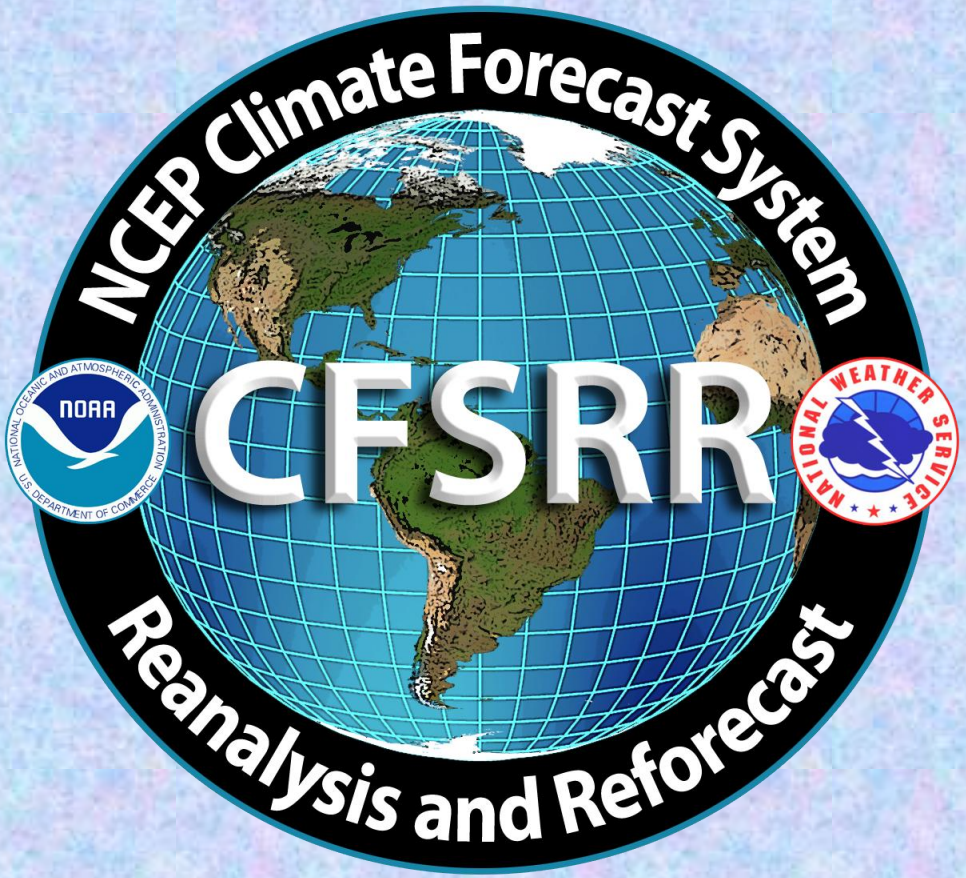
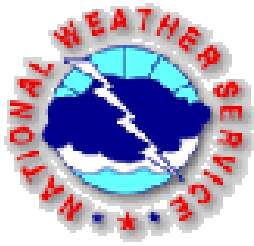
THE NCEP CLIMATE FORECAST SYSTEM



THE ENVIRONMENTAL MODELING CENTER

NCEP/NWS/NOAA



An upgrade to the NCEP Climate Forecast System (CFS)

is being planned for 2011.

For a new Climate Forecast System (CFS) implementation

Two essential components:

A new Reanalysis of the atmosphere, ocean, seaice and land over the 32-year period (1979-2010) is required to provide consistent initial conditions for:

A complete Reforecast of the new CFS over the 29-year period (1982-2010), in order to provide stable calibration and skill estimates of the new system, for operational seasonal prediction at NCEP

An upgrade to the coupled atmosphere-ocean-seaice-land NCEP Climate Forecast System (CFS) is being planned for 18 Jan 2011.

This upgrade involves changes to all components of the CFS, namely:

- **improvements to the data assimilation of the atmosphere with the new NCEP Gridded Statistical Interpolation Scheme (GSI) and major improvements to the physics and dynamics of operational NCEP Global Forecast System (GFS)**
- **improvements to the data assimilation of the ocean and ice with the NCEP Global Ocean Data Assimilation System, (GODAS) and a new GFDL MOM4 Ocean Model**
- **improvements to the data assimilation of the land with the NCEP Global Land Data Assimilation System, (GLDAS) and a new NCEP Noah Land model**

For a new CFS implementation (contd)

1. **An atmosphere at high horizontal resolution (spectral T382, ~38 km) and high vertical resolution (64 sigma-pressure hybrid levels)**
2. **An interactive ocean with 40 levels in the vertical, to a depth of 4737 m, and horizontal resolution of 0.25 degree at the tropics, tapering to a global resolution of 0.5 degree northwards and southwards of 10N and 10S respectively**
3. **An interactive 3 layer sea-ice model**
4. **An interactive land model with 4 soil levels**

There are three main differences with the earlier two NCEP Global Reanalysis efforts:

- **Much higher horizontal and vertical resolution (T382L64) of the atmosphere (earlier efforts were made with T62L28 resolution)**
- **The guess forecast was generated from a coupled atmosphere – ocean – seaice - land system**
- **Radiance measurements from the historical satellites were assimilated in this Reanalysis**

To conduct a Reanalysis with the atmosphere, ocean, seaice and land coupled to each other was a novelty, and will hopefully address important issues, such as the correlations between sea surface temperatures and precipitation in the global tropics, etc.

Motivation to make a Reanalysis ?

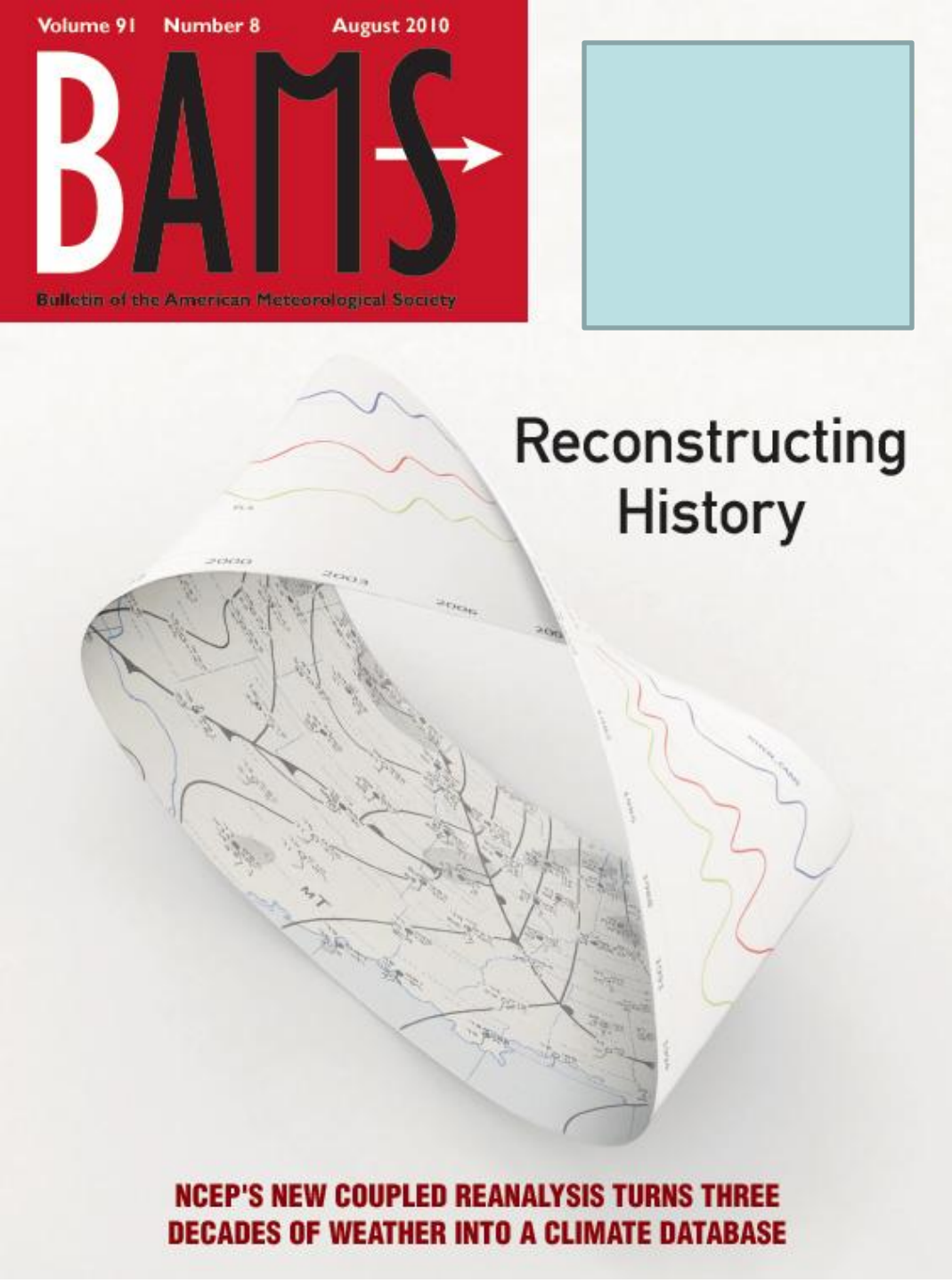
- To create a homogeneous and consistent climate record

Examples: R1/CDAS1: NCEP/NCAR Reanalysis (1948-present) Kalnay et al., Kistler et al

R2/CDAS2 : NCEP/DOE Reanalysis (1979-present) Kanamitsu et al

ERA40, ERA-Interim, MERRA, JRA25, NARR, etc….

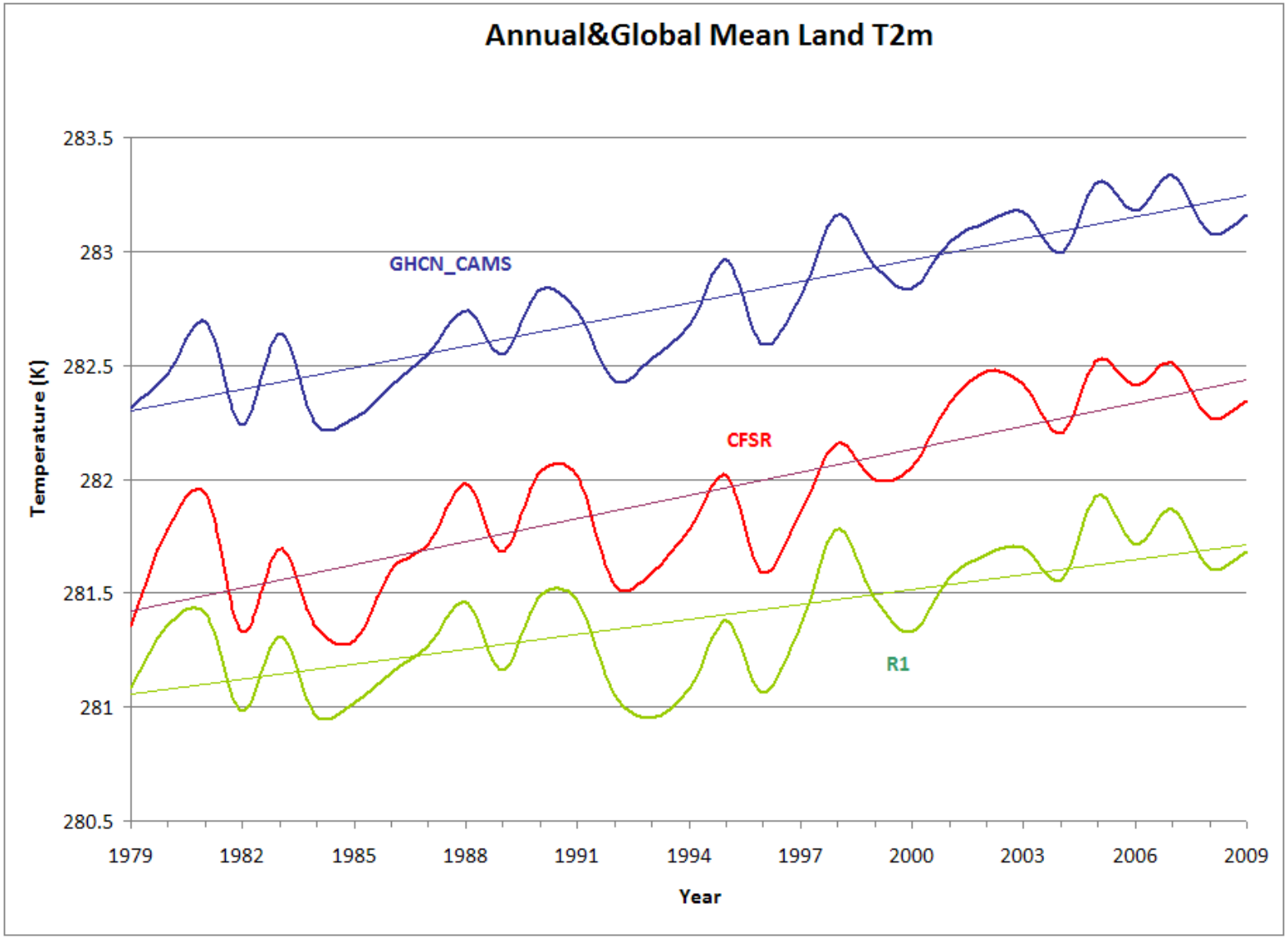
- To create a large set of initial states for Reforecasts (hindcasts, retrospective forecasts..) to calibrate real time extended range predictions (error bias correction).



The NCEP Climate Forecast System Reanalysis

Suranjana Saha, Shrinivas Moorthi, Hua-Lu Pan, Xingren Wu, Jiande Wang, Sudhir Nadiga, Patrick Tripp, Robert Kistler, John Woollen, David Behringer, Haixia Liu, Diane Stokes, Robert Grumbine, George Gayno, Jun Wang, Yu-Tai Hou, Hui-ya Chuang, Hann-Ming H. Juang, Joe Sela, Mark Iredell, Russ Treadon, Daryl Kleist, Paul Van Delst, Dennis Keyser, John Derber, Michael Ek, Jesse Meng, Helin Wei, Rongqian Yang, Stephen Lord, Huug van den Dool, Arun Kumar, Wanqiu Wang, Craig Long, Muthuvel Chelliah, Yan Xue, Boyin Huang, Jae-Kyung Schemm, Wesley Ebisuzaki, Roger Lin, Pingping Xie, Mingyue Chen, Shuntai Zhou, Wayne Higgins, Cheng-Zhi Zou, Quanhua Liu, Yong Chen, Yong Han, Lidia Cucurull, Richard W. Reynolds, Glenn Rutledge, Mitch Goldberg

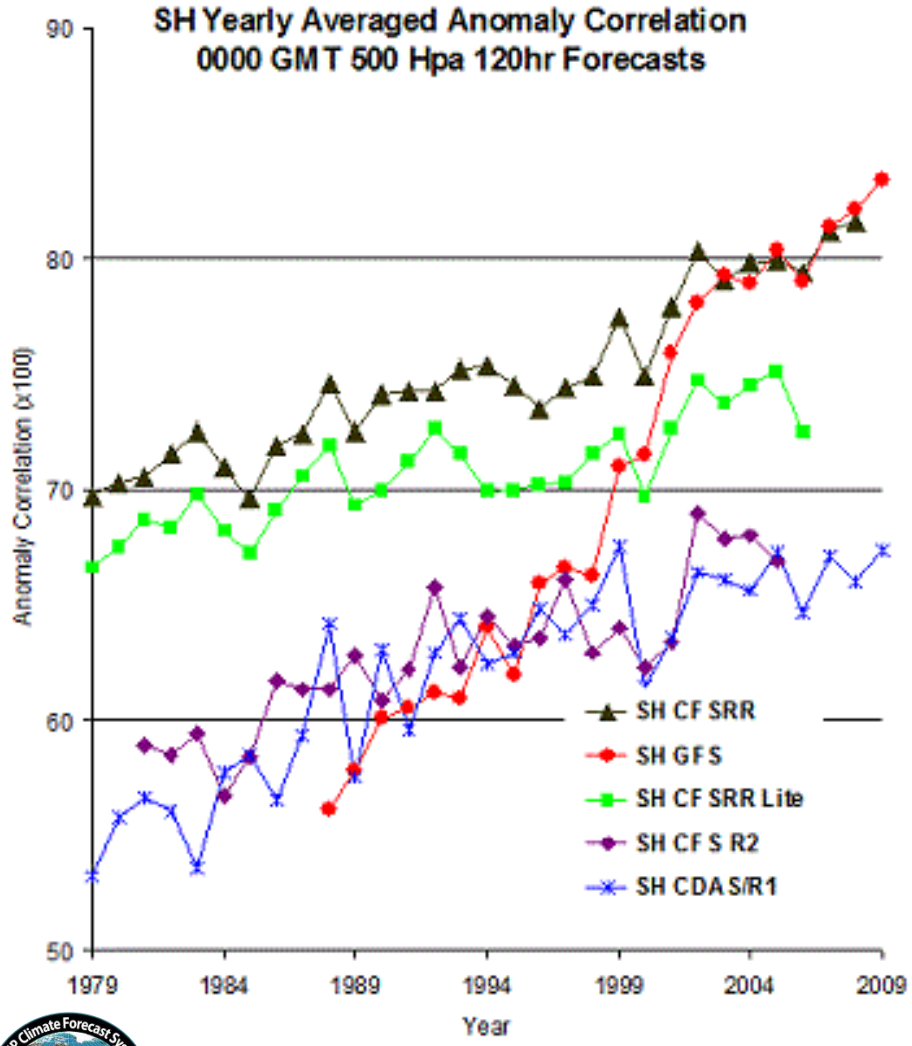
Bulletin of the American Meteorological Society
Volume 91, Issue 8, pp 1015-1057.
doi: 10.1175/2010BAMS3001.1

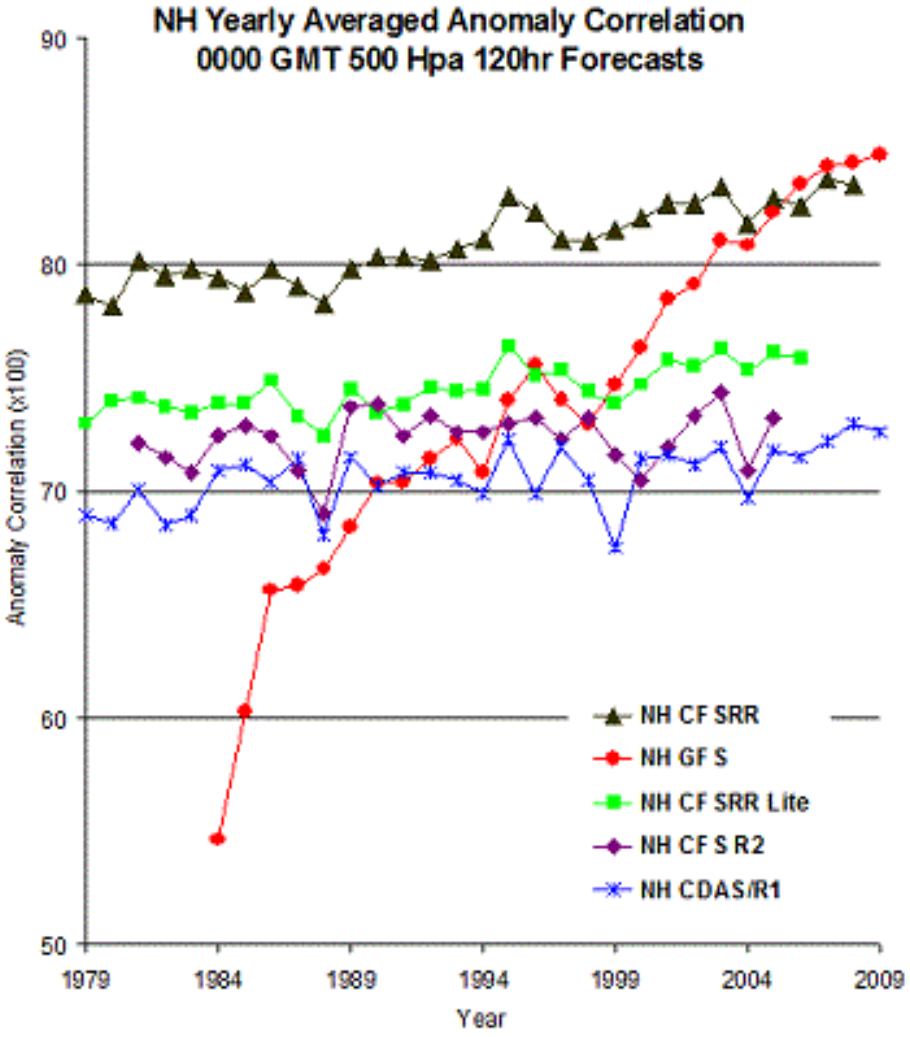


The linear trends are 0.66, 1.02 and 0.94K per 31 years for R1, CFSR and GHCN_CAMS respectively. (Keep in mind that straight lines may not be perfectly portraying climate change trends).

Courtesy: Huug van den Dool

5-day T126L64 forecast anomaly correlations

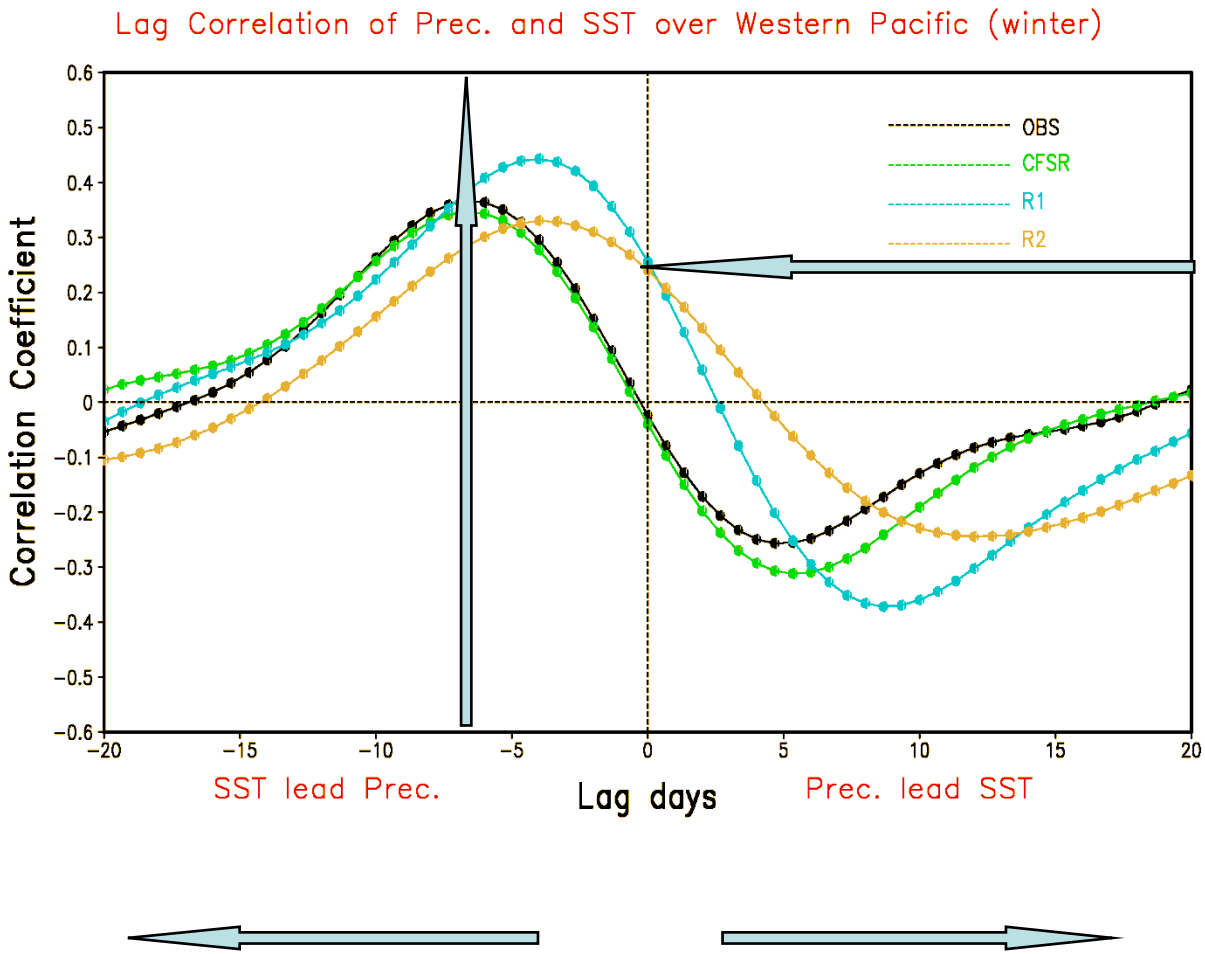




Courtesy: Bob Kistler

SST-Precipitation Relationship in CFSR

Precipitation-SST lag correlation in tropical Western Pacific



Response of Prec. To SST increase : warming too quick in R1 and R2

simultaneous positive correlation in R1 and R2

Courtesy: Jiande Wang

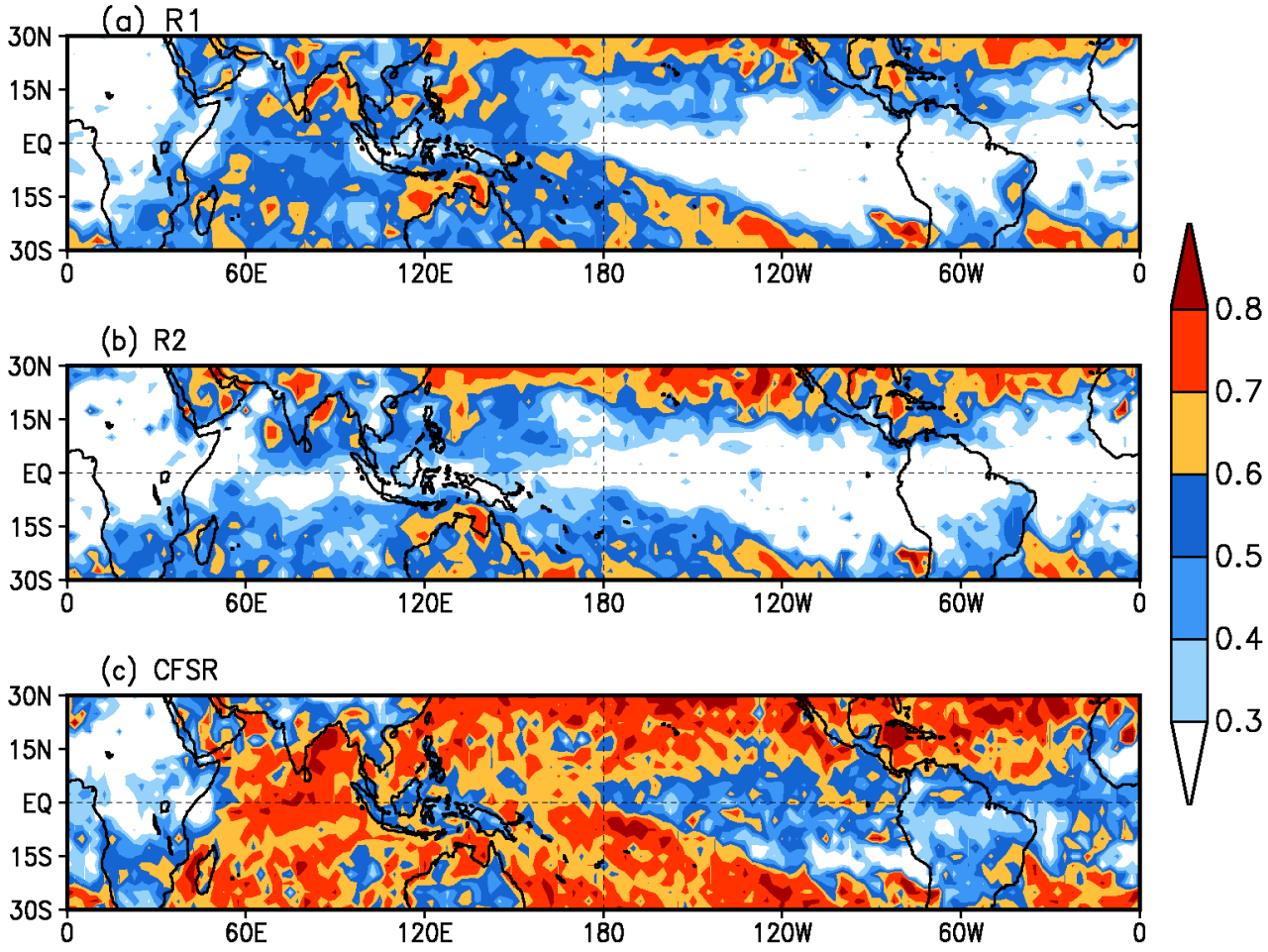


Fig. 3 Correlation of intraseasonal precipitation with CMORPH. (a) R1, (b) R2, and (c) CFSR. Contours are shaded starting at 0.3 with 0.1 interval.

Courtesy: Jiande Wang et al

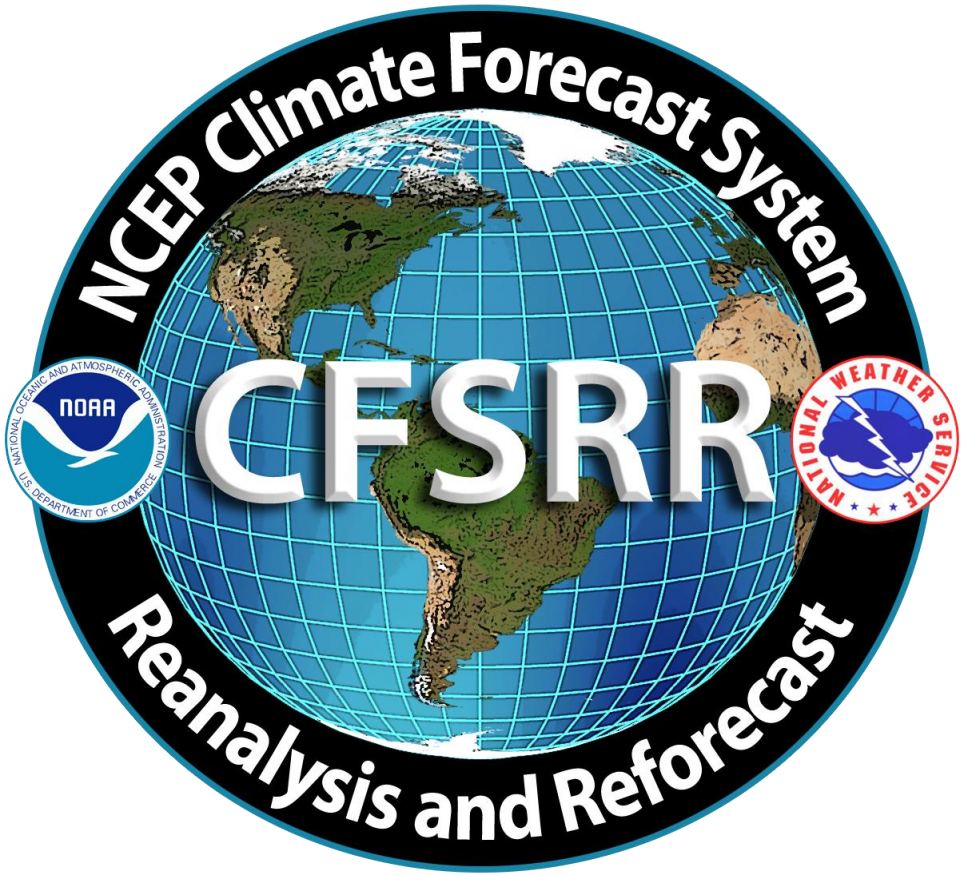
Another innovative feature of the CFSR GSI is the use of the historical concentrations of carbon dioxide when the historical TOVS instruments were retrofit into the CRTM.

Satellite Platform	Mission Mean (ppmv)b
TIROS-N	337.10
NOAA-6	340.02
NOAA-7	342.96
NOAA-8	343.67
NOAA-9	355.01
NOAA-10	351.99
NOAA-11	363.03
NOAA-12	365.15
GEOS-8	367.54
GEOS-0	362.90
GEOS-10	370.27
NOAA-14 to NOAA-18	380.00
IASI METOP-A	389.00
NOAA-19	391.00

Courtesy: http://gaw.kishou.go.jp

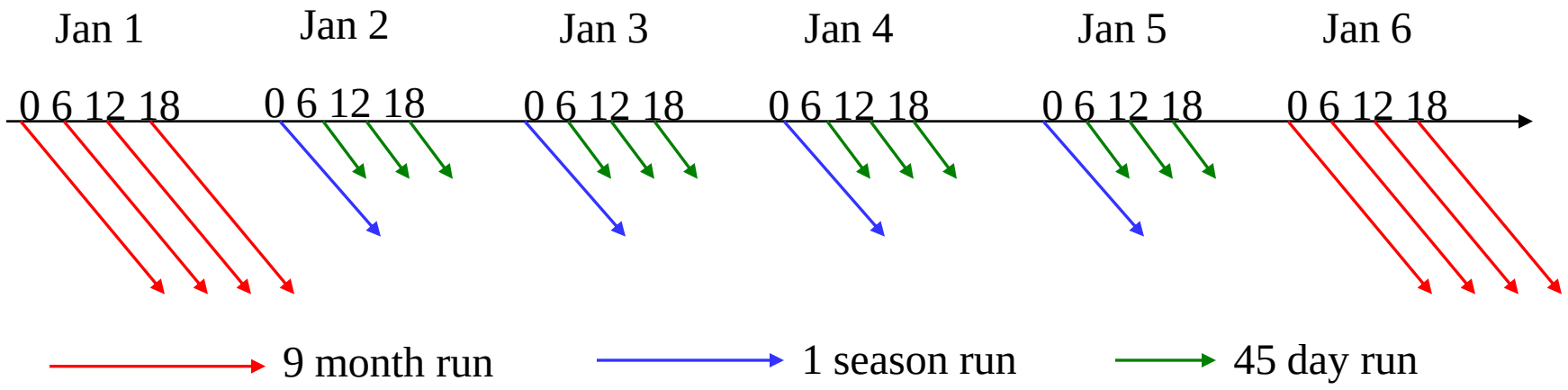
AND NOW……..

THE SECOND ‘R’ IN



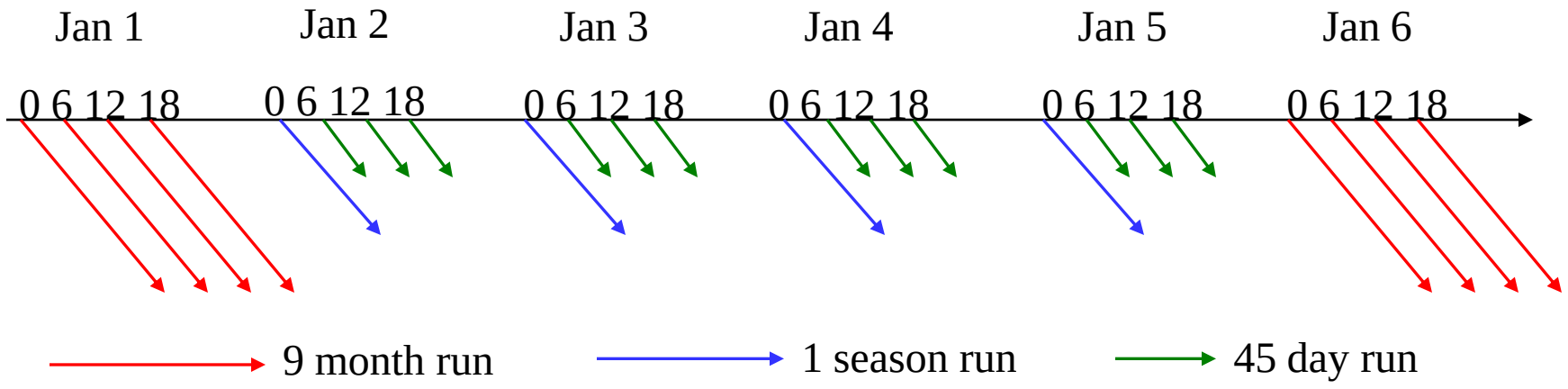
Hindcast Configuration for CFSv2

- 9-month hindcasts were initiated from every 5th day and run from all 4 cycles of that day, beginning from Jan 1 of each year, over a 29 year period from 1982-2010. This is required to calibrate the operational CPC longer-term seasonal predictions (ENSO, etc).
- Total number of 9-month runs = 8468, equivalent of running the CFS for ~ 7000 years !!



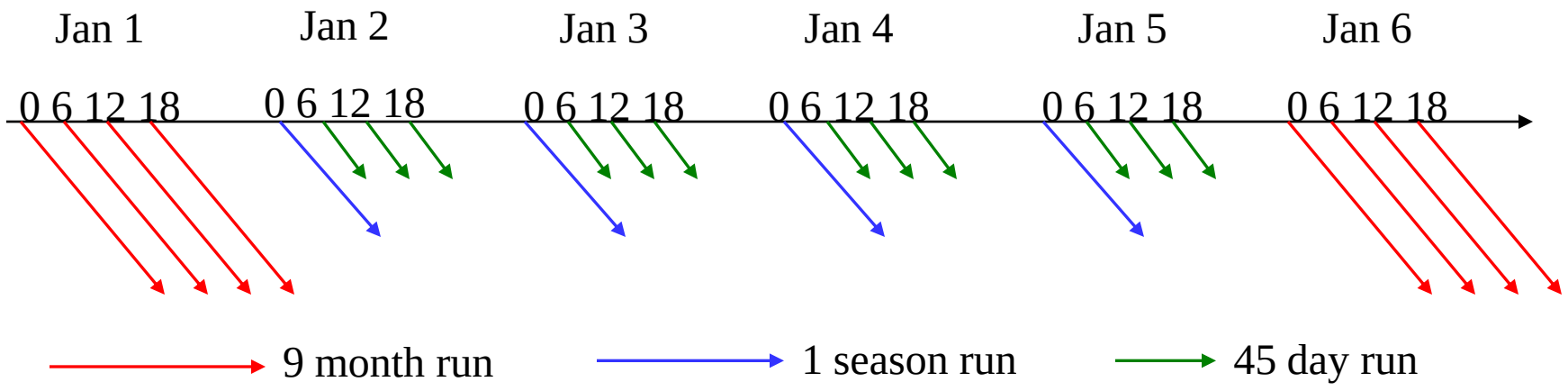
Hindcast Configuration for CFSv2

- There is also a single 1 season (123-day) hindcast run, initiated from every 0 UTC cycle between these five days, over the 12 year period from 1999-2010. This is required to calibrate the operational CPC first season predictions for hydrological forecasts (precip, evaporation, runoff, streamflow, etc)
- Total number of 1 season runs = 4380, equivalent to running the CFS for ~1400 years !!



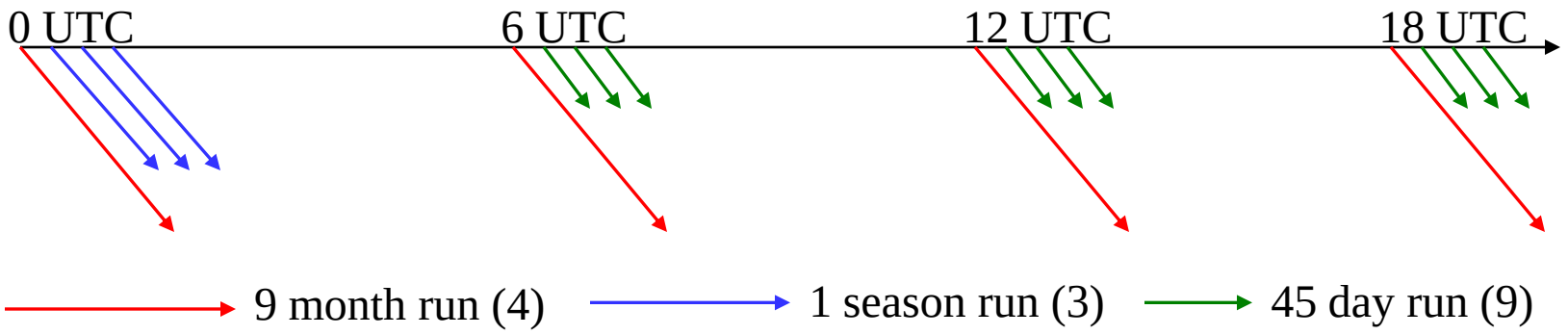
Hindcast Configuration for CFSv2

- In addition, there are three 45-day (1-month) hindcast runs from every 6, 12 and 18 UTC cycles, over the 12-year period from 1999-2010. This is required for the operational CPC week3-week6 predictions of tropical circulations (MJO, PNA, etc).
- Total number of 45-day runs = 13140 , equivalent to running the CFS for ~1600 years !!



Operational Configuration for CFSv2

- There will be 4 control runs per day from the 0, 6, 12 and 18 UTC cycles of the CFS real-time data assimilation system, out to 9 months.
- In addition to the control run of 9 months at the 0 UTC cycle, there will be 3 additional runs, out to one season. These 3 runs per cycle will be initialized as in current operations.
- In addition to the control run of 9 months at the 6, 12 and 18 UTC cycles, there will be 3 additional runs, out to 45 days. These 3 runs per cycle will be initialized as in current operations.
- There will be a total of 16 CFS runs every day, of which 4 runs will go out to 9 months, 3 runs will go out to 1 season and 9 runs will go out to 45 days.



9-MONTH HINDCASTS

28 years: 1982-2009; all 12 months.

CFSv1 : 15 members per month, total of 180 initial states per year

CFSv2: 24 members per month (28 for November), total of 292 initial states per year.

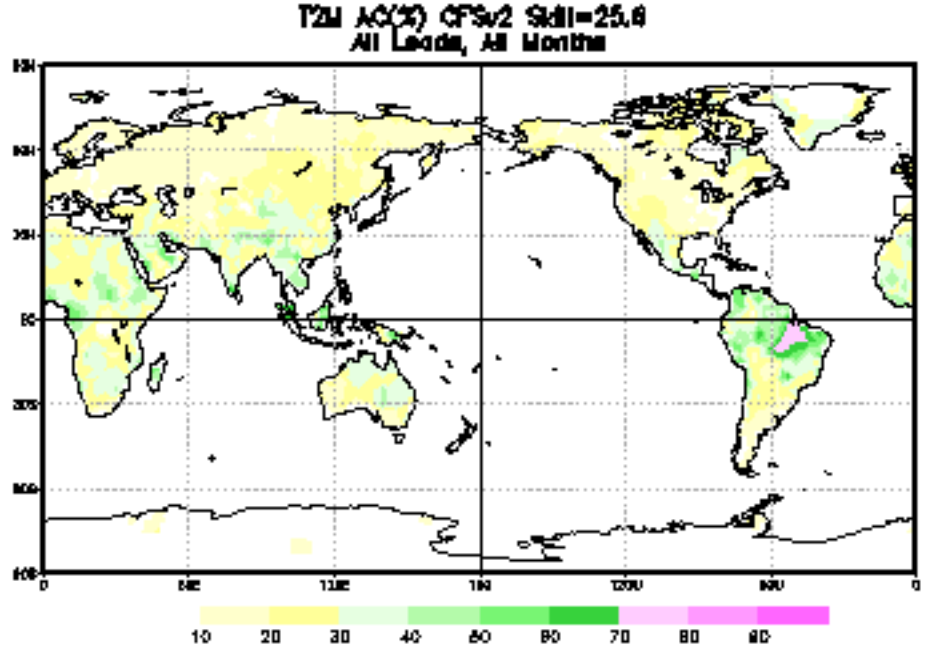
Sample size: 5040 for CFSv1; 8176 forCFSv2.

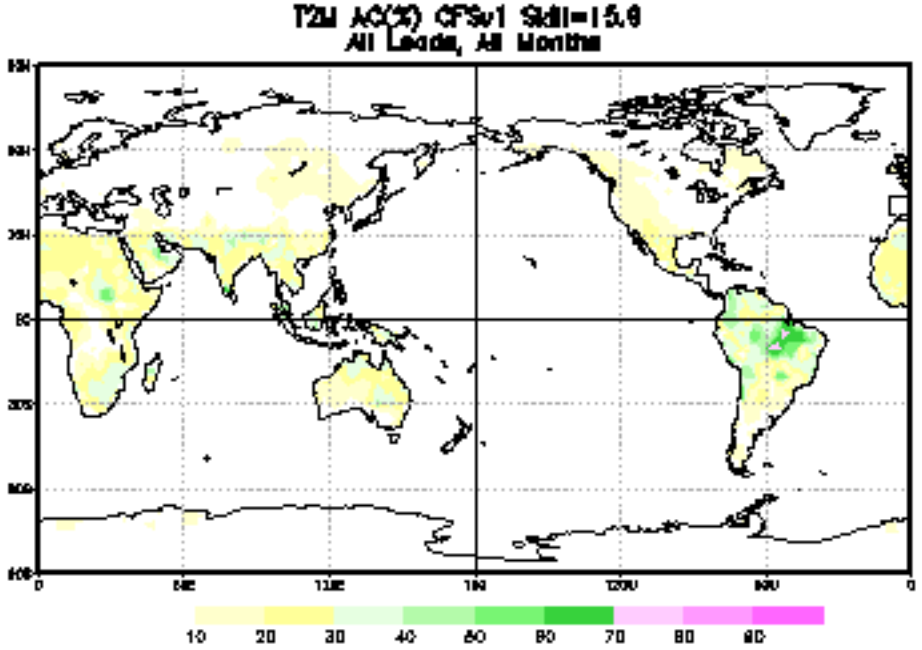
Definitions and Data

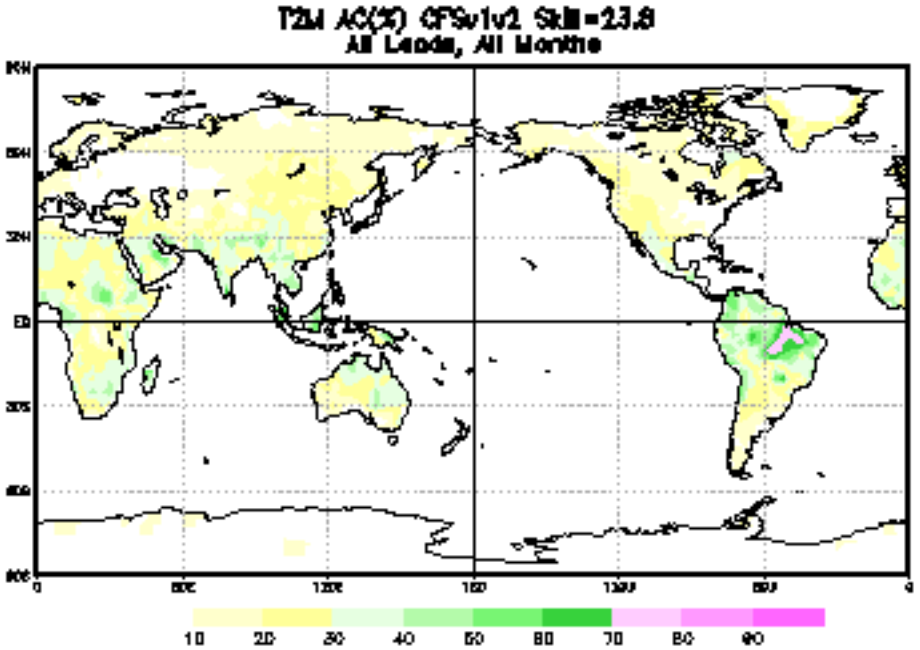
- AC of ensemble averaged monthly means
- GHCN-CAMS (validation for Tmp2m)
- CMAP (validation for Prate)
- OIv2 (validation for SST)
- 1982-2009 (28 years)
- Common 2.5 degree grid
- Variables/areas studied: US T, US P, global and Nino34 SST, global and Nino34 Prate.
- Two climos used for all variables within tropics

  30S-30N: 1982-1998 and 1999-2009

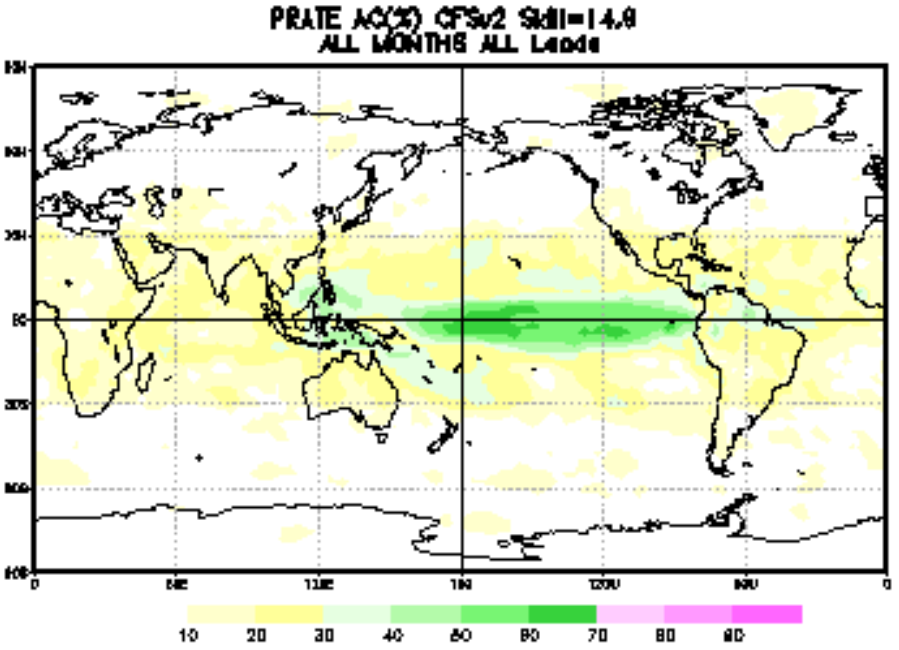
  Elsewhere: 1982-2009

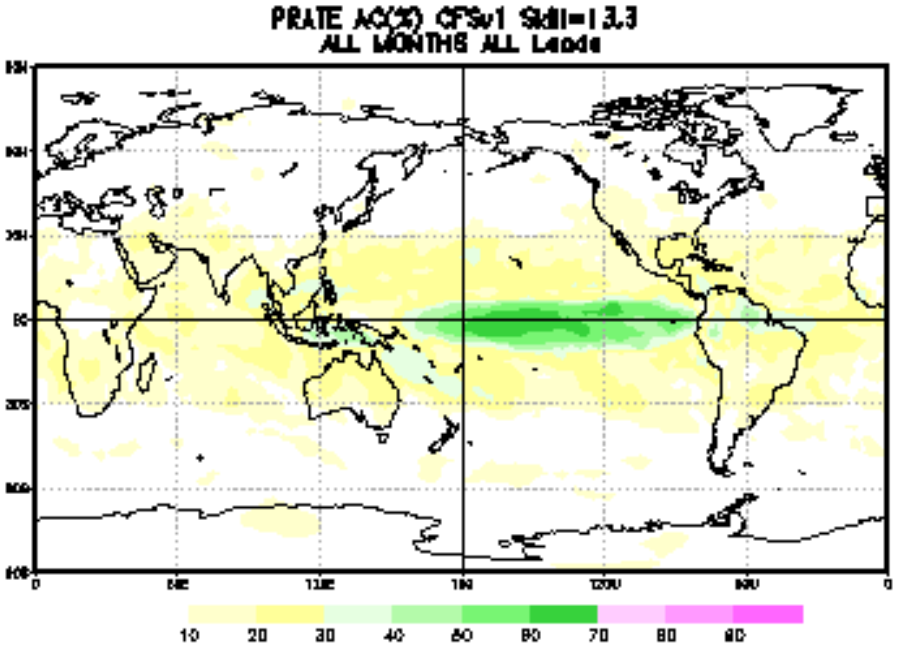


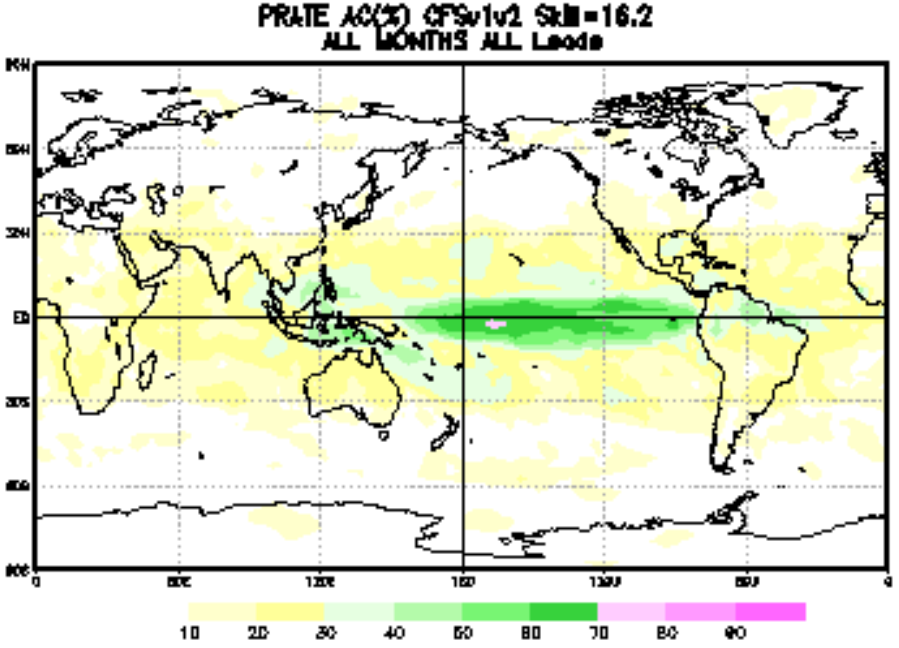




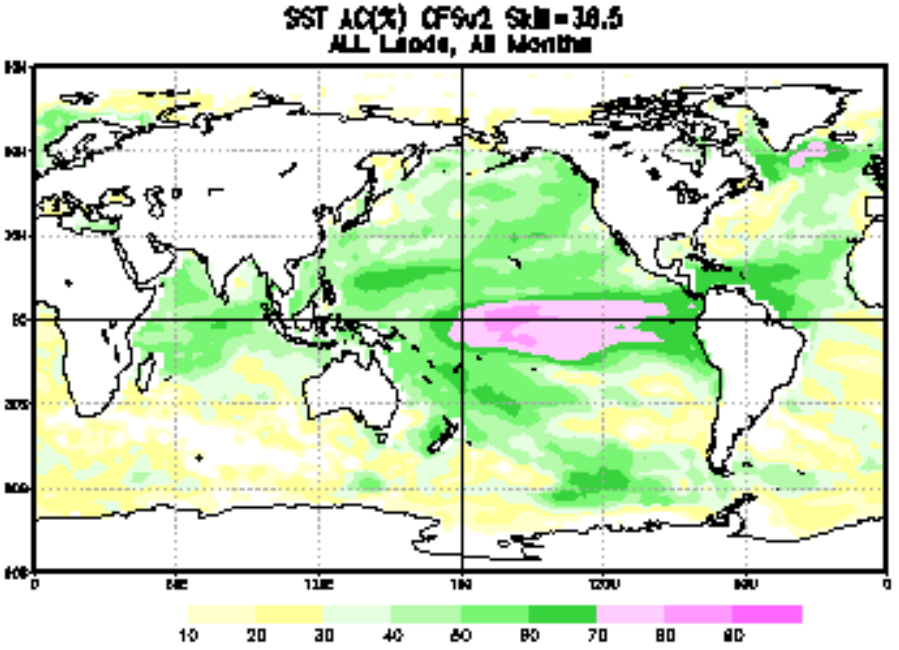
More skill globally for CFSv2

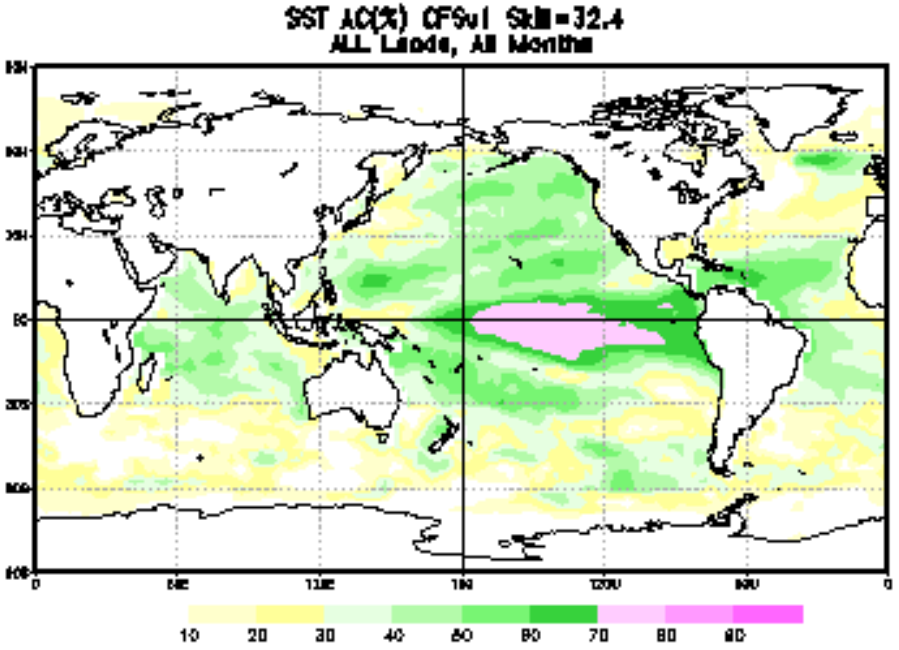


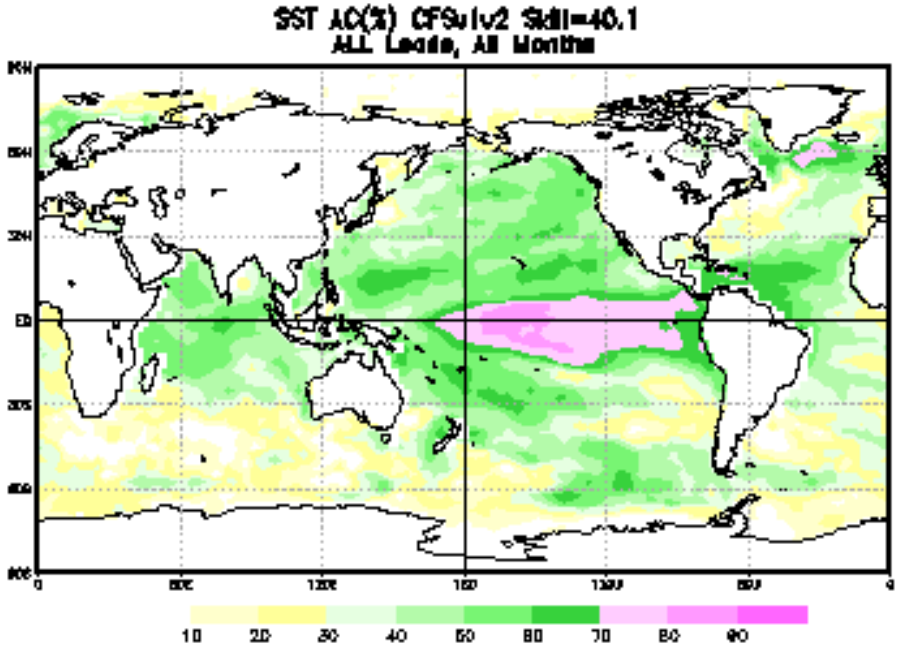




More skill in the western Pacific for CFSv2







More skill west of the dateline and over the Atlantic for CFSv2

THE BOTTOM LINE FOR CPC

Anomaly Correlation: All Leads (1-8), All Months (10)

Green is good **Red is not good**

Model	US T	US P	Nino34 SST	Nino34 Prate	Global SST (50N-50S)
CFSv2	16.3	9.5	77.2	54.5	42.2
CFSv1	9.5	10.3	71.8	52.8	37.7
CFSv1v2	15.4	12.2	78.3	57.0	45.4
CFSv1v2-CFSv2	-0.9	+2.7	+1.1	+2.5	+3.2
%tage change	(-5.8%)	(+22%)	(+1.4%)	(+4.4%)	(+7%)

Anomaly Correlation for other Regions

(collaboration with EUROSIP and India)

All Leads (1-8), All Months (10)

Green is good **Red is not good**

Model	US T	Europe T	India T	US P	Europe P	India P
CFSv2	16.3	16.4	48.1	9.5	6.0	18.9
CFSv1	9.5	9.6	2.4	10.3	4.5	18.0
CFSv1v2	15.4	15.5	30.7	12.2	6.2	22.8
CFSv1v2-CFSv2	-0.9	-0.9	-18.1	+2.7	+0.2	(+3.9)
%tage change	(-5.8%)	(-5.8%)	(-59%)	(+22%)	(+3.2%)	(+17.1%)

45-DAY HINDCASTS

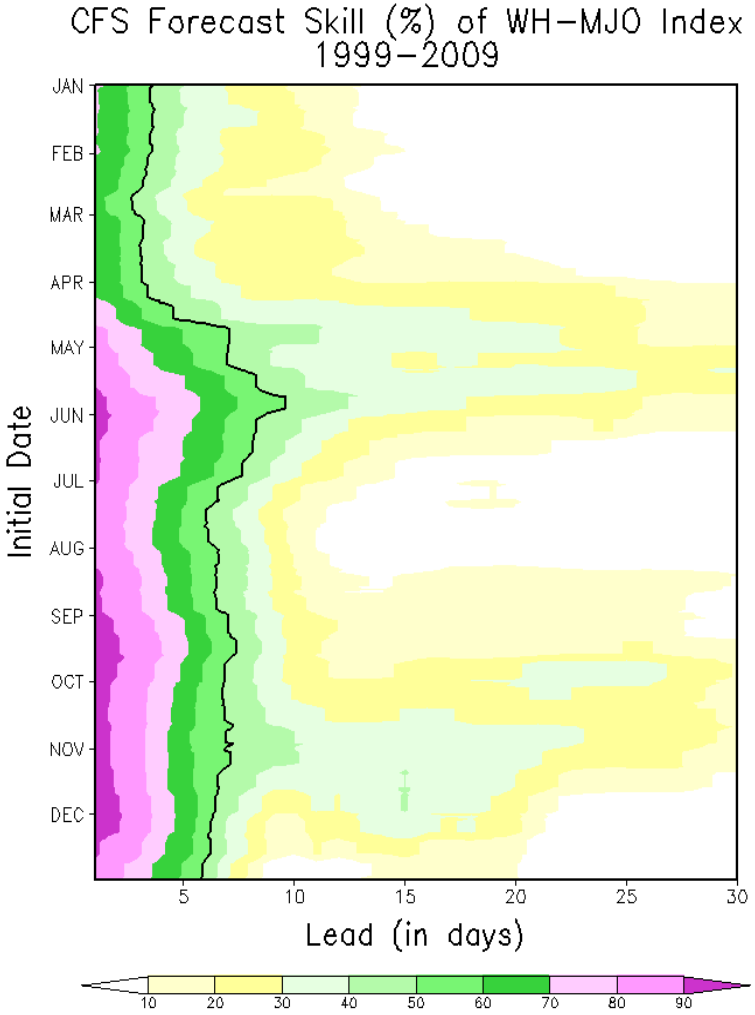
11 years: 1999-2009; all 12 months.

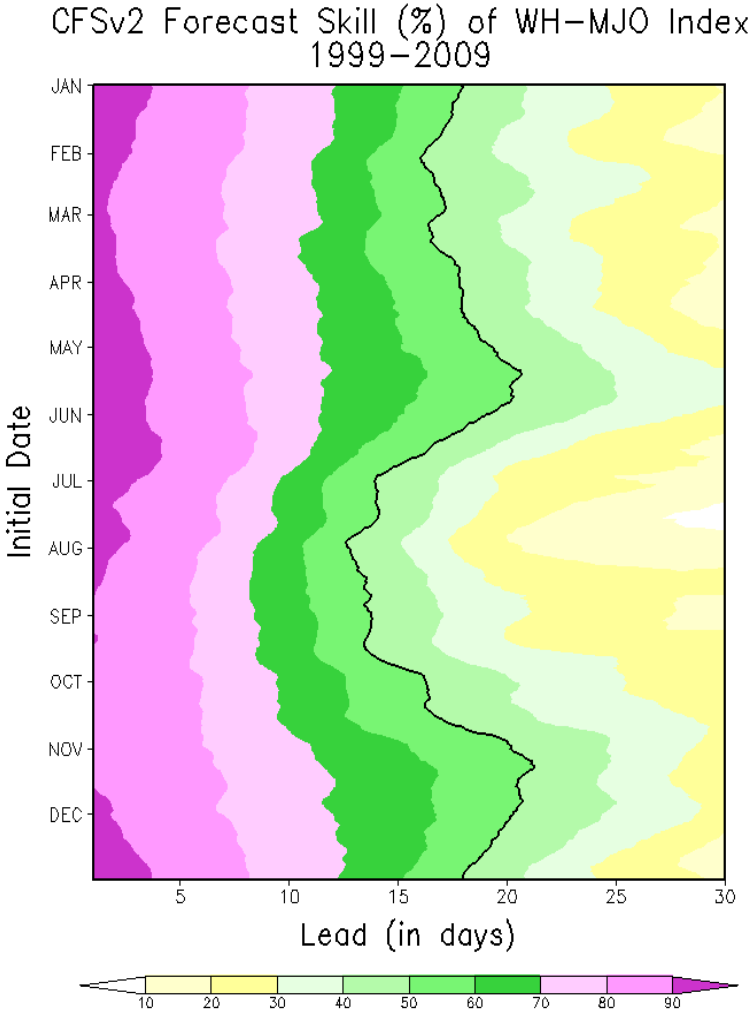
CFSv1 : 15 members per month, total of 180 initial states per year

CFSv2: every cycle of every day of the year, total of 1460 initial states per year.

Sample size: 1980 for CFSv1; 16060 for CFSv2.

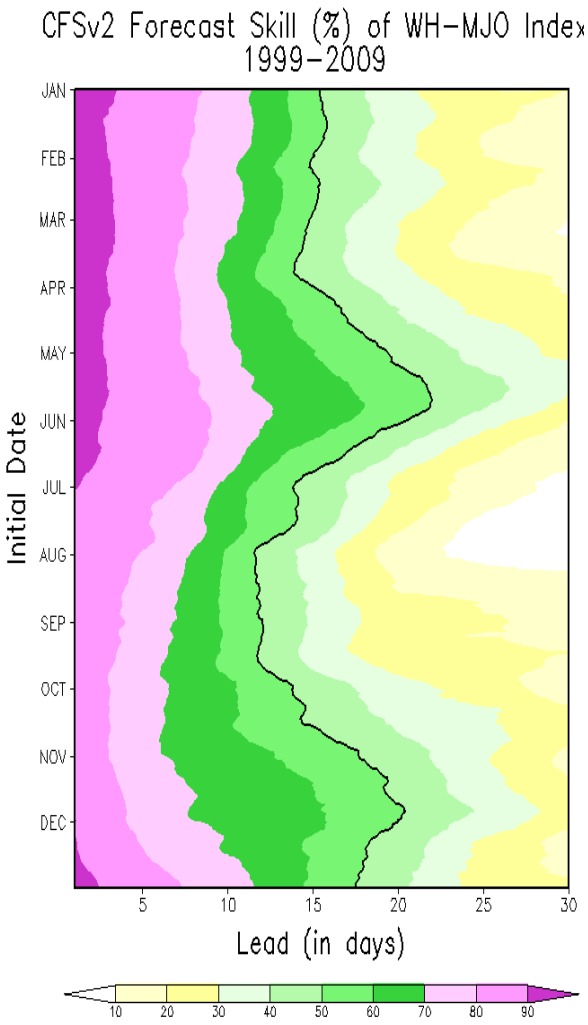
Forecast Skill of WH-MJO index



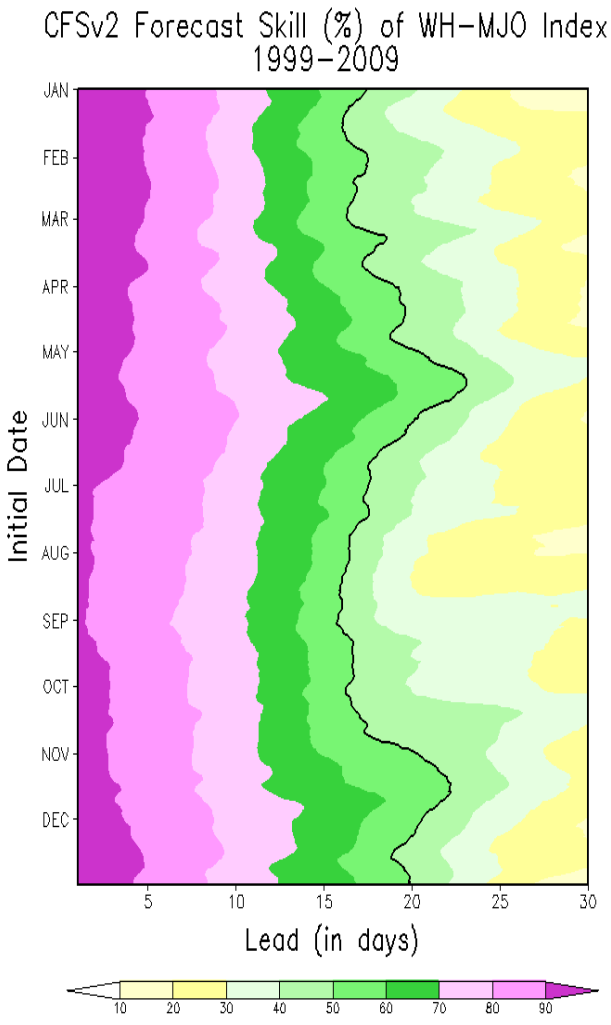


Qin Zhang and Huug van den Dool, CPC

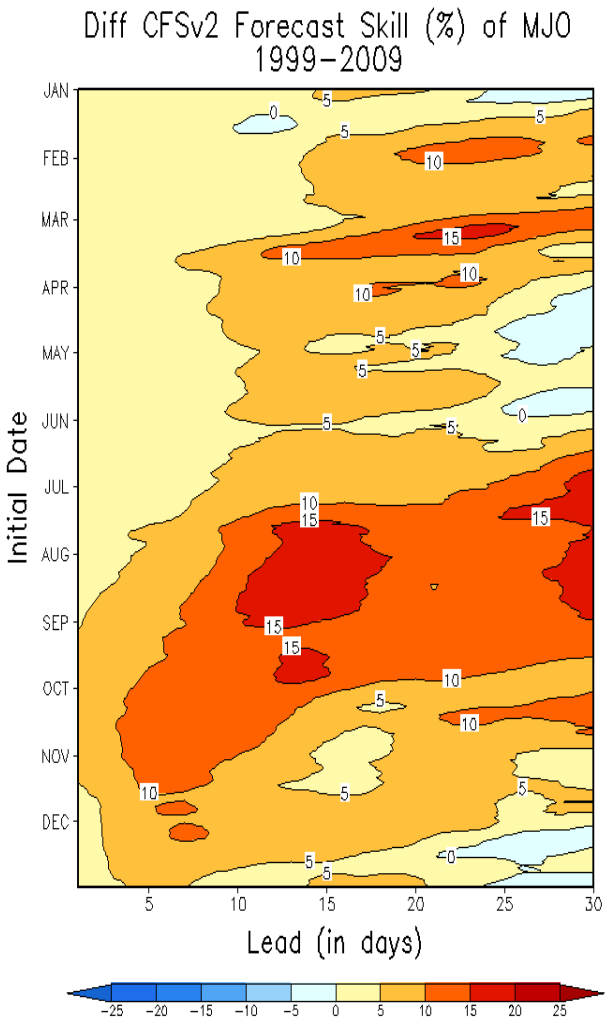
Before Model Bias Correction



After Model Bias Correction



Difference (After - Before)



Qin Zhang and Huug van den Dool, CPC

TECHNICAL INFORMATION NOTICE:

EFFECTIVE AROUND THE END OF MARCH 2011...BEGINNING WITH THE 1200 COORDINATED UNIVERSAL TIME /UTC/ RUN OF THE DAY OF IMPLEMENTATION...THE NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION /NCEP/ WILL UPGRADE THE CLIMATE FORECAST SYSTEM /CFS/.

ALL COMPONENTS OF THE CFS, THE ATMOSPHERIC MODEL, OCEAN MODEL, LAND-SURFACE MODEL, AND DATA ASSIMILATION, WILL BE UPGRADED AS PART OF THIS CHANGE.

PLEASE NOTE THAT NCEP WILL CONTINUE TO RUN THE CURRENT OF THE CFS UNTIL June 28, 2011 TO ALLOW USERS TO TRANSITION TO THE NEW CFS OUTPUT. NCEP ENCOURAGES ALL USERS TO ENSURE THAT THEY UPGRADE THEIR PROCESS OF OBTAINING CFS DATA, AS THERE WILL BE MAJOR CHANGES IN CONTENT, FORMAT AND VOLUME OF DATA WITH THIS UPGRADE.