



EMC FY15 Upgrade Review

GEFS Upgrade

**N
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Presented by:

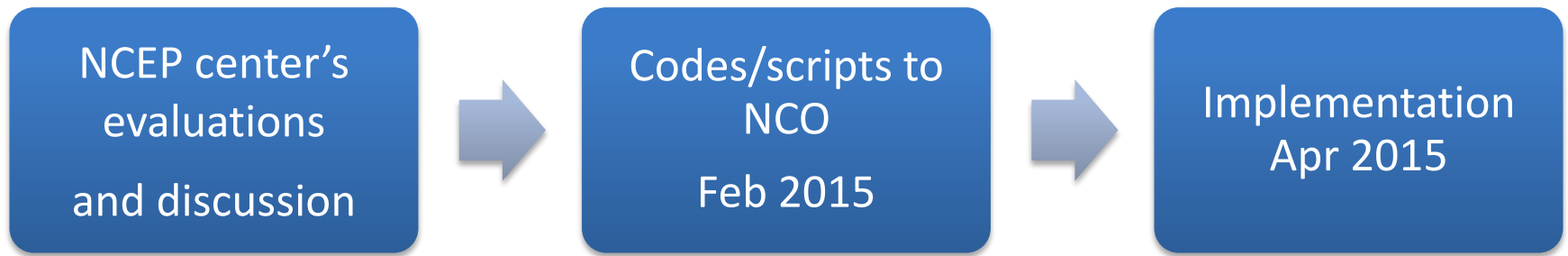
Yuejian Zhu

Update: 2/5/2014

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 _L 574 (34km) L64 (hybrid)
Resolution 192-384 h	T190 (70km) L42 (hybrid)	T _L 382 (52km) L64 (hybrid)
Computational Cost	84 nodes (+ post process)	300 nodes 1 st segment 250 nodes 2 nd segment
Execution time	55 min	35 min 1 st segment 30 min 2 nd segment
Output resolution	1 ^o x 1 ^o	0.5 ^o x 0.5 ^o for 0-8 days 1 ^o x 1 ^o the rest
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 DA and Ensemble Generation
 - Direct link to the hybrid 3D-Var EnKF DA system
- Perturbations are 6h forecasts EnKF 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 tropical
 - to reduce the spread growing of geopotential height

Expected improvements

- Hurricane track forecast
 - Main reason: Model and spatial resolutions
- Probabilistic forecast guidance
 - Main reason: 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 (Q2FY15)
 - NCO 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: +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
 - Nearly 70% has been done, NCO is helping to run part of them
 - 18 years ensemble control only reforecast
 - Year 1995-2012
 - 00UTC and every other day
 - Forecasts has been finished, OHD has received the data
 - All data will be saved in HPSS tapes
 - Currently, no public ftp access, but NCEP service centers could access through WCOSS.
 - Will work with NCO to publish part of data: pgrba data at 1.0 degree, every 6 hours, out to 16 days.

Hurricane Sandy Study for GEFS

Period: 10/22 – 10/28/2012

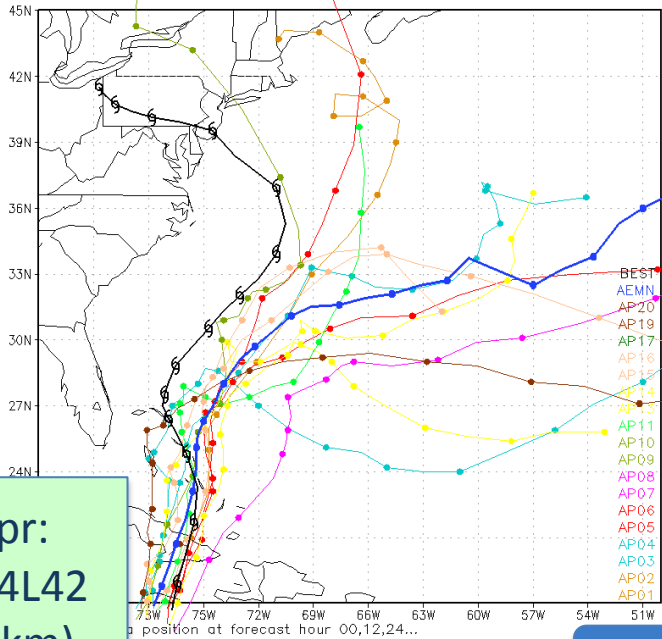
Named: 10/23/2012

Yuejian Zhu
EMC/NCEP

September 15 2014

Acknolegements:
Dingchen Hou, Xiqiong Zhou and Jiayi Peng

NCEP Ensemble Forecast TC Track Verification 2012102200



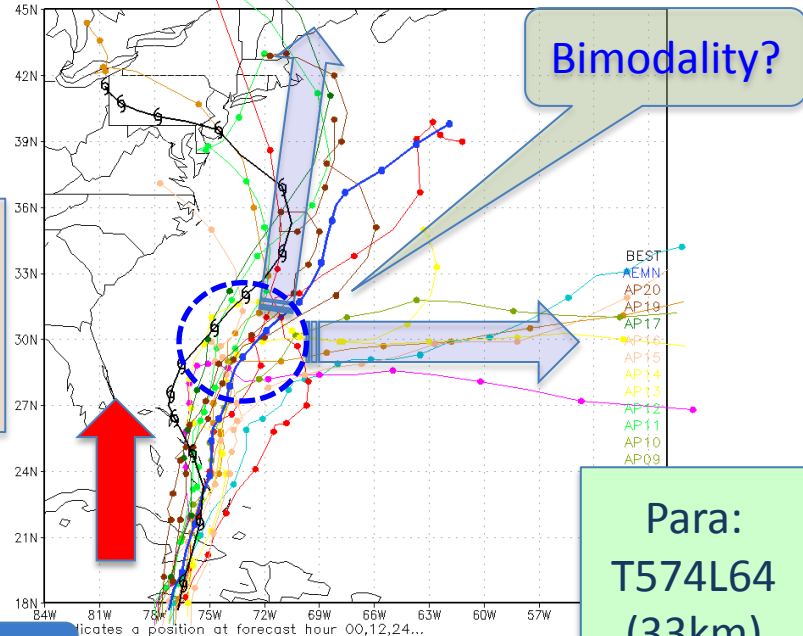
00UTC

Thick blue:
ensemble
mean

Opr:
T254L42
(55km)

20121022 (8 days)

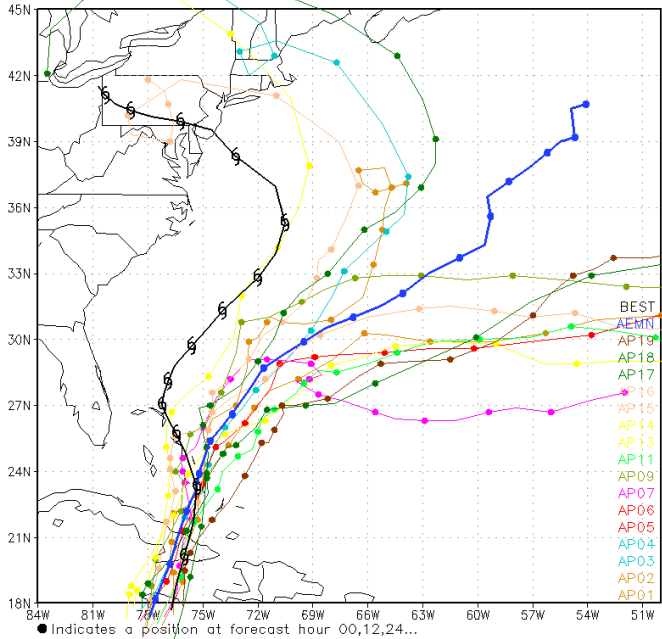
NCEP Ensemble Forecast TC Track Verification 2012102200



Bimodality?

Para:
T574L64
(33km)

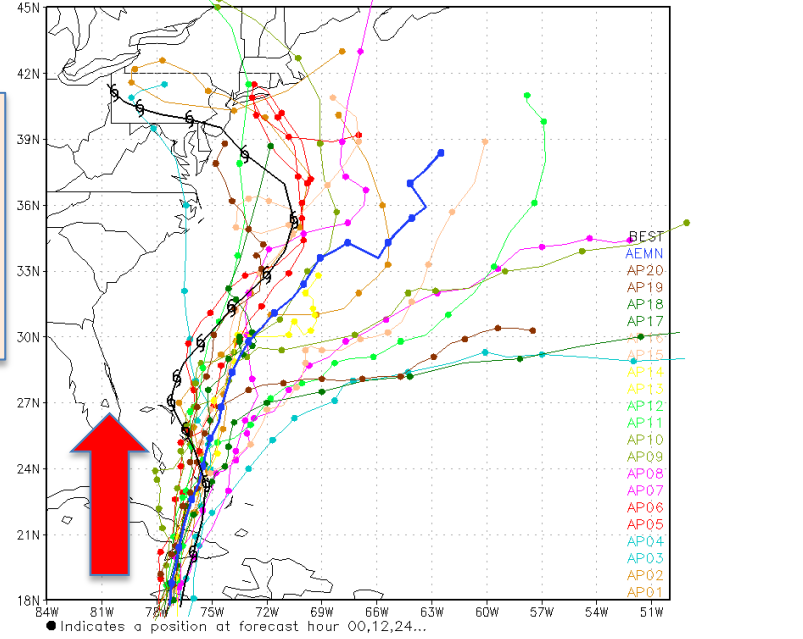
NCEP Ensemble Forecast TC Track Verification 2012102206



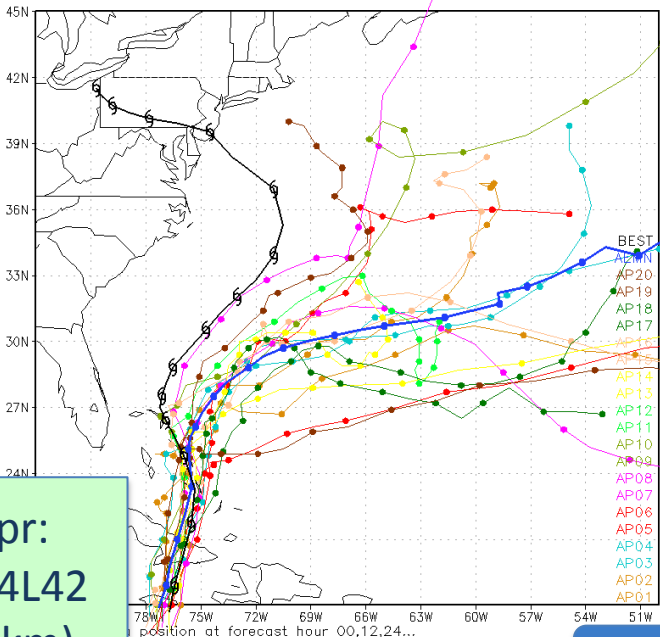
Red arrow
means good
forecast

06UTC

NCEP Ensemble Forecast TC Track Verification 2012102206



NCEP Ensemble Forecast TC Track Verification 2012102212



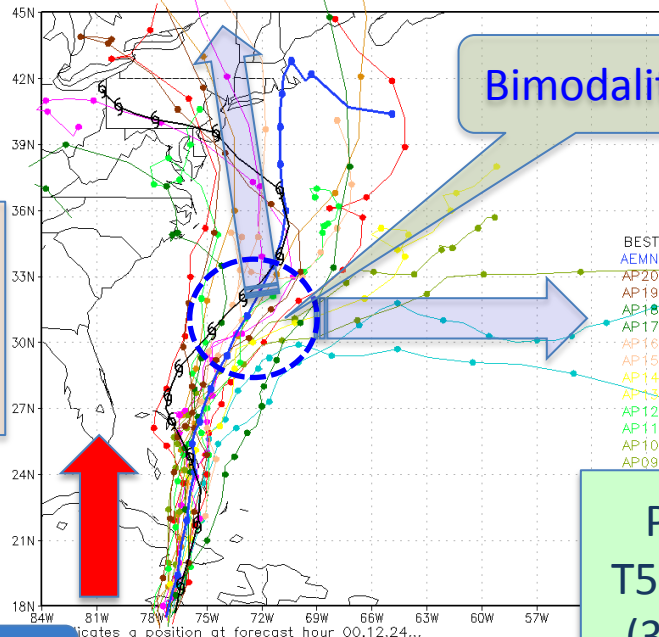
12UTC

Thick blue:
ensemble
mean

Opr:
T254L42
(55km)

20121022 (7.5 days)

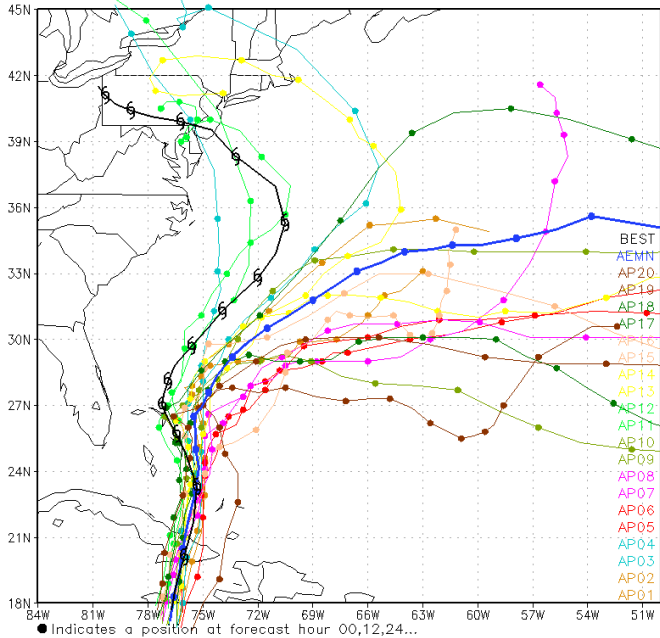
NCEP Ensemble Forecast TC Track Verification 2012102212



Bimodality?

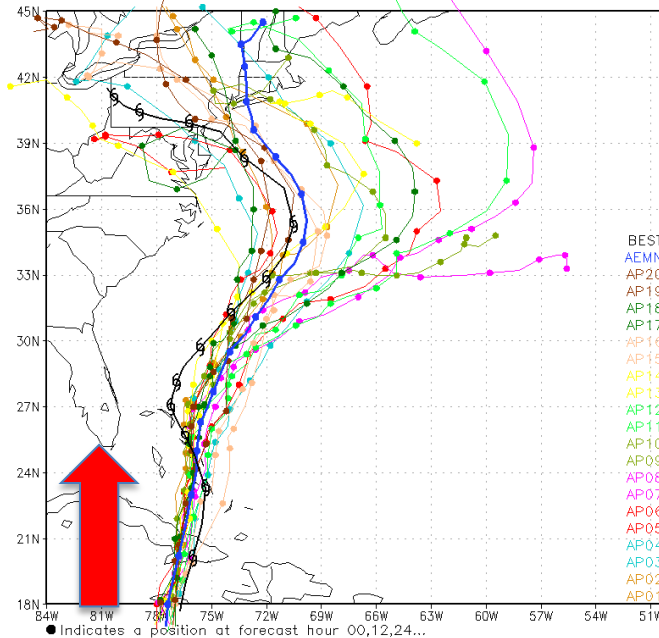
Para:
T574L64
(33km)

NCEP Ensemble Forecast TC Track Verification 2012102218



18UTC

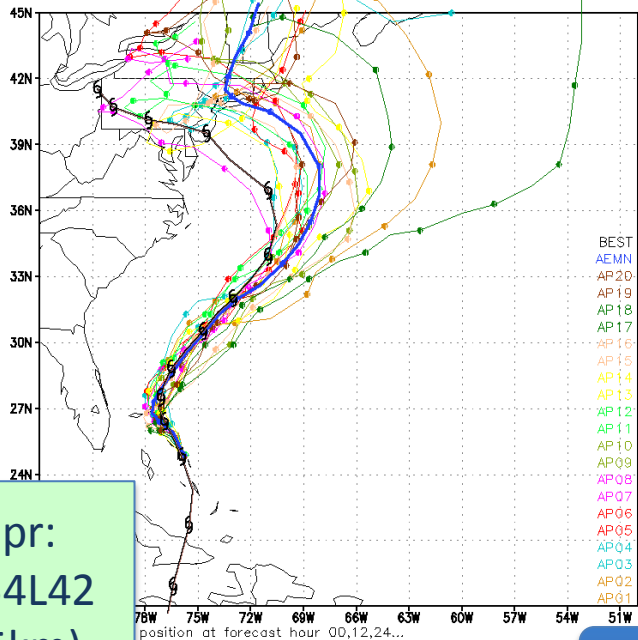
NCEP Ensemble Forecast TC Track Verification 2012102218



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

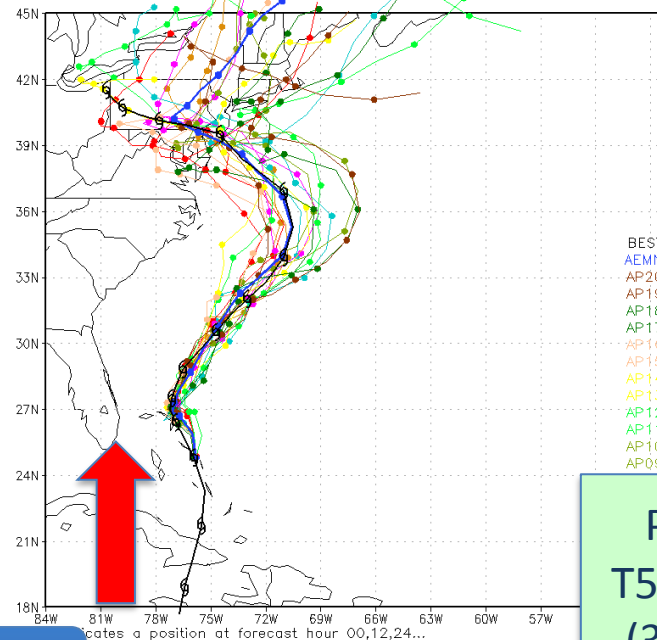
● Indicates a position at forecast hour 00,12,24...

NCEP Ensemble Forecast TC Track Verification 2012102600



00UTC

NCEP Ensemble Forecast TC Track Verification 2012102600

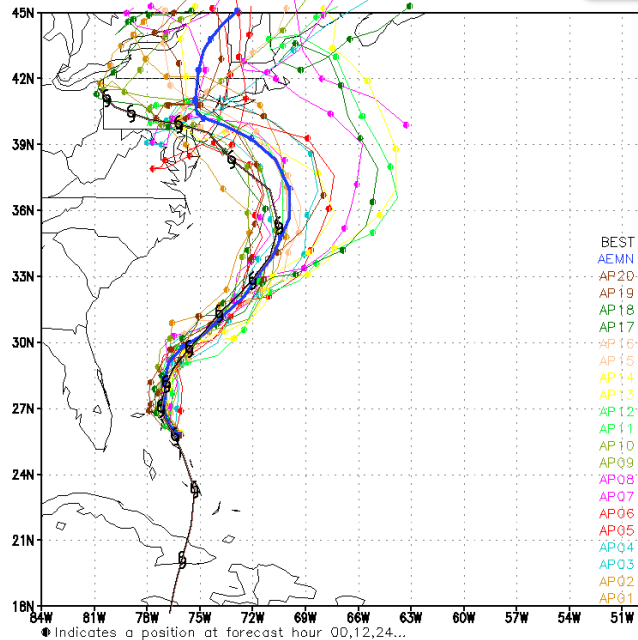


Para:
T574L64
(33km)

Opr:
T254L42
(55km)

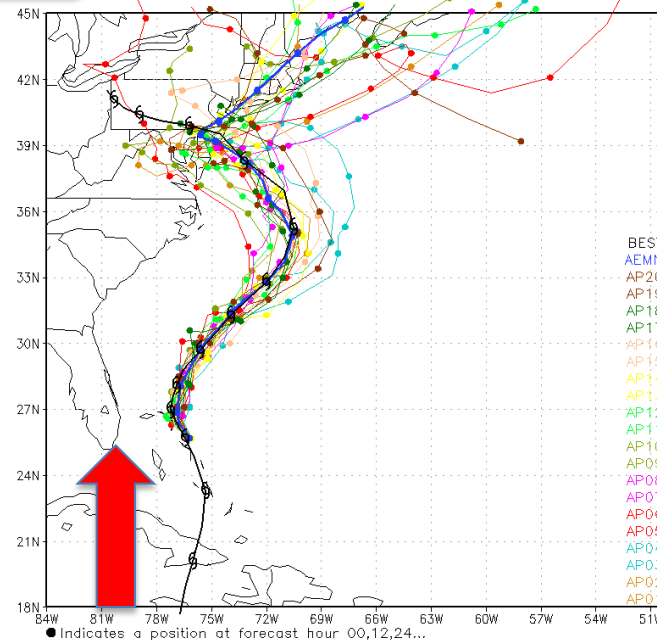
20121026 (4 days)

NCEP Ensemble Forecast TC Track Verification 2012102606

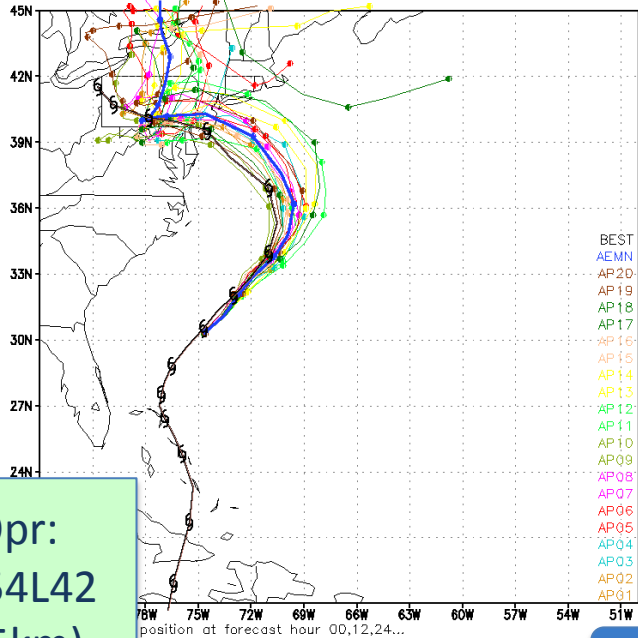


06UTC

NCEP Ensemble Forecast TC Track Verification 2012102606



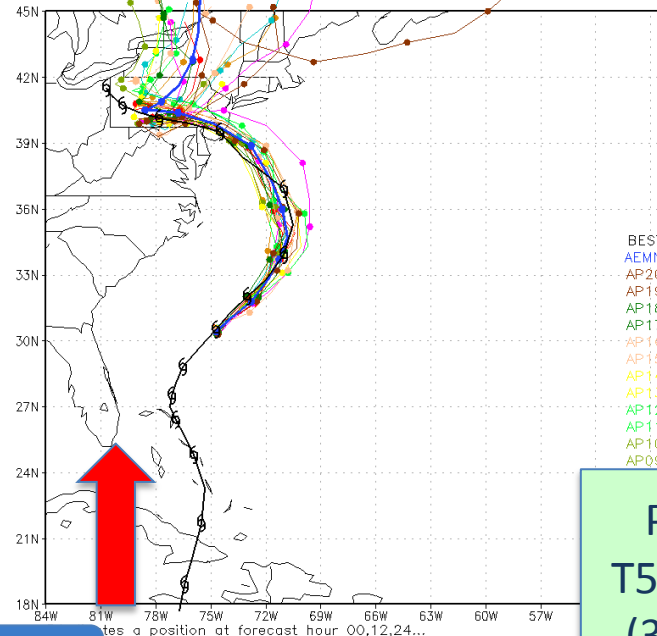
NCEP Ensemble Forecast TC Track Verification 2012102800



Opr:
T254L42
(55km)

00UTC

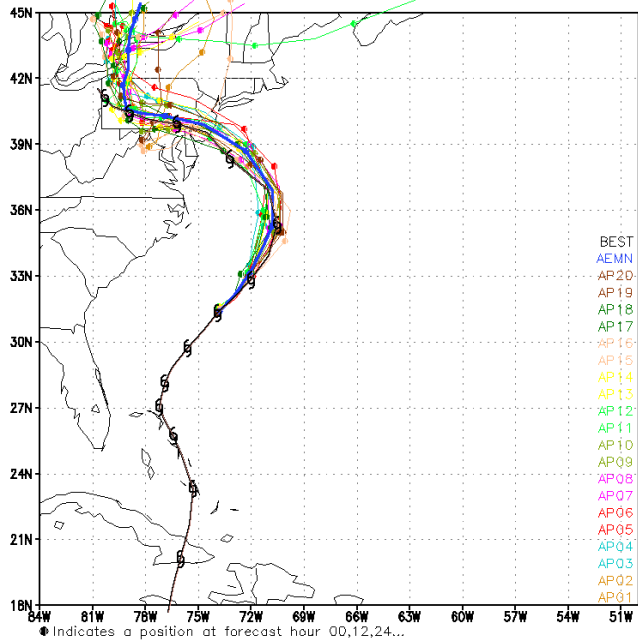
NCEP Ensemble Forecast TC Track Verification 2012102800



Para:
T574L64
(33km)

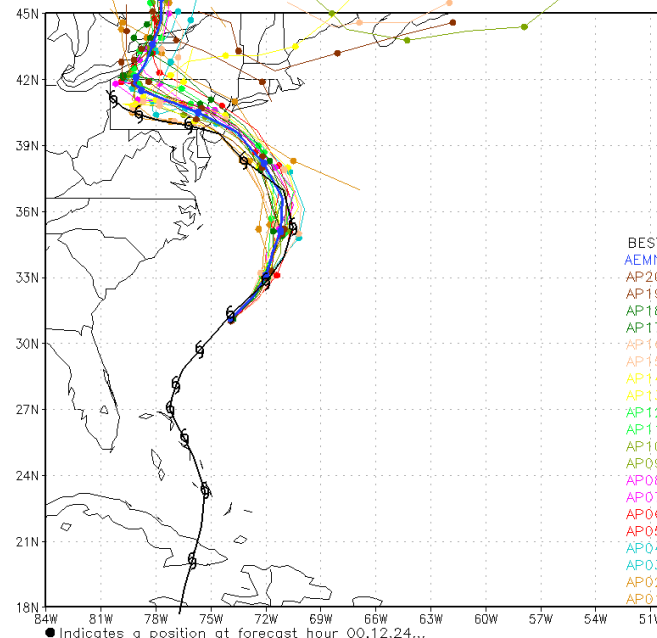
20121028 (2 days)

NCEP Ensemble Forecast TC Track Verification 2012102806



06UTC

NCEP Ensemble Forecast TC Track Verification 2012102806



Short Summary for Sandy case

- Higher resolution and new model improve the forecast skill (and predictability) for most lead-time, especially for longer lead-time (day 7-8).
- Bimodality (or uncertainties) 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

Review of 2015 NE Blizzard

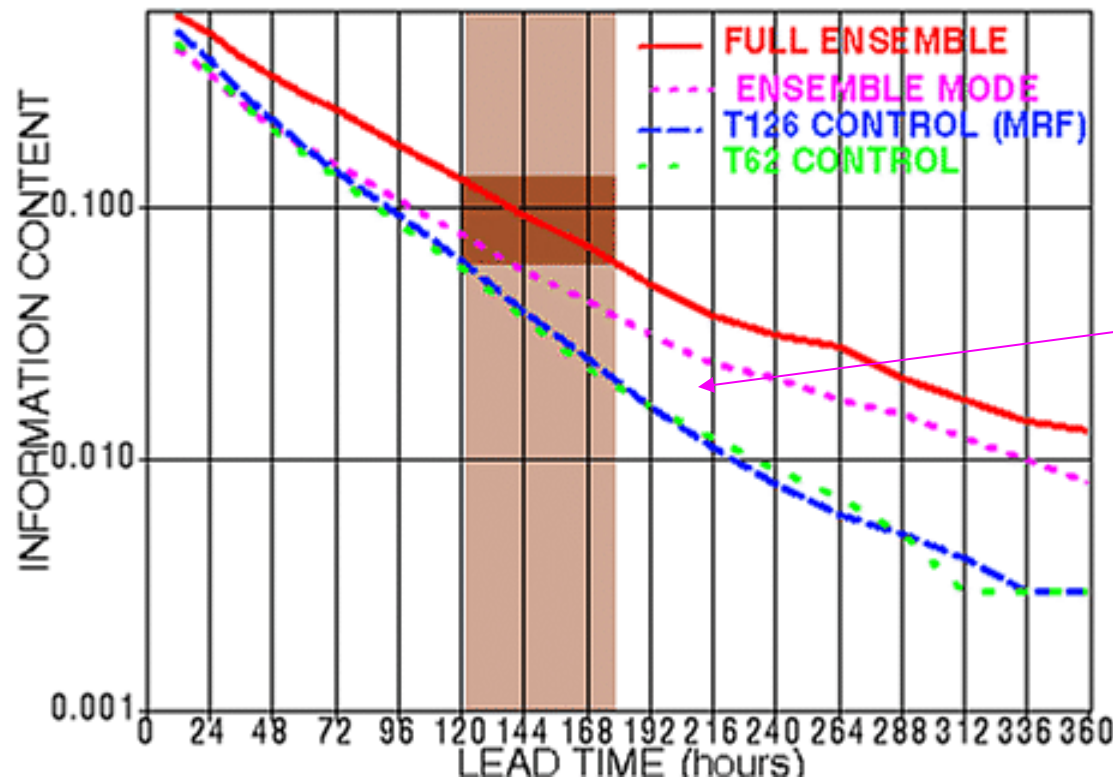
01/26 12UTC – 01/28 12UTC 2015

Yuejian Zhu
EMC/NCEP/NWS
Jan. 30 2015

Acknowledgements:
Hong Guan, Yan Luo and Xiaxiong Zhou

Ensemble Forecast – Information Content

Statistics show a **7.5-day** fully probabilistic forecast or **6-day** categorical forecast has as much information content as **5-day** control forecast. Or fully probabilistic forecast has more than **twice** as much information content at **day-5**.



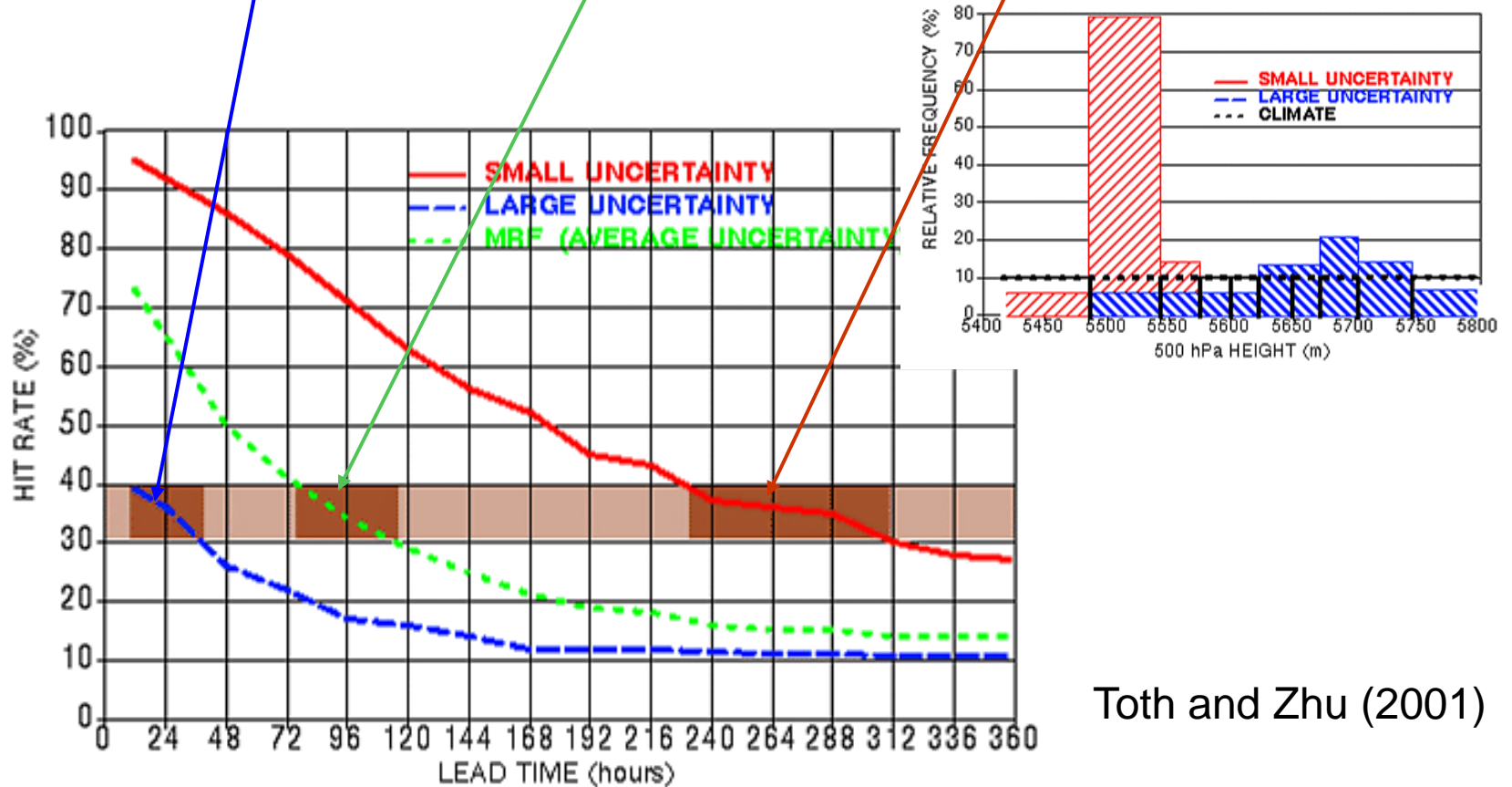
*ensemble mode
considers as
most frequent
forecasts*

Toth and Zhu (2000)

Ensemble Forecast - Uncertainty

Small and large uncertainty.

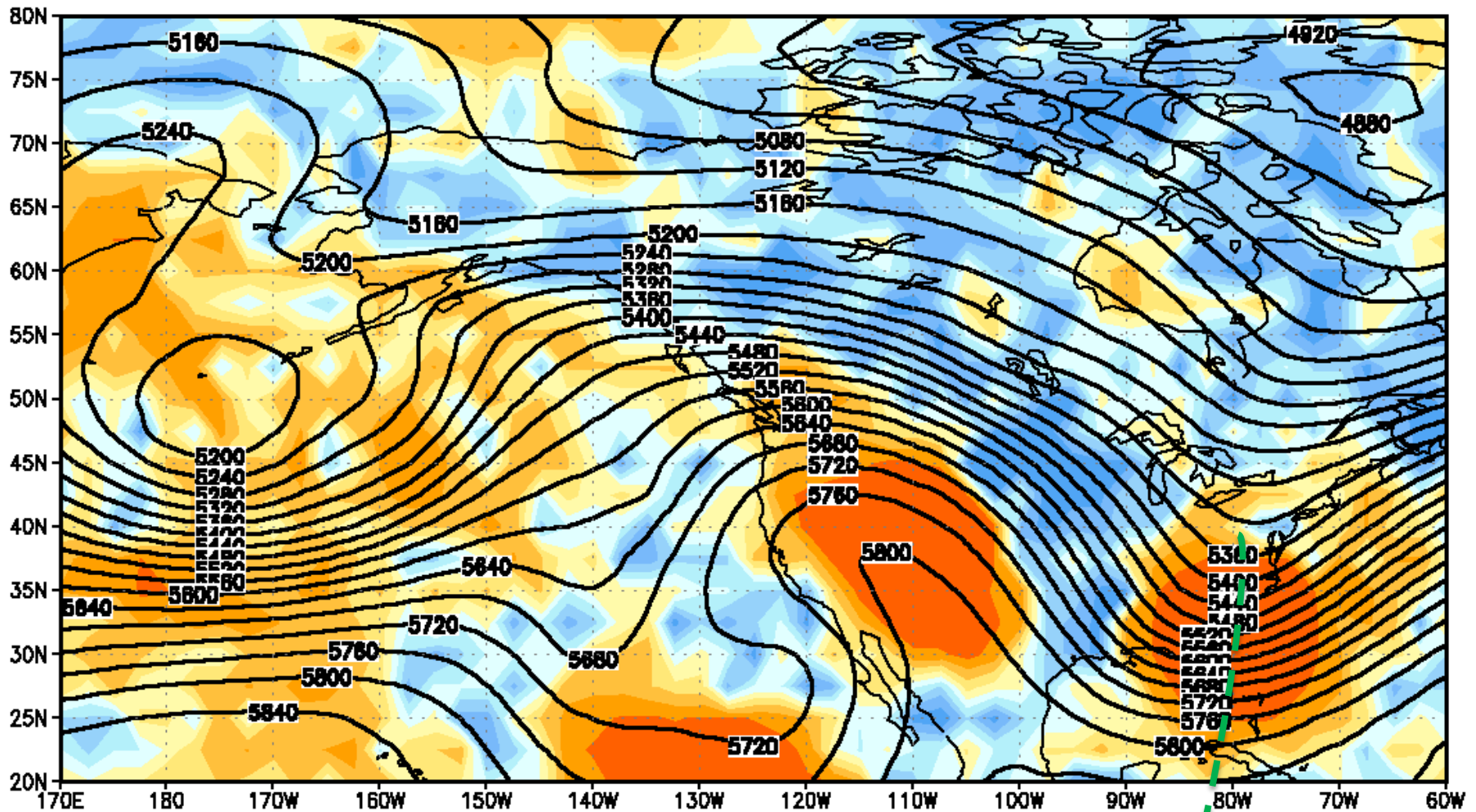
1 day (large uncertainty) = 4 days (control) = 10-13 days (small uncertainty)



Toth and Zhu (2001)

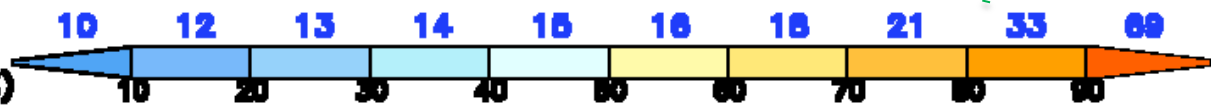
Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

In: 2015012000 valid: 2015012700 fcst: 168 hours



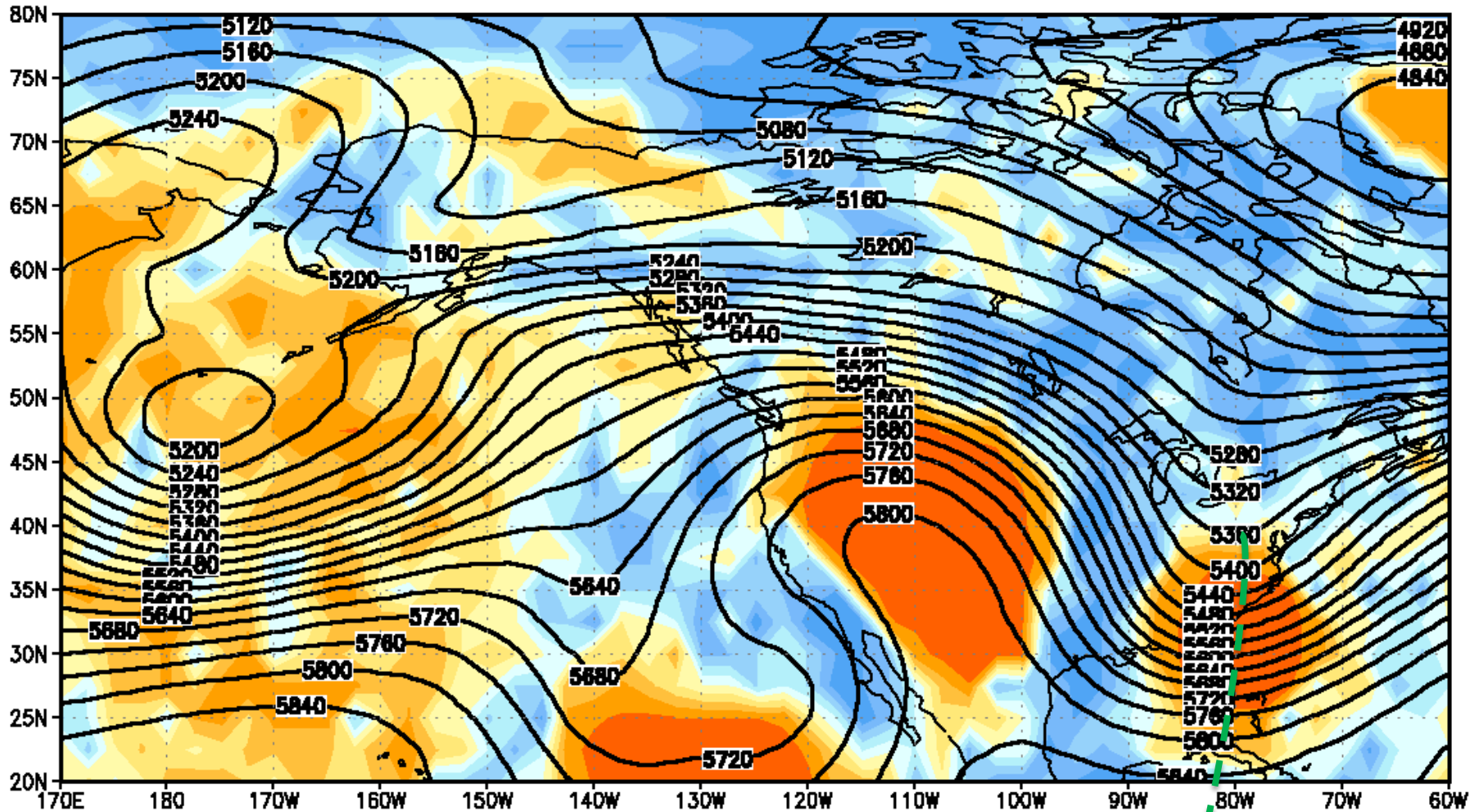
Probability (%)

Measure of predictability (%)



Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012100 valid: 2015012700 fcst: 144 hours



Probability (%)

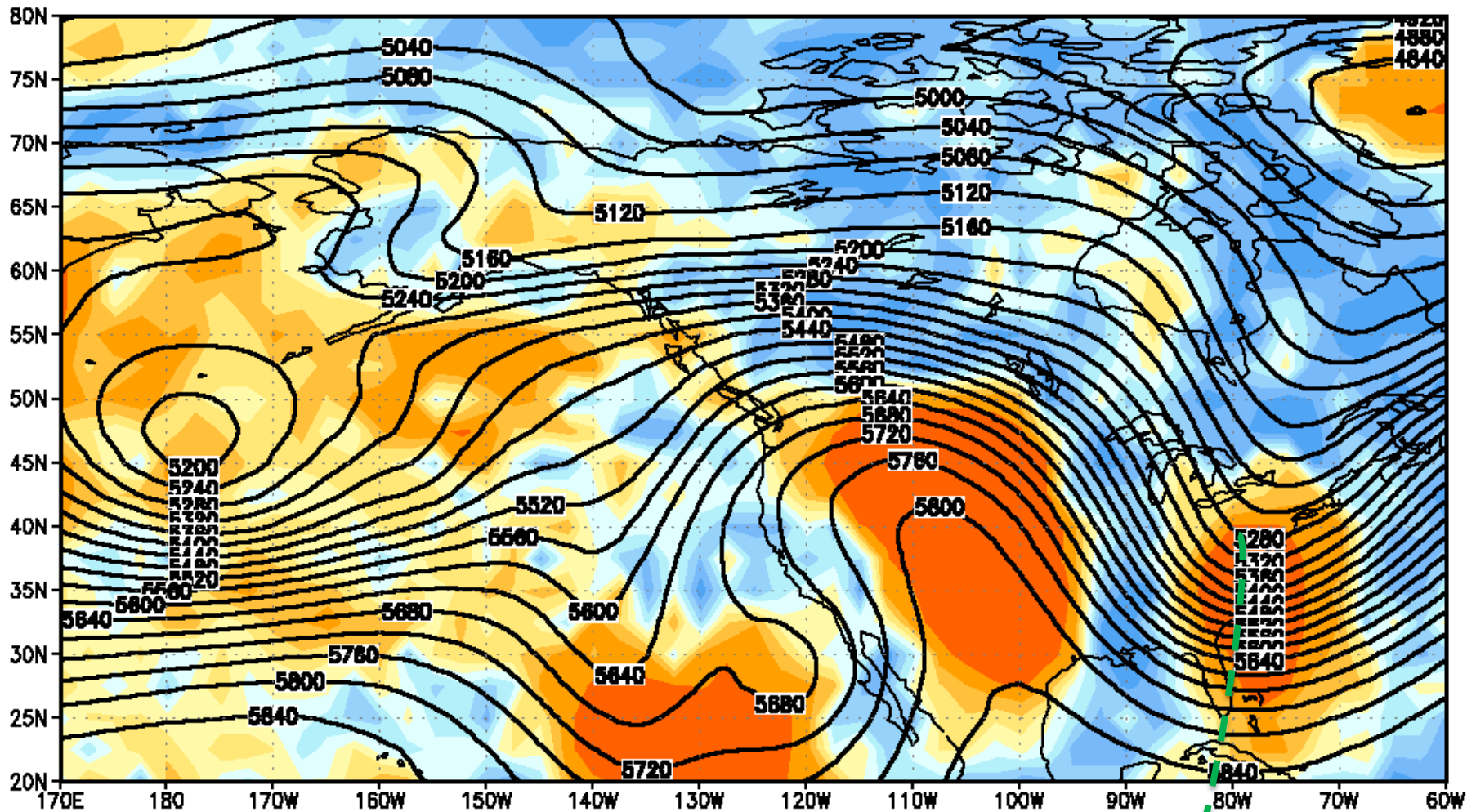
12 14 15 16 18 18 20 23 28 42 79

Measure of predictability (%)

10 20 30 40 50 60 70 80 90

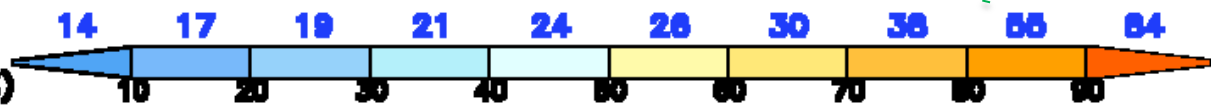
Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012200 valid: 2015012700 fcst: 120 hours



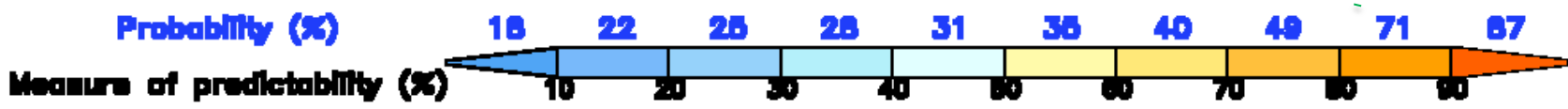
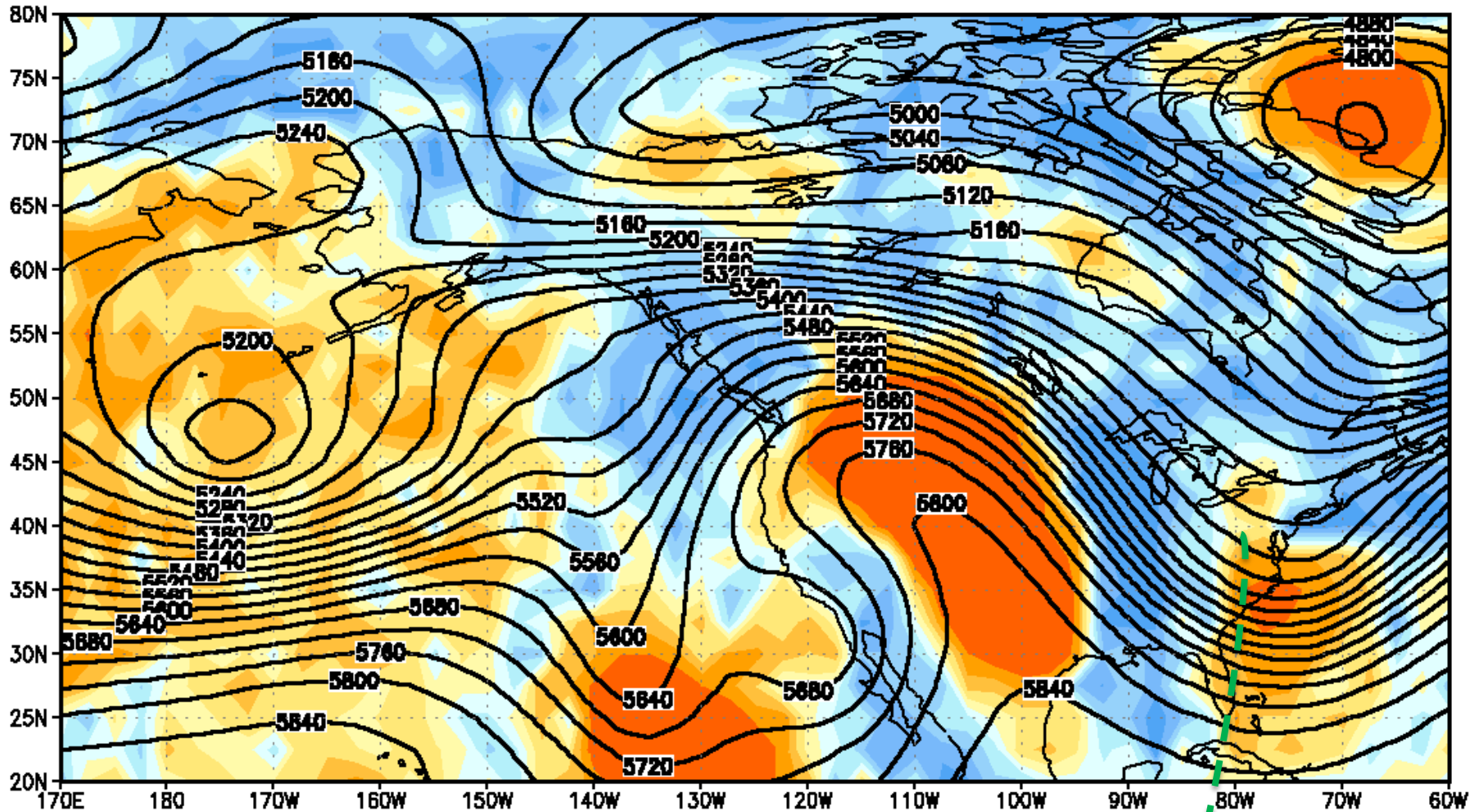
Probability (%)

Measure of predictability (%)



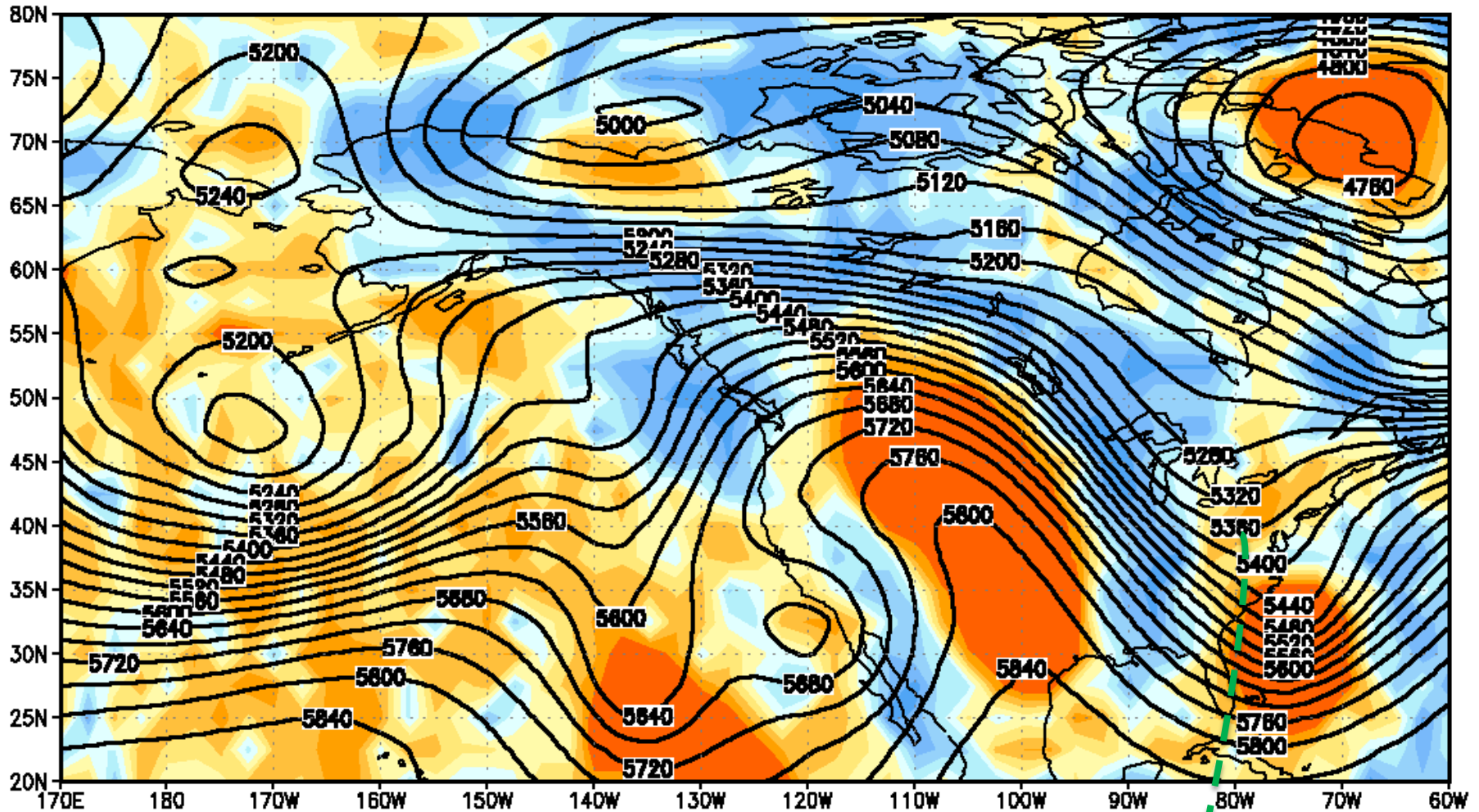
Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012300 valld: 2015012700 fcst: 96 hours



Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012400 valld: 2015012700 fcst: 72 hours



Probability (%)

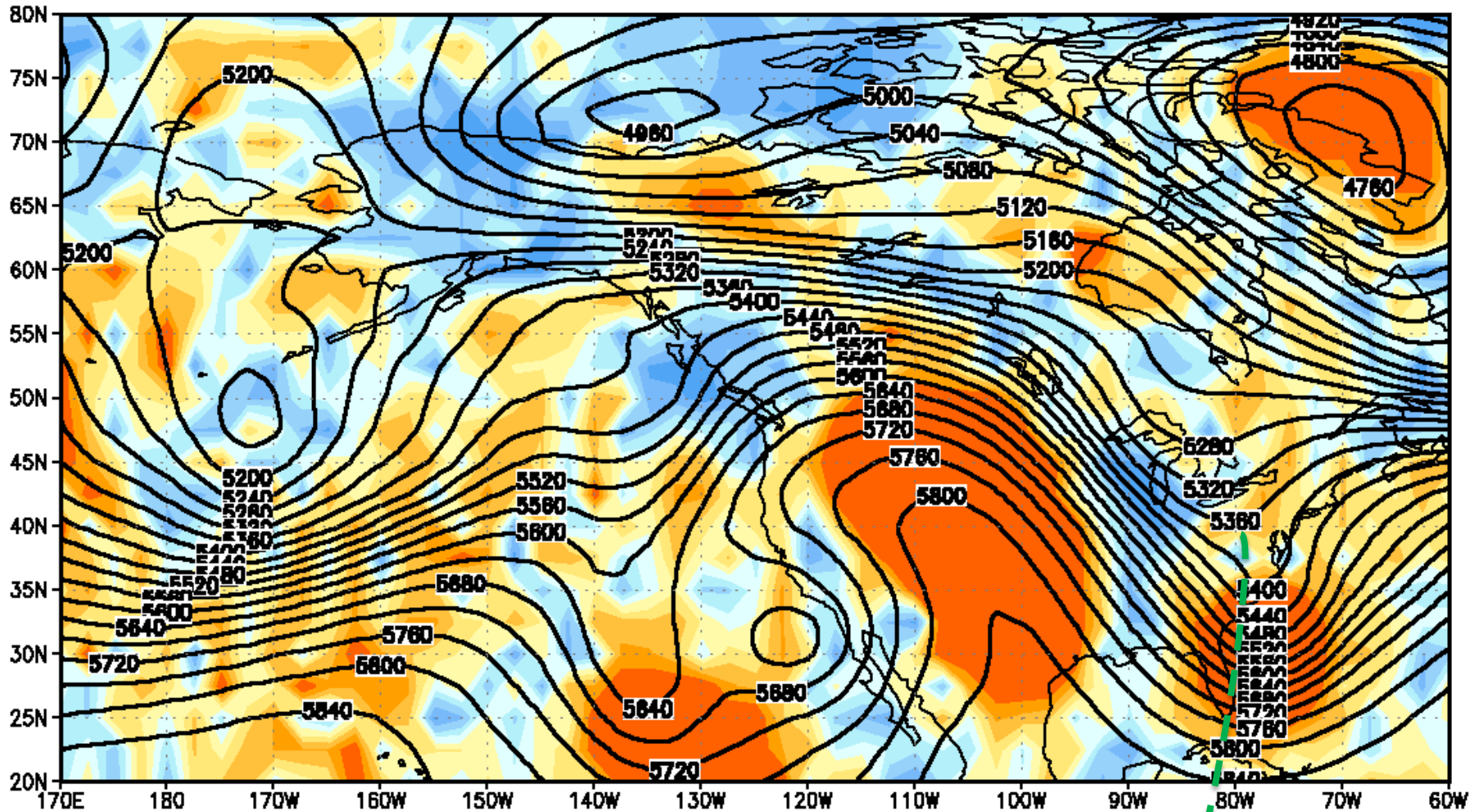
25 31 36 39 43 48 53 64 68 91

Measure of predictability (%)

10 20 30 40 50 60 70 80 90

Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012500 valld: 2015012700 fcst: 48 hours



Probability (%)

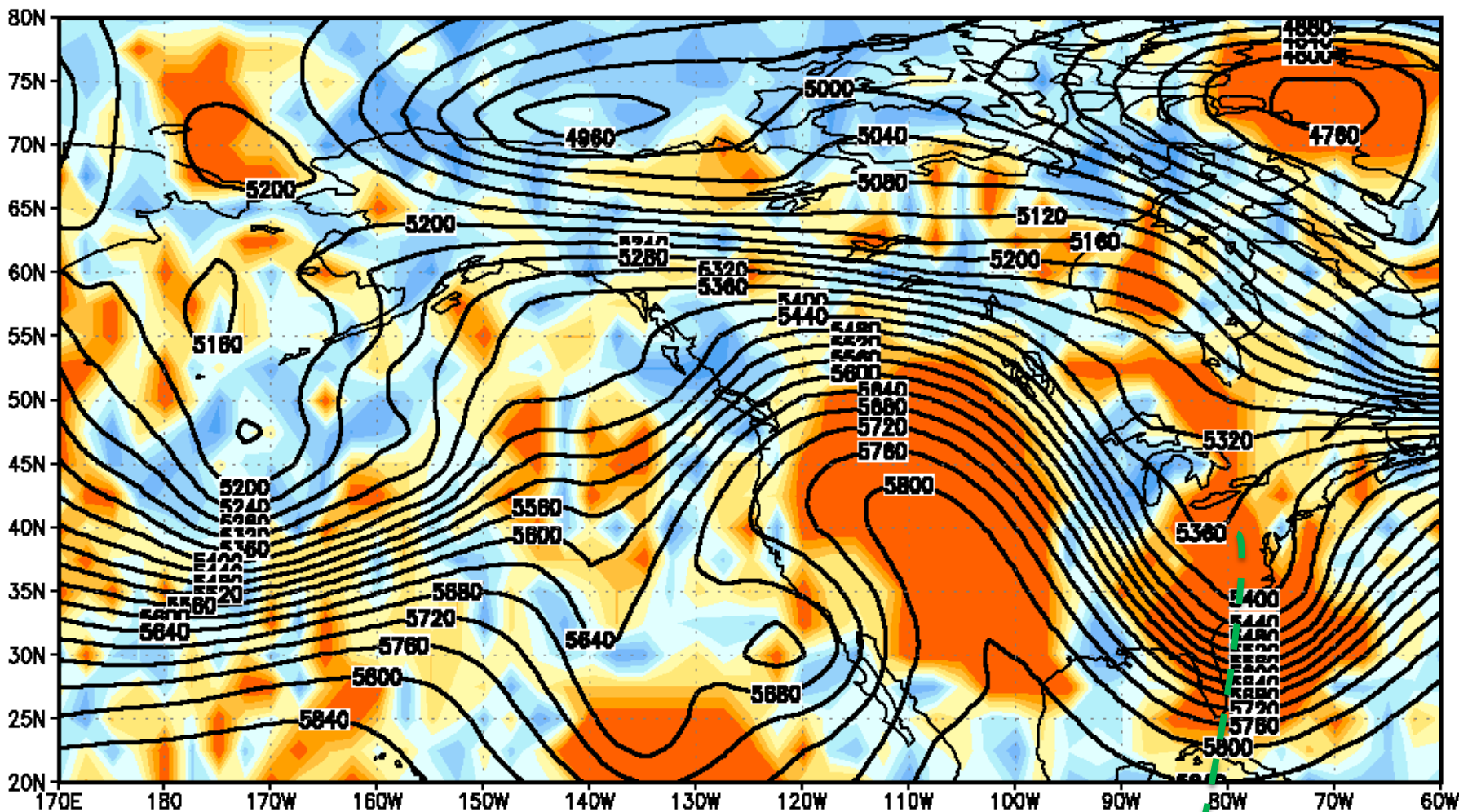
36 44 49 54 59 64 72 84 93 93

Measure of predictability (%)

10 20 30 40 50 60 70 80 90

Relative measure of predictability (colors) for ensemble mean forecast (contours) of 500 hPa height

Inl: 2015012600 valid: 2015012700 fcst: 24 hours



Probability (%)

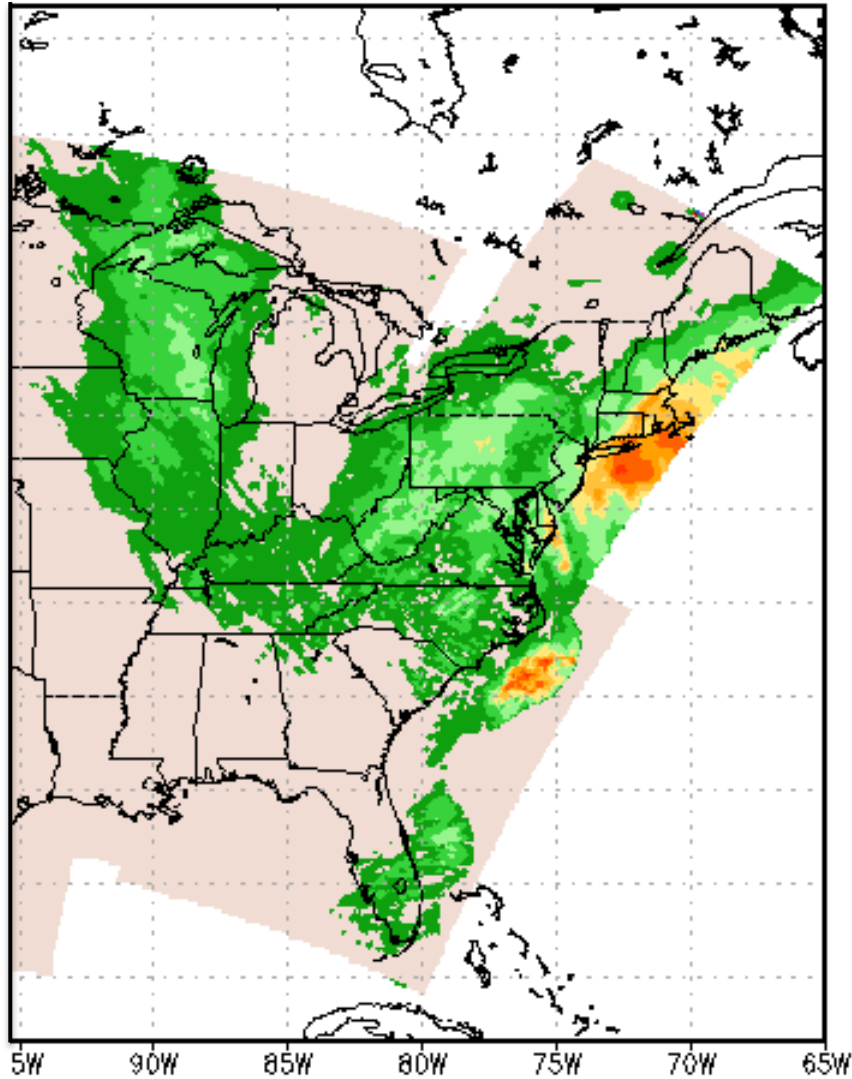
49 63 68 74 79 85 90 95 95 95

Measure of predictability (%)

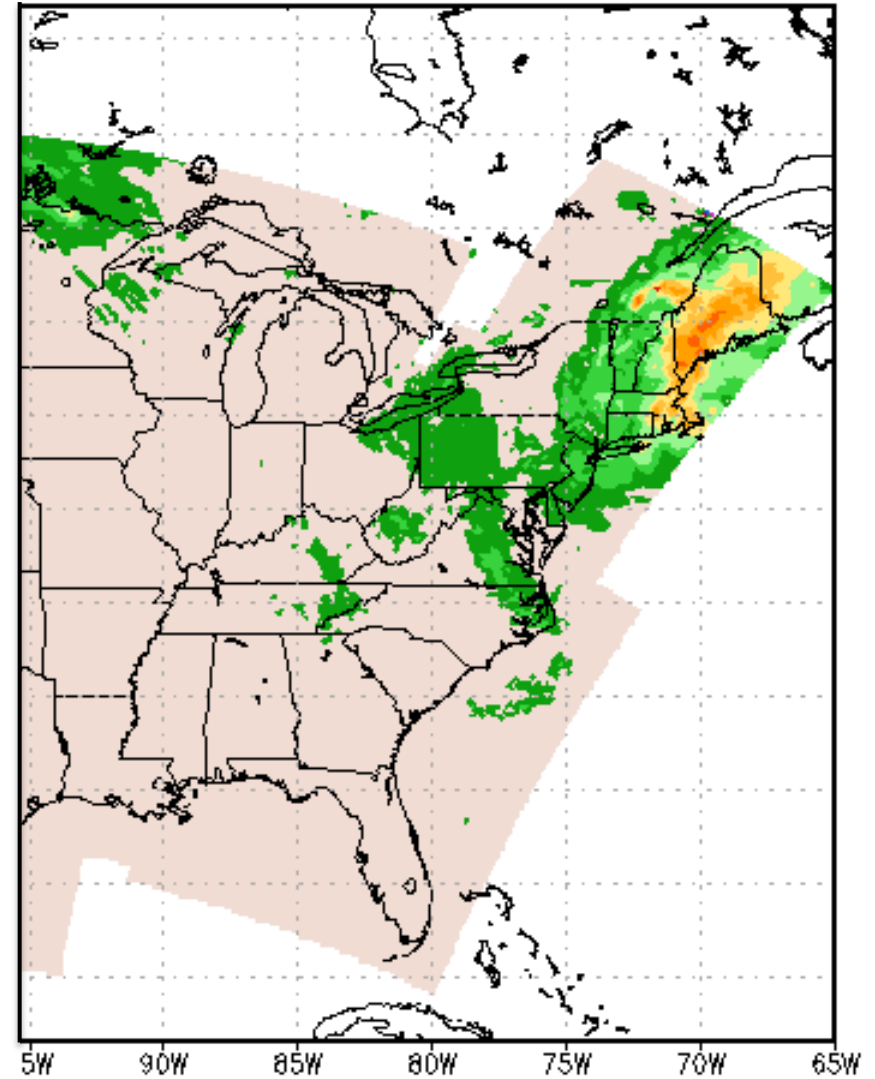
10 20 30 40 50 60 70 80 90

CCPA 24 hours accumulation (mm)

ENDING 12 UTC 20150127



ENDING 12 UTC 20150128



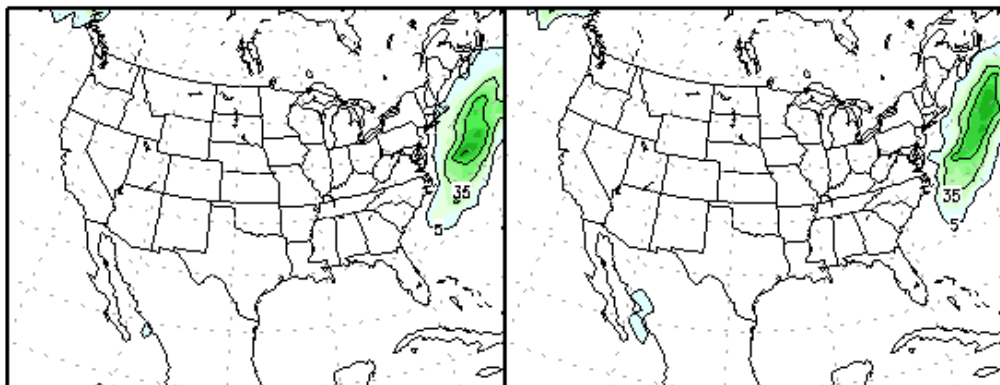
Ensemble Based Probabilistic Quantitative Precipitation Forecast (PQPF)

Valid: 2015012612 – 2015012712 Amount 24hr >25.4mm (1 inch)

Initial Time

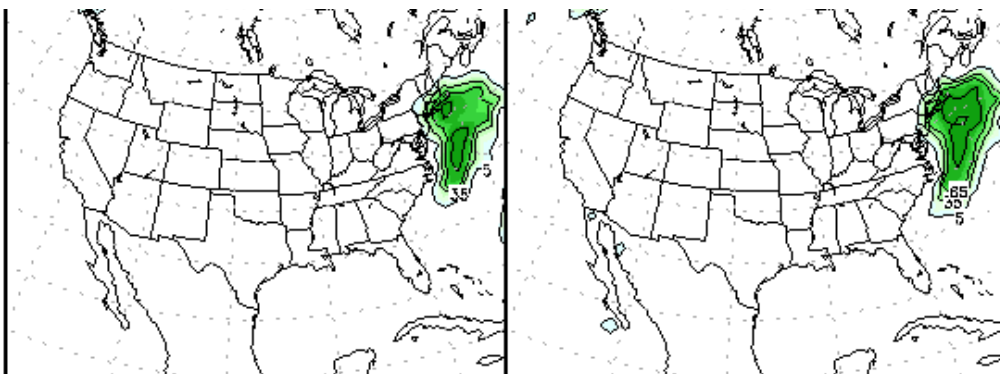
2015012400

60-84 hr fcst



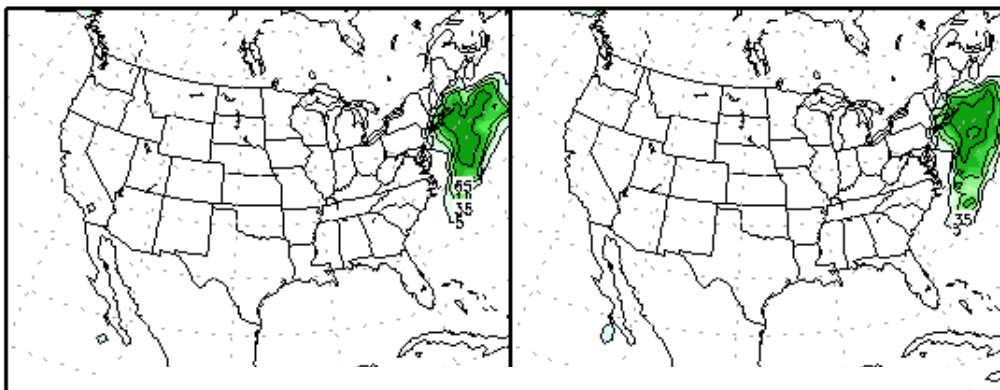
2015012500

36-60 hr fcst

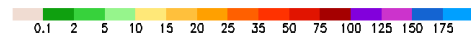
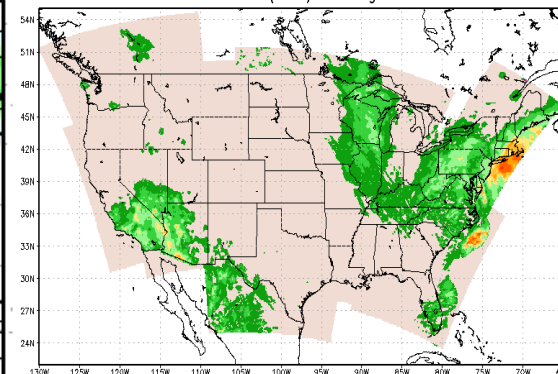


2015012600

12-36 hr fcst



CCPA 24h Accum (mm) Ending 2015012712



NCEP GEFS
PROD/PARA
Forecast difference

PROD

PARA



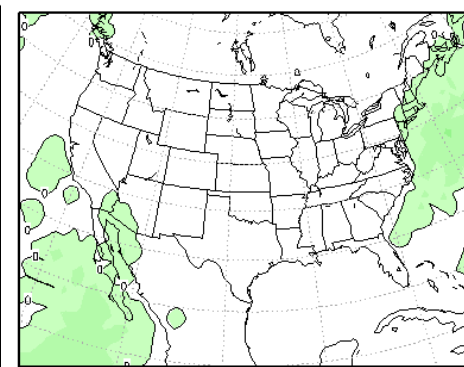
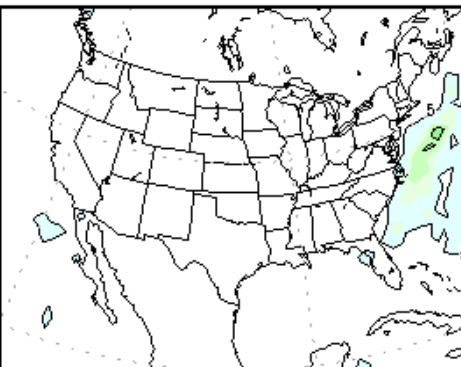
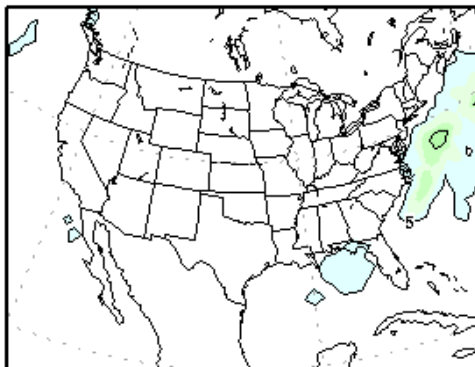
Ensemble Based Probabilistic Quantitative Precipitation Forecast (PQPF)

Valid: 2015012612 – 2015012712 Amount 24hr >25.4mm (1 inch)

Initial Time

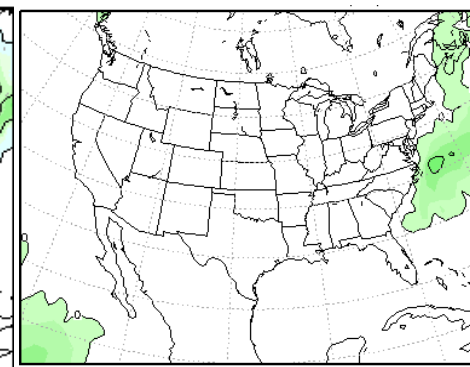
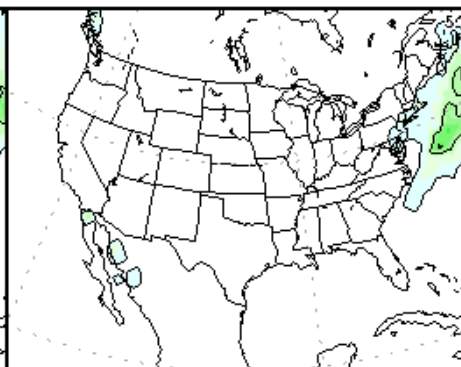
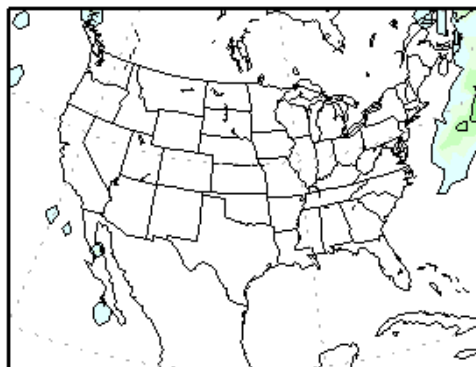
2015012100

132–156 hr fcst



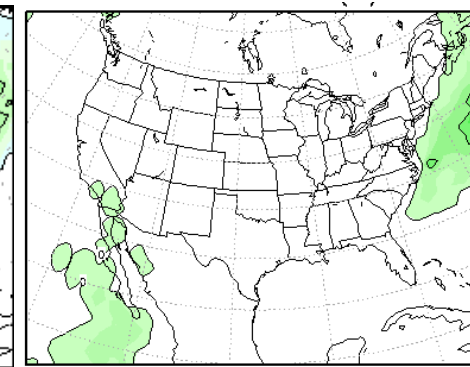
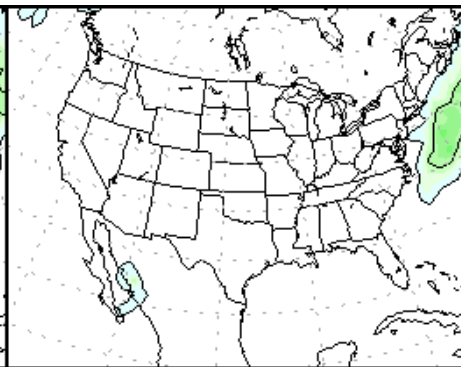
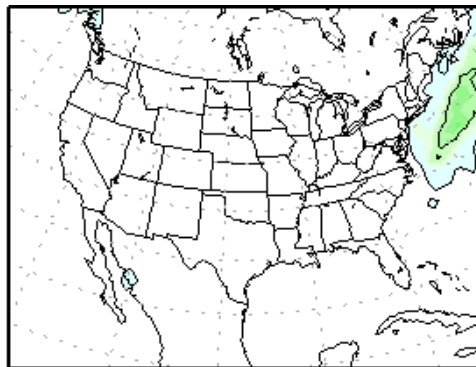
2015012200

108–132 hr fcst



2015012300

84–108 hr fcst



PROD

PARA

ECMWF

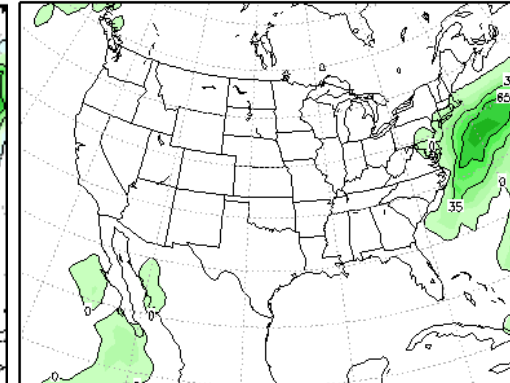
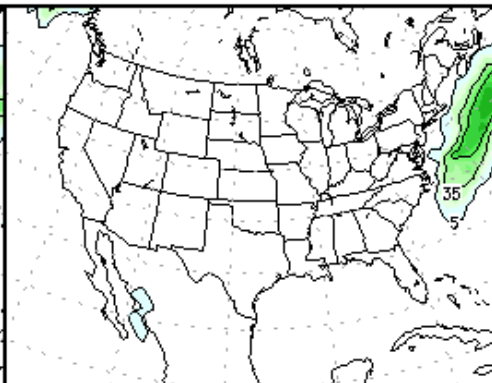
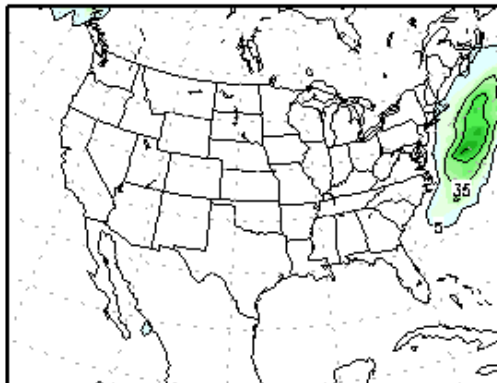
Ensemble Based Probabilistic Quantitative Precipitation Forecast (PQPF)

Valid: 2015012612 – 2015012712 Amount 24hr >25.4mm (1 inch)

Initial Time

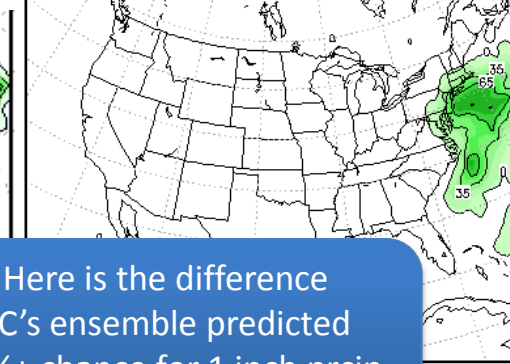
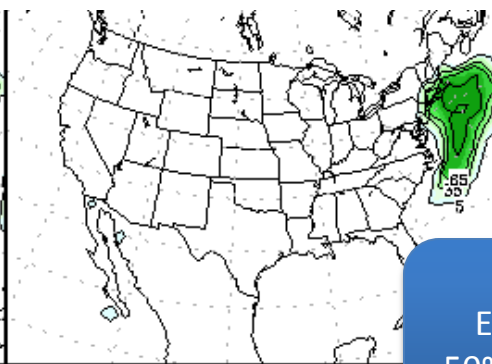
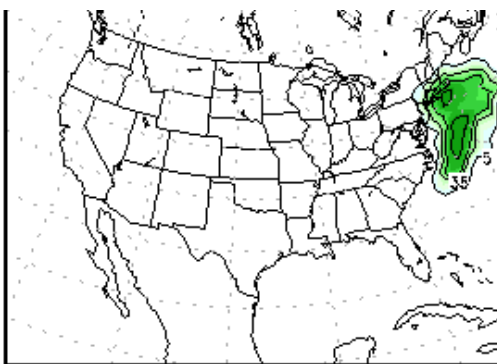
2015012400

60-84 hr fcst



2015012500

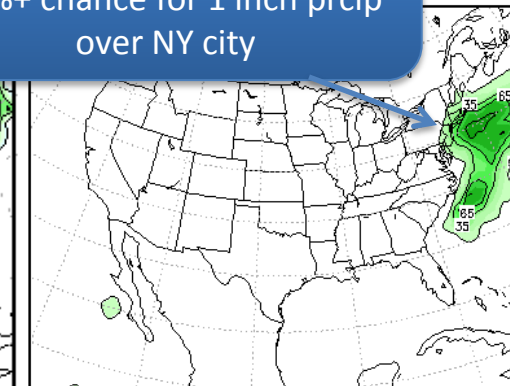
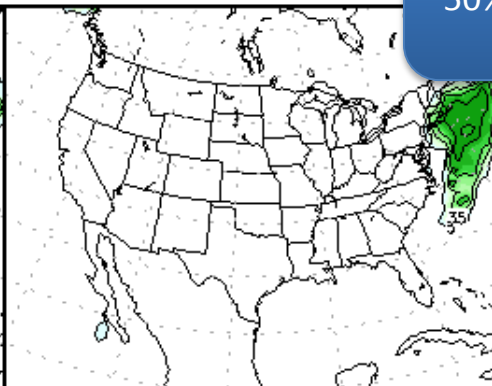
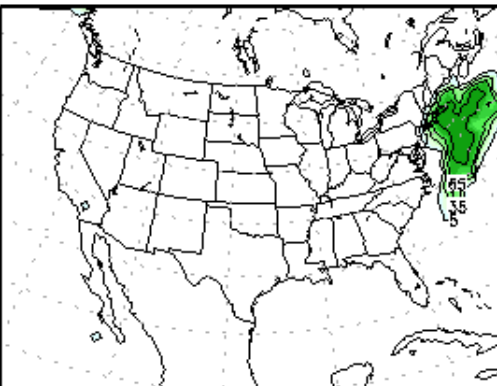
36-60 hr fcst



Here is the difference
EC's ensemble predicted
50%+ chance for 1 inch prcip
over NY city

2015012600

12-36 hr fcst



PROD

PARA

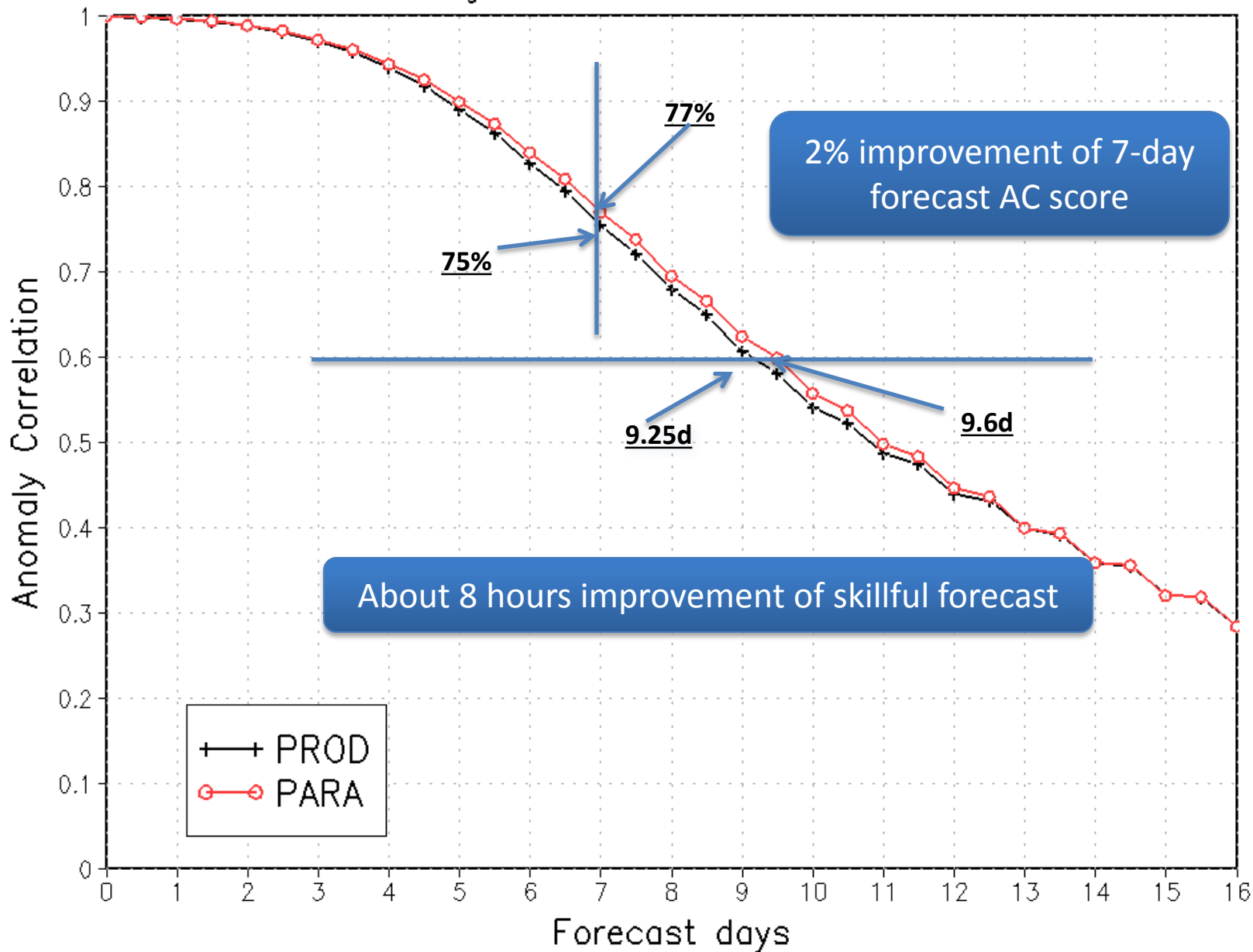
ECMWF

Evaluation for next GEFS

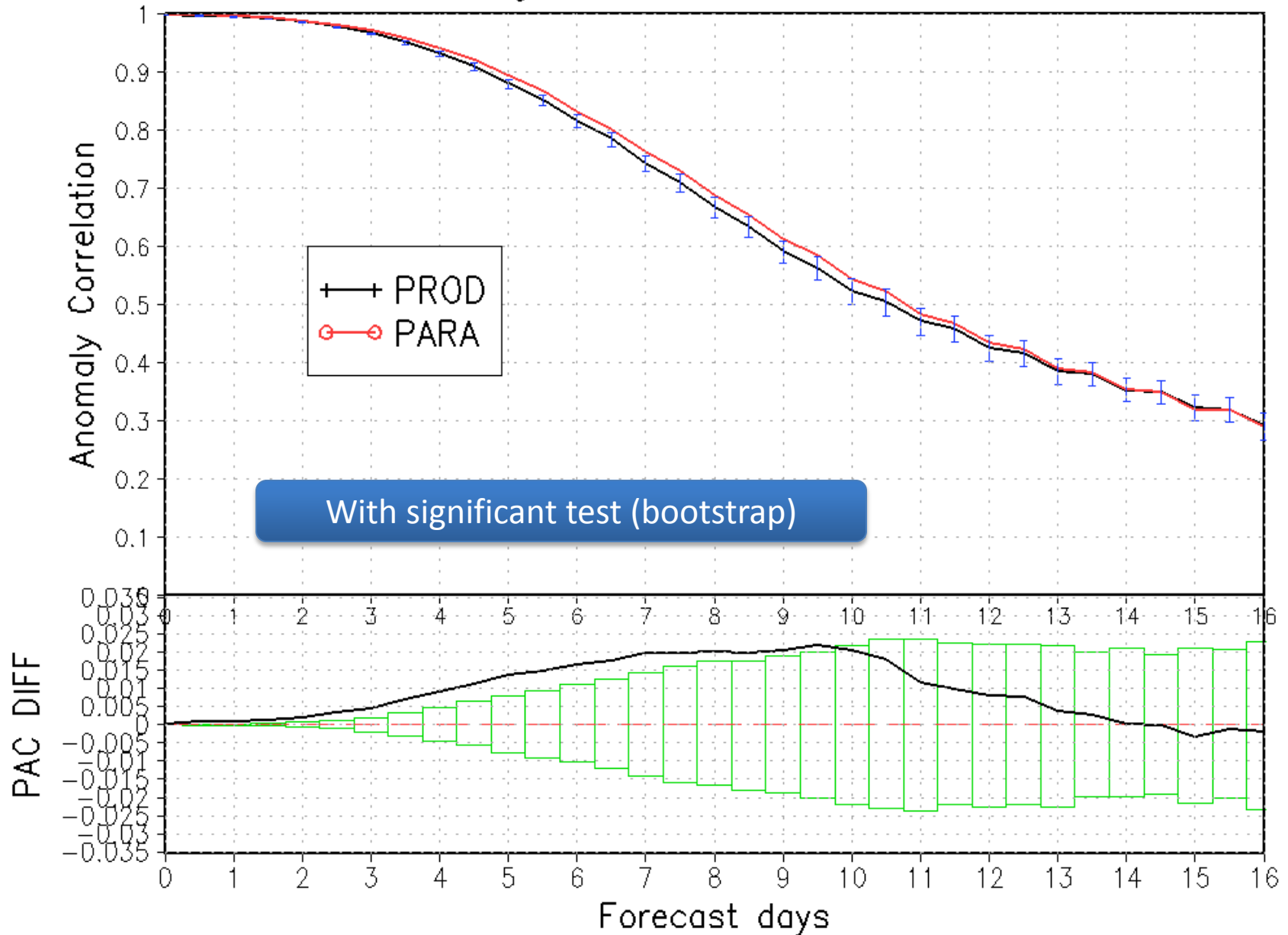
- Based on one-year (plus) retrospective runs
 - Upper atmosphere
 - Near surface
 - Precipitation
 - TC track
- Based on 18 year ensemble control only reforecasts
 - Upper atmosphere
 - Near surface

409 cases

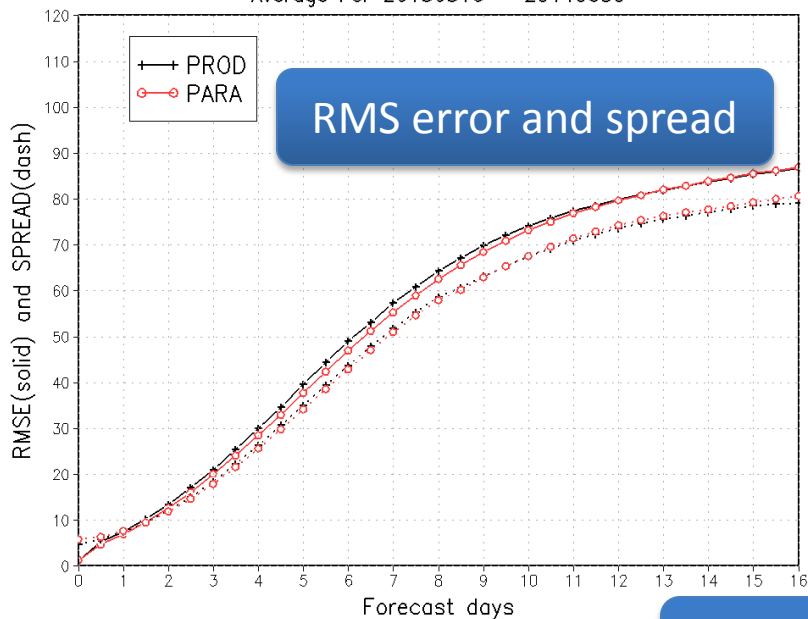
Northern Hemisphere 500hPa Height
Ensemble Mean Anomaly Correlation
Average For 20130516 – 20140630



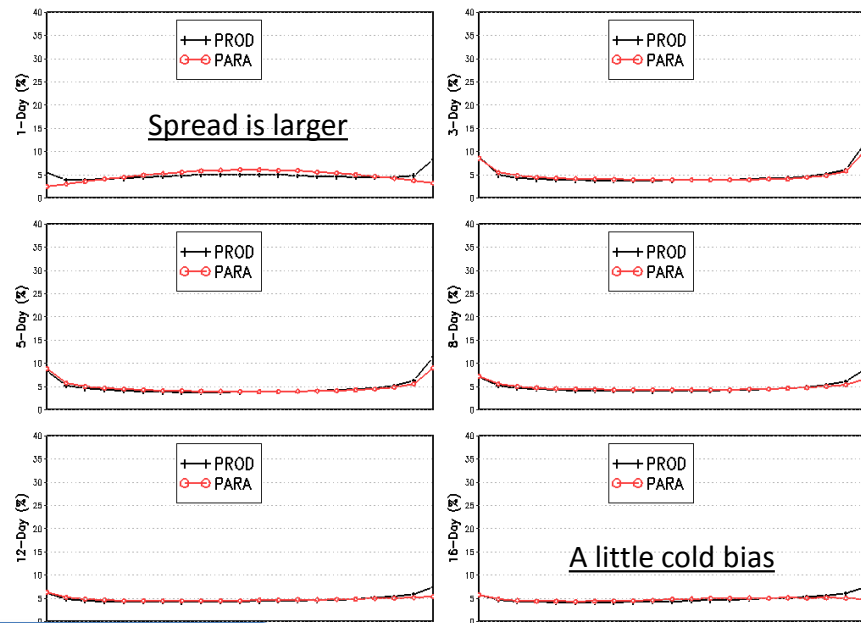
Northern Hemisphere 500hPa Height
Ensemble Mean Anomaly Correlation
Average For 20130516 – 20131031



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

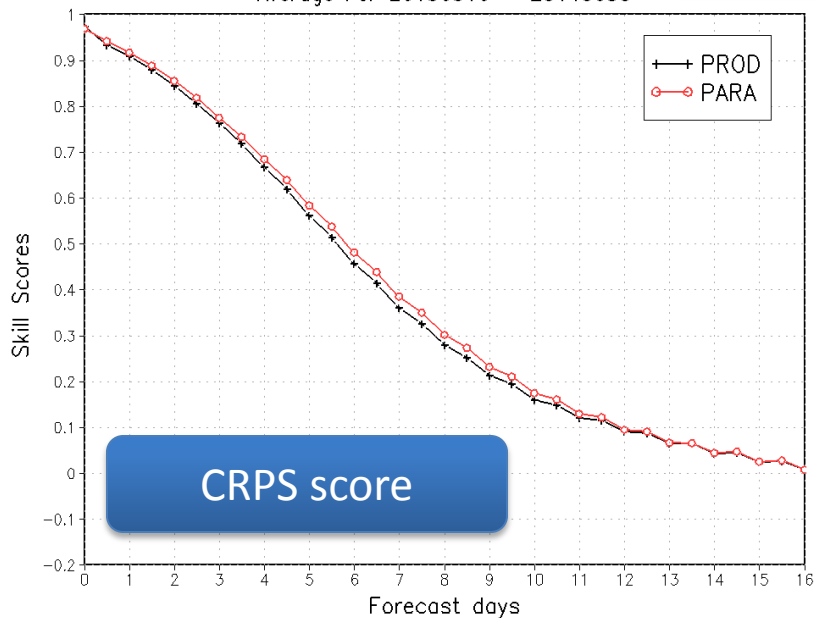


Northern Hemisphere 500hPa Height Histogram Distribution
Average For 20130516 – 20140630

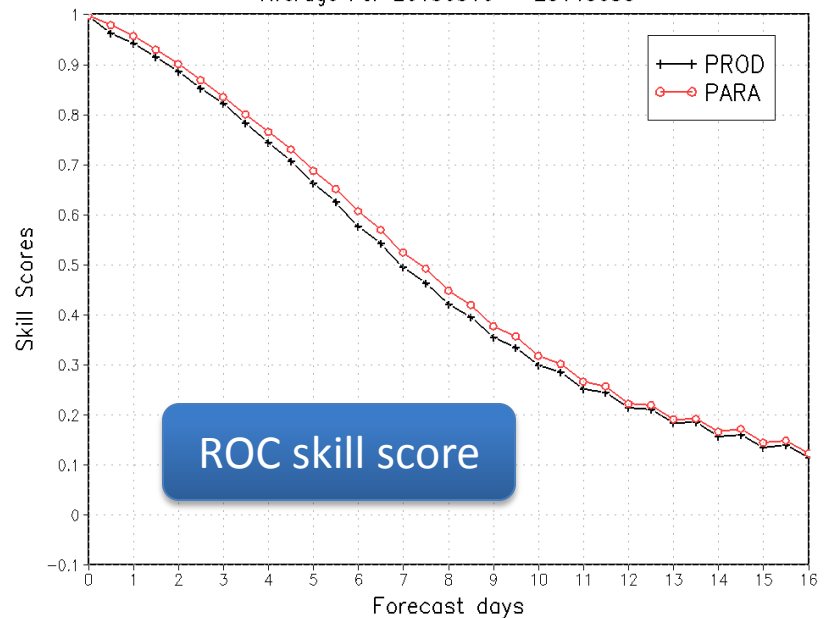


NH 500hPa height

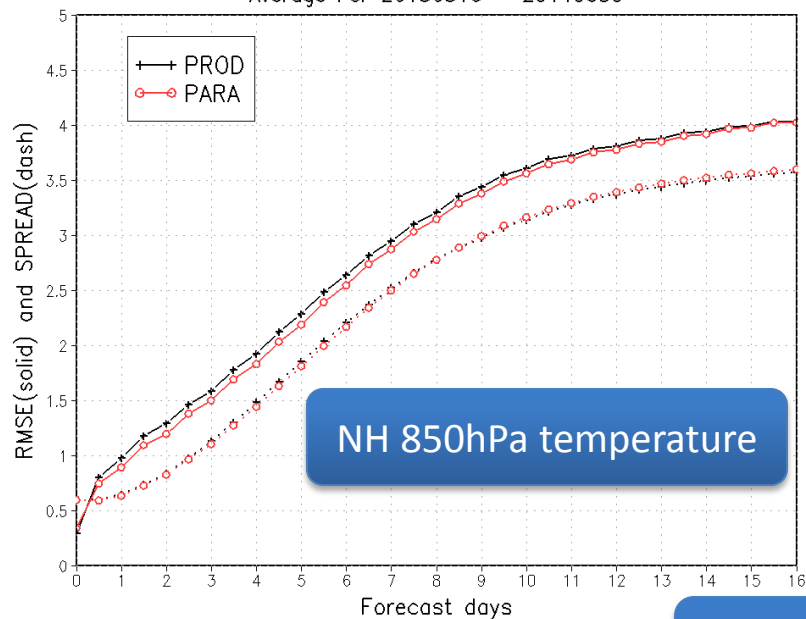
Northern Hemisphere 500hPa Height
Continuous Ranked Probability Skill Scores
Average For 20130516 – 20140630



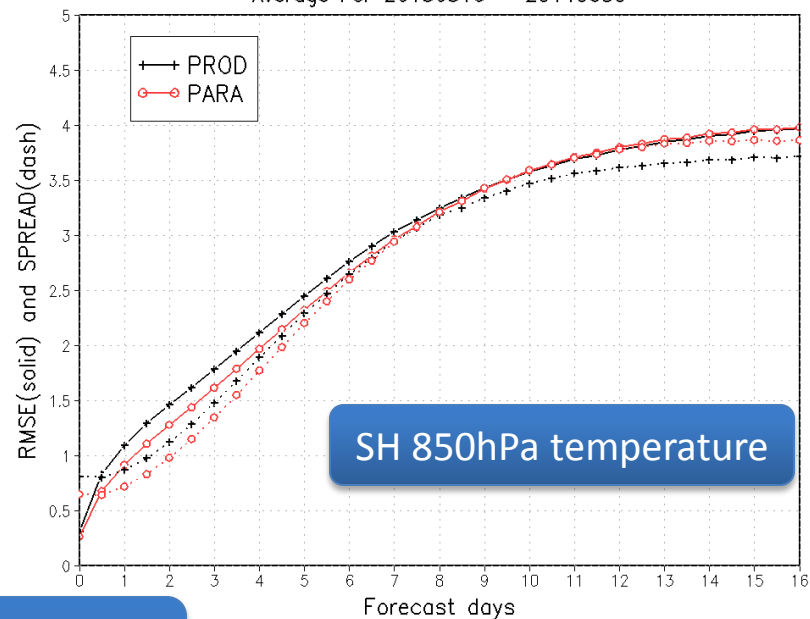
Northern Hemisphere 500hPa Height
ROC area (0-1)
Average For 20130516 – 20140630



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

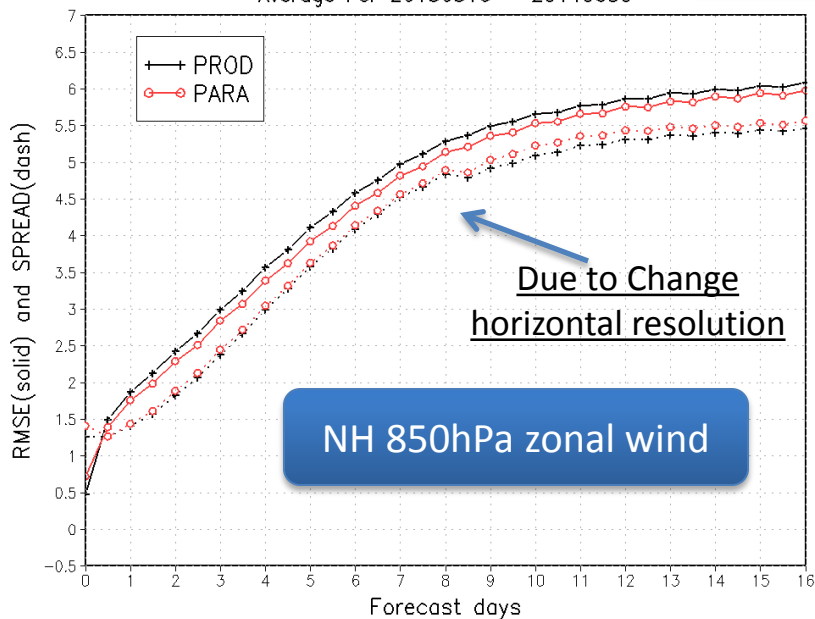


Southern Hemisphere 850hPa Temp.
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20130516 – 20140630

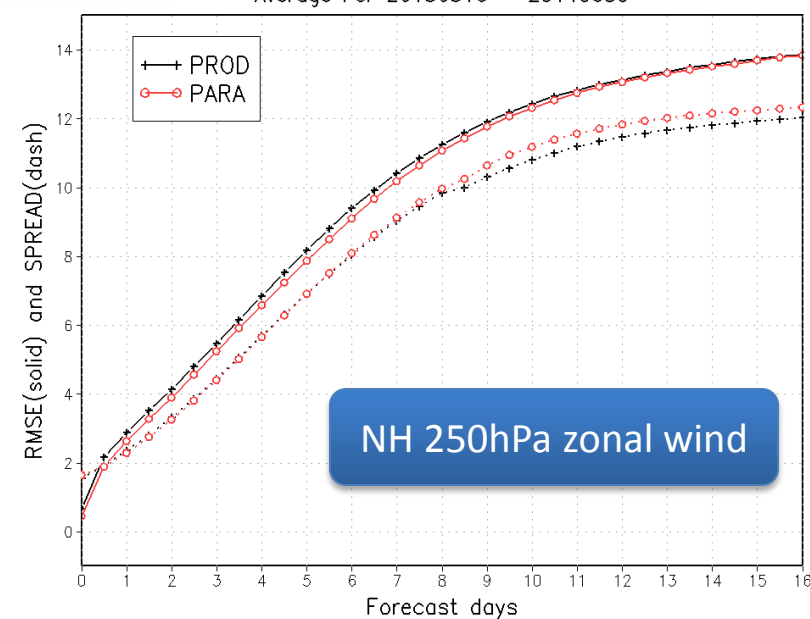


RMS error and spread

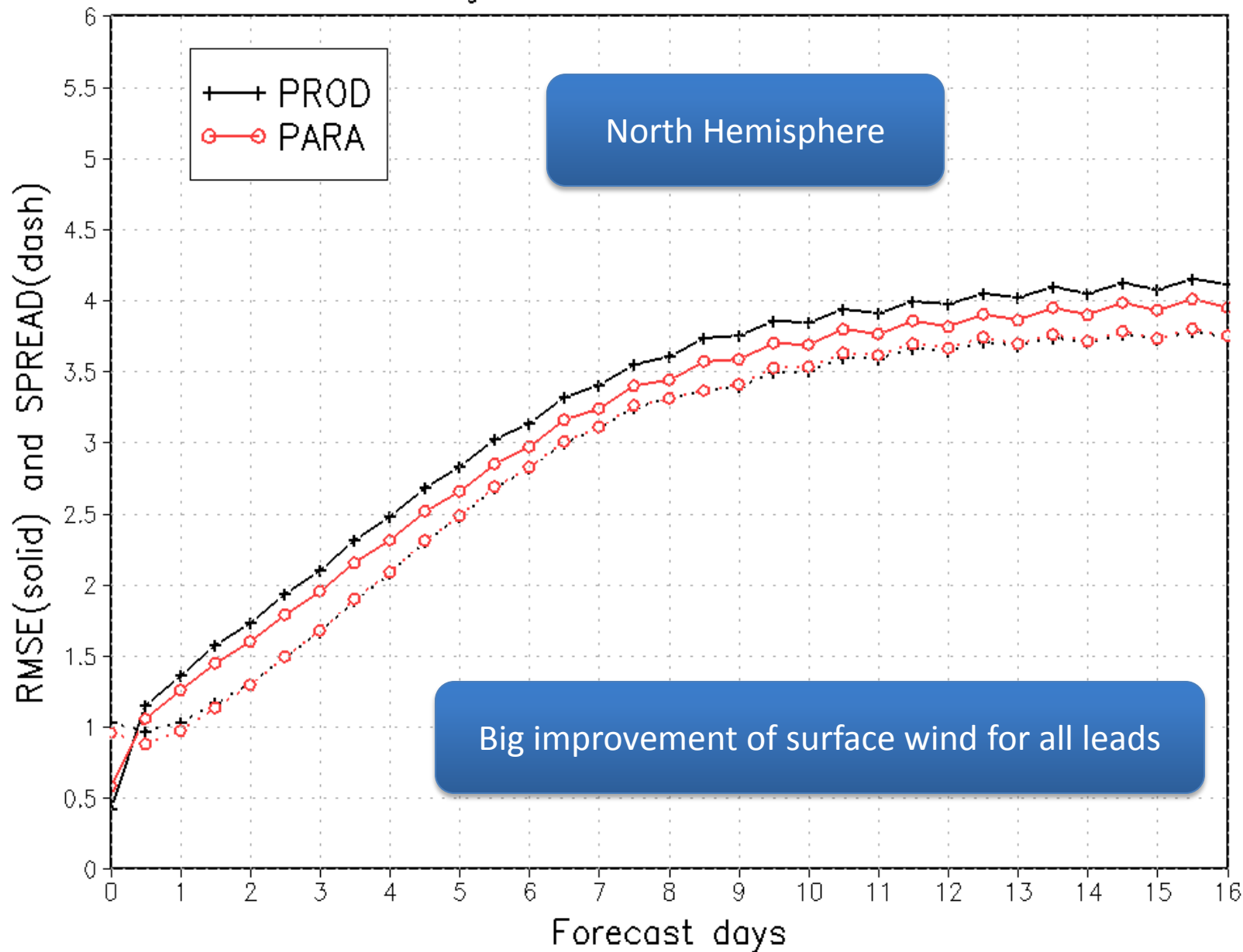
Northern Hemisphere 850hPa U.
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20130516 – 20140630



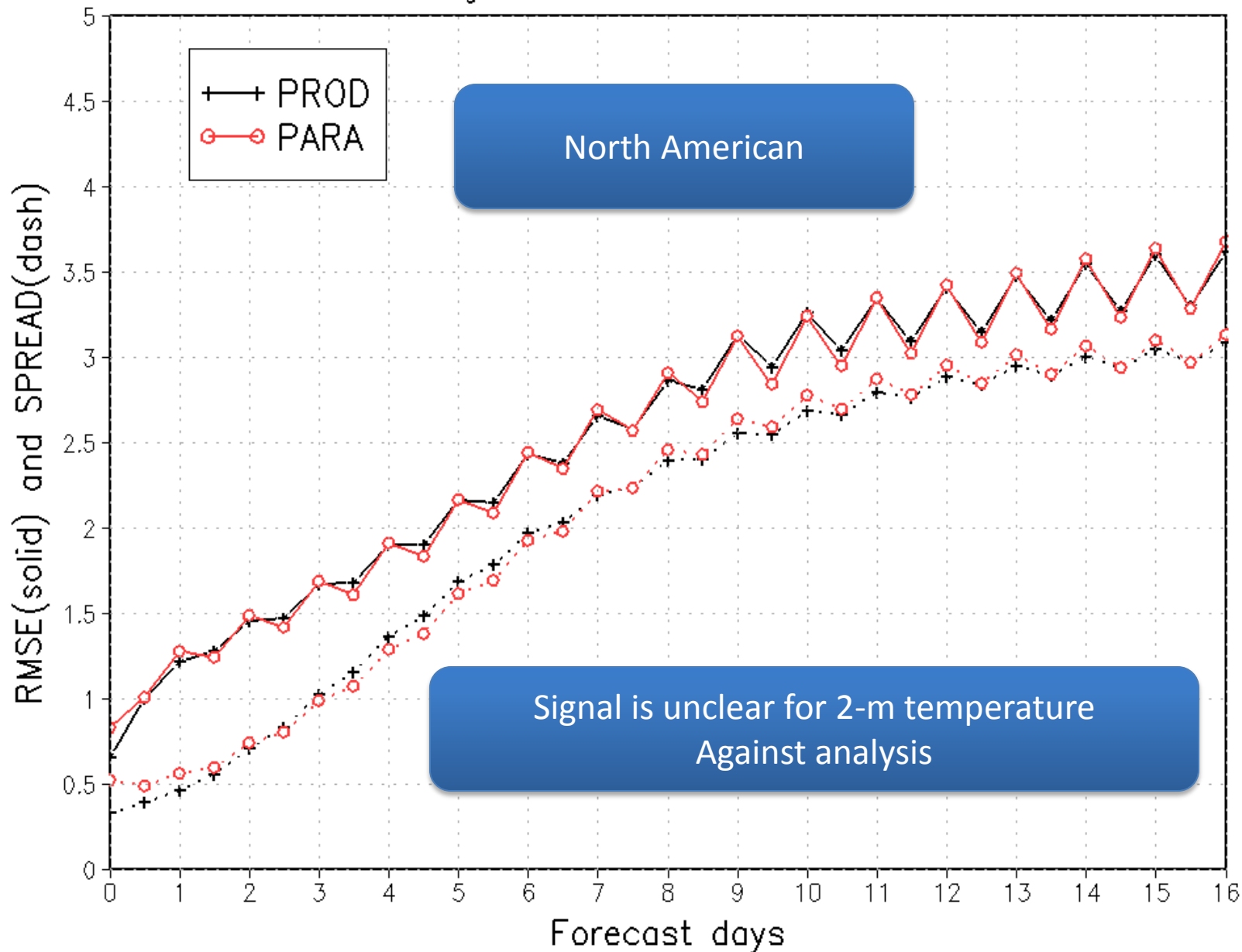
Northern Hemisphere 250hPa U.
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20130516 – 20140630



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



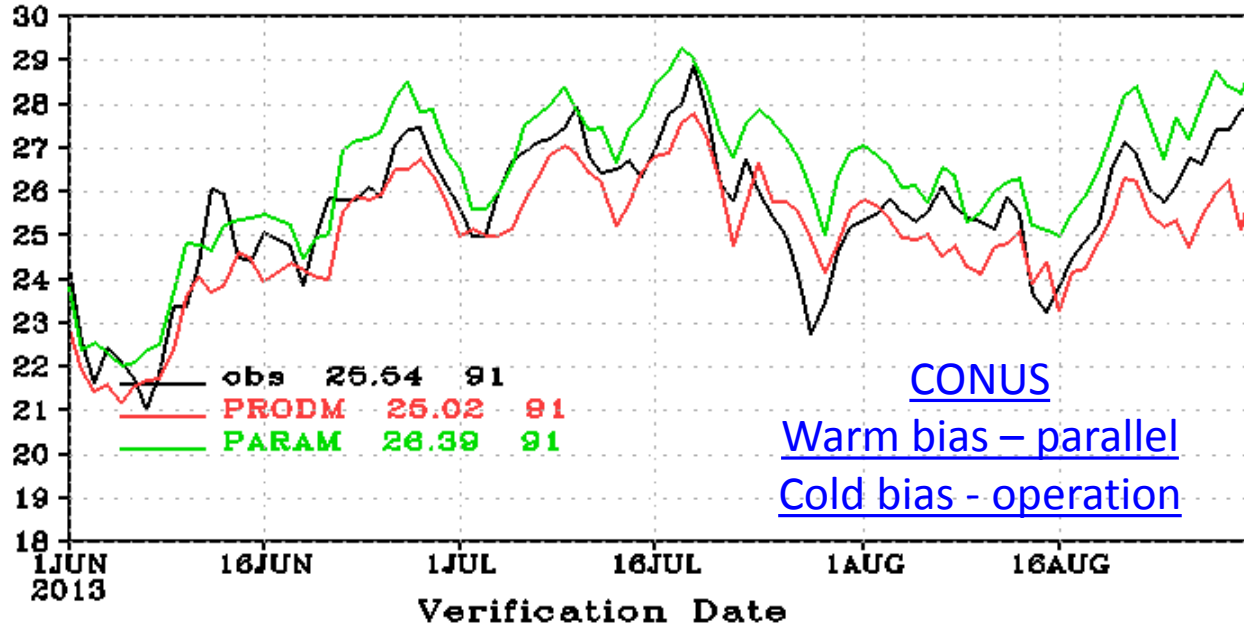
North American 2 Meter Temp.
Ensemble Mean RMSE and Ensemble SPREAD
Average For 20130516 – 20140630



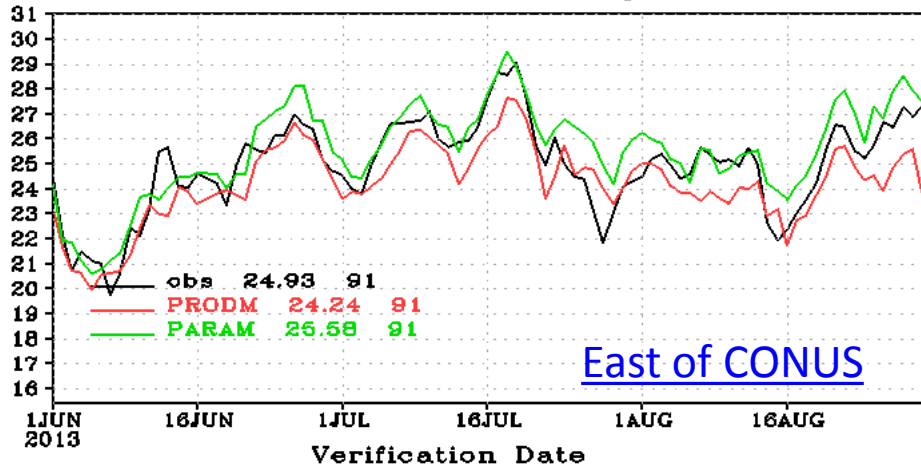
2-meter temperature evaluation against observation

(6 days – 144 hrs forecast)

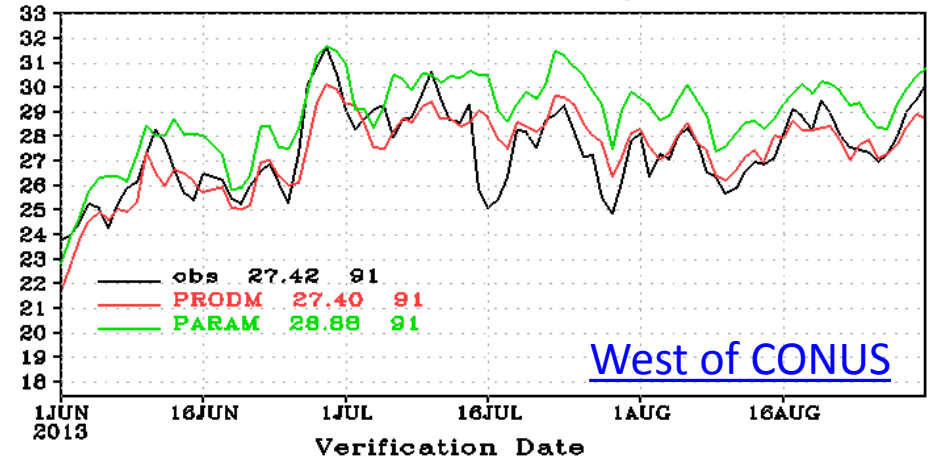
T SFC, CONUS, 00Z cycle, fh144



T SFC, CONUS East, 00Z cycle, fh144



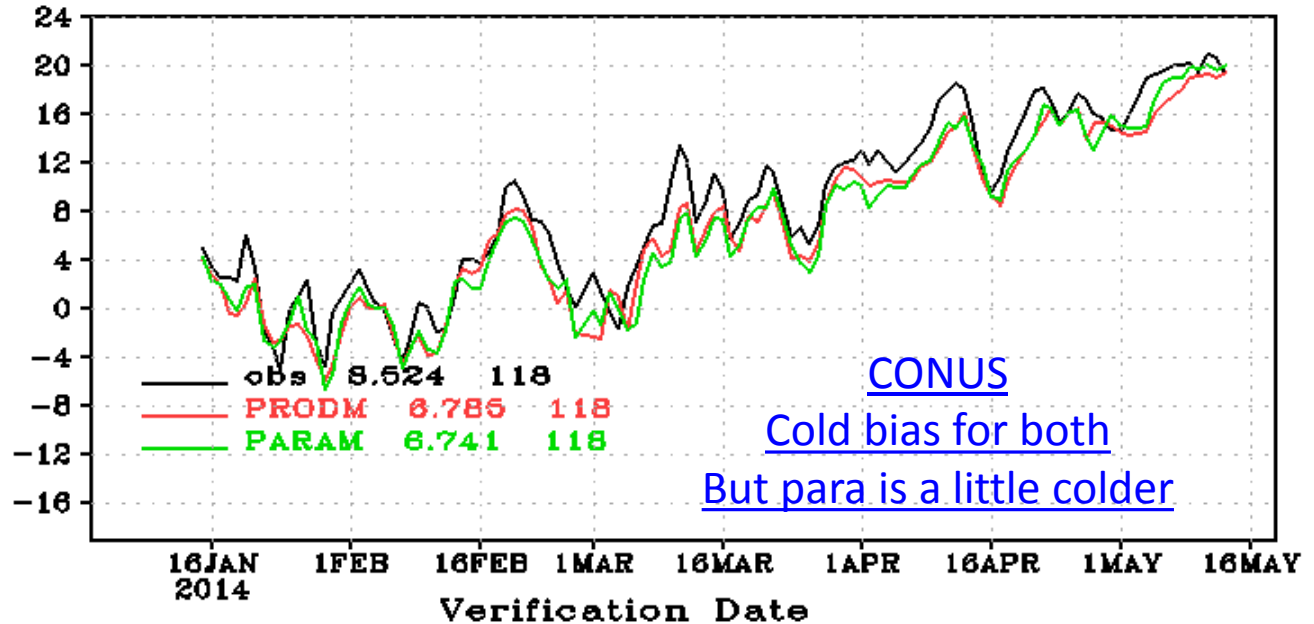
T SFC, CONUS West, 00Z cycle, fh144



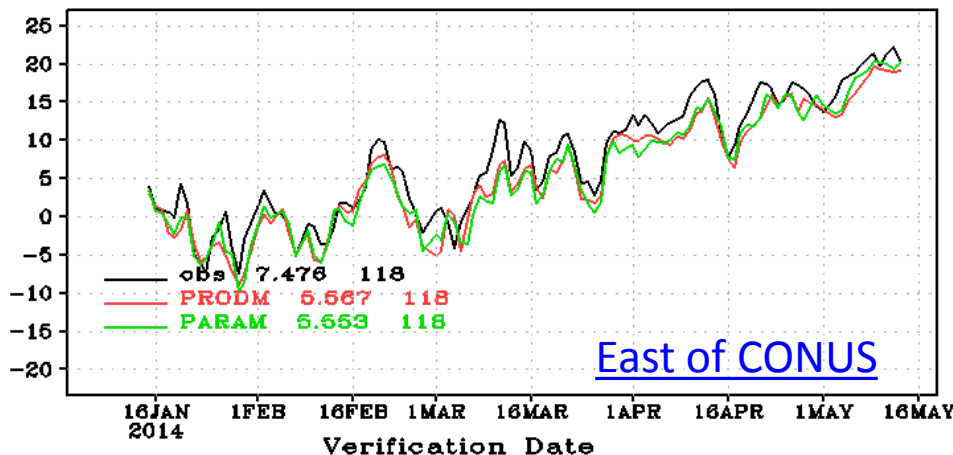
2-meter temperature evaluation against observation

(6 days – 144 hrs forecast)

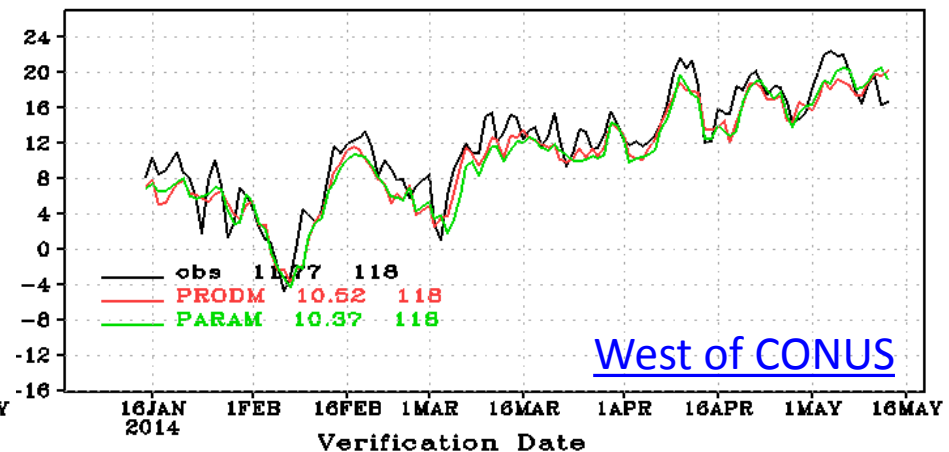
T SFC, CONUS, 00Z cycle, fh144



T SFC, CONUS East, 00Z cycle, fh144

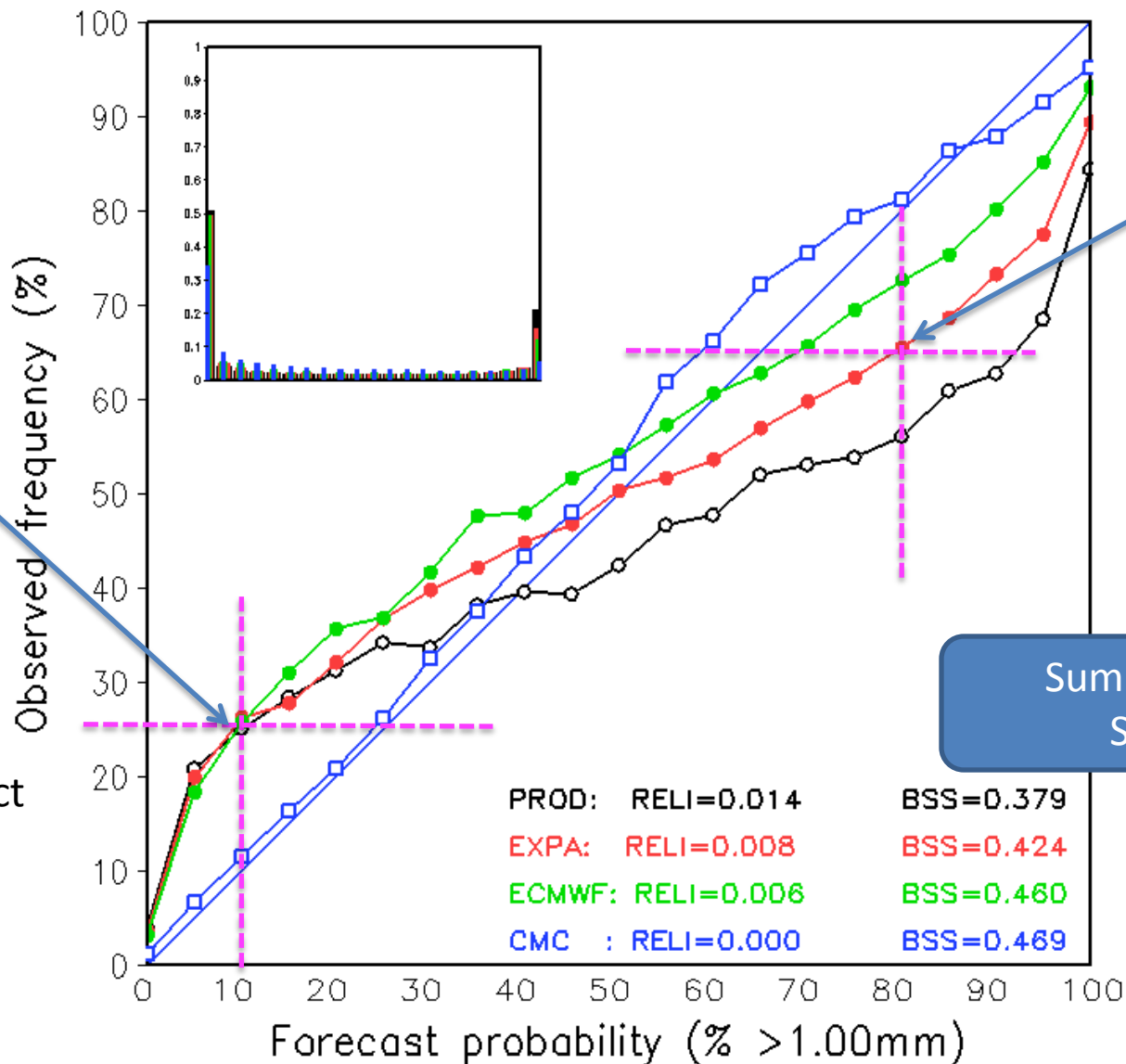


T SFC, CONUS West, 00Z cycle, fh144



Reliability Diagram

fhr 12-36 For 20130516 - 20131031



80% <-> 65%

Summer-Fall 2013
Six months

10% <-> 25%

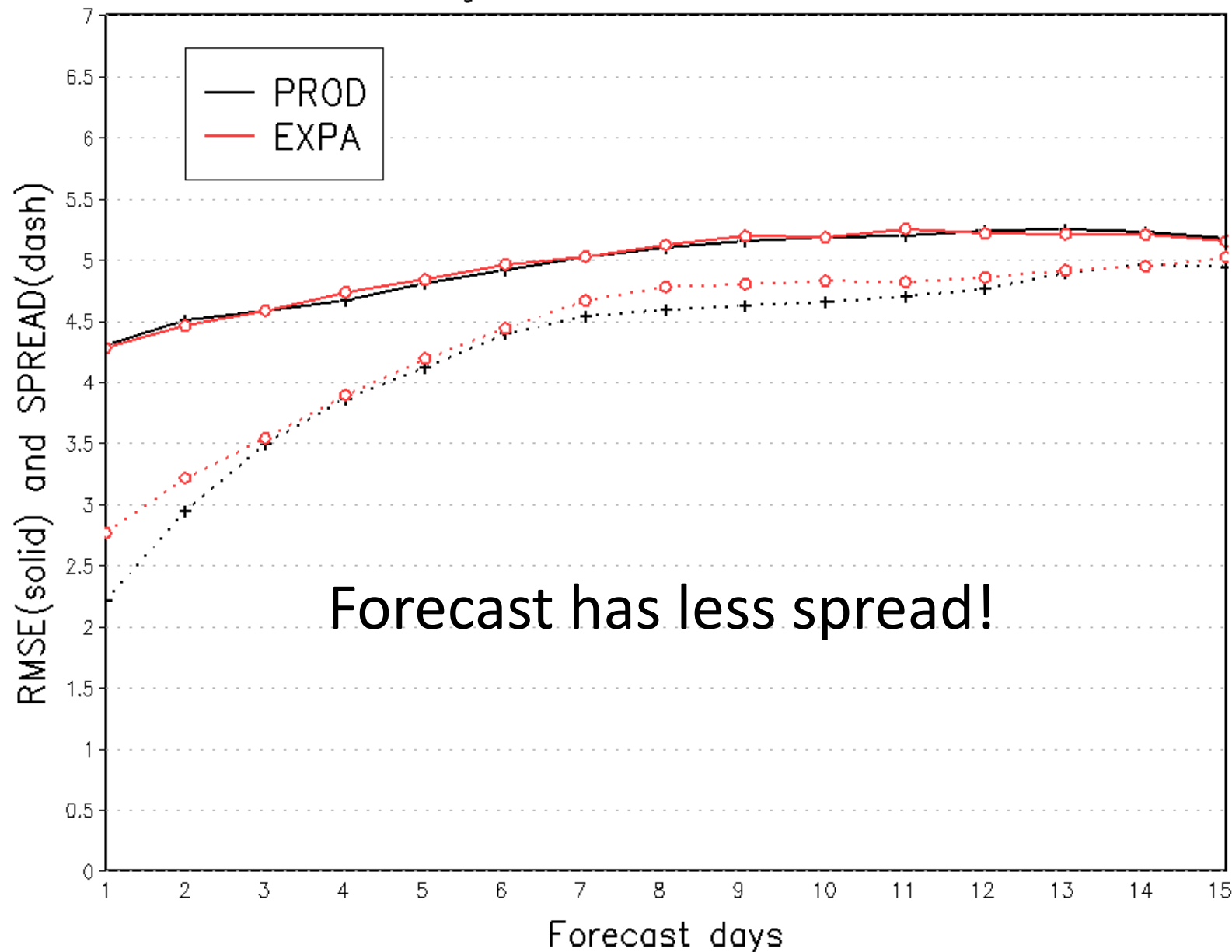
e.g. we predict
100 10% QPF,
but happens
25/100

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

Unreliable - Why???

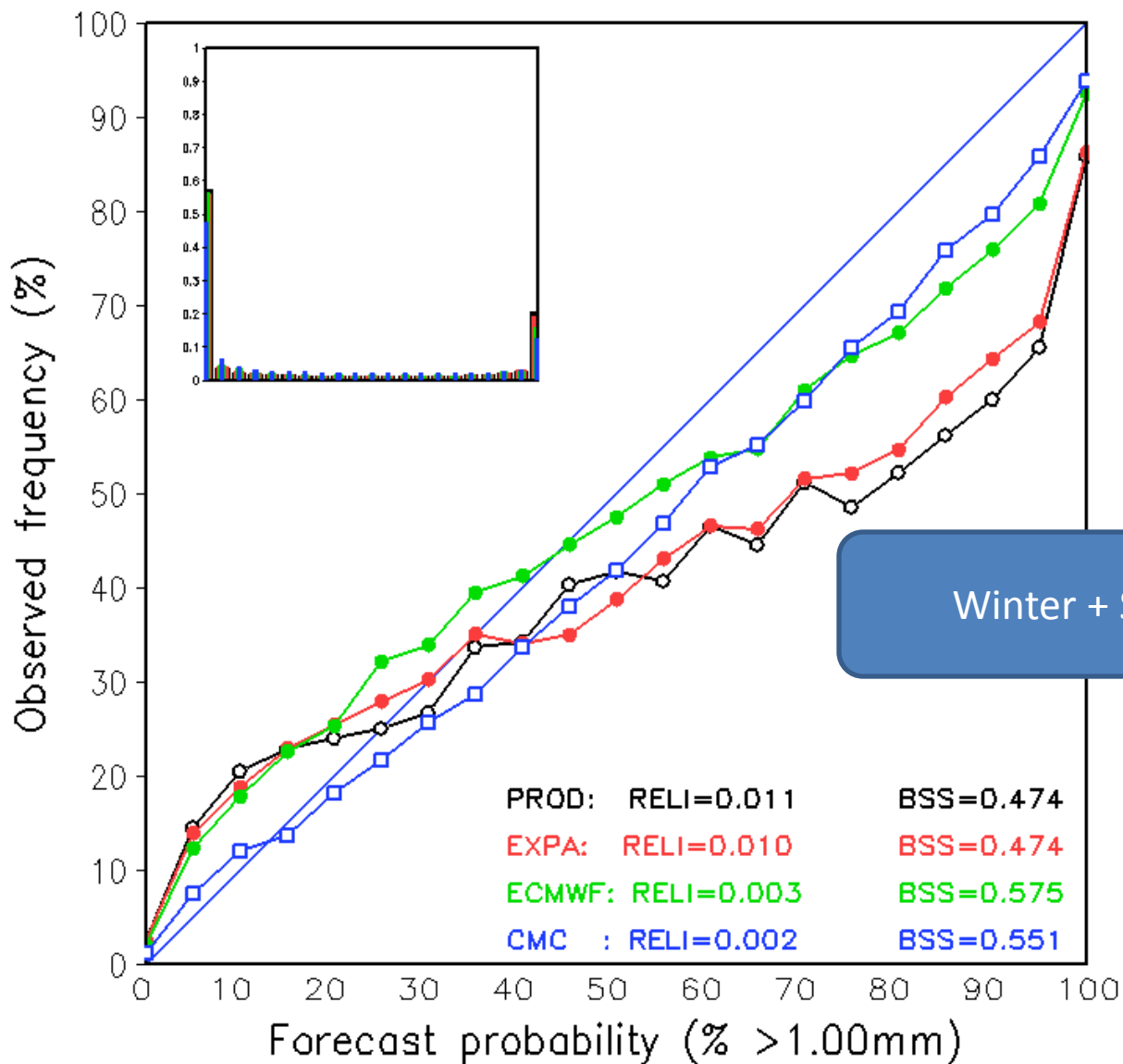
- Ensemble is under-dispersion (less spread)
 - Model is not perfect
 - Single model ensemble
- How to improve?
 - Improve our model
 - Introduce stochastic perturbations for convection
 - Introduce stochastic parameterization
 - Calibration
 - ??? Multi-model or multi-physics ???

Ensemble Precipitation Verification for CONUS
RMSE and SPREAD
Average For 20130516 - 20131031



Reliability Diagram

fhr 12-36 For 20140102 - 20140507

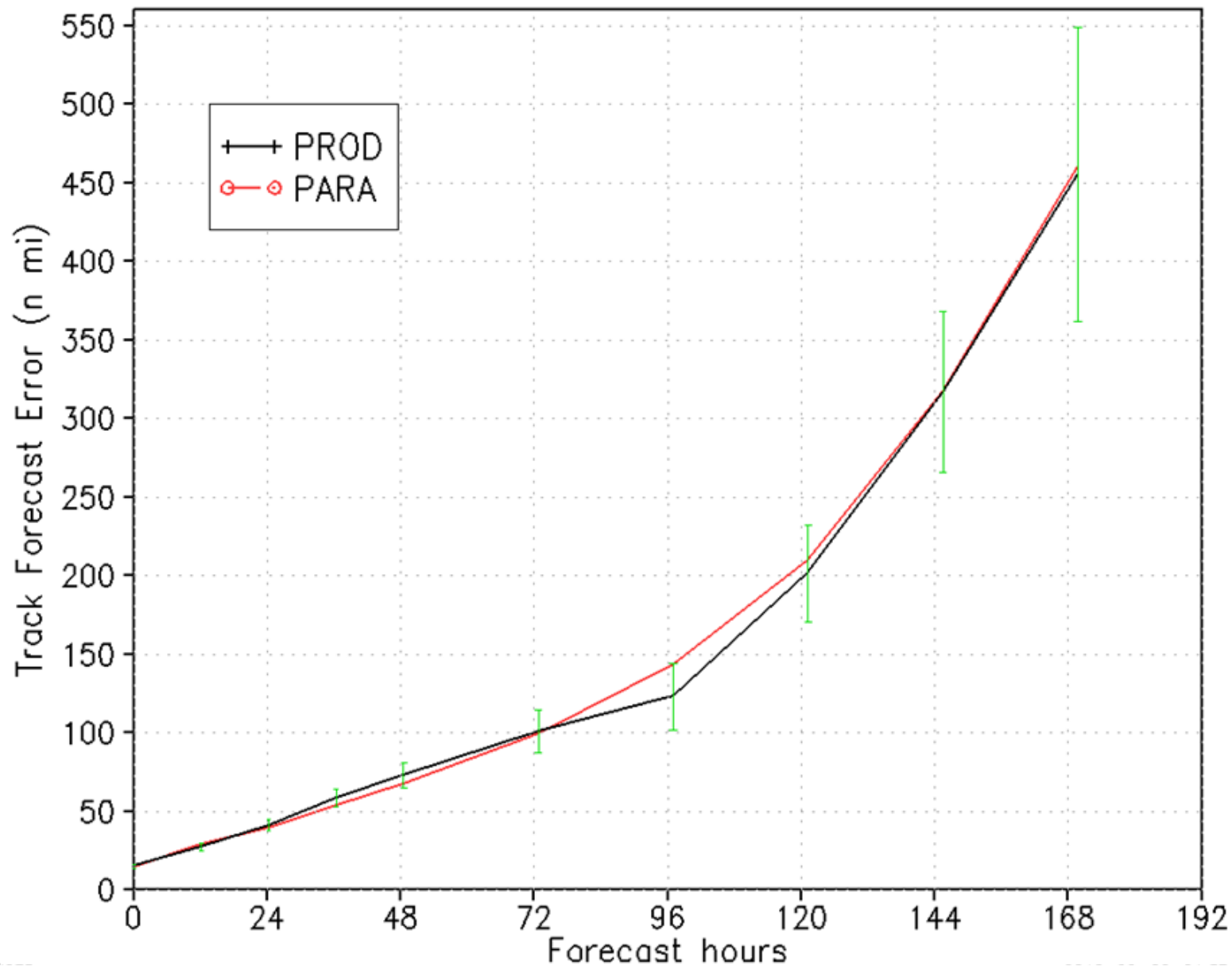


Precipitation reliability for 12-36hr and greater than 1mm/day

Hurricane tracks verification

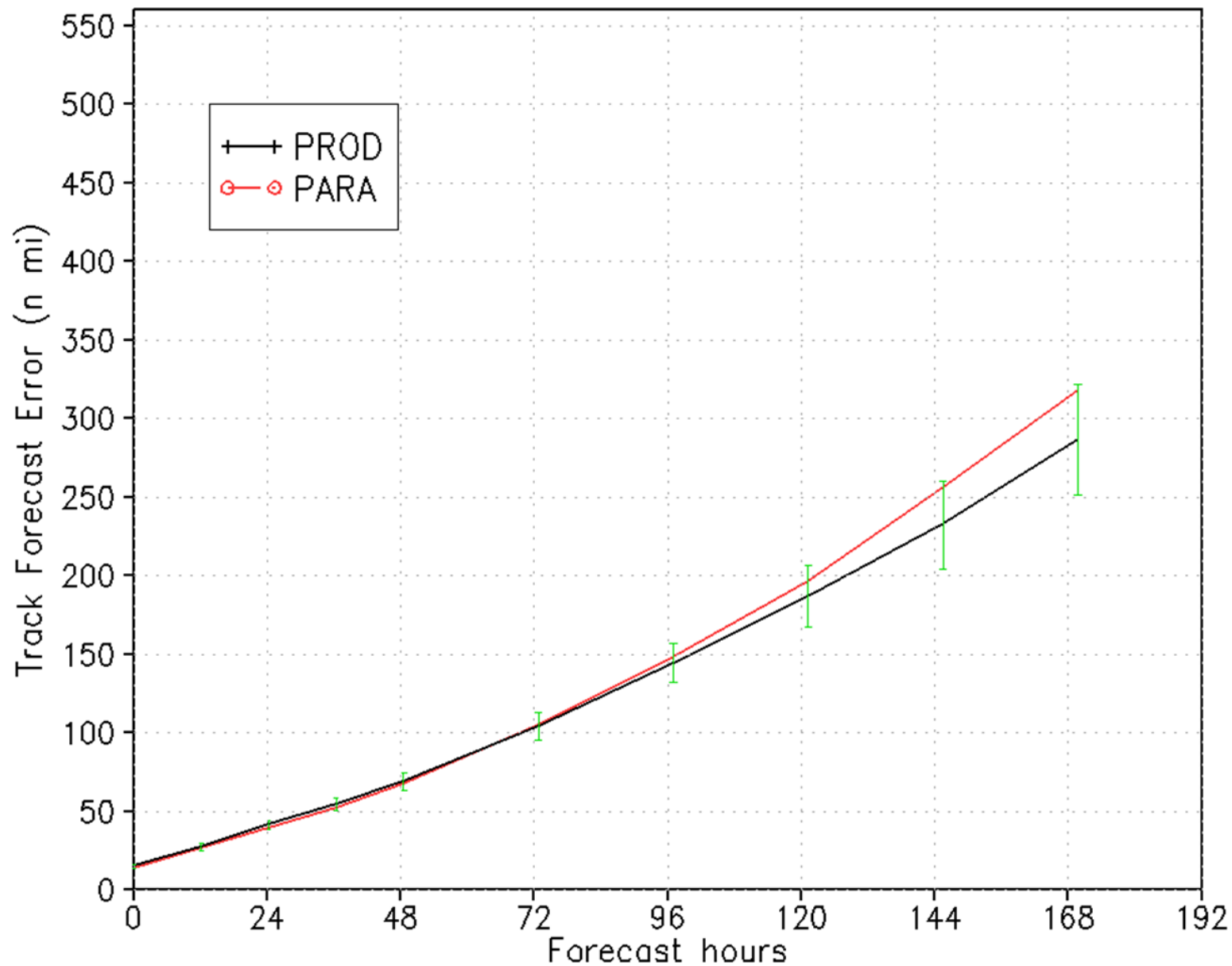
- Limited cases
 - 00UTC – 05/15/2012 – 9/6/2012
 - 00, 06, 12, 18UTC for Sandy period
 - 00UTC – summer of 2013
 - 12UTC – part of summer of 2013
 - 00UTC – summer of 2014
- Three main basins
 - Atlantic
 - East Pacific
 - West Pacific

TC track verification for 2012-2013-2014 (Atlantic)



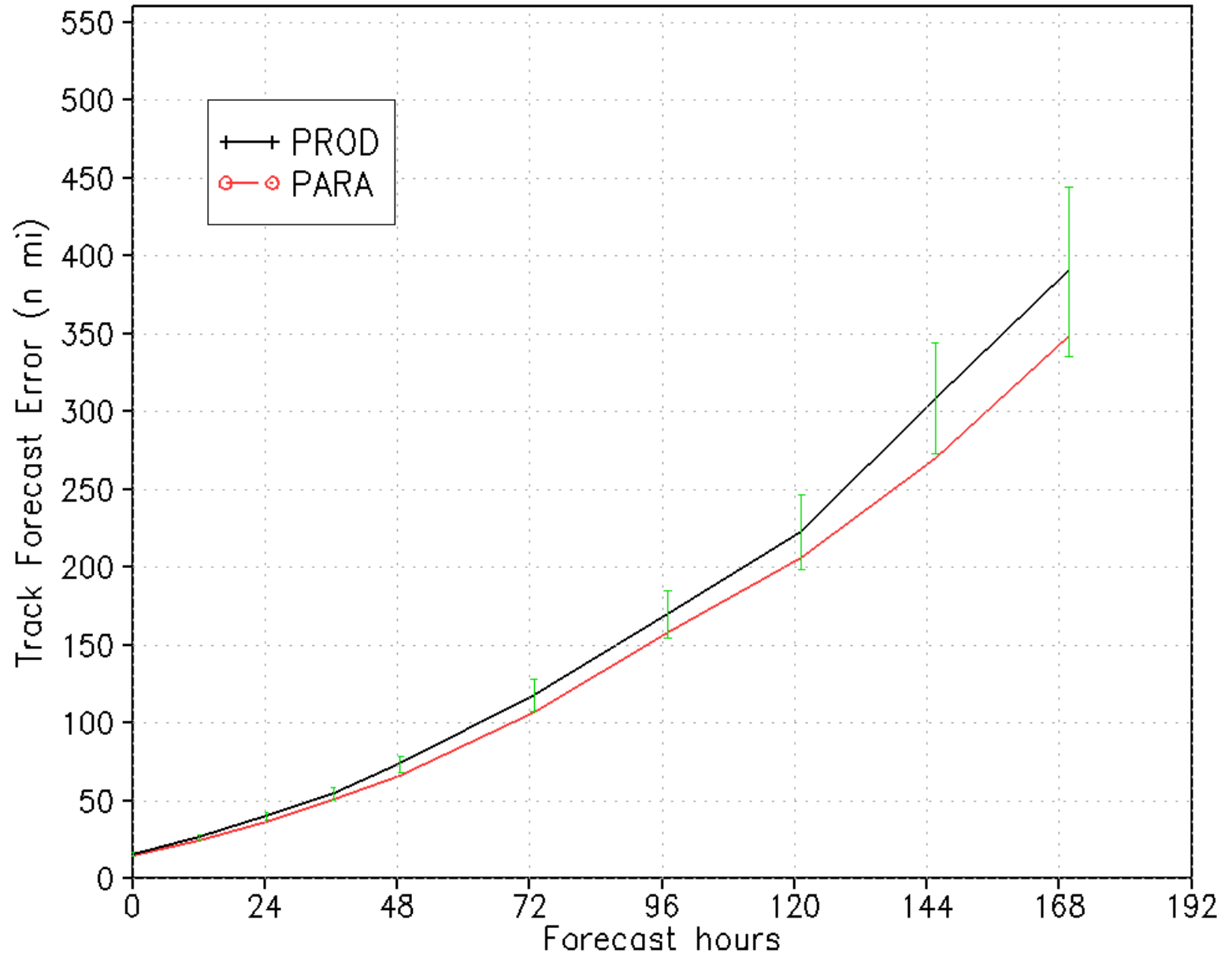
CASES 187 161 129 95 65 47 31 20

TC track verification for 2012-2013-2014 (E. Pacific)



CASES 294 266 225 188 145 104 69 43

TC track verification for 2012-2013-2014 (W. Pacific)

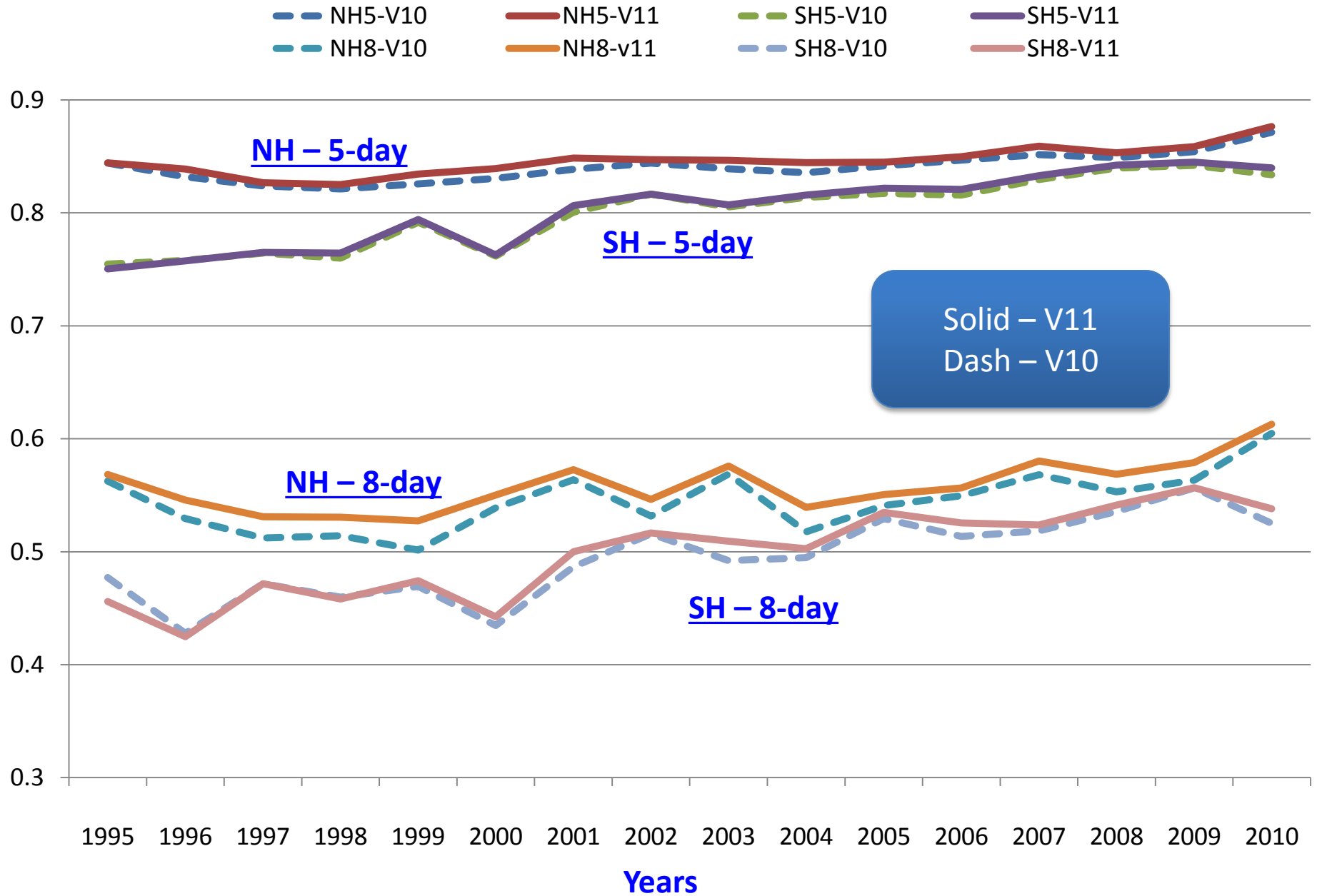


CASES 326 292 238 178 127 86 57 36

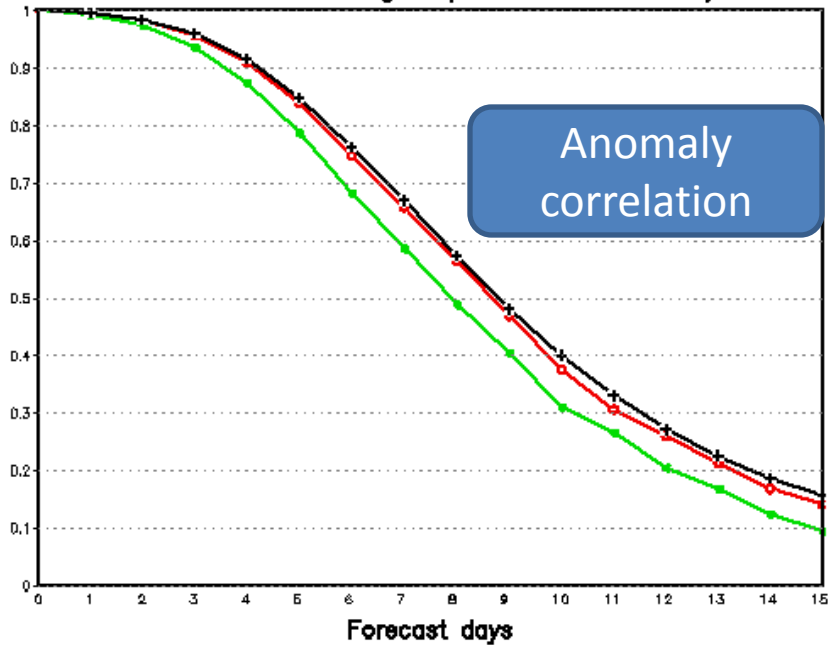
Summary

- Extended summer (05/15 – 10/31/2013)
 - 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 3-4 days (less sample beyond 4 days, especially for Atlantic basin), out to 7 days for West Pacific
 - Neutral:
 - Degrade:
 - Surface temperature – degraded for CONUS (large warm bias against obs)
- Extended winter (01/1 – 05/14/2014)
 - Improvement:
 - Over-all for many atmospheric variables
 - Surface wind
 - Neutral:
 - Surface temperature errors and bias for CONUS (against obs)
 - Precipitation
 - Degrade:

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



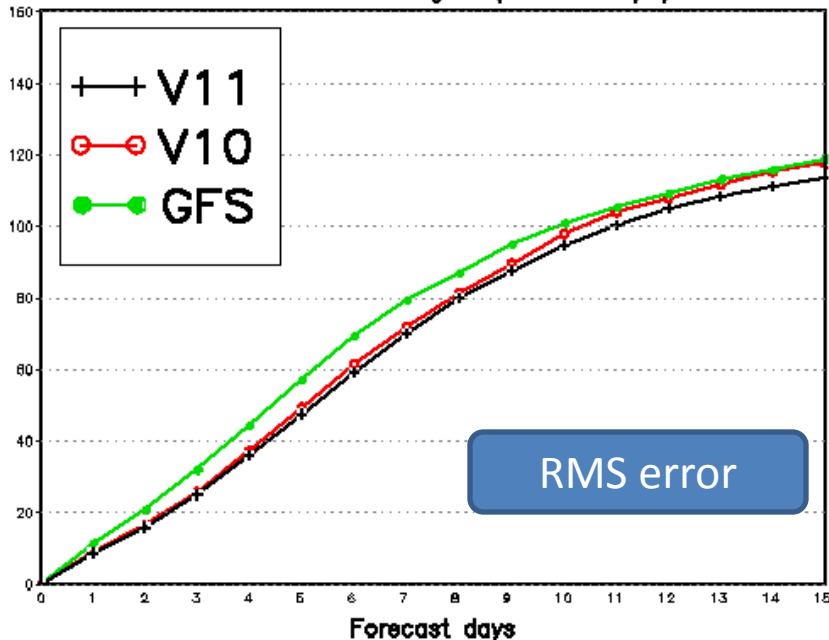
NH 500 mb Height (wave 1-20 AC)



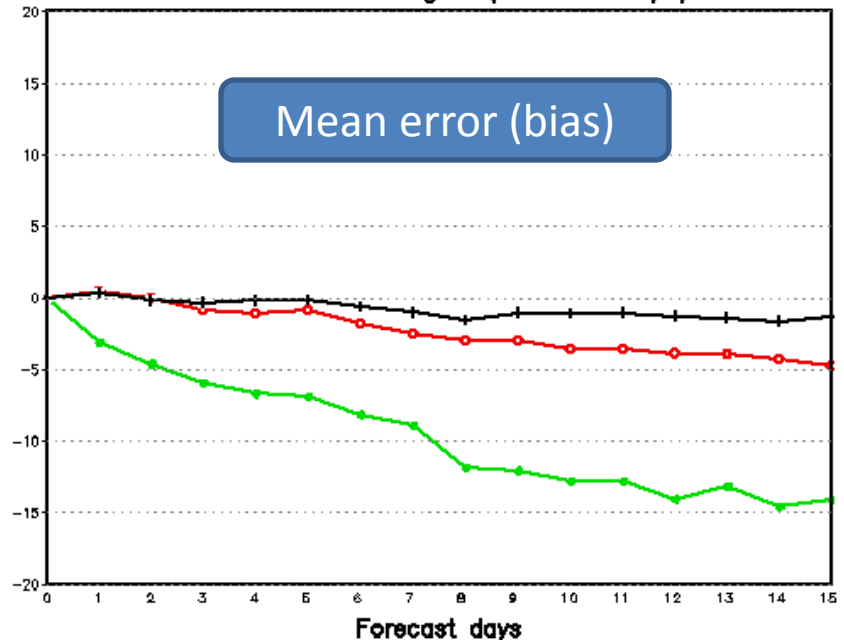
Statistical period:
01/01/2001 – 12/31/2001
(183 cases)

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

NH 500 mb Height (F-A rms)

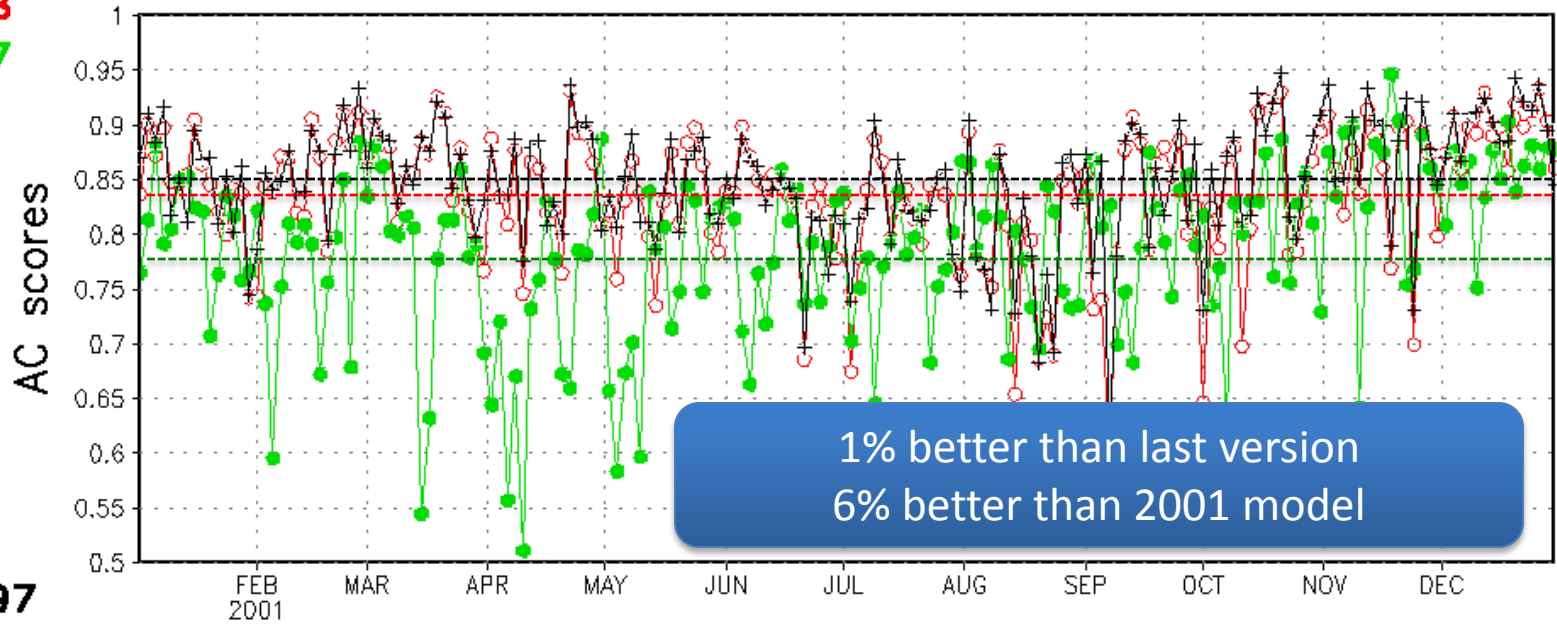


NH 500 mb Height (F-A mean)

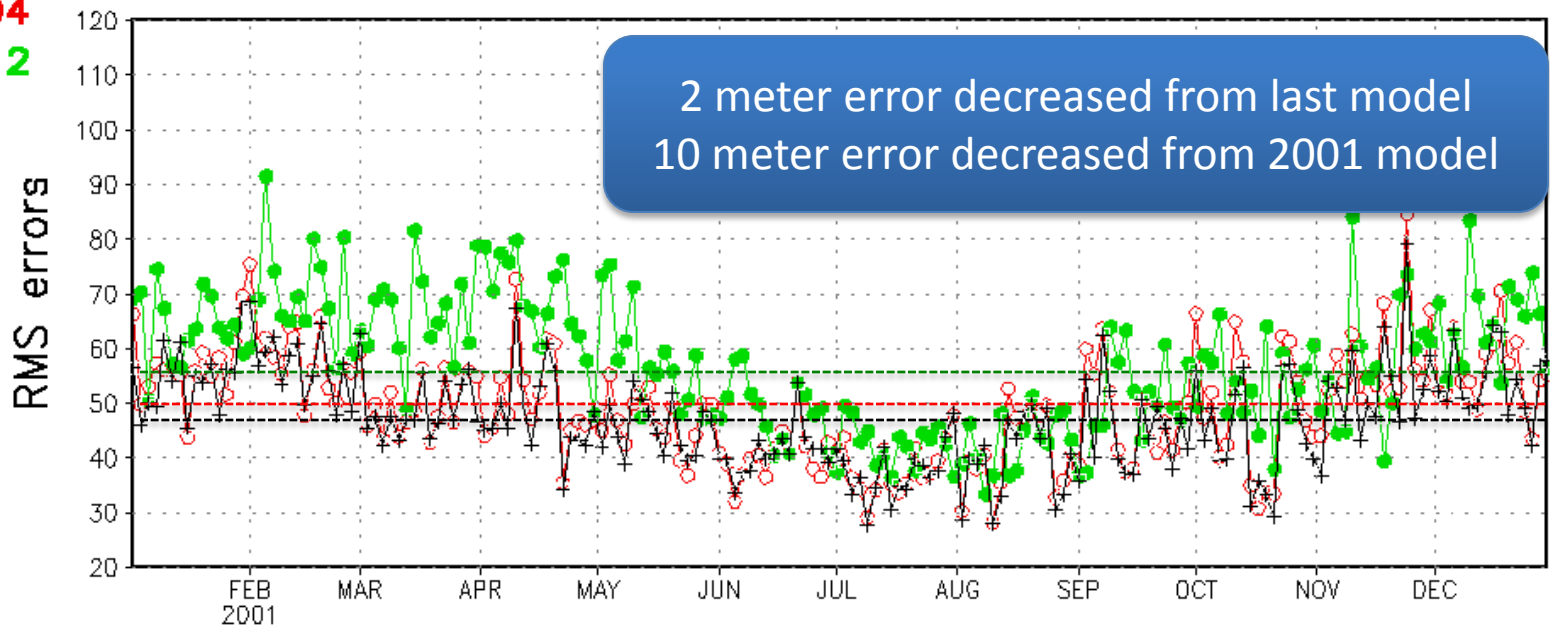


NH 500 hPa Geopotential Height at day 5 for 00Z02JAN2001 – 00Z30DEC2001

V11=0.848
V10=0.838
GFS=0.787

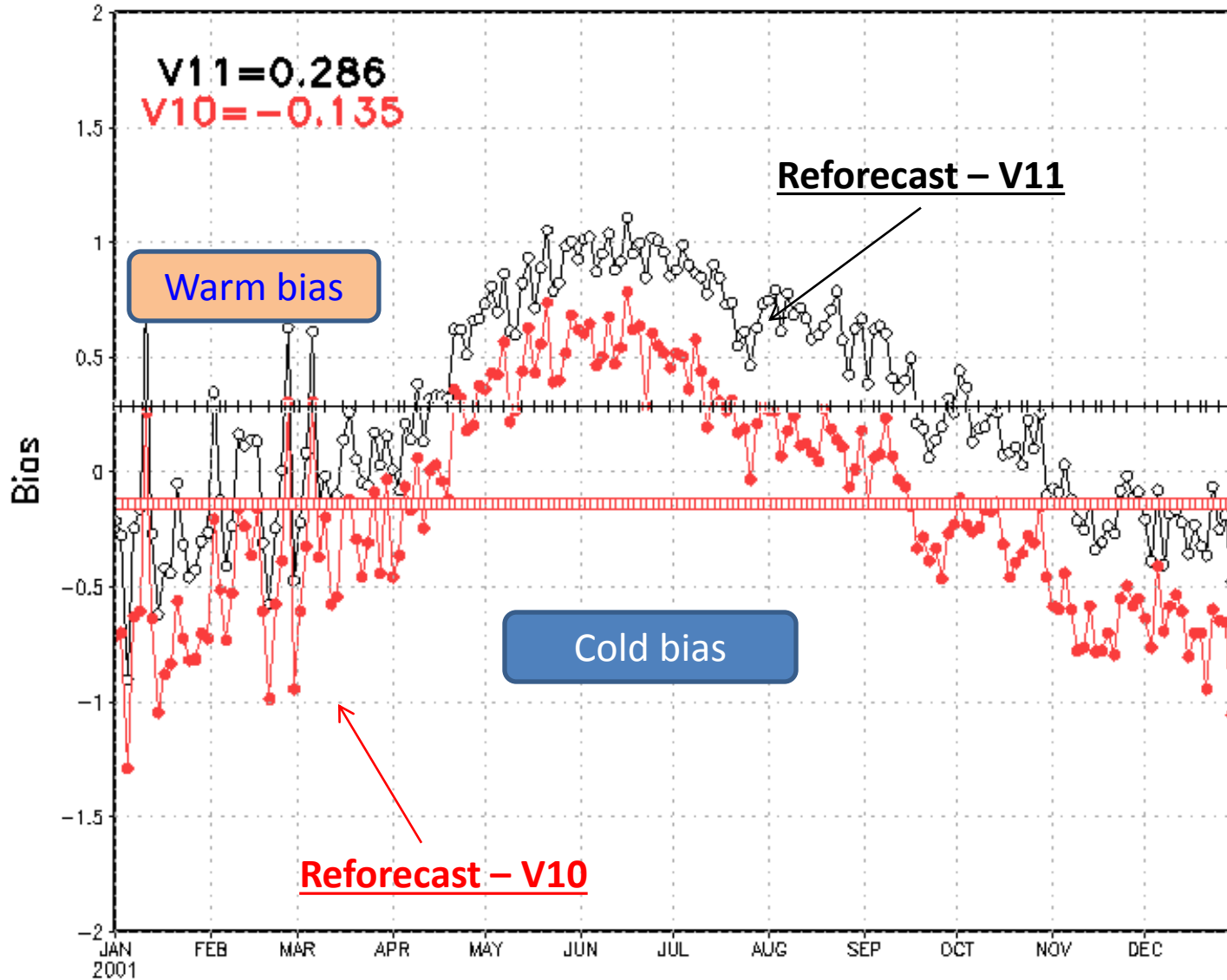


V11=47.297
V10=49.204
GFS=57.112



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

NH T2m at day 6 for 2001



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 will run real time parallel in March 2015
 - Real time data access through NCEP ftp
 - 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
GHT	Surface, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
TMP	2m, 2mMax, 2mMin, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	13
RH	2m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
UGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
VGRD	10m, 10, 50, 100, 200, 250, 500, 700, 850, 925, 1000 hPa	11
PRES	Surface, PRMSL	2
PRCP	APCP, CRAIN, CSNOW, CFRZR, CICEP	5
FLUX (surface)	LHTFL, SHTFL, DSWRF, DLWRF, USWRF, ULWRF	6
FLUX (top)	ULWRF (OLR)	1
PWAT	Total precipitable water at atmospheric column	1
TCDC	Total cloud cover at atmospheric column	1
CAPE	Convective available potential energy, Convective Inhibition	2
SOIL/SNOW	SOILW(0-10cm) , TMP(0-10cm down), WEASD(water equiv. of accum. Snow depth), SNOD(surface)	4
Other	850 hPa vertical velocity	1
Notes	Current NAEFS grids at 1*1 degree	

For More Information

- GEFS configuration/verification website at EMC
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
 - Dingchen.Hou@noaa.gov

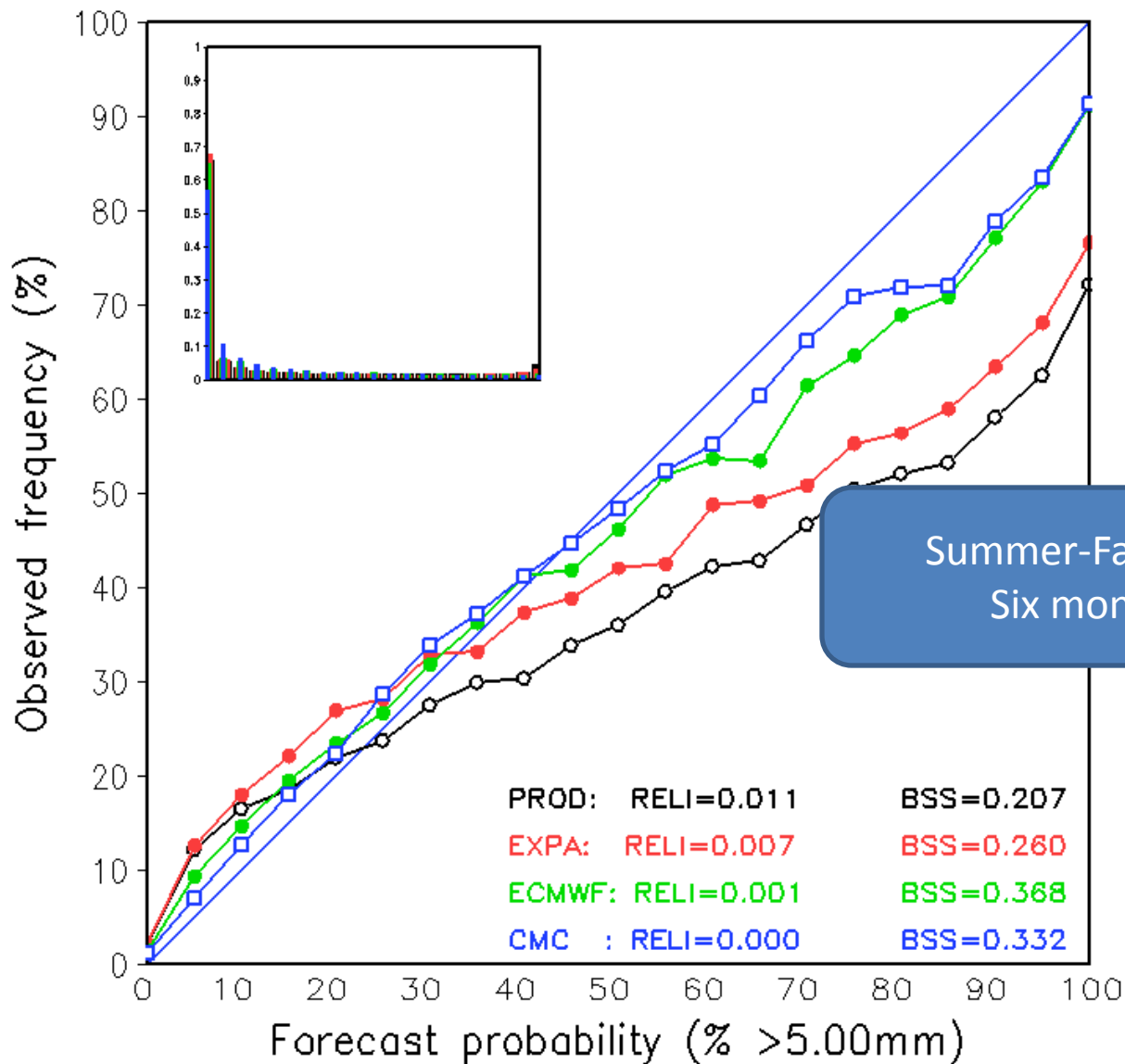
Acknowledgements:

- 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:
 - Luke Lin, Rebecca Cosgrove, Simon Hsiao, Steven Earle

Background !!!

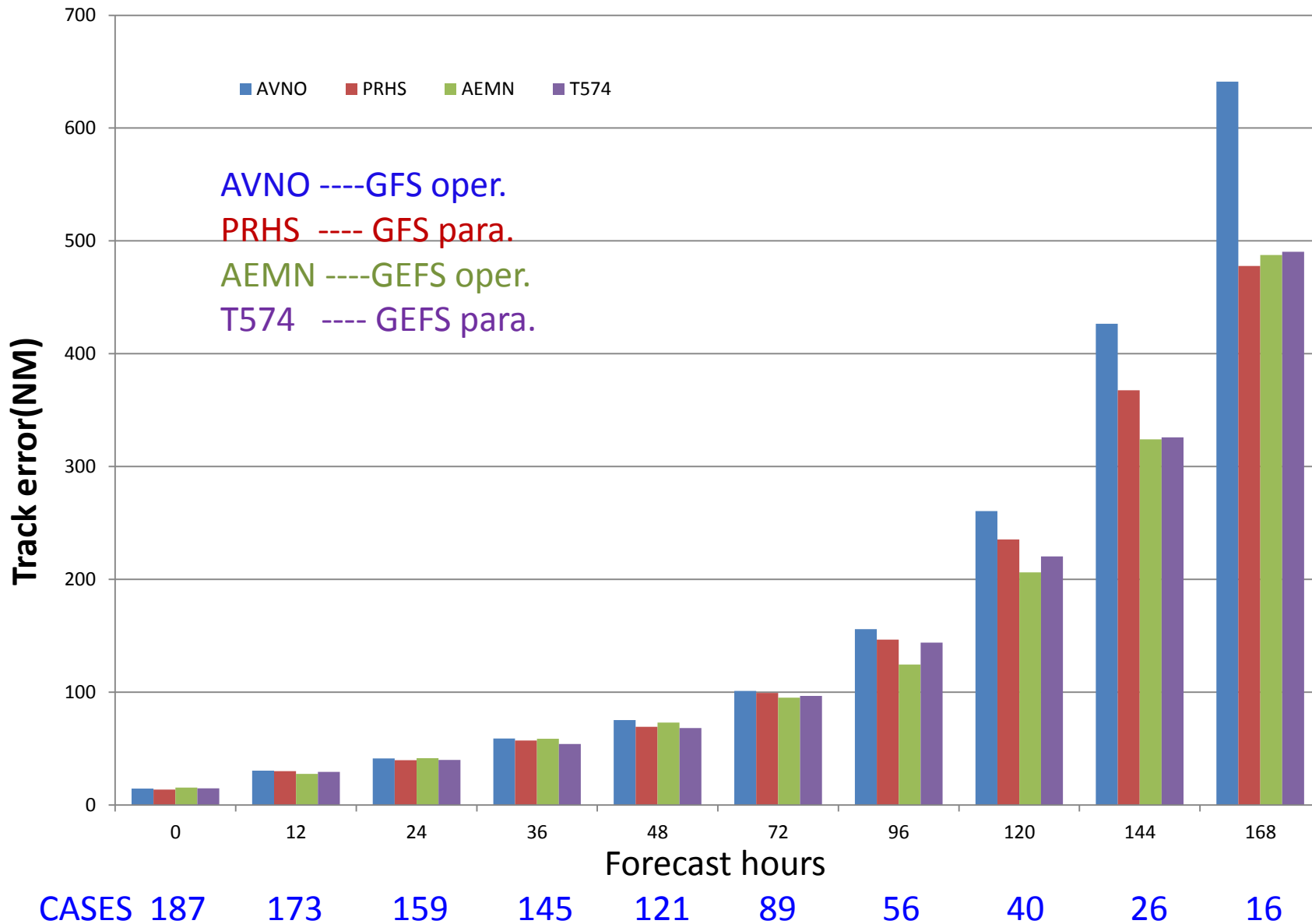
Reliability Diagram

fhr 36-60 For 20130516 - 20131031

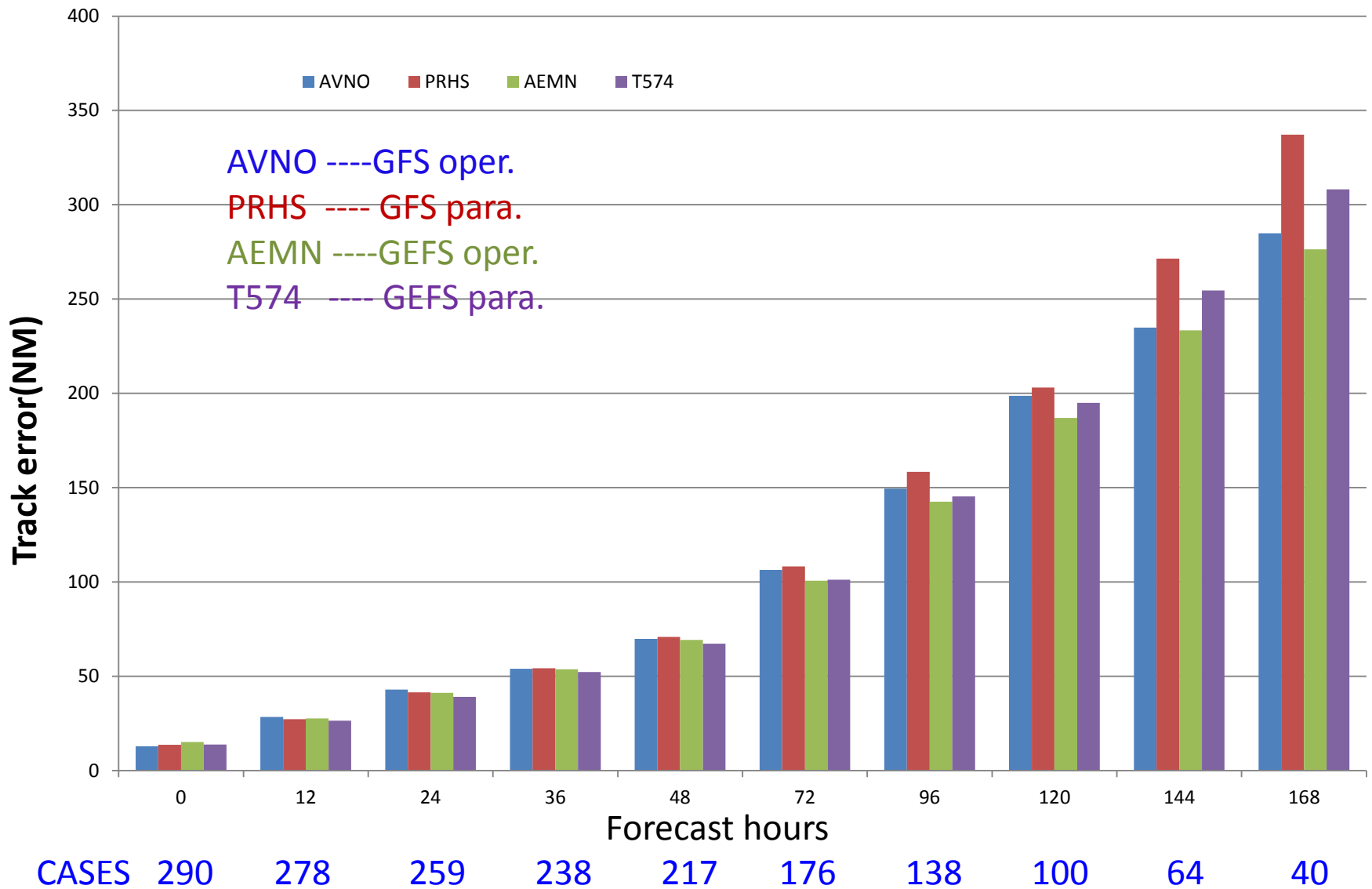


Precipitation reliability for 36-60hr and greater than 5mm/day

Atlantic TC, 2012-13-14



East Pacific TC, 2012-13-14



West Pacific TC, 2012-13-14

