NAEFS Status and Plan

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Key Issues for discussion

- Ensemble configuration and system development
- Post process and product generation
- Verification matrix
- NAEFS expansion – agreement
- Data exchange – associated items

NAEFS/NUOPC Configuration

Updated: February 14 2012

	NCEP	CMC	FNMOC
Model	GFS	GEM	Global Spectrum
Initial uncertainty	ETR	EnKF	(9) 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	T254L42 (d0-d8)~55km T190L42 (d8-16)~70km	L40 ~ 66km	T159L42 ~ 80km
Control	Yes	Yes	No
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 for ensemble mean	Bias correction for each member	Bias correction for member mean
Last implementation	February 14th 2012	August 17th 2011	September 14 2011

Future Configurations (discussion)

- NCEP
  - Variable resolution
  - Hybrid EnKF/ETR???
  - Multi-model???
- CMC
  - Trends towards single physics (perturbed)
  - Hybrid EnKF and EnVar ; resolution increases;
- FNMOC
  - Next 1-3 years???

NAEFS statistical post process

NAEFS (FNMOC) Grid Exchange Variables

Update: July 12 2010

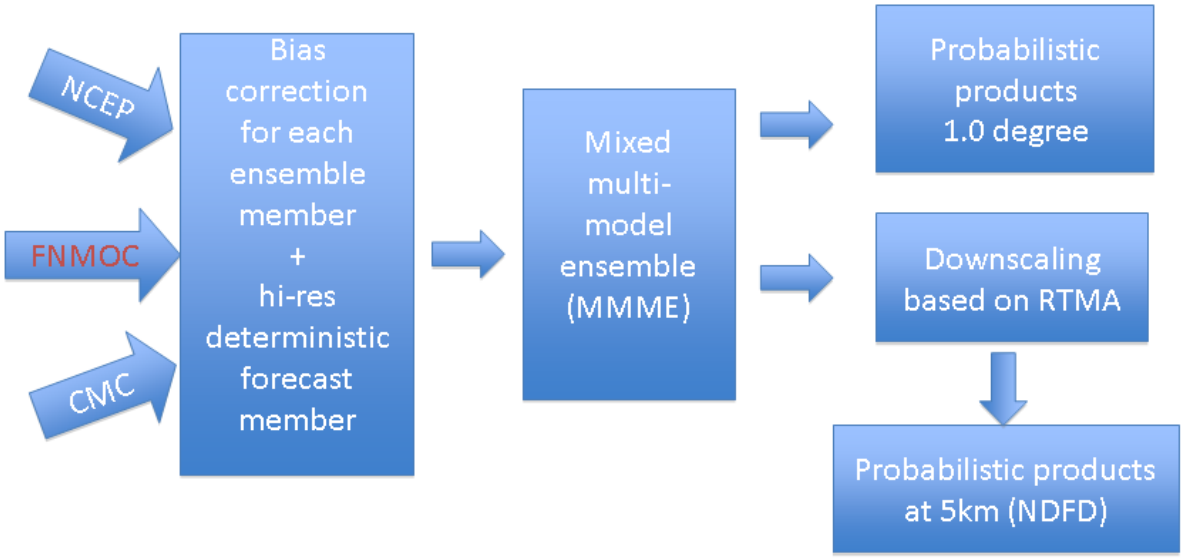
Variables	Pgrba file	Total 80/73
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13/(13)
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11/(11)
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 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

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	

Current NCEP/EMC Statistical Post-Processing System

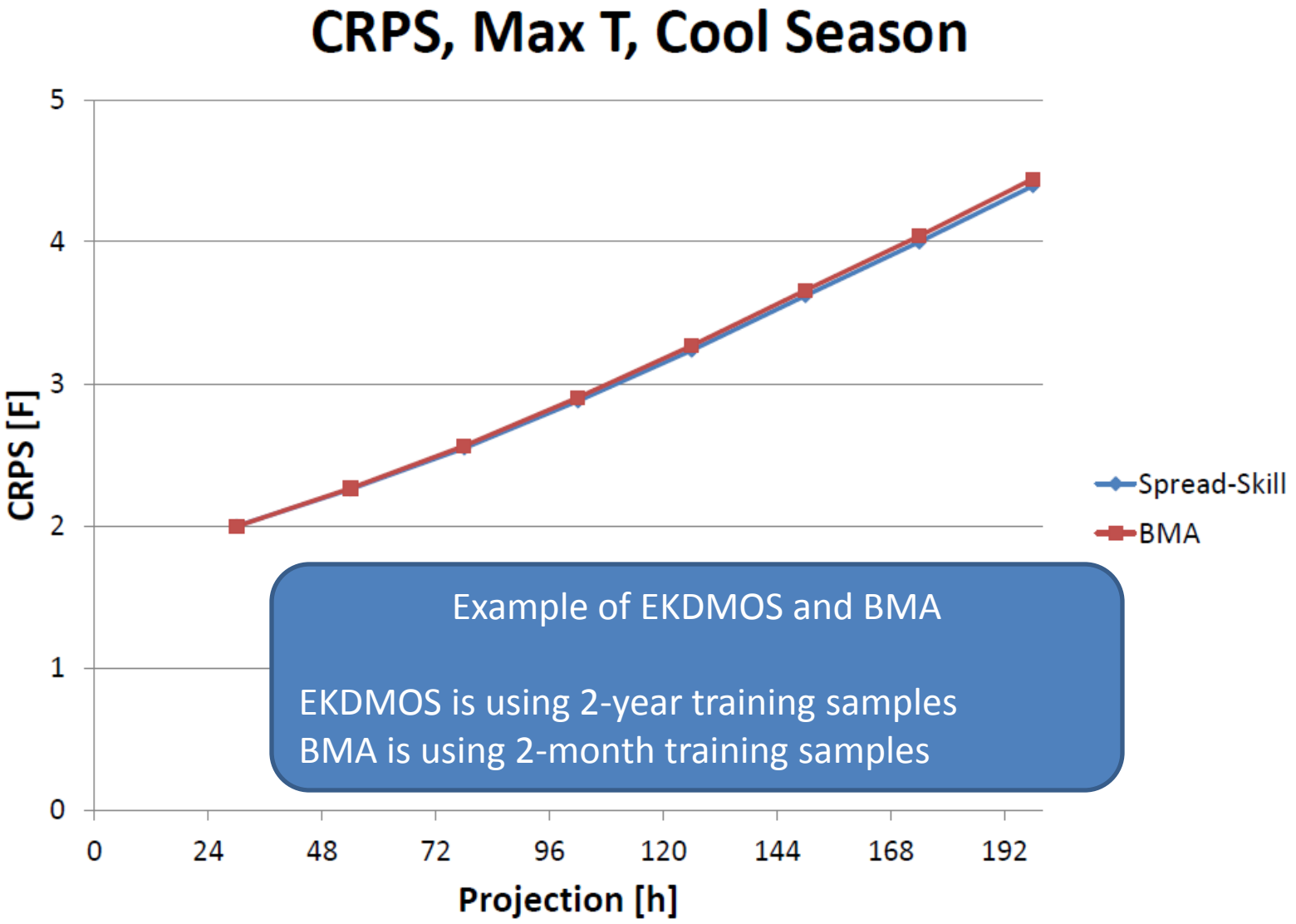


- Bias corrected NCEP/CMC GEFS and GFS forecast (up to 180 hrs), same bias correction algorithm
  - Combine bias corrected GFS and NCEP GEFS ensemble forecasts
  - Dual resolution ensemble approach for short lead time
  - GFS has higher weights at short lead time
- NAEFS products
  - Combine NCEP/GEFS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

Statistical Post Process (SPP)

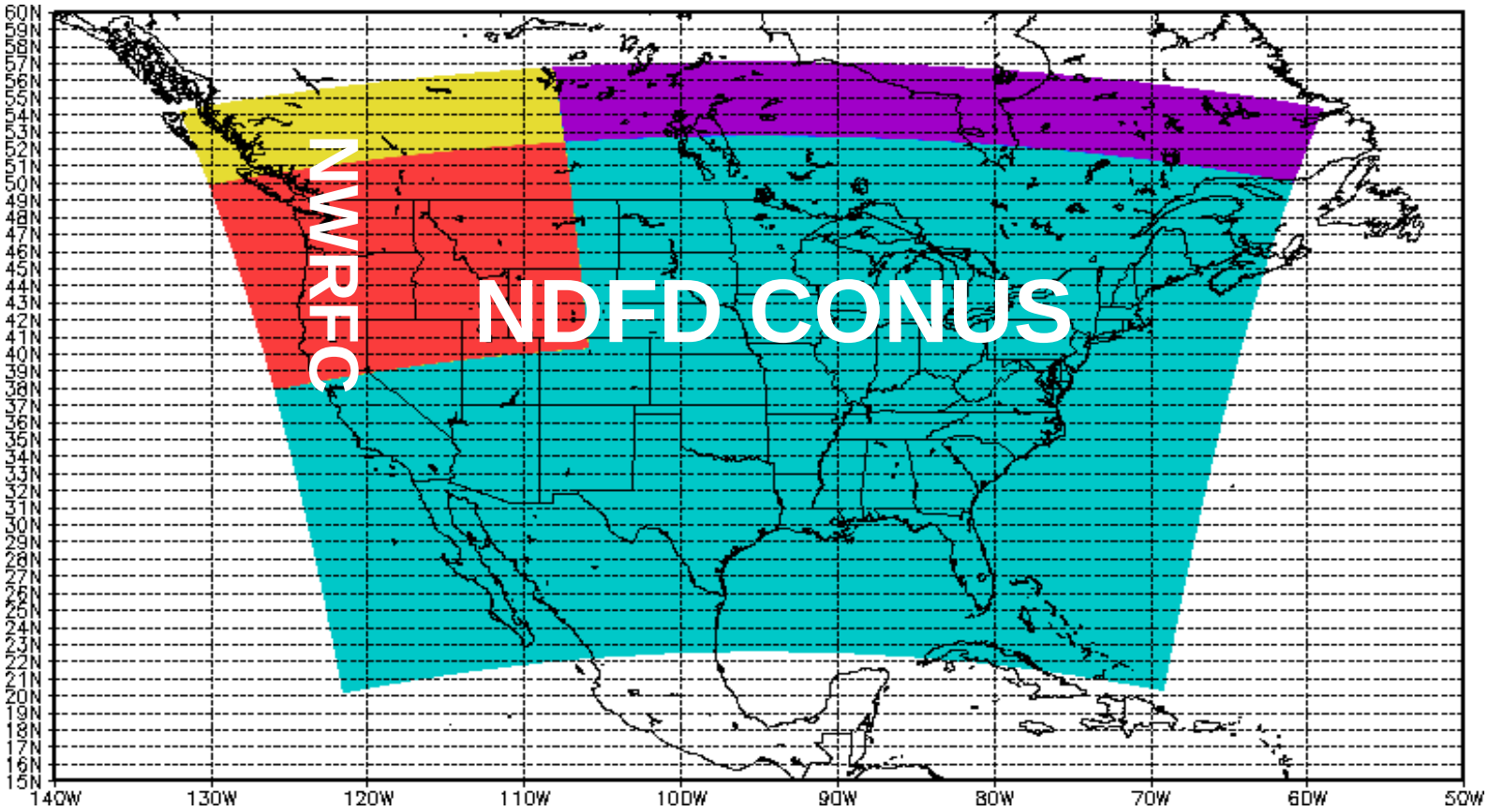
- Improvement of current SPP
  - Methodology
  - 2nd moment adjustment
- Expand RTMA area to cover most Canadian
  - Share NAEFS downscaled products
  - Attach future RTMA cover area
- Introducing Canadian Land Data Assimilation System providing high resolution analysis over all of North America in 2012-13 (including Mexico)
- Share any new products covered NA area???

Concept for Mini-Bayesian Correction



Courtesy of Veenhuis (MDL)

Expand CONUS RTMA-2.5km



Add Support of the Northwest RFC by expanding the CONUS 2.5-km domain northern boundary from 51 N to 56 N. In practice, added 220 pts in y-direction. Produce two GRIB2 files: One for true NDFD CONUS and the other for NWRFC domain. **First Guess: 1-h forecast from the Rapid Refresh downscaled to 2.5km on expanded domain**

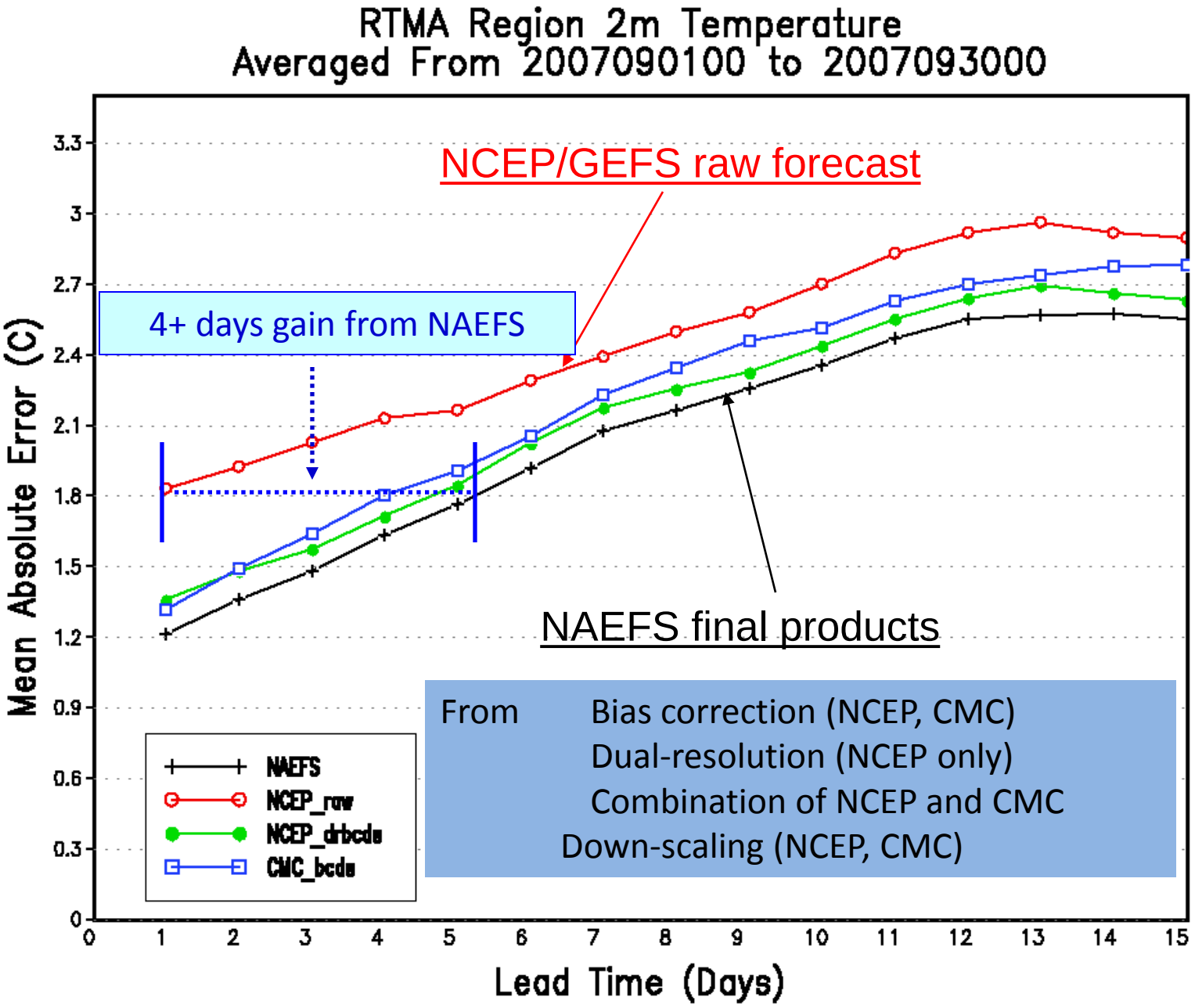
Courtesy of Manuel Pondeca

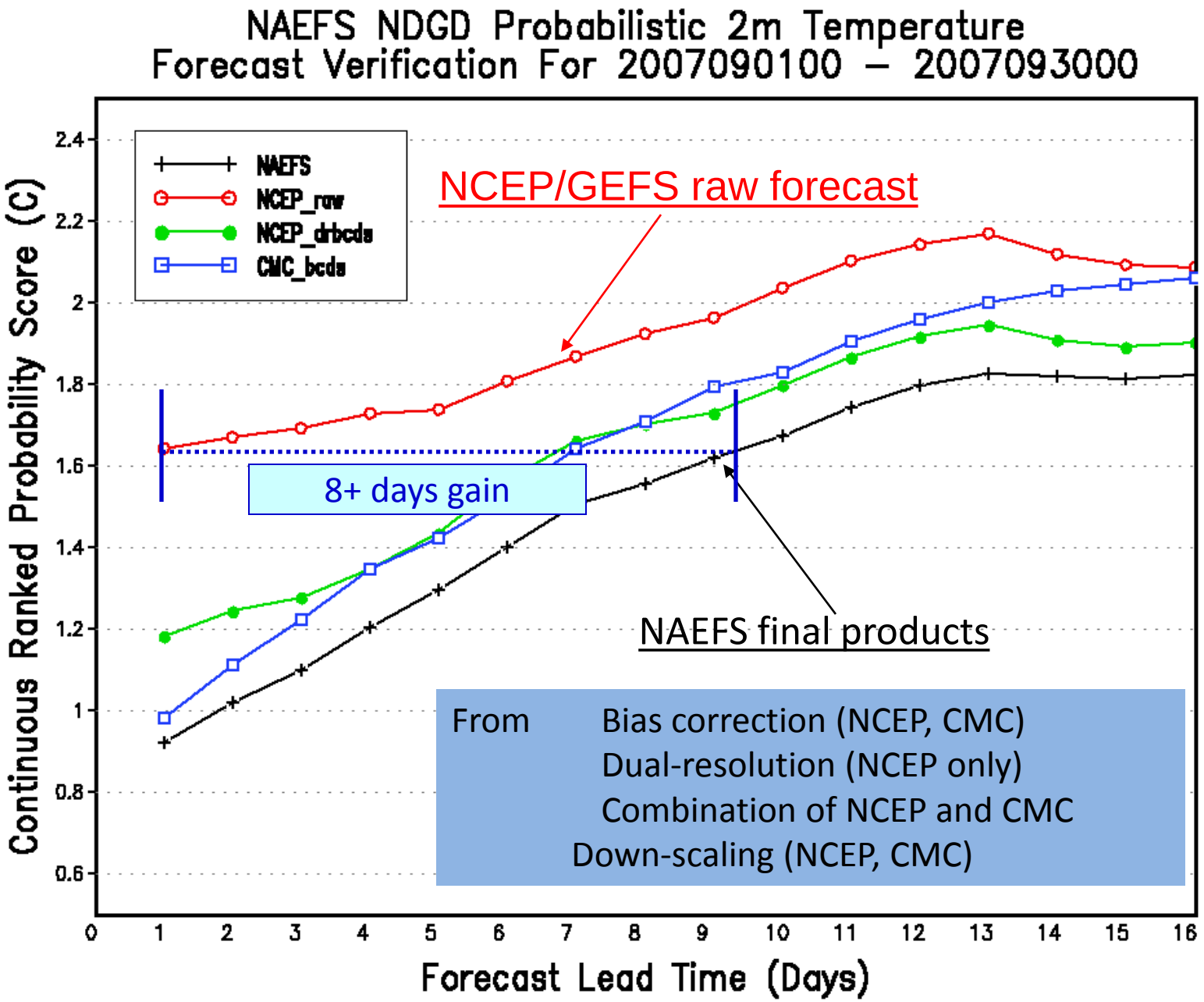
NAEFS downscaling products

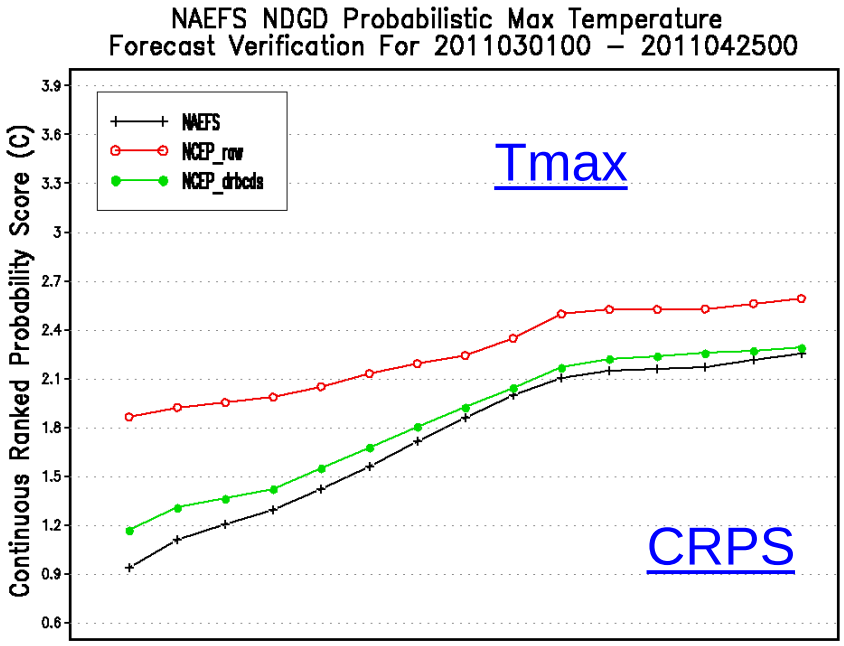
For CONUS (5km) and Alaska (6km)

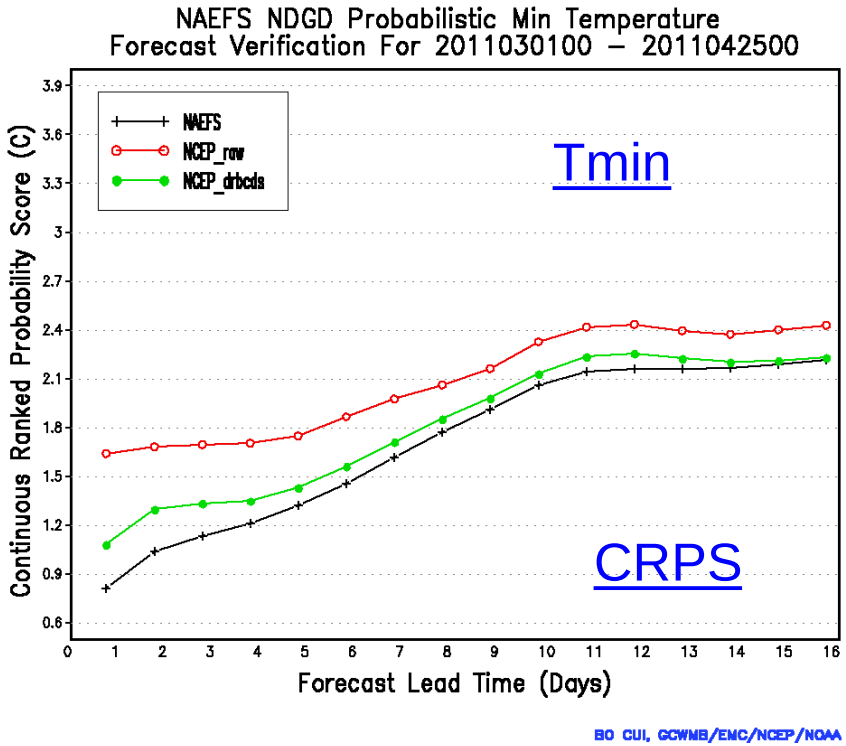
Variables	Domains	Resolutions	Total 4/8
Surface Pressure	CONUS/Alaska	5km/6km	1/1
2-m temperature	CONUS/Alaska	5km/6km	1/1
10-m U component	CONUS/Alaska	5km/6km	1/1
10-m V component	CONUS/Alaska	5km/6km	1/1
2-m maximum T	Alaska	6km	0/1
2-m minimum T	Alaska	6km	0/1
10-m wind speed	Alaska	6km	0/1
10-m wind direction	Alaska	6km	0/1
Note			

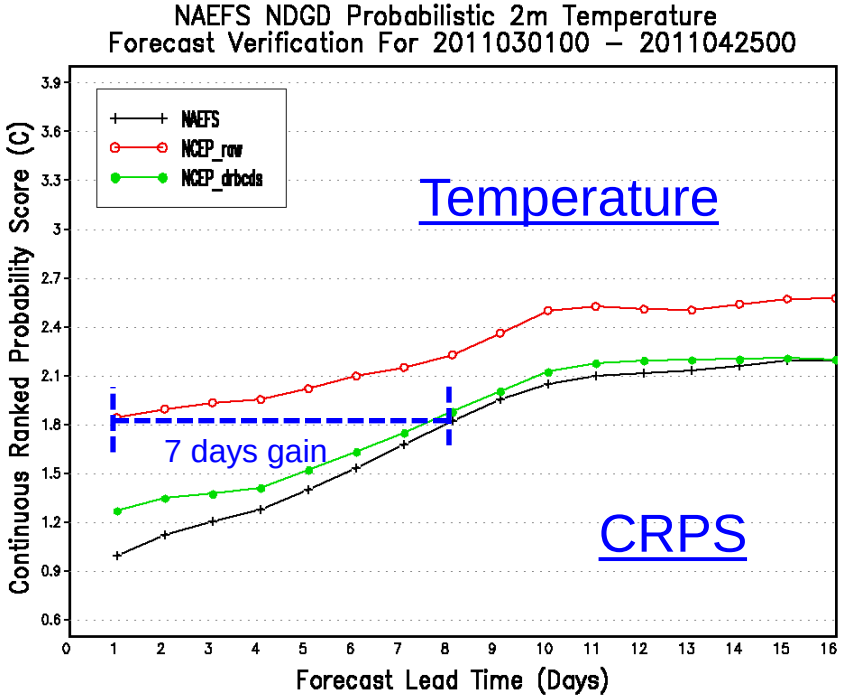
The products include ensemble mean, spread, 10%, 50%, 90% and mode


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







Latest 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

Verification Matrix

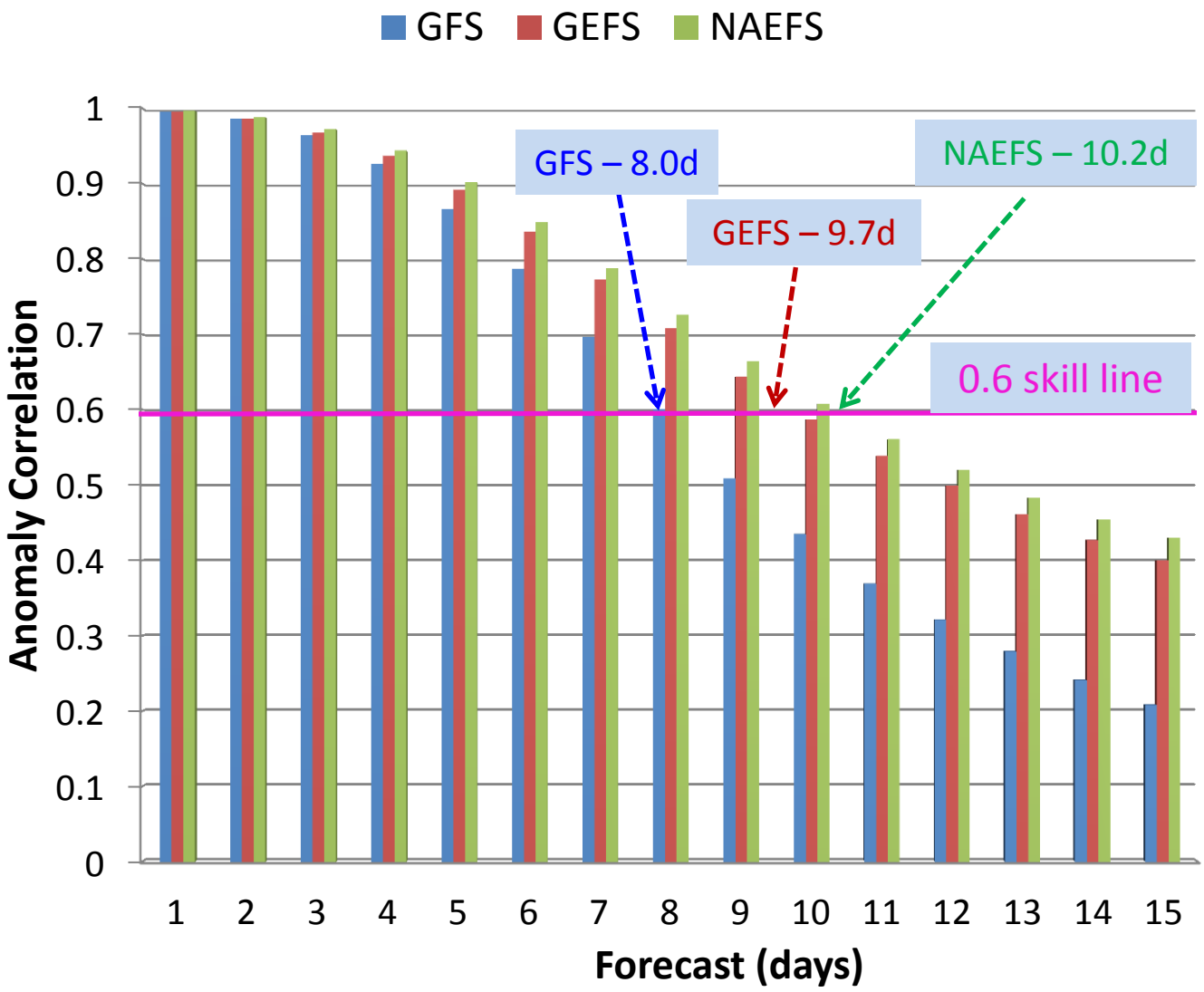
Current status

NAEFS verification

- NCEP – mainly against best analysis
  - Upper air: 500hPa, 1000hPa height, 850hPa temperature, 850hPa and 250hPa winds
  - Surface: T2m, U10m and V10m, precipitation
  - TS tracks (best track), ExTS tracks
  - Skill scores and significant test
  - Statistics – public access through NAEFS web-site
- CMC – mainly against observation
  - Upper air variables
  - Surface variables
  - Skill scores and significant test
  - Statistics -

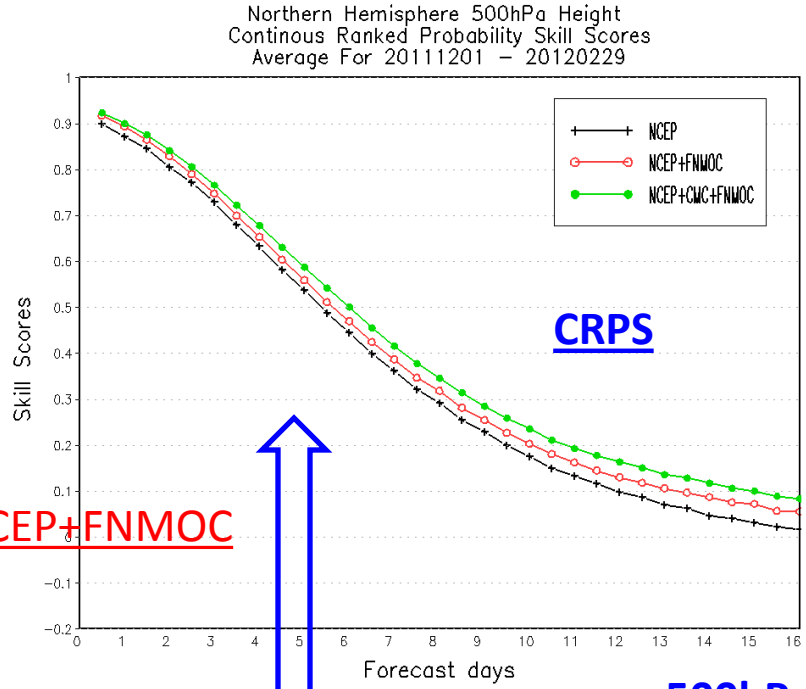
NH Anomaly Correlation for 500hPa Height

Period: January 1st – December 31st 2010



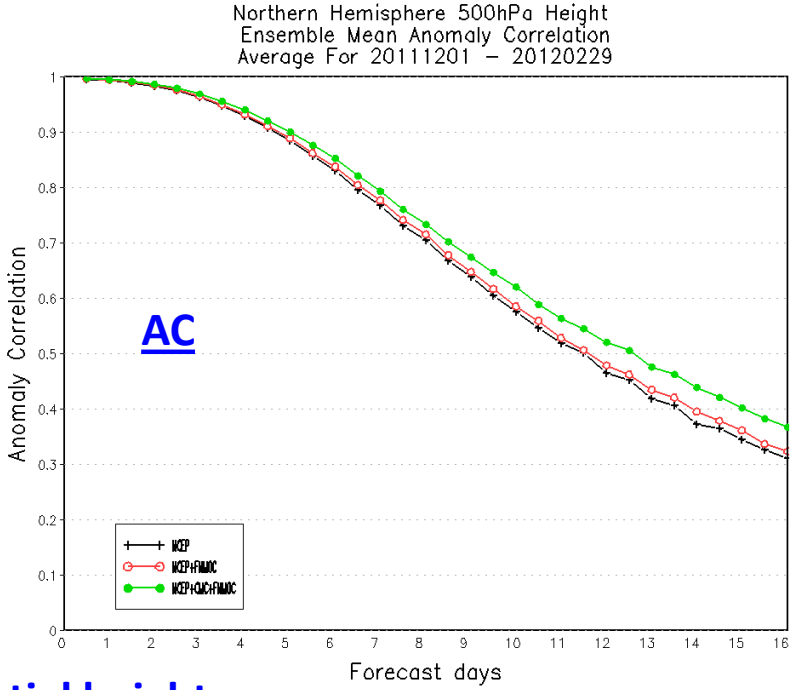
Benefit for forecast:

1. Ensemble mean will extend 1.7 days forecast ability
2. NAEFS will add additional 0.5 day forecast skill
3. Post process will add another additional



CRPS

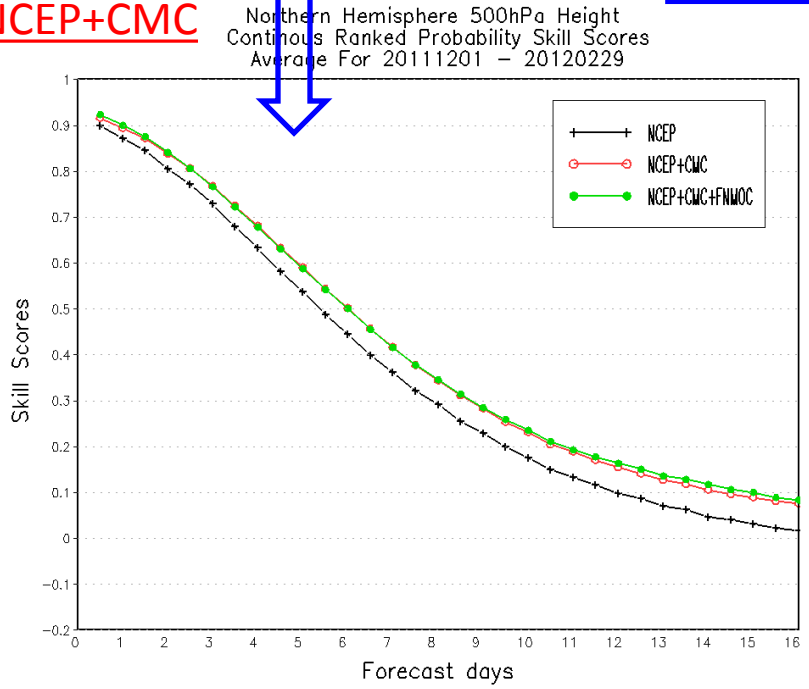
NCEP+FNMOC

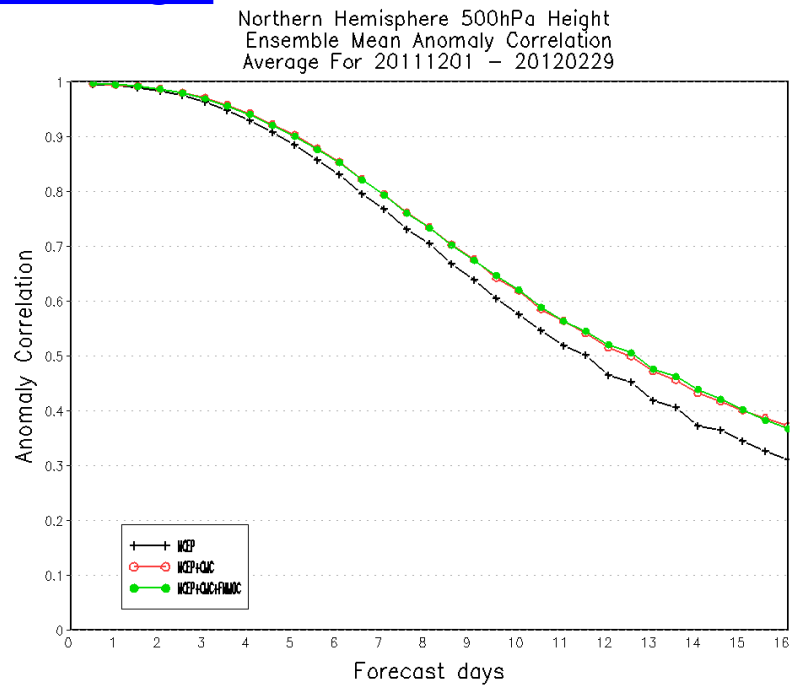


AC

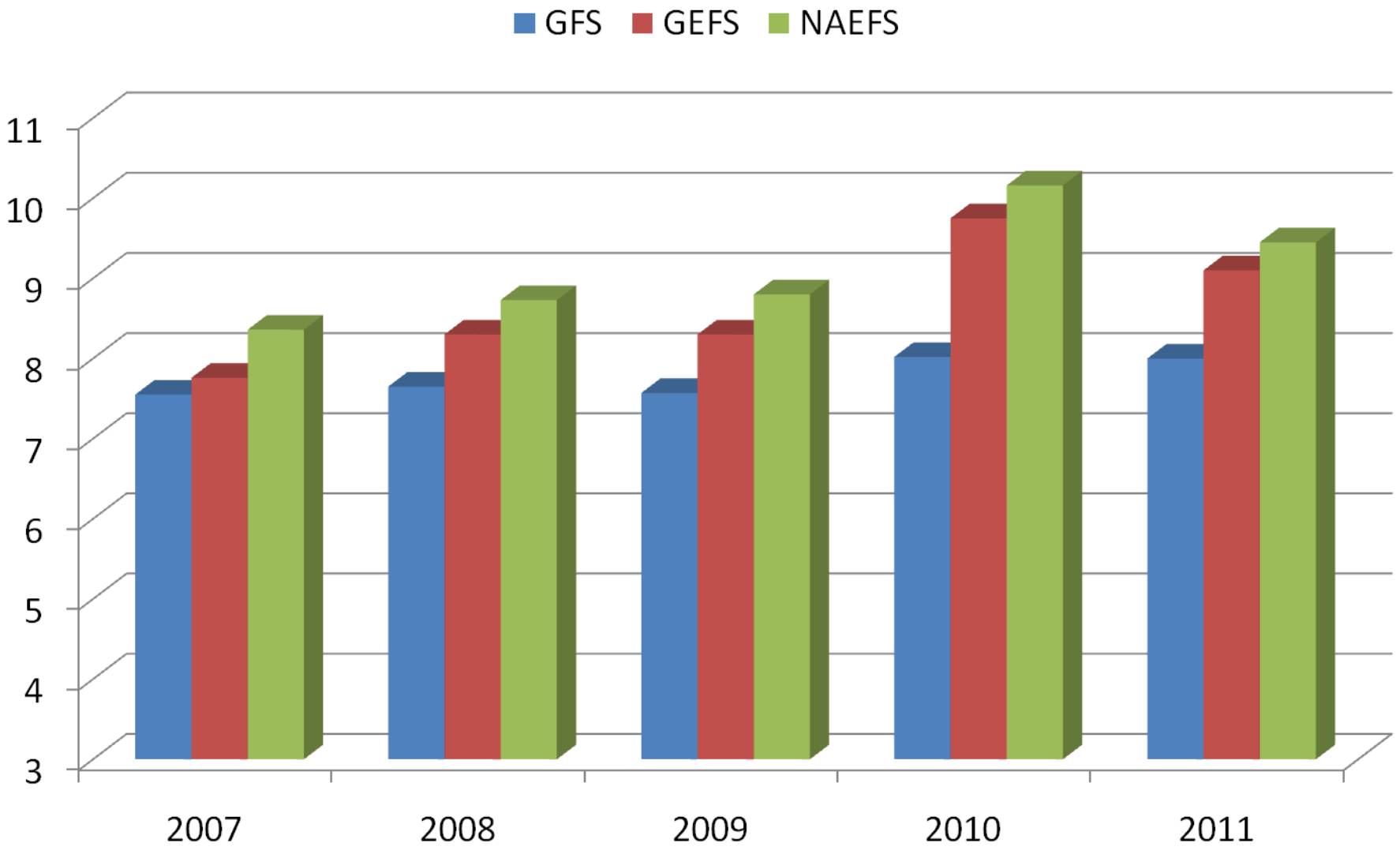
500hPa geopotential height

NCEP+CMC

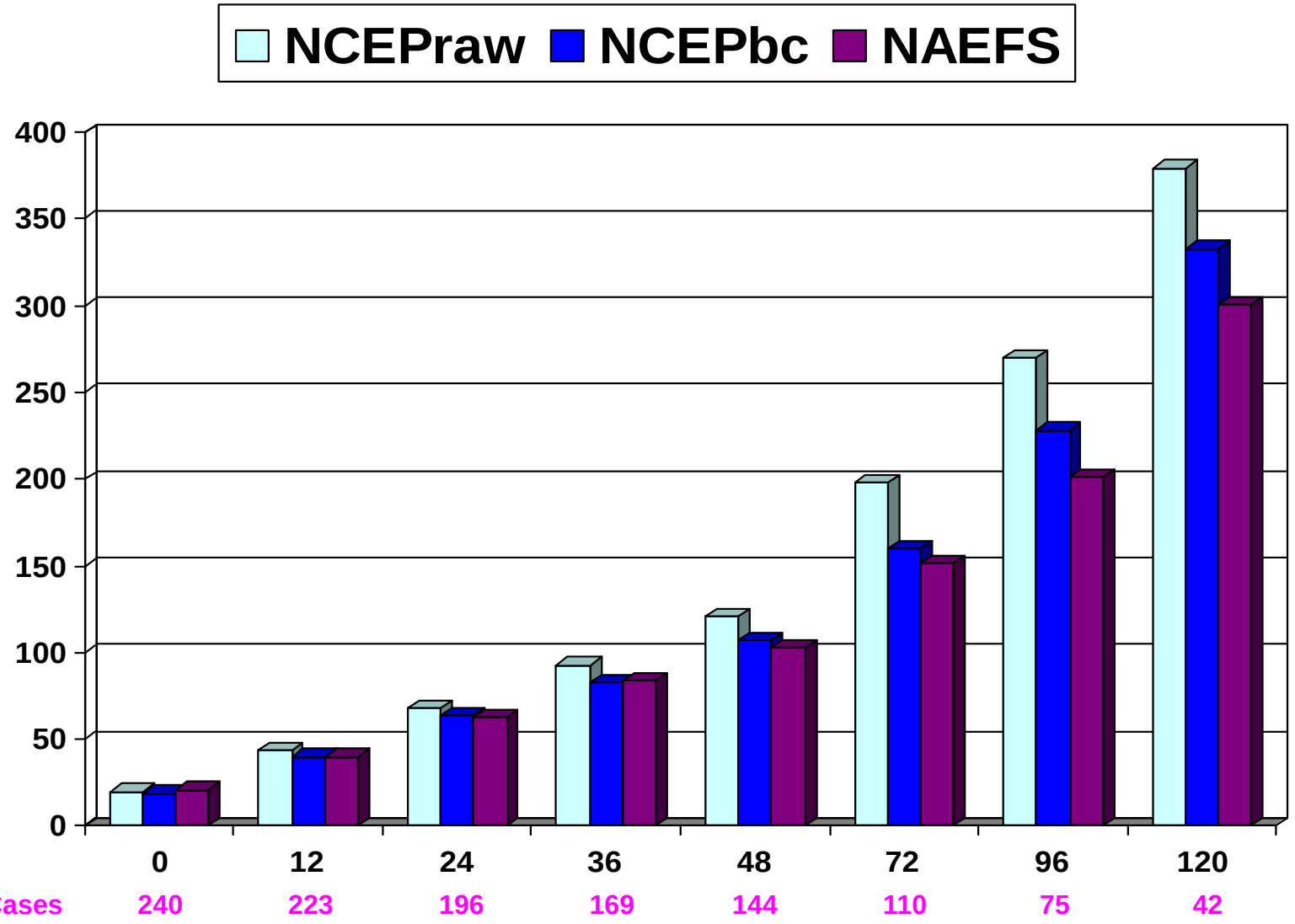




Day at which forecast loses useful skill (AC=0.6)
N. Hemisphere 500hPa height calendar year means

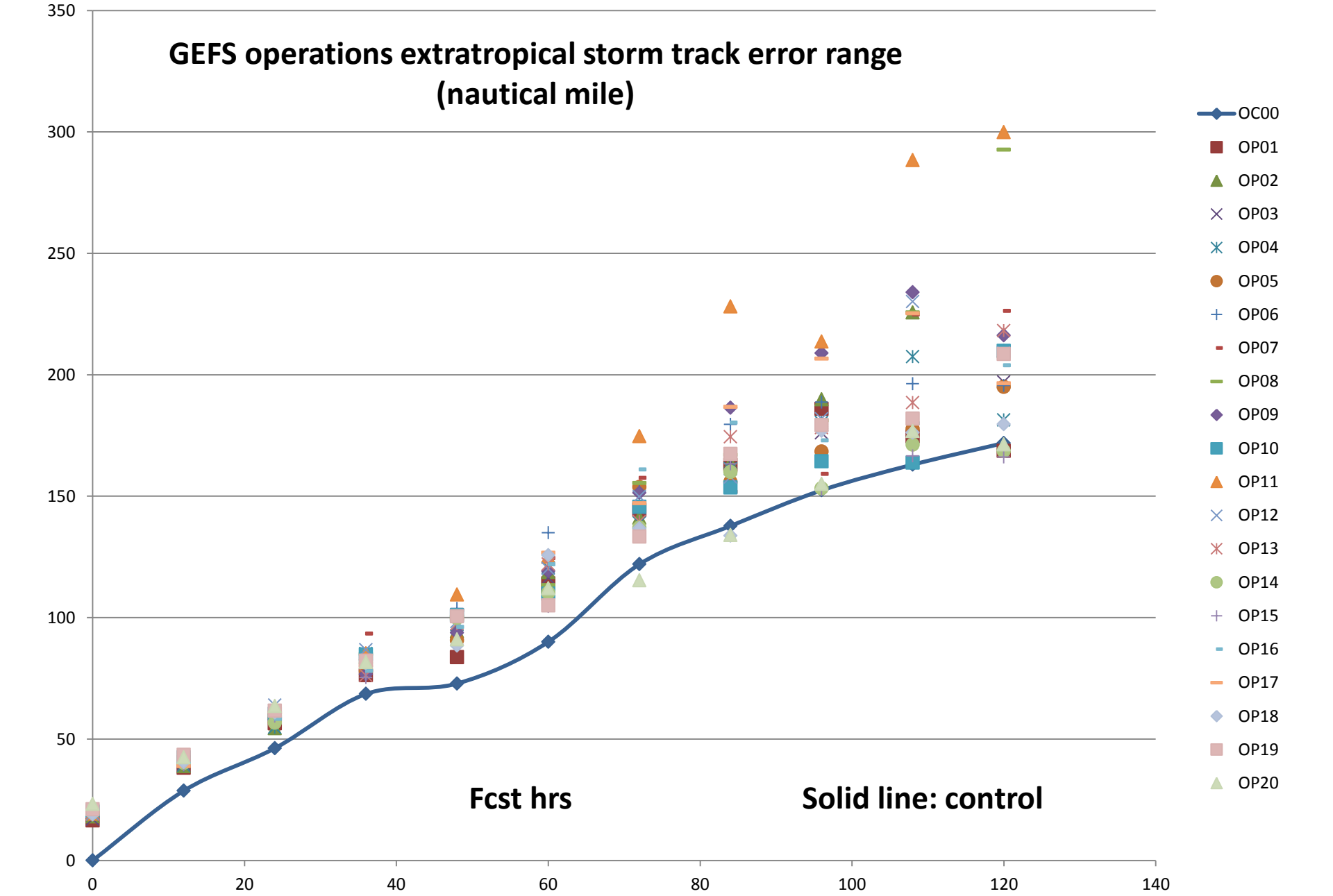


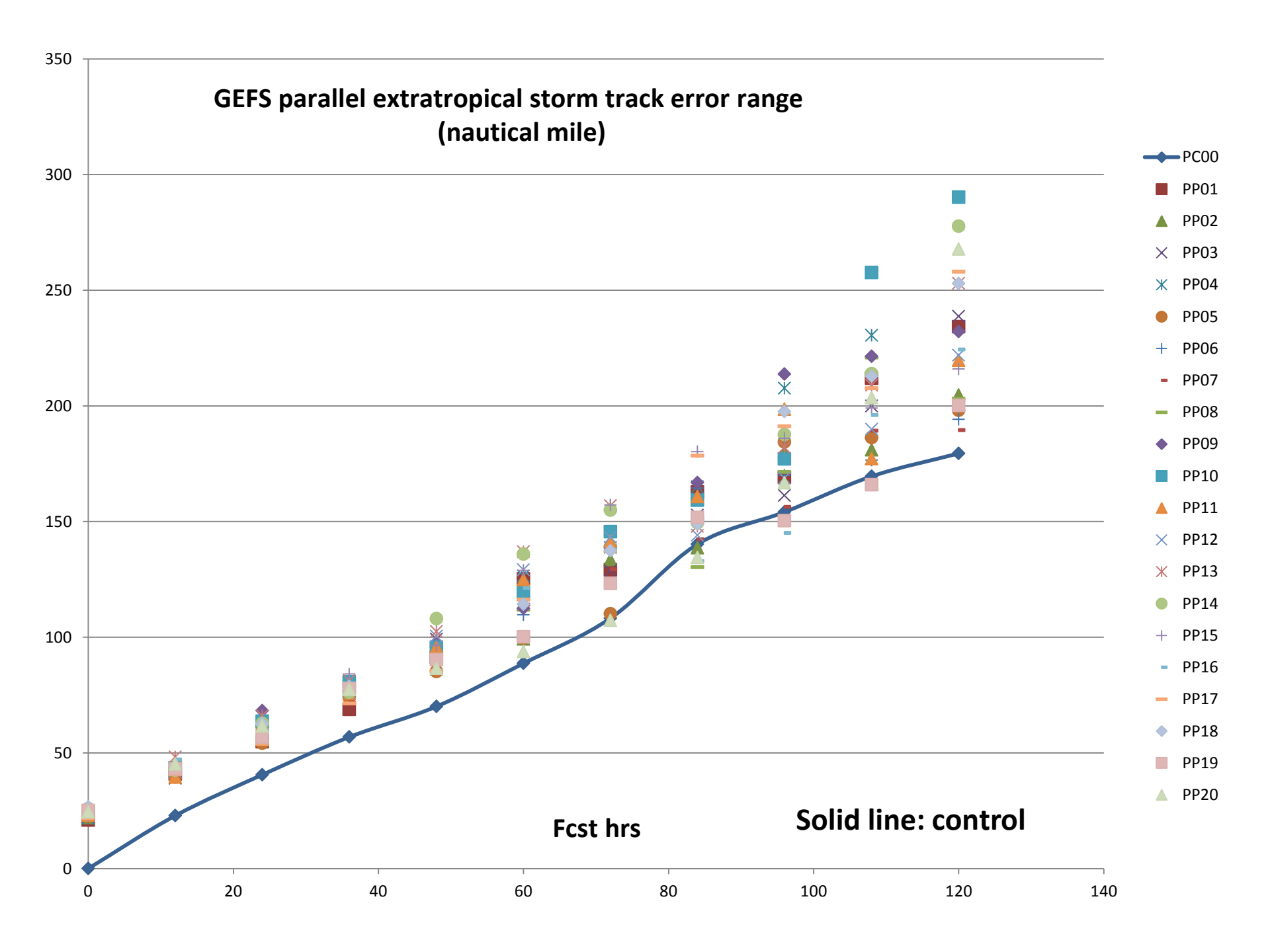
Track forecast error for 2009 season (AL+EP+WP)



NAEFS is combined NCEP (NCEPbc) and CMC's (CMCbc) bias corrected ensemble and bias corrected GFS

Contributed by Dr. Jiayi Peng (EMC/NCEP)


GEFS operations extratropical storm track error range
(nautical mile)
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
Fcst hrs
Solid line: control
OC00
OP01
OP02
OP03
OP04
OP05
OP06
OP07
OP08
OP09
OP10
OP11
OP12
OP13
OP14
OP15
OP16
OP17
OP18
OP19
OP20


GEFS parallel extratropical storm track error range
(nautical mile)
350
300
250
200
150
100
50
0
0
20
40
60
80
100
120
140
Fcst hrs
Solid line: control
PC00
PP01
PP02
PP03
PP04
PP05
PP06
PP07
PP08
PP09
PP10
PP11
PP12
PP13
PP14
PP15
PP16
PP17
PP18
PP19
PP20

NAEFS Future Plan

Expansion and agreement

The National Oceanic and Atmospheric Administration of United States,
The Meteorological Service of Canada and
The National Meteorological Service of Mexico

Recognizing the importance of scientific and technical international cooperation in the field of meteorology for the development of approved global forecast models;

Considering the great potential of model diversity to increase the accuracy of one to fourteen day probabilistic forecasts;

Noting the significant international cooperation undertaken to develop and implement an operational ensemble forecast system for the benefit of North American and surrounding territories;

The signatories, hereby inaugurate the
North American Ensemble Forecast System
at Camp Springs, Maryland, USA, on this
16th day of November 2004

Brig. Gen. David Johnson NOAA Assistant Administrator for Weather Service
Dr. Marc Denis Everell Assistant Deputy Minister, Meteorological Service of Canada
Dr. Michel Rosengaus Head of Unit, National Meteorological Service of Mexico

North America Ensemble Forecast System (NAEFS) ongoing partnership (Draft for MOU of NOAA-EC)

Since 2006, NCEP (NWS, USA) and the CMC (MSC, Canada) have been exchanging ensemble forecast data in real-time within operational framework under the trilateral NAEFS agreement signed in 16th November 2004. Some methods for post-processing are shared and developed jointly. This leads to a large number of coherent operational shared products for North-America up for intra-seasonal forecast lead time. This partnership also promotes and fosters increased Research and Development (R&D) cooperation by the participating centers.

The goal of this partnership is to improve operational short-range to intra seasonal predictions for North America by combining different Ensemble Prediction Systems (EPS) into a super ensemble. Improved ensemble forecasting systems are contributing to a better use of predictions for a variety of socio-economic and public security (e.g. disaster mitigation measures) applications. The EPS are providing suitable datasets compatible with decision making in those many sectors affected by weather.

This collaboration leads to acceleration in the schedule, and enhancement in the quality of ensemble related operational implementations at both centers. This partnership is an efficient way for each National Centre to best pursue their mission since each centre can focus on the ongoing improvement of their own prediction system while benefitting from the added value of inclusion in a combined system.

Planned collaborations and ongoing activities are:

- Forecast systems inter-comparisons aiming at the improvement each centre's prediction system and the overall resulting combined prediction system
- Development of common : statistical combination methods, calibration procedure, and seamless North American products (especially along the boundaries)
- Diagnostics and verification methods targeted at monitoring performance of individuals and combined systems
- Development and assessment specialized products useful for decision makers (e.g. probabilistic forecasts)
- Addition of Regional Ensemble Prediction Systems (limited area models covering North America) into the exchange for short and medium time range
- Extension of the current 16 day to the intra-seasonal monthly lead time
- Collaboration into the generation of hind cast allowing calibration and leading to further improved products
- Explore connection with NACSP (North American Climate Service Partnership) project for drought / water prediction, as well as other predictive atmospheric and environmental parameters
- Explore connection with NEXGEN, 4D-cube for consistent North-American wide aviation-weather related products
- Visit to NCEP or EC-MSC by Mexican meteorologists/climatologists to learn how to take full advantage of NAEFS products for forecasting issues.
- Perform verification of NAEFS data in tropical regions (southern Mexico) and provide feedback to NWS and MSC.

Expansion to include FNMOC

- A need to develop and adopt NAEFS standards:
  - Coding & format standards (grib2) about a set of data (variable, levels, frequency, grid format and resolution, scheduling, etc.
  - Refer to NAEFS working plan
- Scientific validation:
  - Verification against analysis (NCEP) and against Observations (CMC) for both raw and bias corrected forecast, simply combined ensembles
  - Post statistics periodically for review (and public access)
- Technical considerations:
  - Staging period in simulating operational data exchange

Data exchange

Raw and bias corrected data

- Add more exchange variables
- Exchange bias corrected data first
- Maintain raw data exchange as per user request (including AFWA)
- 0.5 degree data exchange for first 8 days for a number of selected variables
- Every 3 hours output for first 8 days

Data exchange: summary

- Add North American LAM EPS data into exchange
- Add Wave data into the exchange thanks to research collaboration on wave forecasting now including Canada (WW-III)
- Add extended (d16-month) forecast data for exchange