EMC FY14 Upgrade CCB Review

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NAEFS Upgrade

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With contributions from
EMC ensemble team

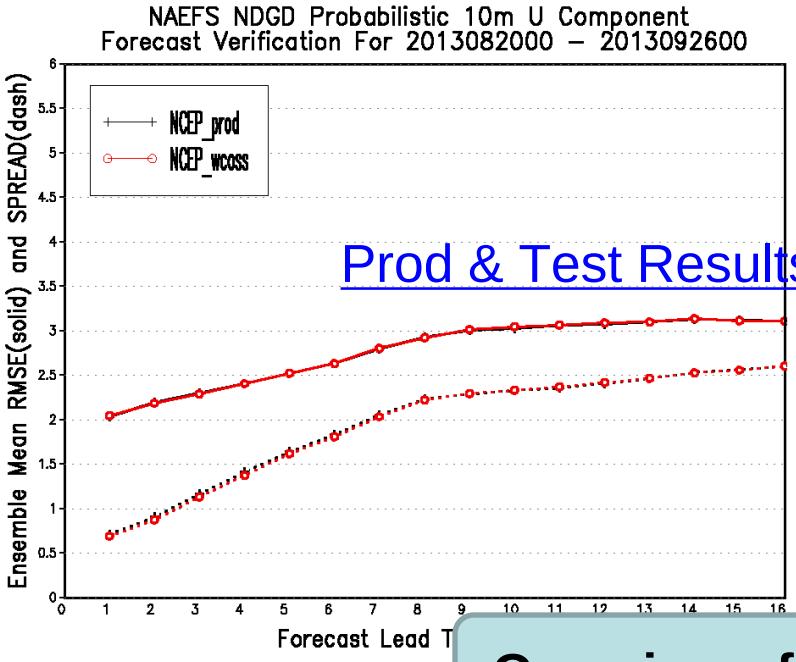
December 12 2013

Summary of changes

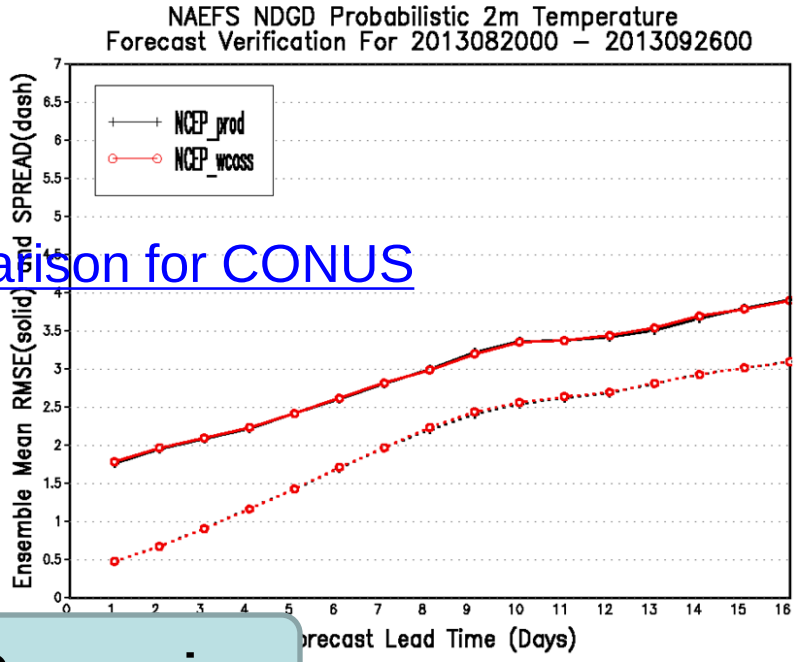
1) GRIB II conversion for all NAEFS products

2) New NAEFS products
   - Bias correction of Td2m and RH2m at 1*1 degree
   - Downscaled products for **CONUS**(5km)
     - Tmax, Tmin, Wdir, Wspd, Td2m and RH2m
   - Downscaled products for **Alaska**(6km)
     - Td2m and RH2m
   - Calibrated **CONUS** precipitation

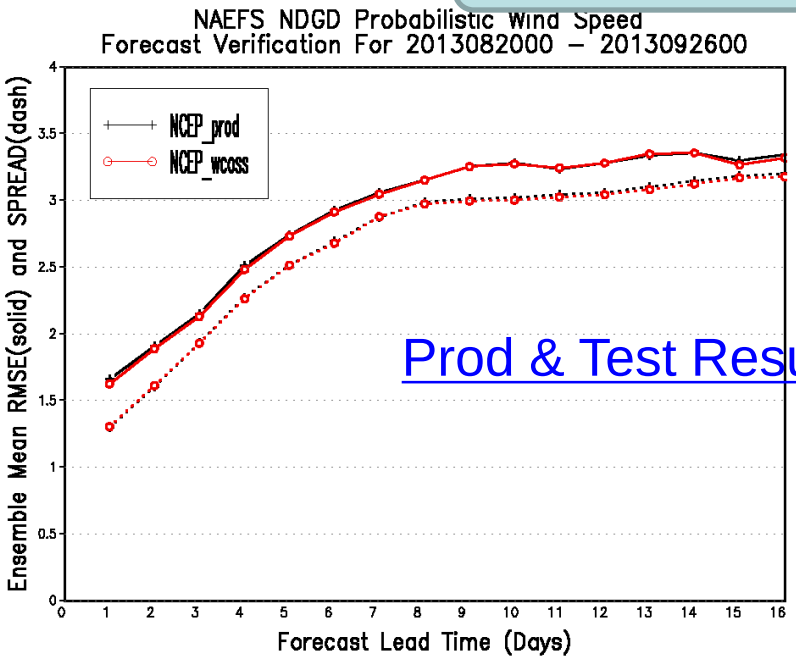
3) Change of climatology for reference
   - CFSR replaces NCEP/NCAR reanalysis



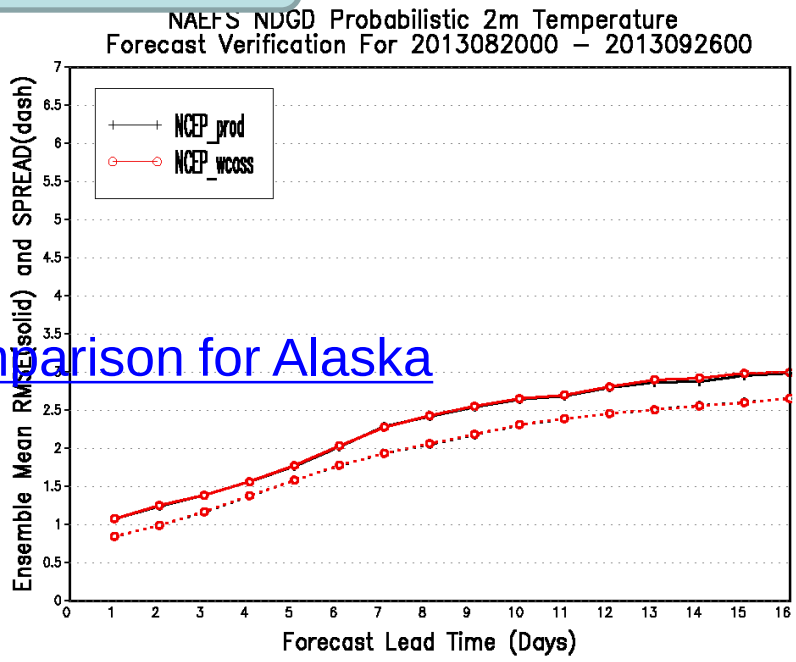
Prod & Test Results Comparison for CONUS



Overview of GRIB Conversion



Prod & Test Results Comparison for Alaska



New NAEFS products (1)

- Bias correction for T2d and RH (1*1 degree globally)
  - NCEP GEFS and CMC's GEFS
    - Reminder for CMC's GEFS
      - Currently, there is no bias corrected T2d and RH variables from CMC directly.
    - NAEFS products should be OK with CMC's ensemble (see results).
    - Please note that there are huge different for moisture part from NCEP and CMC's model, and we don't have proxy truth to cover global domain.
  - Probabilistic products – 10%, 50%, 90%, mean, mode and spread.

- Downscaling to 5km for CONUS
  - Max/Min temperature
  - Wind speed/direction
  - Dew point temperature
  - Relative humidity
  - Probabilistic products – 10%, 50%, 90% …

- Downscaling to 6km for Alaska
  - Variables:
    - Dew point temperature, Relative humidity
  - Probabilistic products – 10%, 50%, 90%, mean, mode and spread

NAEFS Statistical Post-Process (SPP)

- Purpose
  - Improve reliability while maintaining resolution in NWP forecasts
    - Reduce systematic errors (improve reliability) while
    - Not increasing random errors (maintaining resolution)
      - Retain all useful information in NWP forecast

- Methodology
  - Use bias-free estimators of systematic error
  - Need methods with fast convergence using small sample
  - Easy implementation for frequency upgraded forecast system

- Approaches – Computational efficiency
  - Bias Correction : remove lead-time dependent bias on model grid
    - Working on coarser model grid allows use of more complex methods
    - Feedback on systematic errors to model development
  - Downscaling: downscale bias-corrected forecast to finer grid
    - Further refinement/complexity added
      - No dependence on lead time

NAEFS bias correction variables

Plan: Q2FY14 - (bias correction)

Variables	pgrba_bc file	Total 52
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	10
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11
VVEL	850hPa	1
PRES	Surface, PRMSL	2
FLUX (top)	ULWRF (toa - OLR)	1
Td and RH	2m	2
Precip*	CONUS and NCEP only	1
	Last implementation: March 2010	
Notes		

NAEFS downscaling parameters and products

Plan: Q2FY2014 (NDGD resolutions)

Variables	Domains	Resolutions	Total 11/10
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	CONUS/Alaska	5km/6km	1/1
2-m minimum T	CONUS/Alaska	5km/6km	1/1
10-m wind speed	CONUS/Alaska	5km/6km	1/1
10-m wind direction	CONUS/Alaska	5km/6km	1/1
2-m dew-point T	CONUS/Alaska	5km/6km	1/1
2-m relative humidity	CONUS/Alaska	5km/6km	1/1
Precipitation	CONUS	5km	1/0
Total cloud cover?			
Wind Gust?			
Significant wave height			

All downscaled products are from 1*1 (lat/lon) degree bias corrected probabilistic forecast
Products include ensemble mean, spread, 10%, 50%, 90% and mode

Process to Downscale Dew Point Temperature

- Output products: DPT, RH2m
  - NCEP & CMC bias corrected DPT, RH2m on 1 degree
  - NAEFS probabilistic forecasts on 1 degree: mean, spread, mode, 10%, 50% and 90% fcst
  - Downscaled probabilistic forecasts on NDGD 5km

- NCEP/CMC Bias correction process on 1 degree
  - Calculate DPT fcst. & analysis from T2m and RH2m, accumulate bias by applying decaying weight
  - Calculated DPT from T2m and RH2m forecast, bias correct DPT
    - Adjust bias corrected DPT, comparing with bias corrected T2m, smaller value as the DPT
  - Derive bias corrected RH2m from bias corrected DPT and T2m

- NCEP/CMC combination process on 1 degree
  - Combine bias corrected NCEP/CMC DPT to generate probabilistic forecasts
    - Compare DPT and T2m probabilistic forecasts T2m are smaller than DPT
  - Combine NCEP/CMC RH2m to generate probabilistic forecasts
    - Adjust RH2m probabilistic forecasts, values not larger than 100% or smaller than 0%

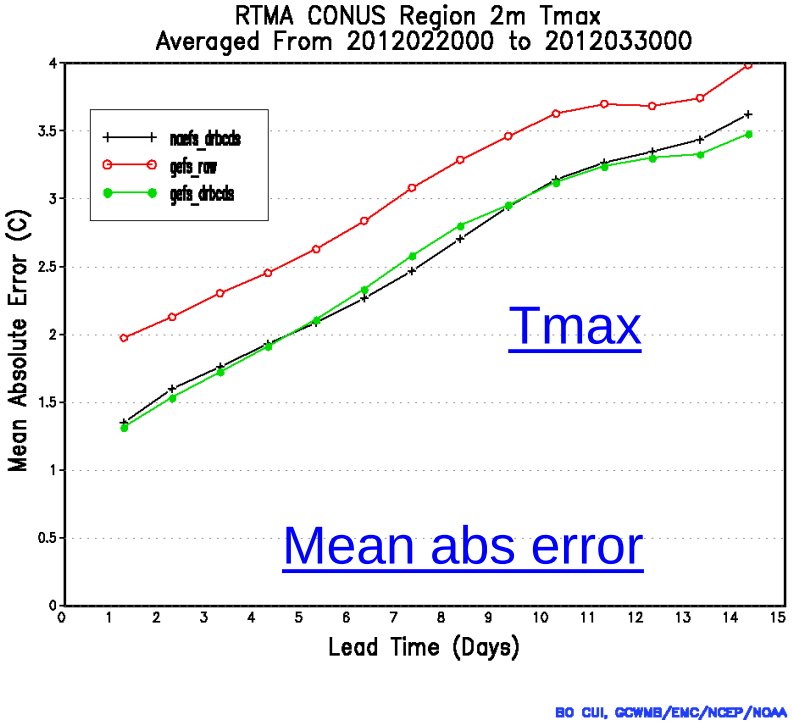
- Downscaling process
  - Get downscaling vectors (DV) for DPT and T2m at each 6-hr cycle
  - Apply DV to produce down-scaled DPT and T2m for each 6-hr lead-time period
  - Generate the mean, spread, mode, 10%, 50% and 90% based on above step
  - Downscaled RH2m

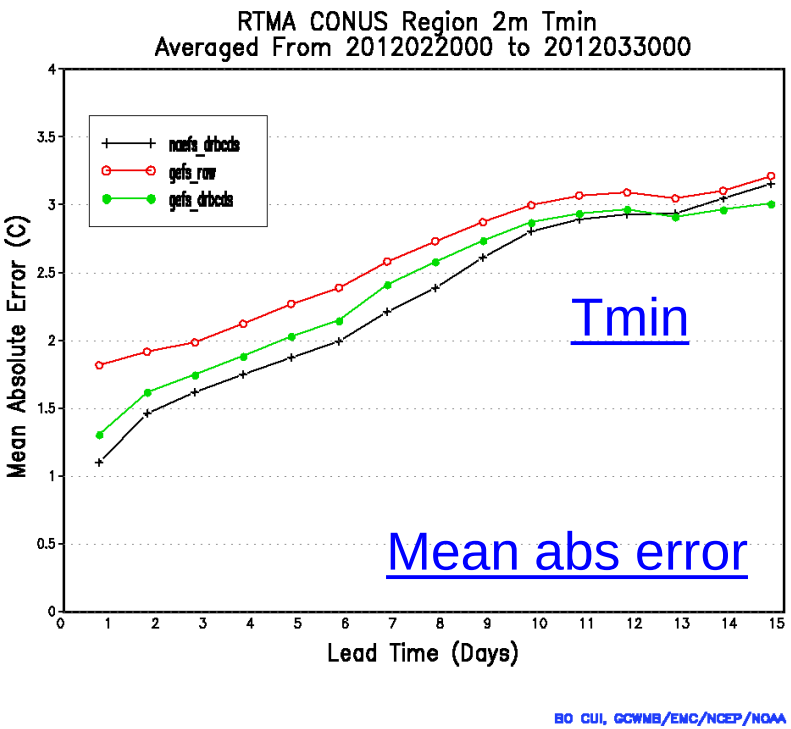
Schemes to develop T2m, Td2m, RH probabilistic products

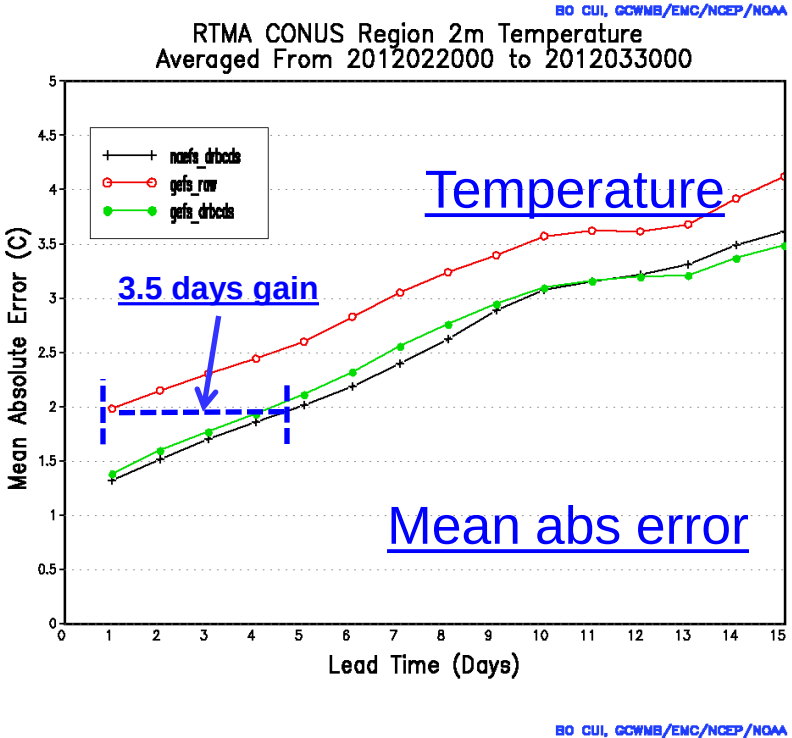
Products	1x1 degree resolution			NDGD (5km) resolution		
	T2m	Td2m	RH	T2m	Td2m	RH
Raw ensemble members	Yes	Yes Derived from t2m and RH	Yes	N/A	N/A	N/A
Bias corrected ensemble members	Yes	Yes One end is bounded (T2m)	Yes Two ends are bounded (0,100)	N/A	N/A	N/A
Ensemble mean, mode, 10%, 50% and 90%	Yes	Yes One end is bounded (T2m)	Yes Two ends are bounded (0,100)	Yes Apply DV RTMA - Yes	Yes Apply DV RTMA - Yes One end is bounded	Yes Apply DV RTMA (T2m &Td2m) Two ends are bounded
Ensemble spread	Yes	Yes	Yes	Yes Interpolated	Yes Interpolated	Yes Interpolated bounded
	Probabilistic products and spread of T2m and Td2m are not compatible to RH					

Preliminary Results For CONUS

February 20 – March 30 2012

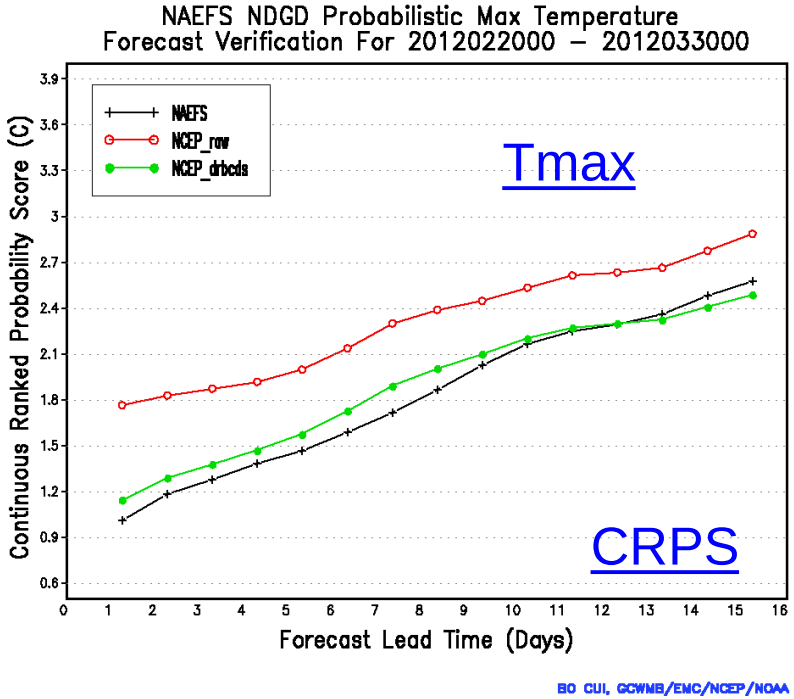


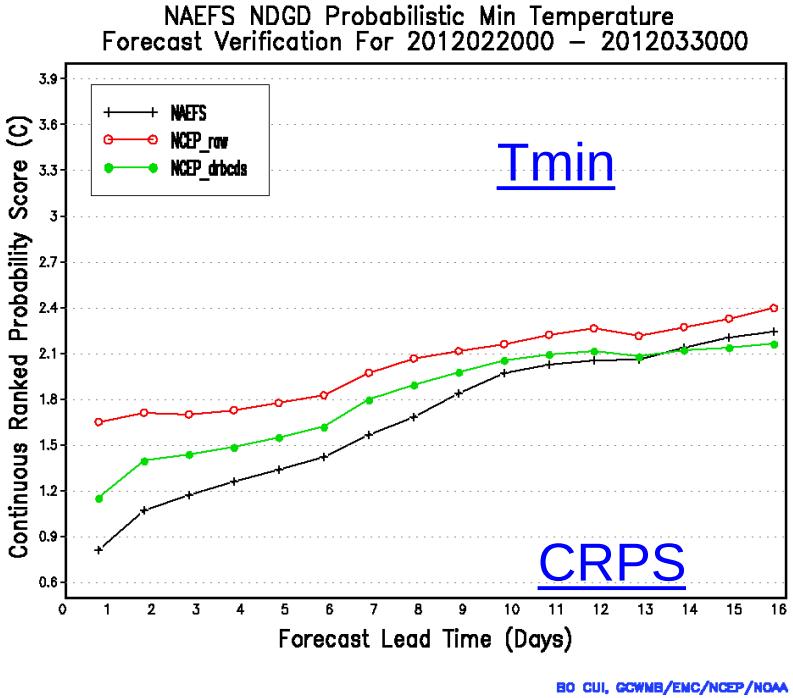


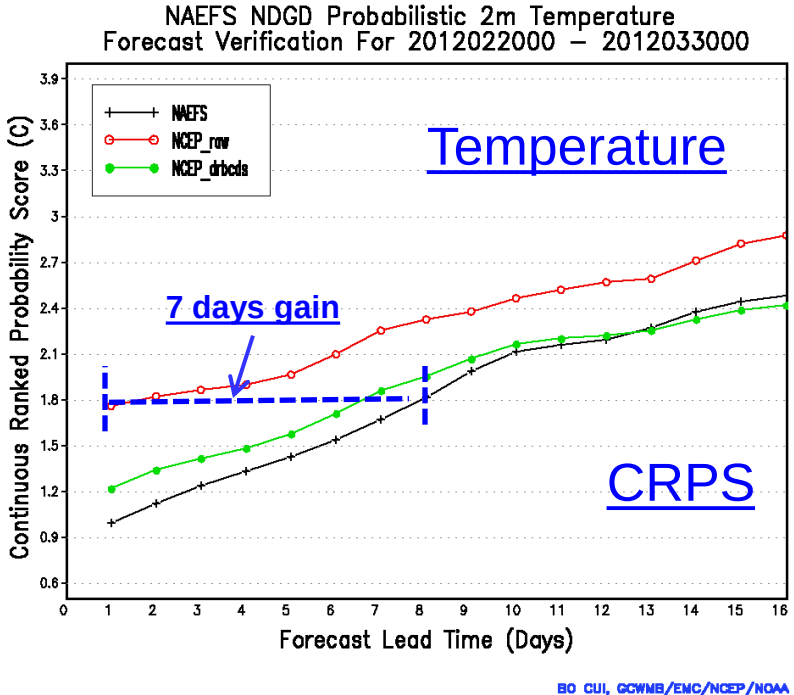


2012 Spring evaluation for CONUS temperature forecast by apply :

1. Bias correction at 1*1 degree for NCEP GFS/GEFS, CMC/GEFS
2. Hybrid bias corrected NCEP GFS and GEFS
3. Apply statistical downscaling for all bias corrected forecast
4. Combined all forecasts at 5*5 km (NDGD) grid with adjustment - NAEFS







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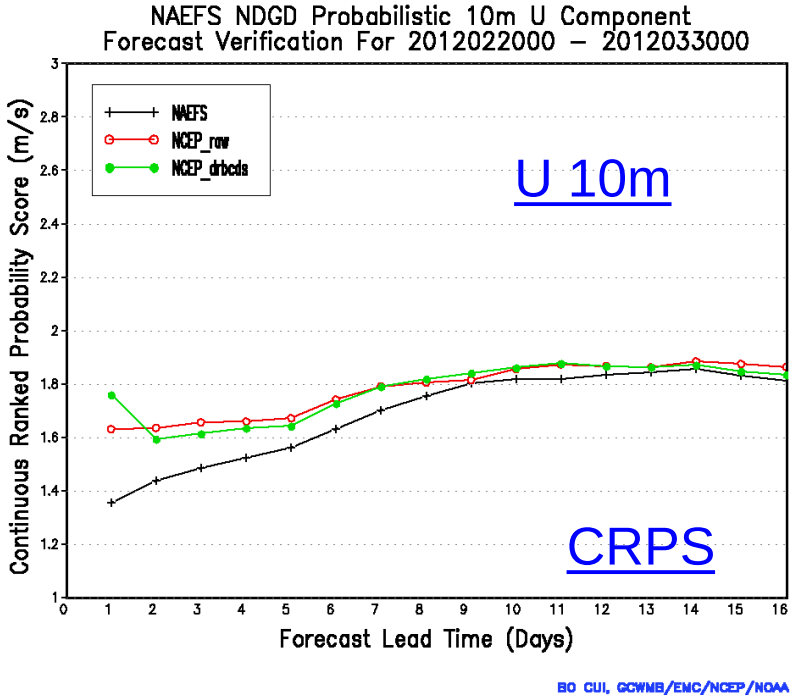
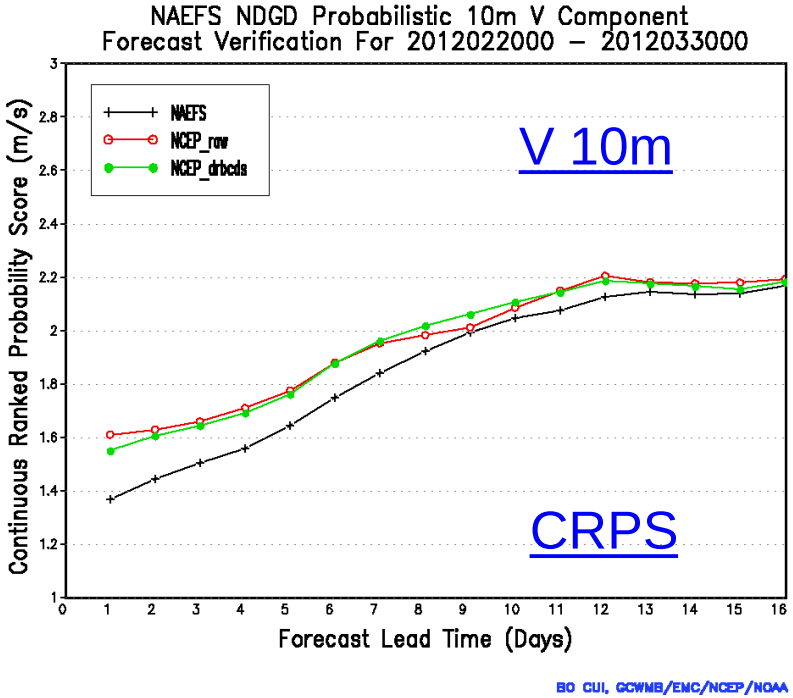
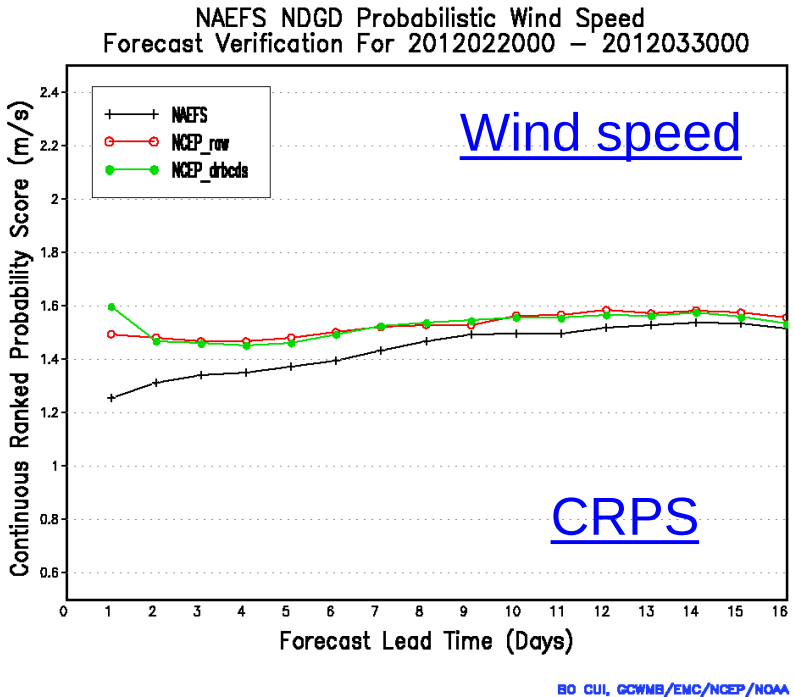
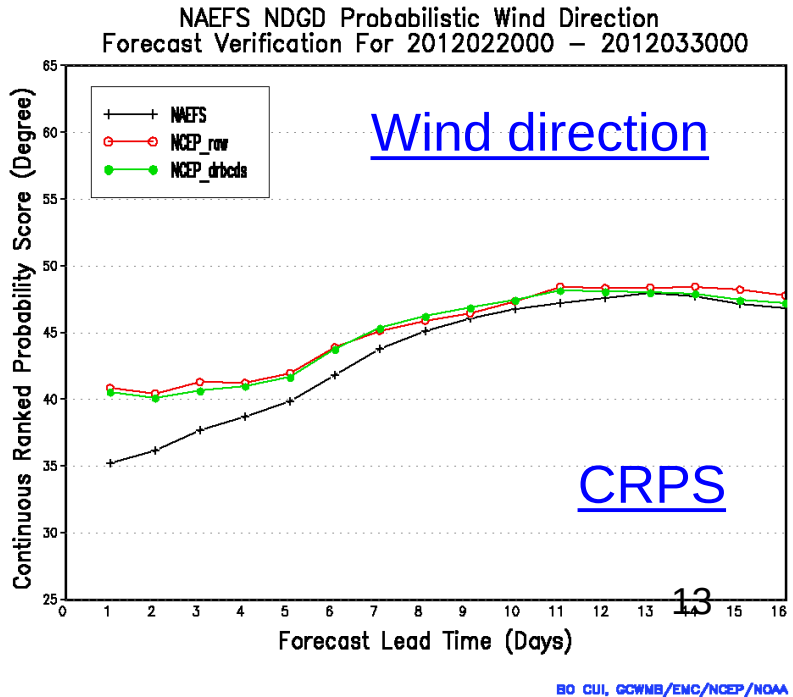

NAEFS NDGD Probabilistic 10m U Component
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcds
U 10m
CRPS
Continuous Ranked Probability Score (m/s)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA


NAEFS NDGD Probabilistic 10m V Component
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcds
V 10m
CRPS
Continuous Ranked Probability Score (m/s)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA


NAEFS NDGD Probabilistic Wind Speed
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcds
Wind speed
CRPS
Continuous Ranked Probability Score (m/s)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA


NAEFS NDGD Probabilistic Wind Direction
Forecast Verification For 2012022000 – 2012033000
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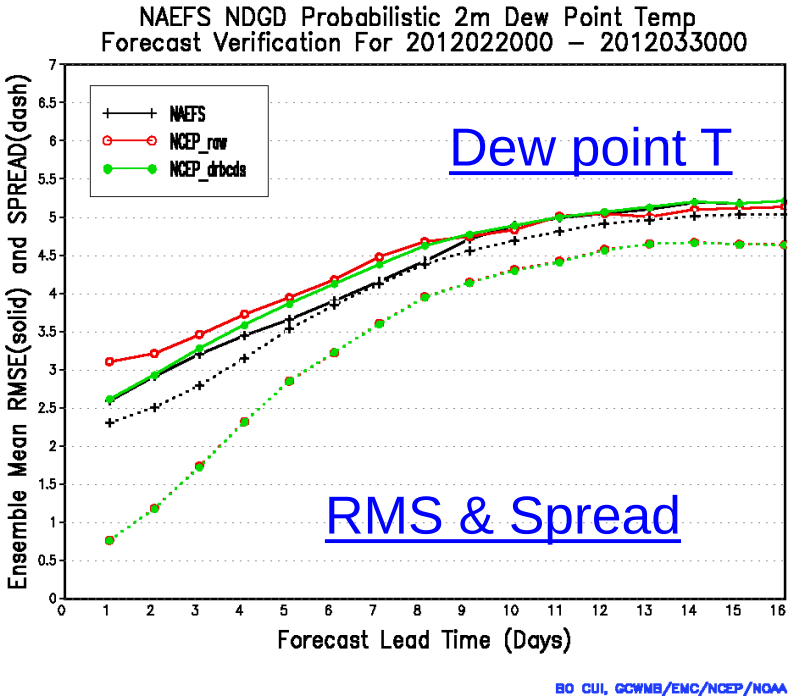
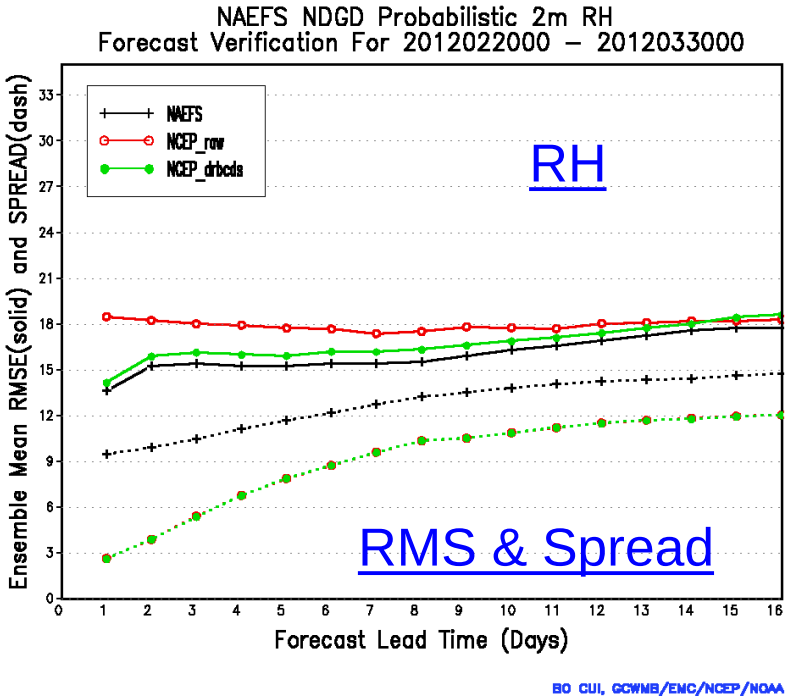
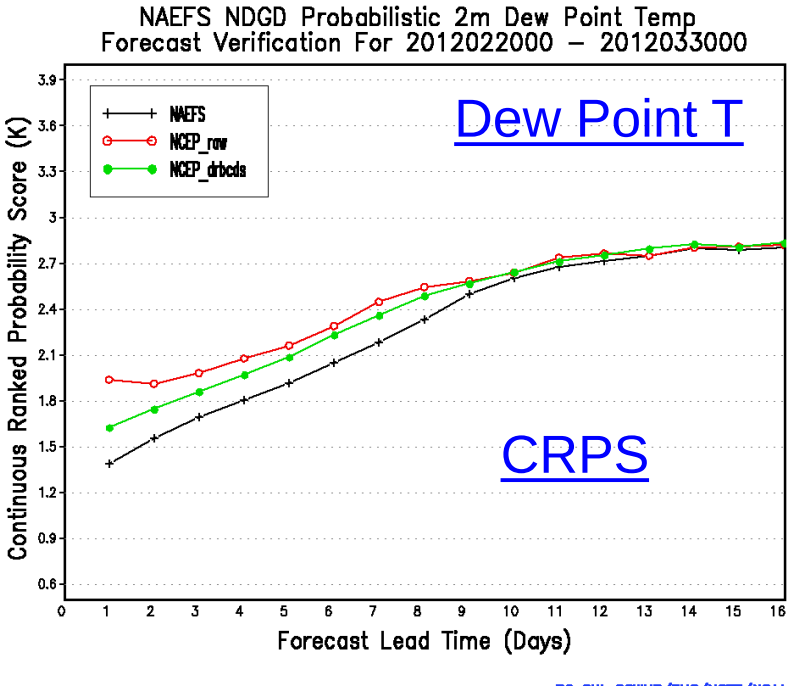
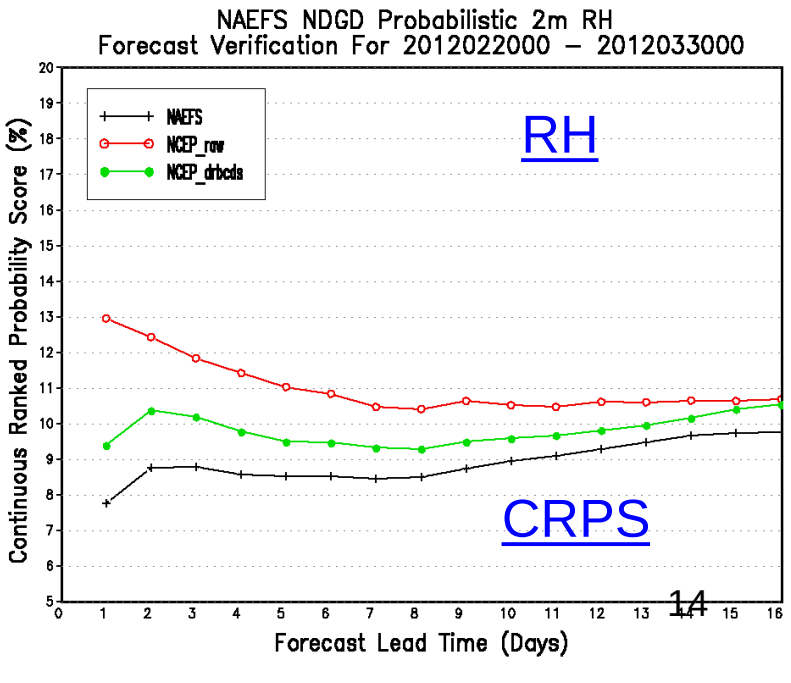
NCEP_raw
NCEP_drbcds
Wind direction
CRPS
Continuous Ranked Probability Score (Degree)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA

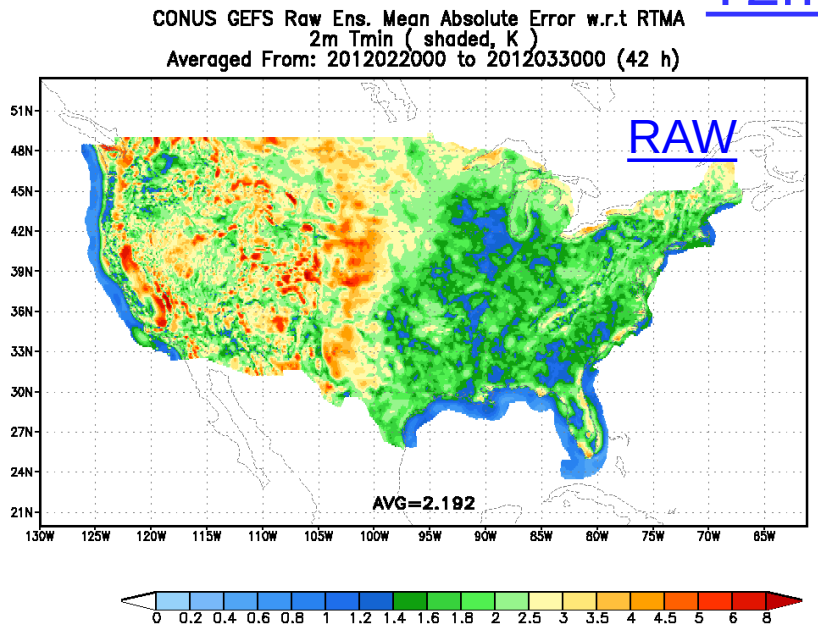

NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcls
Dew point T
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA

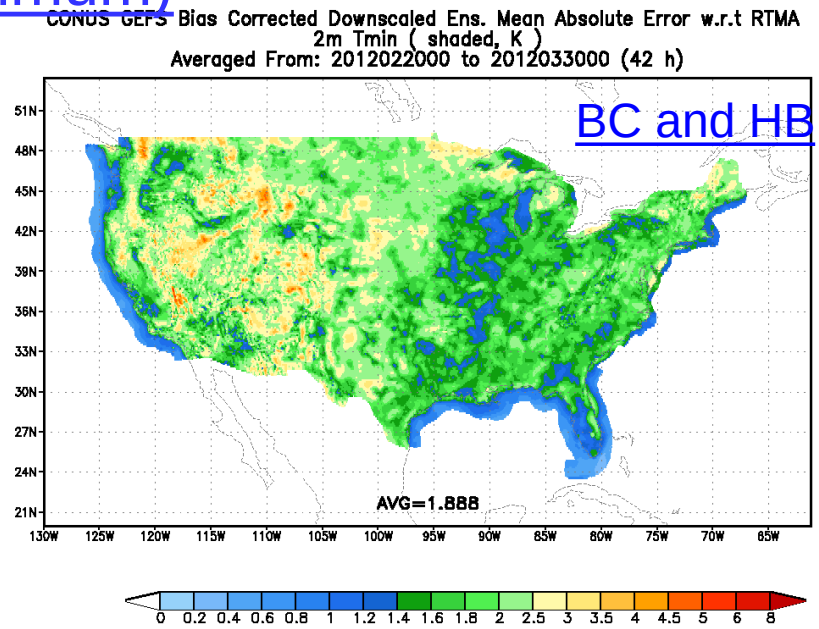

NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcls
RH
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA

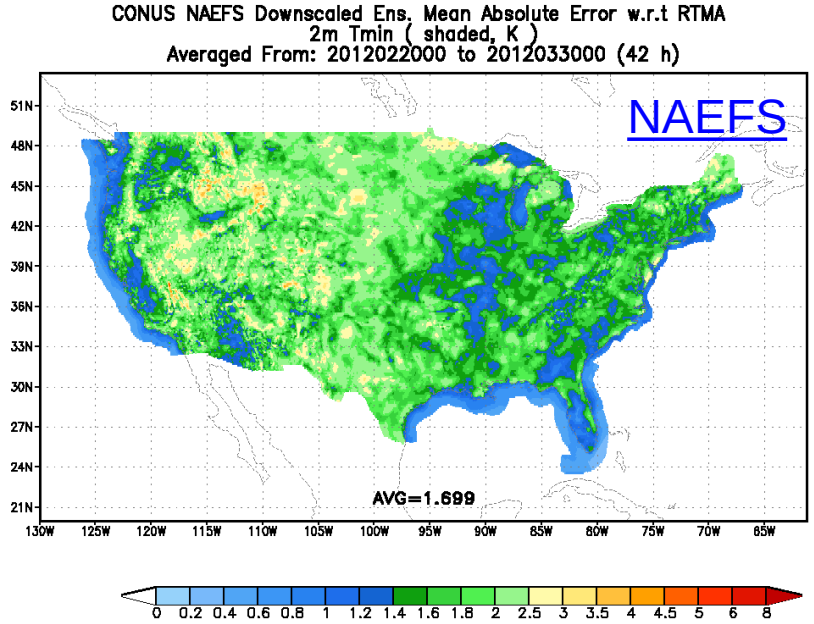

NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcls
Dew Point T
CRPS
Continuous Ranked Probability Score (K)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA


NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2012022000 – 2012033000
NAEFS
NCEP_raw
NCEP_drbcls
RH
CRPS
Continuous Ranked Probability Score (%)
Forecast Lead Time (Days)
BO CUI, GCWMB/EMC/NCEP/NOAA

T2m (Minimum)







Surface minimum temperature for 40 days (2/20/2012 – 3/30/3012) after GEFS upgrade.

Average MAE improvements:

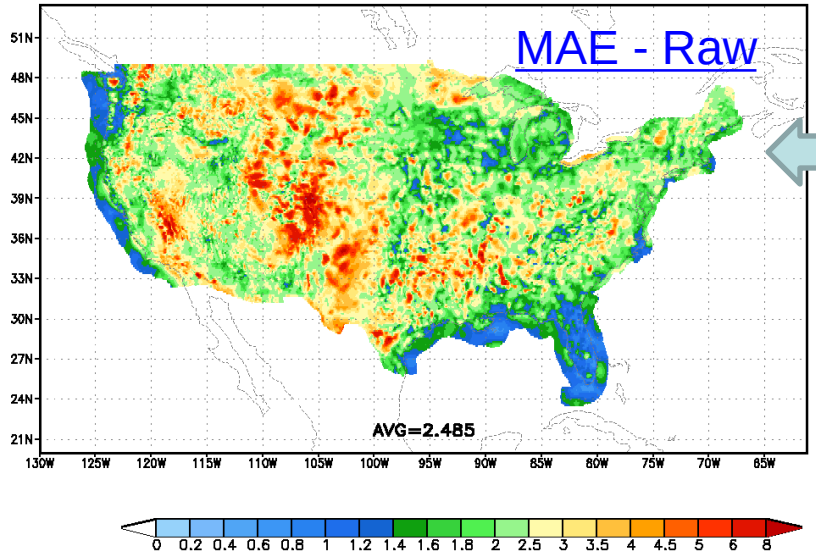
14% from NCEP model post-process only

23% from NAEFS – final product

2-m dew point T

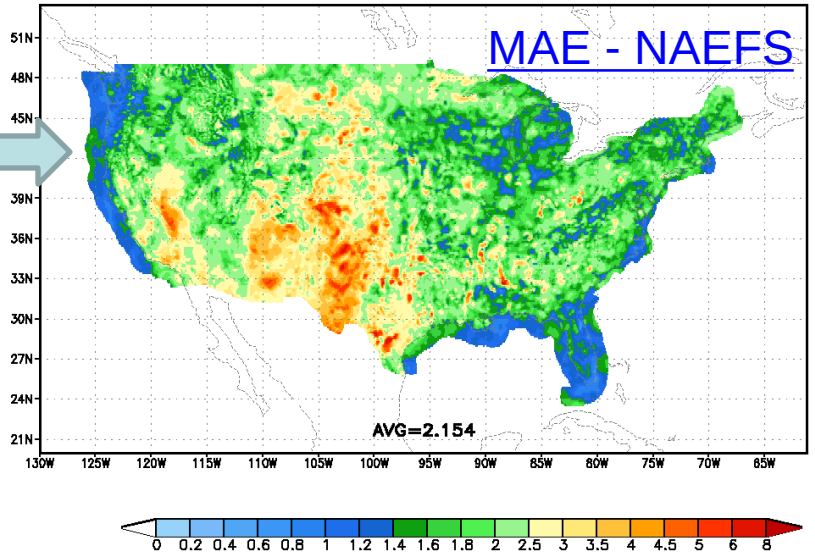
CONUS GEFS Raw Ens. Mean Absolute Error w.r.t RTMA
2m Dew Point Temp (shaded, K)
Averaged From: 2012022000 to 2012033000 (24 h)

MAE - Raw



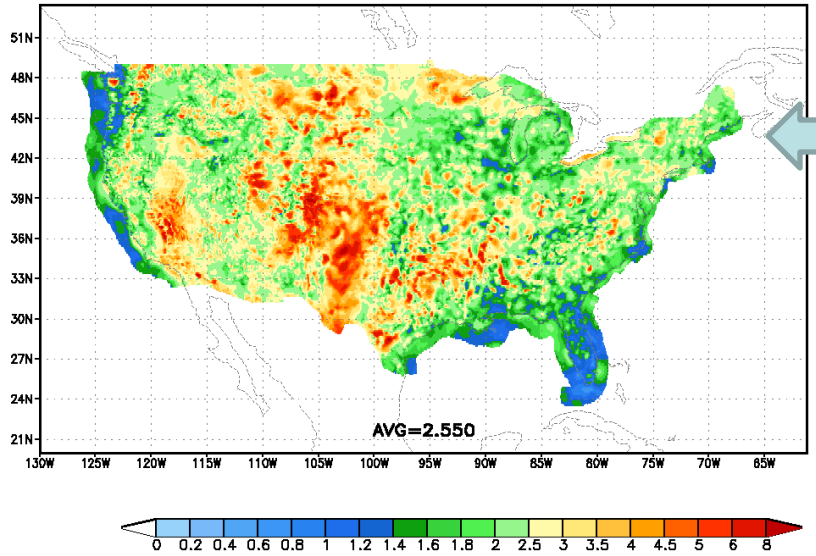
CONUS NAEFS Downscaled Ens. Mean Absolute Error w.r.t RTMA
2m Dew Point Temp (shaded, K)
Averaged From: 2012022000 to 2012033000 (24 h)

MAE - NAEFS

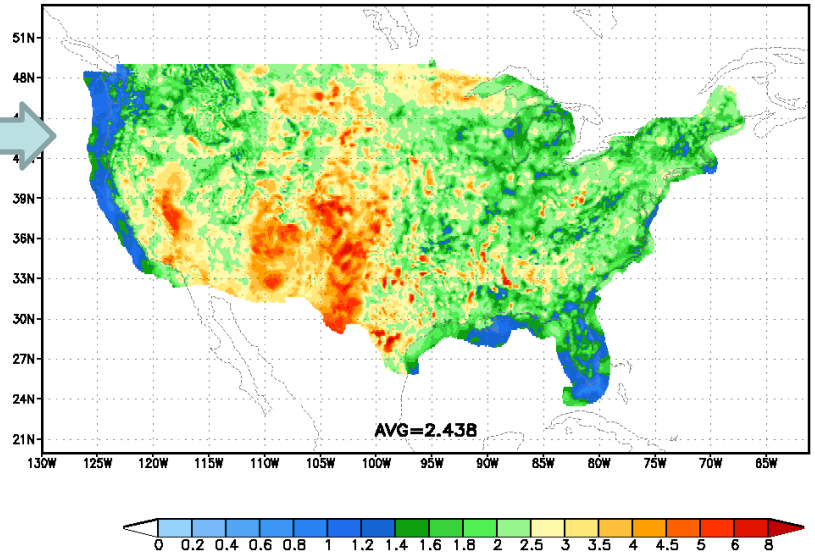


24hr

CONUS GEFS Raw Ens. Mean Absolute Error w.r.t RTMA
2m Dew Point Temp (shaded, K)
Averaged From: 2012022000 to 2012033000 (48 h)



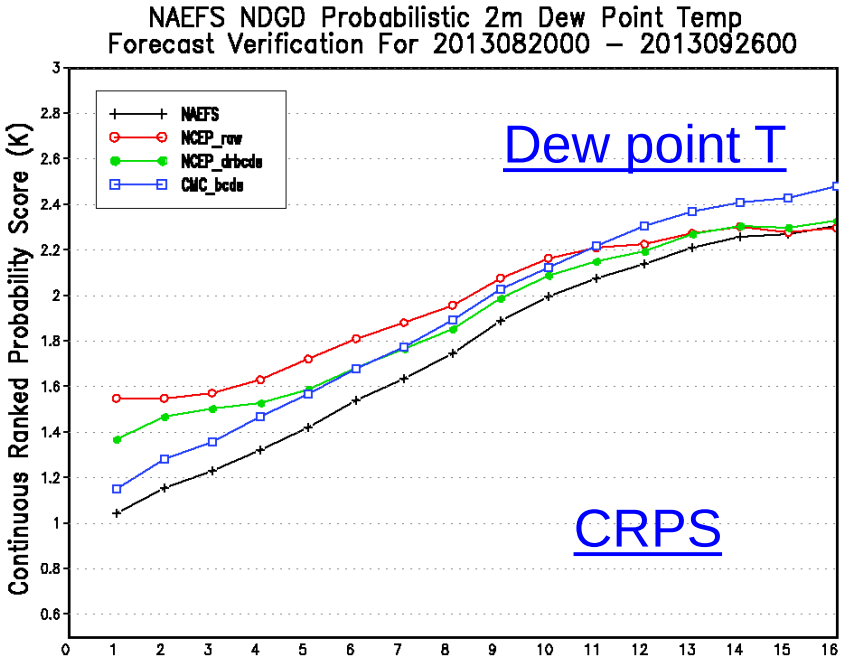
CONUS NAEFS Downscaled Ens. Mean Absolute Error w.r.t RTMA
2m Dew Point Temp (shaded, K)
Averaged From: 2012022000 to 2012033000 (48 h)

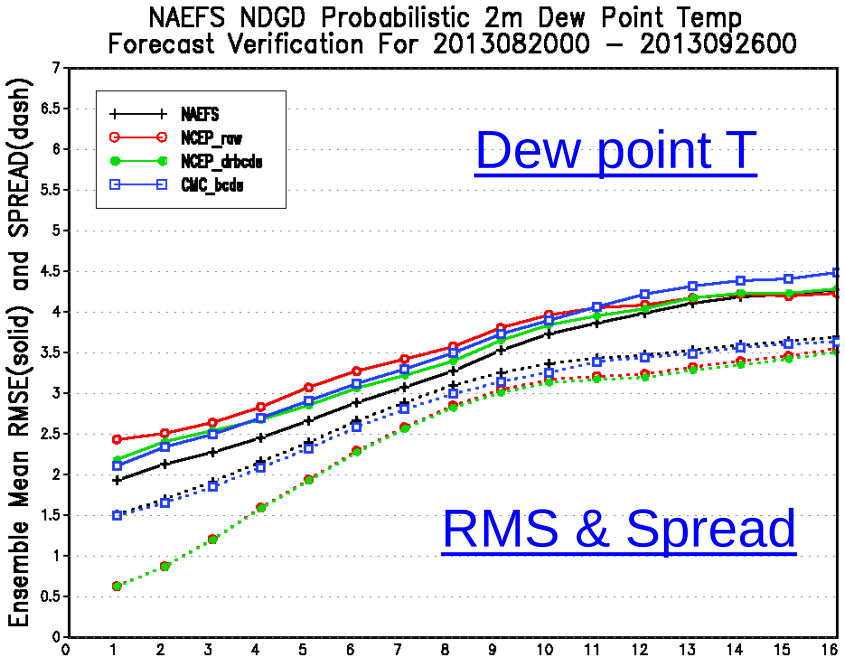


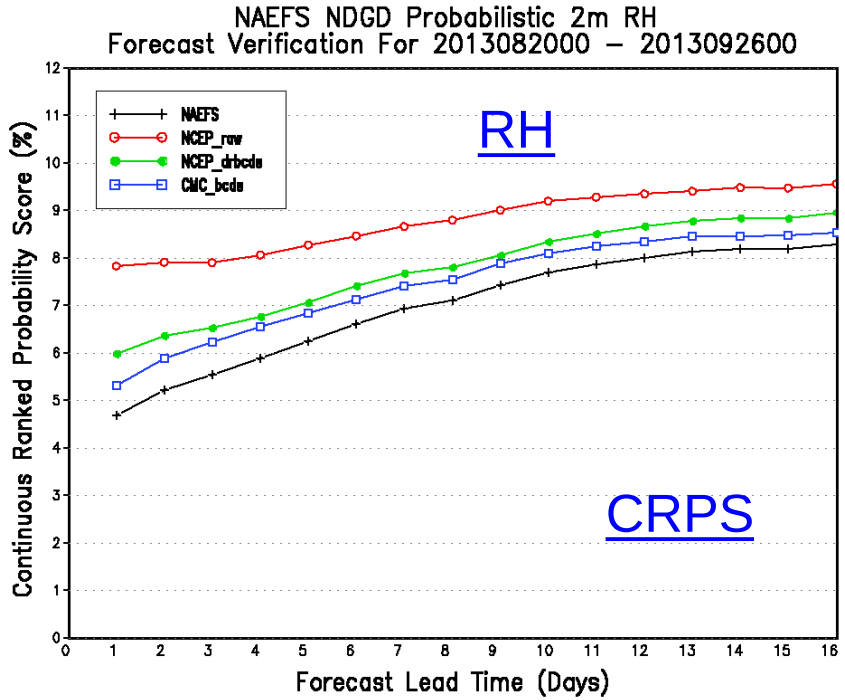
48hr

Latest Evaluation For CONUS 2013

August 20 2013 – September 26 2013


NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2013082000 – 2013092600
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
Dew point T
CRPS
Continuous Ranked Probability Score (K)


NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2013082000 – 2013092600
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
Dew point T
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)


NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2013082000 – 2013092600
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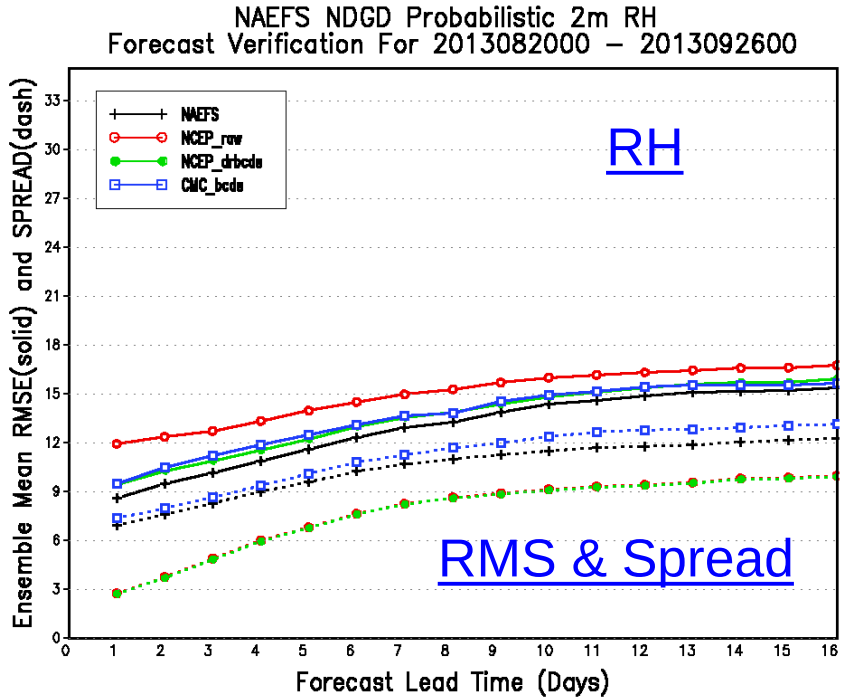
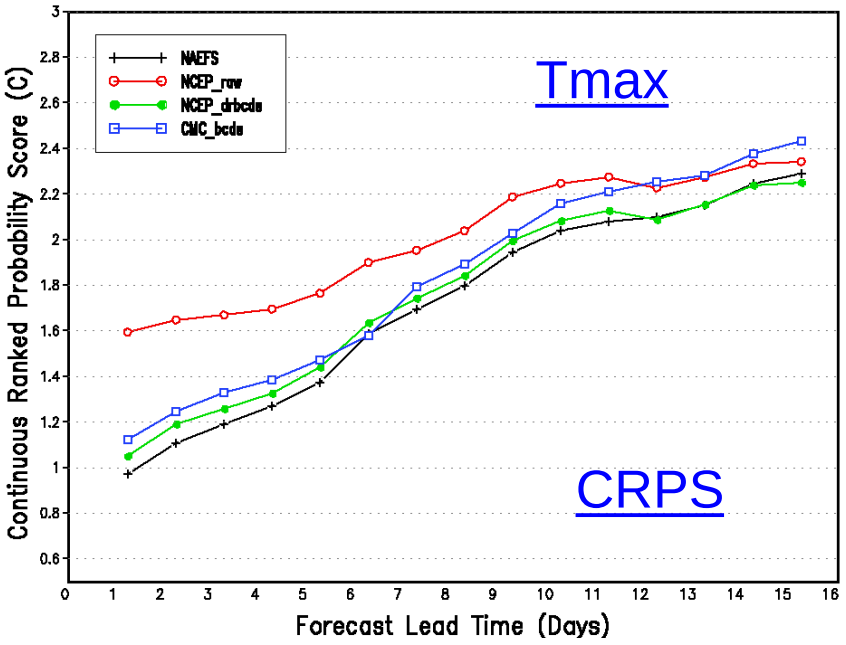
NCEP_raw
NCEP_drbcds
CMC_bcds
RH
CRPS
Continuous Ranked Probability Score (%)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2013082000 – 2013092600
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
RH
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic Max Temperature
Forecast Verification For 2013082000 – 2013092600
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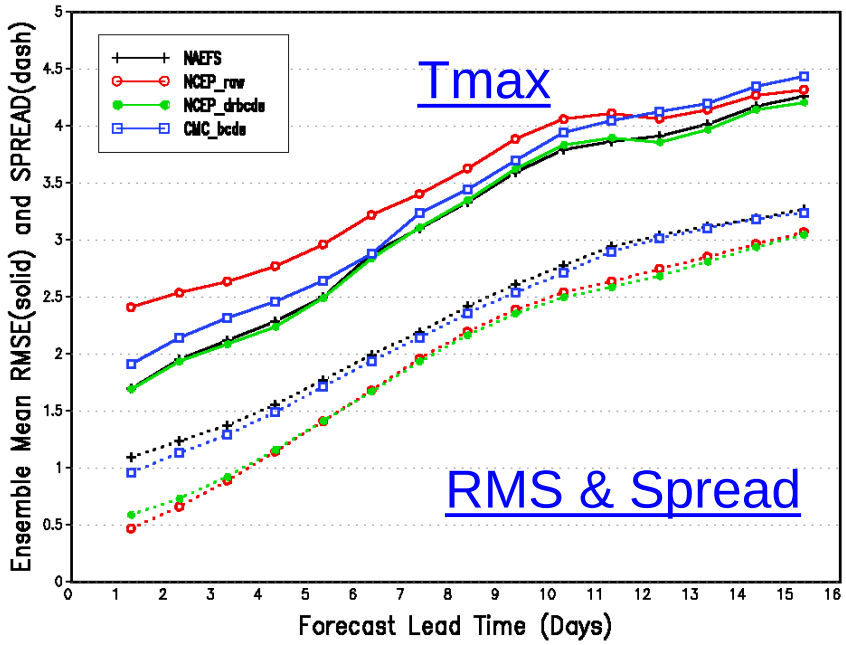
NCEP_raw
NCEP_drbcds
CMC_bcds
Tmax
CRPS
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)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Forecast Verification For 2013082000 – 2013092600
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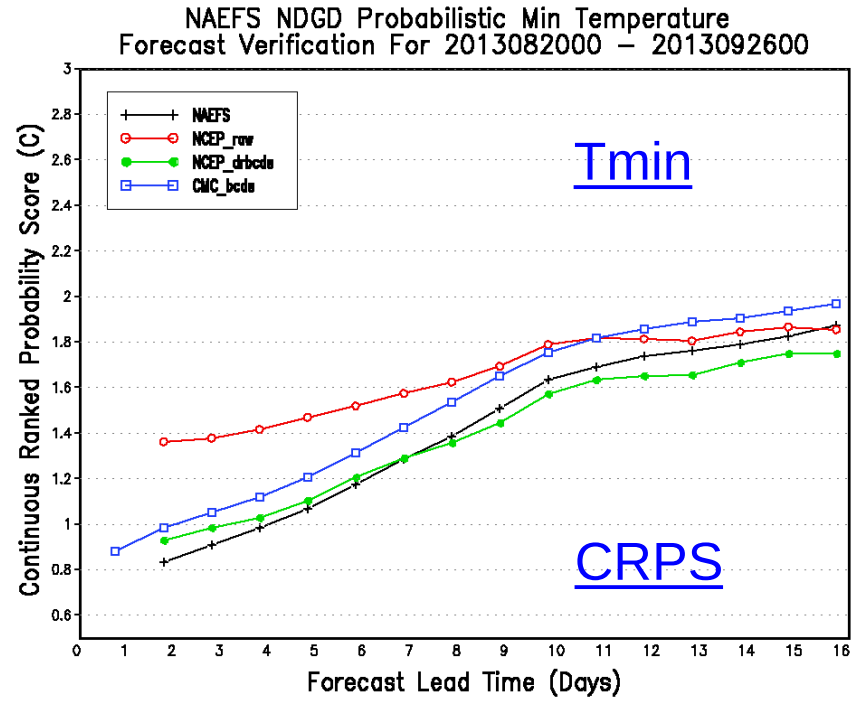
NCEP_drbcds
CMC_bcds
Tmax
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)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Forecast Verification For 2013082000 – 2013092600
NAEFS
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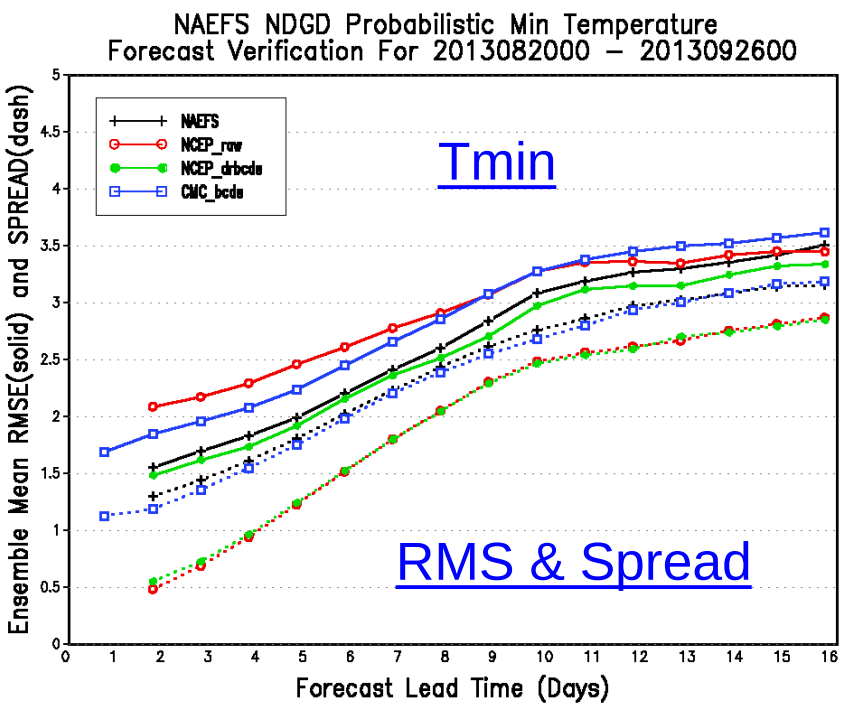
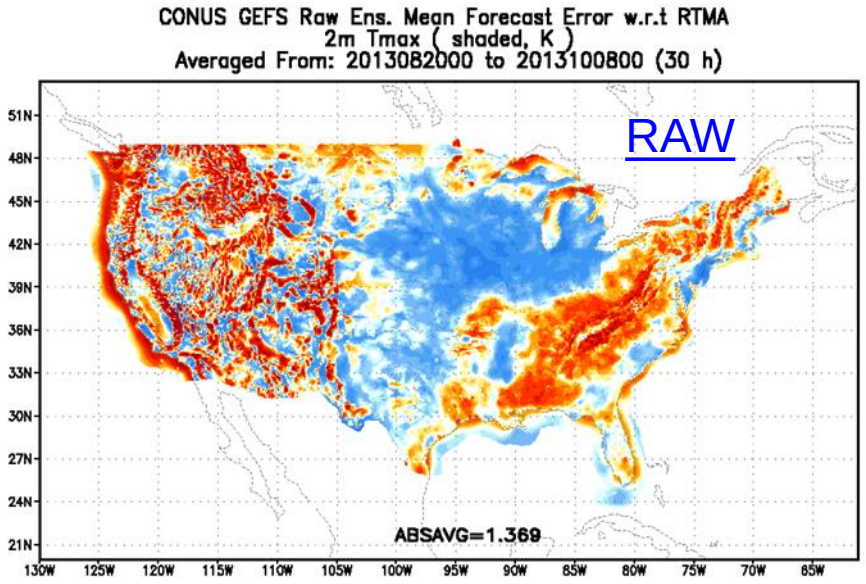
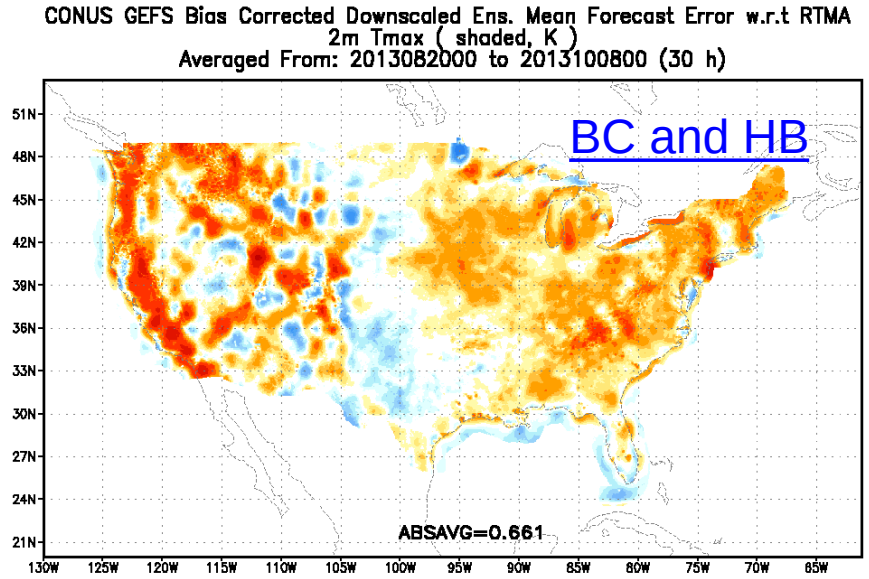
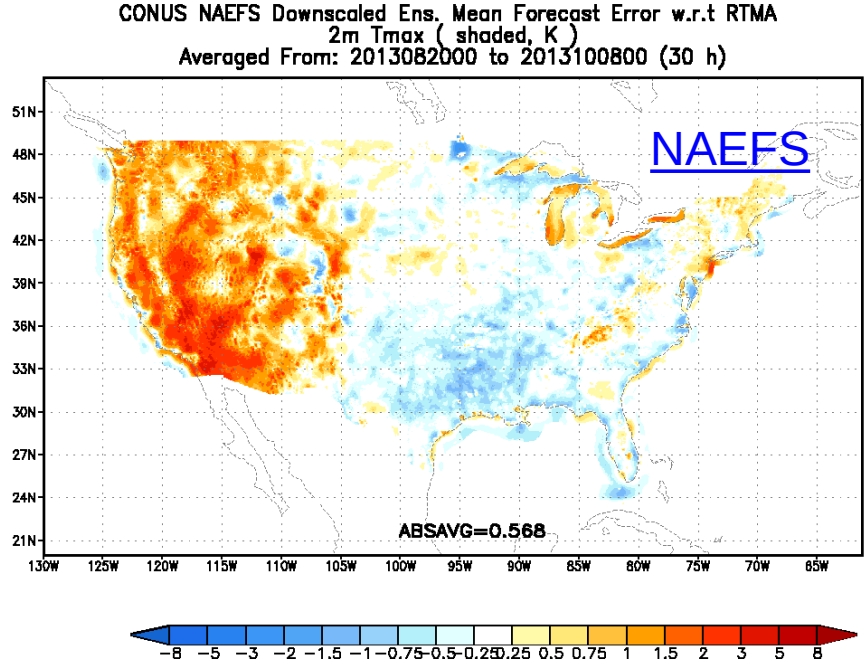
NCEP_drbcds
CMC_bcds
Tmin
CRPS
Continuous Ranked Probability Score (C)
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic Min Temperature
Forecast Verification For 2013082000 – 2013092600
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
Tmin
RMS & Spread
Ensemble Mean RMSE(solid) and SPREAD(dash)
Forecast Lead Time (Days)







T2m (Maximum)

Period: 08/20-10/08/2013

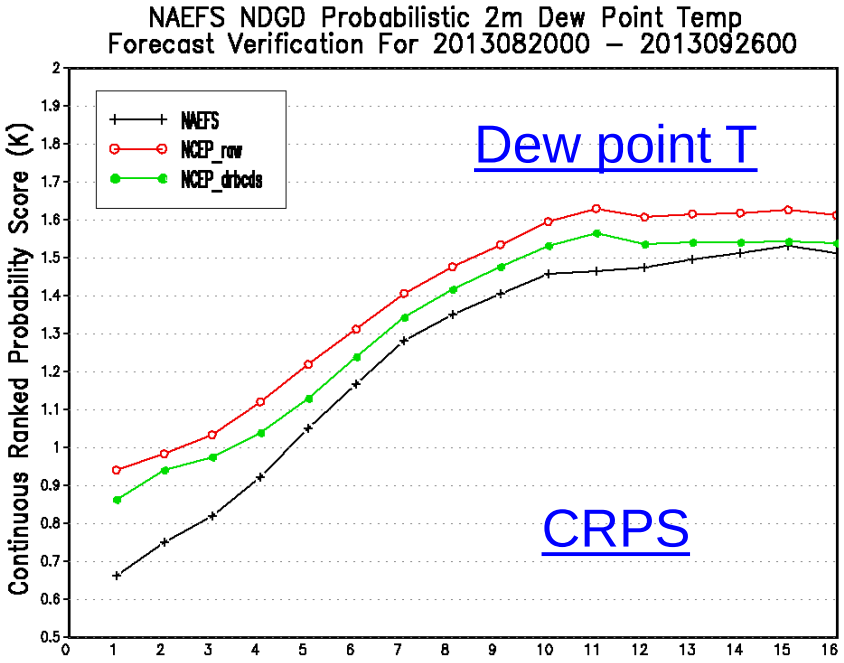
Lead time: 30hr

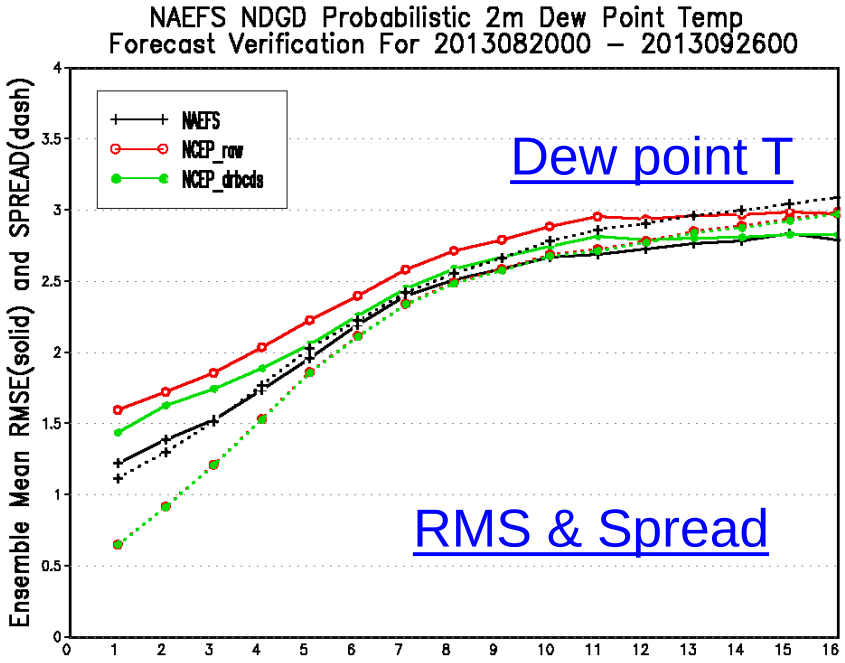
Mean Forecast Error (against RTMA)

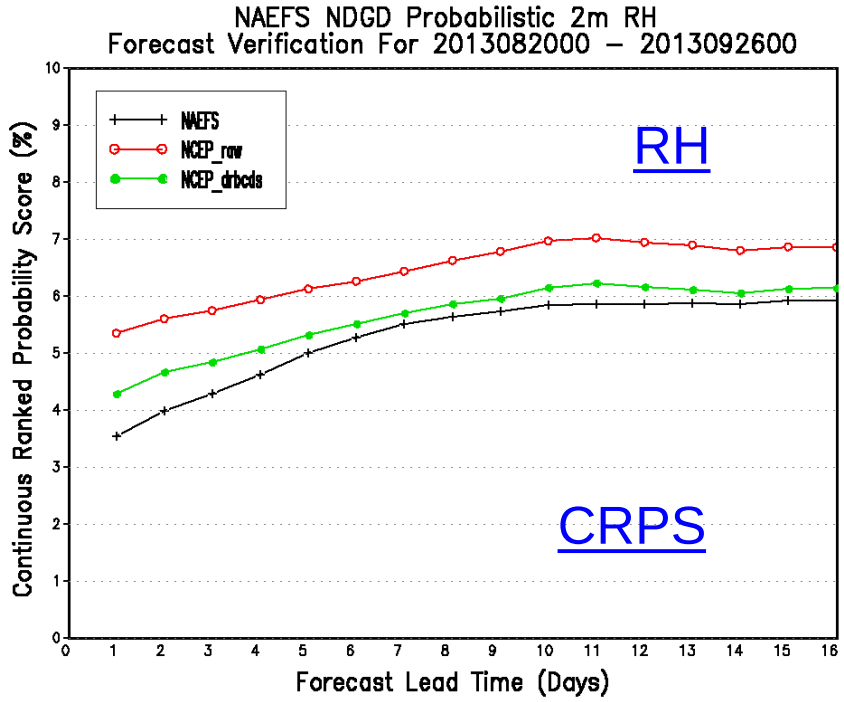
More than 50% error reduction

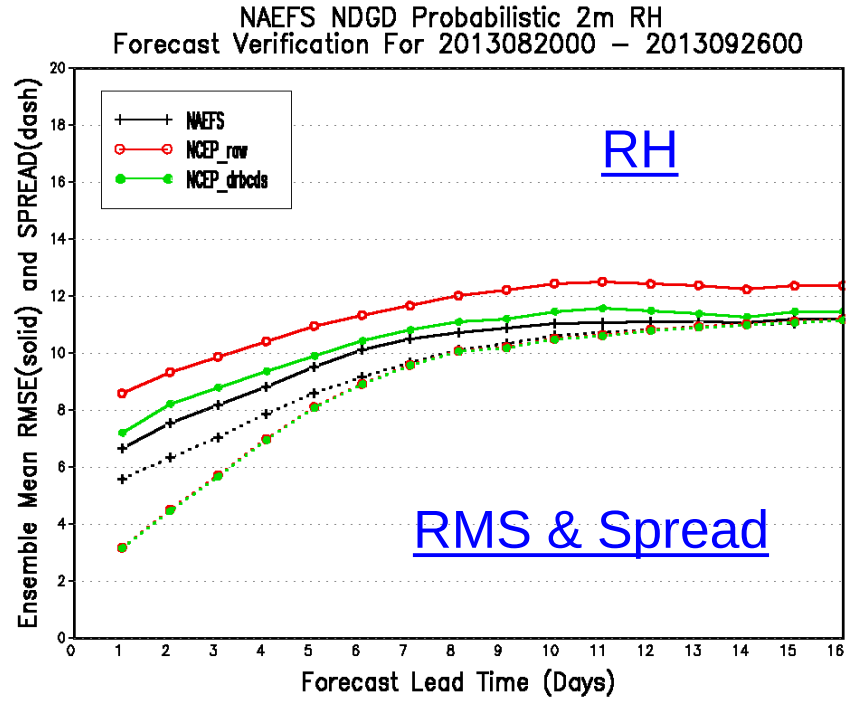
Latest Evaluation For Alaska 2013

August 20 2013 – September 26 2013


NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2013082000 – 2013092600
Continuous Ranked Probability Score (K)
NAEFS
NCEP_raw
NCEP_drbcds
Dew point T
CRPS


NAEFS NDGD Probabilistic 2m Dew Point Temp
Forecast Verification For 2013082000 – 2013092600
Ensemble Mean RMSE(solid) and SPREAD(dash)
NAEFS
NCEP_raw
NCEP_drbcds
Dew point T
RMS & Spread


NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2013082000 – 2013092600
Continuous Ranked Probability Score (%)
NAEFS
NCEP_raw
NCEP_drbcds
RH
CRPS
Forecast Lead Time (Days)


NAEFS NDGD Probabilistic 2m RH
Forecast Verification For 2013082000 – 2013092600
Ensemble Mean RMSE(solid) and SPREAD(dash)
NAEFS
NCEP_raw
NCEP_drbcds
RH
RMS & Spread
Forecast Lead Time (Days)

New products (2): Precipitation (CONUS)

- Precipitation calibration for COUNS
  - Bias correction
  - At 1*1 degree resolution
  - Proxy truth: CCPA at 1*1 degree resolution
  - Methodology: frequency match and decaying average - *Ref: Zhu and Luo, 2013: Weather and Forecasting (in process)*
  - What is the optimum weight? (w=0.02)
  - CDF for both of CONUS and each RFCs

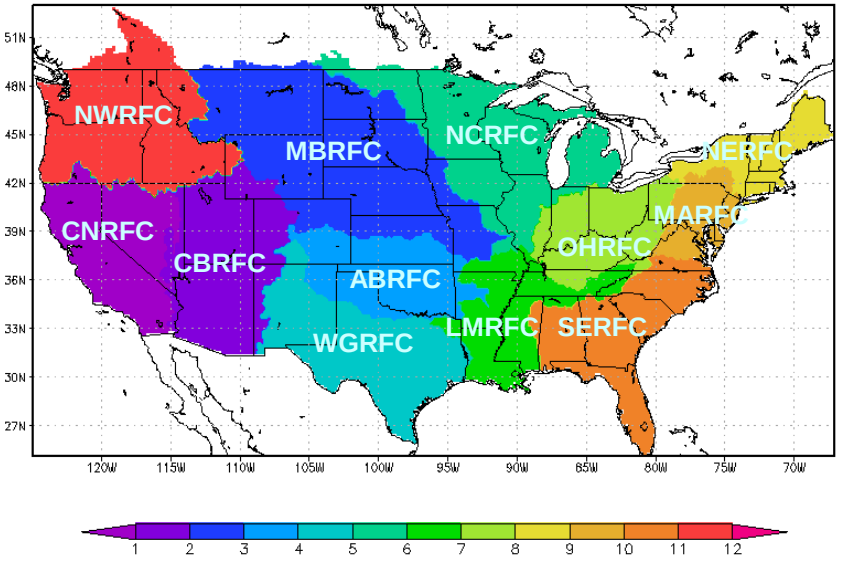
- Downscaled forecast for CONUS
  - 0-6 hour forecast as best 1 degree analysis
  - 5km CCPA as best observation
  - DVs come from above two
  - DV is formed for regions, or each grid point
  - *Reference for downscaling process: Cui and Zhu, 2013: Weather and Forecasting (in process)*

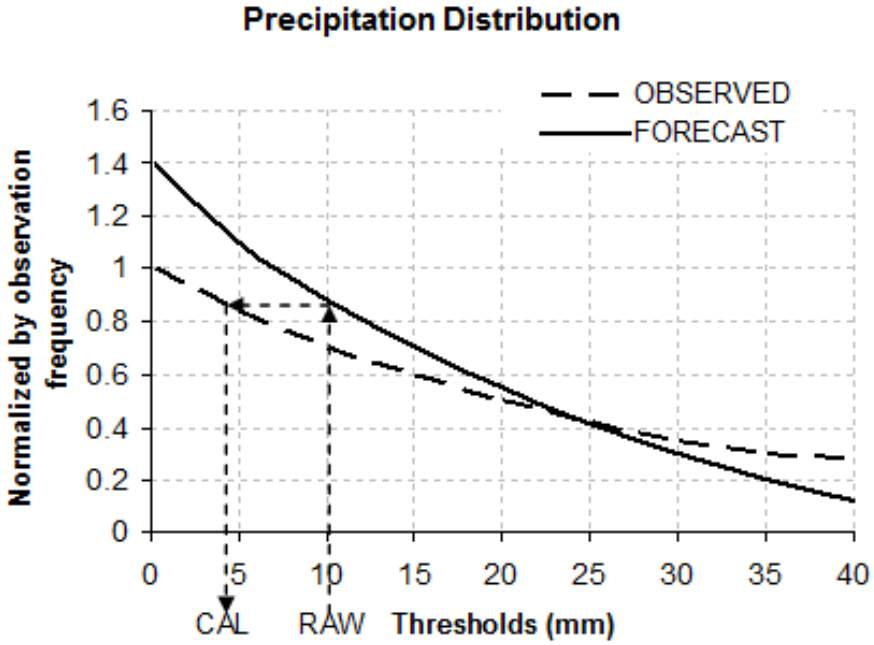
Precipitation Calibration Based on Frequency Matching Method (FMM)

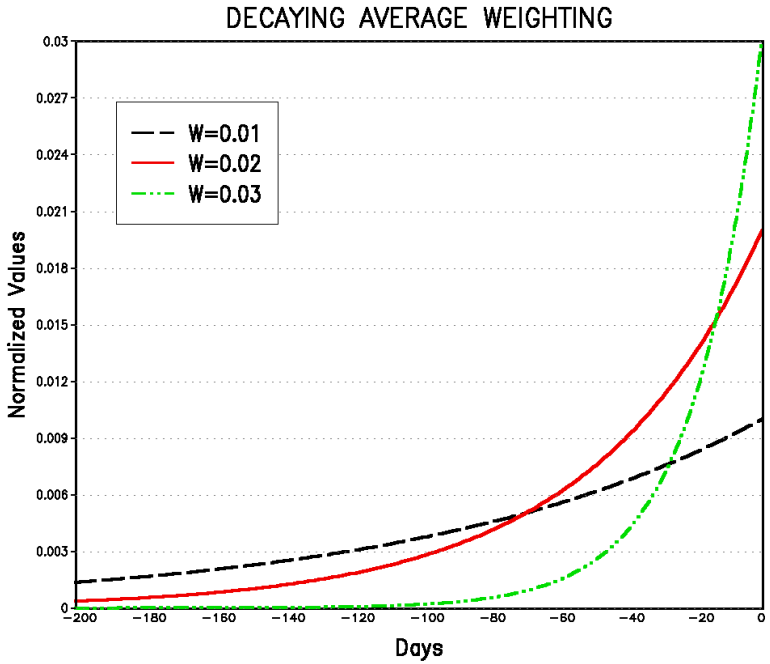
Calculate for Obs and Fcst respectively

$$\overline{PDF}_j = (1-W) * \overline{PDF}_{j-1} + W * PDF_j$$

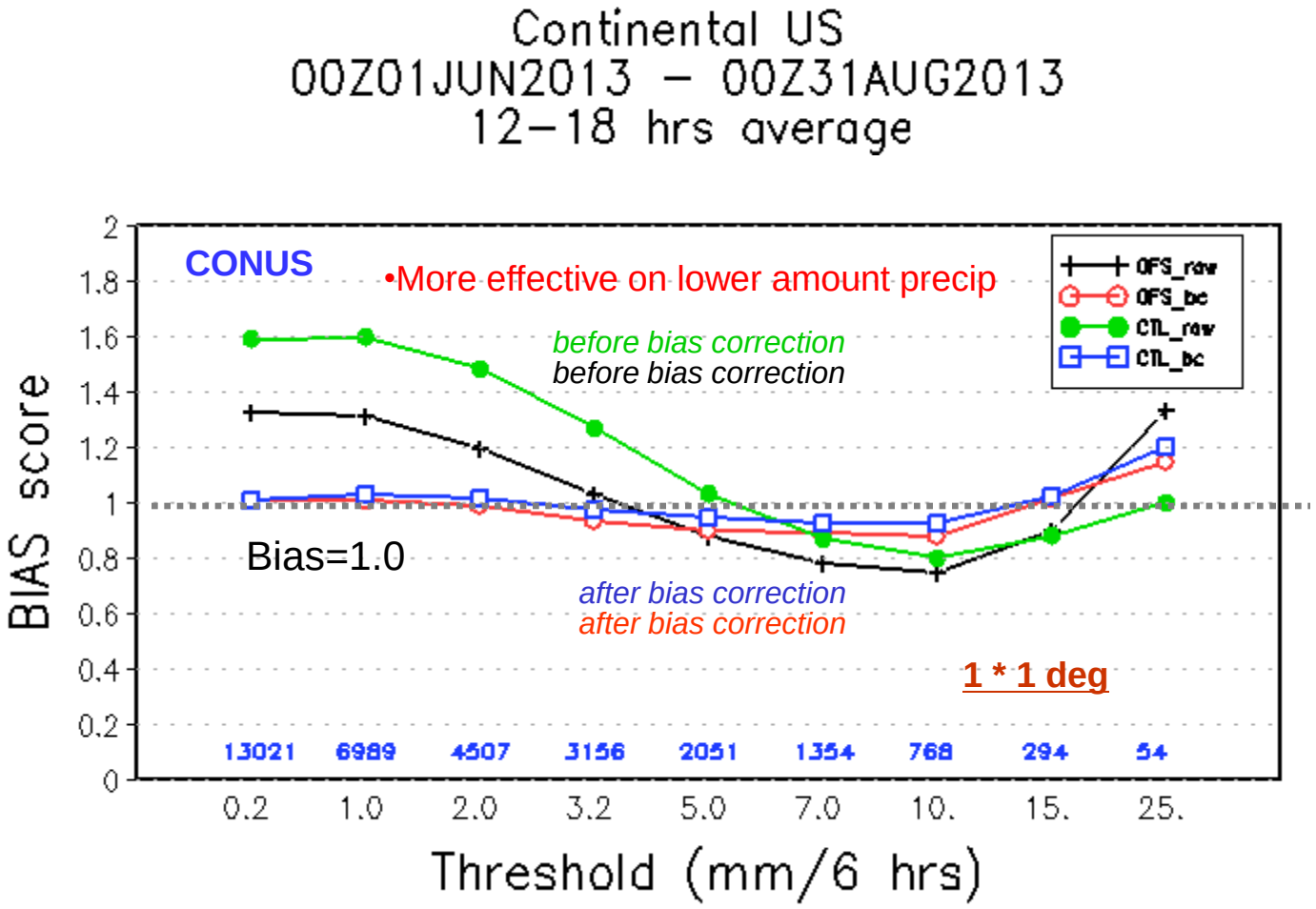
W is weight to accumulate PDF



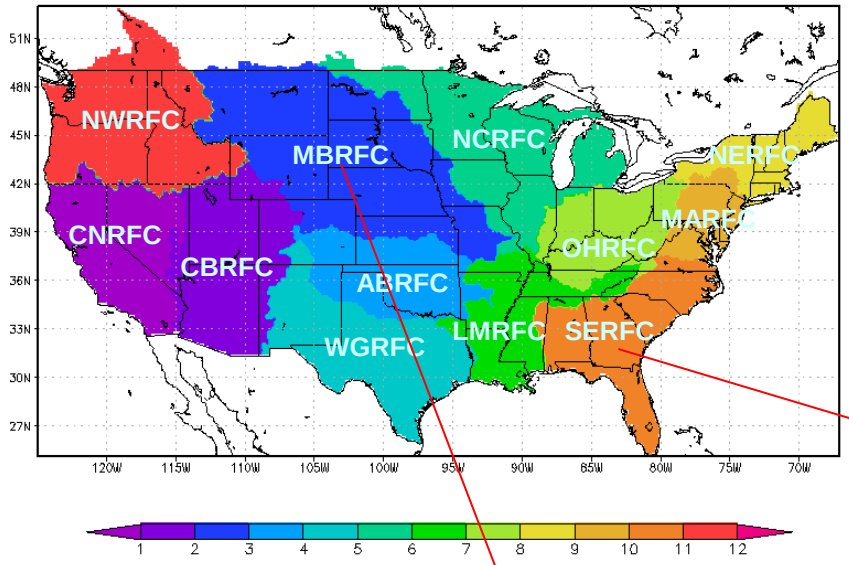


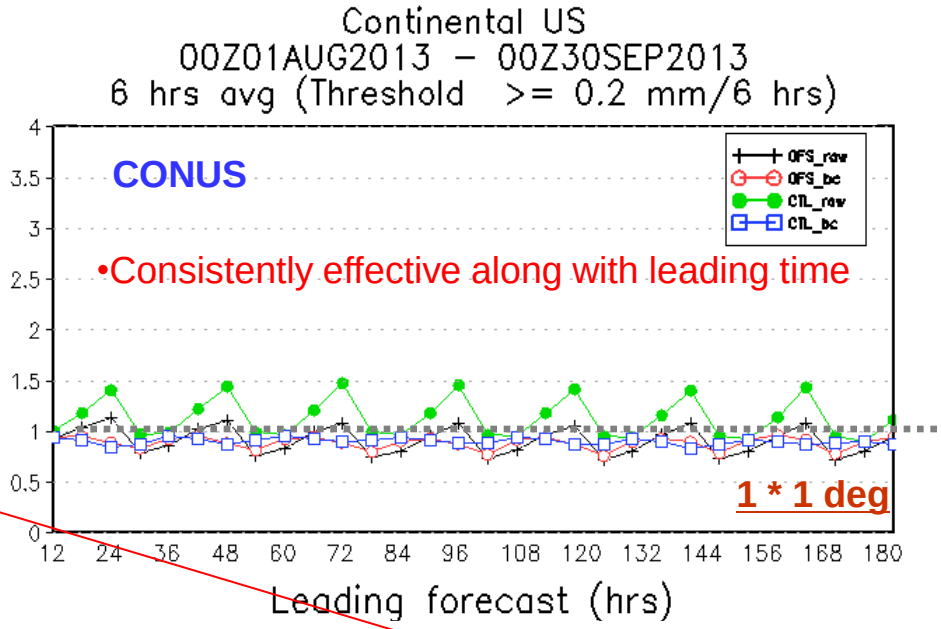


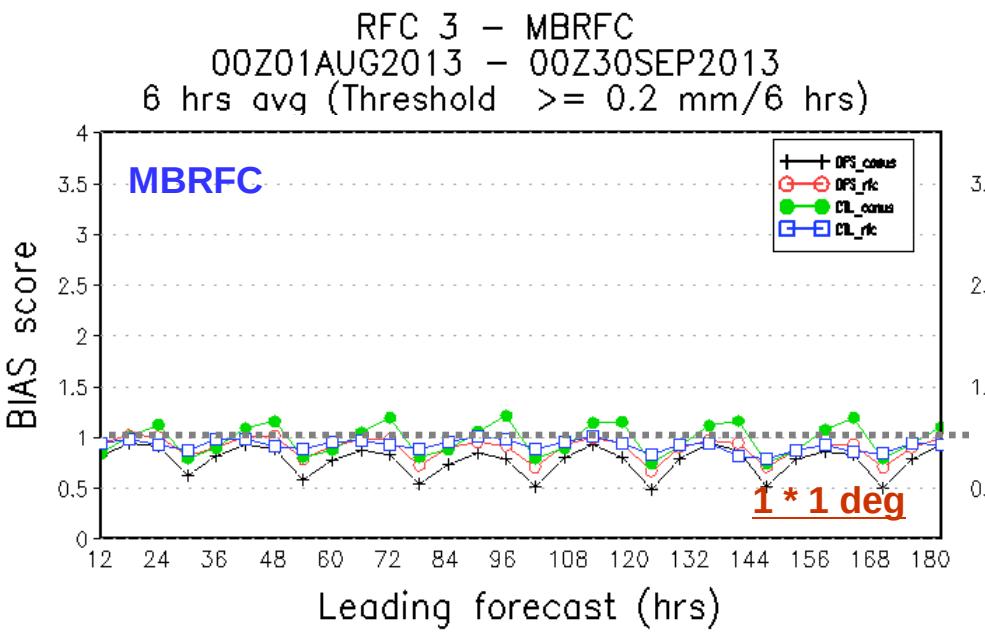
Significantly reduced bias

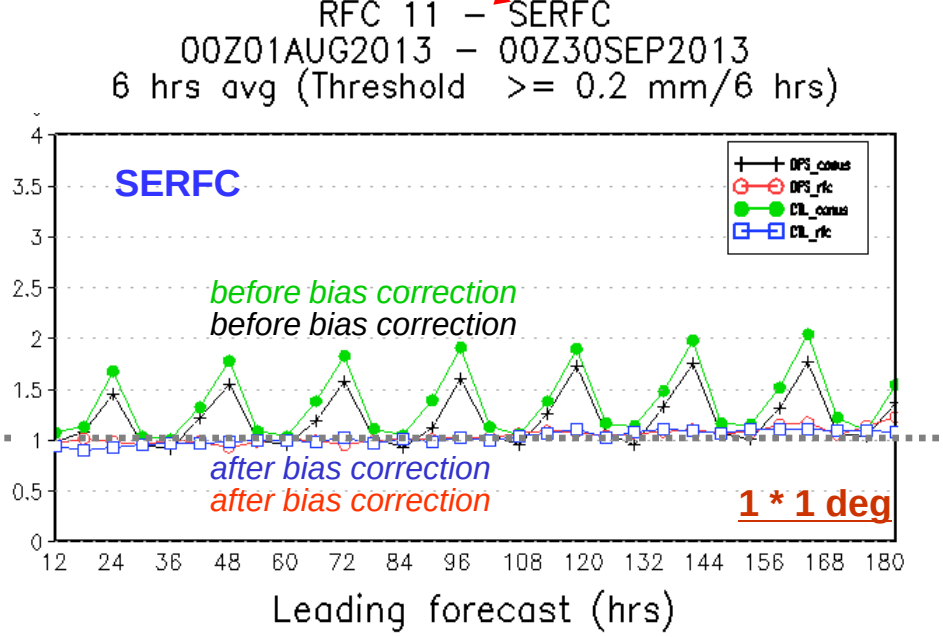


Significantly reduced bias for CONUS and each RFC

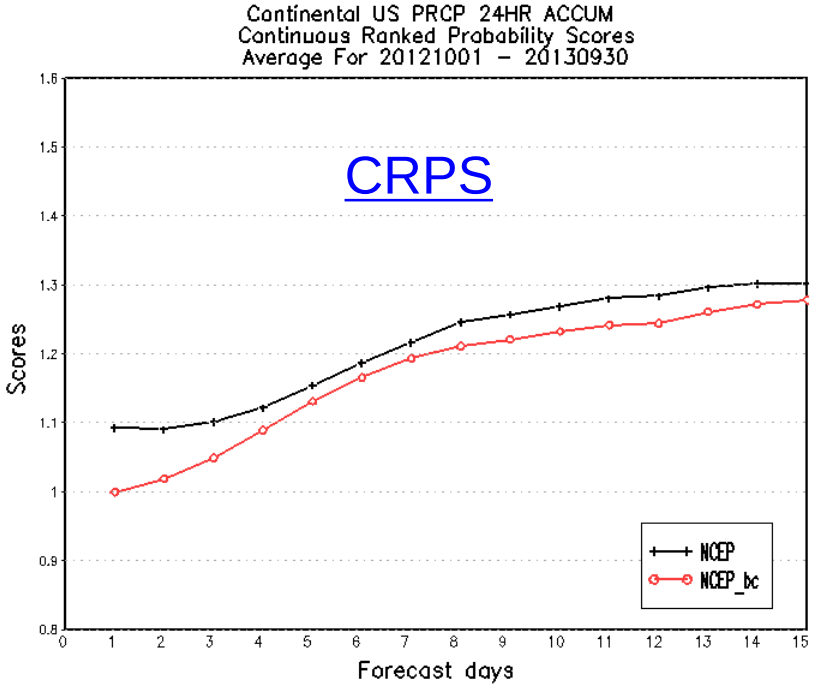


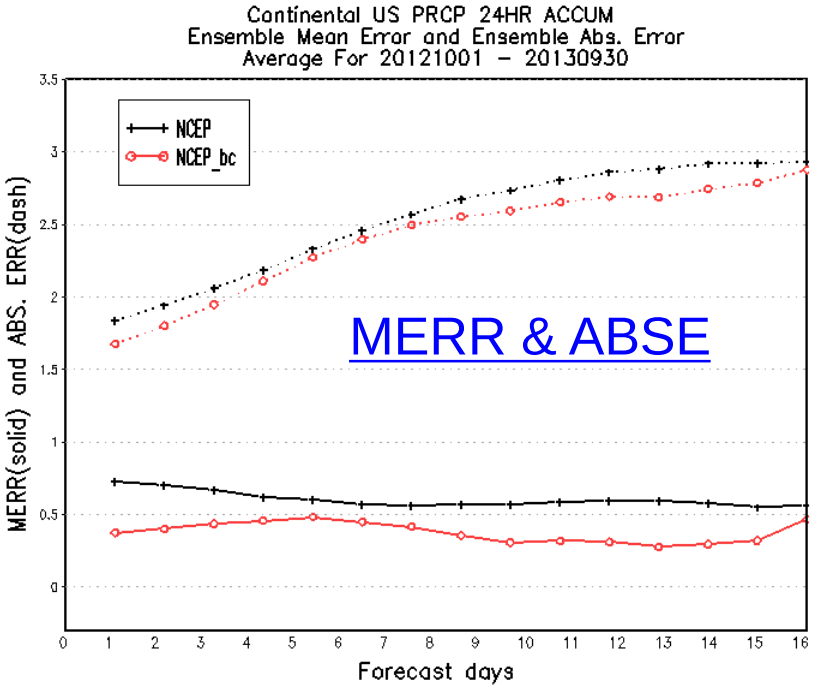


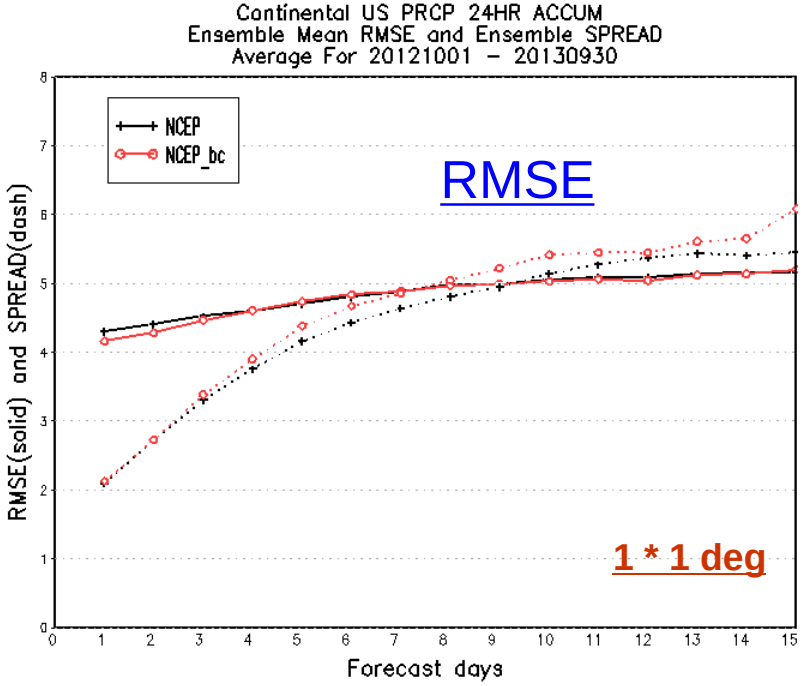


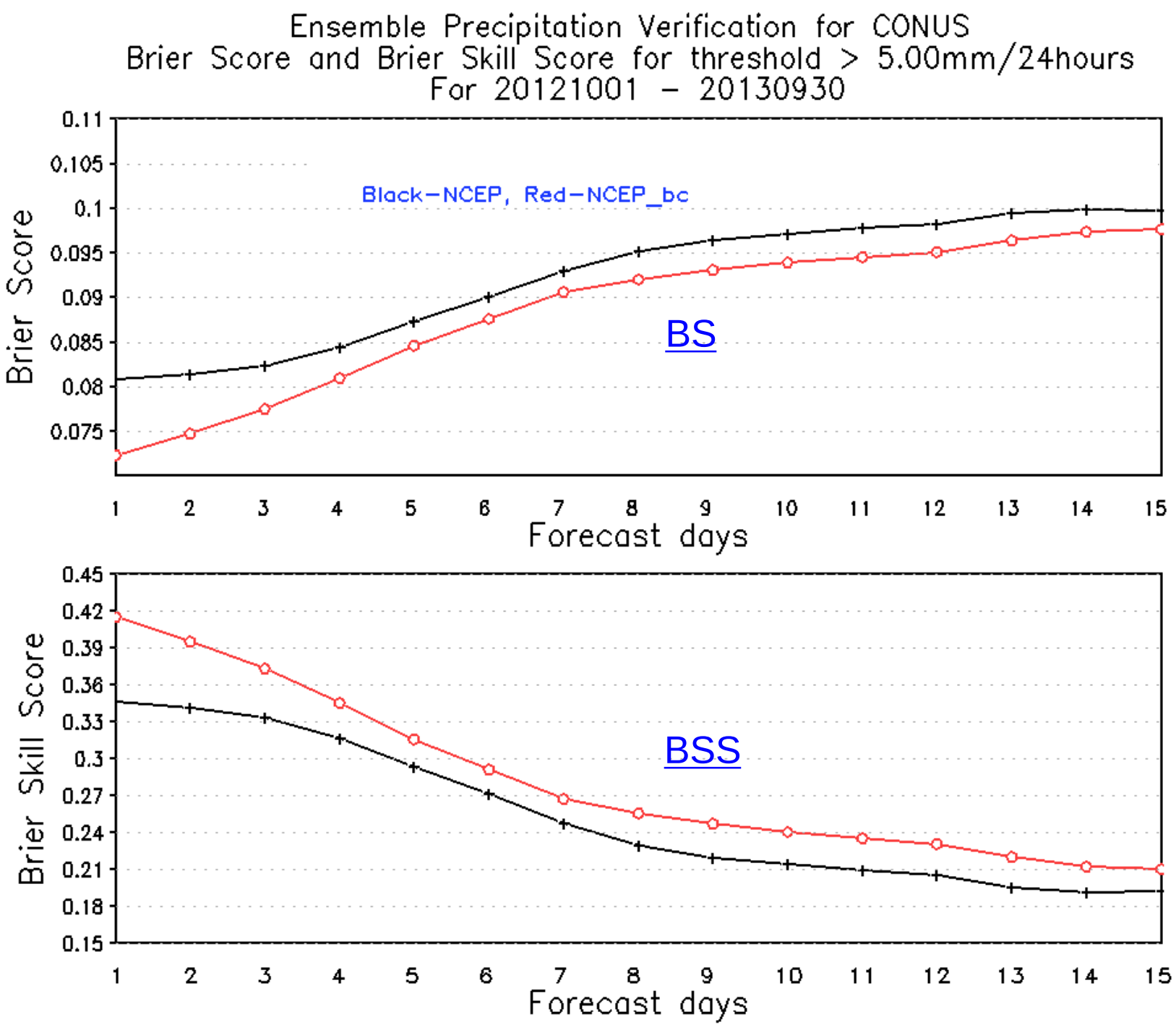


2012-2013 NCEP/GEFS forecast





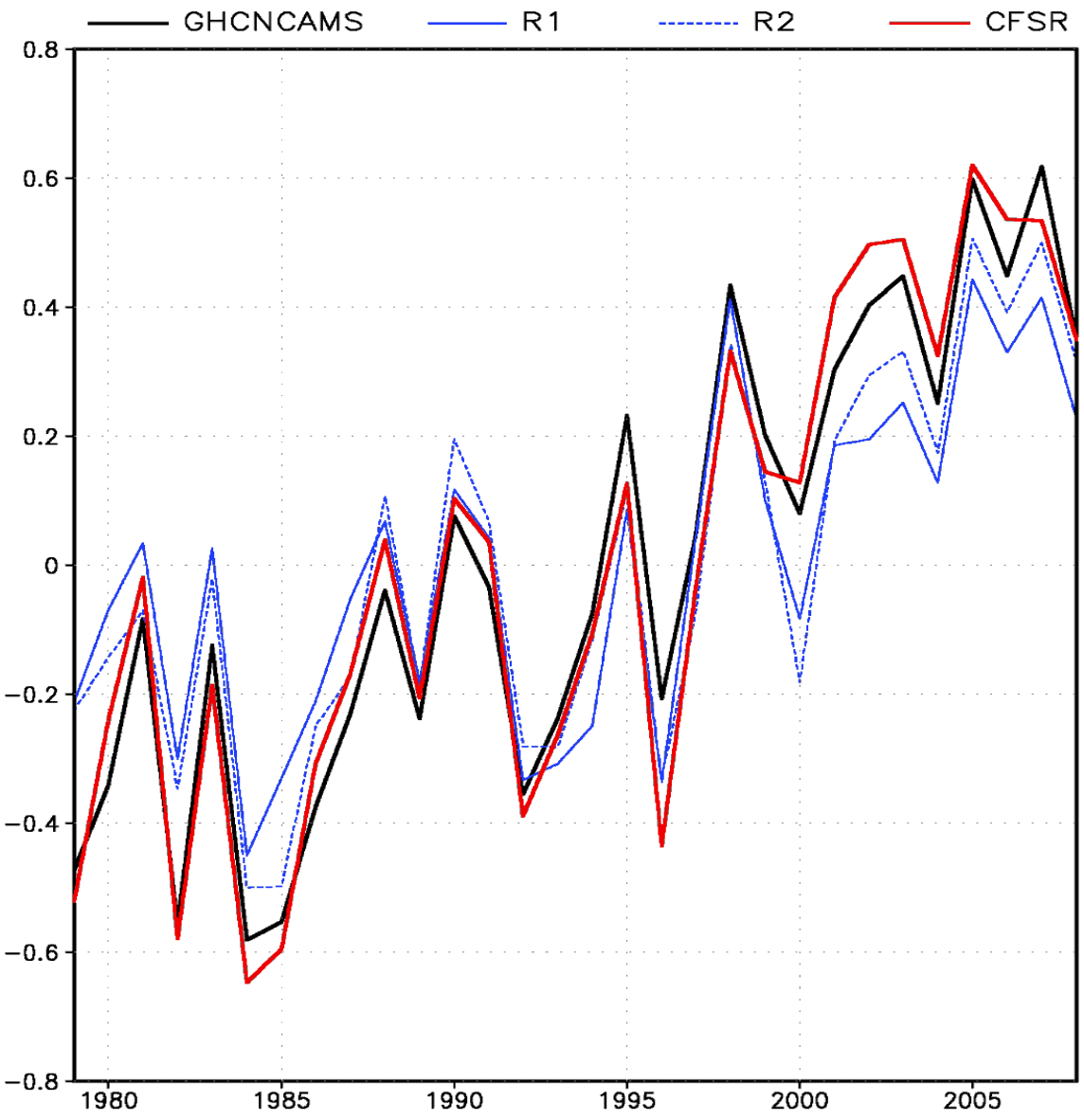



Ensemble Precipitation Verification for CONUS
Brier Score and Brier Skill Score for threshold > 5.00mm/24hours
For 20121001 - 20130930
Black=NCEP, Red=NCEP_bc
Brier Score
0.11
0.105
0.1
0.095
0.09
0.085
0.08
0.075
BS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Forecast days
Brier Skill Score
0.45
0.42
0.39
0.36
0.33
0.3
0.27
0.24
0.21
0.18
0.15
BSS
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Forecast days

3: Change of climatology

- CFS analysis instead of CDAS (daily analysis)
  - Accumulate the difference between GSI analysis and CFS analysis
  - Send this to CMC for daily operation
- Daily climatology – mean and stdv
  - Using state-of-art CFS reanalysis (30 years) instead of NCEP/NCAR reanalysis (40 years)
  - To produce new daily climatological mean and standard deviation
  - 21 variables (send/share to CMC for operation, too)
- Affect products and application
  - Anomaly forecast (or extremely forecast index) – 1-16 day forecast (daily) – WPC, NWS regions and WFOs
  - CPC and CMC's extended range anomaly forecast

Annual global mean anomalies over land (K)



GHCN_CAMS as a reference. The closer, the better.

GHCN_CAMS:

- 2 data sets combination of Global Historical Climatology Network & Climate Anomaly Monitoring System
- High res. (0.5x0.5) analyzed global land surface temp. for 1948 – present

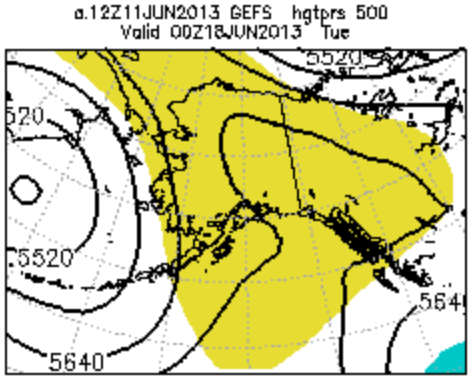
CFSR

- Climate Forecast System (CFS) reanalysis

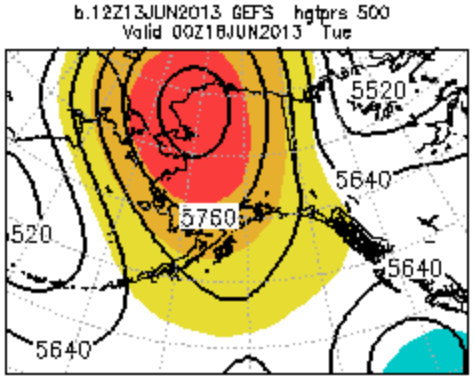
Courtesy of Wanqiu Wang

Alaskan heat episode of 16-19 June 2013

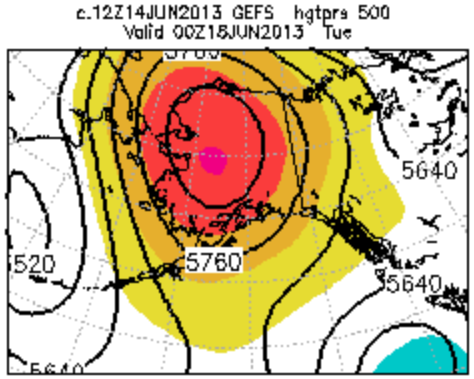
- Trevor Alcott and Ricahard Grumm



[7-day fcst]

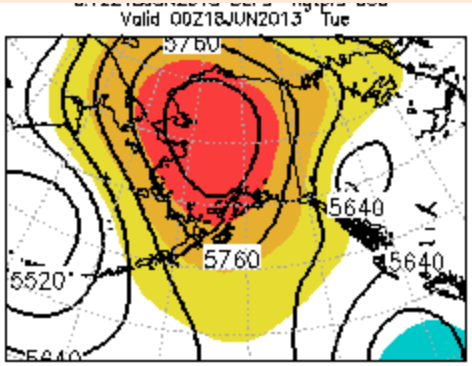


[5-day fcst]

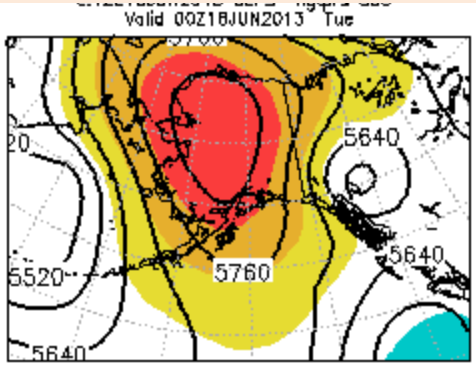


[4-day fcst]

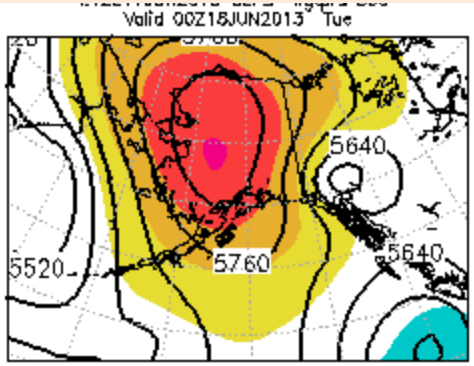
- Fcst. of a ridge over Alaska had ~7 days of lead-time.
- Fcst. of a strong ridge in excess of +3σ above normal had ~ 5 days of predictability
- Standardized anomaly provides useful insights into the potential for extreme events



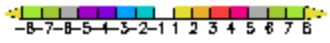
[60-hr fcst]



[36-hr fcst]



[12-hr fcst]



GEFS forecasts of 500 hPa heights and 500 hPa height anomalies (shaded) from 6 GEFS forecasts valid at 0000 UTC 18 June 2013 from GEFS forecasts initialized at a) 1200 UTC 11 June, b) 1200 UTC 13 June, c) 1200 UTC 14 June, d) 1200 UTC 15 June, e) 1200 UTC 16 June, f) 1200 UTC 17 June 2013.

Summary

- New and upgrades (for NAEFS) are ready for implementation from various retrospective tests.
- The improvement is all positive.
- The results are presented and discussed with WPC forecasters, at NAEFS monthly meeting.
- Costs of computation and disk storage are minor.

Plan Schedule

- Project kick off – November 12, 2013 (done)
- Start to set up EMC ECflow based parallel – November 2013
- EMC CCB meeting – December 12, 2013
- Submit/discuss TIN – December 6, 2013
- Submit RFCs – December, 2013
- Expect NCO parallel – in Mid-January 2014
  - Service centers evaluation
- Expect implementation – Q2FY14 (Feb. 2014)

Background !!!

NAEFS Upgrade

Project Status as of 11/12/13

G Project Information and Highlights

Lead: Yuejian Zhu, EMC, Chris Magee, NCO

Scope:

- Based on NAEFS/GEFS 1*1 degree products
  - Using RTMA as proxy of truth, downscaled to CONUS 5km & Alasks 6km (matched NDFG grids), Adding new variables (Tmax, Tmin, Wdir, Wspd, Td and RH) for CONUS and variables (Td and RH) for Alaska. Products include 10%, 50%, 90%, mean, mode and spread
  - Using CCPA as proxy of truth, calibrate 1*1 degree precipitation forecast, and downscaled to 5km.
  - Using CFSRR climatology to replace NCEP/NCAR 40-y reanalysis for NAEFS anomaly forecast.
- GRIB II (encoding/decoding directly) for:
  - All new products
  - All exist NAEFS related products (conversion)

Expected Benefits:

- Reduce the bias significantly for most variables
- Increase probabilistic forecast skills
- WPC (Dave Novak) is supporting and participating fully retrospective evaluations

G Scheduling

Milestone (NCEP)	Date	Status
EMC testing complete/ EMC CCB approval	10/01/2013	
Initial Code Delivery to NCO	12/2013	
Technical Information Notice Issued	12/4/2013	
Initial Test Complete		
CCB approve parallel data feed		
IT testing begins	Jan. 2014	
IT testing ends	Jan. 2014	
Parallel testing begun in NCO (Code Frozen)	Mid-Jan 2014	
Real-Time Evaluation Ends	Feb. 2014	
Management Briefing		
Implementation	Feb. 2014	

G Issues/Risks

Issues: N/A

Risks:

Mitigation:

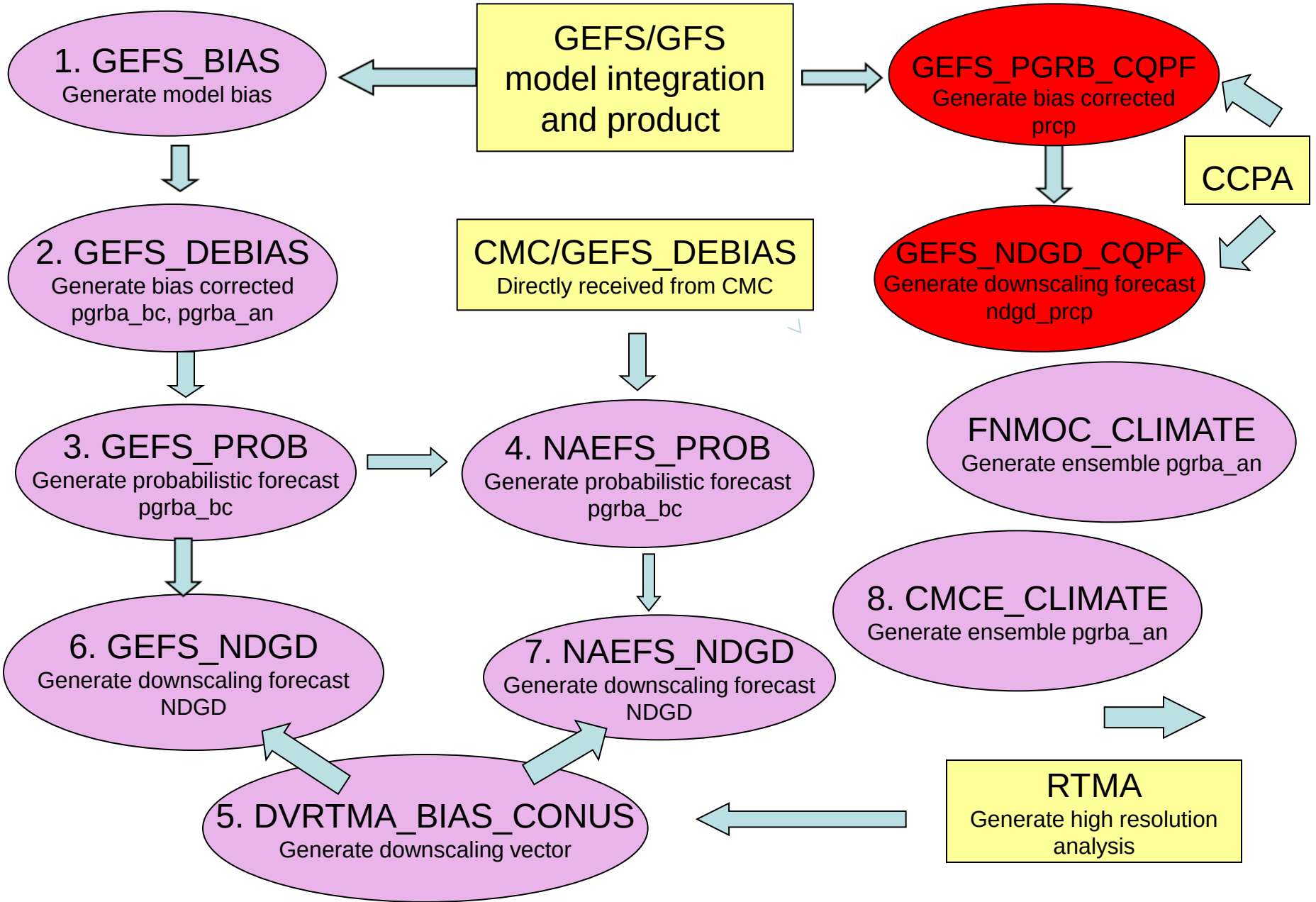
G Finances

Associated Costs:

Funding Sources: EMC Base: T2O 24 Man-months NCO Base: 2 man-months for implementation, 1 man-month annually for maintenance

R	Management Attention Required	Y	Potential Management Attention Needed	G	On Target

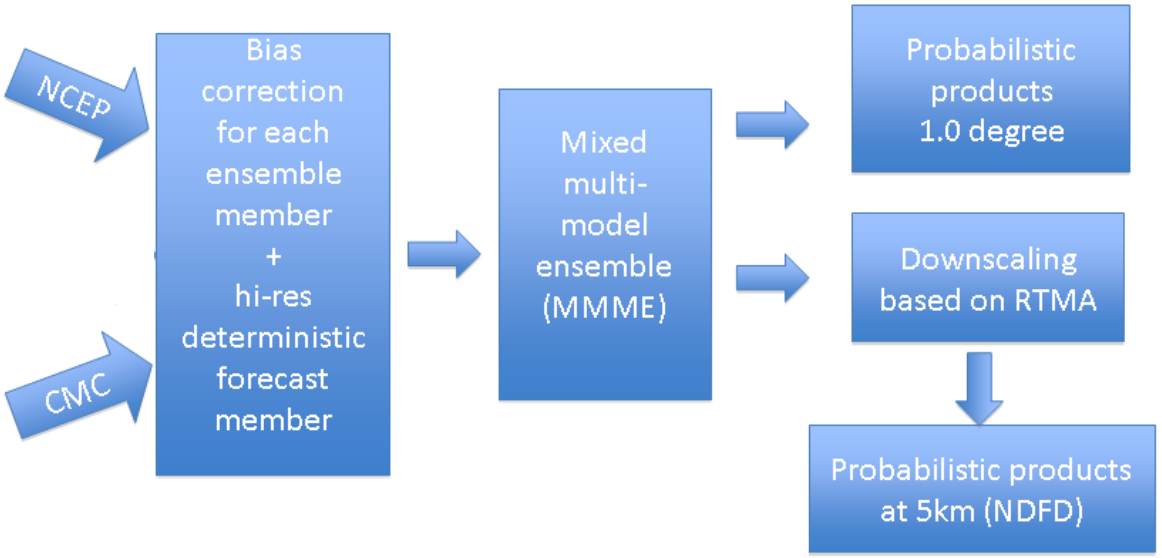
NAEFS FLOW CHART



Issues and risks

- GRIB II encoding
  - There is possible mis-matched GRIB II messages from current exist products (converted from GRIB I) to fully encoded GRIB II.
  - GRIB II local tables
    - Need to have local tables for a couple of products (yes, defined. Confirmed by Boi Voung – no need for RFC)
  - G2 Lib upgrade
    - Precipitation calibration depends on G2/Lib's implementation in Q1Fy14 – done

Current NCEP/EMC Statistical Post-Processing System



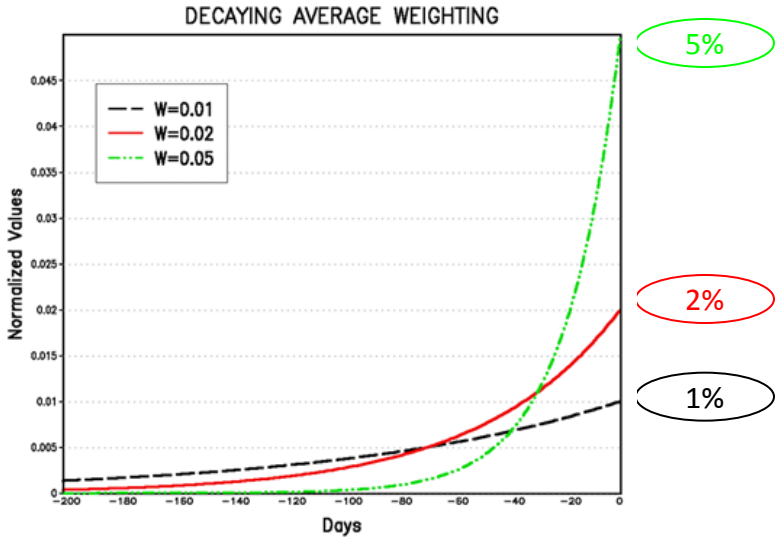
- Bias corrected NCEP/CMC GEFS and NCEP/GFS forecast (up to 180 hrs), same bias correction algorithm
  - Combine bias corrected NCEP/GFS and NCEP/GEFS ensemble forecasts
  - Dual resolution ensemble approach for short lead time
  - NCEP/GFS has higher weights at short lead time
- NAEFS products
  - Combine 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/6km), CONUS and Alaska
  - Generate mean, mode, 10%, 50%(median) and 90% probability forecasts

Bias Correction Method & Application

- **Bias Correction Techniques** – array of methods
  - Estimate/correct bias moment by moment (*e.g., Cui et al and D. Unger et al*.).
    - Simple approach, implemented partially
    - May be less applicable for extreme cases
  - Bayesian approach (*e.g., Roman Krzysztofovicz*)
    - Allows simultaneous adjustment of all modes considered, under development
- **Moment-based method at NCEP**: apply adaptive (Kalman Filter type) algorithm

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

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

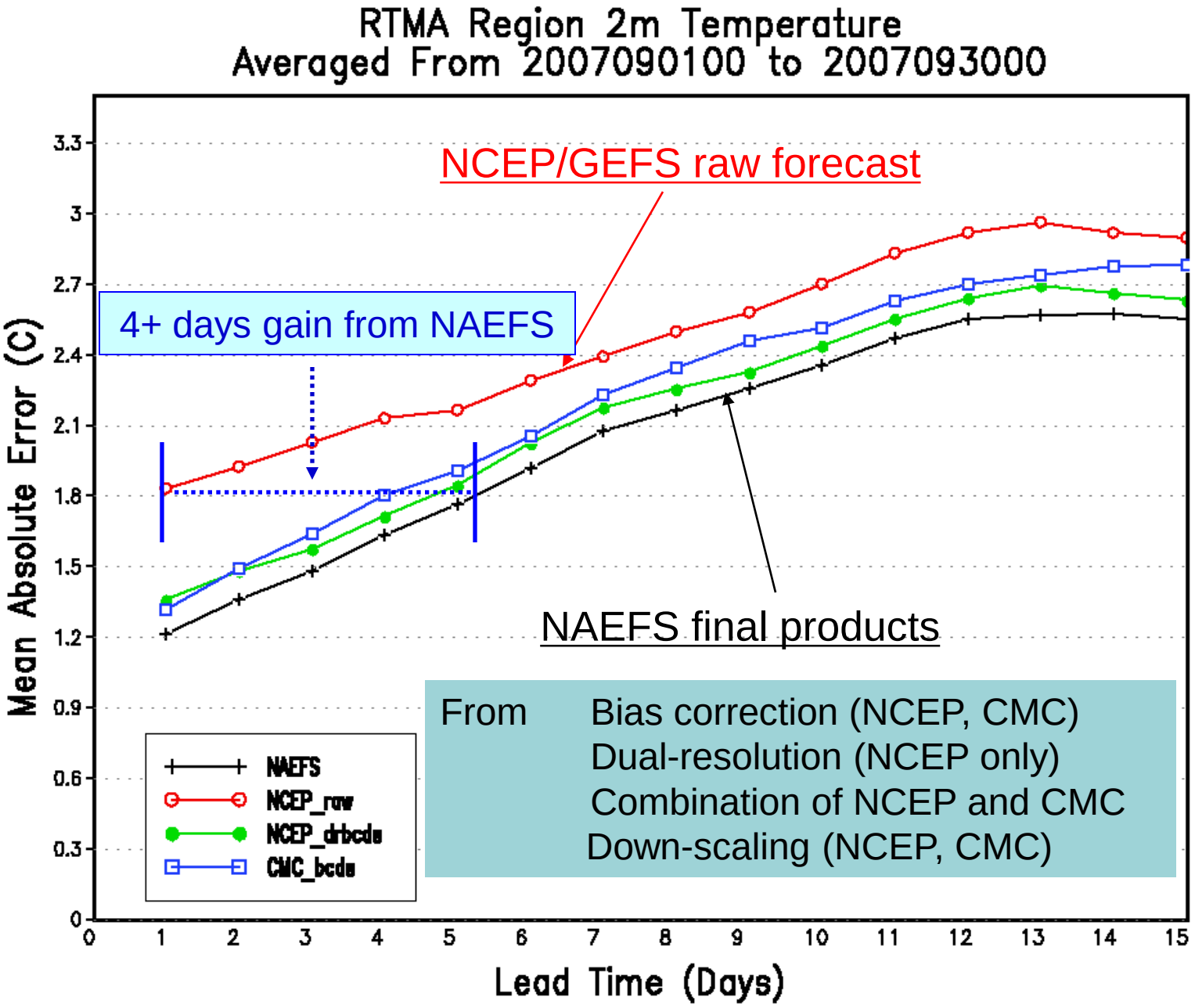


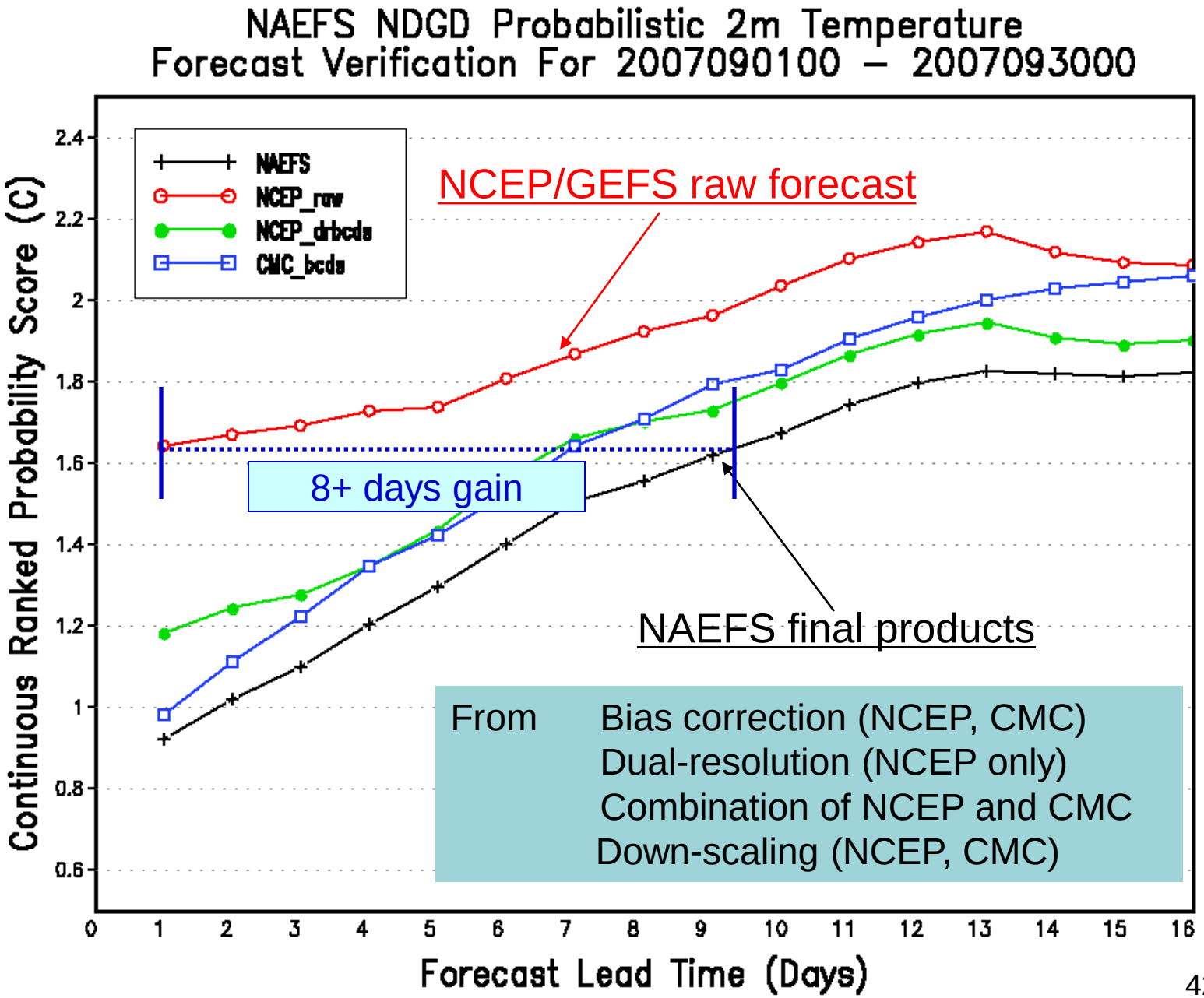
Cui et al. , Weather and Forecasting, 2011

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

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


RTMA Region 2m Temperature
Averaged From 2007090100 to 2007093000
NCEP/GEFS raw forecast
4+ days gain from NAEFS
NAEFS final products
From Bias correction (NCEP, CMC)
Dual-resolution (NCEP only)
Combination of NCEP and CMC
Down-scaling (NCEP, CMC)
NAEFS
NCEP_raw
NCEP_dribcda
CMC_bcda
Mean Absolute Error (C)
Lead Time (Days)
0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
2.4
2.7
3
3.3
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

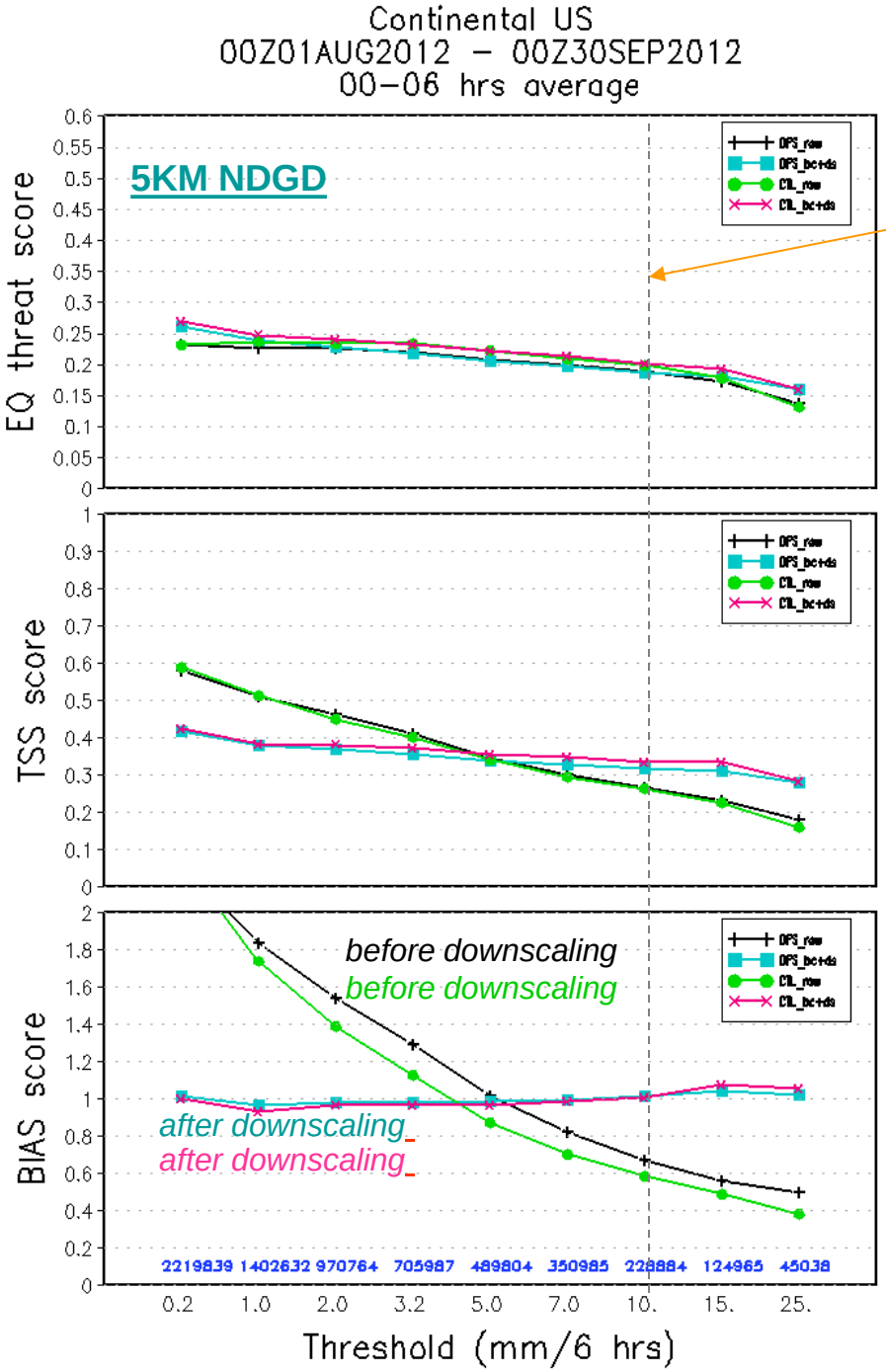

NAEFS NDGD Probabilistic 2m Temperature
Forecast Verification For 2007090100 – 2007093000
NAEFS
NCEP_raw
NCEP_drbcds
CMC_bcds
NCEP/GEFS raw forecast
8+ days gain
NAEFS final products
From Bias correction (NCEP, CMC)
Dual-resolution (NCEP only)
Combination of NCEP and CMC
Down-scaling (NCEP, CMC)
Continuous 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

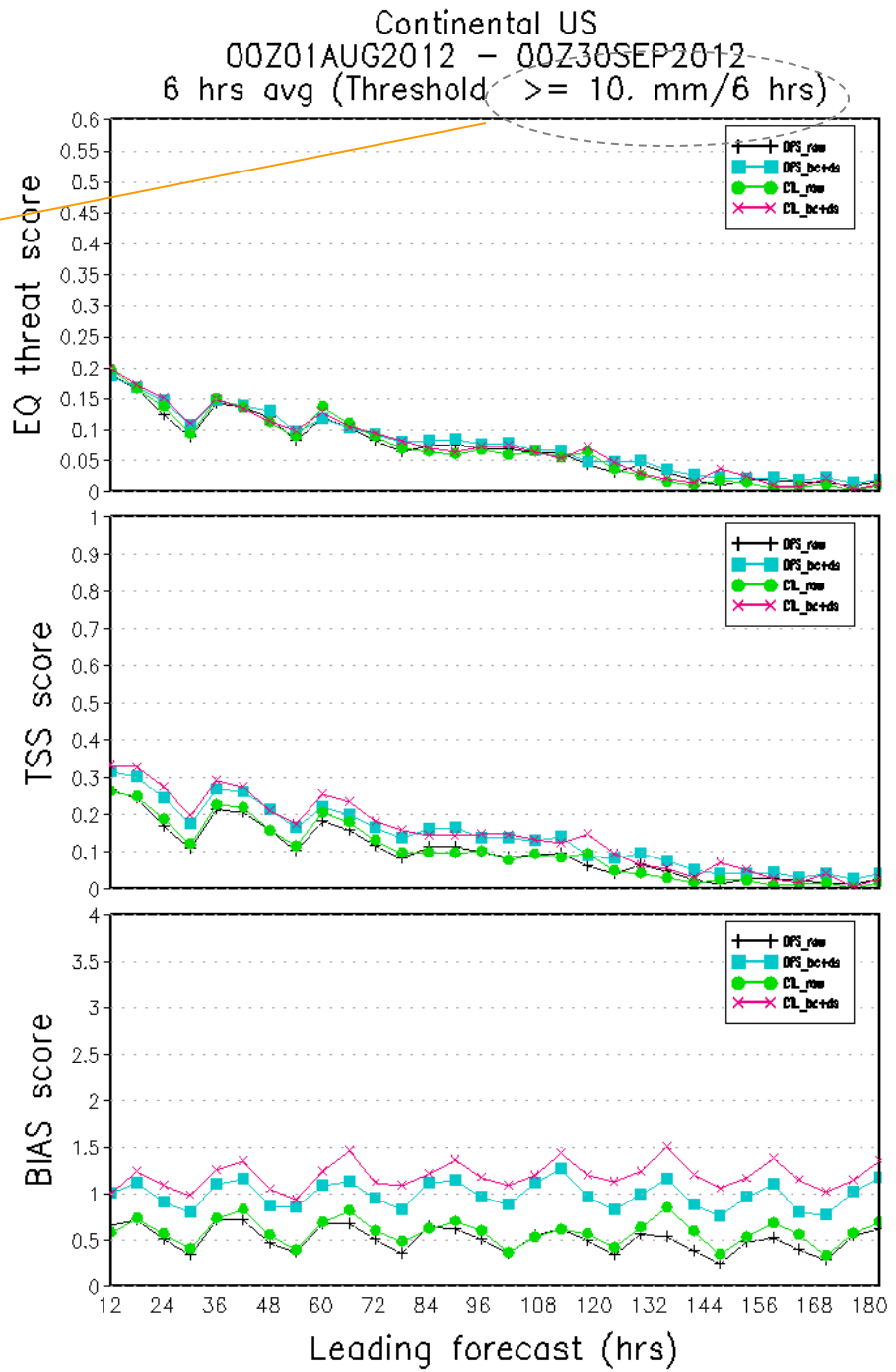
Precipitation Calibration for the NCEP Global Ensemble Forecast System

Yan Luo and Yuejian Zhu

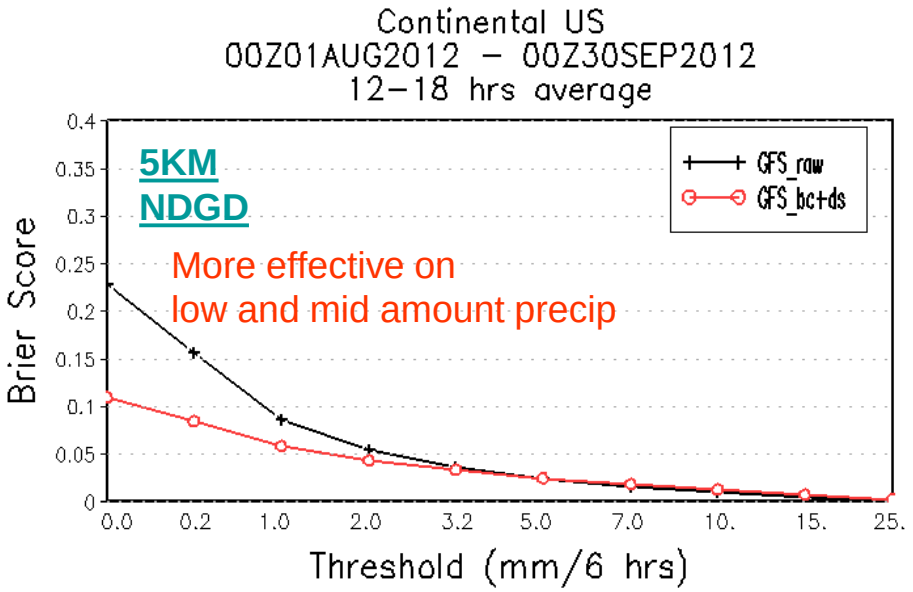
EMC-OHD Meeting

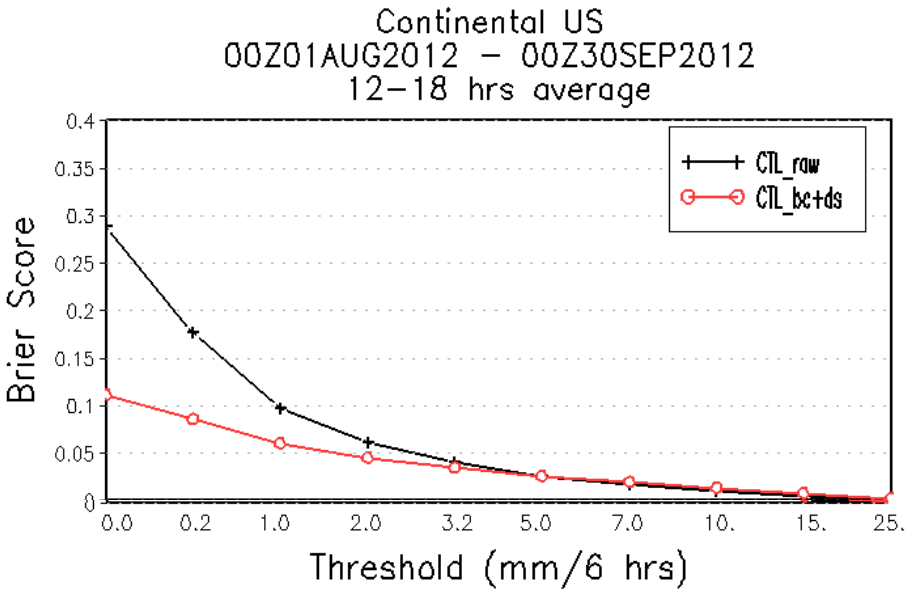
24 March 2011

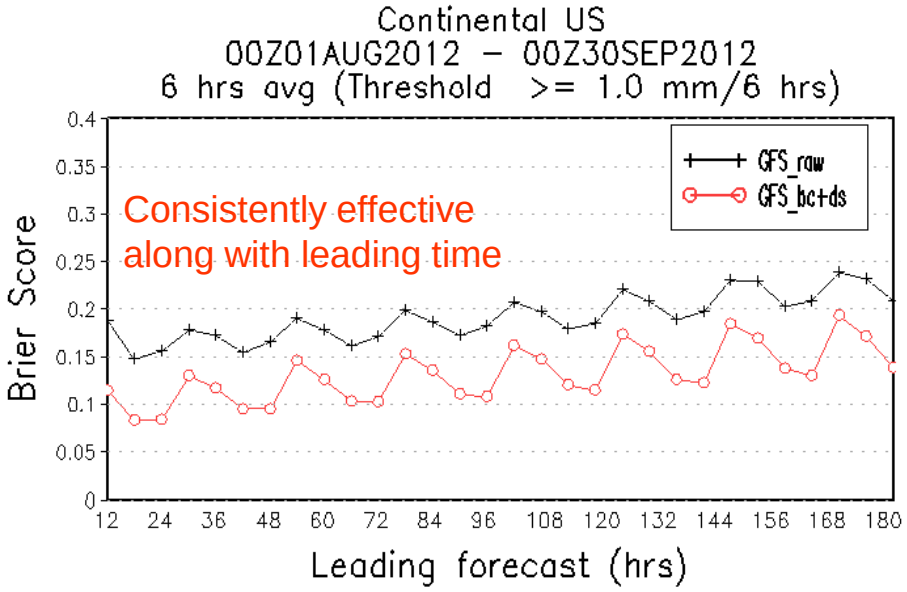

Continental US
00Z01AUG2012 – 00Z30SEP2012
00–06 hrs average
5KM NDGD
EQ threat score
TSS score
BIAS score
before downscaling
before downscaling
after downscaling
after downscaling
2219839 1402632 970764 705987 489804 350985 228884 124965 45038
0.2 1.0 2.0 3.2 5.0 7.0 10. 15. 25.
Threshold (mm/6 hrs)

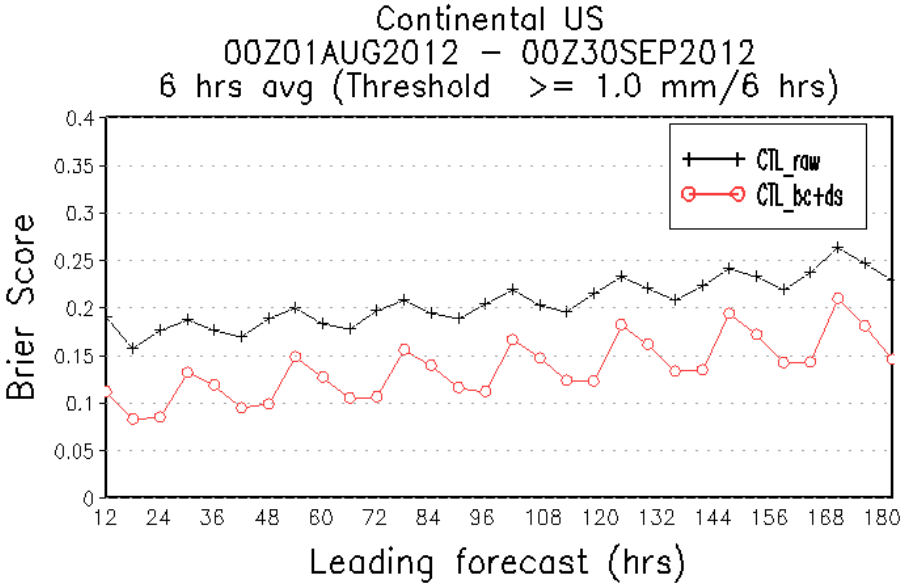

Continental US
00Z01AUG2012 – 00Z30SEP2012
6 hrs avg (Threshold >= 10. mm/6 hrs)
EQ threat score
TSS score
BIAS score
12 24 36 48 60 72 84 96 108 120 132 144 156 168 180
Leading forecast (hrs)

Significantly reduced Brier score

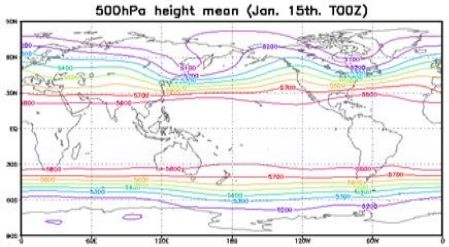


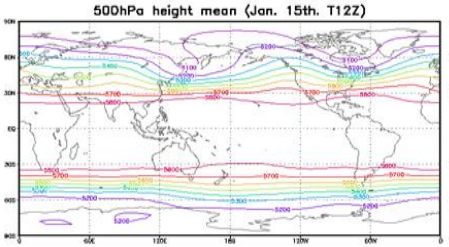


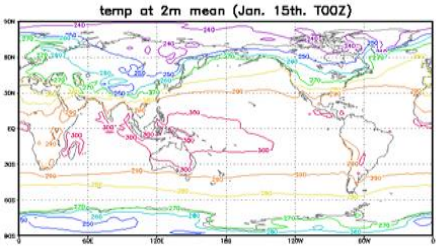


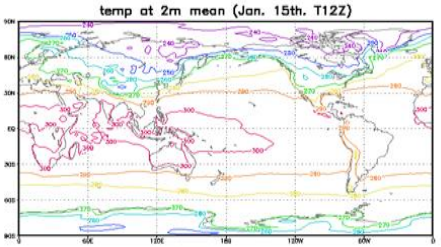


Comparison of current and new climatology

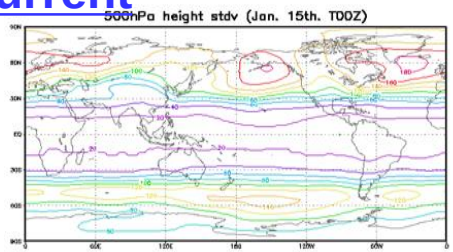


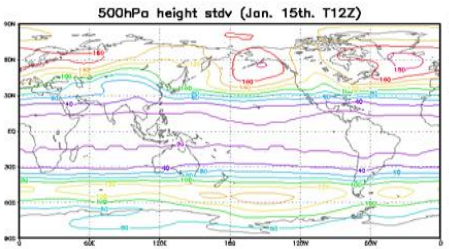


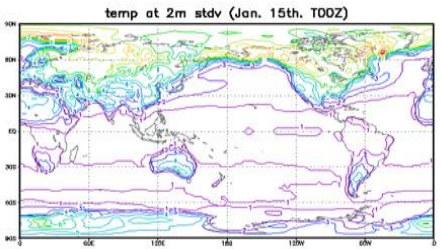


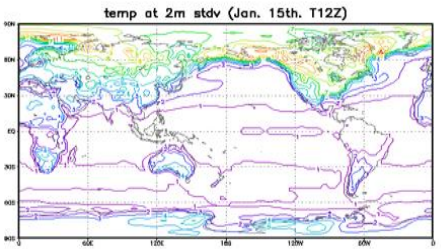


Current



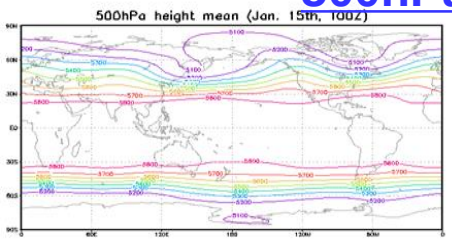


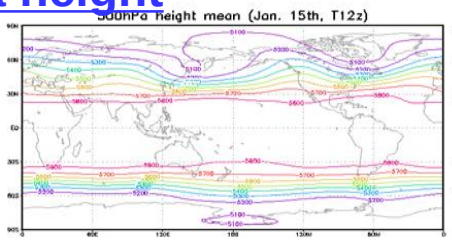


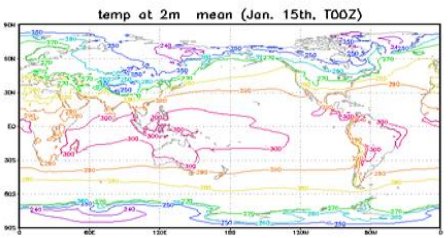


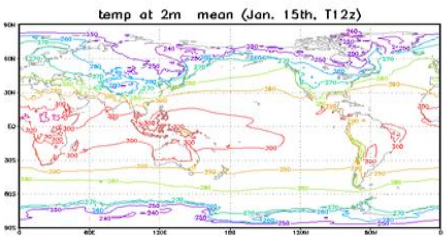
500hPa height

Surface temperature

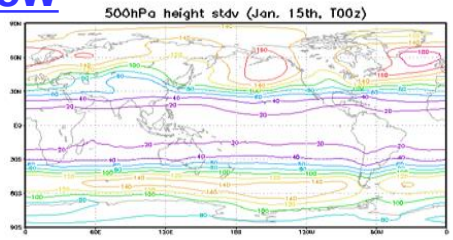


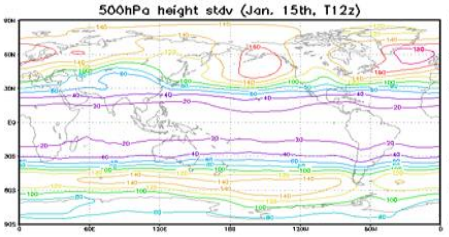


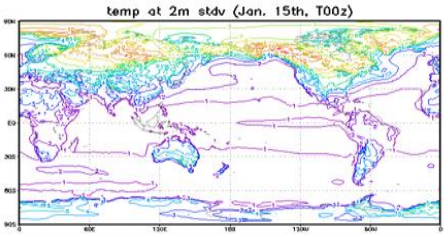


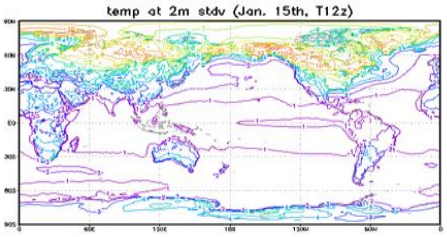


New



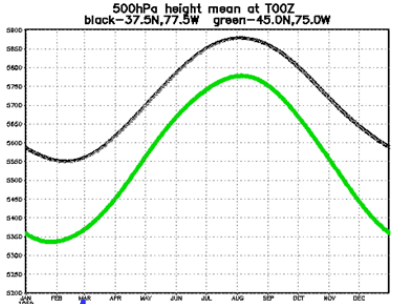


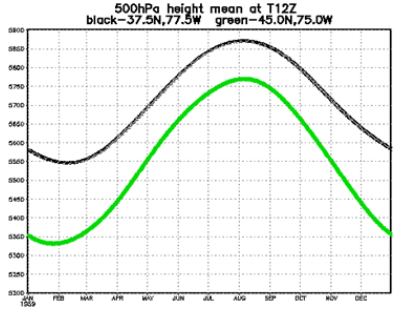


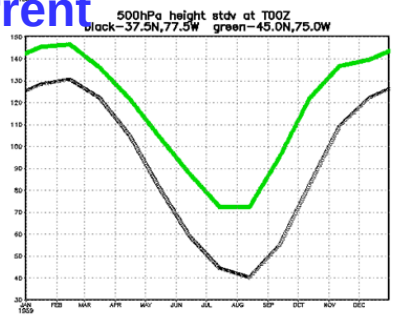


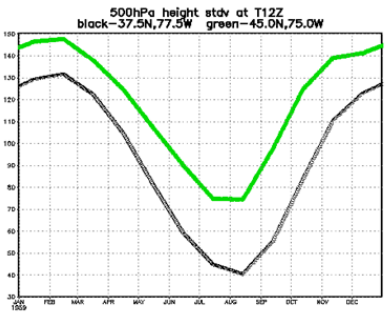
Comparison of current and new climatology

Current

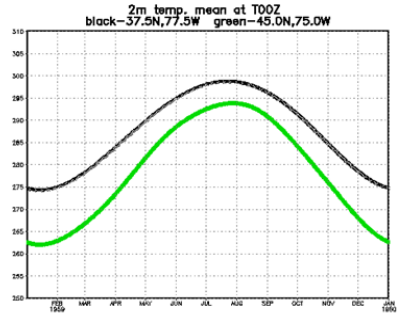


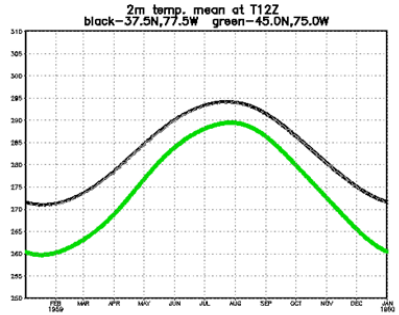


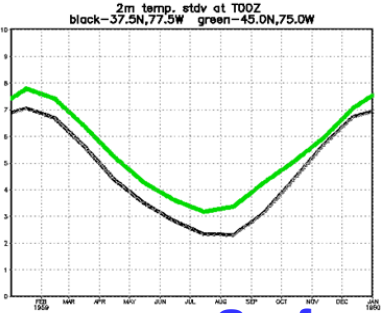


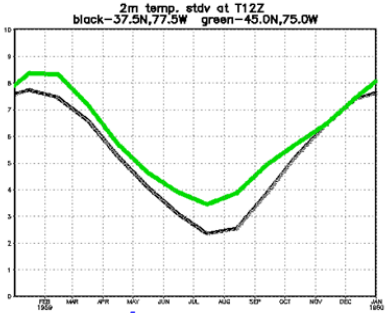


500hPa height



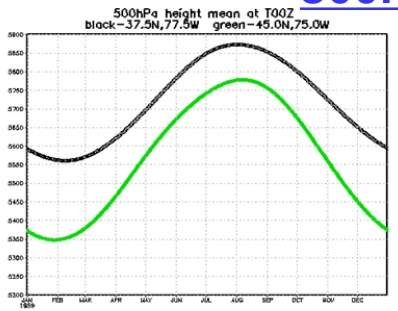


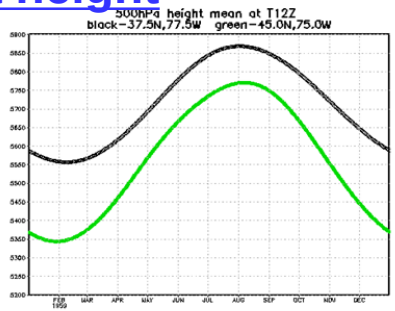


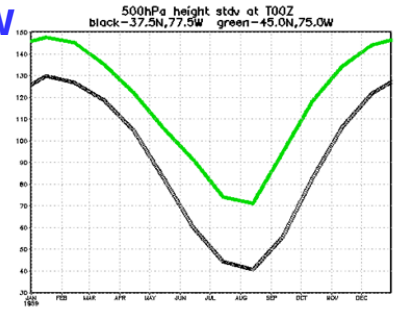


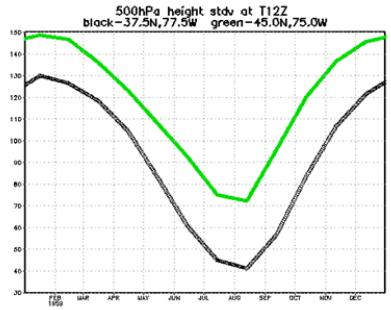
Surface temperature

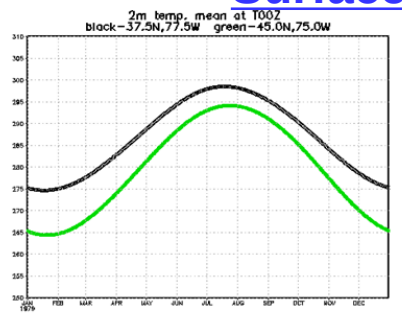
New

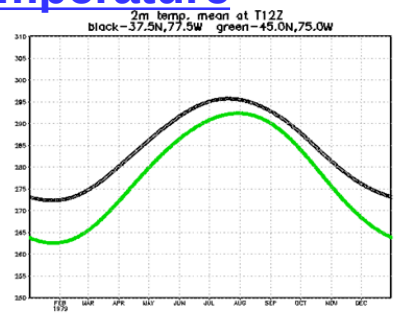


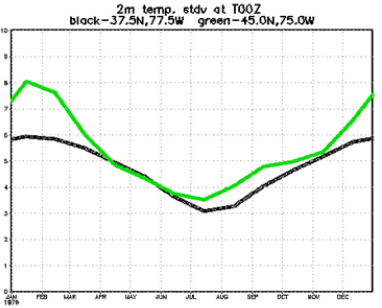


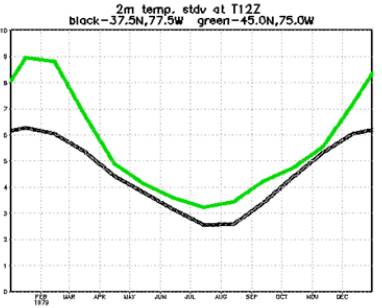




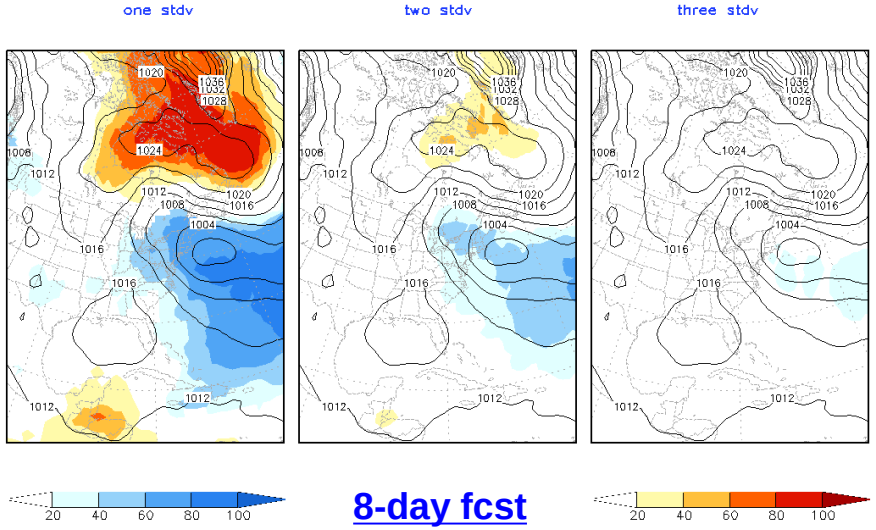








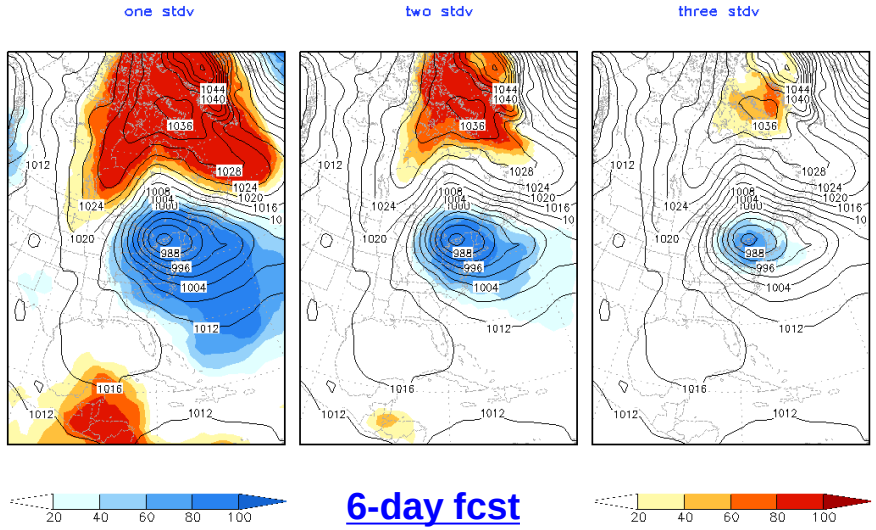
Sea Level Pressure (PRMSL), 192-hour forecast
Ini. time:2012102300 Valid time:2012103100
Contour-mean forecast; Shaded-forecast anomalies



8-day fcst

YUEJIAN ZHU, GCWMB/EMC/NCEP/NOAA

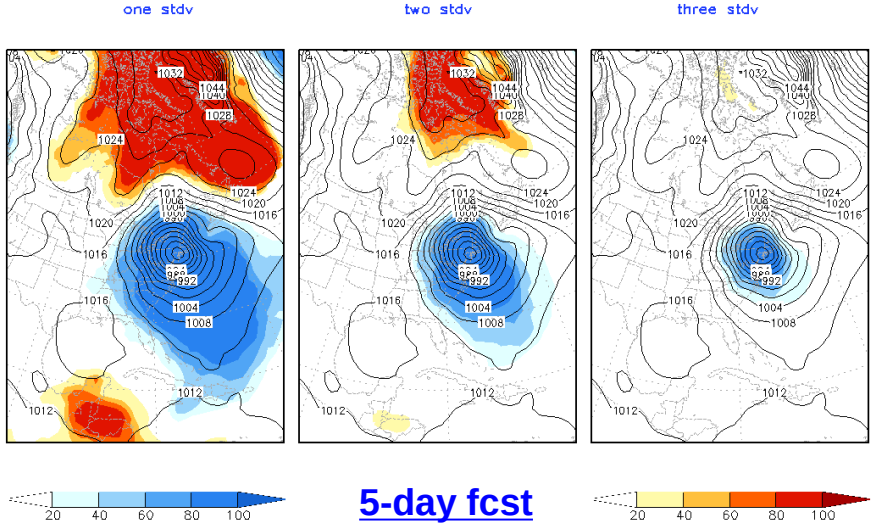
Sea Level Pressure (PRMSL), 144-hour forecast
Ini. time:2012102500 Valid time:2012103100
Contour-mean forecast; Shaded-forecast anomalies



6-day fcst

YUEJIAN ZHU, GCWMB/EMC/NCEP/NOAA

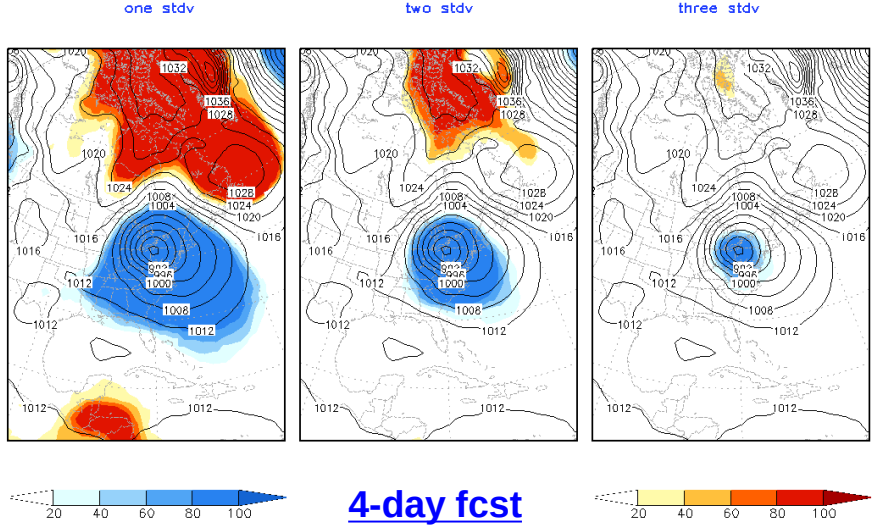
Sea Level Pressure (PRMSL), 120-hour forecast
Ini. time:2012102600 Valid time:2012103100
Contour-mean forecast; Shaded-forecast anomalies



5-day fcst

YUEJIAN ZHU, GCWMB/EMC/NCEP/NOAA

Sea Level Pressure (PRMSL), 96-hour forecast
Ini. time:2012102700 Valid time:2012103100
Contour-mean forecast; Shaded-forecast anomalies



4-day fcst

YUEJIAN ZHU, GCWMB/EMC/NCEP/NOAA