CEOSR Contributions to NASA's Precipitation Missions

John Kwiatkowski

&

Microwave Research Group

Missions.

Who is involved.

What we do.

Center for Earth Observing and Space Research

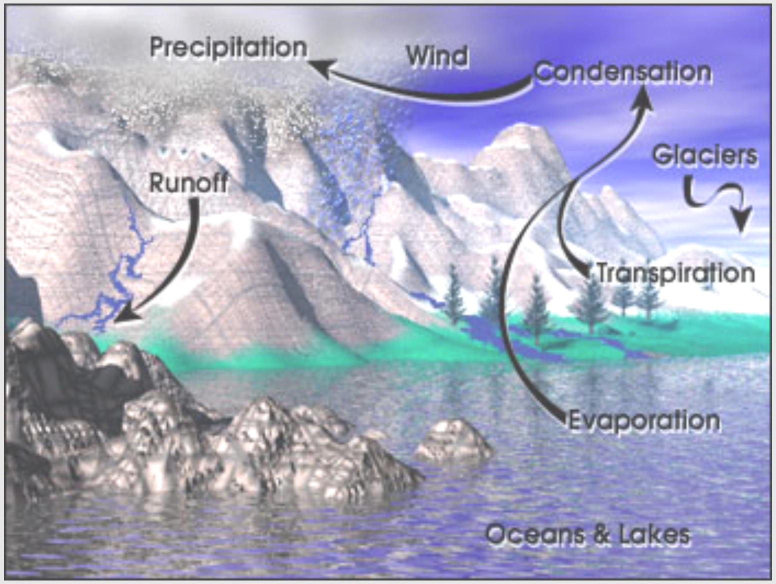
CEOSR Center for Earth Observing and Space Research

NASA Precipitation Missions

NASA has dedicated significant resources to enhance our ability to measure precipitation from space.

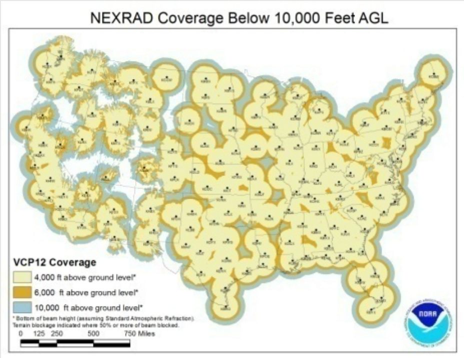
- Monitor water cycle variability.
- Improve weather prediction skills.
- Climate studies.
- Improve hydrology models.
- Develop new sensor technology.

Satellites give us a near-global, consistent data set.



Missions focus on ***microwave*** remote sensing.

- Day/night measurements.
- Penetration through cloud cover.
- Both passive and active sensors.



Tropical Rainfall Measuring Mission (TRMM).

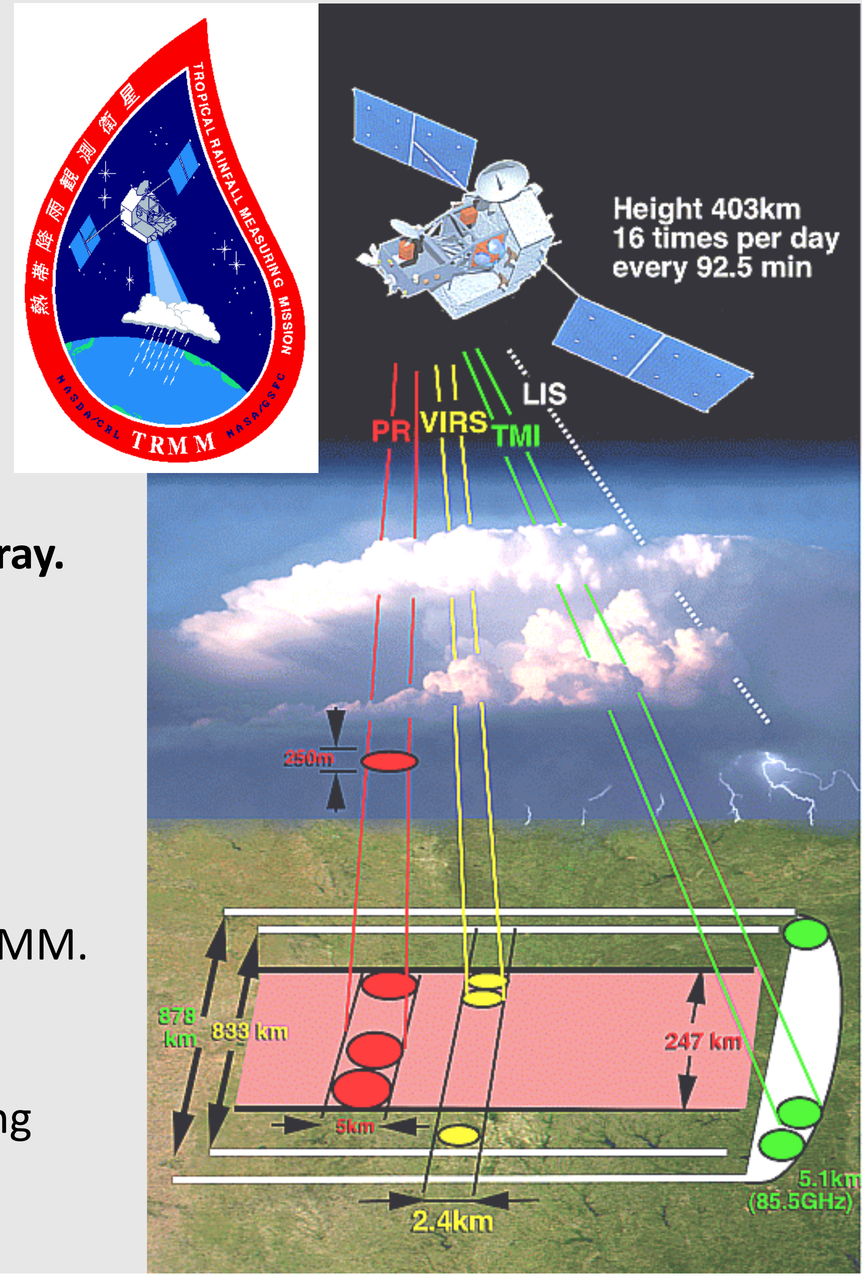
Global Precipitation Measurement (GPM) mission.

TRMM 1997

Joint mission with Japanese Space Agency.
Launched in Nov. 1997 into inclined (35^o) orbit.

Three main precipitation sensors:

- **TRMM Microwave Imager (TMI)**
  10, 19, 21, 37, 86 GHz, conical scanning
- **Visible IR Scanner (VIRS)**
  5-channel, cross-track.
- **Precipitation Radar (PR) (*New technology*)**
  13.8GHz, cross-track scanning, phased array.
  250m vertical resolution.

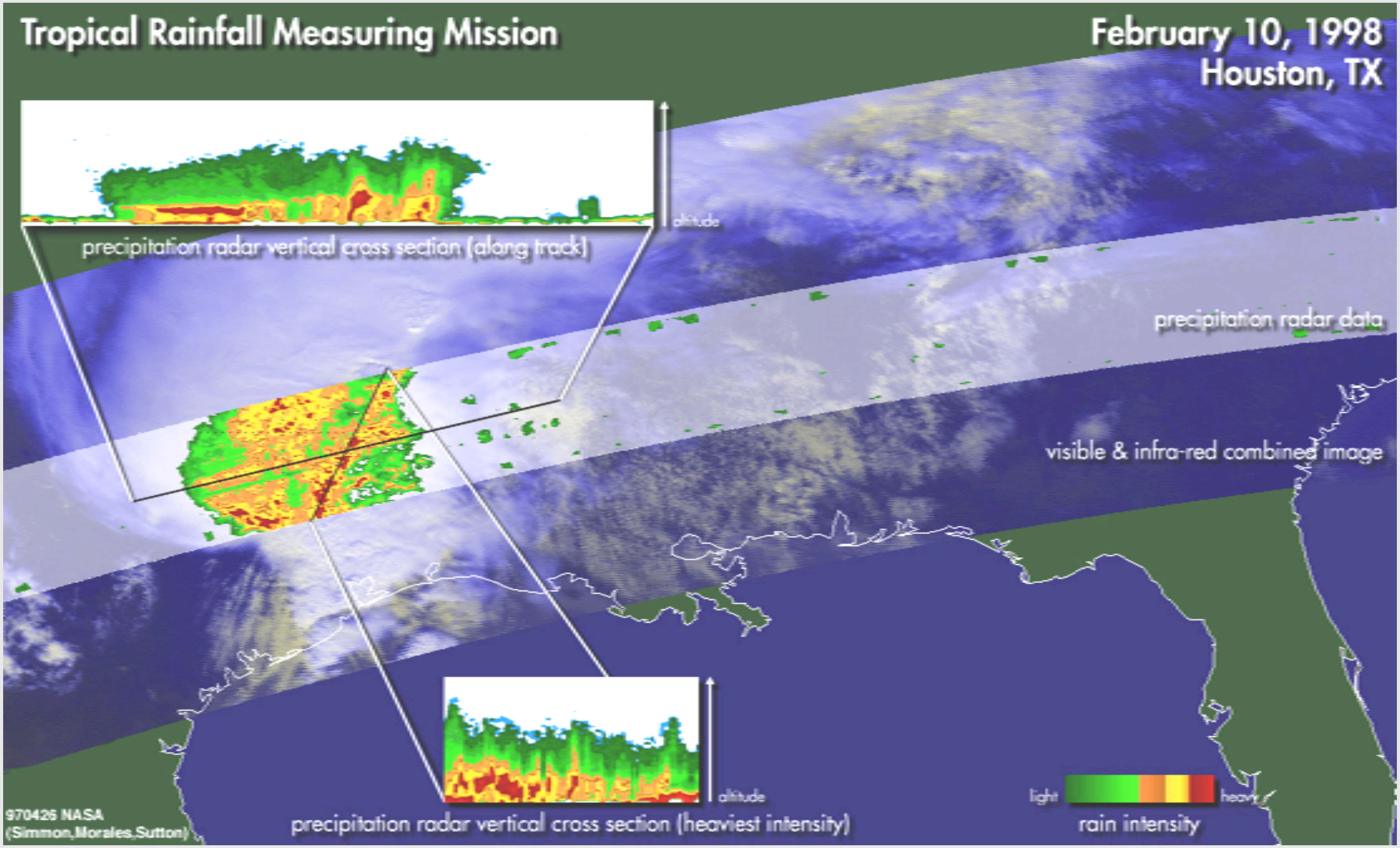


Originally launched to an altitude of 350km.
Altitude increased to extend mission life.
Current predictions show fuel lasting until Jan 2016.

We now have 15+ years of precipitation data from TRMM.
Standard for precipitation measurements from space.

Mission is now producing multi-satellite products using TRMM as a calibration standard.

TRMM PR


Tropical Rainfall Measuring Mission
February 10, 1998
Houston, TX
altitude
precipitation radar vertical cross section (along track)
precipitation radar data
visible & infra-red combined image
altitude
light
heavy
rain intensity
970426 NASA
(Simmon,Morales,Sutton)
precipitation radar vertical cross section (heaviest intensity)

GPM 2014

Global Precipitation Measurement.

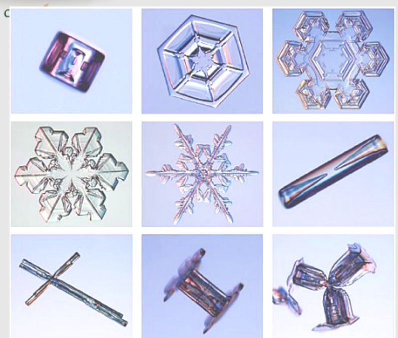
- Goal of 3hr global precipitation map.
- Measurement of lighter precipitation.
- Forecasting.
- Hydrology applications.

International constellation approach.
Partner constellation spacecraft provided by JAXA, NOAA, ISRO-CNES, other space agencies

NASA GPM Core spacecraft to calibrate constellation.

- **Provides a microwave radiometer** (GMI) adding 166GHz and 183GHz channels.
- **Dual-frequency precipitation radar** (DPR) 13.8GHz and 35.5GHz radars (Japan).
- 65^{o} inclination, 400 km altitude.
- Launch in Feb 2014 on HII-A.
- 3 year mission (5 year consumables).

Retrieval Challenges



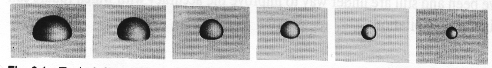
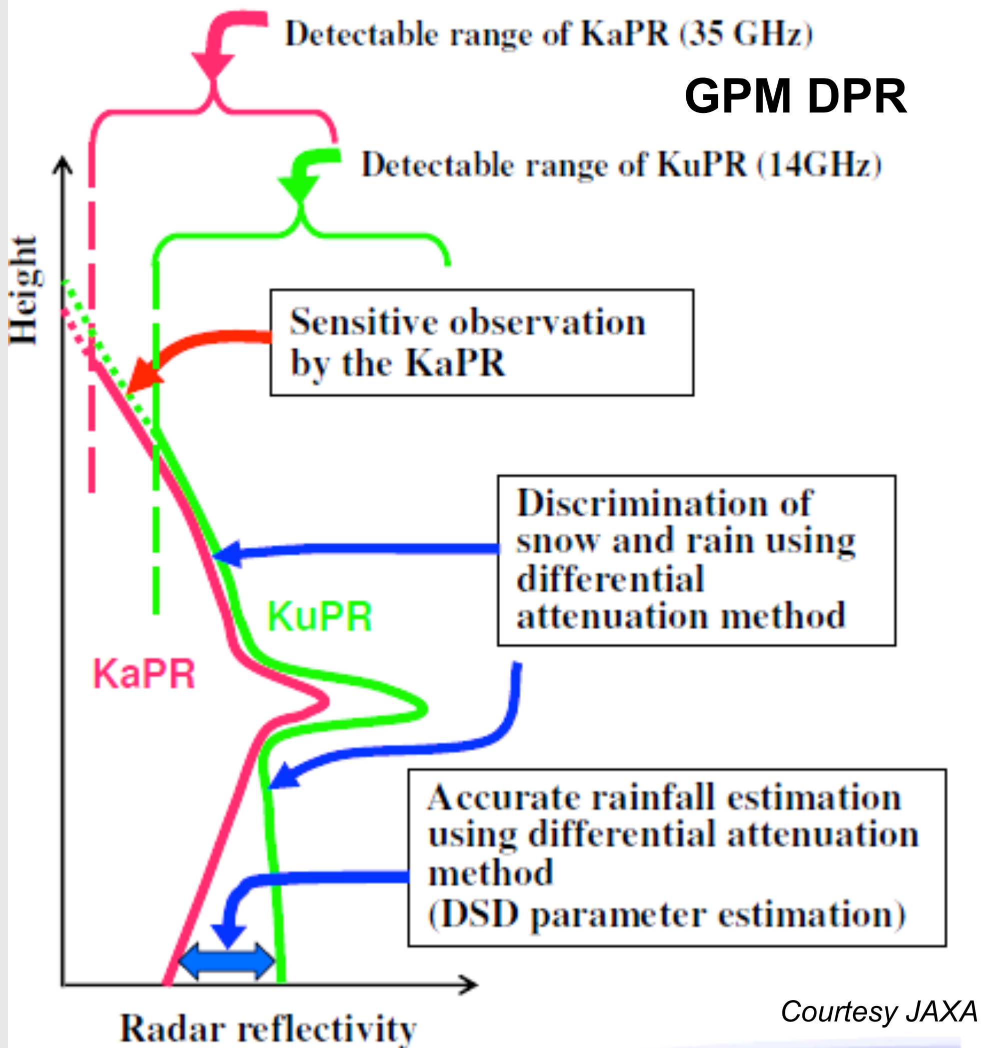


Fig. 8.1 Typical shape of large drops falling at terminal velocity w_t. The diameter D of the drops, from left to right, is 8.00, 7.35, 5.80, 5.30, 3.45, and 2.70 mm, corresponding to the following values of w_t: 9.2, 9.2, 9.17, 9.13, 8.46, and 7.70 m s^{-1}. (From Pruppacher and Beard, 1970.)



Courtesy JAXA

Precipitation is complicated.

- Complicated shapes.
- Mixed phase states.
- Cloud liquid water.

Passive microwave improvements.

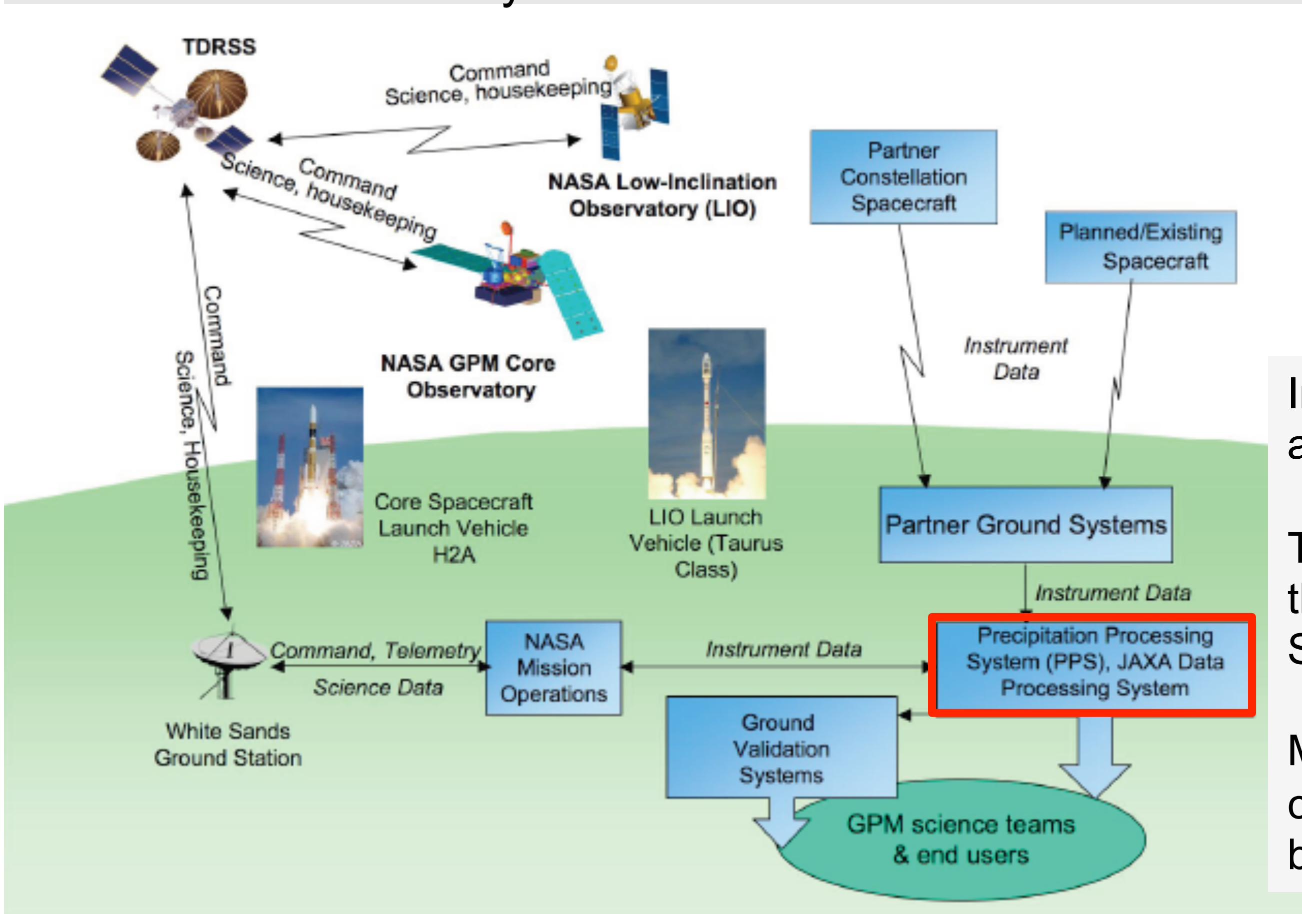
- Emissivity models over land.
- Use of radar data and SST to cluster potential candidate profiles over ocean.
- Merged multi-satellite products, X-cal.

Move towards real-time data assimilation.

- SST
- Model atmospheric profile information.

Data System

Ground System



Precipitation Processing System

Precipitation Processing System

Initially TRMM data system had a singular purpose.

TRMM system transitioned into the Precipitation Processing System (PPS) in 2008.

Move from a mission/satellite centric view to a measurement based approach.

A preliminary version of PPS is now operational, processing TRMM data and additional data from other passive microwave sensors.

TRMM produces a composite 3hr rain map which includes IR: *trmm.gsfc.nasa.gov*
GPM will add complexity and variability to the data system.

Personnel and Components

Software Prototyping:
Joyce Chou
Patrick Kolbe
Patty McCaughey
Jon Mitchell
Connie Li
Jennifer Sun

Components:

- Ingest
- DB/Data manager
- Storage manager
- Scheduler/Console
- Messaging
- Order processing
- Product subsetting
- Format, I/O software

Hardware Prototyping/System Programming
Quyen Nguyen
Tony Stocker

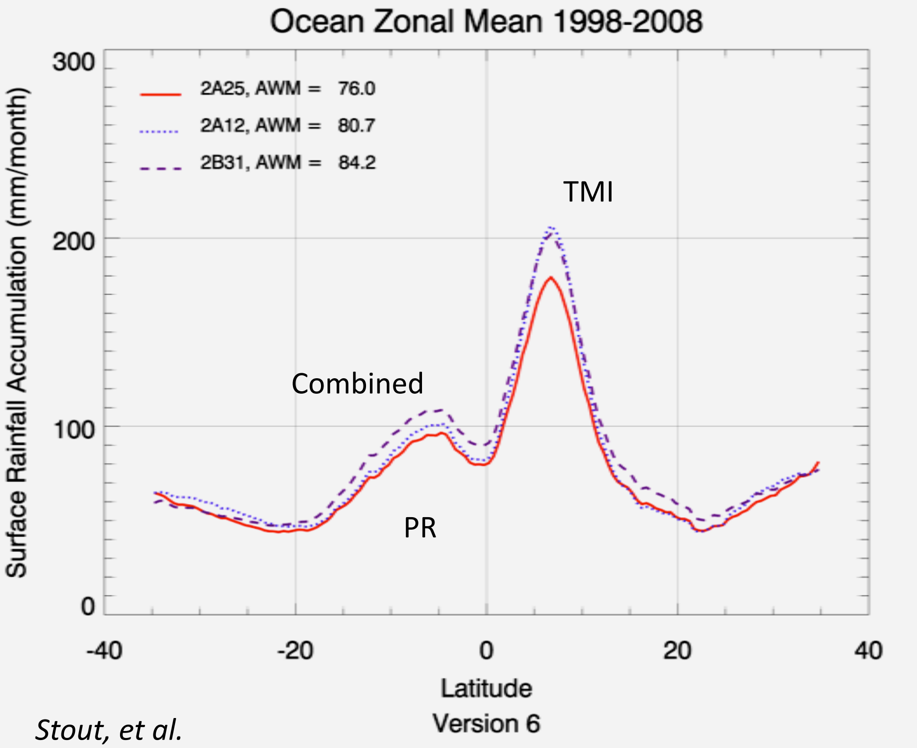
Analysis/Science Algorithm Support
Joyce Chou, John Stout,
John Kwiatkowski

Data Visualization
Owen Kelley

Graphic/Web Design
Peter Kim

Risk Mitigation/Web Maintenance
Bala Velauthapillai

CEOSR personnel contributing to these missions since 1997.



Stout, et al.

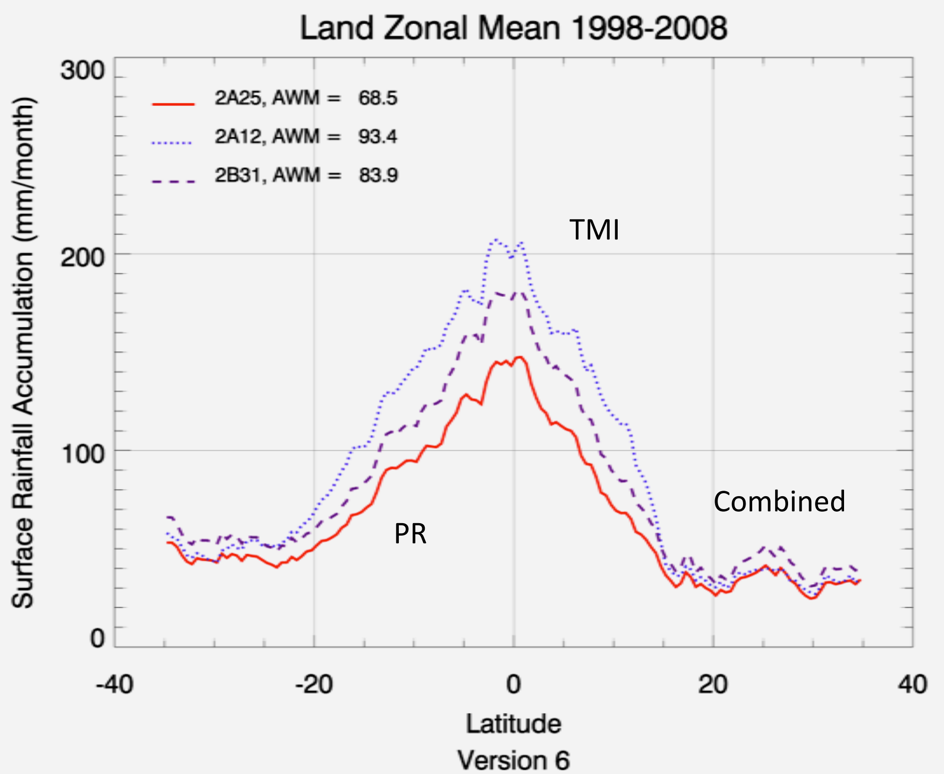
Zonal Means for Retrieval Comparison and Analysis

Based on the accumulation of instantaneous rain rate retrievals for each sensor.

10-20% differences over ocean.

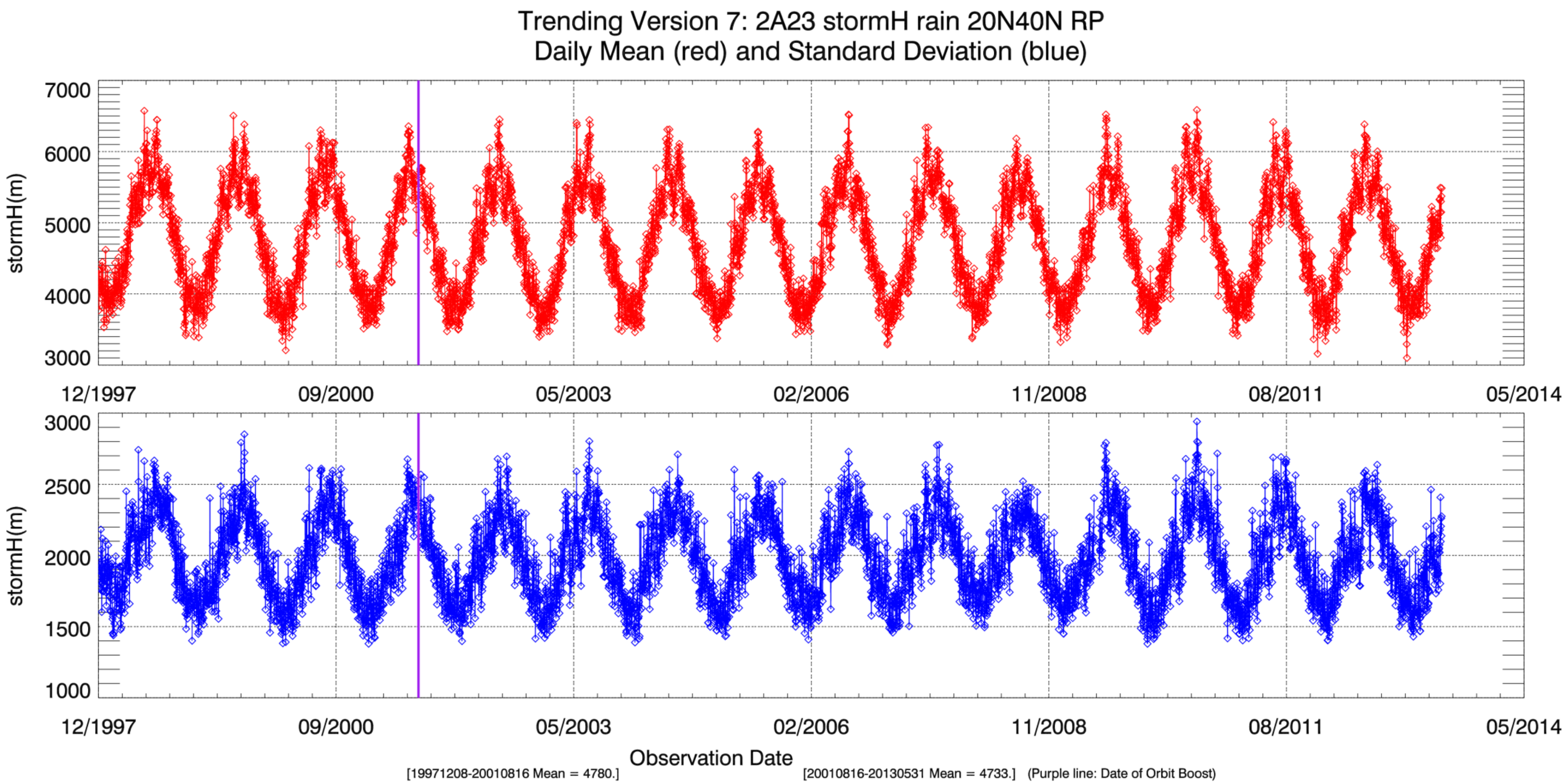
- 30-40% differences over land.
- PR is considered low due to assumptions on wet ice aloft.
- TMI is unreliable over land and considered to be overestimating.

Regional differences are much larger.



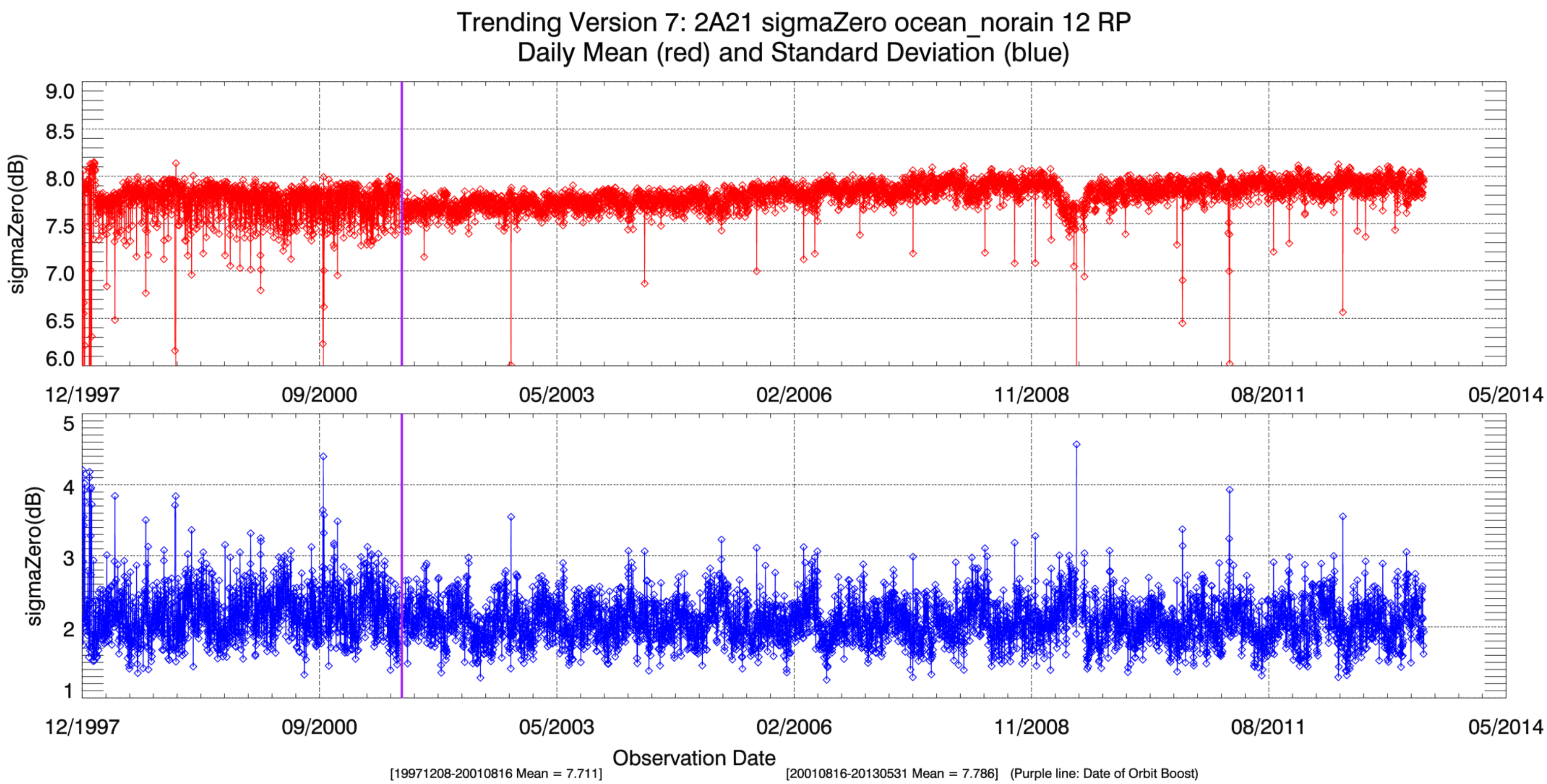
Trending

pps.gsfc.nasa.gov Trending images and ASCII data available.



Trending 2

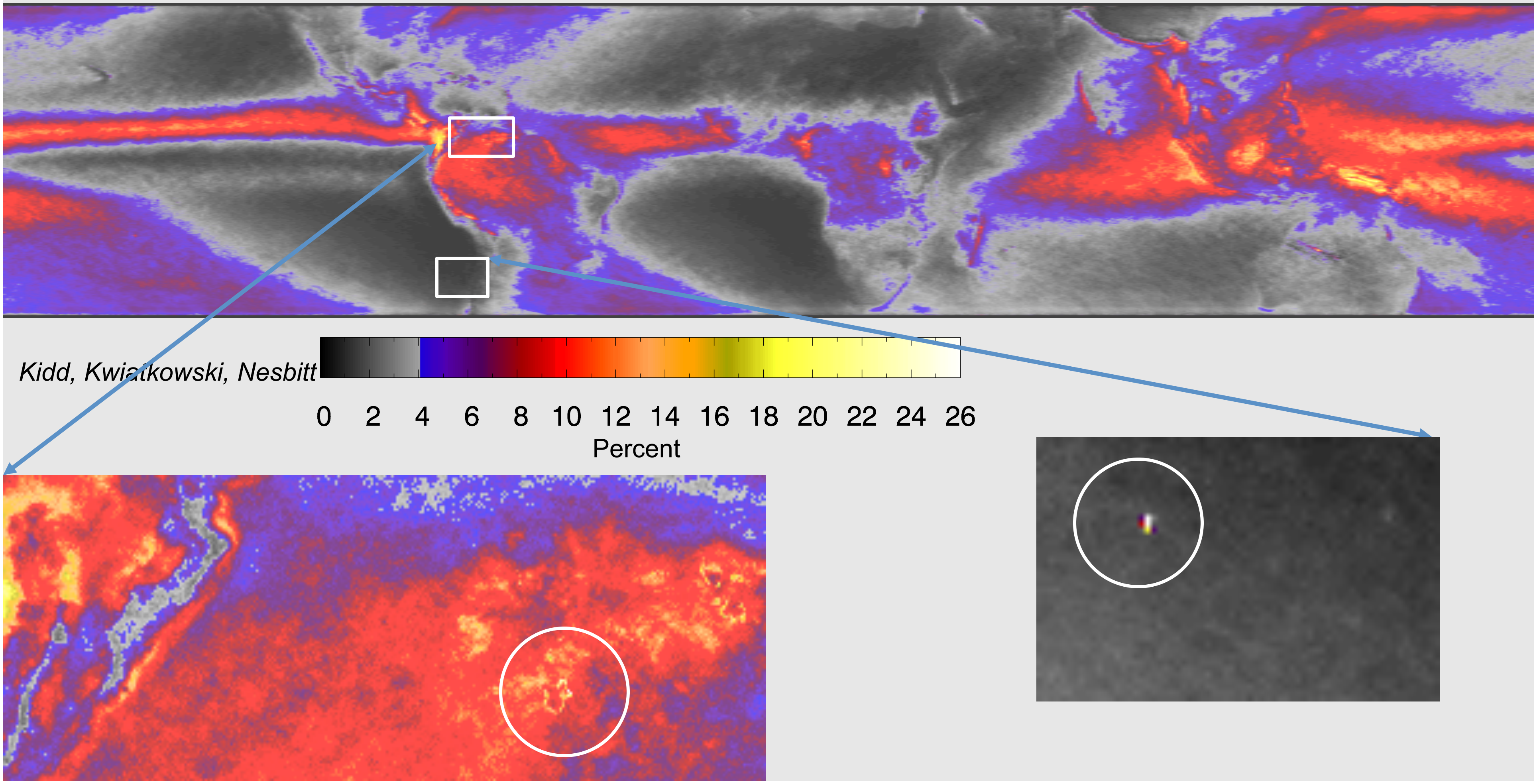
pps.gsfc.nasa.gov Trending images and ASCII data available.



Hi-Res Maps

Many years of data from TRMM allow some unique perspectives.

TRMM PR 12-Year Surface Precipitation Occurrence in Percent, 0.05^{o} Grid, 1998-2009



TRMM and GPM

Data overlap between TRMM and GPM.

- Calibration.
- Useful for retrieval comparisons.
- TRMM is a member of GPM constellation.

Future of TRMM

- Nominal data through Jan. 2016 with current fuel estimates.
- After fuel expenditure TRMM will drift down.
- Instruments off ~ Nov. 2020.

All TRMM retrievals back to 1997 will be improved with knowledge gained from GPM.

The Future

Recent and upcoming NASA milestones.

- TRMM Version 7 Algorithm Reprocessing 7/2011.
- PPS data system reviews 8/2010, 8/2011, 11/2013.
  - Part of NASA's Ground System review for the GPM project.
  - NASA HQ, international peer review panel.
- GPM launch in Feb. 2014.
  - Coming fast.
  - PPS data system has a head start.
  - GPM retrieval algorithms are being worked on now by Science Team.
- Public release of GPM data ~ August 2014.

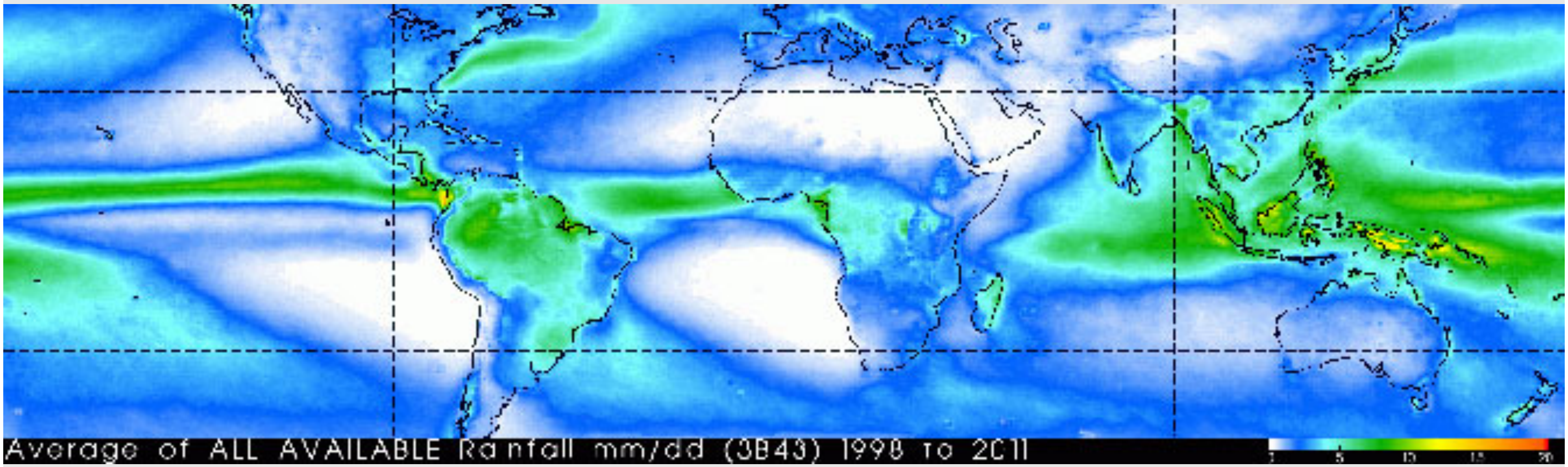
Future for GMU/CEOSR.

- NASA has plenty of work for us to do.

CEOSR
Center for Earth Observing and Space Research

1998-2011

Multi-Satellite Rainfall Climatology
from PMM Merged Science Product



Questions: John Kwiatkowski jkwiatko@gmu.edu