

Understanding the Earth's Water Cycle

The Role of Satellite Observations

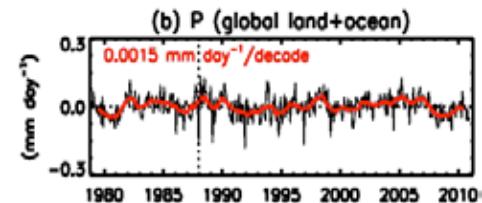
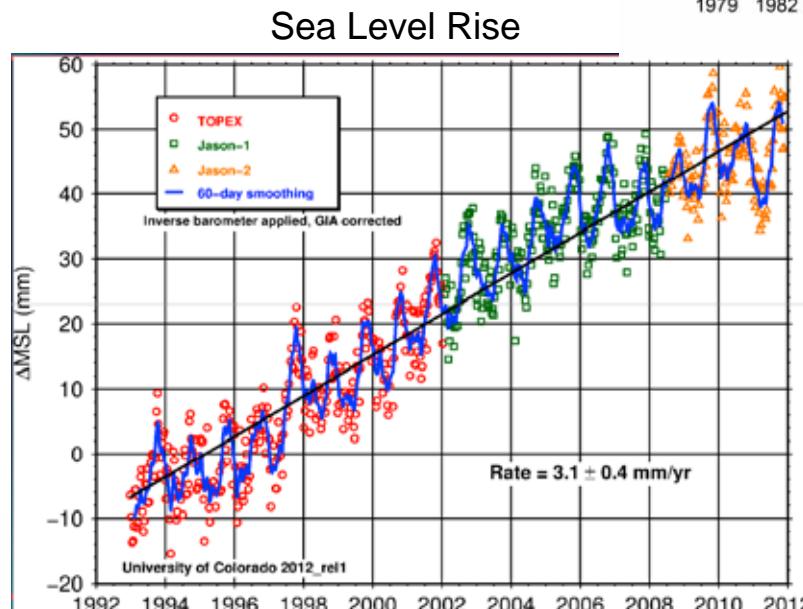
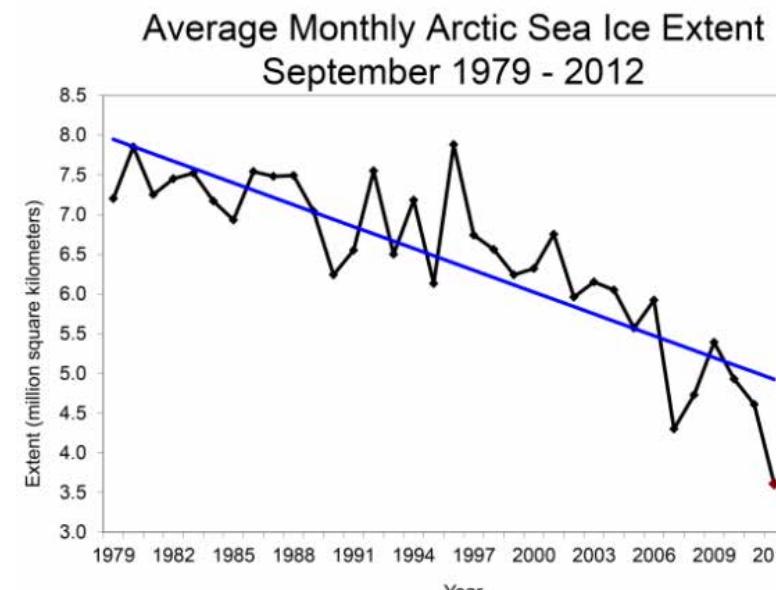
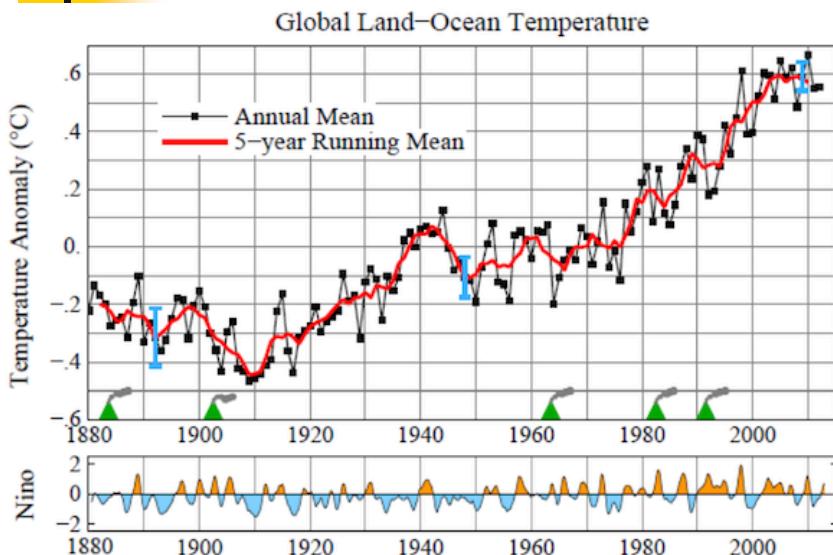
Water - a careful assessment of our Earth's precious resource



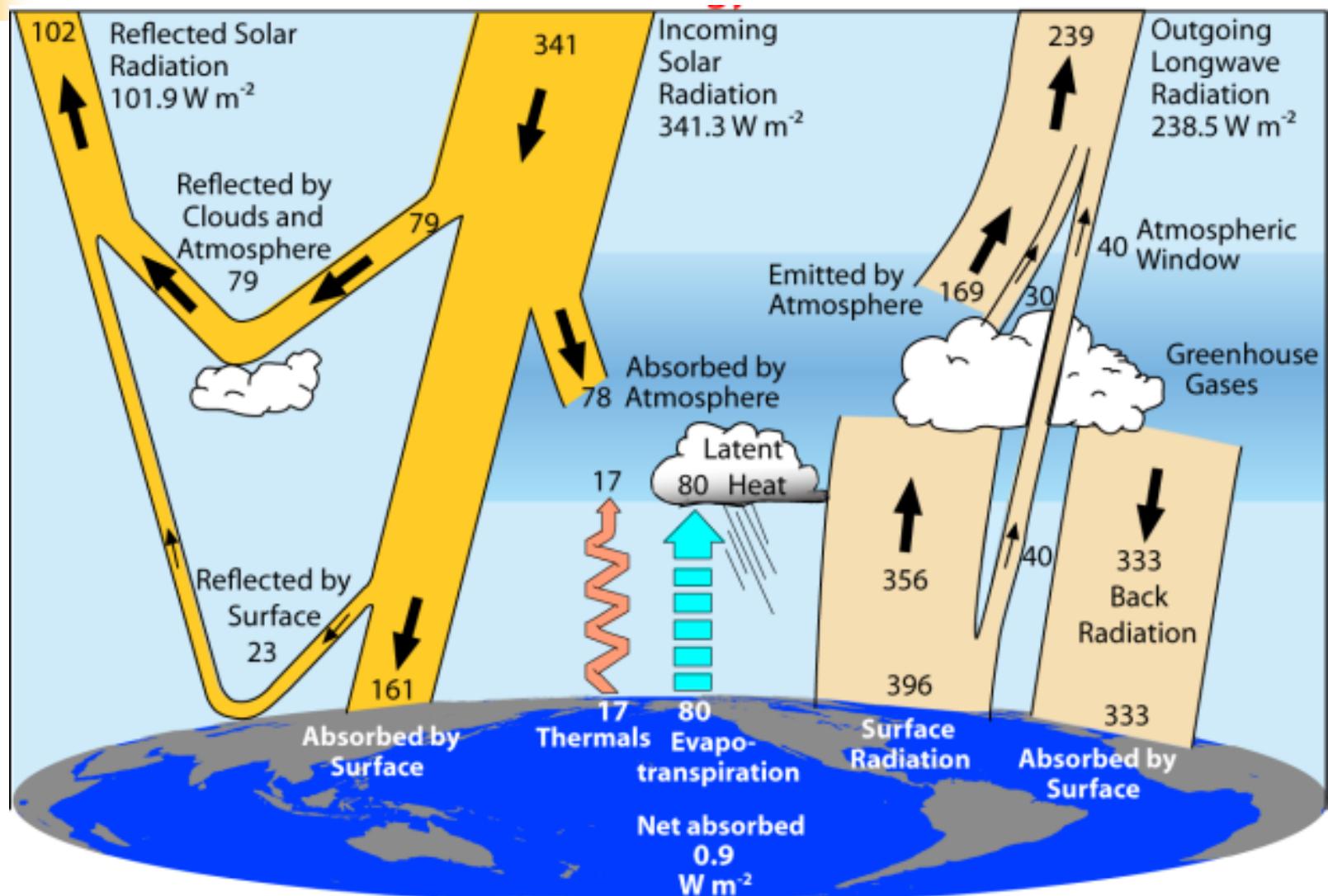
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February 19, 2015

Colorado
State
University

Observed Climate Trends



The Global Energy Flows



Trenberth, Fasullo and Kiehl,
Bull. Amer. Met. Society, 2009

The GEWEX Radiative Flux Assessment



GEWEX Radiative Flux Assessment (RFA)

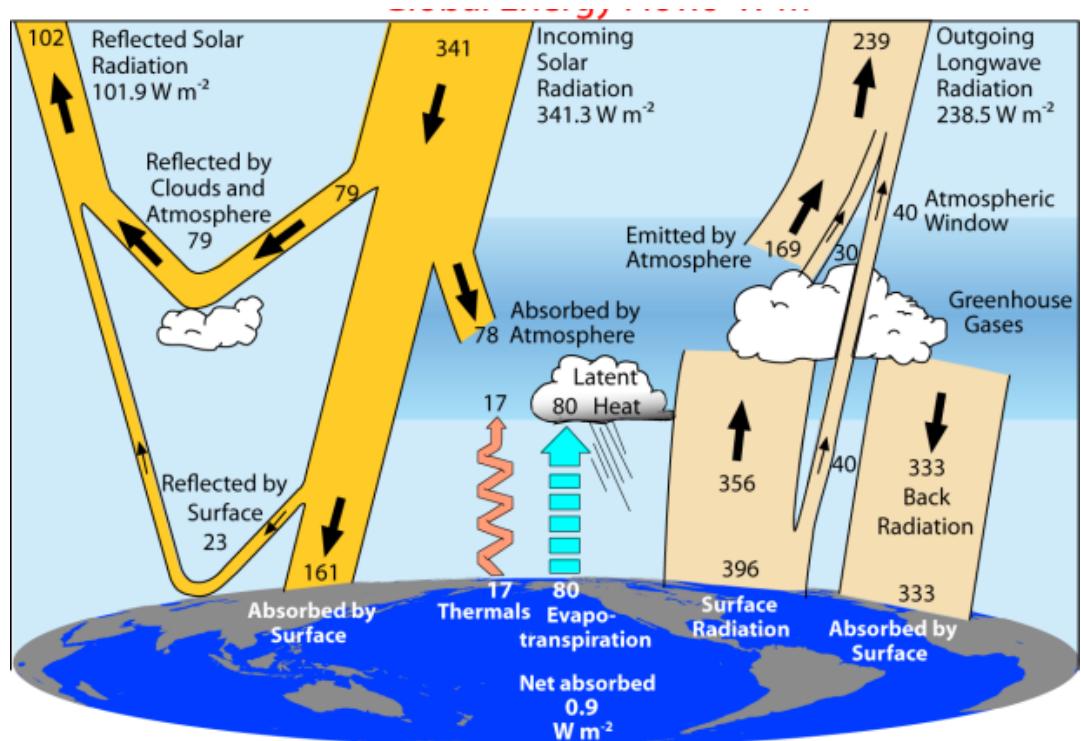
A project of the World Climate Research Programme
Global Energy and Water Cycle Experiment
(GEWEX) Radiation Panel

Lead Authors:

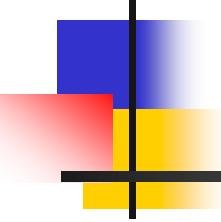
Ehrhard Raschke
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TFK	161	396	333
RFA	166.5	396.0	343.9



Why the Magnitude of Global Precipitation should be increased

- New global precipitation information from the CloudSat radar suggests that very light precipitation in the tropics has been missed by TRMM which could add up to 4% to the global rain.
- The total contribution from snowfall to the global precipitation is also not precisely known and has been excluded from previous global latent heat flux estimates. Based on new estimates of global snowfall, one can estimate up to 5% additional precipitation.
- The contribution from light rain over extra-tropical oceans is systematically underestimated by current estimates as shown by some authors, possibly adding up to 5% globally.

Tropical Rainfall Measuring Mission (TRMM)

Nov. 1997 launch, 35 ° inclination; 402

Precipitation radar (PR):

13.8 GHz
4.3 km footprint
0.25 km vertical res.
215 km swath

Microwave radiometer (TMI):

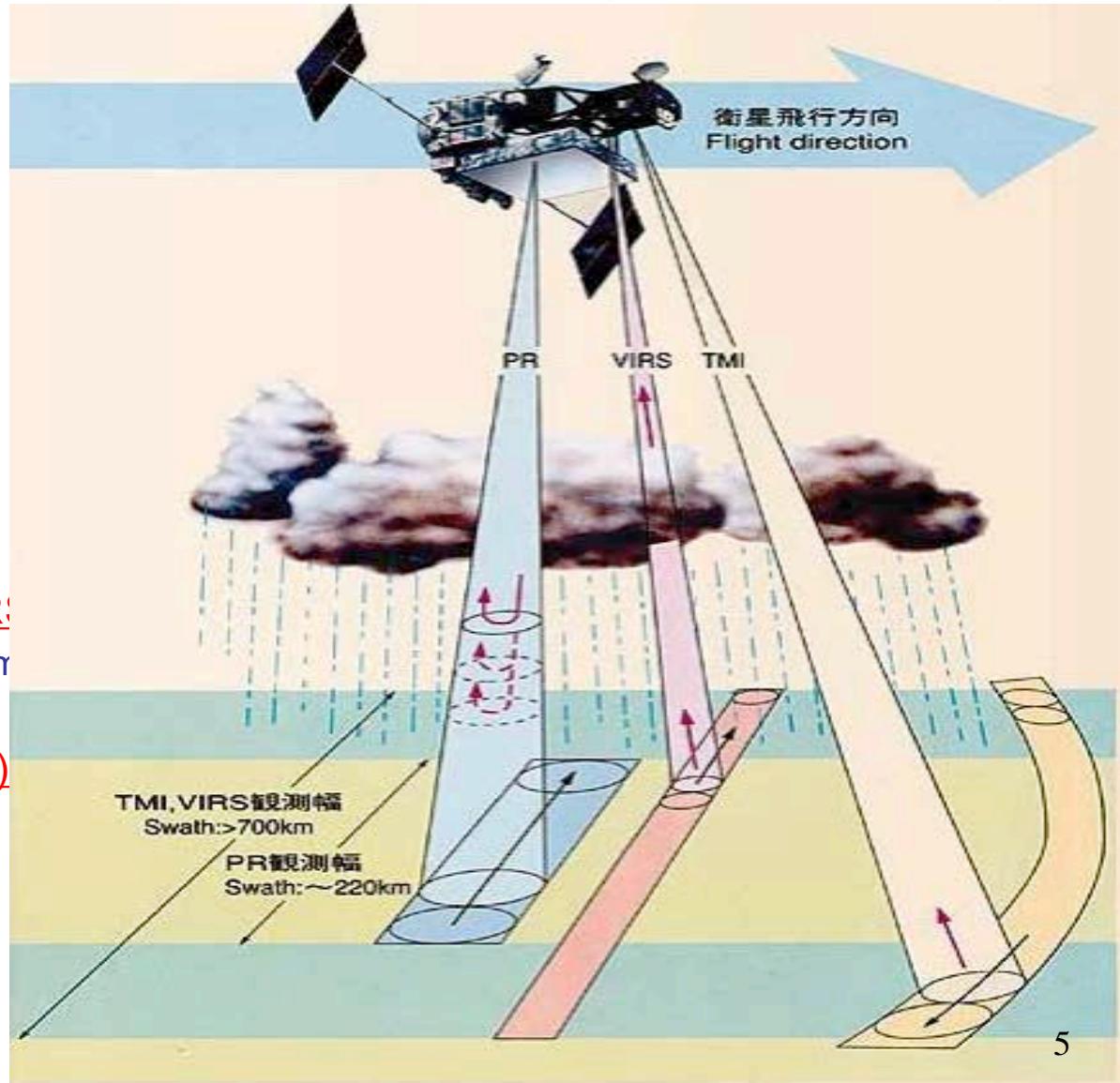
10.7, 19.3, 21.3, 37.0
85.5 GHz (dual polarized
except for 21.3 V-only)
10x7 km FOV at 37 GHz
760 km swath

Visible/infrared radiometer (VIRS):

0.63, 1.61, 3.75, 10.8, and 12 μ m
at 2.2 km resolution

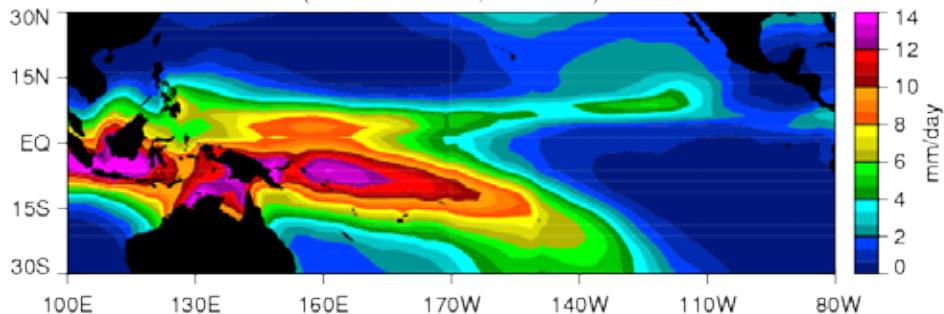
Lightning Imaging Sensor (LIS)

Cloud & Earth Radiant Energy System (CERES)

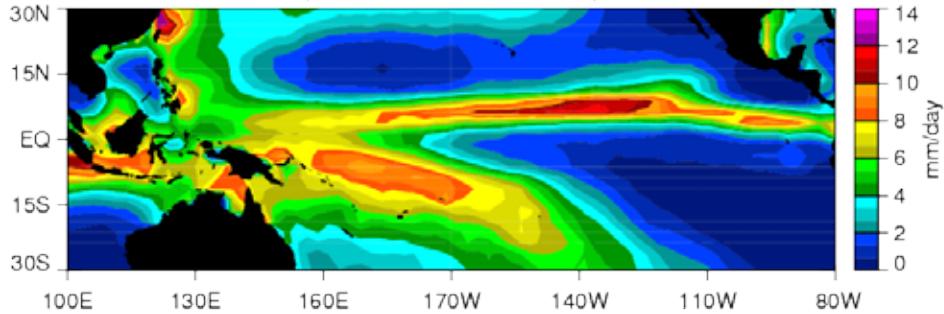


Historical Rainfall Estimates and TRMM

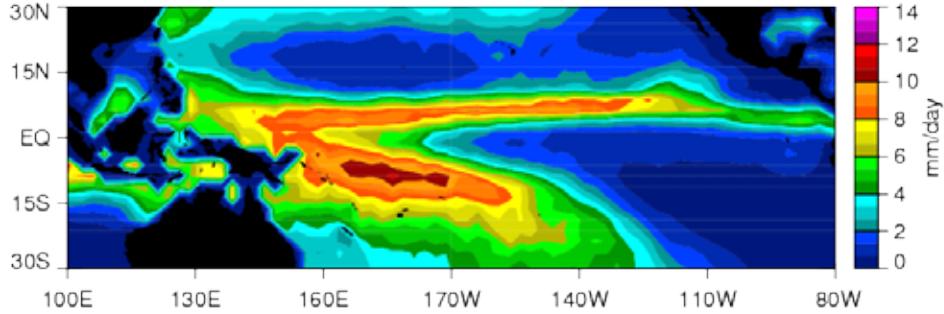
GPI (Arkin and Meisner)
(DJF 1986 - 2003, 53 months)



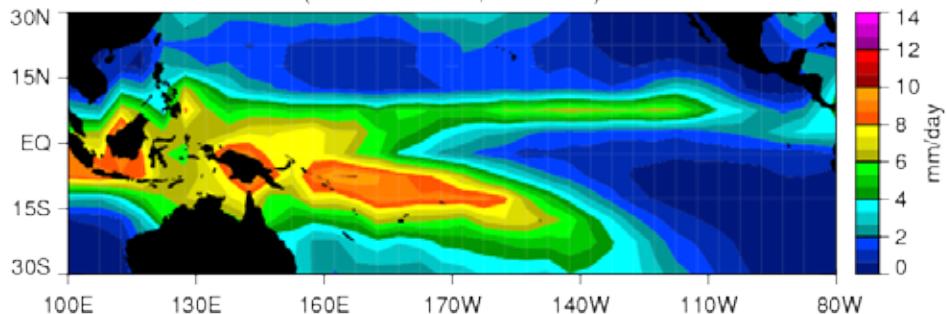
MSU (Spencer)
(DJF 1979 - 1997, 56 months)



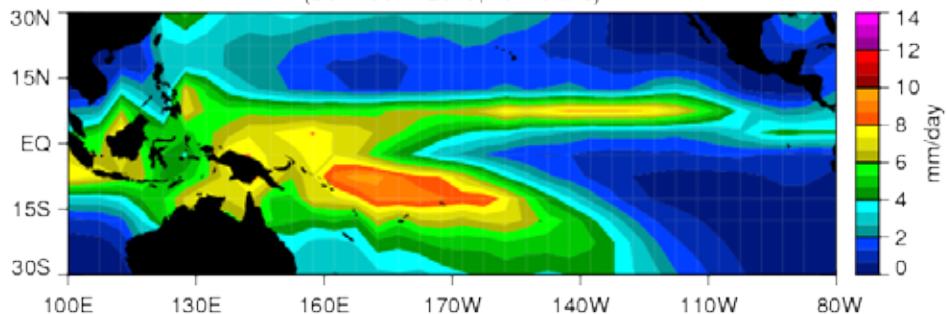
SSM/I Emission (Wilheit and Chang)
(DJF 1987 - 2007, 61 months)



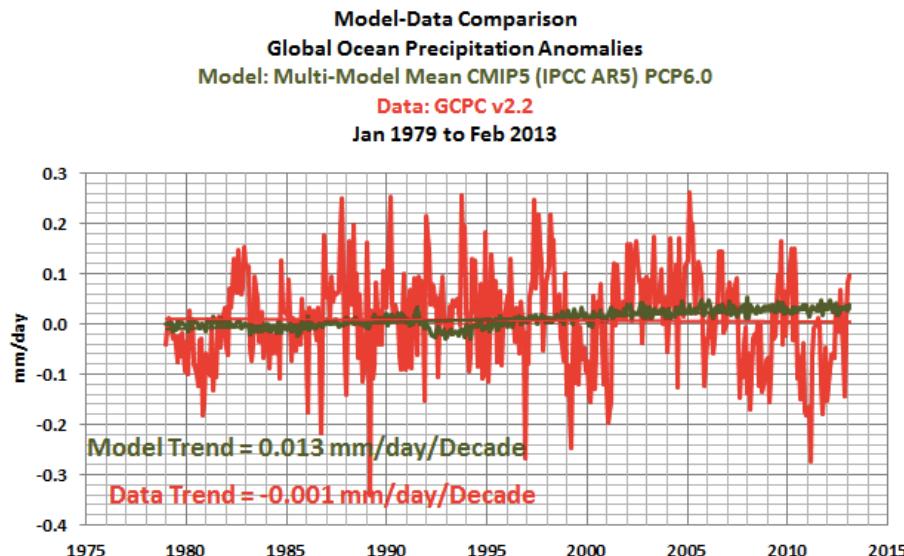
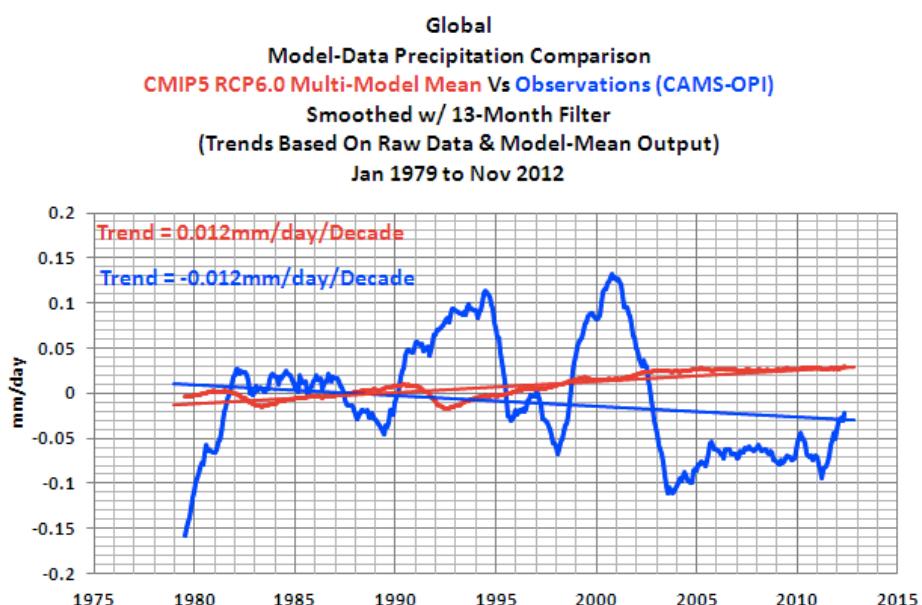
TRMM Precipitation Radar (3A25)
(DJF 1997 - 2013, 48 months)



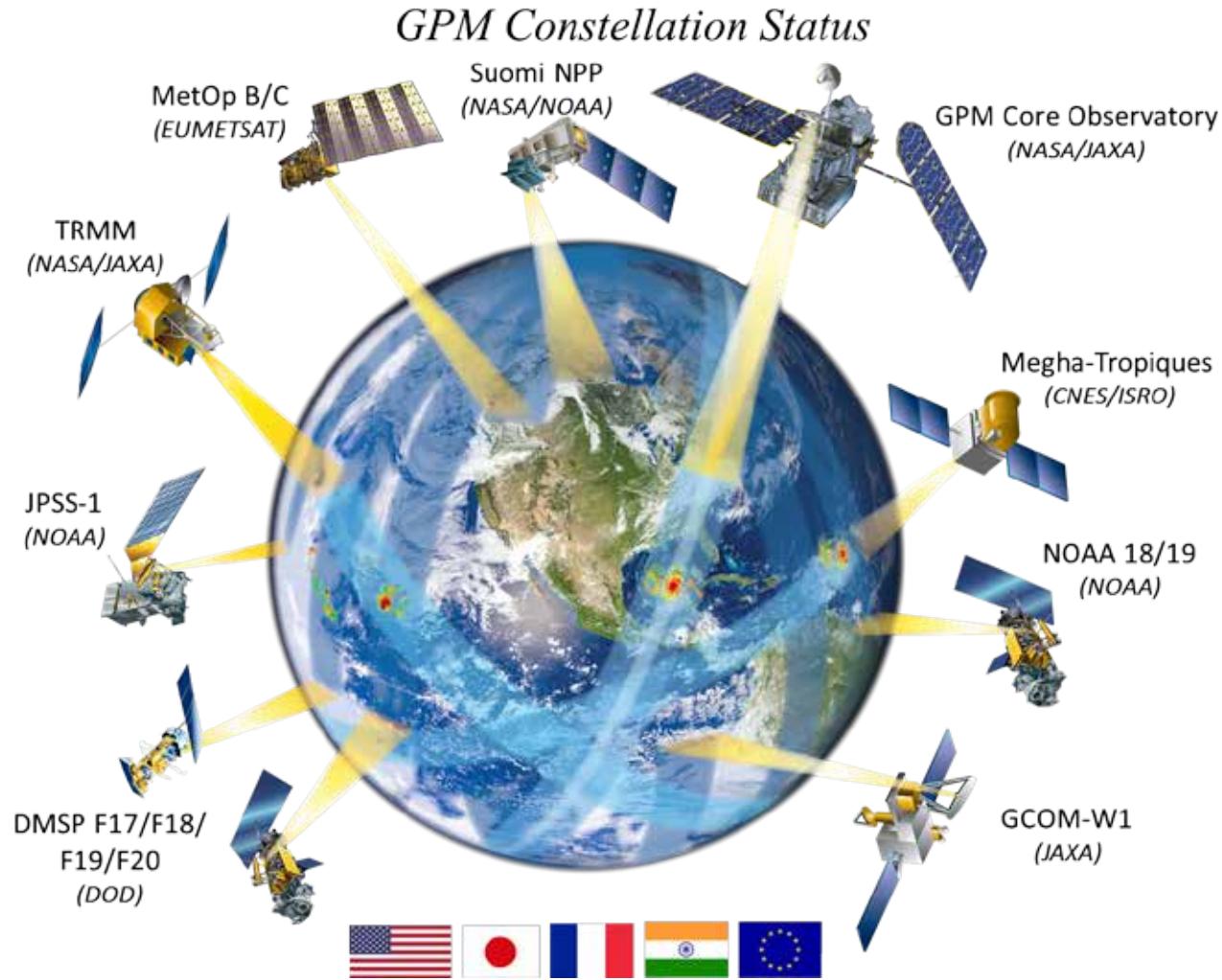
TRMM Microwave Imager (3A12)
(DJF 1997 - 2013, 48 months)



Historical Rainfall Estimates and TRMM



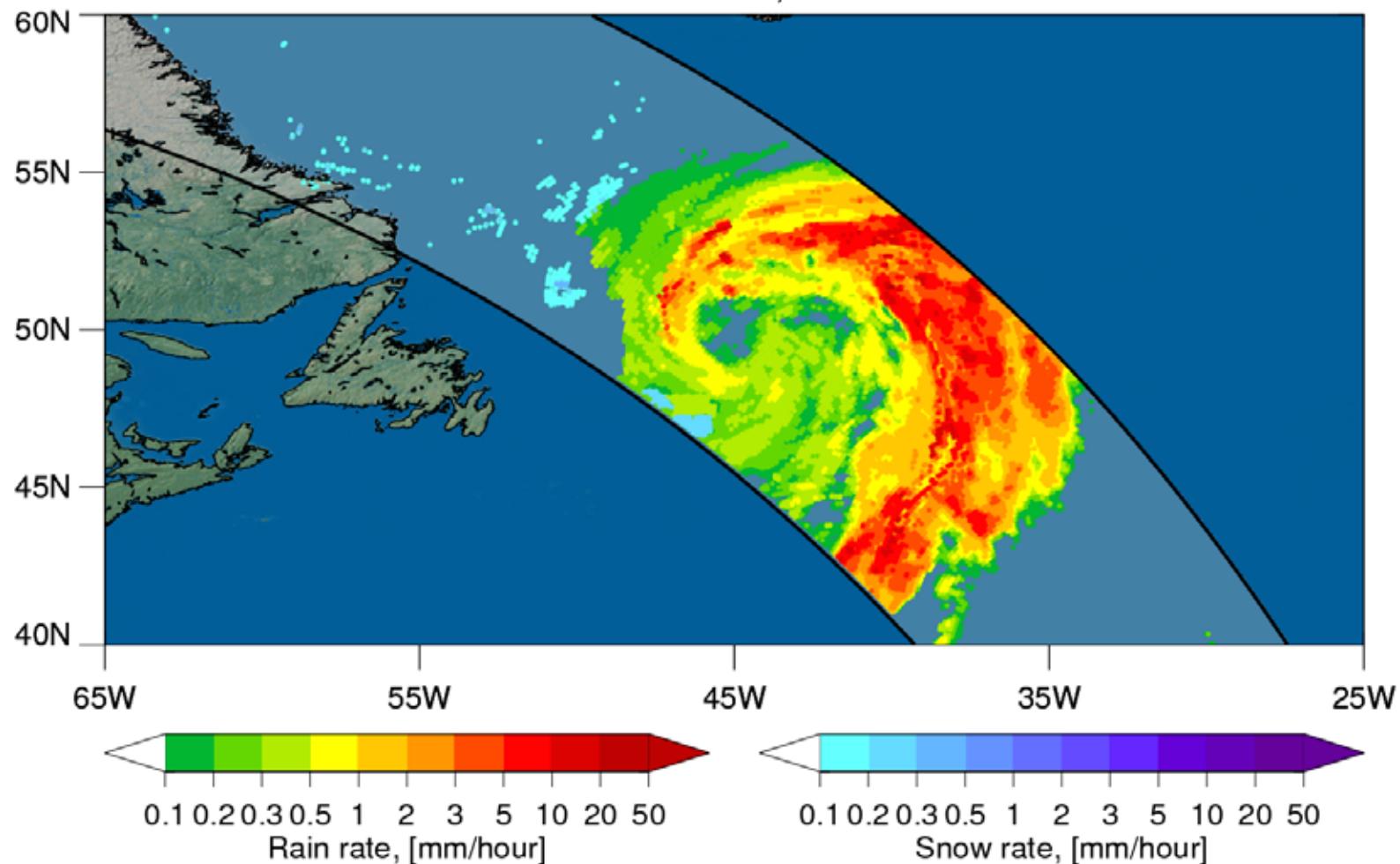
GPM



Low over the N. Atlantic

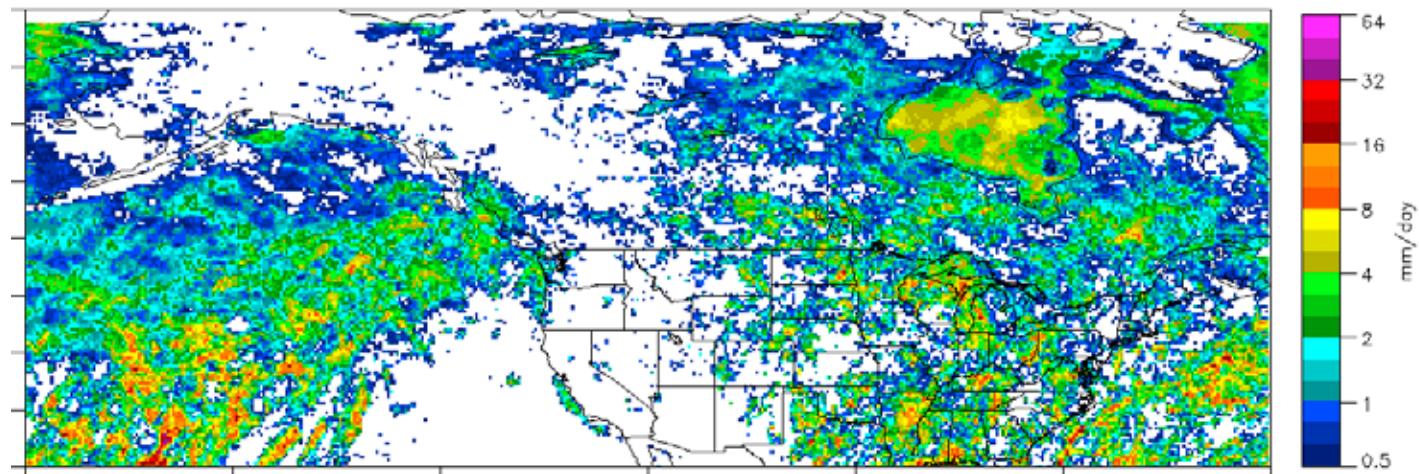
GMI GPROF precipitation

Date = 140420 - orbit # 000808, GPROF version = V01D

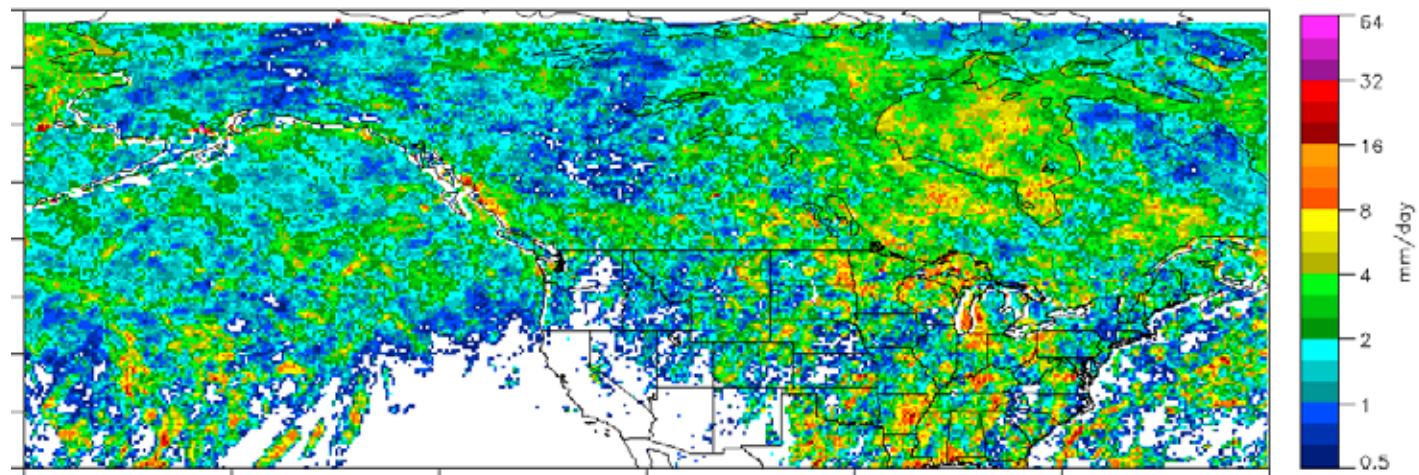


GPM Radiometer Retrieval - April, 2014

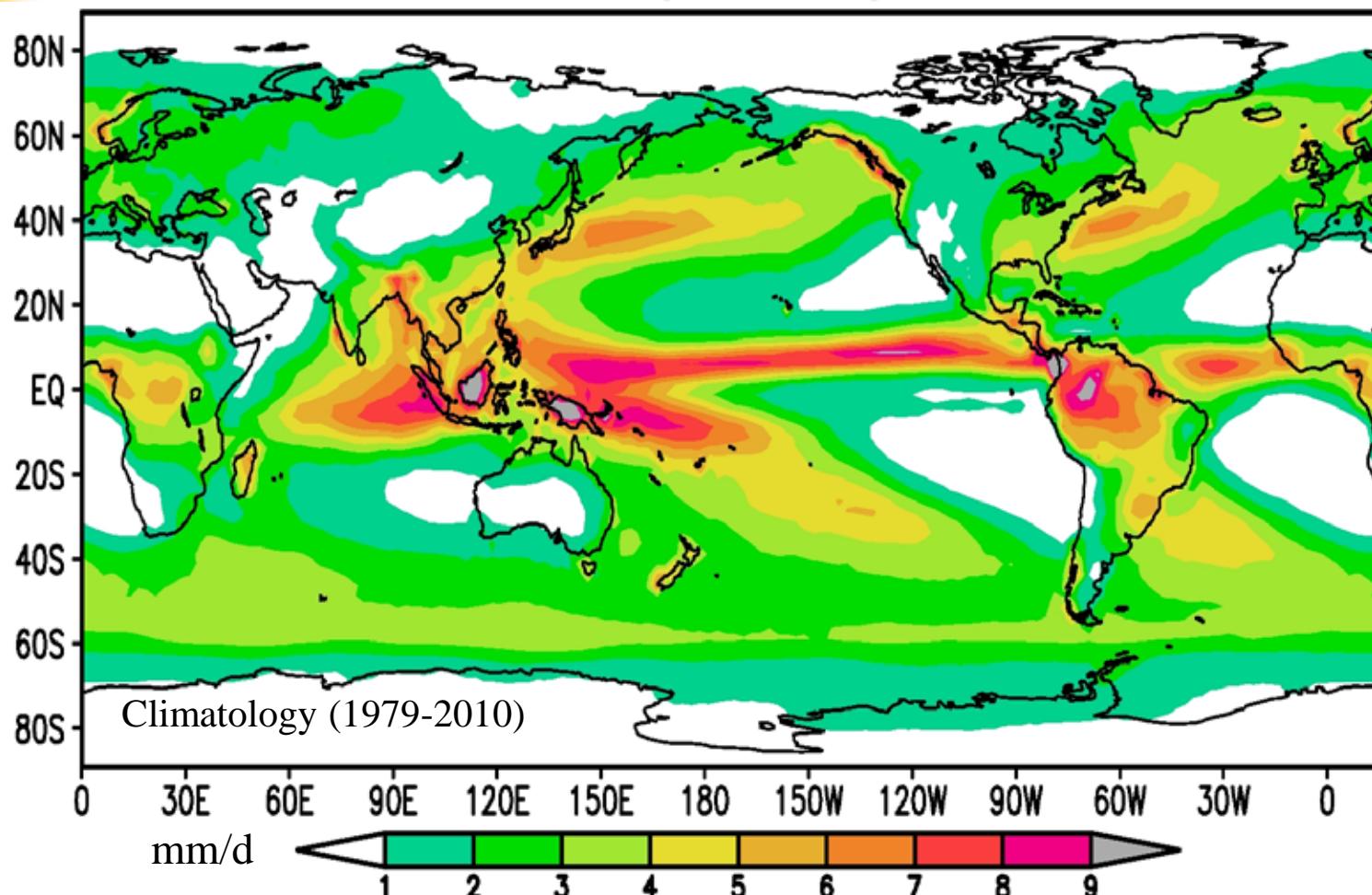
Pre-GPM rain estimate



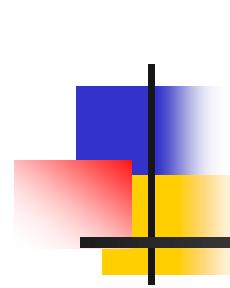
Using GPM knowledge



Global Precipitation Climatology Project (GPCP)

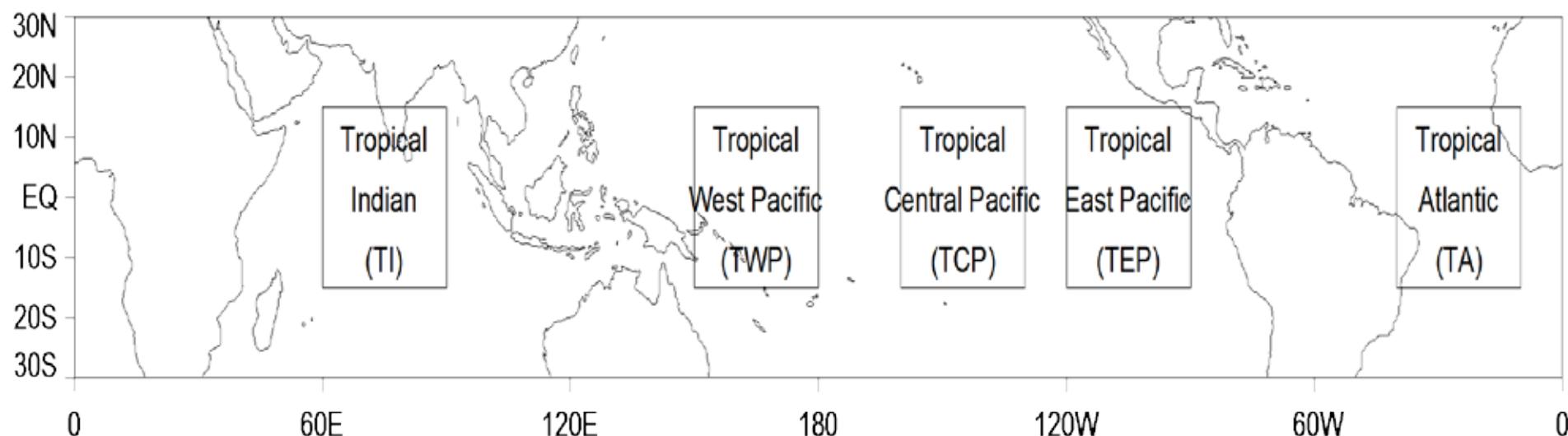


Robert Adler (GPCP Coordinator)
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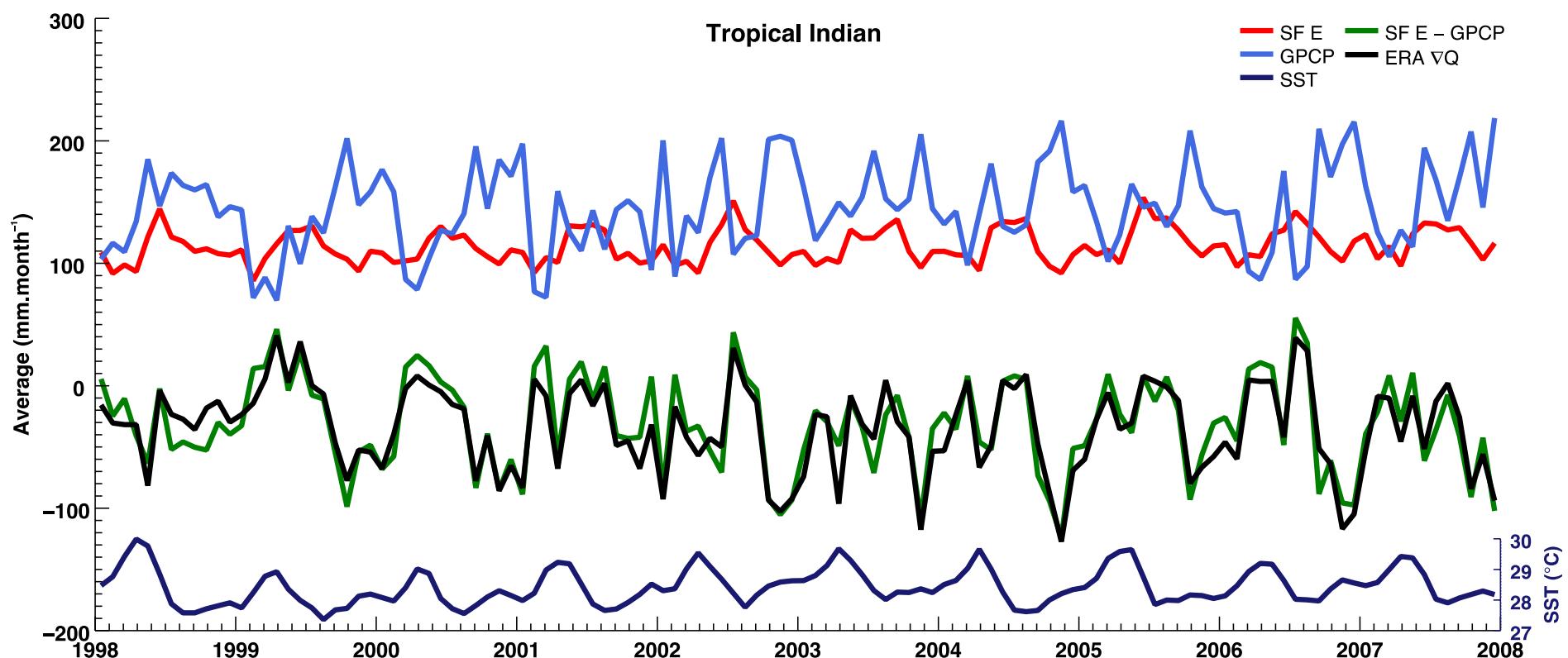


A Water Budget Closure Test

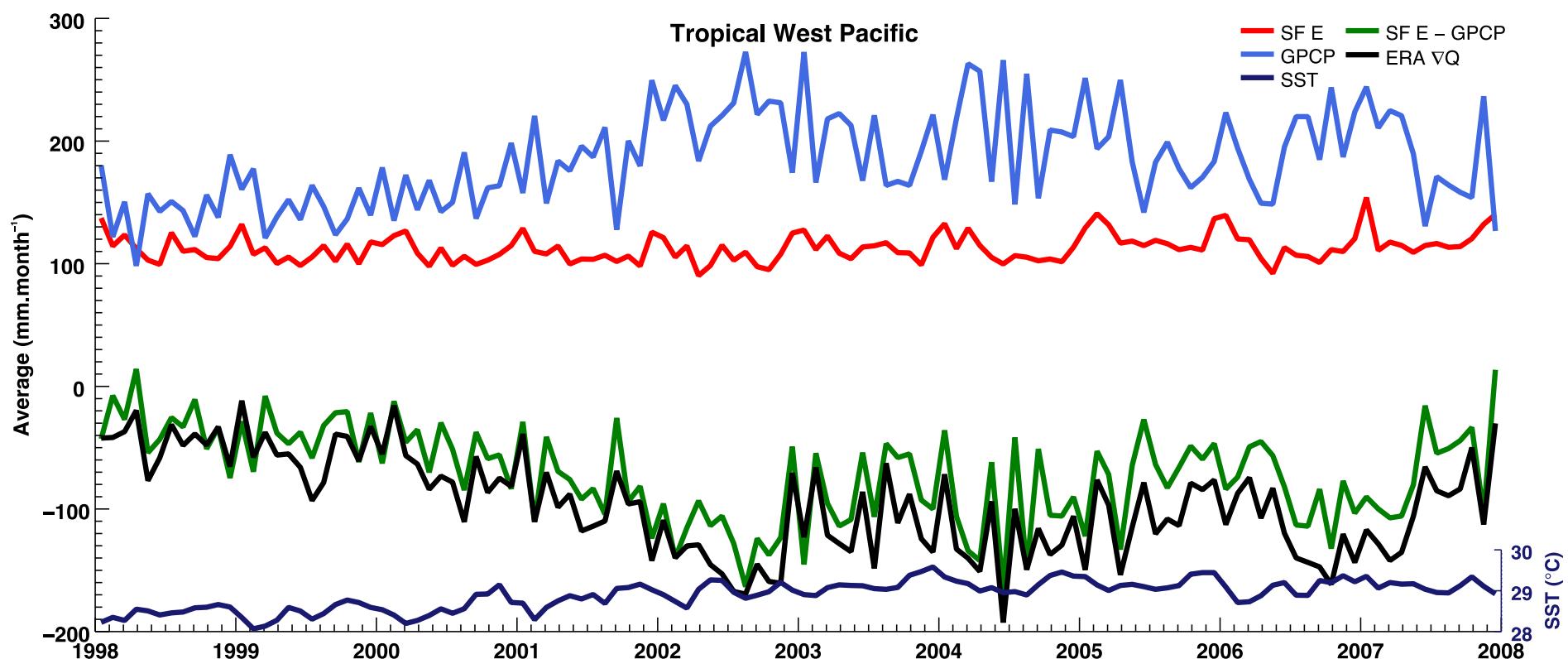
$$E - P = \nabla \cdot Q$$



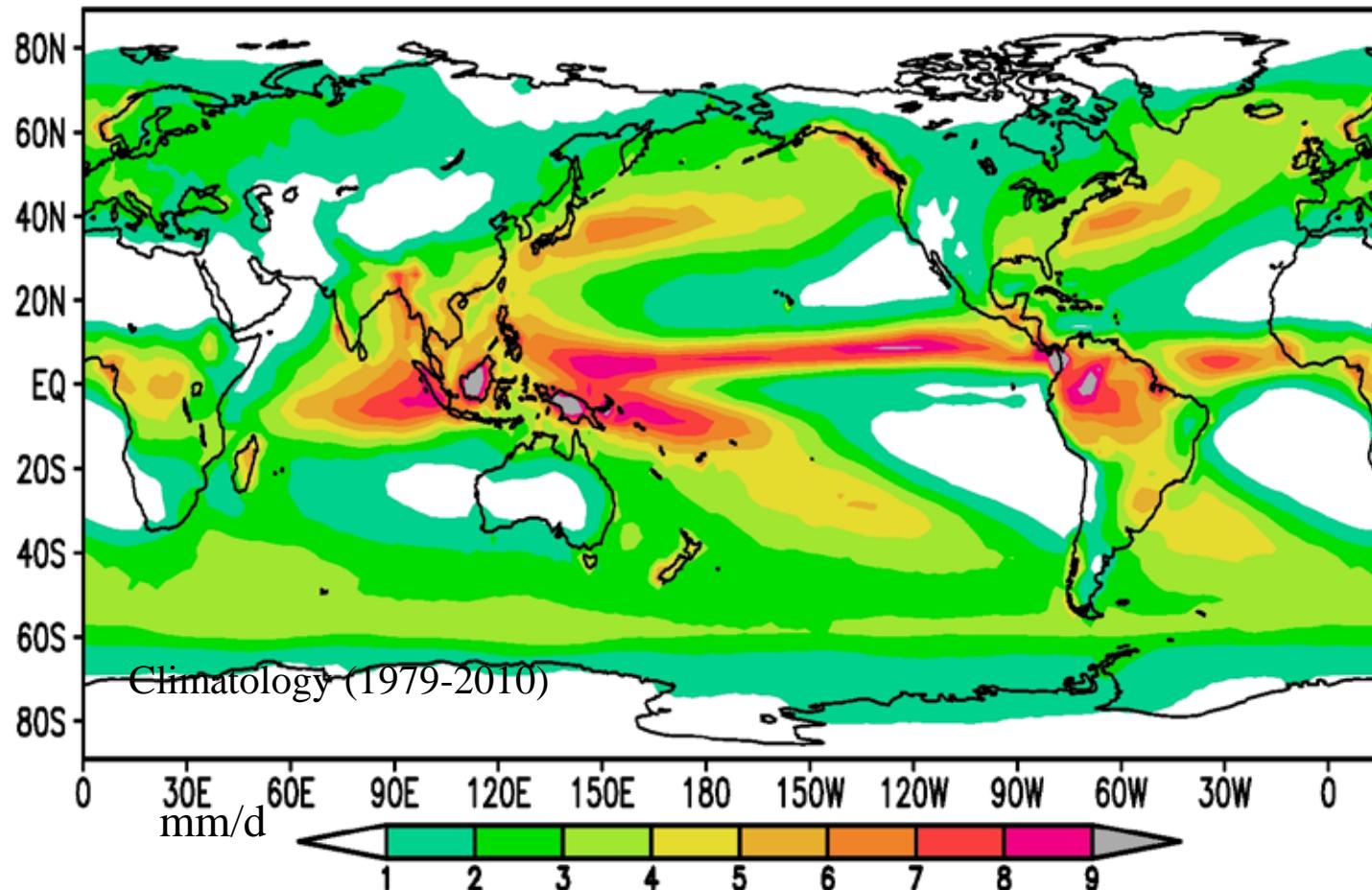
E, P and $\text{Div}(Q)$ for Tropical Indian Ocean



E, P and Div(Q) for Tropical West Pacific



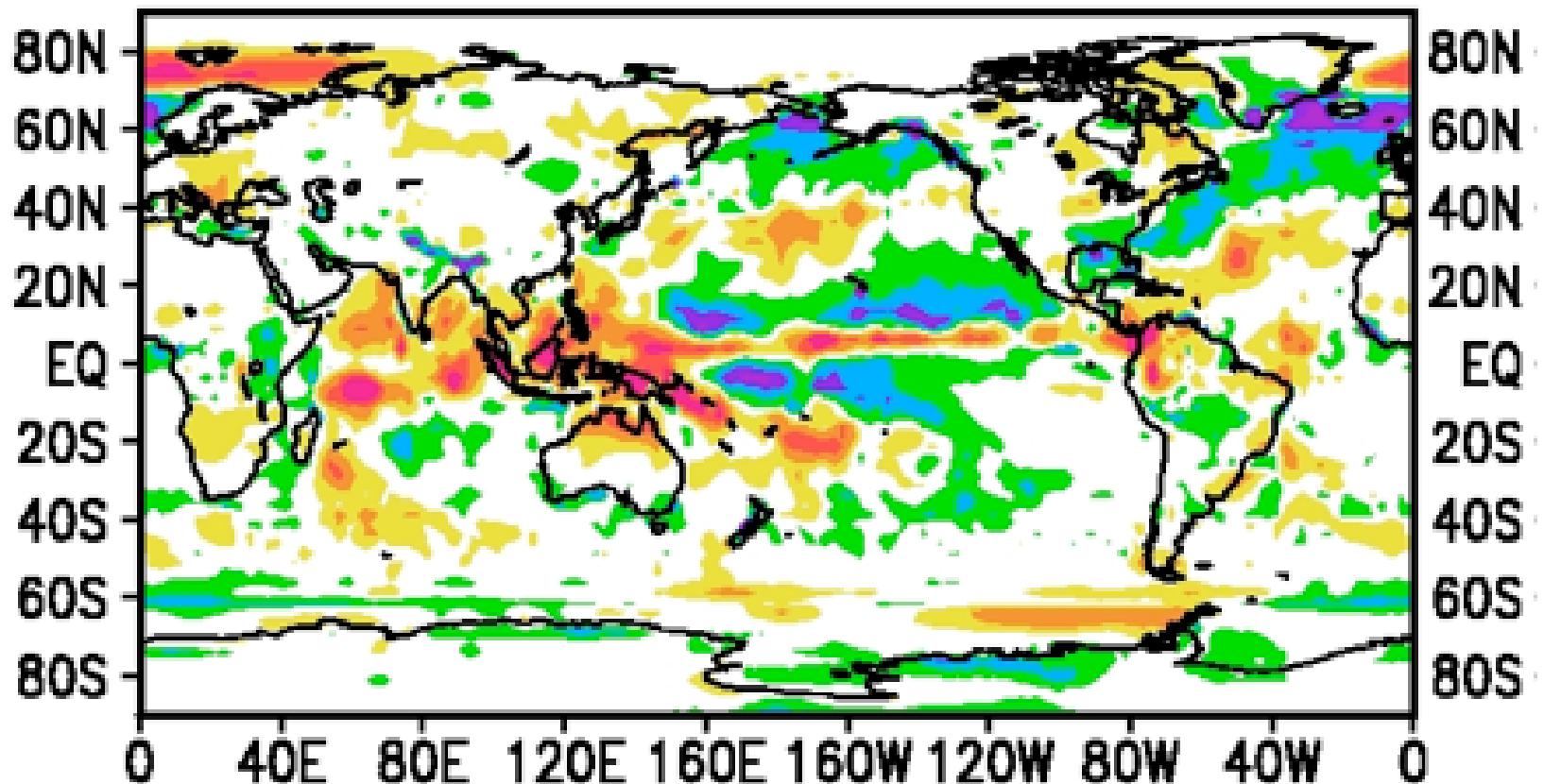
Global Precipitation Climatology Project (GPCP)



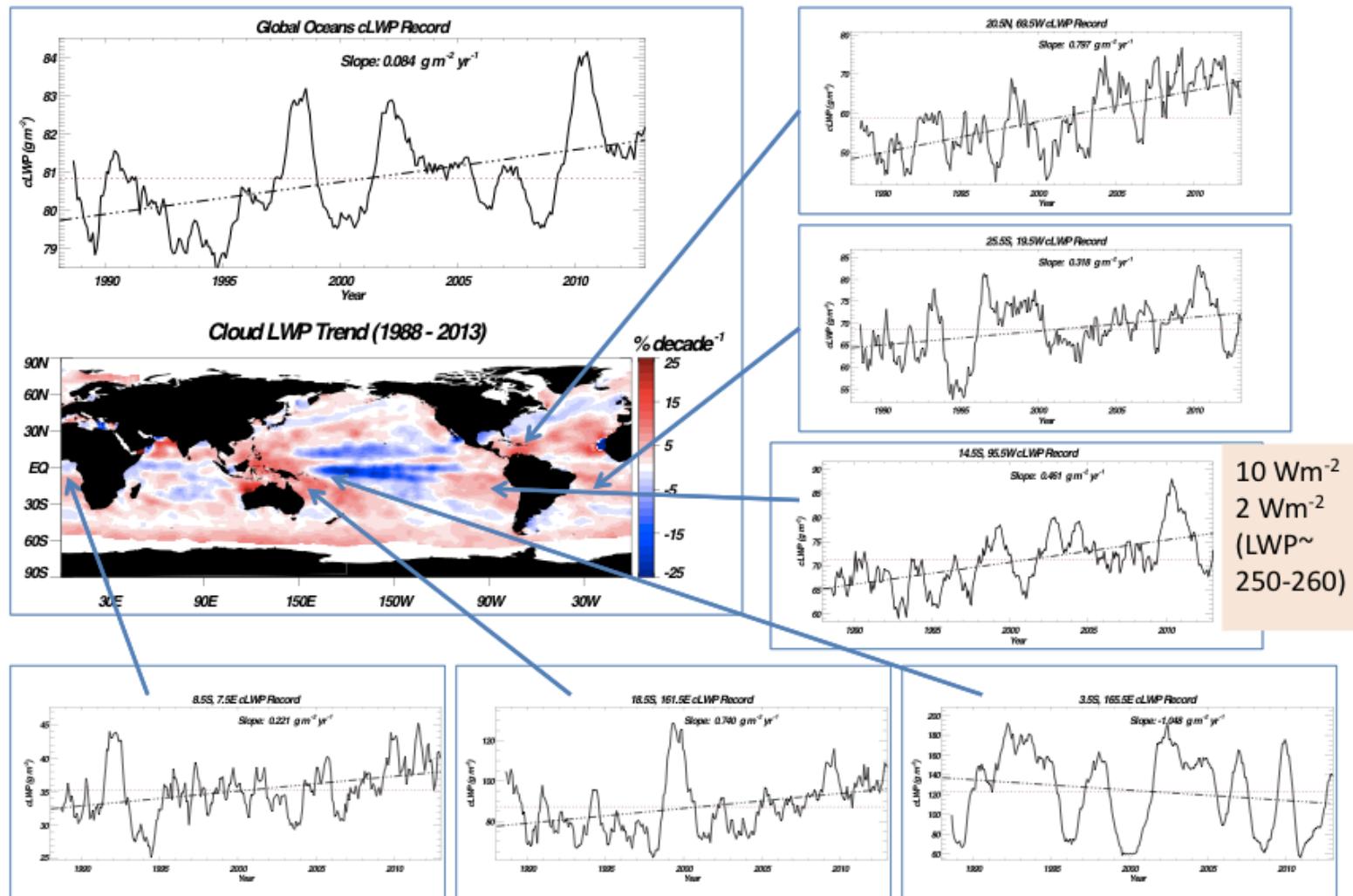
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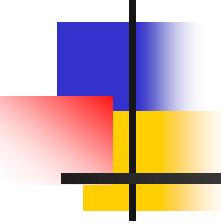
Precipitation Trends

(b) P (1988–2010)



Cloud Liquid Water Trends





Conclusion

- ø Absolute budgets for water and energy budgets are very difficult to close because residuals are small. Improved measurements for each parameter will successively move the science forward. TRMM has done much to define the tropics. GPM will finish the process.

- ø Water and Energy offer hope of better understanding the key feedback processes that will lead to improved predictions of climate. Satellites such as TRMM, GPM and GCOM-W form an essential data record for these studies.