The role of Earth Observation Satellites to observe rainfall

Riko Oki

National Space Development Agency of Japan

Outline

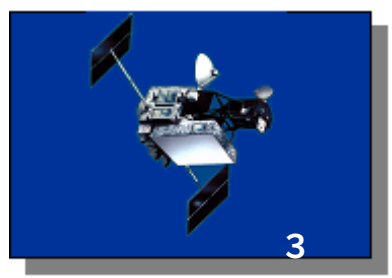
1. Importance of rain measurement
2. TRMM and Its Achievements
3. Outline of GPM
4. Summary

Rainfall Measurement and our life

- Rain affects most everyone's life & work
  - Food production
  - Flood, drought
- Rain is a key variable in
  - Weather prediction models
  - Climate models
  - Air-sea interaction models, etc.
- Rain is one of hardest meteorological parameters to measure, because of its spatial and temporal variability.
  - Contribution by rainfall measuring satellites

  →TRMM

  (Tropical Rainfall Measuring Mission)

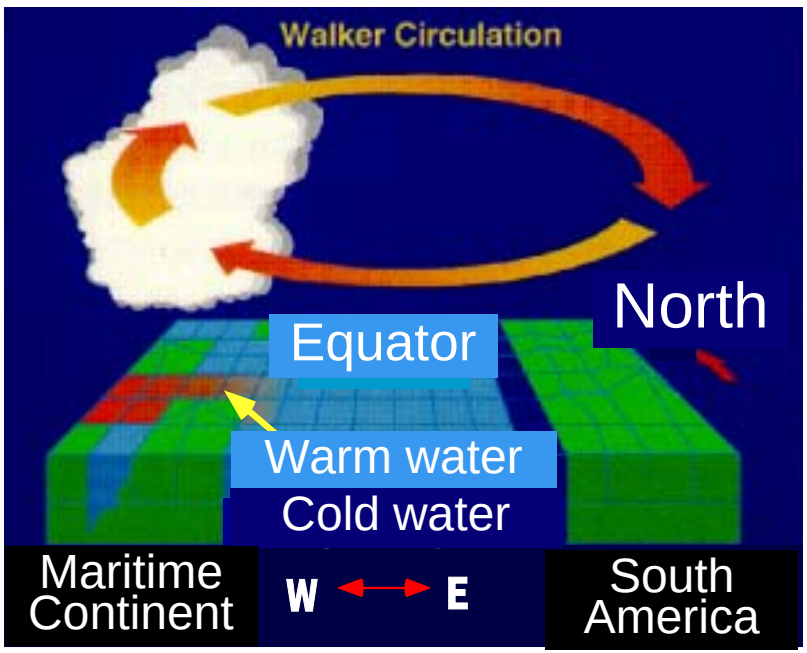


TRMM's Mission Objectives

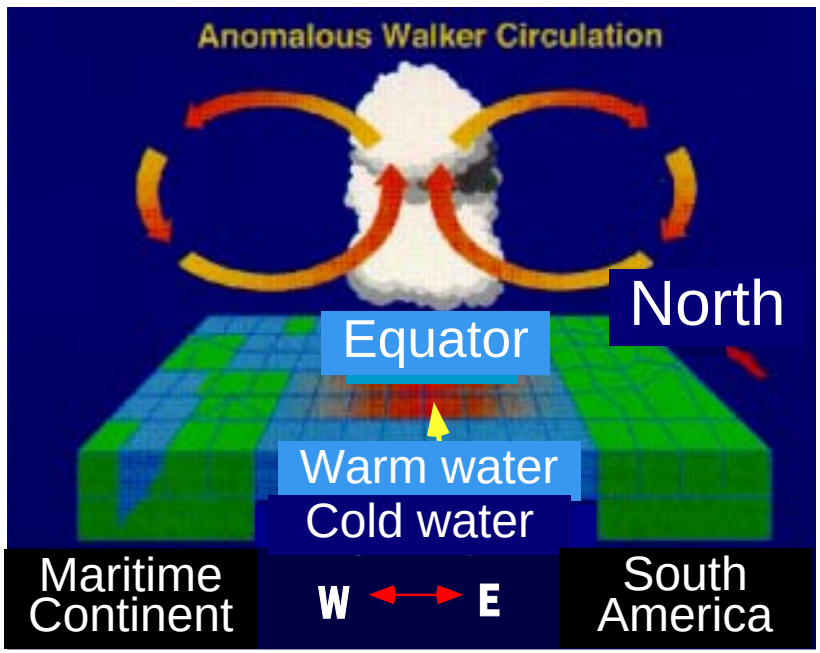
- To advance the understanding of global circulation of energy and water from observation of tropical and subtropical rain
  - **Accurate measurement of tropical rain which affects the global climate**
    - monthly rain accumulation estimates in 5 deg by 5 deg boxes with less than 10% error (Sampling & Retrieval error)
  - **Estimation of vertical distribution of latent heat**
    - PR provides information on vertical rain profiles

Atmospheric Circulation and Tropical rainfall

Normal Condition

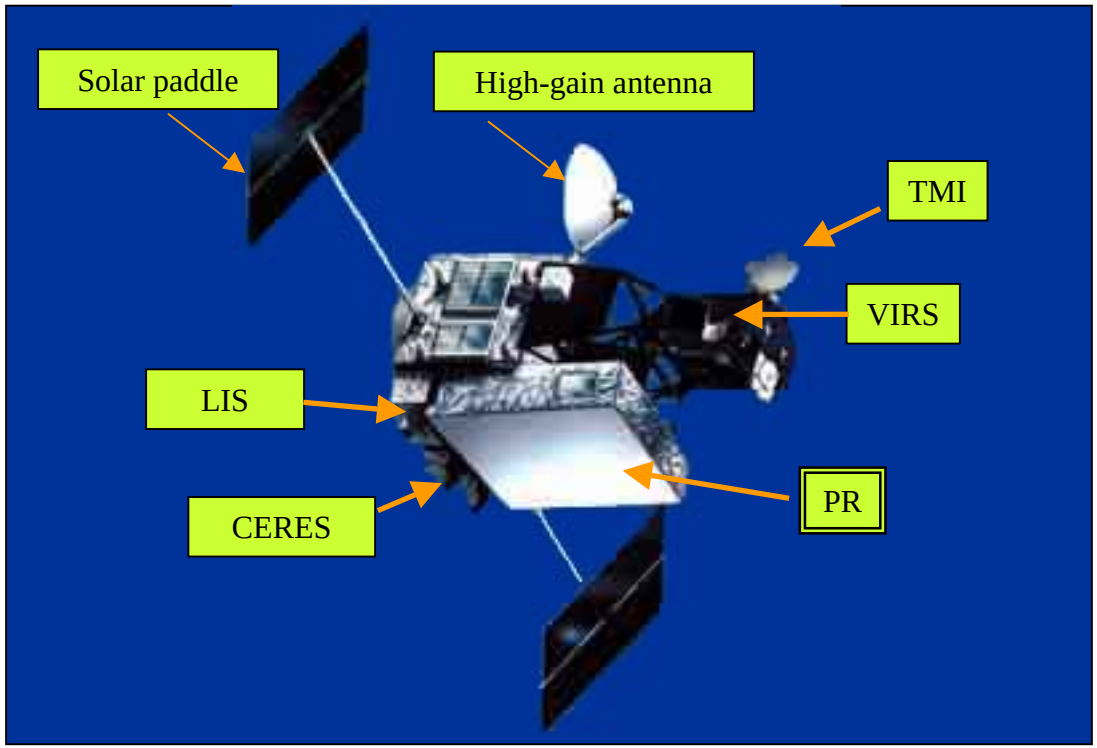


El Nino Condition



- Tropical Rainfall as a "Heat Engine" of global circulation

Tropical Rainfall Measuring Mission: TRMM



Orbit Altitude Inclination	Circular（Non-Sun Synchronous） 350km (402.5km since Aug. 2001) (±1.25km) 35 deg.
Sensor	**Precipitation Radar (PR)** TRMM Microwave Imager (TMI) Visible and Infrared Scanner (VIRS) Clouds and the Earth's Radiation Energy System (CERES) Lightning (LIS)

- Observation of tropical rainfall (Driving engine of global atmosphere)
- US-Japan joint mission (Japan: PR, Launch, US: Bus, 4 sensors, operation)
- Launched in Nov., 1997. Still under operation
- First space-borne precipitation radar developed by Japan (NASDA and CRL)

NASDA NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN

COMMUNICATIONS RESEARCH LABORATORY

NASA

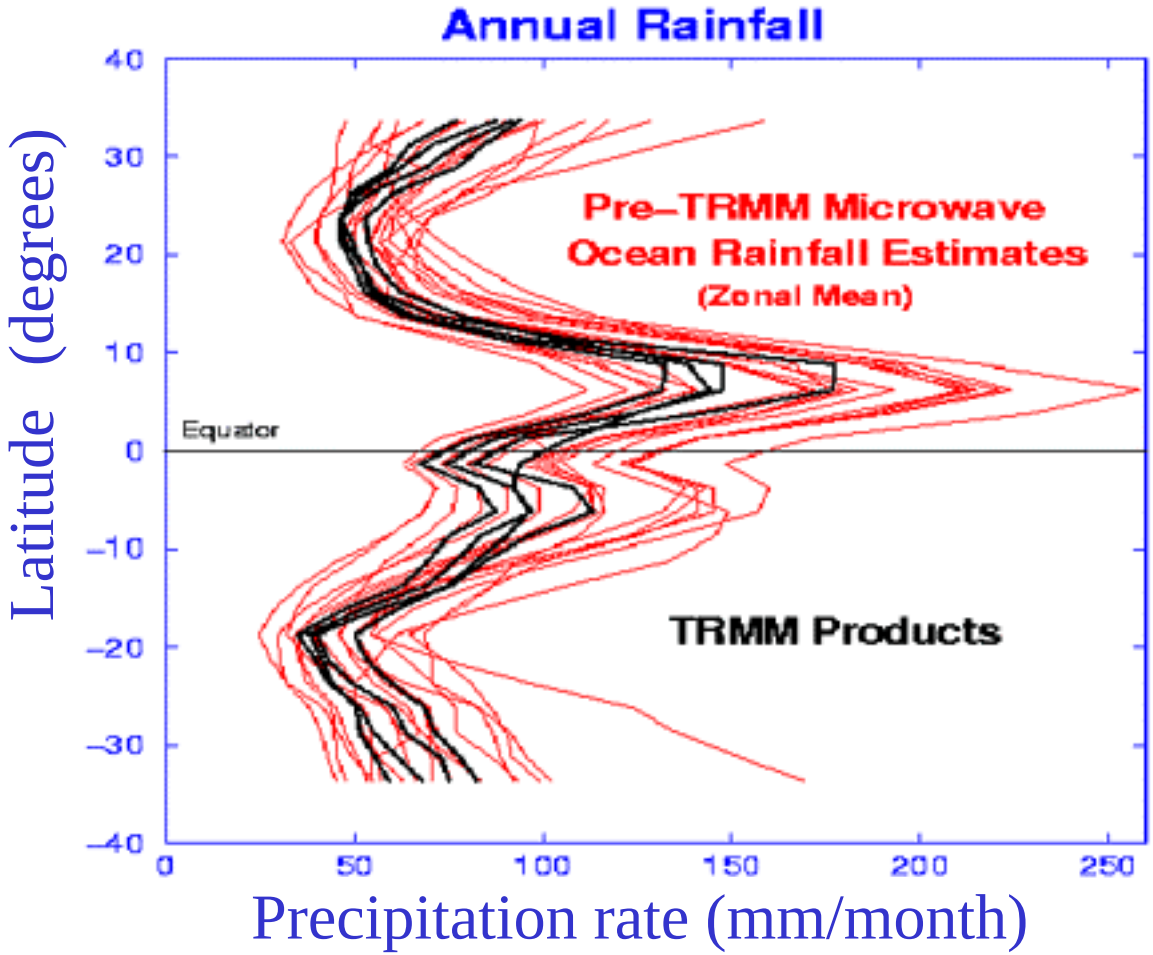
TRMM's Achievements

- Demonstration of the world's first space-borne precipitation radar technology
- Scientific Achievements
  - **Accurate observation of rain distribution in tropical and sub-tropical regions**
  - **Diurnal, annual, and long-term variations of precipitation**
  - **3-dimensional rain structure (PR)**
  - **Accurate rain observation over ocean and land in equal quality (PR)**
  - **Improvement in weather forecasting with 4-D data assimilation**
  - **Sea Surface Temperature (SST) estimation under clouds**
  - **Estimation of soil moisture (PR)**
- Successful cooperation between US and Japan

From TRMM to GPM

Improvement of rainfall measurement accuracy by TRMM

zonal mean precipitation rate

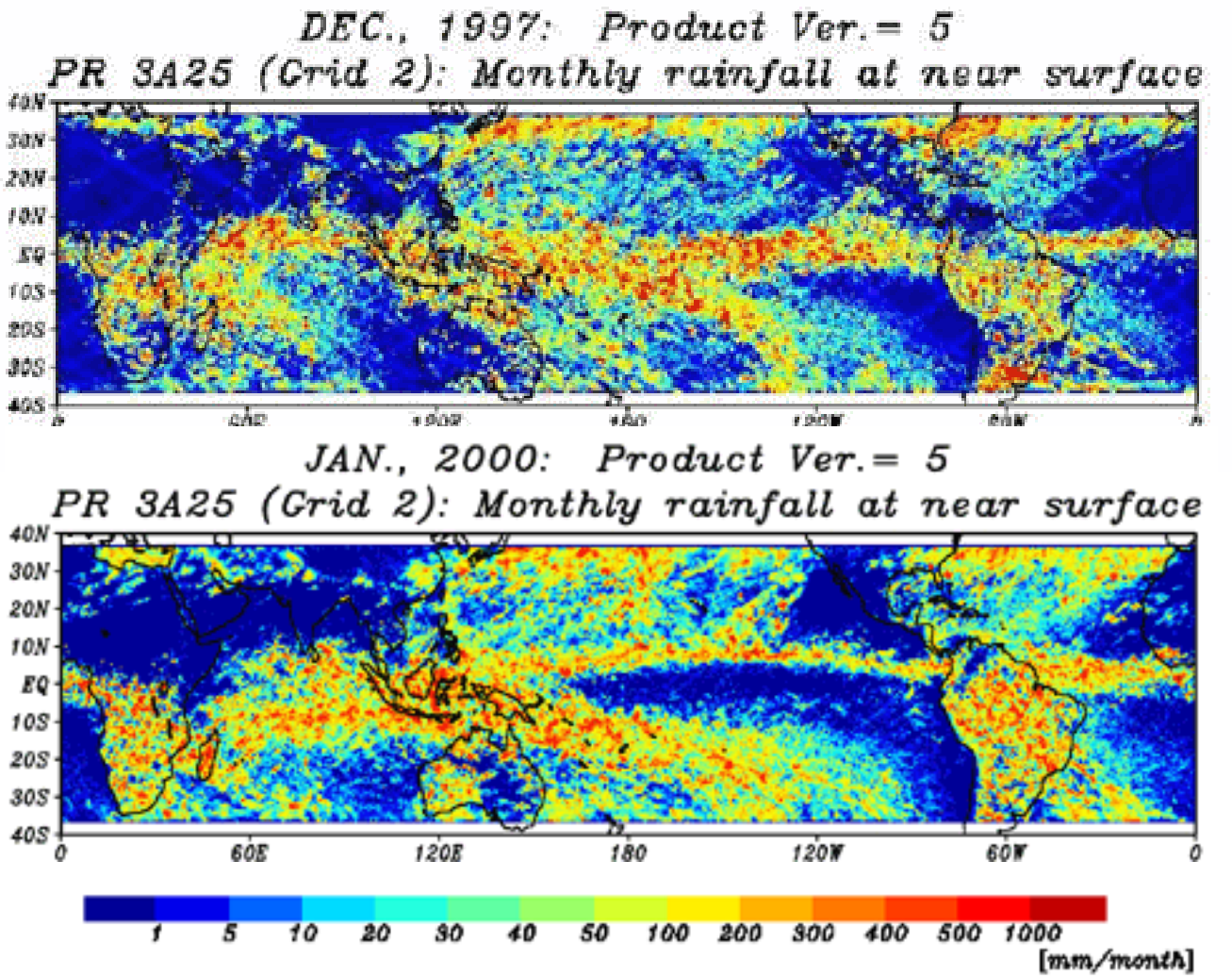


RED：**Pre-TRMM era Microwave radiometers**

BLACK：**TRMM era Precipitation radar (PR) and TRMM microwave imager (TMI)**

(NASA/GSFC)

Changes in Monthly Rain Distribution Observed by TRMM/PR (From Dec. 1997 to June 2001)



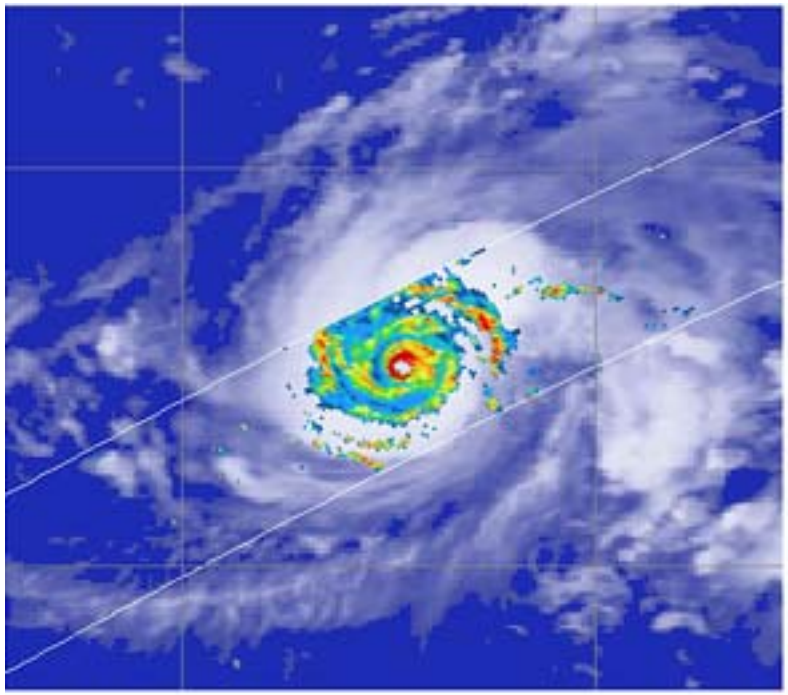
Reference (Normal Year) Jan. 2000

3-D Observation of a Typhoon by TRMM

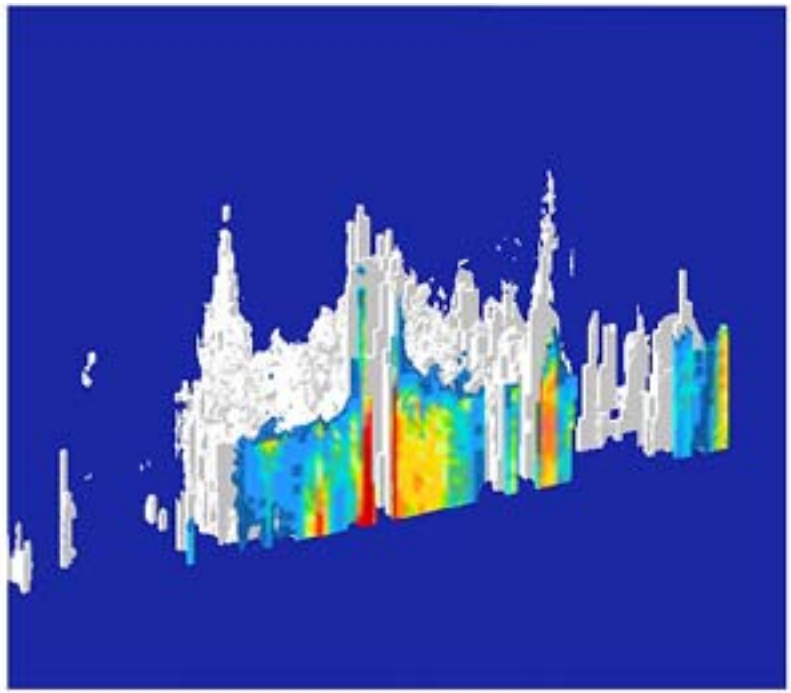
TRMM PR 2A25 RAIN

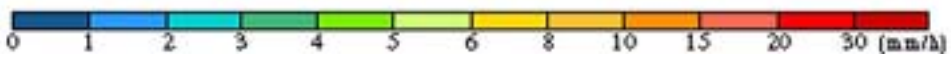
Aug. 2, 2000, 20:49-20:53 (Japanese local time)

Rain intensity at H=2 km



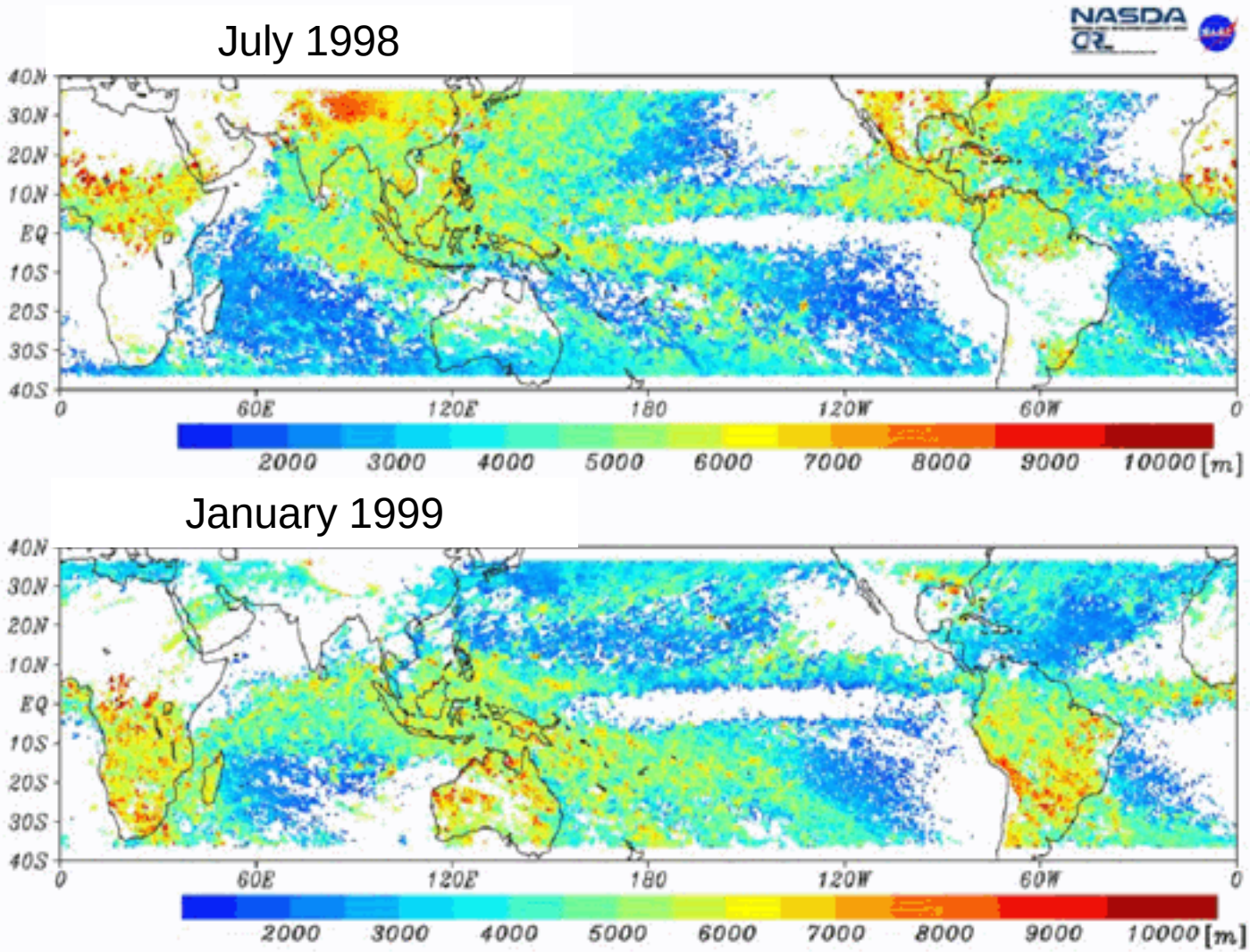
Vertical cross section through the eye and 3D structure





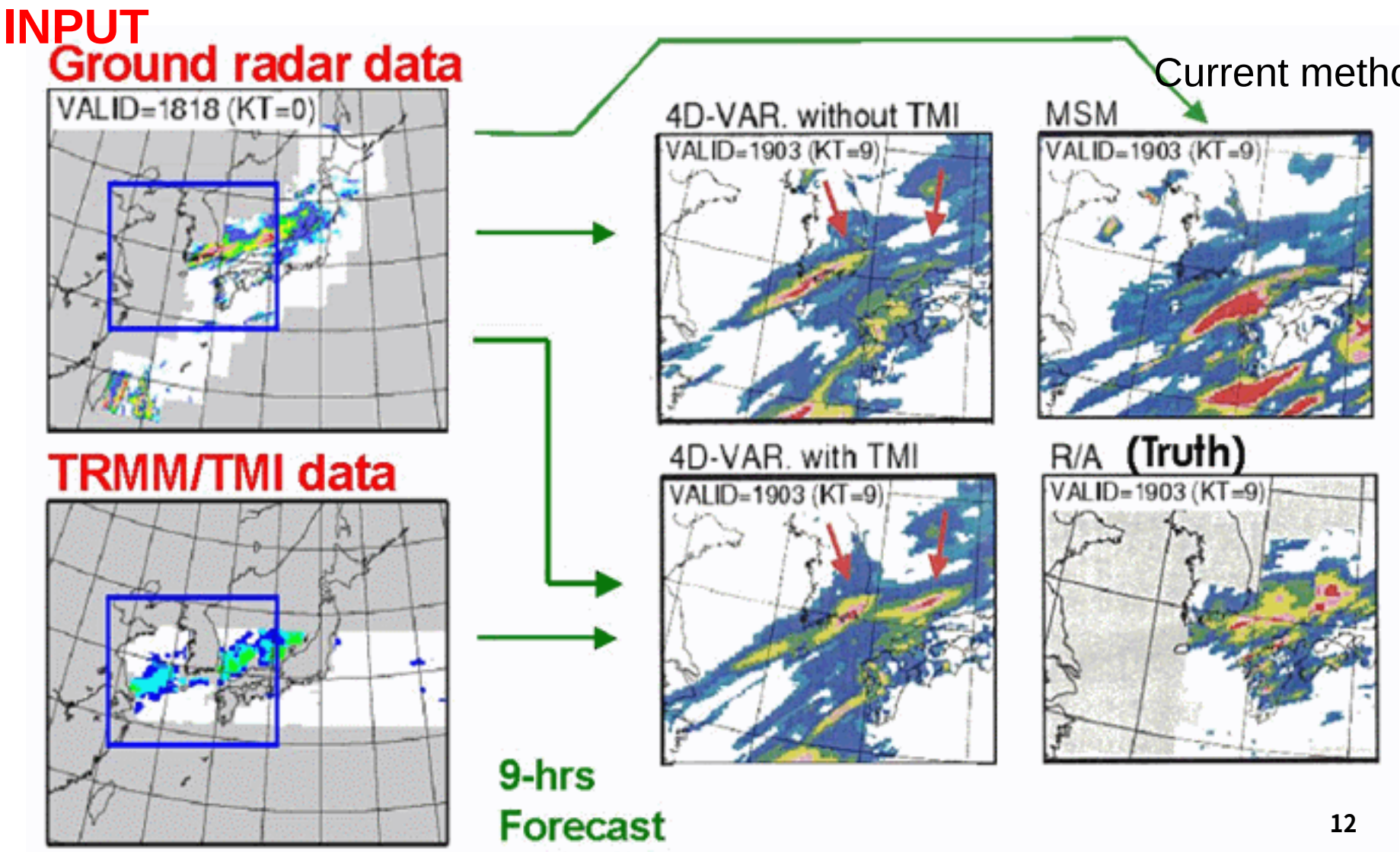
PR realized observation of 3D structure of rain over ocean where few observations had been available.

Global Distribution of the Mean Storm Height Measured by the TRMM Precipitation Radar

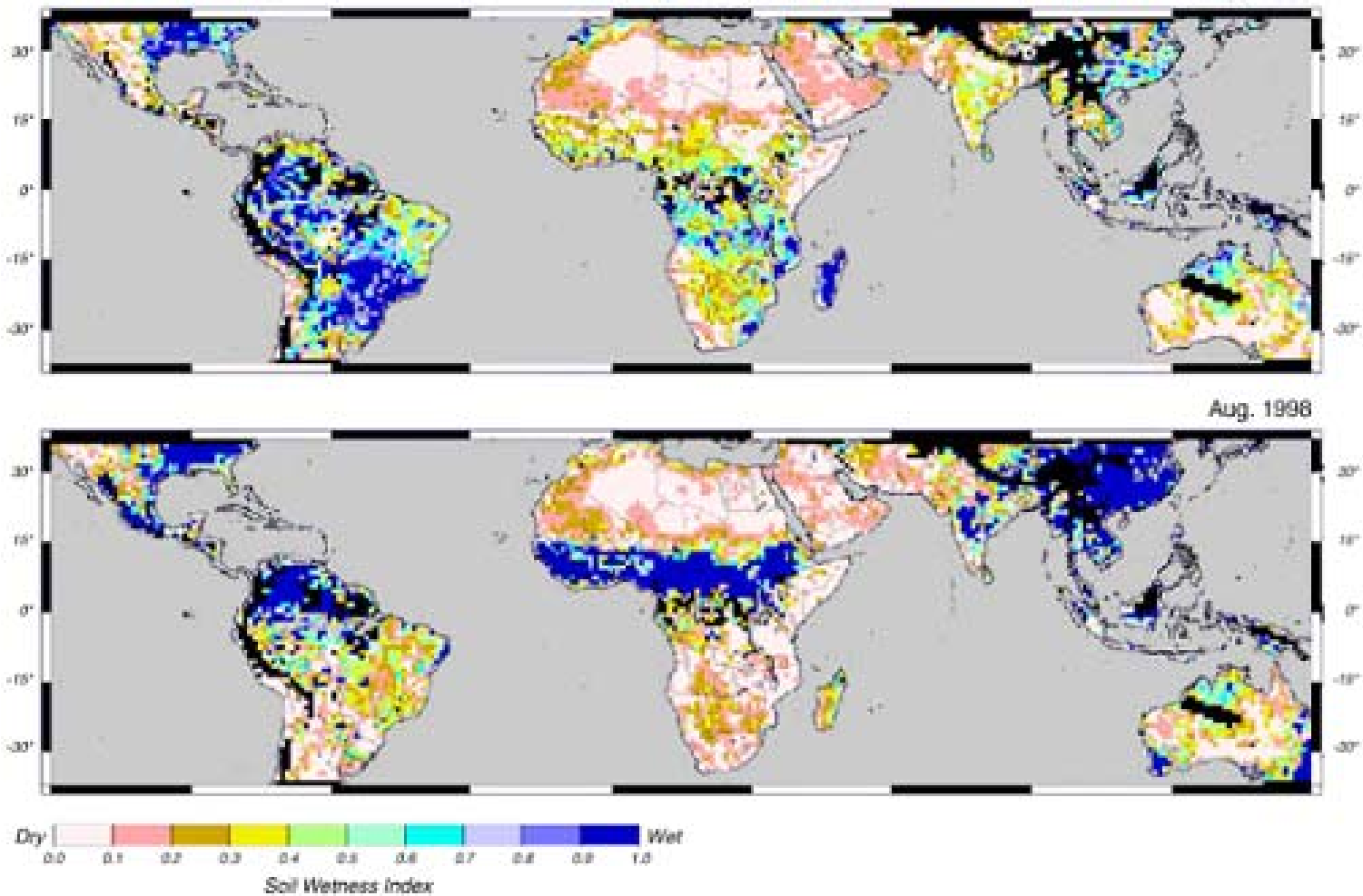


Improvement in weather forecasts

4D-VAR assimilation in the JMA meso-scale model



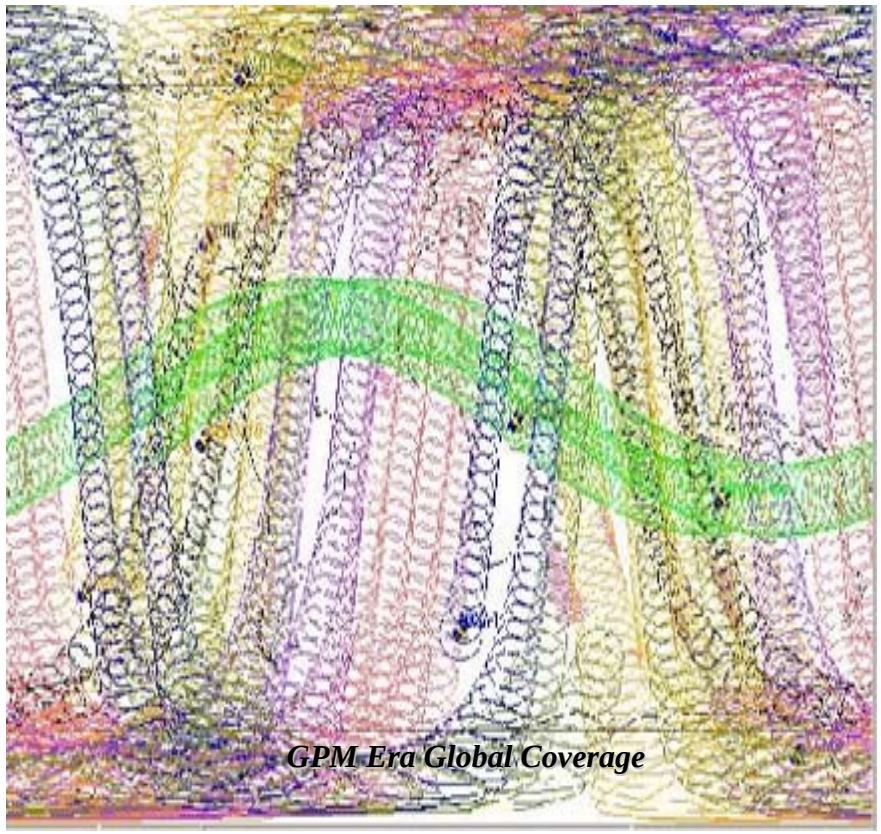
Soil Wetness Estimated from TRMM/PR



What's Next?

A Mission to:

- Measure a broader spectrum of precipitation (e.g. light rain, snow)
- Provide measurements in the tropics and mid-latitudes (e.g. global)
- Provide global precipitation products every 3 hours with 90% accuracy
- Further reduce uncertainty in precipitation microphysics and rainfall-radar reflectivity measurements
- Provide global precipitation measurements at temporal scales needed by weather, climate, and hydrological models
- Enable new societal applications in weather forecasting, flood prediction, freshwater resource management, public communications, and education

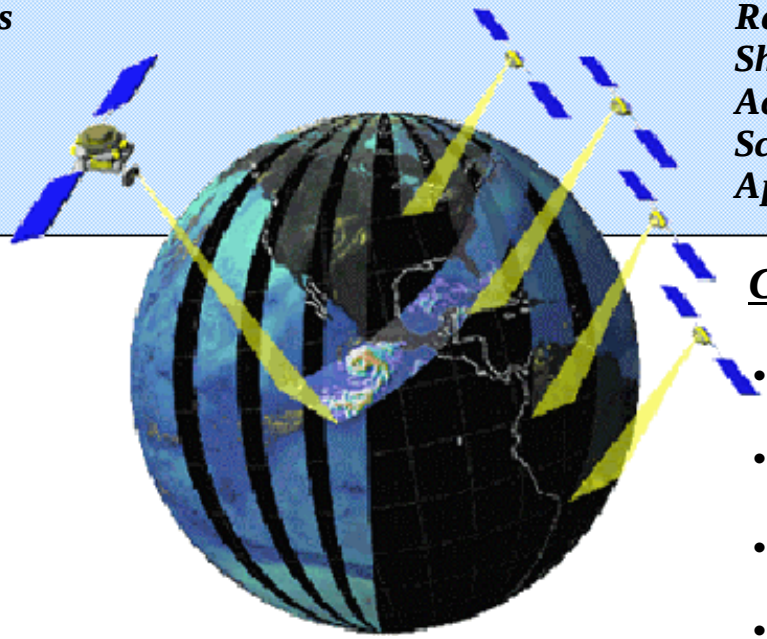


The Mission is Global Precipitation Measurement (GPM)

GPM Reference Concept

OBJECTIVE: Understand the Horizontal and Vertical Structure of Rainfall and Its Microphysical Element. Provide Training for Constellation Radiometers.

OBJECTIVE: Provide Enough Sampling to Reduce Uncertainty in Short-term Rainfall Accumulations. Extend Scientific and Societal Applications.



Core Satellite

- *Dual Frequency Radar*
- *Multi-frequency Radiometer*
- *H2-A Launch*
- *TRMM-like Spacecraft*
- *Non-Sun Synchronous Orbit*
- *~70 ° Inclination*
- *~400 - 500 km Altitude*
- *~4 km Horizontal Resolution*
- *250 m Vertical Resolution*

Constellation Satellites

- *Small Satellites with Microwave Radiometers*
- *Aggregate Revisit Time, 3 Hour goal*
- *Sun-Synchronous Polar Orbits*
- *~600 km Altitude*

Precipitation Validation Sites

- *Global Ground Based Rain Measurement*

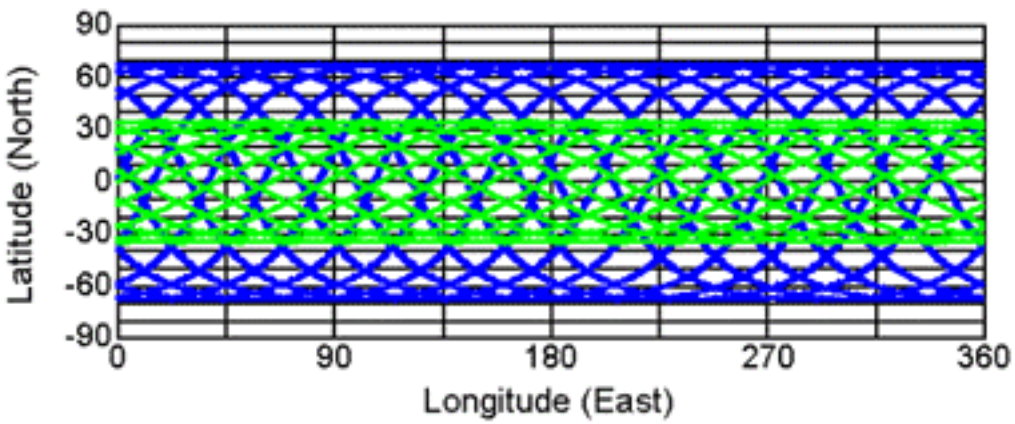
Global Precipitation Processing Center

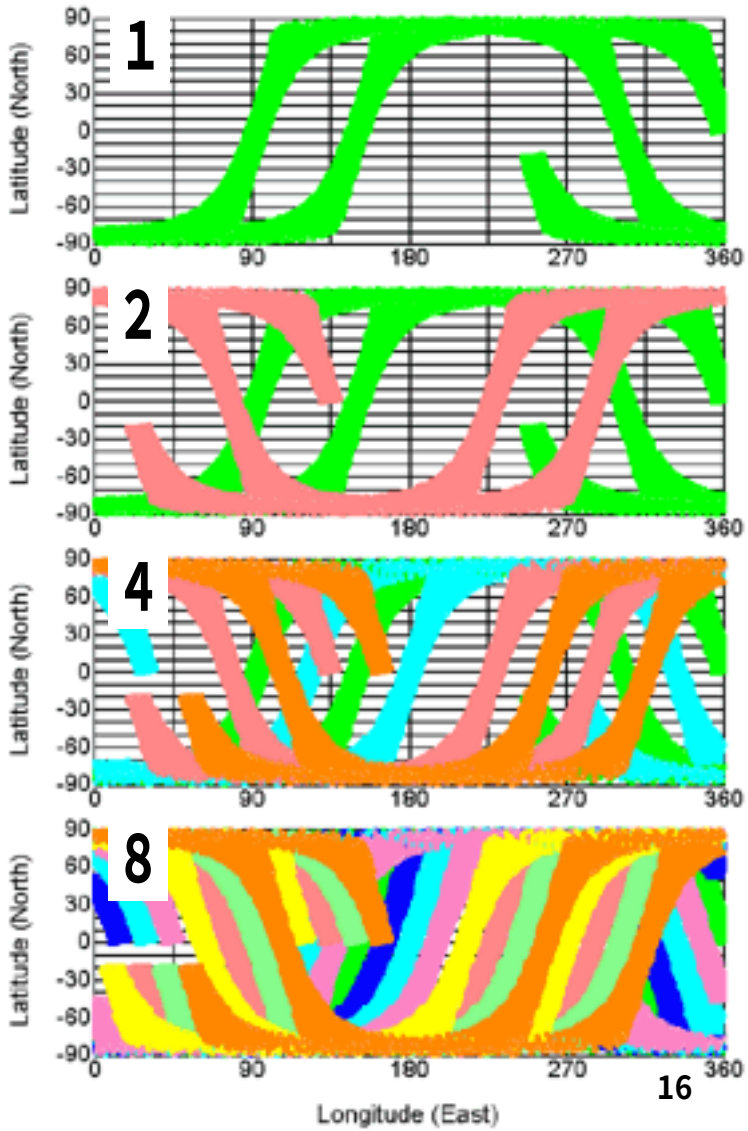
- *Capable of Producing Global Precip Data Products as Defined by GPM Partners*

Observation by a fleet of satellites with microwave radiometer

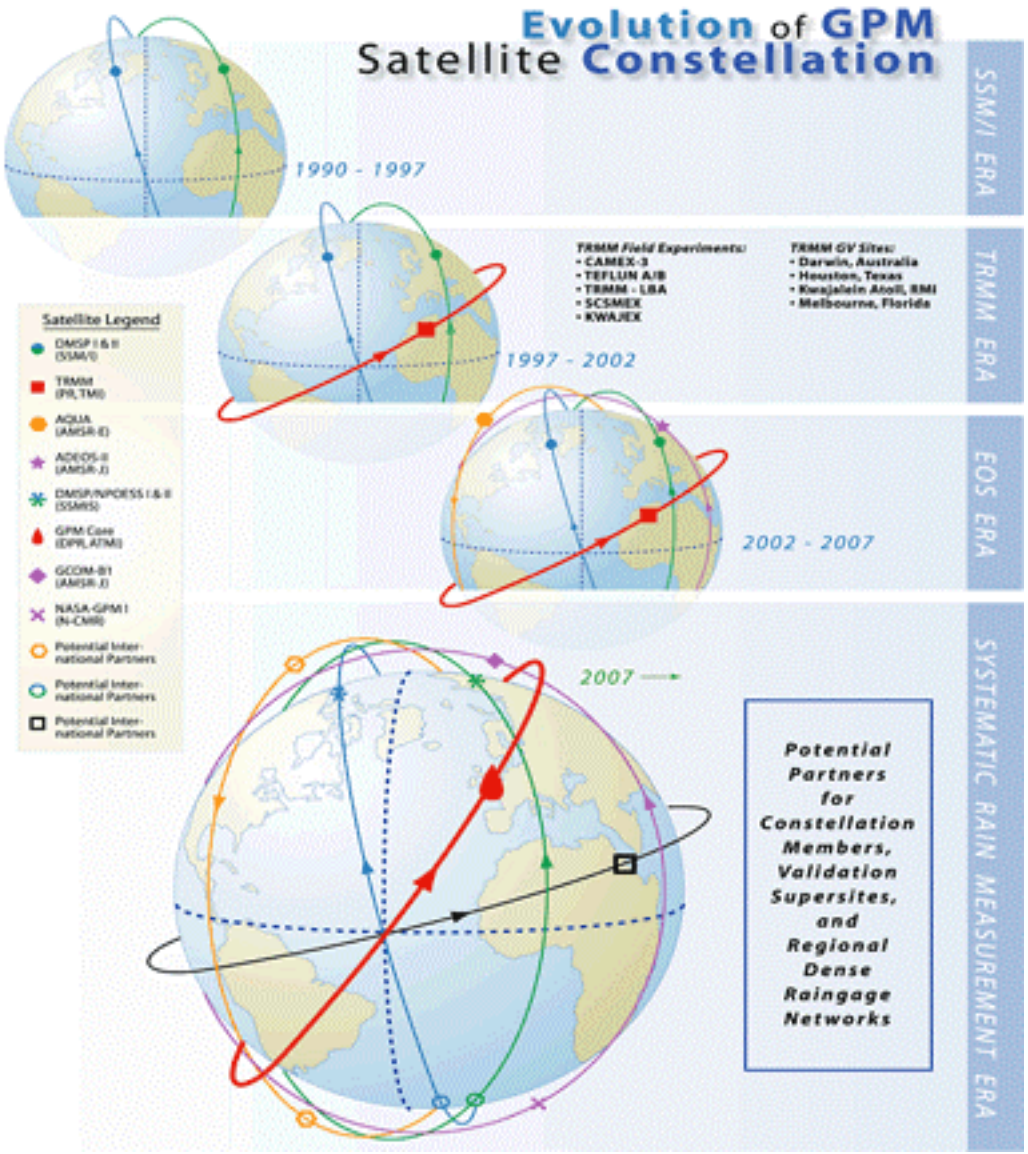
Observation area with MWRs in 3 hours (1, 2, 4 and 8 satellites from top to bottom)

Coverages by **TRMM PR** and **GPM DPR** in a day

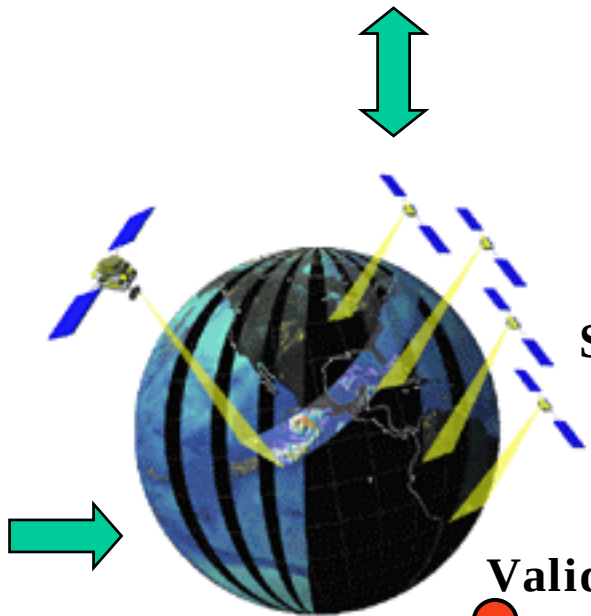




GPM Will Be a Flexible Mission



Flexibility of GPM Allows Mission to Adapt to New Partner Contributions at Any Time!



Const. Satellites

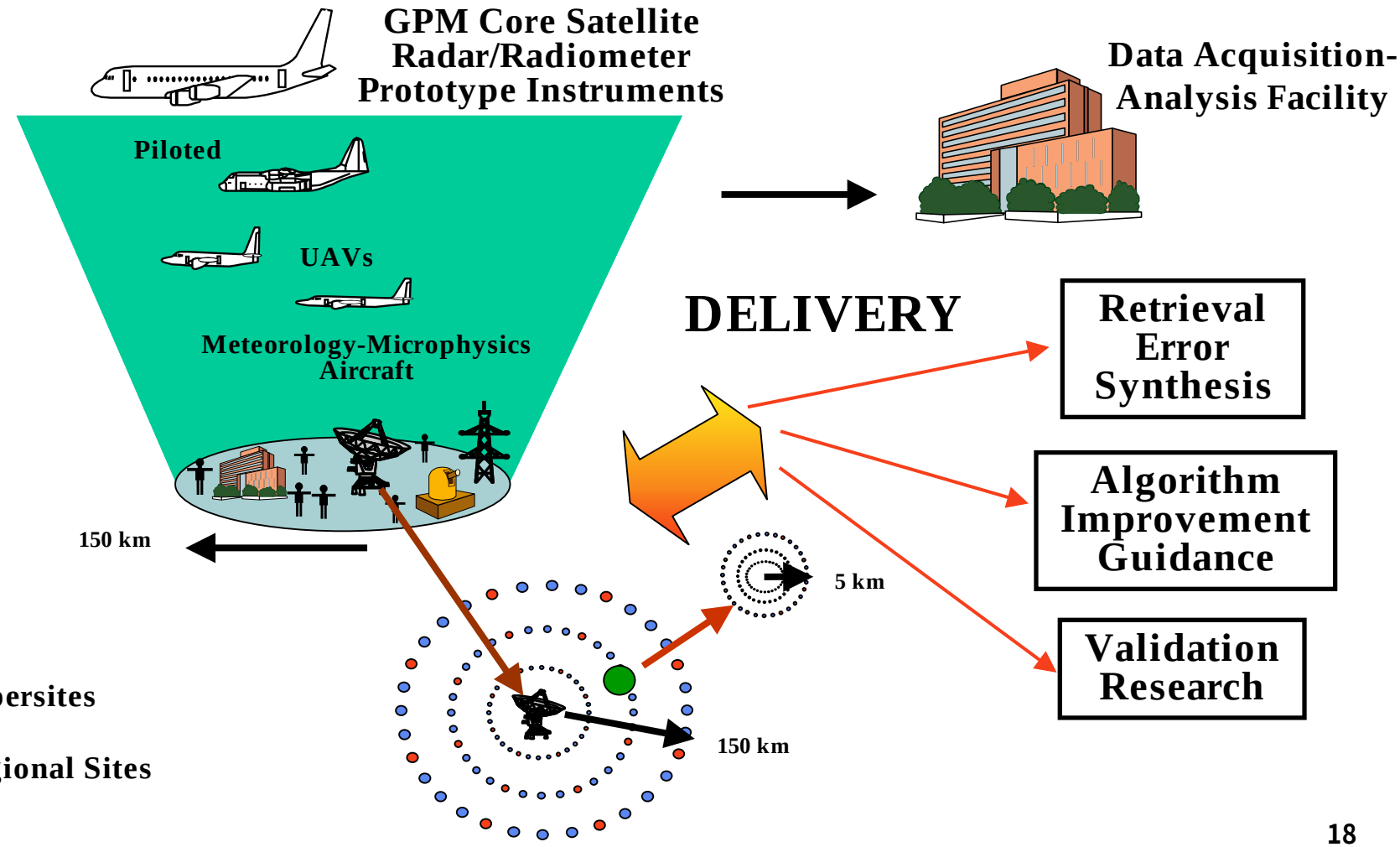
Validation Sites

Data Acquisition-Analysis Facility

Partnership Opportunities Exists in Areas Beyond Spacecraft Hardware or Instruments

1. Validation Efforts

2. Data Systems, Archival, and Distribution



Scientific and Social Significance of GPM

Precision brought by DPR

- High sensitivity to detect weak rain and snow
- Accurate estimation of rainfall rate
- Separation of snow from rain
- Progress in cloud physics

Global rain map in every 3 hours by GPM

- Climate change assessment

  monitor variations in rainfall and rain areas associated with climate changes and global warming

- Improvement in weather forecasts

  Quasi-real-time assimilation of data in numerical prediction models,

  Improved flood prediction

- Water resource management

  river, dam, agricultural water, etc.

- Agricultural production forecasting