NAEFS post-process

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NOAA/NWS/NCEP

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NAEFS Configuration

Updated: February 23rd 2010

	NCEP	CMC
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 for ensemble mean	Bias correction for each member
Last implementation	February 23rd 2010	July 10th 2007

NAEFS exchange parameters

Last update: February 23rd 2010

Variables	pgrba file	Total 80 (28)
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (3)
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (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)
PRCP (types)	APCP, CRAIN, CSNOW, CFRZR, CICEP	5 (0)
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6 (6)
FLUX (top)	ULWRF (OLR)	1 (1)
PWAT	Total precipitable water at atmospheric column	1 (0)
TCDC	Total cloud cover at atmospheric column	1 (0)
CAPE and CIN	Convective available potential energy, Convective Inhibition	2 (1)
SOIL	SOILW(0-10cm), WEASD(water equiv. of accum. snow depth), SNOD(surface), TMP(0-10cm down)	4 (4)
Notes	Surface GHT is only in analysis file and first pgrb file when the resolution changed. 25 of 28 new variables are from pgrbb files, 10, 50hPa RH and SNOD are new variables	28 new vars

NAEFS bias corrected parameters

Last update: February 23rd 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)
		14 new vars
Notes		

NAEFS downscaling parameters

Last update: May 1st 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 is in real time parallel Expect implementation: Q4 FY2010			

NAEFS bias correction

NAEFS – bias correction

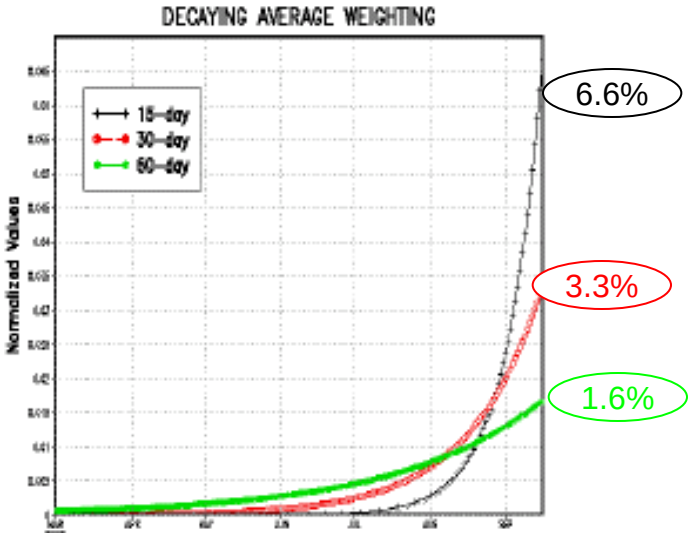
- Bias corrected NCEP/GEFS forecast
  - Consider the same bias for all ensemble members
  - Weight = 0.02 for Kaman filter (decaying) algorithm
- Bias corrected NCEP/GFS forecast
  - Use the same algorithm as ensemble bias correction
  - Up to 180 hours
- Bias corrected CMC/GEFS forecast
  - Consider the different bias for each model (member)
  - Use the same algorithm as ensemble bias correction
- 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) and CMC/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

Bias Correction Method & Application

- **Bias Correction Techniques** – array of methods
  - Estimate/correct bias moment by moment
    - Simple approach, implemented partially
    - May be less applicable for extreme cases
- **Moment-based method at NCEP**: apply adaptive (Kalman Filter type) algorithm

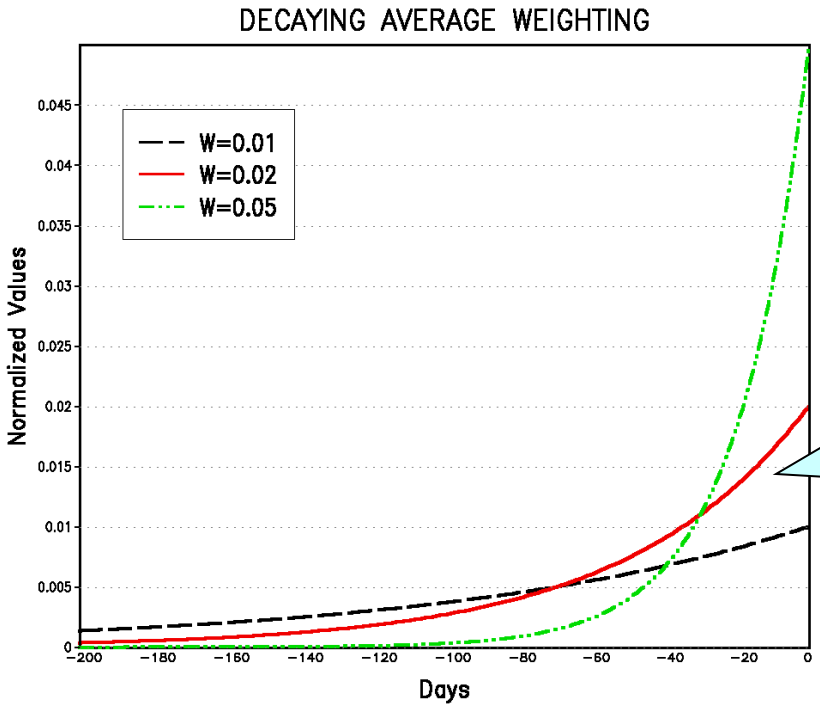
decaying averaging mean error = (1-*w*) * prior a.m.e + *w* * (f – a)

For separated cycles, each lead time and individual grid point, a.m.e = averaging mean error



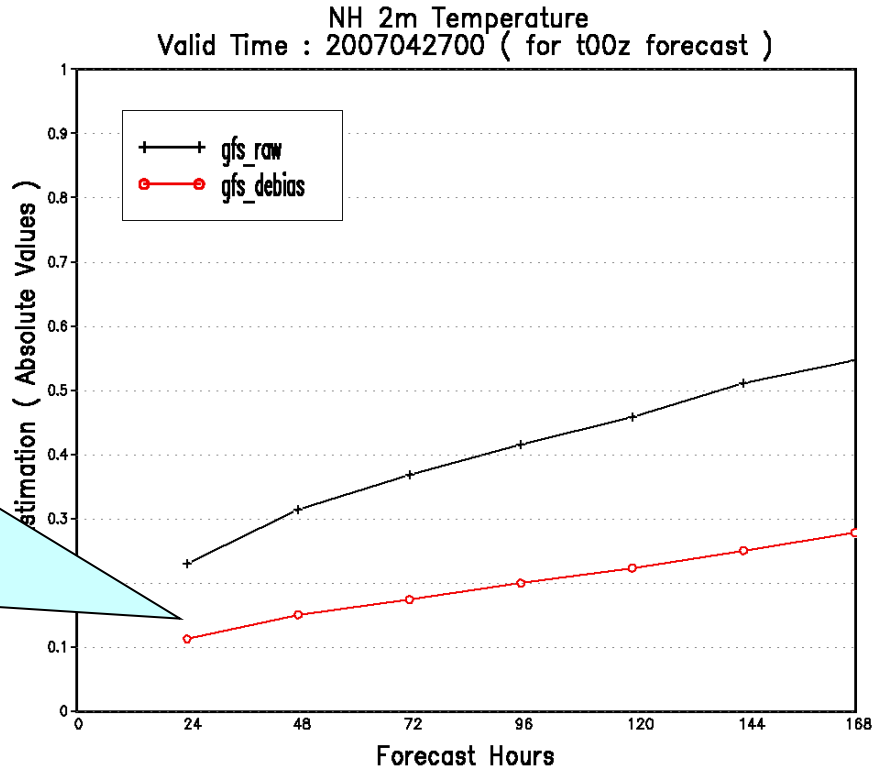
Toth, Z., and Y. Zhu, 2001

- Test different decaying weights. 0.25%, 0.5%, 1%, 2%, 5% and 10%, respectively
- Decide to use 2% (~ 50 days) decaying accumulation bias estimation

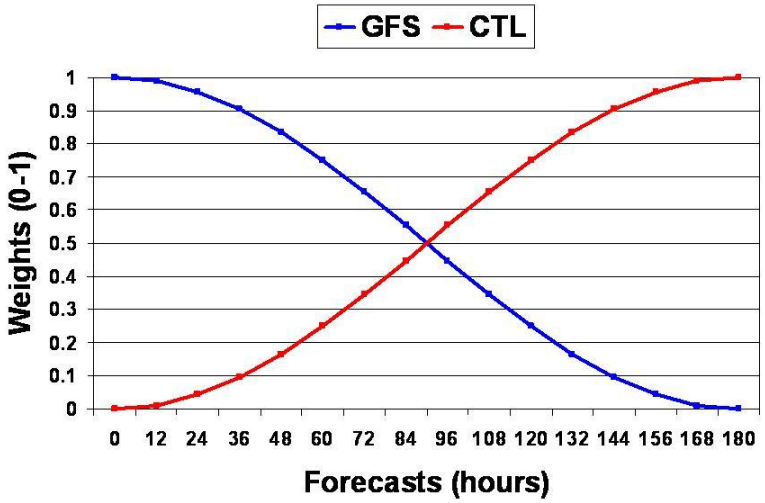


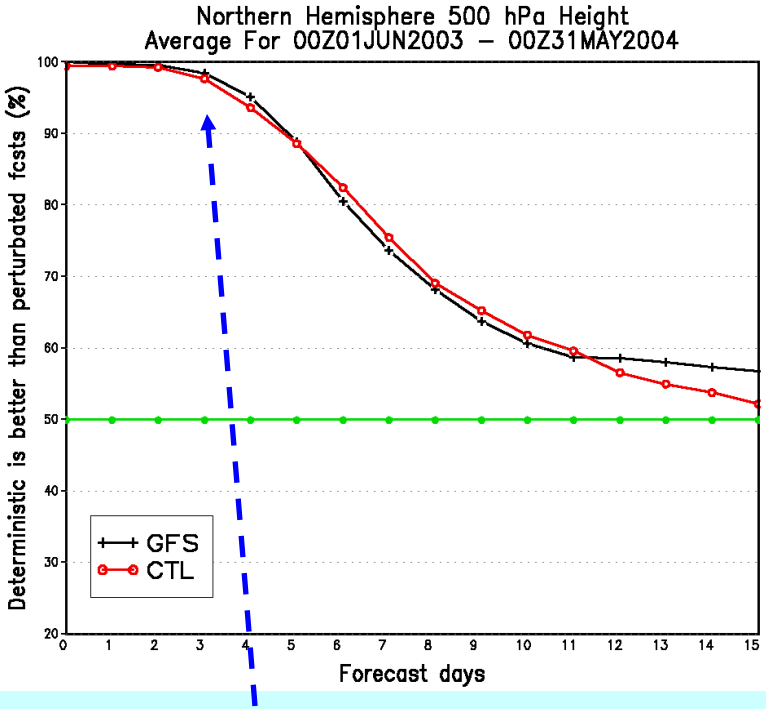
GFS/GEFS bias correction based on an accumulated bias by using decaying average weight (0.02) which is the same as GEFS used

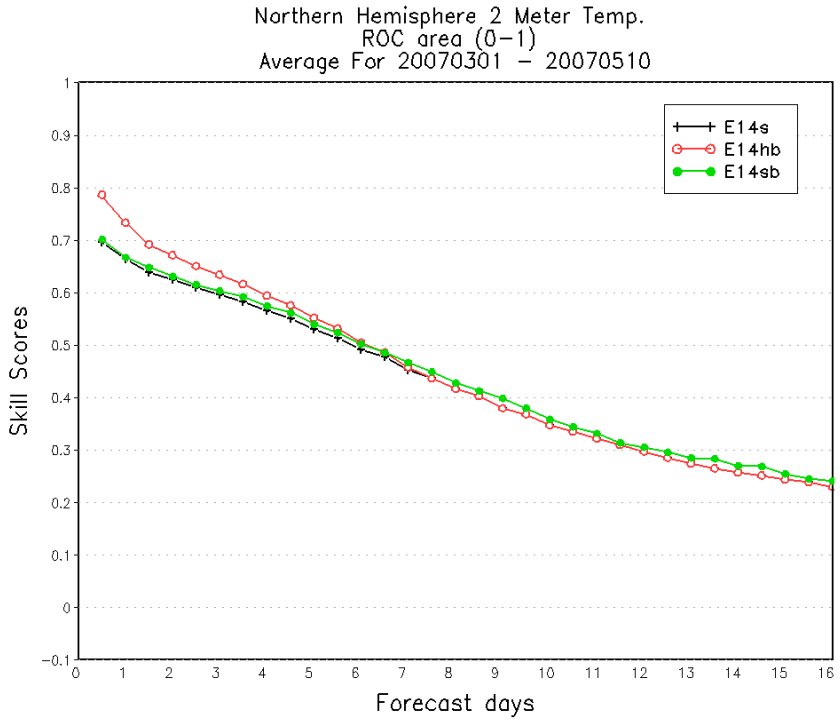
The absolute errors are reduced after bias correction for 2-meter temperature
(The stats are accumulated from 0.02 decaying average)



Combined GFS and GEFS forecasts at first 180hr





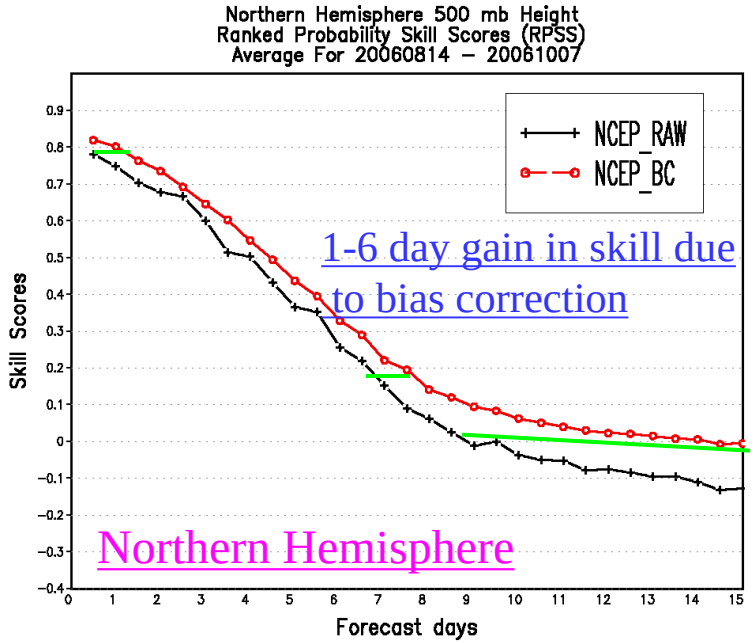


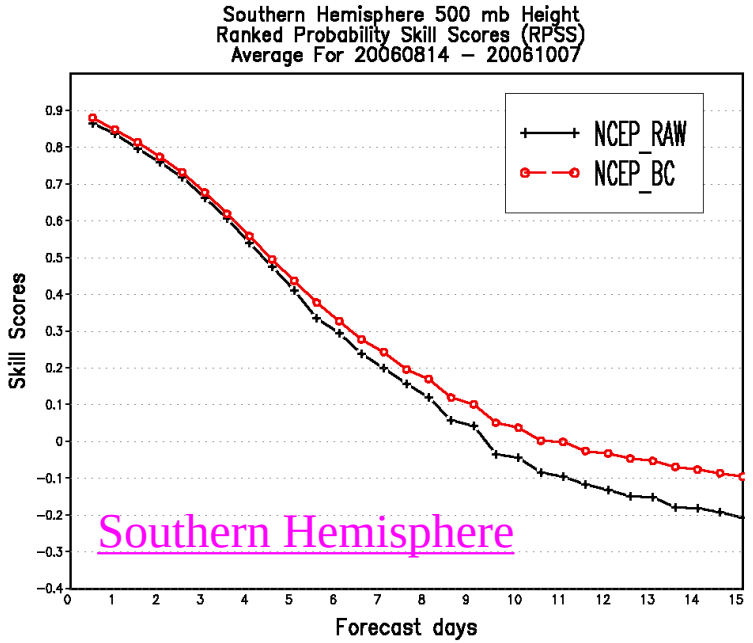
GFS has more skill than ensemble control for short lead time

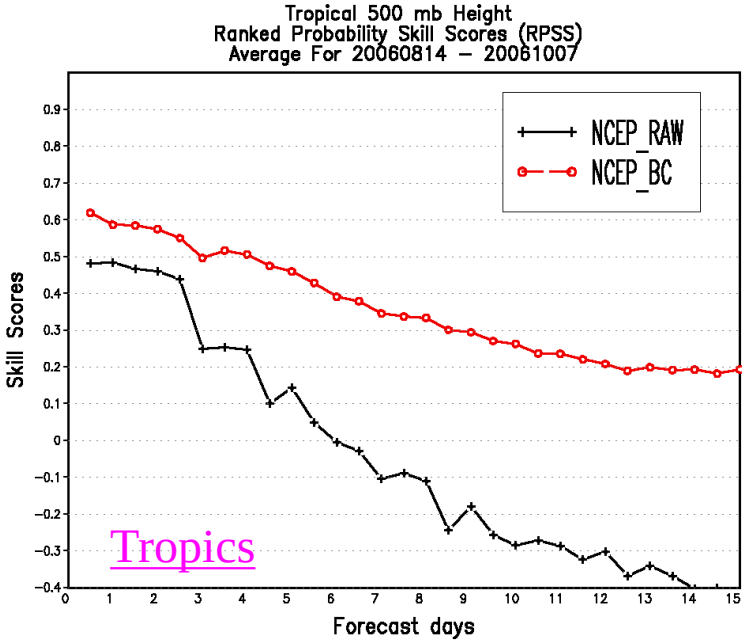
Combined GFS and GEFS Forecast has more skill (red) than GEFS only (black)

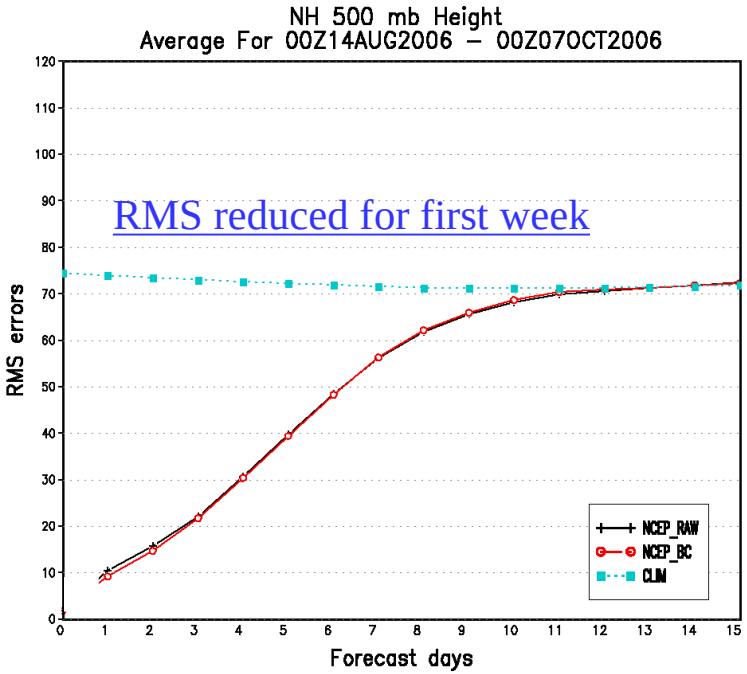
Jun Du first introduced dual-resolution to SREF, by using constant weight

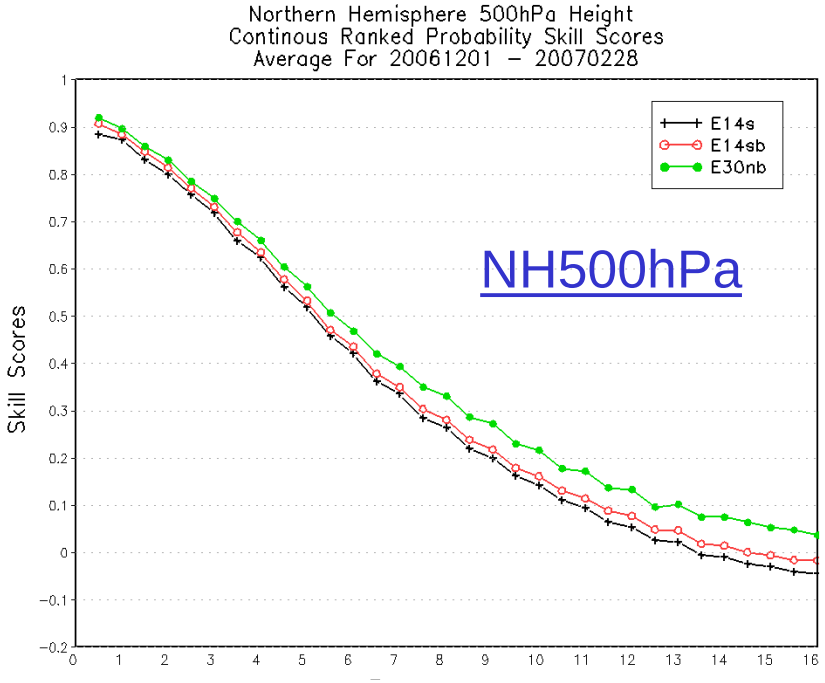
RPSS Before/After Bias Correction (NCEP 500 mb Height)

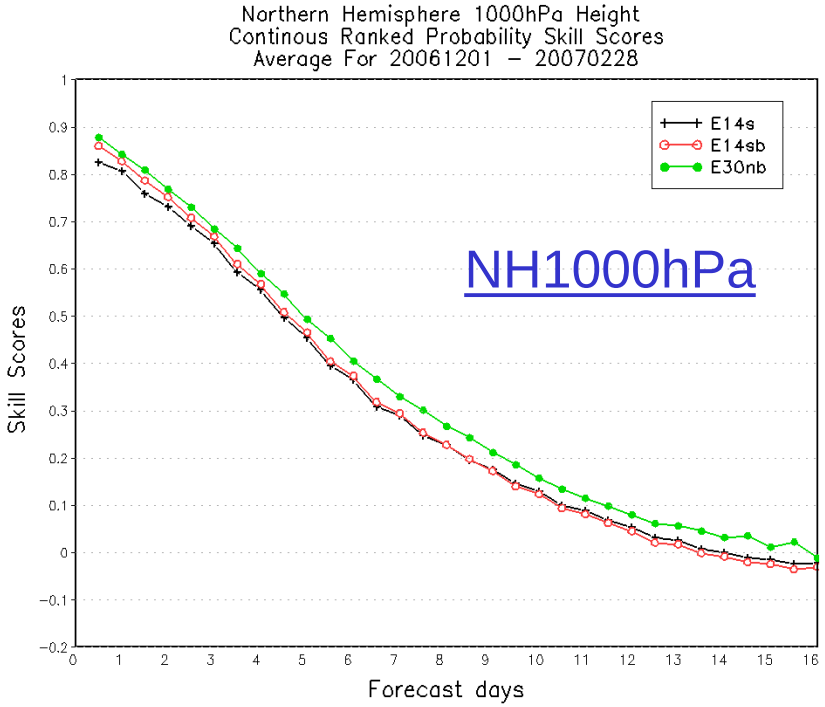


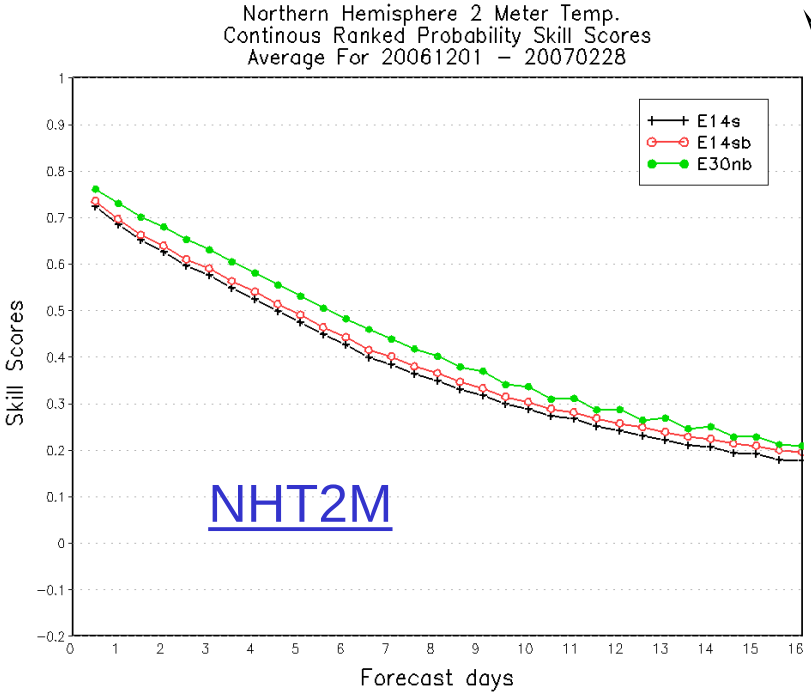






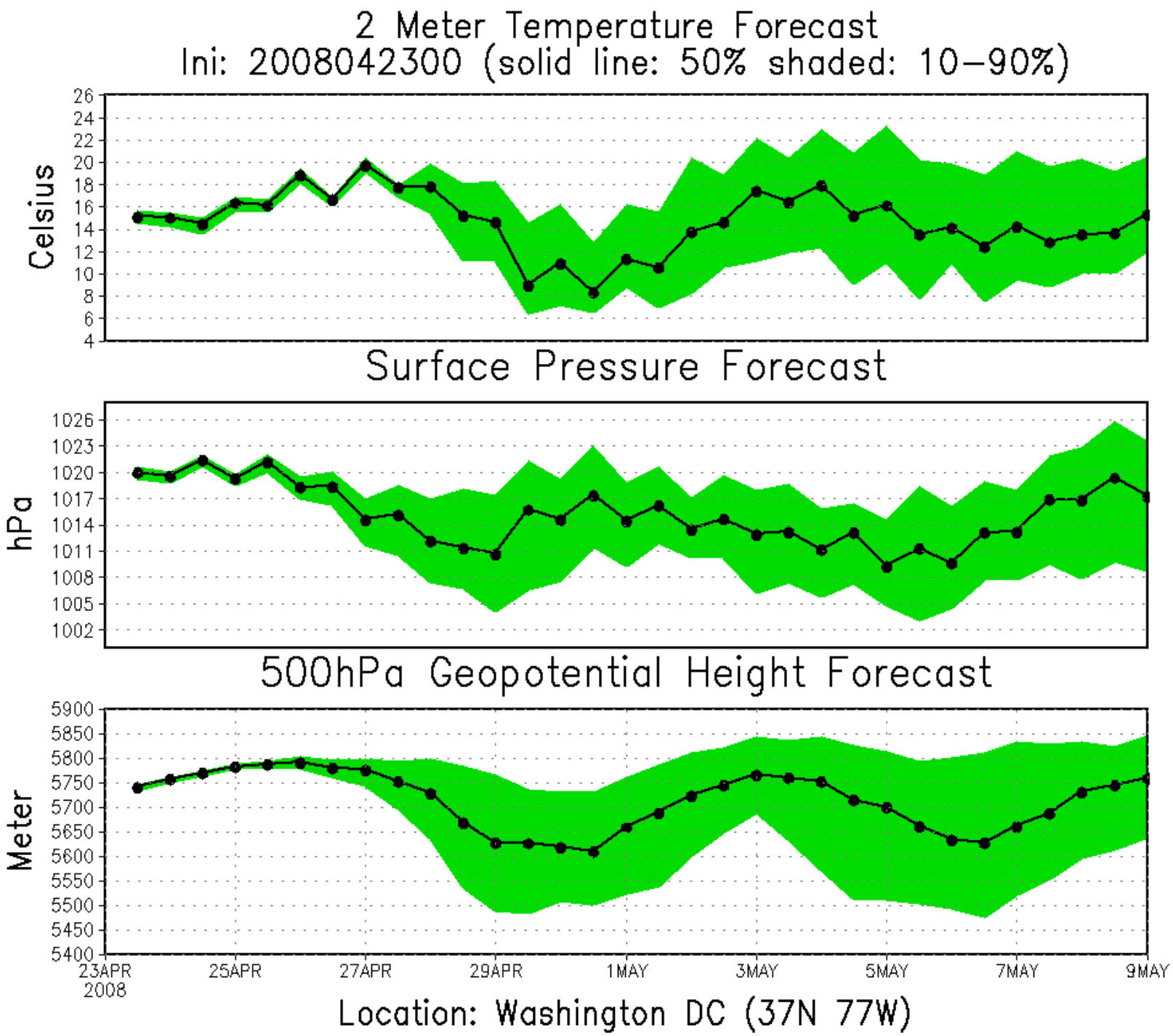




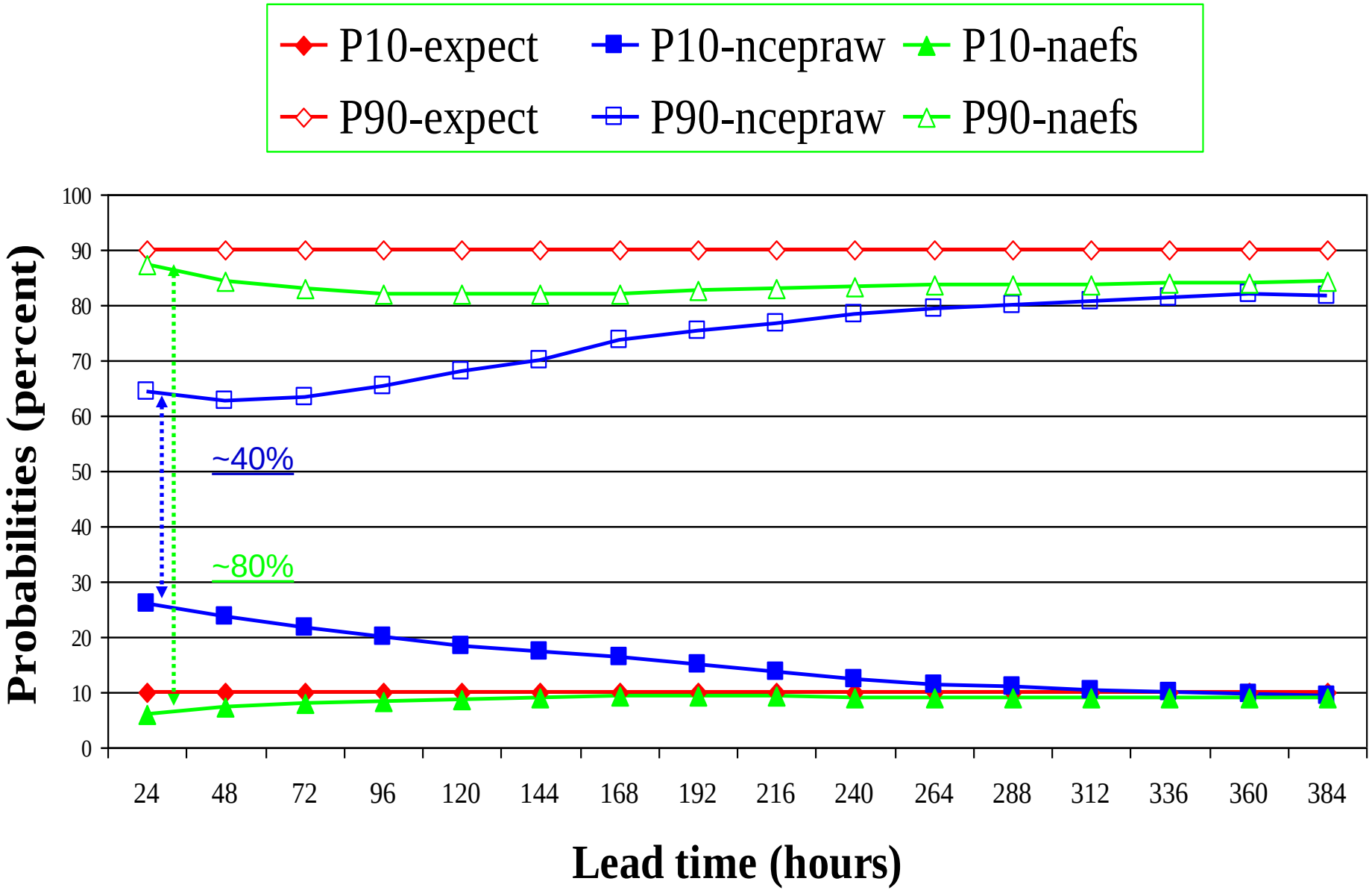


All these stats show the best values from probabilistic distribution of joined ensemble (NAEFS) for upper atmosphere and near surface.

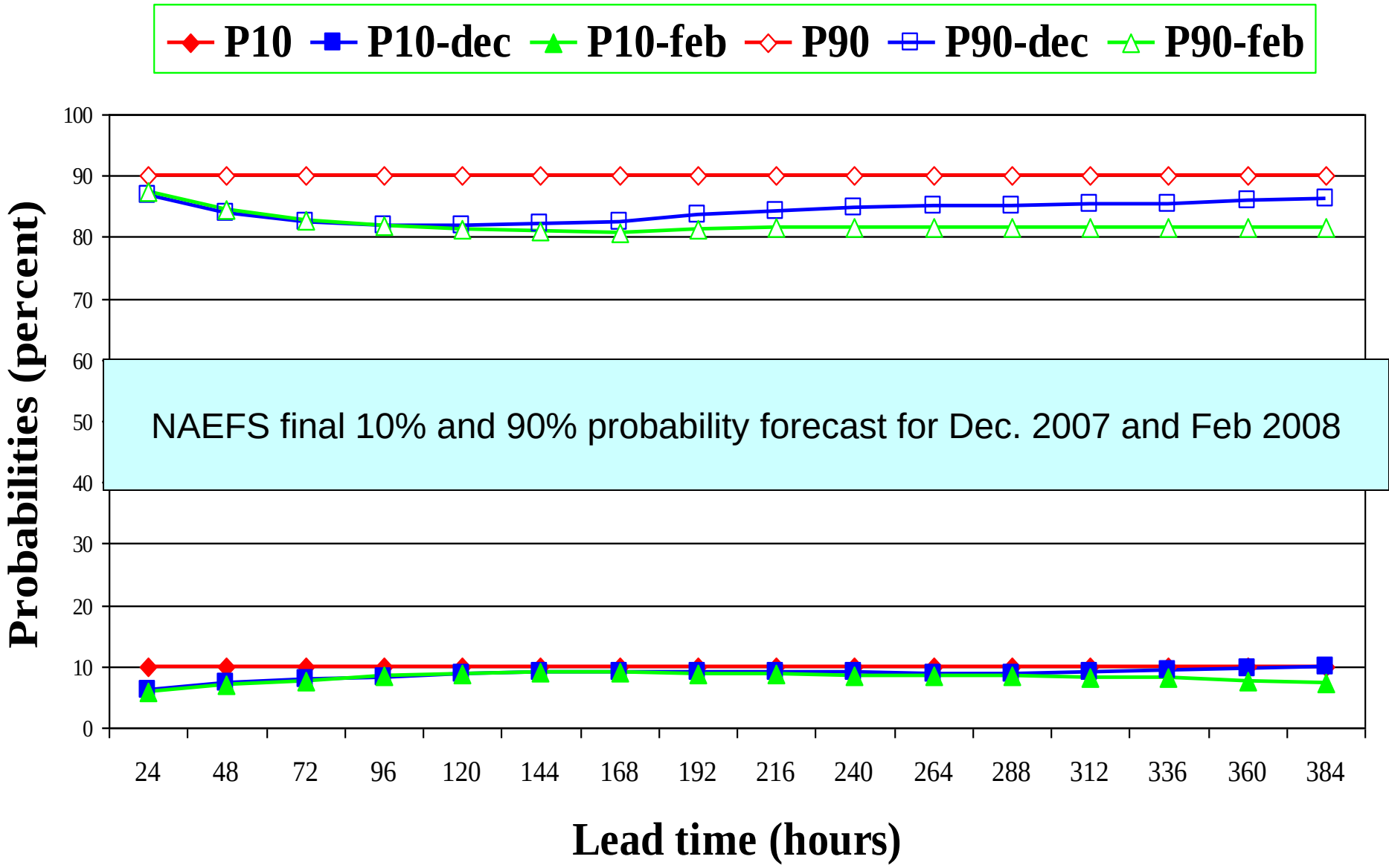
Green line is from NAEFS.


2 Meter Temperature Forecast
Ini: 2008042300 (solid line: 50% shaded: 10-90%)
Celsius
26
24
22
20
18
16
14
12
10
8
6
4
Surface Pressure Forecast
hPa
1026
1023
1020
1017
1014
1011
1008
1005
1002
500hPa Geopotential Height Forecast
Meter
5900
5850
5800
5750
5700
5650
5600
5550
5500
5450
5400
23APR
2008
25APR
27APR
29APR
1MAY
3MAY
5MAY
7MAY
9MAY
Location: Washington DC (37N 77W)

2-meter temperature 10/90 probability forecast verification
Northern Hemisphere, period of Dec. 2007 – Feb. 2008



2-meter temperature 10/90 probability forecast verification
Northern Hemisphere, seasonal variation for NAEFS



NAEFS statistical downscaling

CONUS

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

Downscaling Method with Decaying Averaging Algorithm

- True = high resolution analysis
  - Operational North American Real-Time Mesoscale Analysis (RTMA)
    - 5x5 km National Digital Forecast Database (NDFD) grid (e.g. G. DiMego et al.)
    - 4 variables available: surface pressure, T2m, 10m U and V
  - Other data can also be used

- Downscaling method: apply decaying averaging algorithm

$$\text{Downscaling Vector}^{5km}(t_0) = (1-w) * \text{prior DV}^{5km}(t_{-1}) + w * (\text{GDAS}^{5km}(t_0) - \text{RTMA}^{5km}(t_0))$$

  - *GDAS^{5km}: GDAS 1x1 analysis interpolated to RTMA^{5km} grids by bilinear interpolation*
  - *4 cycles, individual grid point, DV^{5km} = Downscaling Vector on 5km grids*
  - *choose different weight: 0.5%, 1%, 2%, 5%, 10%*

- Downscaling Process

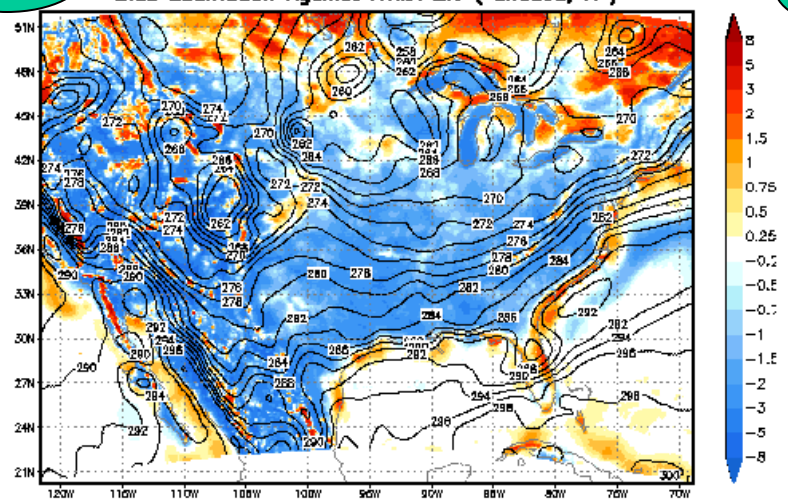
$$\text{Downscaled Forecast}^{5km}(t) = \text{Bias-corrected Forecast}^{5km}(t) - \text{DV}^{5km}(t_0)$$

  - *Bias-corrected Forecast$^{5km:}$ interpolated to RTMA^{5km} grids by bilinear interpolation*
  - *subtract DV^{5km} from bias-corrected forecast^{5km} valid at analysis time*

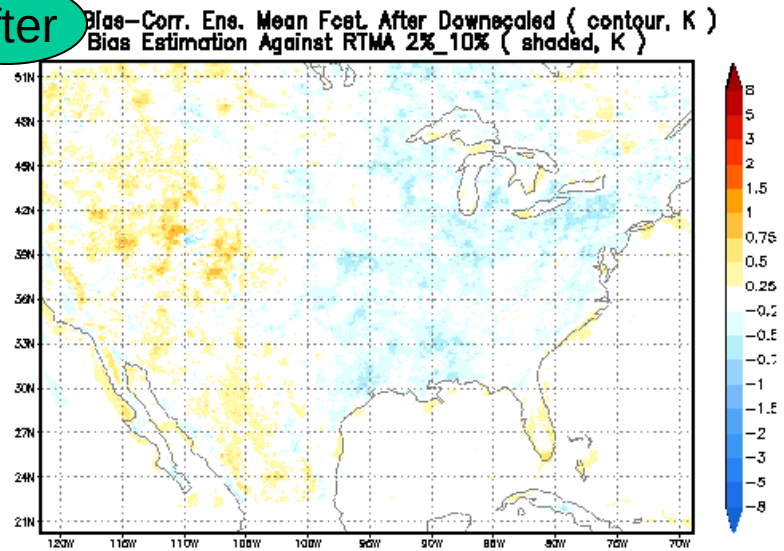
00hr GEFS Ensemble Mean & Bias Before/After Downscaling 10%

2m Temperature

Before



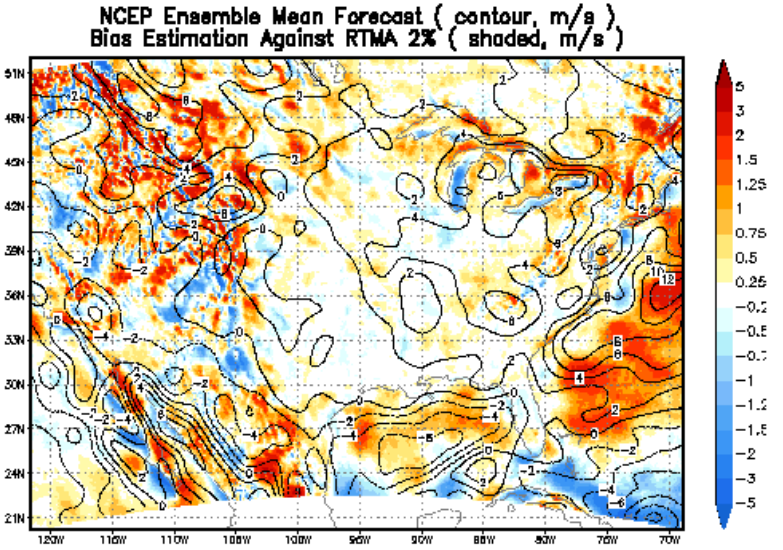
After



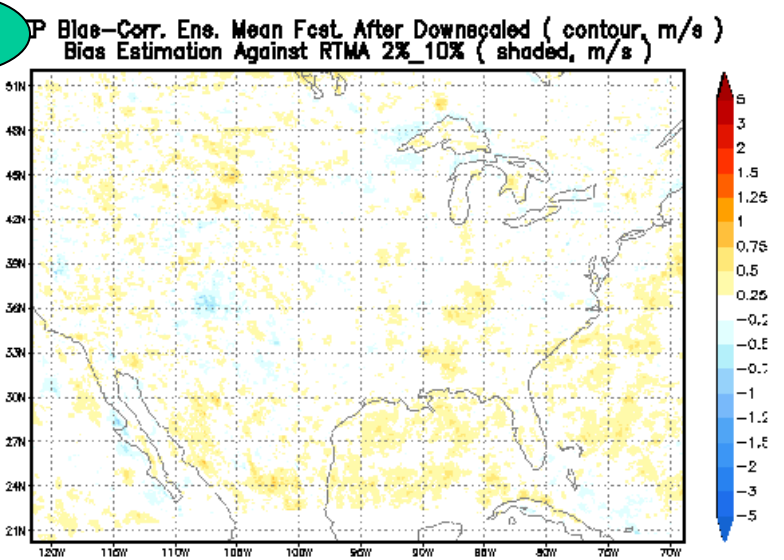
BO CUI, GCWMB/EMC/NCEP/NOAA

10m U Wind

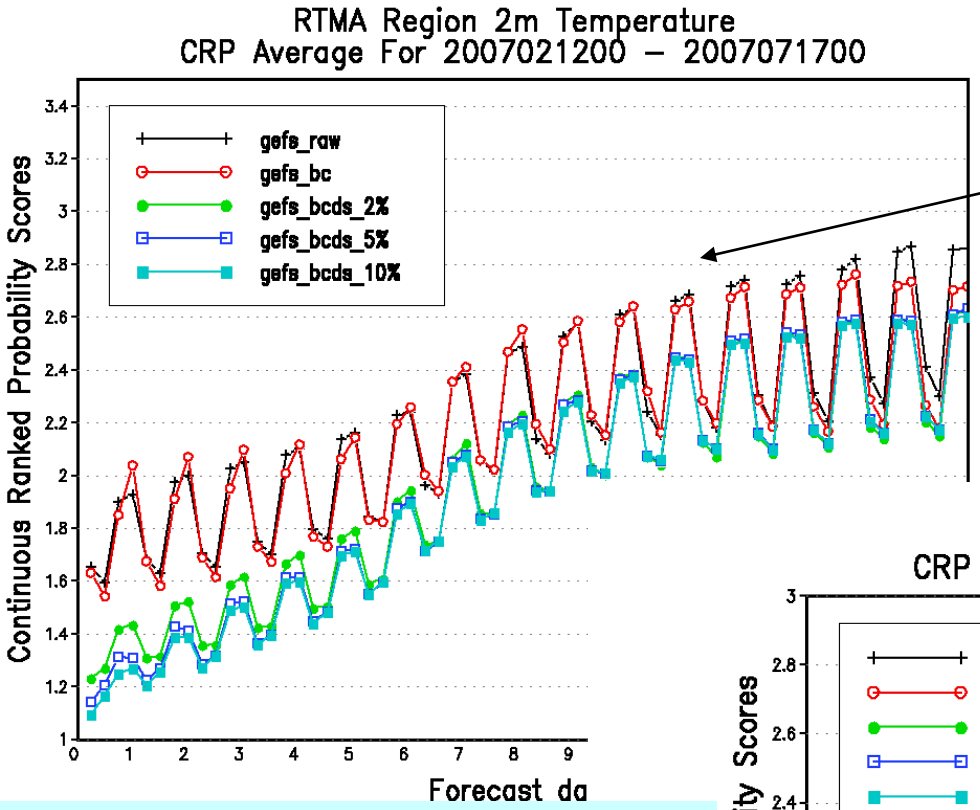
Before



After

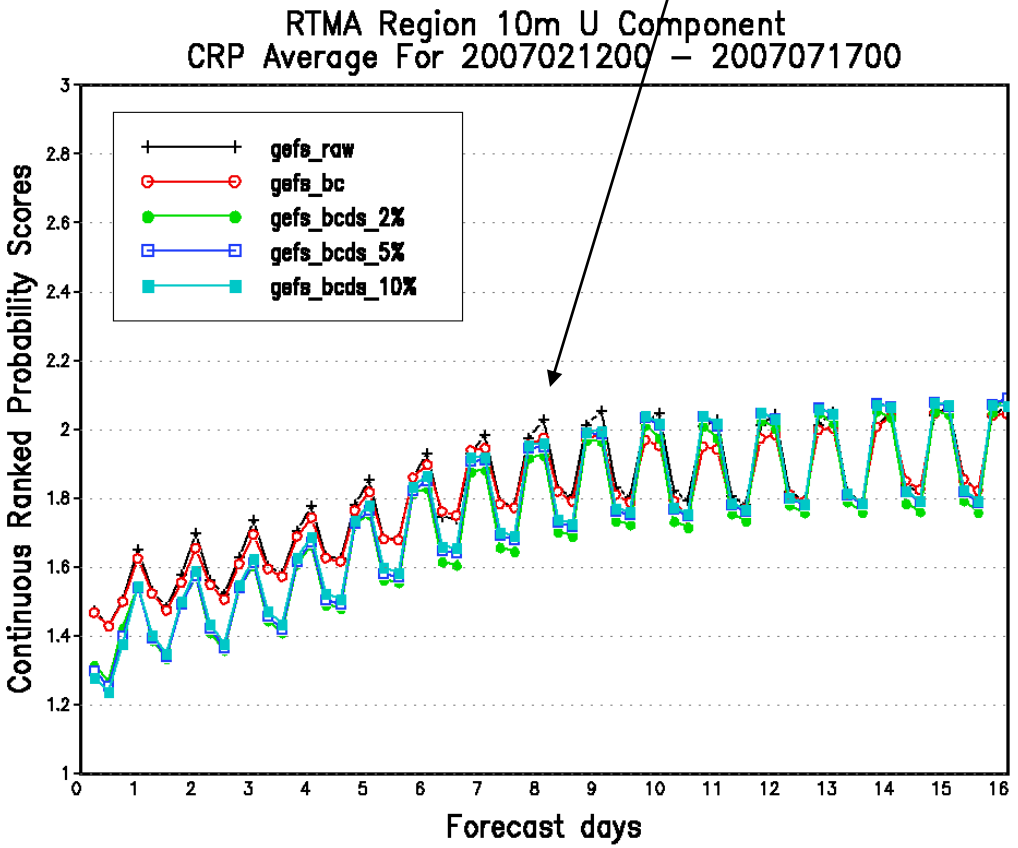


BO CUI, GCWMB/EMC/NCEP/NOAA



T2M for CONUS

U10m for CONUS



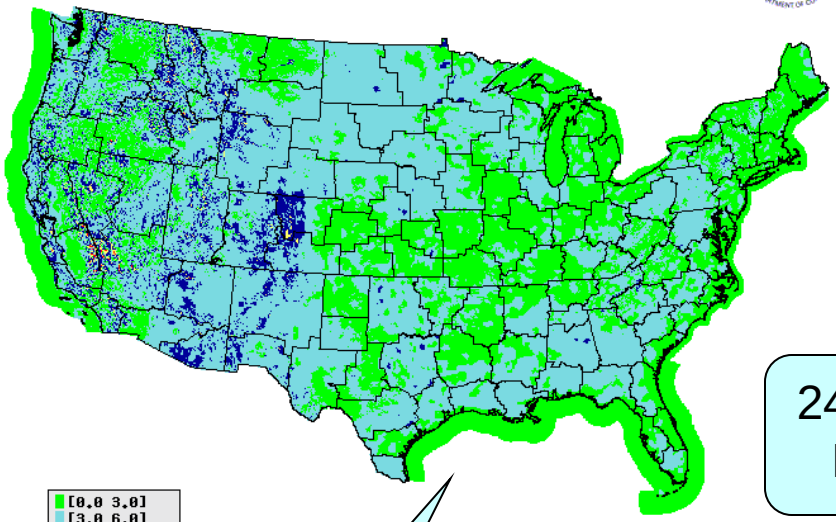
Continuous Ranked Probability Scores (CRPS) is to measure the distance of truth from ensemble's distribution. These two stats show which decaying weight is best to CONUS region statistical down-scaling

Statistical Downscaling Verification

- Contribute by MDL

- 2-meter temperature only
- Period: July 20 – August 28 2007 (40 days)
- All verifications against RTMA
- NDFD: Official forecasts from previous day 12UTC
- GMOS: Gridded MOS forecasts from 00UTC
- GEFS: Bias corrected & downscaled 00UTC GEFS forecasts
  - Bias corrected NCEP GEFS ensemble mean only
    - Significant improvements not assess yet from
      - Dual resolution GEFS
      - NAEFS combination (GEFS + CMC)
      - Tuned downscaling method (0.3 coefficient instead of 0.1)

NDFD vs RTMA Surface Temp. MAE (deg F)
012-h NDFD Proj. from 12Z Ref. Time
July 20-August 28, 2007

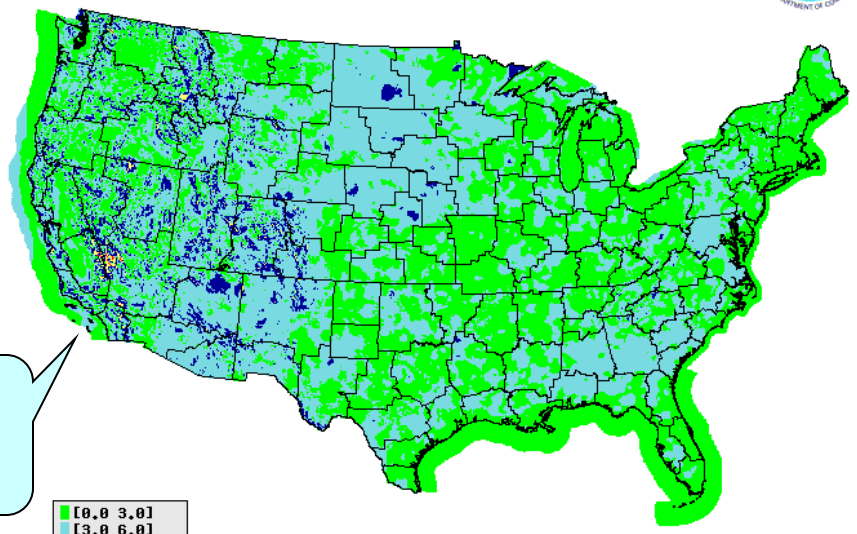


[0.0 3.0]
[3.0 6.0]
[6.0 12.0]
[12.0 20.0]
[20.0 30.0]
[30.0 50.0]
[50.0 999.0]

CONUS	3.60
EASTERN	2.92
CENTRAL	3.55
WESTERN	4.26
SOUTHERN	3.27

12-h NDFD Forecast

GMOS vs RTMA Surface Temp. MAE (deg F)
Matches 012-h NDFD Proj. from 12Z Ref. Time
(024-h GMOS fcst available ~5:30Z)
July 20-August 28, 2007

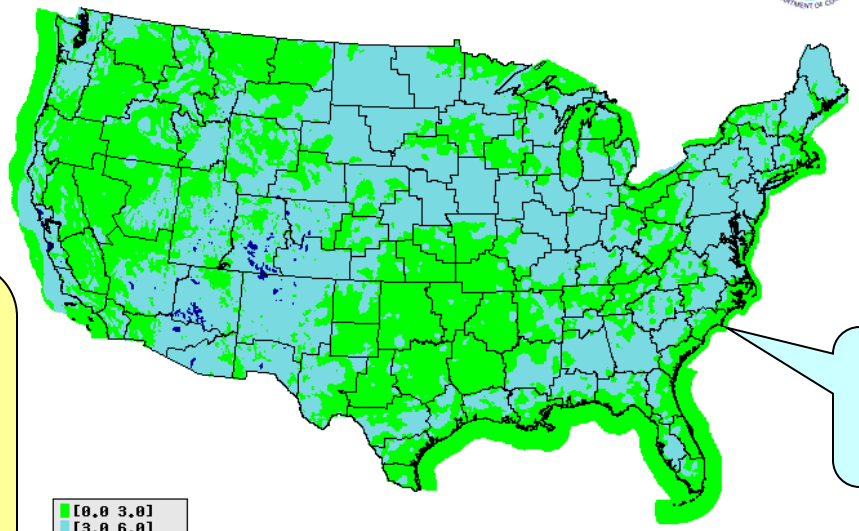


24-h GMOS Forecast

[0.0 3.0]
[3.0 6.0]
[6.0 12.0]
[12.0 20.0]

CONUS	3.37
EASTERN	2.80
CENTRAL	3.43
WESTERN	3.98
SOUTHERN	2.92

ENS vs RTMA Surface Temp. MAE (deg F)
Matches 012-h NDFD Proj. from 12Z Ref. Time
(024-h ENS fcst available ~??:??Z)
July 20-August 28, 2007



24-h GEFS Forecast

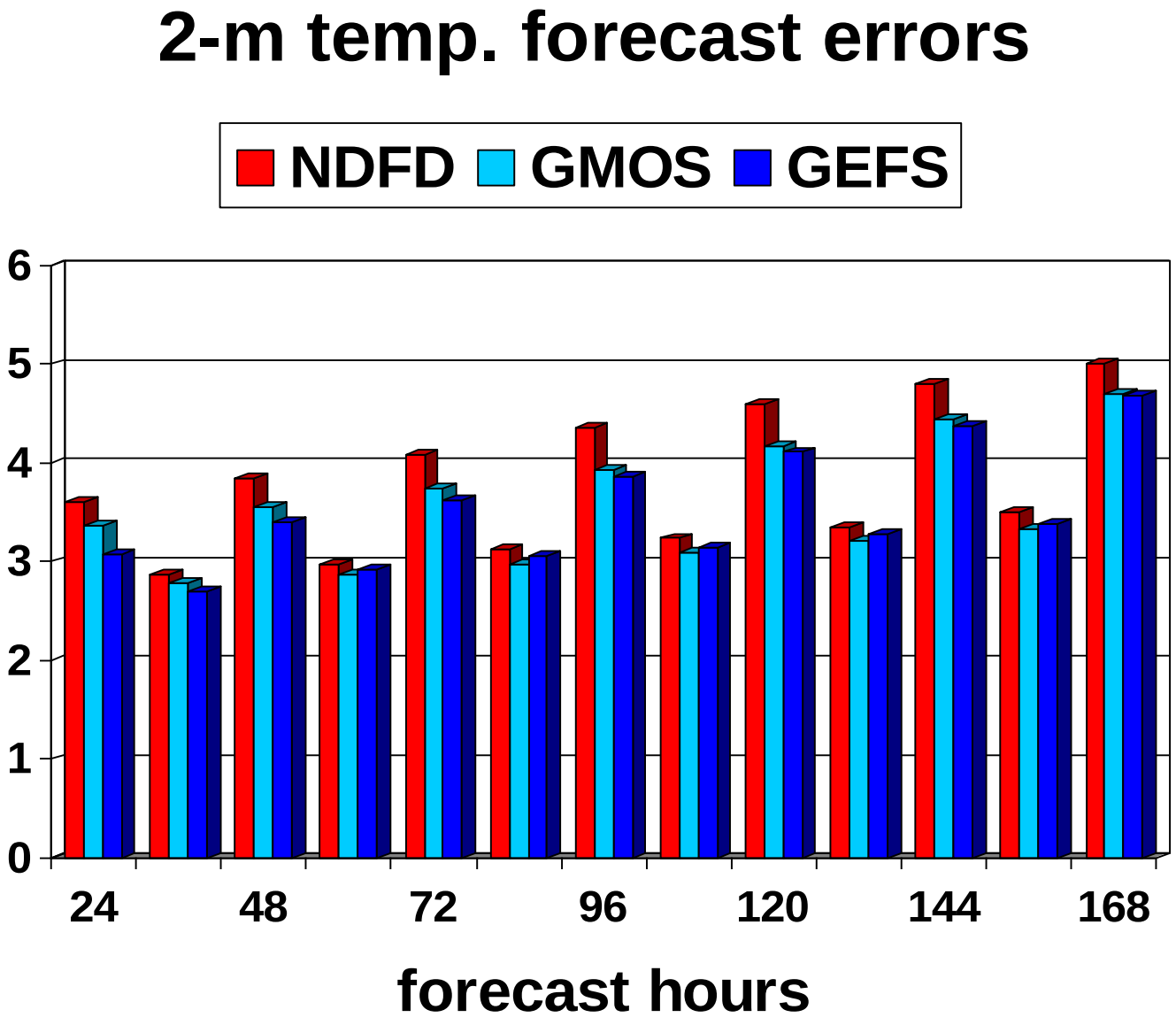
[0.0 3.0]
[3.0 6.0]
[6.0 12.0]
[12.0 20.0]
[20.0 30.0]
[30.0 50.0]
[50.0 999.0]

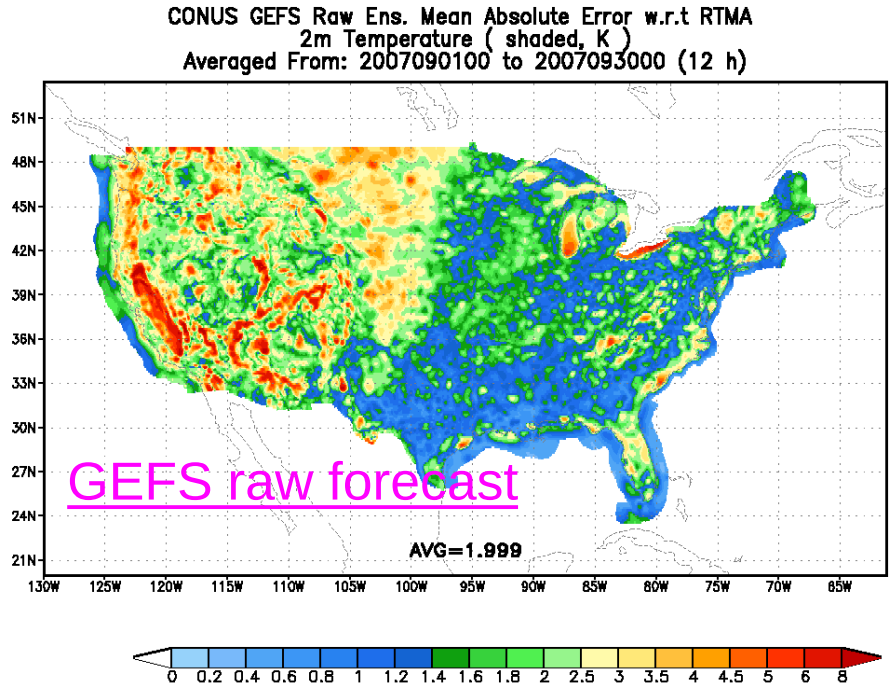
CONUS	3.07
EASTERN	3.12
CENTRAL	3.41
WESTERN	3.01
SOUTHERN	2.72

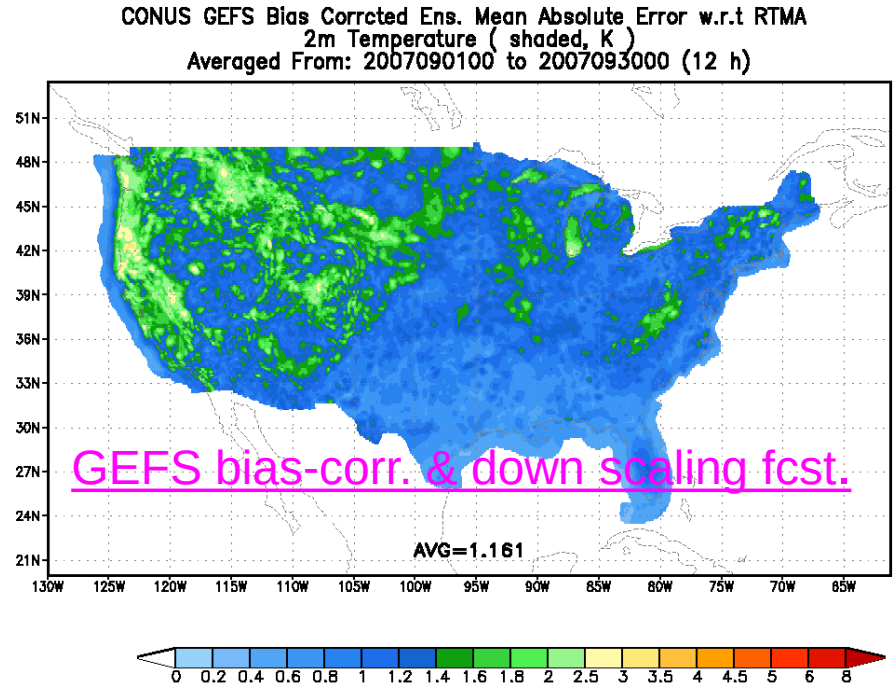
For CONUS:
GEFS(3.07) : NDFD(3.60)
17% impr. Over NDFD
GEFS(3.07) : GMOS(3.37)
10% impr. Over GMOS

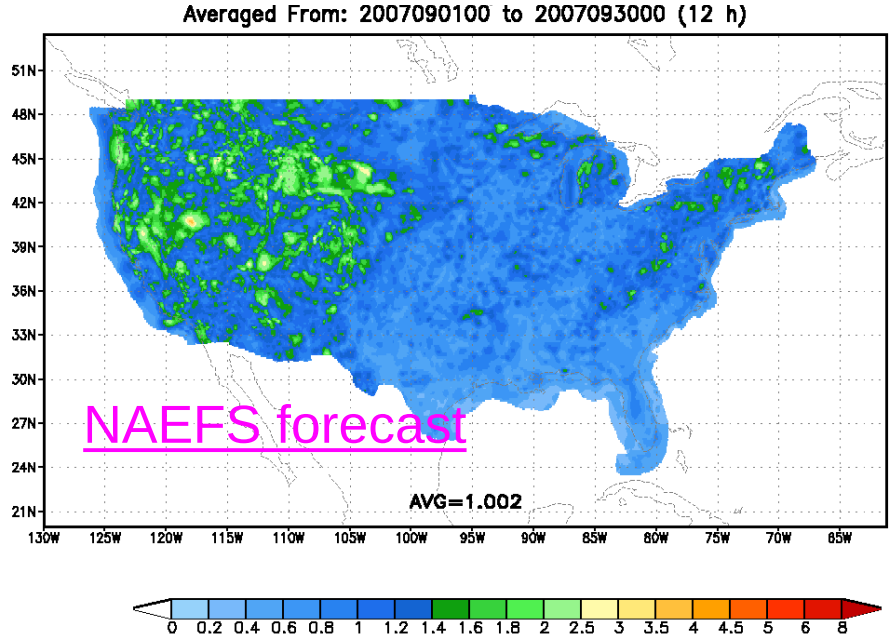
40 day average absolute errors of 2-meter temperature (NDFD has 12hr advantage)

COUNS only – verified against RTMA

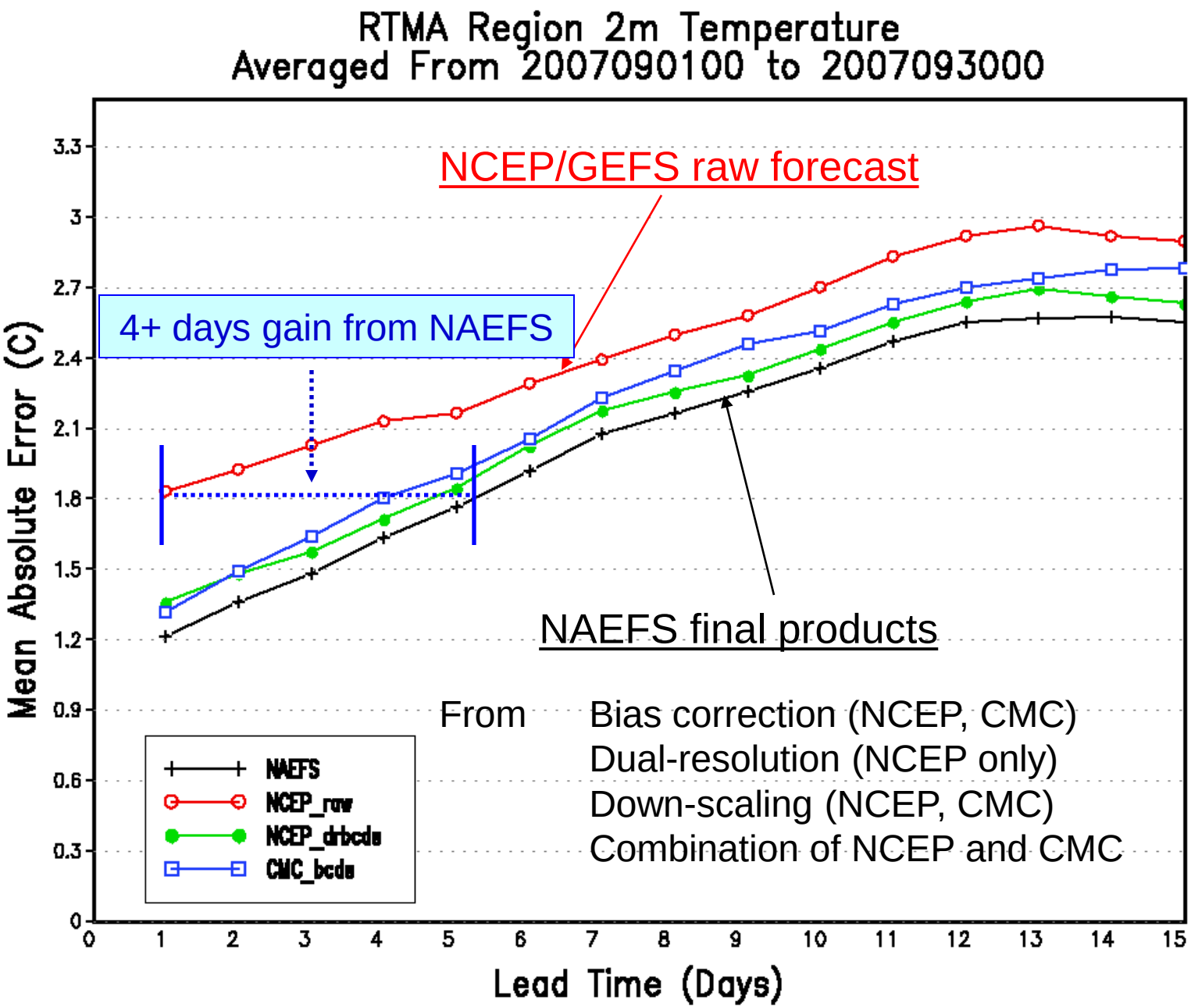




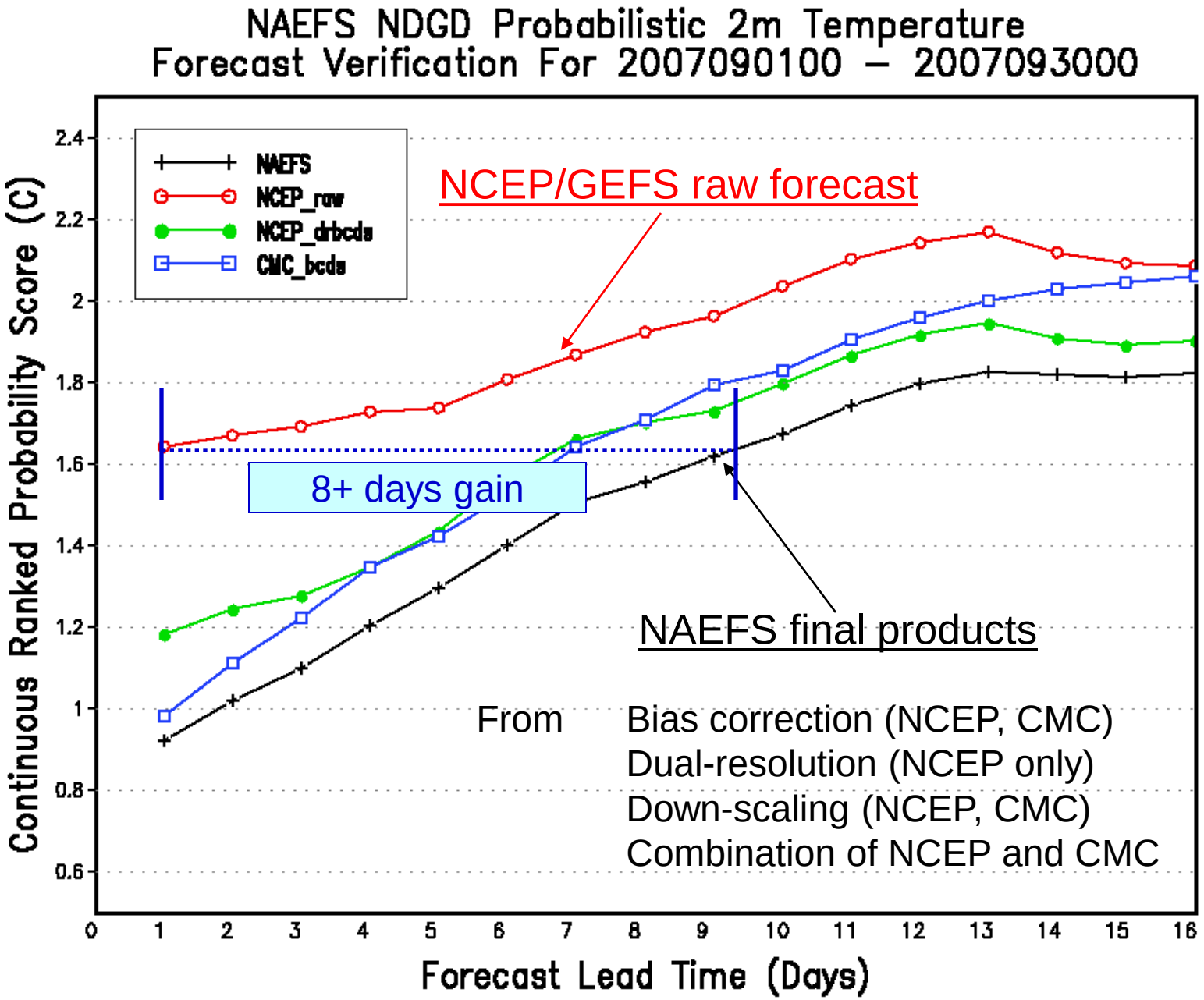




12hr 2m T forecast
Mean Absolute Error
w.r.t RTMA for CONUS
Average for September



BO CUI, GCWMB/EMC/NCEP/NOAA


NAEFS NDGD Probabilistic 2m Temperature
Forecast Verification For 2007090100 – 2007093000
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
NCEP/GEFS raw forecast
8+ days gain
NAEFS final products
From
Bias correction (NCEP, CMC)
Dual-resolution (NCEP only)
Down-scaling (NCEP, CMC)
Combination of NCEP and CMC
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16

Overall temperature forecasts: Average over past 30 days: (20080929-20081028)

		MAE	Bias	>10 err	<3 err	off. rank	Best G.		2nd G.		Worst G.	
1	12-hr	2.44	0.7	0.1%	67.3%	1 out of 7	NAM40	65.4%	NAM12	60.1%	NGM80	44.4%
2	24-hr	2.84	1.0	0.3%	59.1%	2 out of 7	NAM40	60.3%	NAM12	56.9%	SREF	47.0%
3	36-hr	2.94	0.8	0.3%	57.8%	1 out of 7	NAM40	55.9%	NAM12	52.6%	NGM80	44.0%
4	48-hr	3.36	1.6	2.1%	52.8%	1 out of 7	MOSGd	48.9%	NAM40	48.3%	NGM80	12.9%
5	60-hr	3.26	1.0	1.7%	54.8%	1 out of 6	MOSGd	50.1%	NAM12	48.8%	NAM40	6.2%
6	72-hr	3.35	1.3	2.1%	53.1%	1 out of 5	MOSGd	49.9%	NAM12	49.5%	SREF	44.0%
7	84-hr	3.80	0.6	4.7%	49.0%	1 out of 5	NAEFS	48.6%	SREF	44.5%	NAM12	2.6%
8	96-hr	3.96	0.7	4.0%	44.4%	2 out of 4	NAEFS	46.2%	HPCGd	42.6%	MOSGd	40.6%
9	108-hr	4.43	0.9	5.5%	38.5%	2 out of 3	NAEFS	41.7%	MOSGd	37.7%	MOSGd	37.7%
10	120-hr	4.57	1.0	5.9%	36.6%	2 out of 4	NAEFS	40.9%	HPCGd	36.5%	MOSGd	36.3%
11	132-hr	4.83	0.7	7.8%	34.7%	1 out of 3	NAEFS	34.5%	MOSGd	34.4%	MOSGd	34.4%
12	144-hr	4.83	0.5	7.4%	34.7%	3 out of 4	HPCGd	36.4%	NAEFS	35.5%	MOSGd	33.3%
13	156-hr	5.43	0.1	11.9%	30.3%	3 out of 3	NAEFS	32.1%	MOSGd	30.8%	MOSGd	30.8%
14	168-hr	5.74	0.3	14.4%	27.7%	2 out of 4	HPCGd	27.7%	MOSGd	26.9%	NAEFS	26.1

Minimum temperature forecast: Average over past 30 days: (20080929-20081028)

1	12-hr	3.17	-1.2	1.0%	53.4%	3 out of 7	NAEFS	59.7%	SREF	57.1%	NGM80	21.8%
2	24-hr	3.03	-0.9	0.6%	55.5%	2 out of 7	SREF	57.2%	NAEFS	54.2%	NGM80	24.9%
3	36-hr	3.25	-0.8	0.9%	51.6%	3 out of 7	NAEFS	54.2%	SREF	53.9%	NGM80	23.2%
4	48-hr	3.94	-1.1	2.9%	43.2%	3 out of 7	NAEFS	51.9%	SREF	45.8%	NGM80	6.2%
5	60-hr	4.30	-0.4	4.4%	39.1%	4 out of 6	NAEFS	49.2%	SREF	43.0%	NAM40	8.9%
6	72-hr	4.76	0.1	6.4%	33.7%	5 out of 5	NAEFS	42.9%	SREF	40.1%	NAM12	35.2%
7	84-hr	4.85	0.3	7.5%	34.7%	2 out of 6	NAEFS	40.0%	MOSGd	33.4%	NAM12	8.9%
8	96-hr	5.24	0.4	13.0%	33.1%	1 out of 3	NAEFS	32.7%	MOSGd	29.9%	MOSGd	29.9%
9	108-hr	5.11	0.8	12.8%	35.4%	1 out of 4	HPCGd	34.5%	NAEFS	32.1%	MOSGd	30.5%
10	120-hr	5.31	0.7	12.0%	31.9%	1 out of 3	MOSGd	31.6%	NAEFS	24.8%	NAEFS	24.8%
11	132-hr	4.97	0.7	9.9%	35.1%	2 out of 4	HPCGd	38.0%	MOSGd	30.9%	NAEFS	27.2%
12	144-hr	5.42	0.6	15.0%	35.0%	1 out of 3	MOSGd	31.3%	NAEFS	29.0%	NAEFS	29.0%
13	156-hr	5.40	0.5	14.9%	35.7%	1 out of 4	HPCGd	32.9%	MOSGd	32.7%	NAEFS	23.4%
14	168-hr	5.46	1.1	17.7%	38.1%	1 out of 3	MOSGd	35.6%	NAEFS	28.4%	NAEFS	28.4%

Official Guidance: NGM80, NAM40, SREF, NAM12, MOSGd, HPCGd, NAEFS

Contributed by Richard Grumm (WFO)

NAEFS statistical downscaling

Alaska

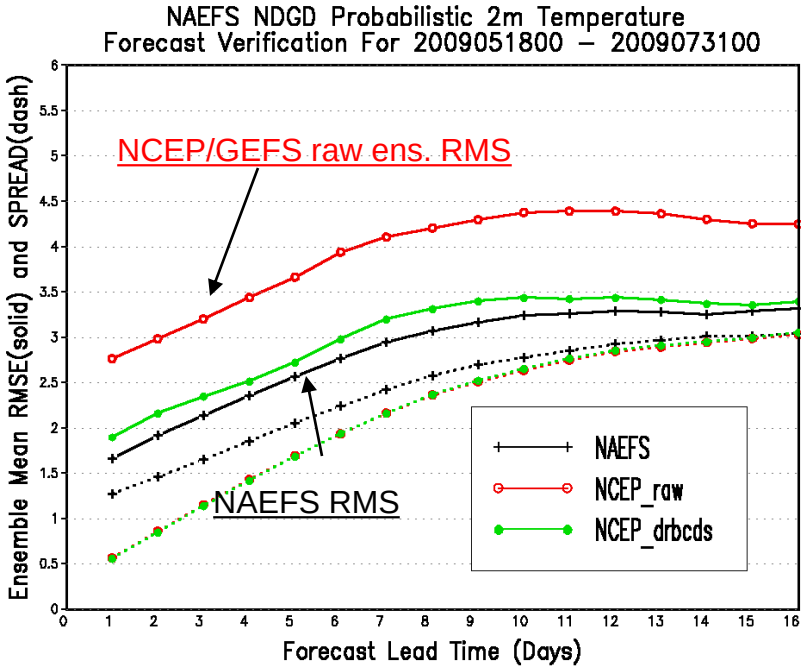
Statistical Down-Scaling for Alaska

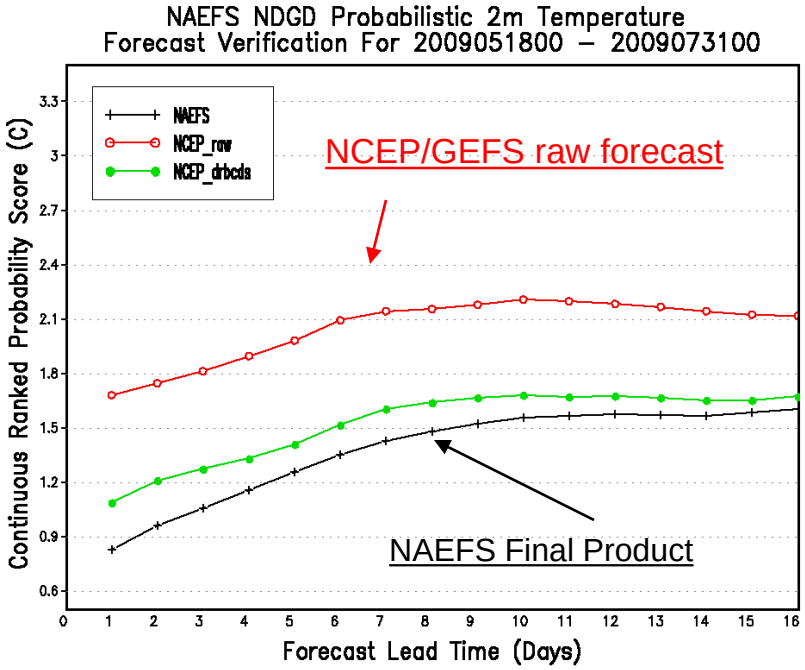
- Downscaling NAEFS products has been implemented in NCEP by
  - December 4th 2007 1200UTC
  - CONUS, 4 variables (surface pressure, 2m temperature and 10m u and v)

- Apply statistical downscaling method to Alaska region
  - Add new variables, wind speed/direction, maximum/minimum temperature

- Statistical Down-Scaling Techniques for Alaska
  - Variable: surface pressure, 2-m temperature, 10-meter wind component
    - work well using current operational technique for CONUS
  - Variable: Tmax and Tmin
    - Choose proper period definition in code/scripts
    - Modification for definition changed July, 2009
  - Variable: wind speed and direction
    - Problem exist in utility “copygb” for wind direction
    - Solution to avoid interpolation of wind speed
    - Not bad, difficult for wind direction improvement
  - Variable: 2m dew point temp and 2m relative humility
    - How to improve methods, future inclusion

- Alaska Verification
  - Next images show some verification for Tmax, Tmin, wind direction/speed





2m Temperature verification
Average for 2 and half months

NAEFS Final Product

From Bias correction (NCEP, CMC)
Dual-resolution (NCEP only)
Down-scaling (NCEP, CMC)
Combination of NCEP and CMC

Process to Downscale Tmax & Tmin for Alaska

- Based on 1°×1° 6-hr bias corrected Tmax/Tmin and down-scaling vectors (DV) for T2m at each 6-hr cycle
  - Definition of Tmax/Tmin for Alaska region
    - Tmax period: 13UTC (5am-local) – 04UTC (8pm-local) – local daylight time
    - Tmin period: 01UTC (5pm-local) – 19UTC (11am-local) – local daylight time
  - Definition of approximated period for Tmax/Tmin for giving initial cycle
  - Mean DV of T2m for 6-hr period: weighted average of two instantaneous DVs
  - Interpolating bias corr. 6-hr Tmax/Tmin (1°×1°) to 6km NDGD grid for Alaska
- Downscaling detailed process
  - Apply mean DV to each grid point, each ens. member, and each 6-hr lead-time period, to produce down-scaled Tmax and Tmin for each 6-hr lead-time period
  - Find out highest Tmax and lowest Tmin for approximated period
  - For different grid points, different ens. members, highest Tmax could be in different 6-hr period, the same for lowest Tmin
  - Only one down-scaled Tmax and Tmin for every 24-hr. fcst, up to 384 hours
- Calculate the Tmax/Tmin statistical outputs: mean, spread, mode, 10%, 50% and 90% based on above step

EFFECTIVE 1200UTC JULY 28 2009, DEFINITIONS OF MAX T AND MIN T FOR ALASKA REGION
CHANGE FROM: **MAX T 7:00 AM - 7:00 PM LST, MIN T 7:00 PM - 8:00 AM LST**
TO: **MAX T 5:00 AM - 8:00 PM LST, MIN T 5:00 PM - 11:00 AM LST**

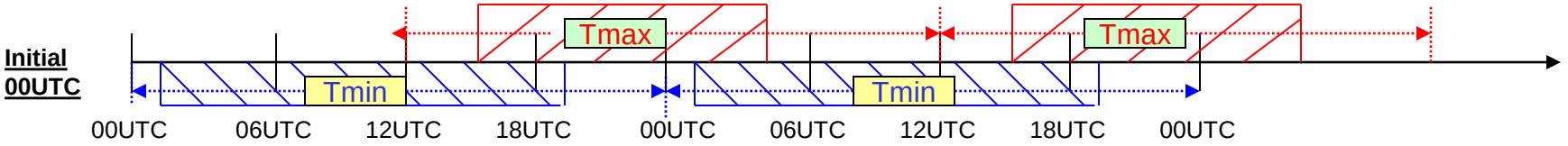
Tmax and Tmin calculations for Alaska region (2009)

Alaska Daylight Time : Tmax period: 13UTC (5am-local) – 04UTC (8pm-local) – local daylight time

Tmin period: 01UTC (5pm-local) –19UTC (11am-local) – local daylight time

OUTPUT: Tmax: f18(no), f24(no), f30(no), f36(yes:12-36hrs), f42(no),f48(no), f54(no), f60(yes:36-60hrs), ……

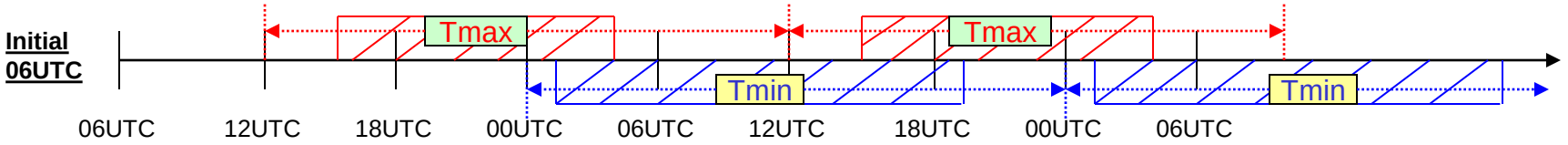
(00UTC) Tmin: f06(no), f12(no), f18(no), f24(yes:0-24hrs), f30(no), f36(no), f42(no), f48(yes:24-48hrs), ……



00UTC temperature forecast at valid time

OUTPUT: Tmax: f12(no), f18(no), f24(no), f30(yes:06-30hrs), f36(no), f42(no), f48(no), f54(yes:30-54hrs), ……

(06UTC) Tmin: f24(no), f30(no), f36(no), f42(yes:18-42hrs), f48(no), f54(no), f60(no), f66(yes:42-66hrs), ……

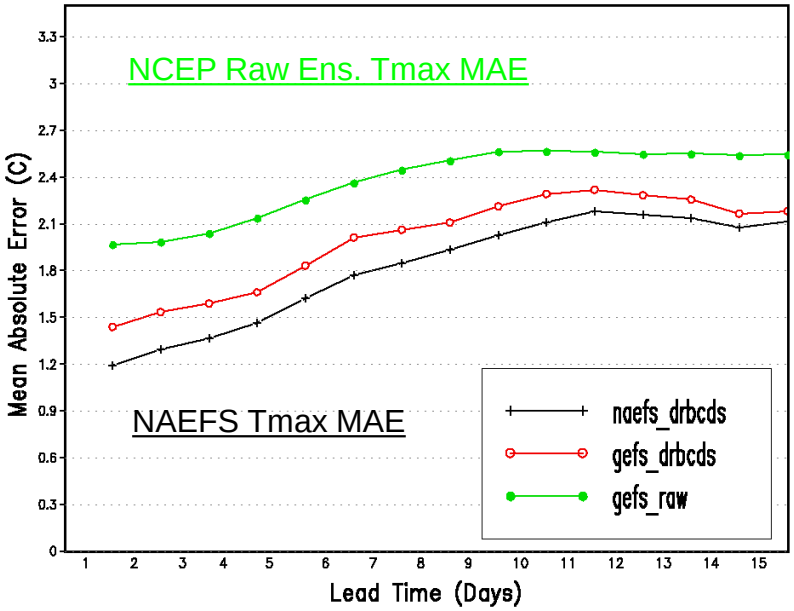


06UTC temperature forecast at valid time

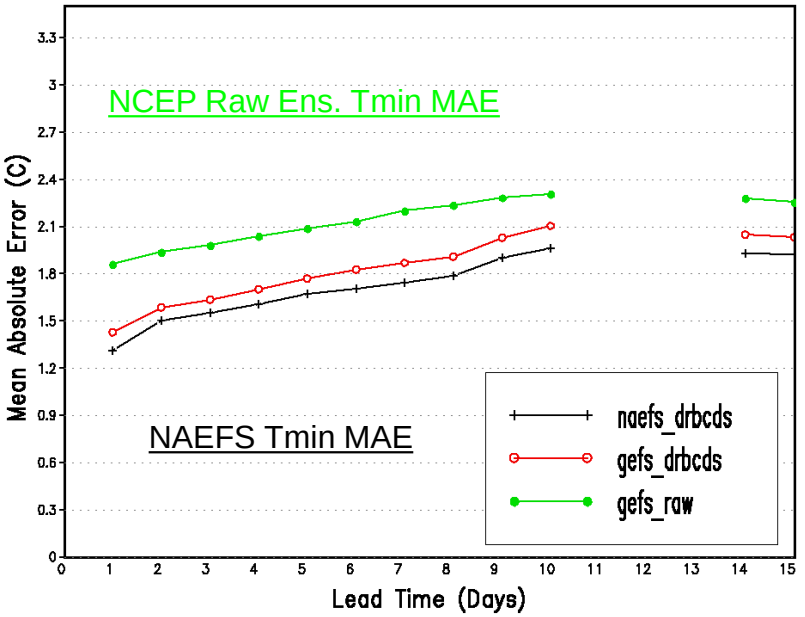
Alaska Standard Time : Tmax period: 14UTC (5am-local) – 05UTC (8pm-local)

Tmin period: 02UTC (5pm-local) – 20UTC (11am-local)

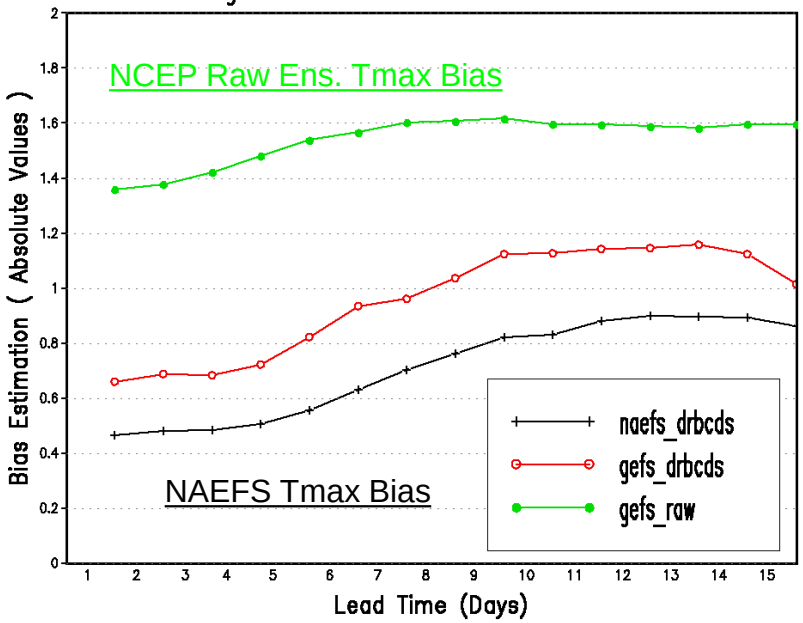
RTMA Alaska Region 2m Tmax
Averaged From 2009051800 to 2009073100



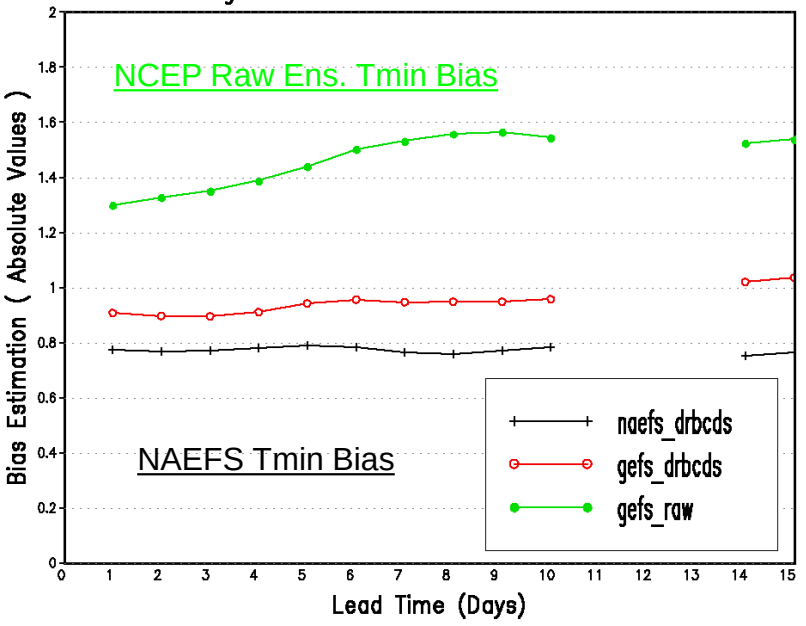
RTMA Alaska Region 2m Tmin
Averaged From 2009051800 to 2009073100

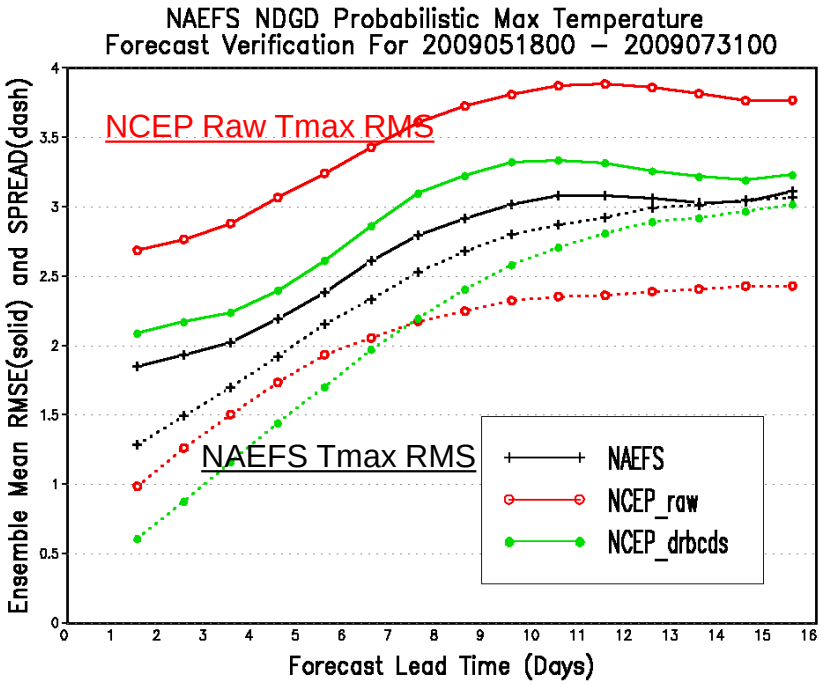


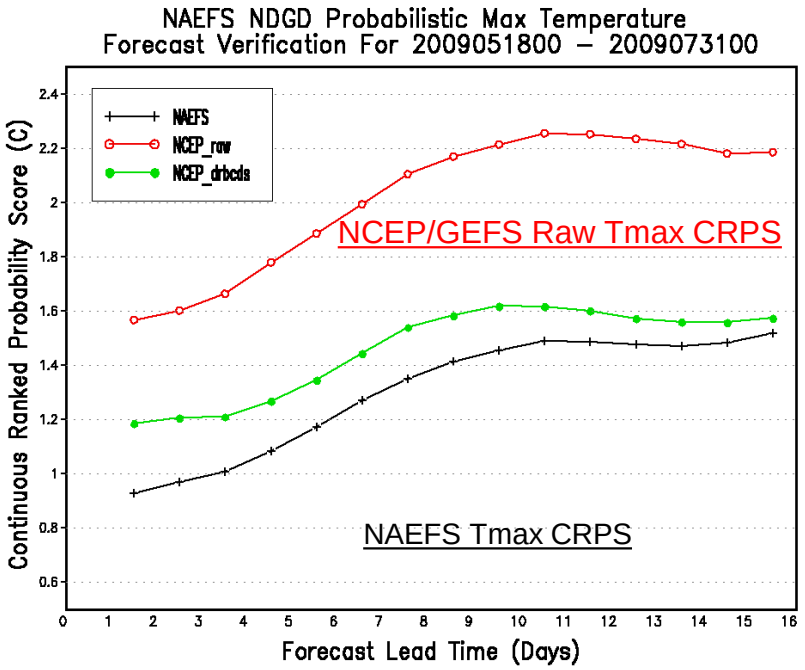
RTMA Alaska Region 2m Tmax
Averaged From 2009051800 to 2009073100

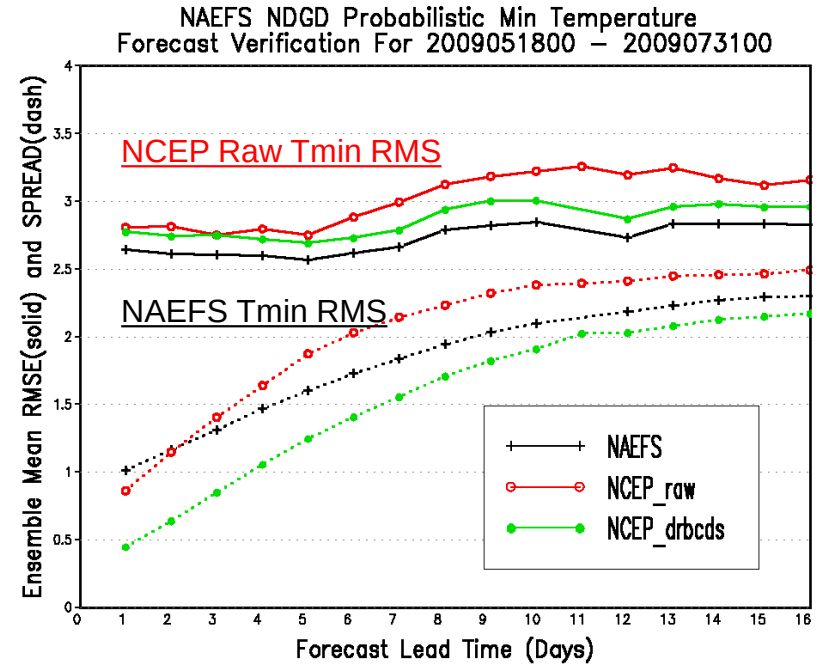


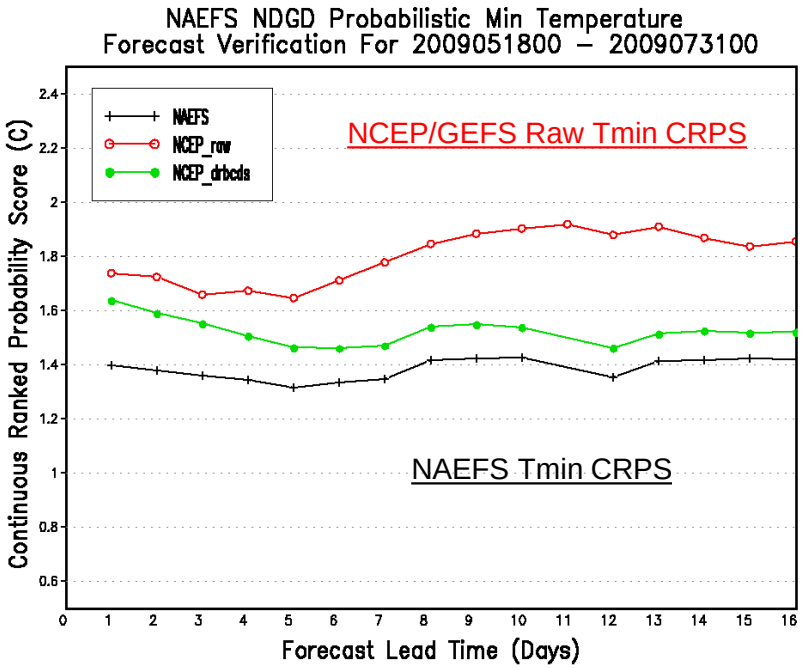
RTMA Alaska Region 2m Tmin
Averaged From 2009051800 to 2009073100




NAEFS NDGD Probabilistic Max Temperature
Forecast Verification For 2009051800 – 2009073100
NCEP Raw Tmax RMS
NAEFS Tmax RMS
NAEFS
NCEP_raw
NCEP_drbcds
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic Max Temperature
Forecast Verification For 2009051800 – 2009073100
NAEFS
NCEP_raw
NCEP_drbcds
NCEP/GEFS Raw Tmax CRPS
NAEFS Tmax CRPS
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic Min Temperature
Forecast Verification For 2009051800 – 2009073100
NCEP Raw Tmin RMS
NAEFS Tmin RMS
NAEFS
NCEP_raw
NCEP_drbcds
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic Min Temperature
Forecast Verification For 2009051800 – 2009073100
NAEFS
NCEP_raw
NCEP_drbcds
NCEP/GEFS Raw Tmin CRPS
NAEFS Tmin CRPS
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)

Process to Statistically Downscale Wind Speed and Direction

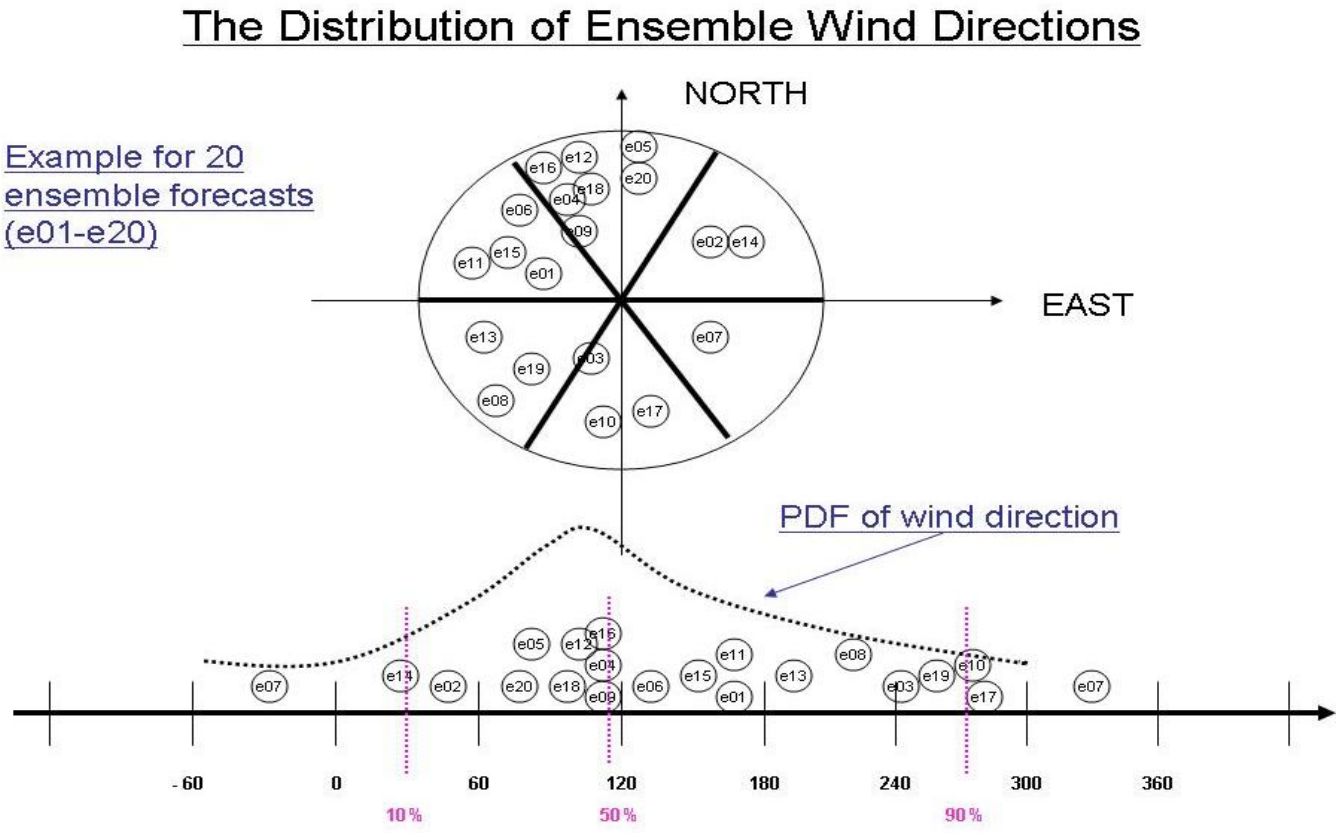
- Wind speed & direction calculation based on downscaled u10m & v10m

$$W_s = \sqrt{u^2 + v^2}$$

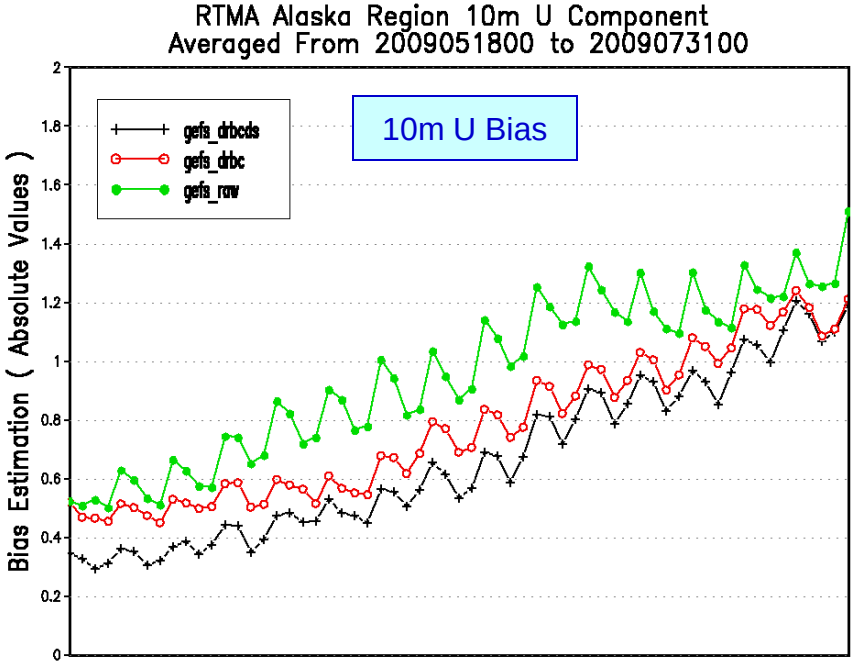
$$W_d = sign(u \cdot v) \cdot \arctan\left|\frac{u}{v}\right| + d_p \text{ where } d_p = \begin{cases} 0, if\_u \le 0, v < 0 \\ 180, if\_u < 0, v \ge 0 \\ 180, if\_u \ge 0, v > 0 \\ 360, if\_u > 0, v \le 0 \end{cases}$$

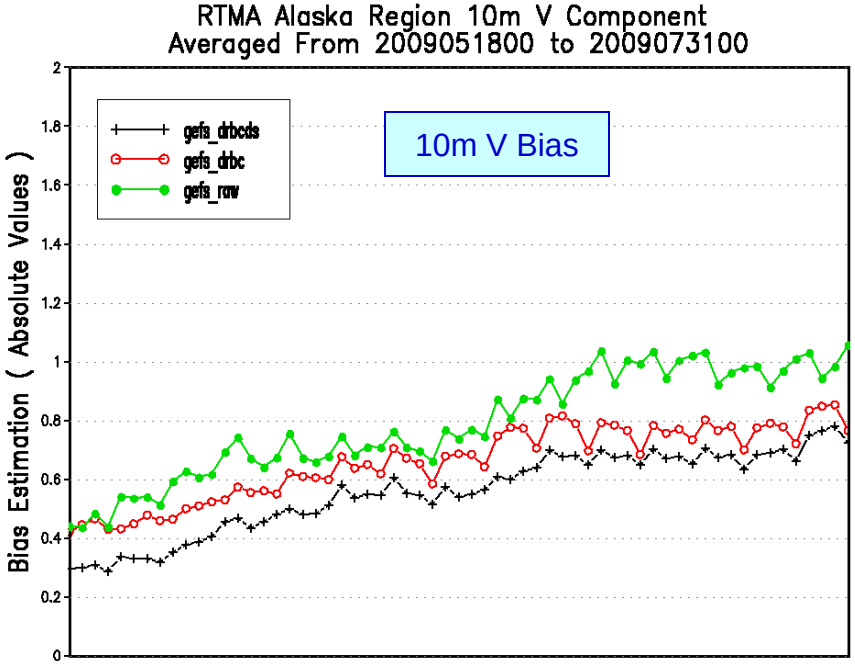
- Downscaling process
  - No action for data on 1°, whole process based and completed on 6km grid u10m & v10m
  - Downscaling process
    - Apply “copygb” utility to interpolate u10m & v10m for NCEP/CMC each ens. member
    - Apply DV to produce down-scaled u10m & v10m for each member and compute its wind speed & direction
    - Combine NCEP/CMC 10m wind speed & direction to generate the mean, spread, mode, 10%, 50% and 90% forecasts
  - No change for wind speed & direction calculation, no change for probabilistic wind direction calculation

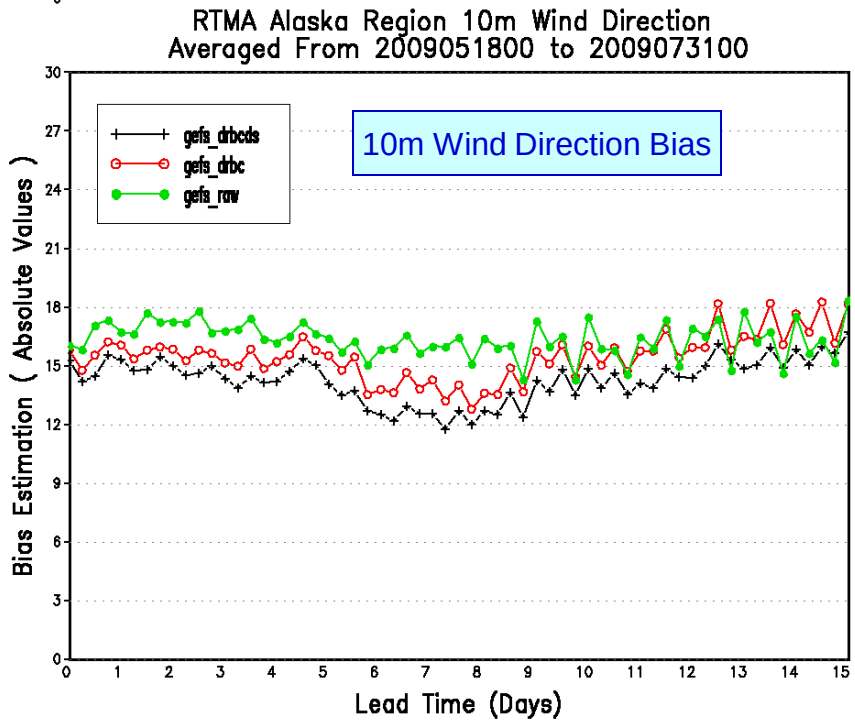
Probabilistic Wind Direction Calculation

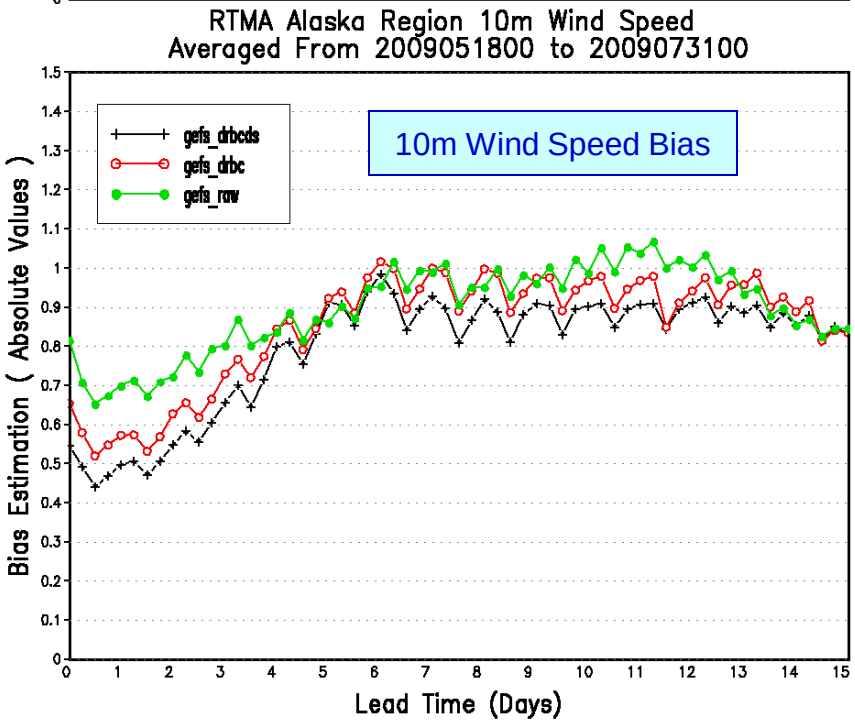


- Divide (0,360) into 6 units, choose the closed 2 units where Wdir data (equal weight currently, different weight by wind speed as a option ?) fall most
- Rearrange the data to allow 2 units in the middle of the distribution
- Set a 60 degree window, move the window through the 2 units, mode is the center of the window with the most members
- Calculate the average wind direction using 6 units data
- Calculate probability 10%, 50% and 90%, mode and spread by using full data
- Adjust wind direction phase in [0,360]









BO CUI, GCWMB/EMC/NCEP/NOAA

NAEFS inclusion of FNMOC ensembles

Example of score cards for ensembles evaluation

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-Z500 in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-T850 in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-Z1000 in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-T2M in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-U10M in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-V10M in Spring 2009

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

- 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.

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-Z500 in Winter 0809

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-T850 in Winter 0809

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-Z1000 in Winter 0809

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-T2M in Winter 0809

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-U10M in Winter 0809

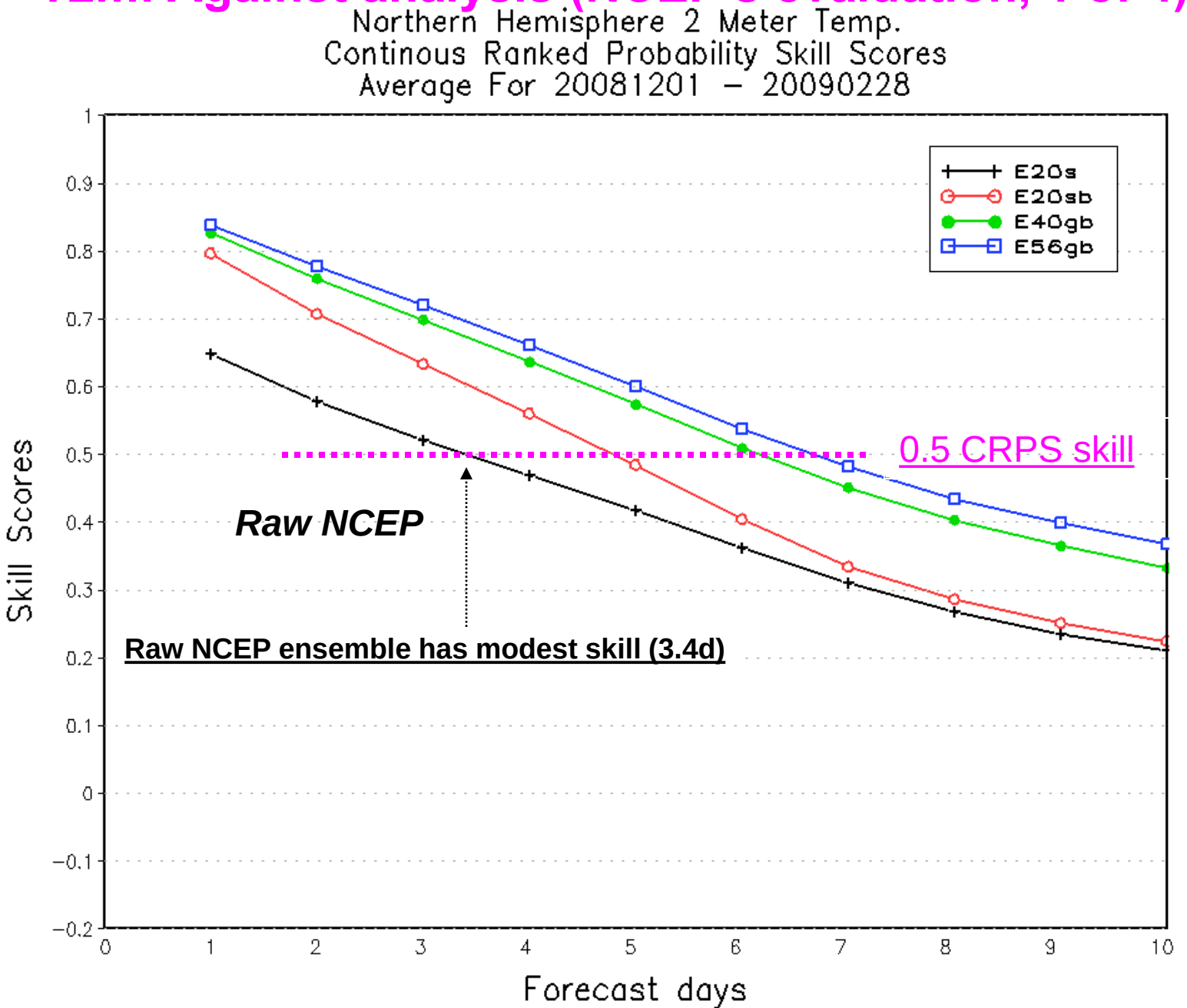
Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

NAEFSb (40 members) vs NAEFSb+FNMOCb (56 members): NH-V10M in Winter 0809

Days	1	2	3	4	5	6	7	8	9	10
AC										
CRPS										
Rel										
Res										

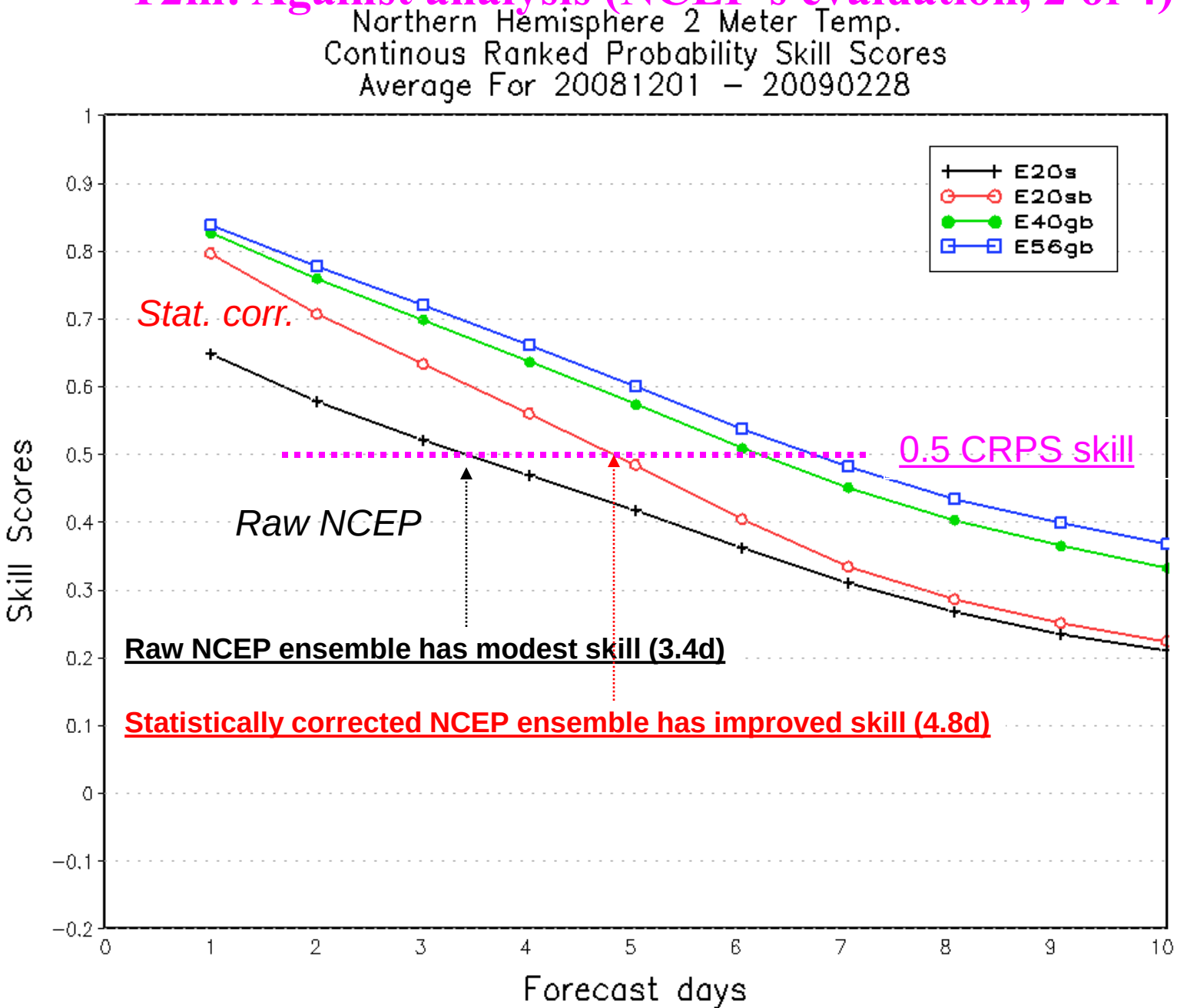
- Using 95% confidence interval (2.5%-97.5%), BLUE means NAEFSb+FNMOCb is significantly better than NAEFSb, RED means otherwise.
- The reliability (Rel) and resolution (Res) are from Brier Score decomposition.

Value-added by including FNMOC ensemble into NAEFS
T2m: Against analysis (NCEP's evaluation, 1 of 4)



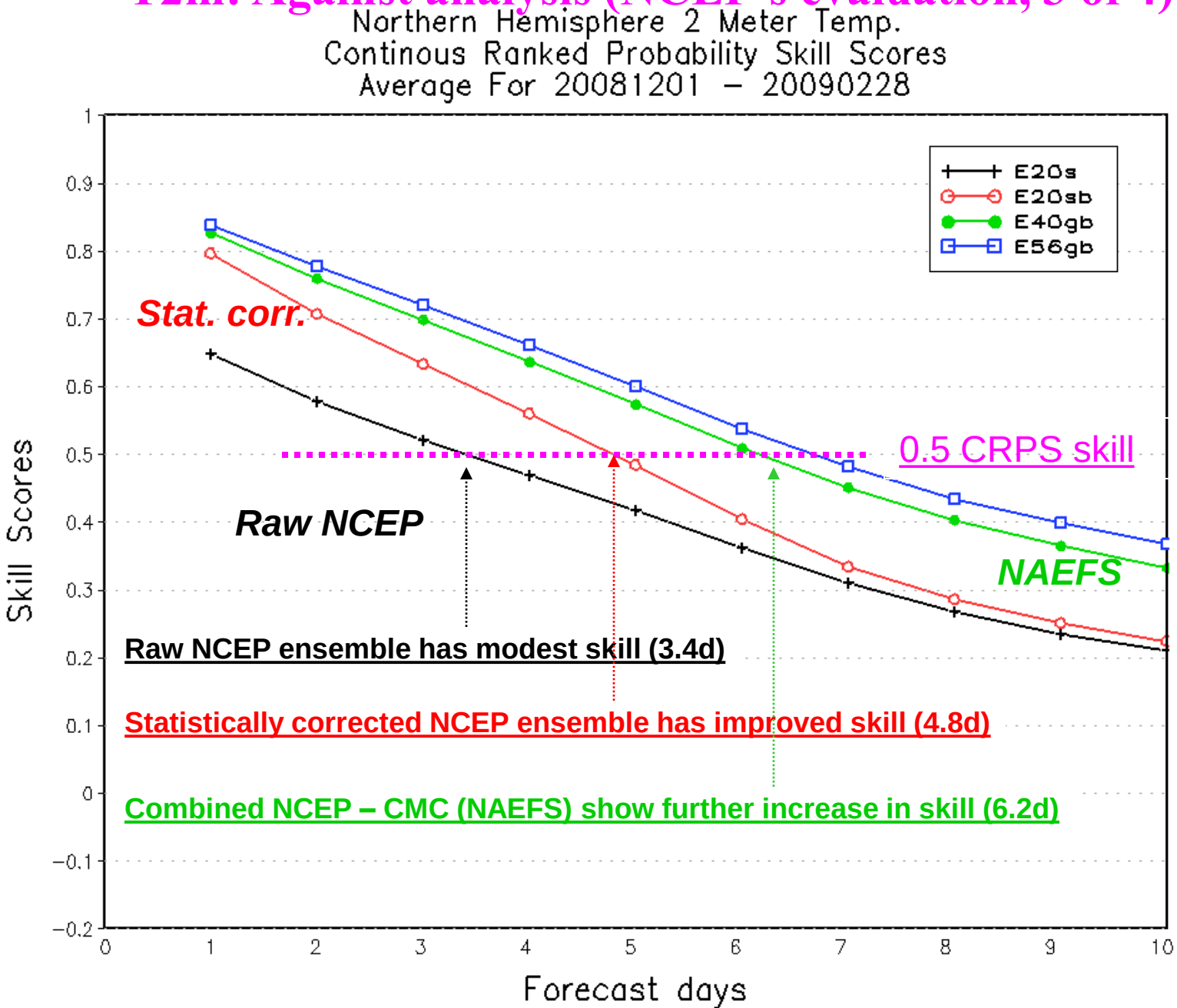
Value-added by including FNMOC ensemble into NAEFS

T2m: Against analysis (NCEP's evaluation, 2 of 4)



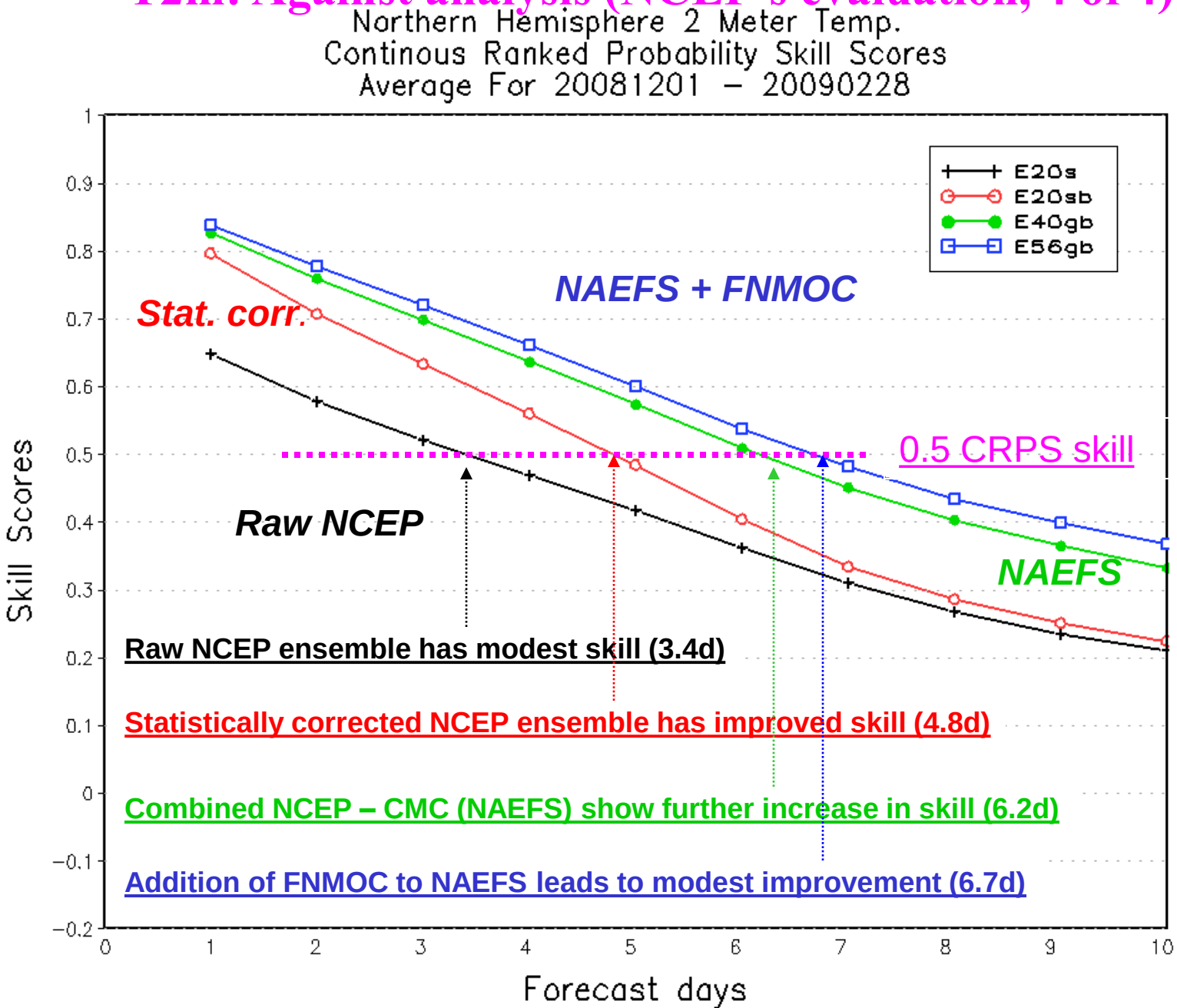
Value-added by including FNMOC ensemble into NAEFS

T2m: Against analysis (NCEP's evaluation, 3 of 4)



Value-added by including FNMOC ensemble into NAEFS

T2m: Against analysis (NCEP's evaluation, 4 of 4)



NOAA THORPEX Proposal Report:

Extensions and Improvements to the NAEFS Post-Processor at NCEP/EMC

Bo Cui[1], Huiling Yuan[2], Yuejian Zhu[3], Paul Schultz[2], Zoltan Toth[2]

[1]SAIC at Environmental Modeling Center, NCEP/NWS
[2]Earth System Research Laboratory, NOAA
[3]Environmental Modeling Center, NCEP/NWS

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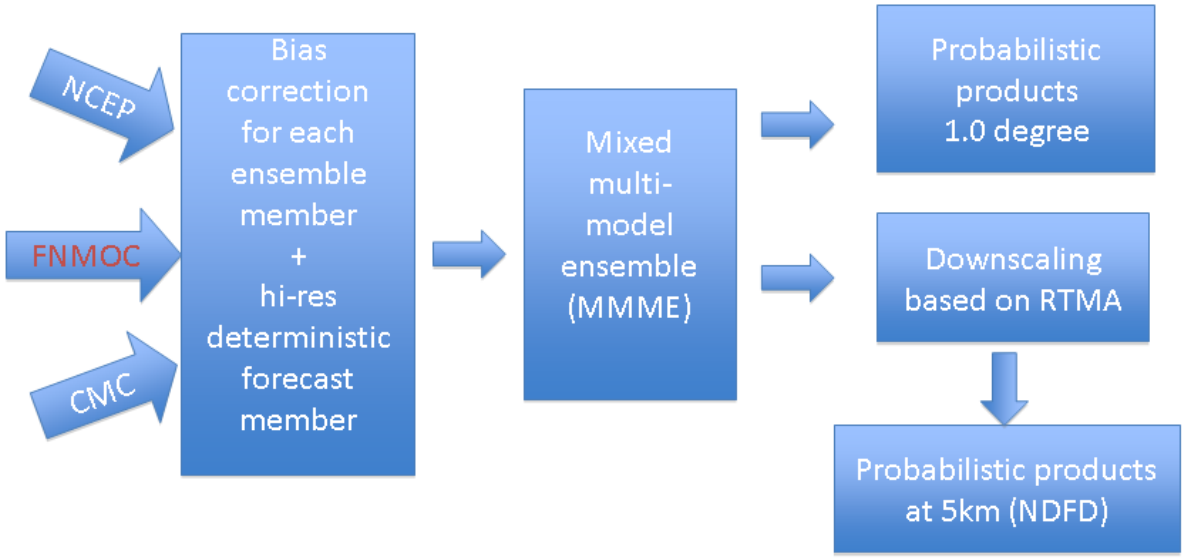
Richard Verret, Poulin Lewis CMC/MSC
David Michaud, Brent Gorden, Luke Lin NCO/NCEP/NWS/NOAA
Valery J. Dagostaro MDL/NWS/NOAA

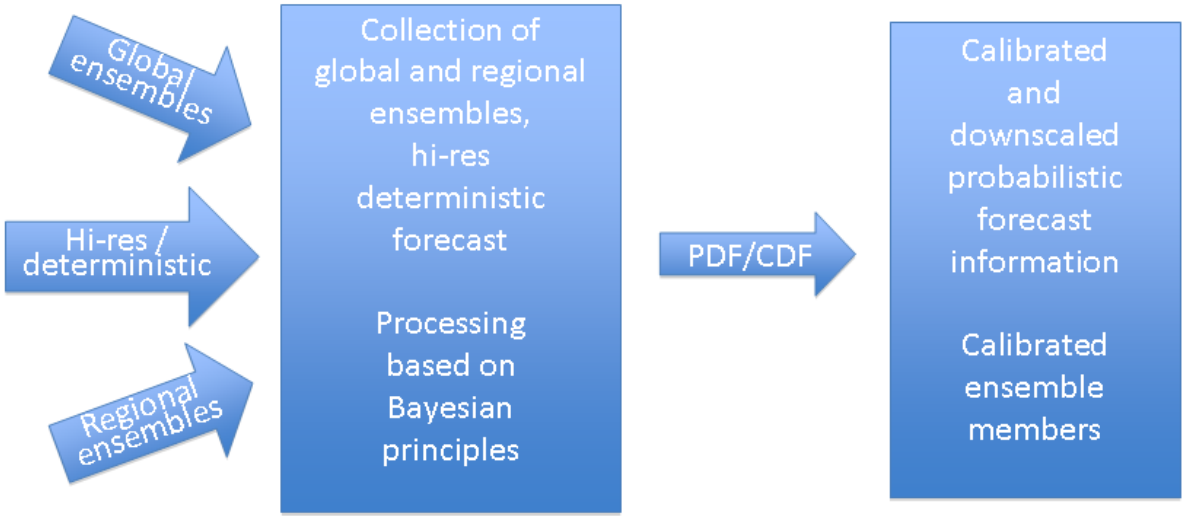
May 6th 2010, NOAA THORPEX Principal Investigators Meeting

Current NCEP/EMC Statistical Post-Processing System



- Bias corrected NCEP/CMC GEFS and GFS forecast (up to 180 hrs), same bias correction algorithm
  - Combine bias corrected GFS and NCEP GEFS ensemble forecasts
  - Dual resolution ensemble approach for short lead time
  - GFS has higher weights at short lead time
- NAEFS products
  - Combine NCEP/GEFS (20m) and CMC/GEFS (20m), FNMOC ens. will be in soon
  - Produce Ensemble mean, spread, mode, 10% 50%(median) and 90% probability forecast at 1*1 degree resolution
  - Climate anomaly (percentile) forecasts also generated for ens. mean
- Statistical downscaling
  - Use RTMA as reference - NDGD resolution (5km), CONUS only
  - Generate mean, mode, 10%, 50%(median) and 90% probability forecasts

Development of Statistical Post-Processing for NAEFS



Future Configuration of EMC Ensemble Post-Processor

- Opportunities for improving the post-processor
  - Utilization of additional input information
    - More ensemble, high resolution control forecasts (hybrid?)
    - Using reforecast information to improve week-2 forecast and precipitation
    - Analysis field (such as RTMA and etc..)
  - Improving calibration technique
    - Calibration of higher moments (especially spread)
    - Use of objective weighting in input fields combination
    - Processing of additional variables with non-Gaussian distribution
  - Improve downscaling methods

References:

- December 14 2007 implementation: http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/20071l_imp.html
- February 23 2010 implementation: http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201002_imp.html
- Q4 FY10 implementation: http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201004_imp.html
- Cui and et al. 2006: http://www.emc.ncep.noaa.gov/gmb/ens/papers/manuscript_thorpex_bocui.pdf
- Cui and et al. 2010 (draft for bias correction):
- Cui and et al. 2010 (draft for downscaling):

Background !!!

NAEFS Products - Summary

- Bias corrected GFS forecast
  - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_bc
    - Files: gegfs* (up to 180 hours)
- NAEFS new products: (early run: NCEP/GEFS only)
  - Probabilistic forecasts at 1*1 degree resolution (global)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_ bc
    - Files: geavg*, gespr*,gemode*,ge10p*,ge50p*,ge90p* represent ensemble mean, spread, mode, 10%, 50% (median) and 90% probability forecast
  - Anomaly forecast for ensemble mean at 1*1 degree resolution (global)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/pgrba_an
    - Files: geavg*
  - At 5km resolution (down-scaling for CONUS only)
    - Directory:/com/gens/para/gefs.yyyymmdd/cyc/ndgd
    - Files: geavg*,gemode*,ge10p*,ge50p* and ge90p*
- NAEFS new products: (later run: combine NCEP and CMC's ensemble)
  - Probabilistic forecast at 1*1 degree resolution (global)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/pgrba_bc
    - Files: geavg*,gespr*,gemode*,ge10p*,ge50p* and ge90p*
  - Anomaly forecast for ensemble mean at 1*1 degree resolution (global)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/pgrba_an
    - Files: geavg*
  - At 5km resolution (down-scaling for CONUS only)
    - Directory:/com/gens/para/naefs.yyyymmdd/cyc/ndgd
    - Files: geavg*,gemode*,ge10p*,ge50p* and ge90p*
    - File: dvrtma.t00z.ndgd_conus (down-scaling vector)