



# EMC FY15 Upgrade Review

## GEFS Upgrade

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C  
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P**

**Presented by:**

**Yuejian Zhu**

**Update: 10/07/2014**

# 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: T<sub>L</sub>574 (~33km) for 0-192 hours, T<sub>L</sub>382 (~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 (2<sup>nd</sup> 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
- Challenges:
  - T<sub>L</sub>574L64 configuration will cost 300 nodes for one hour (plus 5 minutes)
  - Option: T<sub>L</sub>574L42 configuration will use less resources, but the forecast quality will be degraded.

# Evolution of NCEP GEFS configuration (versions)

Version	Implementation	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)			
V4.0	2001.1				T126(0-3.5) T62L28(3.5-16)			
V5.0	2004.3				T126L28(0-7.5) T62L28(7.5-16)			
V6.0	2005.8	BV- ETR	TSR	STTP	T126L28	14	00,06,12, 18UTC	
V7.0	2006.5							
V8.0	2007.3				20			
V9.0	2010.2							T190L28
V10.0	2012.2				T254L42 (0-8) T190L42 (8-16)			
V11.0	2015.03	EnKF (f06)	T1574L64 (0-8) T1382L64 (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



# GEFS (V11.0.0) Upgrade (Q2FY15)

Project Status as of 09/06/2014



## **G** Project Information and Highlights

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

**Scope:**

- Latest GFS model (SLG version with improved physics).
- Configurations: TL574L64 and TL382L64 out to 384 hours
  - 0-192hr - TL574 – 33-35km
  - 192-384hr – TL382 – 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
  - 0.5degree (all leads), 3 hourly output frequency (out to 192 hours)
- **TC tracks and genesis**
  - **Single model (CMC, EC and FNMOC) and multi-model**

**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	12/01/2014	
Initial Code Delivery to NCO	01/15/2015	
Technical Information Notice Issued	01/15/2015	
Initial Test Complete		
CCB approve parallel data feed		
IT testing begins		
IT testing ends		
Parallel testing begun in NCO (Code Frozen)	02/01/2015	
Real-Time Evaluation Ends	03/01/2015	
Management Briefing		
Implementation		

## **G** Issues/Risks

**Issues:** N/A

**Risks:**

**Mitigation:**

## **G** Finances

**Associated Costs:**

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

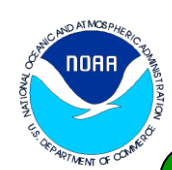
<b>R</b> Management Attention Required	<b>Y</b> Potential Management Attention Needed	<b>G</b> On Target
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# GEFS legacy forecast

- 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, but passwd protected)
    - 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
- Computation resource
  - EMC will look for resource of development of WCOSS and research machine “zeus”



# Legacy GEFS (00UTC only) (Q2FY15)

Project Status as of 09/09/2014



## **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	12/01/2014	
Initial Code Delivery to NCO	01/15/2015	
Technical Information Notice Issued	01/15/2015	
Initial Test Complete		
CCB approve parallel data feed		
IT testing begins		
IT testing ends		
Parallel testing begun in NCO (Code Frozen)	02/01/2015	
Real-Time Evaluation Ends	03/01/2015	
Management Briefing		
Implementation		

## **G** Issues/Risks

**Issues:** N/A

**Risks:**

**Mitigation:**

## **G** Finances

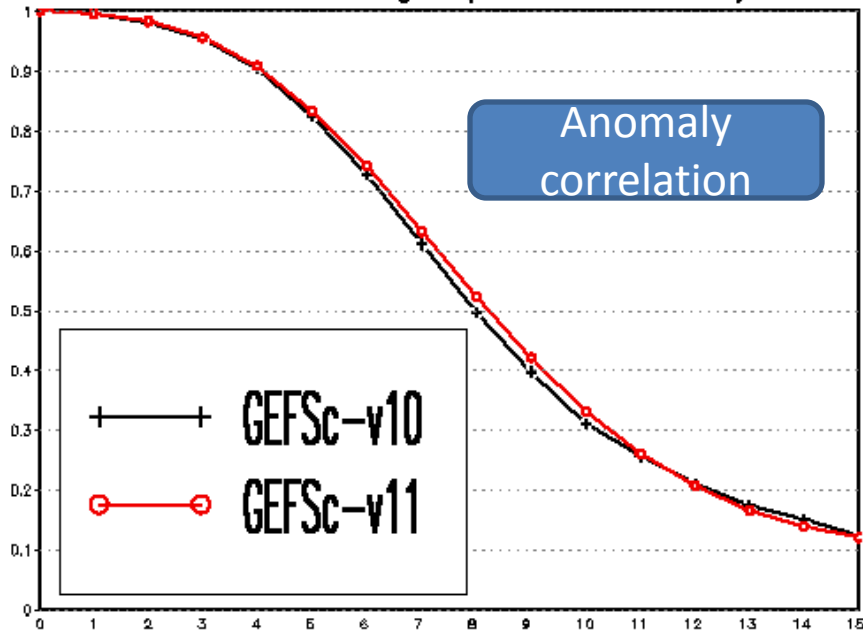
**Associated Costs:**

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

<b>R</b> Management Attention Required	<b>Y</b> Potential Management Attention Needed	<b>G</b> On Target
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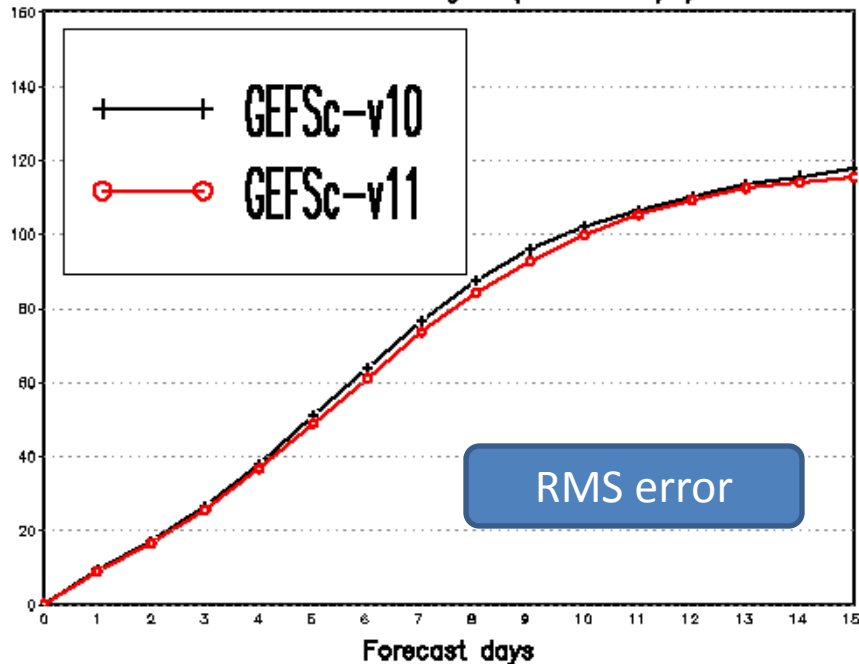
NH 500 mb Height ( wave 1-20 AC )



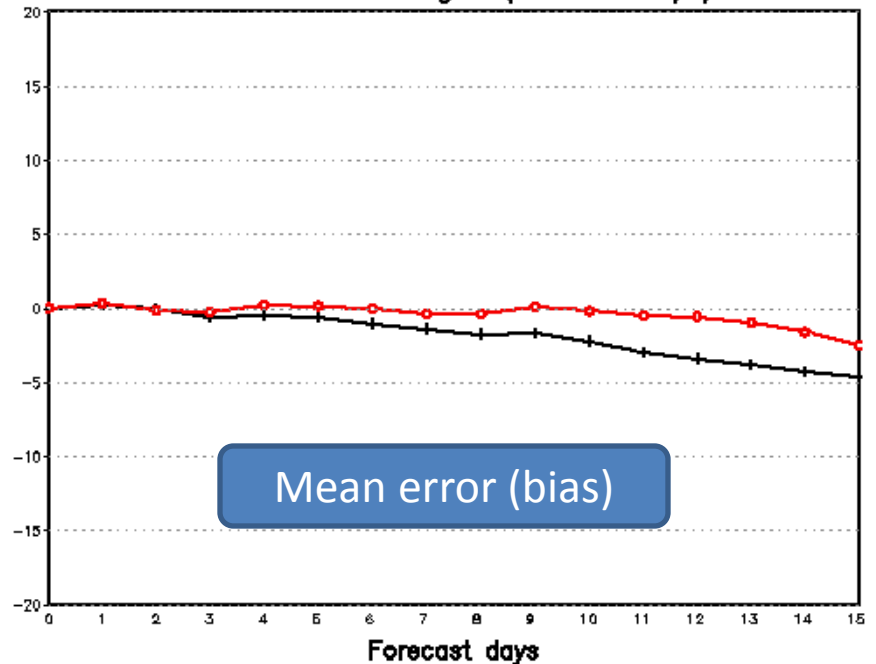
**Statistical period:**  
**01/18/1999 – 12/31/1999**  
**(178 cases)**

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

NH 500 mb Height (F-A rms) )



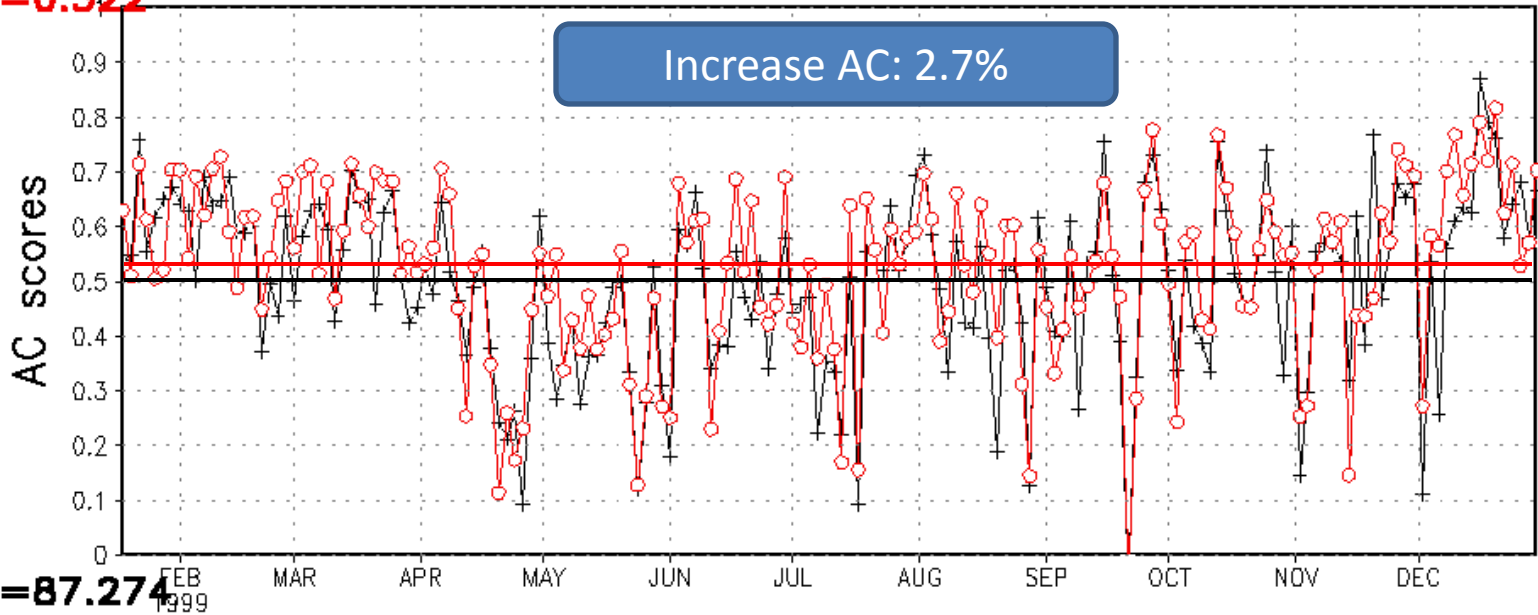
NH 500 mb Height (F-A mean) )



# NH 500 hPa Geopotential Height at day 8 for 00Z18JAN1999 – 00Z30DEC1999

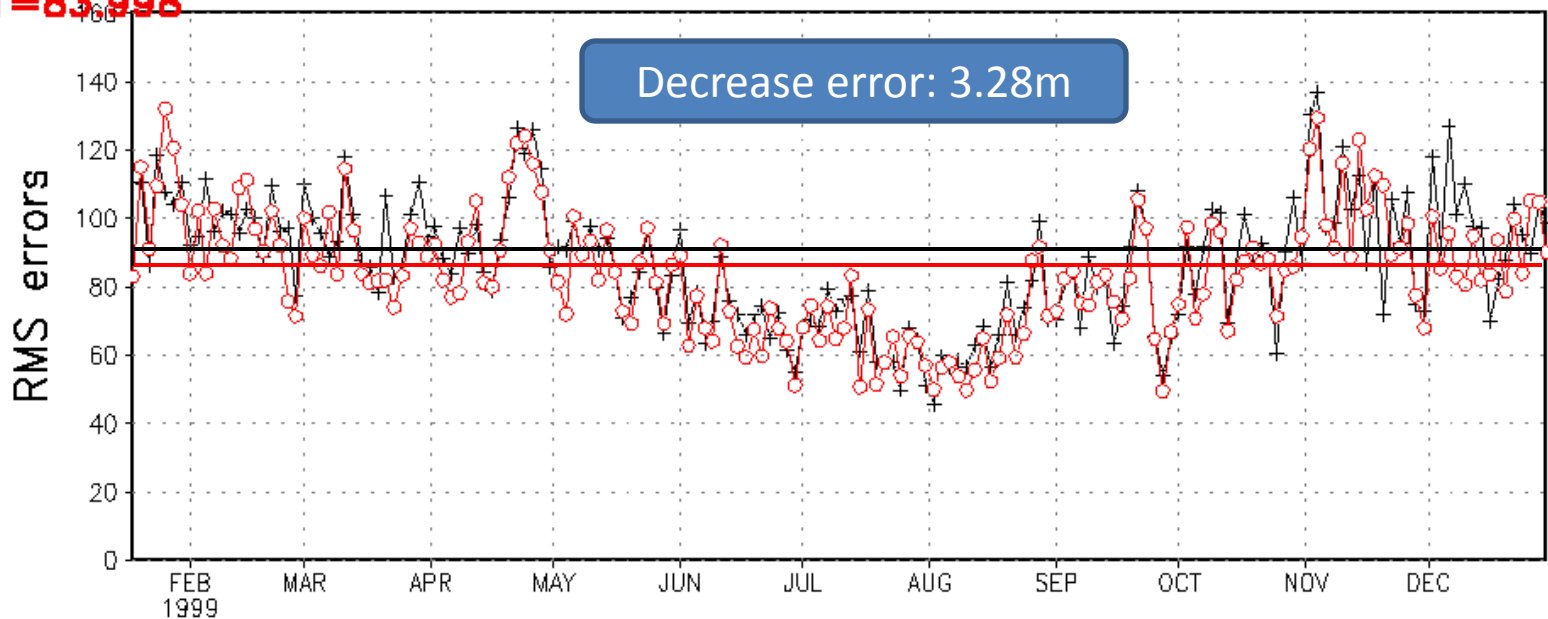
**GEFSc-v10=0.495**

**GEFSc-v11=0.522**

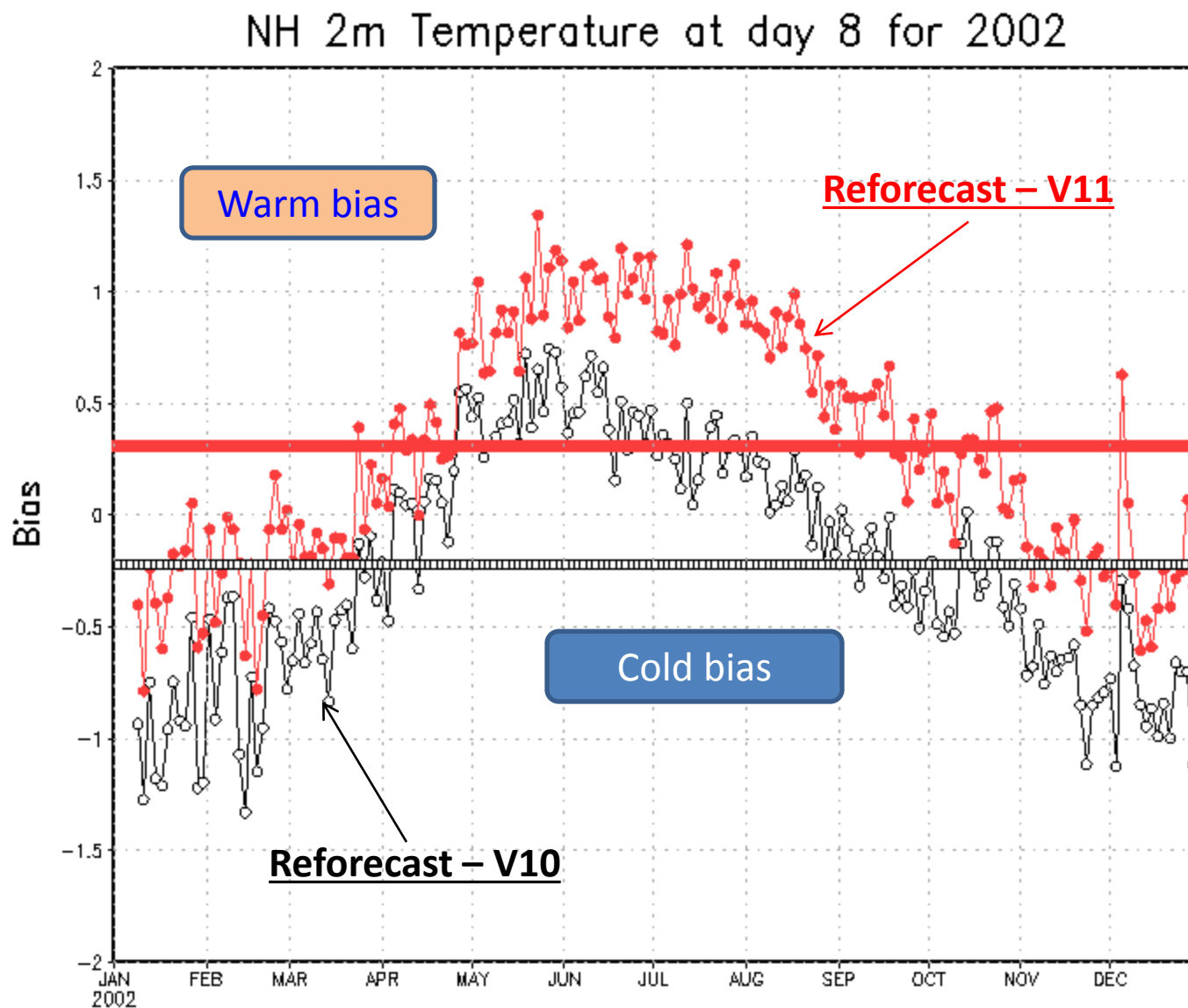


**GEFSc-v10=87.274**

**GEFSc-v11=83.998**



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



# Sandy Case Study for NEXT GEFS

Period: 10/22 – 10/28/2012

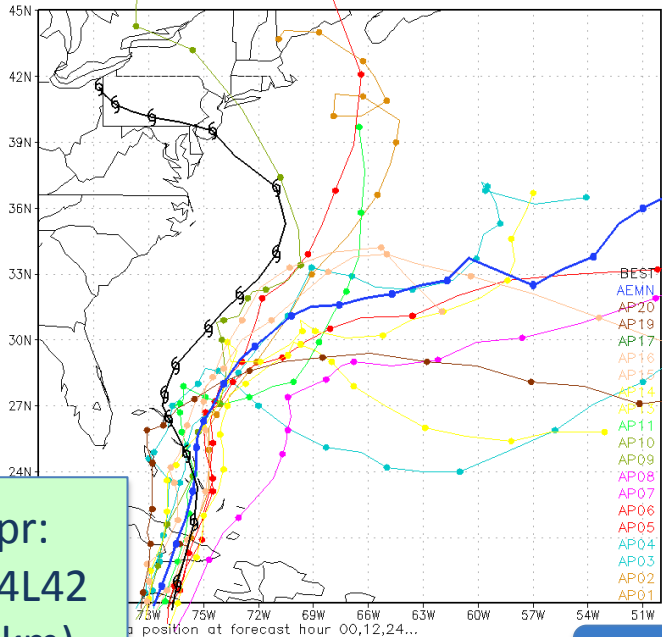
Named: 10/23/2012

Yuejian Zhu  
EMC/NCEP

September 15 2014

Acknolegements:  
Dingchen Hou, Xiaqiong Zhou and Jiayi Peng

NCEP Ensemble Forecast TC Track Verification 2012102200



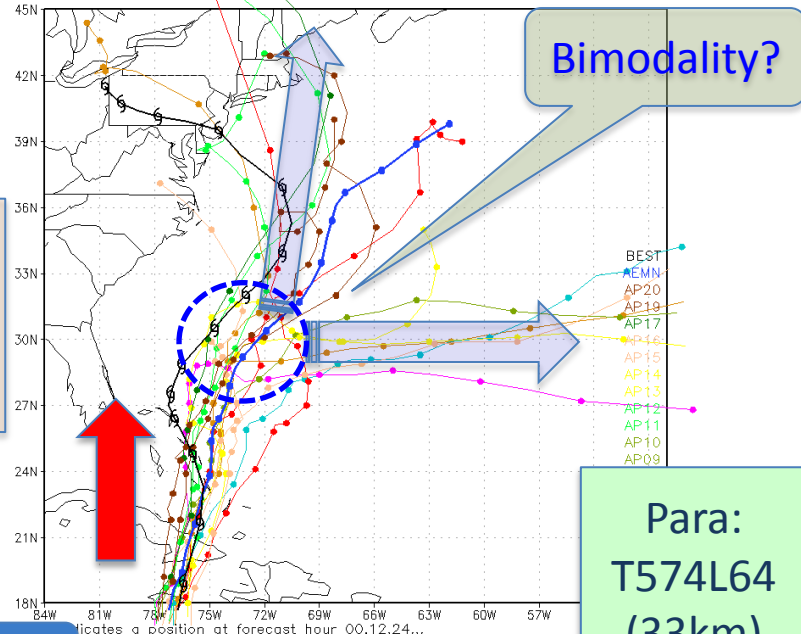
00UTC

Thick blue:  
ensemble  
mean

Opr:  
T254L42  
(55km)

20121022 (8 days)

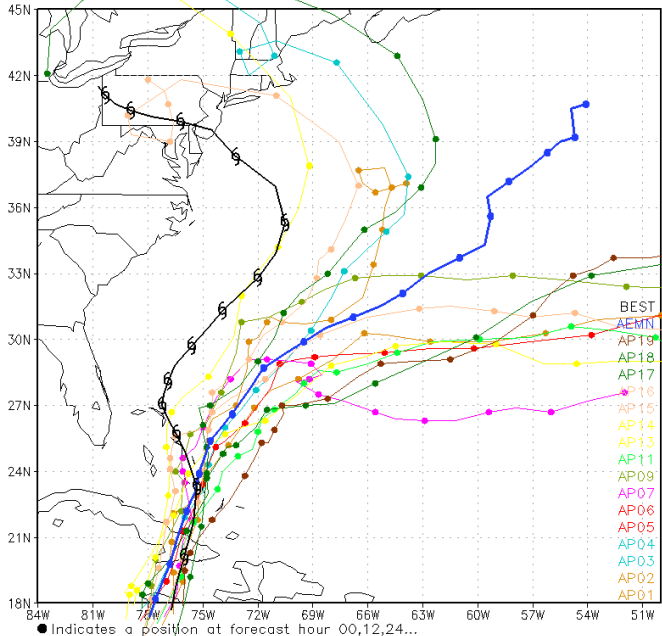
NCEP Ensemble Forecast TC Track Verification 2012102200



Bimodality?

Para:  
T574L64  
(33km)

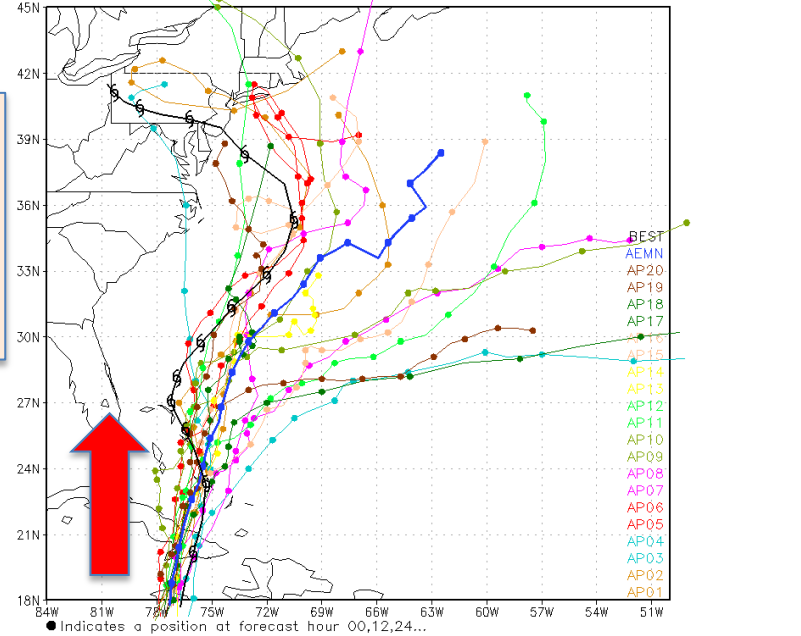
NCEP Ensemble Forecast TC Track Verification 2012102206



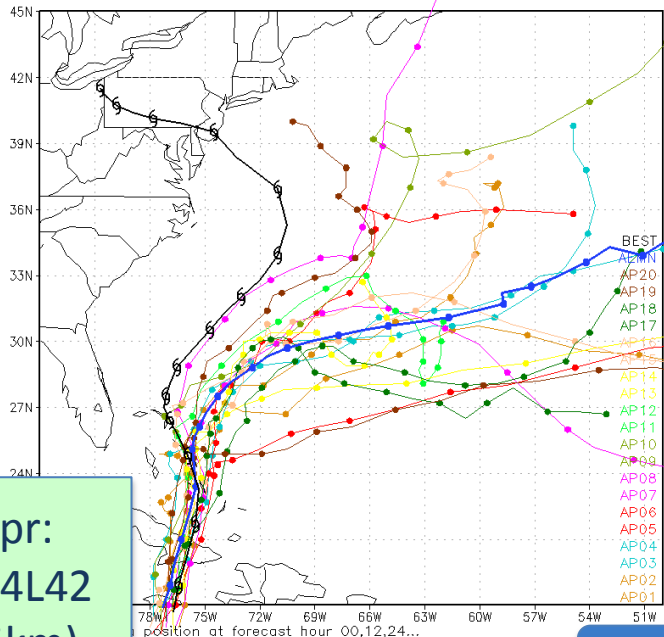
Red arrow  
means good  
forecast

06UTC

NCEP Ensemble Forecast TC Track Verification 2012102206



NCEP Ensemble Forecast TC Track Verification 2012102212



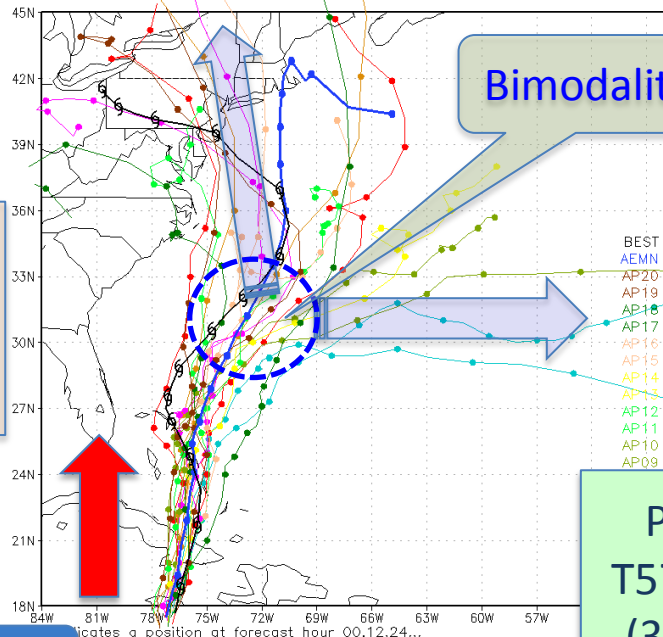
12UTC

Thick blue:  
ensemble  
mean

Opr:  
T254L42  
(55km)

20121022 (7.5 days)

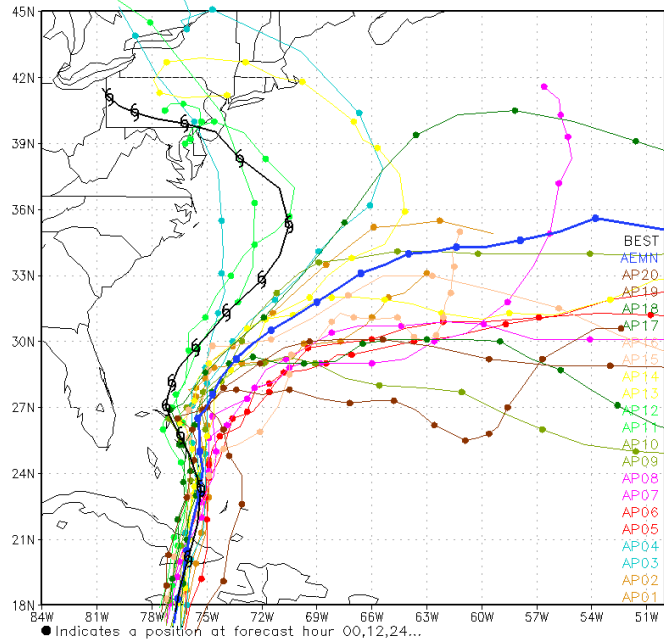
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Bimodality?

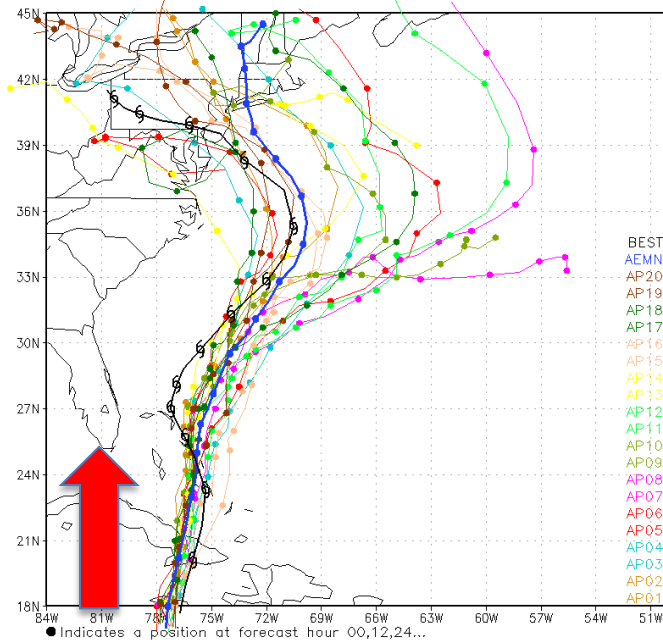
Para:  
T574L64  
(33km)

NCEP Ensemble Forecast TC Track Verification 2012102218



18UTC

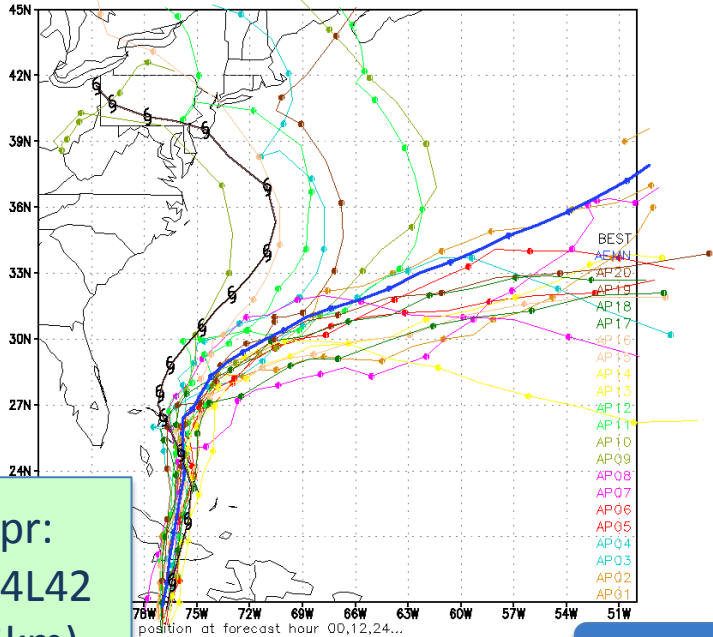
NCEP Ensemble Forecast TC Track Verification 2012102218



● Indicates a position at forecast hour 00,12,24...

● Indicates a position at forecast hour 00,12,24...

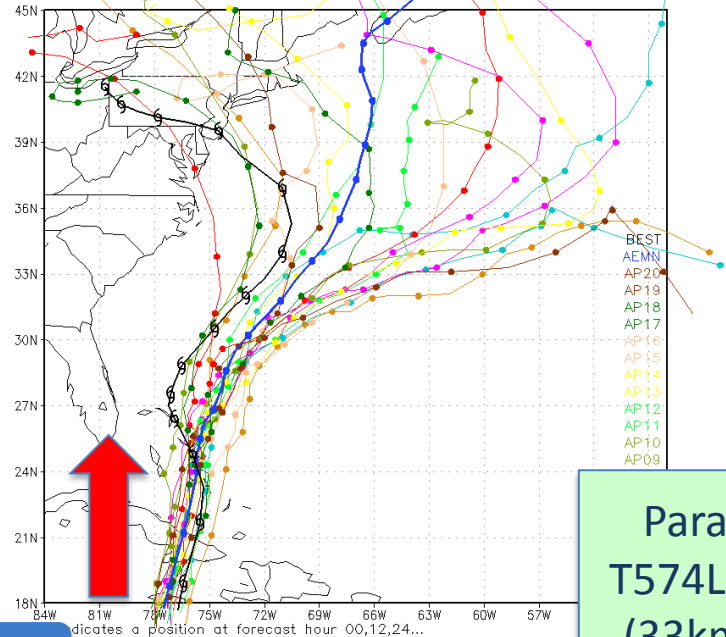
NCEP Ensemble Forecast TC Track Verification 2012102300



00UTC

Opr:  
T254L42  
(55km)

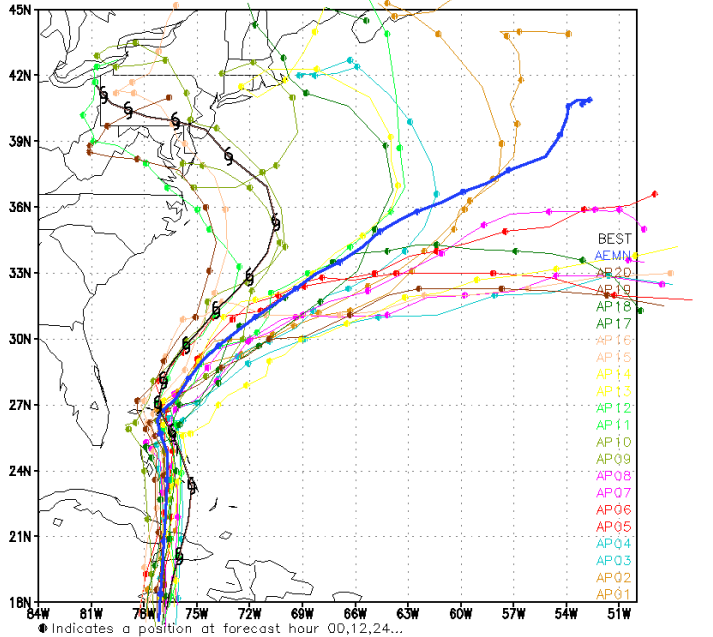
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Para:  
T574L64  
(33km)

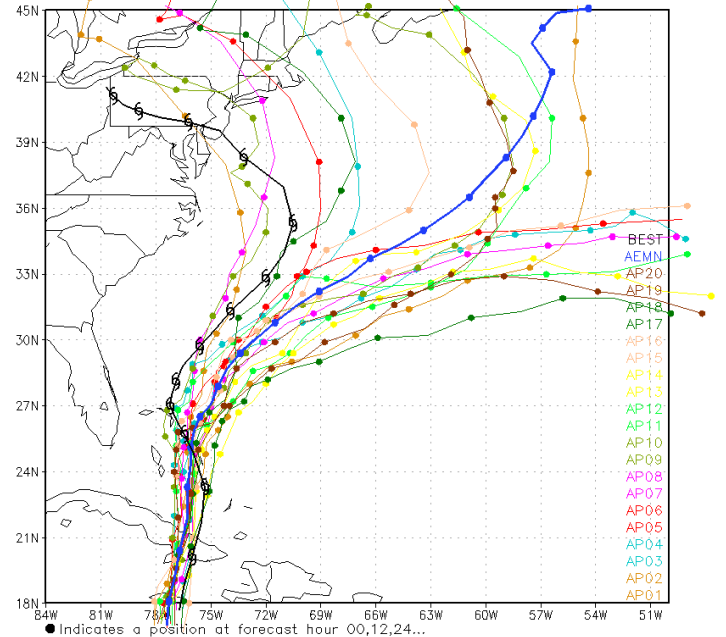
20121023 (7 days)

NCEP Ensemble Forecast TC Track Verification 2012102306



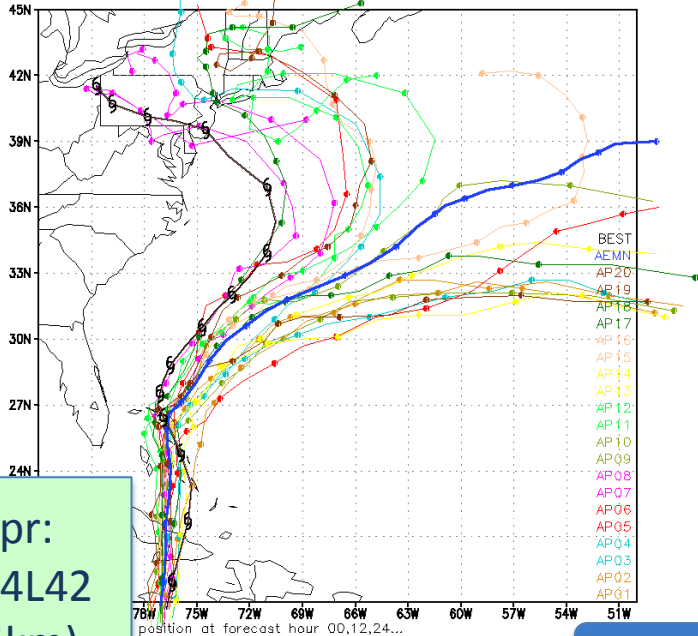
06UTC

NCEP Ensemble Forecast TC Track Verification 2012102306





NCEP Ensemble Forecast TC Track Verification 2012102312

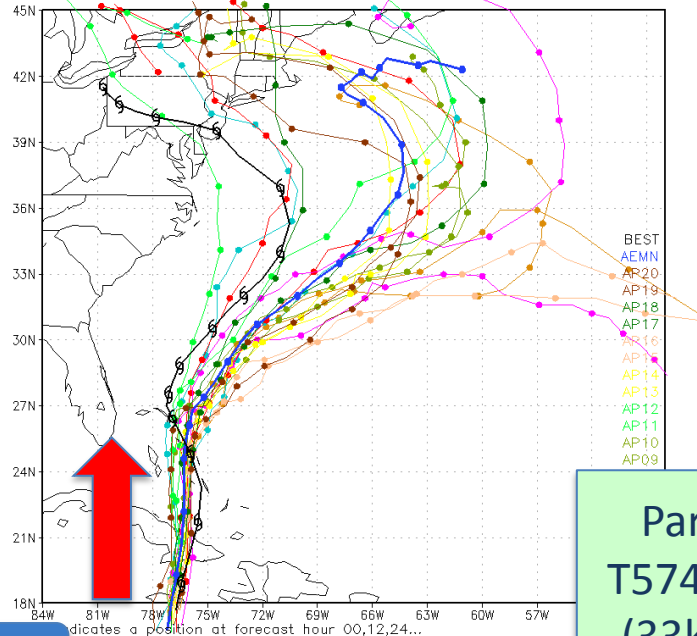


12UTC

Opr:  
T254L42  
(55km)

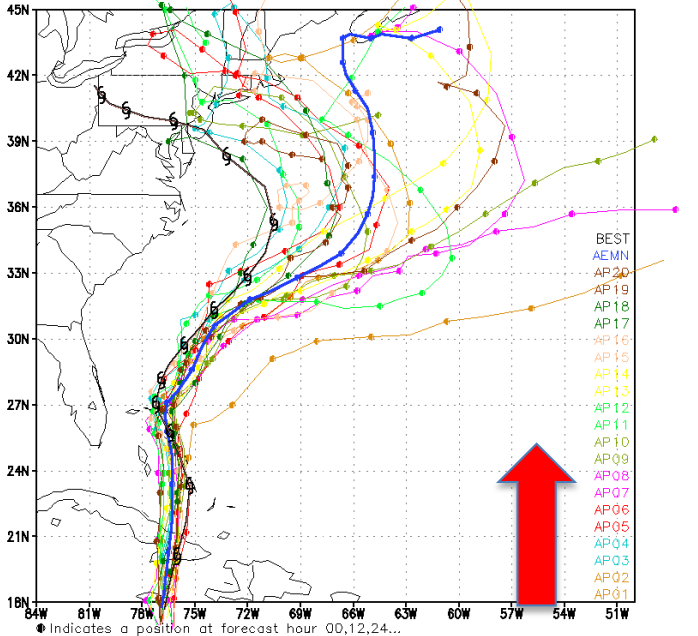
20121023 (6.5 days)

NCEP Ensemble Forecast TC Track Verification 2012102312



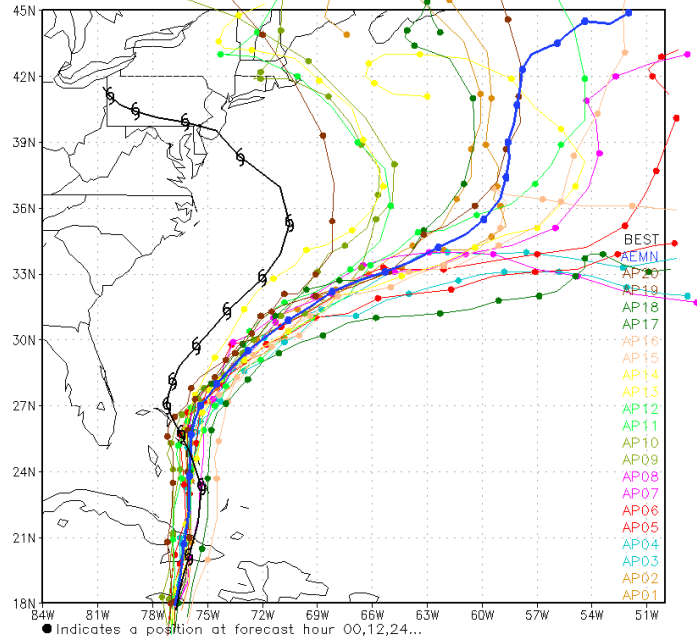
Para:  
T574L64  
(33km)

NCEP Ensemble Forecast TC Track Verification 2012102318

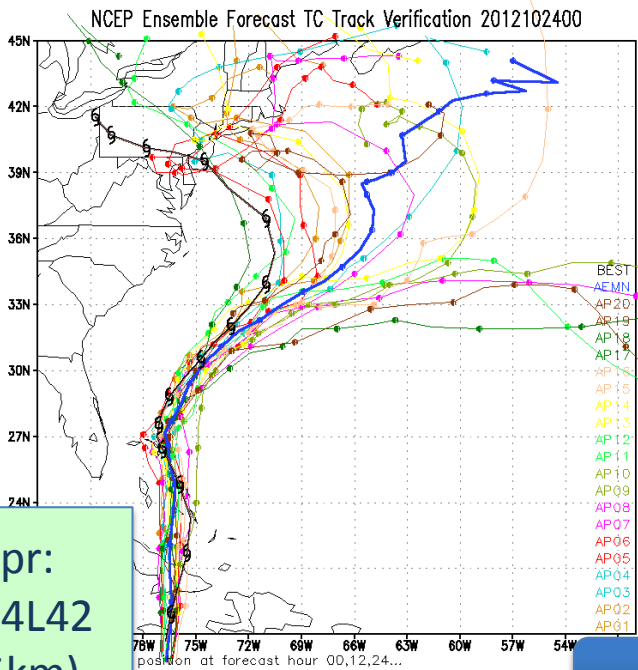


18UTC

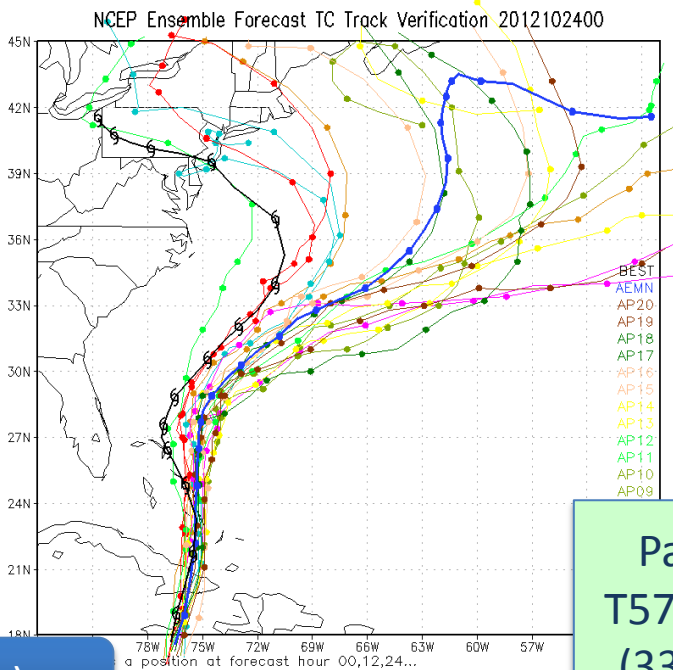
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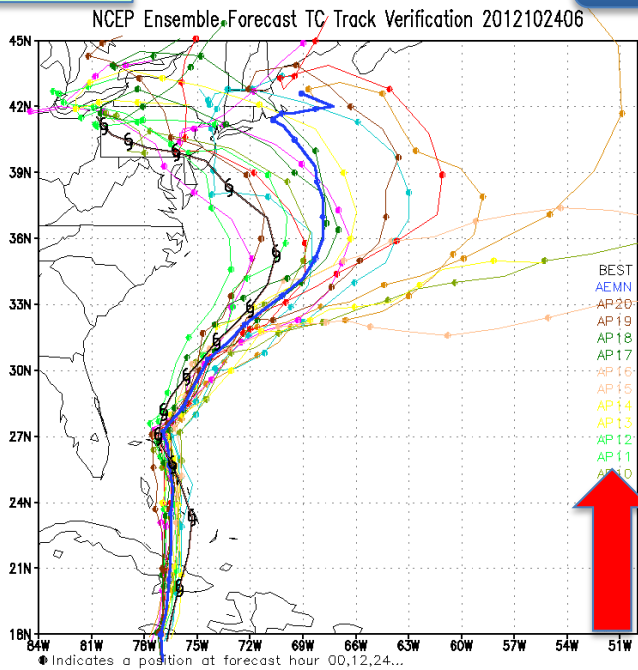
00UTC



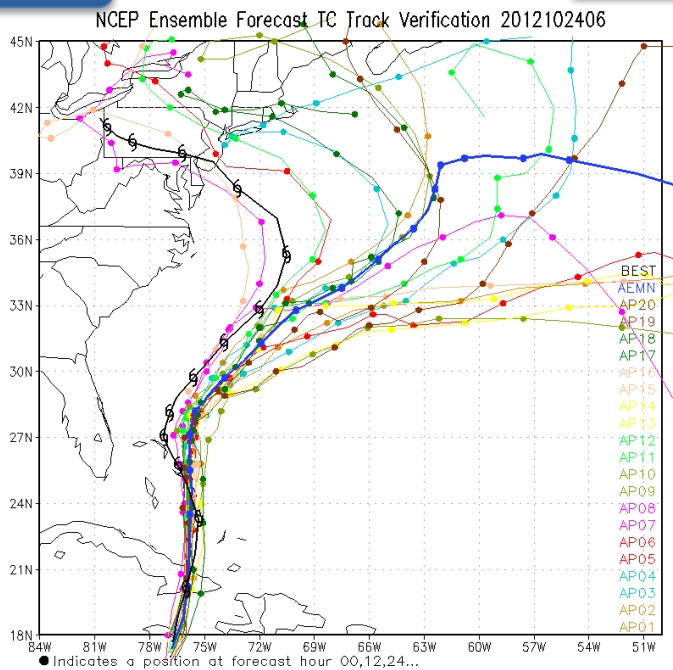
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T574L64  
(33km)

Opr:  
T254L42  
(55km)

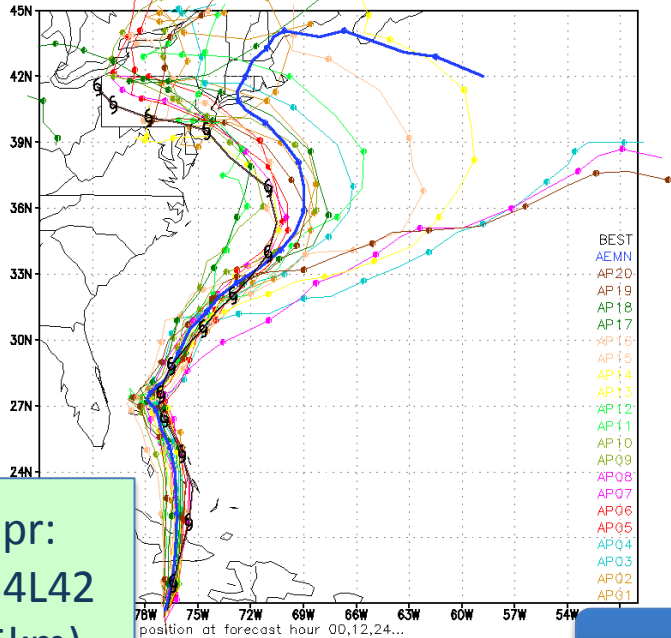
20121024 (6 days)



06UTC



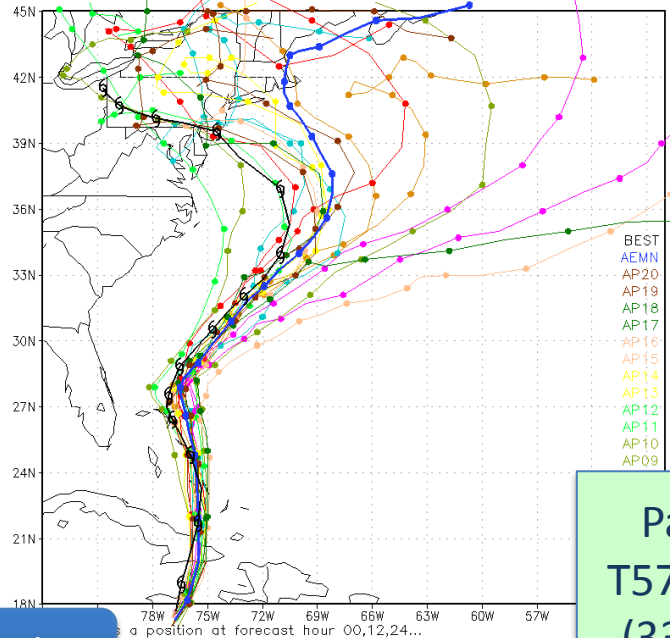
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12UTC

Opr:  
T254L42  
(55km)

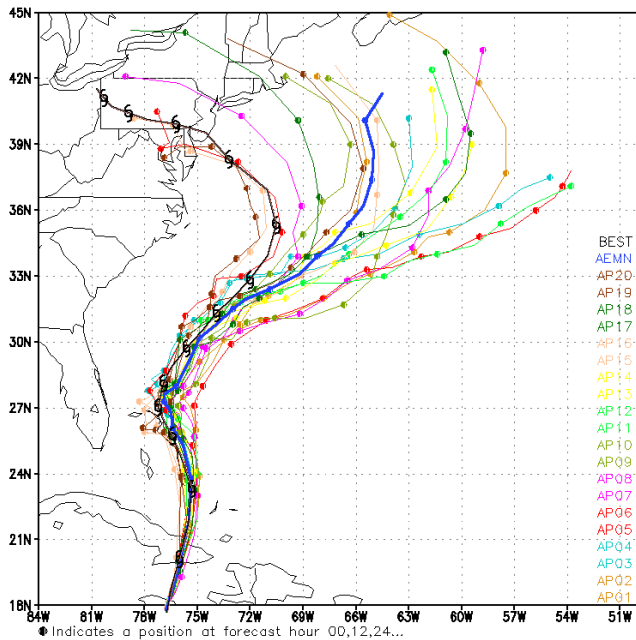
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Para:  
T574L64  
(33km)

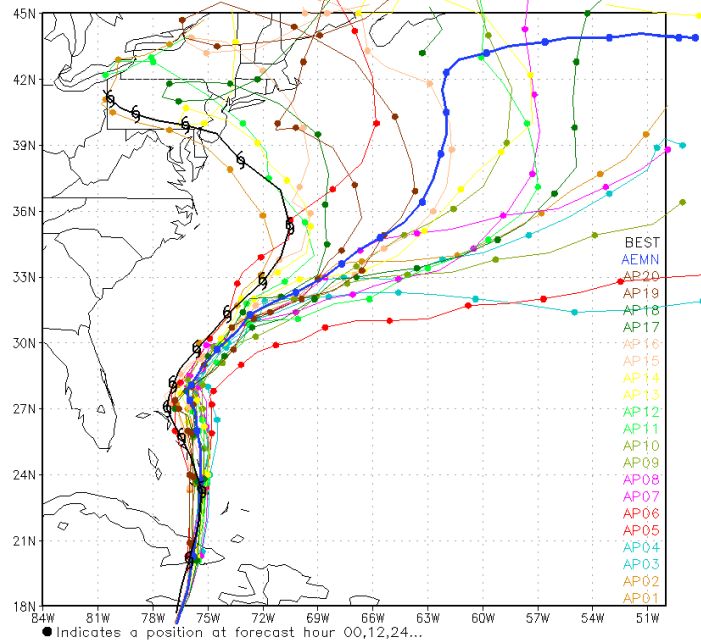
20121024 (5.5 days)

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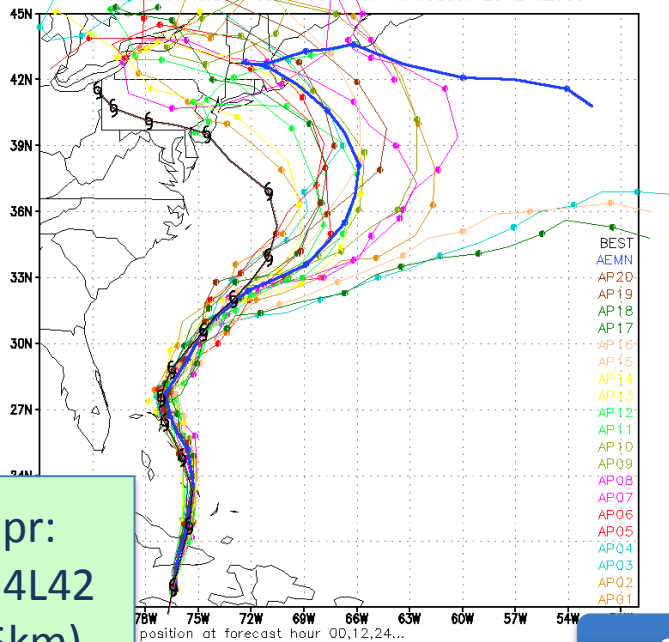


18UTC

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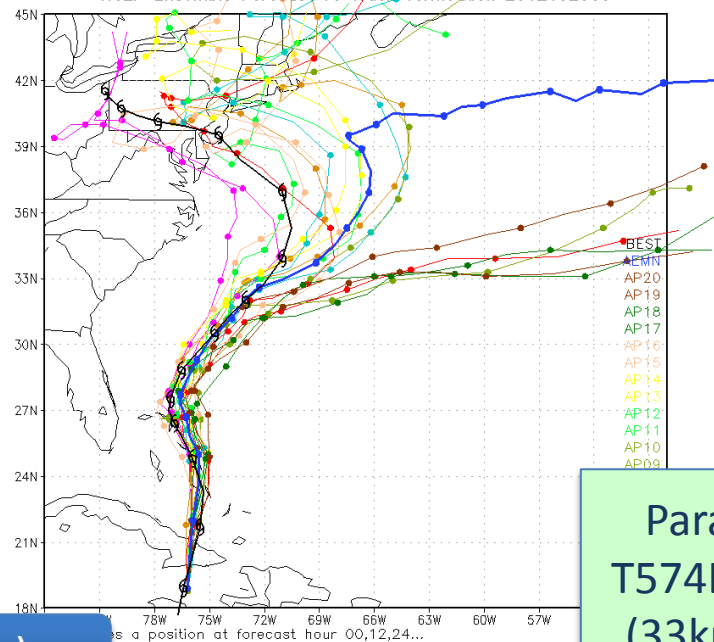


NCEP Ensemble Forecast TC Track Verification 2012102500



00UTC

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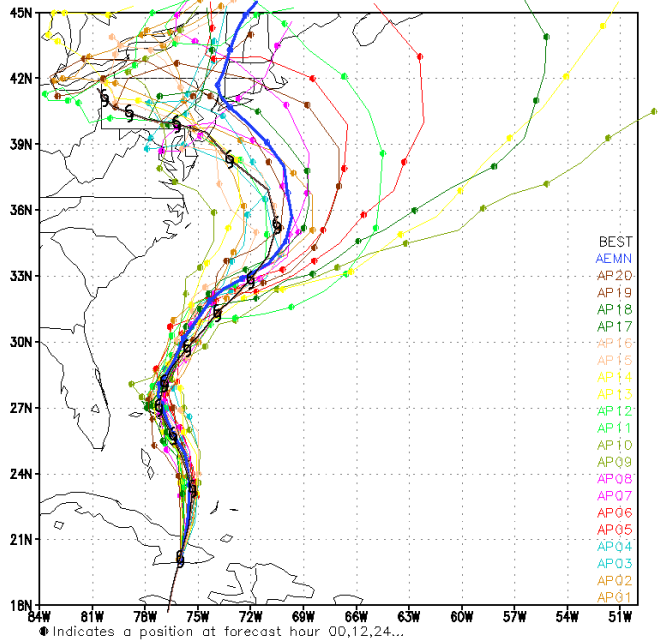


Para:  
T574L64  
(33km)

Opr:  
T254L42  
(55km)

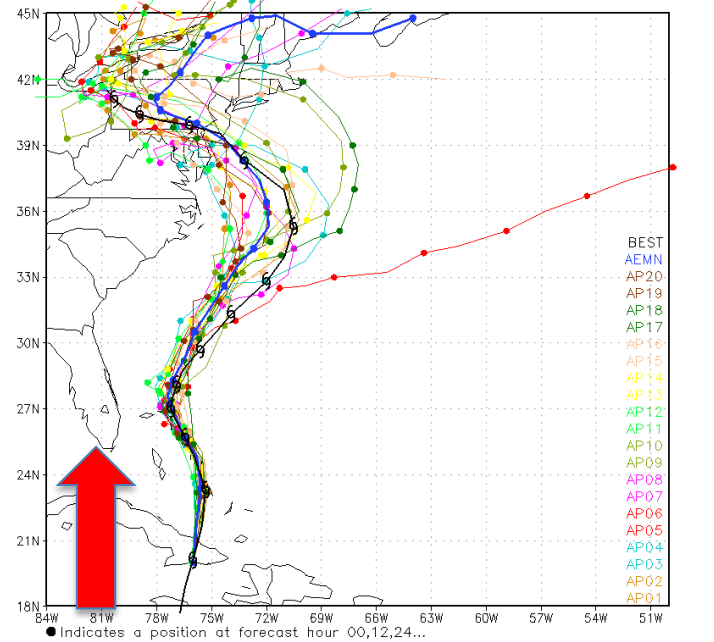
20121025 (5 days)

NCEP Ensemble Forecast TC Track Verification 2012102506

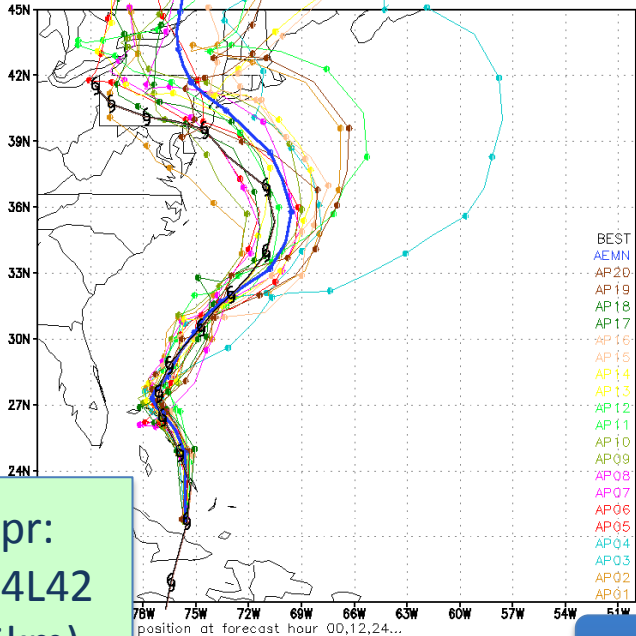


06UTC

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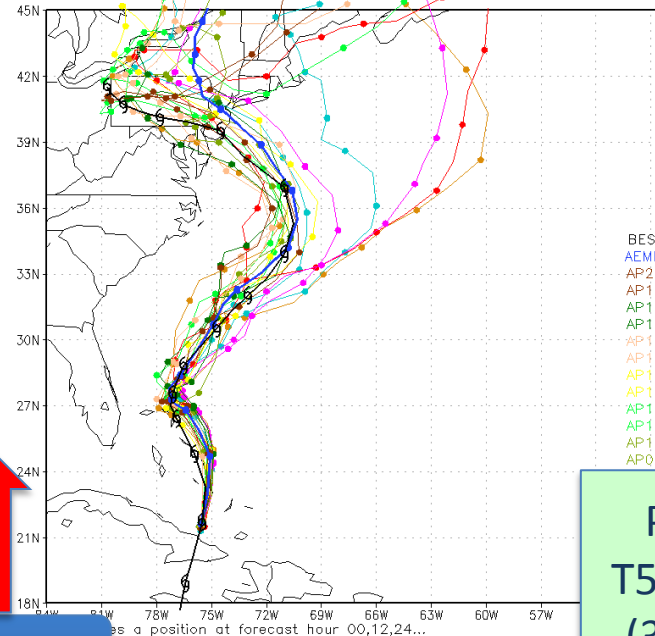


NCEP Ensemble Forecast TC Track Verification 2012102512



12UTC

NCEP Ensemble Forecast TC Track Verification 2012102512

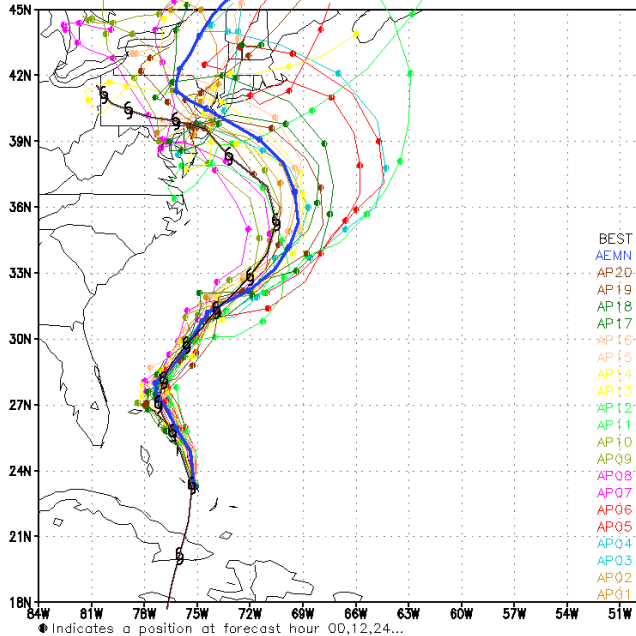


Opr:  
T254L42  
(55km)

Para:  
T574L64  
(33km)

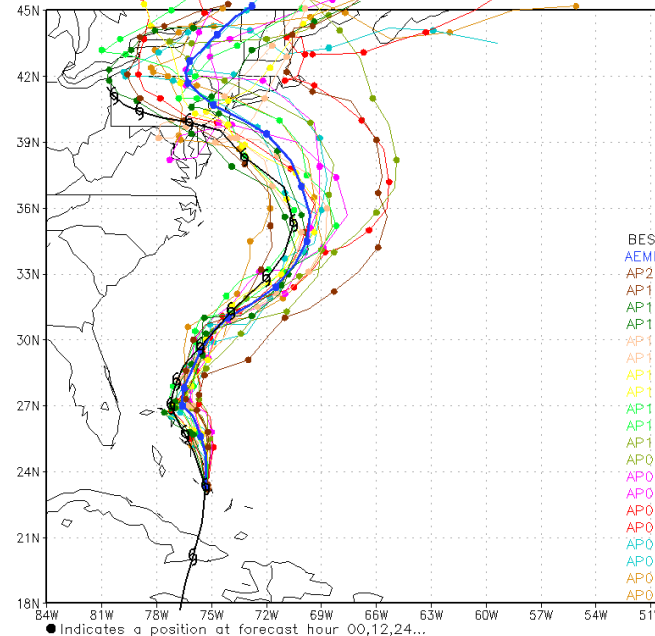
20121025 (5 days)

NCEP Ensemble Forecast TC Track Verification 2012102518

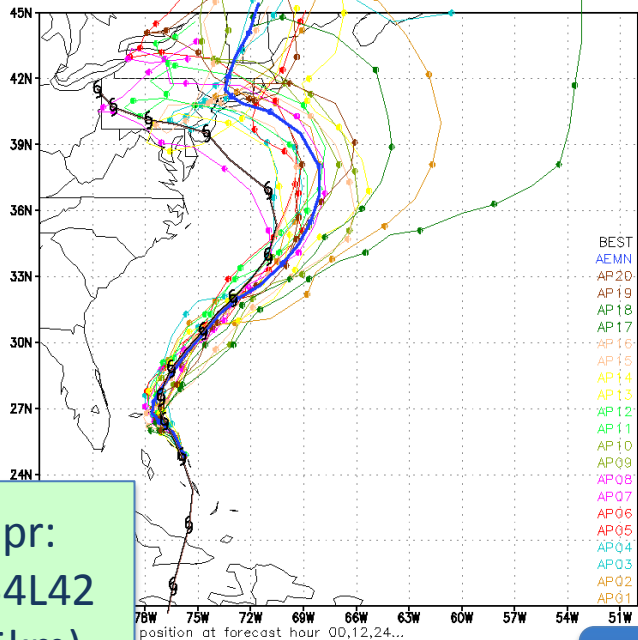


18UTC

NCEP Ensemble Forecast TC Track Verification 2012102518

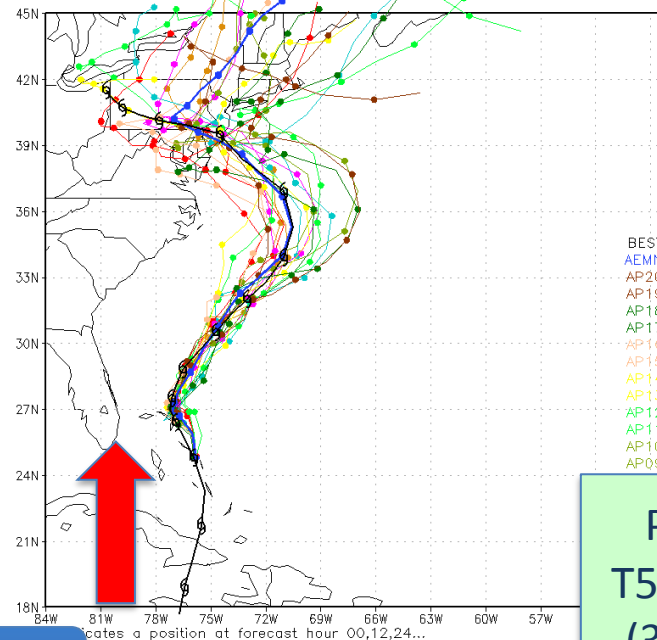


NCEP Ensemble Forecast TC Track Verification 2012102600



00UTC

NCEP Ensemble Forecast TC Track Verification 2012102600

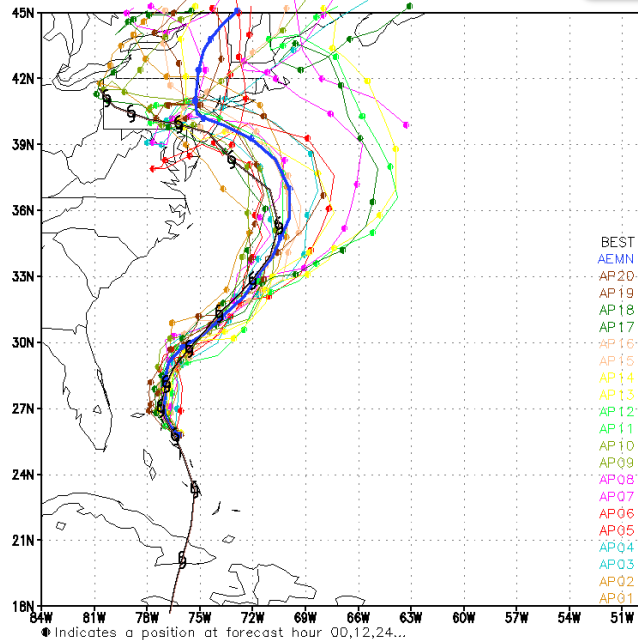


Para:  
T574L64  
(33km)

Opr:  
T254L42  
(55km)

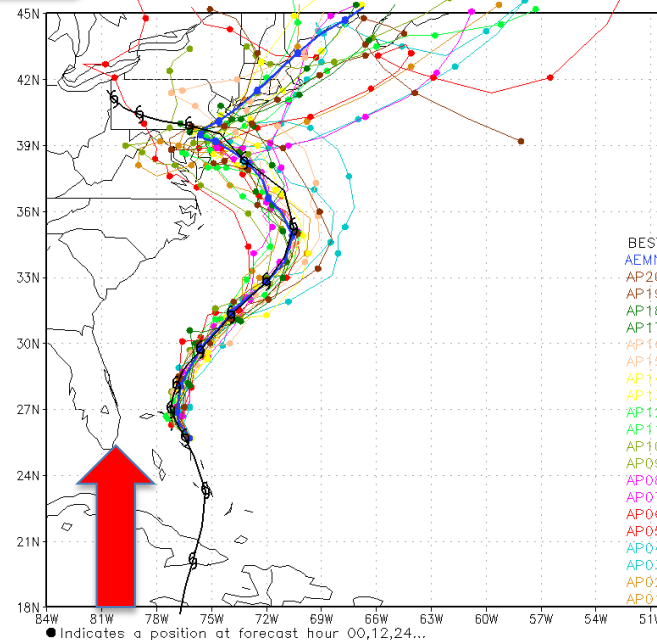
20121026 (4 days)

NCEP Ensemble Forecast TC Track Verification 2012102606



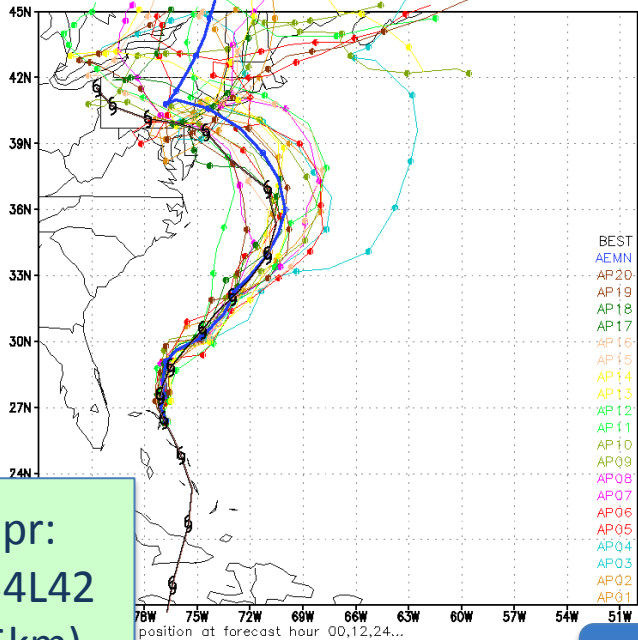
06UTC

NCEP Ensemble Forecast TC Track Verification 2012102606





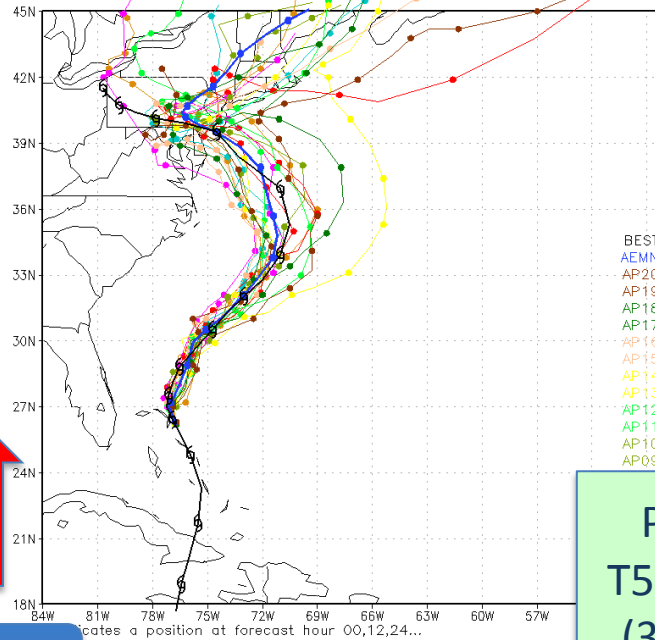
NCEP Ensemble Forecast TC Track Verification 2012102612



12UTC

Opr:  
T254L42  
(55km)

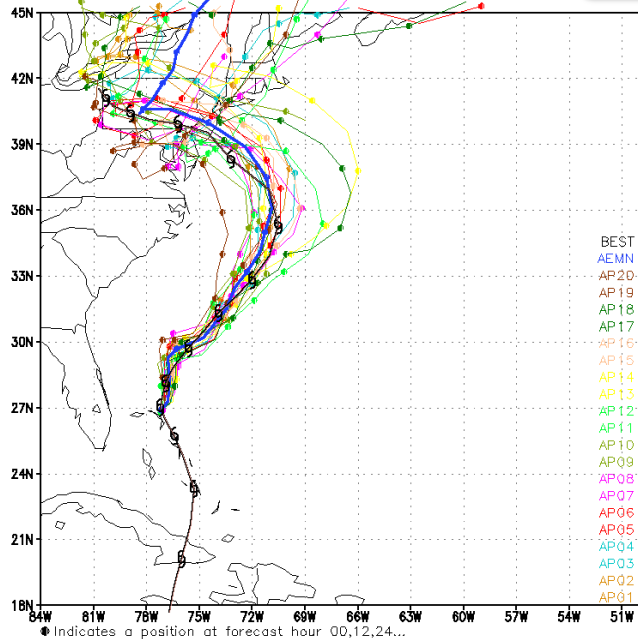
NCEP Ensemble Forecast TC Track Verification 2012102612



Para:  
T574L64  
(33km)

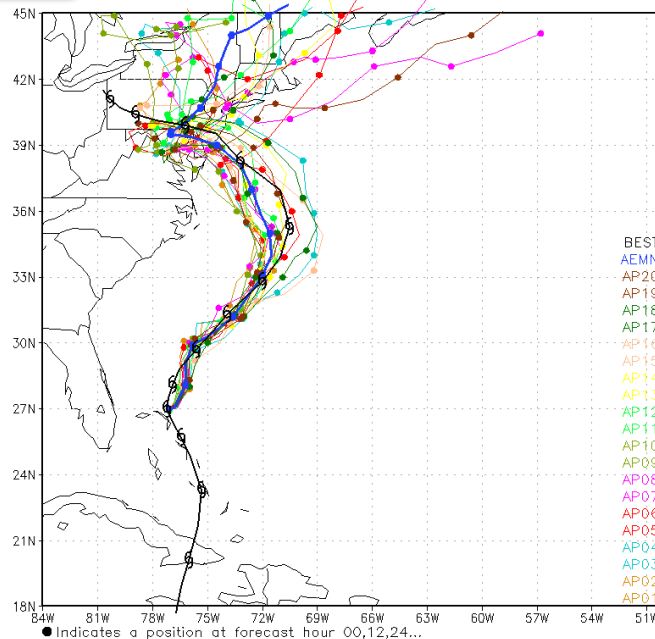
20121026 (3.5 days)

NCEP Ensemble Forecast TC Track Verification 2012102616



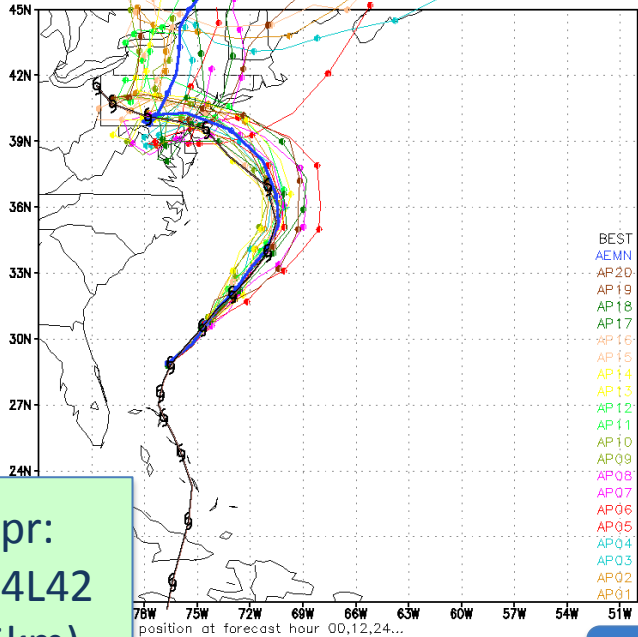
18UTC

NCEP Ensemble Forecast TC Track Verification 2012102618





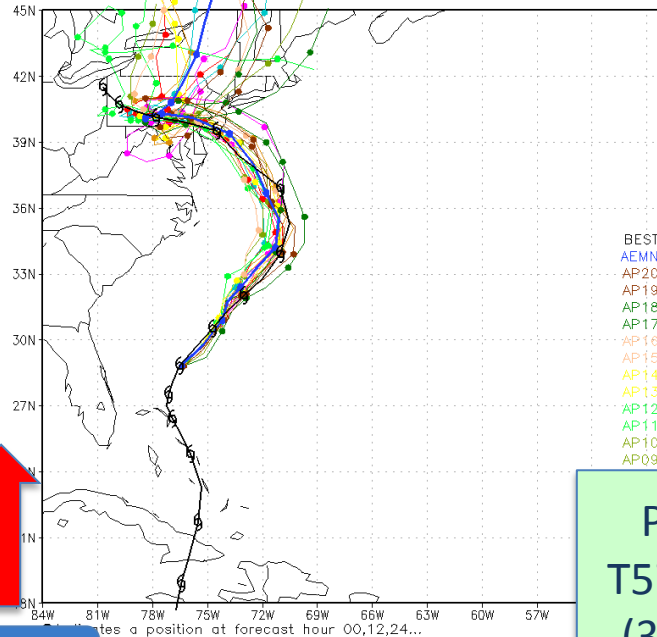
NCEP Ensemble Forecast TC Track Verification 2012102712



12UTC

Opr:  
T254L42  
(55km)

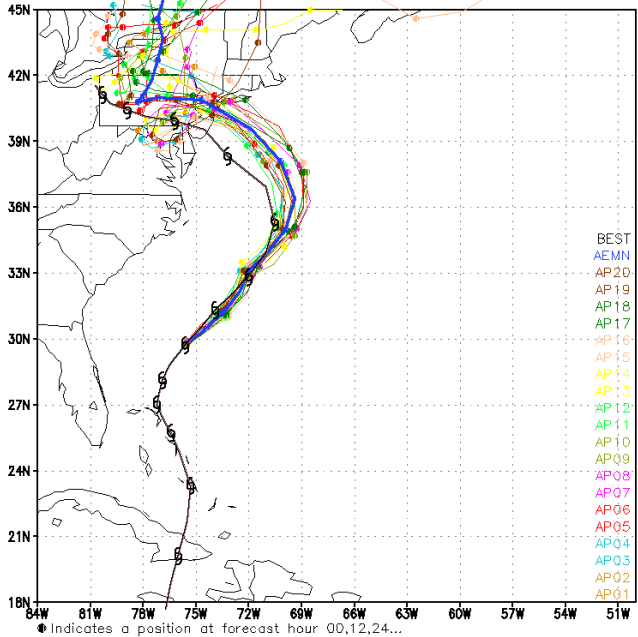
NCEP Ensemble Forecast TC Track Verification 2012102712



Para:  
T574L64  
(33km)

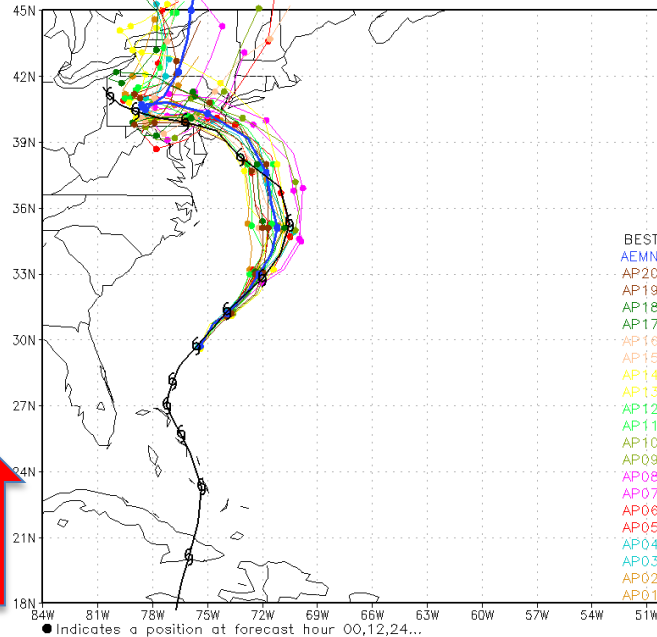
20121027 (2.5 days)

NCEP Ensemble Forecast TC Track Verification 2012102718



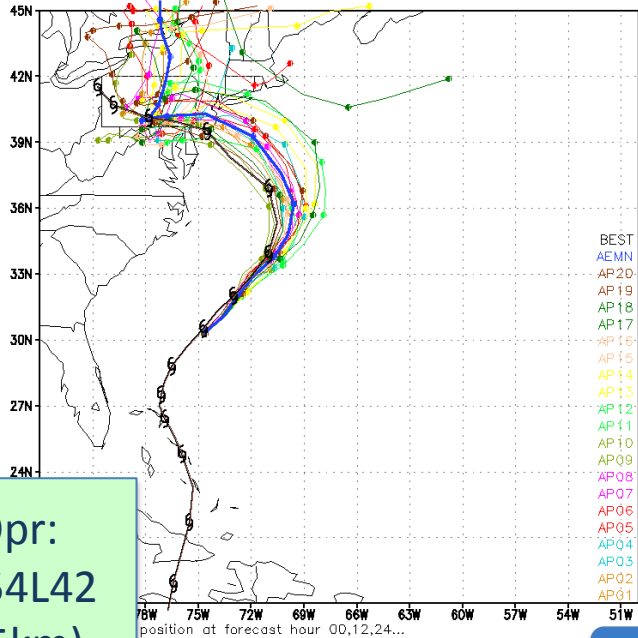
18UTC

NCEP Ensemble Forecast TC Track Verification 2012102718



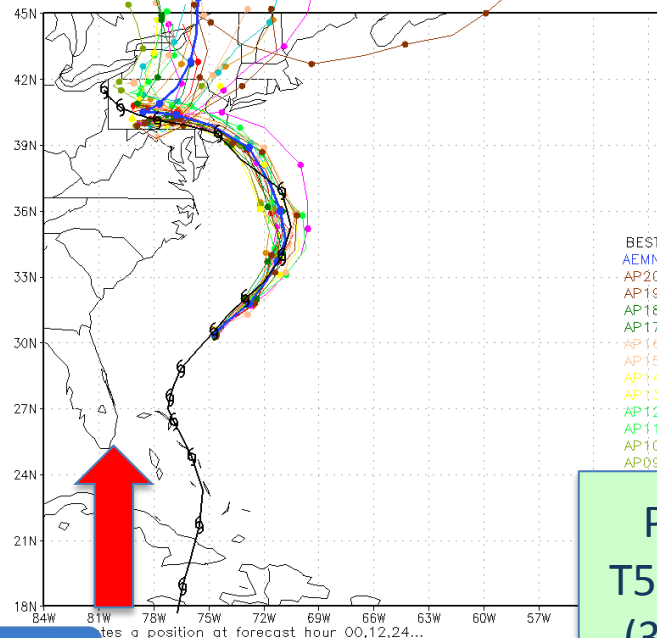


NCEP Ensemble Forecast TC Track Verification 2012102800



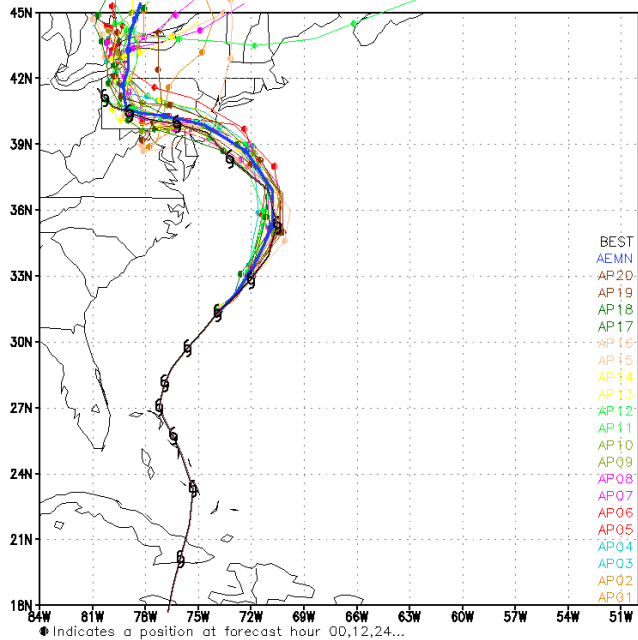
00UTC

NCEP Ensemble Forecast TC Track Verification 2012102800



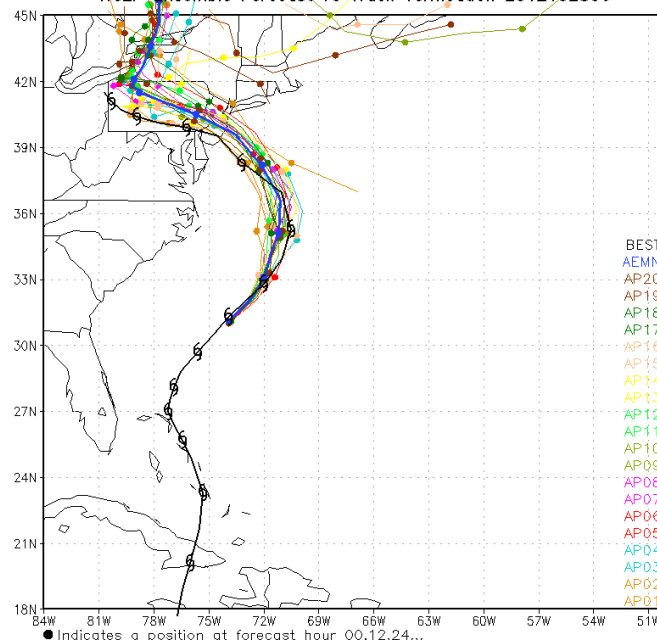
20121028 (2 days)

NCEP Ensemble Forecast TC Track Verification 2012102806

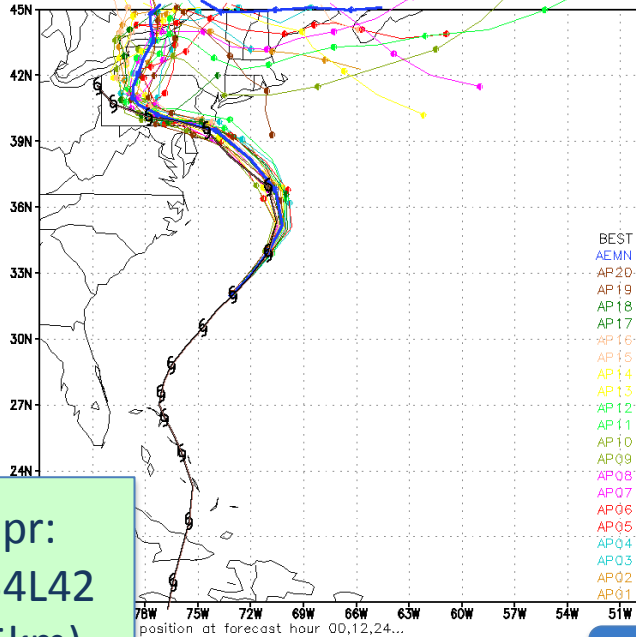


06UTC

NCEP Ensemble Forecast TC Track Verification 2012102806



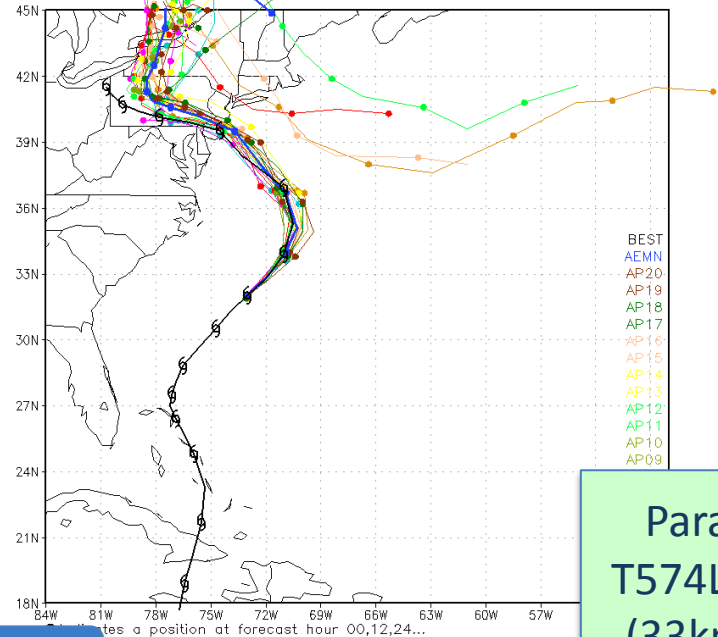
NCEP Ensemble Forecast TC Track Verification 2012102812



12UTC

Opr:  
T254L42  
(55km)

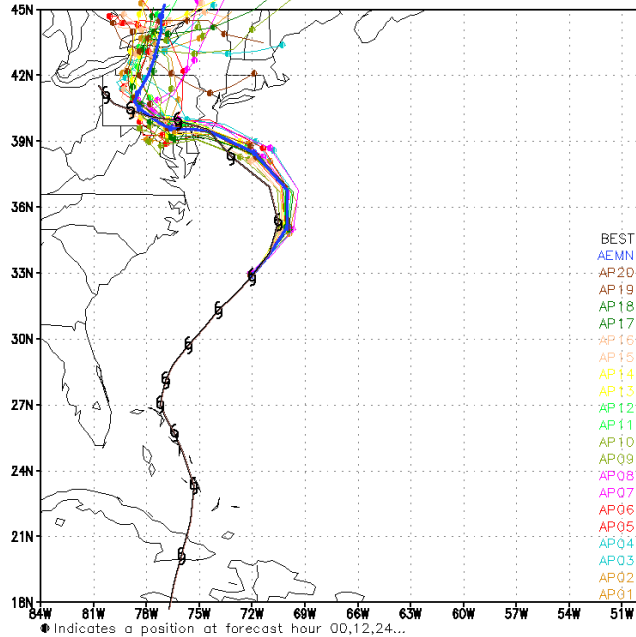
NCEP Ensemble Forecast TC Track Verification 2012102812



Para:  
T574L64  
(33km)

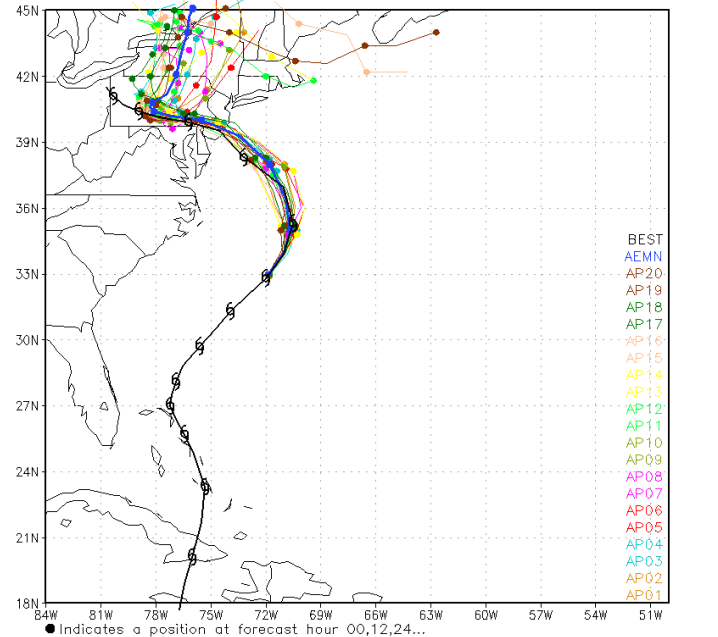
20121028 (2 days)

NCEP Ensemble Forecast TC Track Verification 2012102818

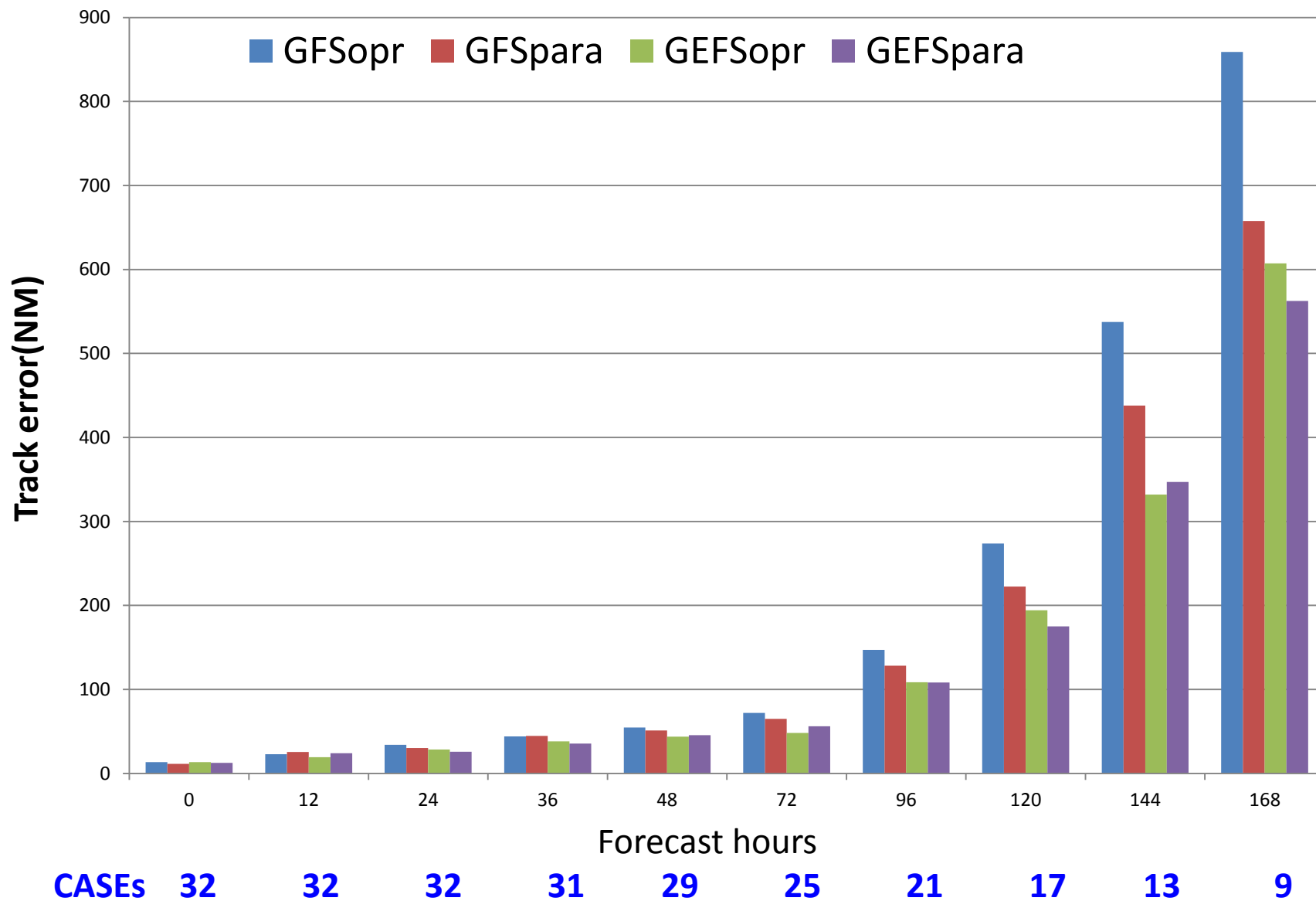


18UTC

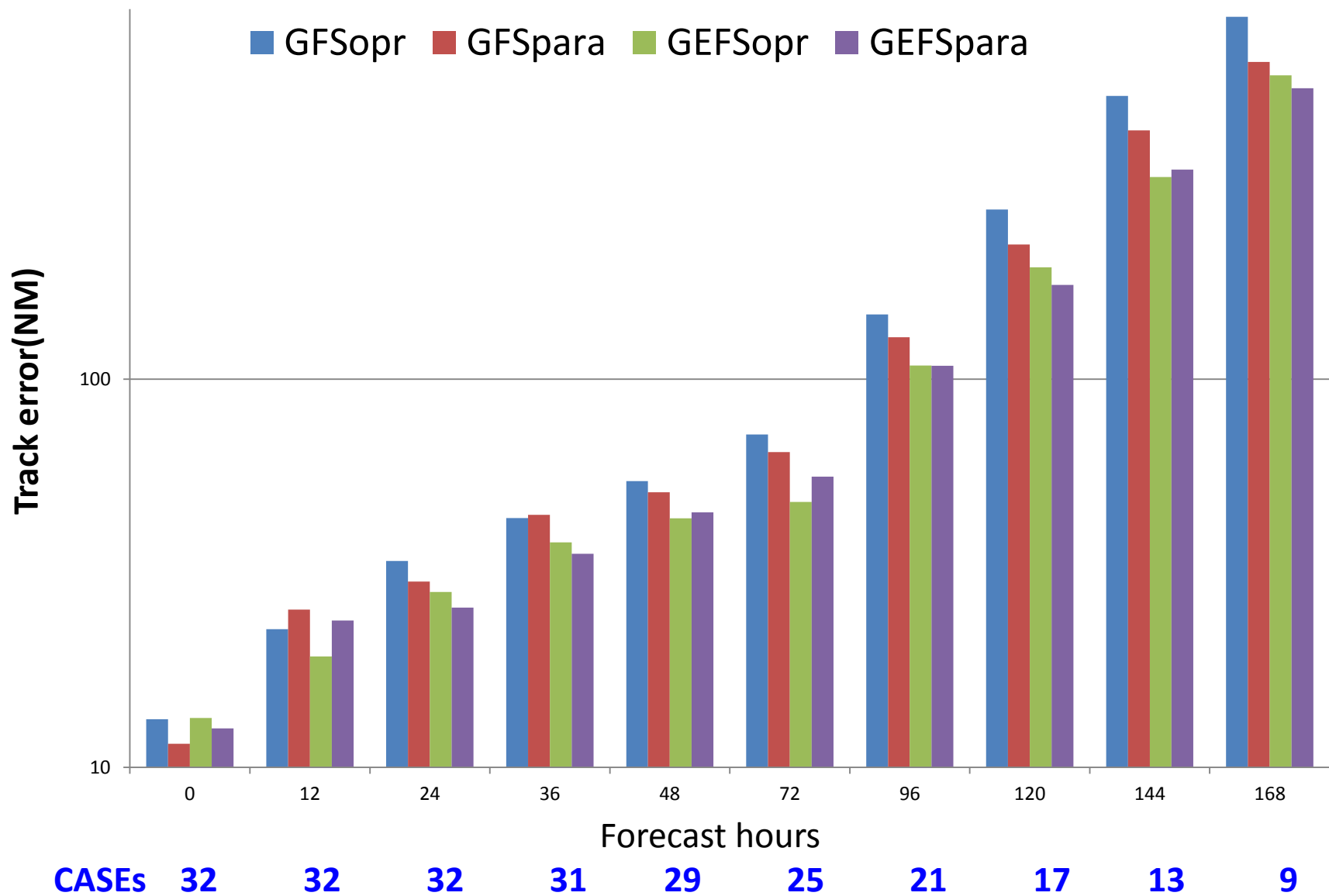
NCEP Ensemble Forecast TC Track Verification 2012102818



# 2012 Sandy Track Verifications (7-days)



# 2012 Sandy Track Verifications (7-days)



# Short Summary for Sandy case

- Higher resolution and new model improve the forecast skill for most lead-time, especially for longer lead-time (day 7-8).
- Higher resolution and new model have excellent predictability around 8-days
- Bimodality of forecast tracks is clearly for early lead-time – around 30-32N
- Very good forecasts for short lead-time (less than 4-5 days) of both production and parallel
- Problem/concern:
  - Forecast inconsistency from cycle to cycle since initial condition changes, especially for Oct. 23 - 24

# Preliminary results for period of May 22<sup>nd</sup> – October 31<sup>st</sup> 2013

## Extended Summer Season

General stats: [http://www.emc.ncep.noaa.gov/gc\\_wmb/xzhou/EnKF\\_prhs13\\_10.HTML](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/>

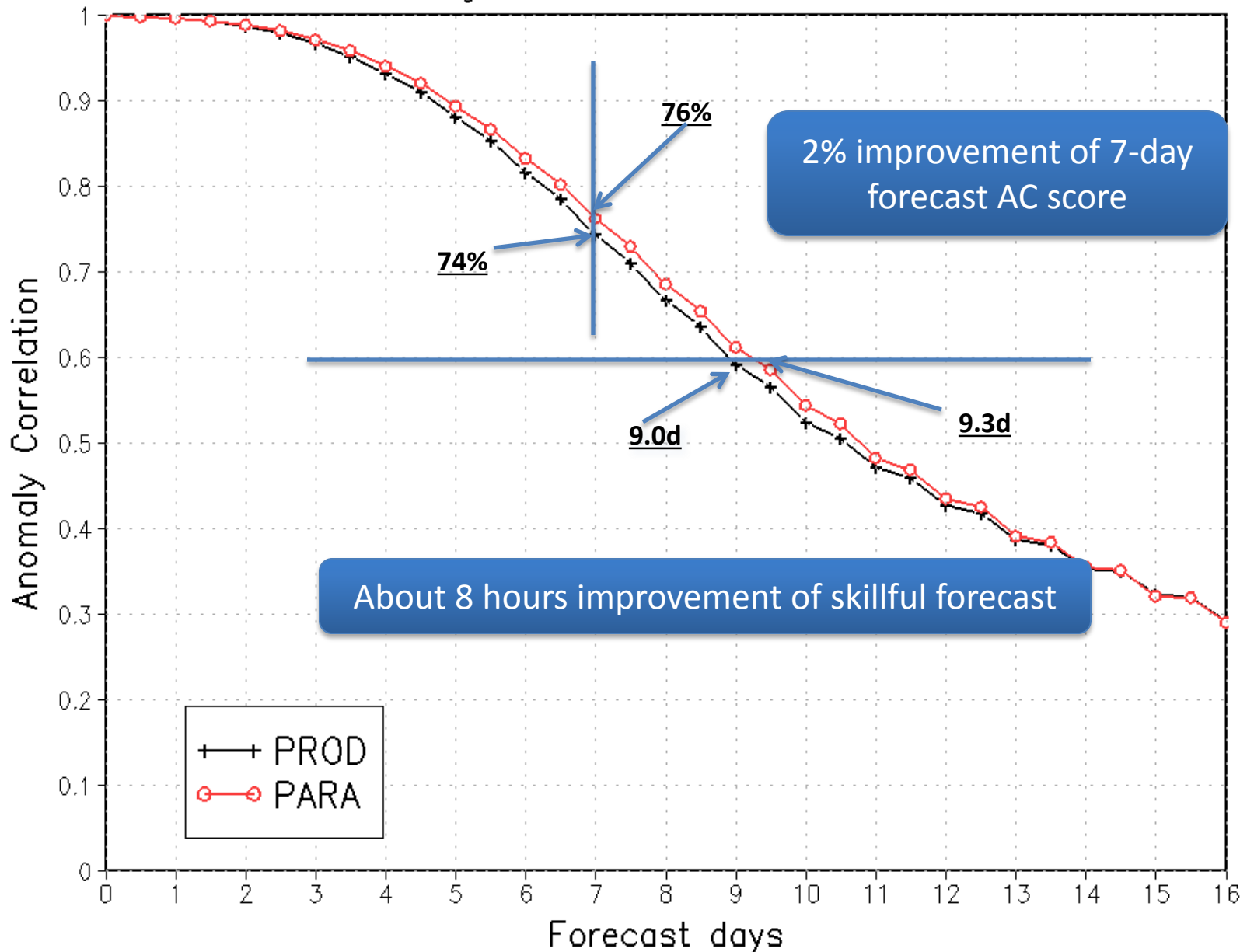
Precipitation:

[http://www.emc.ncep.noaa.gov/gmb/yluo/tmp\\_dir/GEFS\\_PQPFvrfy\\_summer\\_test.html](http://www.emc.ncep.noaa.gov/gmb/yluo/tmp_dir/GEFS_PQPFvrfy_summer_test.html)

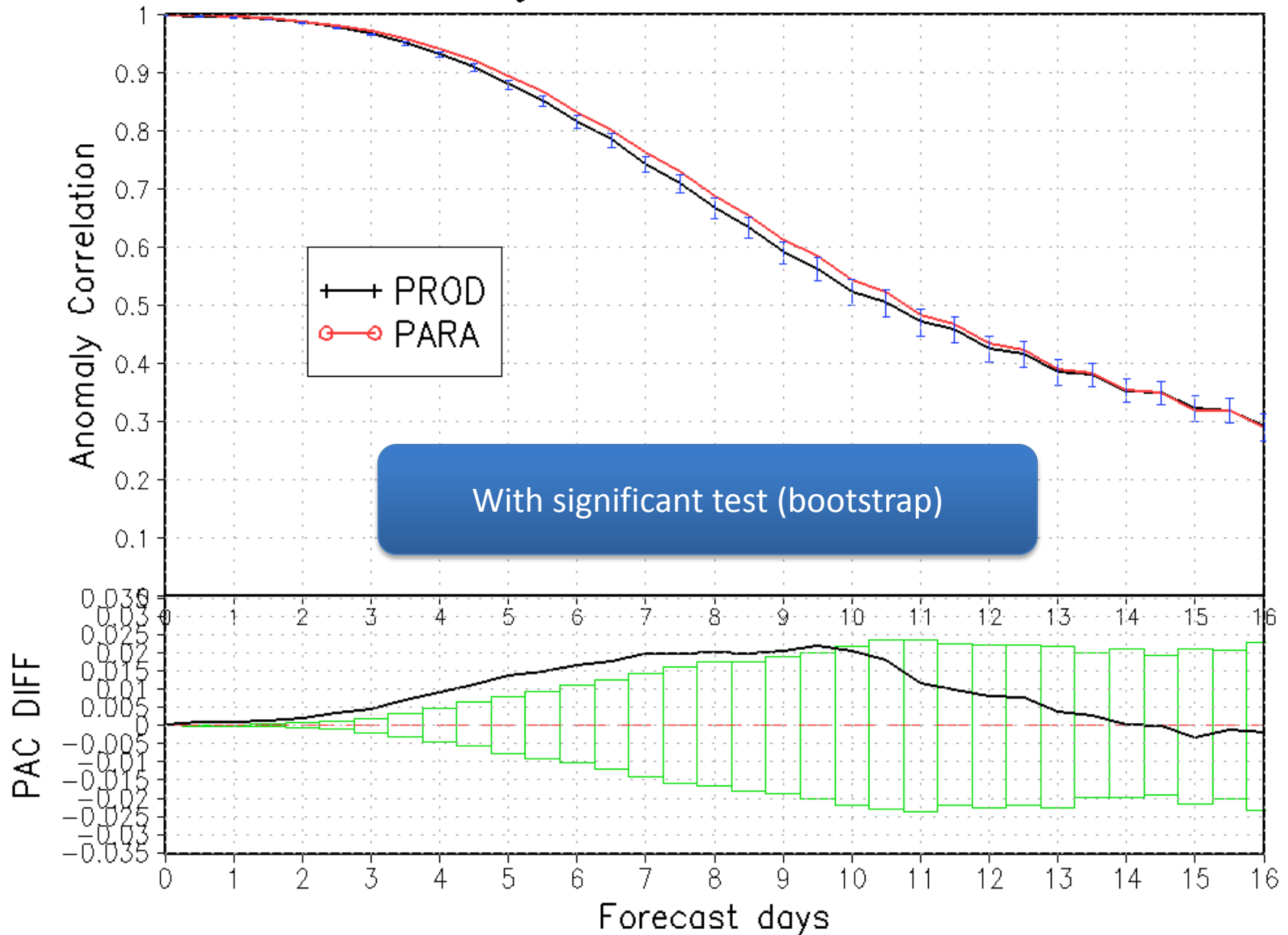
TC tracks (one slide)

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

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

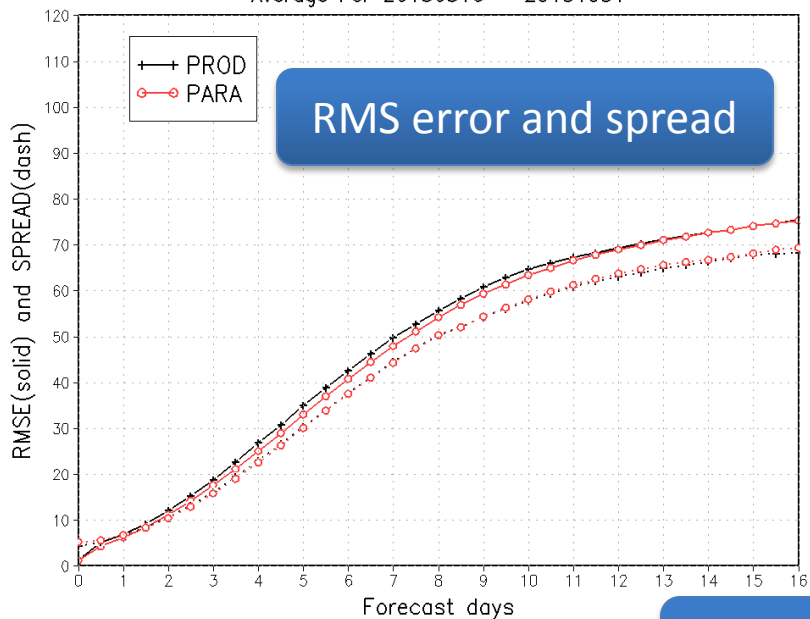


Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20130516 – 20131031

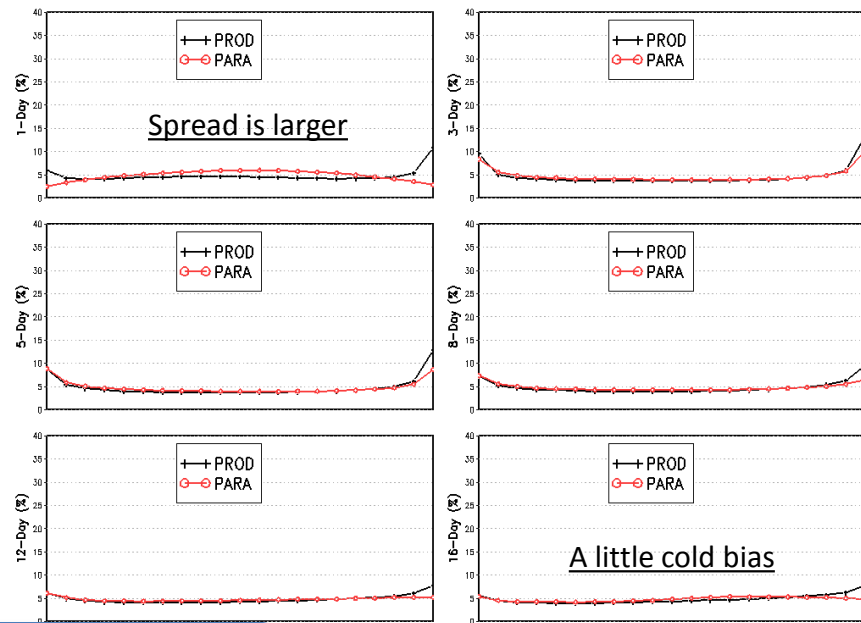




Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031

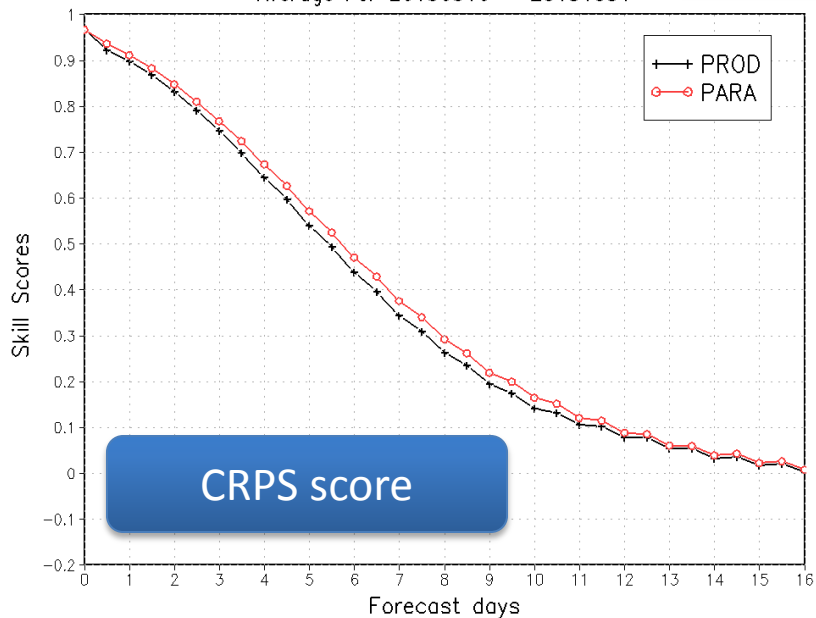


Northern Hemisphere 500hPa Height Histogram Distribution  
Average For 20130516 – 20131031

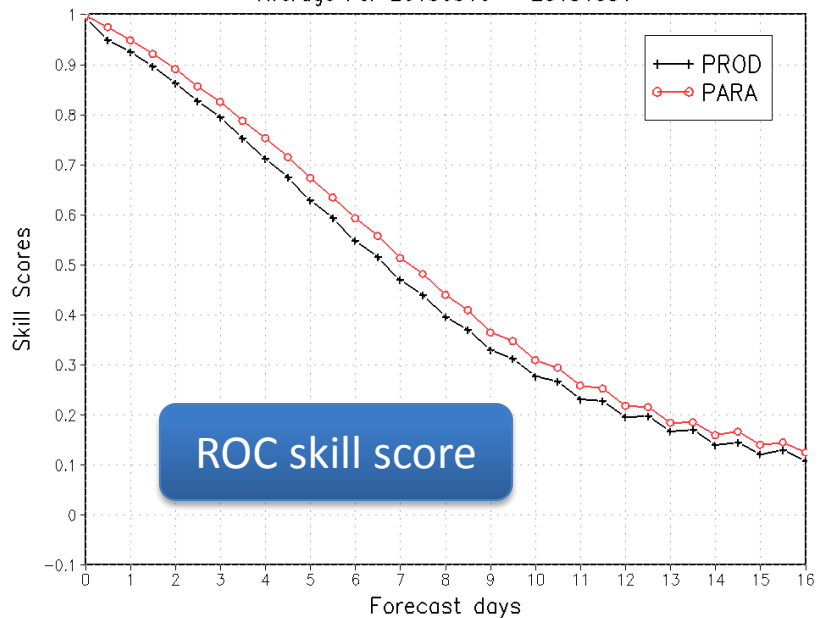


## NH 500hPa height

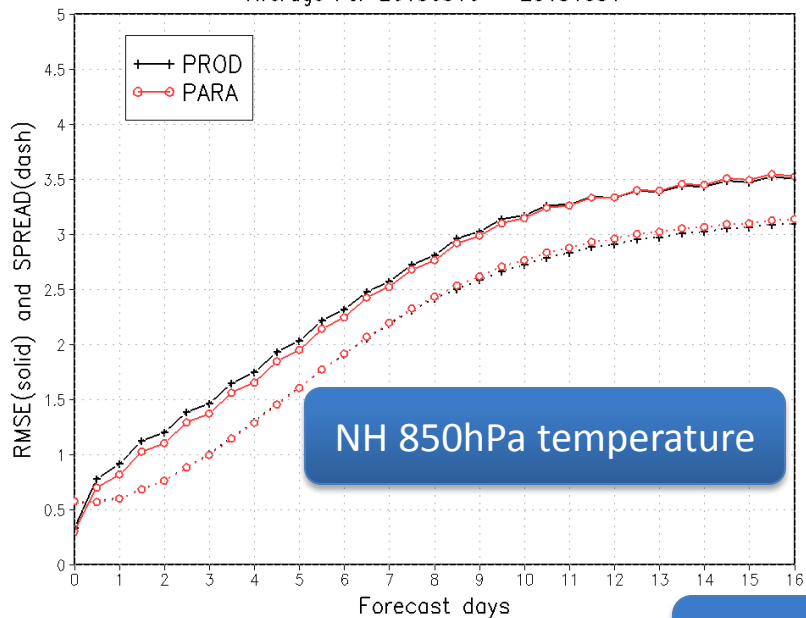
Northern Hemisphere 500hPa Height  
Continuous Ranked Probability Skill Scores  
Average For 20130516 – 20131031



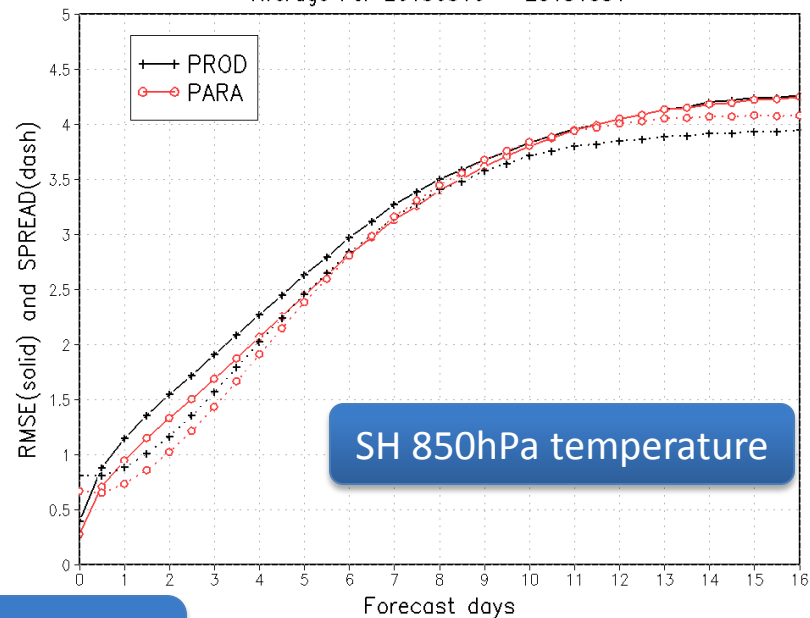
Northern Hemisphere 500hPa Height  
ROC area (0-1)  
Average For 20130516 – 20131031



Northern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031

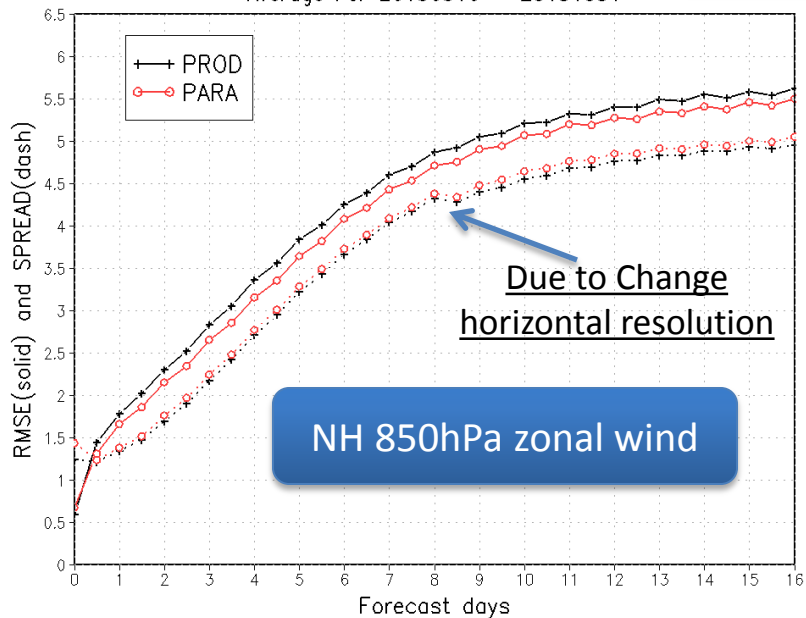


Southern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031

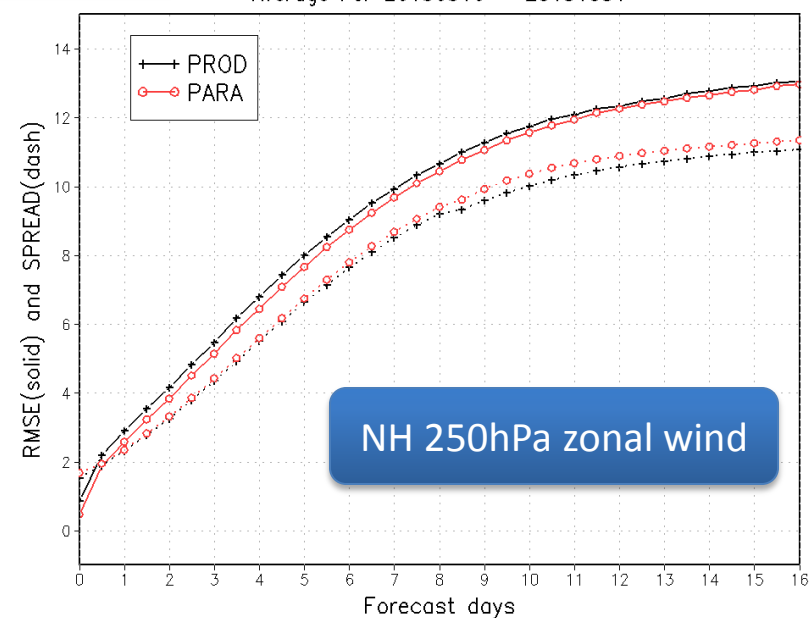


RMS error and spread

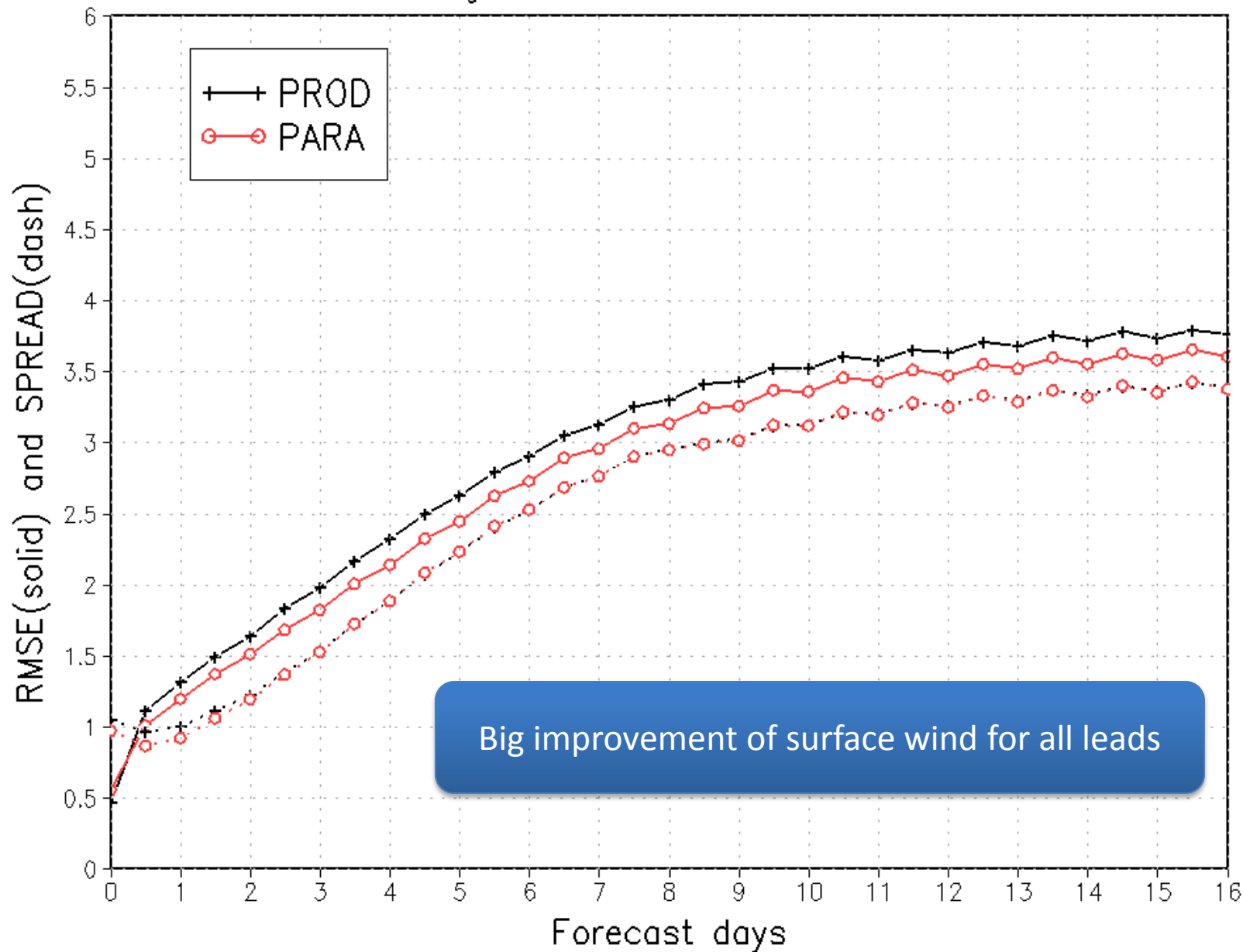
Northern Hemisphere 850hPa U.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031



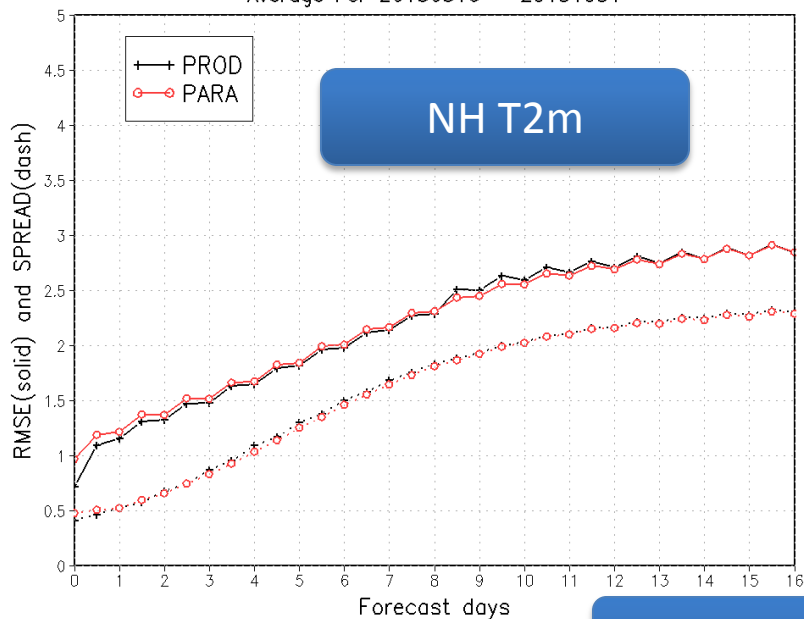
Northern Hemisphere 250hPa U.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031



Northern Hemisphere 10 Meter Wind(U)  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 - 20131031



Northern Hemisphere 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031



# Interesting to review surface temperature

Analysis differences of surface temperature (T2m)

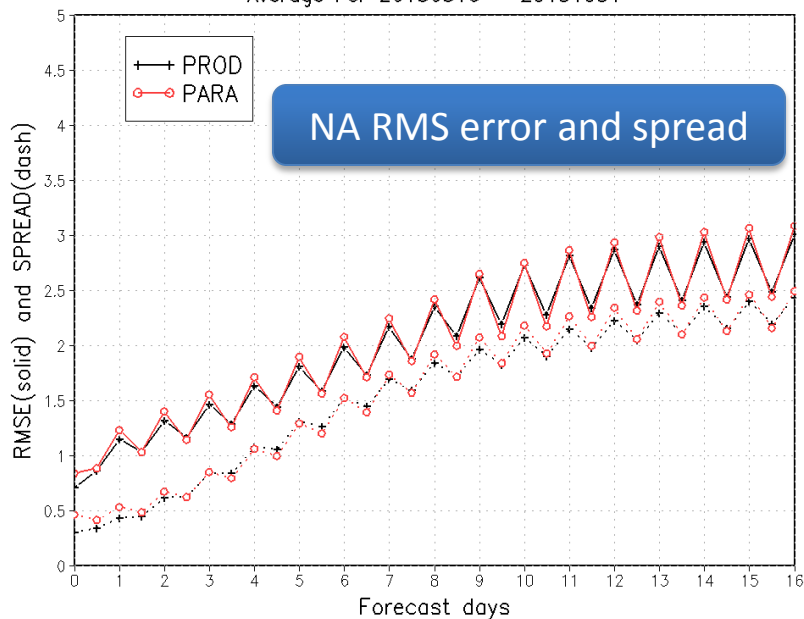
Period: 05/01/2013 – 8/15/13

RMS errors for 107 days (against obs)

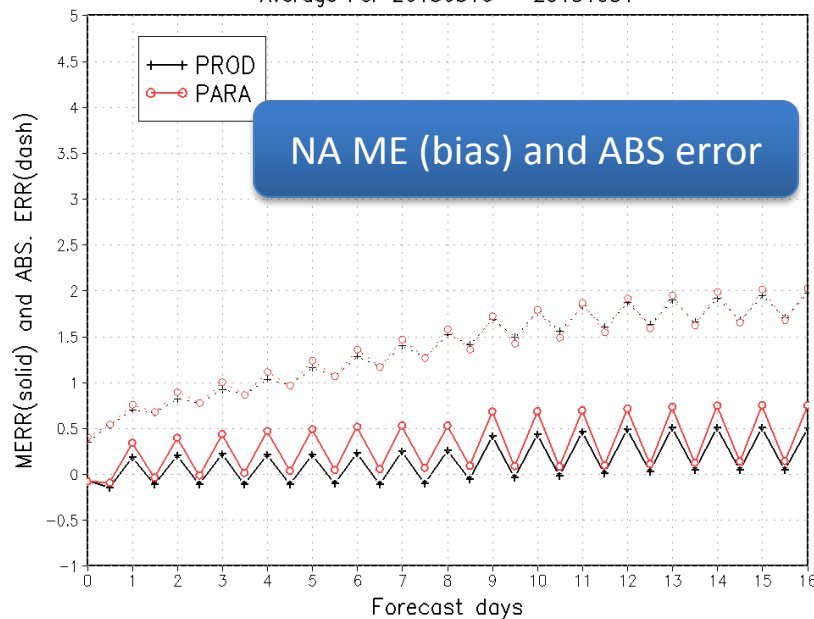
Regions	PROD	PARA
West	3.227	3.383
East	2.637	2.465

## Against own analysis

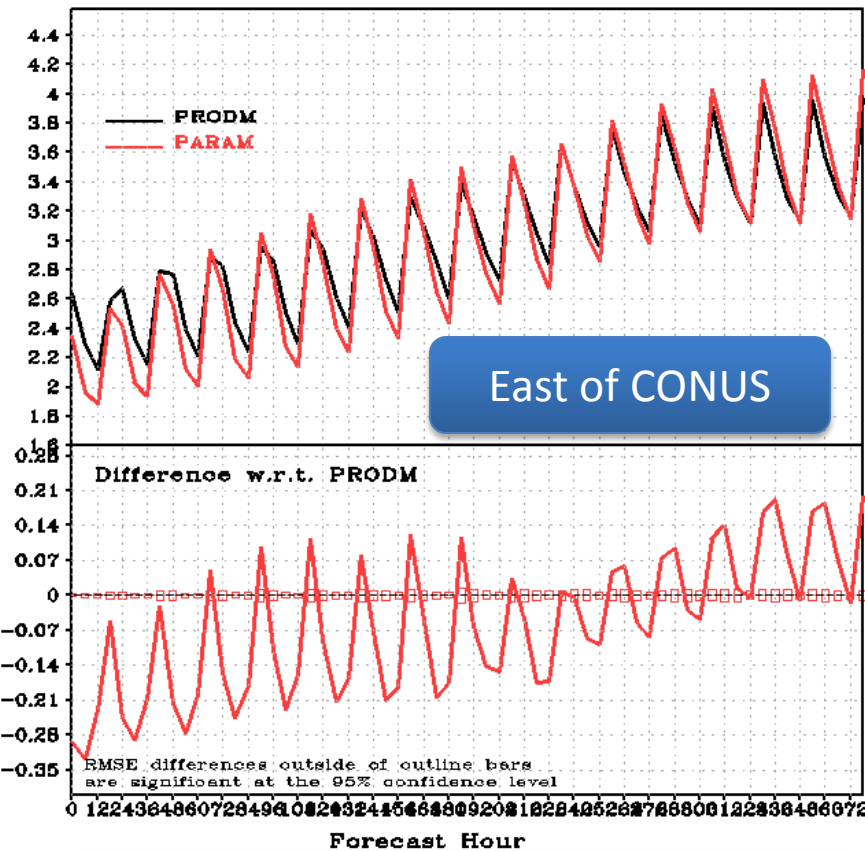
North American 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20130516 – 20131031



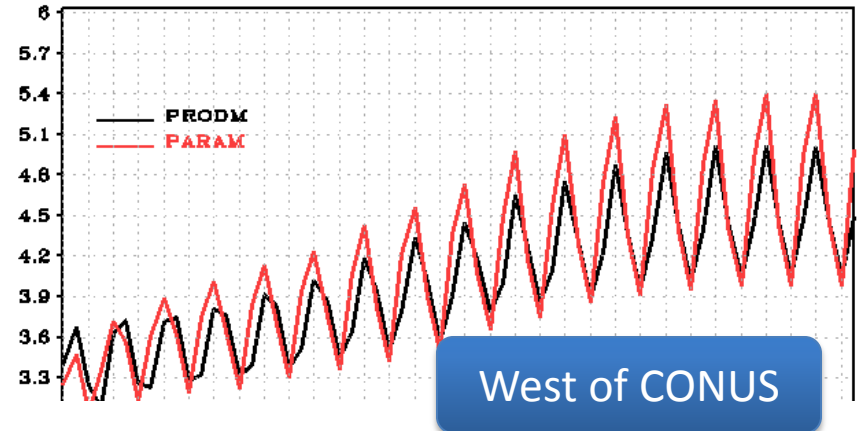
North American 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20130516 – 20131031



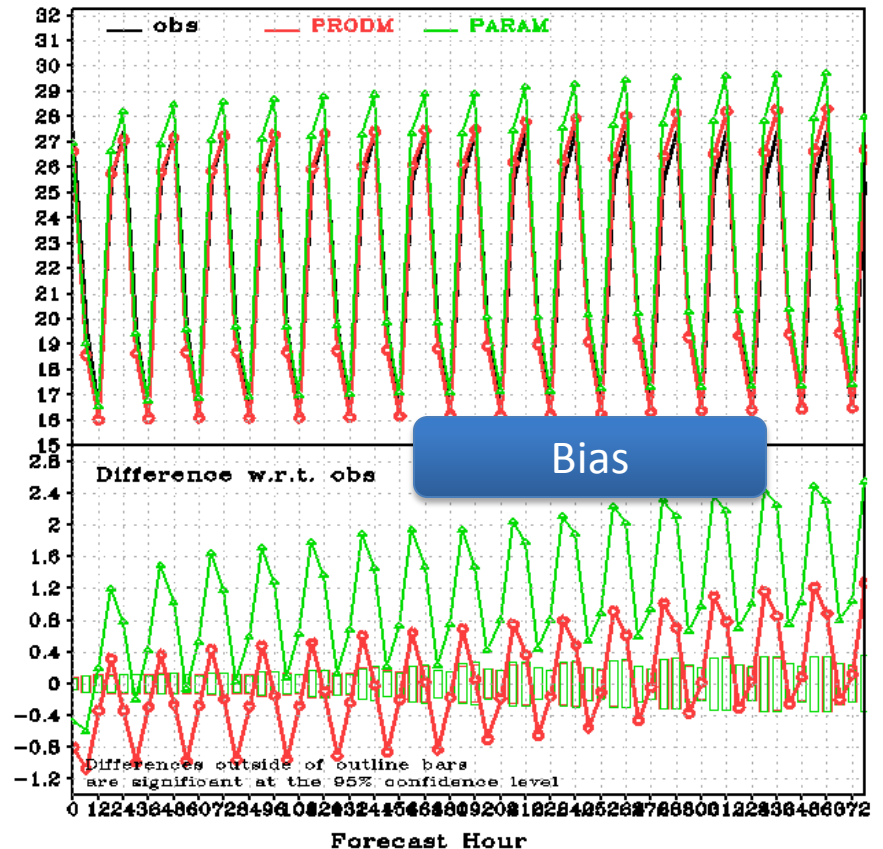
RMS: T SFC, CONUS East, 00Z cyc, 20130601-20130831



RMS: T SFC, CONUS West, 00Z cyc, 20130601-20130831



T SFC, CONUS West, 00Z Cycle, 20130601-20130831 Mean



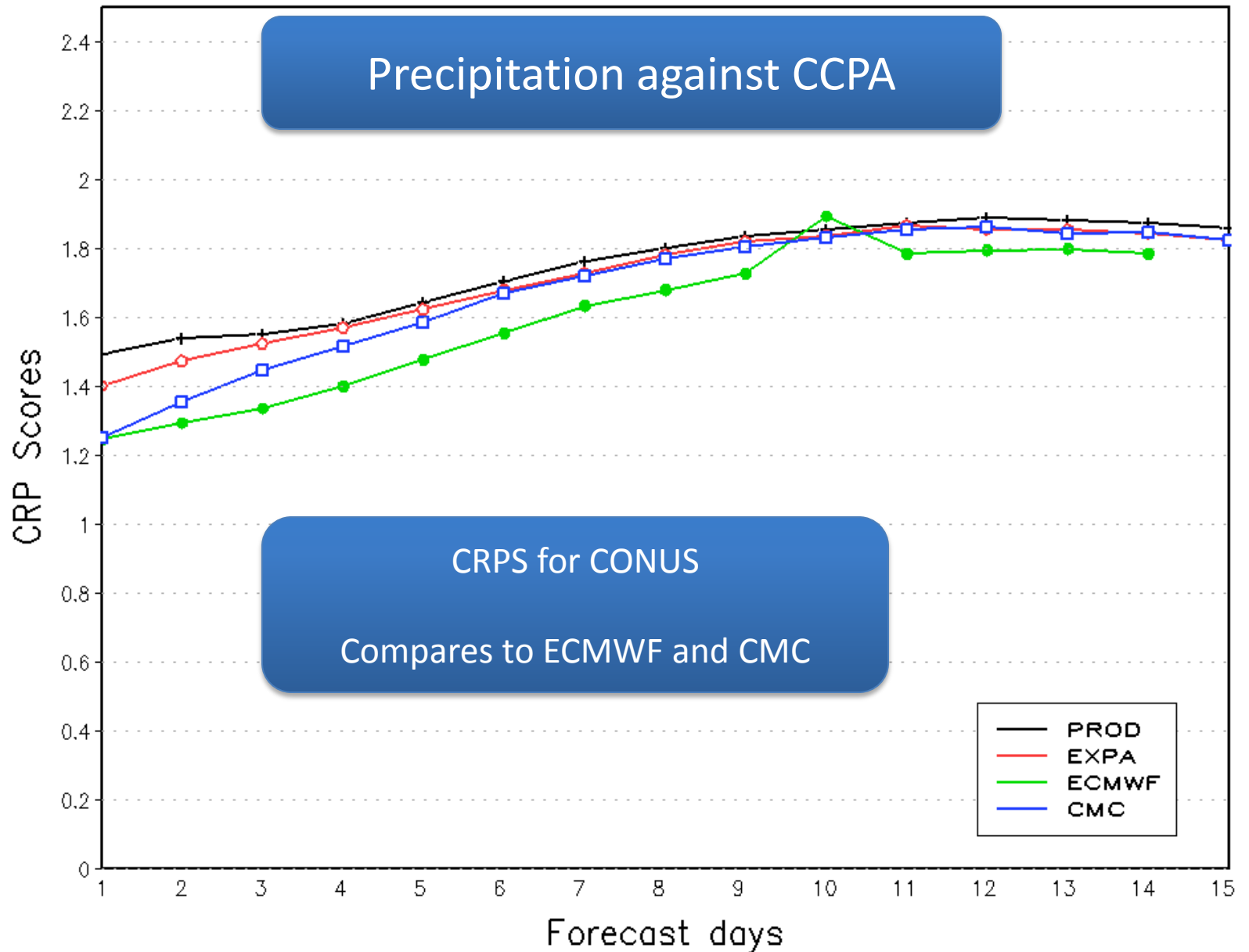
### 3-month (summer) average (against obs)

- Top: T2m RMS error of East region
- Top right: T2m RMS error of West region
- Bottom right: T2m bias of West region

### Conclusion for summer:

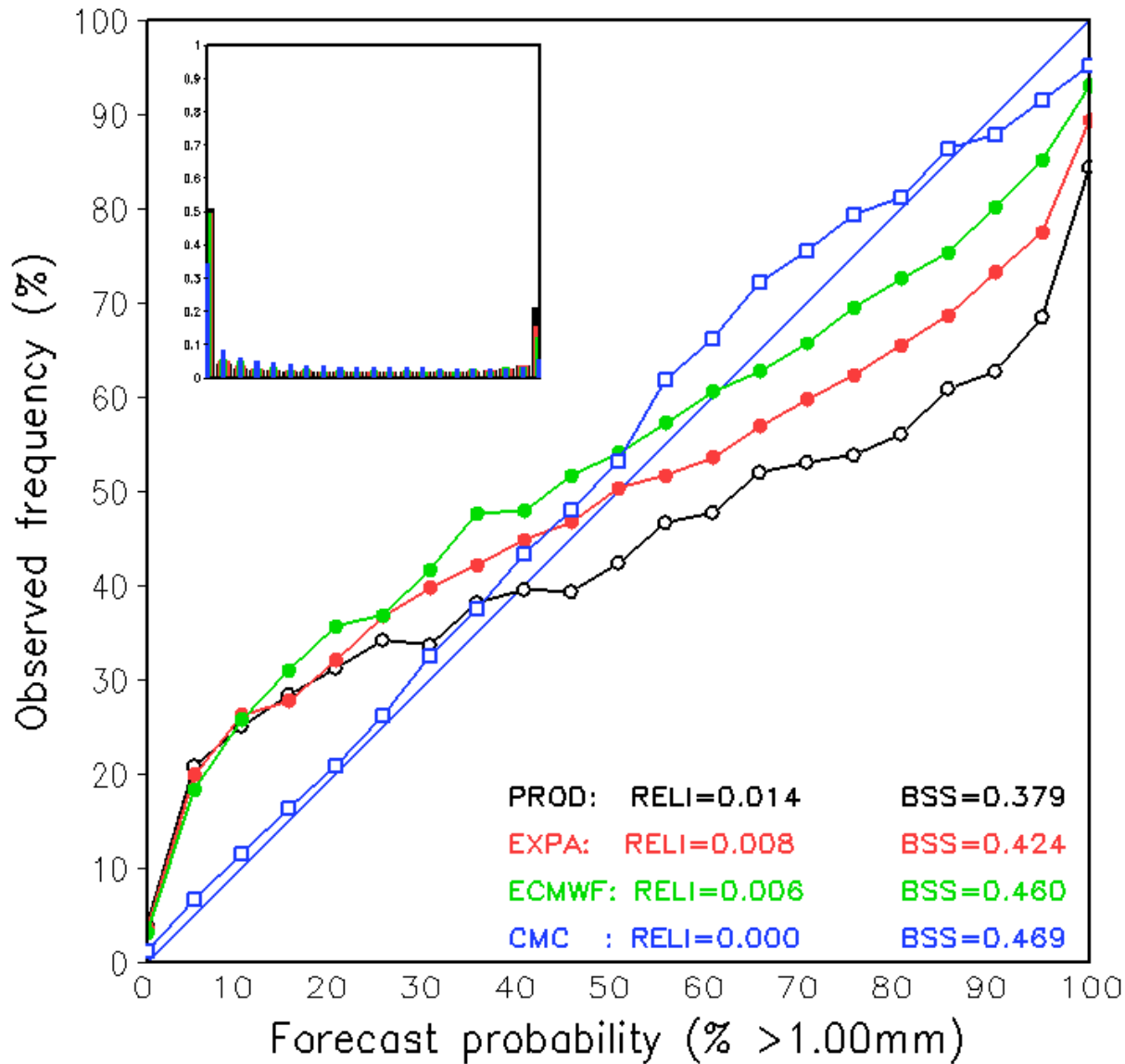
New model has large warm bias (reduce cold bias for night – good; increase warm bias for day – bad) in summer for west region, therefore, RMS error is increased

Ensemble Precipitation Verification for CONUS  
Continuous Ranked Probability Scores  
Average For 20130516 – 20131031



# Reliability Diagram

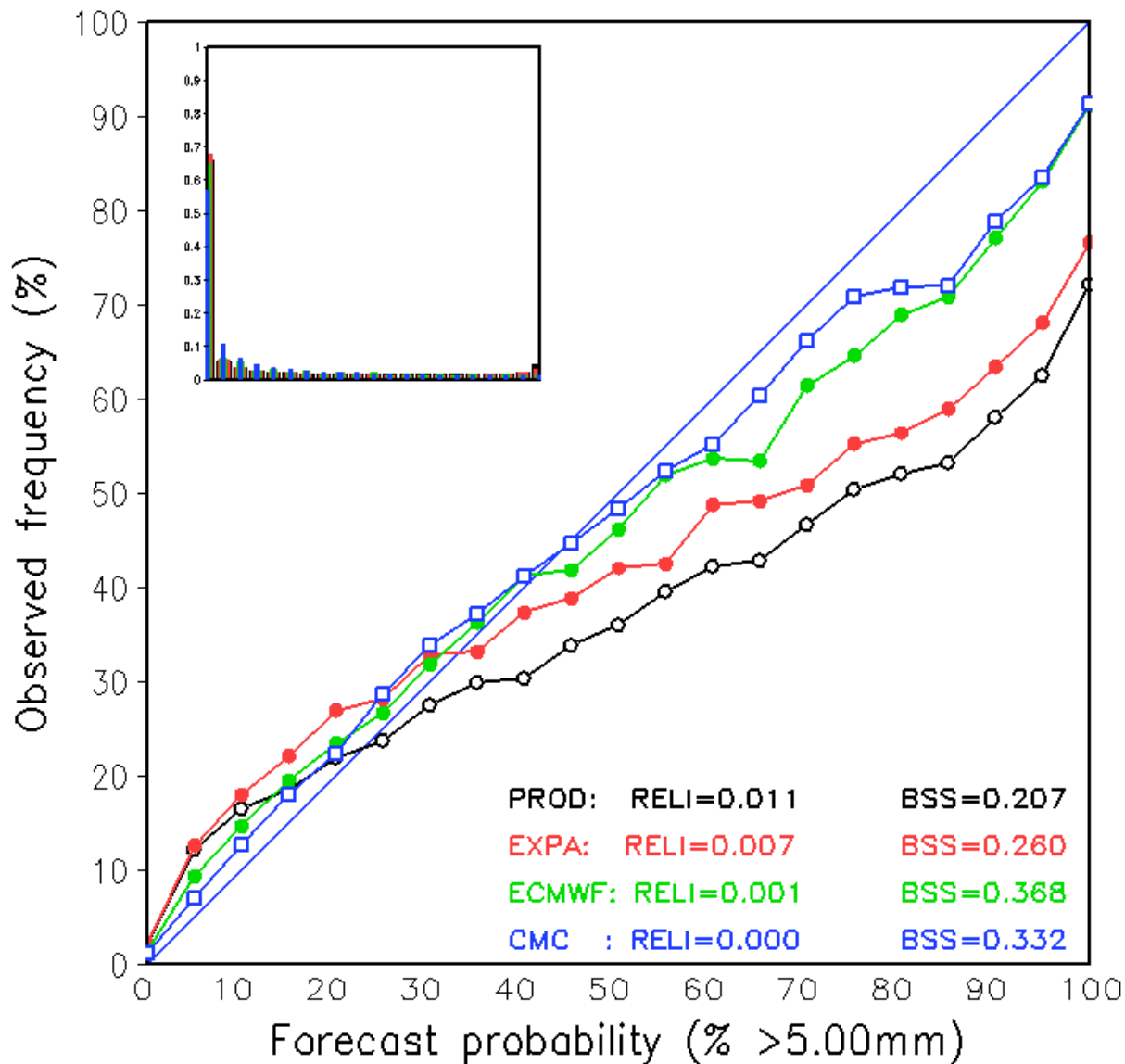
fhr 12-36 For 20130516 - 20131031



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

# Reliability Diagram

fhr 36-60 For 20130516 - 20131031

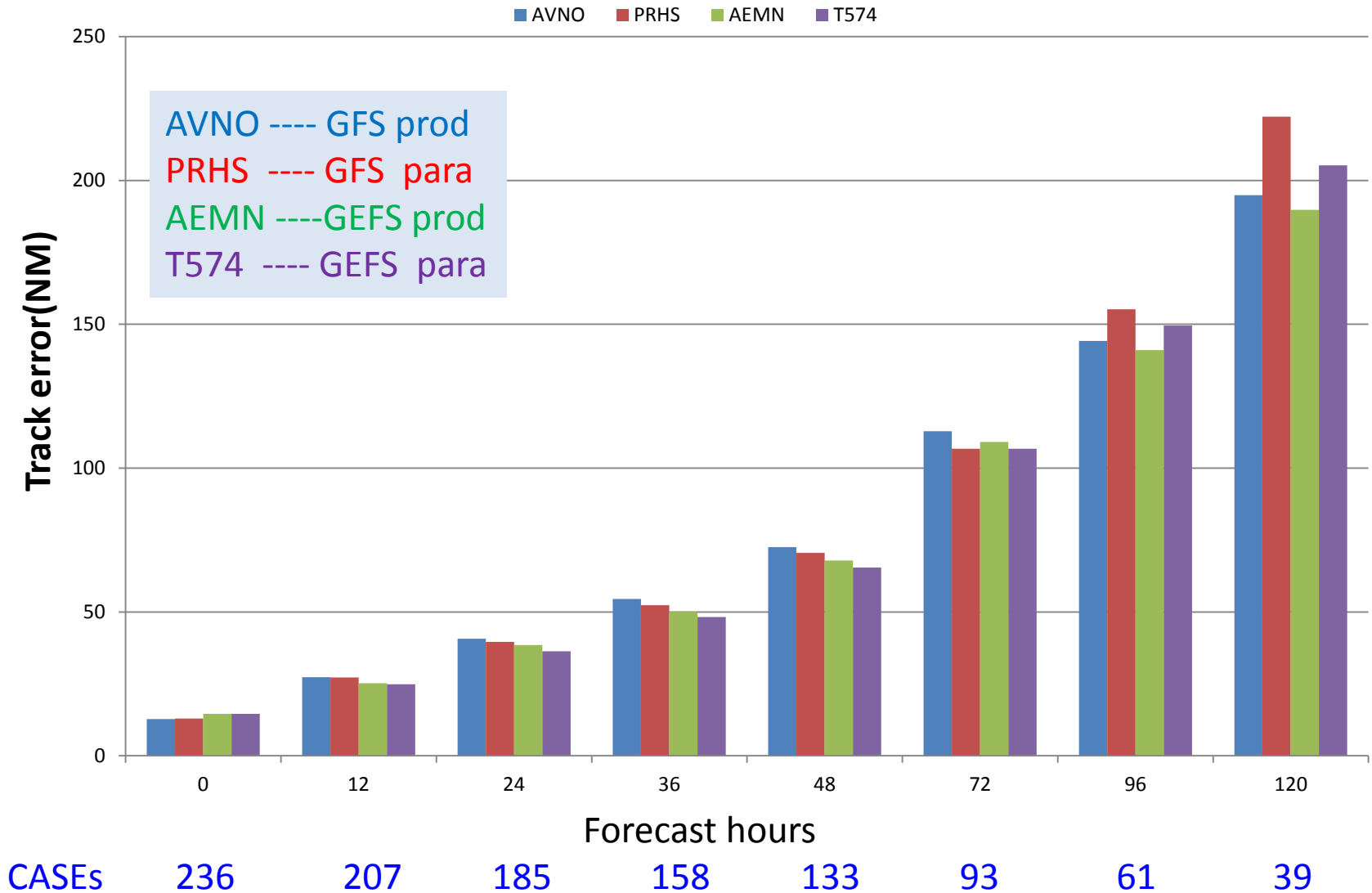


Precipitation reliability for 36-60hr and greater than 5mm/day



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

Retrospective runs – once per day at 00UTC



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

## Extended Winter Season

General stats:

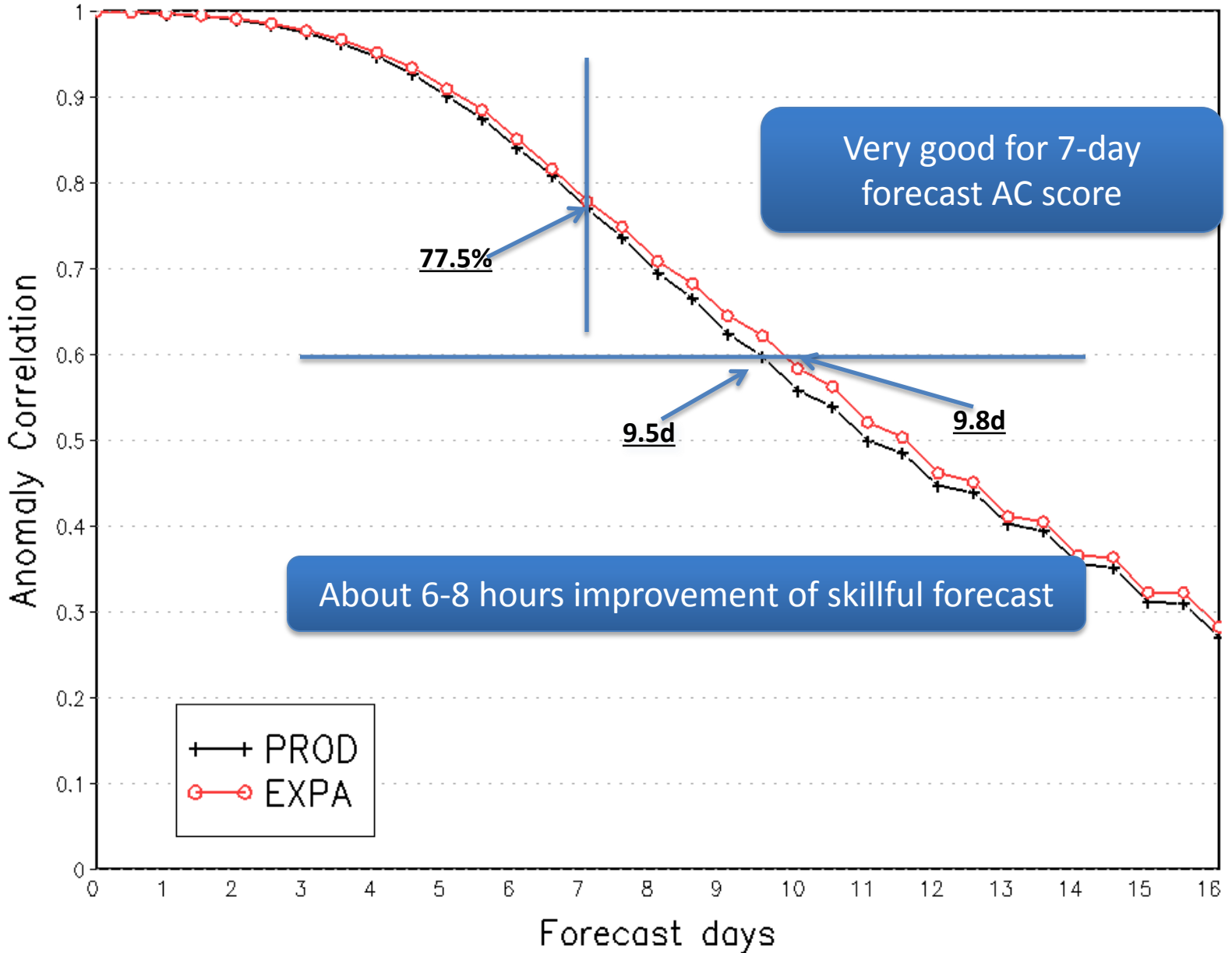
[http://www.emc.ncep.noaa.gov/gmb/wd20dh/STTP2014/PROB\\_OoFa.HTML](http://www.emc.ncep.noaa.gov/gmb/wd20dh/STTP2014/PROB_OoFa.HTML)

Precipitation:

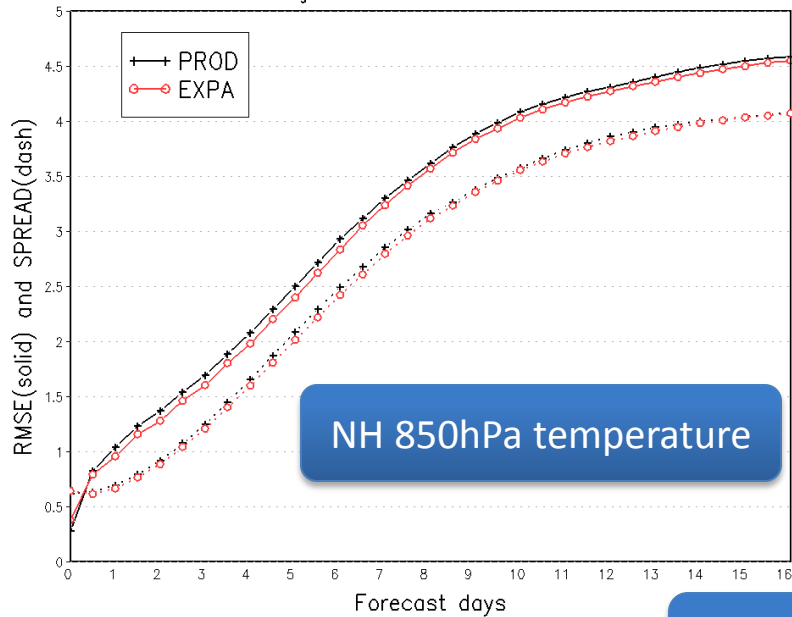
[http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS\\_VRFY/GEFS\\_PQPFvrfy\\_spring\\_test.html](http://www.emc.ncep.noaa.gov/gmb/ylo/GEFS_VRFY/GEFS_PQPFvrfy_spring_test.html)

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

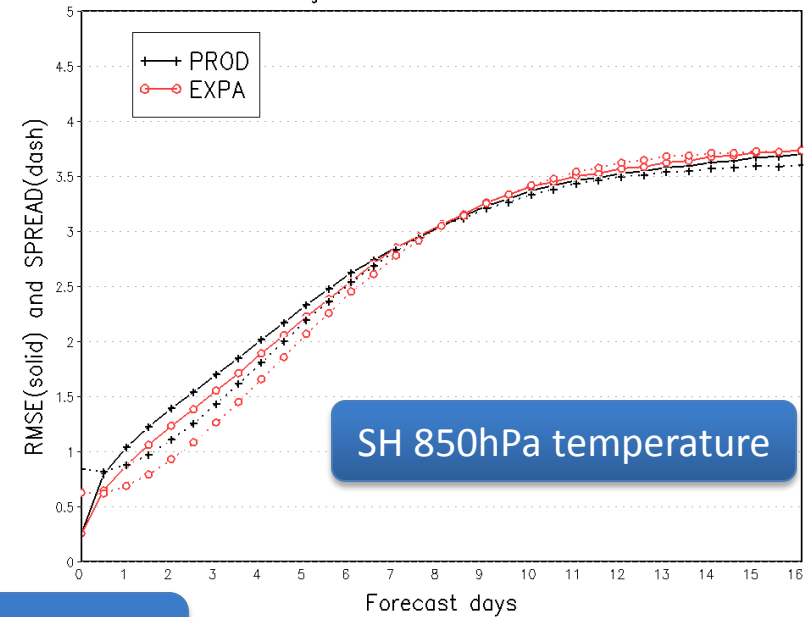
Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20140102 – 20140514



Northern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 – 20140514

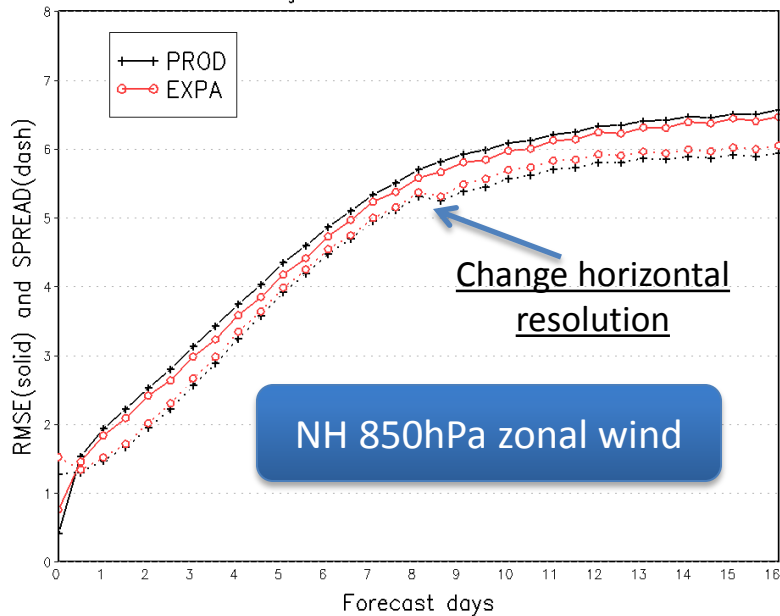


Southern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 – 20140514

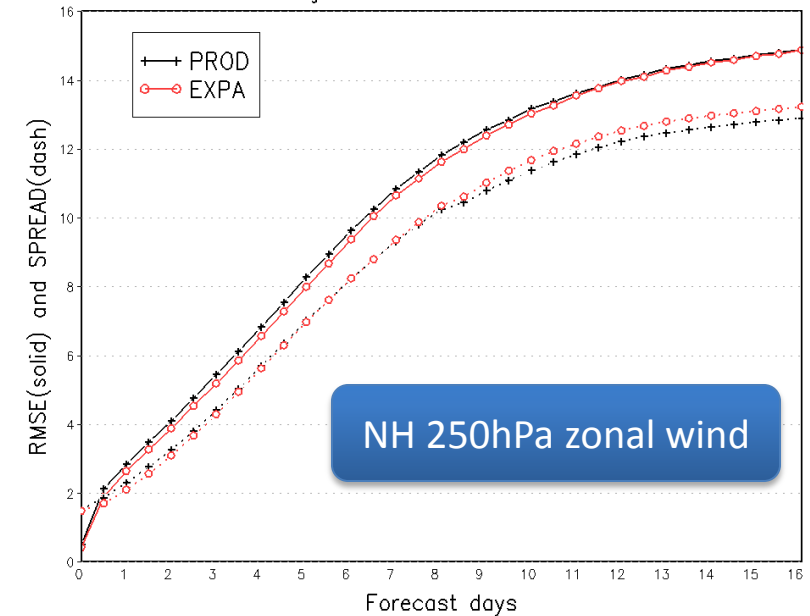


RMS error and spread

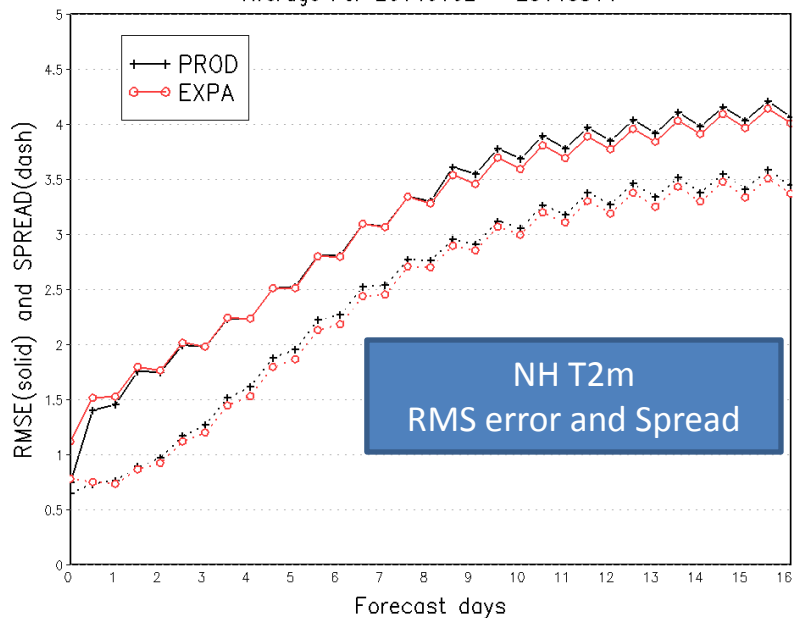
Northern Hemisphere 850hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 – 20140514



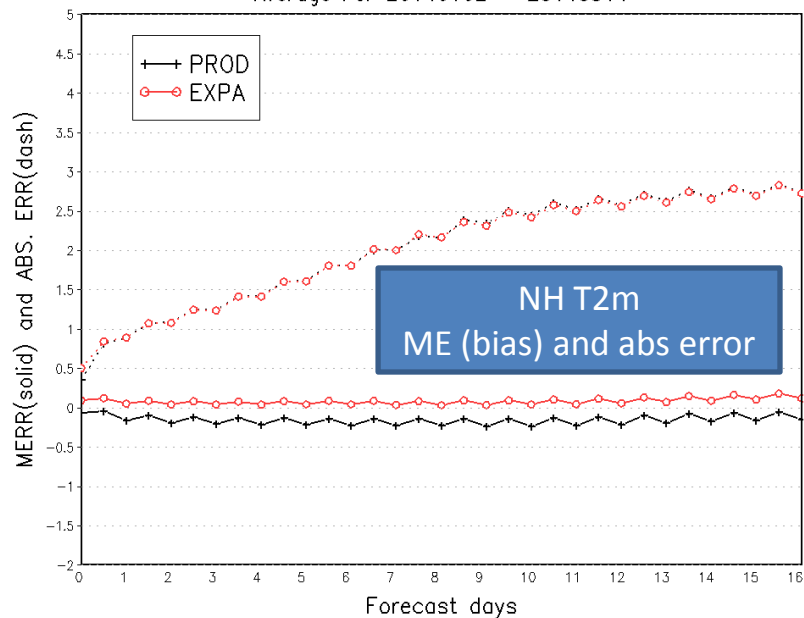
Northern Hemisphere 250hPa U Wind  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 – 20140514



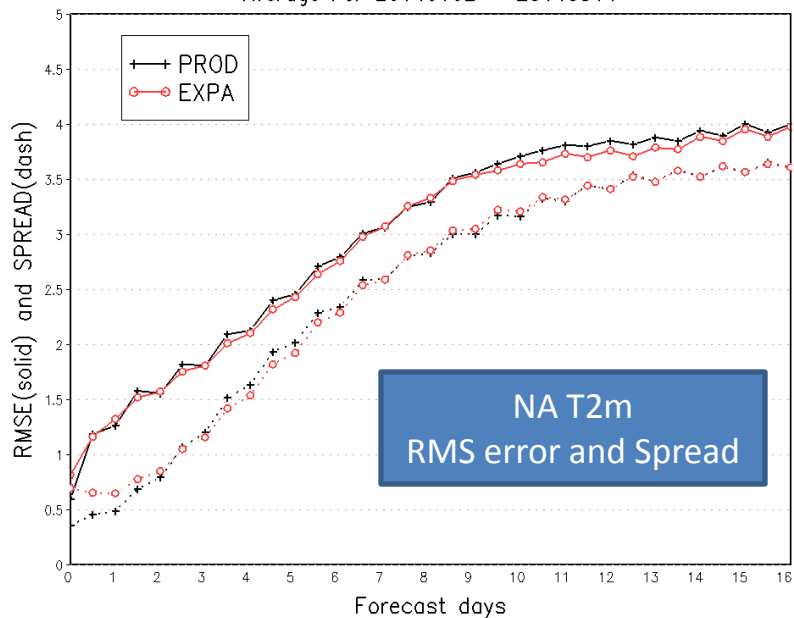
Northern Hemisphere 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 - 20140514



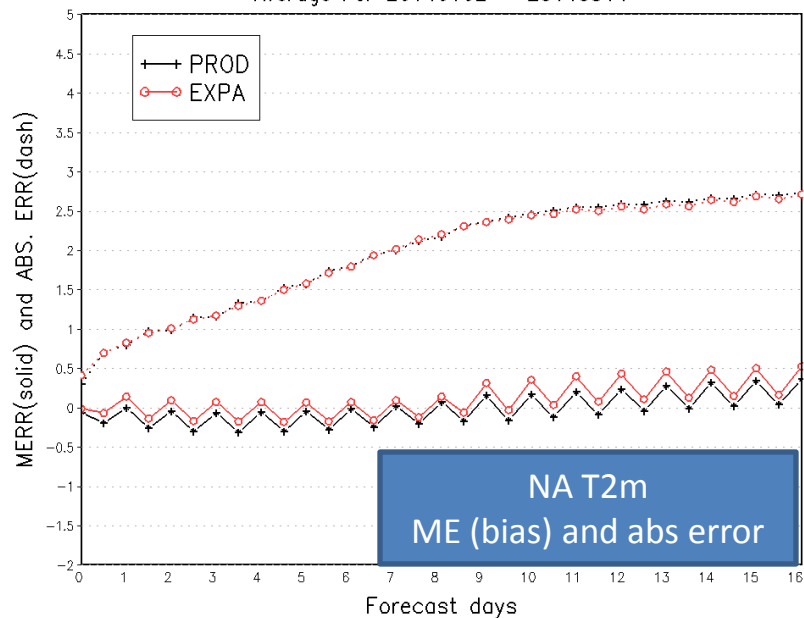
Northern Hemisphere 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20140102 - 20140514



North American 2 Meter Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20140102 - 20140514

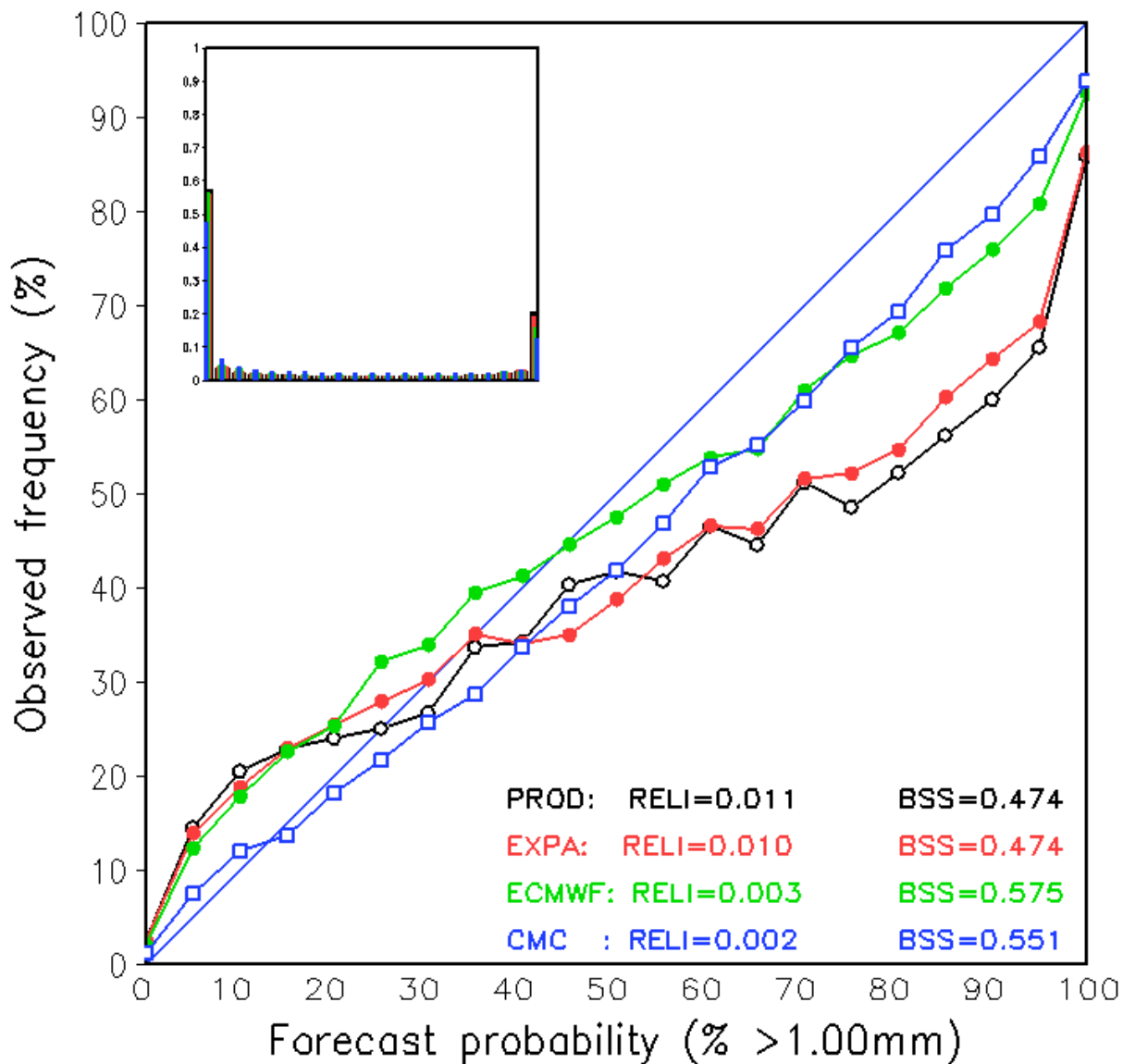


North American 2 Meter Temp.  
Ensemble Mean Error and Ensemble Abs. Error  
Average For 20140102 - 20140514



# Reliability Diagram

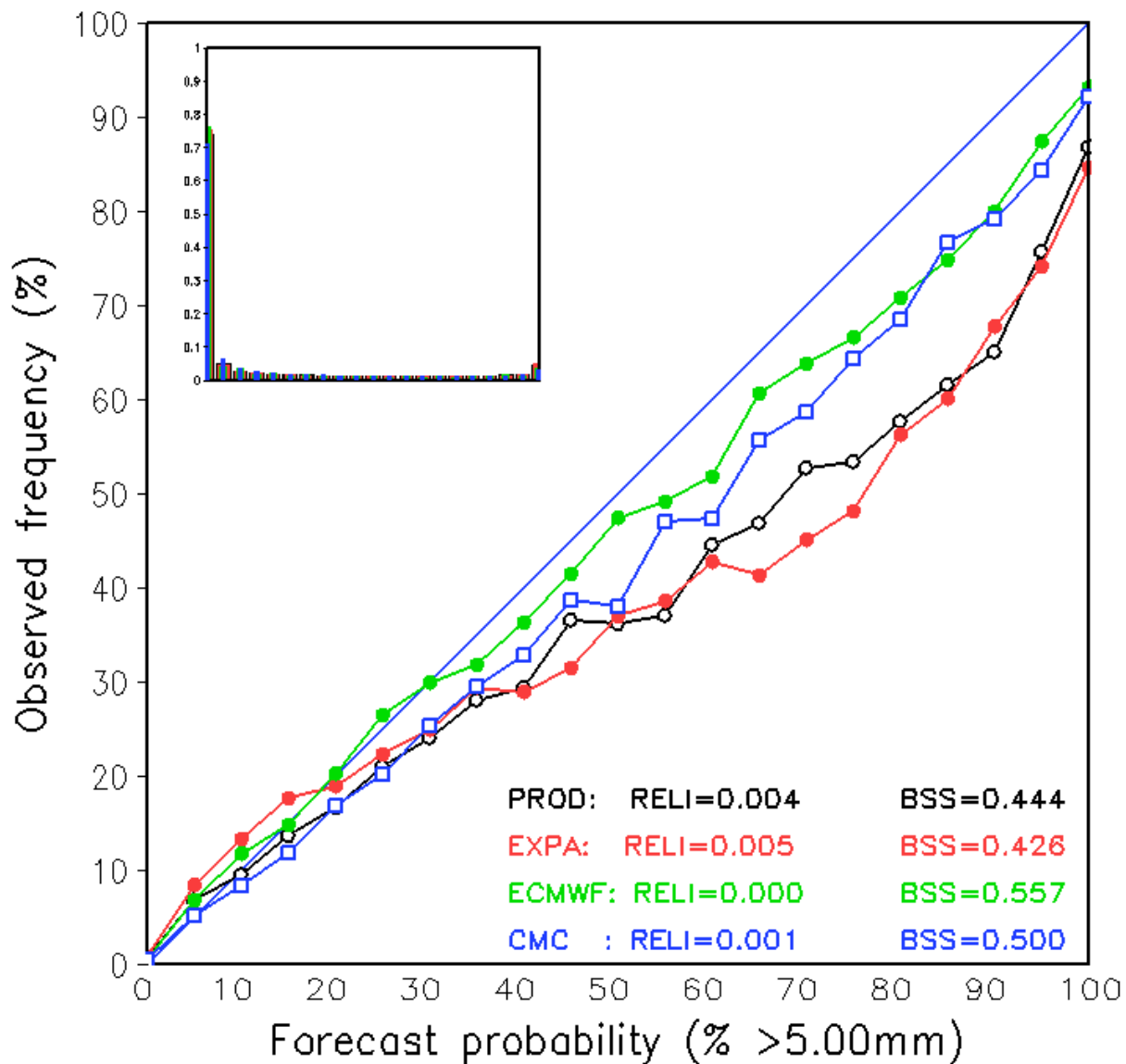
fhr 12-36 For 20140102 - 20140507



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

# Reliability Diagram

fhr 36-60 For 20140102 - 20140507



Precipitation reliability for 36-60hr and greater than 5mm/day

# Summary

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



# Test Plan for Next GEFS

- Keep monitoring the performance of STTP's parameter setting and EnKF f06 initial perturbations.
  - It is still possible to have a minor modification for STTP parameters and initial perturbations.
- At least to run retrospective experiments for three full seasons
  - Hurricane seasons (2012, 2013)
  - Winter (2013-2014)
  - Twice per day (00UTC and 12UTC)
- Have full probabilistic evaluations (or performances) of
  - Upper atmospheric fields (against own analysis)
  - Surface elements which include precipitation for CONUS
    - Will against observations for T2m and precipitation for CONUS
  - Hurricane tracks (also intensity, even there is less skill comparing to others)