NCEP Climate Forecast System Version 2 (CFSv2) in the context of the US National Multi Model Ensemble (NMME) for Seasonal Prediction

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Climate Forecast System (CFSv2)

http://cfs.ncep.noaa.gov

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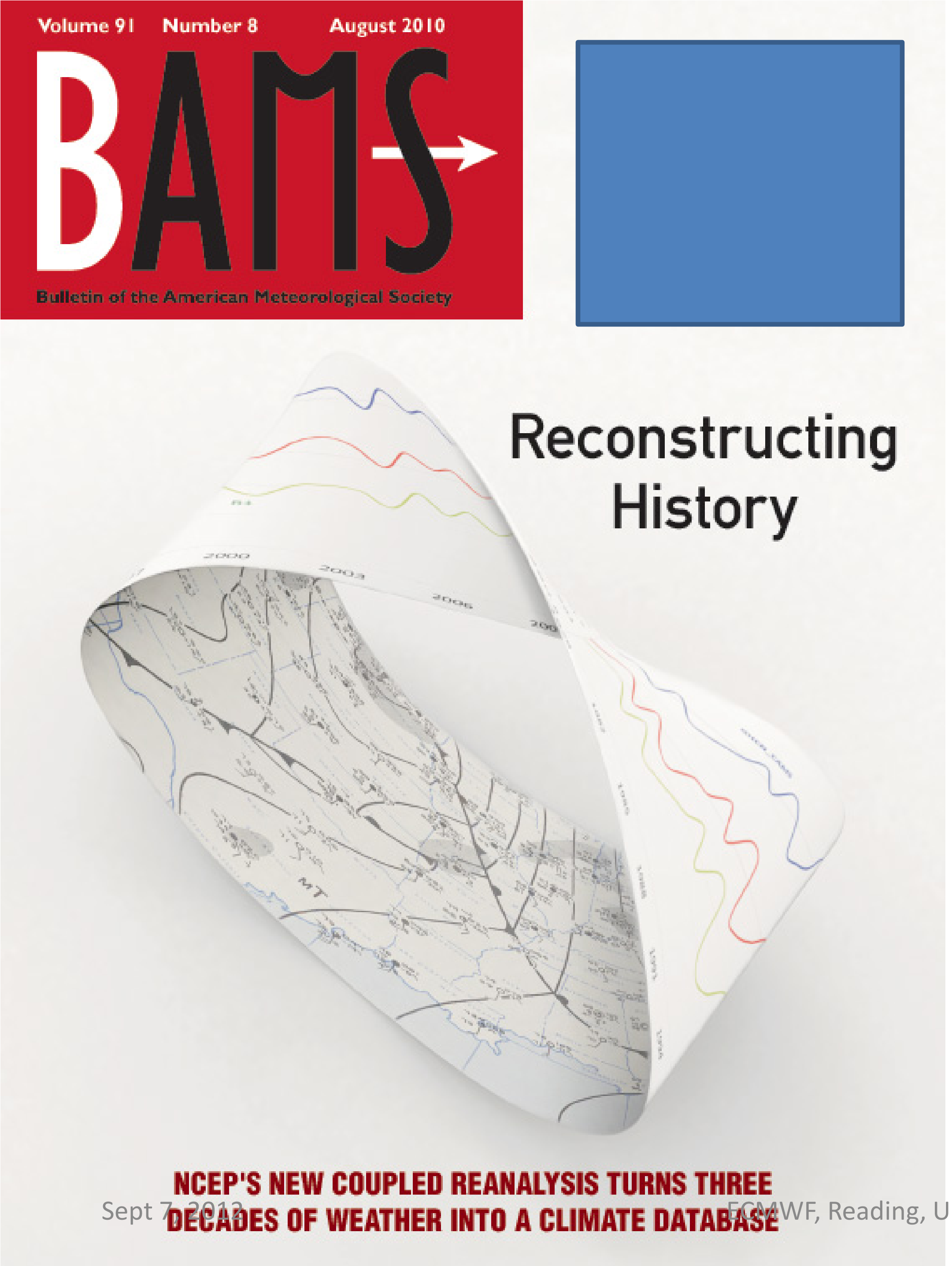
To be submitted to the Journal of Climate

Climate Forecast System (CFSv2)

Four essential components:

1. **Development and testing of an upgraded data assimilation and forecast model for the new system.**
2. **Making a new Reanalysis of the atmosphere, ocean, sea ice and land over the 32-year period (1979-2010), which is required to provide consistent initial conditions for:**
3. **Making 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 sub-seasonal and seasonal prediction at NCEP**
4. **Operational Implementation of the new system**



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Reconstructing History

NCEP'S NEW COUPLED REANALYSIS TURNS THREE DECADES OF WEATHER INTO A CLIMATE DATABASE

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

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	R2 (1997)/ CFSv1 (2004)	*CDASv2 Analysis (2011)*	*CFSv2 Hindcast (2011)*
Vertical coordinate	Sigma	Sigma/pressure	Sigma/pressure
Spectral resolution	T62	T382/T574	T126
Horizontal resolution	~210 ***km***	~38/27 ***km***	~100 ***km***
Vertical layers	28 /64	64	64
Top level pressure	~3 ***hPa/0.27 hPa***	0.27 ***hPa***	0.27 ***hPa***
Layers above 100 hPa	~7/~24	~24	~24
Layers below 850 hPa	~6/~13	~13	~13
Lowest layer thickness	~40 ***m/~20 m***	~20 ***m***	~20 ***m***
Analysis scheme	SSI	GSI	
Satellite data	NESDIS temperature retrievals (2 satellites)	Radiances (all satellites)	

MOM OCEAN MODEL

- **Version**
  - Changing from MOM Version 3 to MOM Version 4.0d (MOM4p0d)
  - The code has been completely rewritten from Fortran 77 to Fortran 90.
  - MOM4p0d supports 2-dimensional domain decomposition for greater efficiency in parallel environments.
  - MOM4p0d supports the Murray (1996) tripolar grid, providing an elegant solution to the problems associated with the convergence of a spherical coordinate grid in the Arctic.
- **Domain and Resolution**
  - Changing from a quasi-global domain (75^{o}S to 65^{o}N) to a fully global domain.
  - Increasing resolution from 1^{o}x1^{o} ($1/3^{o}$ within 10^{o} of the equator) to $1/2^{o}$x$1/2^{o}$ ($1/4^{o}$ within 10^{o} of the equator).
  - The vertical grid of 40 Z-levels with variable resolution (23 levels in the top 230 meters) is retained.
- **Physics**
  - Adding a fully interactive ice model.
  - Changing from the UNESCO equation of state to the newer McDougall et al. (2002) formulation.
  - The Boussinesq approximation is retained.

SEA ICE MODEL

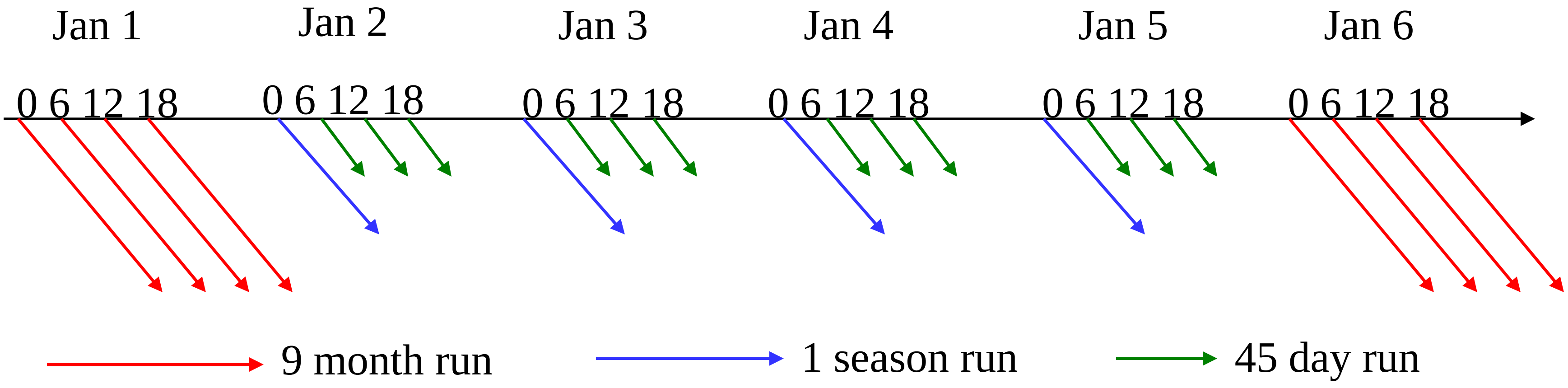
CFSv1 (T62L64)	CFSv2 (T126L64)
• Sea-ice is treated in a simple manner - 3 m depth with 100% concentration (i.e. no open water within the ice covered area). The surface temperature is predicted based on energy balance at the ice surface. • Sea-ice climatology is used to update sea-ice change (with 50% cutoff for sea-ice cover).	• Interactive 3 layer (2-layer of sea-ice and 1-layer of snow) sea ice model. • 5 categories of sea ice thickness representing different type of sea ice. • Fully implicit time-stepping scheme, allowing longer time steps. • Improved numerical method for Hibler's viscous-plastic (VP) model. • Computationally efficient, suitable for fully coupled models.

LAND SURFACE MODEL

CFSv1 (T62L64)	CFSv2 (T126L64)
2 soil layers (10, 190 cm)	4 soil layers (10, 30, 60, 100 cm)
No frozen soil physics	Frozen soil physics included
	Add glacial ice treatment
Only one snowpack state (SWE)	Two snowpack states (SWE, density)
Surface fluxes not weighted by snow fraction	Surface fluxes weighted by snow cover fraction
Vegetation fraction never less than 50%	Improved seasonal cycle of vegetation
Spatially constant root depth	Spatially varying root depth
Runoff & infiltration do not account for subgrid variability of precipitation & soil moisture	Runoff and infiltration account for sub-grid variability in precipitation & soil moisture
Poor soil and snow thermal conductivity, especially for thin snowpack	Improved thermal conduction in soil/snow
	Higher canopy resistance
	Improved evaporation treatment over bare soil and snowpack

Reforecast 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)
- There was 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)
- In addition, there were 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 years of integration = 9447 years !!!!!**



Jan 1 Jan 2 Jan 3 Jan 4 Jan 5 Jan 6

0 6 12 18 0 6 12 18 0 6 12 18 0 6 12 18 0 6 12 18 0 6 12 18

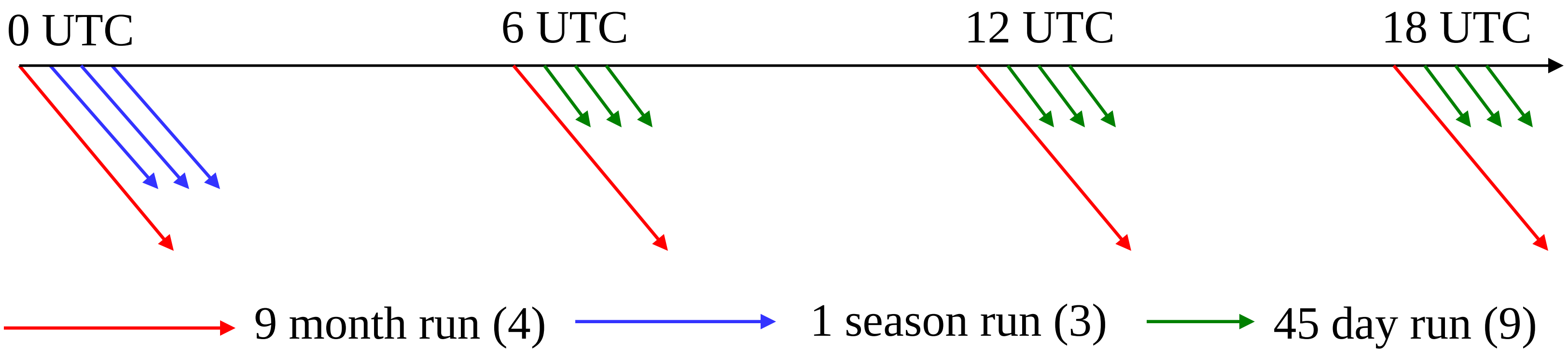
9 month run

1 season run

45 day run

Operational Configuration for CFSv2

- There are 4 control runs per day from the 0, 6, 12 and 18 UTC cycles of the CFSv2 real-time data assimilation system, out to 9 months.
- In addition to the control run of 9 months at the 0 UTC cycle, there are 3 additional runs, out to one season. These 3 runs at 0Z are from perturbed initial conditions.
- In addition to the control run of 9 months at the 6, 12 and 18 UTC cycles, there are 3 additional runs, out to 45 days. These 3 runs from 6, 12 and 18Z are from perturbed initial conditions.
- There are a total of 16 CFS runs every day, of which 4 runs go out to 9 months, 3 runs go out to 1 season and 9 runs go out to 45 days.



0 UTC 6 UTC 12 UTC 18 UTC

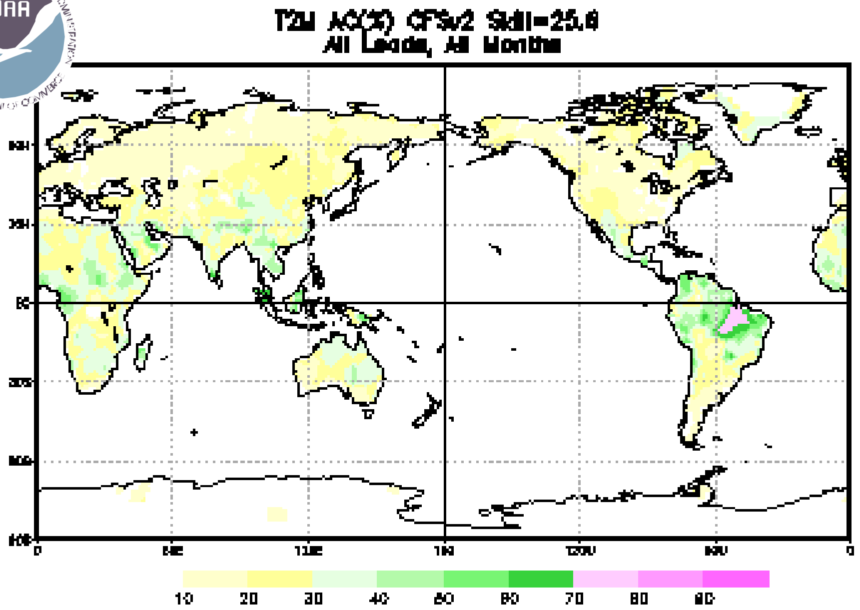
9 month run (4) 1 season run (3) 45 day run (9)

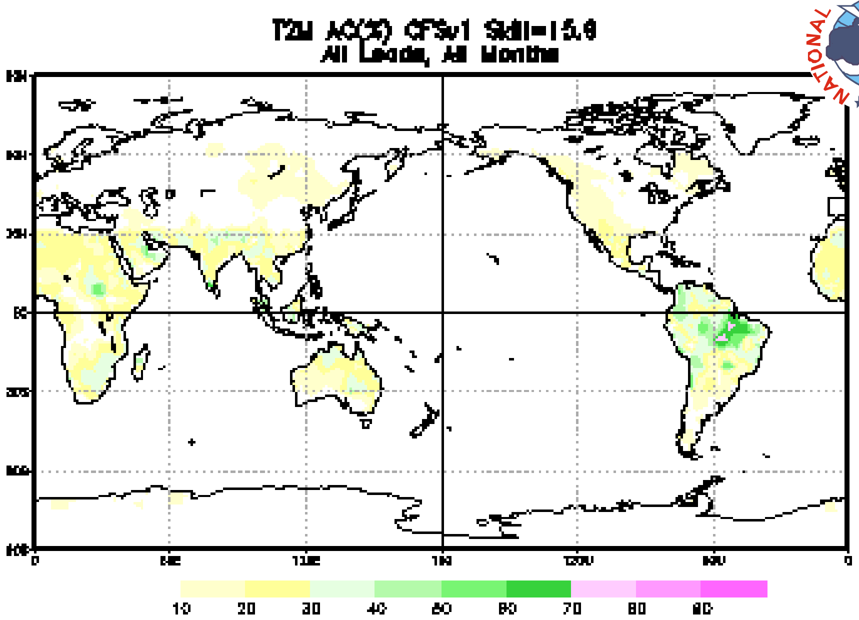
Definitions and Data

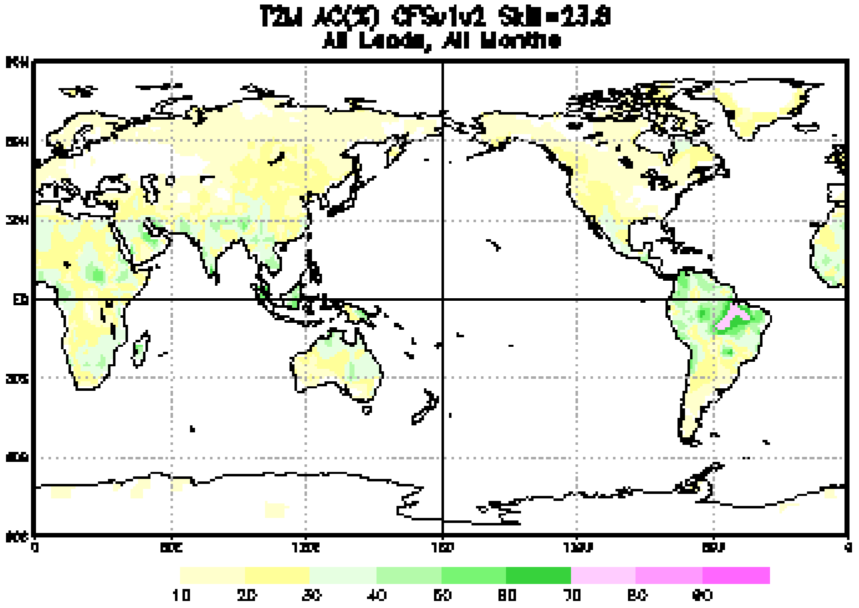
- AC of ensemble averaged monthly means
- GHCN-CAMS (validation for Tmp2m)
- CMAP (validation for Prate)
- OIv2 (validation for SST)
- 1982-2009 (28 years)
- Common 2.5 degree grid
- Variables/areas studied: US T, US P, global and Nino34 SST, global and Nino34 Prate.
- ***A split climatology***: Two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

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

  Elsewhere: 1982-2009







2-meter Temps AC

(All Leads, All Months)

CFSv2: 25.6

CFSv1: 15.9

CFSv1v2: 23.8

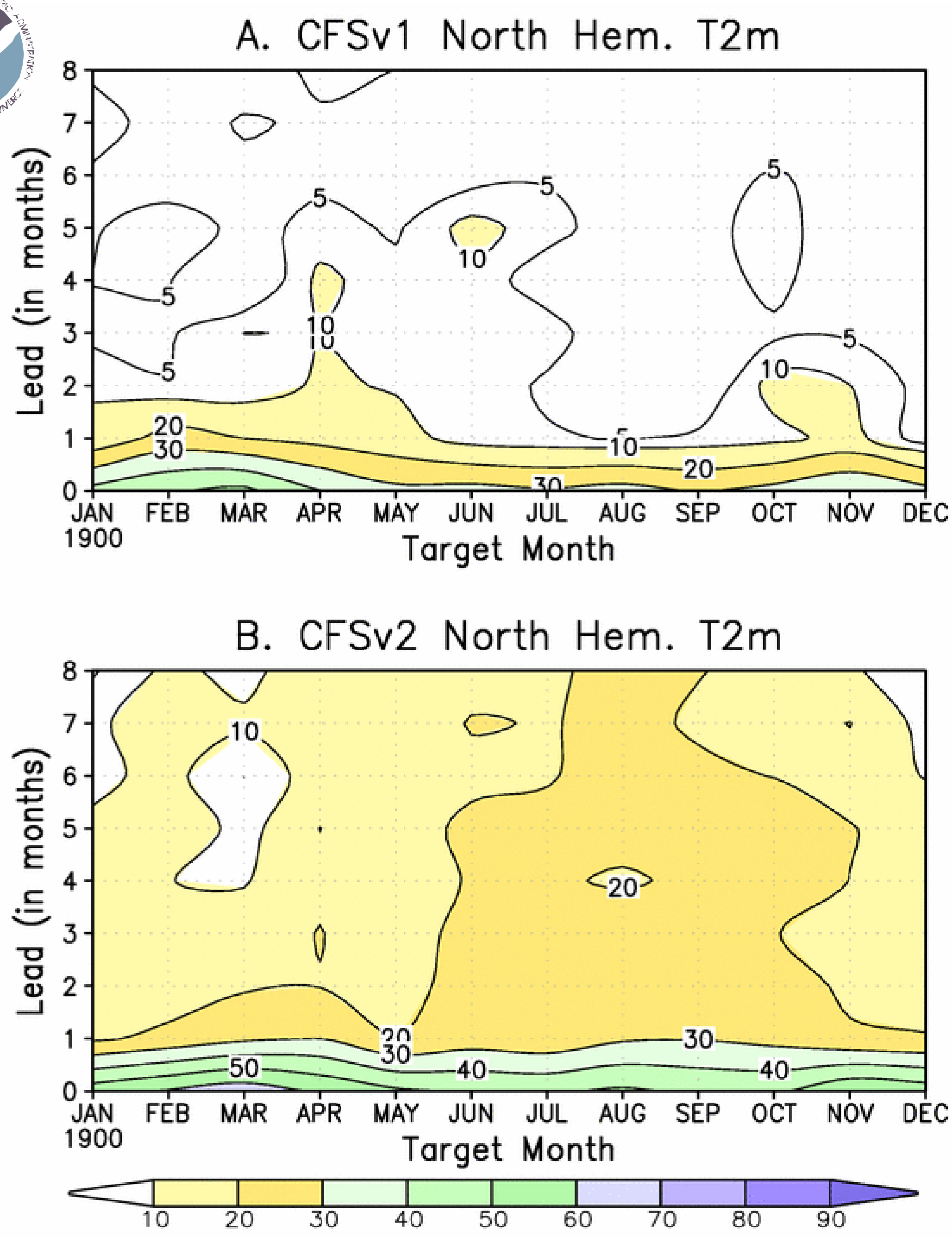
More skill globally for CFSv2

HUUG VAN DEN DOOL, CPC/NCEP/NWS/NOAA

An 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



2-meter Temperature Ensemble skill of Northern Hemisphere (all land north of 20°N)

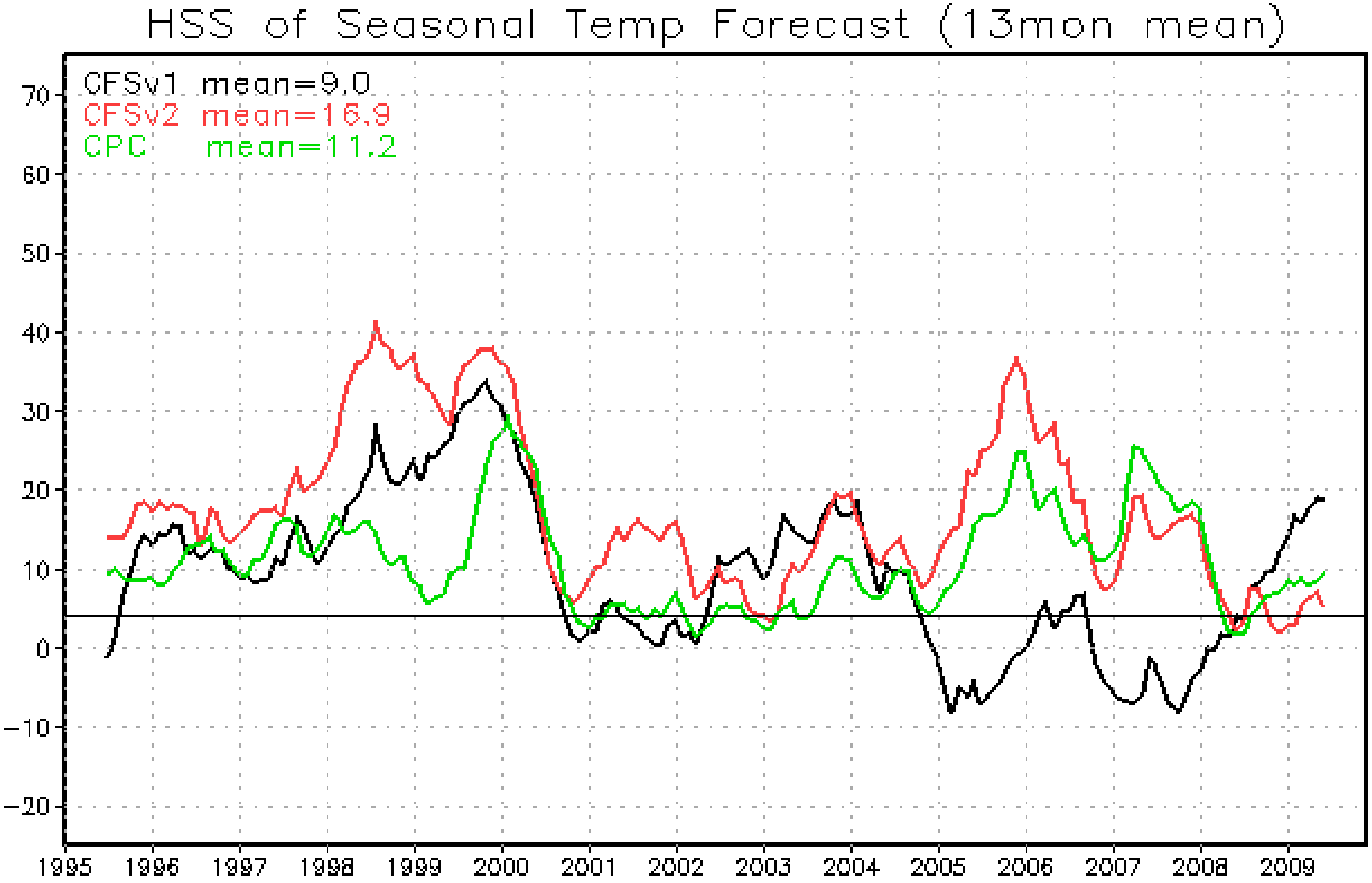
CFSv2 clearly has more skill

Huug van den Dool & Emily Becker, CPC

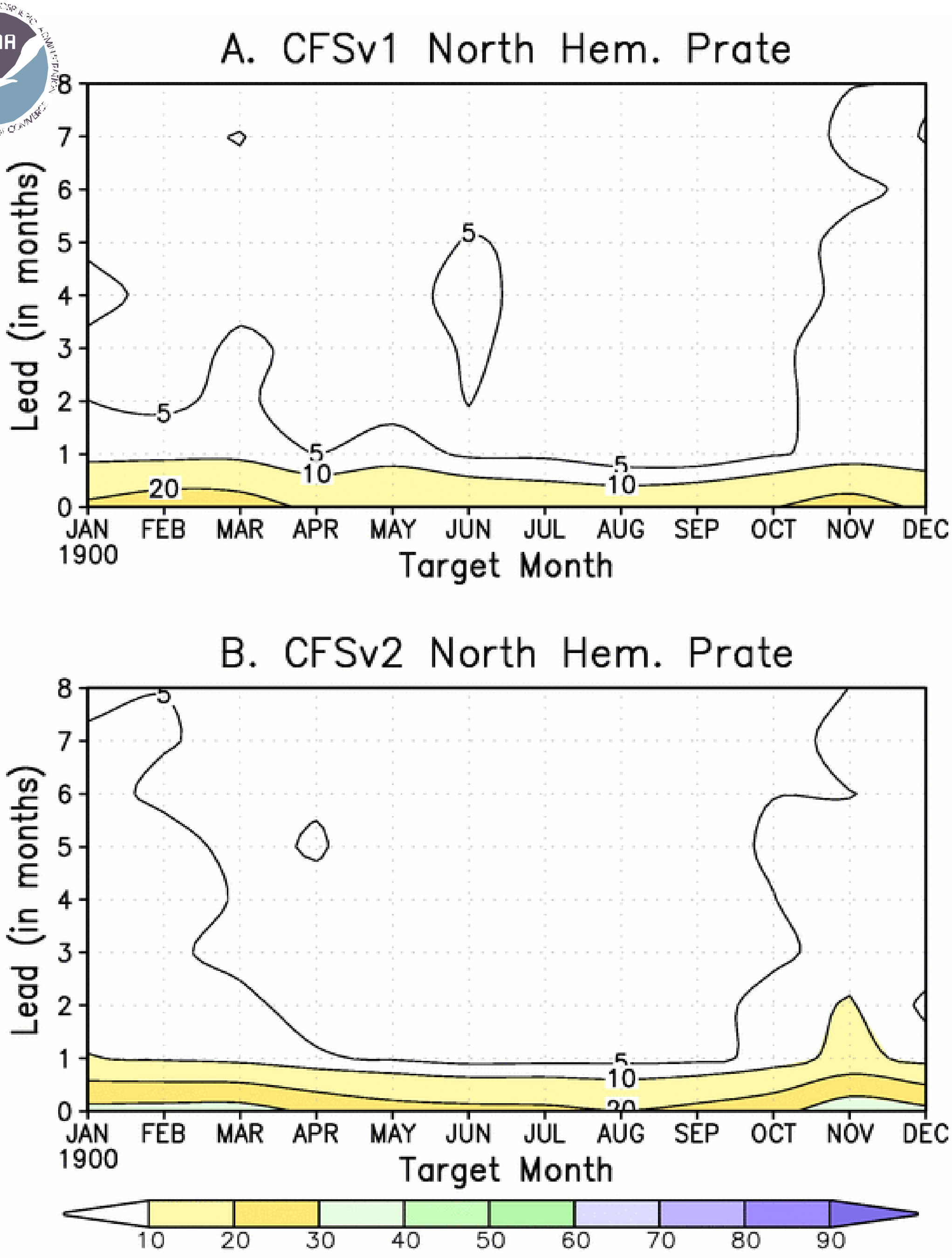
Heidke Skill Score for 2-meter Temp

More skill for CFSv2

HSS of Seasonal Temp Forecast (13mon mean)



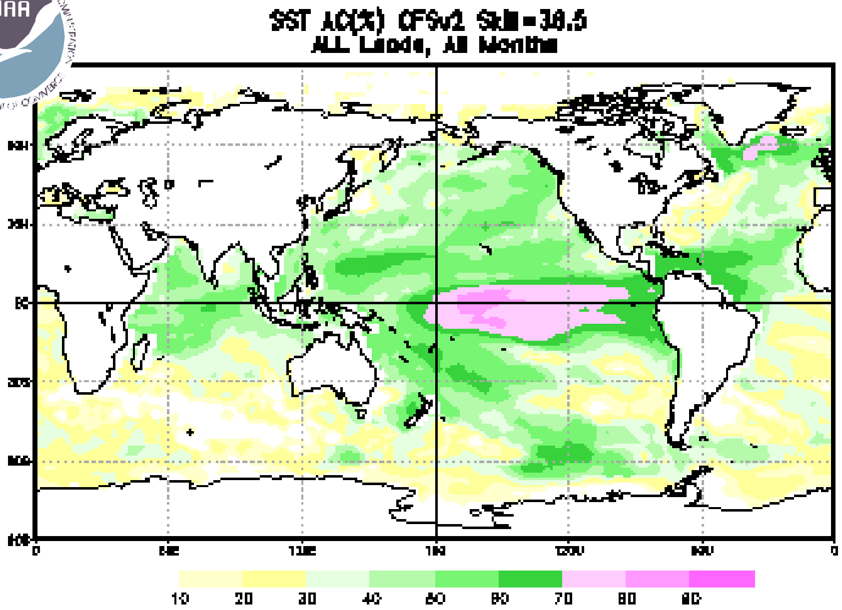
Peitao Peng, CPC

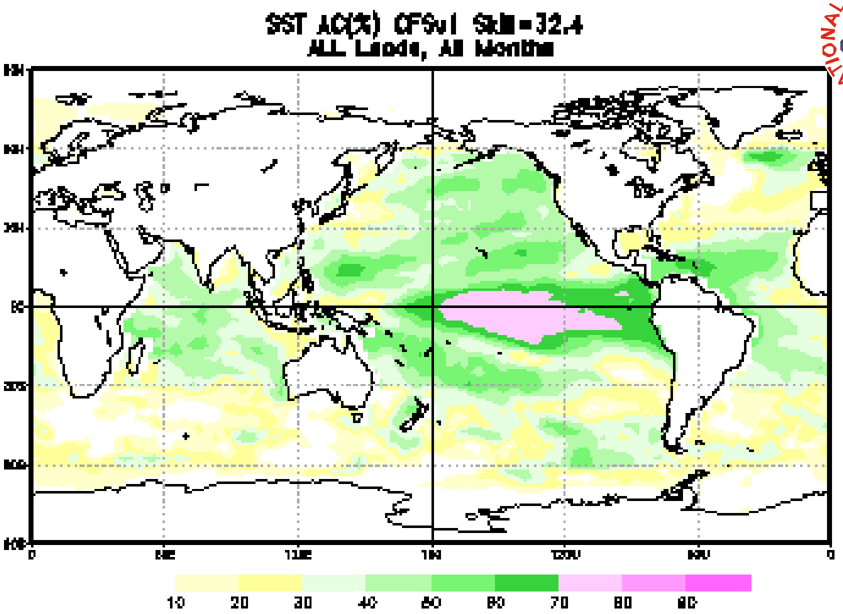


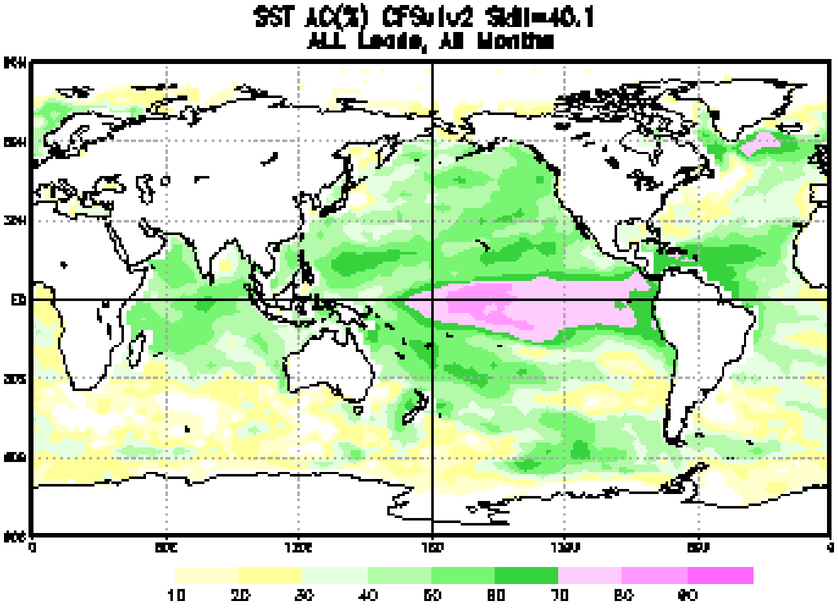
Precipitation Ensemble skill of Northern Hemisphere (all land north of 20°N)

Both systems have very little skill for precipitation

Huug van den Dool & Emily Becker, CPC







HUUG VAN DEN DOOL. CPC/NCEP/NWS/NOAA

Sea Surface Temp AC

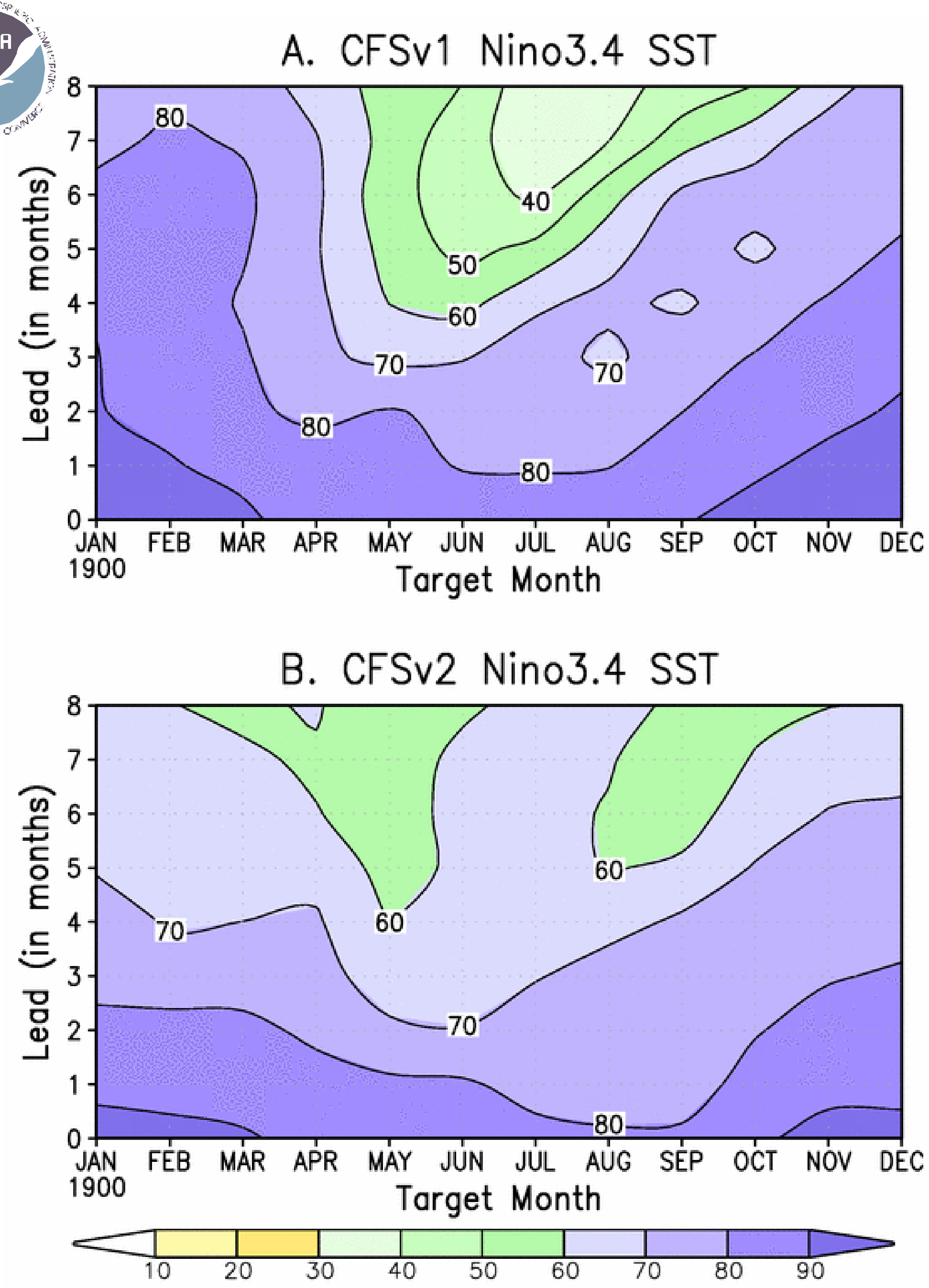
(All Leads, All Months)

CFSv2: 36.5

CFSv1: 32.4

CFSv1v2: 40.1

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



Sea Surface Temperature Ensemble skill of Nino 3.4

CFSv1 has a problem in that it persists large winter anomalies into the spring (a critical ENSO season) and is reluctant to go to neutral, let alone to go from La Nina to El Nino or vice versa (as is common in spring).

The standard deviation for MAM is clearly improved in CFSv2. There appears to be much less of a "spring barrier" in CFSv2.

Huug van den Dool & Emily Becker, CPC

The Bottom Line

2-meter Temps AC

(All Leads, All Months)

CFSv2: 25.6

CFSv1: 15.9

CFSv1v2: 23.8

More skill globally for CFSv2

Sea Surface Temp AC

(All Leads, All Months)

CFSv2: 36.5

CFSv1: 32.4

CFSv1v2: 40.1

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

Precipitation AC

(All Leads, All Months)

CFSv2: 14.9

CFSv1: 13.3

CFSv1v2: 16.2

More skill in the Western Pacific for CFSv2

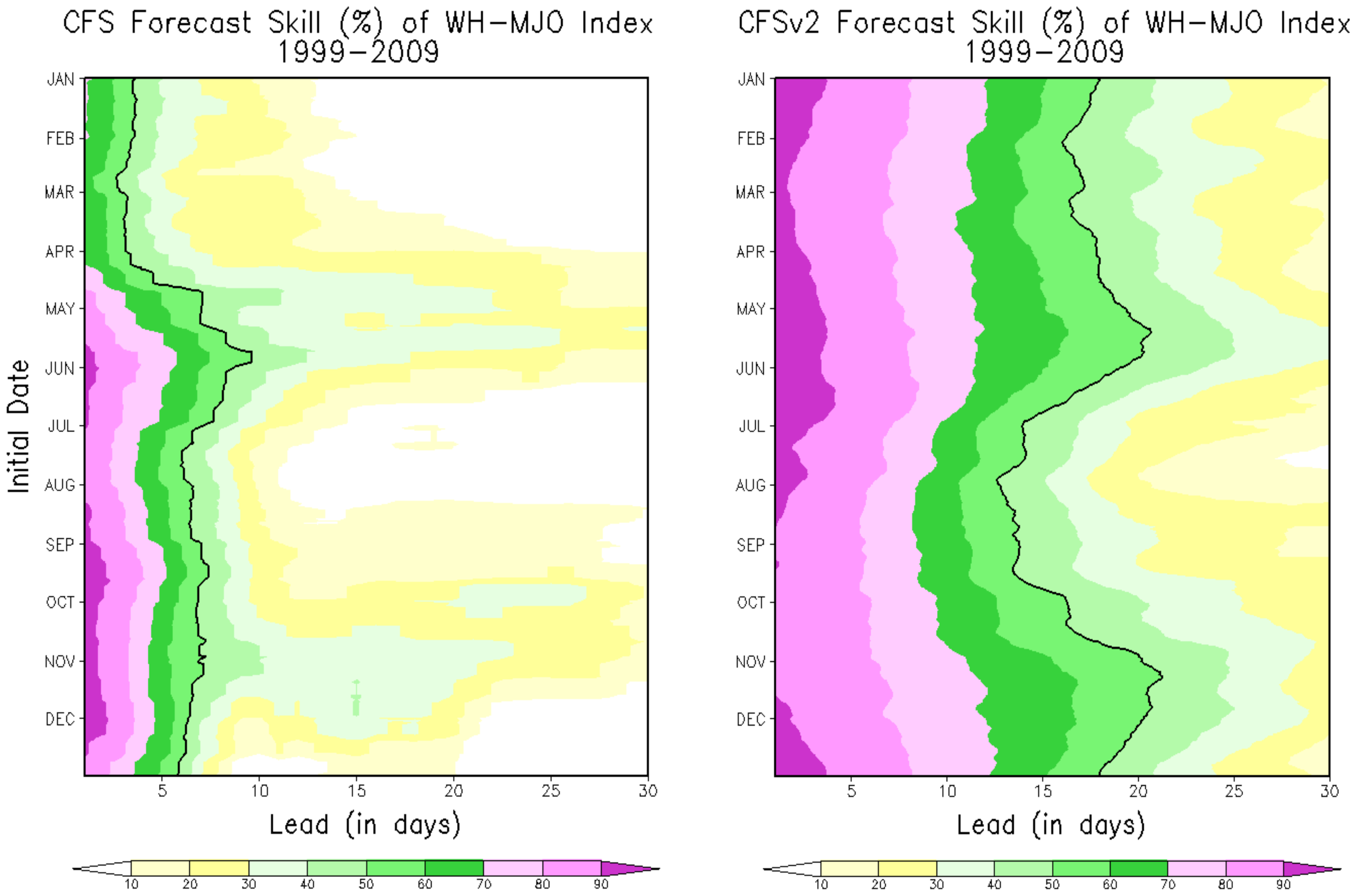
Anomaly Correlation for other Regions (collaboration with EUROSIP and India)

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 CFSv1v2-CFSv2 %tage change	15.4 -0.9 (-5.8%)	15.5 -0.9 (-5.8%)	30.7 -18.1 (-59%)	12.2 +2.7 (+22%)	6.2 +0.2 (+3.2%)	22.8 (+3.9) (+17.1%)

Forecast Skill of WH-MJO index



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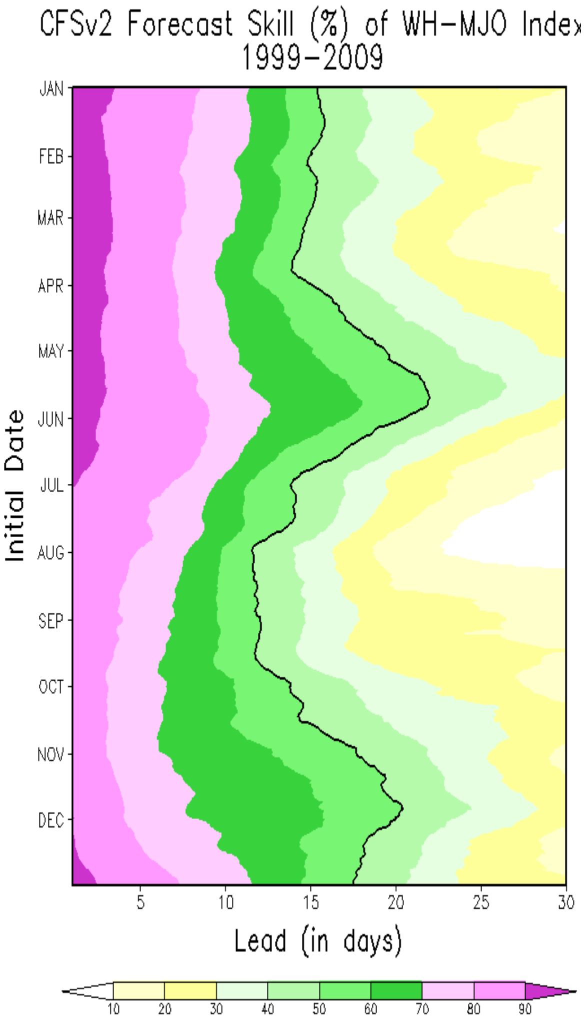
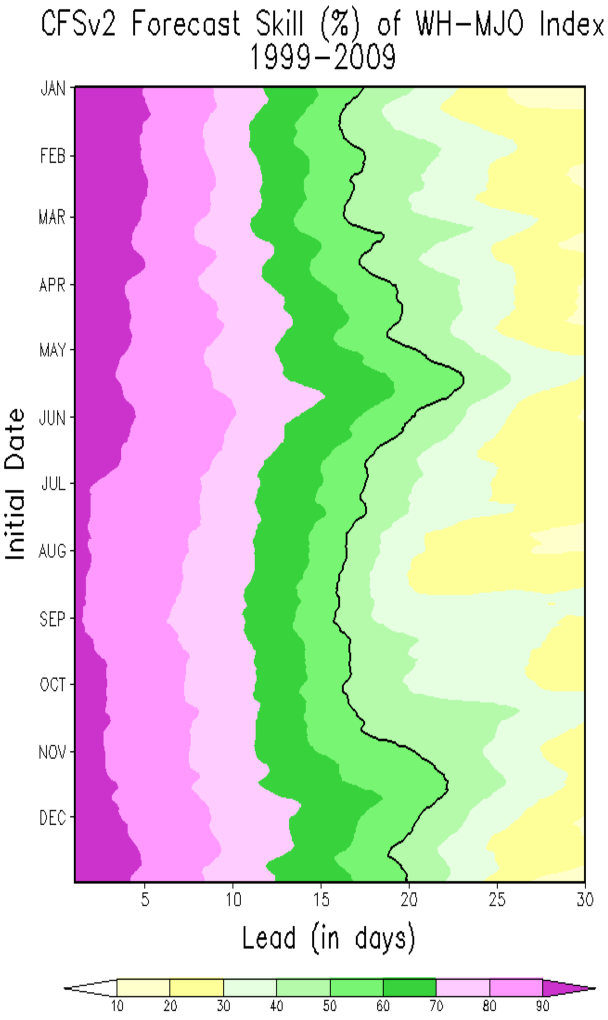
Forecast Skill of WH-MJO index

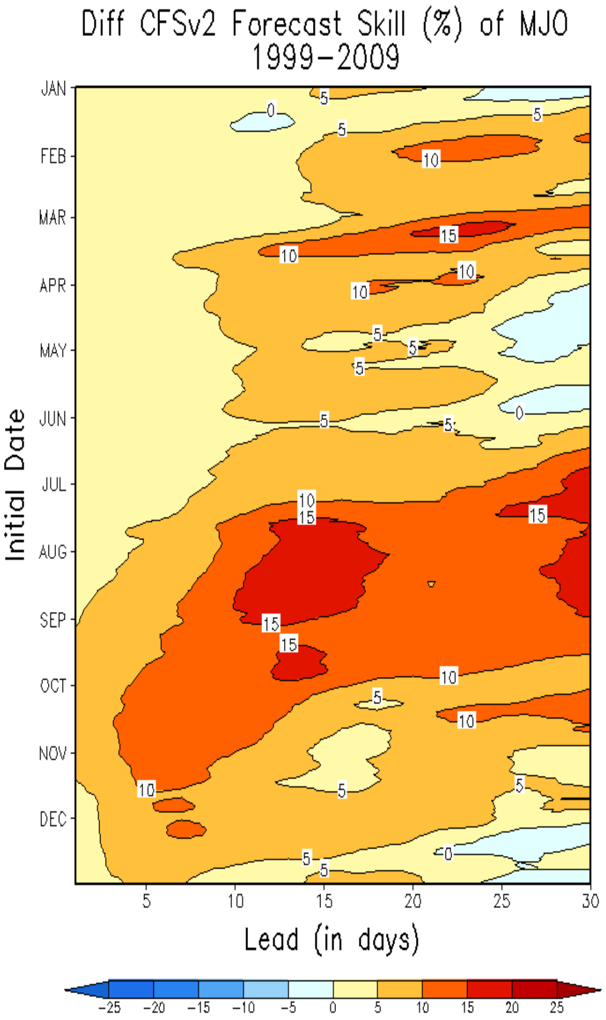
Before Model Bias Correction



After Model Bias Correction



Difference (After - Before)



Qin Zhang and Huug van den Dool, CPC

In Early 2011

- There was a sudden decisiveness about organizing a National MME for seasonal prediction in the US
- It had been a longstanding wish of some, especially funding agents, for this to happen.
- In a sense, we were ready, since IMME was already being prepared.
- There was a willingness to go the extra mile on the part of other modeling centers, especially NASA, GFDL, NCAR and IRI to get this done quickly.
- These were all global coupled atmosphere-ocean models.
- NCEP organized the “rules of engagement” such as time table, common grid, hindcasts, etc.
- The first test run in real time was made in August 2011.

Requirements for NMME
(Huug van den Dool, 4/7/11)

- Real-time model should be the frozen hindcast model (of course, the initial states may change due to ingest of new data types)
- It would be good to follow the CFSv2 lay-out for the start times of the hindcasts.
- Forecast leads out to at least 9 months.
- A minimum of 30 years of hindcasts, especially a common period of 1981-2010.
- The number of ensemble members is up to the originator, but it is assumed they understand that one ensemble member will keep skill low, and for very large N, the “threshold” returns are diminishing, so they have to make a wise choice.
- All individual members must be submitted, not just the ensemble mean.
- Total fields (not anomalies) must be submitted with no systematic error correction at the originator’s end.
- Resolution and physics/numerics of the model are left entirely up to originators.
- Required output would minimally be monthly means of global SST, T2m, prate (in the first instance). Recently, T_{min} T_{max} , runoff, soil moisture and 200 hPa geopotential have been added.
- All data must be submitted in a common 1 x 1 degree grid.
- What about real time operations? All forecasts must be in by the 8th of the month , so that they can be used as a tool in CPC’s official seasonal predictions.

Hindcast Situation YEAR 1

						Model resident Resolutions			
	Start months available NOW	Period	Members	Arrangement of Members	Lead (months)	Atmosphere	Ocean	Reference	
NCEP-CFSv1	12	1981-2009	15	1st 0Z +/-2days, 11th 0Z+/-2d, 21st 0Z+/-2d	0-9	T62L64	MOM3L40 0.30 deq Eq	Saha et al 2006	NCEP-CFSv1
NCEP-CFSv2	12	1982-2010	24(28)	4 members (0,6,12,18Z) every 5th day	0-9	T126L64	MOM4 L40 0.25 deg Eq	Saha et al 2012	NCEP-CFSv2
GFDL-CM2.1	12	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5deg L24	MOM4 L50 0.25 deg Eq	Delworth et al 2006	GFDL-CM2.1
IRI-Echam4-f	12	1982-2010	12	All 1st of the month**	0-7	T42L19	MOM3 L25 0.5 deg Eq	DeWitt MWR2005	IRI-Echam4-f
IRI-Echam4-a	12	1982-2010	12	All 1st of the month**	0-7	T42L19	MOM3 L25 0.5 deg Eq	"	IRI-Echam4-a
NCAR-CCSM3.0	12	1982-2010	6	All 1st of the month**	0-11	T85L26	POP L40 0.3 deg Eq	Kirtman and Min 2009	NCAR-CCSM3.0
NASA	12	1981-2010	6	1 member every 5th day as CFSv2	0-9	1x1.25deg L72	MOM4 L40 0.25 deg Eq	Rienecker et al 2008	NASA

Hindcast Situation YEAR 2

						Model resident Resolutions			
	Start months available NOW	Period	Members	Arrangement of Members	Lead (months)	Atmosphere	Ocean	Reference	
NCEP-CFSv1	12	1981-2009	15	1st 0Z +/-2days, 11th 0Z+/-2d, 21st 0Z+/-2d	0-9	T62L64	MOM3L40 0.30 deq Eq	Saha et al 2006	NCEP-CFSv1
NCEP-CFSv2	12	1982-2010	24(28)	4 members (0,6,12,18Z) every 5th day	0-9	T126L64	MOM4 L40 0.25 deg Eq	Saha et al 2010	NCEP-CFSv2
GFDL-CM2.1	12	1982-2010	10	All 1st of the month 0Z	0-11	2x2.5deg L24	MOM4 L50 0.30 deg Eq	Delworth et al 2006	GFDL-CM2.1
CMC1-CanCM3	12	1981-2010	10	All 1st of the month 0Z	0-11	CanAM3 T63L31	CanOM4 L40 0.94 deg Eq	Merryfield et al 2012	CMC1
CMC2-CanCM4	12	1981-2010	10	All 1st of the month 0Z	0-11	CanAM4 T63L35	CanOM4 L40 0.94 deg Eq	Merryfield et al 2012	CMC2
NCAR-CCSM3.0	12	1982-2010	6	All 1st of the month**	0-11	T85L26	POP L40 0.3 deg Eq	Kirtman and Min 2009	NCAR-CCSM3.0
NASA	12	1981-2010	6	1 member every 5th day as CFSv2	0-9	1x1.25deg L72	MOM4 L40 1/4 deg at Eq	Rienecker et al 2008	NASA

Requirements for NMME (Huug van den Dool, 4/7/11)

- It would be good to follow the CFSv2 lay-out for the start times of the hindcasts.

  Only NASA has the same configuration of hindcasts as the CFSv2 and they make one member per 5th day. All other centers make hindcasts around the 1st of each month
- Forecast leads out to at least 9 months.

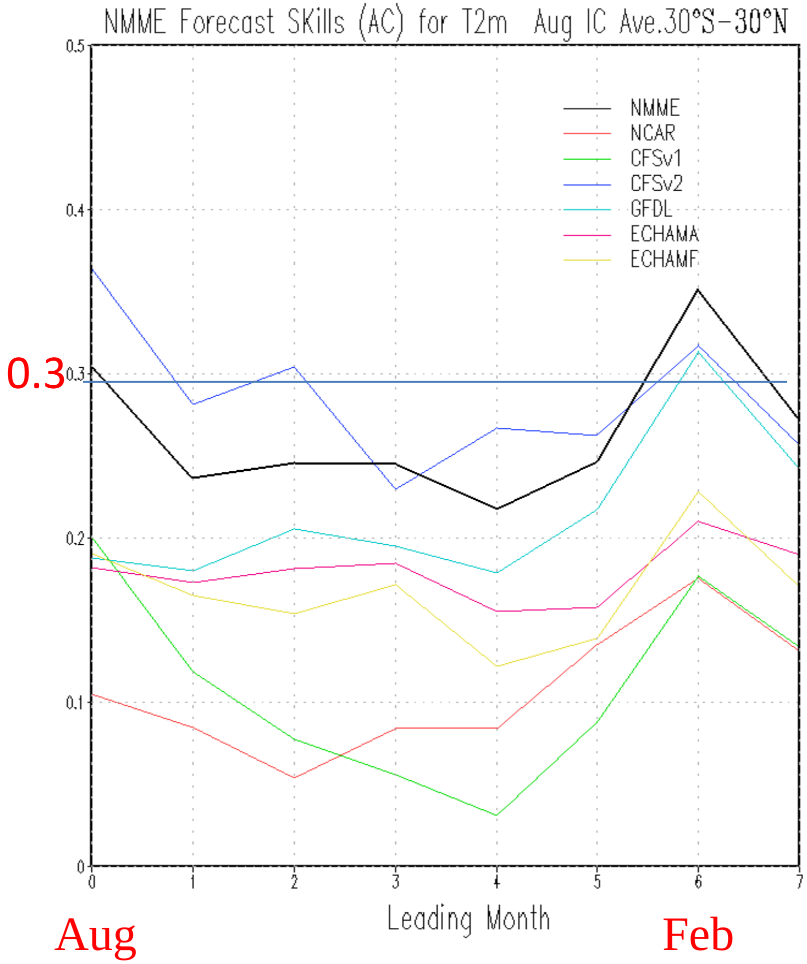
  All model have forecast leads out to 9 months, except for the 2 IRI models which have 7 month leads.
- A minimum of 30 years of hindcasts, especially a common period of 1981-2010.

  All models have at least 29 years, from 1982-2010
- The number of ensemble members per month:

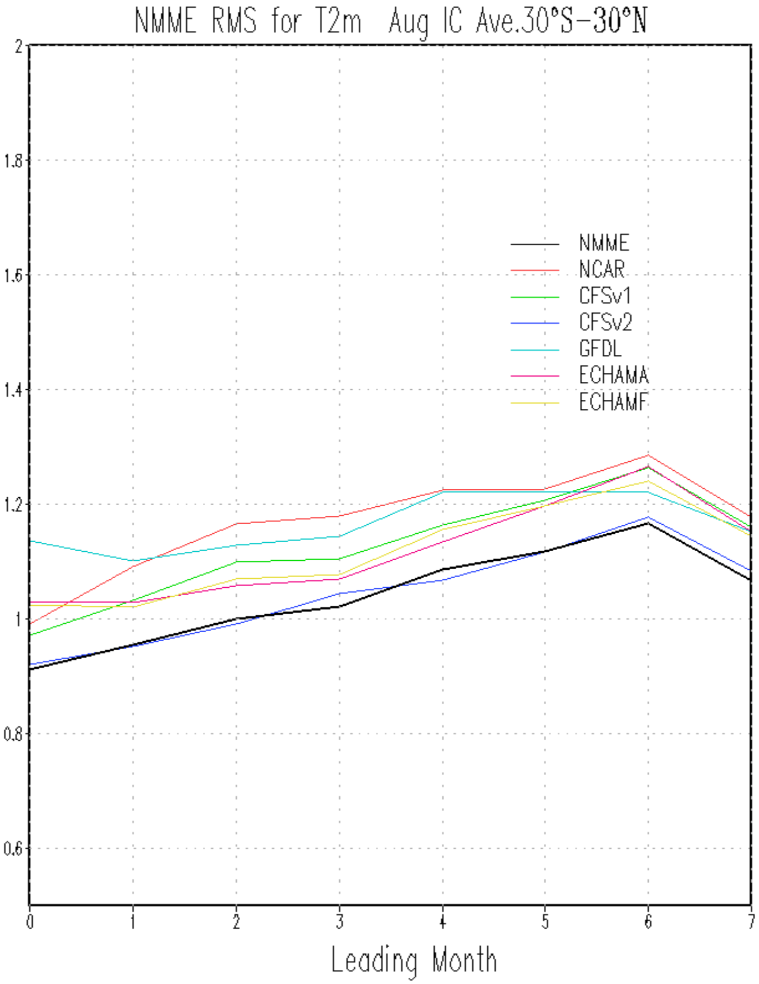
  NCAR has the least number of members (6)
  CFSv2 has the most number of members (24/28)
  Most have around 10-12 members

NMME Forecast Skill of T2m
Aug IC, averaged over 30S-30N

AC T2m

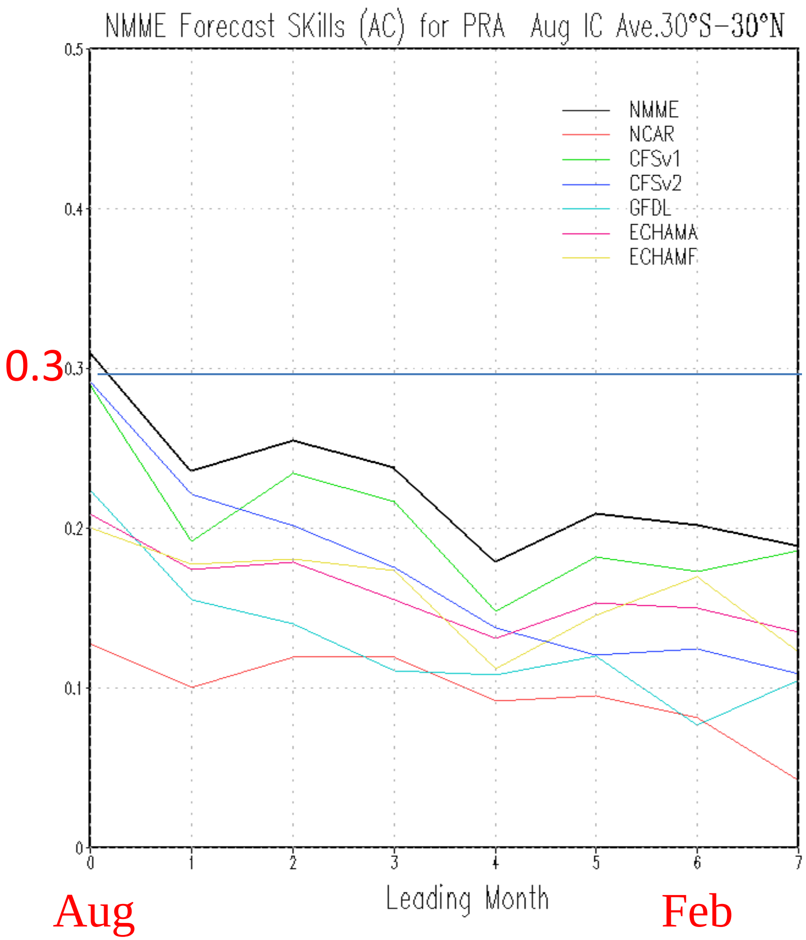

NMME Forecast SKills (AC) for T2m Aug IC Ave.30°S-30°N

RMSE T2m


NMME RMS for T2m Aug IC Ave.30°S-30°N

NMME Forecast Skill of Precipitation
Aug IC, averaged over 30S-30N

AC Precip

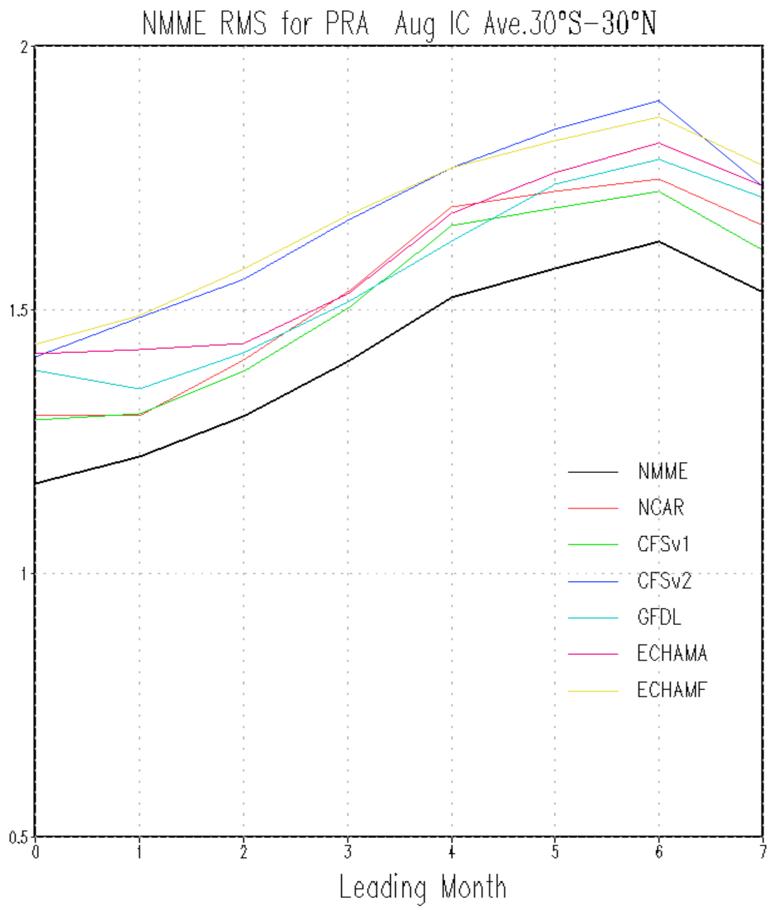


0.3

Aug

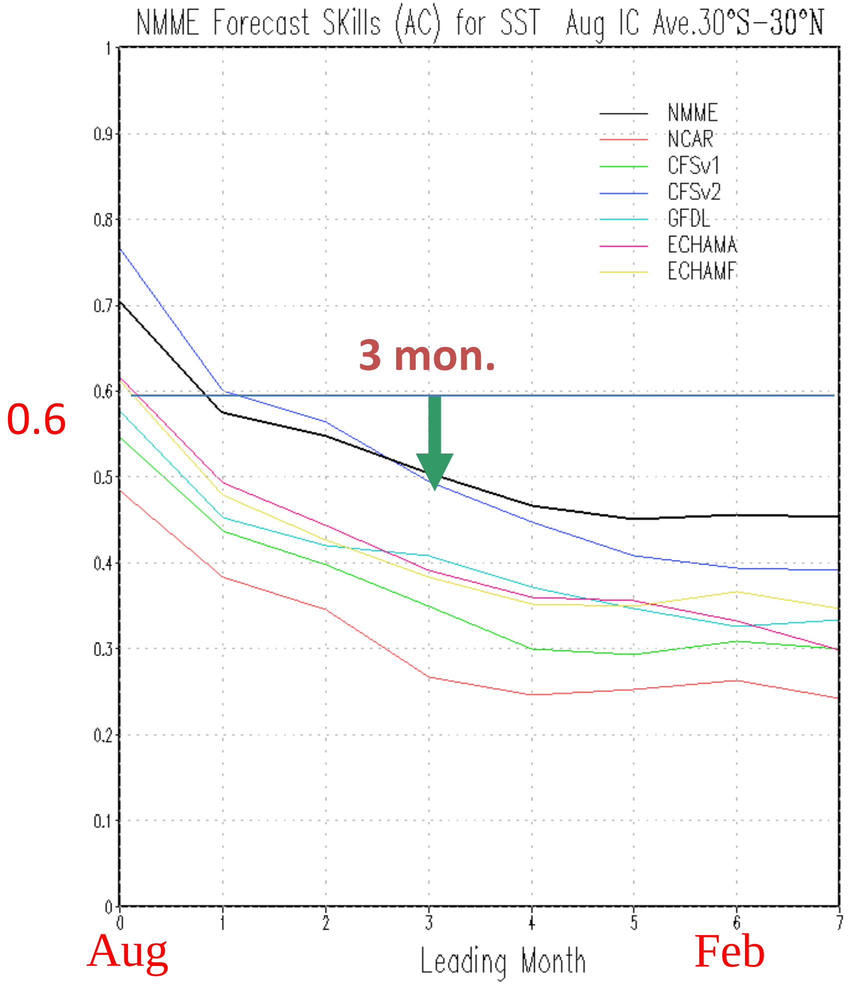
Feb

RMSE Precip

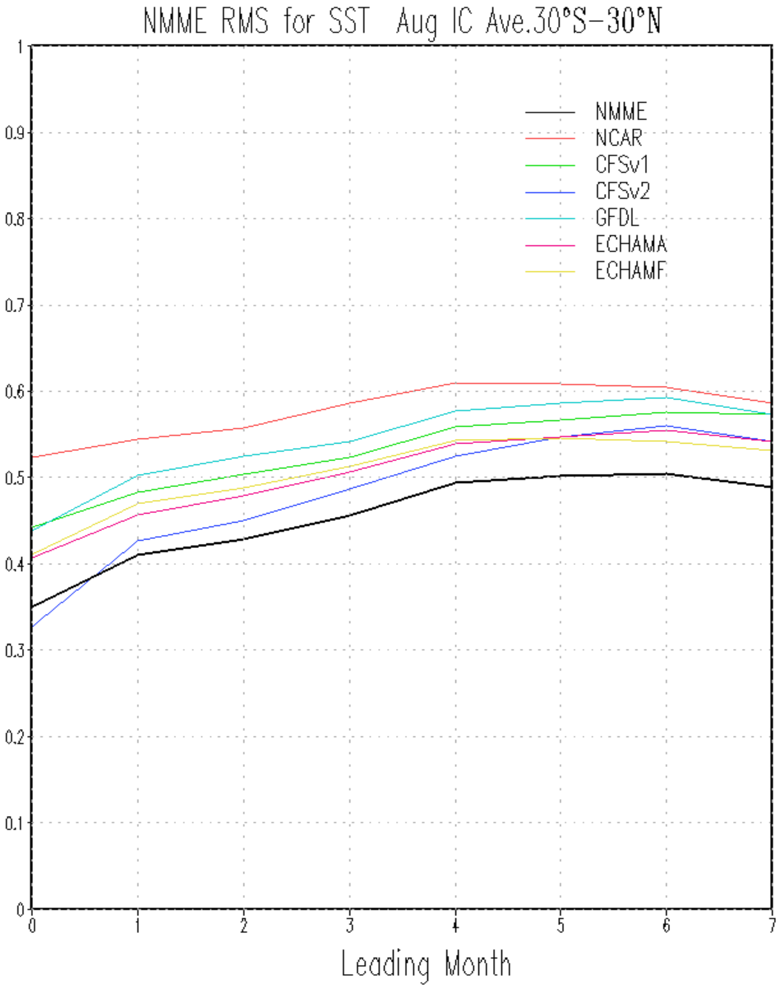


NMME Forecast Skill of SST
Aug IC, averaged over 30S-30N

AC SST

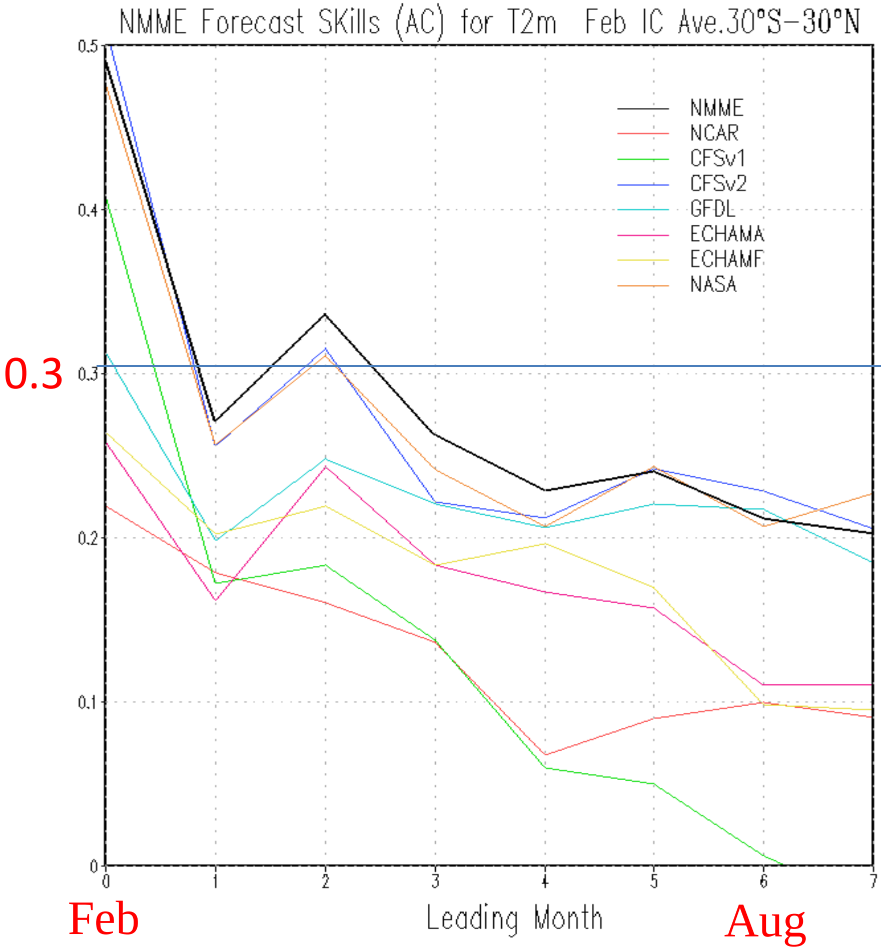


RMSE SST

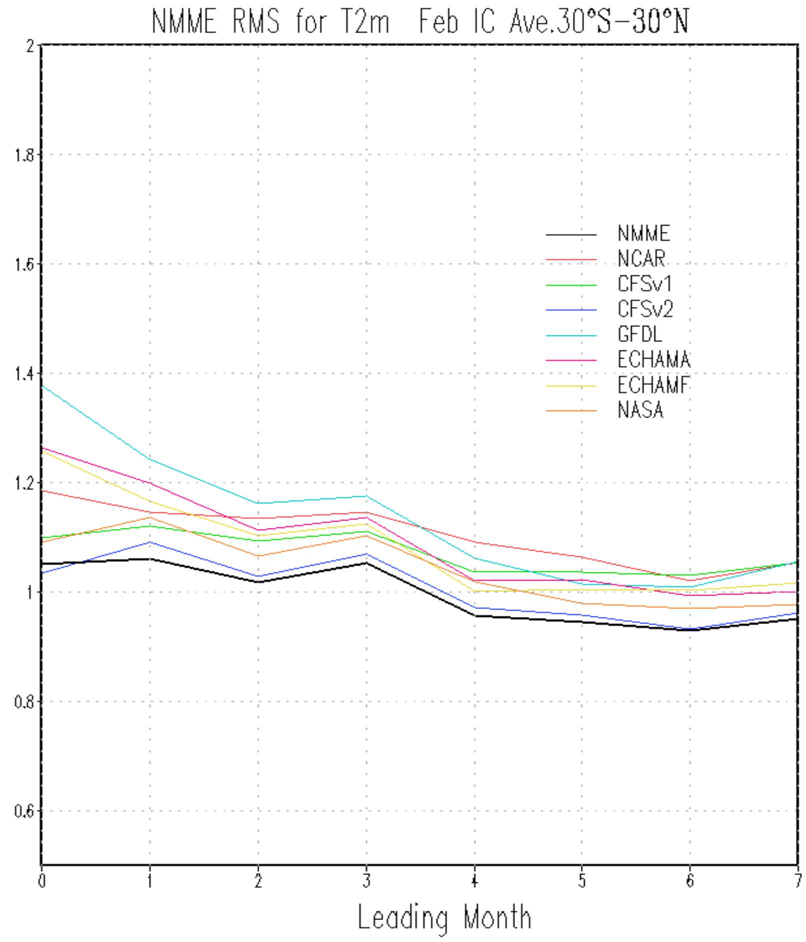


NMME Forecast Skill of T2m
Feb IC, averaged over 30S-30N

AC T2m

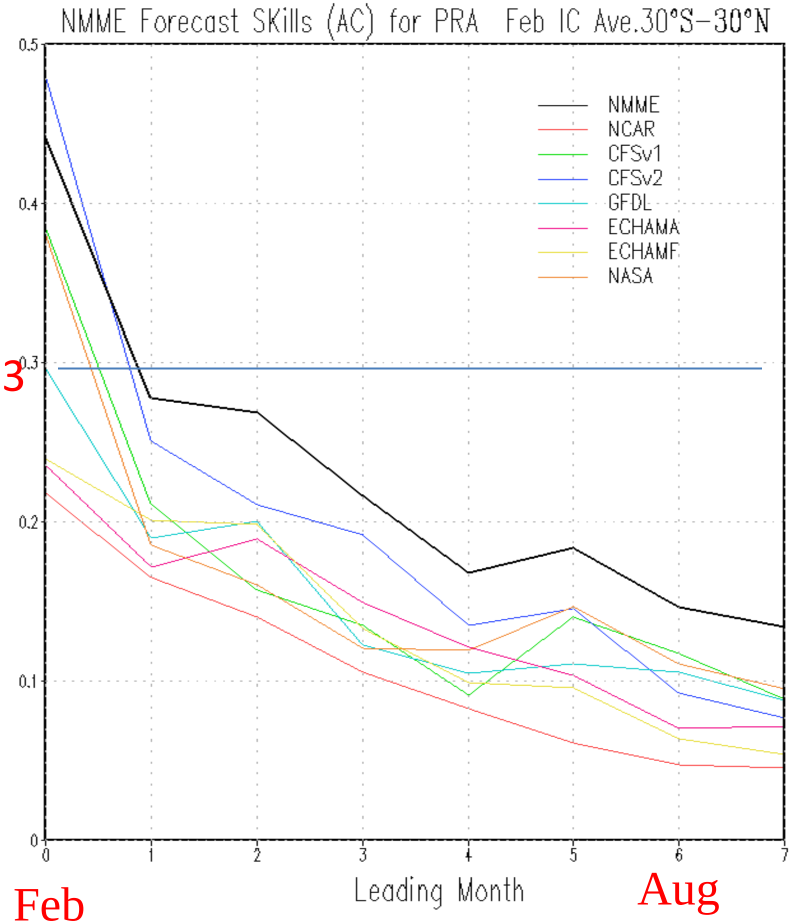


RMSE T2m



NMME Forecast Skill of Precipitation
Feb IC, averaged over 30S-30N

AC Precip

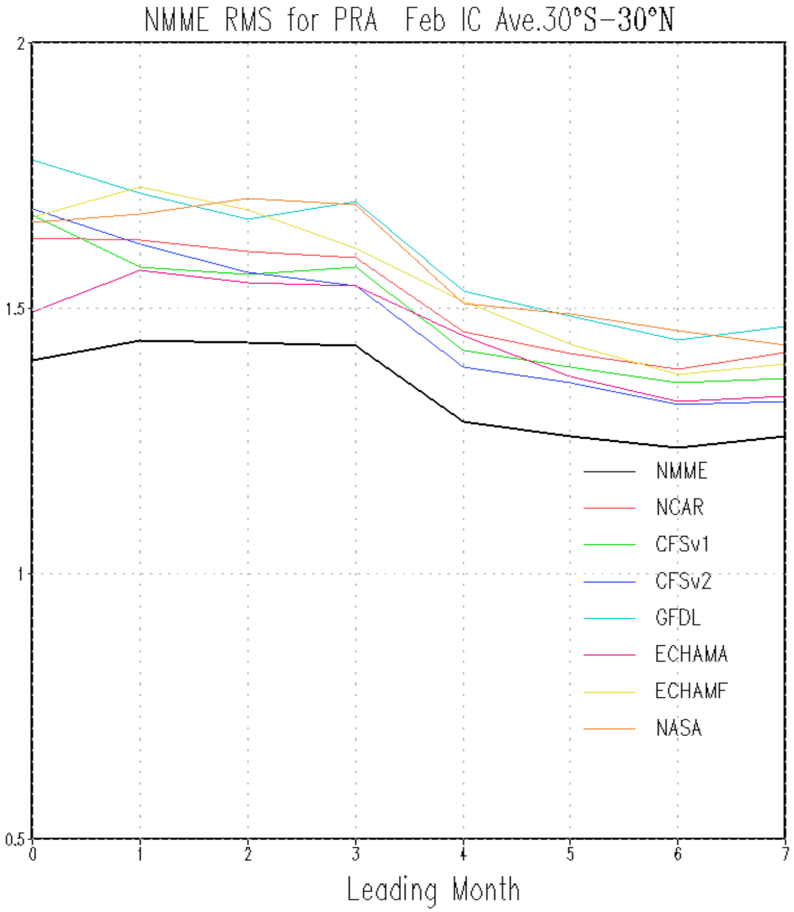


0.3

Feb

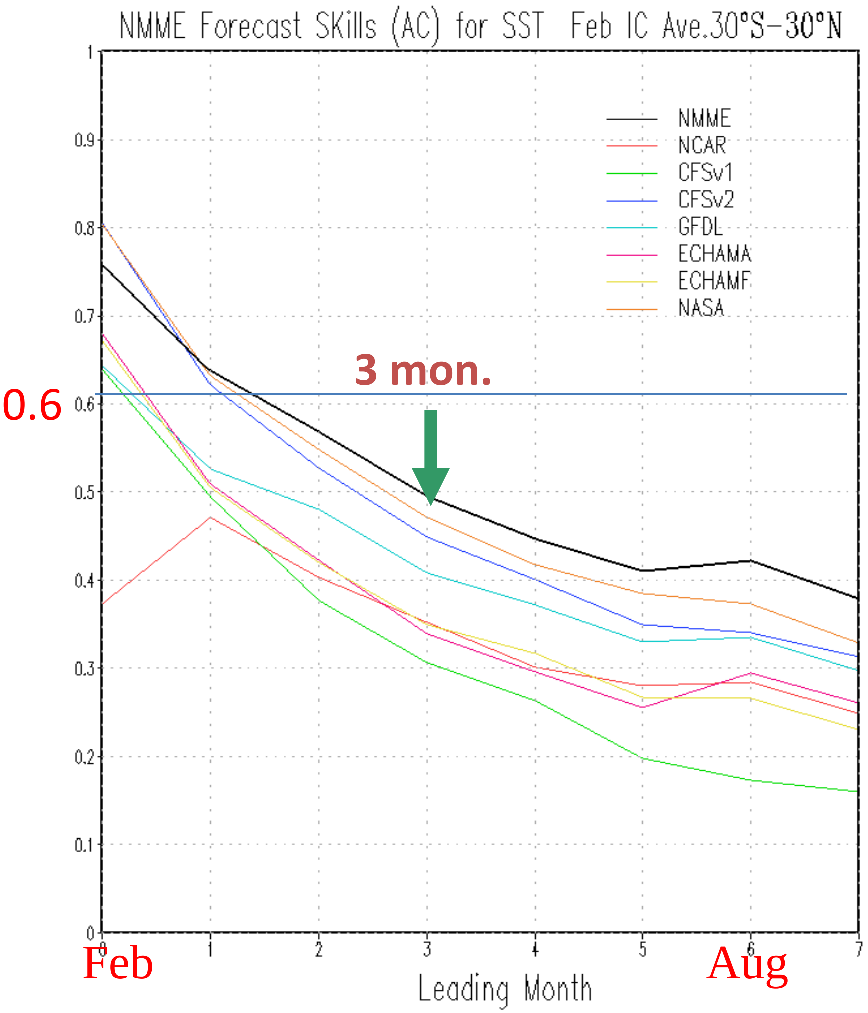
Aug

RMSE Precip

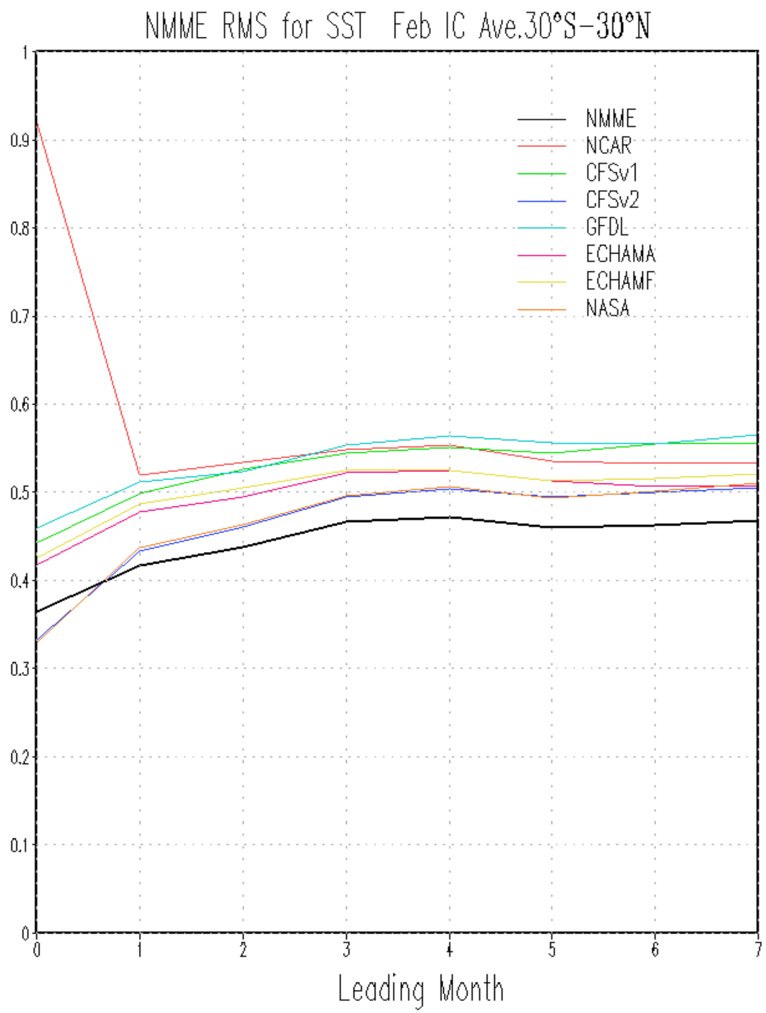


NMME Forecast Skill of SST
Feb IC, averaged over 30S-30N

AC SST

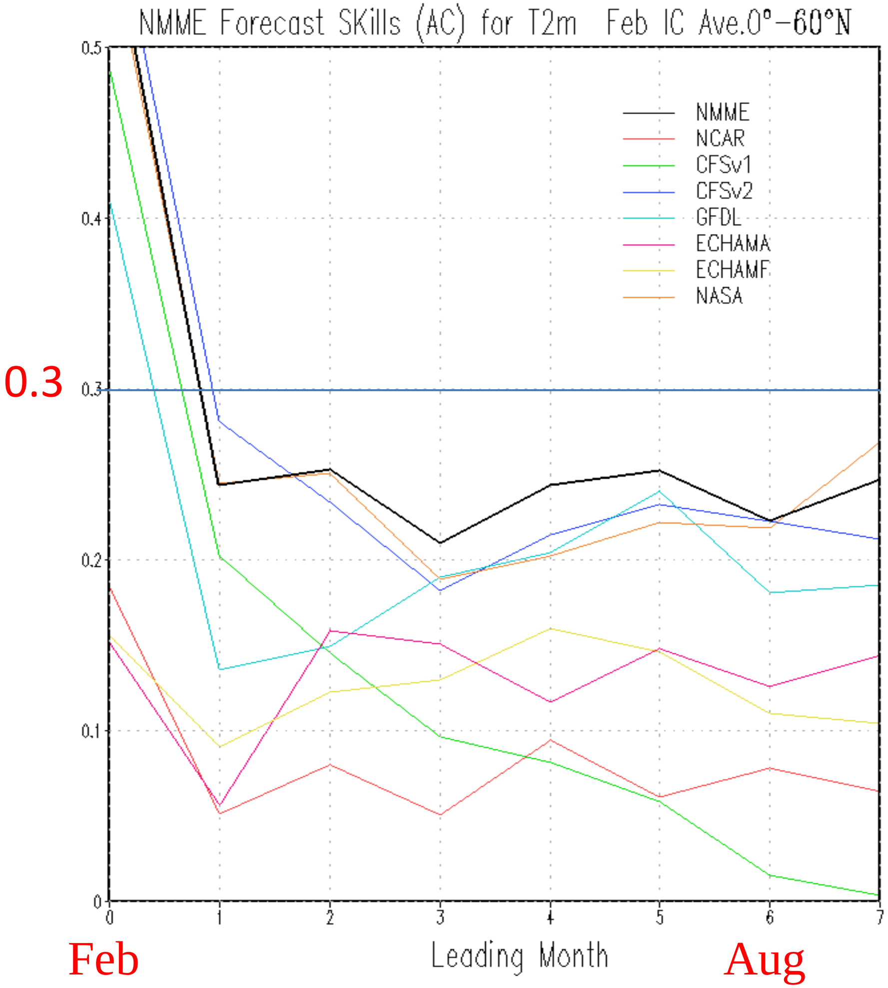


RMSE SST

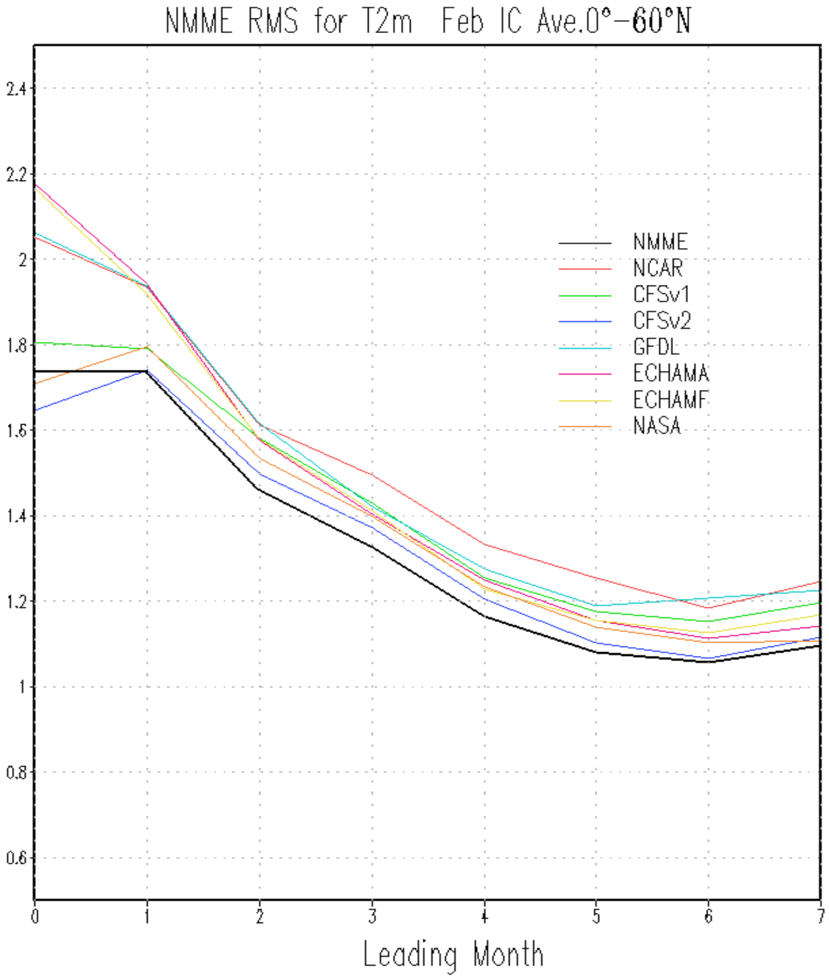


NMME Forecast Skill of T2m over land Feb IC, averaged over Eq to 60N

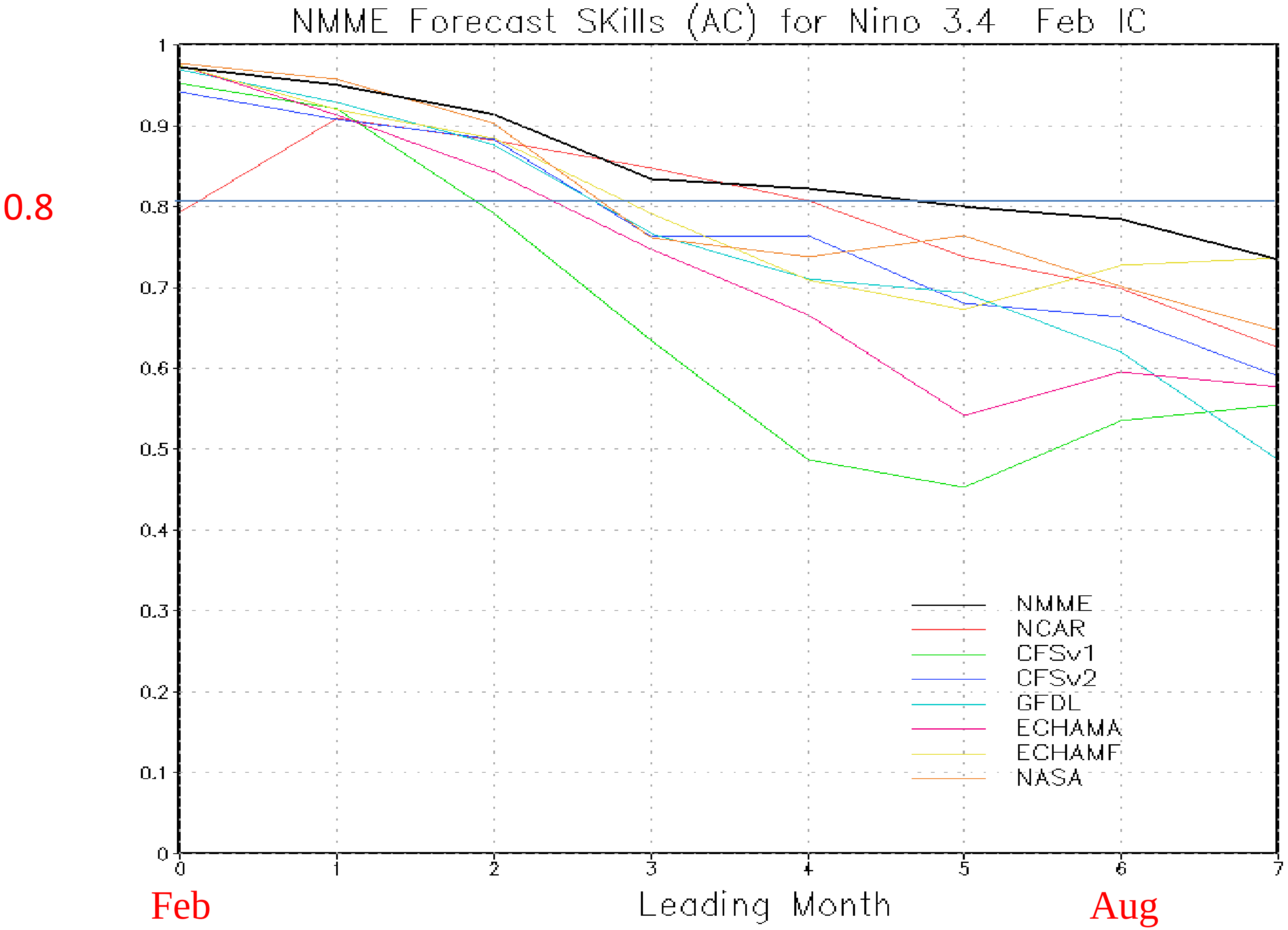
AC T2m



RMSE T2m



NMME Forecast Skill of NINO3.4 Index Feb IC



Area Averaged Correlation (R^2) Over North America: Model Ranks

	Mod A	Mod B	Mod C	Mod D	Mod E	Mod F	Mod G	NMME
JFM P (August IC)	4	6	5	8	7	3	2	1
JFM T2m (August IC)	3	1	5	6	7	4	8	2
MJJ P (December IC)	5	7	1	2	8	6	3	4
MJJ T2m (December IC)	6	1	3	4	8	7	5	2
Mean Rank	4.5	3.75	3.5	5.0	7.5	5.0	4.5	2.2

CONCLUSIONS FROM NMME HINDCASTS

- CFSv2 frequently leads the pack (NMME) in terms of global monthly/seasonal T2m prediction over land. Trends are now modeled with some success in v2.
- CFSv2 leads the pack (NMME) in terms of global monthly/seasonal SST prediction.
- CFSv2 is just one of the models in the pack (NMME) in terms of global monthly/seasonal prate prediction over land. Very little skill for anybody!
- CFSv2’s leading role is more pronounced when probabilistic scores are considered, because many more members.
- CFSv2 is enormously better than CFSv1 in terms of MJO prediction. (CFSR is so much better than R1/R2).
- CFSv2 is run without delay in real time. Therefore, its short & medium range forecasts (16 per day) should contribute to the 6-10 day, week2 and beyond (week3-week6).
- CFSv2 hindcasts are incredibly extensive with 2 foci, SI and intraseasonal.

Real Time Operations

- Only on one occasion was one model completely missing in real time
- On several occasions, one or more centers had “last minute” contributions
- Some centers had a smaller than intended number of ensemble members when they ran out of time.

Real Time Operations (contd)

- We assume that quality control is typically about outliers.
- However, quite often, members i and j of some models are erroneously identical, which is very unexpected !!

Real Time Operations (contd)

- GFDL had to move its model to a new platform. No problem was anticipated, so they did not feel the need to inform anybody.
- However, very large positive T2m anomalies crept up in summer forecasts (at all leads), which was rather suspicious. GFDL was unable to reproduce the real time forecast of the older model.
- They had to redo all hindcasts to match the ‘new’ model.
- On the positive side: For GFDL, we now have two complete sets of hindcasts (all 12 start months) 1981-2011 which can be used for research at least.

Real Time Operations (contd)

- NASA decided that its soil initialization was not good enough and changed that aspect of initialization in May 2012.
- They continued with hindcasts on the fly.
- We now have to wait a whole year to get the updated hindcasts.
- Models could keep changing in this fashion, which is frustrating.

Real Time Operations (contd)

- IRI had two entries in the first year, Echam_a and Echam_f. They completed the first year.
- Serious budget issues, and serious personnel cuts forced IRI to withdraw.
- We introduced two Canadian models in the two IRI slots. Still have 7 models.
- For research purposes, the two IRI hindcast data sets will continue to be useful.

Some interesting NMME quirks

Is NMME more than the sum of its parts ? Hopefully it is. But the smallest common denomination does play a role. For instance:

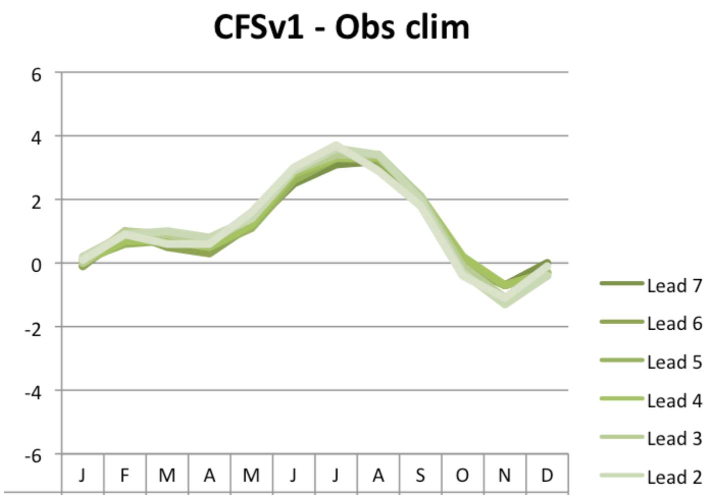
- The longest lead of the NMME tends to be the smallest of the maximum leads of any particular model.
- The period of systematic error correction tends to be the shortest common hindcast record. Same for the climate anomalies.
- The NMME defaults to undefined at a particular gridpoint, if only one model is undefined. Therefore land-sea masks (and lakes) used by individual models and their interpolation techniques have an impact, especially when the resident resolution is low.

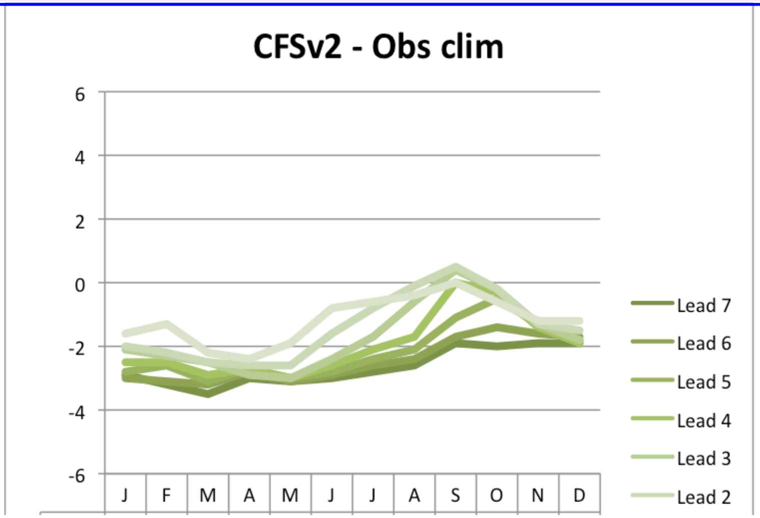
NMME Hindcast Data Repository

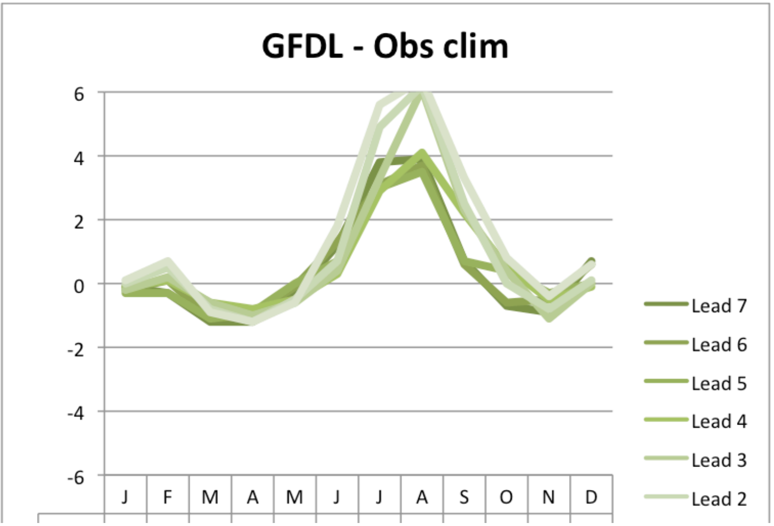
- All 12 start months for GFDL, CFSv1, CFSv2, IRIa, IRIf were provided right at the start in Aug 2011.
- NCAR and NASA were made on the fly for each month, as we went along Aug 2011 – July 2012.
- Every new month gets added to the repository.
- This data is now available to the public for research
- Free download from IRI. Courtesy US Govt.

http://iridl.ldeo.columbia.edu/SOURCES/.Models/.NMME/

Verification of Climate Mean

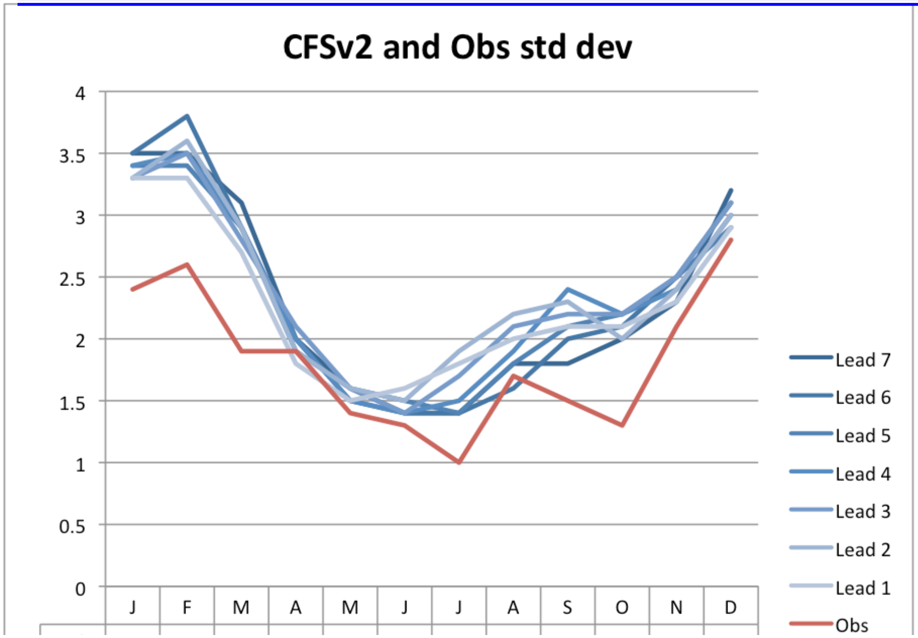

CFSv1 - Obs clim

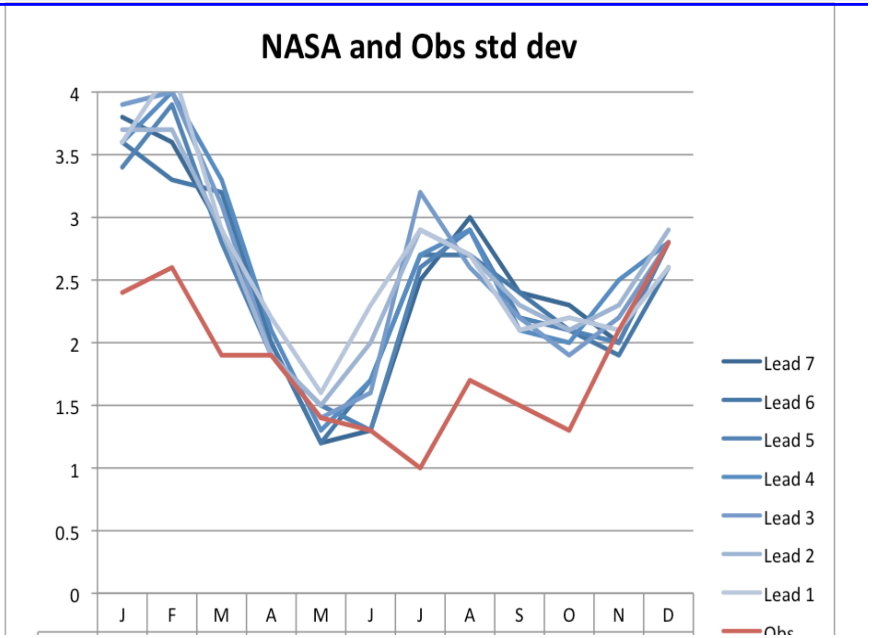

CFSv2 - Obs clim


GFDL - Obs clim

Points to note:
Target is more important than lead
CFSv2 is the only model with cold bias (center US)
Many models have (up to horrible) warm bias in summer climatology

Verification of Climate Variance


CFSv2 and Obs std dev


NASA and Obs std dev

Points to note:

CFS has a reasonable seasonality in interannual standard deviation of monthly T2m (center US)

Several model have a spurious maximum in summer (NASA, GFDL).

If anything, all models have too much spread thruout the year.

Predictability as seen by each model

TMP2m	All months and lead 1-3 combined. 1981-2010. NH land.						
Nor Hem	cfsv1	cfsv2	echama	echamf	gfdl	nasa	ncar
cfsv1	0.19	0.09	0.06	0.06	0.08	0.07	0.03
cfsv2	0.10	0.23	0.09	0.08	0.16	0.17	-0.02
echama	0.06	0.07	0.15	0.15	0.08	0.08	0.03
echamf	0.07	0.06	0.15	0.12	0.08	0.07	0.04
gfdl	0.06	0.14	0.07	0.06	0.23	0.15	-0.01
nasa	0.07	0.14	0.06	0.06	0.14	0.22	-0.02
ncar	0.03	0.00	0.04	0.05	0.03	0.00	0.14

Points to note:

Diagonal shows predictability in T2m estimated by each model under 'perfect model' assumption

Models agree at 0.14-0.23 correlation, not that much higher than actual forecast skill unfortunately

Heterogeneous predictability (lower in general) is shown in off diagonal

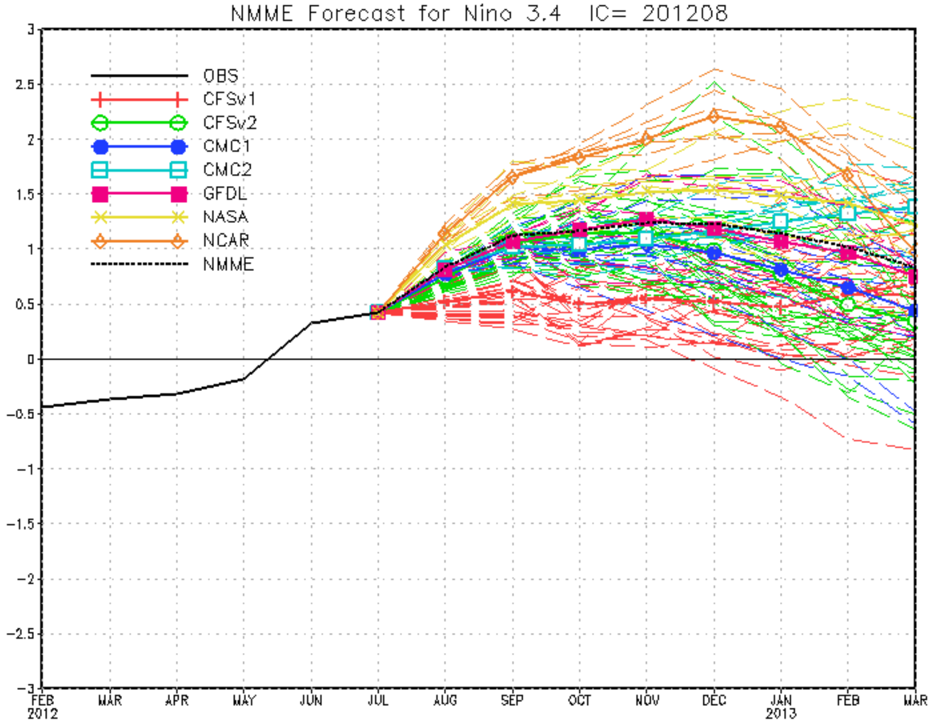
(defined as model A single member vs model B ensemble mean.)

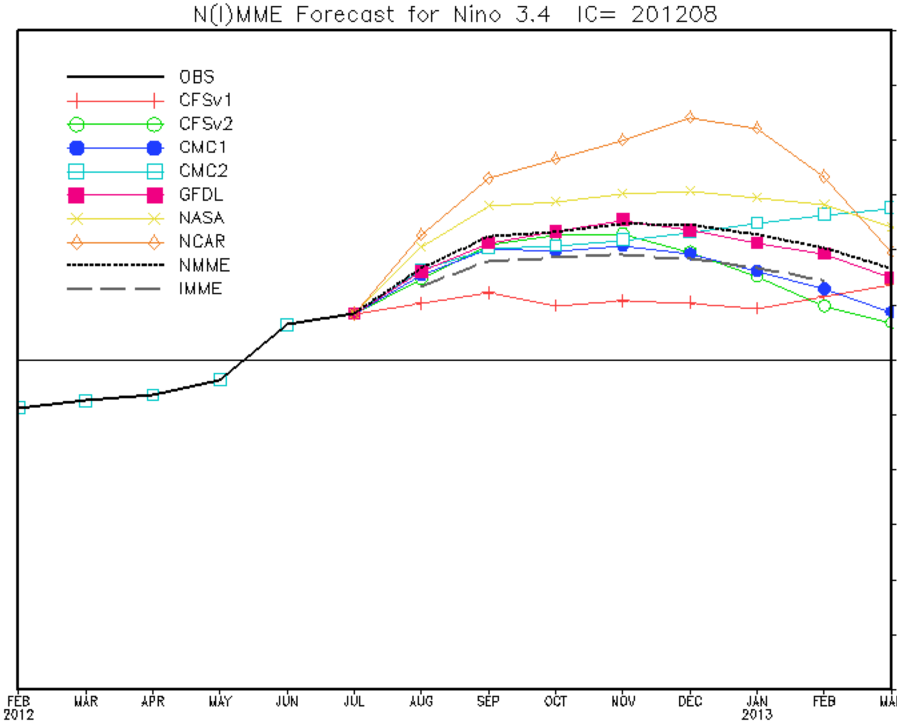
NCAR has no ability to predict (or be predicted by) any of the other models!!

For your one stop shopping for NMME and IMME products, visit

http://www.cpc.ncep.noaa.gov/products/NMME/

Real time display

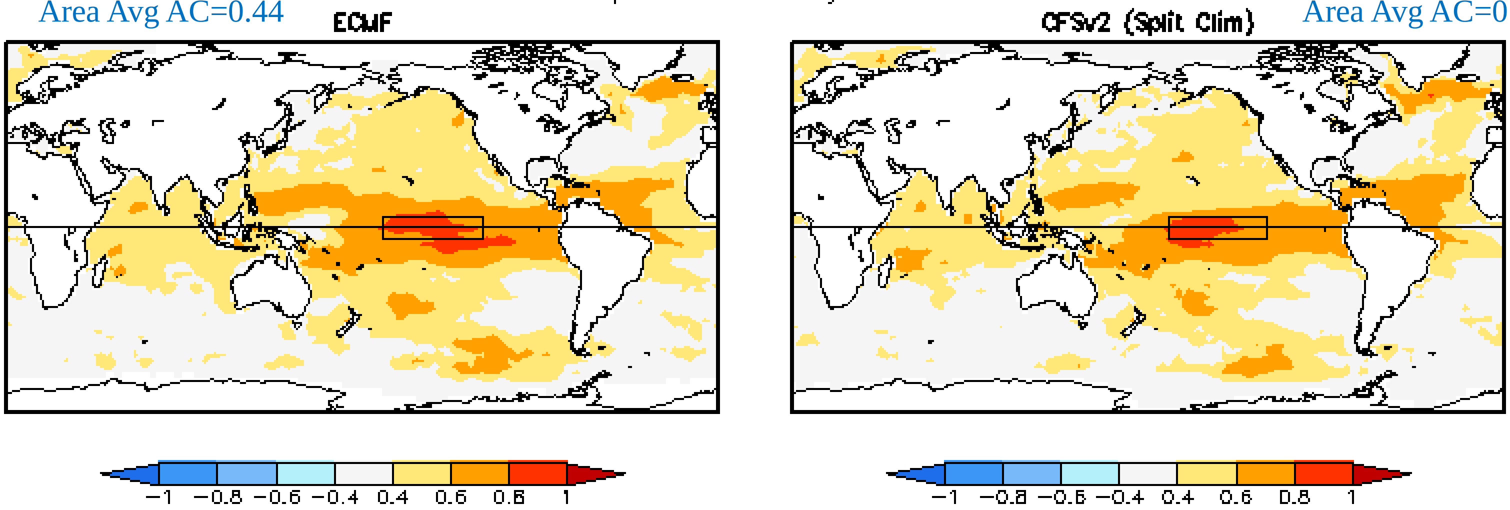




Points to note in the above 'live' example from August 2012…
Large #of ens members (La Nina extremely unlikely in late 2012)
Different models occupy somewhat different parts of the graph!
IMME version (on the right) has ensemble means of NMME and a single IMME line

SST AC and SE

All initial months, all leads average
Gridpoint-wise Anomaly Correlation



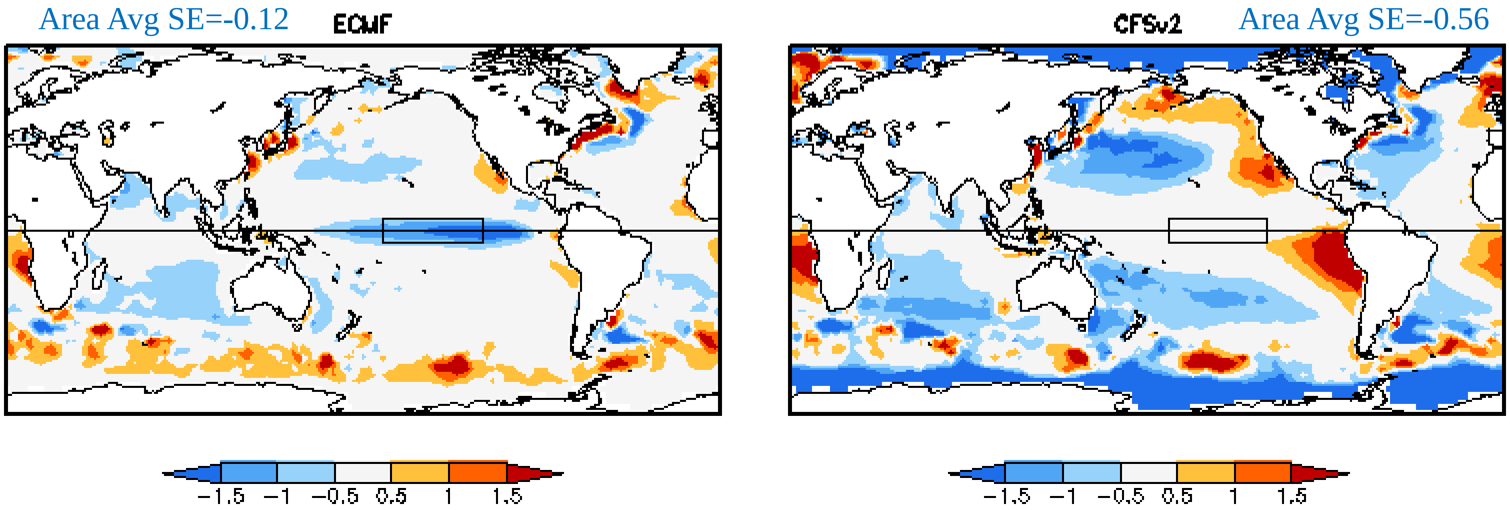
Area Avg AC=0.44

ECMF

CFSv2 (Split Clim)

Area Avg AC=0.42

Systematic Error [K]



Area Avg SE=-0.12

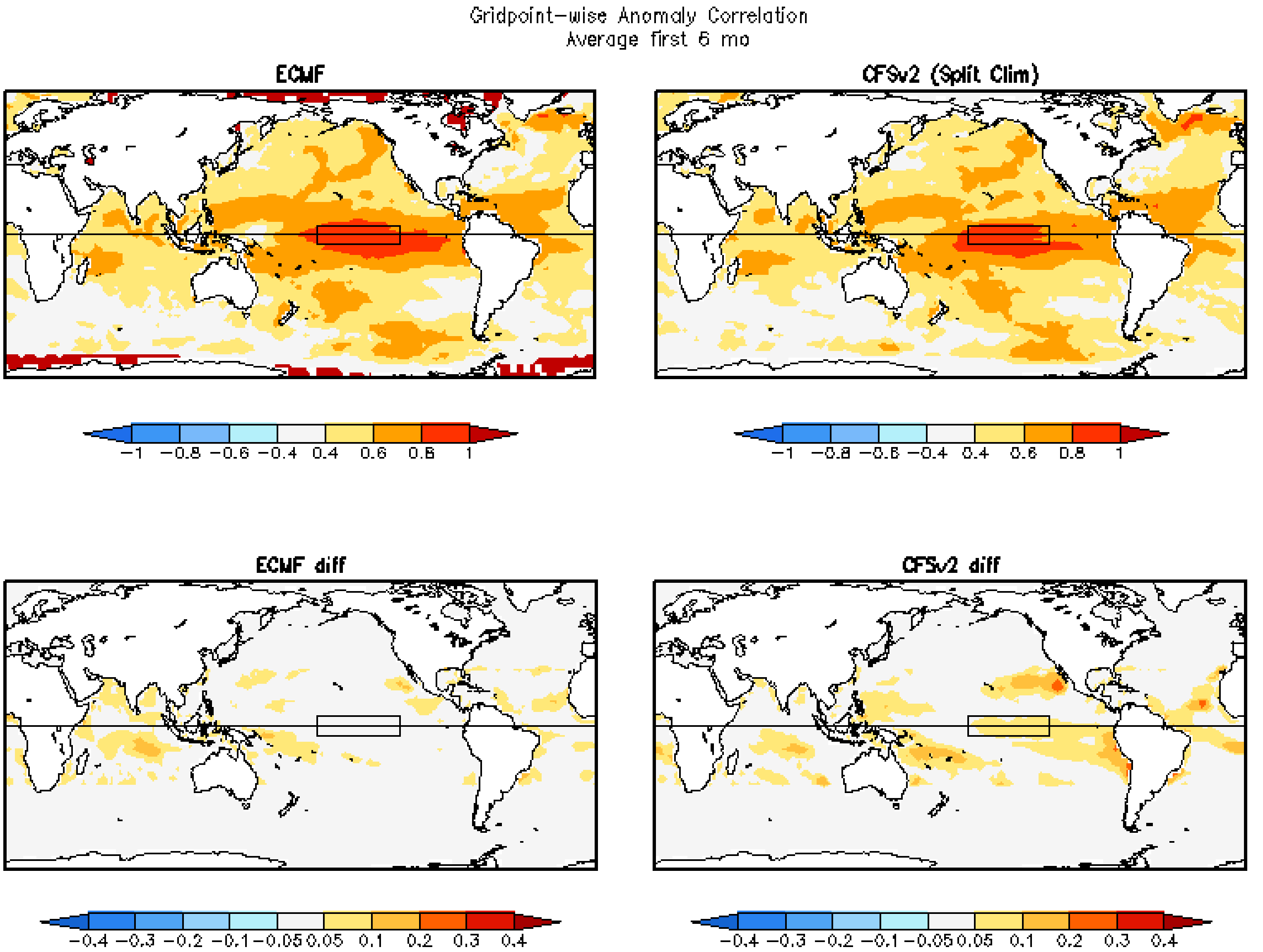
ECMF

CFSv2

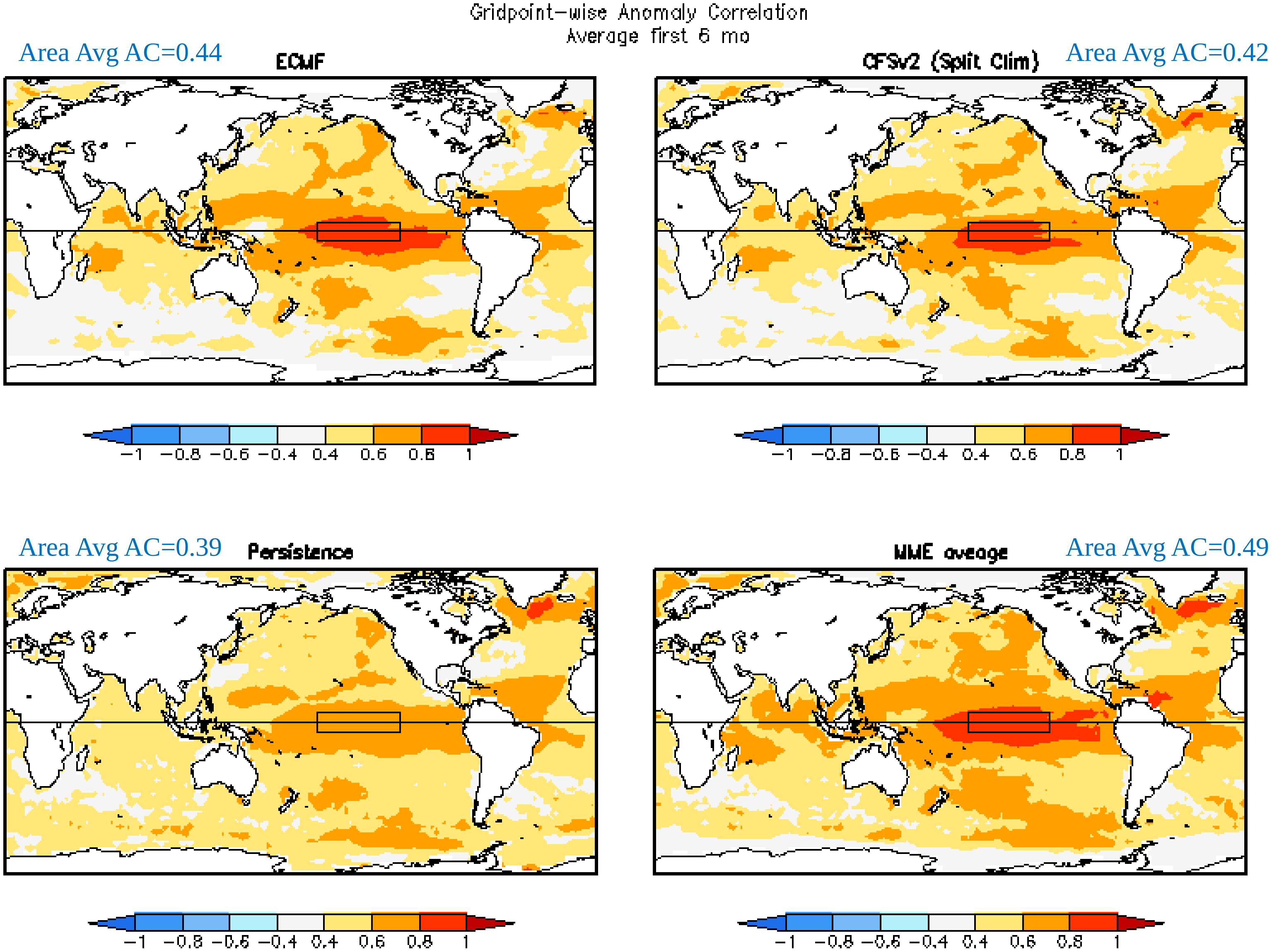
Area Avg SE=-0.56

Lead 0 excluded

Effect of Split climatology (30S to 30N) on SST AC



Comparison with Persistence and MME SST AC



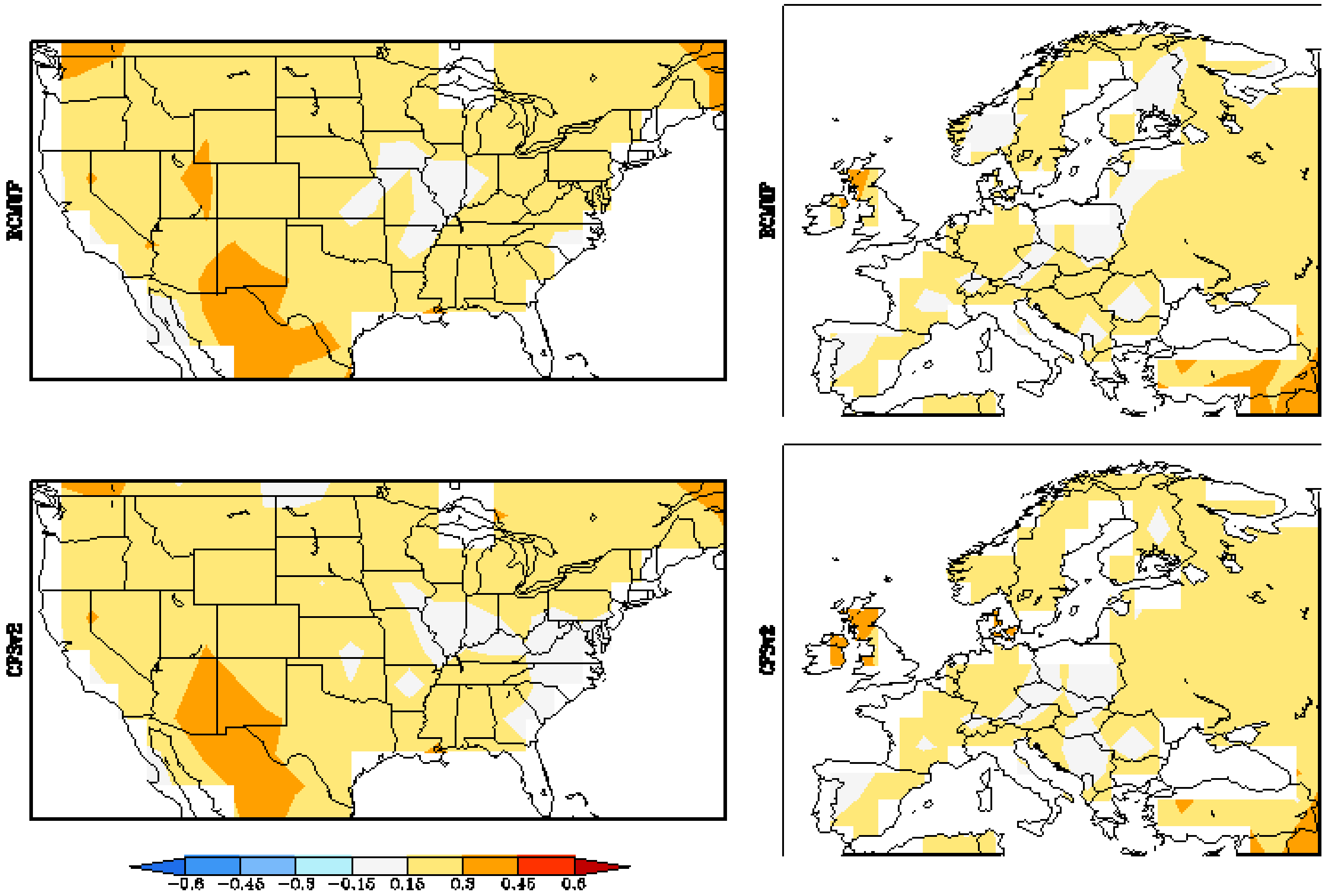
Area Avg AC=0.44

Area Avg AC=0.42

Area Avg AC=0.39

Area Avg AC=0.49

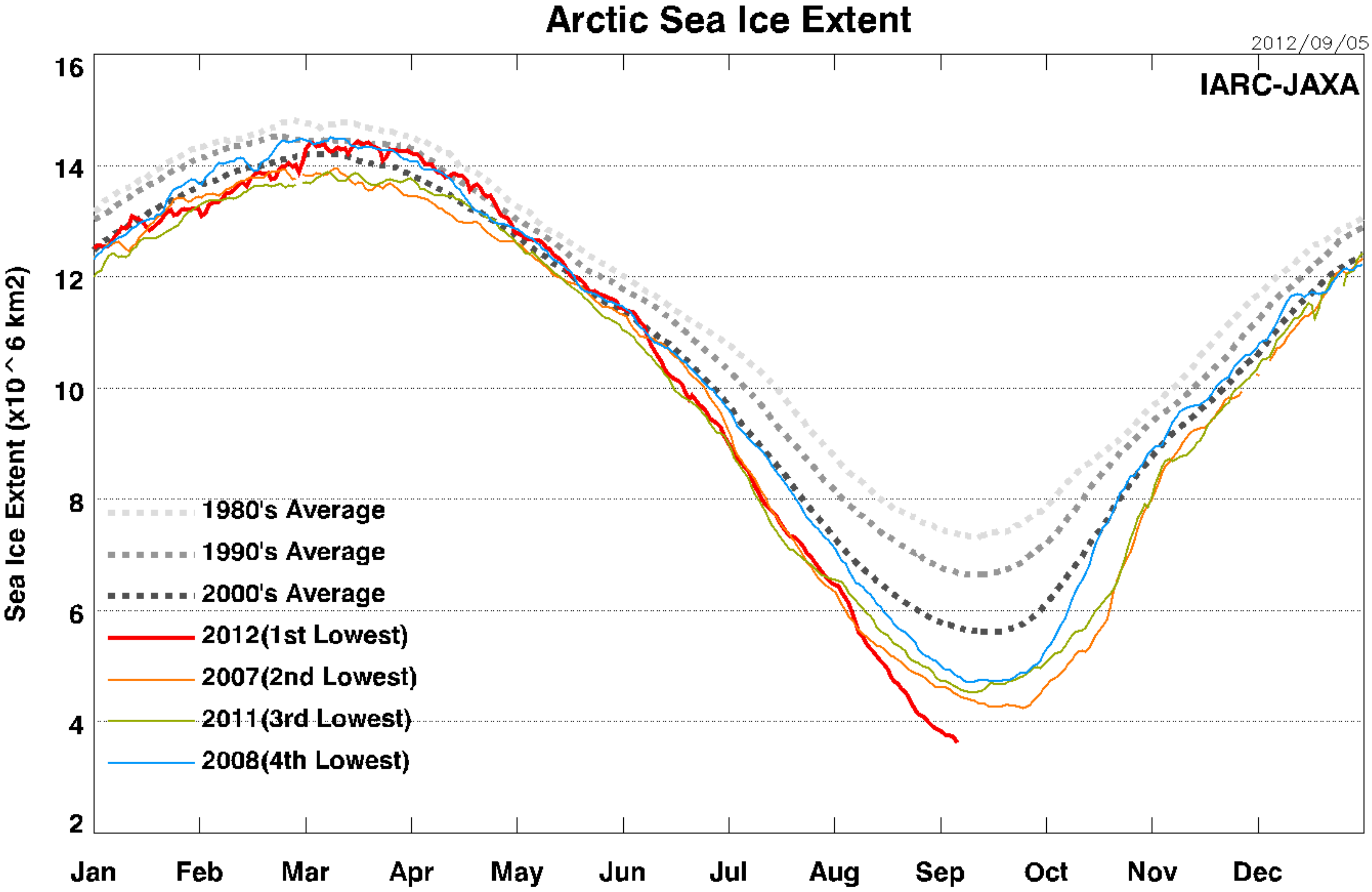
All initial months, all leads average
Gridpoint-wise Anomaly Correlation



Arctic Sea Ice Extent (2012)

- The Arctic sea ice extent (SIE) broke the previous minimum record (September 2007) in August 2012.
- The current Arctic SIE is just above 3.6 millions km^2
- Arctic minimum SIE has decreased by about 45% since 1979.
- CFSv2 “assimilates” sea ice concentration and predicts the Arctic sea ice distribution for up to 9 months in advance.

The Observed Arctic Sea Ice Extent from: http://www.ijis.iarc.uaf.edu/en/home/seaice_extent.htm



Arctic Sea Ice Extent (SIE) from CFSv2

- The predicted minimum Arctic SIE from the CFSv2 showed positive bias (due to the lack of sea ice thickness data to initialize the ice model and due to the model bias).

- With bias correction (based on the hindcast) the predicted (40-member ensemble mean) minimum Arctic SIE for 2011 was 4.8 millions km^2 with 9-month lead time and 4.6 millions km^2 with 3-month lead time; the observed value was 4.6 millions km$^{2.}$

- The predicted (40-member ensemble mean) minimum Arctic SIE for 2012 (with bias correction) is 4.9 millions km^2 with 9-month lead time, it has been reduced to 4.7 millions km^2 with 3-month lead time

Arctic SIE from CFSv2 (cont.)

- The predicted minimum Arctic SIE (using ICs from late July 2012, with bias correction and 40-member ensemble mean) is 3.9 million km^2, which is much lower than that of 2011 but still larger than the current observed value of 3.6 million km2.
- The predicted minimum Arctic SIE for 2012 was one of the lowest from the coupled model predictions (at least 1.5-months ahead of real time).
- Case studies for 2012 will be carried out to evaluate the CFSv2 capability in the prediction of the Arctic minimum SIE.
- Future improvements of the CFS in the sea ice module includes the improvement of ICs for sea ice thickness

THANK YOU