



# EMC FY15 Upgrade Review

## GEFS Upgrade

**N  
C  
E  
P**

**Presented by:**

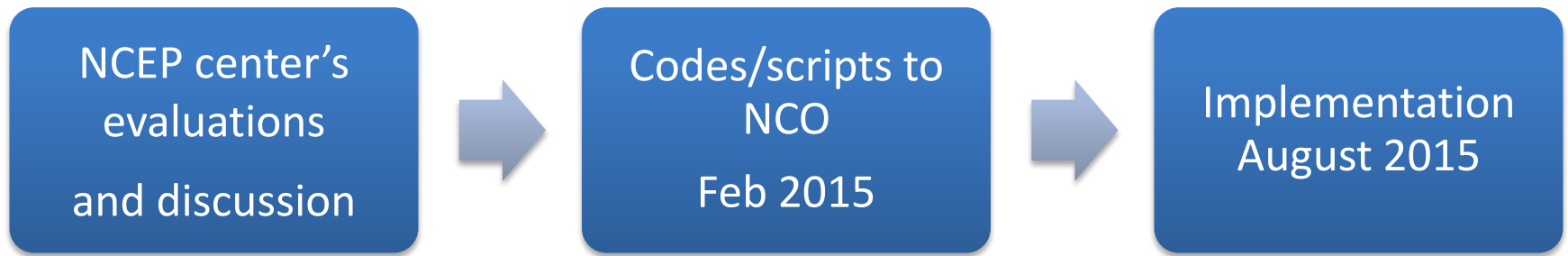
**Yuejian Zhu**

**Update: 7/8/2015**

# GEFS Configuration

	V10.0.0 (OPR)	V11.0.0 (PARA)
GFS Model	Euler, 2012	Semi-Lagrangian, 2015
Resolution 0-192 h	T254 (52km) L42 (hybrid)	T <sub>L</sub> 574 (34km) L64 (hybrid)
Resolution 192-384 h	T190 (70km) L42 (hybrid)	T <sub>L</sub> 382 (52km) L64 (hybrid)
Computational Cost	84 nodes (+ post process)	300 nodes 1 <sup>st</sup> segment 150 nodes 2 <sup>nd</sup> segment
Execution time	~ 60 min	35 min 1 <sup>st</sup> segment 25 min 2 <sup>nd</sup> segment
Output resolution	1 <sup>o</sup> x 1 <sup>o</sup>	0.5 <sup>o</sup> x 0.5 <sup>o</sup> and 1 <sup>o</sup> x 1 <sup>o</sup>
Output frequency	6h	3h the first 8 days; 6h the rest

# Schedule



Working with partners and centers to keep on schedule

Continue generation and evaluation of control member reforecast and retrospective ensemble forecast

WCOS-Phase II

# Ensemble Generation Method

- Moving from BV-ETR approach to EnKF
  - A major scientific shift
- Unification of DA and Ensemble Generation
  - Direct link to the hybrid 3D-Var EnKF DA system
- Perturbations are 6h EnKF forecasts with adjustments:
  - Tropical Storm Relocation
  - Centering of the perturbations on the ensemble control analysis
- Stochastic perturbation (STTP) upgrade
  - Fine-tune amplitude for changes in model and perturbation method
  - Turn off surface pressure perturbations for tropics
    - to reduce the spread growing of geopotential height

# Expected improvements

- Hurricane track forecast
  - Main reason: DA/model and spatial resolutions
- Probabilistic forecast guidance
  - Main reason: DA/model and spatial resolution, EnKF initial perturbations, stochastic physics and re-forecast
- Prediction of extreme weather events
  - Main reason: DA/model and stochastic perturbations

# GEFS legacy forecast

- Next GEFS implementation will be scheduled for WCOSS phase II (Q4FY15)
  - NCO will continue to run current operational GEFS (with BV-ETR cycling every 6 hours, **but 00UTC forecast only**) for one year (or longer?)
    - Current: 21 members, 00, 06, 12, 18UTC
    - Future: 21 members, 00UTC, initially on WCOSS Phase I (eventually move to Phase II)
  - Timing for legacy data delivery
    - Current: +4:50
    - Future: +4:50 to +8:00, depending on NCO resource analysis
  - Data directory for access (NCEP ftp, under discussion)
    - Current directory: .../com/gefs/prod/....
    - Future directory: .../com/gefs\_legacy/prod/....
  - Data names
    - Will be the same, but in the different directory
  - No statistical bias correction
    - Raw ensemble forecast data only
    - Any products not identified by OHD, CPC and MDL as required will be stopped
  - AWIPS:
    - Only data from the new GEFS will be made available on NOAA/PORT/SBN for use in AWIPS

# Limited Reforecast (retrospective)

- There is no 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)
    - From May 15 2013 to the time of implementation (nearly 2 years)
    - Expect to be available: Mid of March 2015
    - Forecasts have been done, NCO was helping to run part of retrospective cases
  - 18 years ensemble control only reforecast
    - Year 1995-2012
    - 00UTC and every other day
    - Forecasts has been finished, OHD has received the data
  - 18 years ensemble reforecast for CPC
    - Year 1995-2012
    - 00UTC and every 4 days
    - NCO will run them in production machine
    - Starting from mid-July
  - All data will be saved in HPSS tapes
    - NCO to publish part of data: pgrba data at 1.0 degree, every 6 hours, out to 16 days for public access (2-year retrospective runs).
  - Note: EMC and NWC will continue to discuss a configuration of GEFS reforecast
    - Half day meeting will be scheduled in later July
    - One full day workshop will plan in September

# Short description of GEFS (V11.0) retrospective data (3/12/15)

In late August/early September 2015, the NCEP Global Ensemble Forecast System (GEFS) will be updated. In preparation for this upgrade, NCEP has rerun nearly two years GEFS retrospective forecast data, and is offering a sample dataset for our customers' evaluation.

A summary of the scientific details of the GEFS upgrade are listed in Table 1. More details of the upgrade are available at:

[http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201412\\_imp.html](http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201412_imp.html)

Below are highlights of the retrospective dataset:

- Data is available at:  
<http://para.nomads.ncep.noaa.gov/pub/data/nccf/retrospective/gefs/>
- Directory and file:
  - Retrospective runs will be available for May 15, 2013 through the present. There is also the potential to provide data from Summer 2012 if there is interest.
    - *note that the data is being actively sent to the server now, we expect the full dataset to be available by late April*
  - For each day, only the 00Z forecast is available
  - There are about 1495 files in each directory - only the "pgrb2a" files
    - 20 perturbed forecasts (gep01.\*, gep02.\*, ..., gep20.\*)
    - 1 un-perturbed forecast (gec00.\*)
    - Ensemble mean (geavg.\*)
    - Ensemble spread (gespr.\*)
    - 65 lead times (\*f00, \*f06, \*f12, ... , \*f384; every 6 hours)
  - Each file contains 80 variables (see table 1)
- Data format: GRIB II
- Data resolution: 1\*1 degree global

As this is the first time we are offering retrospective data in this manner, we ask that our users contact NCEP Central Operations and let us know your intended use of this data. This will help us determine the level of interest in providing future retrospective data. Please send an email to [Rebecca.Cosgrove@noaa.gov](mailto:Rebecca.Cosgrove@noaa.gov) indicating your interest in and intended use of the data.

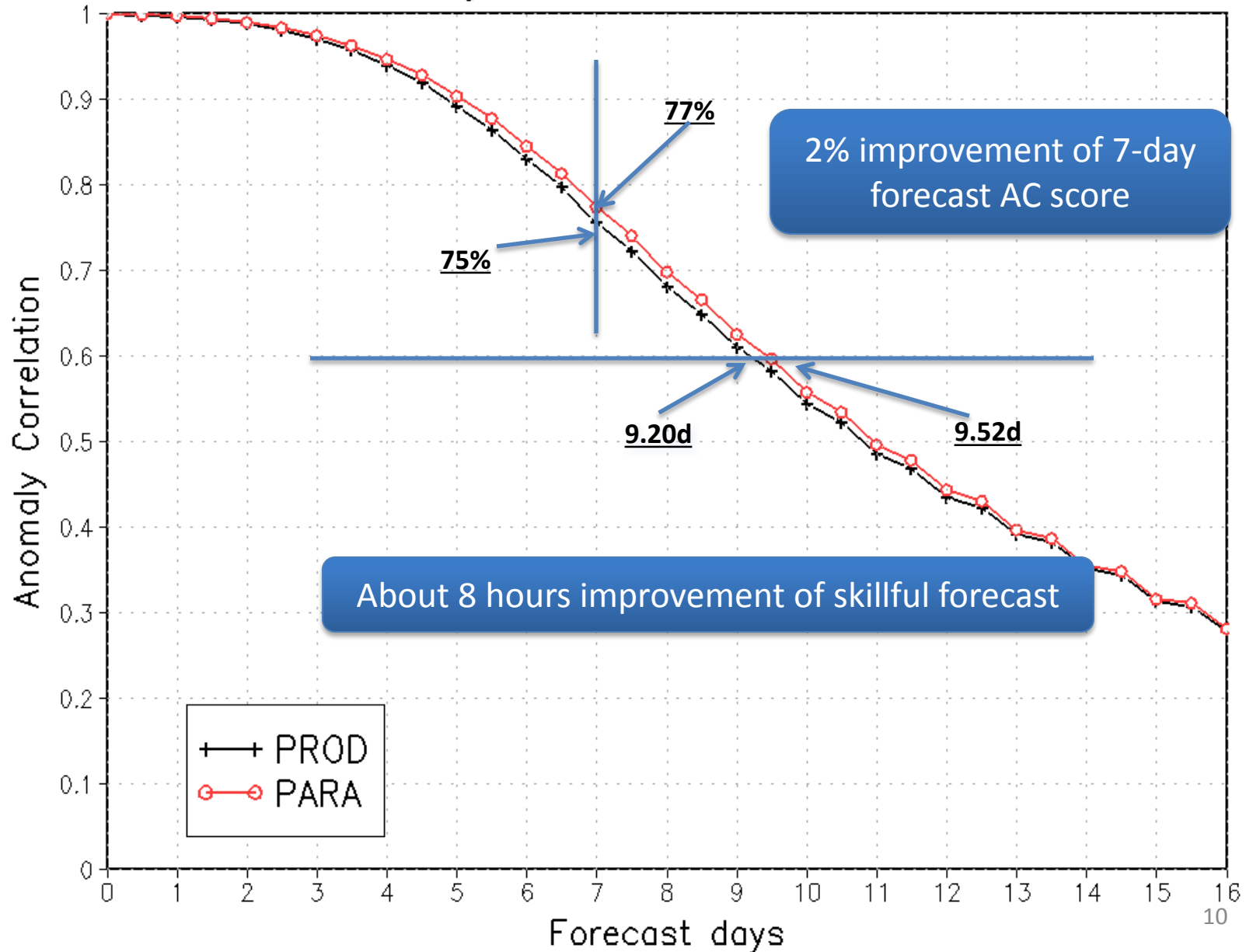


# **EMC evaluations of two-year (+) retrospective runs**

**June 1<sup>st</sup> 2013 – May 31<sup>st</sup> 2015  
and  
Summer of 2011 and 2012**

685 cases

# Northern Hemisphere 500hPa Height Ensemble Mean Anomaly Correlation Average For 20130516 – 20150331



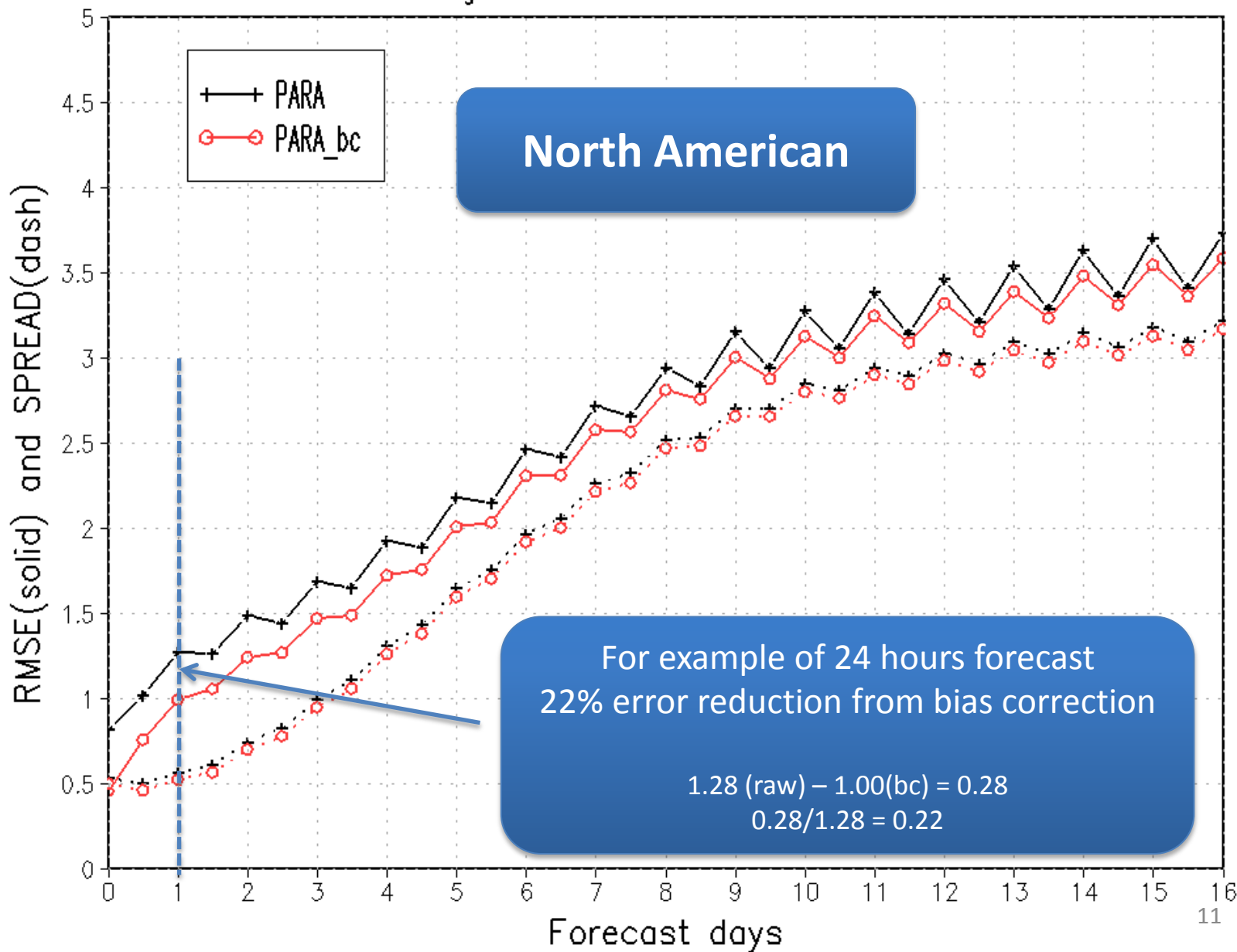
2% improvement of 7-day  
forecast AC score

About 8 hours improvement of skillful forecast

+ PROD  
o PARA

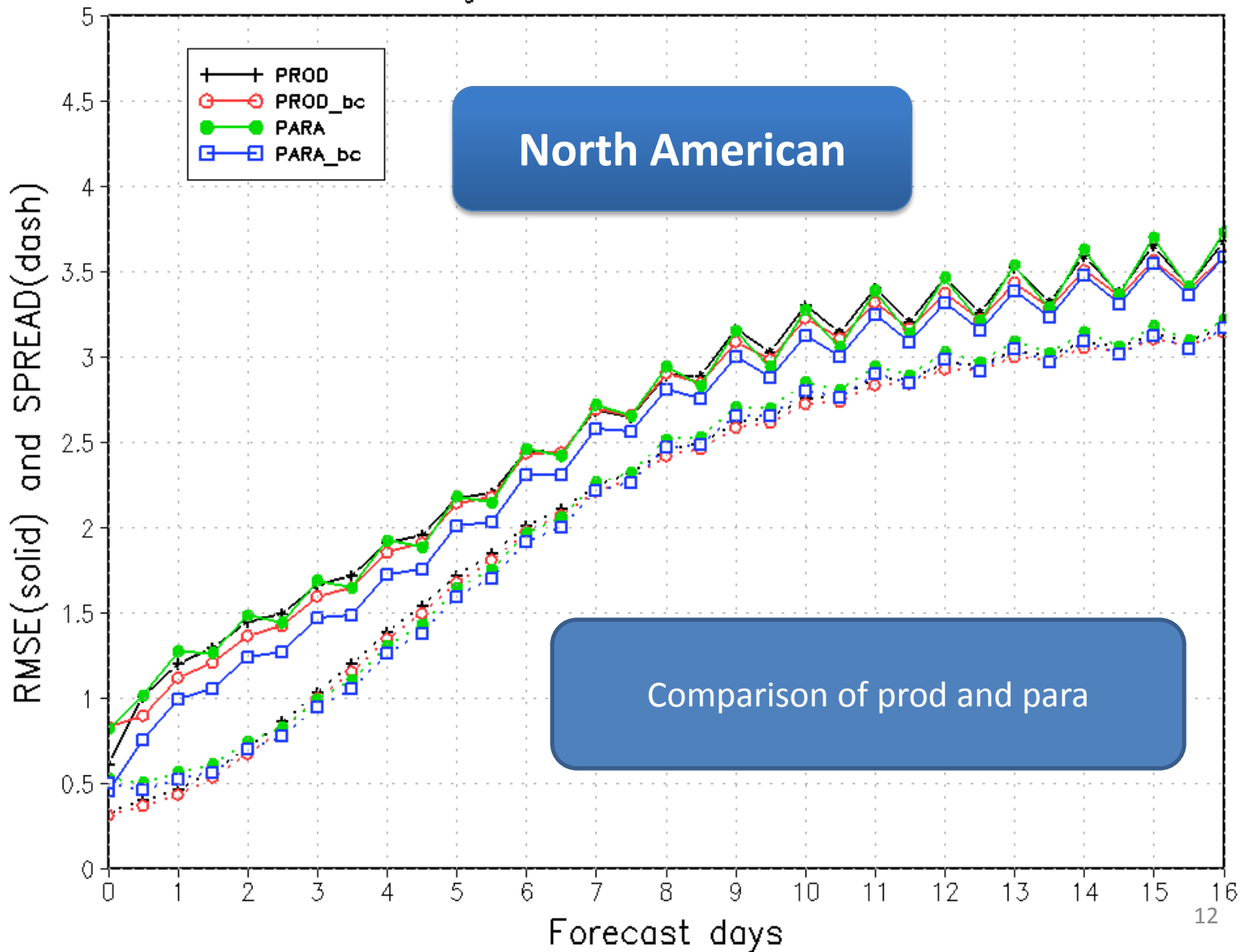
365 cases

North American 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130615 – 20140615



365 cases

North American 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130615 – 20140615

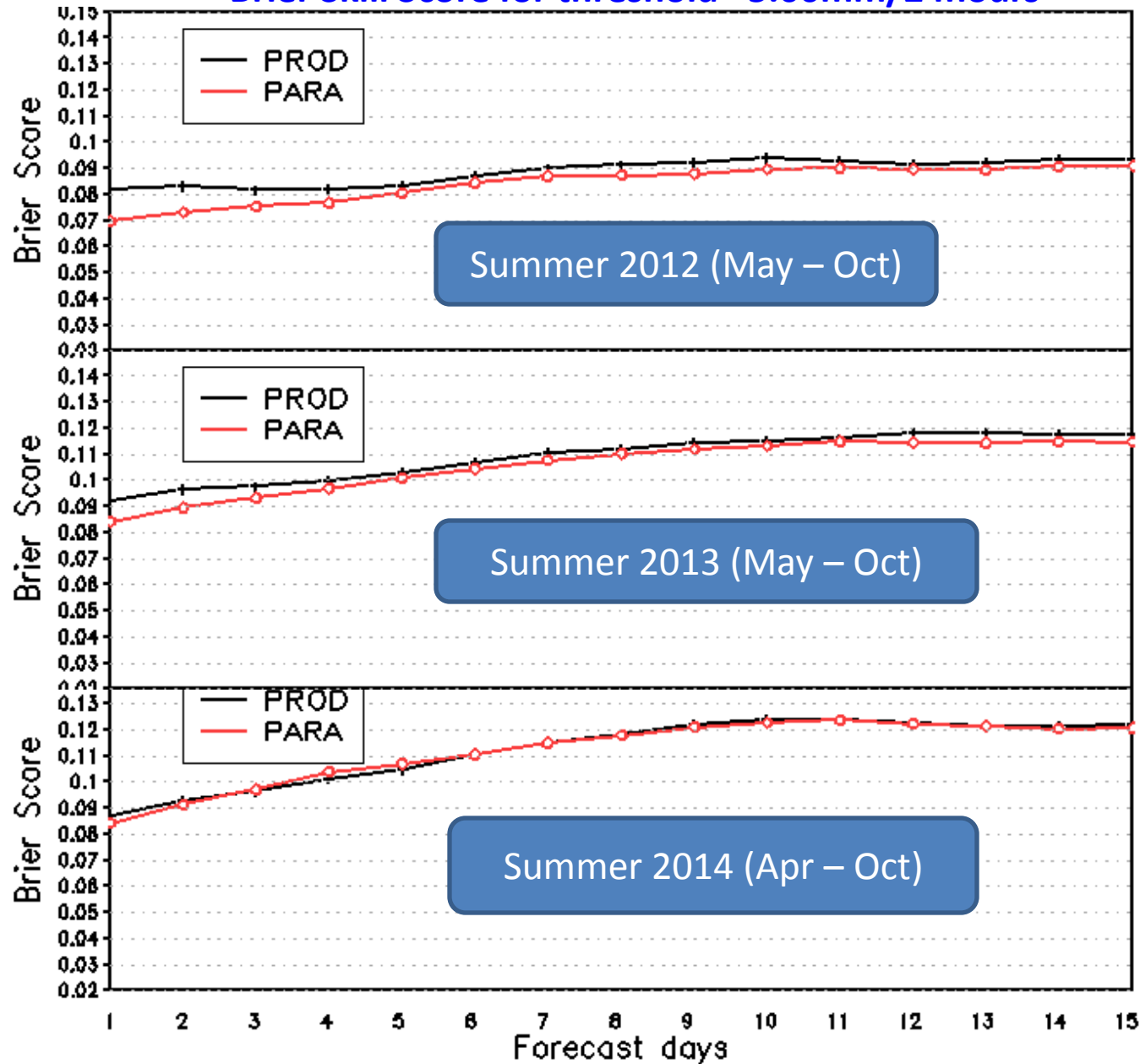


North American

Comparison of prod and para

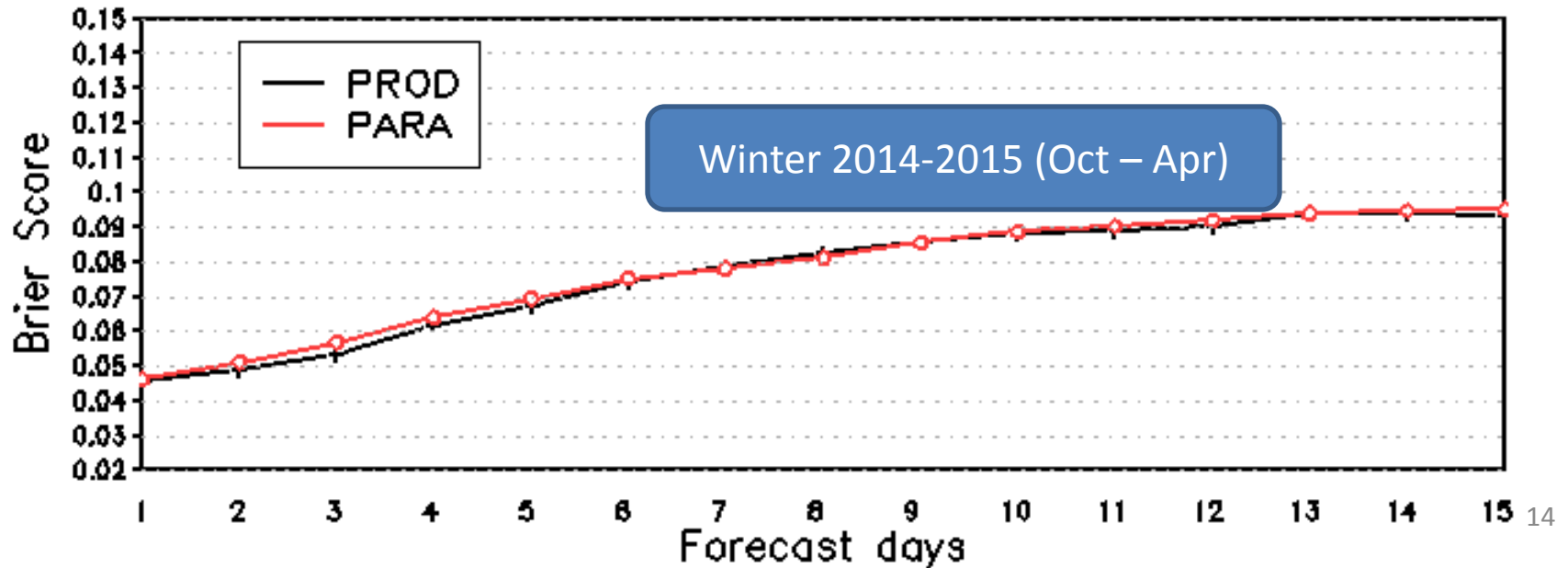
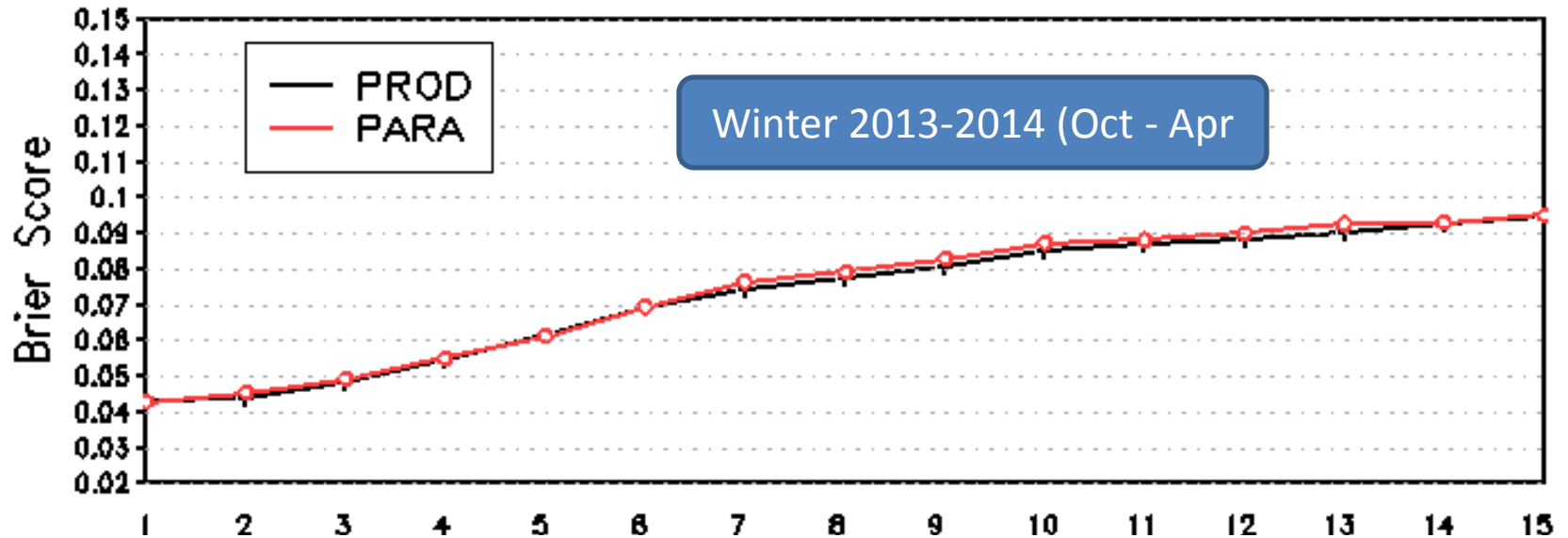
# Ensemble Precipitation Verification for CONUS

Brier Skill Score for threshold >5.00mm/24hours



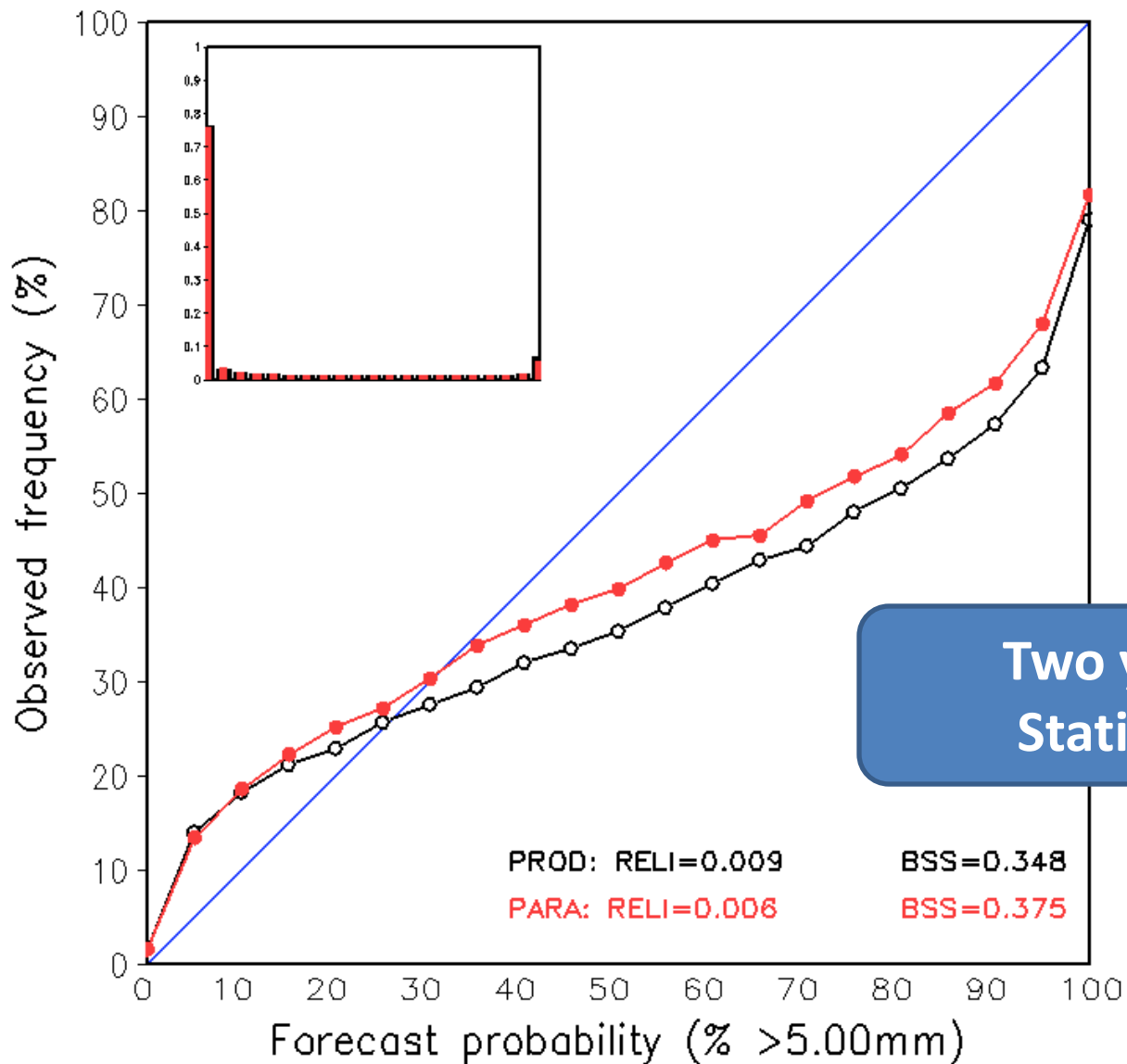
# Ensemble Precipitation Verification for CONUS

Brier Skill Score for threshold >5.00mm/24hours



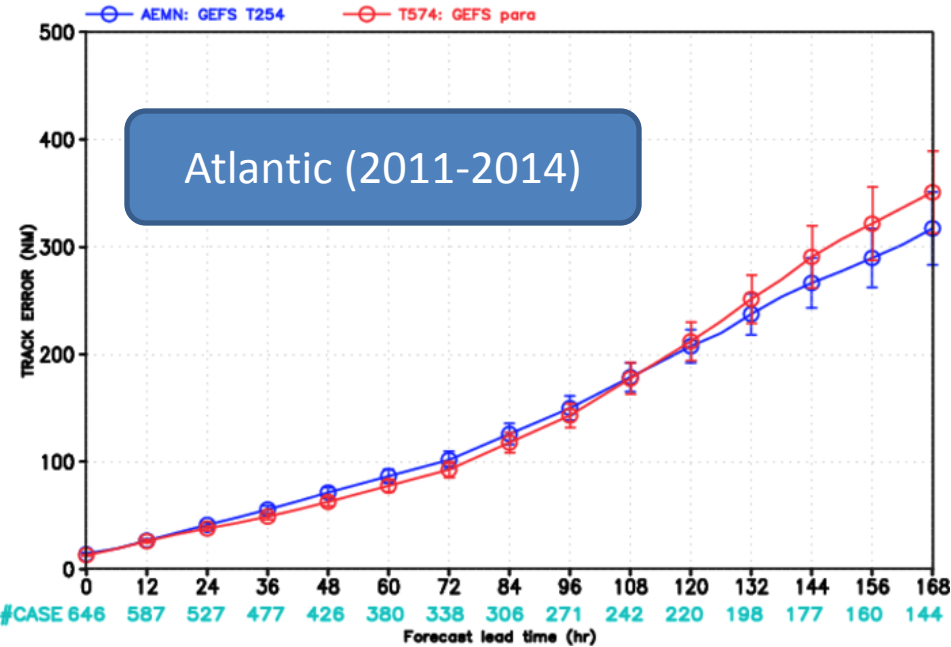
# Reliability Diagram

fhr 12-36 For 20130601 - 20150531

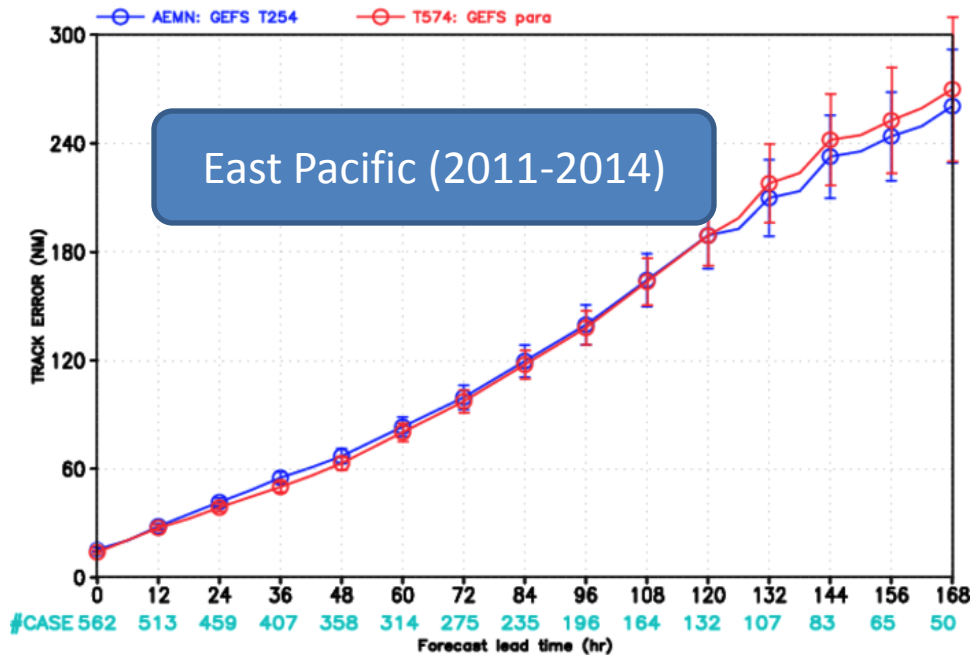


Precipitation reliability for 12-36hr and greater than 5mm/day

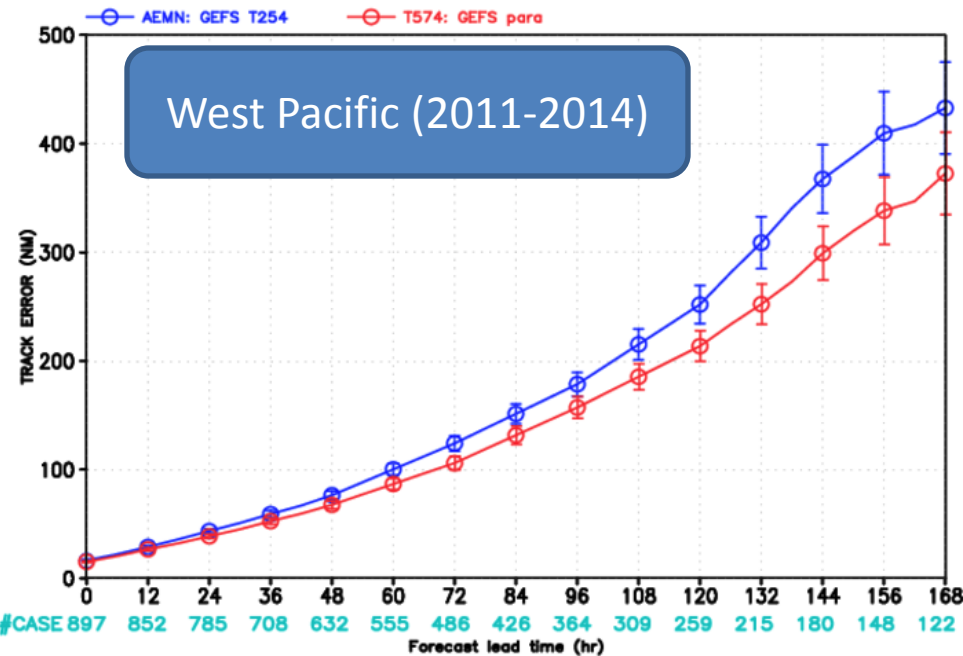
GEFS FORECAST - TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR Atlantic 2011-2014



GEFS FORECAST - TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR East Pacific 2011-2014



GEFS FORECAST - TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR West Pacific 2011-2014

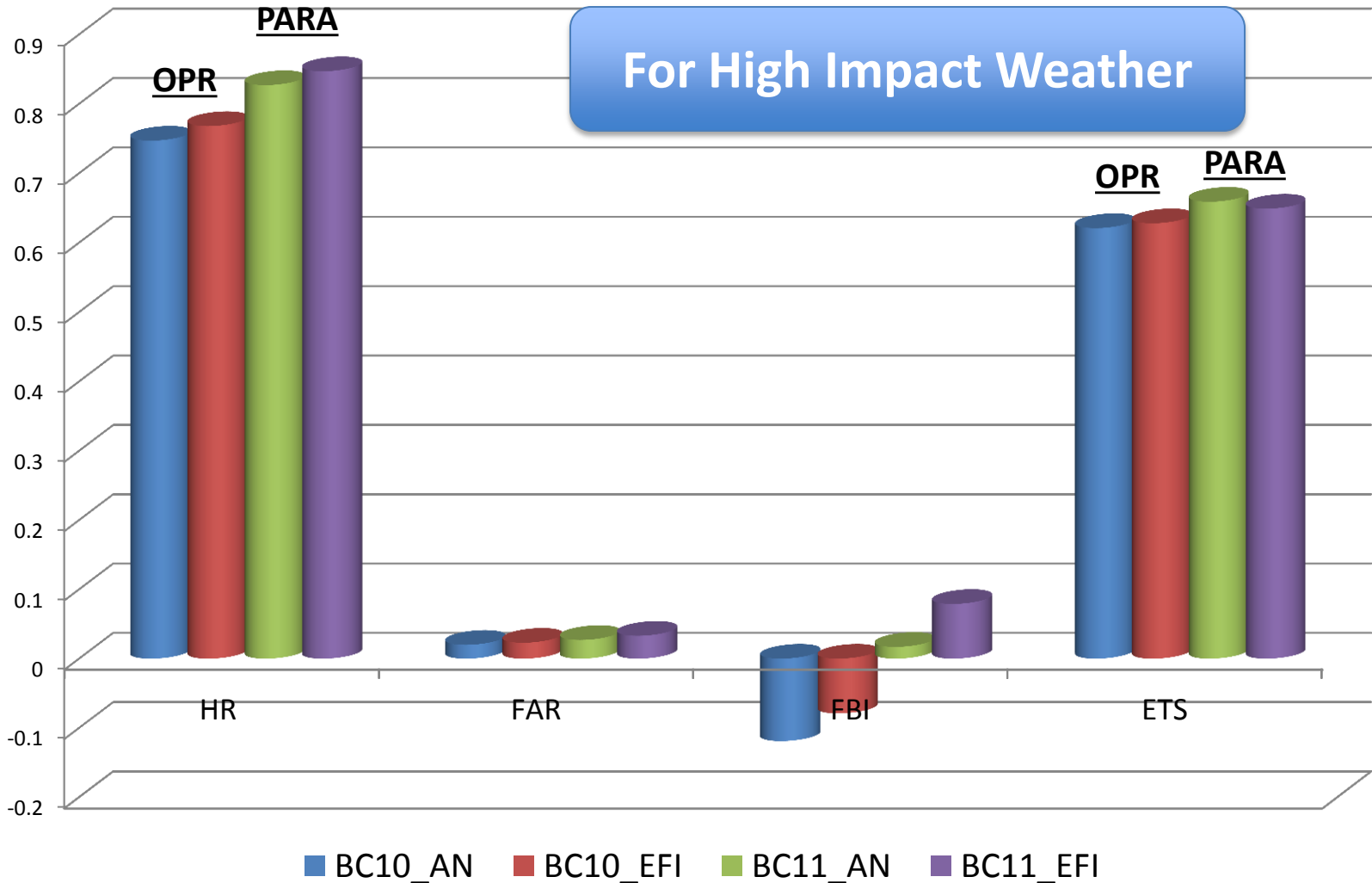


## TS track verification

1. For 2011 season, there are selected Atlantic/East Pacific cases only
2. For 2011 season, we use GEFSv10 parallel to compare, instead of operational GEFSv09
3. Samples included tropical low pressure and extra tropical lows in order to compare to NHC



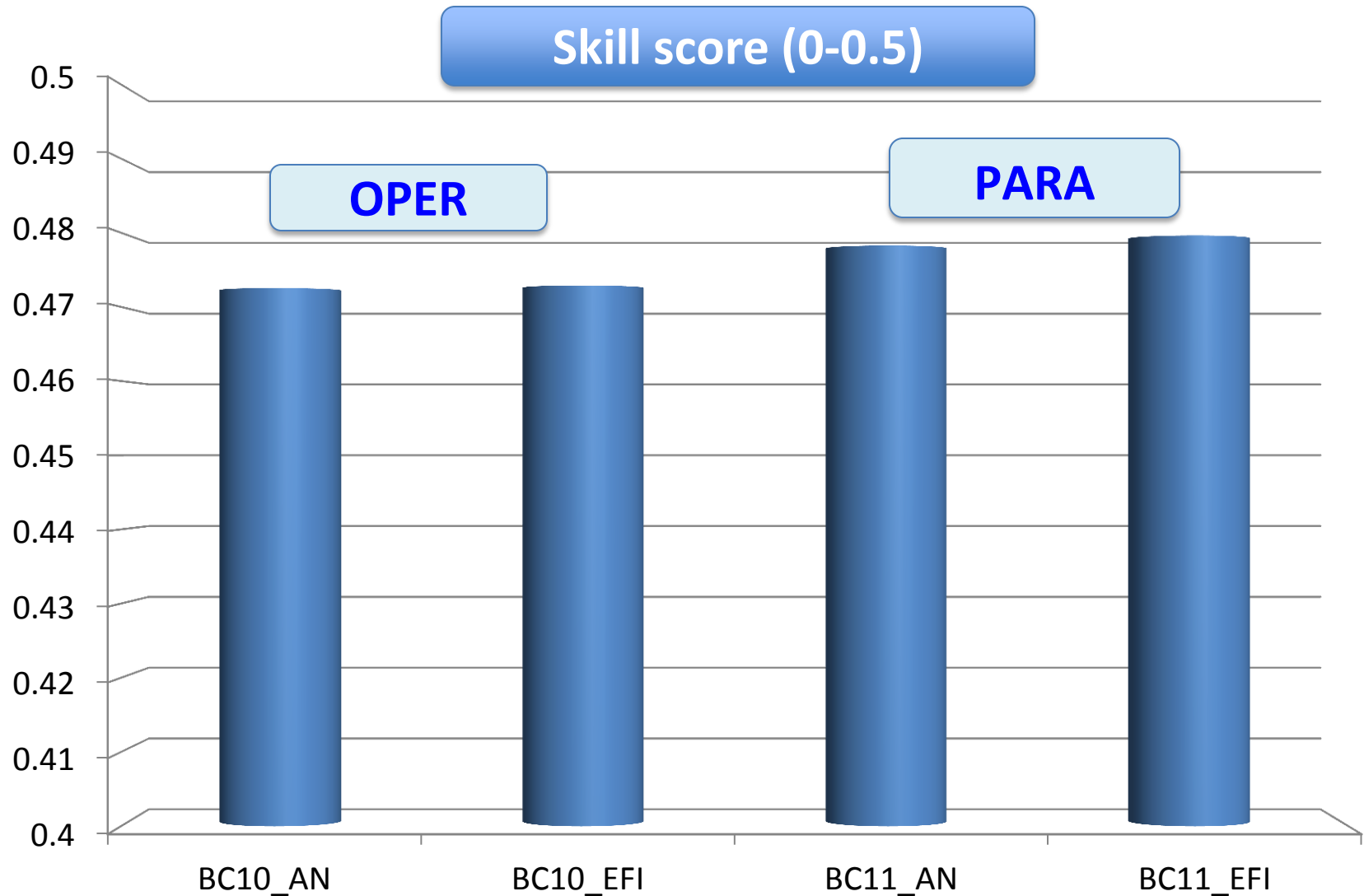
# Statistics for extreme cold weather event (11 cases) – V10 and V11 bias-corrected forecast



HR – Hitting rate; FAR – False alarm rate; FBI – Frequency bias; ETS – Equitable threat score)

# ROC area for extreme cold weather event (11 cases)

– V10 and V11 bias-corrected forecast



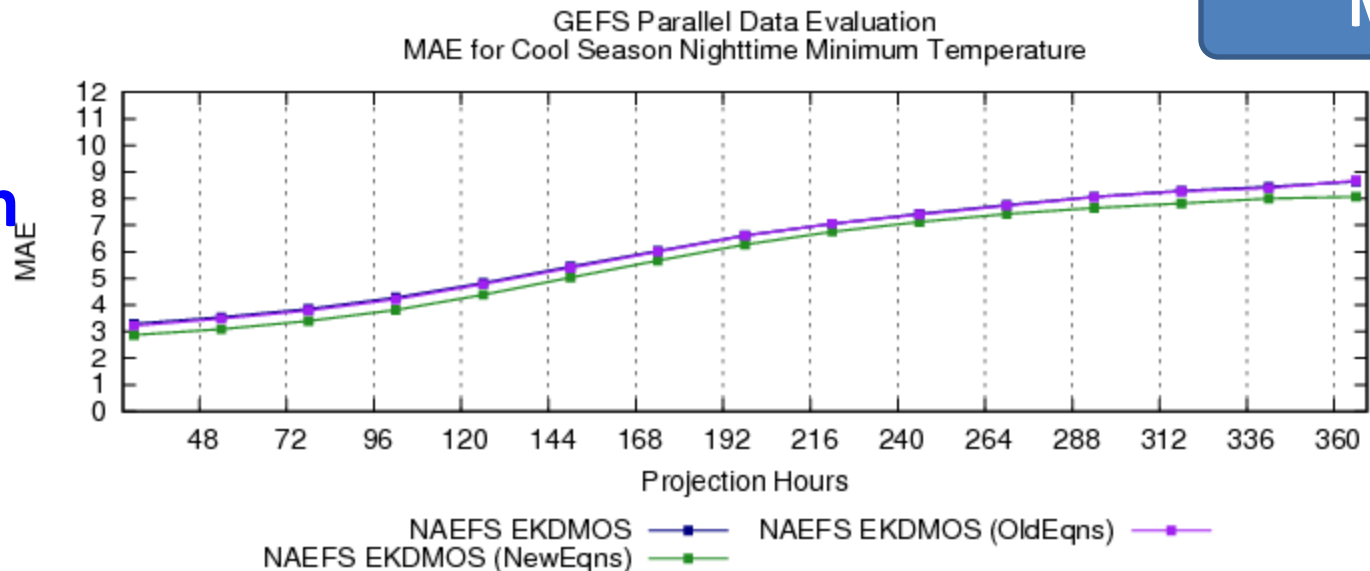
# **Users evaluations of two-year (+) retrospective runs**

**June 1<sup>st</sup> 2013 – May 31<sup>st</sup> 2015  
and  
Summer of 2011 and 2012**

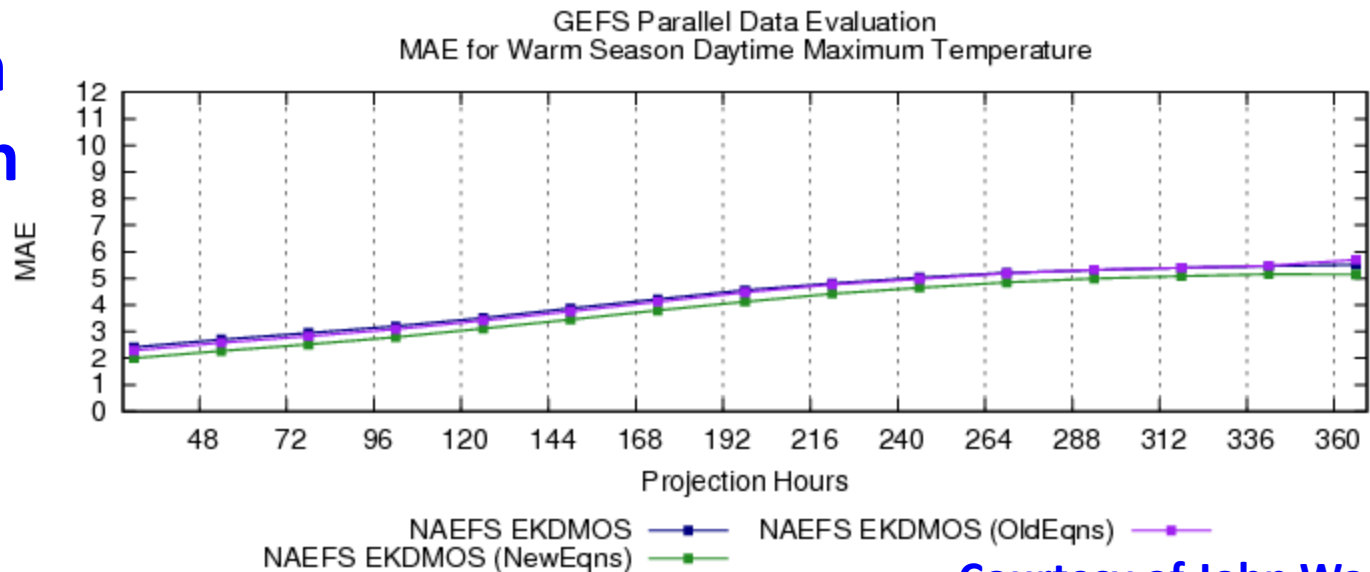
# Evaluation of GEFS retrospective runs (2013-2014) for EKDMOS

MDL

Cold season

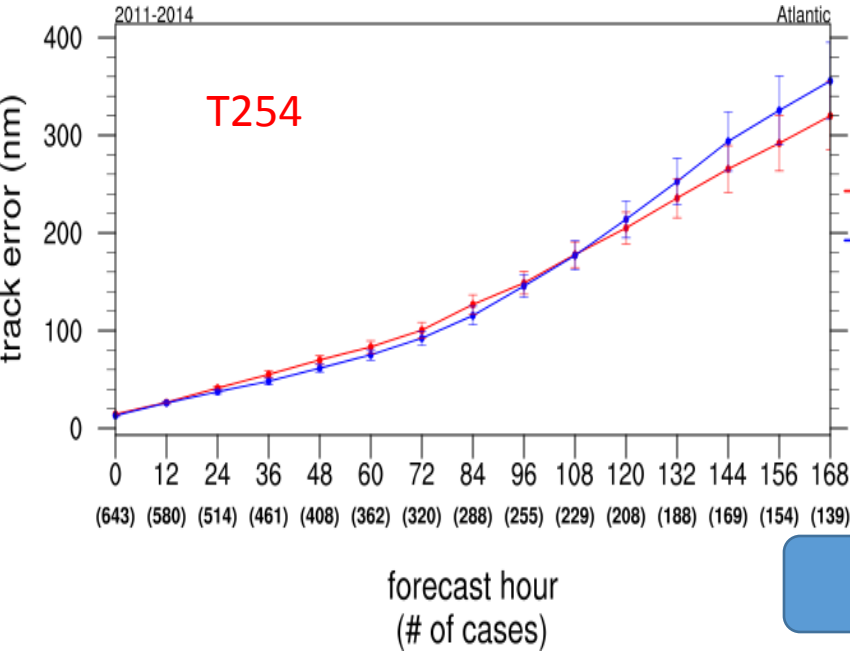


Warm season

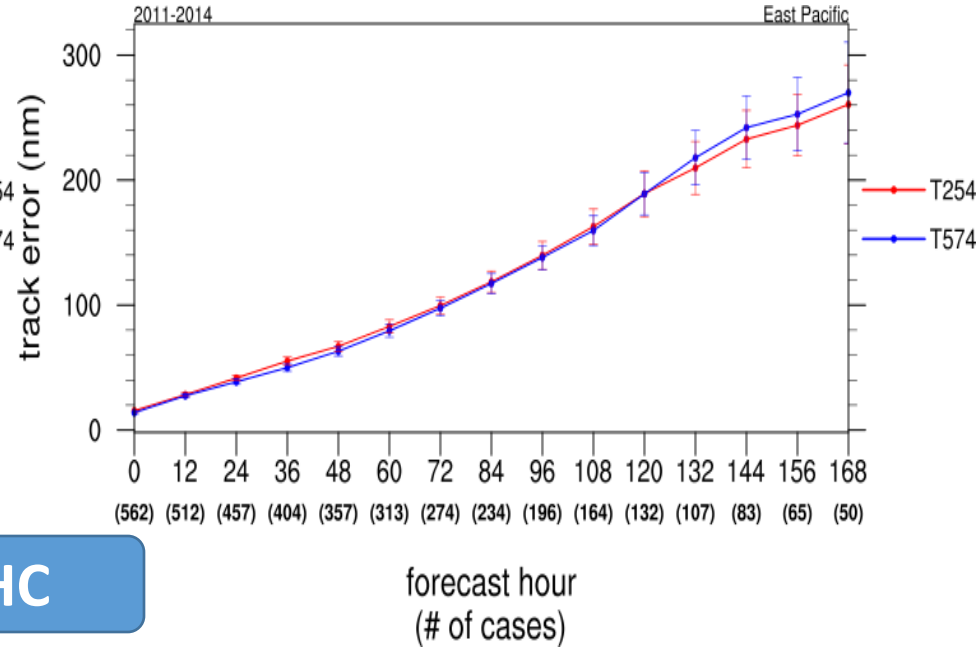


# 2011-2014

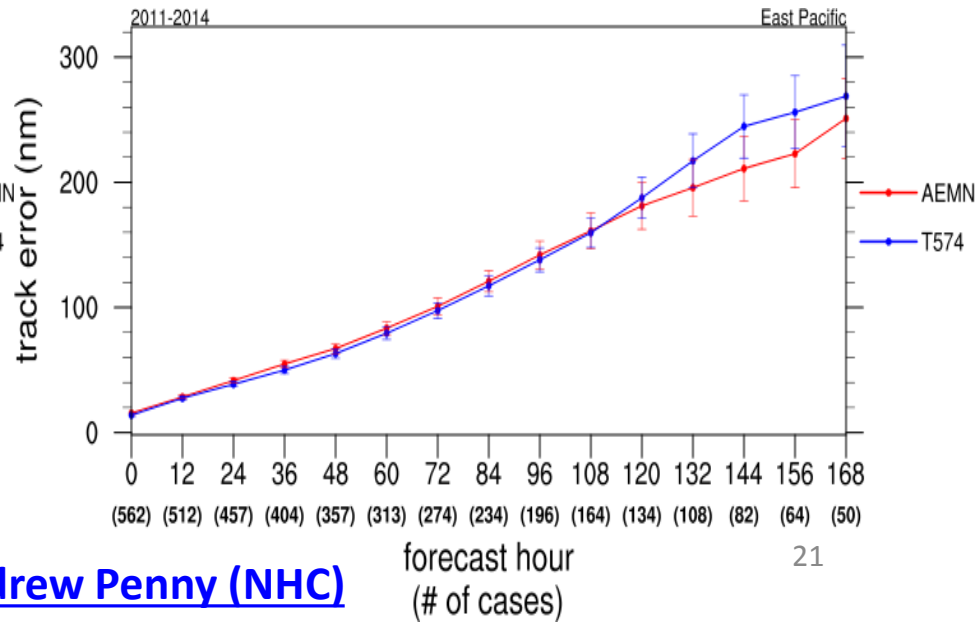
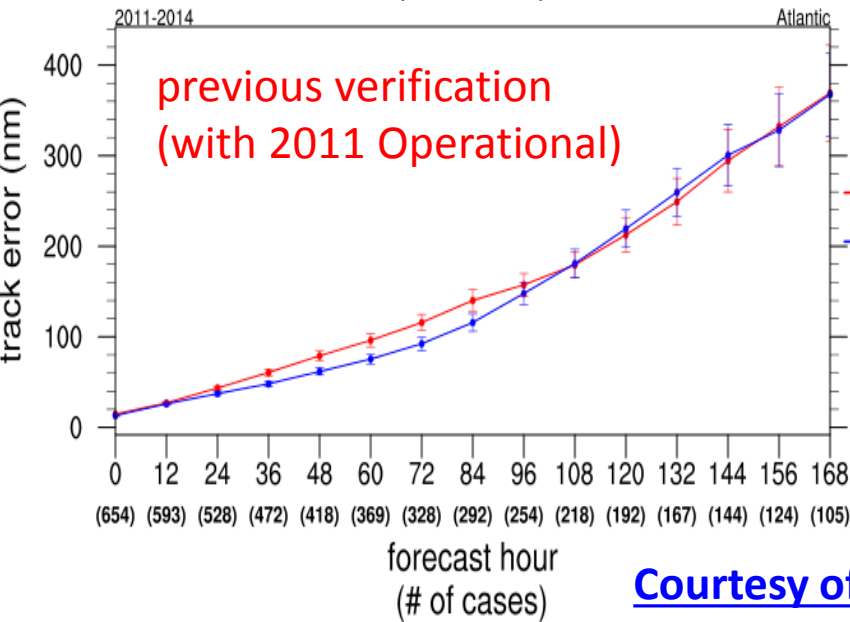
## Atlantic



## East Pacific



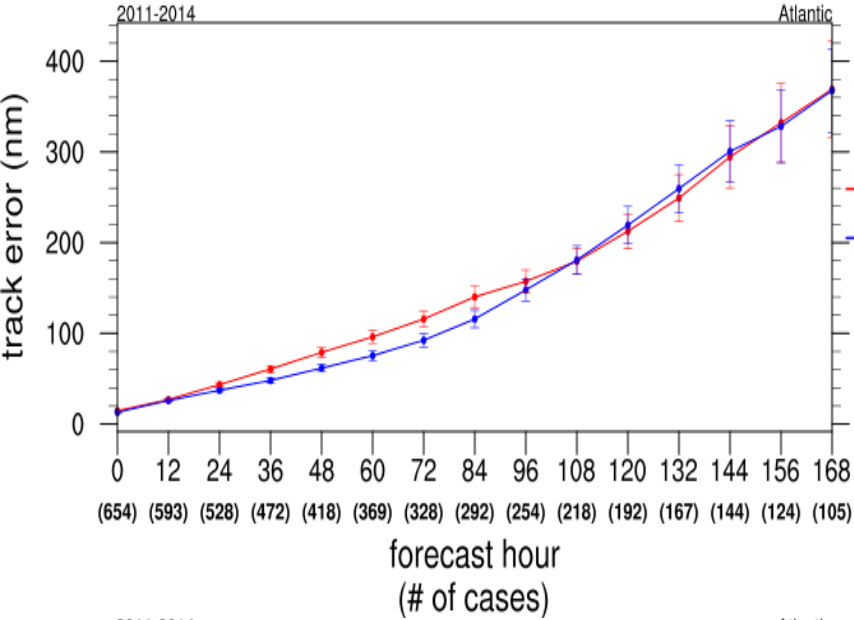
**NHC**



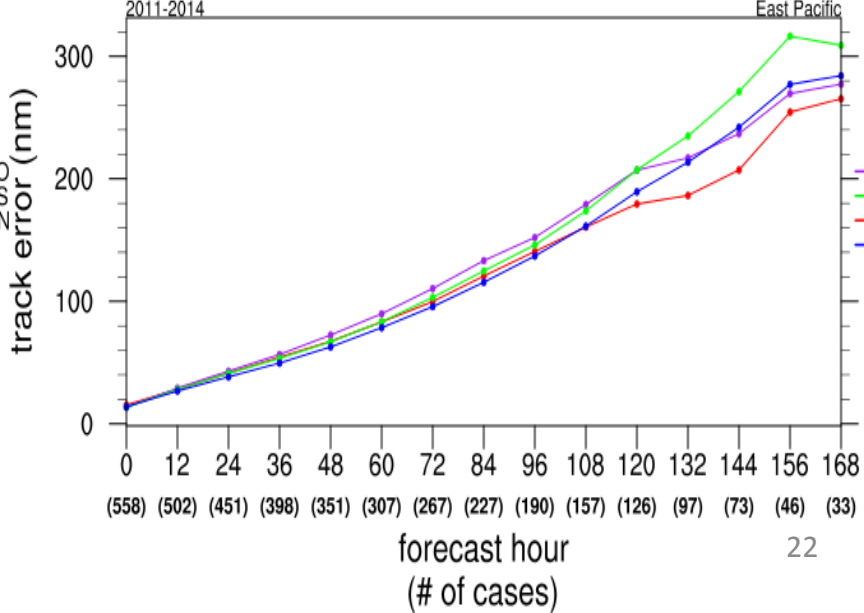
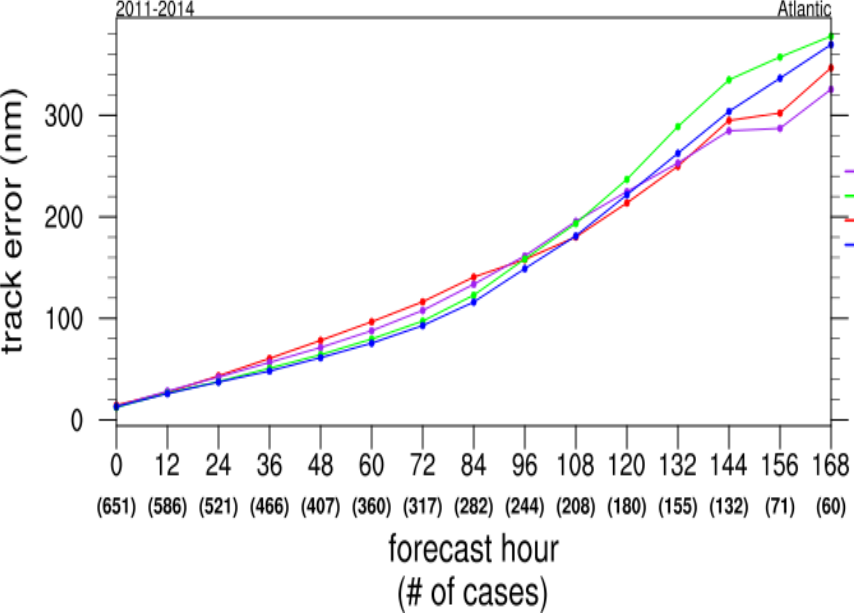
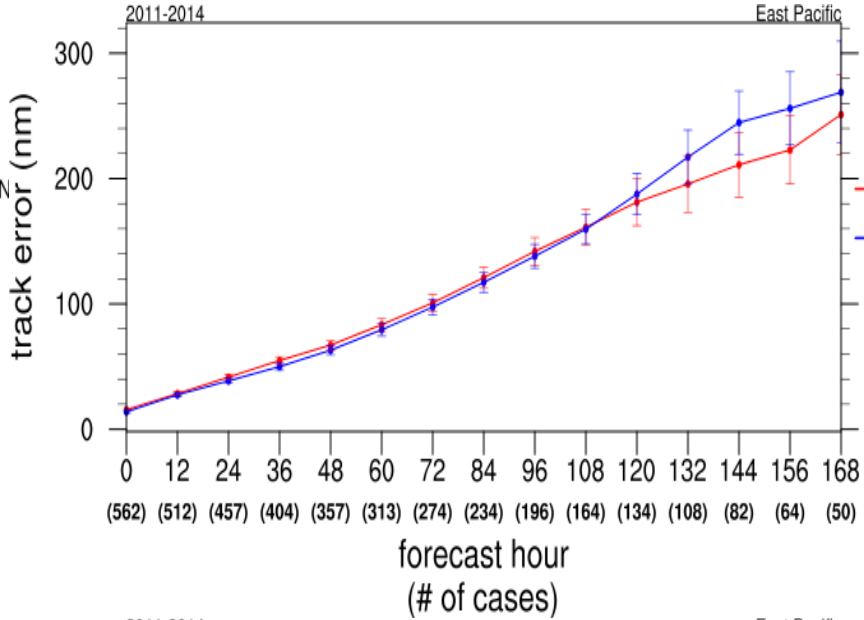
Courtesy of Andrew Penny (NHC)

# 2011-2014

# Atlantic

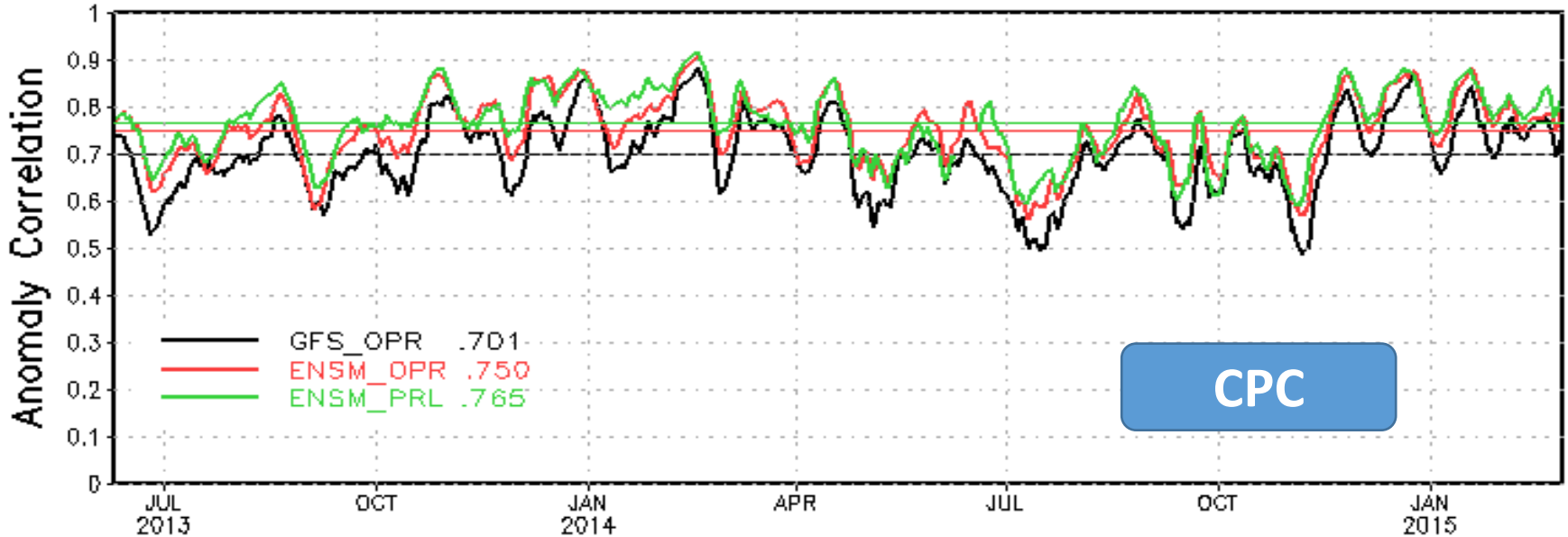


# East Pacific

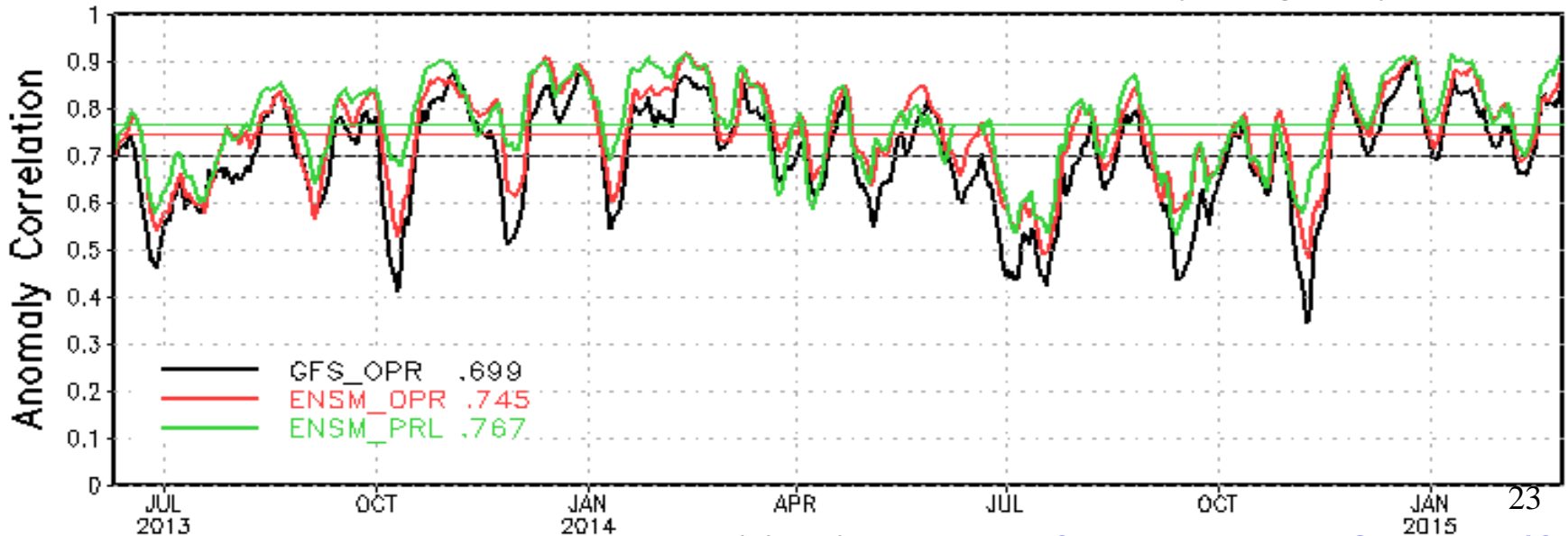


# Z500 Anomaly Correlation Scores for D+8 Forecast

Z500 AC NH 20N-80N; D+8 Jun 10, 2013 - Feb 28, 2015 (10-day RNM)

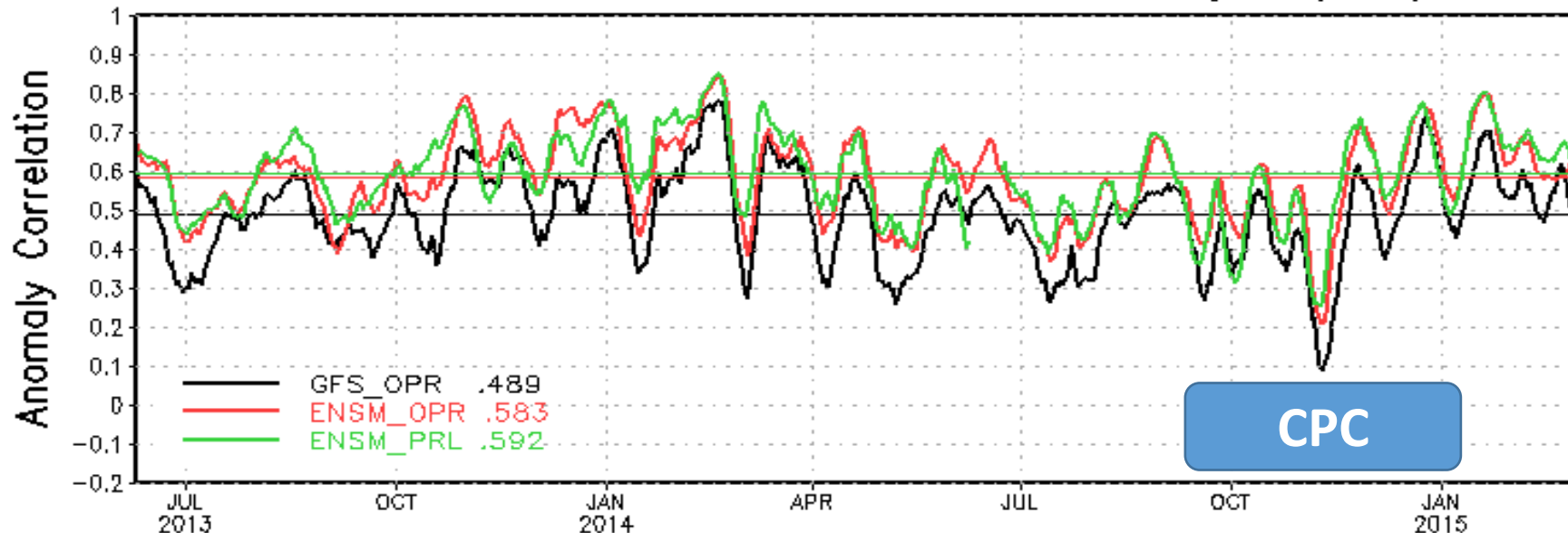


Z500 AC PNA Sector; D+8 Jun 10, 2013 - Feb 28, 2015 (10-day RNM)

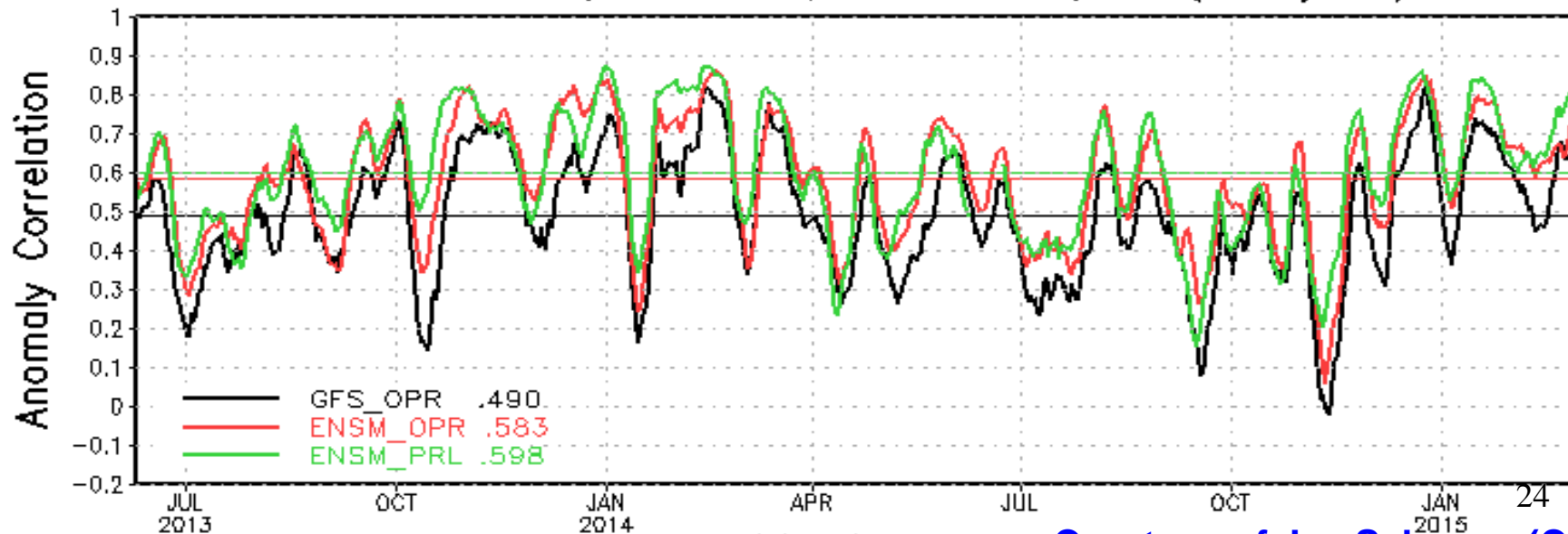


# Z500 Anomaly Correlation Scores for Week 2

Z500 AC NH 20N-80N; WK 2 Jun 10, 2013 - Feb 28, 2015 (10-day RNM)



Z500 AC PNA Sector; Wk 2 Jun 10, 2013 - Feb 28, 2015 (10-day RNM)





# Active Users Feedback

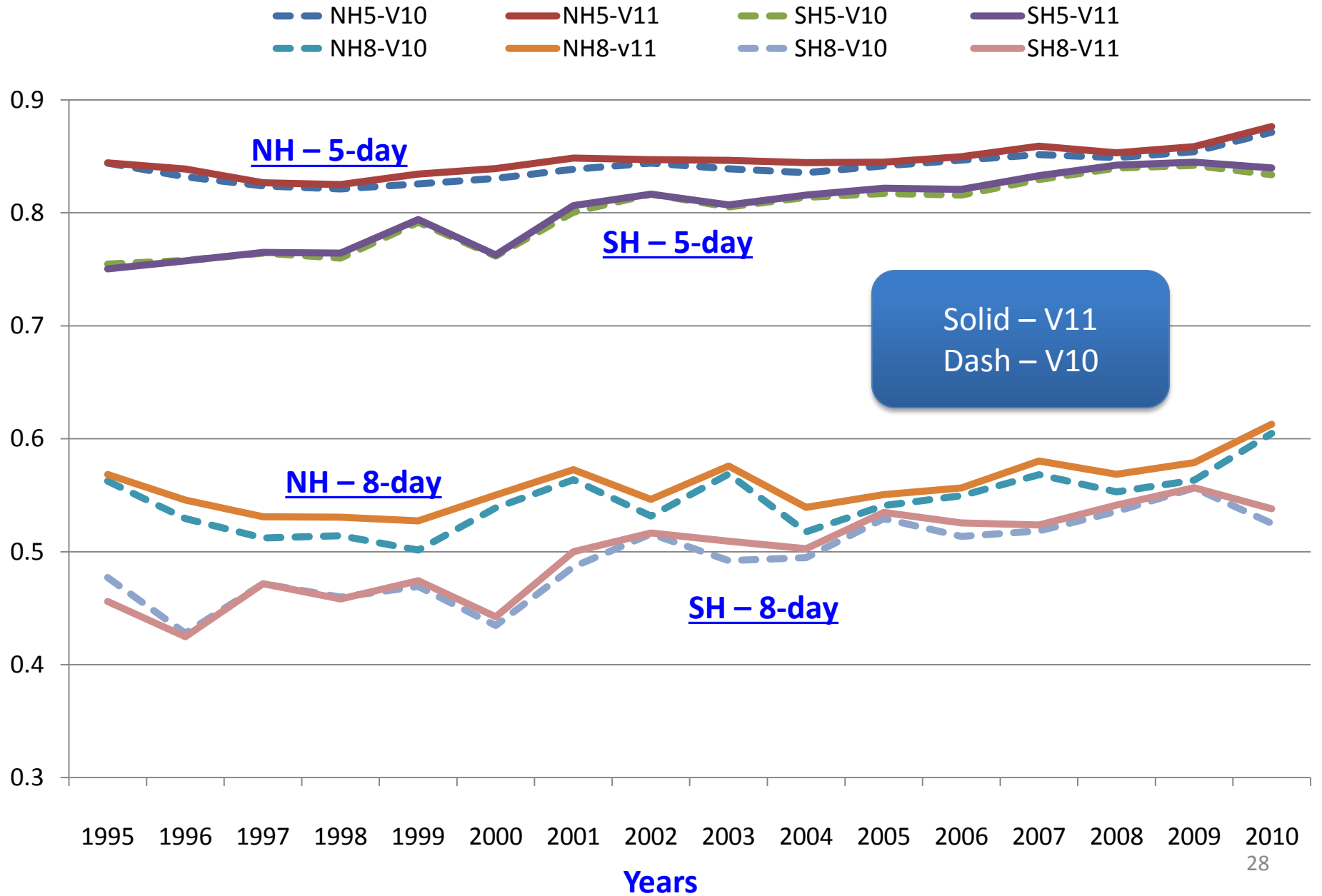
- WPC – EMC has presented for WPC in May
- NHC – Jessica Schauer and Andy Penny
- CPC – Dan Collins and Jae Schemm,
- WFO
  - ER: Richard Grumm and Brian Miretzky
  - WR: Trevor Alcott
- MDL – John Wagner
- JTWC – Matthew Kucas
- University and private sector:
  - Violeta Toma ([vt25@mail.gatech.edu](mailto:vt25@mail.gatech.edu))
  - Nickitas Georgas ([ngeorgas@stevens.edu](mailto:ngeorgas@stevens.edu) )
  - Michael Pass ([wxman11@wxman11.onmicrosoft.com](mailto:wxman11@wxman11.onmicrosoft.com) )
  - Eric Wertz (Manager, Weather Data Solutions)

# Summary

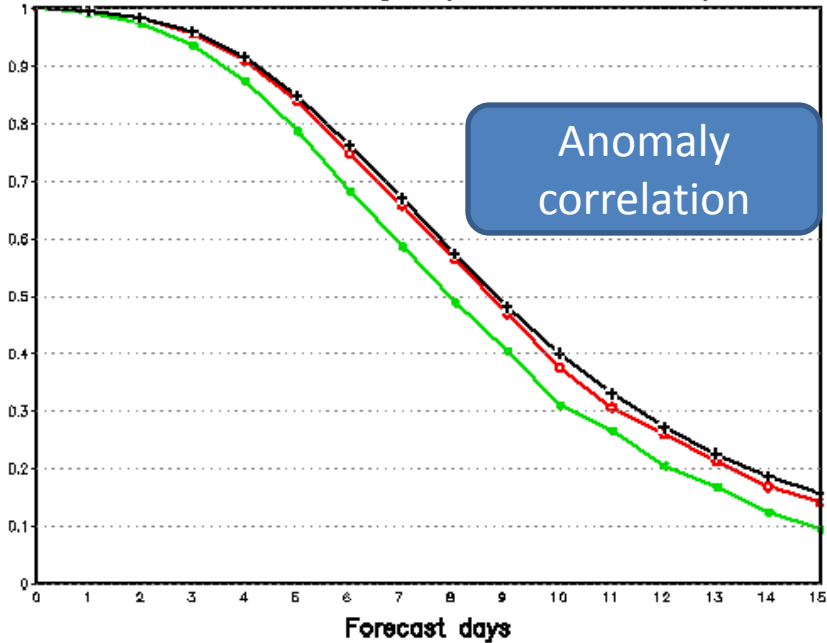
- Extended summer
  - Improvement:
    - Over-all large scale circulation in terms of AC, RMS error, CRPS and other measures
    - Surface temperature – improved for east of CONUS slightly (from cold bias to warm bias)
    - Surface wind
    - Precipitation – improved reliability and skill
    - Hurricane tracks out to 5 days, out to 7 days for West Pacific
  - Neutral:
  - Degrade:
    - Slight degradation of hurricane tracks, beyond day-5
- Extended winter
  - Improvement:
    - Over-all for many atmospheric variables
    - Surface wind
    - Surface temperature after bias correction
  - Neutral:
    - Surface temperature errors and bias for CONUS (against obs)
    - Precipitation
  - Degrade:

Extra slides for  
GEFS control only reforecast (18 years)

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



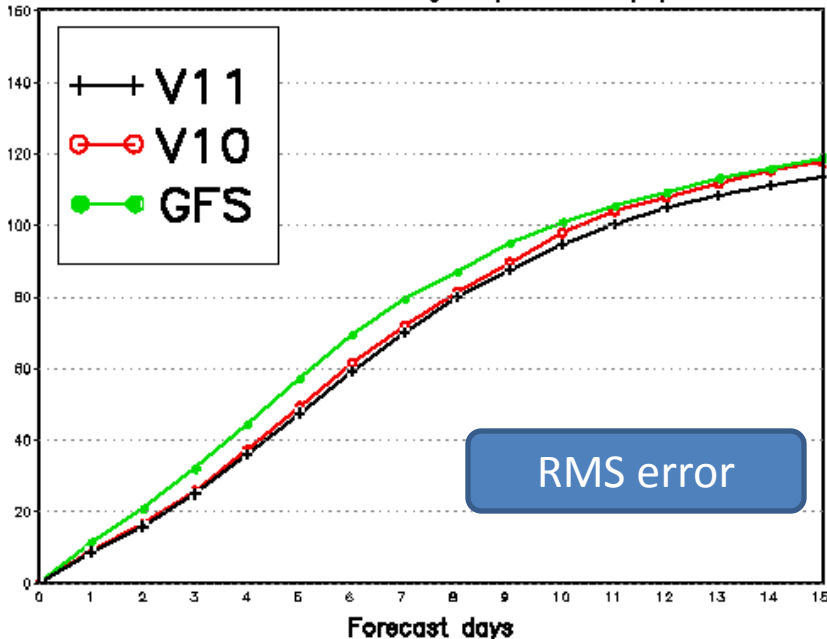
NH 500 mb Height ( wave 1-20 AC )



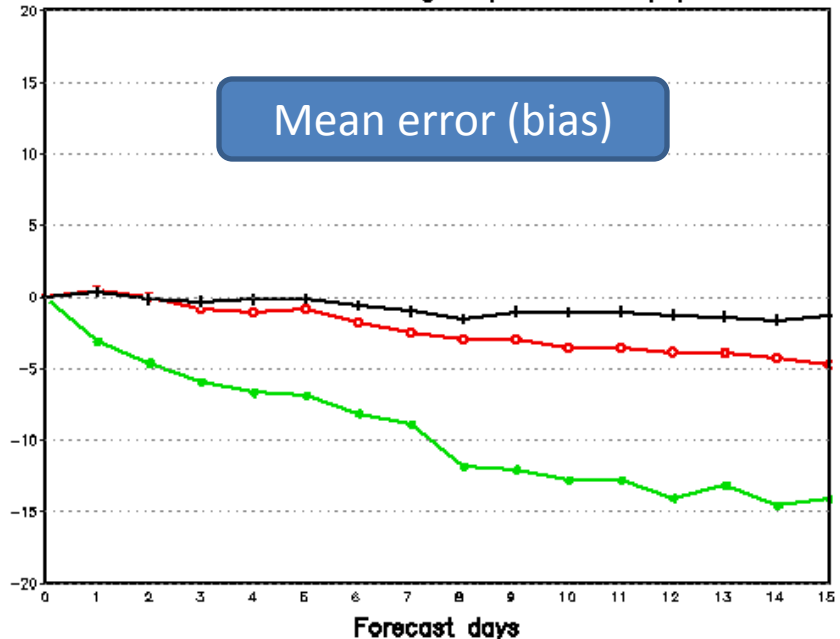
**Statistical period:**  
**01/01/2001 – 12/31/2001**  
**(183 cases)**

Ensemble control only  
TL574L64 (0-192h)  
TL382L64 (192-384h)

NH 500 mb Height (F-A rms )

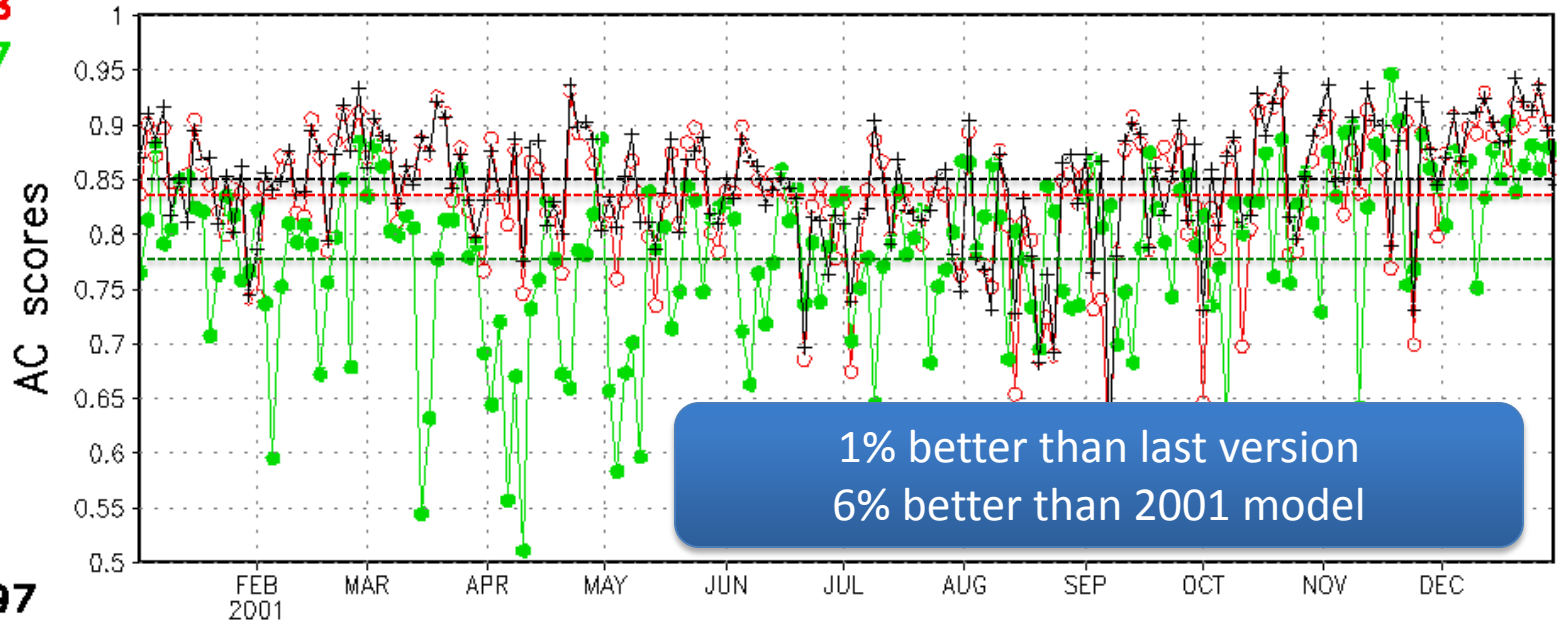


NH 500 mb Height (F-A mean )

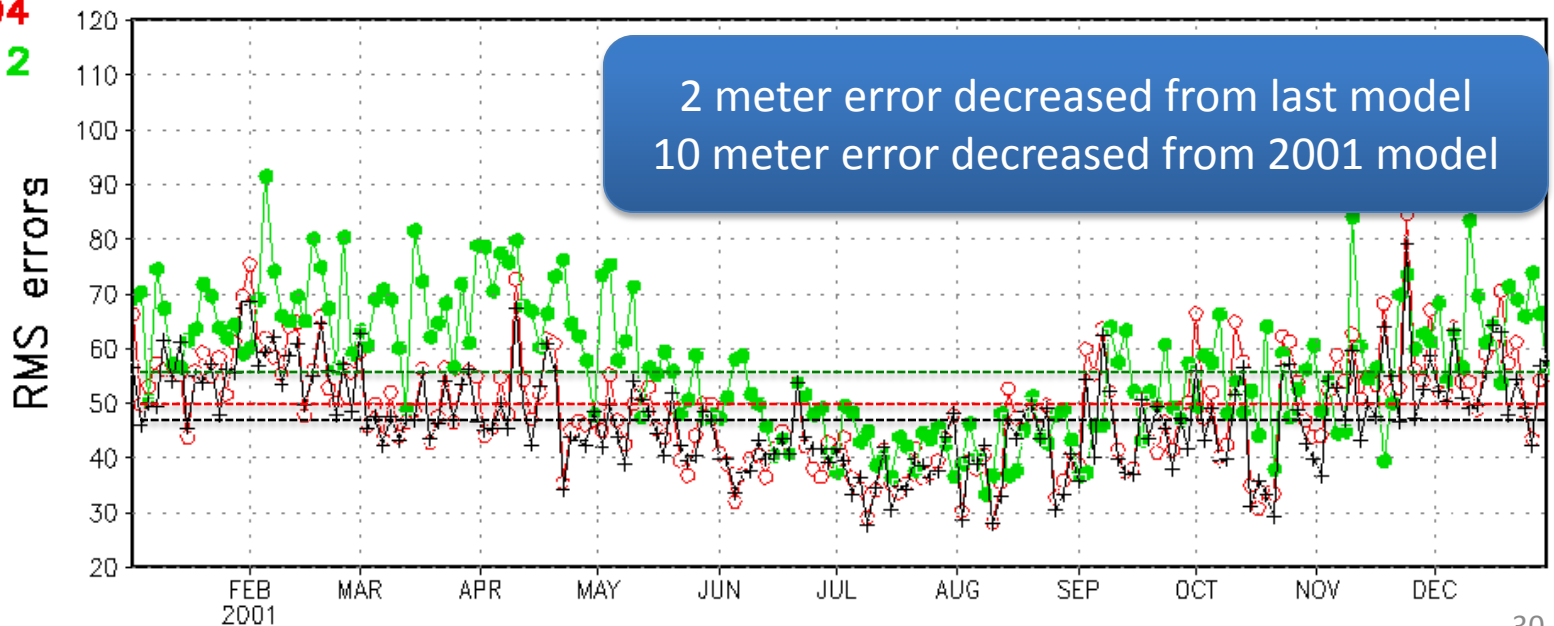


# NH 500 hPa Geopotential Height at day 5 for 00Z02JAN2001 – 00Z30DEC2001

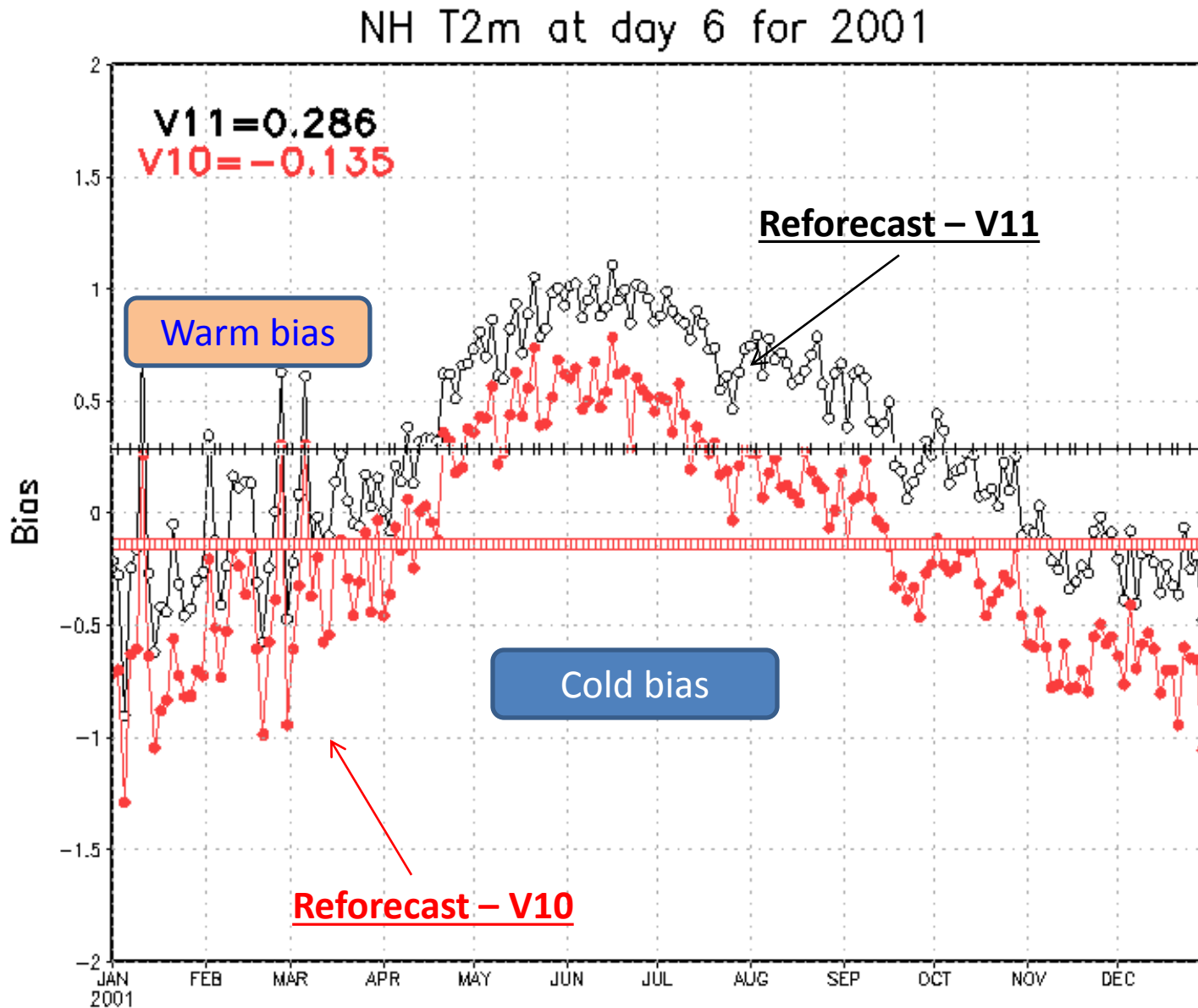
**V11=0.848**  
**V10=0.838**  
**GFS=0.787**



**V11=47.297**  
**V10=49.204**  
**GFS=57.112**



# 2-meter temp. bias of 2001 (fcst: 144 hours)



# Where/when can you get data?

- For NCEP service centers
  - All retrospective forecasts have been saved on HPSS.
  - Selected variables for short period are on disk
- For general public users
  - Will publish part of retrospective forecast for public access (soon)
  - Selected variables (80 NAEFS exchange variables)
  - Period: 5/13/2013 – current: 00UTC forecast only
  - 1x1 degree and every 6 hrs, out to 16 days
  - 18year control only reforecast – possible to have limited variables for anonymous ftp access (request only)
- NCO has run real time parallel in May 2015
  - Real time data access through NCEP ftp (soon)
  - 0.5d and 3 hrly pgrb data for first 8 days will be available



# NAEFS Global Grid Exchange Variables for 1.0d

Update: June 2013

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

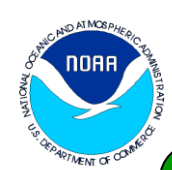
# For More Information ....

- GEFS configuration/verification website at EMC  
[http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201412\\_imp.html](http://www.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201412_imp.html)
- GFS description website at EMC  
<http://www.emc.ncep.noaa.gov/gcwmb/doc.php>
- Contacts at EMC Ensemble Team
  - [Yuejian.Zhu@noaa.gov](mailto:Yuejian.Zhu@noaa.gov)
  - [Dingchen.Hou@noaa.gov](mailto:Dingchen.Hou@noaa.gov)

# Acknowledgements:

- EMC ensemble team members:
  - Dingchen Hou, Richard Wobus, Xiaqiong Zhou, Jiayi Peng, Hong Guan, Malaquias Pena, Yan Luo, Bo Cui, Water Kolczynski and Wei Li
- EMC GWCMC staffs:
  - Hui-ya Chuang, Dana Carlis, Fanglin Yang, Kate Howard, Diane Strokes, Mike Young, Shrinivas Moorthi, Suranjana Saha, Mark Iredell, John Derber.
- NCO staffs:
  - Jianbin Yang, Xiaoxue Wang, Luke Lin, Rebecca Cosgrove, Simon Hsiao, Steven Earle

Background !!!



# GEFS (V11.0.0) Upgrade (Q4FY15)

Project Status as of 5/29/2015



## **G** Project Information and Highlights

**Lead:** Yuejian Zhu, EMC, Becky Cosgrove, NCO

**Scope:**

- Latest GFS model (SLG version with improved physics).
- Configurations: T574L64 and T382L64 out to 384 hours
  - 0-192hr - T574 (T382 for physics – 33-35km
  - 192-384hr – T382 (T254 for physics) – 51-54km
  - L64 – the same vertical resolution as EnKF, GFS
- Initial perturbations
  - EnKF 6h forecast with improved TS relocation and centralization
- Stochastic physics
  - Tuning parameters for STTP to upgrade GFS model
  - Turn off stochastic perturbation of log surface pressure
- Forecast data output
  - All GRIB II format
  - 0.5degree data for pgb files
  - 3 hourly output frequency (out to 192 hours)

**Expected Benefits:**

- Improve TS track forecast
- Increase probabilistic forecast skill
- Improve predictability of HIW and extreme weather event

## **G** Scheduling

Milestone (NCEP)	Date	Status
EMC testing complete/ EMC CCB approval	2/10/2015	
Initial Code Delivery to NCO	2/10/2015	
Technical Information Notice Issued	2/15/2015	
Initial Test Complete		
CCB approve parallel data feed		
IT testing begins		
IT testing ends		
Parallel testing begun in NCO (Code Frozen)	03/01/2015	
Real-Time Evaluation Ends	04/01/2015	
Management Briefing		
Implementation		

## **G** Issues/Risks

**Issues:** N/A

**Risks:**

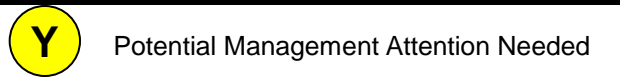
Current: ~100 nodes – 60 minutes  
 Future ~300 nodes – 60 minutes

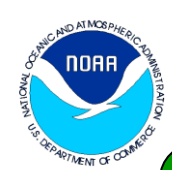
**Mitigation:**

## **G** Finances

**Associated Costs:**

**Funding Sources:** EMC Base: NCO Base:





# Legacy GEFS (00UTC only) (Q4FY15)

Project Status as of 05/29/2015



## **G** Project Information and Highlights

**Lead:** Yuejian Zhu, EMC, Chris Magee, NCO

**Scope:**

- Continue to run current GEFS (00UTC only – once per day)
- Configurations: T254L42 and T190L42 out to 384 hours
  - 0-192hr – T254 – 33-35km
  - 192-384hr – T190 – 51-54km
  - L42 – for all lead times
- Initial perturbations
  - BV-ETR cycling (every 6-hr) with TS relocation
- Stochastic physics
  - Stochastic Total Tendency Perturbation (STTP)
- Forecast data delivery
  - All GRIB II format and raw data only
  - Data will not be for public access
  - Expect time to finish < +8hrs (?)
- Scripts/codes structures
  - Will keep current operational structure (not vertical)

**Expected Benefits:**

- Downstream applications
- OHD (RFCs) and CPC

## **G** Scheduling

Milestone (NCEP)	Date	Status
EMC testing complete/ EMC CCB approval	02/10/2015	
Initial Code Delivery to NCO	02/10/2015	
Technical Information Notice Issued	02/15/2015	
Initial Test Complete		
CCB approve parallel data feed		
IT testing begins		
IT testing ends		
Parallel testing begun in NCO (Code Frozen)	03/01/2015	
Real-Time Evaluation Ends	04/01/2015	
Management Briefing		
Implementation		

## **G** Issues/Risks

**Issues:** N/A

**Risks:**

**Mitigation:**

## **G** Finances

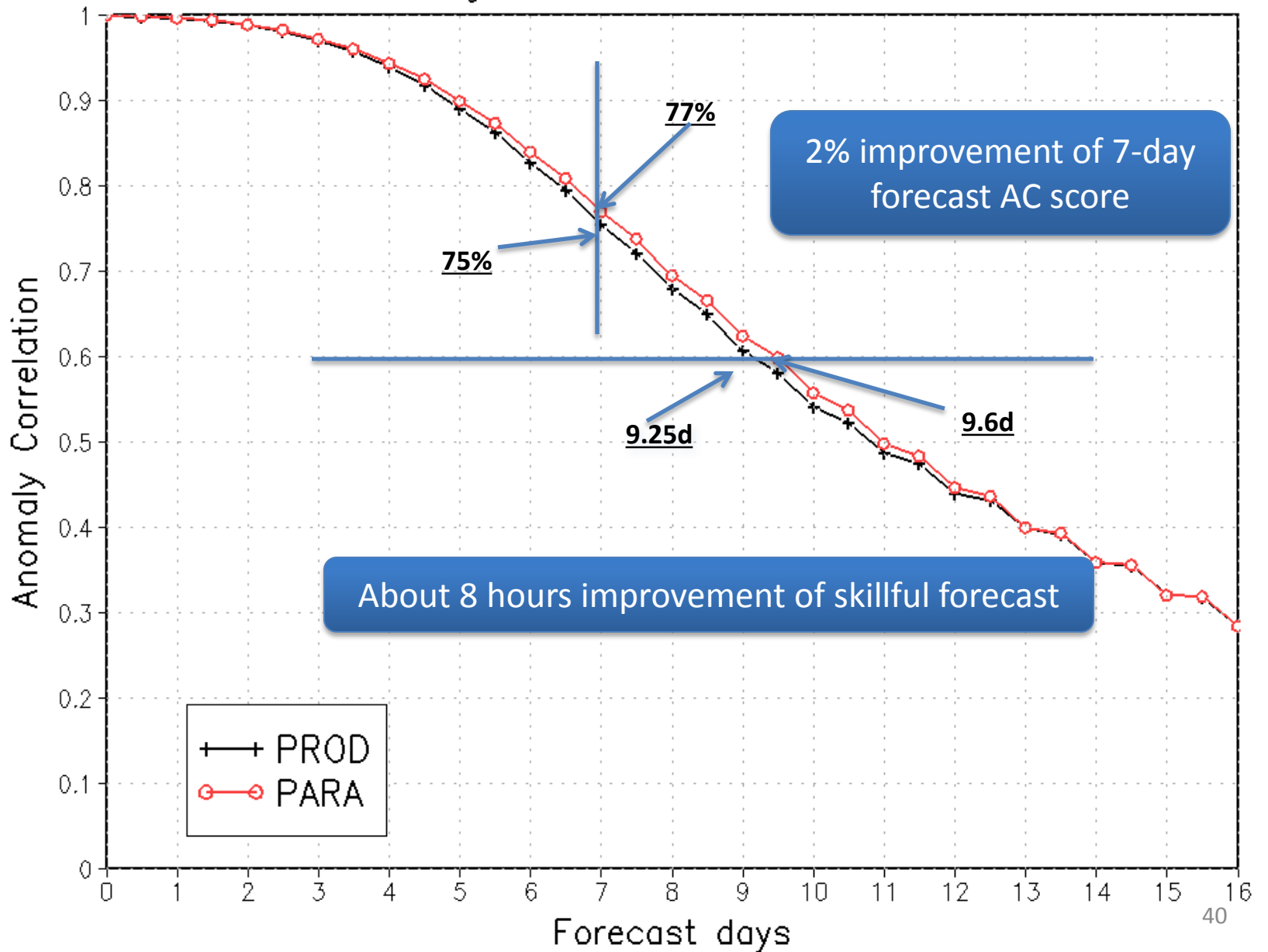
**Associated Costs:**

**Funding Sources:** EMC Base: NCO Base:



409 cases

# Northern Hemisphere 500hPa Height Ensemble Mean Anomaly Correlation Average For 20130516 – 20140630



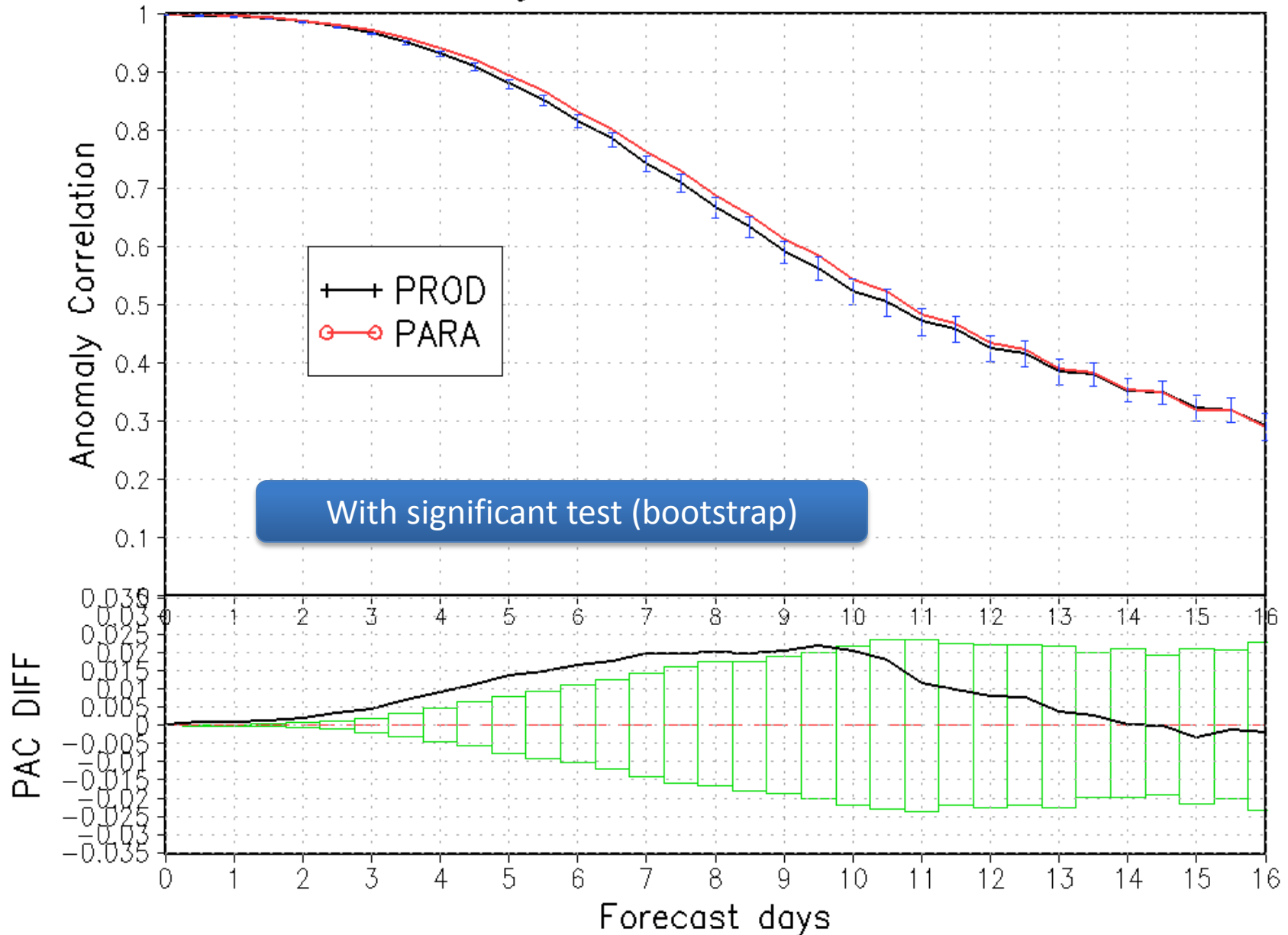
2% improvement of 7-day  
forecast AC score

About 8 hours improvement of skillful forecast

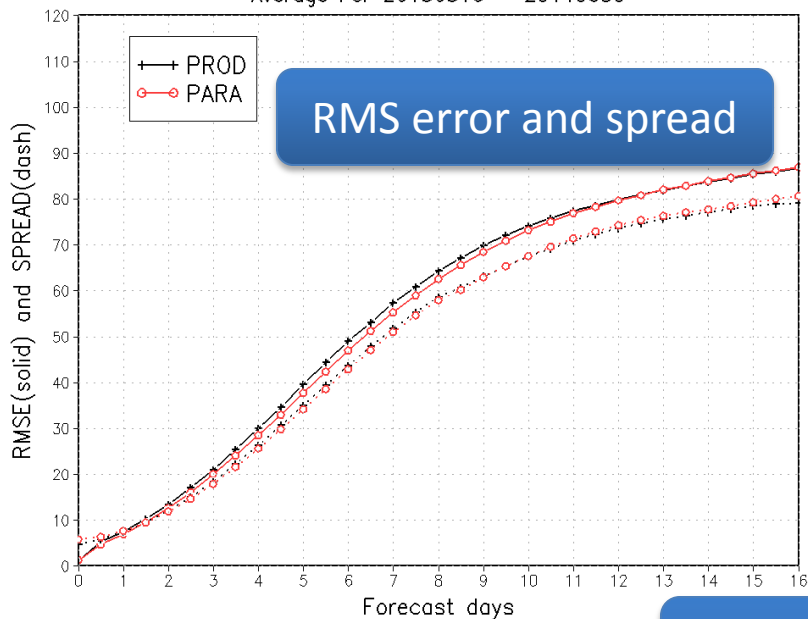
+ PROD  
o PARA



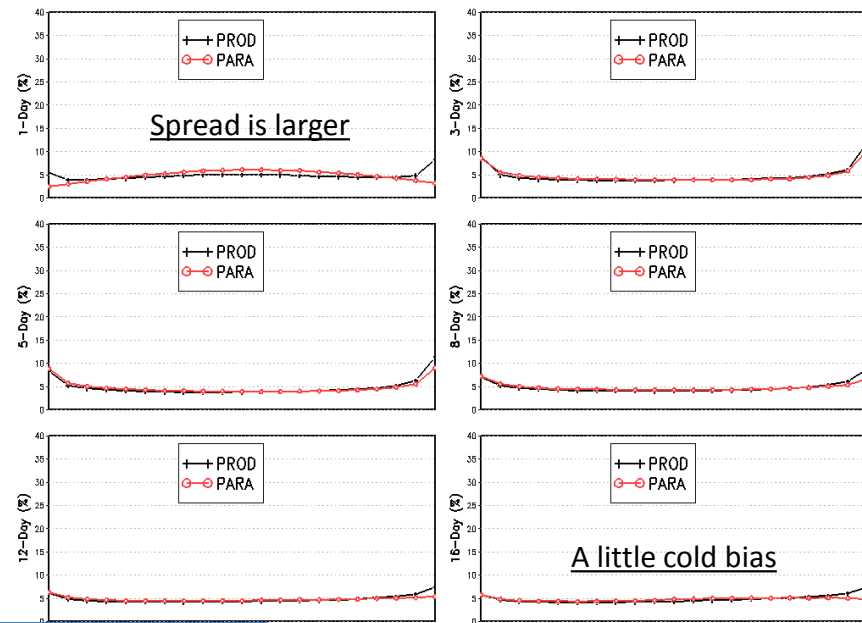
Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20130516 – 20131031



Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20140630

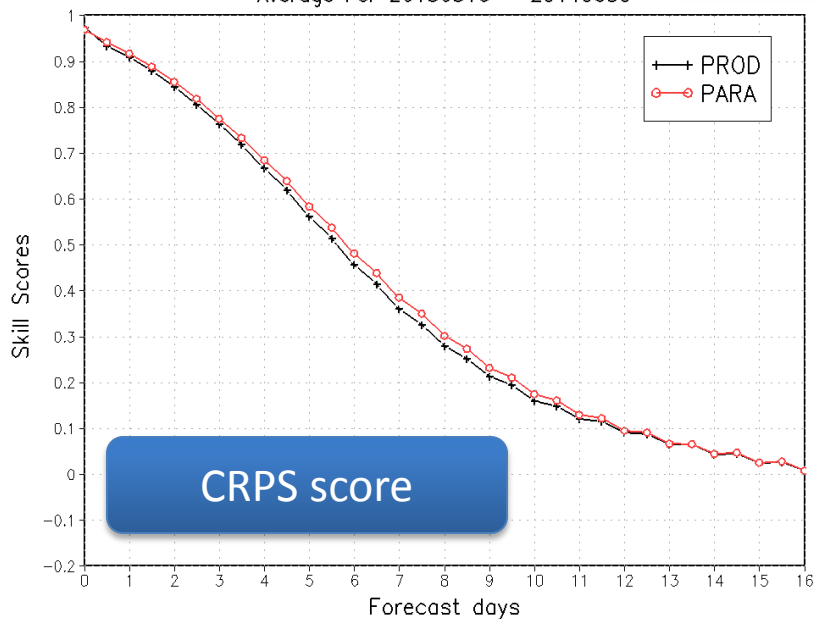


Northern Hemisphere 500hPa Height Histogram Distribution  
Average For 20130516 – 20140630

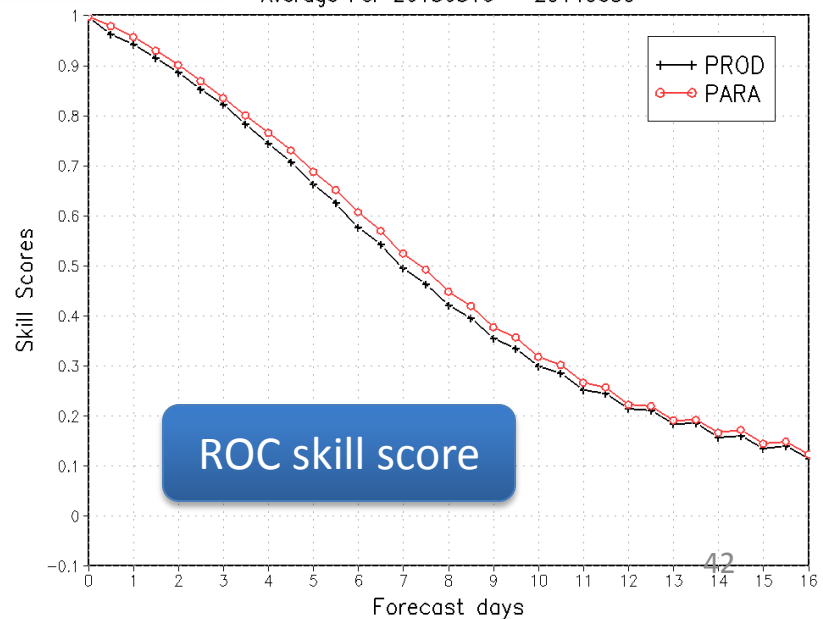


NH 500hPa height

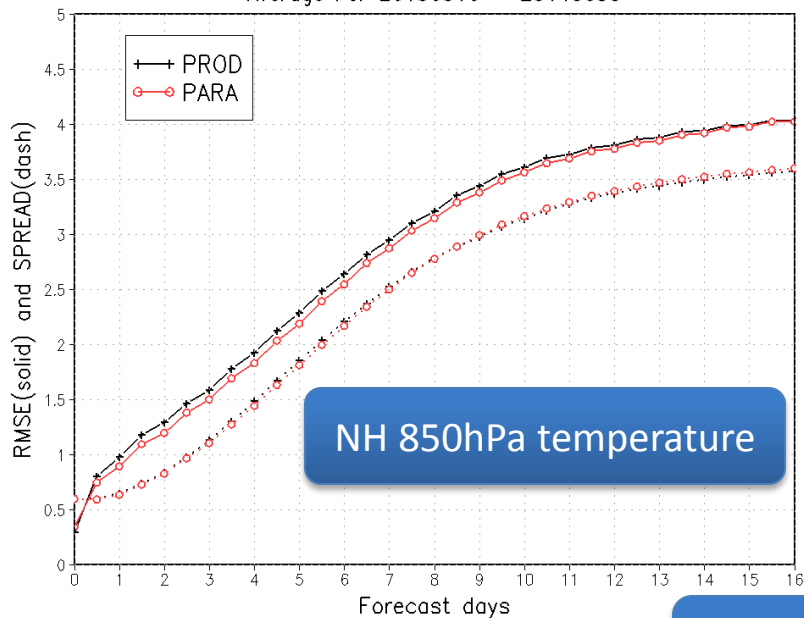
Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20130516 – 20140630



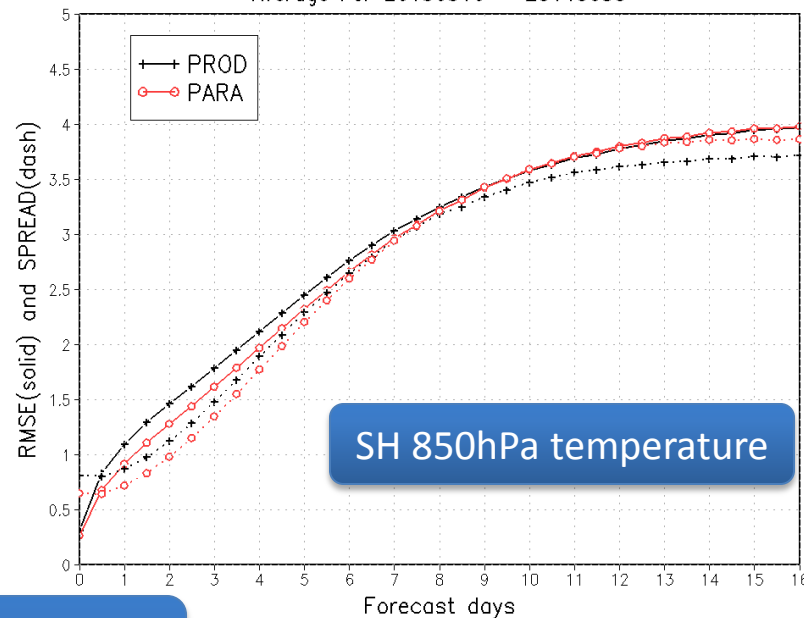
Northern Hemisphere 500hPa Height  
ROC area (0-1)  
Average For 20130516 – 20140630



Northern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20140630

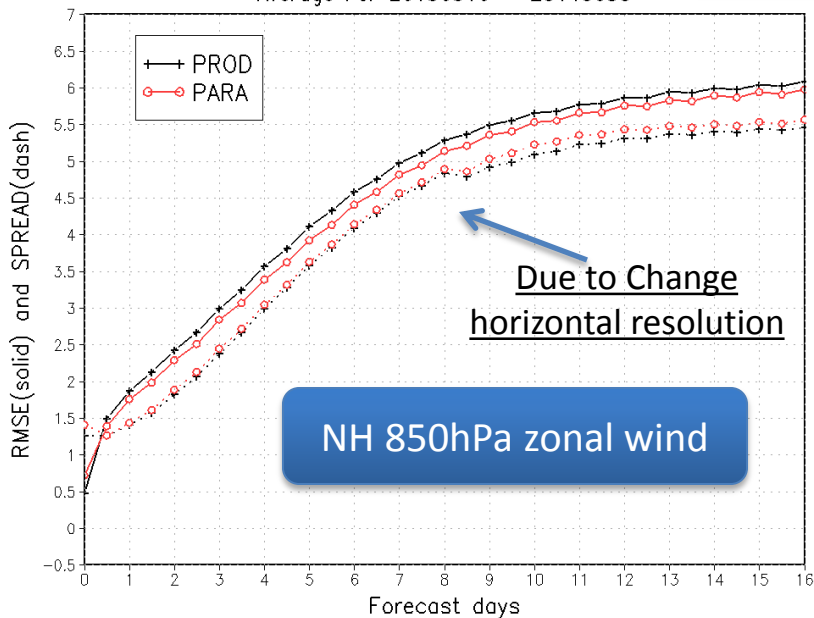


Southern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20140630

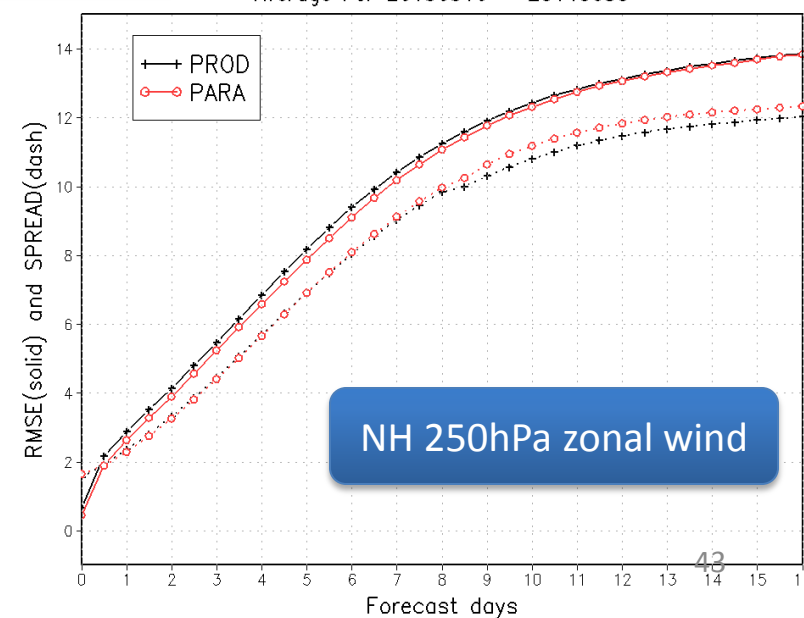


RMS error and spread

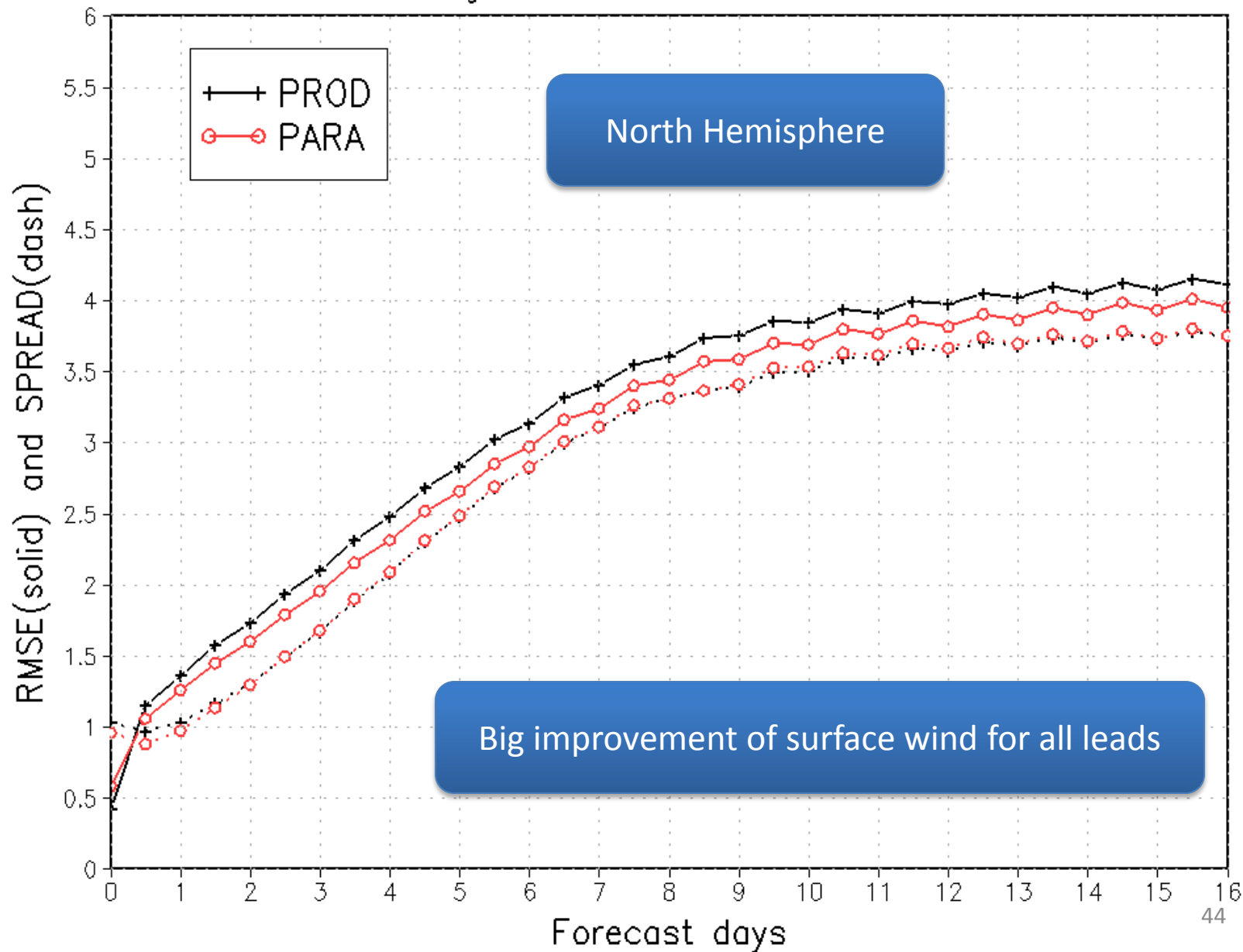
Northern Hemisphere 850hPa U.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20140630



Northern Hemisphere 250hPa U.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20140630



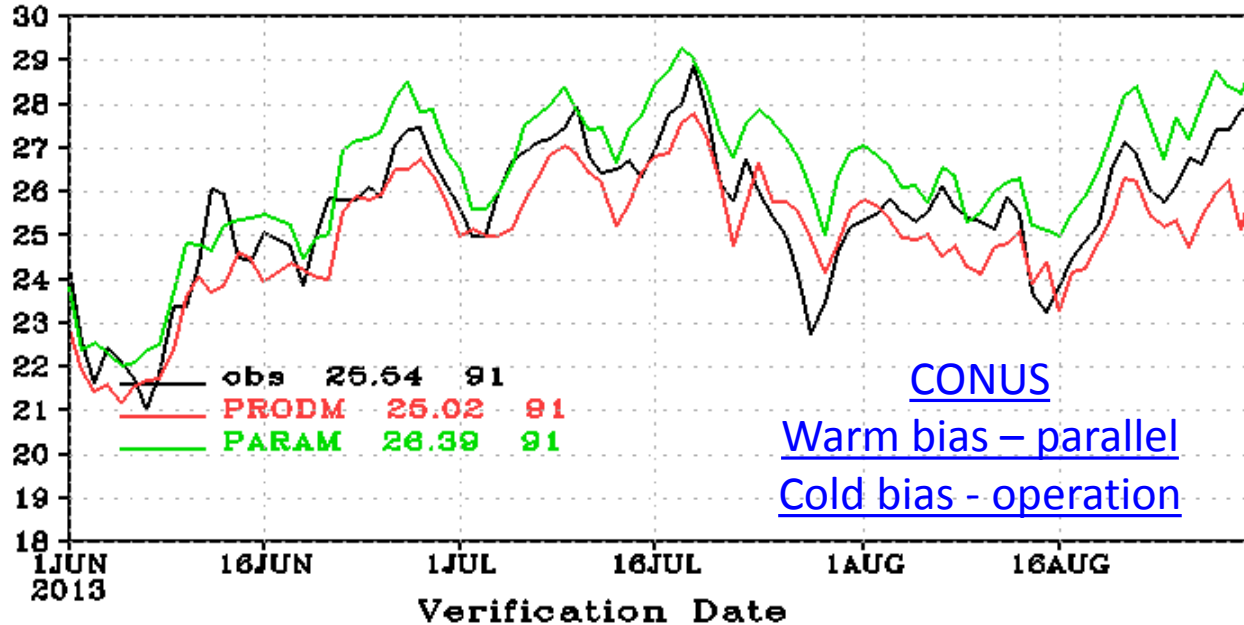
Northern Hemisphere 10 Meter Wind(U)  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 - 20140630



# 2-meter temperature evaluation against observation

(6 days – 144 hrs forecast)

T SFC, CONUS, 00Z cycle, fh144

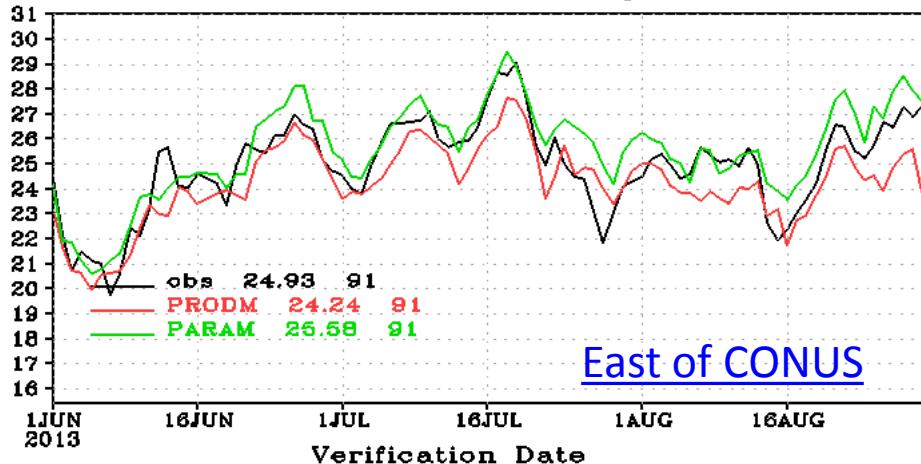


Ensemble mean

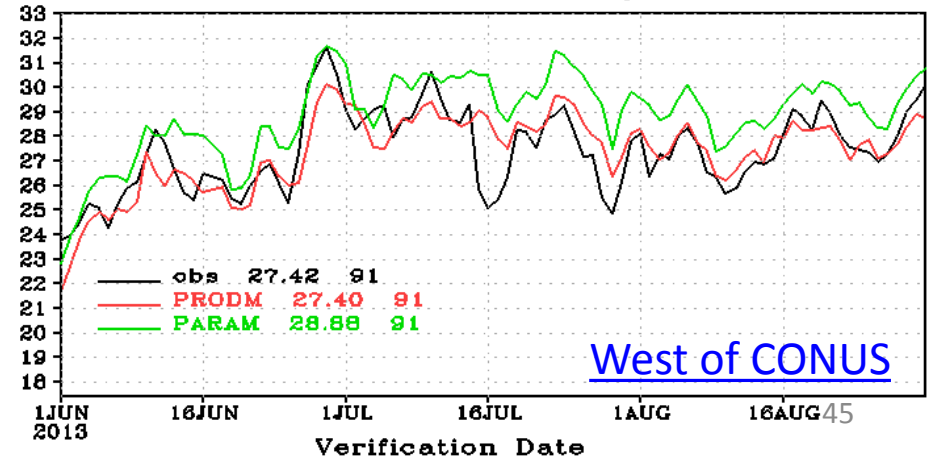
Summer 2013

3 months

T SFC, CONUS East, 00Z cycle, fh144



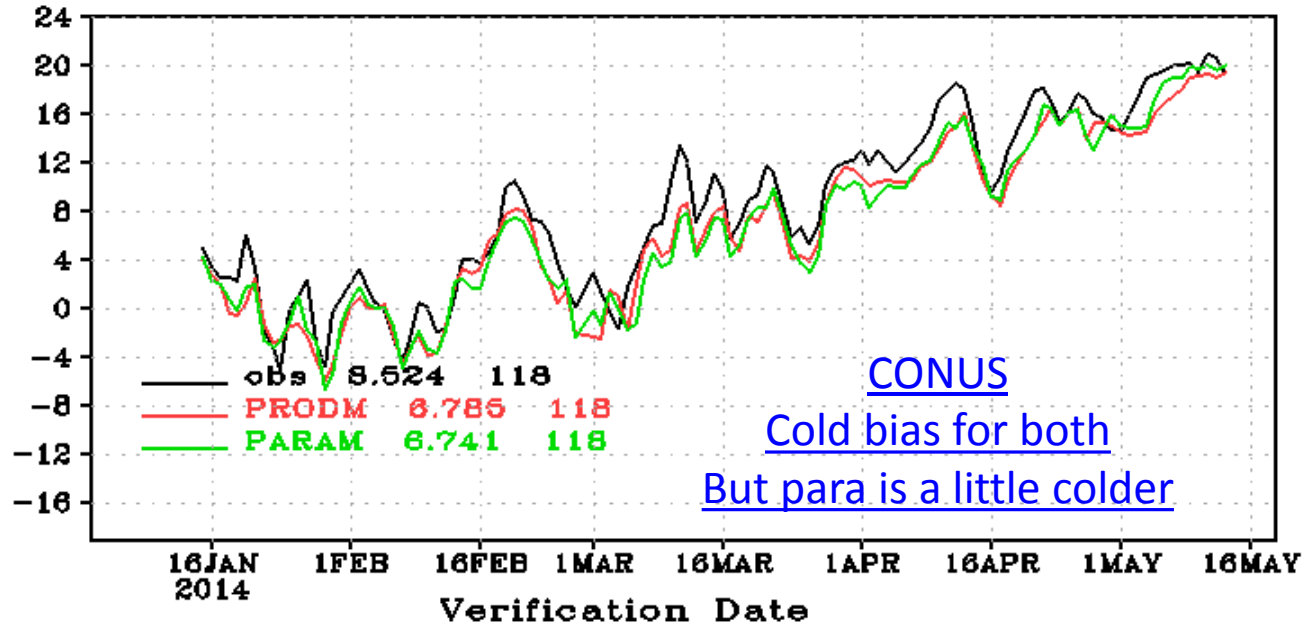
T SFC, CONUS West, 00Z cycle, fh144



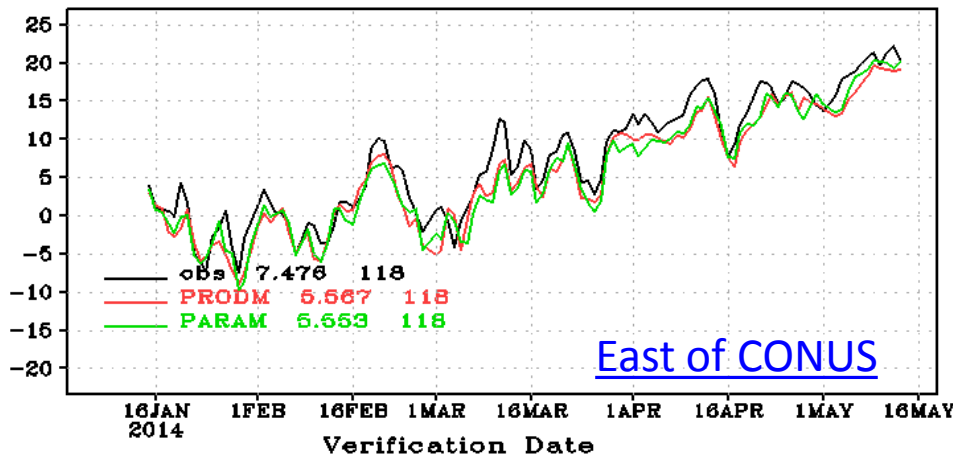
# 2-meter temperature evaluation against observation

(6 days – 144 hrs forecast)

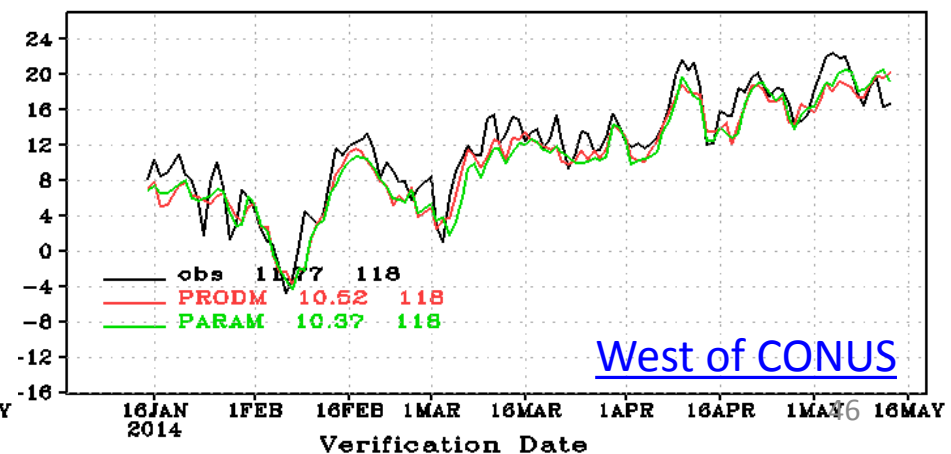
T SFC, CONUS, 00Z cycle, fh144



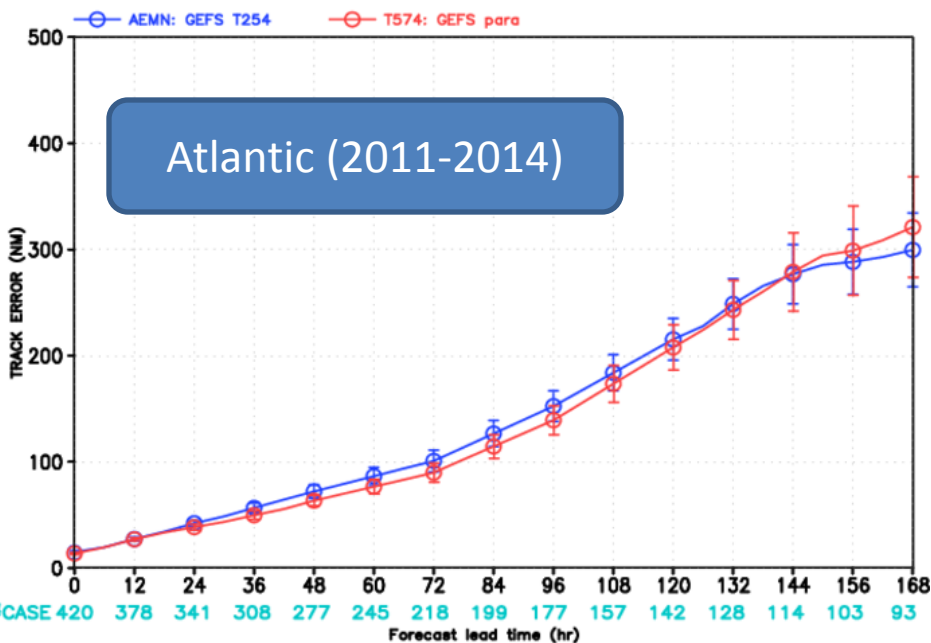
T SFC, CONUS East, 00Z cycle, fh144



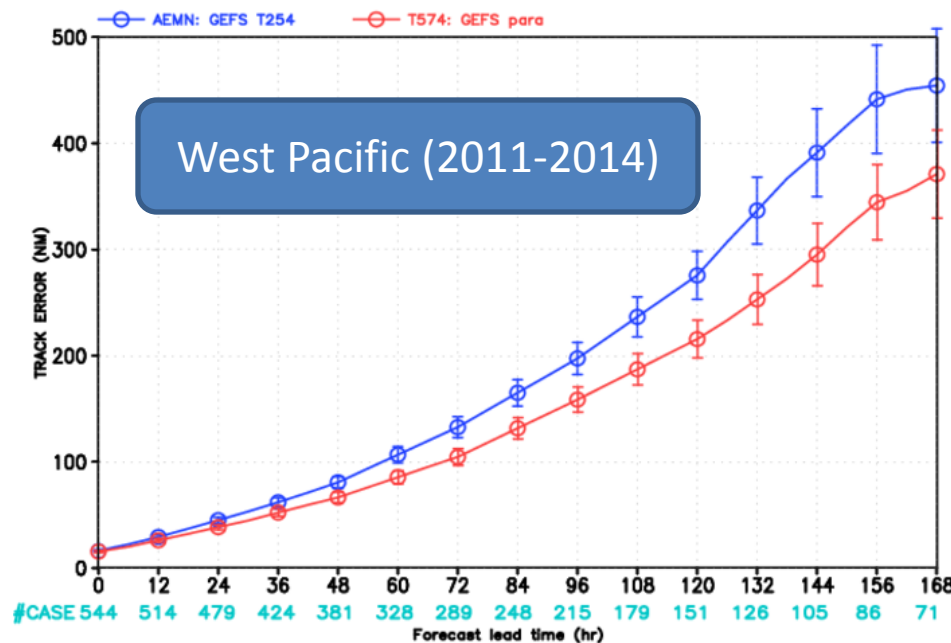
T SFC, CONUS West, 00Z cycle, fh144



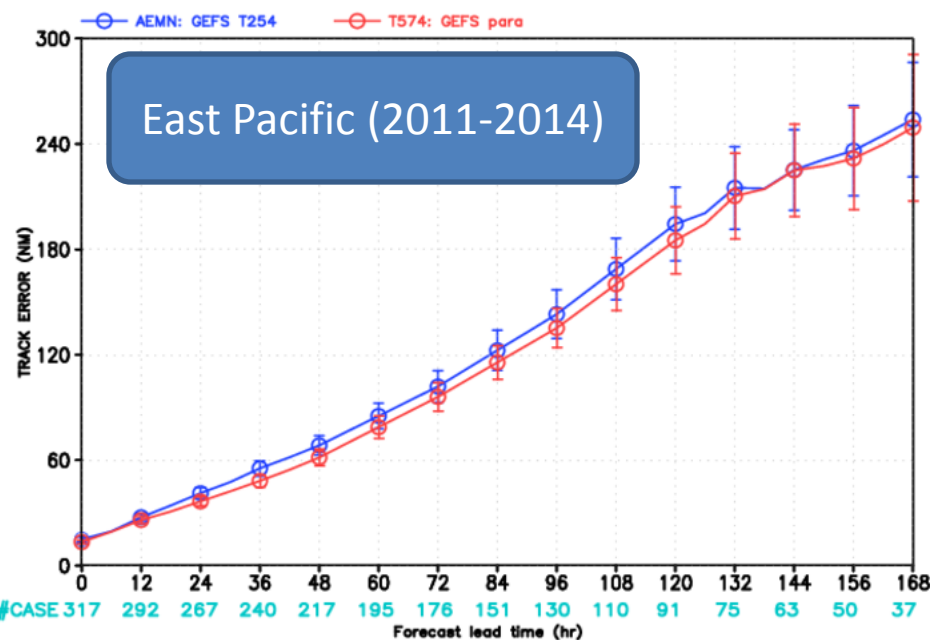
GEFS FORECAST – TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR Atlantic 2011–2014



GEFS FORECAST – TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR West Pacific 2011–2014



GEFS FORECAST – TRACK ERROR (NM) STATISTICS  
 GEFS EXPERIMENT FOR East Pacific 2011–2014



## TS track verification

1. For 2011 season, there are selected Atlantic/East Pacific cases only
2. For 2011 season, we use GEFSv10 parallel to compare, instead of operational GEFSv09
3. Samples are for named TC only (less samples)