Implementation Decision Briefing

N C E P

Short Range Ensemble Forecast (SREF) Version 6.1.3

(initially "bug fix" evolves into an interim package)

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March 14, 2014

Changes
Part I: Bug Fixes or improvements

- **Correct / improve initial conditions:**

a) **replace GFS land states with NDAS land states in NMM & ARW members;**

b) **rewrite NDAS land states in NMMB to fix a bug in NPS related to lake ice;**

c) **correct inadvertent use of global initial conditions with use of RAP for ARW members**

- **Fix bugs in NOAH LSM:**

a) **eliminate negative soil moisture fractions for NMM and ARW members;**

b) **eliminate "urban swamp" (causing too cold surface temperature over urban regions during heat wave periods) for NMMB members**

- **Improve cloud ceiling**

a) **correct GFS physics in 2 NMMB members to produce compatible cloud & ceiling guidance with the rest of SREF members;**

b) **fix post-processor to remove use of snow in diagnosing cloud base height**

- **Correct a mapping bug (eastward shift) in NMM member's pressure-grib output files.**
- **Code improvements: (a) p vs log(p), (b) NetCDF I/O for NMM and ARW**

Changes
part II: New or improved products

- **Add 4 winter weather variables:**

a) **low-level Rime Factor of 21 members;**
b) **snow depth of 21 members;**
c) **% of frozen precipitation of 21 members;**
d) **water equivalent accumulated snow of 7 ARW members**

- **Add 2m temperature and 3-hourly accumulated precipitation of 21 SREF members from the 32km North American domain (grid 221) into AWIPS**

- **Modify the clustering algorithm to "preserve" time-continuity within a cluster over each of the three preselected forecast periods (00-39hr, 42-63hr, 66-87hr)**

- **Add more sites in SREF bufr sounding output by unifying the SREF bufr station list with that used in RAP and coming NAM.**

- **Use model-lowest level fields for T2m, Q2m, U10, V10, Td2m, RH2m at f00 for NMMB**

Overall expectation

- Since the original intention is to fix bugs and there is no major model change (except for ARW), overall performance should be similar between prod and para SREFs. ARW members are expected to have the largest changes.

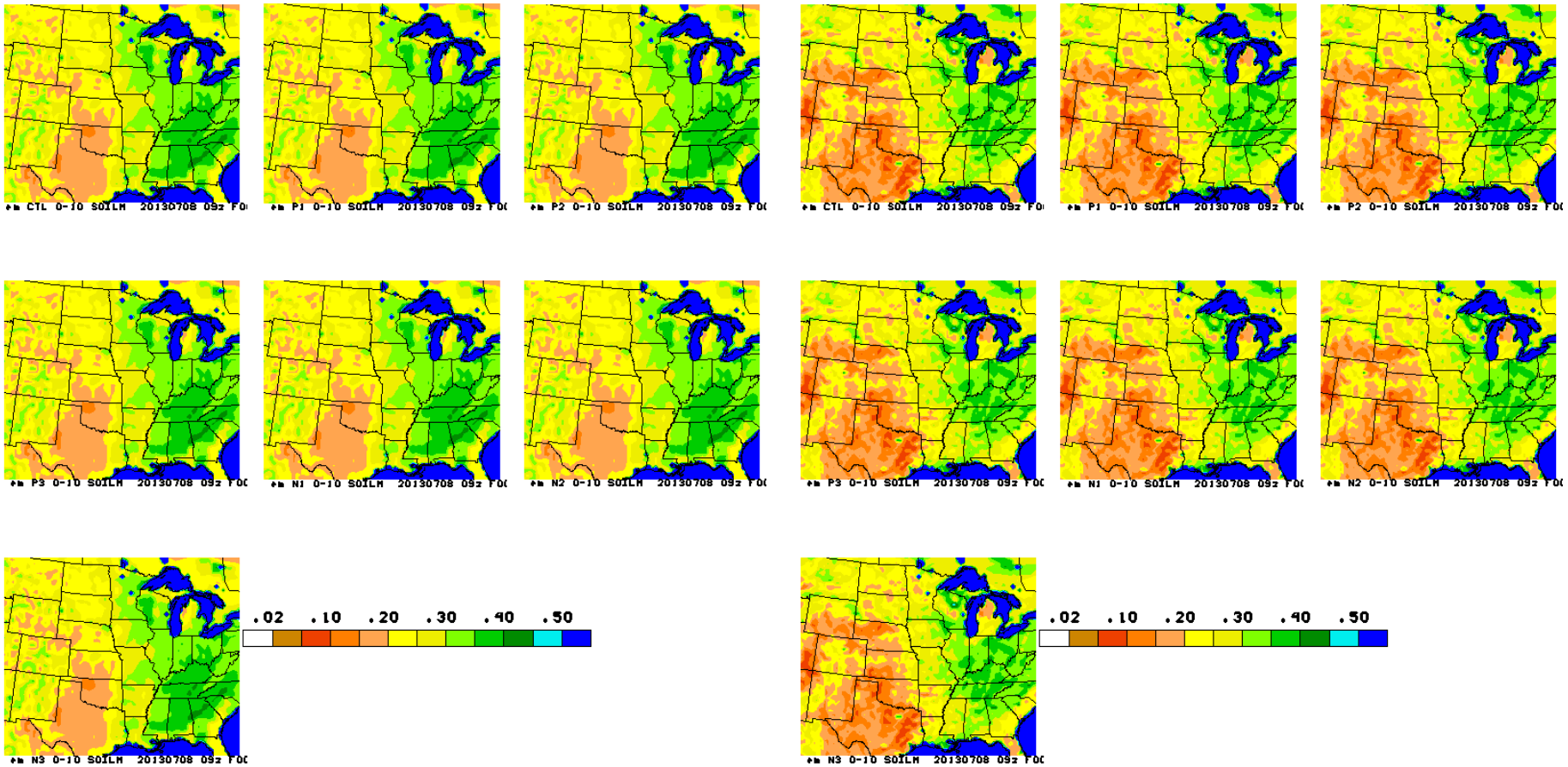
Test Results (1)

Surface wet and cold biases of certain areas in some cases

(SPC concern)

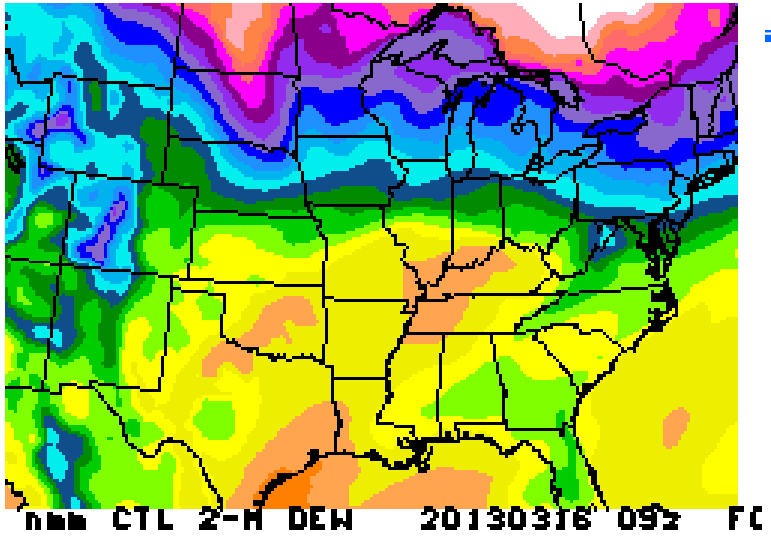
NDAS soil moisture is generally drier than that from GFS (e.g., 09z, 7/8/2013) (both EM & NMM)

GFS (wetter) ⟵ NDAS (drier)

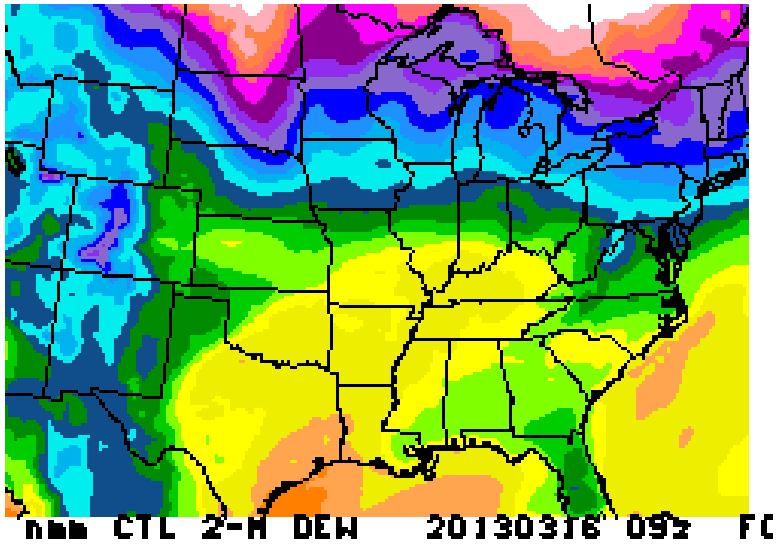


May 16 case: Initial 2m-Td of NMM CTL much better initialization after the land states replacement

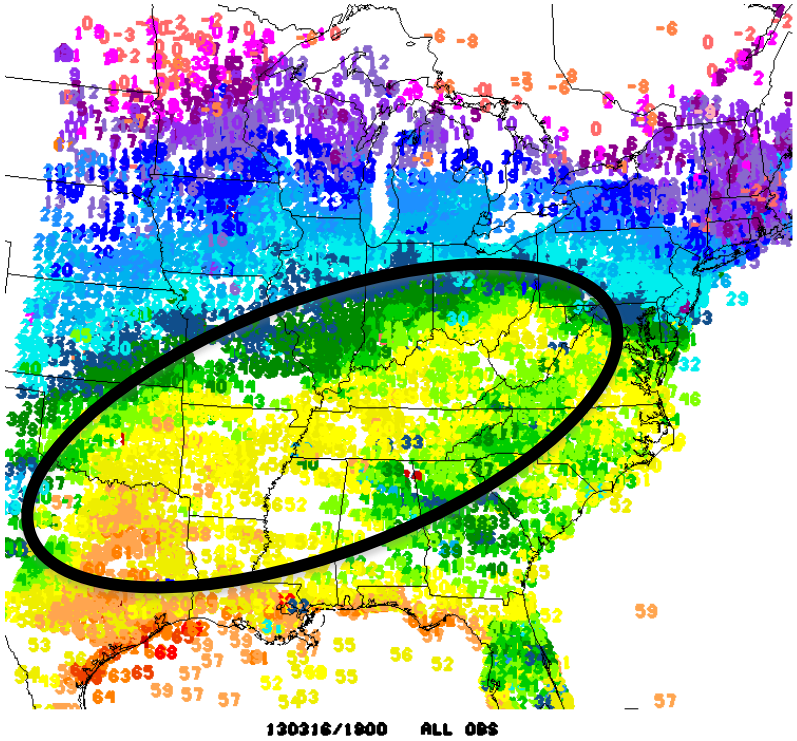
OPS



TEST



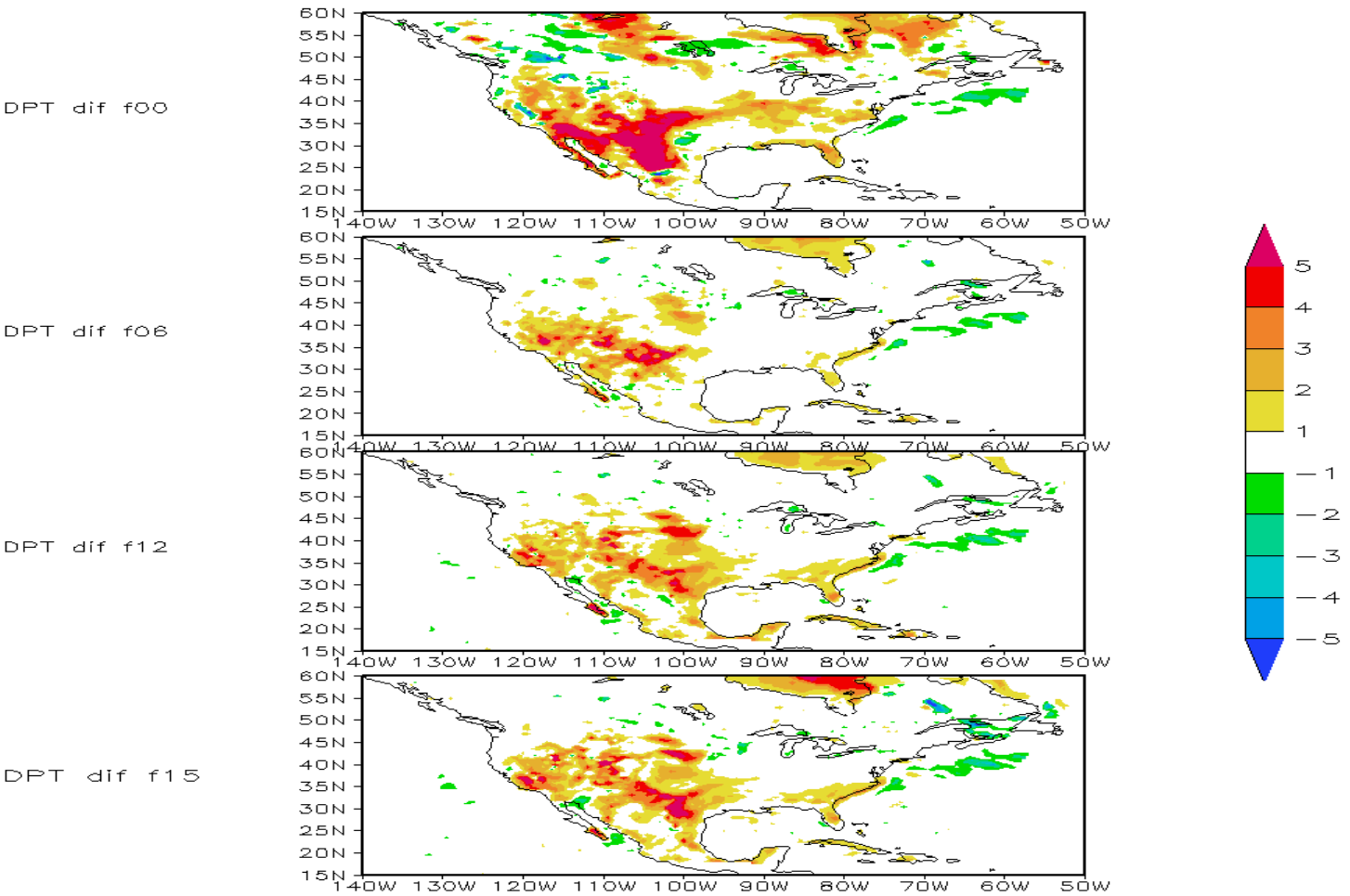
OBS



May 16 case: 2m Td difference (opl – test) (09z)

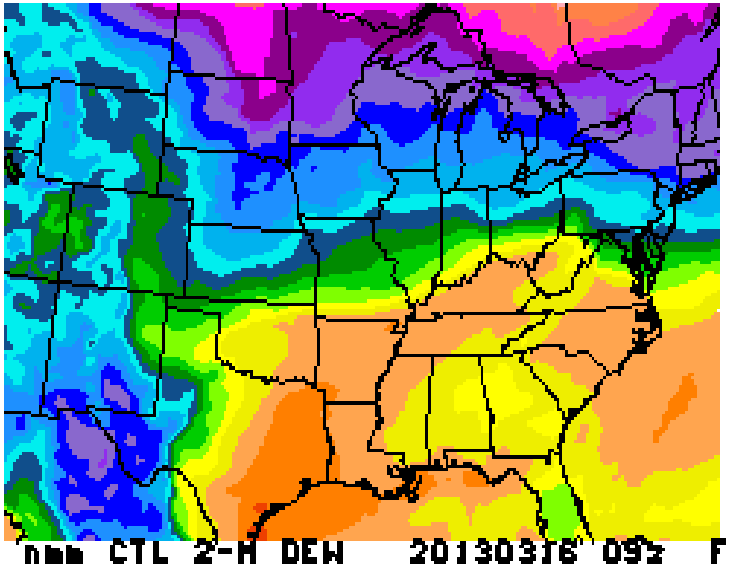
too-high 2m Td reduced after the land states replacement in early hours (also see the stats later) but reduces with time

NMM ctl

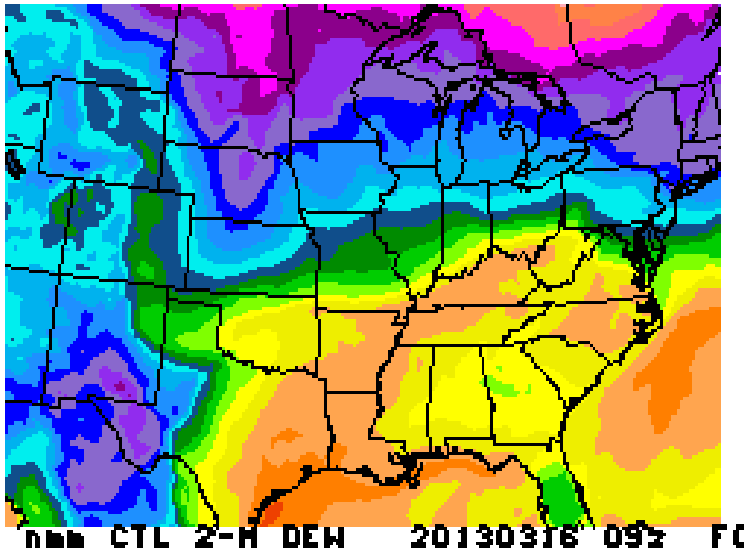


9 hr 2m-Td of NMM CTL: signal lost with time

OPS



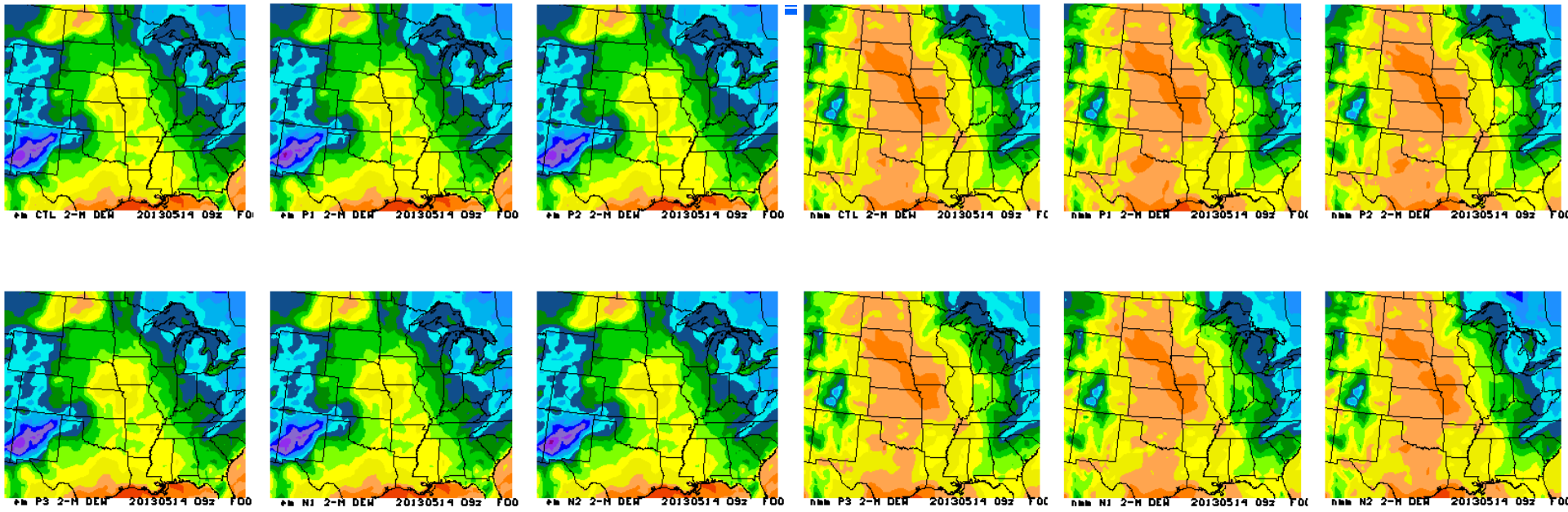
TEST

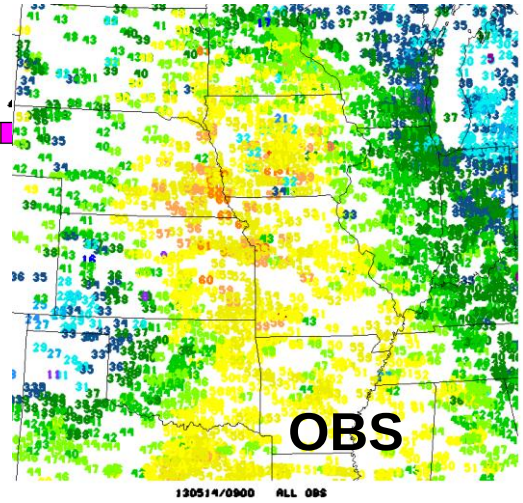


Initial 2m-Td of NMM (from GFS/GEFS) vs. ARW (from RAP) members (09z, May 14, 2013)

ARW

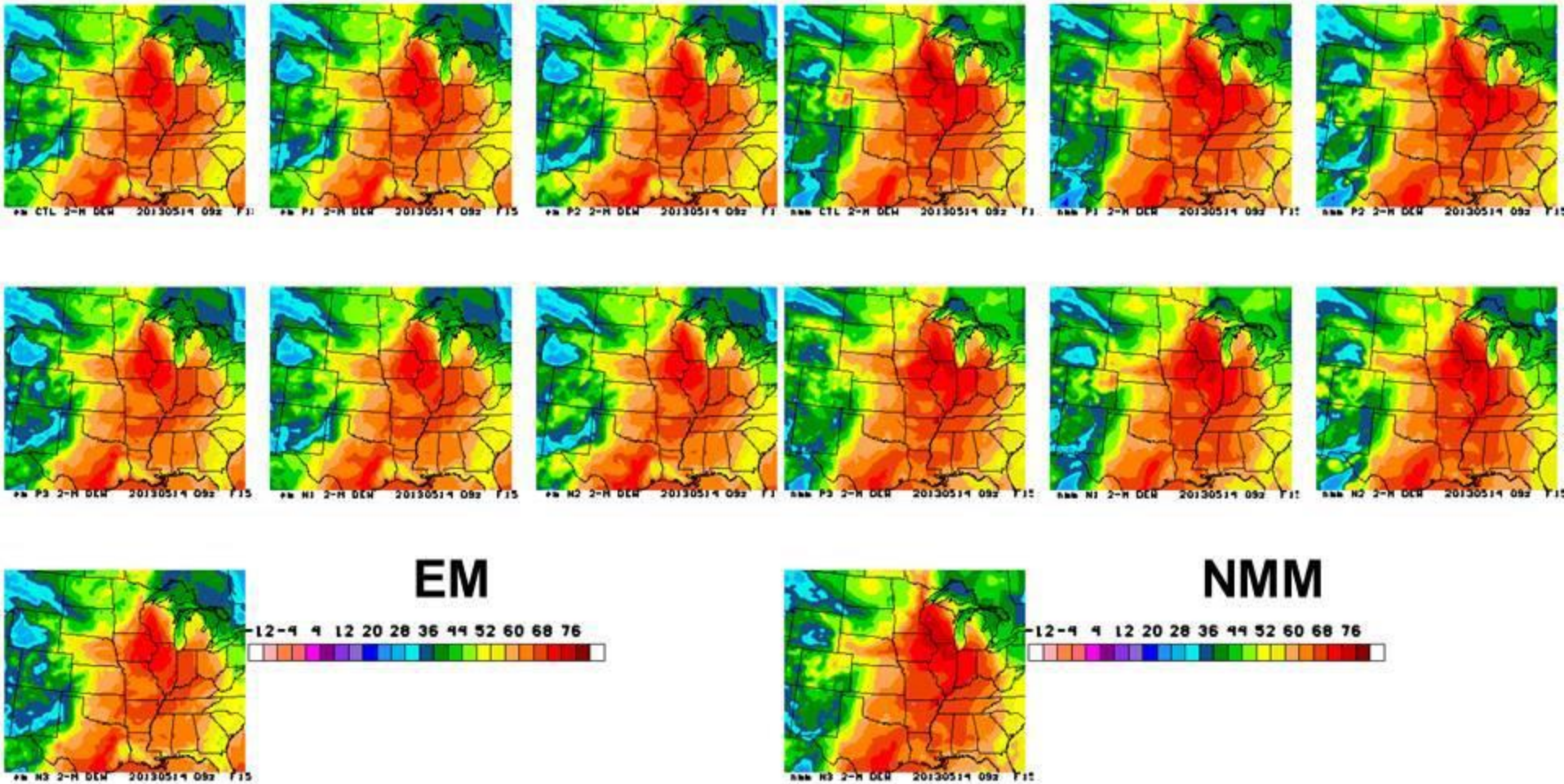
NMM





Much improved initialization

15-HR PARA 09z SREF DEW PT FCSTS

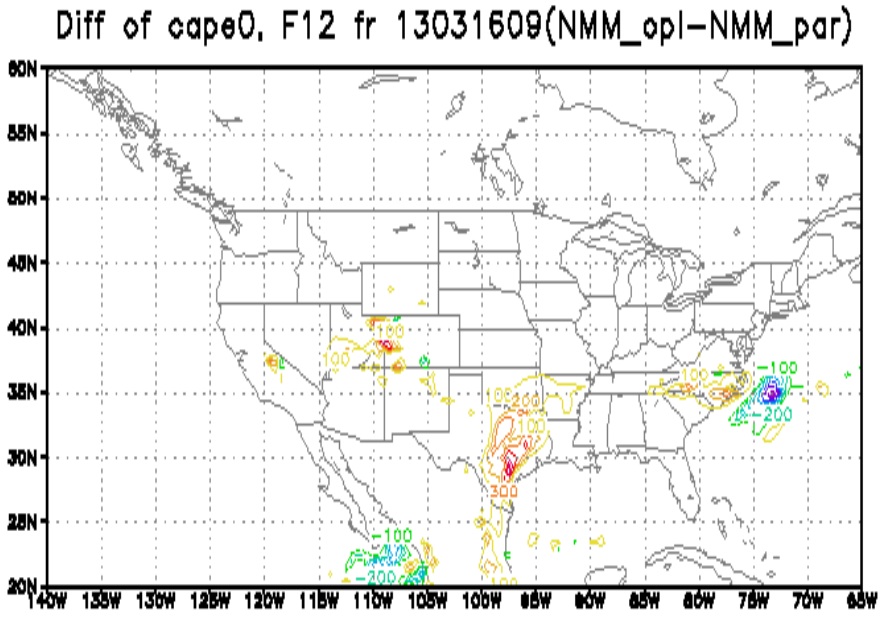


Despite better initialization, EM members quickly turn moist

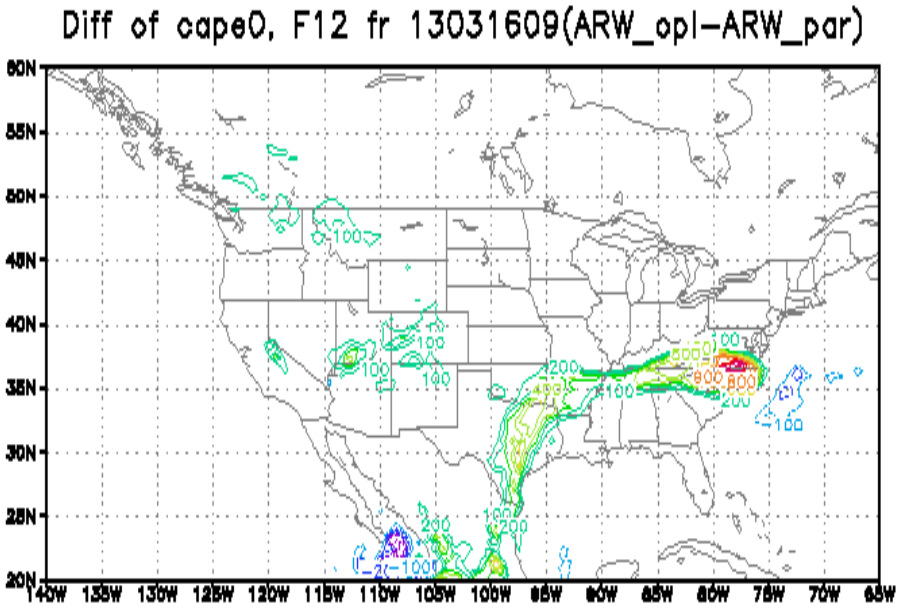
May 16 case: Surface CAPE difference (opl – test) (09z)

too-high surface CAPE reduced after the land states replacement in early forecast

NMM ctl



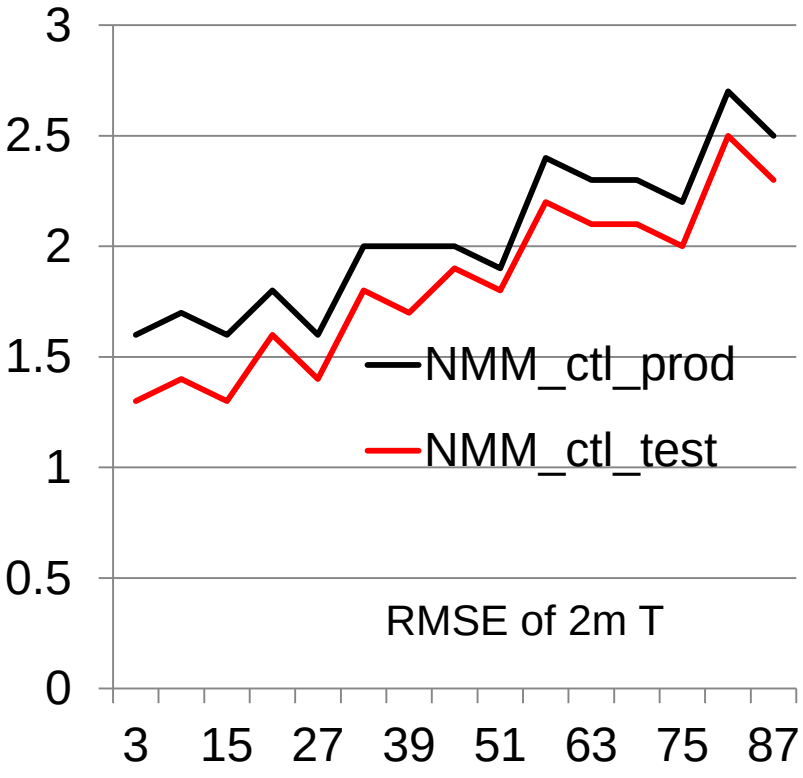
ARW ctl



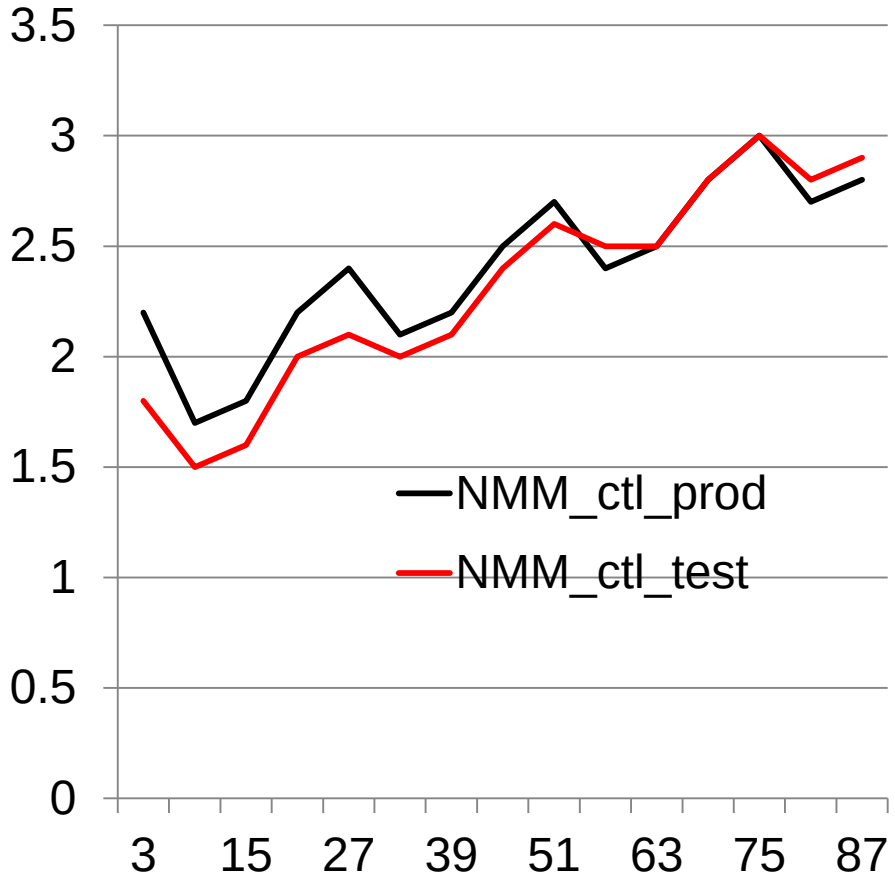
2m T

RMSE of 2m T for NMM_ctl (Prod vs. Para, 2013-2014, 09z cycle)

Warm season (July 15- Aug. 31, 2013)



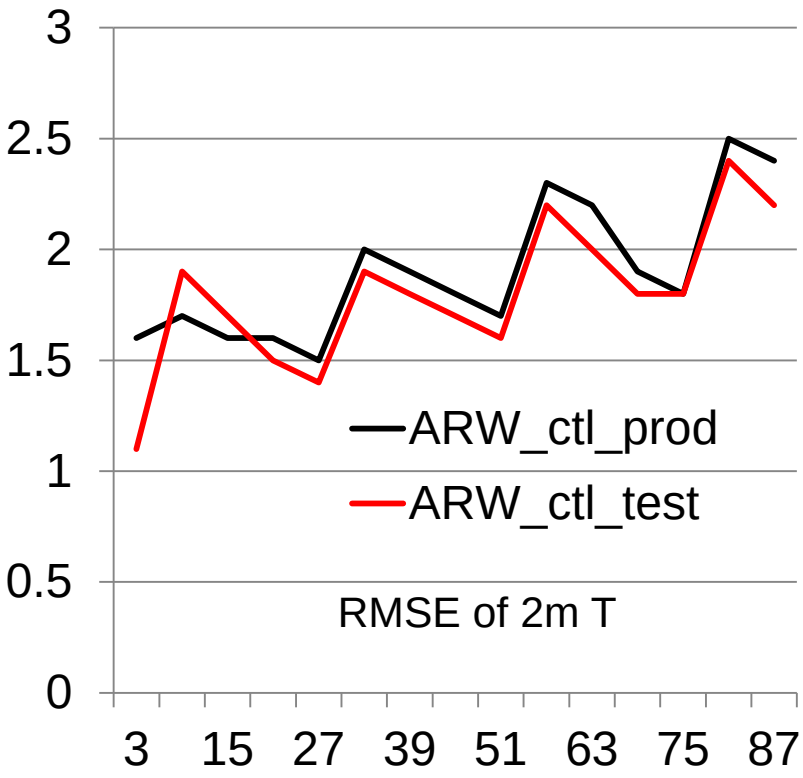
Cold season (Oct. 1 – Feb. 28, 2014)



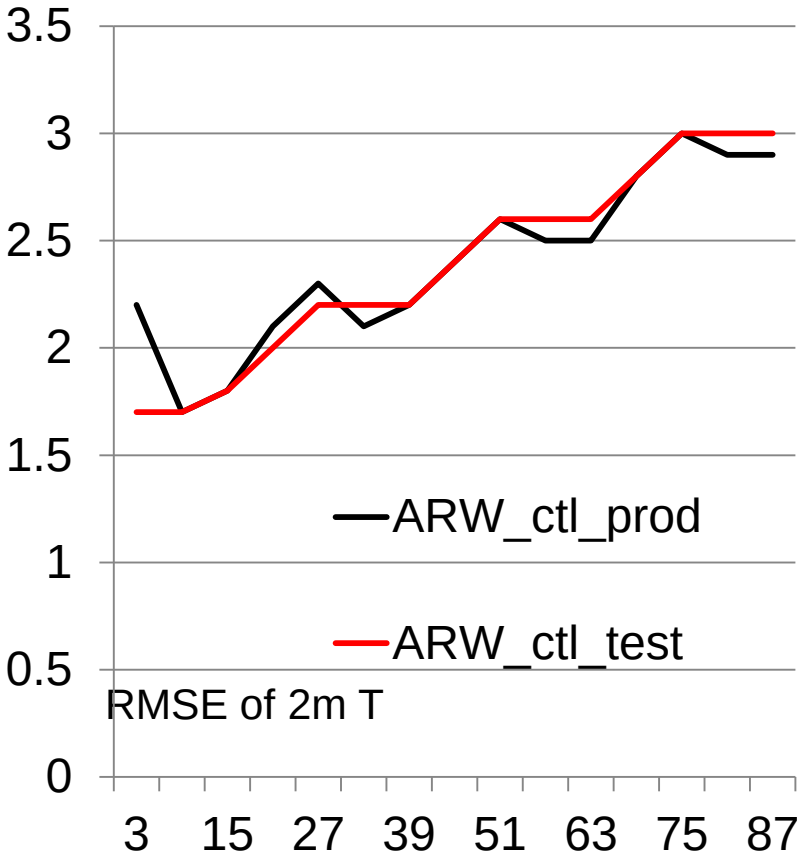
NMM 2m T: reduction in total error for both warm and cold seasons, No reduction or similar in bias.

RMSE of 2m T for ARW_ctl (Prod vs. Para, 2013-2014, 09z cycle)

Warm season (July 15 – Aug. 31)

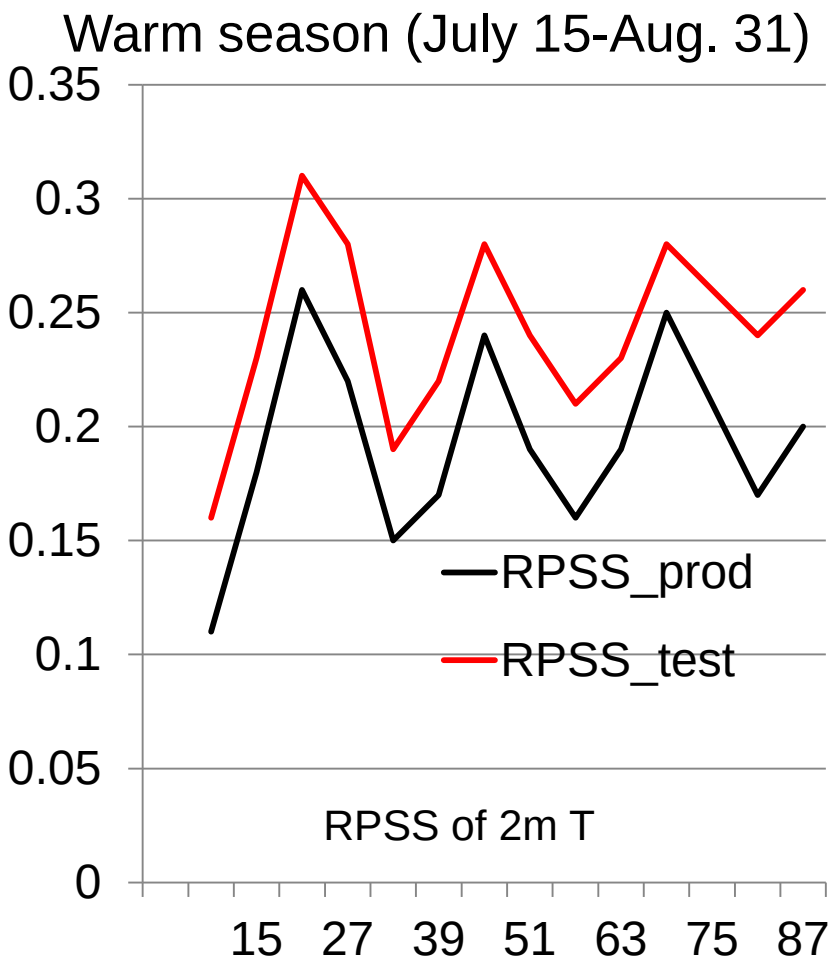


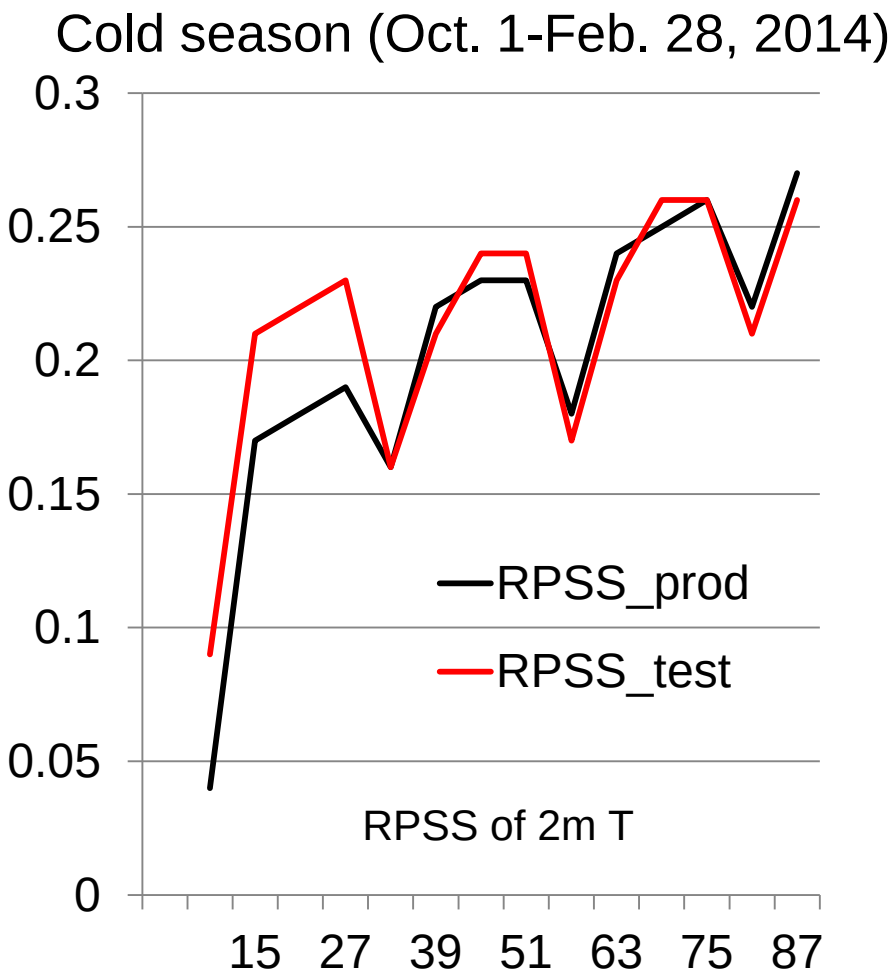
Cold season (Oct. 1 – Feb. 28, 2014)



ARW 2m T: reduction in total error in warm season and similar in cold season. No reduction or similar in bias.

Ranked Probabilistic Skill Score (RPSS) of 2m T (Prod vs. Para, 2013-2014, 09z cycle)

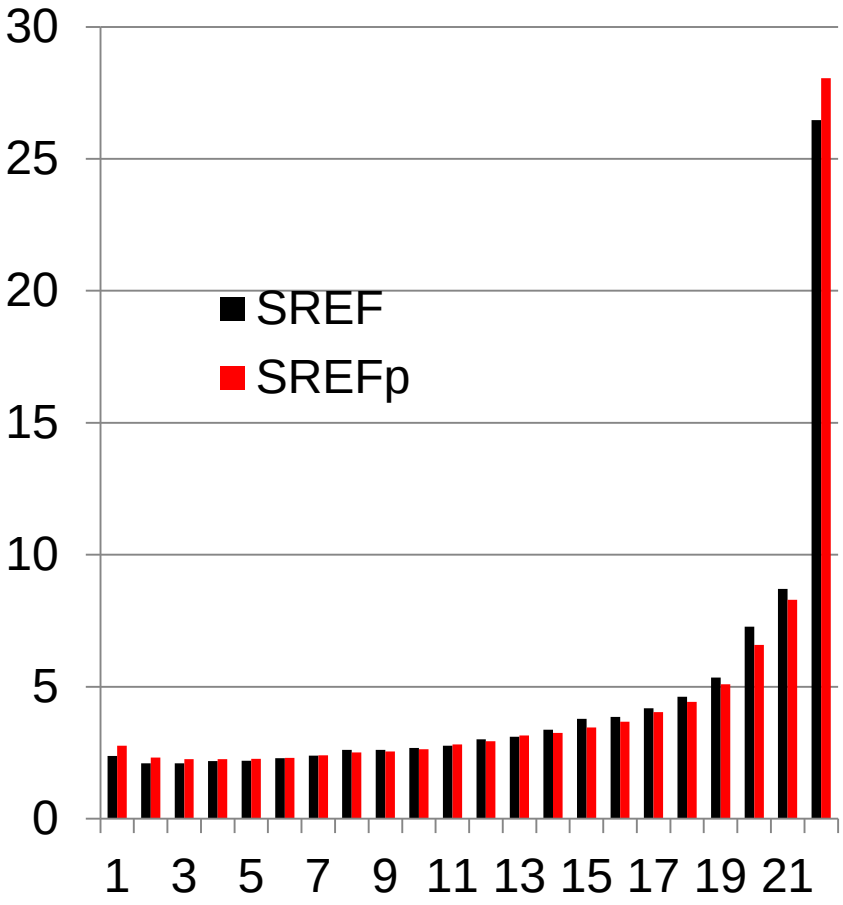




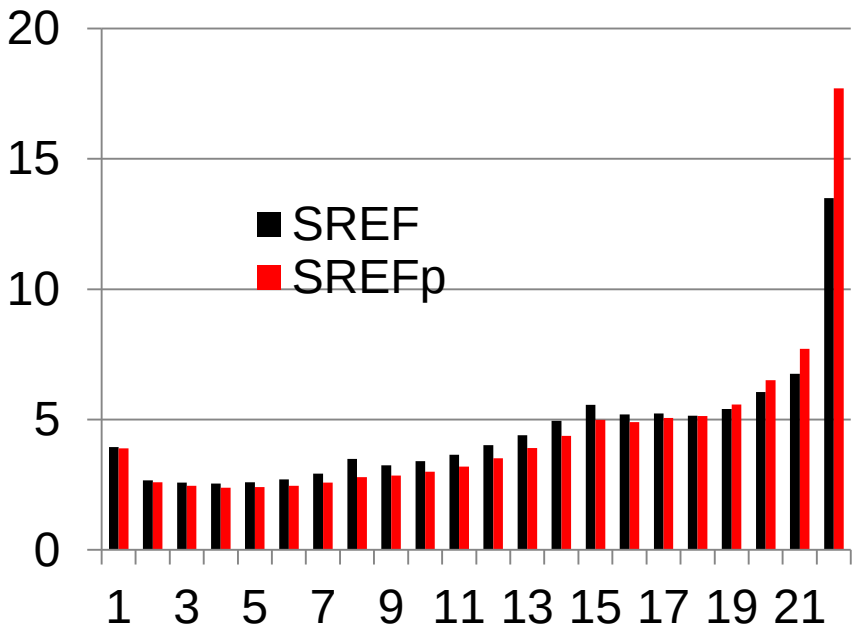
SREF 2m T probabilistic forecasts: More skillful in warm season and similar in cold season

Talagrand Distribution of T2m at F87h

Warm season (July 15 – Aug. 31, 2013)



Cold season (Oct 1 – Feb 28, 2014)

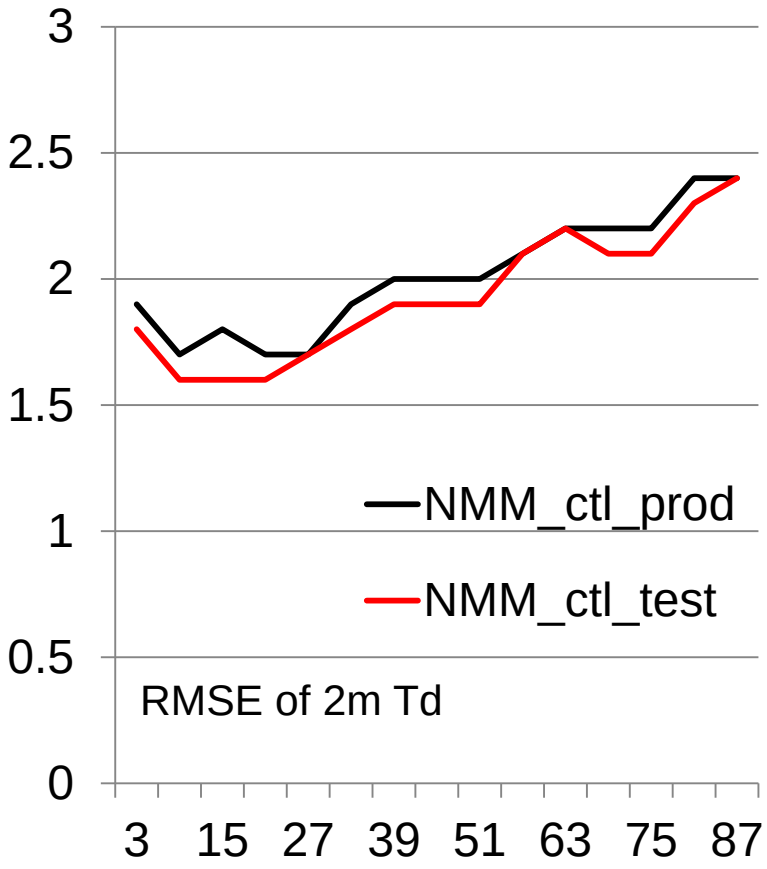


SREF 2m T: Slightly smaller spread or more cold bias

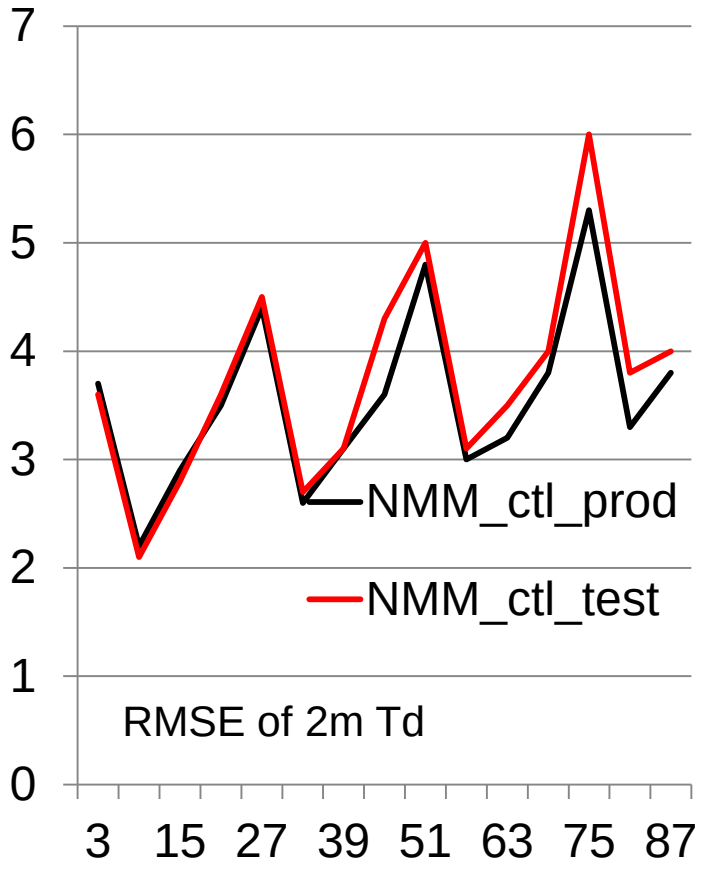
2m Td

RMSE of 2m Td for NMM_ctl (Prod vs. Para, 2013-2014, 09z cycle)

Warm season (July 15- Aug. 31)



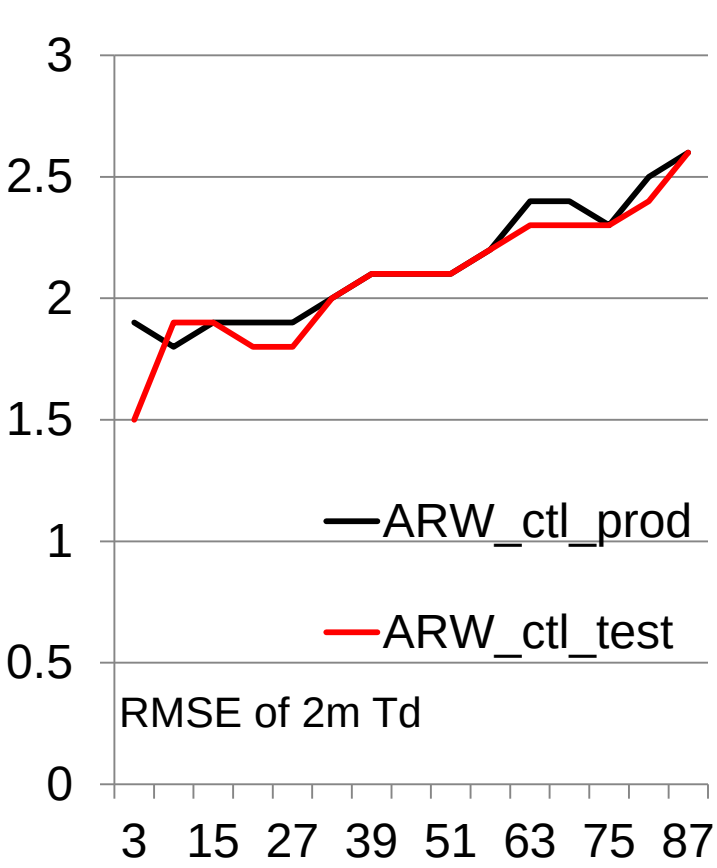
Cold season (Oct. 1 – Feb 28, 2014)



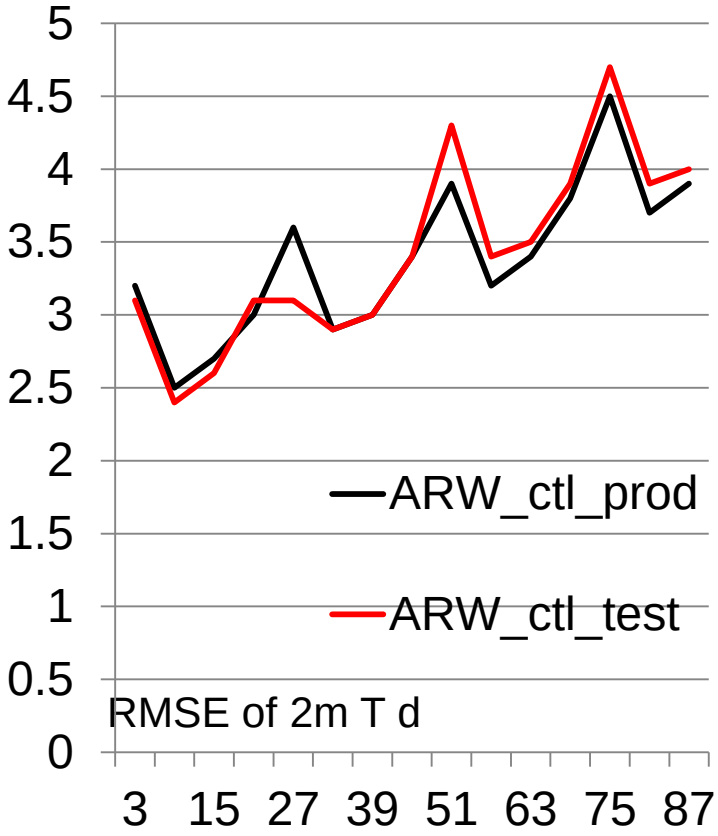
NMM 2m Td: Slight reduction (increase) in total error in warm (cold) seasons. No reduction or similar in bias.

RMSE of 2m Td for ARW_ctl (Prod vs. Para, 2013-2014, 09z cycle)

Warm season (July 15- Aug. 31)



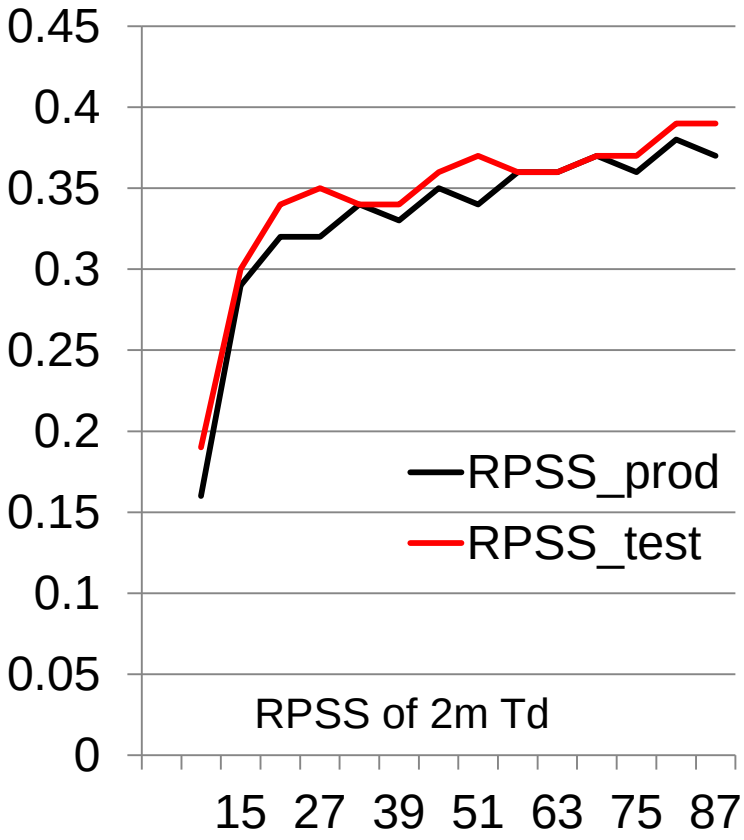
Cold season (Oct. 1 – Feb 28)



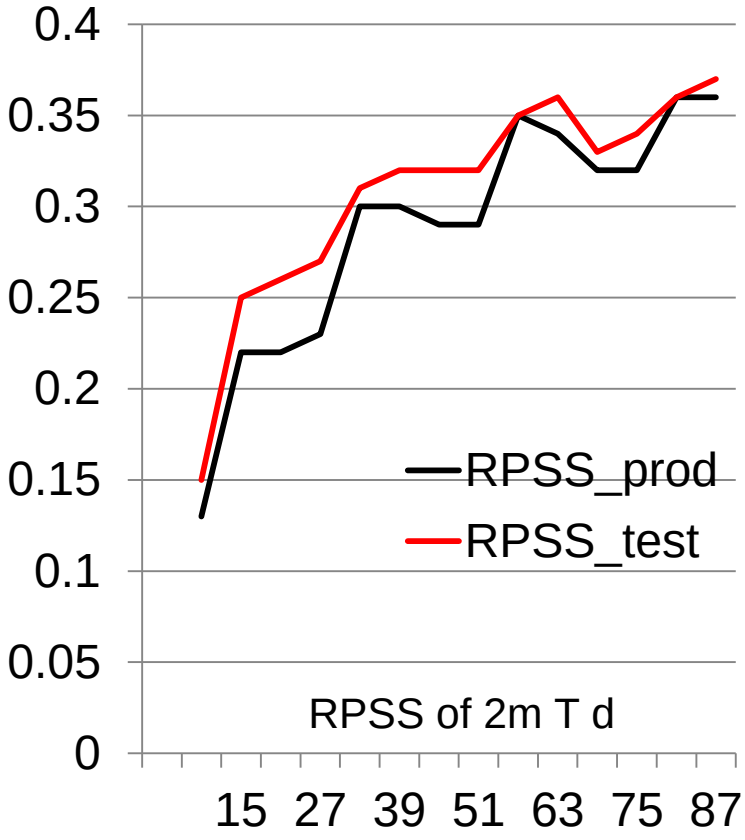
ARW 2m Td: similar or slight reduction (increase) in total error in warm (cold) season. No reduction or similar in bias.

Ranked Probabilistic Skill Score (RPSS) of 2m Td (Prod vs. Para, 2013-2014, 09z cycle)

Warm season (July 15- Aug. 31, 2013)

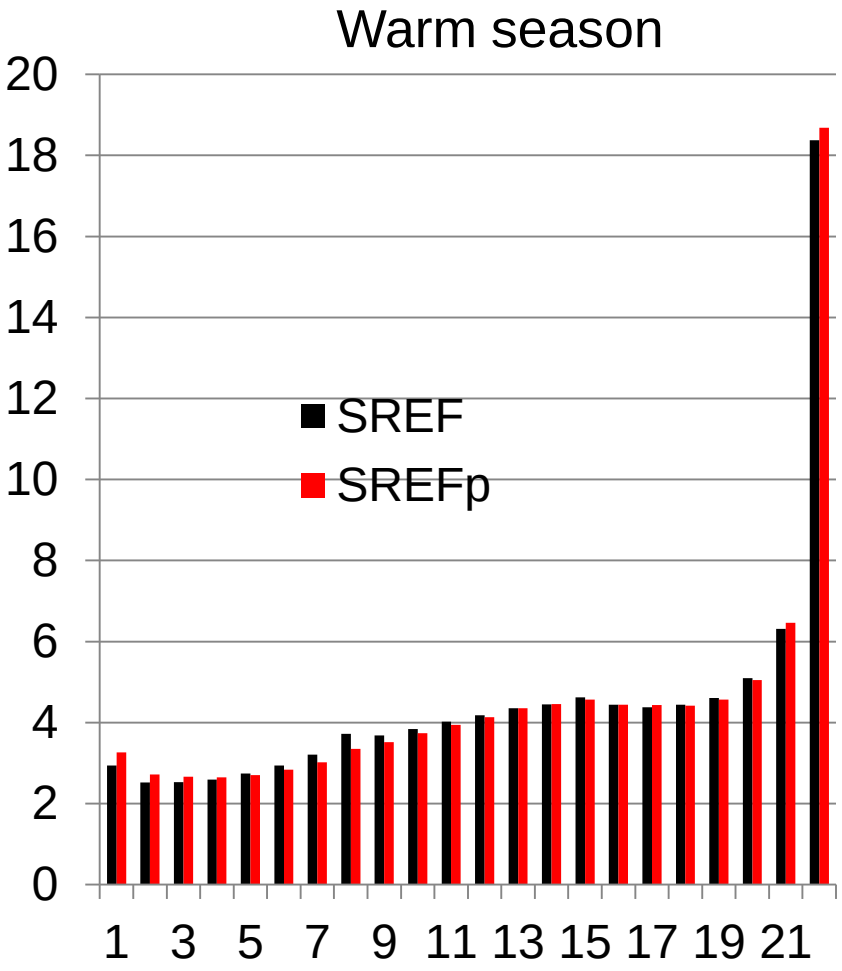


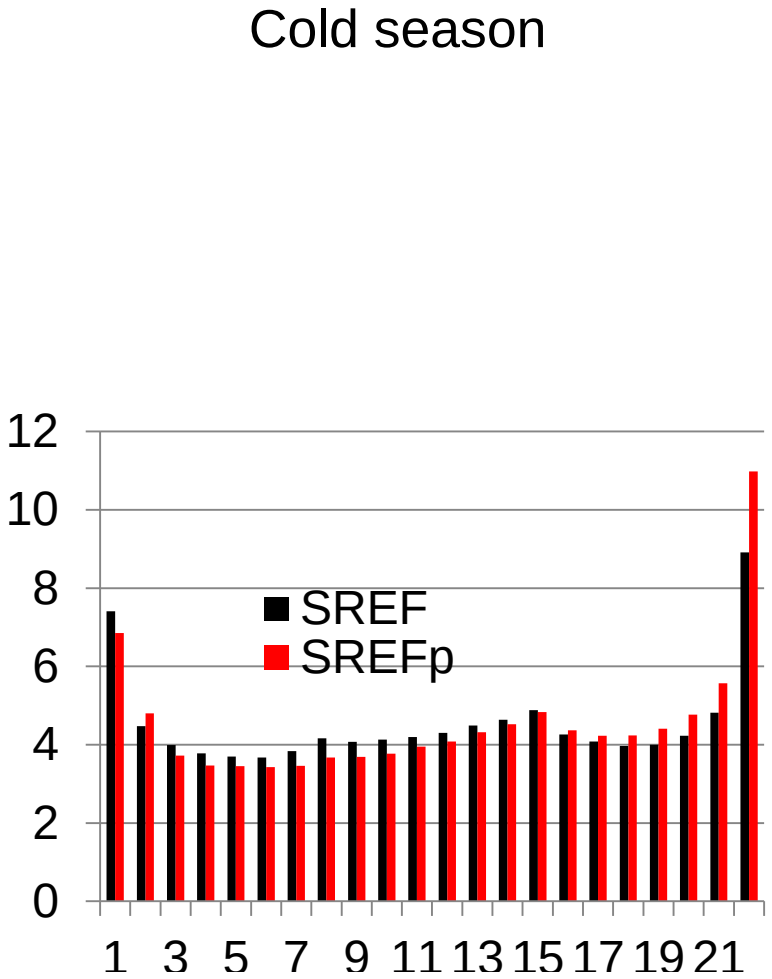
Cold season (Oct. 1 – Feb 28, 2014)



SREF 2m Td probabilistic forecasts: More skillful in both warm season and cold seasons.

Talagrand Distribution of 2m Td at F87h





SREF 2m Td: Slightly smaller spread or more cold or drier in bias

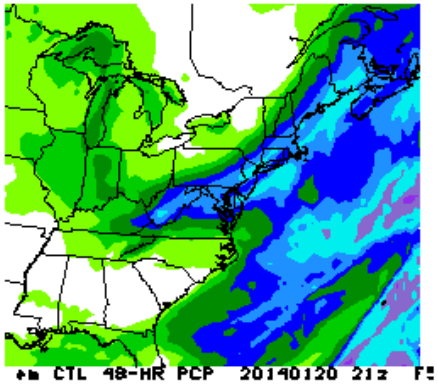
Results (2)

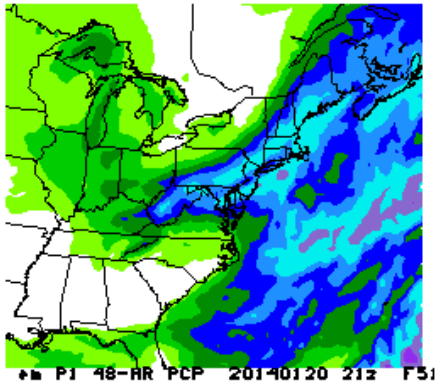
Precipitation, winter weather and fog forecasts

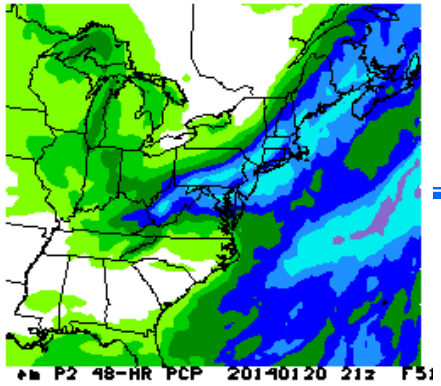
Case 1:
too wet

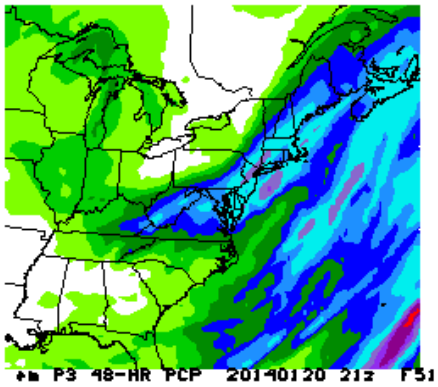
15z
Jan. 20,
2014

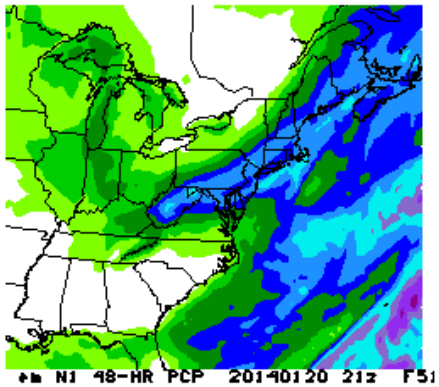
OPS
EM

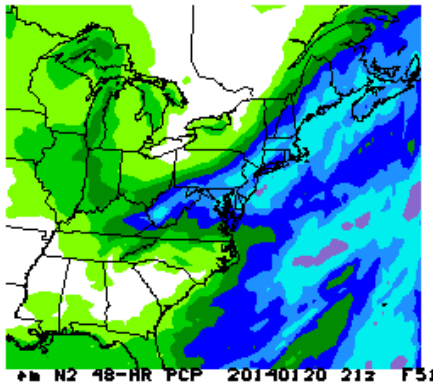


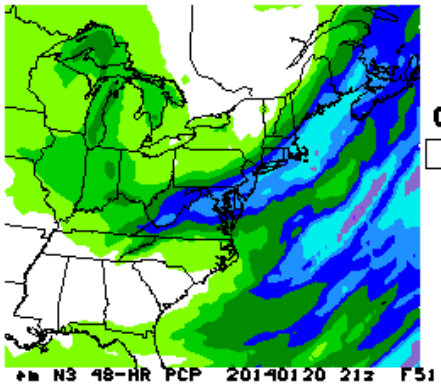


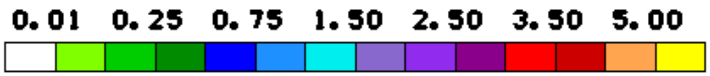




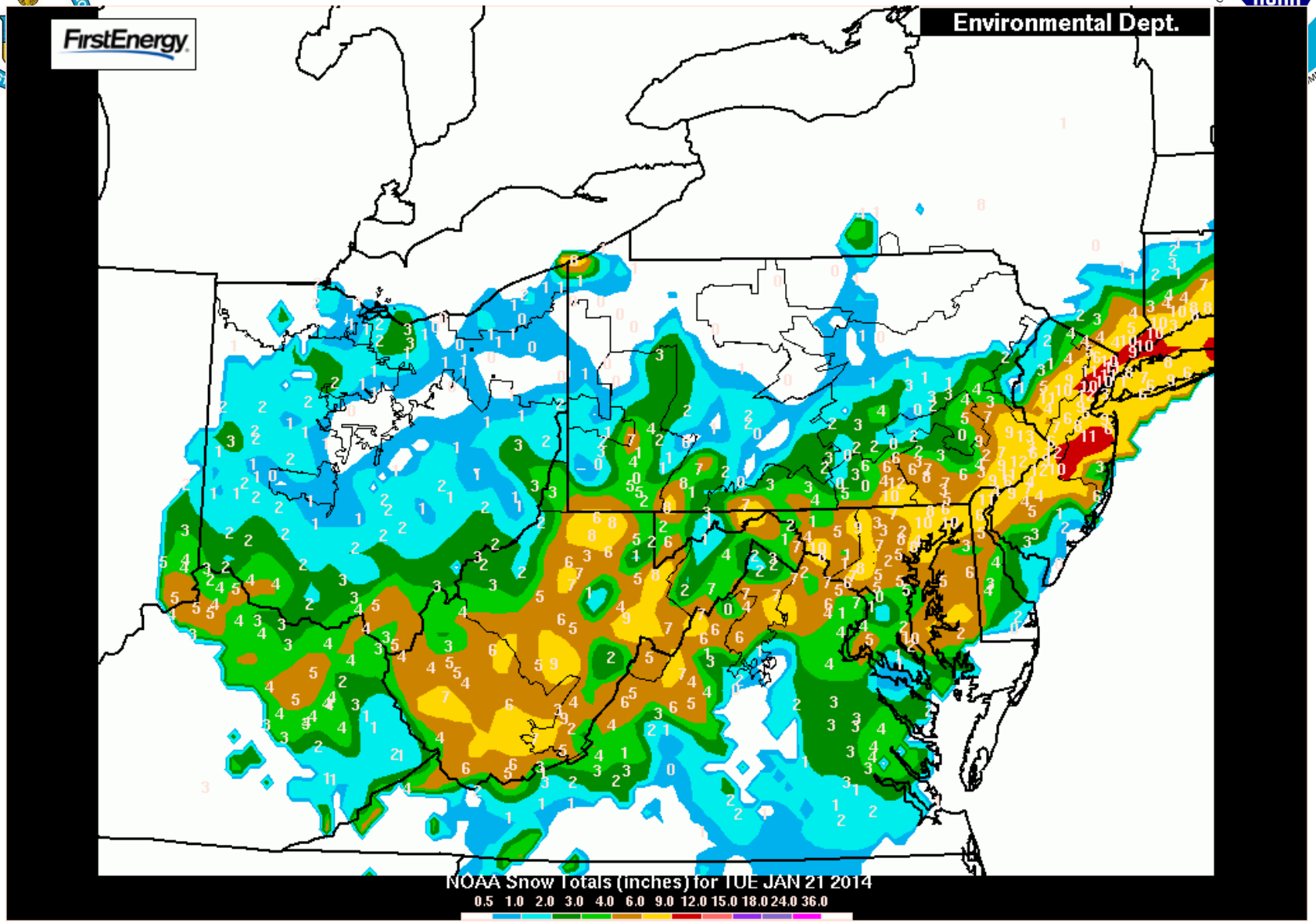








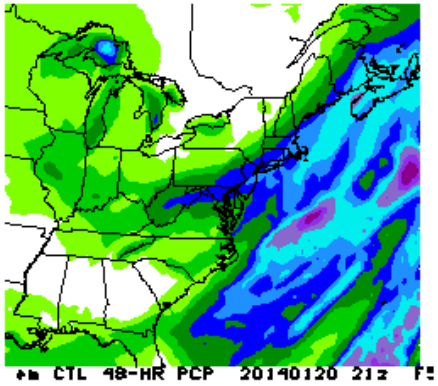
PROD SREF ARW members are all too wet

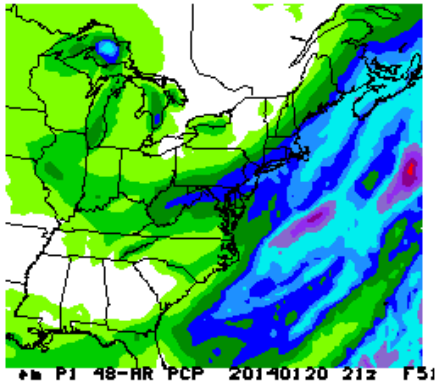


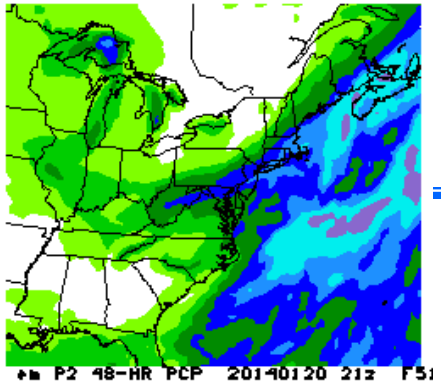
Note: some erroneous low totals near DCA/BWI skewing analysis

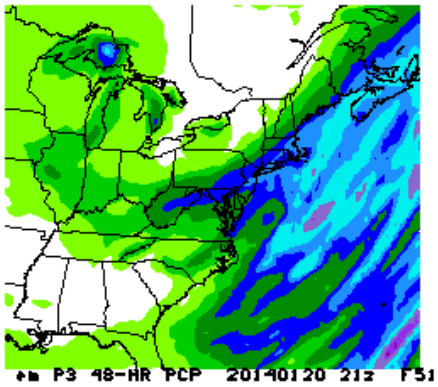
15z
Jan. 20,
2014

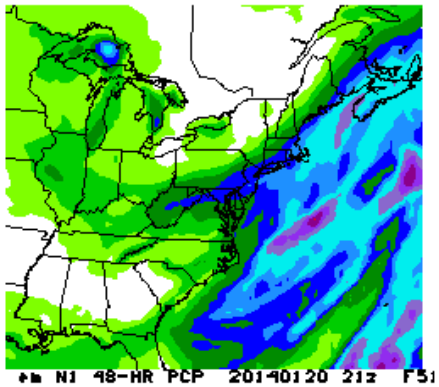
PARA
EM

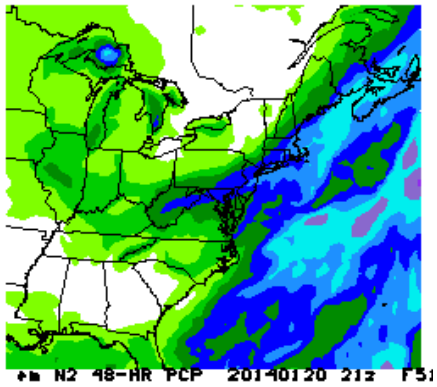


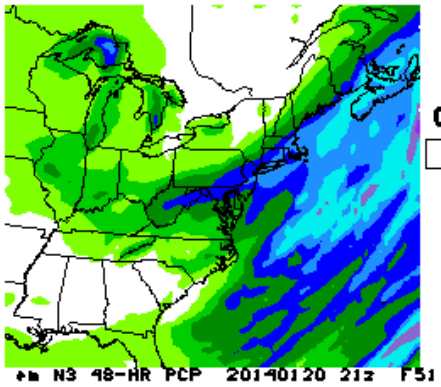












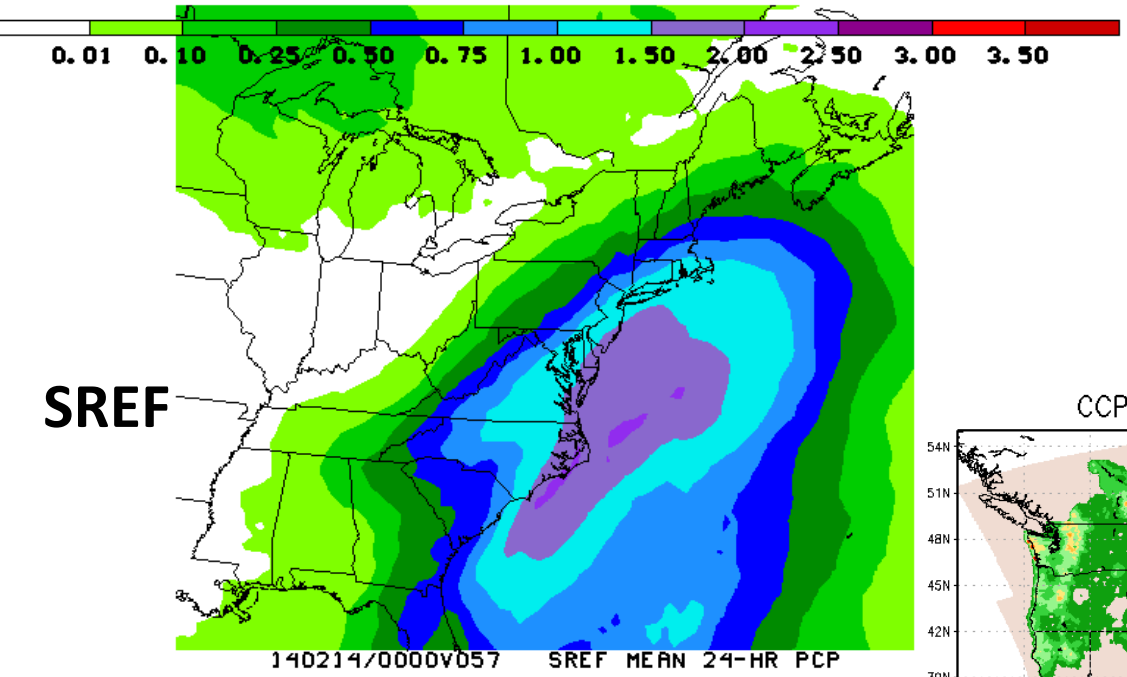
PARA SREF ARW members are corrected in the right direction

Case 2: too dry

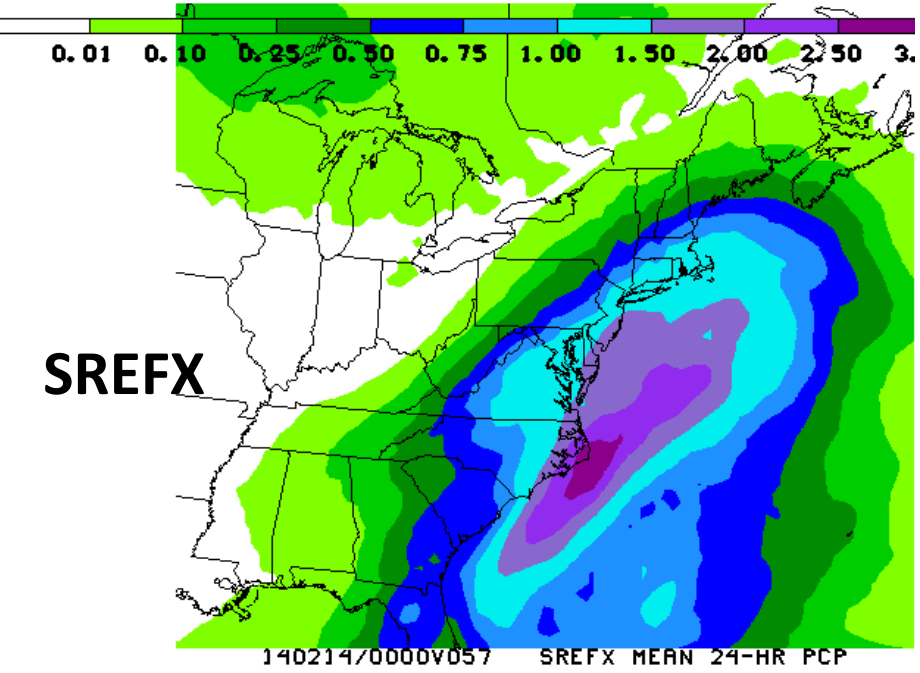
15z Feb. 11, 2014

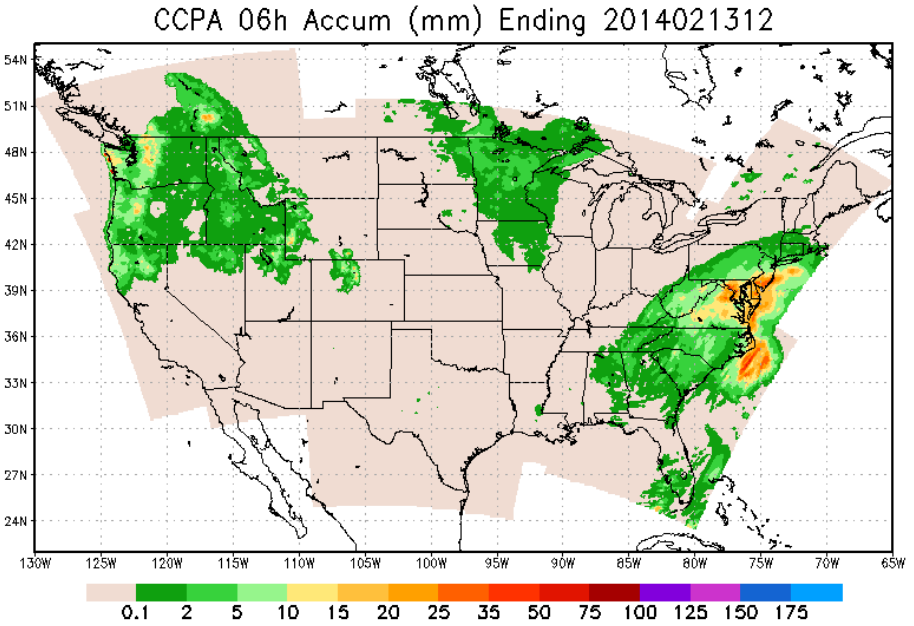
F57

SREF



SREFX

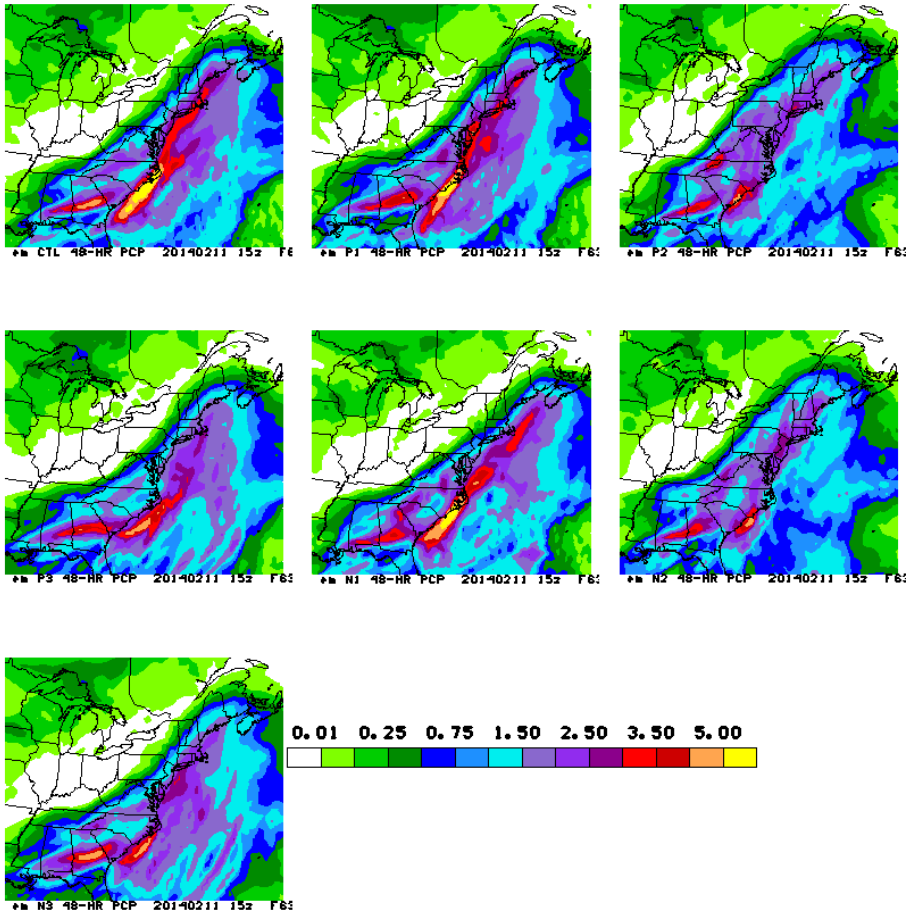




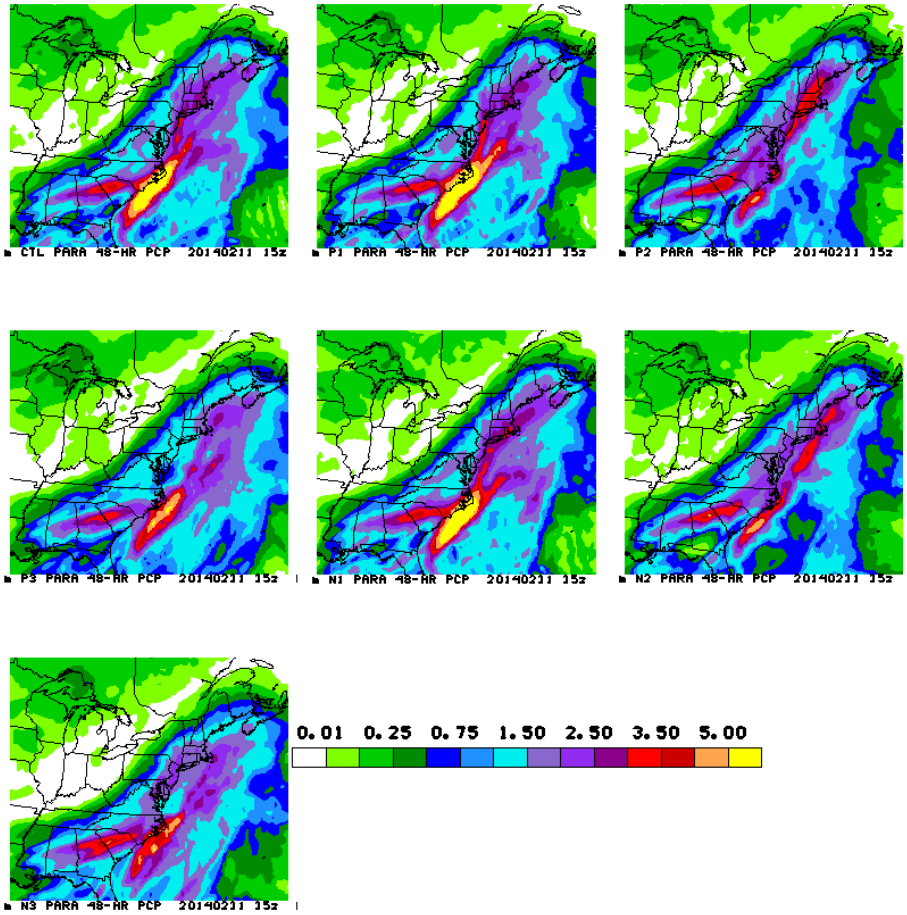
Para has heavier precip further to the northwest across DC metro

Why: similar in NMMB, positive contribution from NMM's eastward-shift correction, and main contribution from ARW

15z 2/11 PROD SREF EM



15z 2/11 PARA SREF EM



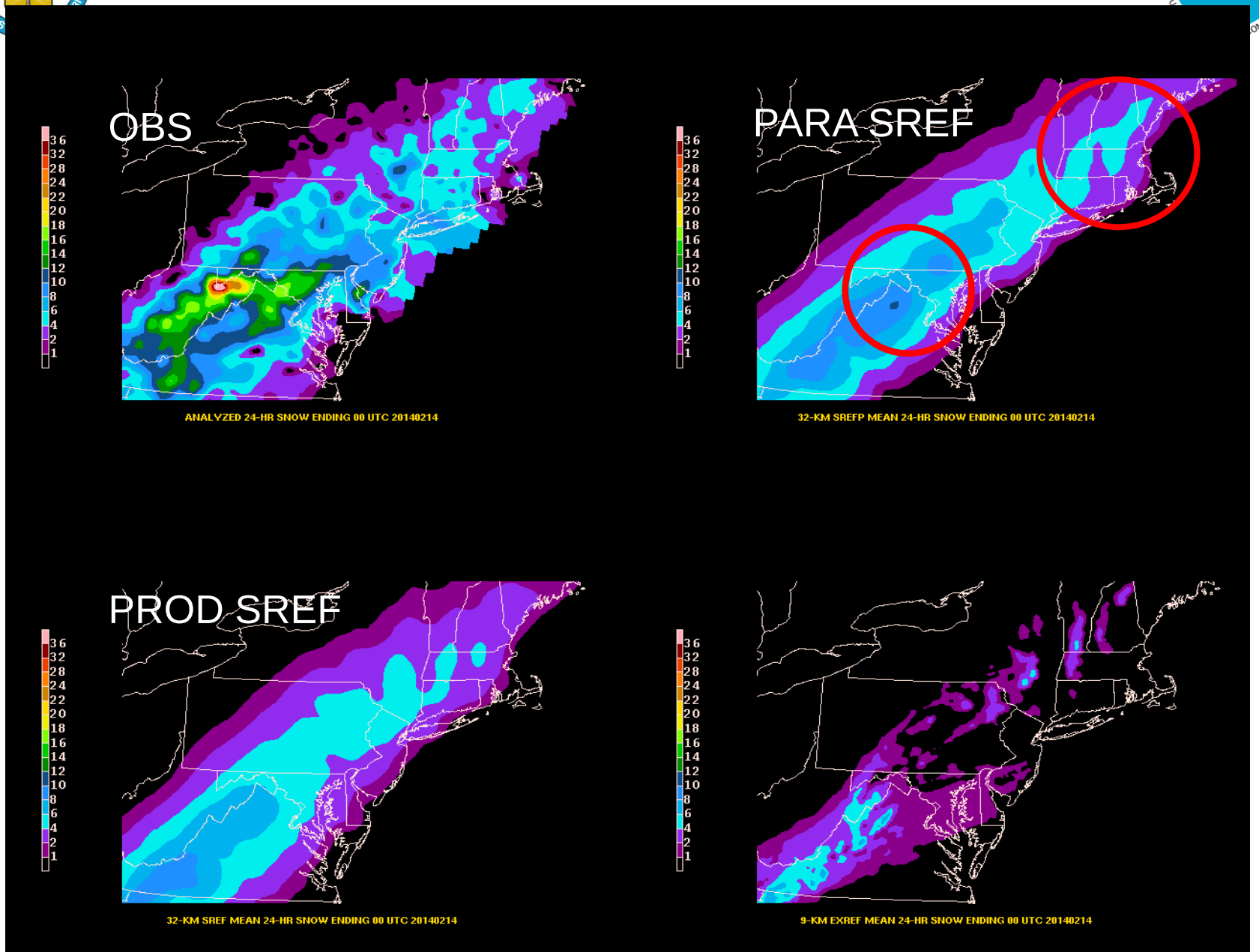
All para ARW members are wetter and shifted to NW

WFO feedbacks (Rich Grumm)

- I think the event last week was a good event for the SREF-PARA

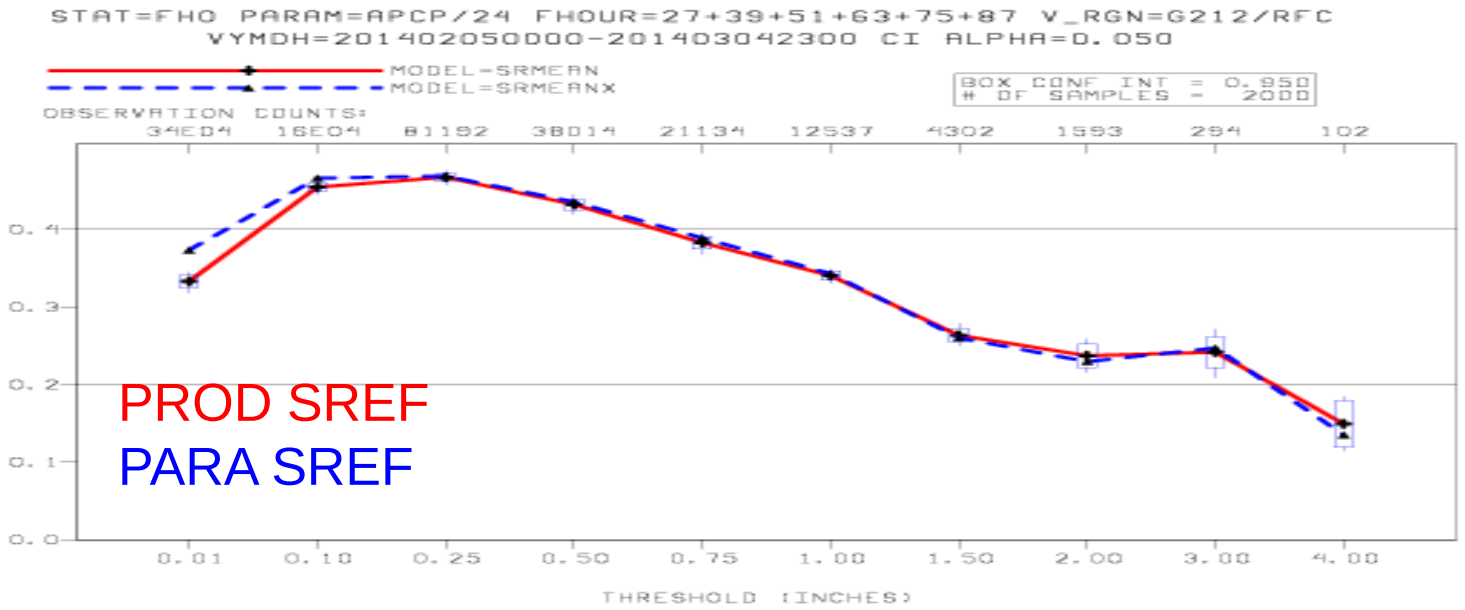
- I suspect convection and the two phasing waves were critical in this event. As the southern low cut-off it developed a new area of QPF and enhanced it. I recall using the SREF/SREF PARA and it was clear there were to be 2 slugs and the PARA had heavy snow in 09Z 10 Feb run, we expanded our Watch and added an advisory 2-3 counties farther west due to this.

Case 3: Snow probability forecasts from AWC Winter Weather experiment

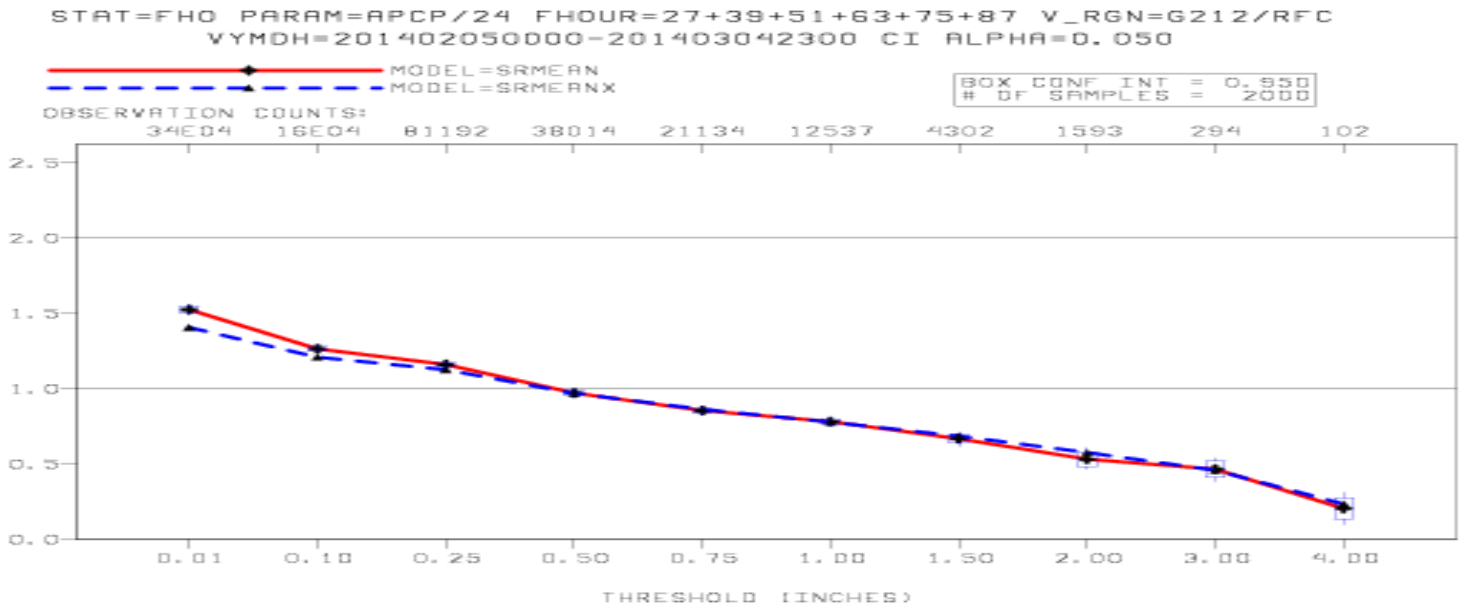


Precipitation Verification (slight improvement in light precipitation): SREF mean (Feb. 5 – Mar 4, 2014)

ETS

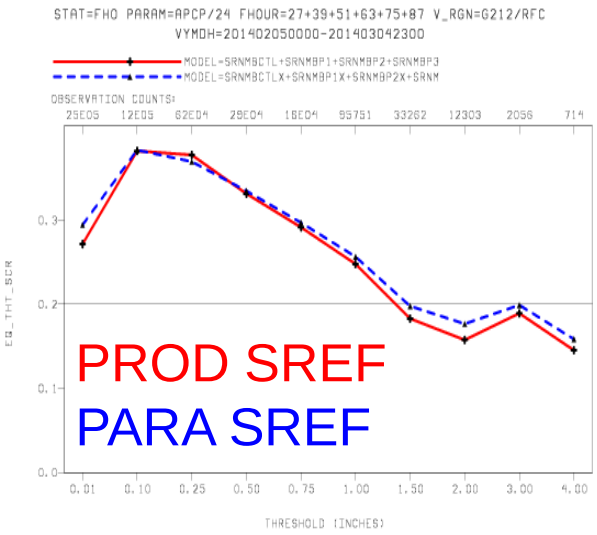


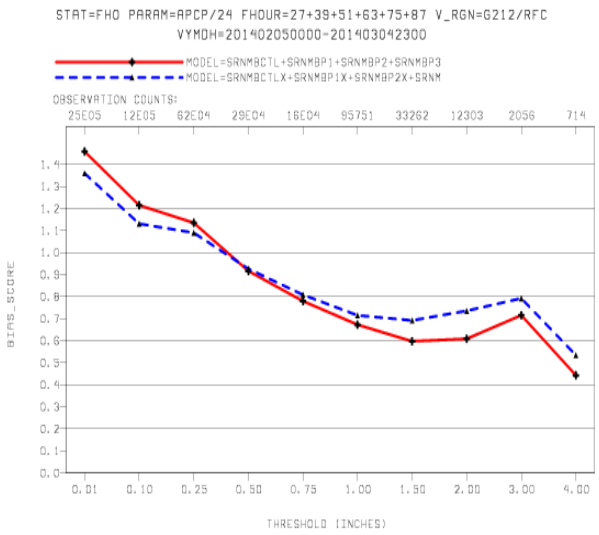
BIAS



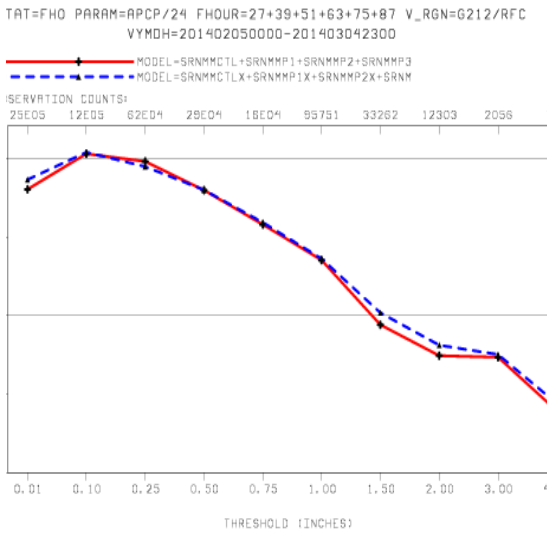
Precipitation Verification (slight improvement in all 3 models): subgroup means (Feb 5 – Mar 4, 2014)

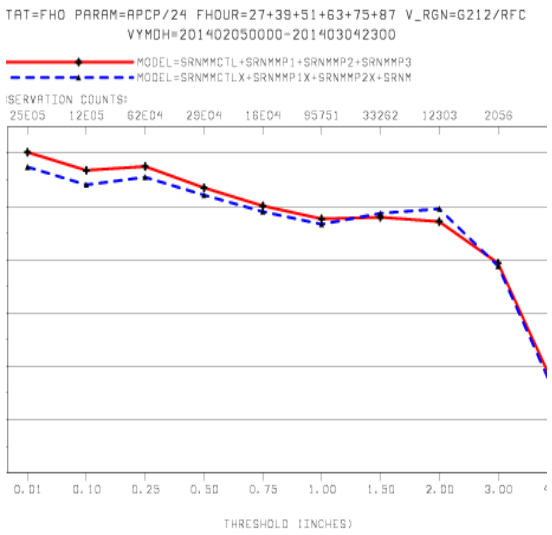
NEMS_NMMB



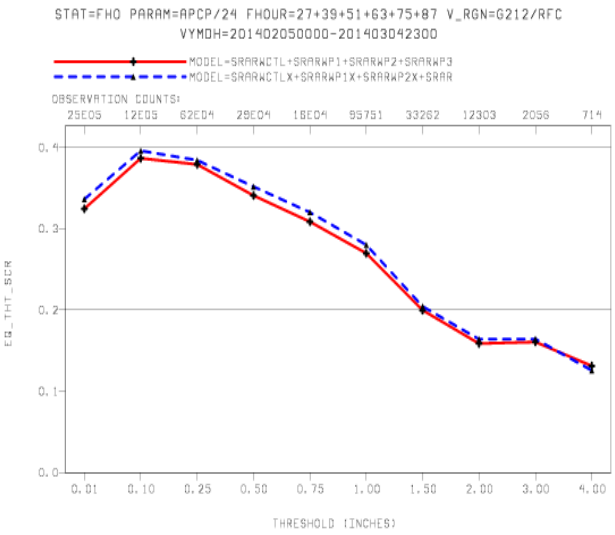


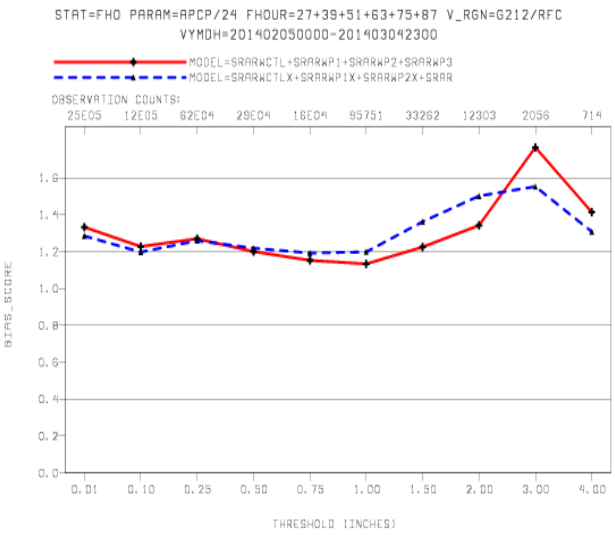
WRF_NMM





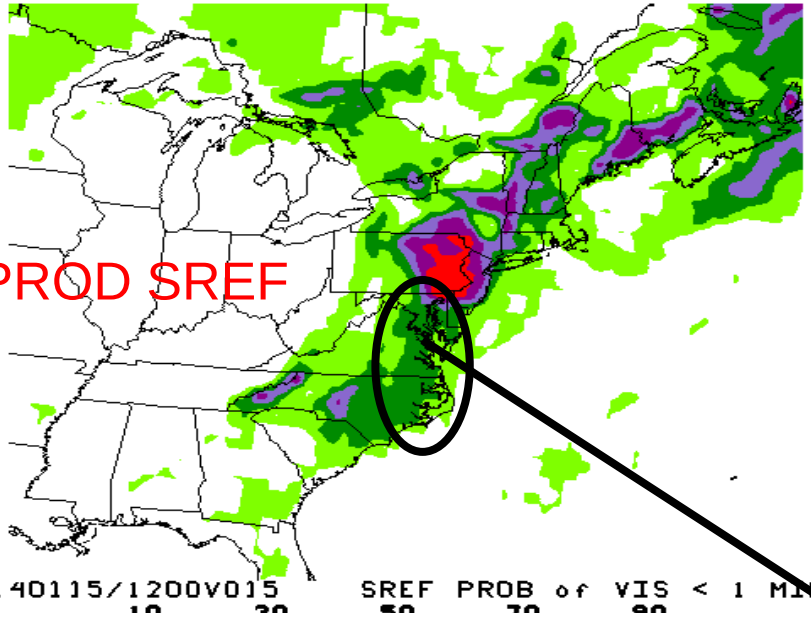
WRF_ARW



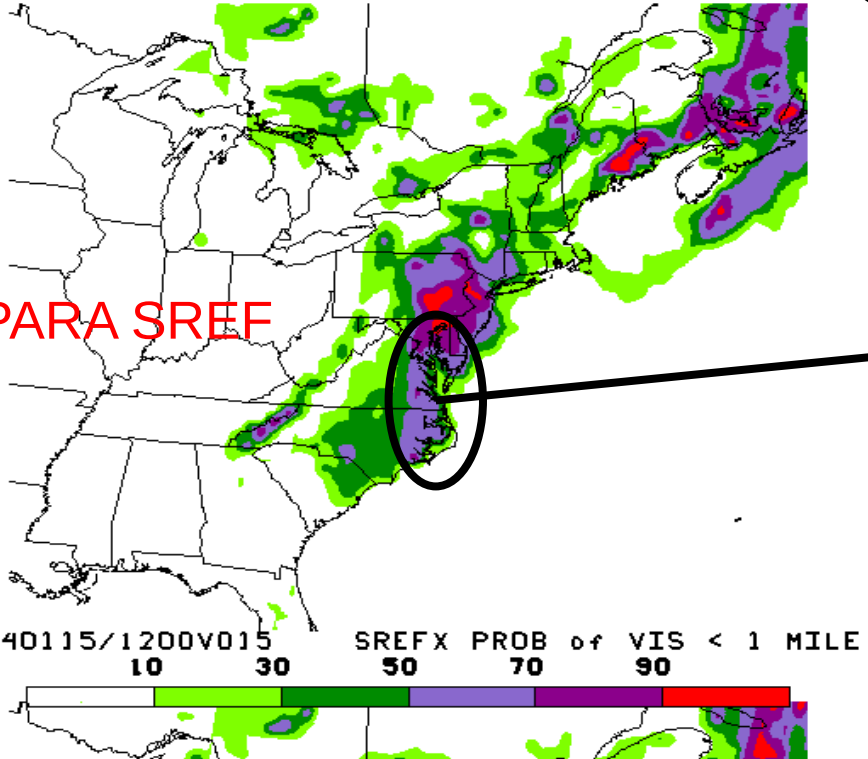


Jan 15, 2014
dense fog case

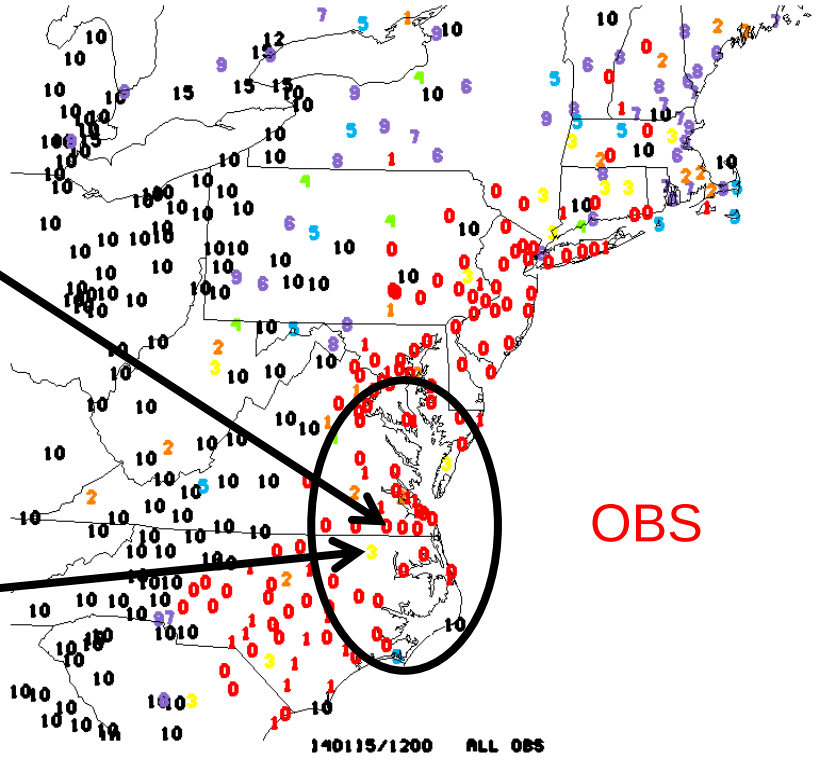
PROD SREF



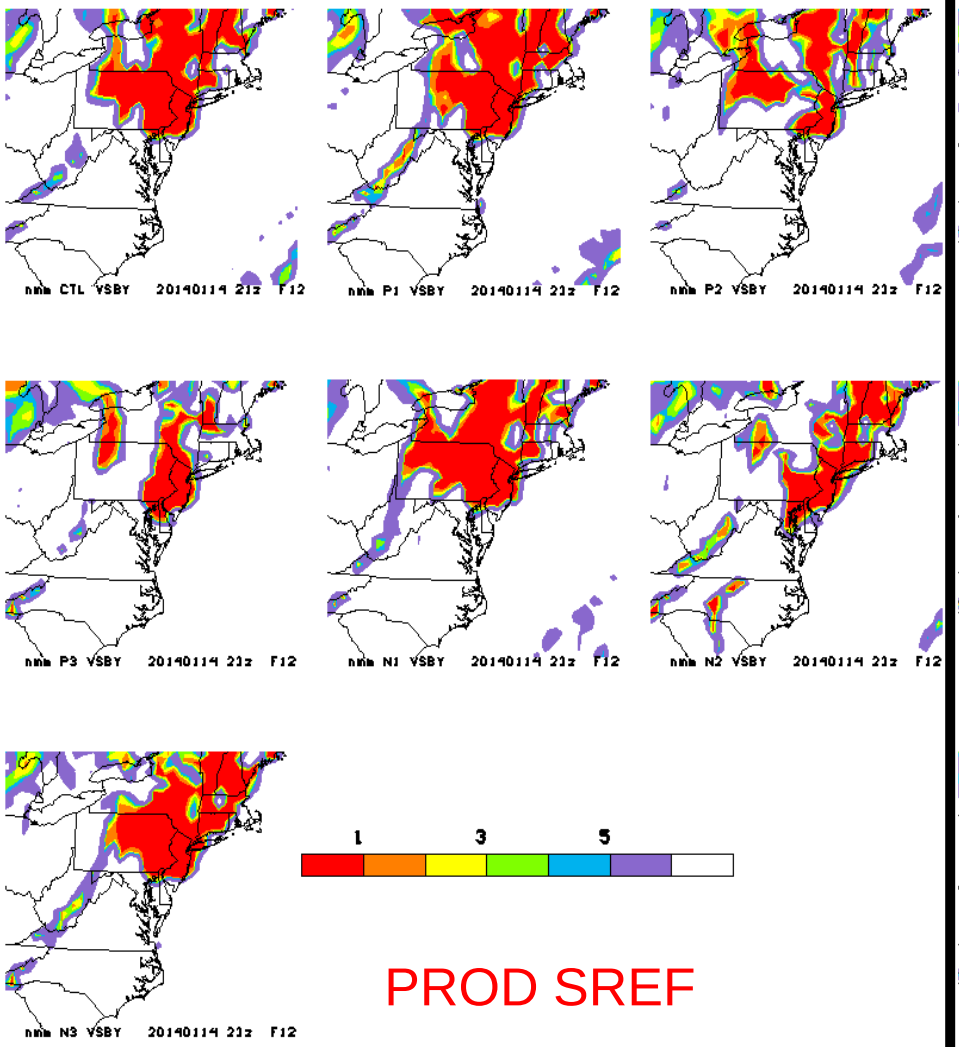
PARA SREF

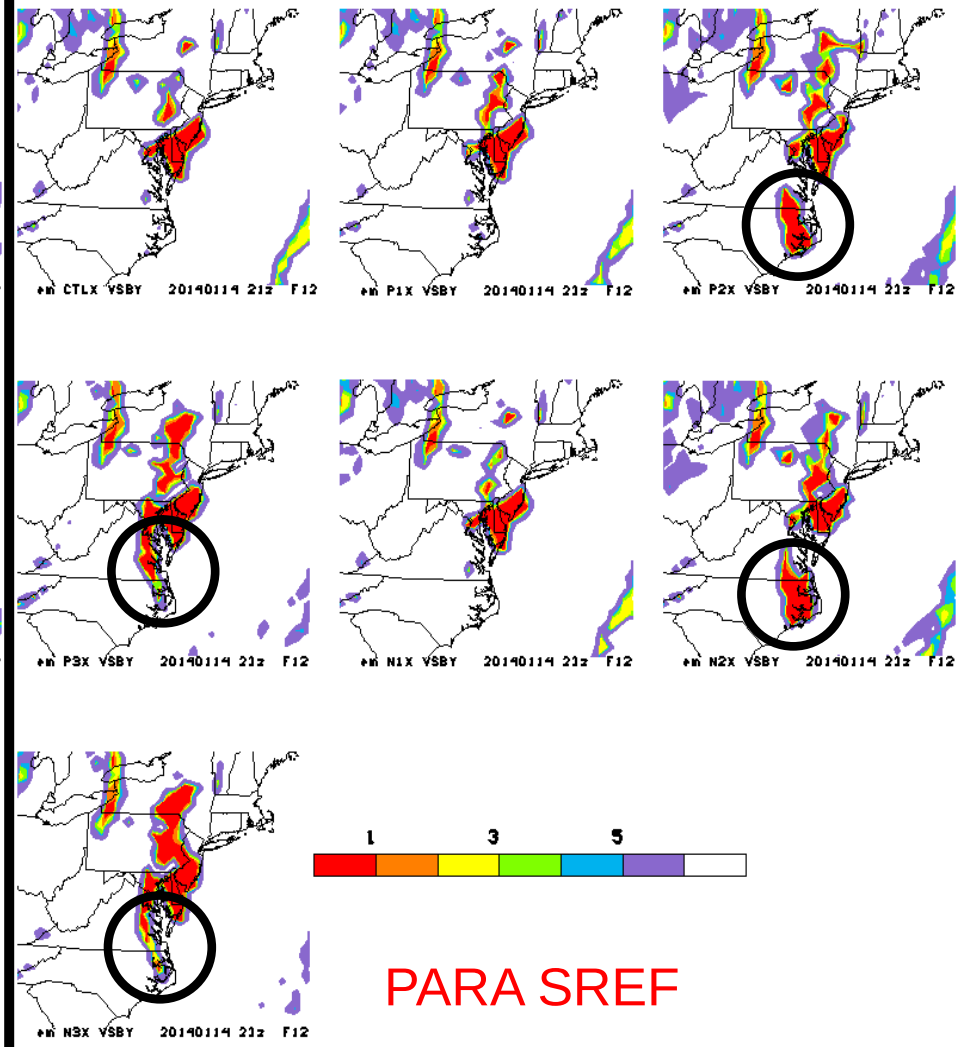


OBS



Why: similar in NMMB and NMM but much improved in some ARW members



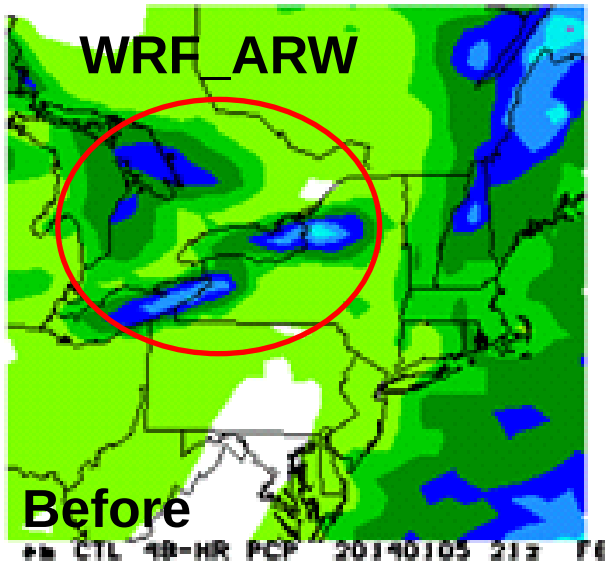


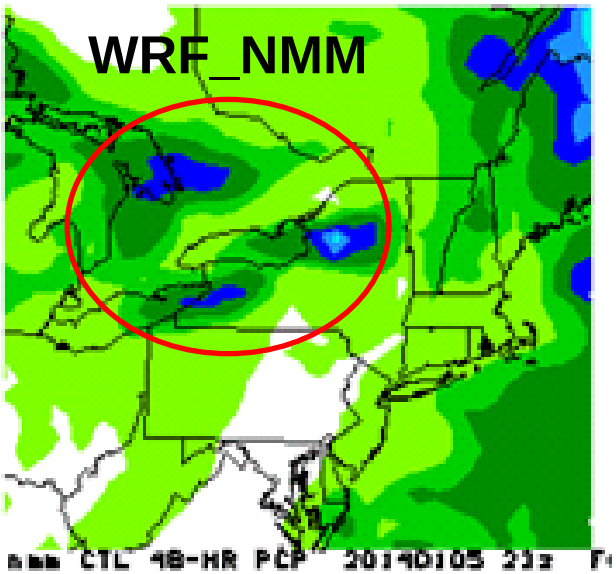
Test Results (3)

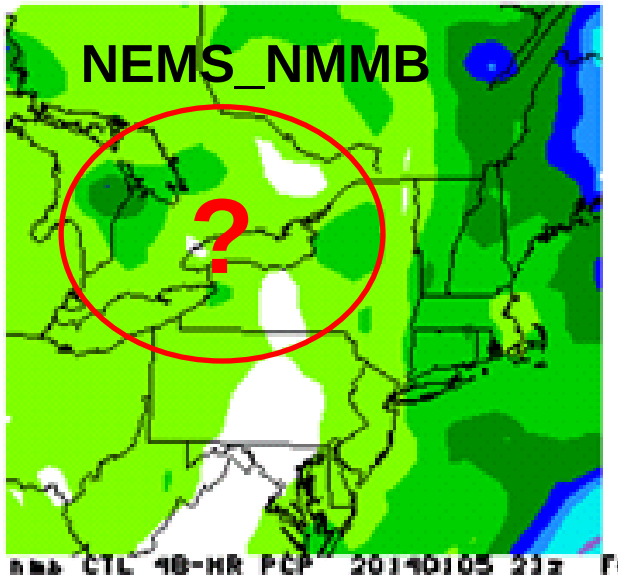
Lake Ice → Lake Effect snow

(WPC concern)

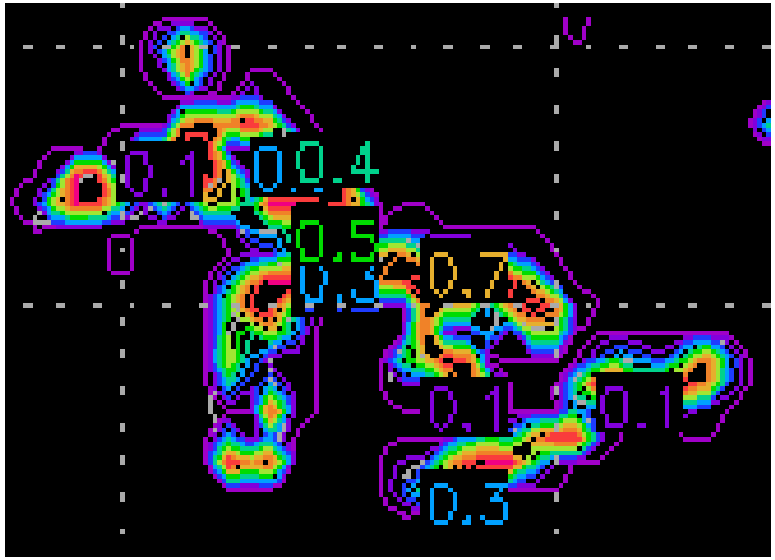
NMMB member lacks of “Lake-Effect” snow



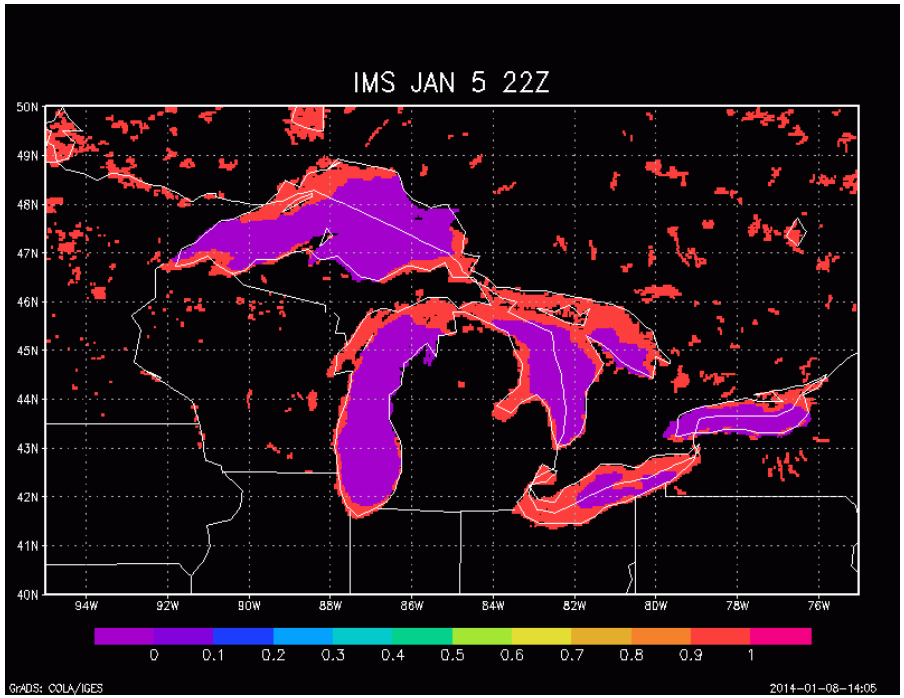


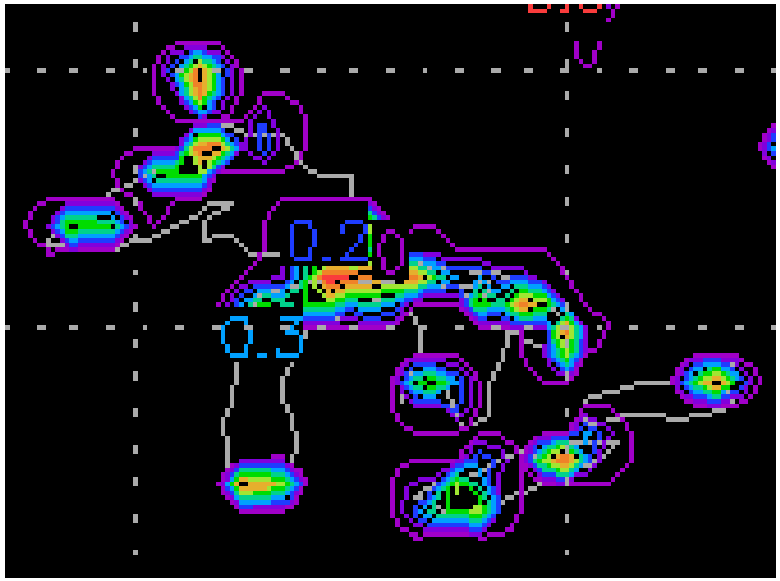


Lake Ice on Jan. 5, 2014



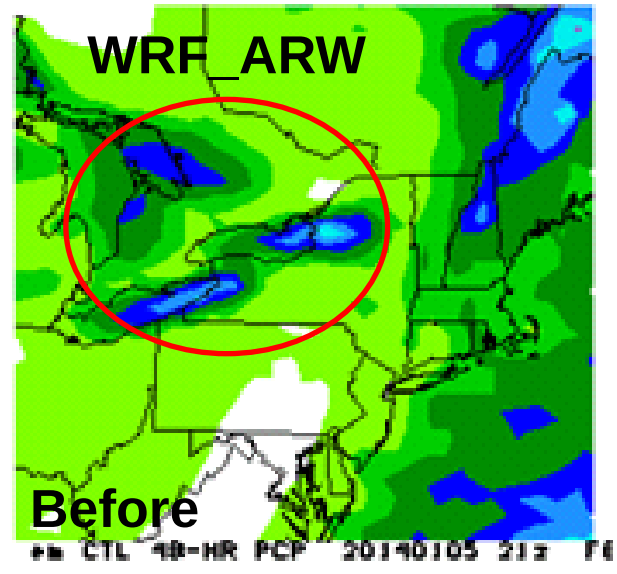
← lake ice in model (before)

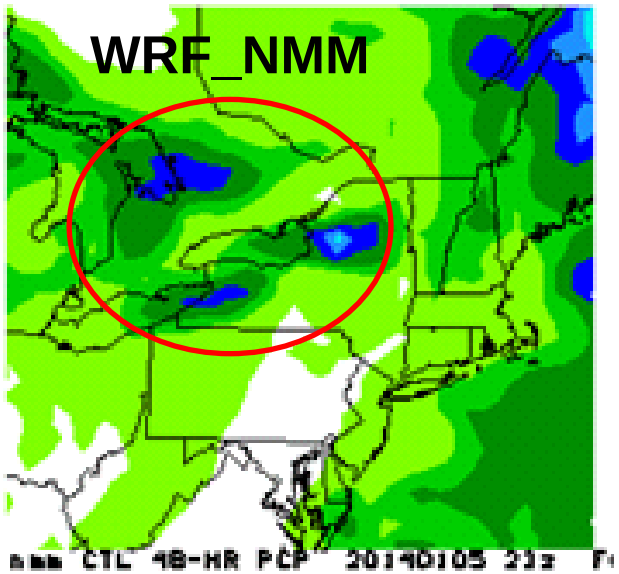


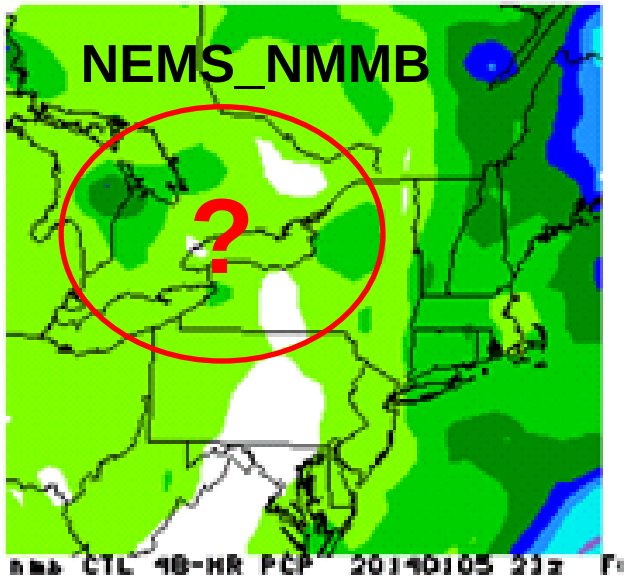


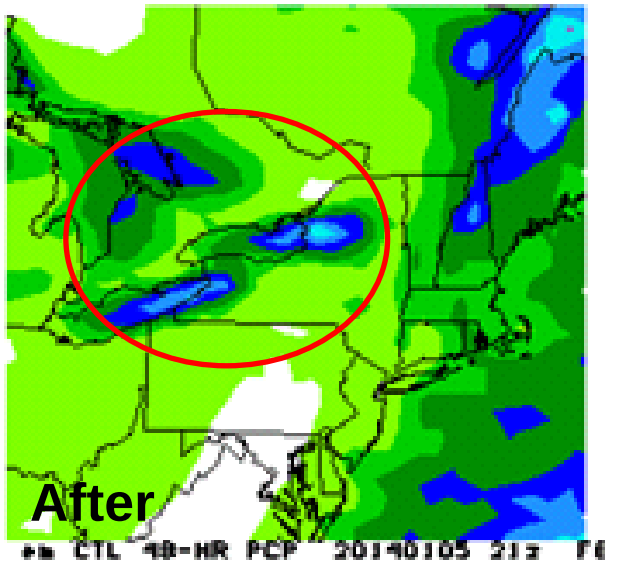
← lake ice in model (after)

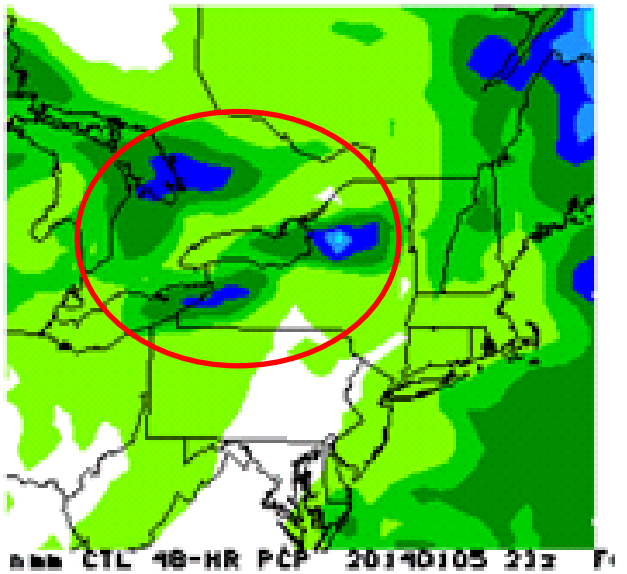
NMMB member lacks of "Lake-Effect" snow

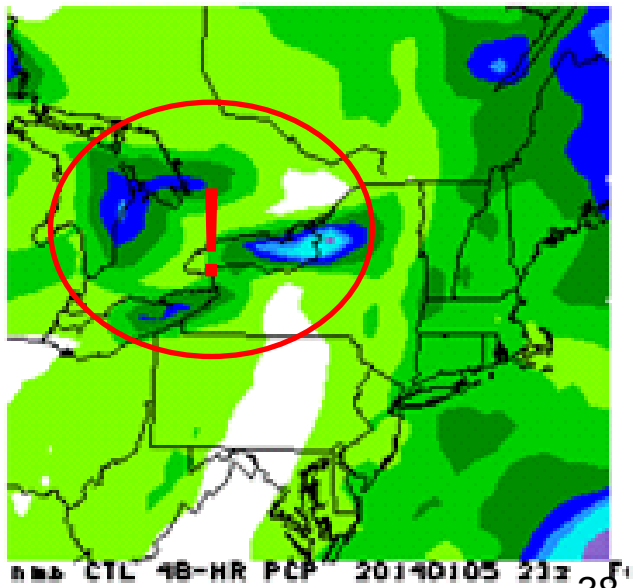












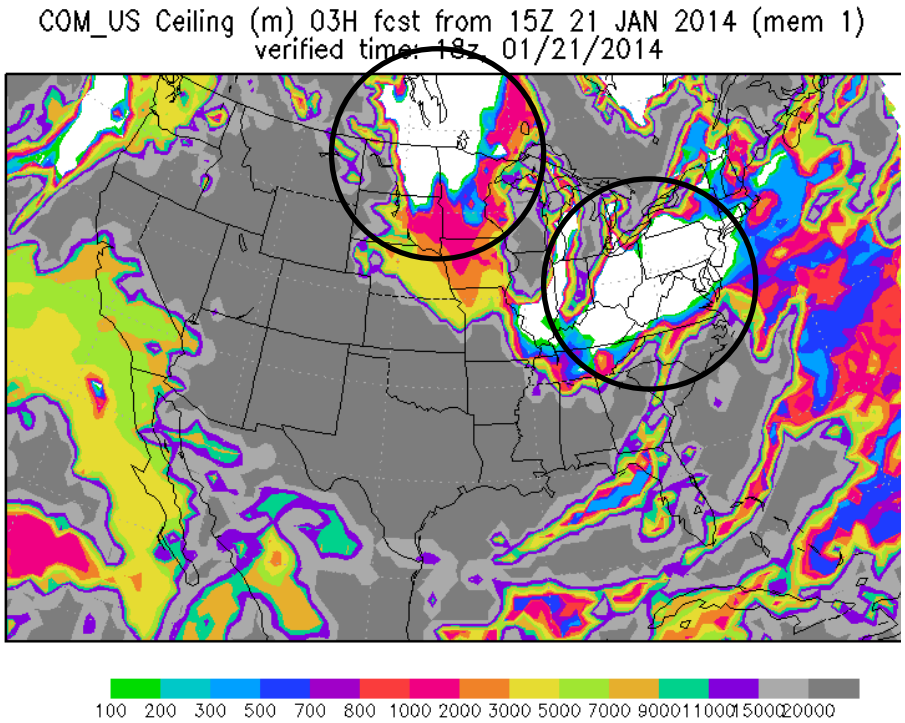
Test Results (4)

Cloud ceiling height issue (over snow and two NMMB_GFS members)

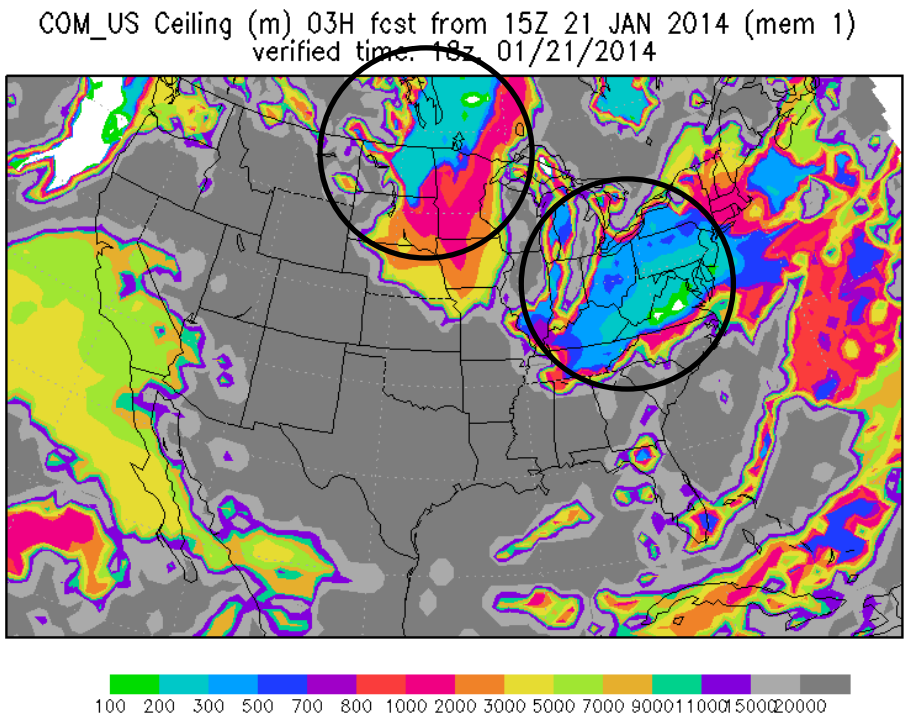
(AWC concern)

Fix of “touching ground cloud-ceiling height over snowing area”

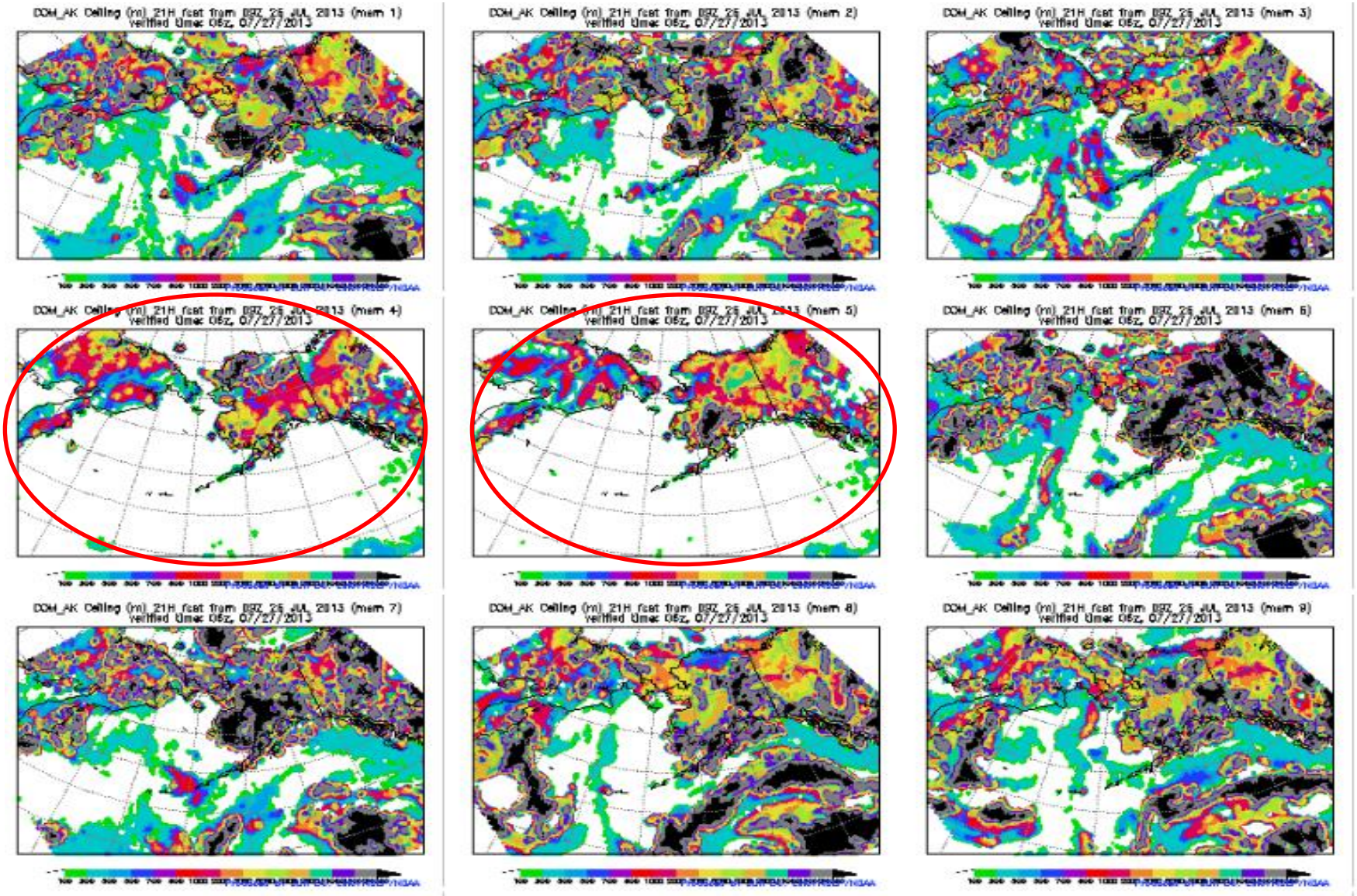
Before



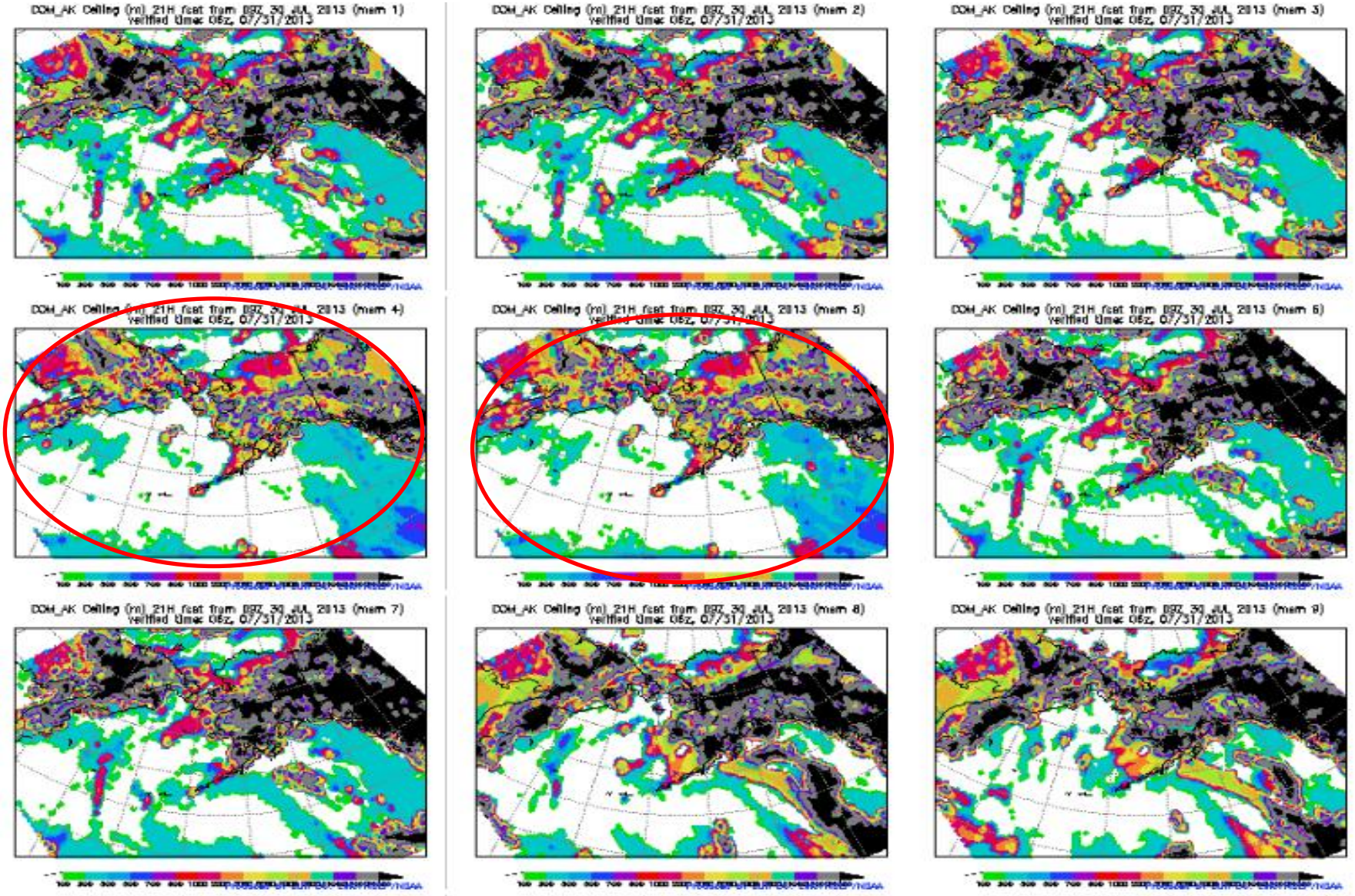
After



Before: two NMMB_GFS members look very different from other members (significant low bias in ceiling height)



After: two NMMB_GFS members look more like other members (low bias much reduced but still exists!)



Consistent with the AWC's evaluation result in SREF Flight Rule Distribution Comparison (Steven Lack)

(Look at Feb 1-28 2014; East Coast North Region with a good mixture of precipitation types)

(1) ARW members decrease the occurrence of LIFR closer to that of the observed distribution. Rain is also fairly similar. Good improvement over current operational version.

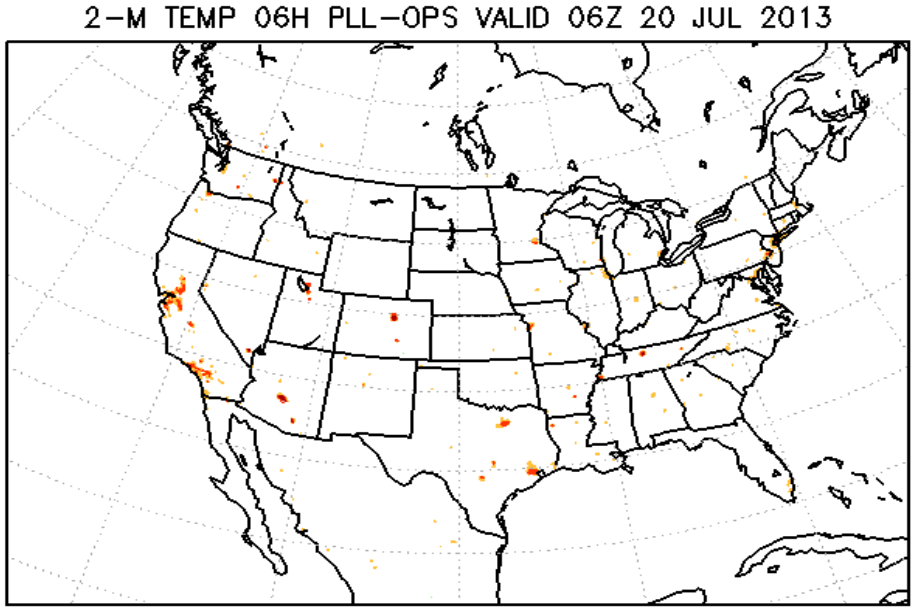
(2) NMM parallel has an overemphasis on IFR conditions in the parallel version during snow, and a little too much LIFR during rain, but much better over the current operational version.

(3) MMB members show an improvement as well, however the P2 and N2 solutions still stick out as being much different in the operational and parallel versions. This is similar to NMM results with slightly too much IFR in snow and LIFR in rain.

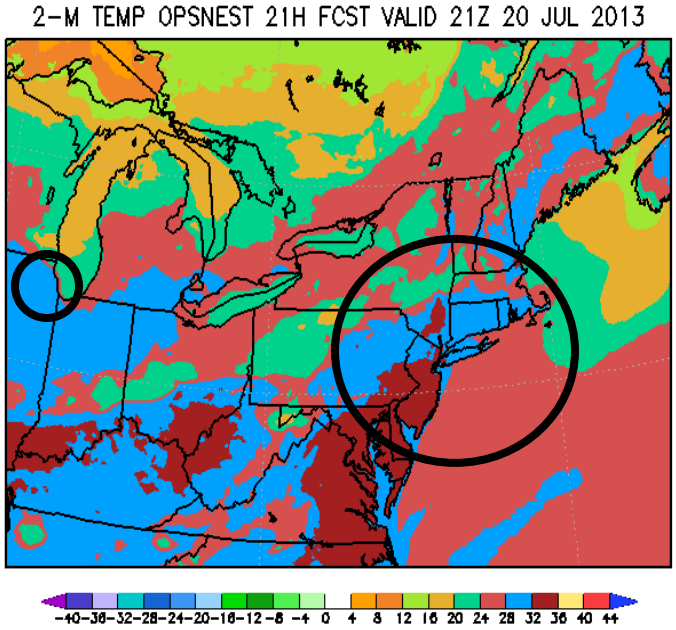
Test Results (5)

Urban Swamp Problem

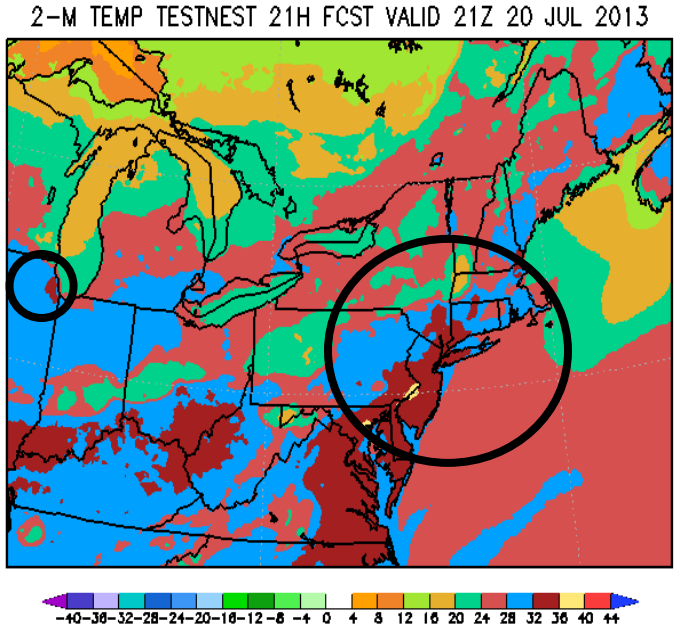
Eric Rogers' rerun with the fix: impact concentrated in major metropolitan areas



(a) Before



(b) After

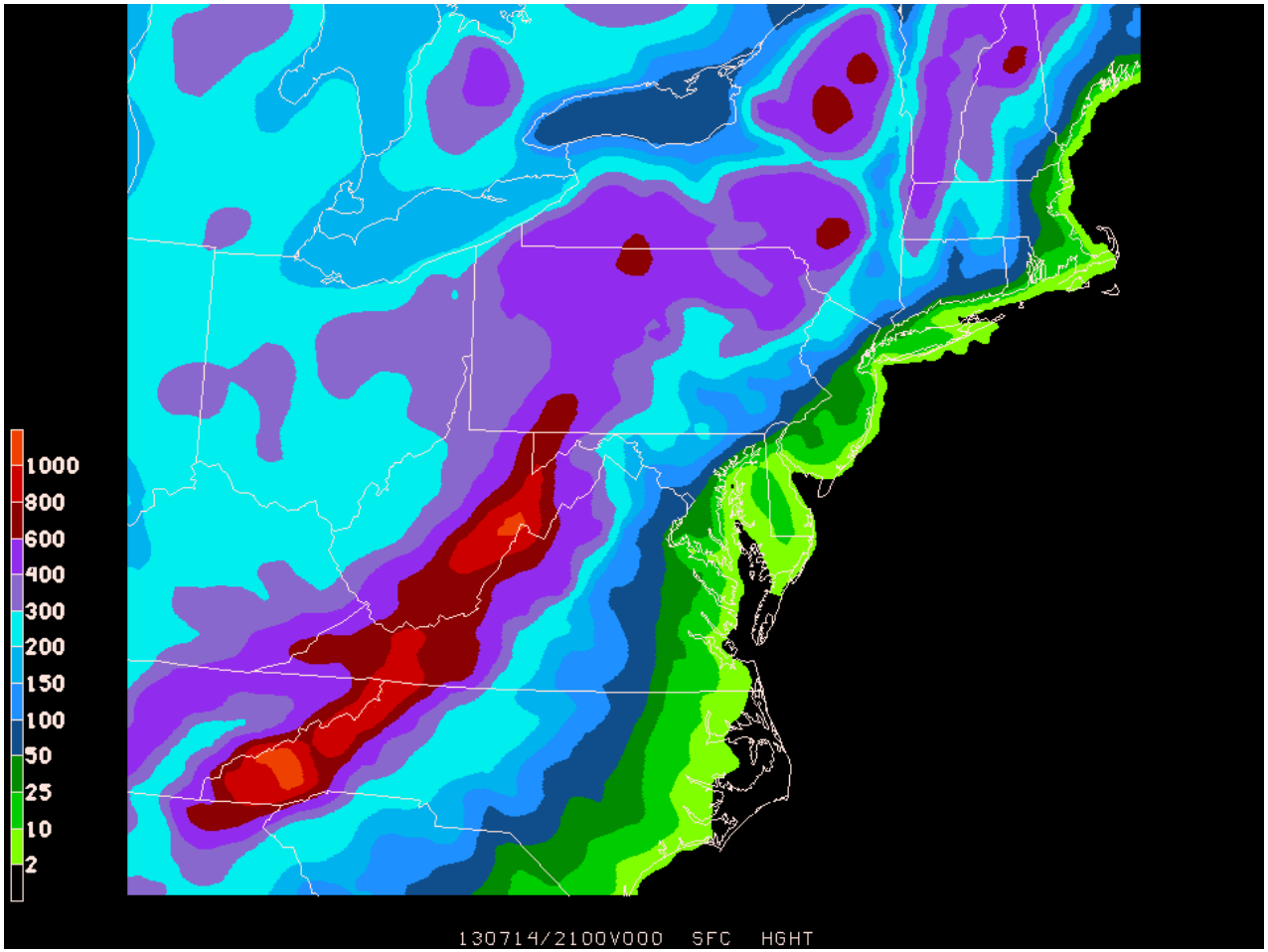


Results (6)

Eastward shift bug

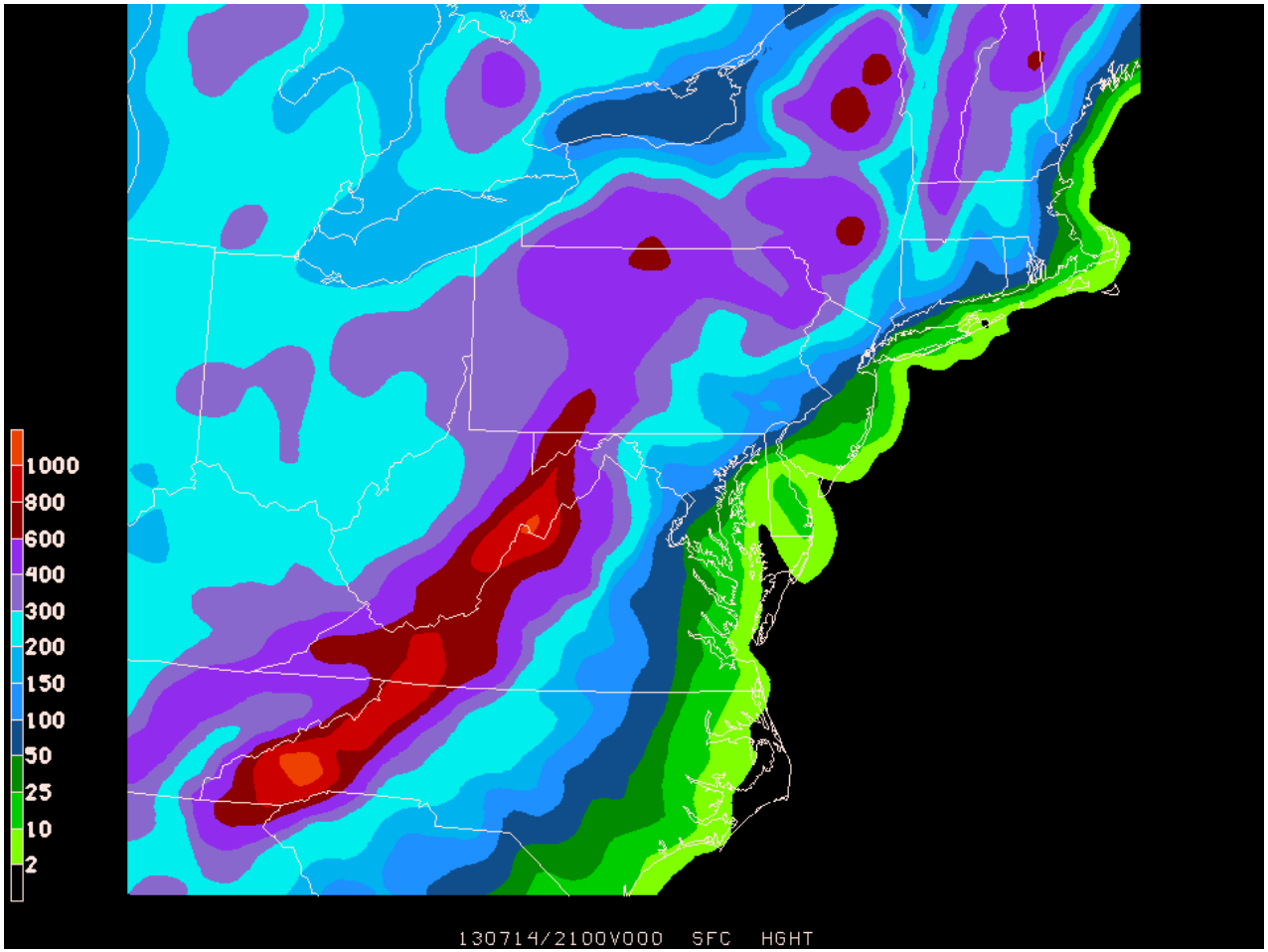
Before: grid-eastward shifting issue prdgen weights in nmm

Native grid



Before: grid-eastward shifting issue prdgen weights in nmm

Posted grid



Results (7)

4 winter weather variables have been added for WPC:

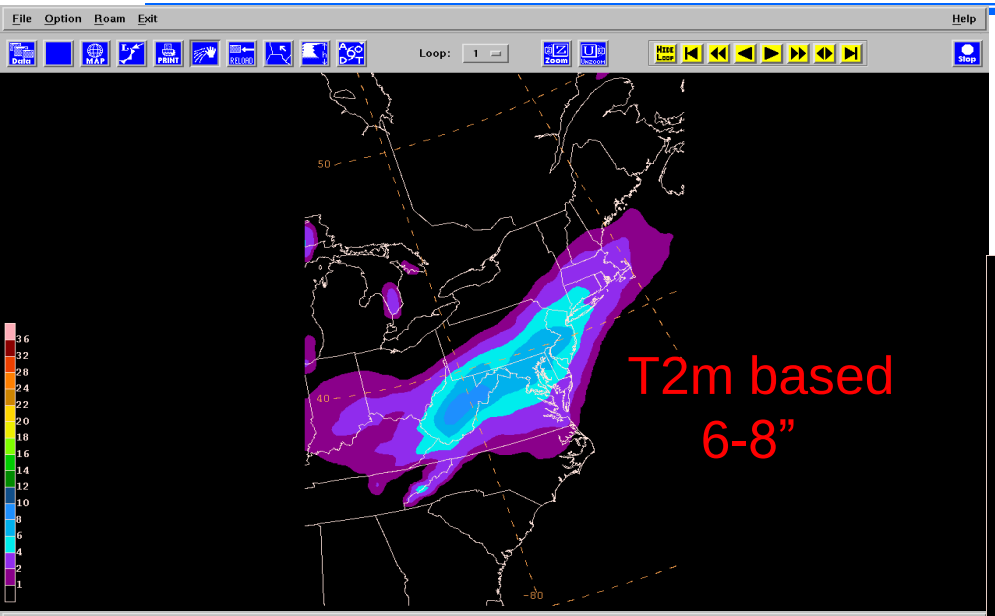
a) low-level Rime Factor;

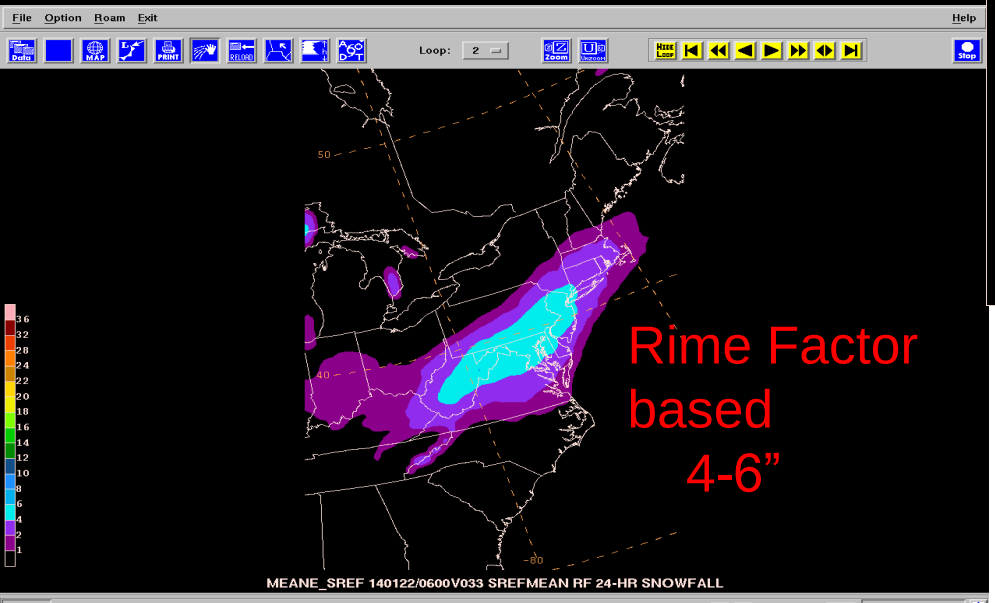
b) snow depth;

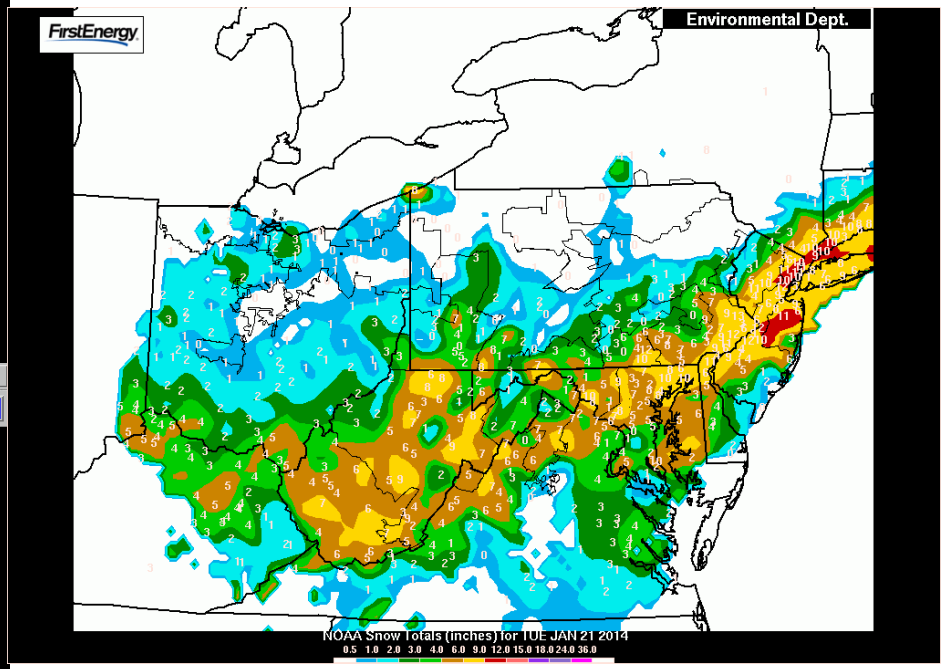
c) percentage of frozen precipitation; and

d) water equivalent accumulated snow depth.

Snowfall with “regular” 2mT-based and “Rime Factor-based” SLR (Rime Factor is normally lower in values)







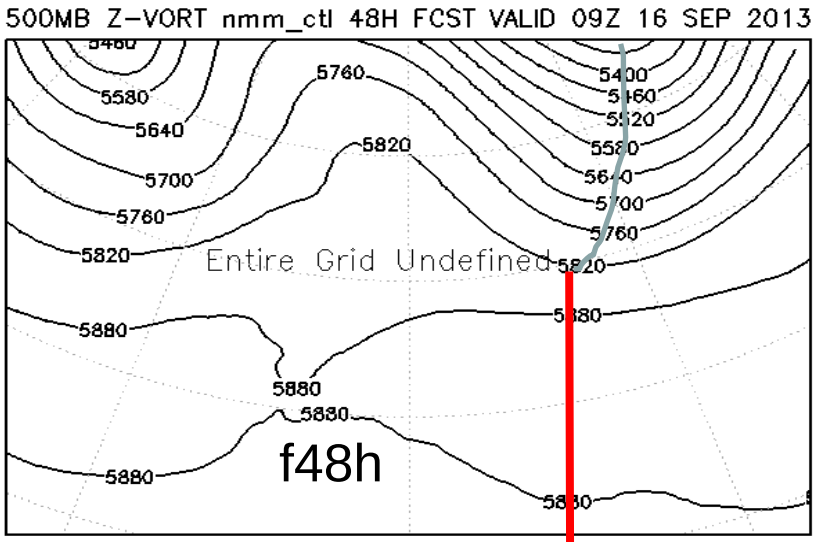
4-6”

Results (8)

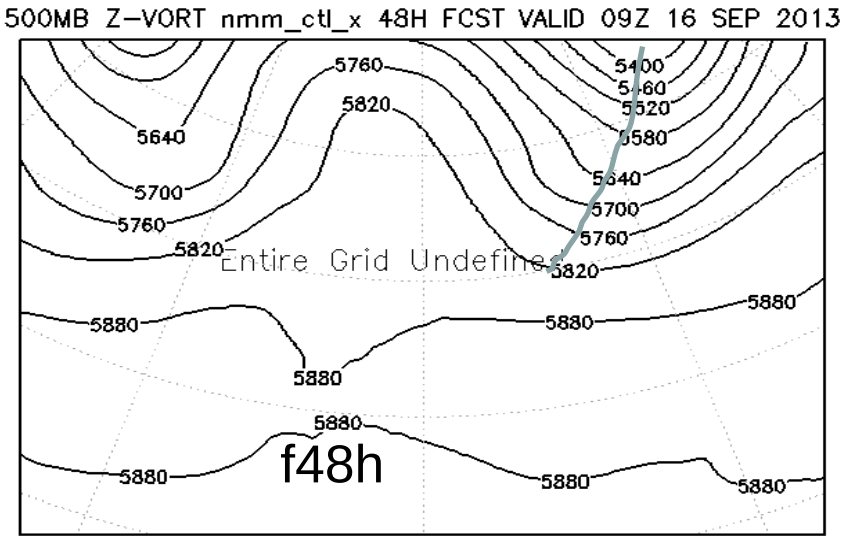
Make-up of “Time-continuity" in clusters (WPC concern)

“Preserving” time-continuity of clusters to increase practical usage (cluster 1)

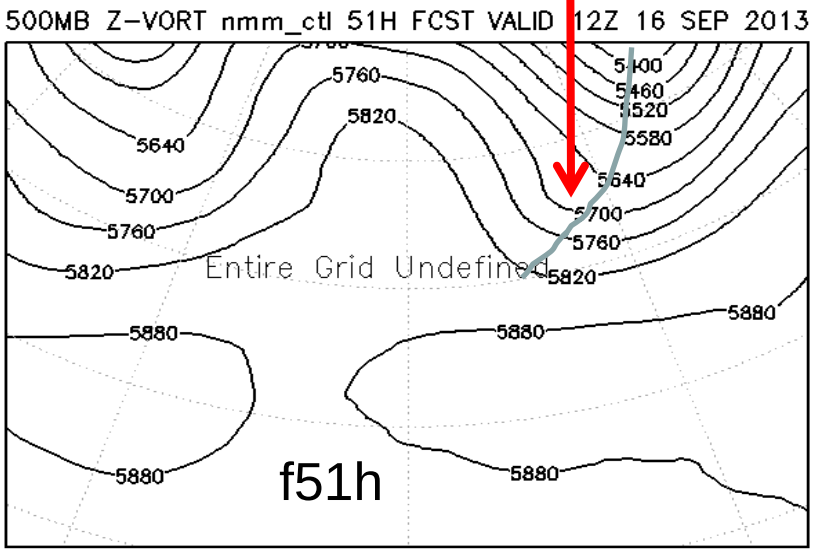
old clustering

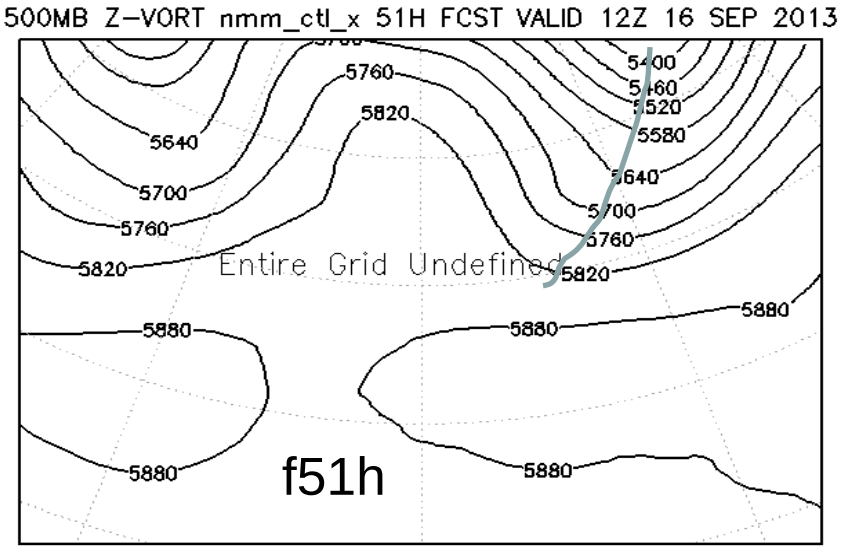


new clustering



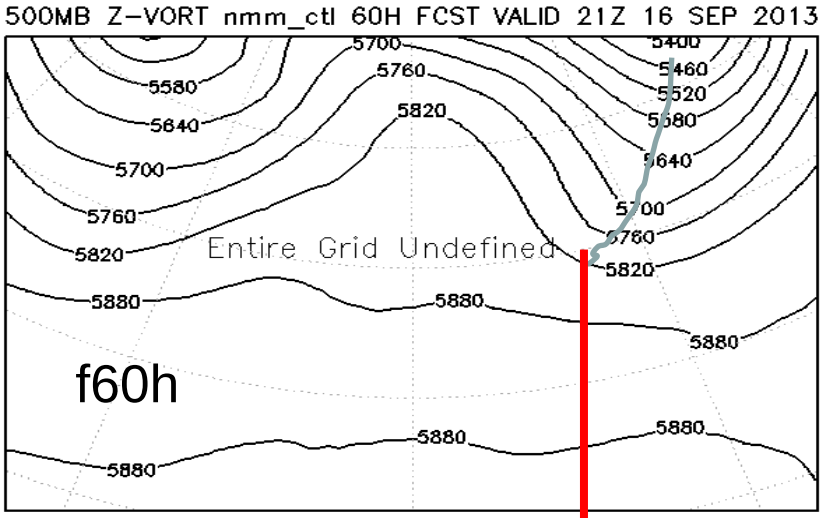
moves backward



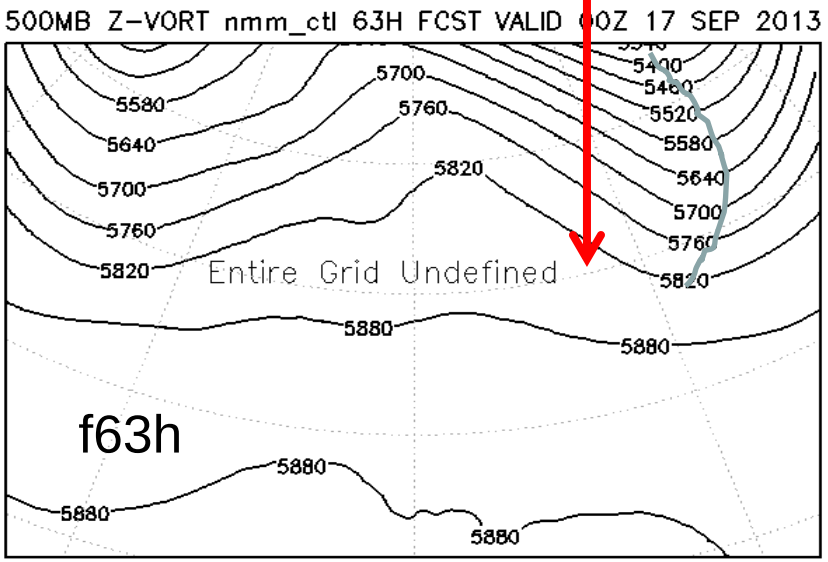


“Preserving” time-continuity of clusters to increase practical usage (cluster 1)

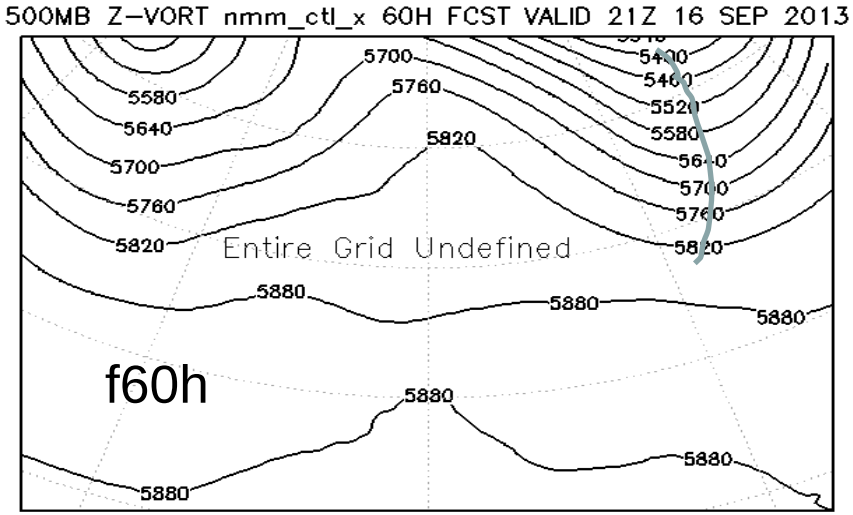
old clustering

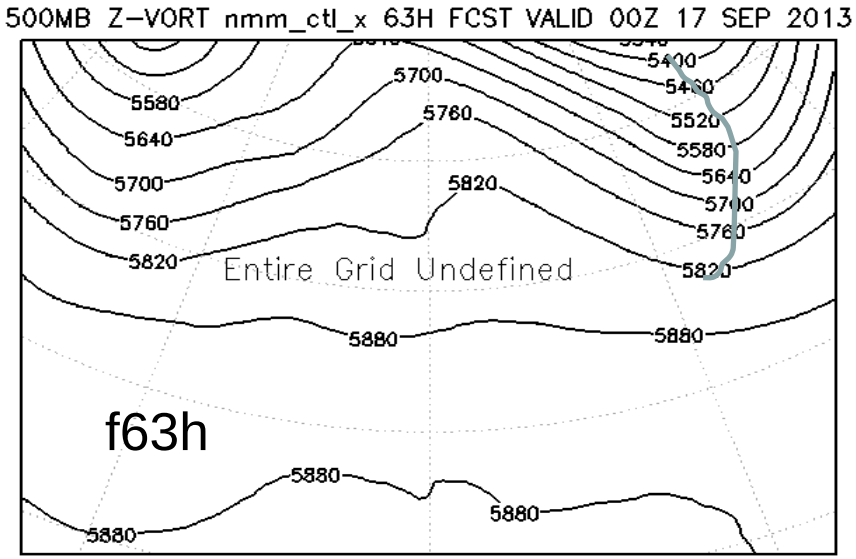


moves too fast



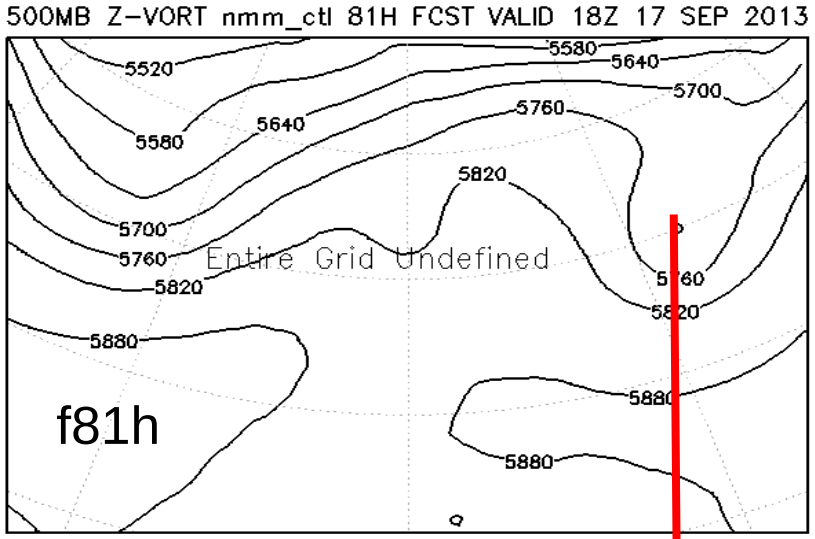
new clustering



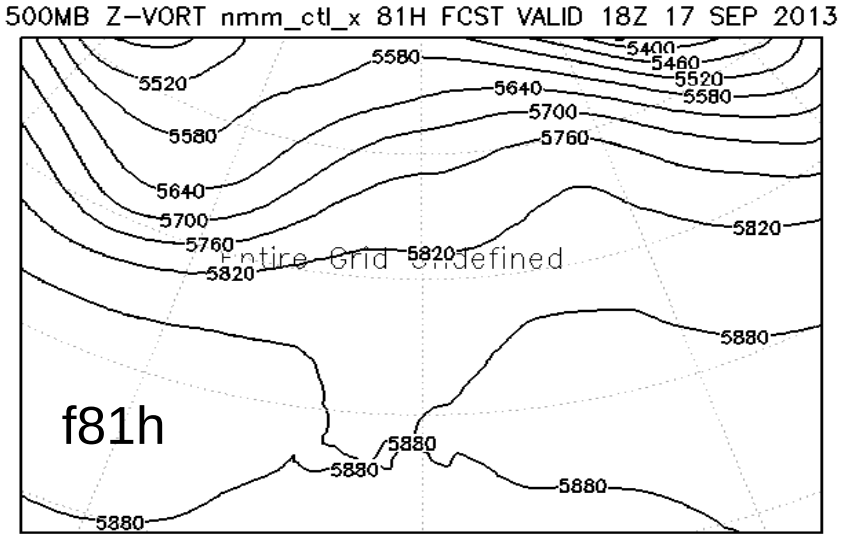


“Preserving” time-continuity of clusters to increase practical usage (cluster 1)

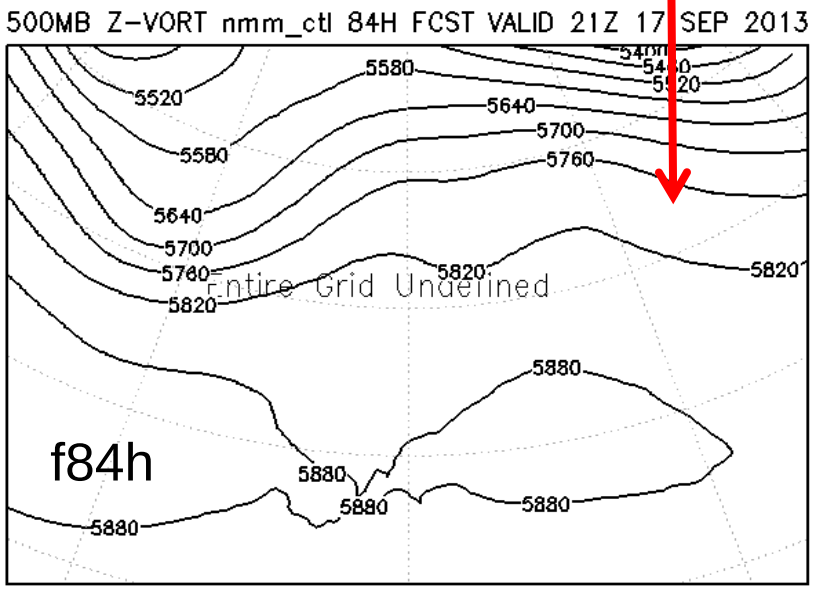
old clustering

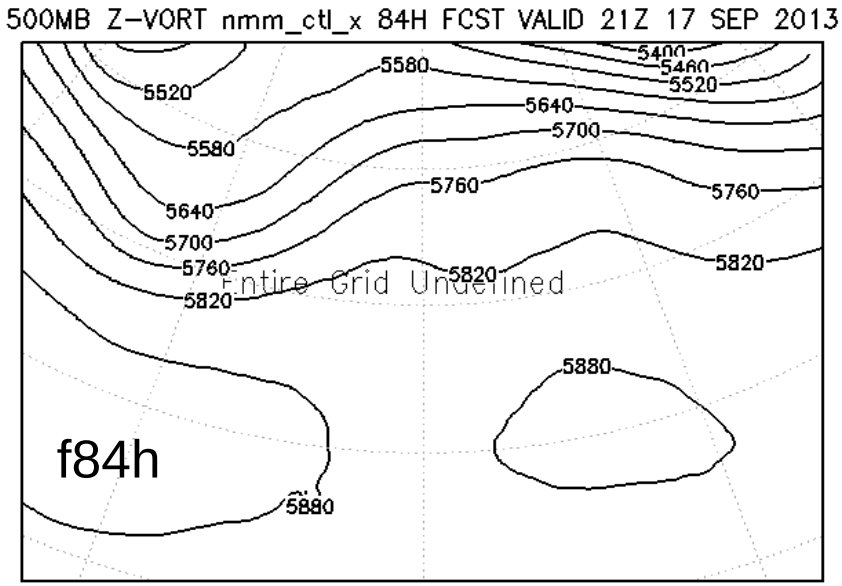


new clustering



no continuity at all

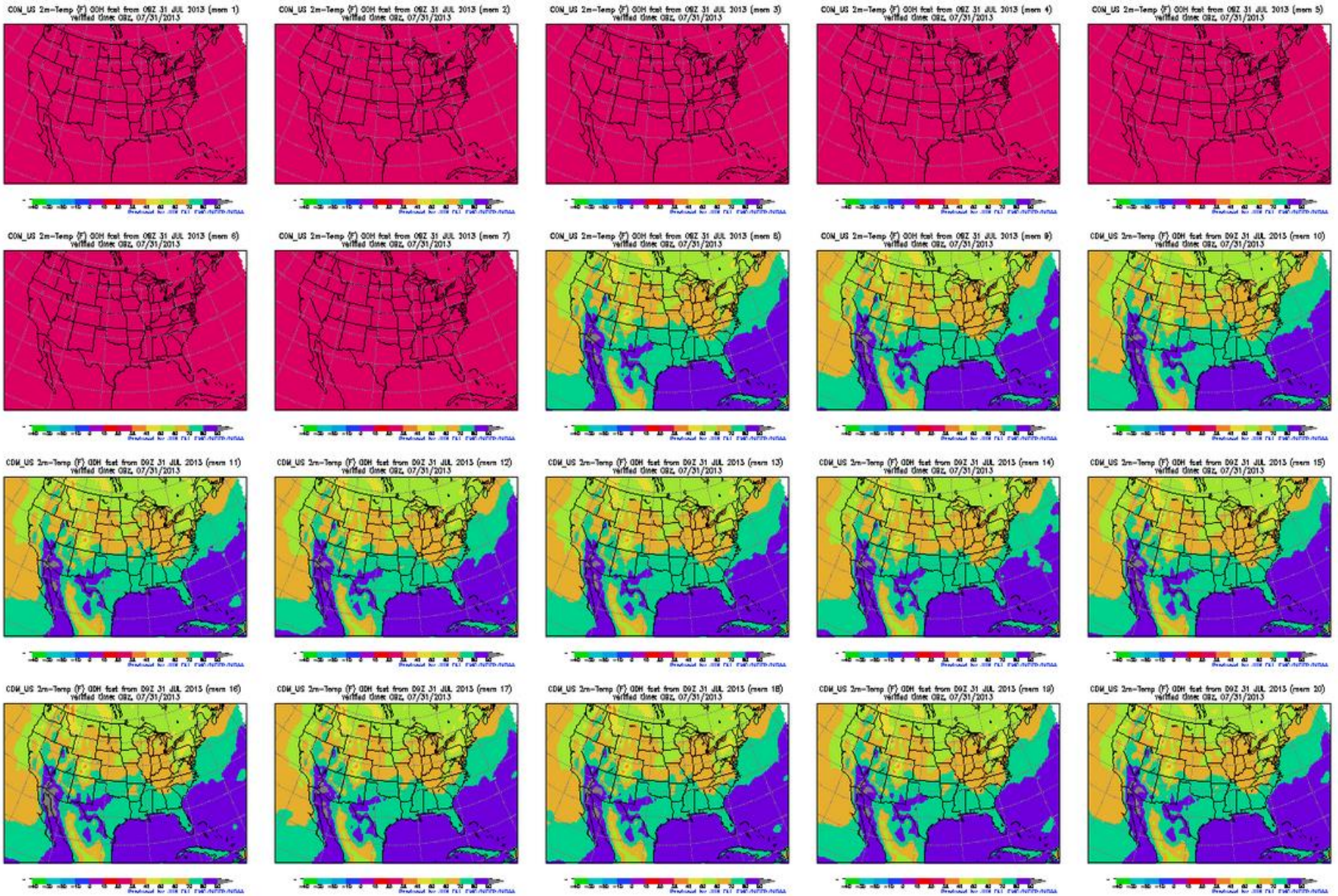




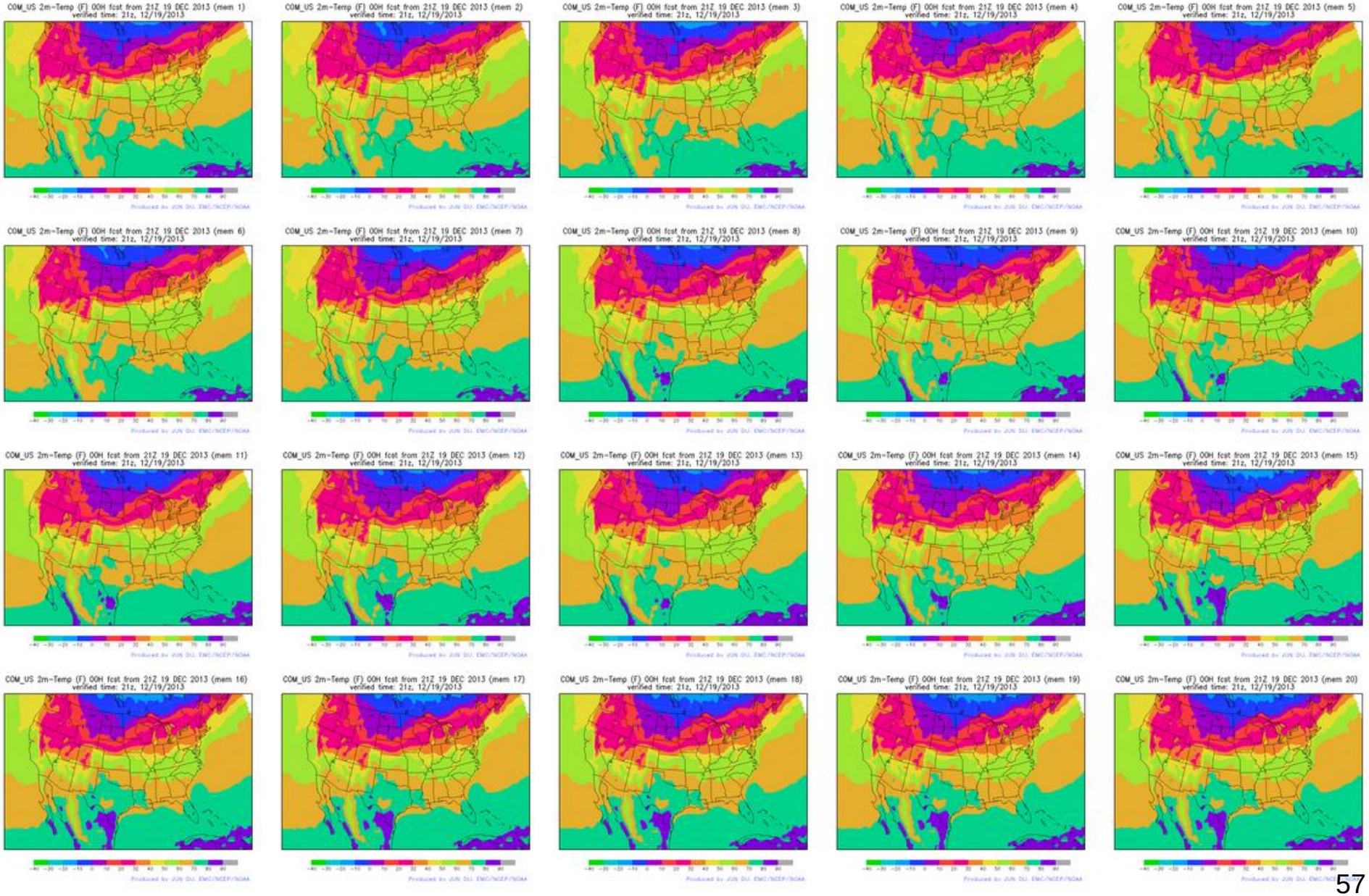
Results (9)

- Using model lowest level fields to fill in the 2m and 10m fields at f00 in NMMB members

Before: no 2m, 10m fields at f00 from NMMB



After: use model-lowest-level fields to fill in the 2m, 10m fields such as T2m, Td2m, Q2m, RH2m, U10, V10



Test Results 10

- T2m and 3h-apcp of 21 SREF members were added to 32km NA domain (g221) into AWIPS (Eastern region request for RFC hydro ensemble via NCO)

- SREF bufr sounding sites change (AWC request etc.):
  68 sites added
  3 sites removed
  7 sites replaced by a nearby site

- Code improvements: (a) p vs log(p) , tiny change in result, (b) NetCDF I/O for NMM and ARW, identical result – ARW model code more reliable and NMM/ARW runs resource saving.

Summary 1

1. Replacing GFS/GEFS IC with RAP IC as well as replacing GFS land surface initial states with NDAS ones improve moist and cold bias in initial time and early forecasts, but the impact reduces with time for both ARW and NMM.

For NMM, the total error in T2m and Td2m is reduced especially in warm season;

For ARW, total error of T2m and Td2m is slightly reduced in warm season but opposite in cold season, while no improvement is seen in their biases in domain averaged statistics;

Probabilistic forecasts of 2mT and 2m Td are generally improved in both warm and cold seasons for both NMM and ARW;

Spread is slightly reduced due to ARW members;

2. Cases show impressive improvements in precipitation forecasts, winter weather and dense fog forecasts especially for ARW members, statistics shows similar or slight improvement in precipitation forecasts;

Summary 2

3. Significant improvements in ceiling forecasts over snow;

4. Many new user-requested variables have been added: individual member 2m and precipitation to AWIPS, 4 winter-weather variables, extra bufr sites, f00 fields at 2m and 10m levels in NMMB;

5. Improved clustering (time continuity) requested by WPC;

6. Many bugs have been fixed leading to important improvements in various detail aspects:
   (a) eastward shift in NMM,
   (b) lake ice in NMMB,
   (c) NOAH LSM for urban swamp in NMMB,
   (d) NOAH LSM for negative soil moisture fractions for NMM and ARW;

7. Improvement in codes to be more reliable and resource saving:
   (a) log(p) → p in ARW;
   (b) NetCDF I/O in NMM and ARW (save 10 min).

Remaining known issues for next upgrade

1. ARW spread is too small as well as having a spread shock at 3hr (root cause is IC discontinuity due to the RAP domain being smaller than SREF, so we cannot simply increase IC perturbation size);

2. Too large in winter weather ptype area of ARW members (a fix is ready);

3. Low bias of two NMMB_GFS members ceiling height;

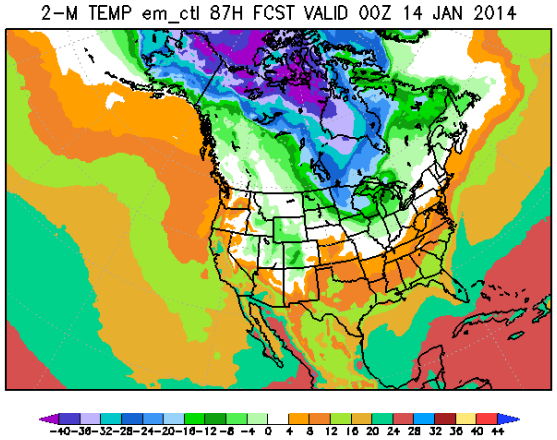
4. Cold bias in NMM and ARW models. Since IC and land states have been taken care of, indicating the problem might in physics;

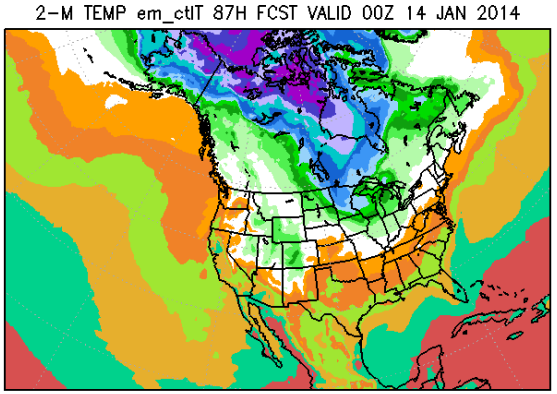
5. Investigate March 3rd case why warmer and further north solution.

Backups

Member (Model)	IC	IC perturb.	physics							Land surface		
			conv	mp	lw	sw	pbl	Sfc layer	stochastic	model	initial	perturb.
nmmb_ctl	NDAS	BV	BMJ	FER	GFDL	GFDL	MYJ	MYJ	no	NOAH	NAM	no
nmmb_n1												
nmmb_p1												
nmmb_n2			SAS	GFS	GFDL	GFDL	GFS	MYJ	no	NOAH		
nmmb_p2												
nmmb_n3			BMJ	WSM6	GFDL	GFDL	MYJ	MYJ		NOAH		
nmmb_p3												
nmm_ctl	GFS	BV+ETR	BMJ	FER (new Eta)	GFDL	GFDL	MYJ	M_Obuhov (Janjic Eta)	no	NOAH	NAM	no
nmm_n1												
nmm_p1												
nmm_n2			SAS	FER (new Eta)	GFDL	GFDL	MYJ	M_Ouhov (janjic Eta)	no	NOAH		
nmm_p2												
nmm_n3			KF (new Eta)	FER (new Eta)	GFDL	GFDL	MYJ	M_obuhov (janjic Eta)	no	NOAH		
nmm_p3												
arw_ctl	RAP	BV	KF (new Eta)	FER (new Eta)	GFDL	GFDL	MYJ	M_obuhov (Janjic Eta)	no	NOAH	NAM	no
arw_n1												
arw_p1												
arw_n2			BMJ	FER (new Eta)	GFDL	GFDL	MYJ	M_obuhov (Janjic Eta)	no	NOAH		
arw_p2												
arw_n3			BMJ	FER (new eta)	GFDL	GFDL	MYJ	M_Obuhov (Janjic Eta)	no	NOAH		
arw_p3												

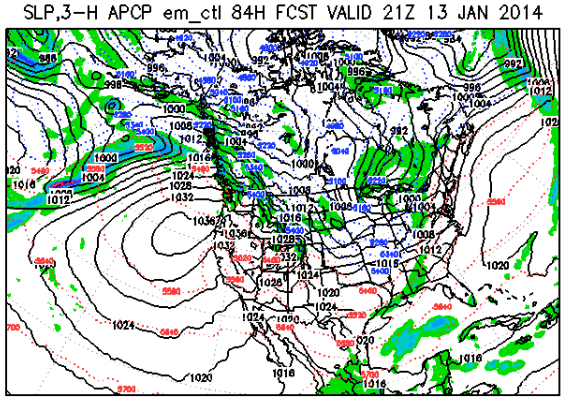
Little impact of hypsometric change In ARW from 2 (logP) To 1 (P)

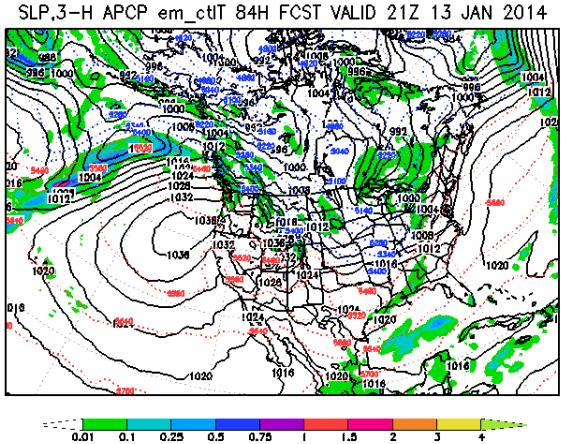


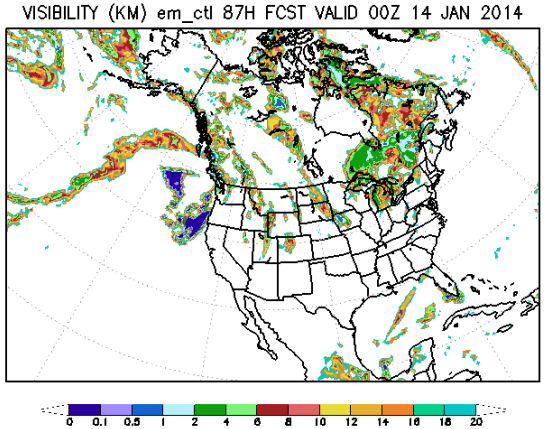


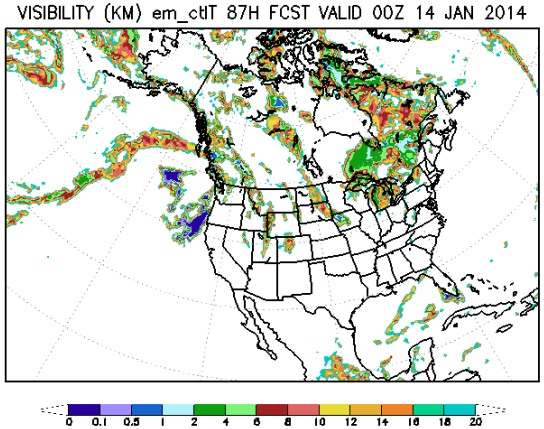
⇦ **T2m at F87hr**

SLP and 3h-apcp at F84hr ⇨









⇦ **surface visibility at f87hr**