

# UNOPC-IOC

*Science review*

(Q2FY11)

Yuejian Zhu and Bo Cui

Ensemble & Probabilistic Guidance Team  
Environmental Modeling Center

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# Scopes and Expectations

- NAEFS – North American Ensemble Forecasting System (*version 3.0.0*)
  - Jointly with Meteorological Service of Canada and Meteorological Service of Mexico since 2004
  - Upgrade to include FNMOC global ensembles
  - Improve the overall skills of NAEFS performance
- NUOPC – National Unified Operational Prediction Capability (*version 1.0.0*)
  - IOC – Initial Operational Capability
  - Unified NOAA-NAVY-AF tri-agency's numerical forecast output and post processing
  - Deliver best products to service US and public

# NAEFS Current Configuration

Updated: February 23<sup>rd</sup> 2010

	<b>NCEP</b>	<b>CMC</b>
Model	GFS	GEM
Initial uncertainty	ETR	EnKF
Model uncertainty/Stochastic	Yes (Stochastic Pert)	Yes (multi-physics)
Tropical storm	Relocation	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC
Resolution	T190L28 (d0-d16)~70km	(d0-d16) ~1.0degree
Control	Yes	Yes
Ensemble members	20 for each cycle	20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)
Post-process	Bias correction (same bias for all members)	Bias correction for each member
Last implementation	February 23 <sup>rd</sup> 2010	July 10 <sup>th</sup> 2007

# NAEFS/NUOPC Configuration

Updated: January 2011

	<b>NCEP</b>	<b>CMC</b>	<b>FNMOC/NOGAPS</b>
Model	GFS	GEM	Global Spectrum
Initial uncertainty	ETR	EnKF	Banded ET
Model uncertainty Stochastic	Yes (STTP)	Yes (multi-physics)	None
Tropical storm	Relocation	None	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC	00 and 12UTC
Resolution	T190L28 ~70km	1.0 degree	T119L30 ~1.0degree
Control	Yes	Yes	Yes
Ensemble members	20 for each cycle	20 for each cycle	20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)	16 days (384 hours)
Post-process	Bias correction (same bias for all members)	Bias correction for each member	Bias correction (same bias for all members)
Last implementation	February 23 <sup>rd</sup> 2010	July 10 <sup>th</sup> 2007	May 2010 5

# NAEFS (FNMOC) Grid Exchange Variables

Update: July 12 2010

Variables	Pgrba file	Total 80/73
<b>GHT</b>	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
<b>TMP</b>	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13/(13)
<b>RH</b>	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
<b>UGRD</b>	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
<b>VGRD</b>	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
<b>PRES</b>	Surface, PRMSL	2/(2)
<b>PRCP</b>	APCP, CRAIN, CSNOW, CFRZR, CICEP	5/(4)
<b>FLUX (surface)</b>	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6/(2)
<b>FLUX (top)</b>	ULWRF (OLR)	1/(1)
<b>PWAT</b>	Total precipitable water at atmospheric column	1/(1)
<b>TCDC</b>	Total cloud cover at atmospheric column	1/(1)
<b>CAPE</b>	Convective available potential energy, Convective Inhibition	2/(2)
<b>SOIL/SNOW</b>	SOILW(0-10cm) , TMP(0-10cm down), WEASD(water equiv. of accum. Snow depth), SNOD(surface)	4/(1)
<b>Other</b>	850 hPa vertical velocity	1/(1)
<b>Notes</b>	Original NAEFS grids currently being sent to NCEP by FNMOC, Require model change to add. (future plan) Not available	FNMOC=72  6

# NAEFS bias corrected parameters and products

Last update: February 23<sup>rd</sup> 2010

Variables	pgrba_bc file	Total 49 (14)
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	10 (3)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (3)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VVEL	850hPa	1(1)
PRES	Surface, PRMSL	2(0)
FLUX (top)	ULWRF (toa - OLR)	1 (1)
Notes	14 new variables for CMC's ensemble 49 new variables for FNMOC's ensemble	
Products	All NAEFS products at 1*1 (lat/lon) degree are globally for ensemble mean, spread, 10%, 50%, 90% and mode, climate anomaly forecast from ensemble mean	

# NAEFS downscaling parameters and products

Last update: December 7<sup>th</sup> 2010  
(NDGD resolutions)

Variables	Domains	Resolutions	Total 4/8
Surface Pressure	CONUS/Alaska	5km/6km	1/1
2-m temperature	CONUS/Alaska	5km/6km	1/1
10-m U component	CONUS/Alaska	5km/6km	1/1
10-m V component	CONUS/Alaska	5km/6km	1/1
2-m maximum T	Alaska	6km	0/1
2-m minimum T	Alaska	6km	0/1
10-m wind speed	Alaska	6km	0/1
10-m wind direction	Alaska	6km	0/1
Note: Alaska products has been implemented by December 7 <sup>th</sup> 2010			

All products at NDGD resolution, regional dependent  
Ensemble mean, spread, 10%, 50%, 90% and mode



# NAEFS – bias correction (details)

- ❑ Bias corrected NCEP/GEFS forecast
  - Consider the same bias for all ensemble members (mean bias)
  - Weight = 0.02 for Kaman filter (decaying) algorithm
- ❑ Bias corrected NCEP/GFS forecast
  - Use the same algorithm as ensemble bias correction
  - Up to 180 hours
- ❑ Bias corrected CMC/GEFS forecast
  - Consider the different bias for each model (member)
  - Use the same algorithm as ensemble bias correction
- Bias corrected FNMOC/GEFS forecast
  - Consider the same bias for all ensemble members (mean bias)
- ❑ Combine bias corrected GFS and ensemble forecast
  - Dual resolution ensemble approach for short lead time
  - GFS has higher weights at short lead time
- ❑ NAEFS products based on bias correction
  - Combine NCEP/GEFS (20m), CMC/GEFS (20m) and FNMOC/GEFS (20m)
  - Produce Ensemble mean, spread, mode, 10% 50%(median) and 90% probability forecast at 1\*1 degree resolution
    - Climate anomaly (percentile) forecasts also generated for ensemble mean

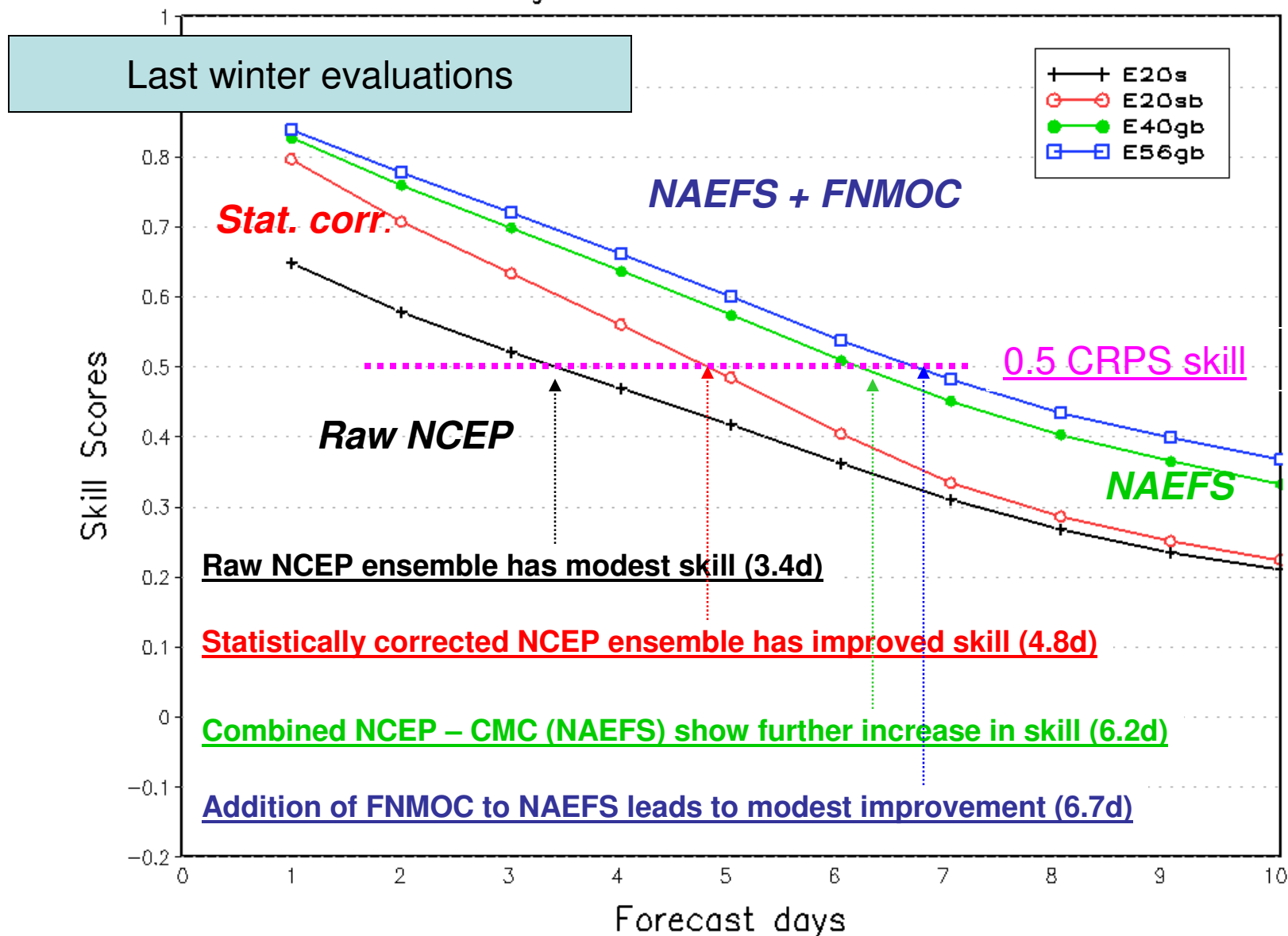
# NAEFS - Statistical downscaling

- Proxy for truth
  - RTMA at 5km resolution
  - Variables (surface pressure, 2-m temperature, and 10-meter wind)
- Downscaling vector
  - Interpolate GDAS analysis to 5km resolution
  - Compare difference between interpolated GDAS and RTMA
  - Apply decaying weight to accumulate this difference – **downscaling vector**
- Downscaled forecast
  - Interpolate bias corrected 1\*1 degree NAEFS to 5km resolution
  - Add the downscaling vector to interpolated NAEFS forecast
- NAEFS products
  - CONUS – NDGD grid/resolution (5km)
    - 4 variables (parameters)
    - Ensemble spread, mean, mode, 10%, 50%(median) and 90% forecasts
  - Alaska – NDGD grid/resolution (6km)
    - 8 variables (parameters)
    - Ensemble spread, mean, mode, 10%, 50%(median) and 90% forecasts

# Value-added by including FNMOG ensemble into NAEFS

## T2m: Against analysis (NCEP's evaluation)

Northern Hemisphere 2 Meter Temp.  
Continuous Ranked Probability Skill Scores  
Average For 20081201 – 20090228



# Preliminary Conclusions From 08/09 Winter

## for adding FNMOC ensemble to current NAEFS

- **Individual ensemble systems (individual Centers' forecasts)**
  - NCEP and CMC have similar performance
  - FNMOC performance similar to NCEP & CMC for near surface variables, including precipitation
  - FNMOC is less skillful than NCEP and CMC for upper atmosphere variable (500hPa)
- **Combined ensemble system (without bias correction)**
  - Multi-model ensembles have higher skill than single system
  - Adding FNMOC ensemble to current NAEFS (NCEP+CMC) adds value for most forecast variables
    - Noticable improvement for surface variables
    - Minimal improvement for upper atmosphere
- **Combined ensemble system (with operational NAEFS bias correction)**
  - Improved near surface variables with FNMOC ensemble
    - NCEPbc + CMCbc + FNMOCbc
  - Less improvement for upper atmosphere (e.g. 500hPa height)
    - Some degradation for short lead times (related to large spread in FNMOC ensemble)
- **CMC evaluation against observations**
  - Preliminary results combining raw ensembles are mixed
  - Results with bias corrected data still mixed

# Real time experiments (EMC and NCO)

Since September 1<sup>st</sup> 2010

There are many upgrading for FNMOC and NCEP ensemble system for past year

FNMOC ensemble with 4DVar data assimilation

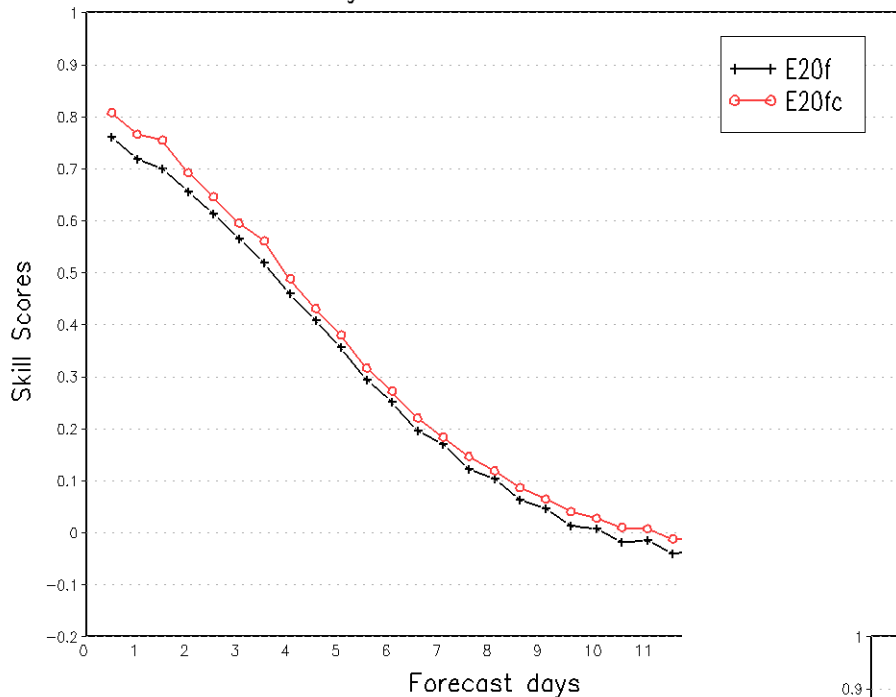
FNMOC ensemble with banded ET

NCEP GEFS increasing resolution in Feb. 2010

NCEP GEFS with new analysis from GFS model upgrade

NCEP GEFS is still running the same GFS model (n-1 version)

Northern Hemisphere 1000hPa Height  
 Continuous Ranked Probability Skill Scores  
 Average For 20100901 – 20101023

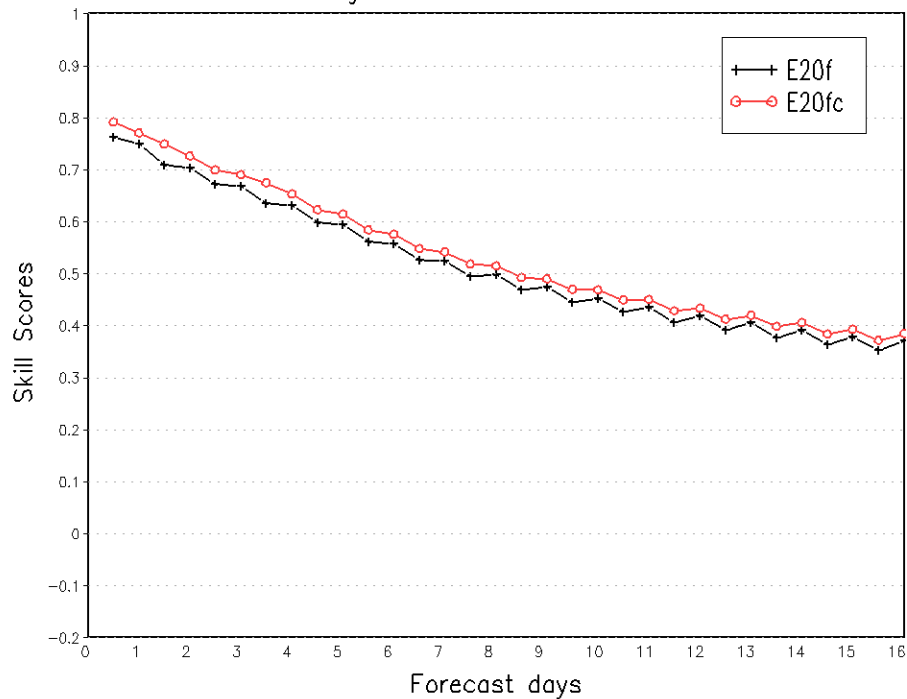


## FNMOc ensembles only

NCEP bias correction improves  
 FNMOc raw ensemble forecast

E20f – FNMOc raw forecast  
 E20fc – FNMOc bias corrected  
 forecast

Northern Hemisphere 2 Meter Temp.  
 Continuous Ranked Probability Skill Scores  
 Average For 20100901 – 20101023

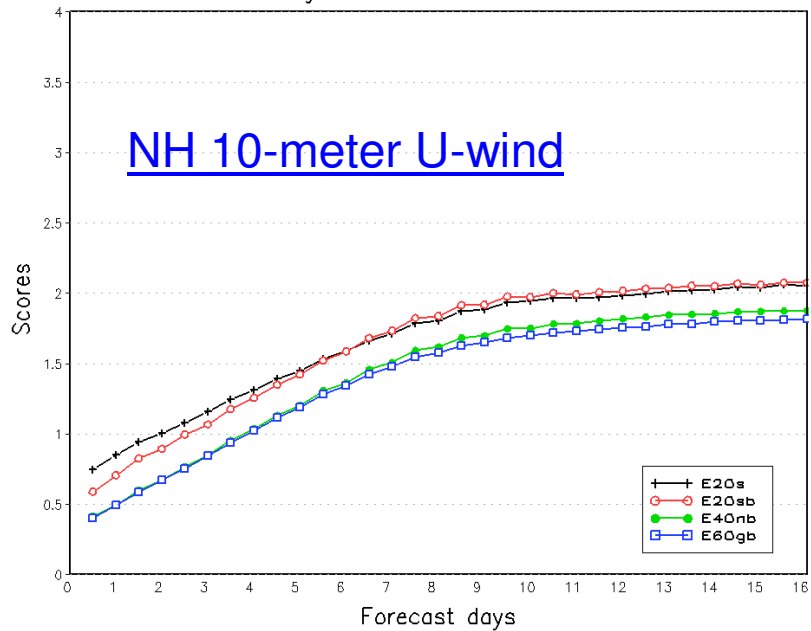


Top: NH 1000hPa height

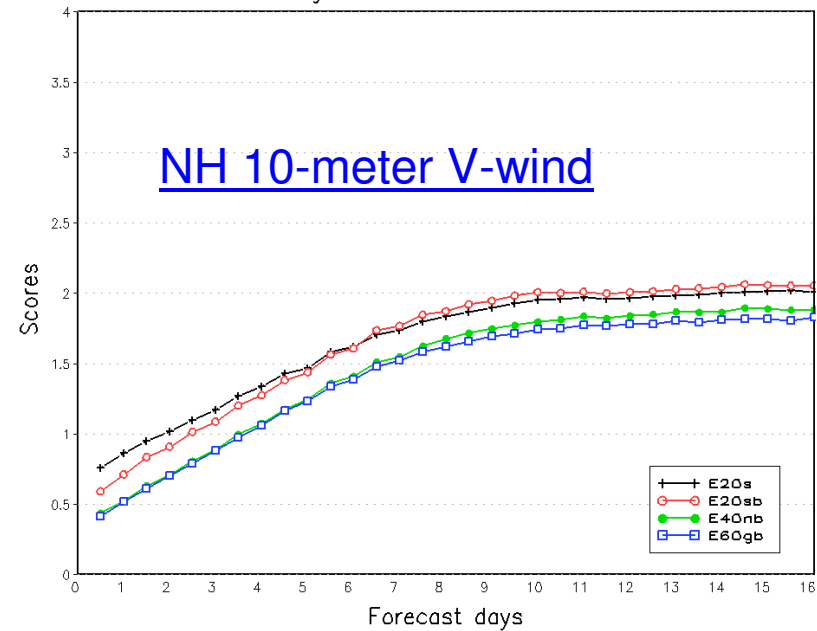
Right: NH 2-meter temperature

# Results from September and October for NAEFS upgrade

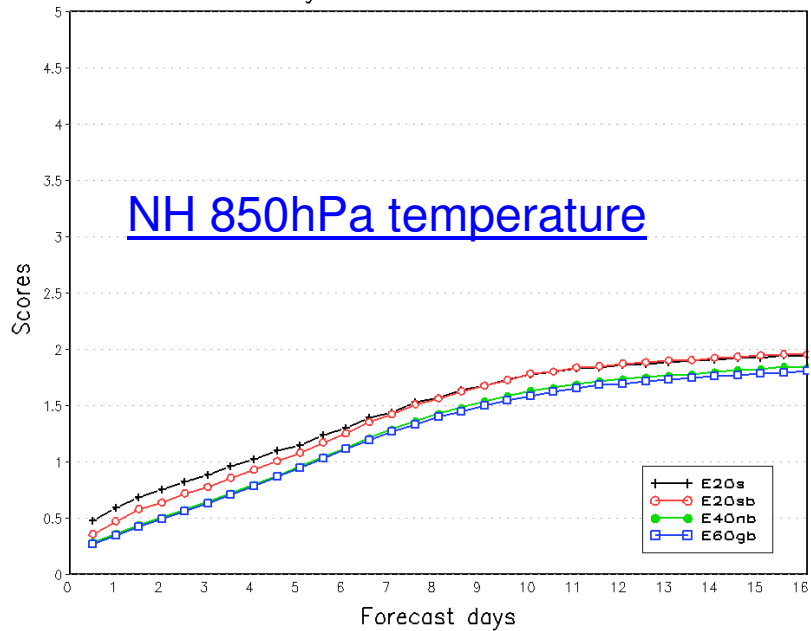
Northern Hemisphere 10 Meter U(wind)  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101023



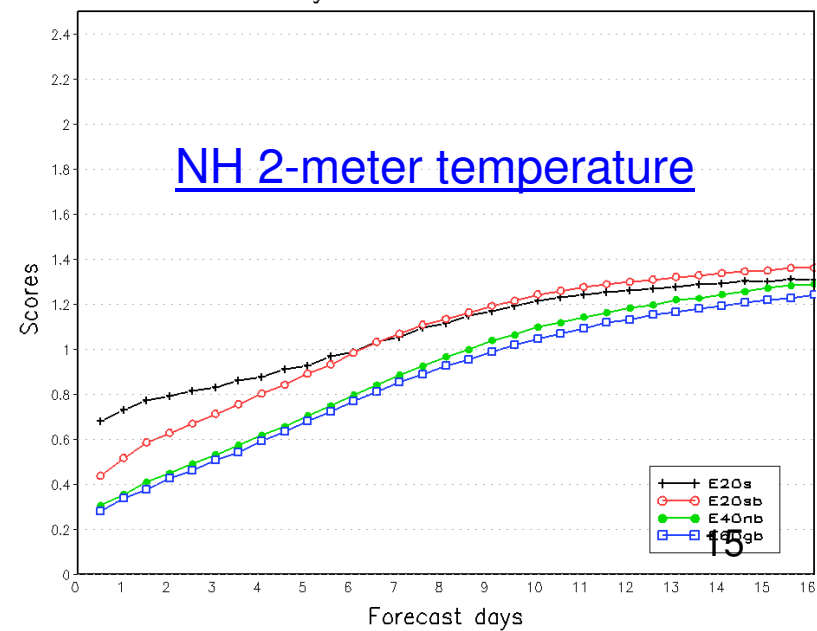
Northern Hemisphere 10 Meter V(wind)  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101023



Average For 20100901 – 20101023



Average For 20100901 – 20101023



NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-Z500 in Fall 2010

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Red	Red														
RMS	Red											Blue	Blue			
AC																

NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-T850 in Fall 2011

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Blue	Blue							Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
RMS	Blue	Blue							Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
AC	Blue	Blue							Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-Z1000 in Fall 2010

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Red	Red										Blue				
RMS	Red															
AC																

NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-T2M in Fall 2010

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
RMS	Blue	Blue	Blue	Blue	Blue	Blue	White	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
AC	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-U10M in Fall 2010

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
RMS																
AC			Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

NAEFSb (40 members) vs NAEFSb+FNMOCb (60 members): NH-V10M in Fall 2010

Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CRPS	Blue	Blue		Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue
RMS								Blue		Blue						
AC				Blue	Blue			Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue

- Using 95% confidence interval (2.5%-97.5%), **BLUE** means NAEFSb+FNMOCb is significantly better than NAEFSb, **RED** means otherwise.
- The reliability (Rel) and resolution (Res) are from Brier Score decomposition.

## Score cards – 45 days of Fall 2010

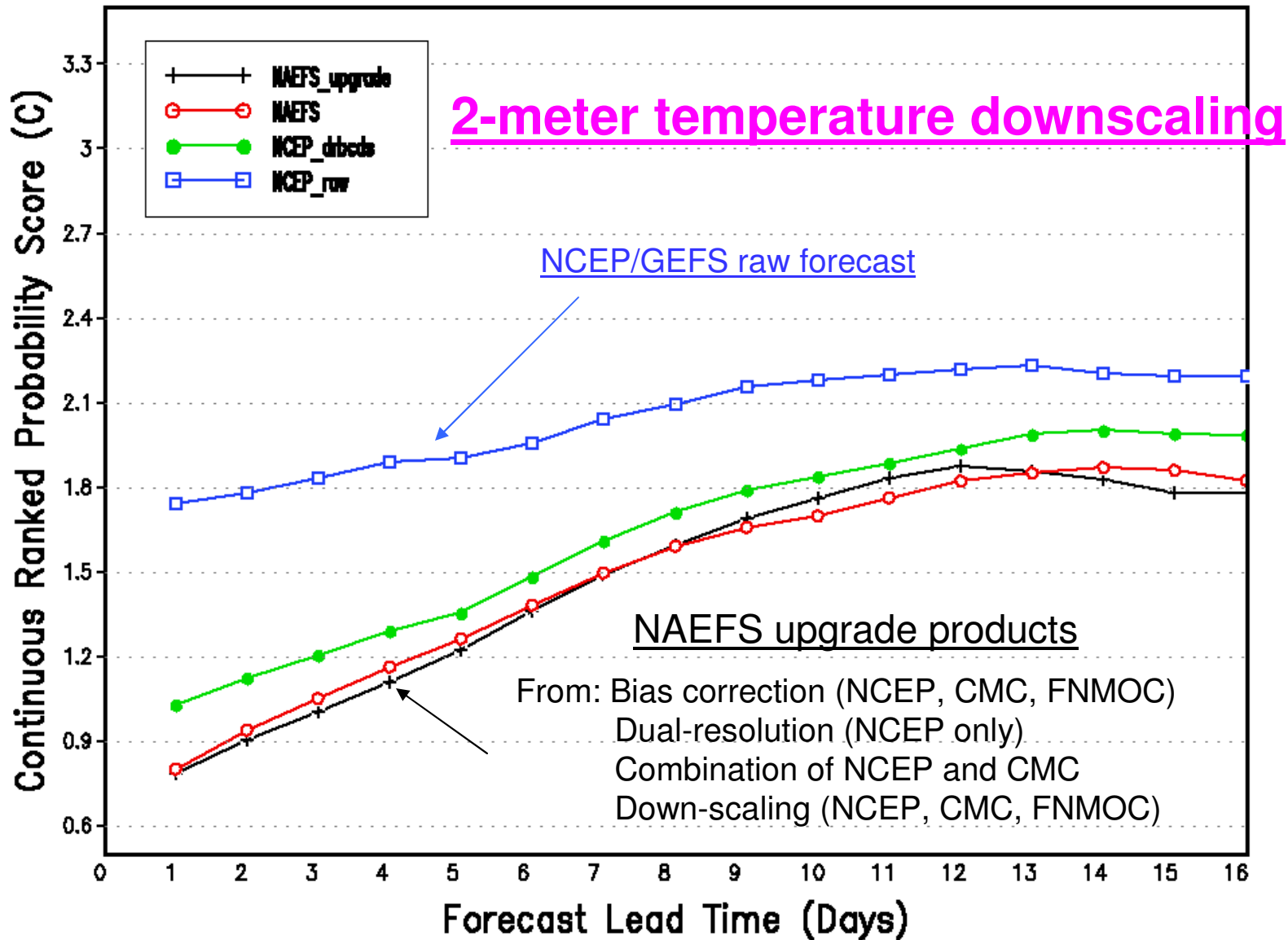
Comparison for NAEFS with/without FNMOc ensembles

All bias corrected ensembles (from own model analysis)

Blue means better to have FNMOc ensembles in, but red is not



# NAEFS NDGD Probabilistic 2m Temperature Forecast Verification For 2010092000 – 2010102100

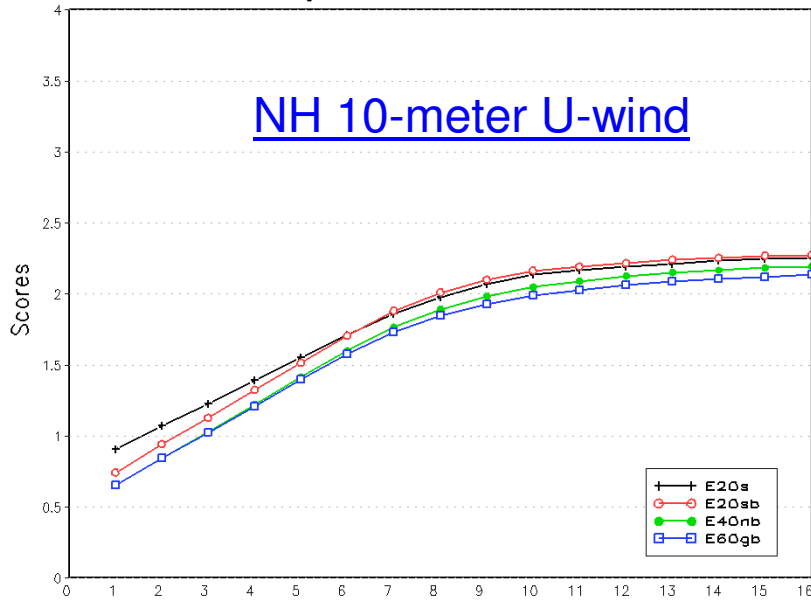


# Recommendation for selected FNMOC variables added to NAEFS probabilistic products

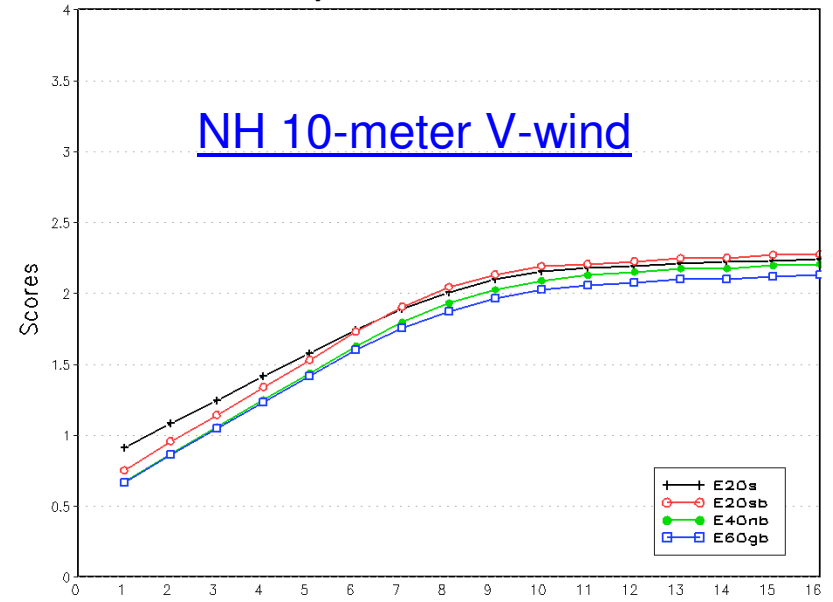
October 25 2010

- Based on the evaluations of past 45 days (since September 1<sup>st</sup> 2010)
  - About 45 variables
  - Most of them are insignificant
  - Some of them are degradation
- The conclusions are not solid from the short period evaluations. The performance may change from season to season.
- Select following variables as first try to upgrade NAEFS (for NUOPC IOC)
  - 850 hPa temperature
  - 2-meter temperature
  - 10-meter U
  - 10-meter V
- NCEP will publish all three ensembles which include raw and bias corrected forecast (about 80 raw variables, 50 bias corrected variables).

Northern Hemisphere 10 Meter U(wind)  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101231

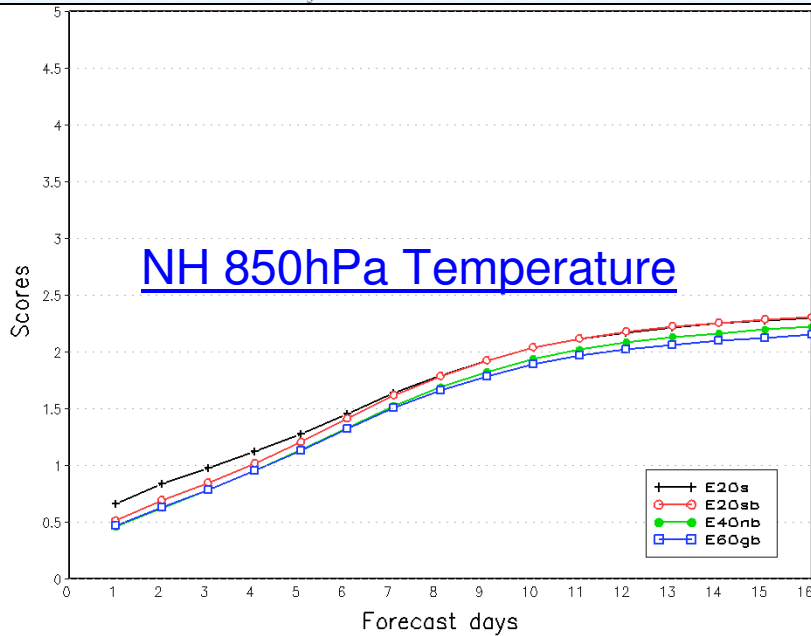


Northern Hemisphere 10 Meter V(wind)  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101231

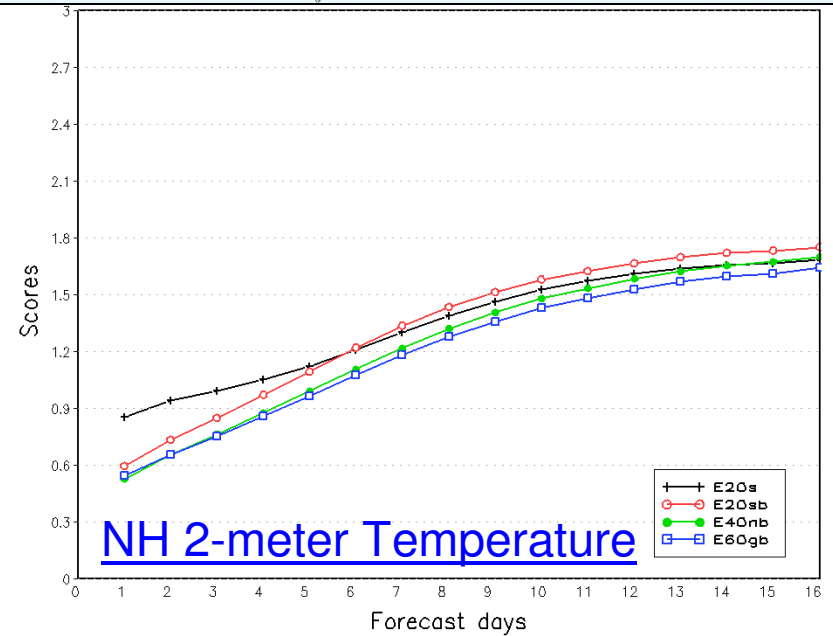


**4 months (Sep-Oct-Nov-Dec 2010) Statistics from NCO real time parallel**

Northern Hemisphere 850hPa Temp  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101231



Northern Hemisphere 2 Meter Temp  
Continuous Ranked Probability Scores  
Average For 20100901 – 20101231



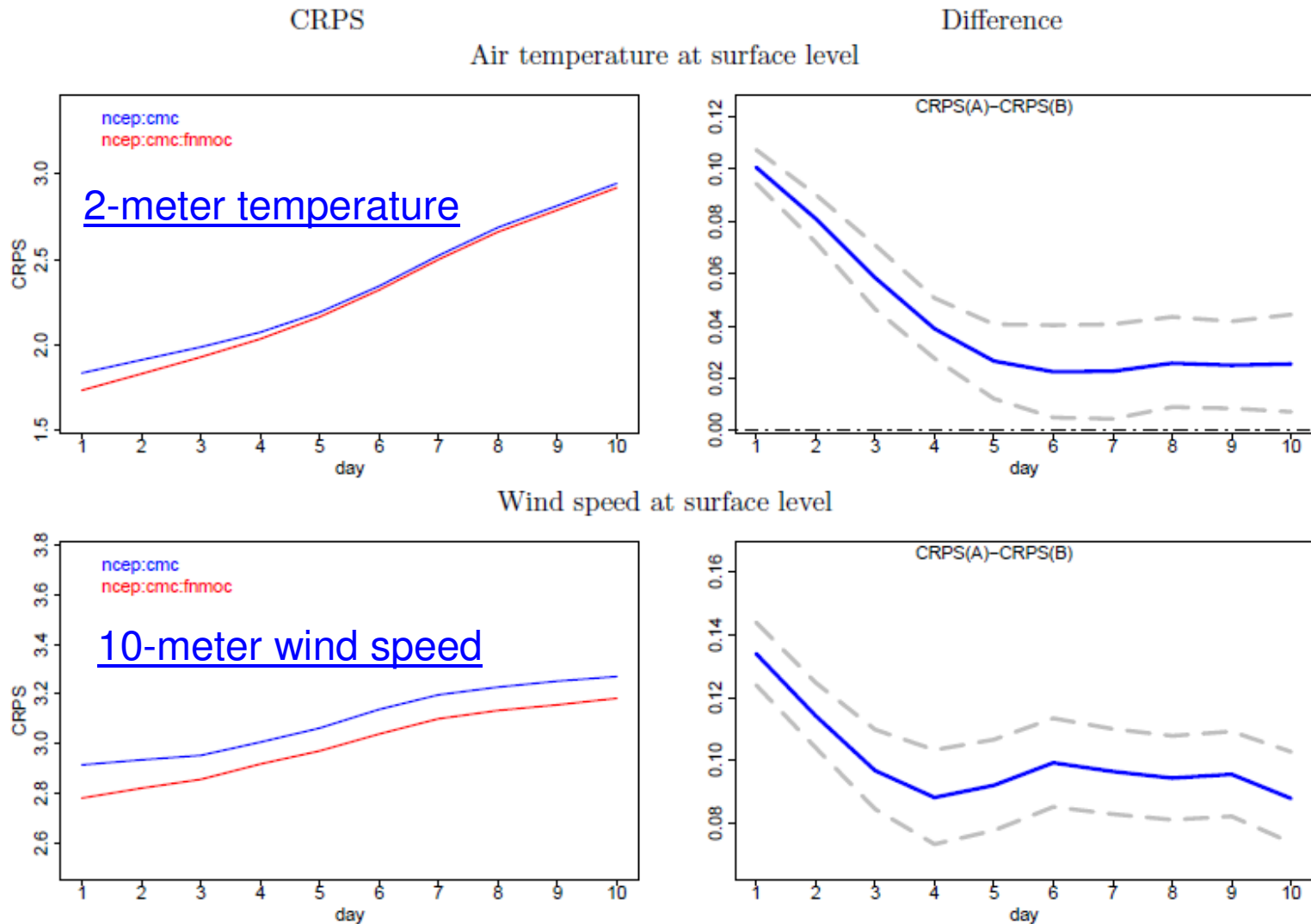
# Evaluations from CMC and AFWA

For raw ensemble forecast

Against observations

# Verification against observation (NH)

Raw ensemble forecast, Period: 11/17-12/21/2010



Courtesy of Normand Gagnon (CMC/MSO)

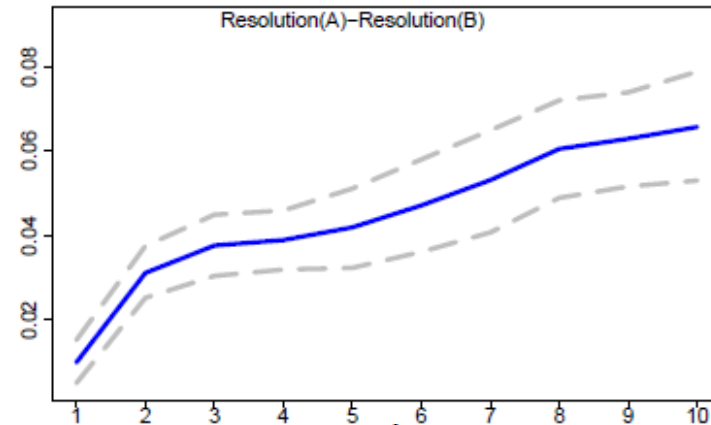
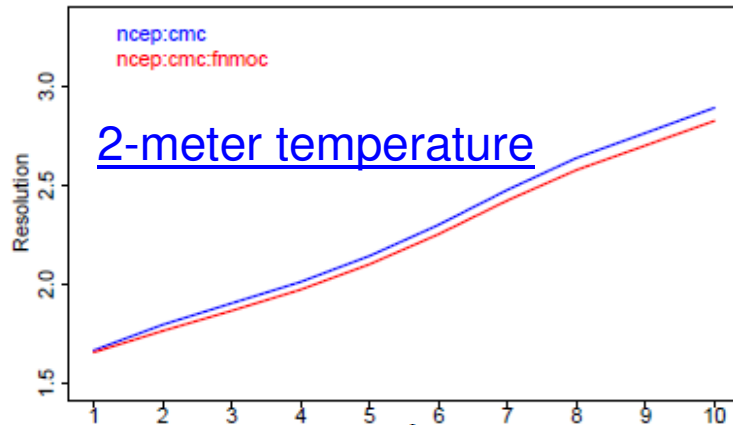
# Verification against observation (NH)

Raw ensemble forecast, Period: 11/17-12/21/2010

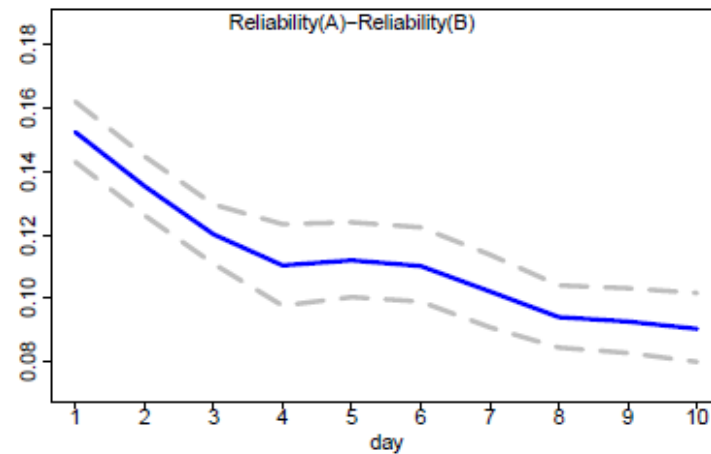
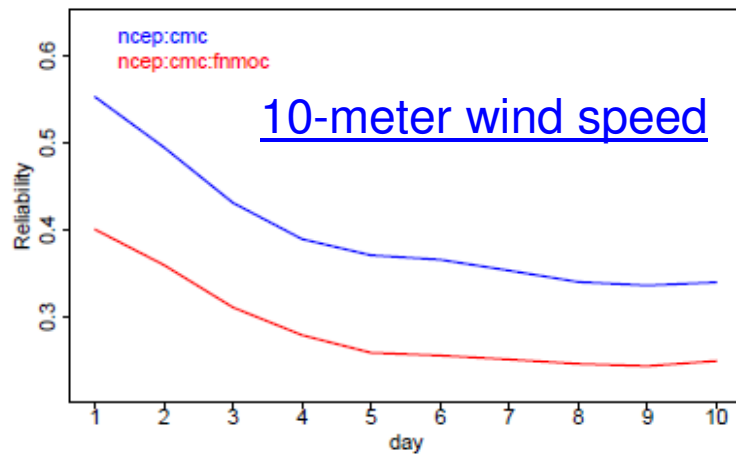
Resolution (CRPS term)

Difference

Air temperature at surface level

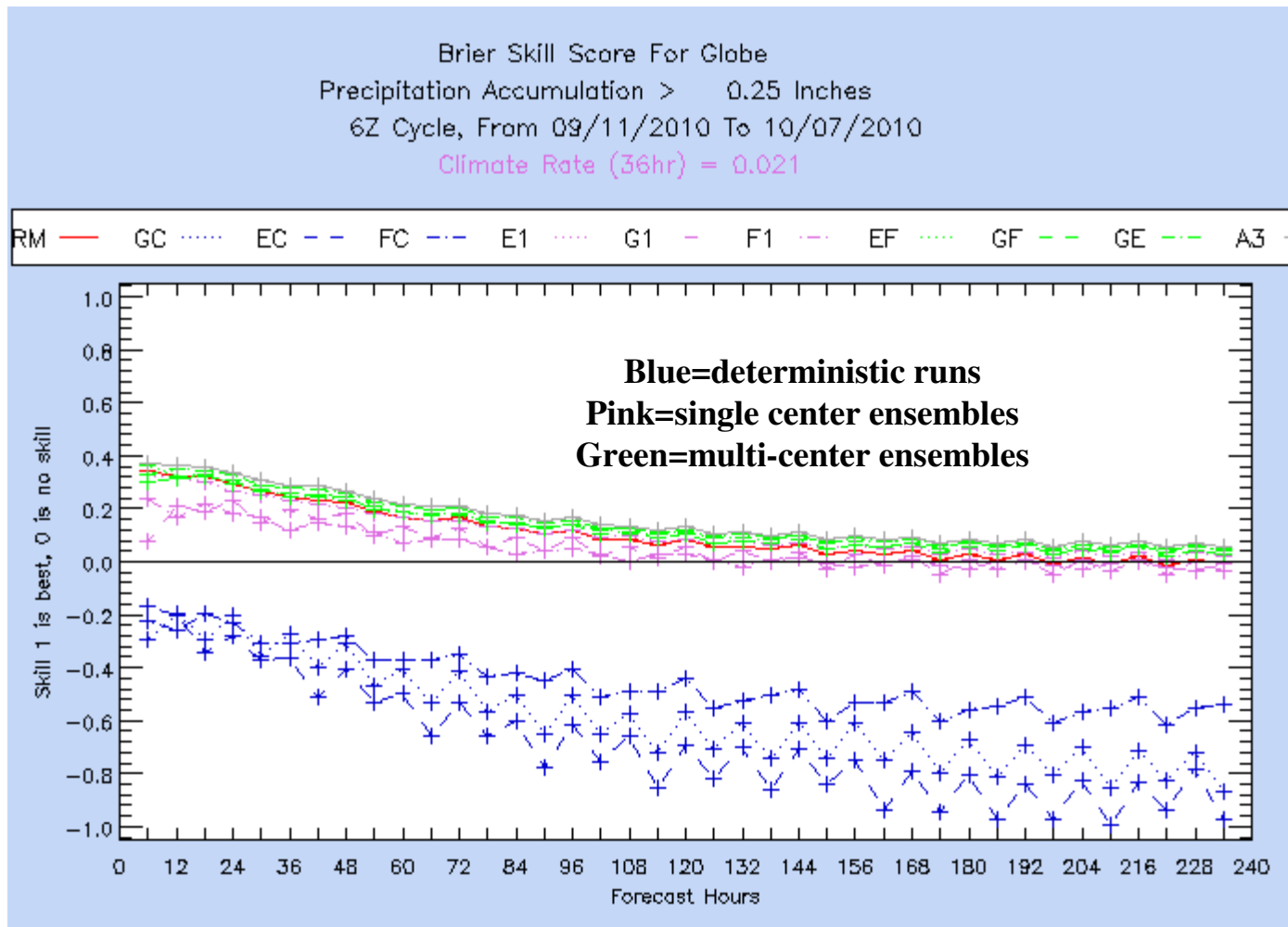


Wind speed at surface level

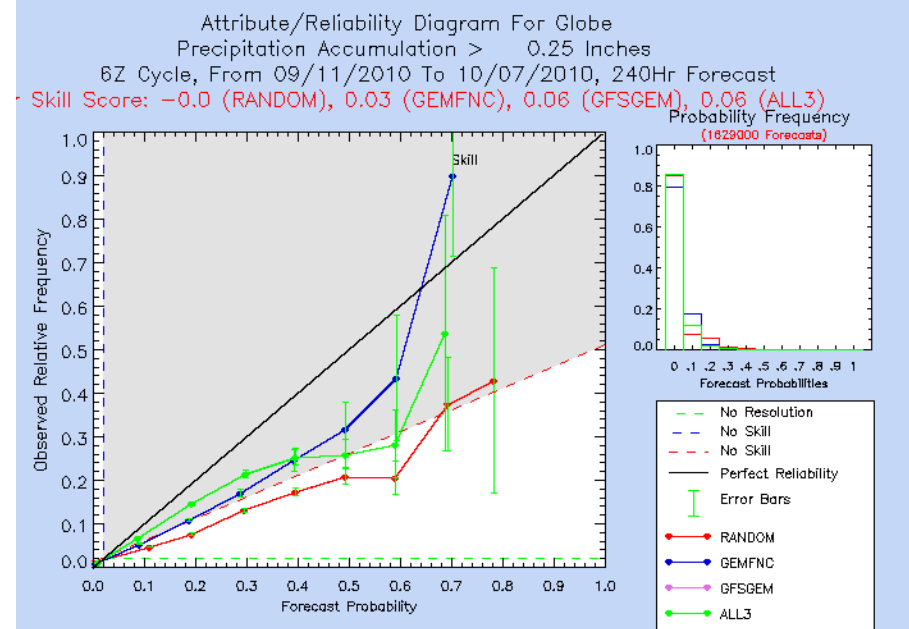
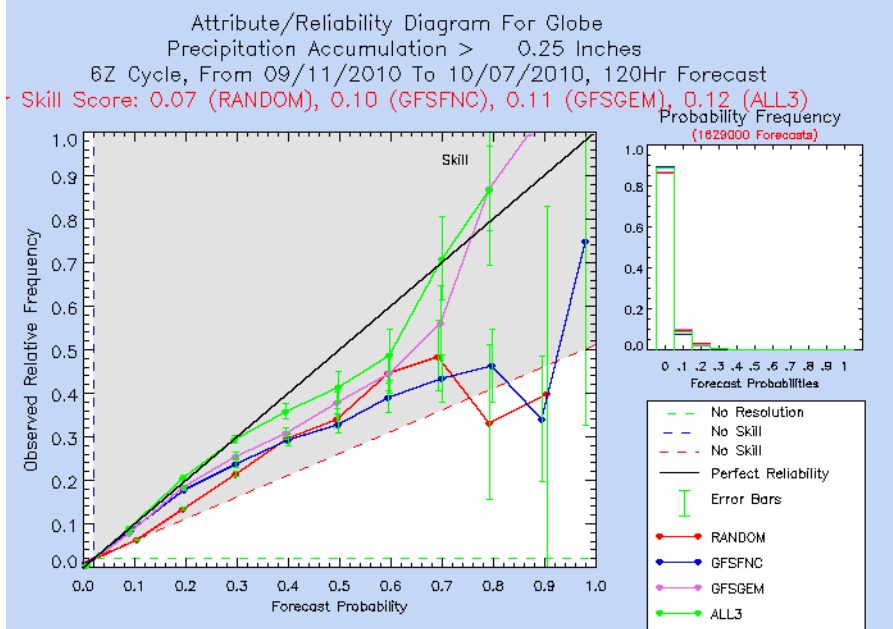
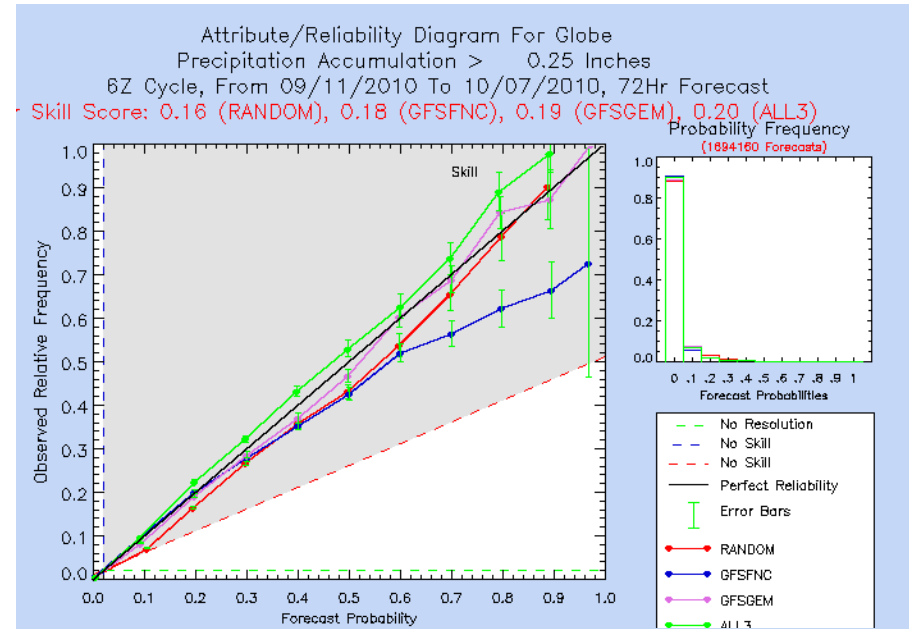
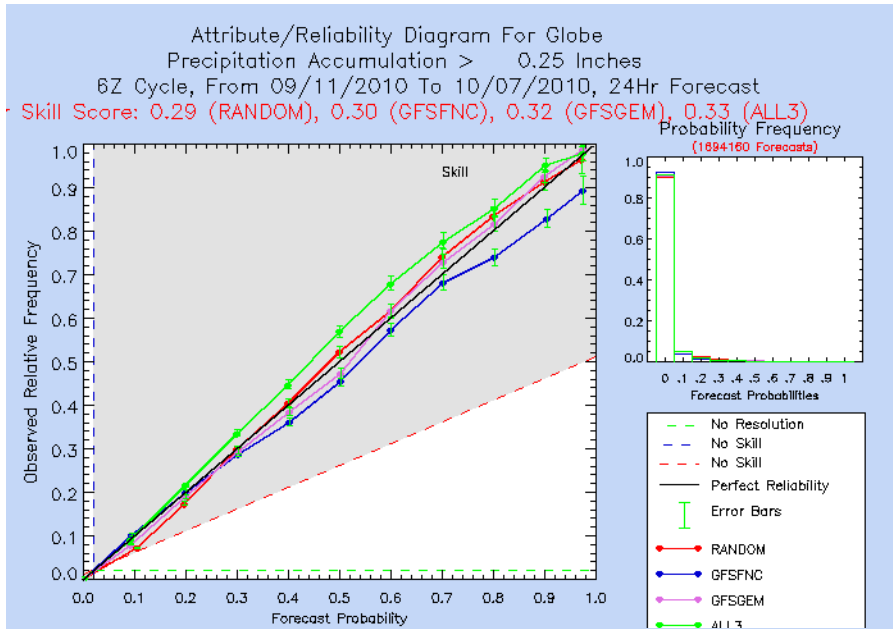


Courtesy of Norman Gagnon (CMC/MS)

# Ensemble Global Precip > .25 Inches (11 Sep – 7 Oct 2010)



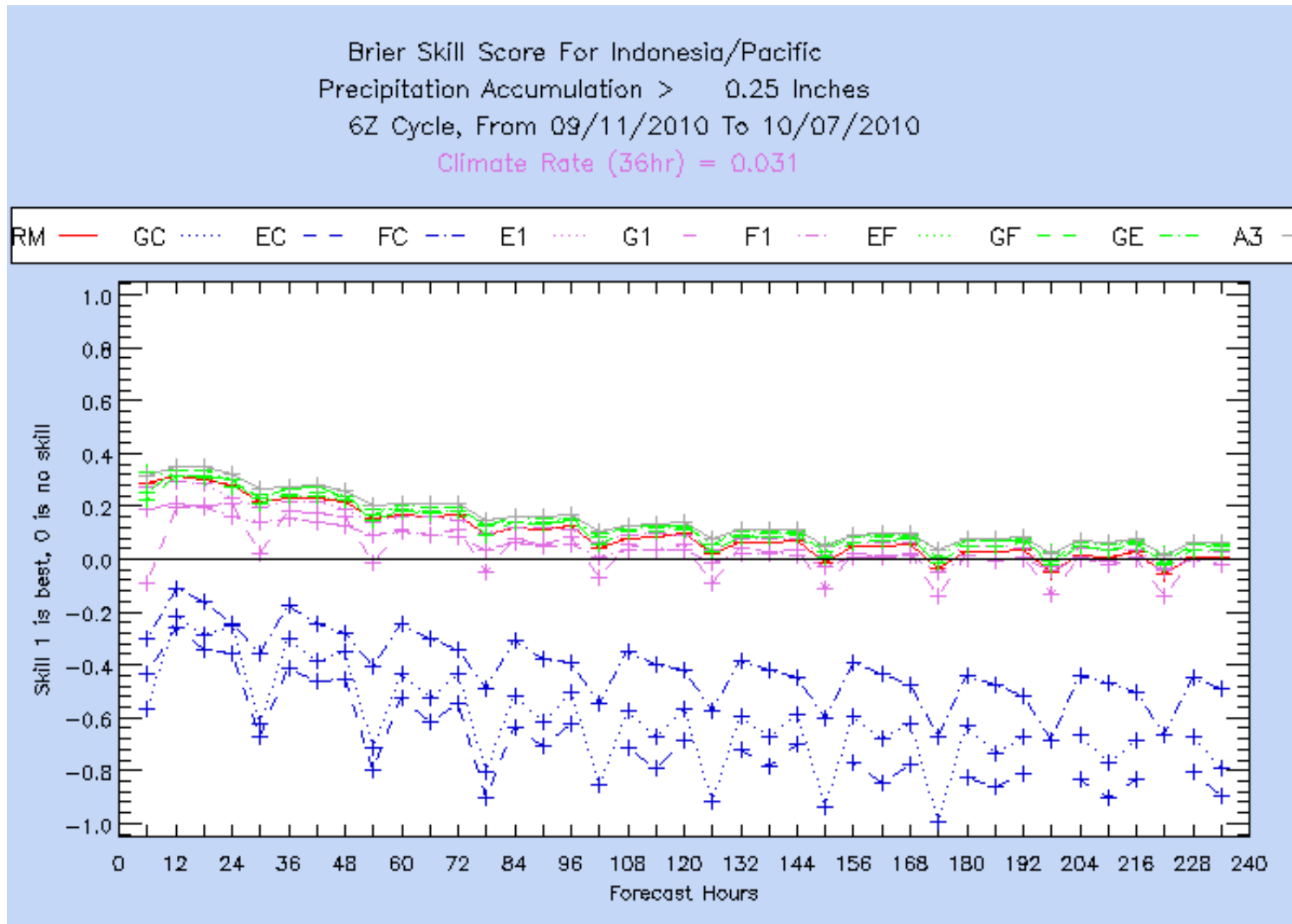
# Ensemble Global Precip > .25 Inches (Sep 11 – Oct 7 2010)



Courtesy of Evan Kuchera (AFWA)



# Ensemble Indo/Pac Precip > .25 Inches (Sep 11 – Oct 7 2010)



Courtesy of Evan Kuchera (AFWA)<sup>25</sup>

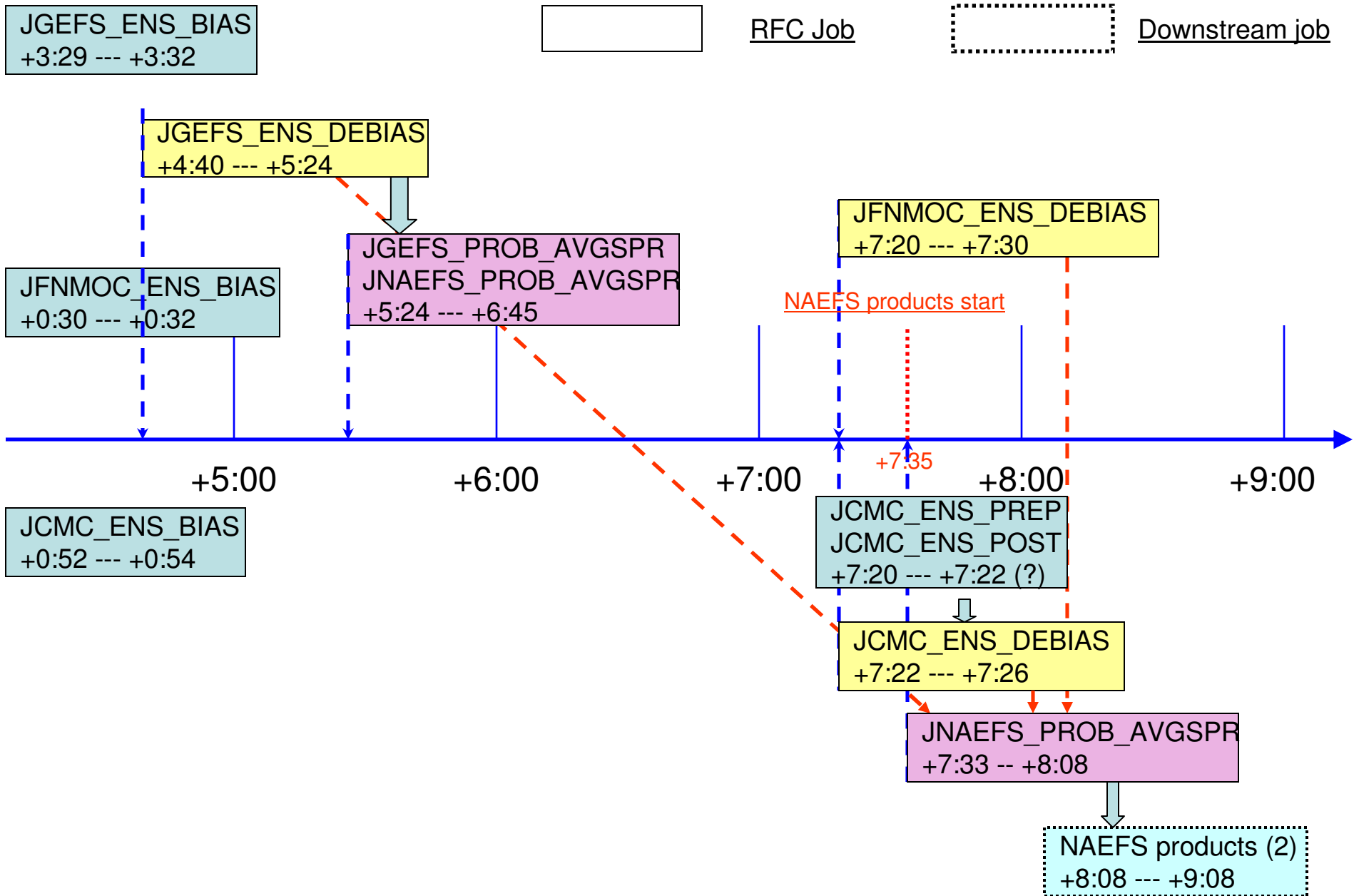
# Participate Evaluations

- HPC – probabilistic forecast for T2m (mainly)
  - 10%, 50%, 90%, mean and mode at 1 degree
  - 10%, 50%, 90%, mean and mode at 5km (CONUS)
  - No change for precipitations
  - *Comment: implement*
- CPC
  - Week-2 temperature anomaly forecast from NAEFS
  - *Comment: not recommend*
- OPC
  - 10-meter winds
  - *Comment: neutral*
- TPC
  - Not affect tracks, but 10-meter winds
  - *Comment: not participate*
- Results – No inclusion of FNMOC ensemble for NAEFS products

Background !!!

# Questions behind

- RFCs to NCO (Oct. 25-29)
- CPU/disk space (not a issue)
- Data distributions
  - TIN – has been sent out (10/12/2010)
- Charter – has been updated
- Risk and uncertainty
  - 30-45 days evaluation – short!!!
    - Not able to evaluate for different season
    - FNMOC ensembles are upgraded in past few month
      - 20 members (from 16 members)
      - Out to 16 days (from 10 days) forecast
      - Upgraded data assimilation (early this year)
      - Banded ET for ensemble initialization (May 2010)
    - NCEP GFS upgraded in July 2010
      - GEFS is still using n-1 GFS model, but analysis and ensemble initialization is using new GFS
      - This (analysis, forecast) unbalance needs to be continue studies
    - Not enough data samples for week-2 forecast evaluation
  - CCS maintenance (switch) – big problem
    - Extreme difficulty for EMC to maintain the data for evaluation
    - Disk space problem



# NAEFS/NUOPC 6-hr window flow chart