Global Precipitation Measurement Science Status

Arthur Hou, Gail Skofronick Jackson

NASA Goddard Space Flight Center

GPM Mission Concept

- Coordinated precipitation measurements by a constellation of microwave sensors to achieve global sampling and coverage through partnerships.

The GPM Core is specifically designed to:

- Set a new reference standard for precipitation measurements from space
- Provide a transfer standard to unify and improve precipitation estimates from passive microwave radiometers

2nd NOAA User Workshop on the GPM Mission
November 29, 2011

Baseline GPM Constellation of Satellites

Next-generation global precipitation products for research & applications

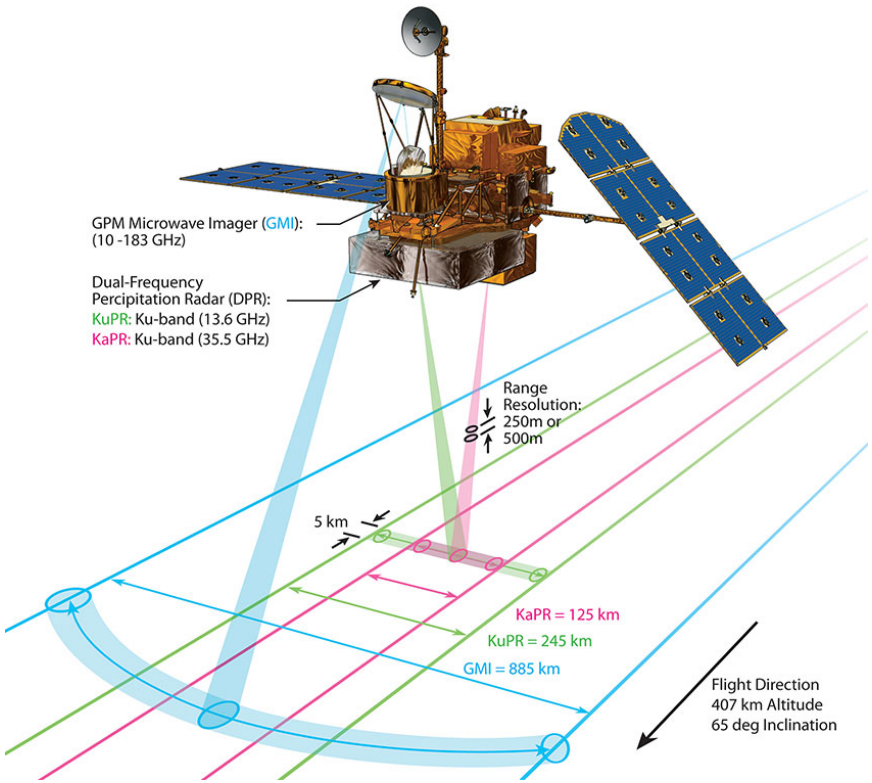
Core Observatory Measurement Capabilities

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

- *Increased sensitivity (~12 dBZ) for light rain and snow detection relative to TRMM*
- *Better measurement accuracy with differential attenuation correction*
- *Detailed microphysical information (DSD mean mass diameter & particle no. density) & identification of liquid, ice, and mixed-phase regions*

Multi-Channel (10-183 GHz) GPM Microwave Imager (GMI):

- *Higher spatial resolution (IFOV: 6-26 km)*
- *Improved light rain & snow detection*
- *Improved signals of solid precipitation over land (especially over snow- covered surfaces)*
- *4-point calibration to serve as a radiometric reference for constellation radiometers*



Combined Radar-Radiometer Retrieval

- *DPR & GMI together provide greater constraints on possible solutions to improve retrieval accuracy*
- *Observation-based a-priori cloud database for constellation radiometer retrievals*

GPM Next Generation Precipitation Products

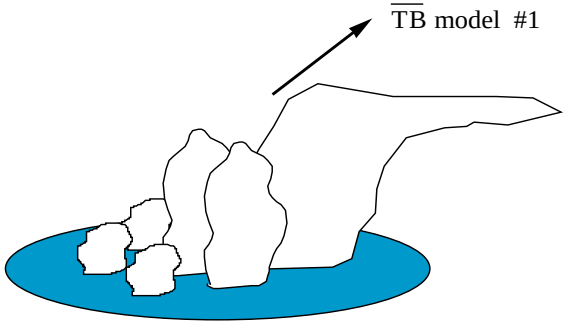
1) Intercalibrate constellation *brightness temperature* data with sensor differences reconciled using the non-Sun-synchronous Core satellite as a transfer standard.

2) Unify *precipitation* retrievals using a common hydrometeor database constructed from combined DPR+GMI measurements

Radiometer precipitation retrievals use a Bayesian database

TRMM's database from cloud models

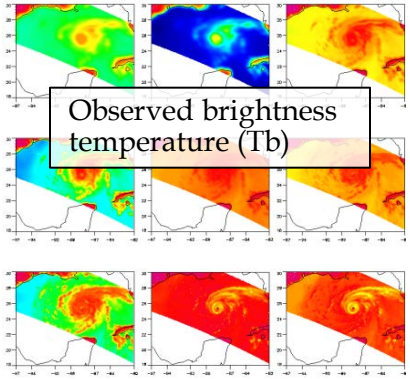
Simulated T_b, Z, & RR

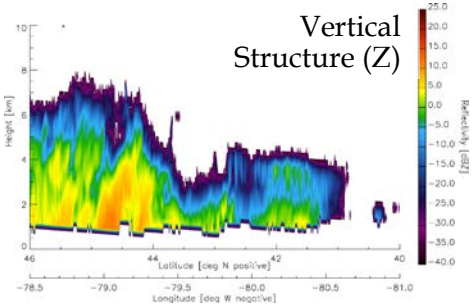


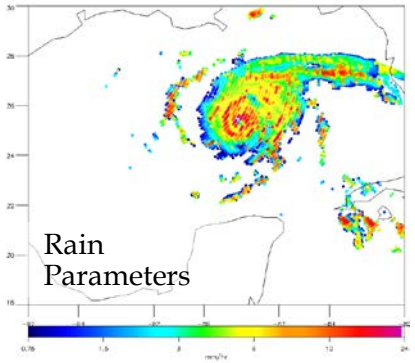
TRMM: Cloud resolving model simulations to database T_b and Z via forward radiative transfer model calculations.

GPM's database from DPR+GMI obs.

Observed T_b, Z, & combined retrievals







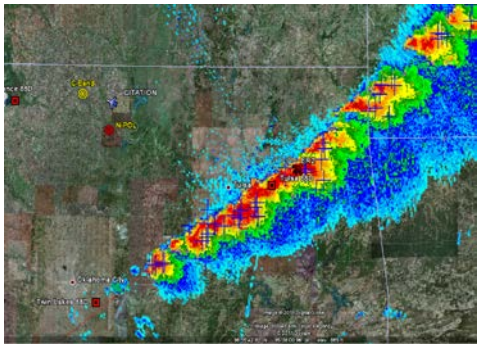
GPM: GPM Core observations provide database T_b and RR, this transfer standard allows for unified precipitation retrievals.

Courtesy of Joe Munchak

GPM Mission Status

- GPM is in (Phase C) implementation at NASA and JAXA
  - Two agencies have signed a Memorandum Of Understanding on GPM cooperation
  - Launch readiness date: Feb 2014
  - NASA Precipitation Processing System (PPS) completed Build 3 Review and is currently producing prototype intercalibrated L1C products for TMI, SSMI, AMSR-E, SSMIS, & WindSat and L3 NRT merged global precipitation products using TMI, SSMI, AMSR-E, AMSU, and MetOp data.
- NASA and CNES, and NASA and ISRO have bi-lateral Implementing Agreements to formalize the participation of Megha-Tropiques in GPM
- The NASA-NOAA Inter-agency Agreement on GPM cooperation is in review
- NASA and EUMETSAT are in discussion to develop a formal agreement on GPM
- NASA and AEB have signed a Cooperative Agreement on GPM Scientific Collaboration in Oct. 2011.
- NASA PMM Science Team is on track to deliver GPM L2 and L3 baseline algorithm codes to PPS and MOS at end of Nov. 2011.
- NASA is conducting a series of GPM ground validation campaigns in cooperation with domestic and international partners.

Ground Validation: MC3E (April 22 – June 6, 2011)


- 70 ER-2 and 45 Citation flight hours including 8 ER-2/Citation coordinated missions
- 3 ER-2 emissivity missions
- Citation microphysics and cloud missions
- Continuous sampling by 5-7 ground radars
- Launch of ~1200 radiosondes








MC3E Algorithm-GV Traceability Matrix

Algorithm issues or assumptions	Applicable Measured and/or Diagnosed Parameters																
	Z	Z_{DFR}	R	PSD_{sfc}	PSD_{col}	PID	ρ_b	ρ_p	T	Q_v	Q_{soil}	CN CCN	TW_c	CW	IW	ε/σ_{sfc}	T_B
Path integrated attenuation approach(es)	◆	◆	◆	◆	◆	◆				◆			◆	◆		◆	
Hydrometeor Identification (3D)	◆	◆	◆	◆	◆	◆	◆		◆				◆	◆	◆		
Hydrometeor melting model	◆	◆			◆	◆	◆	◆	◆				◆		◆	◆	◆
Melting layer identification	◆	◆			◆	◆			◆						◆		
Convective/Stratiform partitioning	◆	◆	◆	◆	◆	◆											◆
Dual-Frequency rain rate retrieval	◆	◆	◆	◆	◆	◆										◆	
Near surface rain estimate/rain profile	◆	◆	◆	◆	◆	◆										◆	
Sub-pixel DSD and rain variability (correlation, errors, beam filling)	◆	◆	◆	◆	◆	◆											◆
DSD profile and "ε" adjustments	◆	◆	◆	◆	◆	◆											◆
Column/Land surface emission			◆						◆	◆	◆					◆	◆
Rain/no rain discrimination	◆	◆	◆	◆	◆	◆			◆	◆			◆	◆	◆	◆	◆
Ice particle vs. volume extinction	◆	◆			◆	◆	◆	◆	◆	◆					◆		◆
Cloud water profiles	◆	◆	◆						◆	◆		◆	◆	◆	◆		◆
Ice process, scattering, and rainfall	◆	◆	◆	◆	◆	◆	◆	◆					◆	◆	◆		◆
Regime controls on precipitation process	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆		◆	◆	◆	◆	◆	◆
DSD Gamma-Triplet correlations	◆	◆	◆	◆	◆	◆							◆				
CRM/LSM Satellite Simulator Physics	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

MC3E GV measurements			Applicable Measured and/or Diagnosed Parameters																
	Instruments	Measurable	Z	Z_{DFR}	R	PSD_{sfc}	PSD_{col}	PID	ρ_b	ρ_P	T	Q_v	Q_{soil}	CN, CCN	TW_c	CW	IW	ε/σ_{sf}	T_B
Ground Radar and Profiler	NPOL, DOE S/C/X Dual-Pol	Z, Vr, W, ZDR, Φ_{DP}, ρ_{hv}, LDR	☒		☒	☒	☒	☒											
	D3R Ka/Ku Dual-Pol	Z, Vr, DFR, W, ZDR, Φ_{DP}, ρ_{hv}, LDR	☒	☒	☒	☒	☒	☒											
	S/UHF Profiling	Z, Vr, W	☒		☒	☒	☒	☒											
	MRR K-band Profiling	Z, Vr, W	☒		☒	☒	☒	☒											
	Ka/W-band Radar	Spectra (Z, Vr)	☒		☒	☒										☒			☒
Ground Gauge and Radiometer	2DVD/Parsivel Array	DSD, shape, fall spd	☒		☒	☒		☒											
	Rain gauge array	Rain rate/accum			☒														
	Sounding Array	P, T, RH, wind									☒	☒							
	ADMIRARI Radiometer, MRR	T_B 19, 37 Z 24 GHz	☒		☒											☒			
	DOE/OK Surface Inst.	P,T,RH, soil moisture and aerosols			☒						☒	☒	☒	☒					
	AERI Radiometers	T/RH Profile									☒	☒							
	DOE Flux tower	Eddy fluxes (T,q,u)									☒	☒							
Aircraft	HIWRAP (Ka/Ku Radar)	Z, Vr, DFR, W, ZDR, Φ_{DP}, ρ_{hv}, LDR	☒	☒	☒		☒	☒										☒	
	CoSMIR (Radiometer)	T_B 37,89, 165.5,183 H/V															☒	☒	☒
	AMPR (Radiometer)	T_B 10,19,37,85 H/V															☒	☒	☒
	2D-C/CIP/2D-P, HVPS	Precip. Image	☒		☒		☒	☒	☒	☒					☒		☒		
	CDP	Cloud Water/Spectra														☒			
	Nevzorov	Total water							☒						☒	☒	☒		
	King Probe	Cloud water bulk														☒			
	Rosemount Icing Probe	Supercooled water														☒			
	CN/UHSAS	Aerosol spectra												☒					
	MAPIR Radiometer	T_B 1.4 GHz H/V									☒		☒						

Improving physical parameters in retrieval algorithms using MC3E campaign measurements

Campaign Data

+

Microphysics/EM Modelers

+

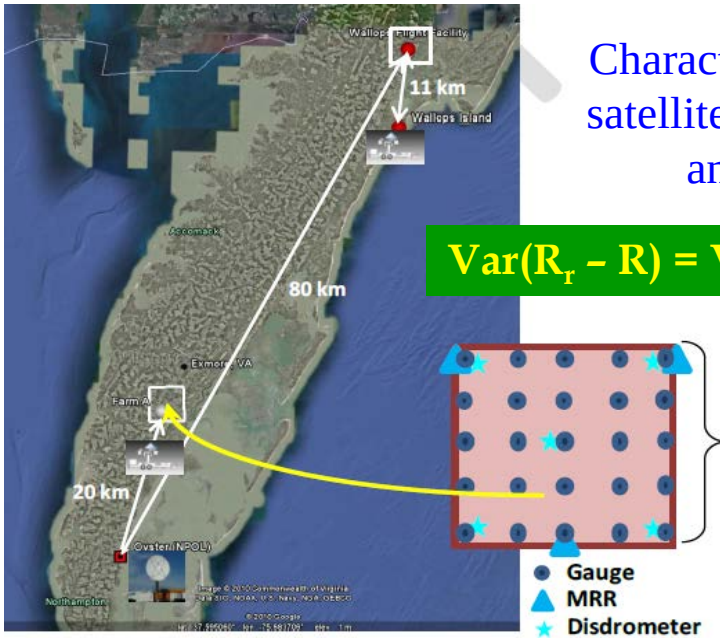
Algorithm Developers

=> *Algorithm Refinements*

Ground Validation

- LPVEx (Sept 15 – Dec 21, 2010):
  - Data review workshop in Helsinki, Oct 13-14, 2011.
  - Fully quality-controlled data release: Dec. 2011. Emphasis on full microphysical and radiometric definition of light-precipitation column and melting layer models.
- GCPEX (Jan 17 – Feb 28, 2012):
  - Ground instrumentation installation underway at and around the EC CARE sites.
- Partnership with NOAA National Mosaic QPE (NMQ) project:
  - GPM radiometer retrieval database development using 3D radar/rain data.
  - NMQ data also being used to characterize uncertainties in satellite precip. products.
- Future campaigns under consideration:
  - Large-scale Flood Testbed in Iowa: Target date - 2013.
  - Orographically-enhance Convection Testbed in the SE U.S.: Target date - 2014
  - Semi-Arid Monsoon Testbed in the SW U.S. (possibly jointly with SMAP)
  - Snow/Rain Testbed on Olympic Peninsula: OLYMPEX campaign (post-launch)

Precipitation GV Science Research Facility at NASA/WFF

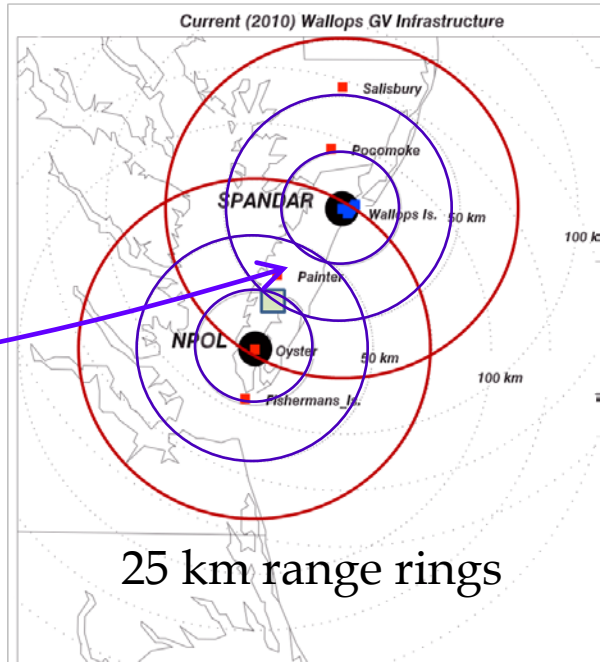


Objective

Characterize uncertainties in satellite products using radar and/or gauge data

$$Var(R_r - R) = Var(R_r - R_g) - Var(R_g - R)$$

Location: NASA/GSFC Wallops Flight Facility



- Approach: Dense long-term gauge/disdrometer network under radar coverage
- **Stage 1**: Dense gauge network and multi-parameter/frequency radars
- 25 gauge pairs, 5 x 5 km^2 area. Total inventory 70+ TB rain gauges
- 4 existing locations with gauge pairs along the Eastern Shore (range studies)
- NPOL (S-band) , SPANDAR (S-band) , WSR-88D (S-band), TOGA (C-band), D3R (Ka-Ku band) – quantify radar reference accuracy as f(scale, measurement type);
- **Stage 2**: 20+ disdrometers, 5 2DVDs, 20+ Parsivel, ~4 Joss; DSD variability studies +6 MRR's
- Addressing precipitation regime diversity via partnerships and collaboration:
- Coastal land/oceanic and seasonal regime gradients;- long term observations between IOPs
- Leverage partnering activities to expand regimes; e.g., Iowa Flood Center, HyMeX, S. Korea

GPM Near Real-time Data Products

- GMI L1 and L2 swath products within 20 min. of data collection
- Selected DPR L2 (e.g., reflectivity and precipitation rate) swath products within 120 min. of data collection
- Combined GMI and DPR L2 swath products within 120 min. of data collection
- L1C intercalibrated brightness temperature swath products and L2 GPROF precipitation products for partner radiometers within 10 min. of receiving L1B data from data providers
- L3 merged MW+IR, 0.1^{o} x 0.1^{o} gridded, half-hourly global precipitation products:
  - Low-latency, quick-look products (with relatively high IR data content) near data collection time
  - Late-look products with all available MW data within the collection window

Summary

GPM is an international satellite mission that will unify and advance precipitation measurements from a constellation of microwave sensors for research and application.

- Advanced active/passive sensor capabilities
  - Higher sensitivity to light rain and solid precipitation than TRMM instruments
  - Insights into precipitation physics with quantitative estimates of PSD parameters
- Next-generation uniform global precipitation data products
  - Inter-calibrated radiometric data from a constellation of MW sensors
  - Unified precipitation retrieval using a common hydrometeor database consistent with combined active/passive sensor measurements
- Near real-time data for operational use and societal applications
- Ground validation is key to refining algorithm assumptions & parameters and characterization of uncertainties in precipitation estimates for improving GPM data products and data utilization:
  - Conducting a series of focused GV field campaigns in collaboration with domestic and international partners to improve GPM satellite algorithms
  - Establishing GV research facilities to characterize uncertainties in satellite and ground-based precipitation estimates to improve understanding error propagation from inputs to forecasts of hydrological models.

URL: pmm.nasa.gov or gpm.nasa.gov