UEO Committee

Co-chairs: Chuck Skupniewicz & Yuejian Zhu

May 2017

Dave McCarren

Current NUE Model Configurations

(Upgrade)	NCEP	CMC	FNMOC
Model	GFS	GEM	NAVGEM v1.4.1
Initial Uncertainty	EnKF (F06)	EnKF	2-layer, 9-band ET with analysis error adjustments
Model Uncertainty/ Stochastic	Yes (Stochastic Pert)	Yes (multi-physics and Stochastic)	SKEB with moisture convergence mask
Tropical Cyclone	Relocation for Named Storms	None	None
Daily Frequency	00, 06, 12, 18 UTC	00, 12 UTC	00, 12 UTC
Resolution	T_L574L64 (35km) / d0-8 T_L382L64 (52km) / d9-16	800x400L72 (50km)	T359L60 (37km)
Control	Yes	Yes	Yes
Ensemble Members	20 for each cycle	20 for each cycle	20 for each cycle
Forecast Length	16 days	16 days 32 days once/week	16 days
Post-Process	Bias correction for ensemble mean	Bias correction for each member	Bias correct each member Based on ensemble mean
Implementation Start / End	December 2, 2015 ------ Present ------	November 18, 2014 ------- Present -------	March 1, 2017 ------- Present -------

Planned Upgrades to NUE Baseline

	2017/18	Future (to ~5 yrs)
NCEP	- T574L64 SL model - GEFS (day 0-16) - Introduce additional stochastic scheme to improve forecast uncertainty and reliability - 20 years GEFS hindcast (reforecast), 5 members, 00UTC only for every 5 days	- T1148/L64 (17km) SL; 0-10days (17km); 10-35days (34km) - Coupled ocean - Perturbed land surface - Extended range (out to 35 days) forecast - Bias correction for model variables
FNMOC	- NAVGEM T359L60 Ensemble - SST initial perturbations - Simple SST diurnal cycle model - NAVGEM 2.0	Increased resolution (TBD) as resources permit - Coupled to HYCOM
CMC	- GEPS Feb 2018 - Resolution: 35km, L80 - 16 days and 32 days, 20 members, 4 runs per day - 8 assimilation cycles per day - Coupled with ocean (25km, L75) in forecast mode	- GEPS Feb 2020 - Resolution 25km , L120 - 16 and 32 days, 20 members, 4 runs perday - Coupled with ocean (25km, L75) in forecast and Data Assimilation

NAEFS Global Grid Exchange Variables for 1°

Update: June 2013

Variables	Levels and Categories	Total 80
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
PRES	Surface, PRMSL	2
PRCP	APCP, CRAIN, CSNOW, CFRZR, CICEP	5
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6
FLUX (top)	ULWRF (OLR)	1
PWAT	Total precipitable water at atmospheric column	1
TCDC	Total cloud cover at atmospheric column	1
CAPE	Convective available potential energy, Convective Inhibition	2
SOIL/SNOW	SOILW(0-10cm) , TMP(0-10cm down), WEASD(water equiv. of accum. Snow depth), SNOD(surface)	4
Other	850 hPa vertical velocity	1
Notes	Current NAEFS grids at 1*1 degree	

NAEFS Global Grid Exchange Variables for 0.5°

Update: 8 August 2016

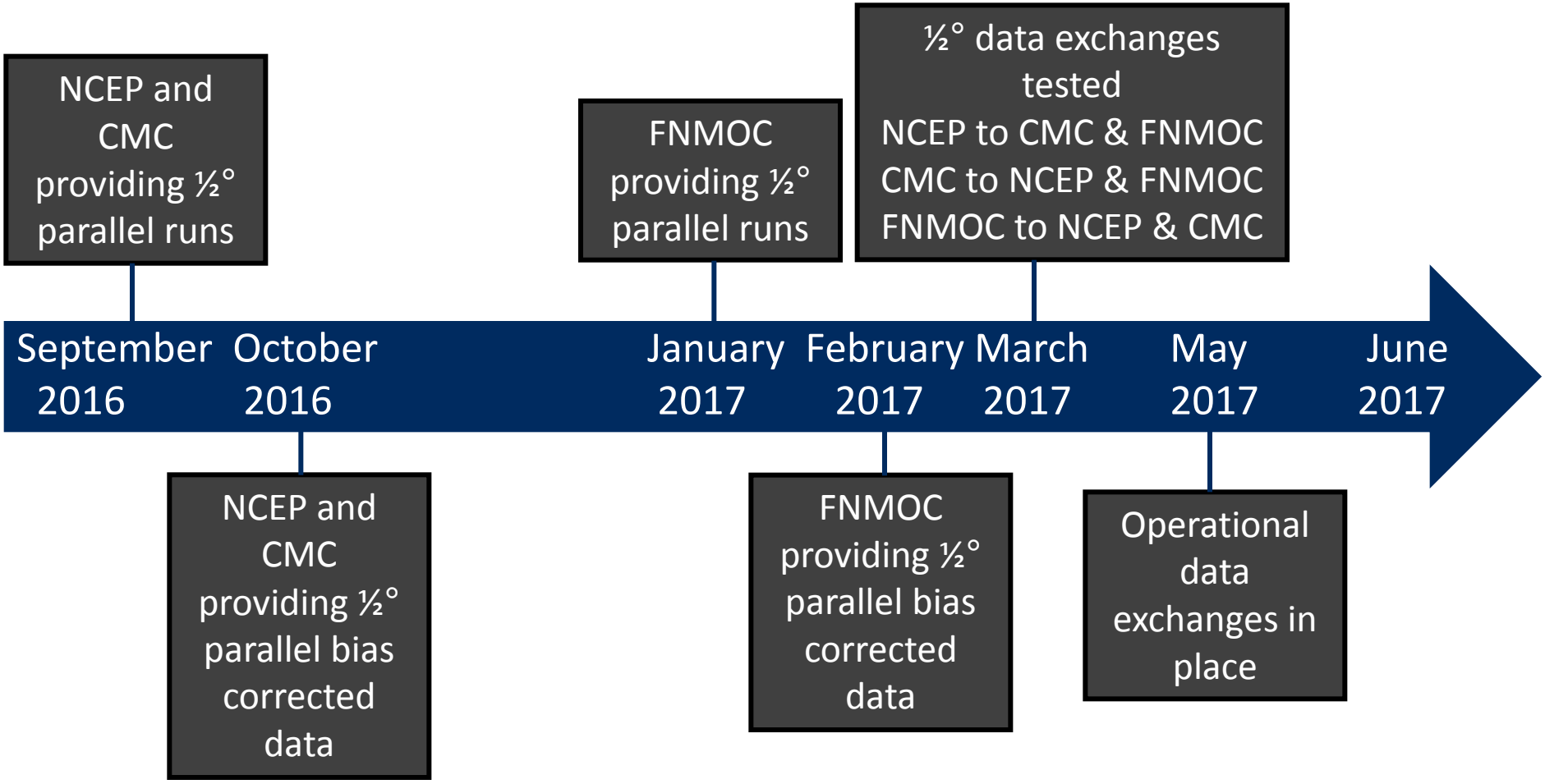
Variables	Levels and Categories	Total 86/43
GHT	Surface, 10, 50, 100, 200, 250, 300, 500, 700, 850, 925, 1000 hPa	12/(5)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13/(6)
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(4)
UGRD	10m, 10, 50, 100, 200, 250, 300, 400, 500, 700, 850, 925, 1000 hPa	13/(8)
VGRD	10m, 10, 50, 100, 200, 250, 300, 400, 500, 700, 850, 925, 1000 hPa	13/(8)
PRES	Surface, PRMSL	2/(2)
PRCP	APCP, CRAIN, CSNOW, CFRZR, CICEP	5/(5)
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6/(0)
FLUX (top)	ULWRF (OLR)	1/(0)
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/(0)
Other	850 hPa vertical velocity, Ice thickness (ICETK)	2/(1)
Notes	Current NAEFS grids at 1*1 degree New 0.5 degree fields already exchanged at 1 degree New 0.5 degree added from users request	

0.5° NAEFS/NUOPC Data Exchange to NCEP Implementation

Date	Activity	NCEP	CMC	FNMOC	Note (3/10/2017)
7/21/2016	Initiated discussion with NCO	Yes			
8/15/2016	Request NCO to archive GEFS 0.5d to 2-y run-history	prod			Approved: 7/25/2016 NCO: 10/18/2016
8/15/2016*1	Deliver codes (1st) to NCO for re-organizing pgrb2ap5 and pgrb2bp5	EMC			NCO needs to start set up NAEFS para mode - done
9/15/2016	Start to exchange raw data	NCO/para	Y		NCO: to CMC - 9/19/2016 NCO: from CMC – 10/16/2016
1/17/2017	Deliver codes (2nd) to NCO for generating bias corrected data	EMC			Delayed, and change plan, NCO will not run parallel for EMC
2/28/2017	Start to exchange bias corrected data	EMC & NCO /para	Y		One month delay: End of Feb, will start exchange
5/15/2017	EMC/NCO CCB	Yes			Pending on approving
5/15/2017	Deliver codes (final) to NCO for implementation	EMC			
1/15/2017	Start to receive FNMOC raw forecast	NCO/para		Y	FNMOC plan to send 0.5d raw forecast
6/15/2017	Issue TIN	NCO			
2/14/2017	Start to receive FNMOC bc forecast	NCO/para		Y	FNMOC plan to send 0.5d bc forecast
6/15/2017	Real-time parallel (evaluation)	NCO			
8/20/2017	Briefing to NCEP director	NCO/EMC			
8/27/2017	Implementation	NCO			

*1: delayed due to upstream master files availability, need extra GEFS upgrade (updated on 09/14/2016)

Half Degree Timeline



Output Size Comparison NAEFS prod vs. NAEFS v6

Update: 15 September 2016

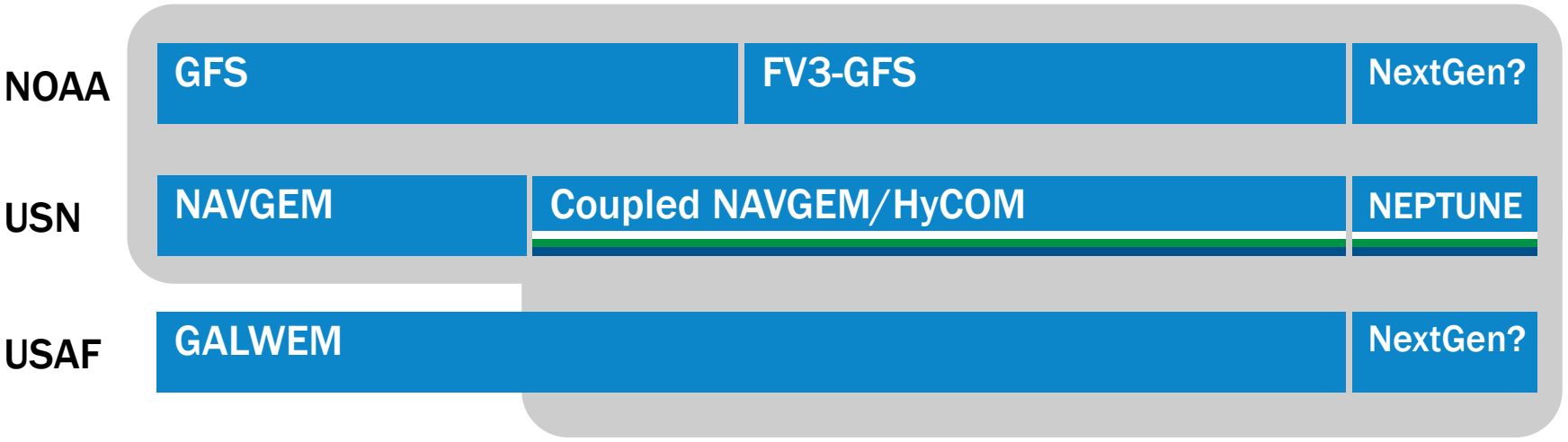
NAEFS Prod

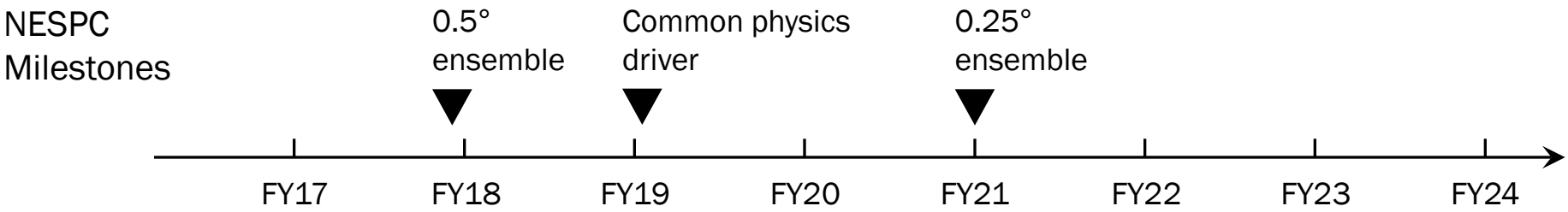
- NCEP/GEFS
  - 1.0d bias corrected forecasts (6 hourly, pgrb2a_bc, 4.8GB)
  - 1.0d anomaly forecast (pgrb2a_an, 2GB)
- CMC
  - 1.0d raw forecast (pgrb2a, 4.2GB)
  - 1.0d bias corrected forecast (/dcom, 3GB)
- FNMOC
  - 1.0d raw forecast (pgrb2a, 4.2GB)
  - 1.0d bias corrected forecast (/dcom, 3GB)
- NAEFS
  - 1.0d probabilistic forecasts (pgrb2a_bc, 944MB)
  - 1.0d anomaly forecast (pgrb2a_an, 69M)

NAEFS v6

- NCEP/GEFS
  - 0.5d bias corrected forecasts (3 hourly for day 8, new pgrb2ap5_bc, 22GB)
  - 0.5d anomaly forecast (new pgrb2ap5_an, 10GB)
  - 0.5d bias corrected prcp (prcp_gb2, 1GB)
  - 2.5km bias corrected and downscaled prcp for CONUS (new ndgd_prcp_gb2, 1GB)
- CMC
  - 0.5d raw forecast (new pgrb2ap5, 28GB)
  - 0.5d bias corrected forecast (/dcom, 21GB)
- FNMOC
  - 0.5d raw forecast (new pgrb2ap5, 28GB)
  - 0.5d bias corrected forecast (/dcom, 21GB)
- NAEFS
  - 0.5d probabilistic forecasts (new pgrb2ap5_bc, 4GB)
  - 0.5d anomaly forecast (new pgrb2ap5_an, 1GB)

SYNOPTIC





Atmospheric Models

- Operational
- Research

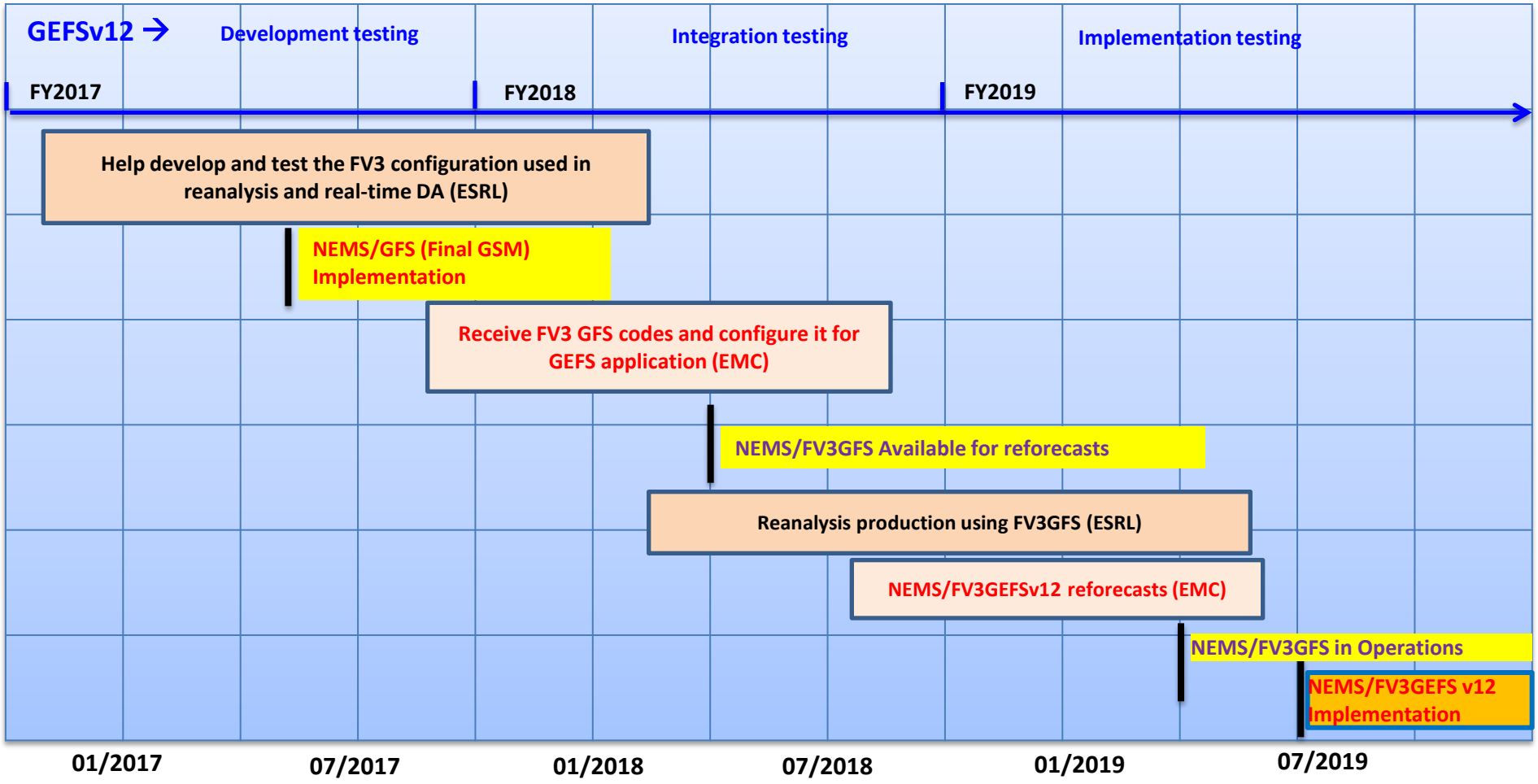
Earth system models (atmosphere-ocean-land-ice)

- Operational
- Research

24 February ESG Action Items

- **AI #1: National ESPC Charter amendment**
  - ESG will be organizationally aligned under FCMSSR paragraph; Amend the charter to reflect this new structure;
  - All Agencies have signed but NSF
- **AI #10: Formalize Temporary HPC Working Group**
  - Brief FCMSSR and ICMSSR
  - Response to NSF RFI
  - Brief Dr. Barb Helland
  - Publish a 3-4 page paper
- **AI #11: Program Manager's Workshop**
  - Staff working with Dr. Harr
  - Waiting on outcomes of ICMSSR, FCMSSR, and climate modeling summit

FV3 based GEFS v12 plan (proposed) with reanalysis and reforecast

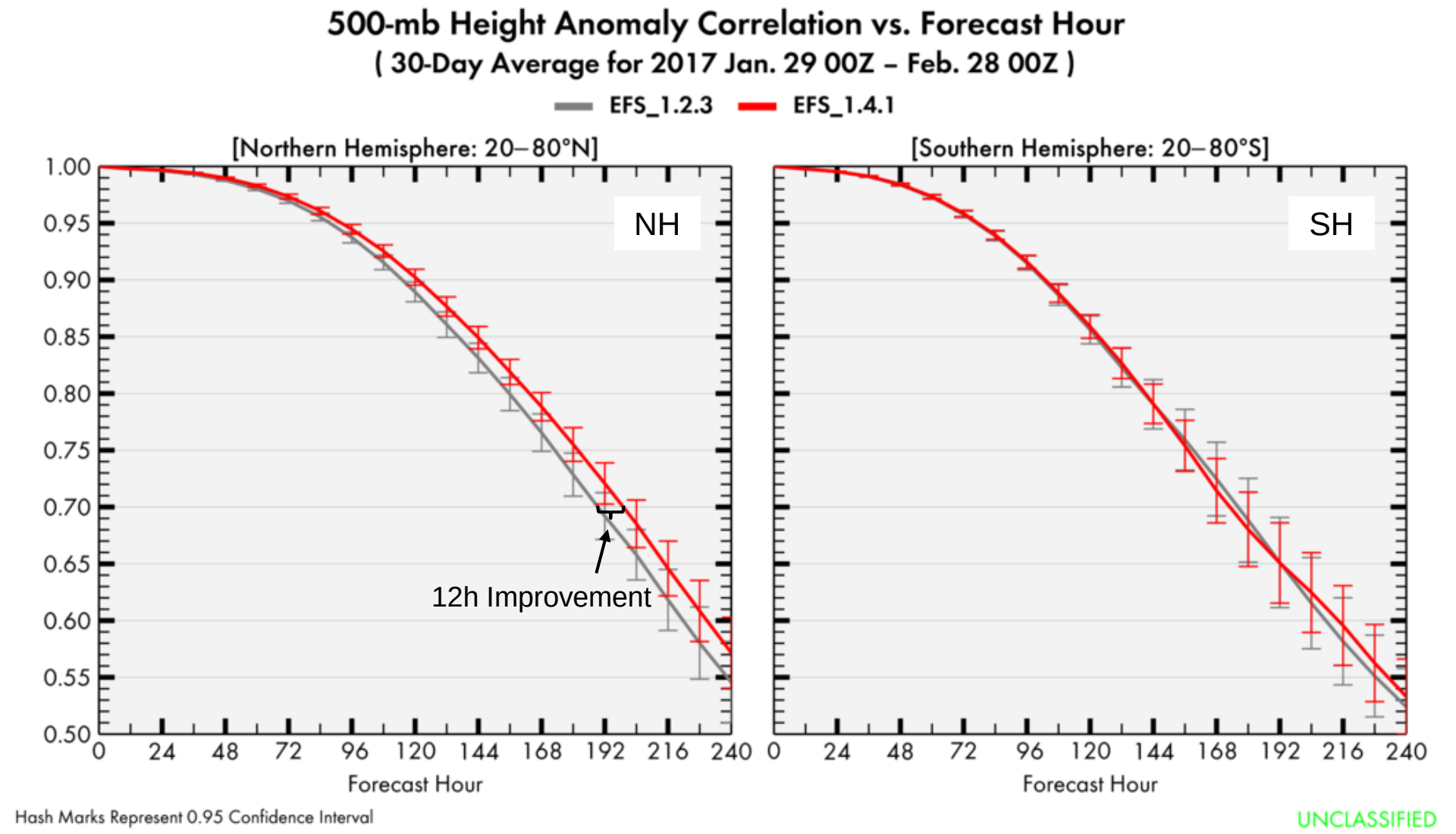


Proposed changes: 1) Start producing FV3-based reanalysis for GEFS v12 in ~Q1 FY18, using the configuration of FV3GFS. 2) Reforecasts will commence soon after starting the reanalysis, uncoupled*, with 2-tier SST approach, and will include extension to 35 days

FNMOC NUOPC Verification

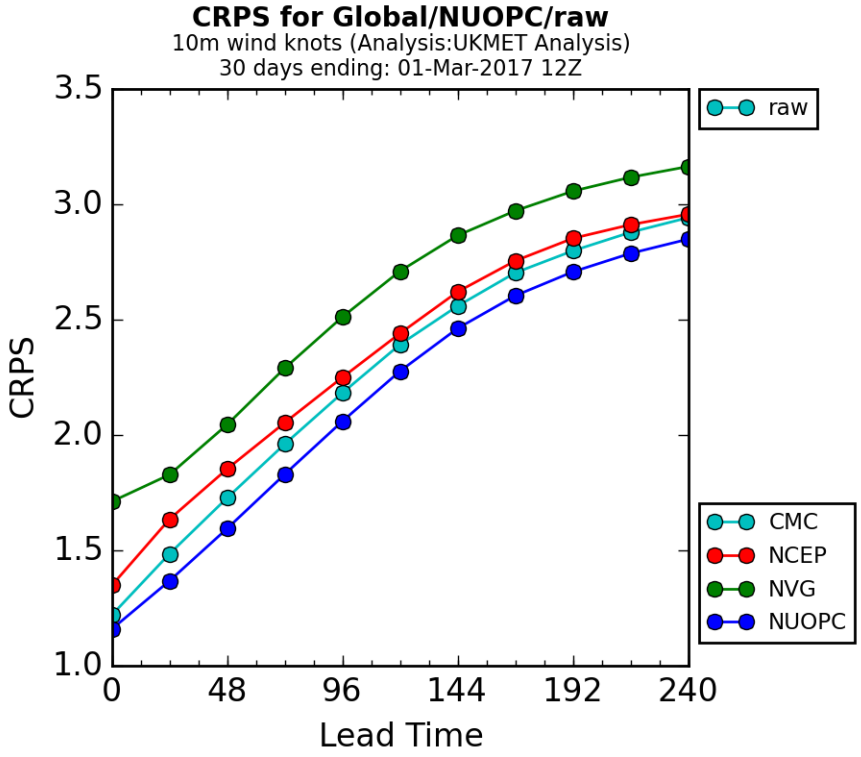
- NAVGEM Ensemble Upgrade V1.4.1
  - 500 hPa AC
  - Winds
  - Waves
  - Clouds

500mb Height

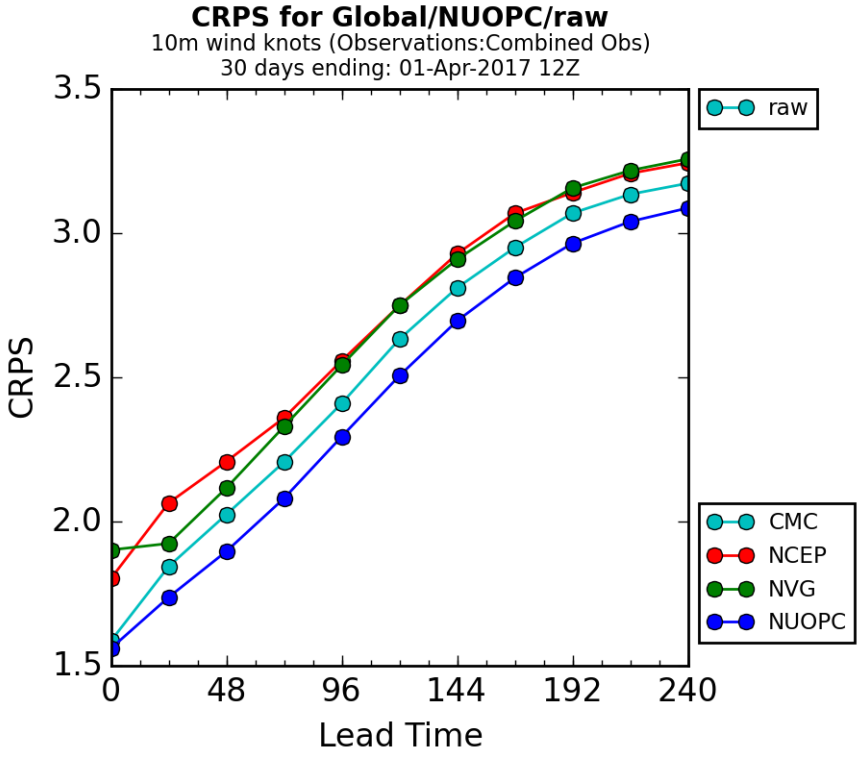


UNCLASSIFIED

10 m Winds

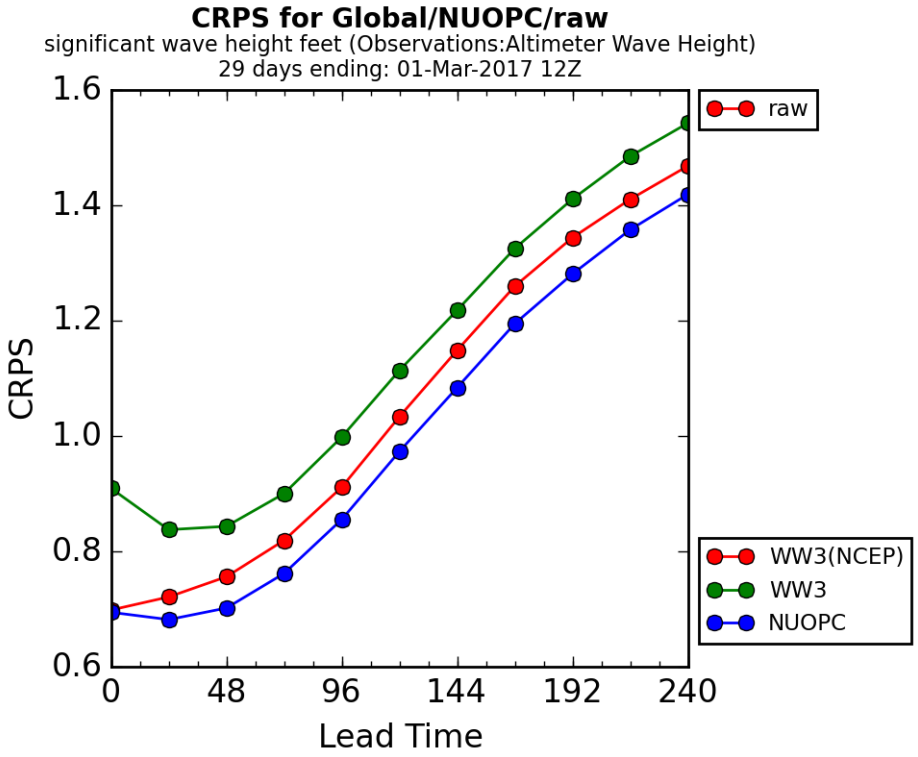


Before NAVGEM 1.4.1

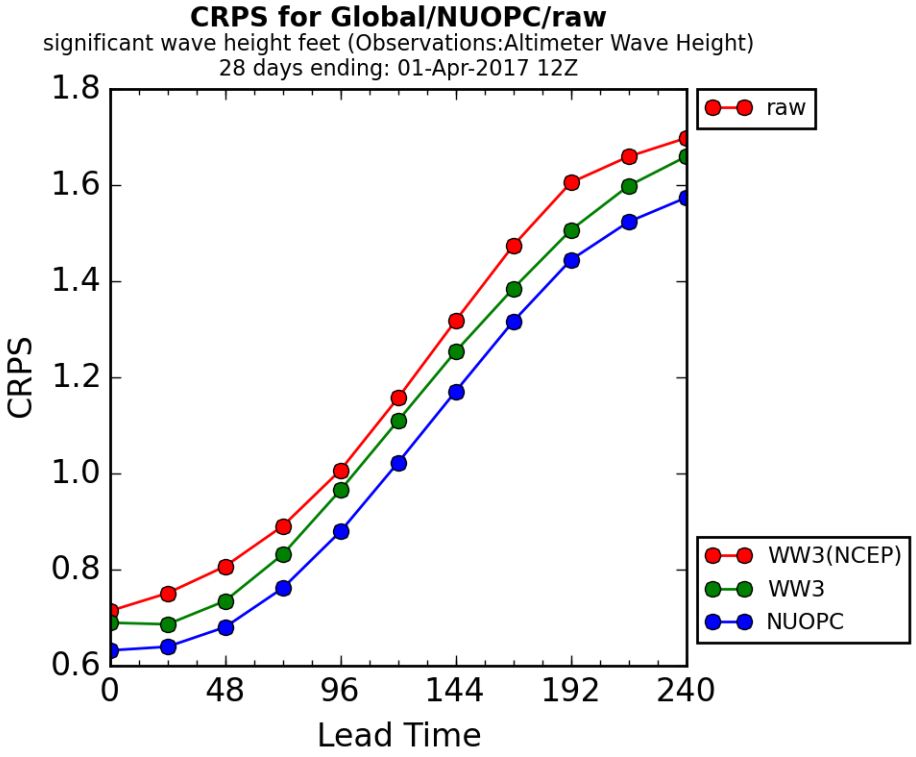


After NAVGEM 1.4.1

Significant Wave Height

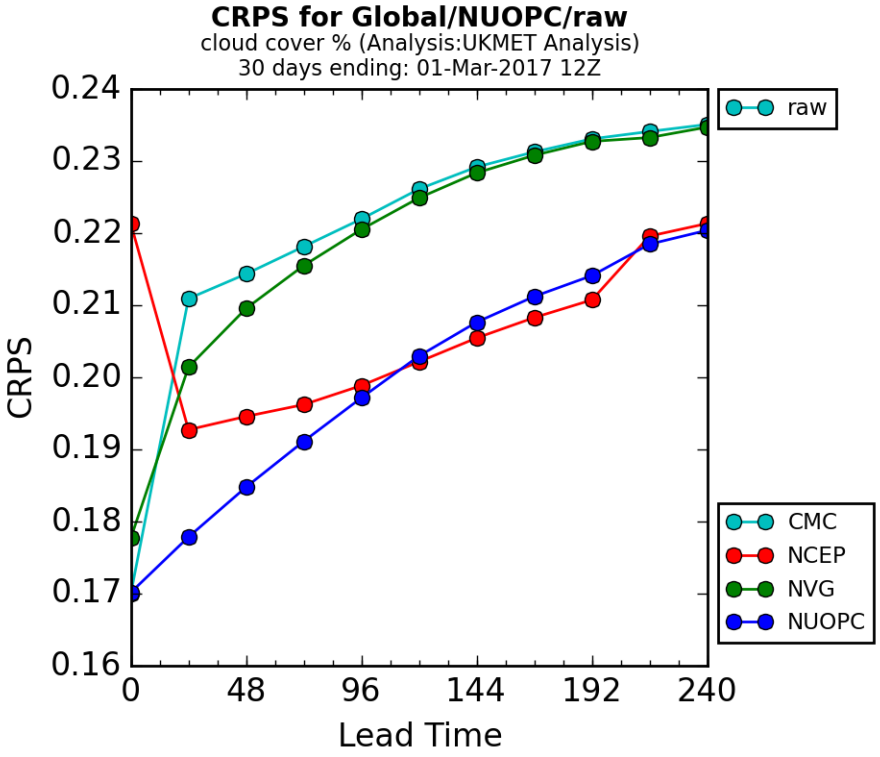


Before NAVGEM 1.4.1

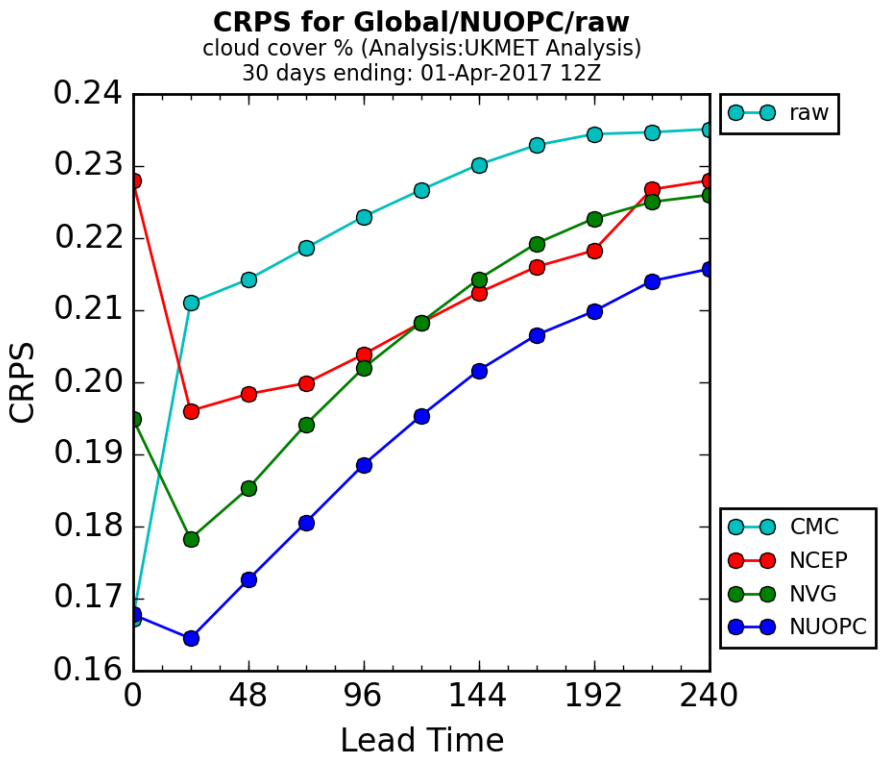


After NAVGEM 1.4.1

Cloud Cover



Before NAVGEM 1.4.1



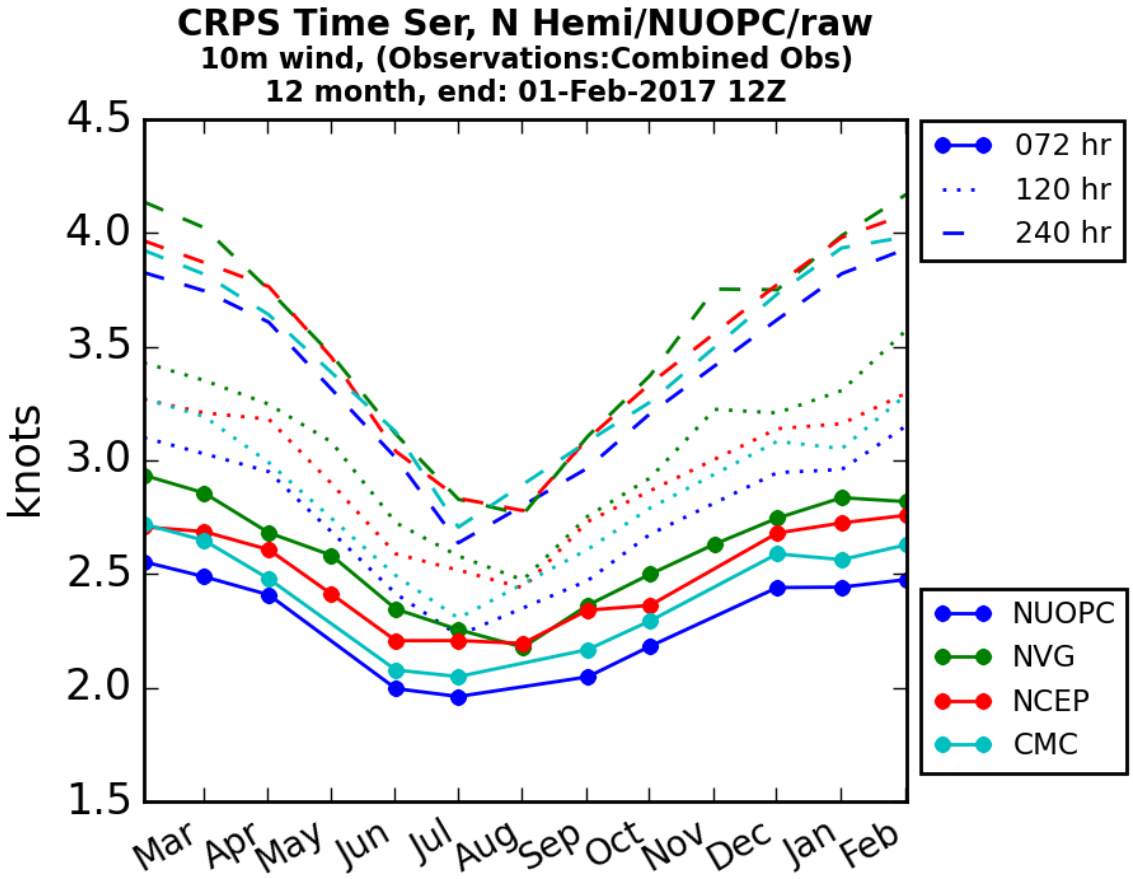
After NAVGEM 1.4.1

Navy Global Ensemble Plans

- Plans
  - NAVEFS v1.4.1 (T359L60) [3QFY17]
    - Exchange 0.5-deg grids with NCEP and CMC
    - Category based bias correction for winds/waves
  - Transition wind/waves user products to bias corrected [FY17]
  - Develop (2004-present) reforecast system [FY17]
  - Develop reforecast products (anomalies, calibration) [FY17/18]
  - NAVEFS v1.4.1+ (T359L60) [FY18]
    - Simple SST diurnal cycle model
    - SST analysis perturbation capability
  - Earth System Prediction Capability IOC [FY19]

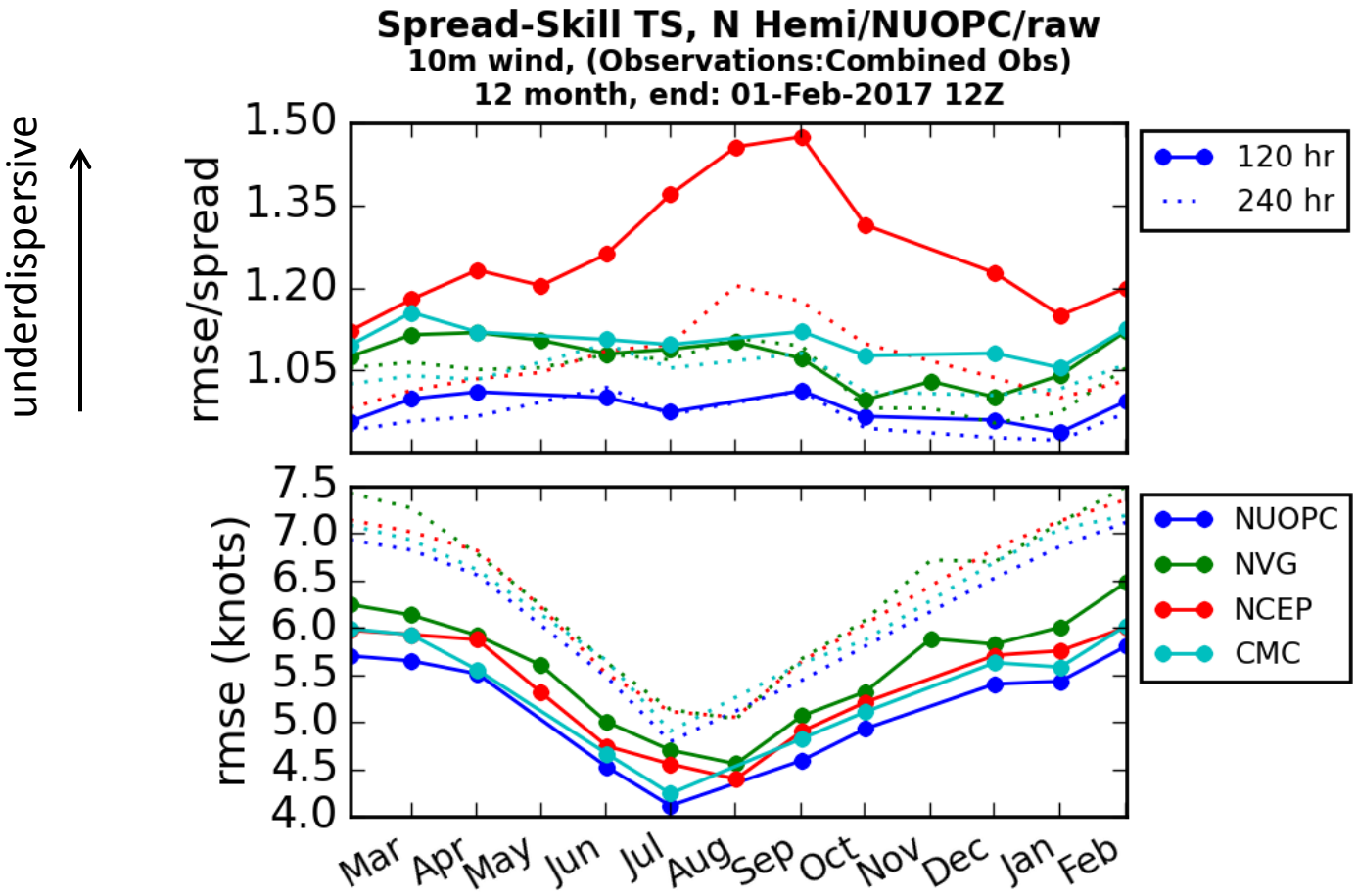
FNMOC

CRPS – 10 Meter Winds



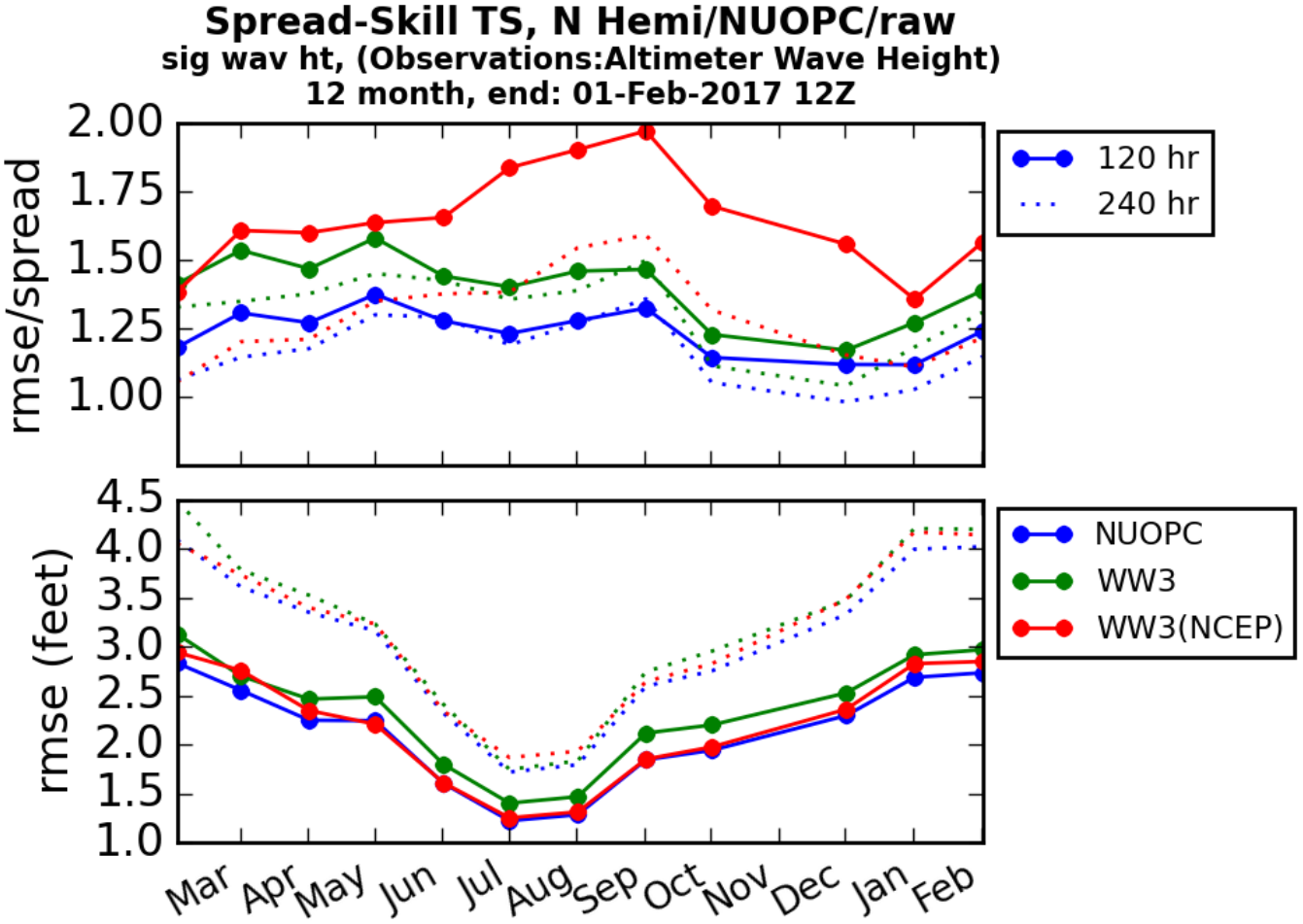
* Continuous Ranked Probability Score (CRPS) is analogous to mean absolute error for a deterministic model
* Verified against ships, buoys, ASCAT, SSMI, and land surface wind observations

Spread and Skill – 10 Meter Winds



* NUOPC has best skill and best spread ratio.

Spread and Skill – Sig Wave Height



CMC Waves Coming Soon!

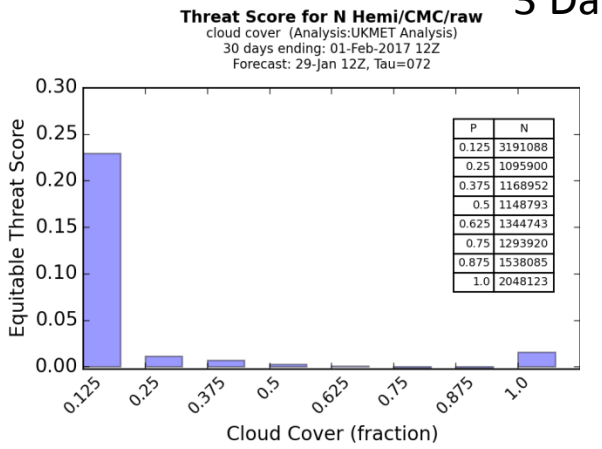
* For waves, NUOPC does not increase skill as much as for winds.
* Still, NUOPC improves spread ratio.

Cloud Cover - Equitable Threat Score

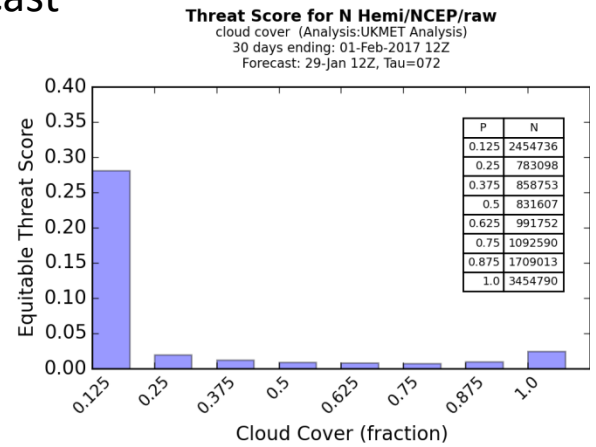
3 Day Forecast

verified against UKMET

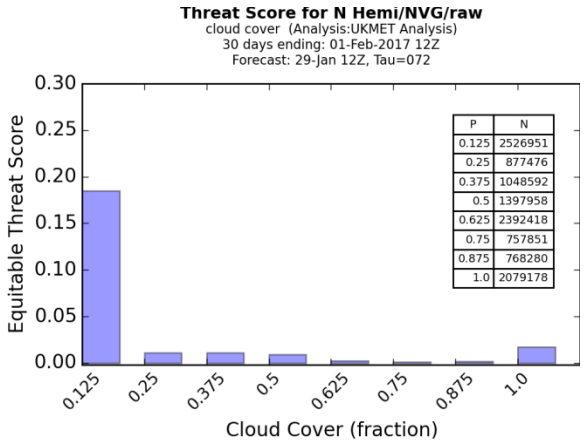
CMC



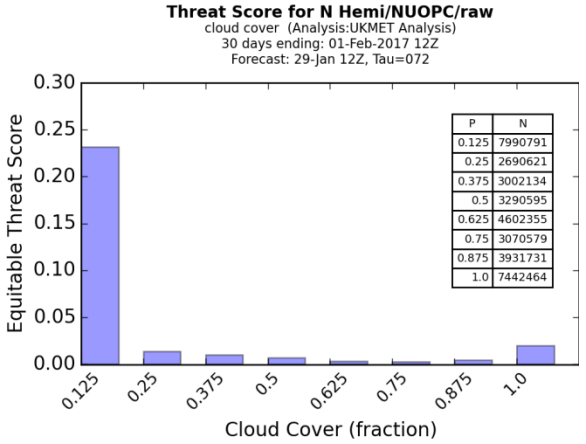
NCEP



NAVY



NUOPC



* NCEP is best, even against NUOPC.
* Note: Not surprisingly, all models do poorly for mean cloud cover and lose all skill after about 5 days. (not shown)

Some Generalizations, and Caveats

- As measured by CRPS, NUOPC skill is greater than all three individual Center's scores for most parameters.

- NUOPC usually adds needed spread to the ensemble distribution.

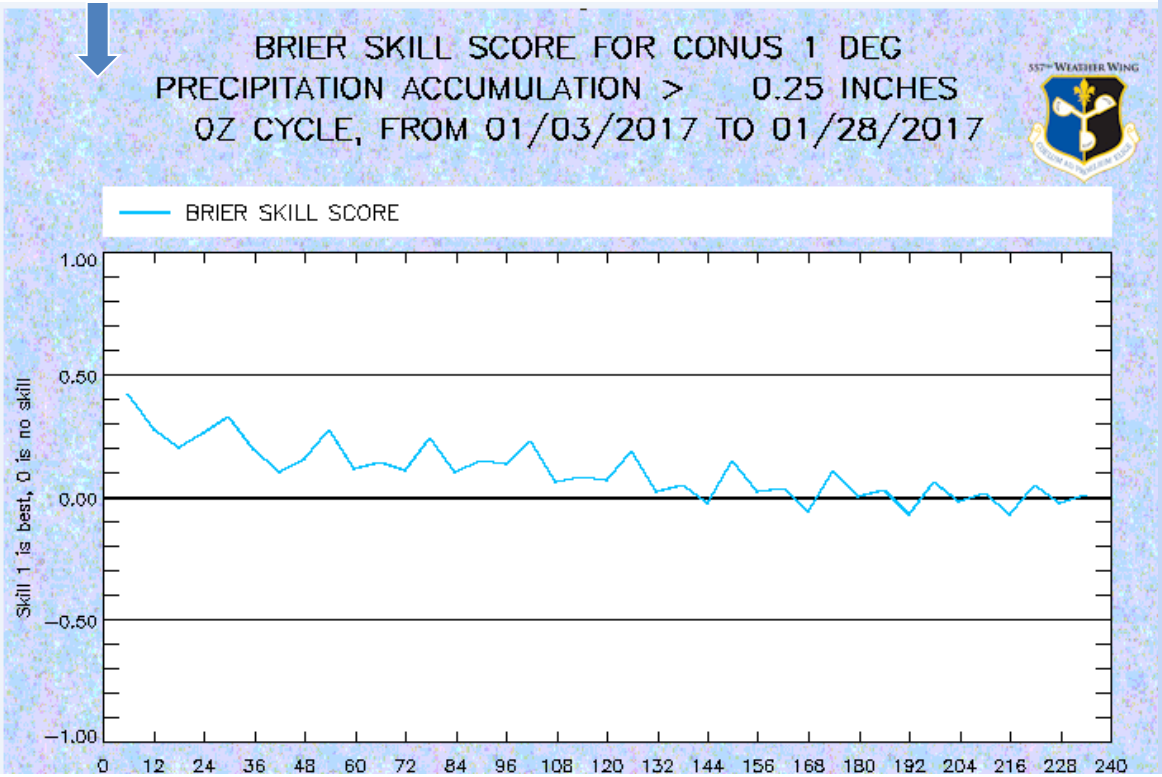
- For mean cloud cover, multi-model ensembles like NUOPC may not be the best approach. Need to assess probabilistic products for clouds.

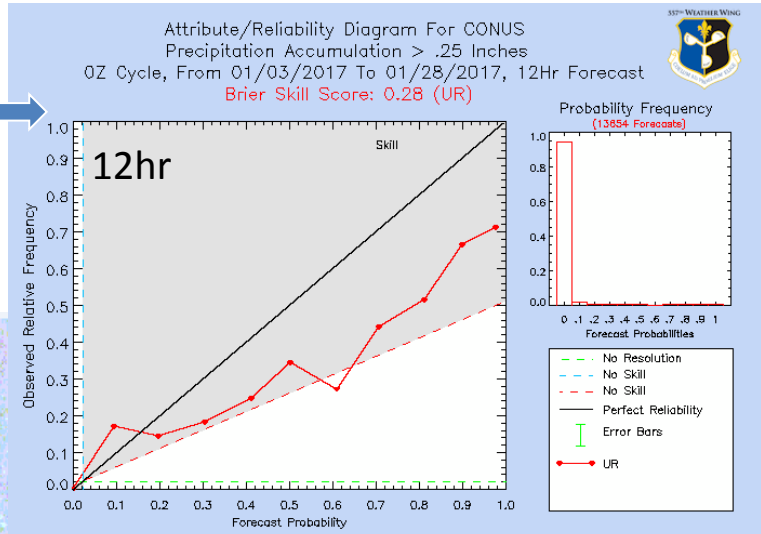
557th Wx Wing

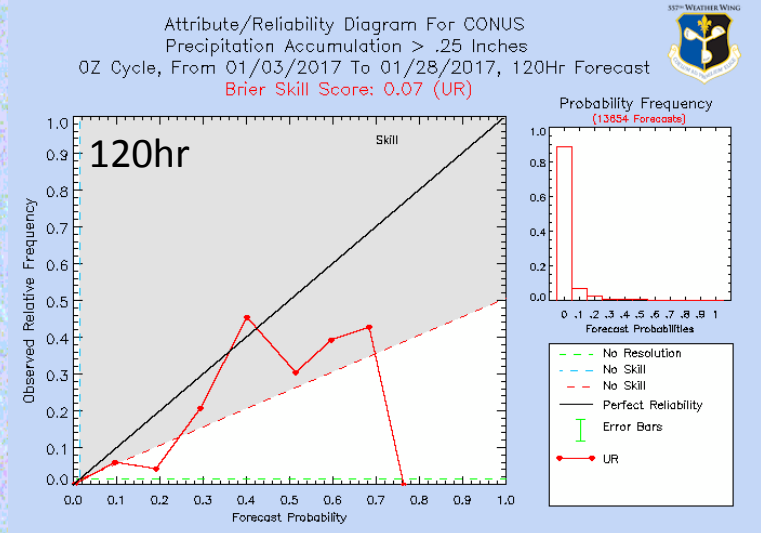
CONUS
Precip Accum > .25”

GEPS is over-forecasting the probability of precipitation > .25”

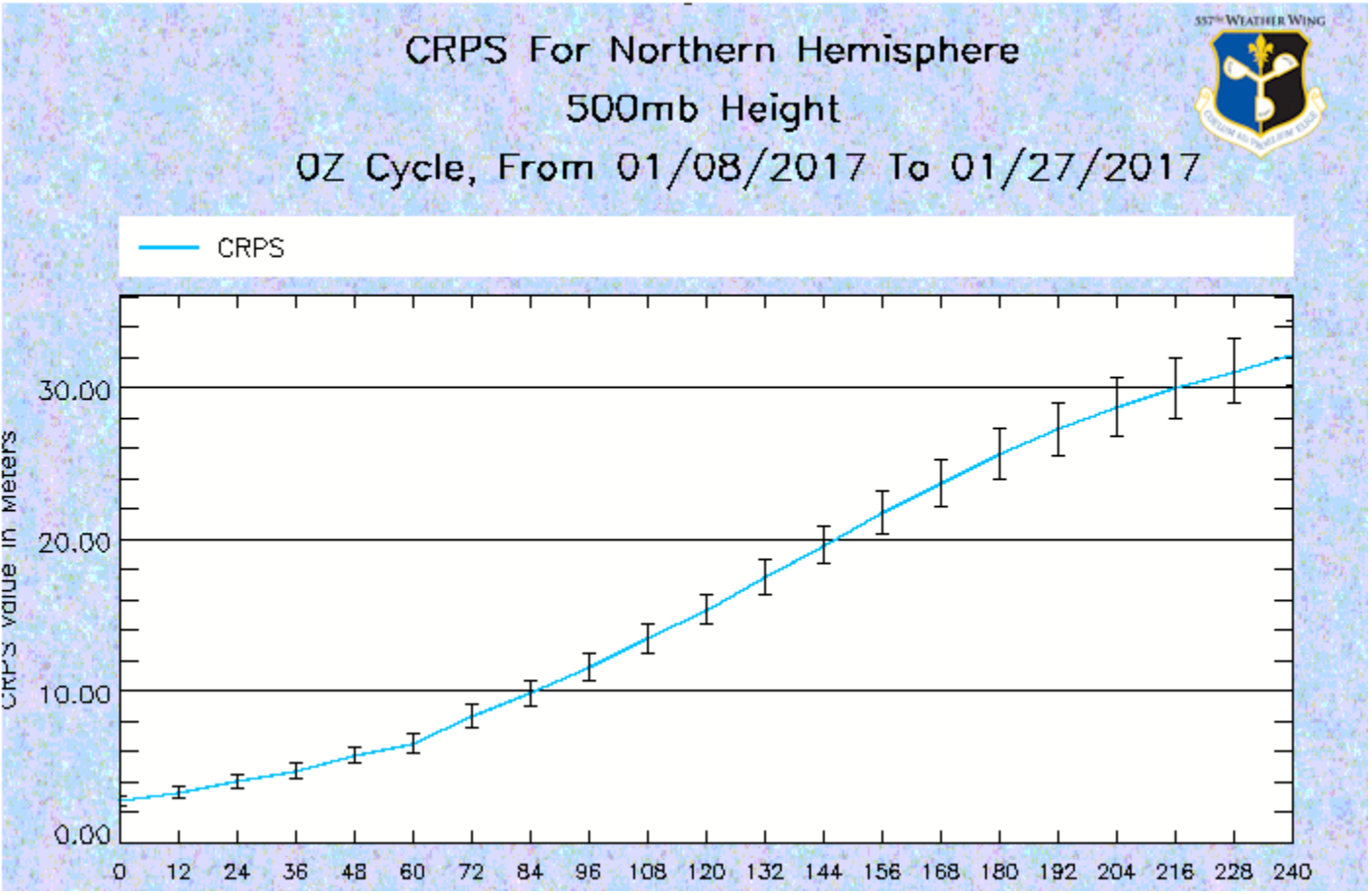
Skill indicated out to about 120hrs – Late afternoon forecasts have the highest skill





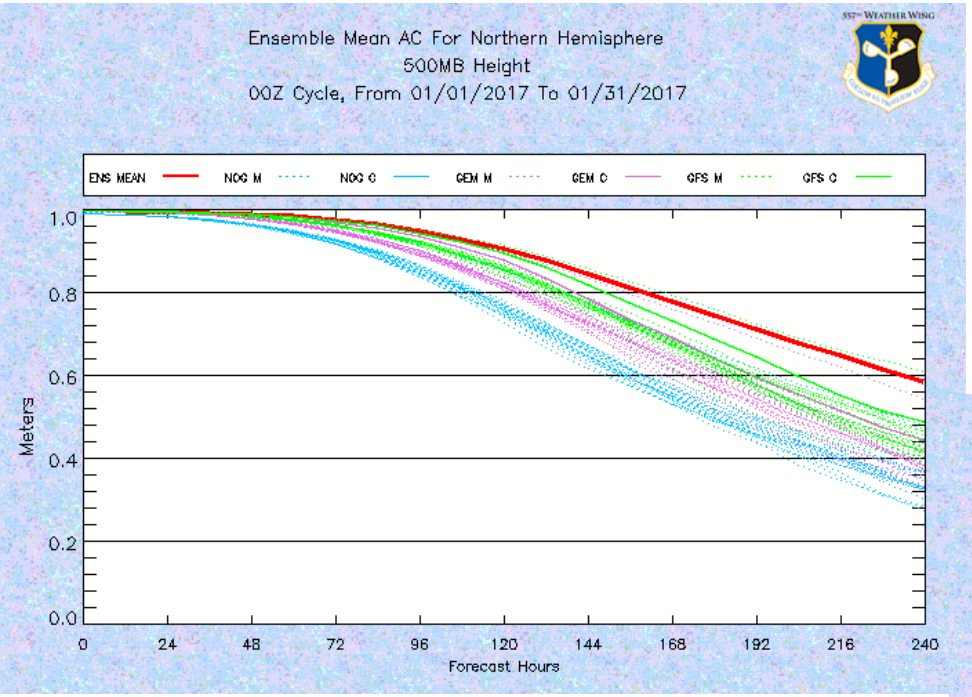


Northern Hemisphere CRPS 500mb Height

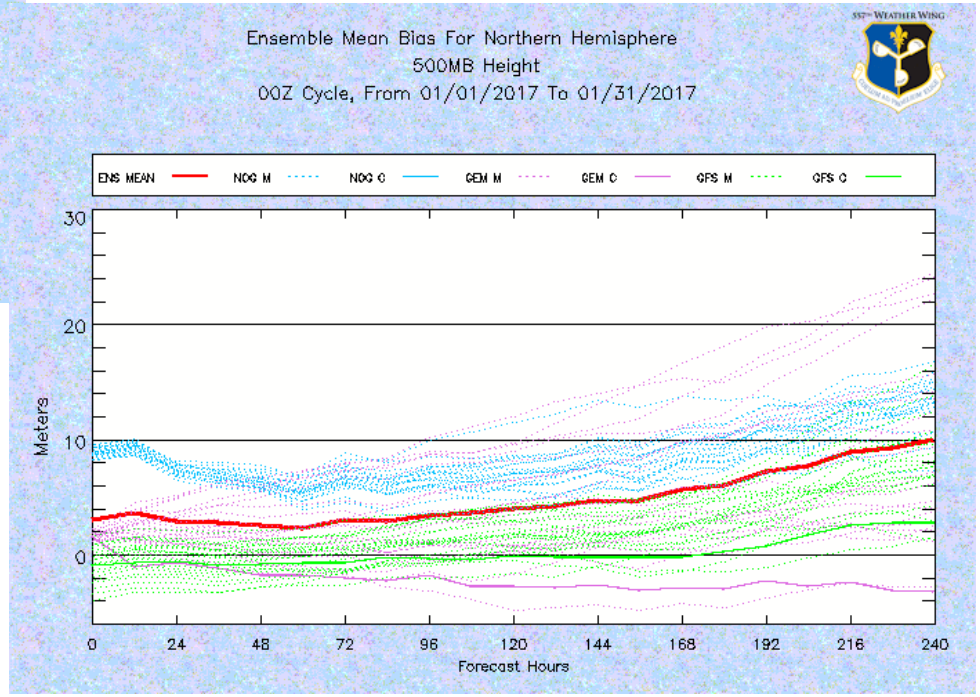


CRPS errors seem to grow a little faster after 60 hr forecast

Northern Hemisphere Ensemble Mean 500mb HGT

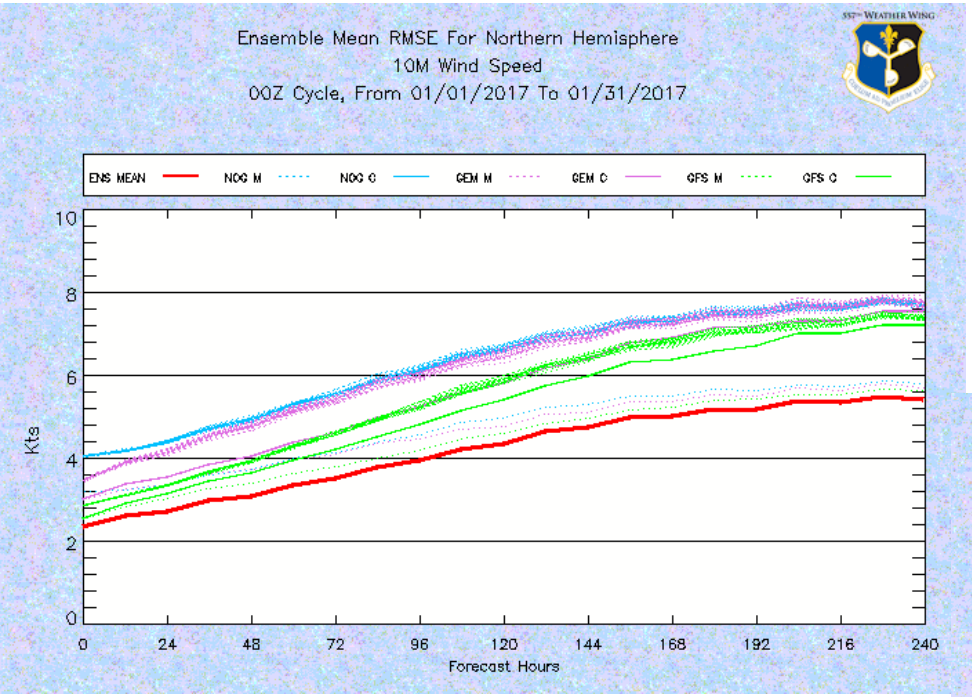


Anomaly Correlation (AC) – GFS members have the highest AC and NAVGEM members have the lowest

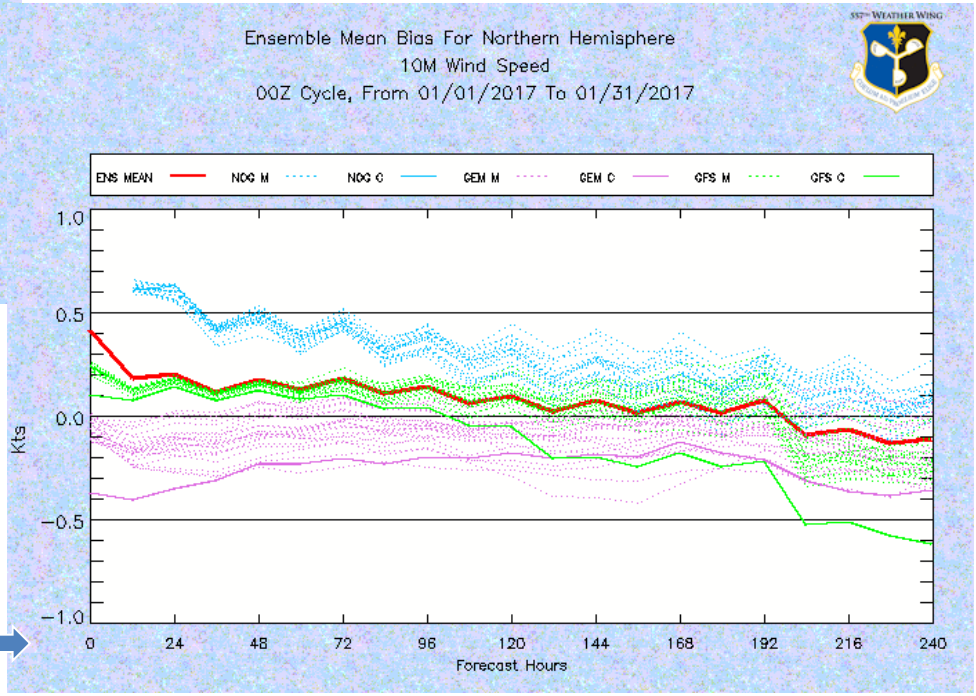


Bias – The ensemble mean has a positive bias and the GEM members seem to have the largest spread

Northern Hemisphere Ensemble Mean 10 Meter Winds

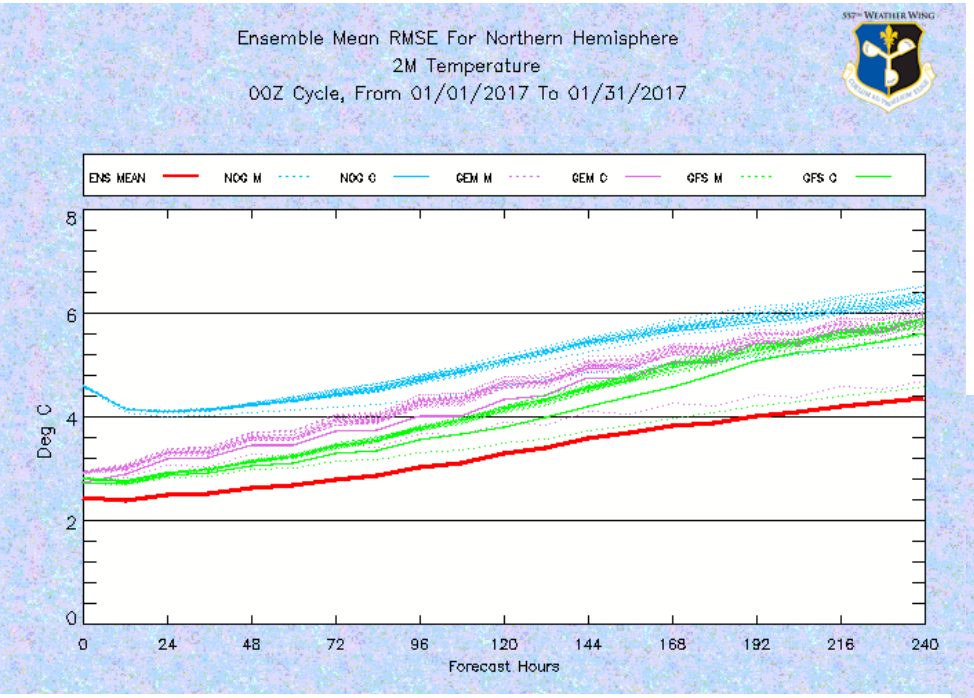


RMSE – GFS members have the lowest error

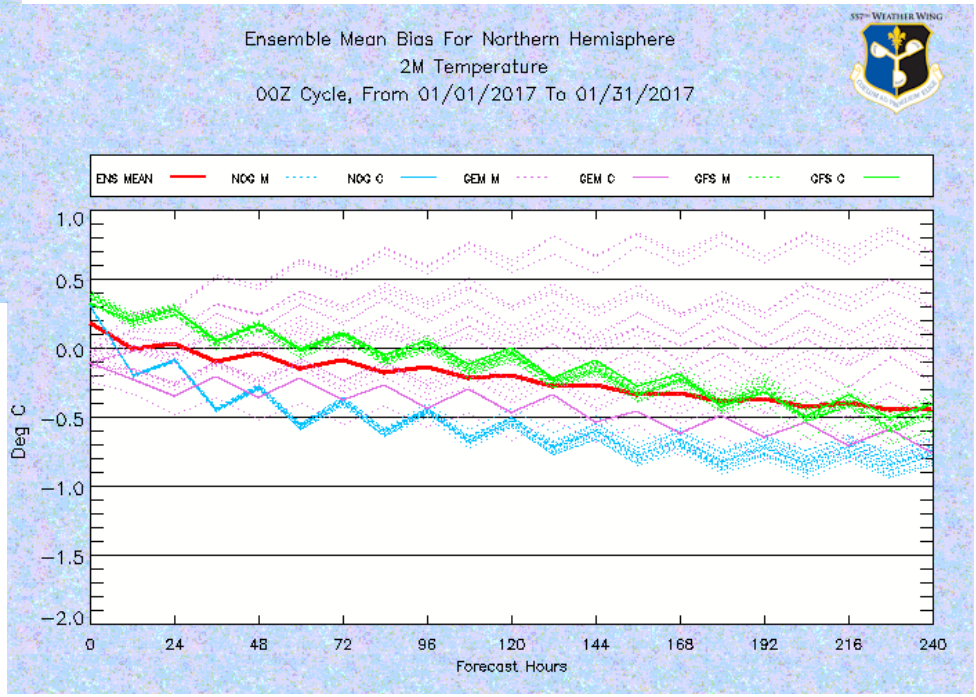


Bias – Ensemble mean has little bias. GEM members are negatively biased and NAVGEM members are positively biased. GFS members become negatively biased abruptly after 192hrs

Northern Hemisphere Ensemble Mean 2 Meter Temp



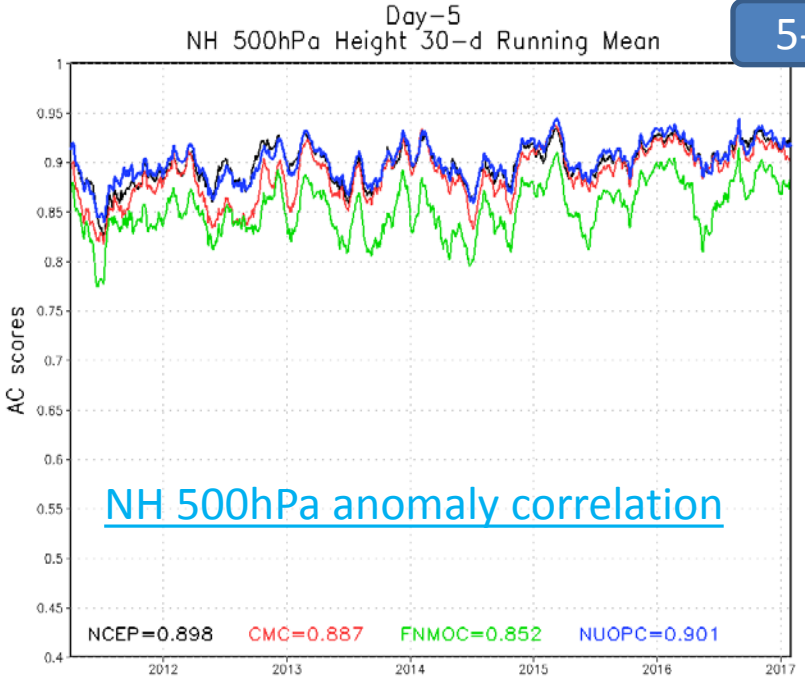
RMSE – Error trends similar to other fields



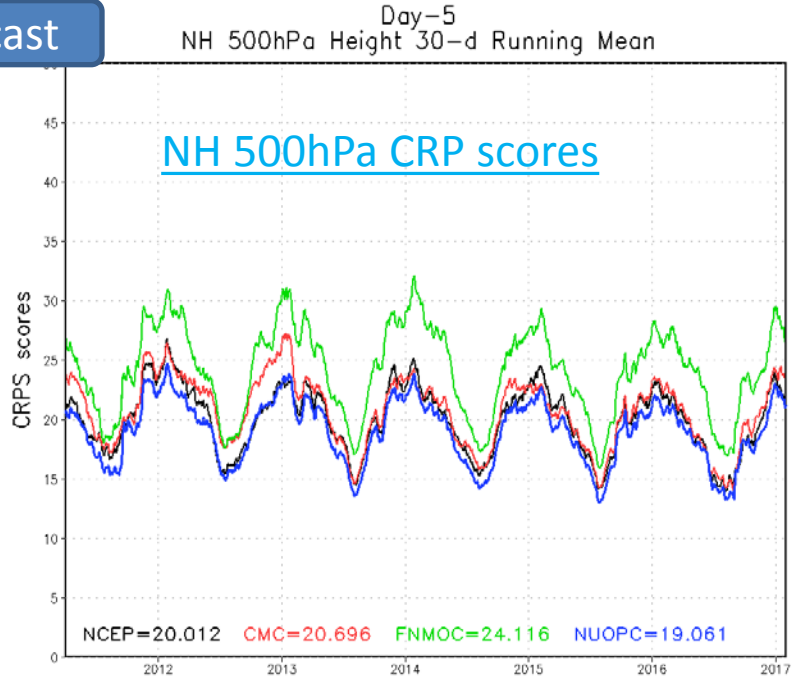
Bias – Ensemble mean shows increasing cold bias with time. GEM member spread is quite large compared to other models

EMC

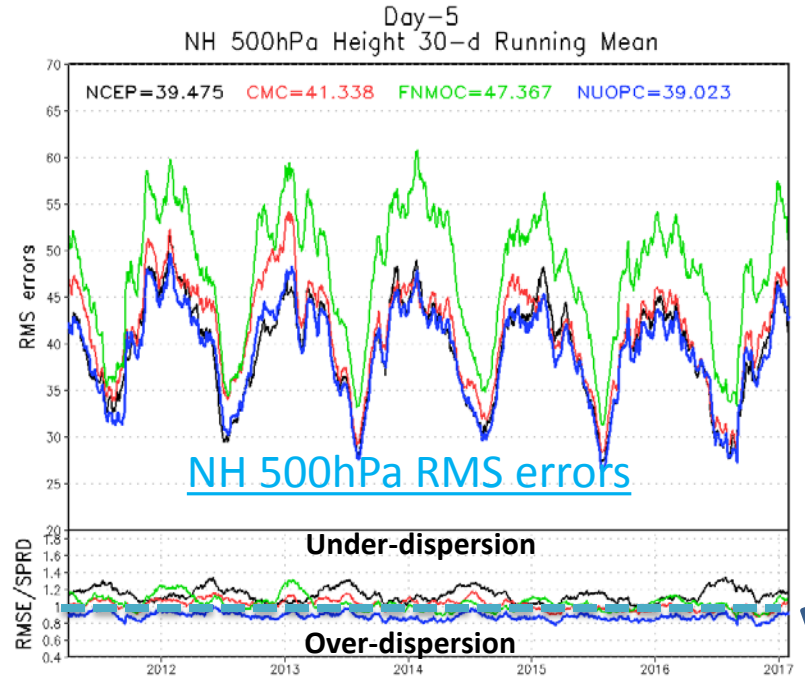
5-day forecast



NH 500hPa anomaly correlation



NH 500hPa CRP scores



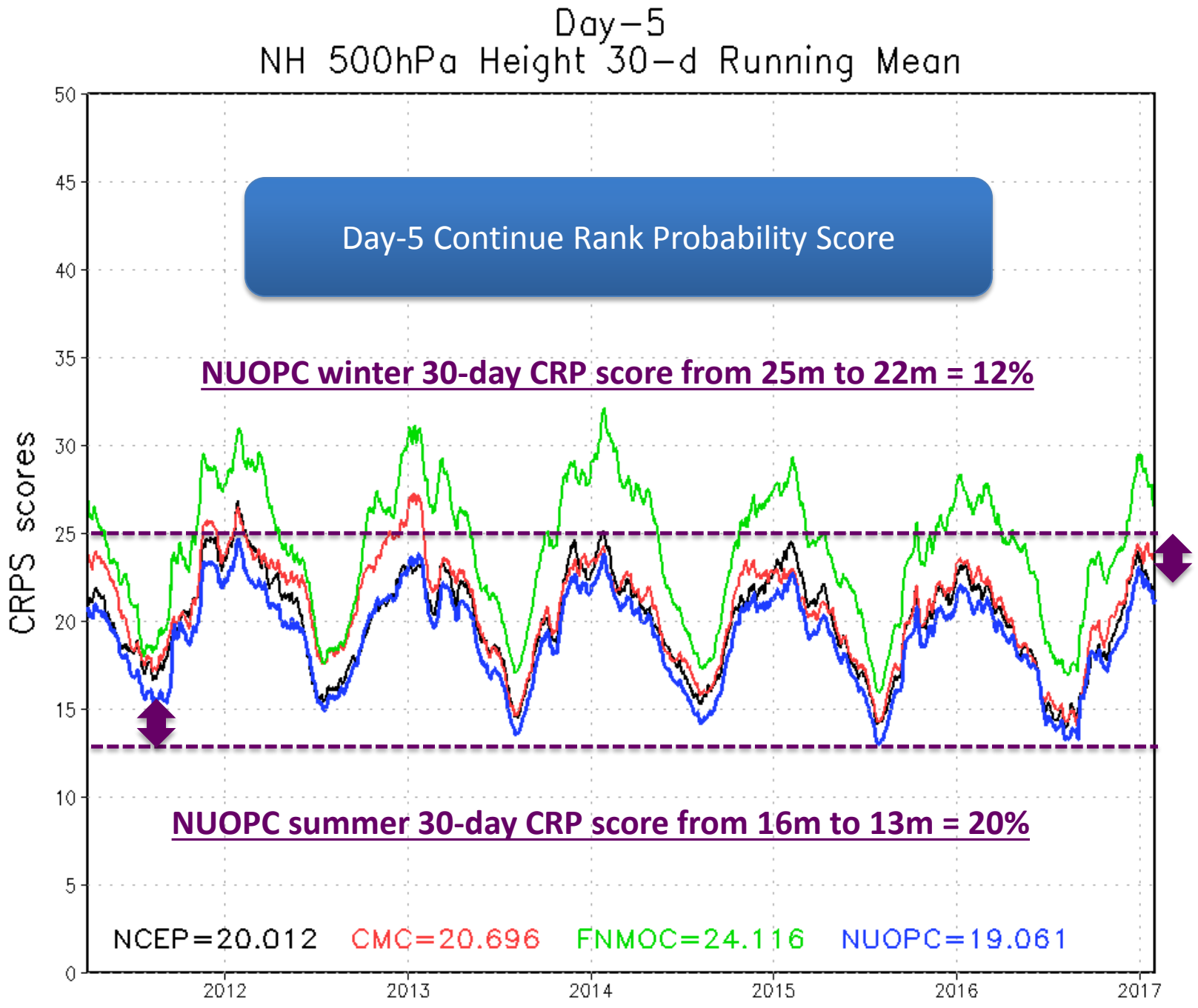
NH 500hPa RMS errors

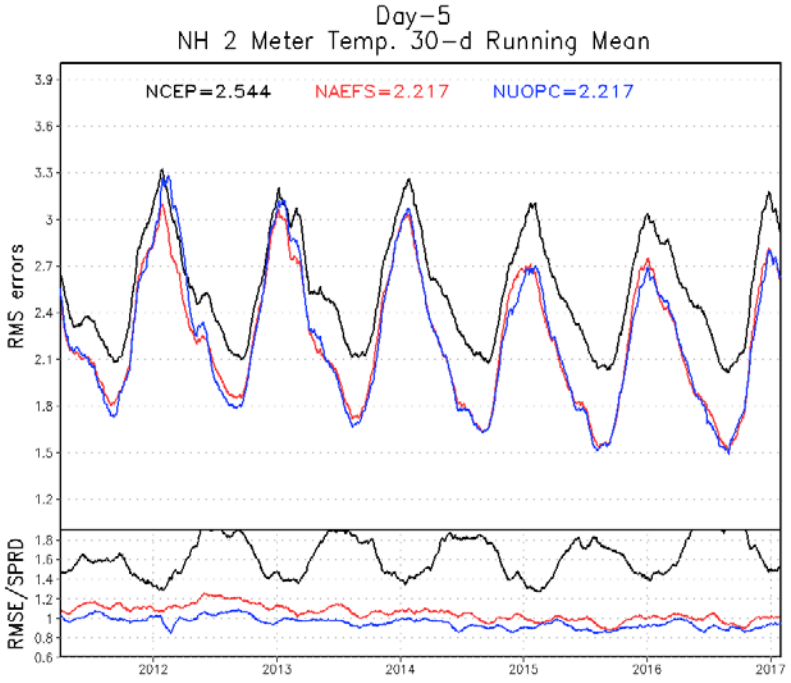
Northern Hemisphere 500hPa height:

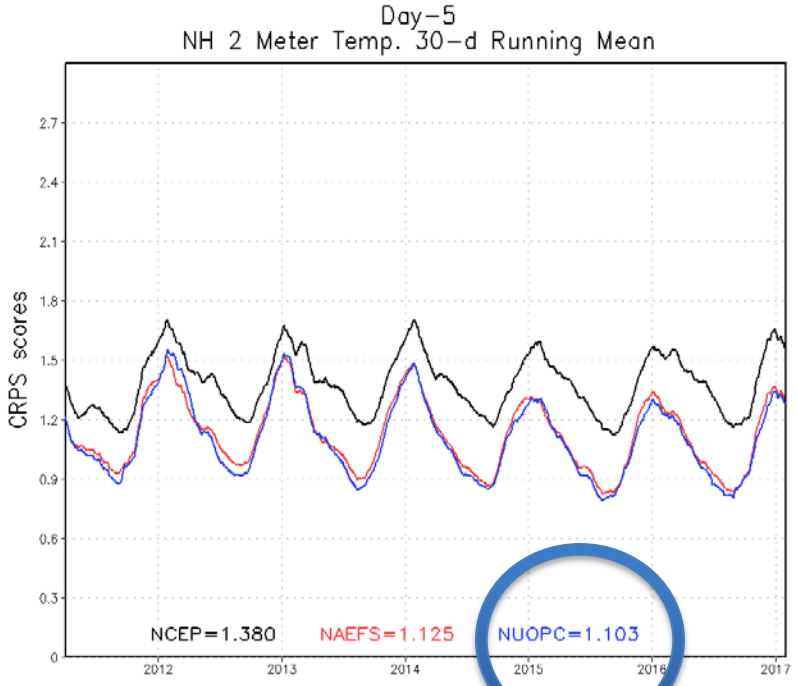
30-day running mean scores of day-5
CRP score
RMS error and ratio of RMS error / spread
Anomaly correlation

All other regions could be seen from:
http://www.emc.ncep.noaa.gov/gmb/yluo/naefs/VRFY_STATS/NUOPC_bc_COMB_win1617_ts.html

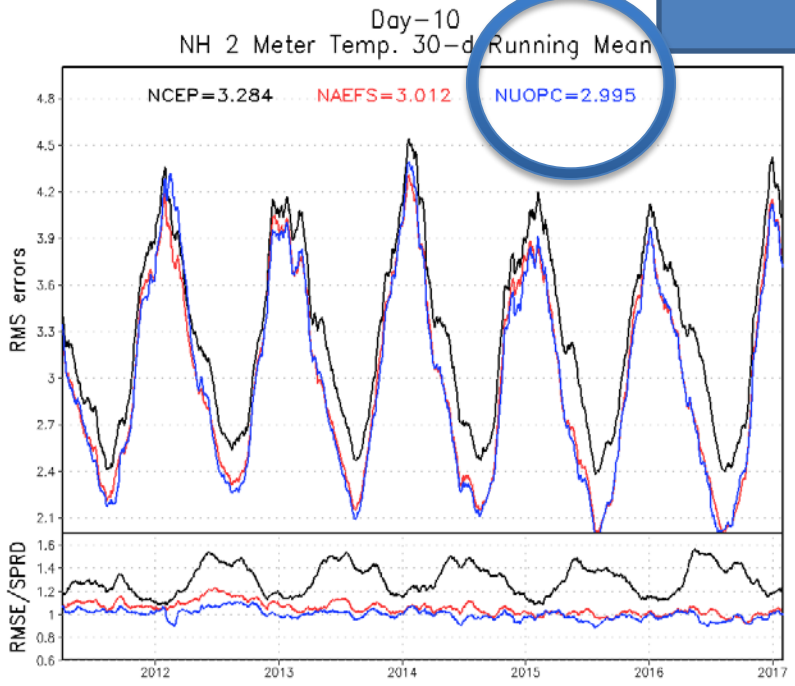
Ratio of RMS error over spread

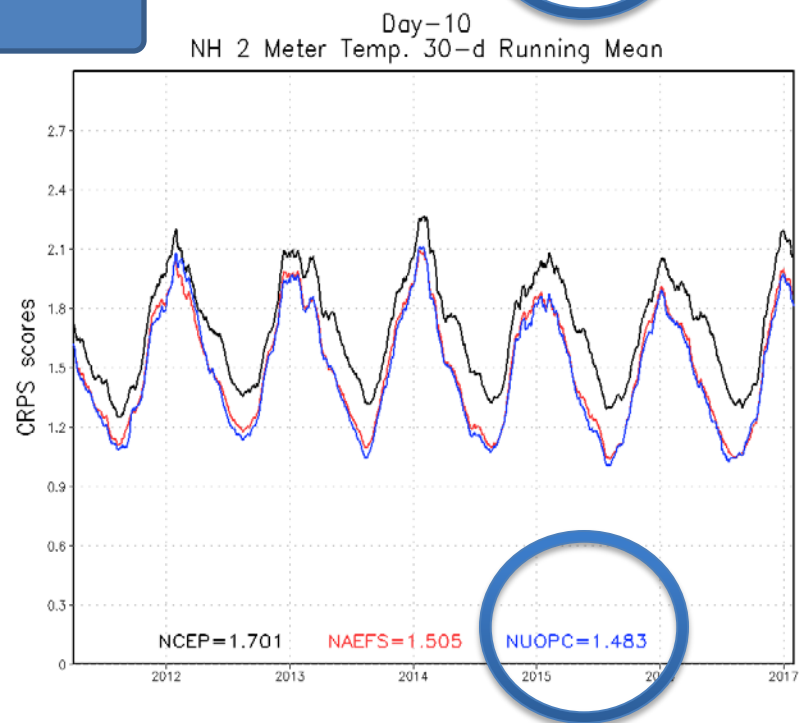

Day−5
NH 500hPa Height 30−d Running Mean
Day-5 Continue Rank Probability Score
NUOPC winter 30-day CRP score from 25m to 22m = 12%
NUOPC summer 30-day CRP score from 16m to 13m = 20%
CRPS scores
50
45
40
35
30
25
20
15
10
5
0
2012
2013
2014
2015
2016
2017
NCEP=20.012
CMC=20.696
FNMOC=24.116
NUOPC=19.061


Day-5
NH 2 Meter Temp. 30-d Running Mean
NCEP=2.544
NAEFS=2.217
NUOPC=2.217
RMS errors
RMSE/SPRD


Day-5
NH 2 Meter Temp. 30-d Running Mean
CRPS scores
NCEP=1.380
NAEFS=1.125
NUOPC=1.103

NH T2m


Day-10
NH 2 Meter Temp. 30-d Running Mean
NCEP=3.284
NAEFS=3.012
NUOPC=2.995
RMS errors
RMSE/SPRD


Day-10
NH 2 Meter Temp. 30-d Running Mean
CRPS scores
NCEP=1.701
NAEFS=1.505
NUOPC=1.483