Climate Validation of MERRA

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and many others in the
Global Modeling and Assimilation Office

5 January 2009
NASA/GSFC

Overview

- **Global Climate Variability**
- **Regional Climate Variability**
- **Analysis Increments, Budgets and Replay**

Results from GEOS-5 2004, 2006 validation runs and some updates using latest available results from MERRA

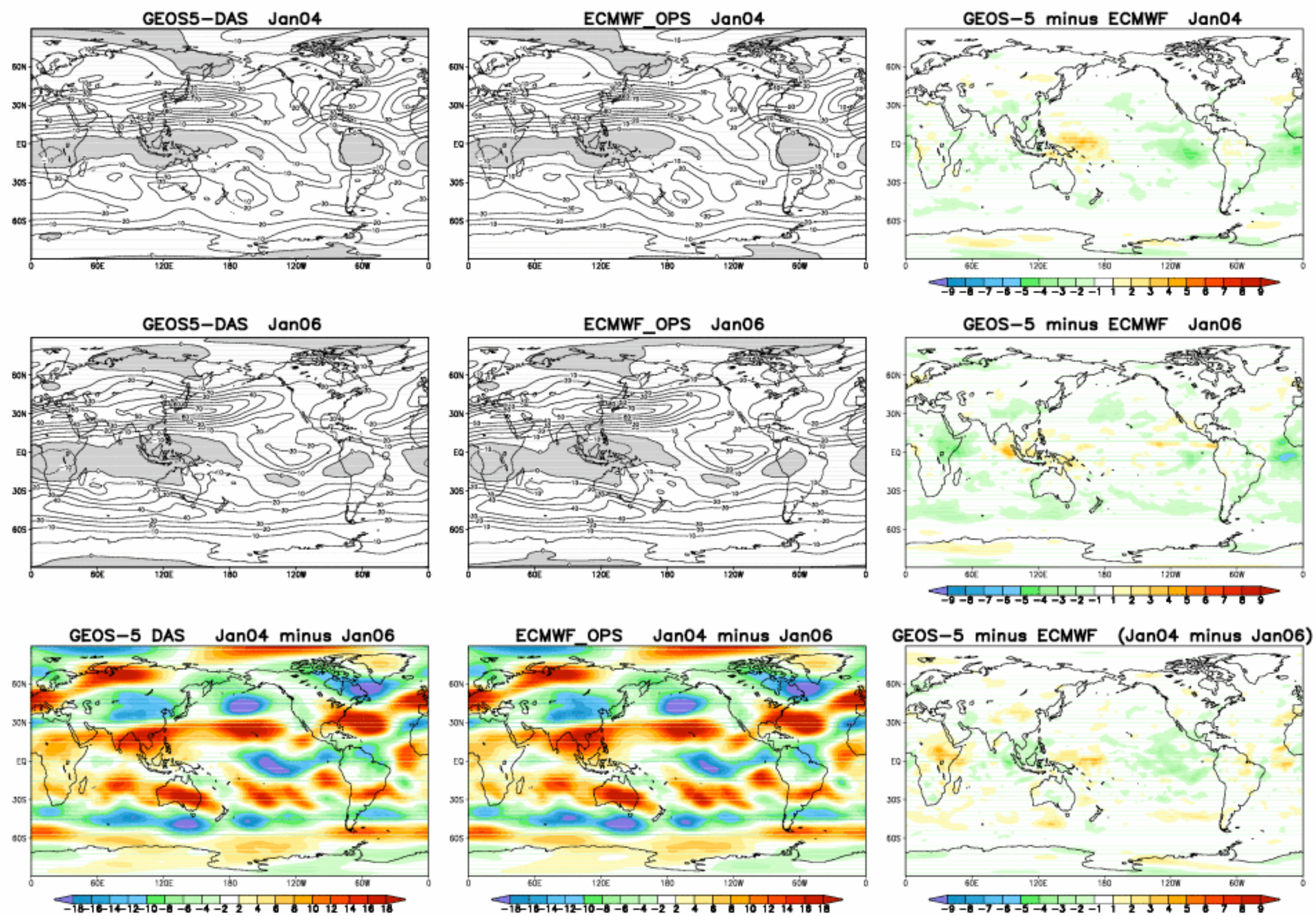
200 MB Zonal Wind vs EC OPS

GEOS-5 | EC OPS | G5 - EC

Jan 04
(neutral)

Jan 06
(weak
La Nina)

04 - 06



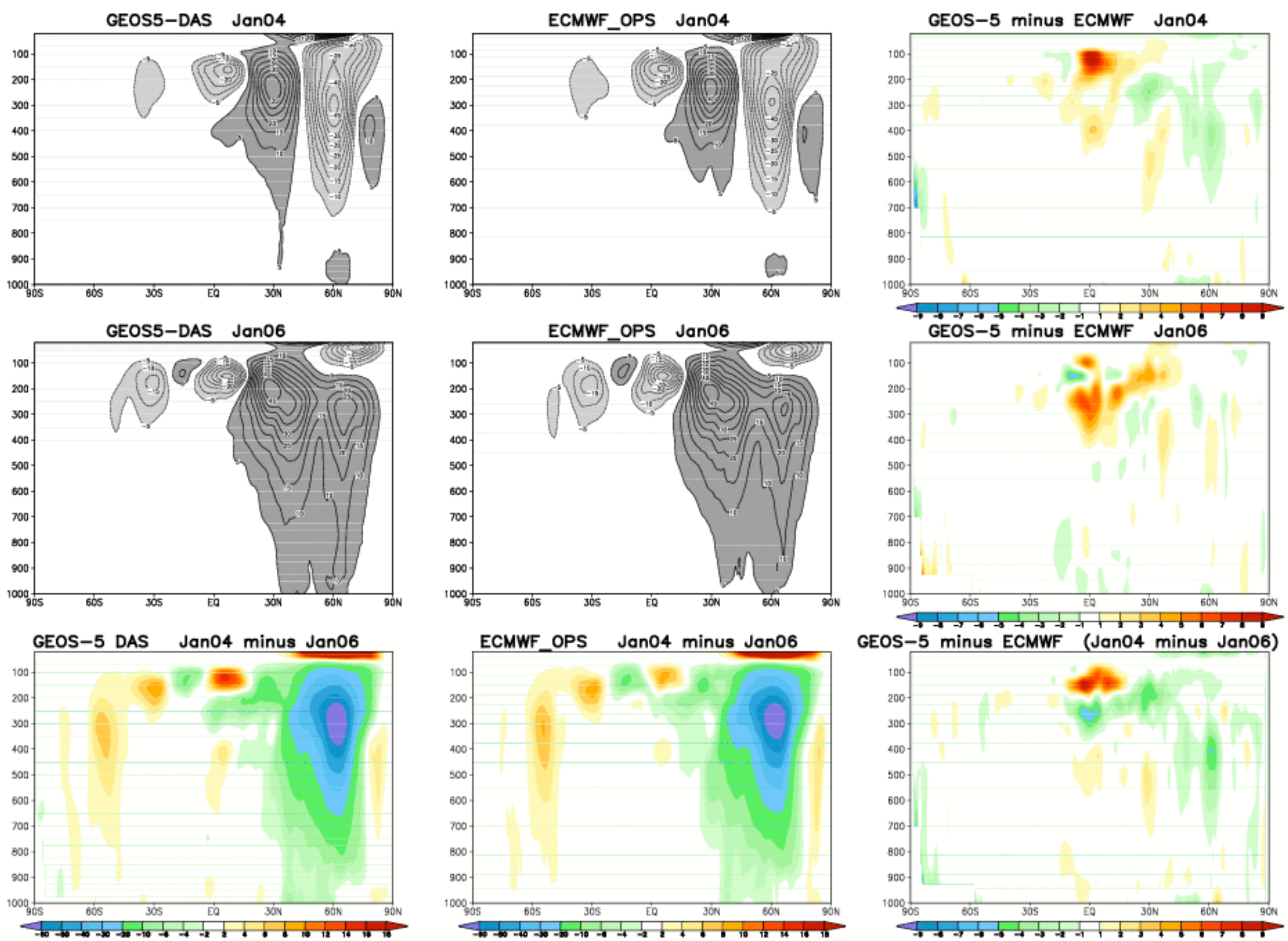
U*V* vs EC OPS

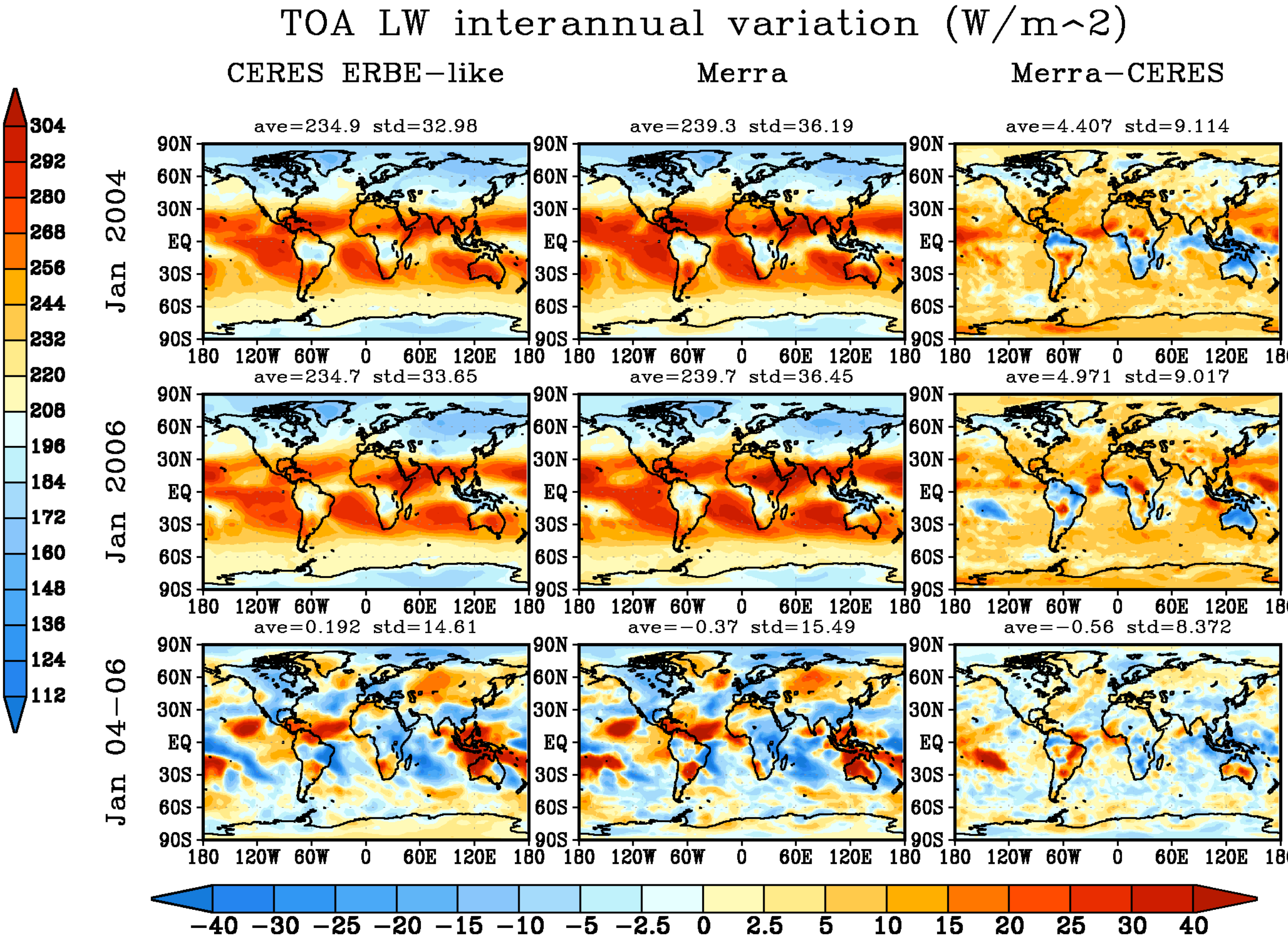
GEOS-5 | EC OPS | G5 - EC

Jan 04 (neutral)

Jan 06 (weak La Nina)

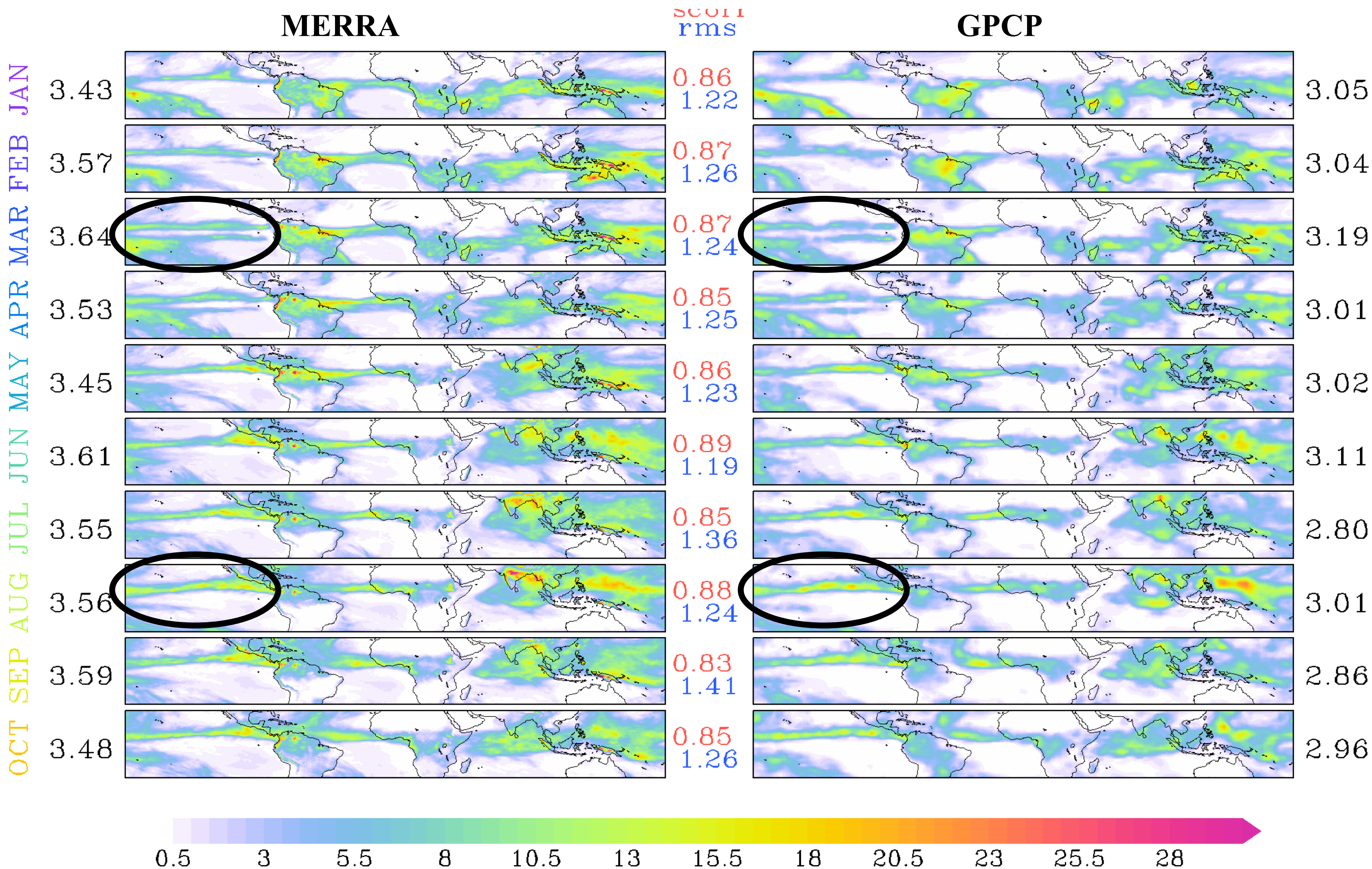
04 - 06

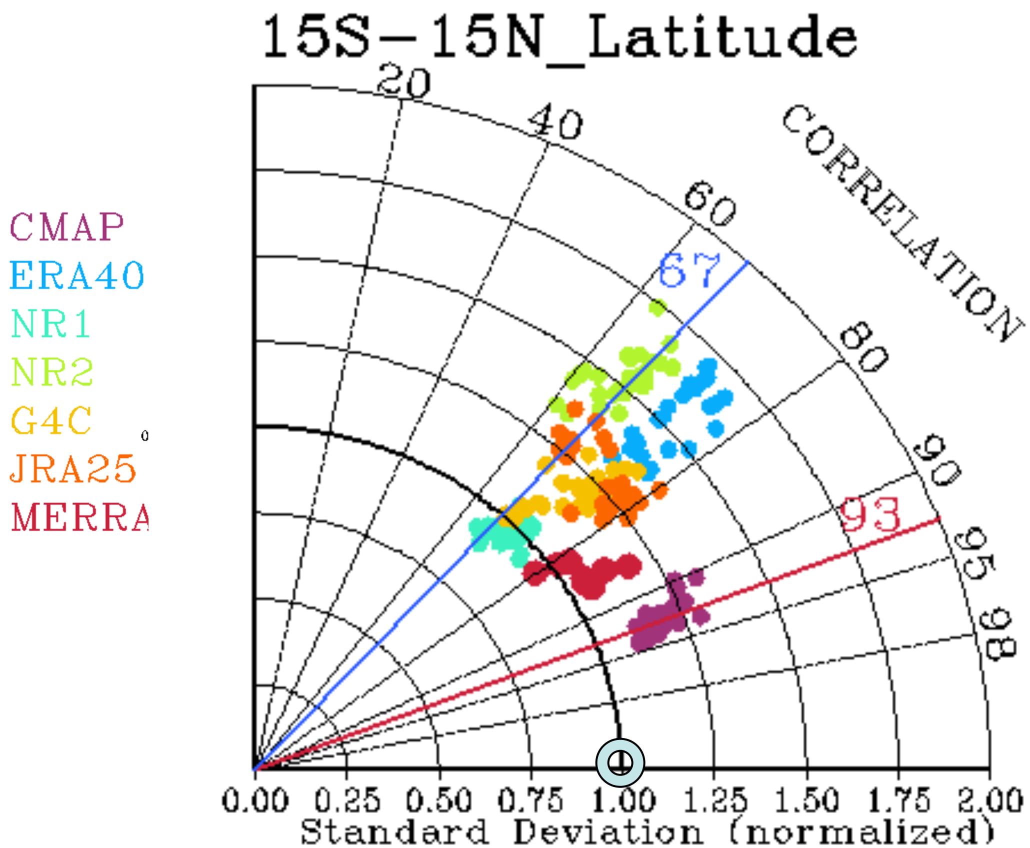




TOA LW interannual variation (W/m^2)
CERES ERBE-like
Merra
Merra-CERES
Jan 2004
Jan 2006
Jan 04-06
ave=234.9 std=32.98
ave=239.3 std=36.19
ave=4.407 std=9.114
ave=234.7 std=33.65
ave=239.7 std=36.45
ave=4.971 std=9.017
ave=0.192 std=14.61
ave=-0.37 std=15.49
ave=-0.56 std=8.372
90N 60N 30N EQ 30S 60S 90S
180 120W 60W 0 60E 120E 180
304 292 280 268 256 244 232 220 208 196 184 172 160 148 136 124 112
-40 -30 -25 -20 -15 -10 -5 -2.5 0 2.5 5 10 15 20 25 30 40

2004 Tropical Precipitation



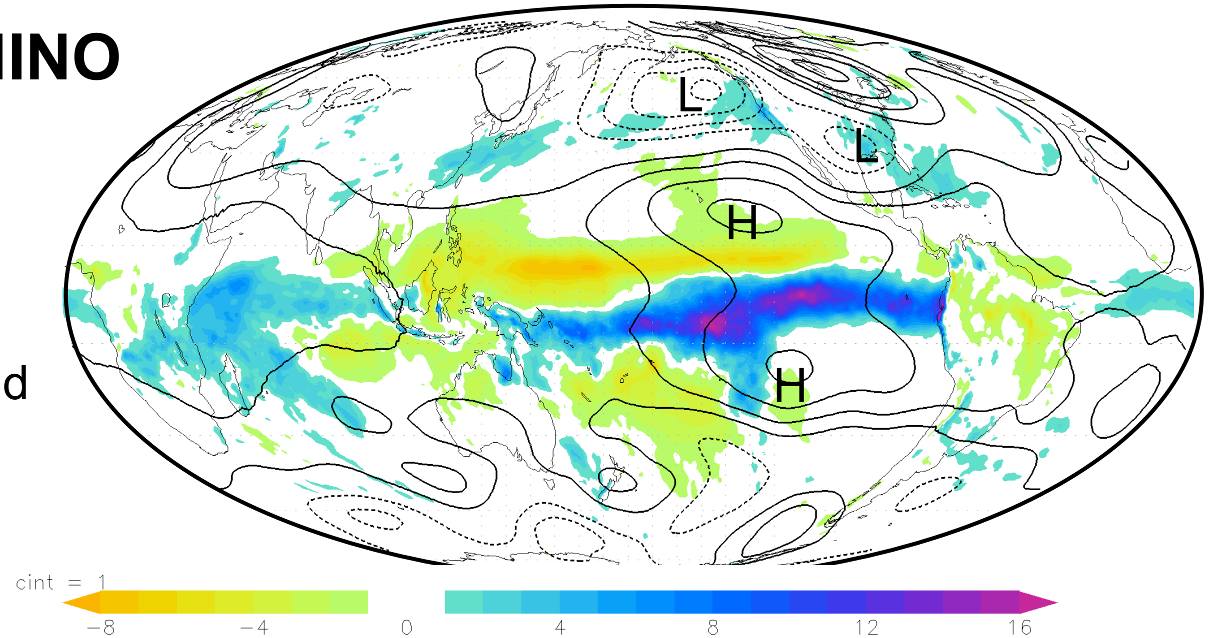


Taylor diagrams for tropical precipitation. GPCP merged precipitation is the reference data set. The diagrams compare spatial correlation (to GPCP) of the analysis to standard deviation normalized by the reference data set. If a field exactly duplicated GPCP, it would be at the 1,1 point. Linear distance to the 1,1 point is a measure of skill in reproducing the reference data set (annual 1979-2005).

JFM 1998 EL NINO

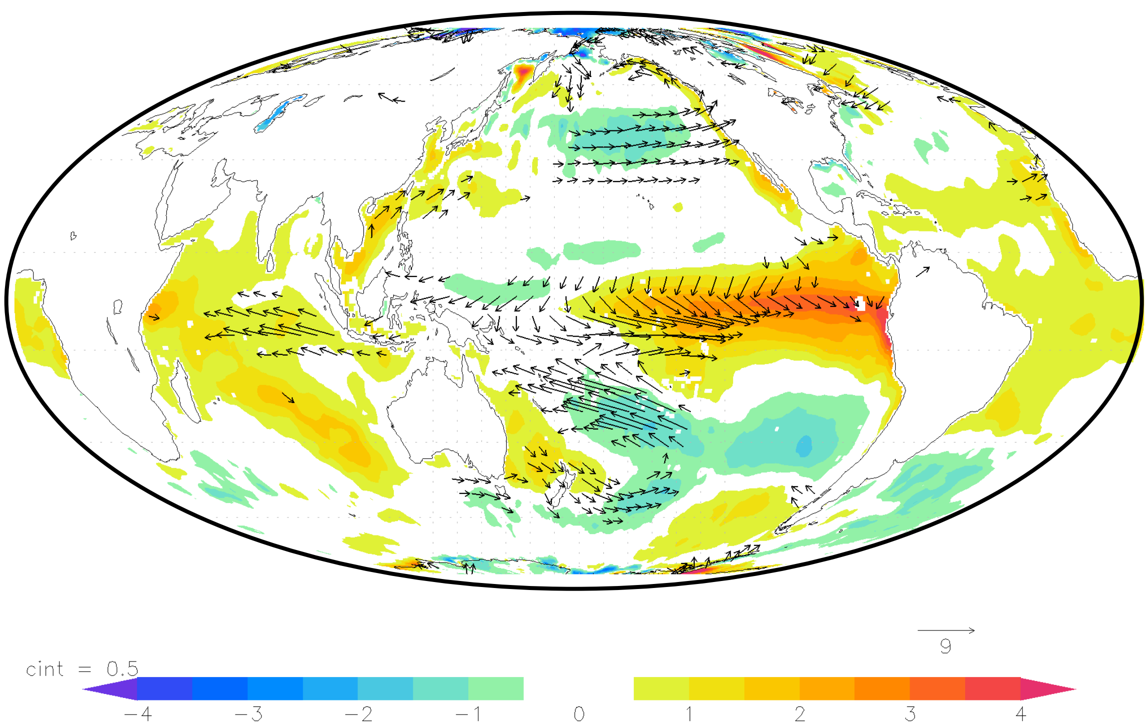
Link to Weather

200mb Height and
Precipitation
Anomalies



Link to Ocean

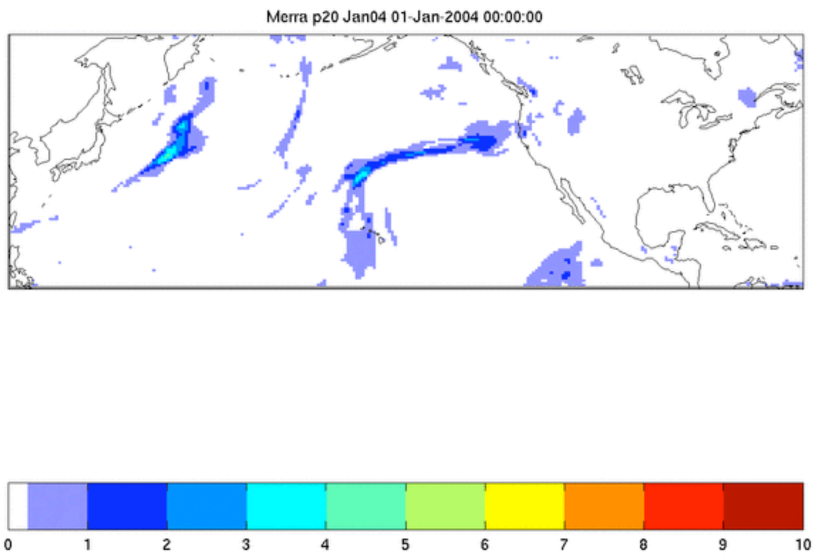
SST and 850mb
Wind Vector
Anomalies



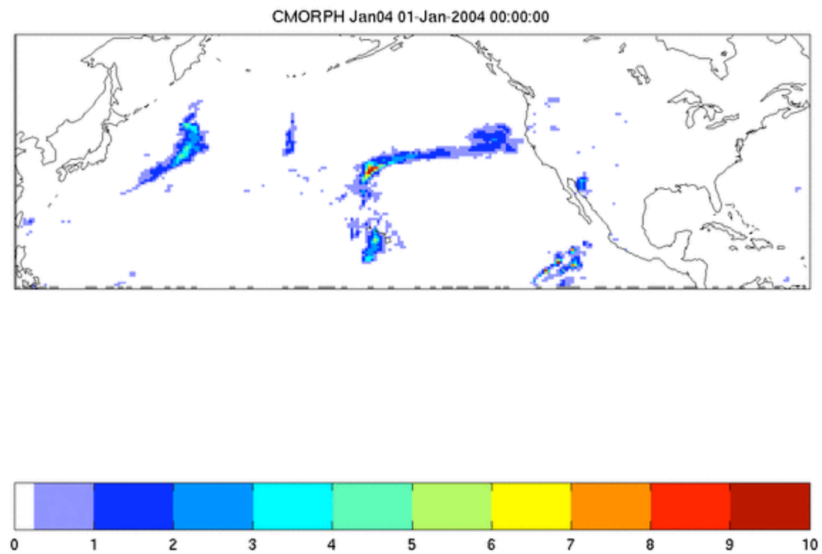
http://snare.gsfc.nasa.gov/intranet/personnel/dvanpelt/MERRA/ENSO/jan98_v2/index.html

Validating 3 hourly Precipitation (Jan04)

MERRA



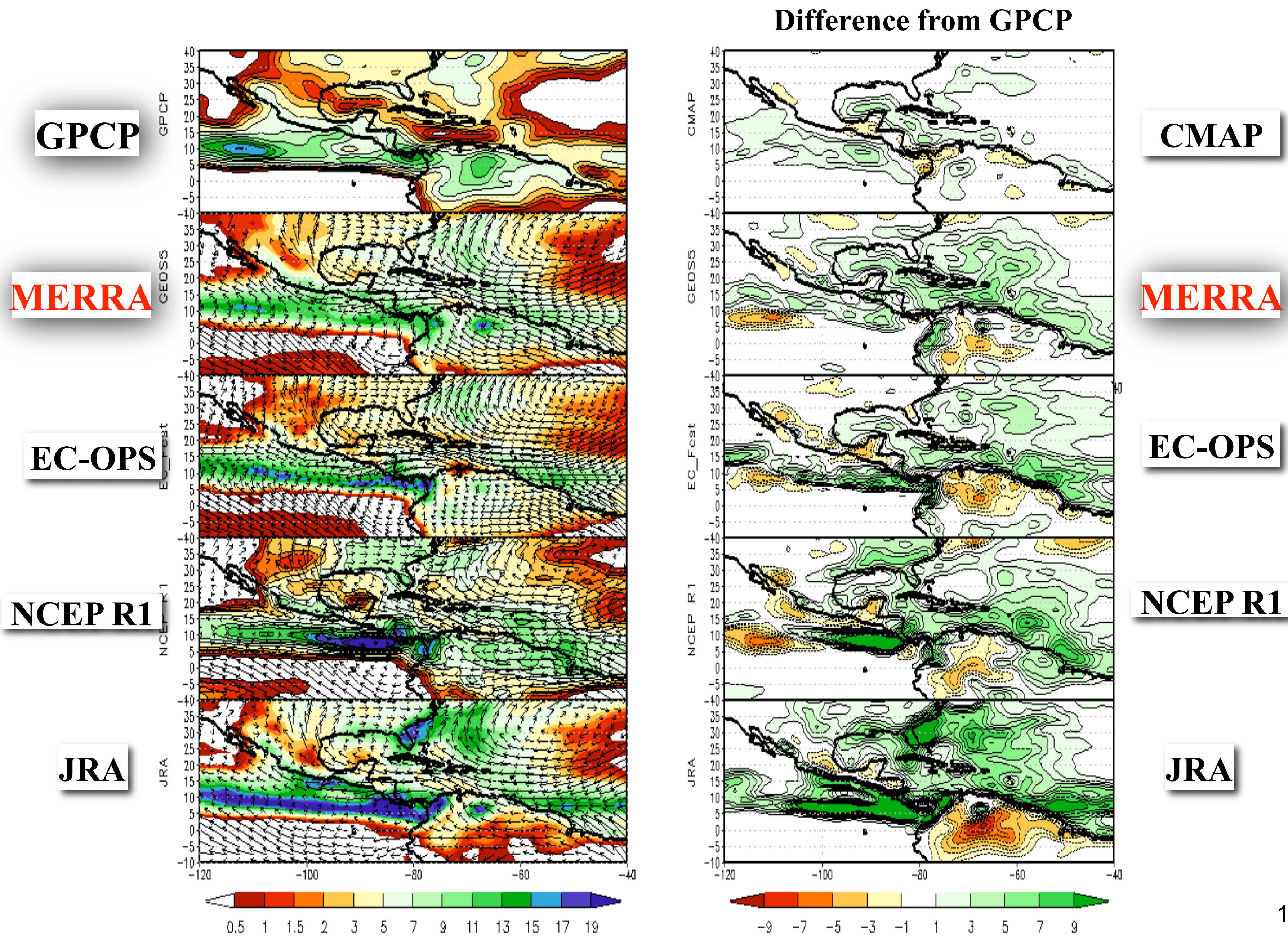
CMORPH (obs)



mm/day

Thanks to Matt Sapiano

Monthly Mean Precipitation over Americas July 2004 (mm/day)

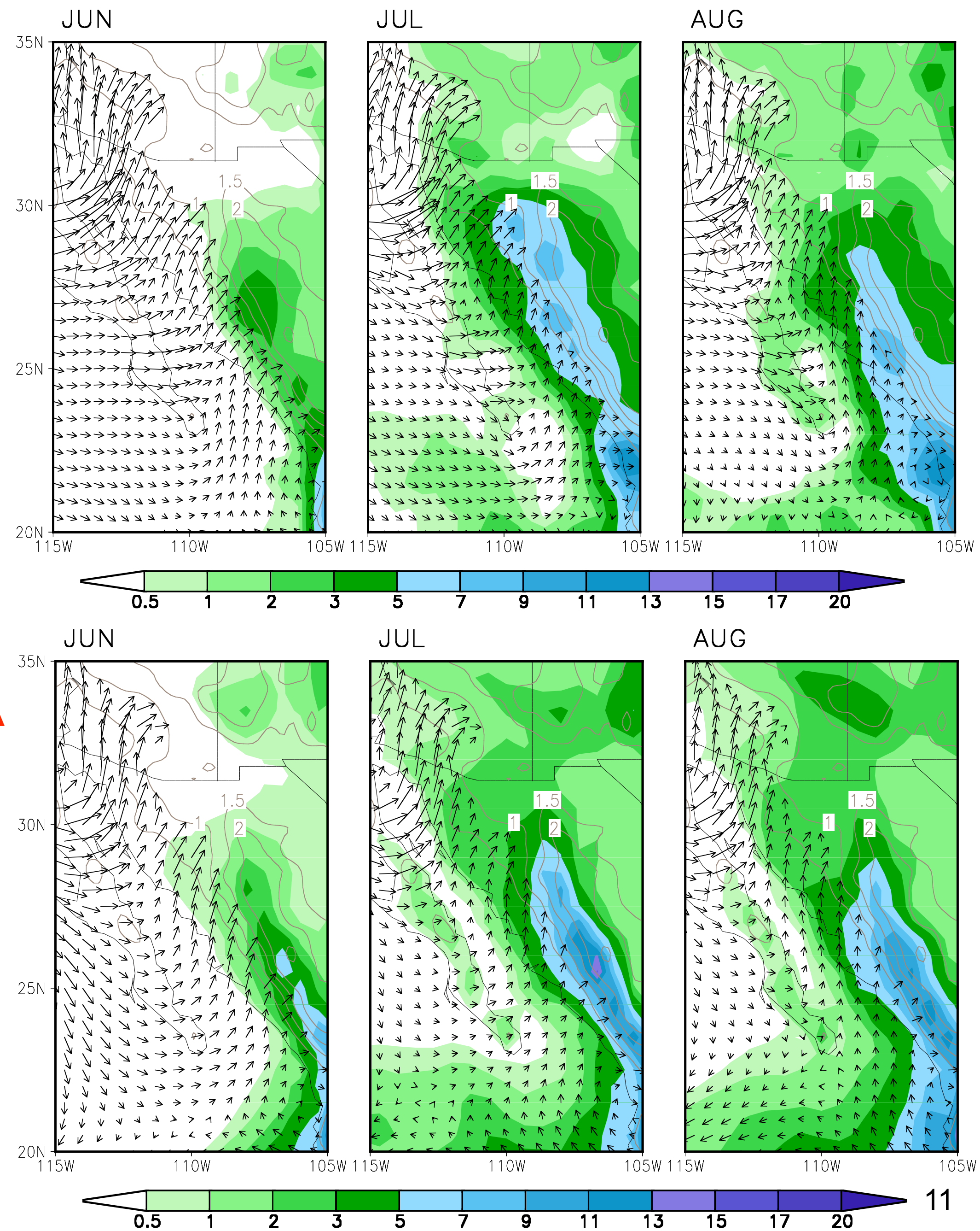


Seasonal evolution of North American monsoon (2004)

Precipitation (mm/d) and 925mb wind

NARR

MERRA



Shading: precipitation rate (mm/d),
Arrows: 925 mb winds
Contours: surface elevation

- GEOS-5 reproduces the typical structure of the monsoon rainband. Seasonal march of the rainband is reasonable, with a peak in July.

- Maximum rainfall region is located reasonably well in the windward slope of the mountains (the Sierra Madre Occidental).

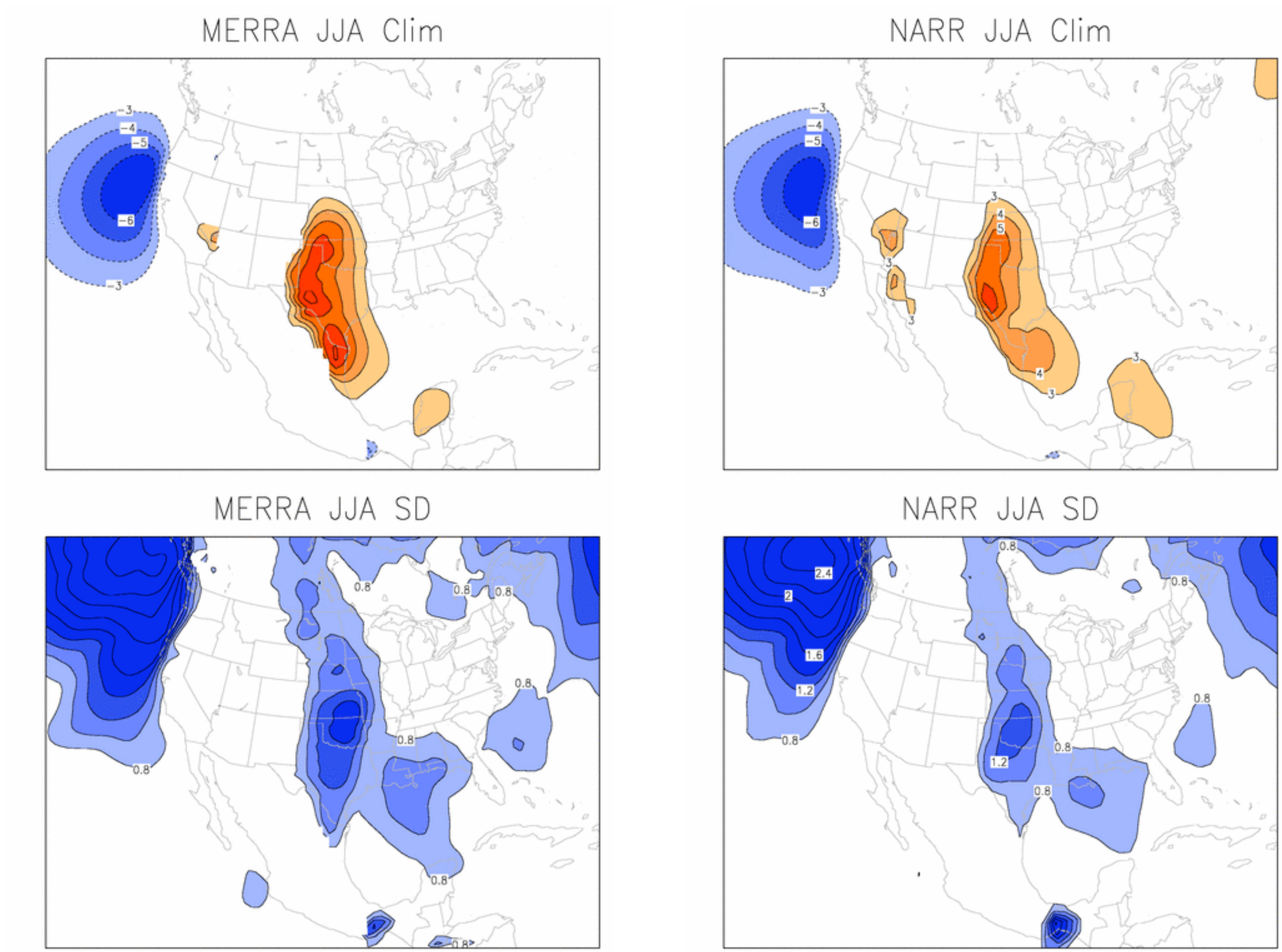
- Southwesterly flows in the Gulf of California and in the upslope of the mountains seem to be benefit from the high-resolution (1/2-degree) data assimilation.

JJA v-wind at 850mb (9-yrs)

MERRA NARR

Mean

Std

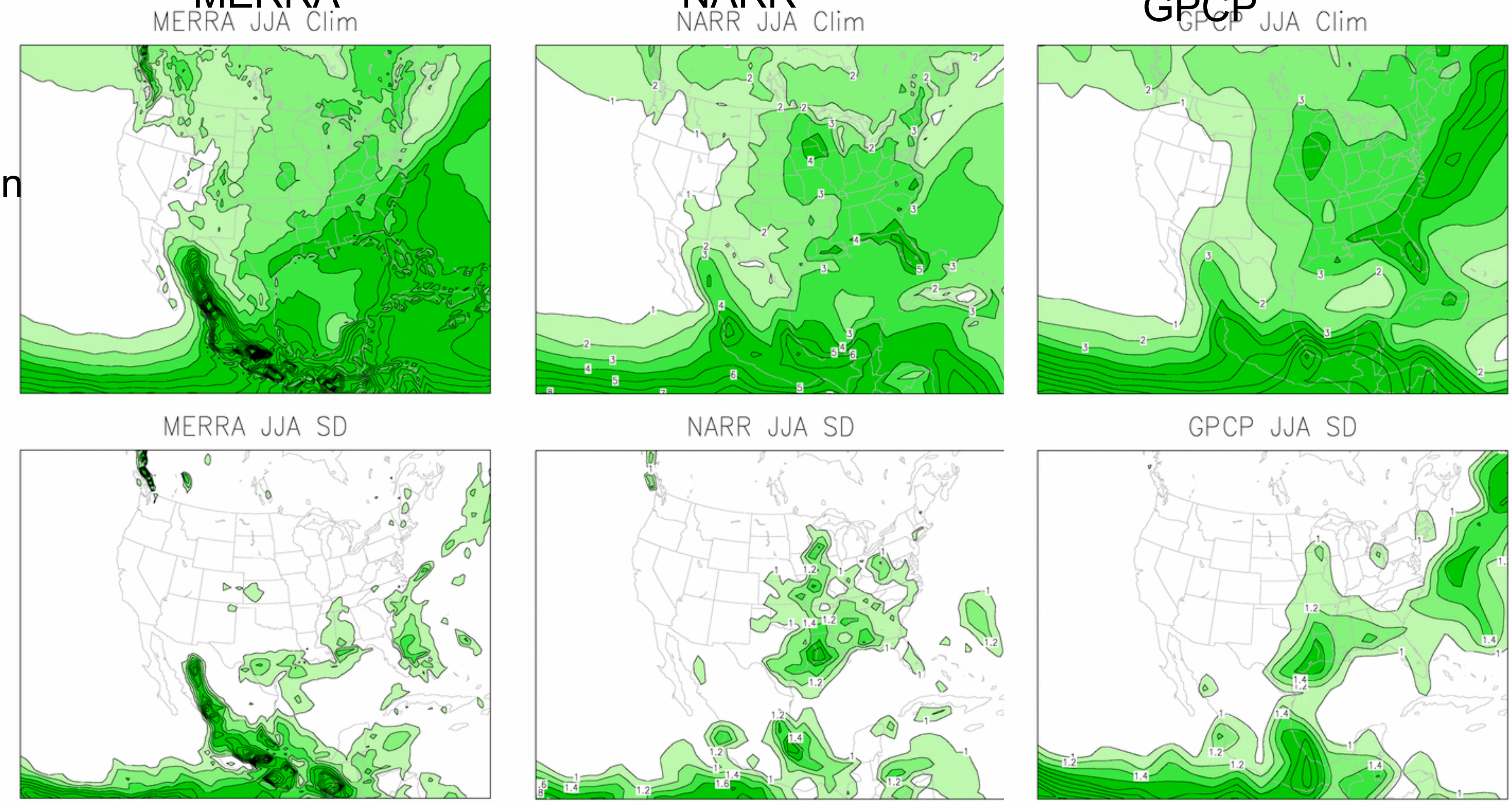


JJA Precipitation (9-yrs)

MERRA NARR GPCP

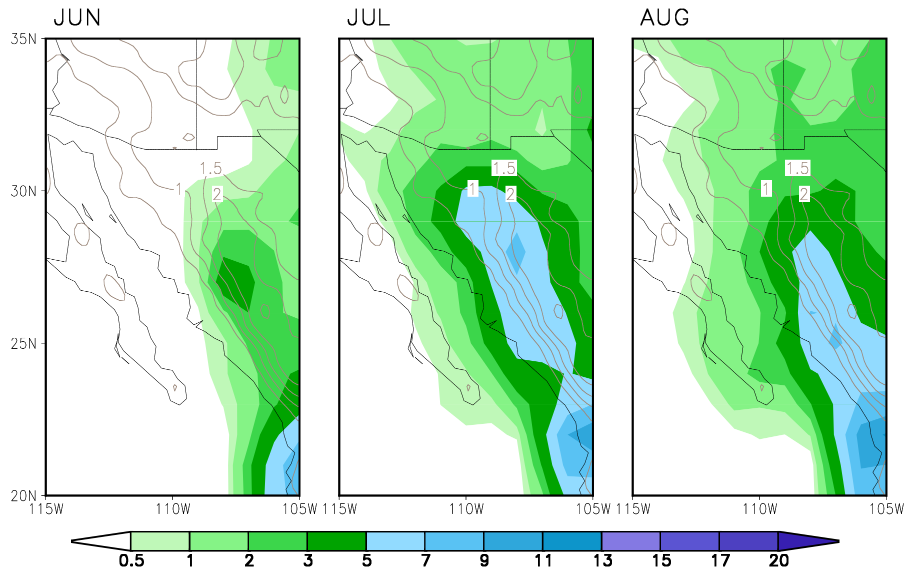
Mean

Std

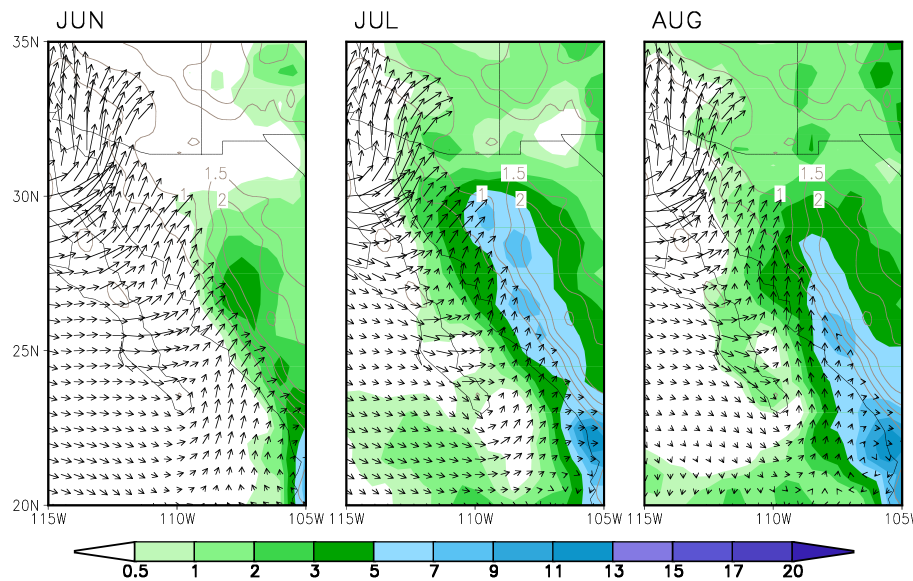


2004 Precipitation Revisited

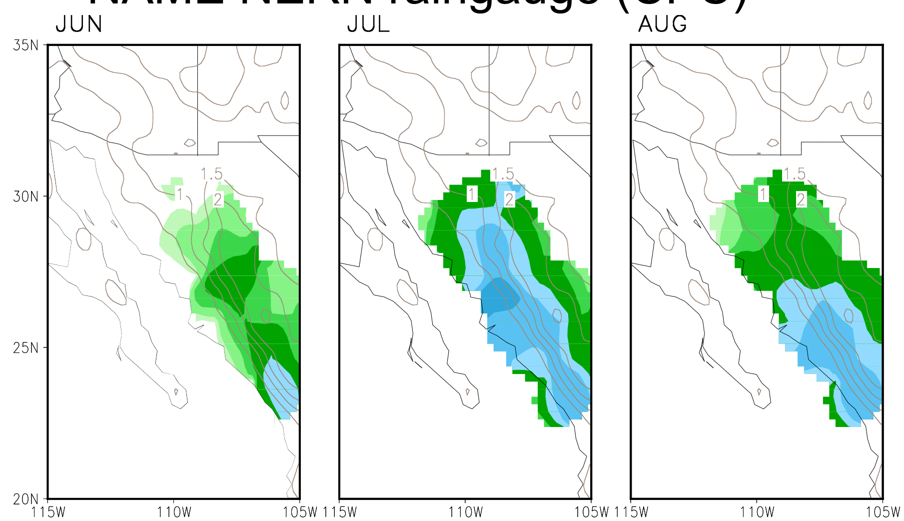
US-Mexico 1 deg raingauge (CPC)



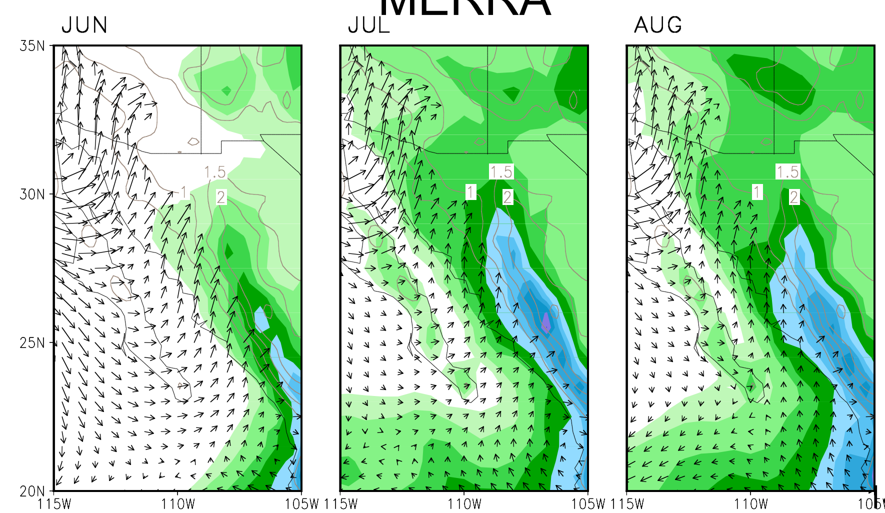
NARR



NAME NERN raingauge (CPC)

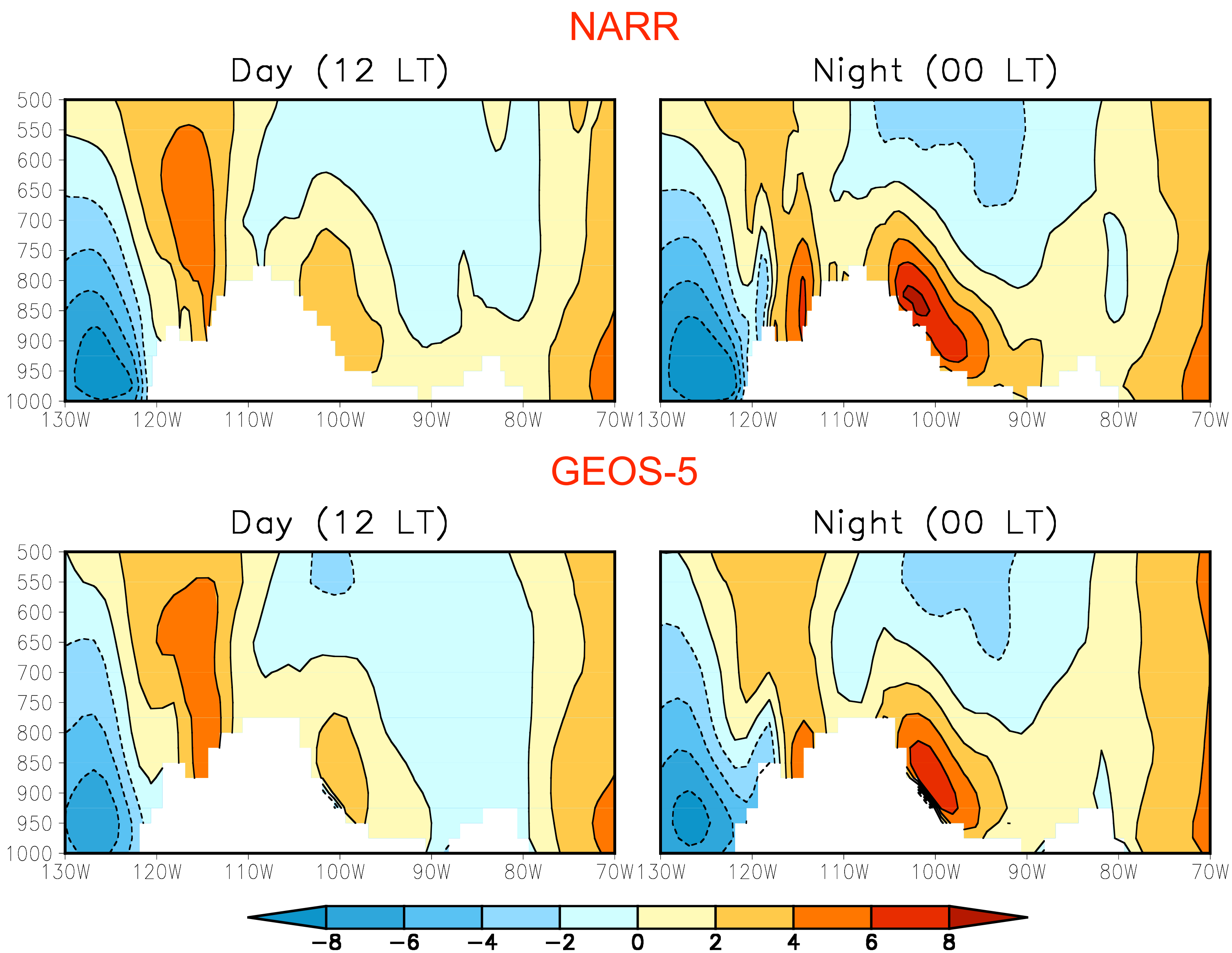


MERRA



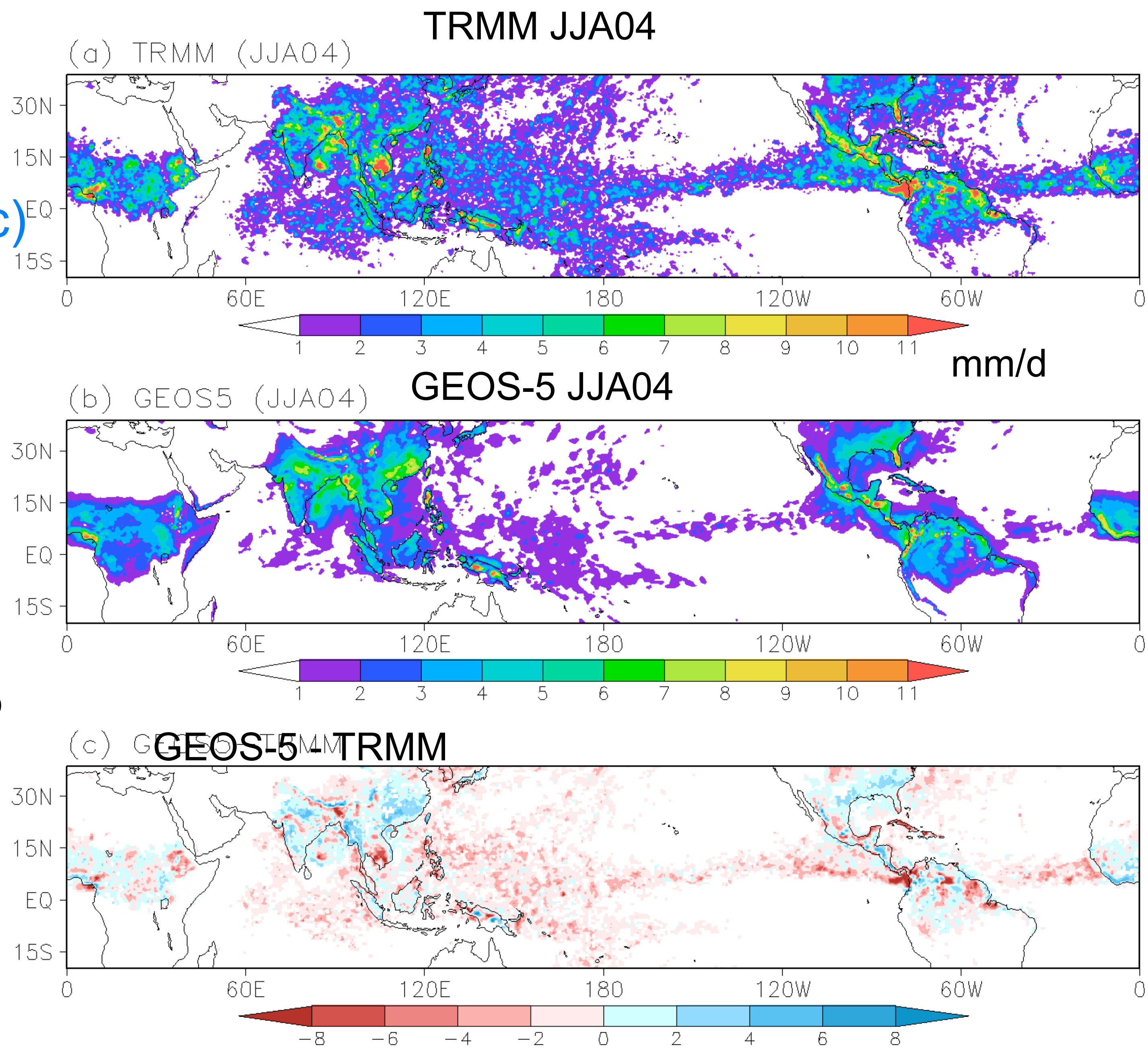
Diurnal Cycle

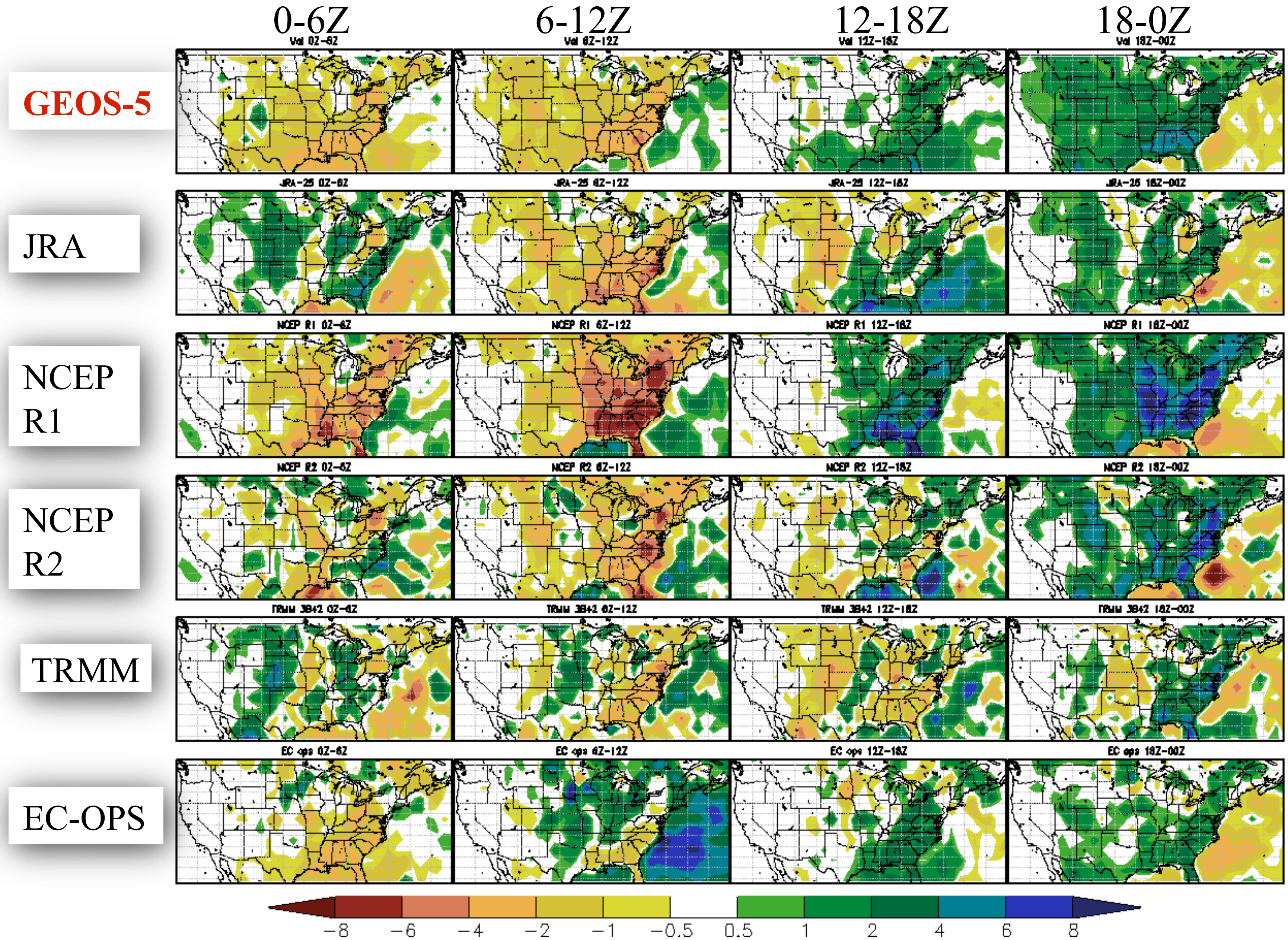
Jul/Aug 2004 v-wind at 35°N



Amplitude of Precipitation Diurnal Cycle (24-h harmonic)

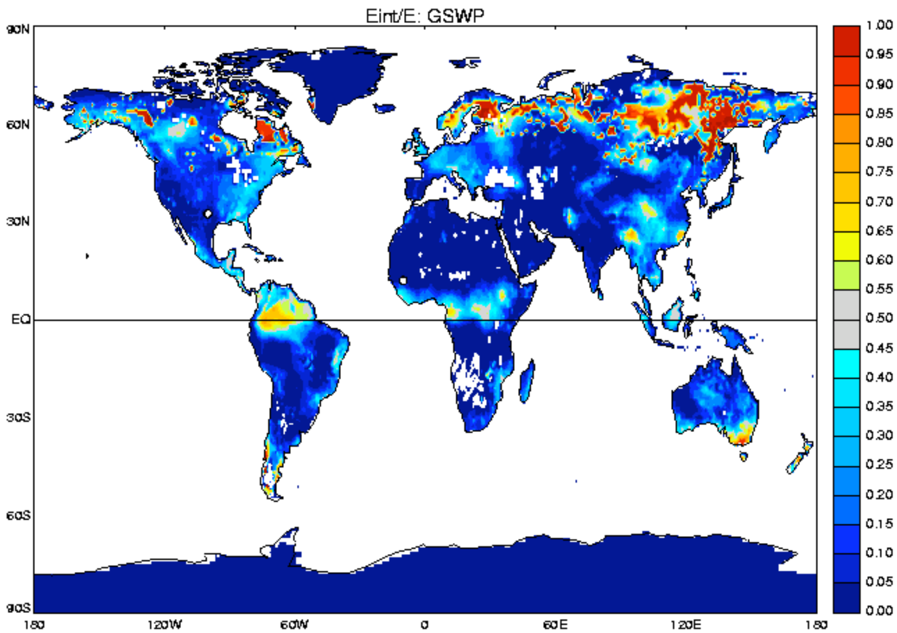
- Larger diurnal variability over continents than oceans
- GEOS-5 tends to overestimate the amplitude over continents and underestimate over oceans



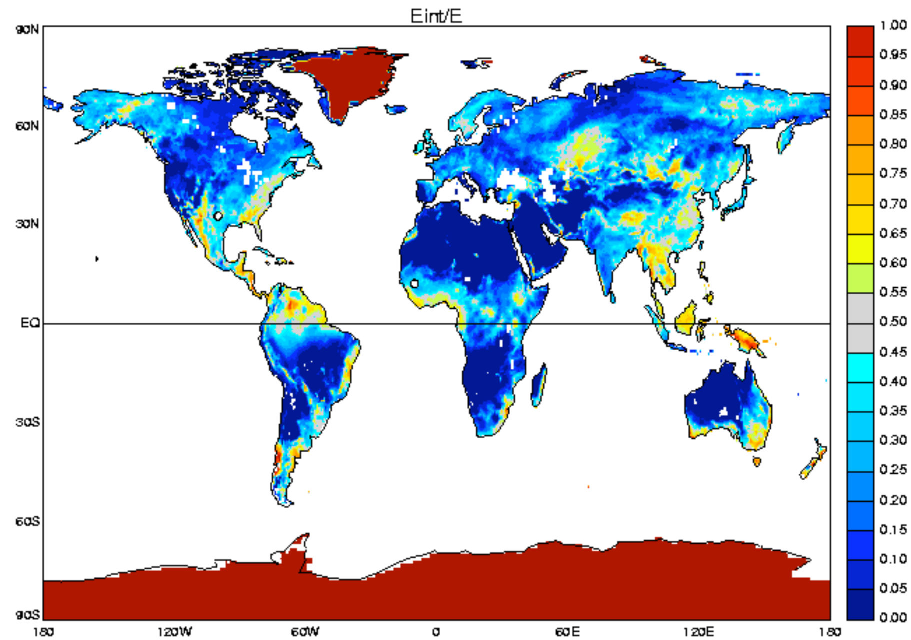


Diurnal variation in precipitation over the United States for July 2004 (mm/day). The July mean is removed.

Interception loss / total evaporation: A defining characteristic of local hydrology



offline catchment (GSWP), June 20-30

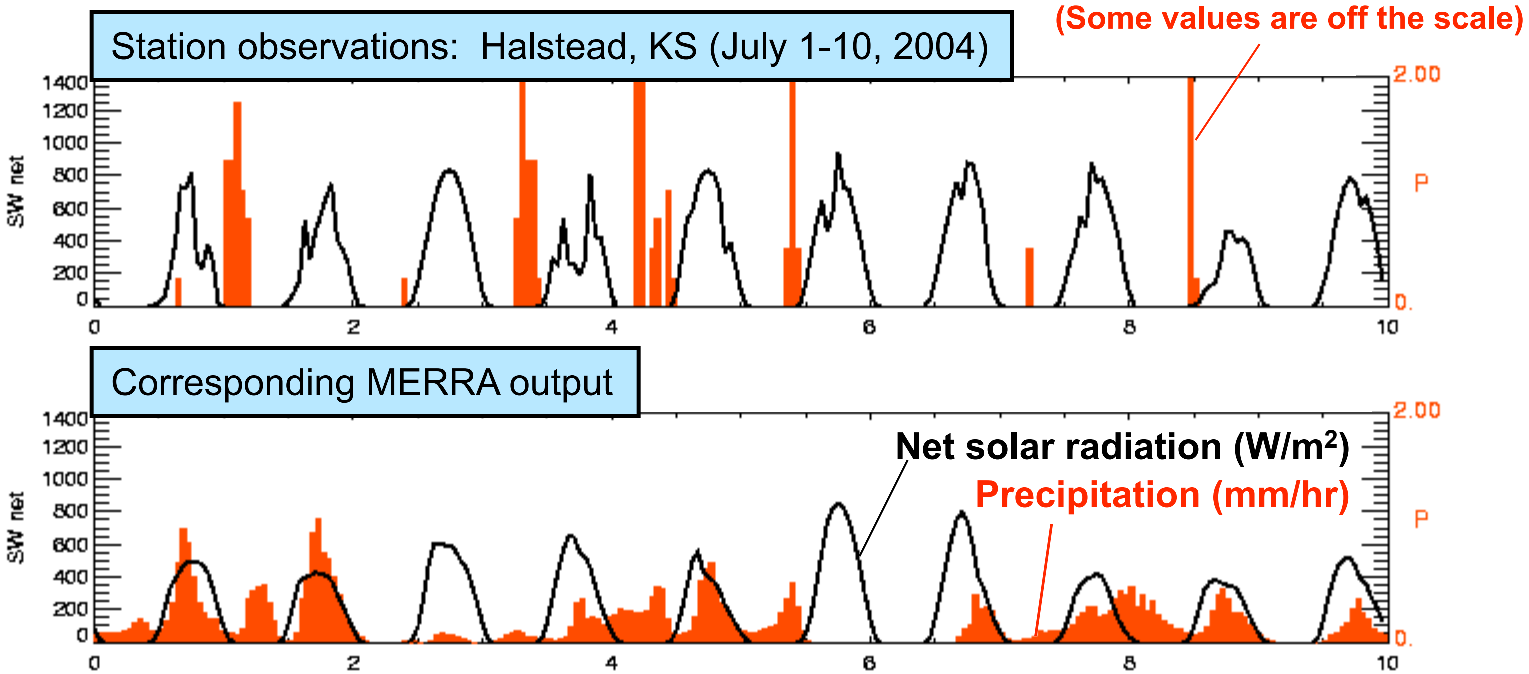


catchment within MERRA, June 20-30

Summary of findings:

-- Interception loss ratio is generally smaller in the offline (“realistic”) forcing environment than it is in the MERRA environment.

Likely Problem Source: Coincidence of Rainfall and High Solar Radiation



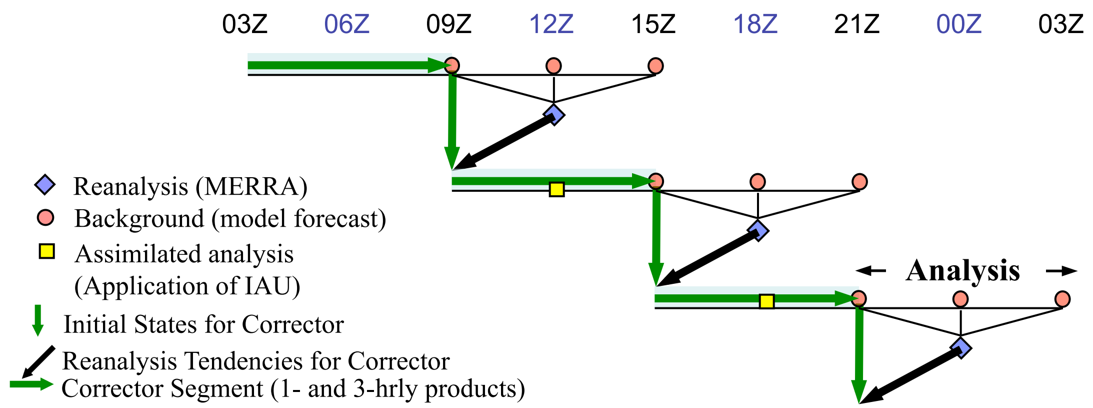
	Total Rainfall for 10-day period	Amount of that rainfall that can be evaporated using concurrent SW-net
Station obs.	55.3 mm	0.3 mm
MERRA	41.3 mm	25.3 mm

Analysis Increments, Budgets and Replay

GEOS-5 DAS

$$\left(\frac{\partial q^n}{\partial t}\right)_{total} = dynamics(adiabatic) + physics(diabatic) + \Delta q$$

Total "observed change" **Model predicted change** **Correction from DAS**



Budgets:

$$\overline{\left(\frac{\partial q^n}{\partial t}\right)_{total}} = \overline{dynamics(adiabatic)} + \overline{physics(diabatic)} + \overline{\Delta q}$$

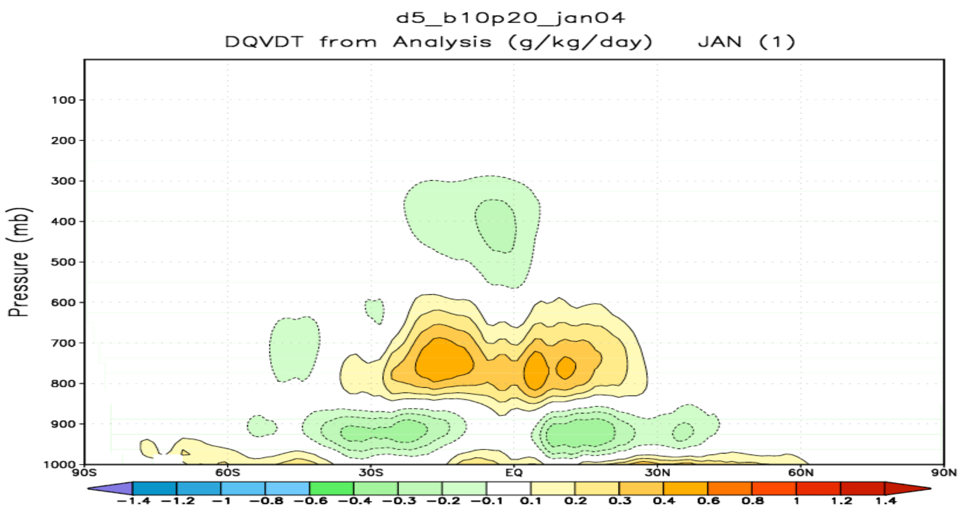
Mean analysis increment: measure of model's mismatch with nature

Replay: $\Delta q = q\,(analysis) - q\,(first\ guess)$

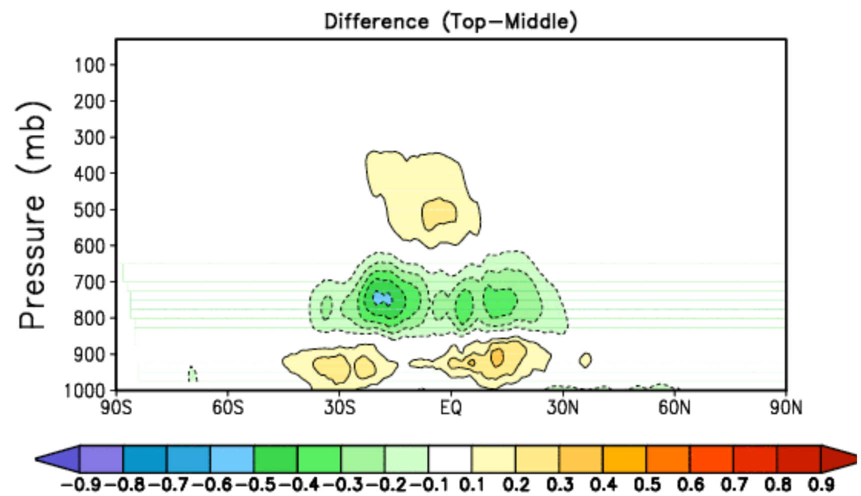
MERRA, Scout, JRA25, NCEP R2, etc.

GEOS-5 AGCM or coupled model

January 2004 Zonal Mean Specific Humidity

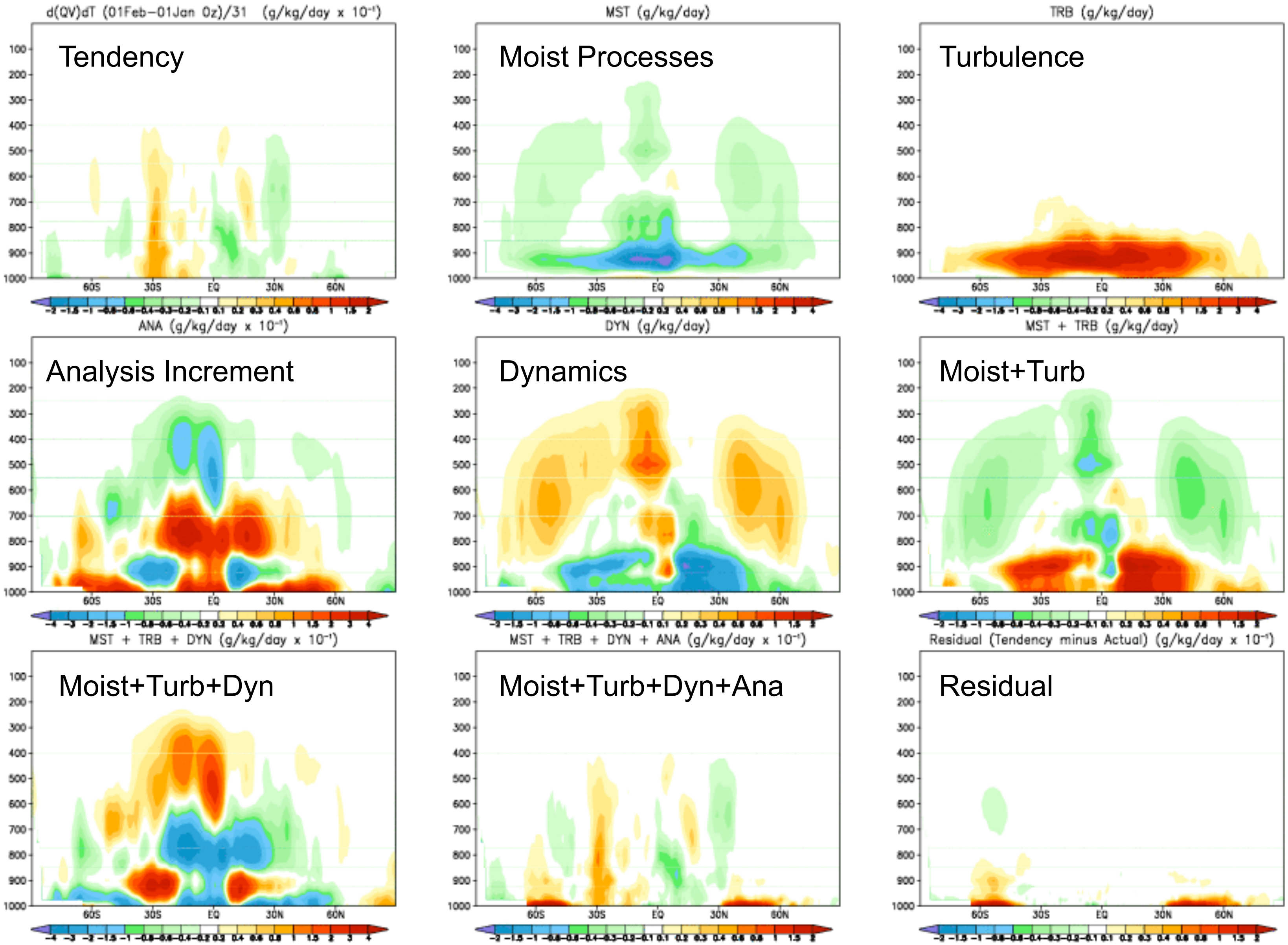


Analysis Increment



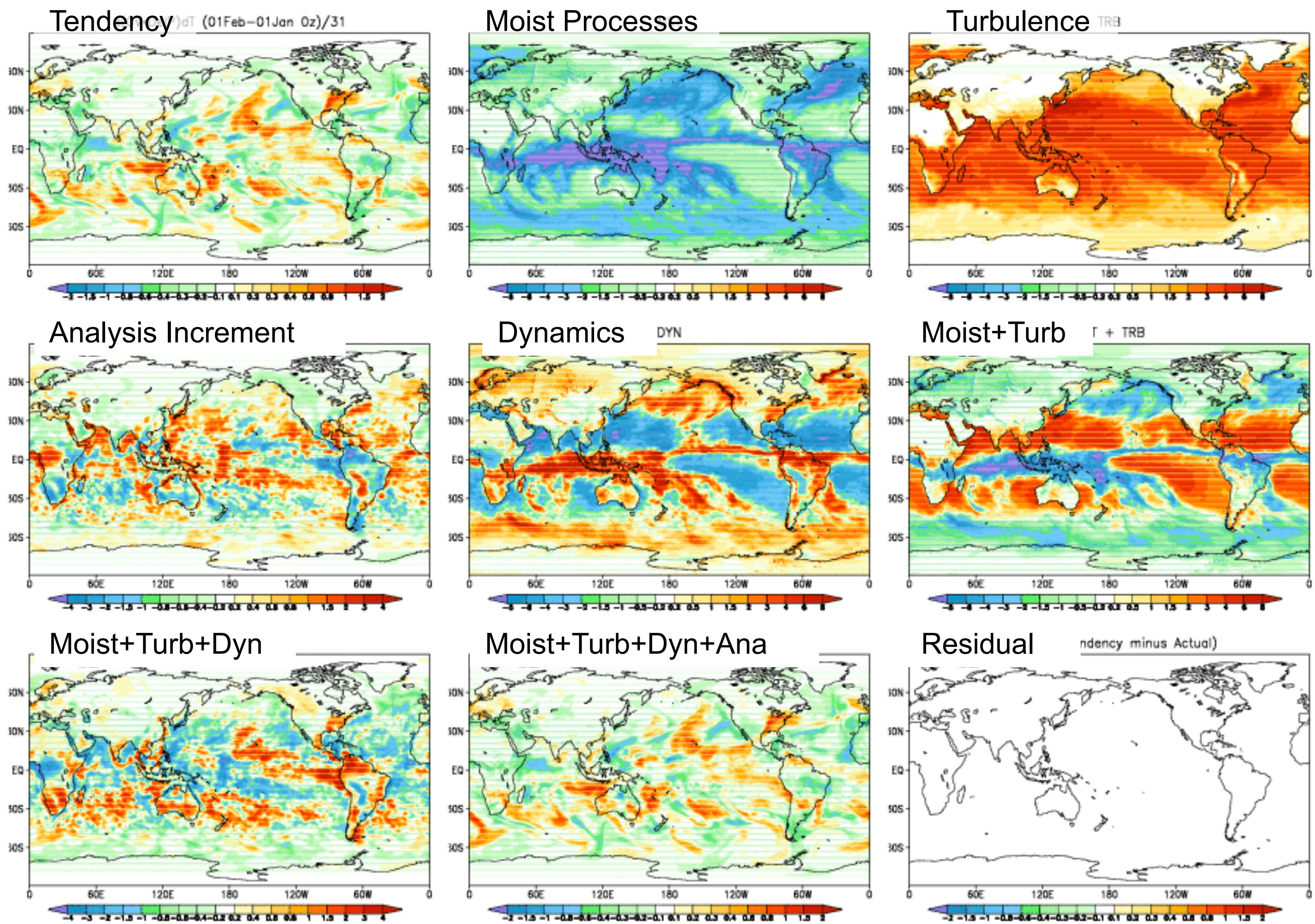
24 Hour Forecast Error

January 2002 Zonal Mean Specific Humidity Budget from MERRA



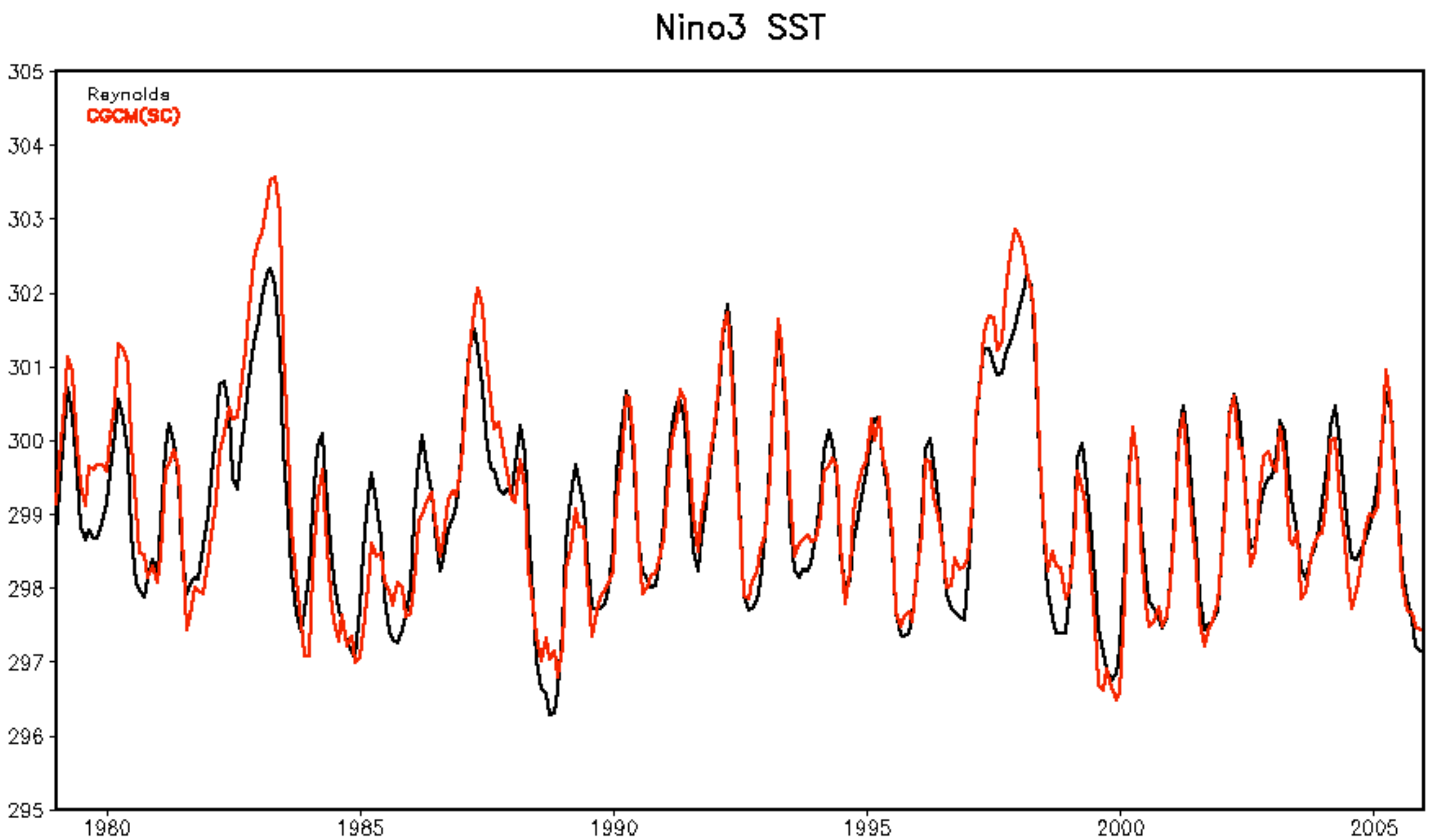
Sum of Physical terms

January 2002 Vertical Mean Specific Humidity Budget from MERRA

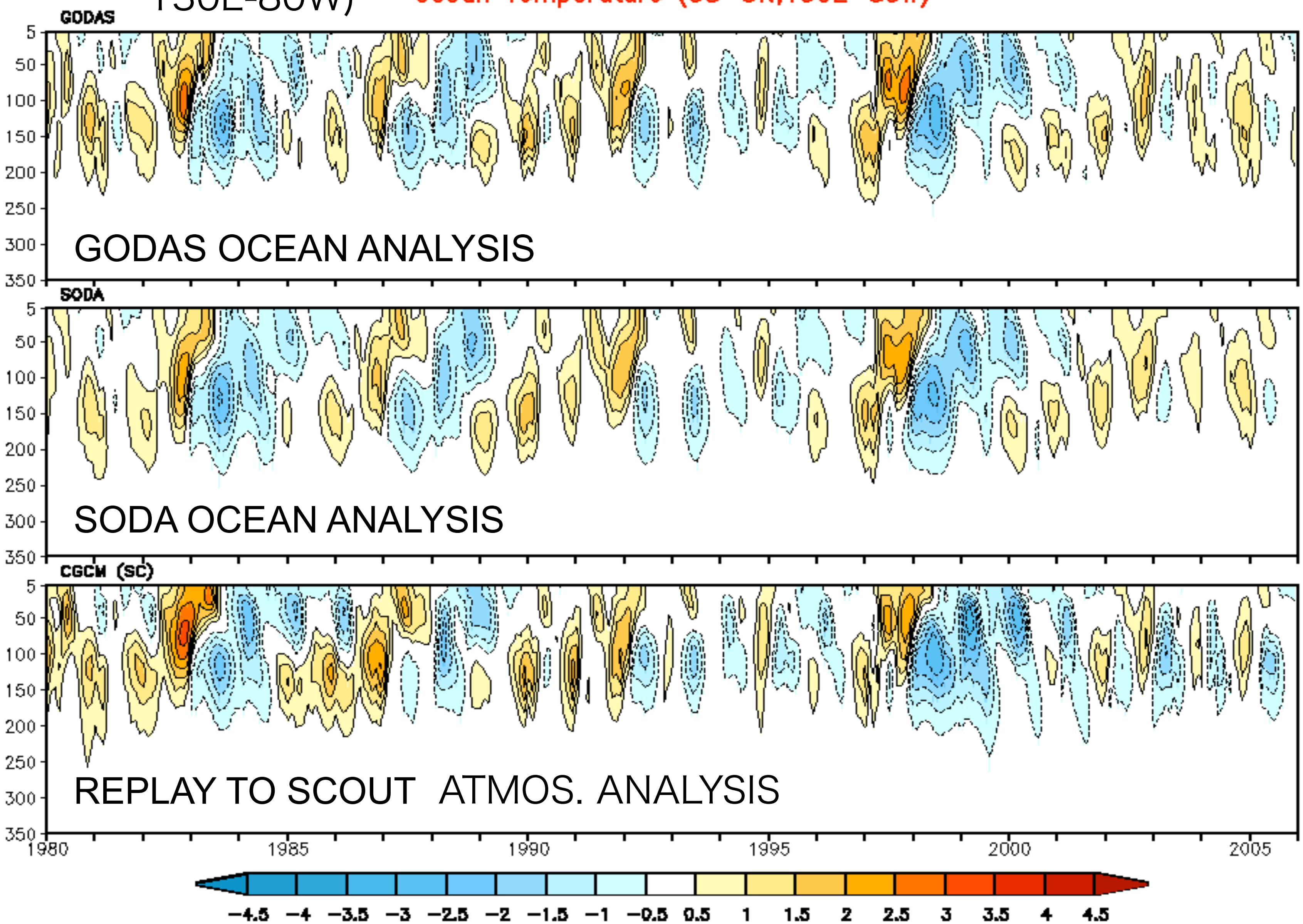


Replay to Scout Using CGCM

NINO3 SST: Replay Results (red) versus Reynolds Observations

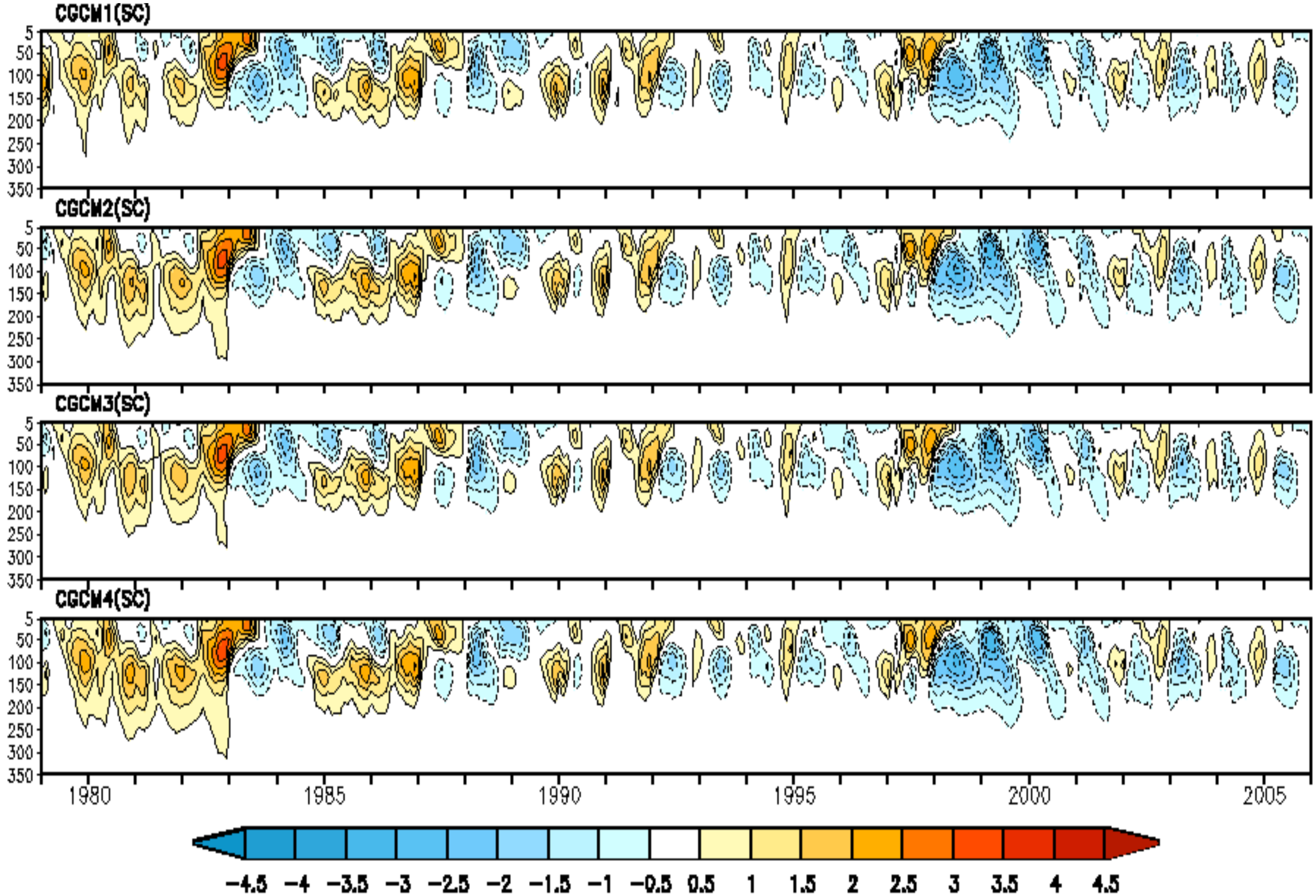


SUBSURFACE OCEAN TEMPERATURE (5S-5N, 130E-80W)



SUBSURFACE OCEAN TEMPERATURE (5S-5N, 130E-80W)

REPLAY TO SCOUT ATMOS. ANALYSIS



Summary

- MERRA improves upon many features of existing reanalyses

- Biases generally smaller than climate signals

- Precipitation issues remain: trends; diurnal cycle, summer land

- Comprehensive output suite including analysis increments

  -anticipate novel uses of MERRA to address climate and modeling issues

movie