NAEFS upgrade and UNOPC-IOC
Science review

(Q2FY11)

Yuejian Zhu and Bo Cui

Ensemble & Probabilistic Guidance Team
Environmental Modeling Center

Acknowledgements

- Julia Zhu (RFCs and test)
- Chad Cary
- Bill Lapenta
- John Ward

- Boi Vuong (NCO/NCEP)
- Rebecca Cosgrove (NCO/NCEP)
- Justin Cooke (NCO/NCEP)
- Christine Caruso Magee (NCO/NCEP)
- Michelle Mainelli (NCO/NCEP)
- Daniel Starosta (NCO/NCEP)
- Allan Darling (NCO/NCEP)

- John Wendel (NAVY)
- John Ertl (NAVY)
- Mike Sestek (NAVY)

- Lewis Poulin (CMC)
- Andre Methot (CMC)

Scopes and Expectations

- NAEFS – North American Ensemble Forecasting System (*version 3.0.0*)
  - Jointly with Meteorological Service of Canada and Meteorological Service of Mexico since 2004
  - Upgrade to include FNMOC global ensembles
  - Improve the overall skills of NAEFS performance
- NUOPC – National Unified Operational Prediction Capability (*version 1.0.0*)
  - IOC – Initial Operational Capability
  - Unified NOAA-NAVY-AF tri-agency's numerical forecast output and post processing
  - Deliver best products to service US and public

NAEFS Current Configuration

Updated: February 23rd 2010

	NCEP	CMC
Model	GFS	GEM
Initial uncertainty	ETR	EnKF
Model uncertainty/Stochastic	Yes (Stochastic Pert)	Yes (multi-physics)
Tropical storm	Relocation	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC
Resolution	T190L28 (d0-d16)~70km	(d0-d16) ~1.0degree
Control	Yes	Yes
Ensemble members	20 for each cycle	20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)
Post-process	Bias correction (same bias for all members)	Bias correction for each member
Last implementation	February 23rd 2010	July 10th 2007

NAEFS/NUOPC Configuration

	NCEP	CMC	FNMOC
Model	GFS	GEM	Global Spectrum
Initial uncertainty	ETR	EnKF	Banded ET
Model uncertainty Stochastic	Yes (STTP)	Yes (multi-physics)	None
Tropical storm	Relocation	None	None
Daily frequency	00,06,12 and 18UTC	00 and 12UTC	00 and 12UTC
Resolution	T190L28 ~70km	1.0 degree	T119L30 ~1.0degree
Control	Yes	Yes	Yes
Ensemble members	20 for each cycle	20 for each cycle	20 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)	16 days (384 hours)
Post-process	Bias correction (same bias for all members)	Bias correction for each member	Bias correction (same bias for all members)
Last implementation	February 23rd 2010	July 10th 2007	May 2010

NAEFS (FNMOC) Grid Exchange Variables

Update: July 12 2010

Variables	Pgrba file	Total 80/73
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13/(13)
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
PRES	Surface, PRMSL	2/(2)
PRCP	APCP, CRAIN, CSNOW, CFRZR, CICEP	5/(4)
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6/(2)
FLUX (top)	ULWRF (OLR)	1/(1)
PWAT	Total precipitable water at atmospheric column	1/(1)
TCDC	Total cloud cover at atmospheric column	1/(1)
CAPE	Convective available potential energy, Convective Inhibition	2/(2)
SOIL/SNOW	SOILW(0-10cm) , TMP(0-10cm down), WEASD(water equiv. of accum. Snow depth), SNOD(surface)	4/(1)
Other	850 hPa vertical velocity	1/(1)
Notes	Original NAEFS grids currently being sent to NCEP by FNMOC, Require model change to add. (future plan) Not available	FNMOC=72

6

NAEFS bias corrected parameters and products
Last update: February 23rd 2010

Variables	pgrba_bc file	Total 49 (14)
GHT	10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	10 (3)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	13 (3)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000hPa	11 (3)
VVEL	850hPa	1(1)
PRES	Surface, PRMSL	2(0)
FLUX (top)	ULWRF (toa - OLR)	1 (1)
		14 new vars for CMC
Notes	All products at 1*1 (lat/lon) degree globally Ensemble mean, spread, 10%, 50%, 90% and mode Climate anomaly forecast from ensemble mean	

NAEFS downscaling parameters and products

Last update: May 1st 2010
(NDGD resolutions)

Variables	Domains	Resolutions	Total 4/8
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	Alaska	6km	0/1
2-m minimum T	Alaska	6km	0/1
10-m wind speed	Alaska	6km	0/1
10-m wind direction	Alaska	6km	0/1
Note: Alaska products is in real time parallel Expect implementation: Q4 FY2010			

All products at 1*1 (lat/lon) degree globally
Ensemble mean, spread, 10%, 50%, 90% and mode

8

NAEFS – bias correction (details)

❑ Bias corrected NCEP/GEFS forecast
- Consider the same bias for all ensemble members (mean bias)
- Weight = 0.02 for Kaman filter (decaying) algorithm

❑ Bias corrected NCEP/GFS forecast
- Use the same algorithm as ensemble bias correction
- Up to 180 hours

❑ Bias corrected CMC/GEFS forecast
- Consider the different bias for each model (member)
- Use the same algorithm as ensemble bias correction

- Bias corrected FNMOC/GEFS forecast
- Consider the same bias for all ensemble members (mean bias)

❑ Combine bias corrected GFS and ensemble forecast
- Dual resolution ensemble approach for short lead time
- GFS has higher weights at short lead time

❑ NAEFS products based on bias correction
- Combine NCEP/GEFS (20m), CMC/GEFS (20m) and FNMOC/GEFS (20m)
- Produce Ensemble mean, spread, mode, 10% 50%(median) and 90% probability forecast at 1*1 degree resolution
  - Climate anomaly (percentile) forecasts also generated for ensemble mean
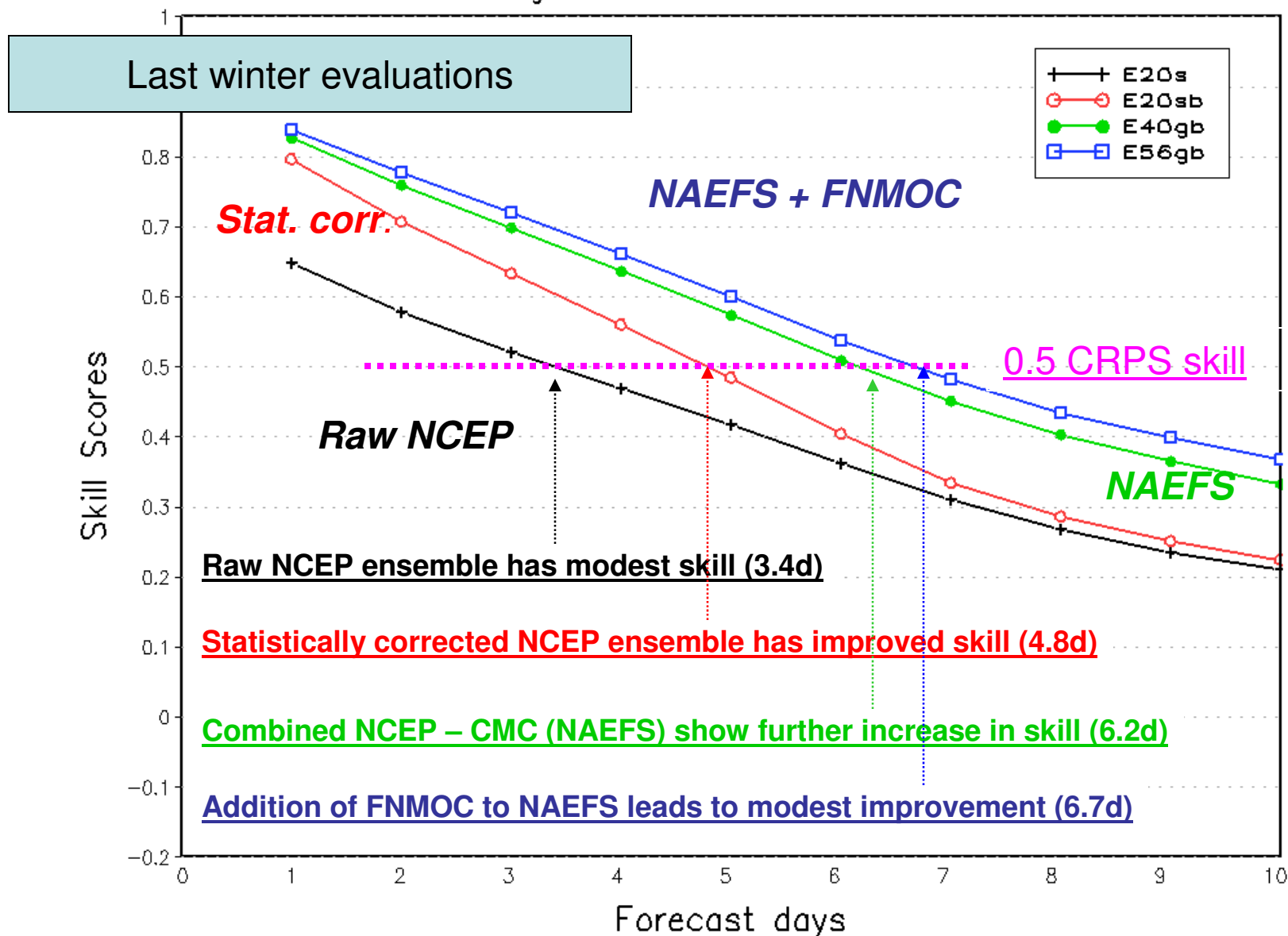
NAEFS - Statistical downscaling

- 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
- NAEFS products
  - CONUS – NDGD grid/resolution (5km)
    - 4 variables (parameters)
    - Ensemble spread, mean, mode, 10%, 50%(median) and 90% forecasts
  - Alaska – NDGD grid/resolution (6km)
    - 8 variables (parameters)
    - Ensemble spread, mean, mode, 10%, 50%(median) and 90% forecasts

Value-added by including FNMOC ensemble into NAEFS
T2m: Against analysis (NCEP's evaluation)

Northern Hemisphere 2 Meter Temp.
Continous Ranked Probability Skill Scores
Average For 20081201 – 20090228

Last winter evaluations

Stat. corr.

NAEFS + FNMOC

Raw NCEP

0.5 CRPS skill

NAEFS

Legend: E20s, E20sb, E40gb, E56gb

Raw NCEP ensemble has modest skill (3.4d)

Statistically corrected NCEP ensemble has improved skill (4.8d)

Combined NCEP – CMC (NAEFS) show further increase in skill (6.2d)

Addition of FNMOC to NAEFS leads to modest improvement (6.7d)

11

Preliminary Conclusions From 08/09 Winter
for adding FNMOC ensemble to current NAEFS

- **Individual ensemble systems (individual Centers' forecasts)**
  - NCEP and CMC have similar performance
  - FNMOC performance similar to NCEP & FNMOC for near surface variables, including precipitation
  - FNMOC is less skillful than NCEP and CMC for upper atmosphere variable (500hPa)

- **Combined ensemble system (without bias correction)**
  - Multi-model ensembles have higher skill than single system
  - Adding FNMOC ensemble to current NAEFS (NCEP+CMC) adds value for most forecast variables
    - Noticable improvement for surface variables
    - Minimal improvement for upper atmosphere

- **Combined ensemble system (with operational NAEFS bias correction)**
  - Improved near surface variables with FNMOC ensemble
    - NCEPbc + CMCbc + FNMOCbc
  - Less improvement for upper atmosphere (e.g. 500hPa height))
    - Some degradation for short lead times (related to large spread in FNMOC ensemble)

- **CMC evaluation against observations**
  - Preliminary results combining raw ensembles are mixed
  - Results with bias corrected data still mixed

Real time experiments

Since September 1st 2010

There are many upgrading for FNMOC and NCEP
ensemble system for past year

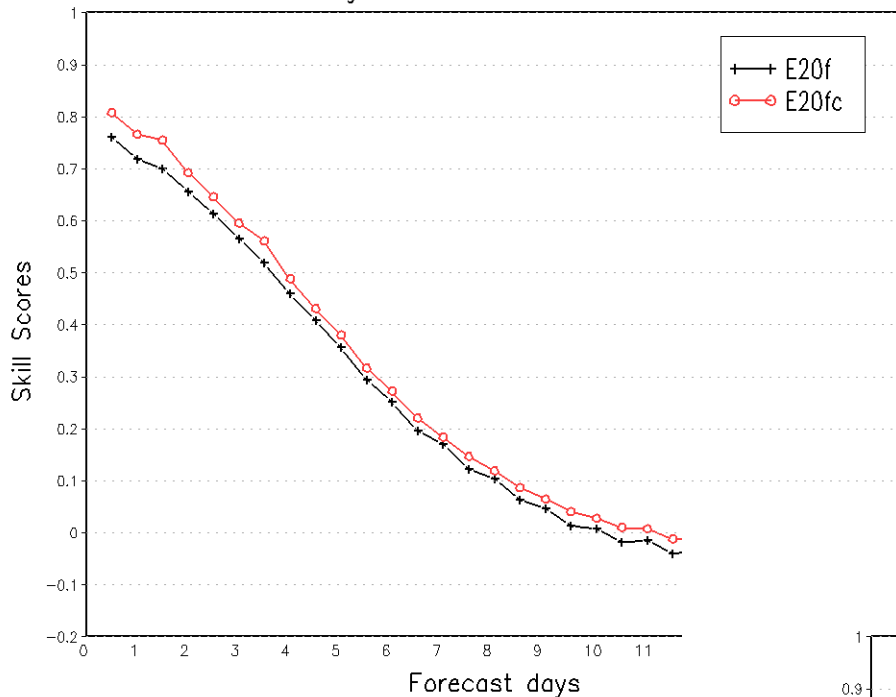FNMOC ensemble with 4DVar data assimilation

FNMOC ensemble with banded ET

NCEP GEFS increasing resolution in Feb. 2010

NCEP GEFS with new analysis from GFS upgrade

NCEP GEFS is still running the same GFS (n-1 version)

Northern Hemisphere 1000hPa Height
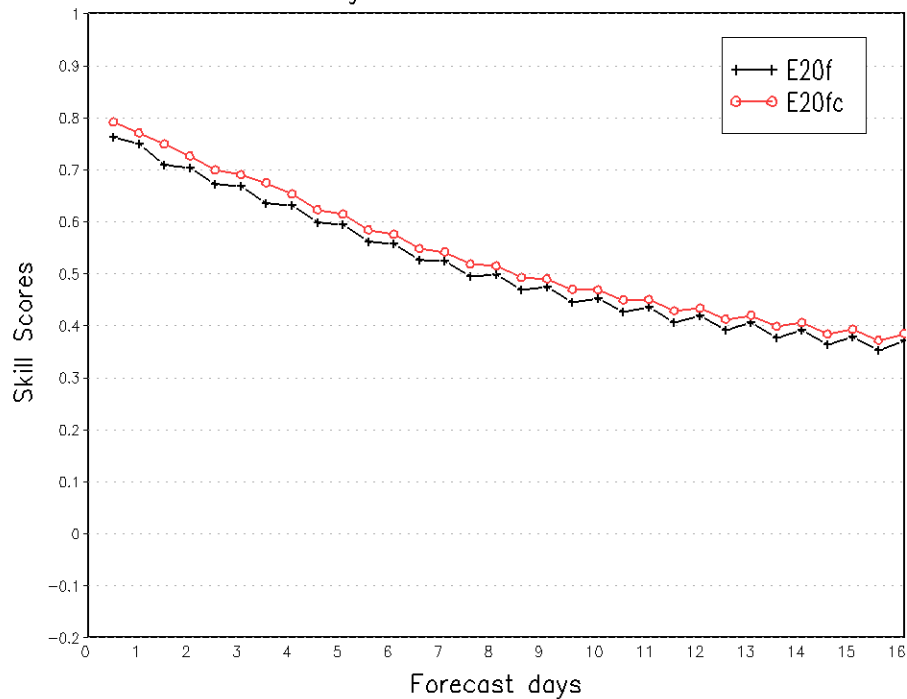Continous Ranked Probability Skill Scores
Average For 20100901 — 20101023

FNMOC ensembles only

NCEP bias correction improves
FNMOC raw ensemble forecast

E20f – FNMOC raw forecast
E20fc – FNMOC bias corrected
forecast

Northern Hemisphere 2 Meter Temp.
Continous Ranked Probability Skill Scores
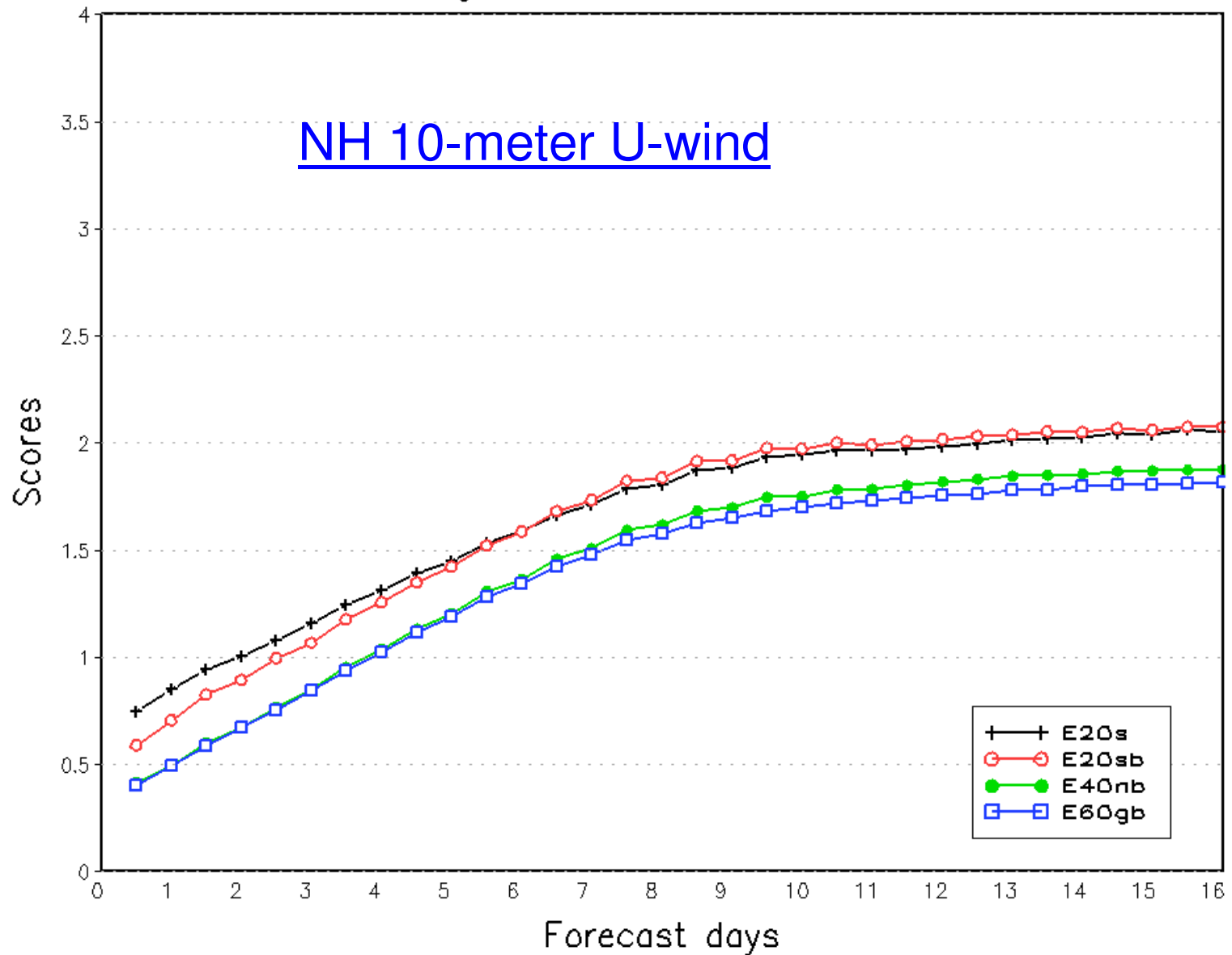Average For 20100901 — 20101023

Top: NH 1000hPa height
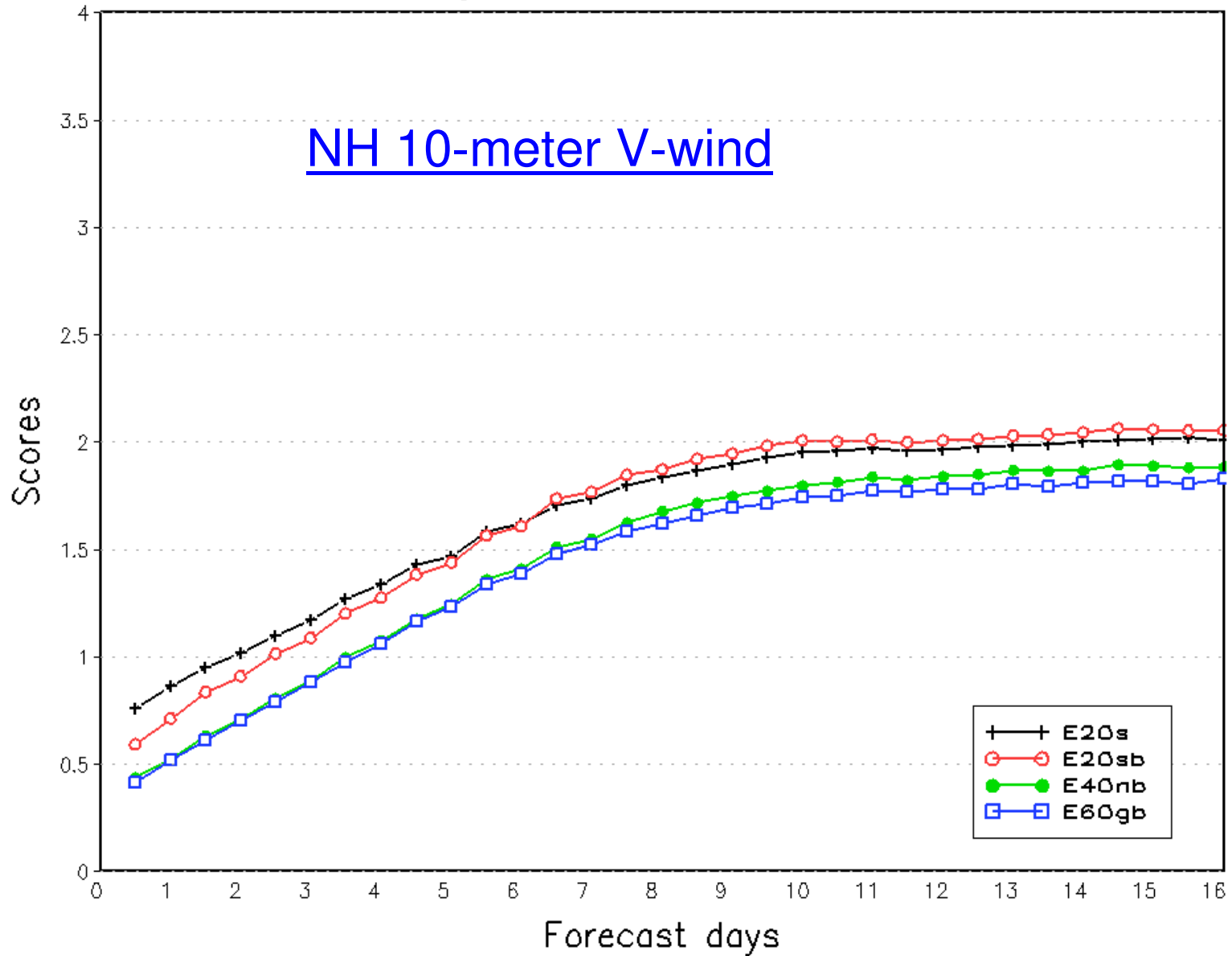
Right: NH 2-meter temperature

Latest results for coming NAEFS upgrade and NUOPC-IOC

Northern Hemisphere 10 Meter U(wind)
Continuous Ranked Probability Scores
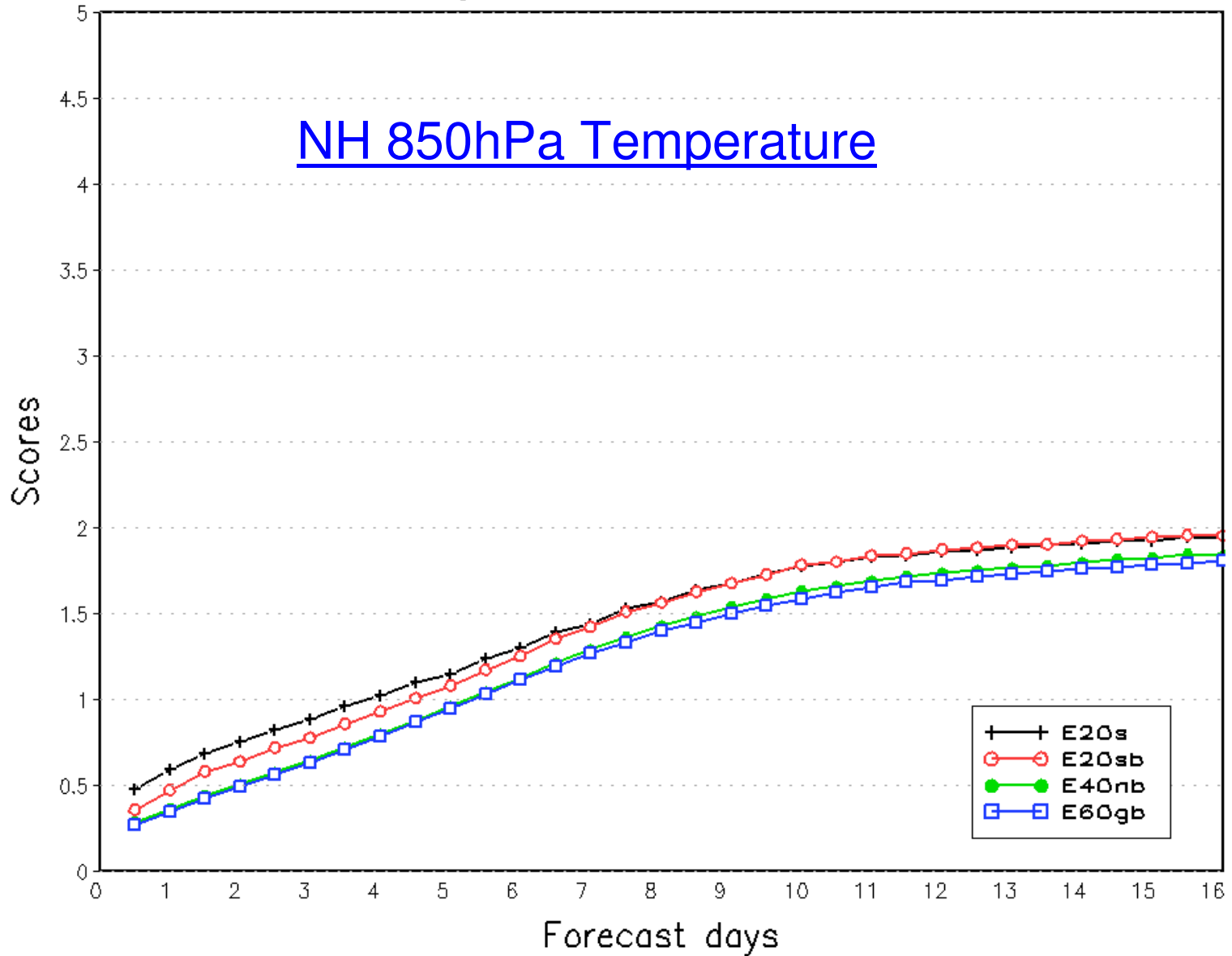Average For 20100901 – 20101023

NH 10-meter U-wind

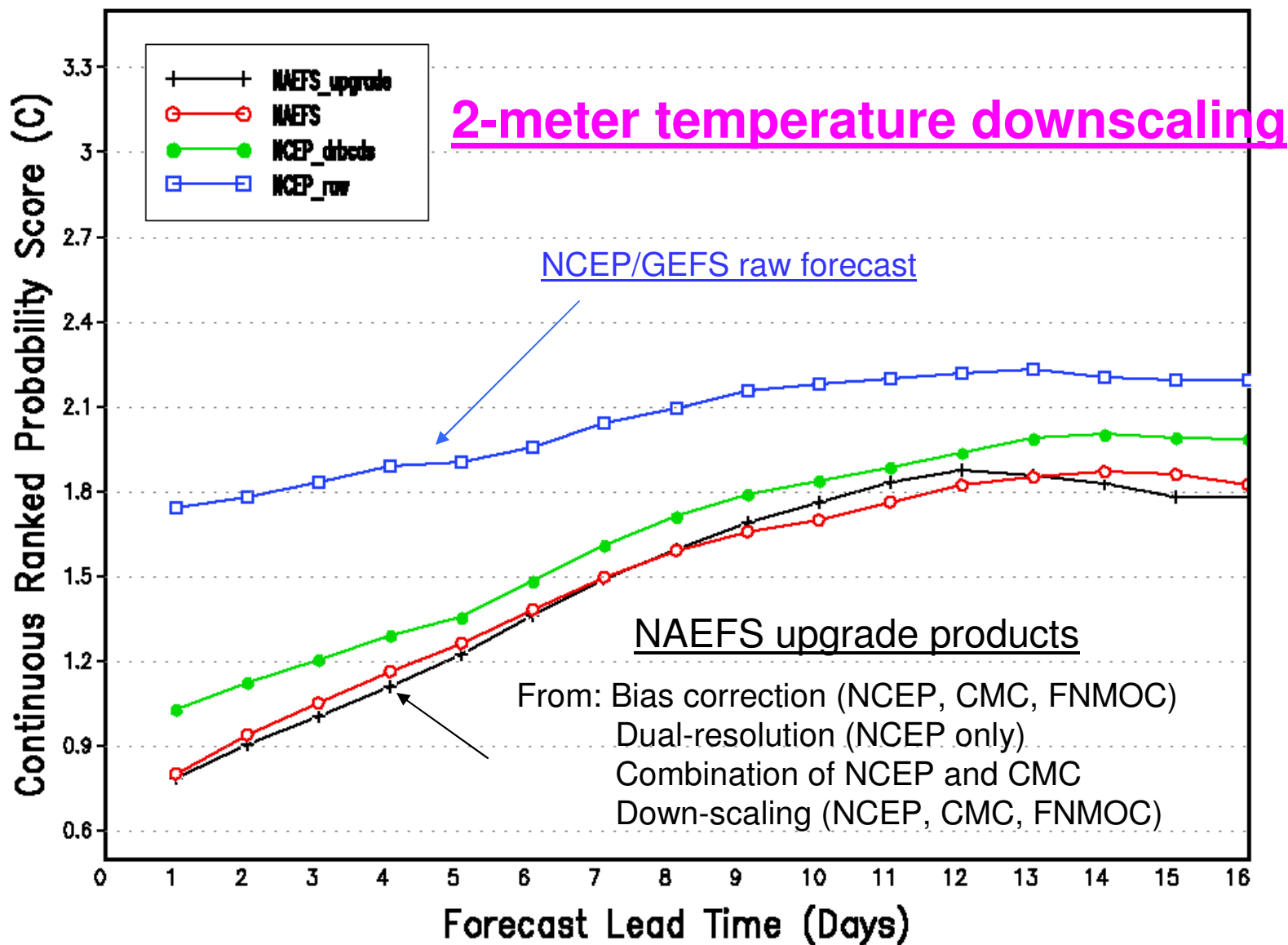Northern Hemisphere 10 Meter V(wind)
Continuous Ranked Probability Scores
Average For 20100901 — 20101023

NH 10-meter V-wind

Northern Hemisphere 850hPa Temp.
Continuous Ranked Probability Scores
Average For 20100901 — 20101023

NH 850hPa Temperature

NAEFS NDGD Probabilistic 2m Temperature
Forecast Verification For 2010092000 – 2010102100

2-meter temperature downscaling

NCEP/GEFS raw forecast

NAEFS upgrade products

From: Bias correction (NCEP, CMC, FNMOC)
Dual-resolution (NCEP only)
Combination of NCEP and CMC
Down-scaling (NCEP, CMC, FNMOC)

BO CUI, GCWMB/EMC/NCEP/NOAA

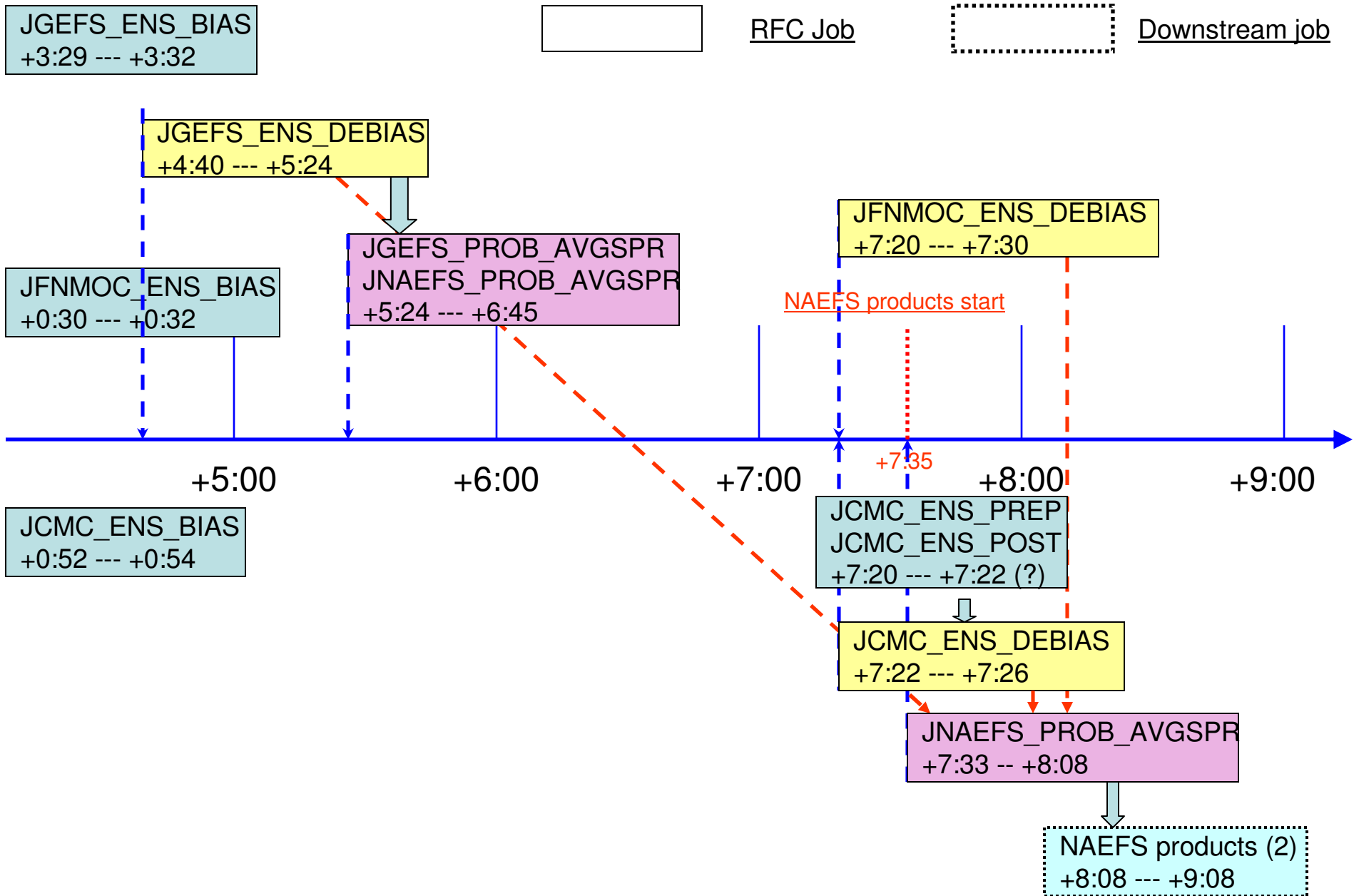# Recommendation for selected FNMOC variables added to NAEFS

- Based on the evaluations of past 45 days (since September 1st 2010)
  - About 45 variables
  - Most of them are insignificant
  - Some of them are degradation
- The conclusions are not solid from the short period evaluations. The performance may change from season to season.
- Select following variables as first try to upgrade NAEFS (for NUOPC IOC)
  - 850 hPa temperature
  - 2-meter temperature
  - 10-meter U
  - 10-meter V
- EMC will keep monitoring a real time evaluations, it may change the recommendation/decision if the performance becomes poor/worse.

Questions behind

- RFCs to NCO (Oct. 25-29)
- CPU/disk space (not a issue)
- Data distributions
  - TIN – has been sent out (10/12/2010)
- Charter – has been updated
- Risk and uncertainty
  - 30-45 days evaluation – short!!!
    - Not able to evaluate for different season
    - FNMOC ensembles are upgraded in past few month
      - 20 members (from 16 members)
      - Out to 16 days (from 10 days) forecast
      - Upgraded data assimilation (early this year)
      - Banded ET for ensemble initialization (May 2010)
    - NCEP GFS upgraded in July 2010
      - GEFS is still using n-1 GFS model, but analysis and ensemble initialization is using new GFS
      - This (analysis, forecast) unbalance needs to be continue studies
    - Not enough data samples for week-2 forecast evaluation
  - CCS maintenance (switch) – big problem
    - Extreme difficulty for EMC to maintain the data for evaluation
    - Disk space problem

Participate Evaluations

- HPC – probabilistic forecast for T2m (mainly)
  - 10%, 50%, 90%, mean and mode at 1 degree
  - 10%, 50%, 90%, mean and mode at 5km (CONUS) - Dave Novak's team
  - No change for precipitations
- CPC
  - Week-2 temperature anomaly forecast from NAEFS (Dave Unger and Dan Collins)
- OPC
  - 10-meter winds
- SPC
  - Not sure they will participate or not
- TPC
  - Not affect tracks, but 10-meter winds
- WFO?

NAEFS/NUOPC 6-hr window flow chart

JGEFS_ENS_BIAS
+3:29 --- +3:32

RFC Job

Downstream job

JGEFS_ENS_DEBIAS
+4:40 --- +5:24

JFNMOC_ENS_DEBIAS
+7:20 --- +7:30

JGEFS_PROB_AVGSPR
JNAEFS_PROB_AVGSPR
+5:24 --- +6:45

NAEFS products start

JFNMOC_ENS_BIAS
+0:30 --- +0:32

+7:35

+5:00   +6:00   +7:00   +8:00   +9:00

JCMC_ENS_BIAS
+0:52 --- +0:54

JCMC_ENS_PREP
JCMC_ENS_POST
+7:20 --- +7:22 (?)

JCMC_ENS_DEBIAS
+7:22 --- +7:26

JNAEFS_PROB_AVGSPR
+7:33 -- +8:08

NAEFS products (2)
+8:08 --- +9:08

22