CAPS Storm-Scale Ensemble Forecast (SSEF) in Support of NOAA HWT 2010 Spring Experiment

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History of CAPS SSEF

- Spring 2007: 10-member WRF-ARW, 4 km, 33 h, 21Z start time, NAM+SREF ICs. 5 members physics perturbations only, 5 with Phy+IC+LBC perturbations. 2/3 CONUS (*+ one single 2 km grid forecast*)
- Spring 2008: 00Z start, Phy+IC+LBC pert for all members. **Radar Vr and Z data assimilation**, large domain - 3/4 CONUS (*+ one single 2 km grid forecast, with radar DA*)
- Spring 2009: 20 members, 4 km, 3 models (ARW, NMM, ARPS), physics/IC/LBCs. 3/4 CONUS (*+ one single 1 km grid forecast, with radar DA*)
- About 1.5 months each spring season from mid-April through early June

New Features in 2010

- Full CONUS domain (+38% computing)
- Total **26** members, at 4-km grid spacing: 19 ARW, 5 NMM, 2 ARPS members
- Upgrade to WRF version 3.1.1 from version 3.0.1.1
- New double moment microphysics (WDM6, Morrison, new-Thompson), and new PBL (MYNN, QNSE) schemes included
- Random perturbations (Gaussian-type & recursive filtered) were added to 3 members
- Post-processed ensemble product in near realtime

System Highlight

- 4 km grid for ARW & ARPS; ~ 4.16 km for NMM
- 51 vertical levels for all three models
- 30 hour forecast initialized at 00 UTC, ended at 06 UTC the next day
- April 26 – June 18 (on weekdays)
- A Cray XT4 supercomputer at NICS/U. of Tennessee (over 18000 cores) was dedicated 6 h each day to run the forecasts
- Selected hourly 2D fields from all members and post-processed ensemble products available to SPC/NSSL, DTC, and HPC in realtime, and evaluated by HWT participants

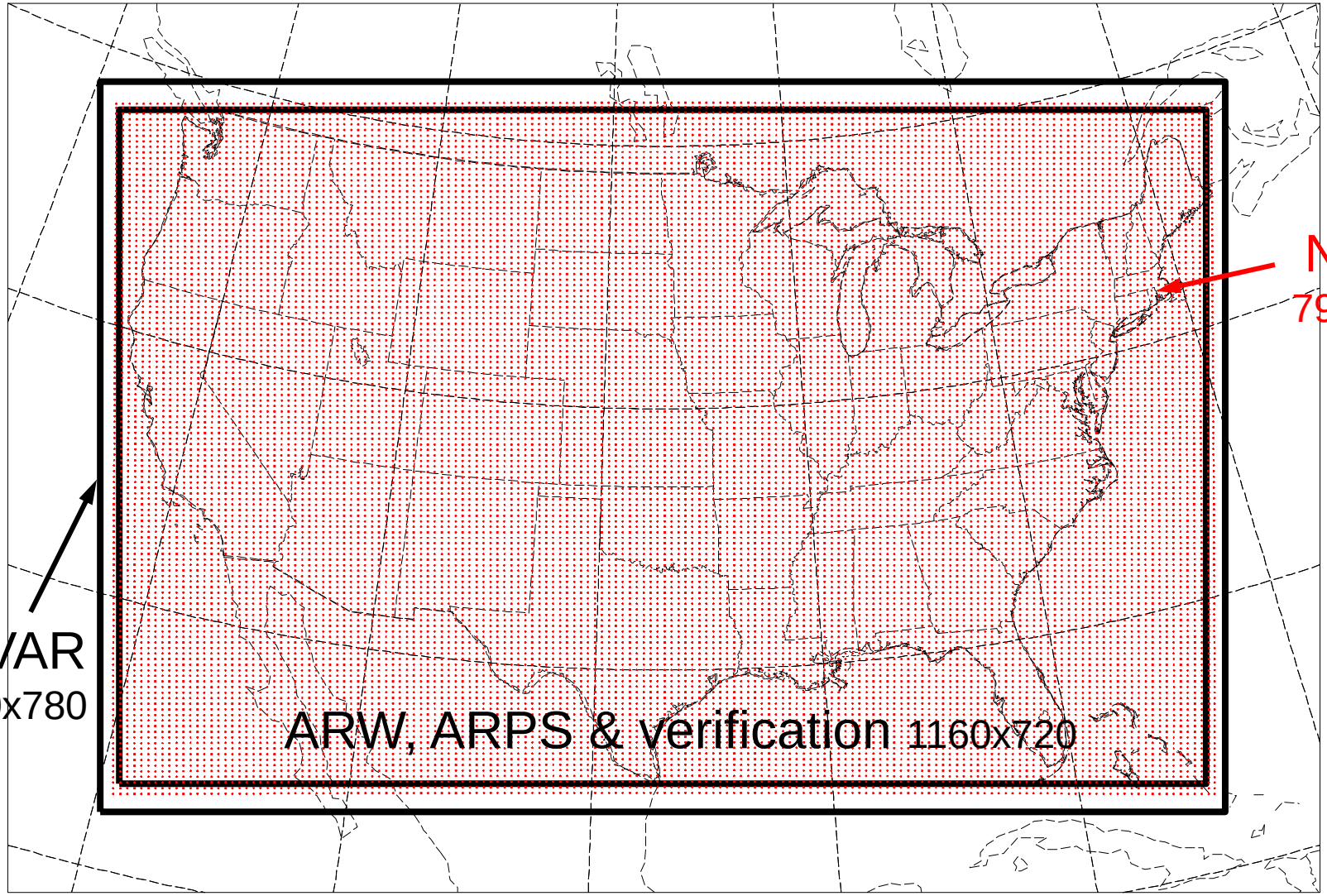
System Highlight

- NAM 12 km 00Z analysis/forecast were used to provide IC/LBC for control members
- 13 SREF 21Z forecast members were used to extract initial perturbations and hourly LBCs for perturbed members
- ARPS 3DVAR and Cloud Analysis are used to analyze 140 WSR-88D Level II radar radial wind and reflectivity to all but three members

Post-processed ensemble product

- Ensemble maximum, mean
- Probability matching mean (accumulated precipitation, reflectivity)
- Frequency-based probability
- Neighborhood probability, with 2D Gaussian smoothing (ROI=40km, σ=10)
- More…

2010 Spring Experiment Domains



ARW member configuration (19)

member	IC	BC	Radar data	microphy	LSM	PBL
arw_cn	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYJ
arw_c0	00Z NAMa	00Z NAMf	no	Thompson	Noah	MYJ
arw_m3	arw_cn + random pert	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m4	arw_cn + RF pert	00Z NAMf	yes	Thompson	Noah	MYJ
arw_m5	arw_cn + em-p1 + RF pert	21Z SREF em-p1	yes	Morrison	RUC	YSU
arw_m6	arw_cn + em-p1_pert	21Z SREF em-p1	yes	Morrison	RUC	YSU
arw_m7	arw_cn + em-p2_pert	21Z SREF em-p2	yes	Thompson	Noah	QNSE
arw_m8	arw_cn – nmm-p1_pert	21Z SREF nmm-p1	yes	WSM6	RUC	QNSE
arw_m9	arw_cn + nmm-p2_pert	21Z SREF nmm-p2	yes	WDM6	Noah	MYNN
arw_m10	arw_cn + rsmSAS-n1_pert	21Z SREF rsmSAS-n1	yes	Ferrier	RUC	YSU
arw_m11	arw_cn – etaKF-n1_pert	21Z SREF etaKF-n1	yes	Ferrier	Noah	YSU
arw_m12	arw_cn + etaKF-p1_pert	21Z SREF etaKF-p1	yes	WDM6	RUC	QNSE
arw_m13	arw_cn – etaBMJ-n1_pert	21Z SREF etaBMJ-n1	yes	WSM6	Noah	MYNN
arw_m14	arw_cn + etaBMJ-p1_pert	21Z SREF etaBMJ-p1	yes	Thompson	RUC	MYNN
arw_m15	00Z ARPSa	00Z NAMf	yes	WDM6	Noah	MYJ
arw_m16	00Z ARPSa	00Z NAMf	yes	WSM6	Noah	MYJ
arw_m17	00Z ARPSa	00Z NAMf	yes	Morrison	Noah	MYJ
arw_m18	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	QNSE
arw_m19	00Z ARPSa	00Z NAMf	yes	Thompson	Noah	MYNN

For all ARW members: *ra_lw_physics*= RRTM; *ra_sw_physics*=Goddard; *cu_physics*=none

NMM member configuration (5)

member	IC	BC	Radar data	mp_phy	lw_phy	sw-phy	sf_phy
nmm_cn	00Z ARPSa	00Z NAMf	yes	Ferrier	GFDL	GFDL	Noah
nmm_c0	00Z NAMa	00Z NAMf	no	Ferrier	GFDL	GFDL	Noah
nmm_m3	nmm_cn + nmm-n1_pert	21Z SREF nmm-n1	yes	Thompson	RRTM	Dudhia	Noah
nmm_m4	nmm_cn + nmm-n2_pert	21Z SREF nmm-n2	yes	WSM 6-class	RRTM	Dudhia	RUC
nmm_m5	nmm_cn + em-n1_pert	21Z SREF em-n1	yes	Ferrier	GFDL	GFDL	RUC

For all NMM members: *pbl_physics*=MYJ; *cu_physics*=none

ARPS member configuration (2)

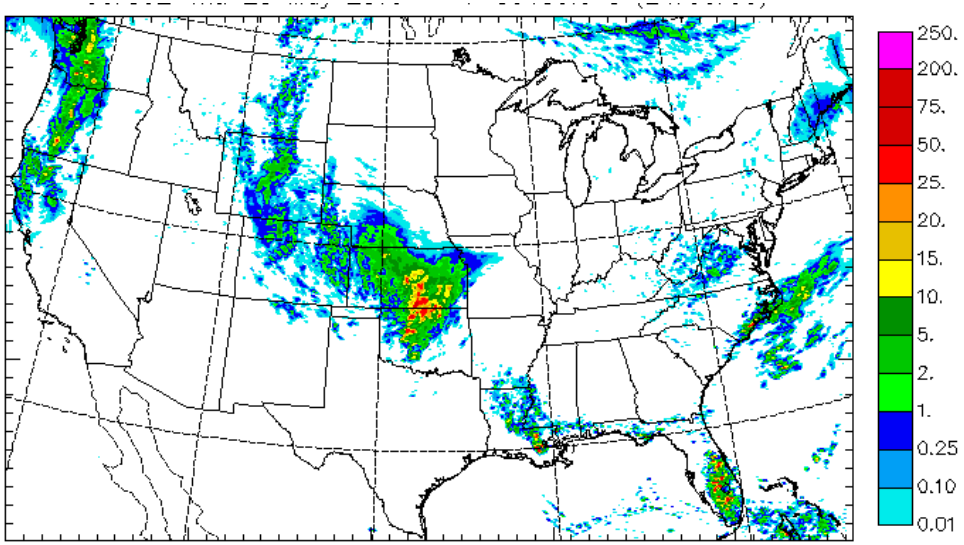
member	IC	BC	Radar data	Microphy.	radiation	sf_phy
arps_cn	00Z ARPSa	00Z NAMf	yes	Lin	Chou/Suarez	Force-restore
arps_c0	00Z NAMa	00Z NAMf	no	Lin	Chou/Suarez	Force-restore

For all ARPS members: no cumulus parameterization

Members in red contribute to the 15-member sub-ensemble for post-processed product

CAPS Ensemble Product

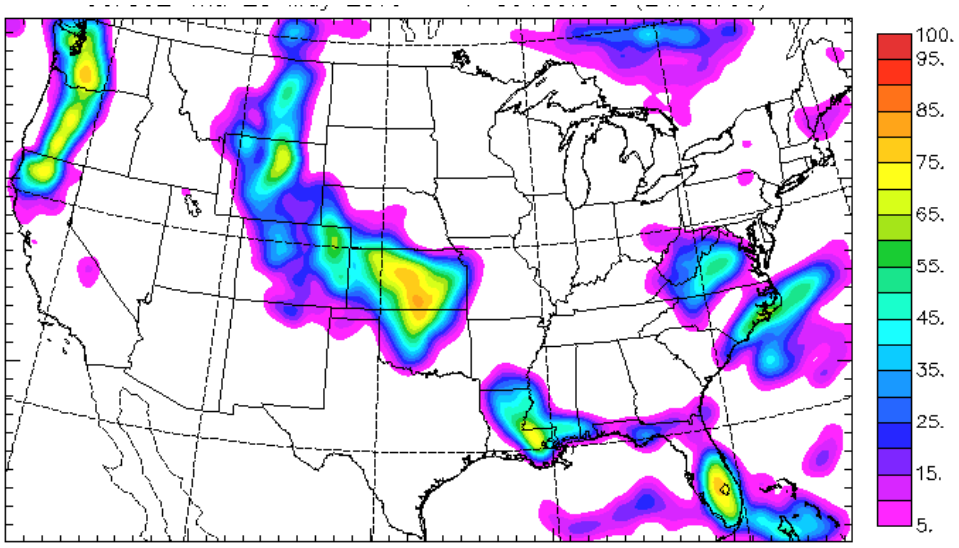
- http://forecast.caps.ou.edu
- http://www.caps.ou.edu/~fkong/sub_atm/spring10.html
- 4TB data per day archived (A total of 36 days complete dataset)



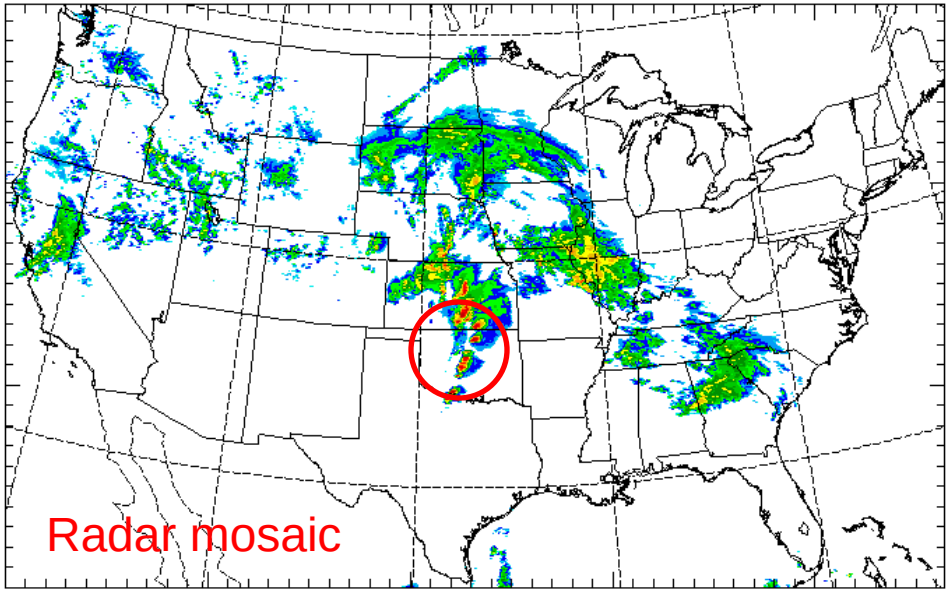
Probability matching mean:
1-h accumulated precipitation

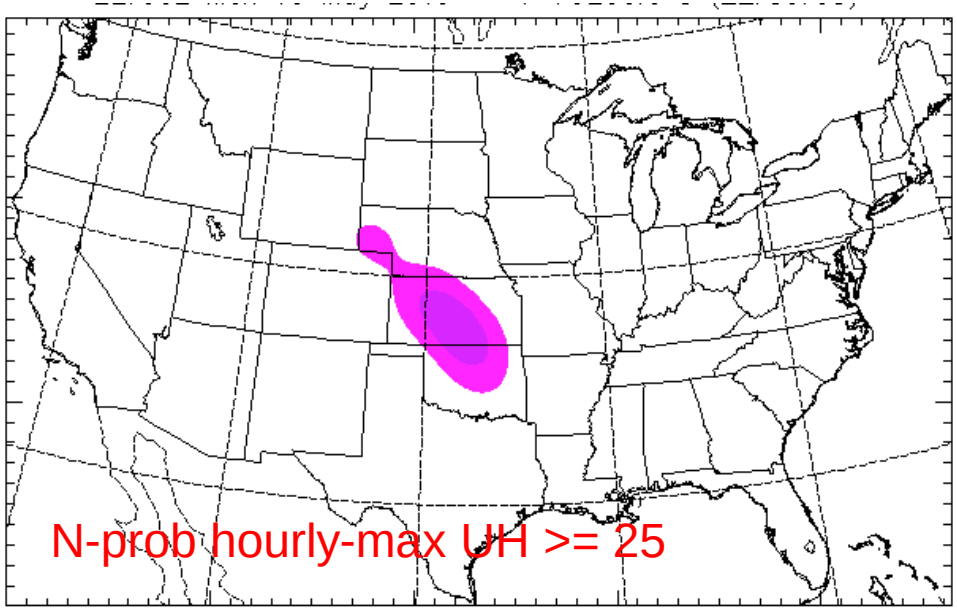
(24-h fcst, valid 00Z May 20)

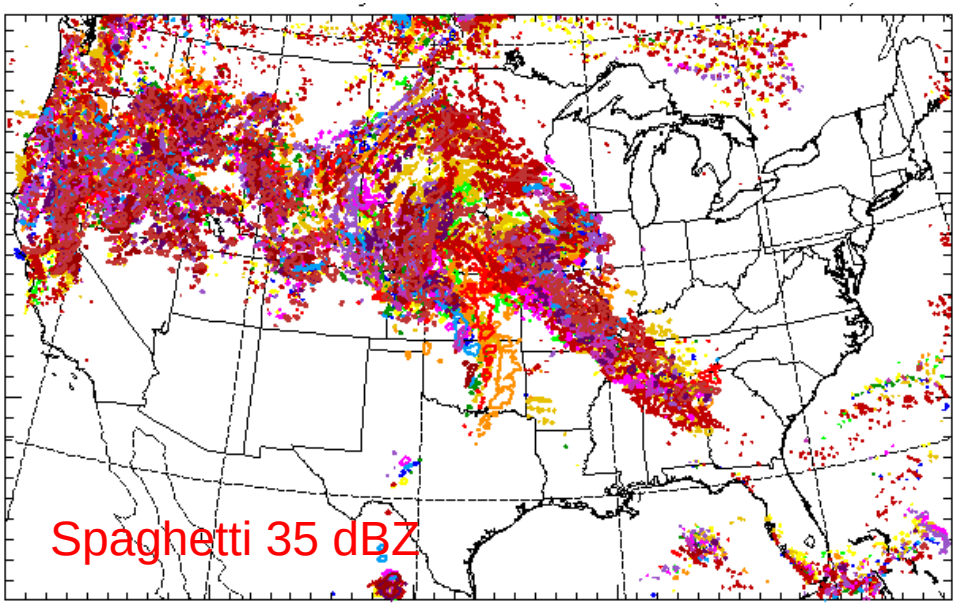
Neighborhood probability:
1-h accumulated
precipitation >=0.25”

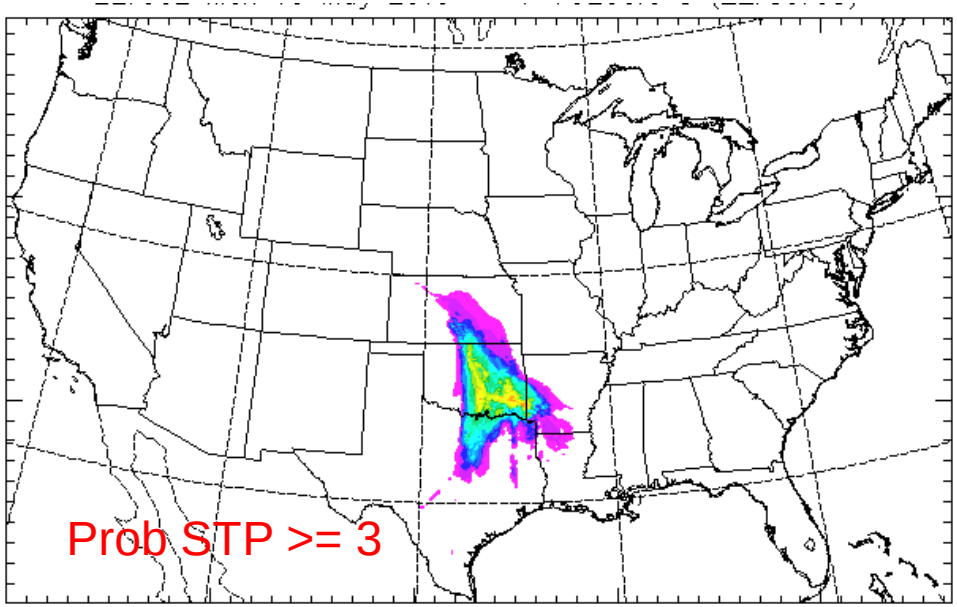


May 10 OKC Tornado – valid 22 UTC



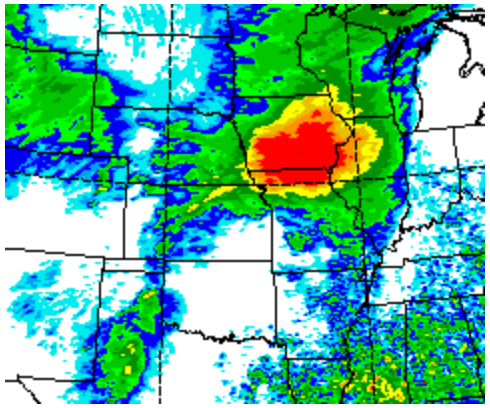




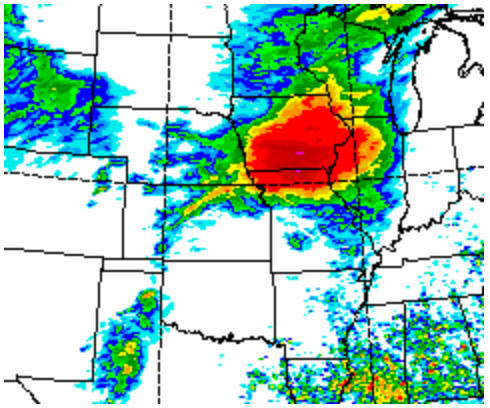


0–6Z accumulated precipitation: 30h (June 1, 2010)

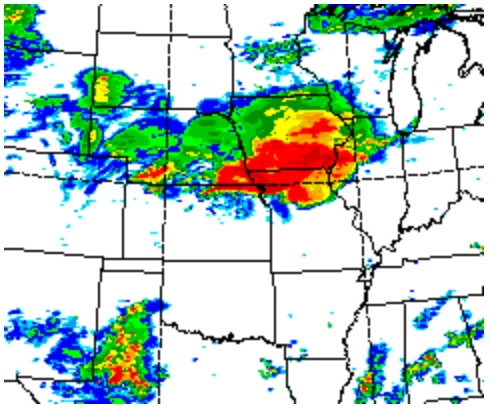
Mean



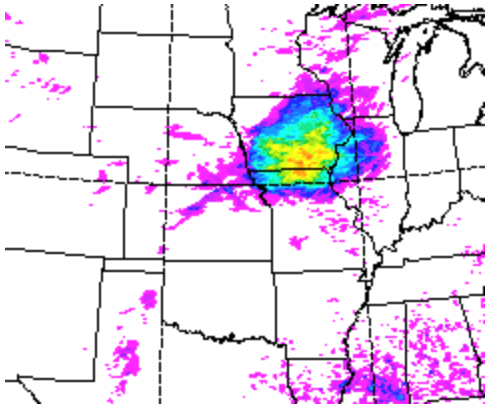
Prob match



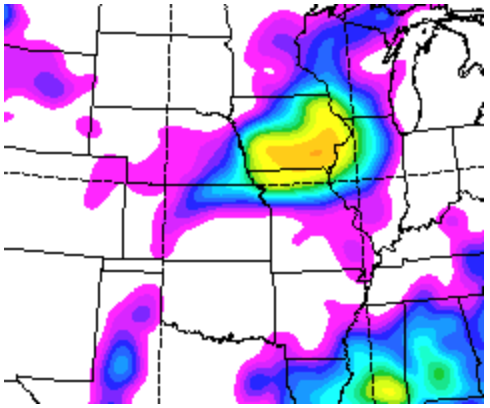
QPE



Prob of 1”



N-prob of 1”



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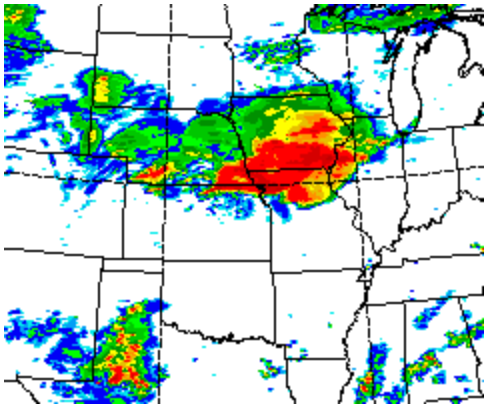
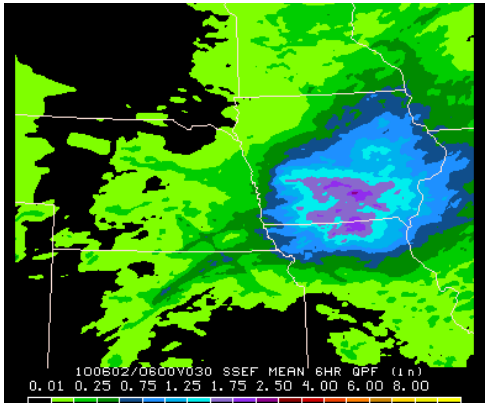
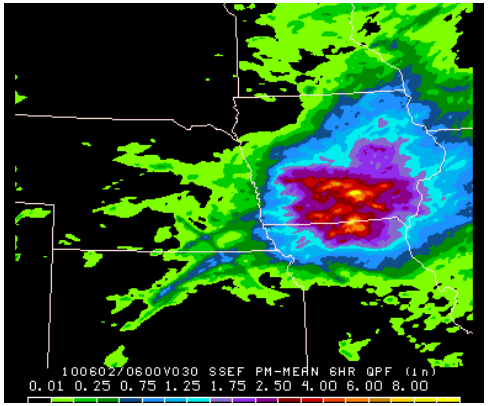


0–6Z accumulated precipitation: 30h (June 1, 2010)

SSEF mean



SSEF Prob match



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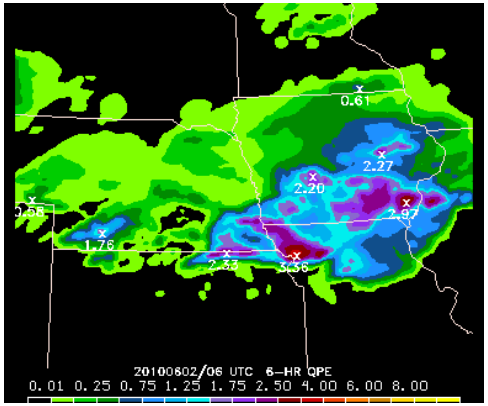
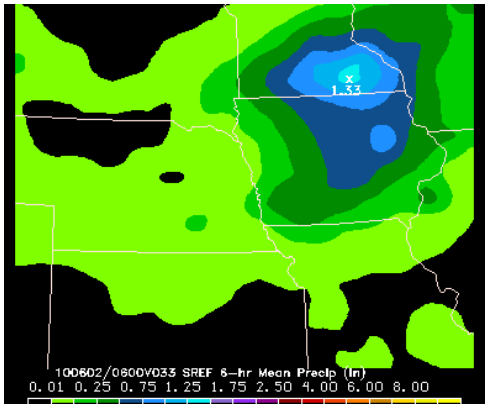


SREF mean



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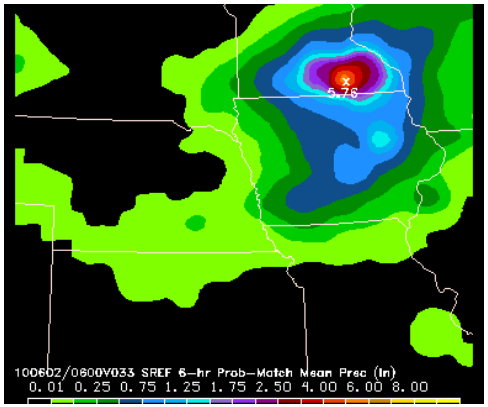

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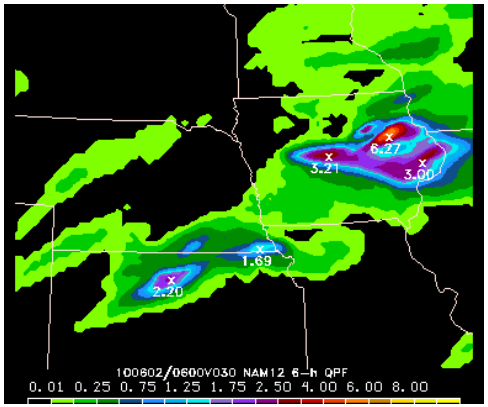
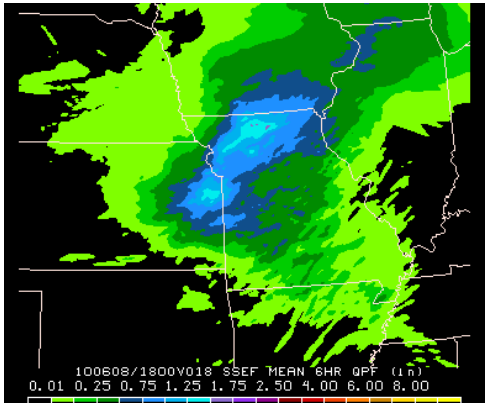


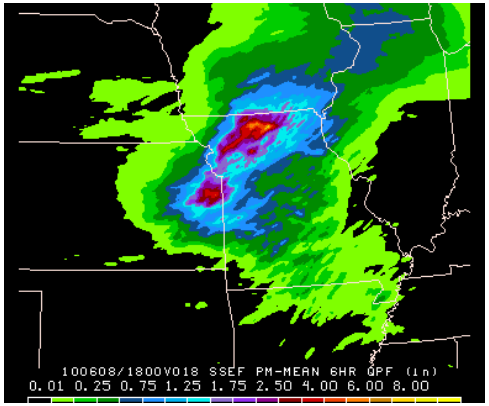
HWT images

12–18Z accumulated precipitation: 18h (June 8, 2010)

SSEF mean



SSEF Prob match



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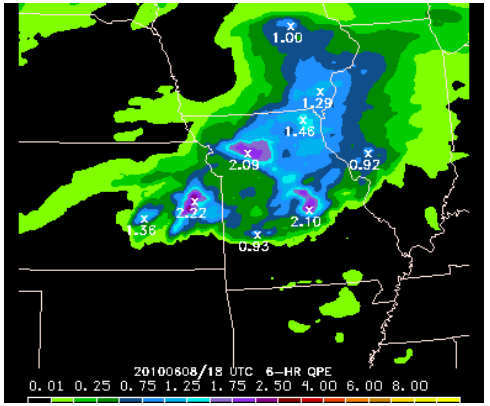

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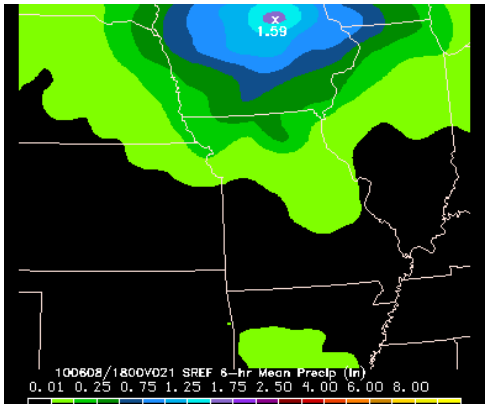

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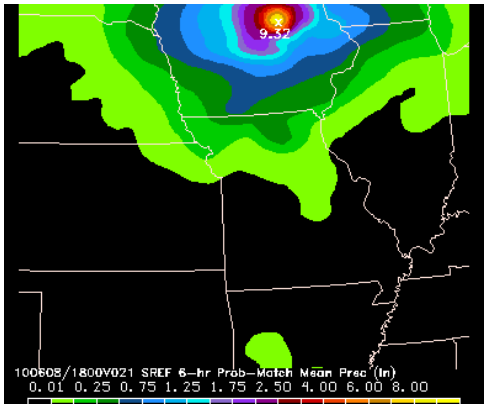

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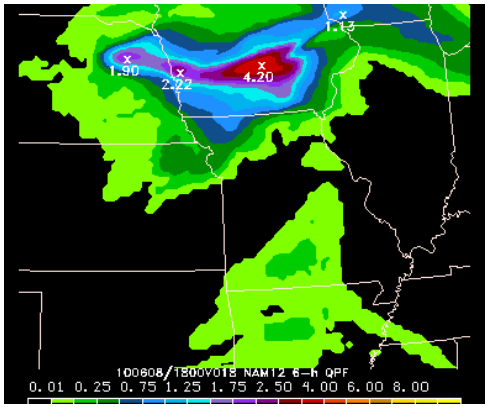
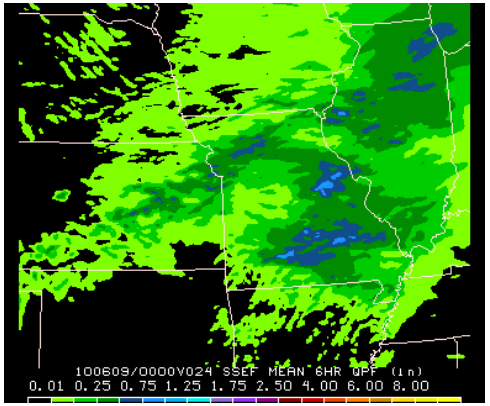


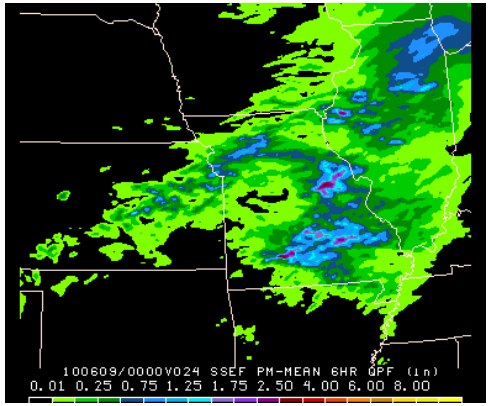
HWT images

18–0Z accumulated precipitation: 24h (June 8, 2010)

SSEF mean



SSEF Prob match



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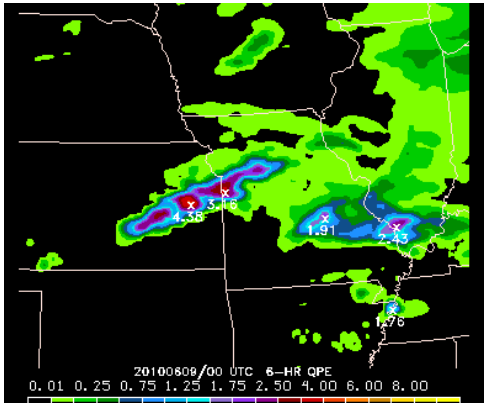

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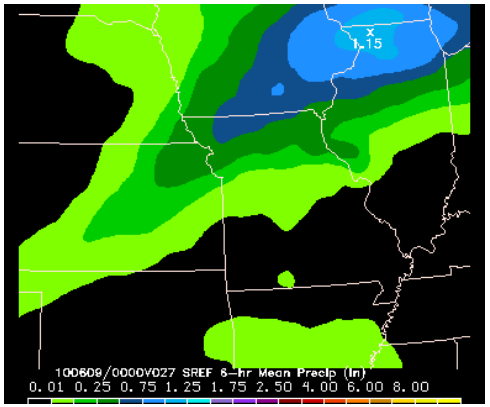

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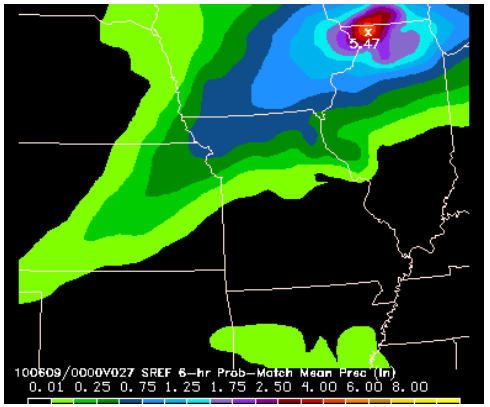

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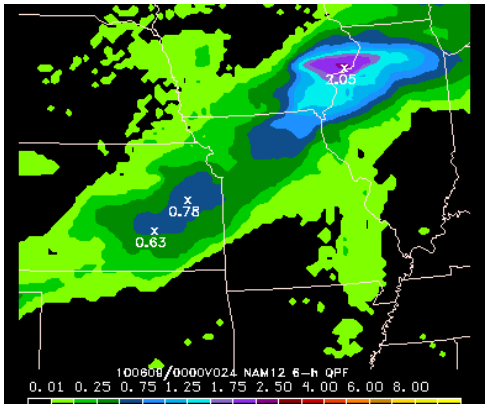
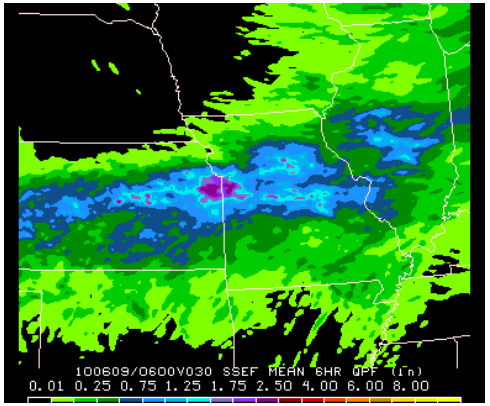


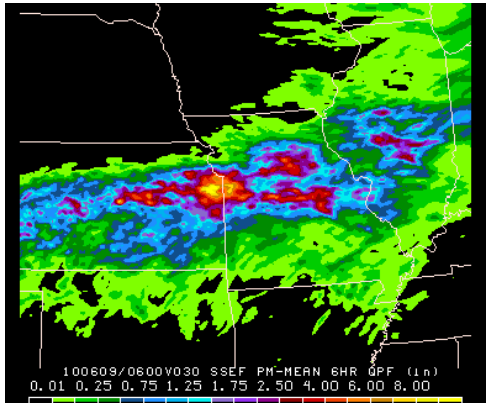
HWT images

0–6Z accumulated precipitation: 30h (June 8, 2010)

SSEF mean



SSEF Prob match



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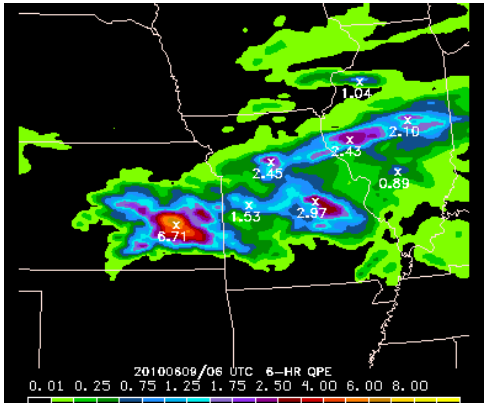

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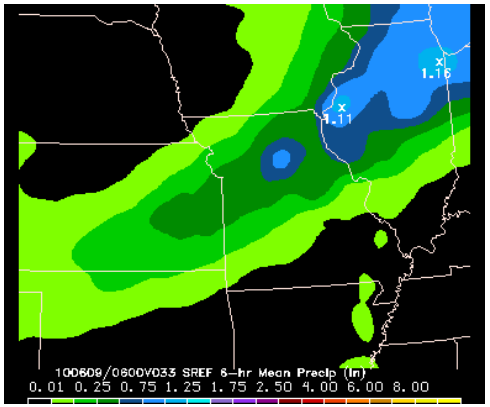

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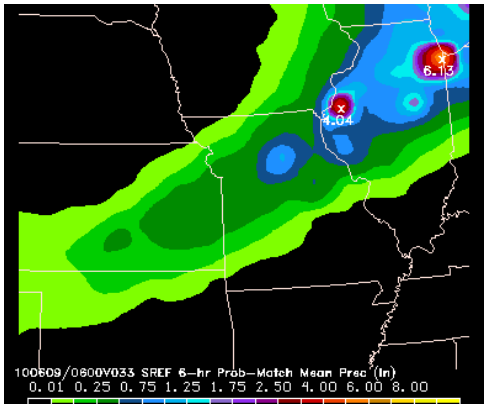

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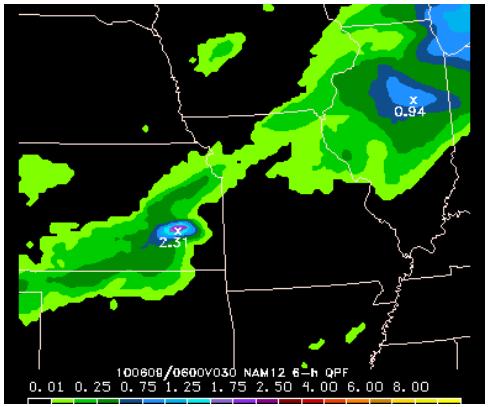
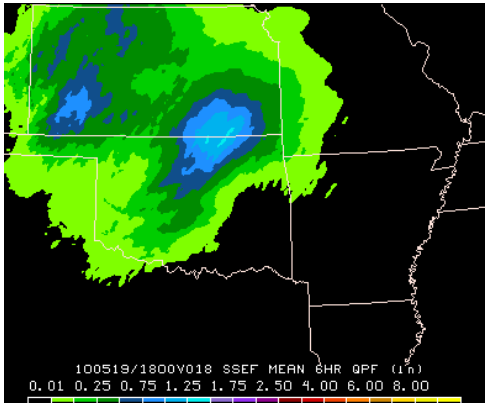


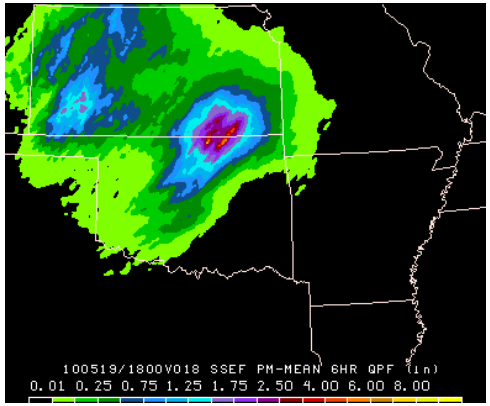
HWT images

12–18Z accumulated precipitation: 18h (May 19, 2010)

SSEF mean



SSEF Prob match



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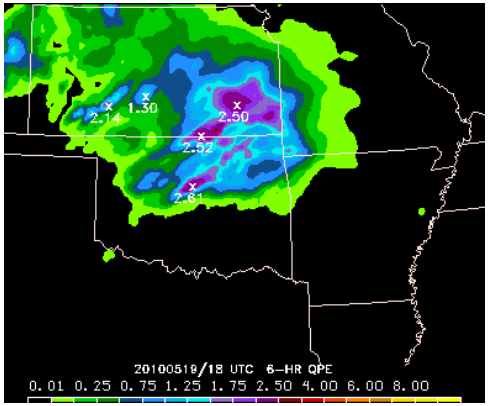

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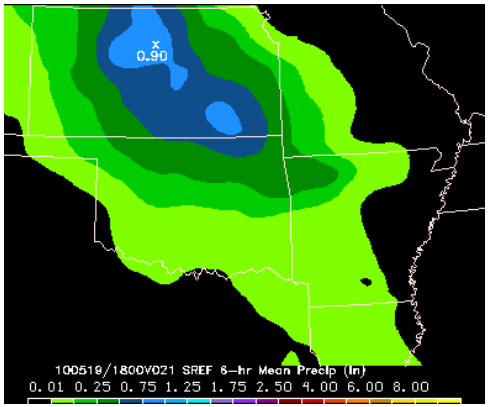

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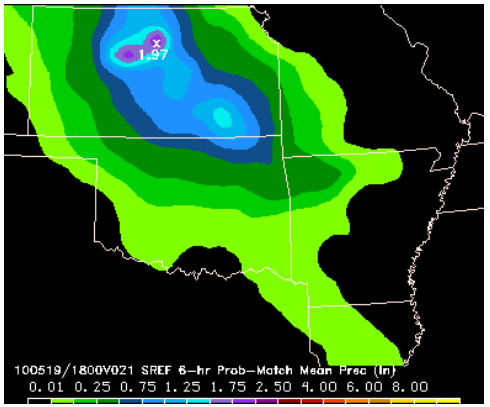

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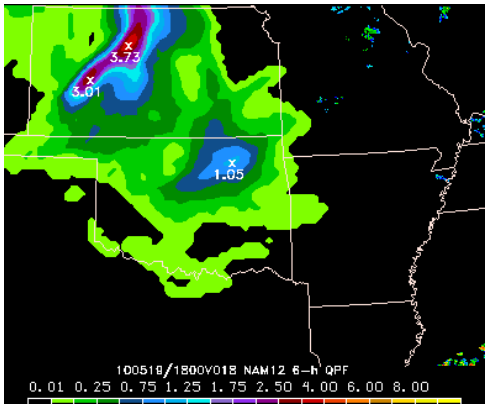
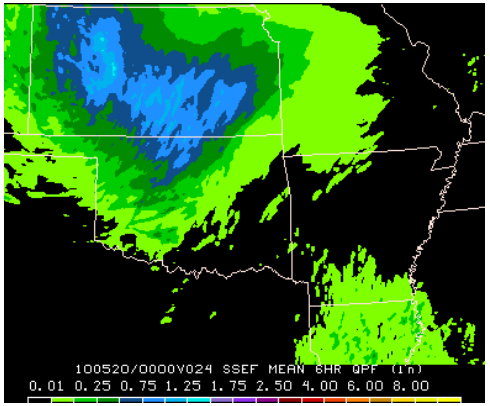


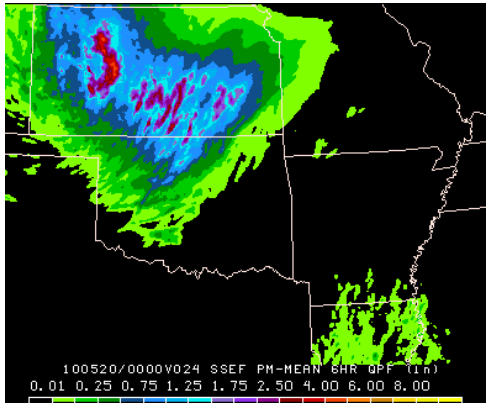
HWT images

18–0Z accumulated precipitation: 24h (May 19, 2010)

SSEF mean



SSEF Prob match



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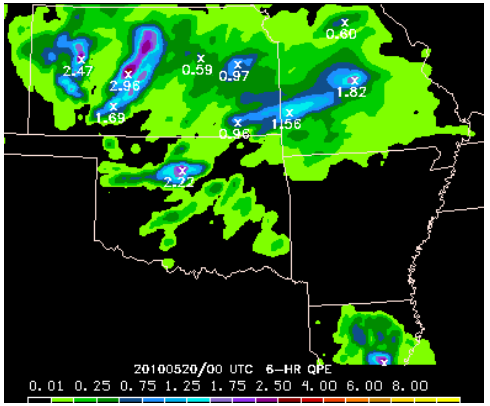
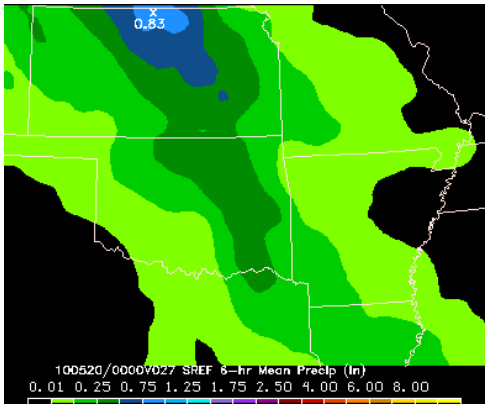
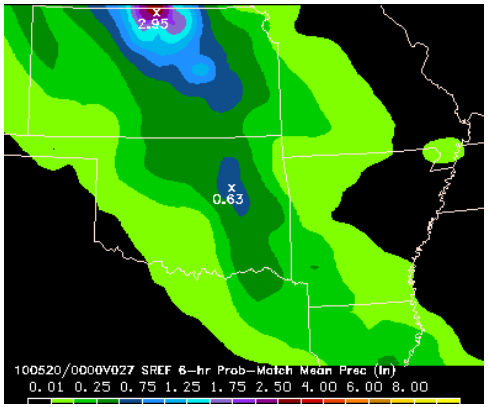


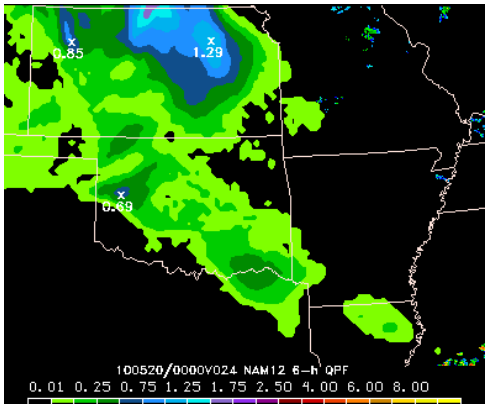
SREF mean



SREF Prob match



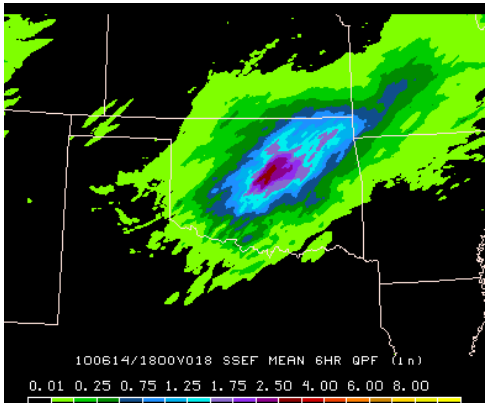
NAM



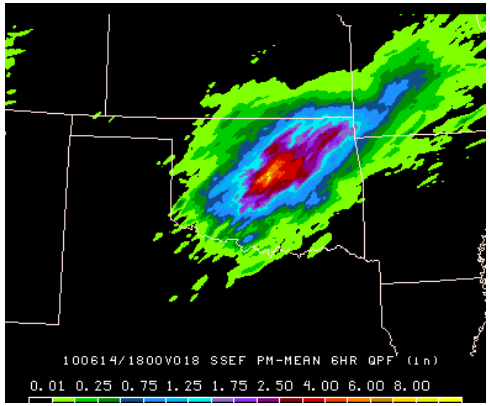
HWT images

12–18Z accumulated precipitation: 18h (June 14, 2010 – OKC Flood Day)

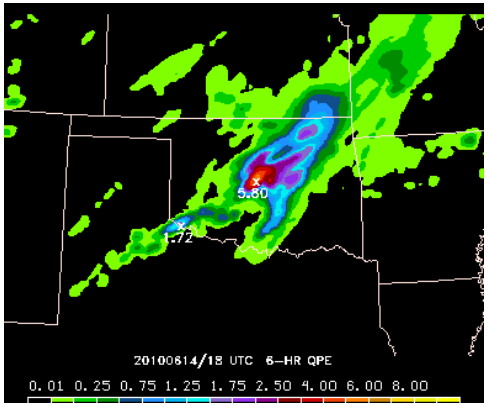
SSEF mean



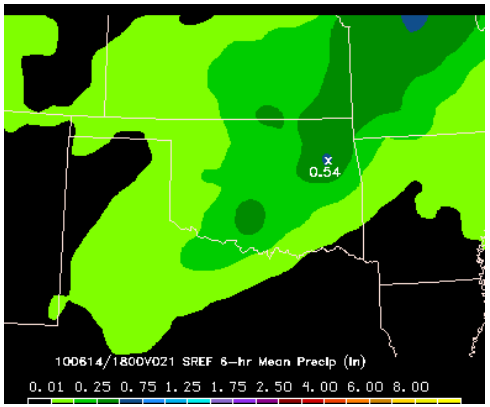
SSEF Prob match



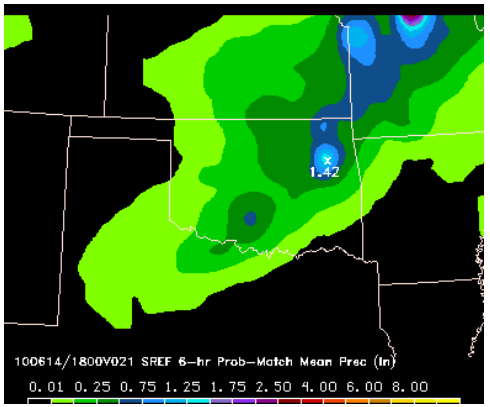
QPE



SREF mean



SREF Prob match



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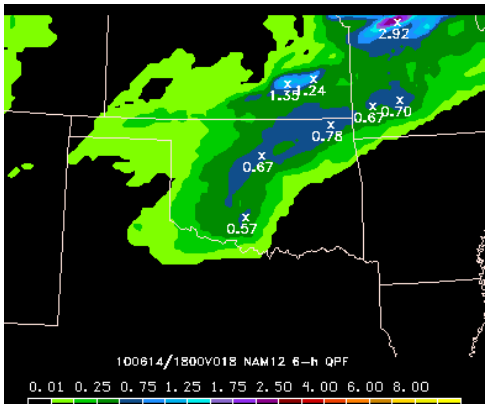
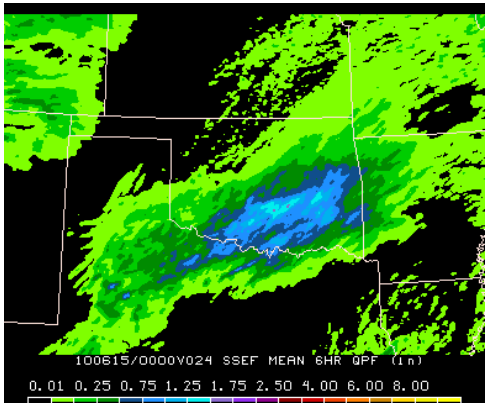


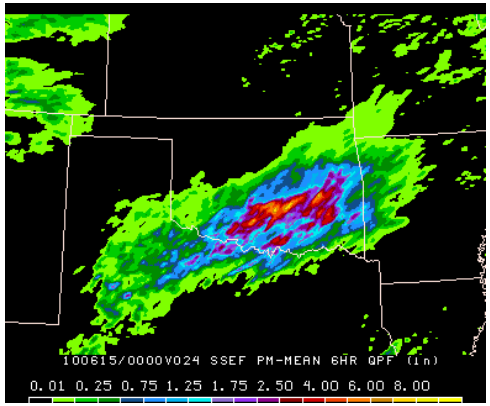
HWT images

18–0Z accumulated precipitation: 24h (June 14, 2010 – OKC Flood Day)

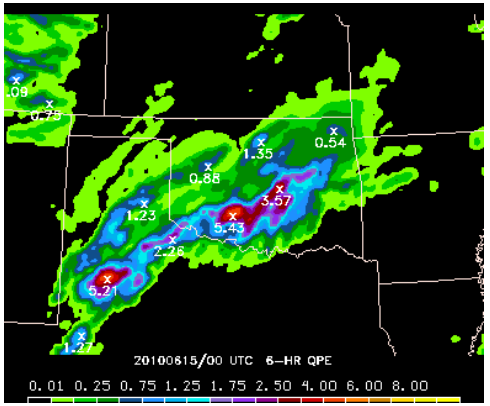
SSEF mean



SSEF Prob match



QPE



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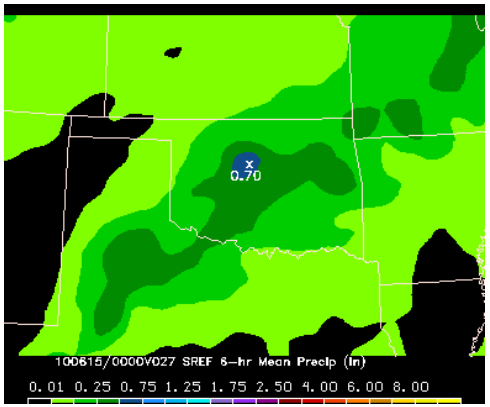
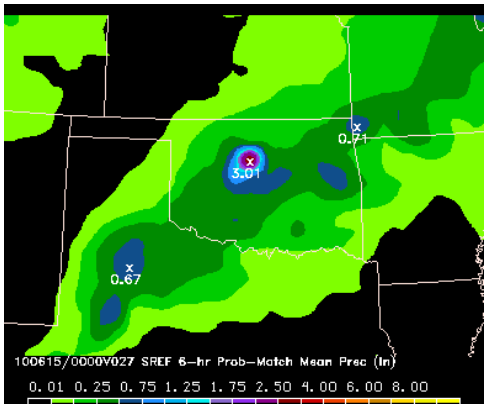


SREF Prob match



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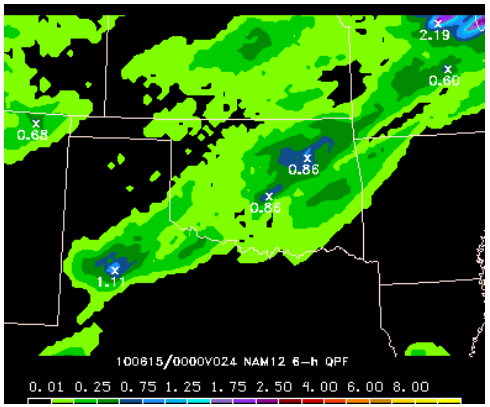


HWT images

- SSEF was a "transformational" event for warm season QPF

- remarks from HPC participant

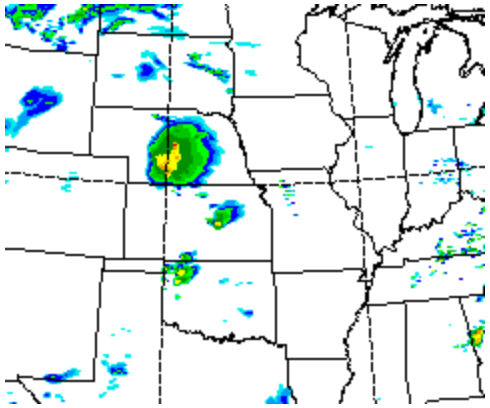
Different microphysics

- Thompson (new)
- WDM6
- WSM6
- Morrison

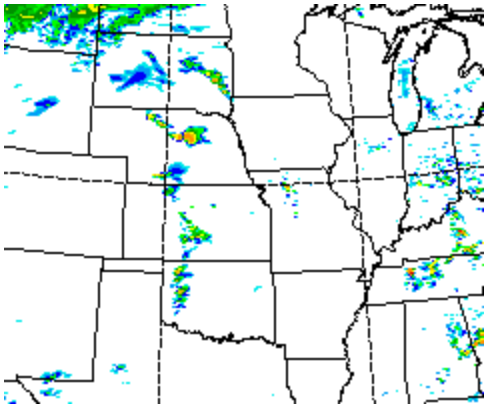
June 1, 2010 case

Different Microphysics - Composite reflectivity at 12h

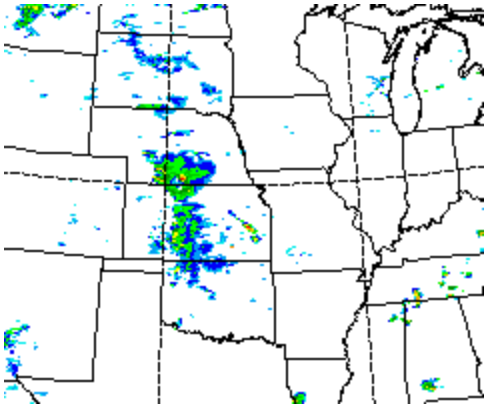
Thomspon



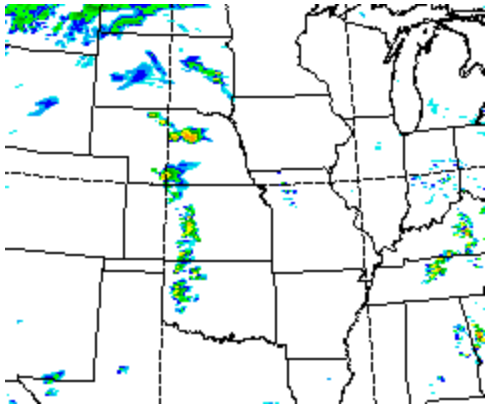
WDM6



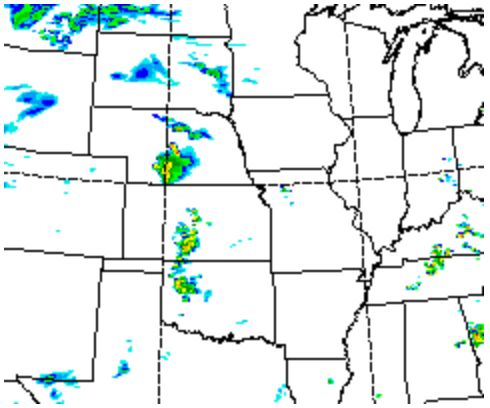
obs



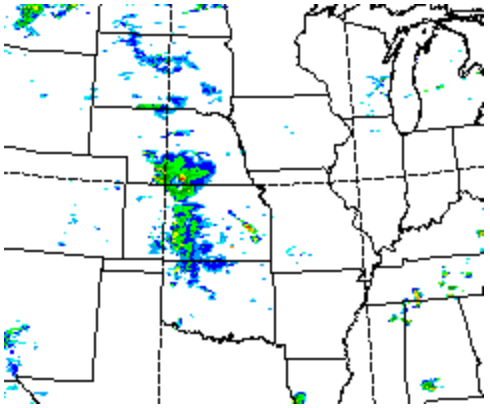
WSM6



Morrison

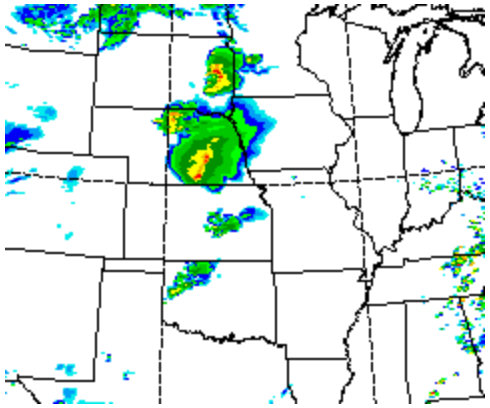


obs

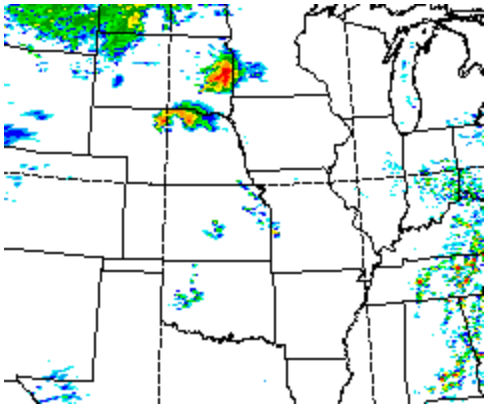


Different Microphysics - Composite reflectivity at 15h

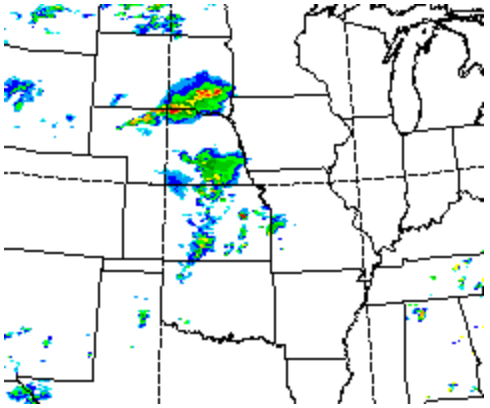
Thomspon



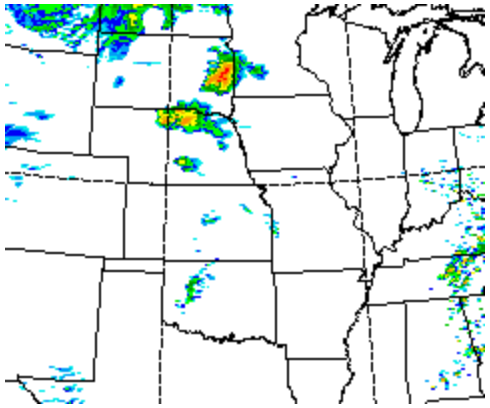
WDM6



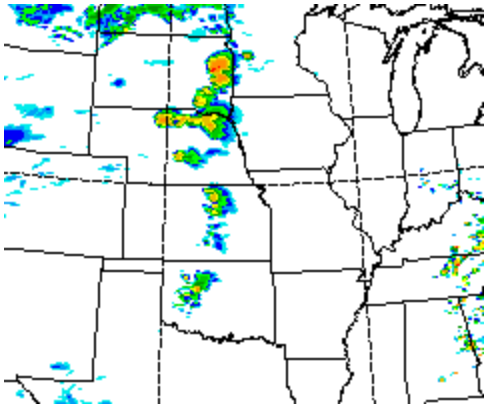
obs



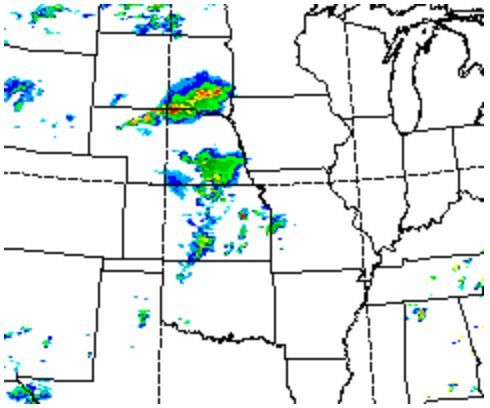
WSM6



Morrison

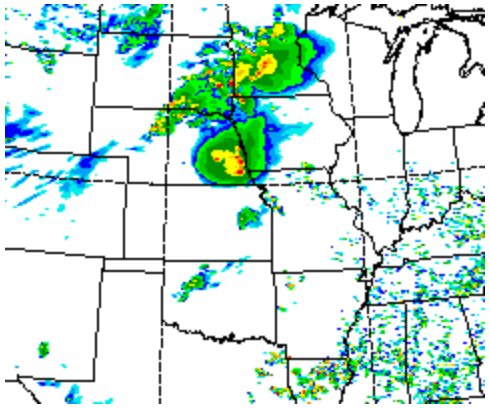


obs

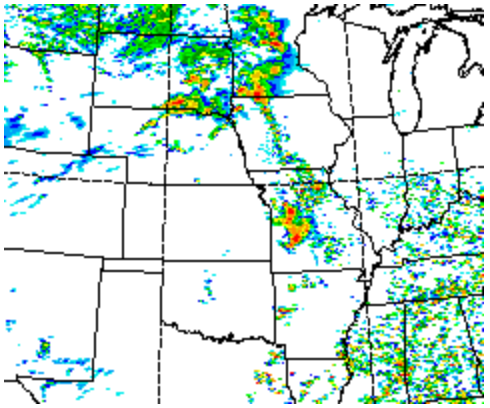


Different Microphysics - Composite reflectivity at 18h

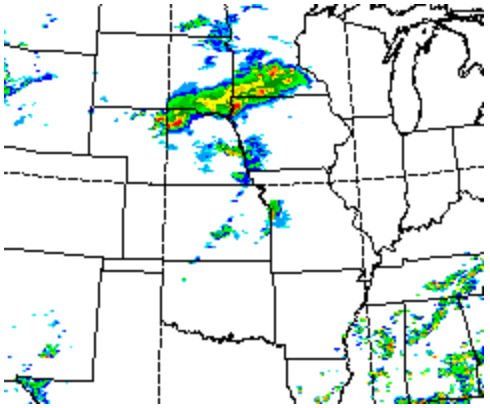
Thomspon



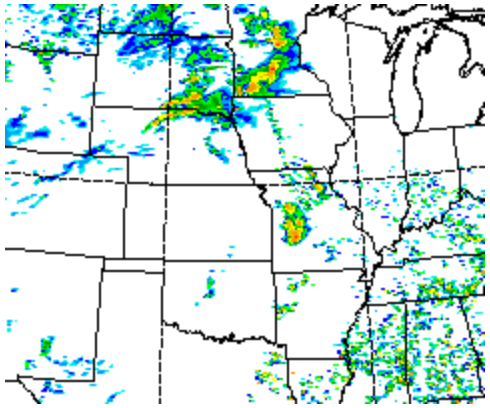
WDM6



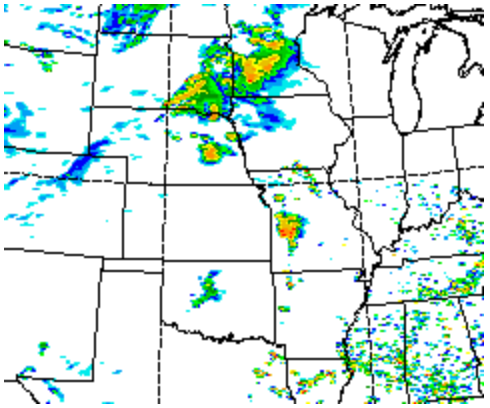
obs



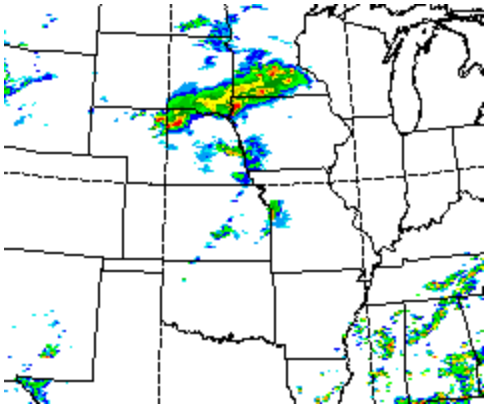
WSM6



Morrison

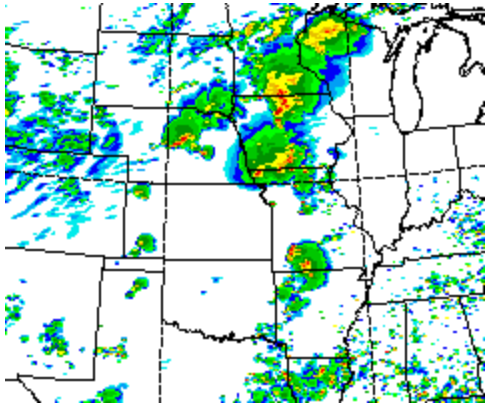


obs

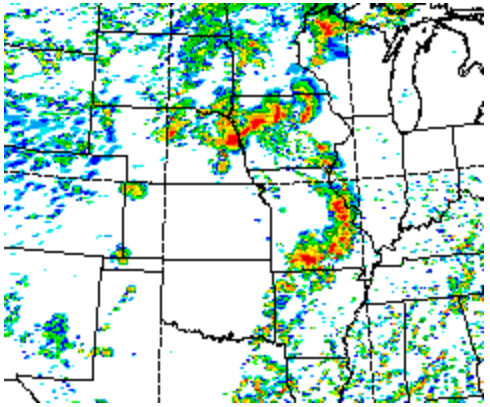


Different Microphysics - Composite reflectivity at 21h

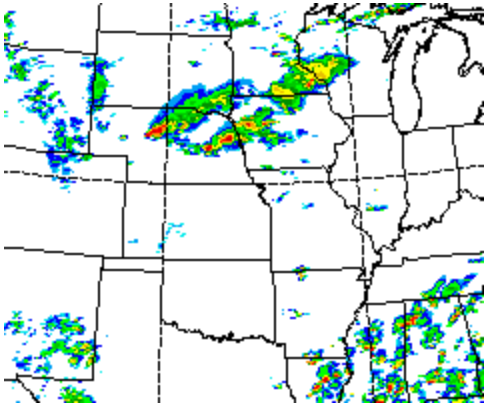
Thomspon



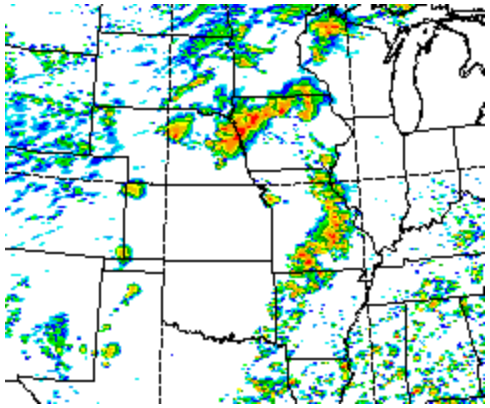
WDM6



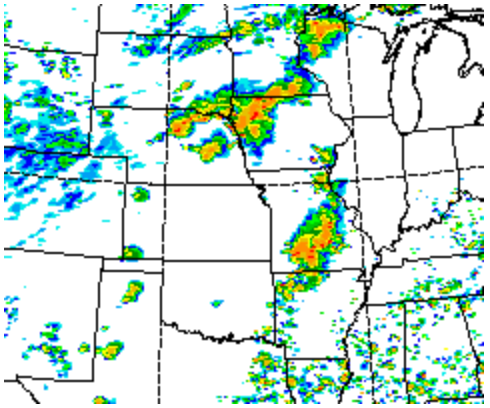
obs



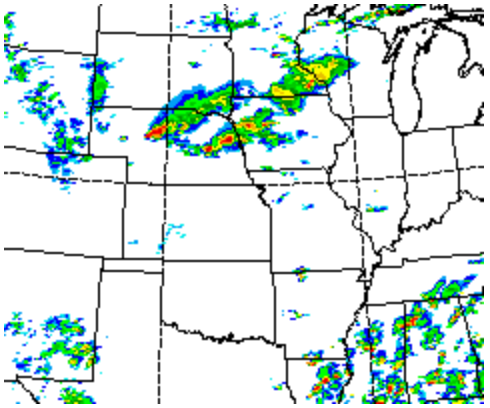
WSM6



Morrison

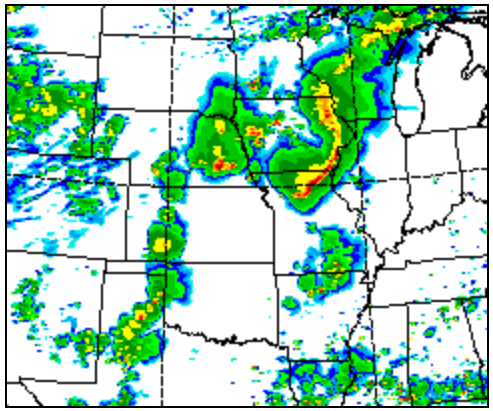


obs

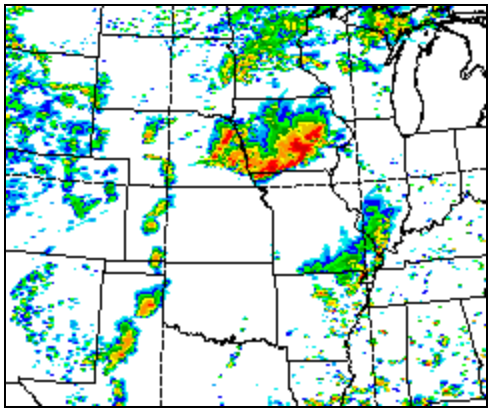


Different Microphysics - Composite reflectivity at 24h

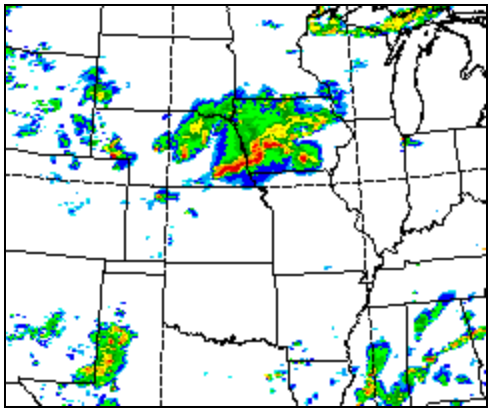
Thomspon



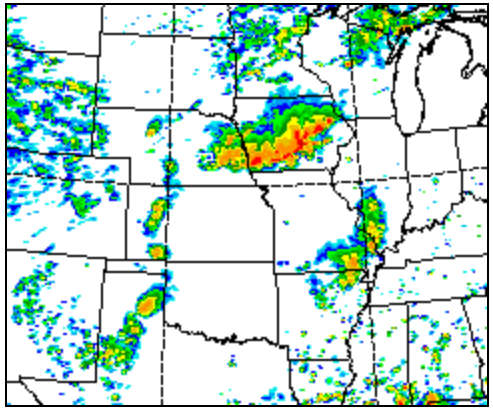
WDM6



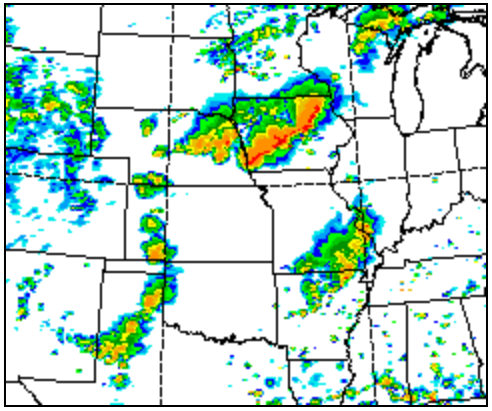
obs



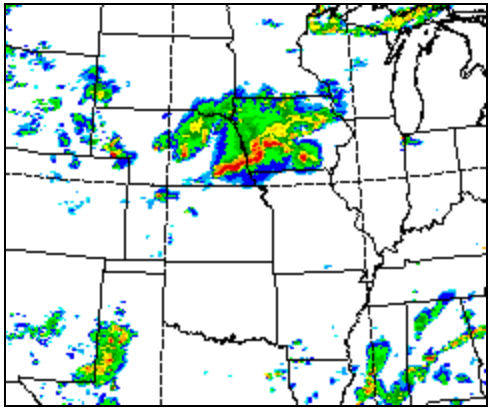
WSM6



Morrison

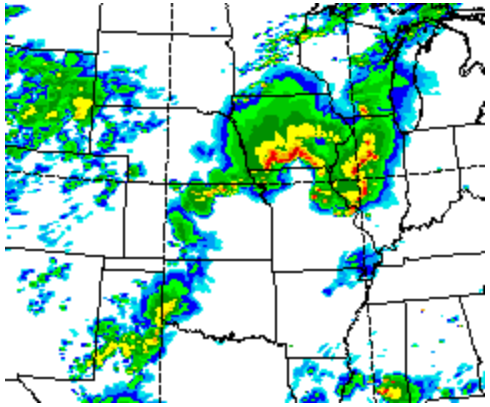


obs

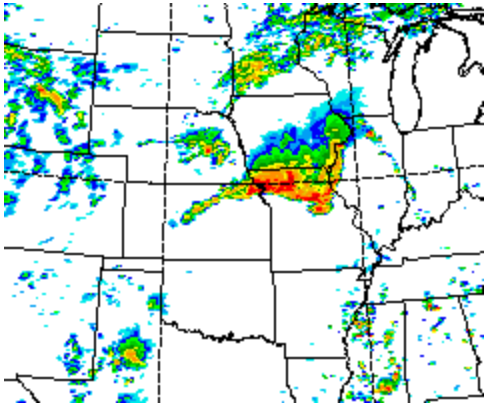


Different Microphysics - Composite reflectivity at 27h

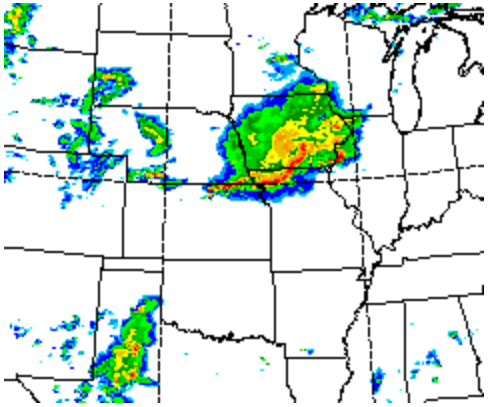
Thomspon



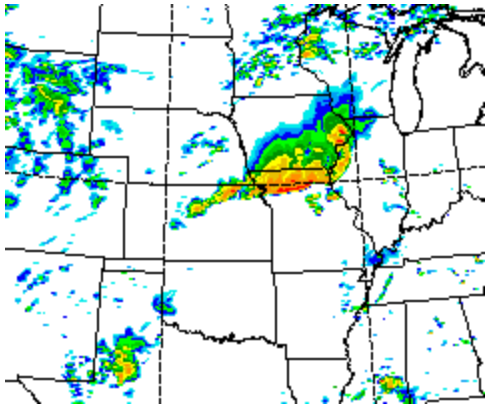
WDM6



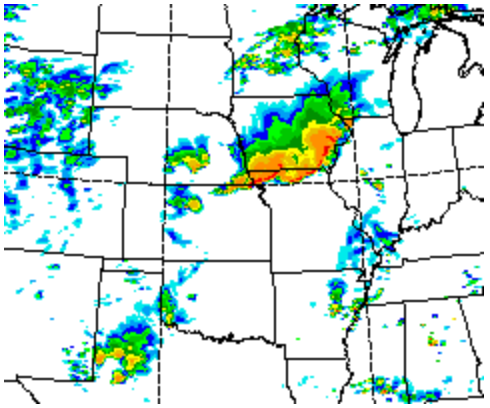
obs



WSM6



Morrison



obs