THE GODDARD EARTH OBSERVING SYSTEM 5 (GEOS-5) MODEL AND ITS APPLICATION TO THE CLIMATE RESEARCH

Myong-In Lee, Siegfried Schubert, Yehui Chang, Michele Rienecker, Max Surez, Ron Gelaro, Michael Bosiolovich, Julio Bacmeister, and the GMAO

Global Modeling and Assimilation Office (GMAO)

NASA Goddard Space Flight Center

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Overview

- MERRA (Modern Era Reanalysis for Research Applications)
  - The GEOS-5 DAS and observations
  - A few early results
- Research applications
  - Hybrid (empirical+dynamical) Forecasts
  - Coupled hindcasts

MERRA

(Modern Era Reanalysis for Research Applications)

- Global atmospheric reanalysis
- Synthesizes the current suite of research satellite observations (1979-present)
- Provides the science and applications communities with of a broad range of weather and climate data with improved estimates of the hydrological cycle
- Will be available from an online data server, the Modeling and Assimilation Data and Information Services Center (MDISC, http://daac.gsfc.nasa.gov/MDISC/index.html)

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

AGCM

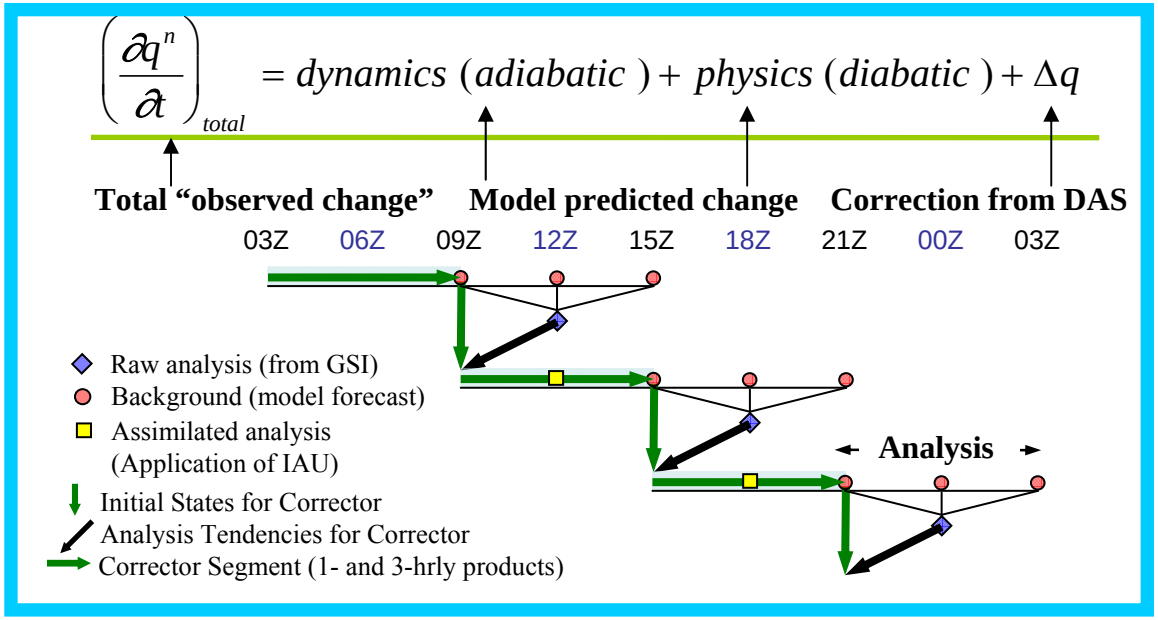
- Finite-volume dynamical core (S.J. Lin)
- Moist physics (J. Bacmeister, S. Moorthi and M. Suarez)
- Physics integrated under the Earth System Modeling Framework (**ESMF**)
- Generalized vertical coord to 0.01 hPa
- Catchment land surface model (R. Koster)
- Prescribed aerosols (P. Colarco)
- Interactive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

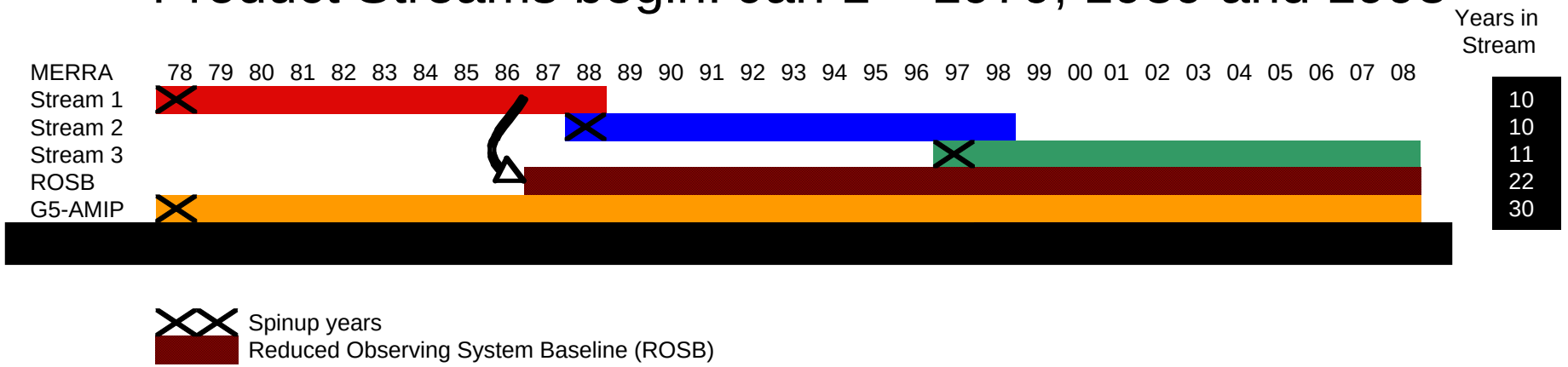
Assimilation

- Apply Incremental Analysis Update (IAU) to reduce shock of data insertion (Bloom et al.)
- IAU gradually forces the model integration throughout the 6 hour analysis period



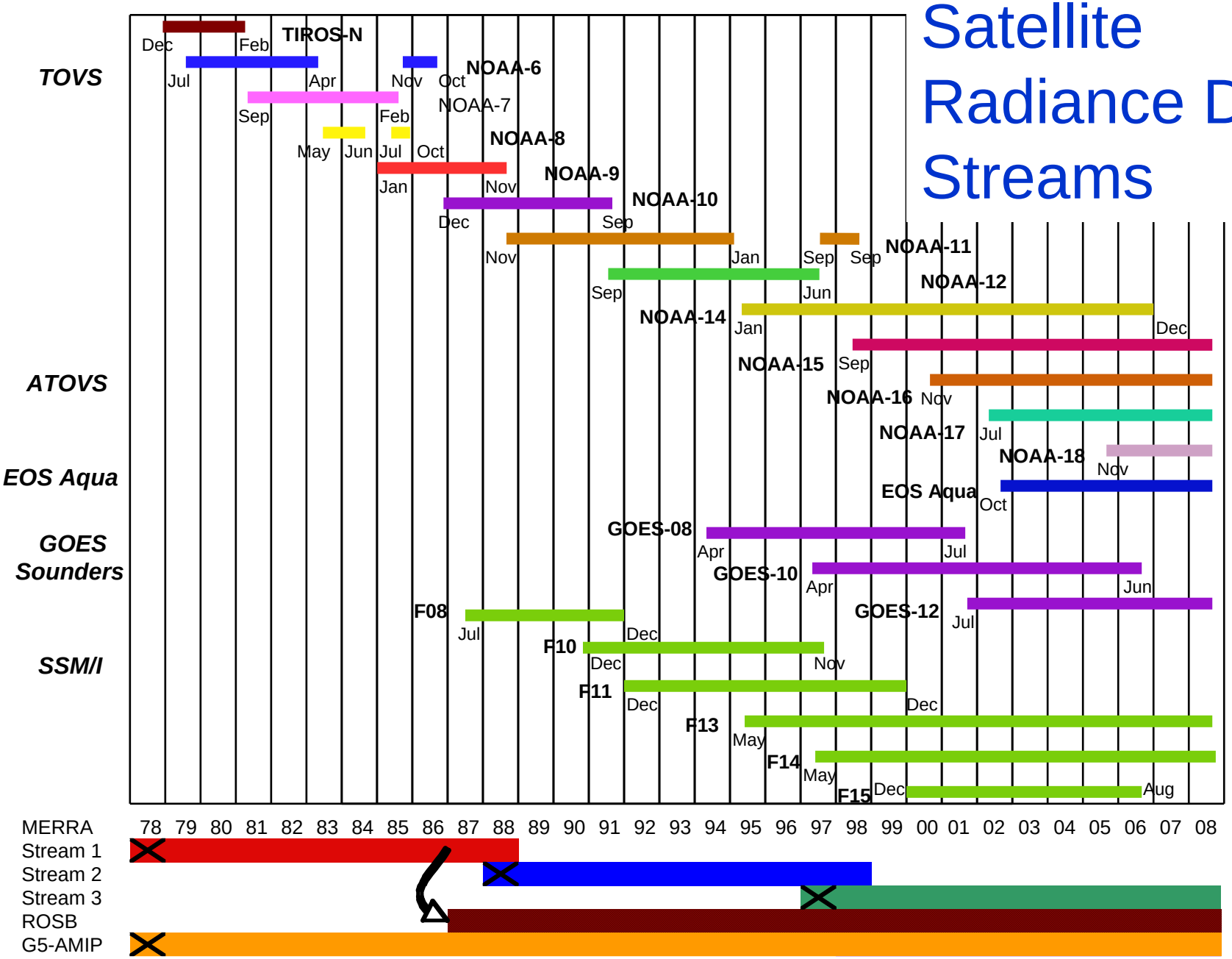
MERRA Production

- 2-year spin up at 2-degree resolution
- 1-year spin up at ½ degree
- Product Streams begin: Jan 1 – 1979, 1989 and 1998



- **2 degree (scout) runs – Coarse resolution MERRA**

Satellite Radiance Data Streams



MERRA FILE COLLECTIONS

- MERRA products are organized into 24 collections in HDF

- Data are produced on three horizontal grids:
  - Native ---------- (1/2 by 2/3 w/ FV conventions)
  - Reduced ------- (1 1/4 by 1 1/4 Dateline-edge, Pole-edge)
  - Reduced FV -- (1 by 1¼ w/ FV conventions)

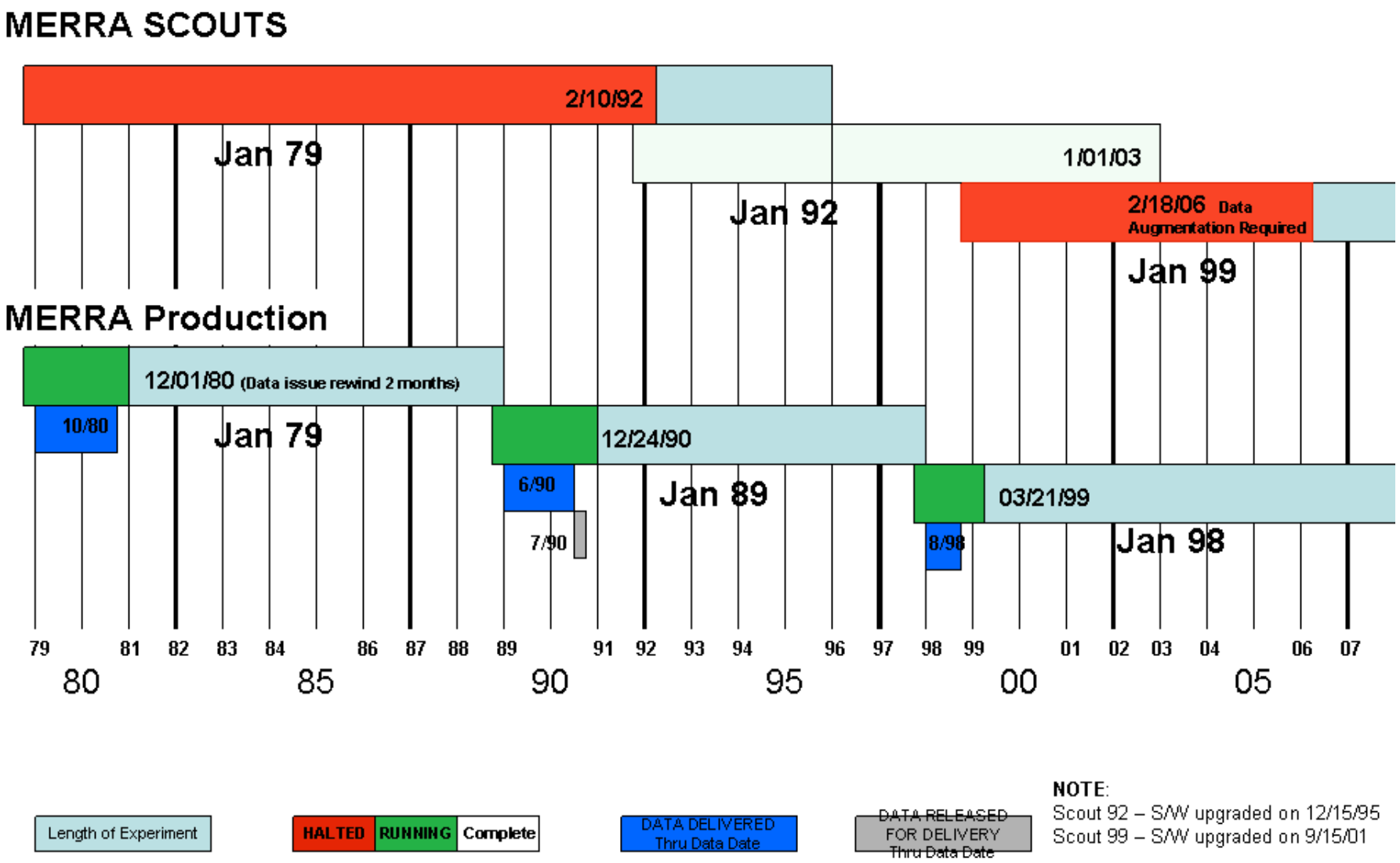
- In the vertical, 3-D data are at:
  - 72 model layers
  - 42 pressure levels

- Temporal resolution:
  - 3D products are 3-hourly
  - 2D products are hourly and at native resolution

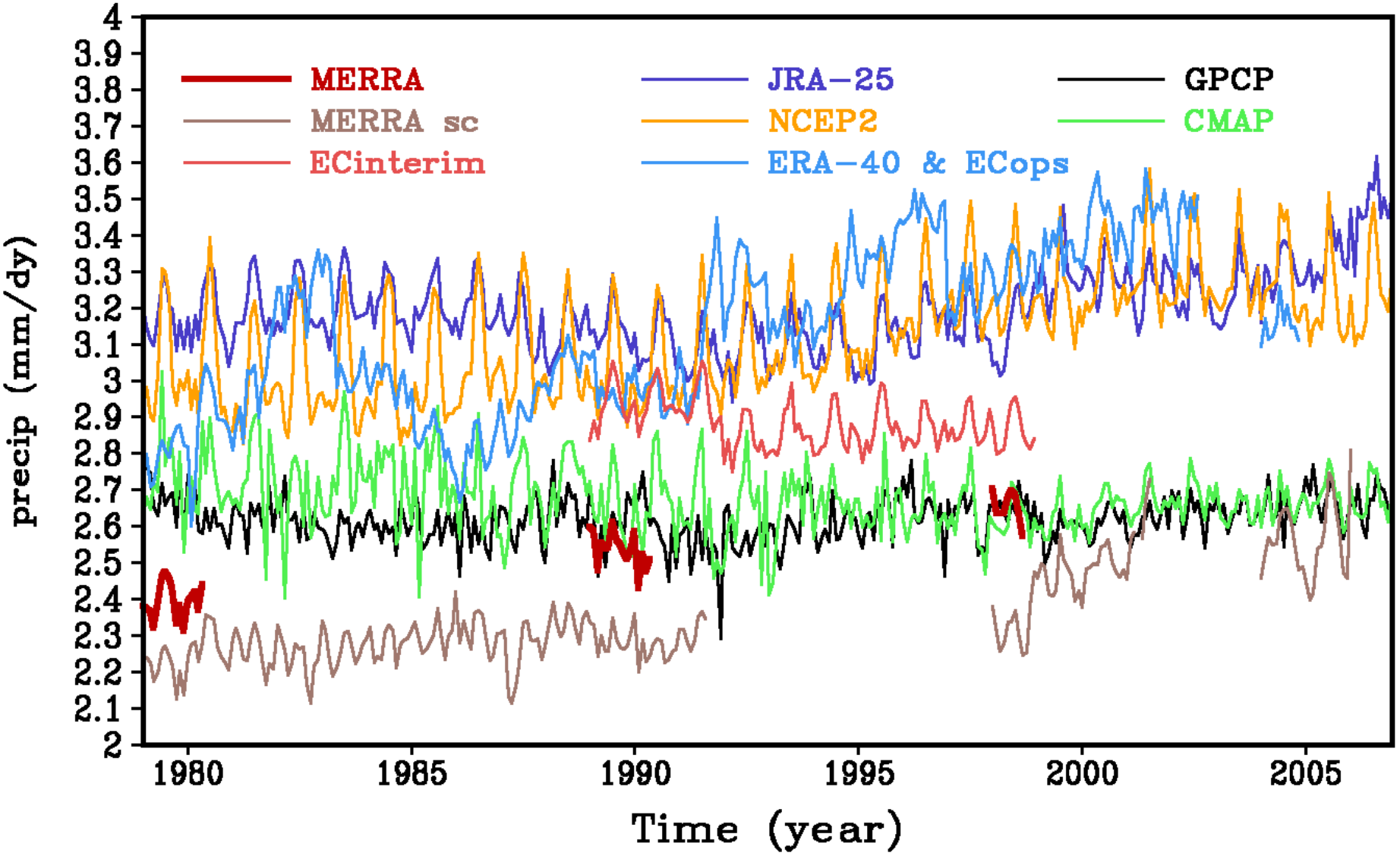
- Total online collections ~150TB

- **Distributed through a modeling data portal at the Goddard DAAC (including GDS, ftp)**

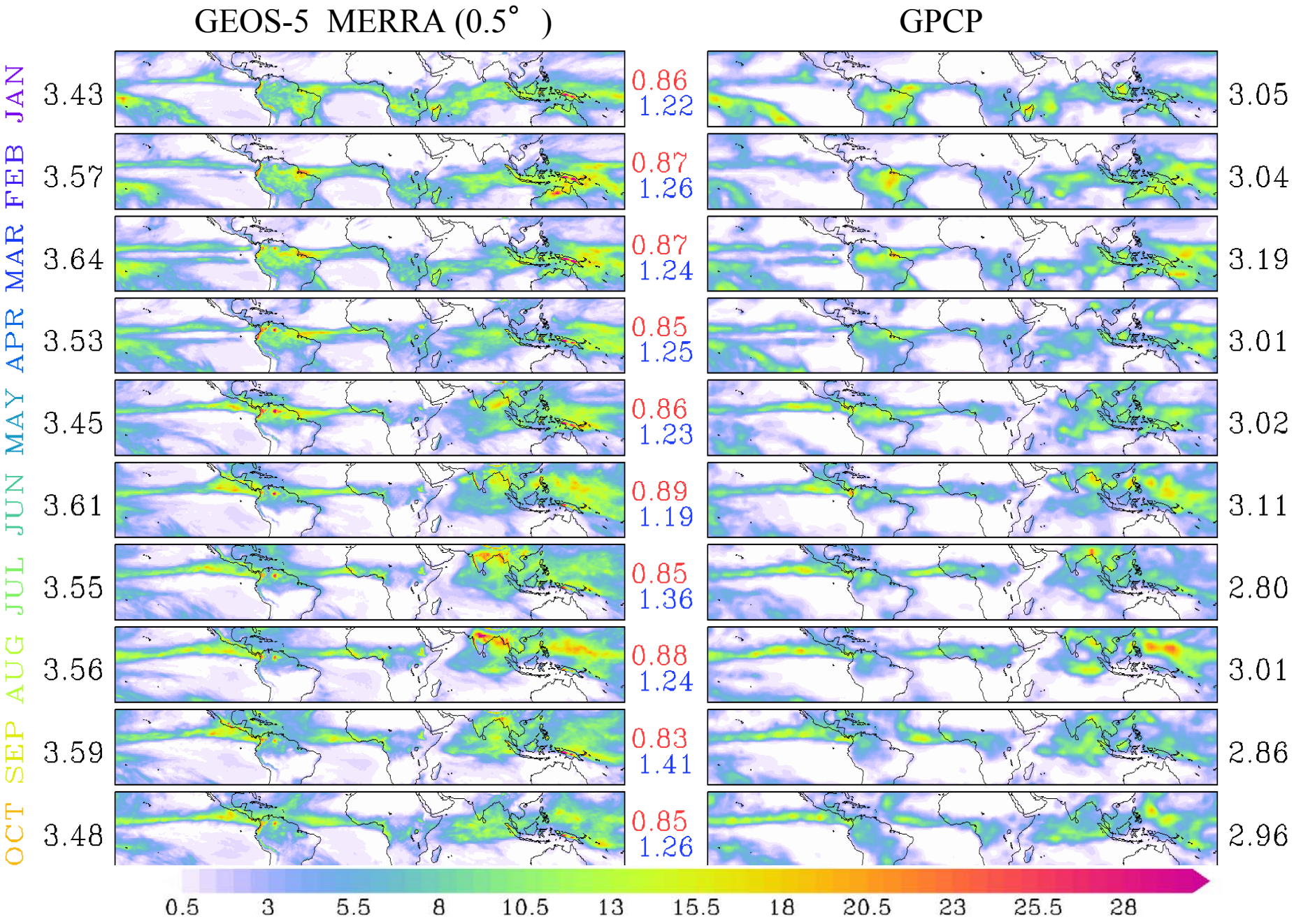
MERRA Status (as of 8/08/08)



Global mean Precipitation



2004 Tropical Precipitation (mm/day)



On-going Research

Hybrid Forecast (Empirical+Dynamical)

Statistical Forecast Model

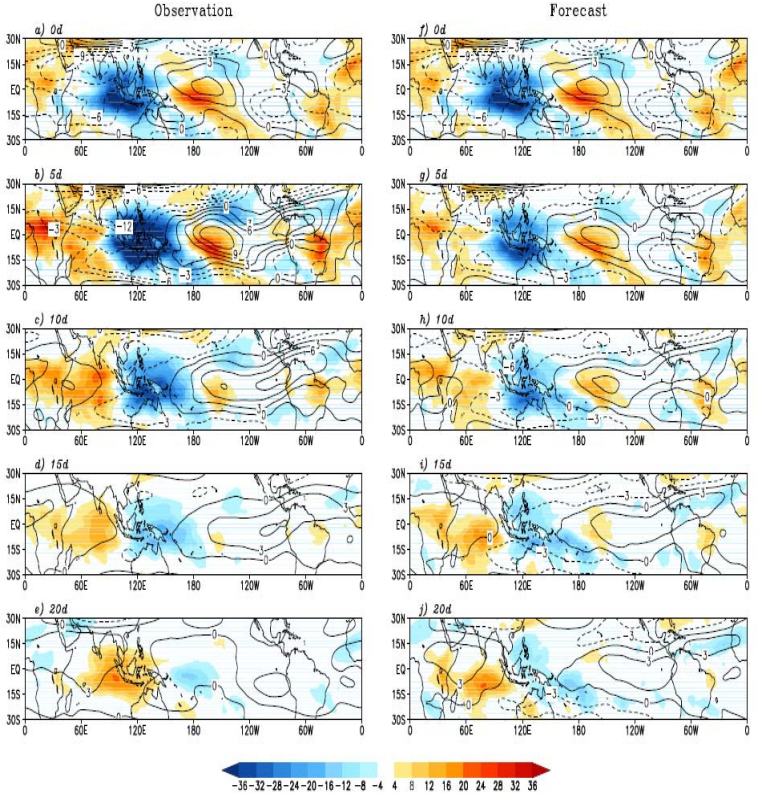
(Jiang et al., 2008, Mon. Wea. Rev.)

(1) Combined EOF analysis

(2) Lag-regression with two leading PCs

$$X(t_0+\tau) = \beta_1 \cdot PC_1(t_0) + \beta_2 \cdot PC_2(t_0)$$

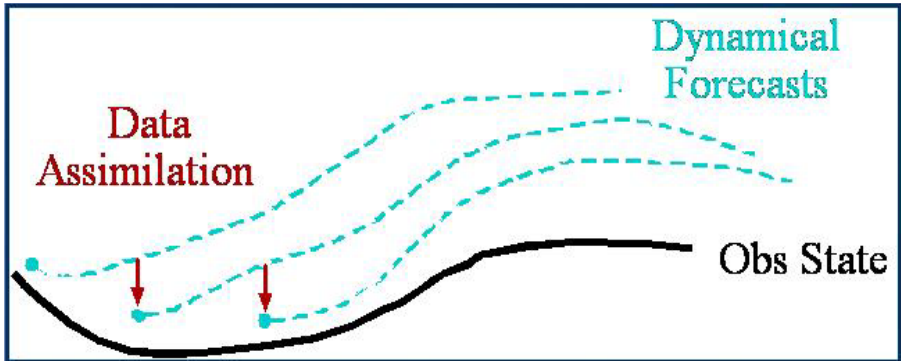
(3) PC Projected onto EOFs



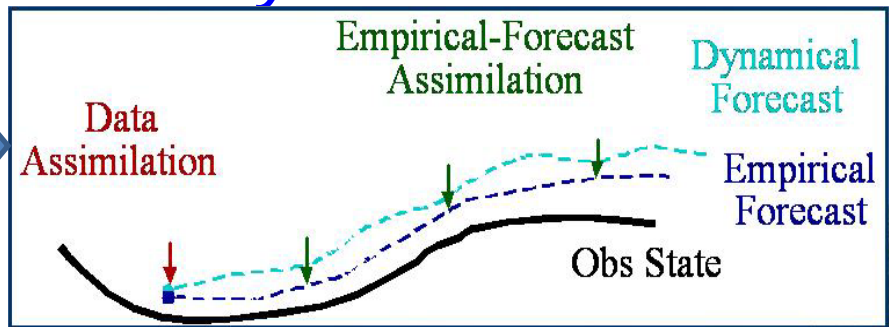
20-day forecast of OLR and 200mb u-wind

Collab w/ JPL (D. Waliser, X. Jiang)

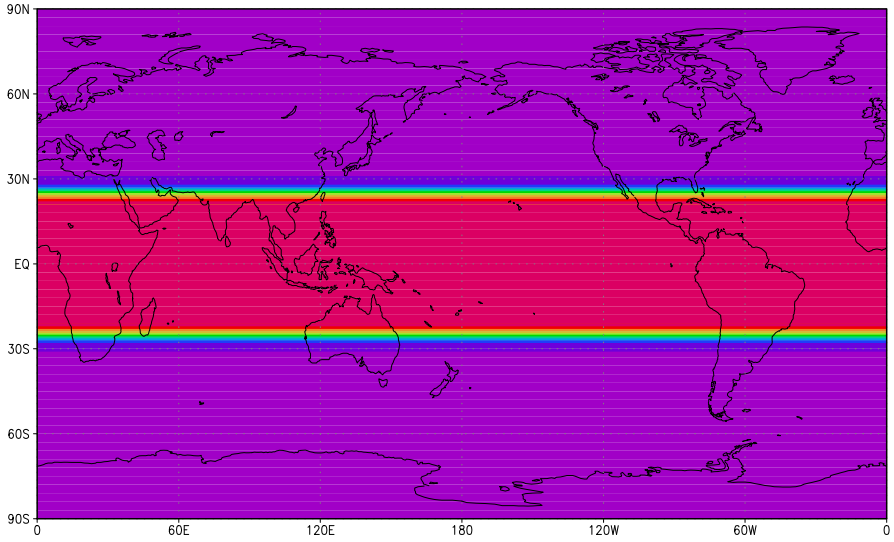
Dynamical Forecast (conventional)



Hybrid Forecast



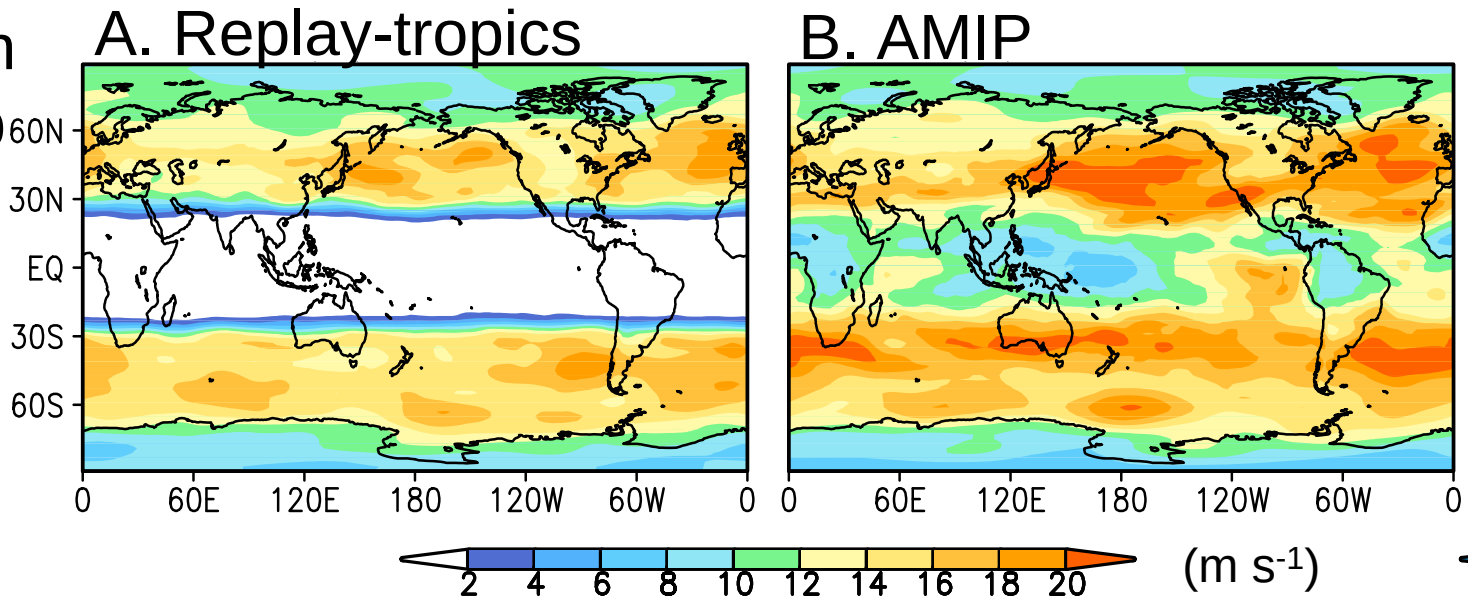
Assessing the impact of the tropics



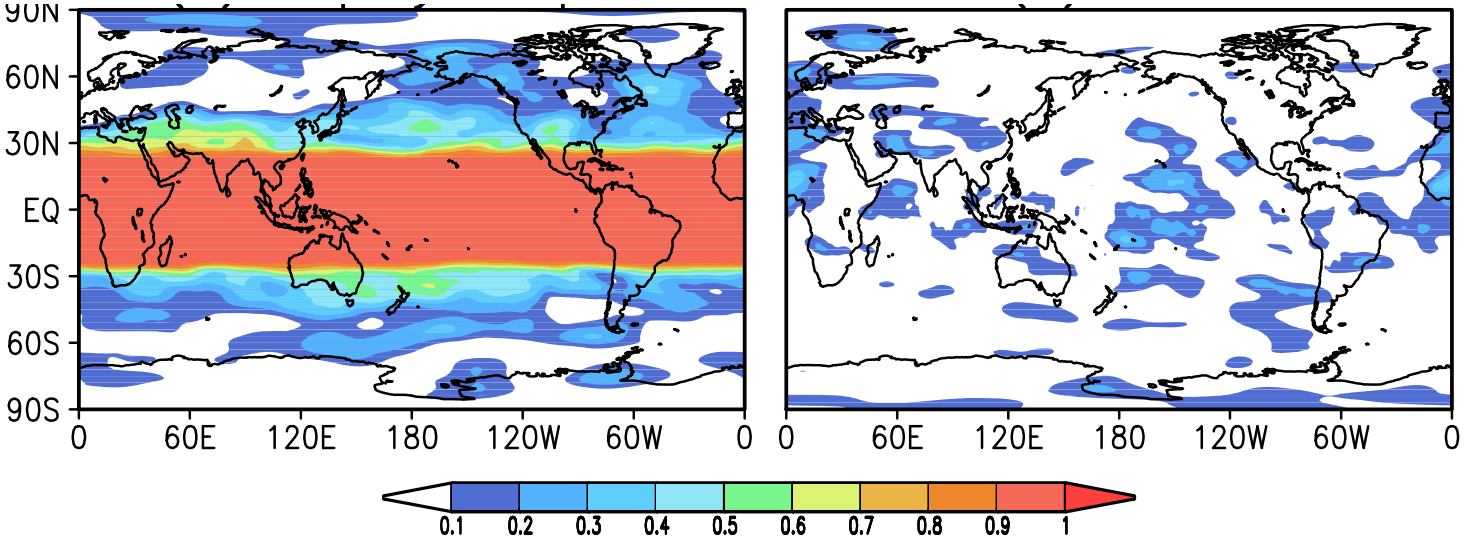
- Develop an idealized approach by constraining the tropics (30S-30N) to a reference analysis
- Assess the tropical influences on the extra-tropics

Assessing the Impact of the Tropics *(Tropical IAU)*

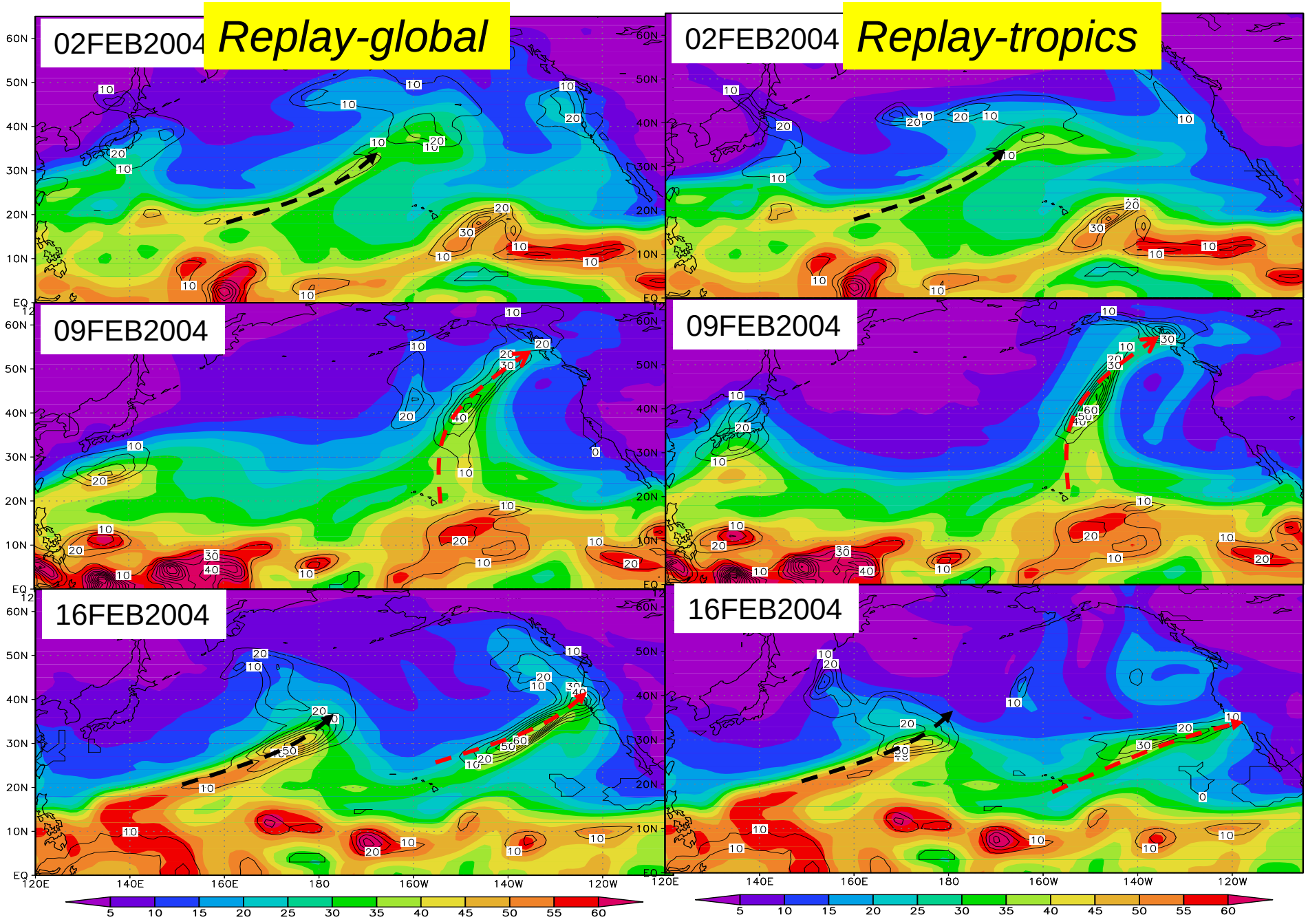
RMS Errors in daily U200mb



Correlation Coefficient



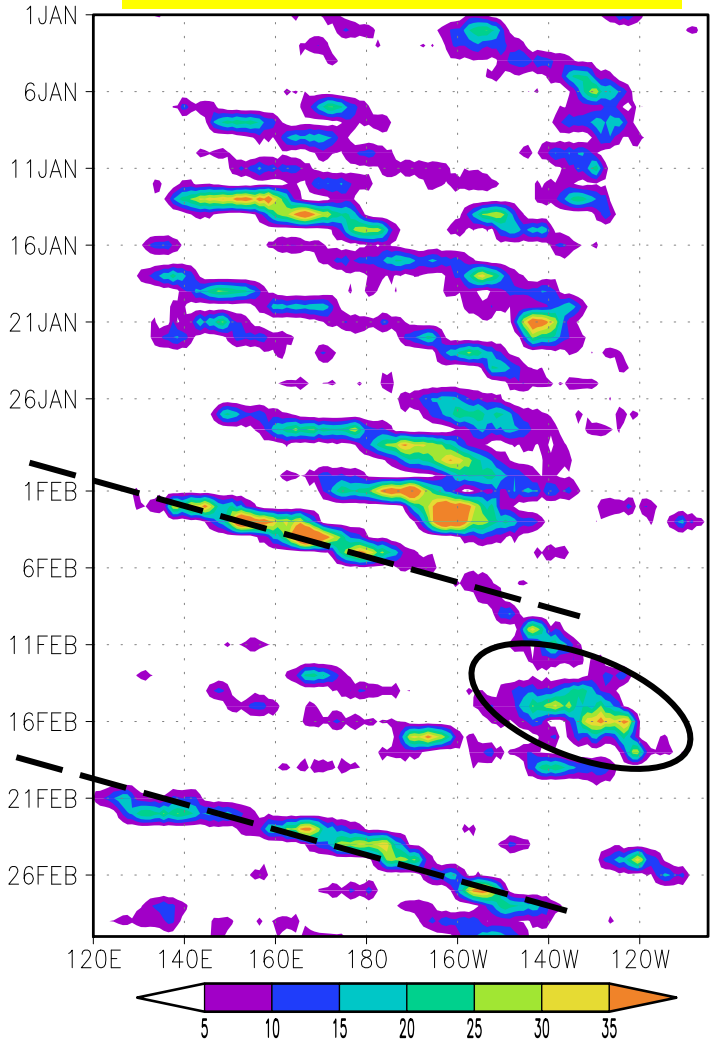
Total precipitable water (shading) and precipitation (contour)



Extratropical precipitation

(35N-45N)

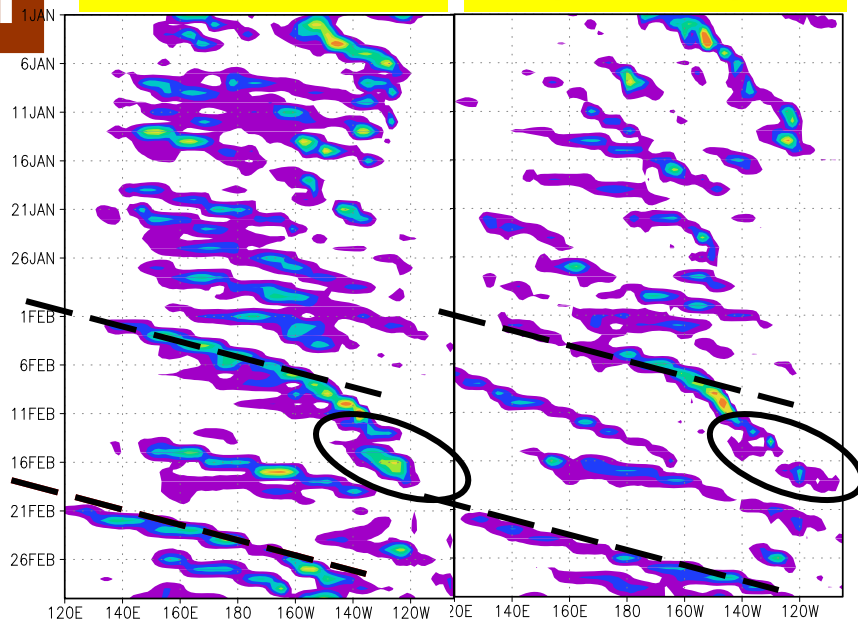
Observations (GPCP)



Sensitivity to the tropical forcing

Replay-global

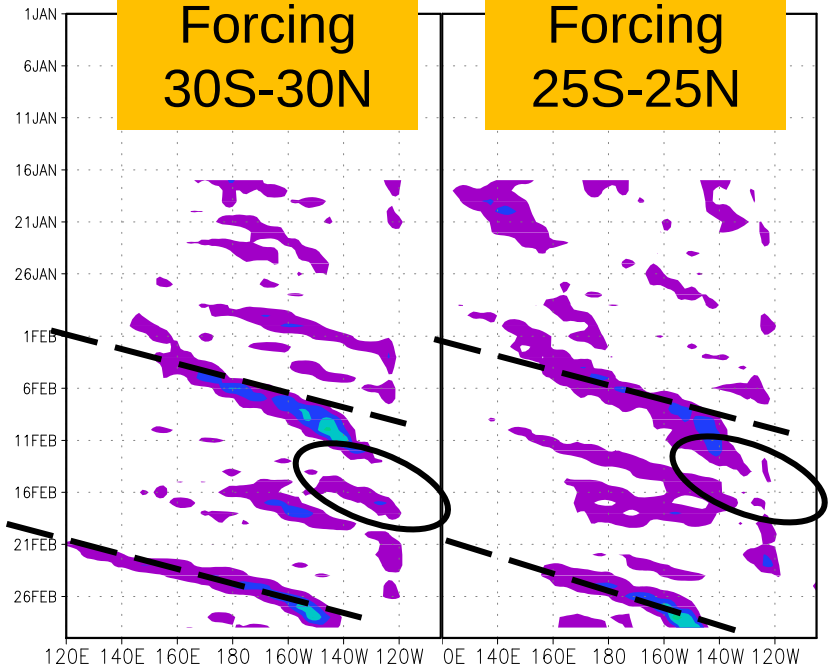
Replay-tropics



Ensemble Experiments (based on 10 with different ICs)

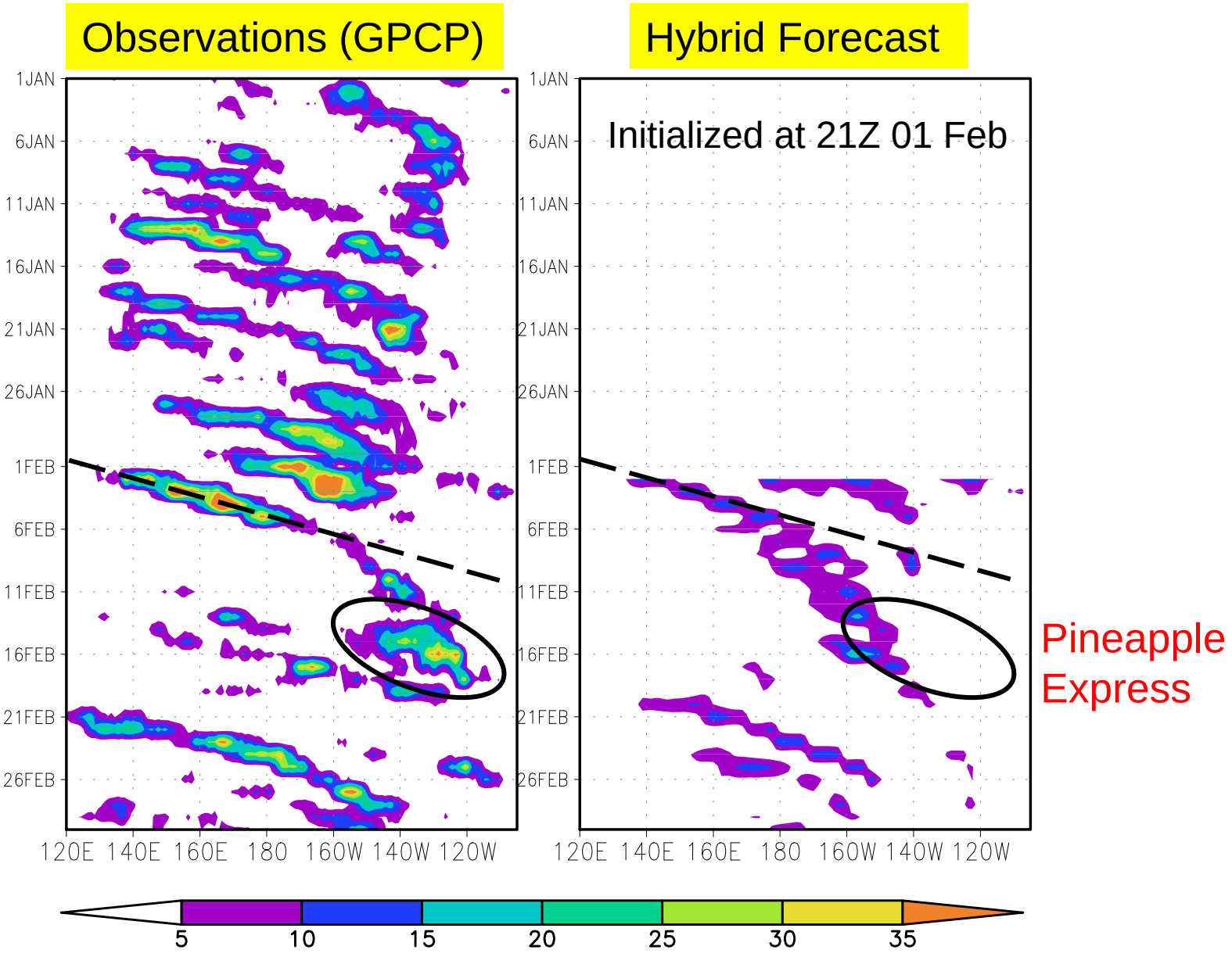
Forcing 30S-30N

Forcing 25S-25N



Pineapple Express Storm

Precipitation (35N-45N)



MJO hindcasts - Initialized from Coupled and Uncoupled Scout Replays

- **Models**

  AGCM (GEOS5 at 2X2.5X72)

  CGCM (GEOS5+MOM4)

- **Replay runs (Scout data)**

  AGCM replay run: 1979, 1996, 1997, 2002

  AGCM replay run (w/o Q): 2002

  CGCM replay run: 1979, 1996, 1997

- **35-day Hindcasts**

  AGCM (1368 cases): 1979, 1996, 1997, 2002

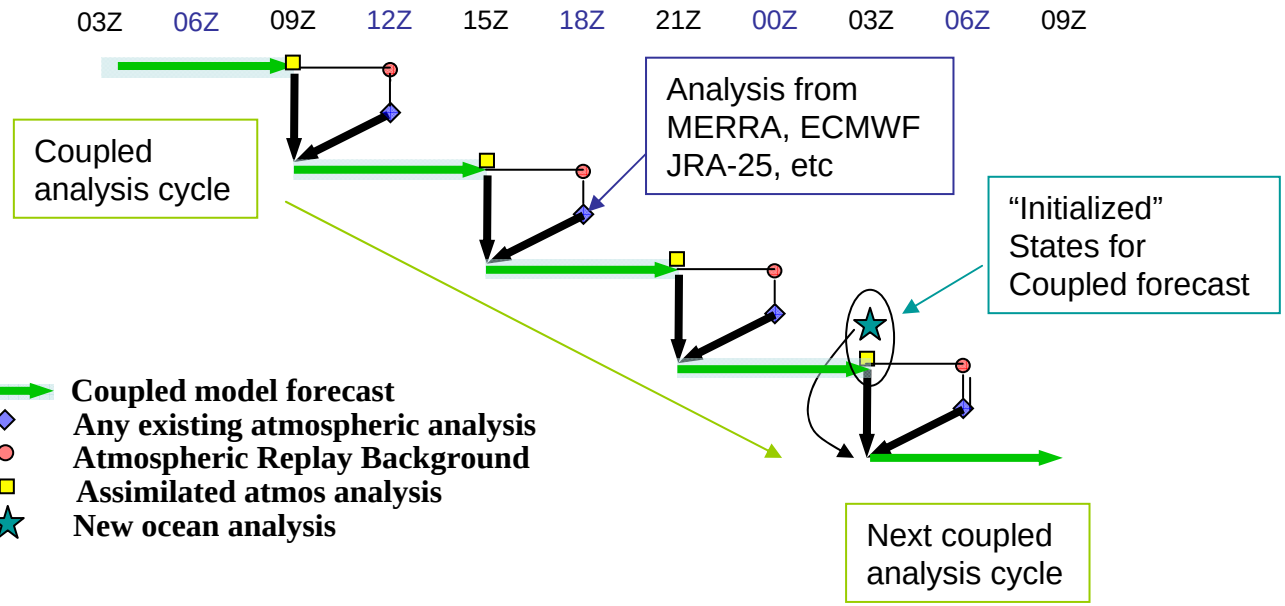
  CGCM (668 cases): 1979, 1996, 1997

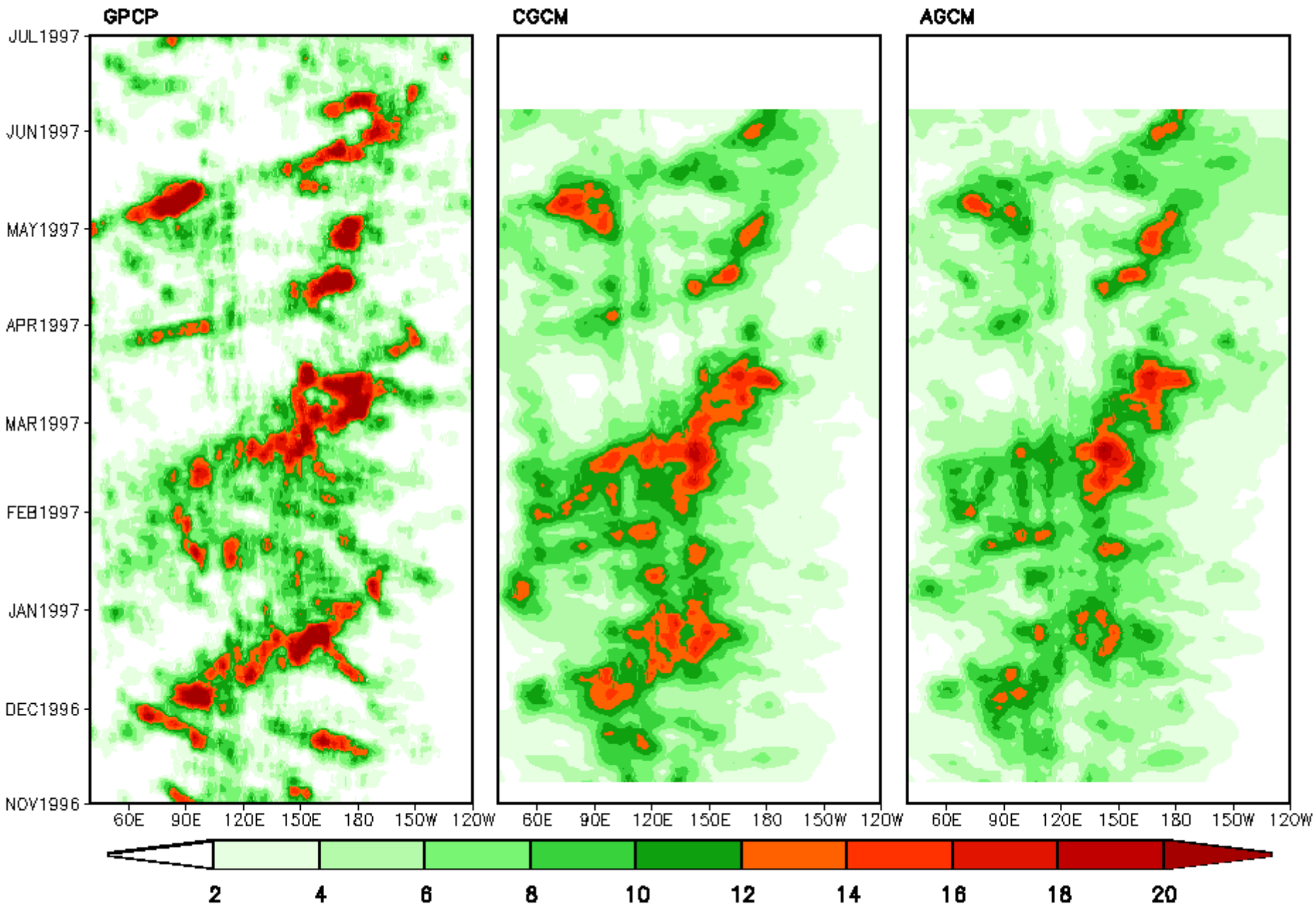
  ICs: daily 21z in 1979, 1996, 1997, 2002 from replay runs

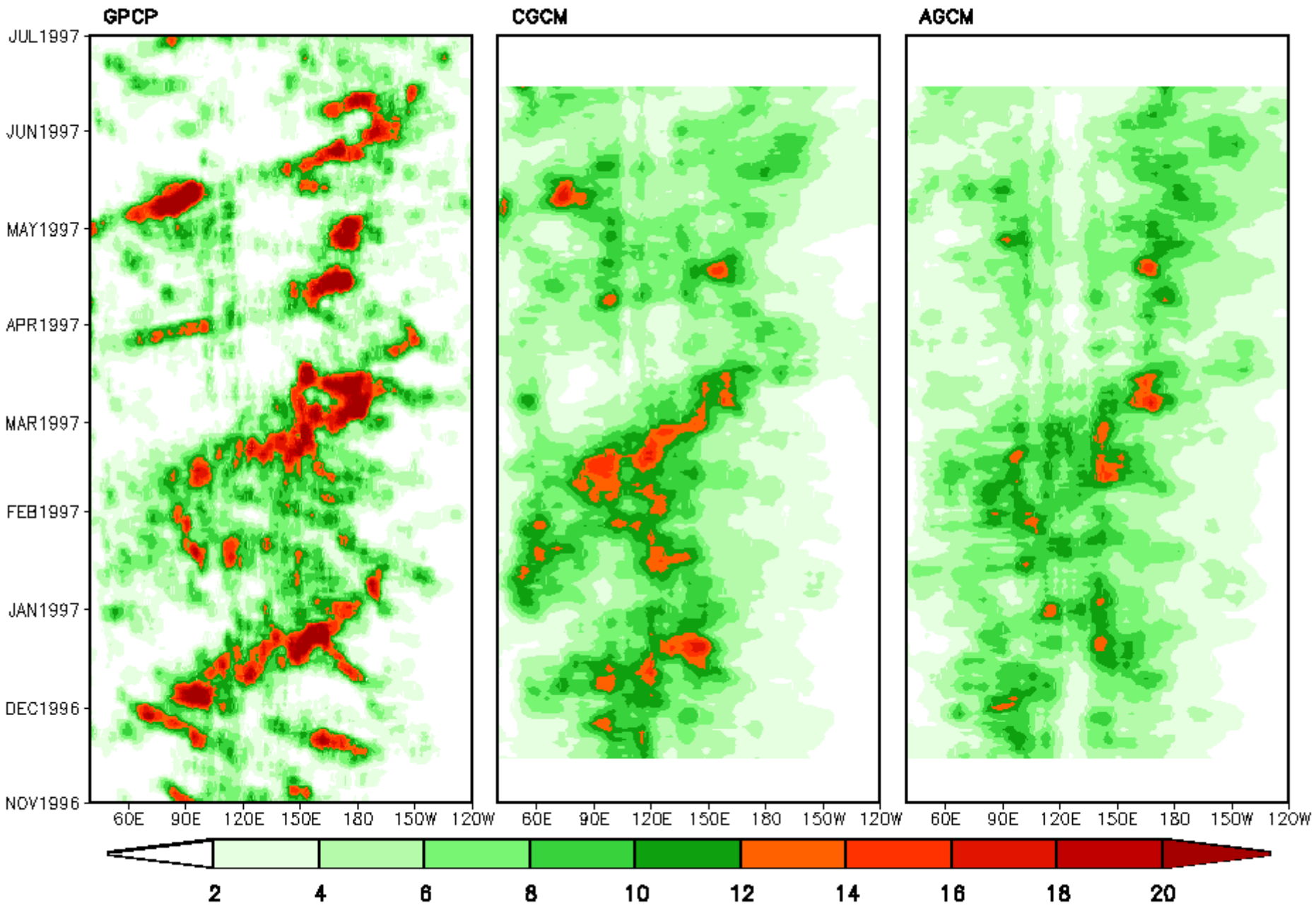
GEOS-5 “Coupled” Ocean Assimilation Using Atmospheric Replay

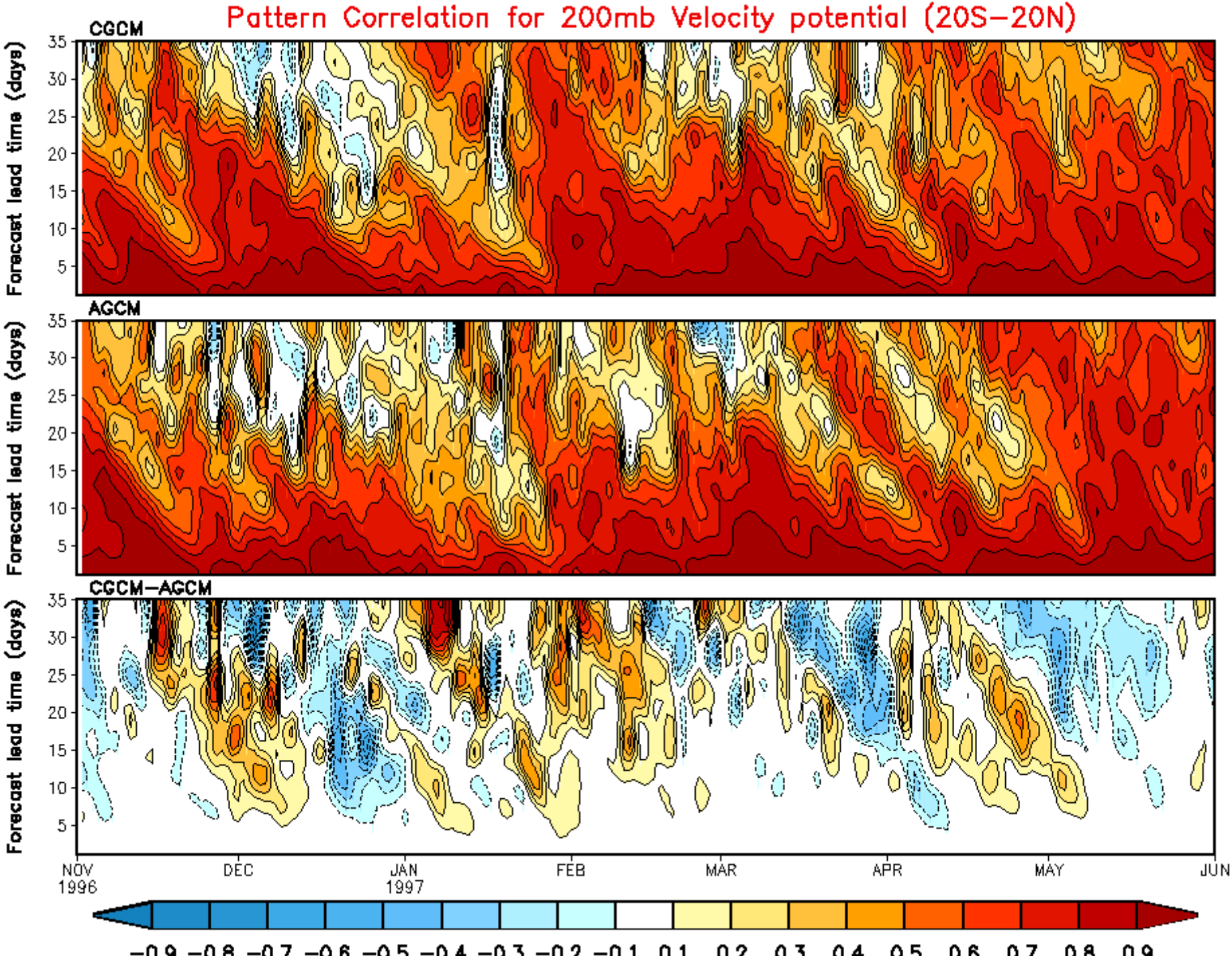
$$\left(\frac{\partial q^n}{\partial t}\right)_{total} = dynamics\ (adiabatic) + physics\ (diabatic) + \Delta q$$

Total “observed change” | **Model predicted change** | **Replay Correction from Existing Analysis**




Day−7: PRATE (mm/day) (15S−5N average)
GPCP
CGCM
AGCM
JUL1997
JUN1997
MAY1997
APR1997
MAR1997
FEB1997
JAN1997
DEC1996
NOV1996
60E
90E
120E
150E
180
150W
120W
2
4
6
8
10
12
14
16
18
20

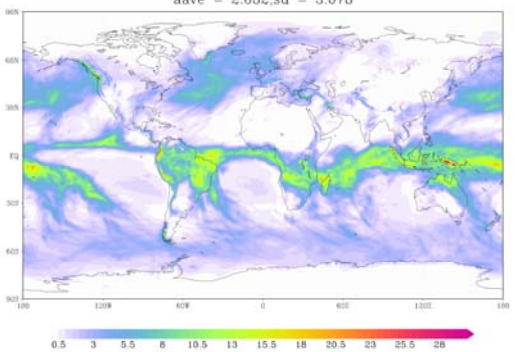

Day−14: PRATE (mm/day) (15S−5N average)
GPCP
CGCM
AGCM
JUL1997
JUN1997
MAY1997
APR1997
MAR1997
FEB1997
JAN1997
DEC1996
NOV1996
60E
90E
120E
150E
180
150W
120W
2
4
6
8
10
12
14
16
18
20


Pattern Correlation for 200mb Velocity potential (20S–20N)
CGCM
AGCM
CGCM–AGCM
Forecast lead time (days)
35
30
25
20
15
10
5
NOV
1996
DEC
JAN
1997
FEB
MAR
APR
MAY
JUN
−0.9 −0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9

Next Steps beyond MERRA

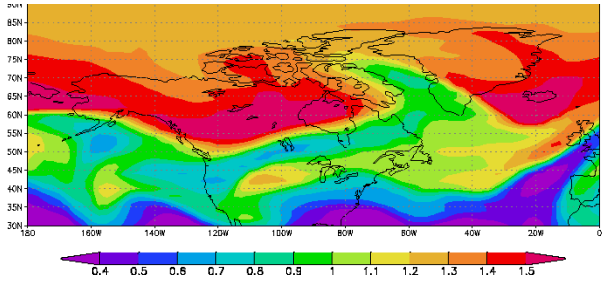
Developing Components of Future Integrated Earth System Analysis, with consistent analyses across all components

Jan 04 Precipitation in MERRA



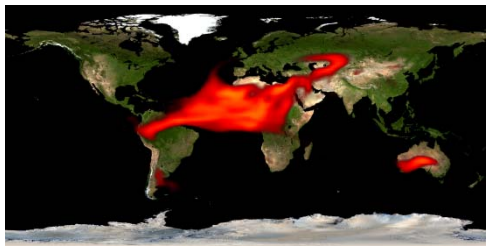
Atmosphere

Assimilation of AURA/MLS and OMI Ozone



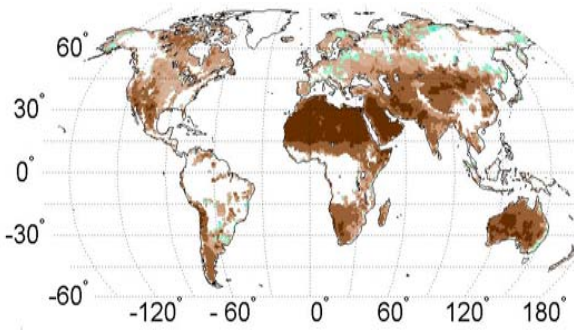
Constituents

Aerosol Transport



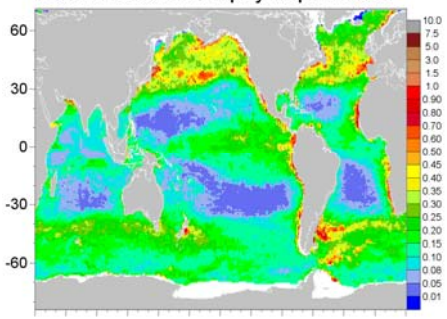
Aerosols

Assimilation of AMSR-E soil moisture retrievals



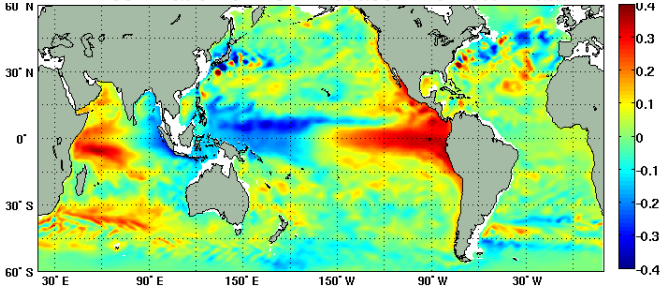
Land Surface

Assimilated Chlorophyll Apr 1 2001



Ocean Biology

Assimilation of TOPEX/Jason Altimeter Data



Physical Ocean

- Thank you!!

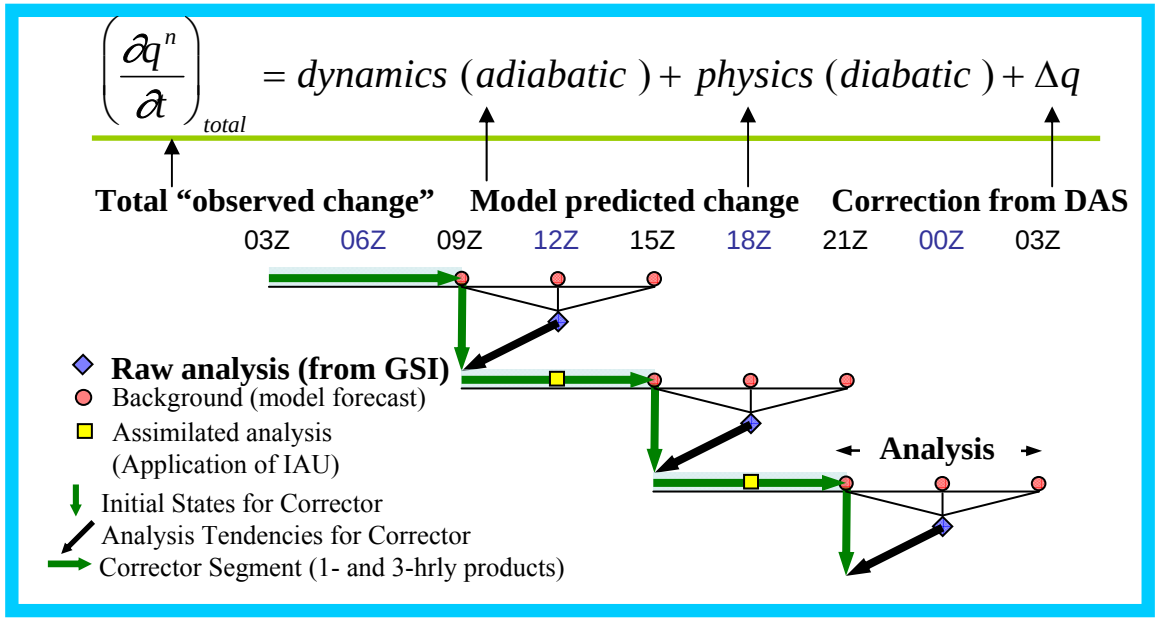
Major Source of Input Data

DATA SOURCE/TYPE	PERIOD	DATA SUPPLIER
Conventional Data		
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 Ğpresent	NOAA/NCEP
GOES cloud drift winds	1997 Ğpresent	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
SSM/I V6 wind speed	1987/7 - present	RSS
TMI rain rate	1997/12 - present	NASA/GSFC
QuikSCAT surface winds	1999/7 - present	JPL
ERS-1 surface winds	1991/8/5 Ğ1996/5/21	CERSAT
ERS-2 surface winds	1996/3/19 Ğ2001/1/17	CERSAT
Satellite Data		
TOVS (TIROS N, N-6, N-7, N-8)	1978/10/30 Ğ1985/01/01	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

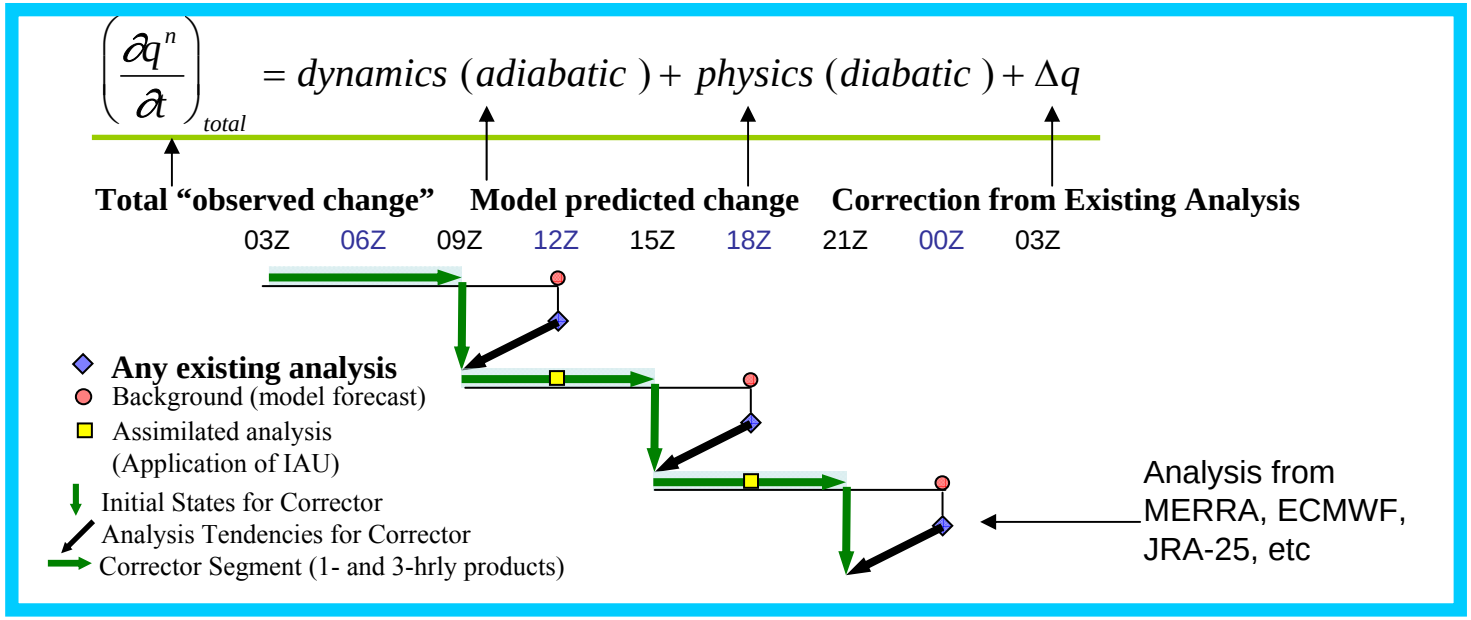
A special thanks to Jack Woollen for help with the conventional data streams and Leo Haimberger for the radiosonde corrections!!!!

This builds upon previous collaborative efforts between NCEP and ECMWF to improve input observations

GEOS-5 DAS



GEOS-5 REPLAY



GEOS System Roadmap