Ensemble Forecasting

Yuejian Zhu

Ensemble & Probabilistic Guidance Team Leader
Environmental Modeling Center

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Acknowledgment for:
Members of Ensemble & Probabilistic Guidance Team

Responsibilities of Ensemble Team

- Assess, model, communicate uncertainty in numerical forecasts

- Present uncertainty in numerical forecasting
  - Tasks
    - Design, implement, maintain, and continuously improve ensemble systems
  - Presents
    - Initial value related uncertainty
    - Model related forecast uncertainty
  - Ensemble systems
    - Global – GEFS / NAEFS / NUOPC
    - Regional – SREF / HREF / NARRE-TL / HWAF ensemble
    - Climate – CFS, IMME and NMME
    - NAEFS/GEFS downscaled
    - Ocean wave ensemble (MMA/EMC)
  - Other systems
    - CCPA – Climate Calibrated Precipitation Analysis
    - WSR – Winter Storm Reconnaissance (discontinue)
    - CSTAR - Collaborative Science, Technology, and Applied Research Program
- Statistical correction of ensemble forecasts
  - Tasks
    - Correct for systematic errors on model grid
    - Downscale information to fine resolution grid (NDGD)
    - Combine all forecast info into single ensemble/probabilistic guidance
- Probabilistic product generation / user applications
  - Contribute to design of probabilistic products
  - Support use of ensembles by
    - Internal users (NCEP Service Center, WFOs, OHD/RFC forecasters and et al.)
    - External users (research, development, and applications)

Coverage of This Presentation

- Will mainly focus on:
  - GEFS upgrade and future plan
  - NAEFS upgrade and future plan
  - GEFS/NAEFS post products and future plan
  - CCPA – Climate Calibrated Precipitation Analysis
  - CSTAR - Collaborative Science, Technology, and Applied Research Program
  - GEFS extended forecast
  - IMME and NMME
- Wave ensemble and its products will be reviewed by **Arun Chawla** (tomorrow)
- Regional ensemble and related products will be reviewed by **Jun Du** (this afternoon)
- Regional hurricane ensemble (HWRF experimentally) will be reviewed by **Vijay Tallapragada** (tomorrow)

Main Accomplishment in 2014

- NAEFS upgrade – April 2014

SREF Upcoming Major Upgrade

(~April 2015 – WCOSS Phase II)

1. 3 model core system becomes 2 model core system (NMMB, WRF_ARW, WRF_NMM)
2. Vertical resolution is increased from 35 to 41 levels (horizontal resolution remains the same of 16km)
3. Ensemble membership is increased from 21 to 26 members
4. IC diversity is enhanced: (a) mix use of multiple analyses (NDAS, GFS and RAP) for each model core, and (b) blending of GEFS and SREF IC perturbations for all members
5. Physics diversity is enhanced: (a) more variety of physics schemes, and (b) stochastic flavor in physics parameters (GWD and soil moisture)
6. New variables and products are added

Next GEFS (V11.0.0) configuration

- Model
  - Current: GFS Euler model (V9.0.1)
  - Plan: GFS Semi-Lagrangian model (V10.0.0)
- Horizontal resolution
  - Current: T254 (55km for 0-192 hours), T190 (73km for 192-384 hours)
  - Plan: T574 (T382 physics - 34km for 0-192 hours), T382(T254 physics – 55km for 192-384 hours)
- Vertical resolution
  - Current: L42 hybrid levels
  - Plan: L64 hybrid levels to match with GFS and DA
- Computation cost:
  - Current: 84 nodes (+ post process) for 55 minutes
  - Plan: 300 nodes (first 35 minutes), 250 nodes (2nd 30 minutes)
- Output:
  - Current: every 6-hr for 1*1 degree pgrb files
  - Plan: every 3-hr for 0.5*0.5 degree pgrb files
- Schedule:
  - Jan. 2015 – deliver codes/scripts to NCO
  - Apr. 2015 – implementation (WCOSS-phase II)

Evolution of NCEP GEFS configuration (versions)

Version	Implem entation	Initial uncertainty	TS relocation	Model uncertainty	Resolution	Forecast length	Ensemble members	Daily frequency
V1.0	1992.12	BV	None	None	T62L18	12	2	00UTC
V2.0	1994.3				T62L18	16	10(00UTC) 4(12UTC)	00,12UTC
V3.0	2000.6				T126L28(0-2.5) T62L28(2.5-16)		10	
V4.0	2001.1				T126(0-3.5) T62L28(3.5-16)			
V5.0	2004.3				T126L28(0-7.5) T62L28(7.5-16)			00,06,12, 18UTC
V6.0	2005.8		TSR		T126L28			
V7.0	2006.5	BV- ETR					14	
V8.0	2007.3						20	
V9.0	2010.2			STTP	T190L28			
V10.0	2012.2				T254L42 (0-8) T190L42 (8-16)			
V11.0	2015.04	EnKF (f06)			T574L64 (0-8) T382L64 (8-16)			

Next GEFS Sciences

- Initial perturbations
  - Base: EnKF 6hr forecast
    - TS relocation
    - Centralization
    - Ensemble transform - un-necessary if there is no significant difference
    - Rescaling – un-necessary if we confirm EnKF parallels have the similar characteristics for different seasons
- Stochastic perturbations
  - Tune STTP for model change and initial perturbation changes
  - Turn off stochastic perturbations for surface pressure in STTP
- Expectations
  - Improve hurricane track forecast
  - Improve probabilistic forecast guidance
  - Improve predictability of HIW and extreme weather event

Preliminary results for period of May 22nd – October 31st 2013

Extended Summer Season

General stats:
http://www.emc.ncep.noaa.gov/gc_wmb/xzhou/EnKF_prhs13_10.HTML

Surface against observations:
http://www.emc.ncep.noaa.gov/gmb/wx20cb/vsdb/geavg.20130601.20130831/g2o/

Precipitation:
http://www.emc.ncep.noaa.gov/gmb/yluo/tmp_dir/GEFS_PQPFvrfy_summer_test.html

TC tracks (one slide)

Note: model version may be slightly (minor) different during integration period.

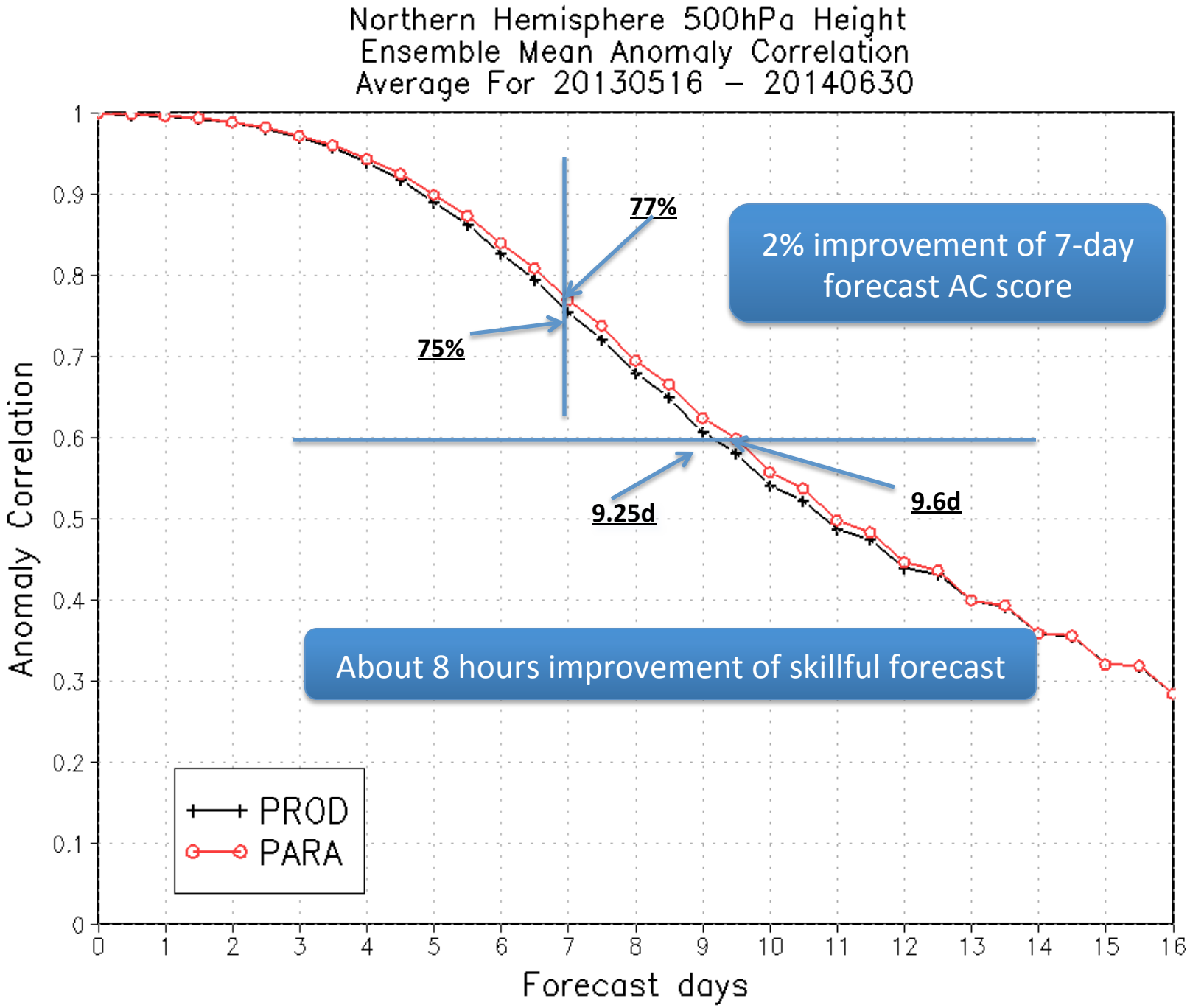
Preliminary results for period of January 2nd – May 14 2014

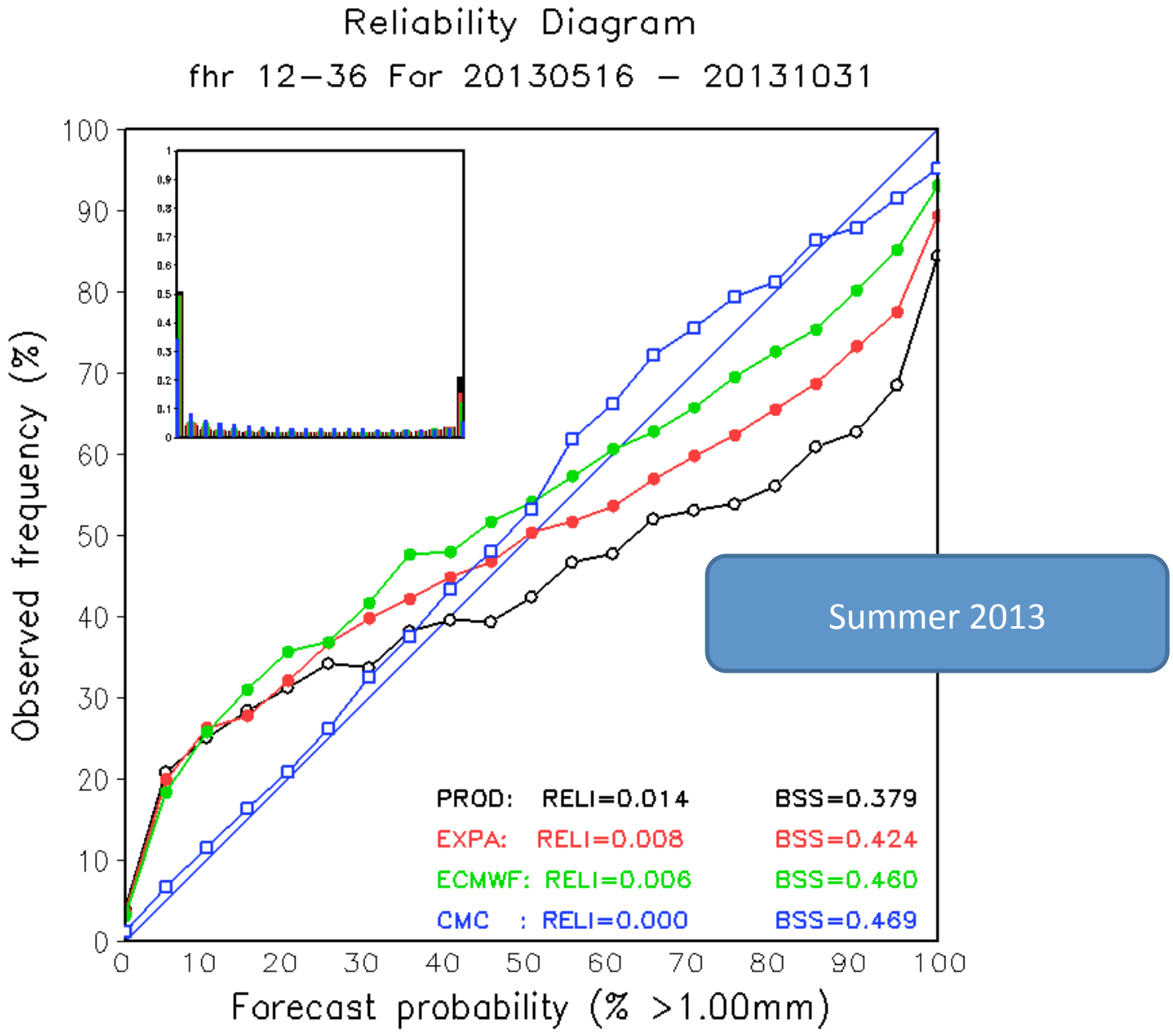
Extended Winter Season

General stats:
http://www.emc.ncep.noaa.gov/gmb/wd20dh/STTP2014/PROB_OoFa.HTML

Precipitation:
http://www.emc.ncep.noaa.gov/gmb/yluo/GEFS_VRFY/GEFS_PQPFvrfy_spring_test.html

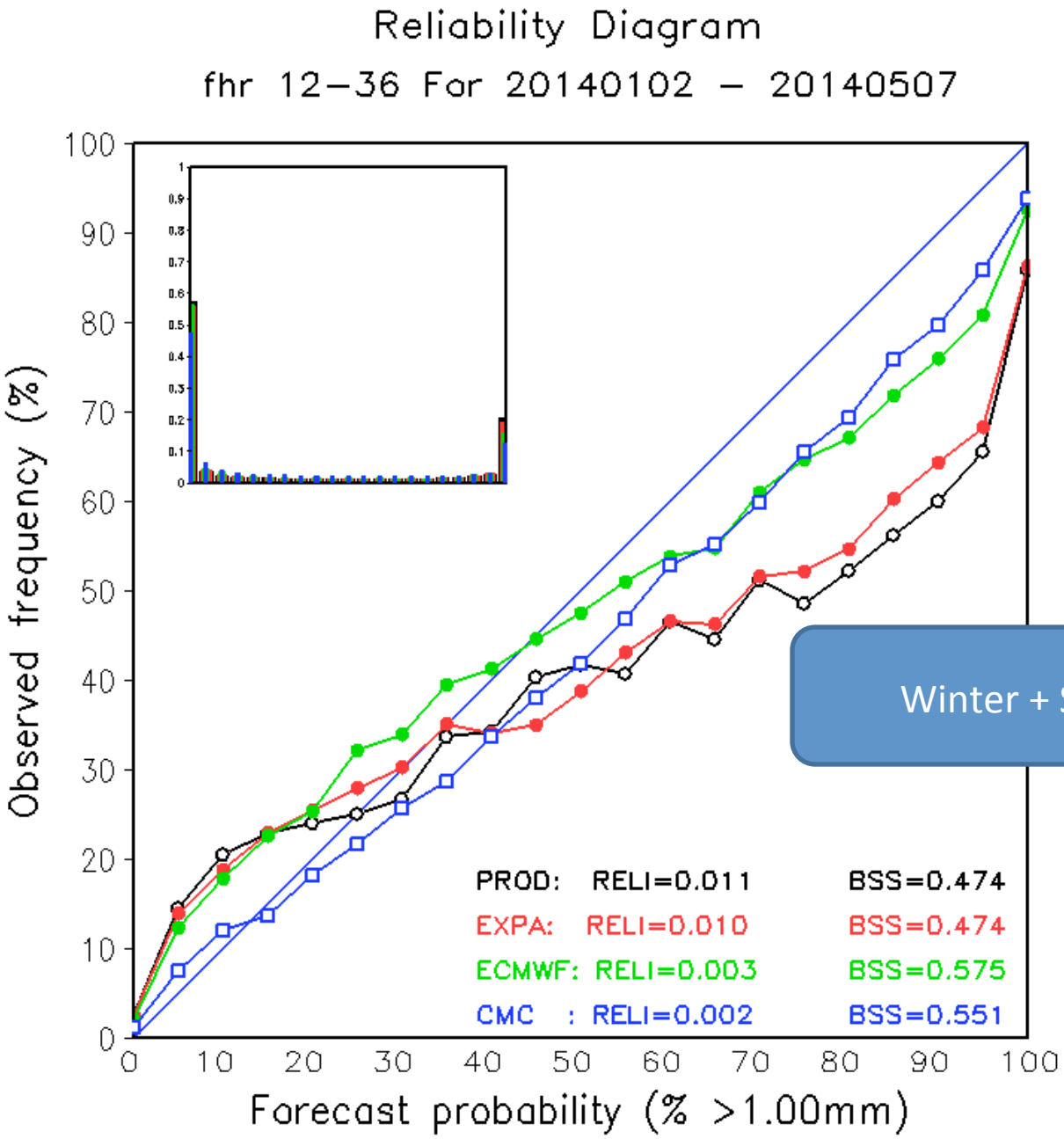
Note: model version may be slightly (minor) different during integration period.


Northern Hemisphere 500hPa Height
Ensemble Mean Anomaly Correlation
Average For 20130516 – 20140630
Anomaly Correlation
Forecast days
PROD
PARA
77%
75%
9.25d
9.6d
2% improvement of 7-day forecast AC score
About 8 hours improvement of skillful forecast



Summer 2013

Precipitation reliability for 12-36hr and greater than 1mm/day

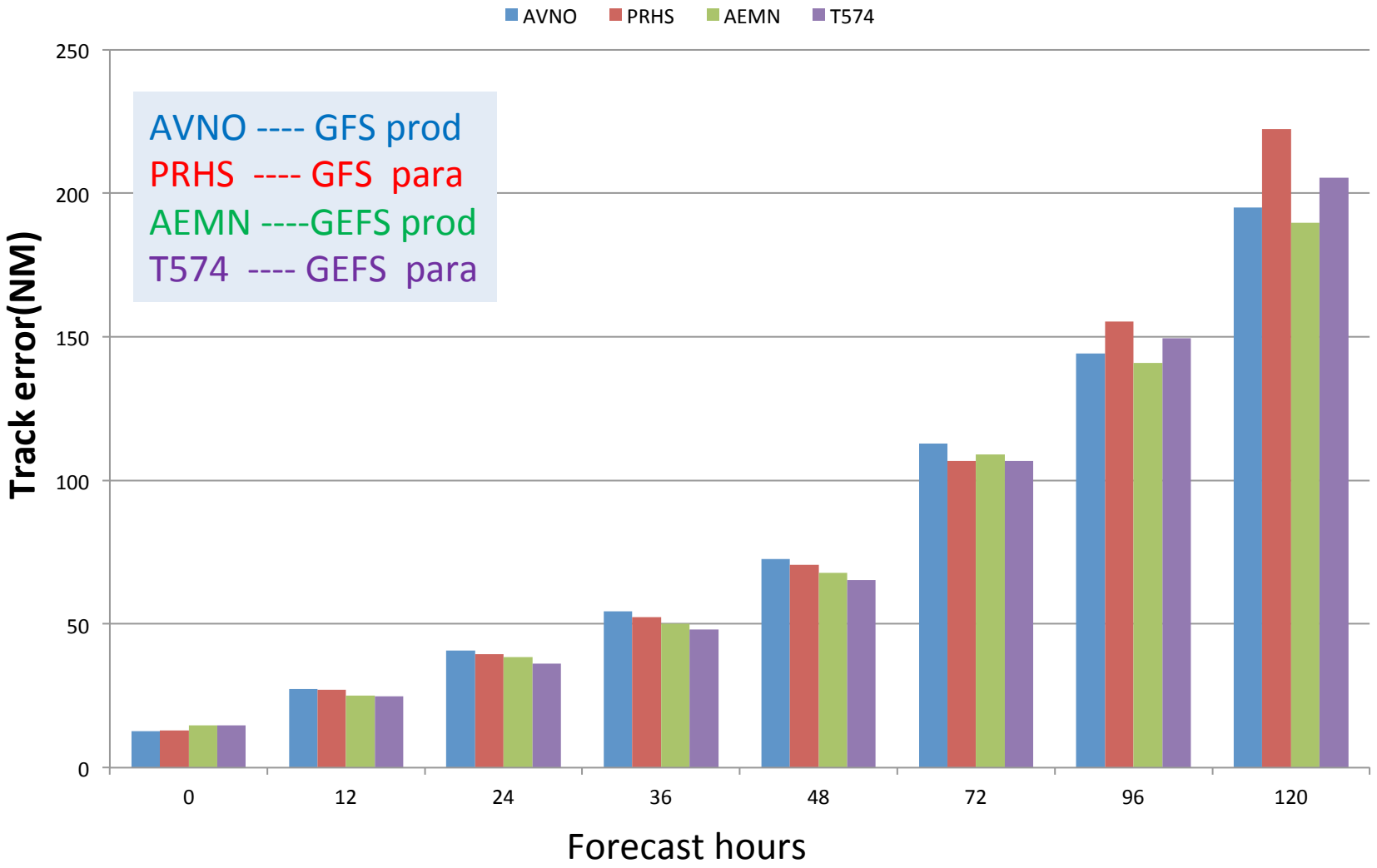


Winter + Spring 2014

Precipitation reliability for 12-36hr and greater than 1mm/day

May 15 – Oct. 31 2013 AL/EP/WP TC Track Verifications

Retrospective runs – once per day at 00UTC



CASEs	236	207	185	158	133	93	61	39

Summary

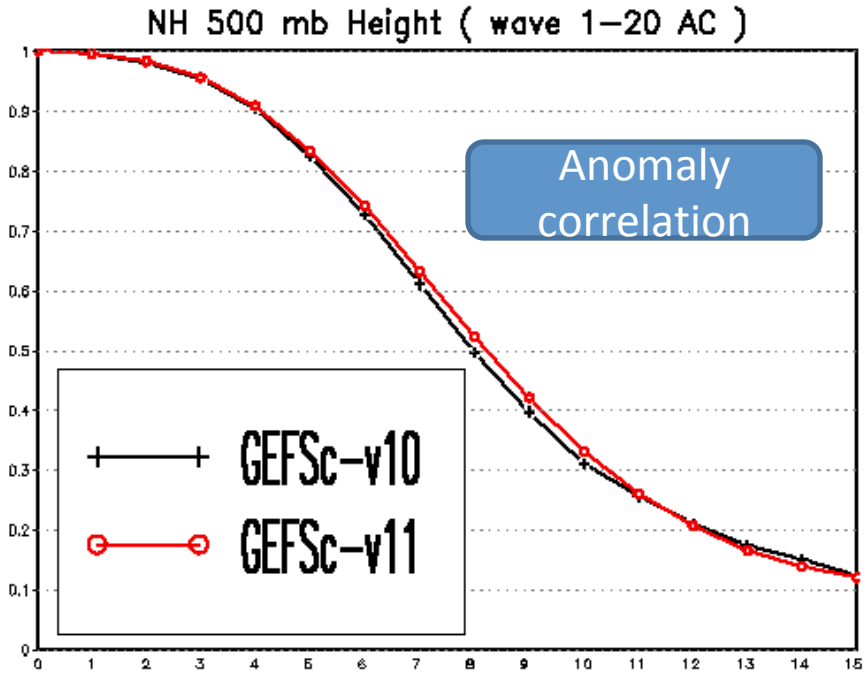
- Extended summer (05/15 – 10/31/2013)
  - Improvement:
    - Overall large scale circulation in terms of AC, RMS error, CRPS and other measures
    - Hurricane tracks out to 3 days (smaller sample beyond 3 days, especially for Atlantic basin)
    - Precipitation – improved reliability and skill
    - Surface temperature – improved for east CONUS
    - Surface wind
  - Neutral:
  - Degrade:
    - Surface temperature – degraded for west CONUS (large warm bias)
- Extended winter (01/1 – 05/14/2014)
  - Improvement:
    - Overall for many atmospheric variables
    - Surface wind
    - Surface temperature - improved bias for short lead-time
  - Neutral:
    - Surface temperature errors
    - Precipitation
  - Degrade:

GEFS legacy forecast

- Next GEFS implementation will be scheduled for WCOSS phase II (Q2FY15)
  - EMC will continue to run current operational GEFS (with BV-ETR cycling every 6 hours, but 00UTC forecast only) for one year
    - Current: 21 members, 00, 06, 12, 18UTC
    - Future: 21 members, 00UTC
  - Timing for legacy data delivery
    - Current: +4:50
    - Future: +8:00 (???)
  - Data directory for access (NCEP ftp – work with NCO)
    - Current directory: …/com/gefs/prod/….
    - future directory (???): …/com/gefs_v10/prod/….
  - Data names
    - Will be the same, but in the different directory
  - No statistical bias correction
    - Raw ensemble forecast data only
  - Issues for NCO:
    - AWIPS can not handle two GEFS data streams (???), GEFS data was already implemented to AWIPS in April 2014 from NWS ER's request

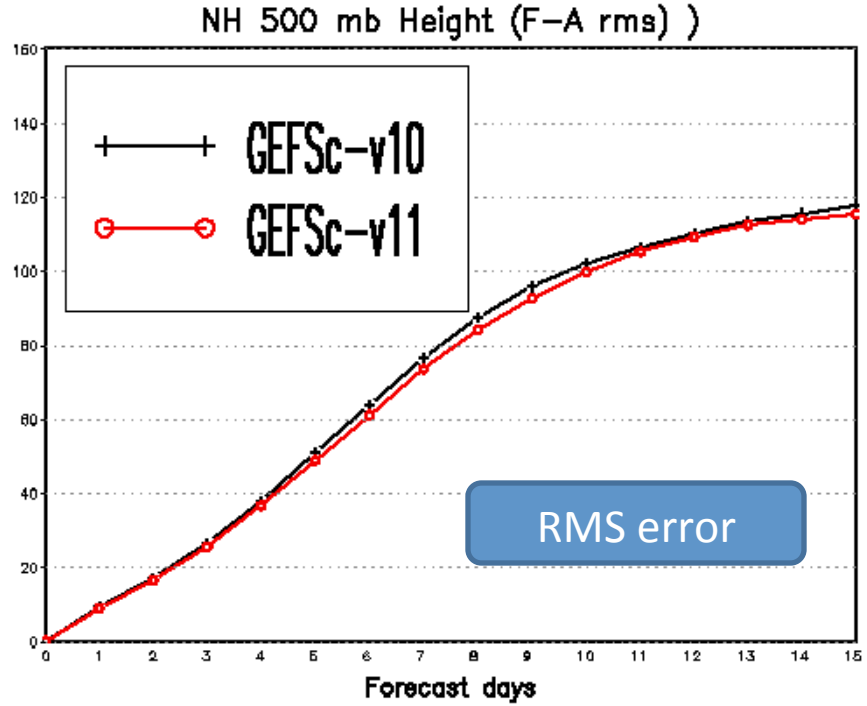
Limited Reforecast (retrospective)

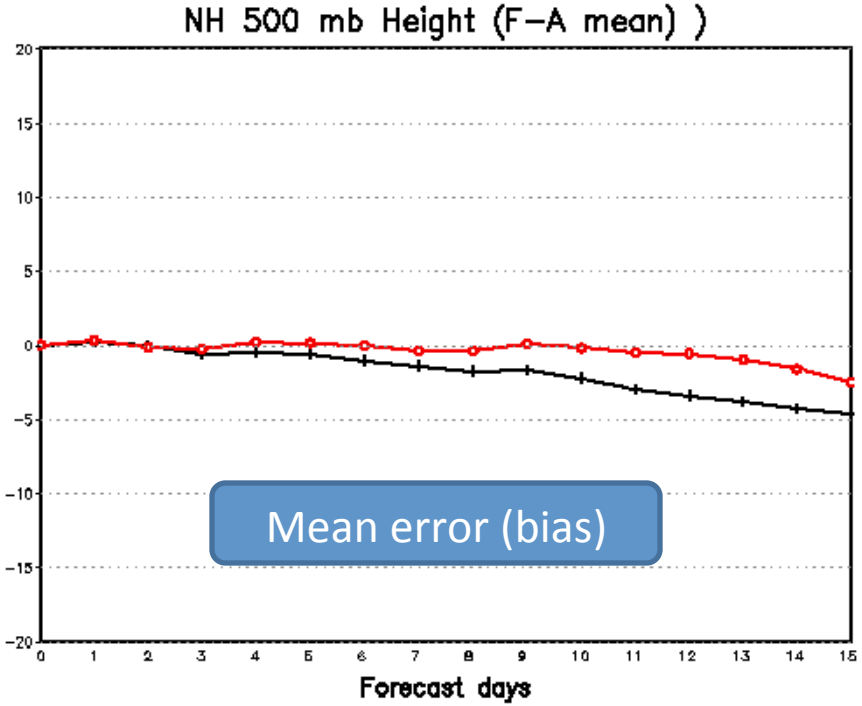
- There is no plan for real time GEFS reforecast for next GEFS implementation.
- Based on communications with WPC, CPC, SPC, OHD, MDL and other users. EMC will provide:
  - 2-years retrospective runs (00UTC and 12UTC)
    - May 2013 – the time of implementation
    - Expect to be available: Mid of March 2015
  - 18 years ensemble control only reforecast
    - Year 1995-2012
    - 00UTC and every other day
    - Expect to be available: end of Jan. 2015
  - All data will be saved in HPSS tapes
    - No public ftp access
- Computational resources
  - EMC will look for resources of development of WCOSS and research machine “zeus”
- Still in the discussion with CPC to have 18 years ensemble retrospective runs

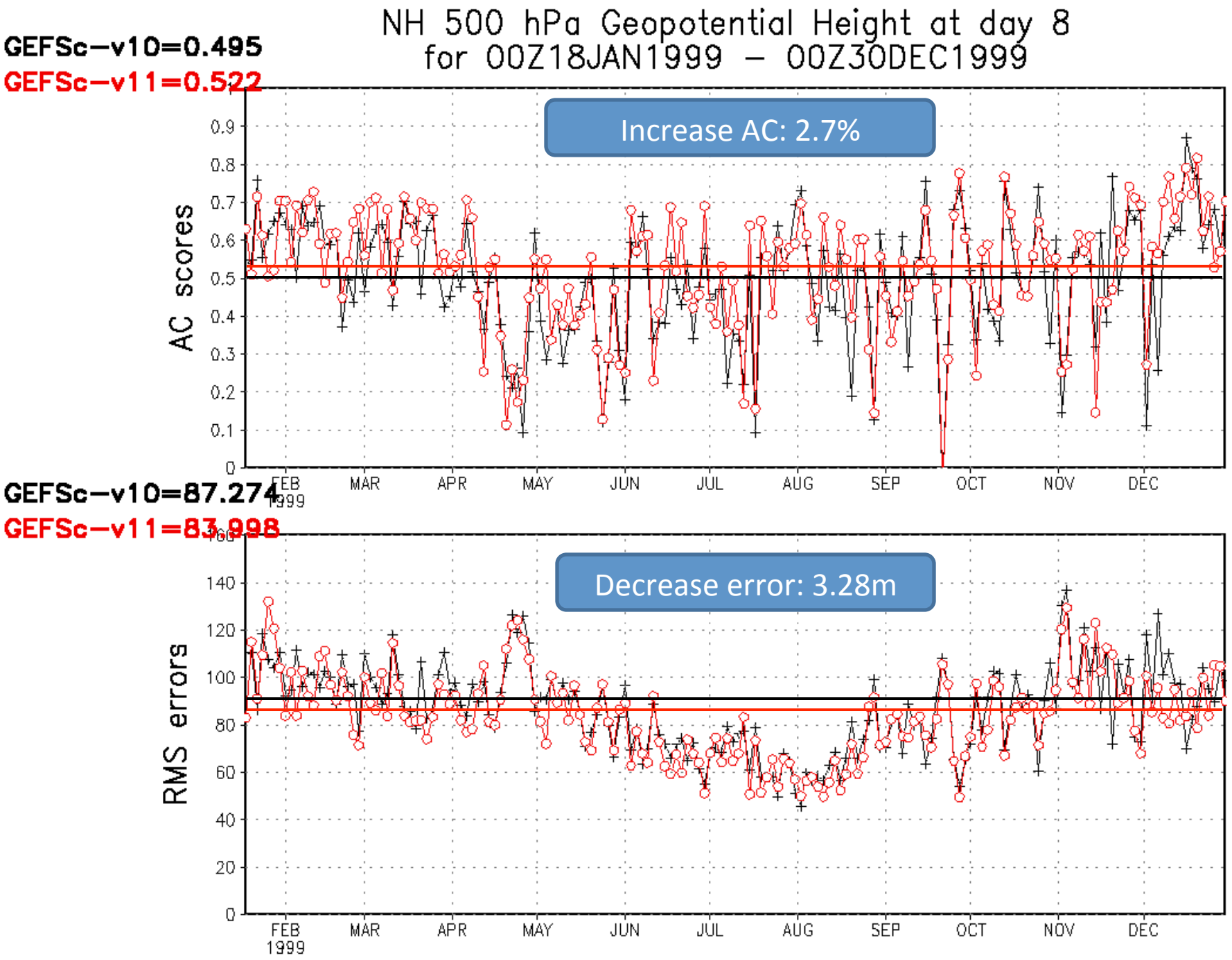


Statistical period: 01/18/1999 – 12/31/1999 (178 cases)

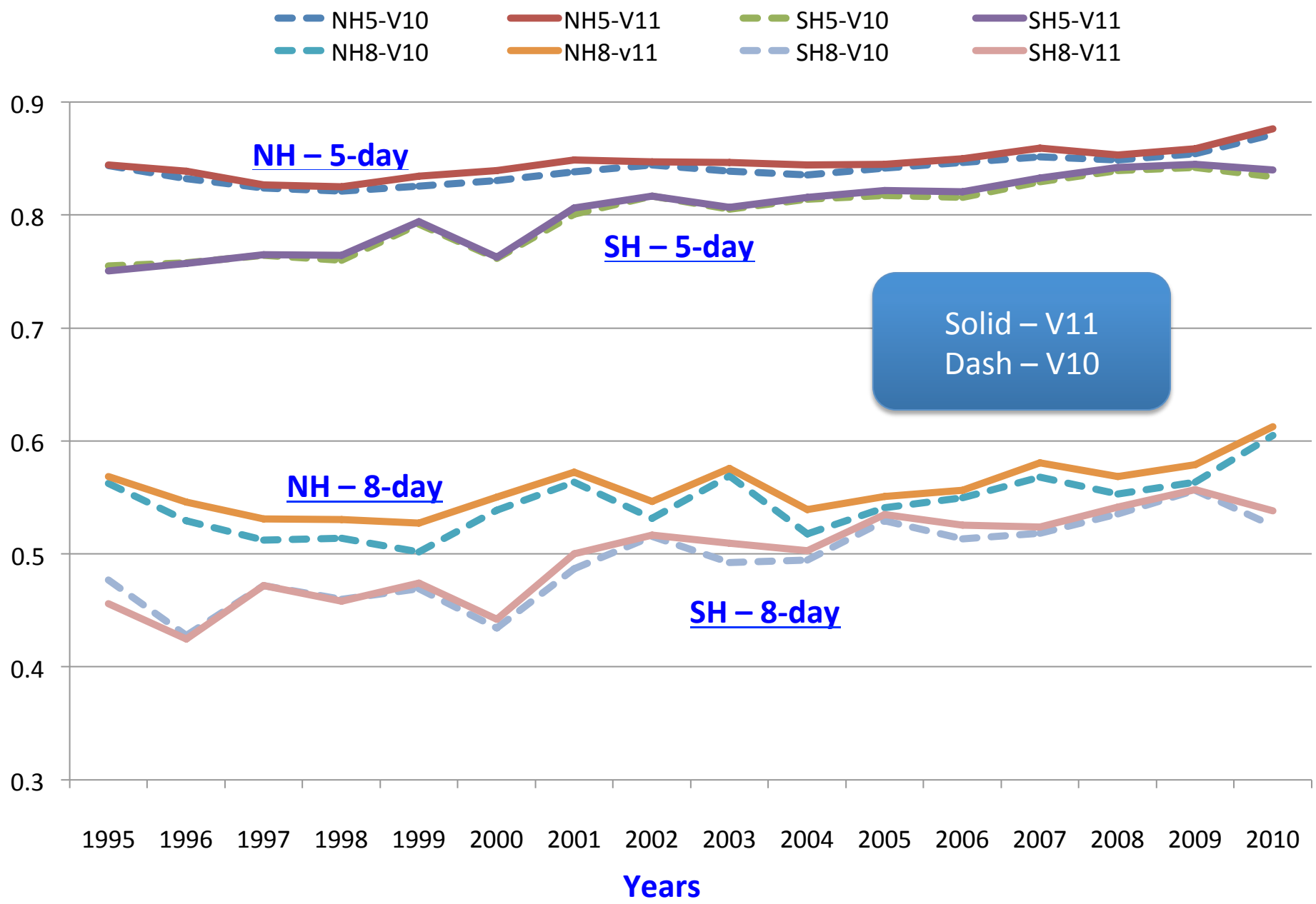
Ensemble control only
T574L64 (0-192h)
T382L64 (192-384h)



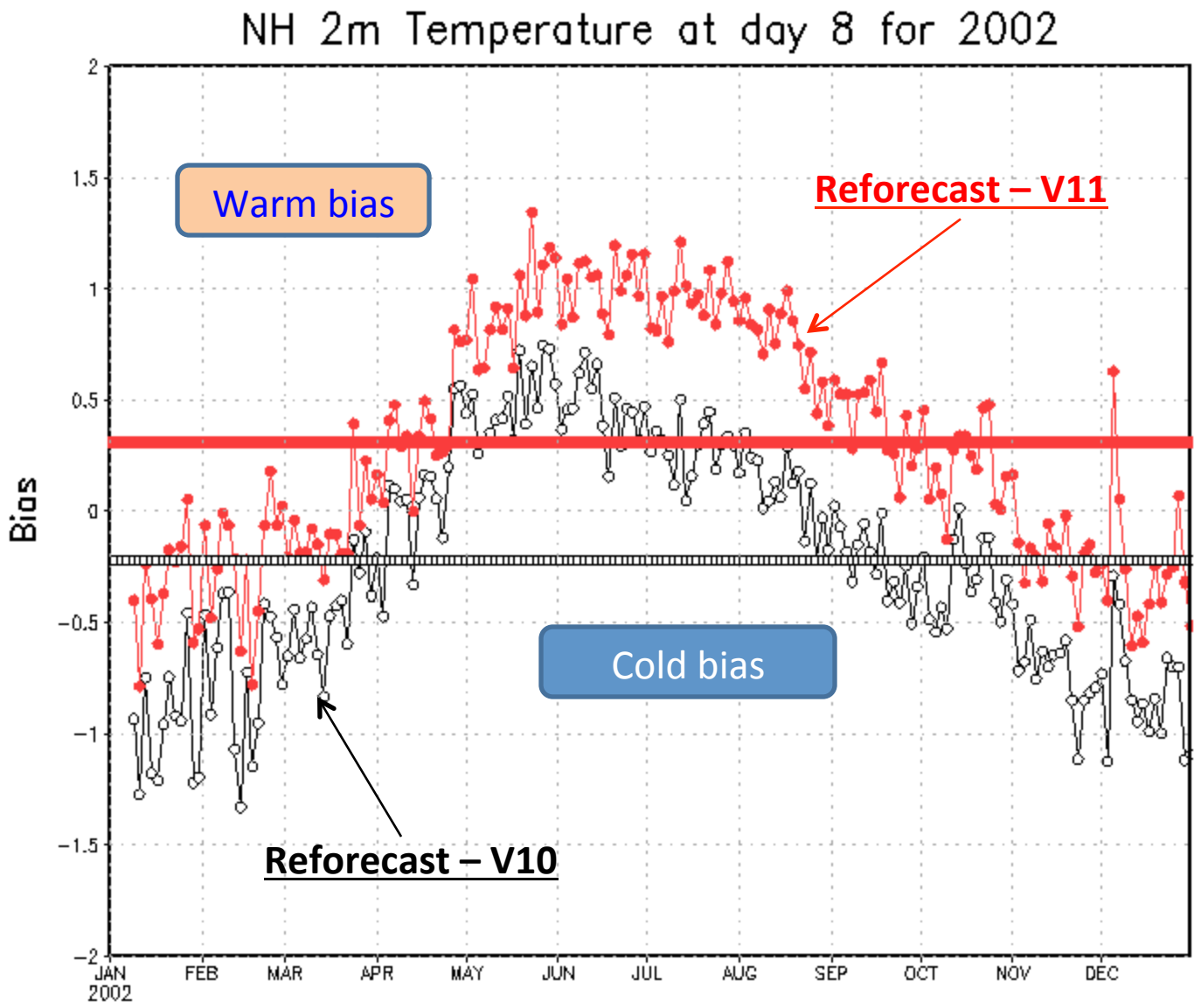



NH 500 hPa Geopotential Height at day 8
for 00Z18JAN1999 – 00Z30DEC1999
GEFSc–v10=0.495
GEFSc–v11=0.522
Increase AC: 2.7%
AC scores
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
FEB 1999
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
GEFSc–v10=87.274
GEFSc–v11=83.998
Decrease error: 3.28m
RMS errors
0
20
40
60
80
100
120
140
FEB 1999
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

500hPa Anomaly Correlation for Control Only Reforecast (V10 .vs V11)

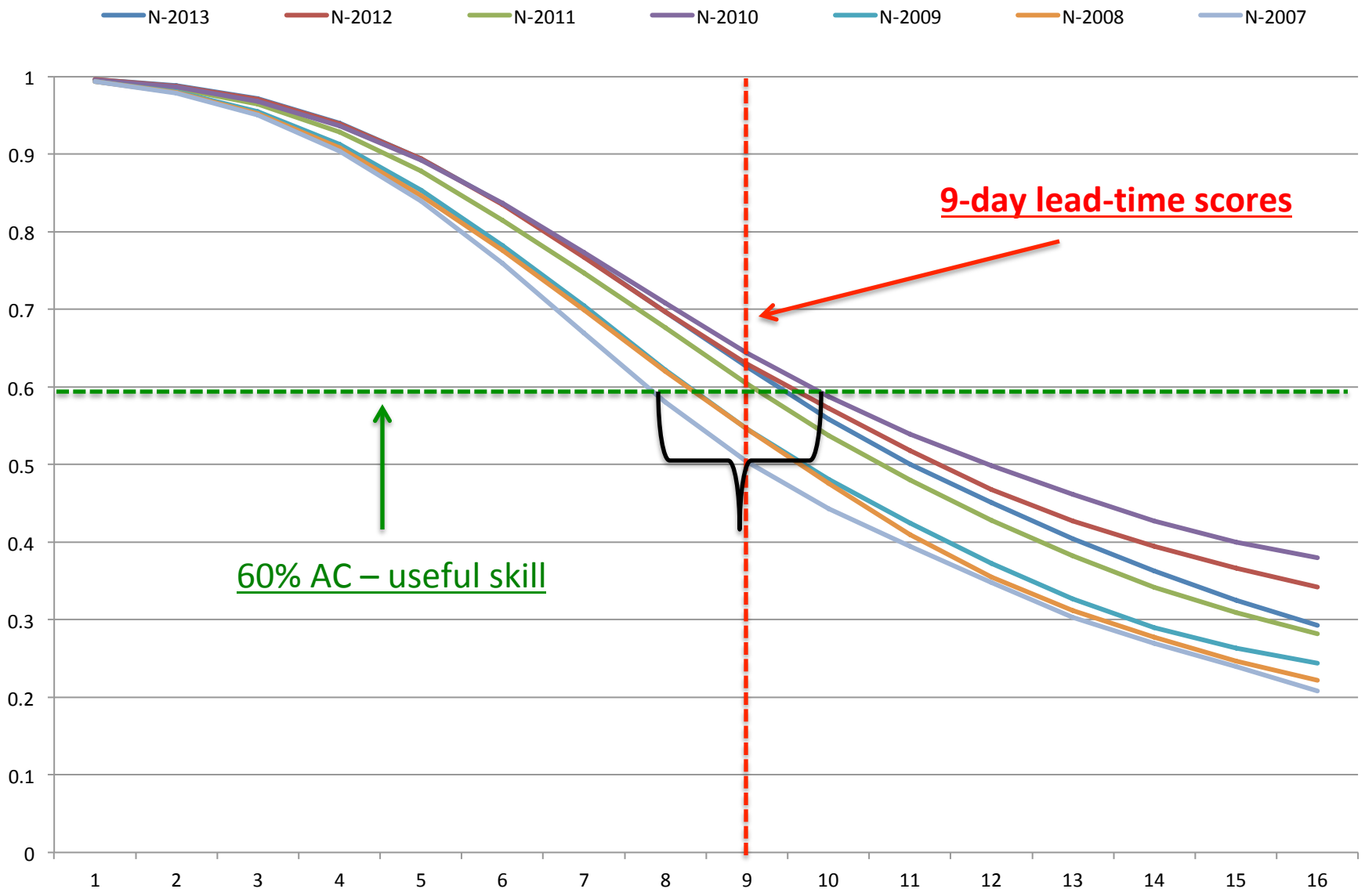


Example of 2-meter temp. bias of 2002 (fcst: 192 hours)



GEFS future

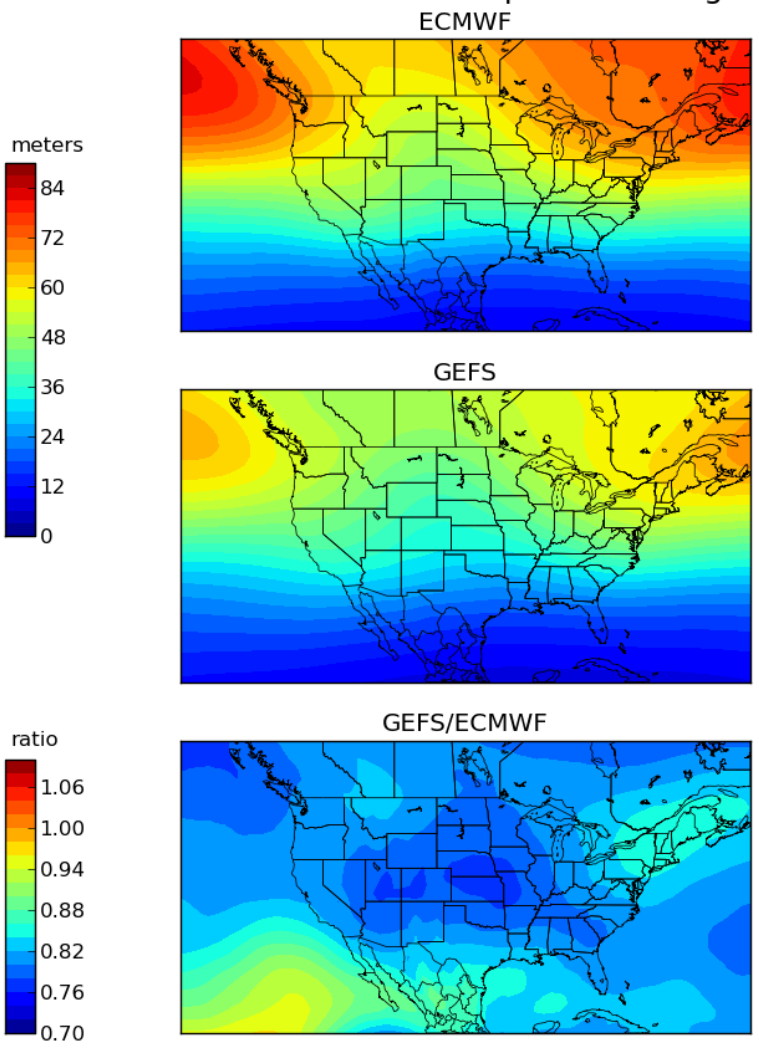
NH 500hPa height anomaly correlation (NCEP ensembles)



Changes of Ensemble Spread

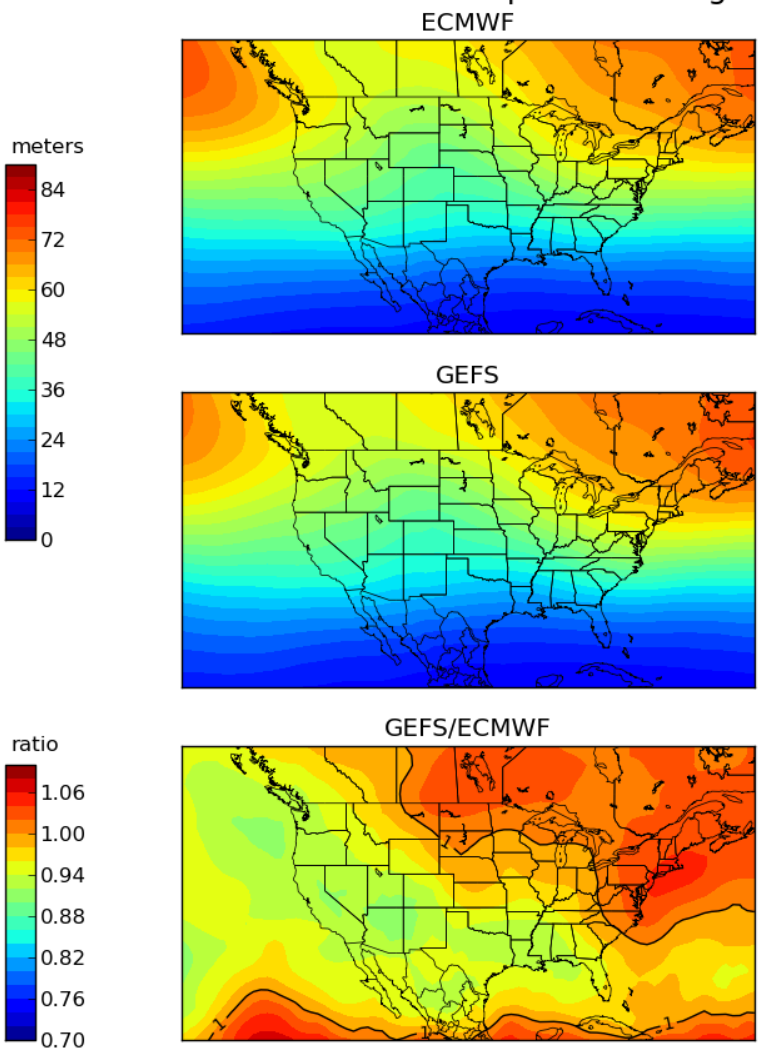
Then

Average 00Z Ensemble Spread (Mar 2007 - Mar 2009)
168-h Forecasts of 500-mb Geopotential Height (n=745)



Now

Average 00Z Ensemble Spread (Mar 2012 - Mar 2013)
168-h Forecasts of 500-mb Geopotential Height (n=360)



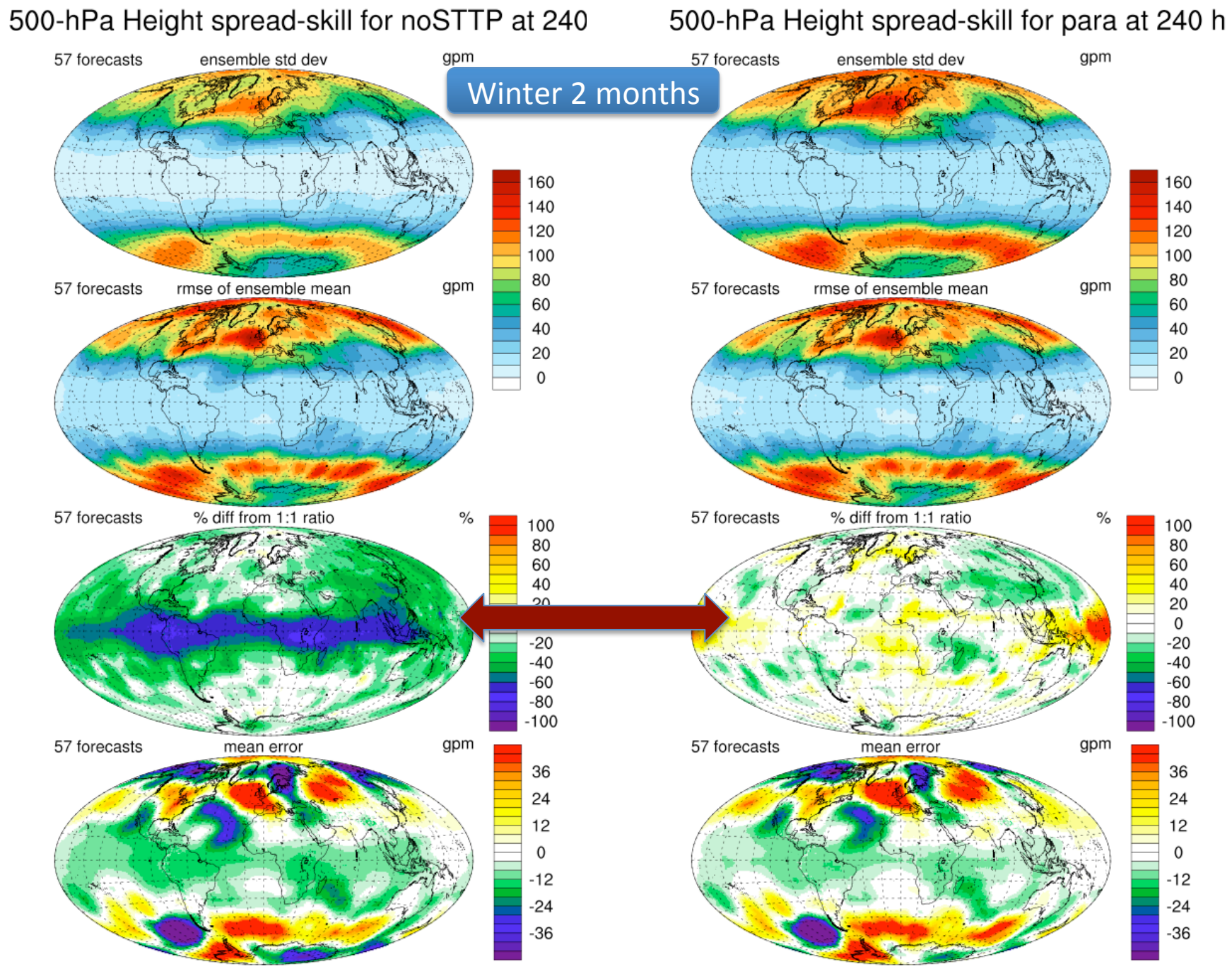
Courtesy of Dr. Alcott Trevor

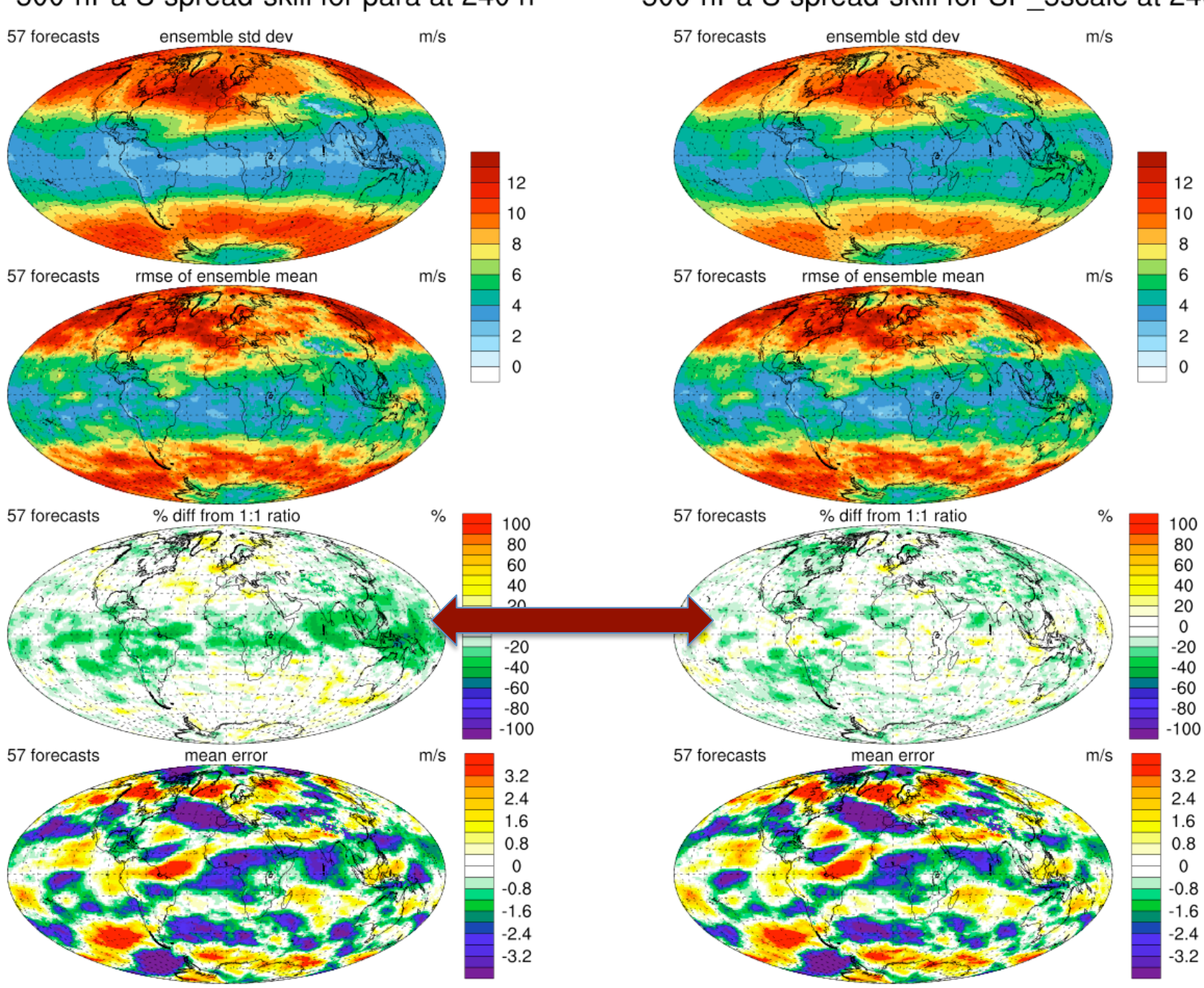
Introduce other stochastic schemes

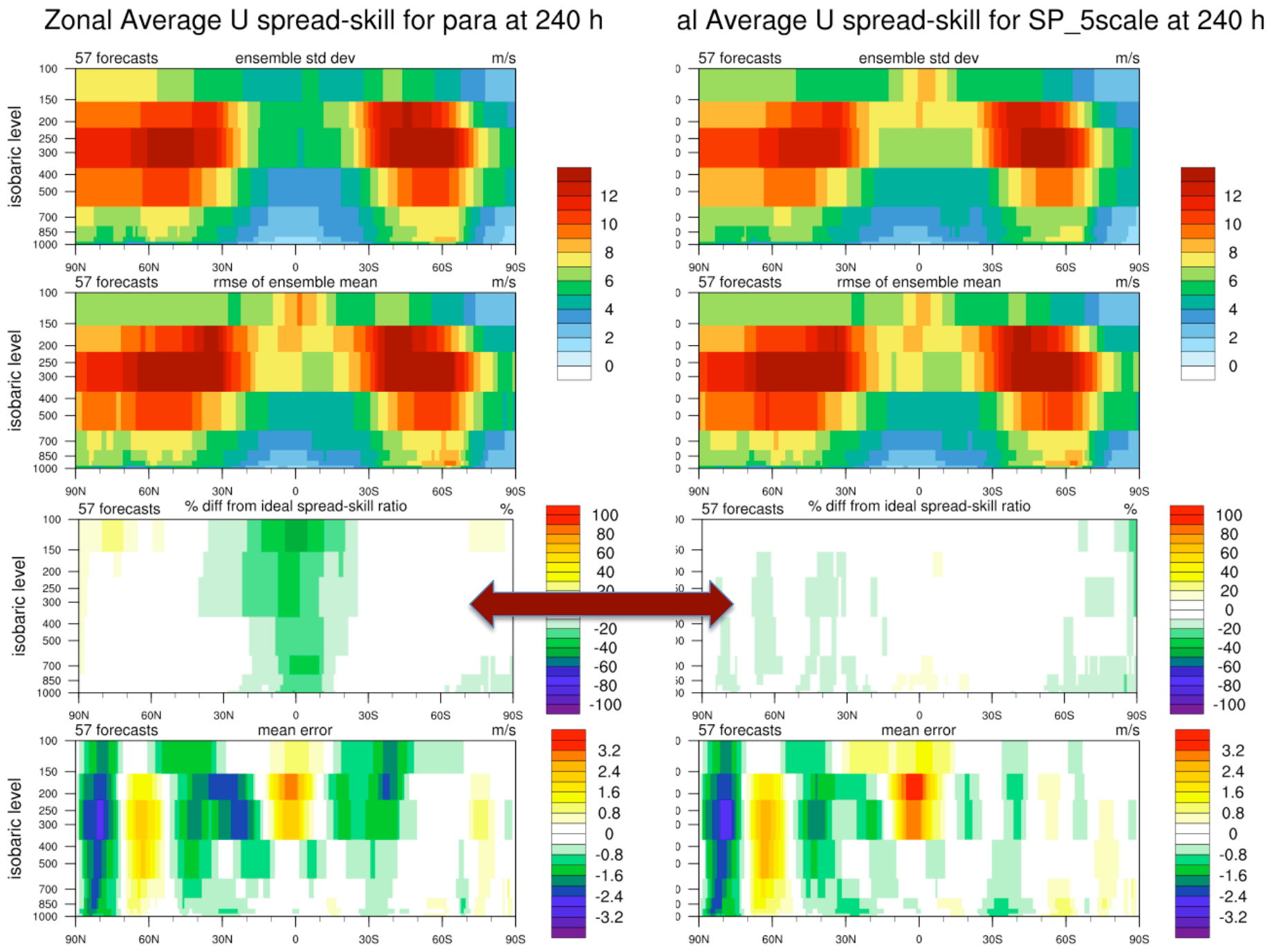
- **Stochastic Kinetic Energy Backscatter (SKEB)**
  - Represents processes absent from model
  - Stream function is randomly perturbed to represent upscale kinetic energy transfer (Berner et al., 2009)

- **Stochastic Perturbed Physics Tendencies (SPPT)** – (ECWMF tech memo 598)
  - Designed to represent the structural uncertainty (or random errors) of parameterized physics
  - Multiplicative noise used to perturb the total parameterized tendencies (Palmer et al., 2009)
  - Biggest impact for tropics

- **Stochastically-perturbed boundary layer HUMidity (SHUM)**
  - The similar formula as SPPT
  - Designed to represent influence of sub-grid scale humidity variability on the the triggering of convection (Tompkins and Berner 2008)


500-hPa Height spread-skill for noSTTP at 240
500-hPa Height spread-skill for para at 240 h
Winter 2 months
57 forecasts
ensemble std dev
gpm
160
140
120
100
80
60
40
20
0
57 forecasts
rmse of ensemble mean
gpm
57 forecasts
% diff from 1:1 ratio
%
100
80
60
40
-20
-40
-60
-80
-100
57 forecasts
mean error
gpm
36
24
12
0
-12
-24
-36

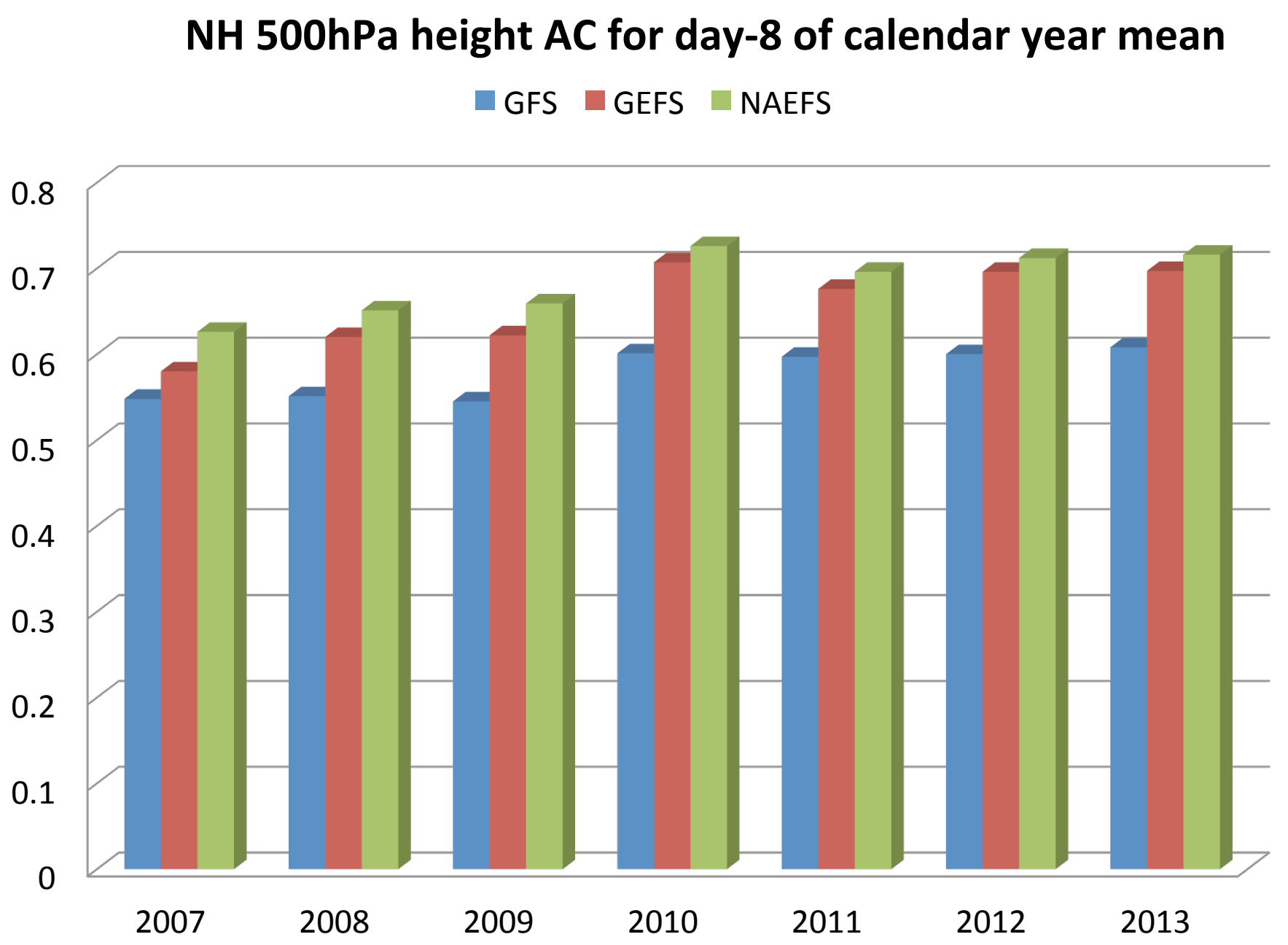

500-hPa U spread-skill for para at 240 h
500-hPa U spread-skill for SP_5scale at 240 h
57 forecasts
ensemble std dev
m/s
rmse of ensemble mean
% diff from 1:1 ratio
%
mean error
12
10
8
6
4
2
0
100
80
60
40
20
-20
-40
-60
-80
-100
3.2
2.4
1.6
0.8
-0.8
-1.6
-2.4
-3.2


Zonal Average U spread-skill for para at 240 h
al Average U spread-skill for SP_5scale at 240 h
57 forecasts
ensemble std dev
m/s
57 forecasts
rmse of ensemble mean
m/s
57 forecasts
% diff from ideal spread-skill ratio
%
57 forecasts
mean error
m/s
isobaric level
100
150
200
250
300
400
500
700
850
1000
90N
60N
30N
0
30S
60S
90S
12
10
8
6
4
2
0
100
80
60
40
-20
-40
-60
-80
-100
3.2
2.4
1.6
0.8
0
-0.8
-1.6
-2.4
-3.2

NAEFS Current Status

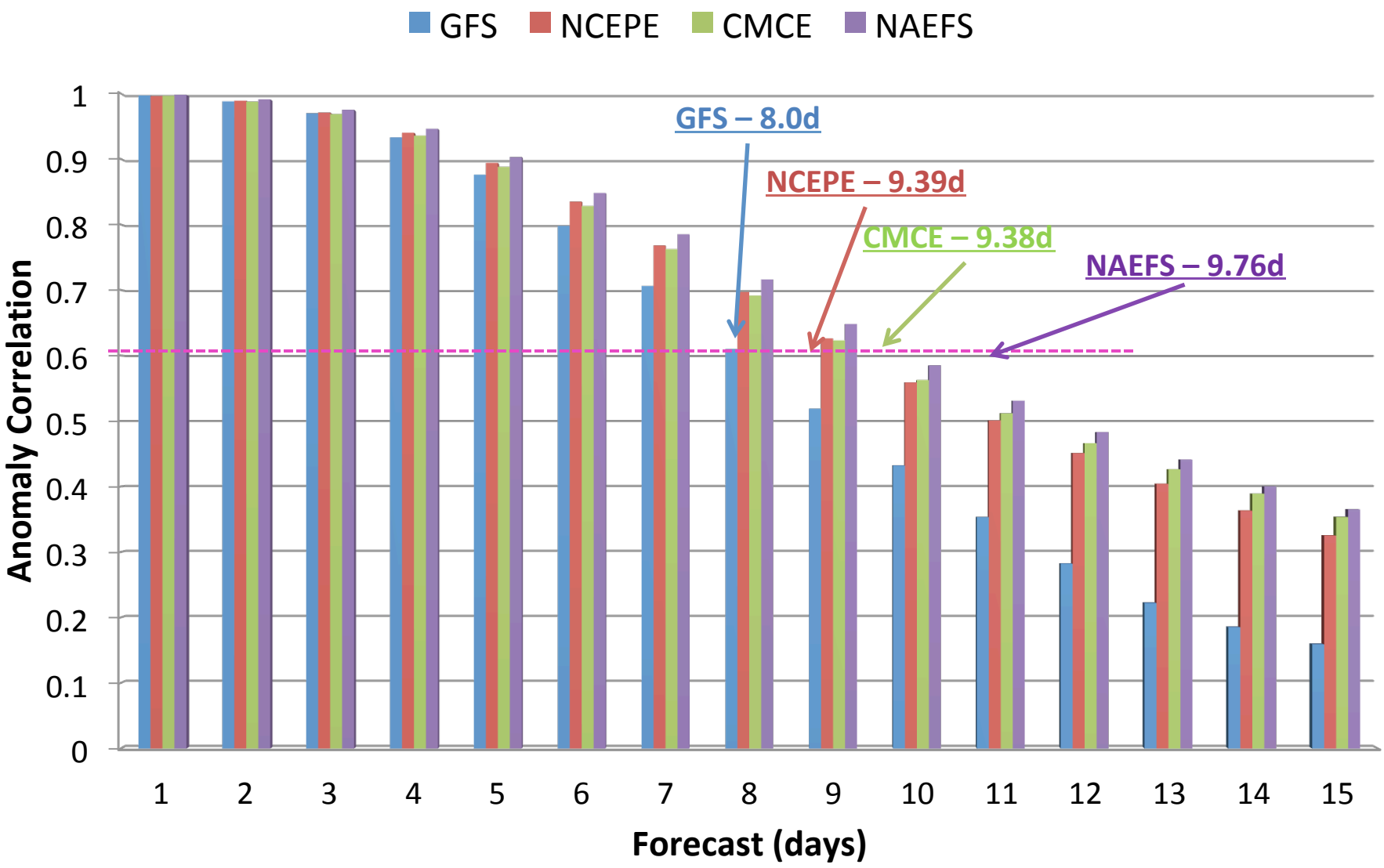
Updated: November 18th 2014

	NCEP	CMC	NAEFS
Model	GFS	GEM	NCEP+CMC
Initial uncertainty	ETR	EnKF	ETR + EnKF
Model uncertainty/ Stochastic	Yes (Stochastic Pert)	Yes (multi-physics and stochastic)	Yes
Tropical storm	Relocation	None	
Daily frequency	00,06,12 and 18UTC	00 and 12UTC	00 and 12UTC
Resolution	T254L42 (d0-d8)~55km T190L42 (d8-16)~70km	About 50km L72	1*1 degree
Control	Yes	Yes	Yes (2)
Ensemble members	20 for each cycle	20 for each cycle	40 for each cycle
Forecast length	16 days (384 hours)	16 days (384 hours)	16 days
Post-process	Bias correction (same bias for all members)	Bias correction for each member	Yes
Last implementation	February 14th 2012	November 18th 2014	

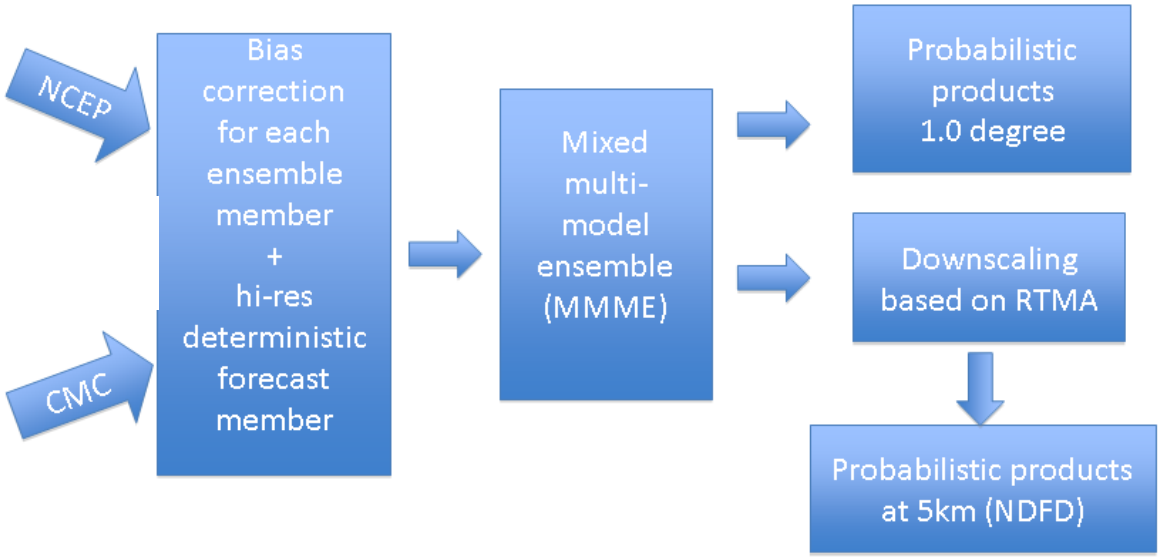

NH 500hPa height AC for day-8 of calendar year mean
GFS
GEFS
NAEFS
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2007
2008
2009
2010
2011
2012
2013

NH Anomaly Correlation for 500hPa Height

Period: January 1st – December 31st 2013



Current NAEFS SPP System



- Bias corrected NCEP/CMC GEFS and NCEP/GFS forecast (up to 180 hrs), same bias correction algorithm
  - 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
  - Combine NCEP/GEFS (20m) and CMC/GEFS (20m), FNMOC ens. will be added 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/6km), CONUS and Alaska
  - Generate mean, mode, 10%, 50%(median) and 90% probability forecasts

NAEFS Bias Correction Variables

Variables	pgrba_bc file	Total 49 (3)
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
New	Td2m, RH2m and Precipitation	3

NAEFS Downscaled Variables

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

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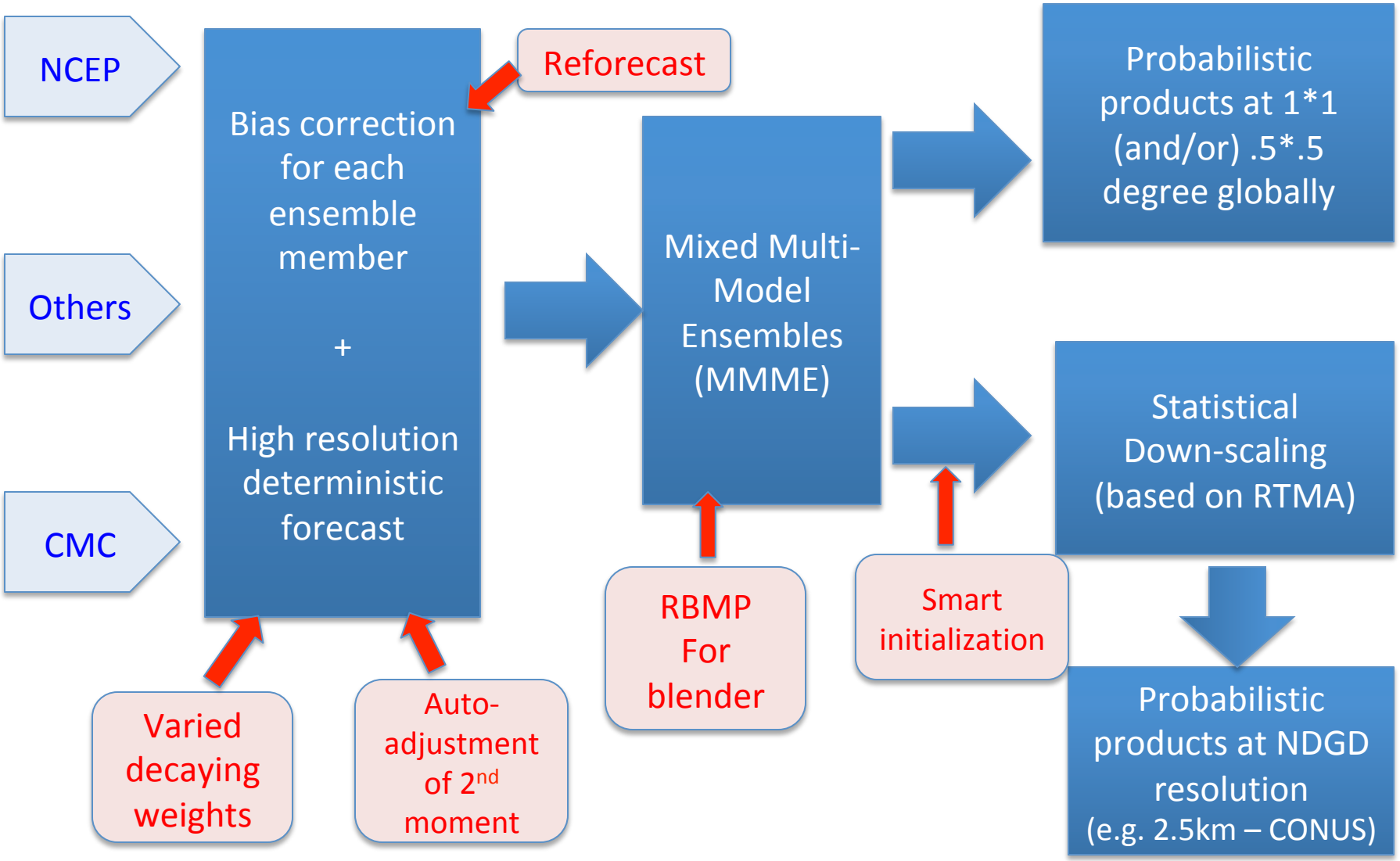
Future NAEFS Statistical Post-Processing System

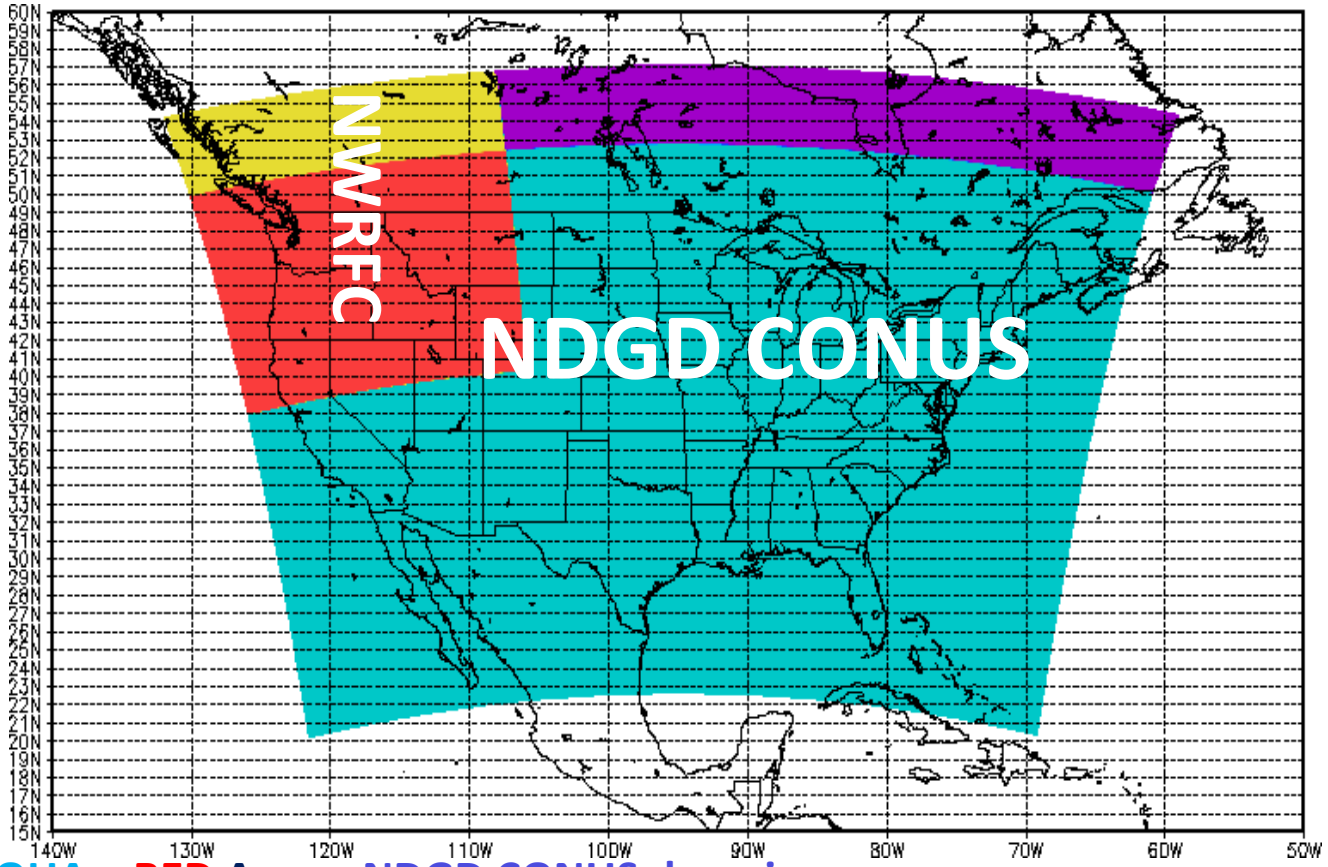


Expect new products through NAEFS (priority)

- All downscaled products are finer resolution.
  - CONUS – 2.5km
  - Alaska – 3km
- Extend CONUS domain
  - to North (part of Canada)
  - to South (part of Mexico)
- NAEFS SPP applies to ECMWF ensemble
  - Bias correction and downscaling
  - Restrict data
- Cloud cover – bias correction and downscaling
  - Two analysis (AFWA and CLAVR) for bias correction
  - Implementation time depends on RTMA upgrade
- Precipitation?
  - Suggested to use 6hr forecast as truth for bias correction globally.
  - Need to find out the difference of CCPA and f06 (already have?)
  - For CONUS, we will have downscaling step to 2.5km.
- Possible other parameters
  - Visibility
  - Wind guest
- Background information
  - 2-year retrospective runs (full size ensembles and twice per day)
  - 18 years control only runs (every other day)

Update of RTMA/URMA

Extend CONUS-2.5km domain to provide support for Northwest River Forecast Center (NWRFC)



AQUA + RED Areas: NDGD CONUS domain

RED + YELLOW Areas: NWRFC domain produced at NCEP and shipped to WFO Seattle

PURPLE: Extended area currently not disseminated

Courtesy of Manuel Pondeca

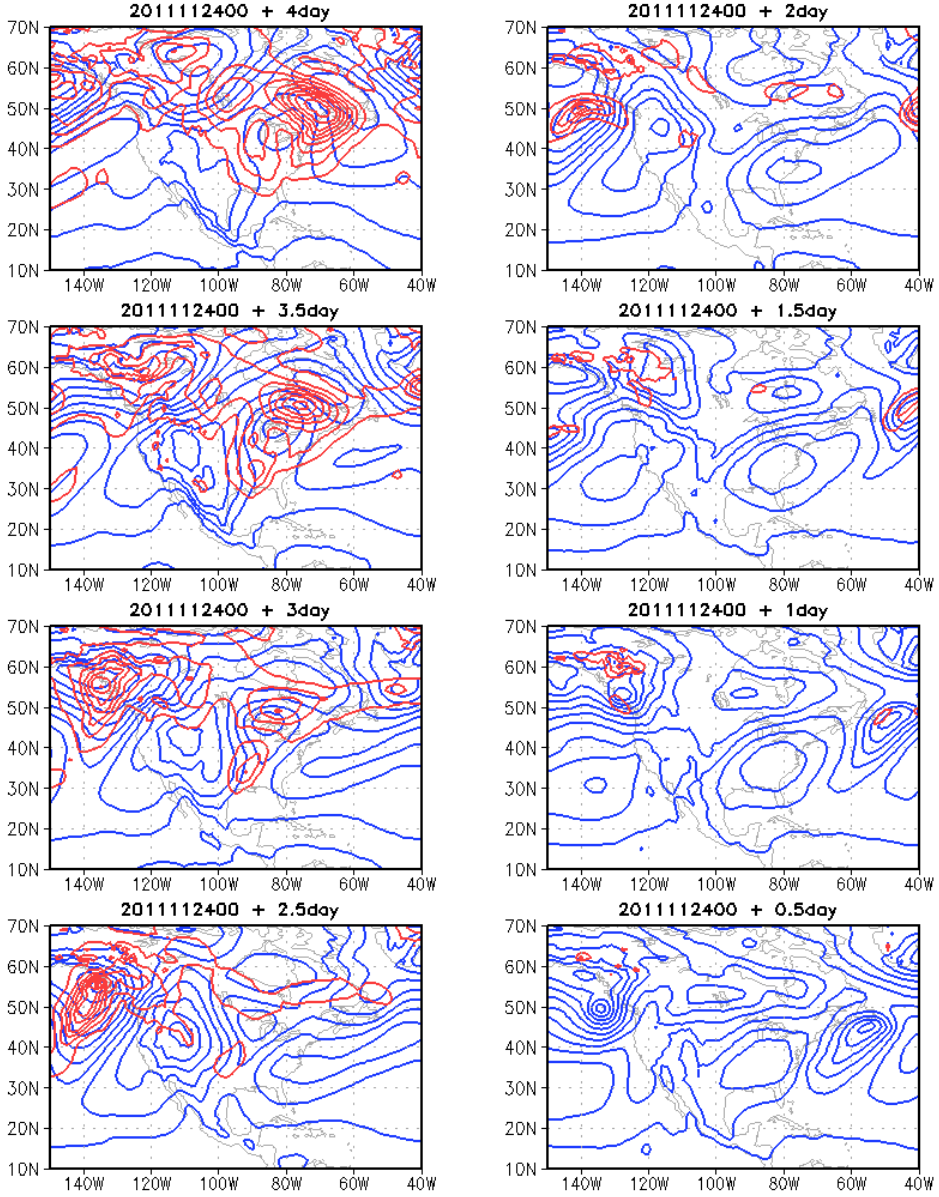
Climatology Calibrated Precipitation Analysis

- Background - (QPF bias correction in NCEP)
  - Implemented on 2004 (HPC, CPC endorsed)
  - Bias corrected GFS/GEFS forecasts
    - At 2.5 degree resolution, every 24 hours, using Gauge (12UTC-12UTC)
    - Using decay average (or Kalman Filter) method for sampling
    - Using frequency match algorithm for CDF of OBS/FCST
- Climatological Calibrated Precipitation Analysis (CCPA)
  - Use CPC unified analysis at 1/8 degree, daily, global land - reliability
  - Use RFC/QPE (stage IV) 5km resolution, 6-h(CONUS) – resolution
  - Use regression method to generate a and b from above two datasets
  - Produce CCPA analysis (CCPA = $a*QPE_{rfc} + b$)
  - Resolution is 5km (NDGD) grid (and subsets) for CONUS
  - Update every year by apply longer stage IV to produce better regression coefficients
- Important Applications
  - Improving QPF/PQPF bias correction – GEFS, NAEFS, SREF and etc…
  - Statistical downscaling QPF/PQPF forecast for GEFS, NAEFS, SREF and etc…
  - HPC daily precipitation analysis products – CCPA web products (2012)
  - Daily precipitation verifications (WPC and EMC map discussion)
  - Future NAM's precipitation analysis (replaced CPC's analysis)
  - Hydrological application – OHD and RFC
  - Research Communities
- Reference
  - Publication: http://journals.ametsoc.org/doi/abs/10.1175/JHM-D-11-0140.1
  - Web display (EMC): http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA.html

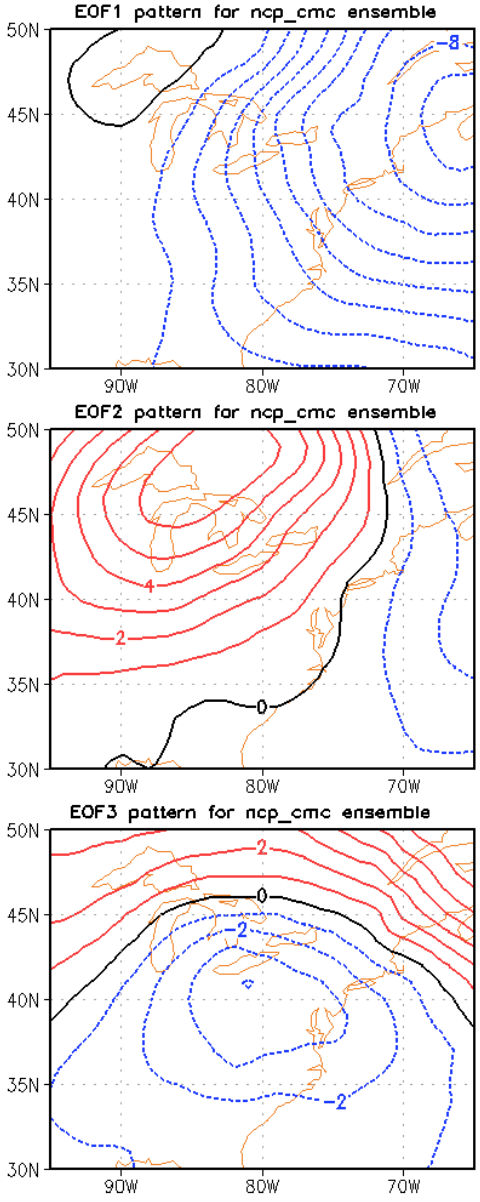
CSTAR Program

- CSTAR - Collaborative Science, Technology, and Applied Research Program
- Collaborate with SUNYSB, EMC, HPC, OPC of NCEP and ESRL
- Predictability of high impact weather during the cool season over the eastern U.S: from model assessment to the role of the forecaster
- Produce daily ensemble sensitivity analysis maps based on
  - NCEP GEFS
  - CMC GEFS
  - ECMWF GEFS (passwd protected)
- A set of variables
  - MSLP and 500hPa height
  - CSTAR web-site: http://dendrite.somas.stonybrook.edu/CSTAR/
  - EMC web-site: http://www.emc.ncep.noaa.gov/gmb/yluo/CSTAR/

Daily maps to support CSTAR program for winter season



red contours: variance of MSLP at different fcst time; unit(mb²); contour interval: 15mb²
blue contours: ensemble mean of MSLP at different fcst time; unit(mb); contour interval: 5mb
ncp_cmc ensemble initialized at 2011112400; LON: from 150W to 40W; LAT: from 10N to 70N



first three EOF space patterns for MSLP; unit(mb); valid time: 2011113000
; is computed for default area; LON: from 95W to 65W; LAT: from 30N to 50N

GEFS/NAEFS Product/Data Distribution

System	Current available products
Config.	1.deg 0-384h, every 6 hours, 20 members (NCEP) and 20 members (CMC), ens. control (NCEP and CMC)
Format	GRIB1 (and GRIB2, GIF images for web display)
CCS	NCEP: pgrba, pgrbb, pgrba_bc, pgrba_an, pgrba_wt, ensstat, ndgd CMC: pgrba, pgrba_bc, pgrba_an, pgrba_wt, ensstat NAEFS: ndgd, pgrba_an, pgrba_bc
NCEP FTPPRD	ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd gefs.${yyyymmdd} for NCEP ensemble 1. pgrb2a (00, 06, 12 and 18UTC) (1.0 degree, all lead times, 1(c) + 20 (p)) 2. pgrb2alr (00, 06, 12 and 18UTC (2.5 degree, all lead times, 1(c) +20 (p)) 2. pgrb2b (00, 06, 12 and 18UTC) (1.0 degree, all lead times, 1(c) + 20 (p)) 4. pgrb2blr (00 and 12UTC) (2.5 degree, all lead times, 1(c) + 20 (p)) 5. ensstat (00UTC) (prcp_bc, pqpf and pqpf_bc files) 6. wafs (00 and 12UTC) 7. ndgd_gb2 (00, 06, 12, 18UTC) (CONUS-5km, all lead times and all probability forecasts) ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd cmce.${yyyymmdd} for CMC ensemble 1. pgrba (00 and 12UTC) (1.0 degree, all lead times,1 control + 20 members) ftp://ftpprd.ncep.noaa.gov/pub/data/nccf/com/gens/prod cd naefs.${yyyymmdd} for NAEFS products 1. pgrb2a_an (00, 12UTC) (1.0 degree, all lead times, anomaly for ensemble mean) 2. pgrb2a_bc (00,12UTC) (1.0 degree, all lead times, probabilistic forecasts) 3. ndgd_gb2 (00,12UTC) (CONUS-5km, all lead times, probabilistic forecasts)
TOC	ftp://tgftp.nws.noaa.gov/SL.us008001/ST.opnl/ cd MT.ensg_CY.${cyc}/RD.${yyyymmdd} for NCEP only 1. PT.grid_DF.gr1_RE.high (00 and 12UTC) (Pgrba: 1.0 and 2.5 degree, 0-384 hrs, c + 10 (p)) 2. PT.grid_DF.gr1_RE.low (00 and 12UTC) (Pgrbb: 1.0 degree, 0-84 hrs, 2.5 d, 90-384 hrs, c + 10 (p)) 3. PT_grid_DF.bb
NOMADS	http://nomads.ncep.noaa.gov (click: GFS Ensemble High Resolution – html) for NCEP, CMC and FNMOC raw and bias corrected ensemble forecast at all lead time (0-384 hours) http://nomad5.ncep.noaa.gov/pub/gens/archive/ for http: combined pgrba and pgrbb at 1 degree resolution

Ensemble Products on AWIPS?

- Ensembles in NCEP operation
  - 22 years anniversary of global ensemble in operation for both NCEP and ECMWF (Dec. 1992)
  - 13 years of regional ensemble (SREF) for NCEP operation (2001)
- Current status of ensemble products
  - NCEP service centers could use all possible ensemble products (information)
  - But regional office and WFO not, if they rely on AWIPS ……
  - For example: GEFS/NAEFS
    - wafs38, wafs39, wafs40 grids (3447 grid points)
    - 00UTC and 12UTC initial forecasts
    - Every 6 hours out to 192 hours
    - GFS control + ens control + 10 ensemble members (+/- 5)
    - 22 variables only
    - T2m and precipitation for all ensemble members (early this year)
- What is the expectation from AWIPS II?
  - We have already developed functionality of probabilistic forecast
- SREC - Software Recommendation and Evaluation Committee
- Increase bandwidth/storage, setup priorities?
- What can we do?
- Can we have ensemble mean and spread first on AWIPS?

Extending NCEP GEFS from 16 days to 30 days

Our Strategy

To improve numerical guidance and prediction capability for week 3 & 4 and build up seamless forecast system across all time scales, NCEP is planning to accelerate the development and implementation of extending GEFS to 30 days with the inclusion of one/two way(s) coupling with a thermodynamic ocean. By contrast to NCEP Climate Forecast System (CFS), there are many advantages for extending GEFS to cover the intra-seasonal time range, including

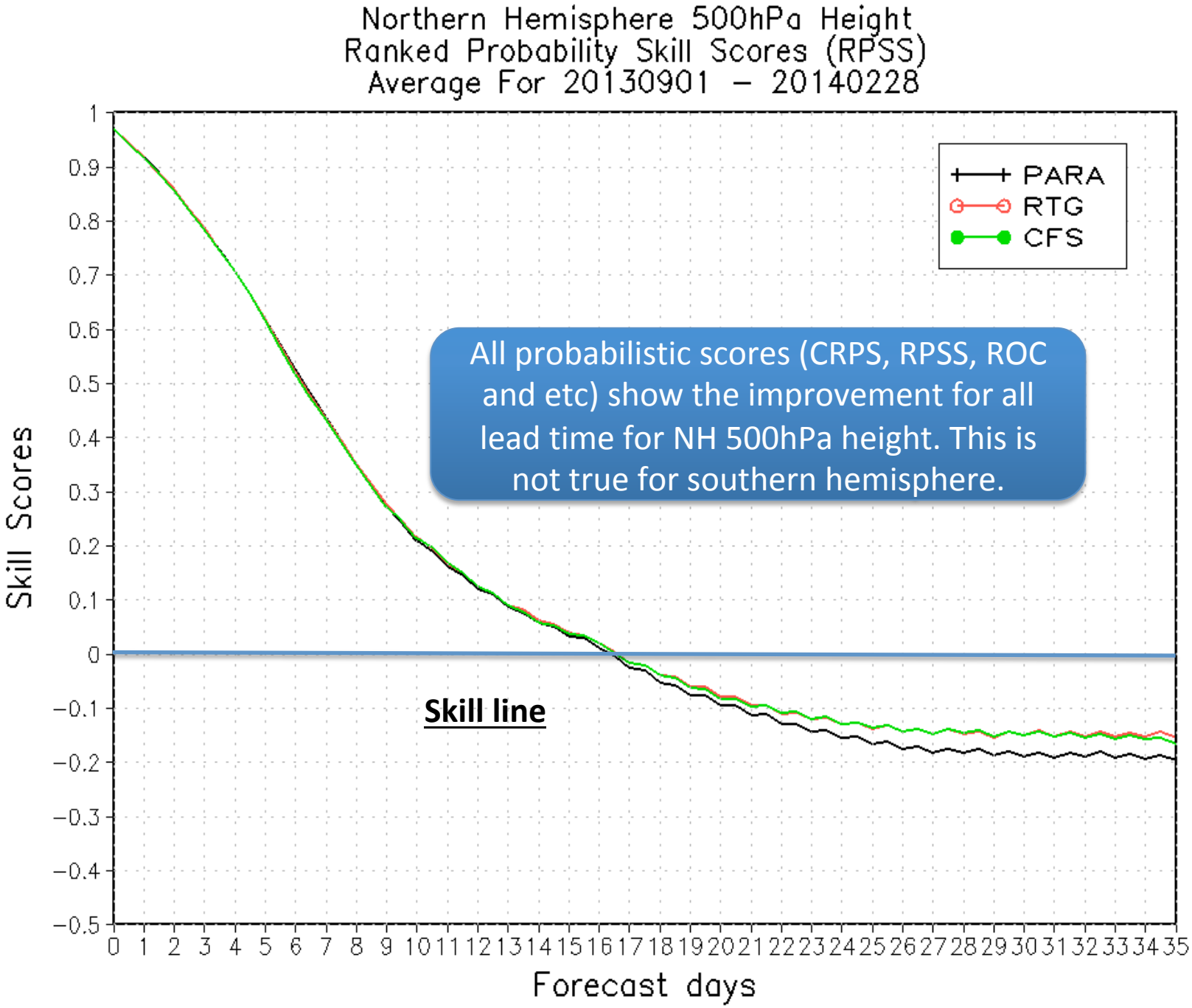
1) Better initial perturbations to represent analysis errors and initial uncertainties;
2) Higher resolution continuously from weather to extend range to allow more interactions of different scales;
3) Advanced model physics with various stochastic perturbations to assimilate model uncertainties;
4) Large ensemble size (80+4 members for one synoptic day) to provide reliable and skillful forecast;
5) Acceptable configuration of reforecast/hindcast in real time for calibration;
6) Seamless forecasts across weather and short-term climate.

Science: Types of couplings for the GEFS

- Type 1: Un-coupled
  - Short and medium range skill benchmark
  - Experimental runs readily available
  - Multi-model ensembles (NCEP, CMC, CFSv2)
  - Bias correction procedures

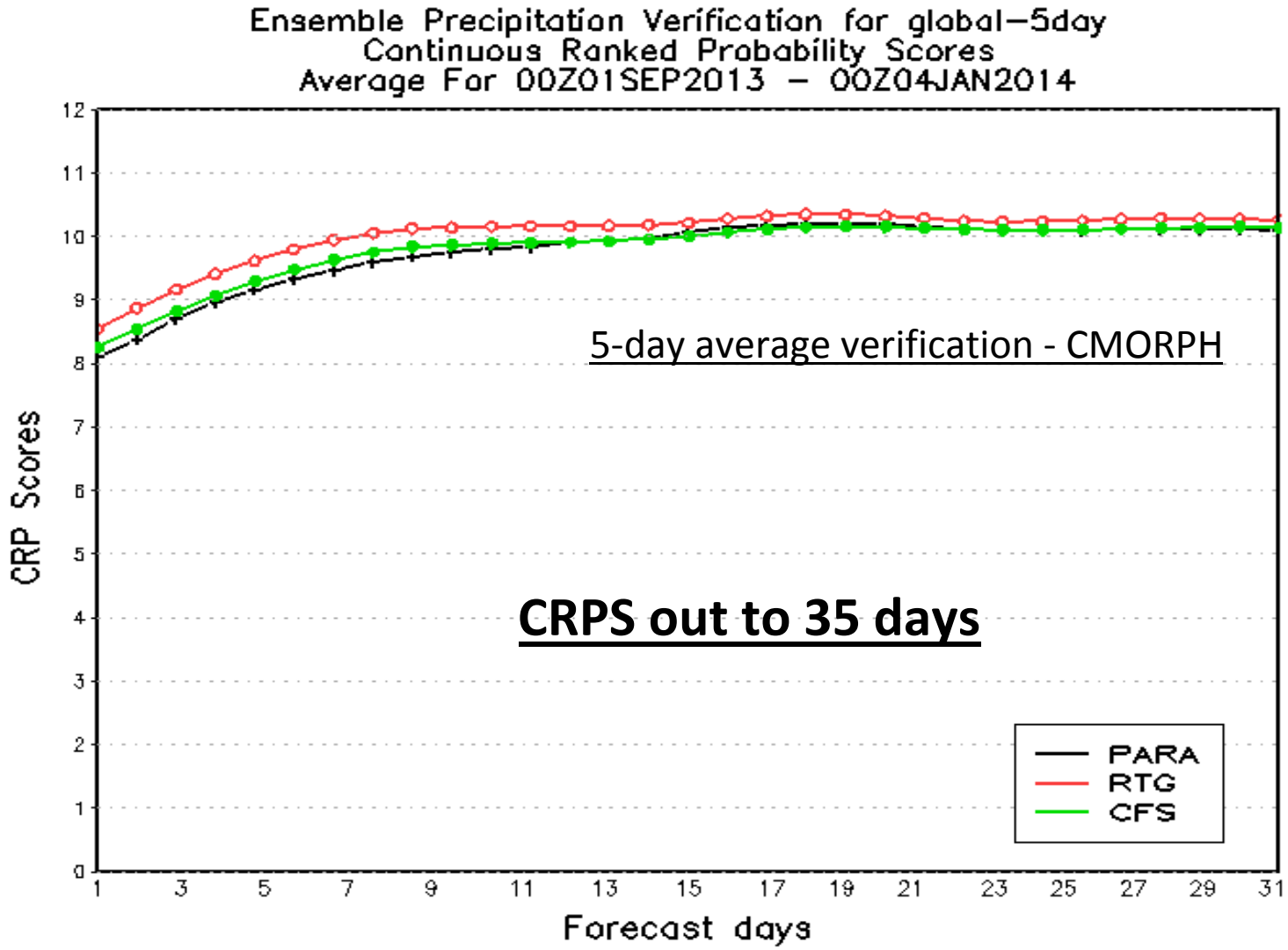
- Type 2: One-way forcing
  - Perturbed SST – various methods
  - Predicted and bias corrected SST from CFSv2

- Type 3: Two-ways coupling
  - Suitable coupled GFS model
  - Coupled to mixed layer model
  - Coupled perturbations
  - Coupling with ocean to take either from day-0 or day-10


Northern Hemisphere 500hPa Height
Ranked Probability Skill Scores (RPSS)
Average For 20130901 – 20140228
PARA
RTG
CFS
All probabilistic scores (CRPS, RPSS, ROC and etc) show the improvement for all lead time for NH 500hPa height. This is not true for southern hemisphere.
Skill line
Skill Scores
Forecast days

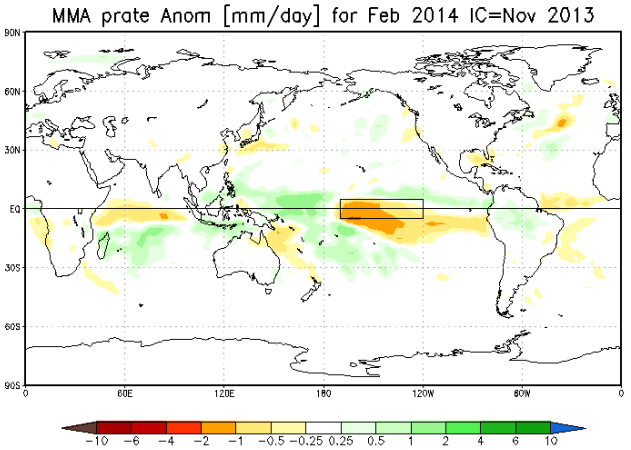
Global precipitation verification

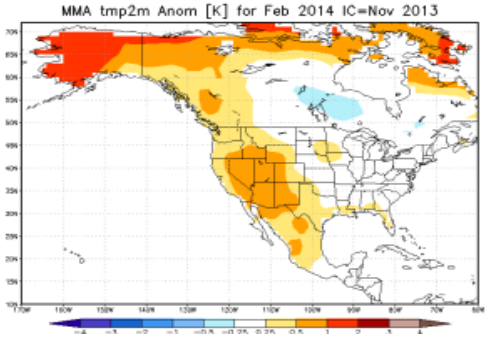
50N-50S Global

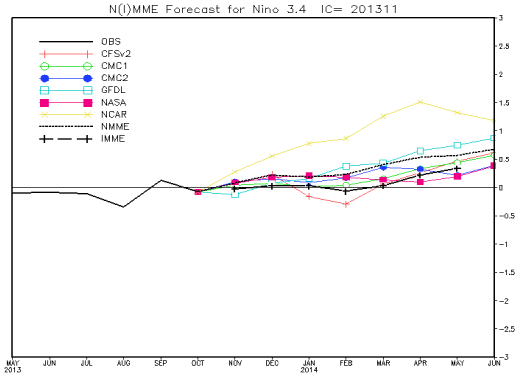


IMME Status – Malaquias Pena

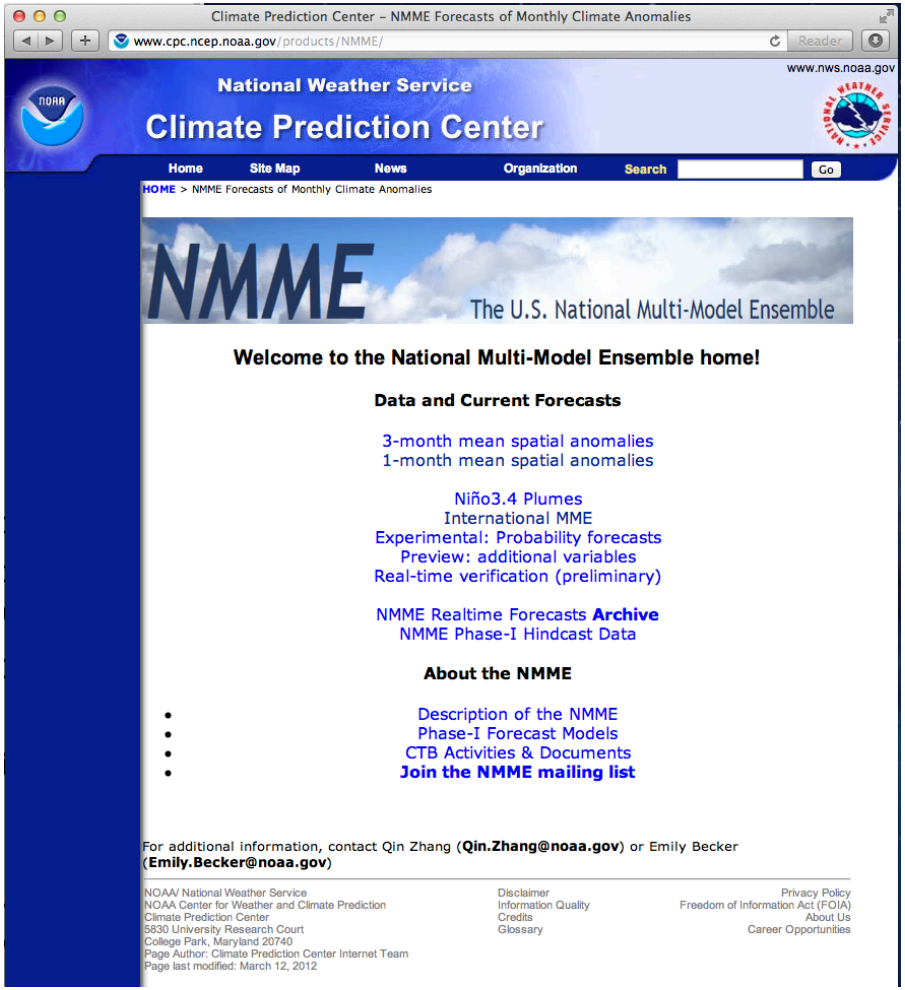
- Datasets:
  - CFSv2, ECMWF, MeteoFrance and MetOffice
  - Real-time forecasts and corresponding model hindcasts
  - Leads: 0 to 6 months. Variables: Precip Rate, 2mT, SST
- Data process algorithms
  - Decoding, bias correction, multi-model combination and data display
  - Created algorithms and transitioned to WCOSS
  - Created algorithms for model intercomparison prediction skills
- Products
  - Monthly mean forecasts maps: Globe and North America
  - Niño 3.4 forecast plumes
  - Posted individual model forecasts on a regular basis in a password-protected website for use by CPC's forecasters
- Developments
  - Probabilistic forecast products
  - Sophisticated multi-model combination
  - Potential to use for seasonal Hurricane prediction







NMME Status – Malaquias Pena



- Data process algorithms
  - Decoding and encoding into a uniform GRIB format
  - Transitioned algorithms to WCOSS
  - Forecast verification algorithms
- Products are generated by CPC personnel
  - IMME and NMME share similar product generation strategy
- Developments
  - CFSv2 6hr data format conversion and transfer to NCAR for NMME Phase II

2014 HWRF ensemble Configuration

- Use 2014 operational deterministic HWRF model except for
  - Less vertical resolution: L43 vs. L61;
  - Smaller D02, D03 domains, same as H213;
  - No GSI due to lack of GDAS data;

- IC/BC Perturbations (large scale): 20 member GEFS.

- Model Physics Perturbations (vortex scale):
  - Stochastic Convective Trigger in SAS: -50hPa to + 50hPa white noise ;
  - Stochastic boundary layer height perturbations in PBL scheme, -20% to +20%;
  - Stochastic initial wind speed perturbations with zero mean and -3kts to +3kts.

NCEP Wave Ensemble Forecast System

- Contributed by Henrique Alves

- Latest Upgrade
  - July 2014
- Three major changes impacting quality of output
  - New physics Package
    - Tolman & Chalikov (1996) -> Ardhuin et al (2010)
  - Spatial resolution increase
    - From 1d to 0.5d
  - Initialization/cycling
    - Effects on spread and accuracy
- Longer-term upgrades to NCEP Wave ensembles
  - 2015 and beyond
    - Increase resolution of forcing fields from 3h to 1h.
    - Introduce 20 new members: multi-model ensemble.
    - Downscaling: neural networks for coastal probabilistic forecasts.
    - Hurricane wave ensembles using HWRF ensembles.

Rescheduled
6th NCEP Ensemble User Workshop

25-27 March 2014, College Park, MD

The workshop brought together developers and users of ensemble forecast systems and products, as well as the research and the applications communities interested in the use of ensembles.

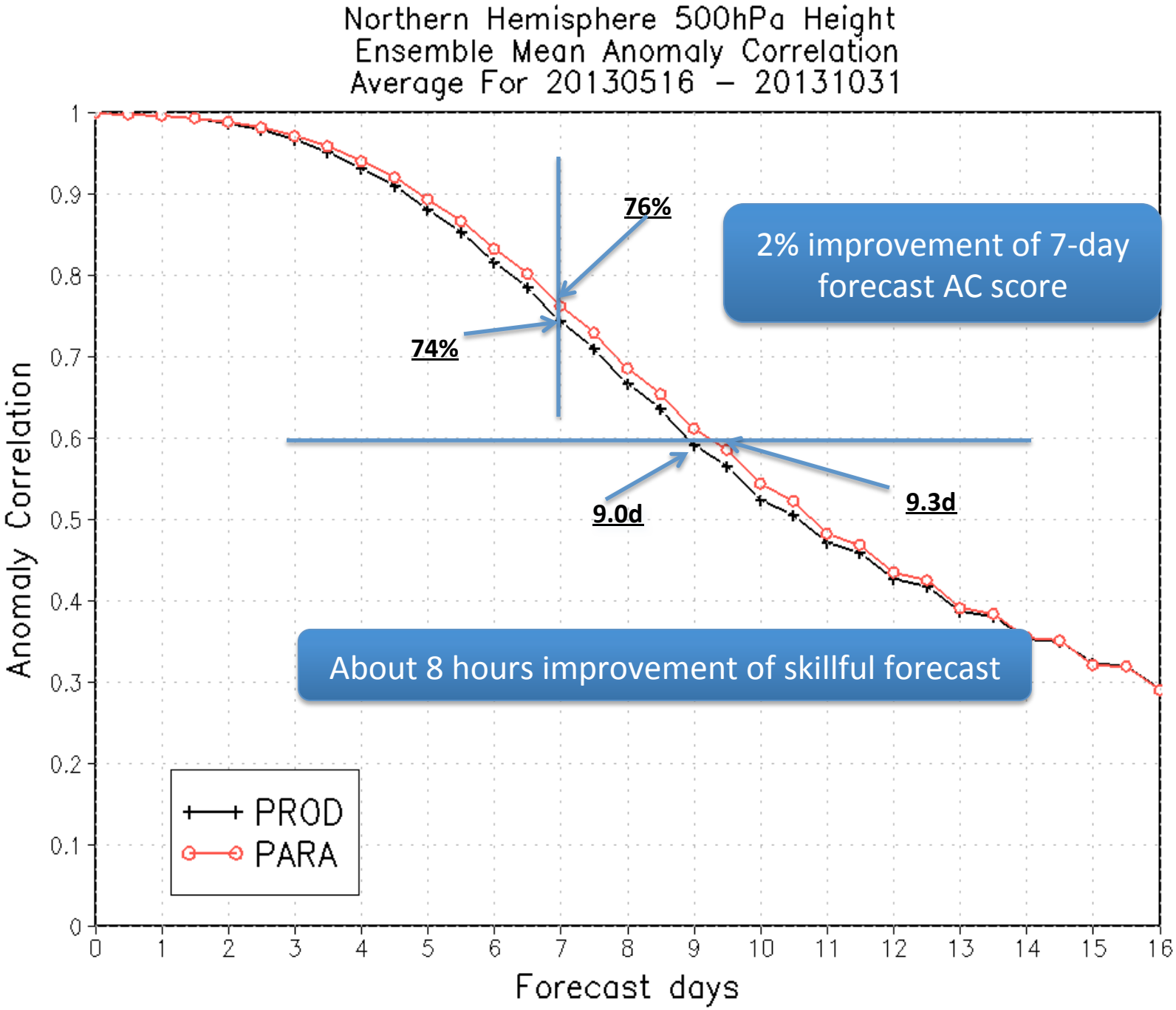
Following topics have been addressed to the workshop during three days course

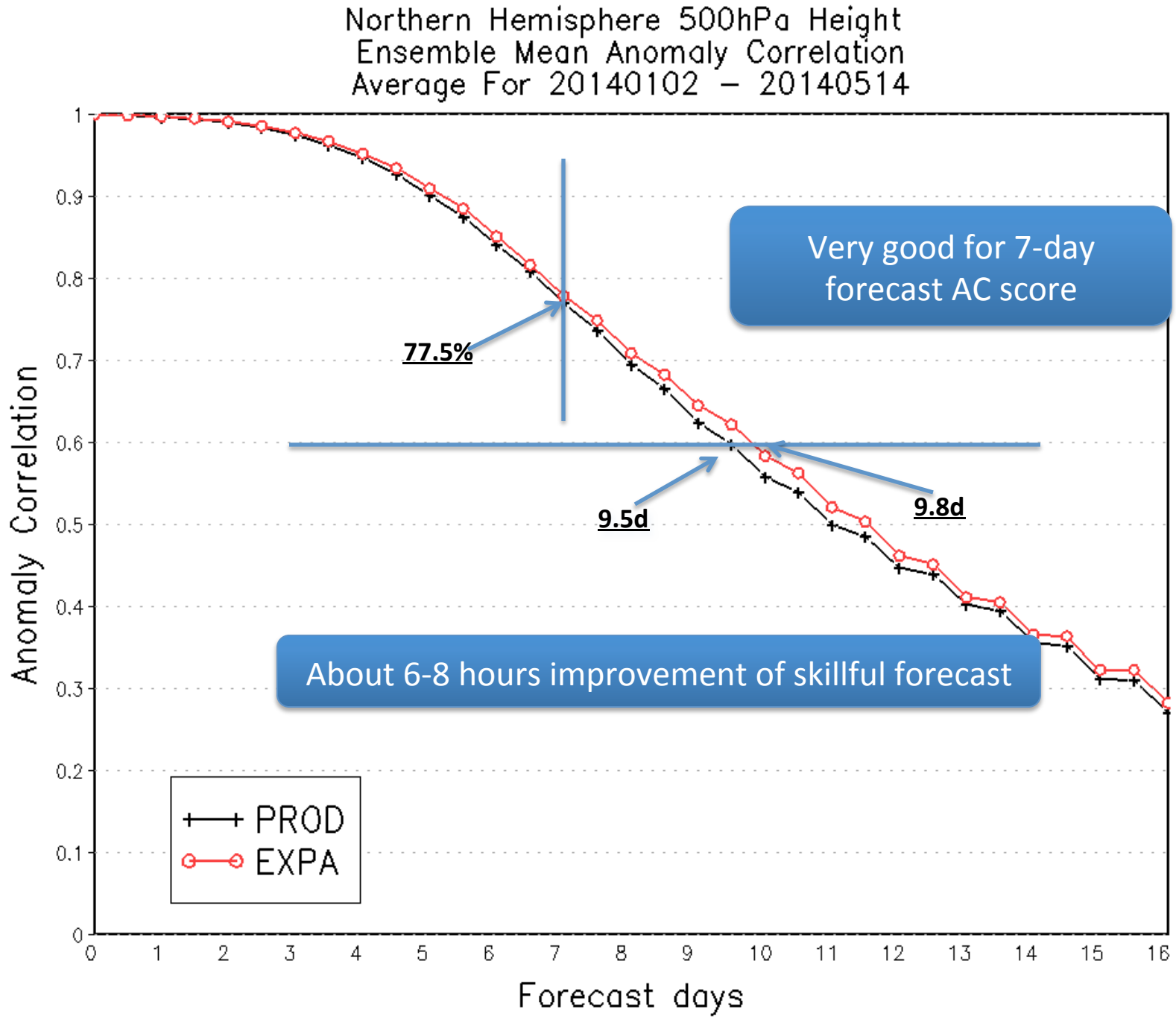
- **Review progress on the generation and use of operational products since the 5th workshop that took place in 2011.**
- **Discuss plans for future efforts and collaborations**
- **Define actions to continue support the NWS in its transition from single value to probabilistic forecasting**

7th NAEFS Workshop in Montreal, Canada

- Time: 17-19 June 2014
- Locations:
  - 17-18 June – Biosphere, Montreal, Canada
  - 19 June – CMC, Dorval, Canada
- Co-chairs: Andre Methot and Yuejian Zhu
- Topics (or sessions)
  - Status and plan of Global ensemble forecast systems;
  - Operational data management and distribution;
  - Ensemble verification and validation metrics;
  - Reforecast, bias correction and post process;
  - Regional ensemble and data exchange;
  - Wave ensembles;
  - Integration of ensemble in forecasts: user feedback and recommendation;
  - Products – hazard weather, high impact weather and diagnostic variables;
  - Open discussion of the NAEFS research, development, implementation and operation plan

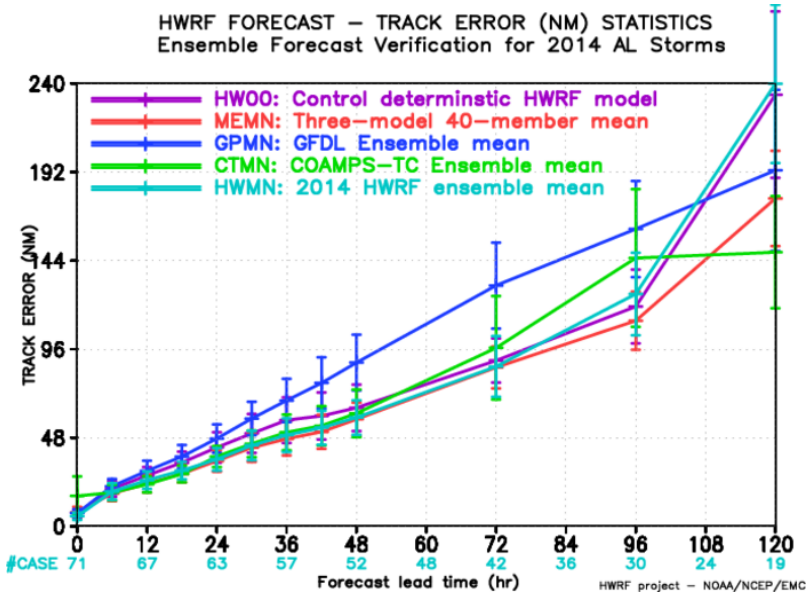
Background!!!


Northern Hemisphere 500hPa Height
Ensemble Mean Anomaly Correlation
Average For 20130516 – 20131031
Anomaly Correlation
Forecast days
76%
74%
9.0d
9.3d
2% improvement of 7-day forecast AC score
About 8 hours improvement of skillful forecast
PROD
PARA

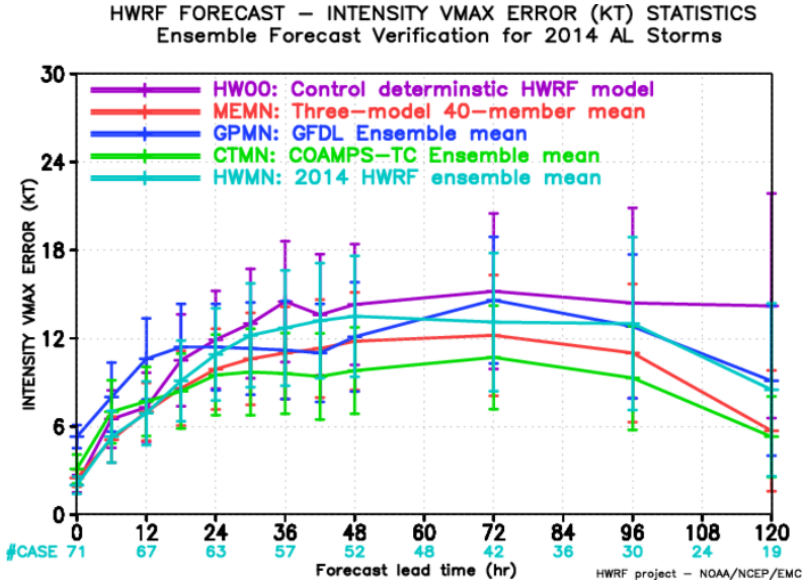

Northern Hemisphere 500hPa Height
Ensemble Mean Anomaly Correlation
Average For 20140102 – 20140514
Anomaly Correlation
Forecast days
PROD
EXPA
77.5%
9.5d
9.8d
Very good for 7-day forecast AC score
About 6-8 hours improvement of skillful forecast

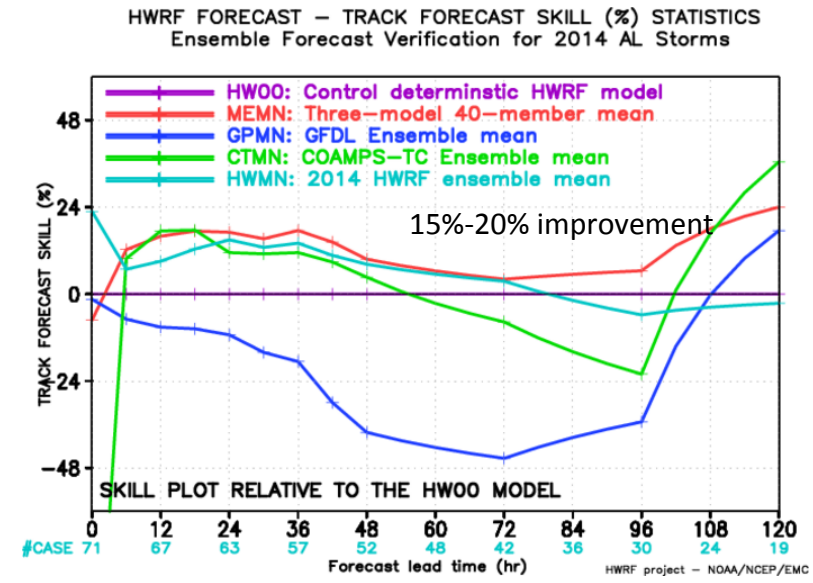
Verification for 2014 Atlantic Storms

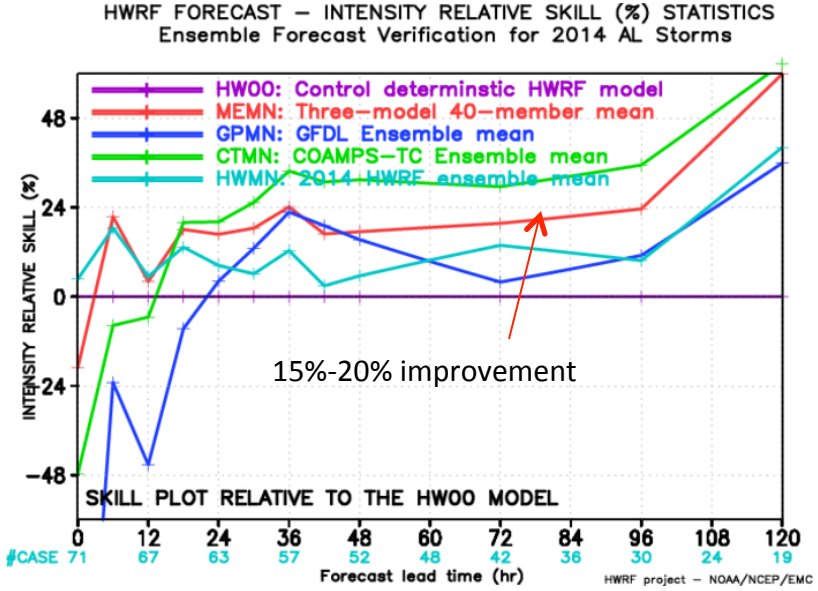
Track



Intensity

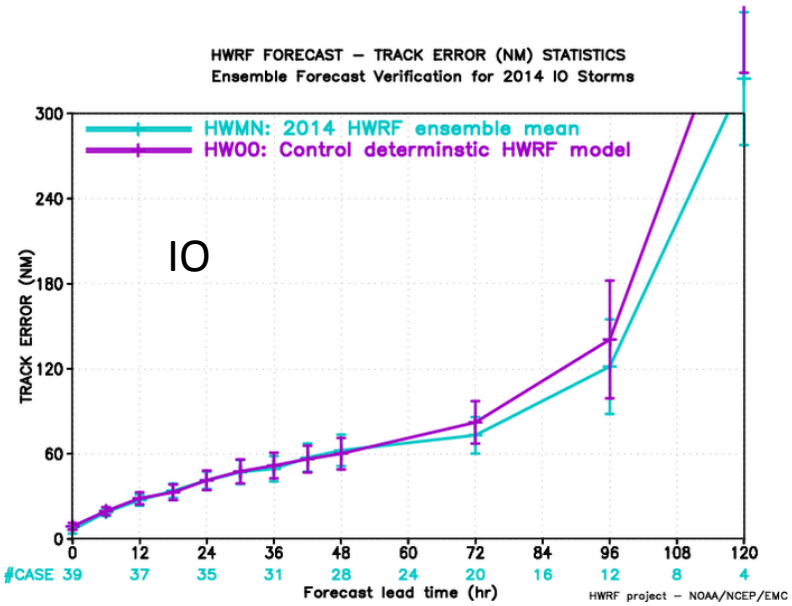


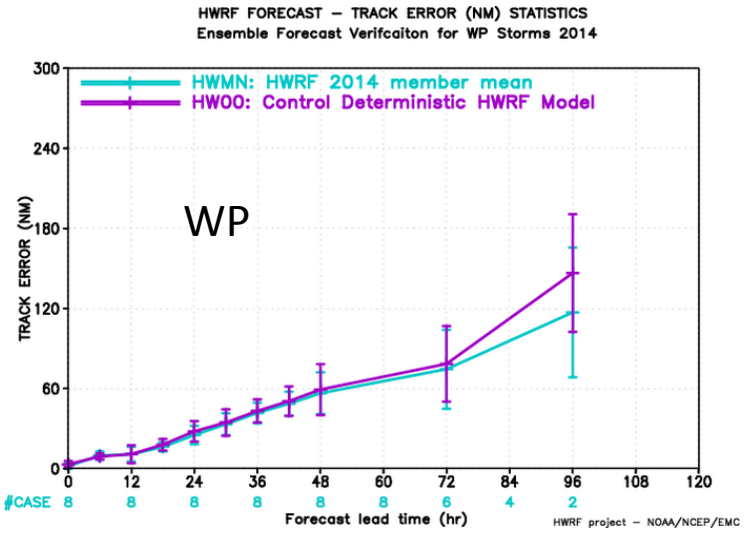




Verification for 2014 IO/WP Storms

Track





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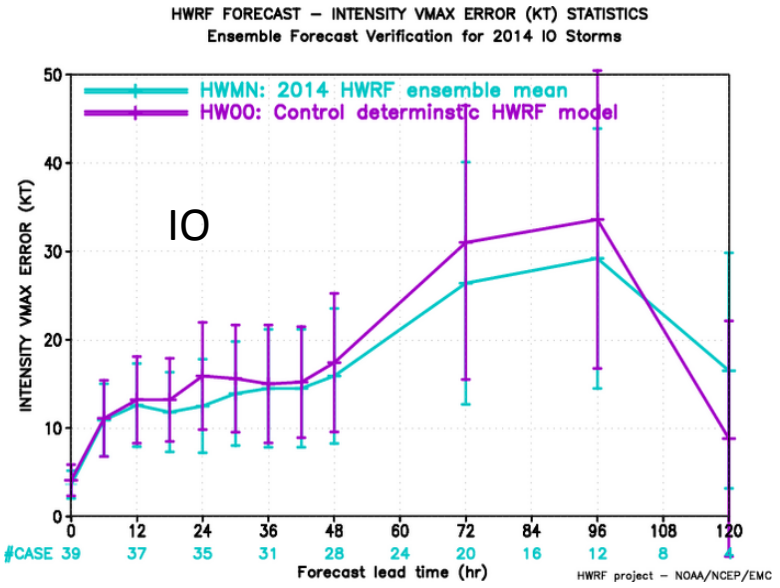
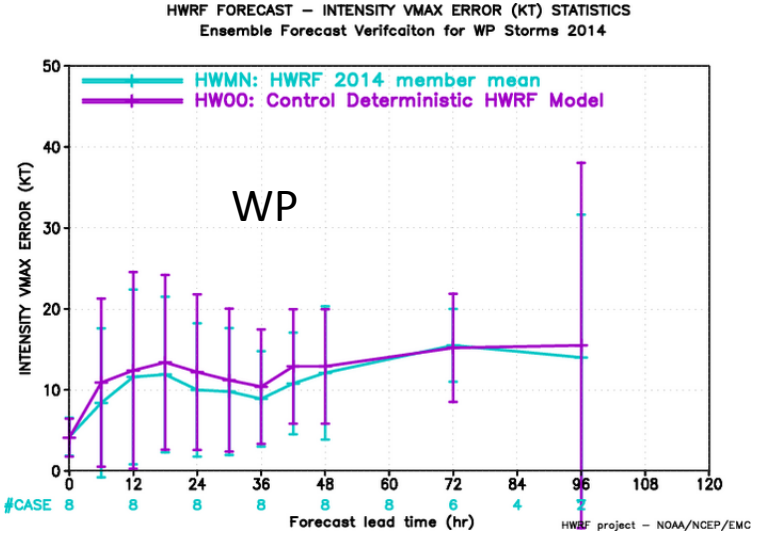




Probabilistic Verification

Continuous Rank Probability Score:

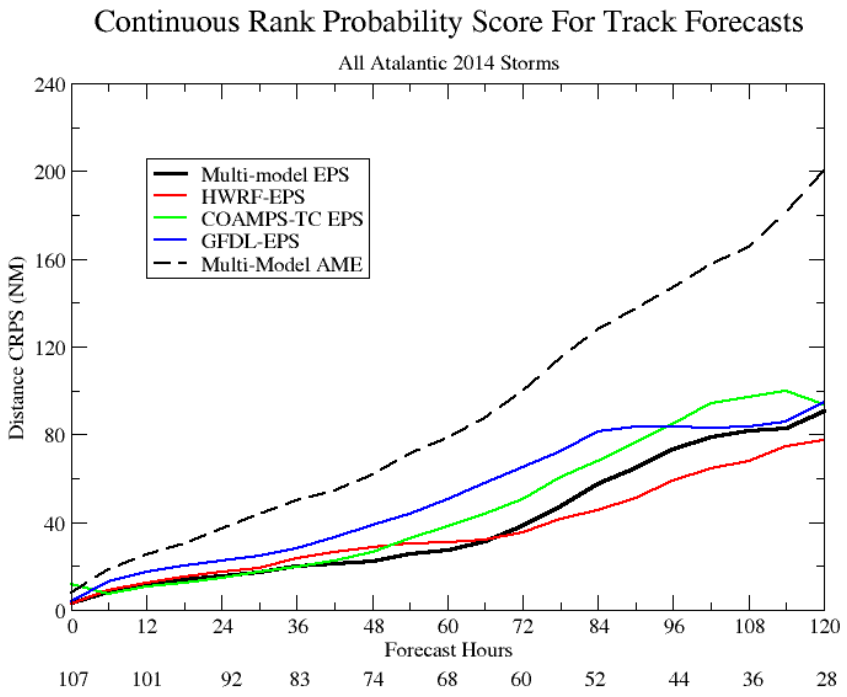
$$CRPS = \sum_{i=0}^{N} [p_i - H(x_i - x_{obs})]^2 (x_{i+1} - x_i)$$

$$p_i = \frac{i}{N}$$

is cumulative distribution, i denotes ensemble member, N is total number of ensemble

H(x) is Heaviside function, which equals 0, when x<0, equals 1, when x>0.

Track



Intensity