Framework for GPM Ground Validation: Science Strategy and Implementation

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GPM

Unify and advance global precipitation measurements from a constellation of dedicated and operational satellites for research and applications

GPM LIO (40^o)
(Low-Inclination Observatory)
10-183 GHz radiometer

- Asynoptic observations
- Improved sampling for near-realtime monitoring of hurricanes and midlatitude storms

GPM CORE (65^o)
Ku-Ka band radar
10-183 GHz radiometer

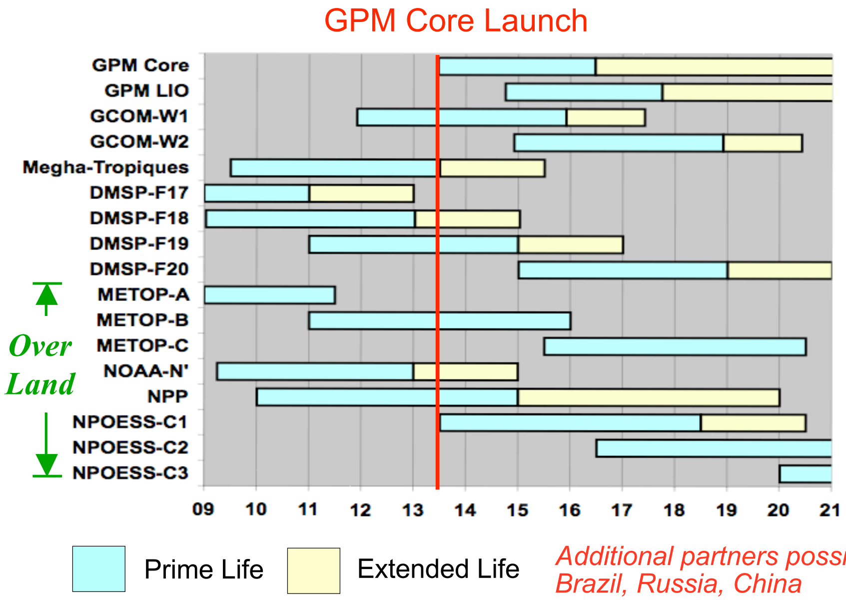
- Precipitation physics observatory
- Reference standard for intercalibration of constellation precipitation measurements

Next-generation global precipitation products through

- advanced active & passive microwave sensor measurements
- a consistent framework for inter-satellite calibration (radiance & rain rates)
- international collaboration in algorithm development and ground validation

Cornerstone for the CEOS Precipitation Constellation under GOESS & GEO

Baseline GPM Constellation Performance

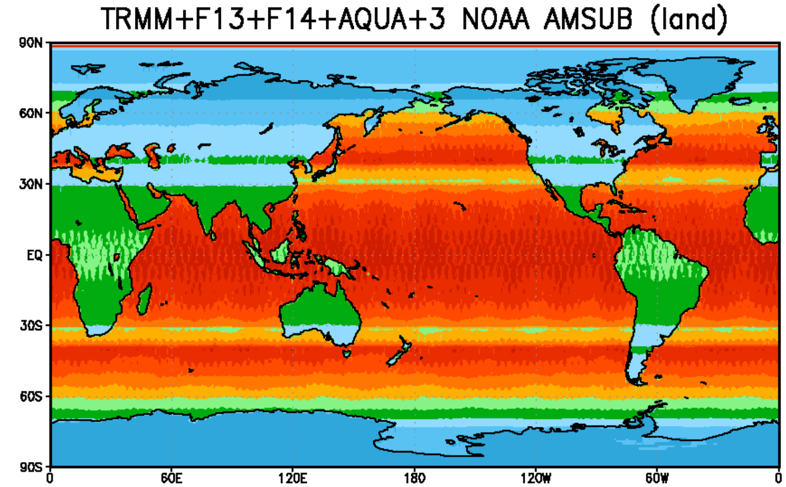


Additional partners possible: Brazil, Russia, China

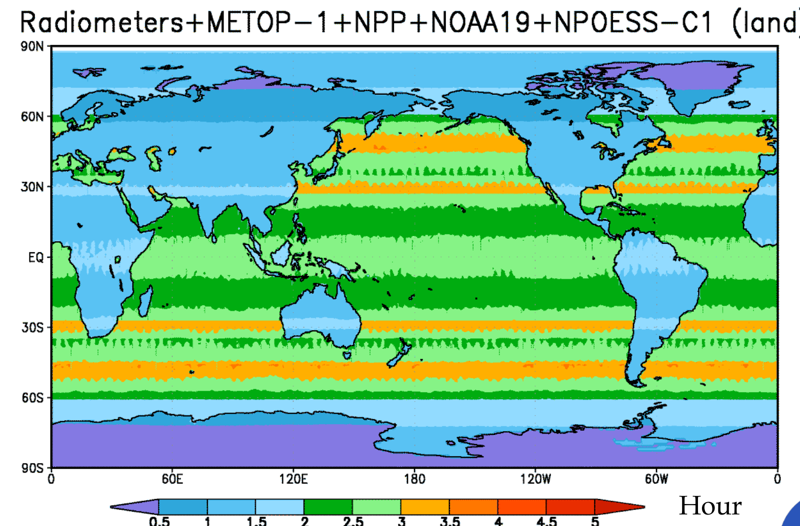
Year	Average Revisit Time (hr)				
	2013	2014	2015	2016	2017
	Land				
Tropics	1.6	1.5	1.6	1.8	2.3
Extratropics	1.1	1.0	1.0	1.0	1.4
Globe	1.4	1.2	1.3	1.4	1.8
	Ocean				
Tropics	3.1	2.5	3.2	3.9	4.9
Extratropics	3.2	2.6	2.1	2.6	3.3
Globe	3.1	2.5	2.7	3.3	4.2
	Land and Ocean				
Tropics	2.6	2.2	2.7	3.1	4.0
Extratropics	2.3	1.9	1.6	1.9	2.5
Globe	2.4	2.0	2.1	2.5	3.3

1-2 hr revisit time over land

TRMM Era
($\leq$ 3h over 45% of globe)



GPM (2015)
($\leq$ 3h over 92% of globe)



GPM: A science mission with integrated application objectives

Scientific Contributions

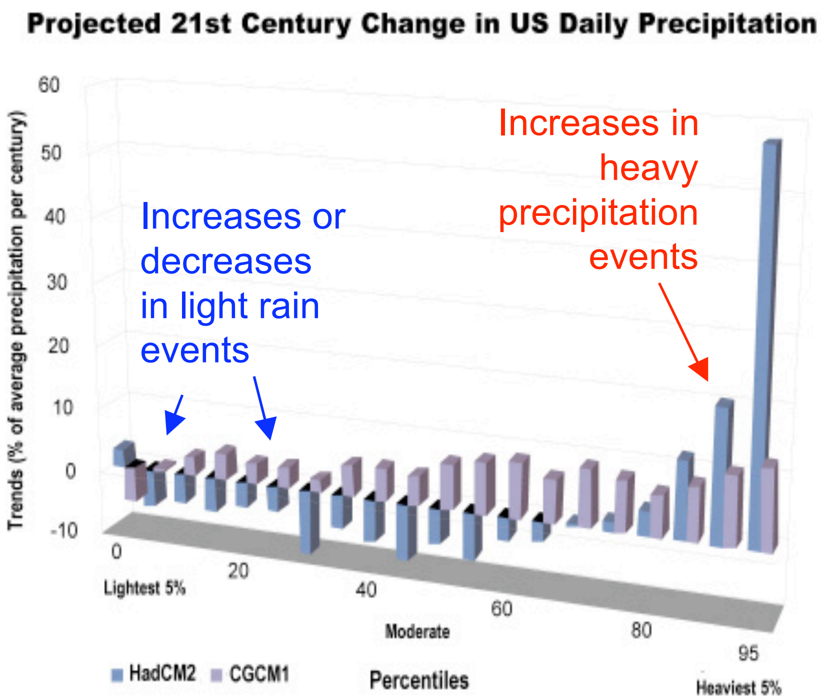
- *New reference standards for global precipitation measurements from space*
- *Better understanding of water cycle variability and its link to climate change*
- *New insights into storm structures, cloud microphysics, & mesoscale dynamics*
- *Improved understanding of climate processes for better prediction of future climate*

Societal Benefits

- *Extending current capabilities in monitoring of hurricanes and other extreme weather events*
- *Enhanced numerical weather and precipitation prediction skills through assimilation of instantaneous precipitation observations*
- *Improved forecasting for freshwater resources, river flows, and natural hazards (floods, droughts, landslides) through better estimation of rainfall accumulation*
- *Assessment of human impact on precipitation and the environment*

Science needs for improved precipitation measurement capabilities

GLOBAL CLIMATE MODELS PREDICT SIGNIFICANT CHANGES IN PRECIPITATION AMOUNT AND INTENSITY OVER THE 21st CENTURY



ARE THE MODELS RIGHT?

Detection of changes in precipitation characteristics requires better measurements of

- light rain rates (prevalent in middle & high latitudes)
- solid precipitation (cold seasons)
- microphysical information

- *Is the global water cycle accelerating as the climate warms?*

  - How do precipitation frequency, distribution, and intensity change in a warmer climate?

- *How do precipitation microphysical properties (particle size distribution, liquid/ice partition, hydrometeor profiles, etc.) and precipitation efficiency vary with the environmental state and climate regimes?*

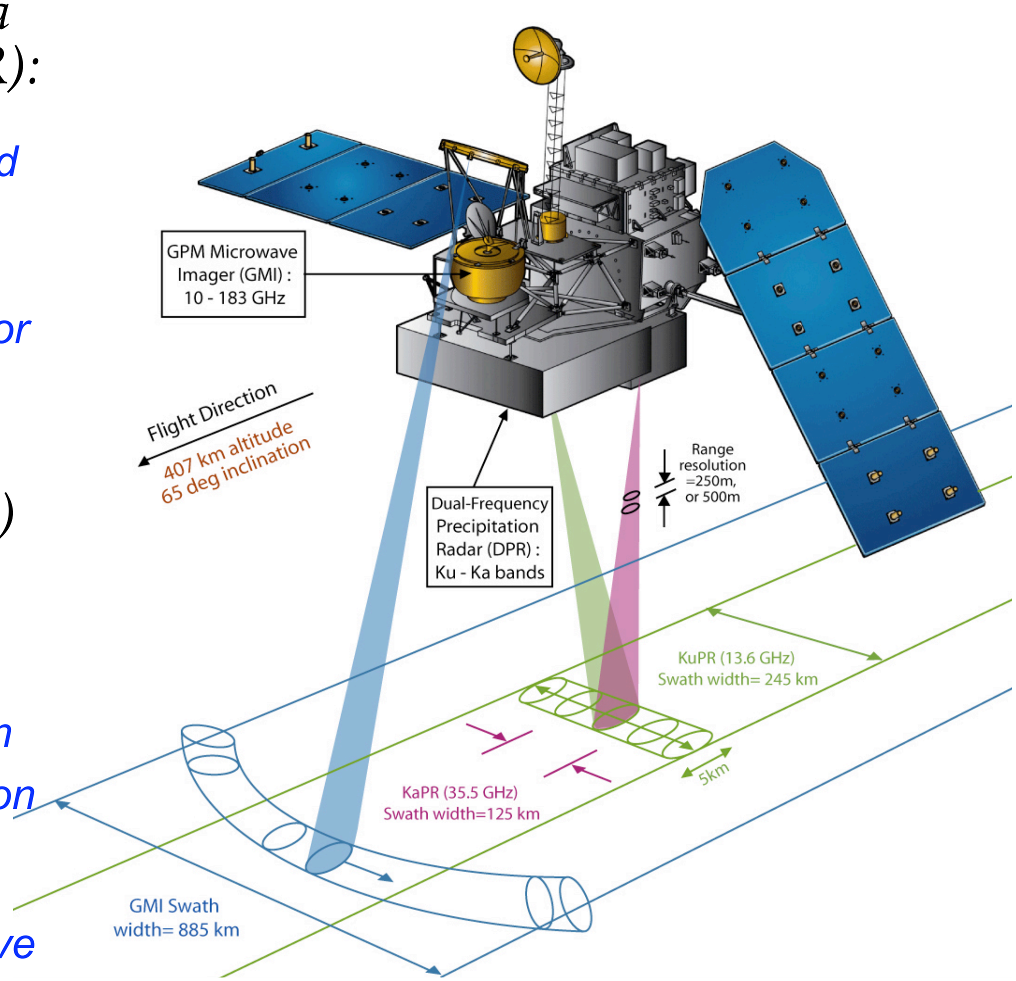
GPM Core Observatory Sensors

JAXA Dual-Frequency (Ku-Ka band) Precipitation Radar (DPR):

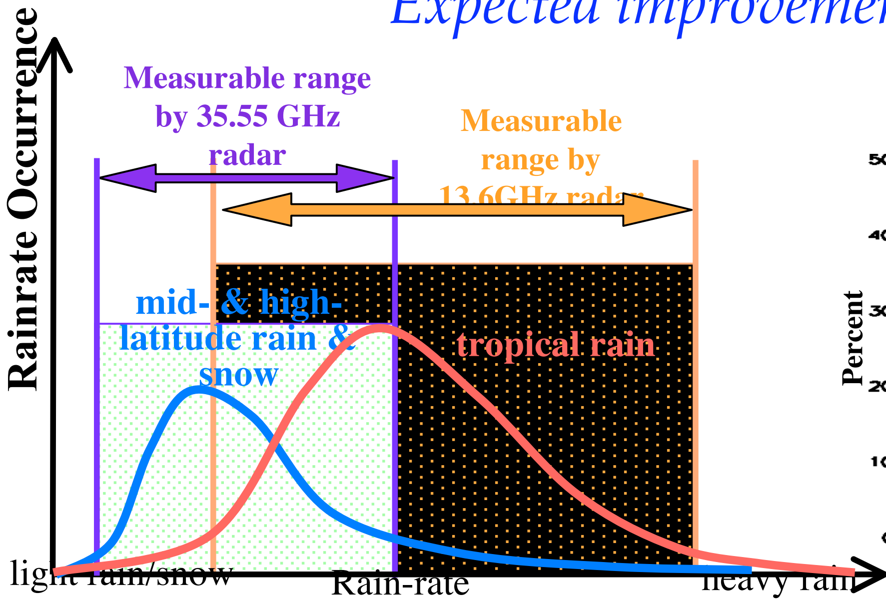
- *Increased sensitivity for light rain and snow detection*
- *Better measurement accuracy*
- *Detailed microphysical information for improving radiometer rain retrievals*

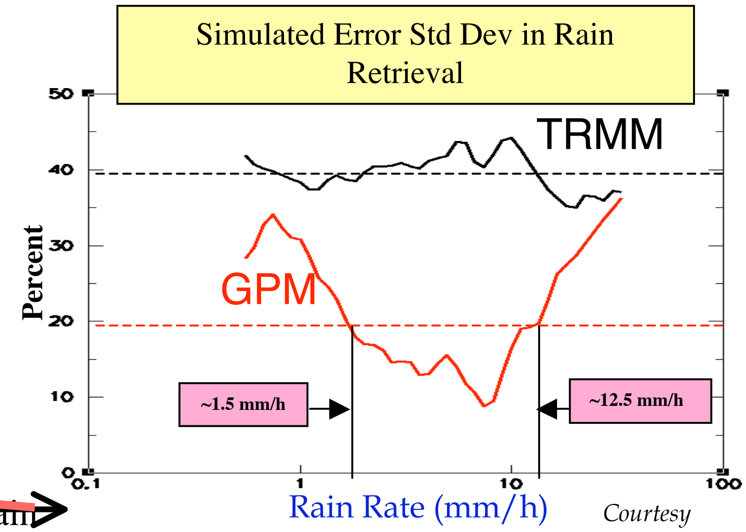
NASA Wide-Band (10-183 GHz) Microwave Imager (GMI):

- *High spatial resolution*
- *Improved light rain & snow detection*
- *Improved signals of solid precipitation over land (especially over snow-covered surfaces)*
- *Accuracy & stable calibration to serve as a radiometeric reference for constellation radiometers*



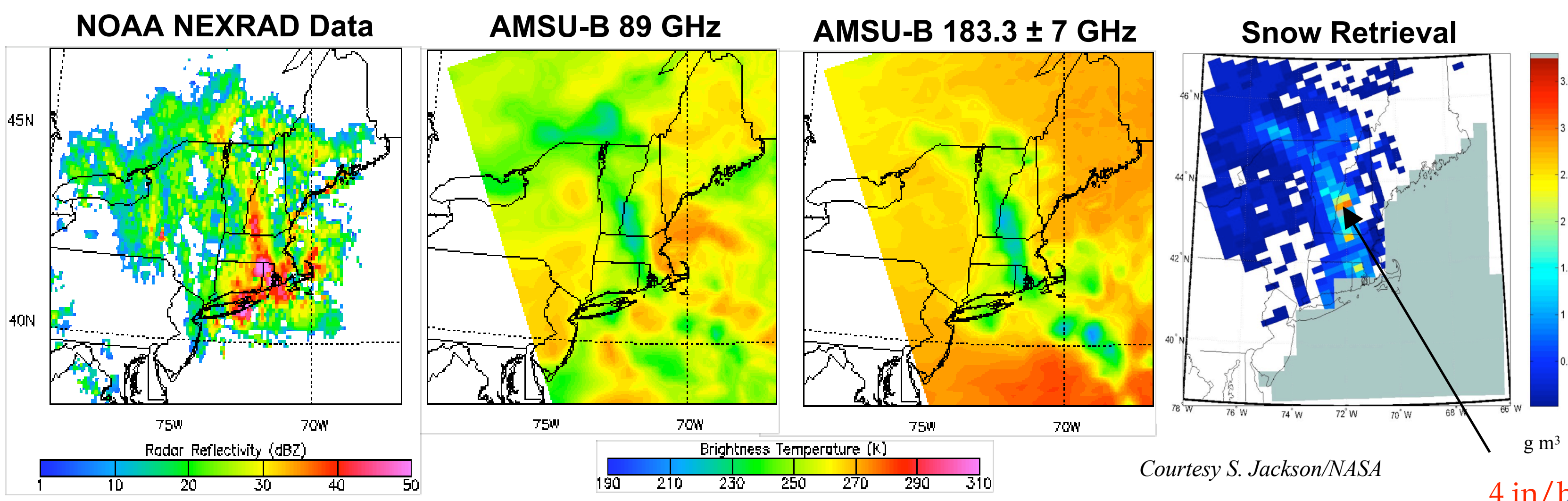
Expected improvements with DPR





Courtesy Z. Haddad

Snowfall rate retrieval from HF channels over frozen surface



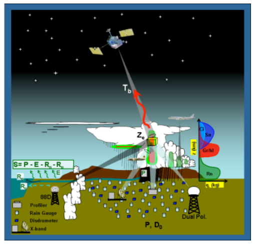
Courtesy S. Jackson/NASA

GPM Ground Validation Strategy

For pre-launch algorithm development & post-launch product evaluation

GPM GV goes beyond direct comparisons of surface rain rates between ground and satellite measurements to provide the means for improving satellite simulators, retrieval algorithms, & model applications

Three approaches to GPM GV:



- *Direct statistical validation (at the surface):*

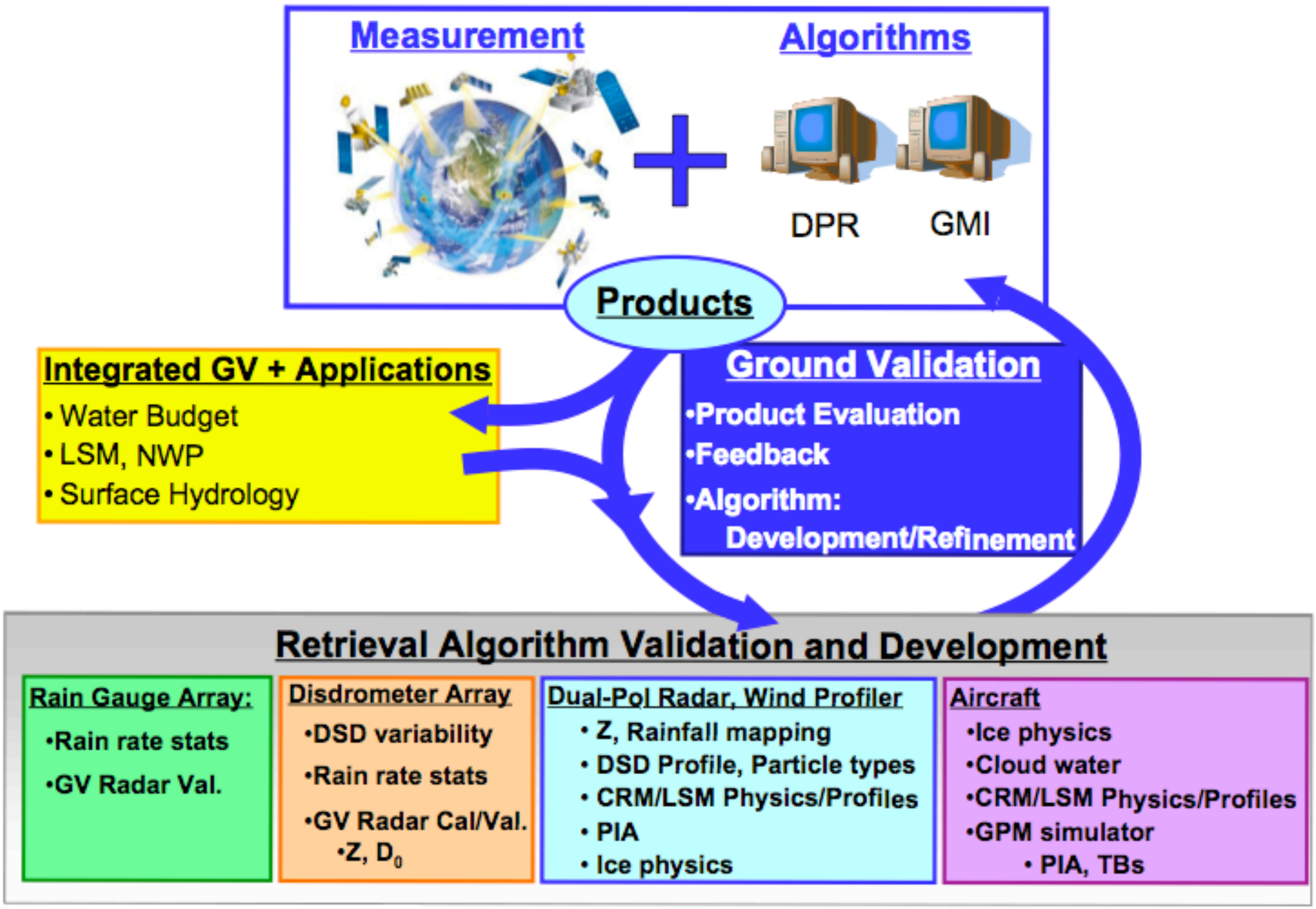
  - Leveraging off operational networks to identify and resolve significant discrepancies between satellite and ground-based precipitation estimates

- *Precipitation physics validation (in a vertical column):*

  - Cloud system and microphysical studies geared toward testing and refinement of satellite simulators and retrieval algorithms

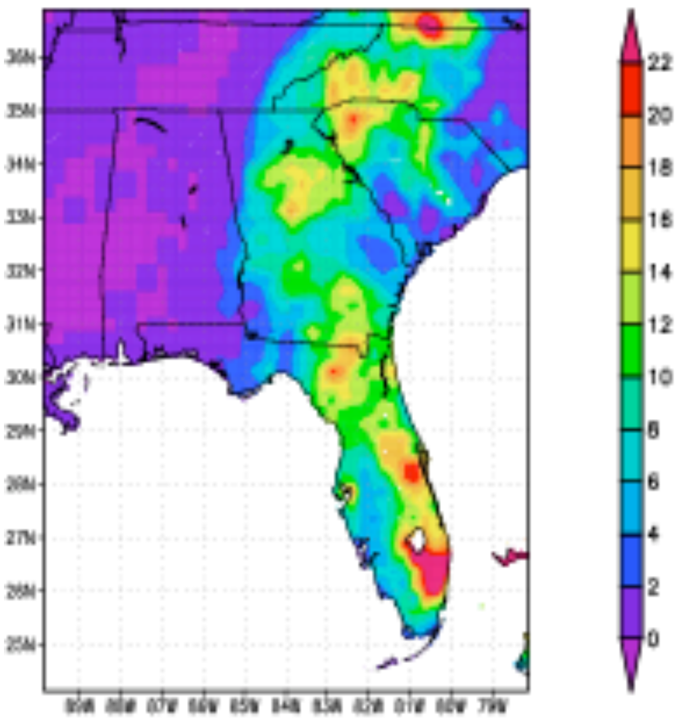
- *Integrated science validation (4-dimensional):*

  - Integration of satellite precipitation products into weather, land surface, and hydrological prediction models to evaluate the strengths and limitations of satellite precipitation products

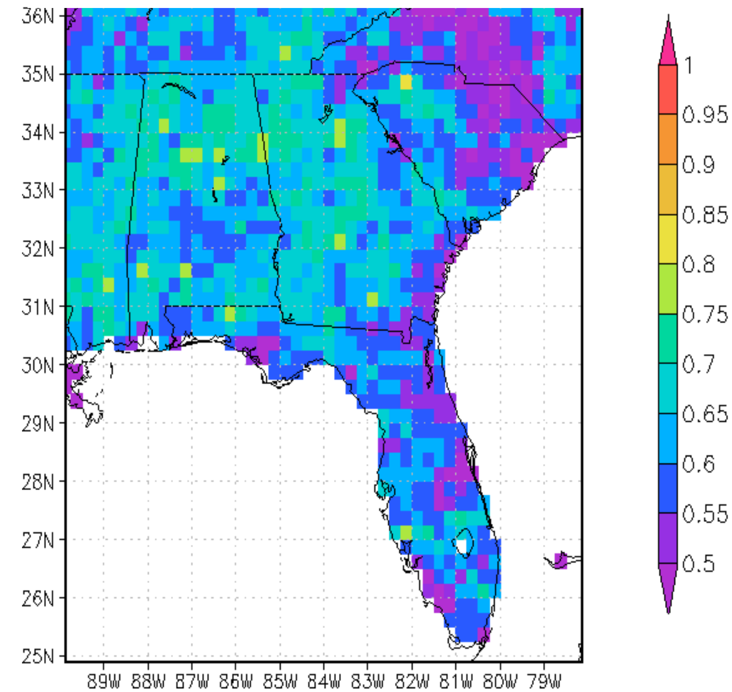

Measurement
Algorithms
DPR
GMI
Products
Integrated GV + Applications
• Water Budget
• LSM, NWP
• Surface Hydrology
Ground Validation
•Product Evaluation
•Feedback
•Algorithm: Development/Refinement
Retrieval Algorithm Validation and Development
Rain Gauge Array:
•Rain rate stats
•GV Radar Val.
Disdrometer Array
•DSD variability
•Rain rate stats
•GV Radar Cal/Val.
•Z, D0
Dual-Pol Radar, Wind Profiler
• Z, Rainfall mapping
• DSD Profile, Particle types
• CRM/LSM Physics/Profiles
• PIA
• Ice physics
Aircraft
•Ice physics
•Cloud water
•CRM/LSM Physics/Profiles
•GPM simulator
• PIA, TBs

6-days of satellite-based rainfall and runoff from Hurricane Jeanne Sept. 25-30, 2004

Avg daily TMPA rainfall (mm)



POD/TMPA (16 mm/day) w.r.t. Higgins Daily

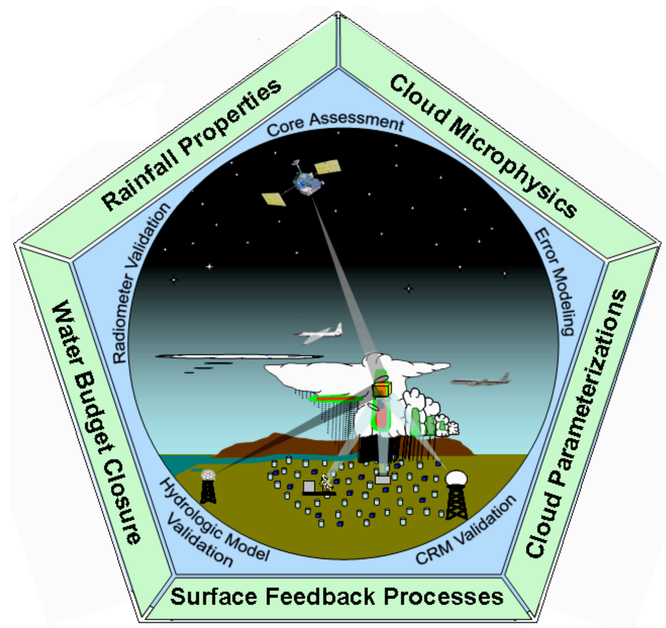


Peters-Lidard et al., 2007

GPM GV

3 approaches supporting

5 cross-cutting science themes:



1. Core satellite error characterization
2. Constellation satellites validation
3. Development of physical models of snow, cloud water, and mixed phase
4. Development of CRM and land-surface models to bridge observations and algorithms
5. Development of coupled CRM-land surface modeling for basin-scale water budget studies and natural hazard predictions

GPM GV Success Criteria

- *Providing stable, calibrated surface precipitation measurements as an independent assessment of satellite-based precipitation estimates.*
- *Providing "microphysics laboratories" for improving the performance of satellite algorithms and the quality of GPM data products.*
- *Providing information for improving error characterization of satellite precipitation products for NWP, multi-satellite precipitation analyses, climate re-analyses, and hydrological applications.*
- *Providing testbeds for improving satellite precipitation data usage in hydro-meteorological modeling and prediction.*

U.S. GPM GV Organizational Structure

Precipitation Measurement Missions (PMM) Science Program (R. Kakar/NASA HQ)

PMM Science Team
(Algorithm development, GV science, science research and applications)

(Supporting TRMM/GPM & other NASA missions)

PMM GV Facilities:
S-Band Dual-Pol Radar (NPOL)
Kwajalein Radar, TOGA Radar, Disdrometers, Profilers, gauges

Precipitation Processing System (PPS)

GPM Program Executive
(S. Neeck/NASA HQ)

GPM (Flight) Project
(Art Azarbarzin/NASA GSFC)
(Instruments, spacecrafts, mission operations)

GPM Project Scientist
(A. Hou/NASA GSFC)

GV Science Manager
(W. Petersen/UAH)

(GPM-specific support)

GPM GV System (M. Schwaller/NASA GSFC)
Ku-Ka(-W?) radar
Field campaign operations
VN data processing

International partnership: Key to GPM GV success

Potential GPM GV
Sites and Partners

NASA welcomes international participation in the PMM Program GV activities to improve GPM products for the benefit of all nations

- international investigators invited to submit no-cost proposals to the PMM program to establish joint GV projects to complement existing activities

- selection offers scientific collaboration, data sharing, and leveraged resources in joint projects as members of the PMM Science Team