Statistical Down-Scaling for Alaska Region

Bo Cui[1], Yuejian Zhu[2] , Zoltan Toth[2]

[1]SAIC at Environmental Modeling Center, NCEP/NWS
[2]Environmental Modeling Center, NCEP/NWS

Acknowledgements

Keith Brill, David Novak, Manuel Pondeca

Overview

Statistical Down-Scaling Techniques for Alaska

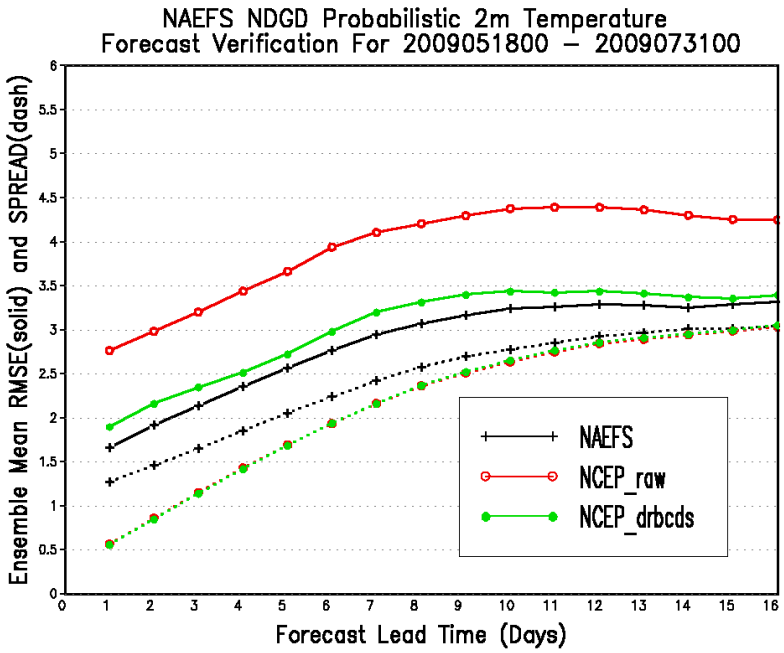
- Variable: surface pressure, 2-m temperature, 10-meter wind component
  - work well using current operational technique for CONUS
- Variable: Tmax and Tmin
  - Choose proper period definition in code/scripts
  - Modification for definition changed July, 2009
- Variable: wind speed and direction
  -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

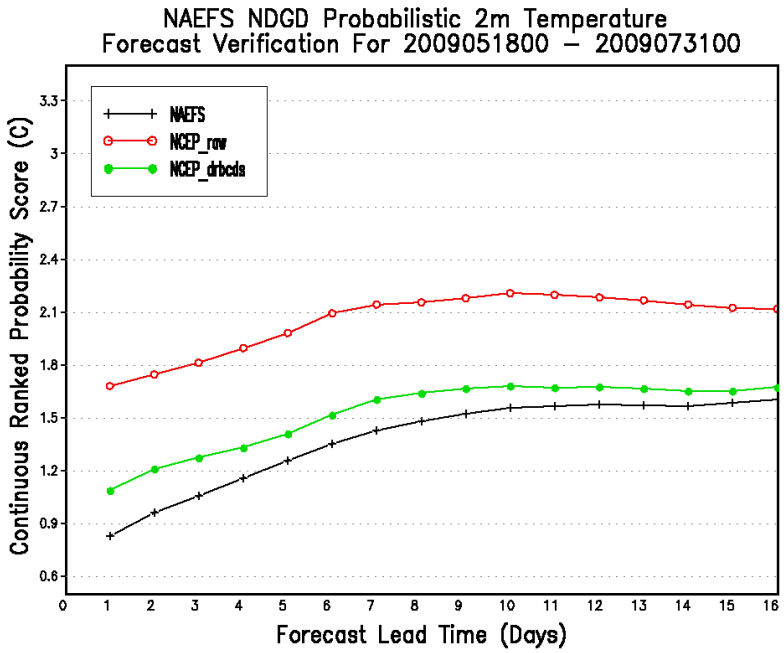
Alaska Verification

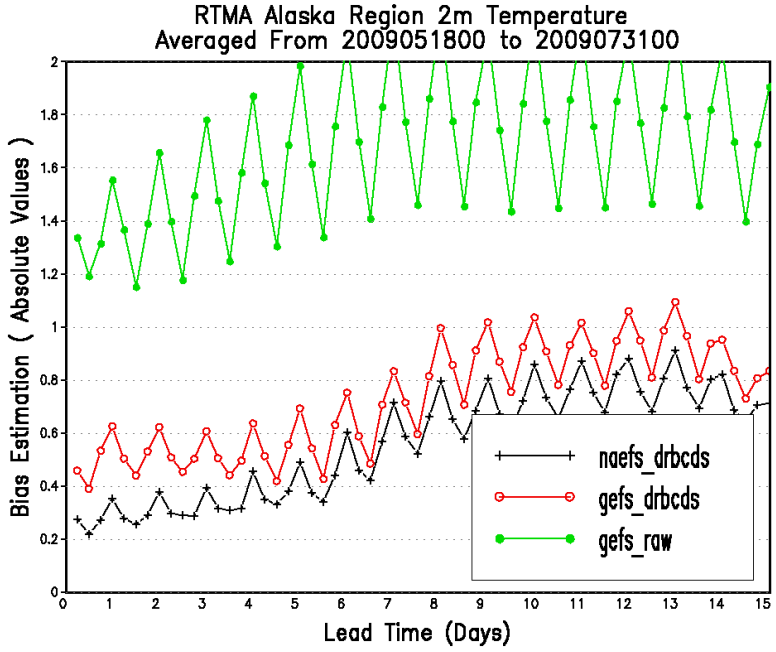
- Next images show some verification for Tmax, Tmin, wind direction/speed
- First a few key points:
  - Statistical down-scaling data adds value
  - Bias correction alone is of value
  - Bias correction with downscaling adds significant value to the forecasts
  - NAEFS is better than lone GEFS
    - More members is better

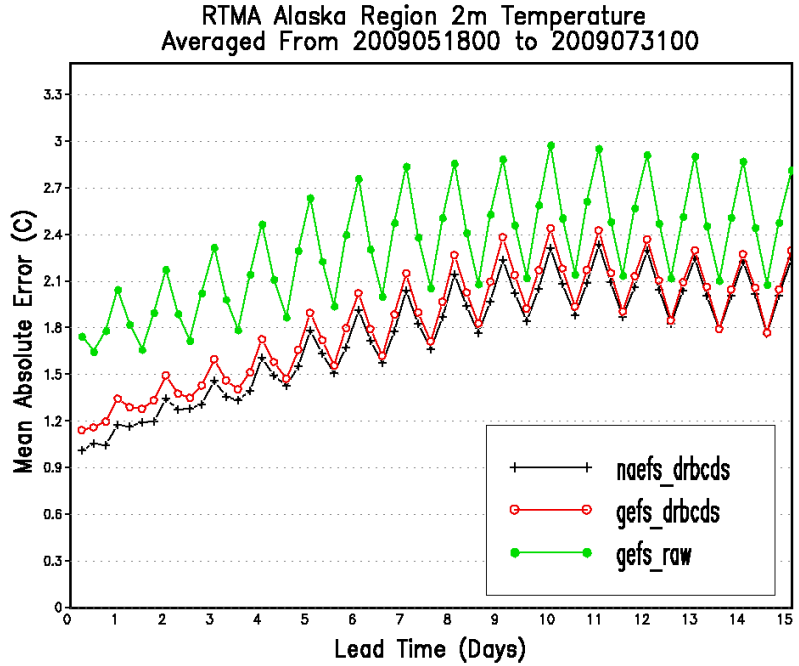
Statistical downscaling for NAEFS forecast

- 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
- Application
  - Ensemble mean, mode, 10%, 50%(median) and 90% forecasts


NAEFS NDGD Probabilistic 2m Temperature
Forecast Verification For 2009051800 – 2009073100
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds


NAEFS NDGD Probabilistic 2m Temperature
Forecast Verification For 2009051800 – 2009073100
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds


RTMA Alaska Region 2m Temperature
Averaged From 2009051800 to 2009073100
Bias Estimation (Absolute Values)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw


RTMA Alaska Region 2m Temperature
Averaged From 2009051800 to 2009073100
Mean Absolute Error (C)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw

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**

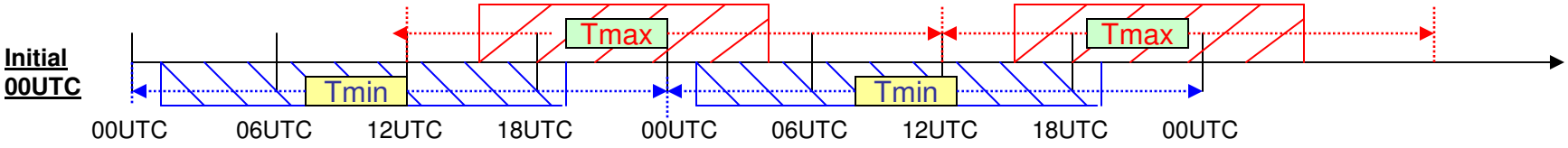
Tmax and Tmin calculations for Alaska region (2009)

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), ……

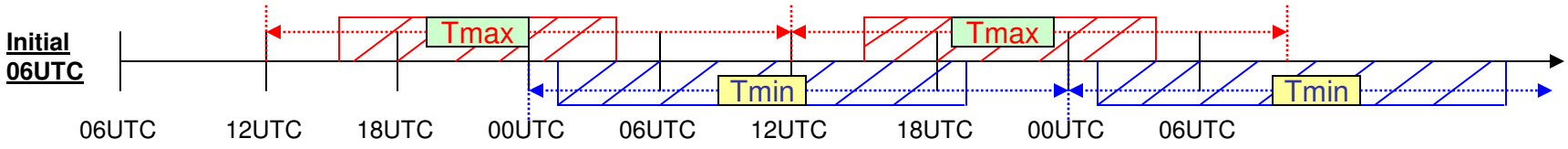
(00UTC) Tmin: f06(no), f12(no), f18(no), f24(yes:0-24hrs), f30(no), f36(no), f42(no), f48(yes:24-48hrs), ……



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), ……

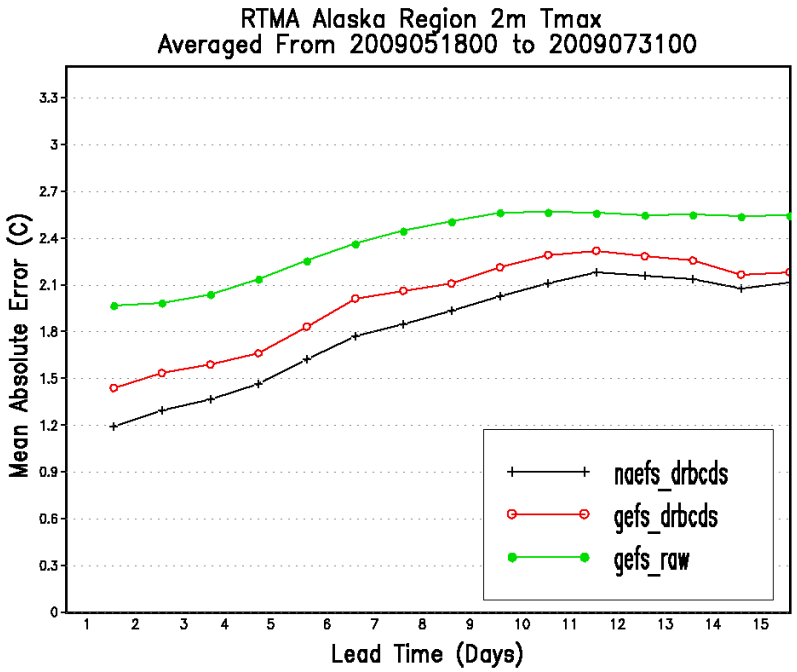
(06UTC) Tmin: f24(no), f30(no), f36(no), f42(yes:18-42hrs), f48(no), f54(no), f60(no), f66(yes:42-66hrs), ……

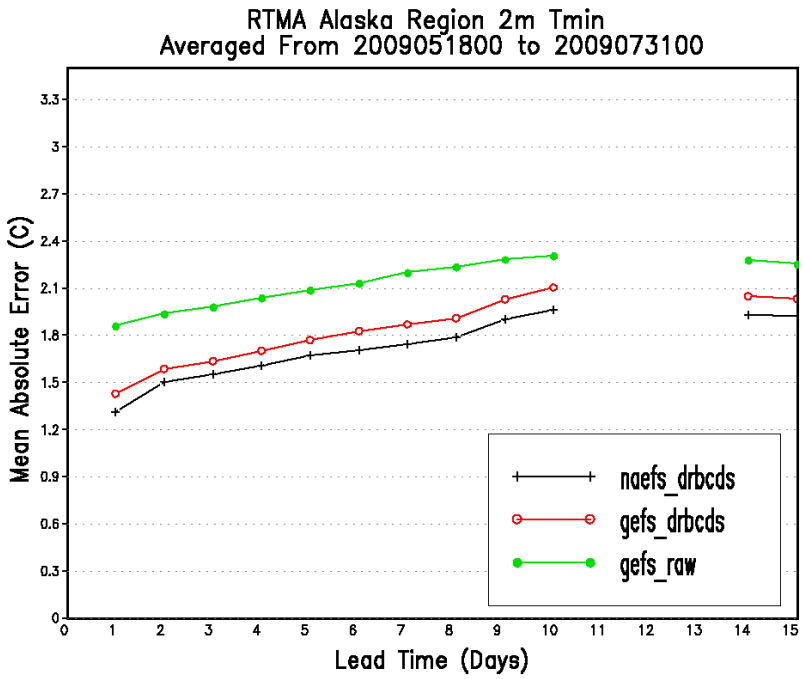


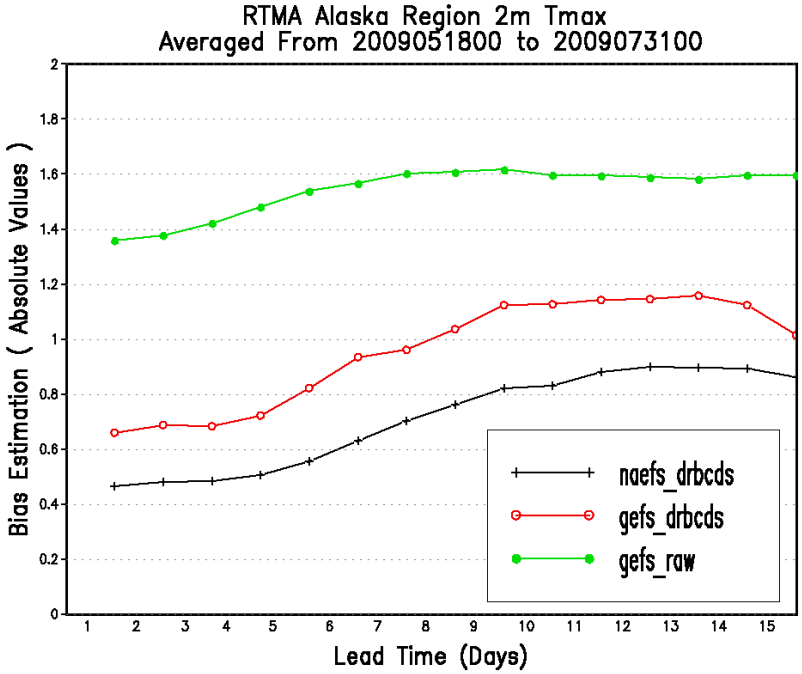
06UTC temperature forecast at valid time

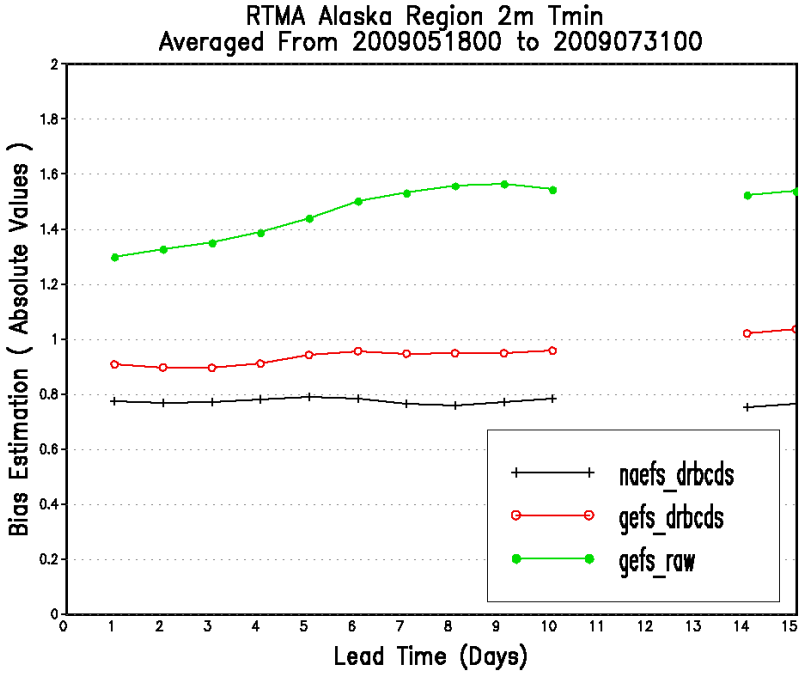
Alaska Standard Time : Tmax period: 14UTC (5am-local) – 05UTC (8pm-local)

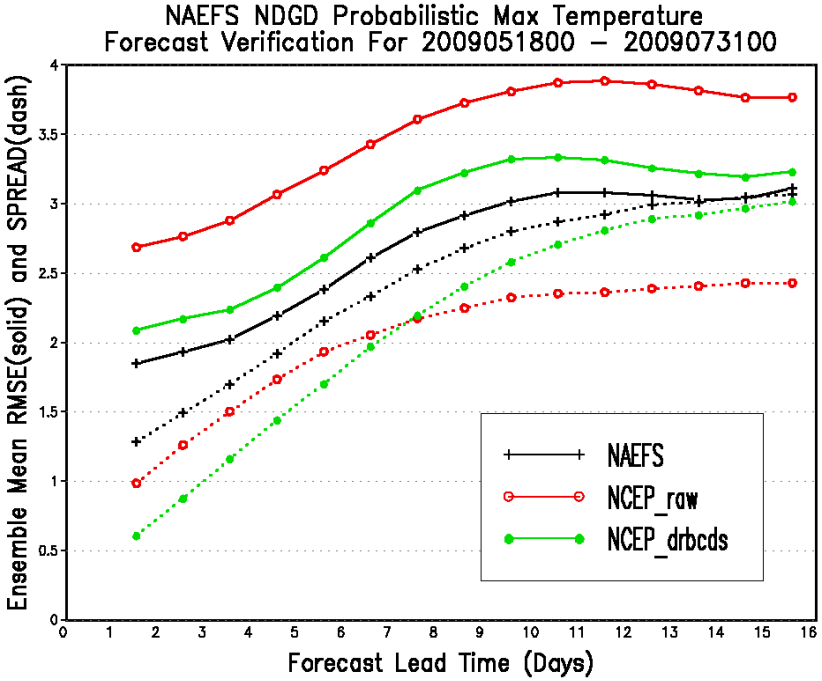
Tmin period: 02UTC (5pm-local) – 20UTC (11am-local)

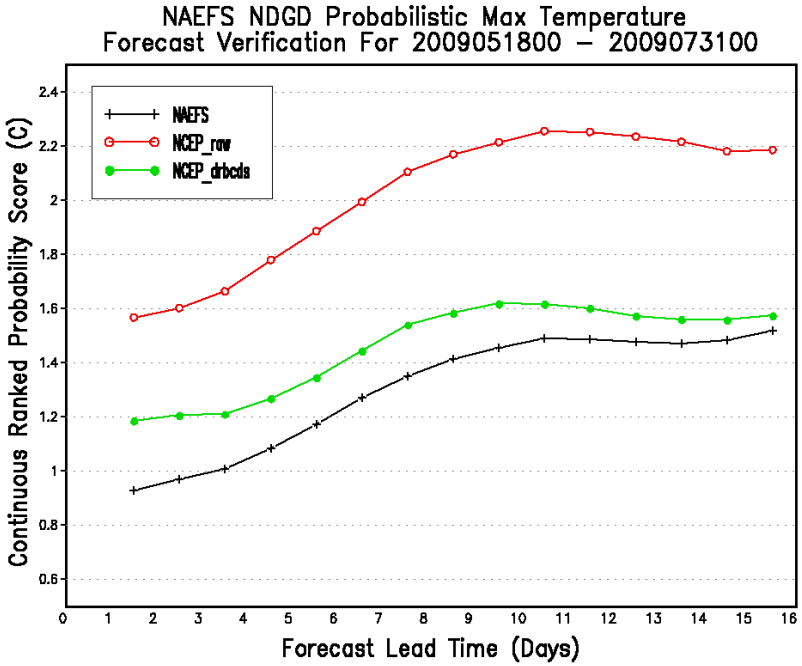

RTMA Alaska Region 2m Tmax
Averaged From 2009051800 to 2009073100
Mean Absolute Error (C)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw

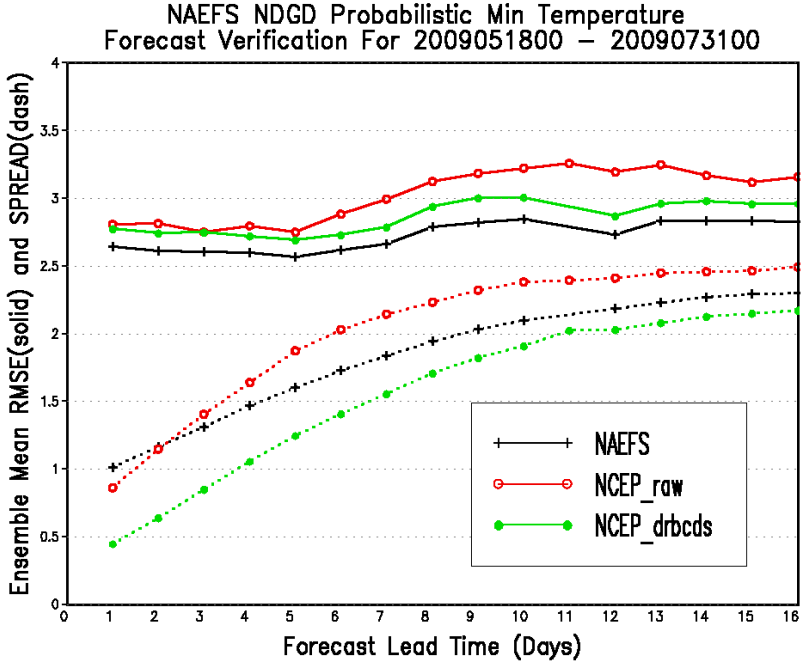

RTMA Alaska Region 2m Tmin
Averaged From 2009051800 to 2009073100
Mean Absolute Error (C)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw

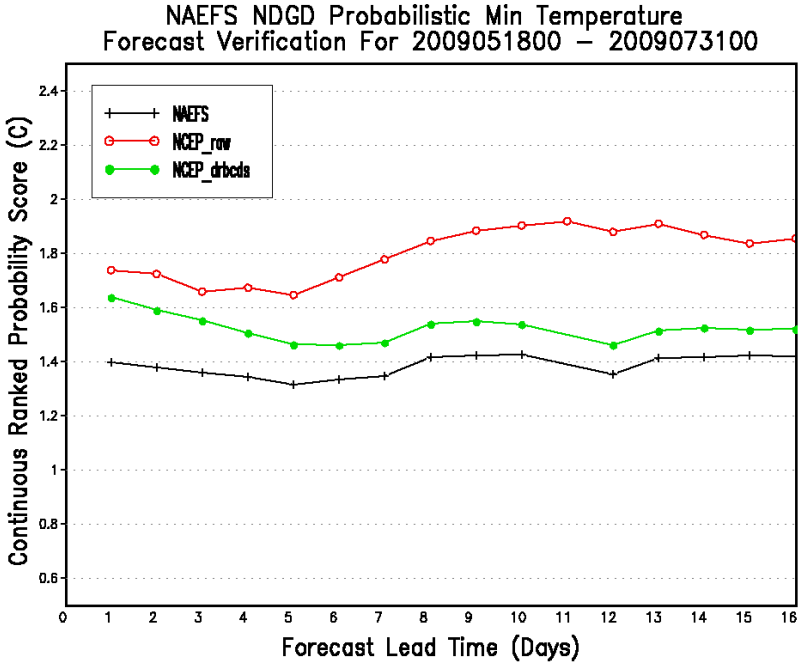

RTMA Alaska Region 2m Tmax
Averaged From 2009051800 to 2009073100
Bias Estimation (Absolute Values)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw


RTMA Alaska Region 2m Tmin
Averaged From 2009051800 to 2009073100
Bias Estimation (Absolute Values)
Lead Time (Days)
naefs_drbcds
gefs_drbcds
gefs_raw

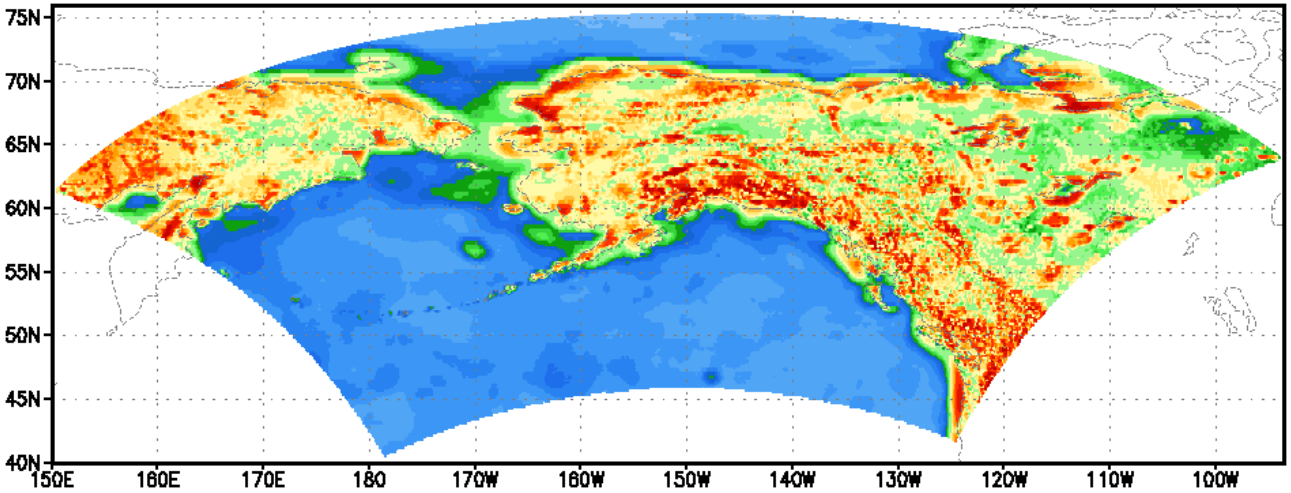

NAEFS NDGD Probabilistic Max Temperature
Forecast Verification For 2009051800 – 2009073100
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds


NAEFS NDGD Probabilistic Max Temperature
Forecast Verification For 2009051800 – 2009073100
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds

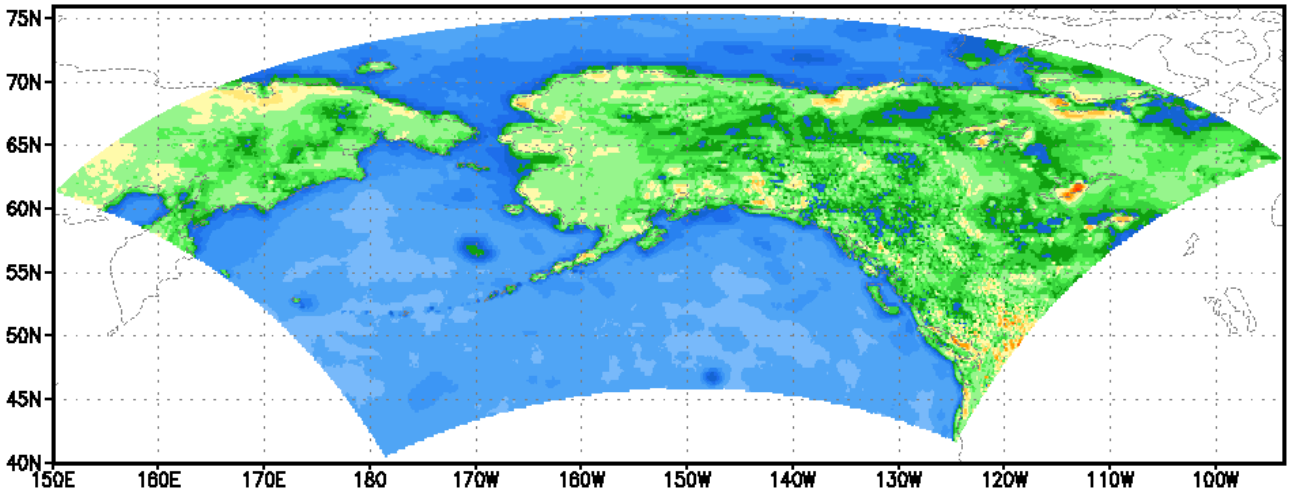

NAEFS NDGD Probabilistic Min Temperature
Forecast Verification For 2009051800 – 2009073100
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds

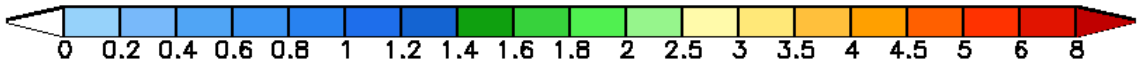

NAEFS NDGD Probabilistic Min Temperature
Forecast Verification For 2009051800 – 2009073100
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)
NAEFS
NCEP_raw
NCEP_drbcds

ALASKA GEFS Raw Ens. Mean Absolute Error w.r.t RTMA
2m Tmax (shaded, K)
Averaged From: 2009051800 to 2009073100 (36 h)



ALASKA NAEFS Ens. Mean Absolute Error w.r.t RTMA
2m Tmax (shaded, K)
Averaged From: 2009051800 to 2009073100 (36 h)





Process to Statistically Downscale Wind Speed and Direction

Old Method

- Based on 1°×1° 10m U and V
  - Compute 10m wind speed & direction forecasts
  - Combine bias corrected NCEP/CMC 10m wind speed & direction to generate the mean, spread, mode, 10%, 50% and 90% forecasts
- Downscaling process
  - Apply "copygb" utility to interpolate wind speed & direction (both forecasts and analysis) from 1 degree to 6km grid
  - Get downscaling vectors (DV) for wind speed & direction at each 6-hr cycle
  - Apply DV to the mean, mode, 10%, 50% and 90% forecasts to produce down-scaled wind speed & direction for each 6-hr lead-time period

Question: "copygb" work properly for wind direction? For example, interpolation between 6° and 350°?

Current 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 ensemble member
  - Apply DV to produce down-scaled 10m U and V for each member and compute itsm wind speed & direction for each member
  - 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

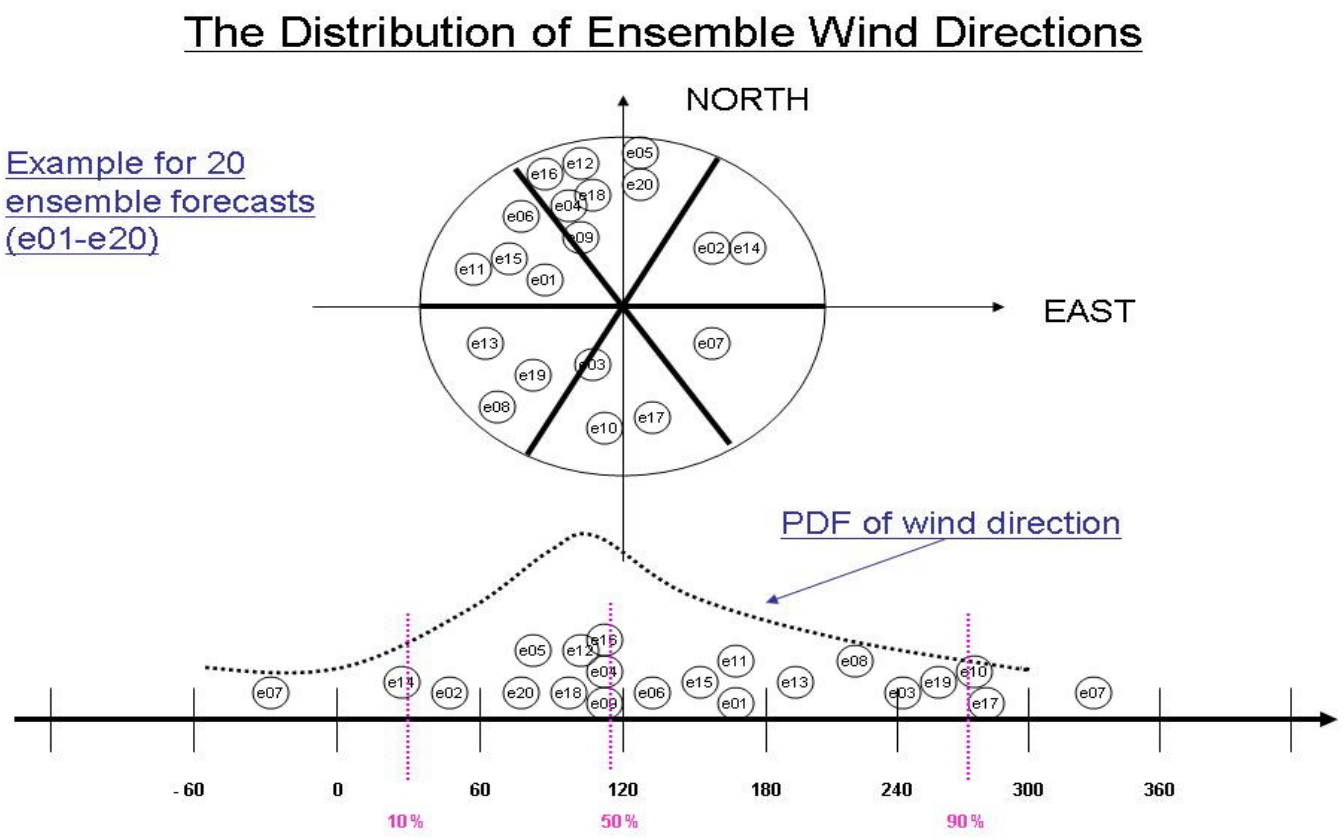
Process to Statistically Downscale Wind

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

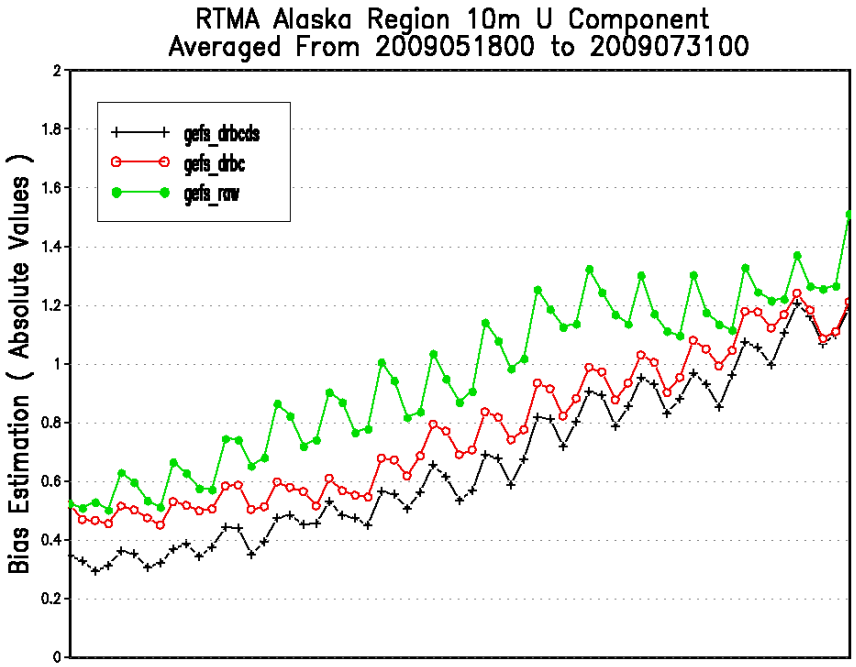
$$W_s = \sqrt{u^2 + v^2}$$

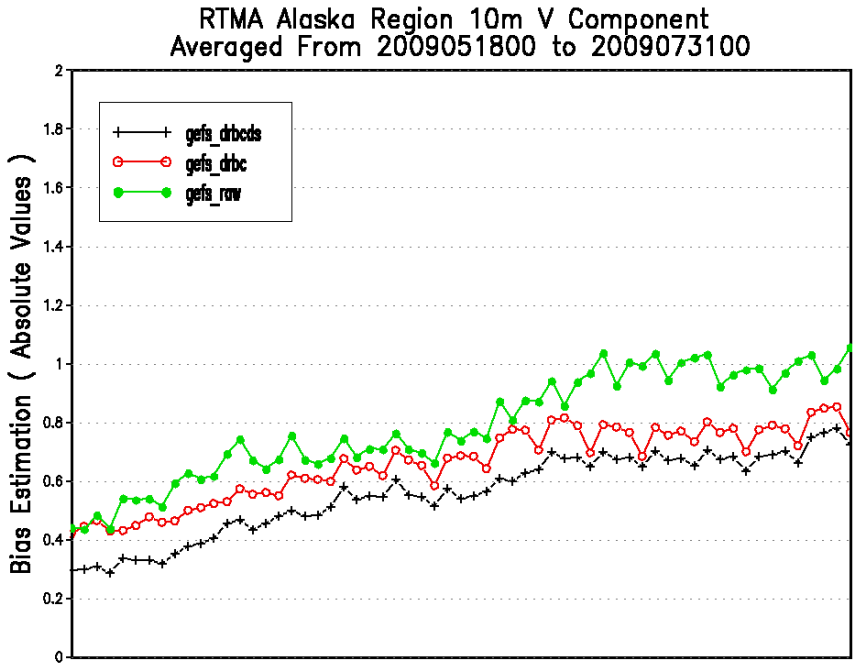
$$W_d = sign(u \cdot v) \cdot \arctan\left|\frac{u}{v}\right| + d_p \text{ where } d_p = \begin{cases} 0, if\_u \le 0, v < 0 \\ 180, if\_u < 0, v \ge 0 \\ 180, if\_u \ge 0, v > 0 \\ 360, if\_u > 0, v \le 0 \end{cases}$$

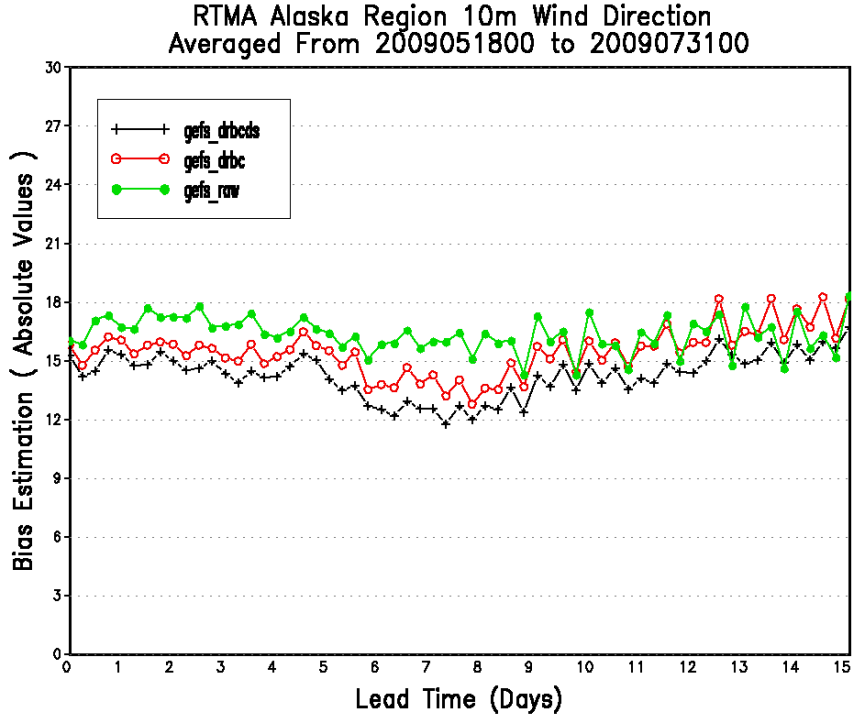
Probabilistic Wind Direction Calculation

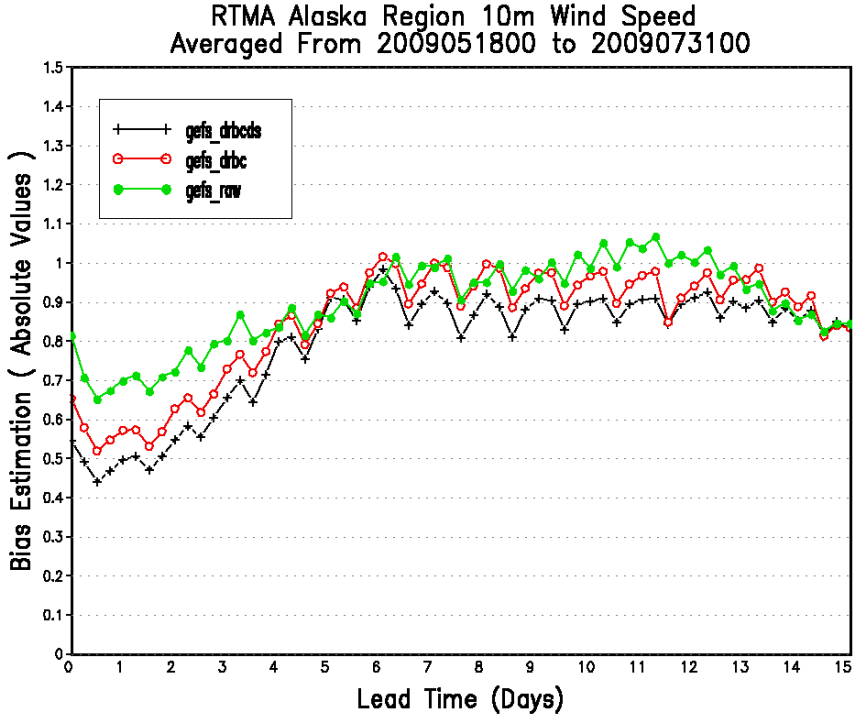


- Divide (0,360) into 6 units, choose the closed 2 units where Wdir data (equal weight currently, different weight by wind speed as a option ?) fall most
- Rearrange the data to allow 2 units in the middle of the distribution
- Set a 60 degree window, move the window through the 2 units, mode is the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





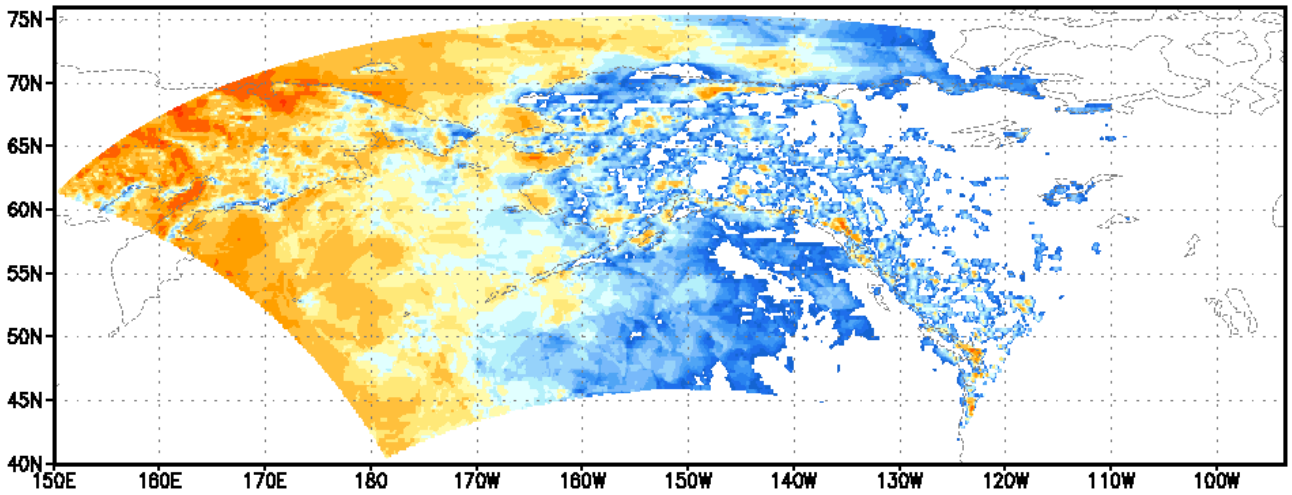




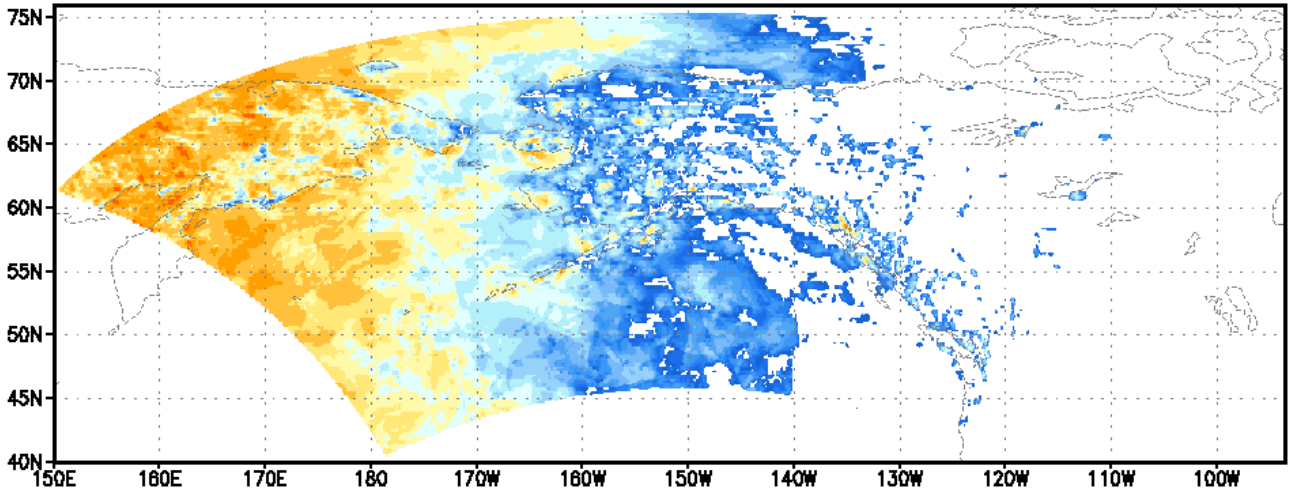
BO CUI, GCWMB/EMC/NCEP/NOAA

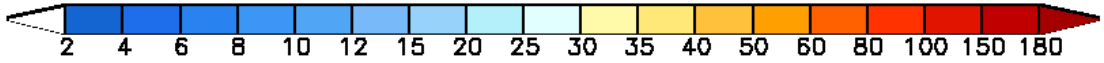
BO CUI, GCWMB/EMC/NCEP/NOAA

ALASKA GEFS Raw Ens. Mean Forecast Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (36 h)

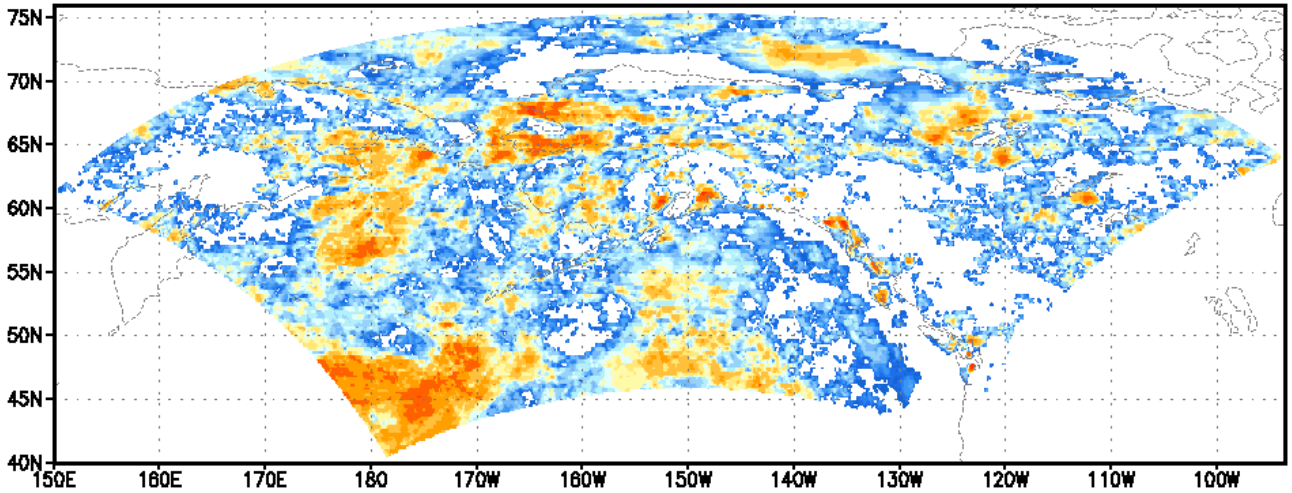


ALASKA GEFS Bias Corrected Downscaled Ens. Mean Forecast Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (36 h)

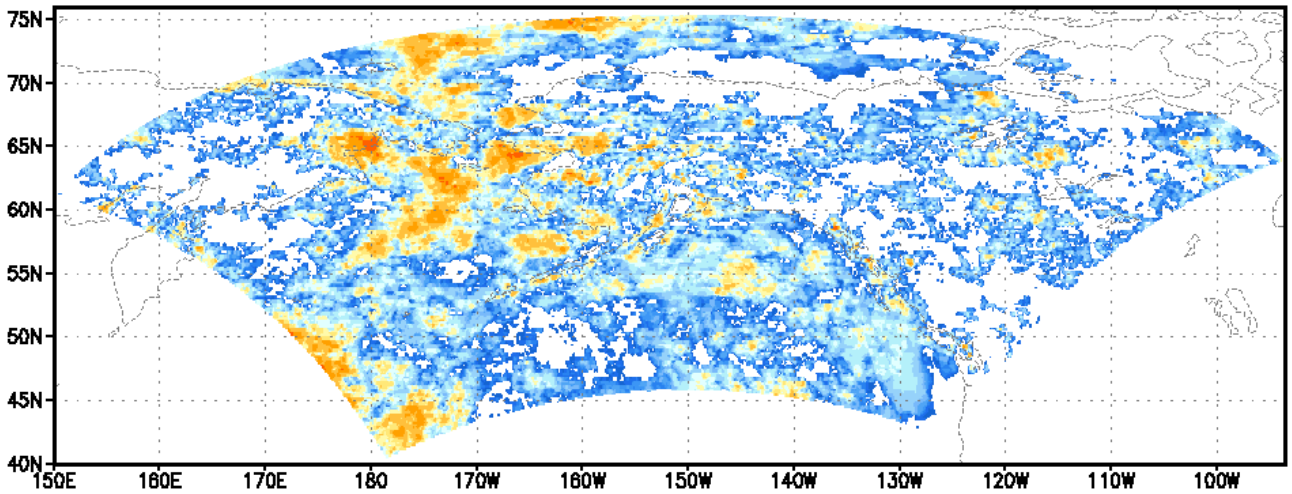


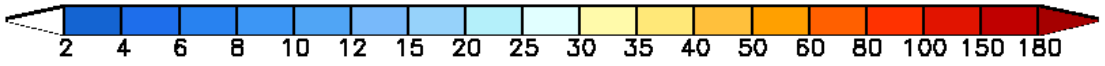


ALASKA GEFS Raw Ens. Mean Forecast Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (360 h)

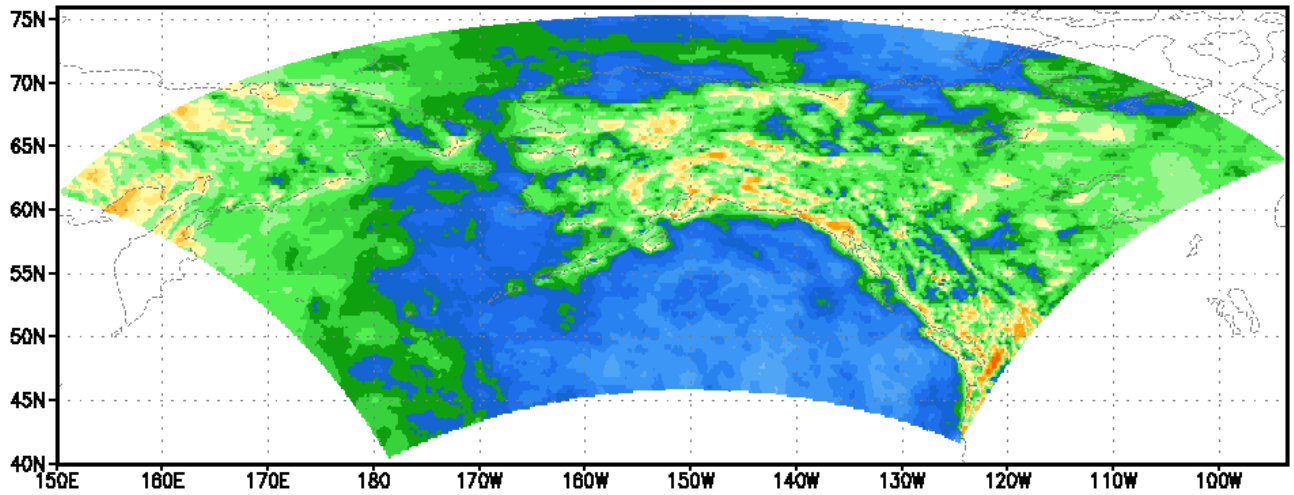


ALASKA GEFS Bias Corrected Downscaled Ens. Mean Forecast Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (360 h)





ALASKA GEFS Raw Ens. Mean Absolute Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (36 h)



ALASKA GEFS Bias Corrected Downscaled Ens. Mean Absolute Error w.r.t RTMA
Wind Direction (shaded, Degree)
Averaged From: 2009051800 to 2009073100 (36 h)