High-Resolution Ensemble Forecast (HREF) v2 and HiresW v7

Matthew Pyle

6/5/2017 EMC CCB

Summary of biggest changes

Reminder: The HiresWindow and NAM nest runs feed into HREF, which aggregates deterministic model runs into ensemble products.

- Transforms the HREF into something more like SPC's SSEO:
  - membership: Adds a NAM-initialized WRF-ARW run (configured like the NSSL WRF-ARW); reduces NAM nest contribution
  - products: Adds probability matched (PM) mean and neighborhood probability output for more isolated fields, and many other new output fields
- Increases HREF product frequency to hourly (from 3 hourly), adds non-CONUS HREF guidance (AK, HI, PR).
- Unifies HiresW model resolutions at ~ 3 km.
- *60-90+ minute* earlier product delivery for HiresW and HREF

Expected benefits to users

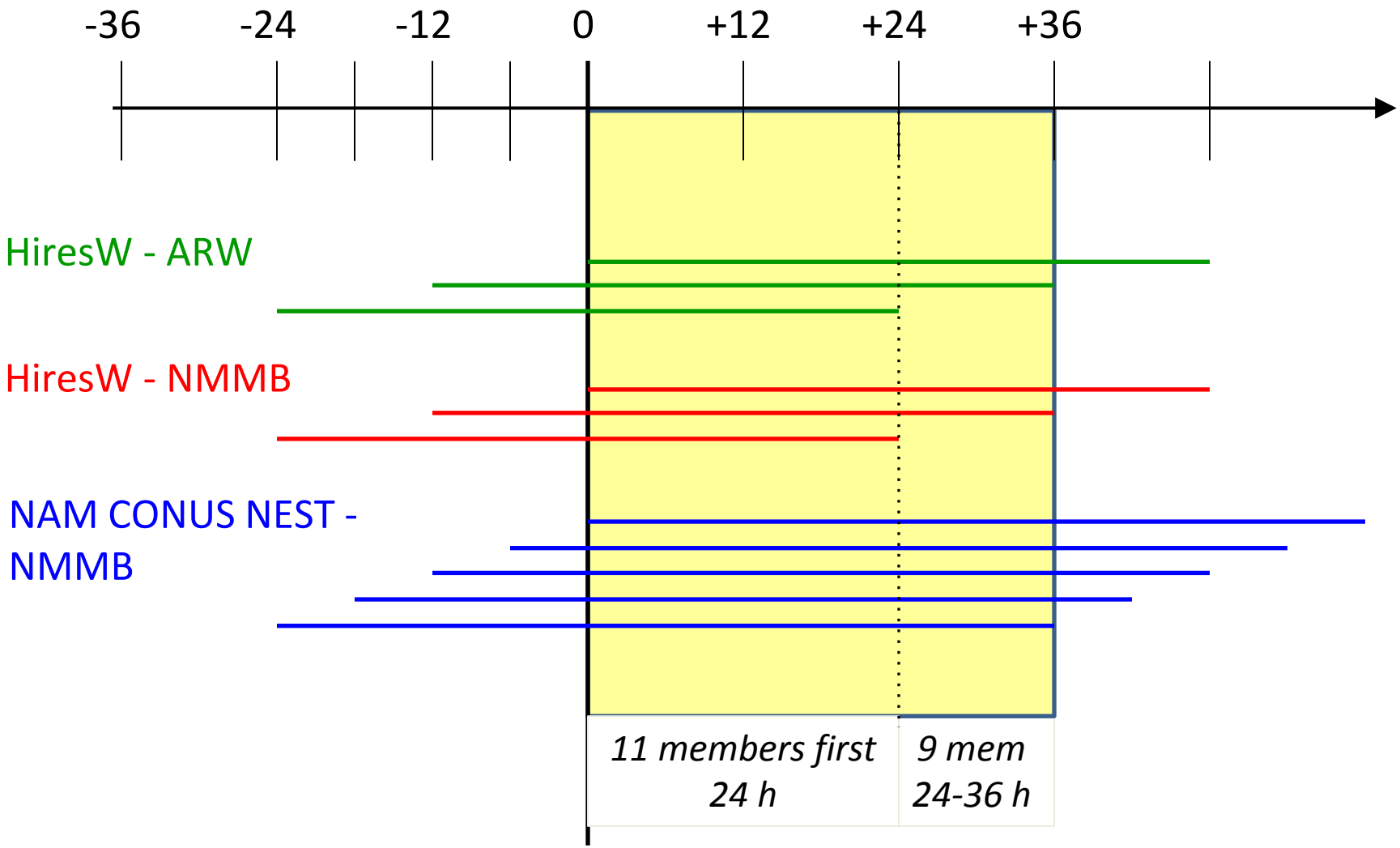
- The addition of PM mean and neighborhood probability fields to HREF, along with the switch to hourly output, provides better and more numerous tools to forecasters.

- The earlier product delivery will enable use of HiresW/HREF in more forecast products:

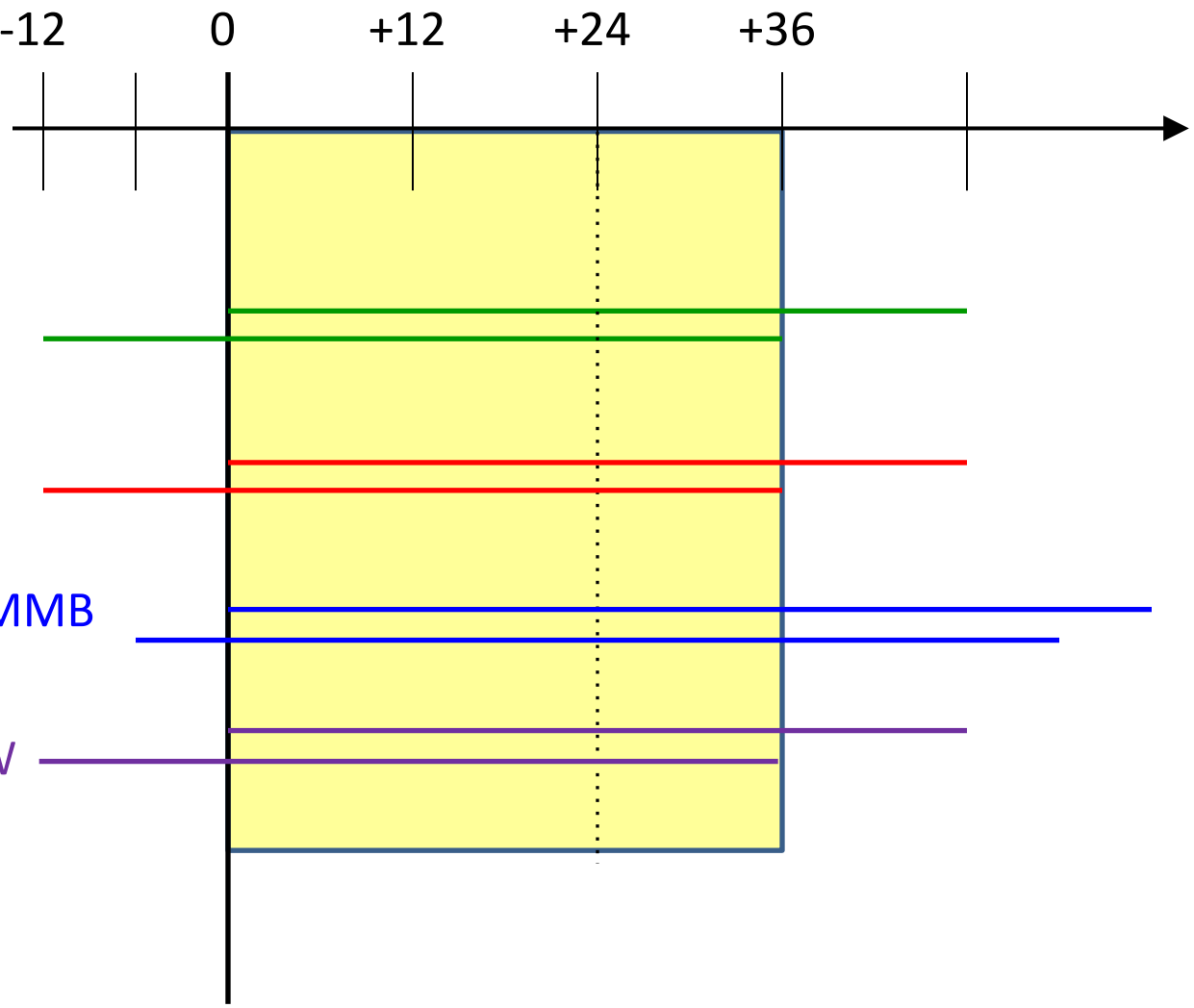
  "I think the HiResW runs and ultimately the HREF would get more effective usage at SPC with an earlier receipt time. This is likely not only true for the 1630Z Day 1 Outlook and the 1730Z Day 2 … but also for the 0600Z Day 1 and 0600Z Day 2 Outlooks." Israel Jirak, SPC SOO, 10/18/2016 e-mail

- Increased resolution, particularly for the CONUS ARW run, will enhance convective signatures.

HREFv1 (current ops) membership overview (00/12Z)



HREFv2 CONUS membership



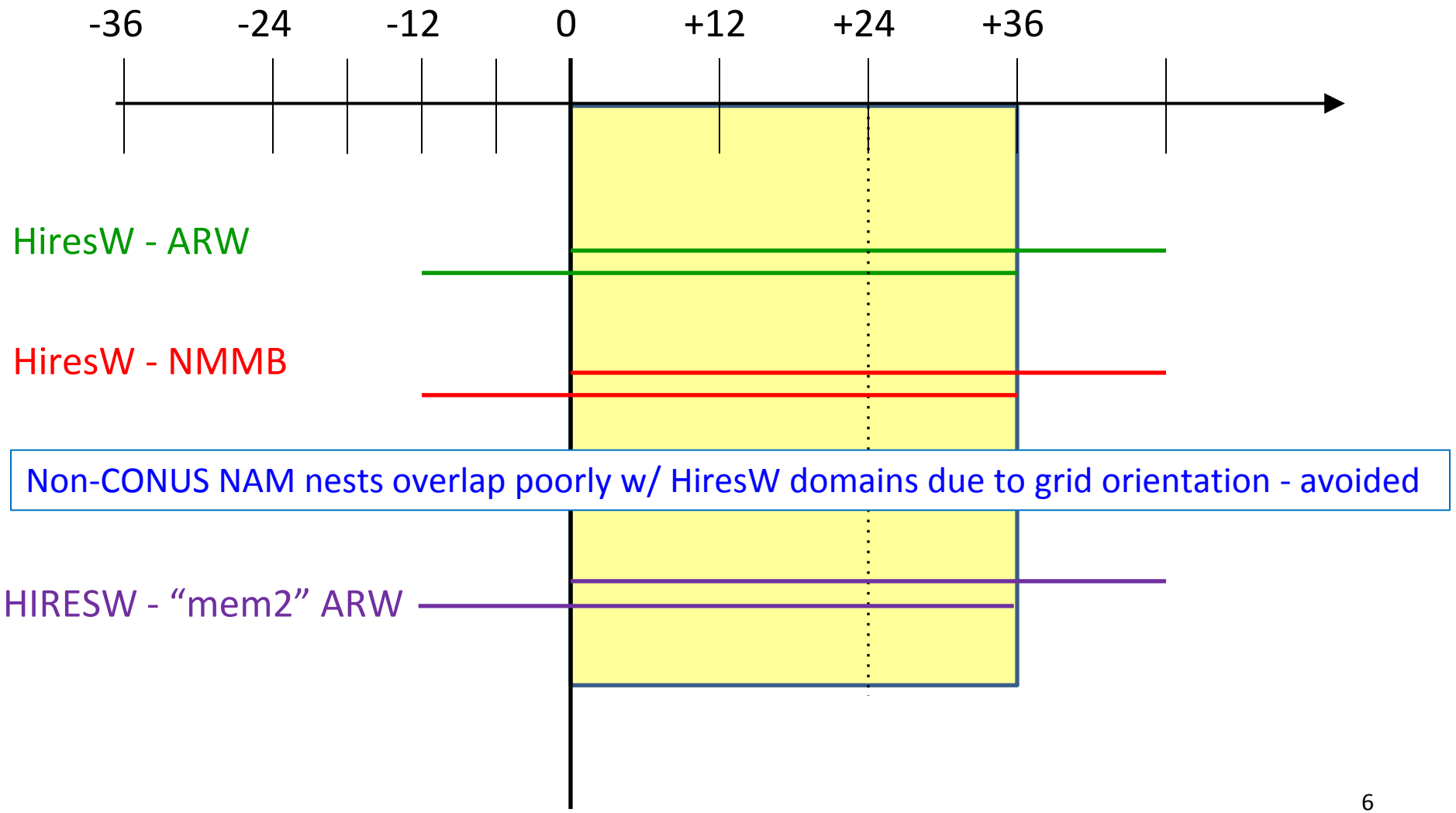
HiresW – ARW
(RAP init)

HiresW – NMMB
(RAP init)

NAM CONUS NEST - NMMB
(NAM init)

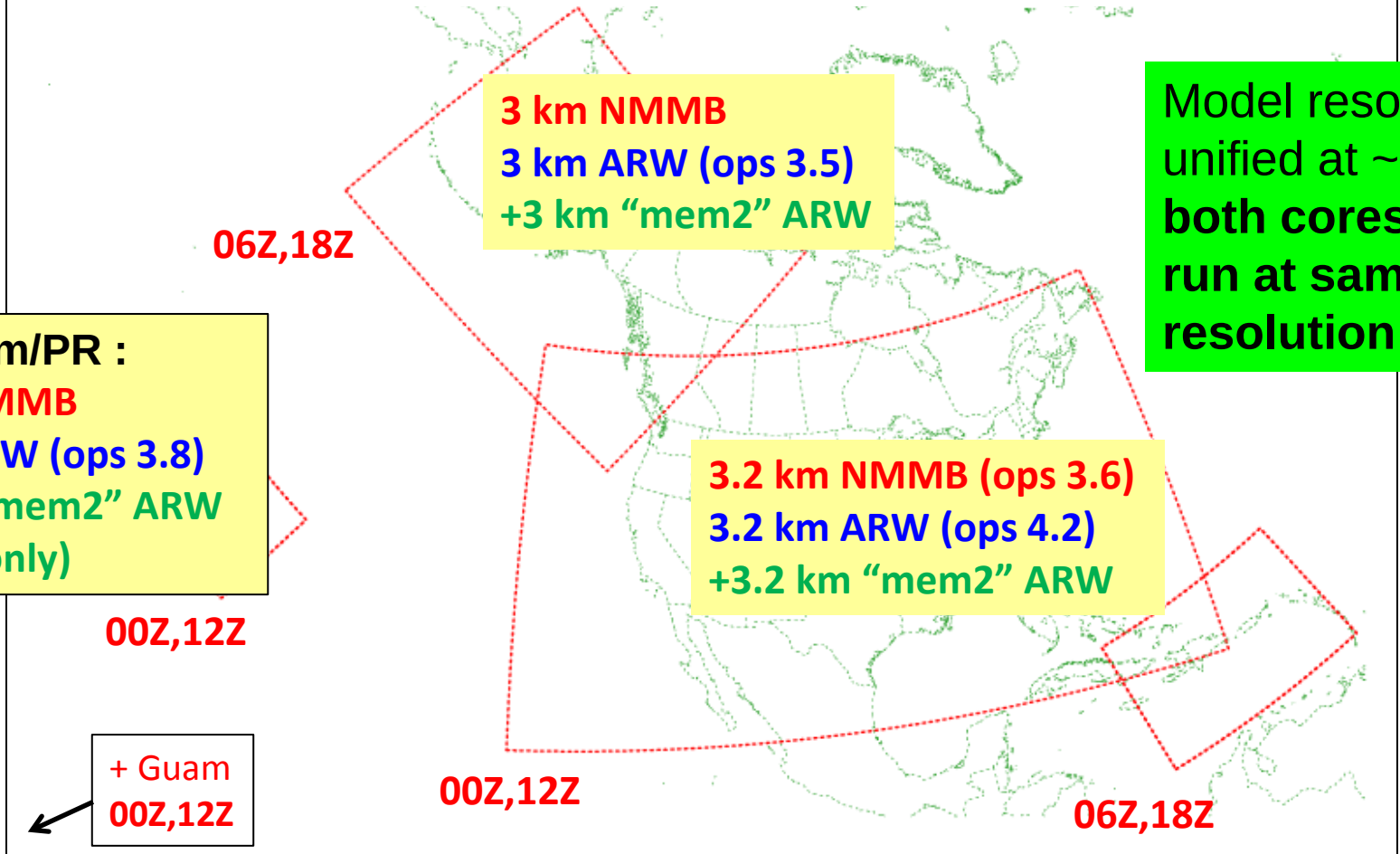
HIRESW - “mem2” ARW
(NAM init)

HREFv2 non-CONUS membership



HiresW overview (v7.0)

Integration domains and run times



Model resolution unified at ~3 km, **both cores now run at same resolution**.

HiresW changes

- What is changing:
  - Resolution unified at 3 km (3.2 km CONUS)
  - 2nd WRF-ARW member added
  - *NMMB run calls physics more frequently*
  - SPC-requested product tweaks
  - *When it runs and how it is initialized*

- What isn't changing:
  - Model forecast codes

Initially planned to update NMMB code to match latest NAM version, but saw QPF degradation using that version in HiresW

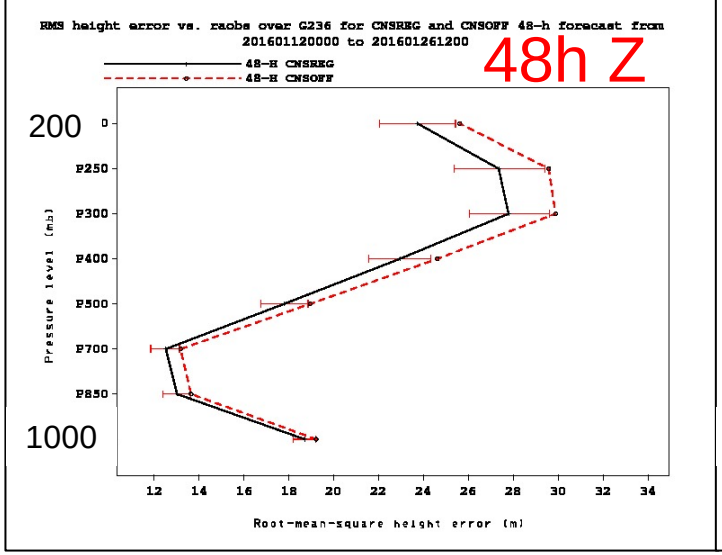
Running much earlier in production suite

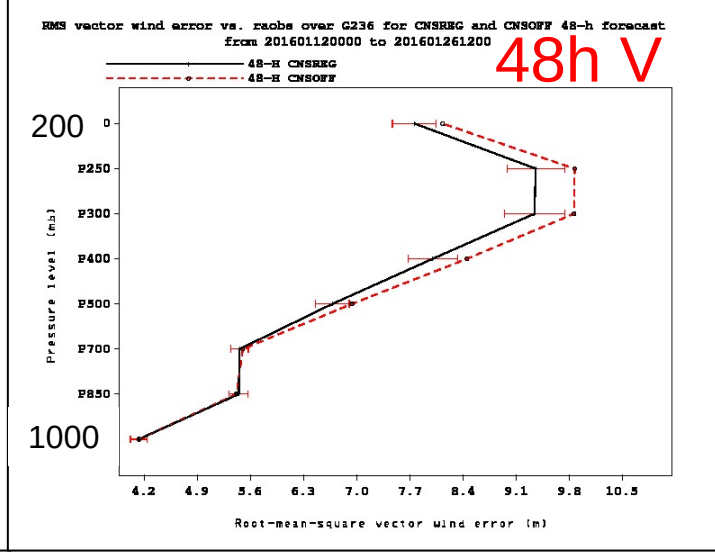
- Should be possible for HiresW/HREF products to be made available roughly 60 to 90 minutes earlier than in current ops.

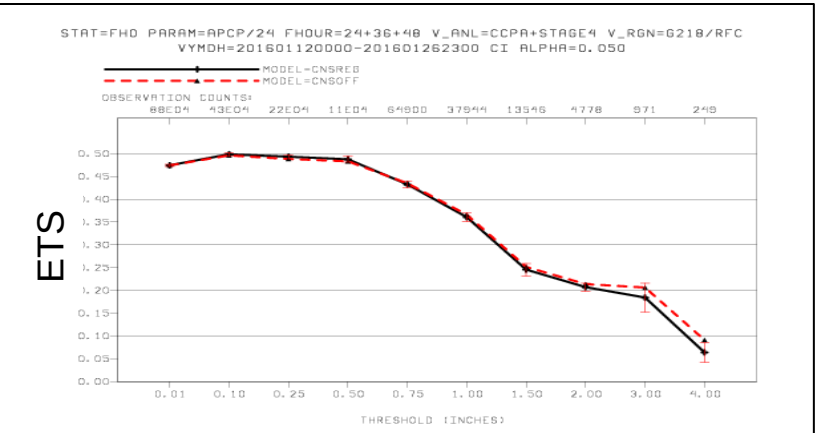
- This earlier product availability adds forecast utility, but does come at a price:

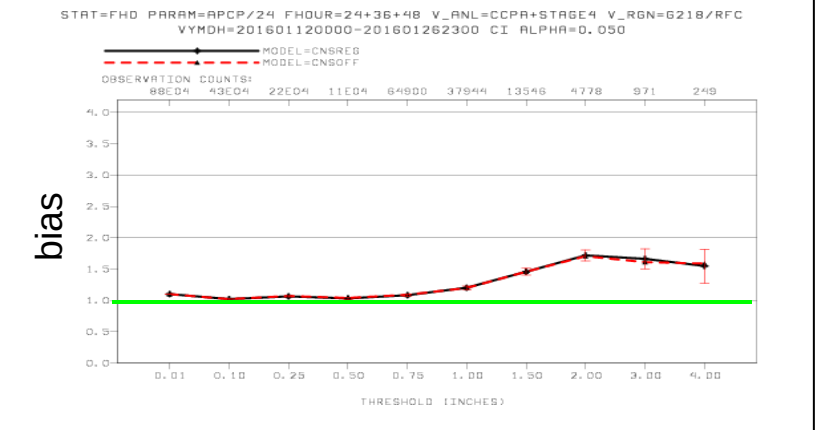
  – Forced to generate lateral boundary conditions from 6 h old model data – some slight degradation in synoptic skill at longer forecast ranges.

Two week period of January 2016 (strong flow) testing impact of 6 h old GFS for LBCs



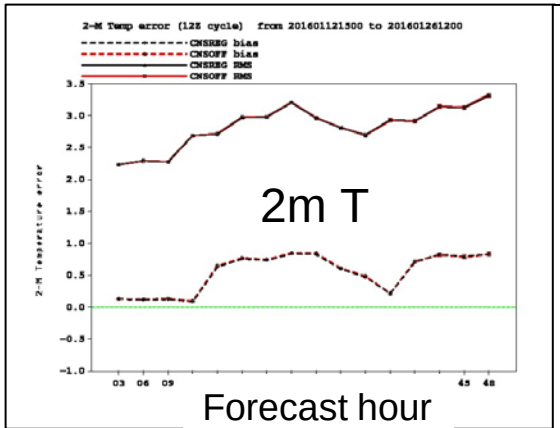


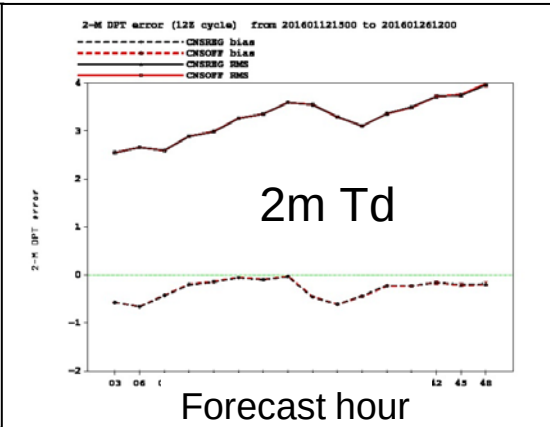




Ctl (on time GFS files)

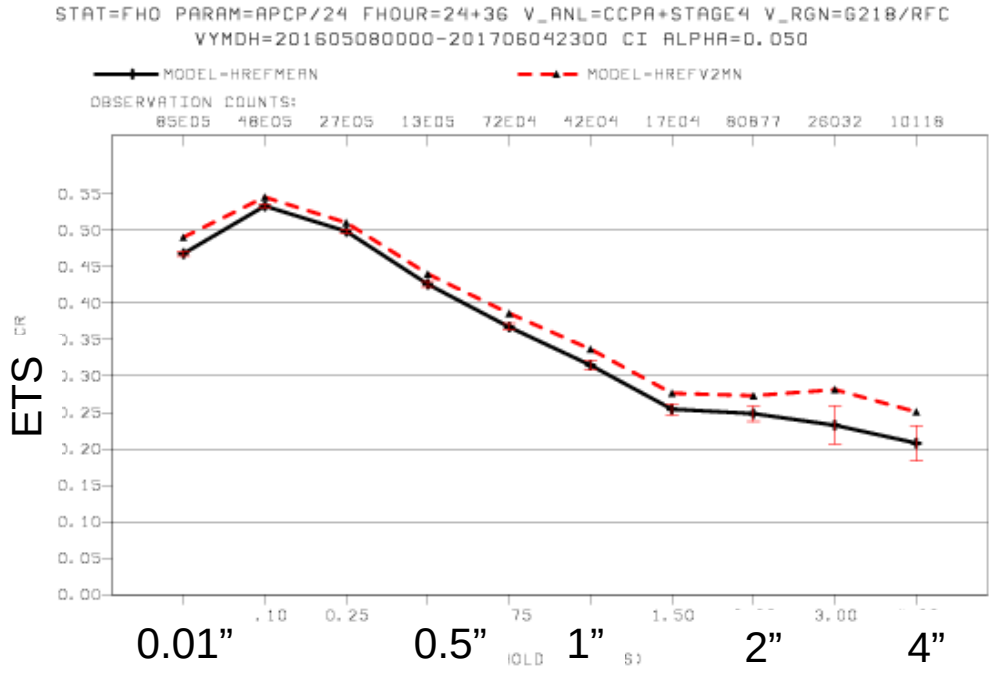
Exp (6 h old GFS files)

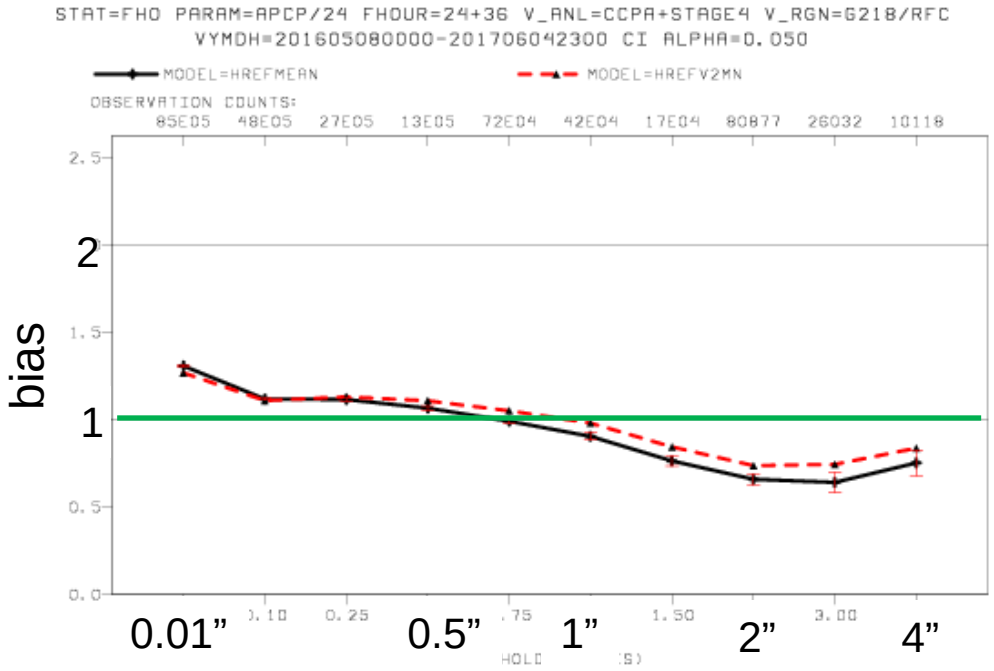




Pre-Implementation Testing

- Full real-time runs since Feb 2017 (both HiresWv7 and HREFv2)
- HREFv2 (but primarily using ops HiresW as input) from Sept 2016 until the full parallel began in Feb 2017
- Retrospective runs (HiresW only) from early May to early July 2016.
- Real-time testing with the new NAM-initialized “mem2” ARW over CONUS from July 2016 to date.





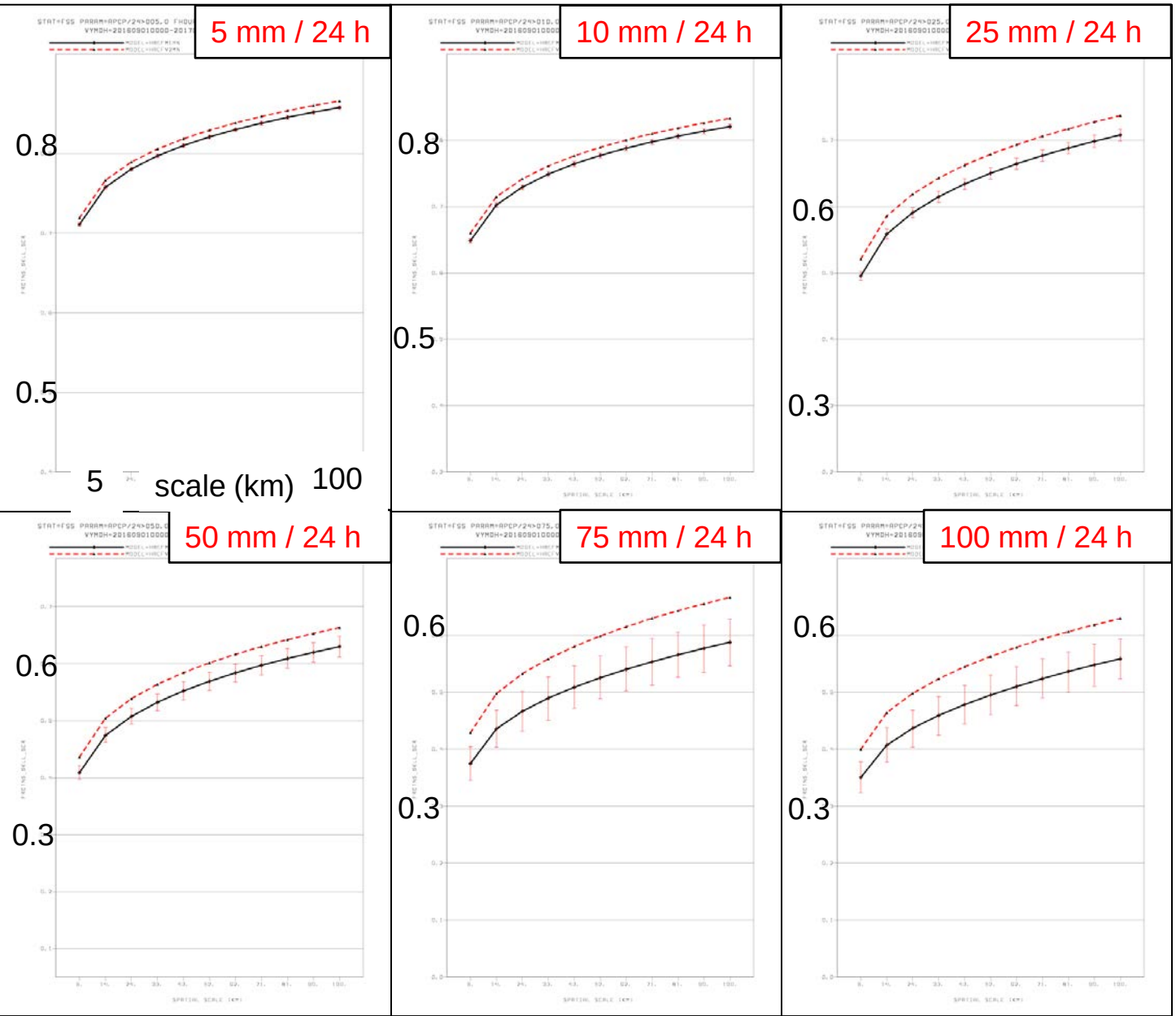
HREF precipitation

Sept 1, 2016 to June 4, 2017
(~205 days to date)

HREFv1 mean

HREFv2 mean

Sept 1, 2016 to June 4, 2017



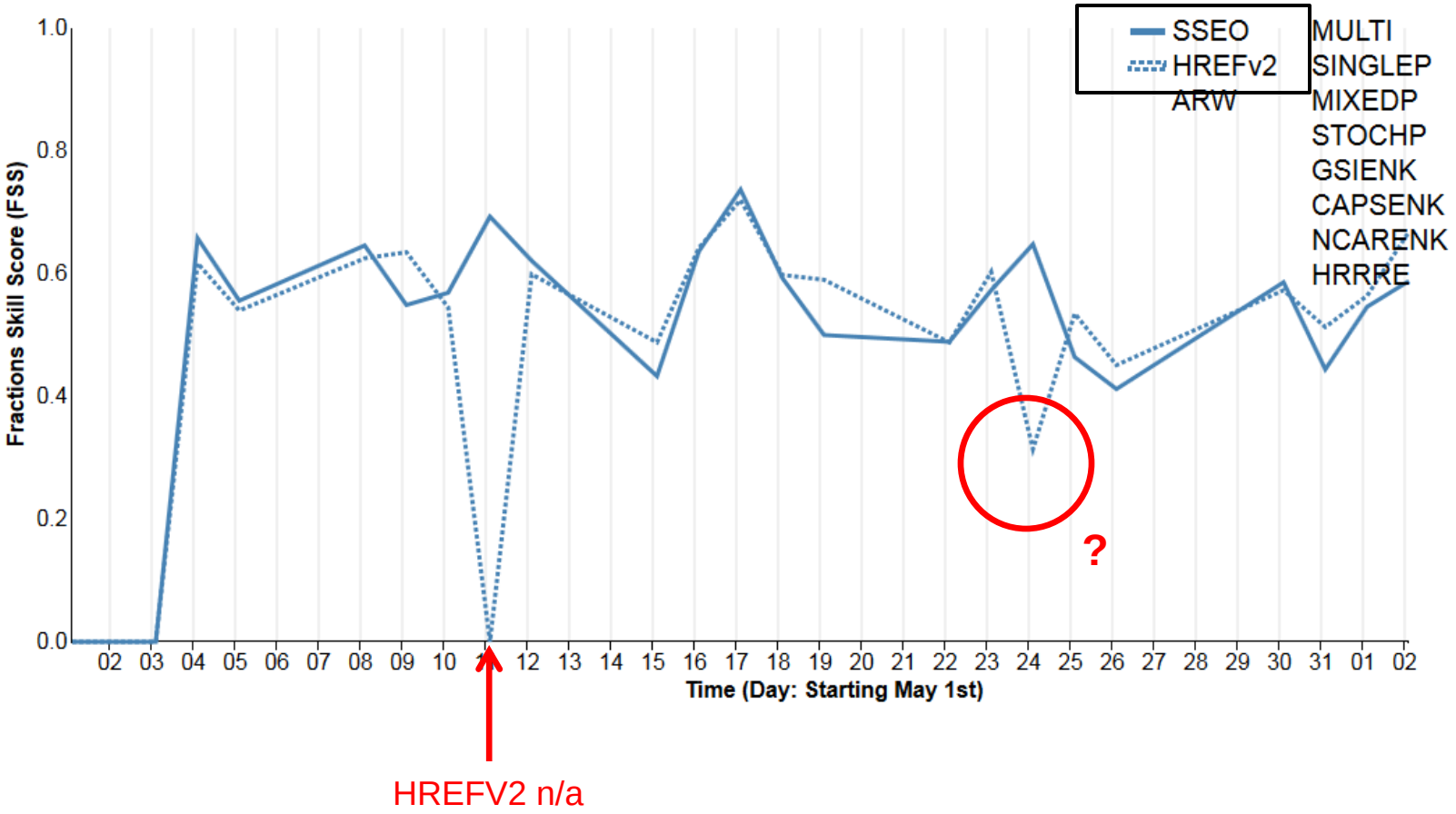
HREFv1 mn (ops)

HREFv2 mn (para)

Fraction Skill Score (neighborhood verification – rewards being “close”)

As was seen in ETS on last slide, HREFv2 advantage larger for heavier precipitation

HWT experiment 1 km REFD
FSS summary for daily region of interest

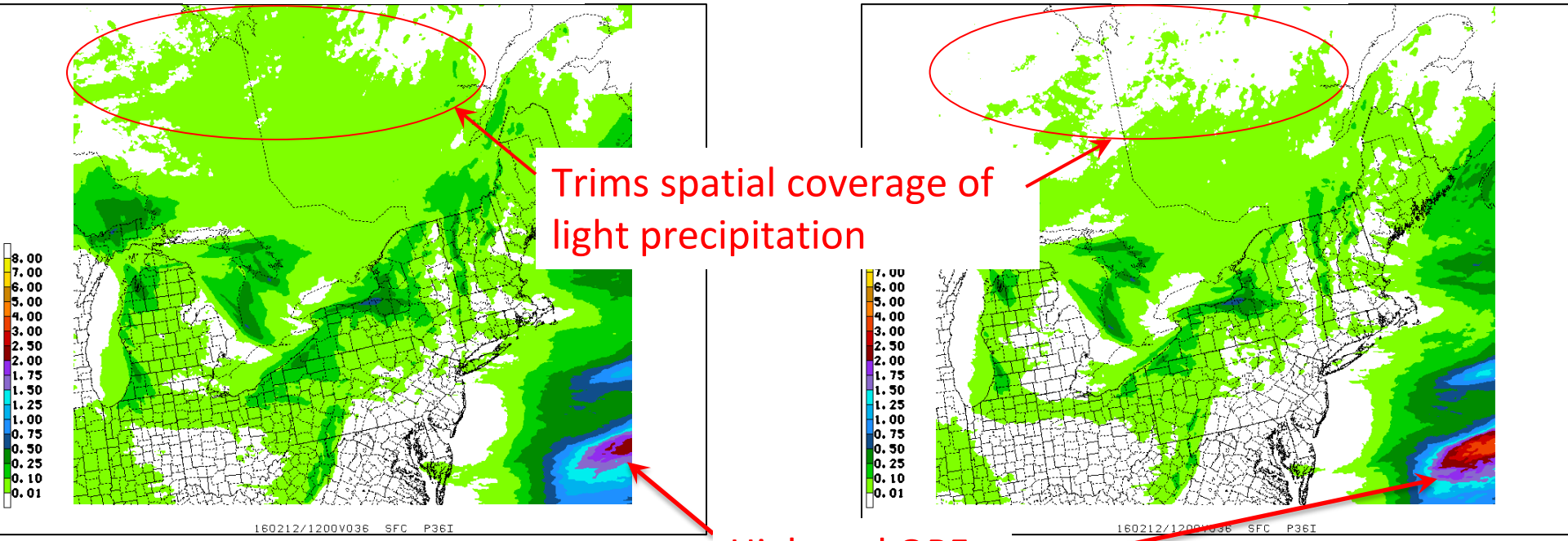


Probability matched (PM) mean

Restores amplitude from the individual ensemble member forecasts, but guided by the skill of the arithmetic mean (which typically highlights proper regions but underdoes amounts).

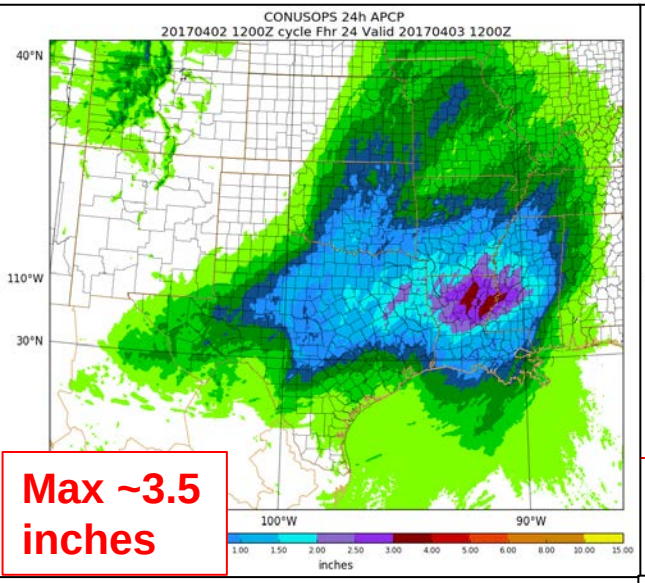
arithmetic mean

PM mean



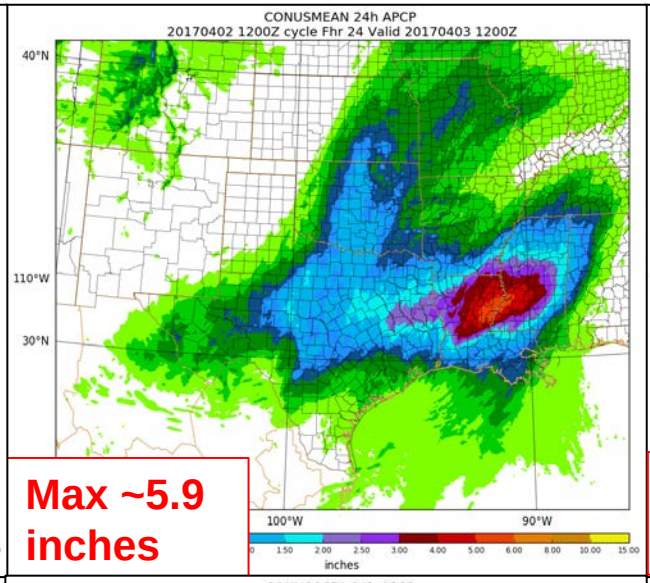
24 h HREF totals, ending 0403/12Z

V1 Mean



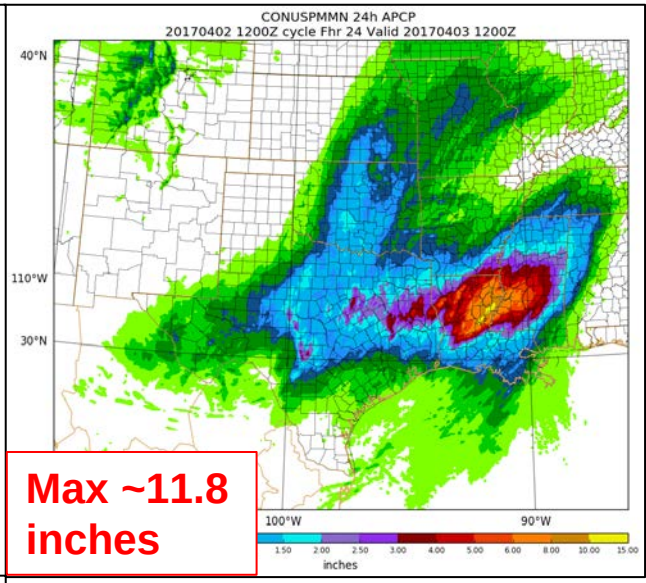
Max ~3.5 inches

V2 Mean



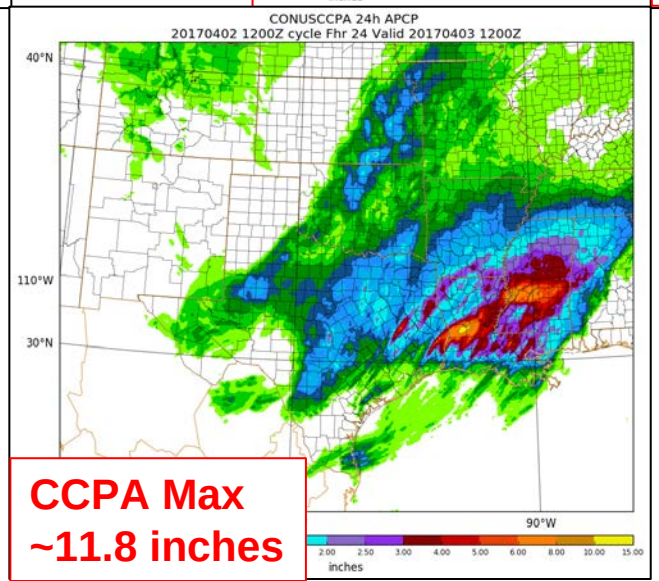
Max ~5.9 inches

V2 PM Mean



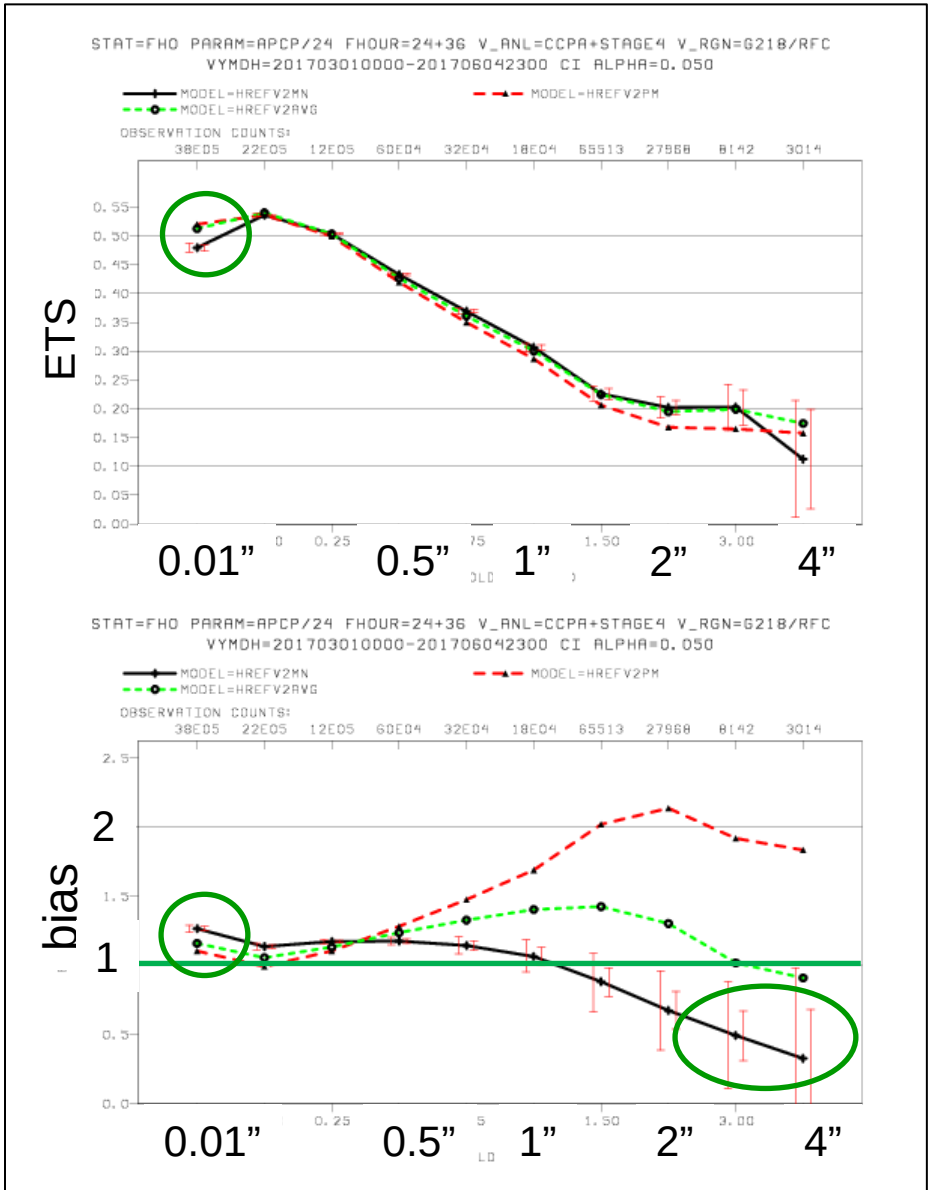
Max ~11.8 inches

CCPA verification



CCPA Max ~11.8 inches

PM mean impact in warmish season



March 1 to June 4, 2017

HREFv2 mean

HREFv2 PM mean

HREFv2 avg (mean and PM)

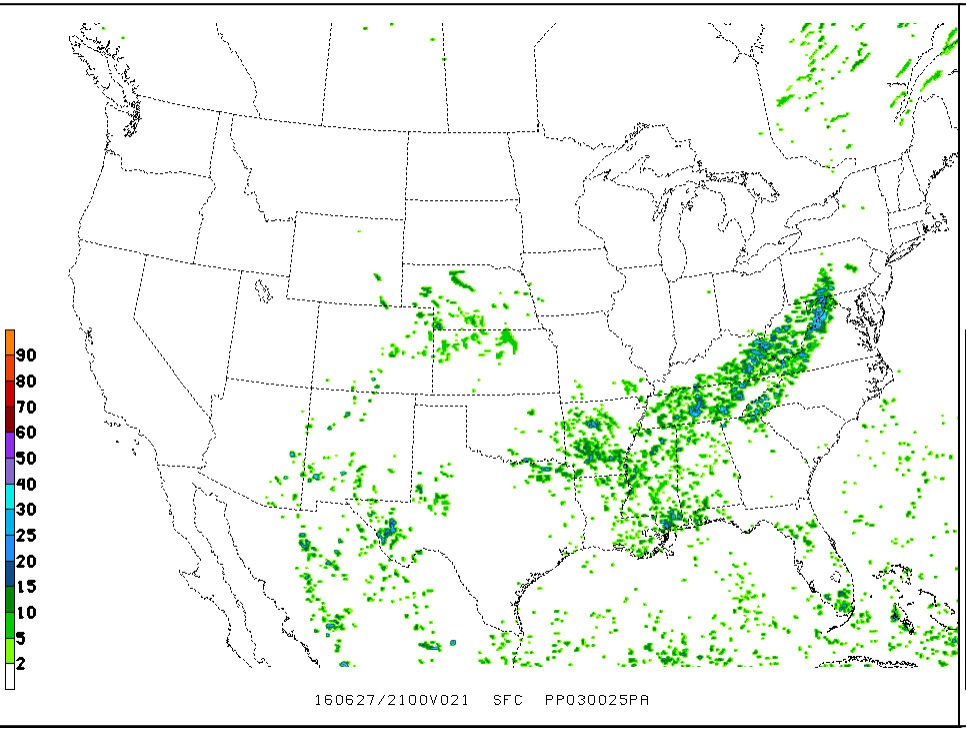
PM mean improves bias at low end, but overamplifies heavier precipitation.

Blending mean and PM mean together often best overall.

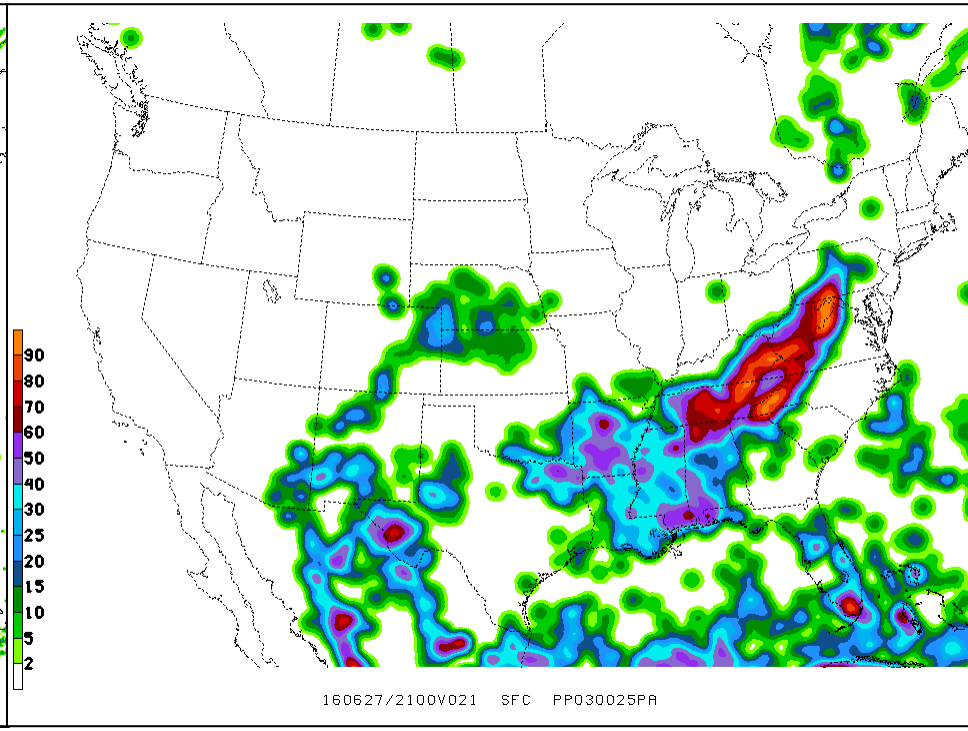
Neighborhood probabilities

- Accounts for slight displacement of features between different members by searching within a surrounding neighborhood of points.
- The smoothed neighborhood approach is applied to probabilistic output for more localized, discontinuous fields (e.g., precipitation, simulated reflectivity, other severe weather attributes)
- Following SPC's convention, the "neighborhood" extends 40 km out from a gridpoint.

Probability of 3 h QPF > 1.0”

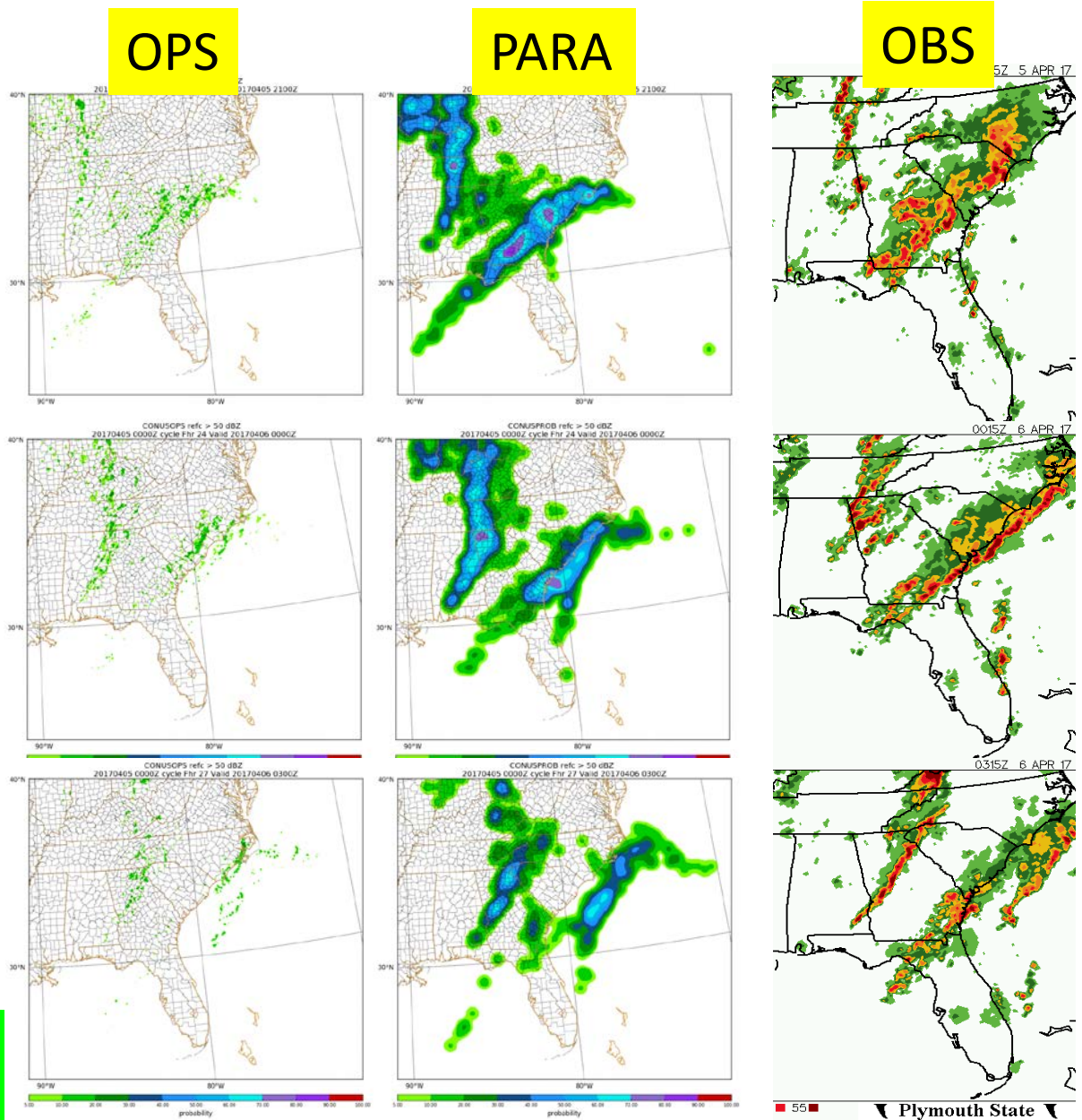


Ops HREF – point probabilities



Para HREF – w/ smoothed neighborhood probabilities

April 5-6 2017 severe wx
HREF probability of composite reflectivity > 50 dBZ



Courtesy G. Manikin, 4/13/2017 MEG brief

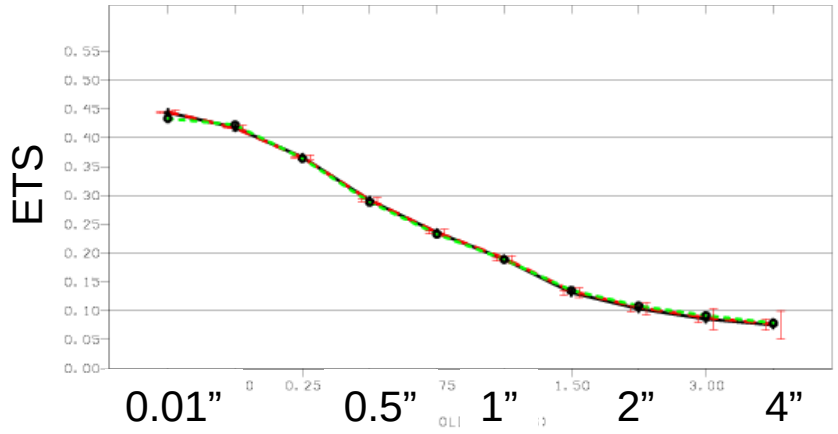
HiresW CONUS precipitation

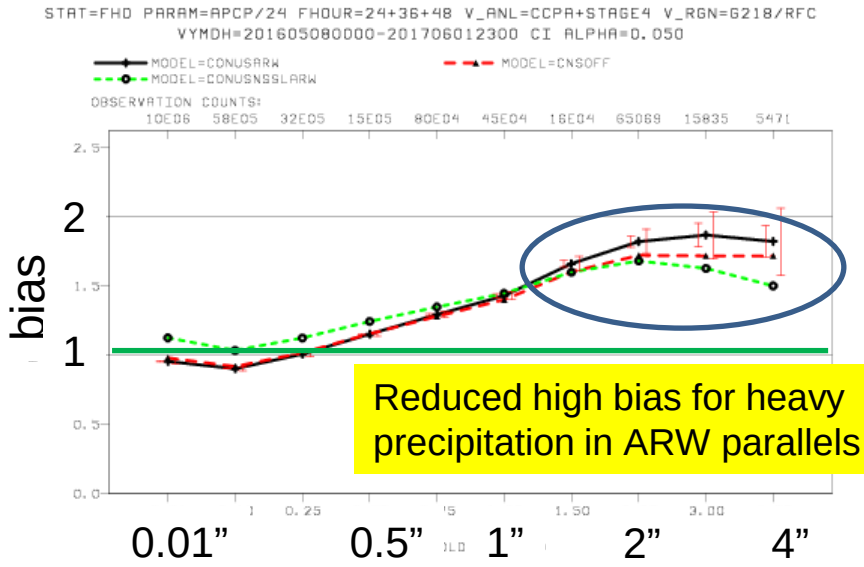
May 8, 2016 to June 1, 2017

(discontinuous; 150+ days to date)

Ops mem2 (NSSLlike) Para

ARW

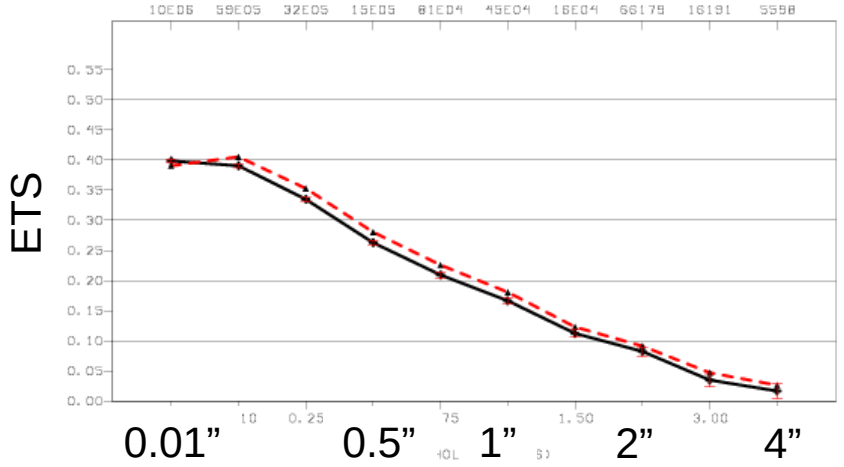


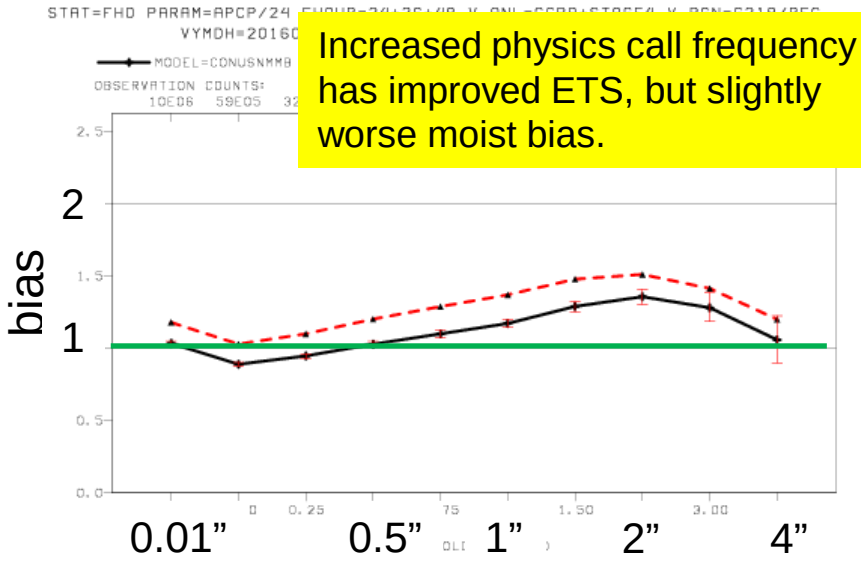


Reduced high bias for heavy precipitation in ARW parallels

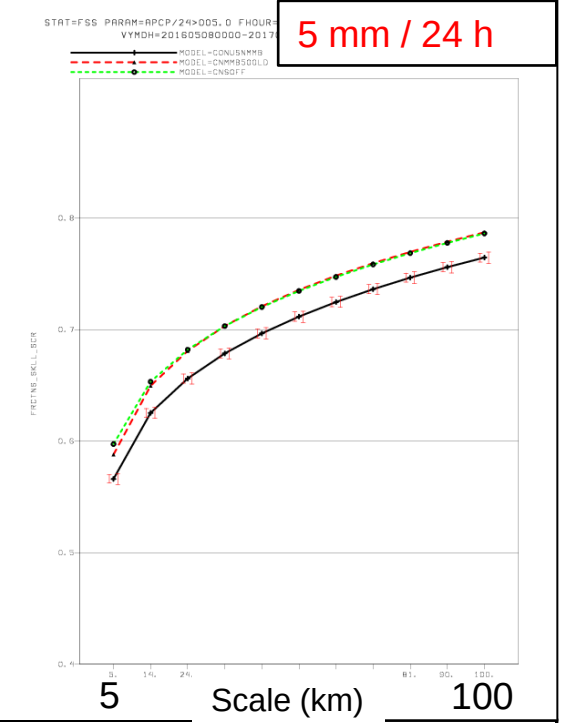
Ops Para

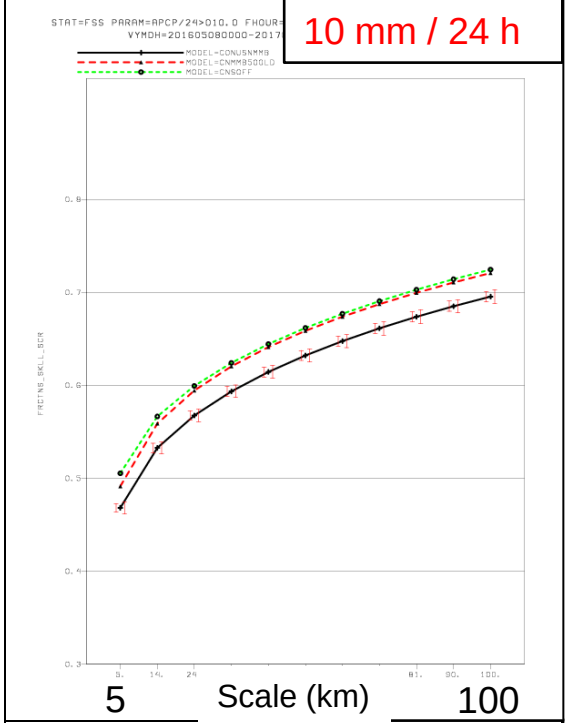
NMMB

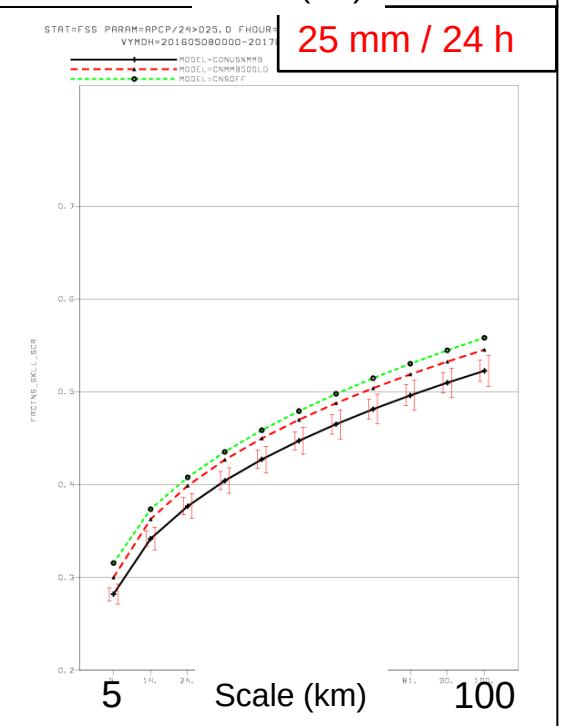


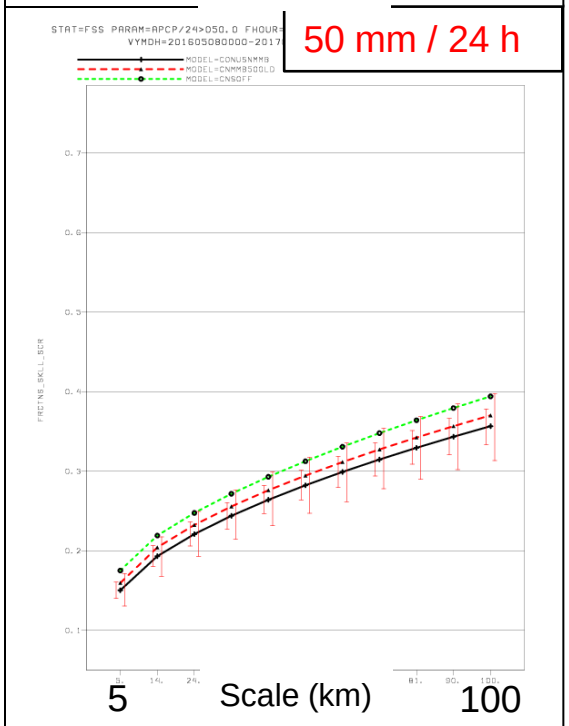


Increased physics call frequency has improved ETS, but slightly worse moist bias.









Ops NMMB

Para NMMB

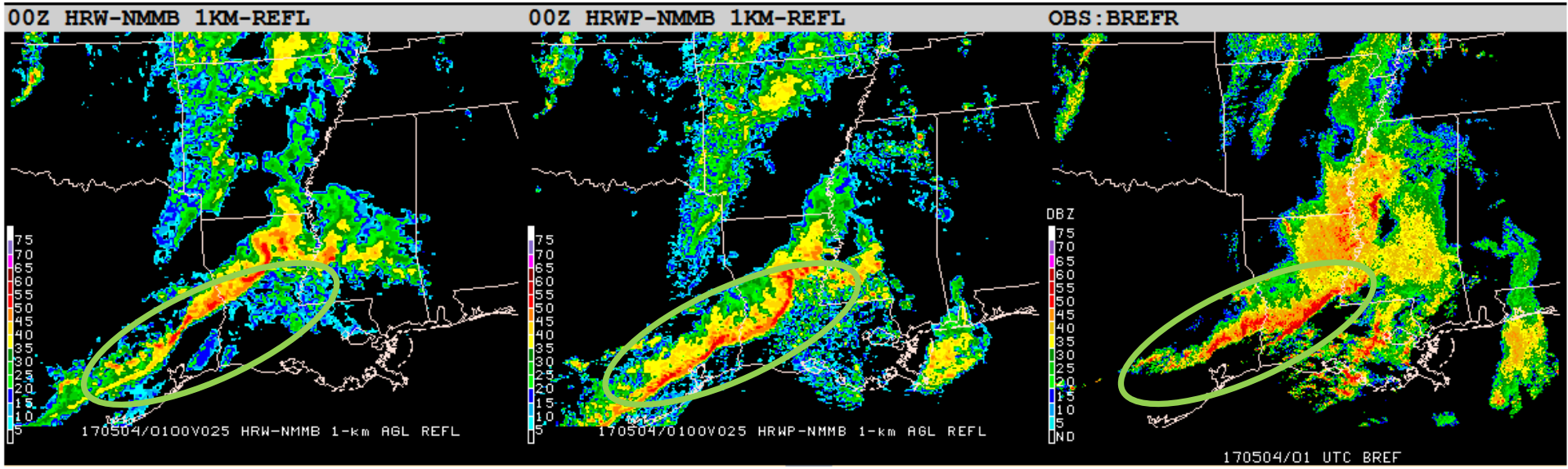
Para ARW

Fraction Skill Score (neighborhood verification – rewards being “close”)

May 8, 2016 – May 30, 2017

Para NMMB much better than Ops NMMB for lighter precipitation – competitive with Ops/PARA ARW

Reflectivity comparison from the HWT experiment
25 h forecast valid 01Z

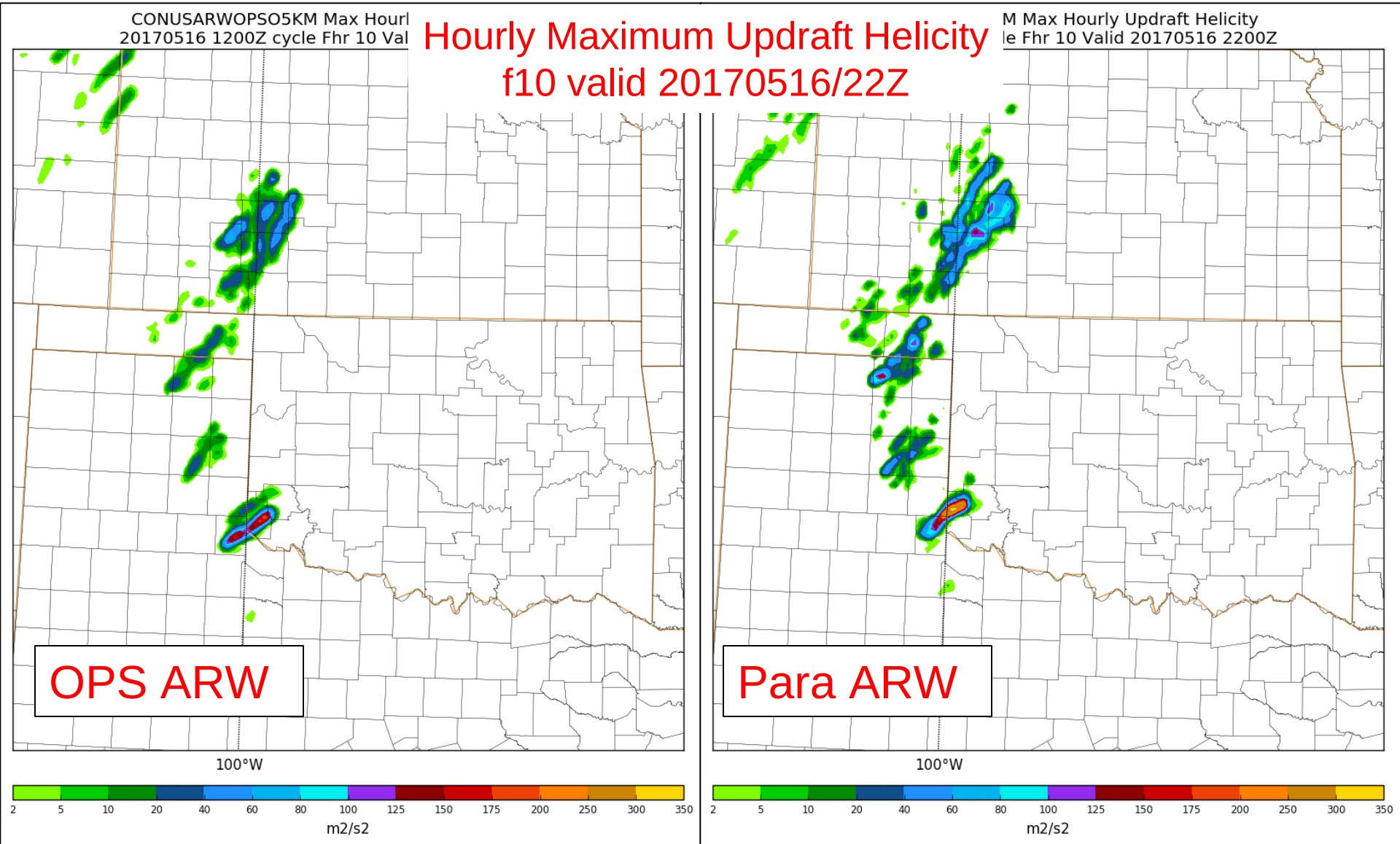


Ops HiresW NMMB

Para HiresW NMMB

Observed

Increased horizontal resolution – sharper convective structures



NMMB surface verification scorecard

	CONUS RMS	CONUS bias	AK RMS	AK bias	HI RMS	HI bias	PR RMS	PR bias
2 m T								
2 m Td					--	--		
10 m V								
SLP			--	--	--	--	--	--
Visibility					--	--		

Para sig worse

Para slightly better

Fairly neutral

Para slightly worse

Para significantly better

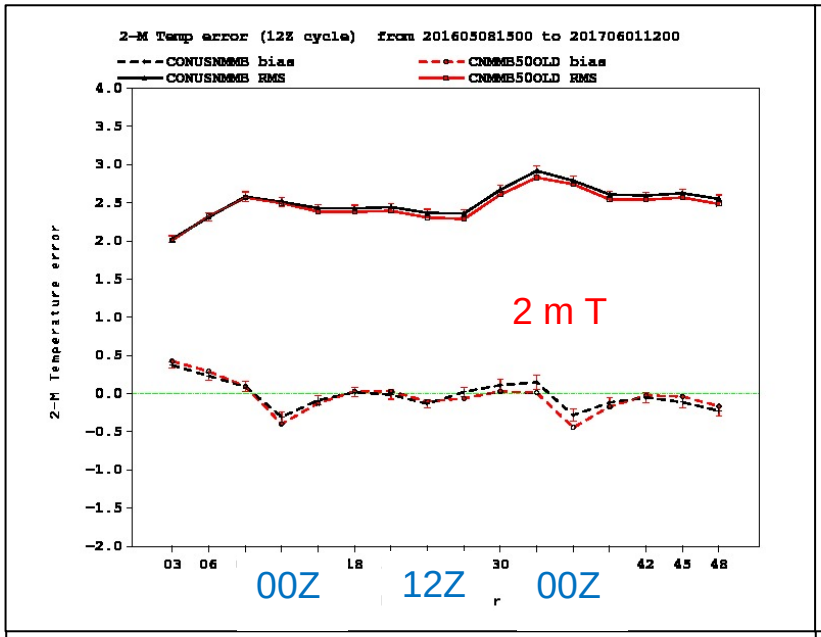
--

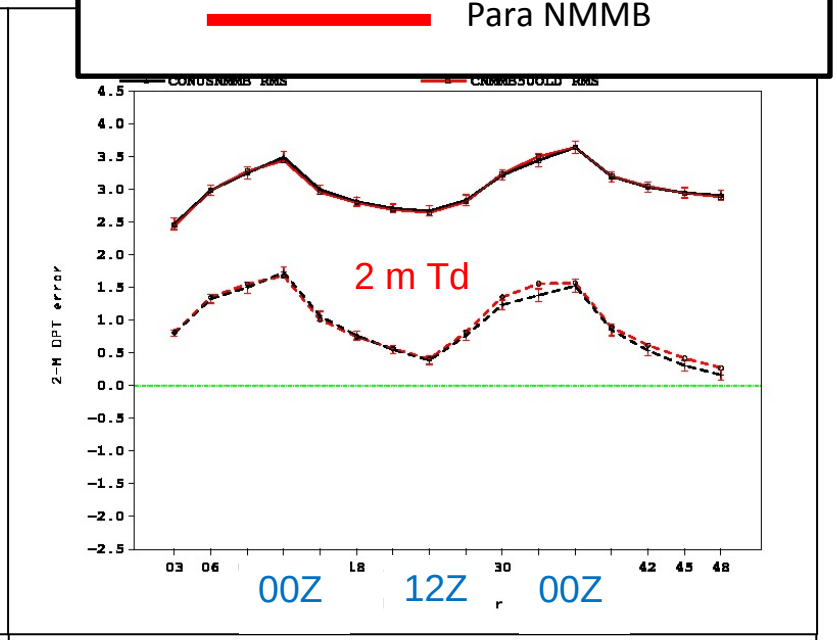
N/A

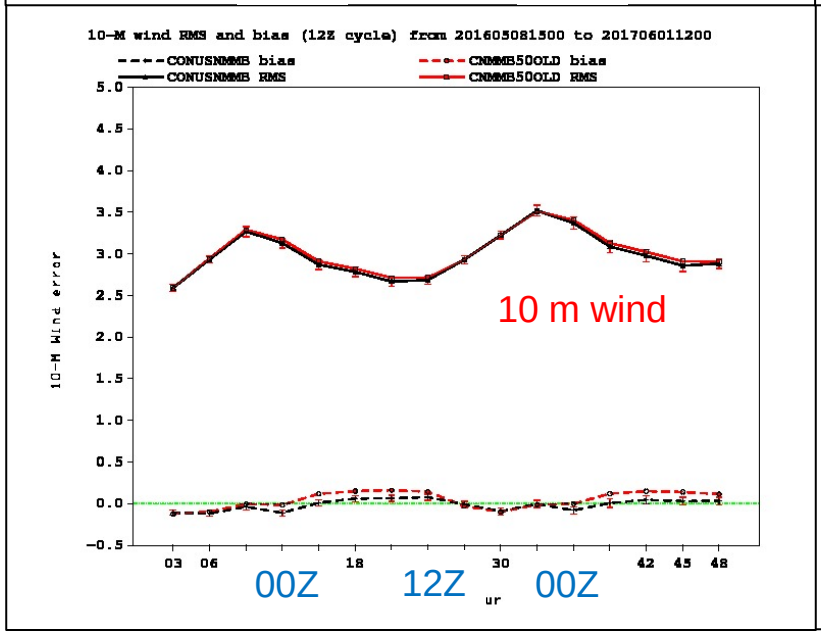
CONUS NMMB, 12Z cycles

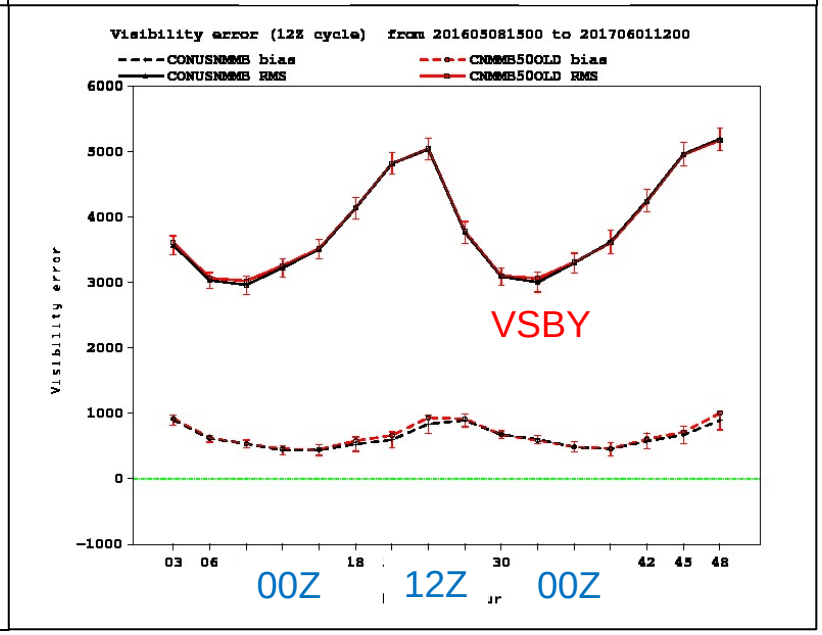
Ops NMMB

Para NMMB





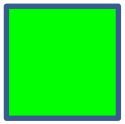




ARW surface verification scorecard

	CONUS RMS	CONUS bias	AK RMS	AK bias	HI RMS	HI bias	PR RMS	PR bias
2 m T								
2 m Td					--	--		
10 m V								
SLP			--	--	--	--	--	--
Visibility					--	--		

Para sig worse



Para slightly better

Fairly neutral

Para slightly worse

Para significantly better

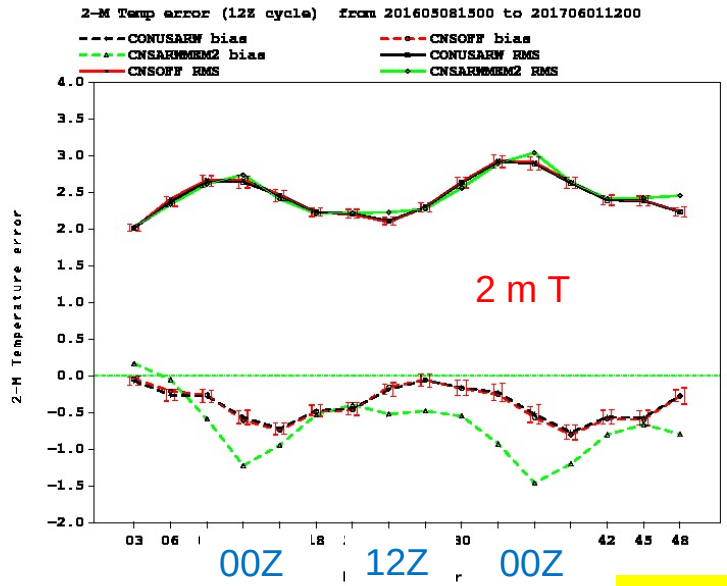
N/A

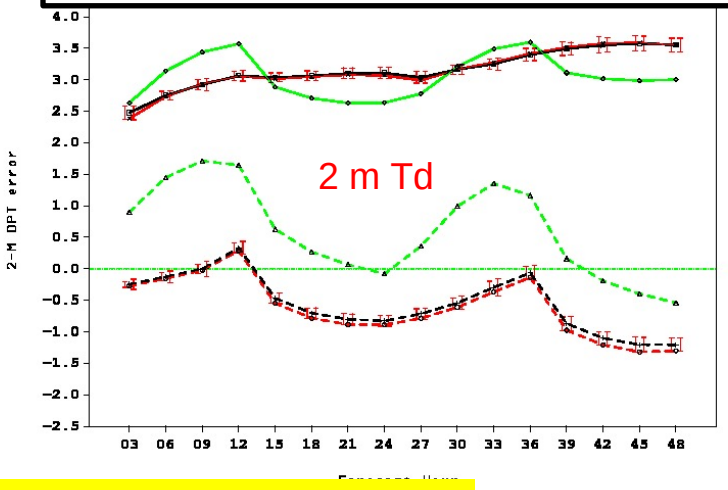
CONUS ARW, 12Z cycles

Ops ARW

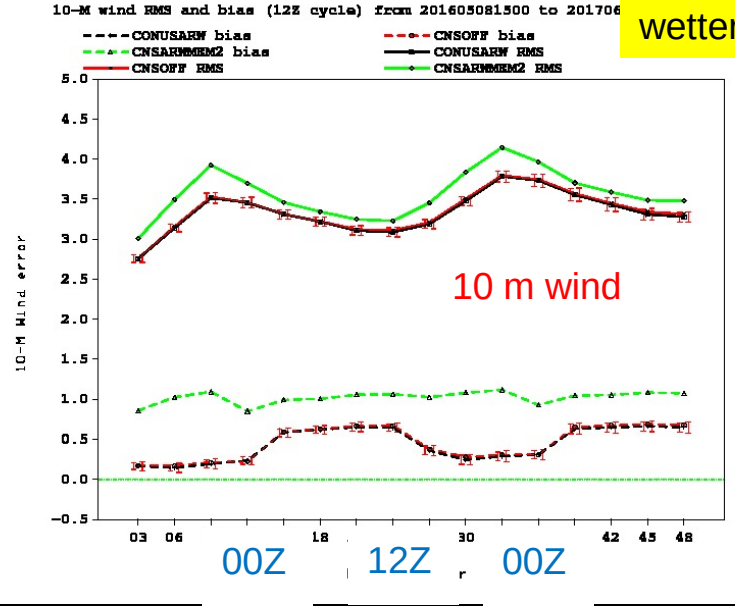
Para ARW

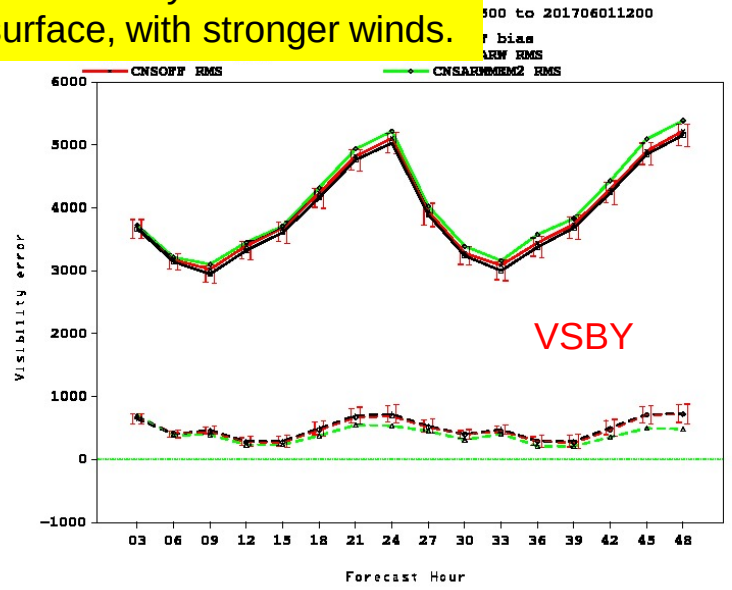
Para ARW (mem2)





Mem2 ARW distinctly cooler and wetter at surface, with stronger winds.





Ops

Mem2 (ARW only)

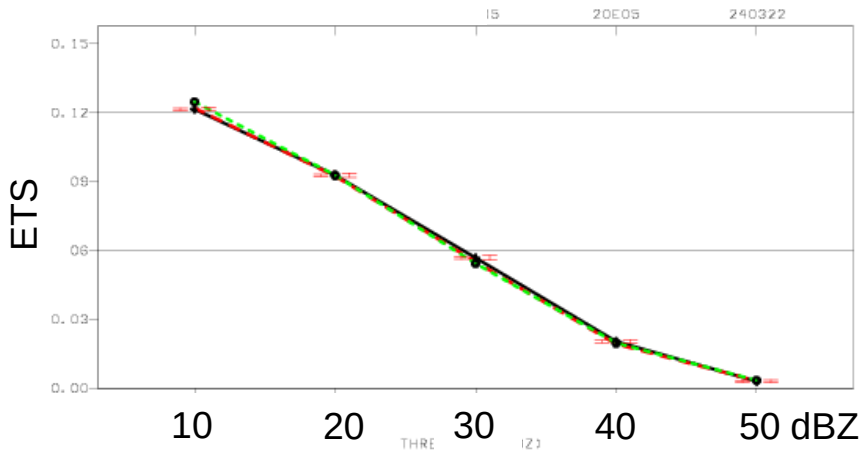
Para

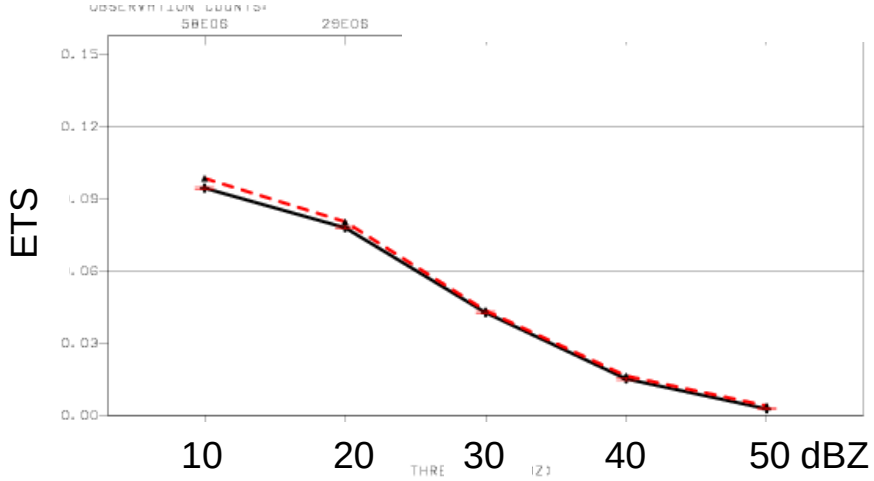
CONUS, all cases

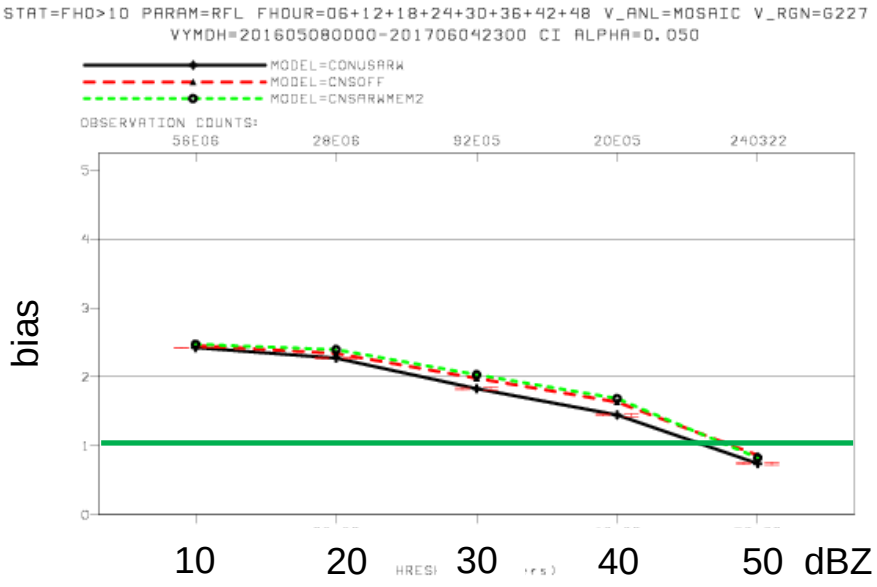
ARW

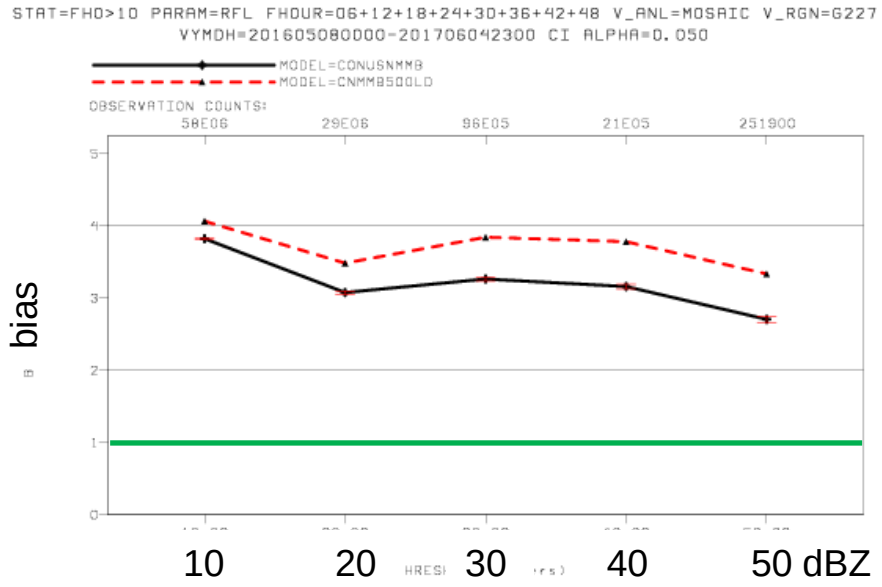
Composite reflectivity

NMMB









Ops

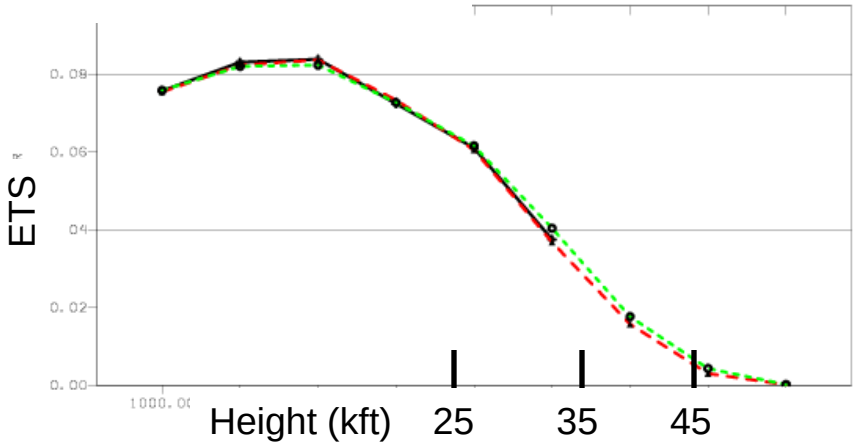
Mem2 (ARW only)

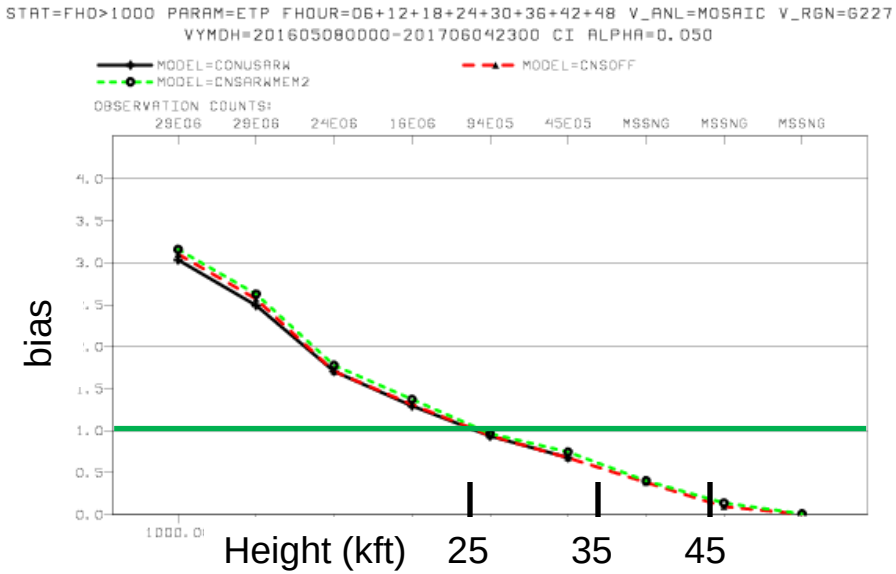
Para

CONUS, all cases

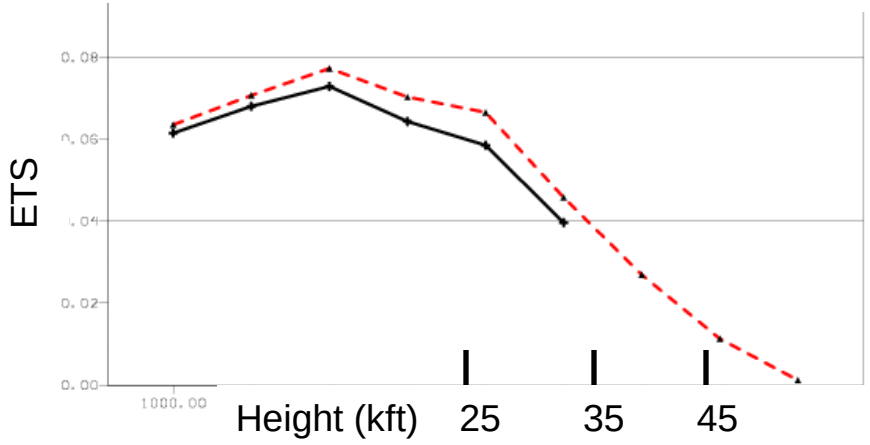
Echo Top Height

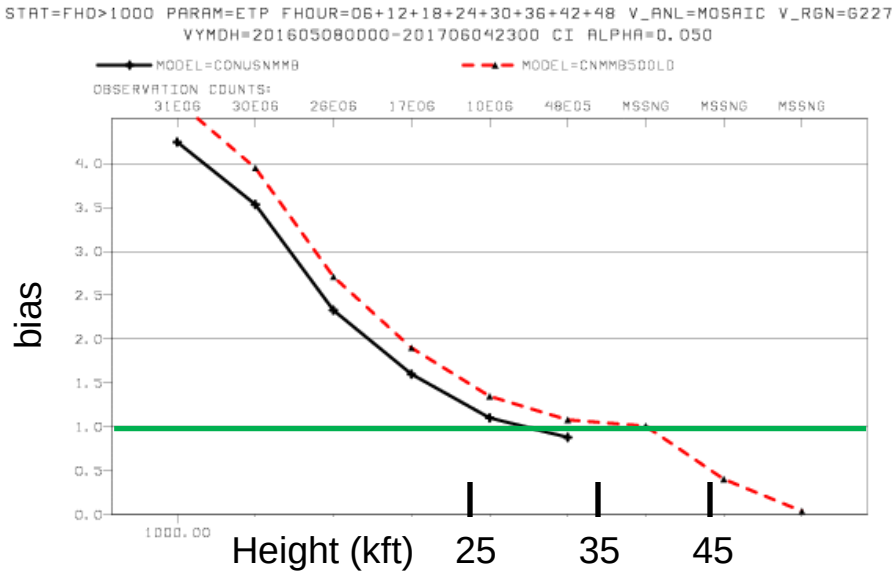
ARW





NMMB





Summary

- Biggest improvements on the HREF side
  - expanded product list and neighborhood probabilities
  - greater skill from more balanced membership
  - higher temporal frequency of output
- HiresW changes more neutral from most statistical measures
- Overall utility of combined system greatly enhanced by much earlier product delivery for both.