N
C
E
P

EMC Implementation Briefing of SREF.v7.0 (Q4FY15)

Jun Du, Geoff DiMego, Dusan Javic, Brad Ferrier, Bo Yang

(NCWCP, September 25, 2015)

Changes

1. 3 model core system becomes 2 model core system (NMMB, WRF_ARW, WRF_NMM)

2. Vertical resolution is increased from 35 to 40 layers (horizontal resolution remains the same of 16km)

3. Ensemble membership is increased from 21 to 26 members

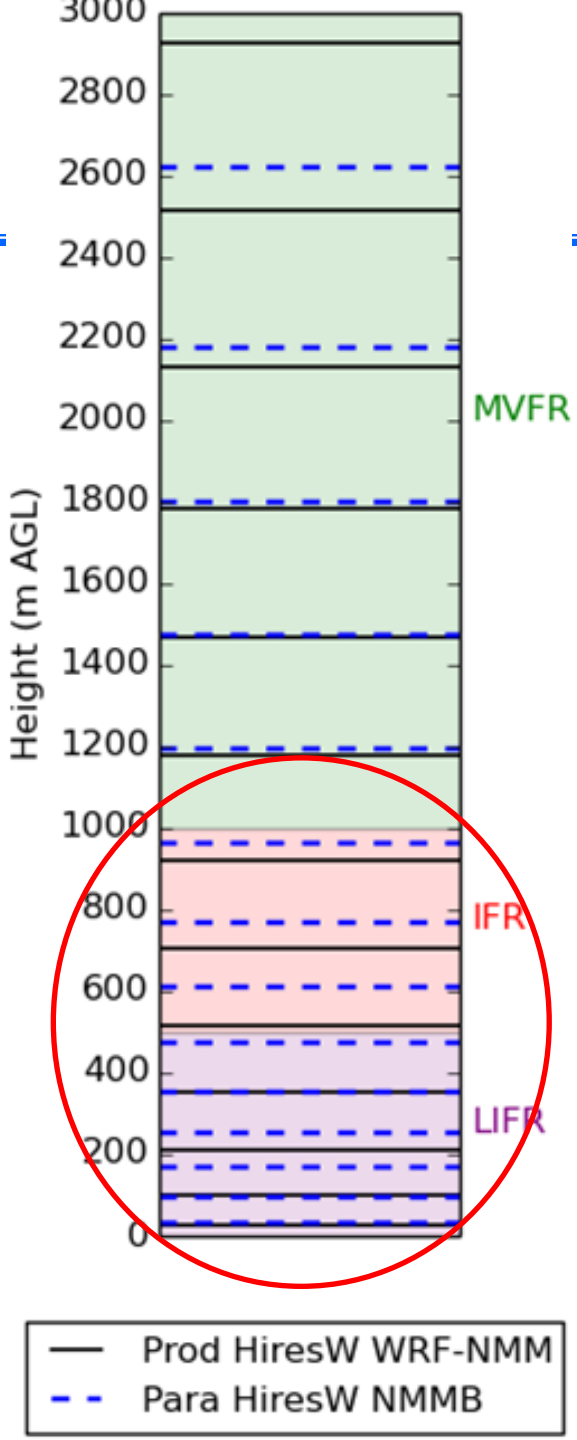
4. IC diversity is enhanced: (a) mix use of multi analyses (NDAS, GFS and RAP) for each model core, and (b) blending of GEFS and SREF IC perturbations for all members

5. Physics diversity is enhanced: (a) more variety of physics schemes, and (b) stochastic flavor in physics parameters (GWD and soil moisture)

6. Others: name change from em to ARW; individual member ID in pgrb files; addition of 138 new stations in bufr/sounding output, unit change of ceiling height (from AGL to ASL) etc.

Vertical level increase

- As for HiResWindow displayed here (35-40), adding vertical levels to SREF members will improve models' ability to distinguish ceiling heights at boundaries between critical flight categories



13 NMMB members

Mod-Mem	IC	IC pert	LBCs	Physics 1			Physics 2		GWD	Land Surface		
				Conv	**PBL**	**Sfc layer**	**Microphys**	**LW, SW Rad**	**cleffamp**	**LSM**	**Initial**	**Soil pert?**
nmmb_ctl	**NDAS**	Blending (GEFS + SREF)	GFS	BMJ old shal	MYJ	MYJ	Fer_hires	RRTM	**cleffamp=1**	Noah	NAM	no
nmmb_n1			GEFS 2	SAS	GFS	MYJ	WSM6	GFDL	**cleffamp=0.5**	Noah	NAM	no
nmmb_p1			GEFS 1	BMJ new shal	MYJ	MYJ	Fer_hires	RRTM	**cleffamp=2**	Noah	NAM	no
nmmb_n2			GEFS 4	SAS	GFS	MYJ	Fer_hires	GFDL	**cleffamp=1**	Noah	NAM	Drier soil
nmmb_p2			GEFS 3	BMJ old shal	MYJ	MYJ	WSM6	RRTM	**cleffamp=0.5**	Noah	NAM	Drier soil
nmmb_n3	**GFS**	Blending (GEFS + SREF)	GEFS 6	SAS	GFS	MYJ	Fer_hires	GFDL	**cleffamp=2**	Noah	NAM	Drier soil
nmmb_p3			GEFS 5	BMJ new shal	MYJ	MYJ	WSM6	RRTM	**cleffamp=1**	Noah	NAM	Drier soil
nmmb_n4			GEFS 8	SAS	GFS	MYJ	WSM6	RRTM	**cleffamp=0.5**	Noah	NAM	no
nmmb_p4			GEFS 7	BMJ old shal	MYJ	MYJ	Fer_hires	GFDL	**cleffamp=2**	Noah	NAM	no
nmmb_n5	**RAP**	Blending (GEFS + SREF)	GEFS 10	SAS	GFS	MYJ	WSM6	RRTM	**cleffamp=1**	Noah	NAM	Drier soil
nmmb_p5			GEFS 9	BMJ new shal	MYJ	MYJ	Fer_hires	RRTM	**cleffamp=0.5**	Noah	NAM	Drier soil
nmmb_n6			GEFS 12	SAS	GFS	MYJ	Fer_hires	GFDL	**cleffamp=2**	Noah	NAM	no
nmmb_p6			GEFS 11	BMJ old shal	MYJ	MYJ	WSM6	GFDL	**cleffamp=1**	Noah	NAM	no

13 ARW members

Mod-Mem	IC	IC pert	LBCs	Physics 1			Physics 2				Land surface		
				Conv	PBL	Sfc layer	Microphy	LW Rad	SW Rad	Stochastic	LSM	Initial	Soil pert?
arw_ctl	RAP	Blending (GEFS + SREF)	GFS	KF	YSU	MM5	WSM6	RRTMG	RRTMG	no	Noah	NAM	no
arw_n1			GEFS 14	BMJ	MYJ	MYJ	Fer	GFDL	GFDL	no	Noah	NAM	Drier soil
arw_p1			GEFS 13	Grell	MYNN	MYNN	Thompson	Old RRTM	GSFC	no	Noah	NAM	no
arw_n2			GEFS 16	KF	YSU	MM5	Fer	GFDL	GFDL	no	Noah	NAM	Drier soil
arw_p2			GEFS 15	BMJ	MYJ	MYJ	Thompson	RRTMG	RRTMG	no	Noah	NAM	no
arw_n3	GFS	Blending (GEFS + SREF)	GEFS 18	Grell	MYNN	MYNN	WSM6	RRTMG	RRTMG	no	Noah	NAM	Drier soil
arw_p3			GEFS 17	KF	YSU	MM5	Thompson	Old RRTM	GSFC	no	Noah	NAM	no
arw_n4			GEFS 20	BMJ	MYJ	MYJ	WSM6	RRTMG	RRTMG	no	Noah	NAM	no
arw_p4			GEFS 19	KF	YSU	MM5	Fer	GFDL	GFDL	no	Noah	NAM	Drier soil
arw_n5	NDAS	Blending (GEFS + SREF)	GEFS 2	Grell	MYNN	MYNN	Fer	GFDL	GFDL	no	Noah	NAM	no
arw_p5			GEFS 1	KF	YSU	MM5	WSM6	RRTMG	RRTMG	no	Noah	NAM	Drier soil
arw_n6			GEFS 4	BMJ	MYJ	MYJ	Thompson	Old RRTM	GSFC	no	Noah	NAM	Drier soil
arw_p6			GEFS 3	Grell	MYNN	MYNN	Thompson	RRTMG	RRTMG	no	Noah	NAM	no

Expected Benefits

1. Reduce cold bias in surface temperature (2m T)

2. Reduce wet bias in surface moisture field (2m RH, not precipitation)

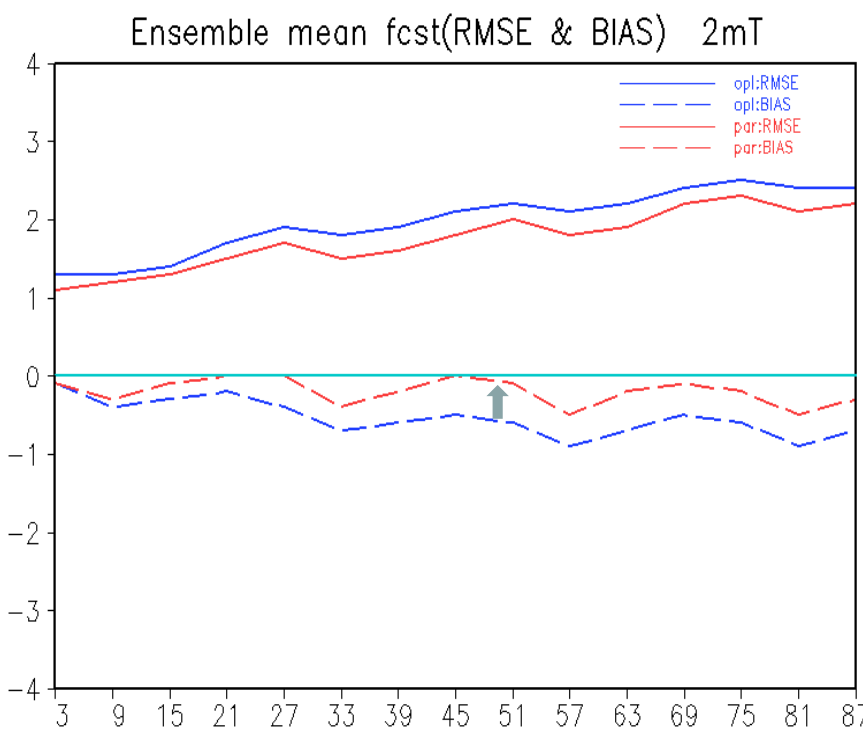
3. Increase ensemble spread (diversity) especially for ARW members

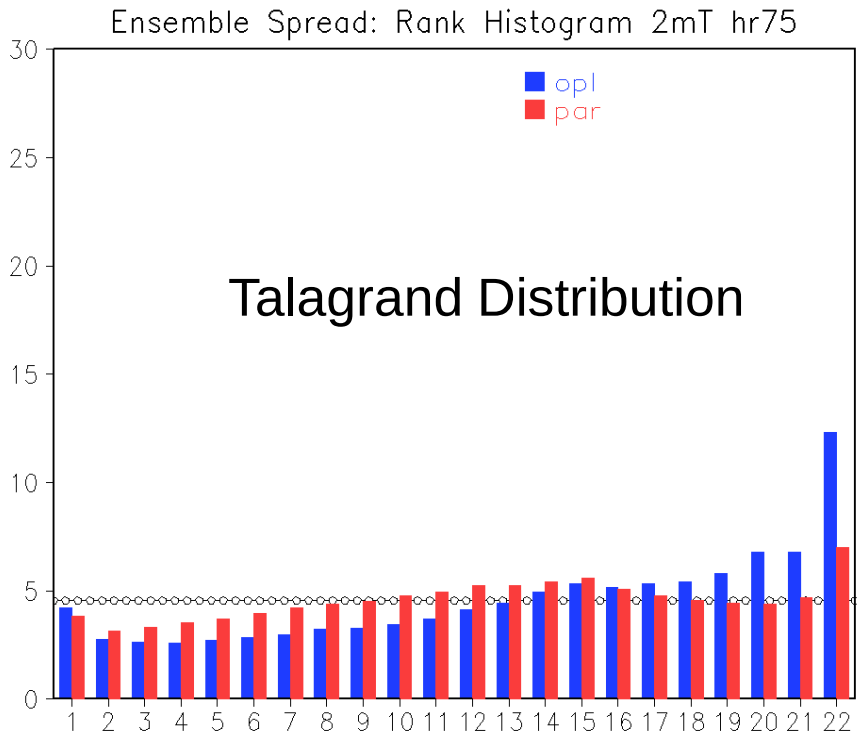
4. Improve overall skill of probabilistic forecasts in general

5. Improve visibility and cloud ceiling etc. due to increased vertical resolution (verified by AWC)

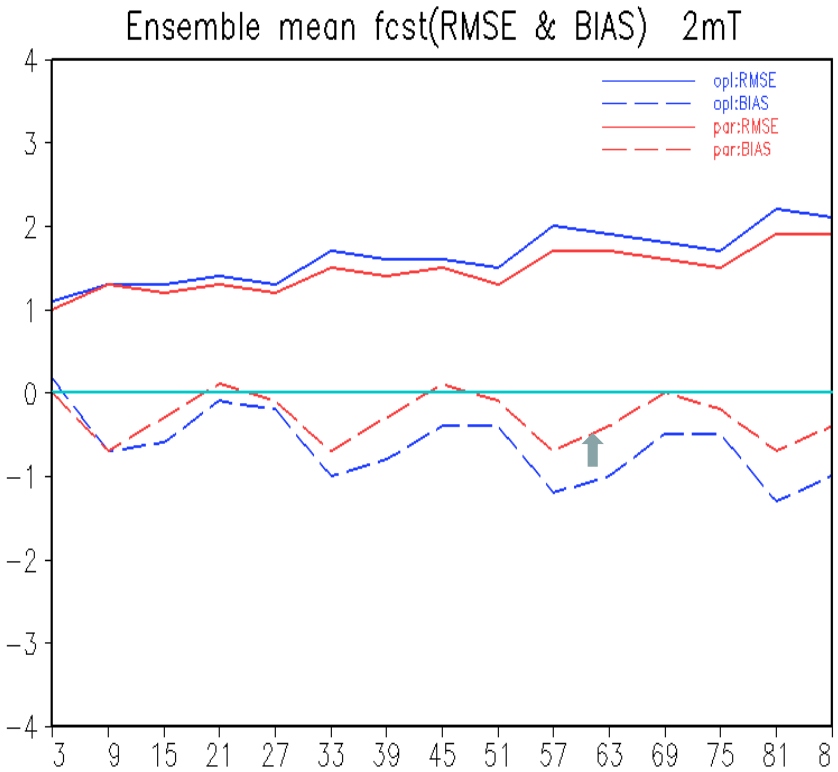
Improvement in forecast performance

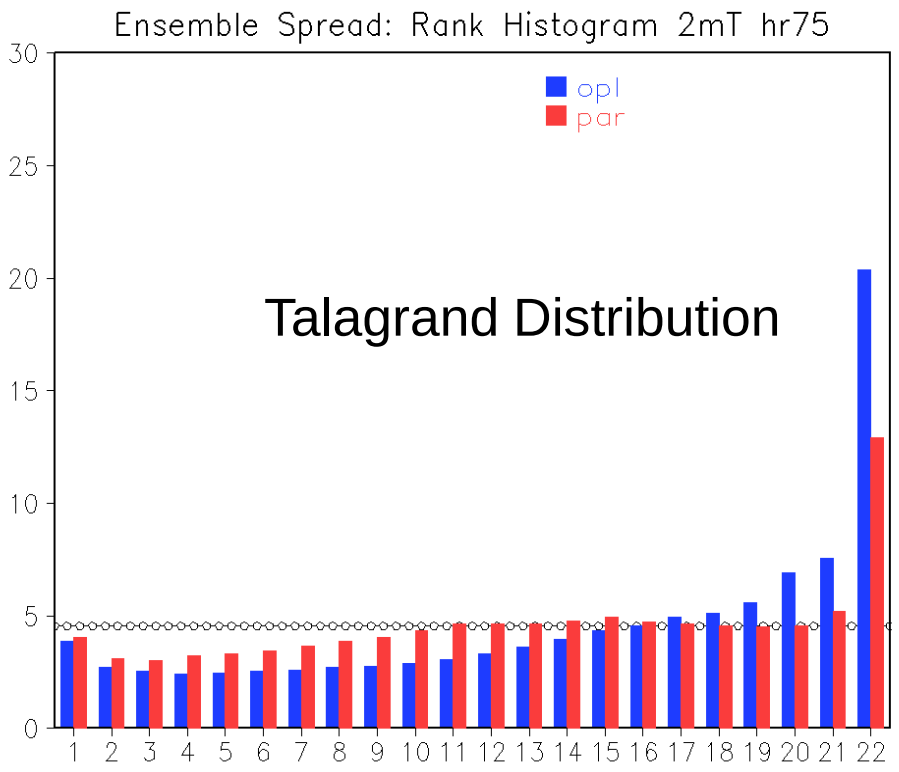
Reduced cold bias in 2mT to a lesser degree (cold season: Oct. 2014 – March 2015)



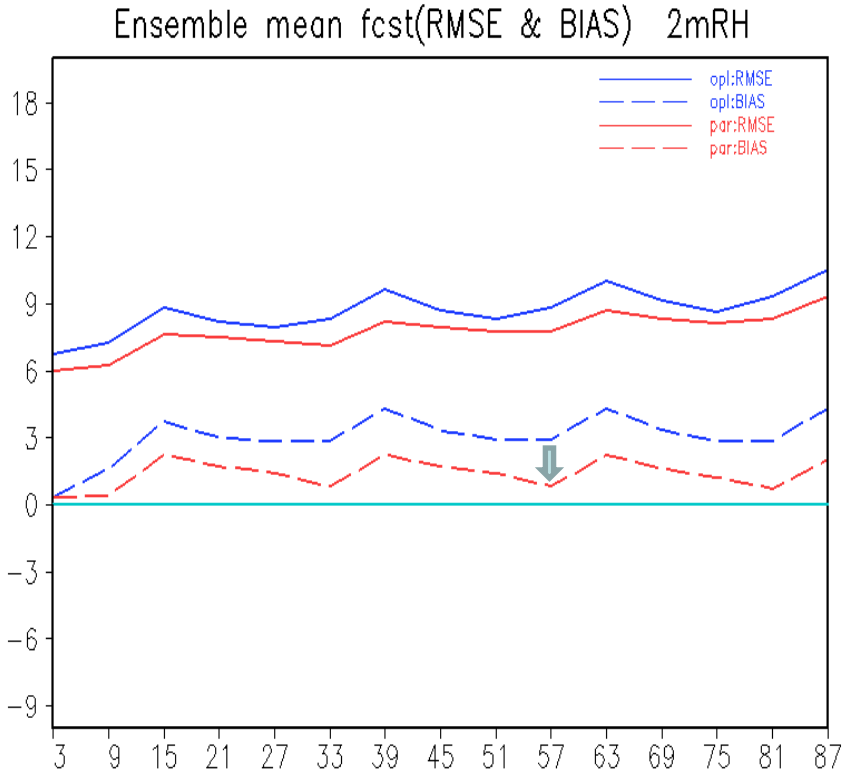


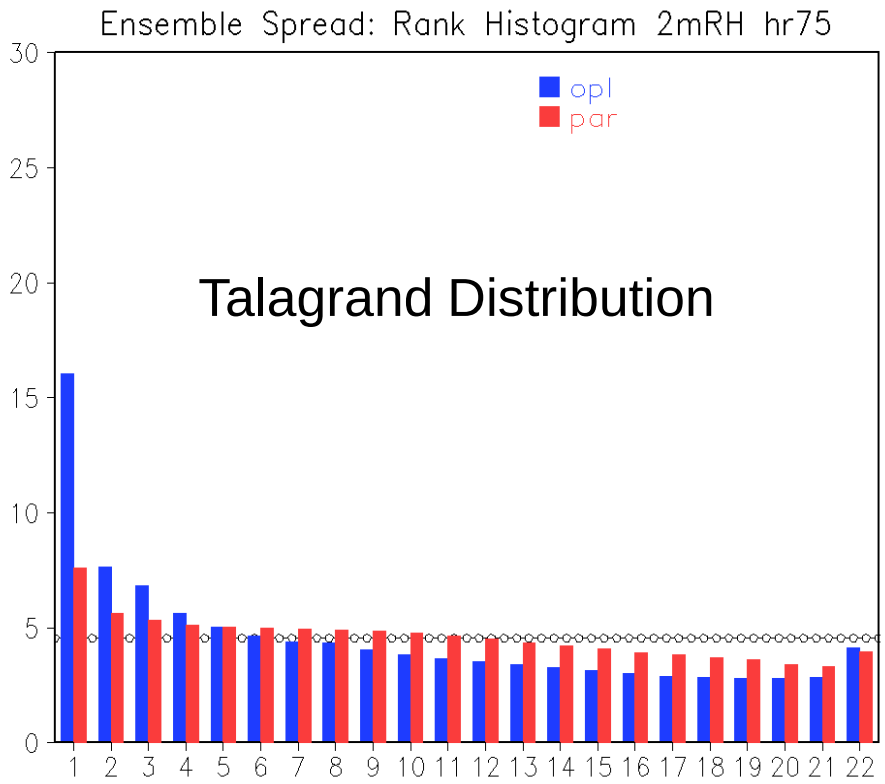
Reduced cold bias in 2mT to a lesser degree (warm season: April – Sept. 2015)



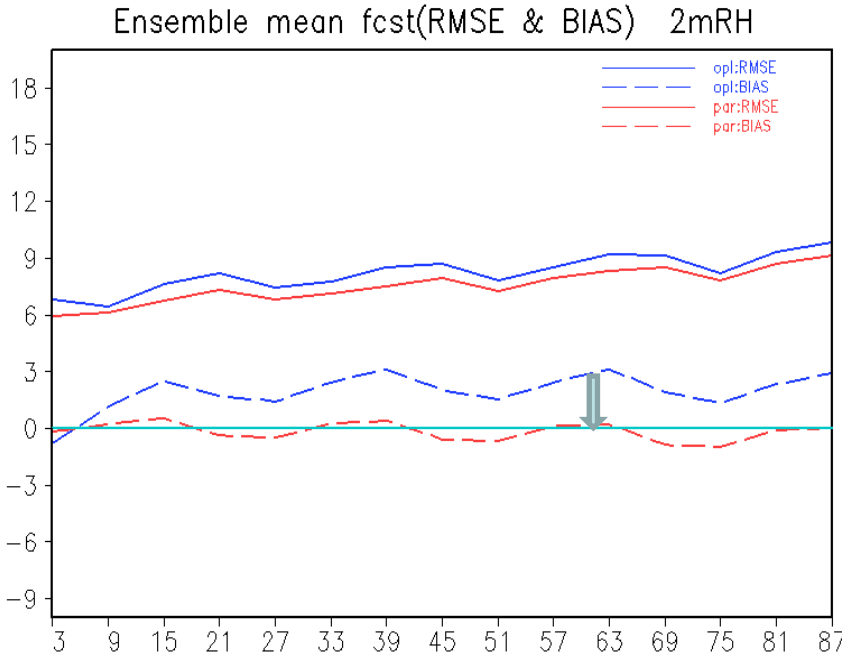


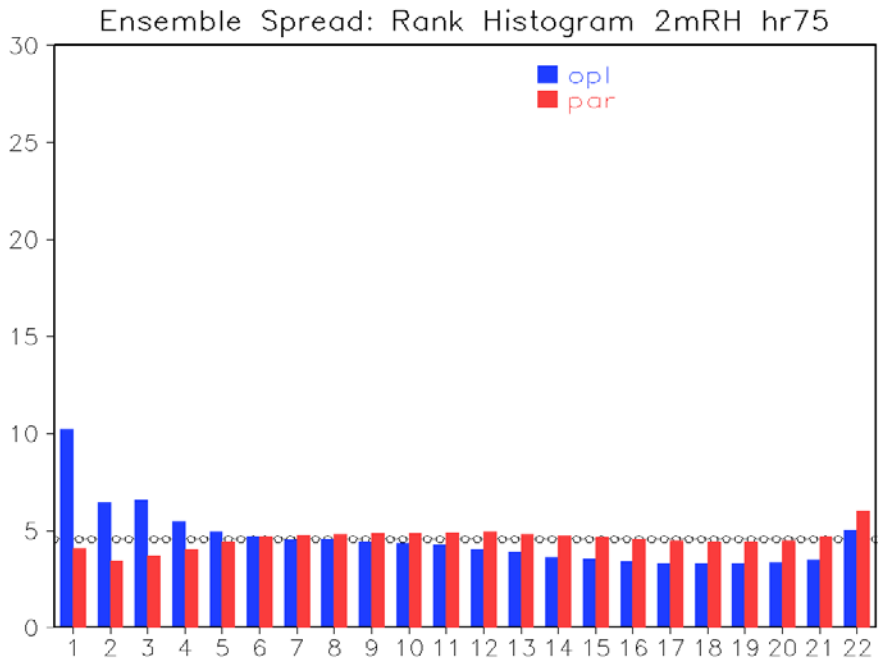
Reduced wet bias in 2mRH to a lesser degree (cold season: Oct. 2014 – March 2015)





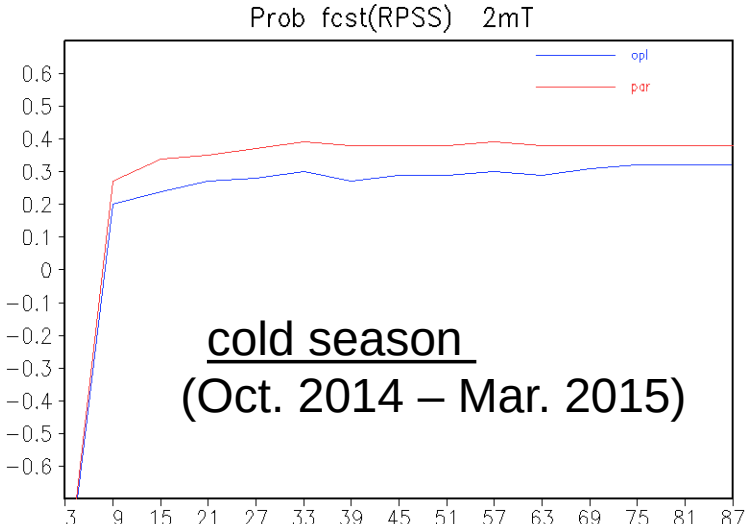
Almost eliminate wet bias in 2mRH (warm season: April – Sept. 2015)





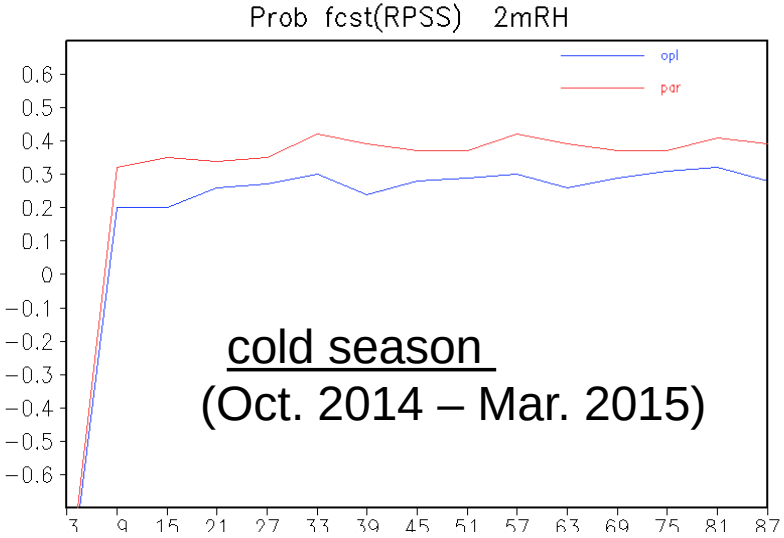
More skillful probabilistic forecasts (measured by RPSS) of 2mT and 2mRH

2m T

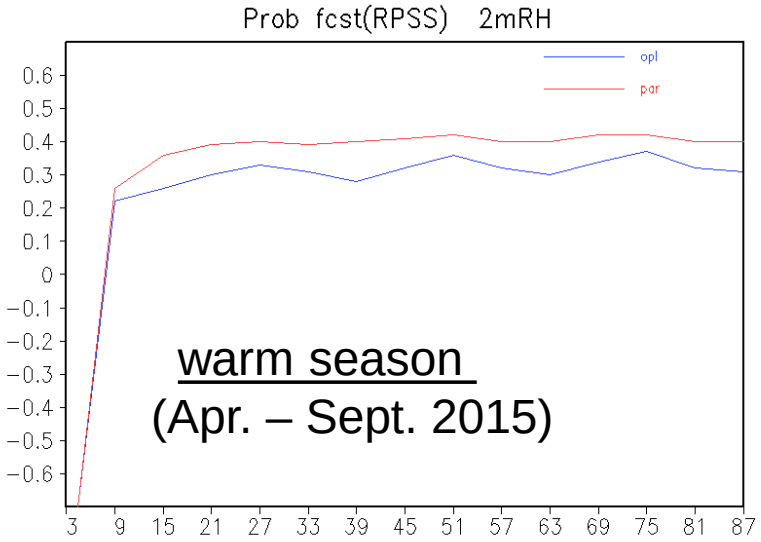


cold season
(Oct. 2014 – Mar. 2015)

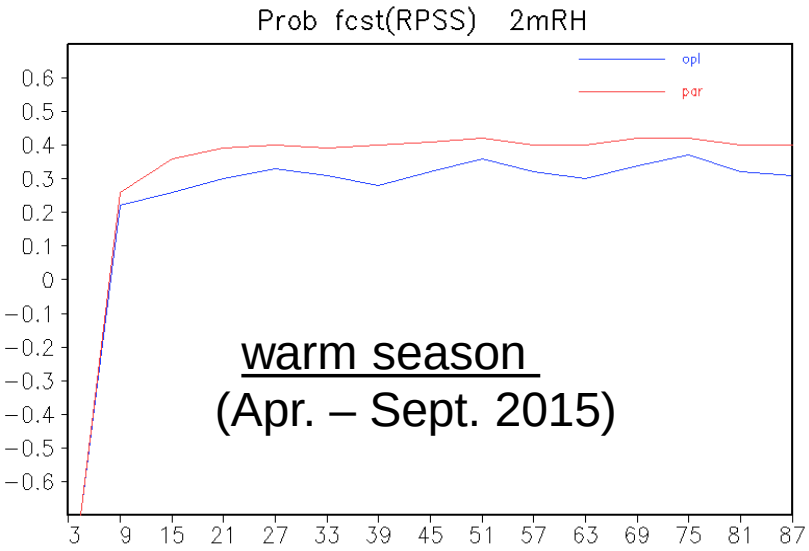
2m RH



cold season
(Oct. 2014 – Mar. 2015)



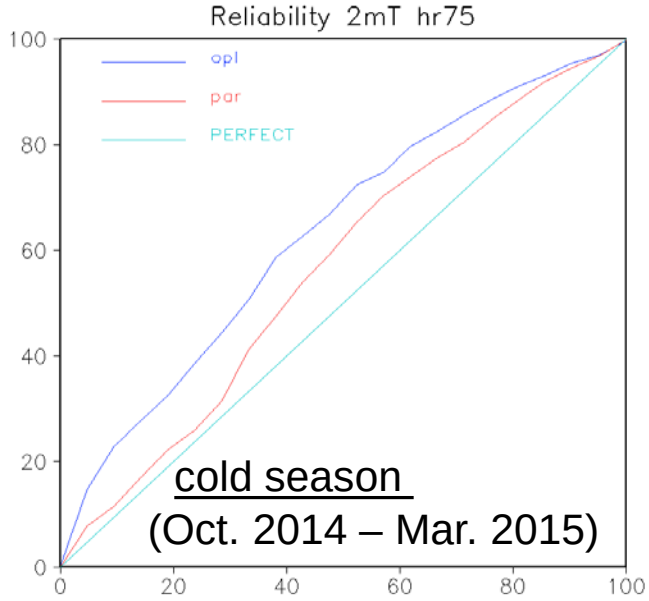
warm season
(Apr. – Sept. 2015)

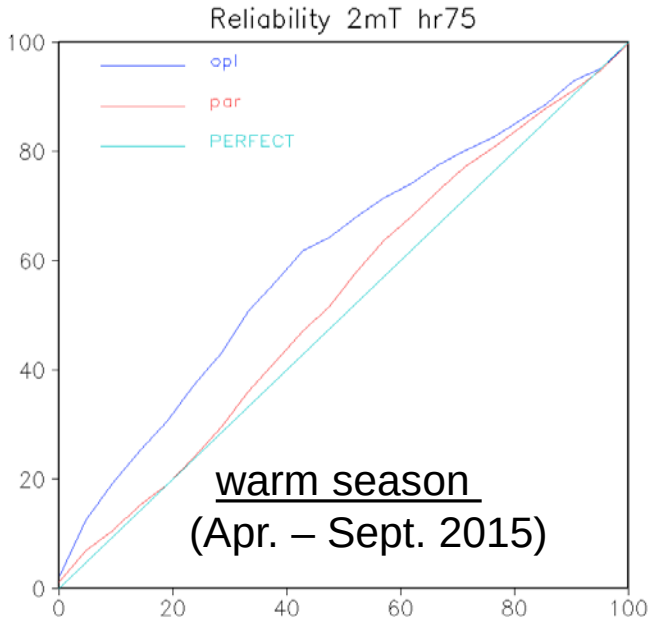


warm season
(Apr. – Sept. 2015)

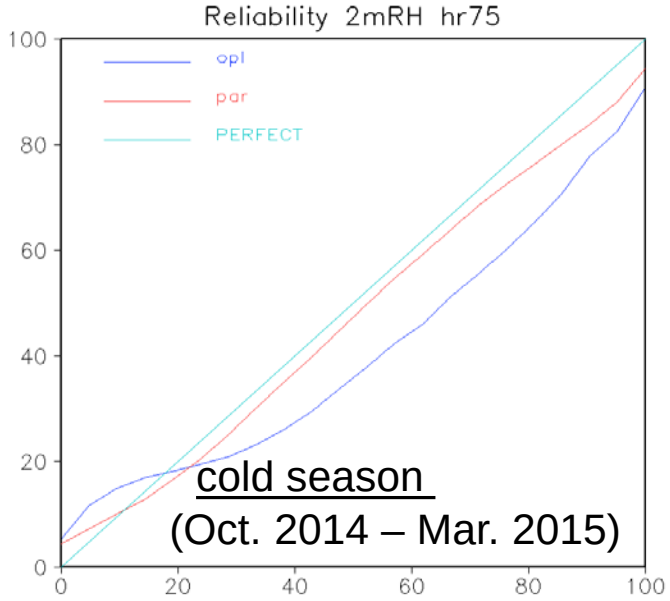
More reliable probabilistic forecasts (measured by Reliability) of 2mT and 2mRH

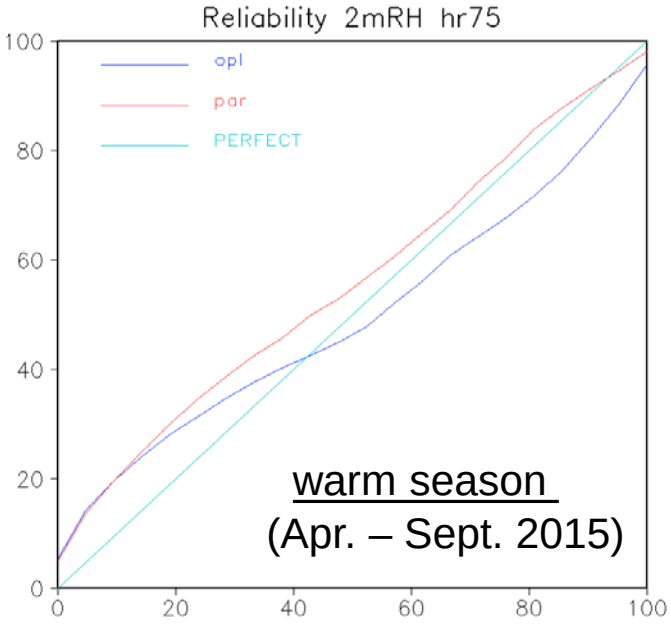
2m T



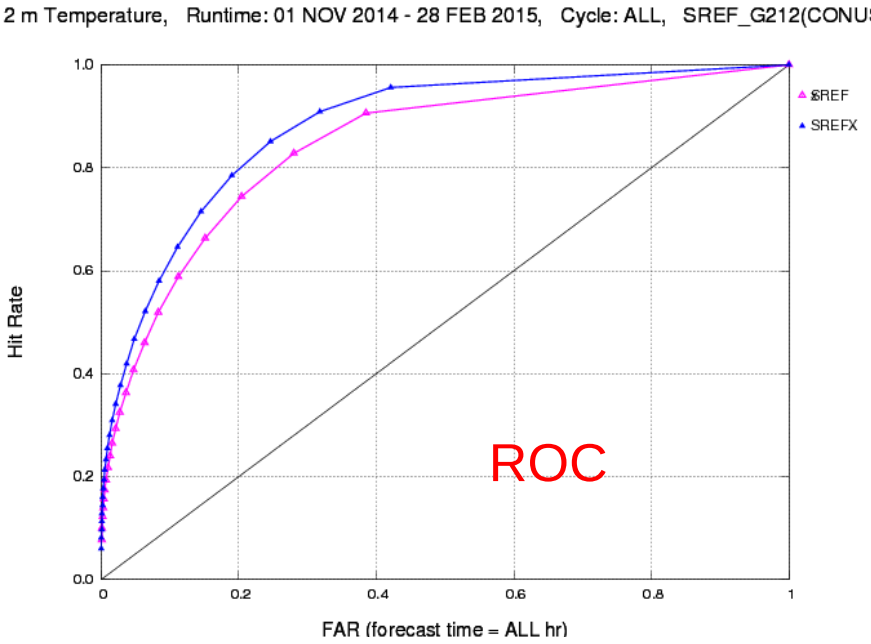


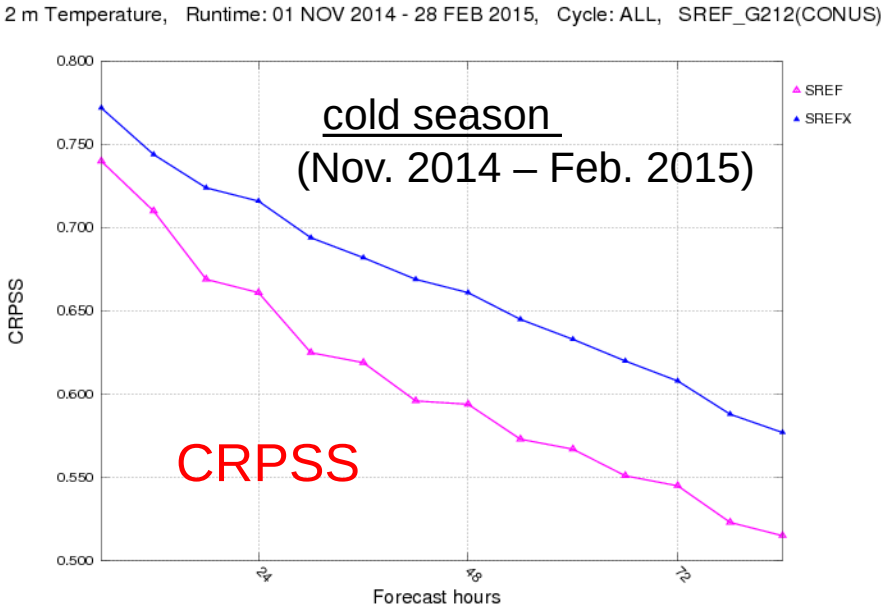
2m RH

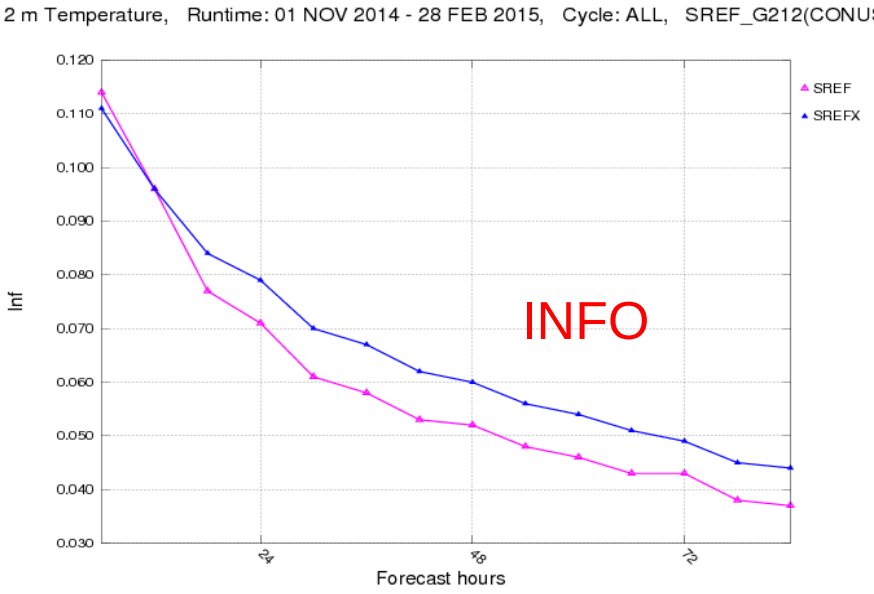


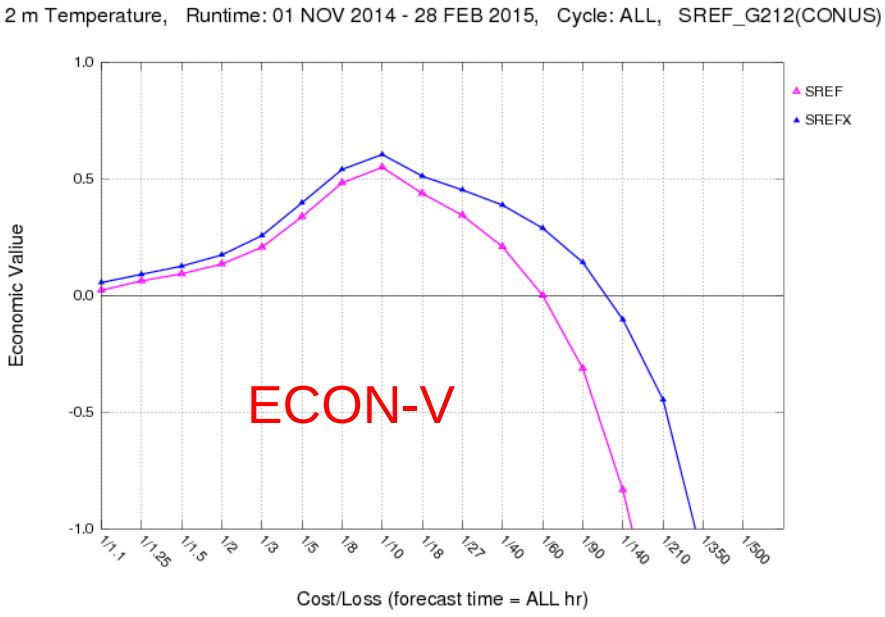


Improvements in various other measures (SREF vs. SREFx, cold season, Binbin's g2g)

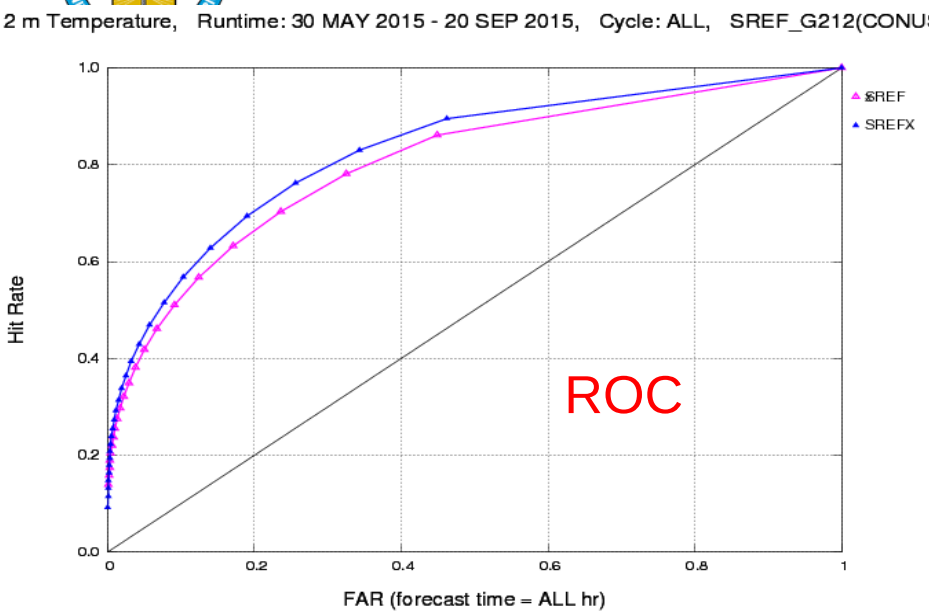


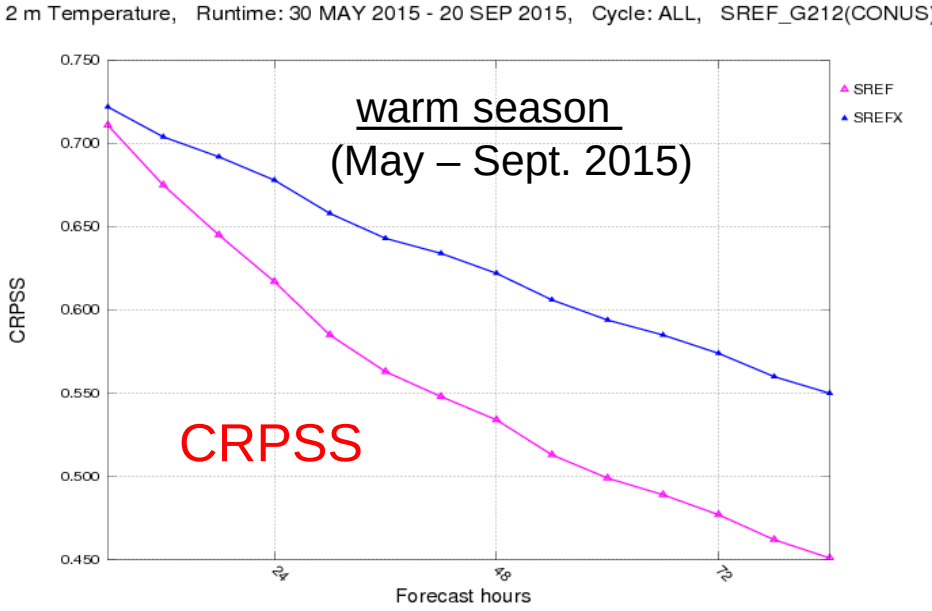


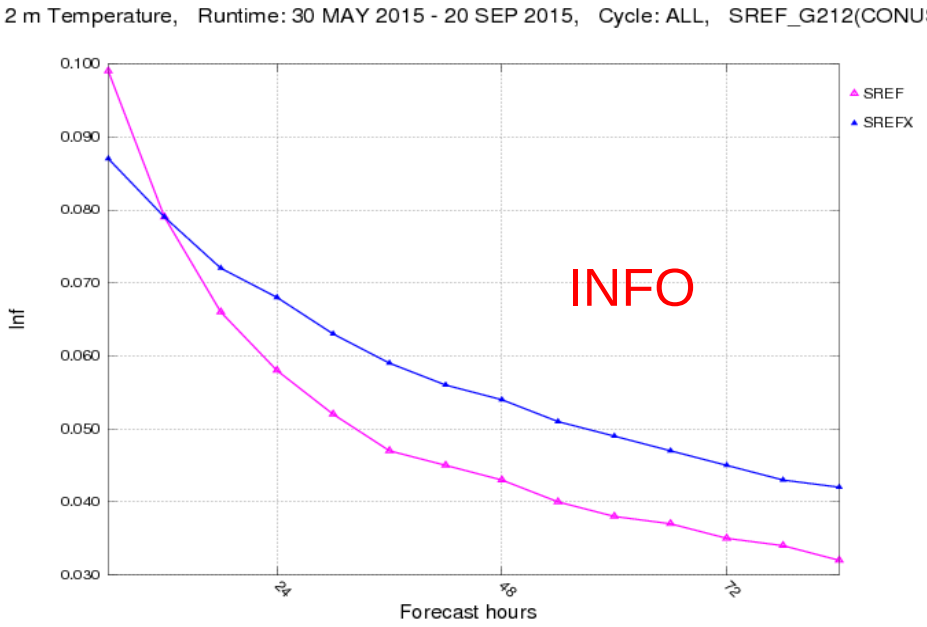


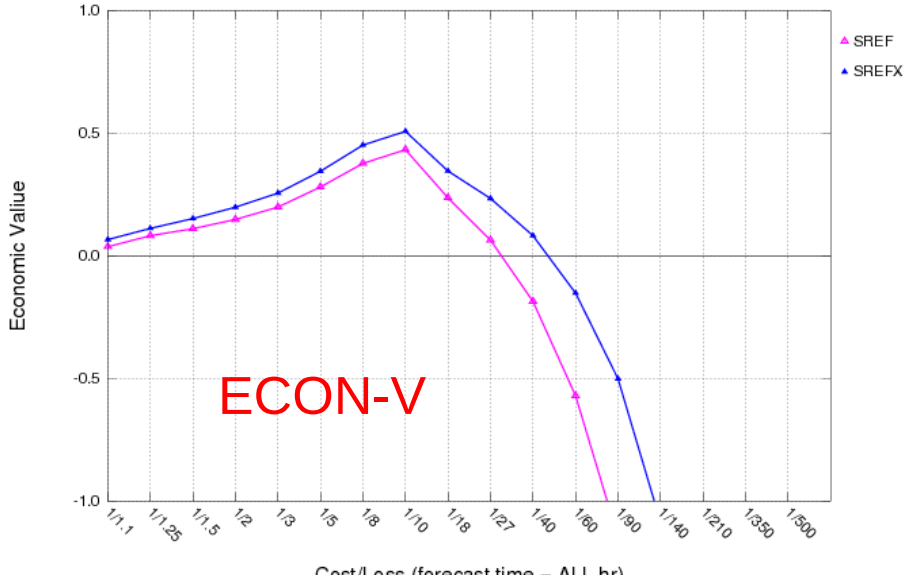


Improvements in various other measures (SREF vs. SREFx, warm season, Binbin's g2g)

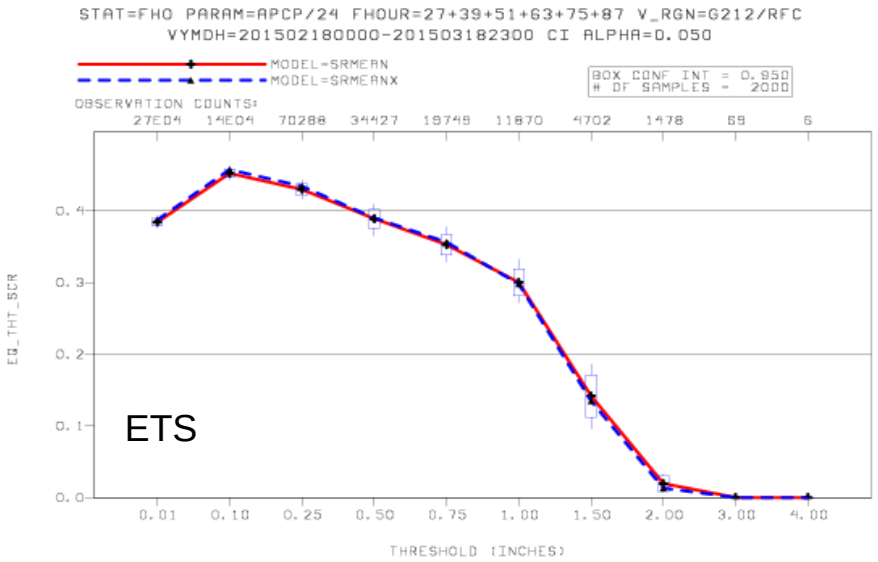


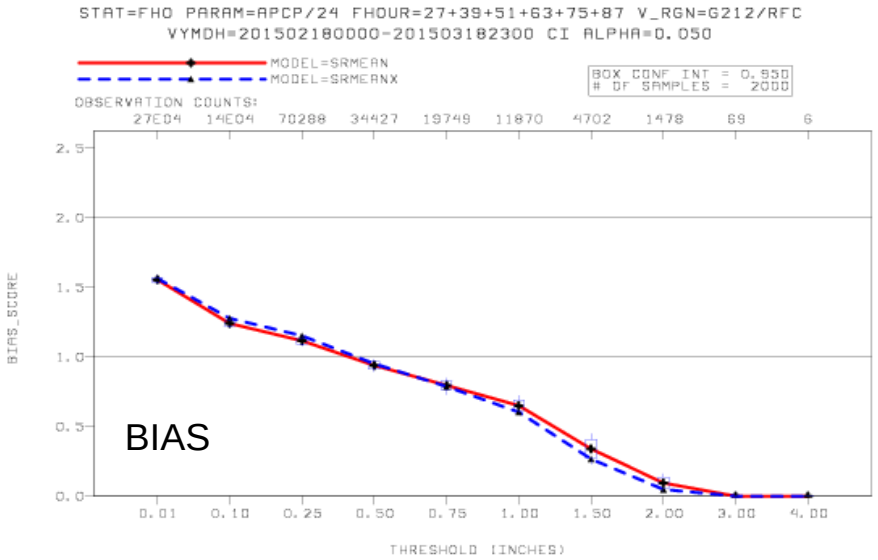


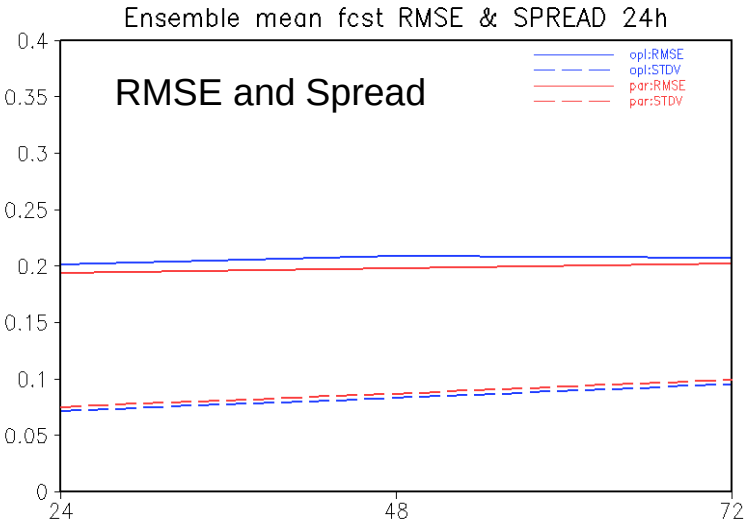




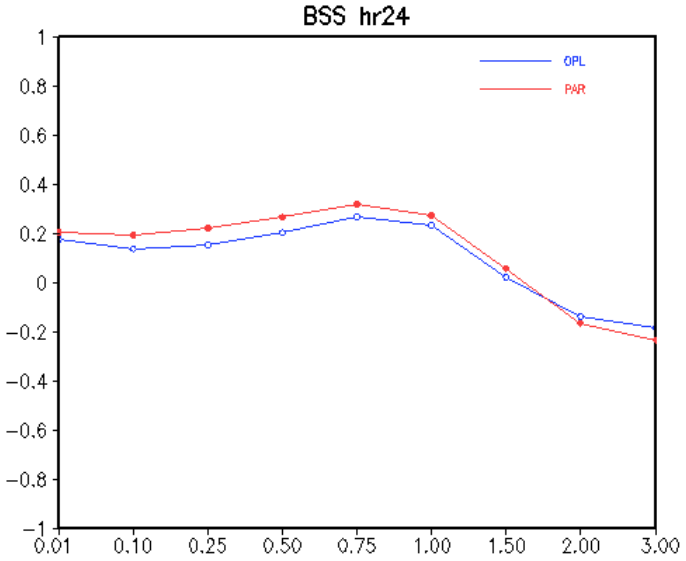
Precipitation forecasts of ensemble mean in cold season: similar in position and improvement in amount

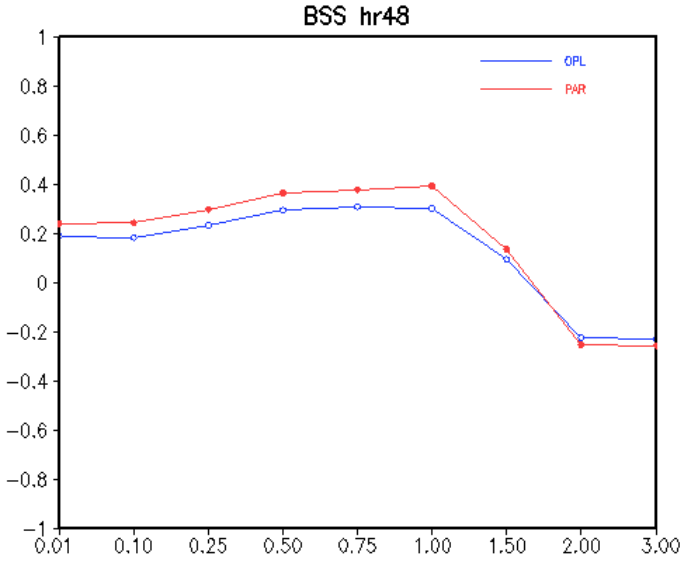


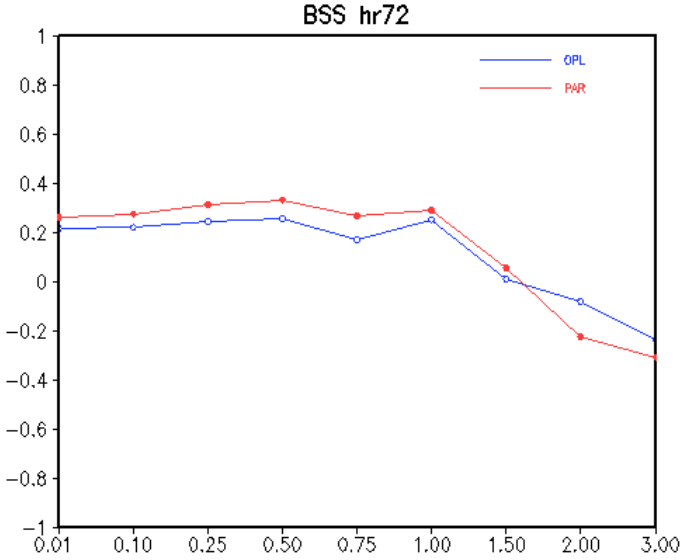




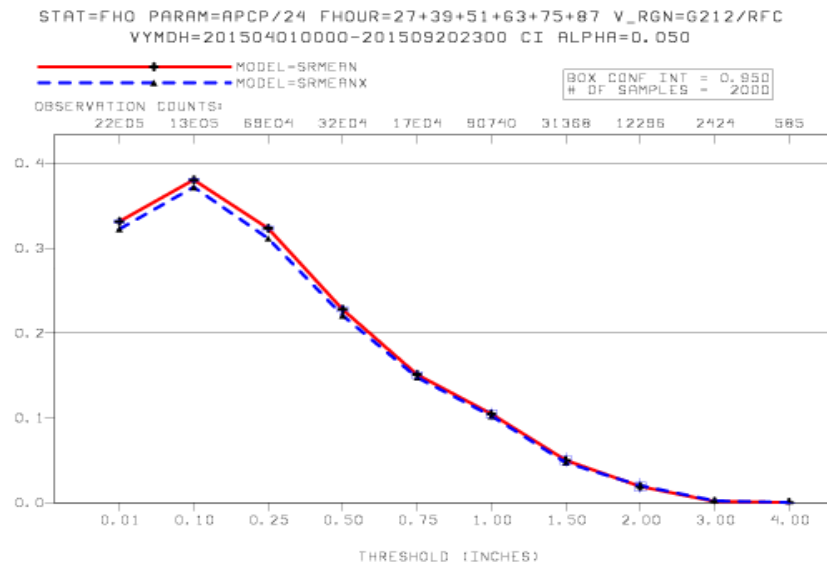
Precipitation forecasts of probabilistic information in cold season: an improvement in Brier Skill Score

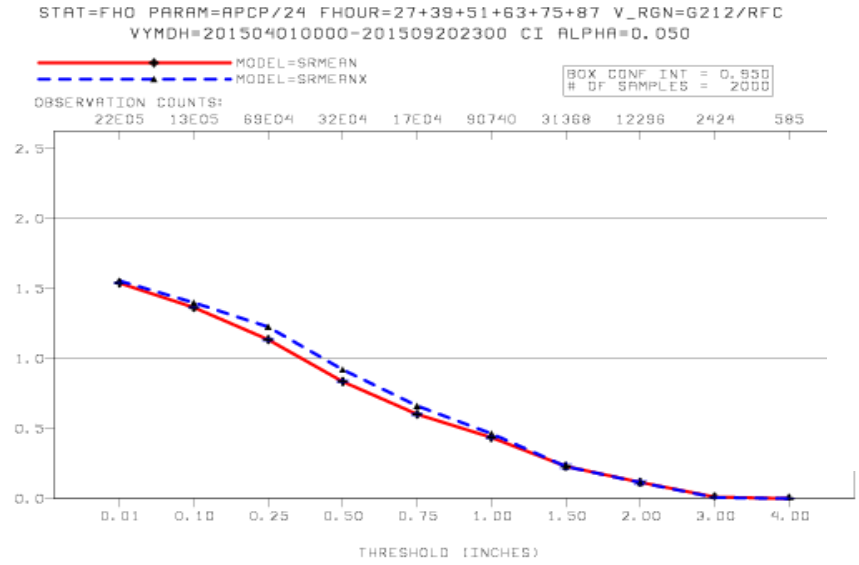


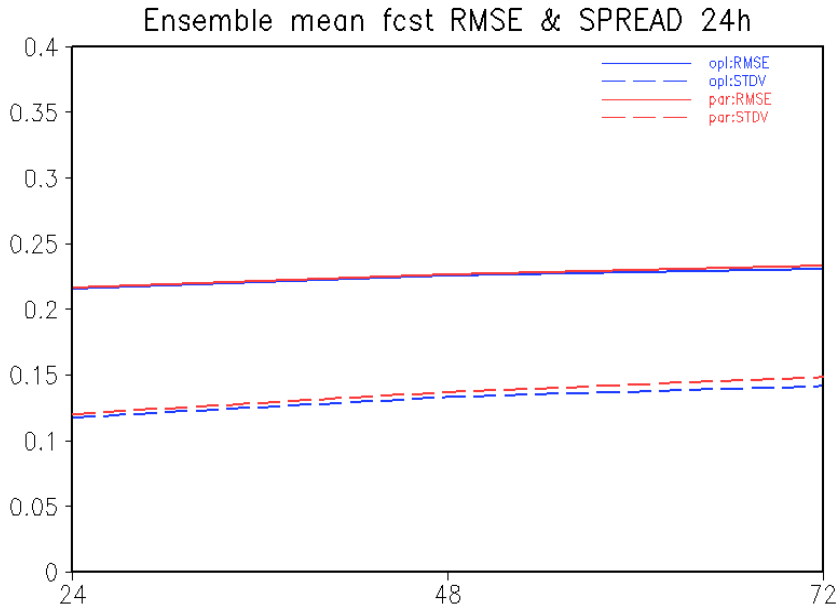




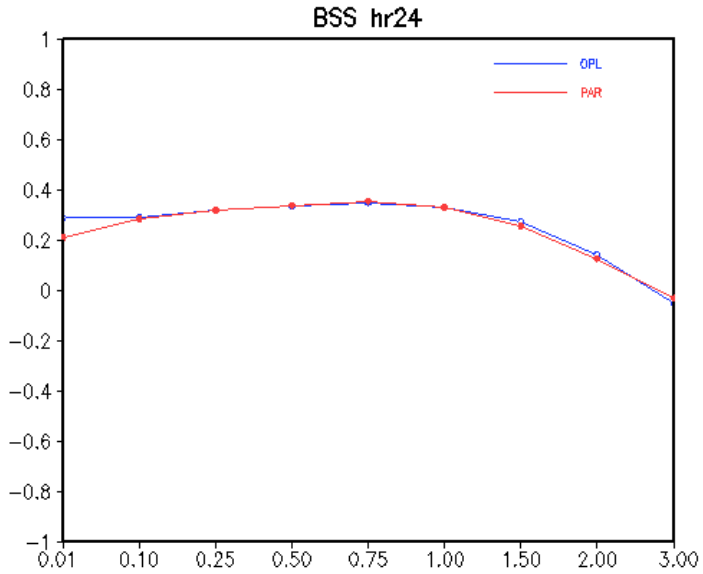
Precipitation forecasts of ensemble mean in warm season: similar in both position and amount

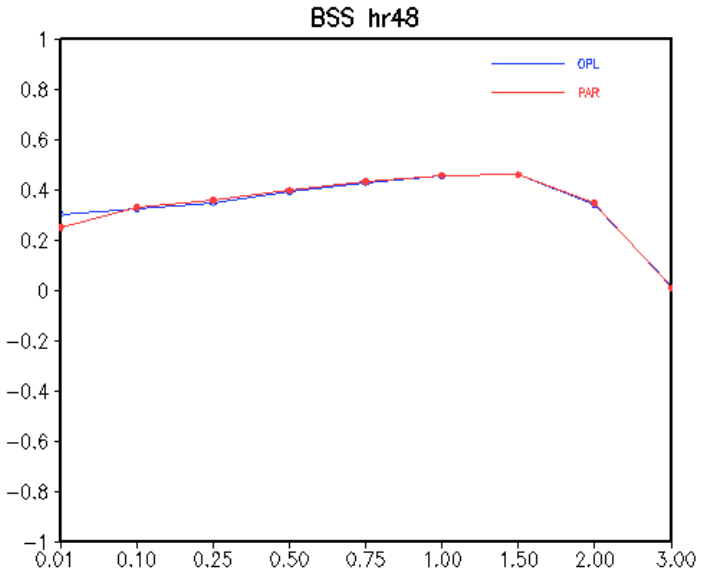


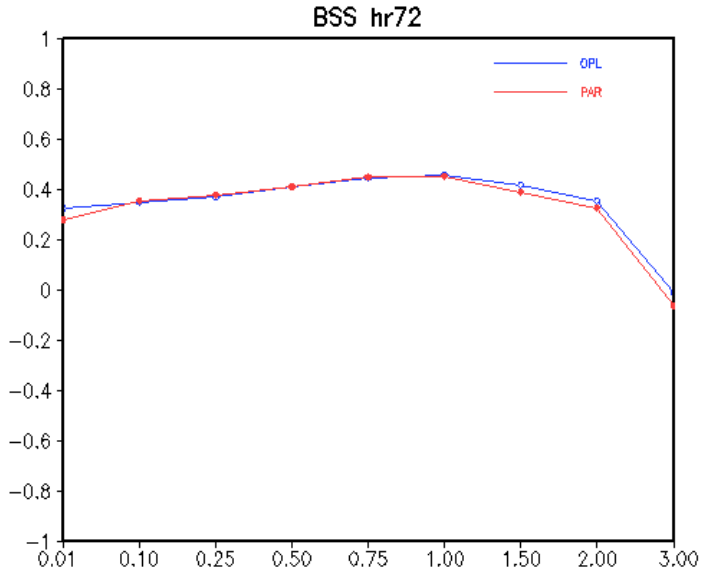




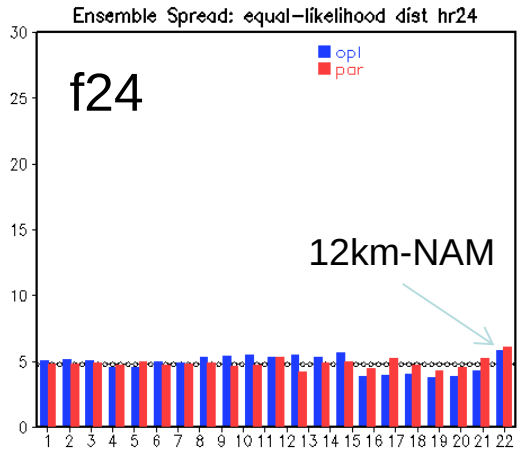
Precipitation forecasts of probabilistic information in warm season: similar in Brier Skill Score

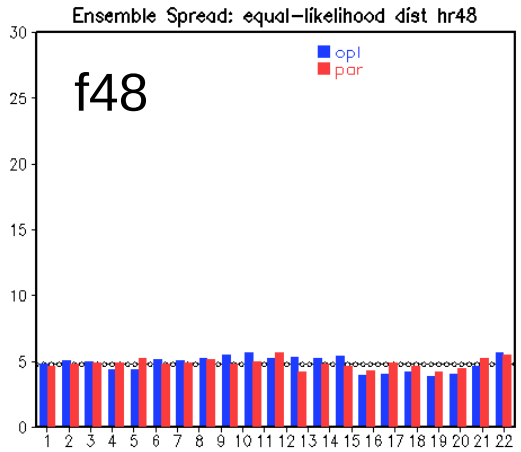


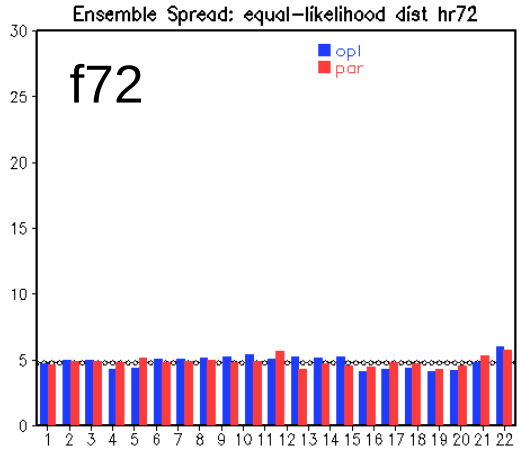




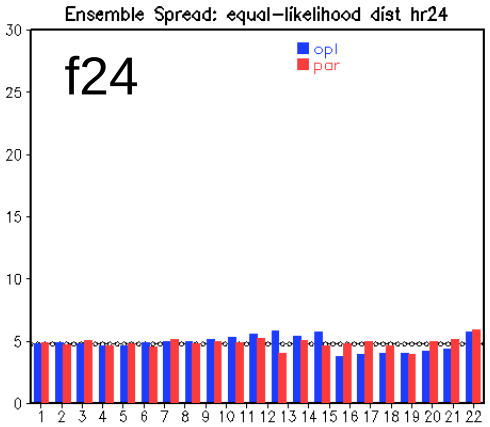
Equal-likelihood of ensemble members (24h-apcp forecasts)

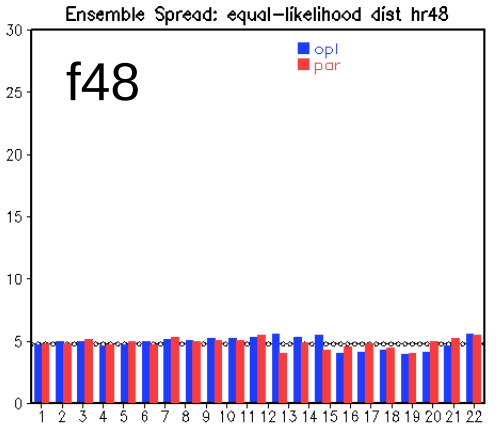


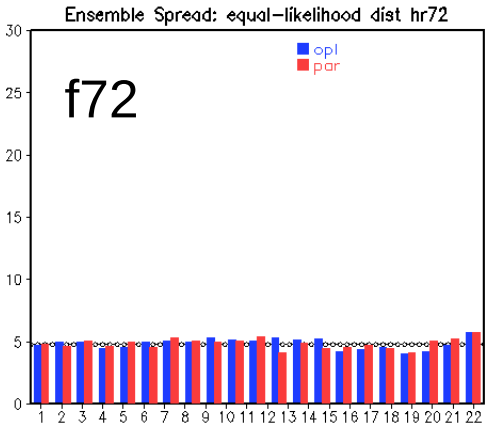




Cold season (Dec. 2014 - Mar. 2015)



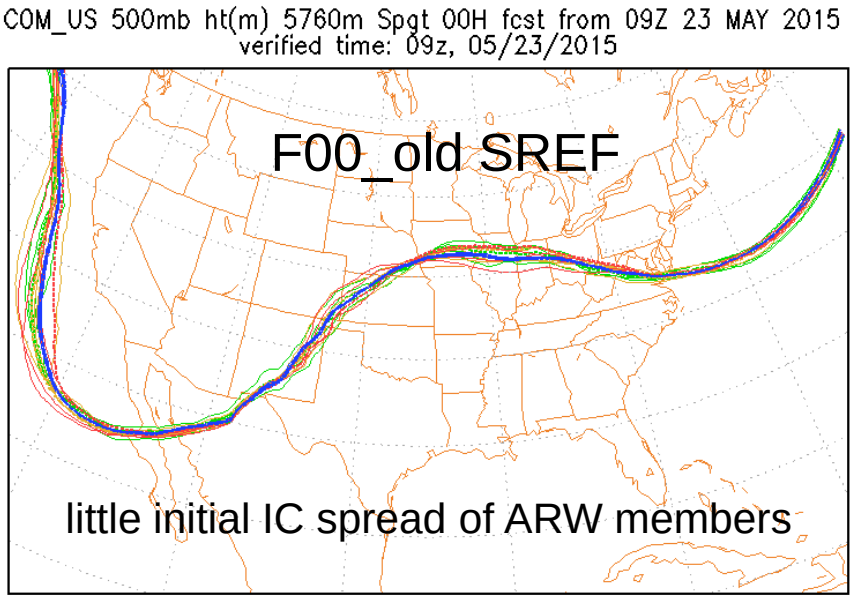


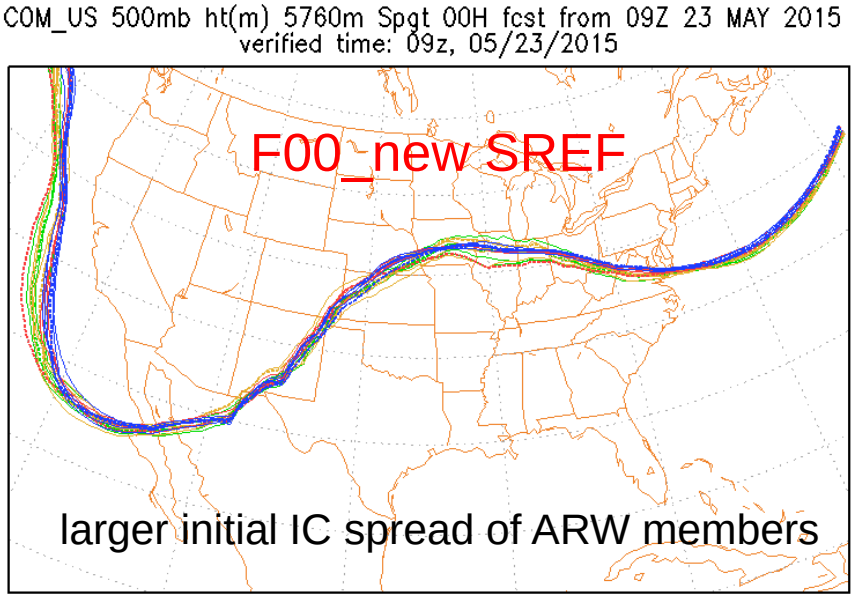


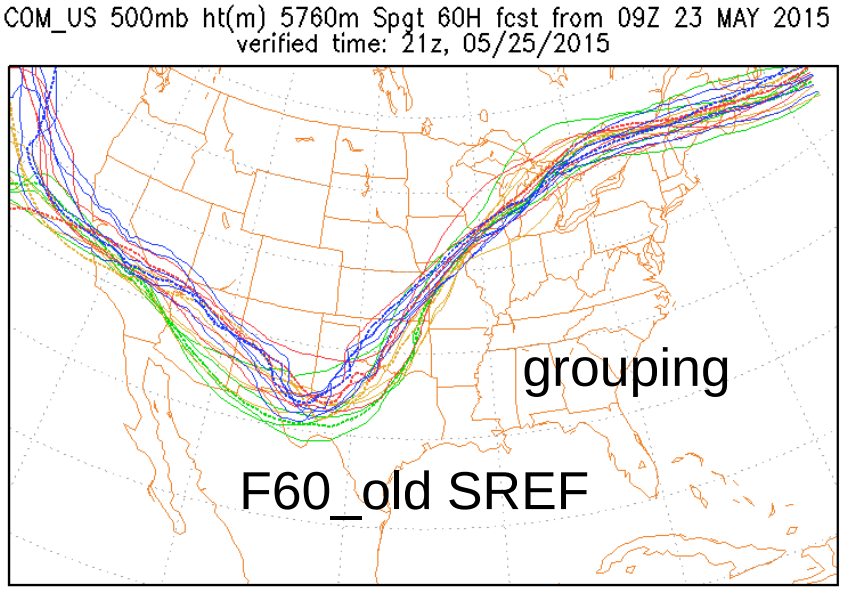
Warm season (Apr. – July 2015)

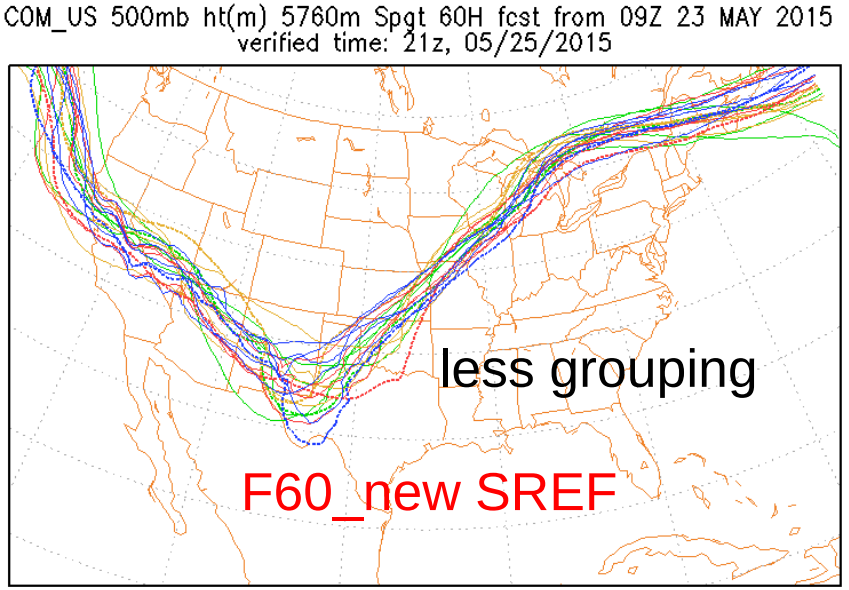
Improvement in ensemble spread

Increased IC-perturbation size and more mixed members in forecast projection (Texas flooding case)

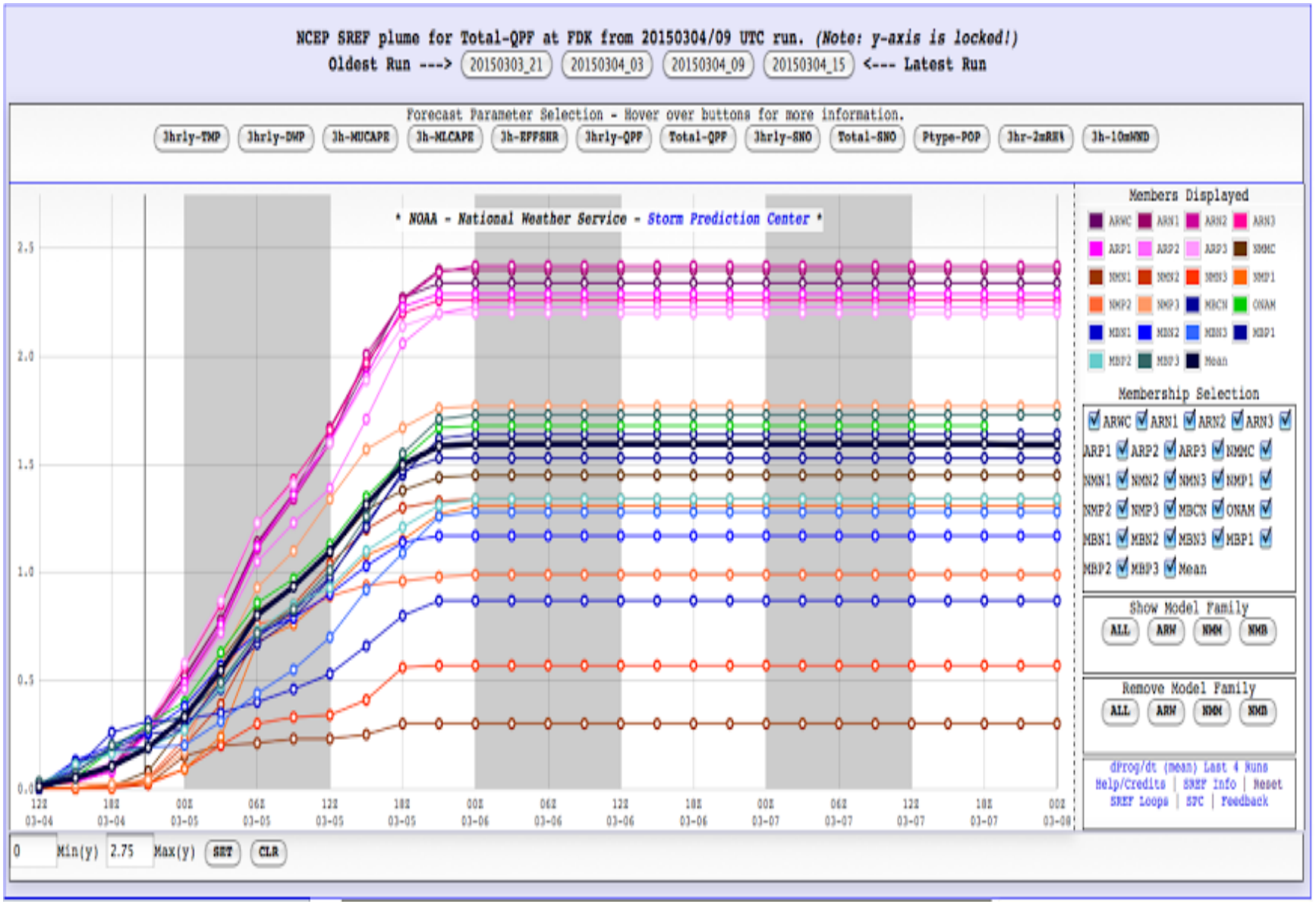






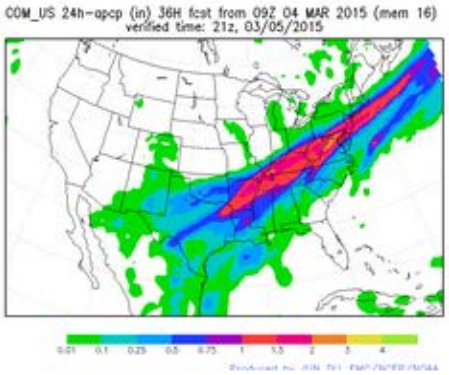


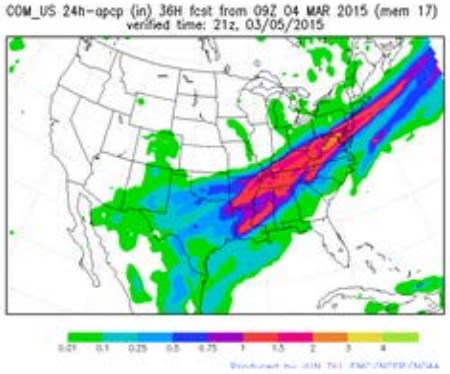
Forecaster's complain: all ARW members are grouped to be too wet: March 5, 2015 DC snow storm

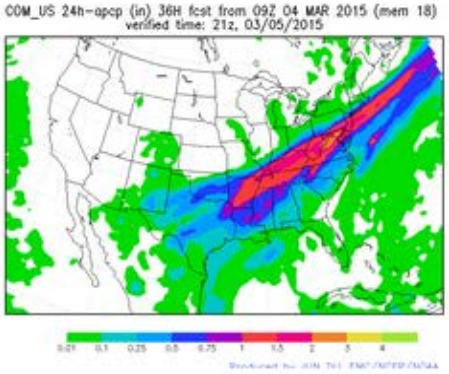


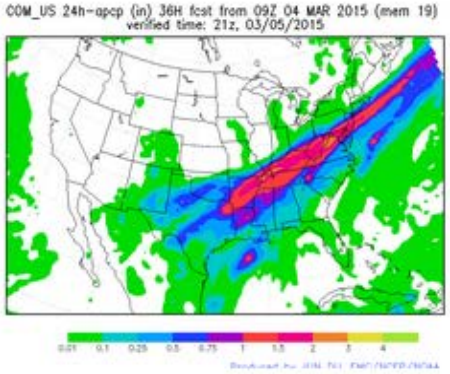
OPL SREF

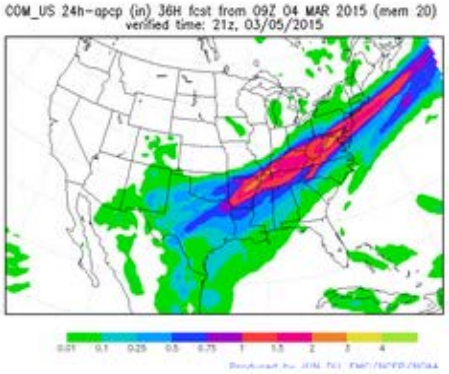

COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 15)
verified time: 21z, 03/05/2015


COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 16)
verified time: 21z, 03/05/2015

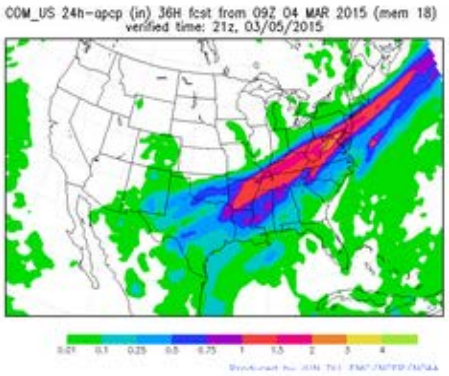

COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 17)
verified time: 21z, 03/05/2015

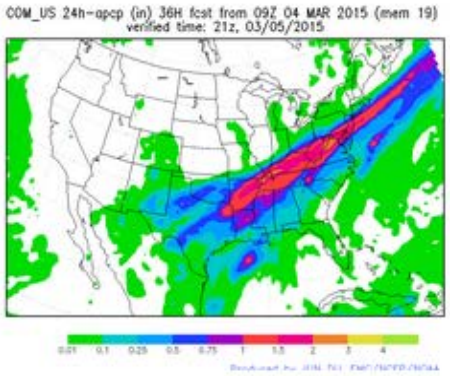

COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 18)
verified time: 21z, 03/05/2015

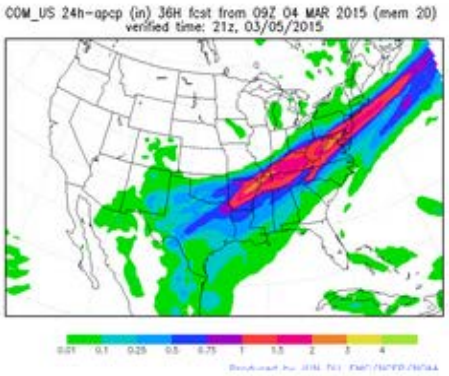

COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 19)
verified time: 21z, 03/05/2015


COM_US 24h-apcp (in) 36H fcst from 09Z 04 MAR 2015 (mem 20)
verified time: 21z, 03/05/2015

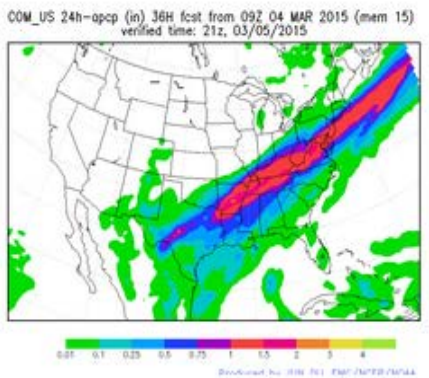
OPL SREF

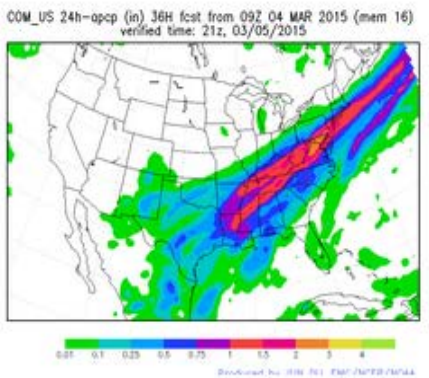


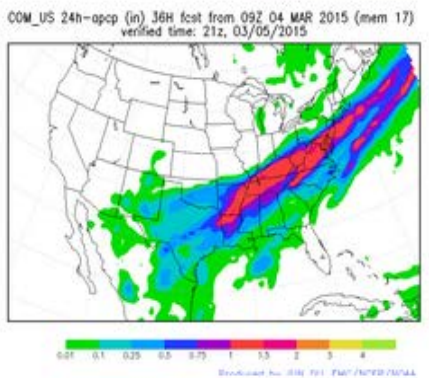


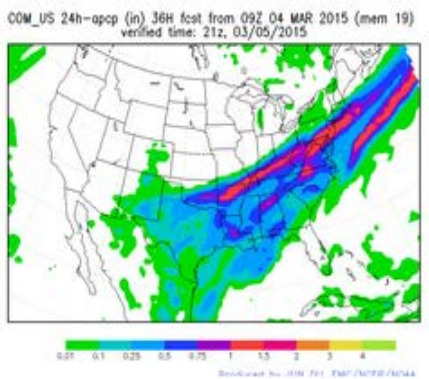


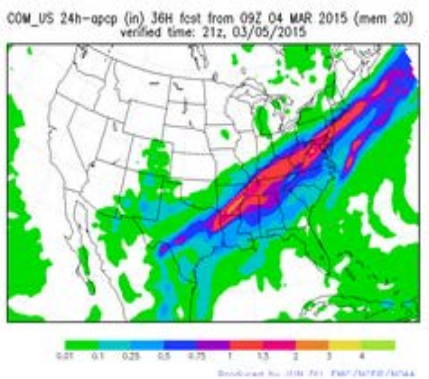
PARA SREF





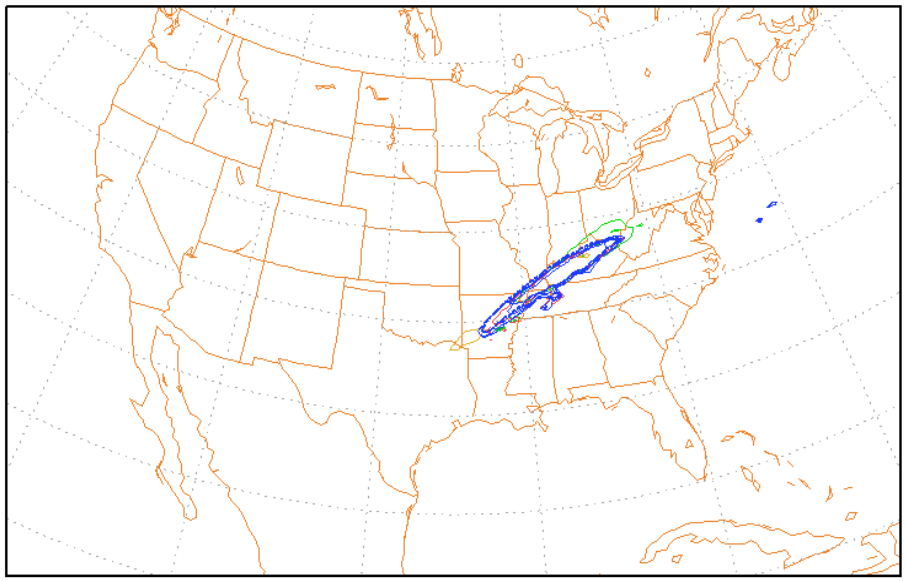






OPL SREF

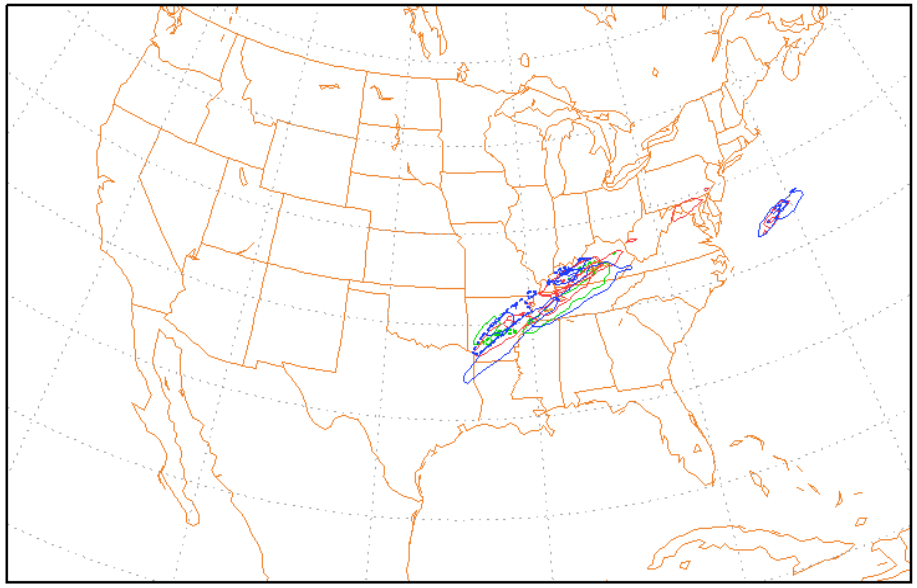
COM_US 24h-precip 2.0 in Spgt 27H fcst from 09Z 04 MAR 2015
verified time: 12z, 03/05/2015



Produced by JUN DU, EMC/NCEP/NO

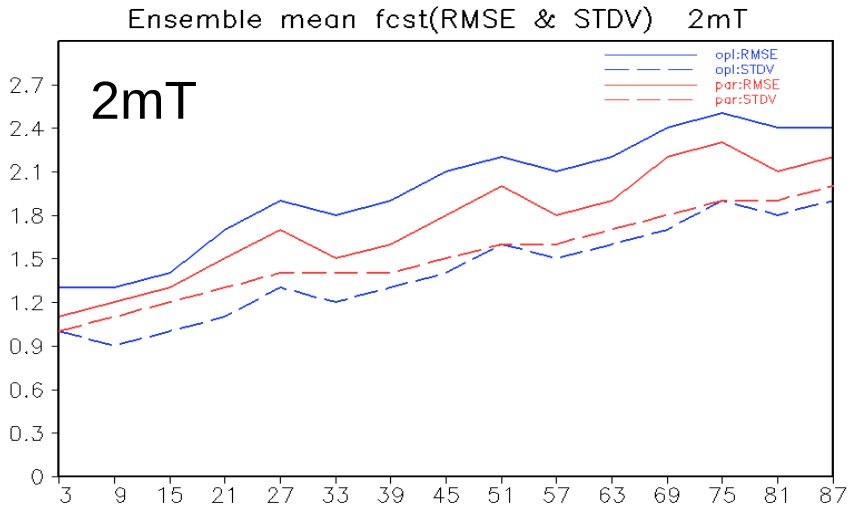
PARA SREF

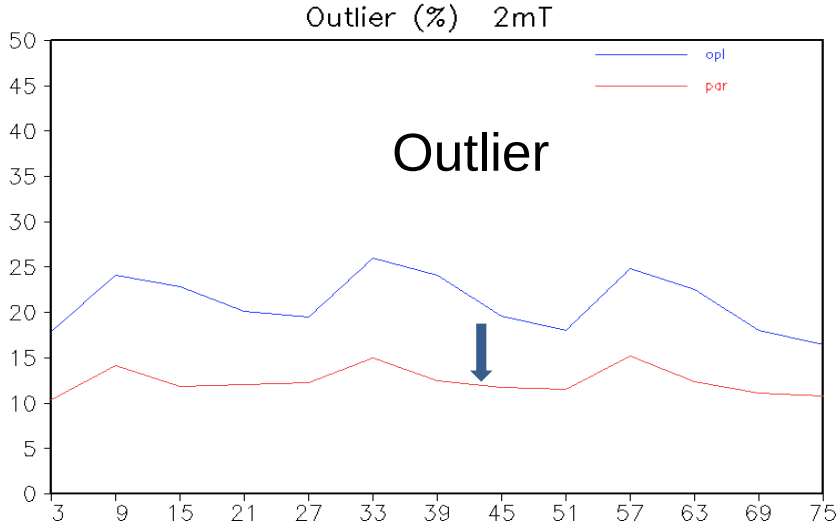
COM_US 24h-precip 2.0 in Spgt 27H fcst from 09Z 04 MAR 2015
verified time: 12z, 03/05/2015

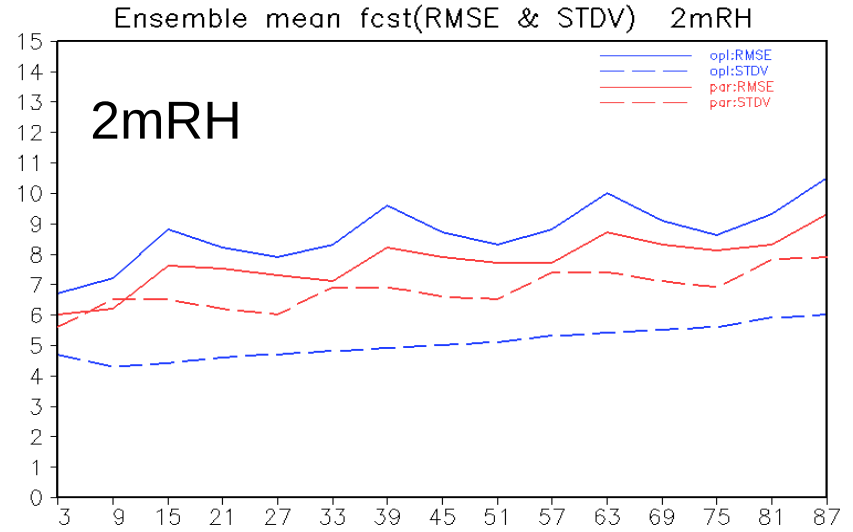


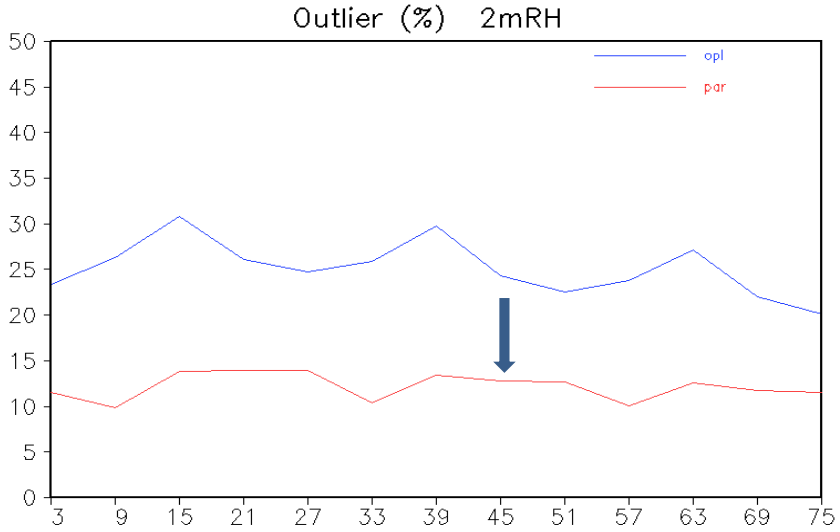
Produced by JUN DU, EMC/NCEP/NOAA

Spread closer to ensemble mean forecast error and less outlier in forecasts in the new SREF than the old SREF (cold season: Oct. 2014 – March 2015)

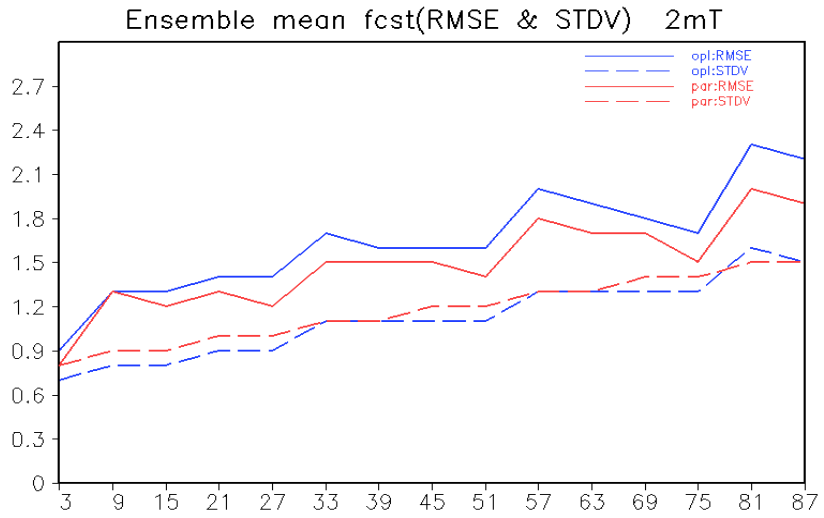


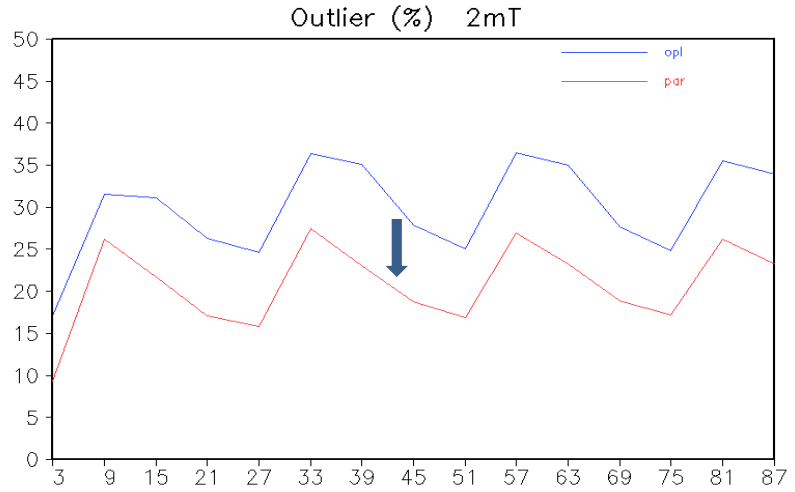


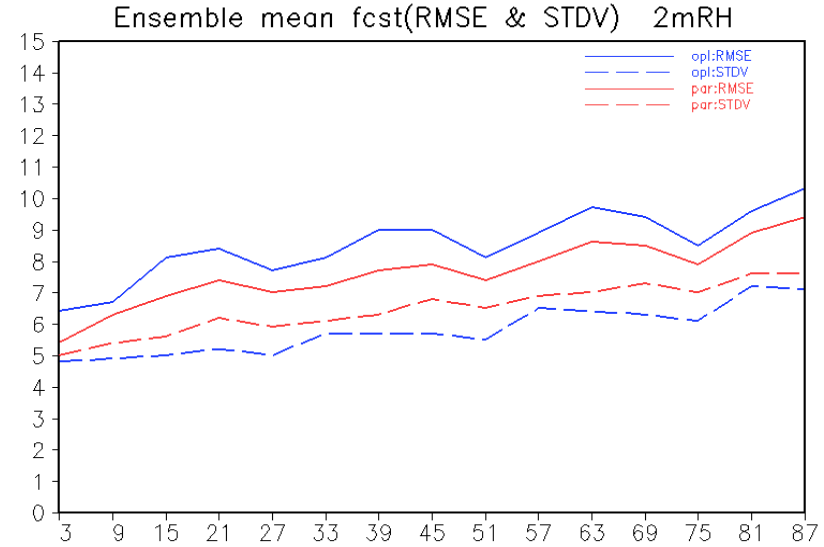


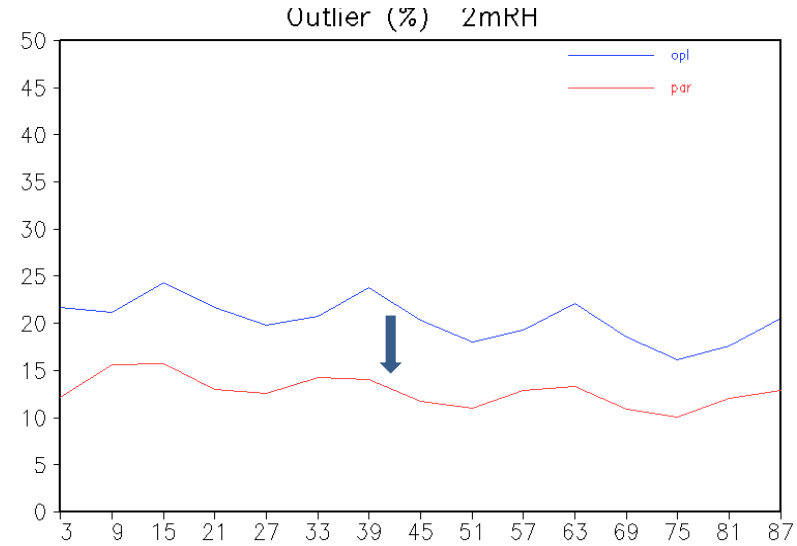


Spread closer to ensemble mean forecast error and less outlier in forecasts in the new SREF than the old SREF (warm season: April – July 2015)



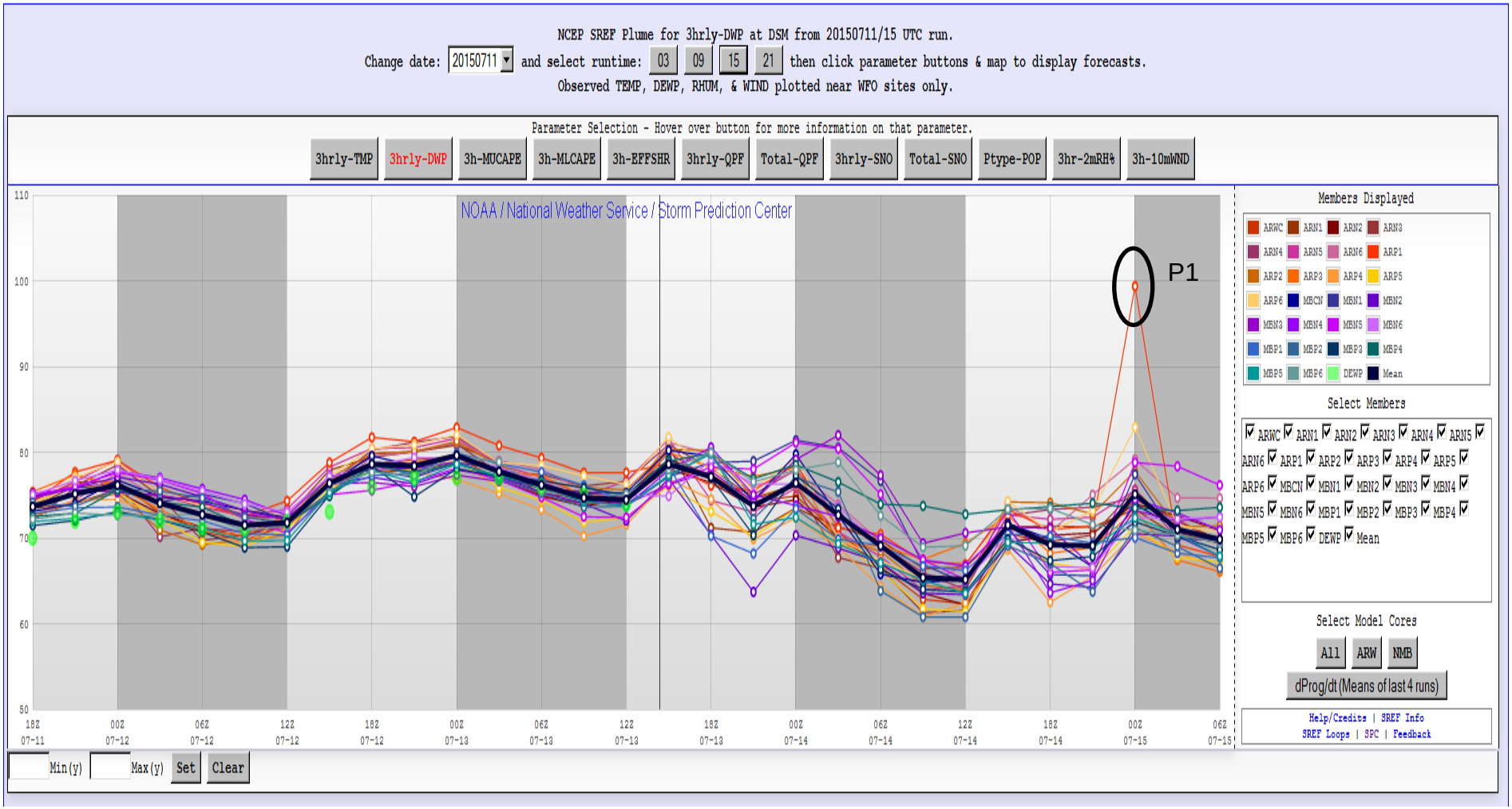


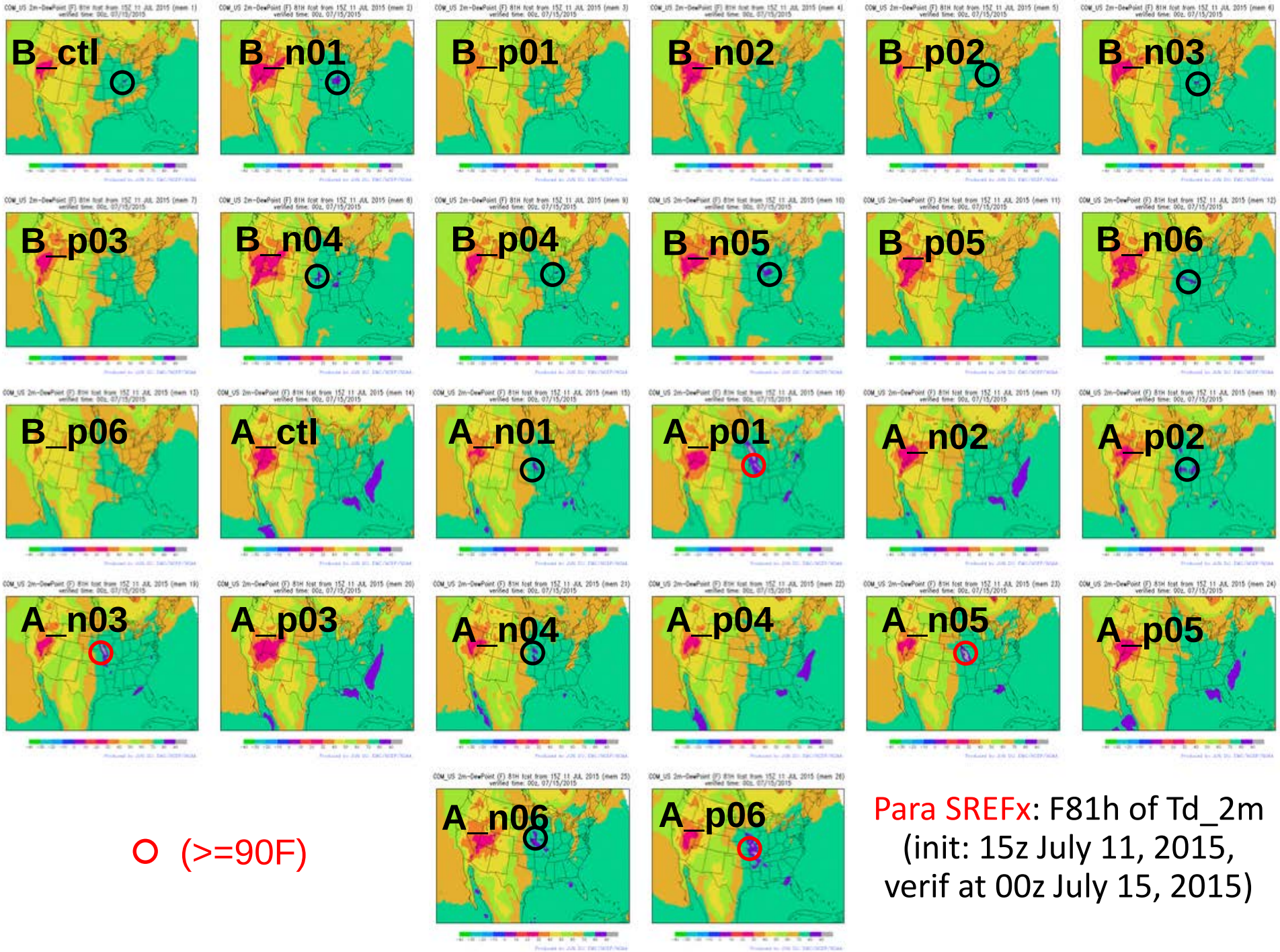




Too high local peak value of 2m Td from a couple of ARW members (p1, n3, n5 and p6 in particular)

2-m Td Plume for DSM (Des Moines, Iowa): 20150711/15Z (Israel Jirak of SPC)

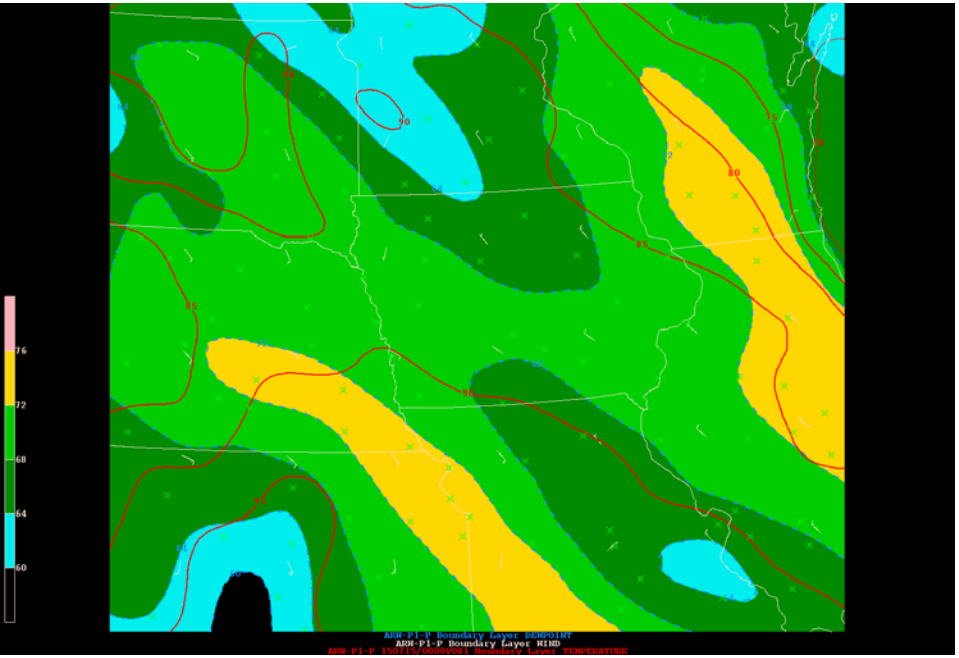


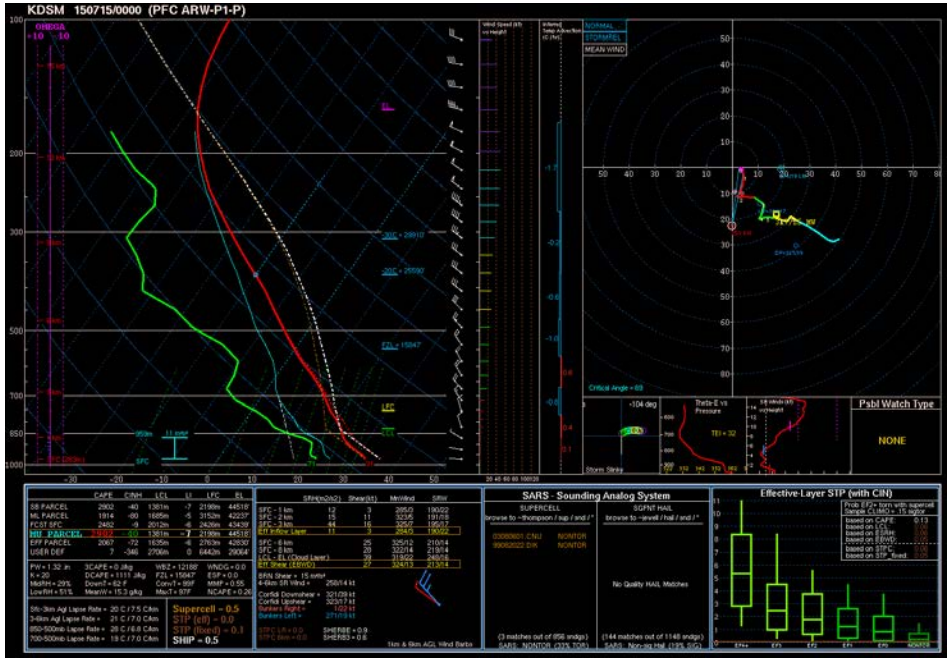


O (>=90F)

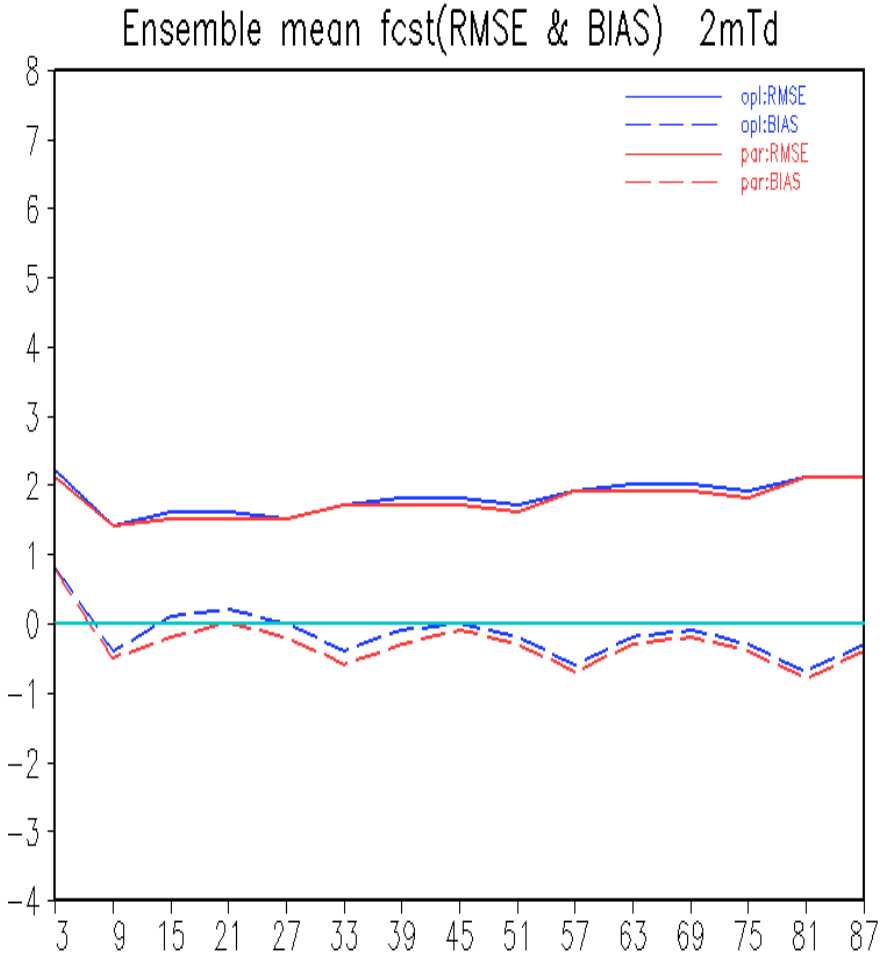
Para SREFx: F81h of Td_2m
(init: 15z July 11, 2015,
verif at 00z July 15, 2015)

It’s only in 2m diagnostic Td but not in atmospheric lower level Td (Andy Dean of SPC)

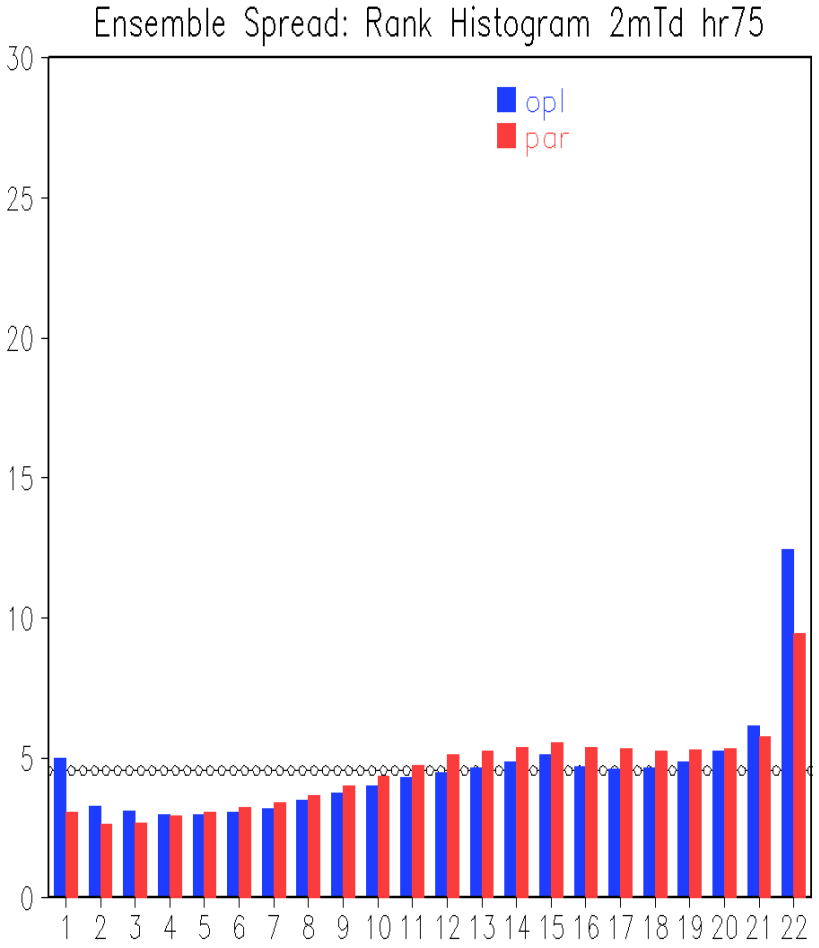




Slightly reduced total error in 2m-Td (warm season: April – Sept. 2015)

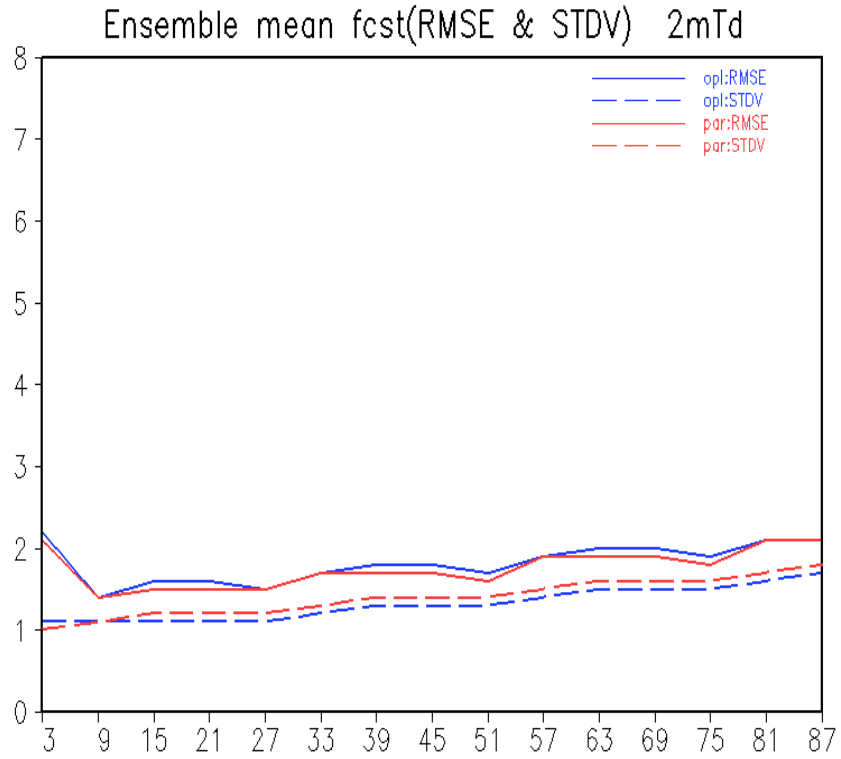


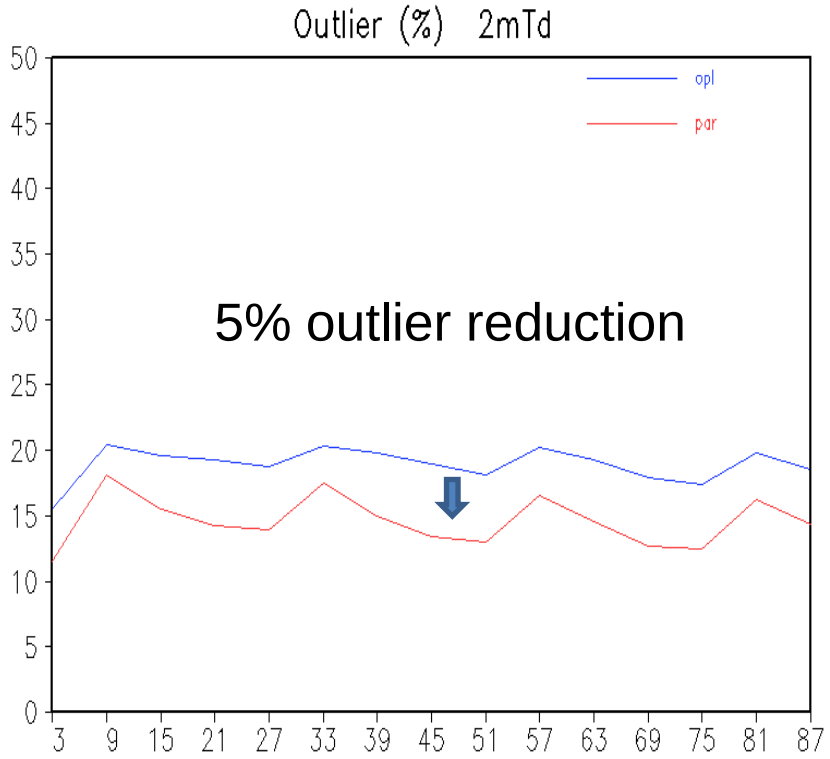
No improvement in bias magnitude



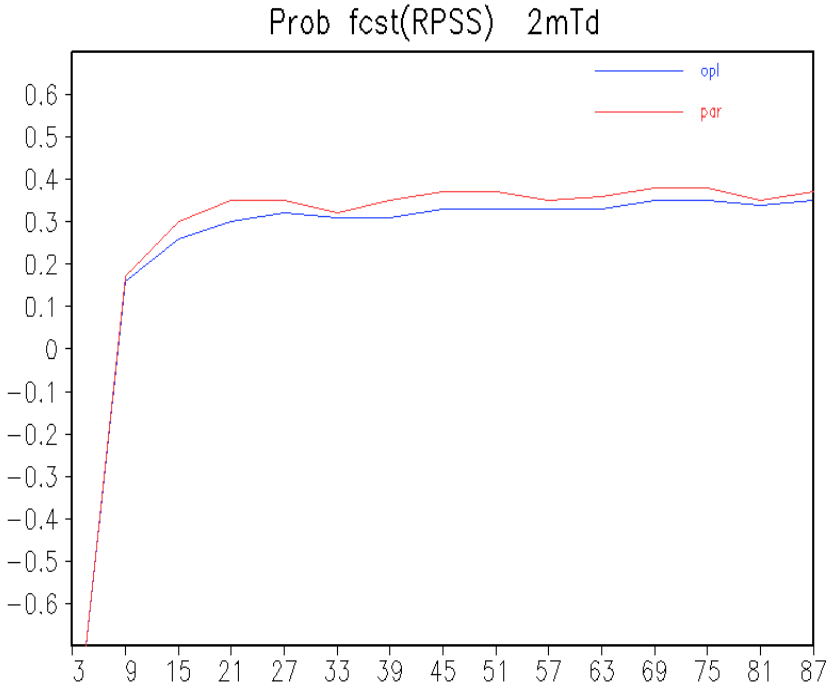
But reduced bias frequency

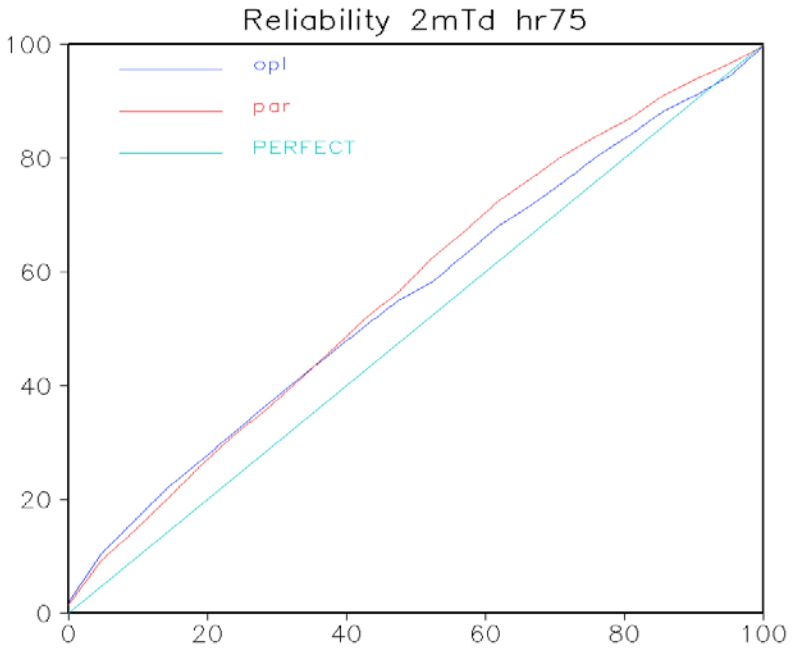
Improved spread: better spread-error relation and less chance to miss truth (warm season: April – Sept. 2015)





Probabilistic forecasts: more skillful, slightly more reliable in low prob end and less reliable in higher prob (but overall reliability is good) (warm season: April – Sept. 2015)





Tests of three methods to fix local too high 2m-Td values of a few ARW members (particularly the 4 using MYNN scheme)

(1) Simple cap of 82F

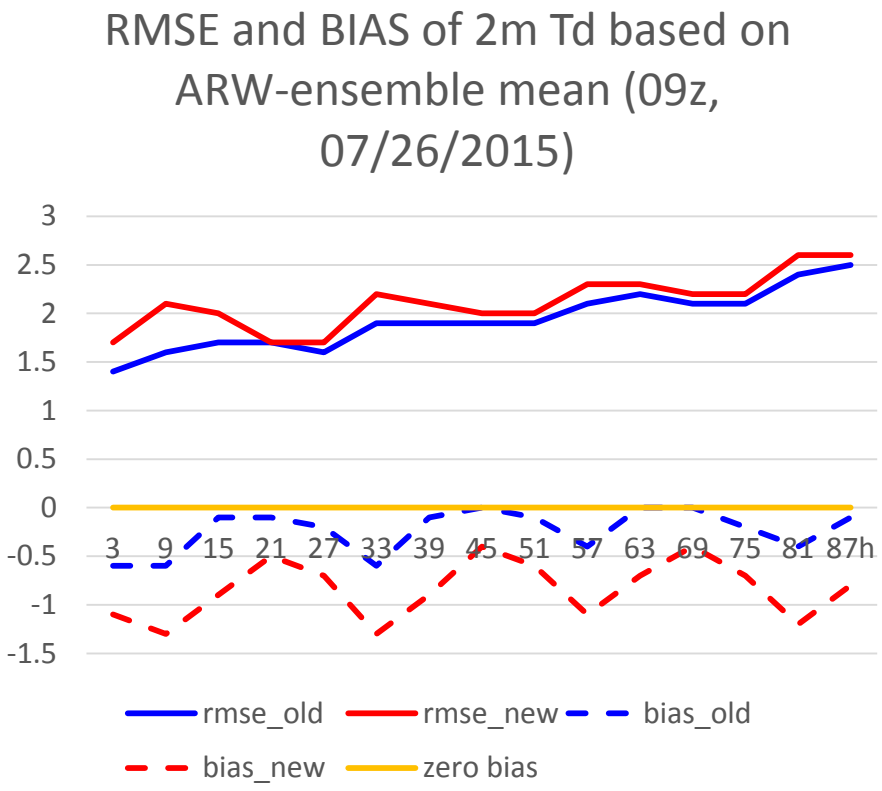
(2) Using model's lowest layer q to calculate 2m-Td over the entire model domain (sophisticated but degraded the overall performance by being too dry)

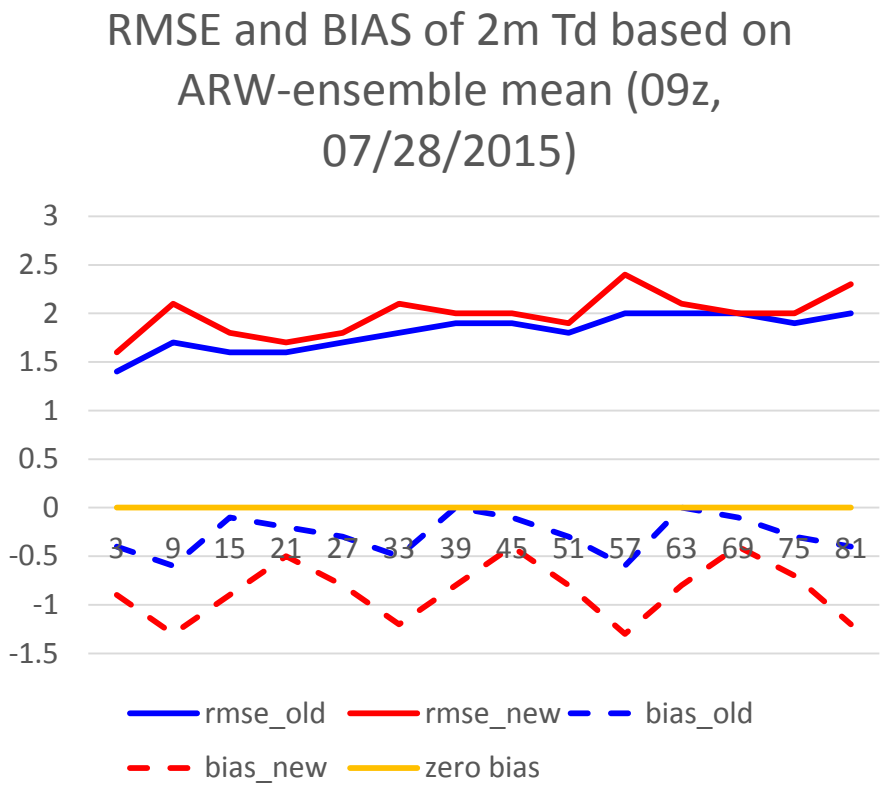
(3) Using model-lowest layer q to calculate 2m-Td only over the area where Td > 82F (kept the overall performance un-degraded but destroyed the spatial structure of high-impact area)

It turns out that the method 1 is the best method to keep both the overall performance not being degraded and spatial structure not being distorted.

Method 2: severely degraded overall performance of 2m-Td by dramatically increasing dry bias

Increased RMSE and dry bias over all forecast hours from 00 to 87h



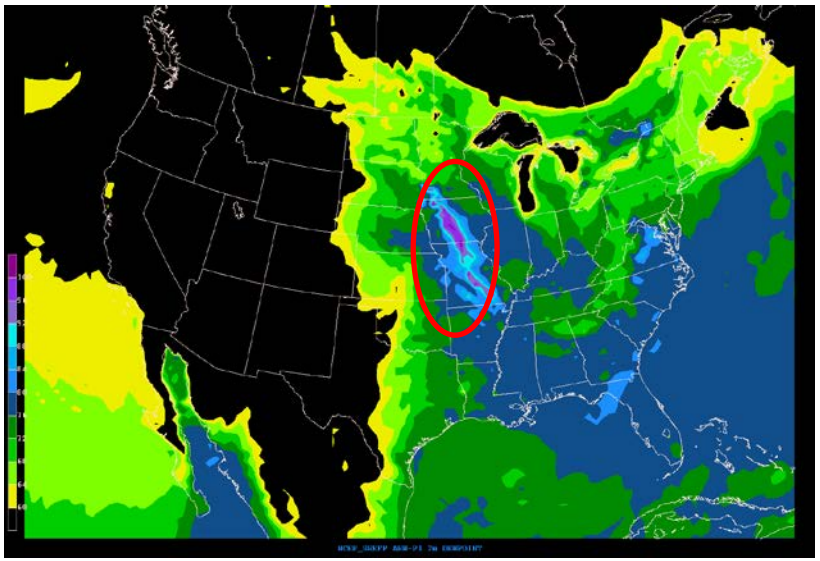


Reason

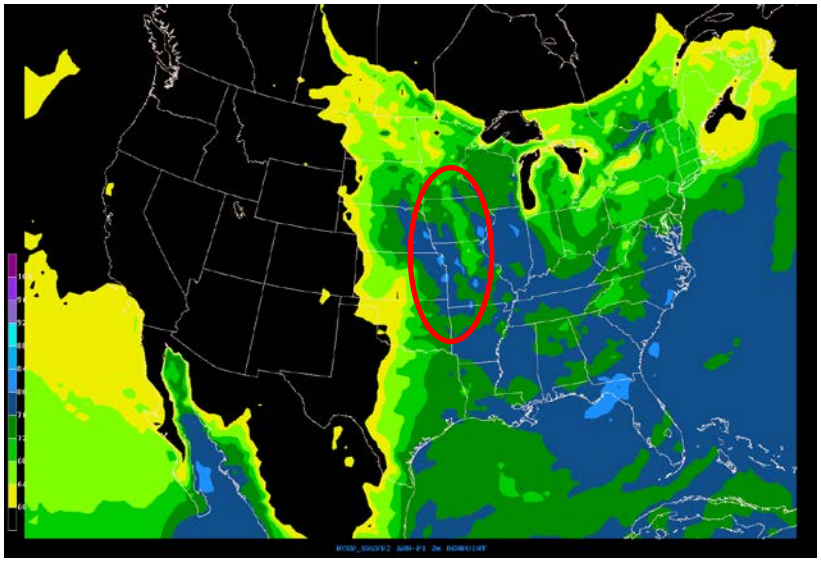
- First layer in the SREF is 7mb deep (1.000 – 0.9930) which is roughly 52m thick and its mid-point would be at 26m.
- 26m level is usually drier than 2m level

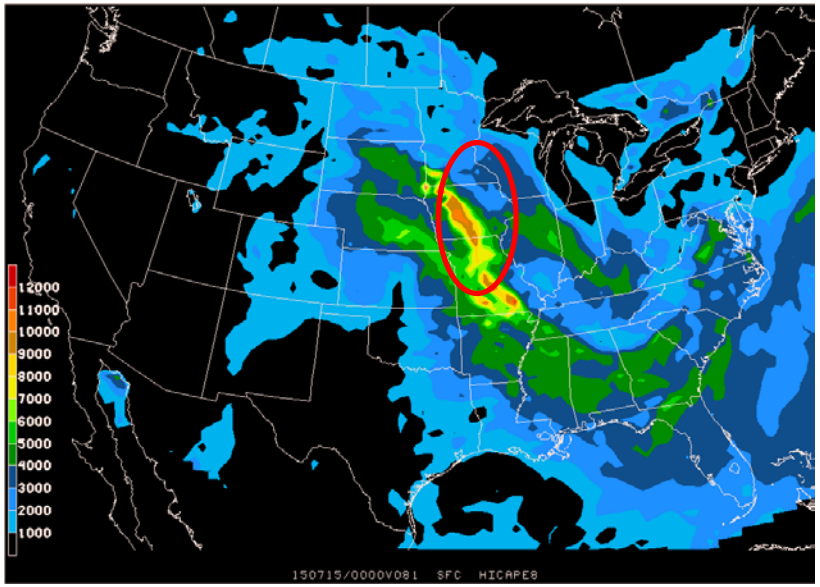
So, how about apply this method only over the area where 2m-Td >82F and leave other areas unchanged (method 3)?

Method 3: inadvertently changed the maximum to local minimum

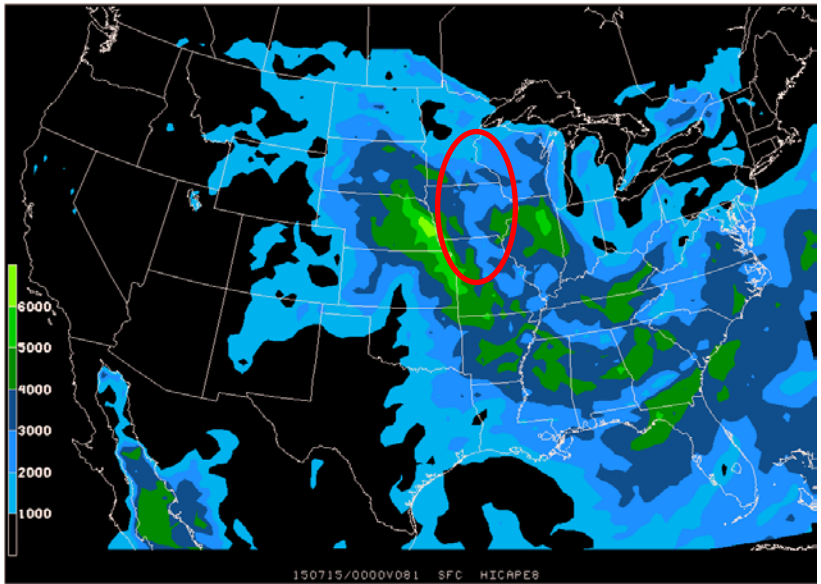


2m-Td





MUCAPE



SPC comment

- After looking at this case, it seems that applying the LML specific humidity value where the 2-m Td exceeds the cap has too strong of a drying effect. While it may not be an elegant solution, it might be better and more physically consistent to just use a constant cap value of 82F (i.e., to keep a maximum plateau rather than introduce a relative minimum).

Method 1 is, therefore, implemented

The impact is limited

- The cap applies only to the dew point at the 2-m level and that it's purely a diagnostic value.
- The primary products that were affected by the problem are the SPC SREF plumes and MUCAPE with a dew members.
- GSD has a new way to calculate 2m-Td to deal with this issue in newer version of ARW which will be used for the next SREF upgrade.

Summary note about the 2m Td cap

- A few ARW members especially p01, n03, n05 and p06 occasionally produce too high dew-point temperature value at 2m level (2m-Td) such as greater than 90F at local locations where 2m-Td is generally expected to be high (greater than 80F). Therefore, a cap of 28C or 82.4F has been added. Based on the tests done by both EMC and SPC, this fix is the best one among the three approaches being tested at this time. It preserves good domain-averaged performance (i.e. no impact on the overall performance of 2m Td) and correct spatial structure of individual cases besides taking care of these occasional high value spikes.

- Note that 2m Td is strictly an alone diagnostic parameter done at model post and does not impact any other forecast parameters. All model-produced variables are good and nothing to do with this issue. In other words, the issue is only pertinent to this particular variable 2m Td itself. Impact on the ensemble products of 2m Td such as its mean and probability is expected to be minimal since majority of 26 members have no this issue. No impact is expected on the overall performance of this field. The newest version of ARW model has a new way to calculate 2m Td to take care of this issue, which will be used in the next SREF upgrade.

Activities of involving users and managers during the development

Step leading to implementation	SREF.v7.0
Brief staff, team and/or management via EMC Branch and/or quarterly science briefings	07/10/2014 (WCOSS Science Quarterly) 10/07/2014 (WCOSS Science Quarterly) 11/18/2014 (NAEFS conference) 12/03/2014 (NCEP Production Suite Review) 04/20/2015 (EMC-WPC meeting about winter weather exp) 06/29/2015 (NWP/WAF conference) 07/16/2015 (Model Evaluation Group, MEG, meeting) 08/03/2015 (EMC-SPC meeting about 2m Td) 10/05/2015 (EMC-WPC meeting reviewing winter storm cases)
1-year parallel data to forecasters to use (such as WPC winter weather experiment in Jan.-Feb. 2015)	Oct. 2014 – April 2015 (by EMC) April 2015 – Sept. 2015 (by NCO)
Specifically requested 2-month retrospective run for SPC	April 25 – June 30, 2014
Hold initial coordination discussions with NCO (aka EE or kickoff meeting)	12/3/2014
Draft/Issue/Amend/Final-issuance of Technical Information Notice (TIN)	5/20/2015D TIN 15-32 6/25/2015 I 7/07/2015 A 8/20/2015A
Hold Change Control Board briefing for EMC & NCO prior to code delivery	3/23/2015
Code frozen - begin 30-day pre-implementation test	6/22/2015 -- 7/24/2015 8/17/2015 – 9/15/2015 (restart 30 day for SPC due to 2m Td)
Brief NCEP Director to obtain authorization to implement	9/25/2015 (primary for overall) and 10/13/2015 (supplementary for winter storms)
NCO implements into NCEP Production Suite	10/20/2015

Summary

Highlight: Unified the models by eliminating NMM: one step closer to NCEP strategic unified modeling system, increased ensemble membership from 21 to 26

1. Reduced cold bias in surface temperature (2m T)

2. Reduced wet bias in surface moisture field (2m RH, not precipitation)

3. Increased ensemble spread (diversity) especially for ARW members

4. Precipitation: improved in winter and similar in summer due probably to the removal of NMM model (WPC concern)

5. Improved overall skill of probabilistic forecasts for most variables.

6. Improved visibility and cloud ceiling etc. aviation products due to the increased vertical resolution (verified by AWC)

Future: To improve precipitation forecasts by adding probability-matched mean

To implement the new way of calculating 2m Td in ARW model (GSD)

To add reliability score in precipitation verification

N
C
E
P

Supplementary material for

EMC Implementation Briefing of SREF.v7.0 (Q1FY16):

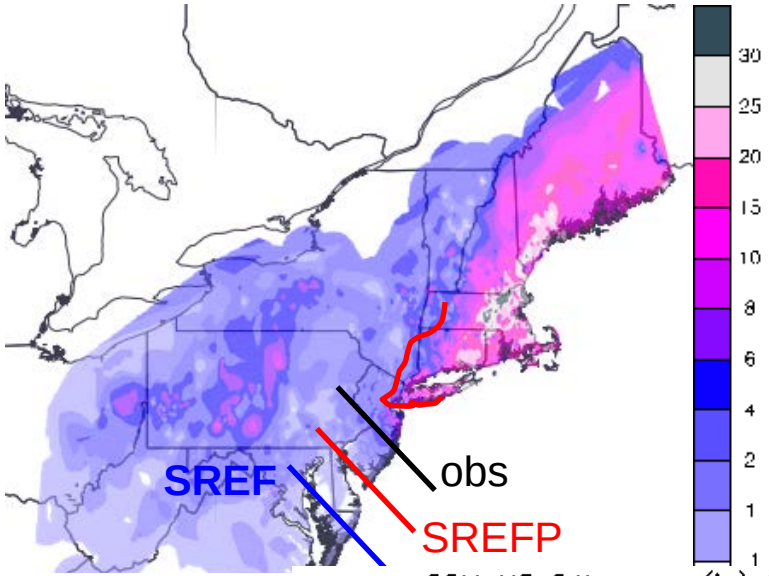
Performance in winter storms

(NCWCP, October 13, 2015)

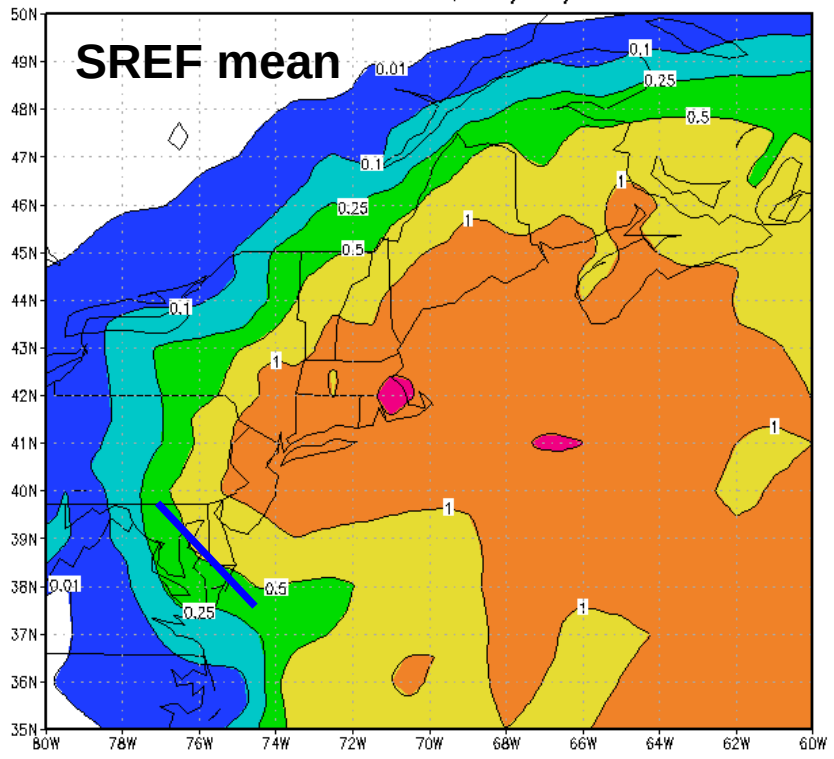
High-impact winter storms investigated (Mar. 2014 – Feb. 2015)

Case	Model cycle	Verification time	Parameter	Result
1. Northeast Blizzard	09z, 01/25/15	00z, 01/28/15	24h-apcp	Improvement
2. Mid-west holiday storm	09z, 12/22/14	00z, 12/25/14	SLP/cyclone position and 12h-apcp	Improvement
3. False alarm mid-Atlantic clipper	09z, 12/28/14	00z, 12/31/14	24h-apcp	Improvement
4. Mid-Atlantic heavy rain	09z, 02/24/15	00z, 02/27/15	24h-apcp	Improvement
5. Lake effect snow	09z, 11/26/14	00z, 11/29/14	24h-apcp	Both excellent, SREF even better in max amount
6. East Cost snow	09z, 03/01/14	12z, 03/03/14	T2m and 24h-apcp	No improve in T2m and improve in precipitation
7. Midwest/Western Great Lakes snow	09z, 03/16/14	00z, 03/19/14 06z, 03/19/14	24h-apcp	Improvement
8. South New England snow	09z, 02/07/15	00z, 02/10/15	24h-apcp	Mixed
9. Midwest and western Great Lakes snow	21z, 11/08/14	00z, 11/11/14 12z, 11/11/14 00z, 11/12/14	24h-apcp	Both excellent, SREFP better in north boundary

Case 1: Northeast blizzard, 24h-apcp over 00z 1/27 – 00z 1/28, 2015: SREF extended heavy precip too much to the southwest, while SREFP corrected most of this error

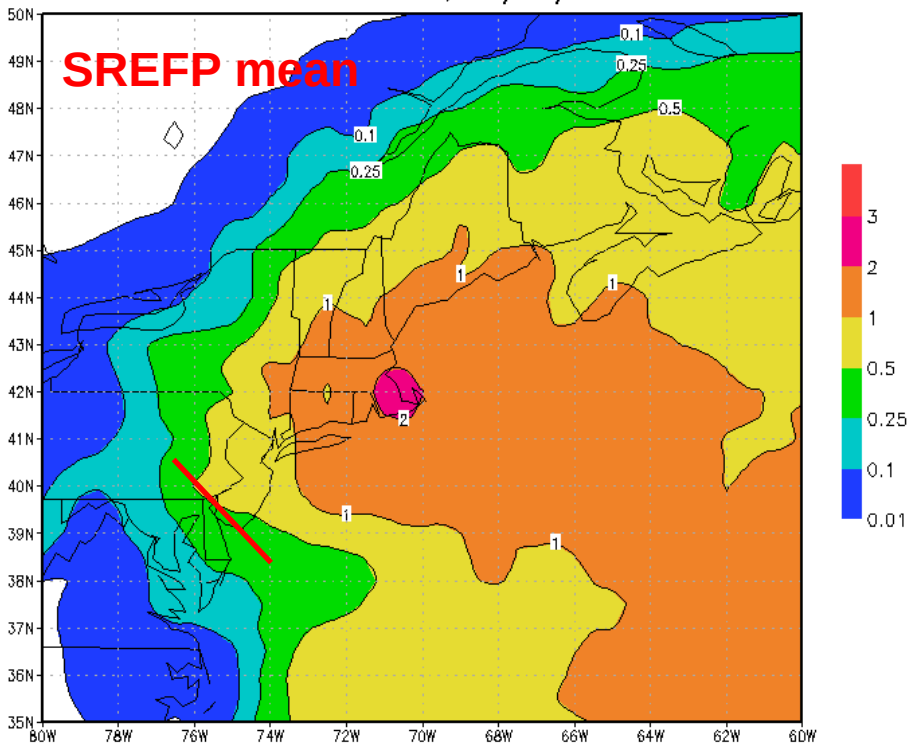


COM_US 24h-apcp (in) 63H fcst from 09Z 25 jan 2015
verified time: 00z, 01/28/2015



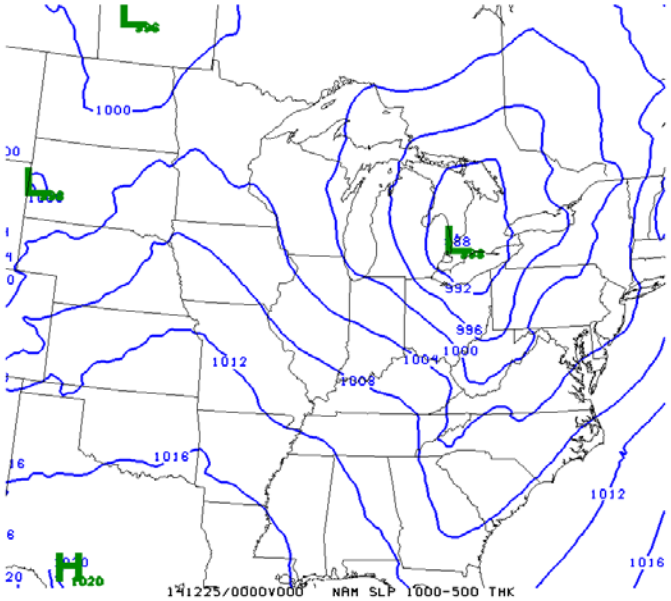
Produced by

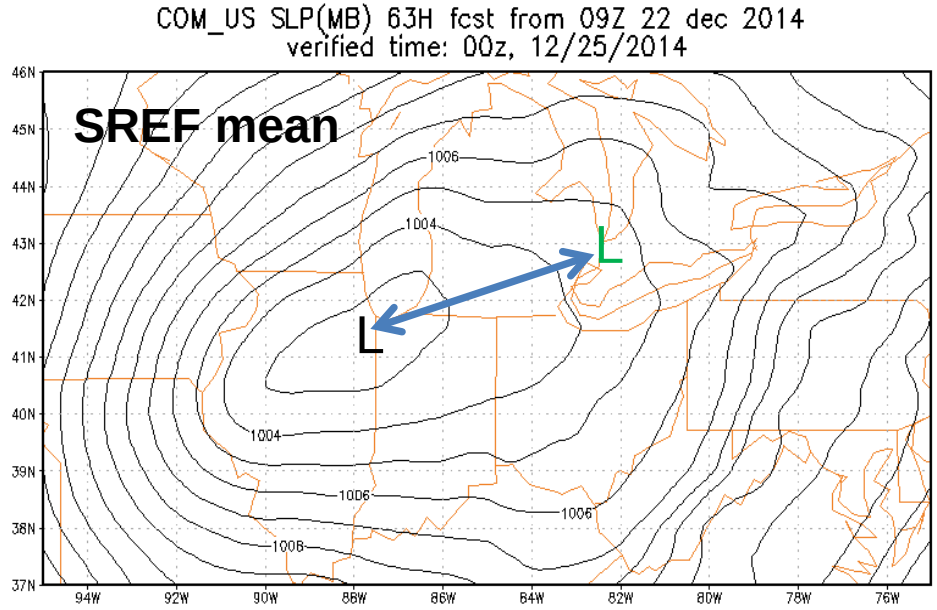
COM_US 24h-apcp (in) 63H fcst from 09Z 25 jan 2015
verified time: 00z, 01/28/2015

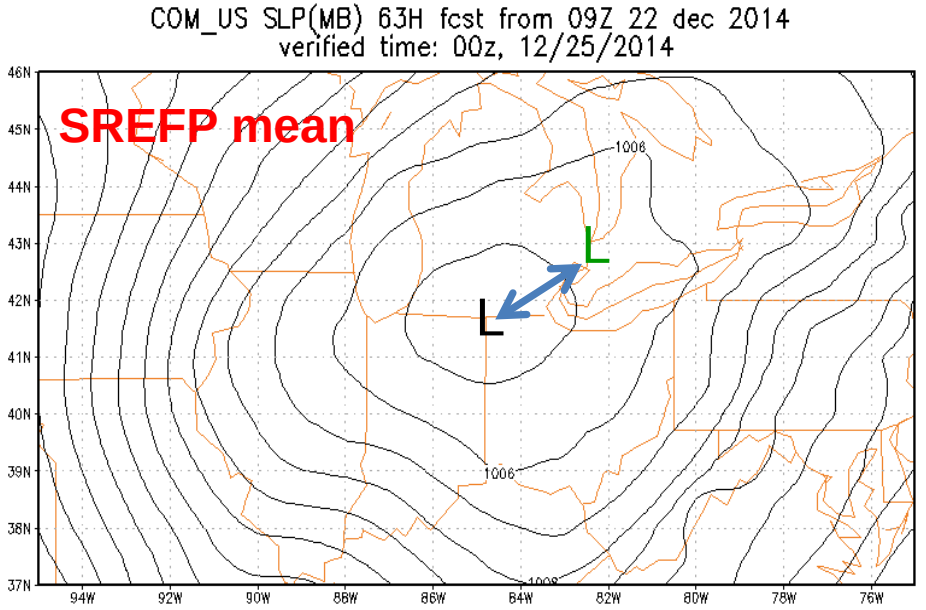


Produced by JUN DU,

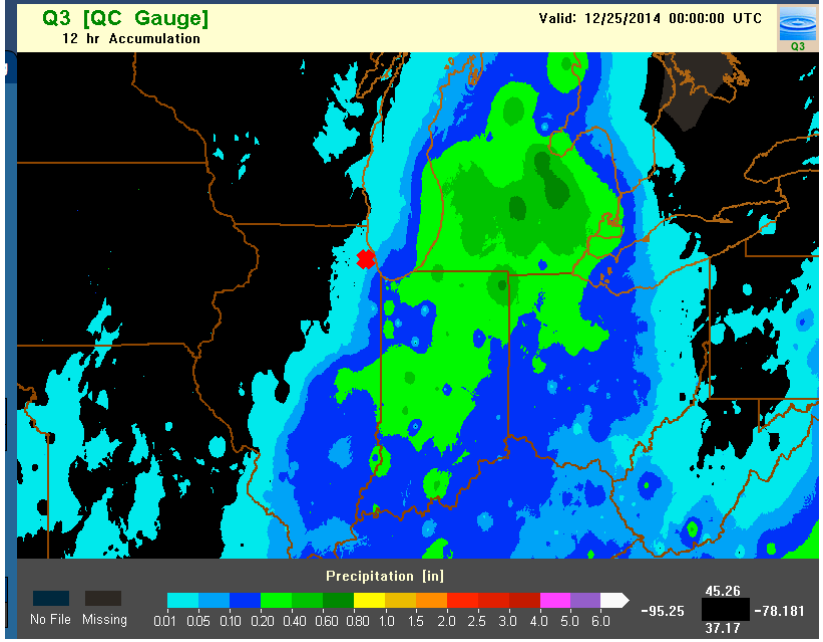
Case 2: Mid-west holiday storm, SLP/cyclone position at 00z, 12/25, 2015: SREFP has much smaller error than SREF in cyclone position

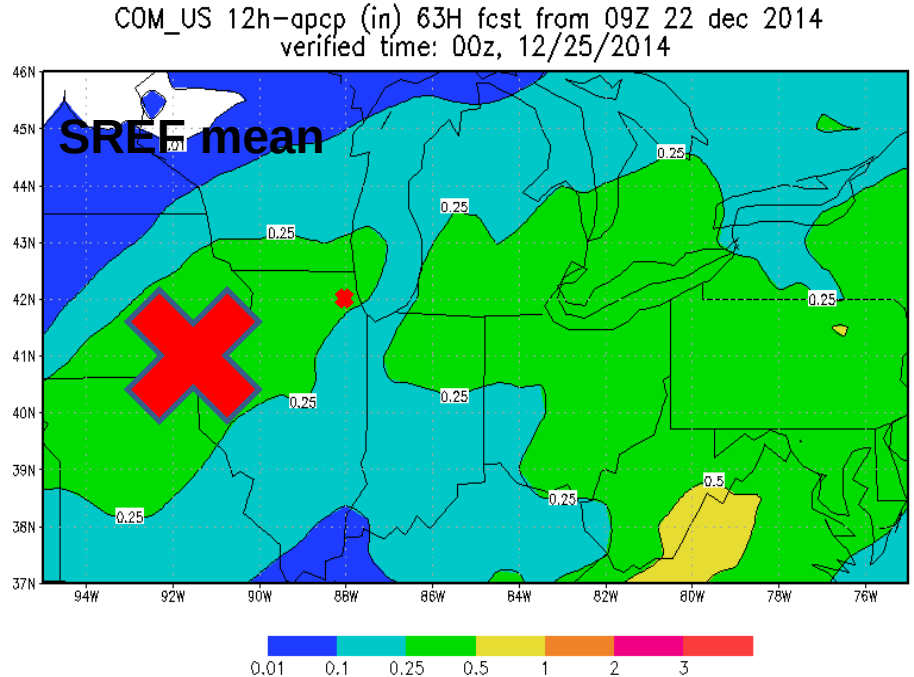


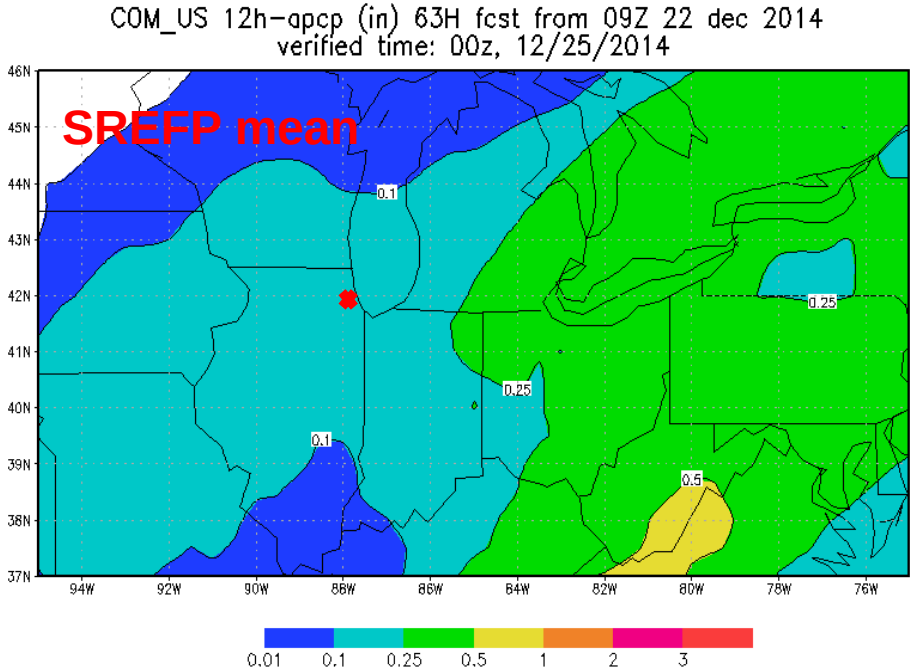




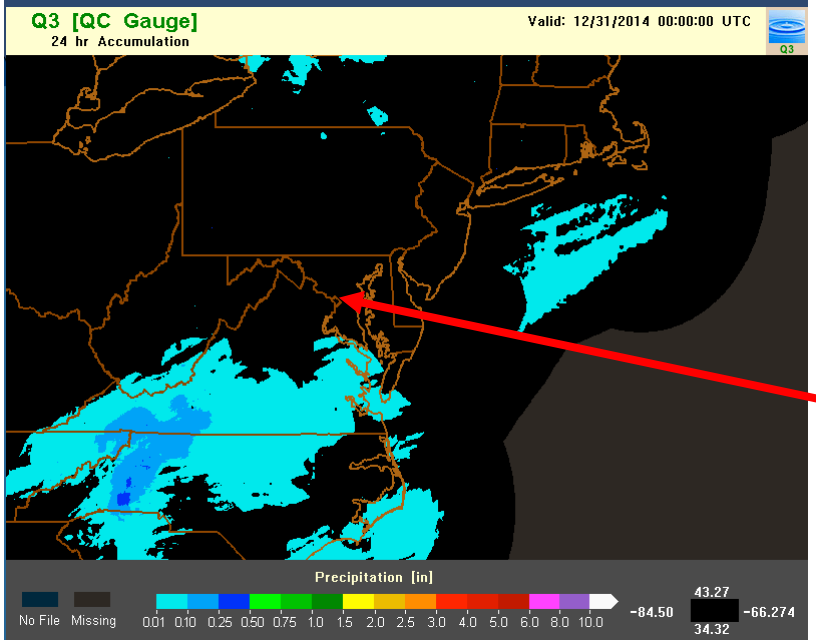
Case 2: Mid-west holiday storm, 24h-apcp over 00z 12/24 - 00z 12/25, 2015: as a result of better cyclone position, a large false alarm area of heavy precipitation southwest of Chicago is correctly removed in SREFP .



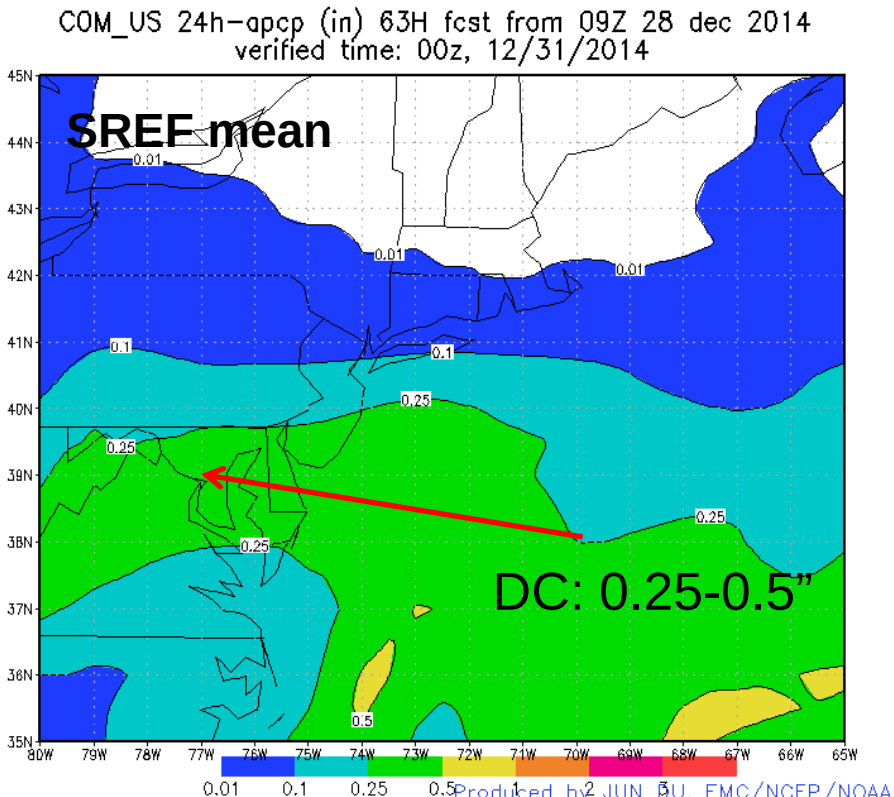


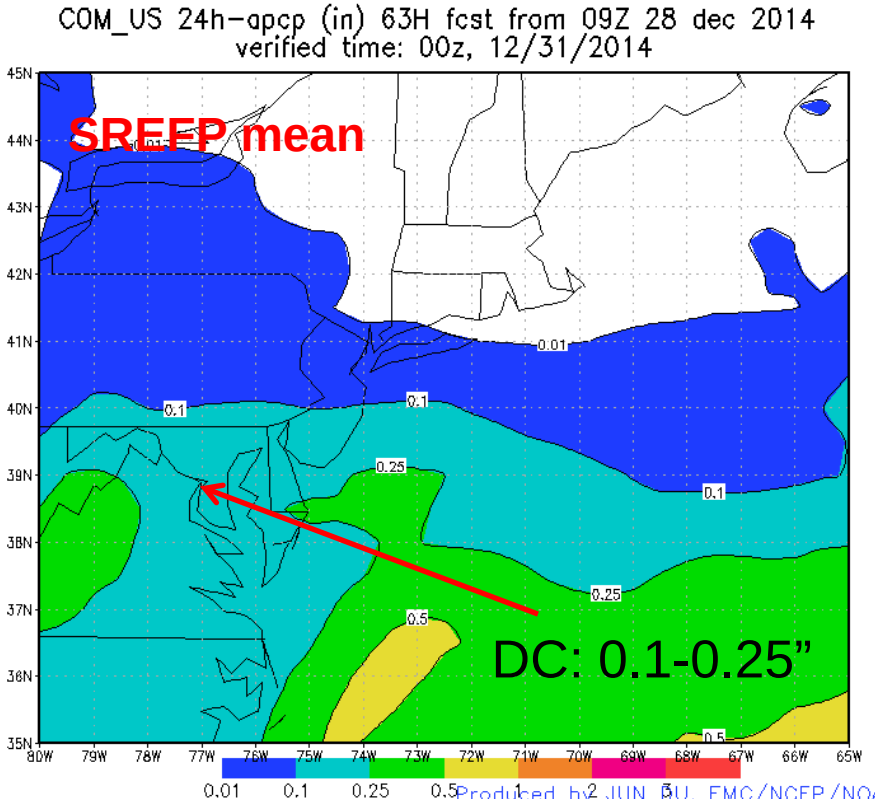


Case 3: False alarm mid-Atlantic clipper, 24h-apcp over 00z 12/30 - 00z 12/31, 2014: SREFP has smaller error in precip forecast



DC: <0.01”





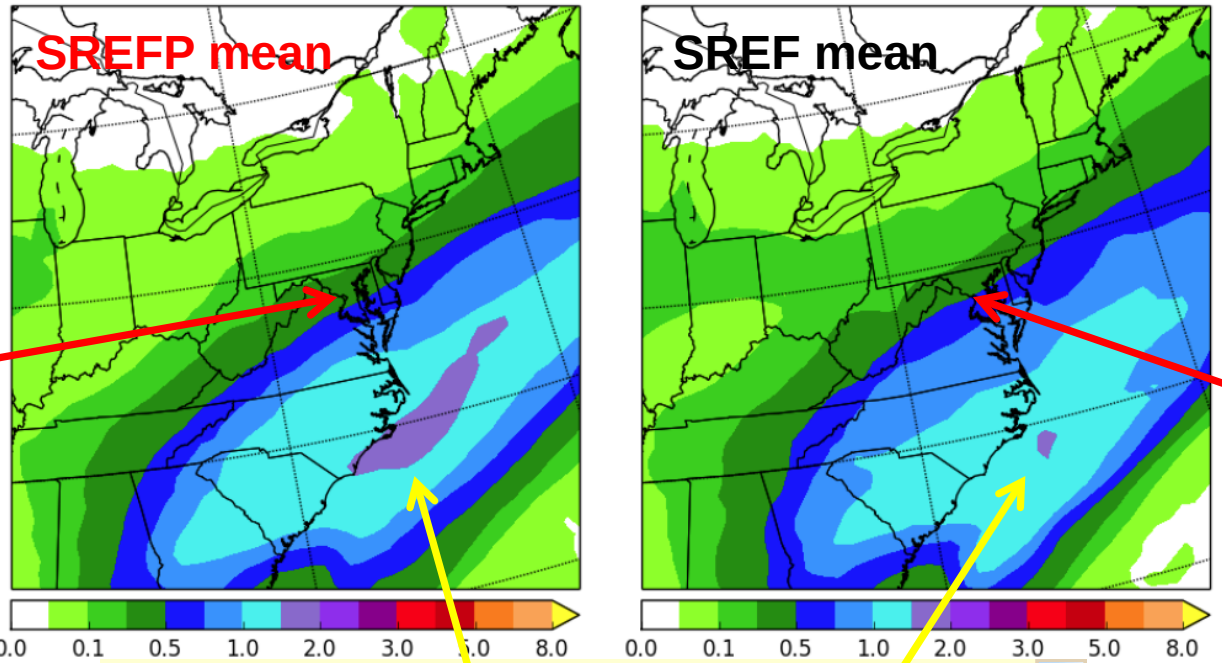
Case 4: Mid-Atlantic heavy precipitation, 24h-apcp over 00z 2/26 - 00z 2/27, 2015: SREFP has smaller error and better heavy rain band structure

Mean 24-hour accumulated precipitation ending 0000 UTC 27 February

09Z/24

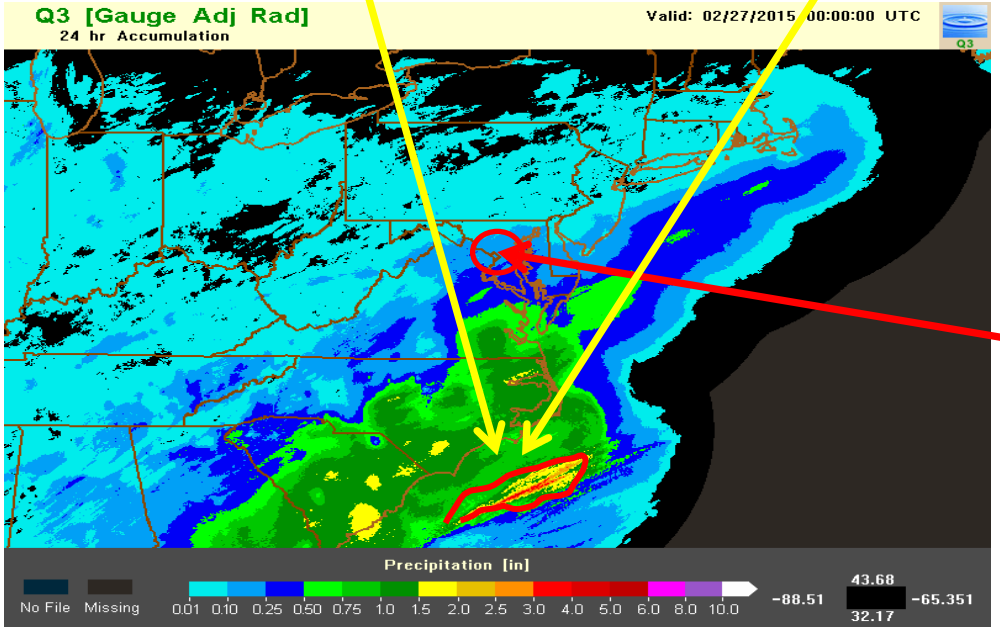
Parallel SREF

Operational SREF



0.25-0.5”

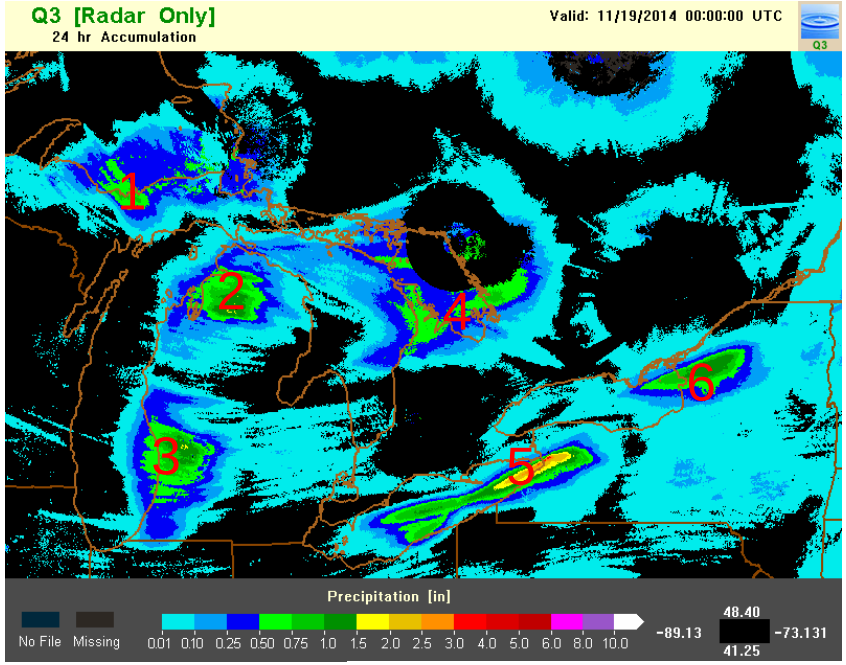
>0.5”

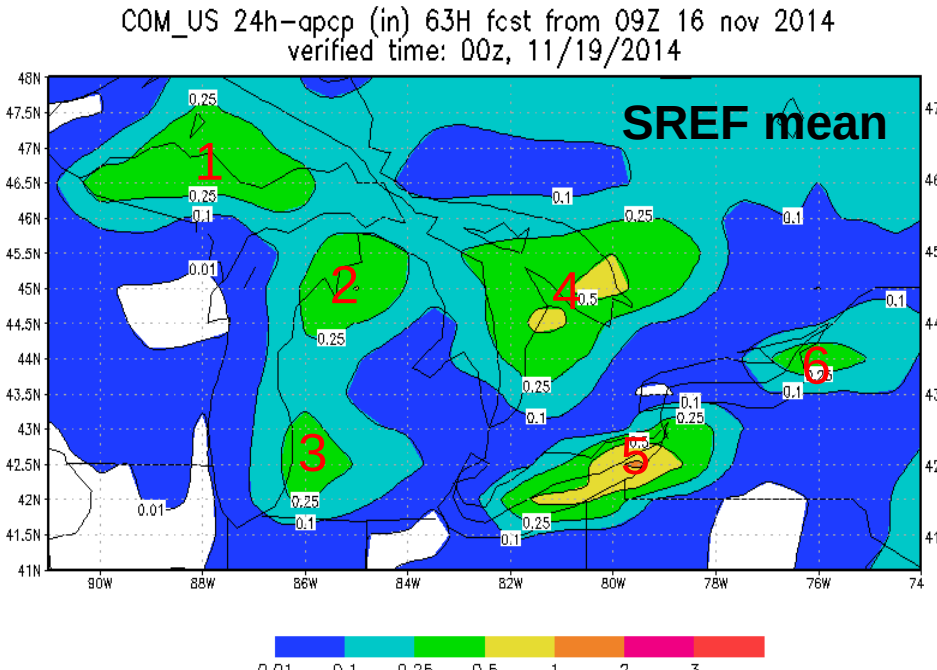


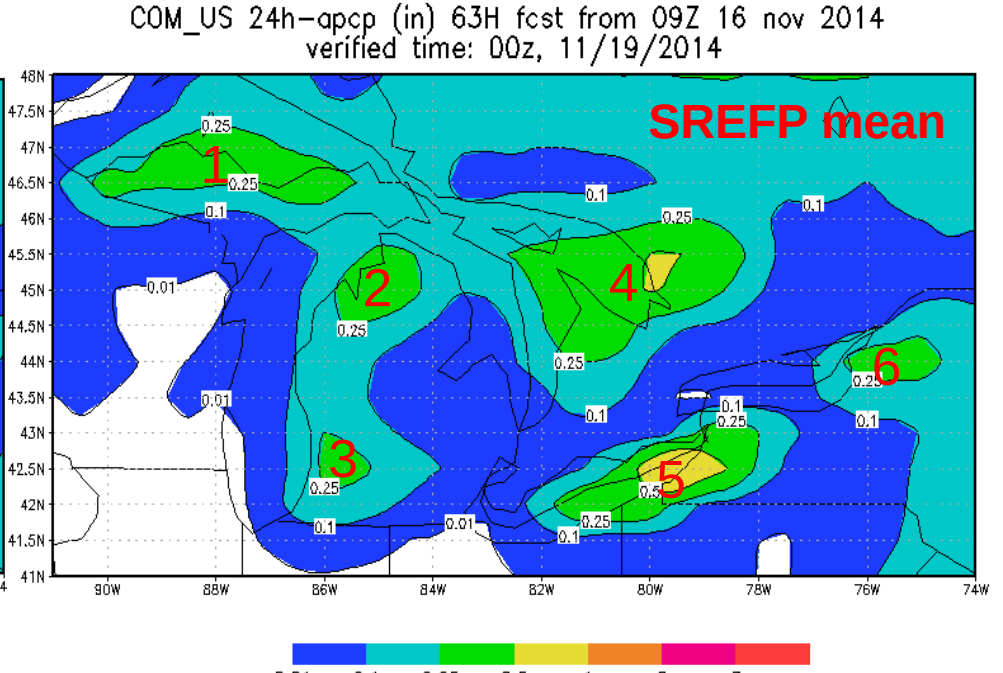
0.1-0.25”

(Provided by Corey Guastini)

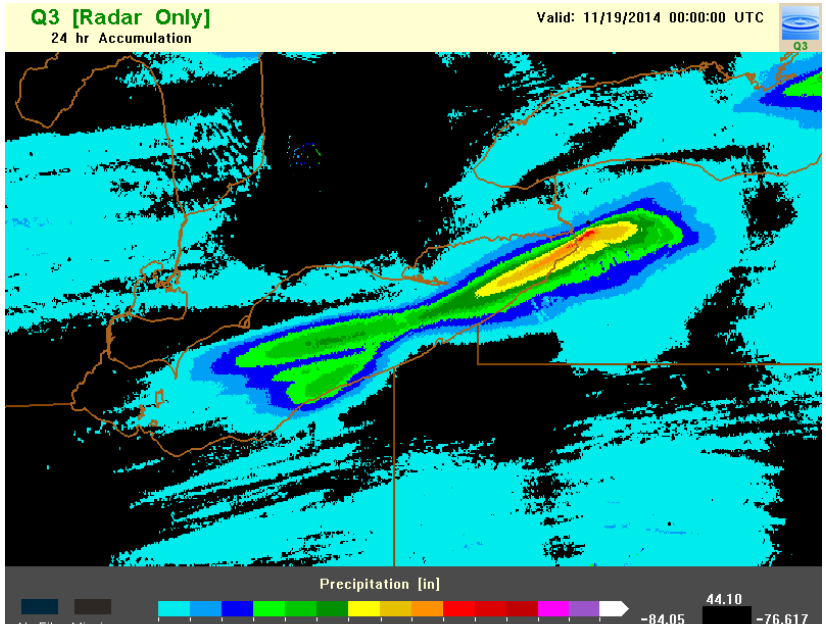
Case 5: Lake effect snow events, 24h-apcp over 00z 11/18 - 00z 11/19, 2014: both SREF and SREFP did an excellent job but SREF is even better in max amount.

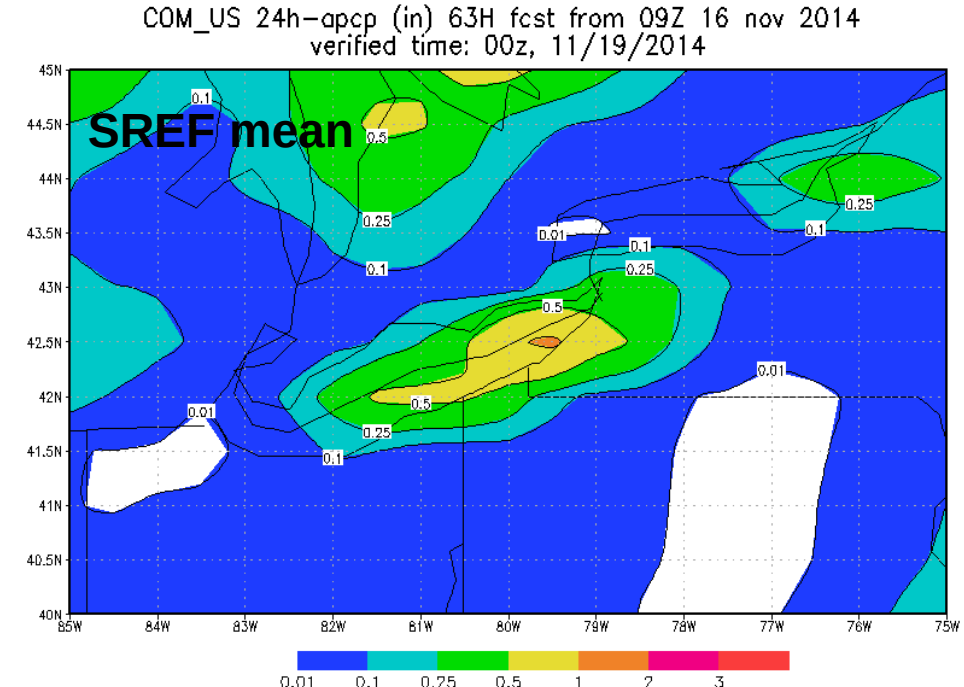


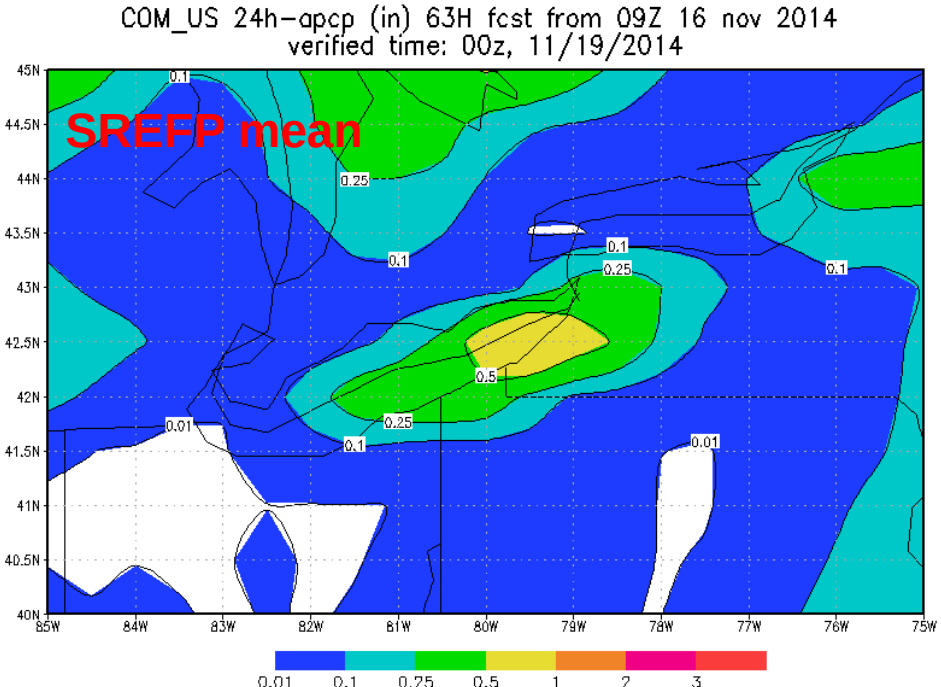




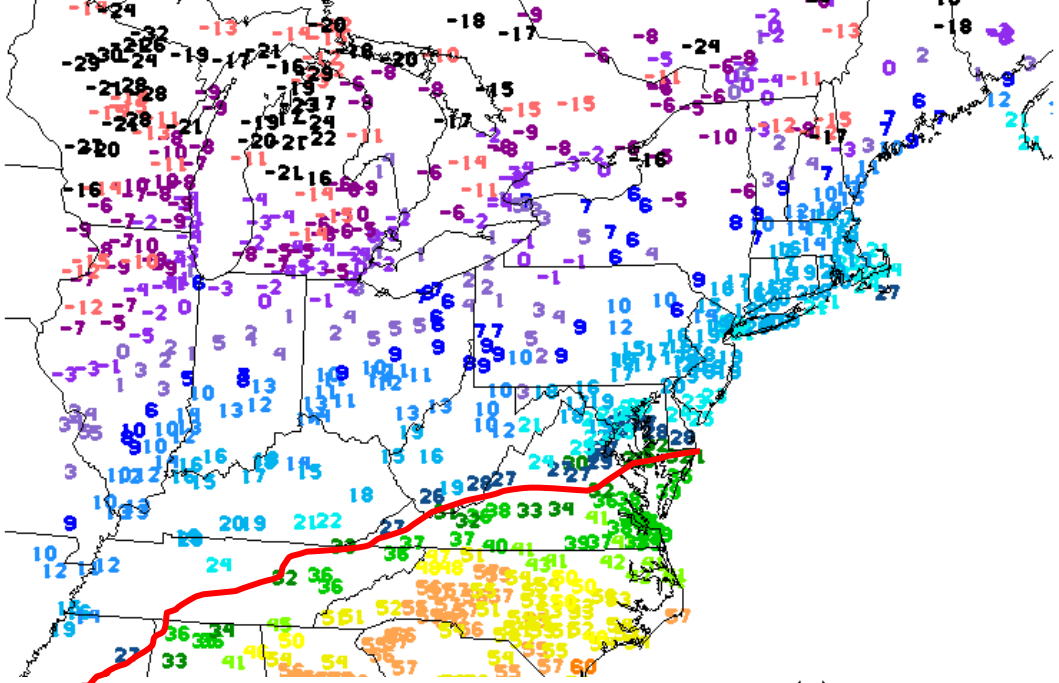
Case 5 (zooming to storm#5): Lake effect snow, 24h-apcp over 00z 11/18 - 00z 11/19, 2014: both SREF and SREFP did an excellent job but SREF is even better in max amount.



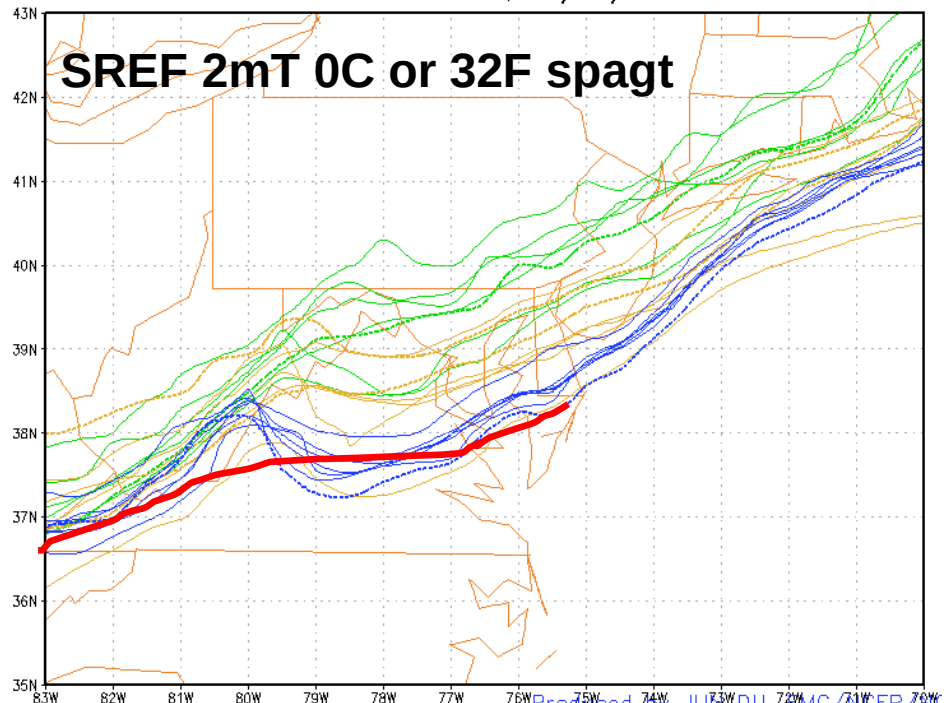




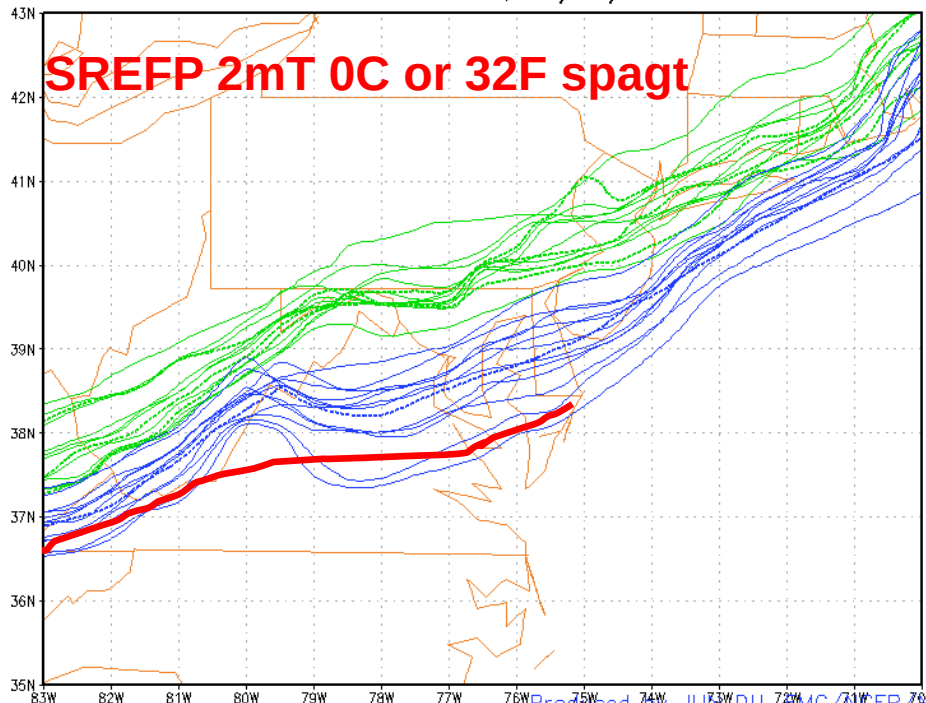
Case 6: East coast wintery precipitation, 2m T at 12z 3/3, 2014: no improvement in warm and dry bias



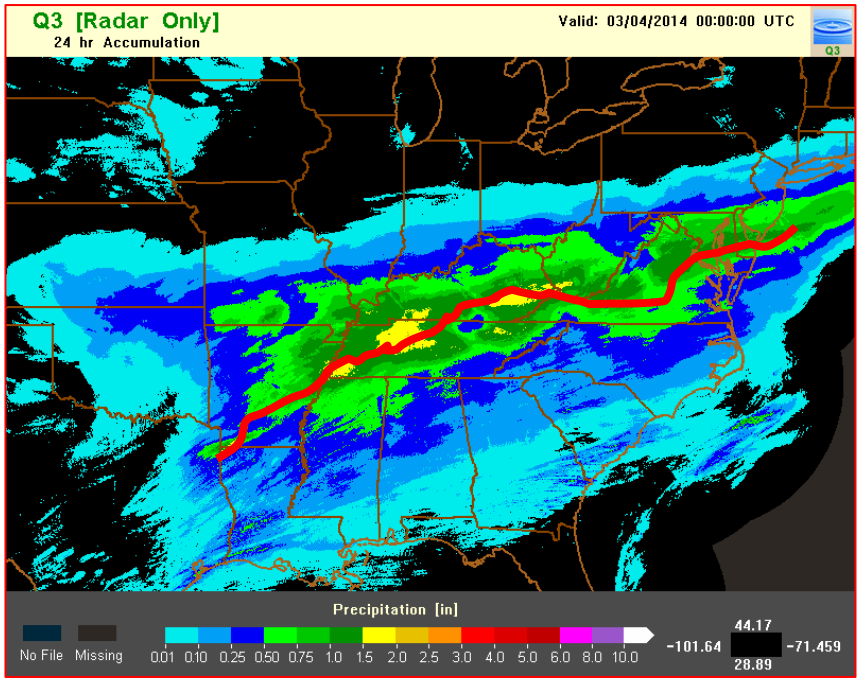
COM_US 2m temp(C) 0C Spgt 51H fcst from 09Z 01 MAR 2014
verified time: 12z, 03/03/2014

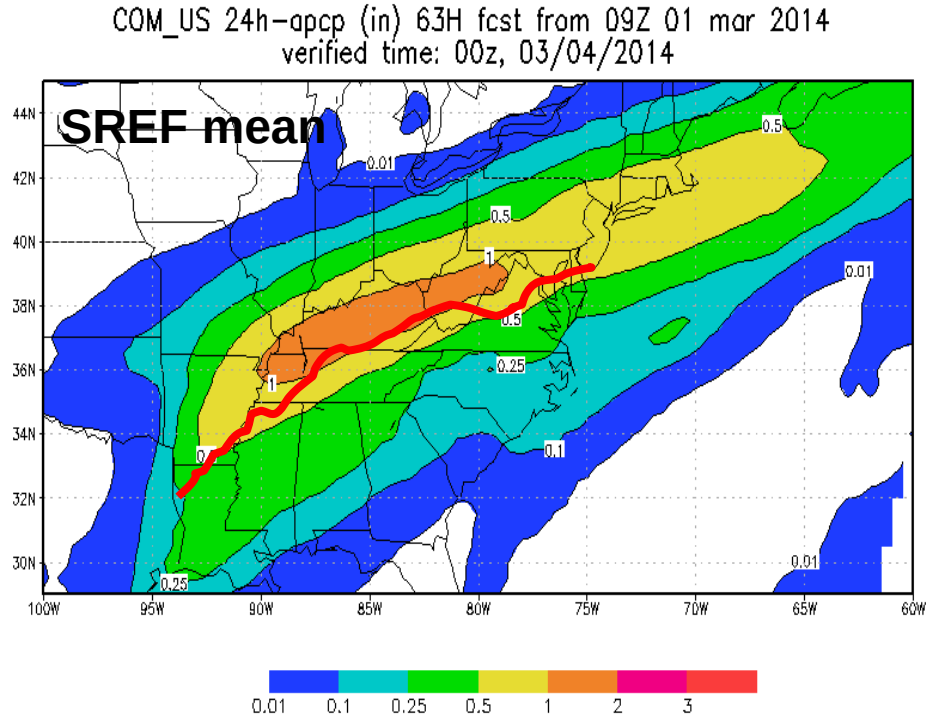


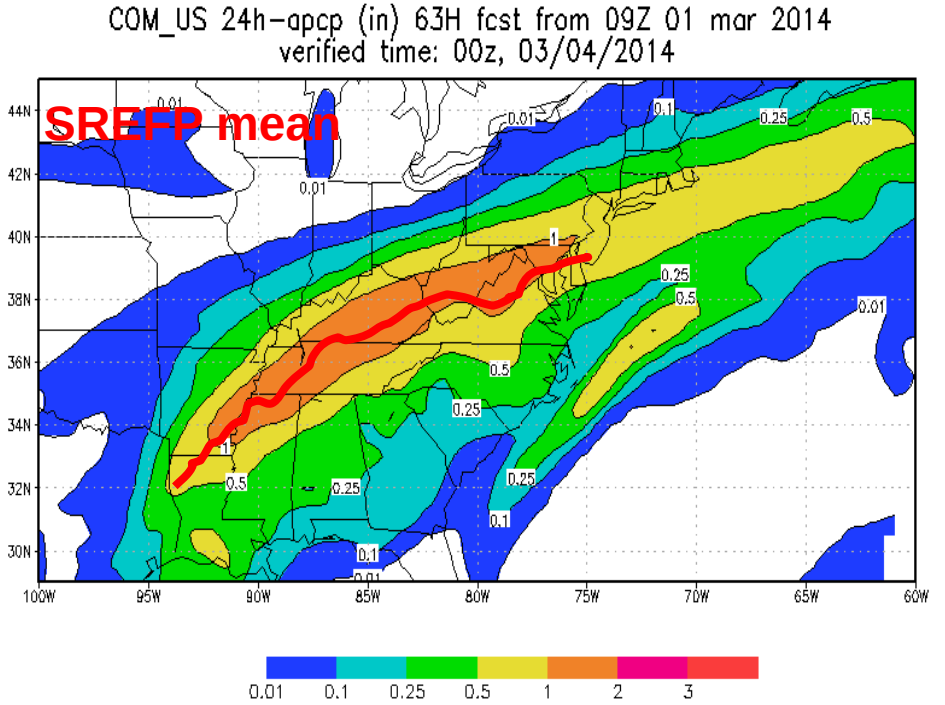
COM_US 2m temp(C) 0C Spgt 51H fcst from 09Z 01 MAR 2014
verified time: 12z, 03/03/2014



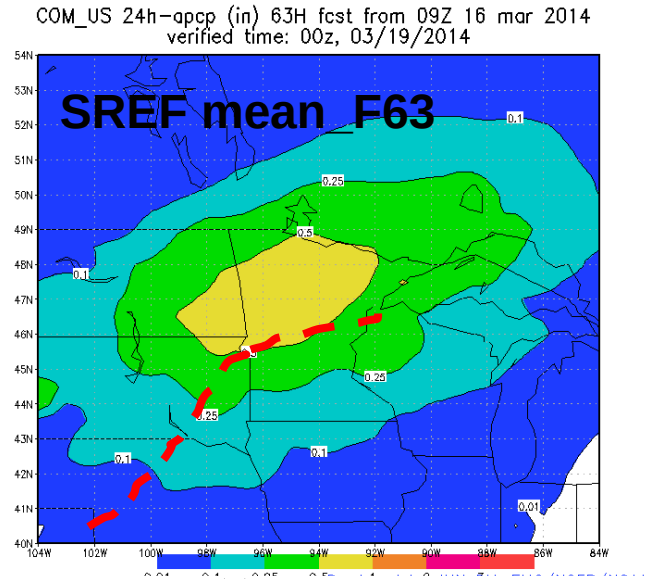
Case 6: East coast wintery precipitation, 24h-apcp over 00z 3/3 - 00z 3/4, 2014: but SREFP has more accurate heavy precipitation band location

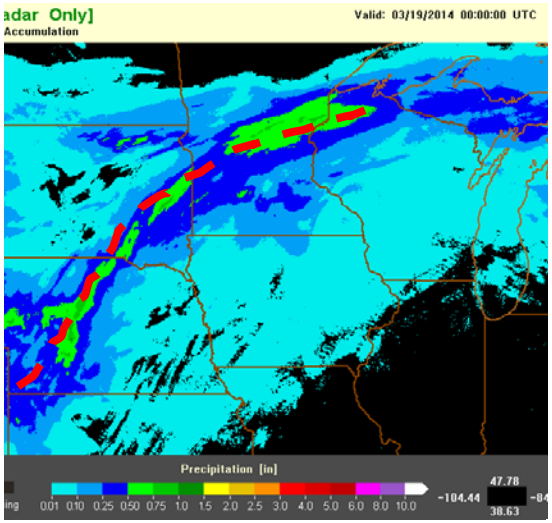


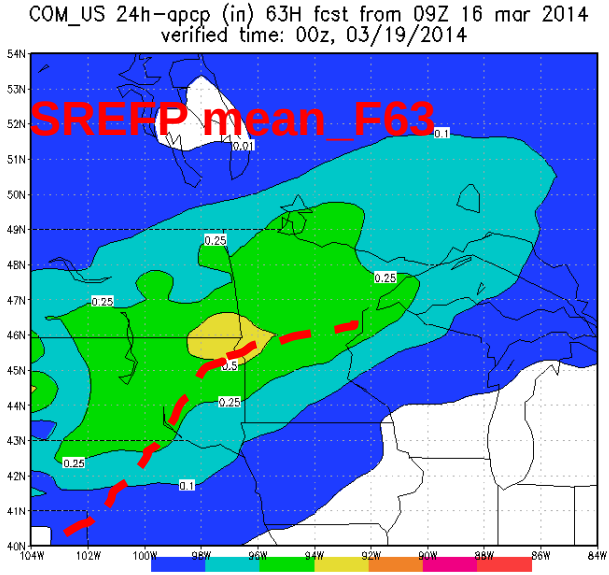


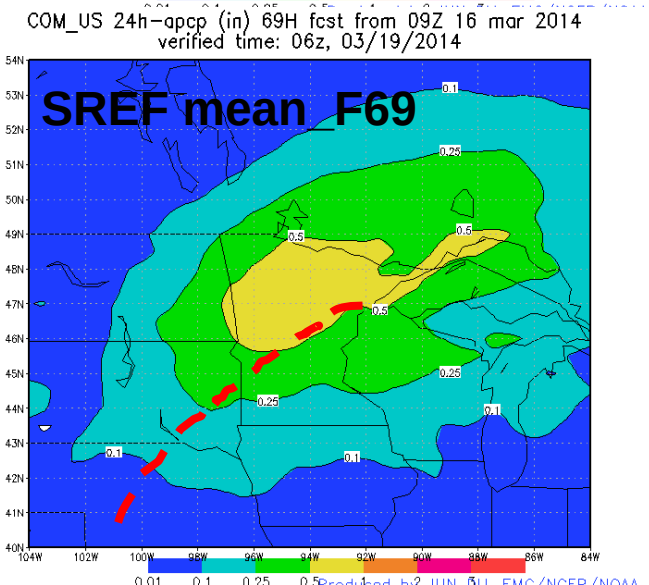


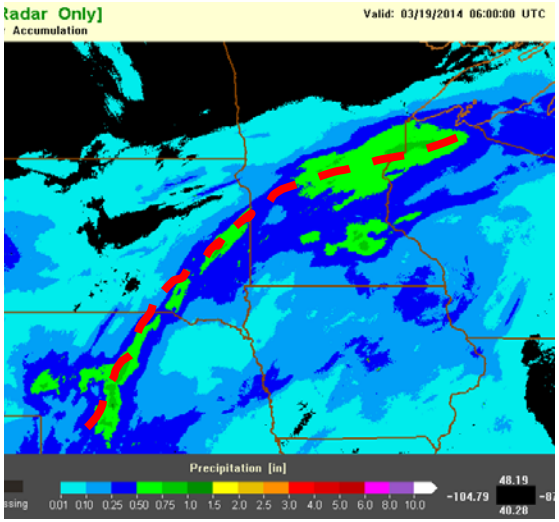
Case 7: Midwest/Western Great Lakes snow event, 24h-apcp over 00z 03/18 - 00z 03/19, 2014: SREFP has slightly better south storm track

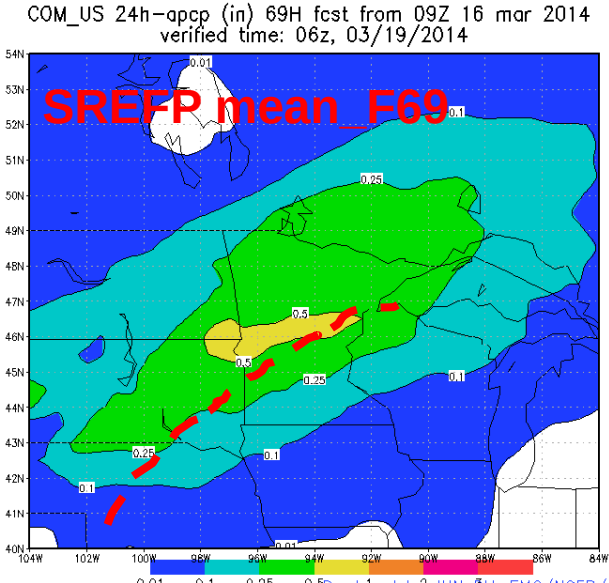




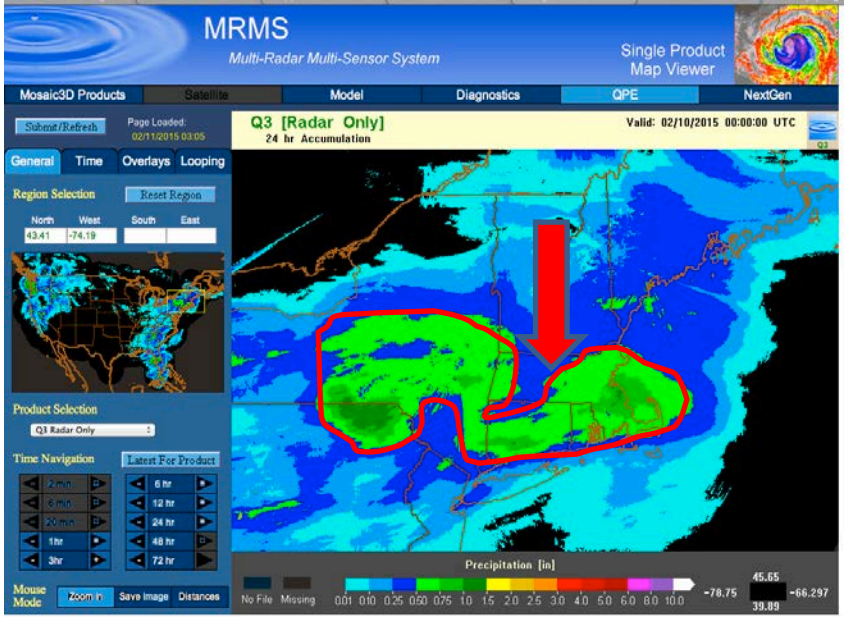


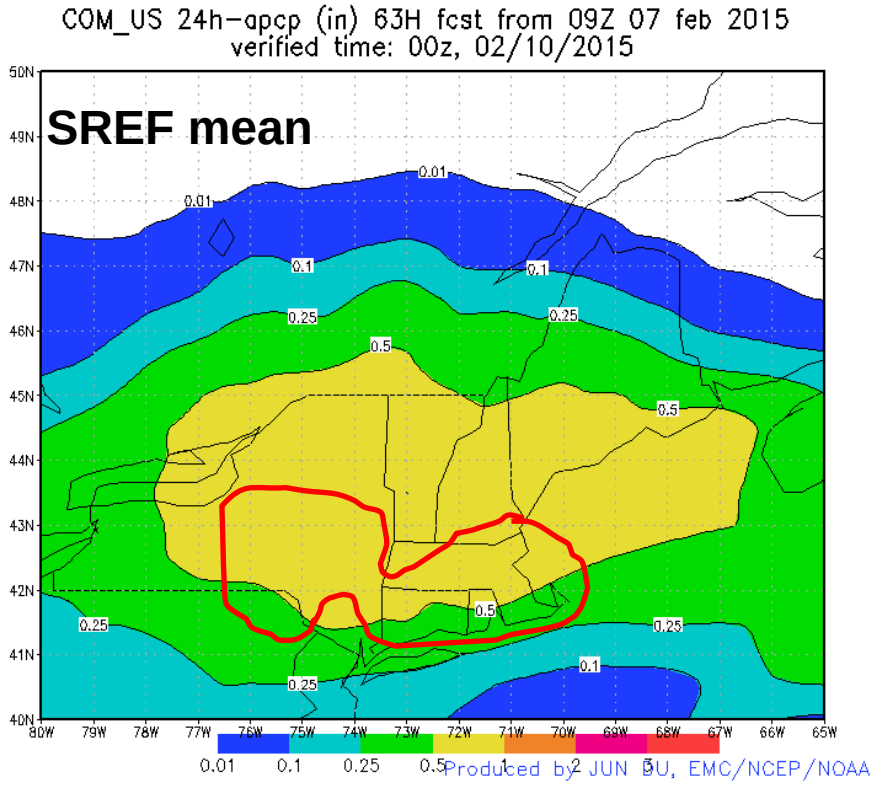


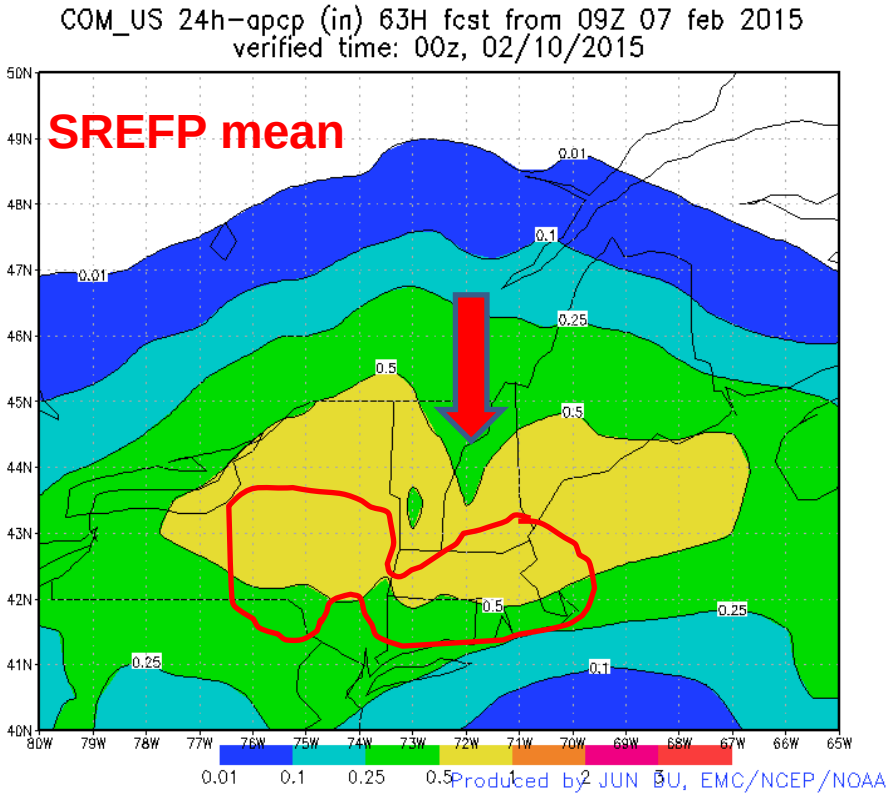




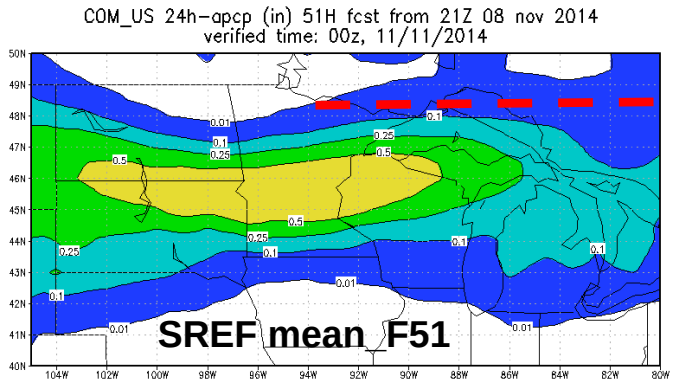
Case 8: South New England snow, 24h-apcp over 00z 2/9 – 00z 2/10, 2015: too large area of heavy precip has been partially corrected, improvement in the north edge but degraded in the south edge, a mixed result

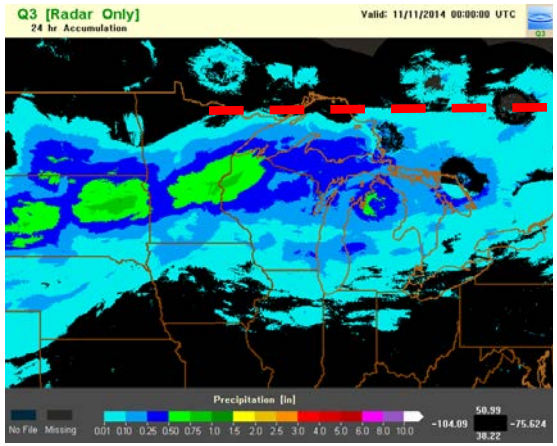


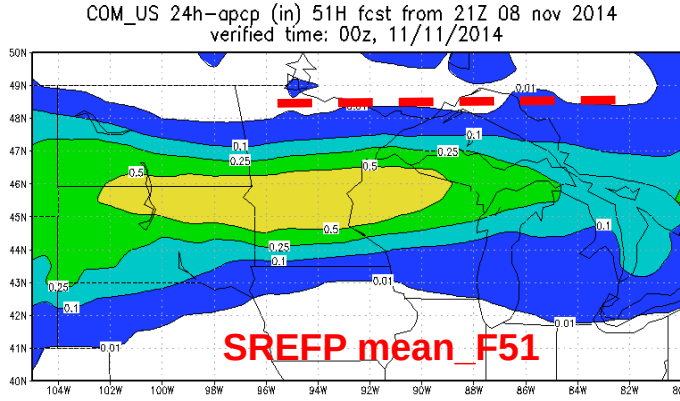


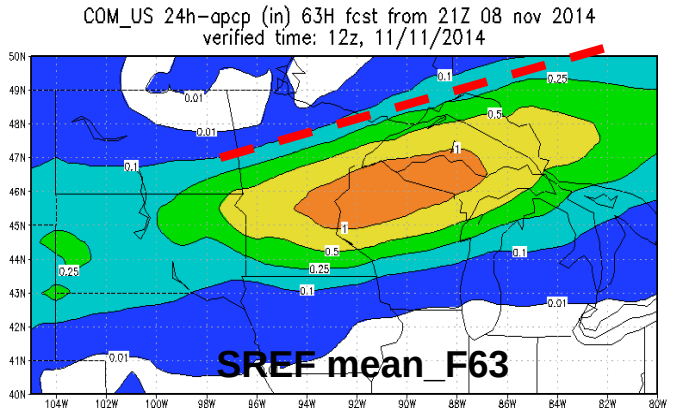


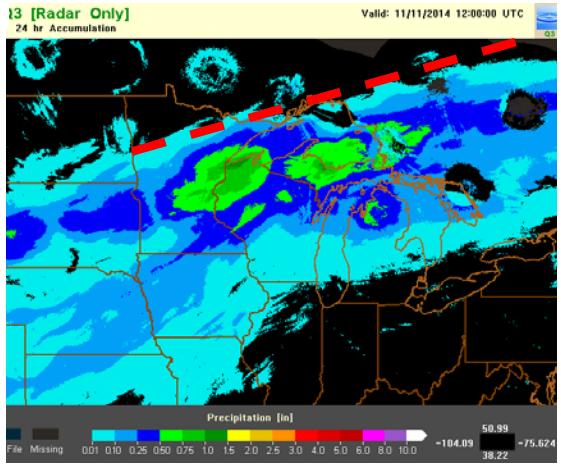
Case 9: similar and both excellent jobs maybe better in defining the north boundary for SREFP

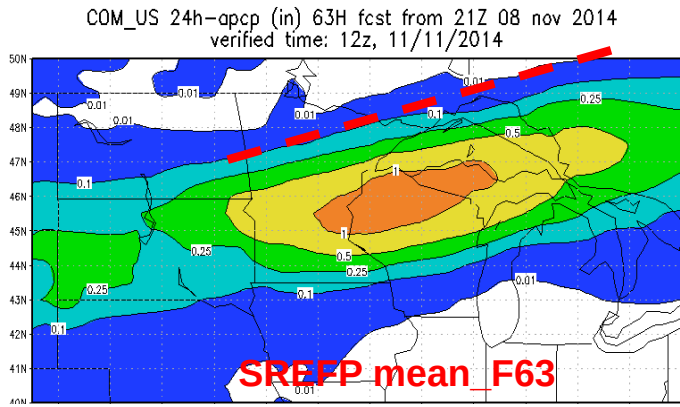


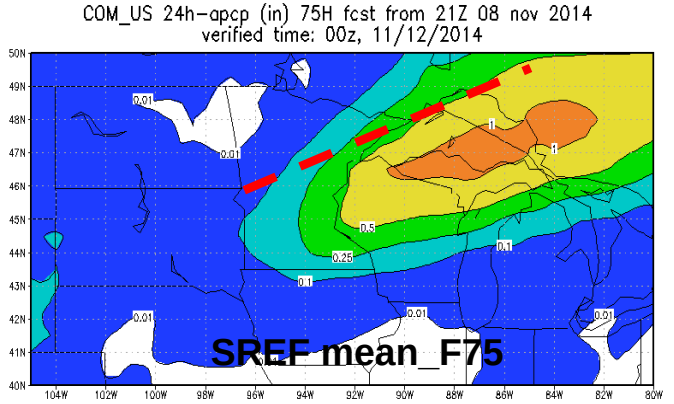


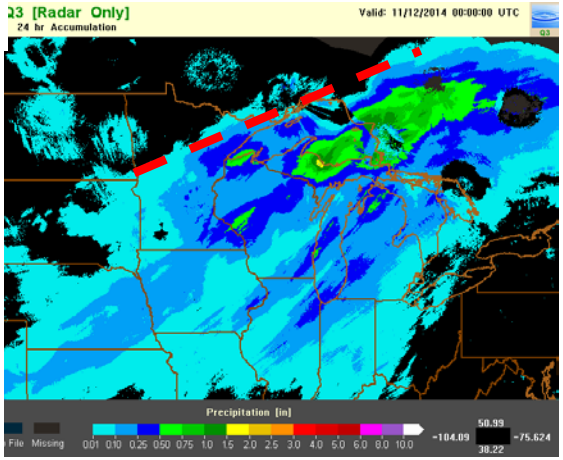


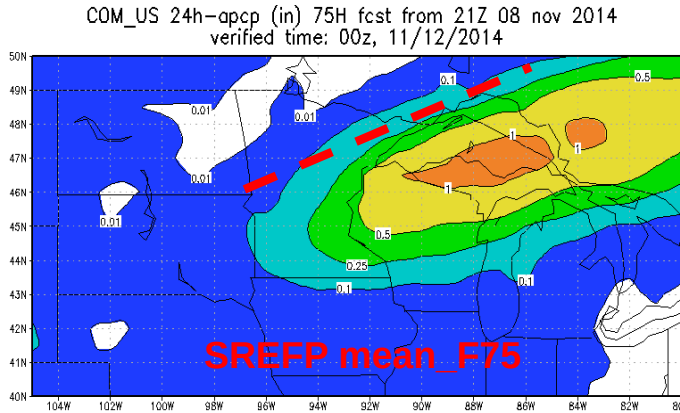












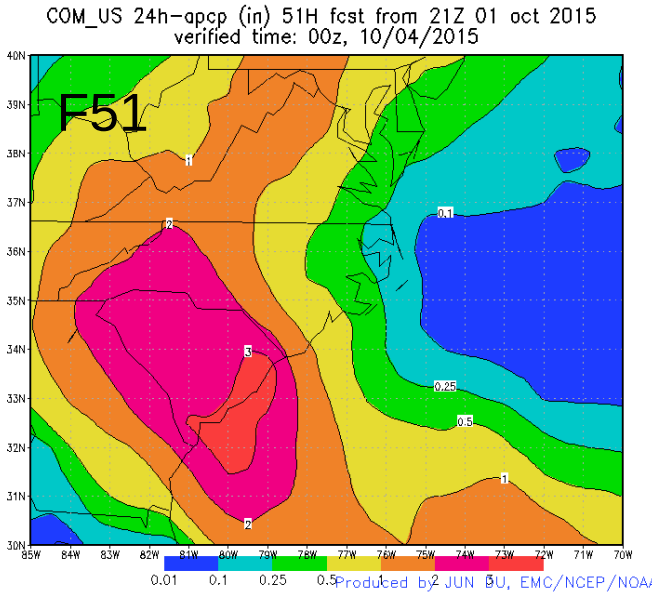
Summary

In overall, SREFP noticeably outperformed SREF for major high-impact winter storms, which should greatly help WPC and WFOs in daily winter storm prediction

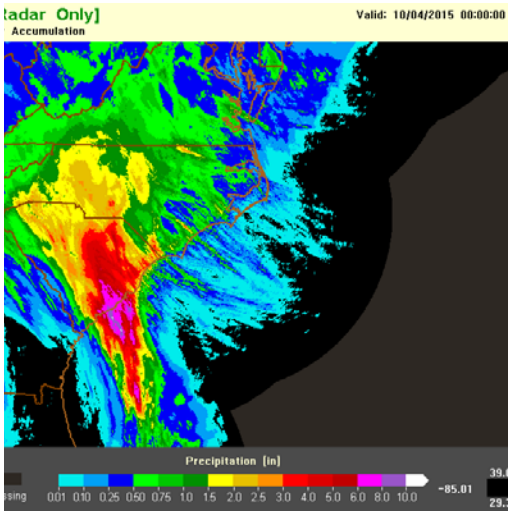
Backup

South Carolina historical flooding events: 24h-apcp of 21z 10/1/15 run
SREFP improved in position and structure of heavy rain area

SREF mean



OBS



SREFP mean