Science Review for Alaska Down-Scaling

Yuejian Zhu and Bo Cui

Environmental Modeling Center, NCEP/NWS

Acknowledgements

- EMC: Julia Zhu, Manuel Pondeca, Geoff Manikin, Chad Cary, Geoff DiMego, John Ward, Bill Lapenta, Steve Lord

- HPC: Christopher Bailey, Keith Brill, David Novak

- NCO: Xiaoxue Wang, Rebecca Cosgrove, Christine Caruso Magee

- GSD/ESRL: Zoltan Toth (former Ensemble Team leader at EMC)

Overview

Statistical Down-Scaling Techniques for Alaska

- Variables: surface pressure, 2-m temperature, 10-meter wind component
  - work well using current operational technique for CONUS
- Variables: Tmax and Tmin
  - Choose proper period definition in code/scripts
  - Modification for definition changed July, 2009
- Variables: wind speed and direction
  - There are many ways to interpolate winds(?)
  - Solution to avoid interpolation of wind speed
  - Not bad, but difficult for wind direction improvement

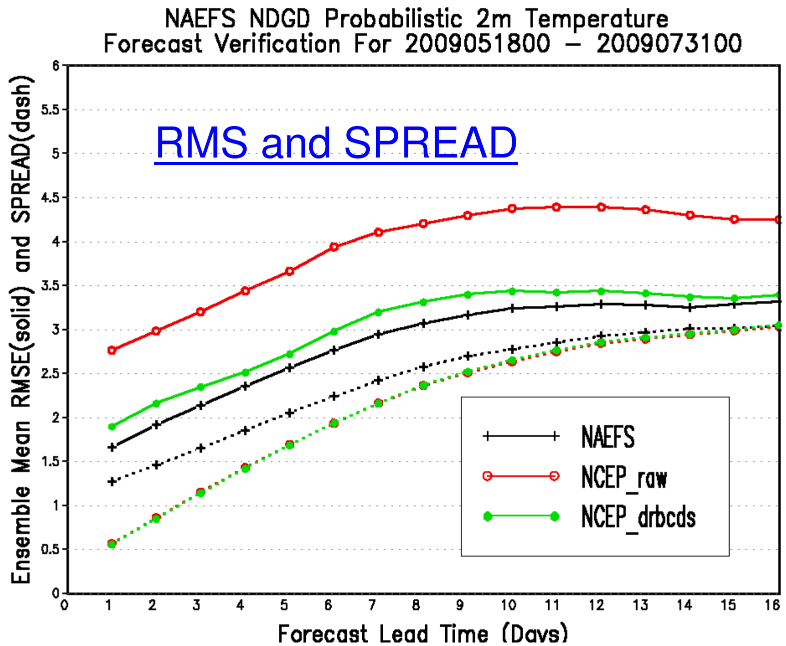
Alaska Down-Scaling evaluations

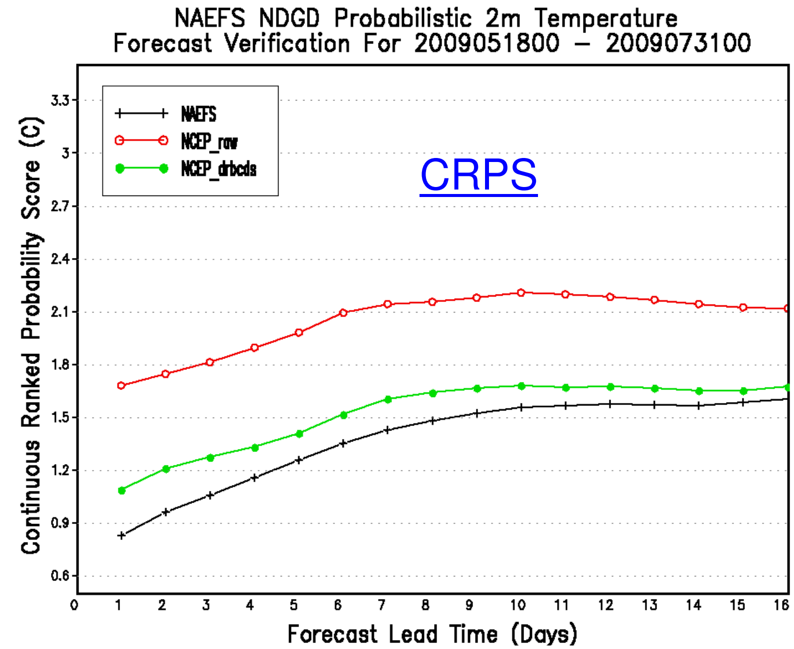
- Verification for all 8 variables for Alaska domain
- Preliminary experiments since early 2009
- NCO real time parallel

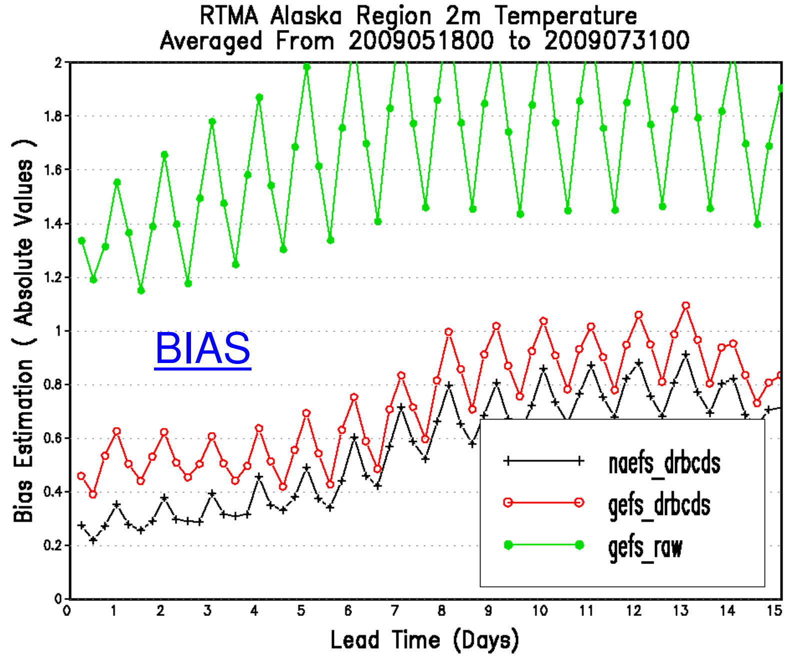
Statistical downscaling for NAEFS forecast

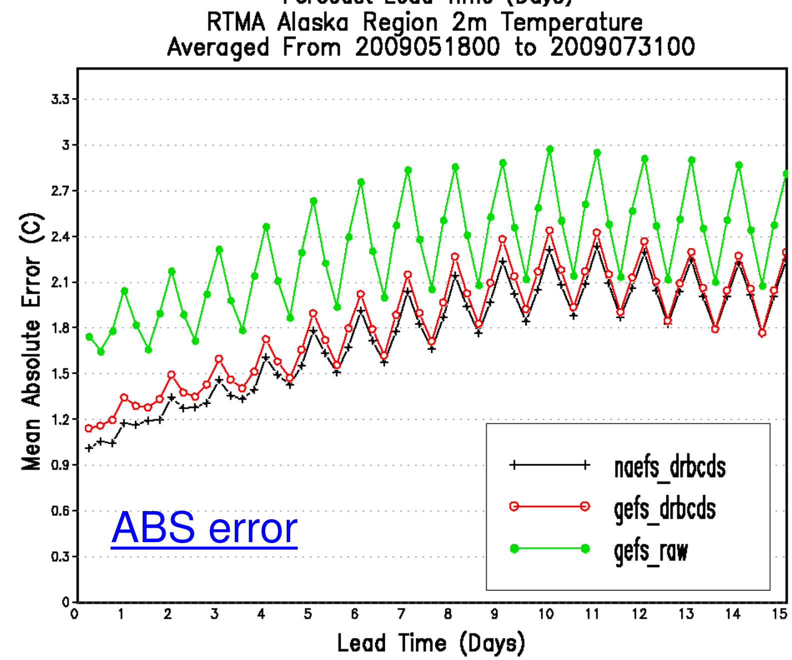
- Proxy for truth
  - *RTMA* for Alaska at 6km resolution
  - Variables (surface pressure, 2-m temperature, and 10-meter wind)
- Downscaling vector
  - Interpolate GDAS analysis to 6km resolution
  - Compare difference between interpolated GDAS and RTMA
  - Apply *decaying weight* to accumulate this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

Preliminary Statistics for T2m (period: 20090518 – 20090731)









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**

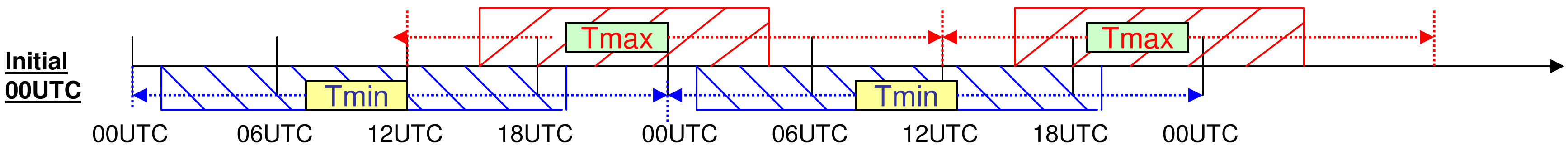
Tmax and Tmin calculations for Alaska region (2009)

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), ……

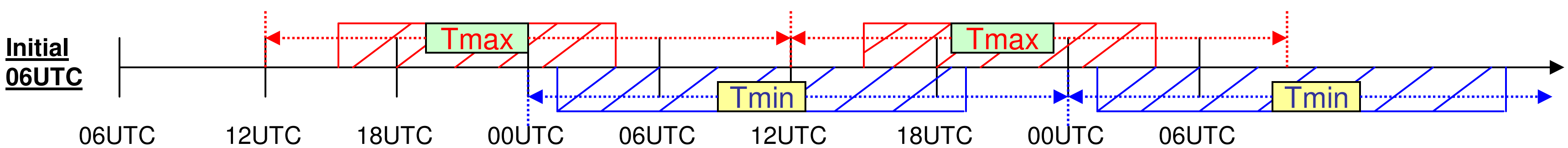
(00UTC) Tmin: f06(no), f12(no), f18(no), f24(yes:0-24hrs), f30(no), f36(no), f42(no), f48(yes:24-48hrs), ……



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), ……

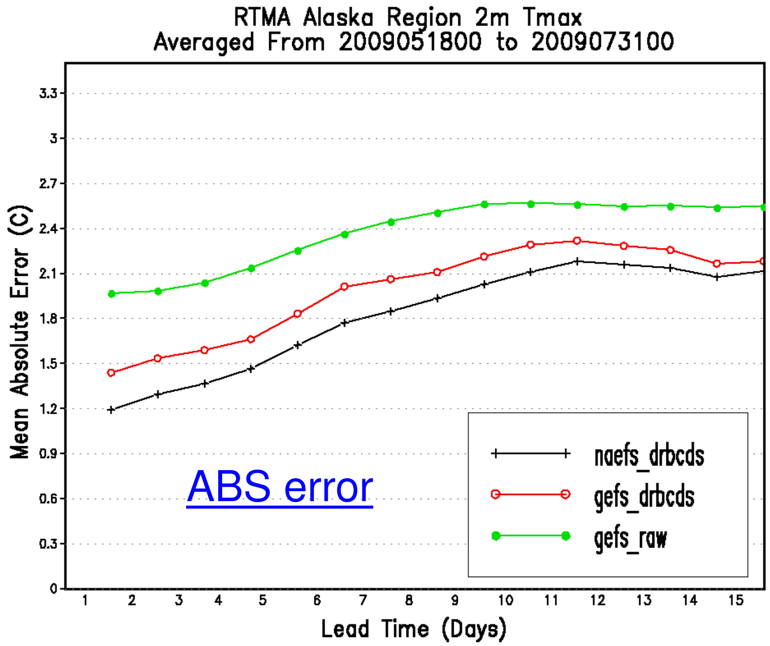


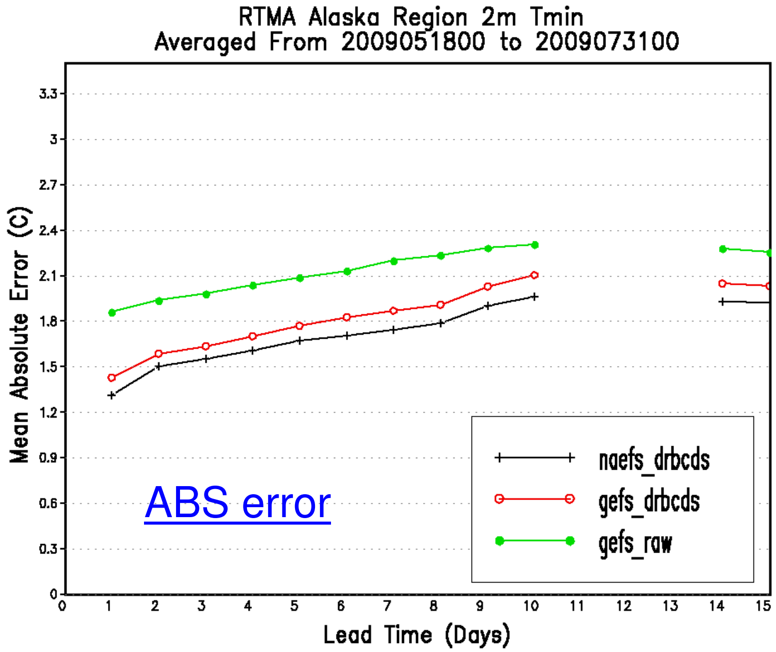
06UTC temperature forecast at valid time

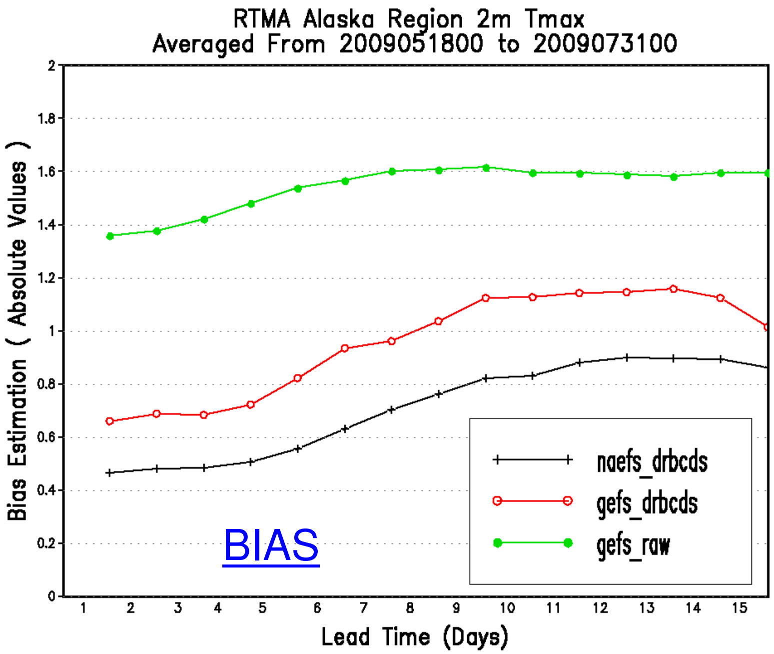
Alaska Standard Time : Tmax period: 14UTC (5am-local) – 05UTC (8pm-local)

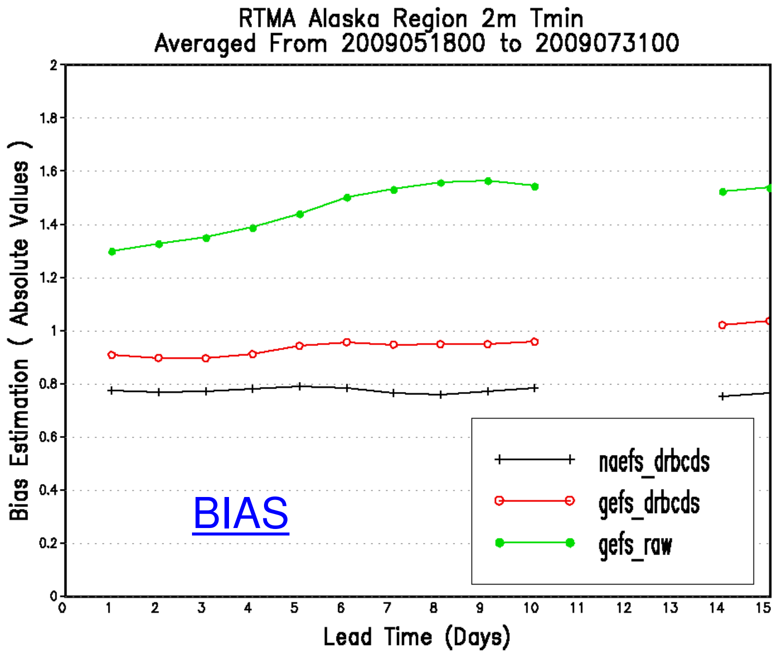
Tmin period: 02UTC (5pm-local) – 20UTC (11am-local)

Preliminary Statistics for Tmax and Tmin (period: 20090518 – 20090731)

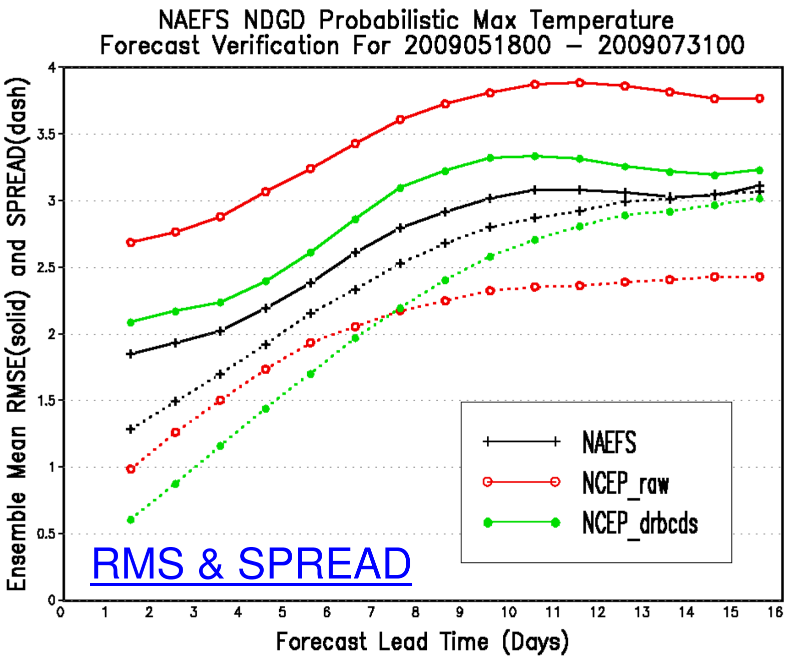


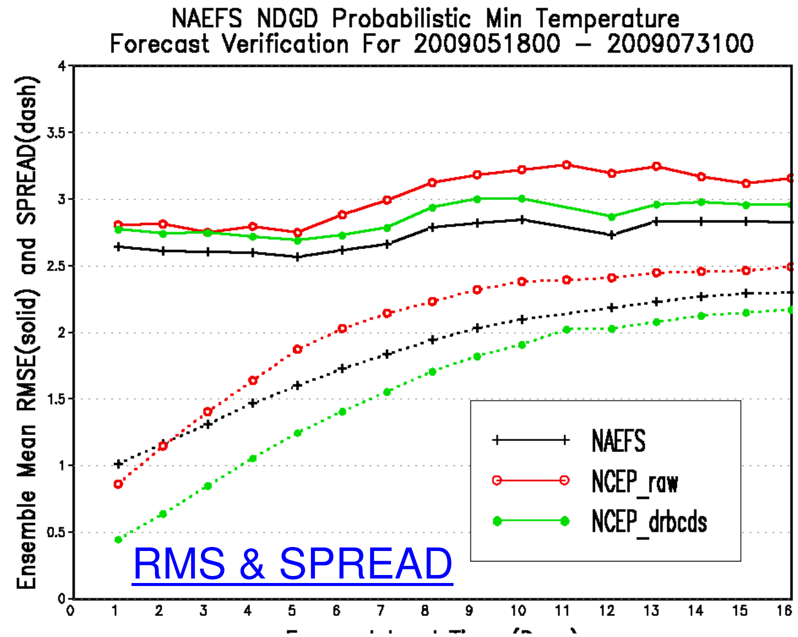


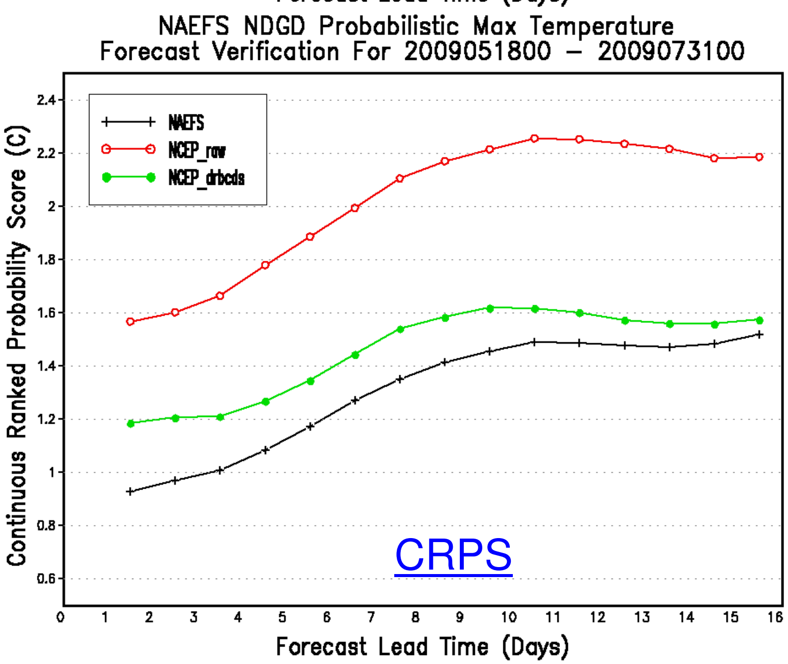


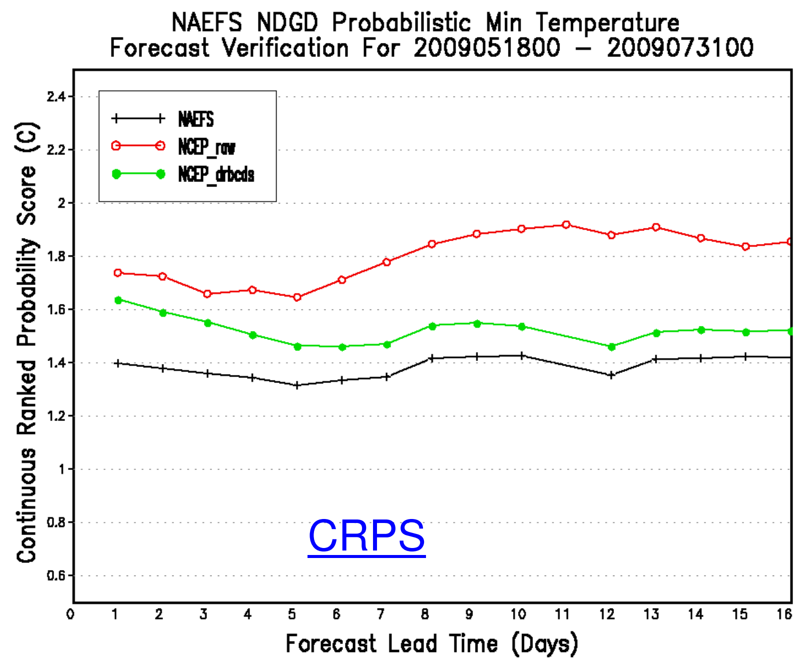


Preliminary Statistics for Tmax and Tmin (period: 20090518 – 20090731)





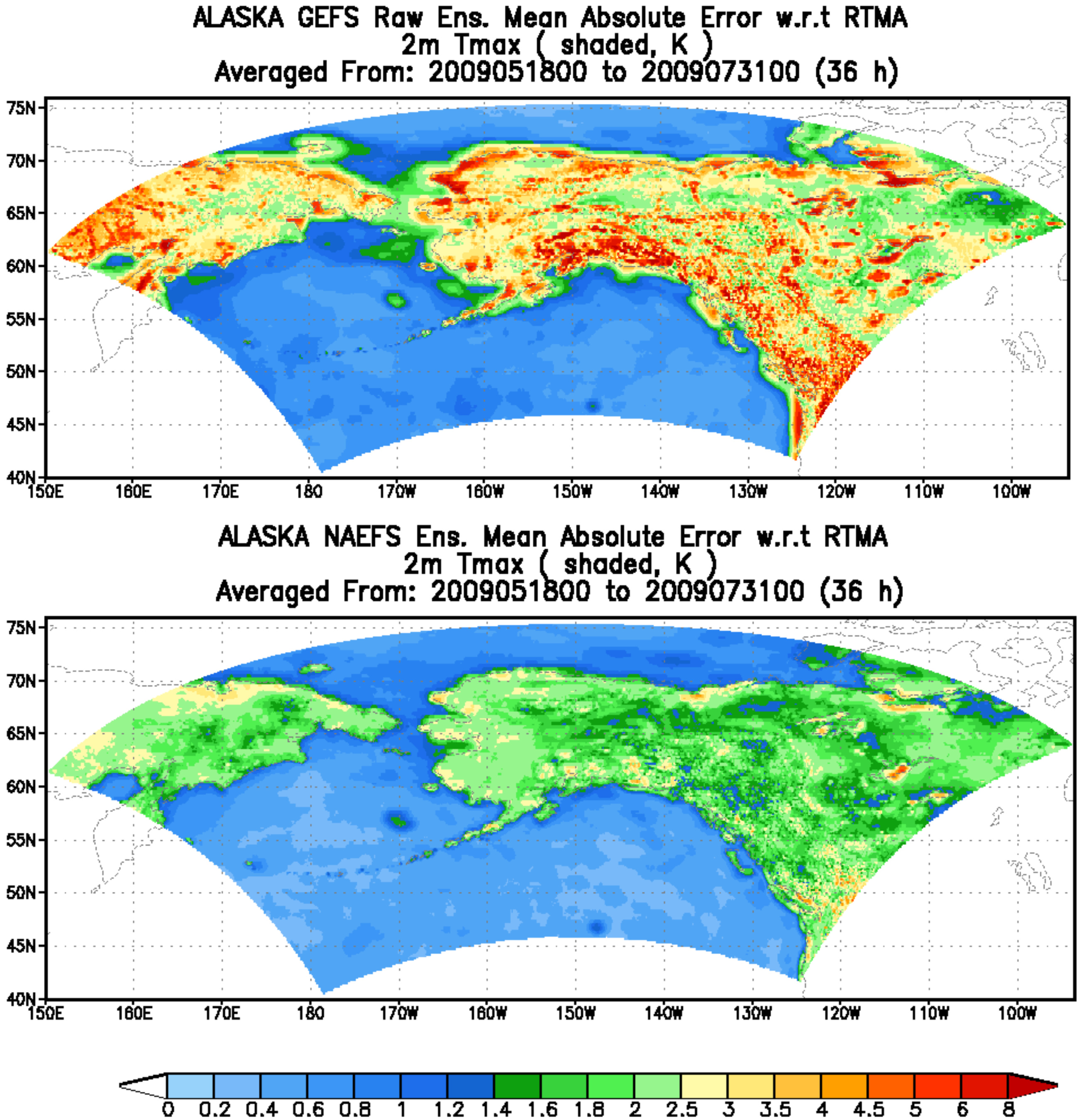




Tmax 36 hours FCST

NCEP raw GEFS

NAEFS down-scaling



Process to Statistically Downscale Wind Speed and Direction

Method

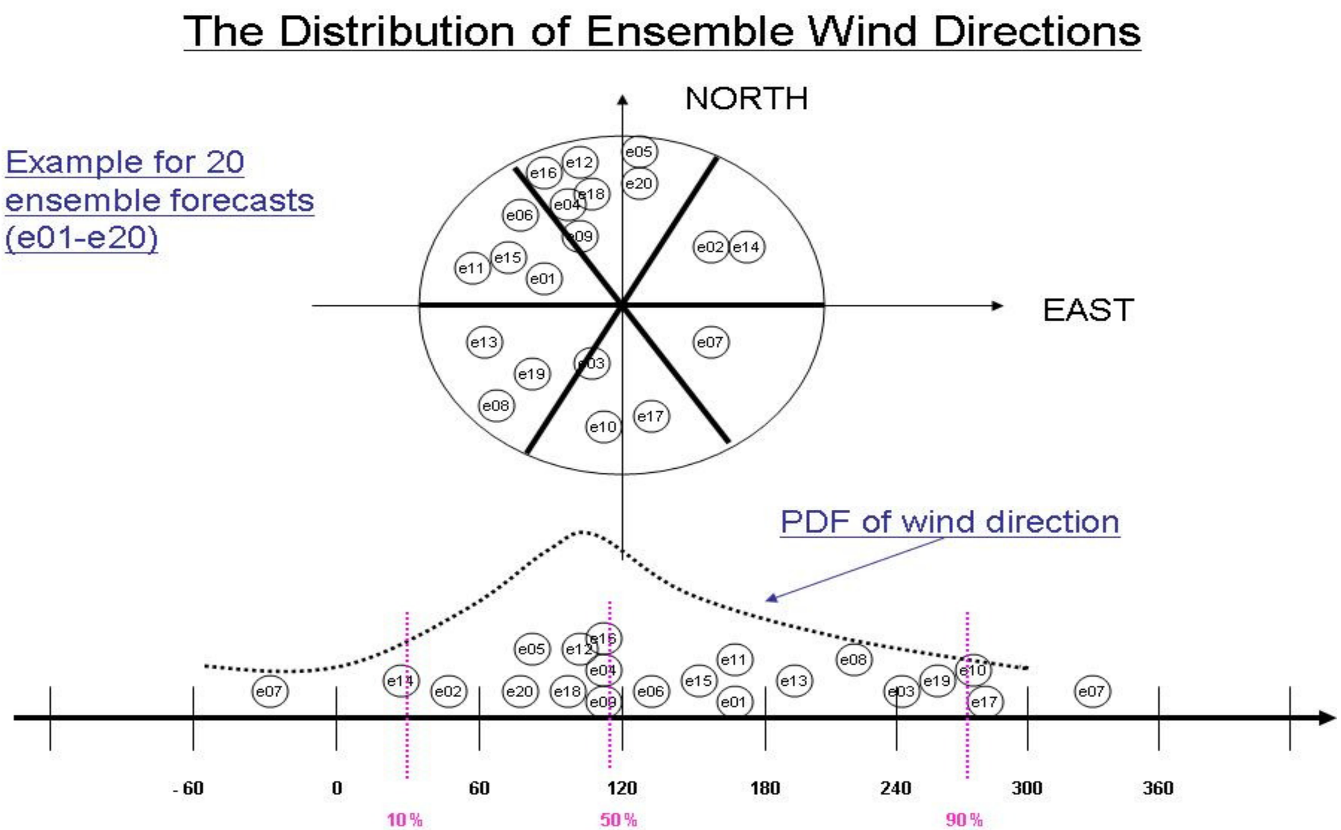
- No action for data on 1 degree, whole process based and completed on 6km grid 10m U and V
- Downscaling process
  - Apply “copygb” utility to interpolate 10m U and V for NCEP/CMC each bias corrected ensemble member
  - Apply DV to produce down-scaled 10m U and V for each member and compute its wind speed & direction for each member
  - Combine NCEP/CMC 10m wind speed & direction to generate the mean, spread, mode, 10%, 50% and 90% forecasts

- Wind speed & direction calculation based on 1*1 degree bias corr. u10m & v10m

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

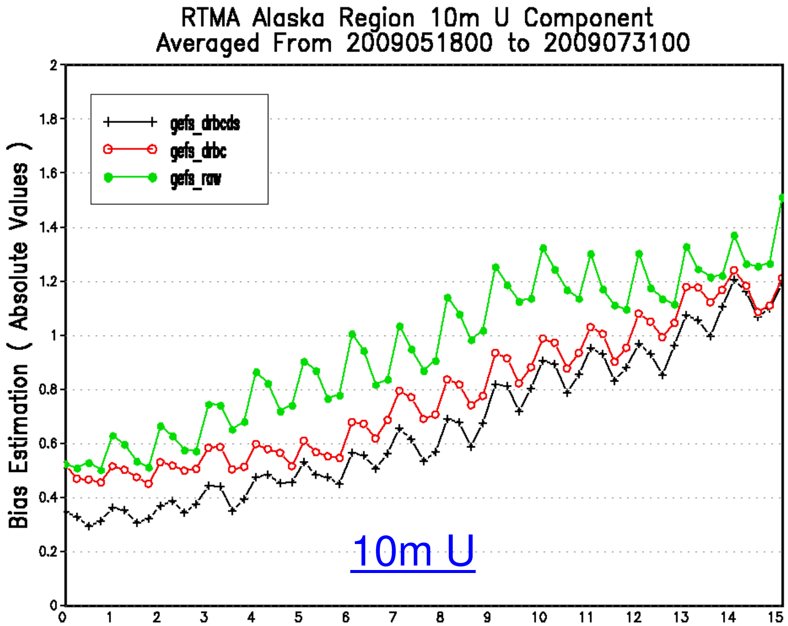
$$W_d = sign(u \cdot v) \cdot \arctan\left|\frac{u}{v}\right| + d_p \text{ where } d_p = \begin{cases} 0, if\_u \le 0, v < 0 \\ 180, if\_u < 0, v \ge 0 \\ 180, if\_u \ge 0, v > 0 \\ 360, if\_u > 0, v \le 0 \end{cases}$$

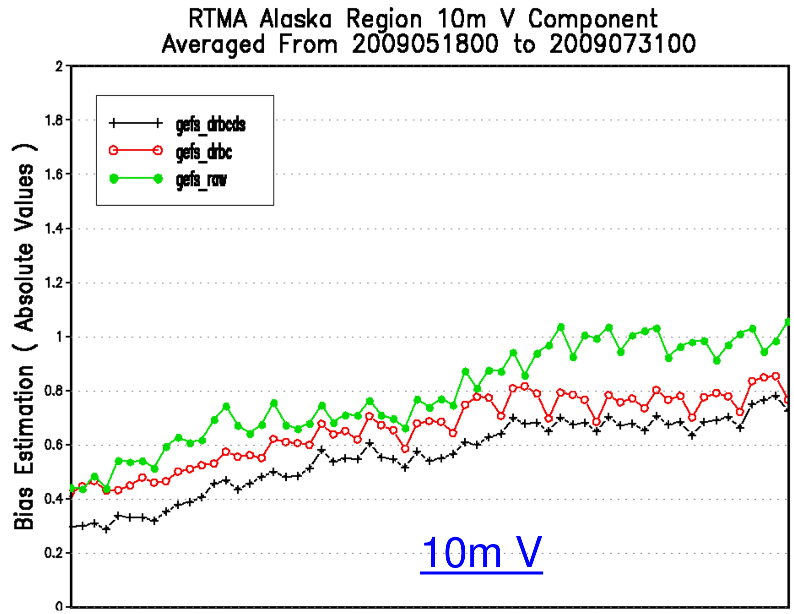
Probabilistic Wind Direction Calculation

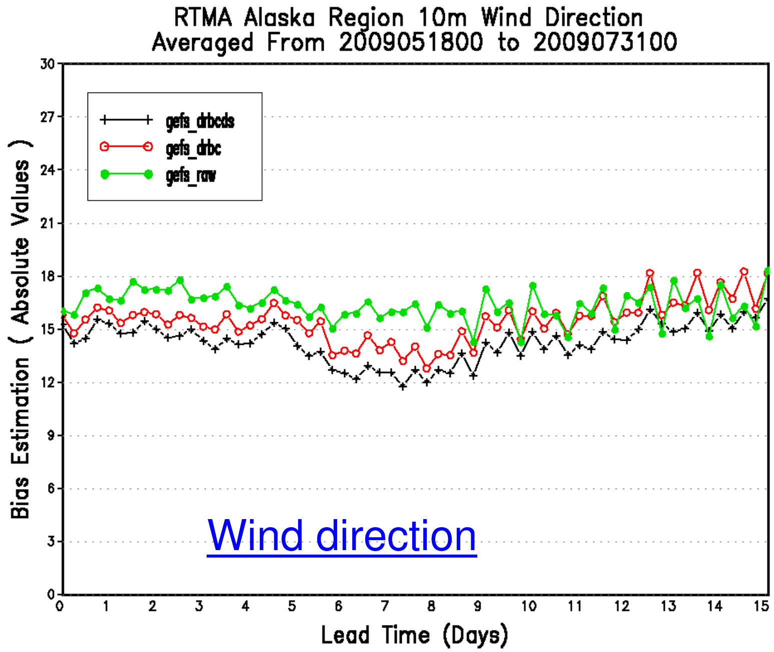


- Divide (0,360) into 6 units, choose the closed 2 units where Wdir data (equal weight currently, different weight by wind speed as a option ?) fall most
- Rearrange the data to allow 2 units in the middle of the distribution
- Set a 60 degree window, move the window through the 2 units, mode is the 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]

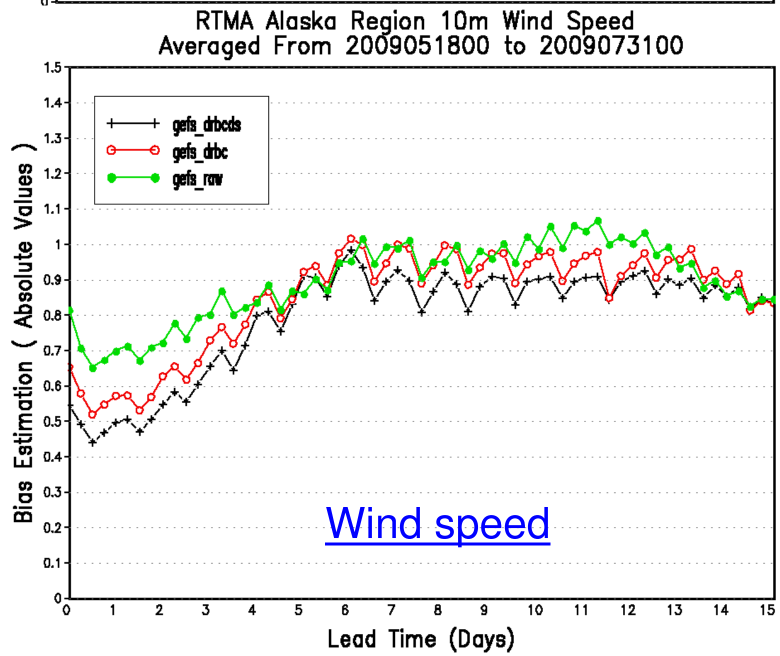
Preliminary Statistics for Winds BIAS (period: 20090518 – 20090731)



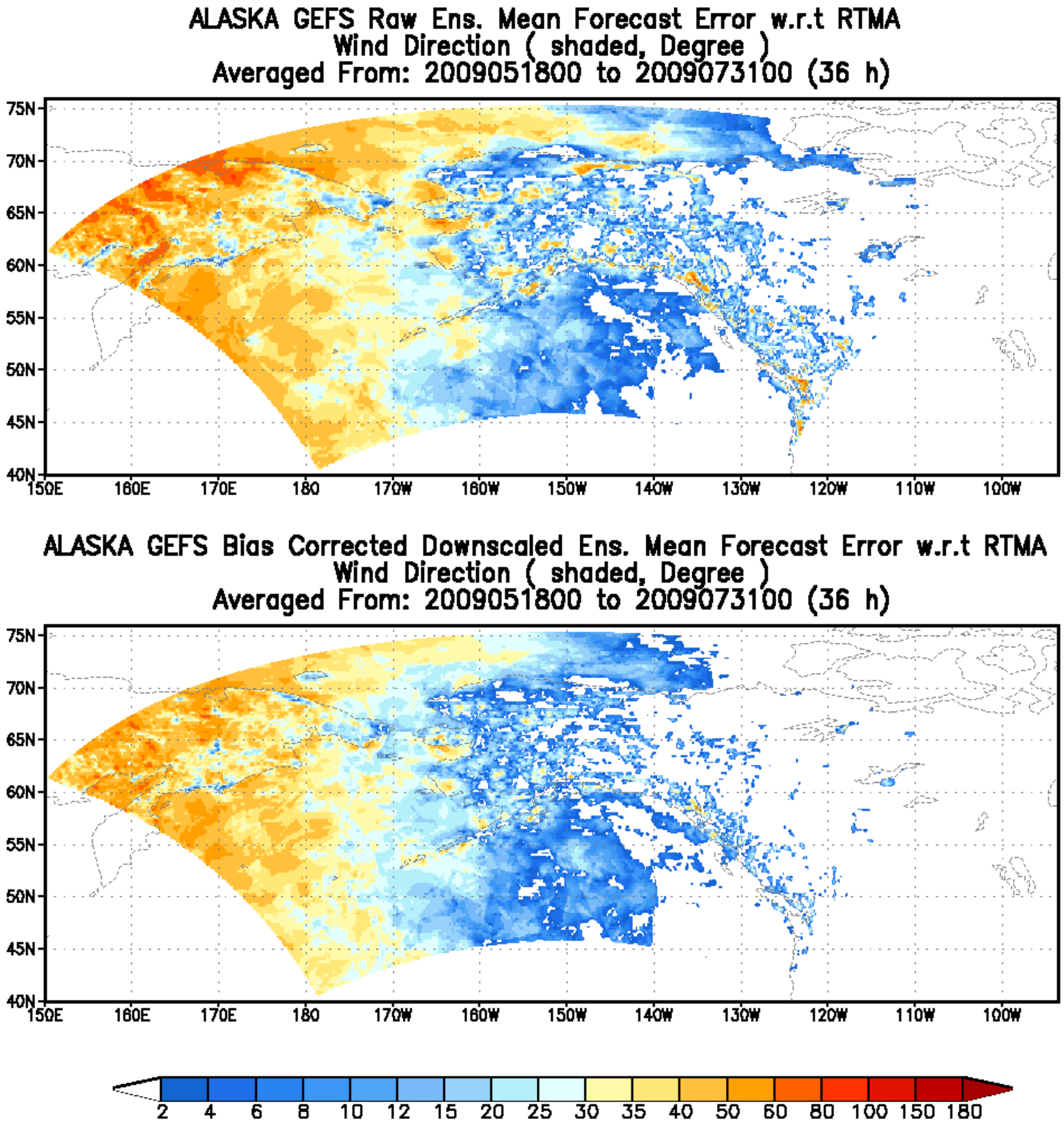




BO CUI, GCWMB/EMC/NCEP/NOAA



BO CUI, GCWMB/EMC/NCEP/NOAA



Wind direction – 36h

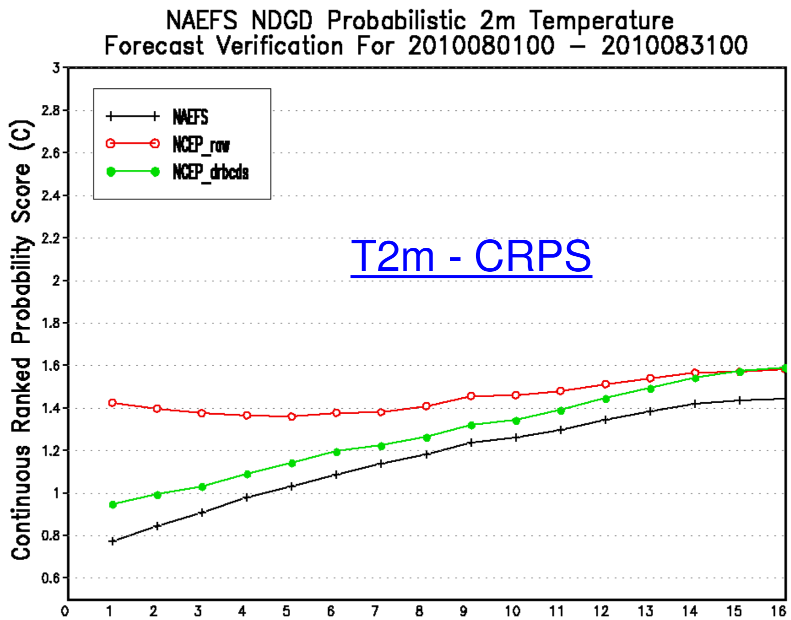
NCEP raw GEFS

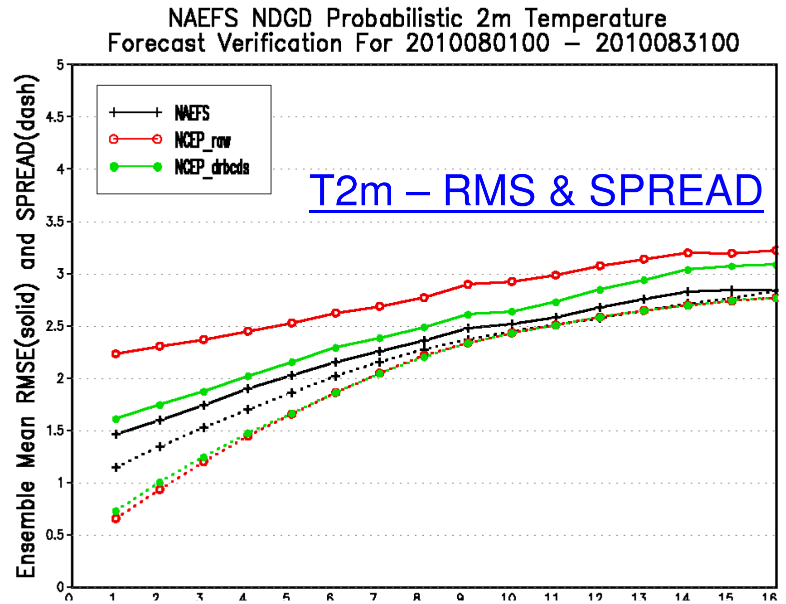
Bias corrected

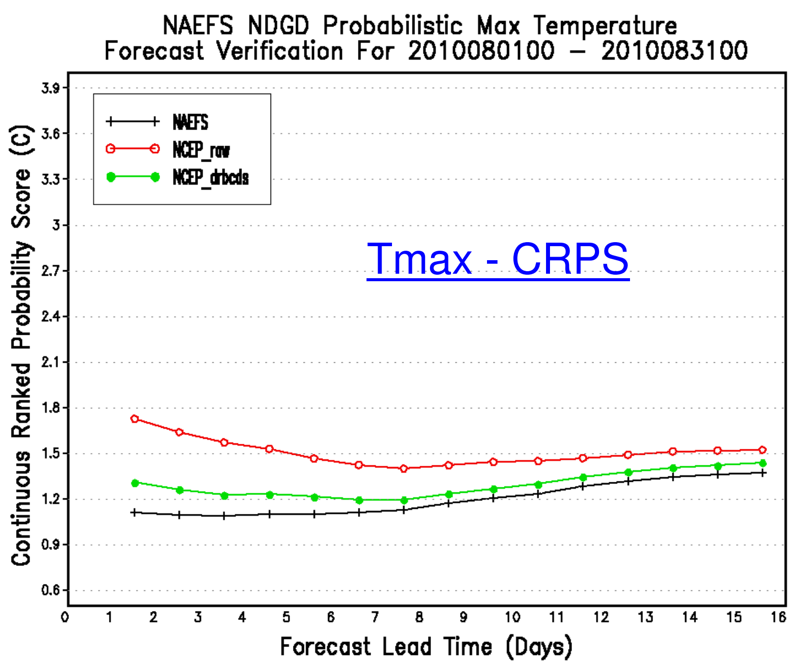
+ down scaling

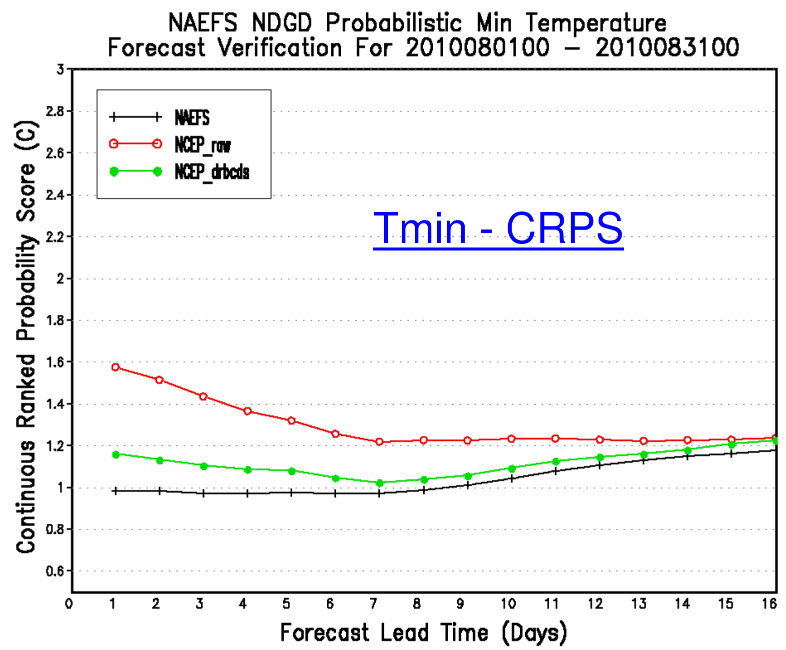
NCO real time parallel evaluations

Latest temperature evaluation (period: 20100801-20100831)

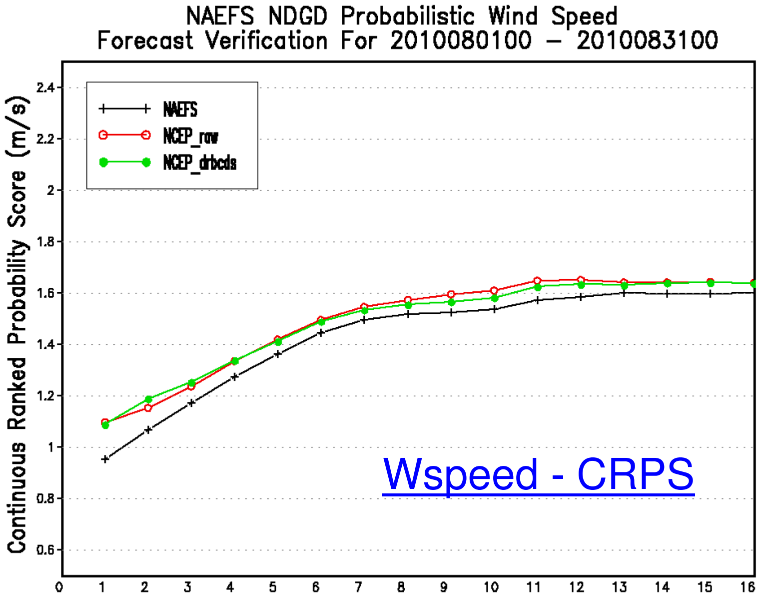


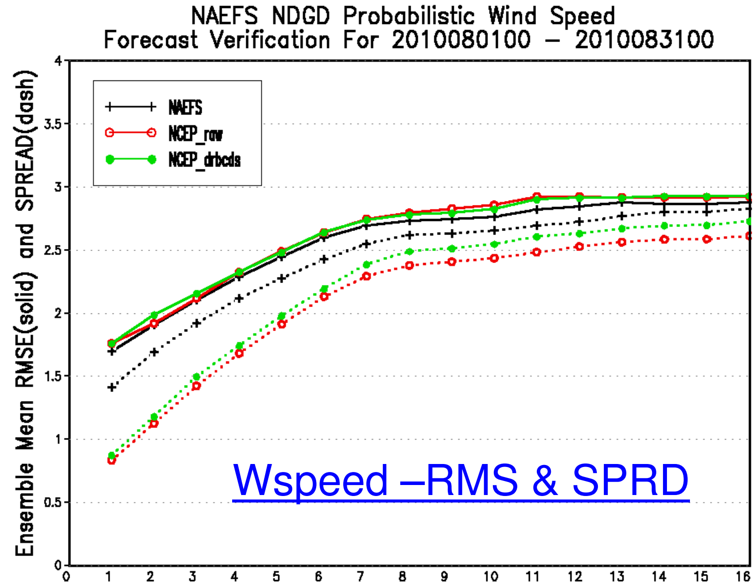


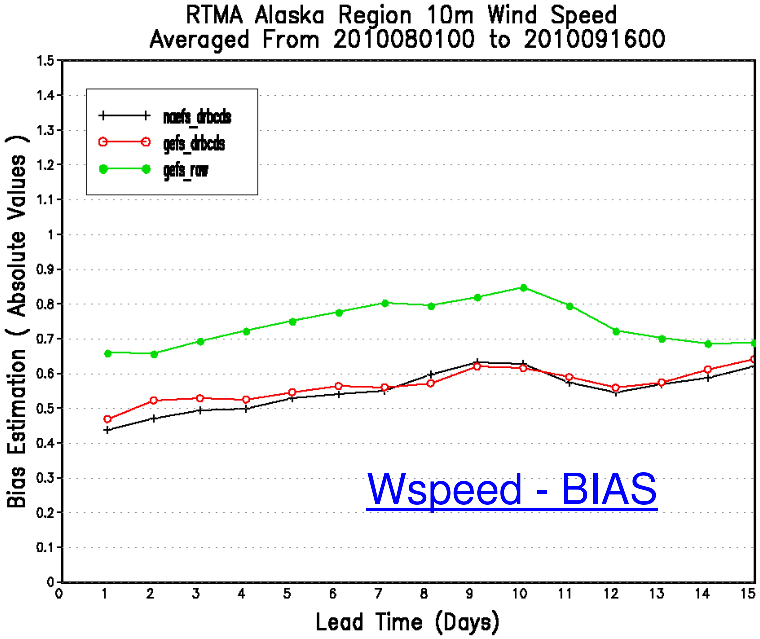


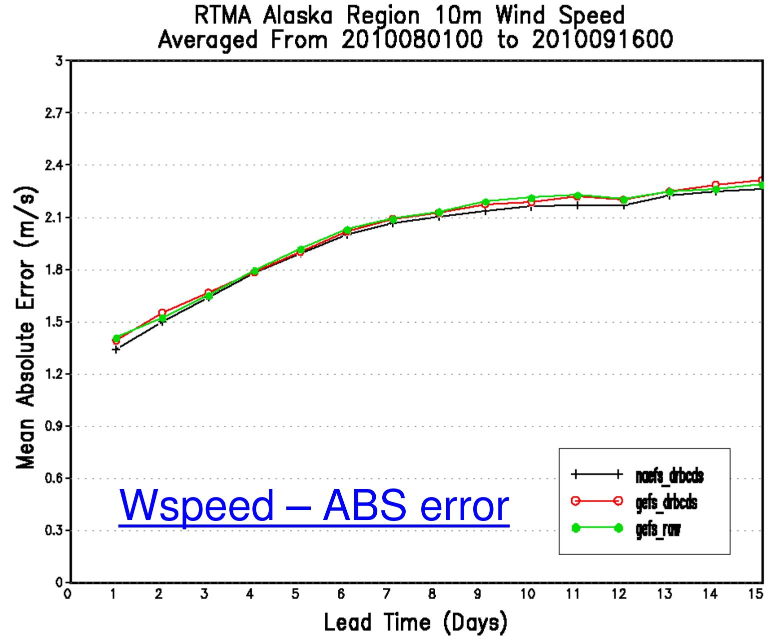


Latest wind evaluation (period: 20100801-20100831)









BO CUI, GCWMB/EMC/NCEP/NOAA

BO CUI, GCWMB/EMC/NCEP/NOAA

Summary and future plan

- Bias correction adds value
- Statistical down-scaling adds value
- Bias correction with downscaling adds significant value to the forecasts
- NAEFS is better than GEFS alone
- T2m, Tmax and Tmin are significant improved when compared to winds (seasonal dependent).
- Plan to improve the algorithm for winds calibration (speed/direction)
- Plan to calibrate Td (2-meter dew-point temperature for CONUS)
- Plan to expand additional 4 variables to CONUS (Tmax, Tmin, Wspeed and Wdir)

2010 NAEFS AK Implementation

HPC Evaluation

Presented by David Novak

With contributions from Chris Bailey, Paul Kocin, and Tony Fracasso

and

With concurrence of HPC Director, Jim Hoke

Evaluation Method

Forecaster evaluation focused on basic quality rather than detailed comparison with existing products, given it is an entirely new dataset.

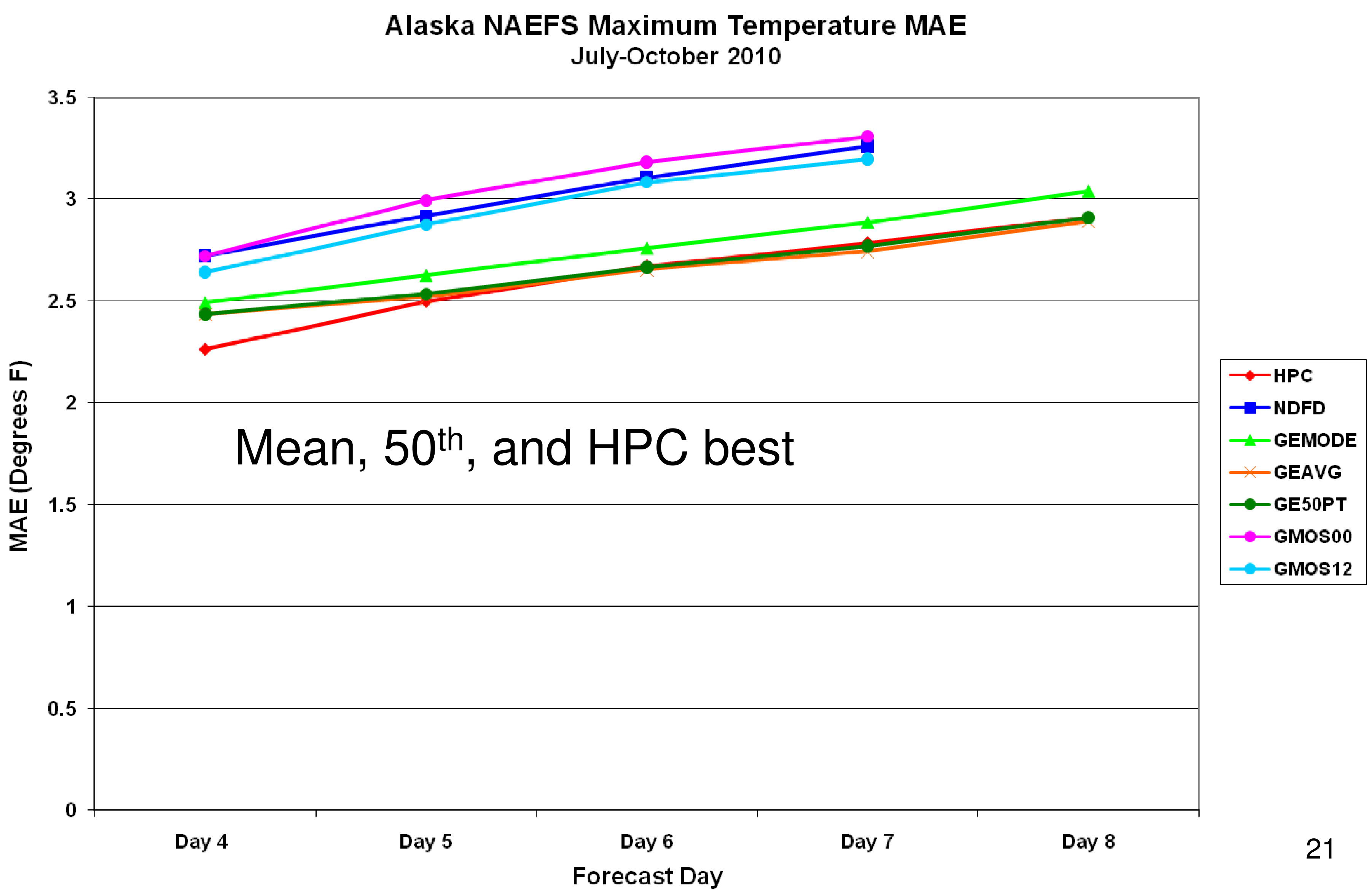
Forecasters viewed 10^{th}, 50^{th}, 90^{th}, mean, and mode in NMAP

Daily subjective evaluations provided via web form

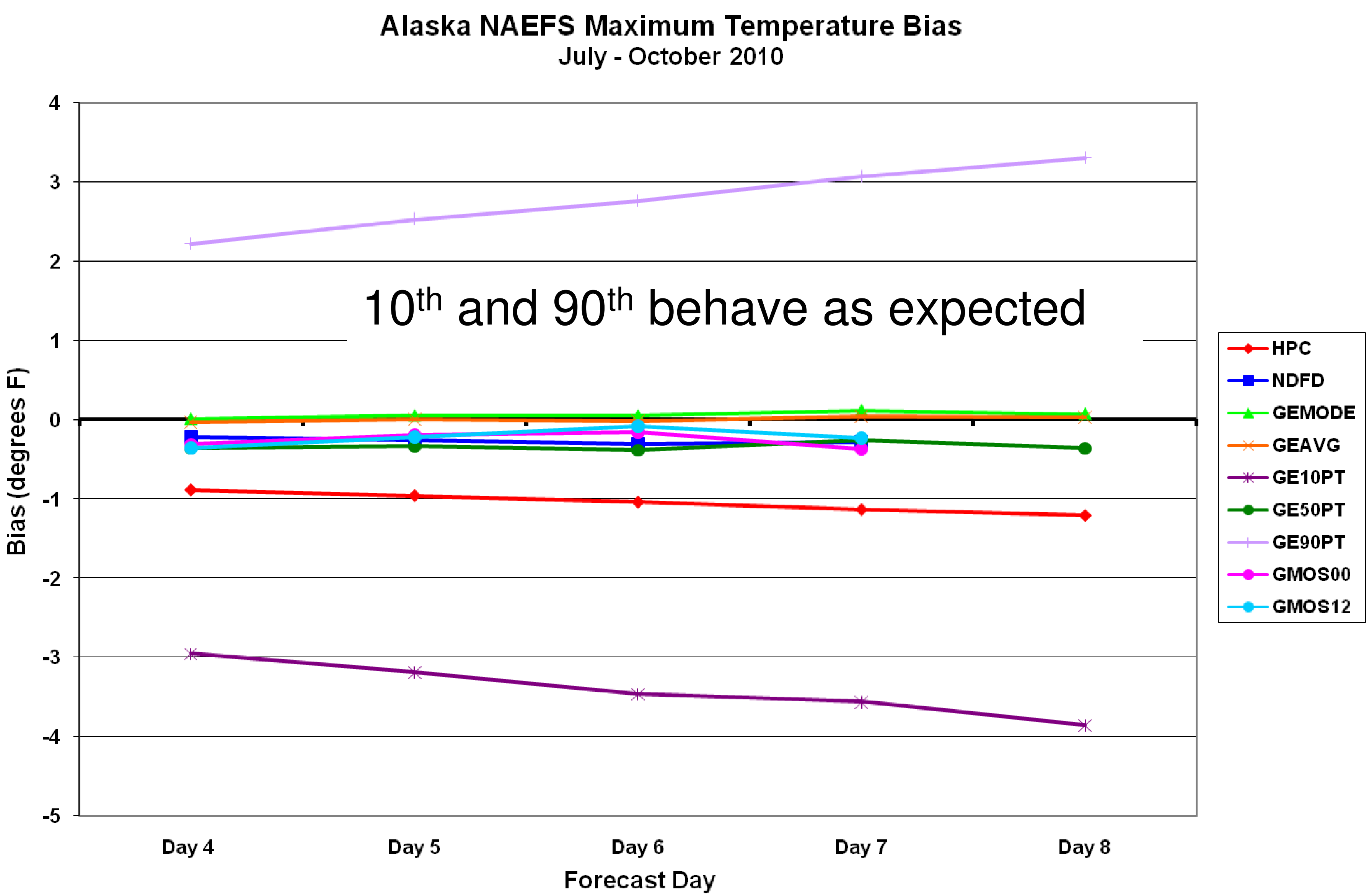
Multi-month objective verification compiled

-HPC had reliable access on CCS since July 2010

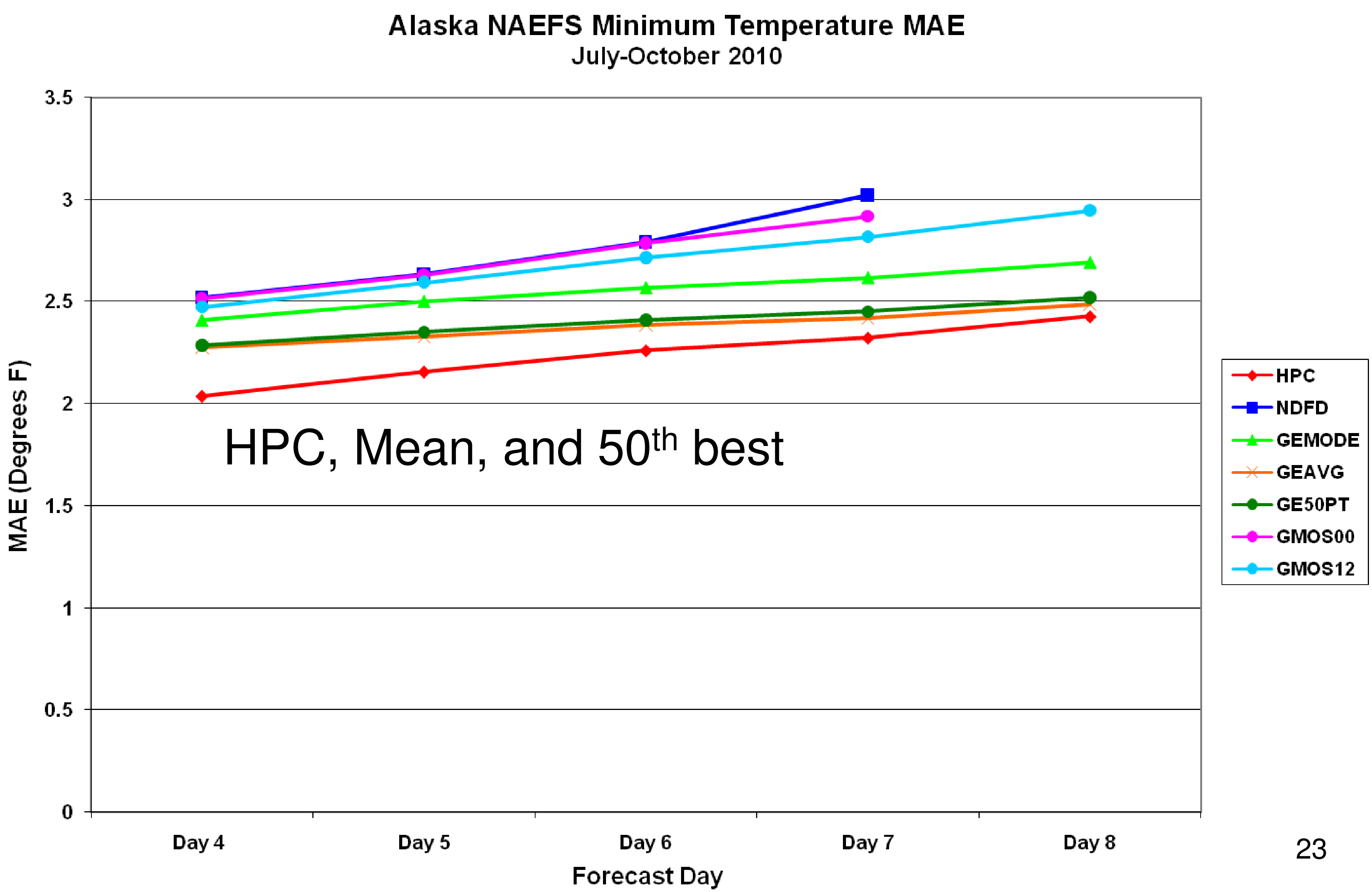
Objective Evaluation

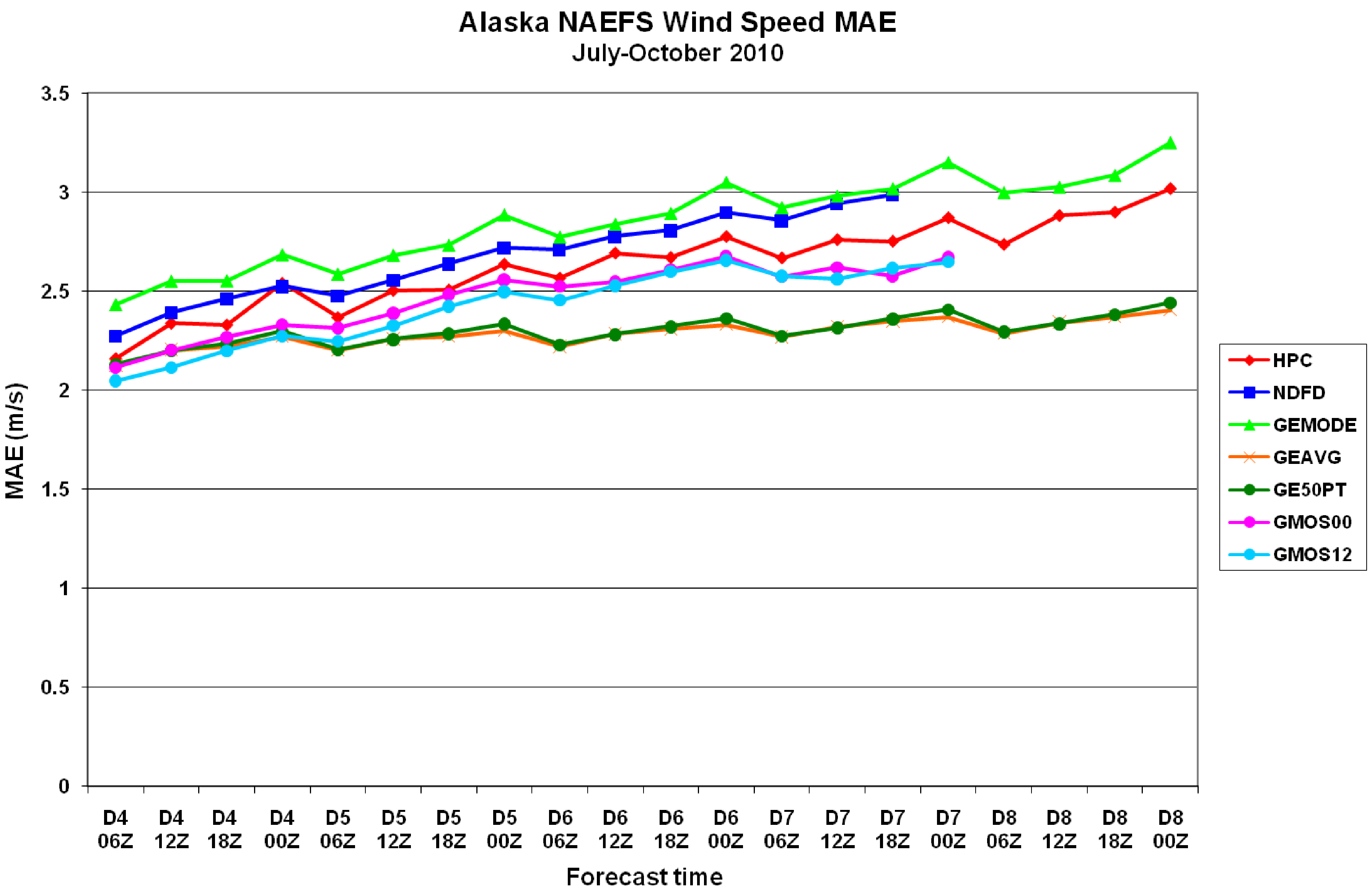


Objective Evaluation



Objective Evaluation




Alaska NAEFS Wind Speed MAE
July-October 2010
MAE (m/s)
3.5
3
2.5
2
1.5
1
0.5
0
D4 06Z
D4 12Z
D4 18Z
D4 00Z
D5 06Z
D5 12Z
D5 18Z
D5 00Z
D6 06Z
D6 12Z
D6 18Z
D6 00Z
D7 06Z
D7 12Z
D7 18Z
D7 00Z
D8 06Z
D8 12Z
D8 18Z
D8 00Z
Forecast time
HPC
NDFD
GEMODE
GEAVG
GE50PT
GMOS00
GMOS12

Objective Evaluation

50th percentile and Mean very impressive:

-improves over MOS.

-very competitive with HPC.

Behavior of 10th and 90th consistent with expectations except for wind speed.

Did not evaluate reliability and probabilistic skill.

Near-term Operational Implications

Add Mean as option to HPC blender for forecaster use.

Ingest mean data into GFE for forecaster use.

NOTE: Difficult to load 5 km fields in NMAP.

Overall HPC Evaluation

Overall, impression was that the guidance will be very useful. Verification shows Mean and 50th percentile improve over deterministic MOS.

-HPC will consider integrating into forecaster blender and GFE.

•HPC Recommends Implementation

•Enthusiastically endorse expansion to CONUS