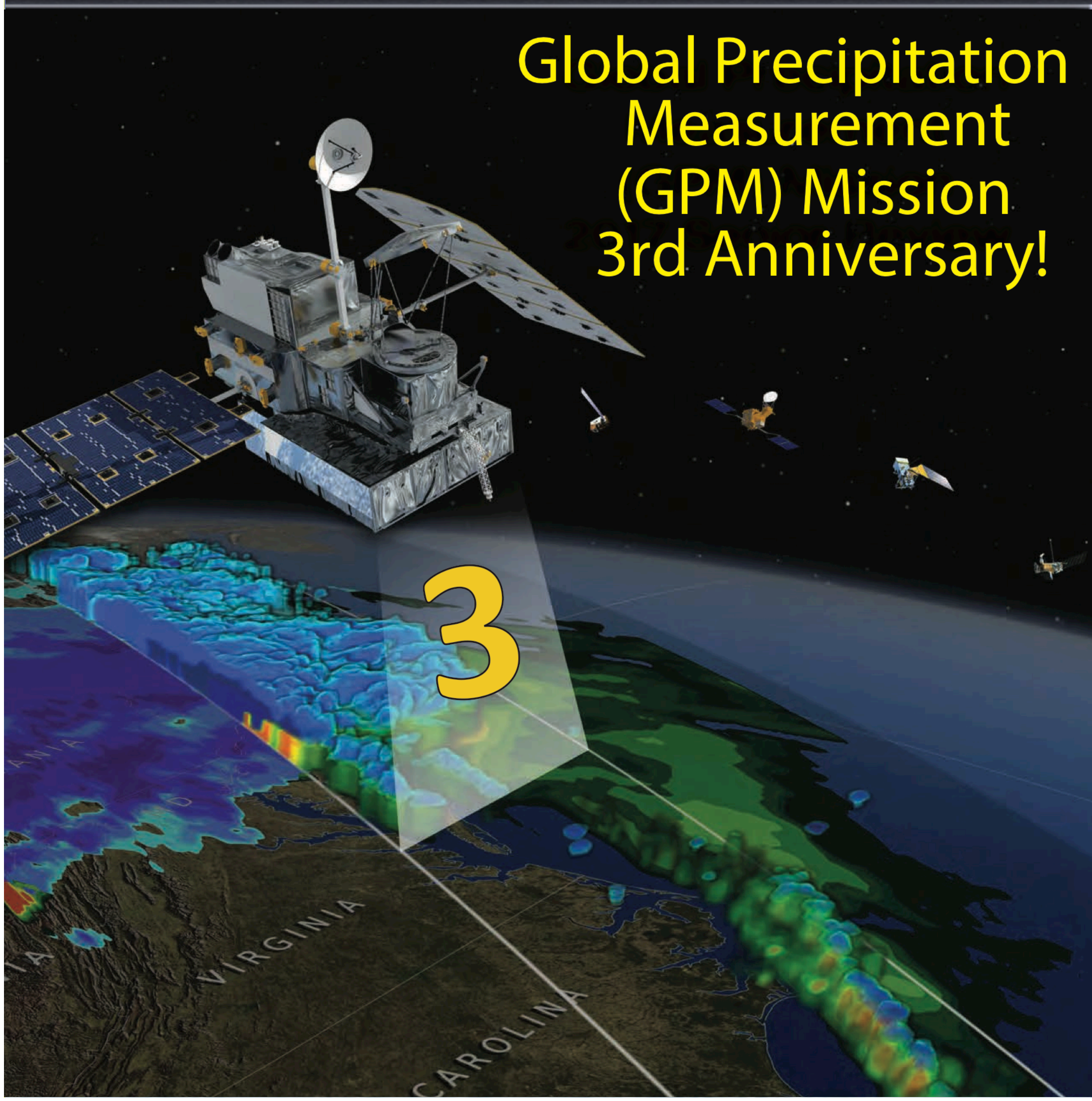
GPM Science Status



Gail Skofronick Jackson
GPM Project Scientist

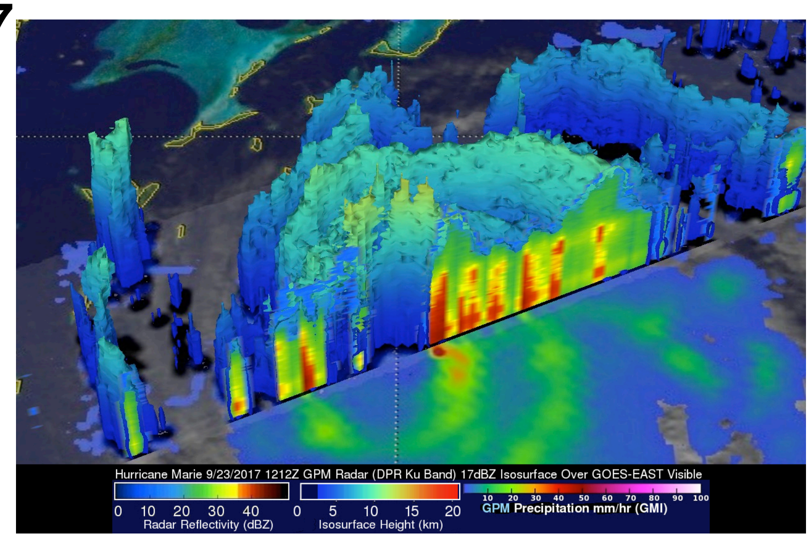
NASA Goddard Space Flight Center

PMM Science Team Meeting
October 16-20, 2017
San Diego, CA

www.nasa.gov/gpm
Twitter: NASARain
Facebook: NASARain

Presentation Outline

- Status of the GPM Core Observatory spacecraft, its data and reviews in 2017
  - Extended operations
- Recent data & imagery
- Science team activities
- Awards and honors



Hurricane Maria: 23 Sept 2017

GPM Core Observatory Summary

Spacecraft Status:

C&DH: **GREEN** GN&C: **GREEN**
Deployables: **GREEN** Propulsion: **GREEN**
EPS: **GREEN** RF/Comm: **GREEN**
FSW: **GREEN** Thermal: **GREEN**

Instrument Status:

DPR - KaPR: **GREEN**
DPR – KuPR: **GREEN**
GMI: **GREEN (well calibrated & stable)**

Data Capture Statistics 6/1/14-5/31/17:

Mission Capture %: **100.000 %**
Mission Data Volume: **3,364.84 GB**
Mission Files: **2,569,087**
Mission Latency: **99.7%**

Spacecraft (2017):

- Constant review of cubesat locations
- Sept 2017: one cell of solar array hit by micro meteorite, no power impact

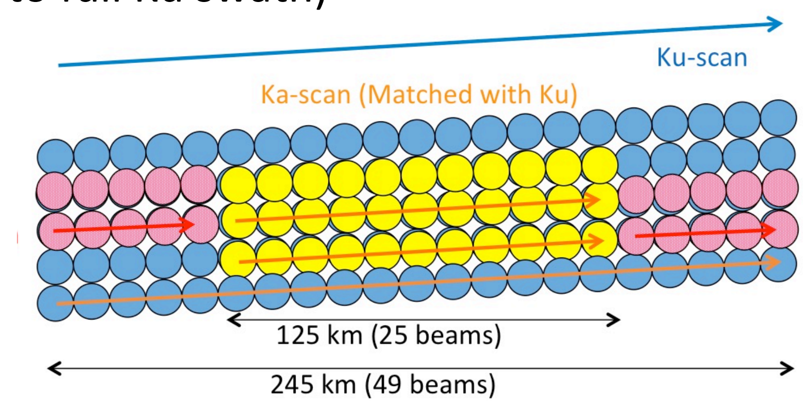
Fuel Predictions (w/controlled re-entry)

Prediction	Plus/Early	Mean/Nominal	Minus/Late
May 2015	06/2029	11/2039	06/2043
Nov 2015	03/2027	04/2035	08/2039
May 2016	03/2032	04/2037	08/2047
Nov 2016	08/2029	04/2035	10/2038
May 2017	**12/2034 (20 years)**	**05/2036 (22 years)**	**02/2037 (23 years)**

Fuel is unlikely to be the limiting factor

Operational Testing 2017:

Aug 2017: TDRSS MA increased data rate tests (from 230 kbs to 3.2 Mbs)
Sept 2017: DPR Scan adjustments (Ka swath to full Ku swath)



GPM Data Summary

Data Products:

See Erich's Presentation for more details

GPM Version 05 reprocessing May 2017

- except IMERG

TRMM Version 8=GPM V05

- Level 1 (TMI, DPR, VIRS) products reprocessed Oct 2, 2017
- Level 1C (AMSRE, SSMI, SSMIS, AMSR2, MHS, SAPHIR, AMSU-B, ATMS) pre-GPM launch reprocessed Oct 6, 2017
- Level 2 & 3 (MHS, SSMIS, AMSR2, ATMS) pre-GPM launch reprocessing started Oct 16, 2017

GPM Version 06

- Tentatively scheduled for 2020

IMERG (TRMM + GPM)

- mid-2018

Want GPM/TRMM data?

See Dalia's presentation

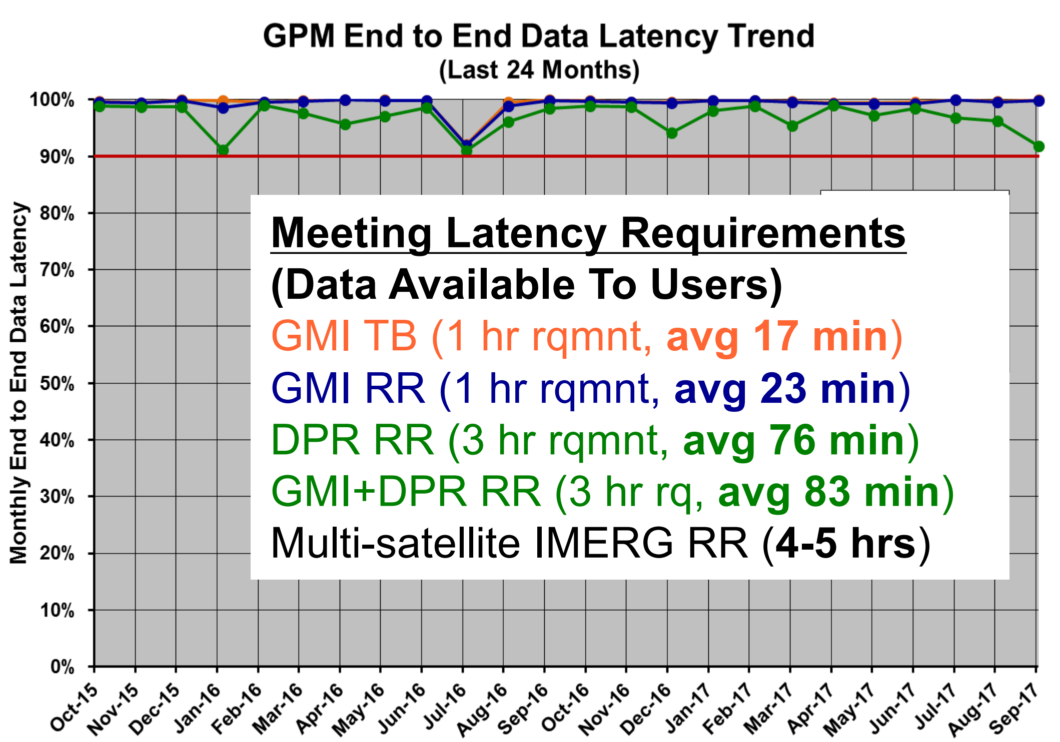
http://pps.gsfc.nasa.gov

http://gpm.nasa.gov

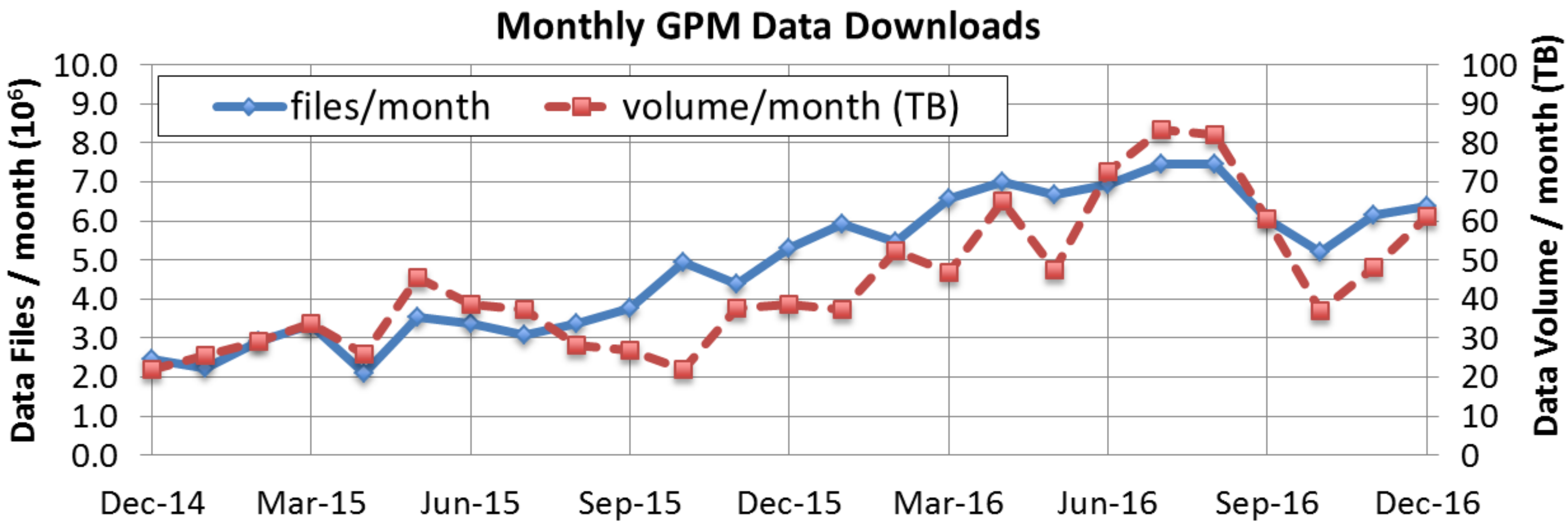
New Users Start Here

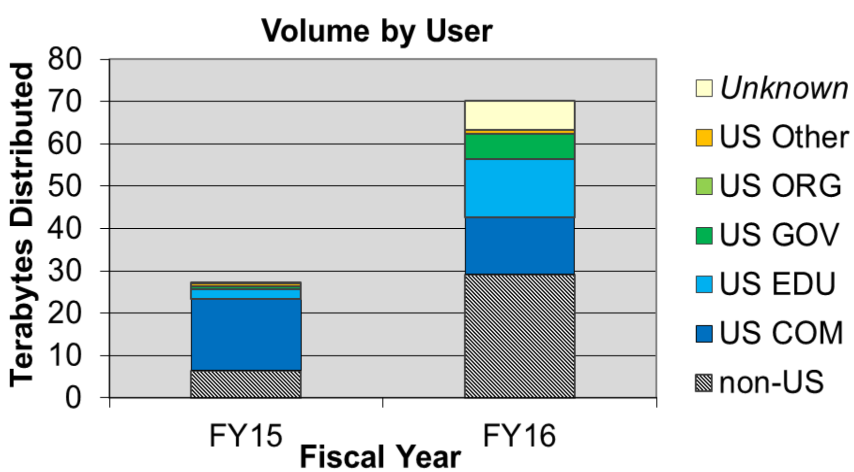
GPM Ground Validation:

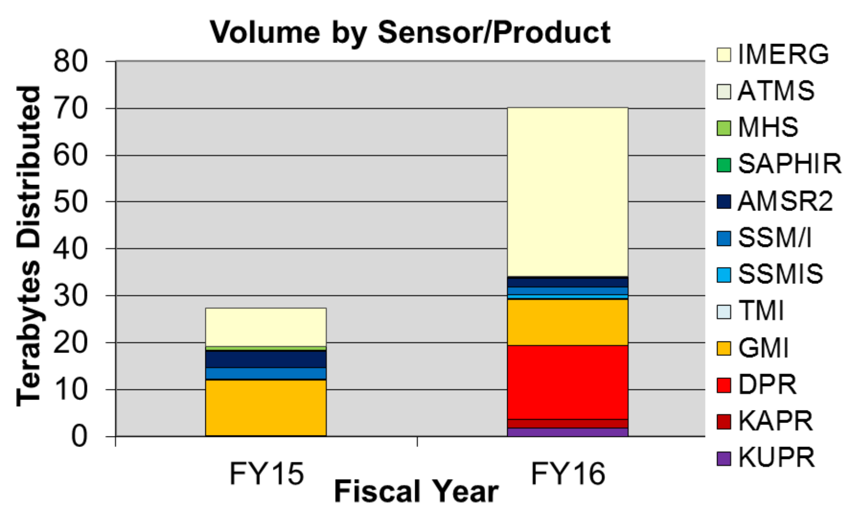
See Walt's presentation



GPM Data Distribution







Dec 2014- Dec 2016

GPM Senior Review

- **Senior Review**
  - Senior Review document submitted February 28, 2017
    - 30 pages of primary text
      - Overview
      - Science merit
      - Data products
      - Applied and op users
      - Extended operation plans
      - Programmatic elements
      - Technical & budget
    - 70 pages of supporting information
  - Panel for Senior Review May 9, 2017
  - Results soon to be formalized

Global Precipitation Measurement (GPM) 2017 Senior Review Proposal

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Objectives for Extended GPM Operations

The primary objectives for an extended mission are to **maximize the scientific and societal benefits** of GPM.

Extended Operation Activities include but are not limited to:

Algorithm activities:

(1) improve and reprocess from Version 05 to Version 06,

(2) lengthen the temporal record by reprocessing back to 1998/TRMM

(3) extend GPM merged constellation algorithms pole to pole,

(4) reduce the discrepancies in the over-land retrievals,

(5) improve the estimates of falling snow and light rain retrievals.

Science activities:

(1) research on processes, microphysical and physical properties,

(2) studies on global precipitation patterns, water cycle, water resources, precipitation extremes, weather, and climate.

Continued computation of near-real-time estimates will enable a range of application and operational users to improve their work for high-impact societal benefit activities such as storms, floods, landslides, droughts, agricultural forecasting, and resource management

End of Prime Review

- **End of Prime Review**: June 21, 2017
- After 3 years 2 months (GPM's prime lifetime), an End of Prime review was held to ensure that all Level 1 mission requirements were met
- Presentations and Reviews included those for:
  - Mission Operations by Jamie Pawloski
  - PPS by Erich Stocker
  - GV by Walt Petersen
  - Science by Gail Skofronick Jackson
- Passed End of Prime Review
- From GPMEoPMR_Summary_Report:

8. Conclusions

The mission has met all success criteria and Level 1 science requirements, and has exceeded many Level 1 requirements including latency, data capture, and snow detection estimates. The mission has been a highly successful follow-on to the Tropical Rainfall Measuring Mission (TRMM) with over 250 publications to date. The GPM mission has presented to the 2017 Senior Review panel for input to mission extension.

Level 1 Overview - Flow from Science Objectives

GPM Mission Science Objectives

1. Advancing Precipitation Measurement Capability From Space

* Provide measurements of microphysical properties and vertical structure information of precipitating systems using active and passive remote-sensing techniques.

* Combine remote-sensing techniques to provide a calibration standard for unifying and improving global precipitation measurements by a constellation of research and operational microwave sensors.

2.Improving Knowledge of Precipitation Systems, Water Cycle Variability, and Freshwater Availability

* Provide 4-dimensional measurements of space-time variability of global precipitation to better understand storm structures, water/energy budget, freshwater resources, and interactions between precipitation and other climate parameters.

3. Improving Climate Modeling and Prediction

* Provide estimates of surface water fluxes, soil moisture storage, cloud/precipitation microphysics and latent heat release in the atmosphere to improve Earth system modeling and analysis.

4. Improving Weather Prediction and 4-D Climate Reanalysis

* Provide accurate and frequent measurements of precipitation-affected microwave radiances and instantaneous precipitation rates with quantitative error characterizations for assimilation into numerical weather prediction systems.

5.Improving Hydrometeorological Modeling and Prediction

* Provide high-resolution precipitation data through downscaling and innovative hydrological modeling to advance predictions of high-impact natural hazard events (e.g. flood/drought, landslide, and hurricanes).

Level 1 GPM Project Requirements (Section)

Programmatic
-Budget (4.1)
-Schedule (4.2)
-Procedural (4.3)
-External Agreements (4.4, 6)
-Multi-Mission Facilities (4.5)
-Outreach and Education (5)
-Mission Success Criteria (7)

Baseline Performance Requirements (4.6)

-Science (4.6.1)
-Core Observatory Space Segment (4.6.2)
-Ground Segment (4.6.3: MOC, PPS, GV)
-Core Observatory Launch Segment (4.6.4)

Threshold Performance Requirements (4.7)

Gail Jamie
Erich Walt

NASA GPM Project Level 1 Requirements

GLOBAL PRECIPITATION MEASUREMENT

Science Requirements

•Measurements of the same geophysical scenes using both active and passive technique from 65N to 65S latitude with mean sampling time of 24 hours

•DPR, Ku/Ka bands

– Quantify rain rates between 0.22 ~~{0.3}~~ and 110 mm/hr

– Detection of snowfall at effective resolution of 5 km

•GMI, multi-channel wide-band

– Quantify rain rates between 0.2 ~~{0.3}~~ and 60 mm/hr

– Detection of snowfall at effective resolution of 15 km

•Estimate precipitation particle size distribution

•Rain rate biases at 50 km resolution <50% at 1 mm/hr; <25% at 10 mm/hr ~~{within the tropics}~~

~~•{Outside the tropics: Rain rate biases at 50 km resolution <100% at 1 mm/hr; <50% at 10 mm/hr}~~

•Rain rate random error at 50 km resolution <50% at 1 mm/hr; <25% at 10 mm/hr ~~{within the tropics}~~

~~•{Outside the tropics: Rain rate random error at 50 km resolution <100% at 1 mm/hr; <50% at 10 mm/hr}~~

•Standard data products (level 1, 2, 3), metadata and documentation available to all users

•Combined radar/radiometer swath products available within 3 hours of observation time, 90% of the time

•Radiometer precipitation products available within 1 hour of observation time, 90% of the time

Core Observatory Space Segment

•Design life of 3 years, with propellant sized for 5 years

•Orbit maintained to within +- 1 km of operational orbital attitude

•LRD February 2014 [internal commitment]

•Meet NPR 8715.6A and NSS 1740.14 requirements for limiting orbital debris

Ground Segment

•Core observatory monitoring and control (8x5 staffing, with automation at other times, after PLAR)

•Precipitation Processing System operations

•Ground validation

Core Observatory Launch Segment

•JAXA-provided H-IIA ELV

•Launch from Tanegashima, Japan

•407 km, 65 degree inclination orbit

Mission Success

•Meet the Threshold Performance Requirements, excepting the data latency requirements, for a minimum of three years.

Data latency requirements eliminated pre-launch

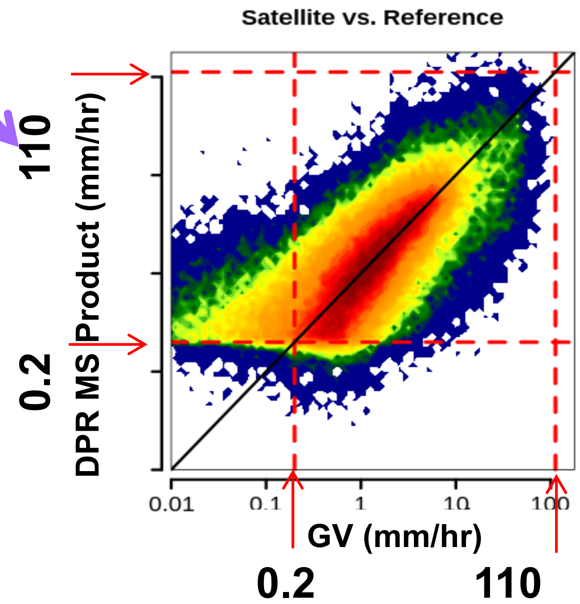
Baseline Performance

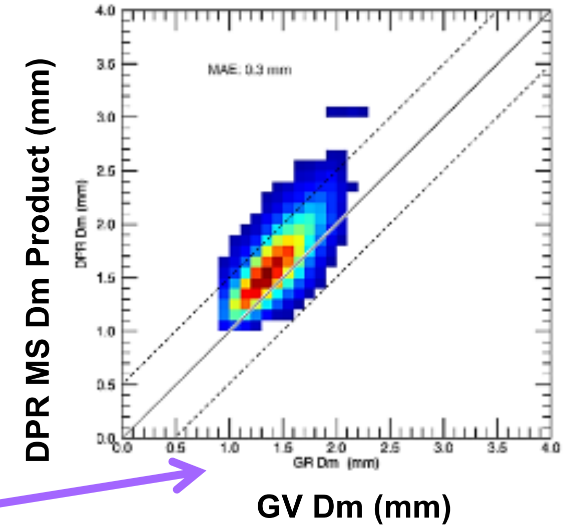
~~Threshold Performance~~

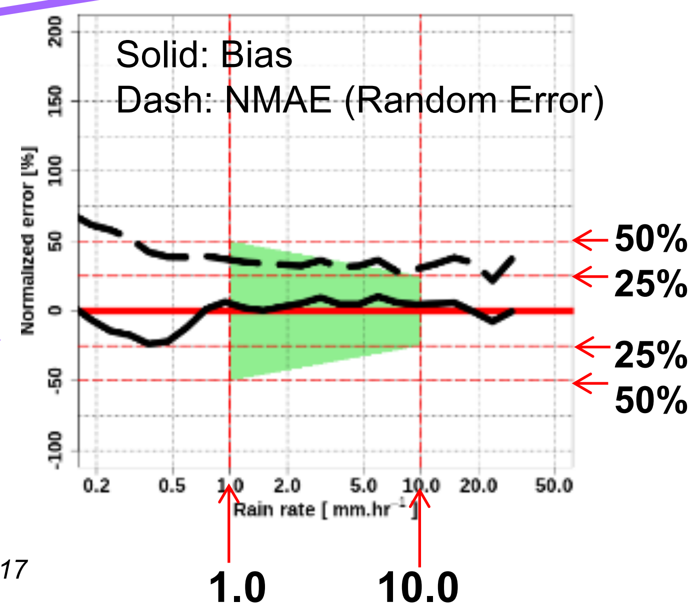
Mission Success Criteria simplified and updated in May 2012

Meeting L1 Science Requirements

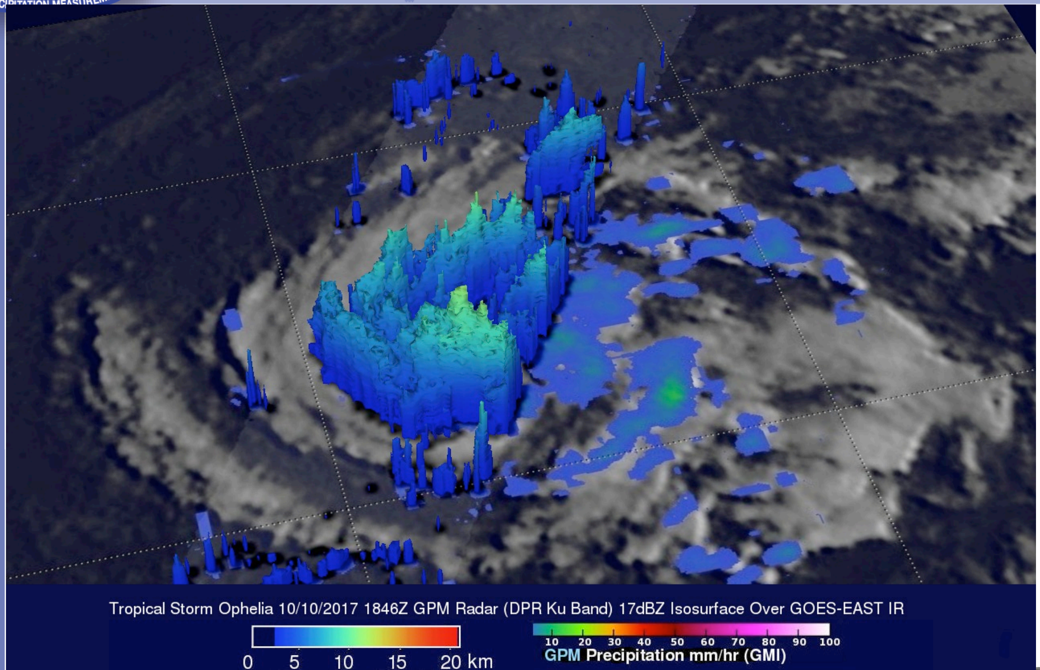
- DPR: **quantify rain rates** between ***0.2*** and **110** mm/hr and demonstrate the detection of snowfall.
- Estimate the D_m of precipitation particle size distribution to **within +/- 0.5 mm.**
- The instantaneous rain rate bias and random error estimates are **<50% at 1 mm hr^{-1} and <25% at 10 mm/hr**.





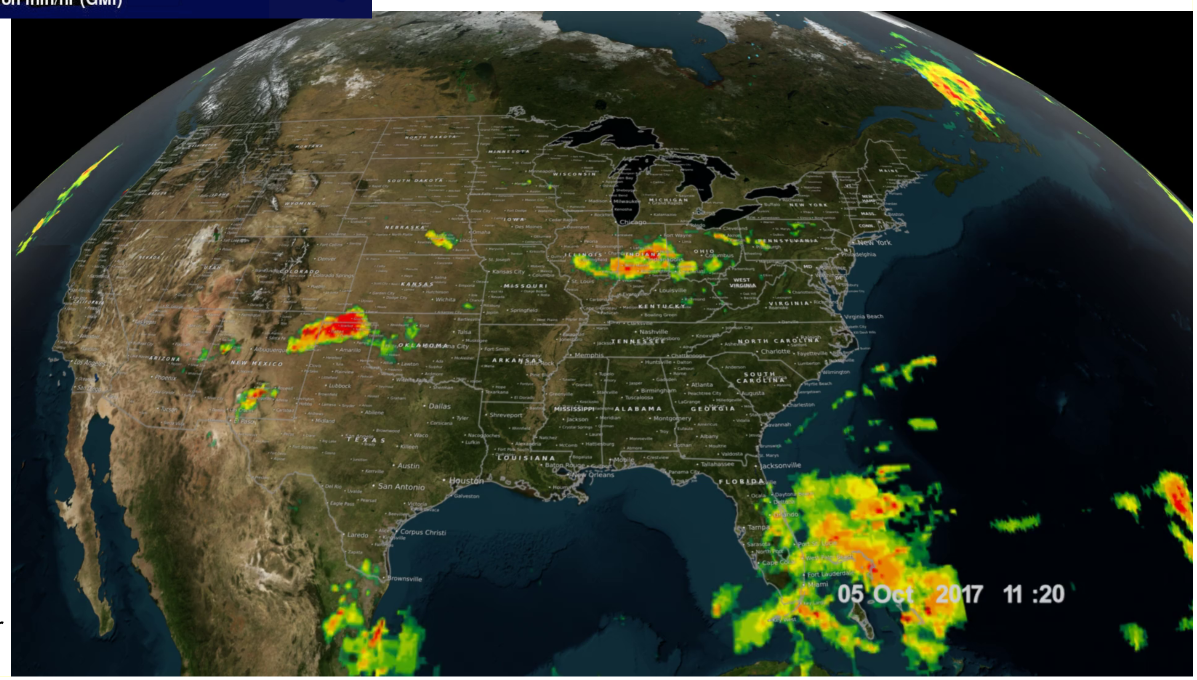


Recent Events

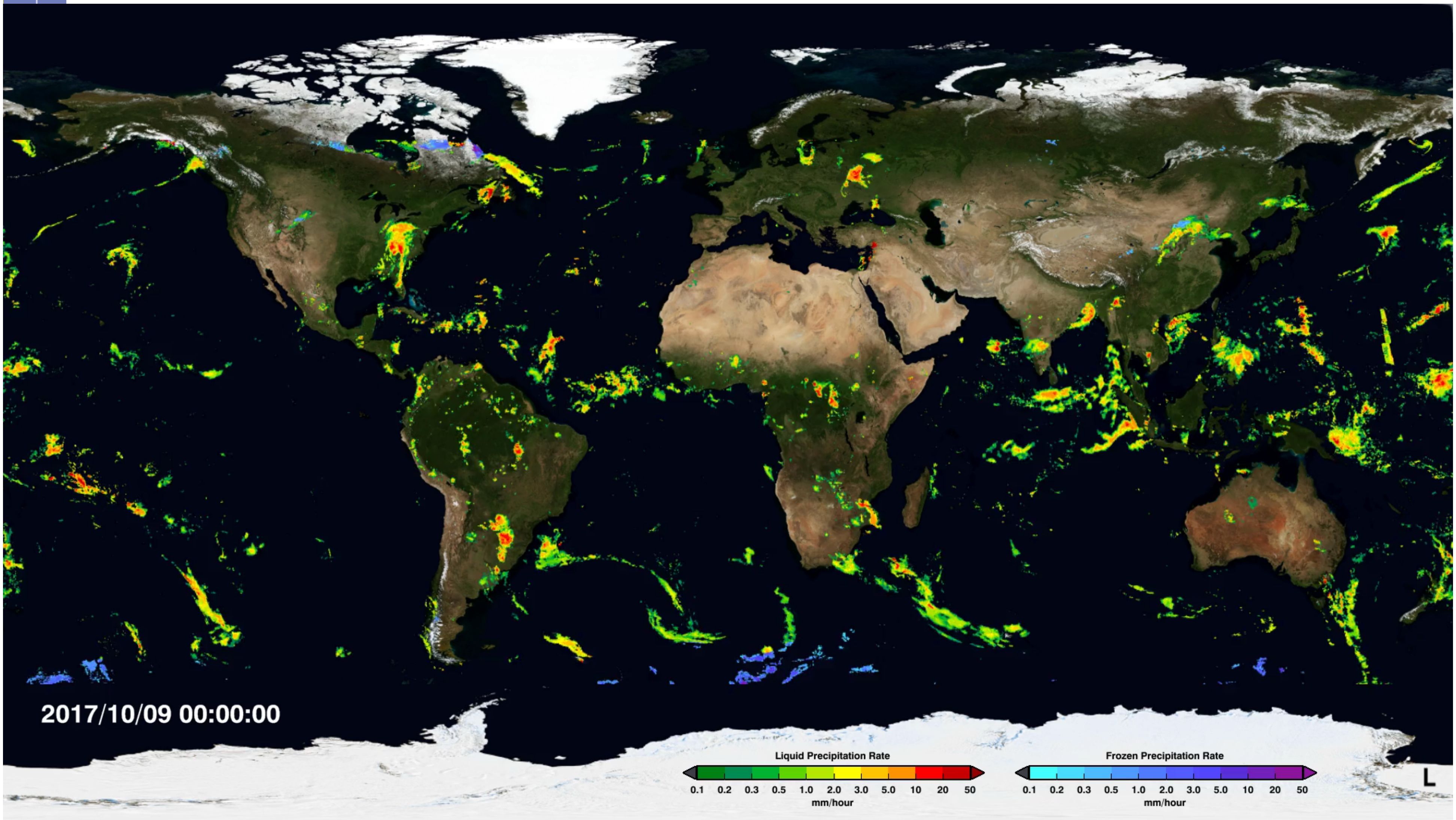


Tropical Storm Ophelia 10 Oct 2017

Hurricane Nate: Two GPM-CO Overpasses 7th & 8th Oct 2017



IMERG Rain (9-16 Oct 2016)



30 minute by 0.1deg by 0.1deg; available ~ 4-6 hours after obs.

PMM Project Teams

Mission Operations (MO) – Spacecraft Operations

(Jamie Pawloski)

Precipitation Processing System (PPS) – raw instrument data to precipitation products

(Erich Stocker; Deputy PS for Data)

GPM Program Scientist
(Ramesh Kakar)
GPM Project Scientist
(Gail Skofronick-Jackson)
TRMM Project Scientist
(Scott Braun)

Science Team - 60 NASA funded PI's, 22 no-cost international PIs, **Algorithm Development** (Iguchi, Meneghini, Olson, Kummerow, Huffman), **Ground Validation** (Walt Petersen, Deputy PS for GV, **David Wolff**, GPM GV Manager), **Intersatellite Calibration** (Wes Berg)

Application and Communications Team (Dalia Kirschbaum; Associate Deputy PS for Applications)

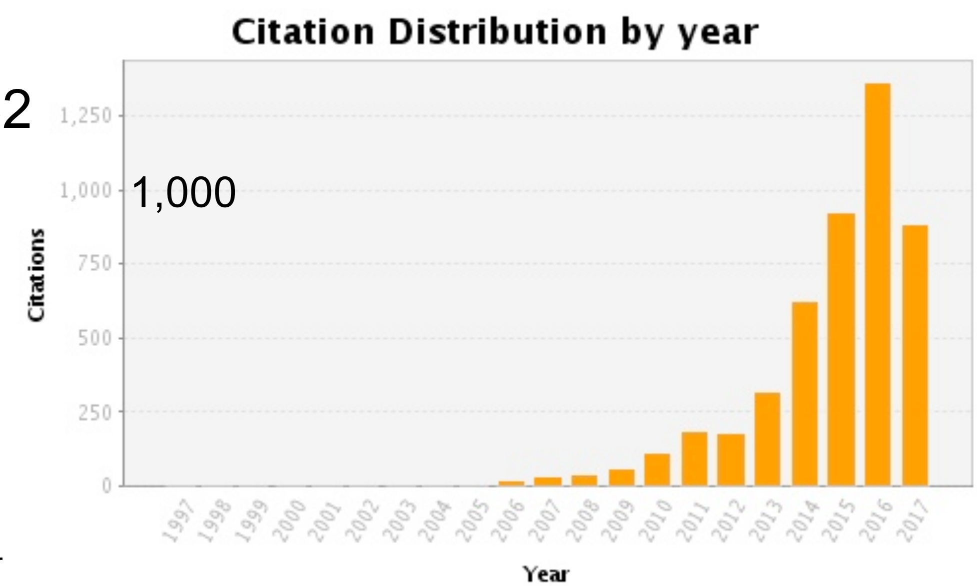
Working Groups & Algorithm Teams

Working Group	Lead	Meeting Time
Land Surface	Turk/Peters-Lidard	Monday 2-3:30pm
Latent Heating	Tao	Monday 5-7pm
Hydrology	Peters-Lidard	Monday 3:30-5pm
Orographic GV	Petersen	Monday 4-5:30pm
PSD	Williams	Monday 1-3pm
DPR	Iguchi (invitation only)	Monday 9:30am-noon
GPM Follow-on/CaPPM	Skofronick-Jackson	Friday 9am-4pm
Algorithm	**Lead**	**Meeting Time**
X-Cal	Berg	Monday 8am-1:30pm
GPROF	Kummerow	Friday 9am-noon
Combined	Olson	Friday 8am-5pm
Radar	Iguchi/Meneghini	Friday 8am-5pm
Multi-Satellite	Huffman	Monday 6-9pm

GPM Peer Reviewed Publications

- The AMS special collection on GPM is well underway.
  - 13 accepted papers; 6 in review
  - http://journals.ametsoc.org/topic/global_precipitation_measurement
  - Articles can still be submitted to multiple AMS journals
- Please send accepted GPM related publications (in any journal) to Lisa Nalborczyk for inclusion on the GPM webpage listing
  - Currently at > 225 publications (starting a few years prior to launch)
  - https://pmm.nasa.gov/resources/gpm-publications

Sum of the times cited: 4762
Avg citations per article: 18

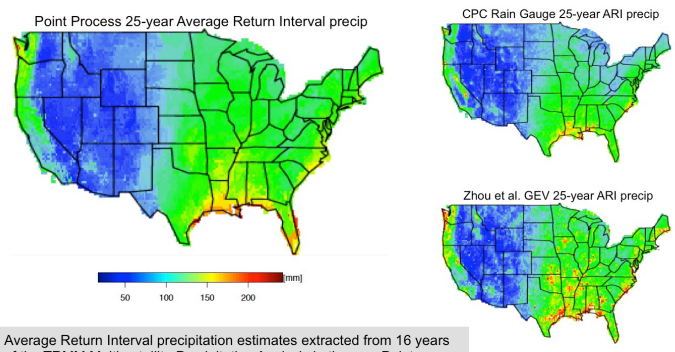


GPM Science

- Want your work reported in GPM? Send us your science highlights and/or your paper URL's with a brief summary

Making Better Estimates of Extreme Precipitation with TRMM Data

L. Demirdjian[1], Y. Zhou[2,3], G.J. Huffman[4]
[1]UCLA, [2]Morgan State Univ., [3]NASA/GSFC 613, [4]NASA/GSFC 612



Average Return Interval precipitation estimates extracted from 16 years of the TRMM Multi-satellite Precipitation Analysis in the new Point Process analysis are closer to the 65-year NOAA/Climate Prediction Center rain gauge map than the values produced by the previous Zhou et al. Generalized Extreme Value analysis.

Earth Sciences Division - Atmospheres

Name: George J. Huffman, NASA/GSFC Code 612
E-mail: george.j.huffman@nasa.gov
Phone: 301-614-6308

References:

Demirdjian, L., Y. Zhou, G.J. Huffman, 2017: Statistical Modeling of Extreme Precipitation with TRMM Data. *Journal of Applied Meteorology and Climatology*, in revision, doi: pending.

Data Sources: Version 7 TRMM Multi-satellite Precipitation Analysis (TMPA; using precipitation estimates from Aqua, DMSP, METOP, NOAA, and TRMM satellites, and the Global Precipitation Climatology Centre monthly precipitation gauge analyses), and NOAA/Climate Prediction Center (CPC) Average Return Interval (ARI) maps. Support was provided by a Burroughs Wellcome Fund Population and Laboratory Based Sciences Award at UCLA, the NASA/GSFC internship program, NASA PMM, and NASA Terra/Aqua.

Technical Description of Figures:
The new Point Process (PP) statistical model was developed to address perceived issues in the initial Zhou et al. (2015) extreme value analysis. That study fitted a Generalized Extreme Value (GEV) probability distribution to the set of annual maximum daily precipitation accumulations that TMPA provided in each latitude/longitude grid box separately. This approach gave relatively noisy estimates for ARIs longer than the 16-year data record (lower right) when compared to the NOAA/CPC analysis of daily precipitation gauge data (upper right). [The CPC analysis uses 65 years of data over some 8,000+ stations, and is considered the standard of comparison.] In the new study, the entire domain was partitioned into clusters of about 30 gridboxes based on the 90th percentile daily precipitation, and then event-maximum daily values (for days exceeding the 99th percentile) were pooled. A PP analysis was used to create fitted extreme parameters for each cluster. The PP results are relatively smooth and close to the NOAA/CPC analysis. Despite a better overall pattern, the PP generally gives somewhat higher values than the CPC in the eastern half of the country.

As well, a version of the PP was created to account for the seasonal cycle so that it is possible to evaluate events in the context of "typical" for the time of year. [The previous study lacked this capability.] The eastern part of the U.S. showed a relatively modest seasonal cycle in ARI values, but the Southwest, and California, in particular, showed strong seasonality, as expected.

Scientific significance, societal relevance, and relationships to future missions: Although demonstrated here just for the Coterminous United States, the analysis has been performed for the entire latitude belt 50°N-S, providing extreme value estimates for all areas, land and ocean, without regard to the density of surface observations. The new estimation approach makes much better use of the available short record of satellite data, giving much more confidence in the values provided. Such information is critical for for scientifically and practically evaluating current and previous precipitation events. As well, it supports the definition of design standards for infrastructure, including siting buildings, laying out transportation grids, and sizing water management projects. When the new Integrated Multi-satellitE Retrievals for Global Precipitation Measurement (GPM) mission (IMERG) datasets are extended to cover both the TRMM and GPM eras, this methodology will be directly applicable.

- Science in GPM Senior Review
  - More than 125 of your publications were cited in the GPM Senior Review
  - Many of your publications were also cited in the post-launch GPM paper:
    - Skofronick-Jackson, et al., 2017: The Global Precipitation Measurement (GPM) for Science and Society. *Bull. Amer. Meteor. Soc.*, August, doi:10.1175/BAMS-D-15-00306.1

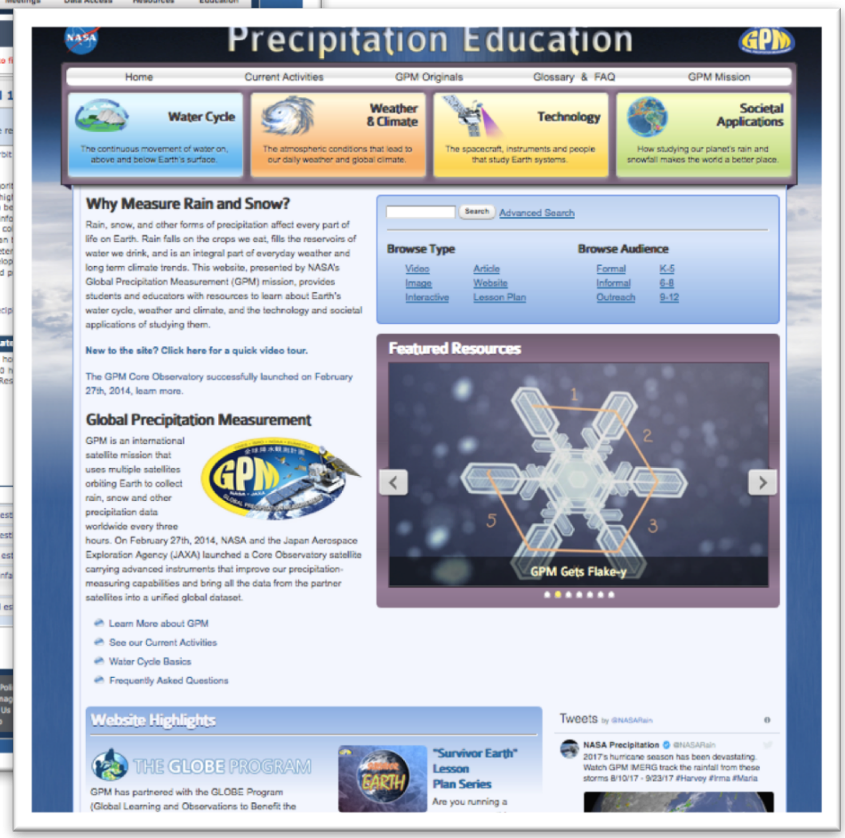
Looking forward to hearing your science presentations this week!

PMM Websites

PMM Website

Data Access Pages

PMM Education



pmm.nasa.gov
Pageviews Oct. 2016-2017:
571,460

pmm.nasa.gov/data-access
Pageviews Oct. 2016-2017:
166,180

pmm.nasa.gov/education
Pageviews Oct. 2016-2017:
1,221,945

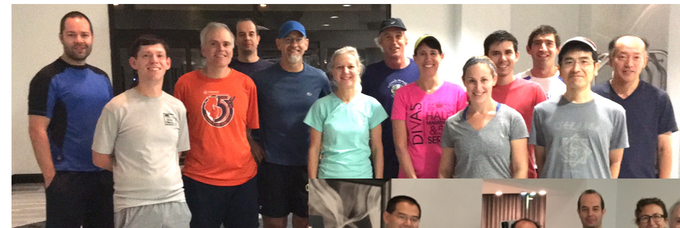
Notable Awards for PMM Team Members

- AMS Awards (2018):
  - THE HELMUT E. LANDSBERG AWARD: J. Marshall Shepherd
  - THE HYDROLOGIC SCIENCES MEDAL: Witold F. Krajewski
  - THE JULE G. CHARNEY AWARD: Dennis P. Lettenmaier
  - FELLOWS: Ramesh K. Kakar, Fuzhong Weng
  - Editor Awards: *Journal of Hydrometeorology*, Pierre-Emmanuel Kirstetter, *Journal of Applied Meteorology and Climatology*, Ali Tokay
  - SPECIAL AWARD: Jeff Hawkins, … F. Joseph Turk…, Tropical Cyclone Satellite Analysis Team, NRL
- AGU Awards (2017):
  - ROBERT E. HORTON MEDAL: Eric F. Wood
  - FELLOWS: Edward J. Zipser
- Presidential Early Career Awards for Scientists and Engineers (PECASE), Dalia Kirschbaum (2017)
- Others
- Send us your news!

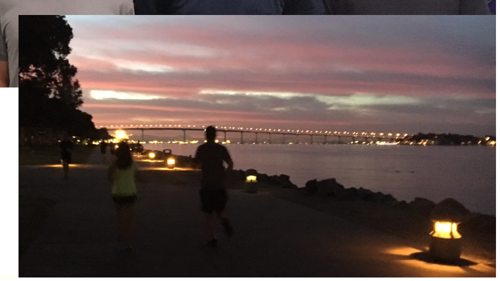
Fun Announcements/PMM Integrated with Life

- Team Precipitation participated in the NASA Let's Move Challenge and placed 3rd at Goddard
- Average of 386,848 steps for 10 team members from May 5-26, 2017 (avg 17.5K steps/day/person)
- Sailing even counted as steps

- PMM meeting run/walks
- In 2016, about 10% participated

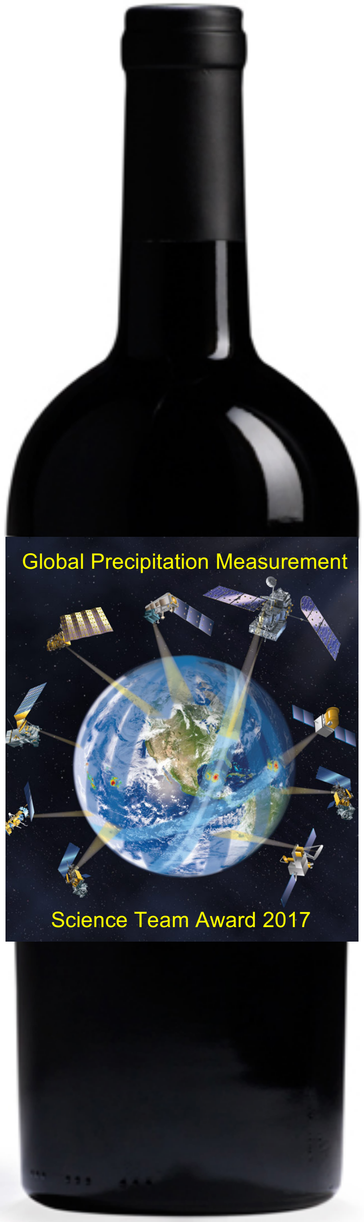


- 2017:



GLOBAL PRECIPITATION MEASUREMENT

Today's Science Team Award



Arthur's tradition: Award WG/team that improves algorithm performance using actual data

Gail's Update: Award Person(s) or Team(s) that significantly enhance PMM science

2017 Award Winner: Dr. John Kwiatkowski

Citation: for his long-term continuous and sustained support of the Japanese and U.S. Radar algorithm team by carrying out testing, analyzing, debugging and coding in support of the radar algorithm. He also worked closely with the GV team to ensure that they understood the radar products and got the targeted data that they needed for their work.

PPS DPR

Science Analyst

GLOBAL PRECIPITATION MEASUREMENT

Let's have a productive science team meeting and much success over the next year(s) with scientific studies using PMM data.