Advances in Calibration of QPF/PQPF for the NCEP Global Ensemble Forecast System

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Objective

- Develop and enhance bias-correction and downscaling techniques that apply to the NCEP ensemble precipitation forecasts to gain more reliable and much finer resolution products.

NCEP GFS/GEFS precipitation forecast products

Level 1 products- model direct output

6h-QPF–
High Reso. GFS
Low Reso. GEFS/CTL
20 GEFS ensembles:
1 deg, globally

Level 2 products - 1st Post-processing

Bias corrected
6h-QPF/PQPF –
High Reso. GFS
Low Reso. GEFS/CTL
20 GEFS ensembles:
1 deg, globally

More reliable

Level 3 products – 2nd Post-processing

Downscaled
6h-QPF/PQPF –
High Reso. GFS
Low Reso. GEFS/CTL
20 GEFS ensembles:
5KM, NDGD, CONUS

Much finer

Green: operational, verified against 1deg CCPA
Blue: developed and tested, verified against 1 deg CCPA
Purple: developed and under testing, verified against 5KM NDGD CCPA

Current capabilities in calibration of QPF/PQPF for NCEP GFS/GEFS ensembles

1. Bias correction for NCEP operational ensemble precipitation forecasts at higher temporal and spatial resolution

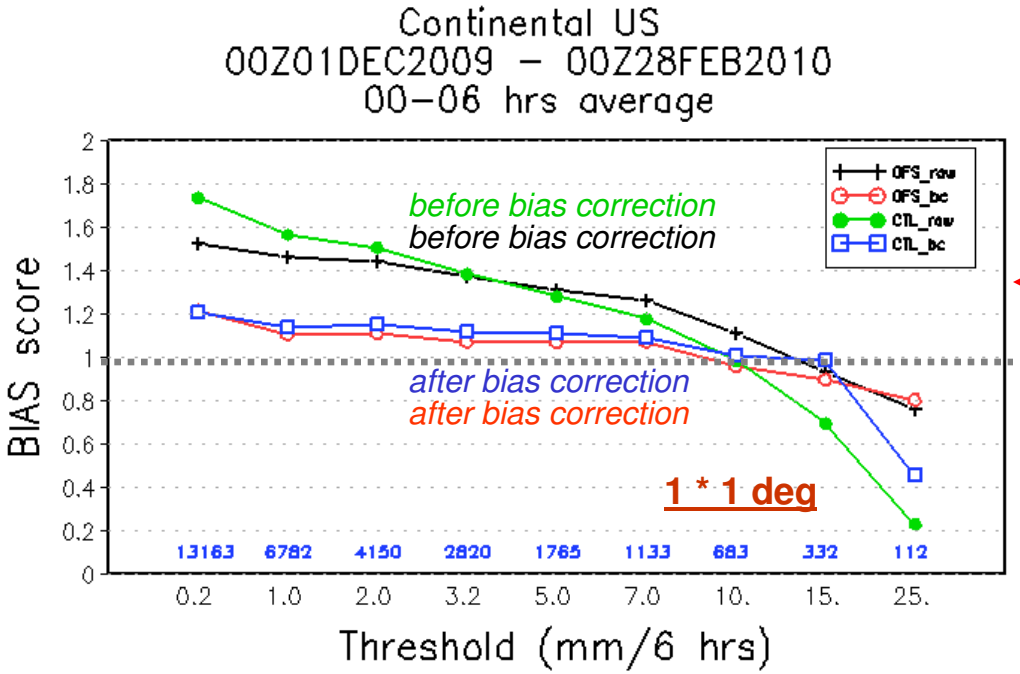
- An upgrade from May 2004 implementation (2.5*2.5 deg, daily)
- Frequency match algorithm
- Construct Cumulative Frequency Distribution for each RFC (or previously over CONUS)
- Select 9 thresholds: 0.2, 1, 2, 3.2, 5, 7, 10, 15, 25 mm/6hrs
- Use decaying weight = 0.02 (50 days decaying)
- CCPA used as best analysis (truth)
- Bias corrected at 1 degree model output grid, globally
- 4 cycles per day, 6-hr accumulation
- Every 6 hours, out to 384 hours
- GFS, GEFS 20+1 members

Current capabilities in calibration of QPF/PQPF for NCEP GFS/GEFS ensembles (cont'd)

2. Statistical downscaling bias corrected precipitation forecast to 5KM

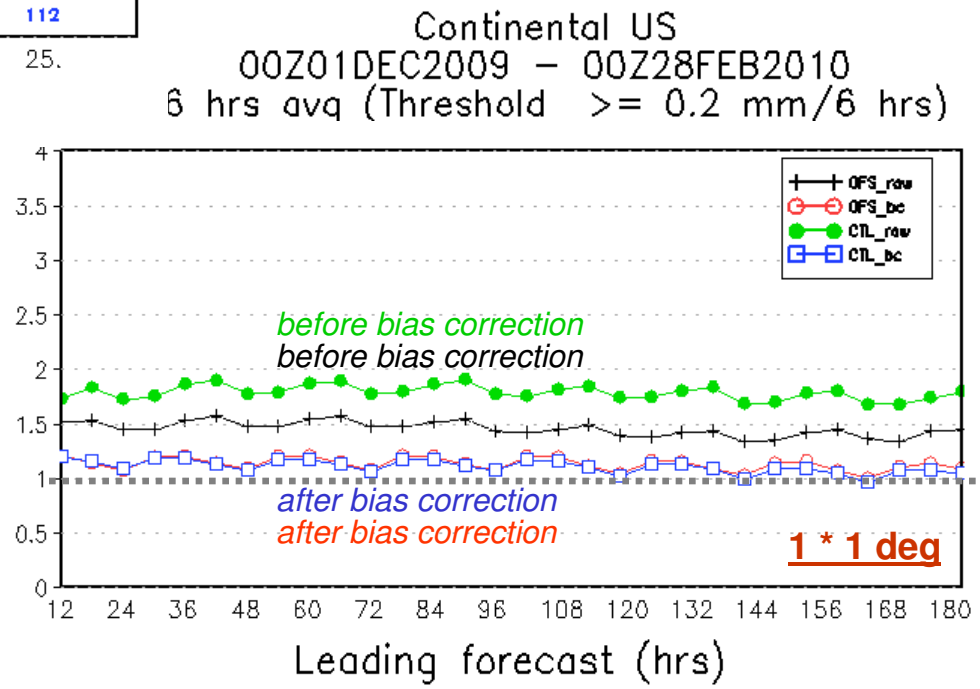
- Use first 6 hours bias corrected forecast (at 1degree) as model analysis and interpolate to 5KM NDGD grid
- Use CCPA at 5KM NDGD grid as a proxy truth
- Generate downscaling vector by calculating above two CDFs for each RFC using high decaying weight = 0.1 (10 days decaying)
- Interpolate 1 degree bias corrected forecast to 5KM NDGD grid
- Apply downscaling vectors through frequency matching the forecast CDF to true CDF
- Produce downscaled GFS, GEFS 20+1 QPF/PQPF on 5km NDGD grid over CONUS
- Every 6 hours out to 384 hours
- 00Z cycle (one vector only, later totally four vectors)

Significantly reduced bias

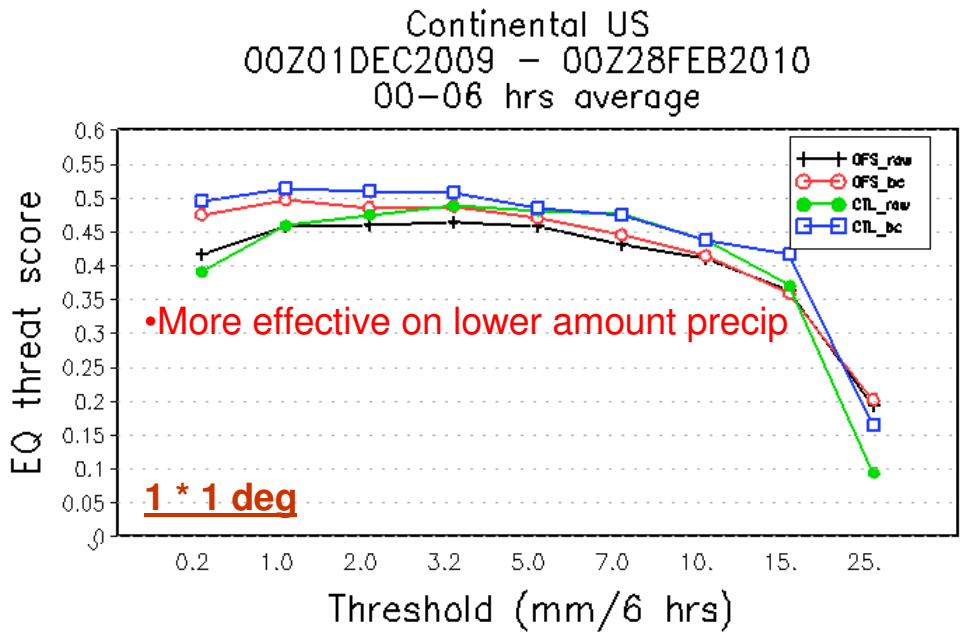


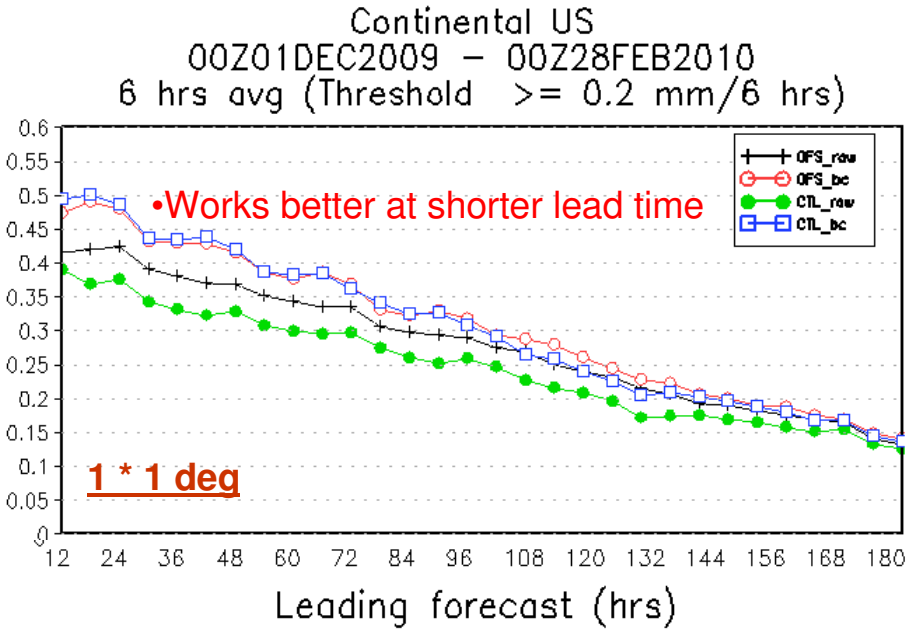
More effective on
low and mid amount precip

Consistently effective
along with leading time

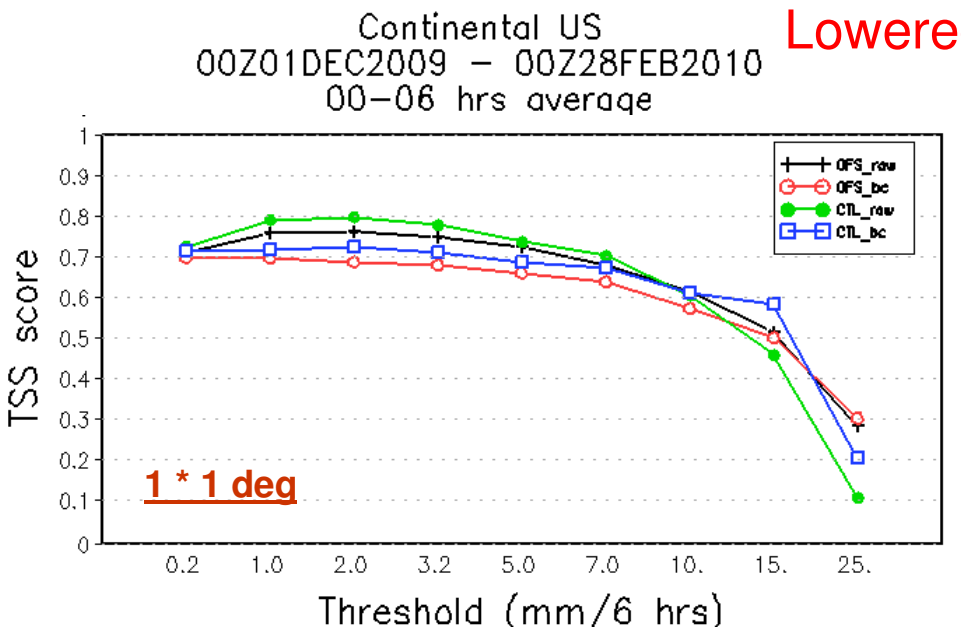


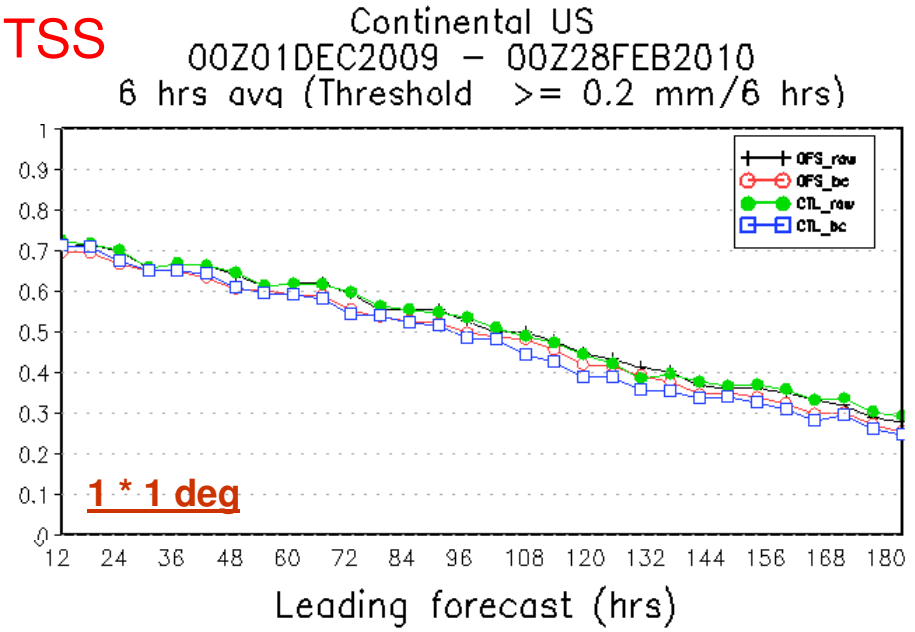
Mostly improved ETS





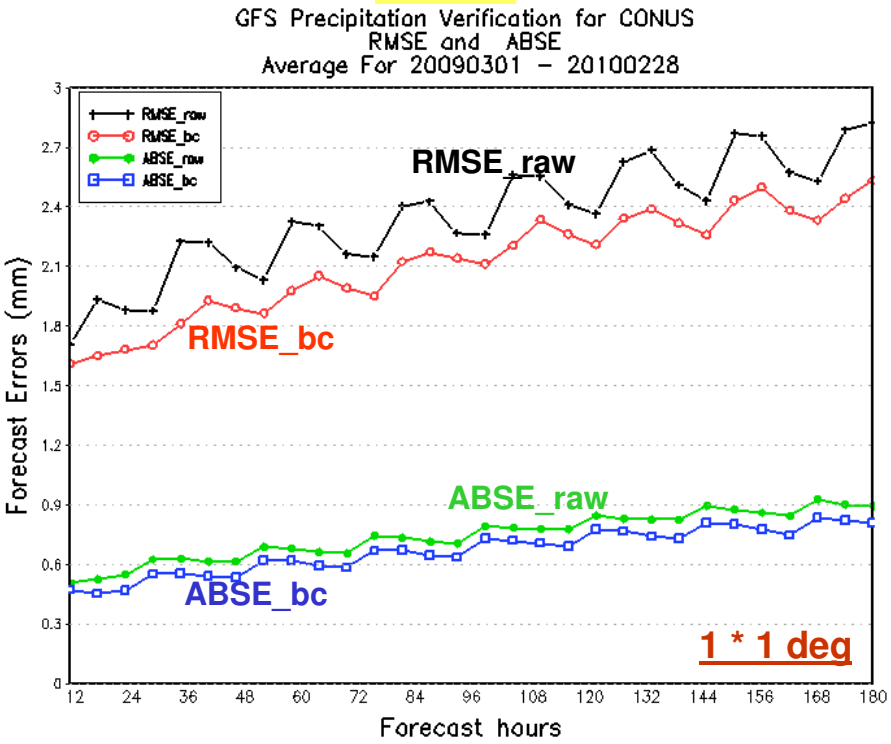
Lowered TSS



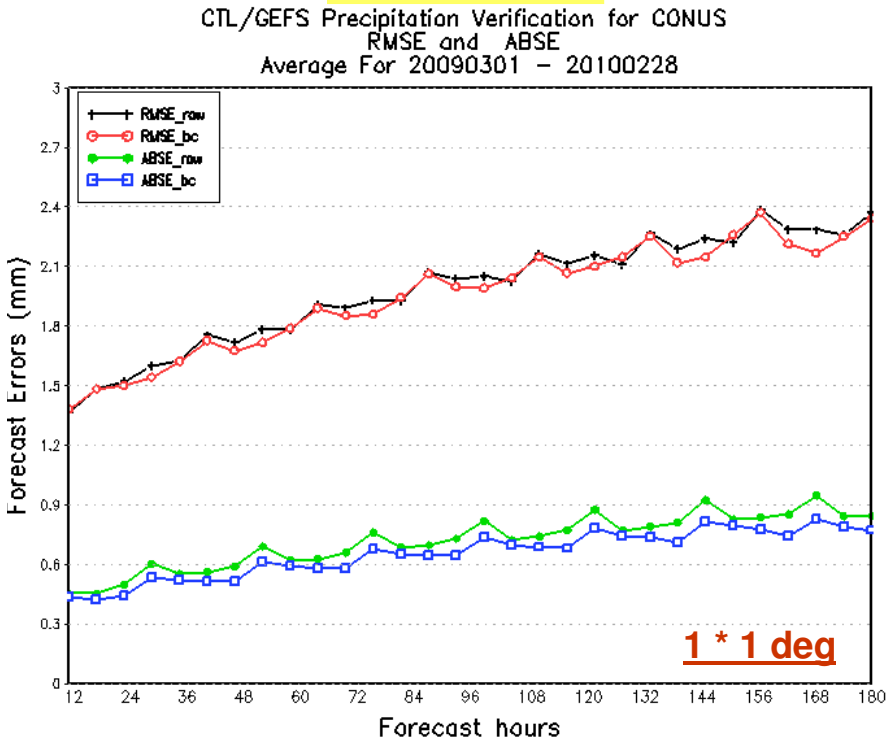


Reduced RMSE and ABSE for GFS and GEFS/CTL

GFS



GEFS/CTL



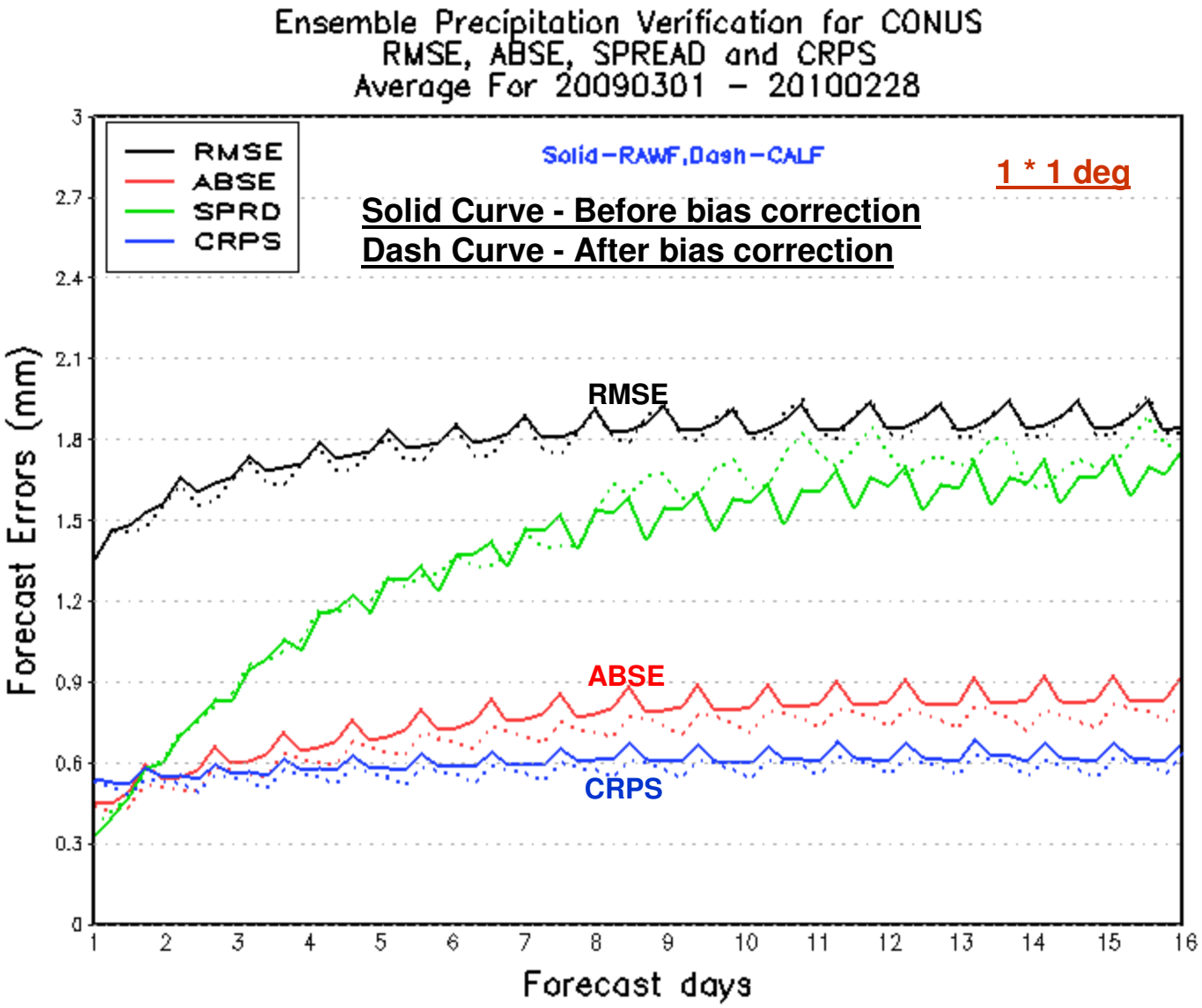
RMSE:

- Significantly smaller RMSE in GFS
- Marginally smaller RMSE in GEFS/CTL

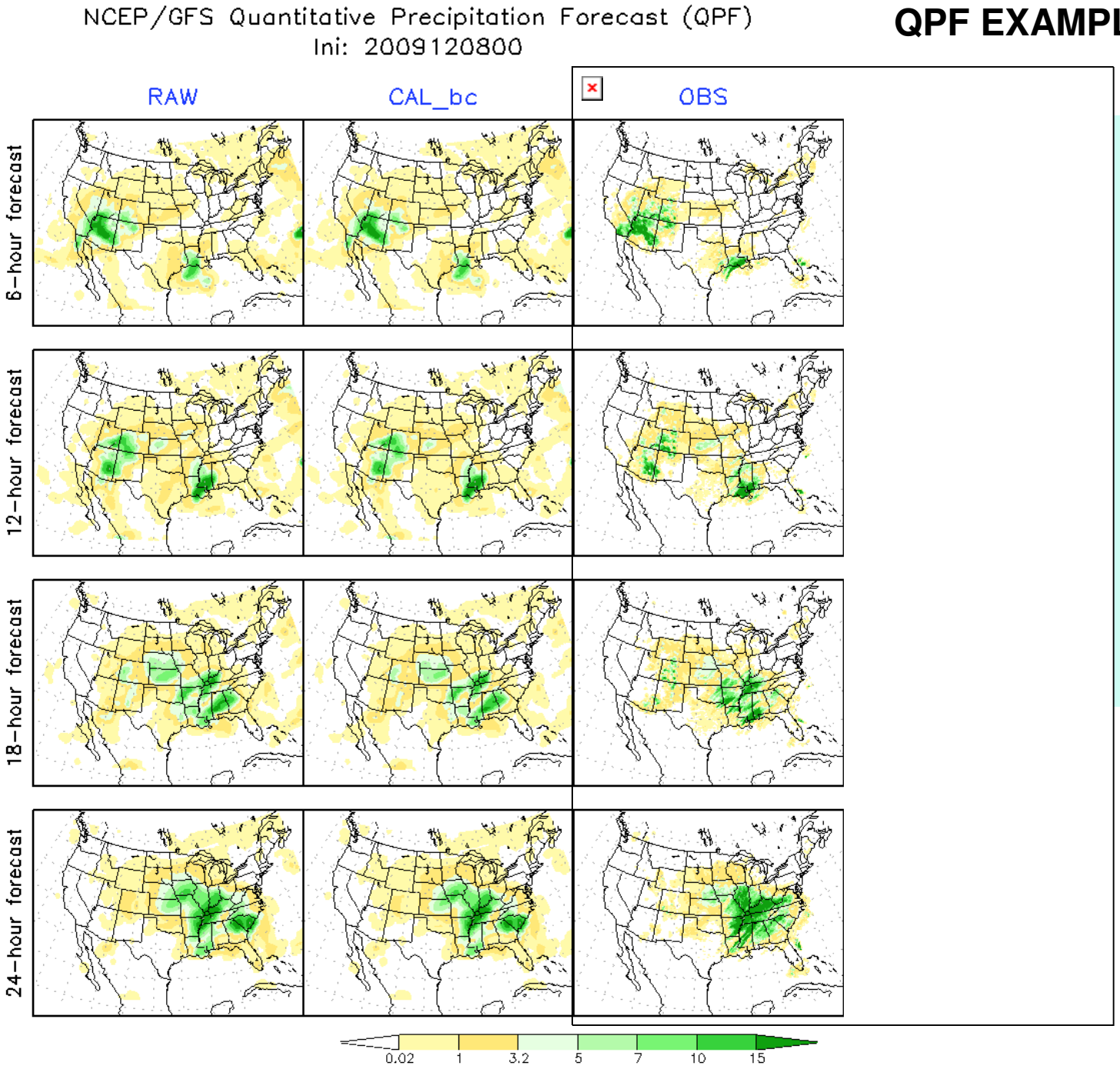
ABSE:

- Both smaller than raw FCSTs.

Improved RMSE, ABSE and CRPS for GEFS ensembles



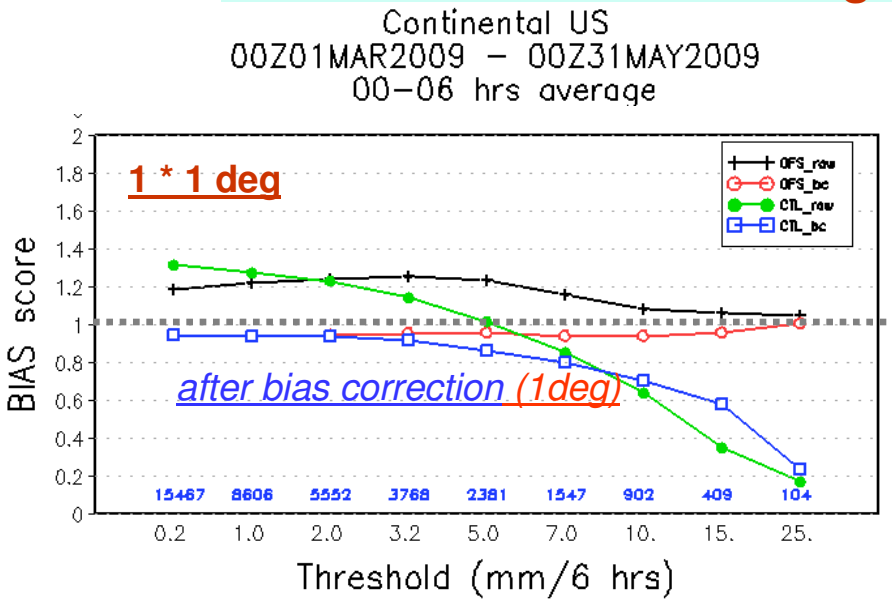
QPF EXAMPLE (5KM NDGD)

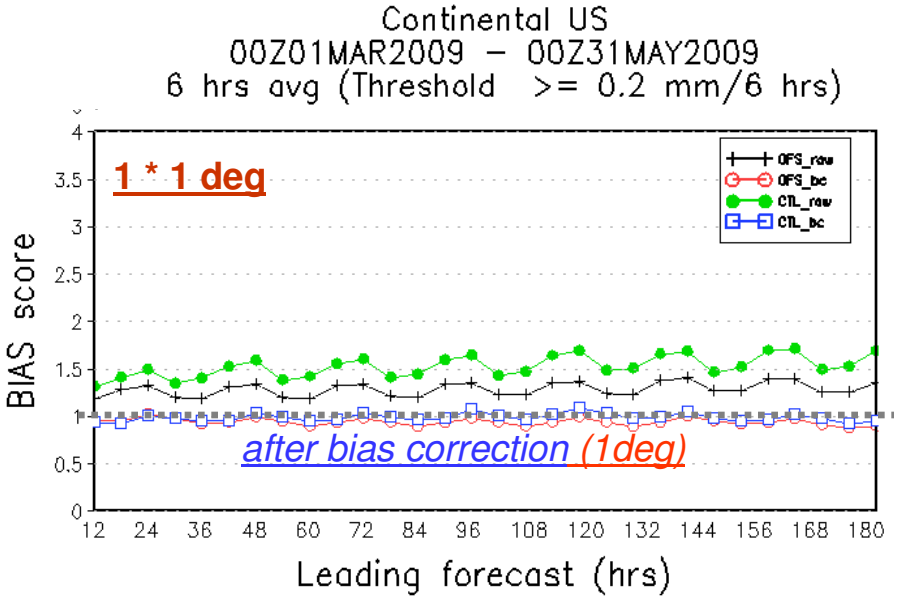


Downscaling to 5Km NDGD:

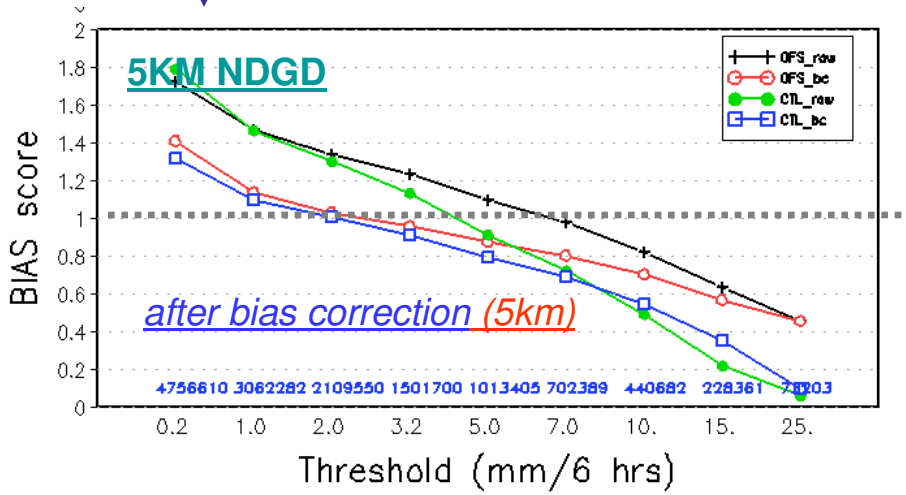
- Further reduction in precipitation extent
- Slight increased in high QPF amounts
- Much closer to OBS(CCPA)
- Still less detail than OBS

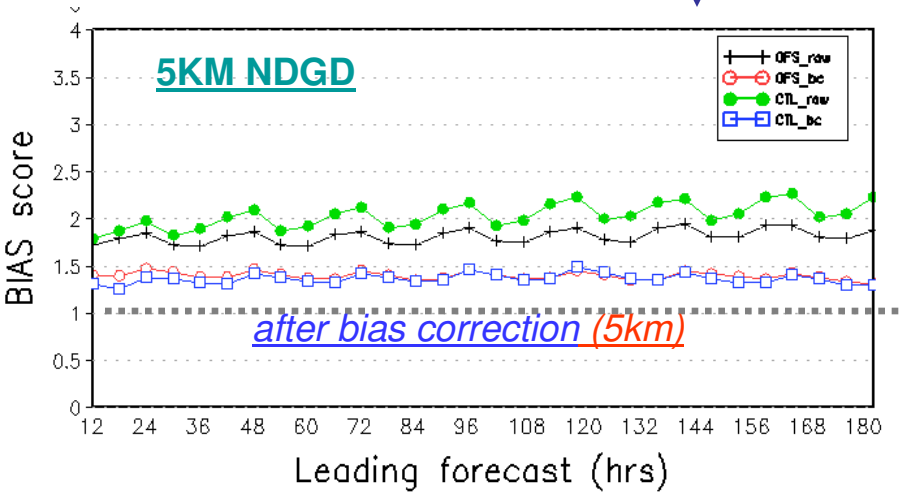
Comparison of bias score after bias correction @ 1*1 deg V.S. 5KM NDGD



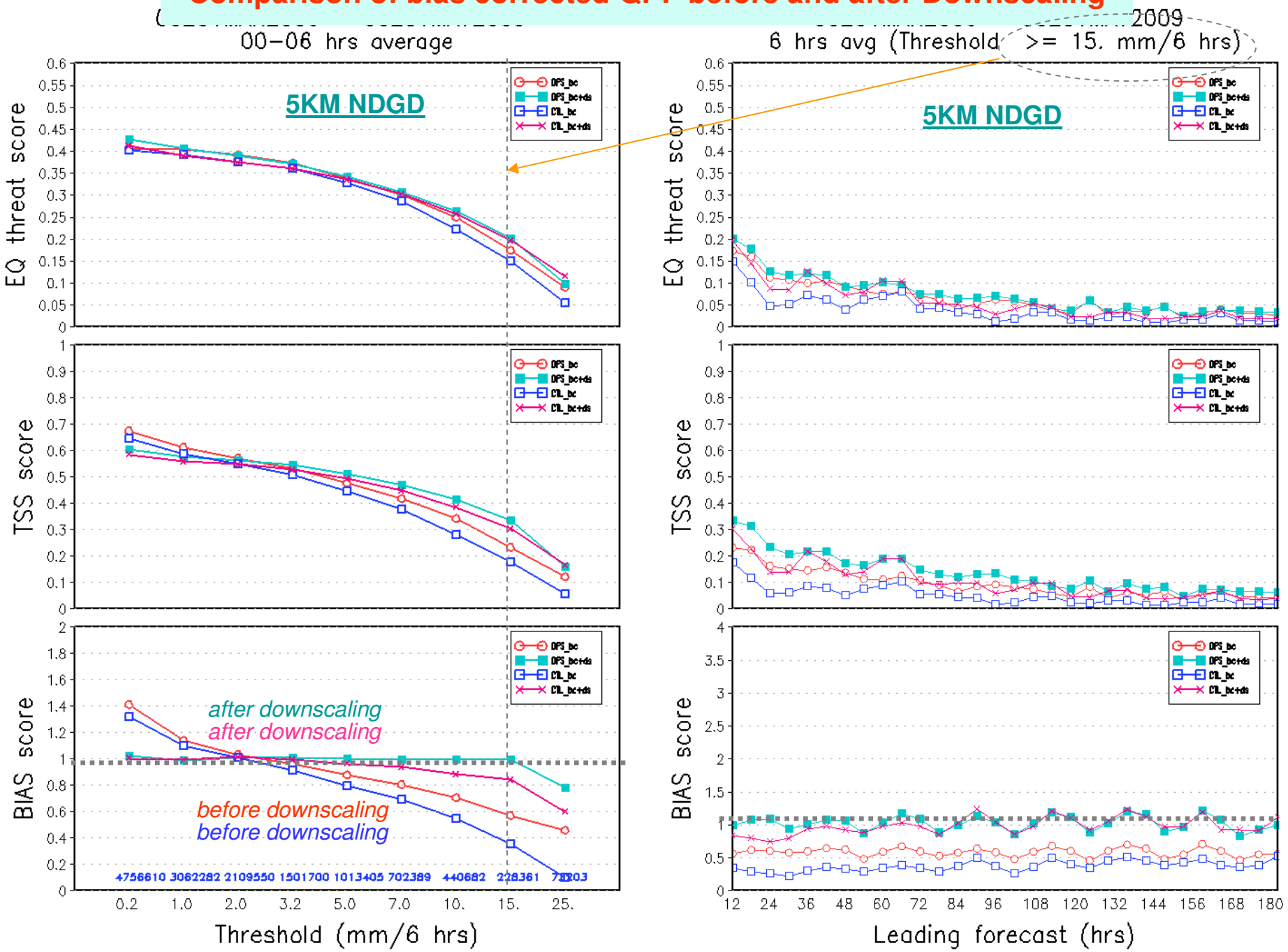


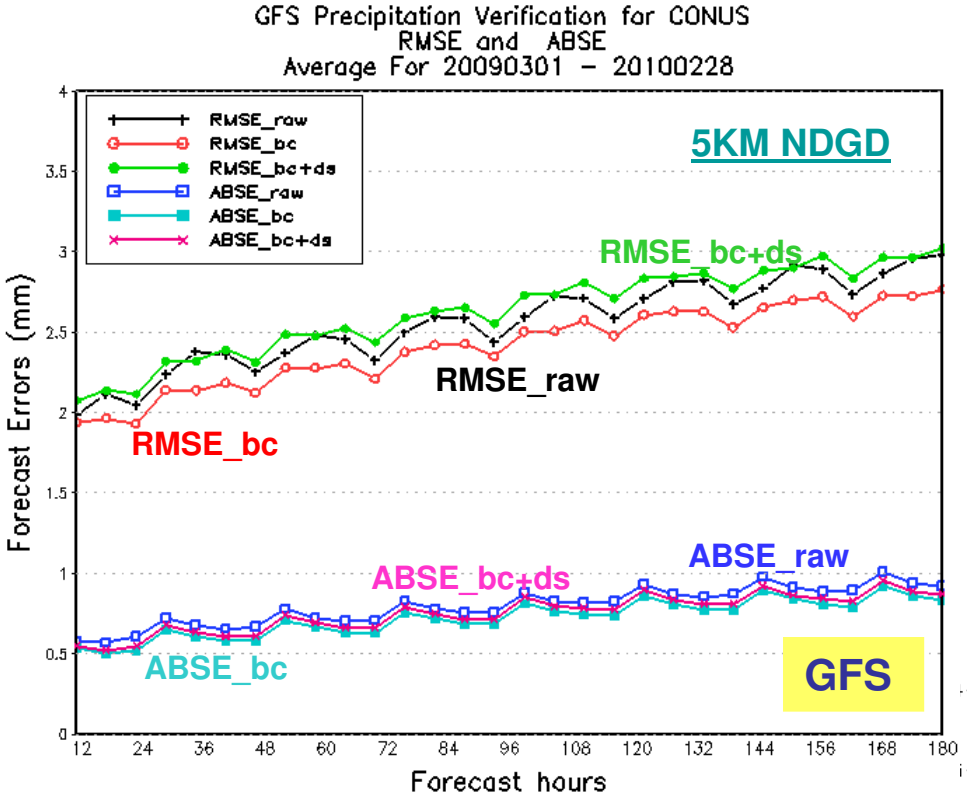
Directly interpolate QPF from 1 * 1 deg to 5KM NDGD

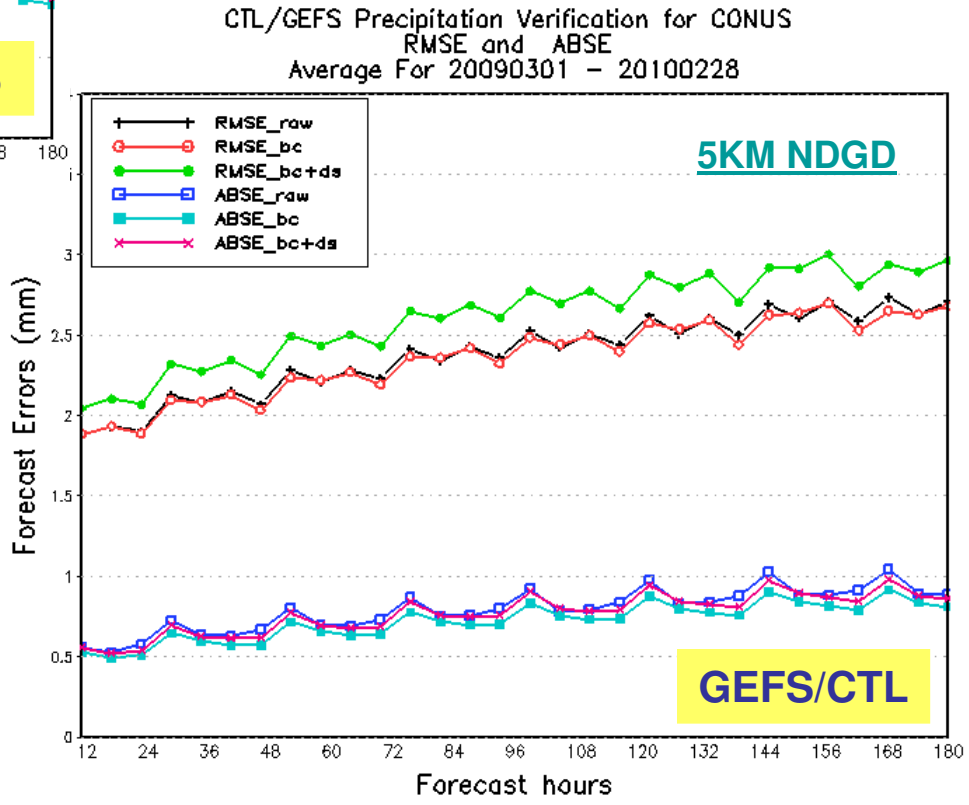




Comparison of bias corrected QPF before and after Downscaling




GFS Precipitation Verification for CONUS
RMSE and ABSE
Average For 20090301 – 20100228
RMSE_raw
RMSE_bc
RMSE_bc+ds
ABSE_raw
ABSE_bc
ABSE_bc+ds
5KM NDGD
RMSE_bc+ds
RMSE_raw
RMSE_bc
ABSE_raw
ABSE_bc+ds
ABSE_bc
GFS
Forecast Errors (mm)
Forecast hours


CTL/GEFS Precipitation Verification for CONUS
RMSE and ABSE
Average For 20090301 – 20100228
RMSE_raw
RMSE_bc
RMSE_bc+ds
ABSE_raw
ABSE_bc
ABSE_bc+ds
5KM NDGD
GEFS/CTL
Forecast Errors (mm)
Forecast hours

Summary

- Frequency match algorithm is an effective way to remove model bias
- 1-deg bias-corrected forecasts
  - Much reduced bias.
  - Improved skill scores for ETS, reduced RMSE, ABSE and CRPS
  - Work well for low amount precipitation
- 5km NDGD downscaled forecasts
  - Much reduced bias.
  - Improved skill scores for ETS and TSS for high amount precipitation
- Remaining issues
  - 1 deg bias correction lowers TSS scores
  - Downscaling introduces additional errors, the random errors into the RMSE

Future Plans

- Refine the bias correction and downscaling techniques.
- Introduce “pseudo precipitation” by collaborating with DTC Ensemble Testbed.