursday this week (morning/afternoon)
- Informal Education:
  - Earth to Sky partnership: stipends to National Parks, Fish and Wildlife Centers, etc. to develop an activity for their park

"Survivor" Modules

GLOBAL PRECIPITATION MEASUREMENT

developed by the Global Precipitation Measurement Mission

GPM.NASA.GOV / EDUCATION TWITTER.COM / NASA_RAIN FACEBOOK.COM / NASA.RAIN

Name- Date- Period-

Atmosphere Student Capture Sheet

Guiding Questions

What is the atmosphere and why is it important?
Is there water in the atmosphere right now? How do you know?
How is the atmosphere an important part of Earth's water cycle?

Engage

1. The atmosphere is
   _____
2. What is the difference between weather and climate?
   _____
   _____
   _____
3. Prediction: Water is _____ (not present, somewhat present, highly present) in the atmosphere today.

Explore

Record your data below. Remember to include units!

	Data	Notes
Current Air Temperature		
Amount of Rainfall		
pH of Rain Water		
Relative Humidity		

developed by the Global Precipitation Measurement Mission

GPM.NASA.GOV / EDUCATION TWITTER.COM / NASA_RAIN FACEBOOK.COM / NASA.RAIN

Cloud Type

☐ **Cirrus:** High wispy clouds; contain ice crystals	☐ **Cumulus:** Low to middle white puffy clouds; contain water drops	☐ **Stratus:** Low layered clouds cover most of the sky; contain water drops	☐ **Nimbostratus:** Low layered clouds with rain falling
			

Low moisture → **Higher Moisture**

Cloud Cover

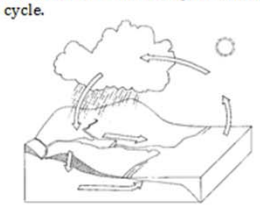
No Clouds	*Clear*	*Isolated*	*Scattered*	*Broken*	*Overcast*
					
❑ 0%-No Clouds	❑ <10% Clouds	❑ 10-25% Clouds	❑ 25-50% Clouds	❑ 50-90% Clouds	❑ >90%

Explain

Based on the data you collected, water is _____ (not present, somewhat present, highly present) in the atmosphere today. Provide evidence to support your answer.
_____
_____
_____

Evaluate

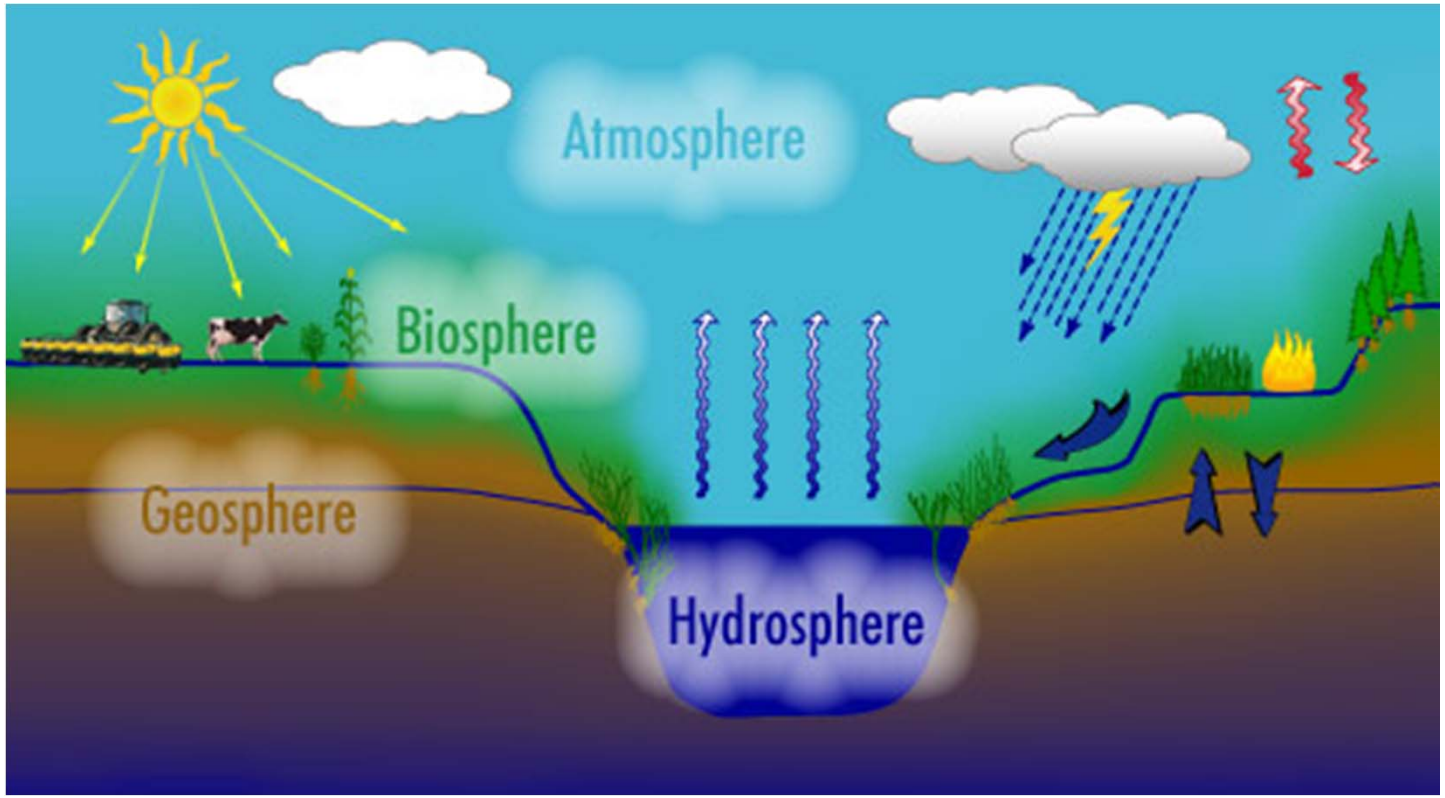
Label the parts of the water cycle that involve the atmosphere and describe how the atmosphere is an important part of the water cycle.



GPM.NASA.GOV / EDUCATION

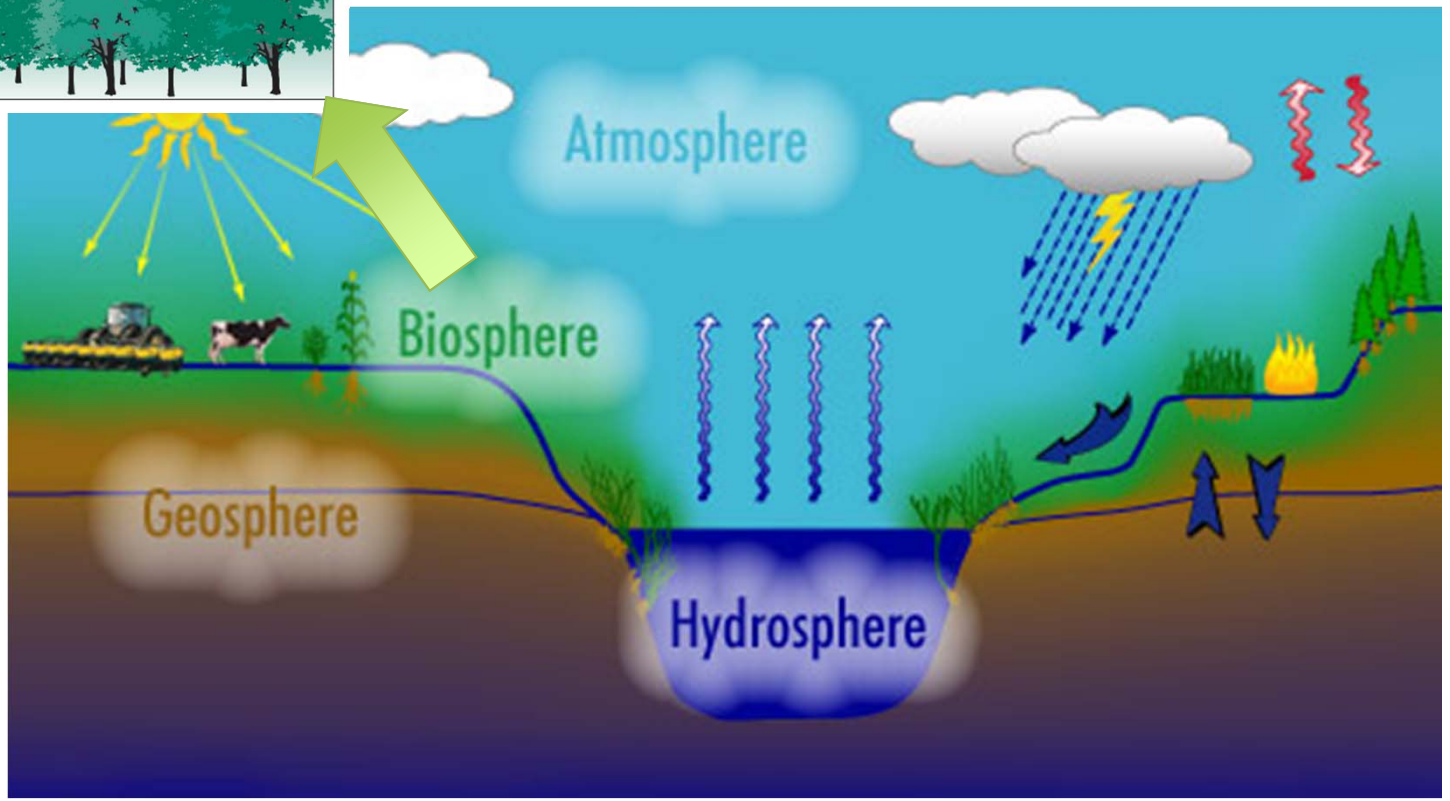
Lessons introduce students to making hands-on measurements through GLOBE protocols to explore Earth's Hydrosphere, Biosphere, Geosphere and Atmosphere

Types of Measurements



Types of Measurements

- ✓ Land Cover
- ✓ Water in Biosphere

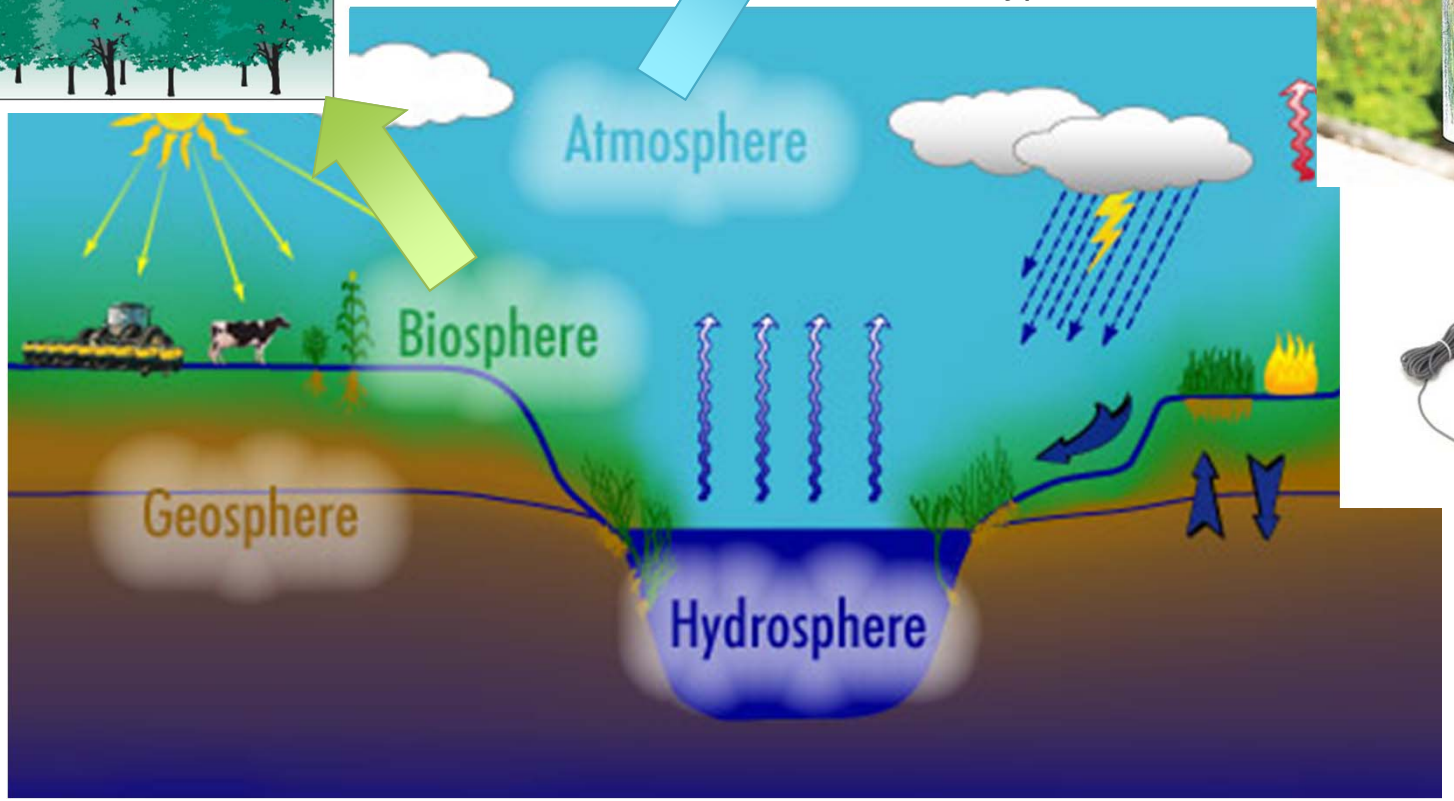


GLOBAL PRECIPITATION MEASUREMENT

Types of Measurements

- ✓ Land Cover
- ✓ Water in Biosphere

- ✓ Rainfall
- ✓ Air temperature
- ✓ pH of rain
- ✓ Relative humidity
- ✓ Cloud type and cover



Types of Measurements

GLOBAL PRECIPITATION MEASUREMENT

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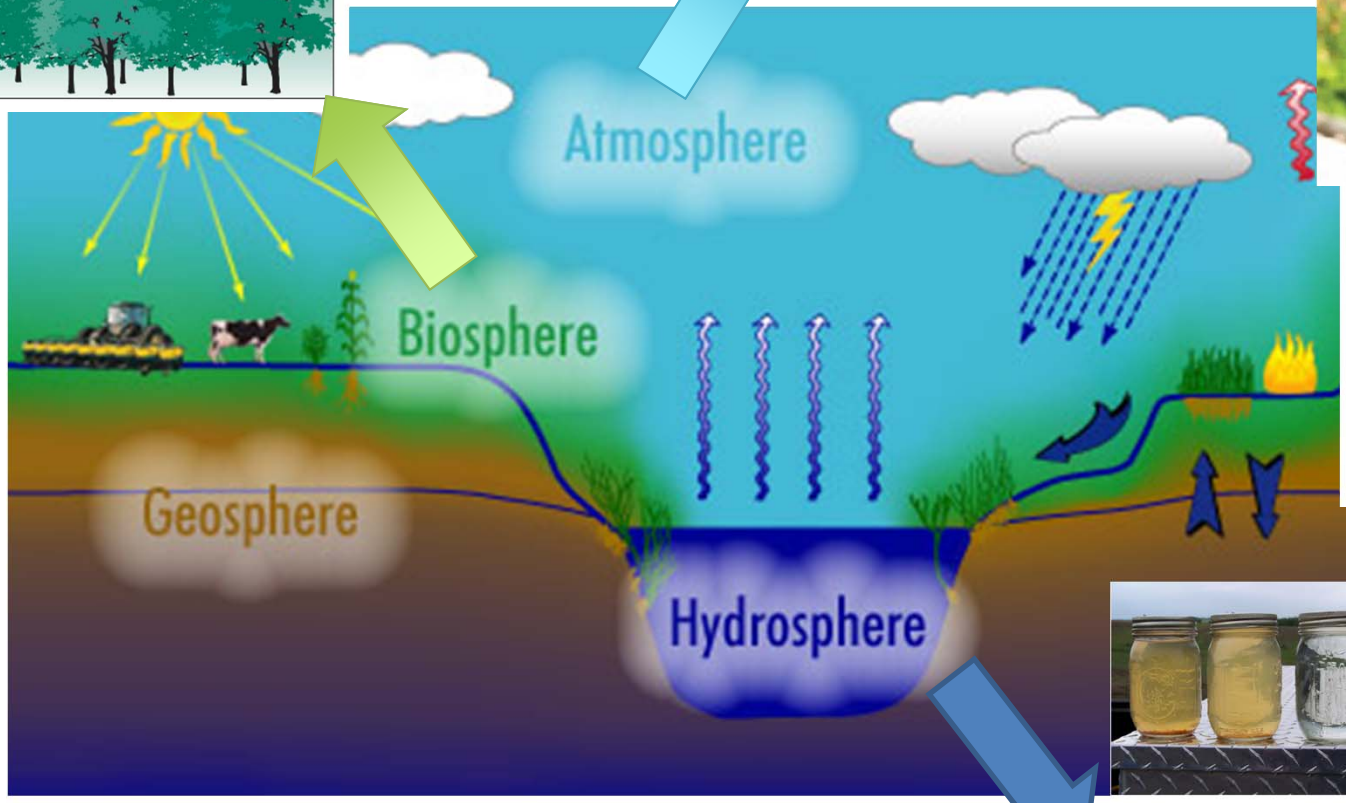
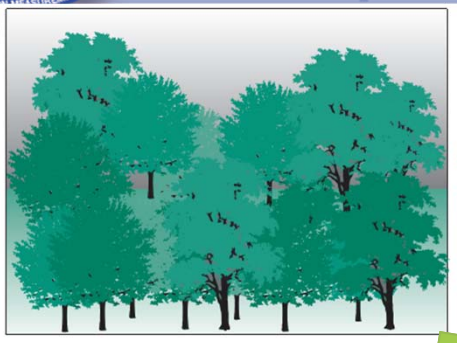


- ✓ pH
- ✓ Temperature
- ✓ Transparency

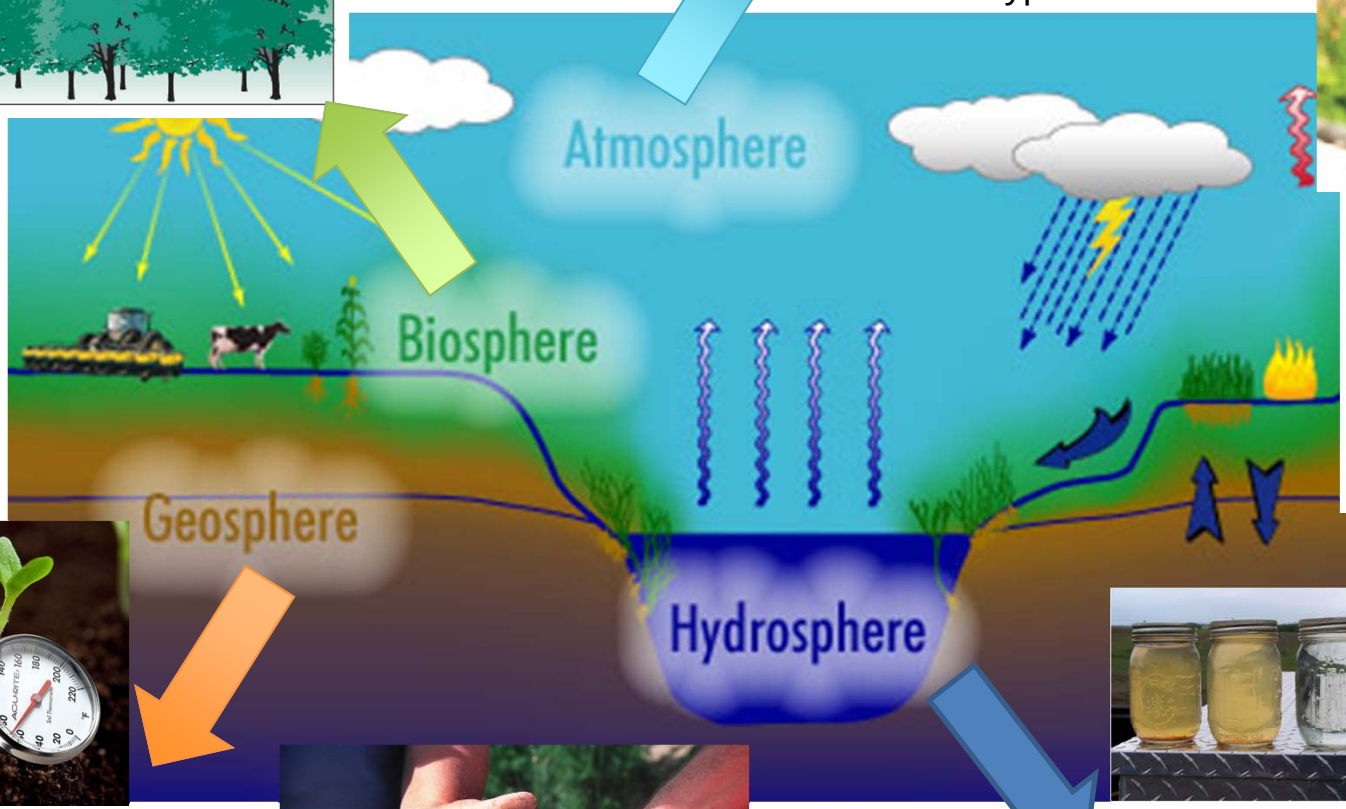
Types of Measurements

GLOBAL PRECIPITATION MEASUREMENT



- ✓ Land Cover
- ✓ Water in Biosphere

- ✓ Rainfall
- ✓ Air temperature
- ✓ pH of rain
- ✓ Relative humidity
- ✓ Cloud type and cover



- ✓ Soil Moisture
- ✓ Soil Temperature
- ✓ Soil Consistence
- ✓ Soil Color

- ✓ pH
- ✓ Temperature
- ✓ Transparency

Educator Resources

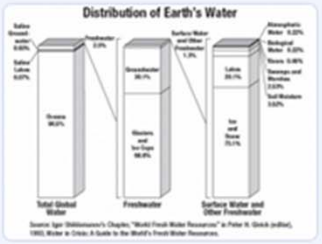
Precipitation Education

Home | Current Activities | GPM Originals | Glossary & FAQ | GPM Mission

Water Cycle | Weather & Climate | Technology | Societal Applications

Home > Societal Applications > Freshwater Availability Classroom Activity

Freshwater Availability Classroom Activity



Type: Lesson Plan
Audience: Formal, 9 - 12, 6 - 8, K - 5
Standards: ESS3.A, ETS2.B
Keywords: groundwater, glaciers, saline, blue marble
Summary: This classroom activity (originally developed for the GPM Poster) will teach students about the value of Earth's freshwater resources and how important it is to study how water is transferred and stored.

This activity can be used with any age level, from elementary level students to adult groups.

Educational Standards:
Earth and Space Science: Structure of Earth System

- Water, which covers the majority of the Earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle"
- Fresh water, limited in supply, is essential for some organisms and industrial processes. 4B/M8*

Classroom Activity

This activity is designed to introduce participants to the concept that although about 70% of Earth's surface is covered by water, only a small fraction of that water is available to humans as an essential resource.

Engage:

Show participants a picture of the Earth taken from space to begin a discussion about water on Earth and how we have learned about water on Earth from satellites in space.

Show students the following image and use the following questions as discussion starters:

Search

Advanced Search

Browse Type

Video | Article
Image | Website
Interactive | Lesson Plan

Browse Audience

Formal | K-5
Informal | 6-8
Outreach | 9-12

Related Topics:

- Water & Life
- Remote Sensing
- Freshwater Resources
- World Health

PRODUCED BY 全球降水觀測計畫 GPM GLOBAL PRECIPITATION MEASUREMENT

http://pmm.nasa.gov/education

Other E/PO Activities

- Outreach:
  - Science on a Sphere show, “Water Falls” premiering in October!
  - Social Media, websites, Photo contests, Anime Character Challenge
  - Videos, feature stories, Google+ Hangouts, LEGO Model, Launch parties

GLOBAL PRECIPITATION MEASUREMENT

For more information on the TRMM and GPM Missions:

http://gpm.nasa.gov

www.nasa.gov/gpm

Twitter: NASA_Rain Facebook: NASA.Rain

EXTRA SLIDES

For Good Measure

http://pmm.nasa.gov/education/videos/for-good-measure

Applications Video

http://pmm.nasa.gov/education/videos/gpm-hurricanes-beyond-tropics

Constellation Partners

- Special Sensor Microwave Imager/Sounder (SSMIS) instruments on U.S. Defense Meteorological Satellite Program (DMSP) satellites
- The Advanced Microwave Scanning Radiometer-2 (AMSR-2) on JAXA's Global Change Observation Mission - Water 1 (GCOM-W1) satellite
- The Multi-Frequency Microwave Scanning Radiometer (MADRAS) and the multi-channel microwave humidity sounder (SAPHIR) on the Megha-Tropiques satellite provided by the Centre National D'Etudies Spatiales (CNES) of France and the Indian Space Research Organisation (ISRO)
- The Microwave Humidity Sounder (MHS) instrument on the National Oceanic and Atmospheric Administration (NOAA)-19 satellite
- MHS instruments on the MetOp series of satellites launched by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT)
- The Advanced Technology Microwave Sounder (ATMS) instruments on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP)
- ATMS instruments on the upcoming NOAA-NASA Joint Polar Satellite System (JPSS) satellites
- A microwave imager planned for the Defense Weather Satellite System (DWSS)

Ou Mi-Lim Korea Meteorological Administration / National Institute of Meteorological Research (KMA/NIMR)