Short-Range Ensemble Forecast (SREF) v.6.0.0 implementation review (Aug. 9, 2012)

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2012 SREF upgrade

- Model Change
  1. Model adjustment (eliminate Eta and RSM legacy models and add new NEMS-based NMMB model)
  2. Model upgrade (two existing WRF cores from v2.2 to version 3.3)
  3. Resolution increase (from 32km/35km to 16km)
  4. All models run with 35 levels in the vertical and 50 mb model top.

- IC diversity improvement
  1. More control ICs (NDAS -> NMMB, GDAS -> NMM, RAP blended @ edges w/GFS -> ARW)
  2. More IC perturbation diversity (blend of regional breeding and downscaled ETR)
  3. Diversity in land surface initial states (NDAS, GFS, and RAP).

- Physics diversity improvement
  1. More diversity of physics schemes (flavors from NAM, GFS, NCAR and RAP)

- New capabilities of post-processing & product generation
  1. precipitation bias correction (individual members and ensemble mean)
  2. clustering and associated mean/prob/spread within a cluster
  3. member performance ranking (different weights for different members)
  4. downscaling to 5km using RTMA and associated ensemble products.
- New ensemble products
  1. max/min, mode, 10-25-50-75-90% forecasts
  2. probs of severe thunderstorm, lightning, dry lightning, fire weather (SPC) as well as LLWS, composite reflectivity, echo top, ceiling and visibility
  3. addition of hourly ensemble product output from 1-39 hr.
  4. ensemble mean bufr
  5. a new 16km output grid covering North America (g132)

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	Blend	BMJ	FER (new Eta)	GFDL	GFDL	MYJ	M_Obuhov (Janjic Eta)	no	NOAH	GFS	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	ETR	KF (new Eta)	FER (new Eta)	GFDL	GFDL	MYJ	M_obuhov (Janjic Eta)	no	NOAH	RAP	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												

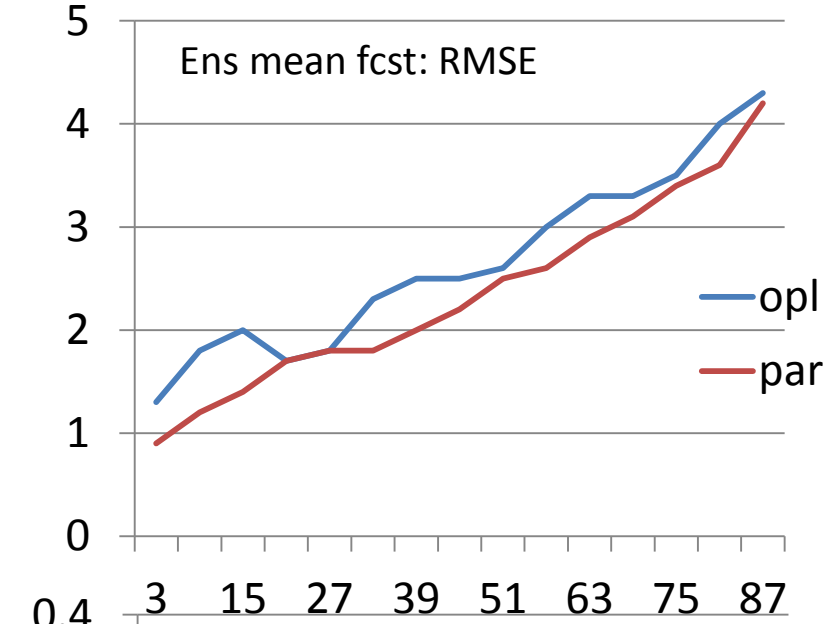
List of ensemble products

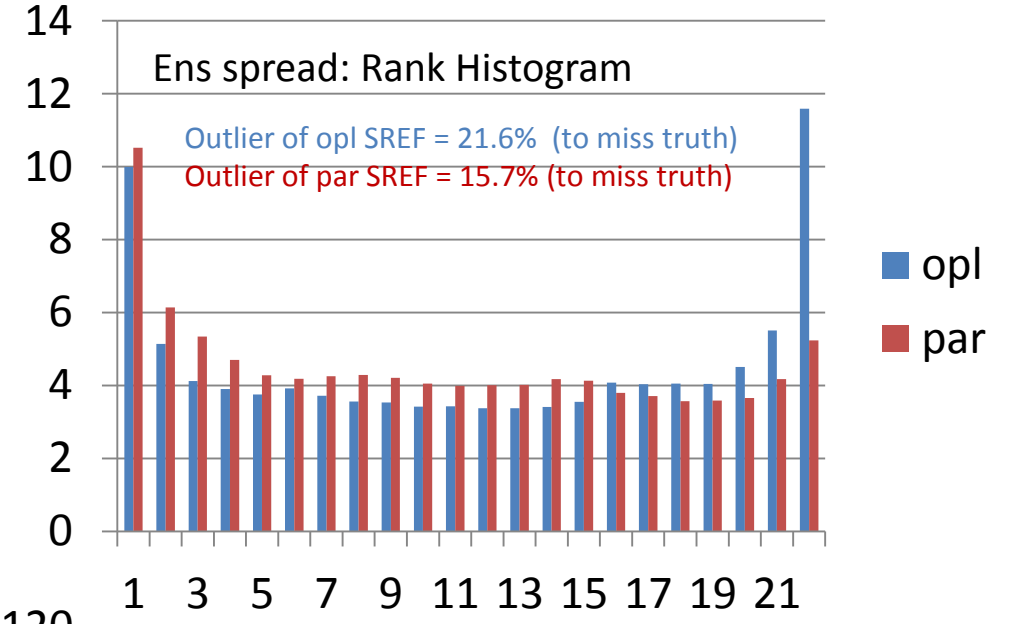
	Surface products	Upper-air products
Mean and Spread	● 10m U, V, and speed ● SLP ● 2m RH ● 2m T ● 2mTd ● CAPE ● CIN ● PWTR ● LI ● 1, 3, 6, 12, and 24 hr APCP ● 3, 6, 12, and 24hr acc snow ● Precip type ● Visibility ● Fog LWC ● Ceiling ● Cloud top ● Total cloud ● LLWS	● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● Height at 1000, 850, 700, 600, 500, 300, 250mb ● Abs Vorticity at 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300mb ● T at 700, 600, 500, 300mb ● Td at 850, 700, 500, 300mb ● SREH at 7600m ● Wind speed at 1000, 850,7 00, 600, 500, 300, and 250mb ● Thickness 218600m, 12900m,18005m ● Thickness of 1000-850, 1000-500,850-700mb
Prob	● Ceiling<500, 1000, 2000, 3000, 4000, 6000 feet ● Visibility<0.25, 0.5, 1, 2, 3, 5, 6 mile ● Flight condition of LIFR, IFR, MVFR,VFR ● LLWS > 20knots / 2000feet ● Reflectivity > 10, 20, 30, 40 dBZ ● Echo-top > 3000, 9000, 15000, 21000,30000feet ● Fog light, medium, dense ● 10m wind speed > 20, 35, 50 knots ● Precip types of rain, snow, freezing ran ● 1, 3, 6, 12, 24hr APCP > 0.01, 0.05, 0.1, 0.25, 0.5, 1, 1.5, 2, and 4 inch ● 3,6,12 and 24hr acc snow > 1, 2, 4, 6, 7.5, 8 , 10, 12, 14, 20 inch ● T2m < 0C, > 25.8 C ● CAPE > 250, 500, 1000, 2000, 3000, 4000 J/kg ● CIN < -50, -100, -200, -300, -400 J/kg ● LI < 0, -2, -4, -6, -8 ● Total cloud = 0~20, 20~50, 50~80, 80~100	● T850mb < 0C ● SREH7600 > 100, 150, 200 250 300 ● Icing occurrence at 900, 800,725,650,575,500 and 400 mb ● Severe, mid and light CAT at 500, 450, 400, 350, and 300, 275,225 200 mb

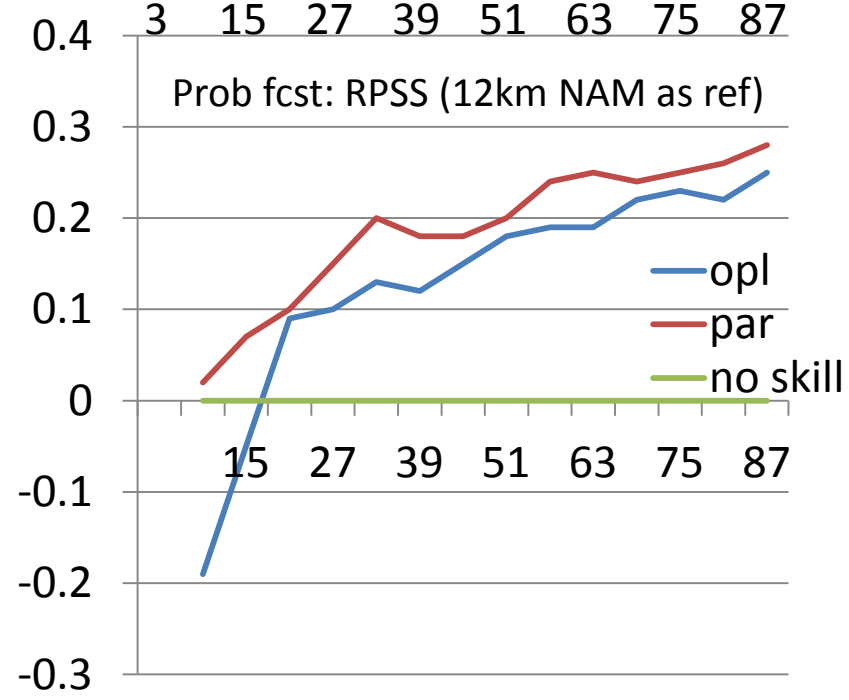
Max	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
Min	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
Mode	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
10%	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
25%	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
50%	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
75%	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb
90%	● T2m ● SLP ● 10m U, V ● Ceiling ● Visibility	● T at 700, 600, 500, 300 mb ● height at 1000, 850, 700, 600, 500, 300, 250mb ● U, V at 1000, 850, 700, 600, 500, 300, 250mb ● RH at 850, 700, 600, 500, 300, 250mb ● Td at 850, 700, 500, 300mb

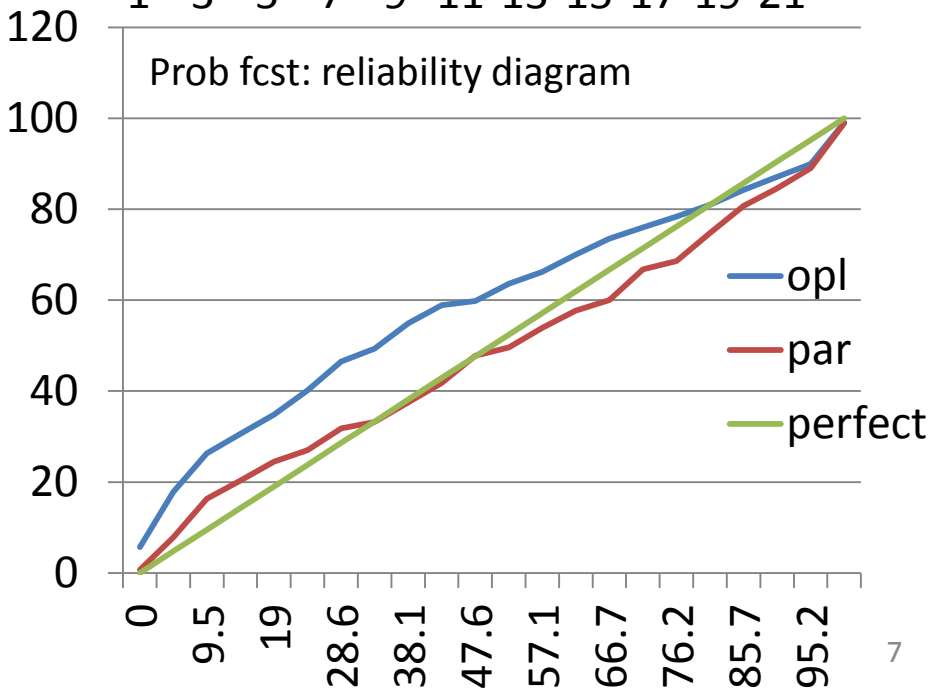
Cold season evaluation

Evaluation of SLP (opl SREF vs. par SREF, Oct. 23 – Dec. 31, 2011)

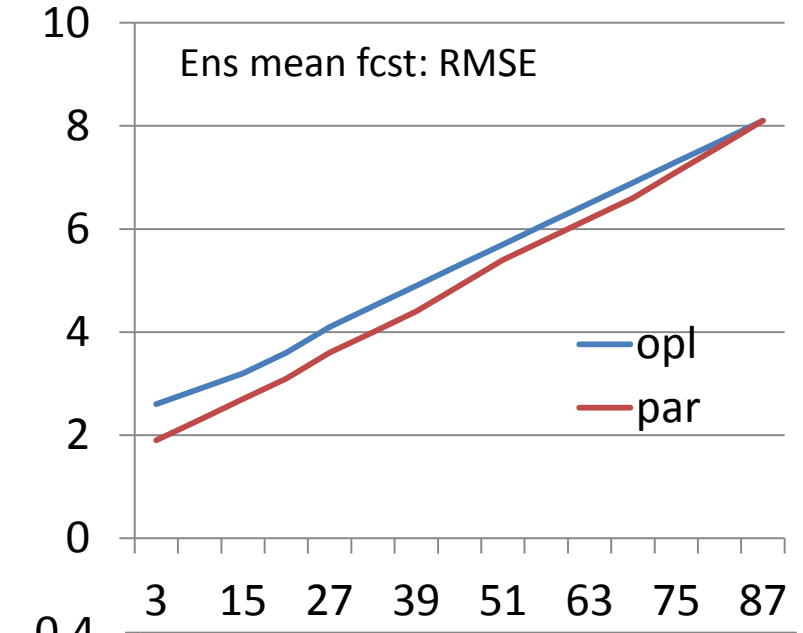


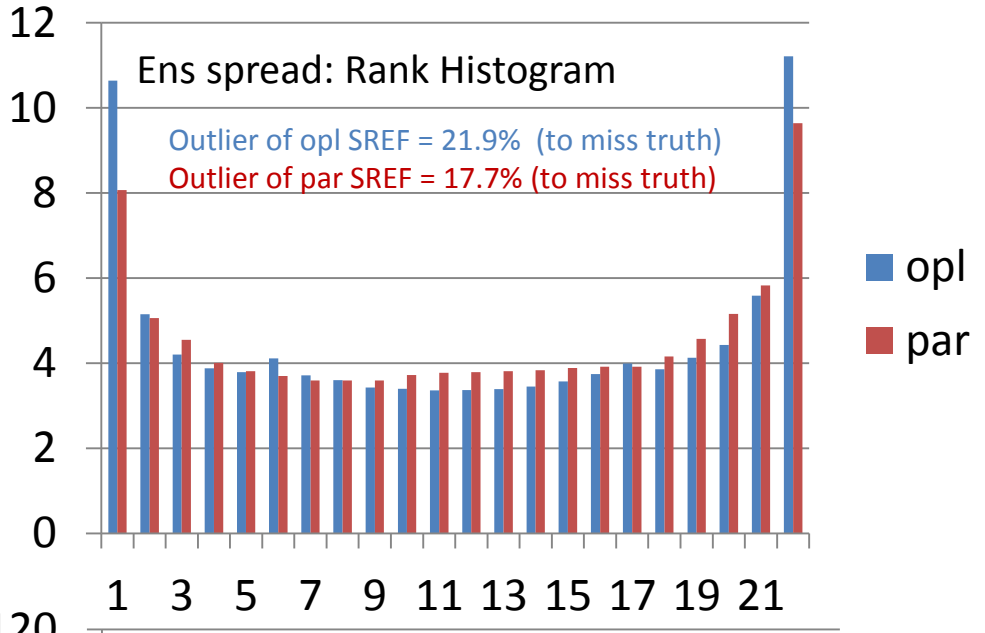


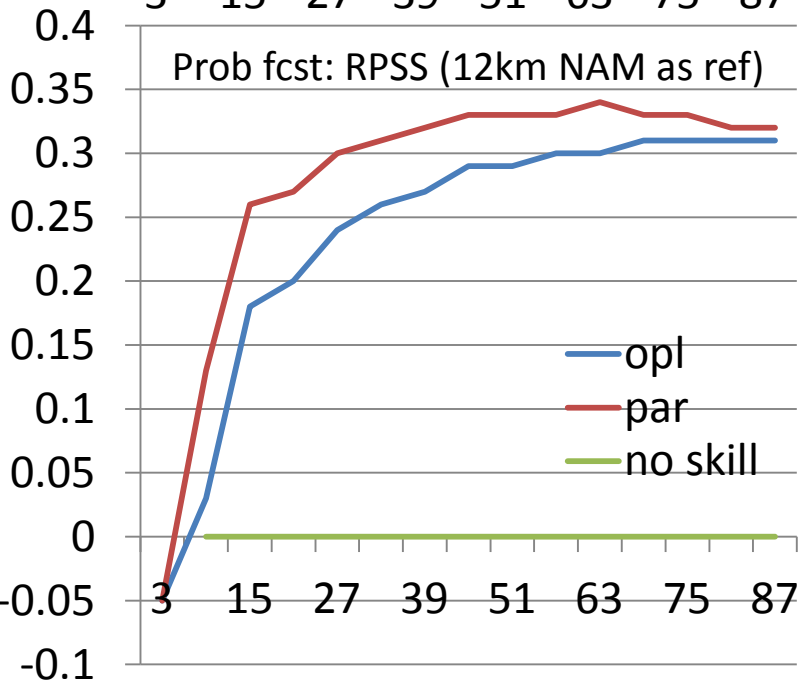


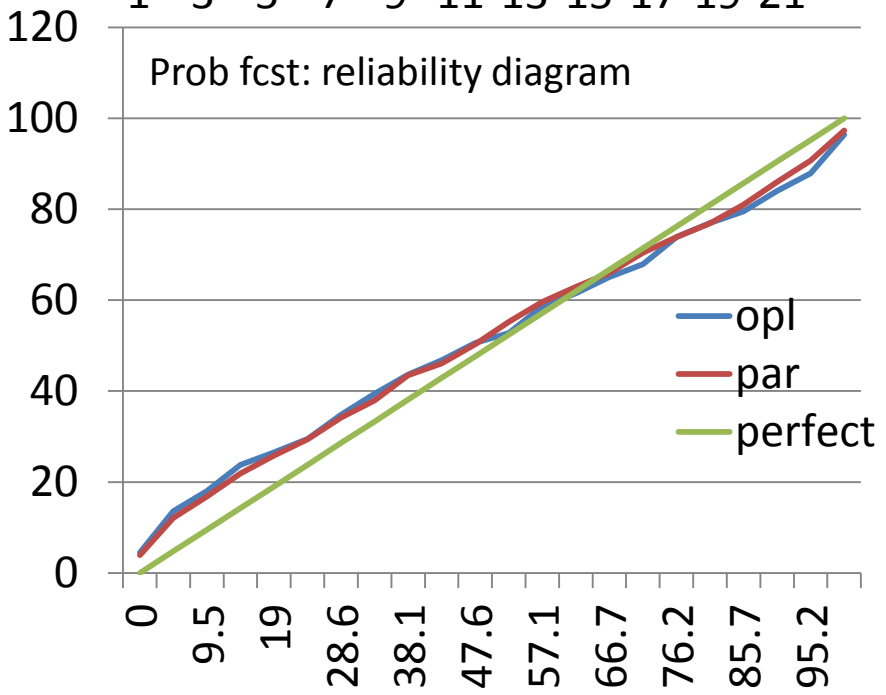


Evaluation of 250U (opl SREF vs. par SREF, Oct. 23 – Dec. 31, 2011)

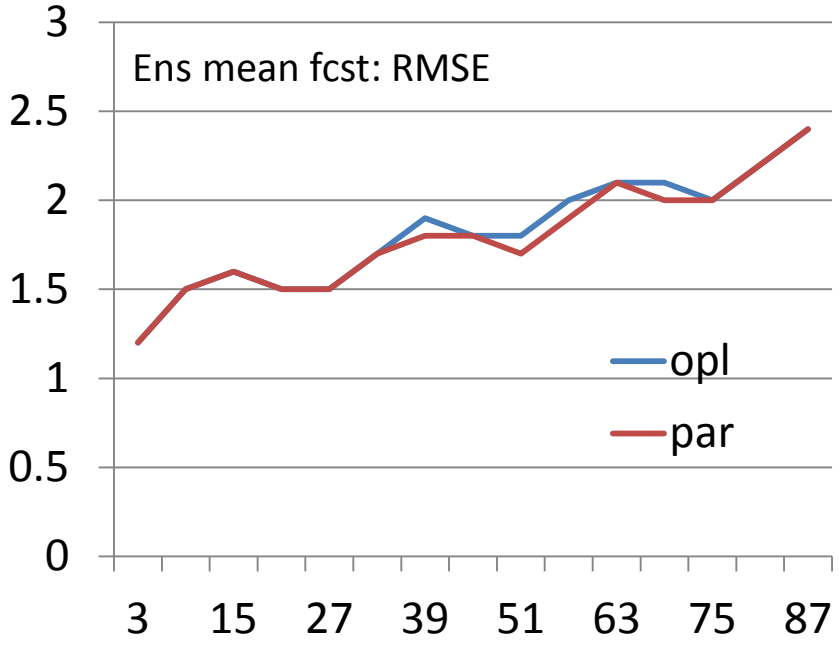


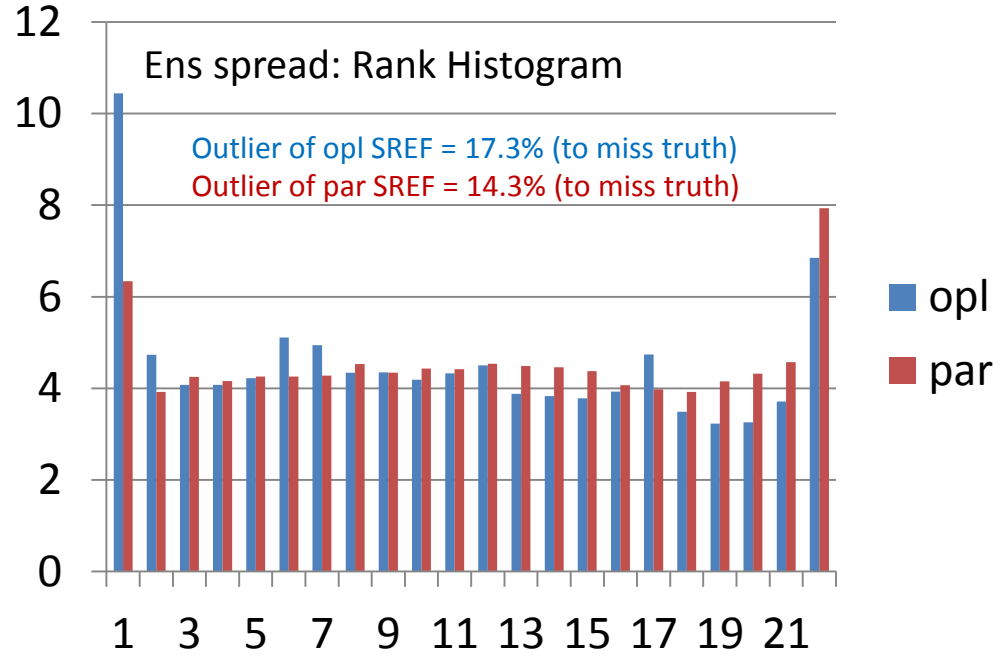


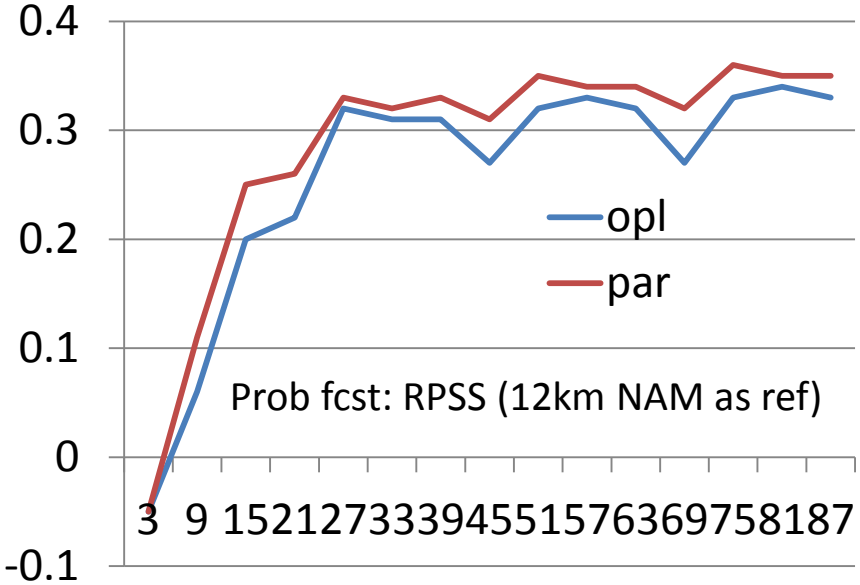


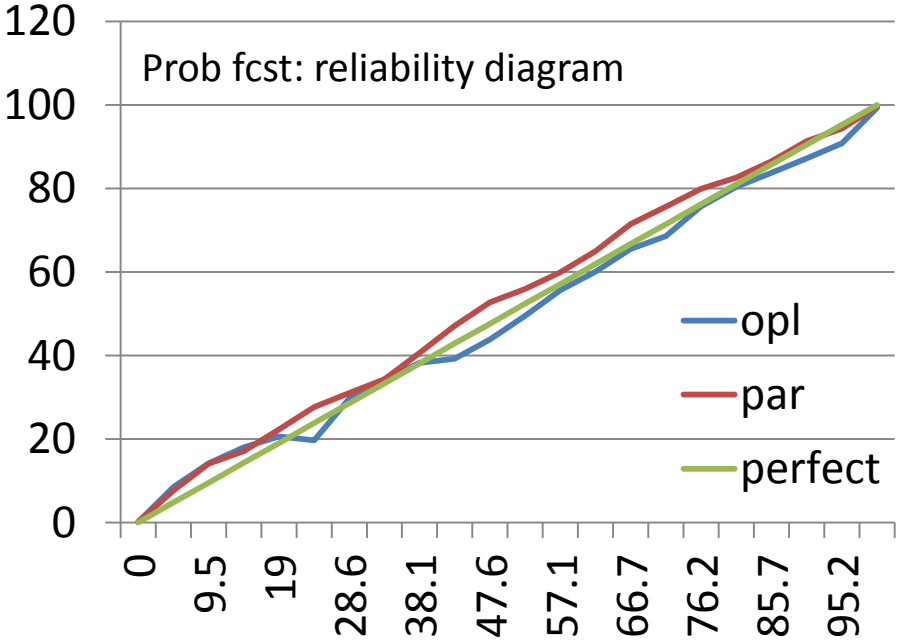


Evaluation of 2mT (opl SREF vs. par SREF, Oct. 23 – Dec. 31, 2011)

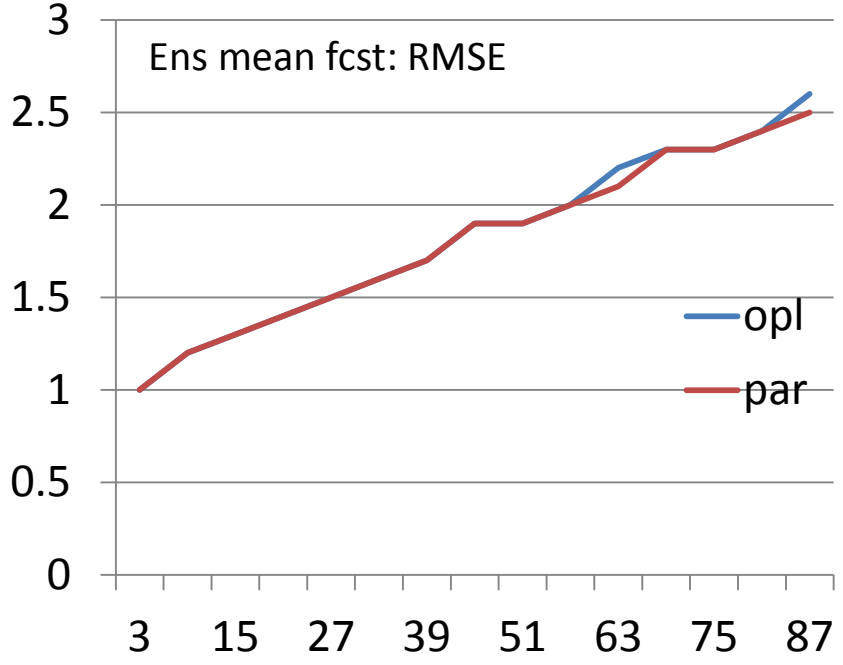


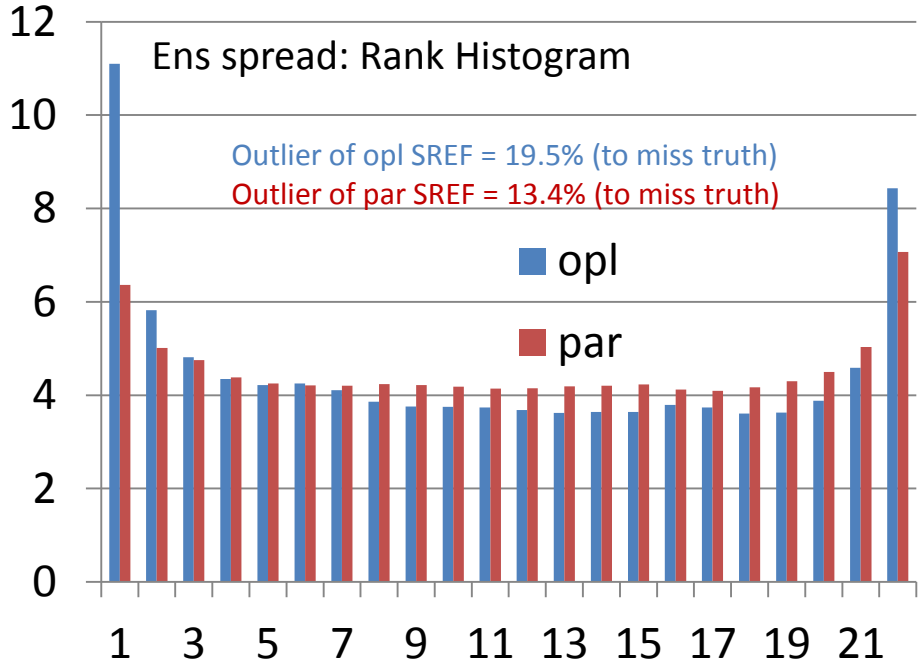


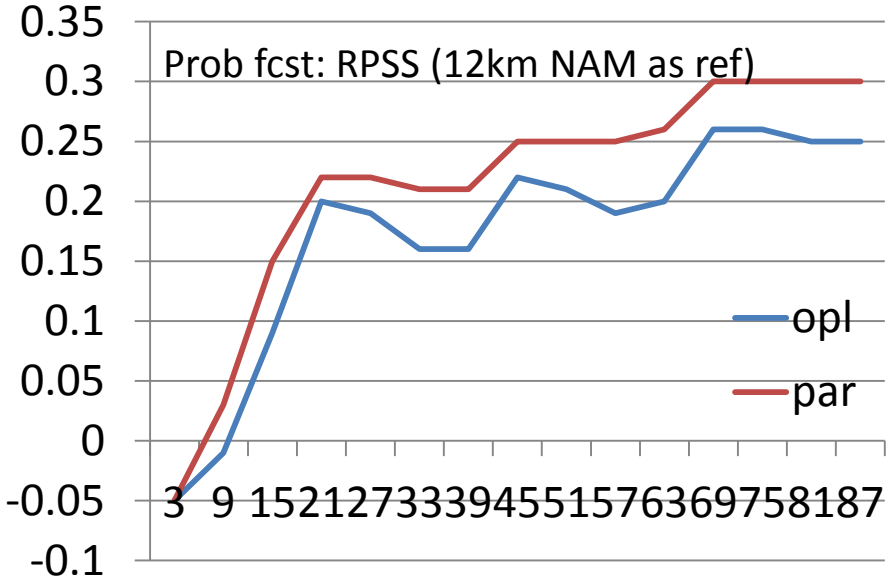


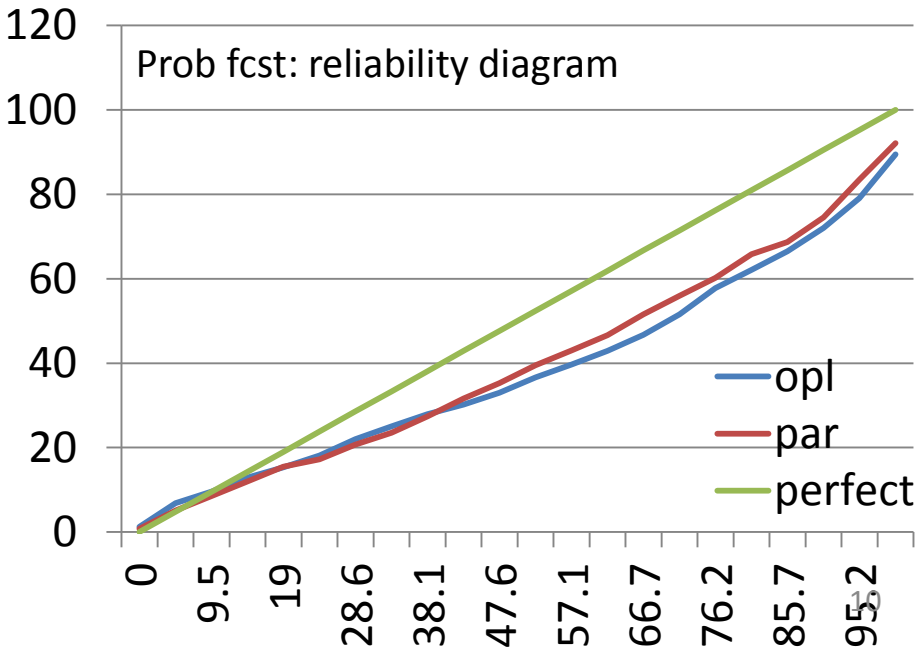


Evaluation of 10m-U (opl SREF vs. par SREF, Oct. 23 – Dec. 31, 2011)

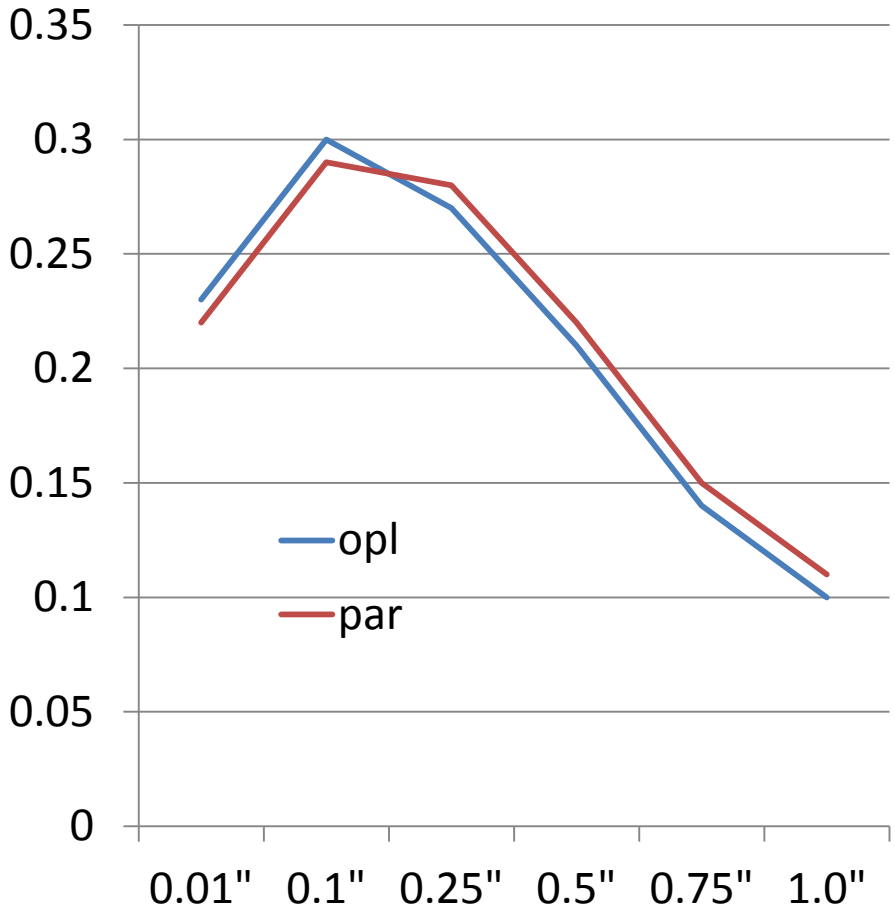


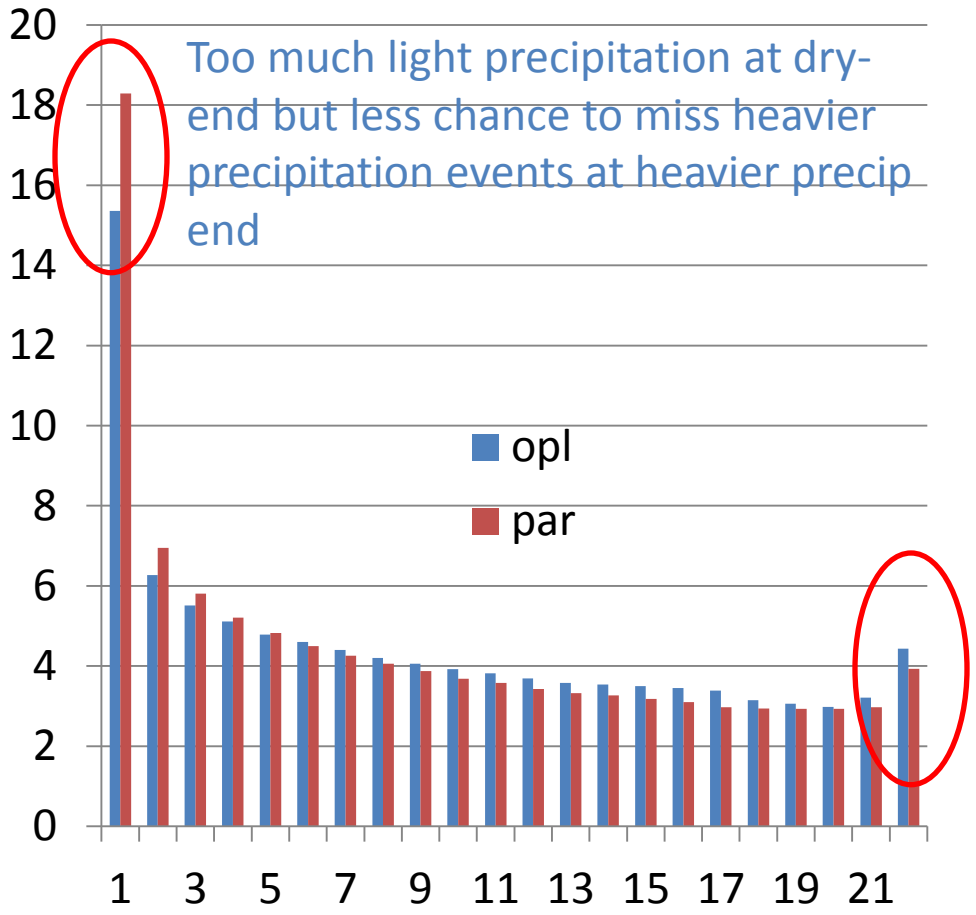






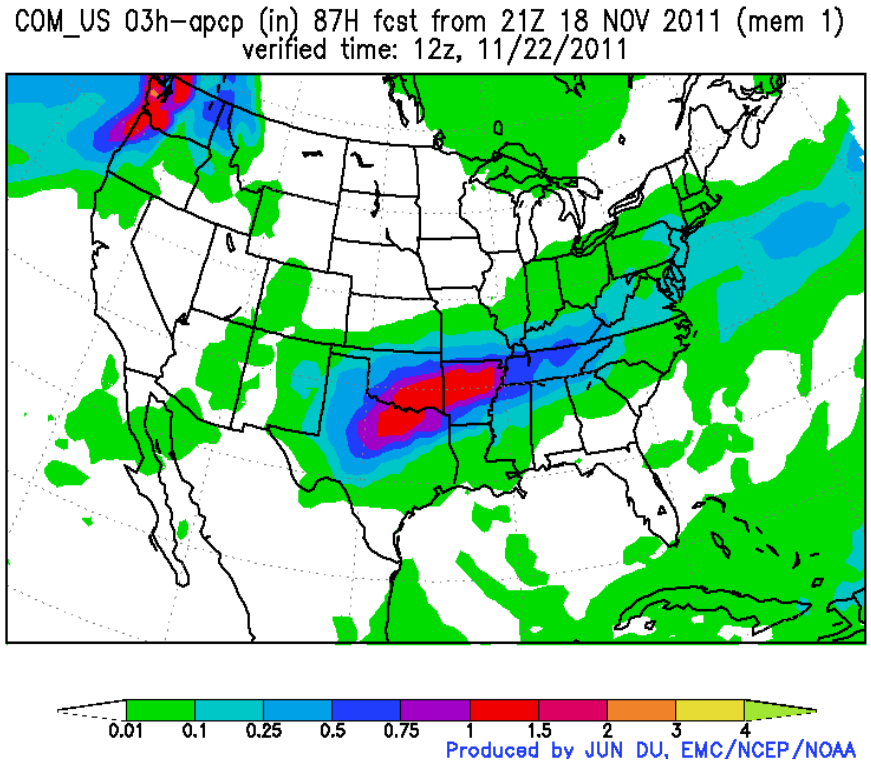
Ensemble mean forecast and ensemble spread (24h-apcp, against CCPA, Oct. 23 – Dec. 31, 2011)



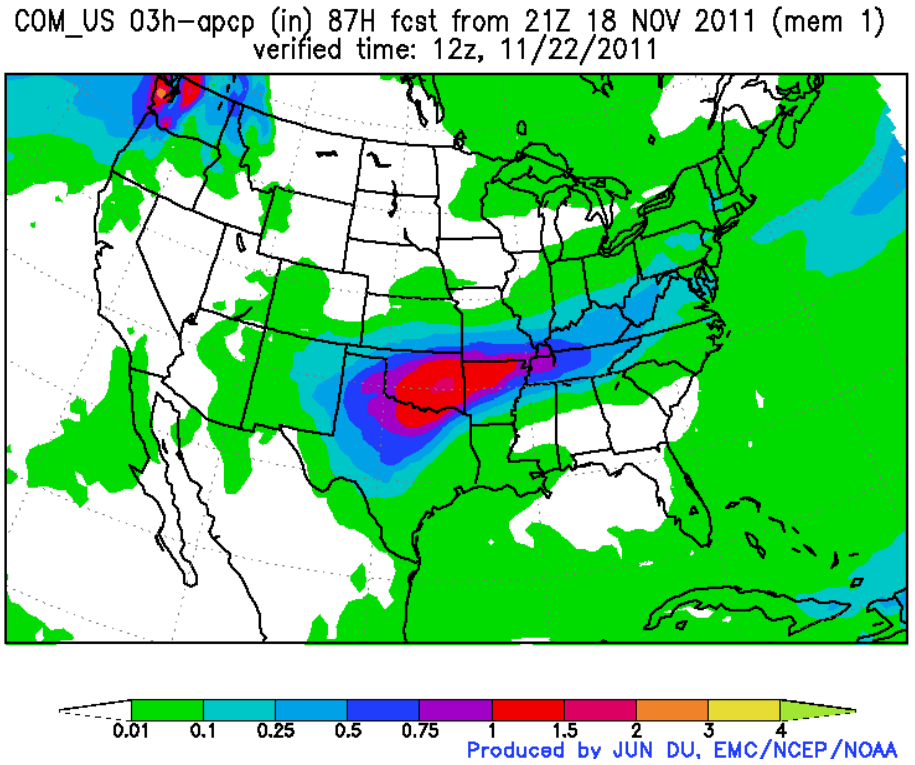


SREF mean forecasts of 24h-accumulated precipitation at F87 (21z, Nov. 18, 2011)

32km SREF mean (opl)



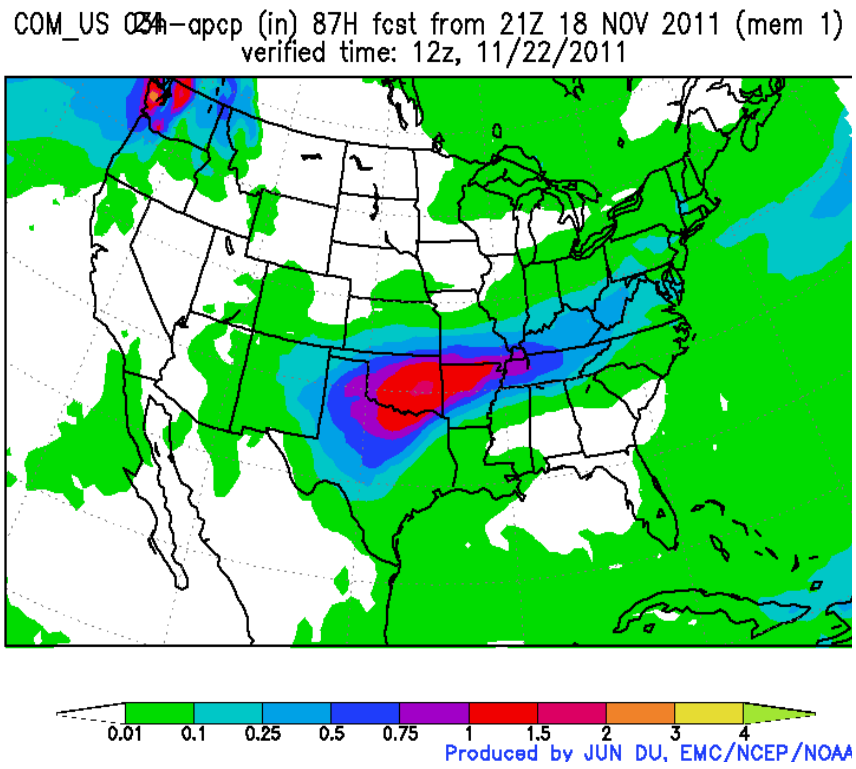
16km SREF mean (par)



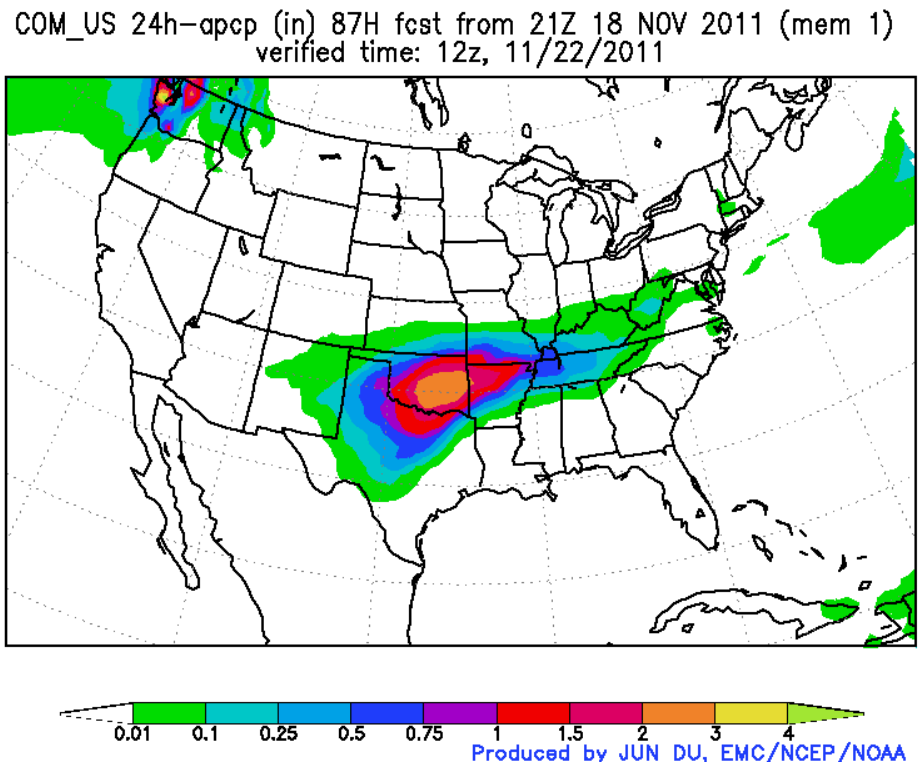
Bias correction can effectively remove over-predicted light precipitation area!

(frequency-matching method similar to that used in GEFS)

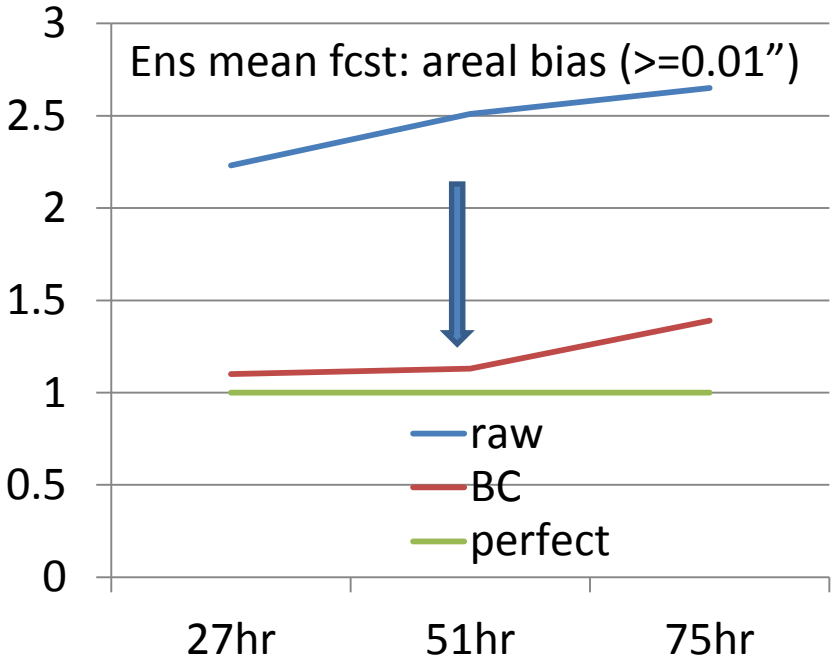
16km SREF mean (raw)

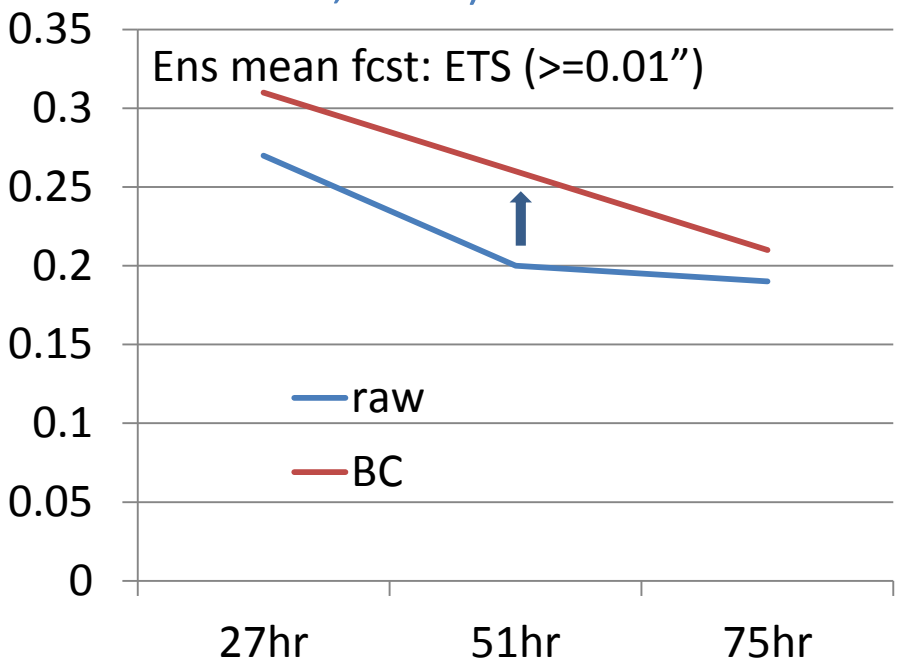


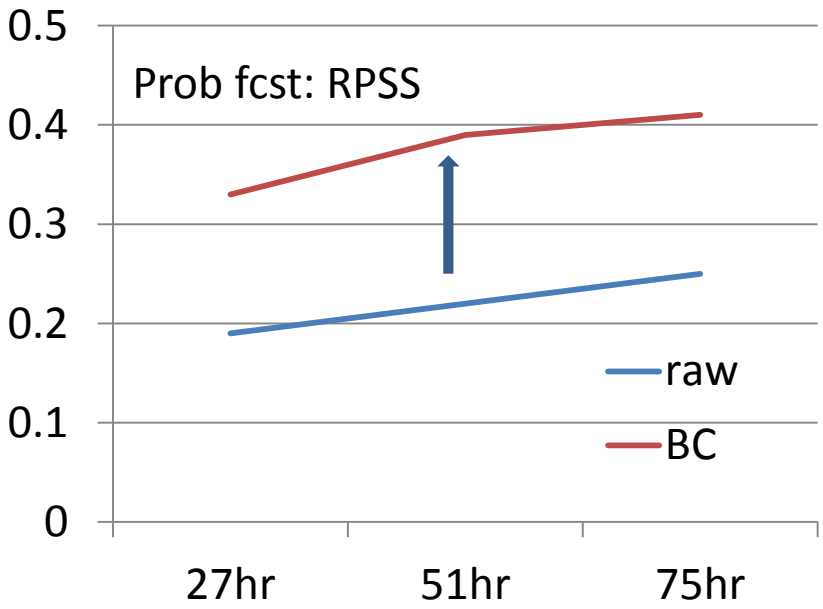
16km SREF mean (bias corrected)



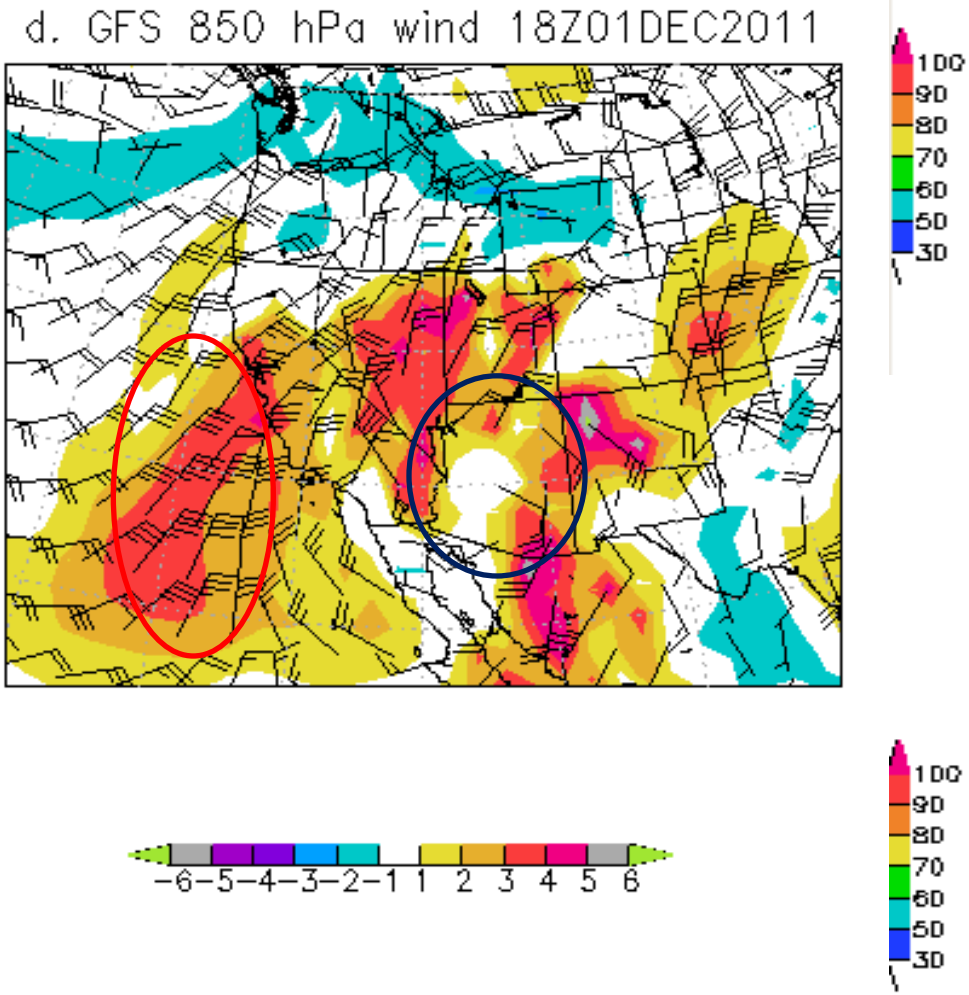
Precipitation bias correction verification (against CCPA, using 12km NAM as reference for RPSS, Nov. 10- Dec. 31, 2011)

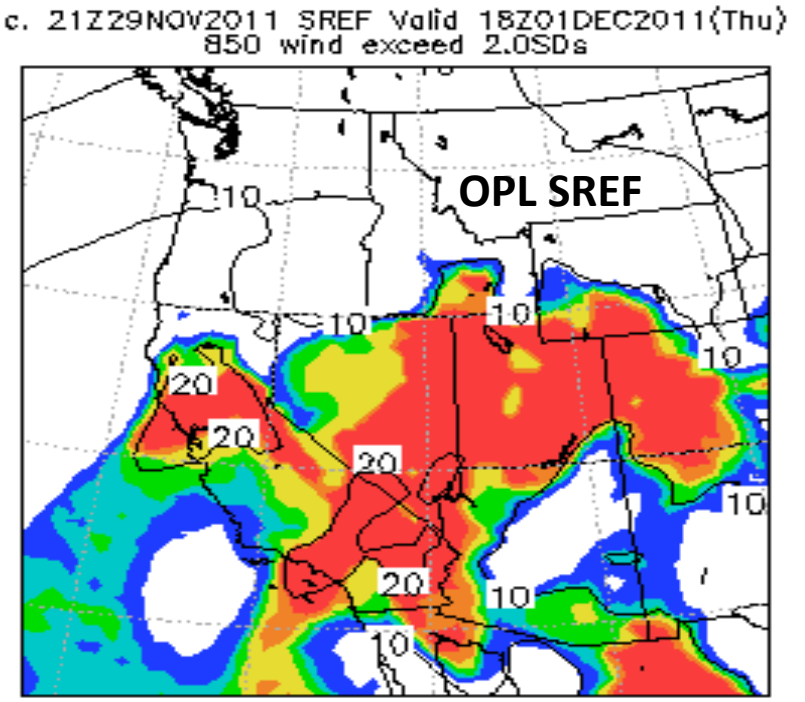


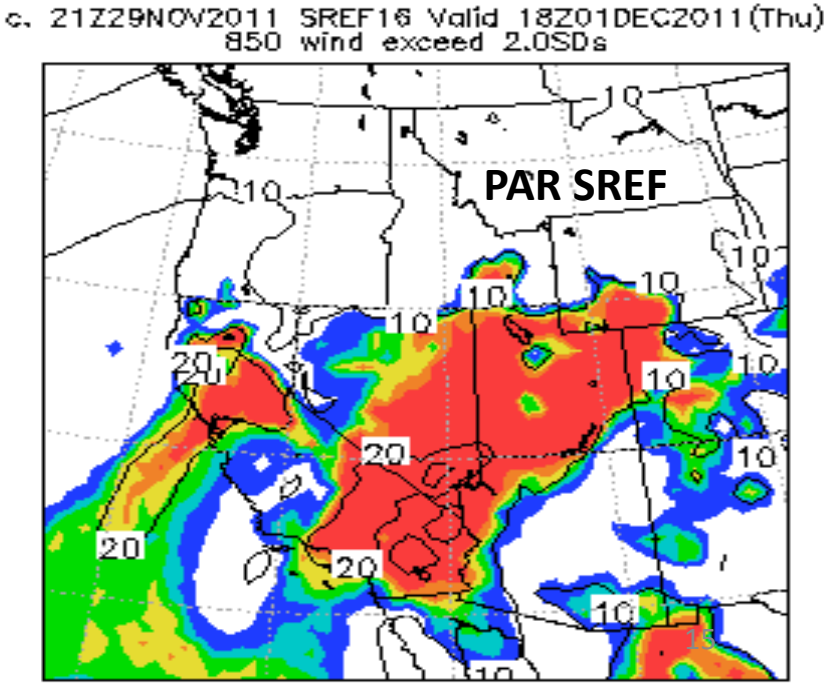




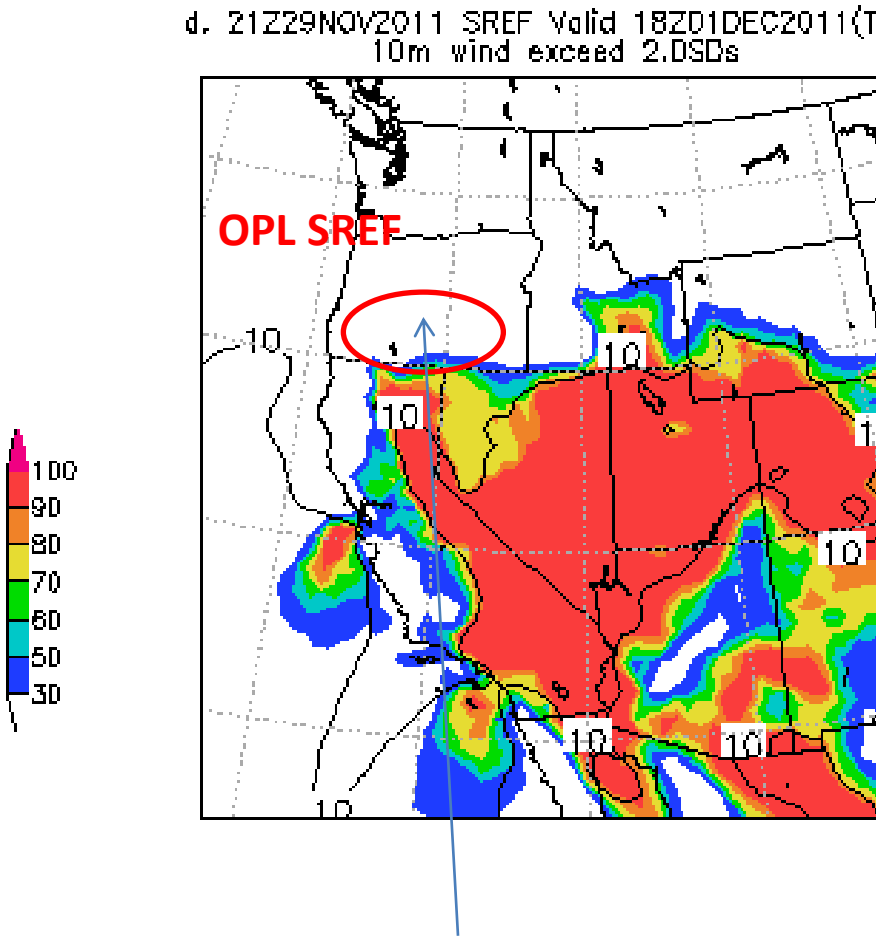
Dec. 1, 2011 West Coast High-Wind Event (R. Grumm)



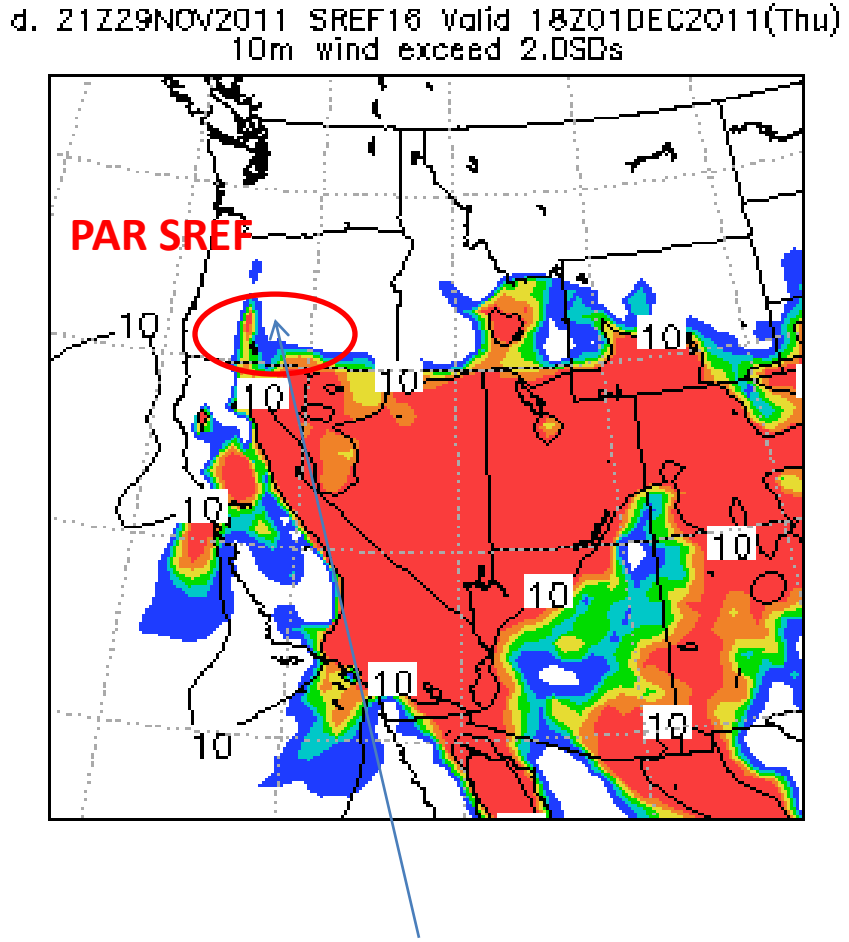




West coast high-wind event (Dec. 1, 2011) at surface: OPL SREF on left and PAR SREF on right

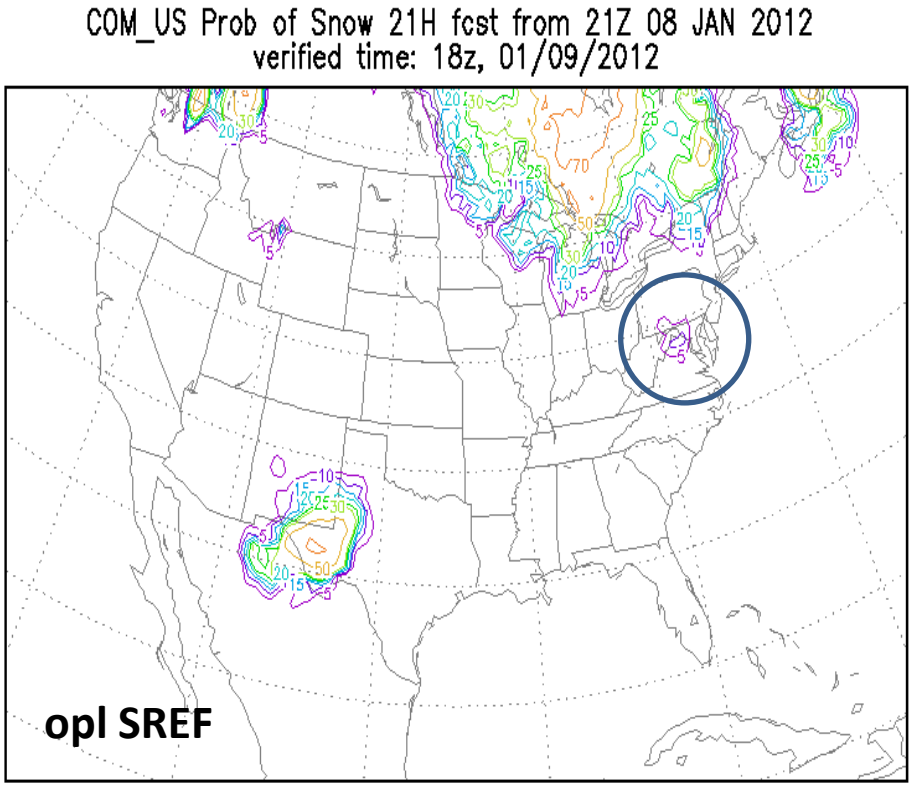


Observed surface high-wind missed by OPL SREF

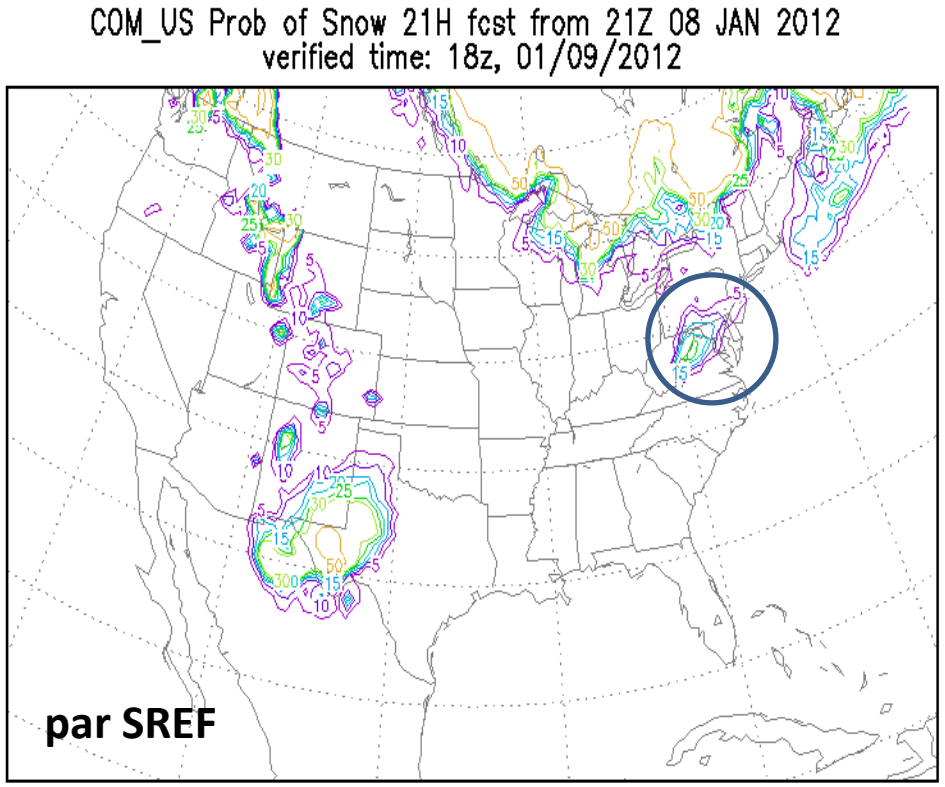


Observed surface high-wind captured by the PAR SREF

Surprising Snow Event of Washington DC (afternoon of Jan. 9, 2012)

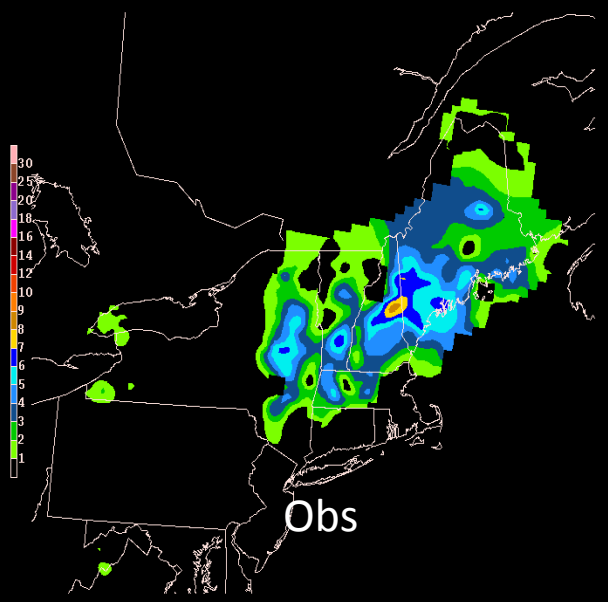


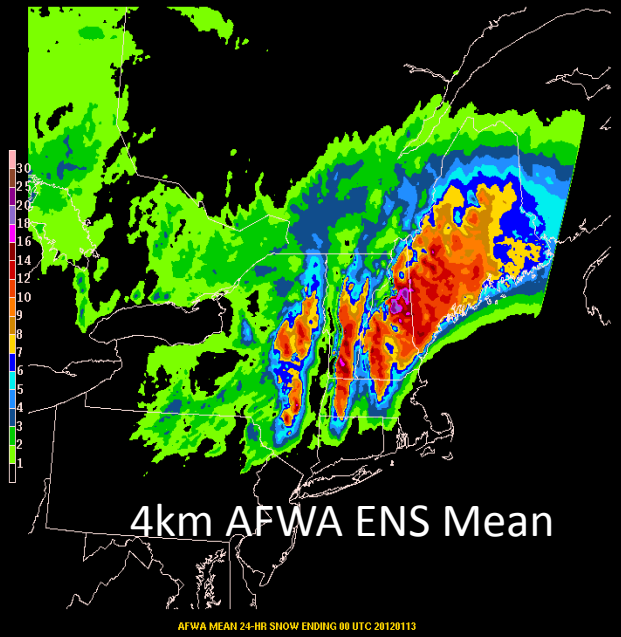
Produced by JUN DU, EMC/NCEP/NOAA

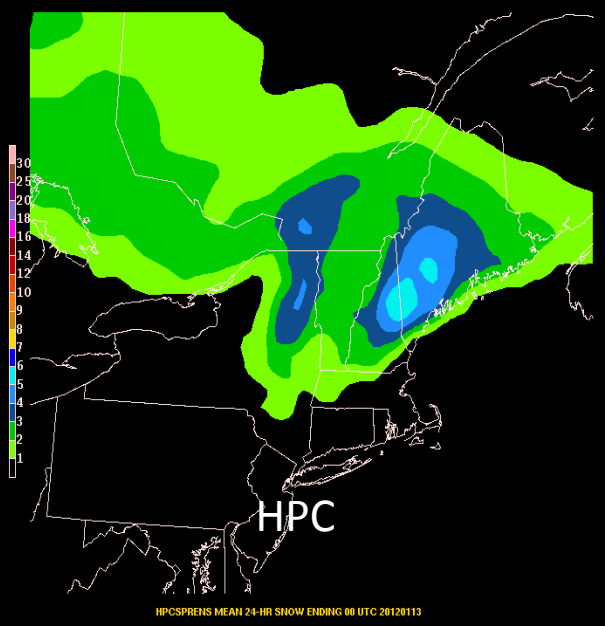


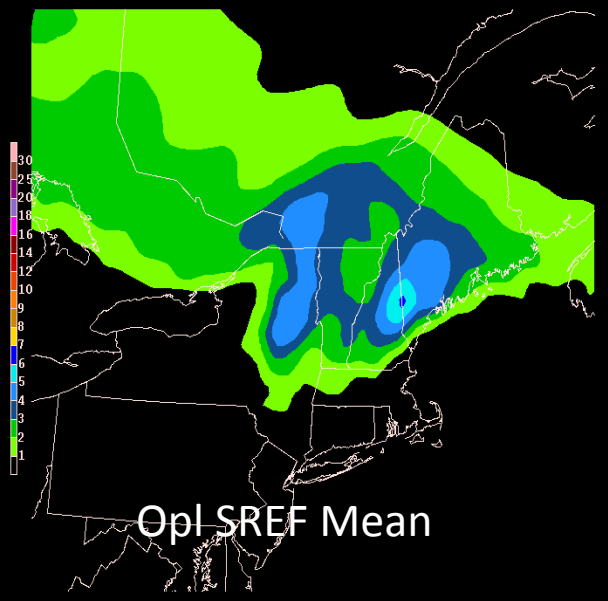
Produced by JUN DU, EMC/NCEP/NOAA

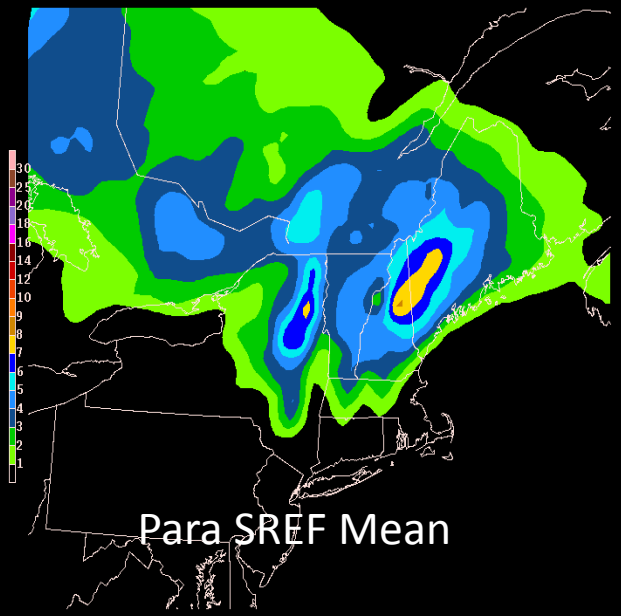
Day 1 forecast of 24h snow amount ending at 01/13/2012



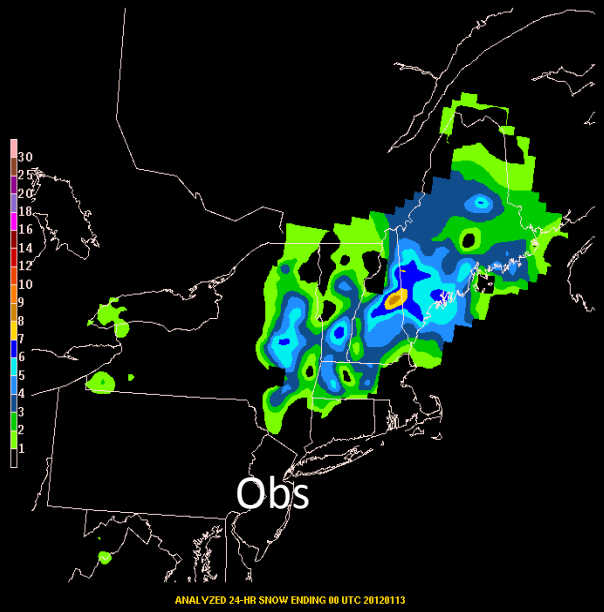


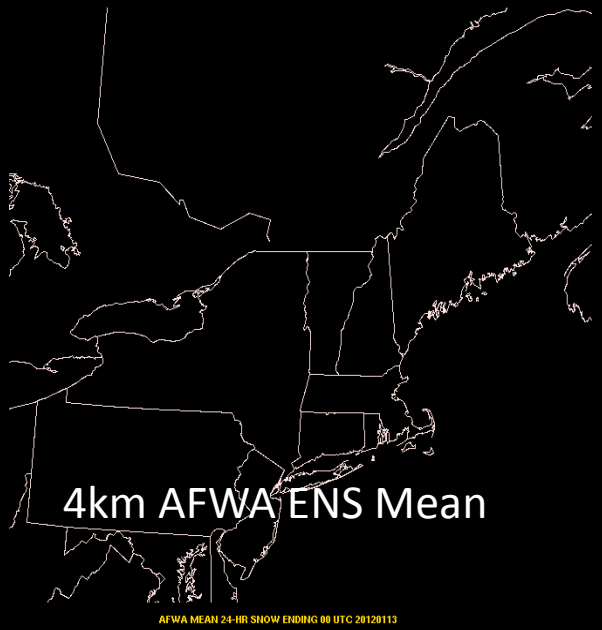


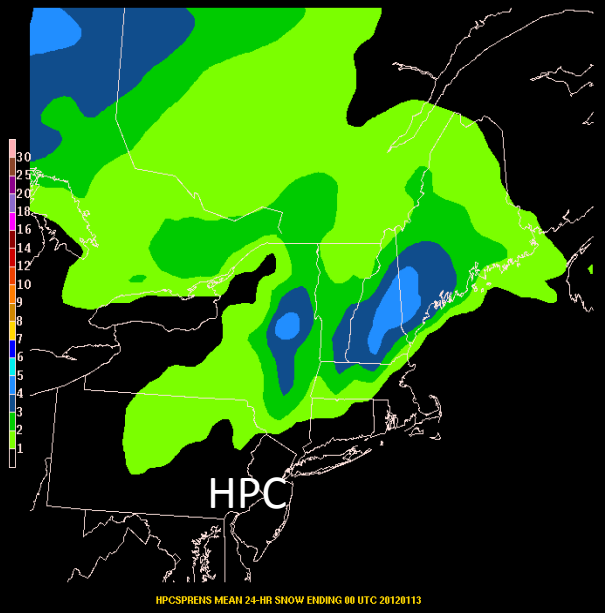


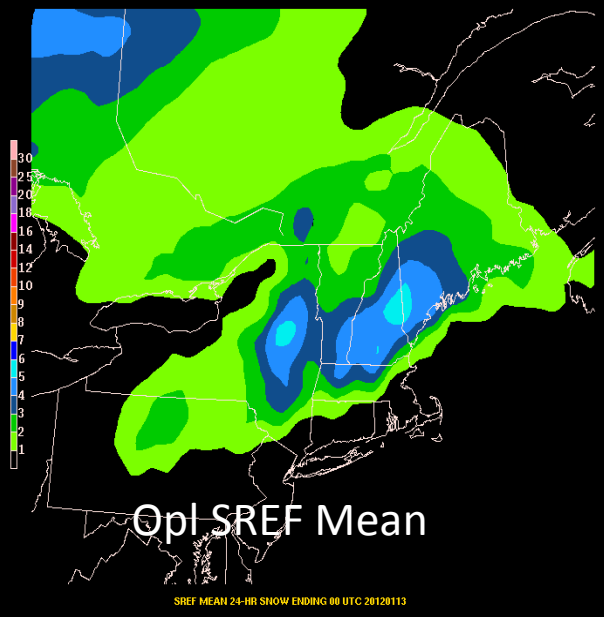


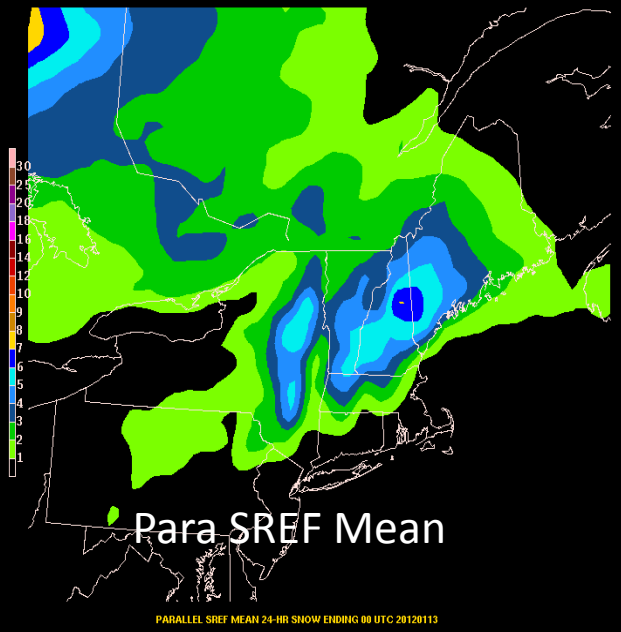
Day 2 forecast of 24h snow amount ending at 1/13/2012











HPC Winter Weather Experiment (2011-2012) result: mean snowfall forecast -- SREFp vs. SREF

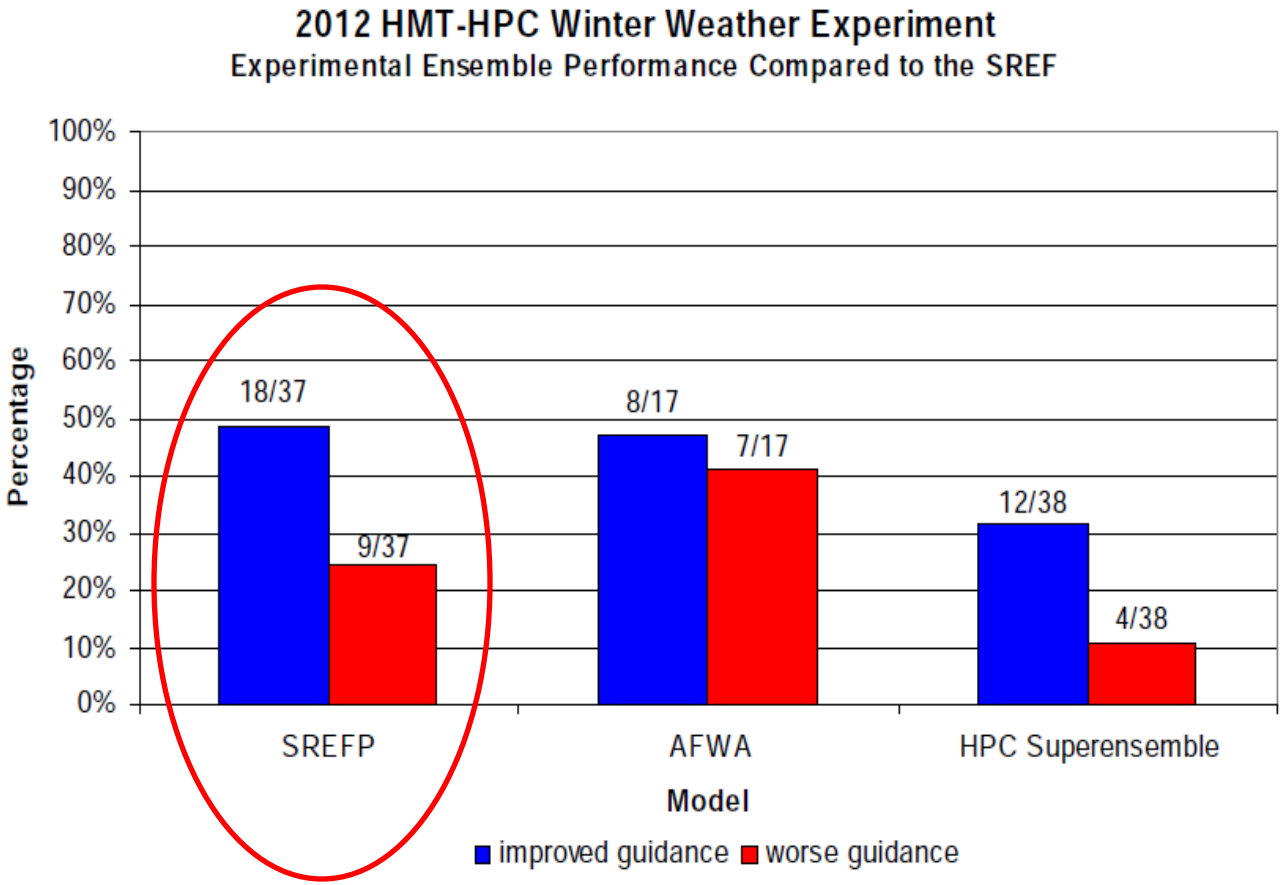
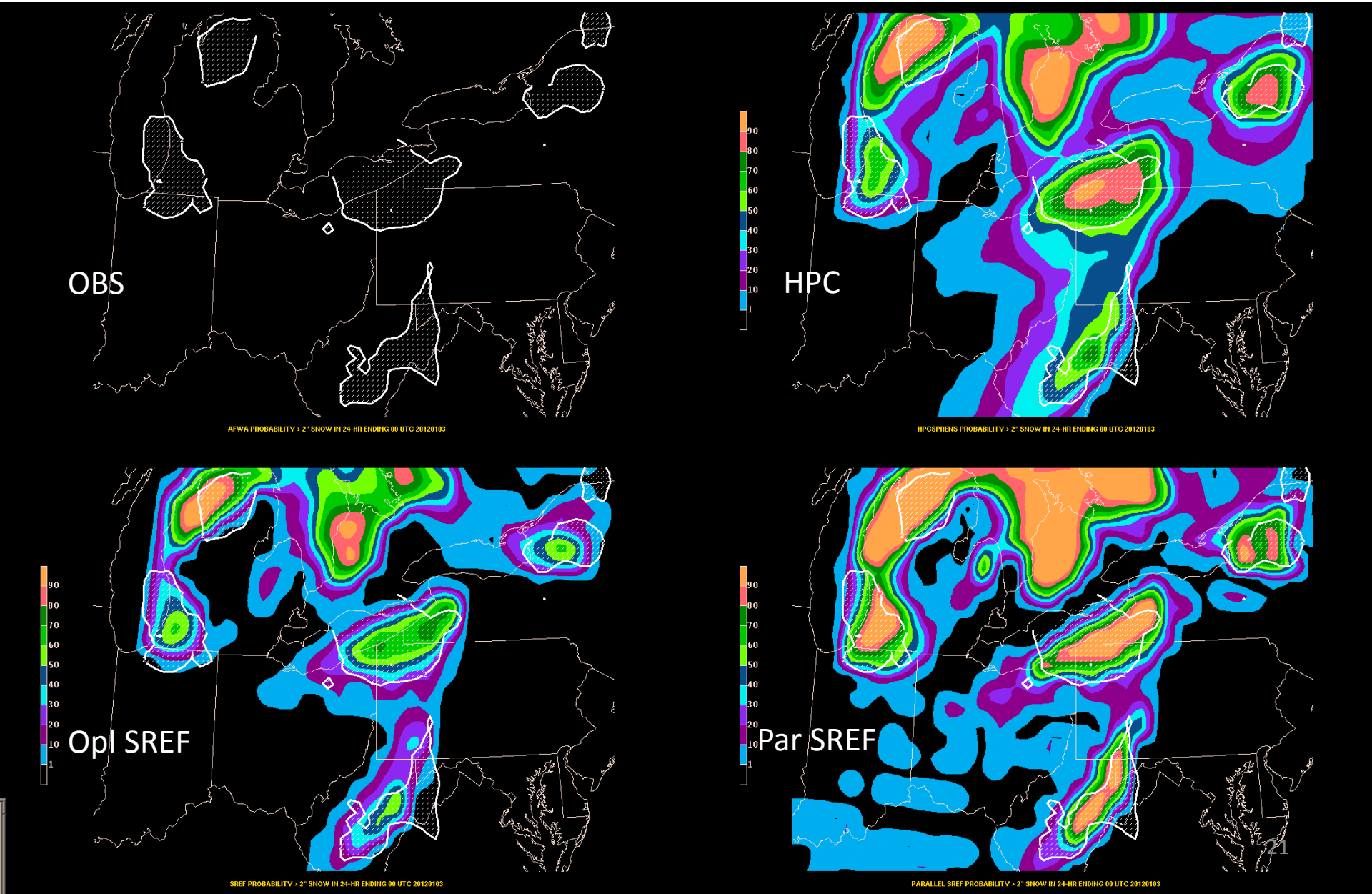


Figure 1. Experimental ensemble performance based on participant feedback from subjective model evaluations conducted during the 2012 HMT-HPC Winter Weather Experiment. Participants were asked to determine whether the ensemble mean snowfall forecasts from the 00Z experimental guidance (21Z SREFP) were much better, better, about the same, worse, or much worse than the guidance provided by the operational 21Z SREF, based on observations from the gridded HPC snowfall analysis. The AFWA ensemble was only available for the Day 1 (24-48hr) forecast period.

HPC Winter Weather Experiment: probabilistic forecasts of snow > 2” during Jan. 2-3, 2012



HPC Winter Weather Experiment (2011-2012) result: "capture" of 2"/24h event -- SREFp vs. SREF

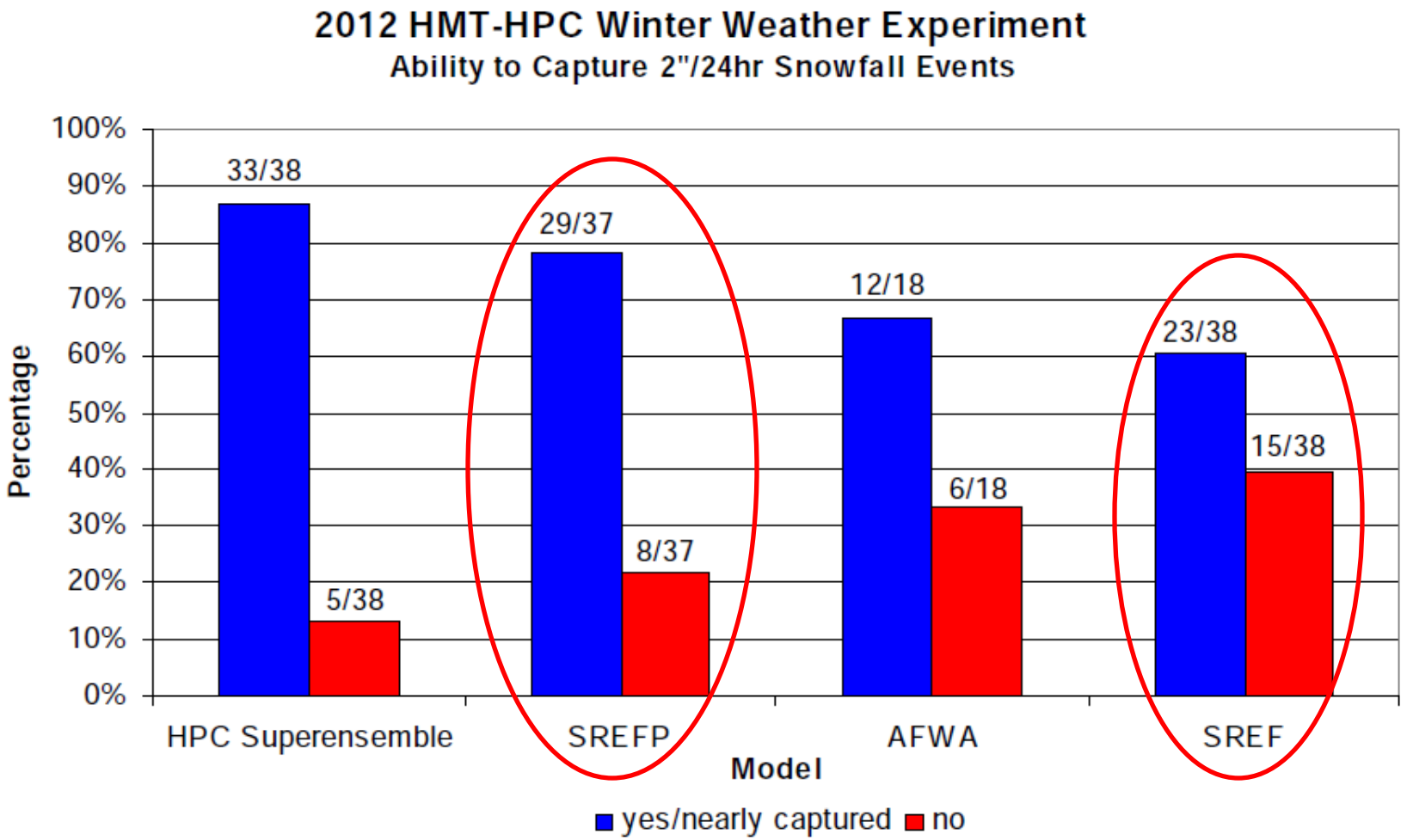
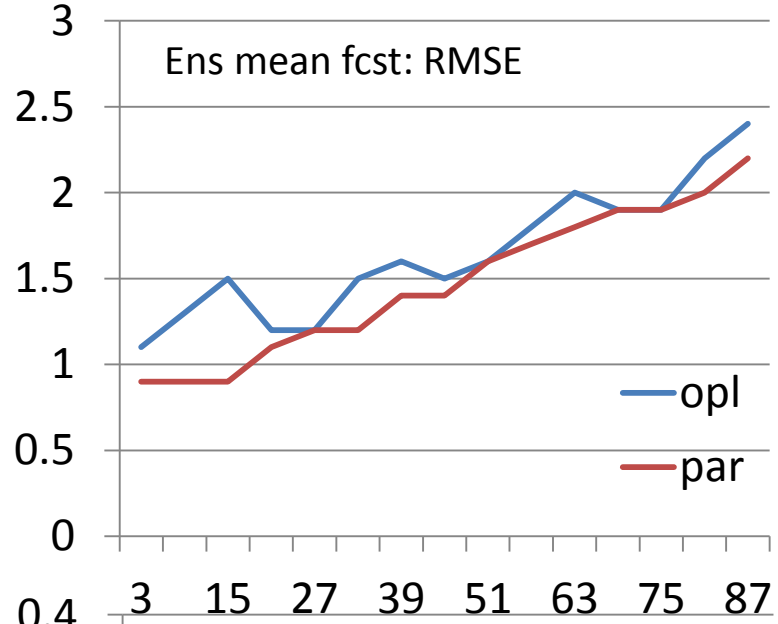
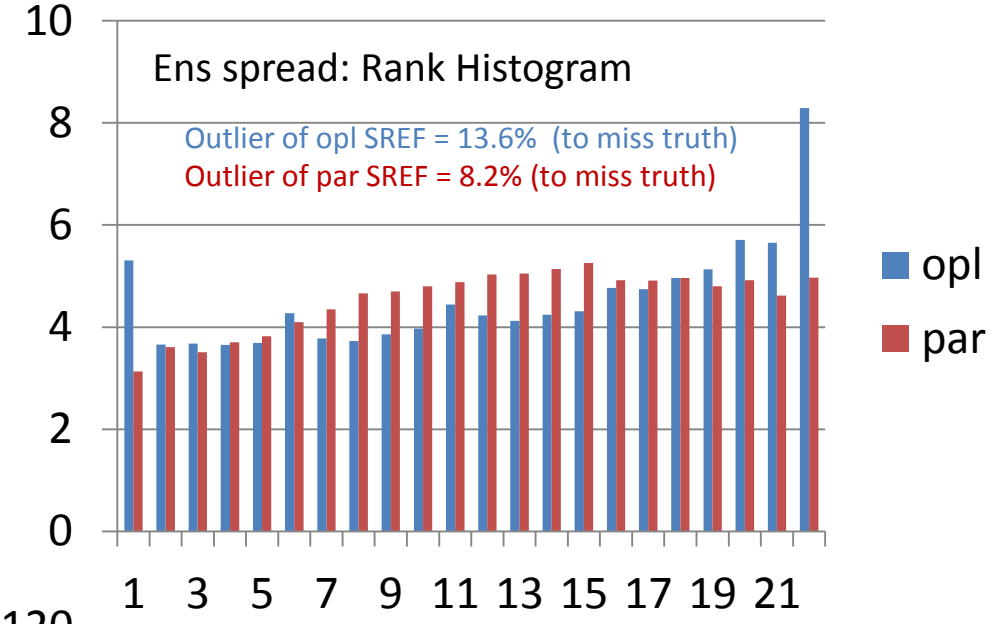


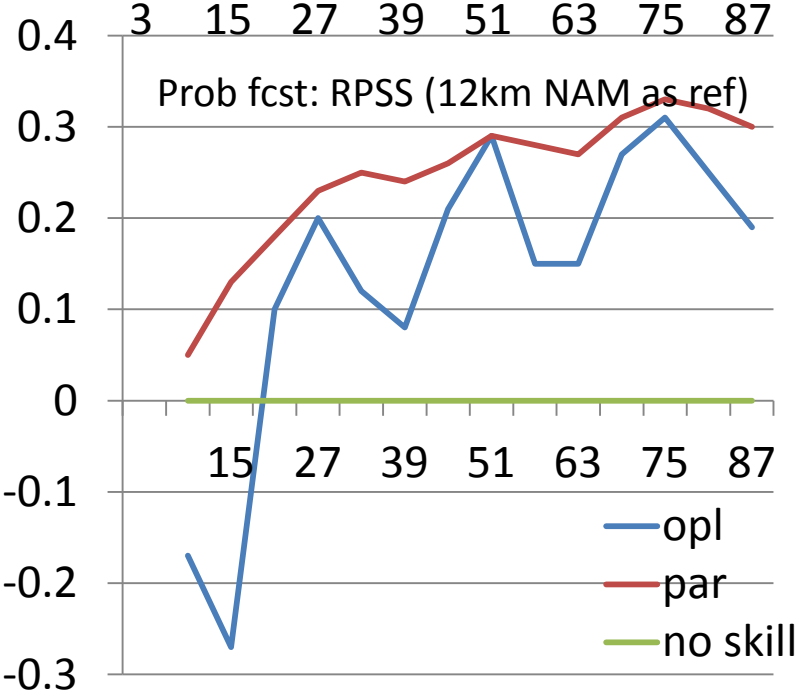
Figure 2. Ability of the experimental ensembles to capture the 2in/24hr snowfall events with the model 1% probability contour. "Nearly captured" represents cases in which there were only very small areas of observed 2 inch snowfall outside of the 1% probability contour. The AFWA ensemble was only available for the Day 1 (24-48hr) forecast period.

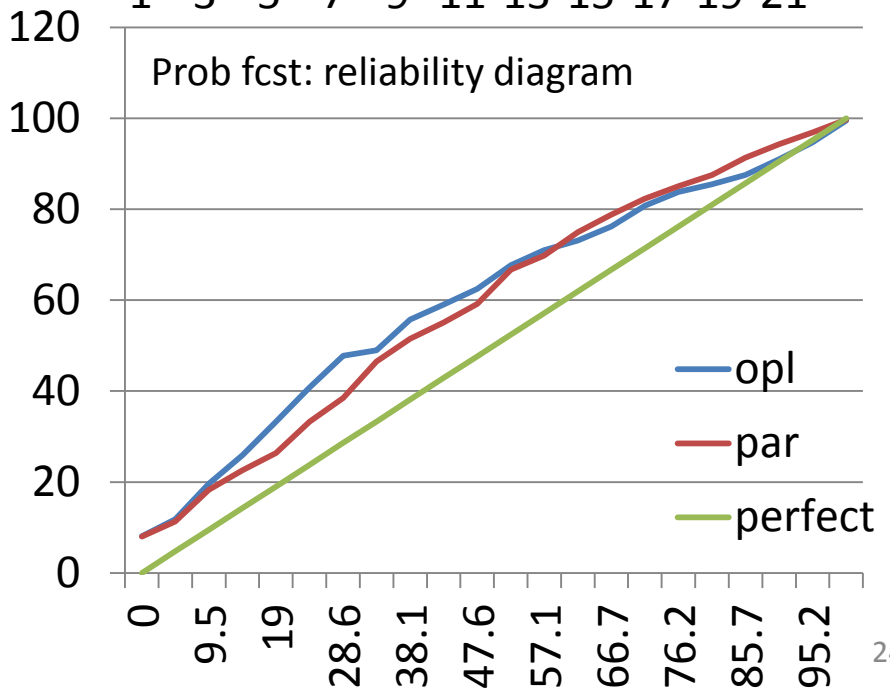
Warm season evaluation

Evaluation of SLP (opl SREF vs. par SREF, Jun. 15 – Jul. 15, 2012)

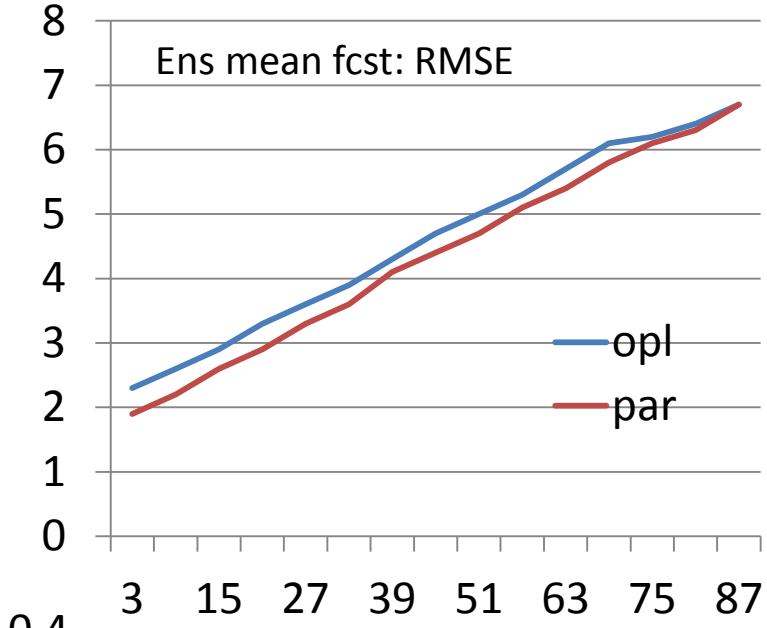


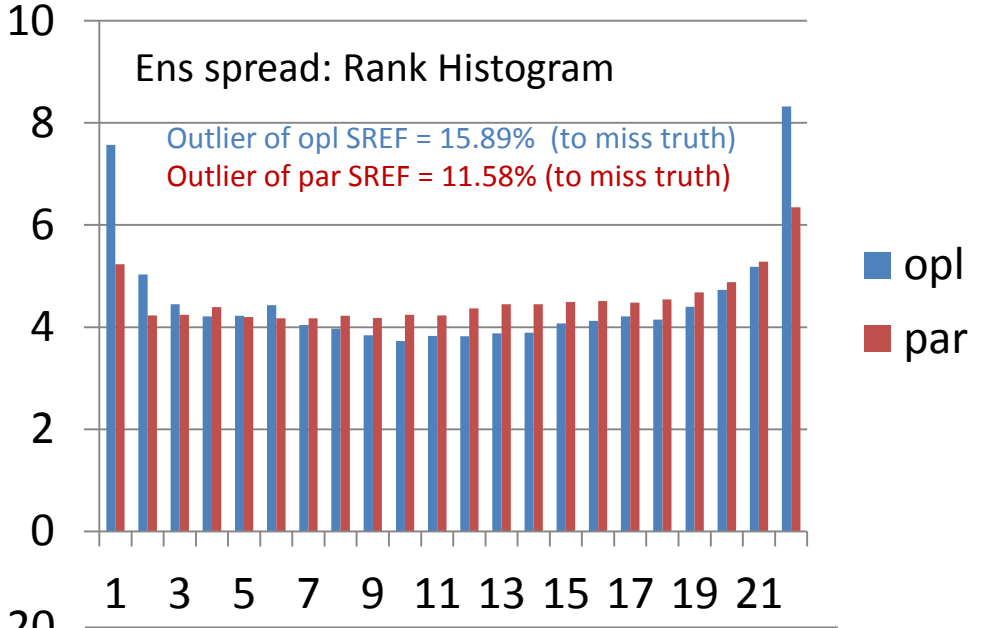


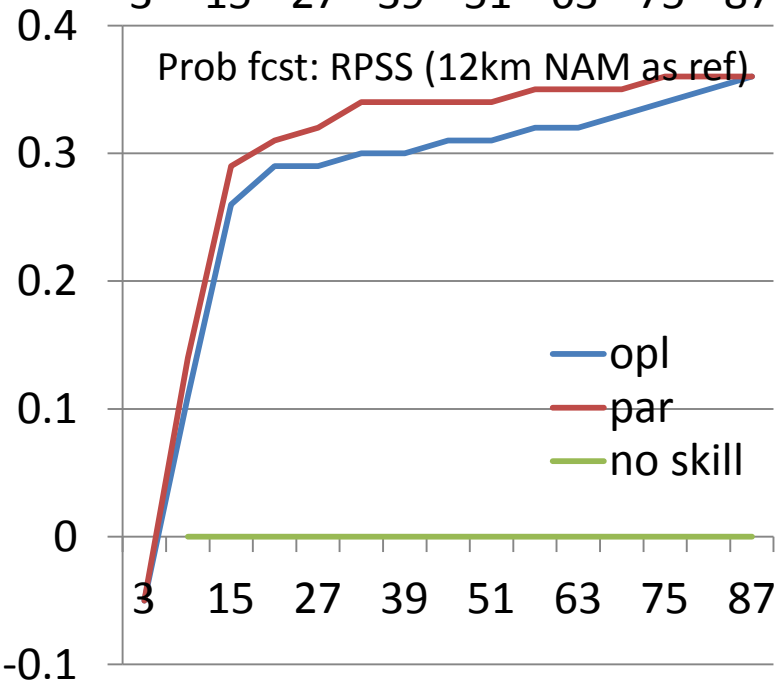


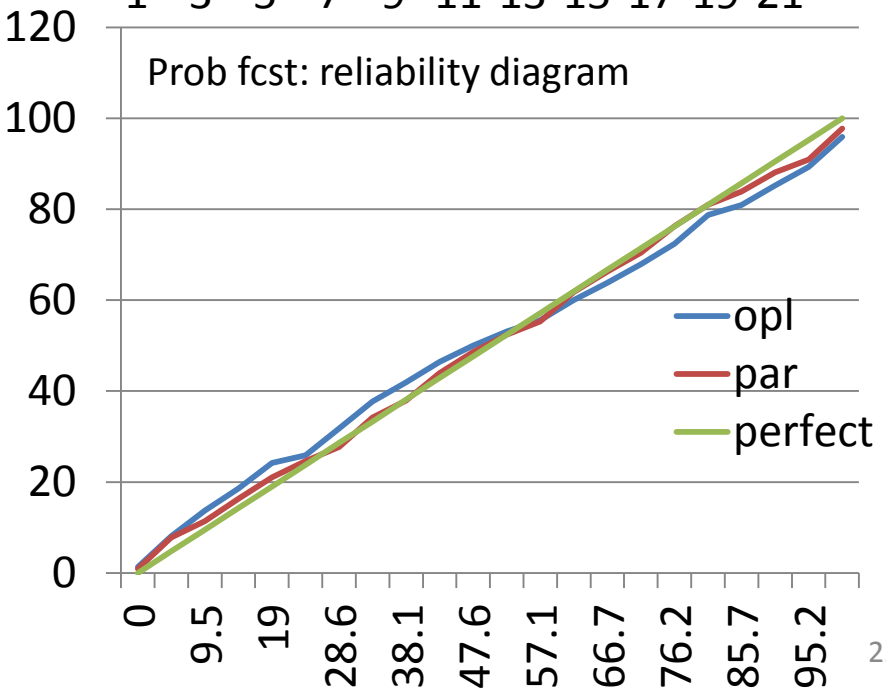


Evaluation of 250U (opl SREF vs. par SREF, Jun. 15 – Jul. 15, 2012)

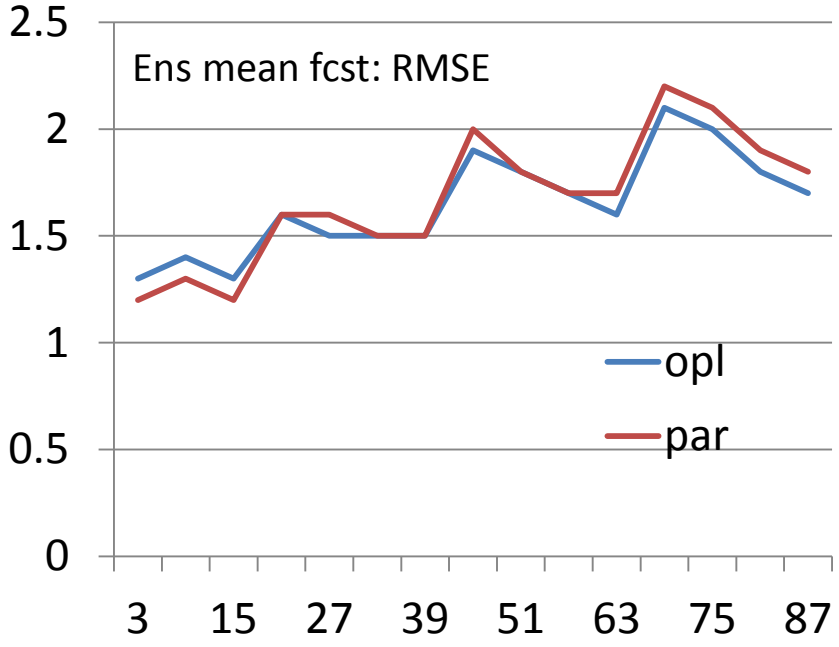


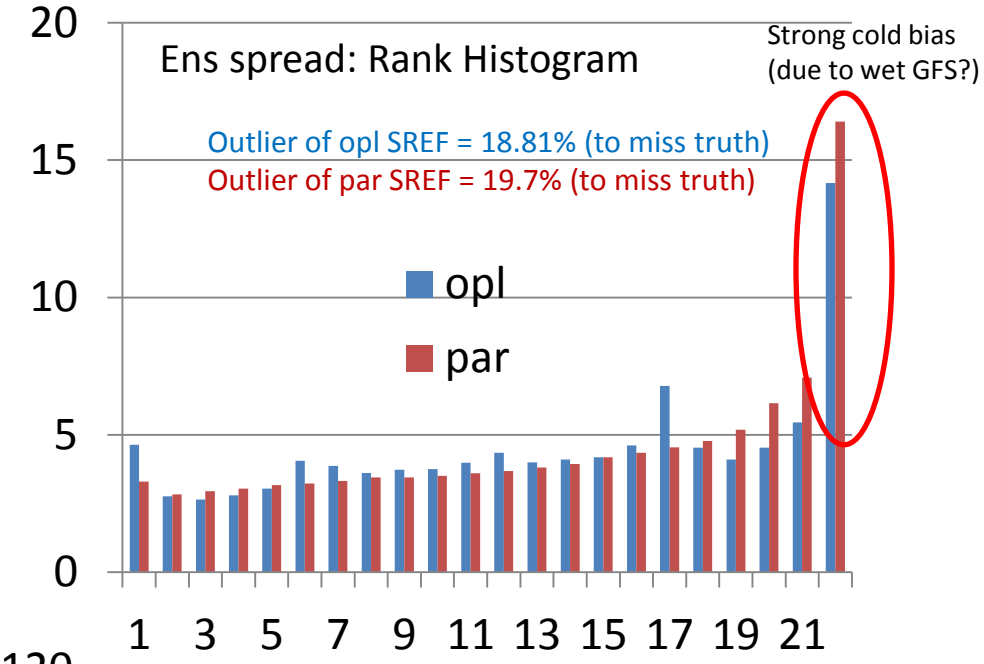


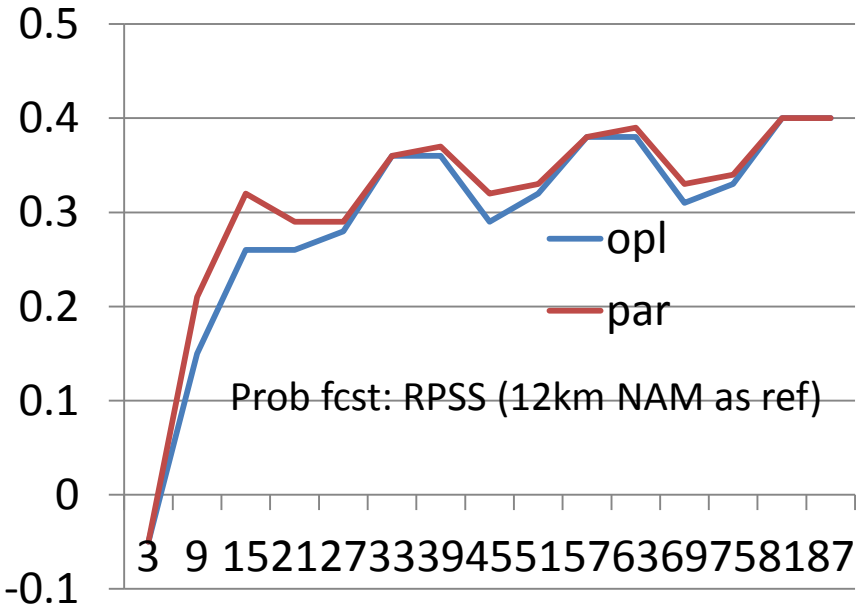


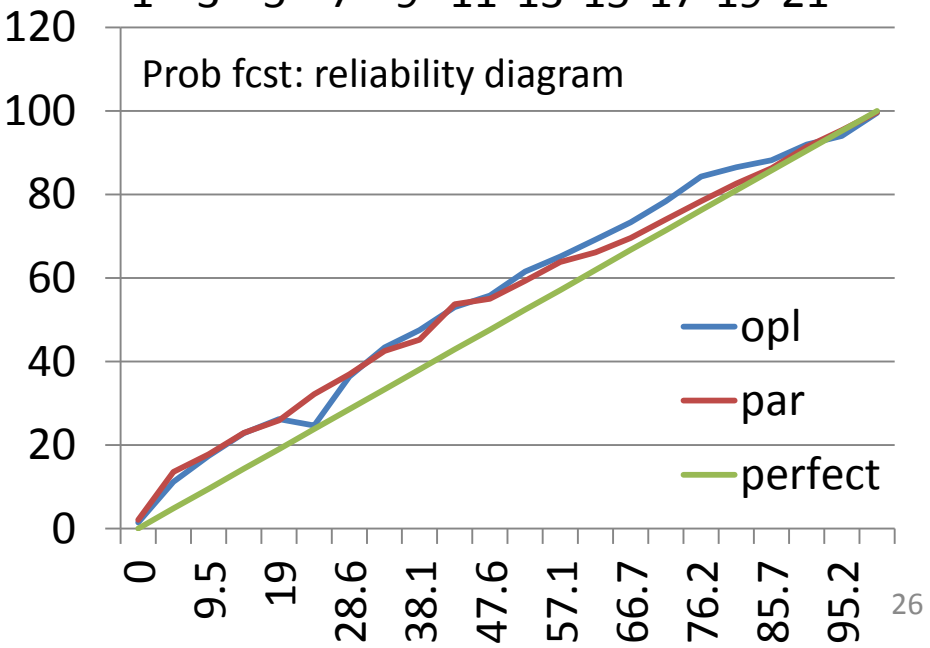


Evaluation of 2mT (opl SREF vs. par SREF, Jun. 15 – Jul. 15, 2011)

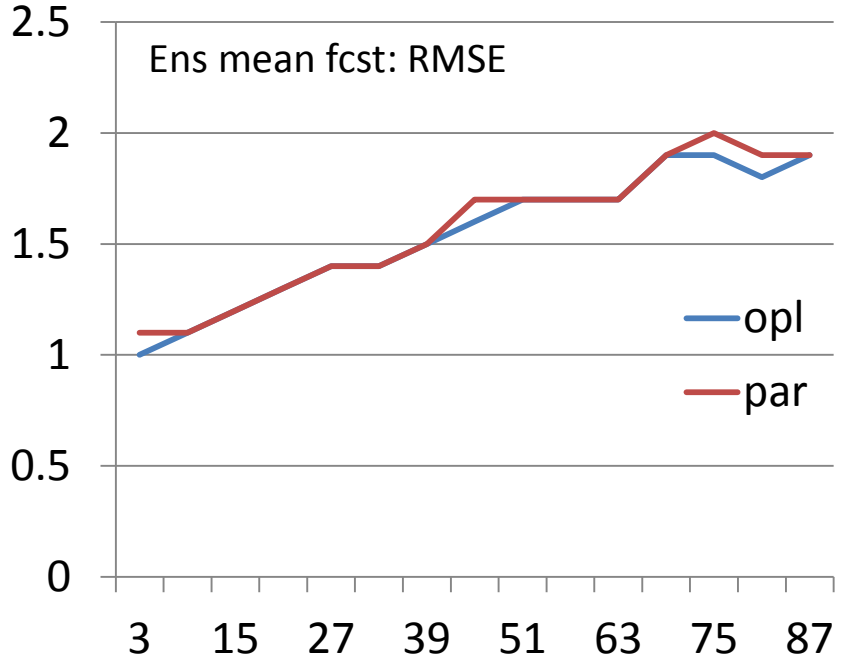


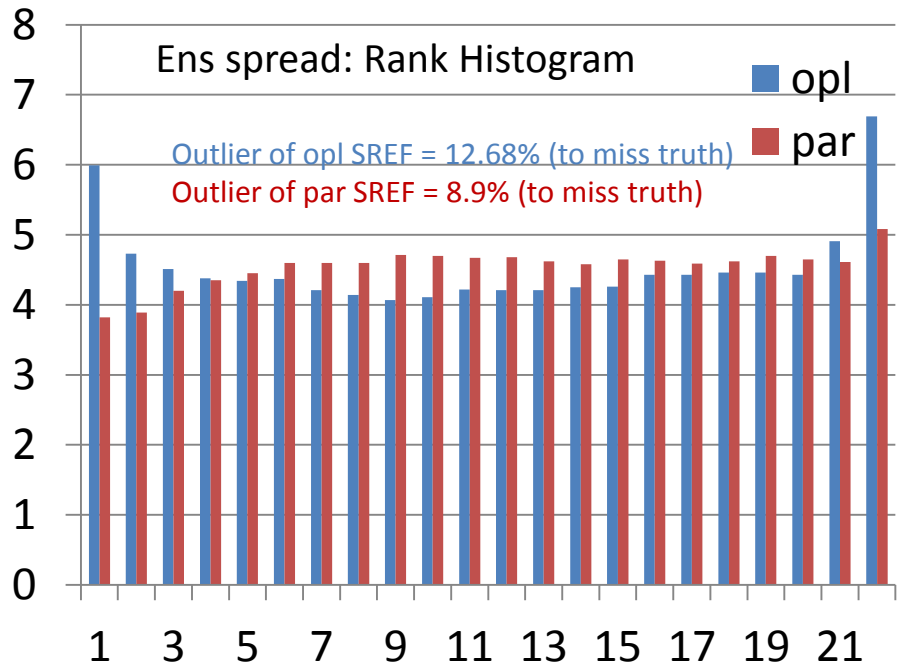


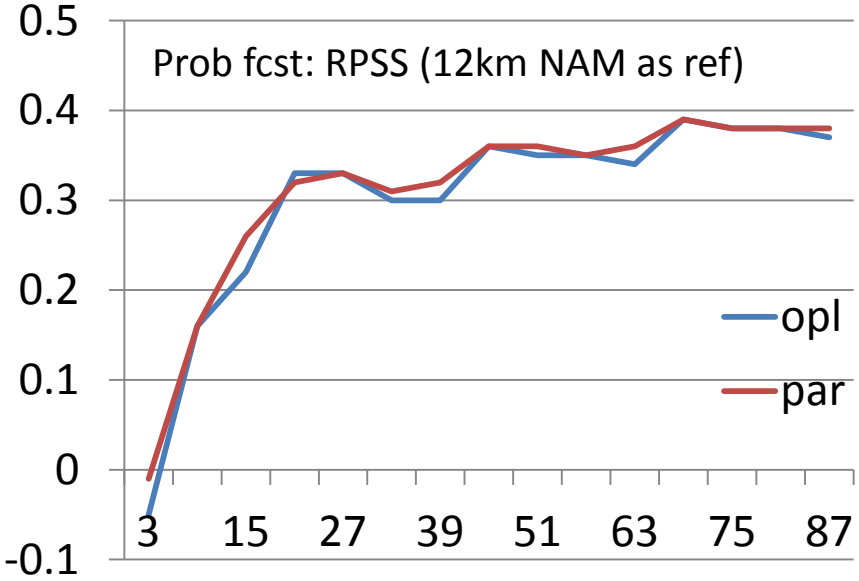


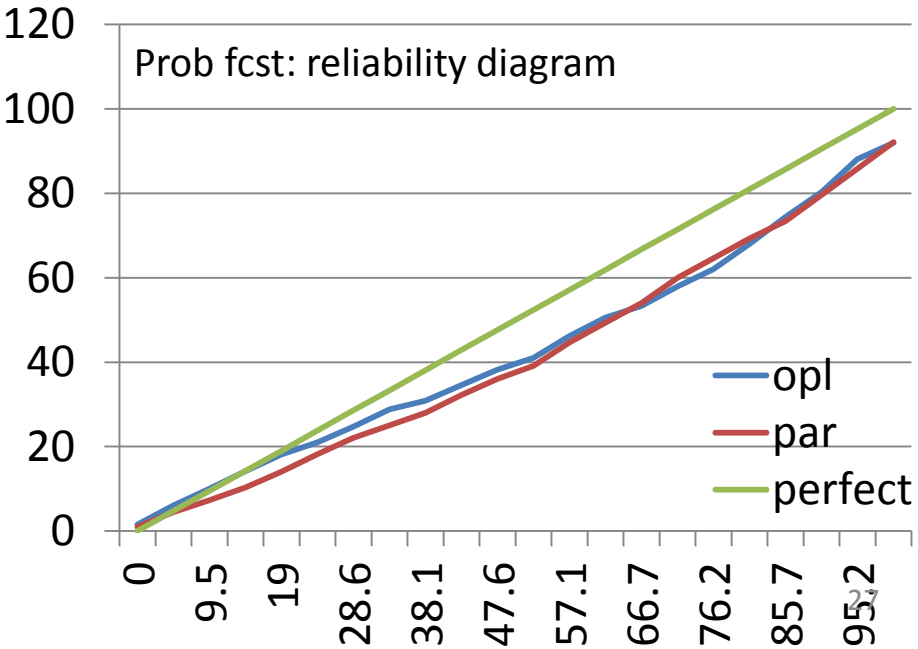


Evaluation of 10m-V (opl SREF vs. par SREF, Jun. 15 – Jul. 15, 2011)

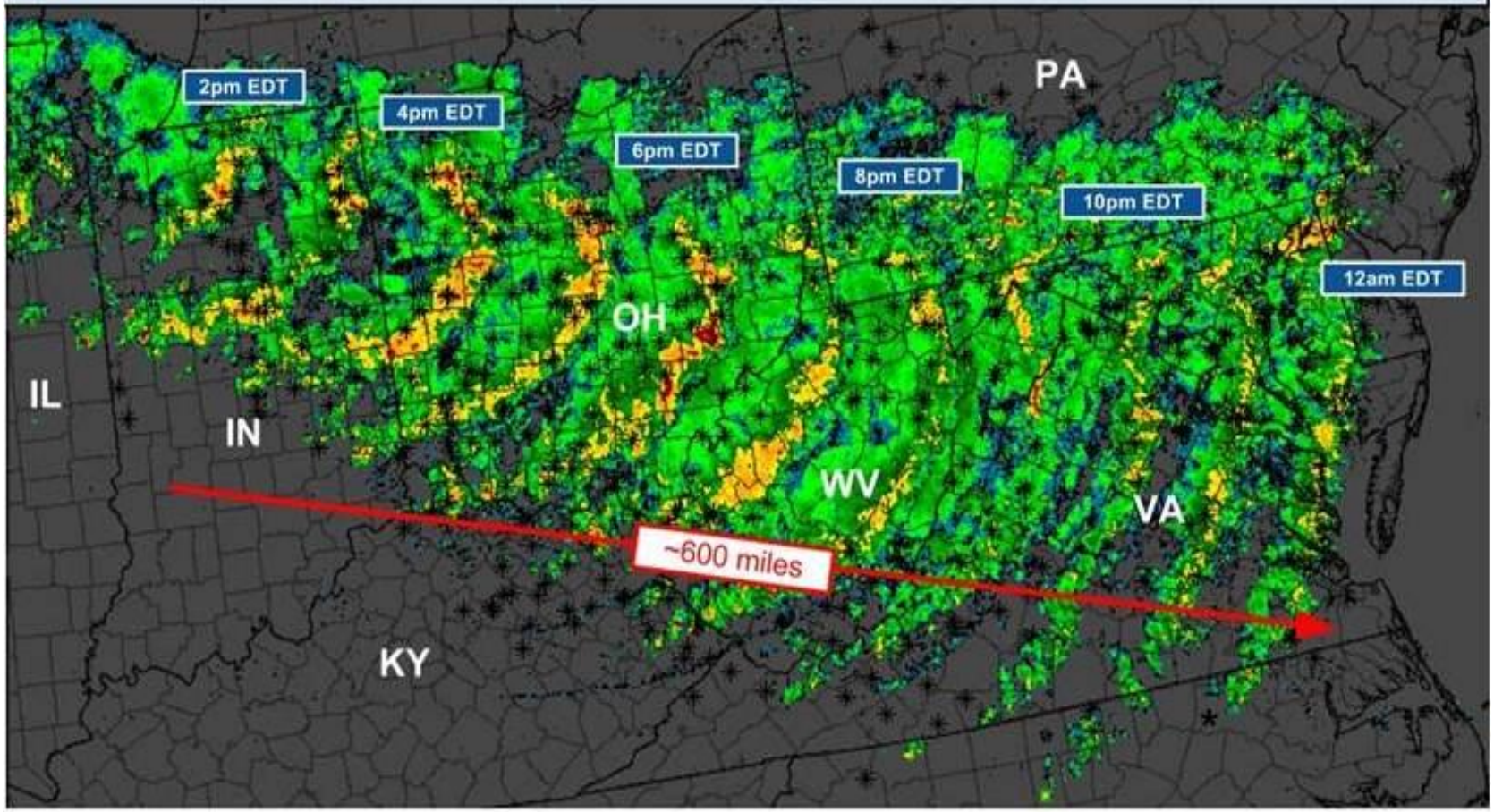








June 29, 2012 Midwest to East Coast Derecho
Radar Imagery Composite Summary 18-04 UTC
~600 miles in 10 hours / Average Speed ~60 mph

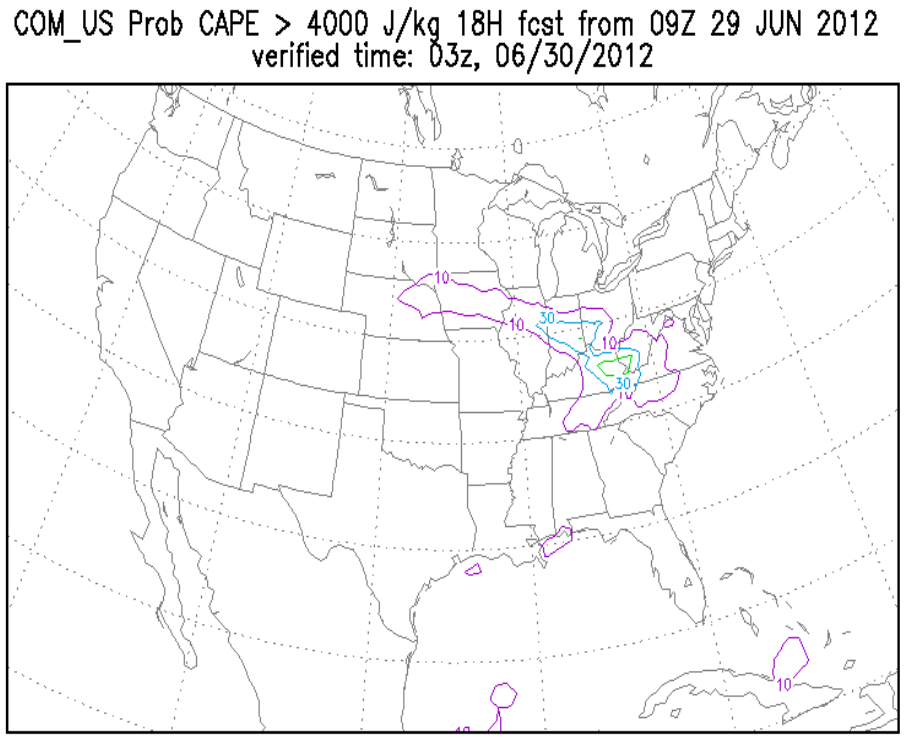


Over 500 preliminary thunderstorm wind reports indicated by *
Peak wind gusts 80-100mph. Millions w/o power.

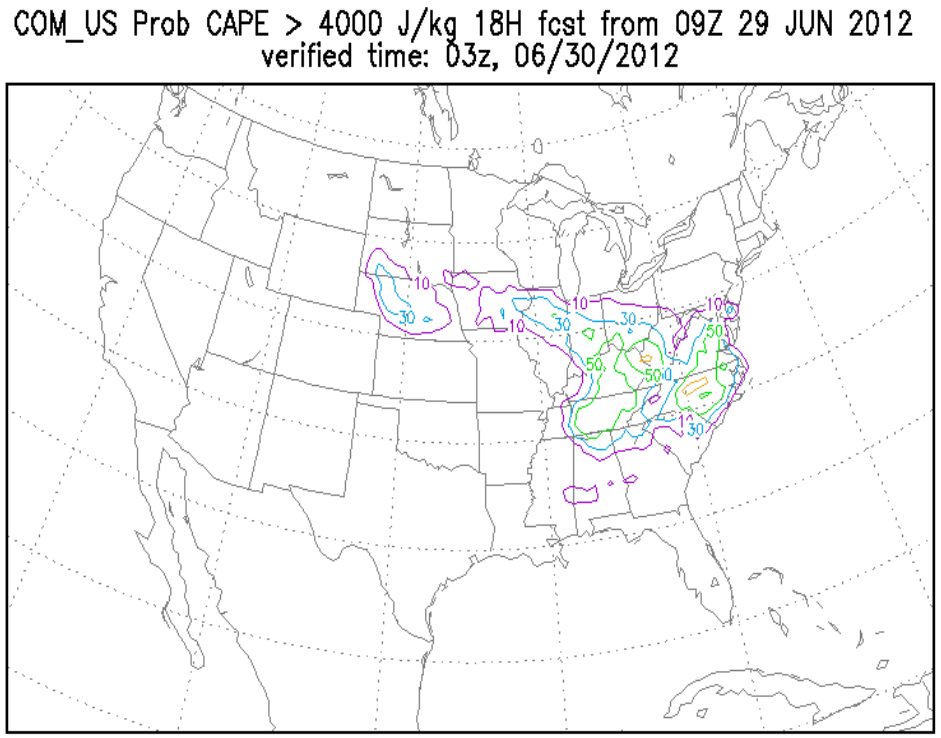
Summary Map by G. Carbin
NWS/Storm Prediction Center

18h-forecast of prob of CAPE > 4000 J/kg (valid at 03z, 6/30/2012)

OPL SREF (underestimated)

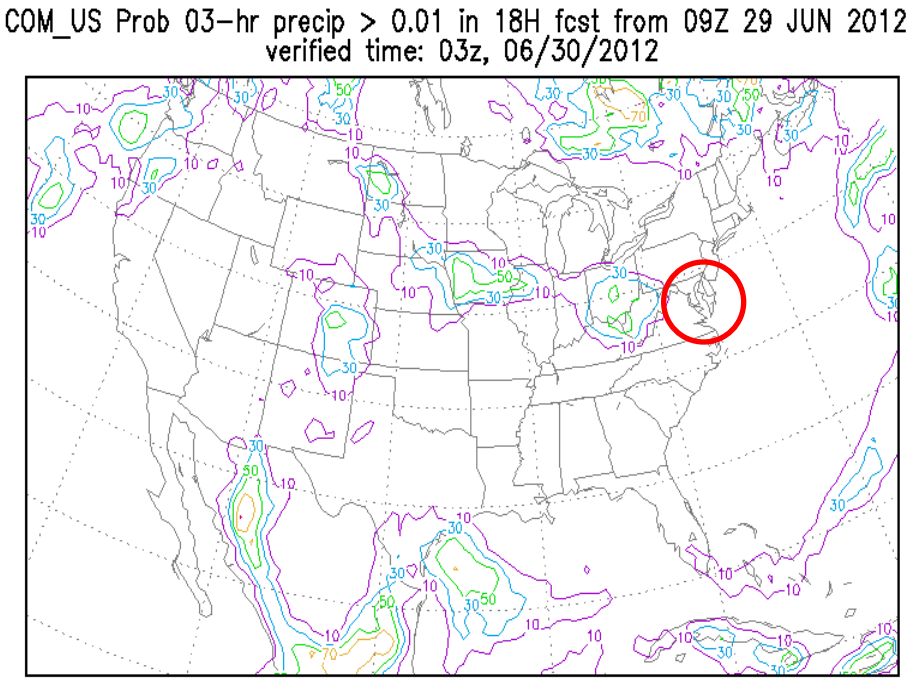


PARA SREF (better)

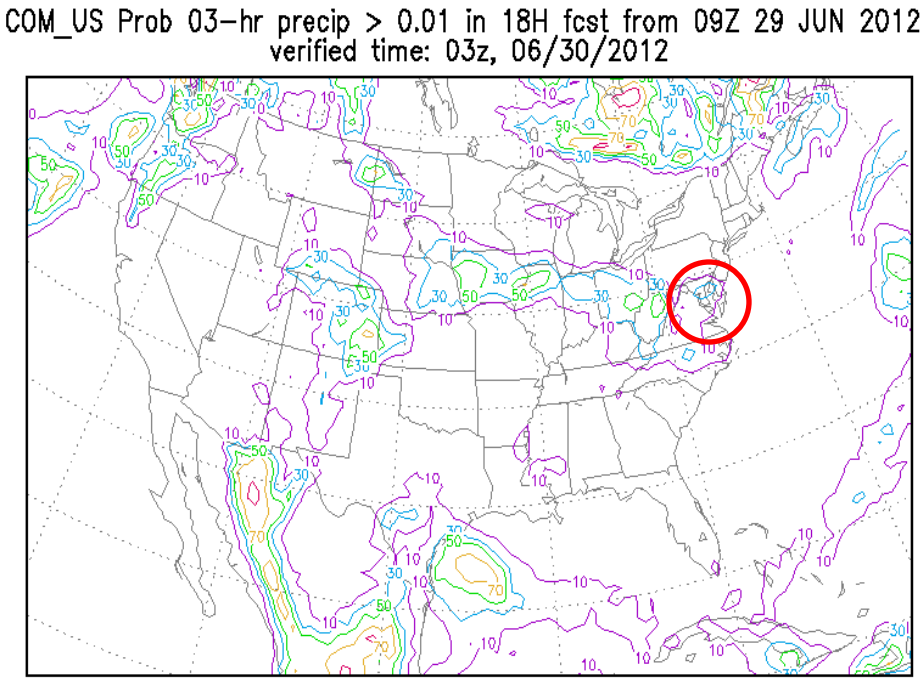


18h-forecast of prob of 3h-apcp > 0.01” (valid at 03z, 6/30/2012)

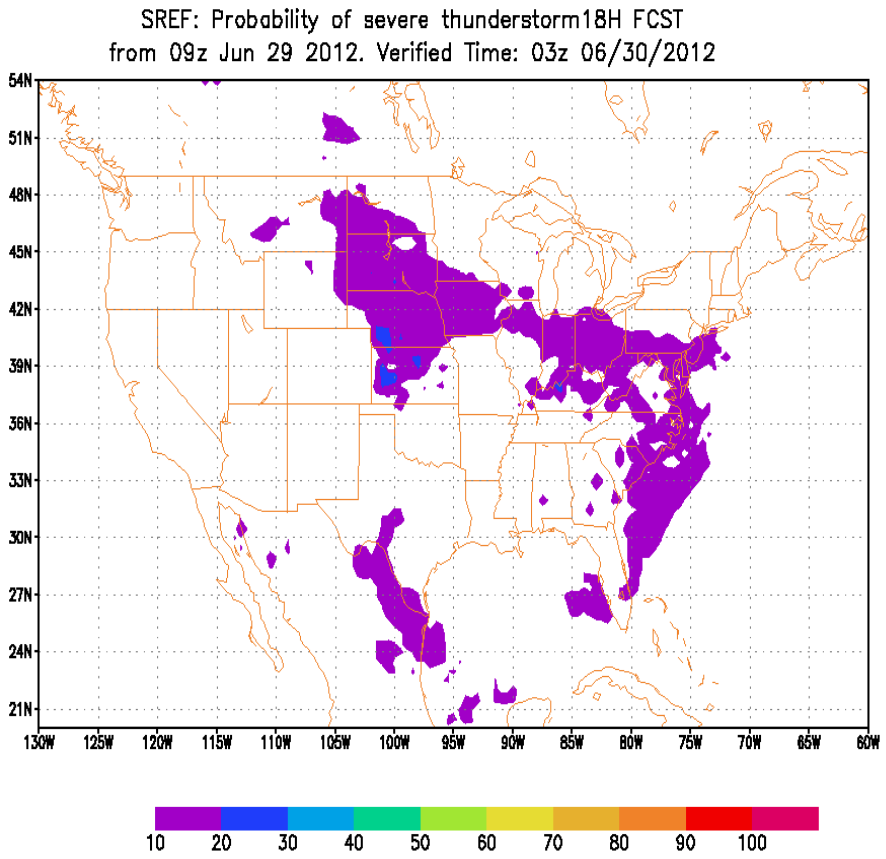
OPL SREF (did not cover DC area)



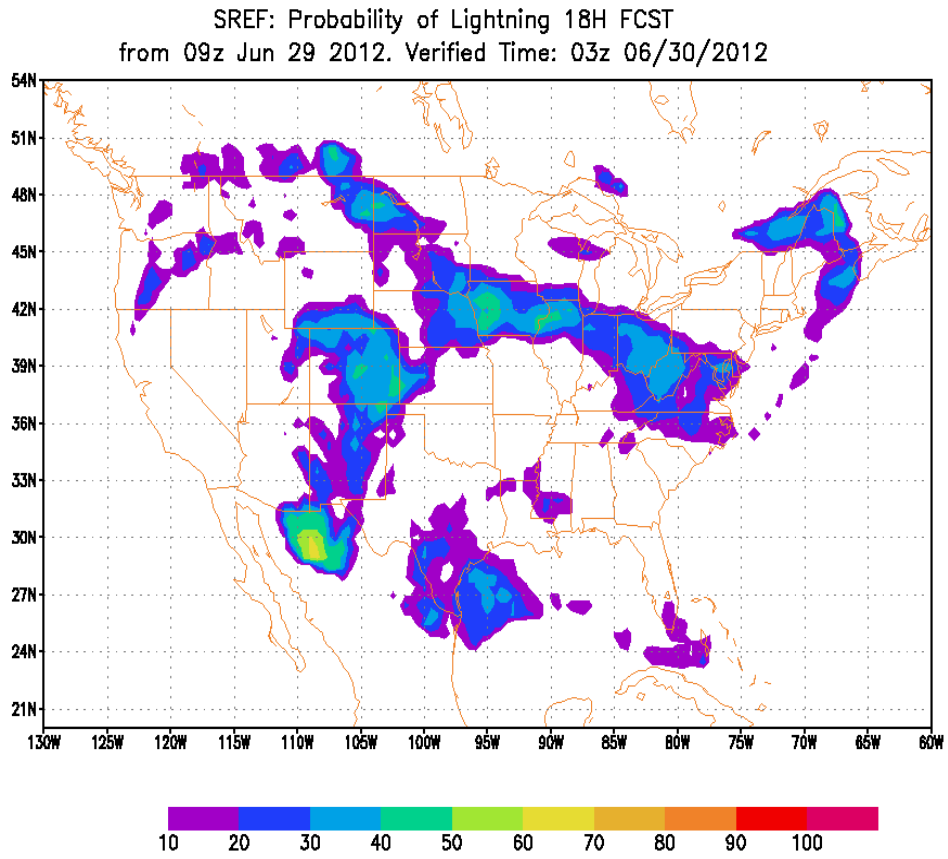
PARA SREF (covered DC area)



Added SPC products for the June 29's derecho case

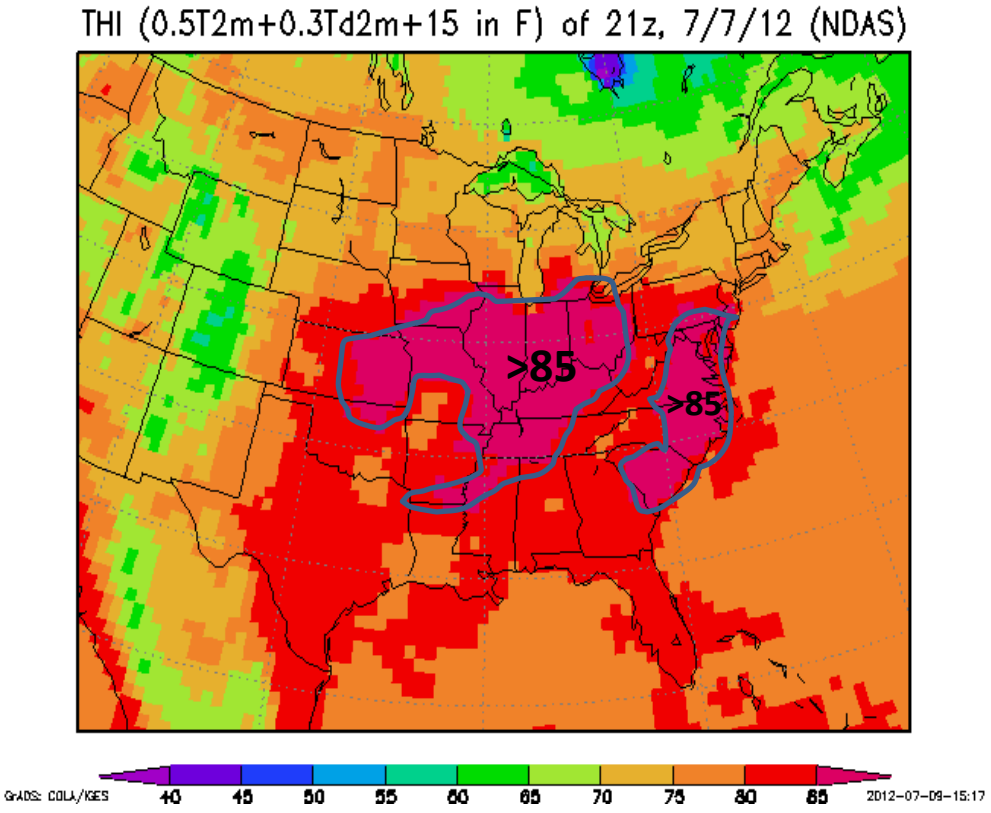


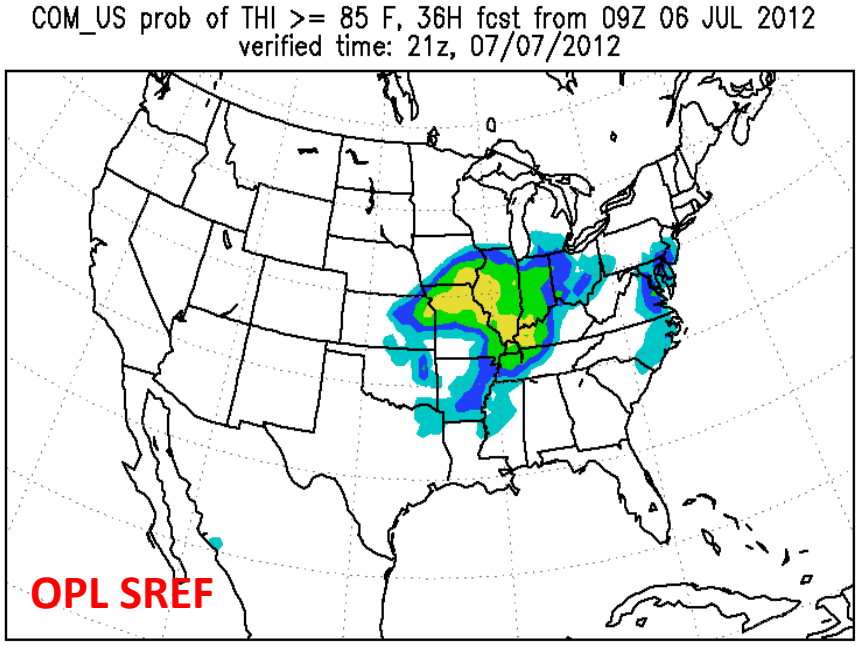
Prob of "Severe Thunderstorm"

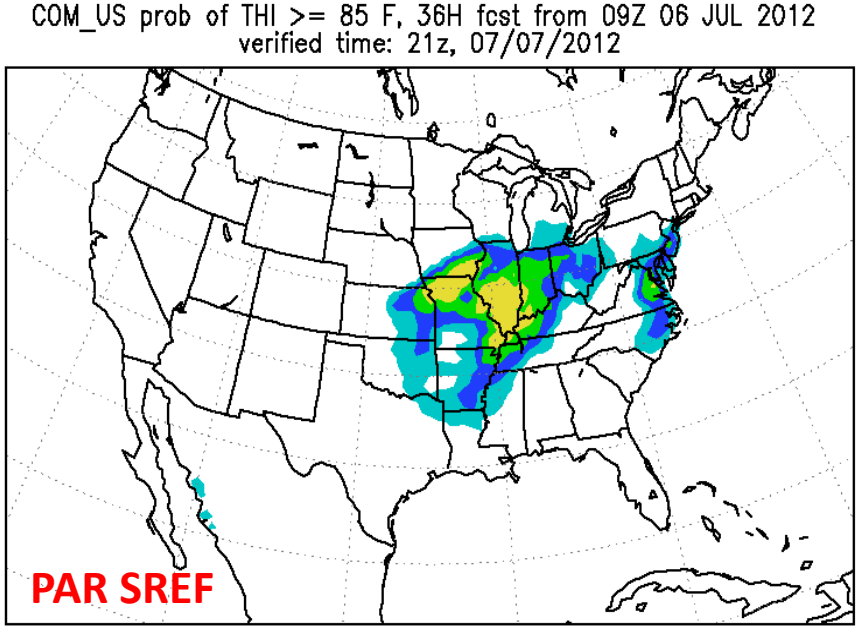


Prob of "Lightening"

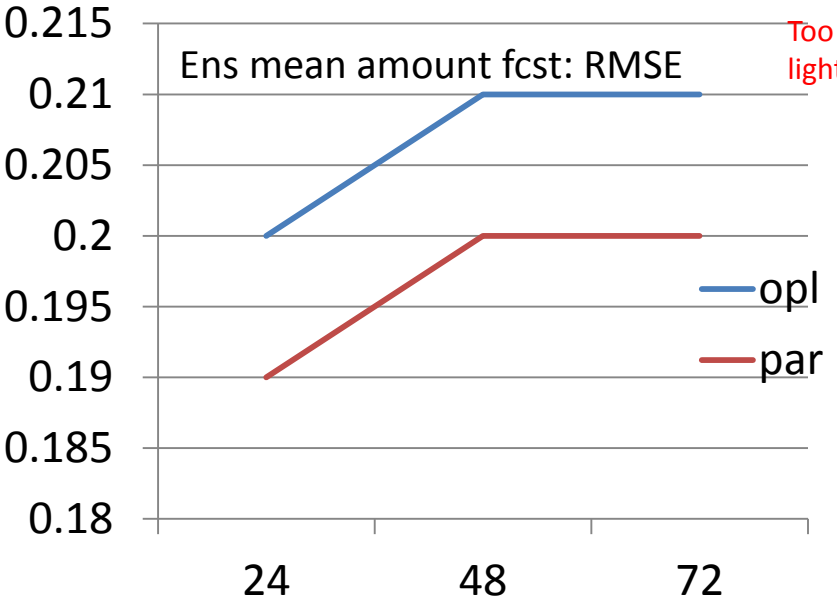
East Coast heat wave: 36h-forecast of prob of THI > 85 (valid at 21z, Saturday of 7/7/2012)

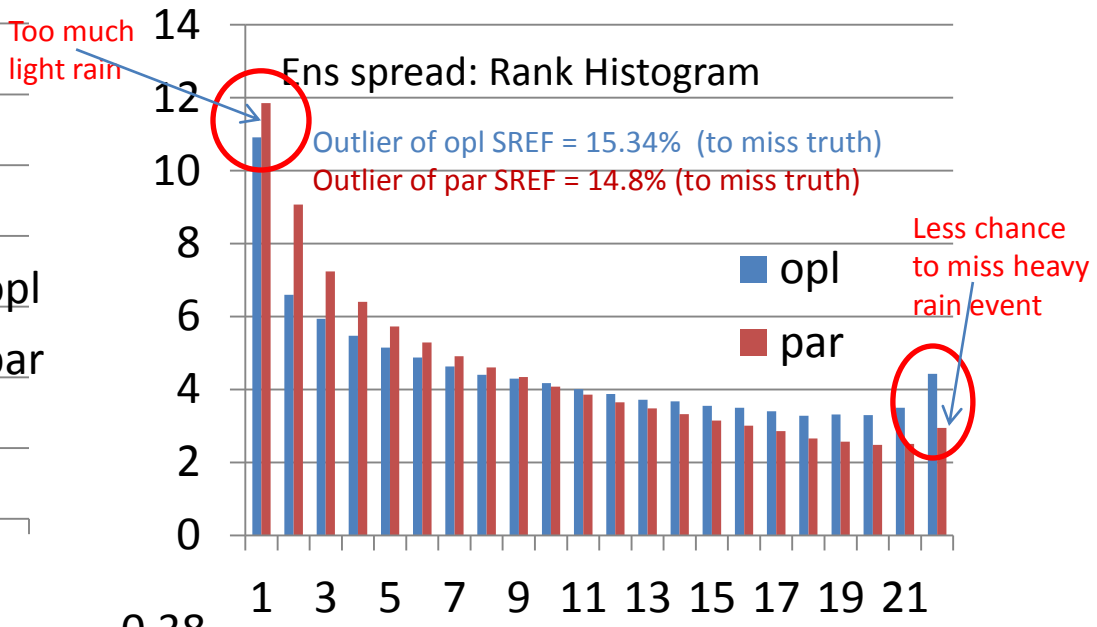


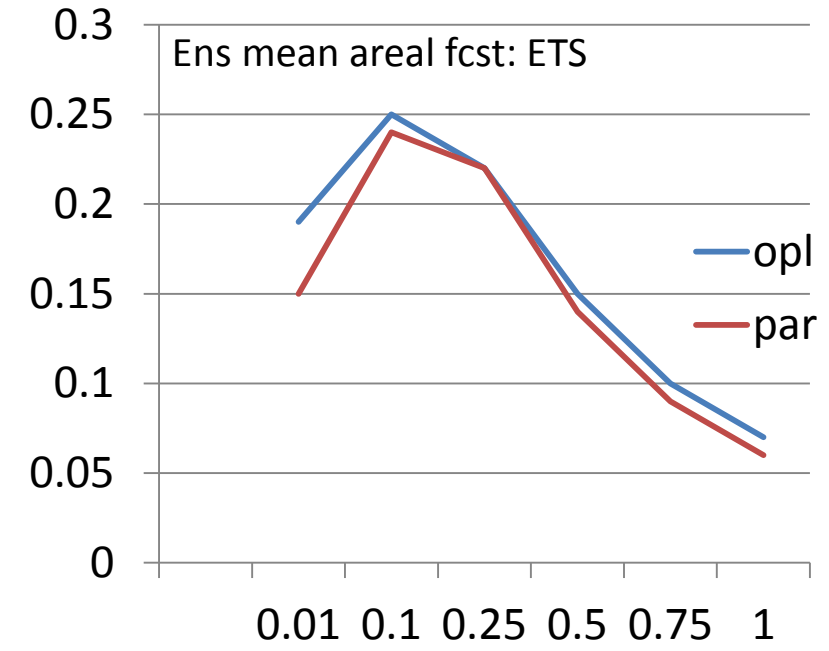


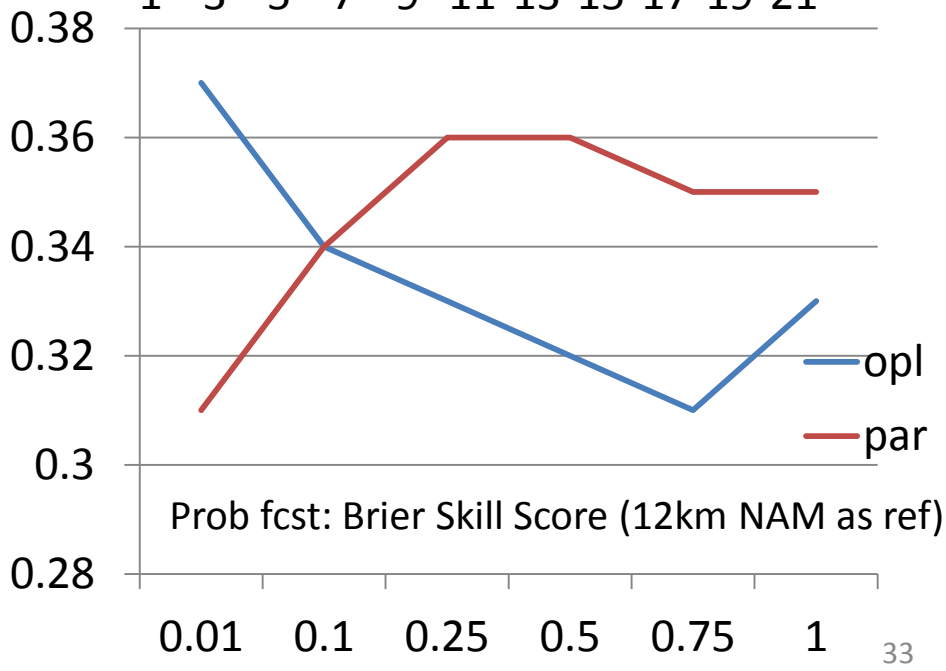


Evaluation of 24-apcp (opl SREF vs. par SREF, Jun. 15 – Jul. 15, 2012)

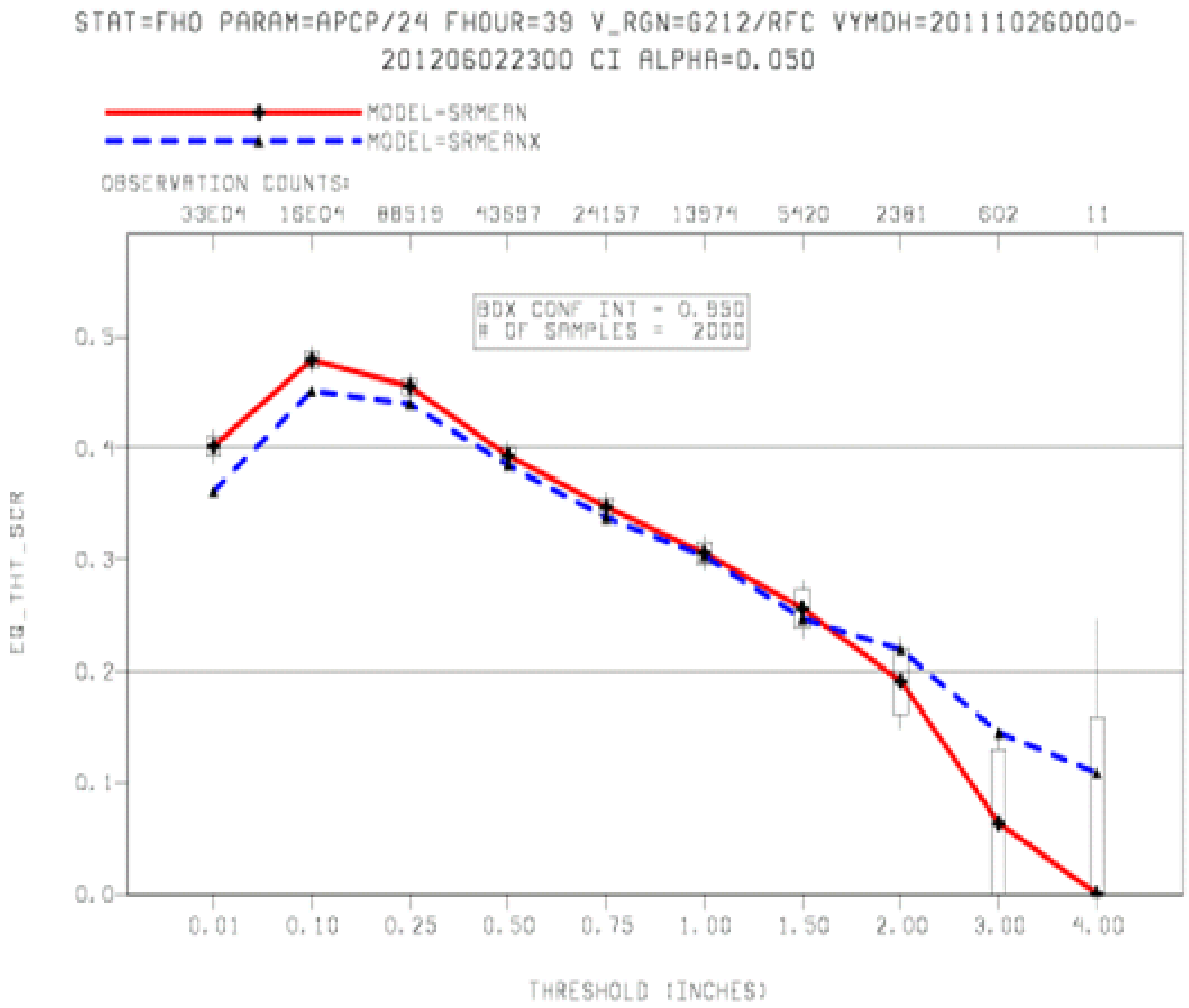




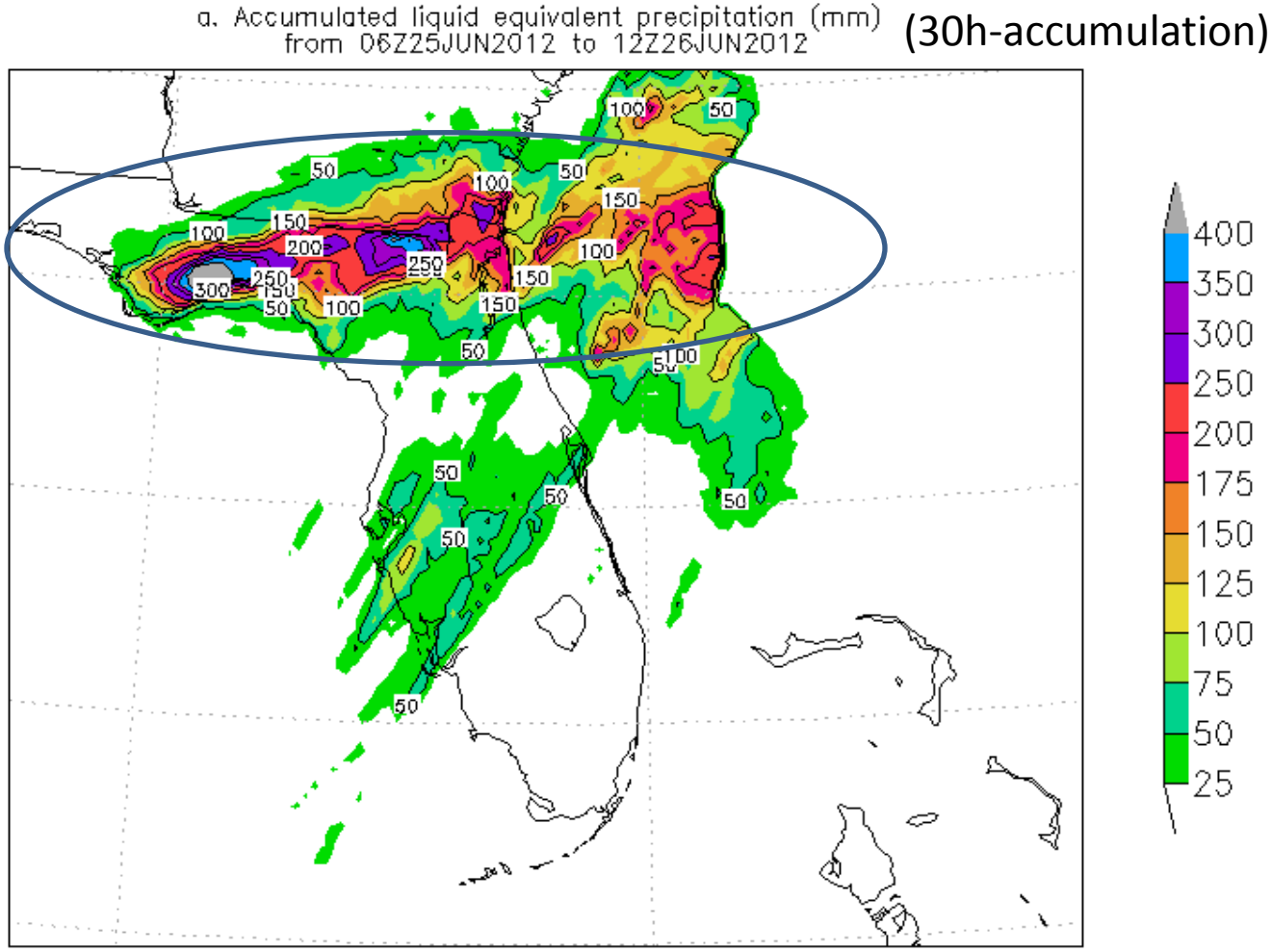




ETS of 24h-apcp (Oct. 2011 – Jun. 2012, F39hr)



Slow-moving Hurricane Debby-induced heavy rain over Florida (provided by Rich Grumm)

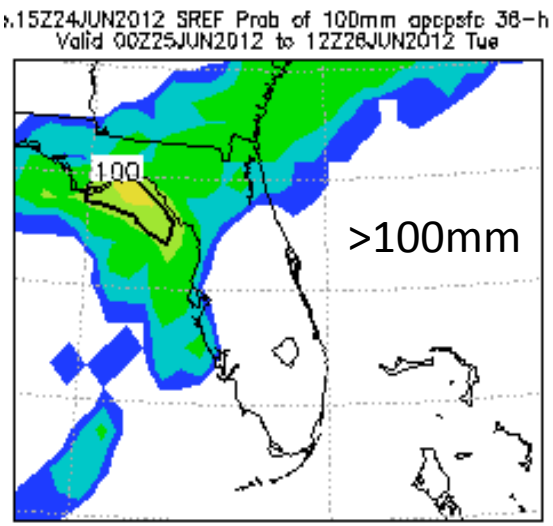


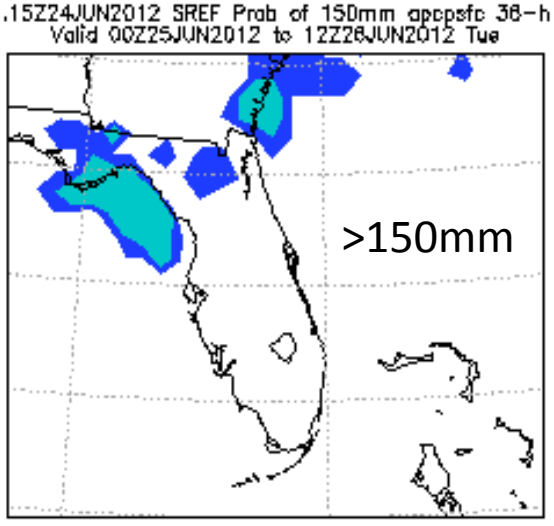
(30h-accumulation)

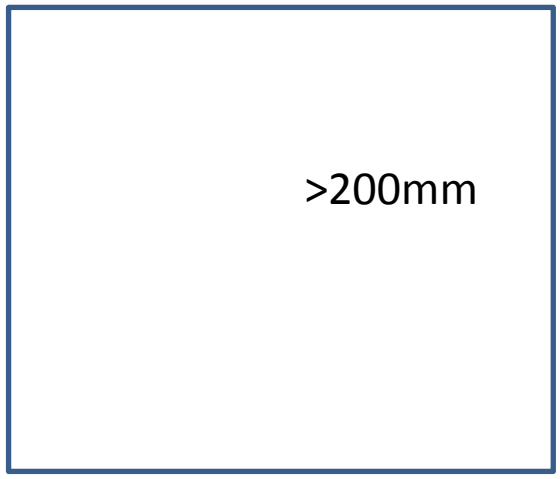
PQPF of Opl SREF (upper, underestimated) vs. Para SREF (lower, much improved)

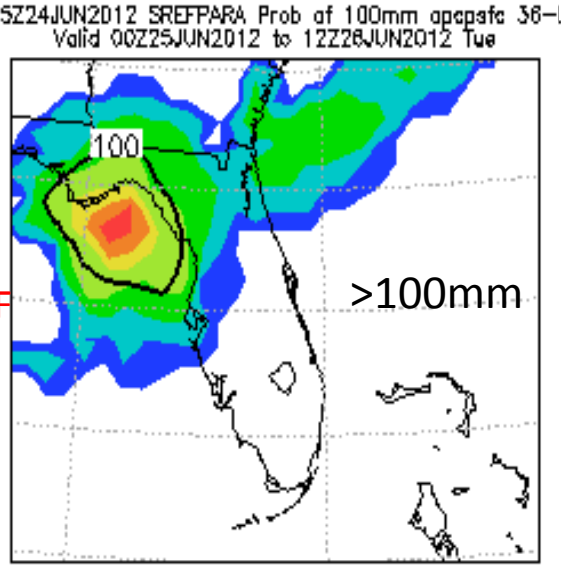
Opl SREF

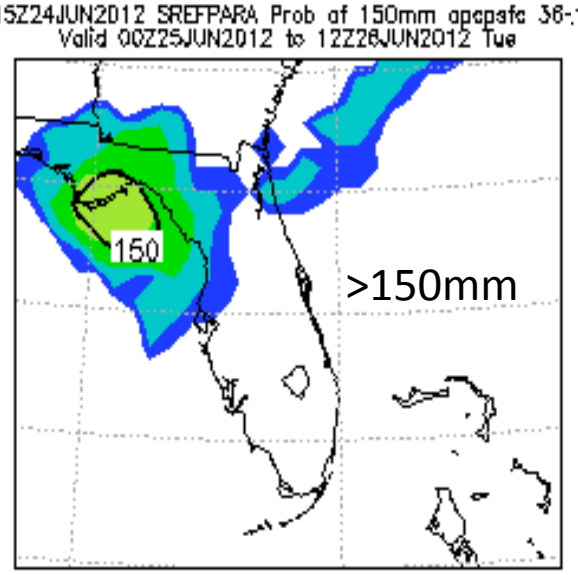
Para SREF

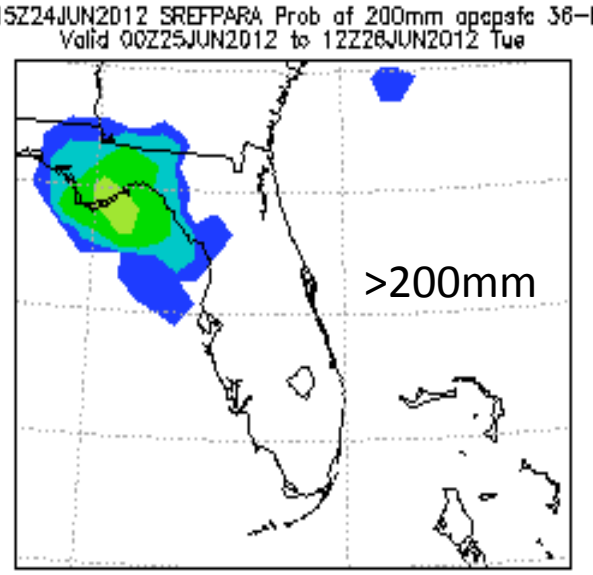


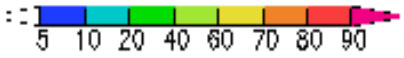






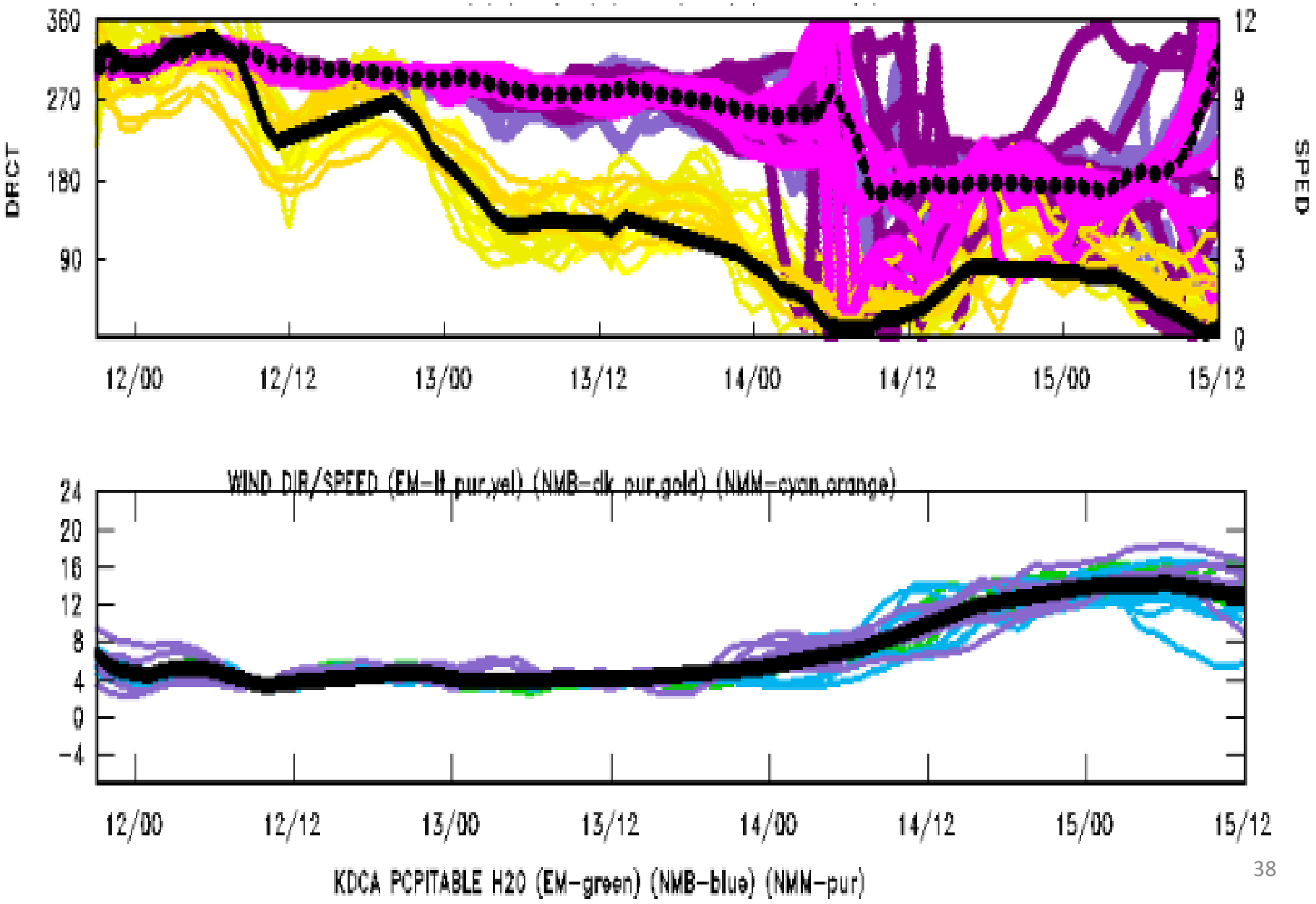




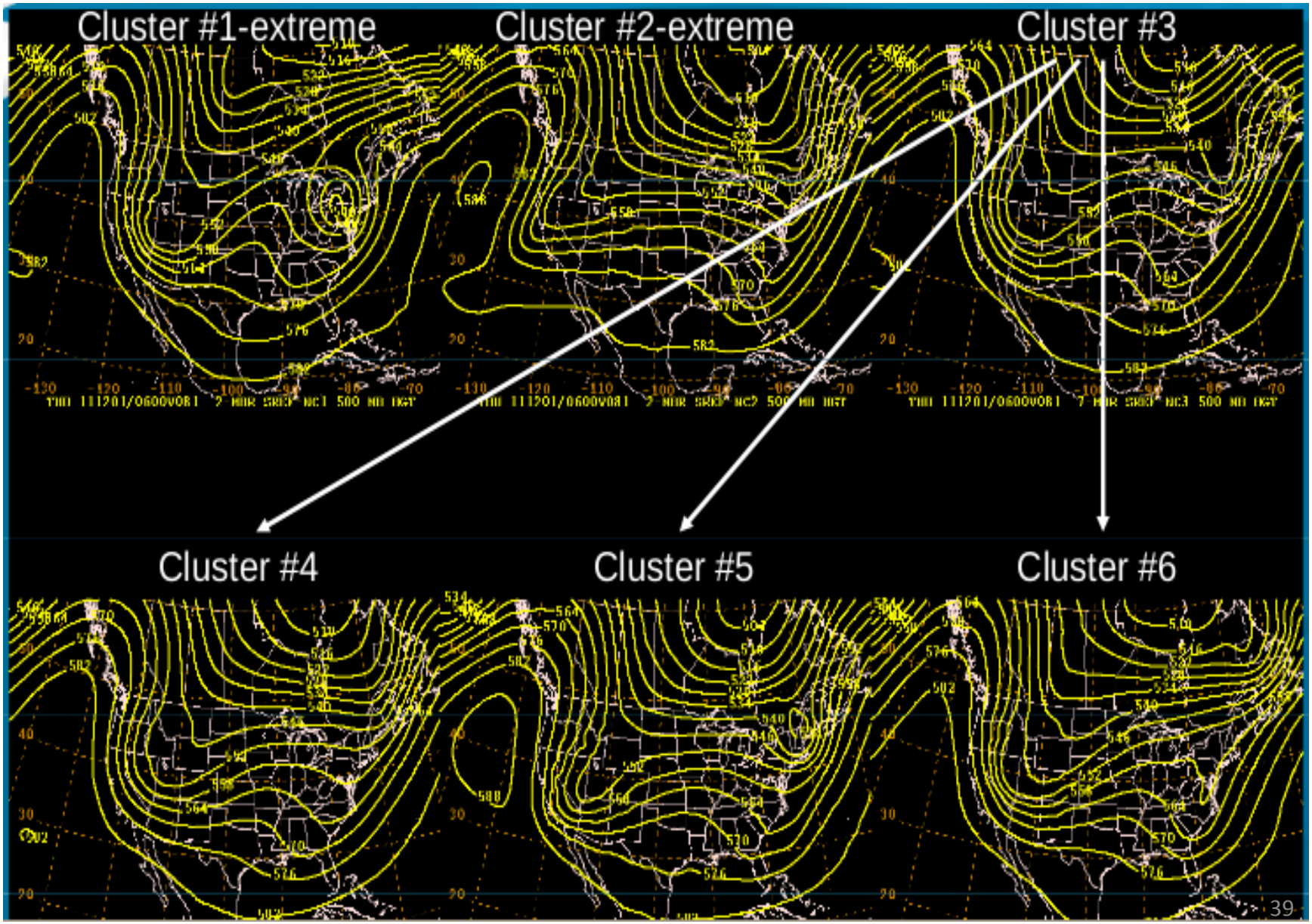


Samples of new products

Ensemble mean bufr forecast at a station



Ensemble Clusters



34 cluster-mean fields

Two clustering methods
– NCEP & OU

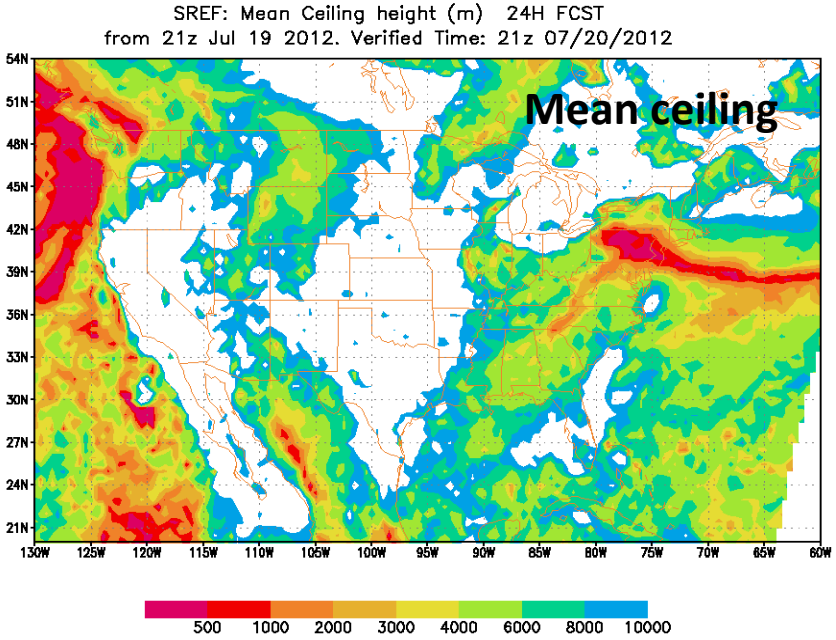
NCEP: varied cluster numbers depending on synoptic situation

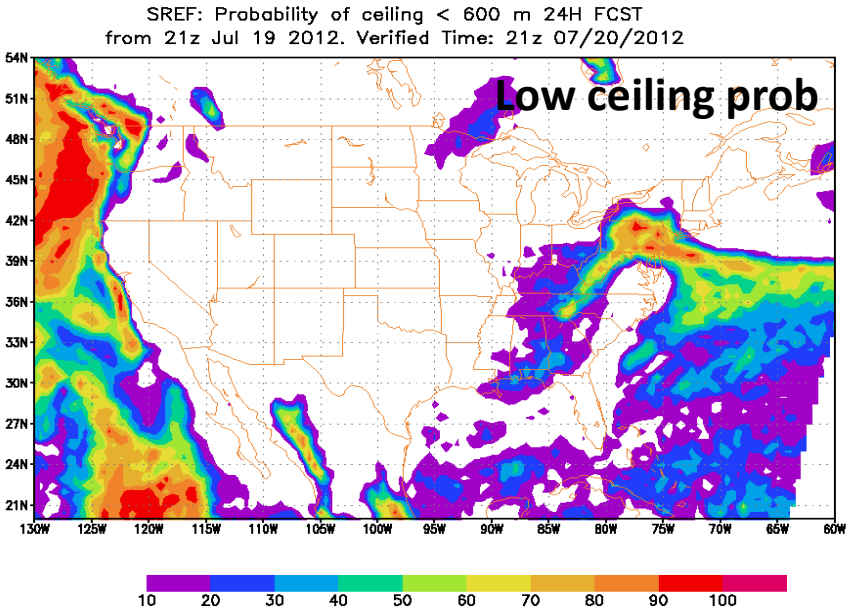
OU: fixed 6 clusters

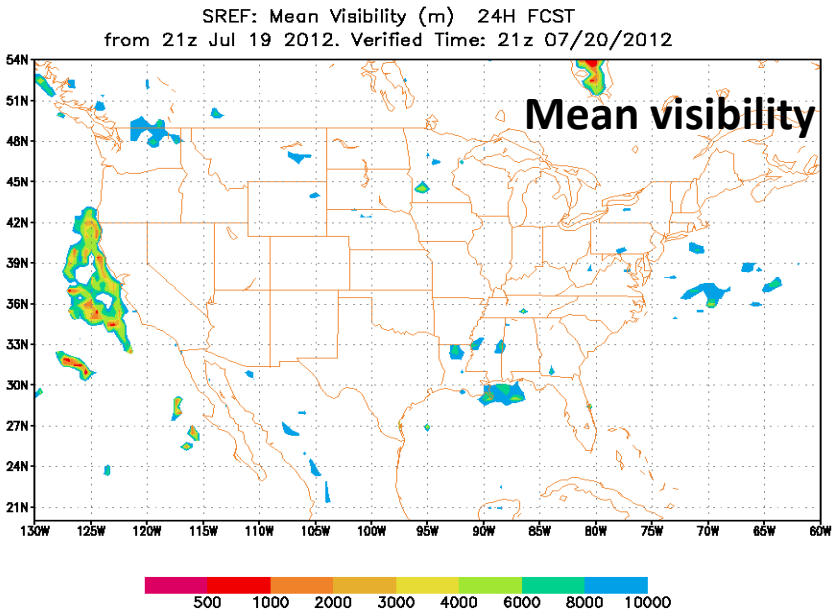
to meet different user needs such as dynamical downscaling

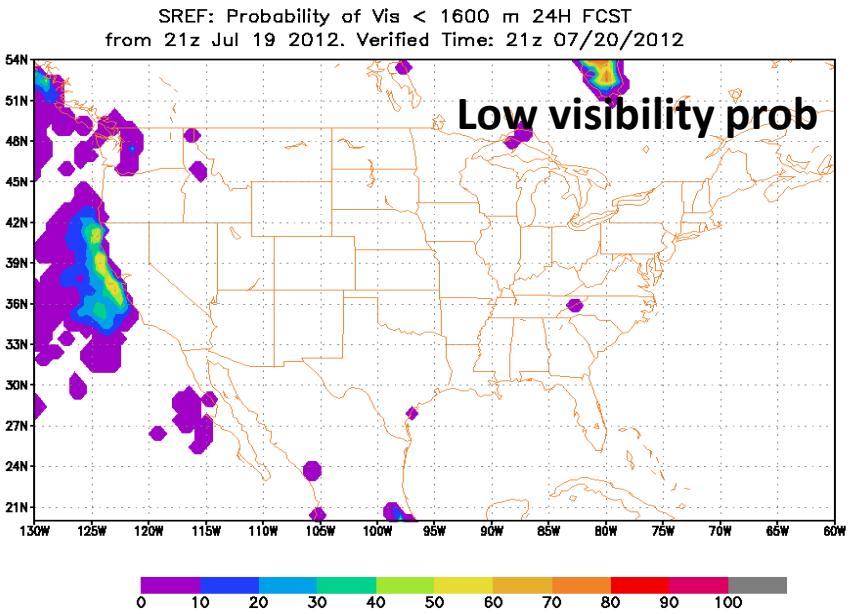
surface	T2m, Q2m, RH2m, U10m, V10m, Precip, SLP, PW
height	1000, 805, 700, 500, 300, 250mb
U	1000, 850, 700, 500, 300, 250mb
V	1000, 850, 700, 500, 300, 250mb
RH	850, 700, 500, 300mb
T	850, 700, 500, 300mb

New ensemble products for aviation weather

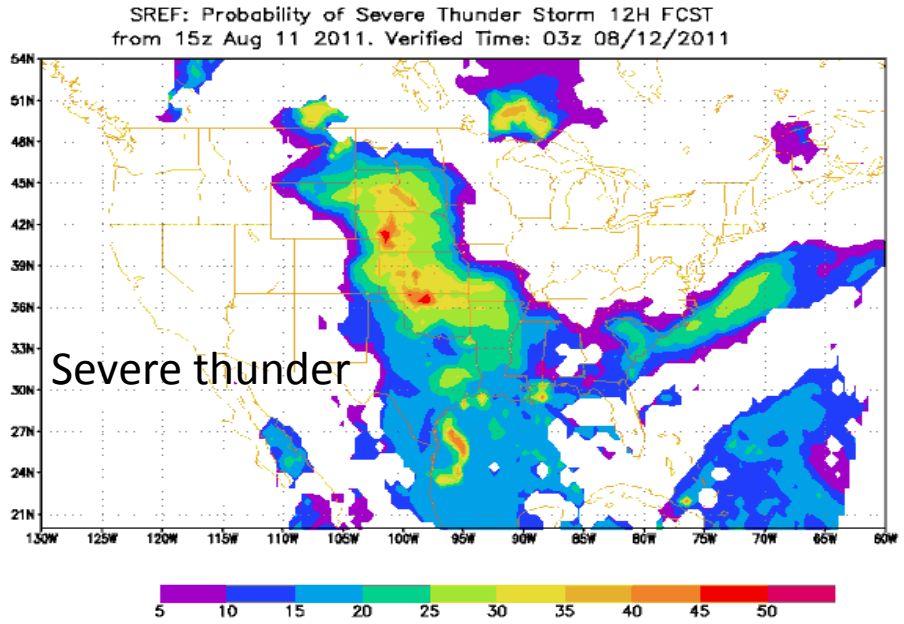


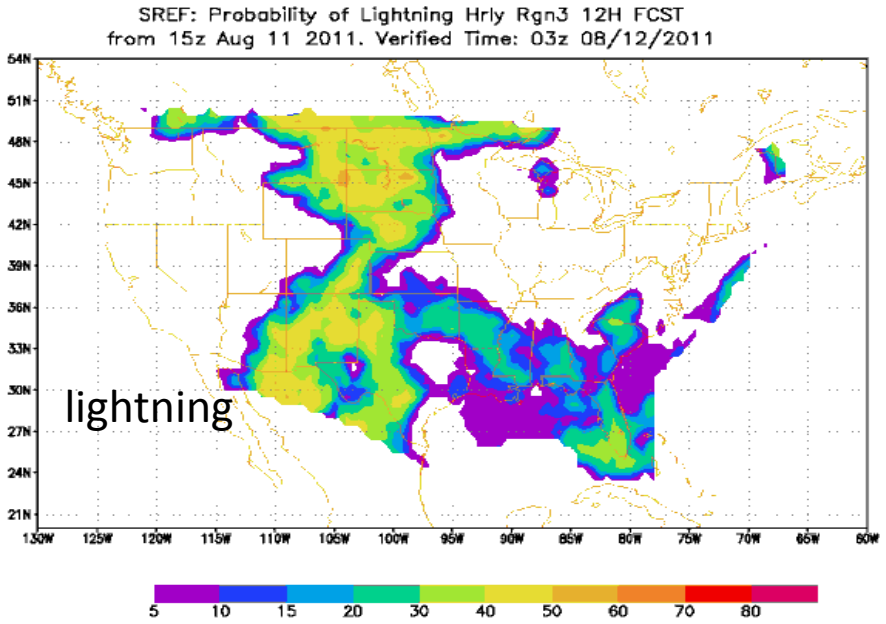


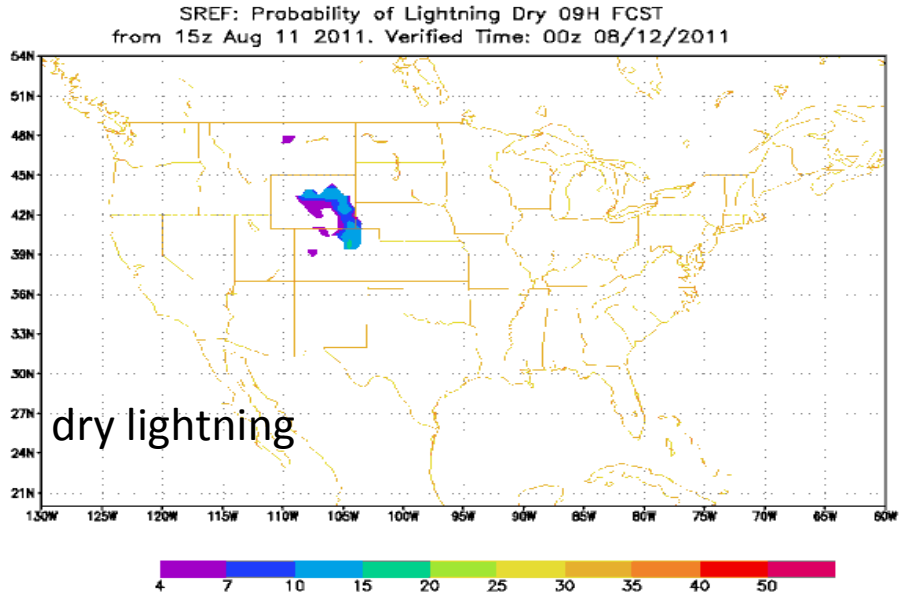


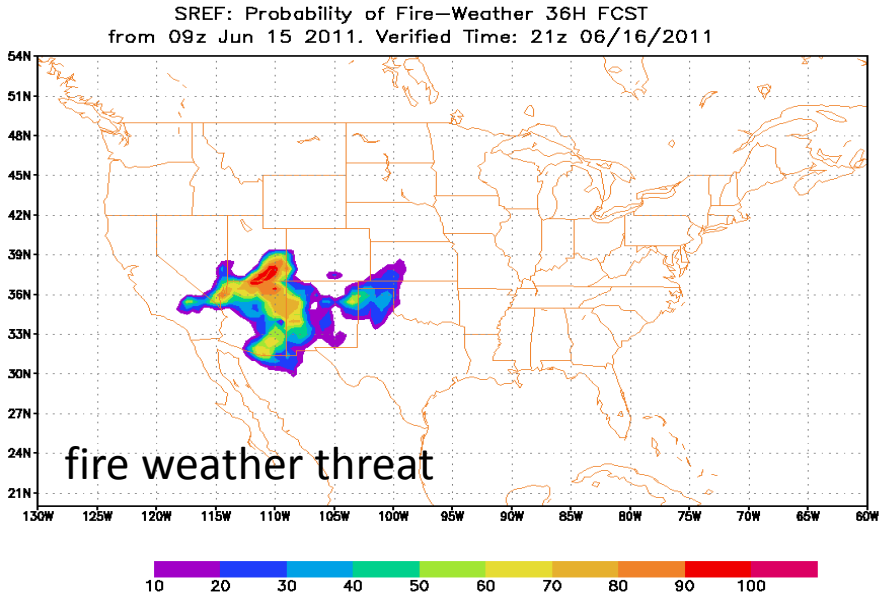


New ensemble products for convection and fire weather (SPC)

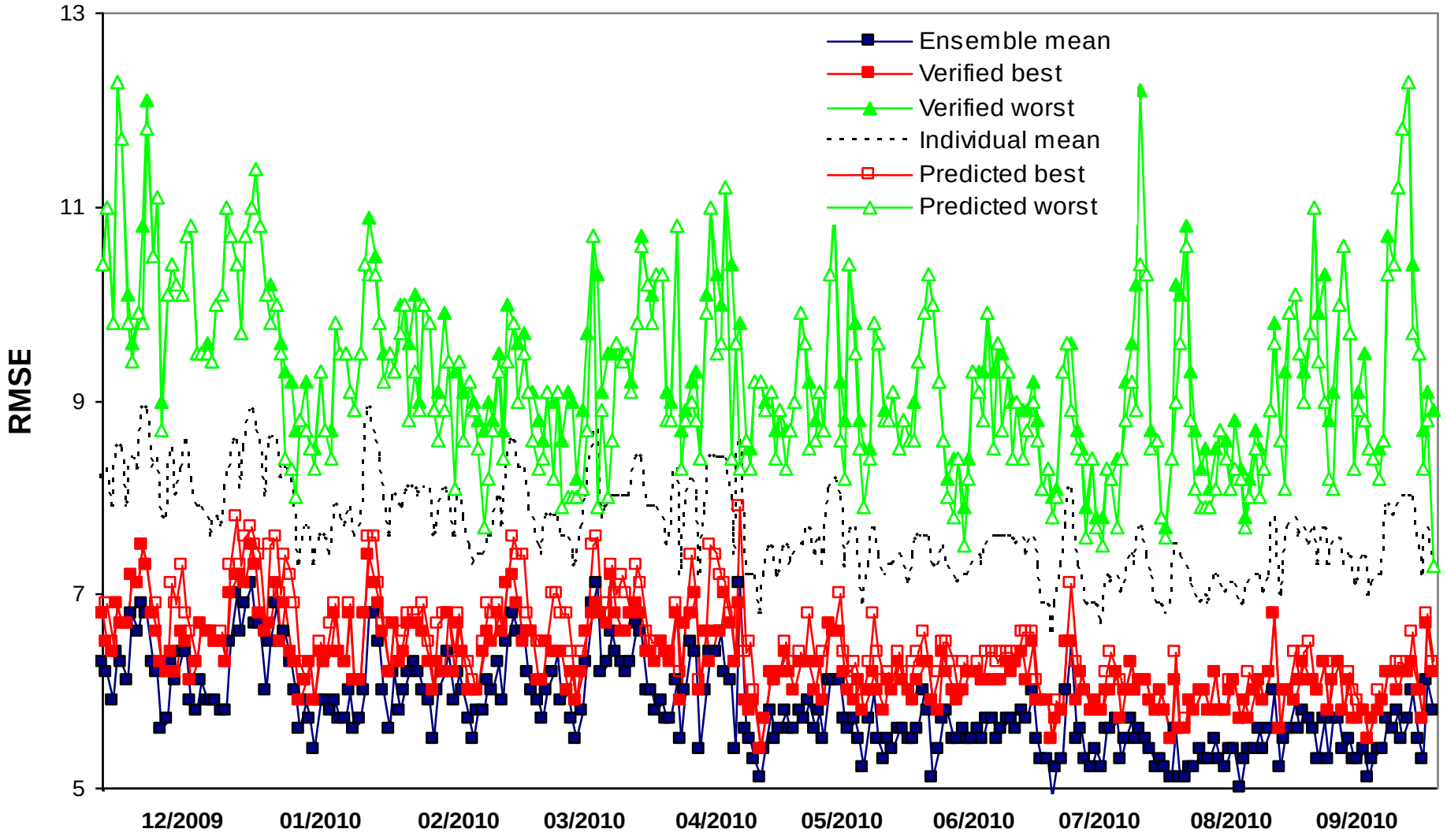




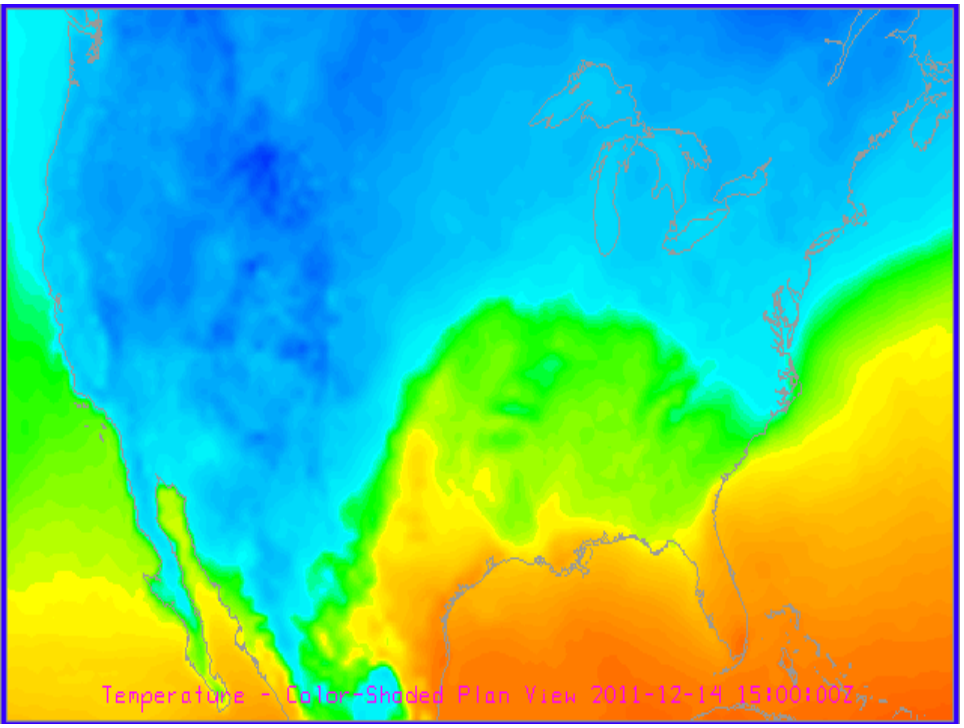


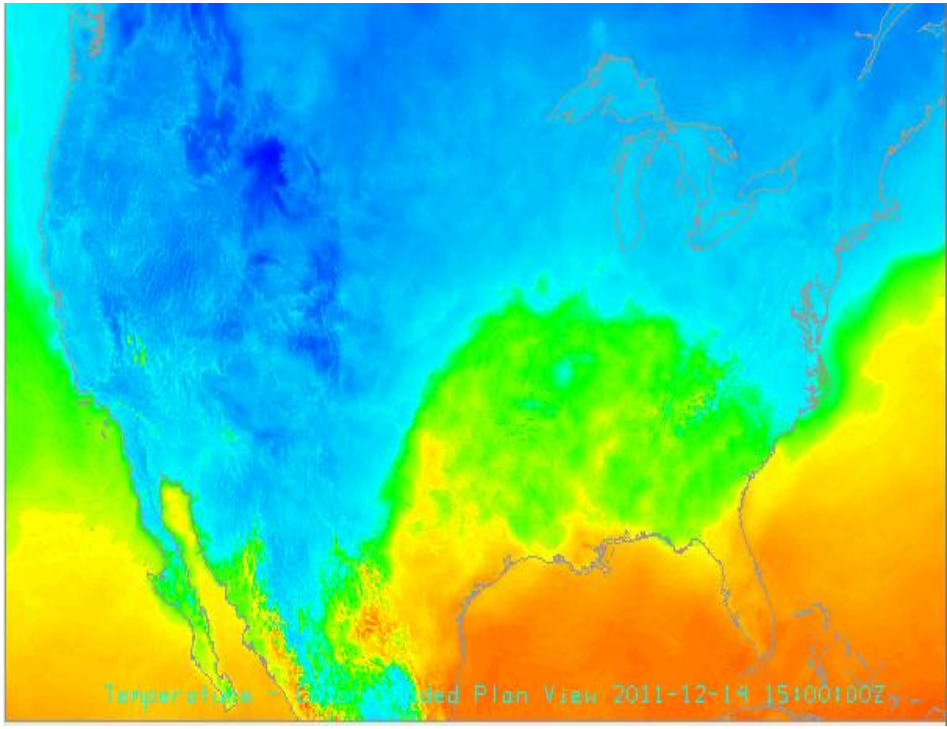


Individual member' performance ranking (weights for each members): Du and Zhou 2011 MWR



Downscaling to 5km (sample: T2m valid at 15Z, Dec. 14, 2011)

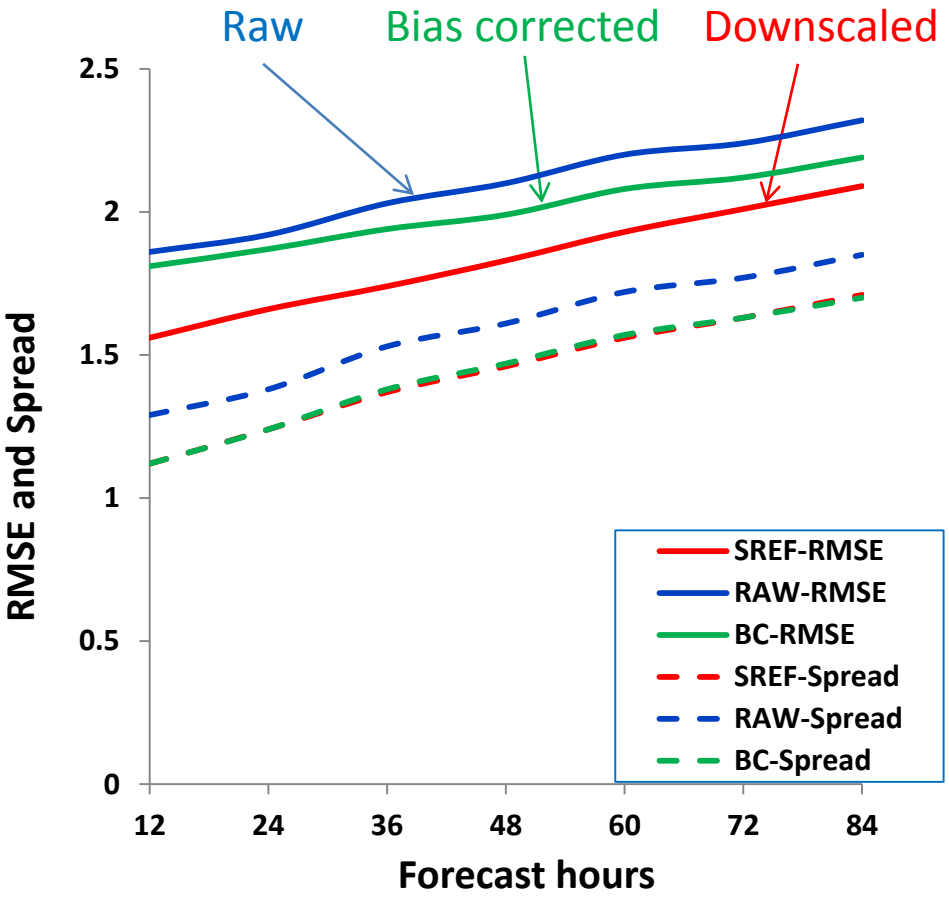


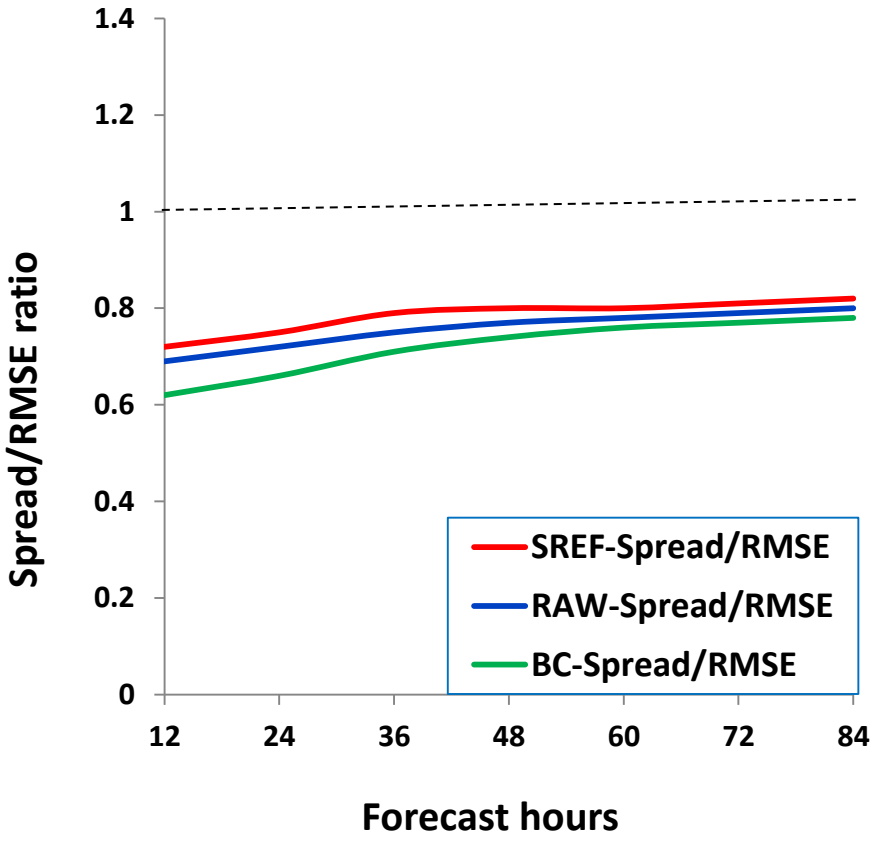


Before (40km)

After (5km)

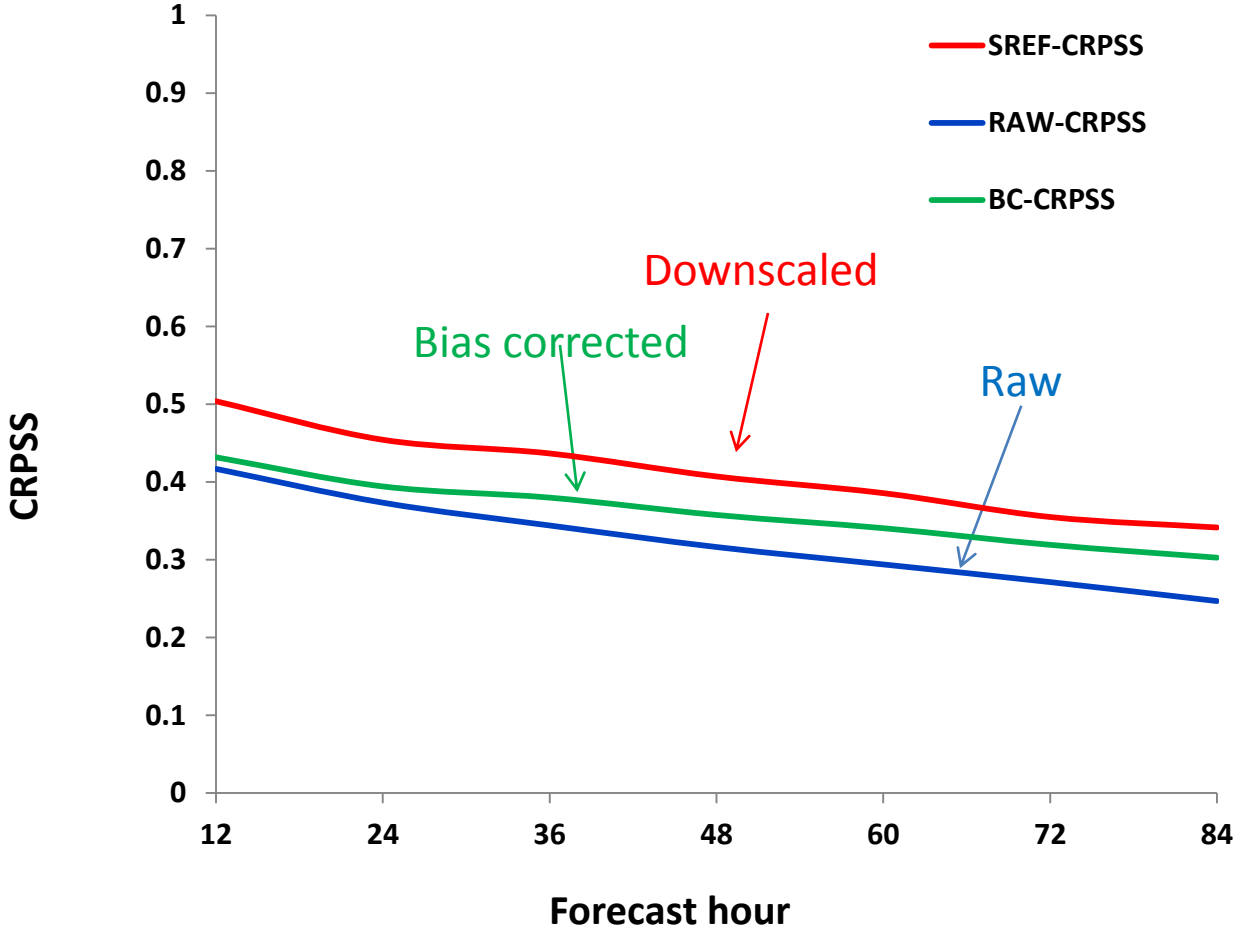
Performance of the downscaled 5km SREF (verified against RTMA, 6/18/12 – 7/16/12)





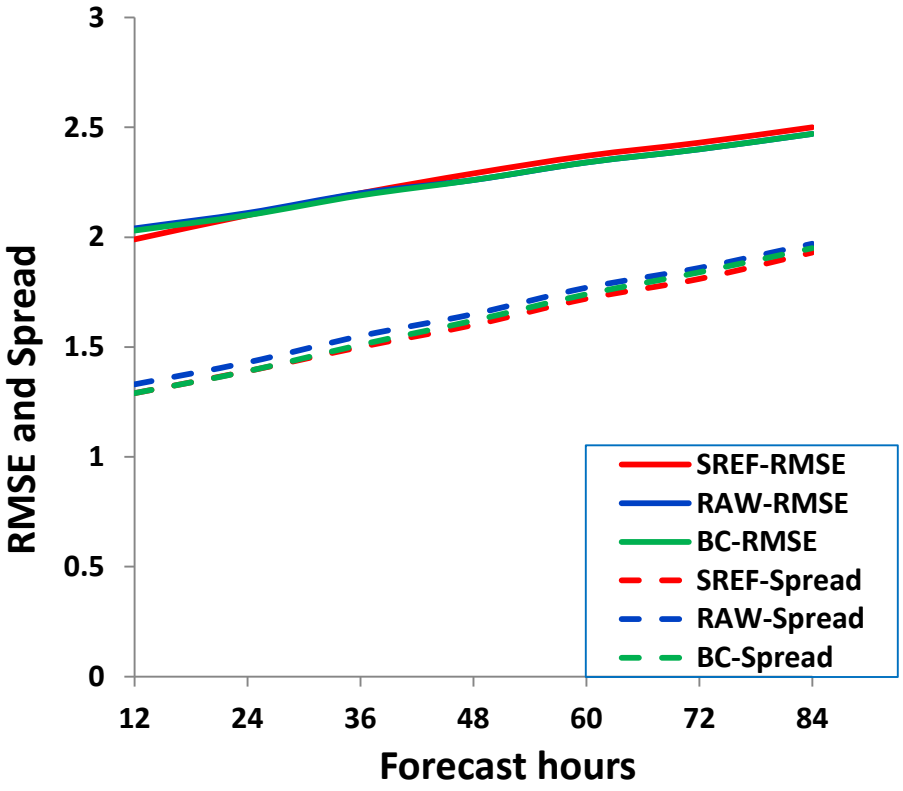
T2m (ens mean)

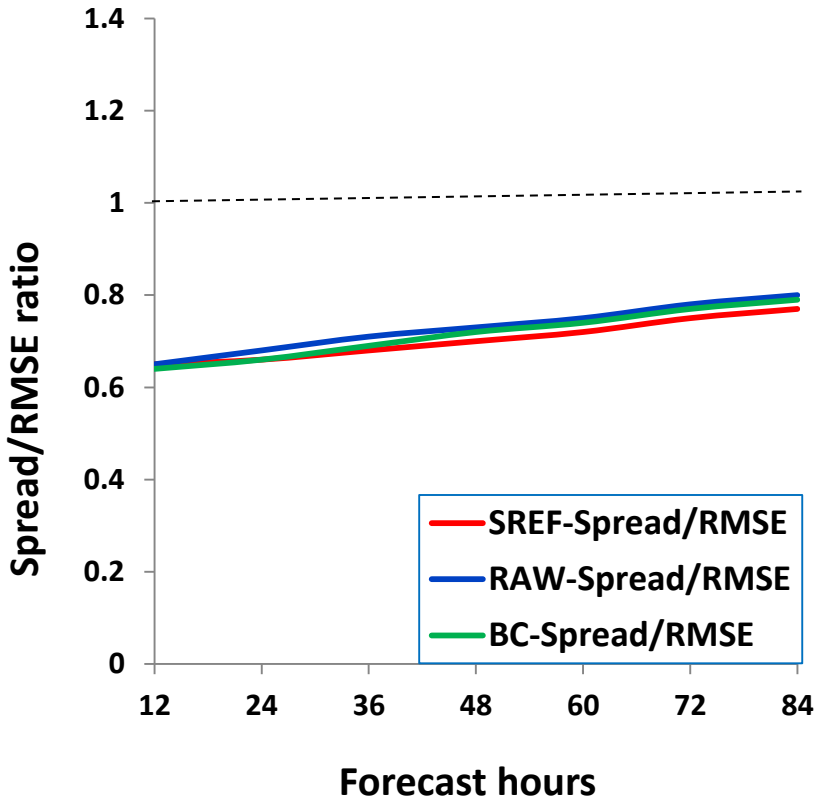
Performance of the downscaled 5km SREF (verified against RTMA, 6/18/12 – 7/16/12)



T2m (probability)

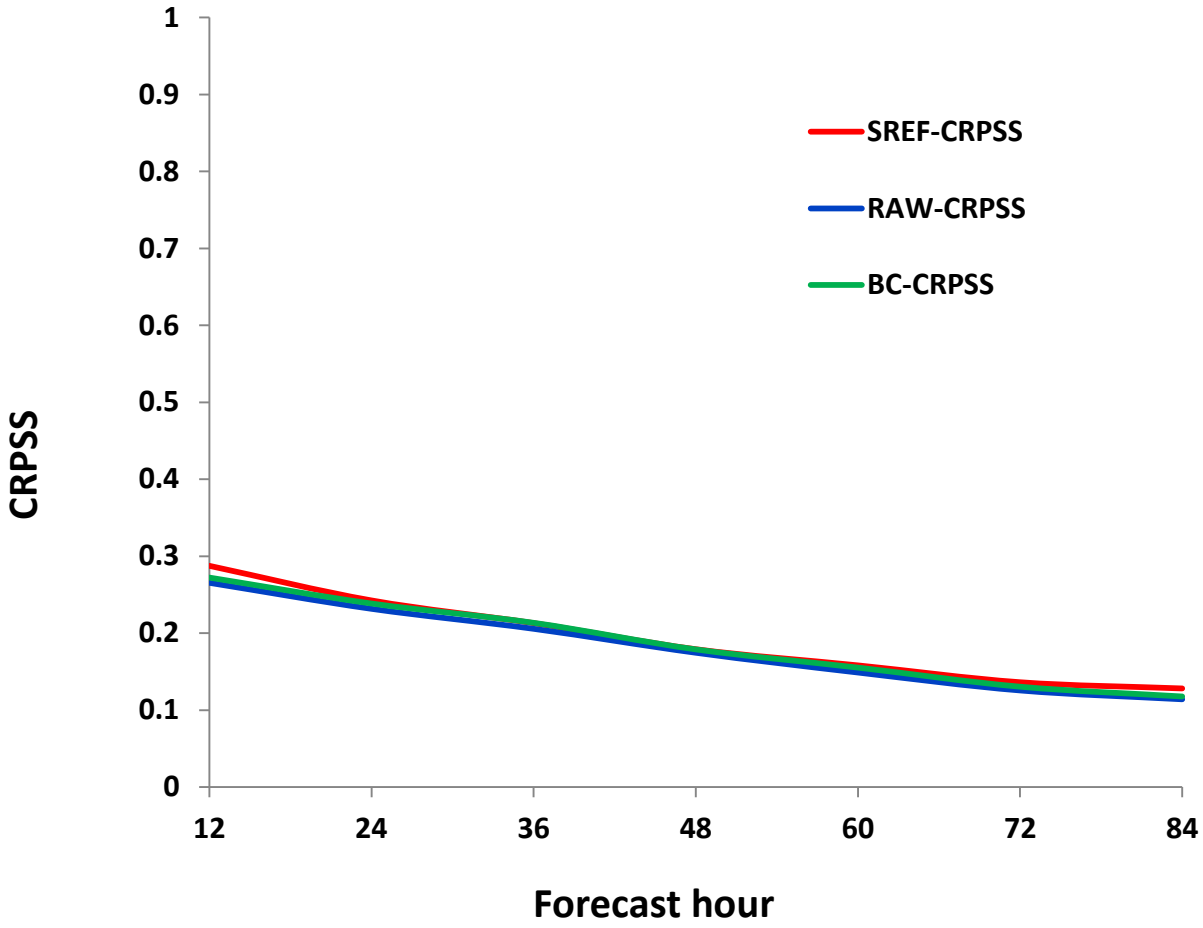
Performance of the downscaled 5km SREF (verified against RTMA, 6/18/12 – 7/16/12)





U10m (ens mean)

Performance of the downscaled 5km SREF (verified against RTMA, 6/18/12 – 7/16/12)



U10m (probability)

Summary

A major milestone and a big step forward by increasing resolution from 32/25km to 16km. A most complex package in implementation and a good example of NCO-EMC closely working together and helping each other to have work done.

Benefit

1. Detailed spatial features by resolving topography better
2. Increased forecast diversity to have less chance to miss truth
3. Improved coverage for heavy precipitation
4. Better or comparable ensemble mean and probabilistic forecasts in general
5. Many new capabilities including precipitation bias correction, member ranking, clustering (grouping) and statistical downscaling
6. Many new aviation and convection fields
7. Many new “forecast confidence” products including 10-25-50-75-90%, mode, max and min as well as mean bufr at stations
8. A new 16km forecast output grid covering North America (g132), a product desired by many users including AWC and MDL.

Caution

1. Smoother ensemble mean due to increased diversity (suggest to explore the best member and cluster means instead of full-ensemble mean)
2. Too much spread of light precipitation (suggest to use bias corrected one)
3. Surface temperature cold bias which needs further investigation to improve (GFS’s wet moisture bias might be a contributing factor) (suggest to use bias-corrected and downscaled one).

AWC

- AWC believes the higher resolution and updated models in the SREF are a notable improvement.
  - Increases to the spatial resolution of the members were obvious in the output, even on the 40 km 212 grid
- Overall, the parallel SREF was highly correlated (qualitative assessment) to the operational SREF. There were no cases that appeared different enough to cause substantial concern.
  - Sharpness of probabilities appeared to increase– less coverage and higher probabilities. However, a quantitative assessment was not performed by AWC
- Convective fields and calibrated thunderstorm forecasts were reasonable.
  - SPC thunder should be recalibrated, but this is expected of any MOS-type guidance when the model changes
- AWC supports the implementation as planned.
  - The AWC will use this opportunity to note that ceiling and visibility from all 21 members is desired, but the existing ceiling and visibility is an improvement and appears useful to AWC operations

SPC

- Major Findings:
  - The higher spatial resolution of the SREFp is beneficial for capturing terrain details for fire weather forecasting in the West
  - The SREFp generally provides similar guidance to the operational SREF for preparing severe weather outlooks
  - However, the SREFp typically yields higher probabilities of CAPE and convective precipitation (>0.01”) than the operational SREF, which leads to a concern of overforecasting and false alarms
  - Calibrated probabilities for the SREFp appear to be able to account for these biases/differences from the operational SREF; however, the lack of a sufficient data sample limits the ability to generate effective calibration tables
  - A statistical analysis reveals that the SREFp appears to be too cool/moist relative to surface observations likely owing to biases in the NMM & ARW members that appear to have similar characteristics
  - **Recommendation:** SPC approves implementation of the SREFp, but would like to see investigation into model/member biases that impact 2-m T/Td, CAPE, and convective precipitation

HPC

- Better snowfall forecasts
- Comparable convective season QPF performance
- Increased resolution provides realistic forecast details
- Cautions – some evidence of smoother mean mass fields and broader areal coverage of mean QPF

HPC Recommends Implementation

We are moving from the old to the new building!