Comparison of NAEFS SPP and EKDMOS

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Acknowledgement: John Wagner (MDL)

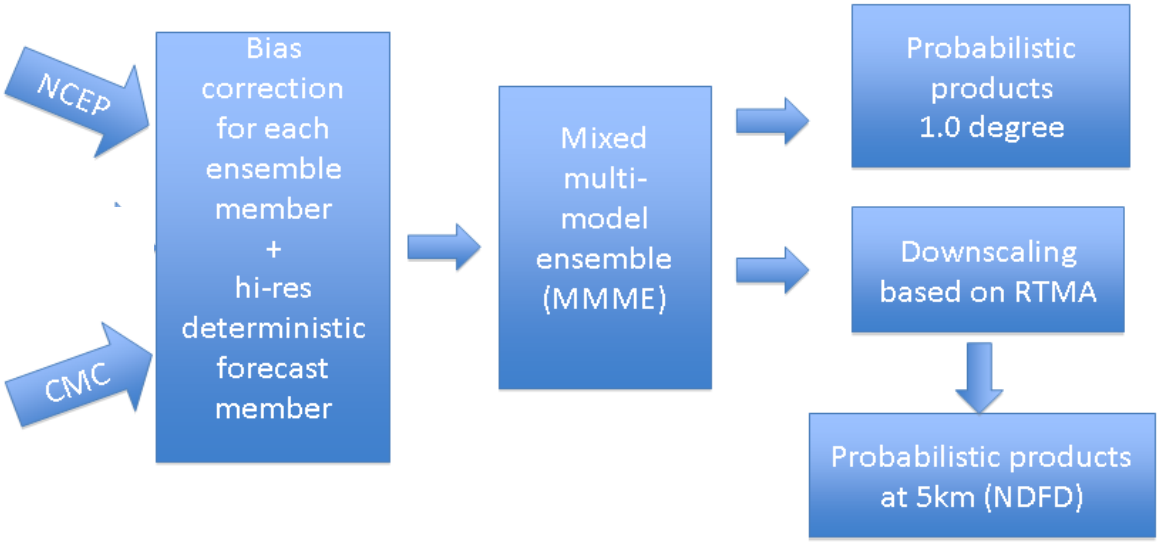
Background

- NAEFS SPP was implemented since 2007
  - Last implementation – April 8 2014
    - Still 5km resolution for CONUS
    - Add additional variables
- EKDMOS (Ensemble Kernel Density MOS) was implemented since 2012
  - Uses output from NAEFS (NCEP and CMC) to produce probability distributions of sensible weather elements
  - Last implementation – May 29 2012
    - 2.5km NDGD resolution for CONUS
    - And other domains
- Comparing two daily operational products
  - Period: Jan – July 2014
  - Variables: T2m and T2d (only 3 months, May-July 2014)
  - Against RTMA (5km and 2.5km NDGD resolution)
  - Against observations (Based on CONUS BUFR data ~7000 obs)

NAEFS SPP Milestones

- Implementations
  - First NAEFS implementation – bias correction — Version 1.00 - May 30 2006
  - NAEFS follow up implementation – CONUS downscaling — Version 2.00 - December 4 2007
  - Alaska implementation – Alaska downscaling — Version 3.00 - December 7 2010
  - Implementation for CONUS/Alaska expansion — Version 4.00 - April 8 2014
- Applications:
  - NCEP/GEFS and NAEFS – at NWS
  - CMC/GEFS and NAEFS – at MSC
  - FNMOC/GEFS – at NAVY
  - NCEP/SREF – at NWS
- Publications (or references):
  - Cui, B., Z. Toth, Y. Zhu, and D. Hou, D. Unger, and S. Beauregard, 2004: *" The Trade-off in Bias Correction between Using the Latest Analysis/Modeling System with a Short, versus an Older System with a Long Archive"* The First THORPEX International Science Symposium. December 6-10, 2004, Montréal, Canada, World Meteorological Organization, P281-284.
  - Zhu, Y., and B. Cui, 2006: *"GFS bias correction"* [Document is available online]
  - Zhu, Y., B. Cui, and Z. Toth, 2007: *"December 2007 upgrade of the NCEP Global Ensemble Forecast System (NAEFS)"* [Document is available online]
  - Cui, B., Z. Toth, Y. Zhu and D. Hou, 2012: *"Bias Correction For Global Ensemble Forecast"* Weather and Forecasting, Vol. 27 396-410
  - Cui, B., Y. Zhu , Z. Toth and D. Hou, 2013: *"Development of Statistical Post-processor for NAEFS"* Weather and Forecasting (In process)
  - Zhu, Y., and B. Cui, 2007: *"December 2007 upgrade of the NCEP Global Ensemble Forecast System (NAEFS)"* [Document is available online]
  - Zhu, Y, and Y. Luo, 2013: *"Precipitation Calibration Based on Frequency Matching Method (FMM)"*. Weather and Forecasting (in process)
  - Glahn, B., 2013: "*A Comparison of Two Methods of Bias Correcting MOS Temperature and Dewpoint Forecasts*" MDL office note, 13-1
  - Guan, H, B. Cui and Y. Zhu, 2013: "*Improvement of NAEFS SPP*", (plan to submit to Weather and Forecasting)

NAEFS Statistical Post-Processing System



- Bias correction:
  - Bias corrected NCEP/CMC GEFS and NCEP/GFS forecast (up to 180 hrs)
  - 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 (global) and downstream applications
  - 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
  - Wave ensemble forecast system
  - Hydrological ensemble forecast system
- Statistical downscaling
  - Use RTMA as reference - NDGD resolution (5km/6km), CONUS and Alaska
  - Generate mean, mode, 10%, 50%(median) and 90% probability forecasts

NAEFS bias corrected variables

Last upgrade: April 8th 2014 - (bias correction)

Variables	pgrba_bc file	Total 51
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
Notes	CMC and FNMOC do not apply last upgrade yet	

NAEFS downscaling parameters and products

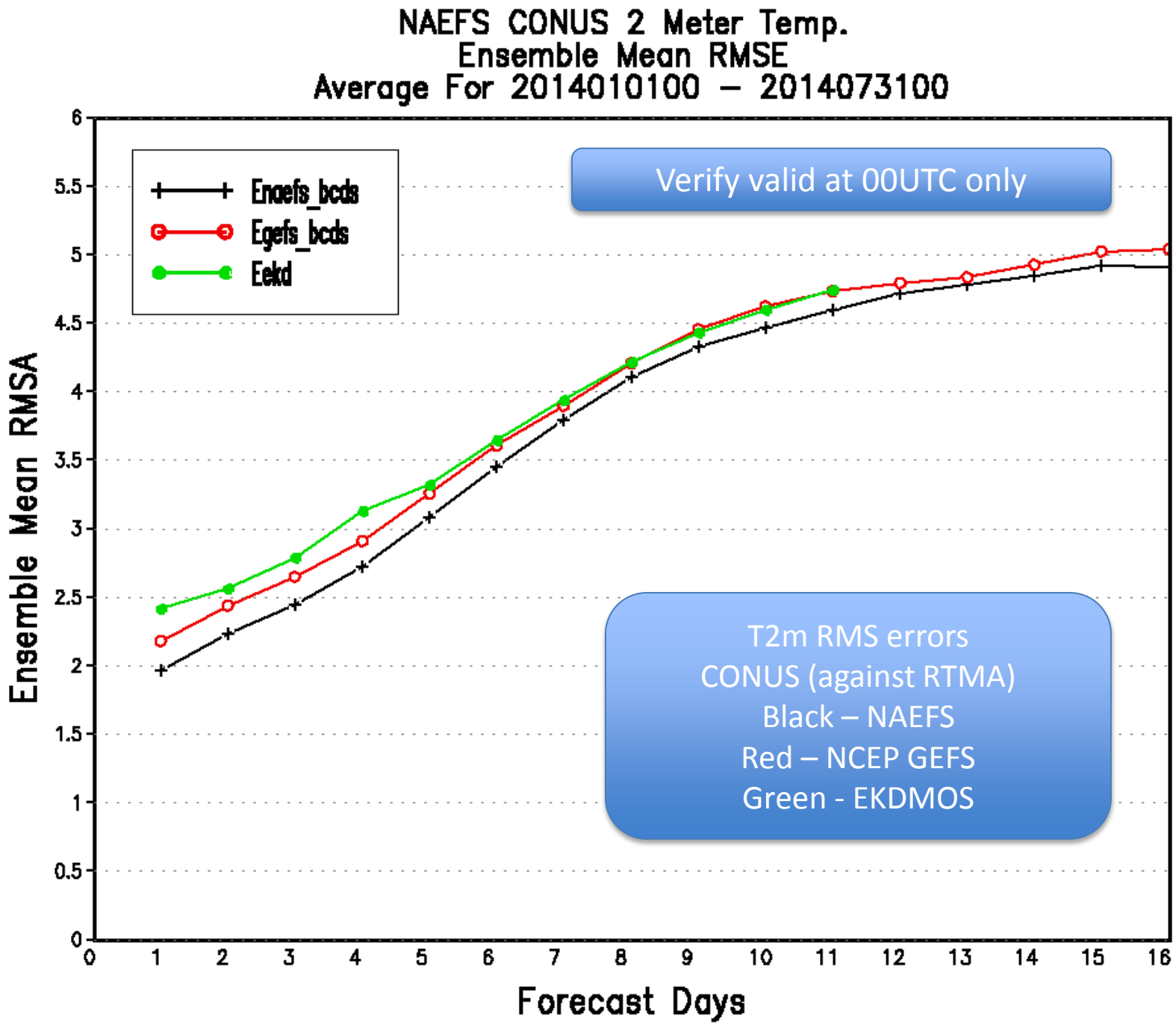
Last Upgrade: April 8 2014 (NDGD resolution)

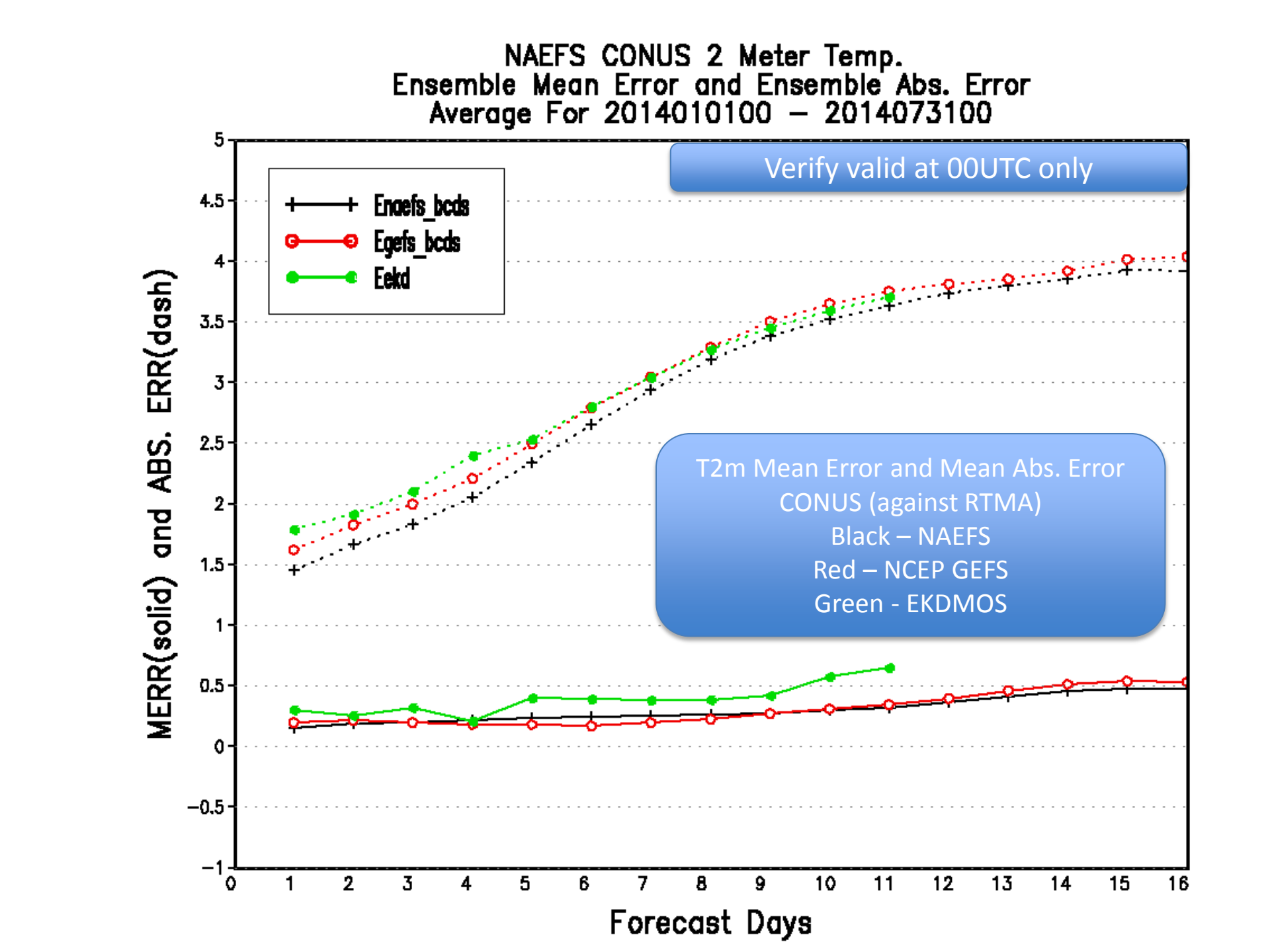
Variables	Domains	Resolutions	Total 10/10
Surface Pressure	CONUS/Alaska	5km/6km	1/1
2-m temperature	CONUS/Alaska	5km/6km	1/1
10-m U component	CONUS/Alaska	5km/6km	1/1
10-m V component	CONUS/Alaska	5km/6km	1/1
2-m maximum T	CONUS/Alaska	5km/6km	1/1
2-m minimum T	CONUS/Alaska	5km/6km	1/1
10-m wind speed	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

All downscaled products are generated from 1*1 degree bias corrected fcst. globally
Products include ensemble mean, spread, 10%, 50%, 90% and mode

T2m Evaluation Against RTMA (CONUS)

Based on NWS products: January - July, 2014


NAEFS CONUS 2 Meter Temp.
Ensemble Mean RMSE
Average For 2014010100 – 2014073100
Enaefs_bcds
Egefs_bcds
Eekd
Verify valid at 00UTC only
T2m RMS errors
CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
Ensemble Mean RMSA
Forecast Days
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


NAEFS CONUS 2 Meter Temp.
Ensemble Mean Error and Ensemble Abs. Error
Average For 2014010100 – 2014073100
Verify valid at 00UTC only
Enaefs_bcds
Egefs_bcds
Eekd
T2m Mean Error and Mean Abs. Error
CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
MERR(solid) and ABS. ERR(dash)
Forecast Days
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
0
1
2
3
4
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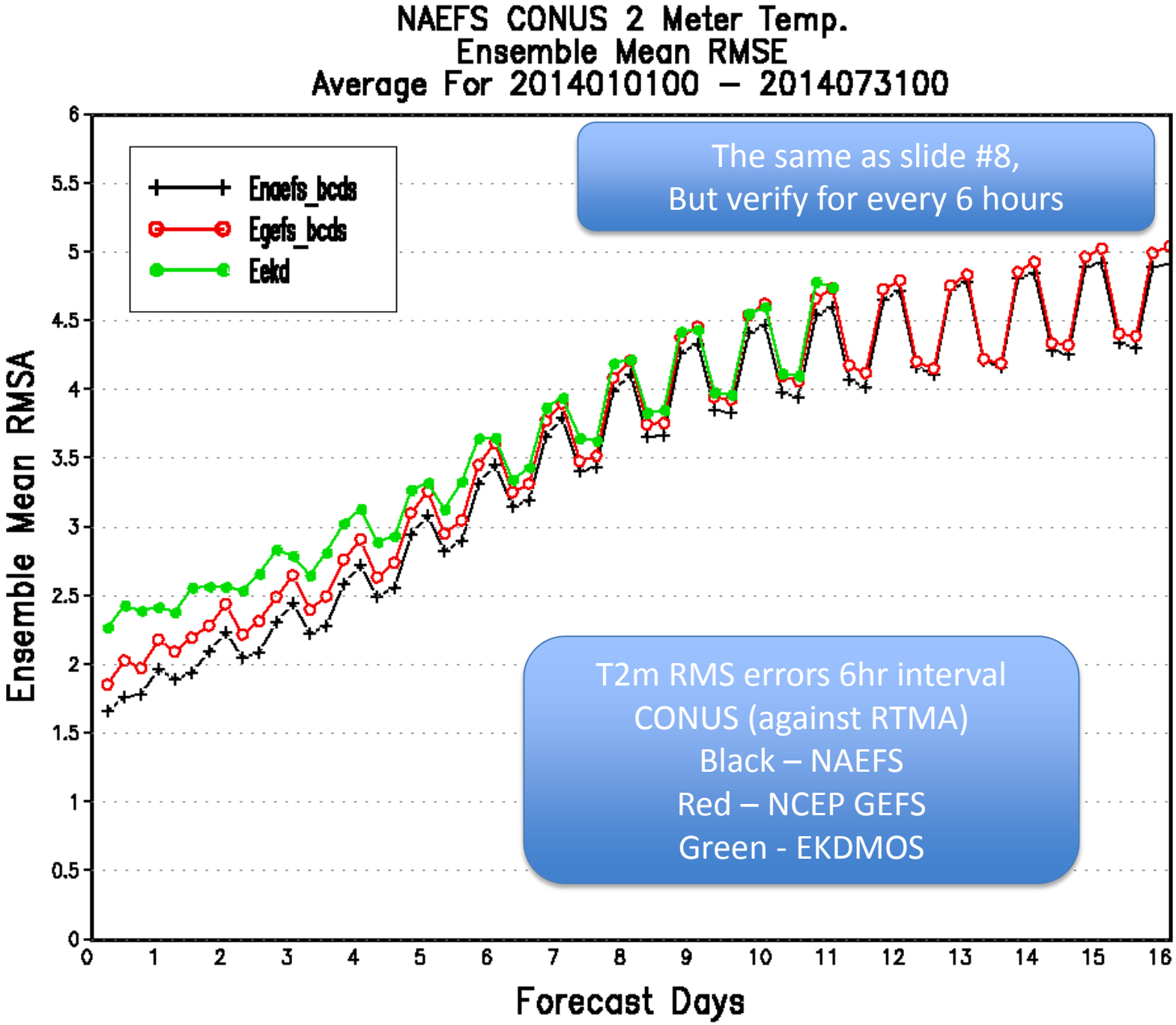
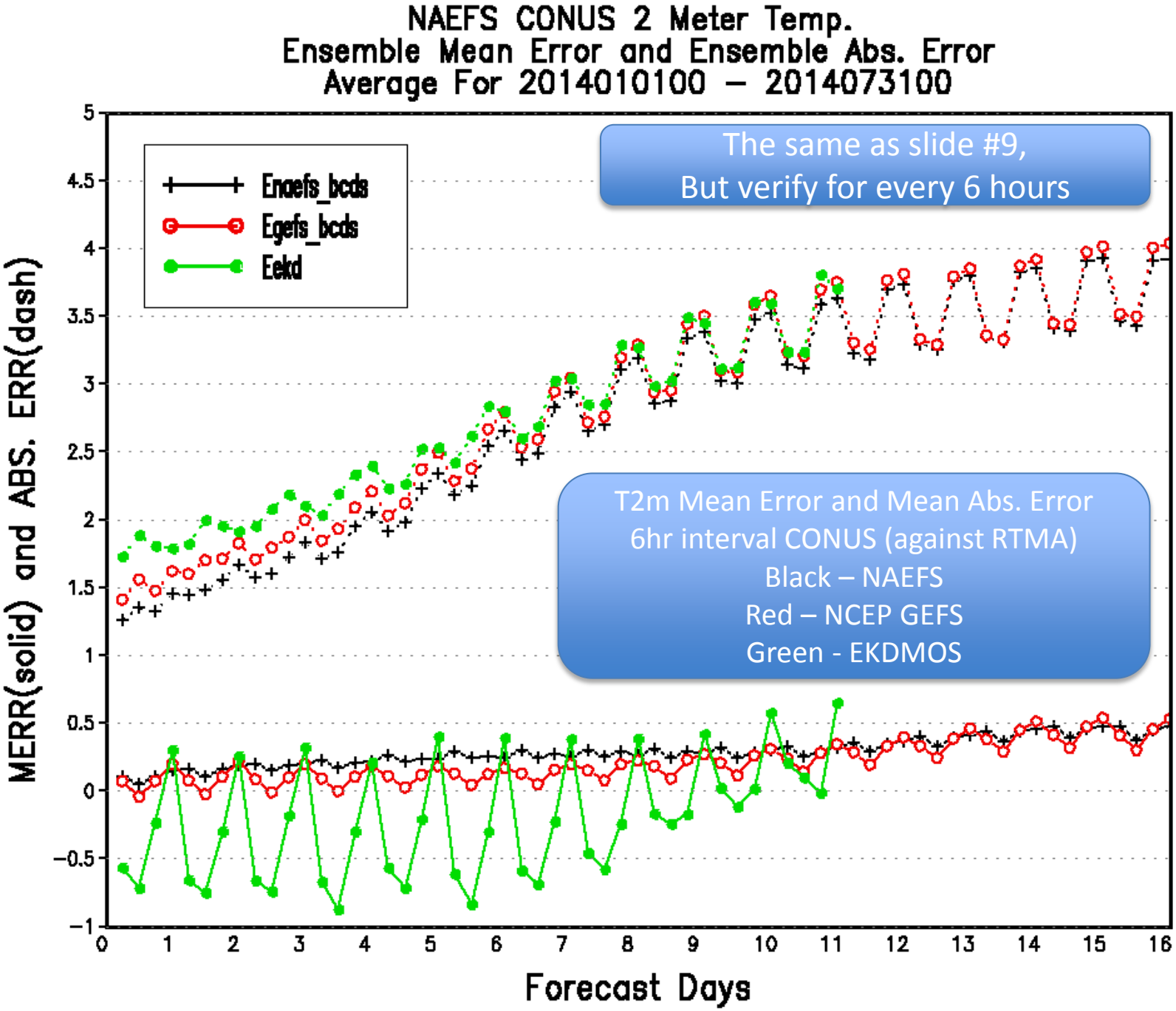
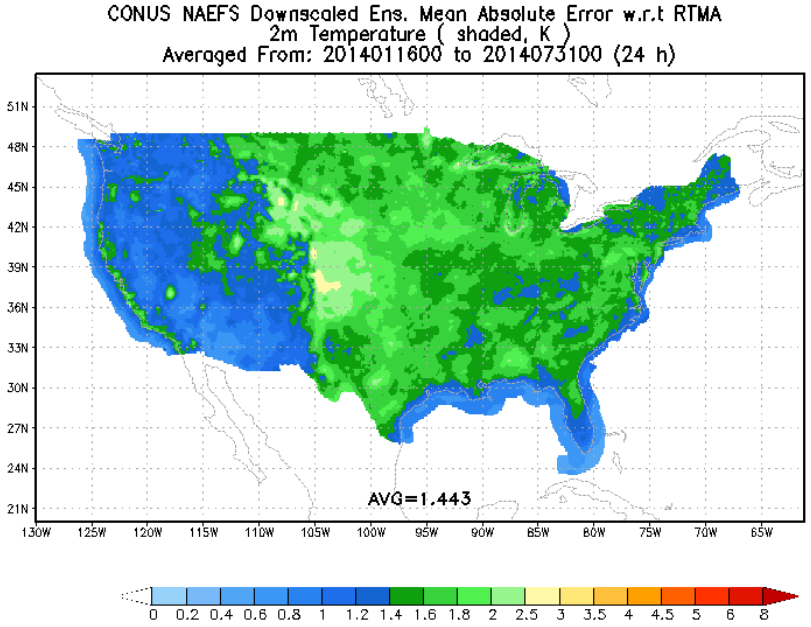
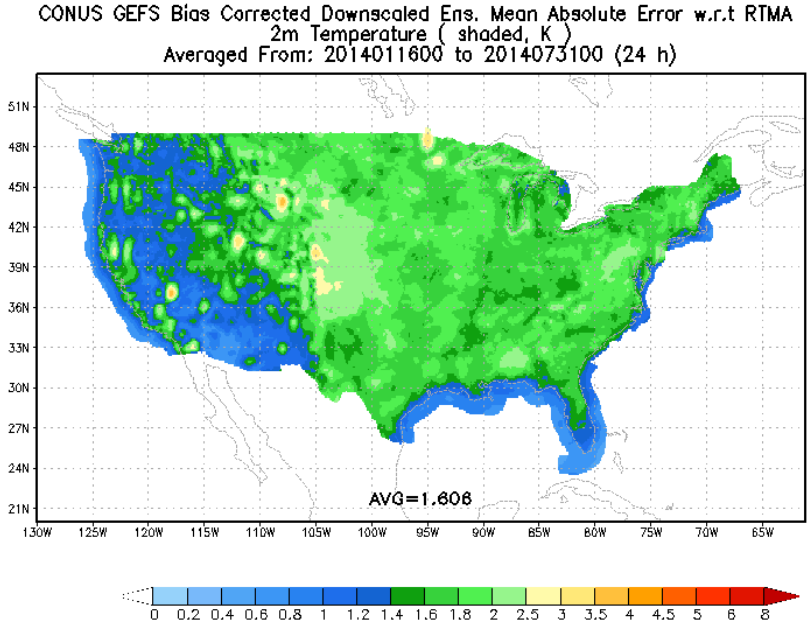
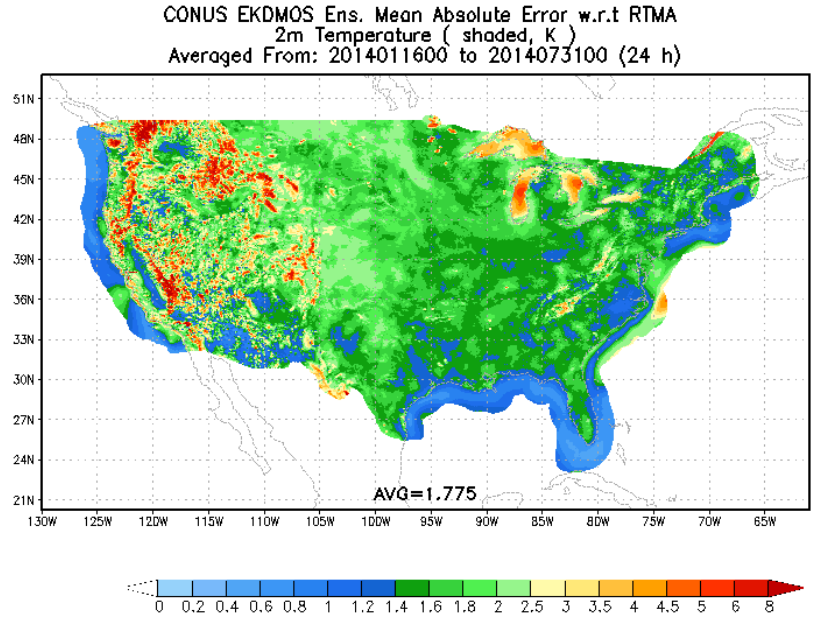
13
14
15
16


NAEFS CONUS 2 Meter Temp.
Ensemble Mean RMSE
Average For 2014010100 – 2014073100
Encefs_bcds
Egefs_bcds
Eekd
The same as slide #8,
But verify for every 6 hours
T2m RMS errors 6hr interval
CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
Ensemble Mean RMSA
Forecast Days
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16


NAEFS CONUS 2 Meter Temp.
Ensemble Mean Error and Ensemble Abs. Error
Average For 2014010100 – 2014073100
Encefs_bcds
Egefs_bcds
Eekd
MERR(solid) and ABS. ERR(dash)
Forecast Days
The same as slide #9,
But verify for every 6 hours
T2m Mean Error and Mean Abs. Error
6hr interval CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS



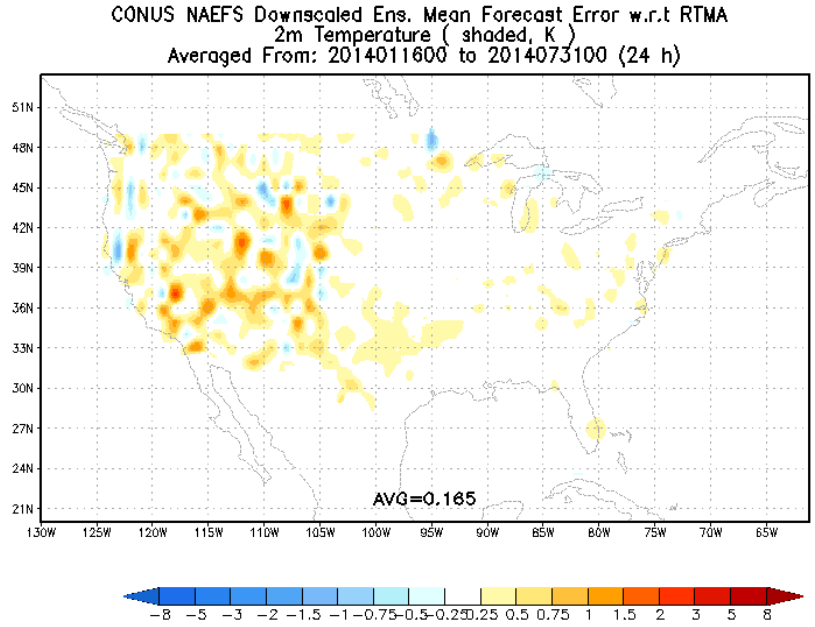


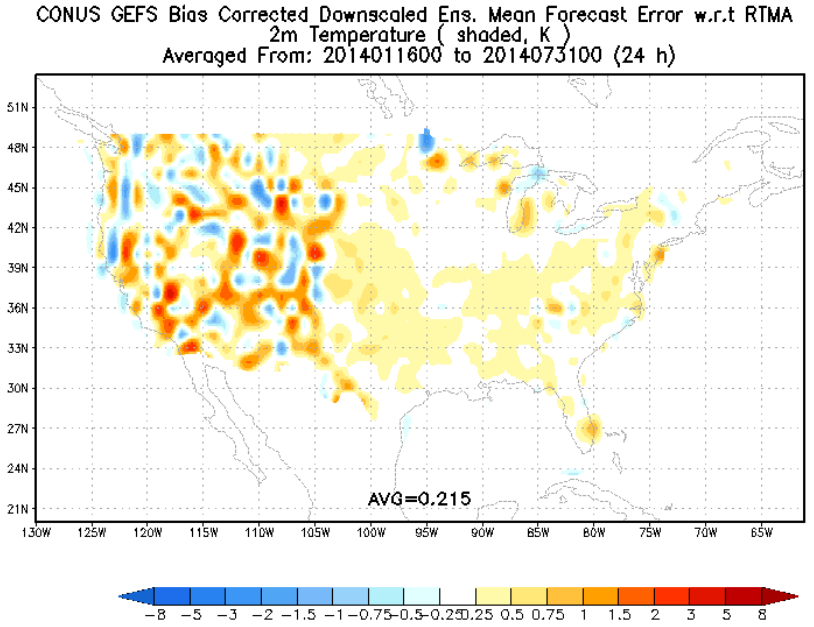


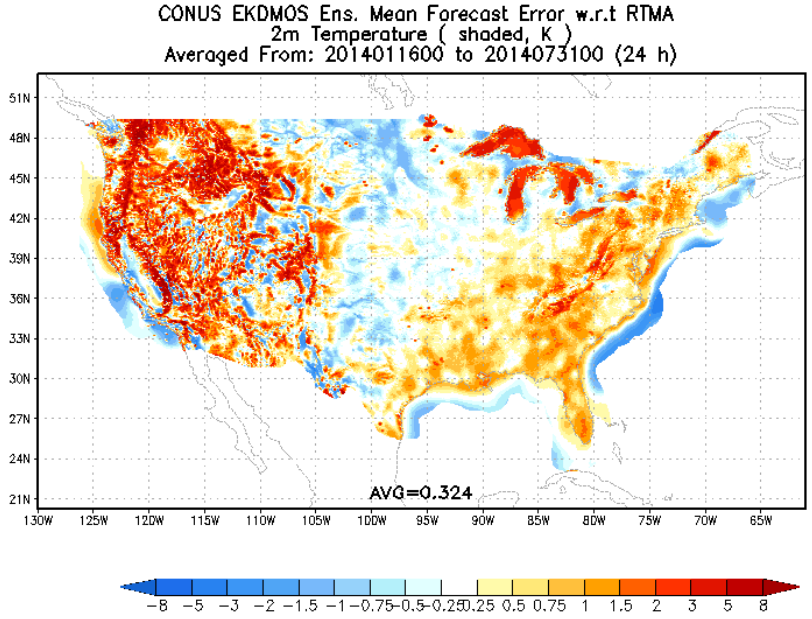
T2m MAE (against RTMA)
Period: 20140116 – 20140731
24 hours forecast

Top left → NAEFS
Top right → NCEP GEFS
Bottom left → EKDMOS

NAEFS is 11% better than GEFS
NAEFS is 23% better than EKDMOS

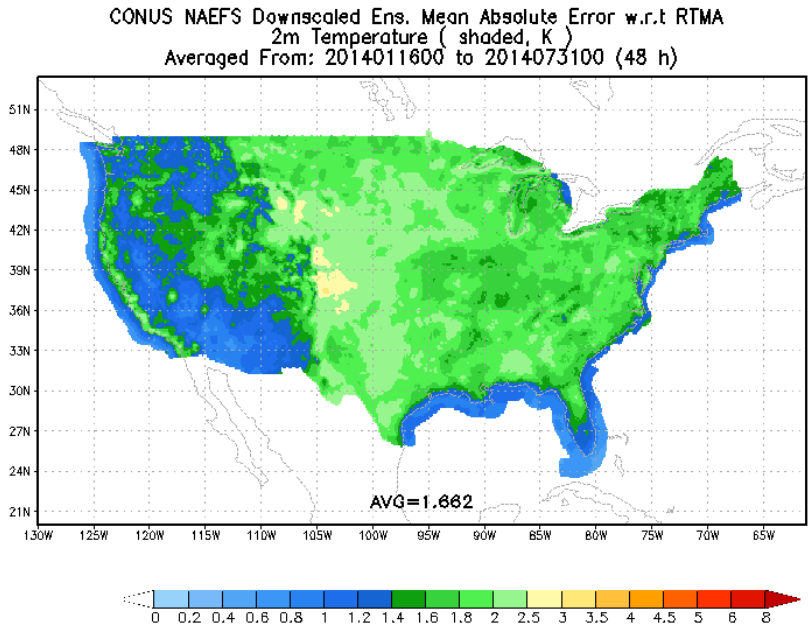


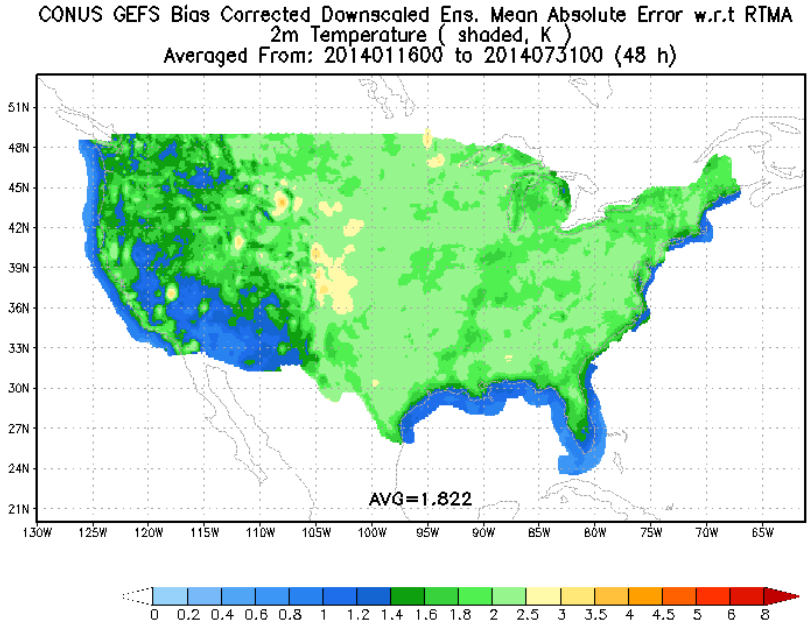


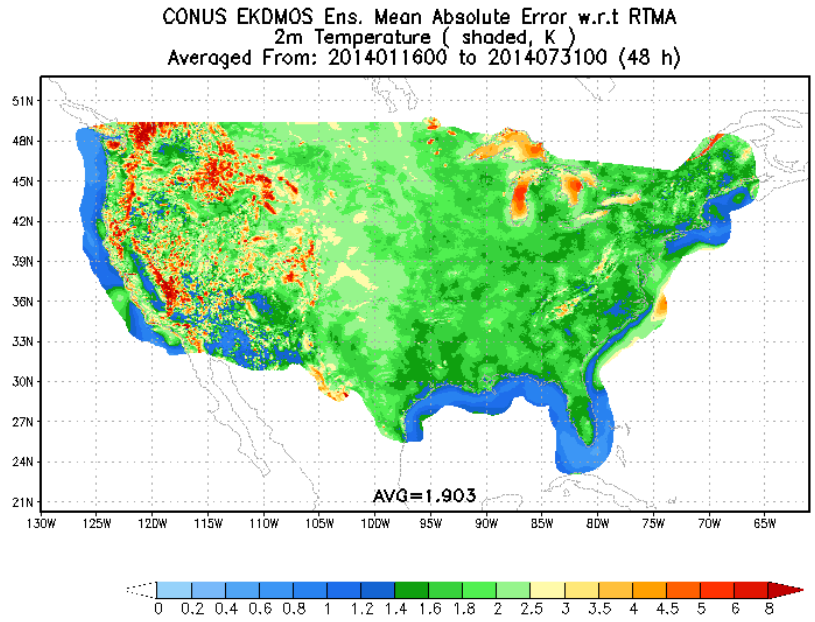


T2m ME (against RTMA)
Period: 20140116-20140731
24 hours forecast

Top left: NAEFS
Top right: NCEP GEFS
Bottom left: EKDMOS



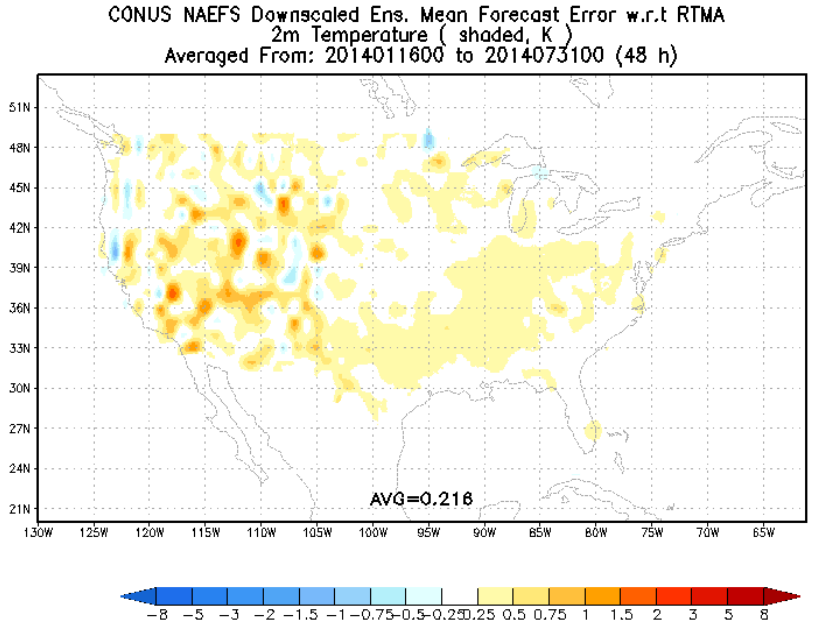


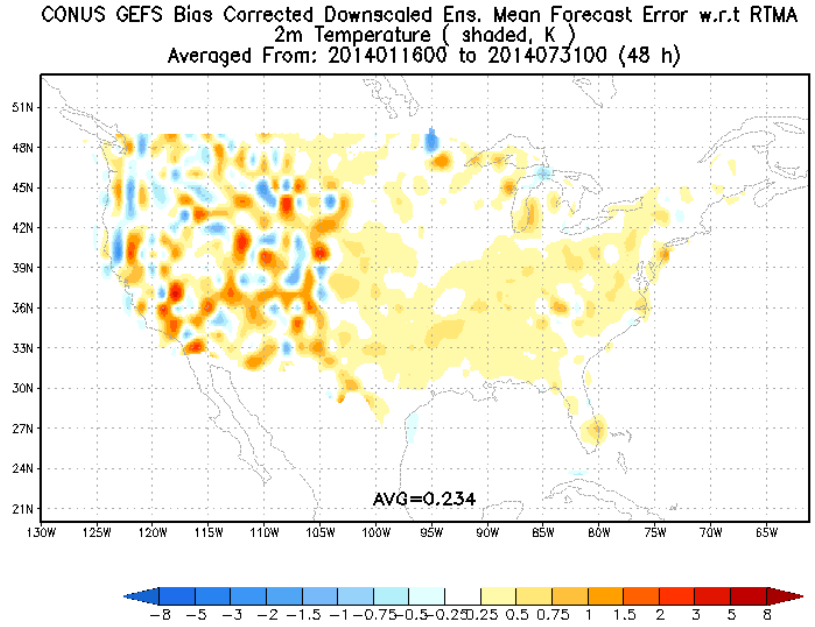


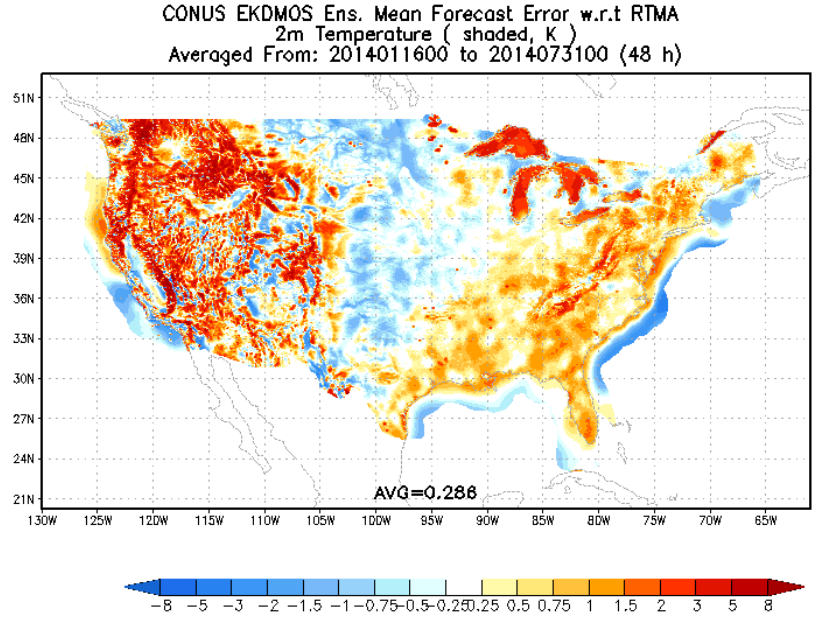
T2m MAE (against RTMA)
Period: 20140116 – 20140731
48 hours forecast

Top left → NAEFS
Top right → NCEP GEFS
Bottom left → EKDMOS

NAEFS is 10% better than GEFS
NAEFS is 14.5% better than EKDMOS







T2m ME (against RTMA)
Period: 20140116-20140731
48 hours forecast

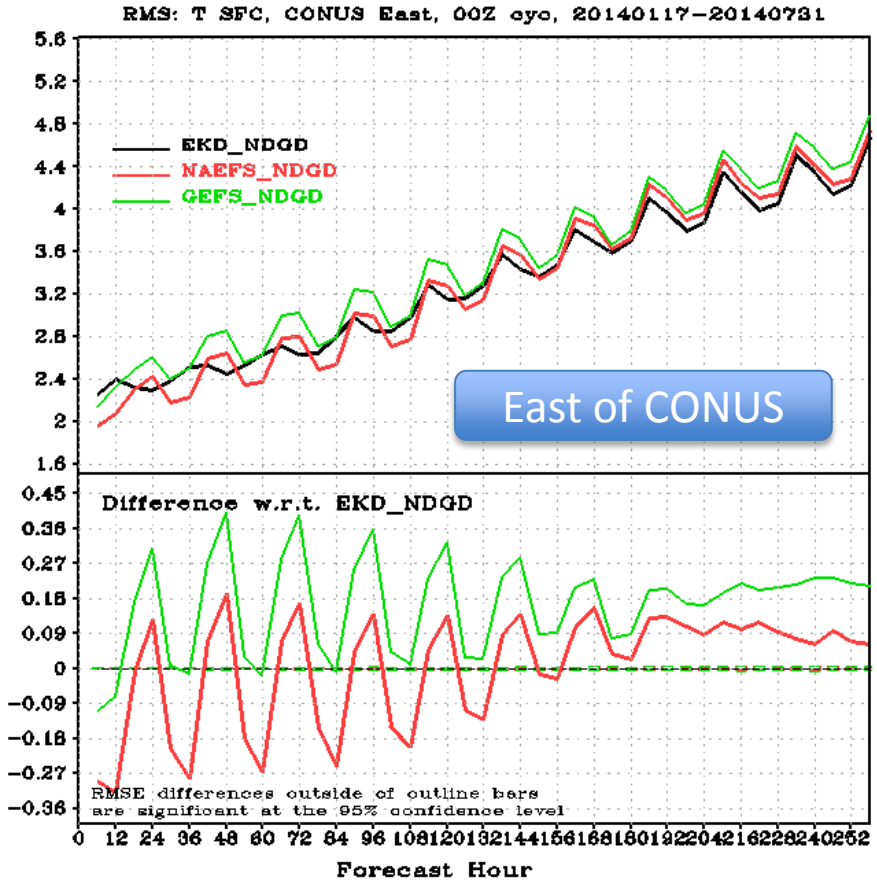
Top left: NAEFS
Top right: NCEP GEFS
Bottom left: EKDMOS

T2m Evaluation Against Observations (CONUS)

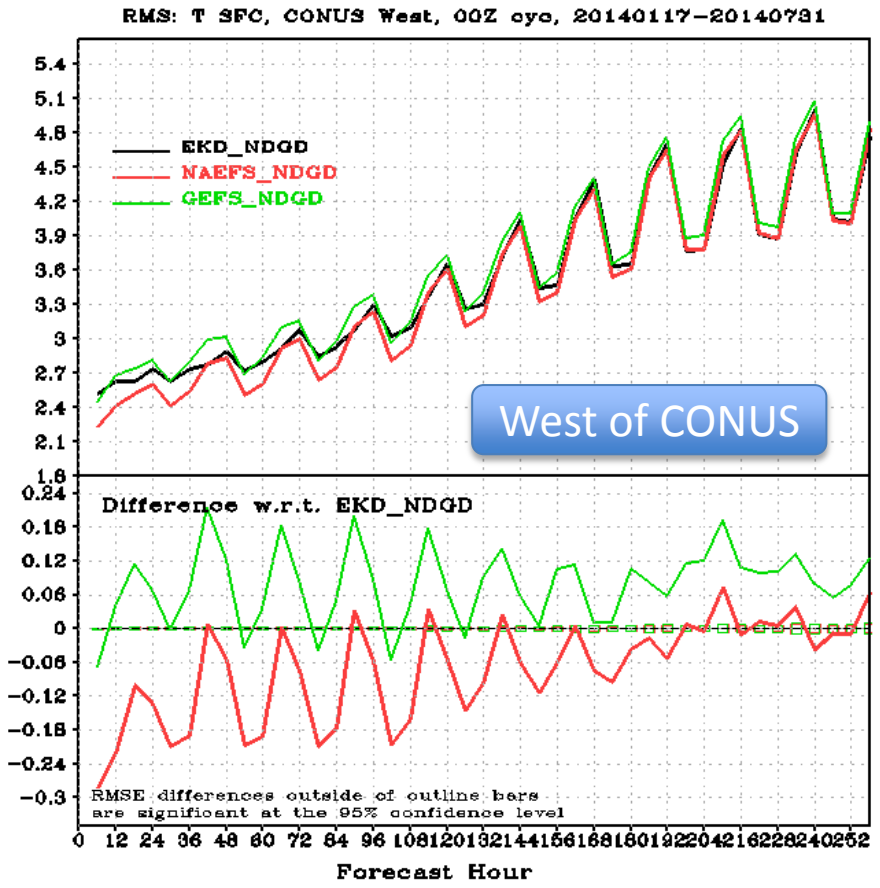
Based on NWS products: January - July, 2014

T2m forecast against observation (CONUS)

RMS error for ensemble mean



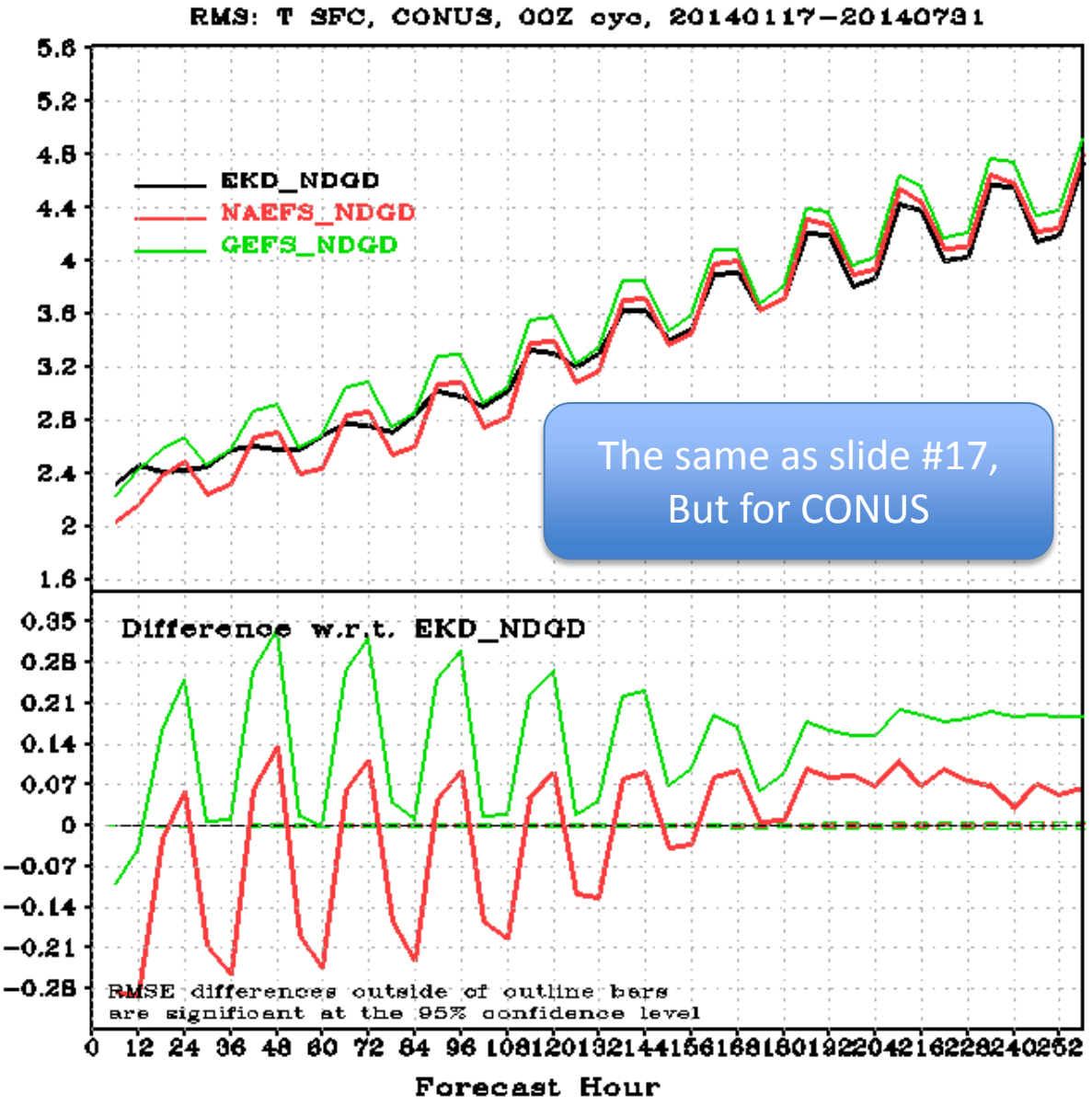
East of CONUS



West of CONUS

Verification period: 20140117 – 20140731
Against all observations of CONUS (~7000)

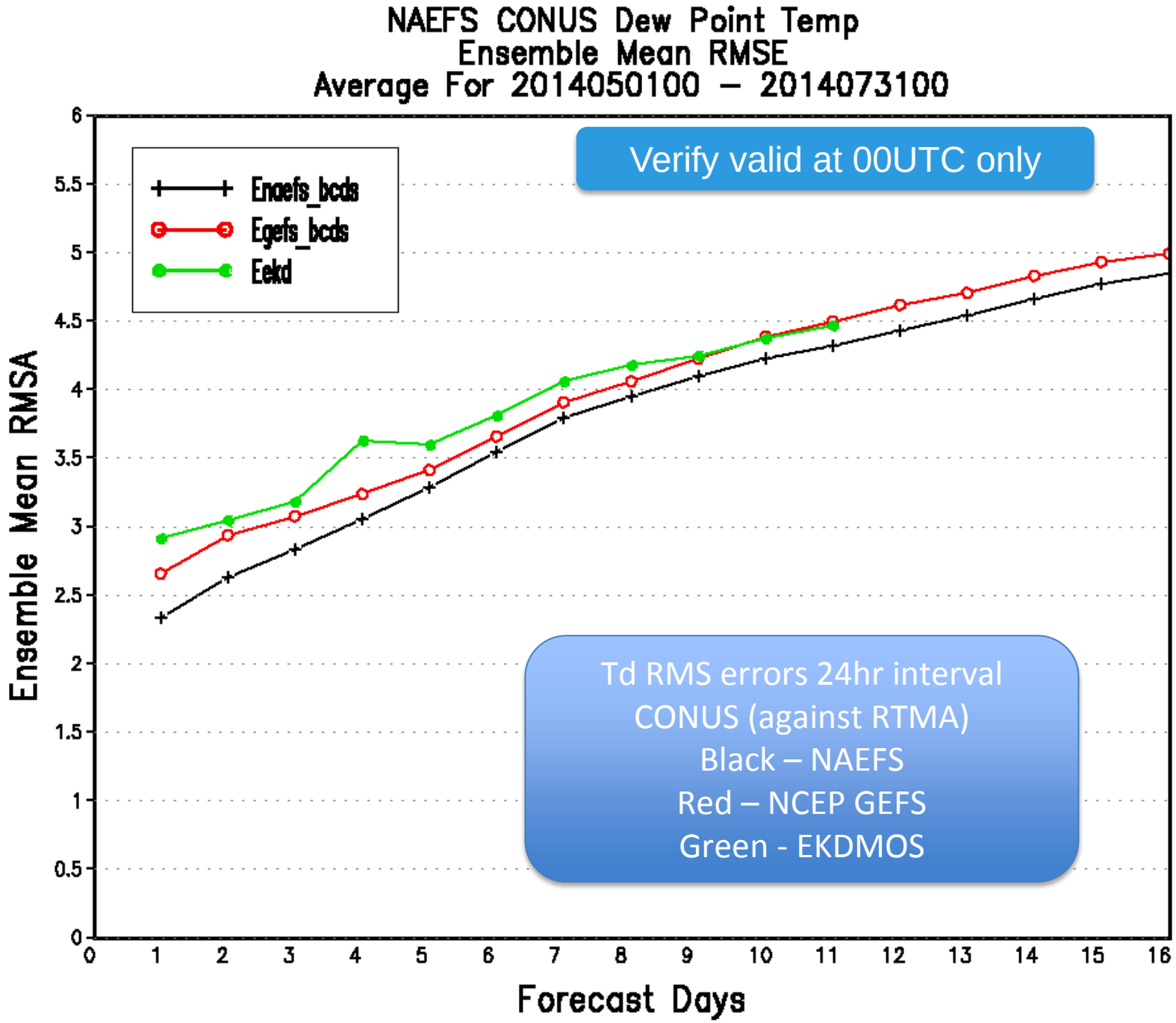
T2m forecast against observation (CONUS)

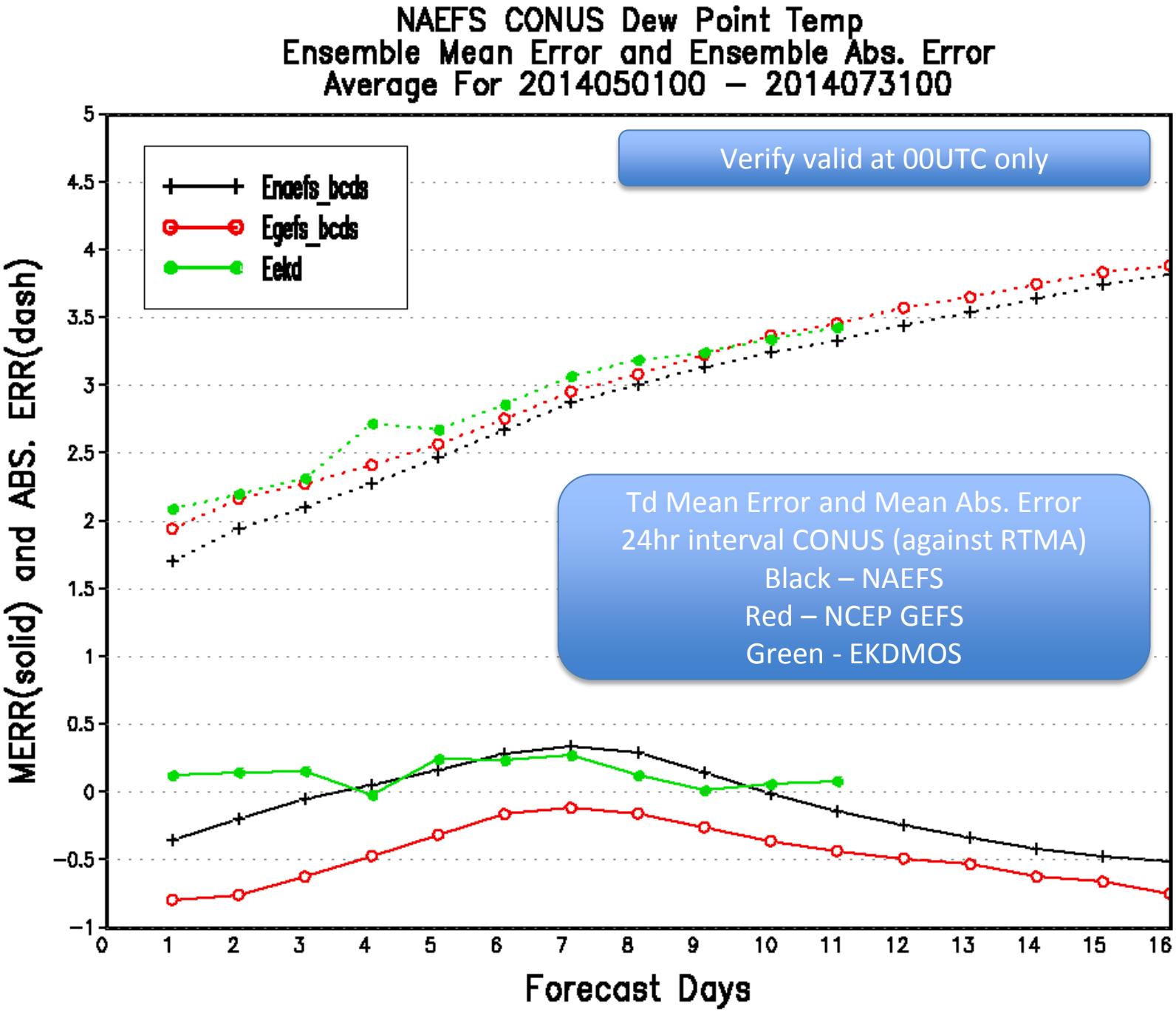


The same as slide #17,
But for CONUS

Td Evaluation Against RTMA (CONUS)

Based NWS products: May - July, 2014


NAEFS CONUS Dew Point Temp
Ensemble Mean RMSE
Average For 2014050100 – 2014073100
Verify valid at 00UTC only
Encefs_bcds
Egefs_bcds
Eekd
Ensemble Mean RMSA
Forecast Days
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Td RMS errors 24hr interval
CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS


NAEFS CONUS Dew Point Temp
Ensemble Mean Error and Ensemble Abs. Error
Average For 2014050100 – 2014073100
Encefs_bcds
Egefs_bcds
Eekd
Verify valid at 00UTC only
Td Mean Error and Mean Abs. Error
24hr interval CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
MERR(solid) and ABS. ERR(dash)
Forecast Days
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
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1
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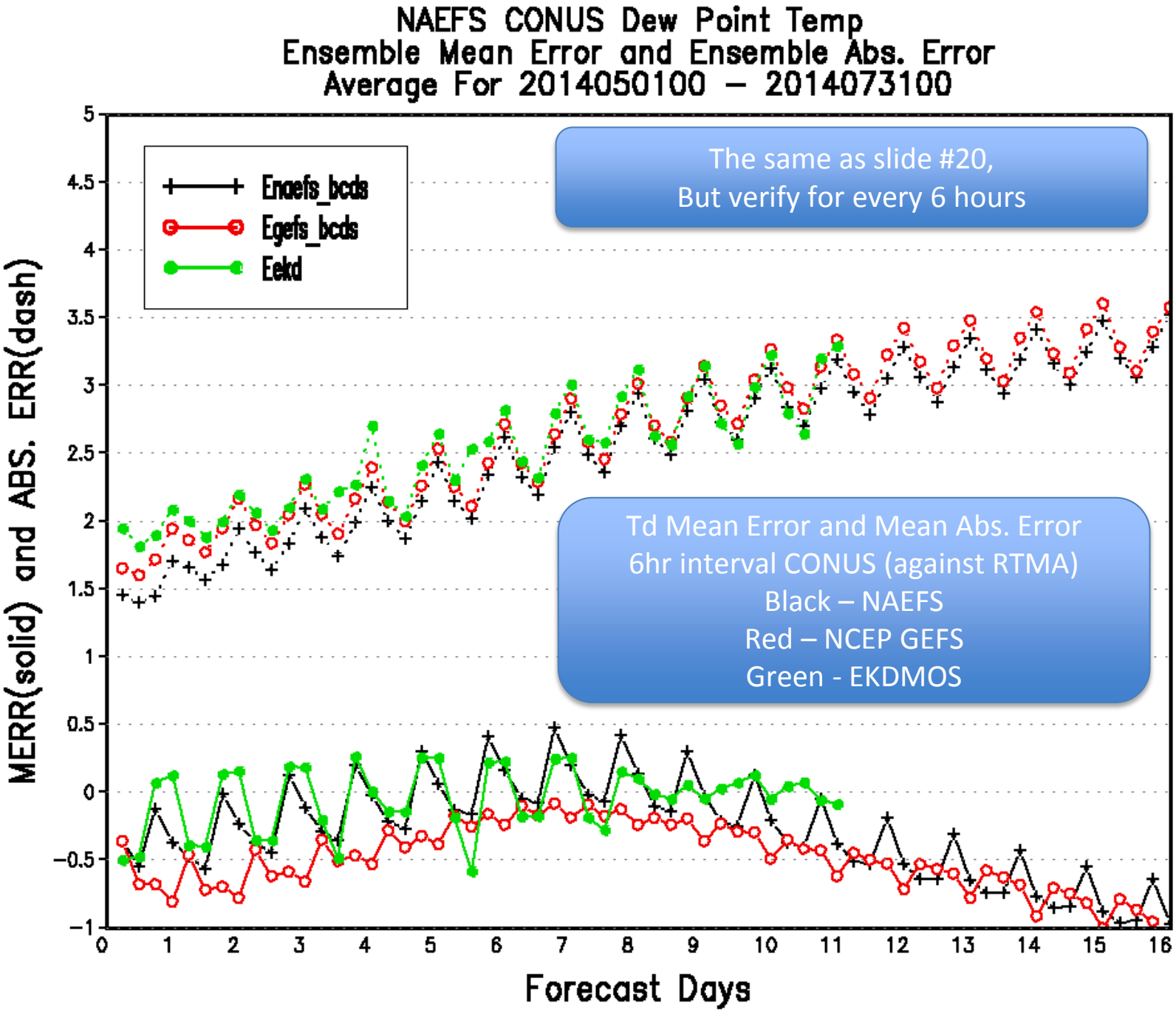
NAEFS CONUS Dew Point Temp
Ensemble Mean Error and Ensemble Abs. Error
Average For 2014050100 – 2014073100
Encefs_bcds
Egefs_bcds
Eekd
The same as slide #20,
But verify for every 6 hours
Td Mean Error and Mean Abs. Error
6hr interval CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
MERR(solid) and ABS. ERR(dash)
Forecast Days
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
−1
0
1
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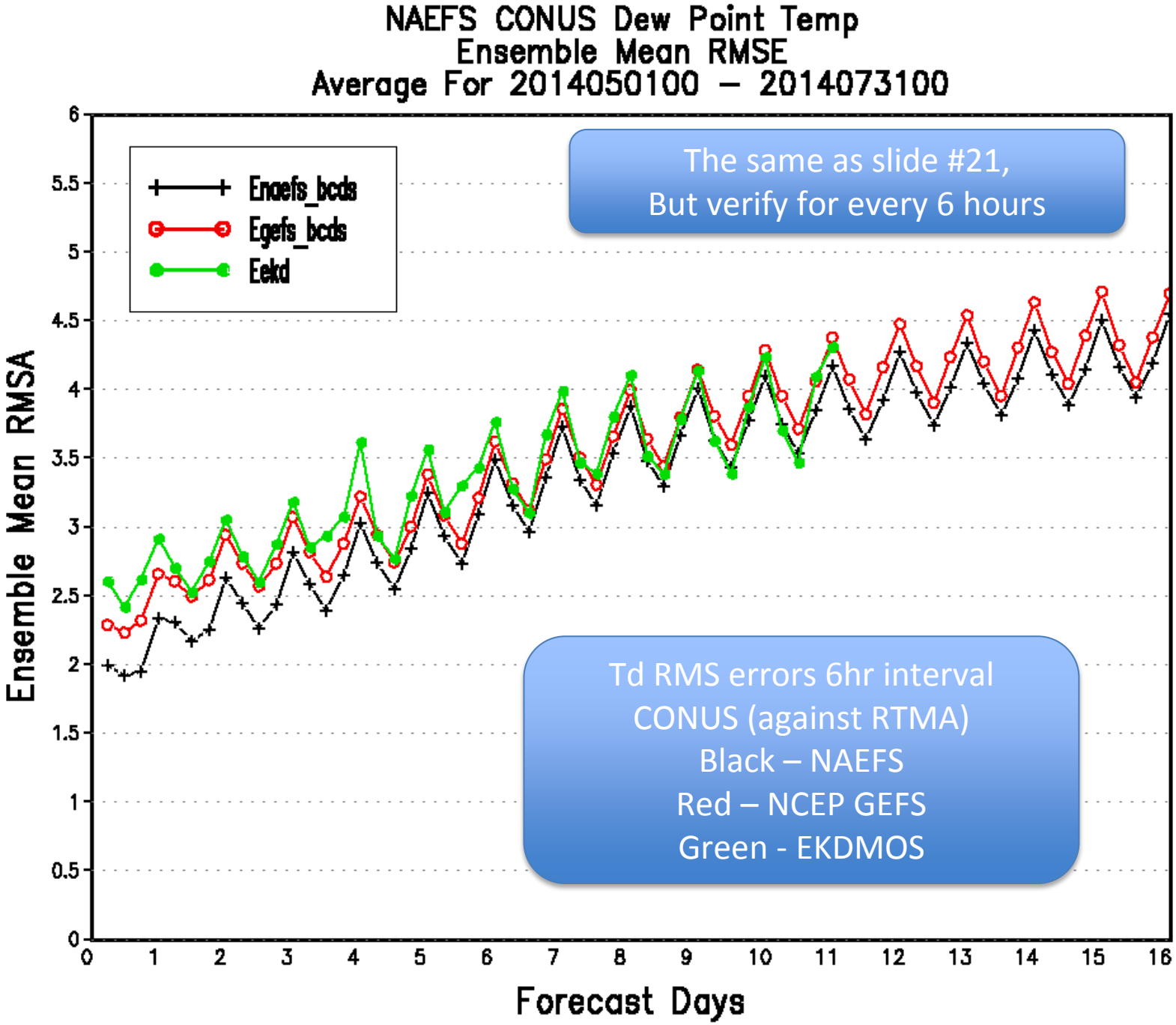
NAEFS CONUS Dew Point Temp
Ensemble Mean RMSE
Average For 2014050100 – 2014073100
Encefs_bcds
Egefs_bcds
Eekd
The same as slide #21,
But verify for every 6 hours
Td RMS errors 6hr interval
CONUS (against RTMA)
Black – NAEFS
Red – NCEP GEFS
Green - EKDMOS
Ensemble Mean RMSA
Forecast Days
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
0
1
2
3
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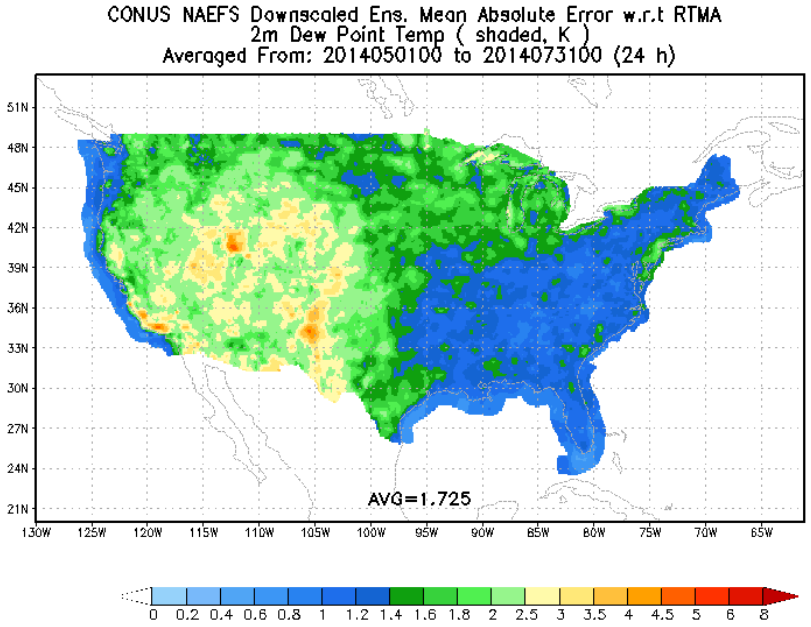
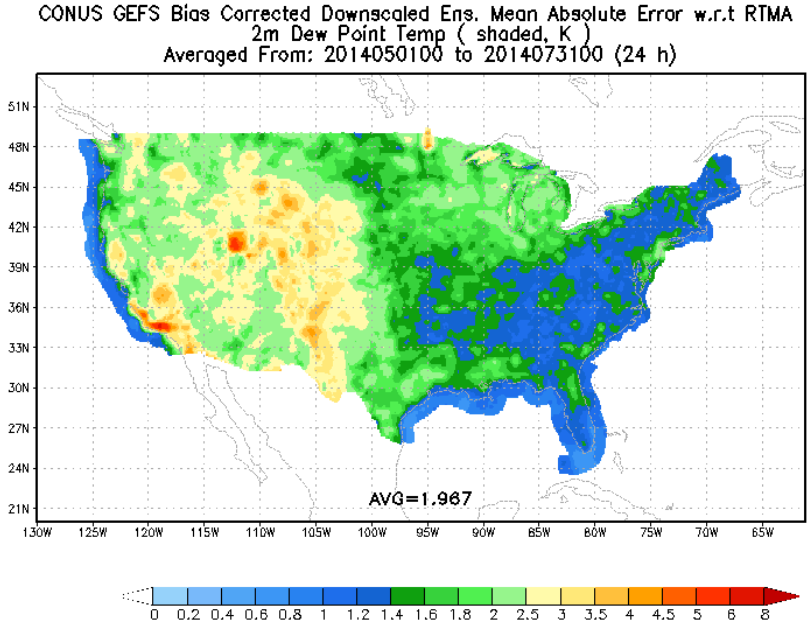
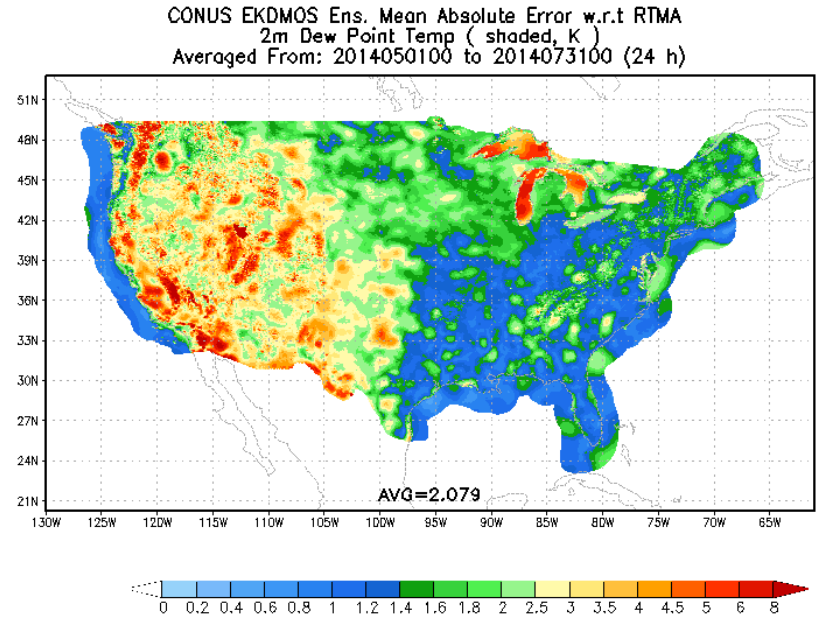
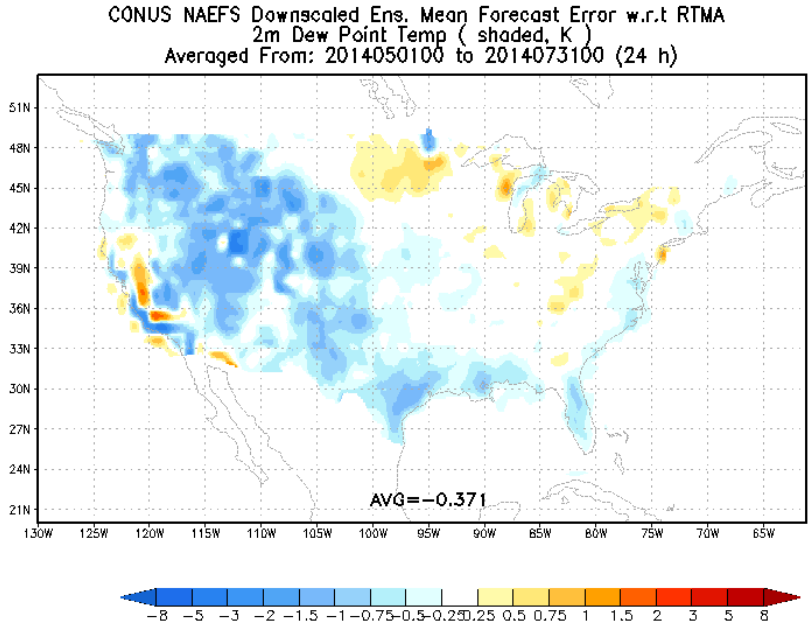


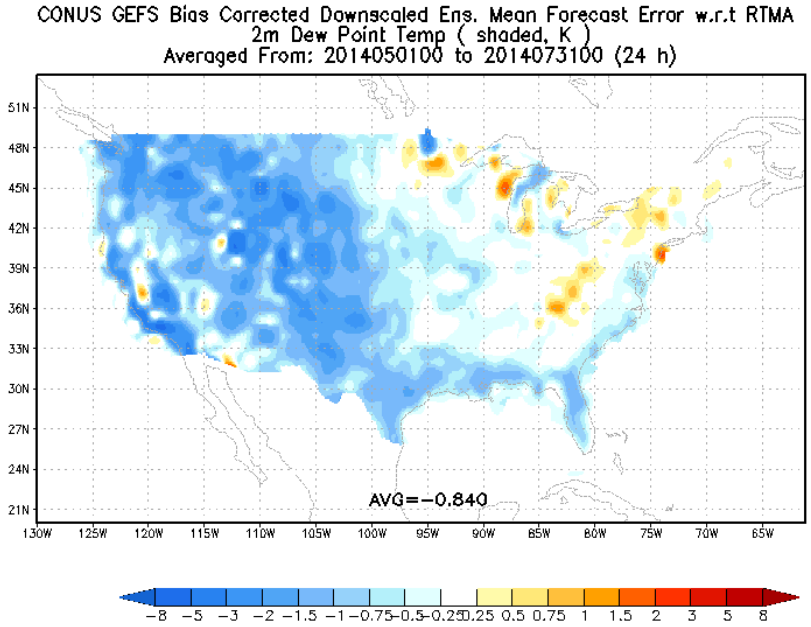


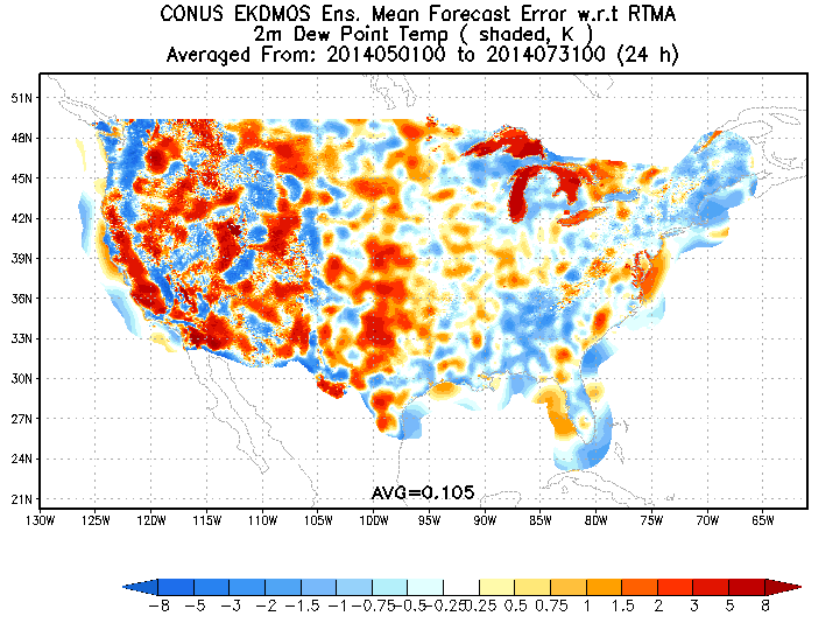


Td MAE (against RTMA)
Period: 20140501 – 20140731
24 hours forecast

Top left → NAEFS
Top right → NCEP GEFS
Bottom left → EKDMOS

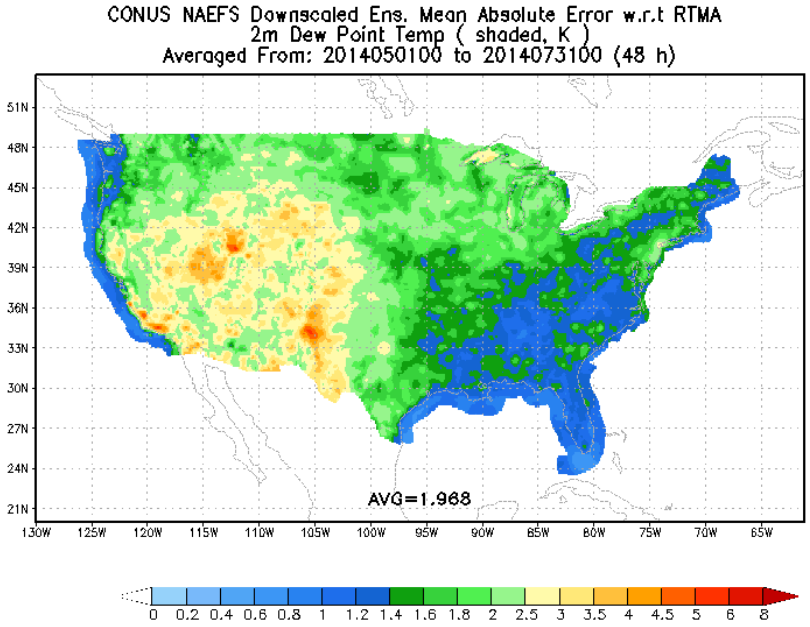


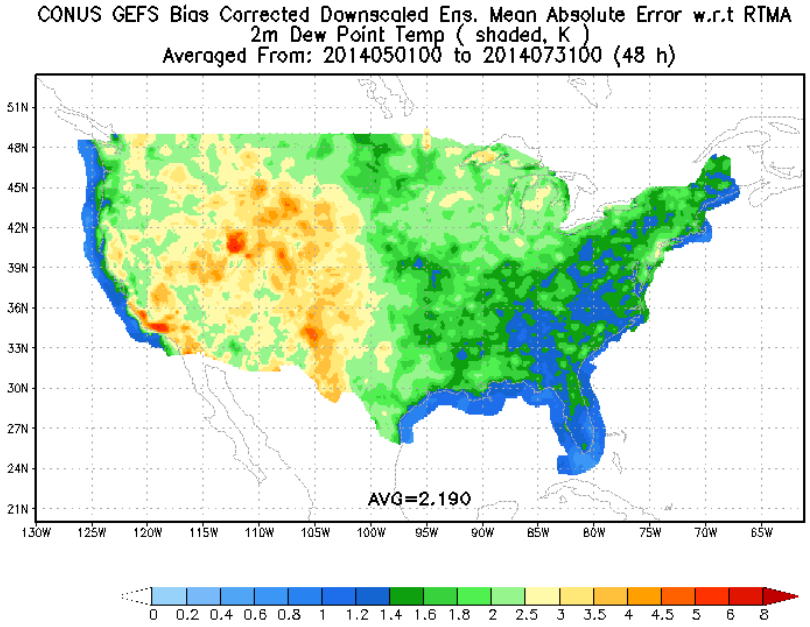


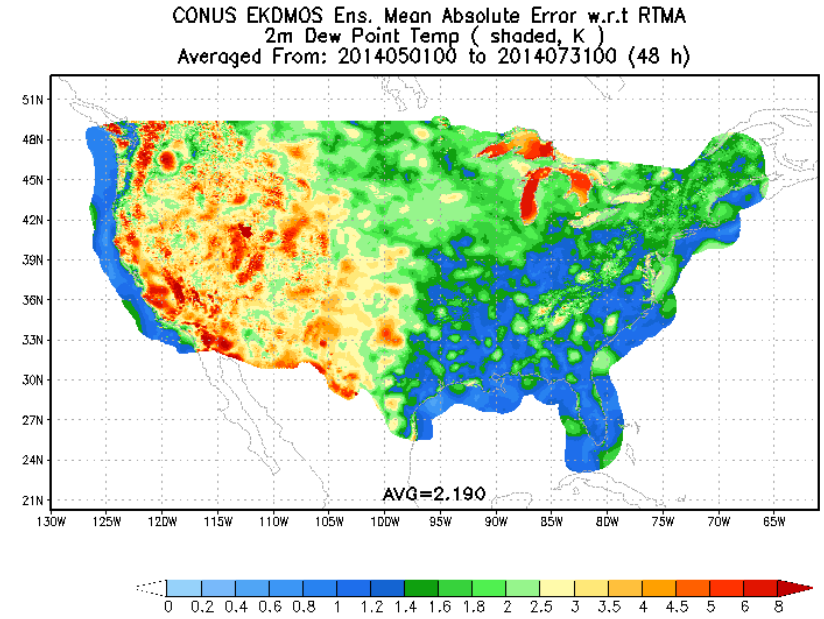


Td ME (against RTMA)
Period: 20140501-20140731
24 hours forecast

Top left: NAEFS
Top right: NCEP GEFS
Bottom left: EKDMOS

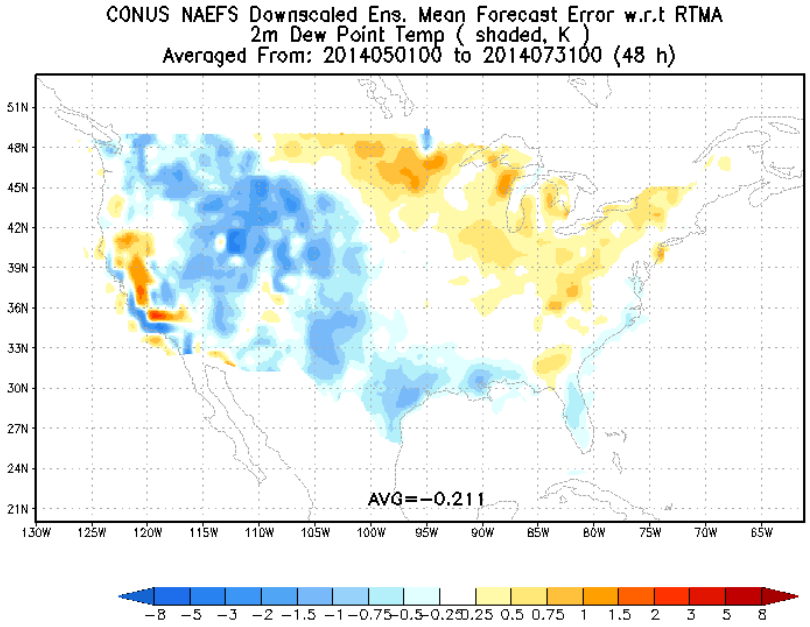


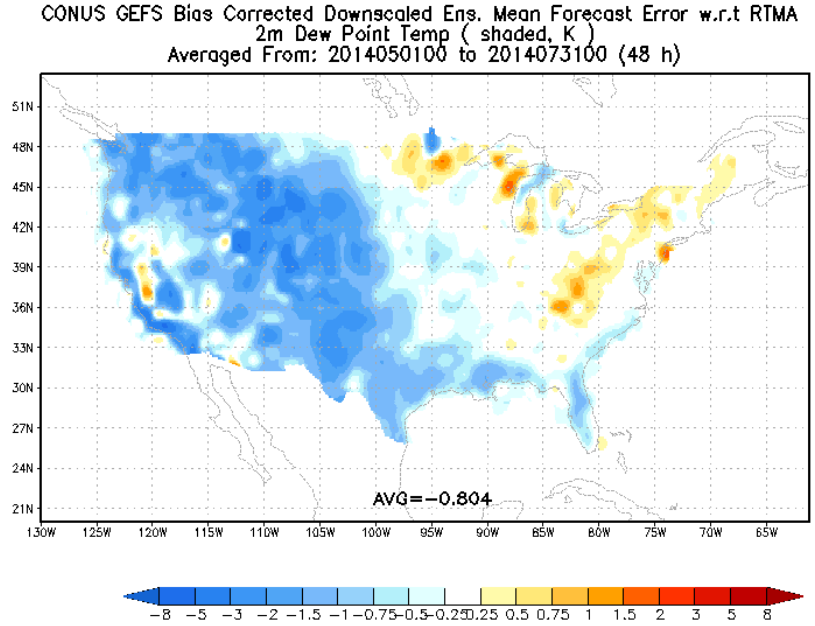


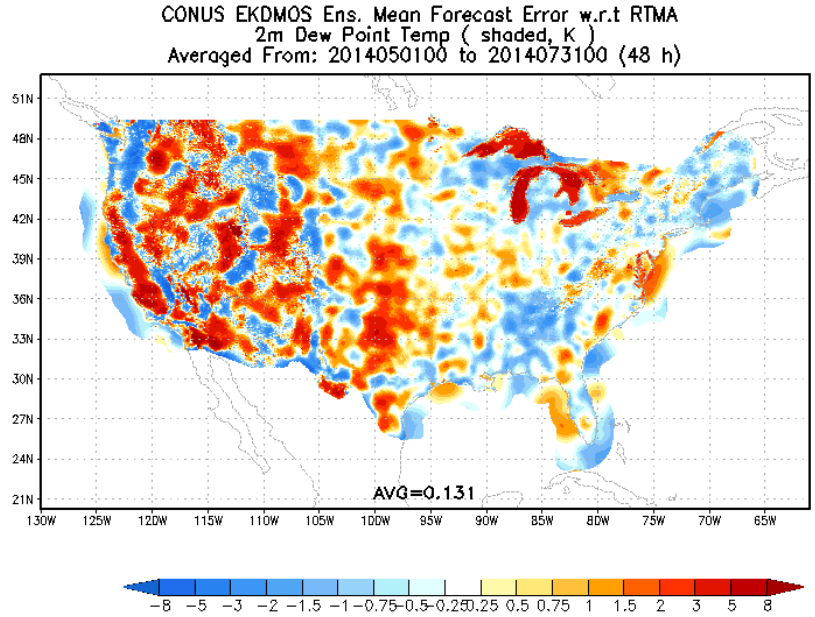


Td MAE (against RTMA)
Period: 20140501 – 20140731
48 hours forecast

Top left → NAEFS
Top right → NCEP GEFS
Bottom left → EKDMOS







Td ME (against RTMA)
Period: 20140501-20140731
48 hours forecast

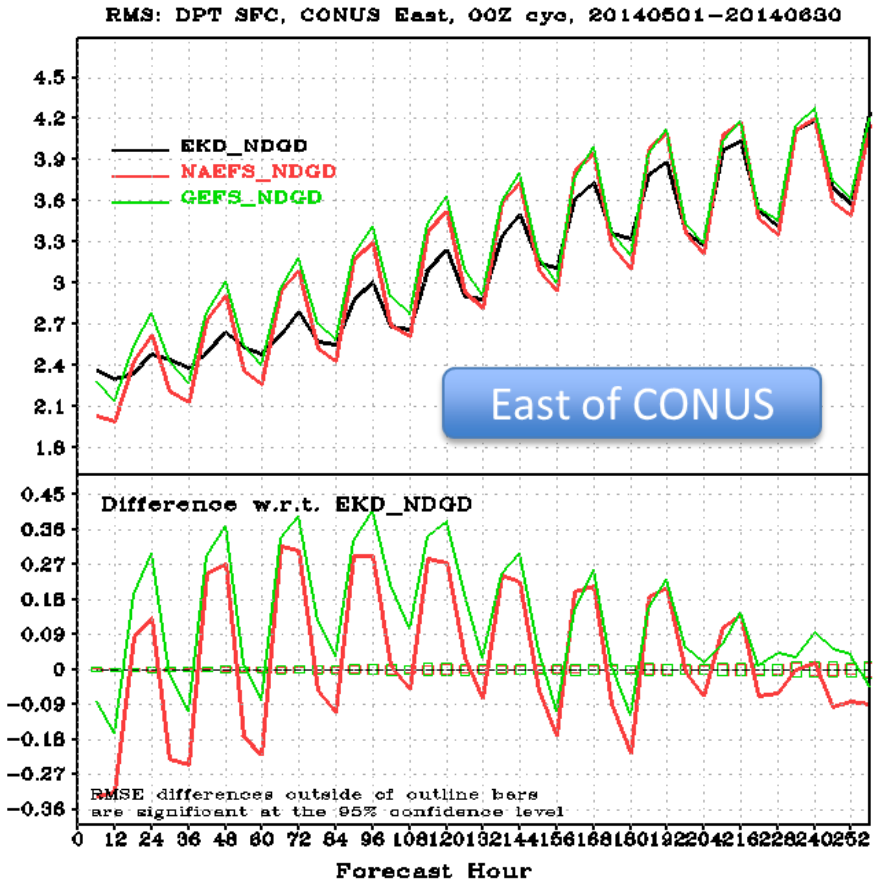
Top left: NAEFS
Top right: NCEP GEFS
Bottom left: EKDMOS

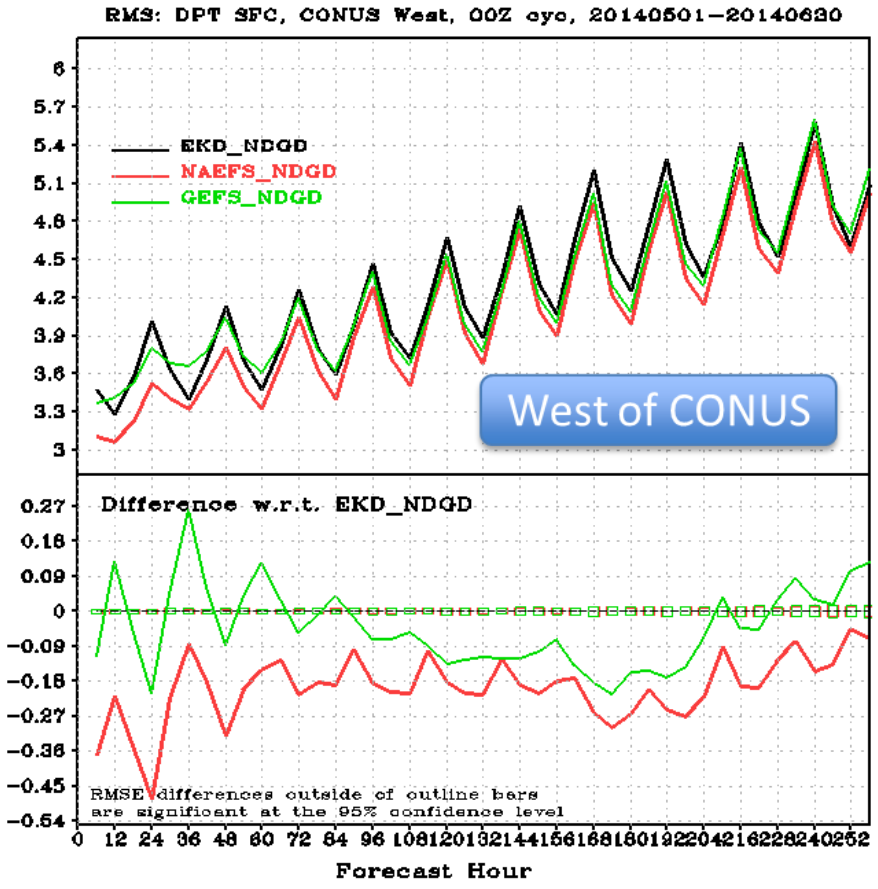
Td Evaluation Against Observations(CONUS)

Based on NWS products: May - July, 2014

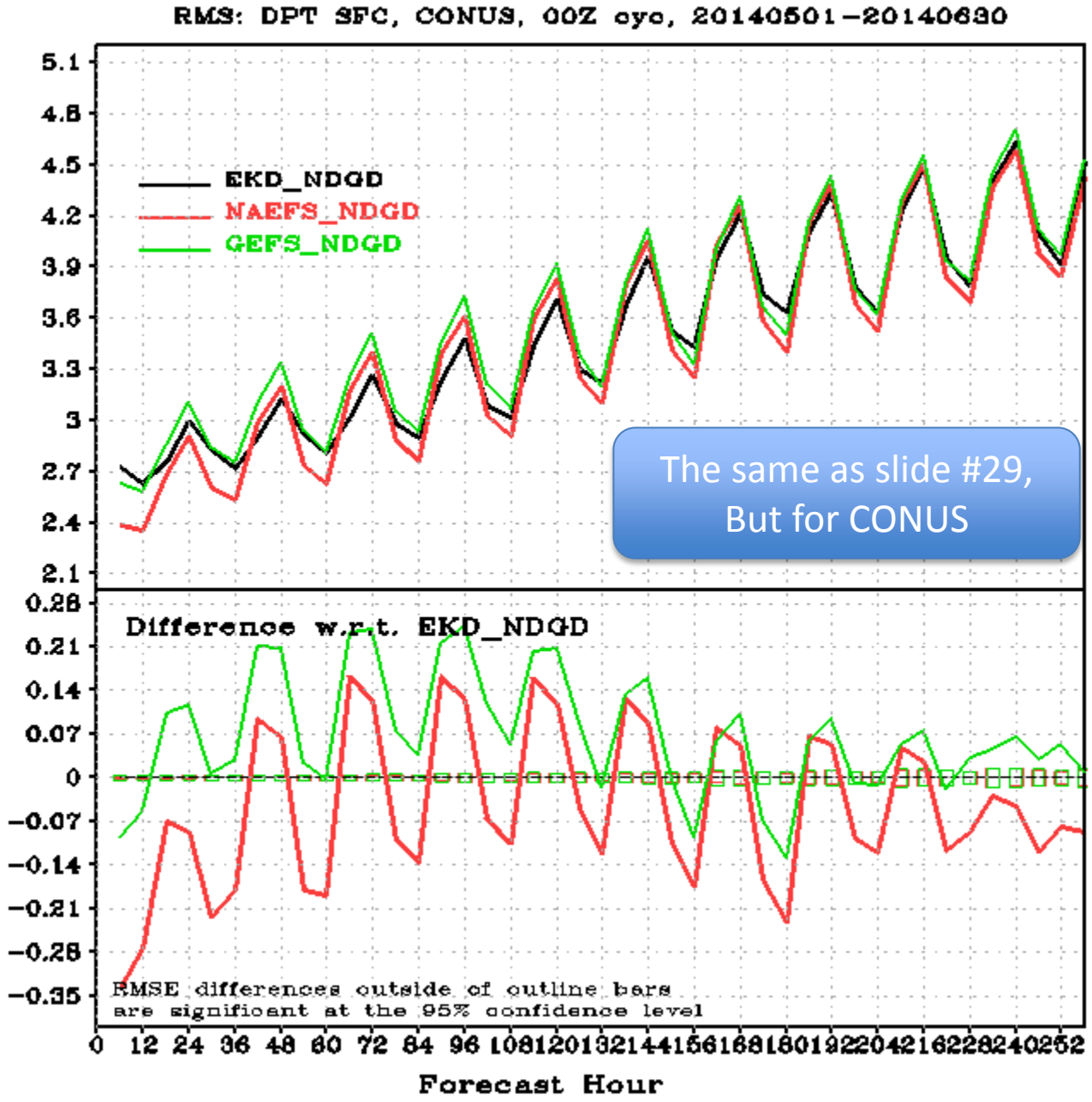
Td forecast against observation (CONUS)

RMS error for ensemble mean





Verification period: 20140501 – 20140630
Against all observations of CONUS



The same as slide #29,
But for CONUS

Conclusion and plan

- Based on 6+ months evaluation of T2m, 2+ months evaluation of Td2m.
- NAEFS SPP demonstrates very valuable benefit in terms of computation efficiency, less errors for first week.

- Will test 2.5km NAEFS SPP with other improved methodologies (variable decaying weights, possible to hybrid with limited reforecast, RBMP, and smartini ….)