GEOS-5 Atmospheric Analyses for Climate Studies

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&
GMAO

Presentation at CERES Science Team Meeting
May 7, 2008

Overview

- The GEOS-5 system
- Observing System - changes for G5-CERES
- Validation
- Climate Variability

GEOS-5 Atmospheric DAS
(Supported by NASA MAP Program)

AGCM

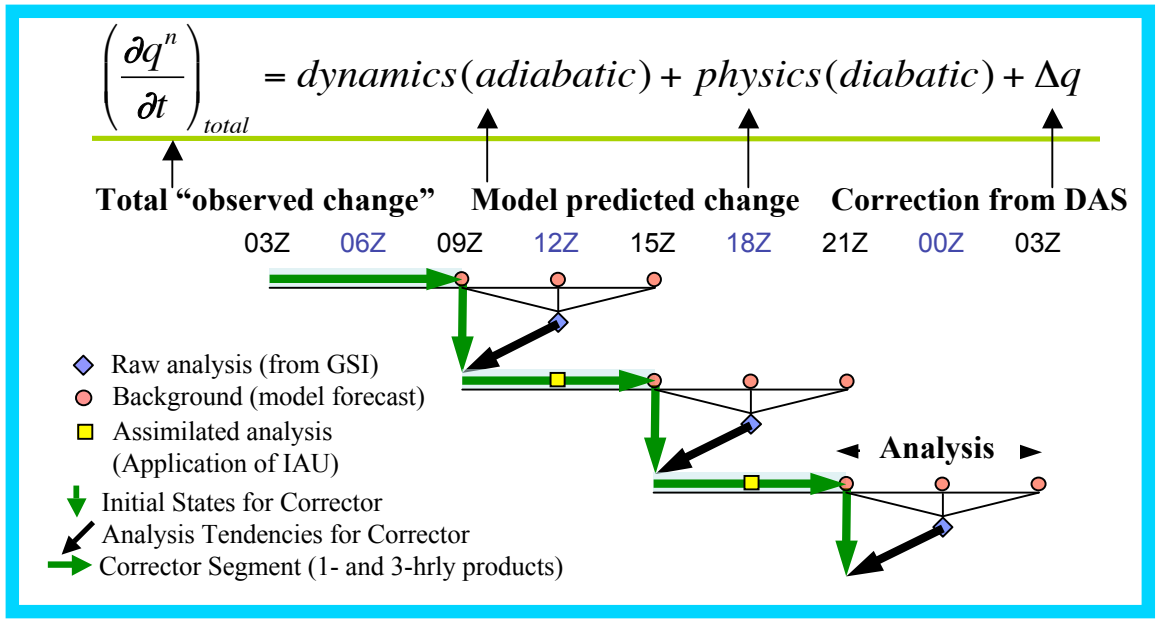
- Finite-volume dynamical core (S.J. Lin)
- Moist physics (J. Bacmeister, S. Moorthi and M. Suarez)
- Physics integrated under the Earth System Modeling Framework (ESMF)
- Generalized vertical coord to 0.01 hPa
- Catchment land surface model (R. Koster)
- Prescribed aerosols (P. Colarco)
- Interactive ozone
- Prescribed SST, sea-ice

Analysis

- Grid Point Statistical Interpolation (GSI from NCEP)
- Direct assimilation of satellite radiance data using JCSDA Community Radiative Transfer Model (CRTM)
- Variational bias correction for radiances

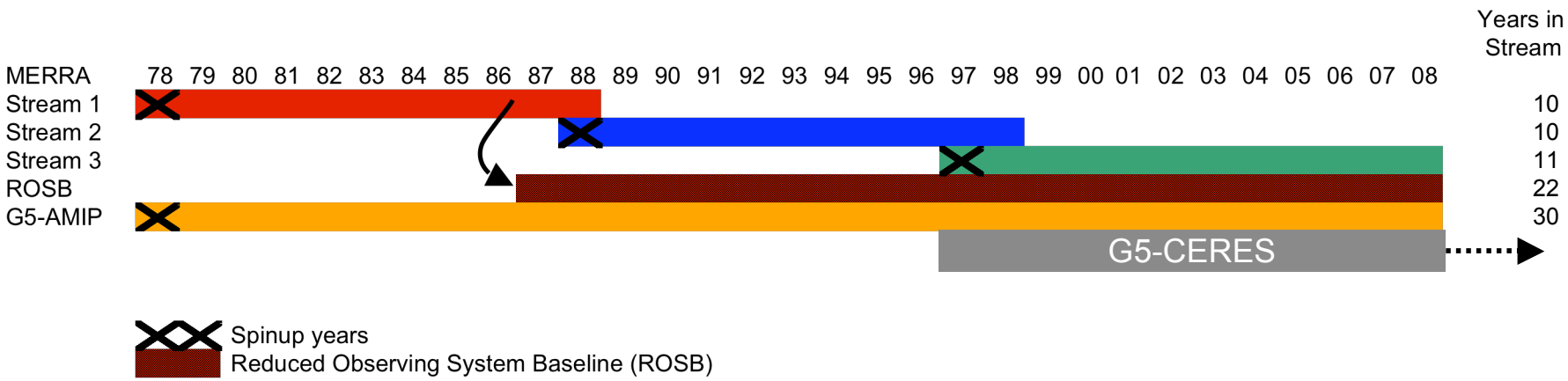
Assimilation

- Apply Incremental Analysis Updates (IAU) to reduce shock of data insertion (Bloom et al.)
- IAU gradually forces the model integration throughout the 6 hour analysis period
- Allows for 1 hourly diagnostic output



MERRA Production

- 2-year spin up at 2-degree resolution
- 1-year spin up at ½ degree
- Product Streams begin: Jan 1 – 1979, 1989 and 1998
- Proposed Objective: Focus on the water cycle



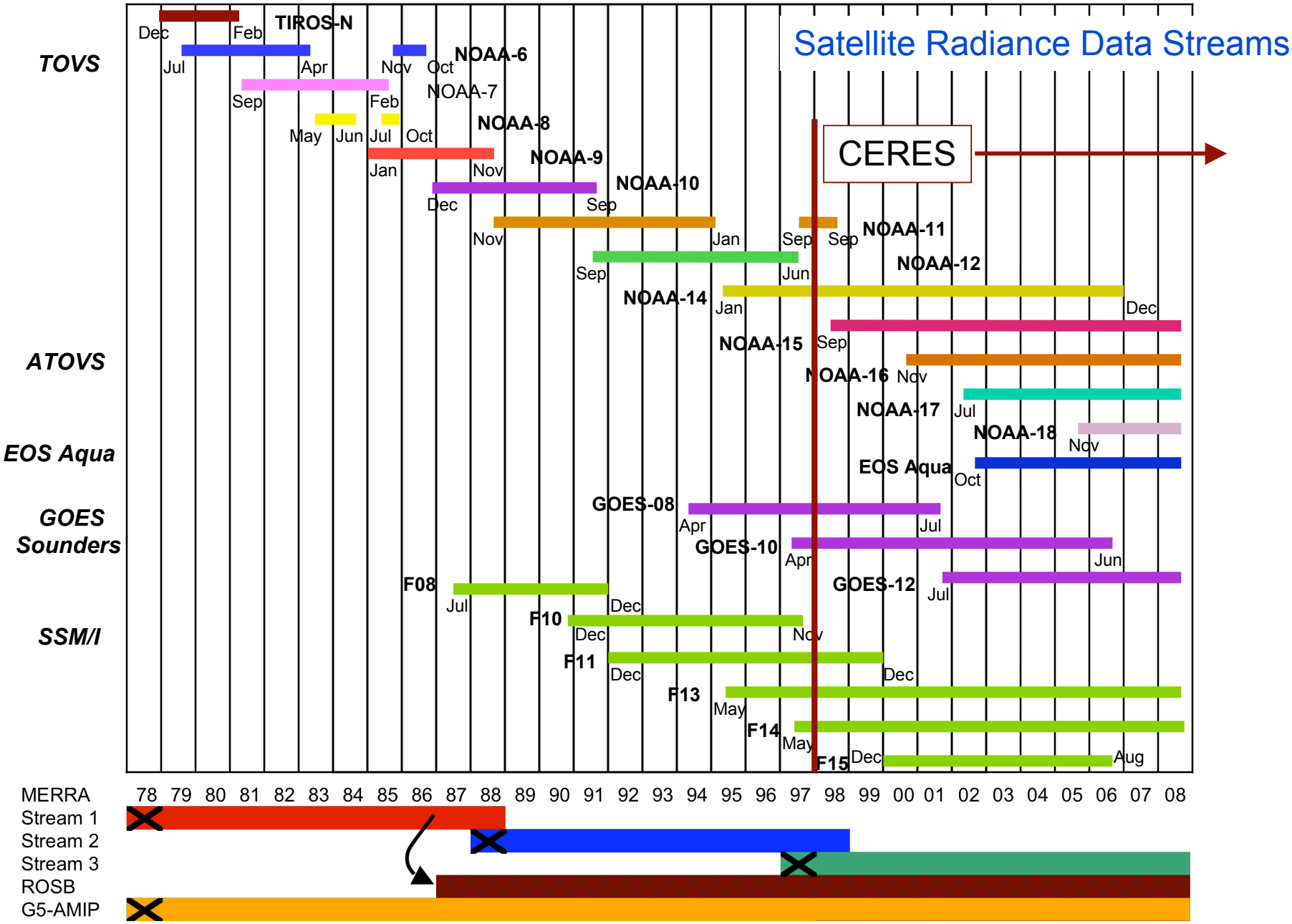
- **Preview/Validation runs:**
  - **Jan, Apr, Jul, Oct 2004**
  - July-August 1987
  - Jan, Jul 2001
  - **Jan 2006**

- **2 degree (scout) runs** ⇒ preliminary look at data and spin-up of satellite bias estimates.

G5-CERES: restricted input data streams

DATA SOURCE/TYPE	PERIOD	DATA SUPPLIER
Conventional Dat a		
Radiosondes	1970 - present	NOAA/NCEP
PIBAL winds	1970 - present	NOAA/NCEP
Wind profiles	1992/5/14 - present	UCAR CDAS
Conventional, ASDAR, and MDCRS aircraft reports	1970 - present	NOAA/NCEP
Dropsondes	1970 - present	NOAA/NCEP
PAOB	1978 - present	NCEP CDAS
GMS, METEOSAT, cloud drift IR and visible winds	1977 – present	NOAA/NCEP
GOES cloud drift winds	1997 – present	NOAA/NCEP
~~EOS/Terra/MODIS winds~~	~~2002/7/01 - present~~	~~NOAA/NCEP~~
~~EOS/Aqua/MODIS winds~~	~~2003/9/01 - present~~	~~NOAA/NCEP~~
Surface land observations	1970 - present	NOAA/NCEP
Surface ship and buoy observations	1977 - present	NOAA/NCEP
SSM/I rain rate	1987/7 - present	NASA/GSFC/DAAC
SSM/I V6 wind speed	1987/7 - present	RSS
TMI rain rate	1997/12 - present	NASA/GSFC/DAAC
QuikSCAT surface winds	1999/7 - present	JPL
~~ERS-1 surface winds~~	~~1991/8/5 – 1996/5/21~~	~~CERSAT~~
~~ERS-2 surface winds~~	~~1996/3/19 – 2001/1/17~~	~~CERSAT~~

Satellite Dat a		
TOVS (TIROS N, N-6, N-7, N-8)	1978/10/30 – 1985/01/01	NCAR
(A)TOVS (N-9; N-10 ; N-11; N-12)	1985/01/01 - 1997/07/14	NOAA/NESDIS & NCAR
ATOVS (N-14; N-15; N-16; N-18; N-18)	1995/01/19 - present	NOAA/NESDIS
~~EOS/Aqua~~	~~2002/10 - present~~	~~NOAA/NESDIS~~
SSM/I V6 (F08, F10, F11, F13, F14, F15)	1987/7 - present	RSS
~~GOES sounder T_B~~	~~2001/01 - present~~	~~NOAA/NCEP~~
SBUV2 ozone (Version 8 retrievals)	1978/10 - present	NASA/GSFC/Code 613.3


Satellite Radiance Data Streams
TOVS
ATOVS
EOS Aqua
GOES Sounders
SSM/I
TIROS-N
NOAA-6
NOAA-7
NOAA-8
NOAA-9
NOAA-10
NOAA-11
NOAA-12
NOAA-14
NOAA-15
NOAA-16
NOAA-17
NOAA-18
EOS Aqua
GOES-08
GOES-10
GOES-12
F08
F10
F11
F13
F14
F15
CERES
MERRA
Stream 1
Stream 2
Stream 3
ROSB
G5-AMIP
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08

MERRA FILE COLLECTIONS

- MERRA products are organized into 24 collections, each consisting of a series of daily HDF files.

- All distributed data products have slightly degraded precision and are compressed with gzip.

- All data within each collection have the same horizontal, vertical, and temporal resolution

- Data are produced on three horizontal grids:
  - Native ---------- (1/2 by 2/3 w/ FV conventions)
  - Reduced ------- (1½ by 1½ Dateline-edge, Pole-edge)
  - Reduced FV -- (1 by 1¼ w/ FV conventions)

- In the vertical, 3-D data can be at:
  - 72 model layers
  - 42 pressure levels

- Temporal resolution can be:
  - 1- or 3-hour averages
  - 3- or 6-hourly instantaneous

MERRA FILE COLLECTIONS

ANALYZED FIELDS (u,v,t,q,O_3,p) [2]
NATIVE, INSTANTANEOUS, 6-HOURLY
MODEL AND PRESSURE LEVELS

INVARIANTS [2]

ASSIMILATED FIELDS [1]
REDUCED, INSTANTANEOUS, 3-HOURLY
PRESSURE LEVELS

3-D DIAGNOSTIC FIELDS [8]
REDUCED, TIME-AVERAGED, 3-HOURLY
PRESSURE LEVELS

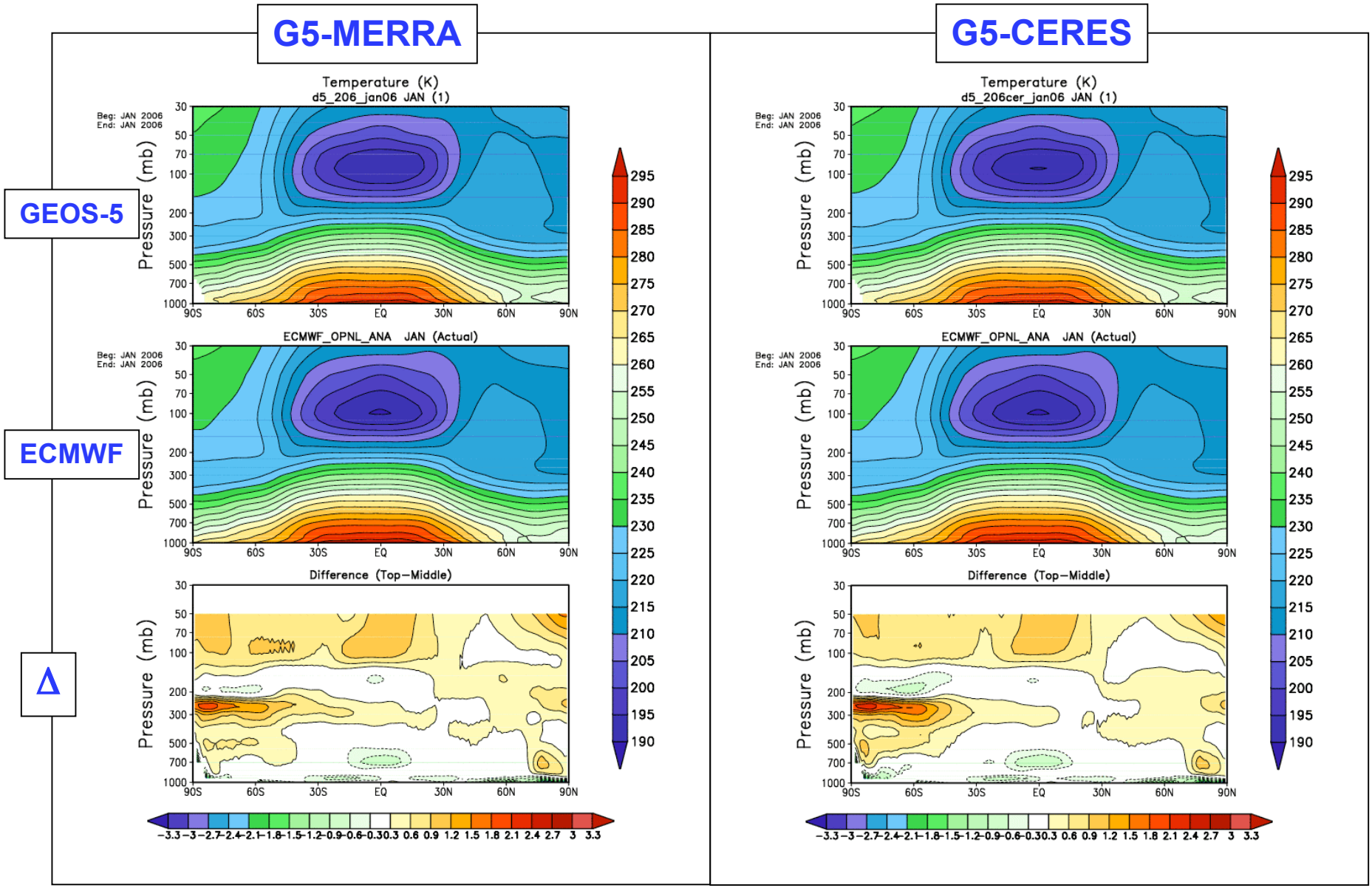
2-D DIAGNOSTIC FIELDS [5]
NATIVE, TIME-AVERAGED, HOURLY

PRODUCTS FOR OFFLINE
CHEMISTRY TRANSPORTMODELS [6]
VARIOUS RESOLUTIONS FREQUENCIES AND GRIDS

Comparisons

What is the impact of removing data for G5-CERES?

Zonal mean temperature comparison

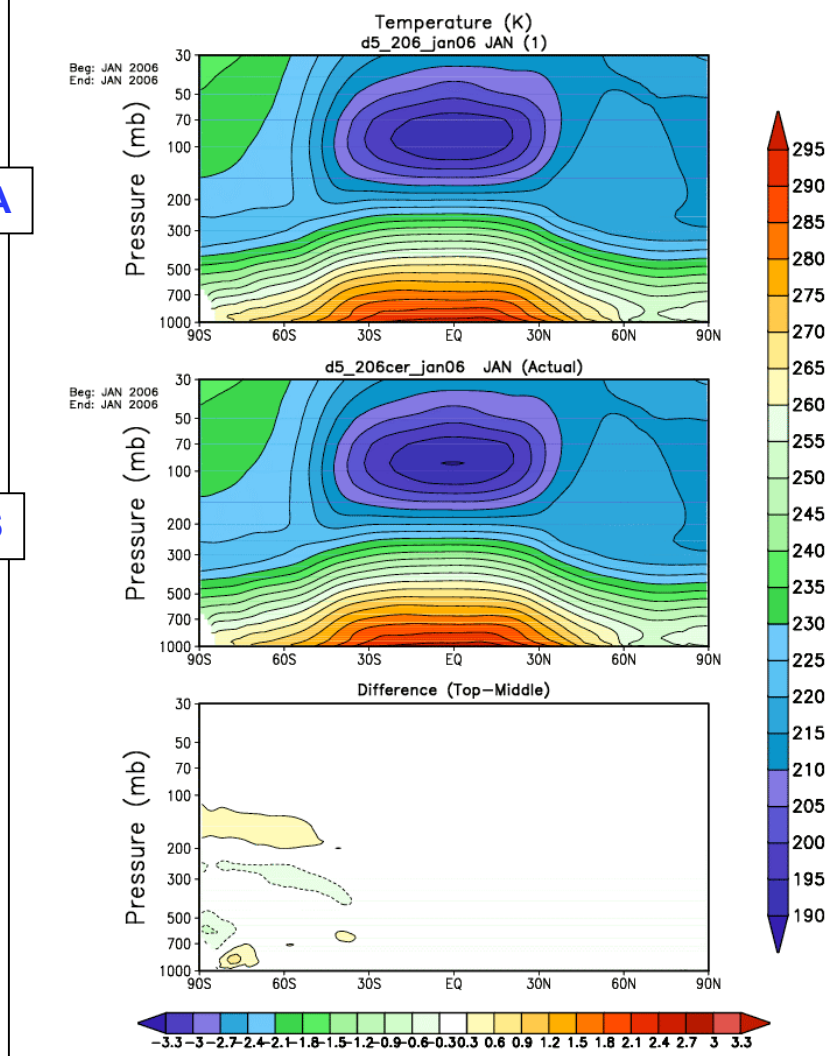


Zonal mean temperature comparison

G5-MERRA

G5-CERES

Δ



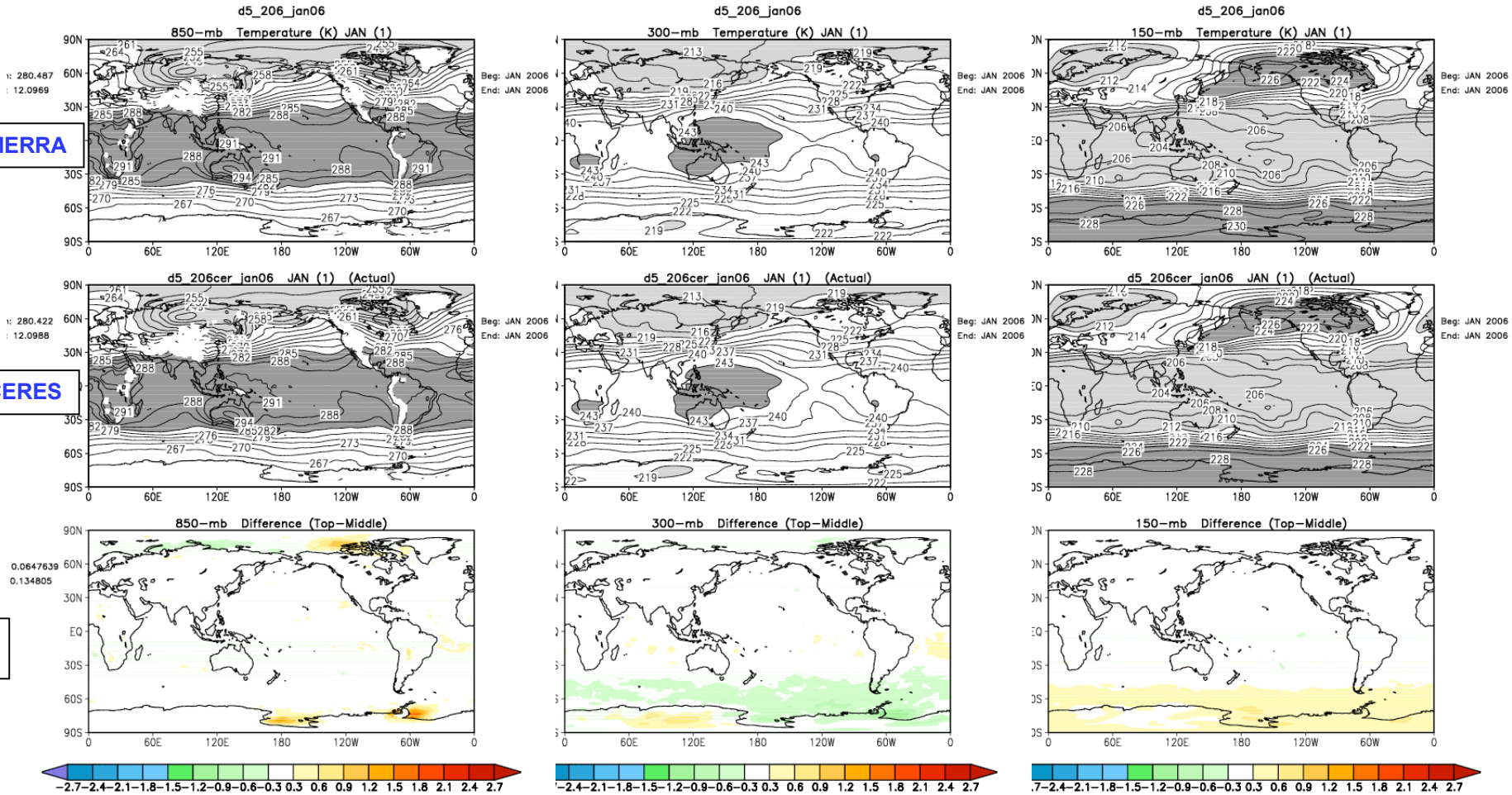
Temperature comparison

850 hPa | 300 hPa | 150 hPa

G5-MERRA

G5-CERES

Δ

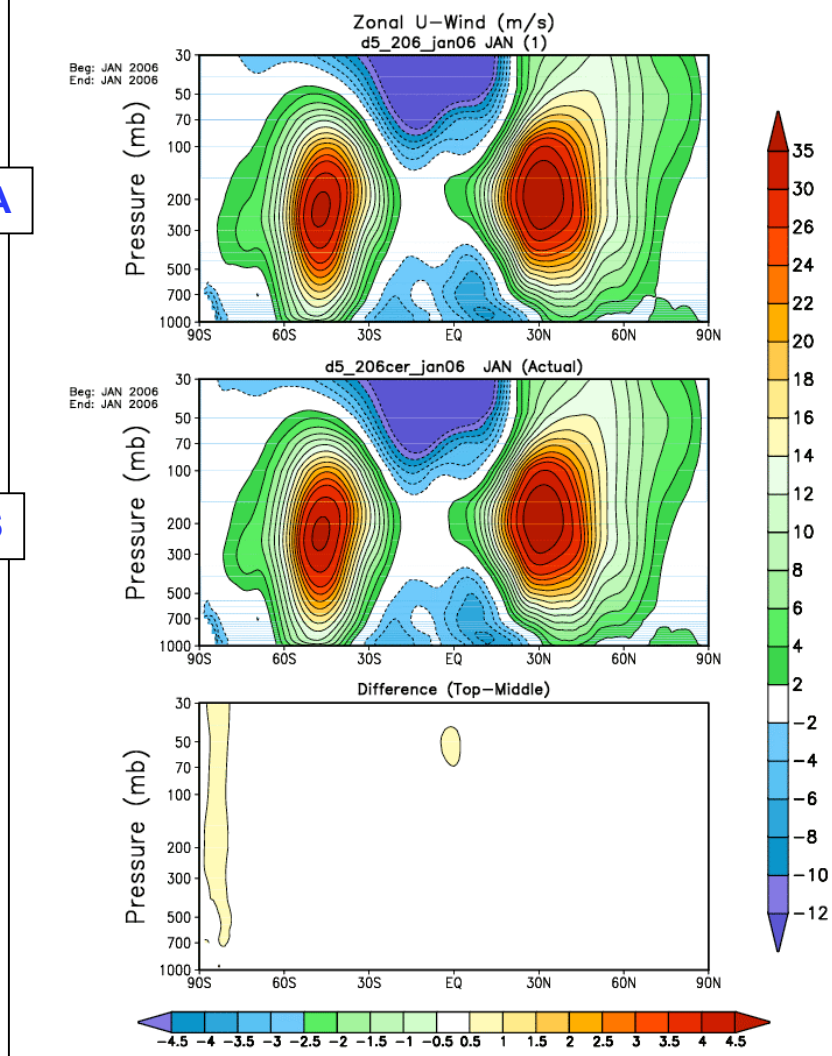


Zonal mean zonal wind comparison

G5-MERRA

G5-CERES

Δ

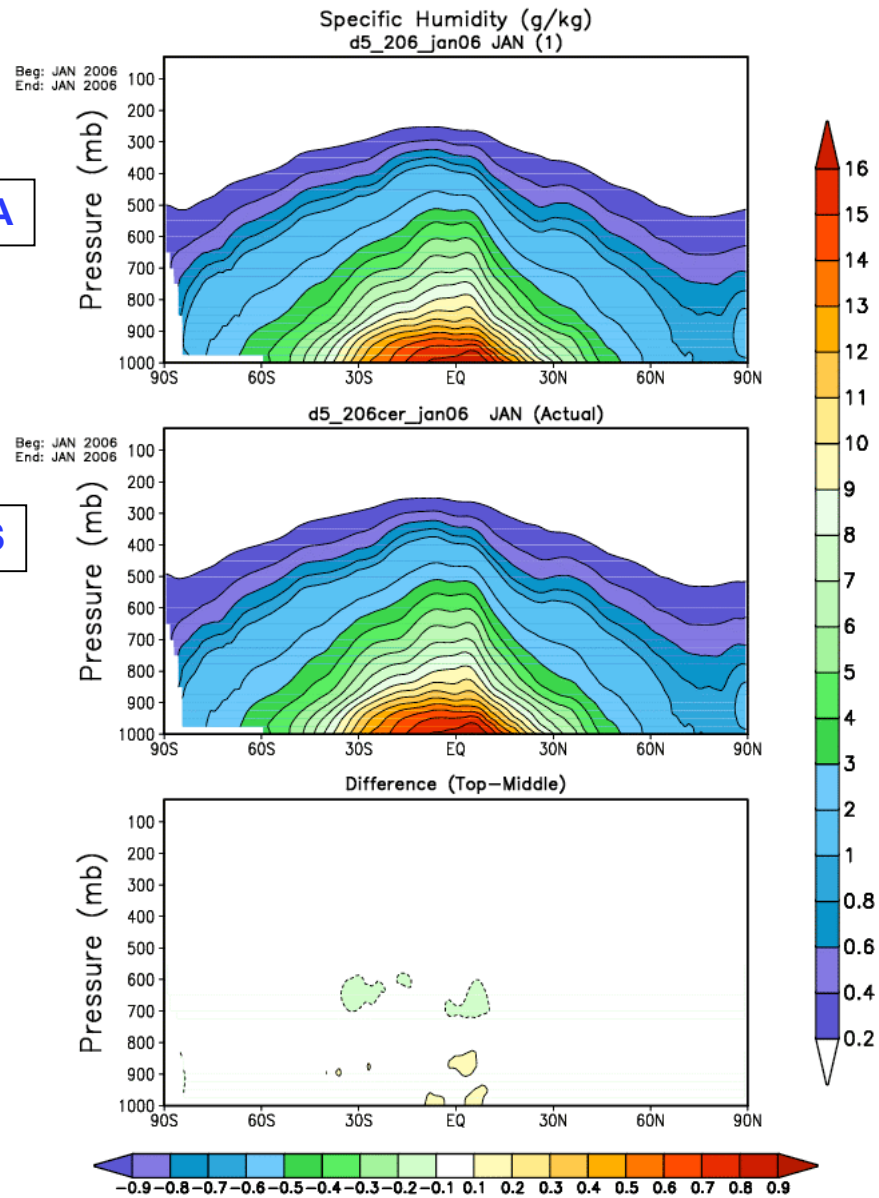


Zonal mean specific humidity comparison

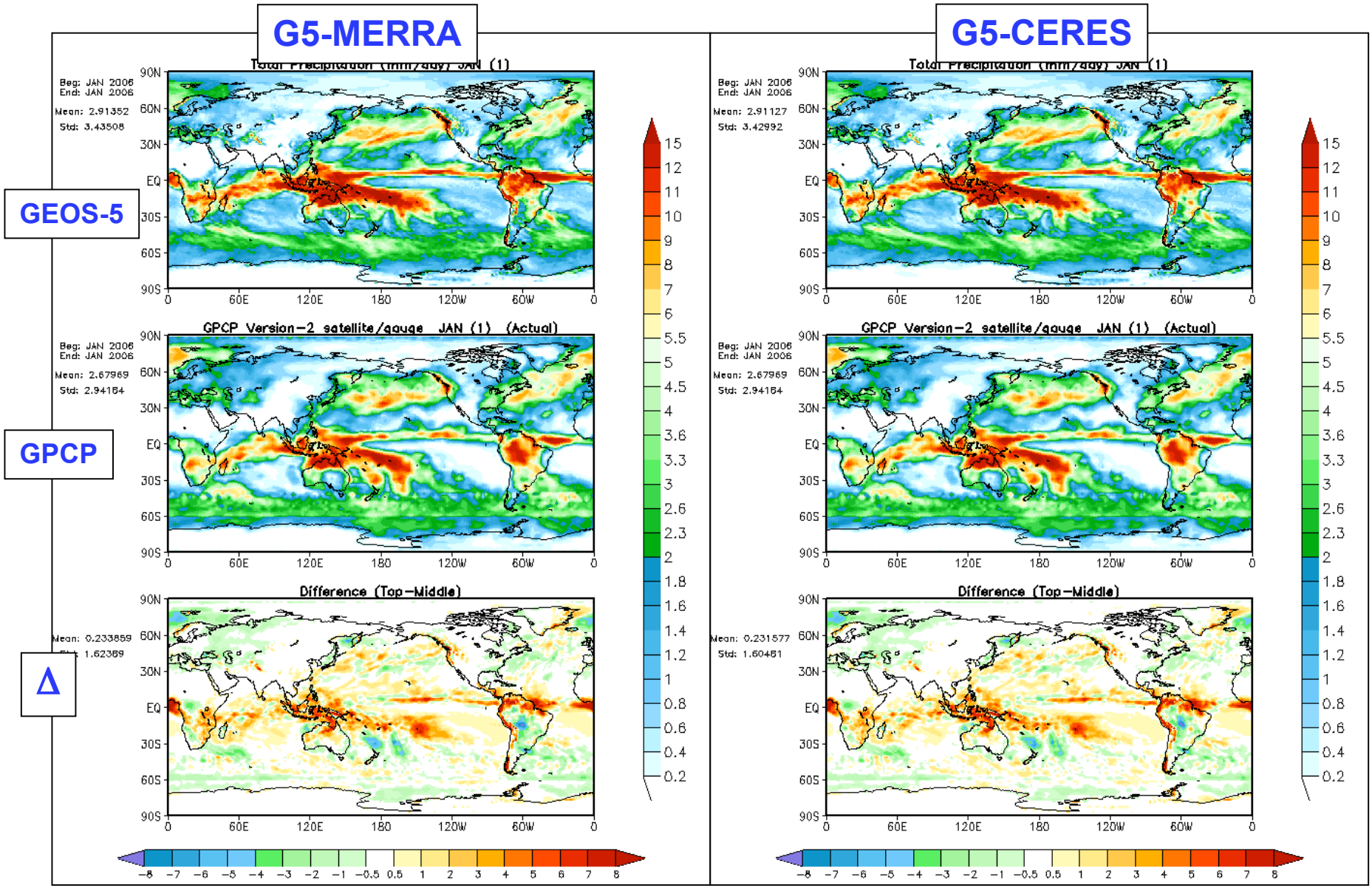
G5-MERRA

G5-CERES

Δ



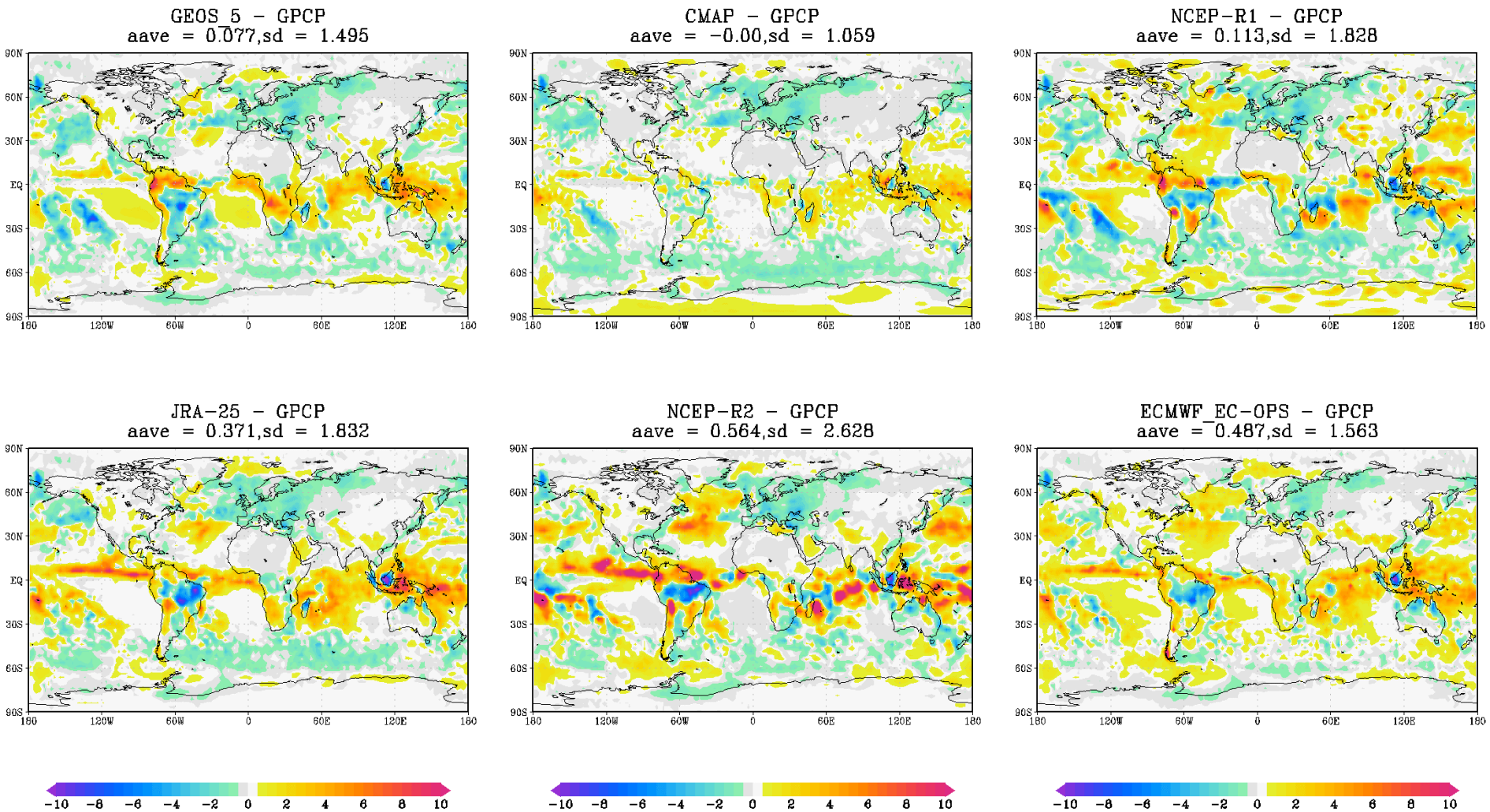
Precipitation comparison



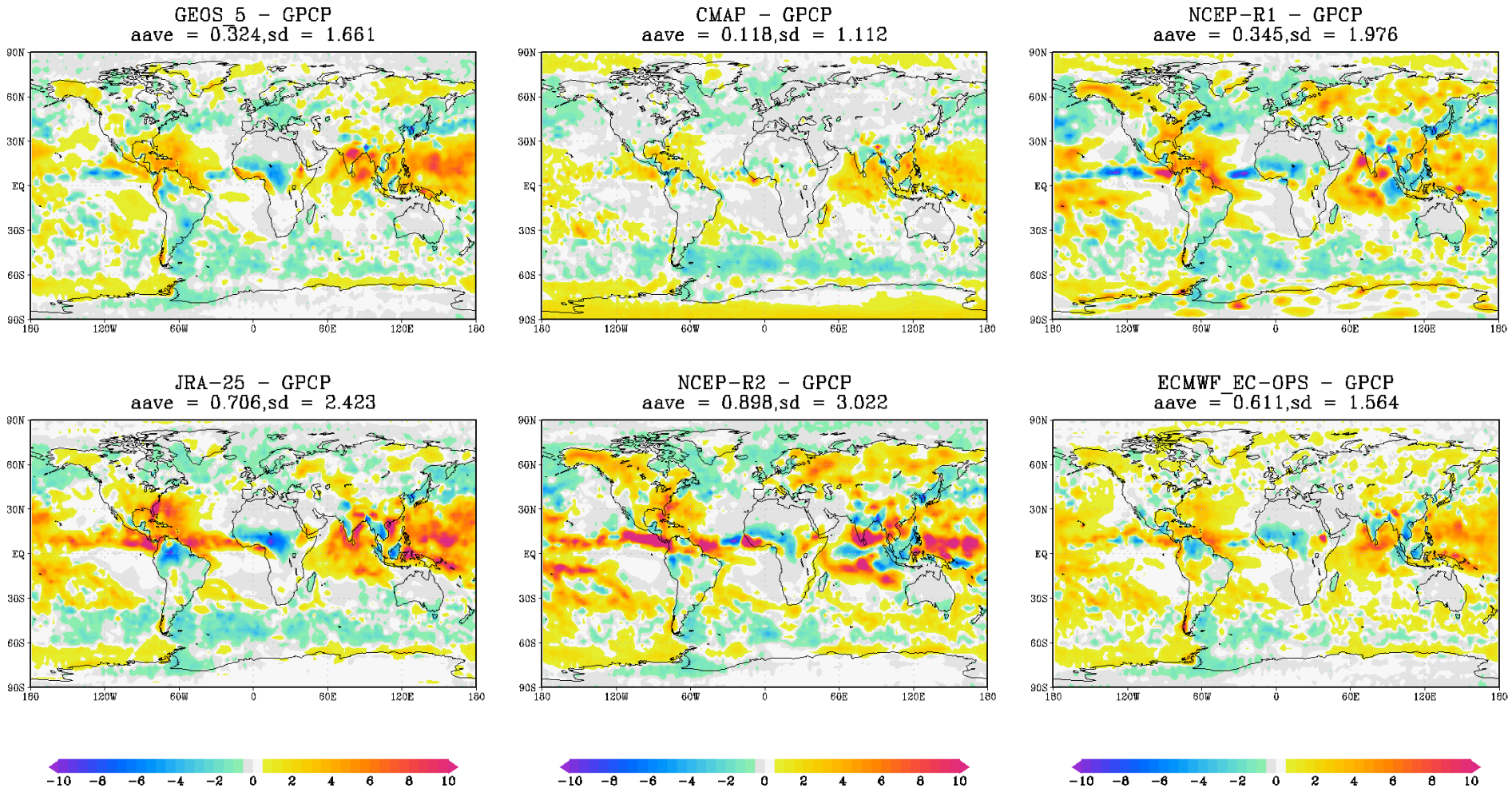
Validation

Including ERA-40, JRA-25

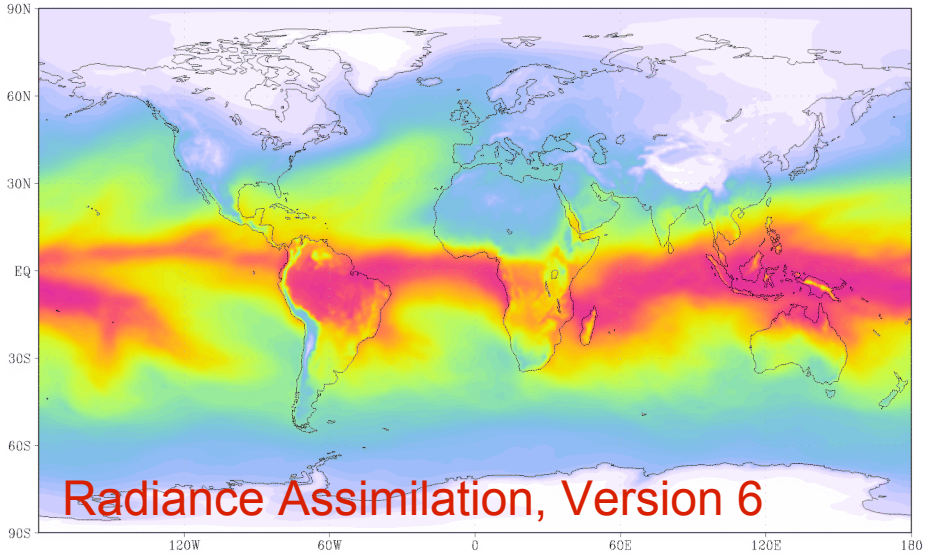
Precipitation c.f. GPCP (mm/day)
January 2004



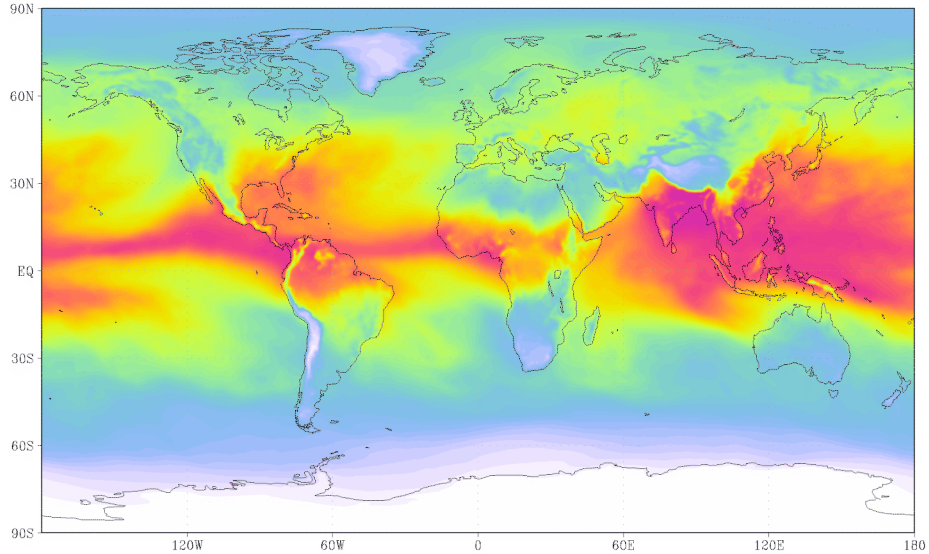
Precipitation c.f. GPCP (mm/day)
July 2004



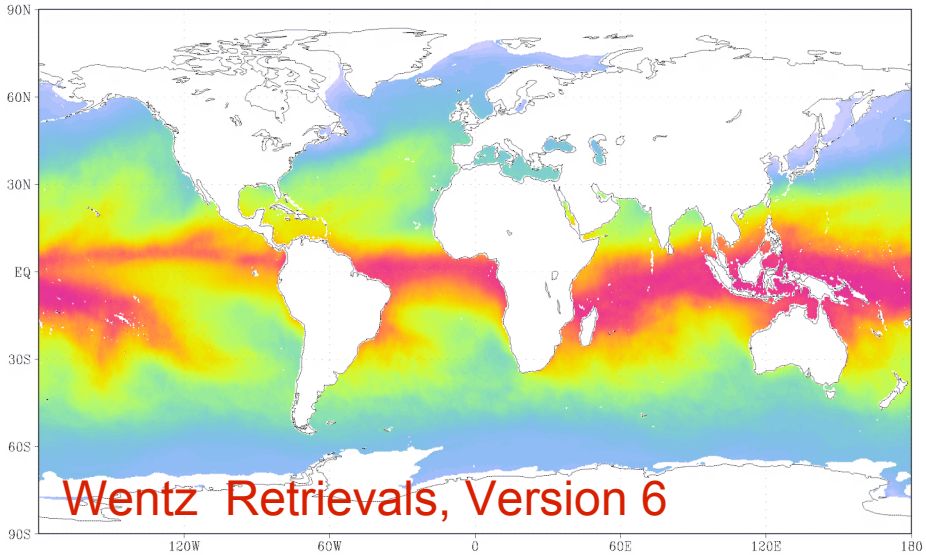
GEOS5 TPW Jan 2004



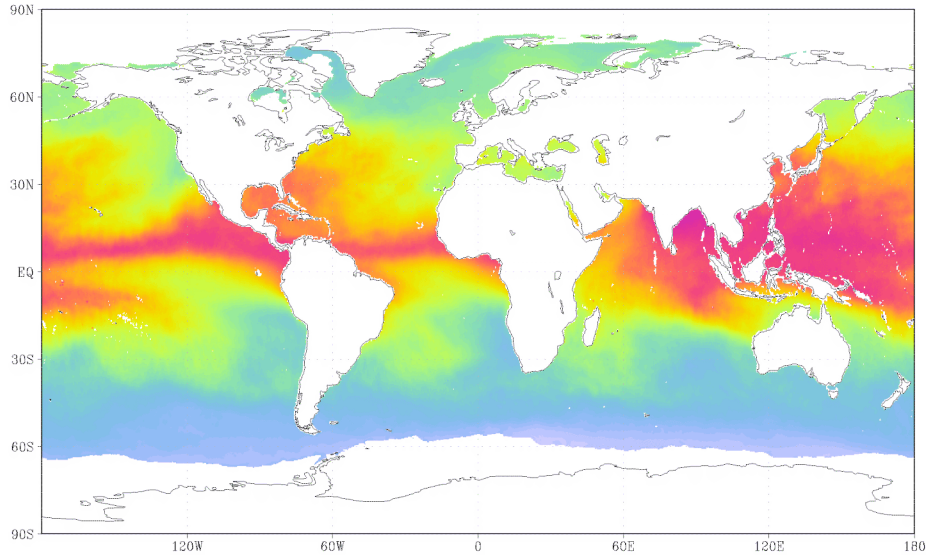
GEOS5 TPW Jul 2004



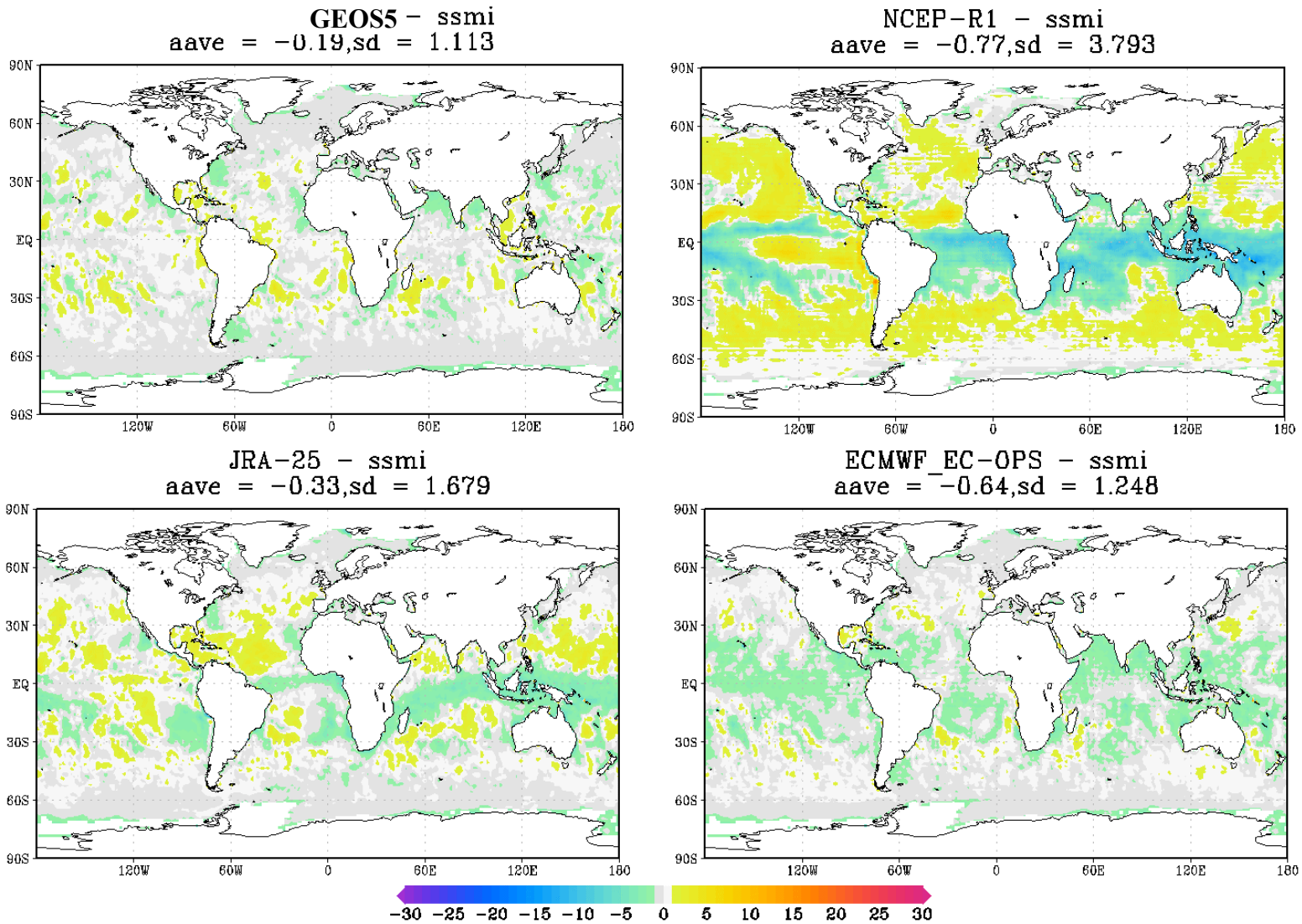
SSMI TPW Jan 2004



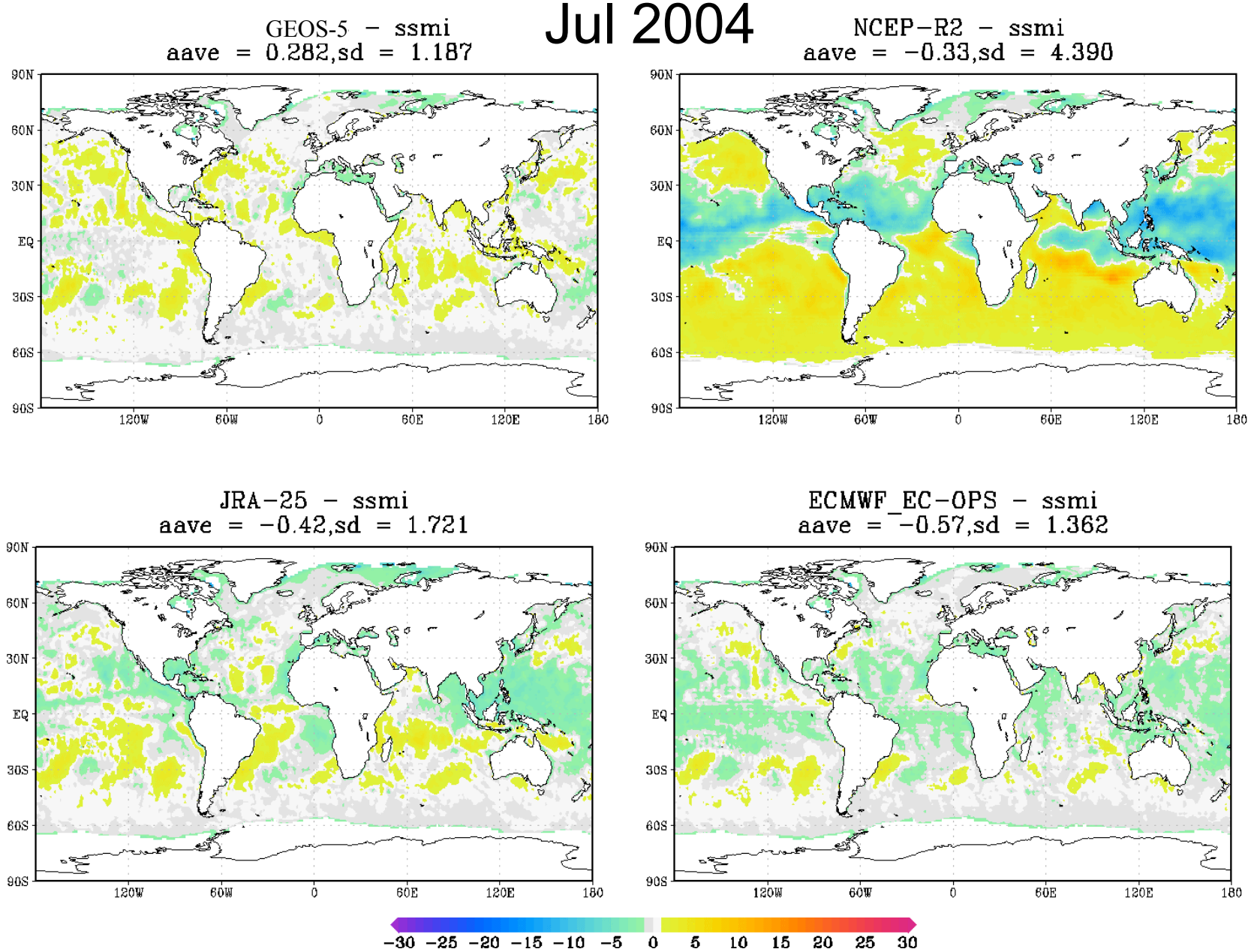
SSMI TPW Jul 2004



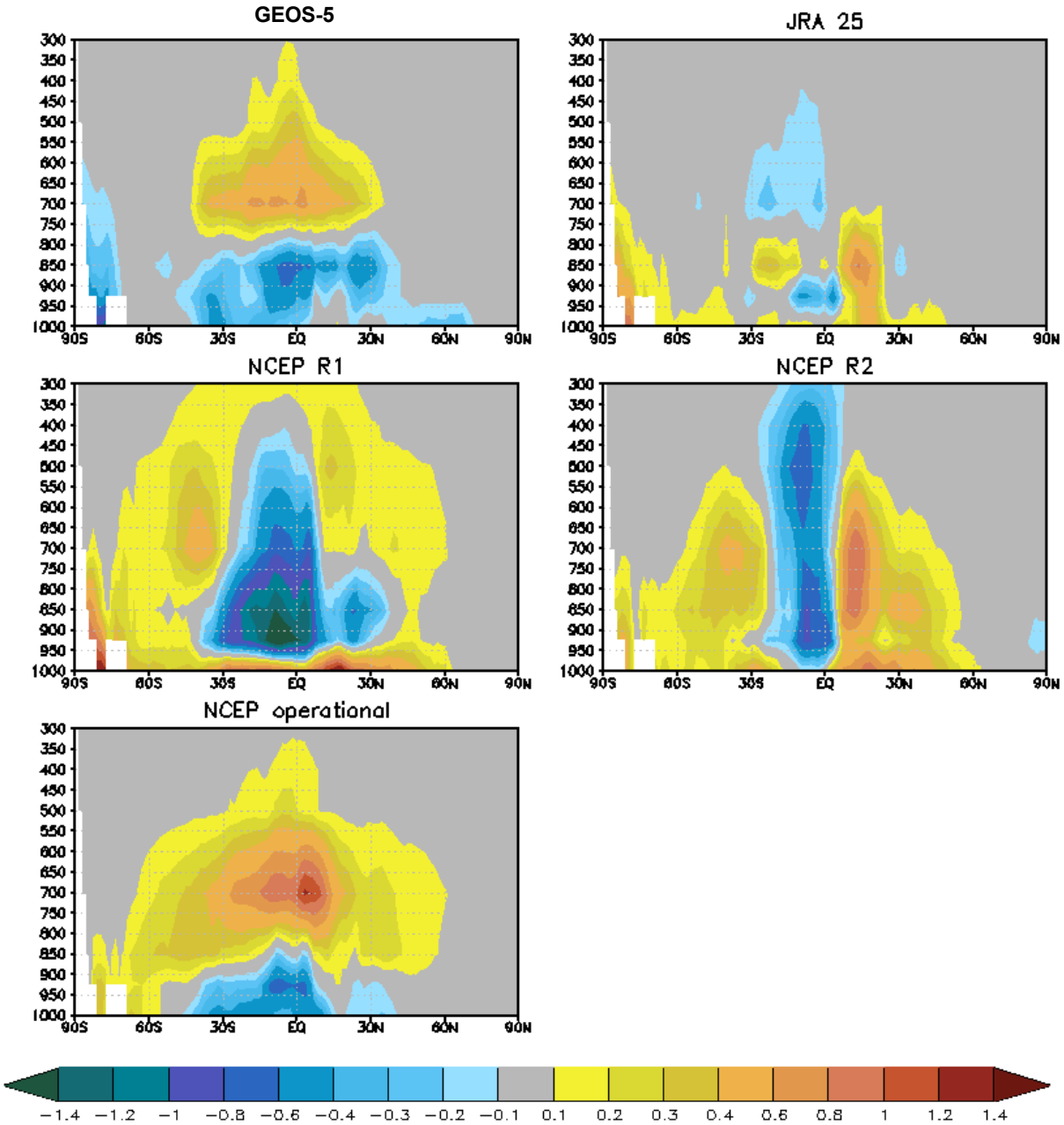
TPW - SSM/I
Jan 2004



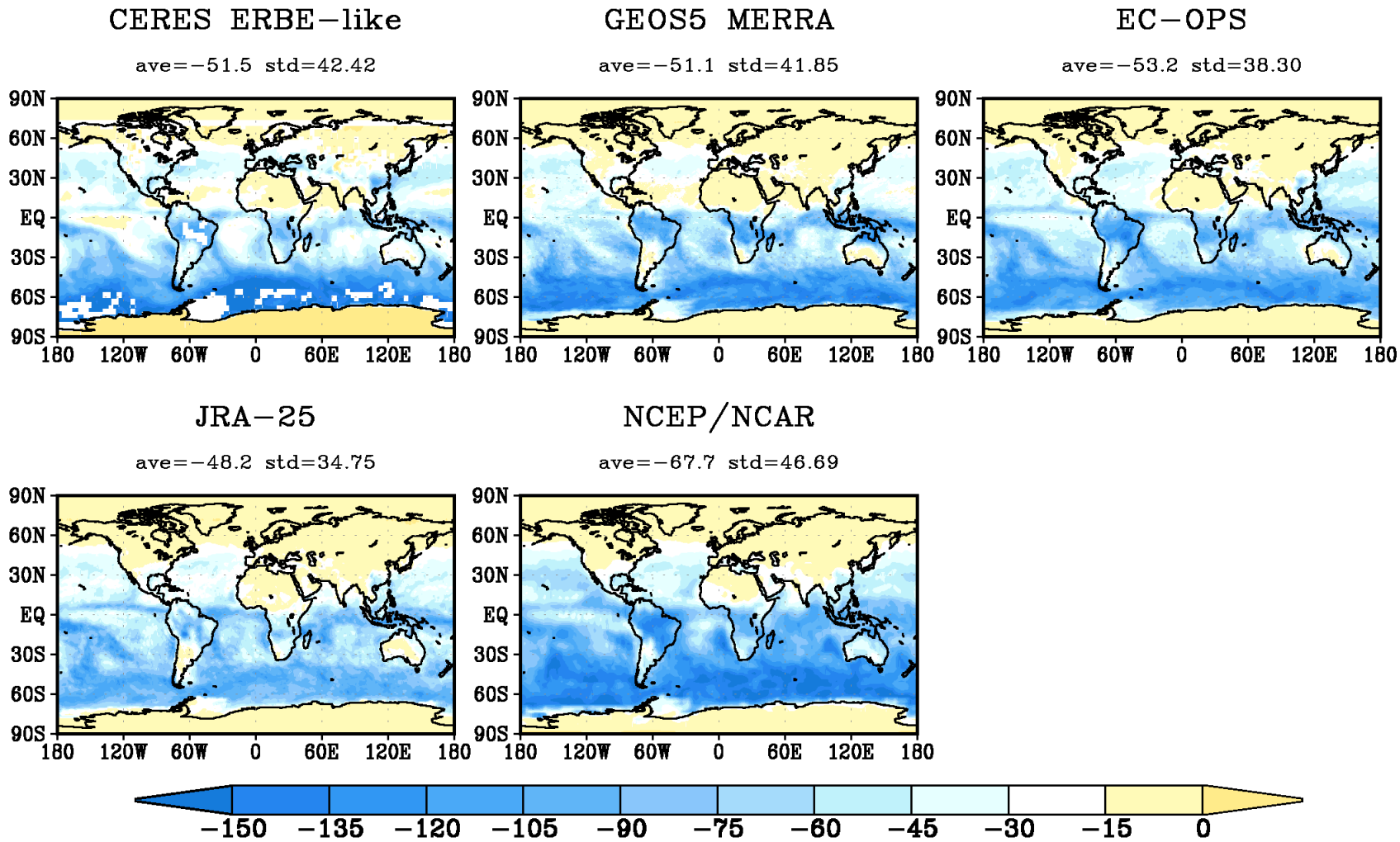
TPW - SSM/I
Jul 2004



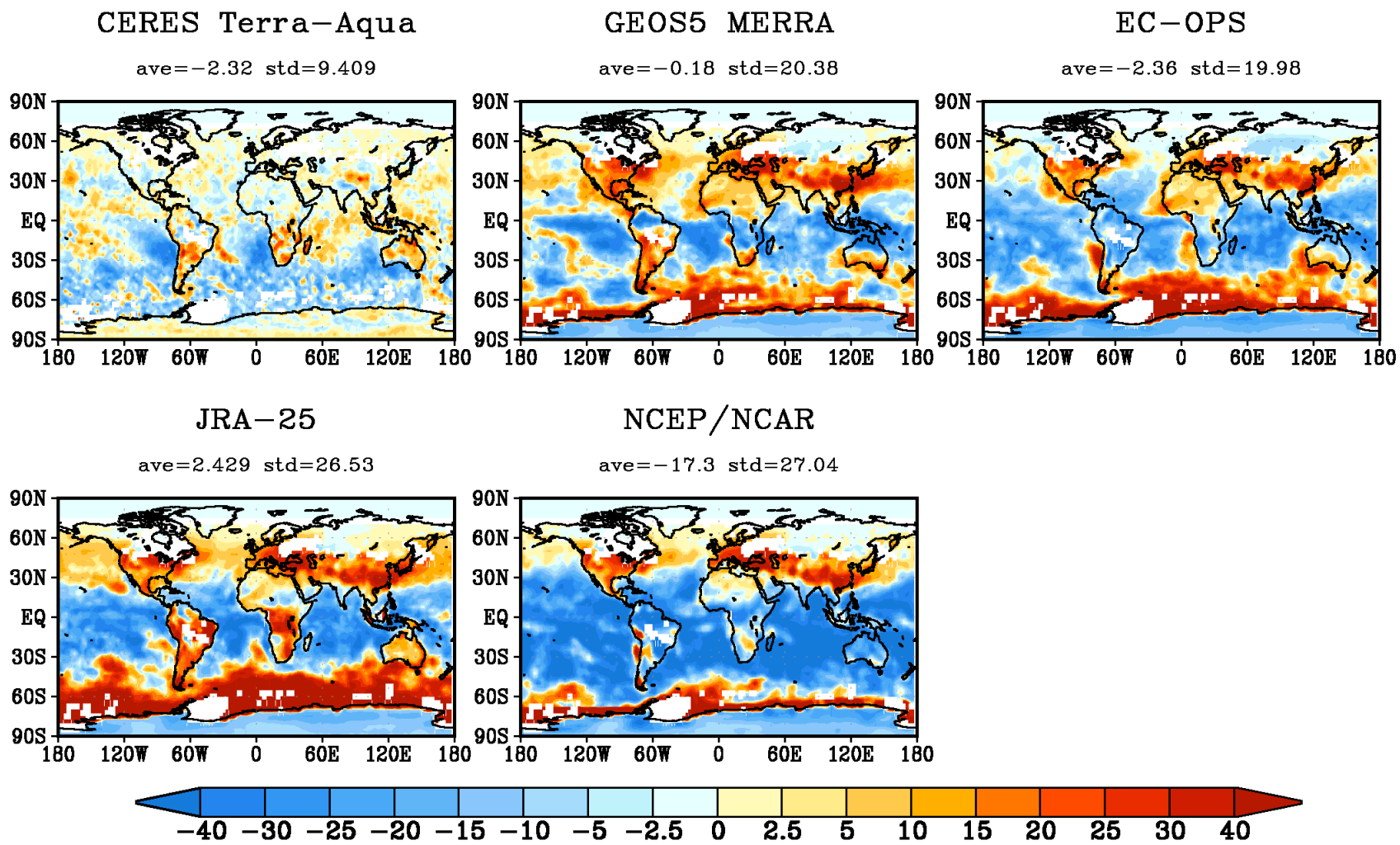
Jan. 2004 Specific Humidity – ECOPS (g/kg)



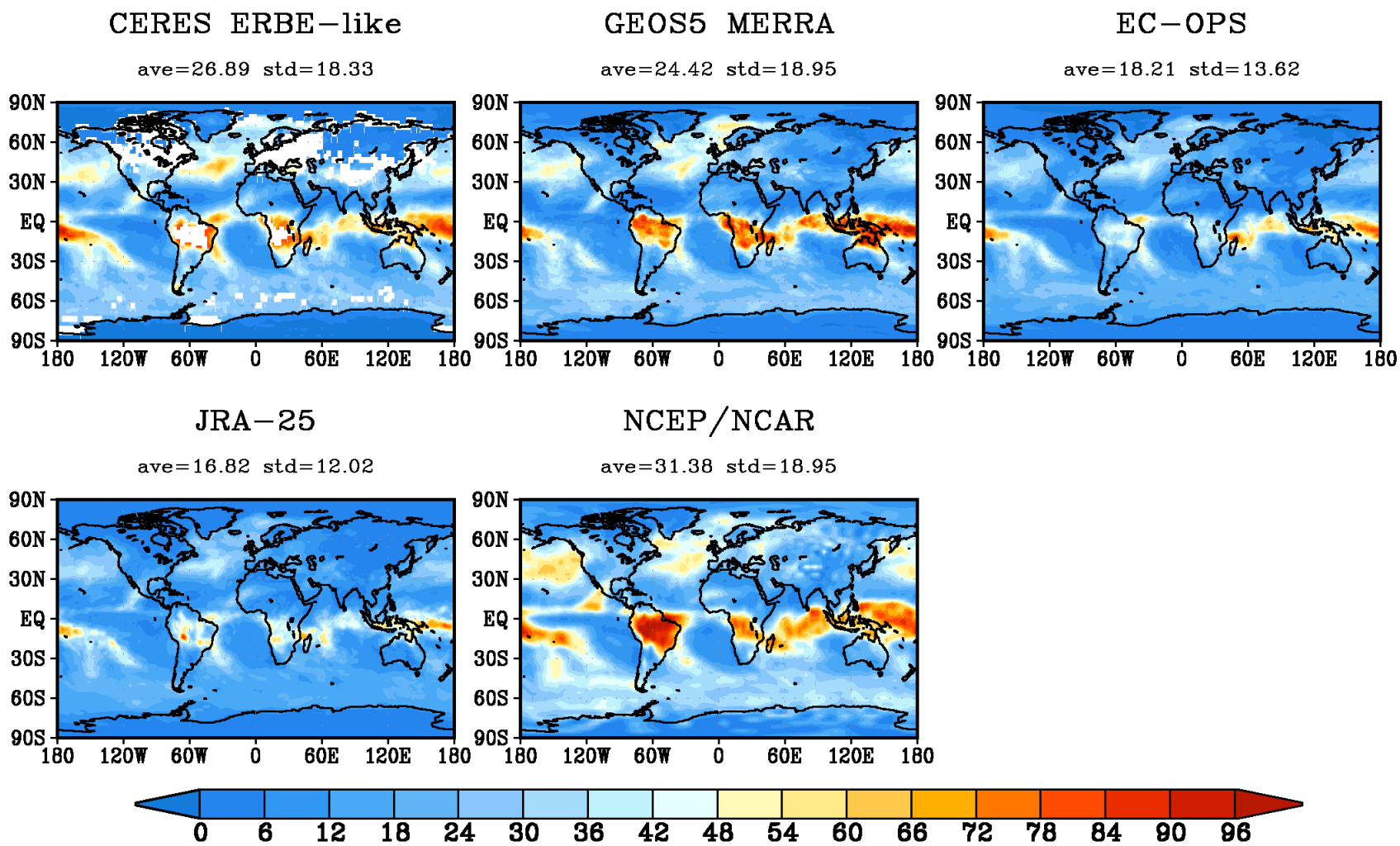
Jan 2004 TOA SW CLDFCN (W/m^2)

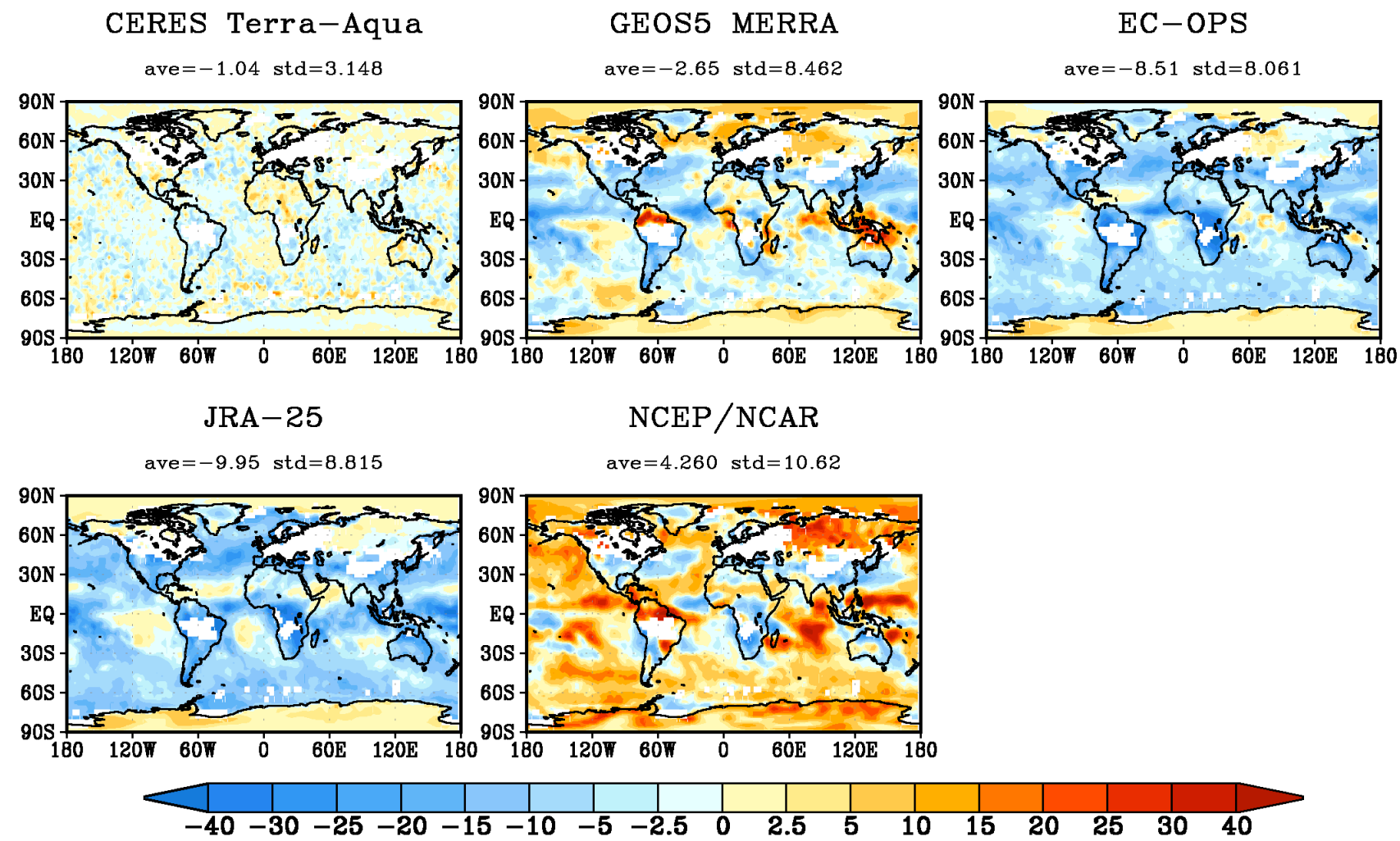


Jan 2004 TOA SW CLDFCN diff from CERES ERBE-like (W/m^2)

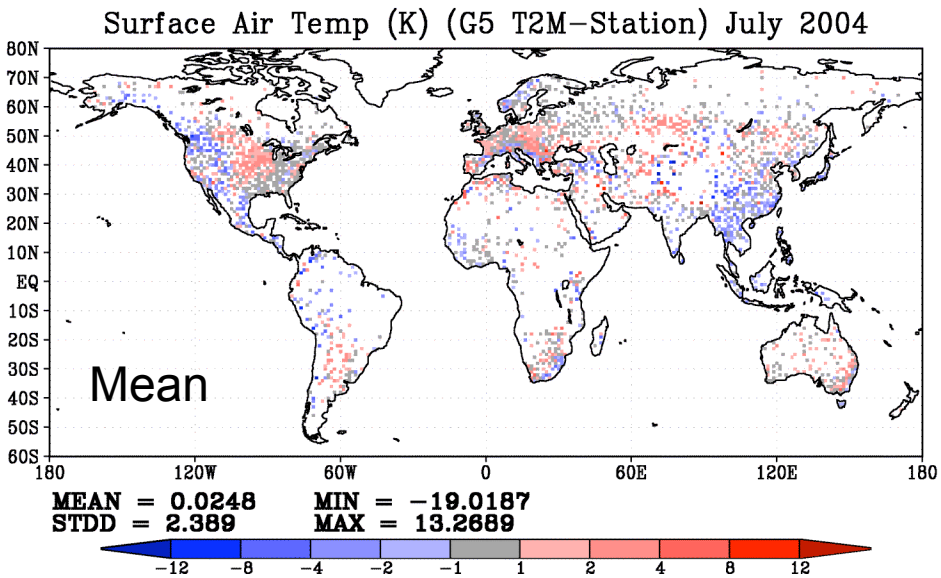


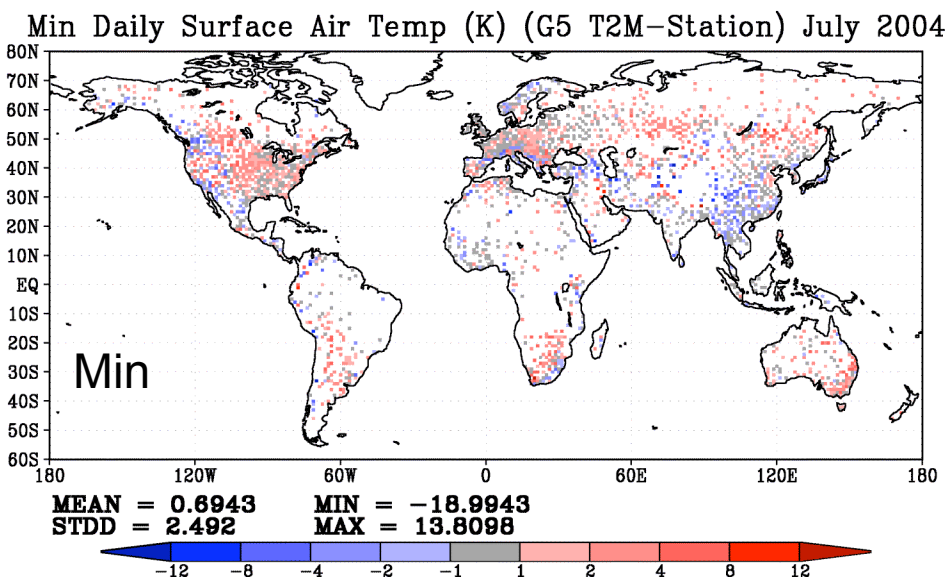
Jan 2004 TOA LW CLDFCN (W/m~2)

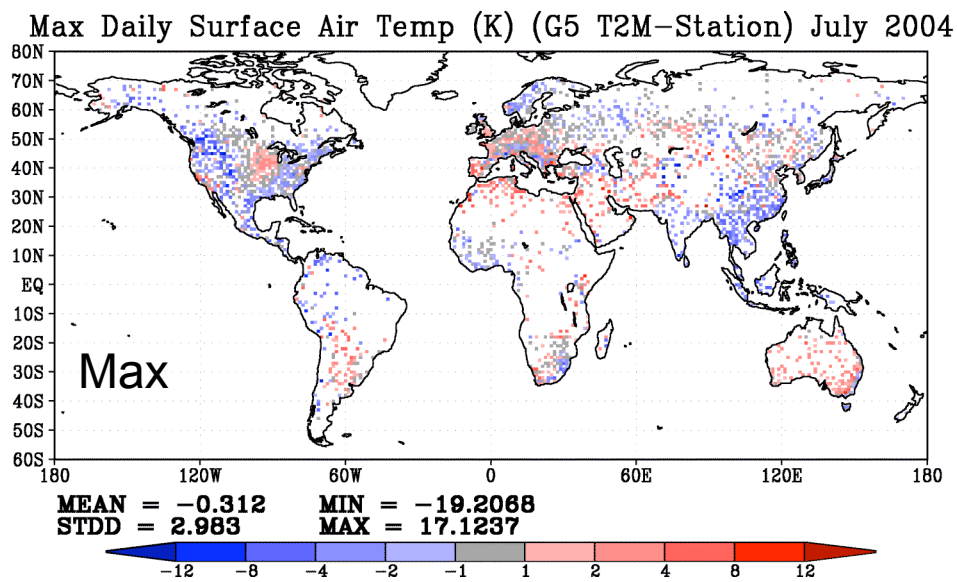



Jan 2004 TOA LW CLDFCN diff from CERES ERBE-like (W/m^2)
CERES Terra-Aqua
ave=-1.04 std=3.148
GEOS5 MERRA
ave=-2.65 std=8.462
EC-OPS
ave=-8.51 std=8.061
JRA-25
ave=-9.95 std=8.815
NCEP/NCAR
ave=4.260 std=10.62
90N
60N
30N
EQ
30S
60S
90S
180
120W
60W
0
60E
120E
180
-40 -30 -25 -20 -15 -10 -5 -2.5 0 2.5 5 10 15 20 25 30 40

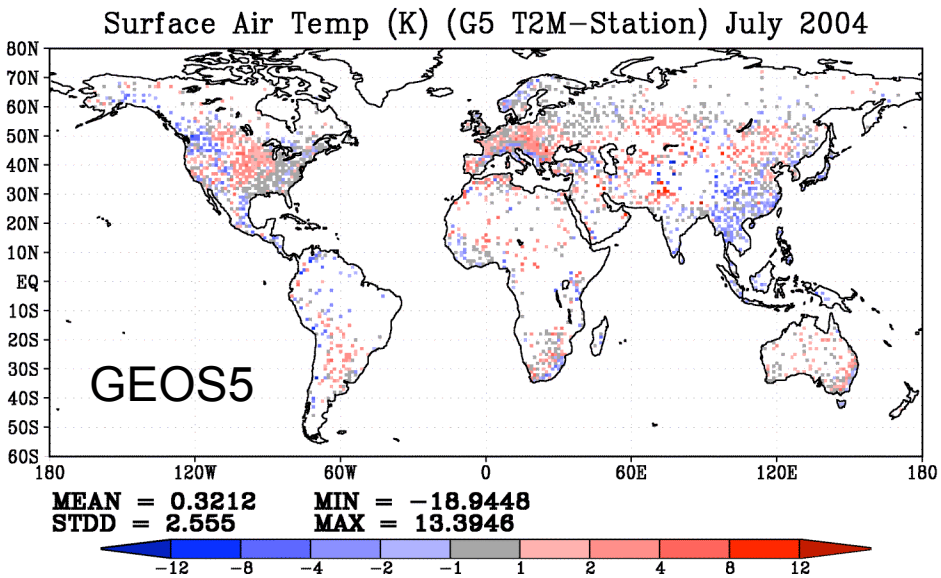
G5P15-NCDC SoD July 2004

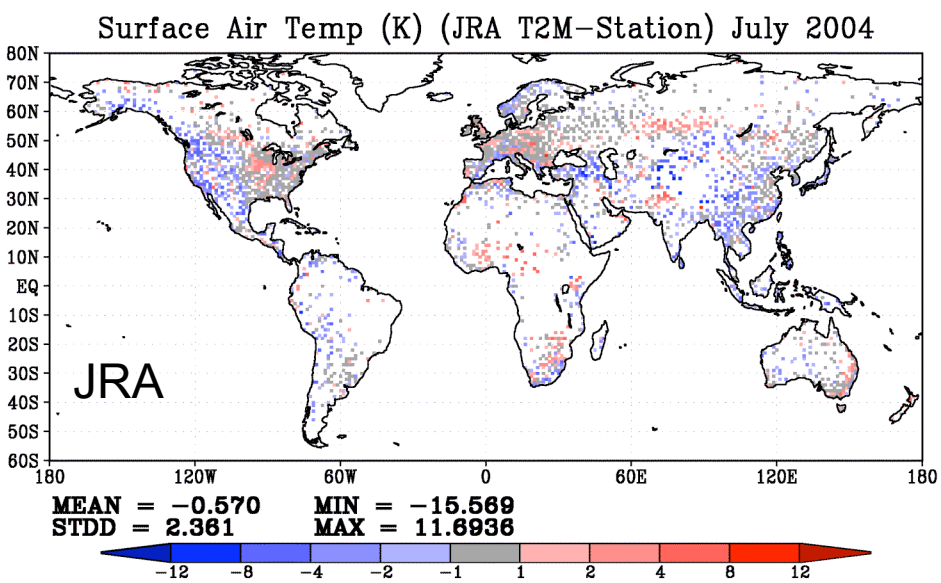


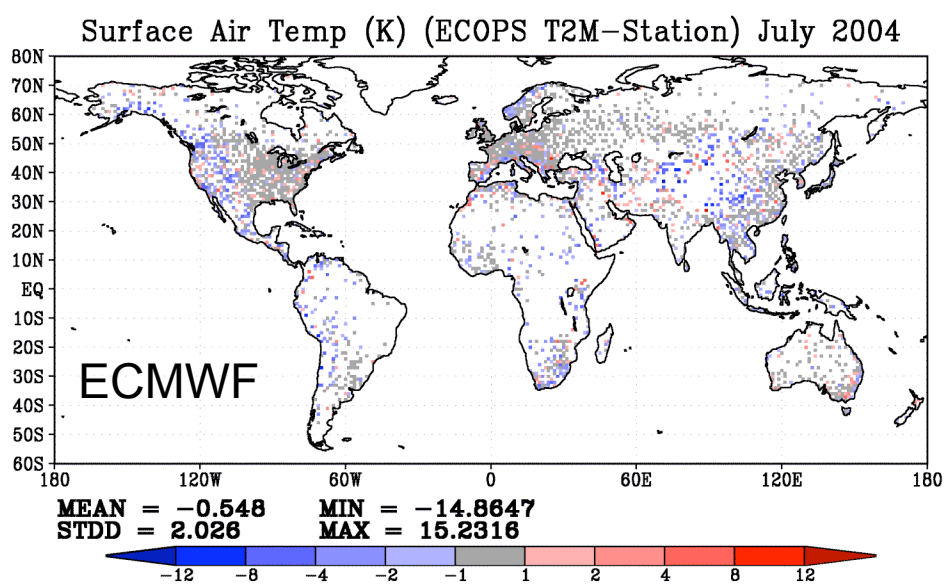




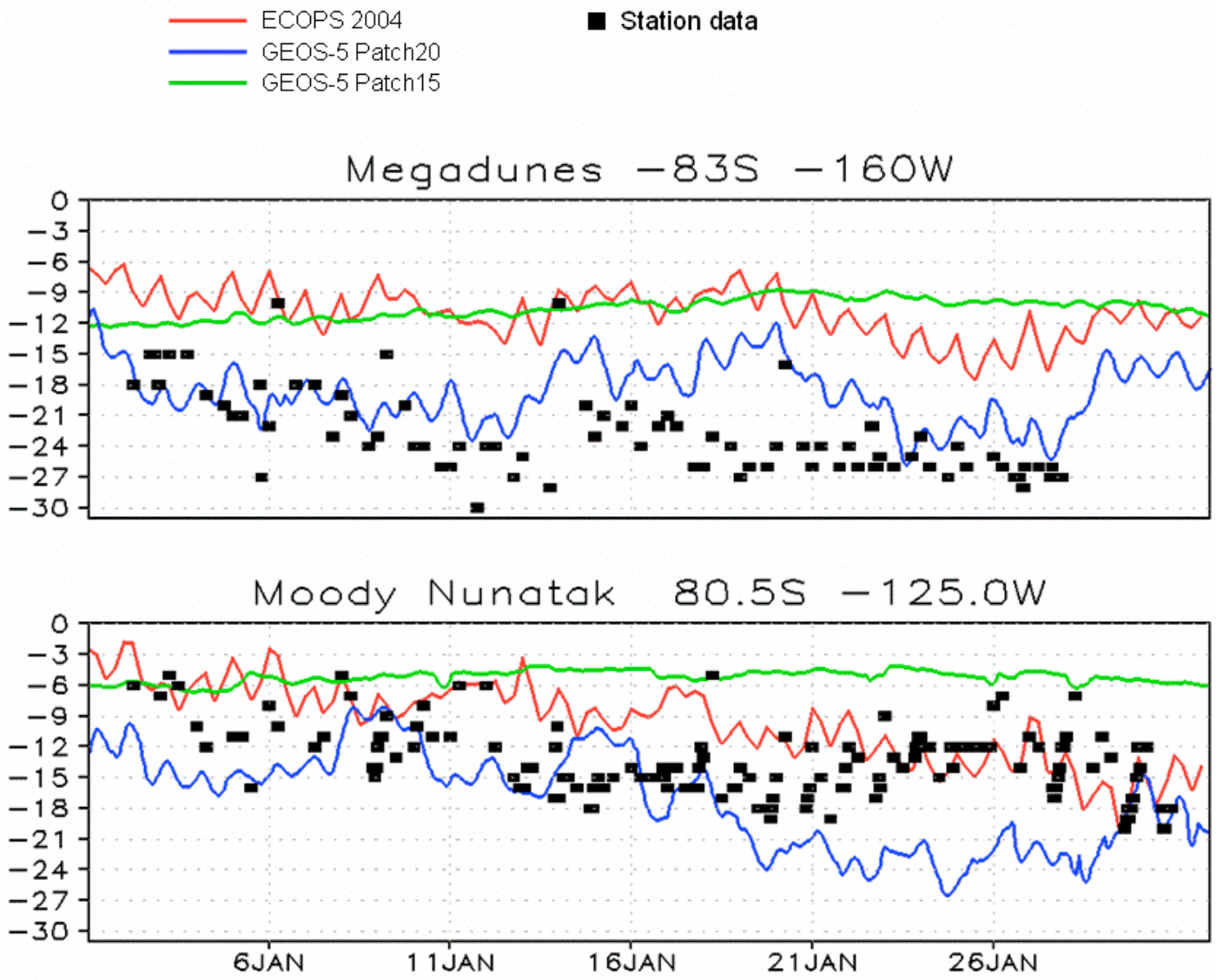
NCDC SoD July 2004







T2m Variations over Antarctica
January 2004



Station Data source: ftp://tstorm.ssec.wisc.edu/pub/aws/spawar/2004/January

Climate Variability
and
Observing system impacts

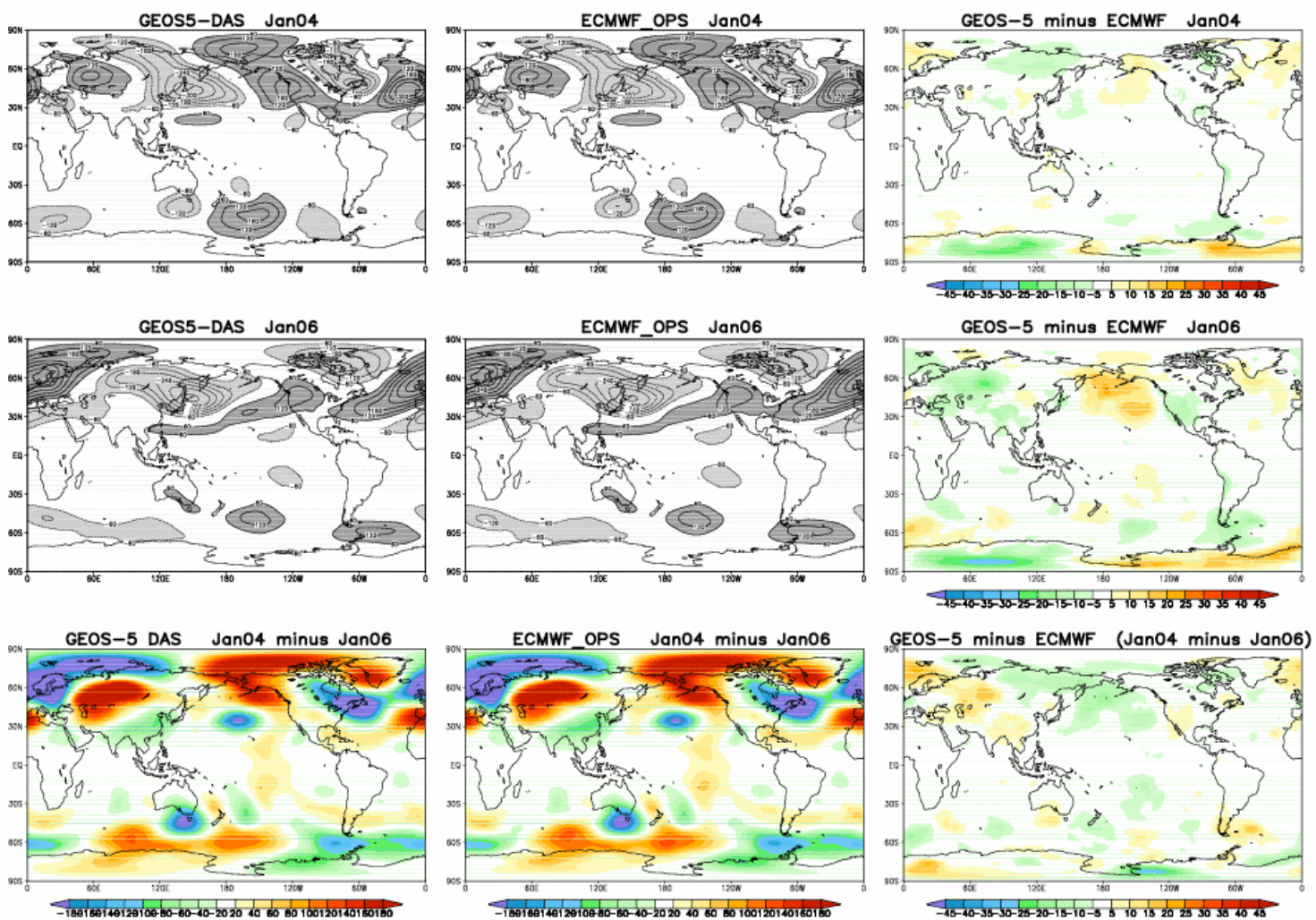
300 MB Eddy Height vs EC OPS

GEOS-5 | EC OPS | G5 - EC

Jan 04 (neutral)

Jan 06 (weak La Nina)

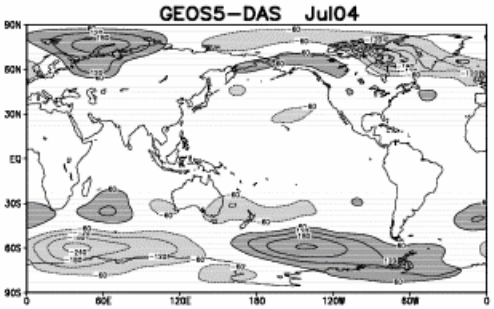
04 - 06

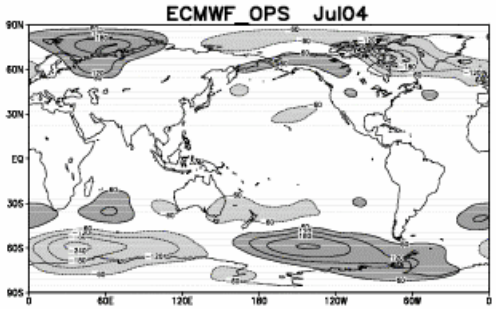


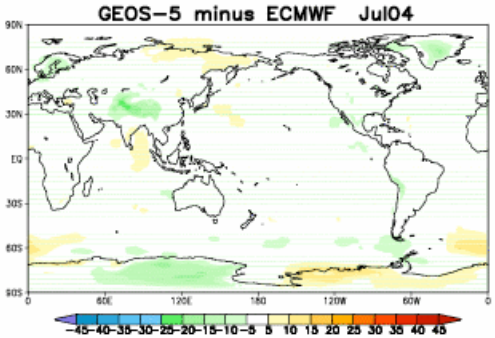
300 MB Eddy Height vs EC OPS

GEOS-5 | EC OPS | G5 - EC

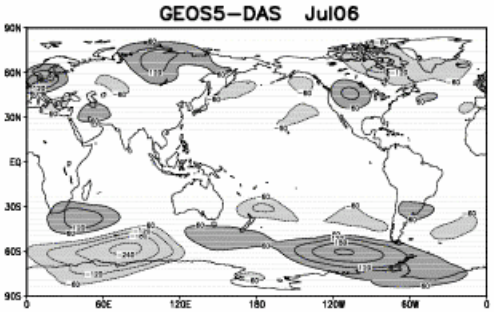
Jul 04

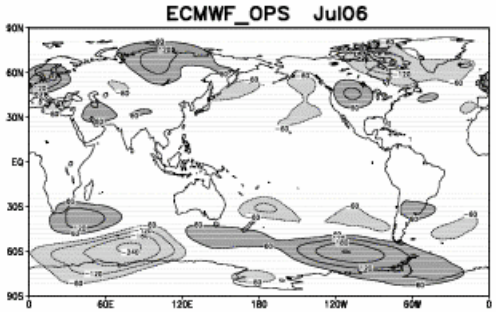


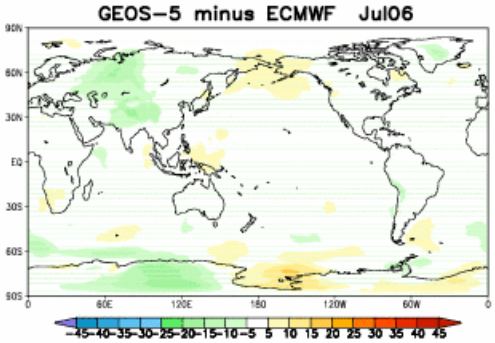




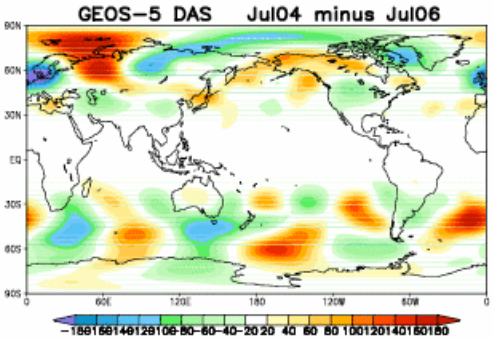
Jul 06

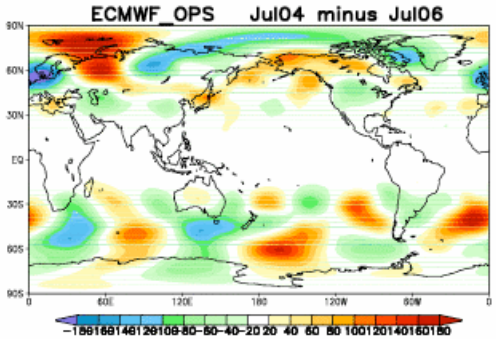


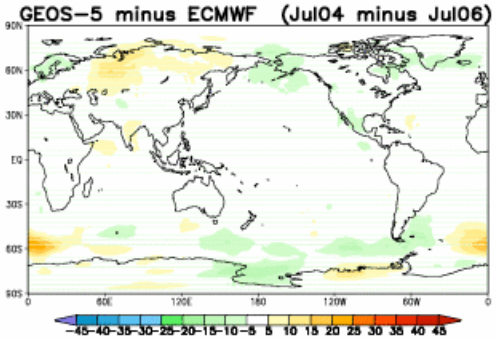


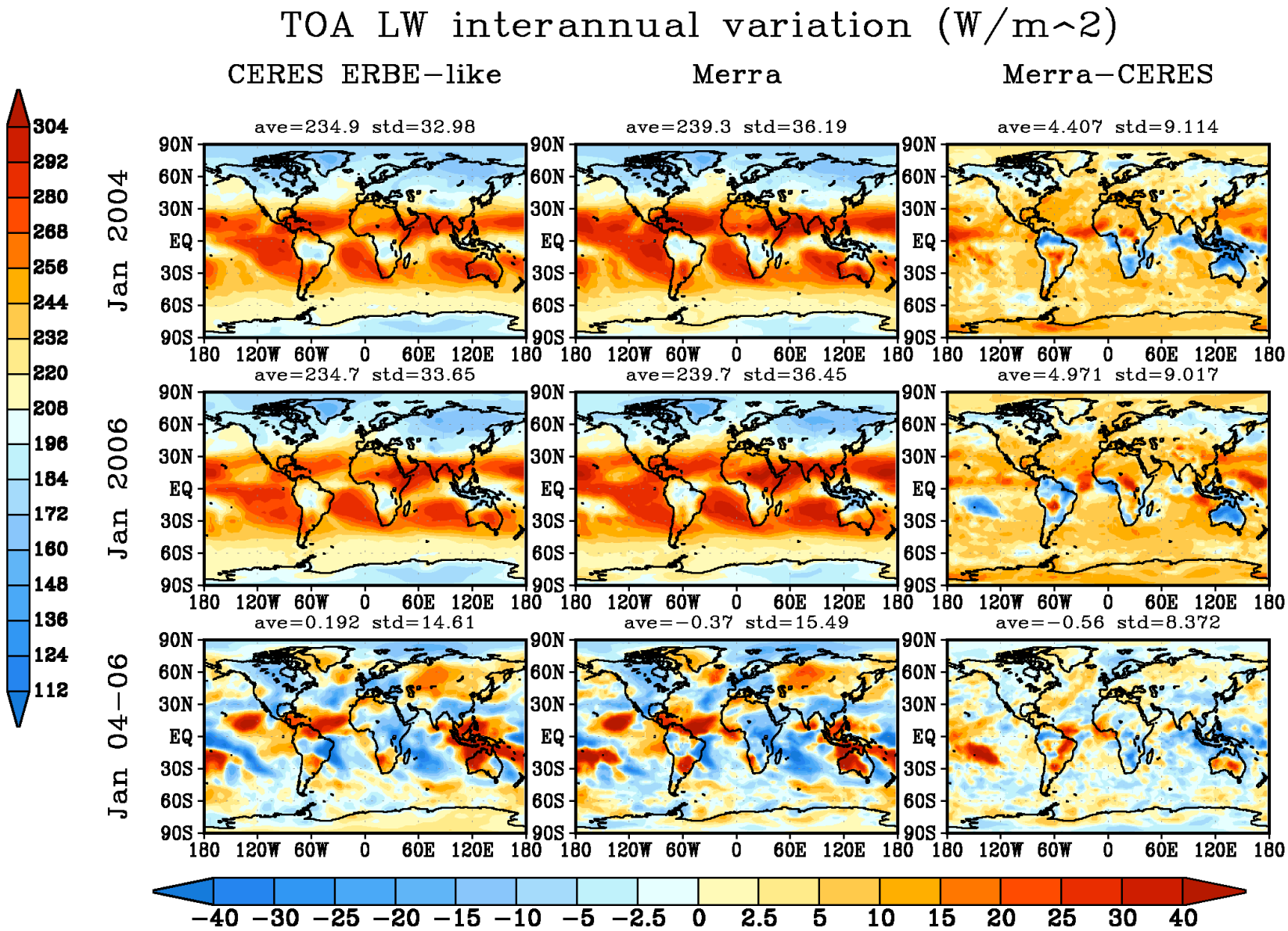


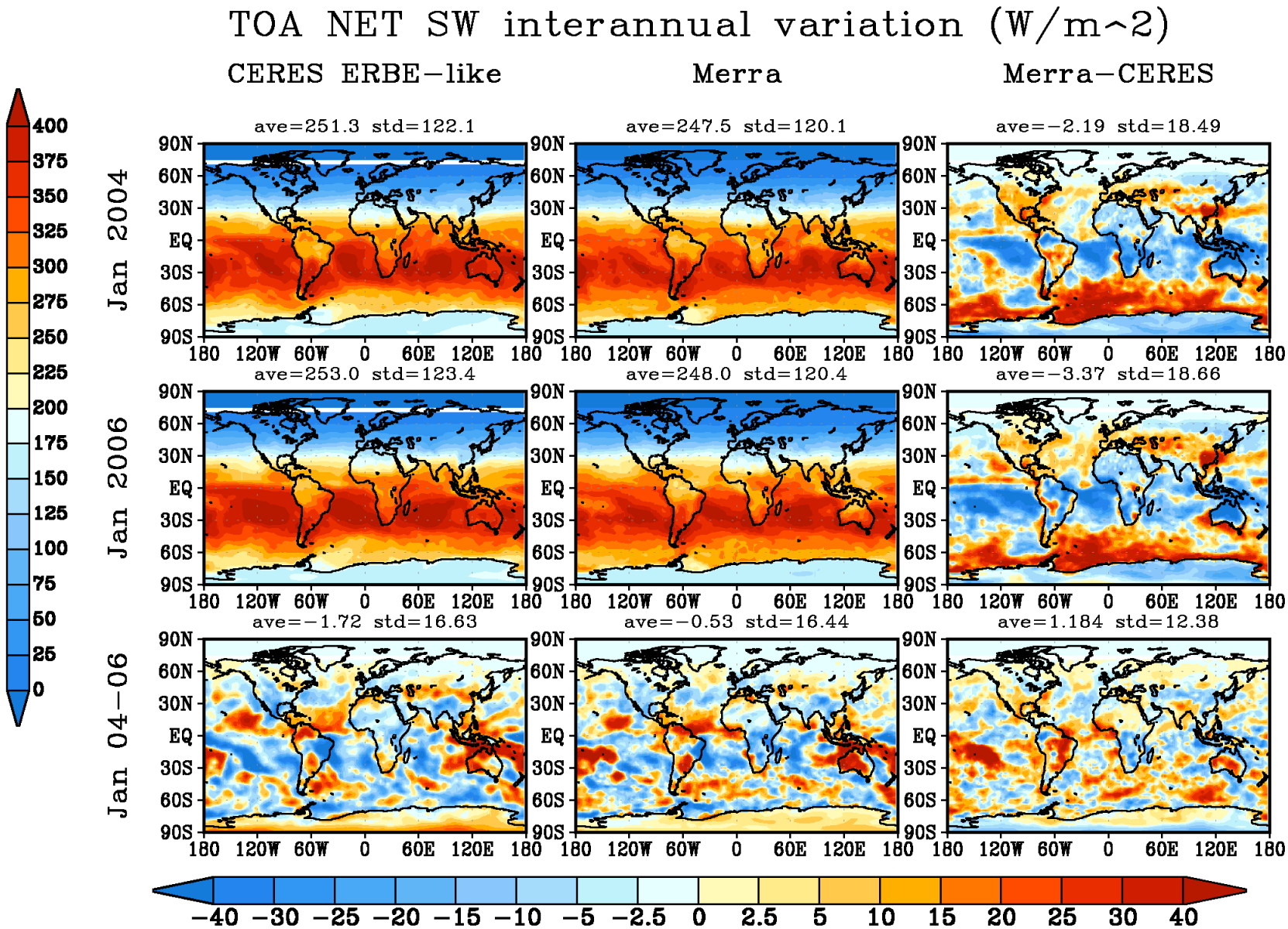
04 - 06







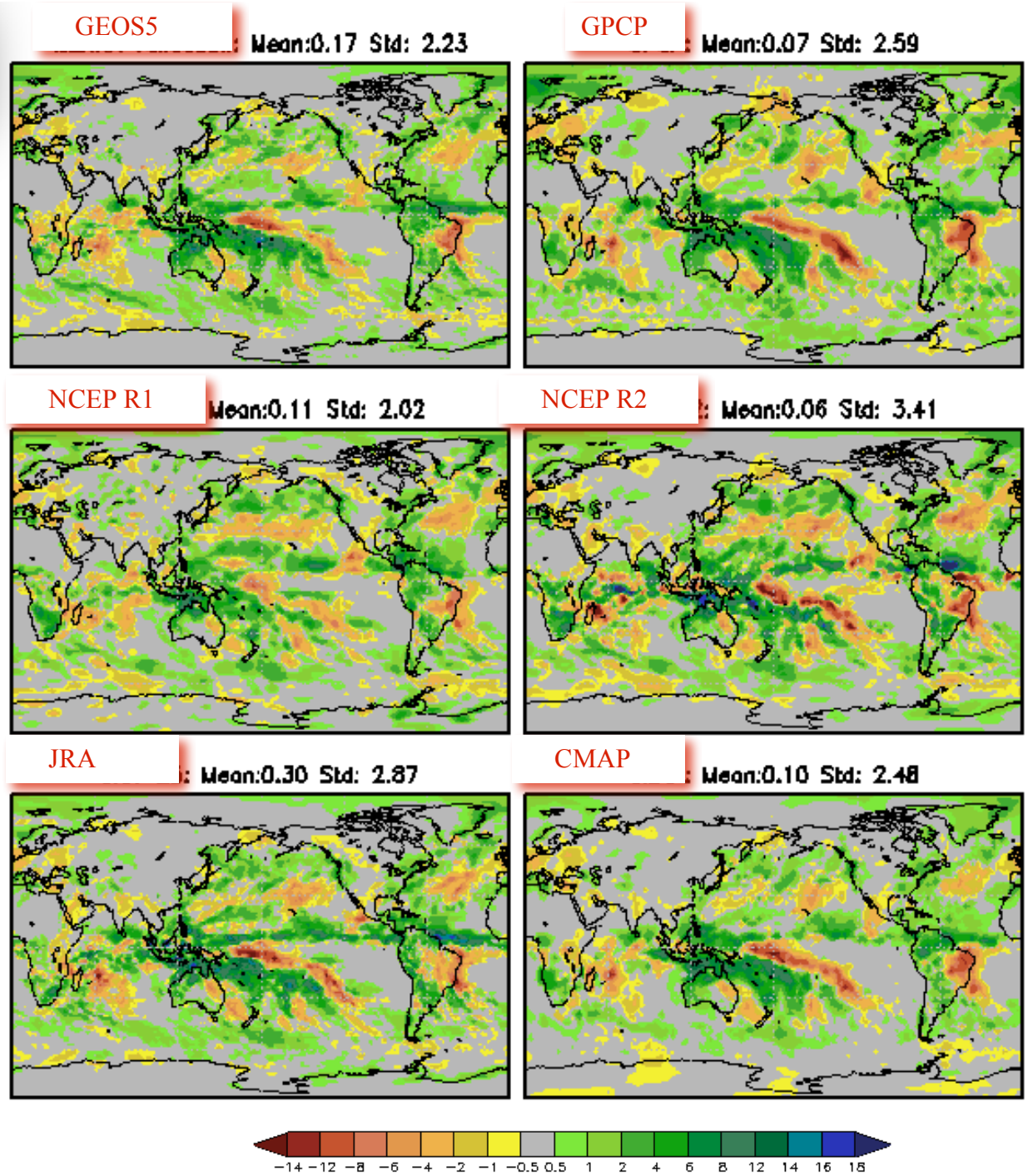

TOA LW interannual variation (W/m^2)
CERES ERBE-like
Merra
Merra-CERES
ave=234.9 std=32.98
ave=239.3 std=36.19
ave=4.407 std=9.114
ave=234.7 std=33.65
ave=239.7 std=36.45
ave=4.971 std=9.017
ave=0.192 std=14.61
ave=-0.37 std=15.49
ave=-0.56 std=8.372
Jan 2004
Jan 2006
Jan 04-06
90N 60N 30N EQ 30S 60S 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


TOA NET SW interannual variation (W/m~2)
CERES ERBE-like
Merra
Merra-CERES
Jan 2004
Jan 2006
Jan 04-06
ave=251.3 std=122.1
ave=247.5 std=120.1
ave=-2.19 std=18.49
ave=253.0 std=123.4
ave=248.0 std=120.4
ave=-3.37 std=18.66
ave=-1.72 std=16.63
ave=-0.53 std=16.44
ave=1.184 std=12.38
90N 60N 30N EQ 30S 60S 90S
180 120W 60W 0 60E 120E 180
400 375 350 325 300 275 250 225 200 175 150 125 100 75 50 25 0
-40 -30 -25 -20 -15 -10 -5 -2.5 0 2.5 5 10 15 20 25 30 40

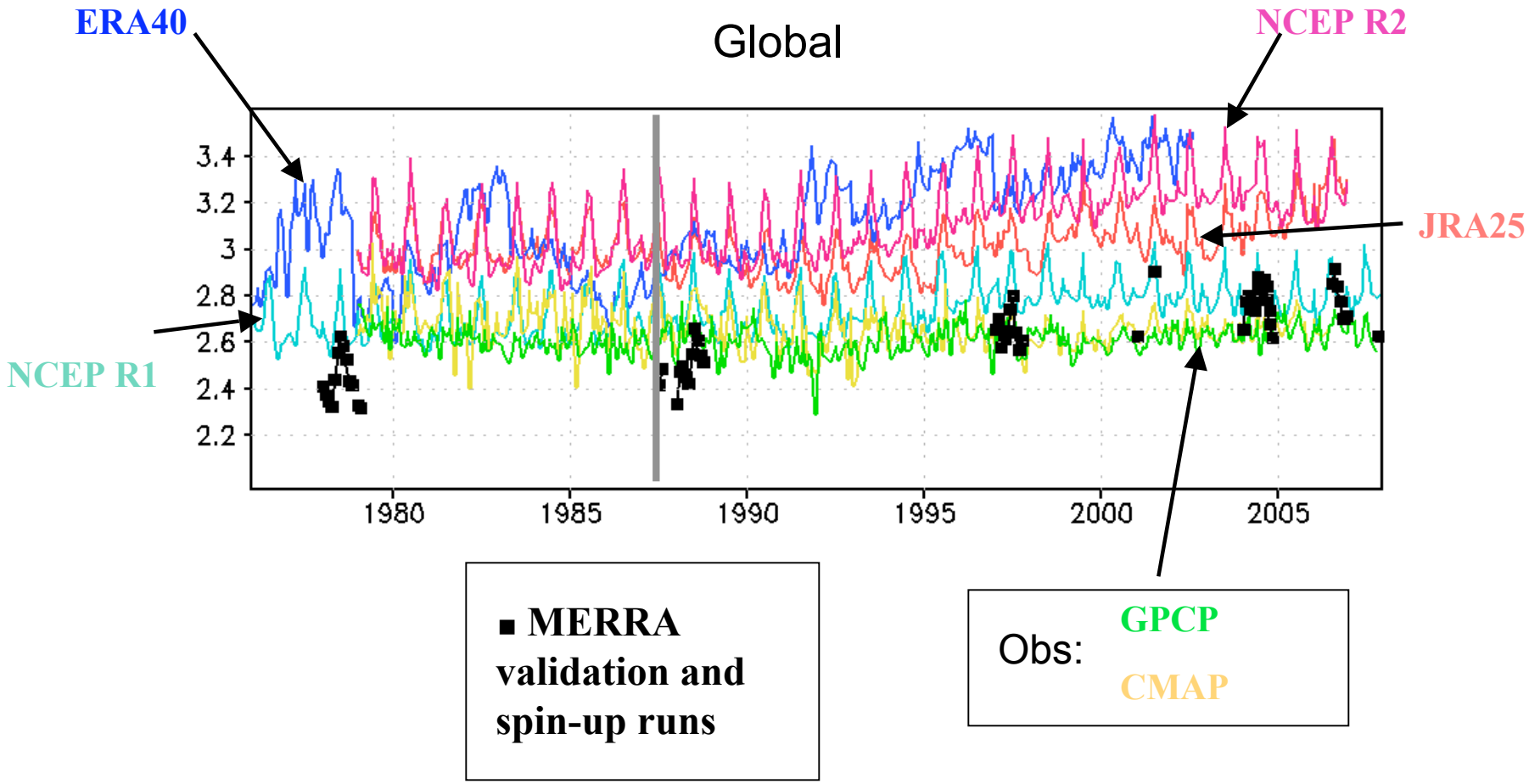
Precipitation (mm/day)
Jan 2006-Jan 2004

Jan 06: weak La Nina

Jan 04: near neutral



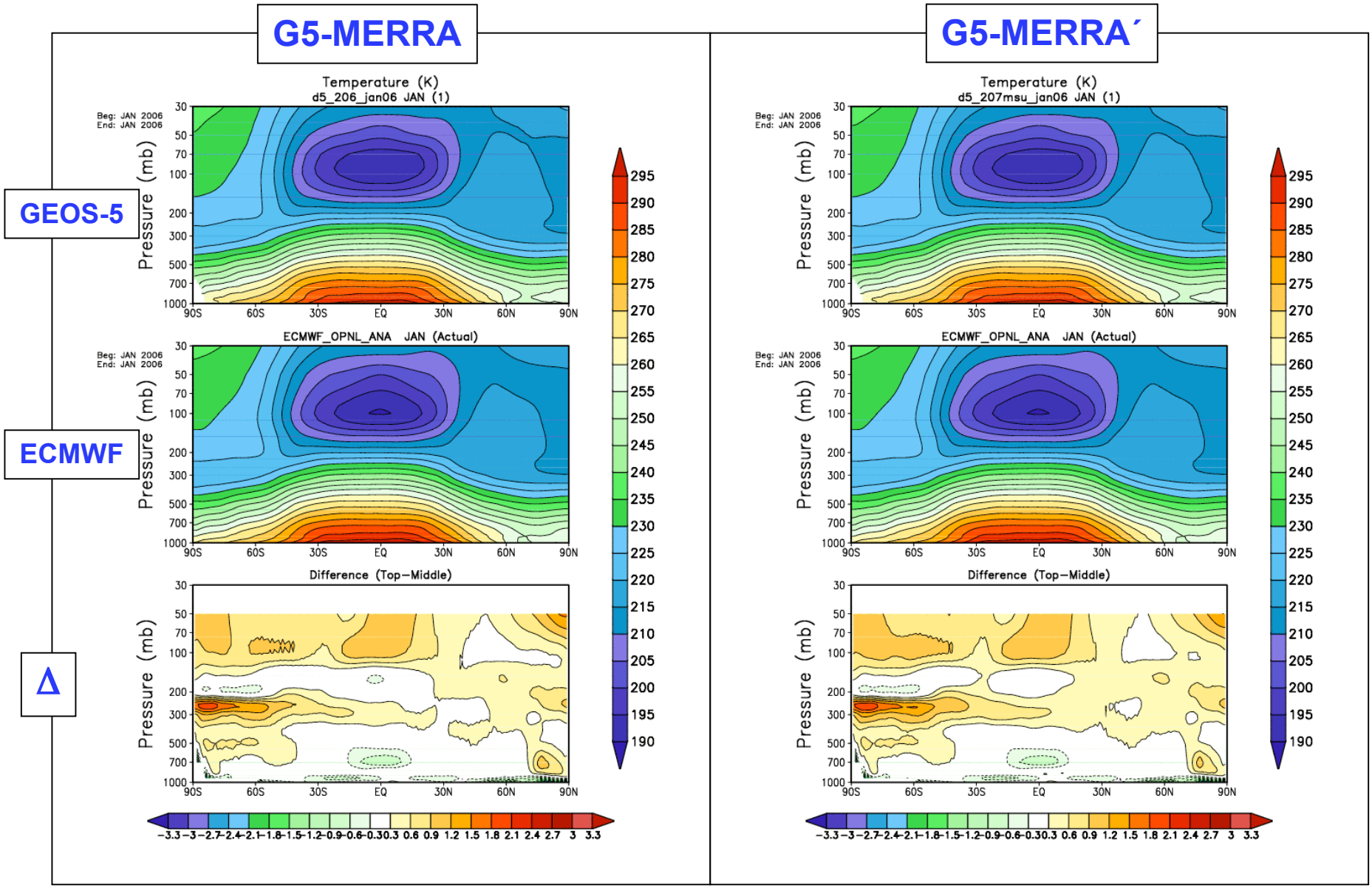
Area Averaged Precipitation (mm/day)



Last changes

CRTM: re-calibrated coefficients for MSU and AMSU-A ch 14
Input data: re-calibrated channels for MSU (reducing inter-satellite biases)
Input data: updated PAOB data

Zonal mean temperature comparison



Summary

- GEOS-5 analysis improves upon many features of existing reanalyses
- G5-CERES is comparable in quality to G5-MERRA
- Biases are generally smaller than climate signals
- Precipitation issues remain: trends; diurnal cycle

- 2-degree SCOUT run precedes 1/2-degree production to provide performance preview

- MERRA: Spin-ups and Scout streams underway
    - Expect to complete processing by Fall 2009

- G5-CERES: 2 streams
    - 1998 - 2008
    - Oct 2007 → (Near real-time stream)

MERRA & NCEP CFSRR
- Comparisons
- Observing system issues: sensitivity of the systems (different models, same analysis);
  performance of assimilation tools (bias corrections);
  feedback files from scout runs