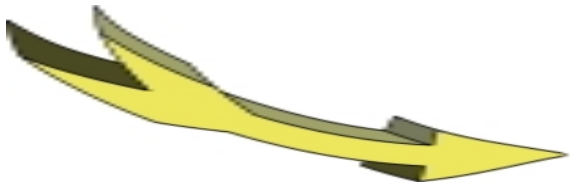
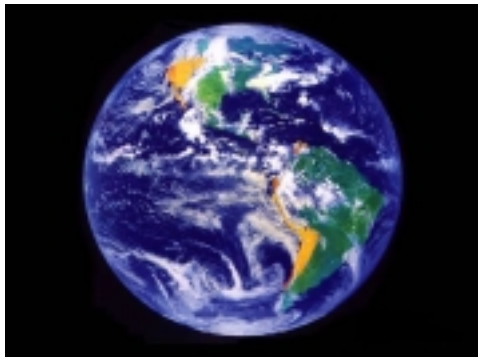
NASA/GSFC's Planned Contribution to GPM

Arthur Hou and Franco Einaudi

NASA Goddard Space Flight Center

- Rainfall and latent heating algorithm development
- Transferring information from instantaneous GPM measurements at satellite footprint scales to larger temporal and spatial scales through data assimilation, analysis, and modeling





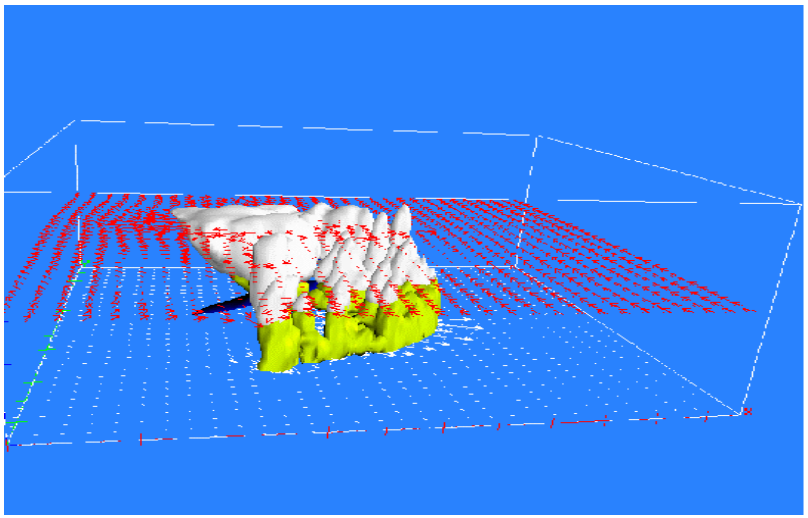
GPM Planning Workshop, 16-18 May 2001, College Park, MD

Goddard TRMM/GPM Research/Applications

- **NASA/GSFC has a rich heritage in TRMM**
- **As NASA's Lead Center in Earth Sciences, GSFC is committed to working with GPM partners to provide state-of-the-art capabilities in:**
  - Rainfall and latent heating algorithm development
    - Radar
    - Passive microwave radiometer
    - Cumulus ensemble models
  - Merged satellite rainfall analyses
    - 3-hr to monthly global rainfall datasets
  - Data assimilation & numerical weather prediction
    - Global scale
    - Regional scale
  - Modeling
    - Atmospheric physical parameterization
    - Land modeling
    - Ocean modeling
  - Climate analysis & process studies

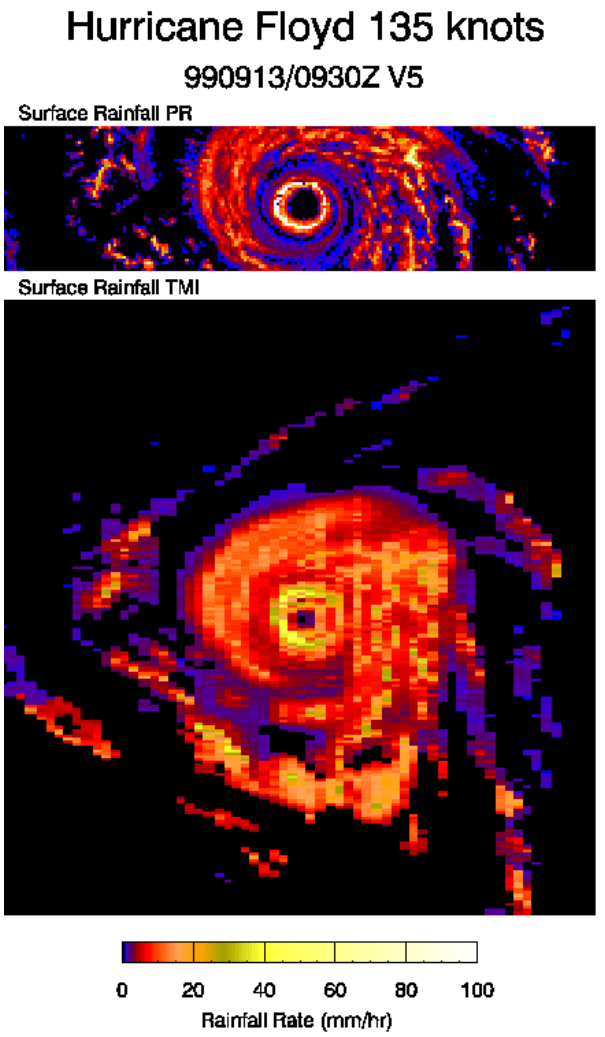
Rainfall & Heating Algorithm Development

- Development of operational algorithms for spaceborne dual-frequency weather radar
- Development of rainfall algorithms for passive microwave radiometers
- Cloud/radiative simulation for interpreting rain and heating information from passive microwave radiance observations



W.K. Tao et al./NASA GSFC

Goddard Cloud Ensemble Model TOGA COARE Simulation



R. Meneghini & J. Stout/NASA GSFC

Merged Satellite Rainfall Analysis

Global rainfall analyses using GPM, polar & Geo satellites

3-hourly to monthly data products

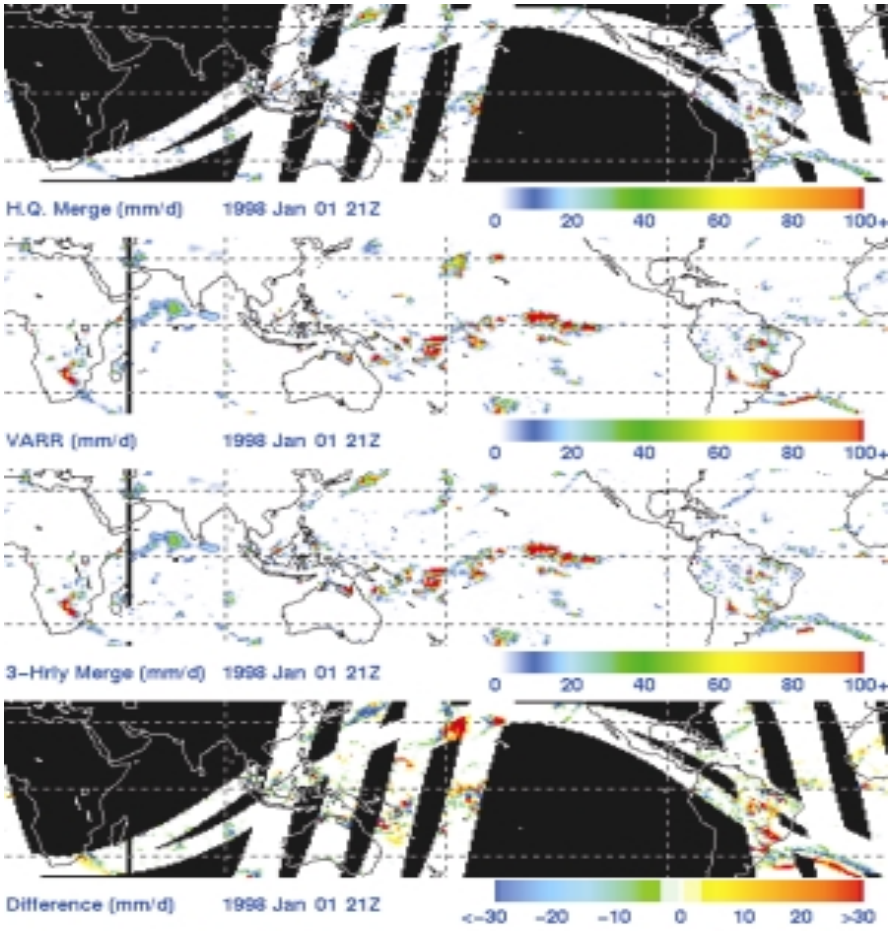
TRMM & SSM/I (adjusted by TRMM)

Geo-IR (adjusted by TRMM)

3-hr Merged (1° resolution)

GeoIR-TRMM-SSM/I Merged

3-hr Merged TRMM Rainfall Analysis



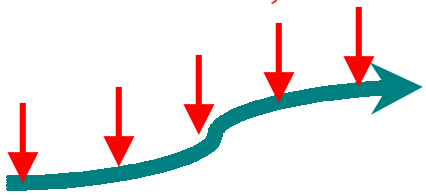
R. Adler & G. Huffman/NASA GSFC

Role of Data Assimilation in GPM

Data Assimilation combines GPM measurements with observations from other platforms in a physical model to provide an optimal estimate of the earth system and predict its future state

- Organizes data (model acts as interpolator)
- Complements data (fills in unobserved regions)
- Supplements data (provides unobserved quantities)
- Quality controls data
- Calibrates data
- Applications: Initial conditions for forecasts, mission and instrument team support, and 4-dimensional climate data sets

Data ingestion generates a correction term, Δx



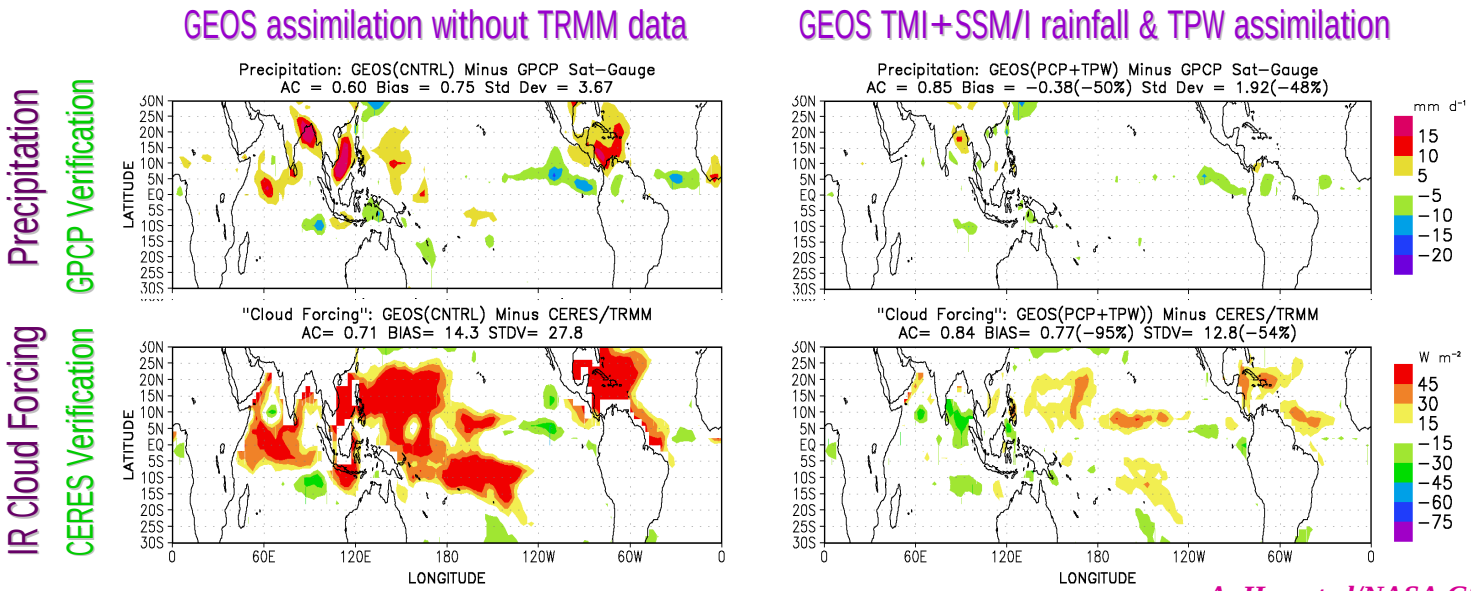
Forecast model integration

$\partial x/\partial t$ = dynamics + physics + Δx

Data Assimilation plays a key role in transferring GPM information from the satellite footprint scales to regional and global scales

Rainfall Data Assimilation

- **Develop assimilation methods to make effective use of GPM observations**
- **Demonstrate their benefits in weather forecasting & climate analyses**

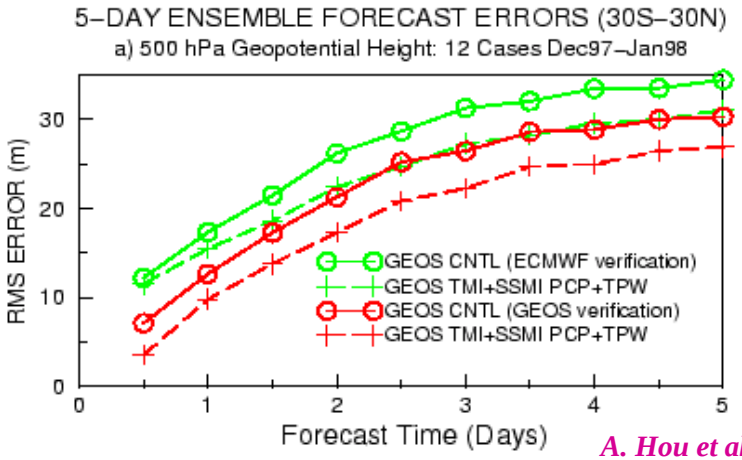


A. Hou et al/NASA GSFC

TRMM has shown: Rainfall assimilation improves not only hydrological parameters but also important climate variables such as clouds and radiation in global analyses

It also improves tropical latent heating, large-scale circulation, and the upper-tropospheric humidity (as verified by comparison with TOVS brightness temperatures)

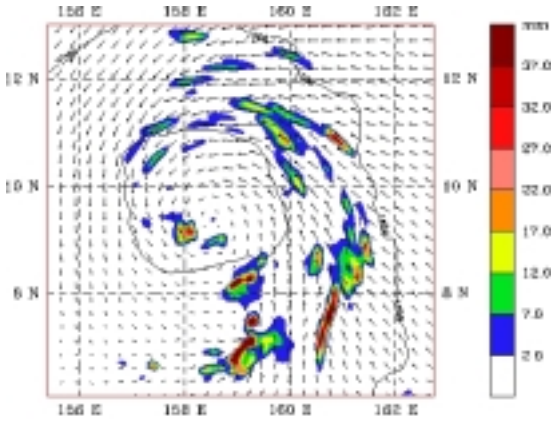
Improving Forecasts and Mesoscale Simulation



A. Hou et al/NASA GSFC

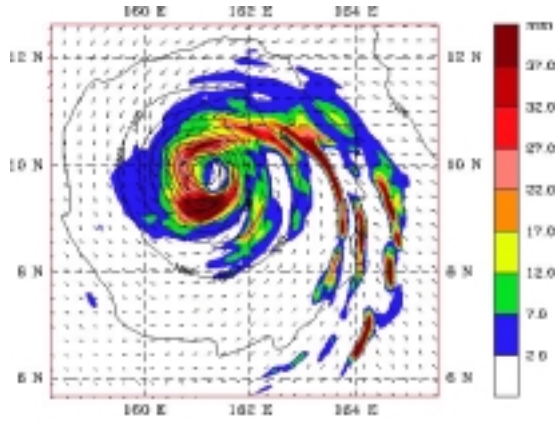
TRMM rainfall assimilation improves tropical forecasts provides better initial condition for mesoscale simulation

Impact of GEOS-TRMM global analysis on MM5 Simulation of Super Typhoon Paka

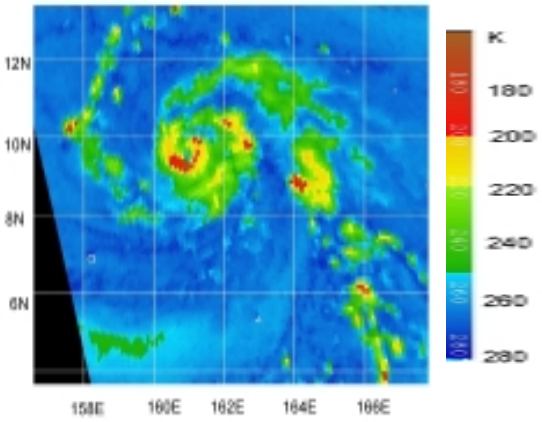


Initialized without TRMM data

Z.X. Pu and W.K. Tao/NASA GSFC



Initialed with GEOS-TRMM &Bogus Vortex
0900 UTC 13 December 1997



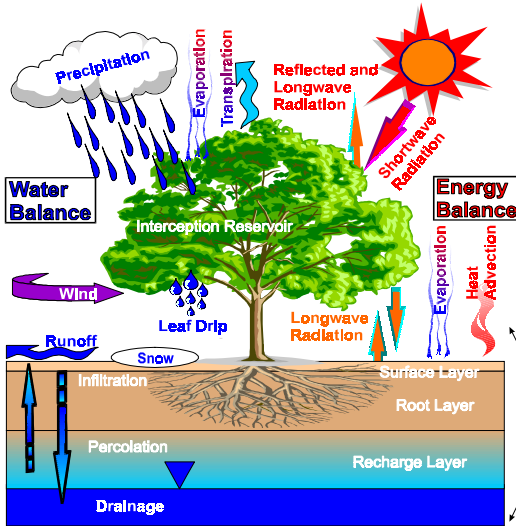
SSM/I 85 GHz Brightness Temperature
0911 UTC 13 December 1997

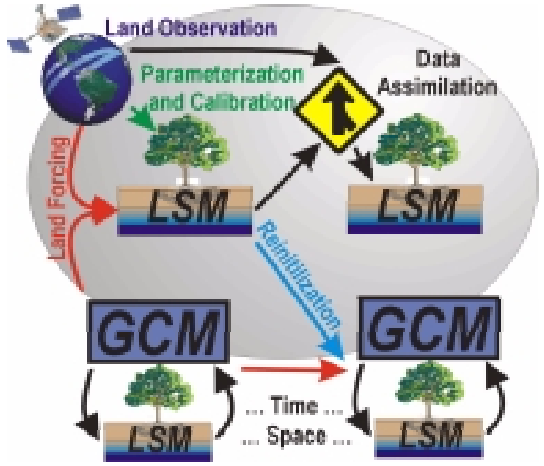
Improving Physical Parameterizations

- Data assimilation compels the model physics to confront observations in a wide range of conditions and provides a dynamic framework for estimating systematic model errors
  - Develop online procedures to use GPM data in data assimilation to estimate state-dependent systematic errors of the forecast model
    - An empirical procedures to estimate state-dependent systematic errors in the moist physics module using moisture/temperature tendency corrections obtained from rainfall assimilation
  - Collaborate with model physics developer to assess performance of improved parameterizations in model simulation and data assimilation

Land Modeling, Data Assimilation, and Hydrology

- Derive soil moisture information from GPM observations
  - Improve rainfall prediction over land
- Offline real-time global land data assimilation
  - Provide high-resolution (at 1/8º) analyses of surface states and fluxes using high-spatial-and-temporal-resolution precipitation observations as forcing
- Land process modeling
  - Use rainfall data to improve models of vegetation biophysics, soil/surface processes, & biogeochemistry
  - Assimilate GPM rainfall in coupled atmosphere-land systems to improve estimates of evapotranspiration, runoff, and river flow
- Precipitation recycling
  - Define the hydrologic feedback between continental evaporation and precipitation through modeling and data assimilation



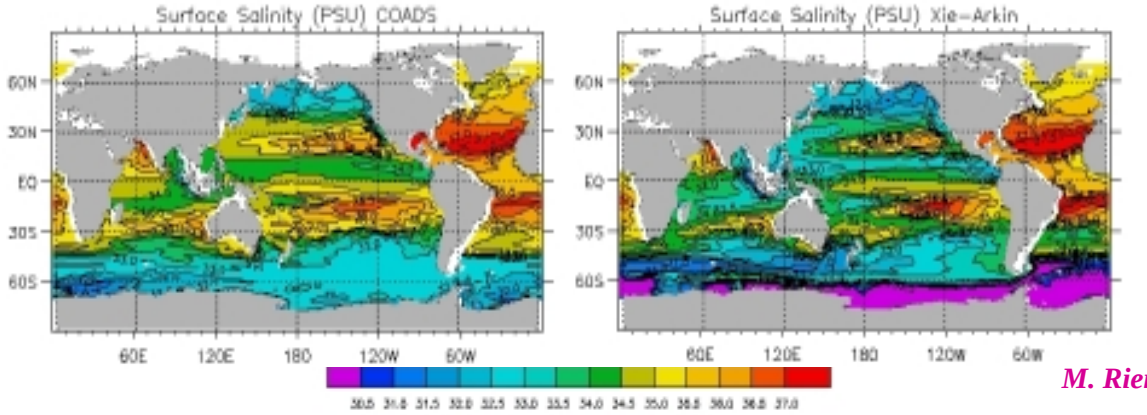


P. Houser & M. Bosilovich/NASA GSFC

Ocean Modeling and Seasonal Prediction

- Global freshwater flux is poorly known, use GPM precipitation to improve freshwater flux forcing for ocean models and simulations of salinity distribution

Surface salinity from OGCM simulation is sensitive to precipitation forcing



M. Rienecker/NASA GSFC

- Surface salinity (not temperature) differentiates the N. Pacific from the N. Atlantic in terms of meridional overturning and deep water formation: maximum penetration of wintertime forcing is set by halocline (not thermocline)

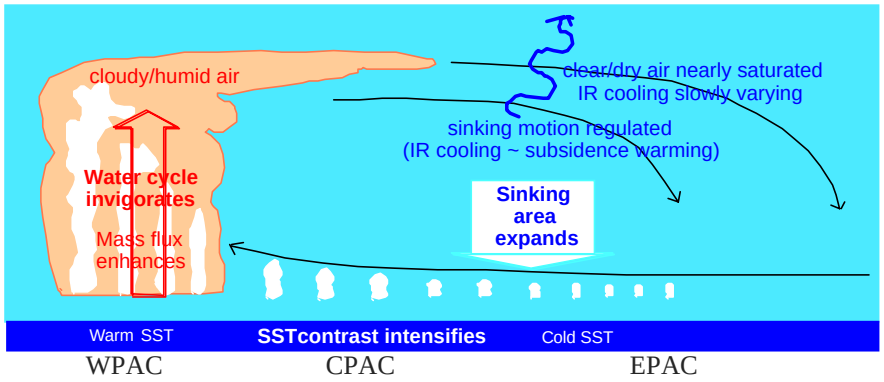
- El Niño predictability may be influenced by tropical stratification - Equatorial pycnocline is affected by off-equatorial subducted water masses. GPM provides global rainfall data, which should improve seasonal forecasts by coupled GCMs

- High frequency wintertime surface mixing events may be important for generation of significant water mass anomalies

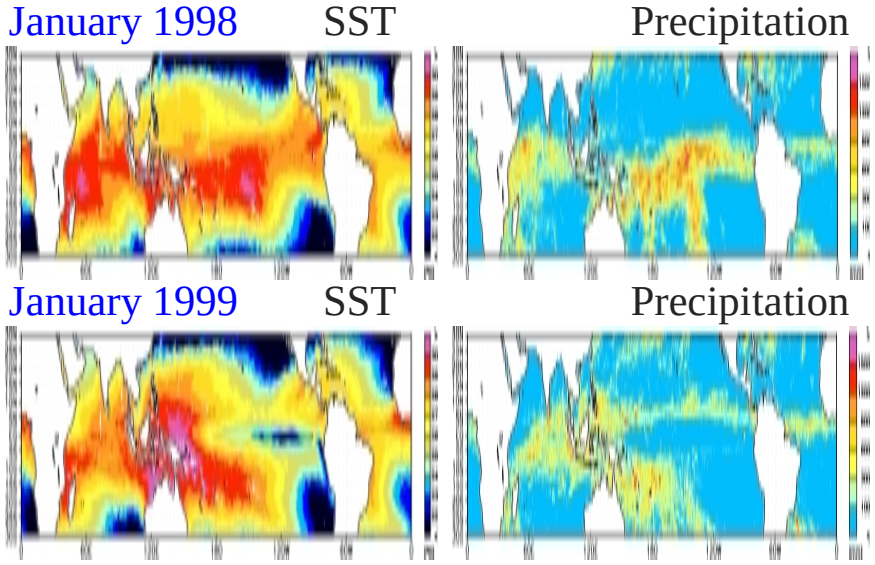
Climate Analysis and Process Studies

- **GPM provides a key observation type for understanding the global water cycle and climate feedback**

  - How does the global water cycle (rain, water vapor, cloud structure and amount) vary with SST?
  - What are the relative roles of large scale circulation and SST?
  - What is the role of the fresh water flux from precipitation in altering SST during El Nino?



W. Lau/NASA GSFC

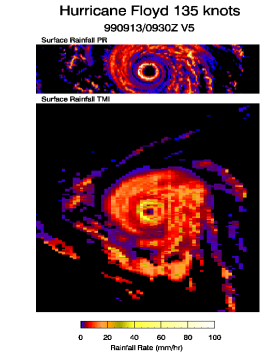


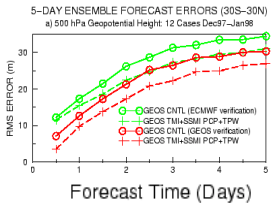
- **Use GPM data to validate multi-year rainfall hindcasts & forecasts and quantify rainfall variability over oceans and its link to seasonal -decadal climate variability**

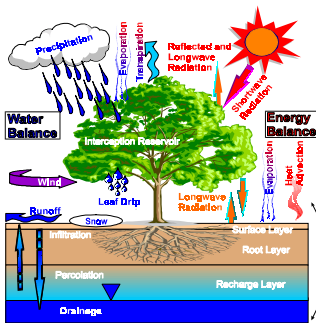
V. Mehta/NASA GSFC & ESSIC

NASA/GSFC Partnership in GPM

NASA/GSFC will build upon the TRMM legacy and work with GPM partners to advance GPM Science Goals and Applications







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