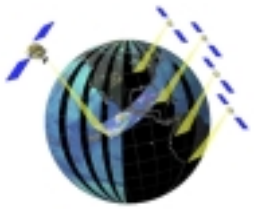


Breakout Group Instructions

General Instructions: meet, deliberate, identify compelling scientific & technical problems which deserve solutions, stay on intellectual high road, get beyond details, write down key points, and engage & enjoy a good debate

Focus Issues (not exhaustive list)

Breakout Grp 1: Engineering & Data System Issues

Dave Everett:	**orbit optimization**
Mike Goodman:	**new data information system techniques**
Toshio Iguchi:	**relevance of DPR to mission**
Steve Neeck:	**required radiometer attributes (Norm Grody -- 157 GHz utility)**

Breakout Grp 2: Retrieval, CalVal, Product Continuity

Ziad Haddad	**role of combined algorithms**
Chris Kummerow:	**GPM algorithm strategy**
Steve Rutledge:	**relevance & value of validation supersites**
Gregory Tripoli:	**future of cloud-radiation models**
Tom Wilheit:	**principles of physical validation**

Breakout Grp 3: Interdisciplinary Sci Requirements

Steve Ackerman:	**bridge to cloud-radiation research -- how?**
Ana Barros	**closing basin scale H2O budgets -- GPM's role?**
Harry Cooper:	**coupling hydromet & carbon assim models**
Vikram Mehta:	**precipitation & ocean research -- key issues?**
Pete Robertson:	**climate trend detection in global precip data?**
Byung-Ju Sohn:	**global precip data & WV transport -- how?**

NASA GPM Level 1 Science/Measurement Requirements

Eric A. Smith (NASA GSFC); James Adams (NASA GSFC);
Ramesh Kakar (NASA HQ); Christian Kummerow (Colo State Univ.)

[[i] Version 0 -- December 1, 2000]

Measurement Factor	Instantaneous			Daily Accumulation			Monthly Accumulation			Outreach & Applications		
	Atmos	Hydro/ Ecol	Ocean	Atmos	Hydro/ Ecol	Ocean	Atmos	Hydro/ Ecol	Ocean	Atmos	Hydro/ Ecol	Ocean
Dynamic Range ($mm\ hr^{-1}$)	[ii, iii] *0.3 to 110*	[iii] *0.3 to 65*	*NA*	—	—	*0 to 30 $mm\ dy^{-1}$*	—	—	—	*NA*	*NA*	*NA*
Sampling Period (hrs)	*NA*	*NA*	*NA*	*≤ 3*	*≤ 3*	*≤ 6*	*≤ 3*	*≤ 3*	*≤ 6*	*NA*	*NA*	*NA*
Spatial Resolution (km)	*≤ 10*	*≤ 10*	*≤ 50*	*≤ 10*	*≤ 10*	*≤ 50*	*≤ 50*	*≤ 50*	*≤ 100*	*NA*	*NA*	*NA*
Vertical Res of Radar (km)	*≤ 0.5*	*NA*	*NA*	*0.5*	*NA-*	*NA-*	*1*	*NA-*	*NA*	*NA*	*NA*	*NA*
[iv] *Meas Accuracy or Bias (%)*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*NA*	*NA*	*NA*
Meas Precision or Random Error (%)	*25*	*50*	*50*	*15*	*20*	*40*	*10*	*15*	*20*	*NA*	*NA*	*NA*
Snow Detection	*yes*	*yes*	*no*	*yes*	*yes*	*no*	*yes*	*yes*	*no*	*NA*	*NA*	*NA*
Snowfall Rate and/or Snow Accumulation	*no ?-*	*no ?-*	*no-*	*no ?*	*yes*	*no*	*yes*	*yes*	*no*	*NA*	*NA*	*NA*
Minimum Latitudinal Extent of Core (deg)	*65*	*65*	*65*	*---*	*---*	*---*	*---*	*---*	*---*	*NA*	*NA*	*NA*
Minimal Latitudinal Extent of Drone (deg)	*90*	*90*	*75*	*---*	*---*	*---*	*---*	*---*	*---*	*NA*	*NA*	*NA*
[v] *Data Latency*	*~3 hrs*	*~3 hrs*	*~1 day*	*~3 hrs*	*~3 hrs*	*~1 day*	*≤ 3 mo*	*≤ 3 mo*	*≤ 3 mo*	*≤ 30 min*	*≤ 30 min*	*NA*

GPM Validation Strategy

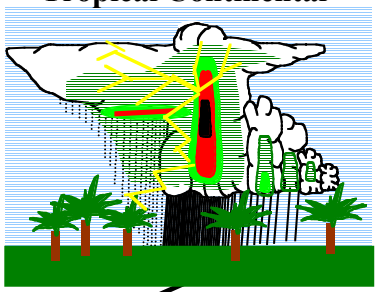
GPM

I. Basic Rainfall Validation
Raingauges/Radars
new/existing gauge networks
new/existing radar networks

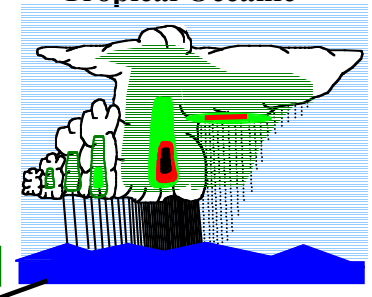
Research Quality Data

Confidence
sanity checks

Tropical Continental



Tropical Oceanic



GPM Satellite Data Streams

Continuous Synthesis
error variances
precip trends

Calibration

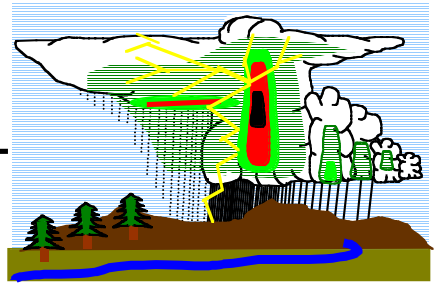
II. GPM Supersites
- Basic Rainfall Validation

hi-lo res guage/disdrometer networks
polarametric Radar system

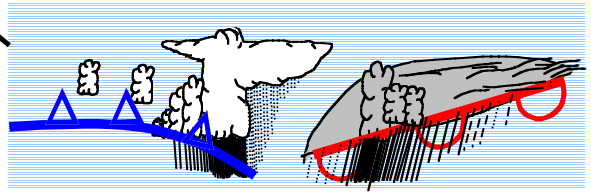
- Accurate Physical Validation

scientists & technicians staff
data acquisition & computer facility
meteorological sensor system
upfacing multifreq radiometer system
D_0/DSD variability/vertical structure
convective/stratiform partitioning

Mid-Lat Continental



Extratropical Baroclinic



High Latitude Snow

Supersite Products

Algorithm Improvements

Research
cloud macrophysics
cloud microphysics
cloud-radiation
modeling

FC Data

III. GPM Field Campaigns
- GPM Supersites

cloud/ precip/radiation/dynamics processes

- GPM Alg Problem/Bias Regions

targeted to specific problems

Supersite Template

Focused Field Campaigns

GPM

GPM Core Satellite
Radar/Radiometer
Prototype Instruments

Piloted

UAVs

Meteorology-Microphysics
Aircraft

150 km

Legend

- Data Acquisition-Analysis Facility
- Polarametric Radar
- Uplooking Radiometer/Radar
- Meteorological Tower
- Site Scientist (3)
- Technician (3)

DELIVERY

- Retrieval Error Synthesis
- Algorithm Improvement Guidance
- Validation Research

5 km

150 km

100-Site Hi-Res Domain
Center-Displaced with Uplooking
Radiometer/Radar System
[10.7,19,22,35,85,157 GHz/14,35,95 GHz]

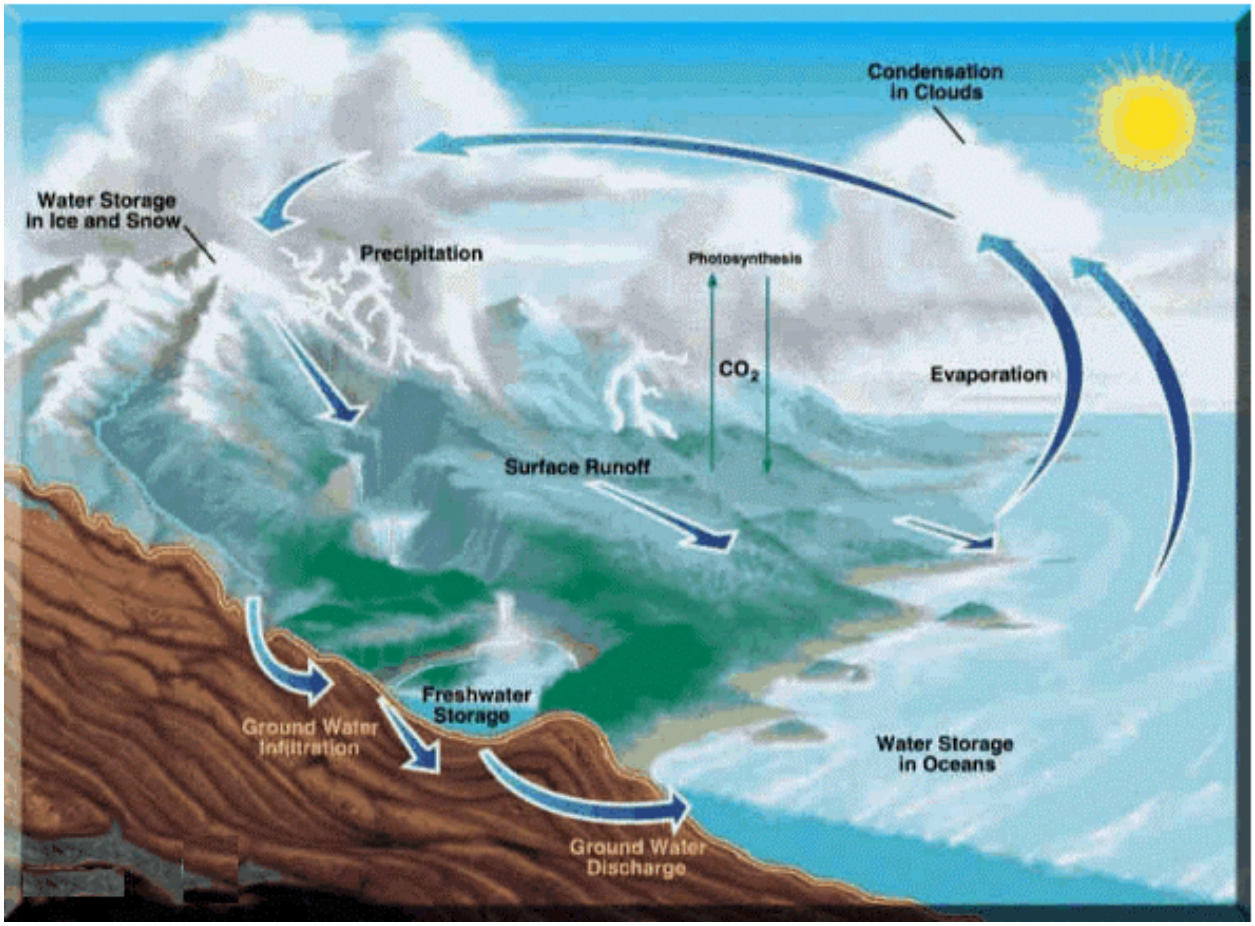
100-Site Lo-Res Domain
Centered on Pol-Radar

Triple Gage Site
(3 economy scientific gages)

Single Disdrometer/
Triple Gage Site
(1 high quality-Large Aperature/
2 economy scientific gages)

GPM

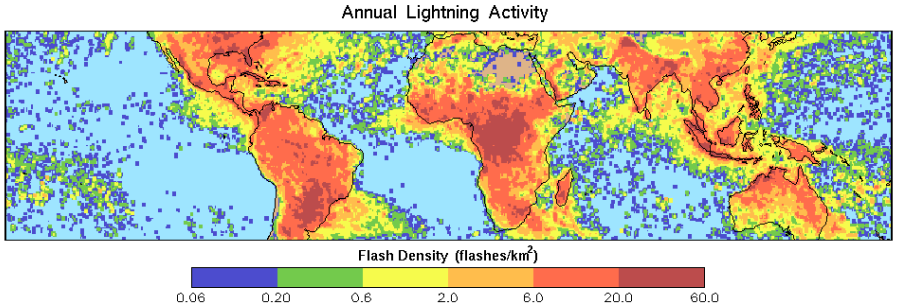
A Global Satellite Precipitation Observing System Would Be Optimized with Additional Global Measurements Central to Understanding & Predicting Global Water Cycle

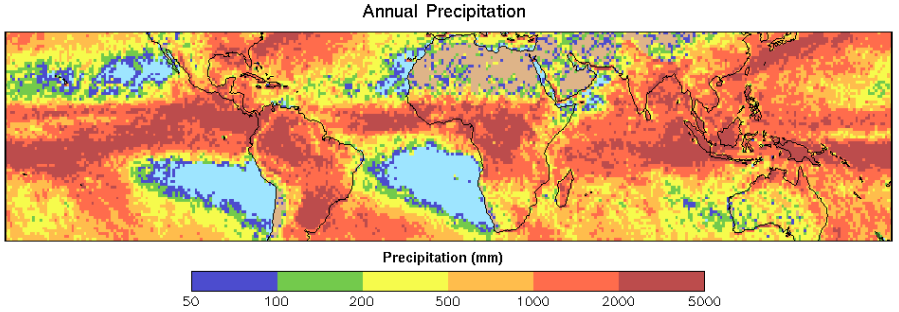


Synergy with Lighting Missions

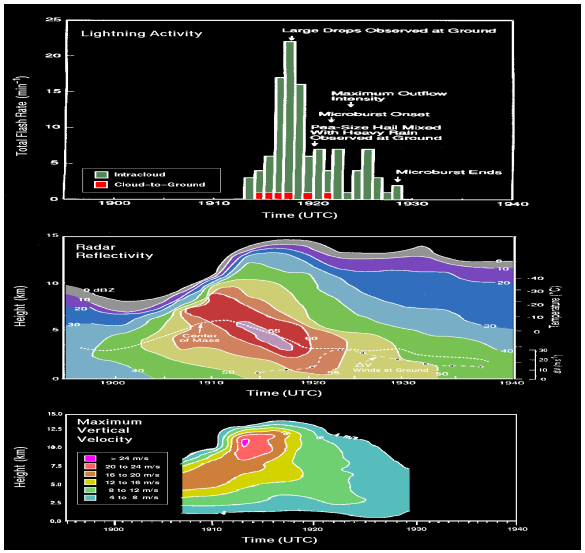
GPM

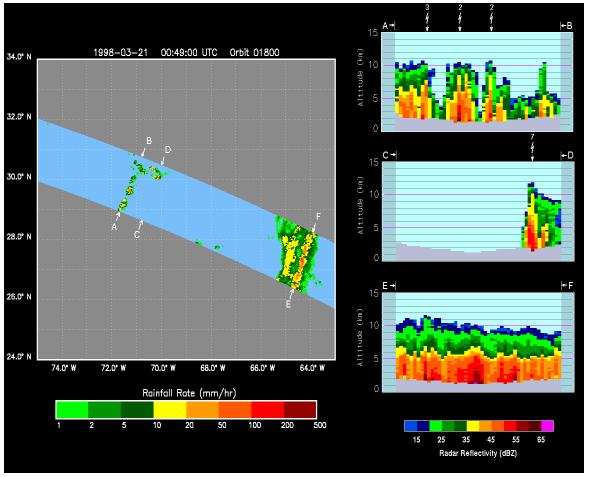
TRMM Lightning & Precipitation Climatologies





Physical Relationships Between Cloud Dynamics, Microphysics, & Electrification



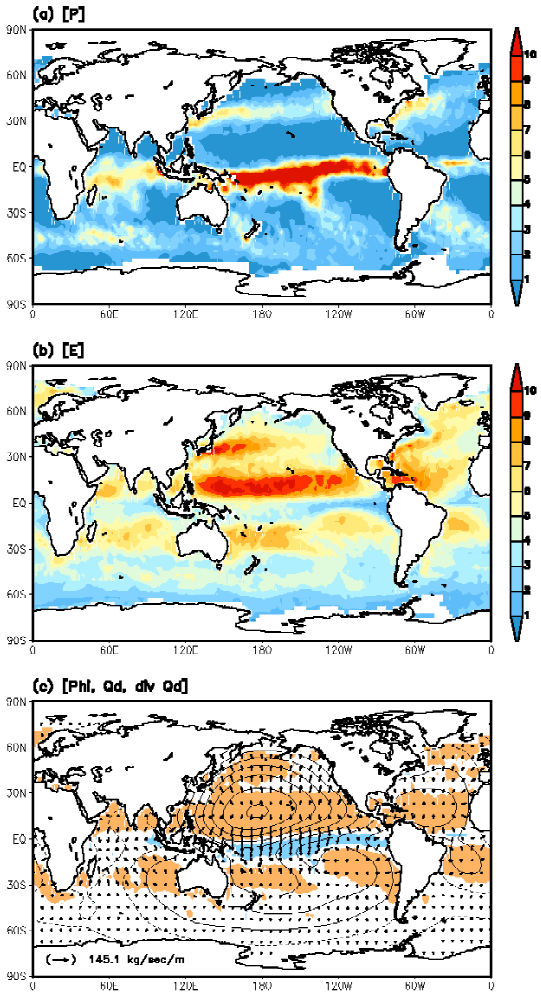


(D. Boccippio, H. Christian, S. Goodman; GHCC)

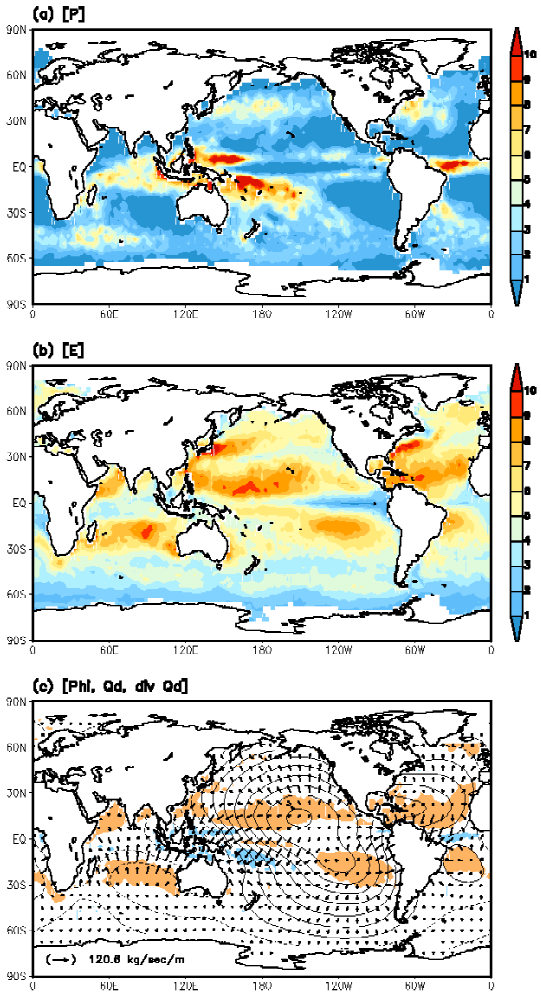
Synergy with WV & Winds Missions

GPM

El Nino Year : JFM 1998 Mean [SAT]



La Nina Year : JFM 1999 Mean [SAT]

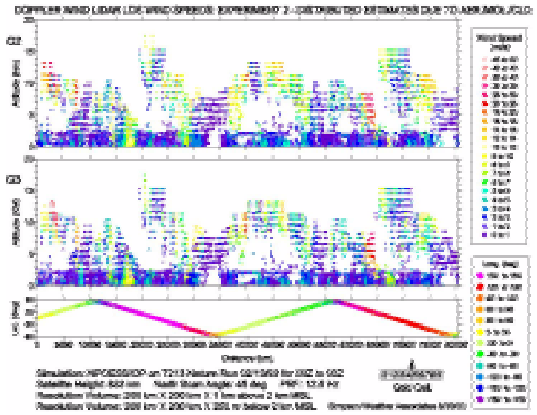


(B.J. Sohn, E.A. Smith; SNU, GSFC)

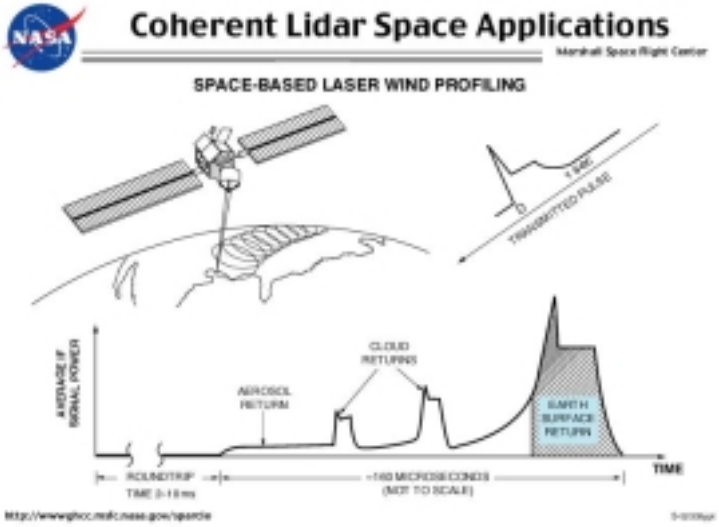
Water Vapor Transport Determined by Global Potential Function of E – P where P is Provided by TRMM

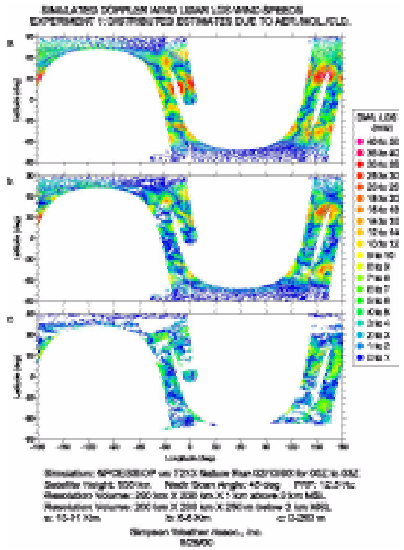
Synergy with Global Wind Lidar Missions

GPM

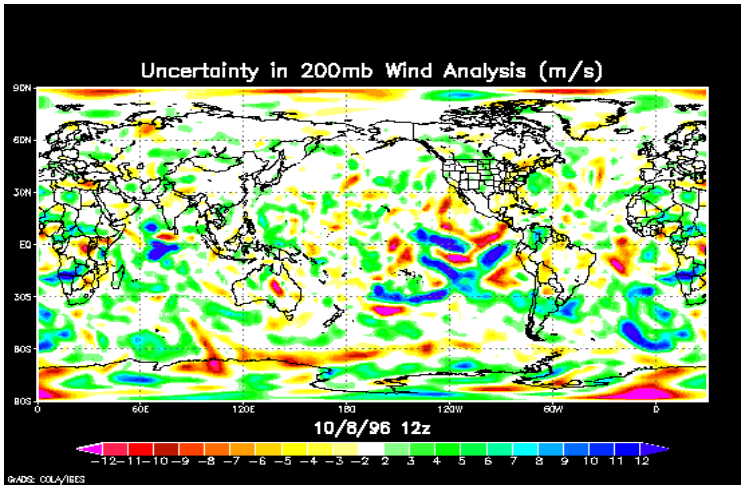


Simulated DWL LOS Winds (D. Emmitt; SWA)





Simulated DWL LOS Winds (D. Emmitt; SWA)



NCEP-ECMWF Wind Speed Differences (R. Atlas; NASA/GSFC)

← **Wind Uncertainties in Global Model Analyses**

↓

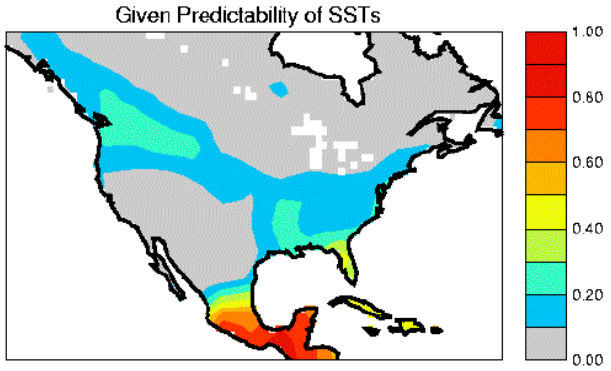
January mean Hadley circulation (left) for 1985-88 calculated as average of GSFC/DAO & NCEP reanalyses. Vertical motion contoured in μbars s^{-1}. Vector differences (right) between two analyses given with percent differences in vertical motion. Uncertainties exceeding 20% are common.

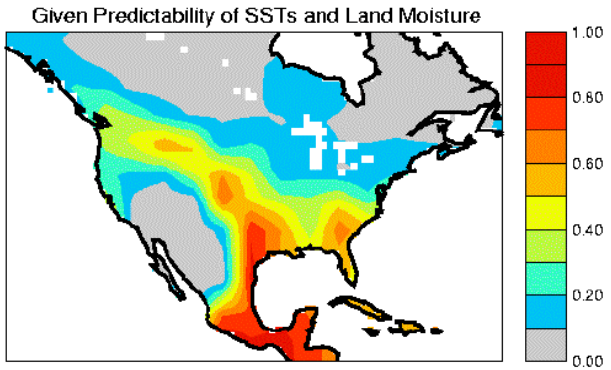
Synergy with Soil Moisture Missions

GPM

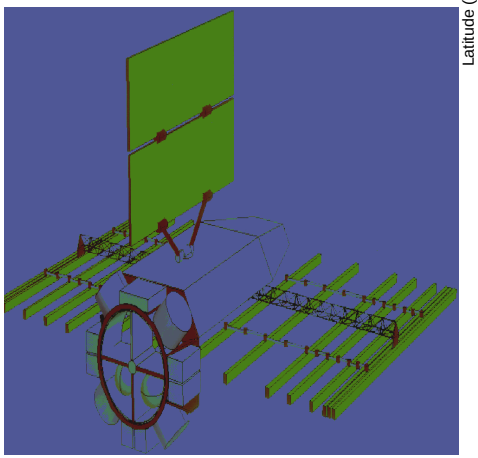
Understanding Impact of Soil Moisture on Flood/Drought Prediction,
Weather Forecasting, & Agriculture is Scientifically Compelling

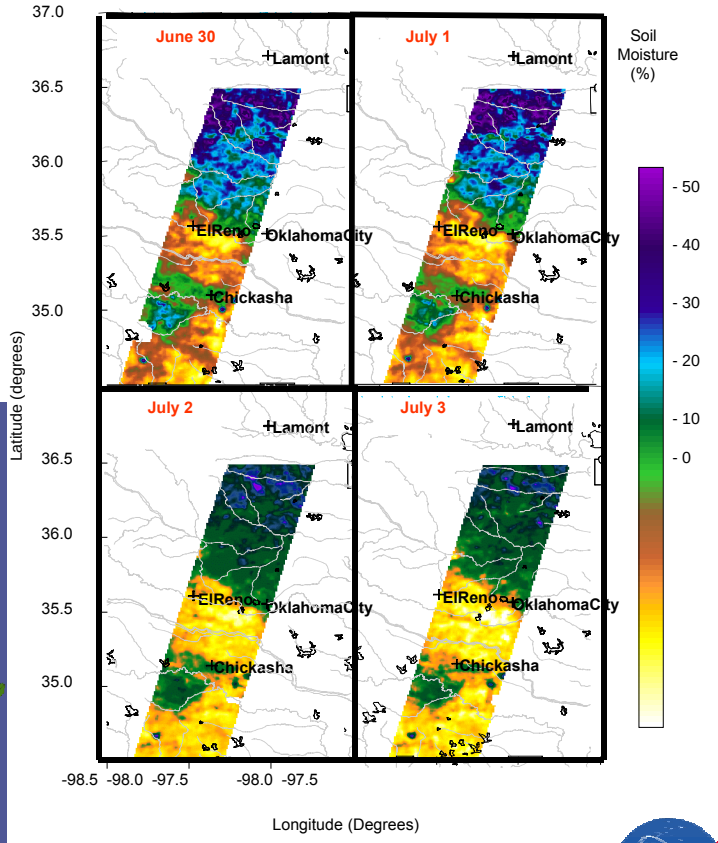
Index of Precipitation Predictability (JJA):





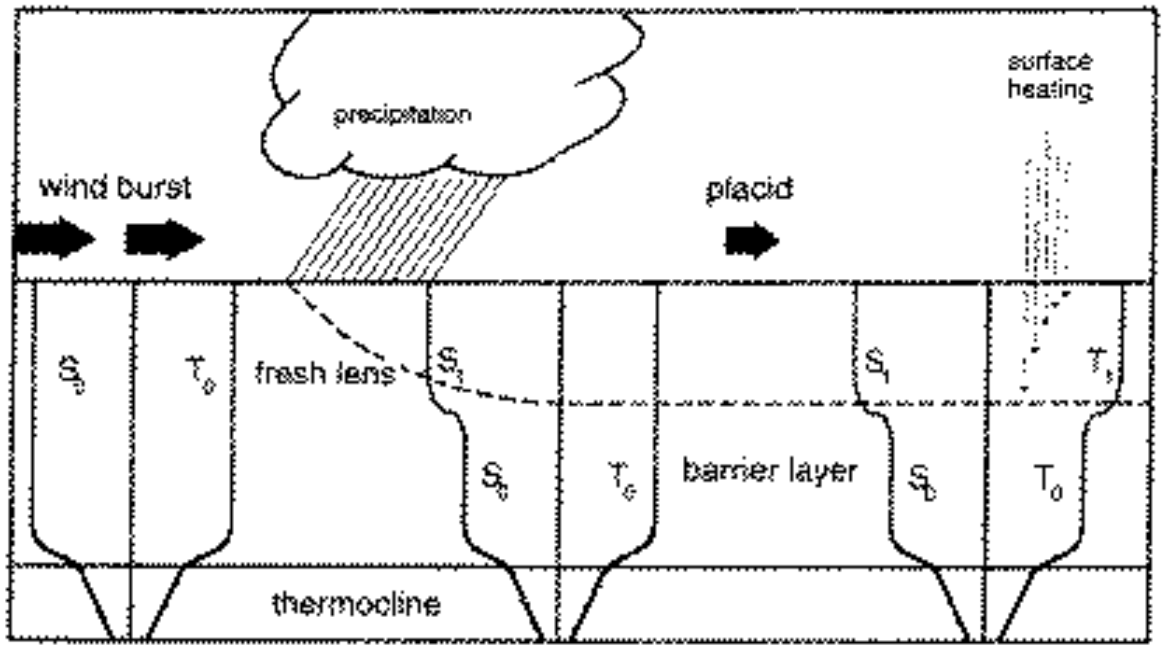
Global soil moisture observation using microwave radiometer





GPM

Synergy with Ocean Salinity Missions



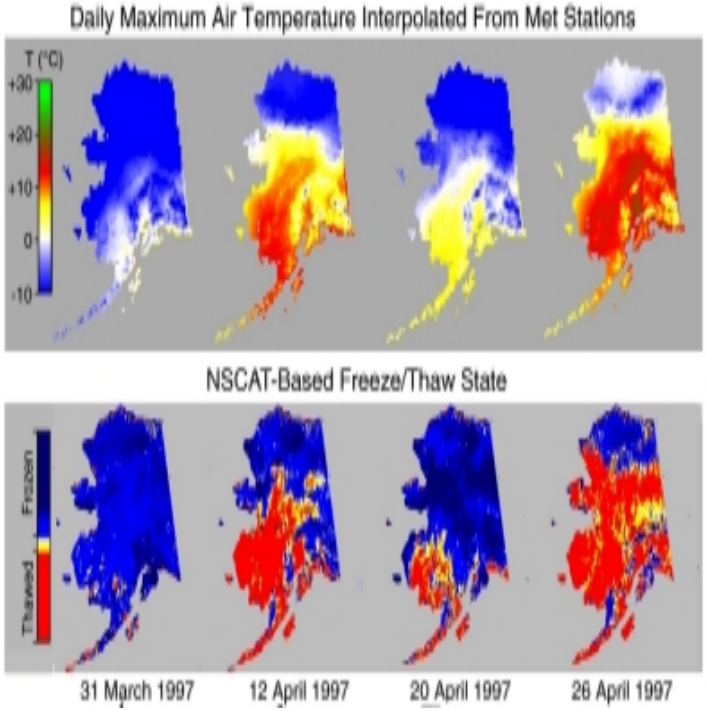
Schematic diagram illustrating Lukas-Lindstrom 'barrier layer' theory. During strong wind burst, surface mixed layer extends down to top of thermocline. Following wind burst, additional buoyancy from precipitation and strong surface heating acts to form relatively warm and fresh thin surface mixed layer. Below thin layer is strong halocline, which effectively decouples surface forcing from deeper water. Further heating is trapped for vertical mixing above barrier formed by halocline.

From: Anderson, S. P., R. A. Weller, and R. B. Lukas, 1996: Surface buoyancy forcing and the mixed layer of the western Pacific warm pool: Observations and 1D model results. J. Climate, 9, 3056-3085.

Synergy with Cold Seasons Hydrology Missions

GPM

Freeze-Thaw
Eco-Hydrometeorology Processes



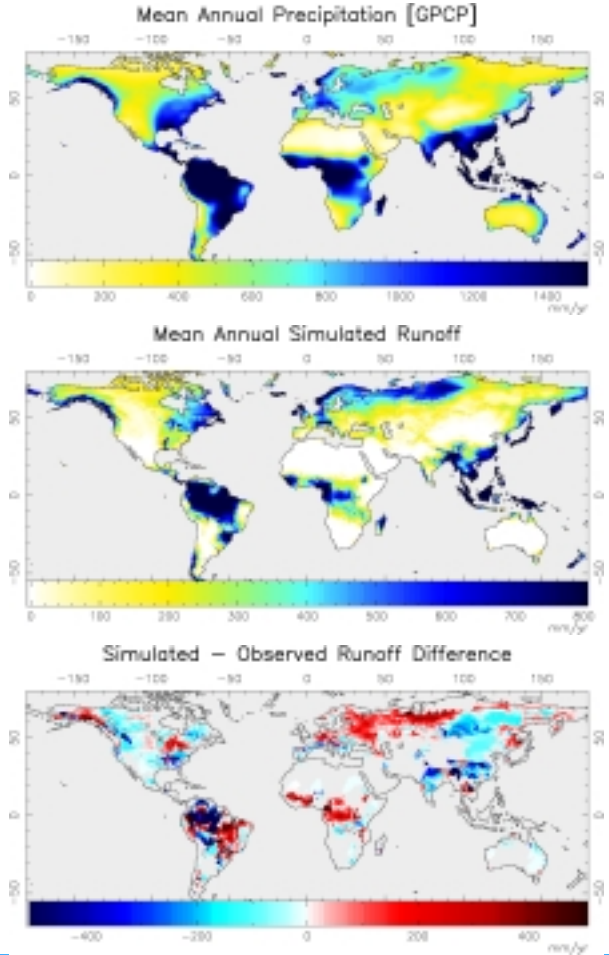
Comparison of daily air temperature interpolated from measurements (acquired from 72 weather stations across Alaska), with freeze/thaw state maps derived from 2-day NSCAT composite mosaics. *In situ* surface station network measurements including air temperature, snow cover, soil temperature, stream flow, and trace gas exchange have been used to validate radar based freeze/thaw maps (e.g., Running et al., 1999; Frolking et al., 1999; Kimball et al., 2000a,b).

(S. Running; Univ. Montana)

Synergy with Major River Runoff Missions

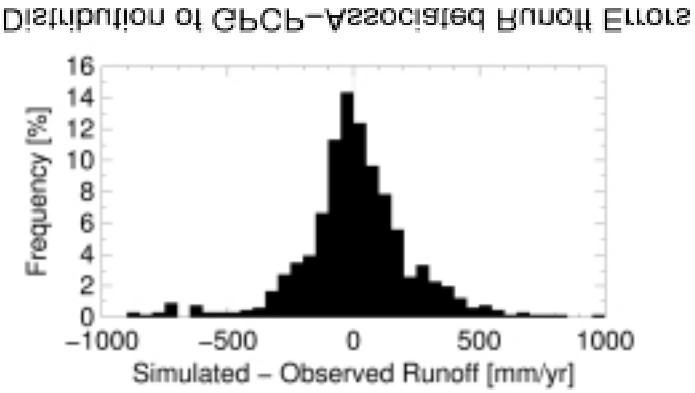
GPM

Use of Distributed Runoff Fields Generated from Observed Discharge to Assess Precipitation Bias



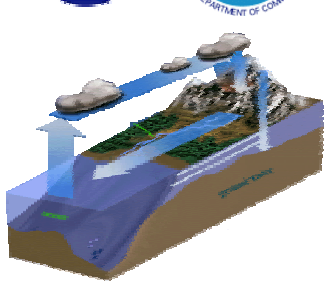
Precipitation estimates from Global Precipitation Climatology Project (GPCP) can be assessed using integrated system of observed & modeled runoff estimates (Fekete, Vorosmarty, Grabs; WMO Report #22).

Comparisons highlight spatial patterns of potential bias in precipitation estimates & therefore water budget closure. An integrated ground-based monitoring system for discharge & co-incident runoff fields would be of substantial value to integrity of GPM rain retrievals.



Water Systems Analysis Group

University of New Hampshire

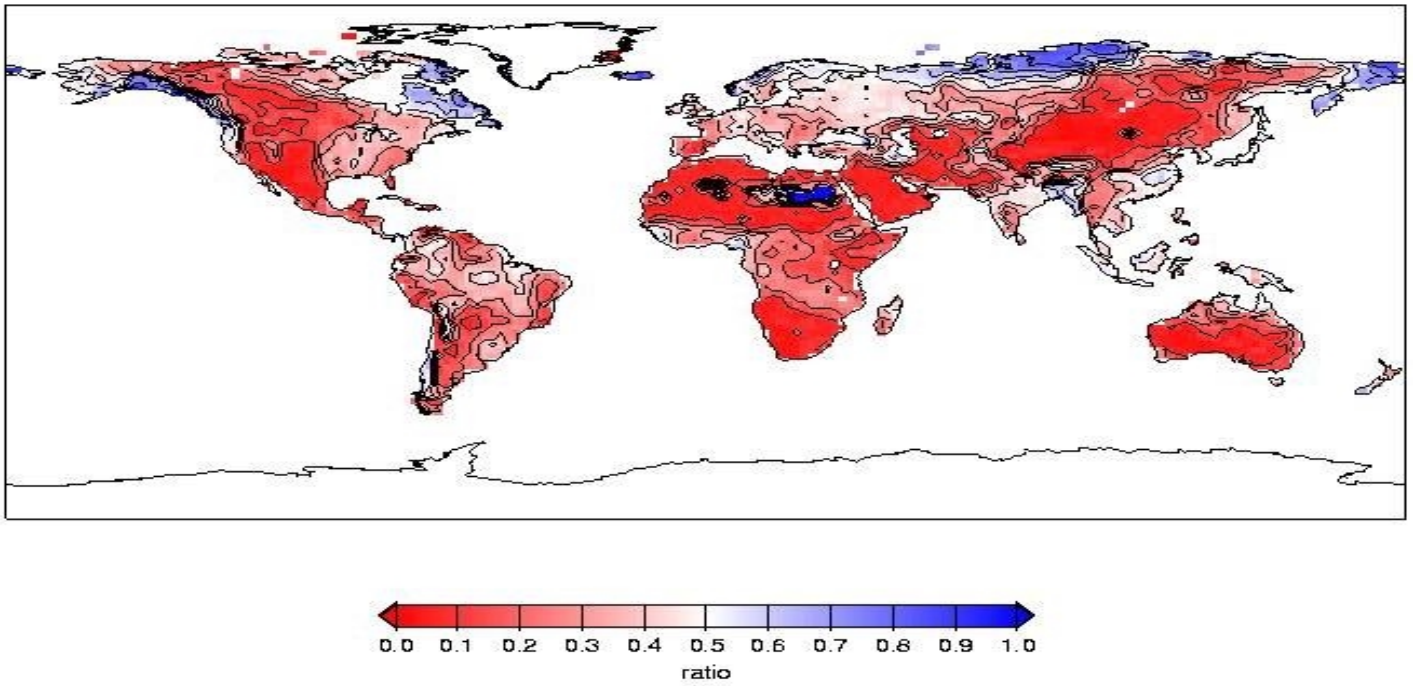


(C. Vorosmarty; UNH)

Synergy with Continental Runoff Missions

GPM

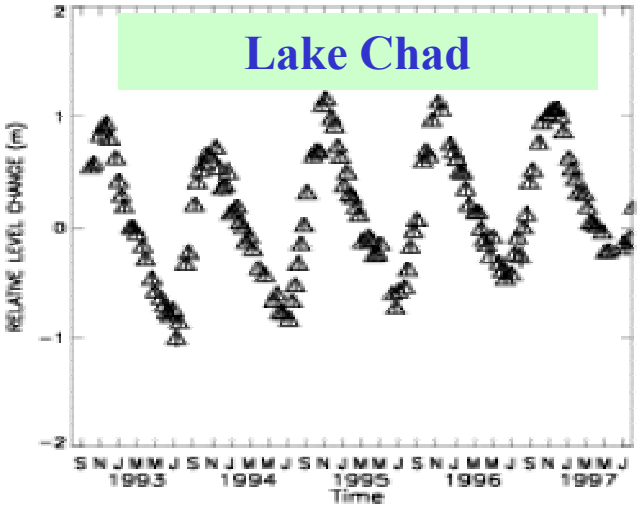
Global Mean Annual Runoff Ratio (1980-1993)

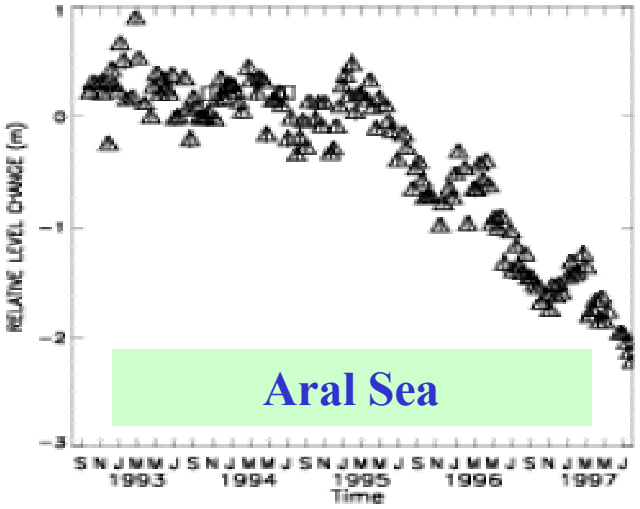


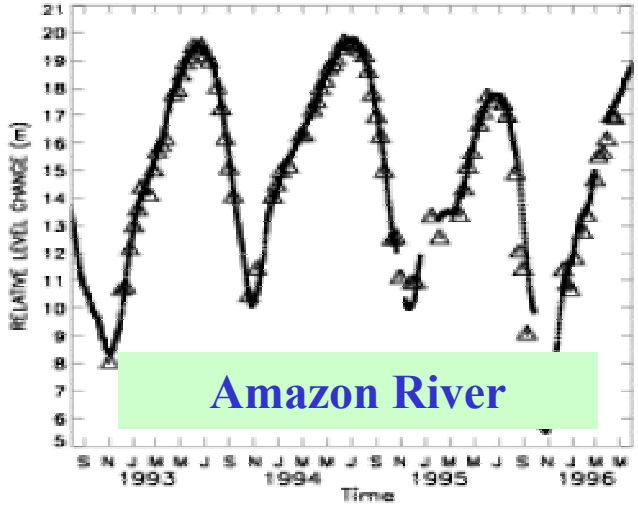
(E.F. Wood; Princeton)

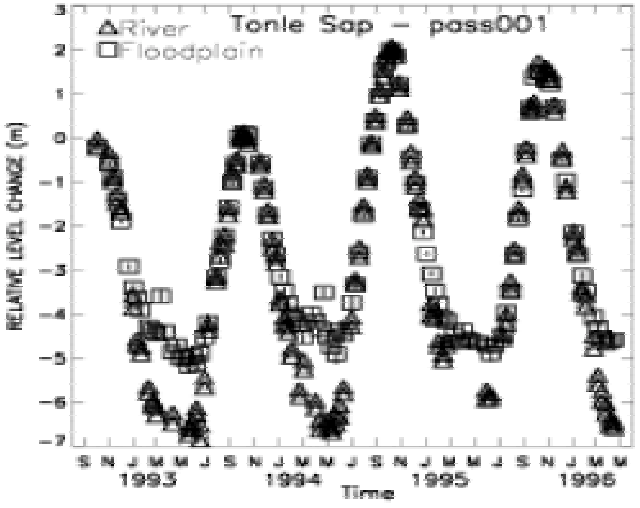
GPM

Synergy with Hydrologic Altimetry Missions









Relative River/Lake Level Change