GPM Applications Activities

**2nd NOAA User Workshop
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JAXA

GLOBAL PRECIPITATION MEASUREMENT
GPM CORE OBSERVATORY - A REFERENCE STANDARD FOR PRECIPITATION MEASUREMENT FROM SPACE

NASA

GPM Science Objectives

1. **Precipitation Remote Sensing:** New reference standards for precipitation measurements from space

2. **Weather**: Improving numerical weather forecasting skill

3. **Climate**: Advancing climate modeling and prediction capabilities

4. **Water Cycle:** Improved understanding of precipitation physics, water cycle variability, and freshwater availability

5. **Hydrometeorology**: Enabling monitoring and forecasting of floods, landslides, and freshwater resources
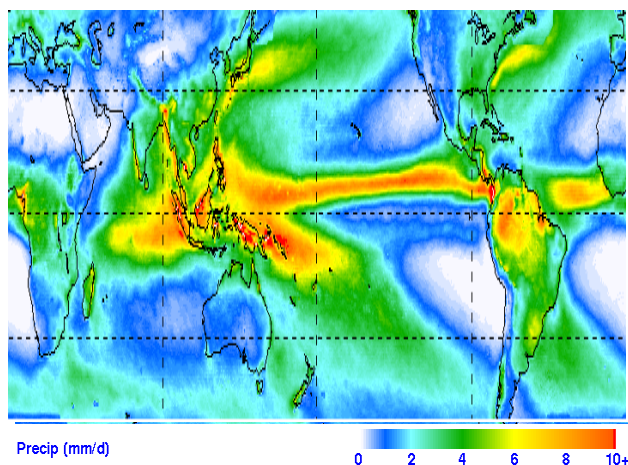
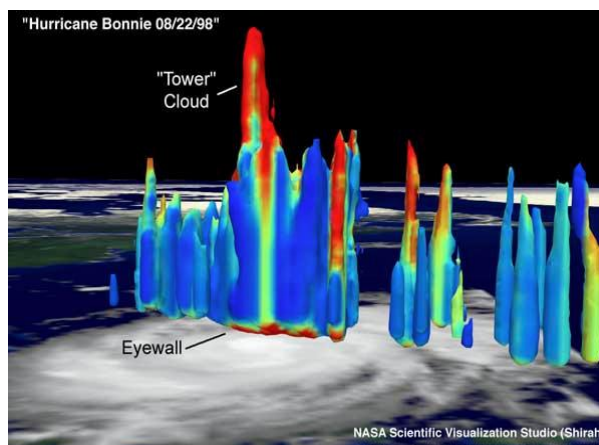# Precipitation Measurement Missions (PMM)

The PMM currently provide and will extend high-resolution microwave instrument capabilities to measure precipitation around the globe, enabling a diverse range of applications across agencies and socio-economic sectors:

- Extreme weather
- Floods and Landslides
- Agriculture
- World Health

- Numerical Weather Prediction
- Land Surface Models
- Freshwater Availability
- Climate modeling and prediction

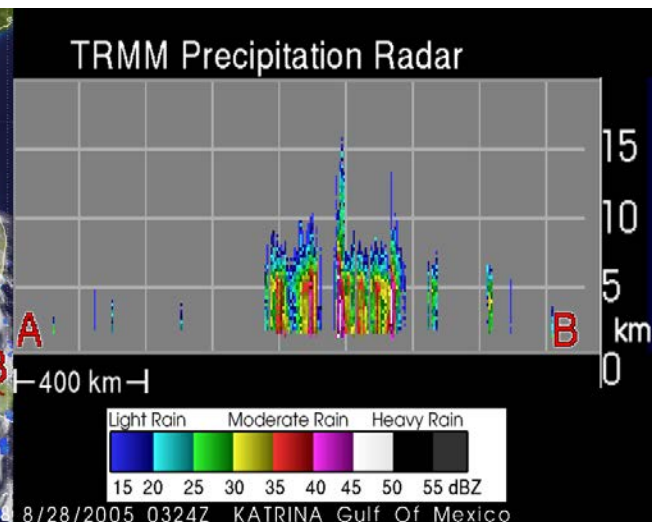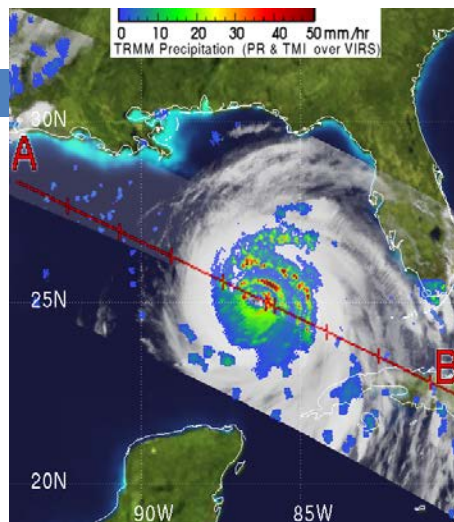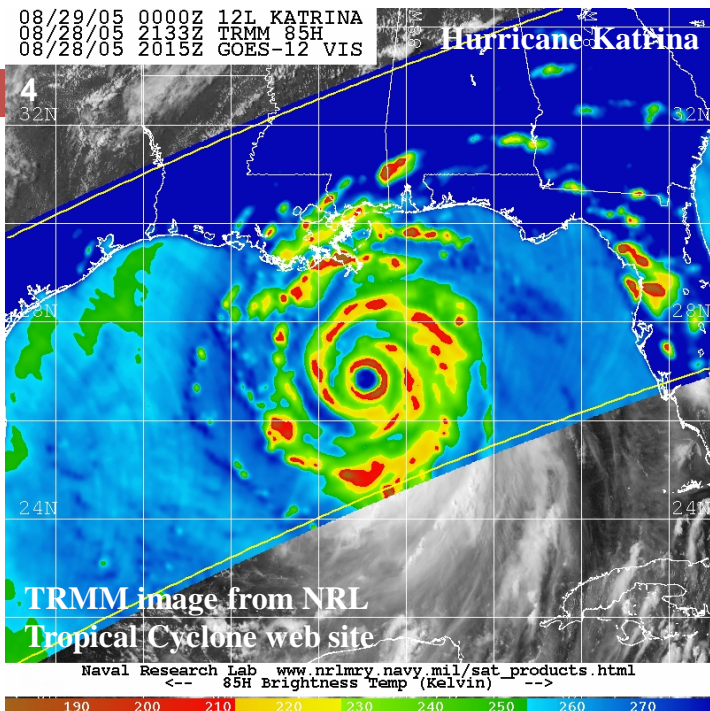*ENSO variability*   *"Hot convective towers"*   *Natural Hazards*

Precip (mm/d)
0   2   4   6   8   10+

"Hurricane Bonnie 08/22/98"
"Tower" Cloud
Eyewall
NASA Scientific Visualization Studio (Shirah)

Tropical Cyclone Tracking

08/29/05 0000Z 12L KATRINA
08/28/05 2133Z TRMM 85H
08/28/05 2015Z GOES-12 VIS

Hurricane Katrina

TRMM image from NRL
Tropical Cyclone web site

Naval Research Lab www.nrlmry.navy.mil/sat_products.html
<-- 85H Brightness Temp (Kelvin) -->


TRMM Precipitation Radar

TRMM <u>radar</u> (PR) cross-sections of hurricanes available in real-time for operational analysis

TRMM <u>TMI</u> data used by NOAA and DoD (and int'l agencies) for tropical cyclone detection, location and intensity estimation--600 TRMM-based tropical cyclone "fixes" in 2004
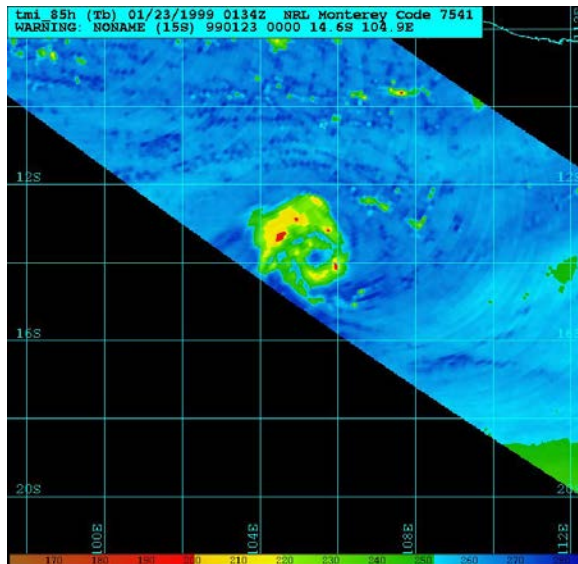
TRMM orbit advantageous for tropical cyclone monitoring--it is always in tropics, sampling best in 10-35° latitude storm band. TMI resolution twice as good as operational sensors, about same as AMSR.

Position Error in Nautical Miles

Position Confidence Accuracy in Hurricane Track
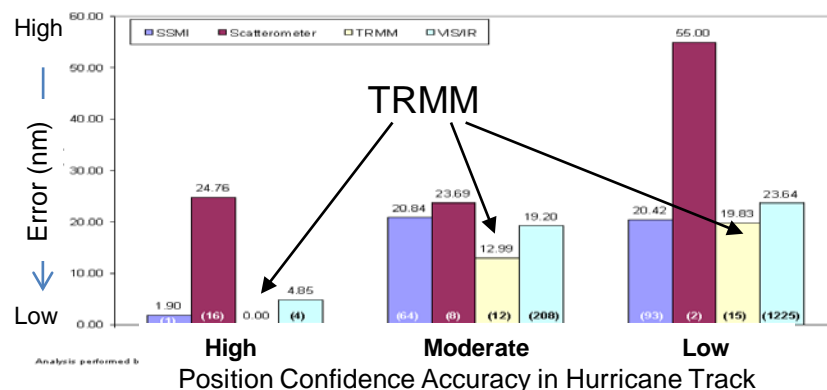
Extratropical Storm Tracking

TMI 85GHz Image
of enclosed eye
with spiral bands

High-resolution radiometer data can provide accurate position fixes of storms. The GMI on the Core offers the highest resolution data in the GPM era.

- Near-realtime "asynoptic" observations (from a non-Sun-synchronous orbit) in-between observations by polar orbiters at fixed local times have high operational values in hurricane monitoring and prediction
  - *TMI data account for 16% of all tropical cyclone position fixes made by the Joint Typhoon Warning Center (JTWC) in a typical year*
- GPM will provide observations of 3D precipitation structure as tropical storms undergo the transition into mid-latitude frontal systems

Numerical Weather Prediction

- Assimilation of precipitation information into global and regional forecast systems has been shown to improve atmospheric analyses and short-range forecasts in a variety of situations.

- Precipitation observations are in use at European (ECMWF), U.S. (NCEP), Japanese (JMA), and other NWP centers to improve weather forecasting.

- Satellite-derived rain rates (such as from DPR) can also be used to verify information from operational forecasts

ECMWF Hurricane Charley track forecasts from analysis 2004081112

CHARLEY TRACK FORECAST (BASE: 2004081112)

Legend:
— OBS
···· CONTROL
--- Rain Ass
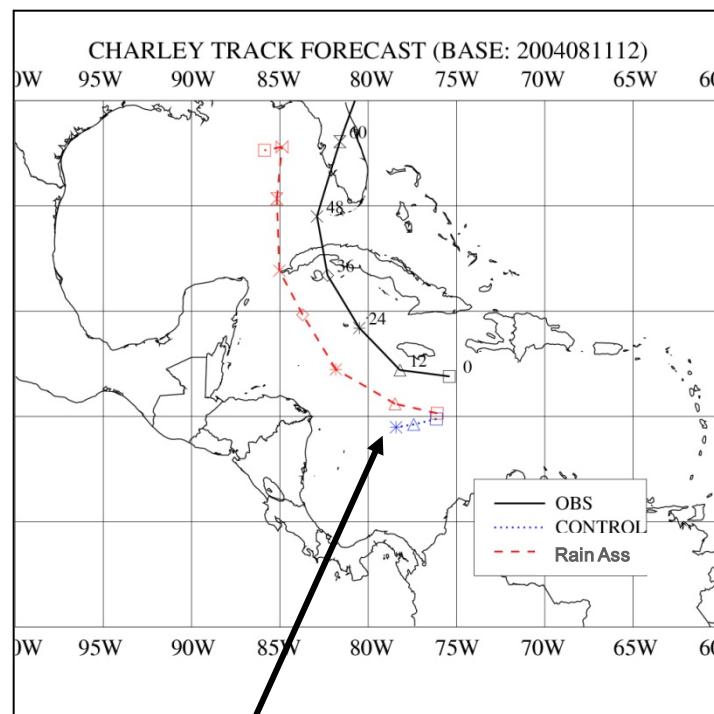
Cyclone disappeared in operational forecast without rain assimilation

Courtesy of P. Bauer/ECMWF

Integrated Hydrological Validation and Applications

Identify space-time scales at which satellite precipitation data become useful to water budget studies and hydrological applications
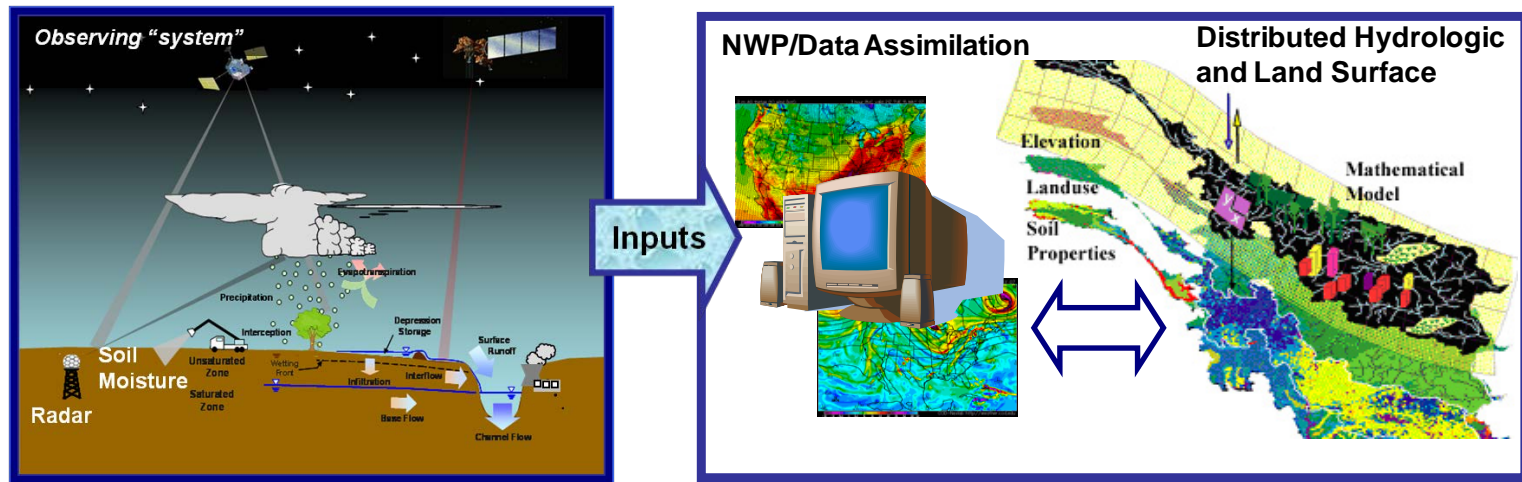
- Characterization of uncertainties in satellite and ground-based (radar, dense gauge networks) rainfall estimates over a broad range of space/time scales

- Characterization of uncertainties in hydrologic models and understanding propagation of input uncertainties into model forecasts

- Assessing performance of satellite rainfall products in hydrologic applications over a range of space-time scales

- Using data from synergistic missions (e.g. SMOS, SMAP, GRACE) to refine hydrologic model parameters and improve predictions driven by GPM input data

GPM Dynamically-Downscaled High-Resolution Product

Assimilate satellite precipitation data into cloud-resolving model to produce observation-constrained dynamically-balanced precipitation analysis at 1-2 km for hydrological applications

Currently developing a prototype dynamic downscaling data assimilation system
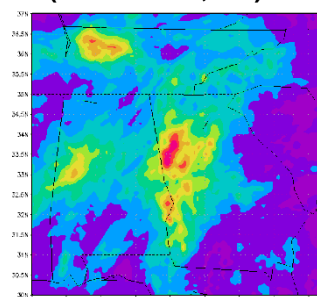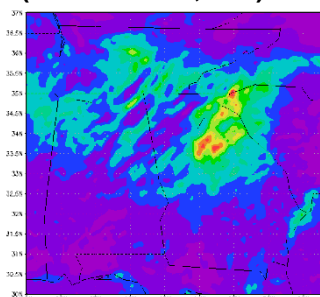
- NASA-CSU prototype WRF EnsDAS assimilating AMSR-E Tb
- *NASA Unified WRF model (9-3-1 km nesting)*
- *NOAA conventional observations (radiosonde, aircraft) and operational clear-sky satellite data*
- *CSU Maximum Likelihood Ensemble Data Assimilation Scheme*

Cloud Resolving Model

KWAJEX Surface Rain Rate (mm/hr)

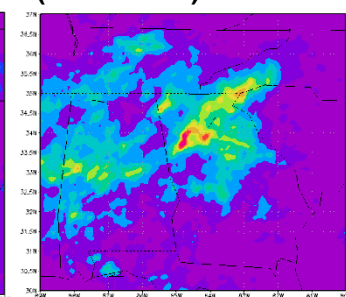**Level-4 Precipitation Analysis**
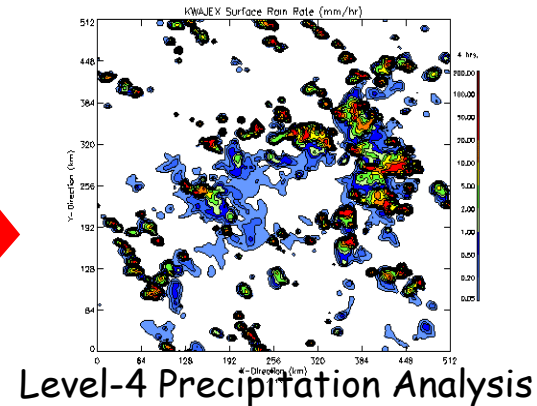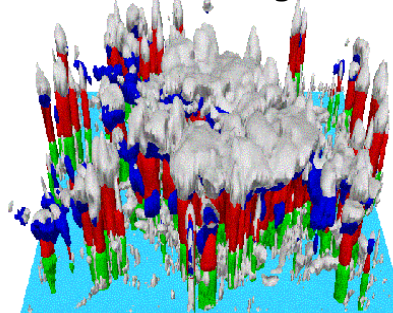
| WRF-GSI (no AMSR-E,TMI) | WRF-EDAS (with AMSR-E, TMI) | NOAA Stage IV data (Verification) |

Rain accumulation for 15-22 September 2009 over the Southeast U.S. flood region

Natural Hazard Forecasting

GPM will provide precipitation accumulation and distribution data at high spatial and temporal resolutions in order to advance evaluation and prediction of high-impact natural hazard events

Global Flood Modeling

Chennai weather: 50 houses flooded in Nandambakkam

TNN | Nov 28, 2011, 01.18PM IST

CHENNAI: Many areas in Nandambakkam, on the southern side of the airport, have been flooded following two days of heavy rain. Residents said construction of a new runway across the Adyar river was the reason for the water logging.

The river used to flow across open land, which the airport acquired and leveled to extend the secondary runway. The work has restrained the free flow of excess water, which entered residential colonies, residents said. Nearly 50 houses in Nandambakkam were flooded on Sunday.

Brinda Brighton, a resident , said the water level increased after the release of water from Chembarambakkam reservoir. "Several houses in Pozhichallur, Pammal and Nandambakkam are flooded. If the rain continues, more houses will be affected," she said.

Soil Layer3   Interflow $R_{I,out}$
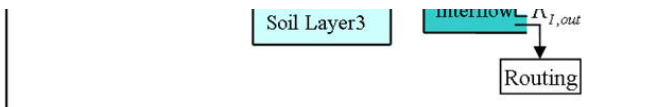
Routing

NASA-OU CREST Distributed Hydrologic Model V1.5

Coupled **R**outing and **E**xcess **ST**orage (CREST): three layers.

- Distributed, fully coupled runoff generation and routing model
- Simulates water and energy fluxes and storage on a regular grid
- Grid cell resolution user defined – currently using 1/8th degree for global model
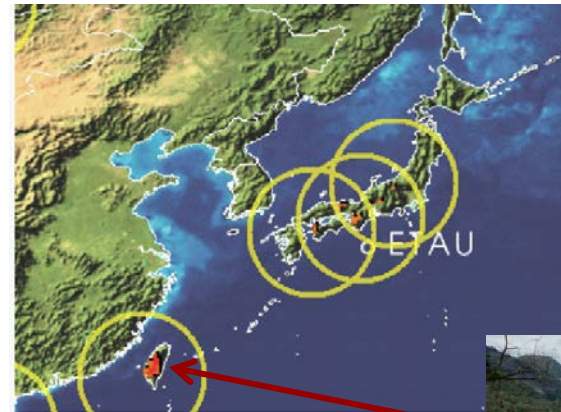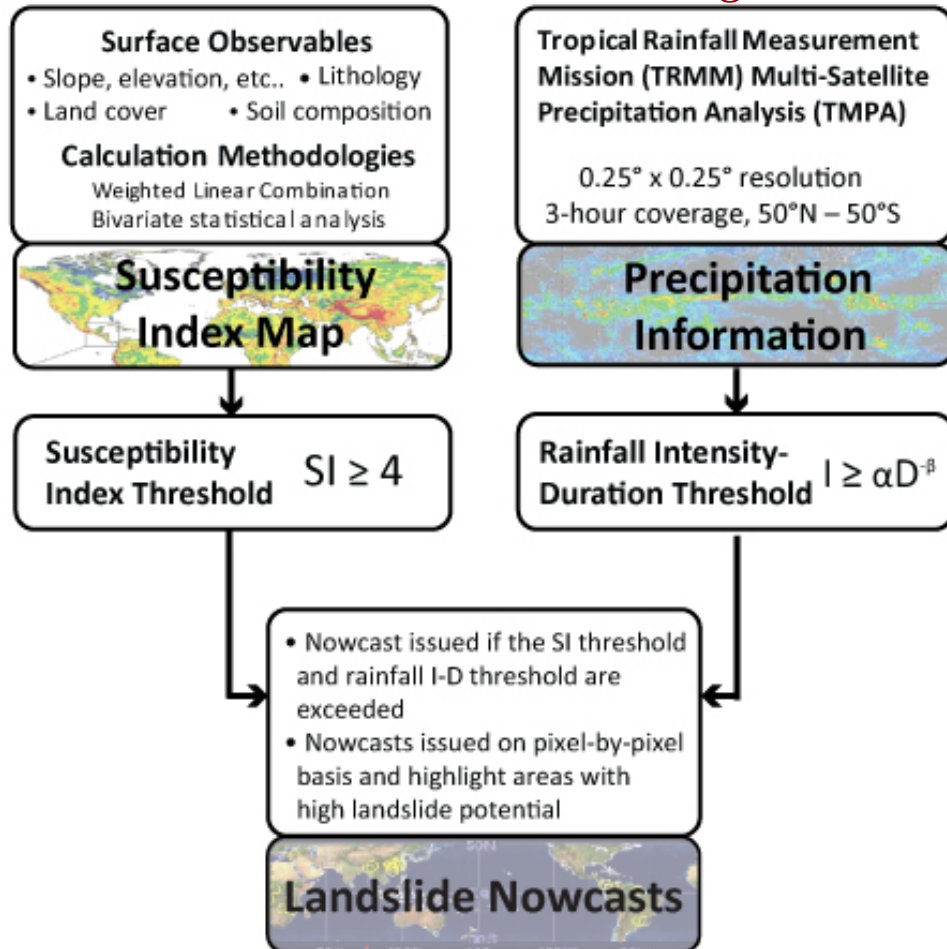
20 NOV 2011 0000 UTC
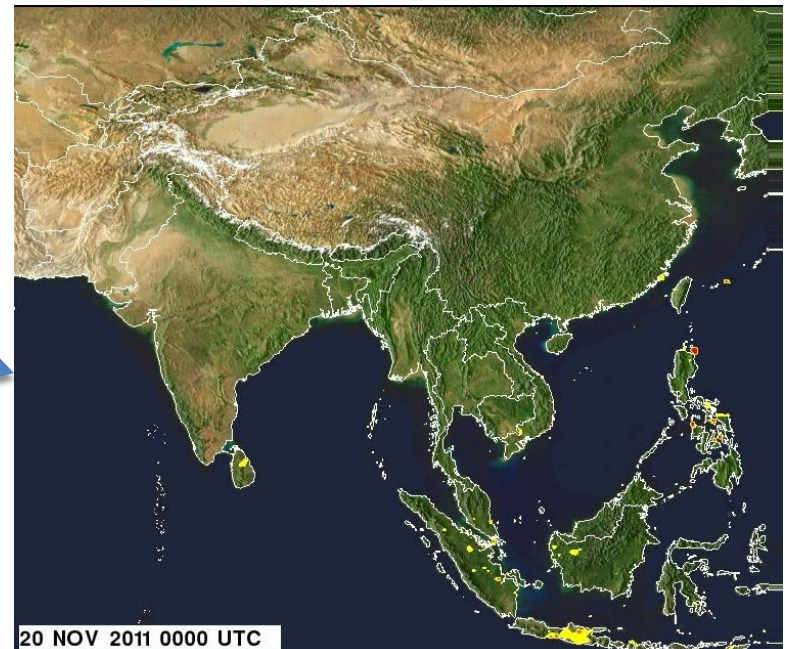
On-line real-time estimates of flood areas using satellite rainfall and a hydrological model updated globally, every 3 hrs at 0.25° resolution (http://trmm.gsfc.nasa.gov)

Landslide modeling

Landslide Hazard Modeling

Surface Observables
- Slope, elevation, etc..
- Lithology
- Land cover
- Soil composition

Calculation Methodologies
Weighted Linear Combination
Bivariate statistical analysis

Susceptibility Index Map

↓

Susceptibility Index Threshold $SI \geq 4$

Tropical Rainfall Measurement Mission (TRMM) Multi-Satellite Precipitation Analysis (TMPA)

0.25° x 0.25° resolution
3-hour coverage, 50°N – 50°S

Precipitation Information

↓

Rainfall Intensity-Duration Threshold $I \geq \alpha D^{-\beta}$

- Nowcast issued if the SI threshold and rainfall I-D threshold are exceeded
- Nowcasts issued on pixel-by-pixel basis and highlight areas with high landslide potential

Landslide Nowcasts

Typhoon Morakot (Etau) August 8th, 2009

Over 500 people killed in Shiao Lin, triggered numerous and **massive landslides** throughout Southern and Central Taiwan
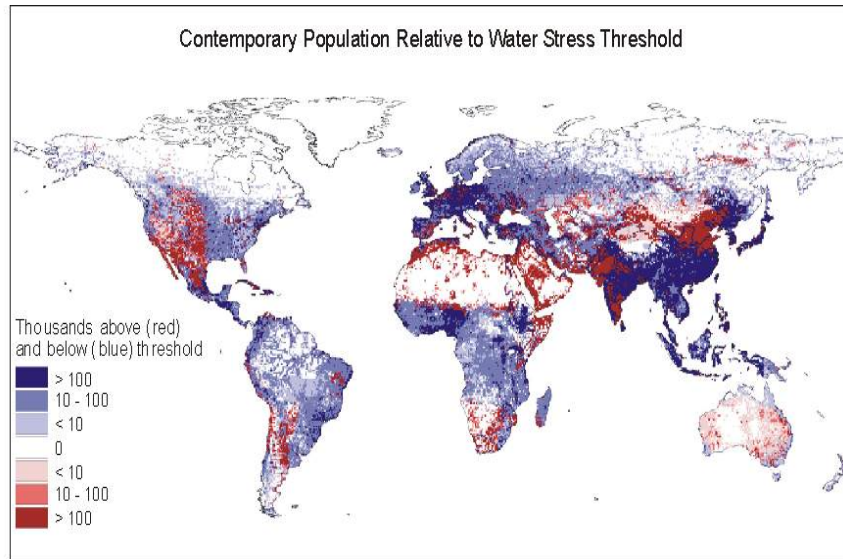
GPM will enhance modeling capabilities to estimate potentially susceptible areas to rainfall-triggered landslides. Forecasts are made every 3 hours based on surface information and rainfall accumulation.

Kirschbaum et al. 2011

Freshwater Resources and Agriculture

Freshwater Resource Monitoring

Contemporary Population Relative to Water Stress Threshold

Thousands above (red) and below (blue) threshold
- > 100
- 10 - 100
- < 10
- 0
- < 10
- 10 - 100
- > 100
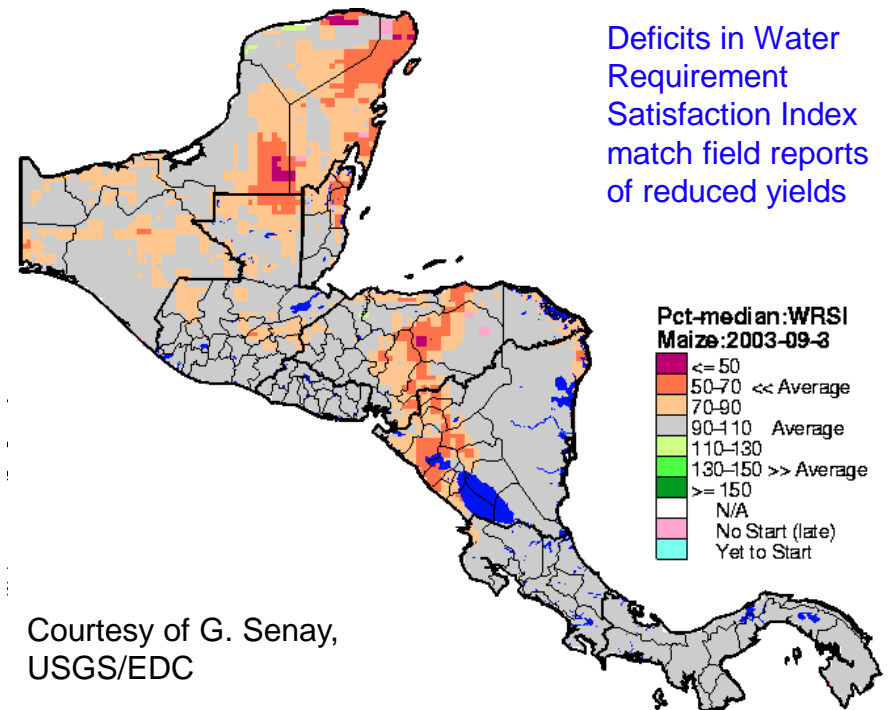
Copyright © 2000 *Science*

Water stress relative to population growth is a major concern around the world. As the primary source of freshwater, global precipitation data are key to monitoring and managing water resources.
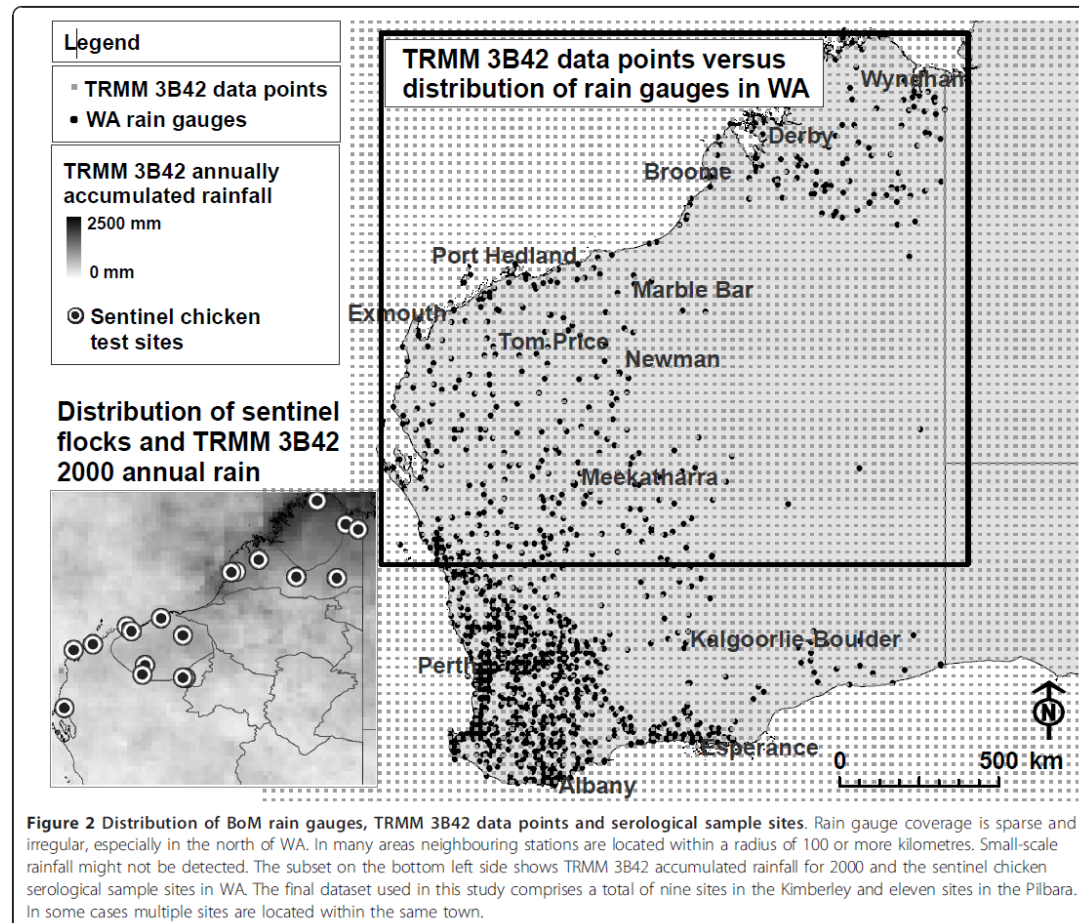
Crop Forecasting

Deficits in Water Requirement Satisfaction Index match field reports of reduced yields

Pct-median:WRSI
Maize:2003-09-3
- <= 50
- 50-70 << Average
- 70-90
- 90-110 Average
- 110-130
- 130-150 >> Average
- >= 150
- N/A
- No Start (late)
- Yet to Start

Courtesy of G. Senay, USGS/EDC

Precipitation data are in use by the USAID/USDA Famine Early Warning System Network (USAID/FEWS-Net) for crop and weather assessment worldwide.

World Health/Disease Outbreak

Application of satellite precipitation data analyses and model arbovirus activity in the tropics

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

"The Tropical Rainfall Measurement Mission (TRMM) Multi-satellite Precipitation Analysis (TMPA) 3B42 product was chosen from a range of remote sensing rainfall products to develop rainfall-based predictor variables and build logistic regression models for the prediction of MVEV (Murray Valley encephalitis virus) activity in the Kimberley and Pilbara regions of WA."

Figure 2 Distribution of BoM rain gauges, TRMM 3B42 data points and serological sample sites. Rain gauge coverage is sparse and irregular, especially in the north of WA. In many areas neighbouring stations are located within a radius of 100 or more kilometres. Small-scale rainfall might not be detected. The subset on the bottom left side shows TRMM 3B42 accumulated rainfall for 2000 and the sentinel chicken serological sample sites in WA. The final dataset used in this study comprises a total of nine sites in the Kimberley and eleven sites in the Pilbara. In some cases multiple sites are located within the same town.

Additional Applications Activities

☐ **Other applications examples from NASA GES DISC**

Public Health	User location
NASA DEVELOP project with Mobile County Health Department examining specific parameters that West Nile/Encephalitis vectors and their larvae require. Interested in rainfall amount.	Alabama
Work on malaria mosquitoes in Asia. Interested in daily accumulated rainfall (3B42-V6).	Belgium
Monitoring weather in NE Kenya for disease outbreaks; comparing rain gauge data and TRMM. Interested in 3B42-V6.	Kenya
Work on possible implications of climate change on enhancement of schistosoma mansoni transmission in humans in the Dhofar region of Sultanate of Oman. Interested in monthly rainfall.	France
Disaster, Flood-related	
Hydrological studies of damaged bridges in Pakistan during floods of July-September 2010.	Pakistan
Creating maps and information graphics in response to complex emergencies and natural disasters. Interested in identifying a good rainfall anomaly data set (monthly and annually).	Central Africa
Using TRMM data for Early Warning System for floods in near real time. Interested in 3B42RT.	Italy

Agriculture	
Using combination of monthly Willmot and Matsuura data, monthly TRMM (3B43 V6), and daily global rainfall (3B42RT) for historical analog analysis for crop yield forecasting in PR China.	China
Human geography	
Analyzing how rainfall affects investments in childrens' education in Uganda. Interested in monthly rainfall data.	Italy
World Bank project on welfare dynamics and risk in Nicaragua. Using TOVAS (3A25V6) to complement "household survey data."	Nicaragua
Studying impact of urbanization on land surface temperature and heat fluxes. Interested in TRMM VIRS data.	India
Interested in daily rainfall patterns and how they affect price of latex.	Georgia
Working with rainwater harvesting systems; gauge data are hard to come by, so trying to access TRMM satellite data.	Uganda
Miscellaneous	
Gathering data for an ecological reserve located just outside Chico, CA.	California
Some study for UNESCO-IHE. Interested in daily TRMM (3B42 V6 derived) data.	China
Studying possible effects of Galactic Cosmic Rays on tropical and overall climate, precipitation amount, and cloud cover.	India
Gathering information on the different types of applications of satellite precipitation estimates.	France

Education and Public Outreach

Formal Education → Informal Education → Outreach

GPM Master Teachers

Earth to Sky

Science on a Sphere (SOS)

GPM Student Ambassadors

Social Media/Website

Anime Character Competition

Key Topics:
Technology and Instruments
Weather and Climate
Water Cycle
Applications

New PMM Website: http://pmm.nasa.gov
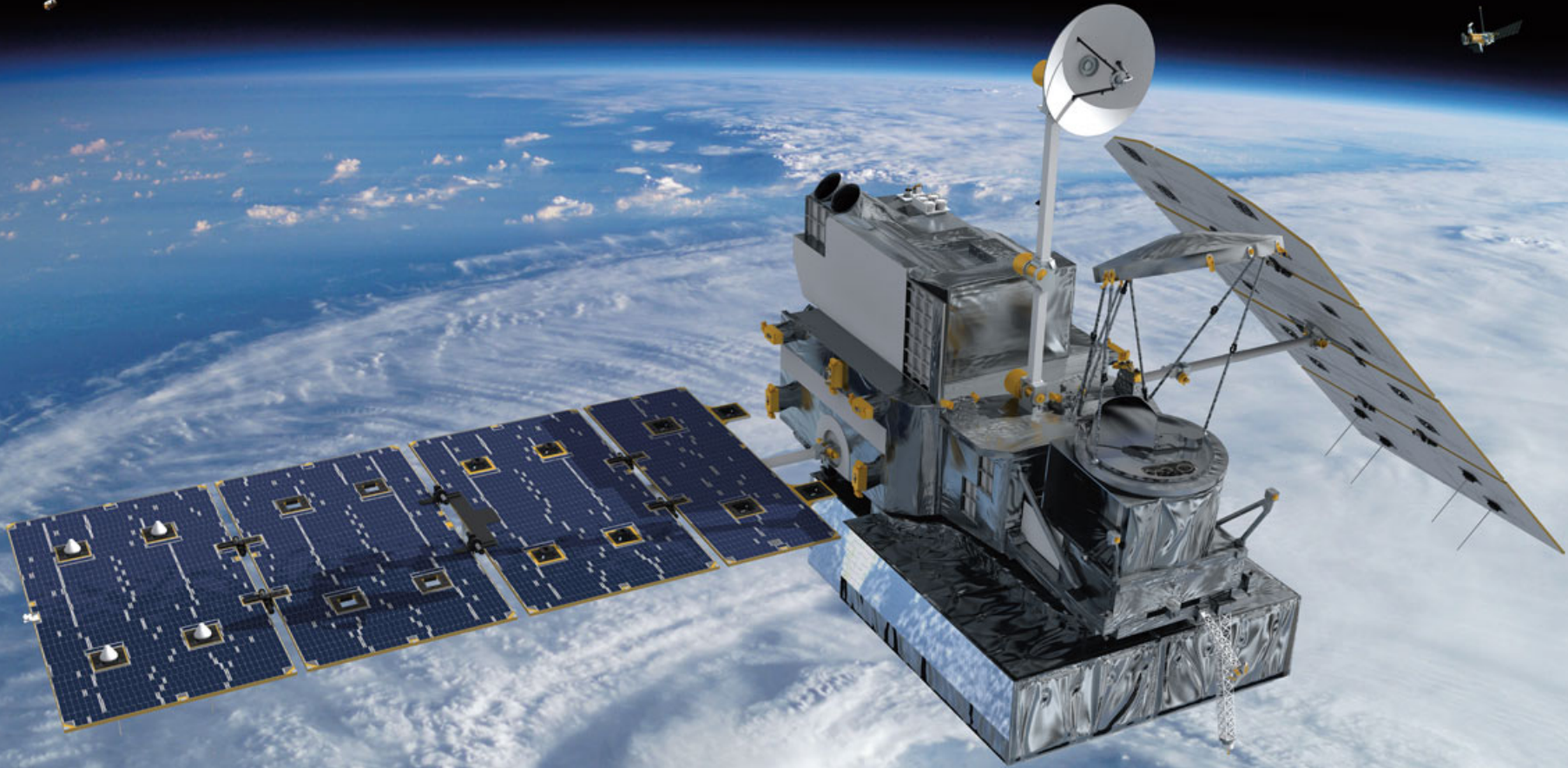
Thank You!

GLOBAL PRECIPITATION MEASUREMENT

GPM CORE OBSERVATORY - A REFERENCE STANDARD FOR PRECIPITATION MEASUREMENT FROM SPACE

JAXA

NASA

GPM Key Advancements

*An international satellite mission specifically designed to:*

- unify and advance precipitation measurements from a constellation of microwave sensors

- provide "next-generation" global precipitation data products within a consistent framework for scientific research and societal applications

- **More accurate instantaneous precipitation information - especially for light rain and solid precipitation – using advanced instrumentation**

- **Better spatial & temporal coverage - for improved estimation of precipitation accumulation – through international partnership**

- **Higher spatial resolution – important for local applications**

- **Inter-calibrated sensor measurements and geophysical retrievals**

TRMM Detects Heavy Rainfall in Dominican Republic from Tropical Storm Noel, 2007

- TRMM Multi-satellite precipitation analysis measures >400 mm of rain over D. R. and Haiti from Noel

- 81 deaths, several hundred thousand displaced
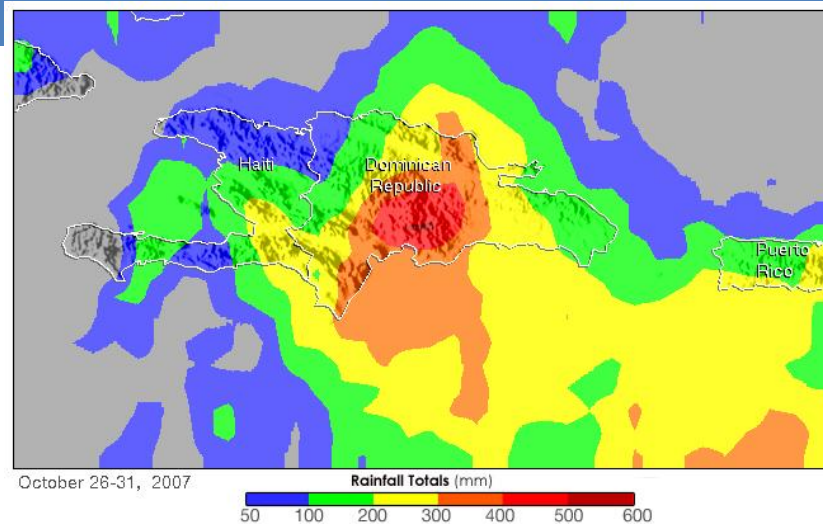
"Your images have been incredible--they are stunning and extremely useful. It was even presented to the minister of environment an head of disasters in the DR. Deeply appreciated. Please know we are crediting you everywhere." – Daniel Irwin, MSFC, SERVIR Project Manager

October 26-31, 2007

Rainfall Totals (mm)
50 100 200 300 400 500 600

0 10 20 30 40 50 mm/hr
TRMM Precipitation (PR & TMI over VIRS)

Images by Hal Pierce, NASA/GSFC