Implementation Decision Briefing

HiresWindow v6.1.5

Presented by:

Matthew Pyle

Outline

- Brief HiresW system overview
- Upgrade elements – what is changing and why
- Parallel testing – stats and examples
  - Echo top height and reflectivity
  - Precipitation
  - Surface sensible weather
  - PBL and surface layer
  - Synoptic/upper air

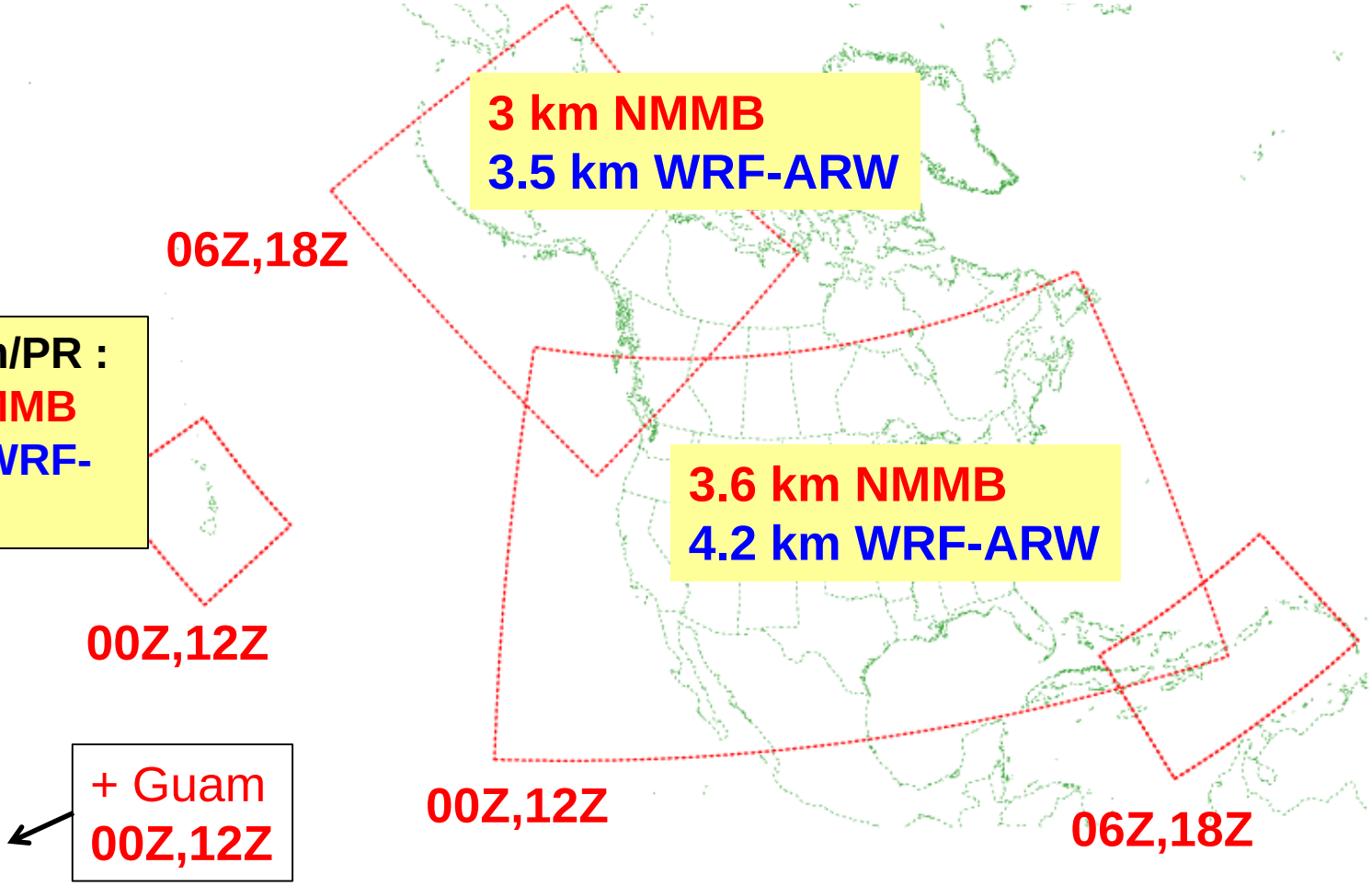
HiresW overview

- Two dynamical cores: WRF-ARW and NMMB
- ~3-4 km, no parameterized convection forecasts
- Twice daily runs to 48 h over CONUS and four non-CONUS domains.

- Complements the NAM nests, helping to provide a variety (multi-model, multi-analysis) of high-resolution model solutions in the NCEP suite, forming a pseudo-ensemble.

HiresW overview

Integration domains and run times (unchanged)



Upgrade elements

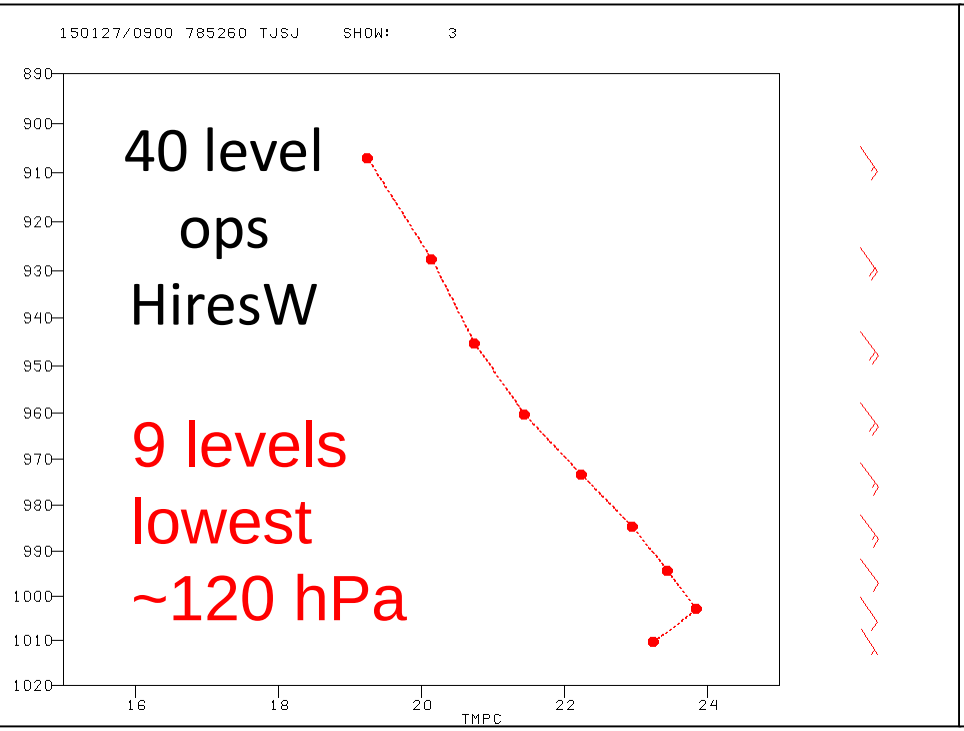
- Many infrastructure changes, the largest being the direct production of GRIB2 output. Also adds job restartability.
- Model code updates
- Increase in vertical resolution (40 to 50 levels)
- New output products:
  - **H**igh-**R**esolution **E**nsemble **F**orecast (**HREF**) – ensemble guidance produced from time-lagged HiresW and NAM nest output
  - Additional fields for aviation and severe weather

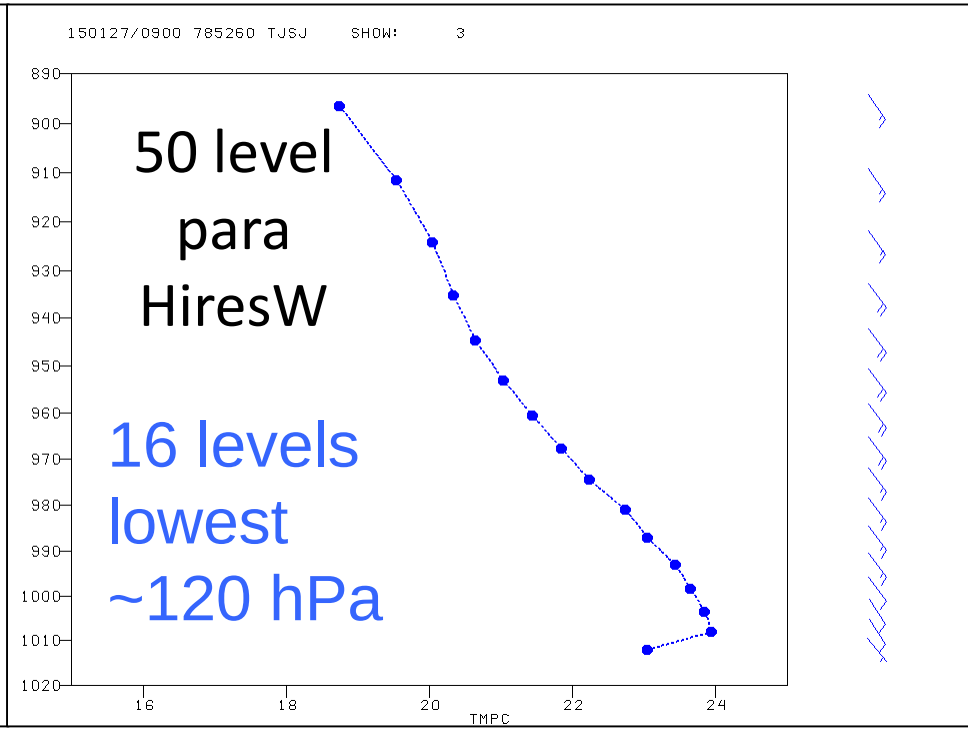
Upgrade elements

	Current ops (v6.0.12)	Parallel system (v6.1.5)
Model code version	WRFV3.5 (ARW) Aug 2013 trunk (NMMB) + updates	WRFV3.6.1 (ARW) + updates Jan 2015 trunk (NMMB) + updates
Vertical levels	40	50
Microphysics (ARW)	WSM6	Modified WSM6* (to slow graupel production, benefiting echo top height forecasts)

** Extends certain Grasso et al (2014) suggestions on improving WSM6 convective cloud anvils – Brad Ferrier provided key guidance*

Enhanced vertical resolution, particularly in PBL





Upgrade elements

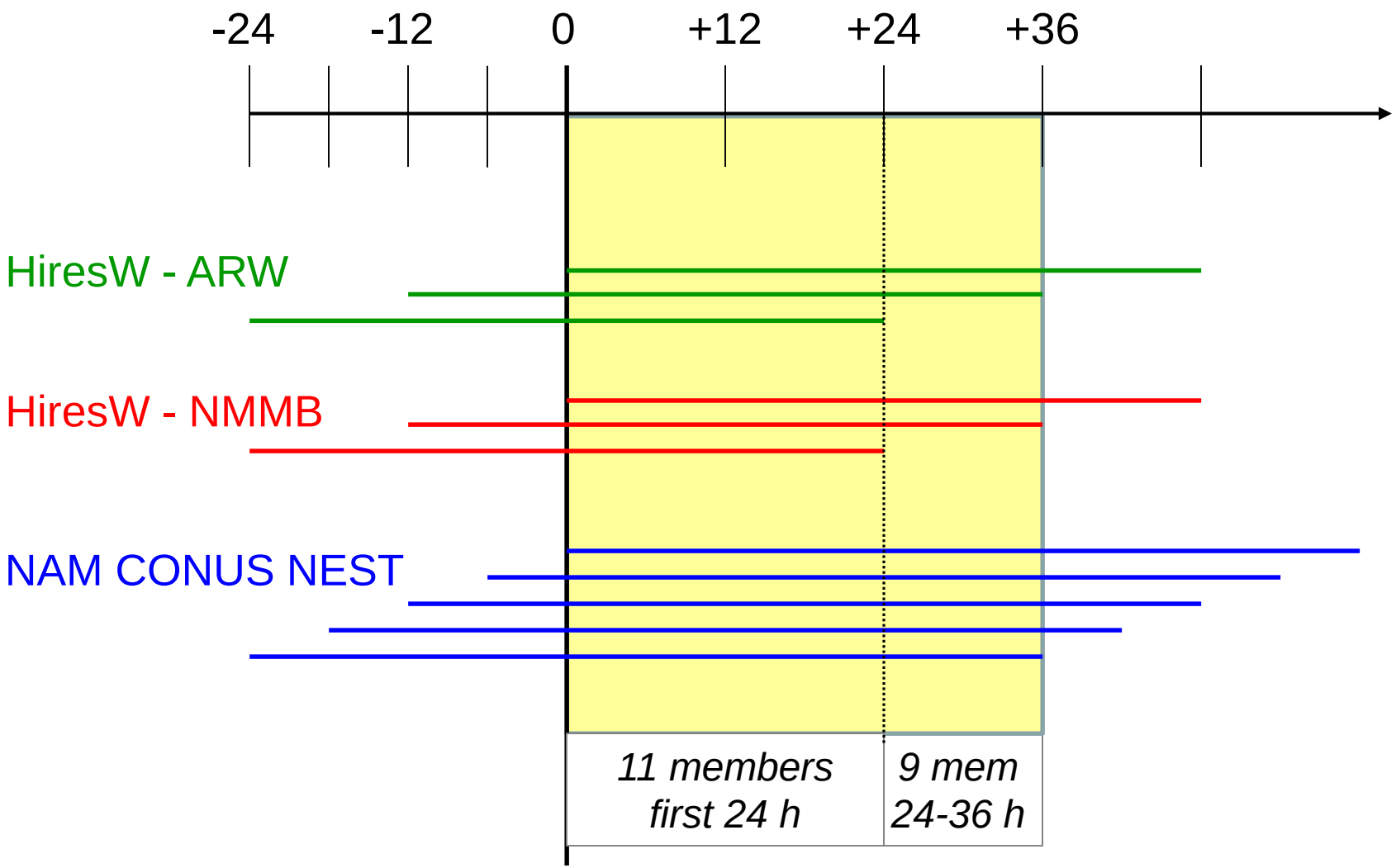
Expected benefits to end users from upgrade:

- Improved WRF-ARW echo top height bias (only model improvement targeted in scope of upgrade); also improved WRF-ARW composite reflectivity
- Improved precipitation bias performance
- Better resolution of PBL and surface layer features
- New forecasting tools:
  - Probabilistic HREF guidance
  - Ceiling height (AWC), -10 C reflectivity (lightning proxy)

HREF overview

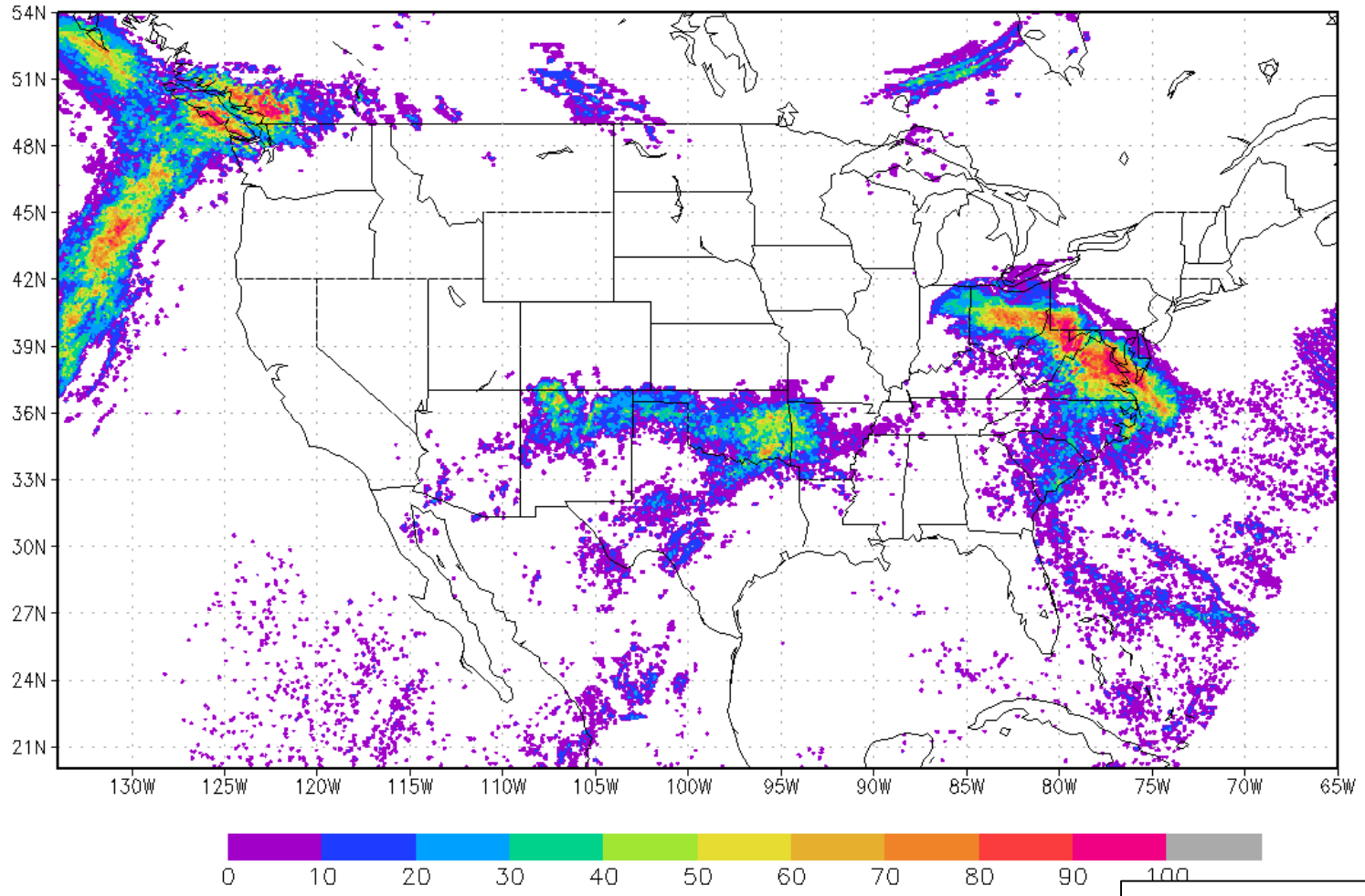
- The High-Resolution Ensemble Forecast (HREF) generates ensemble products from existing deterministic guidance:
  - Utilizes multiple cycles of the HiresWindow (WRF-ARW and NMMB) and the NAM nest.
  - CONUS-only in this initial implementation, with products to 36 h, four cycles per day.
  - Mean, spread, and probability products with an emphasis on aviation and severe weather.

HREF membership overview



HREF example

probability of exceedance, REFC > 30 dBZ



courtesy Binbin Zhou

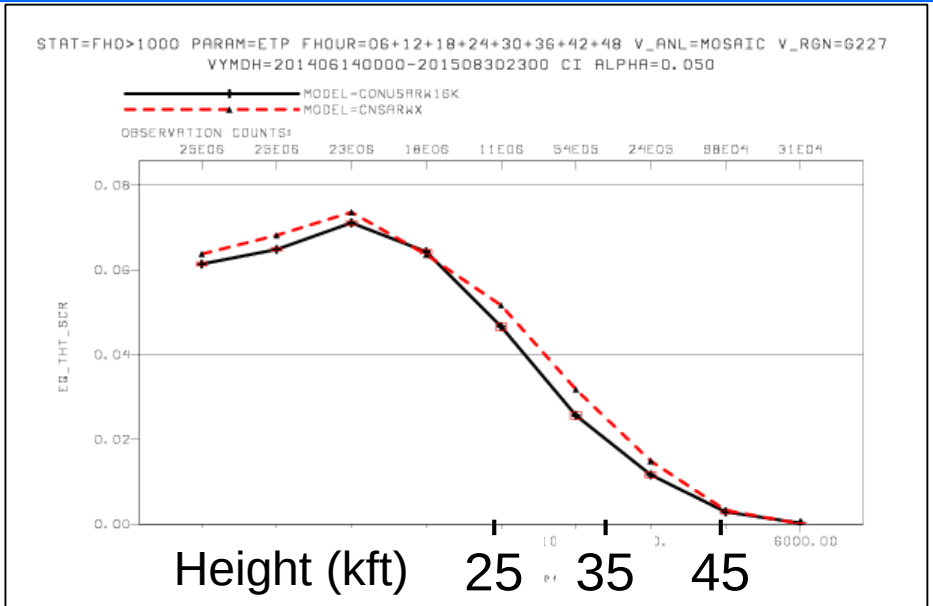
Pre-Implementation Testing

- Testing periods:
  - Warm season retro (June 13 - Jul 8, 2014)
  - Cool season retro (Jan 26 – Feb 26, 2015)
  - Real-time testing (early April 2015 to date)

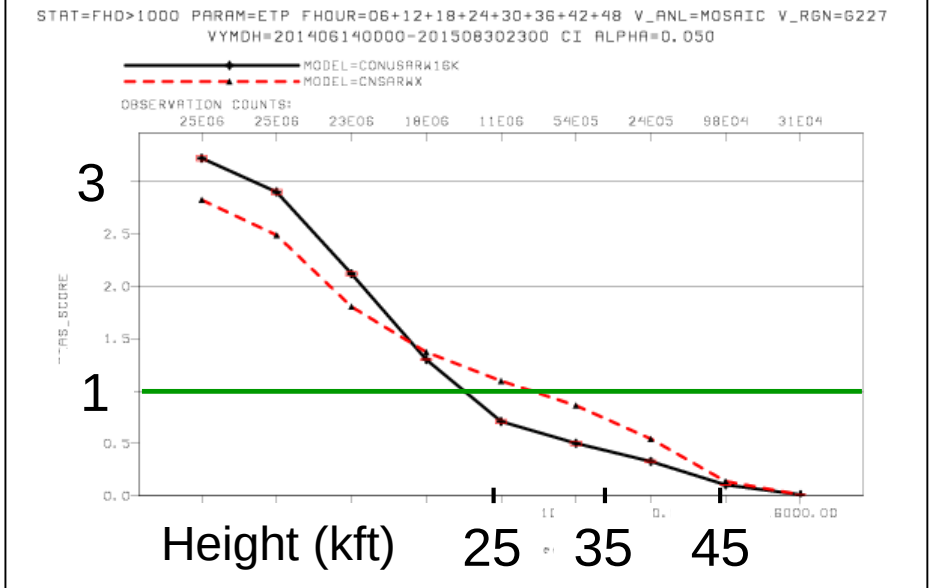
- See improvement in targeted fields (especially echo top height and composite reflectivity in WRF-ARW), but most parallel results are similar in skill to production.

WRF-ARW echo top height

Equitable threat score



Bias



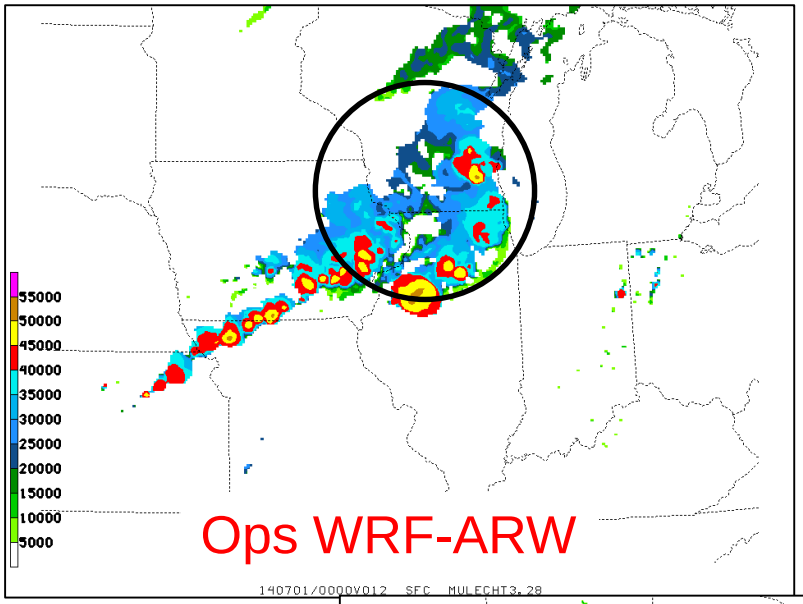
Grid-to-grid verification against radar mosaic

Ops HiresW

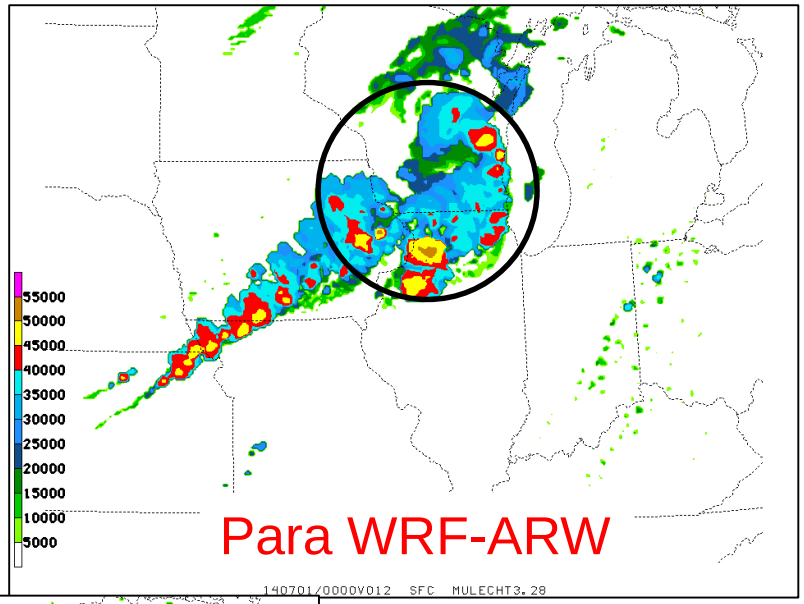
Para HiresW

Improvements both to ETS and bias; low bias reduced in 25-45K foot range important for aviation.

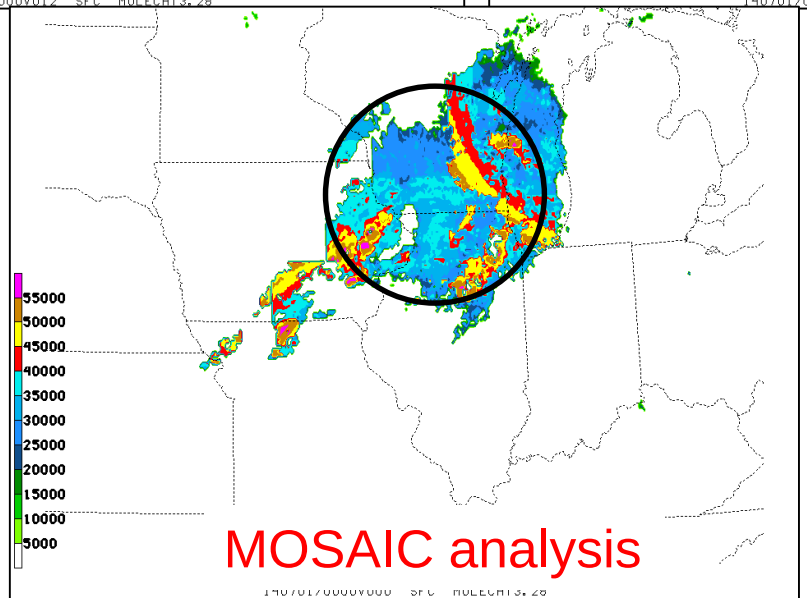
Echo top height
1 Jul 2014, 00Z



Ops WRF-ARW



Para WRF-ARW

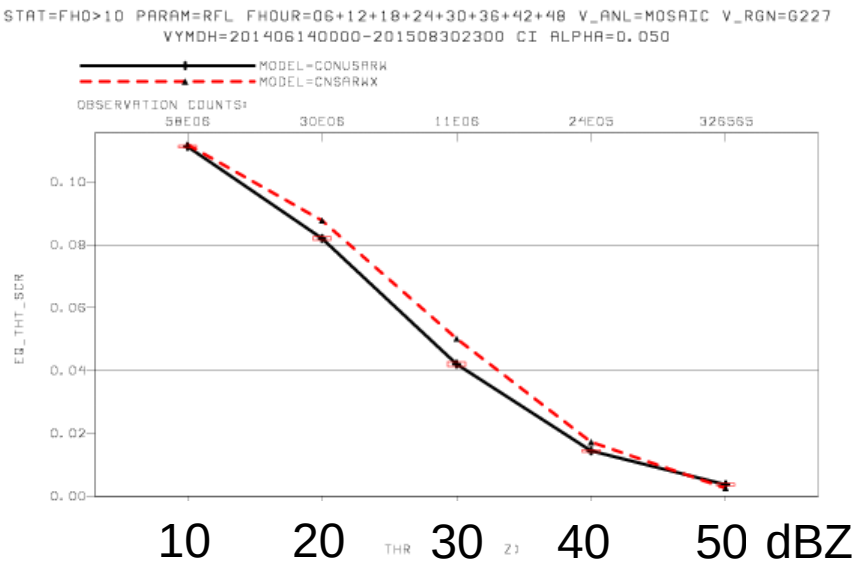


MOSAIC analysis

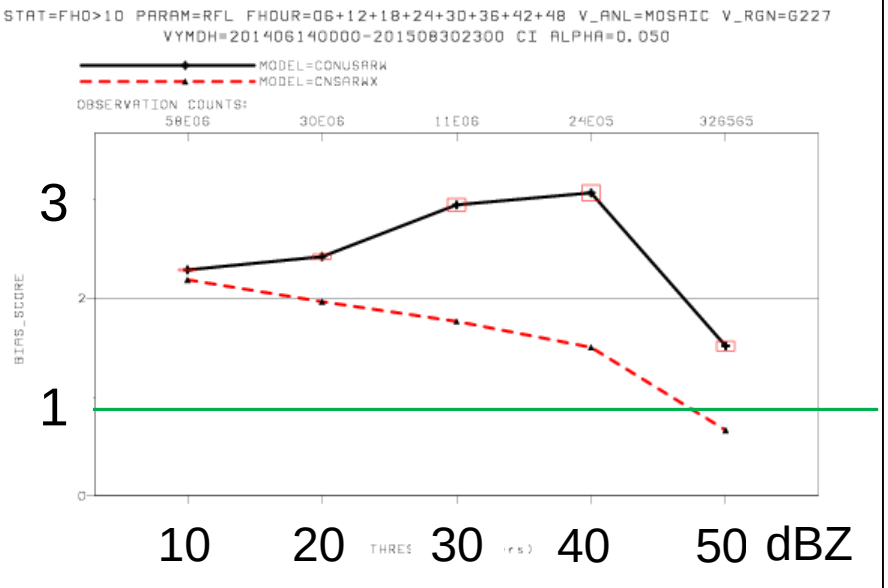
The para WRF-ARW has broader coverage in 25-40K foot range (pale blue colors)

WRF-ARW composite reflectivity

Equitable Threat Score



Bias



Grid-to-grid verification against radar mosaic

Ops HiresW

Para HiresW

Large bias reduction from:

- *shift from model-generated to post-generated reflectivity*
- WSM6 changes

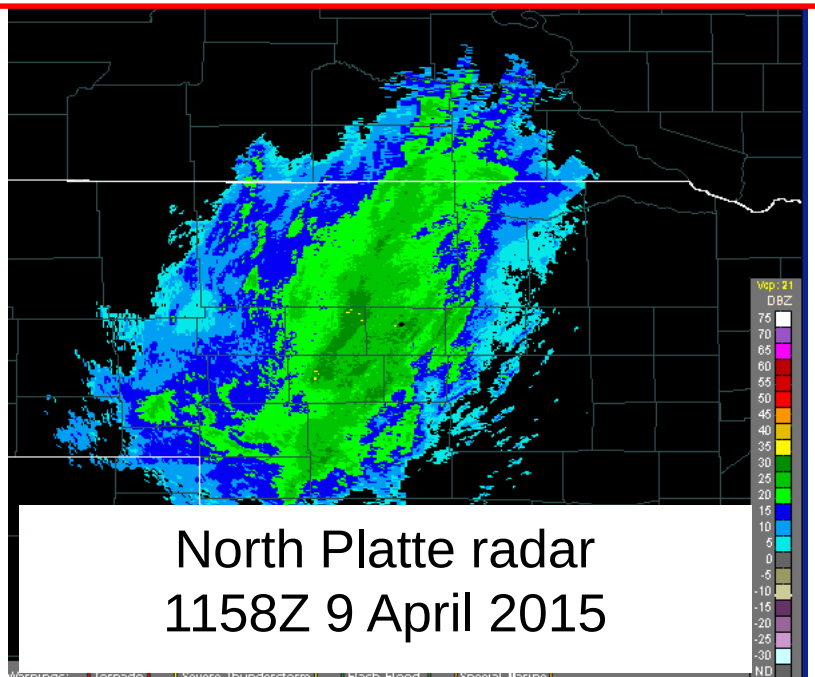
bias=1

Ops WRF-ARW

Para WRF-ARW

All plots are of ***composite*** reflectivity

Microphysics-generated reflectivity exaggerates bright-banding effects, which impacts composite reflectivity

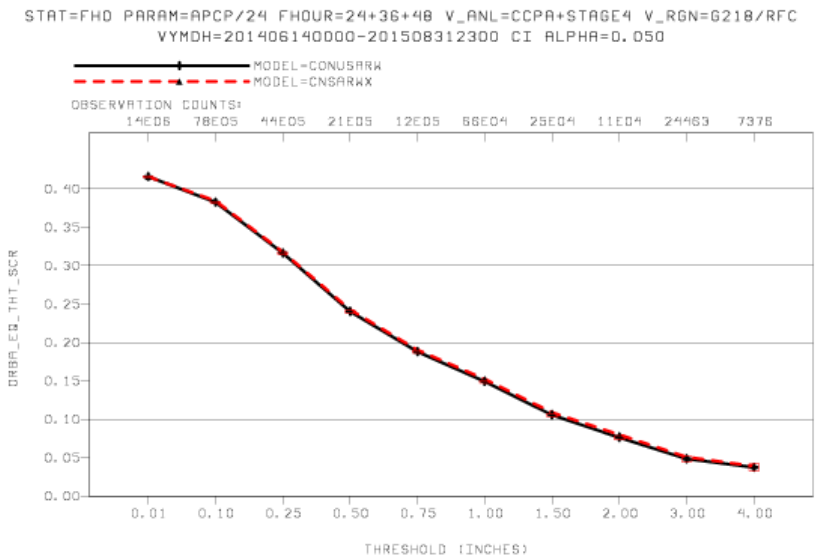


North Platte radar
1158Z 9 April 2015

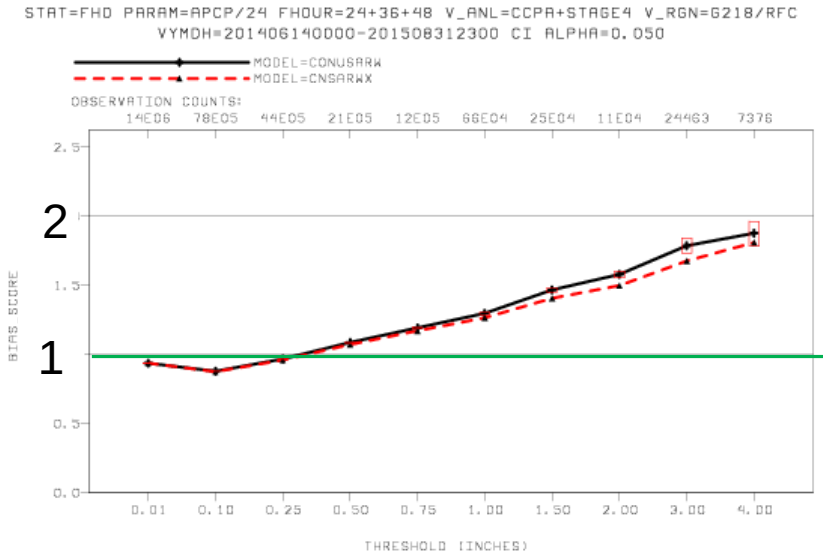
Shift back to post-generated reflectivity produces more reasonable composite reflectivity

CONUS ARW precipitation – all test cases

Bias corr Equitable Threat Score



Bias



June 13 – July 8, 2014
Jan 25 – Feb 26, 2015
Apr 4, 2015 -

24/36/48 h precip verification over CONUS

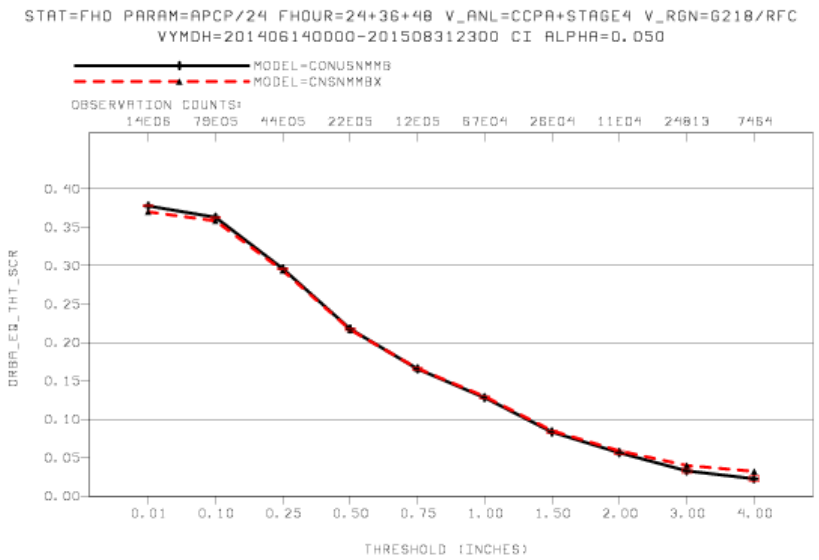
Ops HiresW

Para HiresW

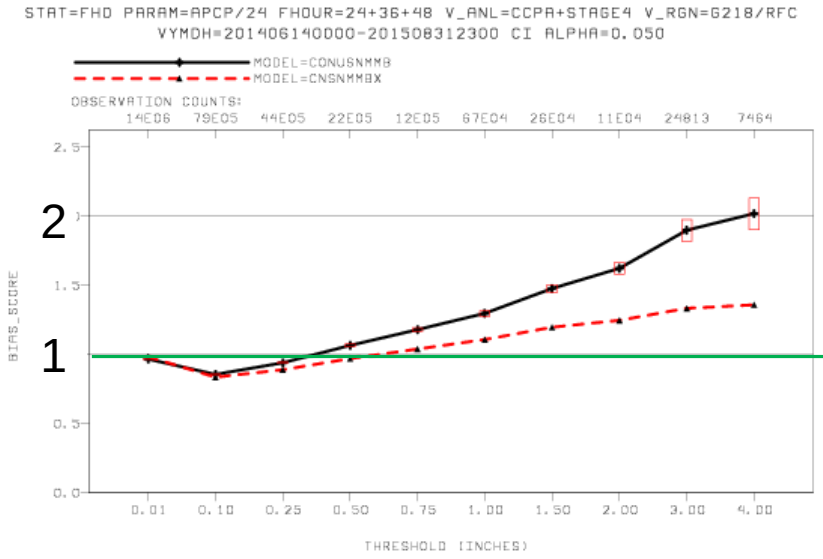
bias=1

CONUS NMMB precipitation – all test cases

Bias corr Equitable Threat Score



Bias



June 13 – July 8, 2014
Jan 25 – Feb 26, 2015
Apr 4, 2015 -

24/36/48 h precip verification over CONUS

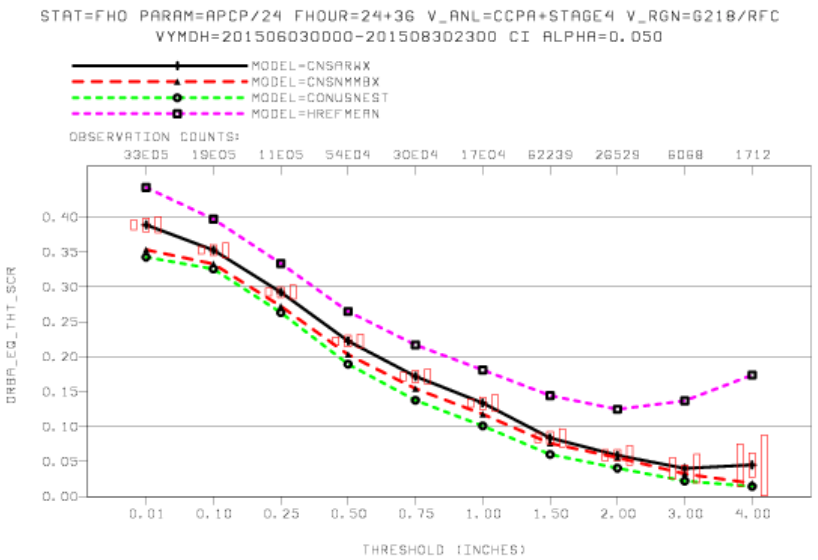
Ops HiresW

Para HiresW

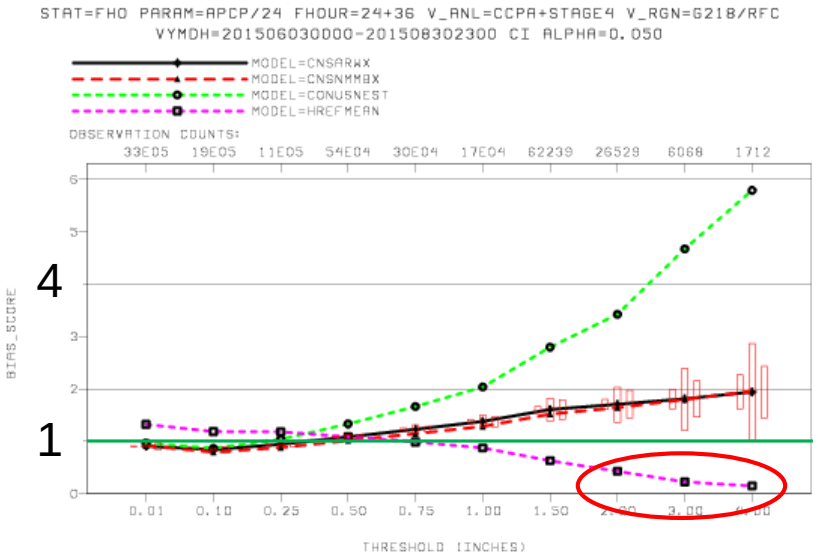
bias=1

HREF mean precipitation versus component models

Bias corr Equitable Threat Score



Bias



24/36 h precip verification over CONUS

June 3, 2015 onward only

HREF mean

HiresW (ARW)

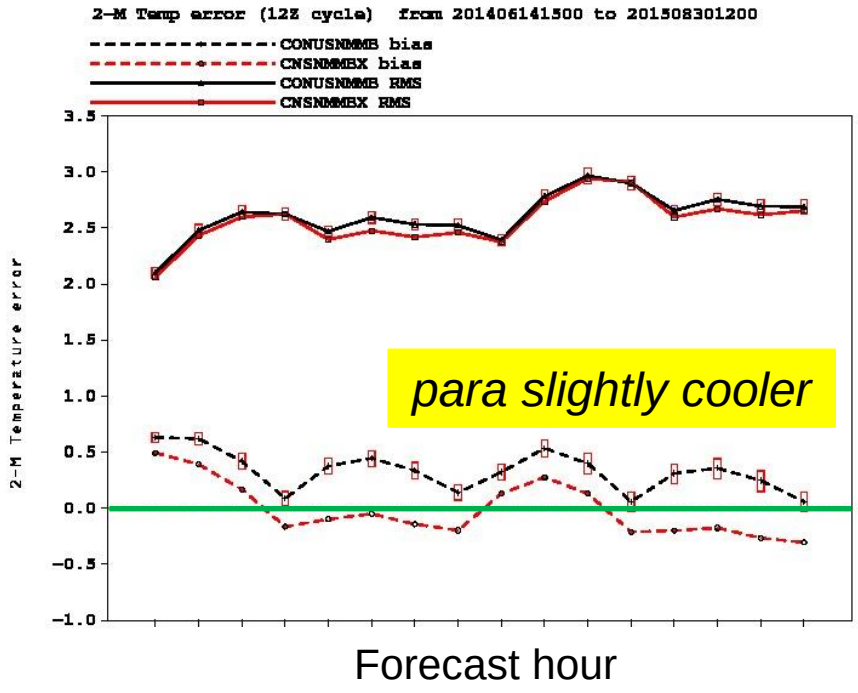
HiresW (NMMB)

NAM CONUS Nest

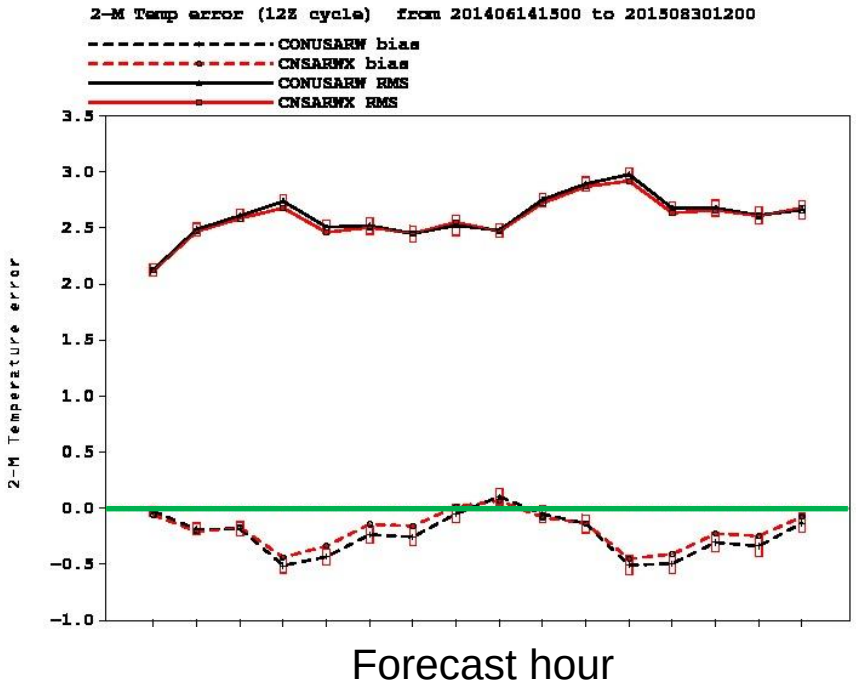
bias=1

CONUS 2 m temp, 12Z cycle

ops RMS
para RMS
ops bias
para bias



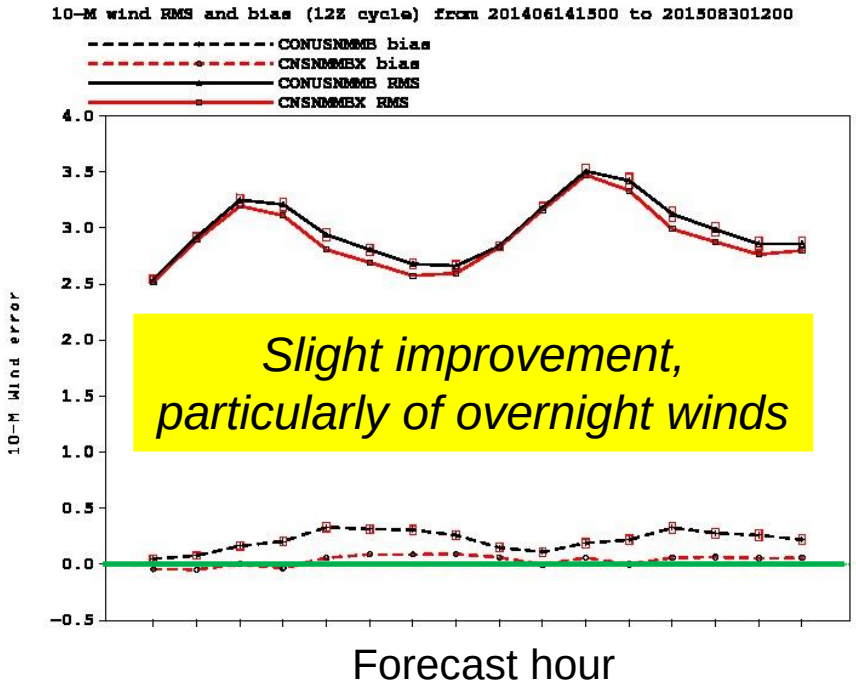
NMMB



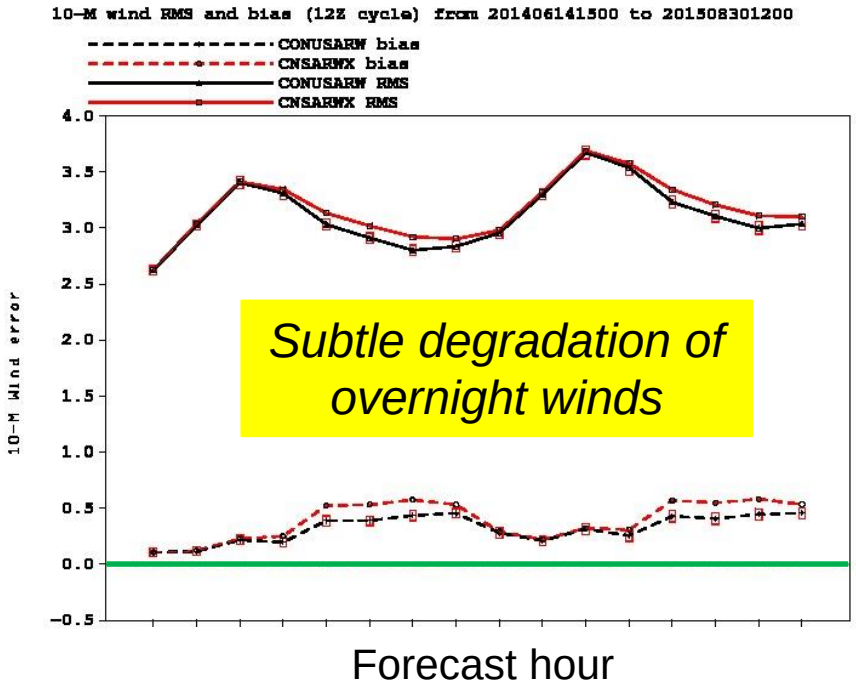
WRF-ARW

CONUS 10 m winds, 12Z cycle

ops RMS
para RMS
ops bias
para bias



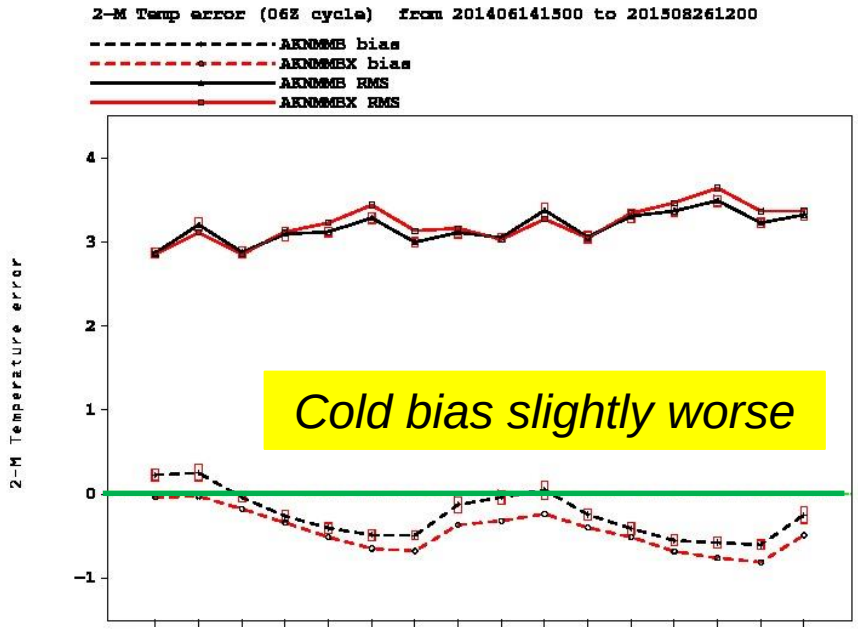
NMMB



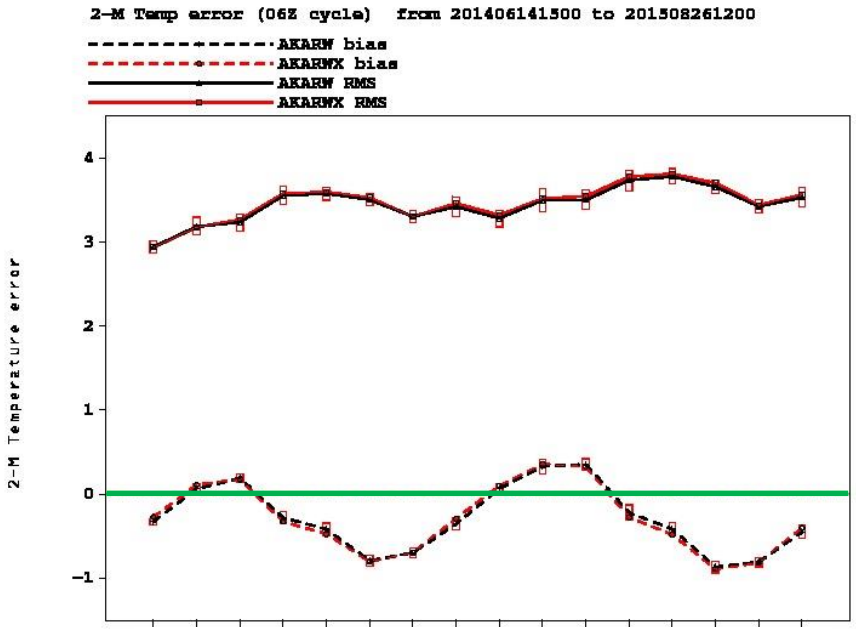
WRF-ARW

AK 2 m temp, 06Z cycle

ops RMS
para RMS
ops bias
para bias



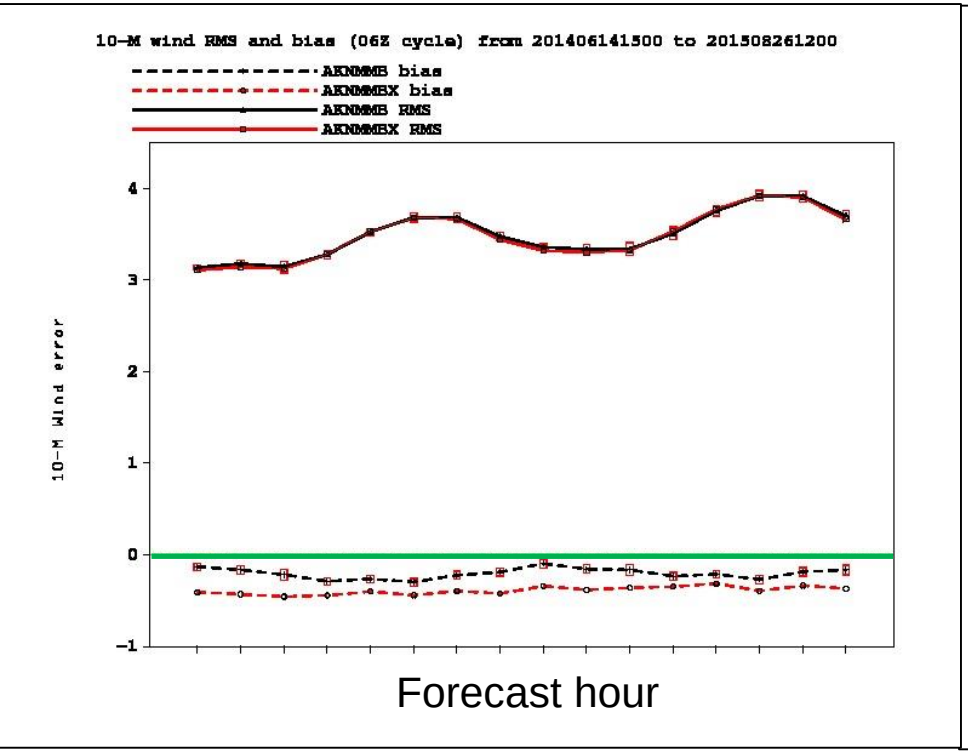
NMMB



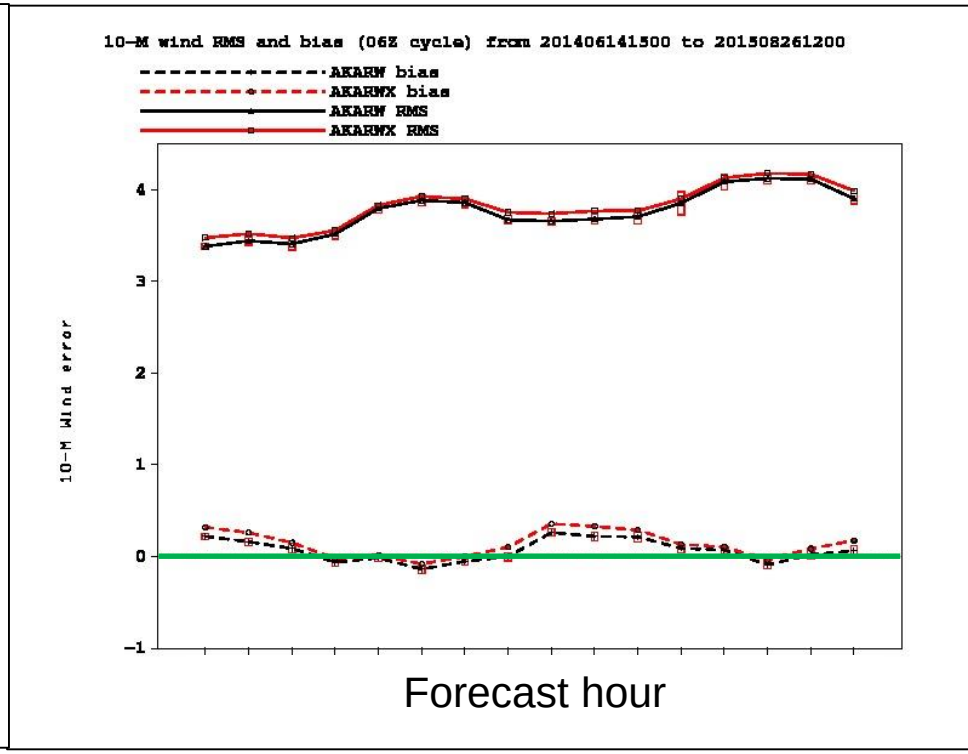
WRF-ARW

AK 10 m winds, 06Z cycle

ops RMS
para RMS
ops bias
para bias

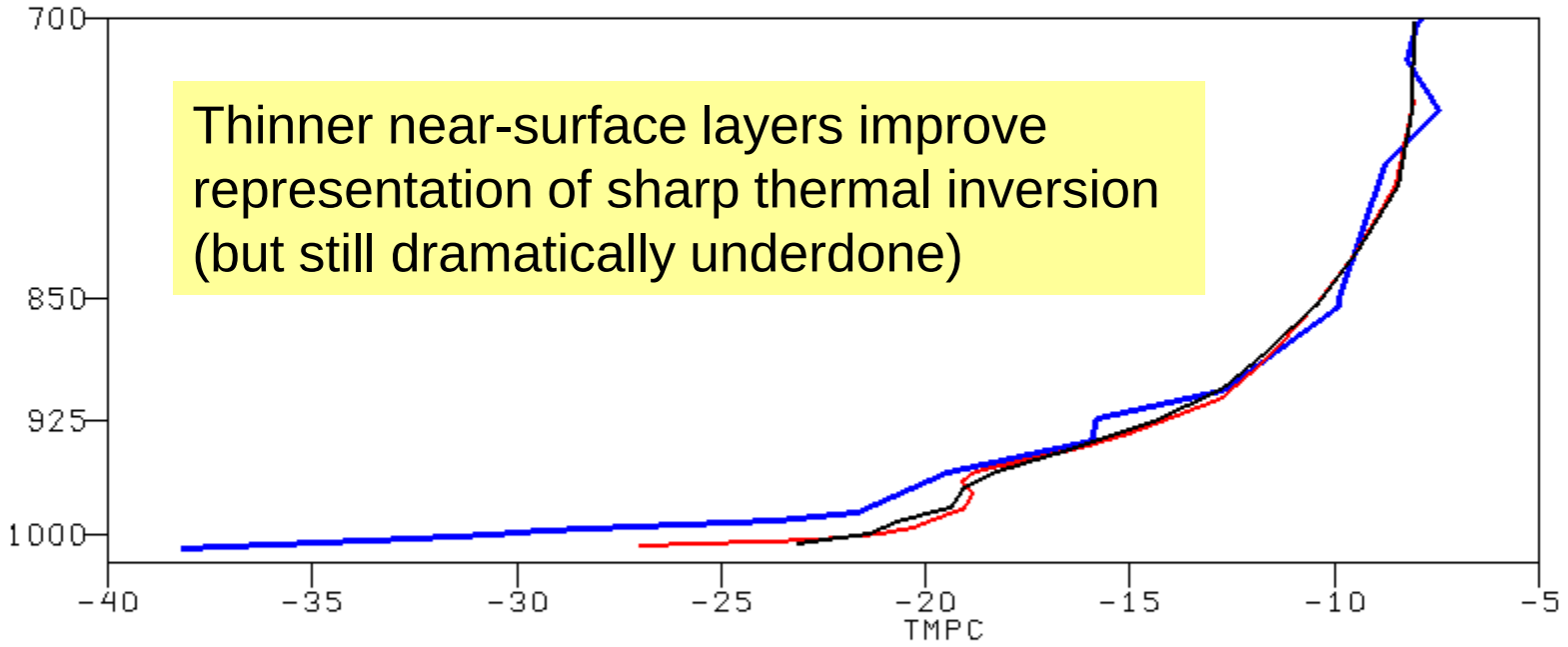


NMMB



WRF-ARW

Improved representation of shallow arctic air



Thinner near-surface layers improve representation of sharp thermal inversion (but still dramatically underdone)

Alaskan NMMB run

Valid 12Z 28 Jan 2015

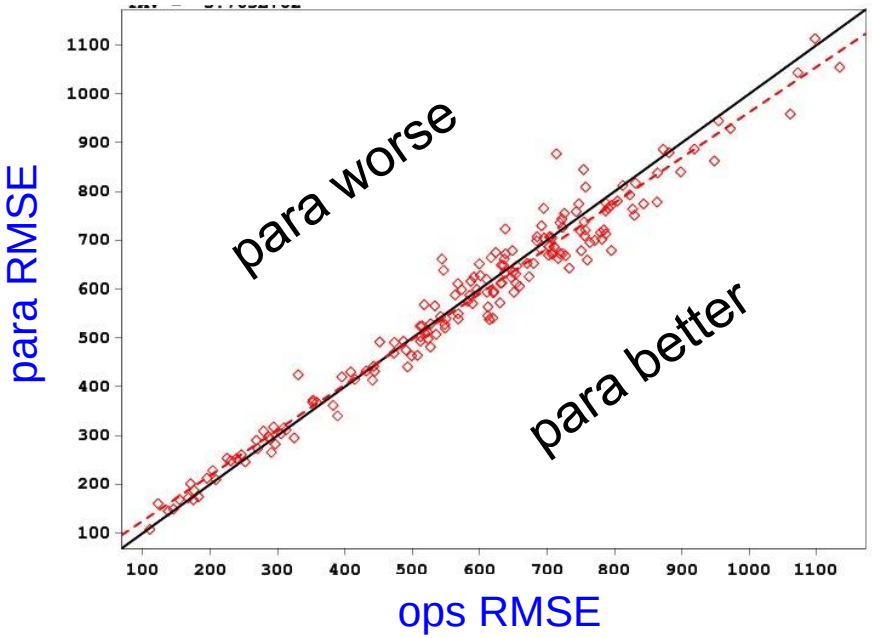
Ops HiresW

Para HiresW

Obs

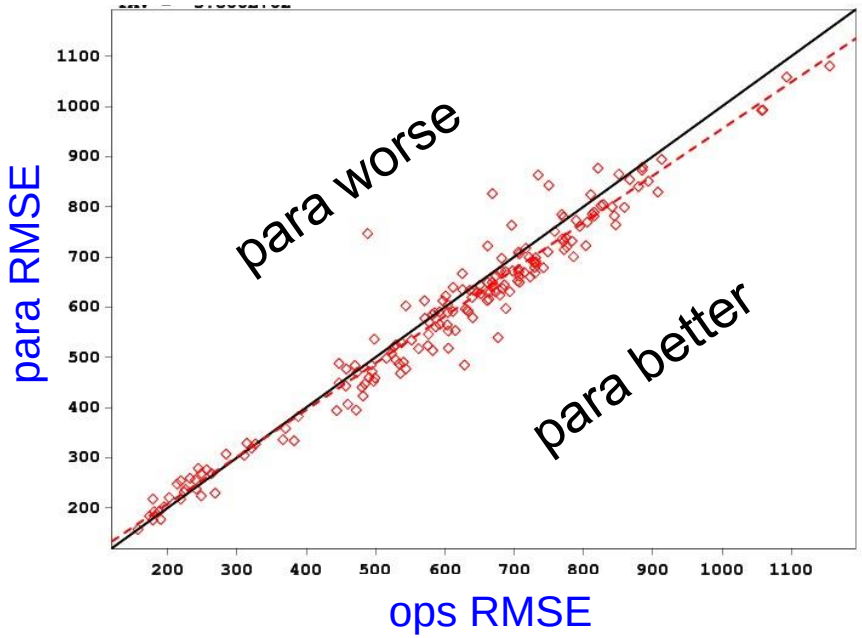
Slightly improved PBL height forecasts (valid 00Z)

AK NMMB



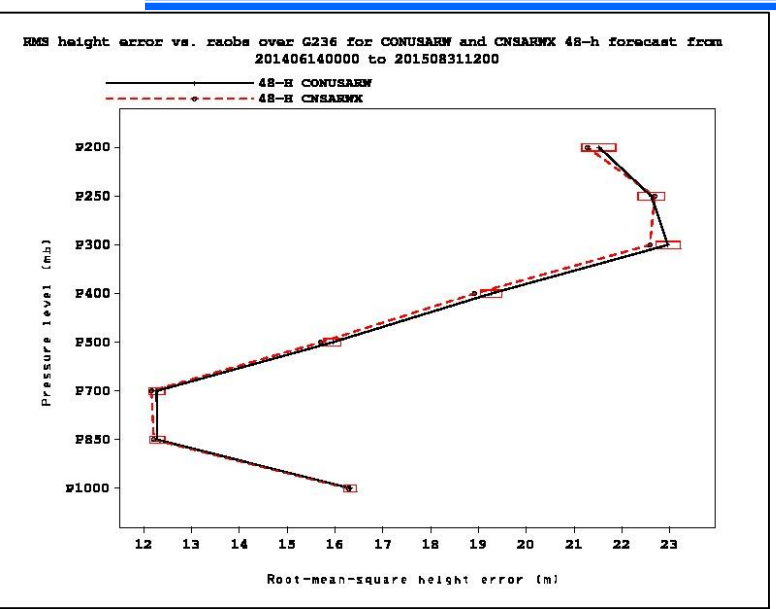
~9 m reduction
avg RMS error

AK WRF-ARW



~18 m reduction
avg RMS error

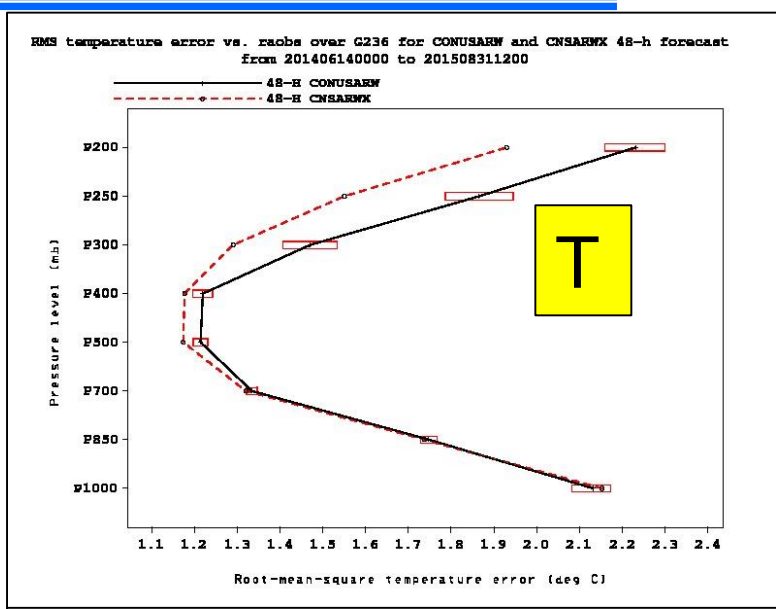
RMS errors at 48 h forecast time for CONUS - ARW

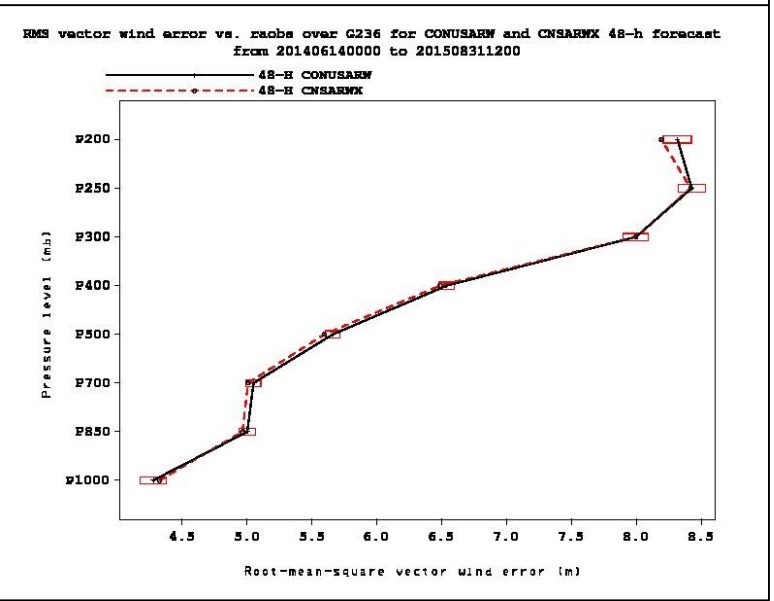


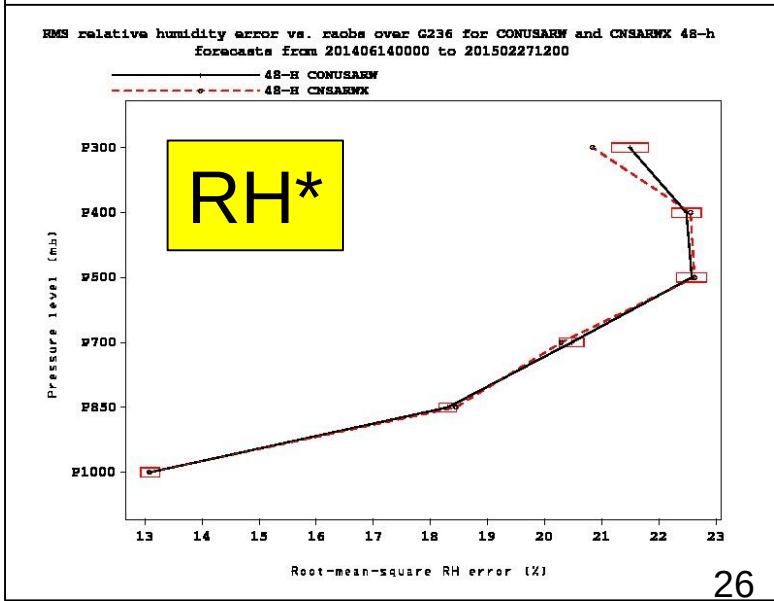
All 00Z cycle test runs

OPS ARW

PARA ARW







Summary

- The parallel HiresW system improves upon the biggest complaints from the 2014 upgrade: echo top height and composite reflectivity in the CONUS WRF-ARW run.
- Also improved are precipitation bias and PBL structure.
- Hints of an enhanced NMMB cool season cold bias will be monitored with an eye on physics developments addressing a similar concern in the NAM.
- By most other metrics, though, forecast skill is little changed.
- HREF helps pave the path to an ensemble-based future, and adds value today as a new forecasting tool.

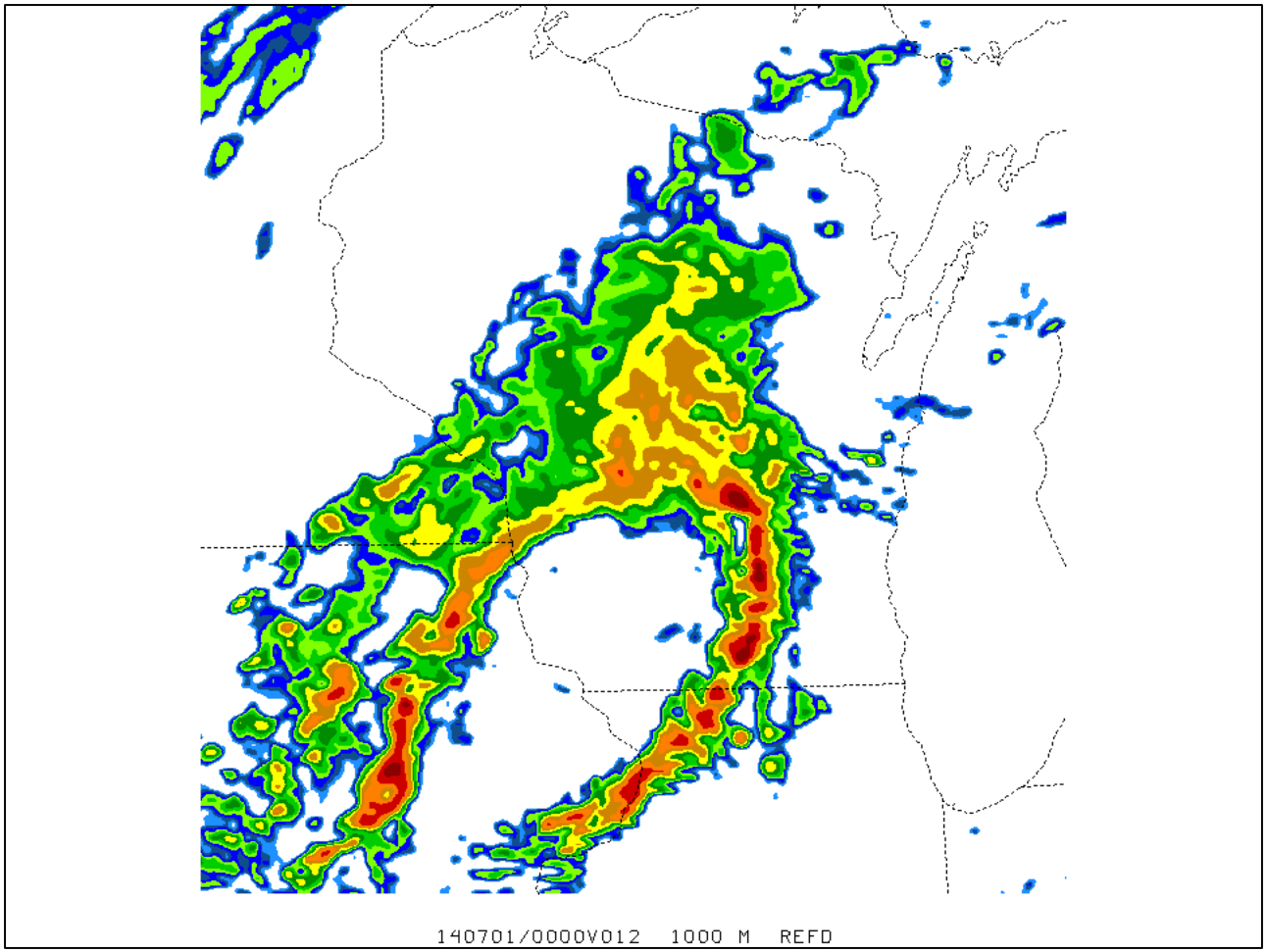
Backup Slides

CPU Usage (model jobs)

Domain	Ops model tasks (nodes) NMMB / ARW phase1 nodes	Para model tasks (nodes) NMMB / ARW phase2 nodes
CONUS	525(33 nodes) / 592(37)	696(29 nodes) / 816(34)
Alaska	496(31) / 540(34)	672(28) / 720(30)
HI	45(3) / 48(3)	72(3) / 67(3)
PR	80(5) / 80(5)	136(6) / 105(5)
Guam	42(3) / 63(4)	72(3) / 72(3)

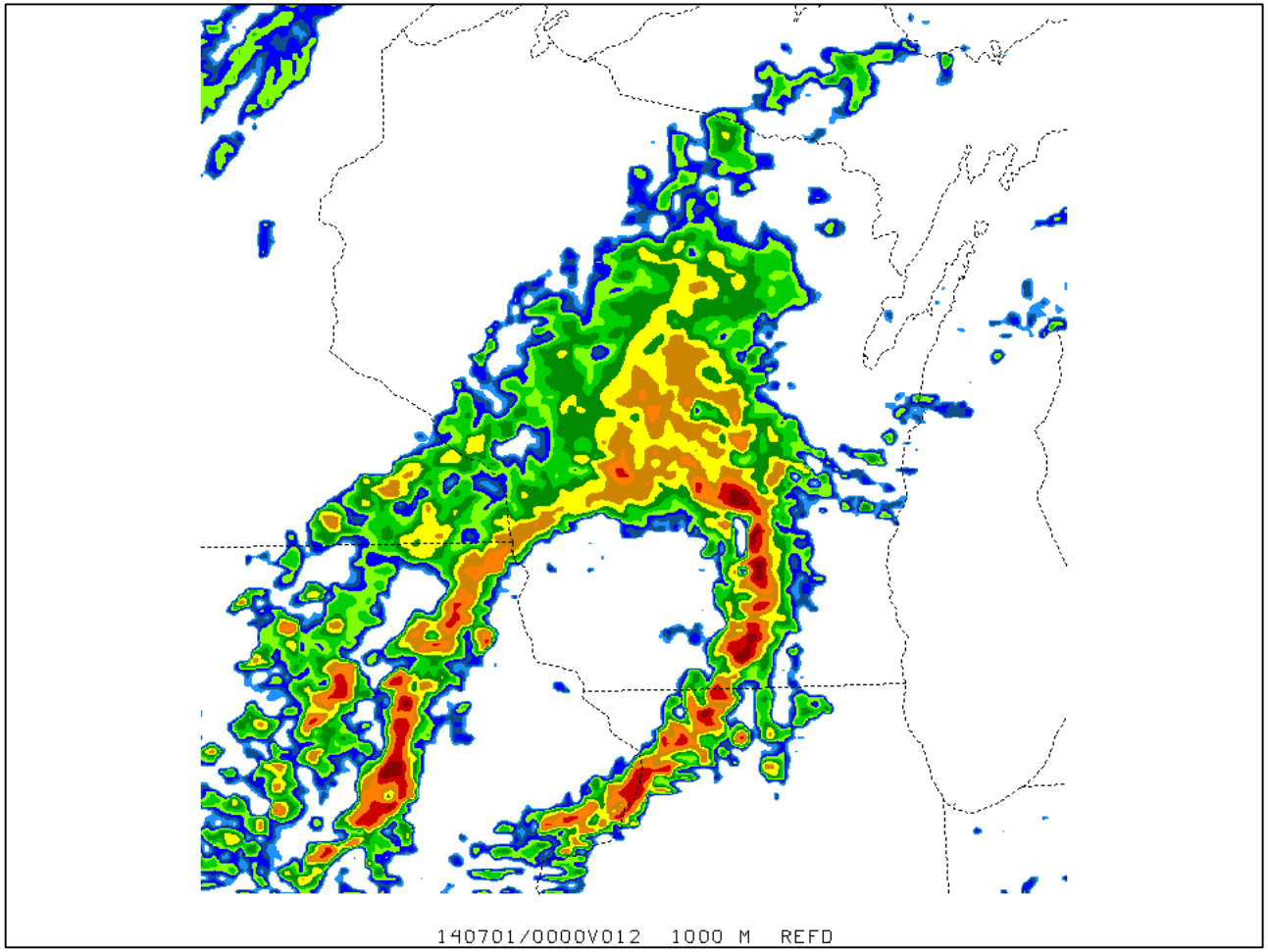
Product Changes

Horizontal interpolation of reflectivity (and echo top height) changed from bilinear…

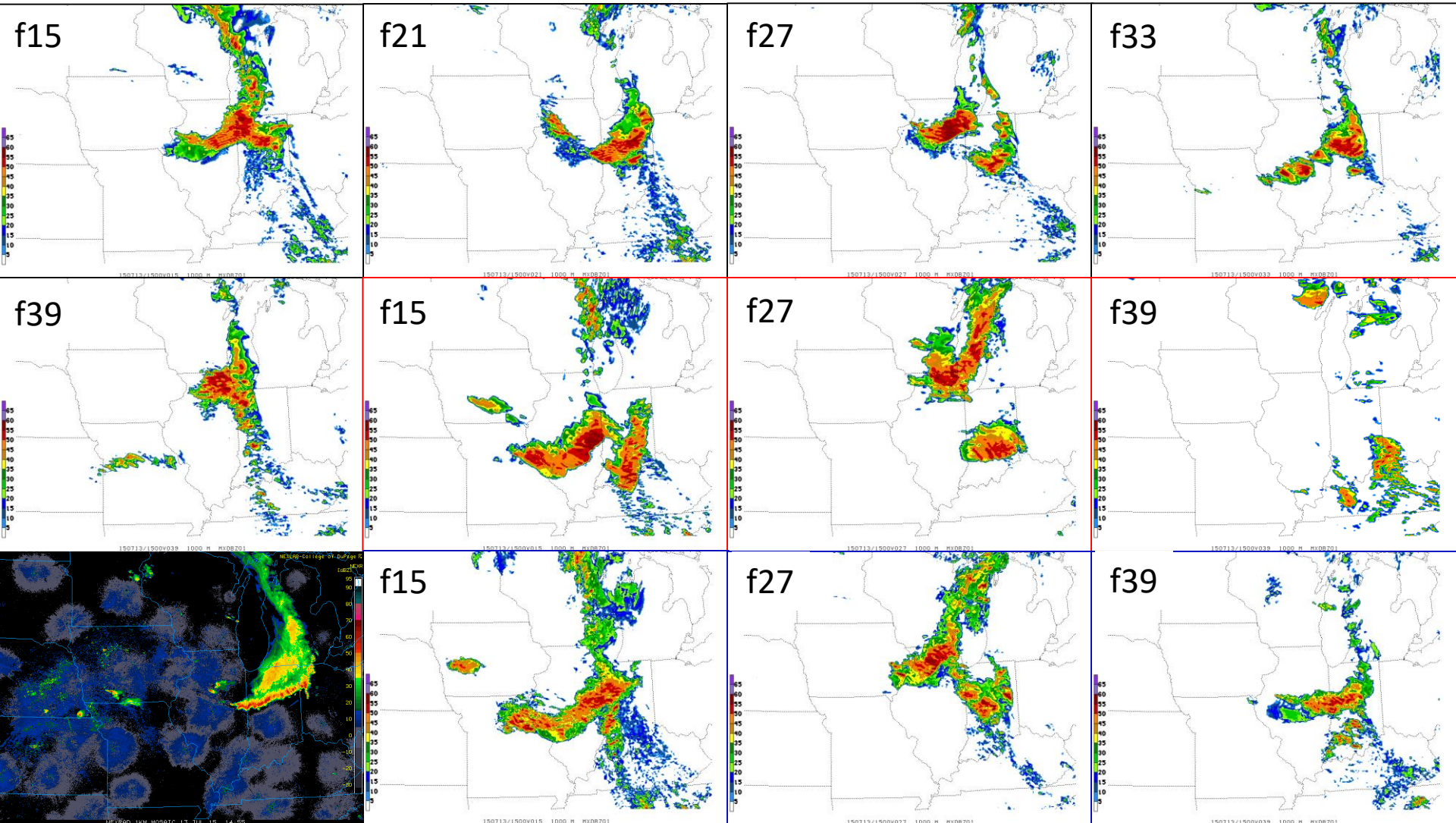


Product Changes (cont.)

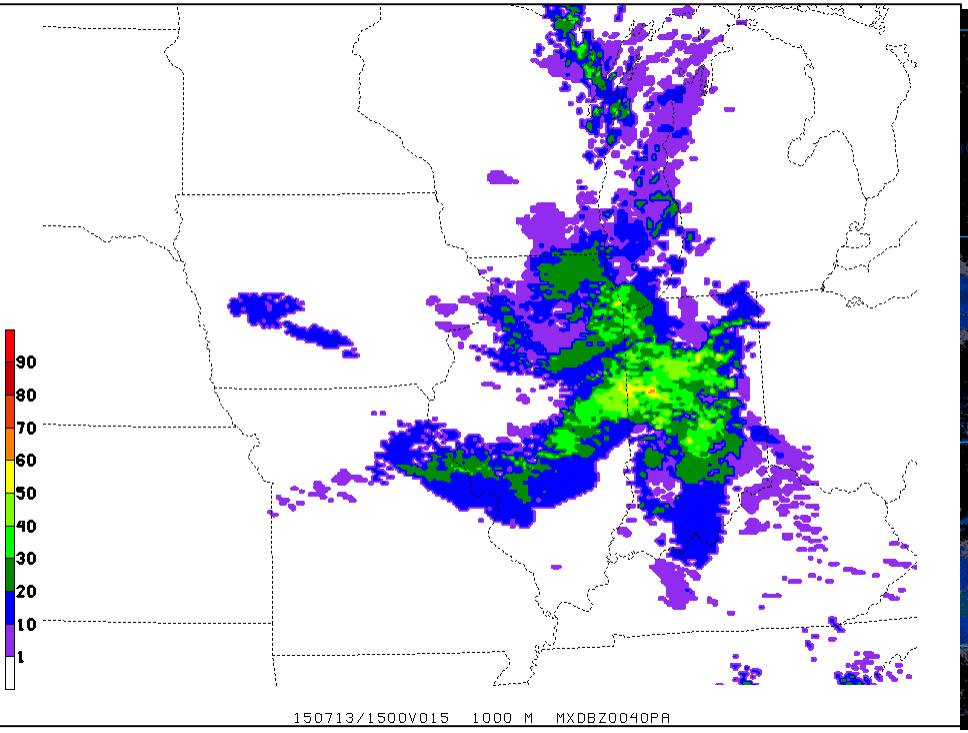
…to nearest neighbor to retain slightly more fine-scale detail



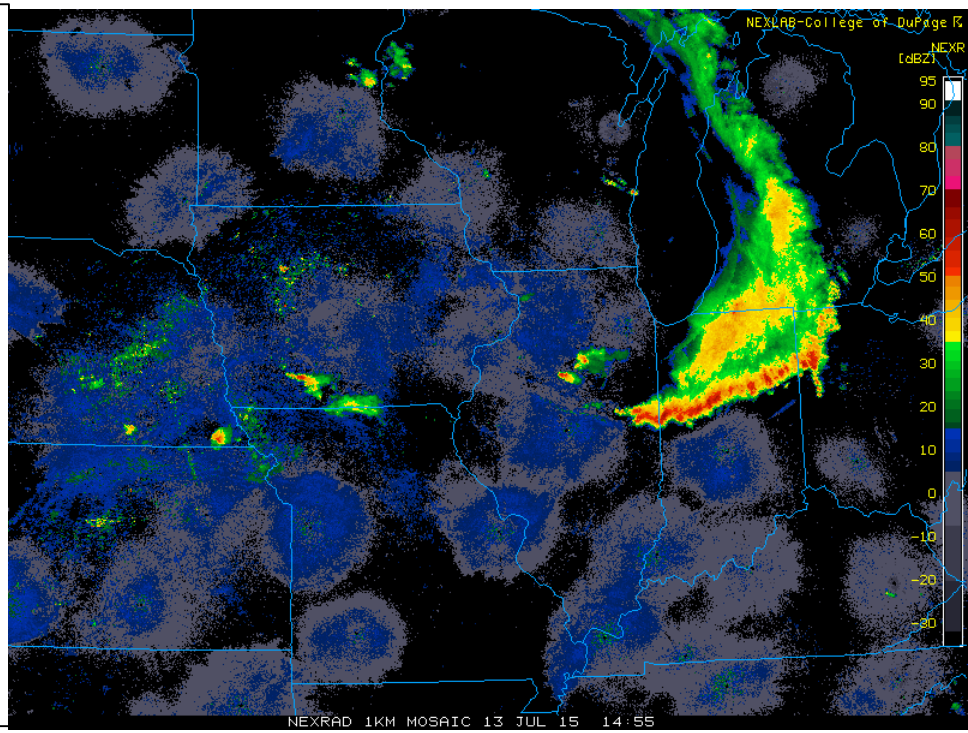
Individual HREF members
hourly max 1000 m AGL reflectivity valid 15Z 13 July



15 h HREF probability of exceedance product

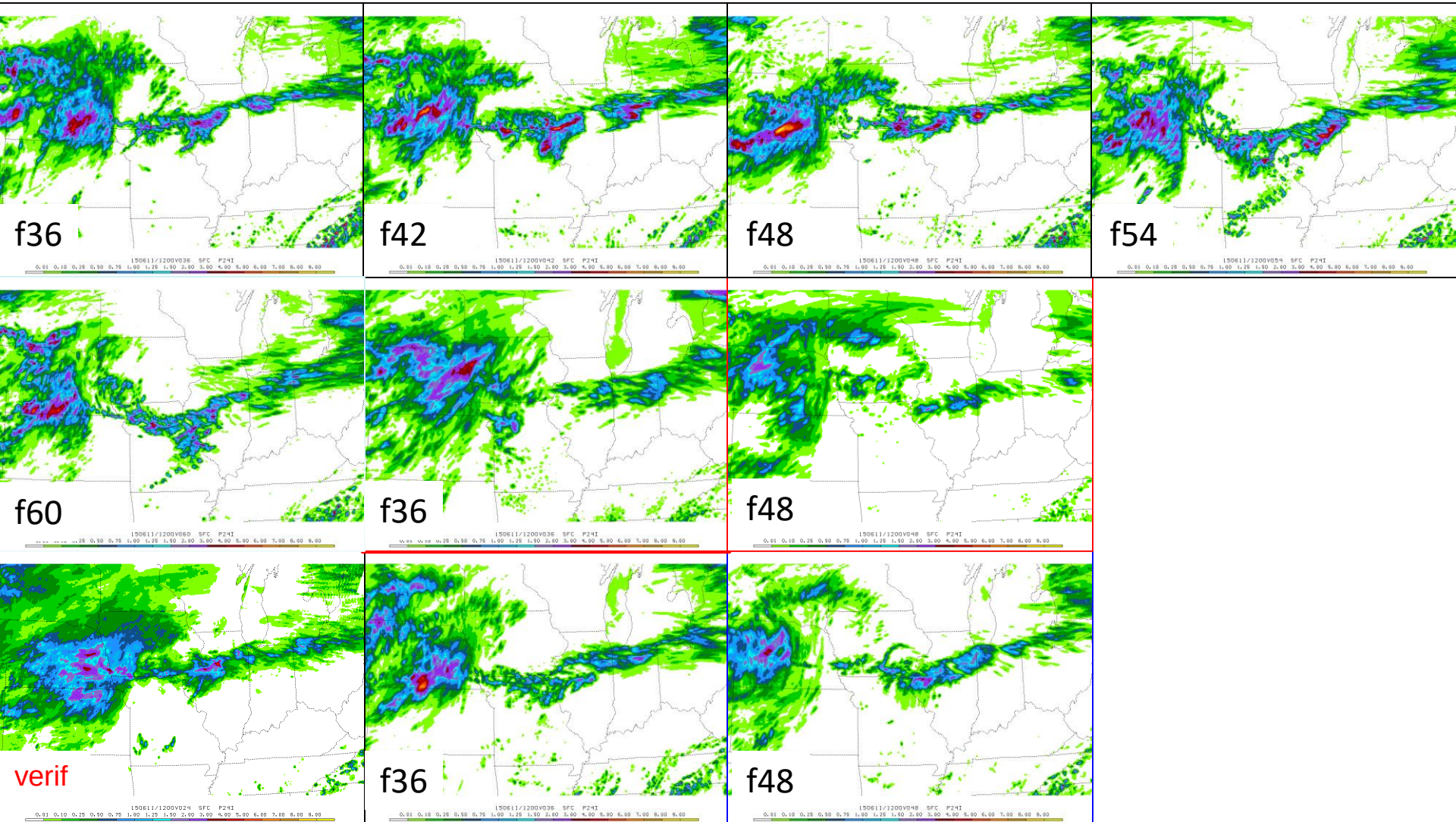


Probability of
hourly max 1000 m REFD > 40 dBZ

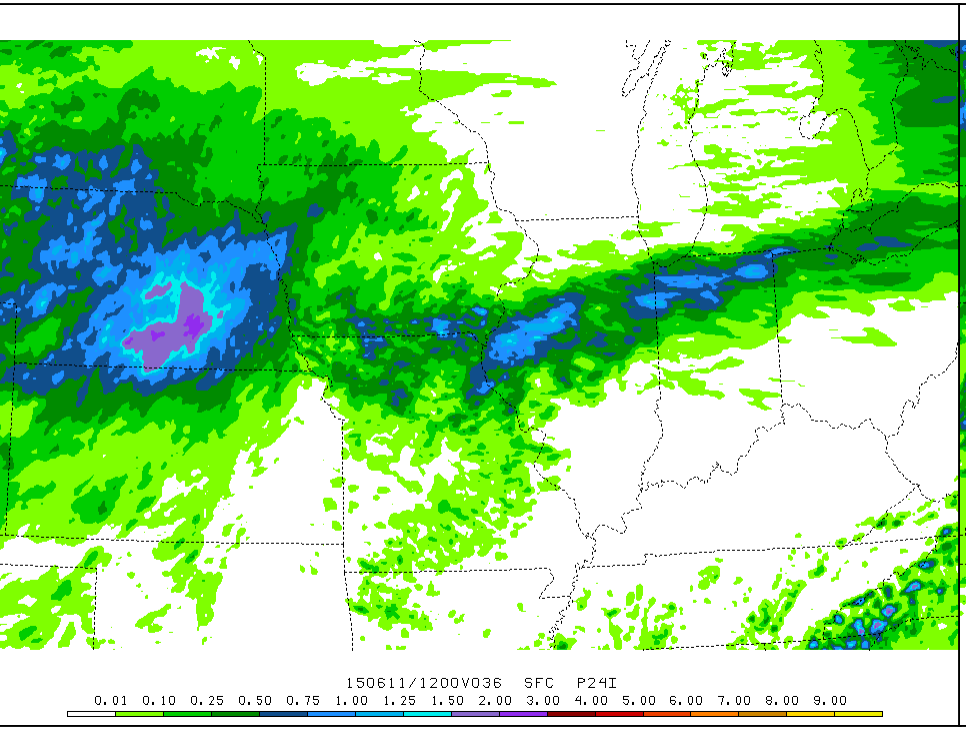


Radar ~15Z 13 July

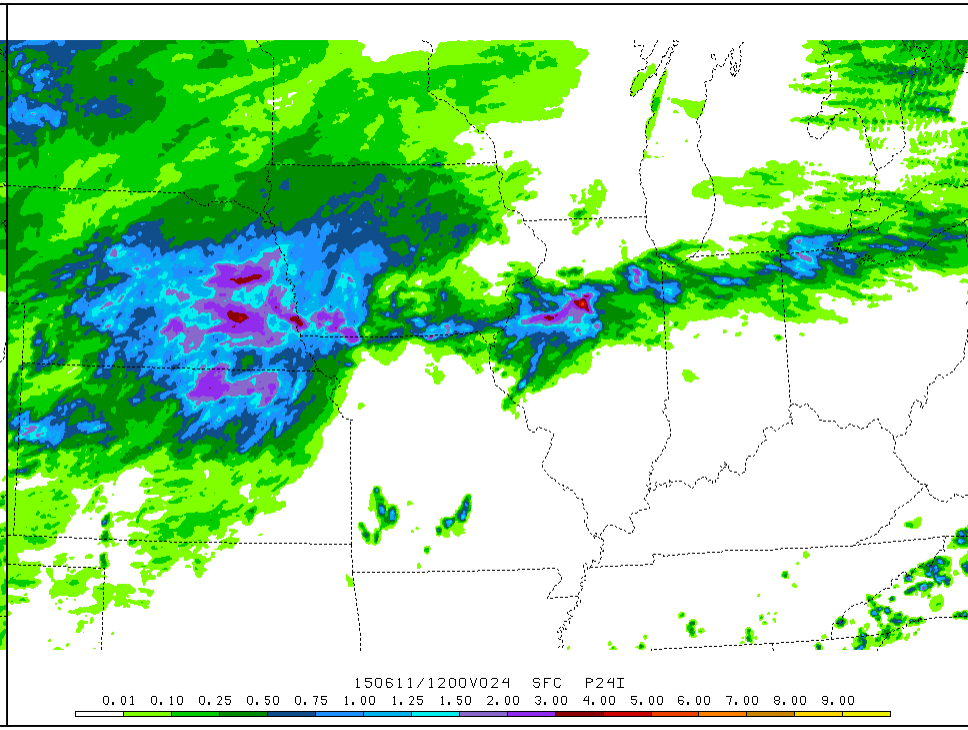
Individual HREF members
24 h precipitation total valid 20150611/12Z



24 h precipitation total valid 20150611/12Z

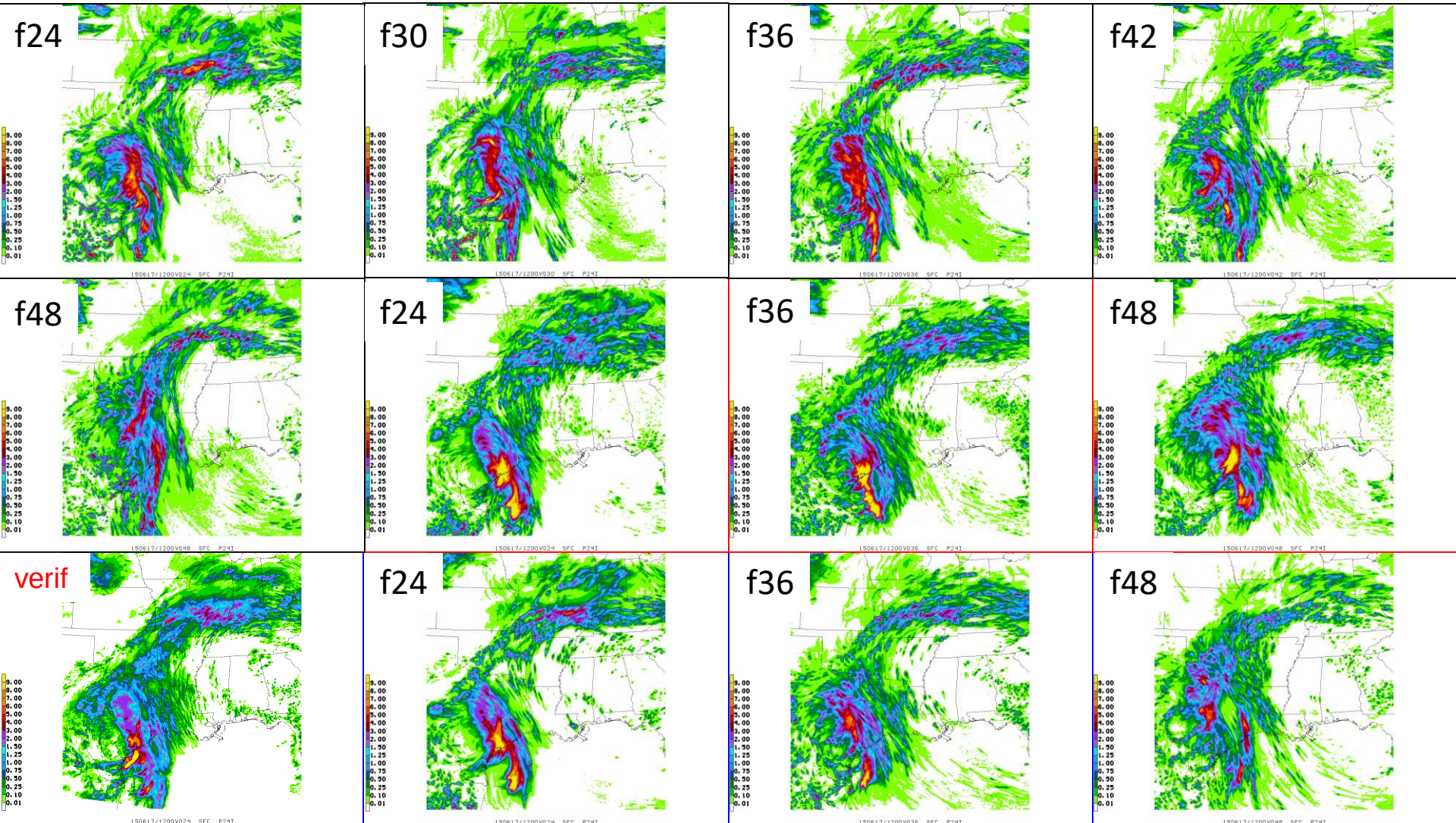


HREF mean

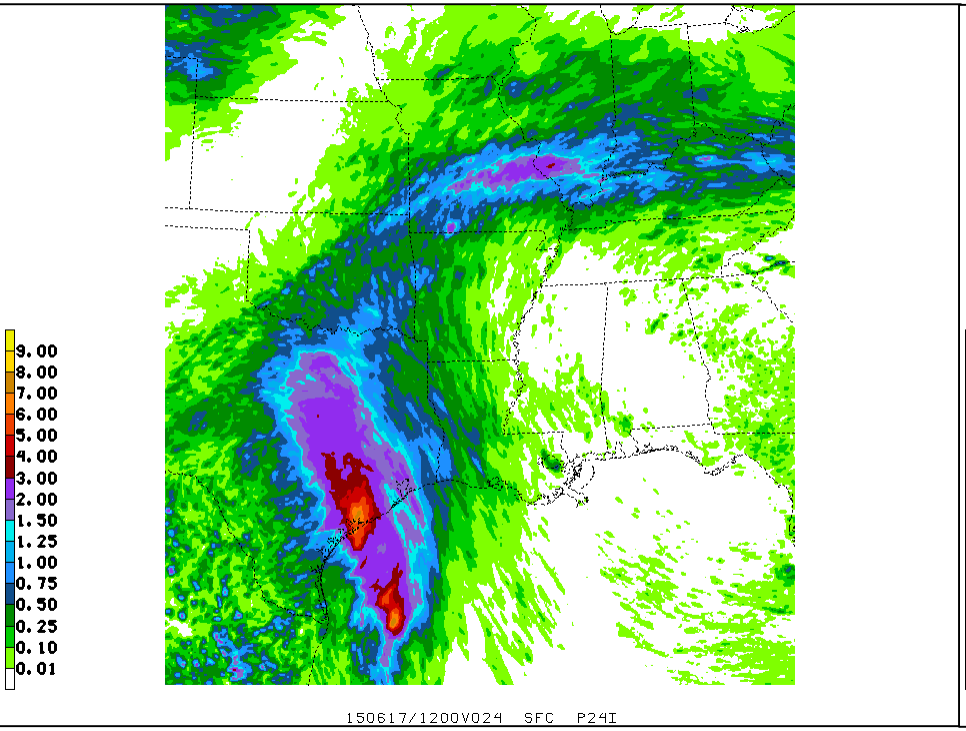


CCPA verification

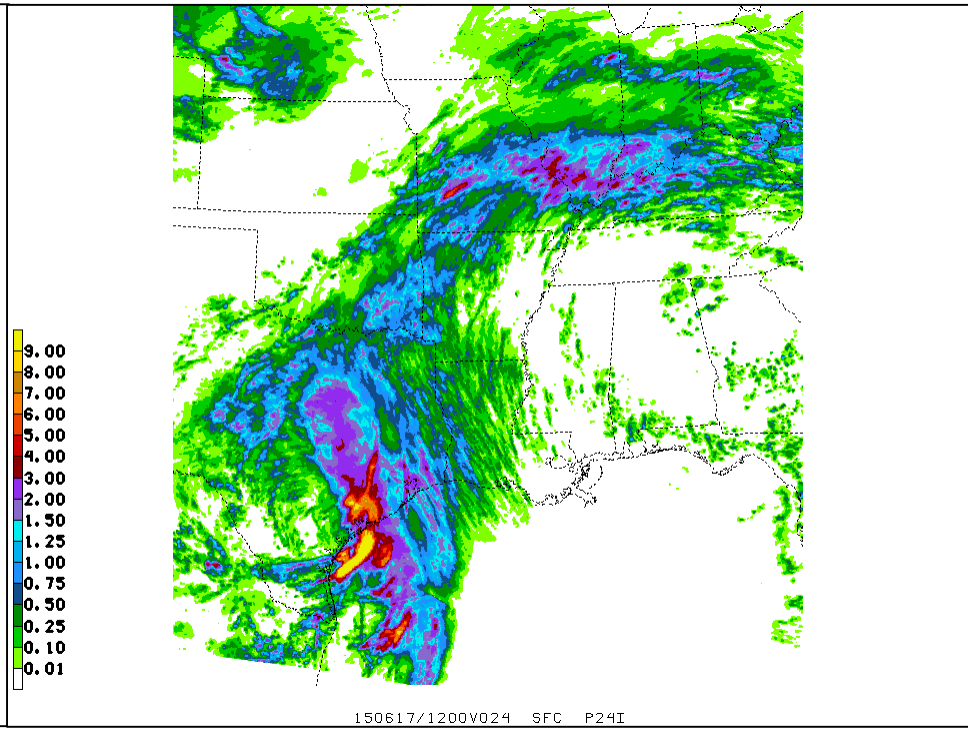
Individual HREF members
24 h precipitation total valid 20150617/12Z (TS Bill)



24 h precipitation total valid 20150617/12Z



HREF mean

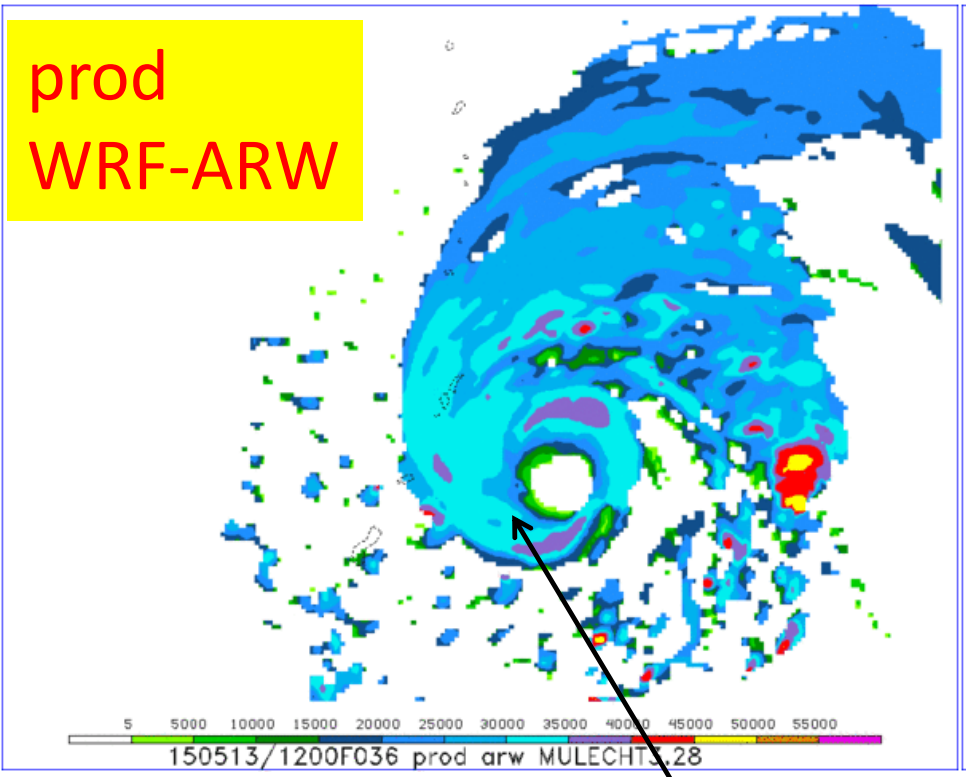


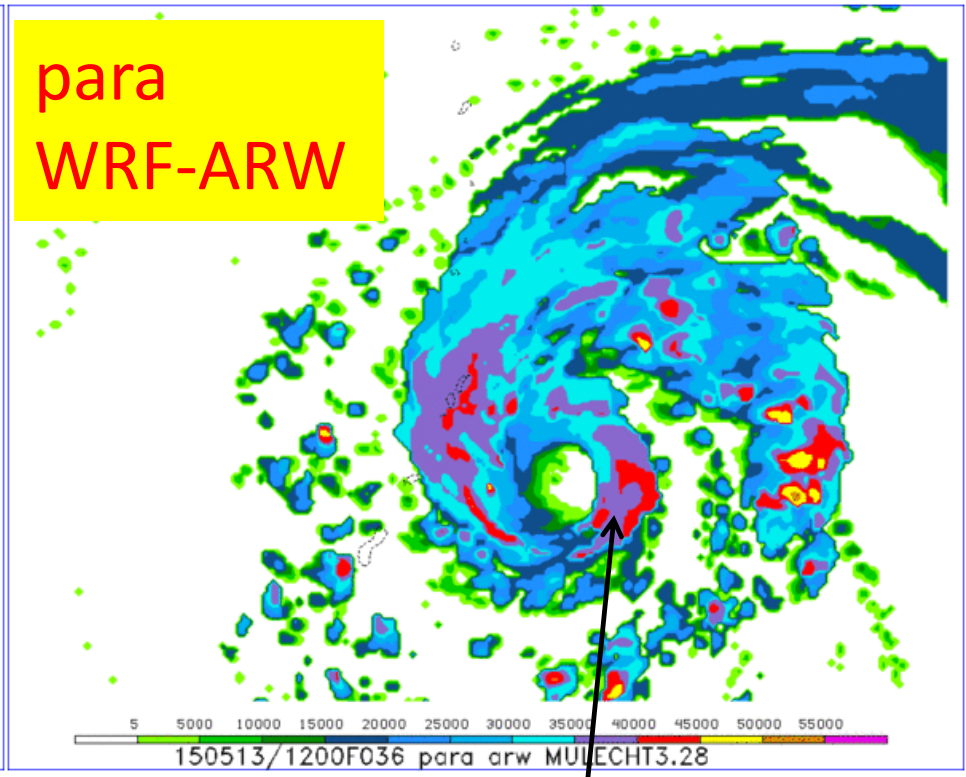
CCPA verification

Typhoon 07W (Dolphin) approaching Guam

36 h forecast valid 12Z 14 May 2015

Echo top height (ft)





Mostly 30-35K in eyewall region

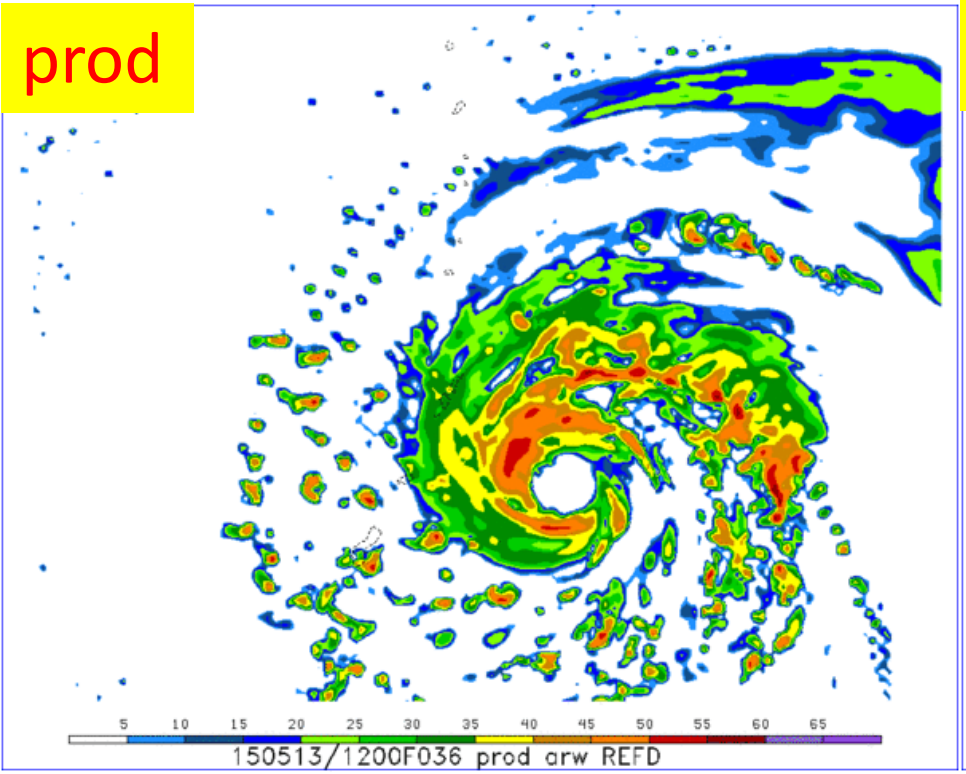
More extensive 35-40K heights in para, some 40-45K (red)

Typhoon 07W (Dolphin) approaching Guam

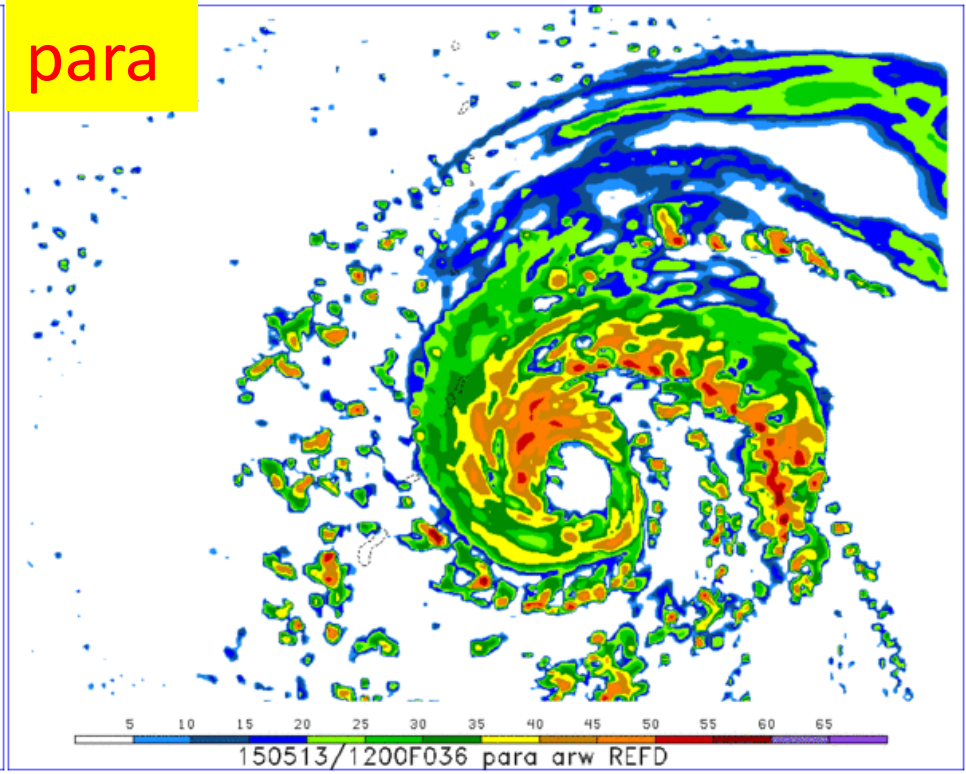
36 h forecast valid 12Z 14 May 2015

1000 m AGL reflectivity

prod



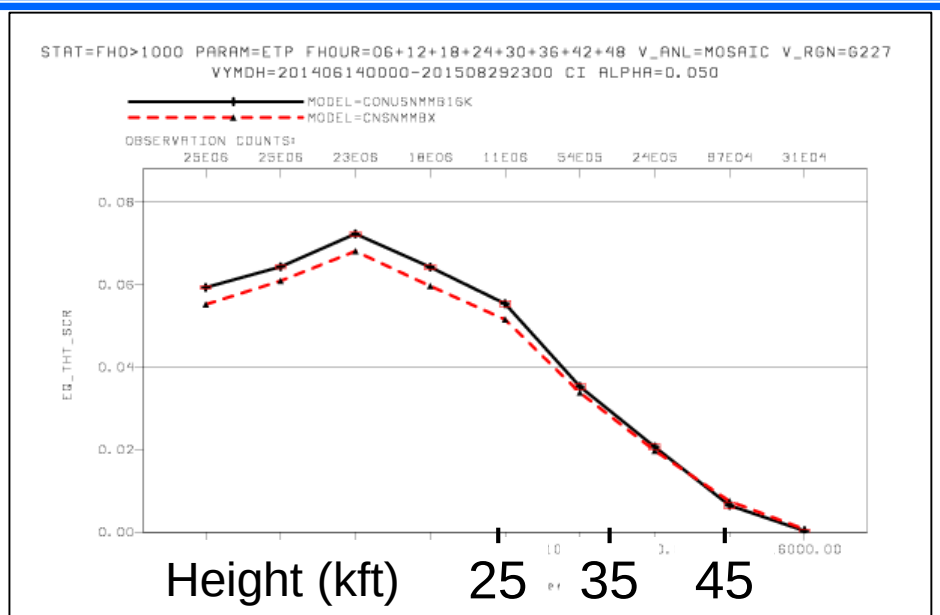
para



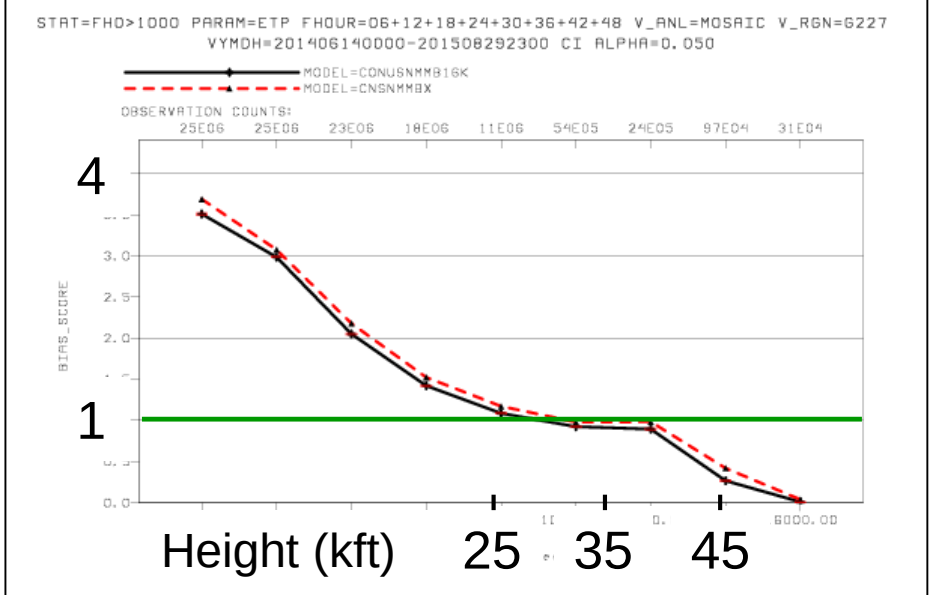
Not identical, but overall signatures much more similar than for echo top height

NMMB echo top height

Equitable threat score



Bias



Grid-to-grid verification against radar mosaic

Ops HiresW

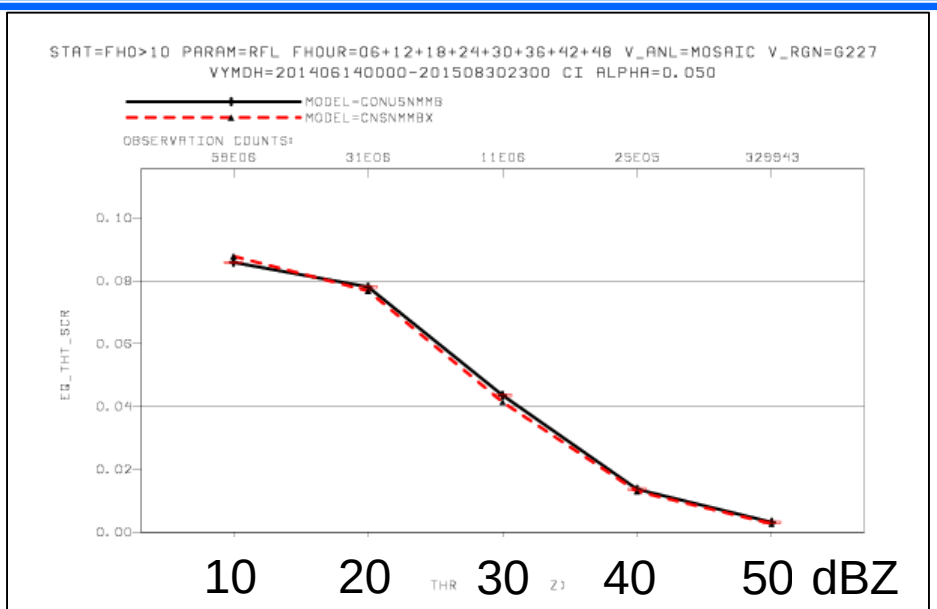
Para HiresW

Little change in the 25-45K foot range important for aviation.

NMMB composite reflectivity

Grid-to-grid verification against radar mosaic

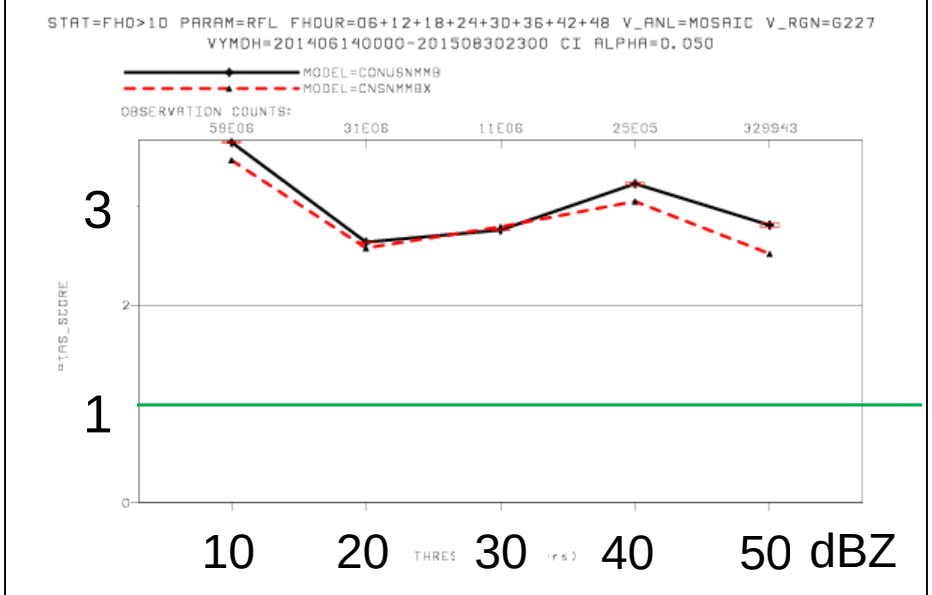
Equitable Threat Score



Ops HiresW

Para HiresW

Bias

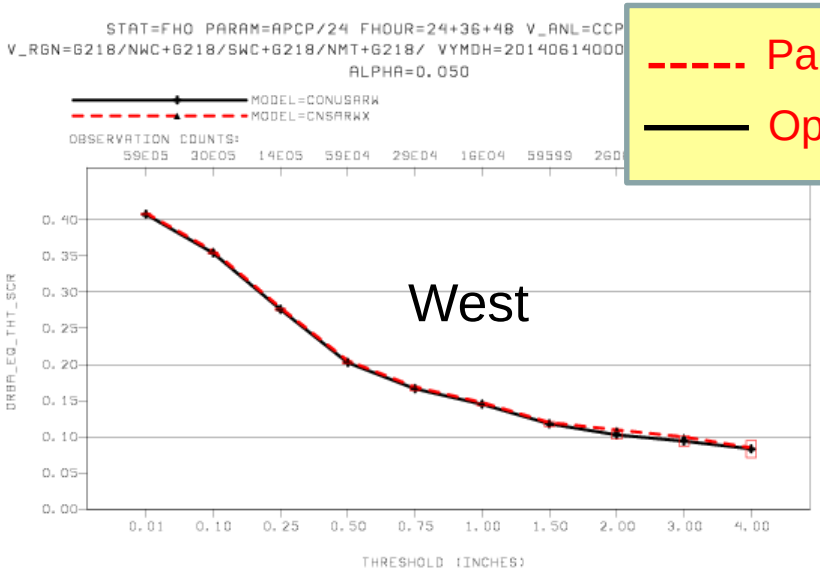


bias=1

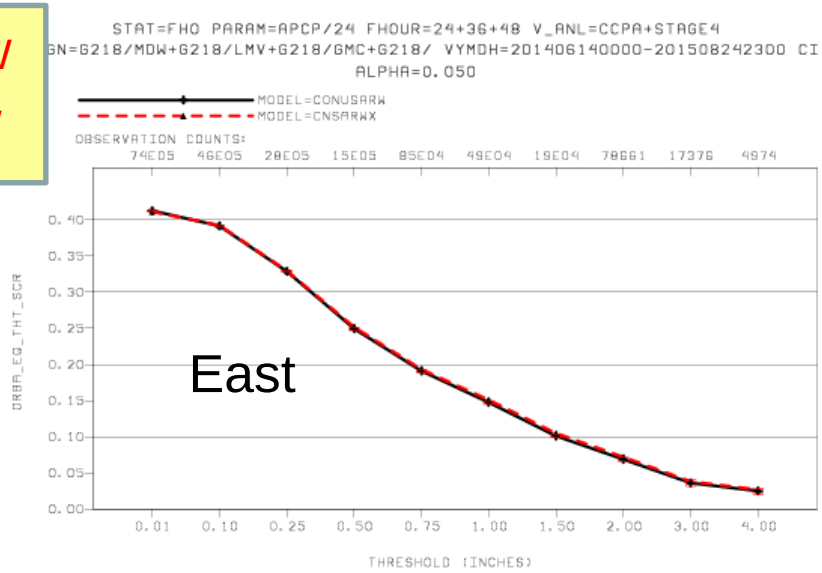
CONUS ARW precipitation – by region

Para HiresW

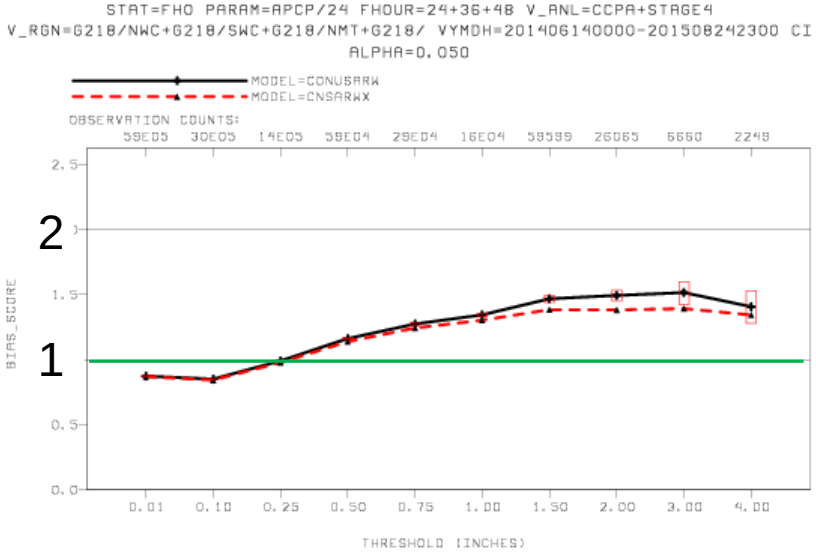
Ops HiresW



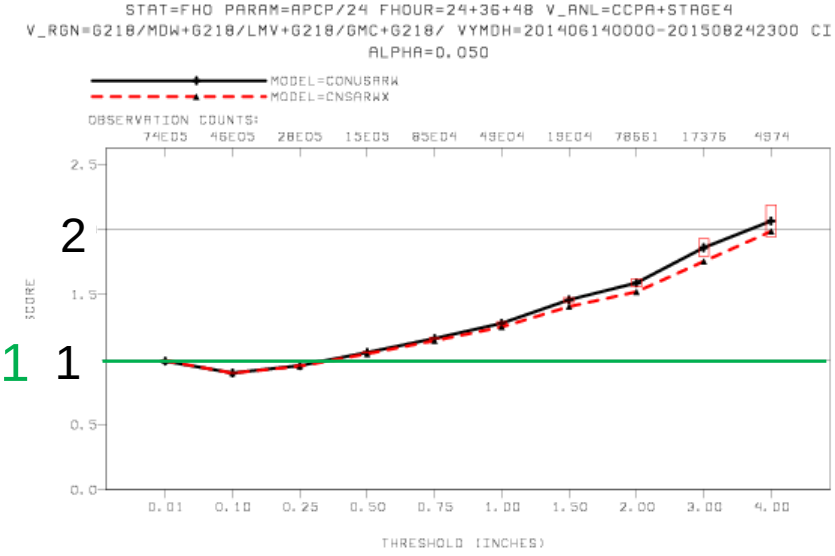
West



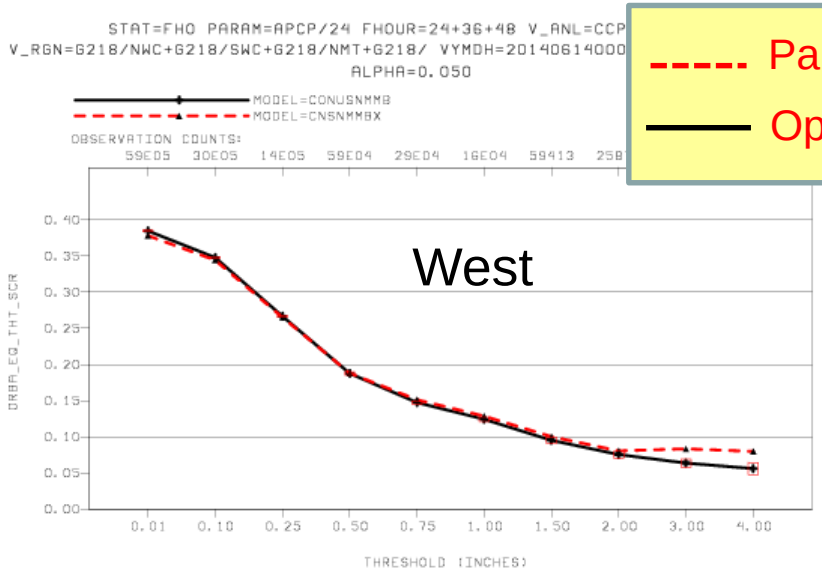
East



bias=1



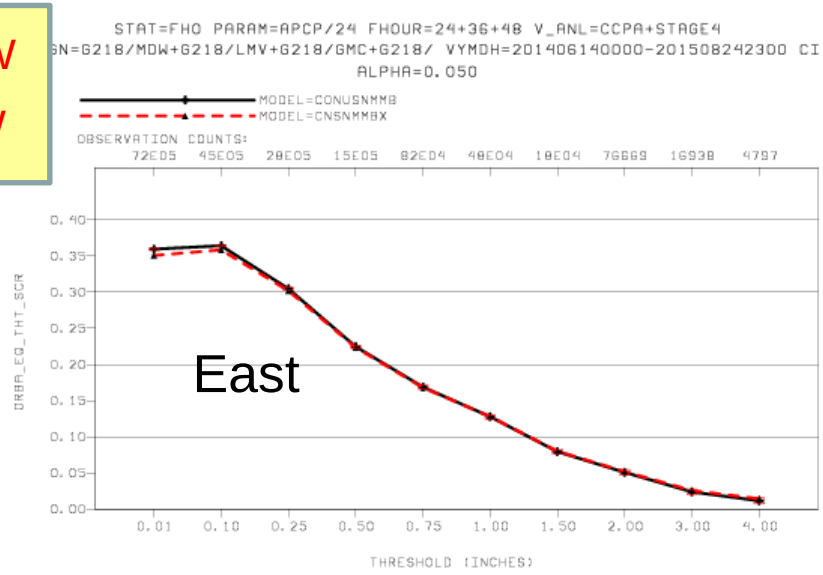
CONUS NMMB precipitation – by region



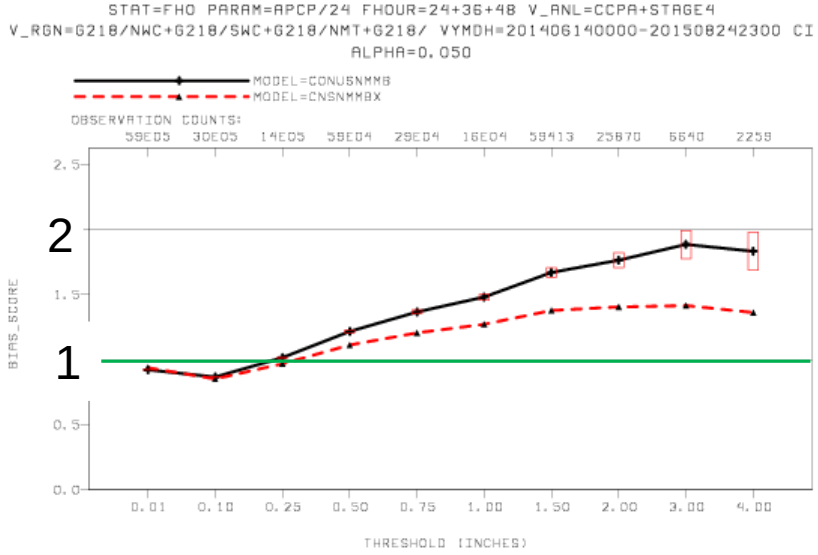
Para HiresW

Ops HiresW

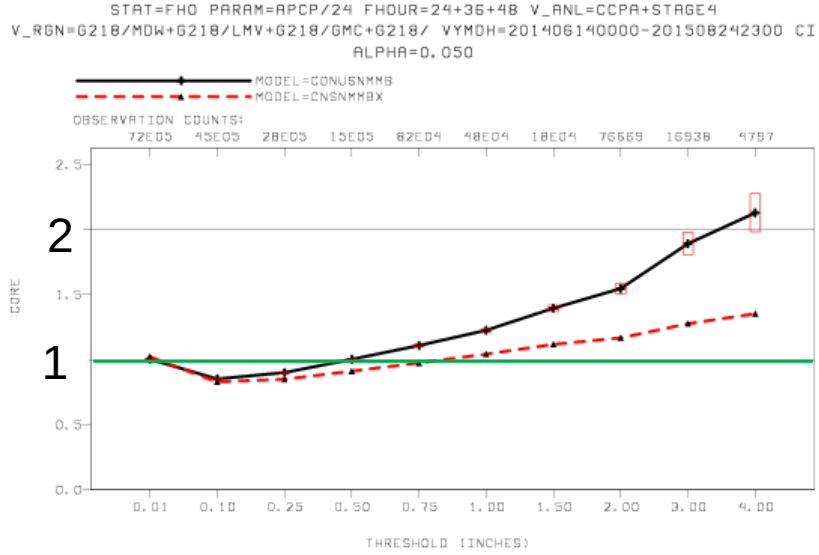
West



East



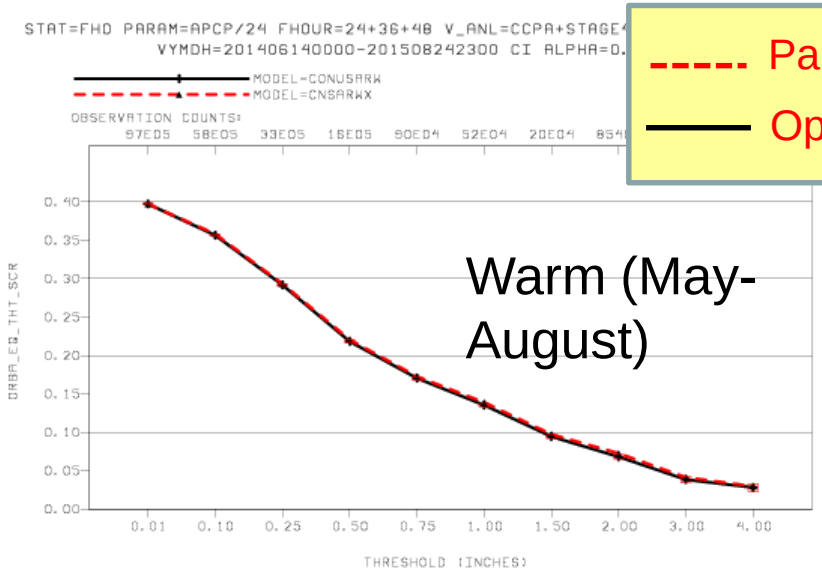
bias=1



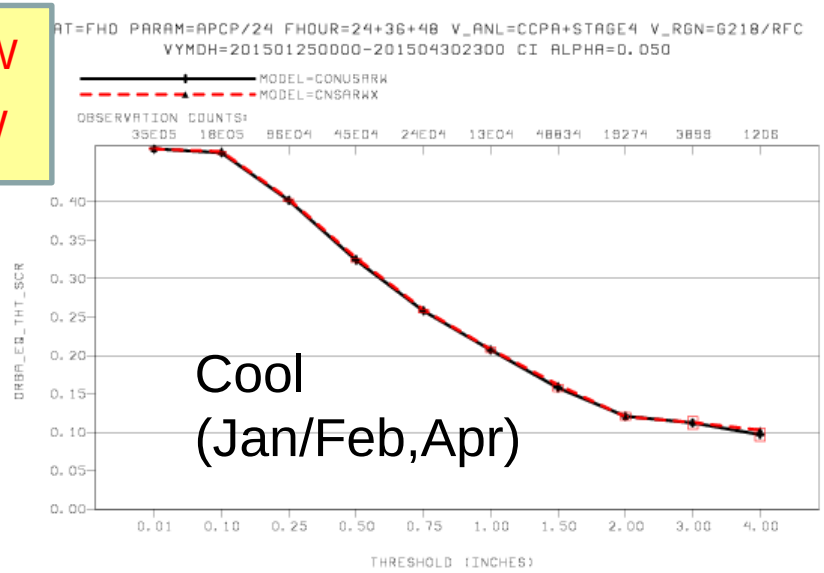
CONUS ARW precipitation – by season

Para HiresW

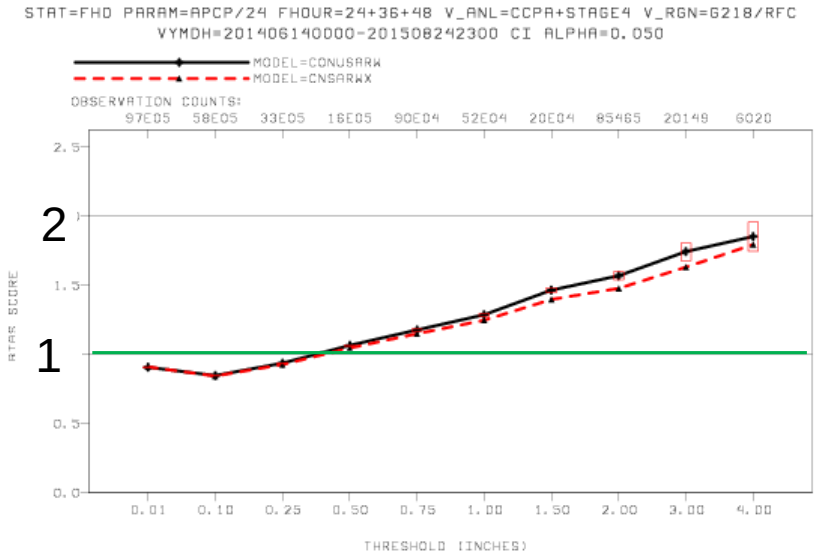
Ops HiresW



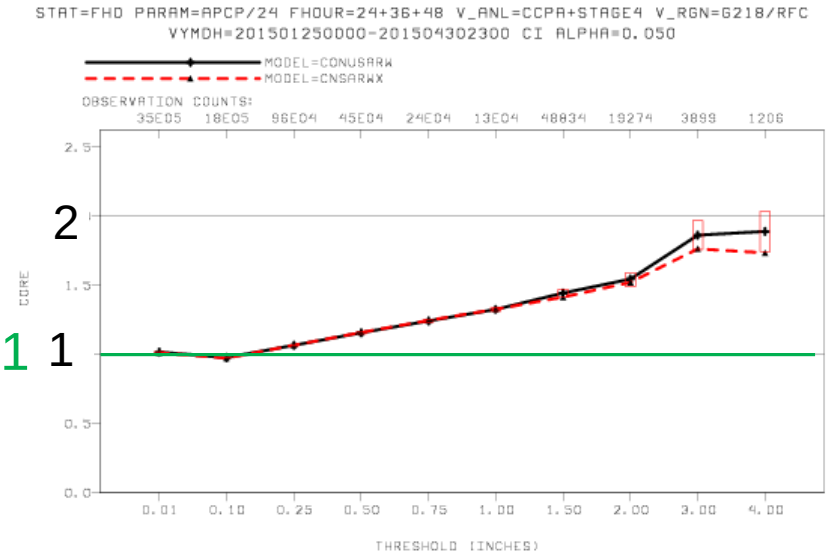
Warm (May-August)



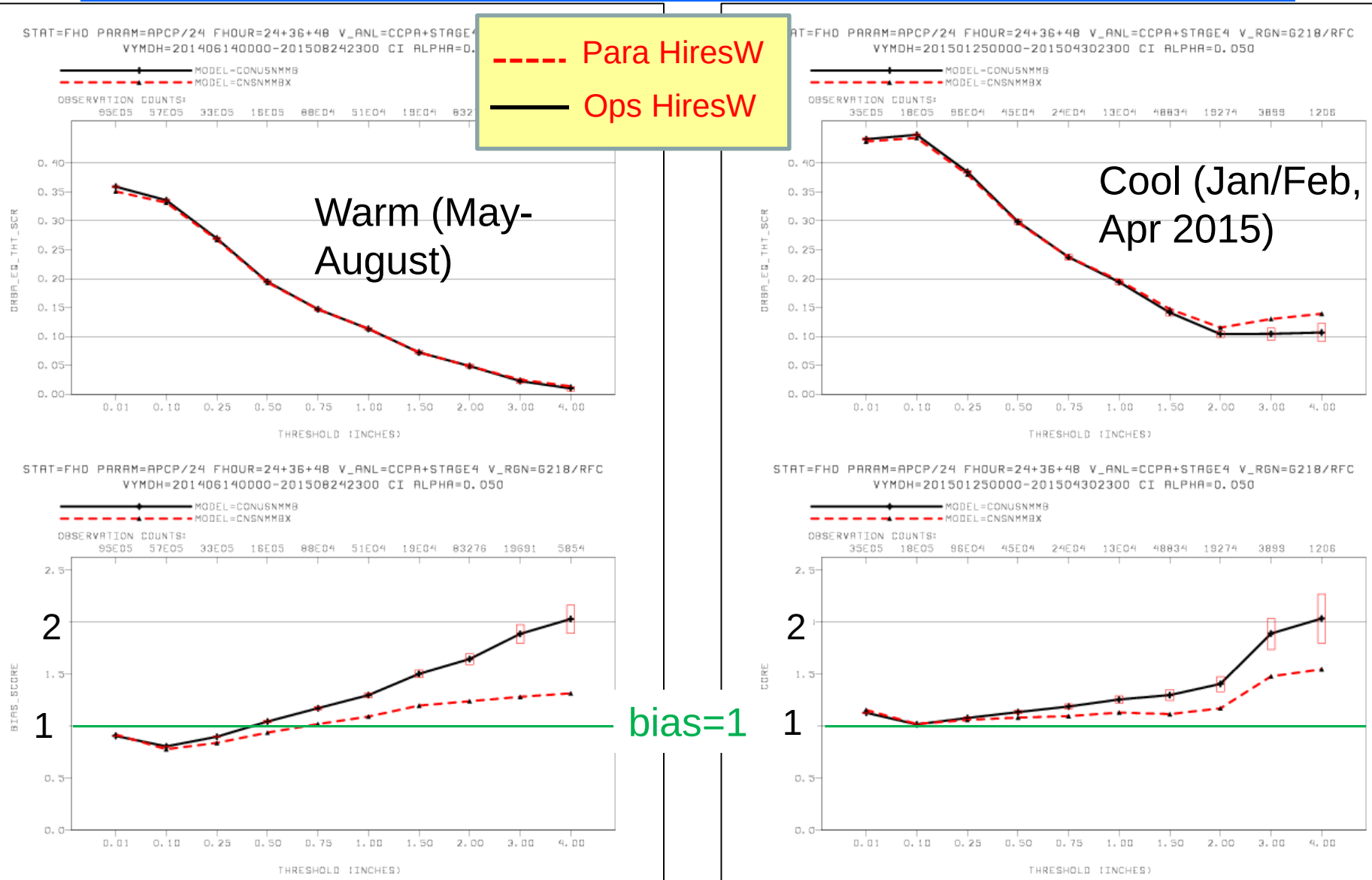
Cool (Jan/Feb,Apr)



bias=1

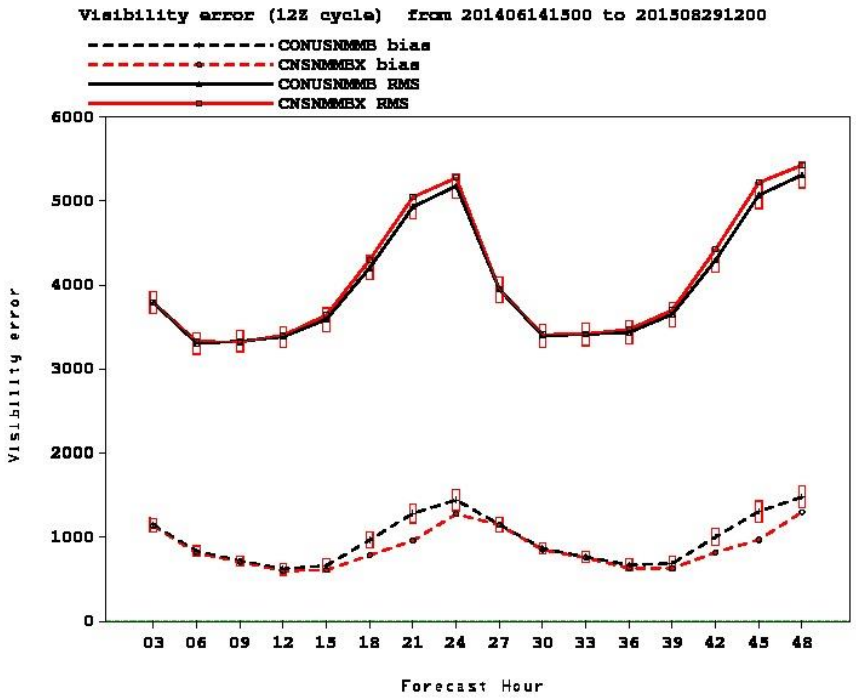


CONUS NMMB precipitation – by season

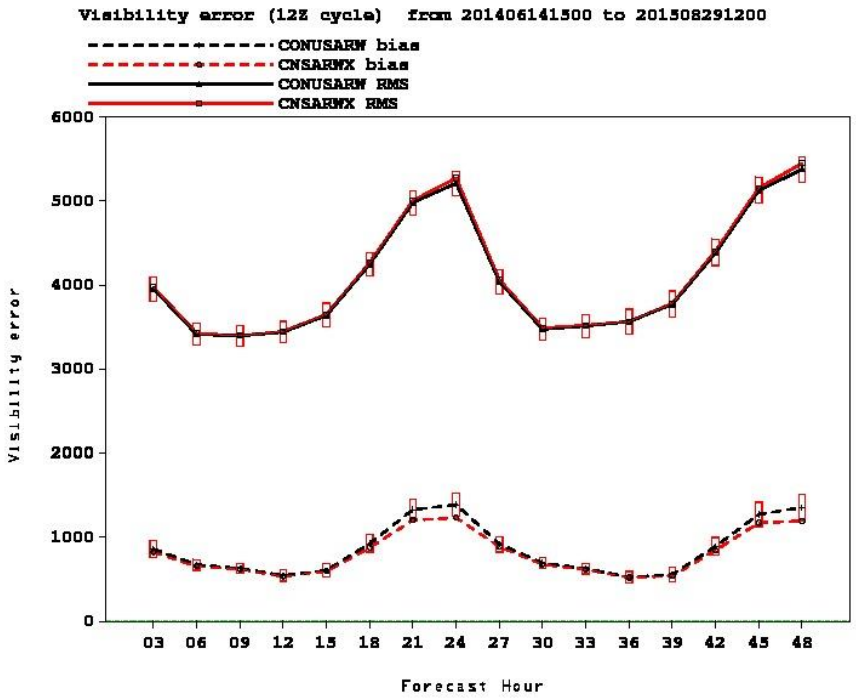


CONUS visibility, 12Z cycle

ops RMS
para RMS
ops bias
para bias



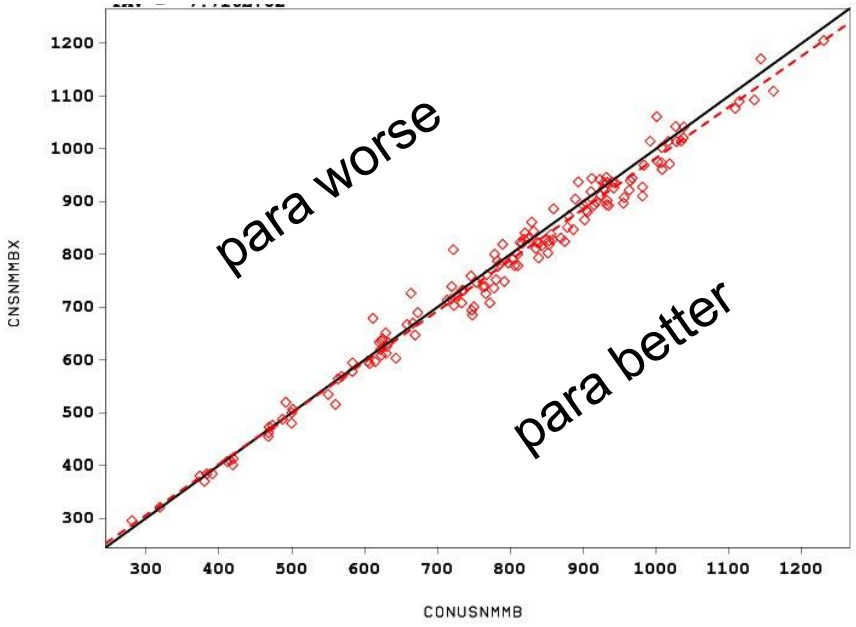
NMMB



WRF-ARW

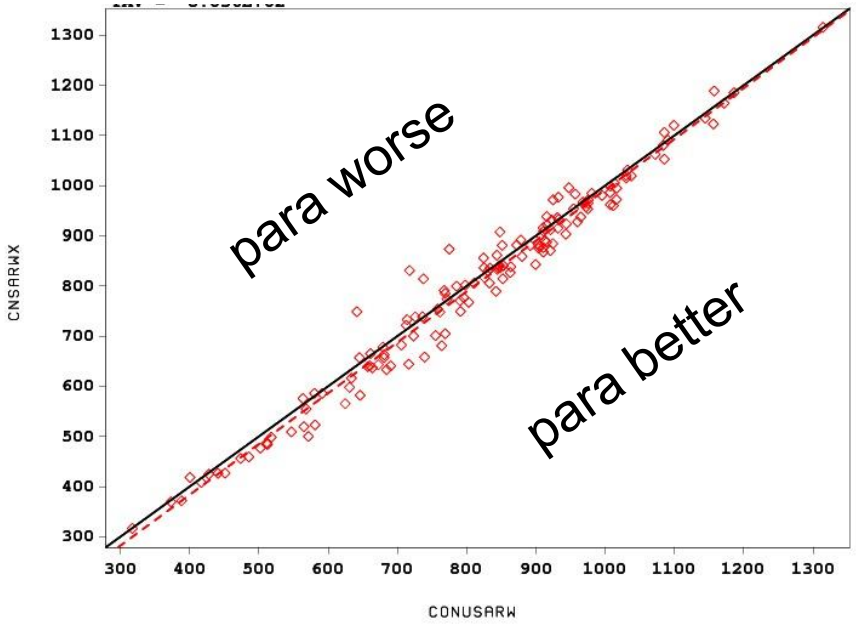
Slightly improved convective PBL height forecasts (valid 00Z)

CONUS NMMB



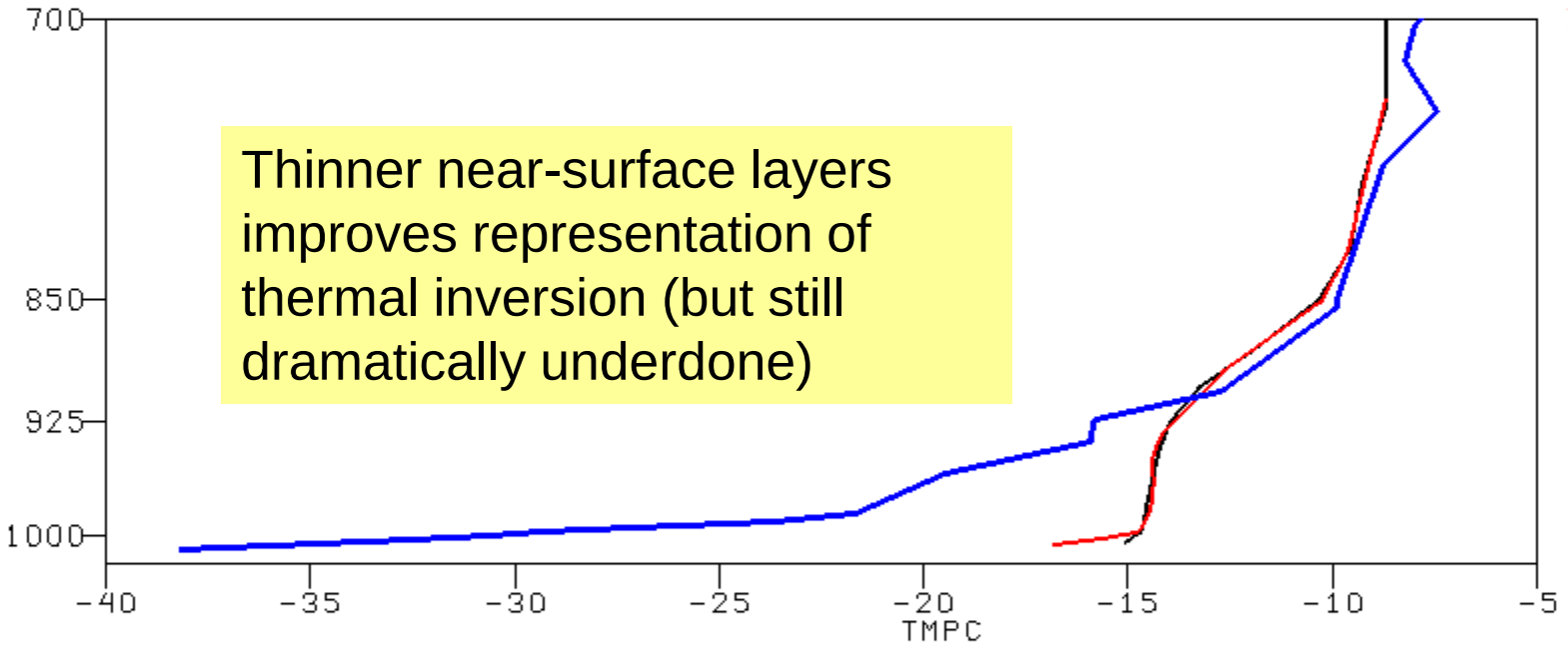
~10 m reduction in RMS error

CONUS WRF-ARW



~11 m reduction in RMS error

Representation of shallow arctic air



Thinner near-surface layers improves representation of thermal inversion (but still dramatically underdone)

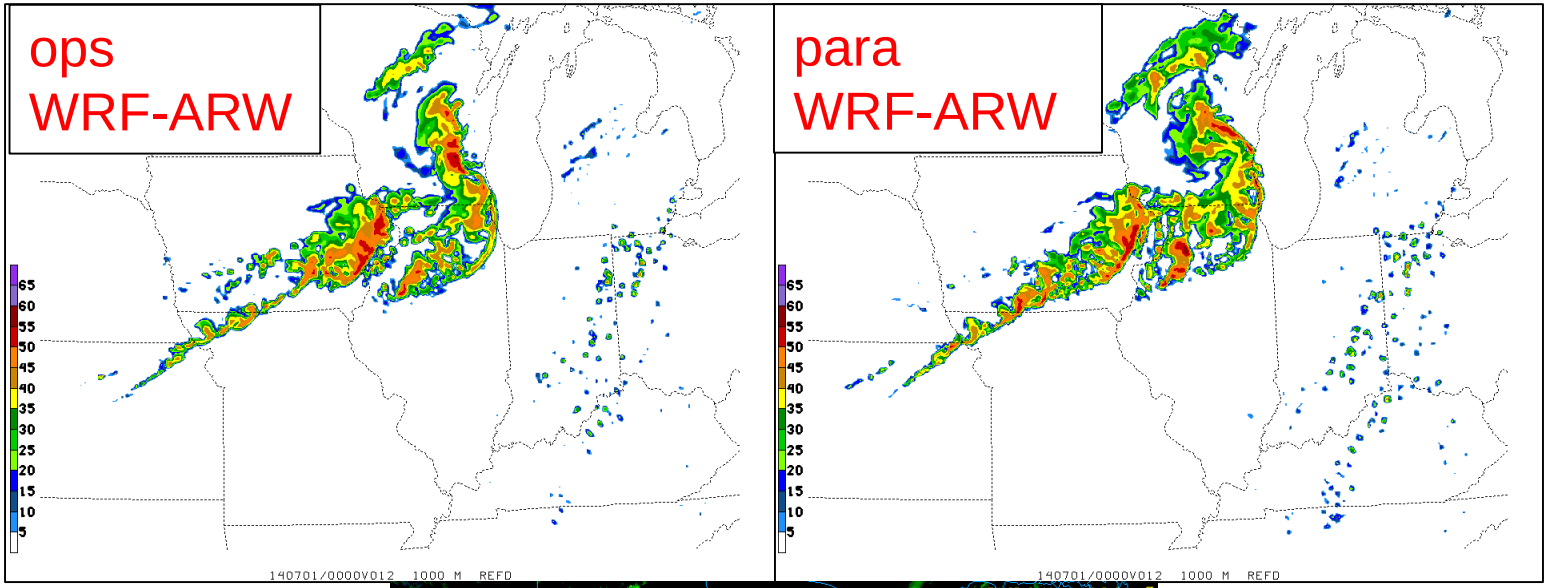
WRF-ARW valid 12Z 28 Jan 2015

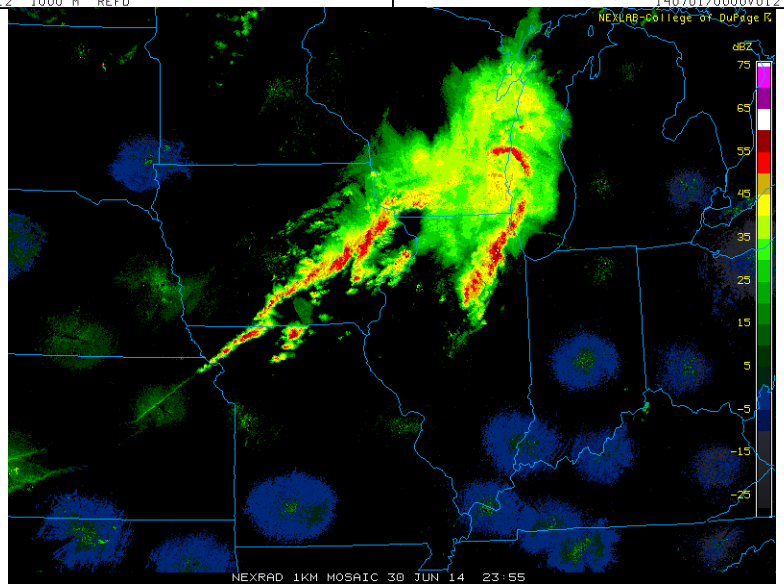
Ops HiresW

Para HiresW

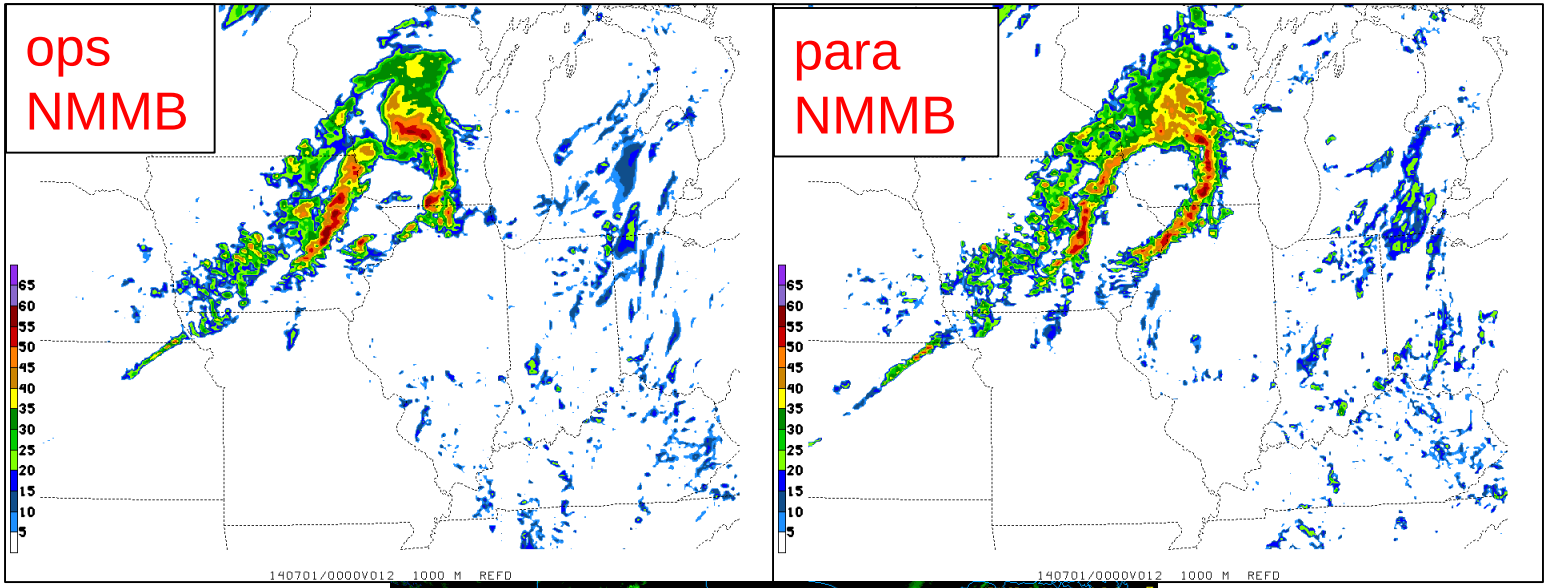
Obs

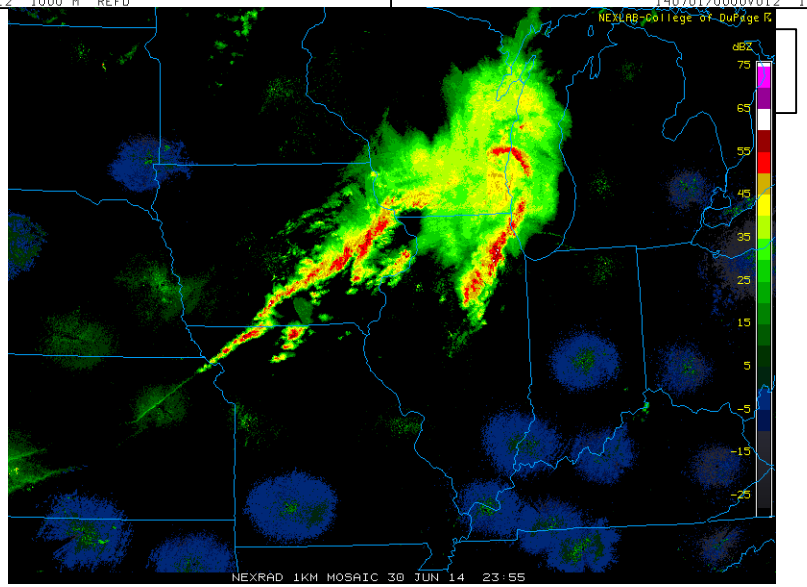
Model and observed 1 km AGL radar, 00Z 1 Jul 2015



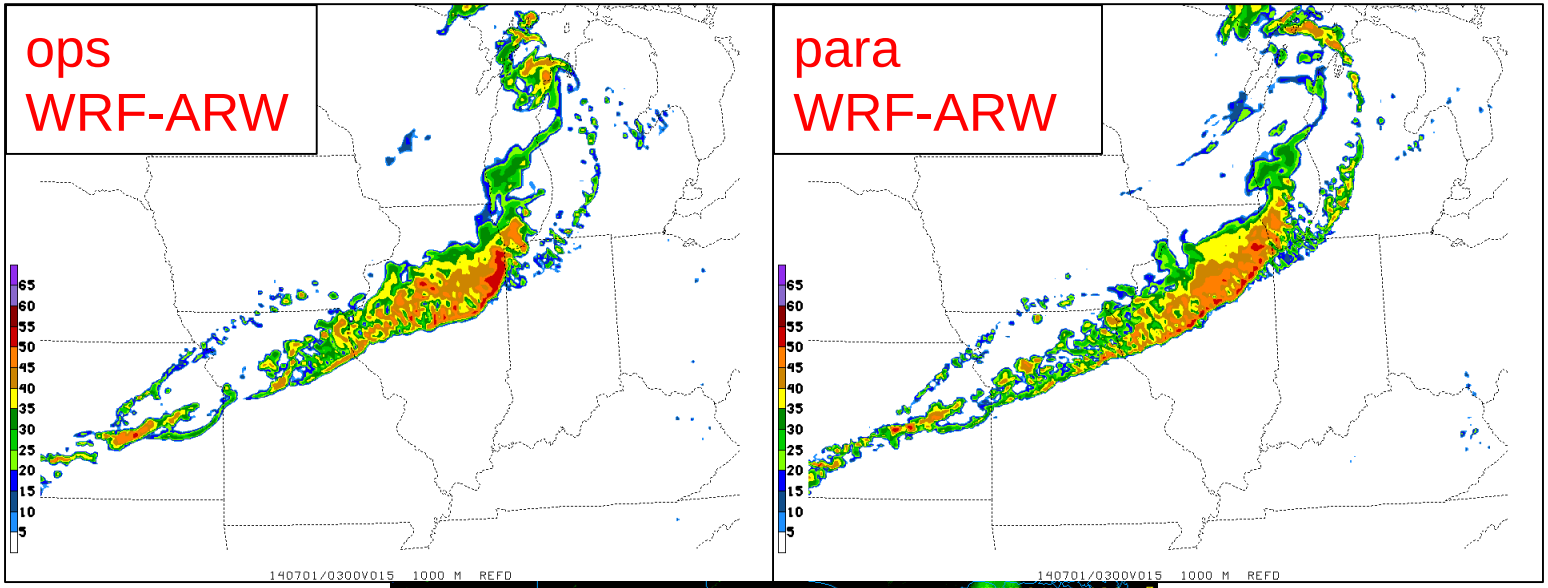


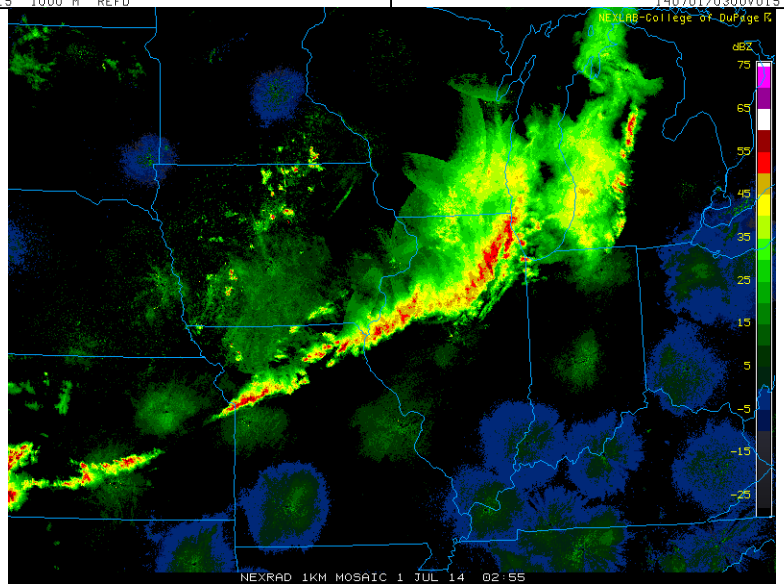
Model and observed 1 km AGL radar, 00Z 1 Jul 2015



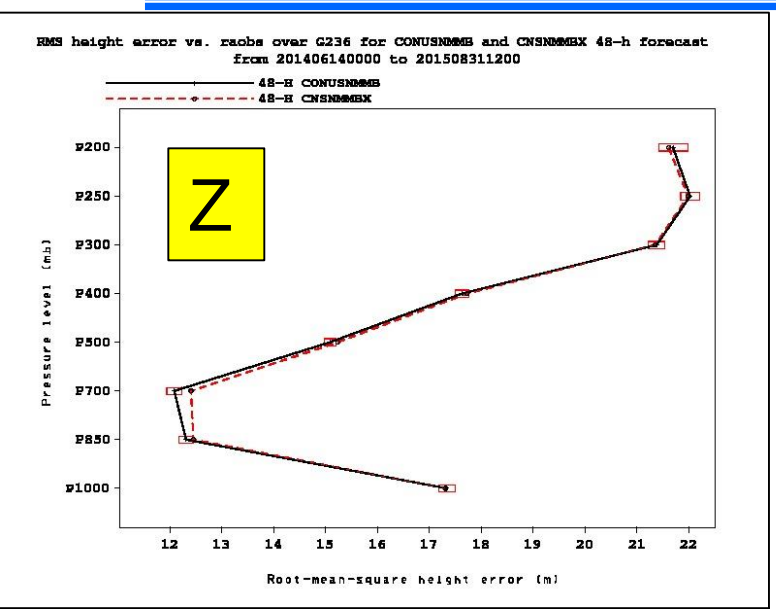


Model and observed 1 km AGL radar, 03Z 1 Jul 2015





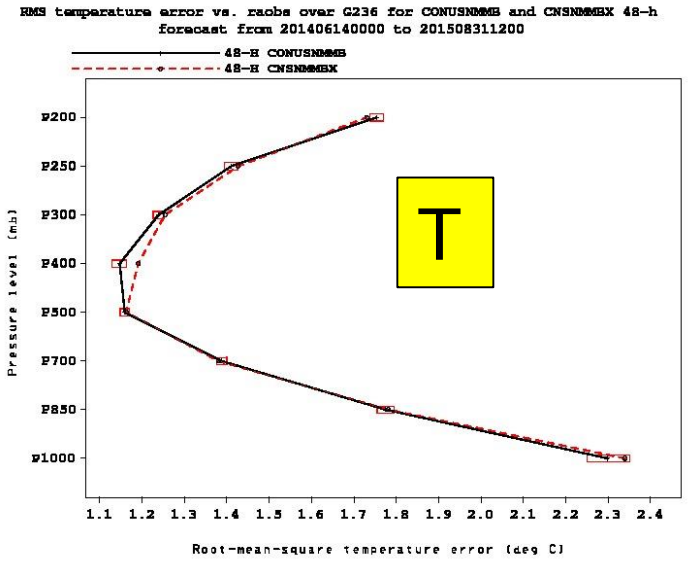
RMS errors at 48 h forecast time for CONUS – NMMB

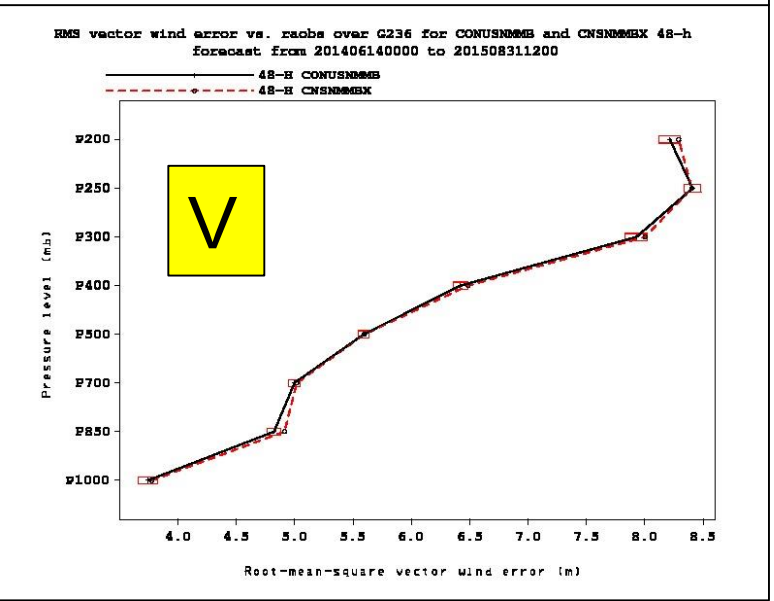


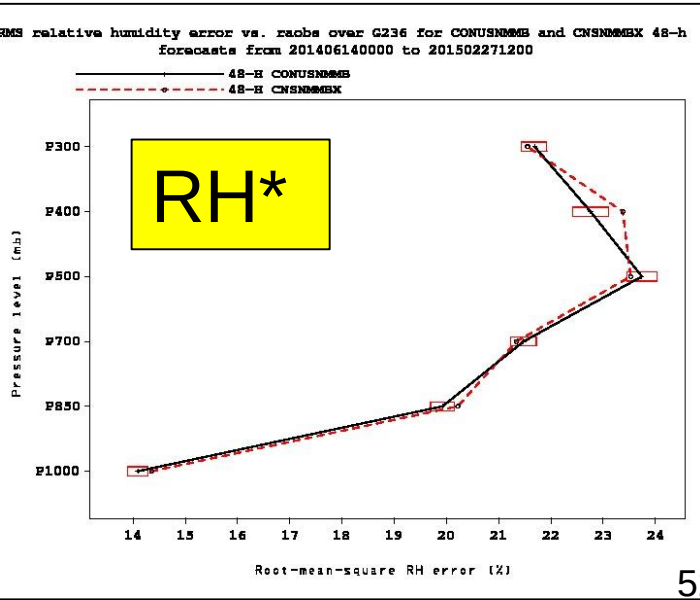
All 00Z cycle test runs

OPS NMMB

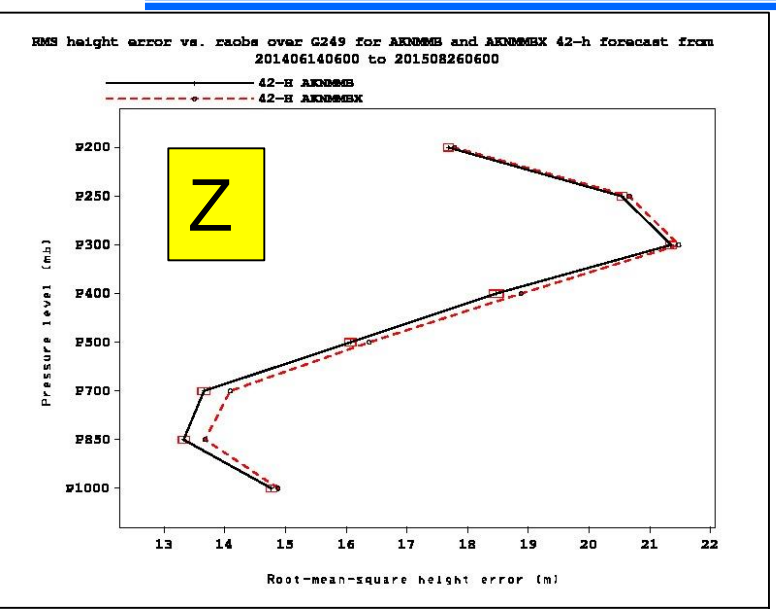
PARA NMMB







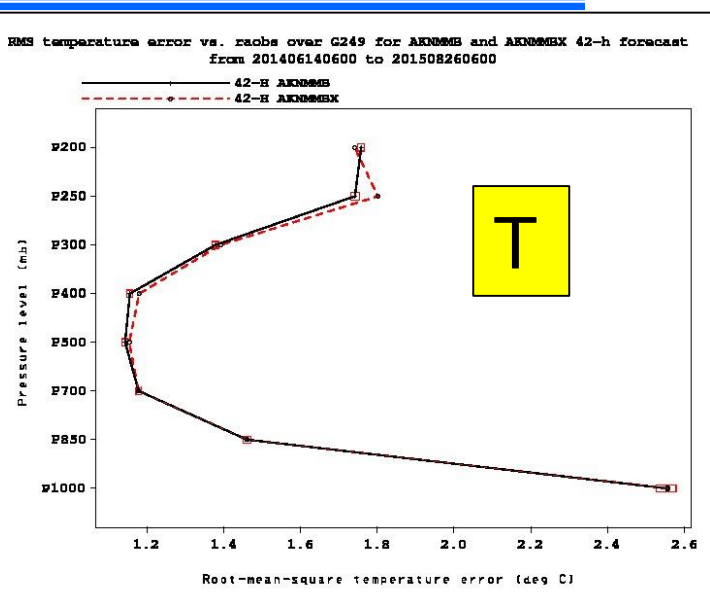
RMS errors at 42 h forecast time for AK – NMMB

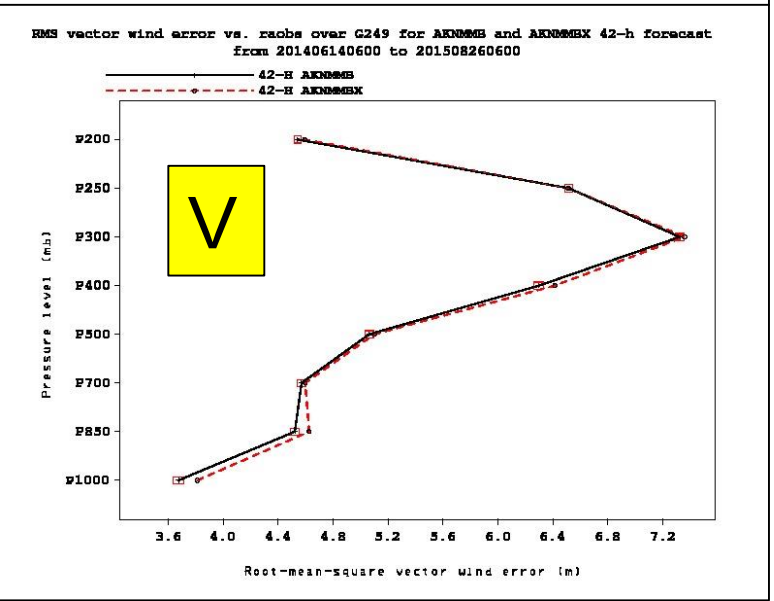


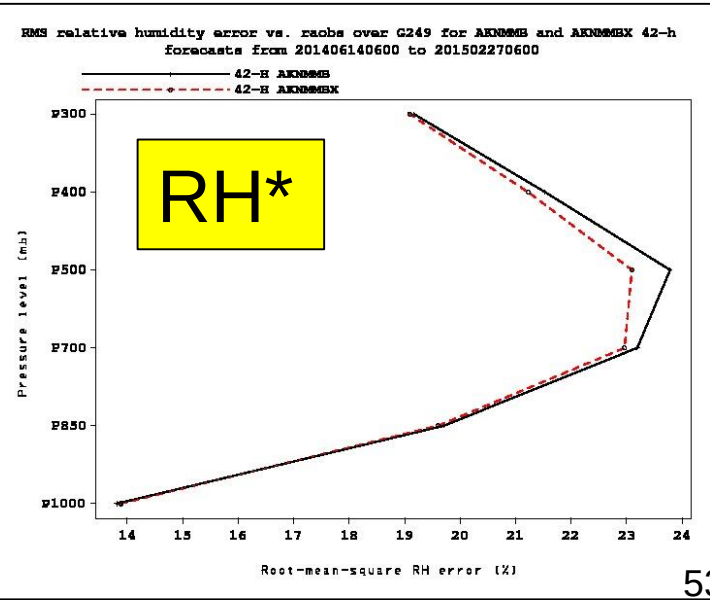
All 06Z cycle test runs

OPS NMMB

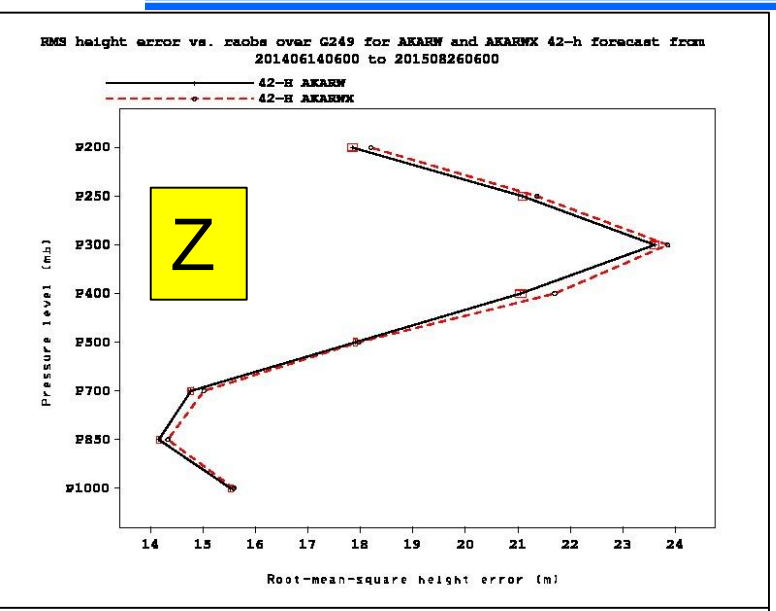
PARA NMMB







RMS errors at 42 h forecast time for AK - ARW



All 06Z cycle test runs

OPS ARW

PARA ARW