MSFC-2044

GPM GV Science Implementation Plan

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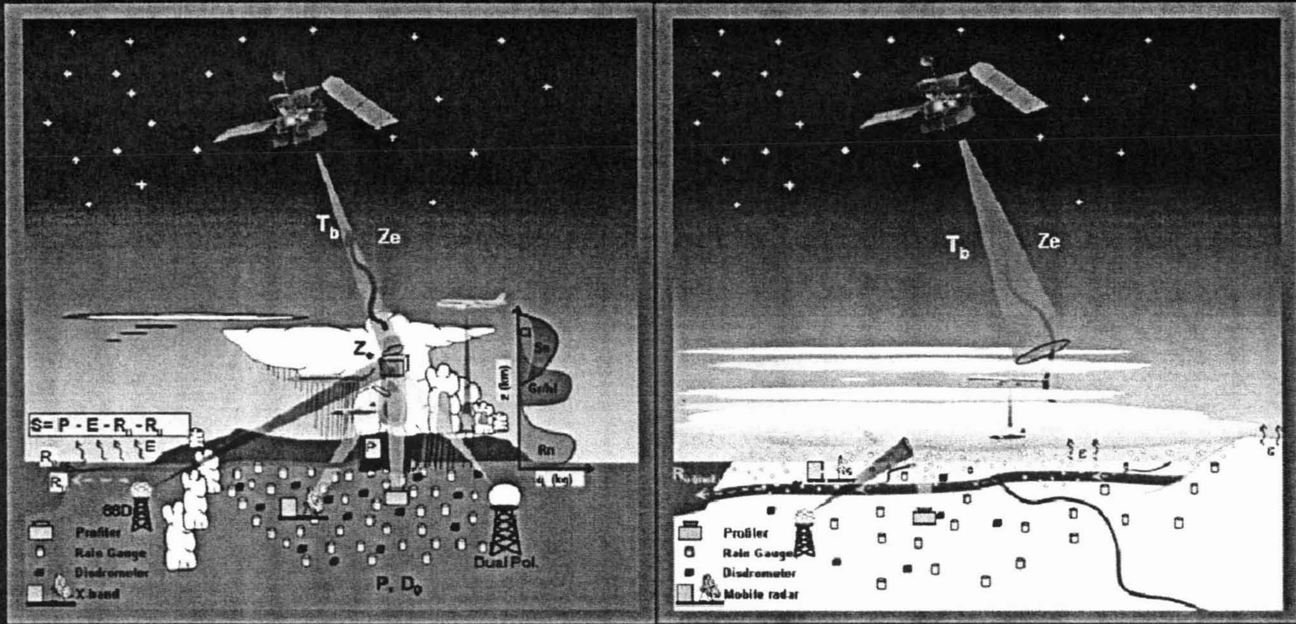
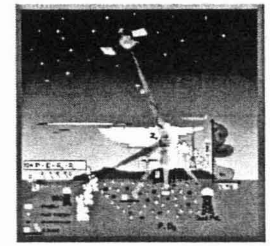


- Overview: Concept and Approaches
- Implementation
  - Direct Validation
  - Physical Validation
  - Integrated Validation
  - International Collaboration

Overview: Concept and Approaches

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 retrieval algorithms, & model applications



Three approaches to GPM GV:

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

  - Leveraging off operational networks to identify and resolve significant first order discrepancies (e.g., bias) between satellite and ground-based precipitation estimates

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

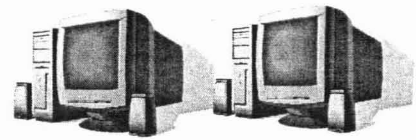
  - Cloud system and microphysical studies geared toward testing and refinement of physically-based retrieval algorithms

- **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

GV Approaches and Supporting Tools

Measurement + **Algorithms**



DPR GMI

Products

Applications / Integrated GV

- Water Budget
- NWP, LSM
- Surface Hydrology

Direct/Physical GV

- **Product Evaluation**
- **Feedback**
- **Algorithm: Development/Refinement**

Retrieval Algorithm Validation and Development Supporting Tools

Rain Gauge Array:
- Rain rate stats
- GV Radar Val.

Disdrometer Array
- DSD variability
- Rain rate stats
- GV Radar Cal/Val.
  - Z, D_0

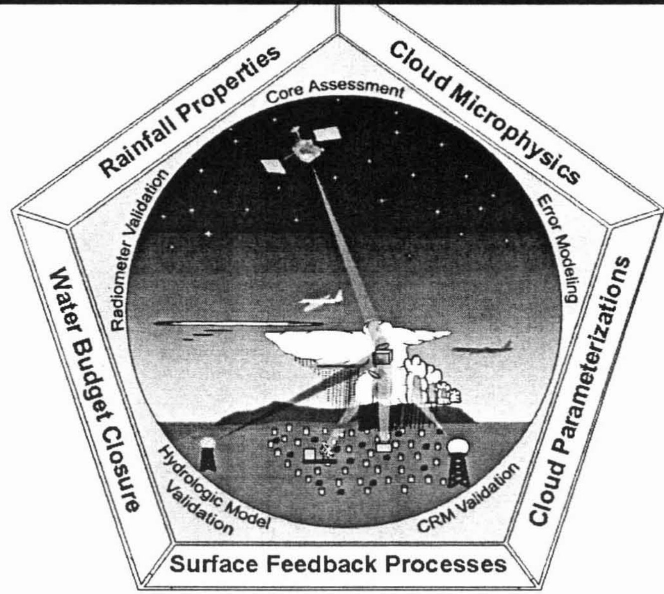
Dual-Pol Radar, Wind Profiler
- Z, Rainfall mapping
- DSD Profile, Particle types
- CRM/LSM Physics/Profiles
- PIA
- Ice physics

Aircraft
- Ice physics
- Cloud water
- CRM/LSM Physics/Profiles
- GPM simulator
  - PIA, TBs

Overview: Cross-cutting themes

GPM GV

3 approaches support
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

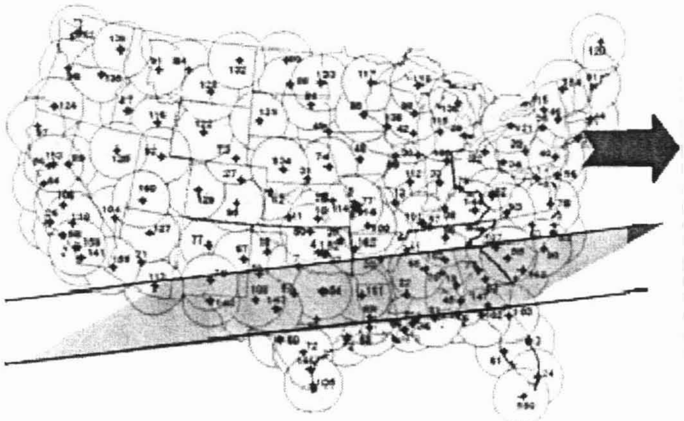
Direct Validation: Validation Network (VN) Architecture

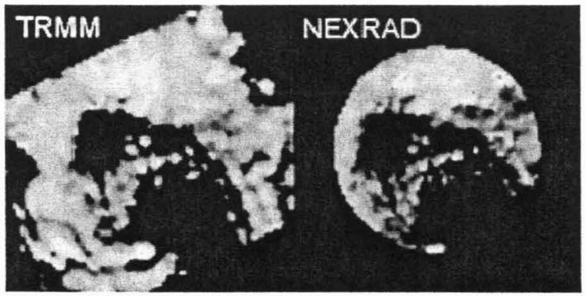
Identify systematic regional or regime issues using a two-tiered approach

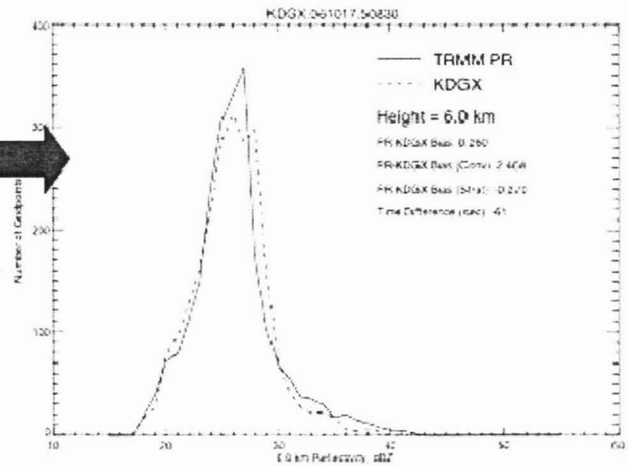
Tier 1): DPR Reflectivity- Ground Radar Validation Network (VN)

Reflectivity measurements/profiles of core satellite are *fundamental* to the entire GPM constellation (i.e. serving as “calibrator”)

- Systematic regime variability in Z_{GPM}-Z_{Ground} can be detected with existing operational radars
- Two-way street, stable calibration of DPR can support a priori knowledge of ground cal.
- Future dual-pol radar upgrades (U.S. and elsewhere) will facilitate broad area DSD statistics (D0) to be added- subsequently permits broad scale linking of DSD variability to Z.



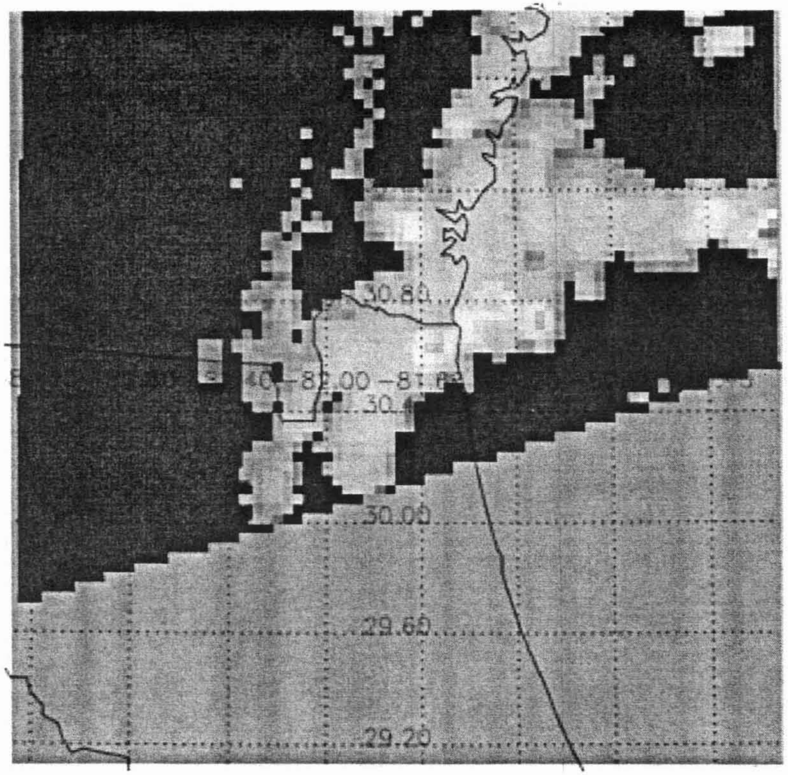




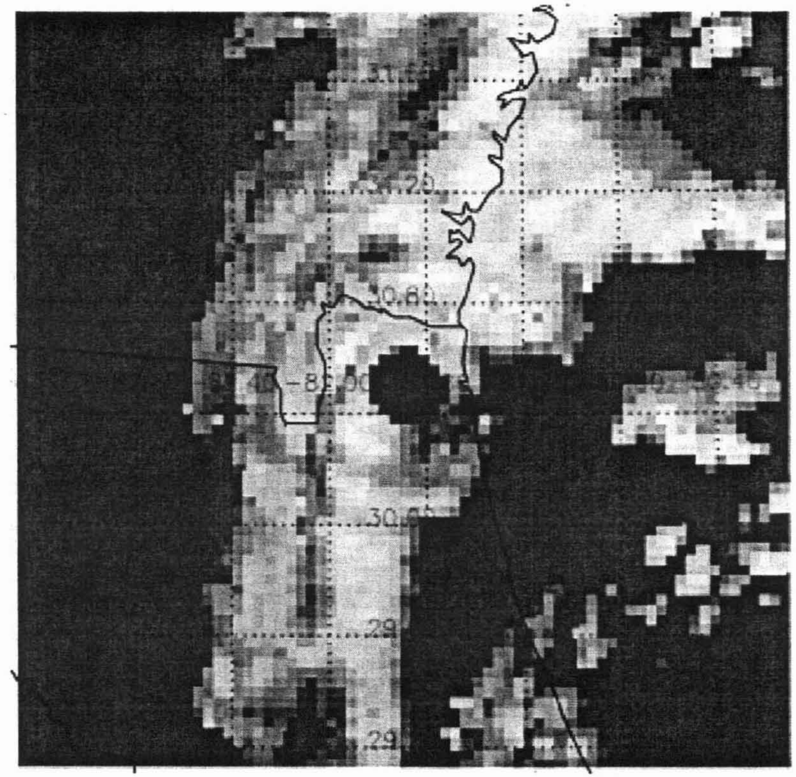
Direct Validation: VN Reflectivity Comparison Methodology

Jacksonville, FL - 31 August 2007 - 6 km AGL

PR Attenuation-Corrected Reflectivity



KJAX WSR-88D Reflectivity



Create TRMM PR and Ground Radar Collocated Linked-Database

GV radar located at central grid point

4 km horizontal resolution, 75 x 75 elements, 300 x 300 km area

13 vertical slices from 1.5 km - 19.5 km, 1.5 km vertical resolution

period of record: August 8, 2006 to present

Expanded Number of Global Contributing Sites

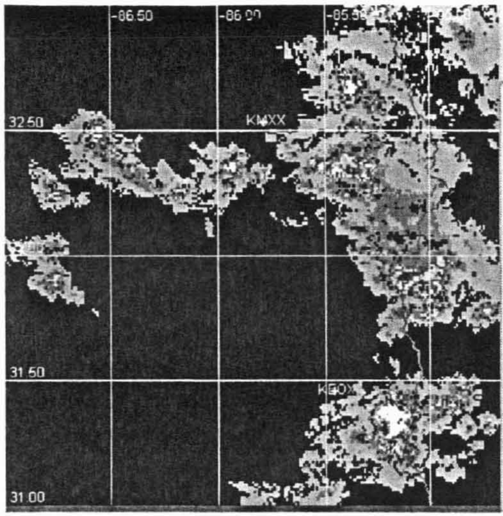
- **21 WSR-88D sites in the southeast US**
  - **Raw data acquired from the NOAA Level-2 archive**
  - **Automated quality control (TRMM 2A-55 GV algorithms)**
- ARMOR
  - **Data provided by NSSTC/University of Alabama/Huntsville**
  - Dual polarimetric C-band radar, 1-degree beamwidth
  - **Automated quality control using polarimetric methods**
- **Gosan (Korea)**
  - **Data provided by Korea Meteorological Administration (KMA) National Institute of Meteorological Research (METRI)**
  - Network of 18 S- and C-band radars
  - **Automated quality control**
  - **Option to add additional sites**
- **Darwin (Australia)**
  - C-band, dual polarization radar
- **Discussions underway**
  - Brazil: **...9 S-band radars in Sao Paulo state**
  - Taiwan: **operational C-band radars**
  - Kwajalein: **historical and on-going QC'd dataset form TRMM GV**

National Network: Direct Validation of Rain Rates

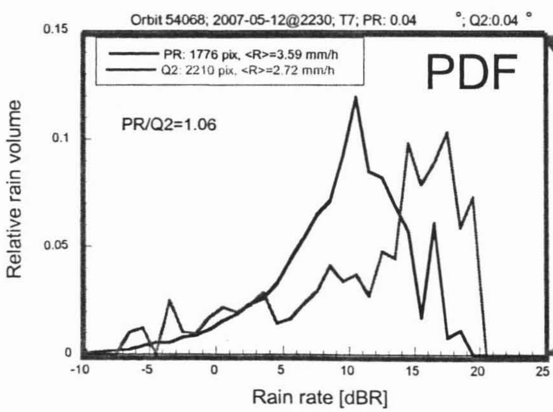
Tier 2): DPR/GMI Rain rates: NOAA Q2 Gridded Product (U.S. NEXRAD Network)

May 12, 2007 @ 22:30 UT

NOAA



TRMM



- NOAA Q2 National gridded merged radar-gauge product
- Evaluate GPM Constellation rain rate PDFs against Q2.
- Incorporation of other assets as appropriate (gauge networks, snowfall, Kwajalein GV etc.) into VN architecture

Courtesy: E. Amitai et al., (George Mason University)

Physical Process Validation: Algorithm Issues

Dual Frequency Precipitation Radar

Detection:

Light rain, snow

Rain type (convective/stratiform)

Attenuation:

PIA Algorithm: Errors/Accuracy

Assessing and/or accounting for impacts of CLW, water vapor, DSD and assumed DSD models

Algorithm Physics:

DSD retrieval:

DFR algorithm and DSD model for 3-D retrieval of rain and snow as f(regimes, temporal / spatial variability, precipitation rate)

Z-R at light rain rates

Sub-pixel variability

Impact of external a priori regime ID

Melting level ID, variability, extinction

Hydrometeor ID and profile

Passive Microwave Radiometer

Detection:

Snowfall detection thresholds and surface/atmospheric emission characteristics

Rain no rain (especially light rain)

Rain type (convective/stratiform)

Algorithm Physics:

Single/bulk ice scattering vs. precipitation rates, types

Melting layer extinction

Water vapor, cloud water, and mixed phase impacts/models

Impacts of a priori "regime" ID

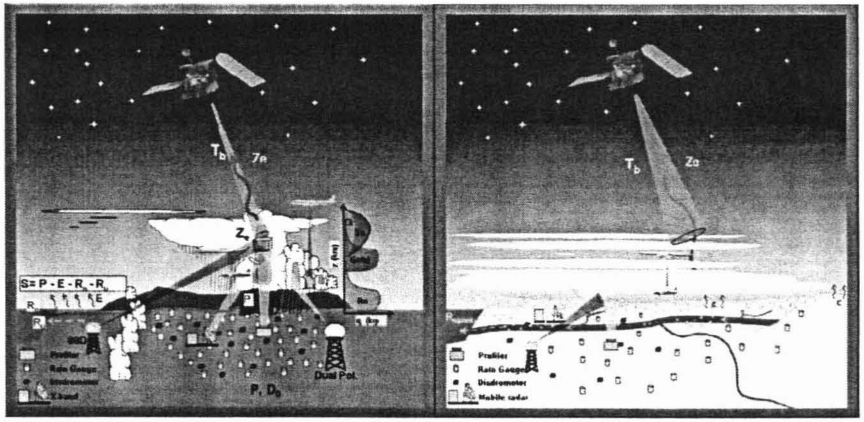
Models:

"Synthetic nature" of Cloud profile databases; empirical vs. numerical

Coupled CRM/LSM physical inputs and associated parameterizations

Implementation of Physical Process Validation: Field Campaigns

- **Designed for:**
  - Pre-launch physical algorithm development, post-launch product validation
  - Study of 3-D precipitation process/physics as a function of regime (**land emphasis**)
  - Improved coupling of CRM/RTMs for algorithm data bases and testing
- **Algorithm developers explicitly involved in planning, execution and analysis**
- **Success: Affect a measurable positive change in an algorithm; validate a process parameterized in an algorithm**
- **Intensive Observations and Extended Observations Programs (IOP, EOP)**
  - 5 Field Campaigns
  - Extended data collections to supplement existing operational infrastructure
  - Kwajalein Atoll: PMM-funded (current)
  - "Target of opportunity" IOP/EOP participation when justified and budget permits.



- ***Completed Winter 2006-2007***
  - Canadian CloudSat Calipso Validation Project (C3VP): Canada/U.S. CloudSat/GPM; Initiate priority pre-launch snowfall measurements. Analysis ongoing (WG Talk today)

Field Campaign Implementation Planning

Objective	Date	Partnership/Location
MC3E: GMI/DPR rainfall retrievals over land surfaces	Spring/early summer 2011	Mid-Latitude Continental Convective Clouds Experiment (MC3E)- DOE ARM SGP S. Central Oklahoma
Cold-season retrieval of frozen and mixed precipitation over land surfaces	Winter 2011/2012	TBD
Physical/Integrated	2013	NOAA Hydrometeorological Testbed, Tar/Neuse River Basin, N. Carolina
Cold season product validation	2015	TBD
Physical/Integrated	2016	TBD

- **Other Targets of Opportunity/Collaboration for PMM (international)**
  - Finland (Fall 2009): Baltic Sea region, **mixed phase/low bright band precipitation** CloudSat collaboration [Aircraft + Helsinki Testbed]
  - Canada (winter 2009/10): British Columbia, Winter Olympics, **snowfall in terrain**
  - Brazil (Late 2010): Amazon/NE Brazil, warm-clouds, ice

Physical Process Studies: Near Term Continental Field Campaign

Mid-Latitude Continental Clouds and Convection Experiment (MC3E)

Target Location/Date: S. Central Oklahoma, April-June 2011 (TRMM Coverage)

Targeted regimes: Land, late spring transition (baroclinic, MCS, convection)

- **GPM GV Interests and Algorithm Needs Addressed:**
  - Process physics for GMI retrieval algorithms over land (mid-lats)
  - DPR retrieval algorithms (PIA, rain rate, DSD spatial/temporal covariance)
  - Robust CRM/LSM for algorithm testing and product development
  - Evaluation of GV instrumentation and validation methodology

Planned Instrument Combination (DOE and NASA Contributed):

- Aircraft: High altitude (ER-2 w/radiometer and radar); In-situ AC for microphysics
- Radars: NASA N-POL, NASA Ka-Ku dual-pol, CASA IP-1 X-band network, ARM Ka/W-band, ARM 915 MHz wind profilers
- Surface: D-scale disdrometer and rain gauge network; soil moisture sensors, flux tower, multi-station
- Soundings: DOE SGP array 6 – 8 launches/day
- Existing: ARS Little Washita micronet, OK Mesonet, NSSL/NOAA

Physical Process Studies: Infrastructure Development

Calibrated measurement continuity across full spectrum of precip. rates/types

Ka-Ku Scanning Transportable Dual-Polarimetric Radar

- Match DPR frequencies, more direct link to PIA and dual-wavelength methods
- Extension to clouds, light precipitation, and improved sampling of ice, snow, mixed phase
- Mobility enables placement in any variety of network configurations/regimes with relative ease

NASA PMM N-POL S-band Scanning Dual-Polarimetric Radar

- Transportable platform for study of heavy/moderate precipitation regimes
- Dual-pol retrieval of 3-D DSD information and qualitative ice microphysics information

Disdrometer/Gauge D-Scale Array

- Validation/extension of GV ground radar DSD retrievals/precipitation rates (liquid/frozen)
- Spatial/temporal covariance of particle size distributions and precipitation rates

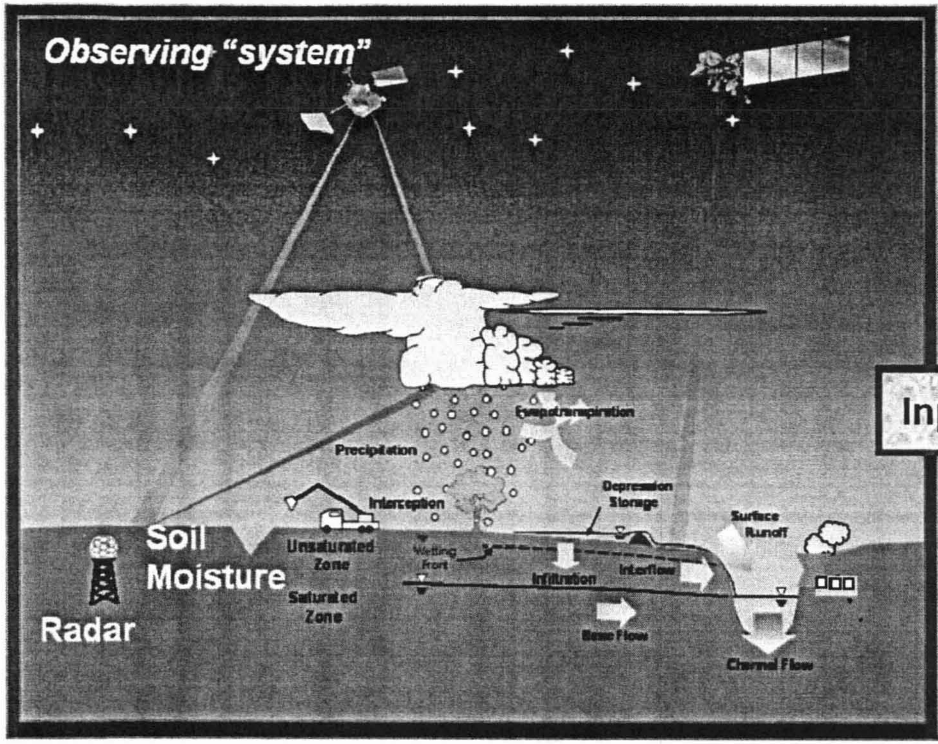
Wind Profiler

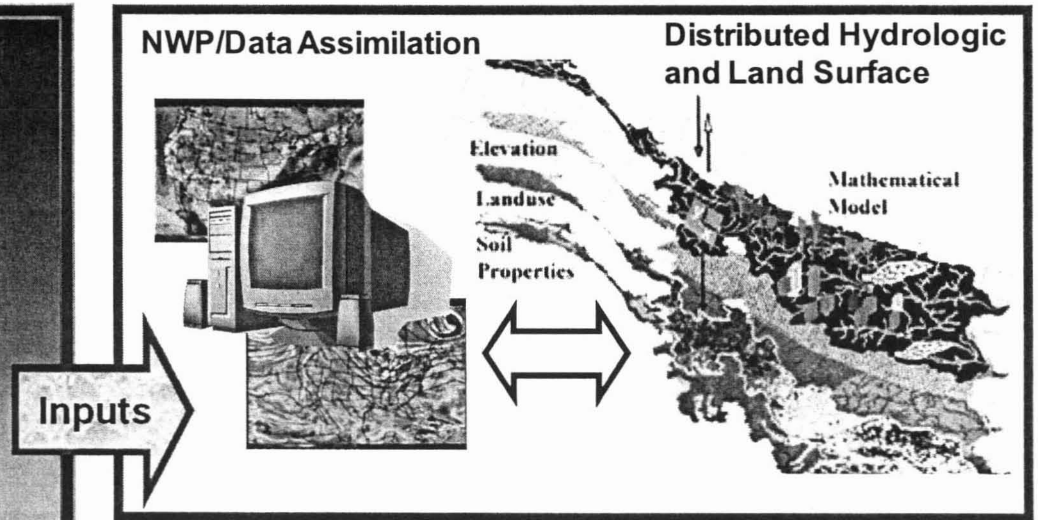
- Vertical profiles of Z, DSD under coverage umbrella of radar

***Support for other platforms (e.g., aircraft) in coordination with other ground/airborne based measurements as needed and funds permit**

Integrated Validation: Collaboration- NOAA Hydrometeorology Testbed (HMT)

End-to-end utility of retrieval algorithms: Pre-launch algorithm physics linked to hydrologic/water budget application, and hydrologic GV methods

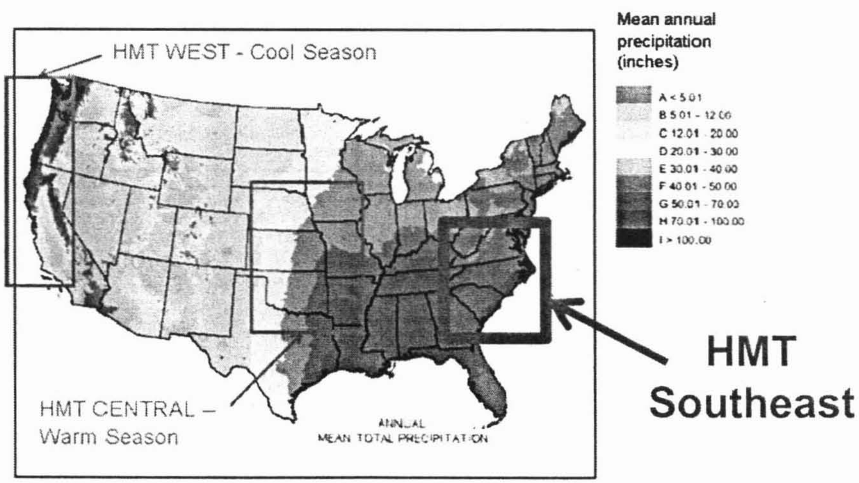




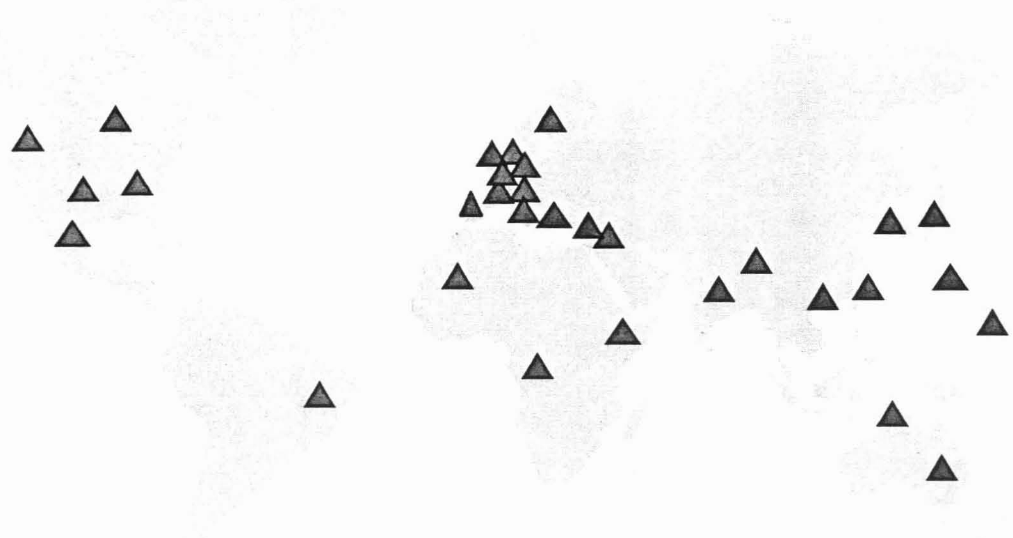
HMT Southeast: "mountain to coast"

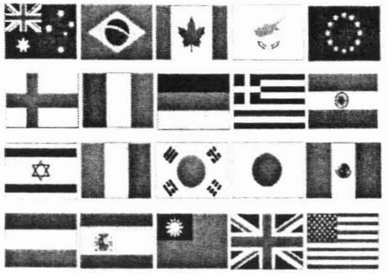
Summer flooding, Hurricane Landfall, Winter mixed events……..

Extensive QPE and hydrologic instrumentation, hydrologic modeling



International partnership: A Key to GPM GV success





Potential GPM GV Sites and Partners

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

3rd International GPM GV Workshop held March 2008 in Buzios, Brazil

- ***Numerous international investigators invited to submit (and are in the process of submitting) no-cost proposals to PMM to establish joint GV projects complement existing activities***
- ***19 Countries, 24 different activities targeting aspects of 3 core approaches***
- ***Scientific collaboration, data sharing, and leveraged resources in joint projects as members of the PMM Science Team***

Summary

- First Draft of U.S. GV Science Implementation finished (GPM GV Website)
  - Stresses involvement of algorithm teams in planning
  - Dynamic plan- responsive to inputs and adaptation as needed
- Approach 1: Direct Validation (Reflectivity, Rainrate)
  - VN Architecture being steadily enhanced/expanded
  - U.S. and international radar datasets being incorporated
  - Expand to accommodate widespread rain rate validation for radiometers
  - V7 vs. V6 comparisons facilitated
- Approach 2: Physical Process (Land Focus)
  - Core infrastructure development underway: Ka-Ku, N-POL, Disdrometers
  - Field campaigns: 5 Planned GPM/PMM
    - Near term (MC3E, Cold Season [Finland, TBD])
    - Following: 2 Physical/Integrated FCs, 1 Cold Season
- Approach 3: Integrated (Hydrologic)
  - NOAA HMT Southeast focus/collaboration underway (2010-2014)
- International activities and collaboration (Required)
  - Gaining momentum rapidly
  - No cost proposal submission and joining to NASA PMM Science Team

Others

Ka/Ku-band Radar for GPM GV

- **DPR frequencies**. Should be able to test with these frequencies on the ground
- **Cover light precipitation (0.2 mm/hr per GPM L2 requirement) and associated rainfall Drop Size Distribution (DSD),** Requires frequency > S, C and X
- **Study snow/ice and the ice process**
- **Sample mixed phase well!** Higher frequencies, polarimetric are better suited to this (Ku-Ka should be promising for snowfall and mixed phase retrievals w/matched beams)
- **Ka-Ku bridge from cloud water to precip.** (potential retrieval with Ku-Ka?)- implications for GMI retrievals and DPR attenuation/DSD retrievals (evolution of DSD)
- **Complex terrain** (high frequency, agile platform attenuation over long distances not an issue)
- **Portability**- sample many regimes in many locations with minimal effort
- **Test dual-wavelength, dual-pol methods with same set of data**
  - Use ϕ_{dp} to estimate PIA
  - Compare DSD, R estimates from both approaches
  - Investigate dual-wavelength retrievals of snow/ mixed phase
- **Test radar/radiometer retrievals**
  - Acquire data in near-zenith mode
  - Test retrievals with & w/o radiometric data
- **Component in nested multi-frequency radar network**
  - Comparisons with X, C, S-band pol data all possible

GPM GV Success Criteria

- Providing ***stable, calibrated surface precipitation measurements*** for independent assessment of satellite-based precipitation estimates.
- Providing ***useful*** "microphysics laboratories" for improving 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 or supplementing ***test beds for improving satellite precipitation data usage*** in hydro-meteorological modeling and prediction.