Global Precipitation Data Sets

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(with thanks to Phil Arkin, Scott Curtis,
Kit Szeto, Ron Stewart, etc)

April 30, 2009
Toronto

Roles of global precipitation products in drought studies:

1.Understanding climate processes: Precipitation plays an important role in removing moisture from the atmosphere. This affects the profile of atmospheric moisture and its horizontal distribution.

2. Estimating hydrologic impacts during droughts: Precipitation recharges surface water systems including soil moisture changes, effects on vegetation, ecosystems and societies and changes in ocean salinity.

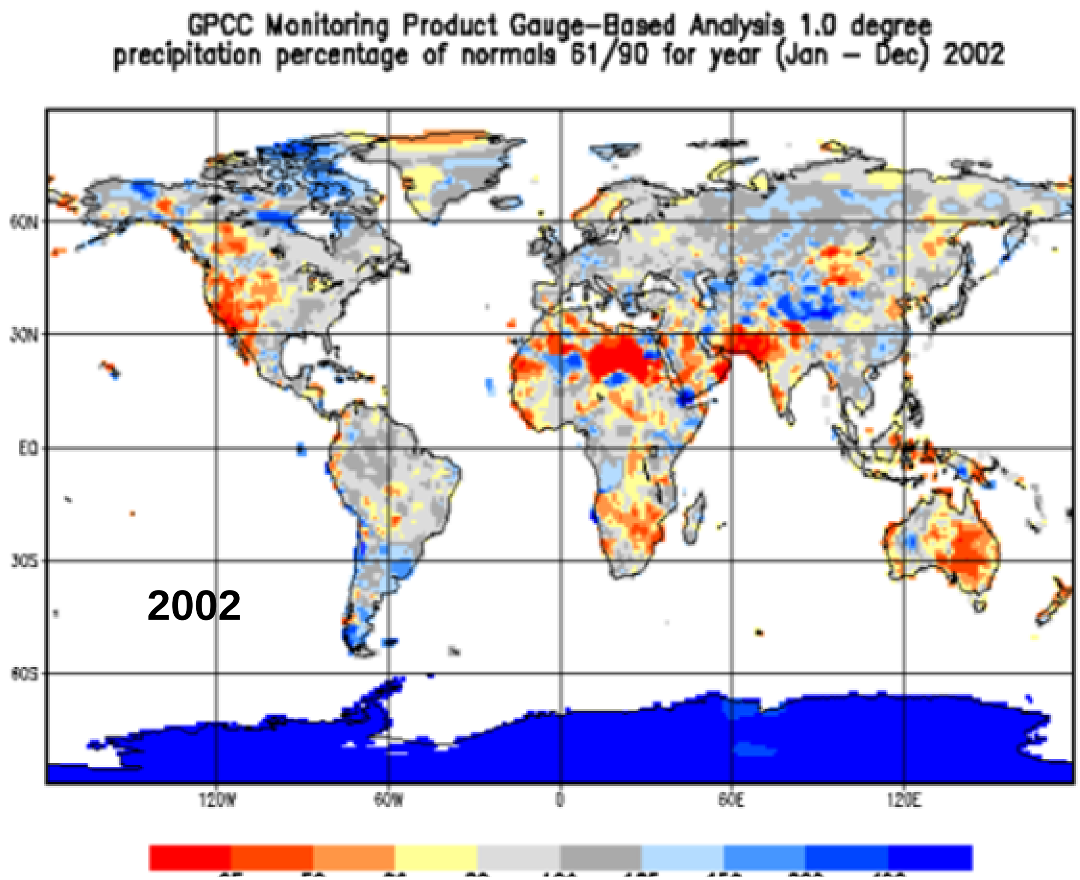
3. Identifying the location and extent of drought.

4. Asse … get.

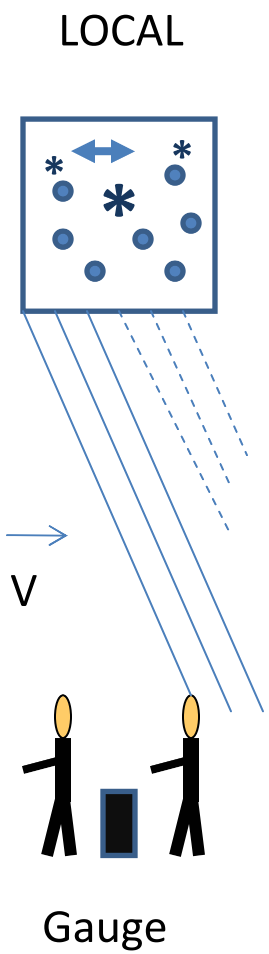
5. Asse … in our ability to close the …

6. Evalu … the ability of climate mod…

7. Und… n events embedded in the …



Scale is a major factor in monitoring and predicting precipitation. Larger scales must be understood to provide context and boundary conditions for local/regional drought.



GLOBAL DATA SETS CONSIDERED IN THIS TALK

1. Global Precipitation Climatology Centre (GPCC)
2. Global Precipitation Climatology Project (GPCP)
3. CPC Merged Analysis of Precipitation (CMAP)
4. Global Satellite Mapping for Precipitation(GSMap)
5. NASA Tropical Rainfall Measuring Mission (TRMM) Multi-Satellite Precipitation Analysis

Evaluation of global products

The future:
Global Precipitation Measurement (GPM)

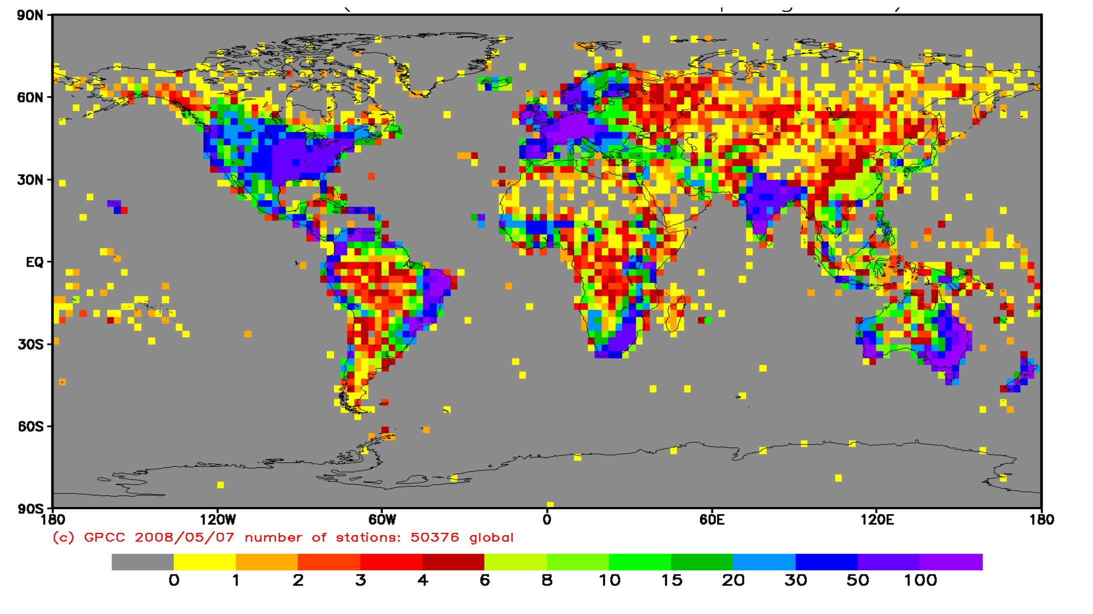
GPCC

The Global Precipitation Climatology Centre (GPCC) is operated by the Deutscher Wetterdienst (DWD) since 1989 following the invitation of the World Meteorological Organisation (WMO). GPCC is integrated in the Global Climate Observing System (GCOS) and in the World Climate Research Programme (WCRP).

The task of the GPCC is:

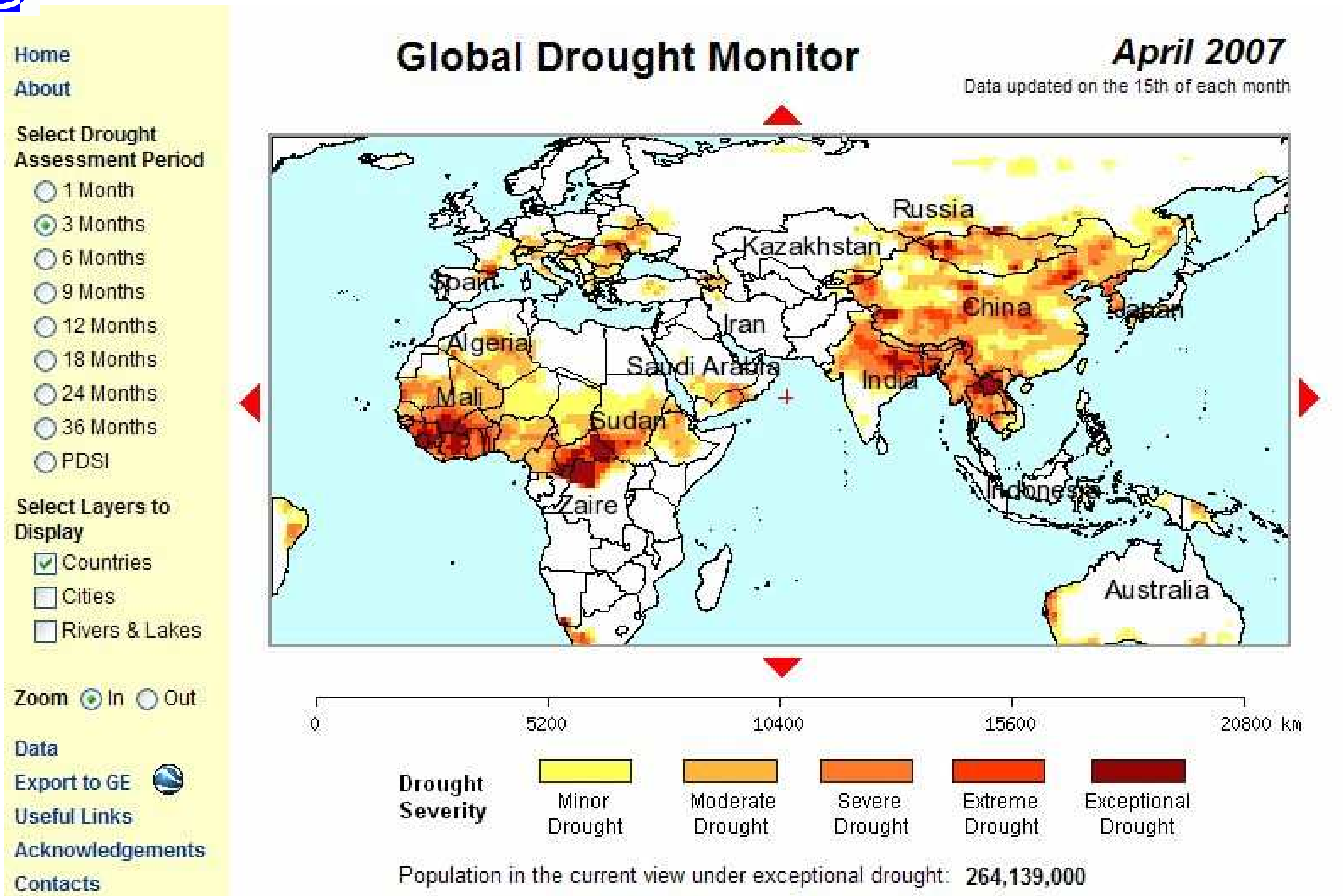
- **to analyse monthly global land-surface precipitation**
- **in its spatio-temporal distribution**
- **based on *in situ* observed data.**

Non Real Time Obs



Green and blue colours indicate grids with data coverage sufficient to meet the GPCC criterion: Sampling error < 10 %

GPCC Products and User Applications



Operational <u>GPCC First Guess Product</u> based application for the „Global Drought Monitor" of the UCL Hazard Research Center (Web: http://drought.mssl.ucl.ac.uk)

GPCC Products

Strengths:

- Integrate most major global precipitation databases
  and of data contributions from most countries of the world
  >70,000 stations
- Products are quality controlled and error assessment of observation
  data from different sources and related metadata
- Applies specific analysis products

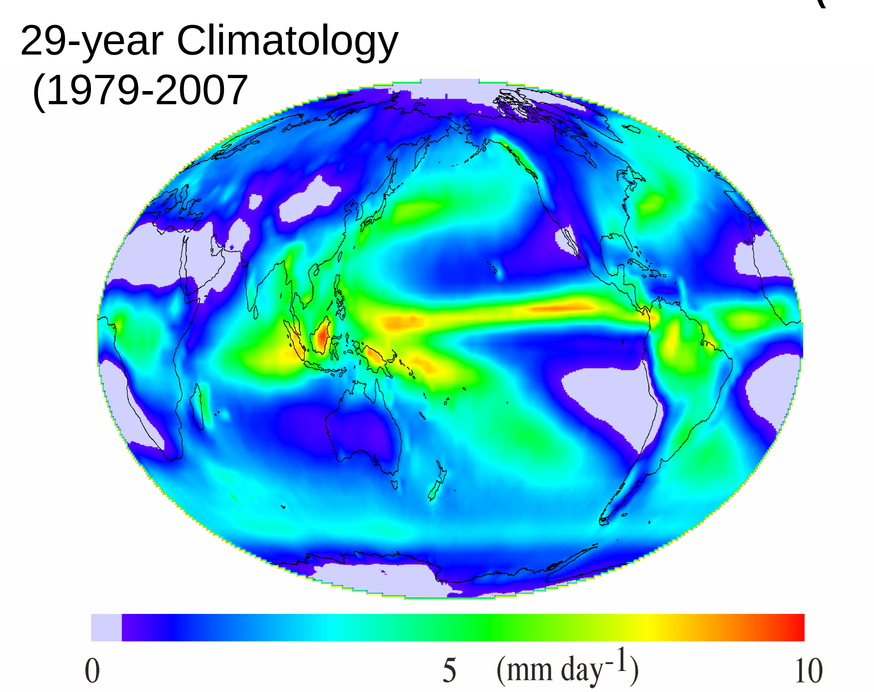
Limitations:

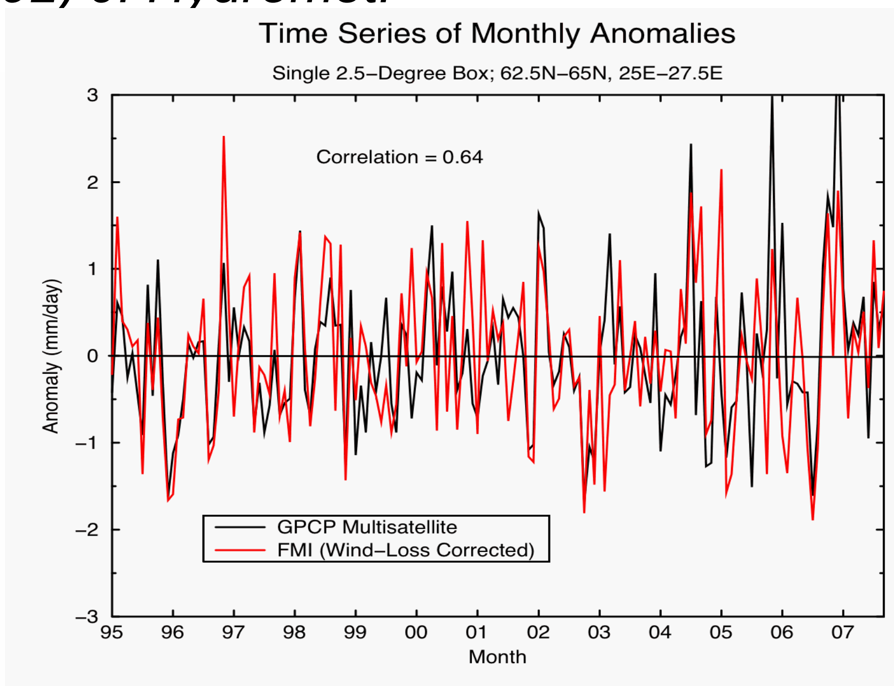
- Covers only land areas
- Coverage is non-uniform
- Allows access to data products but not the raw data

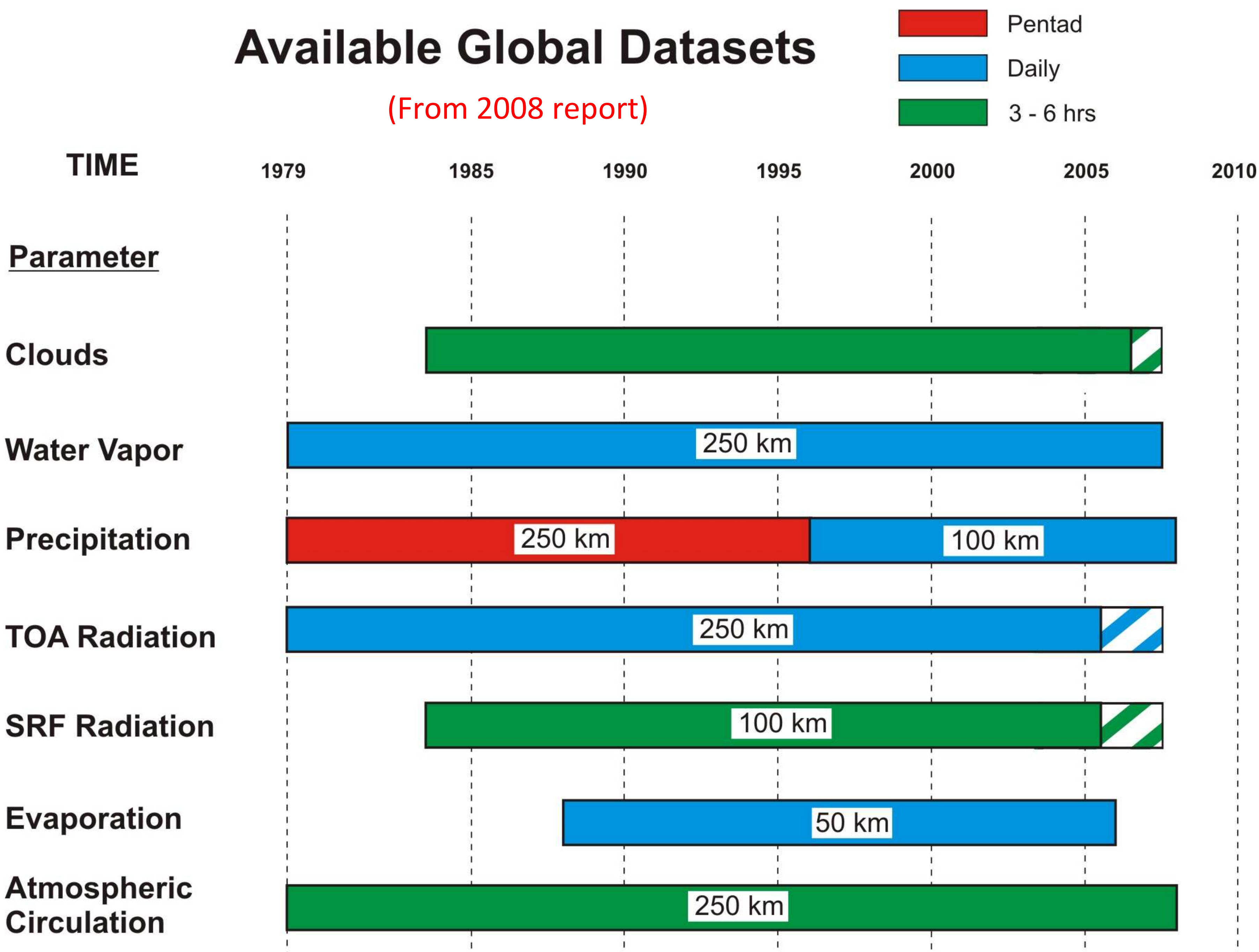
GPCP Global Precipitation Products

NASA, NOAA, DWD, UMD, CUHK, others

- Monthly, 2.5° Merged Analysis (1979-present)
  Adler et al. (2003), J. Hydromet.
- Pentad, 2.5° Merged Analysis (1979-present)
  Xie et al. (2003) J. Climate
- Daily, 1° Merged Analysis (1997-present)
  Huffman et al. (2001) J. Hydromet.

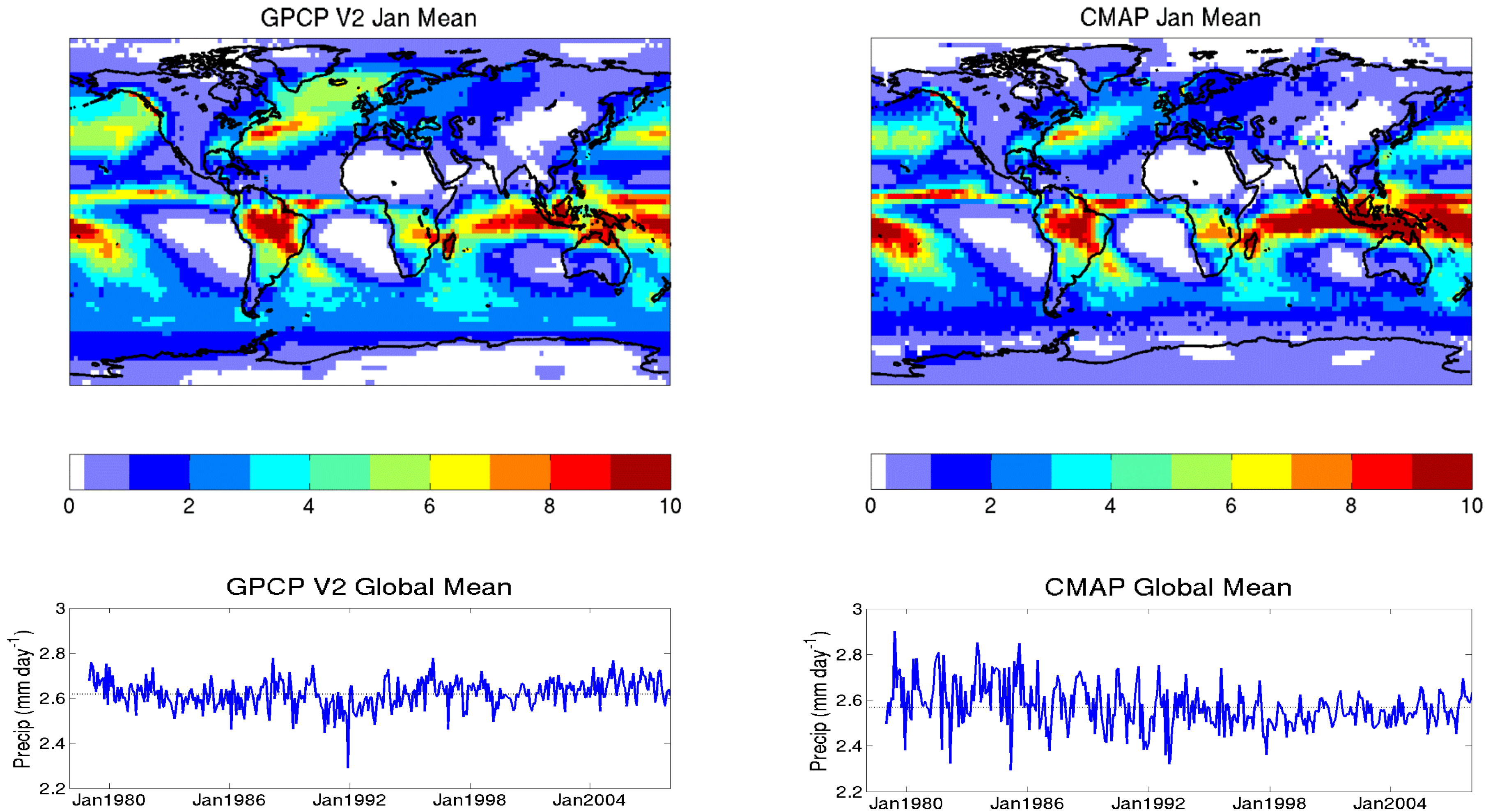






Available Global Datasets
(From 2008 report)
Pentad
Daily
3 - 6 hrs
TIME
1979
1985
1990
1995
2000
2005
2010
Parameter
Clouds
Water Vapor
250 km
Precipitation
250 km
100 km
TOA Radiation
250 km
SRF Radiation
100 km
Evaporation
50 km
Atmospheric Circulation
250 km

Global Precipitation Climatologies



- GPCP (left)/CMAP (right) mean annual cycle and global mean time series
- Monthly/5-day; 2.5° lat/long global
- Both based on microwave/IR combined with gauges

Global Precipitation Climatology Project (GPCP)

Strengths:

1. It provides global coverage including oceans as well as land.
2. The length of record (30 years) provides a basis for comparative analysis.

Limitations:

1. The spatial resolution of the products have been too coarse to deal many types of extremes and applications although it seems to be adequate for drought.
2. The characterization of errors is incomplete,
3. Many of the techniques are dated because they are based on 1979 technologies.
4. It is a challenge to achieve temporal homogeneity in view of changing mix of satellites.

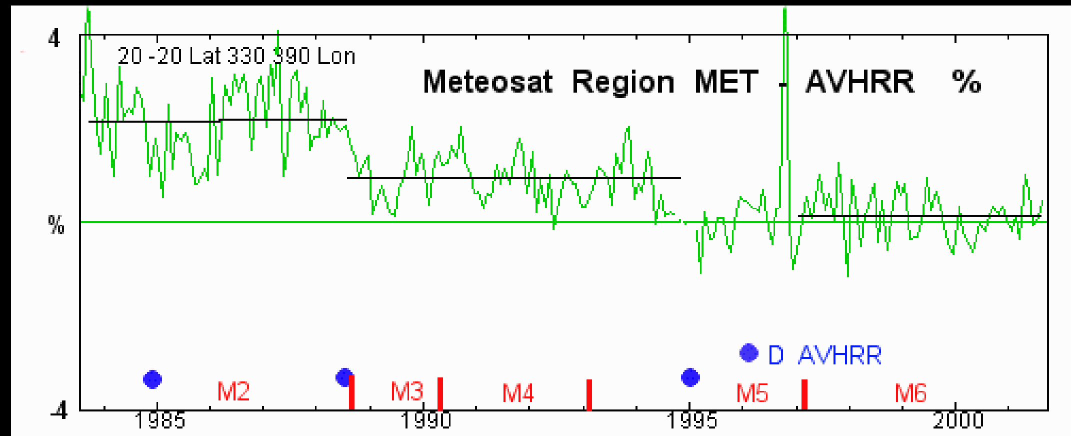
The strengths and weaknesses of the CMAP products are very similar to those of GPCP products. However, differences do arise because CMAP products are Calibrated using data from different regions. In addition, CMAP uses an IR-based product derived from anomalies in OLR, and one version uses precipitation from the NCEP reanalysis as an additional input

DEVELOPING LONG-TERM HOMOGENEOUS DATA SETS

FACTORS WORKING AGAINST HOMOGENEITY INCLUDE:

- CHANGES IN SATELLITE PLATFORM
- DETERIORATION OF SATELLITE FUNCTION OVER TIME (ORBIT DRIFT, SENSOR DEGRADATION, ETC)

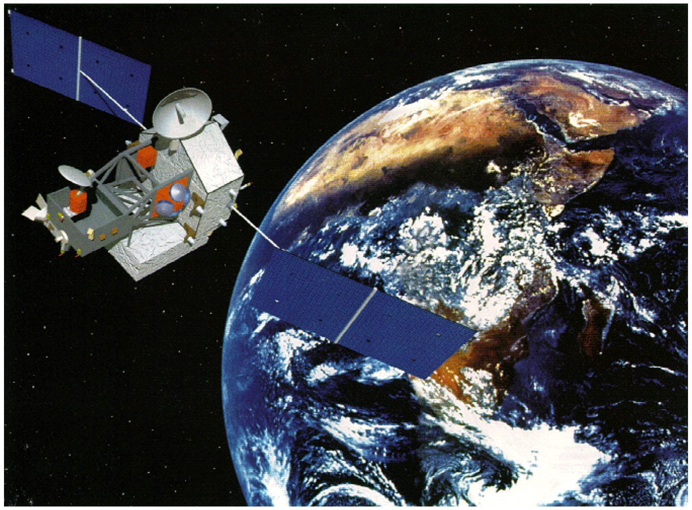
Meteosat - AVHRR



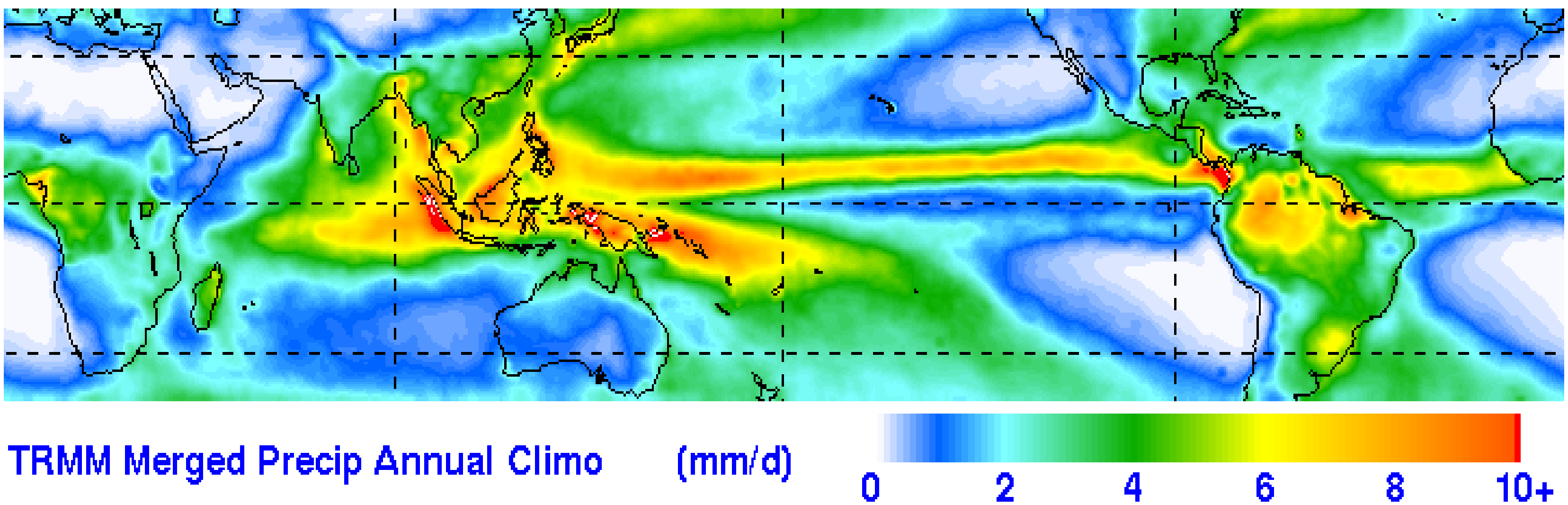
Cloud anomalies (METEOSAT – GEO) over the equatorial region show a “stair-step” when GEO sensors changed. (Campbell and von der Haar)

GEWEX IS DEVELOPING PLANS FOR PRODUCT REANALYSIS THAT WILL LEAD TO BETTER TECHNIQUES FOR THE DEVELOPMENT OF HOMOGENEOUS DATA SETS FROM SATELLITE DATA.

The Tropical Rainfall Measuring Mission (TRMM) has now been providing high resolution data for 10 years

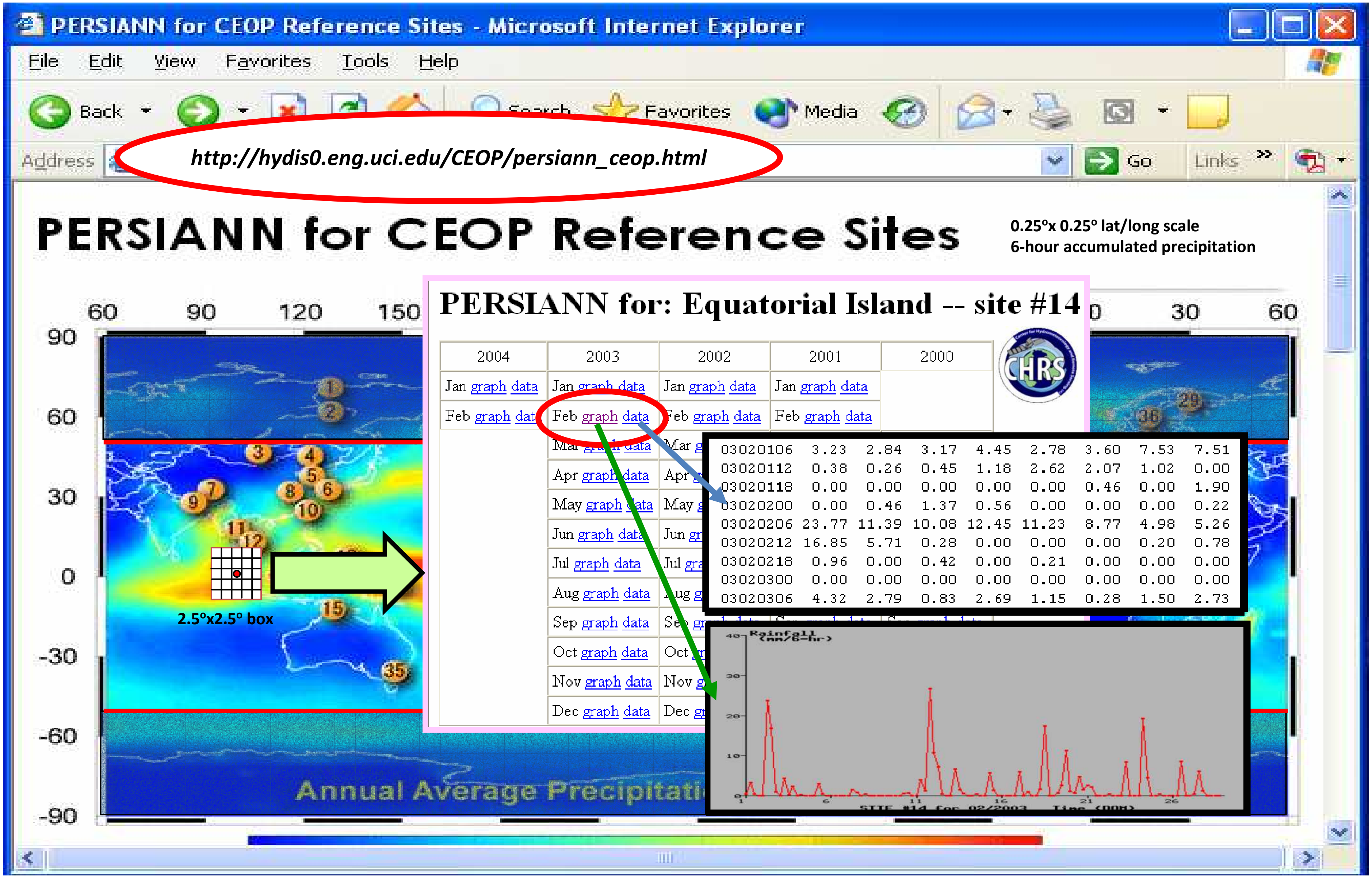


TRMM was launched in November 1997 by NASA and JAXA with a space-borne radar and a "high-resolution" microwave imager on-board to improve tropical precipitation measurements from space. This mission was intended to last for 3 years. However, as a result of robust sensors and public opinion about the value of these data this system has continued to provide valuable information for the past decade.



(Bob Adler) --see *trmm.gsfc.nasa.gov*

PERSIANN Data for CEOP Reference Sites



TRMM Multi-Satellite Precipitation Analysis

Strengths:

1.High resolution allows for the identification of precipitation events that may be missed by the gauge network.

2. The active sensing provides 3-D imagery of the precipitation patterns.

Limitations:

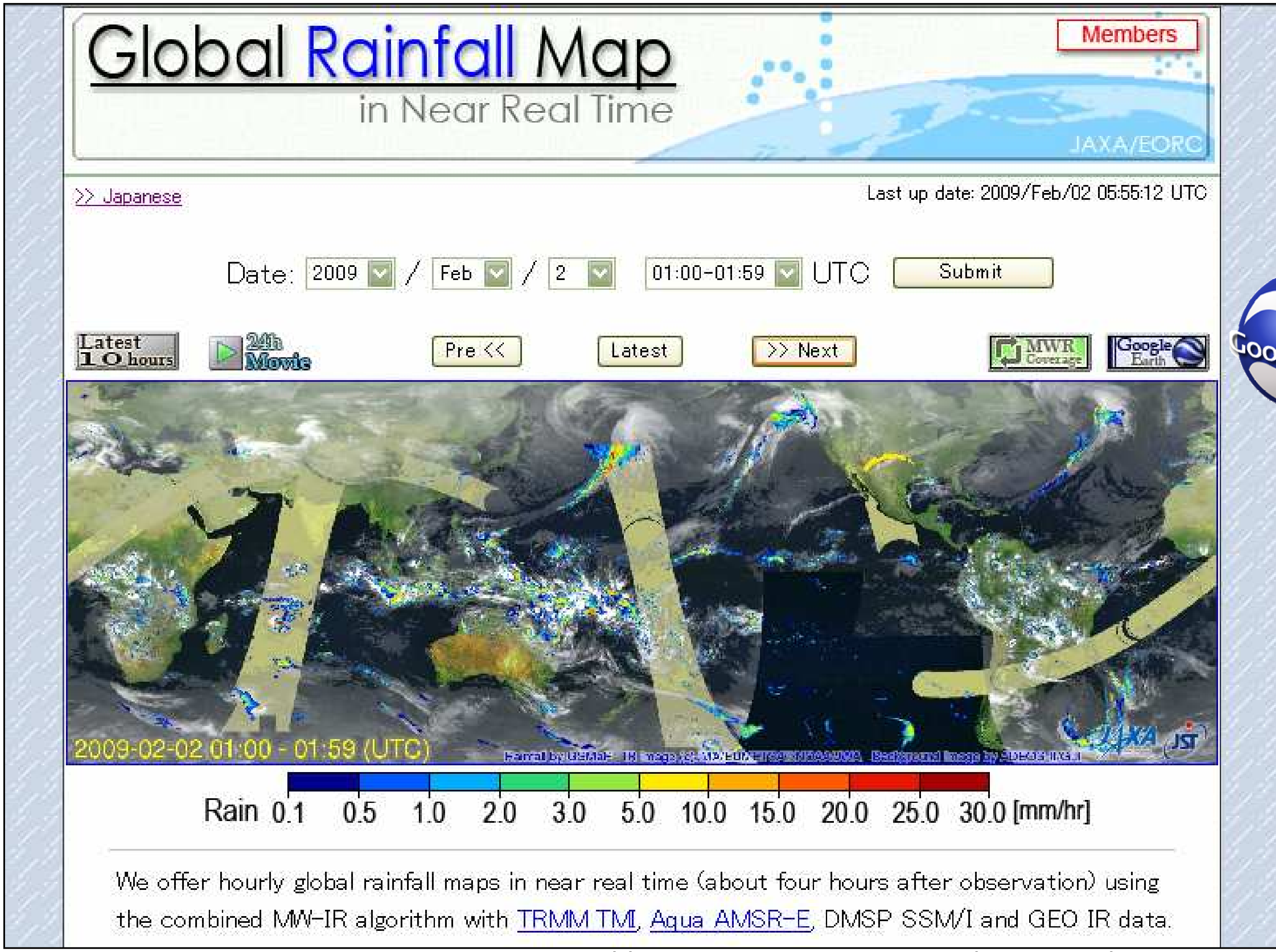
1.The record is only 10 years so it is relatively short for comparative studies.

2.The coverage only extends between 30N and 30S

3.The algorithm to go from the instantaneous measurements to rainfall amount has some significant limitations.

4. Products based on composites and therefore "noisy"

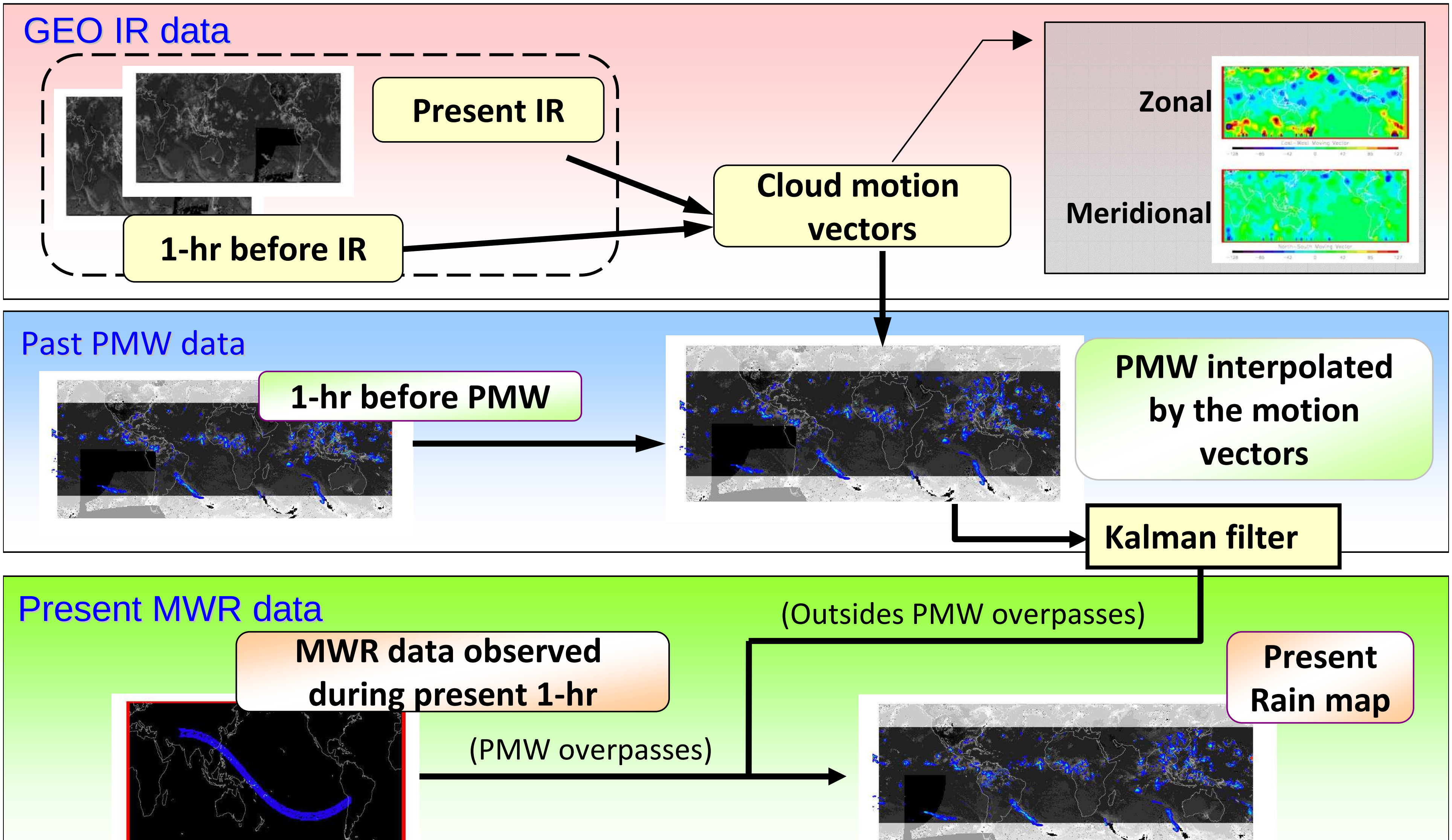
GSMap (Global Satellite Mapping for Precipitation) an hourly global rainfall product



http://sharaku.eorc.jaxa.jp/GSMaP/

PMW – Passive Microwave Radiometers

Flowchart of GSMaP algorithm



(Ushio et al., 2009)

IPWG/IGWCO Program for the Evaluation of High Resolution Precipitation Products (PEHRPP)

- A comprehensive hypothesis-based collaborative effort to understand the capabilities and characteristics of these new HRPP (High Resolution Precipitation Products)

Intercomparisons:

- Suite 1: Continental/Regional Comparisons
- Suite 2: High time resolution comparisons over selected limited regions
- Suite 3: Very high quality field program data sets
- Suite 4: "Big picture" comparisons

Preliminary Results:

Adding geostationary IR improves HRPP

“Morphing” appears to work well more consistently than other methods of utilizing IR

Adding monthly gauge information improves daily statistics

Model forecasts of precipitation correspond better to gauge-based analyses in cold and/or high latitude regimes

Observations

Many issues related to satellite-derived precipitation estimates:

- Solid precipitation – snow, etc.
- Magnitude of tropical rainfall
- Light precipitation – drizzle, fog, cloud liquid water

Broader issues related to global precipitation data sets:

- Temporal stability – critical to understanding global climate change
- Sustainability of integrated global precipitation data sets
- Sustainability of critical observations – both satellite and in situ

The Global Precipitation Measurement (GPM) Mission

Specifically designed to unify and advance precipitation measurements from a constellation of dedicated and operational satellites for research & applications

- *advanced active & passive microwave measurements to establish a reference standard*
- *a consistent framework for inter-satellite calibration*
- *international collaboration in algorithm development and ground validation*

GPM Low-Inclination Observatory (NASA) for enhanced mid and low-latitude sampling

- *2^{nd} GMI at 40^o inclination and 635 km altitude*
- *Improved near real-time hurricane monitoring*

Partner Constellation Satellites:

GCOM-W
DMSP-F18, F19
Megha-Tropiques
NOAA-N'
NPP
MetOp-B
NPOESS-C1

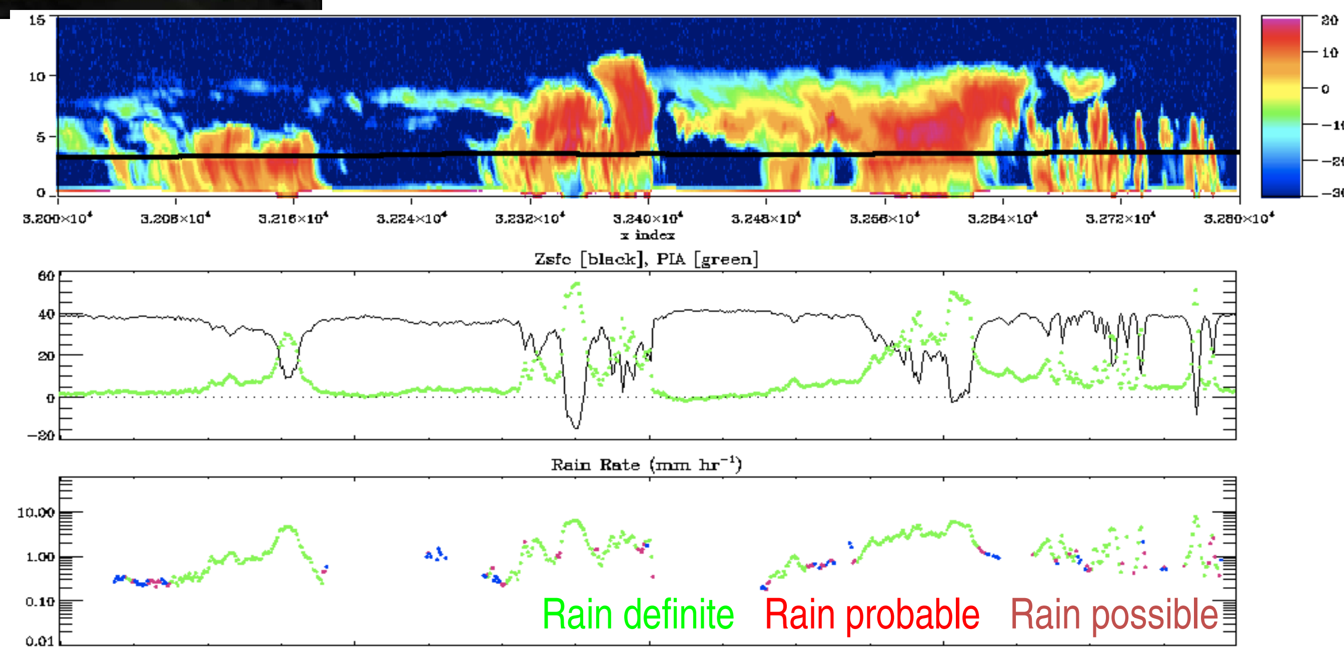
GPM Core Observatory (NASA-JAXA) serving as a physics observatory and a calibration reference

- *Dual-frequency Precipitation Radar (DPR) at Ku-Ka bands and a 10-183 GHz GPM Microwave Imager (GMI) at 65^o inclination and 407 km altitude*
- *"Next-generation" precipitation measurements*

✓ *Increased sensitivity for light rain and snow detection*
✓ *Better overall measurement accuracy*
✓ *Uniform calibration of brightness temperatures of Constellation sensors*
✓ *Detailed microphysical information and a common cloud database for rain & snow retrievals from Core and Constellation sensors*

Data from the new CloudSat Mission opens a new era of active remote sensing

Recently Cloudsat was launched. It measures the vertical structure of clouds and quantifies their ice and water contents as a step toward improved weather prediction and understanding of climatic processes. Cloudsat measures intensities of 0 – 1 mm/h which all other satellites cannot measure.

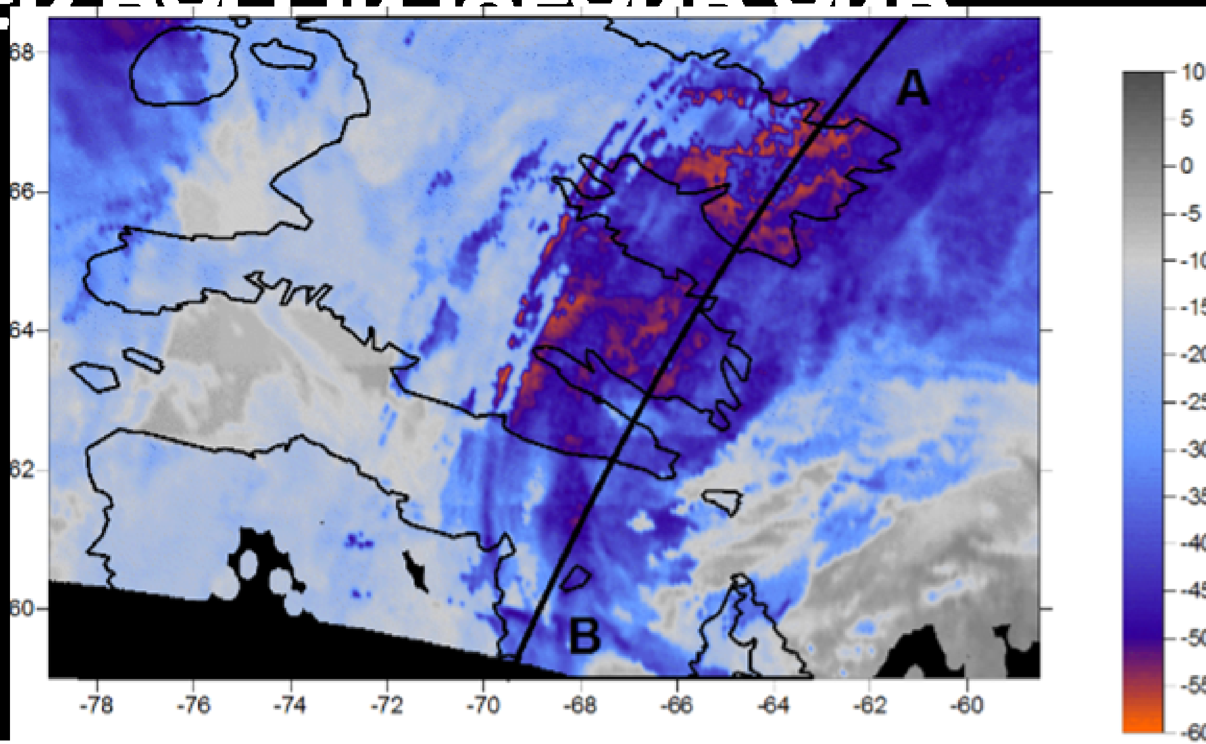


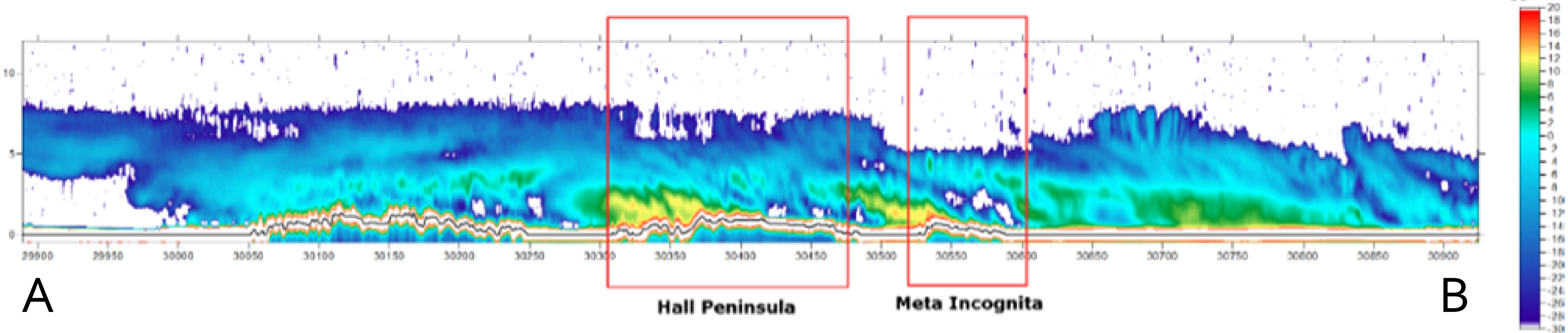
CLOUDSAT OVER BAFFIN ISLAND AND TOPOGRAPHY

(from Ron Stewart)

November 12, 2007

horizontal resolution = 1 km

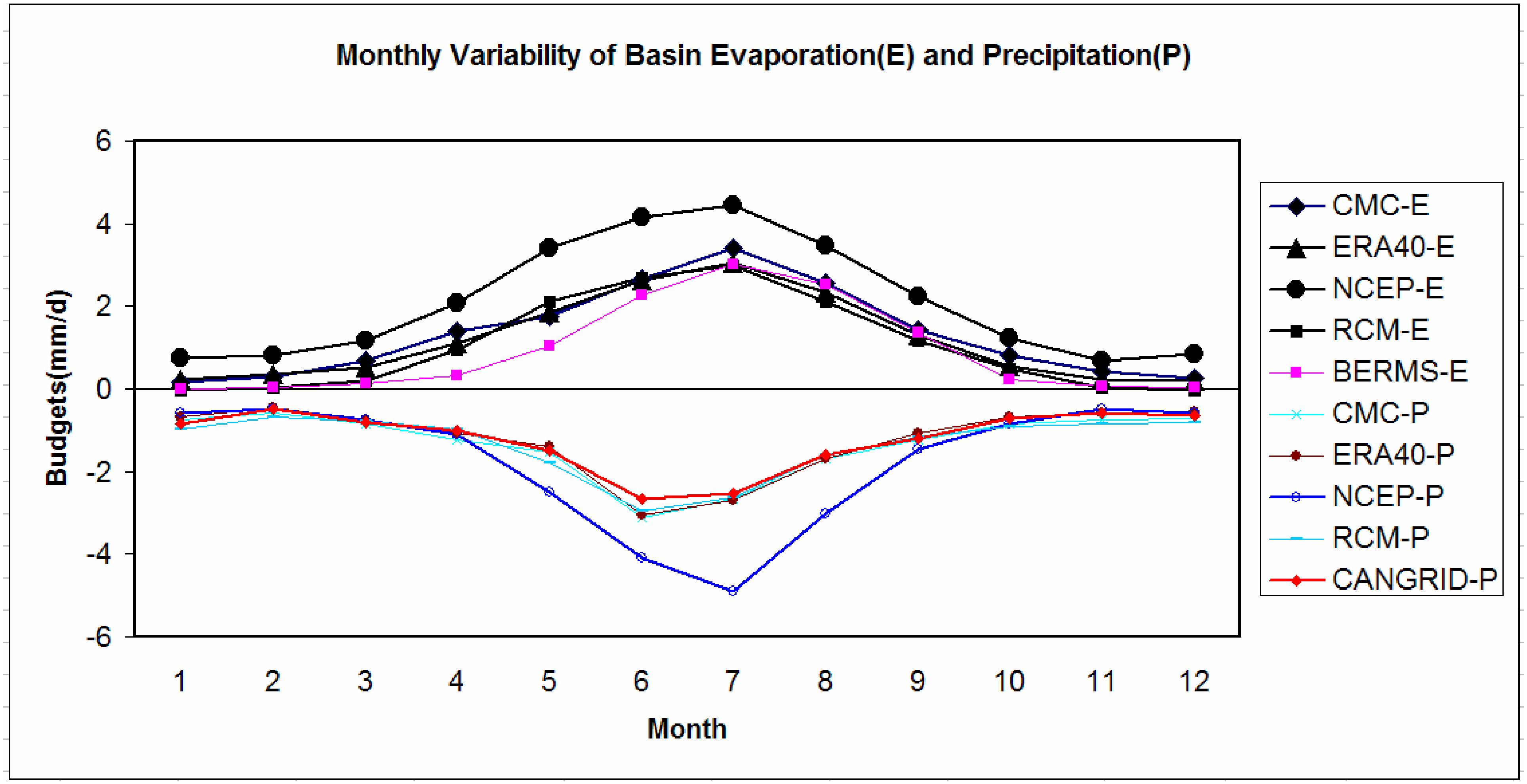




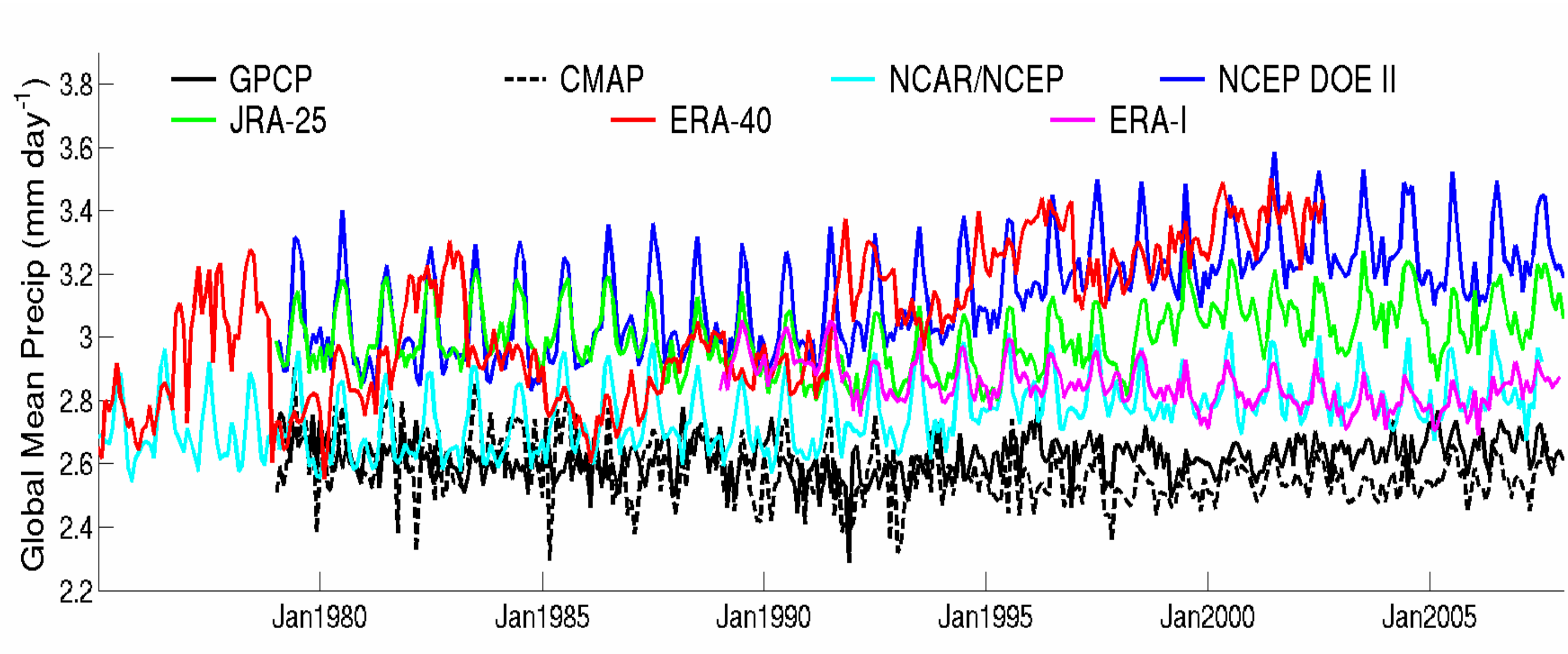
Model-derived estimates

- Precipitation is not a random occurrence - other atmospheric observations contain relevant information
  - Atmospheric winds, temperature, moisture largely determine where precipitation falls and how much occurs
- Physically based dynamical models of the atmosphere predict/specify precipitation in various ways
  - Numerical Weather Prediction models forecast precipitation
  - Assimilation of radiances can yield cloud, hydrometeor distributions
  - These can be used as "estimates" of precipitation
- Best where models best
- Accuracy strongly dependent on validity of modeled physical processes
- Examples: atmospheric reanalyses

Models give a range of results for simulated precipitation values (after Szeto)



Global Mean Precipitation from Reanalyses and Reconstructions (differences largest over oceans)



- Datasets based on observations (GPCP, CMAP) give about 2.6 mm/day (AR4 range is about 2.5-3.2 mm/day)
- Data assimilation products average about 3 mm/day; also have larger mean annual cycle and greater interannual variability than observation-based products
- ESRL-Compo/Whittaker SLP-based reanalysis is about 3.3 mm/day
- (figure courtesy Junye Chen, NASA/GMAO-MERRA)

Issues:

1. How can satellite data and integrated data products be most effectively used in the characterization of extremes?

2. How can Canada most effectively contribute to global precipitation products?

3. What types of precipitation data are most useful for the assimilation of precipitation in Canadian forecast models?

4. What type of research can Canada undertake to improve the ability to detect solid or light precipitation?