The Global Precipitation Measurement (GPM) Mission: U.S. Program and Science Status

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GPM Mission Concept

Unify and advance precipitation measurements from space to provide next-generation global precipitation products within a consistent framework

Low Inclination Observatory (40°)

GMI (10-183 GHz)
(NASA & Partner, 2014)

- Enhanced capability for near-realtime monitoring of hurricanes & midlatitude storms
- Improved estimation of rain accumulation

GPM Core Observatory (65°)

DPR (Ku-Ka band)
GMI (10-183 GHz)
(NASA-JAXA, LRD 2013)

- Precipitation physics observatory
- Transfer standard for inter-satellite calibration of constellation sensors

Partner Satellites:

GCOM-W1
DMSP F-18, F-19
Megha-Tropiques
MetOp, NOAA-19
NPP, JPSS (over land)

Coverage & Sampling

- 1-2 hr revisit time over land
- < 3 hr mean revisit time over 91% of globe

Key Advancement

Using an advanced radar/radiometer measurement system to improve constellation sensor retrievals

GPM Mission Status

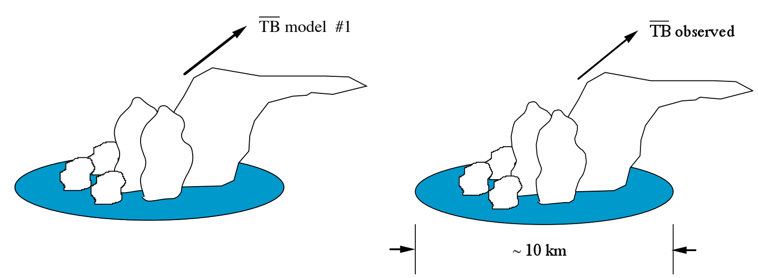
- ***Phase C development at NASA***
  - *Critical Design Review completed in Dec. 2009*
  - *GMI fabrication & assembly underway, Core Spacecraft detailed design nearing completion*
- ***NASA-JAXA Memorandum of Understanding signed in July 2009***
- ***Core Observatory Launch Readiness Date: 21 July 2013***
- ***NASA in partnership discussion for the GPM Low Inclination Observatory (LIO) with Nov. 2014 as target launch date***
- ***CNES-ISRO-NASA trilateral agreement in development to formalize Megha-Tropiques' partnership in GPM***
- ***Final draft of AEB-IPNE-NASA joint study agreement on GPM in review***
- ***EUMETSAT will provide MetOp data to GPM and expressed interest in pursuing a formal partnership***
- ***NASA-NOAA inter-agency agreement under development***
- ***NASA Precipitation Processing System currently producing***
  - *Prototype inter-calibrated Level-1 products for TMI, SSMI, AMSR-E, SSMIS, & WindSat*
  - *Level-3 merged global precipitation products using TMI, SSMI, AMSR-E, AMSU, & MetOp in near real-time for research & applications*

Next-Generation Global Precipitation Products

- Intercalibrated constellation radiometric data reconciling differences in center frequency, viewing geometry, resolution, etc.
  - Converting observations of one satellite to virtual observations of another using non-Sun-synchronous satellite as a transfer standard
  - GMI employs an encased hot load design (to minimize solar intrusion) and noise diodes for nonlinearity removal to attain greater accuracy & stability
  - International working group (NASA, NOAA, JAXA, CONAE, CMA, EUMETSAT, CNRS, GIST, & universities) in coordination with WMO/CGMS GSICS
- Unified precipitation retrievals using a common cloud/hydrometeor database constrained by DPR+GMI measurements from the GPM Core Observatory

Optimally matching observed T_b with simulated T_b from an a priori cloud database

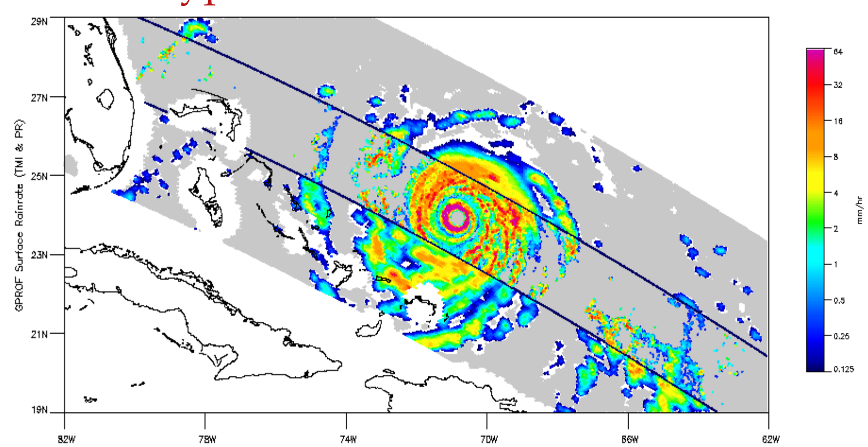
Simulated T_b *Observed T_b*



TRMM uses a model-generated cloud database

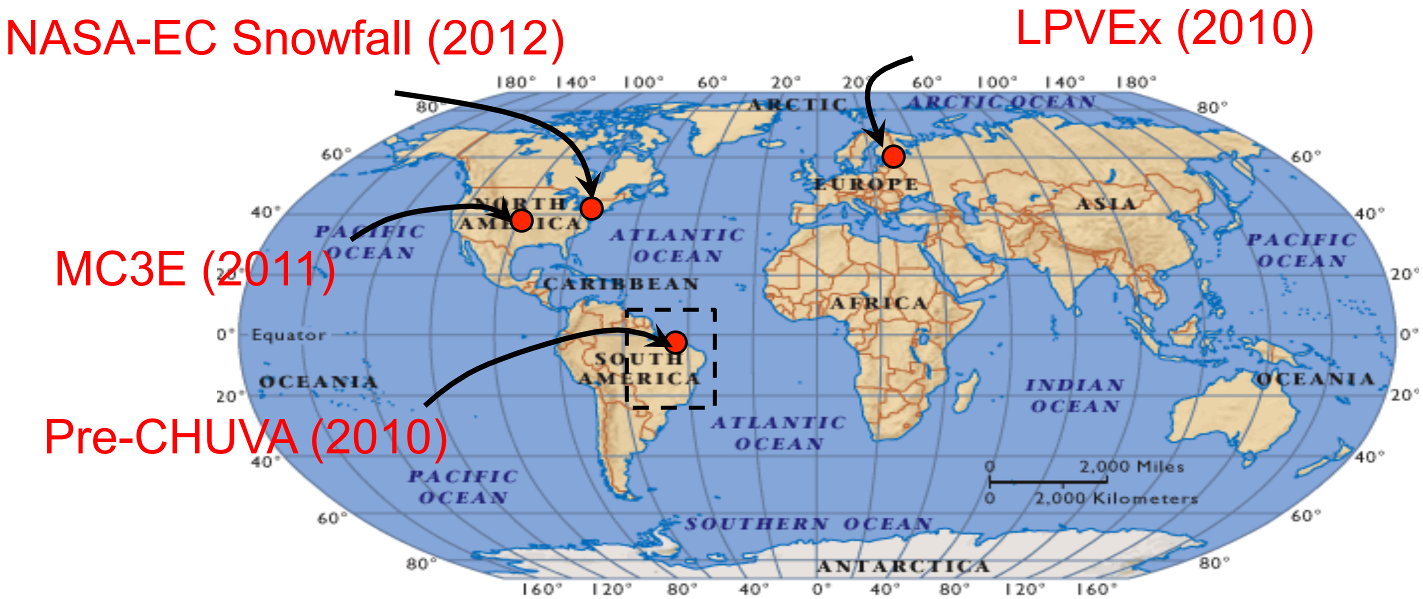
GPM uses a DPR/GMI-constrained database

Prototype GPM Radiometer Retrieval



Comparison of TRMM PR surface rain with TMI rain retrieval using an cloud database consistent with PR reflectivity and GMI multichannel radiances

Physical Validation: Field Campaigns (2010-2012)

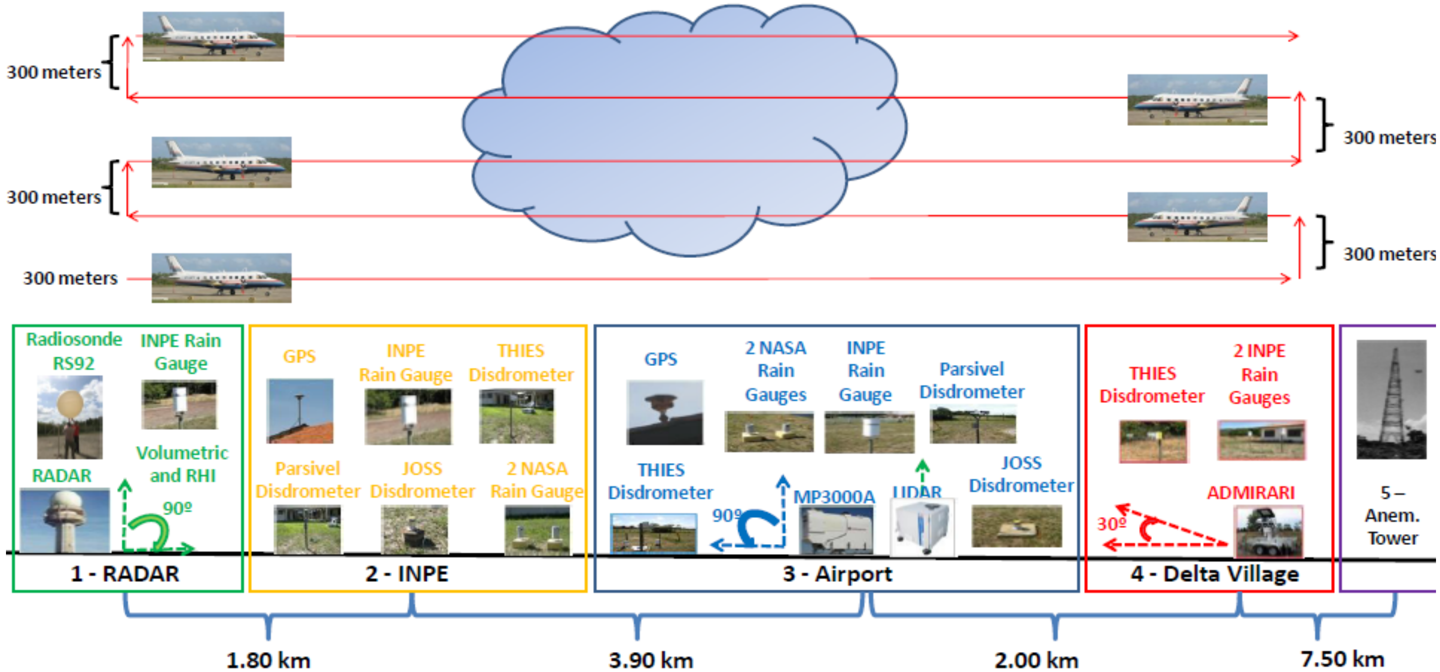


- Pre-CHUVA: GPM-Brazil & NASA field campaign targeting warm rain retrieval over land, Alcântara Launching Center, 3-24 March 2010.
- Light Precipitation Validation Experiment (LPVEx): CloudSat-GPM light rain in shallow melting layer situations, Helsinki Testbed & Gulf of Finland, Sept-Oct 2010.
- Mid-Latitude Continental Convective Clouds Experiment (MC3E): NASA-DOE field campaign at DOE-ASR Central Facility in Oklahoma, Apr-May 2011
- High-Latitude Cold-Season Snowfall Campaign: GPM-Environment Canada campaign on snowfall retrieval, Ontario, Canada, Jan-Feb 2012

Pre-CHUVA Field Campaign (March 3-24, 2010)

Target: Warm rain retrievals over land, discerning cloud vs. rainwater

Measurement Scheme for the Main line



Courtesy of C. Angelis

Coordinated high-resolution sampling using:

- X-band dual-polarimetric radar
- Rain gauge, Parsivel, Thiess and Joss disdrometer network
- ADMIRARI 10-37 GHz radiometer and MRR
- FUNCEME Microphysics aircraft (FSSP, OAP X/Y)
- Soundings

Status: Post field campaign data quality control

LPVEx Field Campaign (Sept. 15 – Oct. 24, 2010)

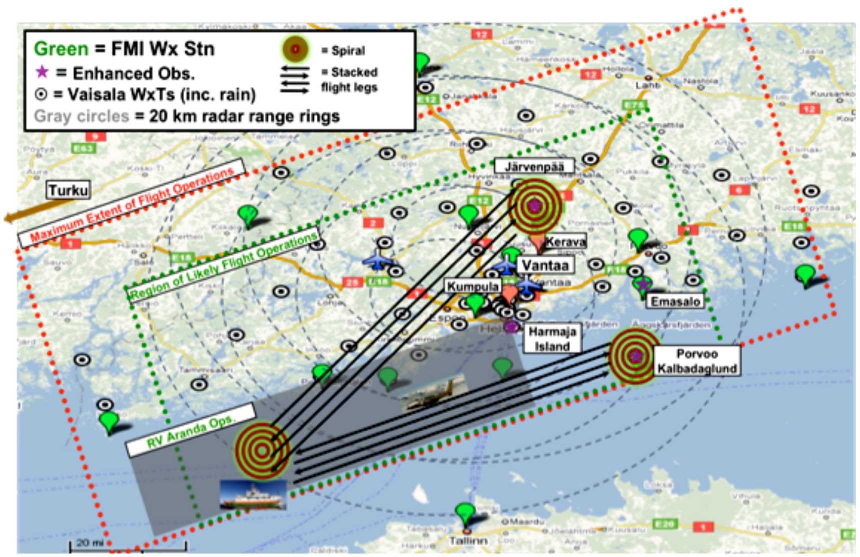
Target: Light rain in cold low altitude melting layer environment

GV Science:

a) Quantify column DSD/precip variability over inland, coastal, sea regimes
b) Melting layer physics coupled to water below and ice above
c) Reconstructed Ka-Ku band (DPR) data for DFR algorithm testing
d) Observationally-validated model databases for radiometer algorithms

Approach:

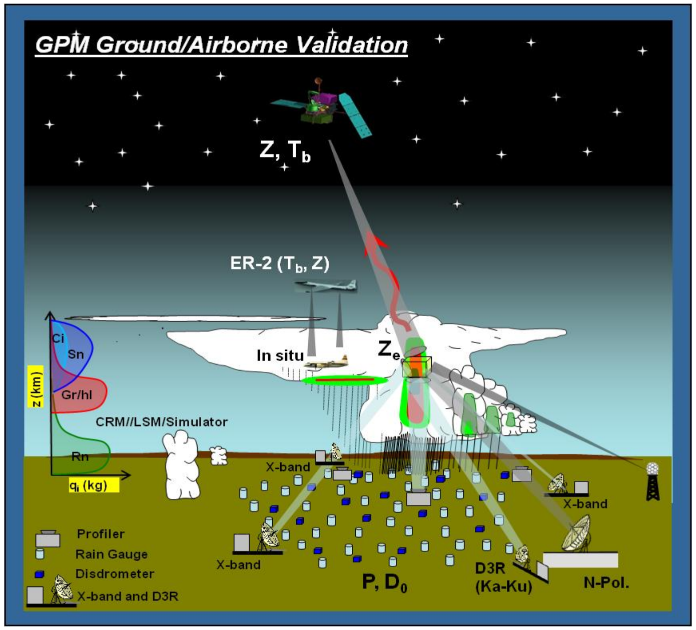
- Heavily instrument surface sites + 1 Ship under radar/aircraft/satellite coverage at Järvenpää (*inland*), Harmaja (*Island*), Emasalo (*coast*), and R/V Aranda (*sea*)
- 3 Dual-pol radars, 6-8 disdrometers/4-MRRs/ADMIRARI radiometer/3 POSS U. Wyoming King Air Airborne microphysics + W-band radar



Helsinki-Testbed & Gulf of Finland

MC3E Field Campaign (April 15 – May 31, 2011)

Target: Mid-latitude convective and stratiform rainfall over land



Location: DOE-ASR Central Facility, Oklahoma

GV Science Priorities

1. **Coordinated Airborne [high altitude/in situ]**
   a. High altitude Ka/Ku-band radar, multi-freq. radiometer with in-situ ice microphysics
   b. Pre/post storm surface properties
2. **3-D Mapping of *hydrometeor distribution/type***
   a. Unified framework for retrieving 3-D DSD
   b. Sub pixel scale DSD variability
   c. Cross validation/comparison of multi-frequency (Ka-Ku) and dual-pol. retrievals
3. **Satellite *simulator models (CRM/LSM/RT)***
   a. High quality sounding-based forcing data
   b. Microphysical and kinematic validation.
   c. Land surface impacts

Confirmed Instruments:

- Aircraft: ER-2, UND Citation (microphysics)
- Radars: NPOL, D3R, DOE X-band(s), C-band, Ka/W, S/UHF profiler
- Surface: Dense disdrometer/gauge net. ASR surface met, radiometer, flux and, aerosol instruments
- Soundings: ASR array 6 – 8 launches/day

Status: Pre-field deployment sampling and logistics planning

NASA-EC Snowfall Campaign (Jan.-Feb. 2012)

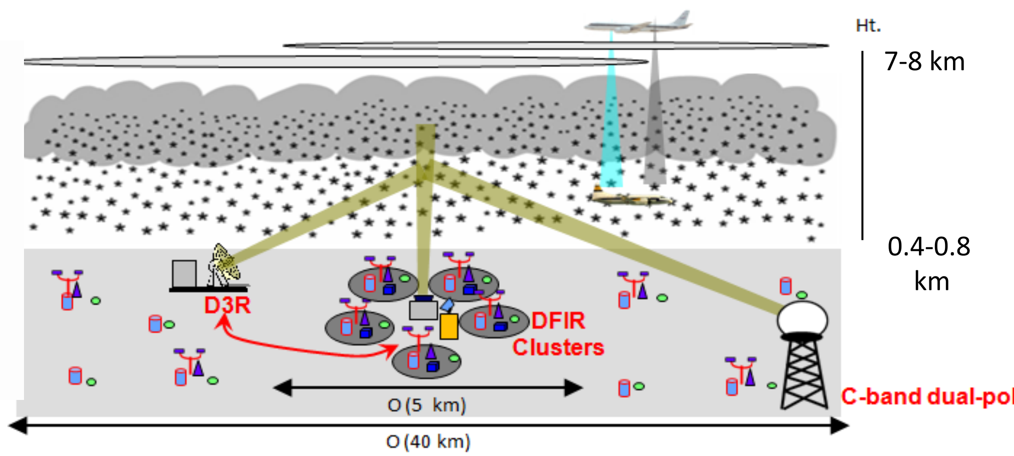
Target: Snowfall retrieval algorithms

GV Science

1. Radiometer/DPR Snowfall measurement sensitivities to snow type, rate, surface and tropospheric characteristics
2. Physics of snowfall in the column and relation to extinction characteristics
3. Model databases for forward modeling and retrieval development.

Approach

- Network observations of SWE and PSD
- In-situ and high-altitude airborne sampling
- Ground-based radar/profiling components
- Soundings for column T and Water Vapor



Status: Planning phase

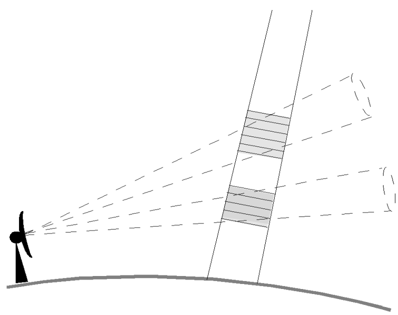
Site chosen: Environment Canada CARE site in Ontario, Canada

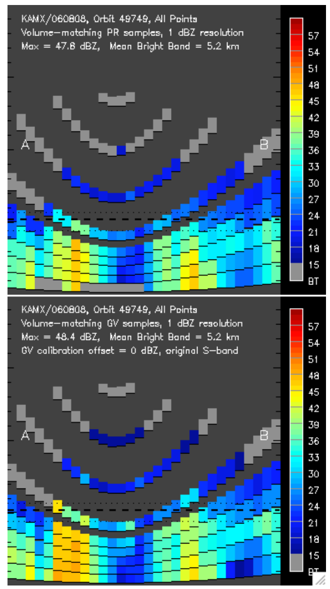
Instruments planned: DC-8 (Ka-Ku band radar, CoSMIR radiometer), microphysics aircraft (TBD), D3R Ka-Ku radar, C-band dual-pol radar, numerous snow-gauge/ disdrometer clusters, profiling radars at S/UHF, X, K, and W-bands.

Direct Statistical Validation

Identify systematic regional or regime issues

Geometrically matches ground and spaceborne radar volumes (TRMM PR used as pre-launch proxy for GPM DPR)





Horizontal/vertical cross-section comparisons

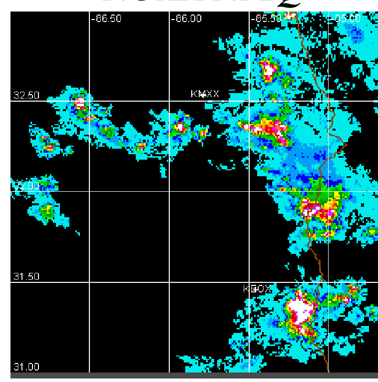
Volume statistics on radar reflectivity

- **Surface rain-rate comparison**
  - Compare satellite rain products with NOAA National Mosaic & QPE (NMQ) data at 0.01° resolution updated every 5 min.
  - Integrate satellite rainfall data into NMQ

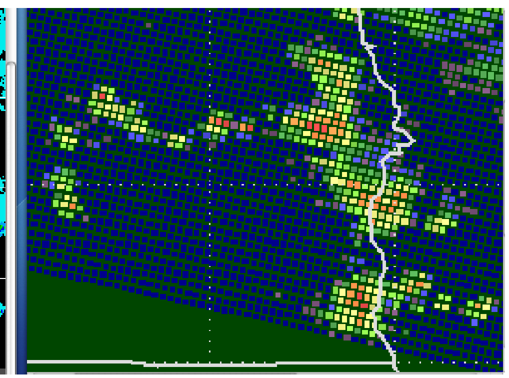
- **Radar reflectivity comparison**
  - Systematic regime variability in reflectivity between space and ground radars can be detected with existing operational networks
  - Stable PR supports ground radar calibration
  - Scalable and Platform-Adaptive Matching Software available as open source

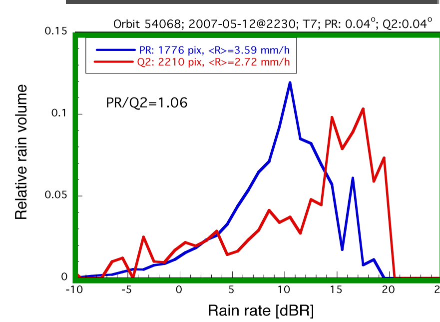
(In use in Korea, Taiwan, Australia, & Europe)

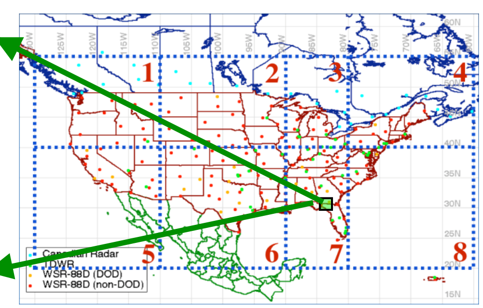
NOAA NMQ



TRMM PR

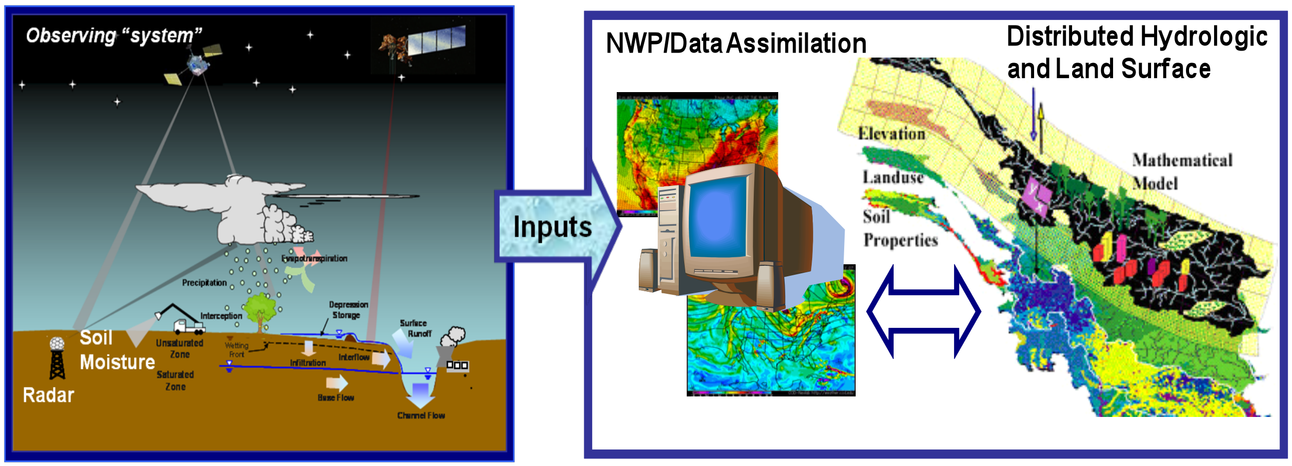






Integrated Hydrological Validation/Applications

Identify space-time scales at which satellite precipitation data are 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

Joint field campaign with NOAA HMT-SE under planning for 2013

International Collaboration Key to GV Success

(Pre-launch algorithm development and post-launch product evaluation)

Active Collaborations

- Argentina (U. Buenos Aires)
- Australia (BOM)
- Brazil (INPE)
- Canada (EC)
- Ethiopia (AAU)
- Finland (FMI)
- France (CNRS)
- Germany (U. Bonn)
- Israel (Hebrew U. Jerusalem)
- Italy (CNR-ISAC)
- Italy (Sapienza U. Rome)
- South Korea (KMA)
- Spain (UCLM)
- United Kingdom (U. Birmingham)

Projects under Development

- Germany (MPI)
- Spain (Barcelona)
- India (ISRO)
- Taiwan

4th International Workshop for GPM Ground Validation hosted by the Finish Meteorological Institute, 21-23 June 2010, Helsinki, Finland

Summary

- GPM is an international satellite mission specifically designed to unify and advance precipitation measurements from a constellation of microwave sensors for scientific research and societal applications.

- Next-generation constellation-based global precipitation products will build on intercalibrated microwave radiances and unified retrievals using a common cloud database constrained by radar/radiometer measurements provided by the GPM Core Observatory

- GPM is more than a partnership sharing space assets – it offers a programmatic framework for international science collaboration on radiometer intercalibration, precipitation retrieval, ground validation, and data utilization.

- Ground validation is central to algorithm physics improvement in the pre-launch phase and mission product evaluation after launch. International collaboration is key to GV success. NASA is conducting a series of targeted field campaigns jointly with domestic and international partners.