

A Cycled GSI+EnKF and Storm-Scale Ensemble Forecasting (SSEF) Experiment

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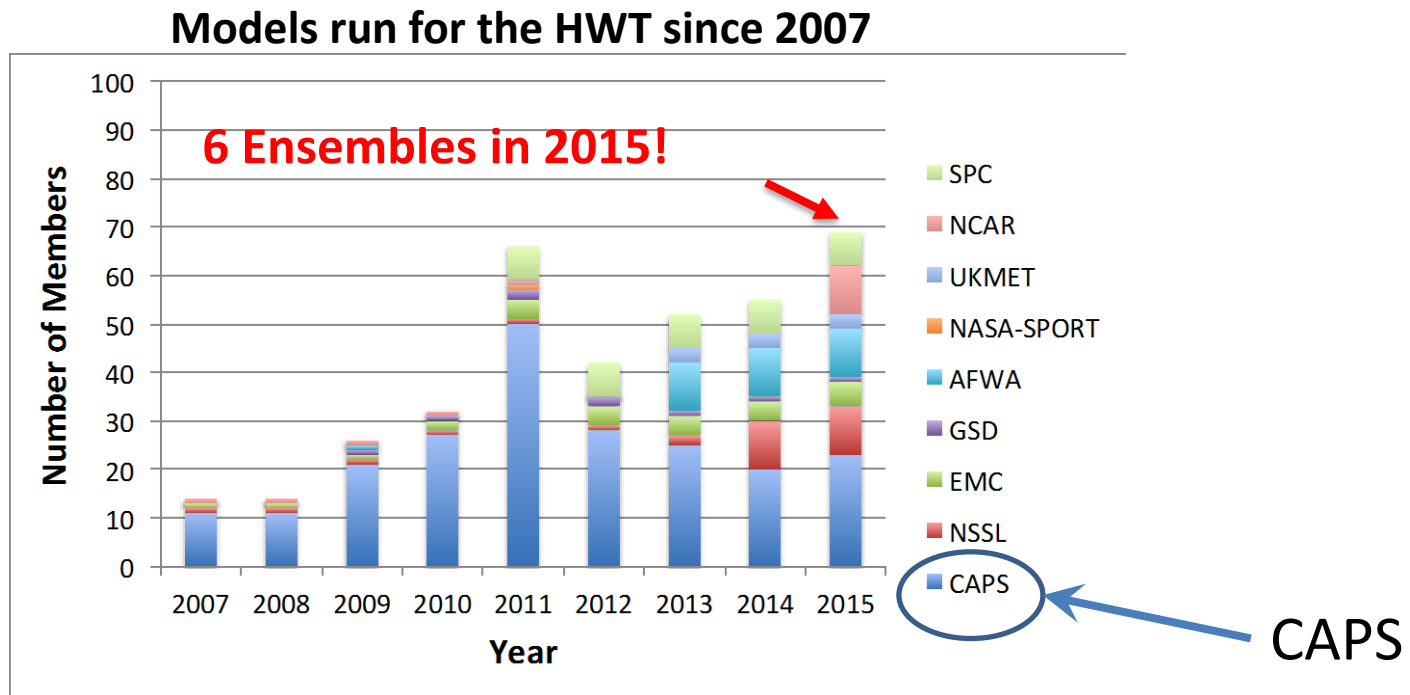
WSN16, Hong Kong, July 25-29, 2016

Outline

- Some background
- 2016 CAPS SSEF highlight
- GSI+EnKF cycled DA
- Validation, and comparison to non-cycled 3DVAR-based SSEF

History of CAM Ensemble for HWT

- CAPS produced 3DVAR-based CONUS scale multi-model multi-physics SSEF since 2007 to support NOAA HWT Spring Experiment every year.
- Recent years, more institutions join the game. CAPS still plays major role.

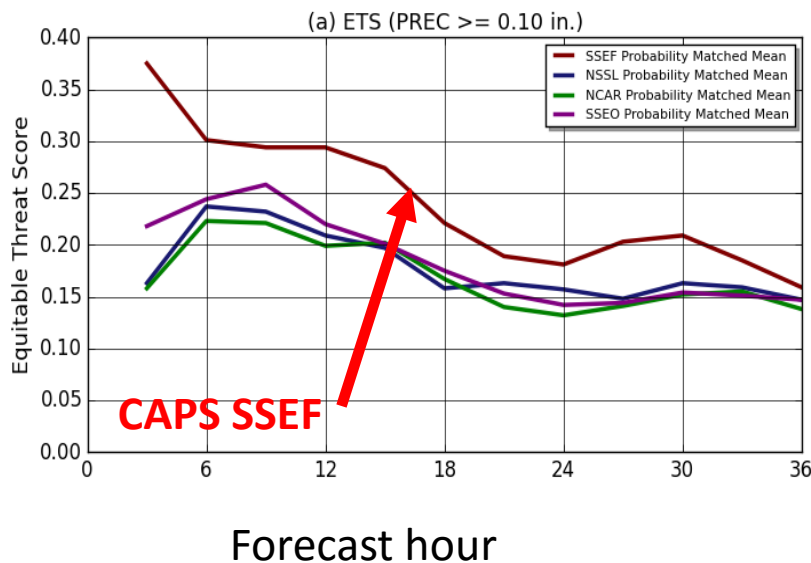


Plot from Adam Clark, NOAA/NSSL

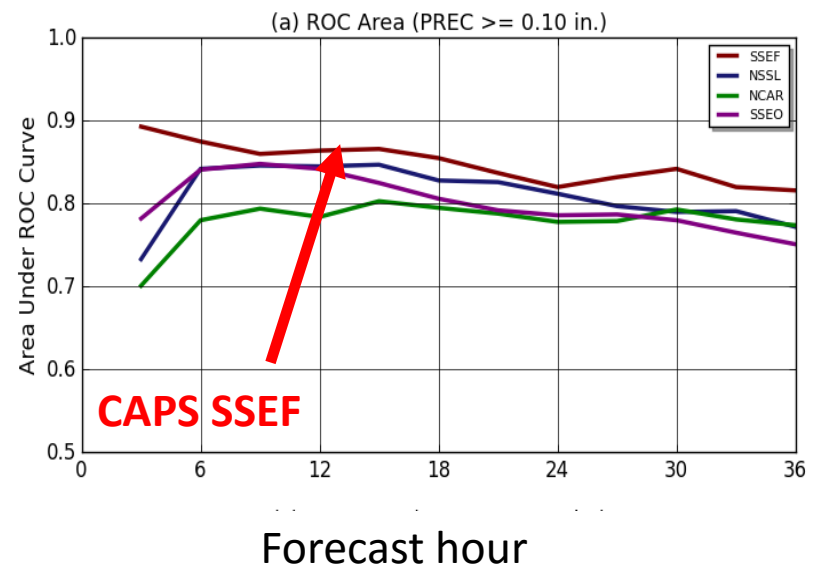


Performance of CAM Ensembles in HWT2015 for 3-h QPF (PM)

Equitable Threat Score Precip > 0.10 in



ROC Area Precip > 0.10 in



CAPS SSEF is a hybrid of IC/LBC **perturbations** and **multi-physics ensemble** with 3DVAR **radar data assimilation**

Plots credited to: Eswar Iyer & Adam Clark, NOAA/NWS/SPC



2016 CAPS SSEF for NOAA/HWT

Storm Scale Ensemble Forecasts (SSEF)

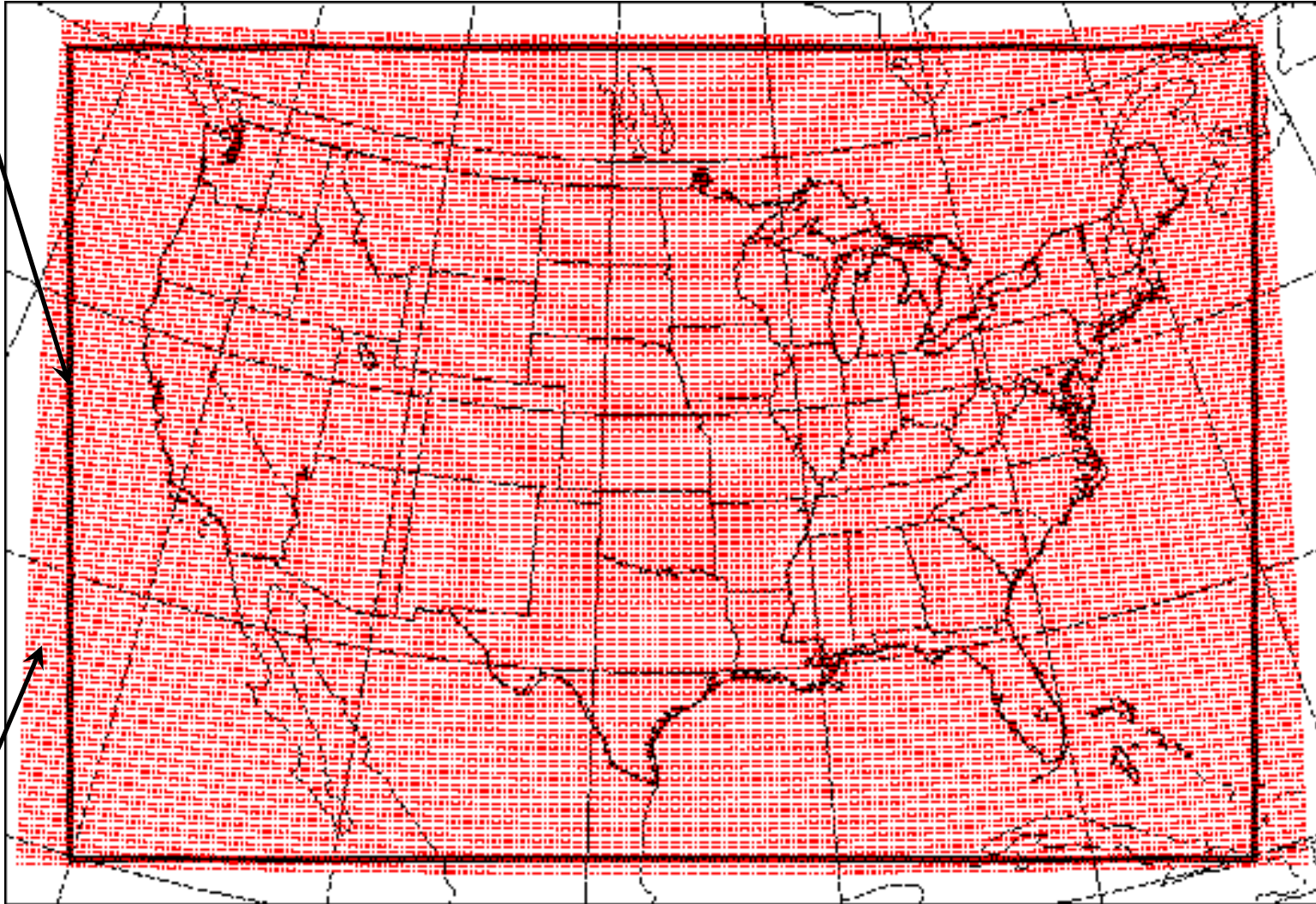
- Run from 18 April 2016 through 3 June 2016
- 3-km horizontal grid spacing (ARW: 1680x1152; NMMB: 1568x1120)
- WRF version 3.7.1 (coupled with ARPS v5.4)
- 1) non-cycled 3DVAR SSEF: 18 ARW members, 6 NMMB members, initiated with 3DVAR analysis & Cloud/Hydrometeor Analysis at 00 UTC, with 36- to 60-h forecast, running on **Stampede at TACC**
- 2) cycled GSI+EnKF SSEF: 40-member ARW storm-scale ensemble background started at 18UTC, a 5-hour GSI-EnKF hourly cycling (1900 to 0000 UTC) and 1-hour CAPS-EnKF radar Vr and Z cycling at 15 min interval (2300 -0000). A 12-member ensemble forecast of 60-h starting at 00 UTC. Running on **Darter at NICS**

Supported by NWS CSTAR & HWT grants and NSF XSEDE computing resources



2016 CAPS SSEF DOMAIN

CONUS ARW Domain



NMMB Domain

CONUS:1680x1152 3km grid

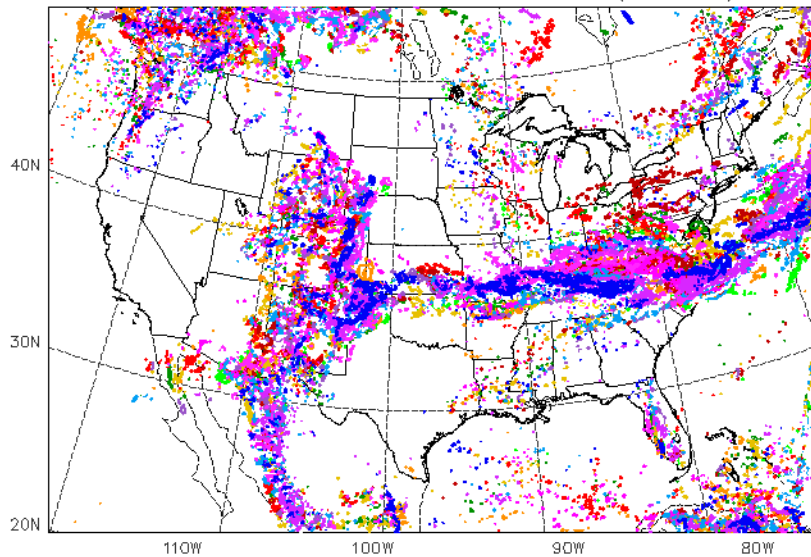


CAPS SSEF Sample Products

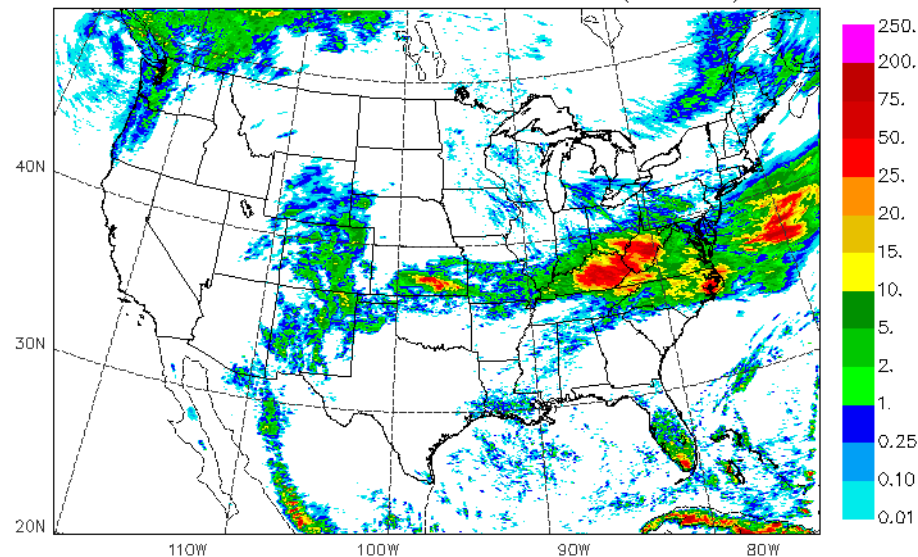
http://www.caps.ou.edu/~fkong/sub_atm/spring16.html
Spaghetti: CREF =35 dBZ
PM: 6-h QPF

48h fcst

00:00Z Fri 24 Jun 2016 T=172800.0 s (48:00:00)

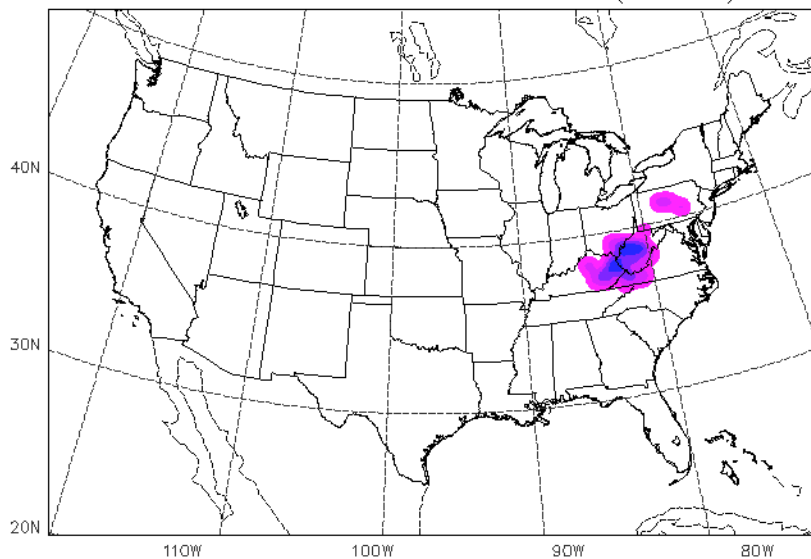


00:00Z Fri 24 Jun 2016 T=172800.0 s (48:00:00)



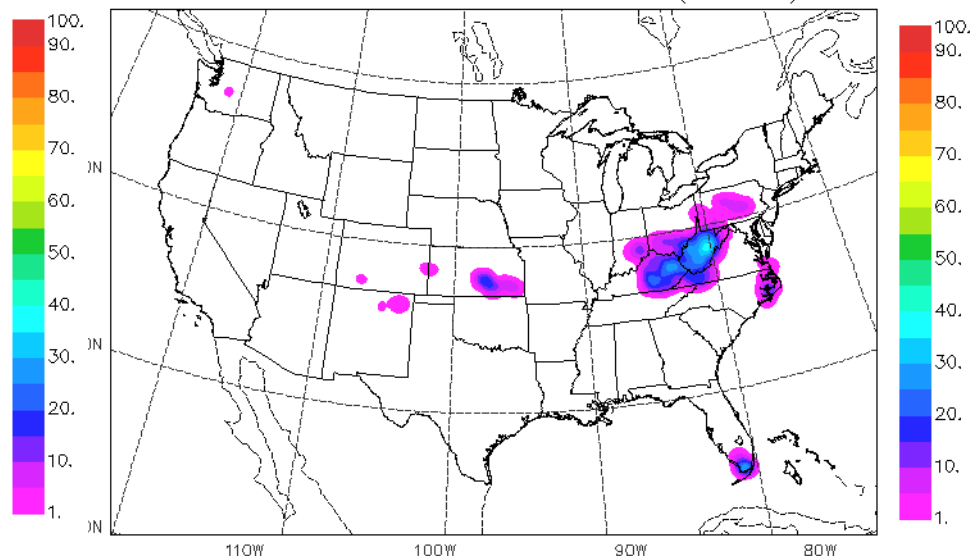
Probability 6-h QPF \geq 100y RI

00:00Z Fri 24 Jun 2016 T=172800.0 s (48:00:00)



Probability 6-h QPF \geq FFG 6h

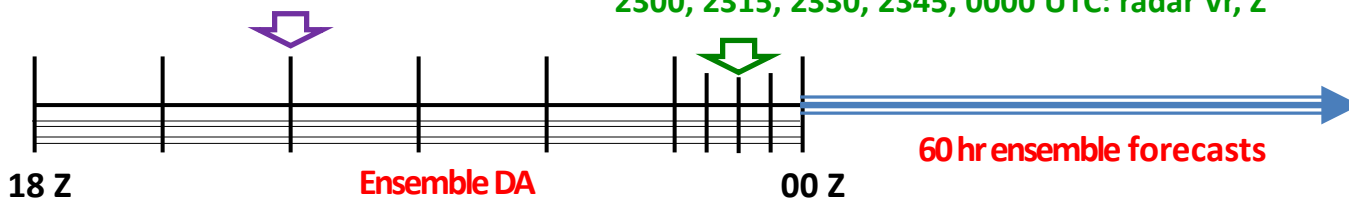
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GSI+ EnKF

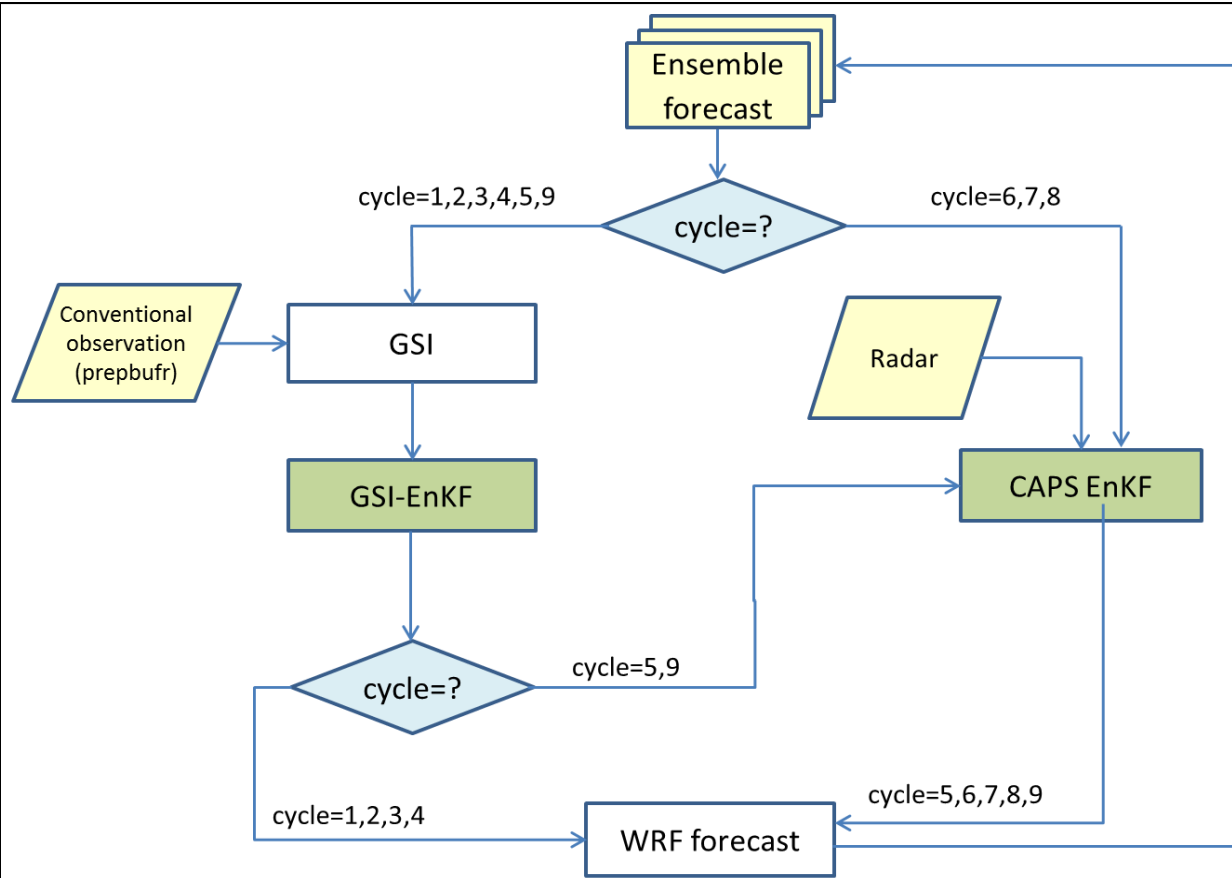
GSI-EnKF: 19, 20, 21, 22, 23, 00 UTC
conventional obs.

CAPS EnKF
2300, 2315, 2330, 2345, 0000 UTC: radar Vr, Z



CAPS experimental GSI+EnKF cycling

- 40-member ARW ensemble initiated at 18 UTC using NAM background with SREF perturbations
- RAP/HRRR GSI data stream (except satellite data and Mesonet1 data) are assimilated hourly from 1900 to 0000 UTC using GSI-EnKF
- Radar Vr and Z data are assimilated using CAPS-EnKF system from 2300 to 0000 UTC every 15 min



Cycled GSI+EnKF based SSEF

Member	IC	BC	Microphysics	LSM	PBL
enkf_cn	enk_m1a	00Z NAMf	Thompson	Noah	MYJ
enkf_m2	enk_m8a	21Z SREF arw-p1	P3	Noah	YSU
enkf_m3	enk_m10a	21Z SREF arw-n1	MY	Noah	MYNN
enkf_m4	enk_m17a	21Z SREF arw-p2	Morrison	Noah	MYJ
enkf_m5	enk_m23a	21Z SREF arw-n2	P3	Noah	YSU
enkf_m6	enk_m24a	21Z SREF nmmb-p1	MY	Noah	MYNN
enkf_m7	enk_m12a	21Z SREF nmmb-n1	Morrison	Noah	YSU
enkf_m8	enk_m9a	21Z SREF nmmb-p2	P3	Noah	MYJ
enkf_m9	enk_m6a	21Z SREF nmmb-n2	Thompson	Noah	MYNN
enkf_mn1	enk_mn	00Z NAMf	Thompson	Noah	MYJ
enkf_mn2	enk_mn	00Z NAMf	P3	Noah	MYJ
enkf_mn3	enk_mn	00Z NAMf	Morrison	Noah	MYJ

Member	IC	BC	Radar data	Microphy	LSM	PBL
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m3	arw_cn + arw-p1_pert	21Z SREF arw-p1	yes	P3	Noah	YSU
arw_m4	arw_cn + arw-n1_pert	21Z SREF arw-n1	yes	MY	Noah	MYNN
arw_m5	arw_cn + arw-p2_pert	21Z SREF arw-p2	yes	Morrison	Noah	MYJ
arw_m6	arw_cn + arw-n2_pert	21Z SREF arw-n2	yes	P3	Noah	YSU
arw_m7	arw_cn + nmmb-p1_pert	21Z SREF nmmb-p1	yes	MY	Noah	MYNN
arw_m8	arw_cn + nmmb-n1_pert	21Z SREF nmmb-n1	yes	Morrison	Noah	YSU
arw_m9	arw_cn + nmmb-p2_pert	21Z SREF nmmb-p2	yes	P3	Noah	MYJ
arw_m10	arw_cn + nmmb-n2_pert	21Z SREF nmmb-n2	yes	Thompson	Noah	MYNN
arw_m11	arw_cn + arw-p1_pert	21Z SREF arw-p1	yes	Thompson	Noah	MYJ
arw_m12	arw_cn + arw-n1_pert	21Z SREF arw-n1	yes	Thompson	Noah	MYJ
arw_m13	arw_cn + arw-p2_pert	21Z SREF arw-p2	yes	Thompson	Noah	MYJ
arw_m14	arw_cn + arw-n2_pert	21Z SREF arw-n2	yes	Thompson	Noah	MYJ
arw_m15	arw_cn + arw-p3_pert	21Z SREF arw-p3	yes	Thompson	Noah	MYJ
arw_m16	arw_cn + nmmb-p1_pert	21Z SREF nmmb-p1	yes	Thompson	Noah	MYJ
arw_m17	arw_cn + nmmb-n1_pert	21Z SREF nmmb-n1	yes	Thompson	Noah	MYJ
arw_m18	arw_cn + nmmb-p2_pert	21Z SREF nmmb-p2	yes	Thompson	Noah	MYJ
arw_m19	arw_cn + nmmb-n2_pert	21Z SREF nmmb-n2	yes	Thompson	Noah	MYJ

Non-cycled 3DVAR-based SSEF Ensemble Members

ARW mixed (9)

ARW single-phys (9)

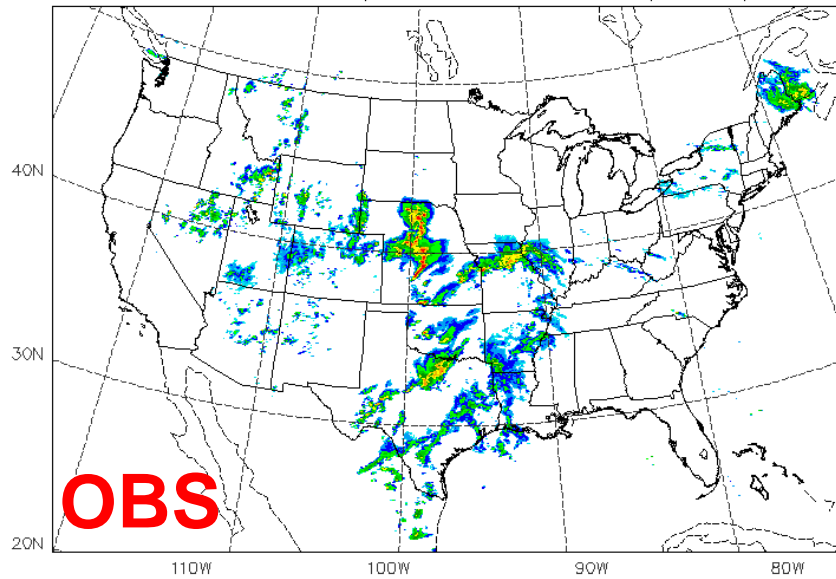
NMMB (6)

member	IC	BC	Radar data	mp_phy	lw_phy	sw-phy	sf_phy
nmmb_cn	00Z ARPSa	00Z NAMf	yes	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m1	00Z NAMA+ arw-p3_pert	21Z SREF arw-p3	no	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m2	00Z NAMA+ nmmb-p1_pert	21Z SREF nmmb-p1	no	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m3	00Z NAMA+ nmmb-n1_pert	21Z SREF nmmb-n1	no	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m4	00Z NAMA+ nmmb-p2_pert	21Z SREF nmmb-p2	no	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m5	00Z NAMA+ nmmb-n2_pert	21Z SREF nmmb-n2	no	Ferrier-Aligo	GFDL	GFDL	Noah



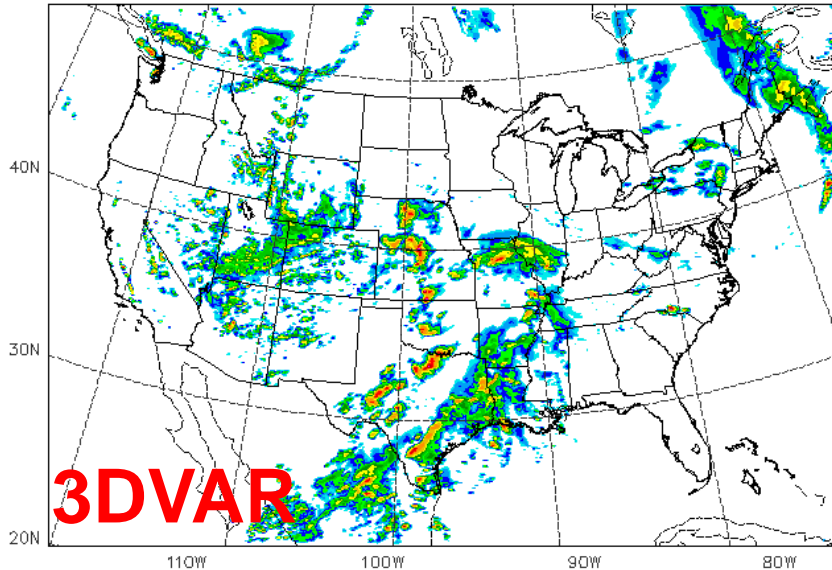
9 May 2016 0100 UTC (1h fcst)

Both 3DVAR and EnKF reflectivity matches observation reasonably well. But 3DVAR produces more spurious echoes over US, in general.



**** Model reflectivity is the PM mean unless said otherwise.****

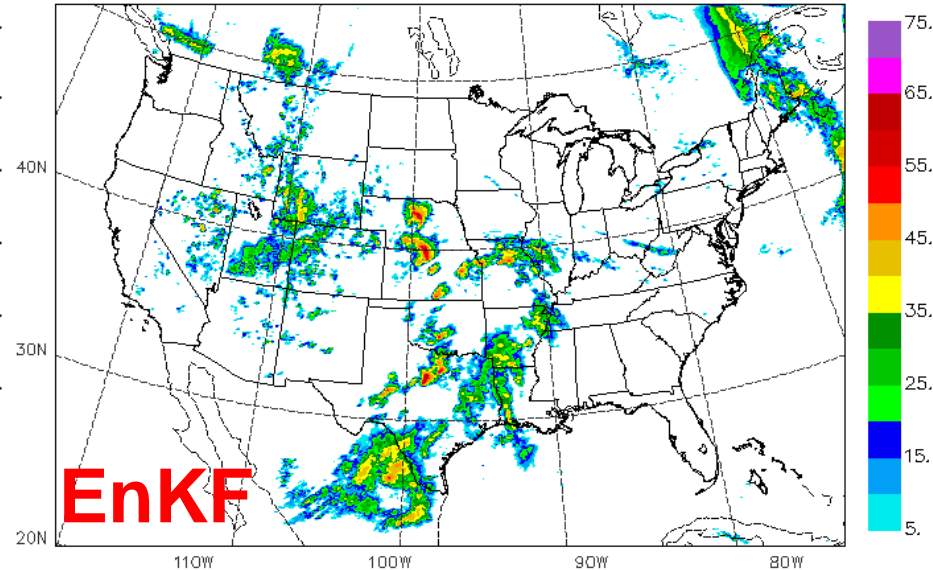
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cmpref(dBZ , Shaded)

Min=0.00 Max=77.3

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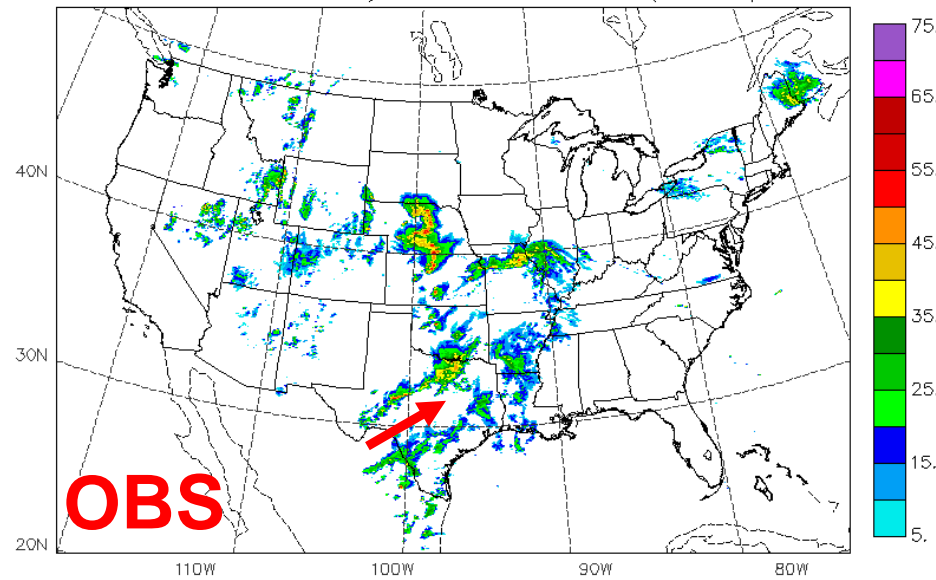


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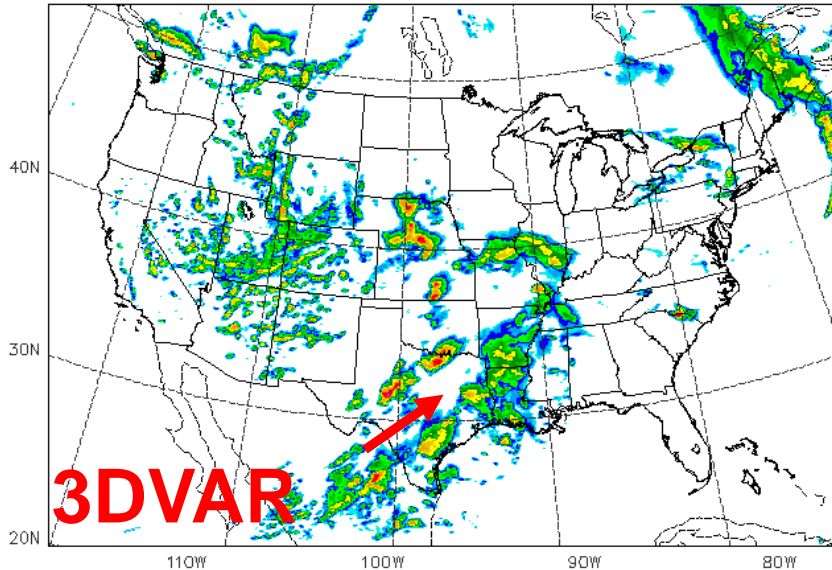
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9 May 2016 0200 UTC (2h fcst)

Storms developing in an arc shape are better captured by EnKF. EnKF also show less spurious echoes on the west half of CONUS.



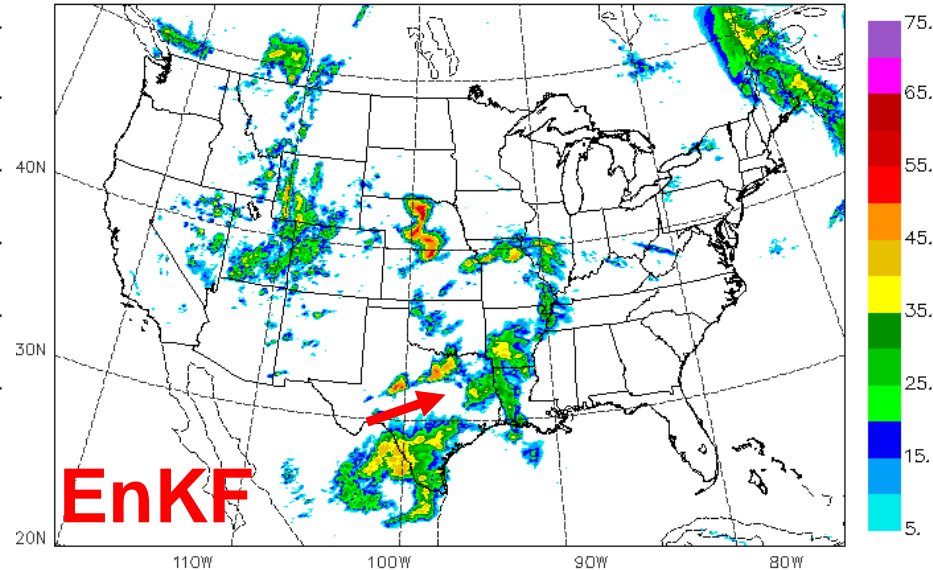
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cmpref(dBZ , Shaded)

Min=0.00 Max=74.9

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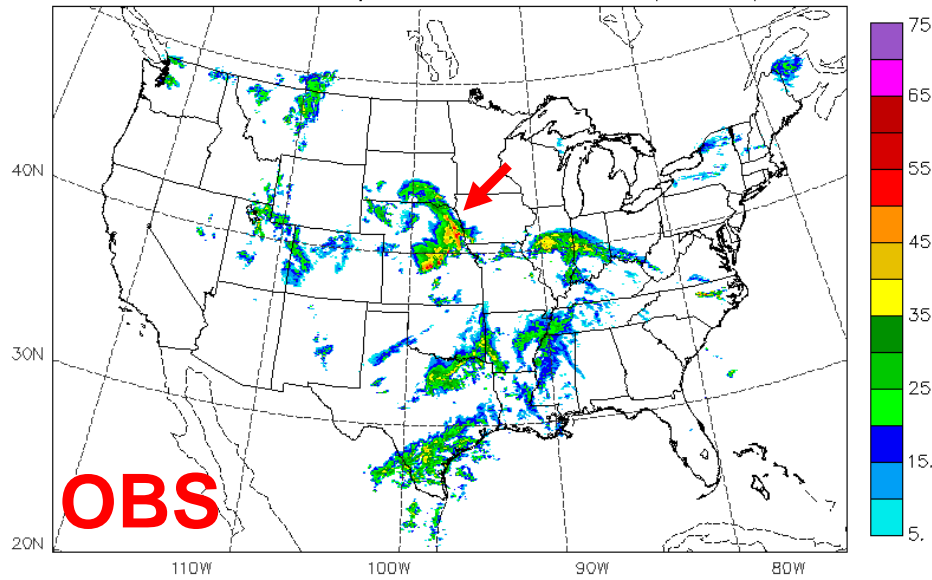


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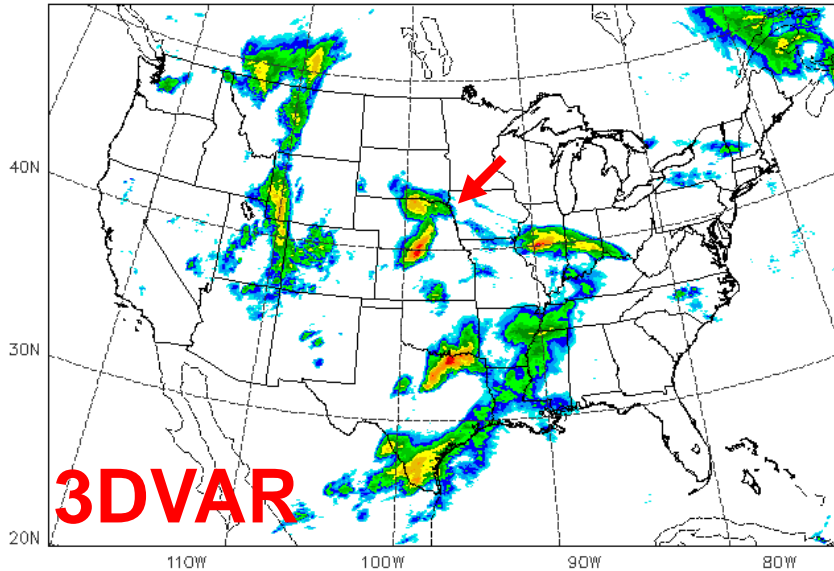
Min=0.00 Max=71.5

9 May 2016 0600 UTC (6h fcst)

Bow shape is predicted better with EnKF.



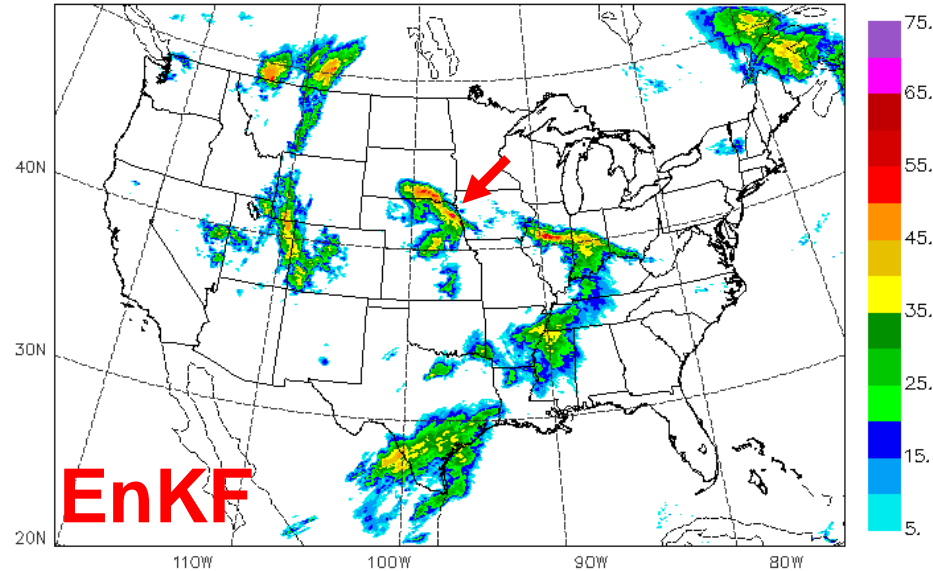
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cmpref(dBZ , Shaded)

Min=0.00 Max=72.2

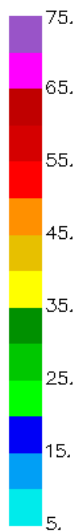
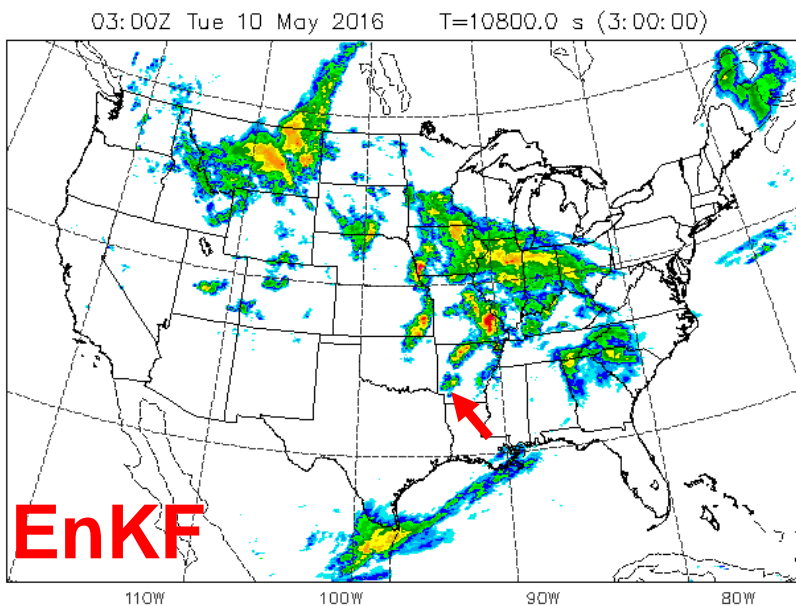
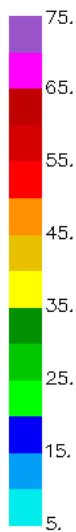
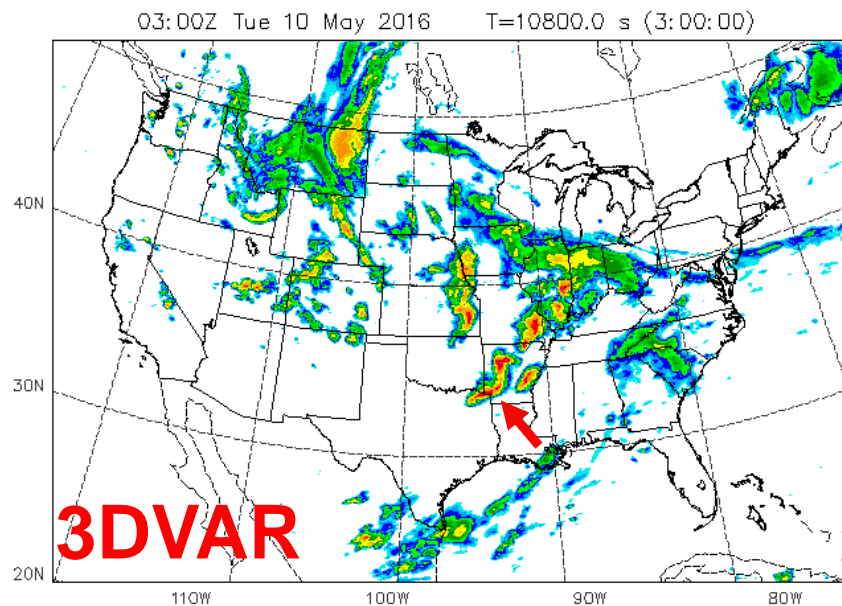
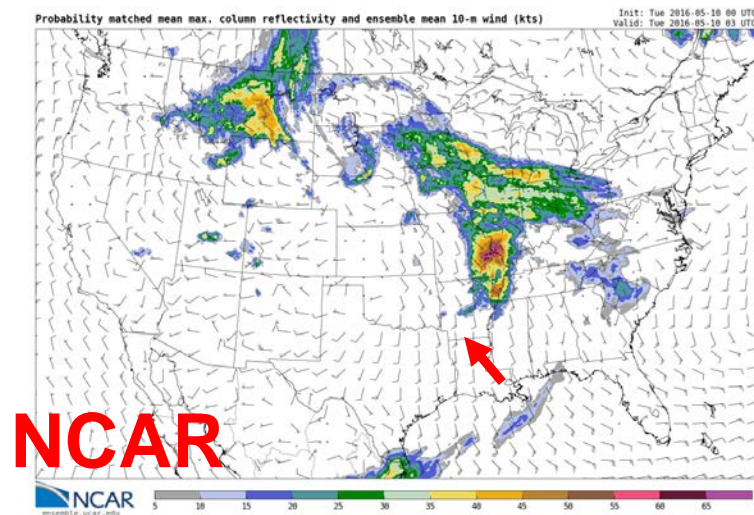
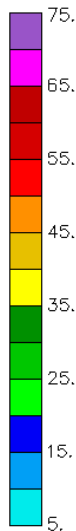
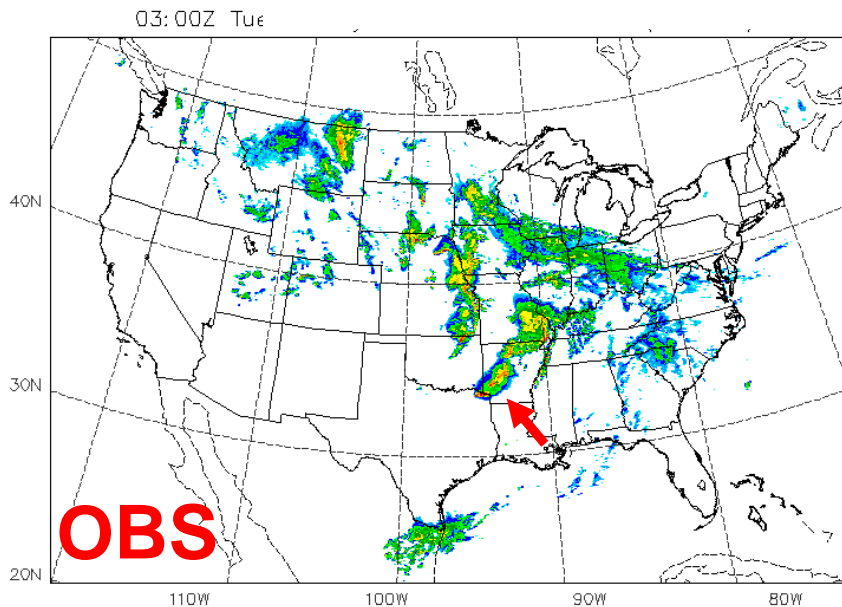
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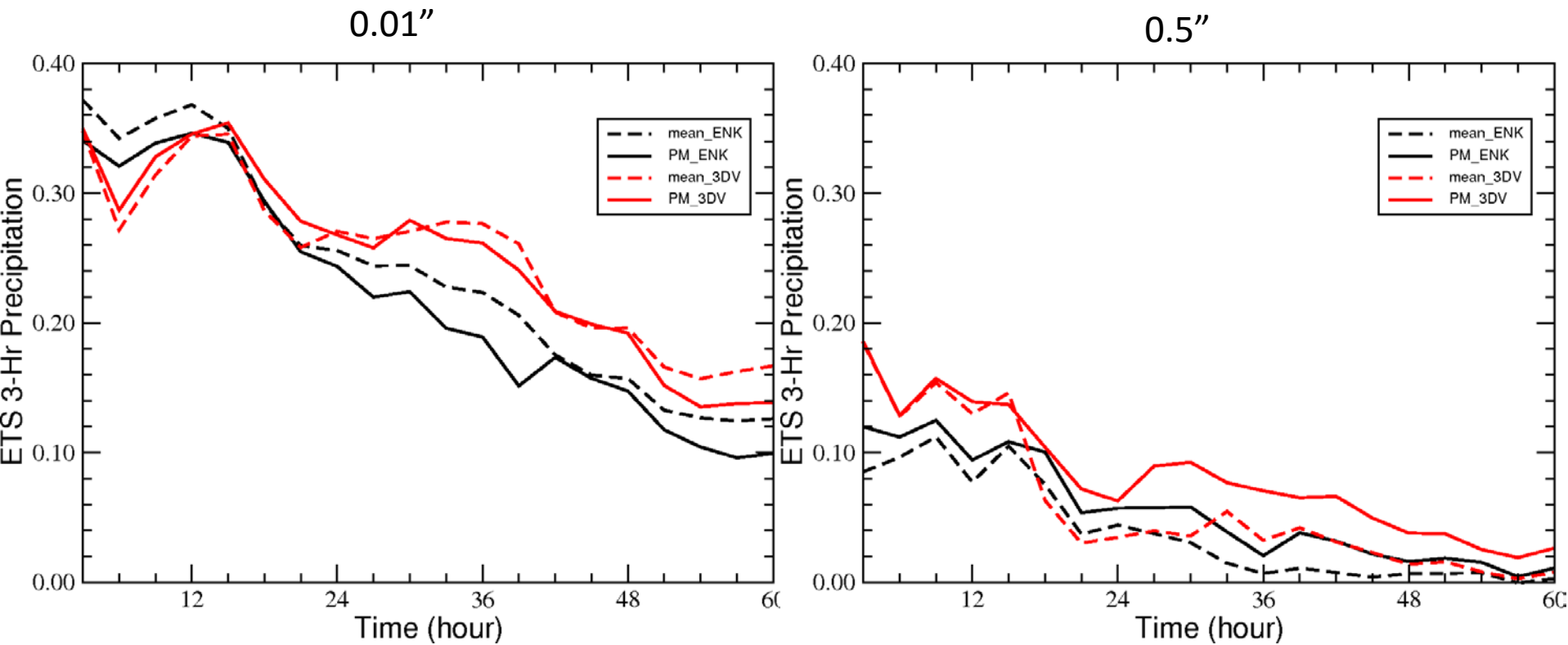
cmpref(dBZ , Shaded)

Min=0.00 Max=71.0

10 May 2016 0300 UTC (3h fcst)



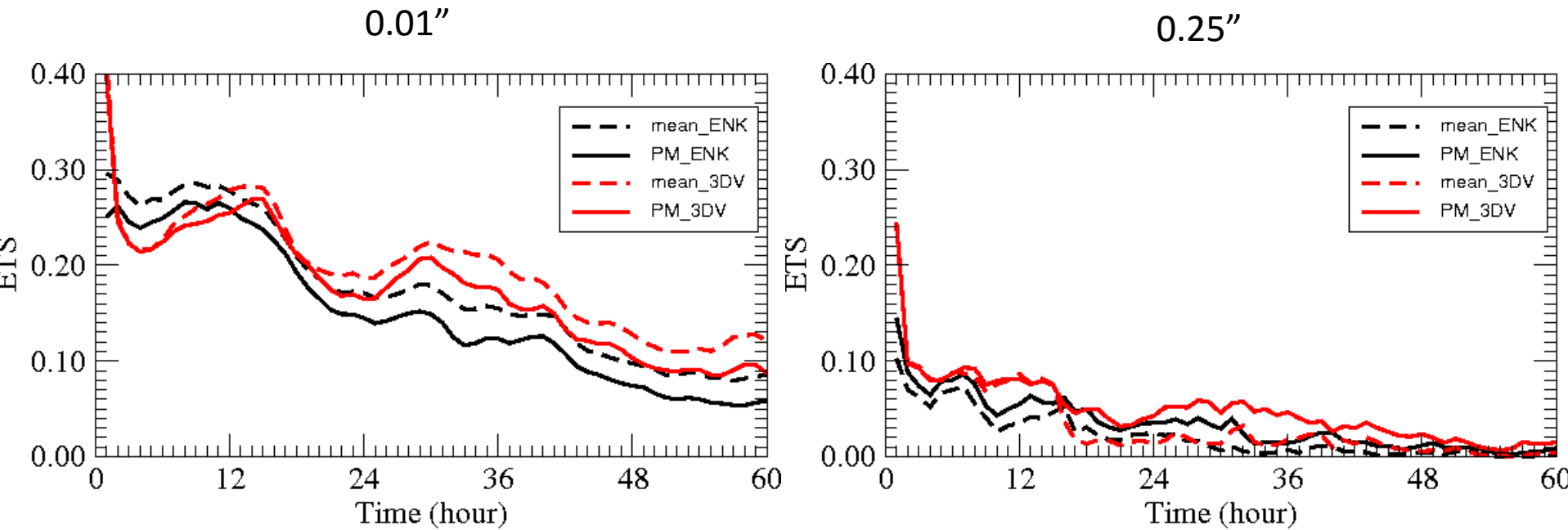
ETS of 3-hourly QPF GSI+EnKF vs 3DVAR (12-day)



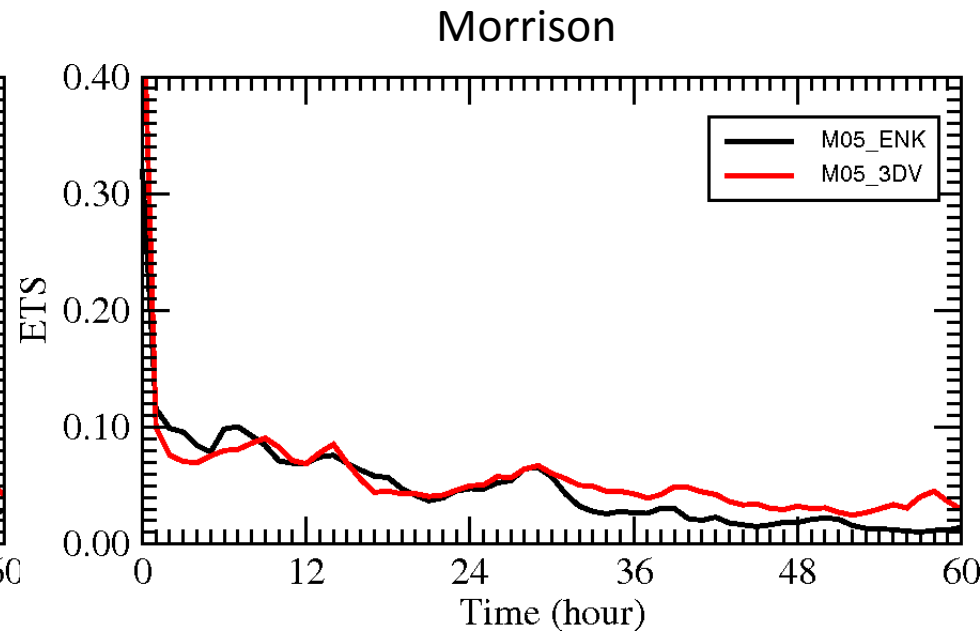
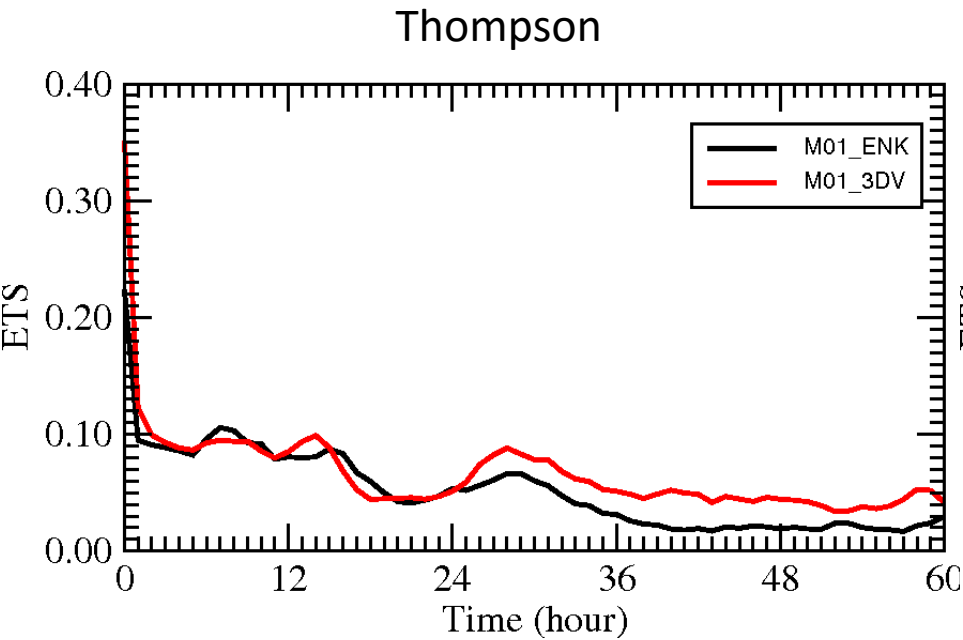
Using NCEP MRMS QPE data for verificatiuon



ETS of 1-hourly QPF GSI+EnKF vs 3DVAR (12-day)



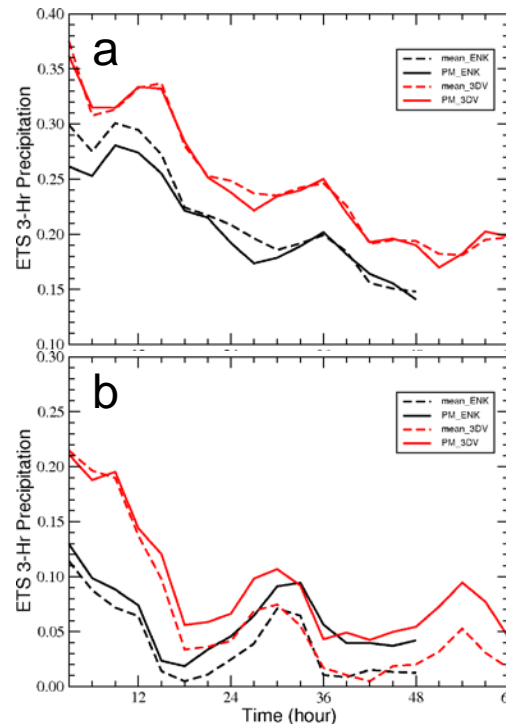
ETS of CREF ≥ 30 dBZ GSI+EnKF vs 3DVAR (12-day)



2015 Result: EnKF vs 3DVAR

2015 CAPS EnKF DA
didn't have GSI
component – only the
15-min interval radar
EnKF cycling from
2300-0000 UTC had
been done

EnKF perform
significantly worse
than 3DVAR



0.01"

0.5"

Summary: GSI+EnKF vs 3DVAR

- In general, both 3DVAR and GSI+EnKF are producing useful forecasts.
- Last year, 3DVAR produced much more skillful forecast than EnKF (no GSI in 2015)
- This year, there are days and times that 3DVAR or EnKF did better than the other. Qualitatively, EnKF forecast seems as good as 3DVAR's or better, at least for short-term forecasts (< 18 hrs).
- Still, there are times that 3DVAR produced more skillful forecast than GSI+EnKF and at significantly lower cost.
- These results are preliminary and not a fair comparison. Mesonet and aircraft data are missing for the EnKF DA.
- More tuning is necessary and will be done for GSI+EnKF



2016 CAPS SSEF for HMT FFaIR

Storm Scale Ensemble Forecasts (SSEF)

- 20 June – 1 July ; 11 - 22 July (4 weeks)
- 3-km horizontal grid spacing (1680×1152)
- WRF version 3.7.1 (coupled with ARPS v5.3.6)
- 3DVAR SSEF, 15-member: **13 ARW** members, **2 NMMB** members initiated with 3DVAR analysis & Complex Cloud/Hydrometeor Analysis at 0000 UTC, with **60-h** forecast
 - first 2 weeks on **Darter at NICS**
 - second 2 weeks on **Stampede at TACC**
- Neighborhood probability of FFG and RI exceedances

Supported by NWS CSTAR & HMT grants and NSF XSEDE computing resources



ARW

Member	IC	BC	Radar data	Microphy	LSM	PBL
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m2	arw_cn + arw-p1_pert	21Z SREF arw-p1	yes	Morrison	Noah	MYNN
arw_m3	arw_cn + arw-n1_pert	21Z SREF arw-n1	yes	MY	Noah	MYNN
arw_m4	arw_cn + arw-p2_pert	21Z SREF arw-p2	yes	Morrison	Noah	MYJ
arw_m5	arw_cn + arw-n2_pert	21Z SREF arw-n2	yes	Thompson	Noah	YSU
arw_m6	arw_cn + nmmb-p1_pert	21Z SREF nmmb-p1	yes	MY	Noah	MYNN
arw_m7	arw_cn + nmmb-n1_pert	21Z SREF nmmb-n1	yes	Morrison	Noah	YSU
arw_m8	arw_cn + nmmb-p2_pert	21Z SREF nmmb-p2	yes	Morrison	Noah	MYJ
arw_m9	arw_cn + nmmb-n2_pert	21Z SREF nmmb-n2	yes	Thompson	Noah	MYNN
arw_m10	00Z ARPSa	00Z NAMf	yes	P3	Noah	MYJ
arw_m11	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ
arw_m12	00Z ARPSa	00Z NAMf	yes	MY	Noah	MYJ
arw_m13	arw_cn + arw-n2_pert	21Z SREF arw-n2	yes	Thompson	Noah	MYJ

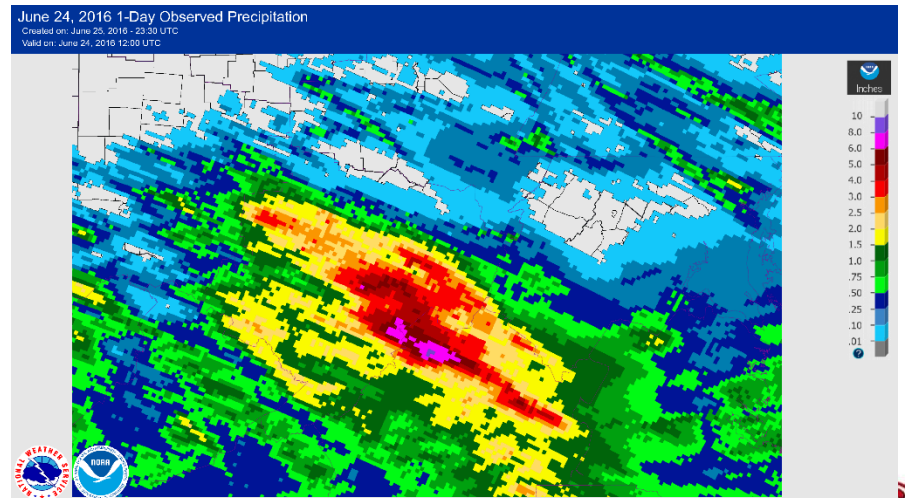
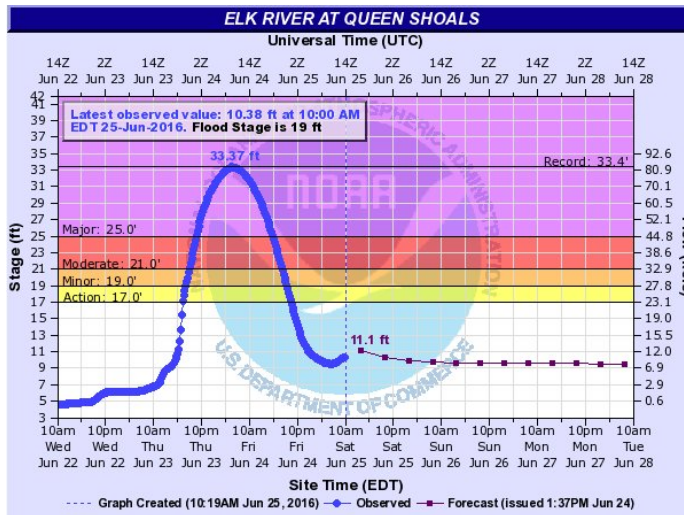
NMMB

member	IC	BC	Radar data	mp_phy	lw_phy	sw_phy	sf_phy
nmmb_cn	00Z ARPSa	00Z NAMf	yes	Ferrier-Aligo	GFDL	GFDL	Noah
nmmb_m1	00Z NAMA+ arw-p3_pert	21Z SREF arw-p3	no	Ferrier-Aligo	GFDL	GFDL	Noah

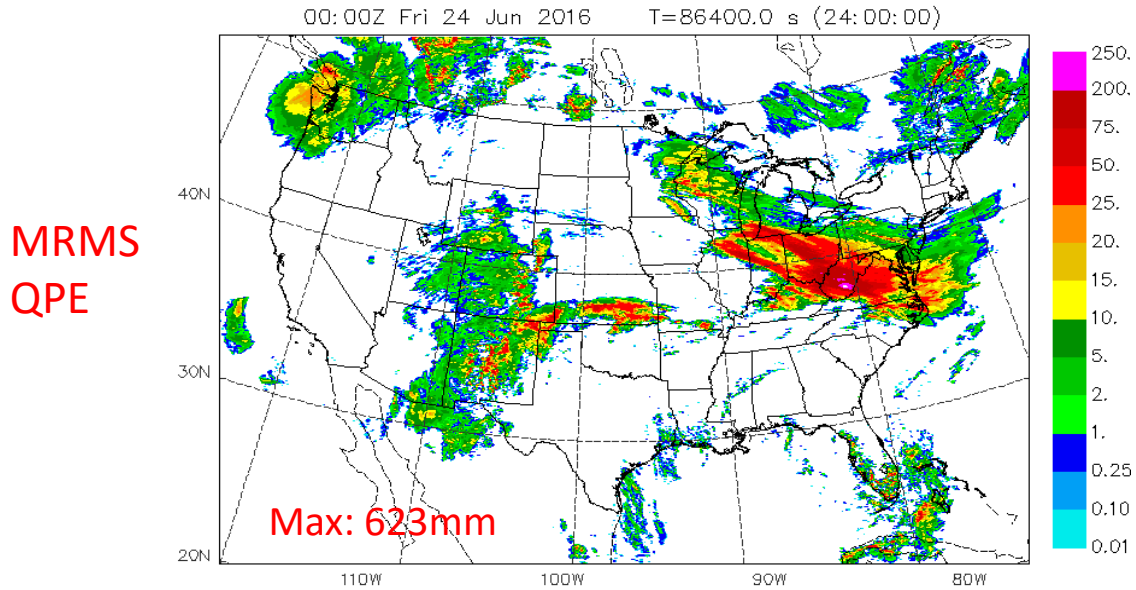


West Virginia Flash Floods

- 23-24 June 2016
- Max Gauge 9.37 inches (238 mm) at Maxwelton, WV
- Elk River all time high 33.37 ft
- 23 Fatalities
15 in Greenbrier Co.
- 44 of 55 WV counties placed in state of emergency



24-h Precip 00Z June 23 - 00Z June 24

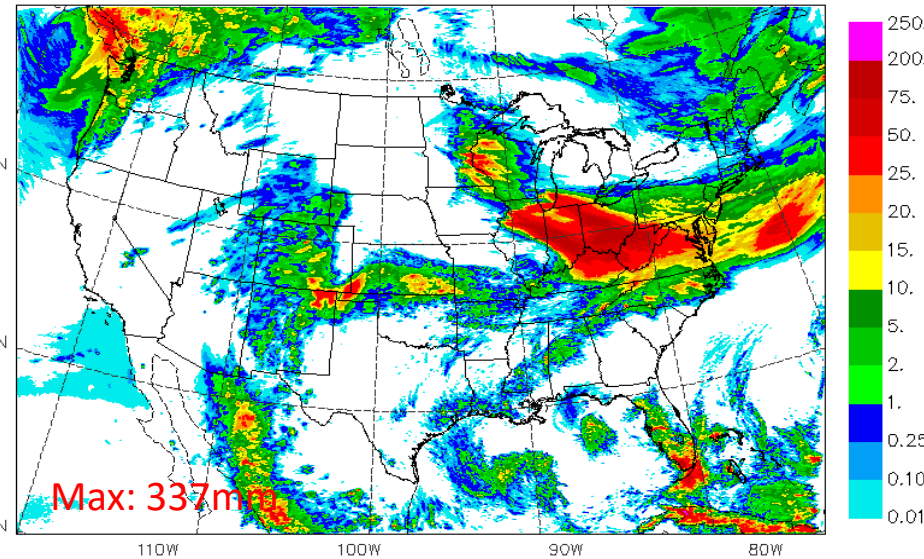
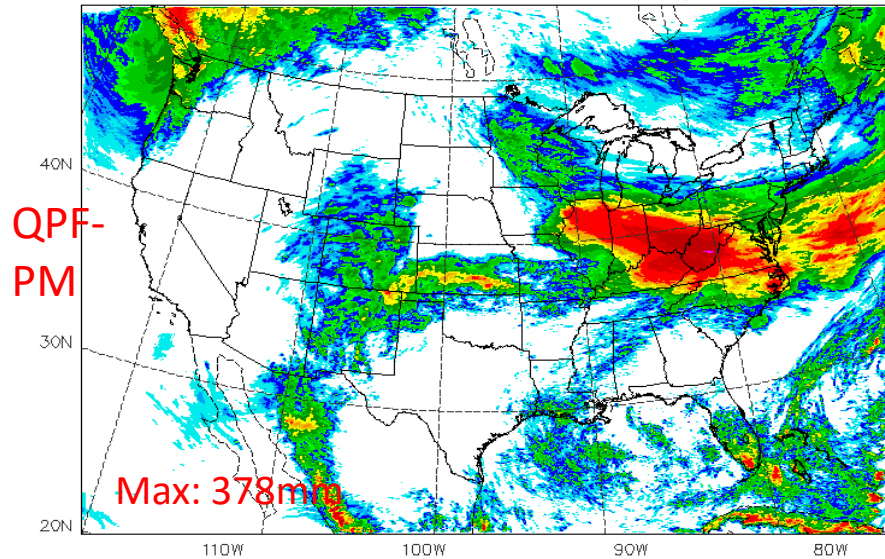


48 h fcst

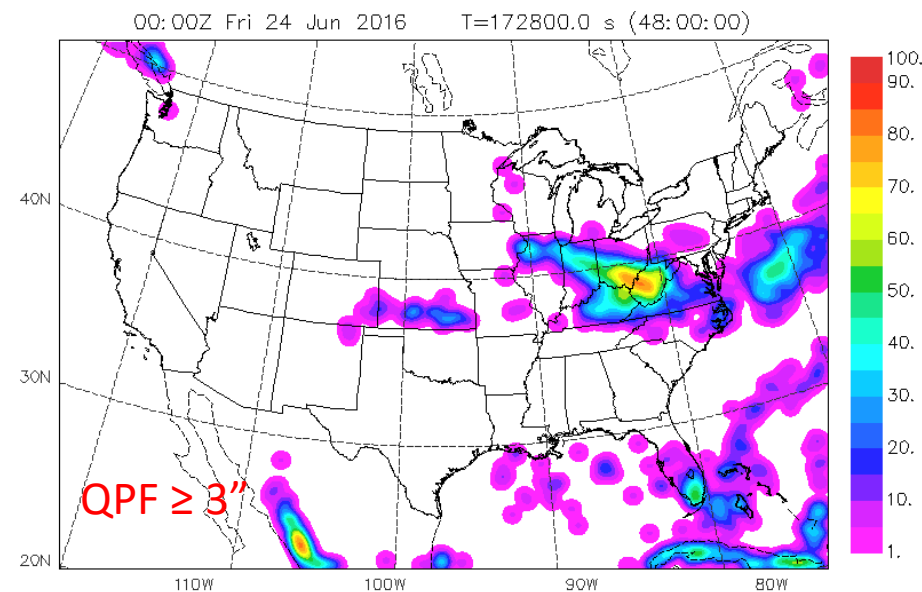
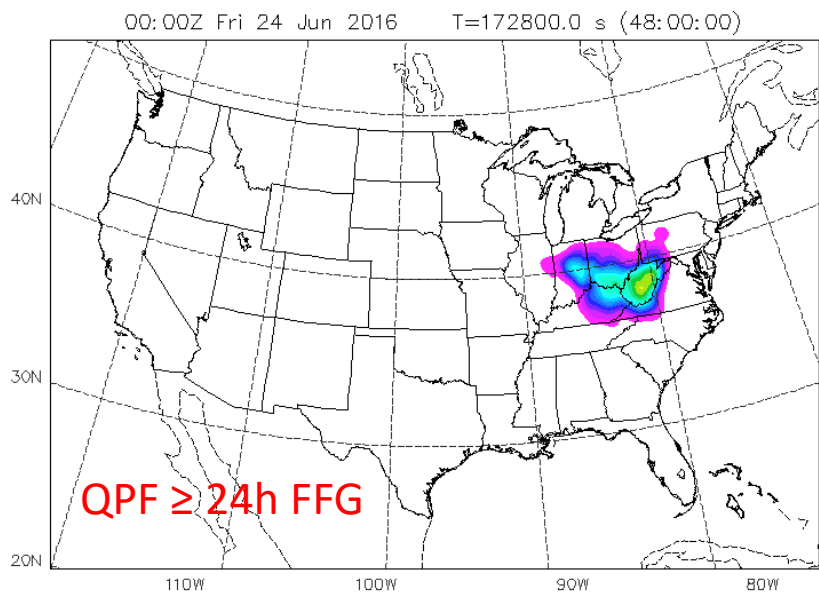
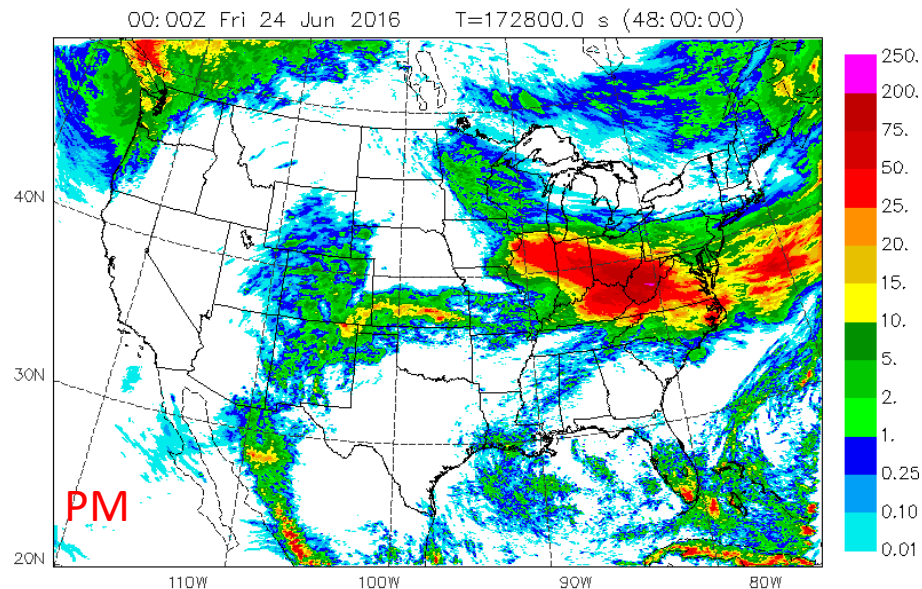
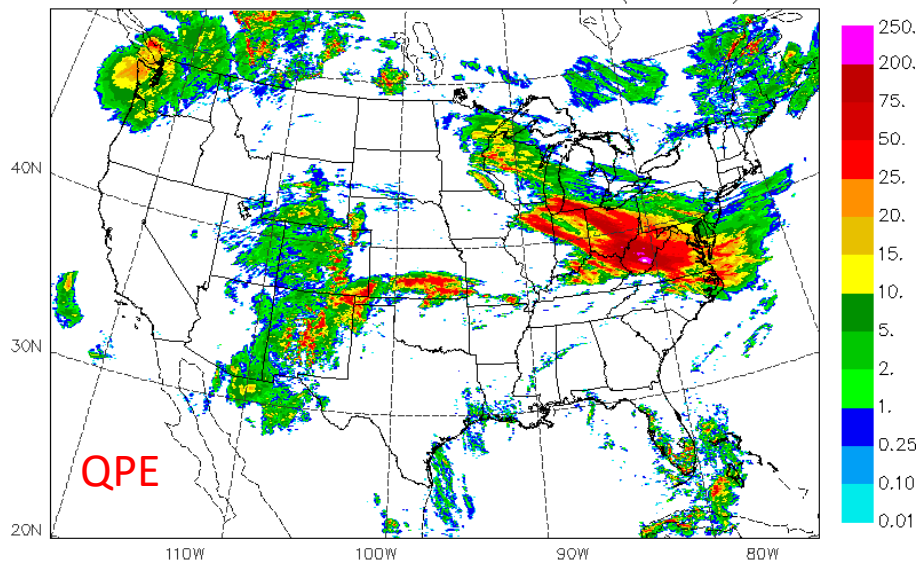
24 h fcst

00:00Z Fri 24 Jun 2016 T=172800.0 s (48:00:00)

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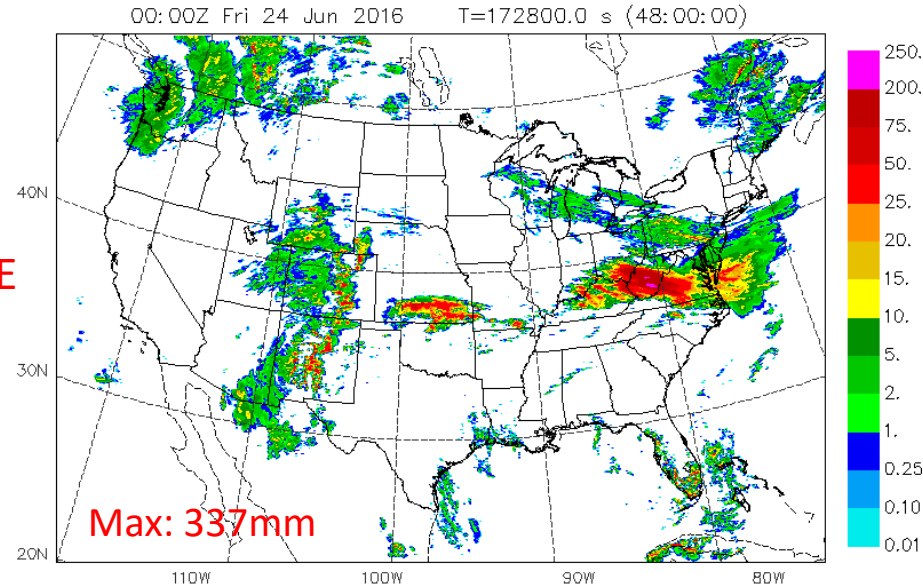


24-h Precip 00Z June 23 - 00Z June 24



12-h Precip 12Z June 23 - 00Z June 24

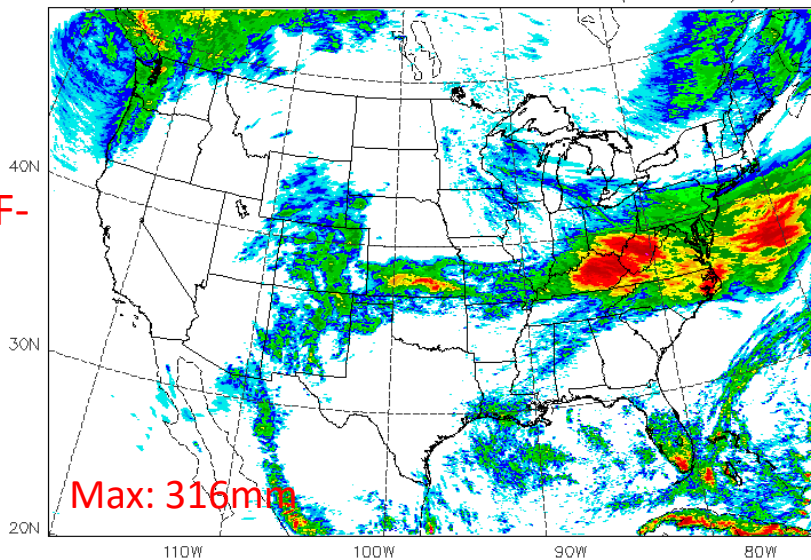
MRMS QPE



48 h fcst

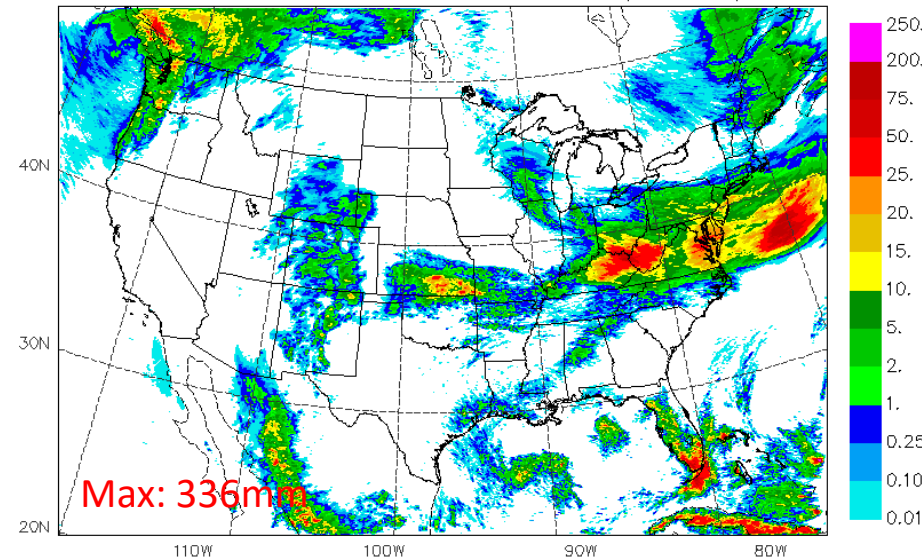
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QPF-
PM



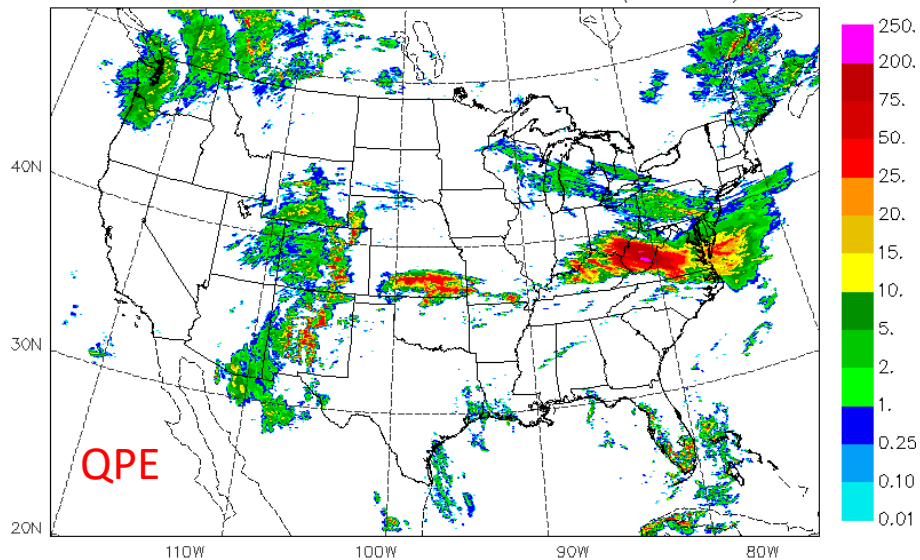
24 h fcst

00:00Z Fri 24 Jun 2016 T=86400.0 s (24:00:00)

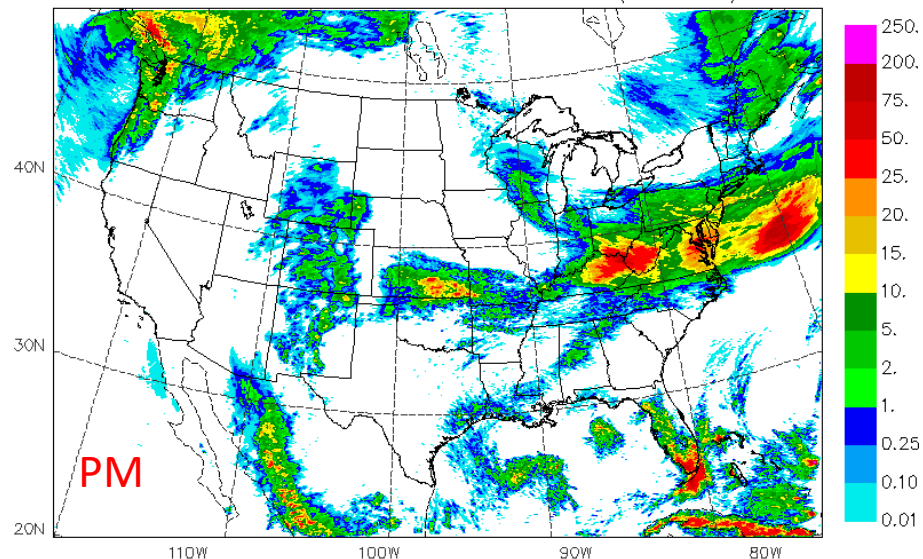


12-h Precip 12Z June 23 - 00Z June 24

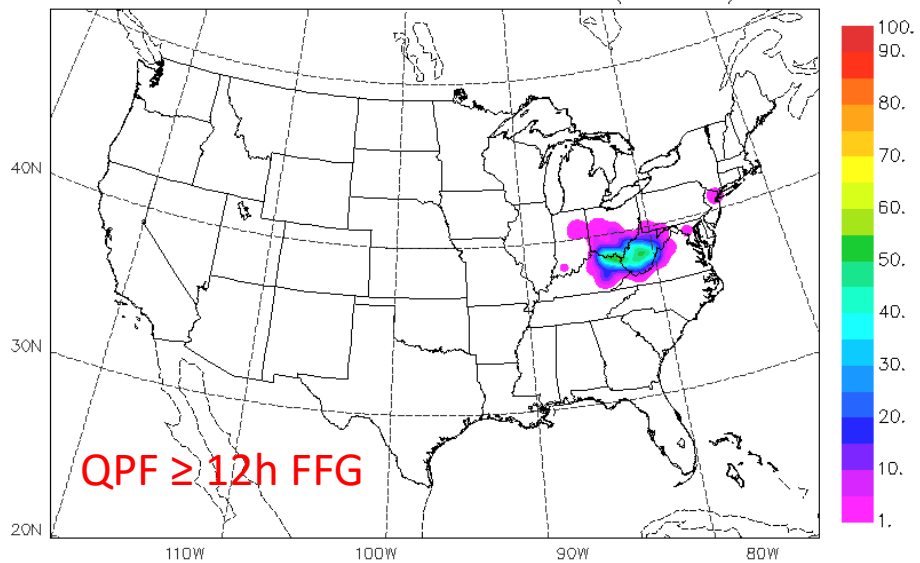
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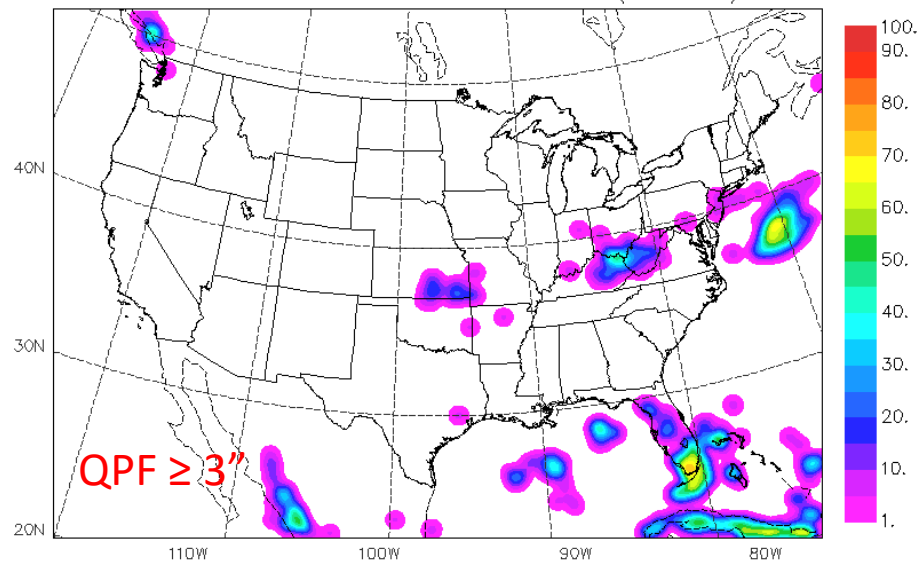
00:00Z Fri 24 Jun 2016 T=86400.0 s (24:00:00)



00:00Z Fri 24 Jun 2016 T=86400.0 s (24:00:00)



00:00Z Fri 24 Jun 2016 T=86400.0 s (24:00:00)



Thanks!

