Model bias analysis and its calibration
- GEFSv11 reforecast

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Presentation for Monthly NAEFS tele-conf
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GEFS Configuration

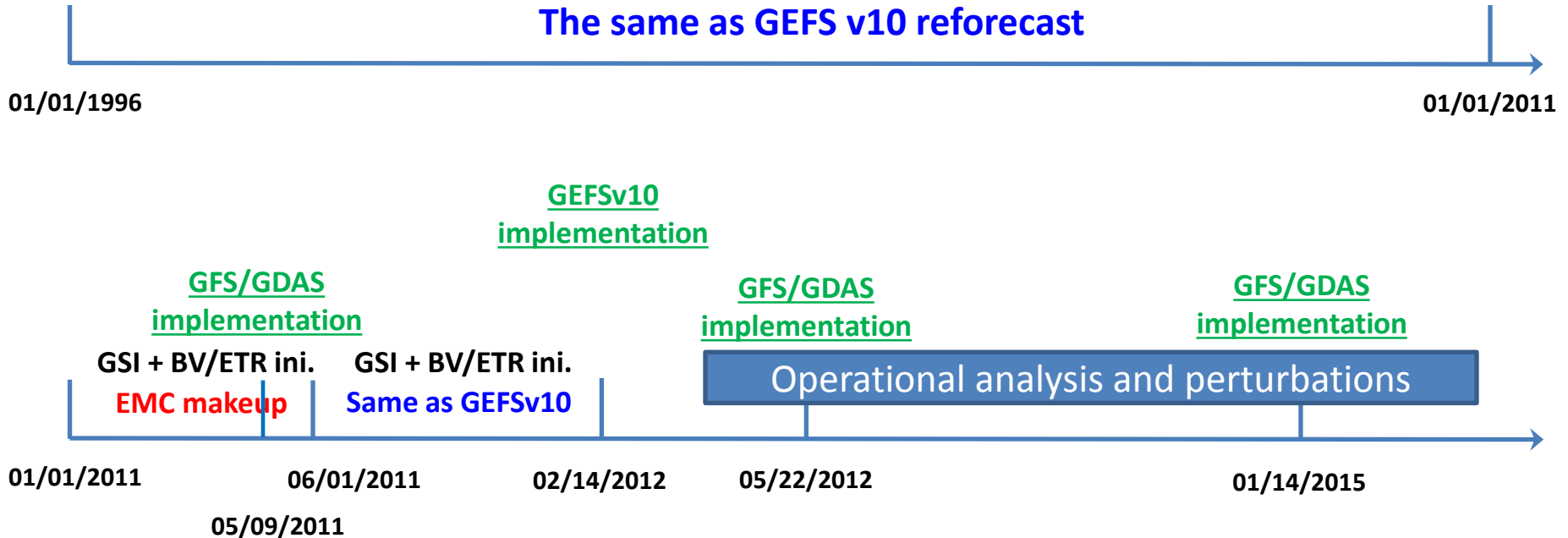|	V10.0.0	V11.0.0
GFS Model	Euler, 2012	Semi-Lagrangian, 2015
Resolution 0-192 h	T254 (52km) L42 (hybrid)	T_L574 (34km) L64 (hybrid)
Resolution 192-384 h	T190 (70km) L42 (hybrid)	T_L382 (52km) L64 (hybrid)
Computational Cost	84 nodes (+ post process)	300 nodes 1st segment 150 nodes 2nd segment
Execution time	~ 60 min	35 min 1st segment 25 min 2nd segment
Output resolution	1^O x 1^O	0.5^O x 0.5^O and 1^O x 1^O
Output frequency	6h	3h the first 8 days; 6h the rest

Reforecast Configurations

20 years: Jan. 1996 – Dec. 2015; 5 members, every 4 days; 00UTC only
Initial analysis: CFSR (1996-2010) and GDAS (2011-2015)
Initial perturbations: ETR (1996-2014) and EnKF (2014-2015)

CFSR analysis + BV ETR initial perturbation
The same as GEFS v10 reforecast

01/01/1996   01/01/2011

GEFSv10 implementation

GFS/GDAS implementation

GFS/GDAS implementation

GFS/GDAS implementation

GSI + BV/ETR ini.   GSI + BV/ETR ini.
EMC makeup   Same as GEFSv10

Operational analysis and perturbations

01/01/2011   06/01/2011   02/14/2012   05/22/2012   01/14/2015

05/09/2011

20 years GEFS v11 reforecasts (Jan. 1996 – Dec. 2015)

Analysis Climatology

- Daily mean:

  Fourier expansion from 20-year daily analysis data.
  The first four Fourier modes (higher smoothing) have been used
  to generate daily climatological means to include annual, semi-
  annual, and seasonal cycles.

- Daily VAR(x) or SD^2:

$$VAR(x) \quad = \quad \frac{1}{L} \sum_{l=1}^{L} (ANL_l - ANL_{mean})^2$$

x: each day
L: number of analysis (9 points and 20 years)

Reforecast (model) Climatology

- Daily mean: the same method as used for analysis climatology mean

- Daily variance VAR (x) or SD^2

$$VAR(x) \quad = \quad \frac{1}{L}\sum_{l=1}^{L}(ENSM_l - ENSM_{mean})^2 \quad + \quad \frac{1}{L}\sum_{l=1}^{L}(\frac{1}{K}\ (\sum_{k=1}^{K}(ENS_k - ENSM_l)^2$$

Model climatological variance (SD^2)   Ensemble mean variance   Ensemble variance

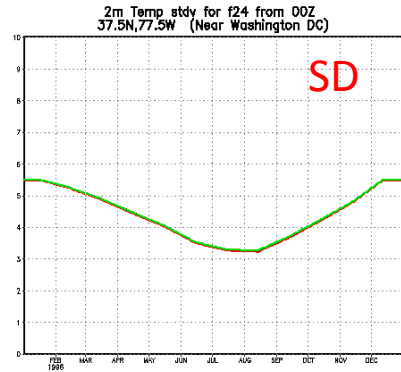x: each day
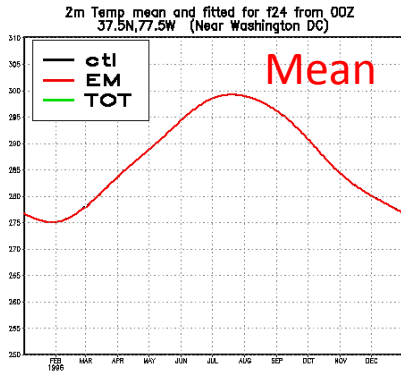L: number of ensemble mean forecasts (9points and 5 years)
K: number of ensemble members (5 members)

Raftery, A. E., T. Gneiting, F. Balabdaoui, and M. Polakowski, 2005: Using Bayesian model averaging to calibrate forecast ensembles. Mon. Wea. Rev.,133,1155–1174."

Comparison of model and analysis climatology for 2-m Temperature

24hr forecast   Analysis
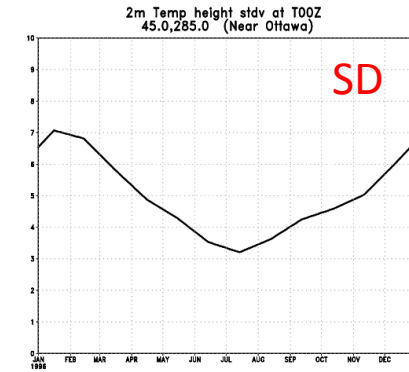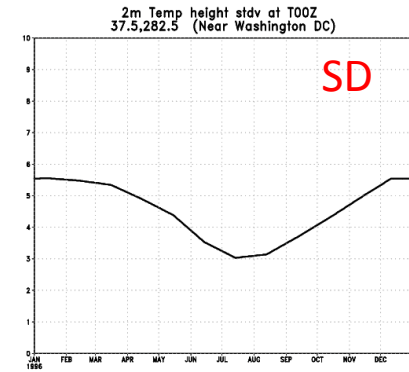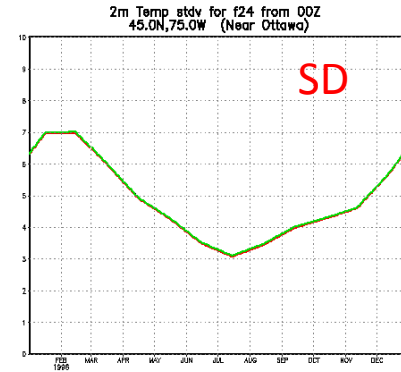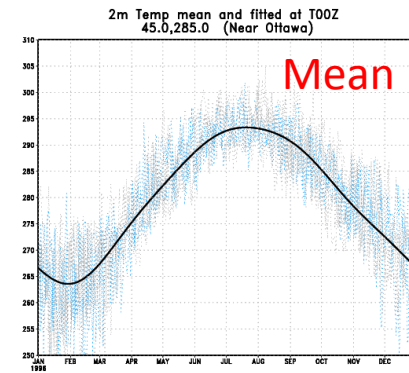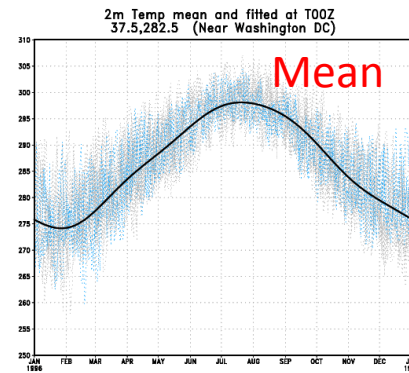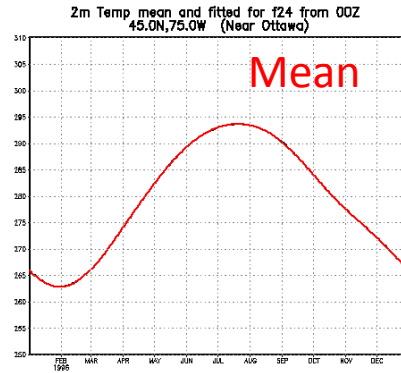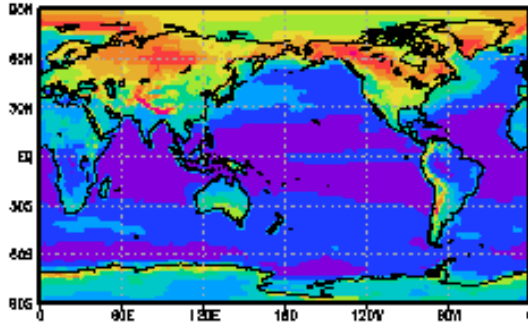

Washington DC   Ottowa   Washington DC   Ottowa
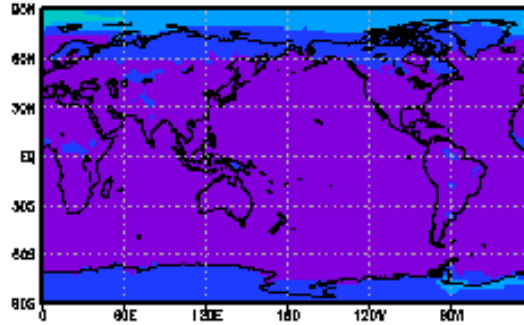
24-hr model climatology is very similar to analysis climatology.

Comparison of ensemble mean SD, ensemble spread, model climatological SD (Valid Jan. 16, 2016)

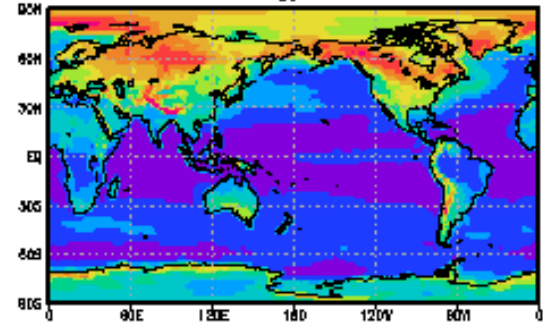a. T2M, ensemble mean stdv, F24hr

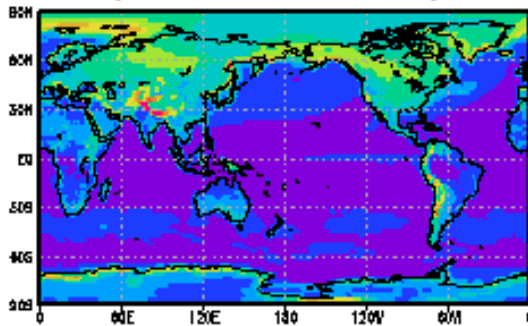b. ensemble stdv, F24hr

c. climatology stdv, F24hr

F24hr

Ensemble Mean SD

Ensemble Spread

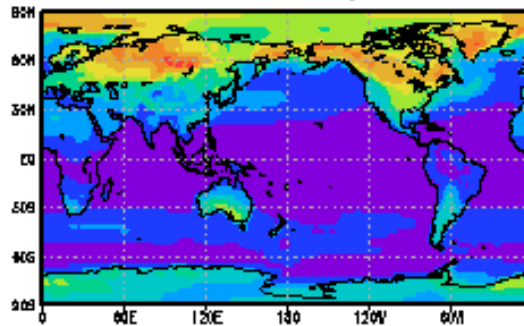Model climatological SD
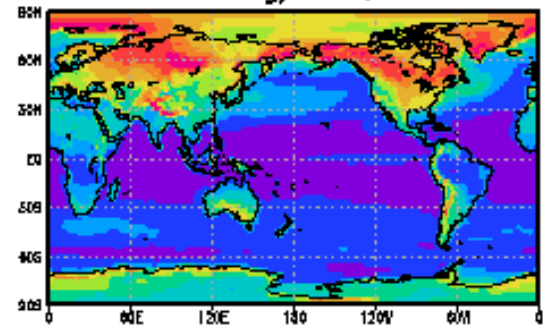
d. T2M, ensemble mean stdv, F360hr

e. ensemble stdv, F360hr

f. climatology stdv, F360hr

F360hr

Reforecast Bias Calculation

Reforecast bias:

b = Model climatology mean − analysis
        climatology mean

NAEFS bias corrected variables

Last upgrade: March 29 2016 - (bias correction)

| Variables	pgrba_bc file	Total 51 (24)
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	10 (5)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (6)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (6)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (6)
VVEL	850hPa	1
PRES	Surface, PRMSL	2 (1)
FLUX (top)	ULWRF (toa - OLR)	1
Td and RH	2m (April 8 2014)	2
TCDC	Total cloud cover (March 29 2016)	1
Notes	CMC and FNMOC do not apply last two upgrades yet Only part of variables could apply reforecast bias if we use the bias from 20-year climatology (CFSR analysis is not avail. for part of variables). All variables could apply reforecast bias if we use the bias from the latest 5-year reforecast and GDAS analysis.	

Ensemble Mean T2m Bias Distribution (120hr forecast)

Cold Season

(a) 2-m temperature bias, cold season V11

Warm Season
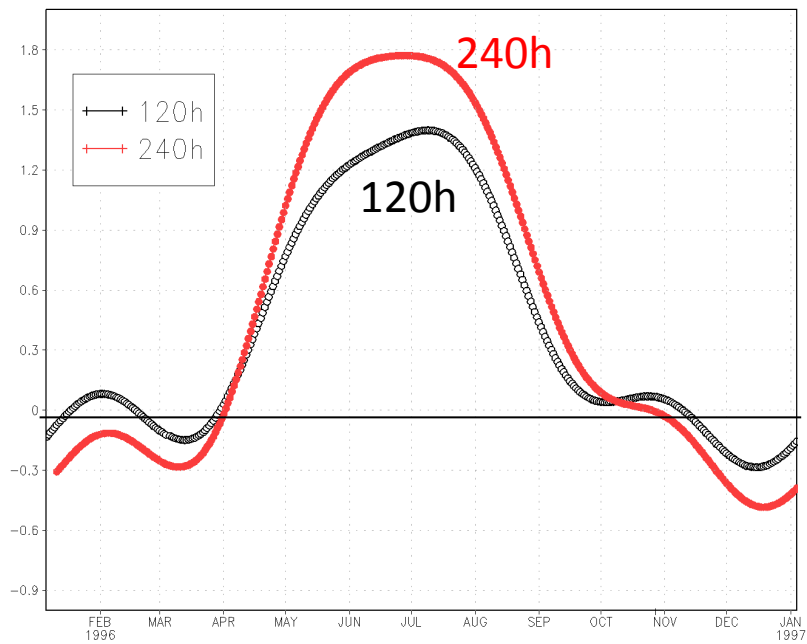
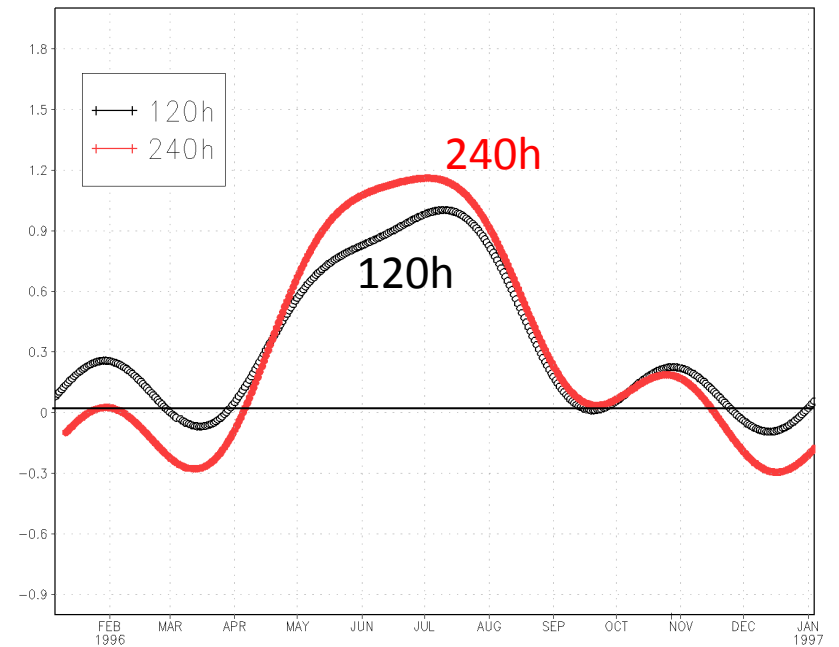(b) 2-m temperature bias, warm season V11
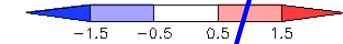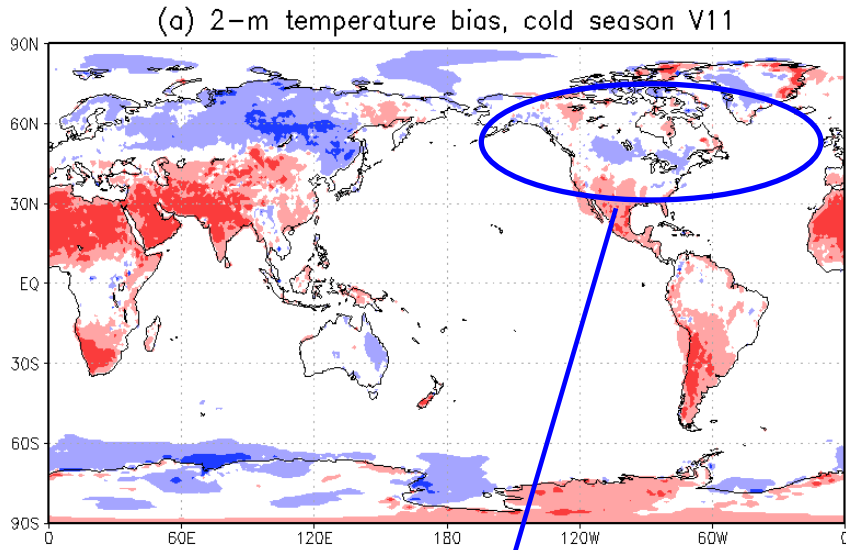
small cold bias
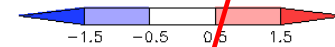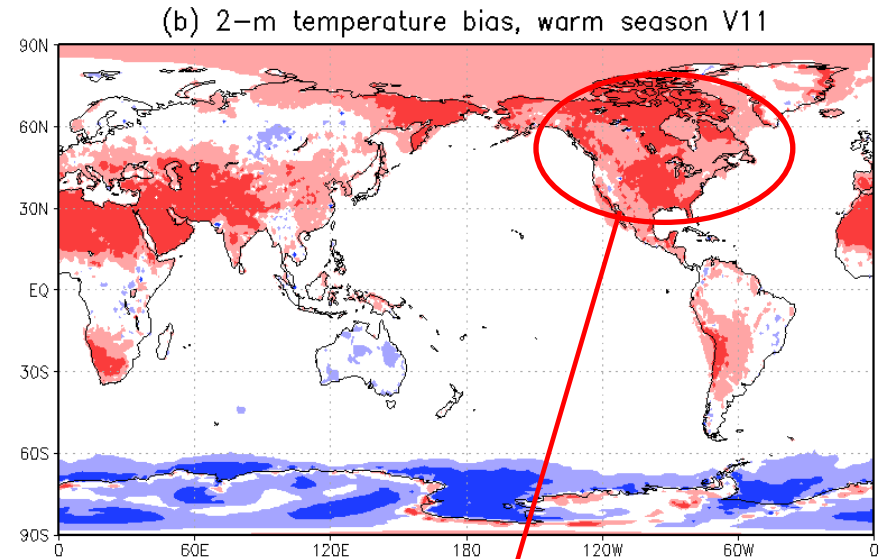
warm bias

Ensemble Mean T2m Errors for NA and NH
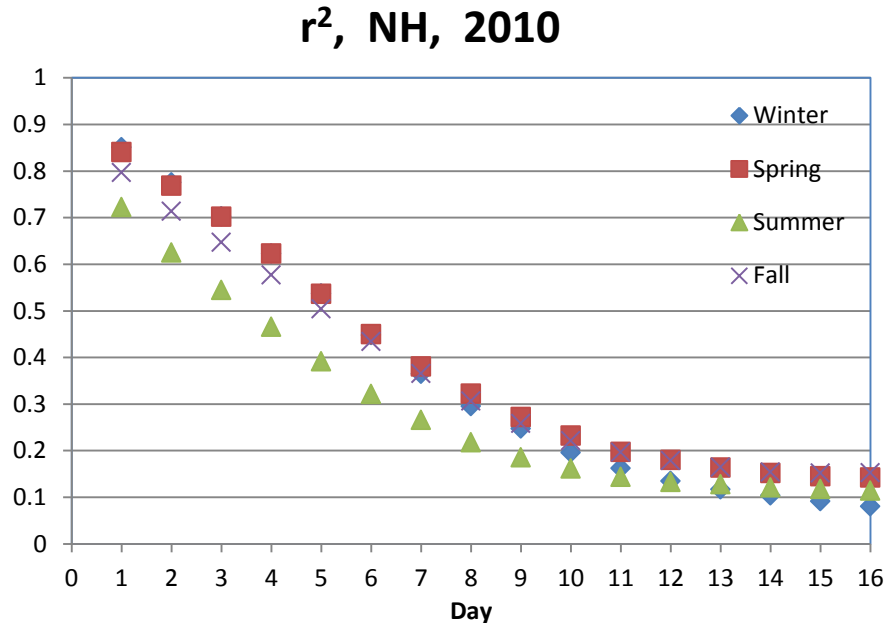

a. NA

b. NH

Using reforecast to improve current bias corrected product (*Guan et al., 2015, WAF*)

r², NH, 2010

r could be estimated by linear regression from joint samples, the joint sample mean could be generated from decaying average (*Kalman Filter* average) for easy forward.

Bias corrected forecast: The new (or bias corrected) forecast (***F***) will be generated by applying decaying average bias (***B***) and reforecast bias (***b***) to current raw forecast (***f***) for each lead time, at each grid point, and each parameter.

$$F_{i,j}^{m} = f_{i,j}^{m} - r_{i,j}^{2} B_{i,j} - (1 - r_{i,j}^{2}) \cdot b_{i,j}$$
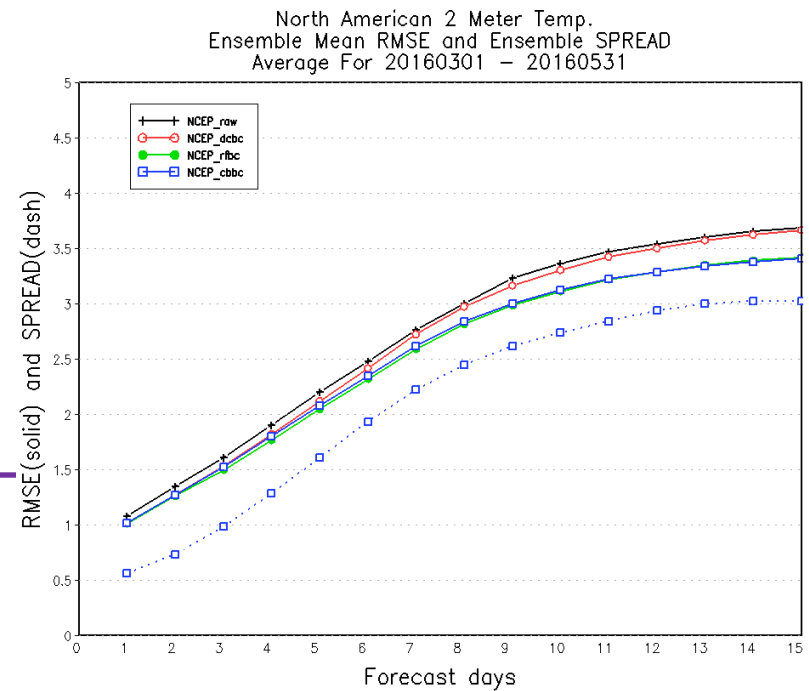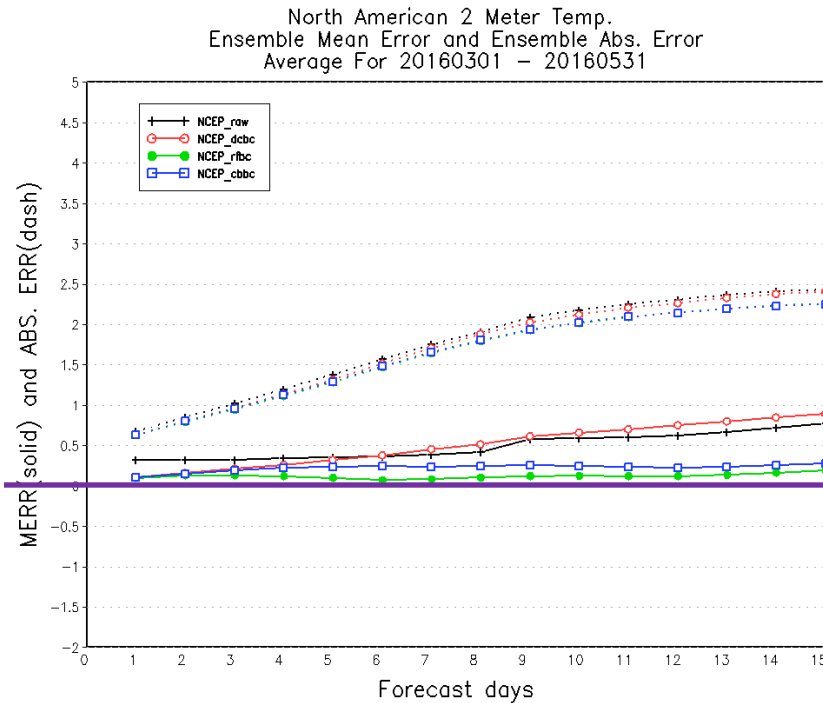
bias corrected forecast
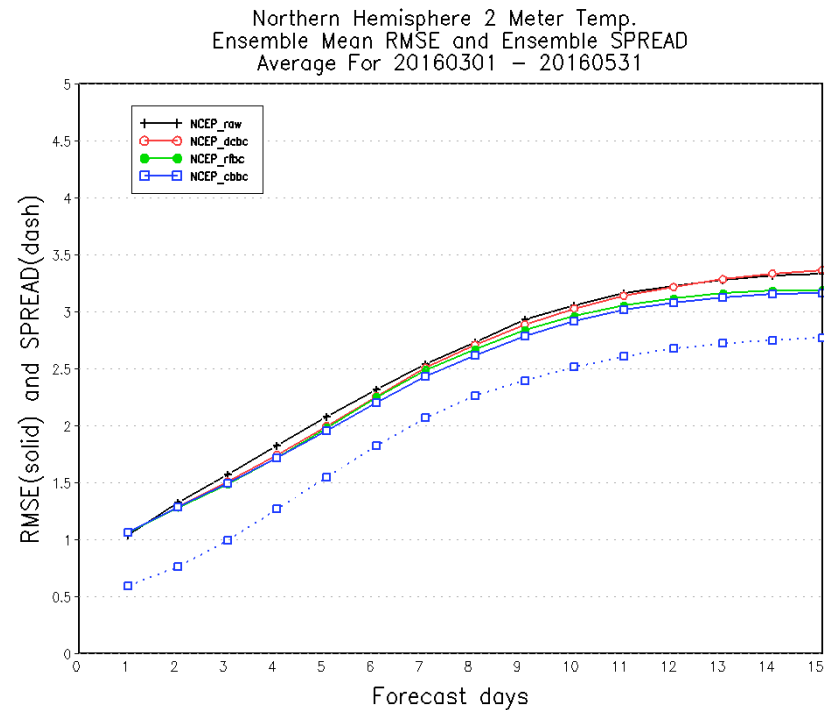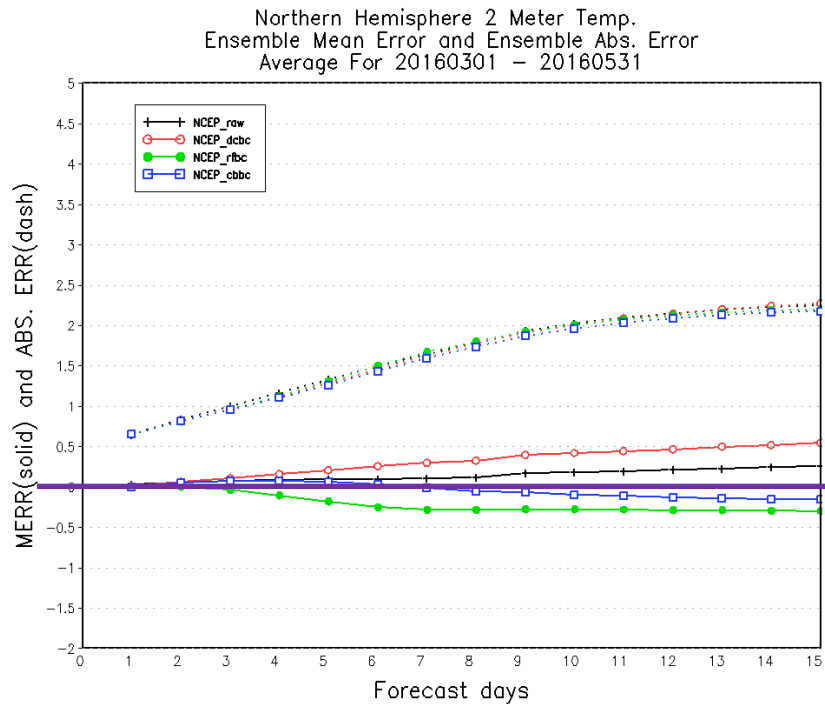
raw forecast

decaying average bias

reforecast bias

Using 20-year reforecast bias (1996-2015) to calibrate Spring, 2016 forecasts (T2M, NA)

The reforecast-decaying combined method did better job than the decaying method!!

Using 20-year reforecast bias (1996-2015) to calibrate Spring, 2016 forecasts (T2M, NH)


The reforecast-decaying combined method did better job than the decaying method!!

Summary

- Positive impact when hybrid decaying- reforecast method is used

- Big improvement for temperature when bias has a sharper change with time (transition seasons)

- Big improvement for longer forecast lead-time

- Full–set of bias will be available for the NAEFS application (bias from the recent 5-year reforecast and analysis data)

- Any comments?

- Will ask if NAEFS partners will accept this change?

Ensemble Mean T2m Errors every 5-yr Period (NH)
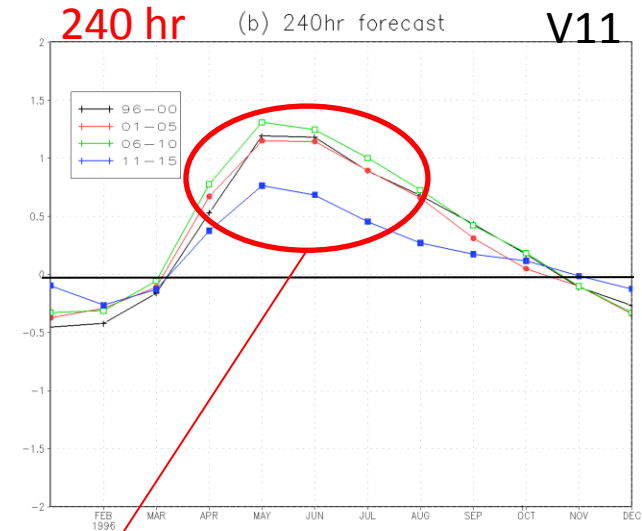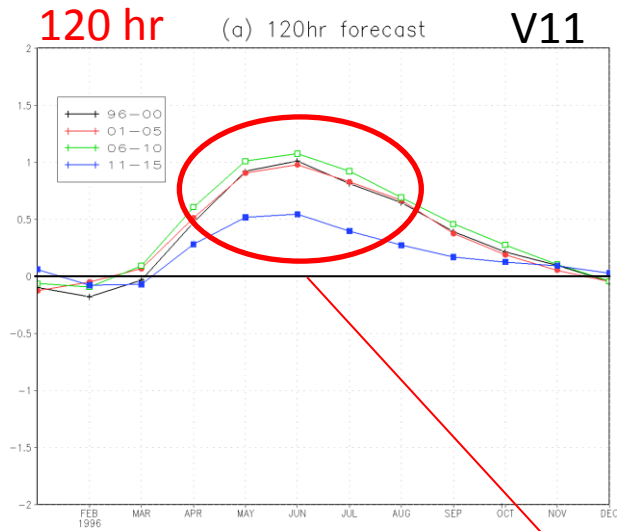
decreased bias for
the recent 5 years.