Explicit Convective Forecasting with the WRF Model

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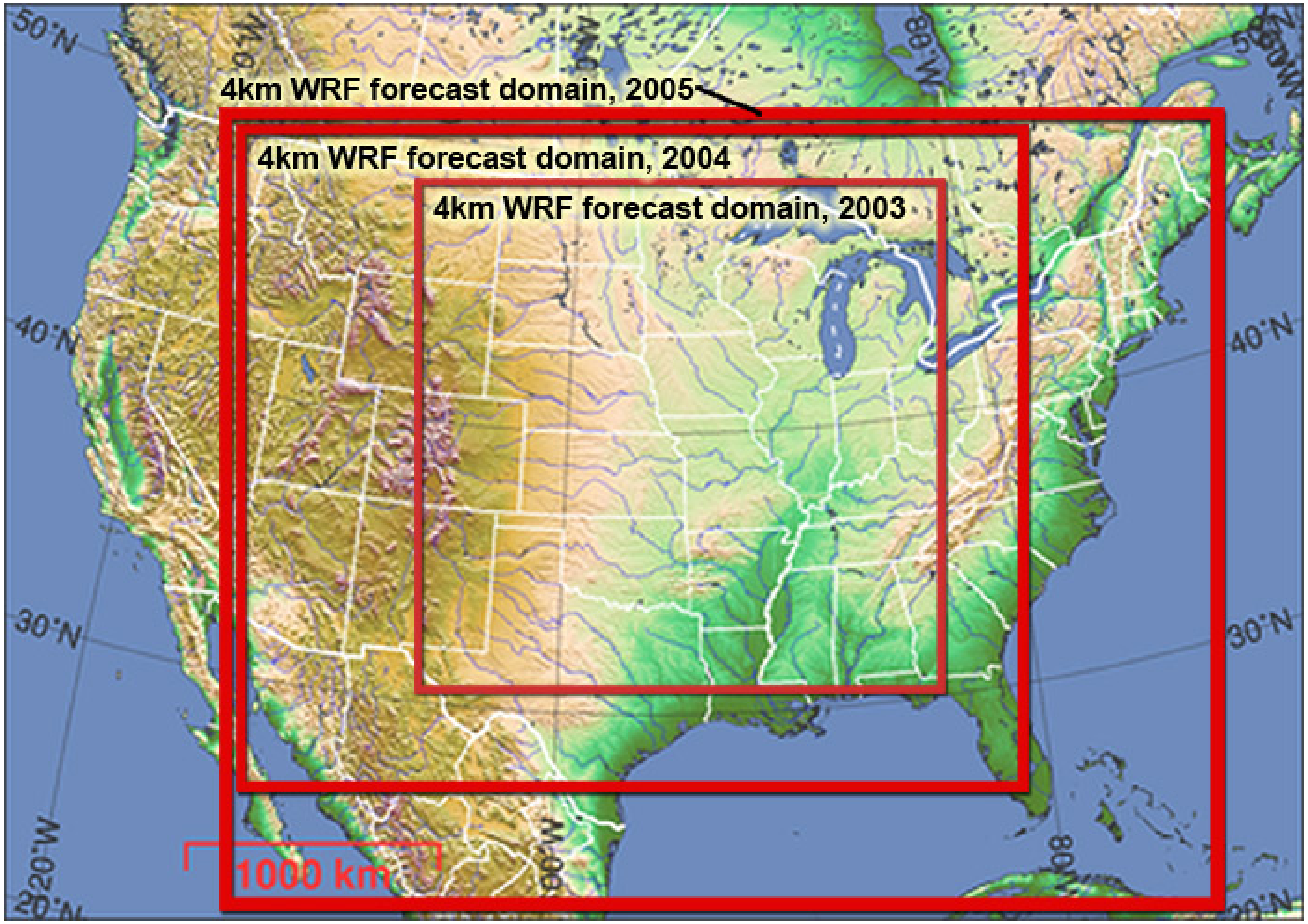
Wei Wang

WRF-MM5 Workshop

June 30, 2005

WRF Realtime Convective Forecasting



May 1 – July 31   4 km   00 UTC -- 36h

2003, 2004, 2005

WRF Real-time Forecasts: 2004, 2005

- 4-km from 0000 UTC - 36 h
- Version 1.3 (2.0.3.1)
- Eta initial and boundary conditions (40 km)
- Physics:

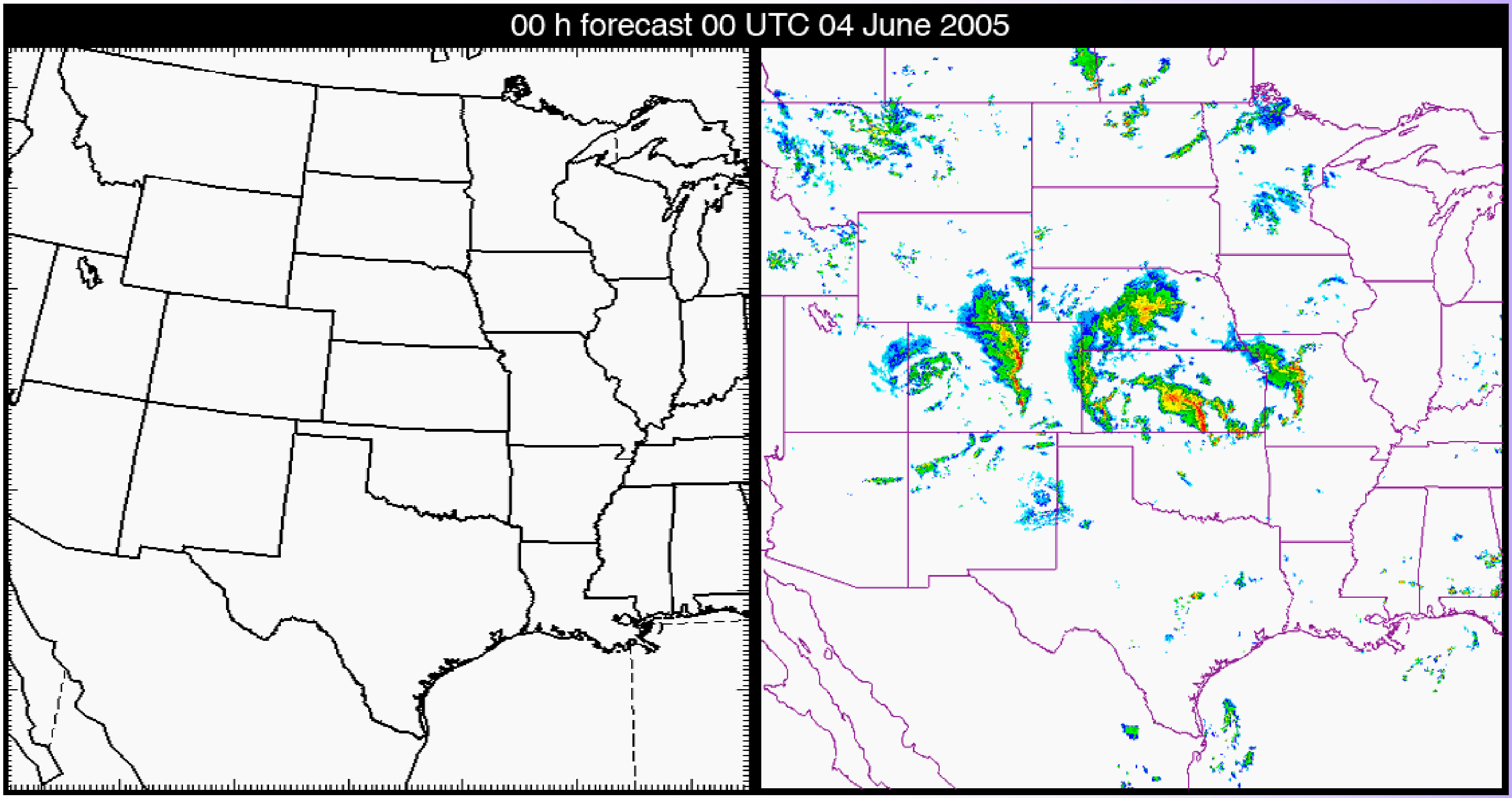
    Lin et al. (5 cat.) microphysics (WSM6)

    YSU PBL (first-order closure)

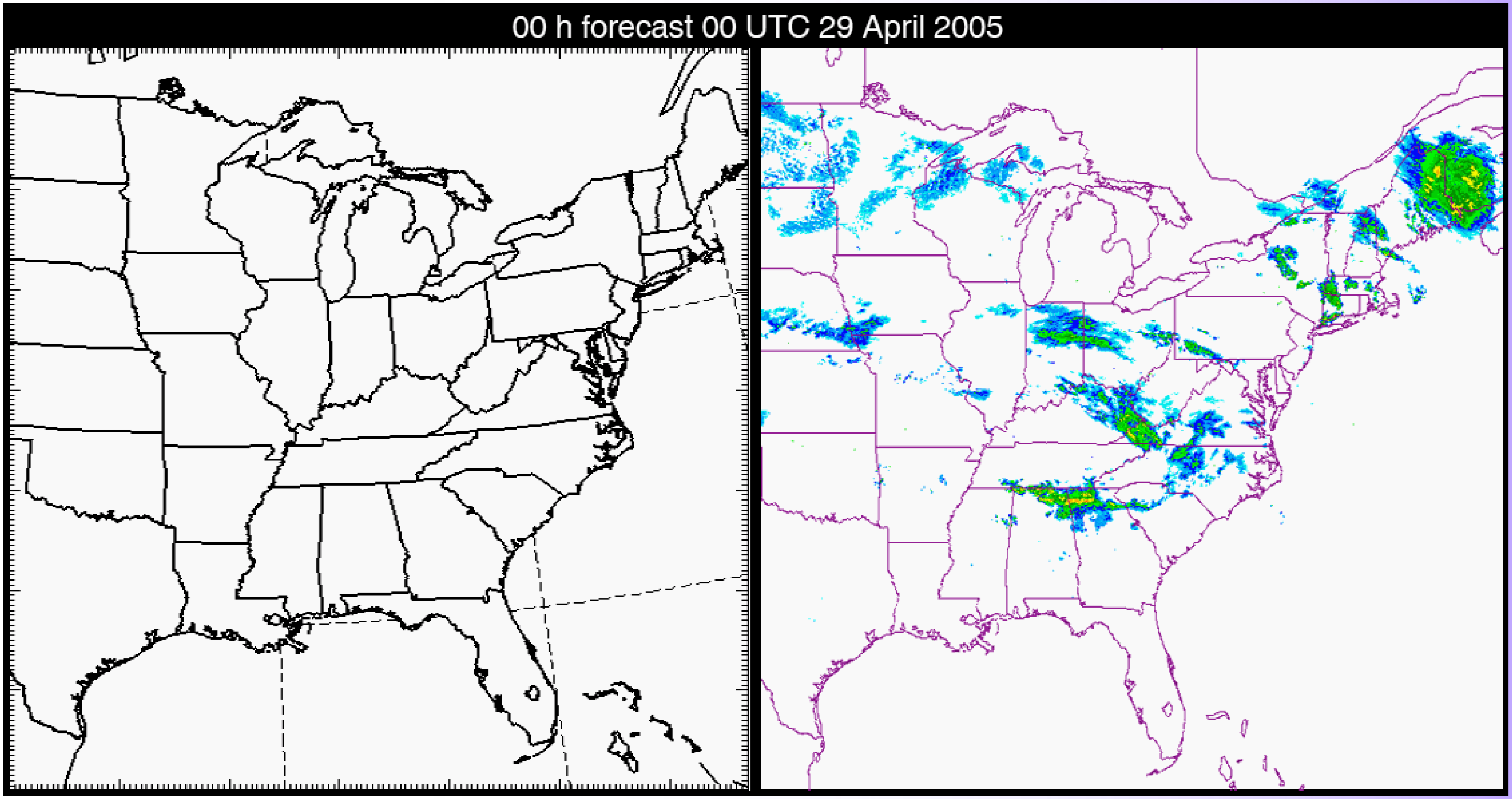
    Noah LSM (HRLDAS)

- 2000 km X 2000 km domain / 2800 km X 2600 km domain
- 5.0h (6.5h) on 128 (192) IBM Power-4 processors

04 June 2005 00 UTC



29 April 2005 00 UTC



Do we have enough evidence to warrant switching to ``convection permitting'' resolutions operationally?

How do we make that decision?

Who is ``WE'' ??

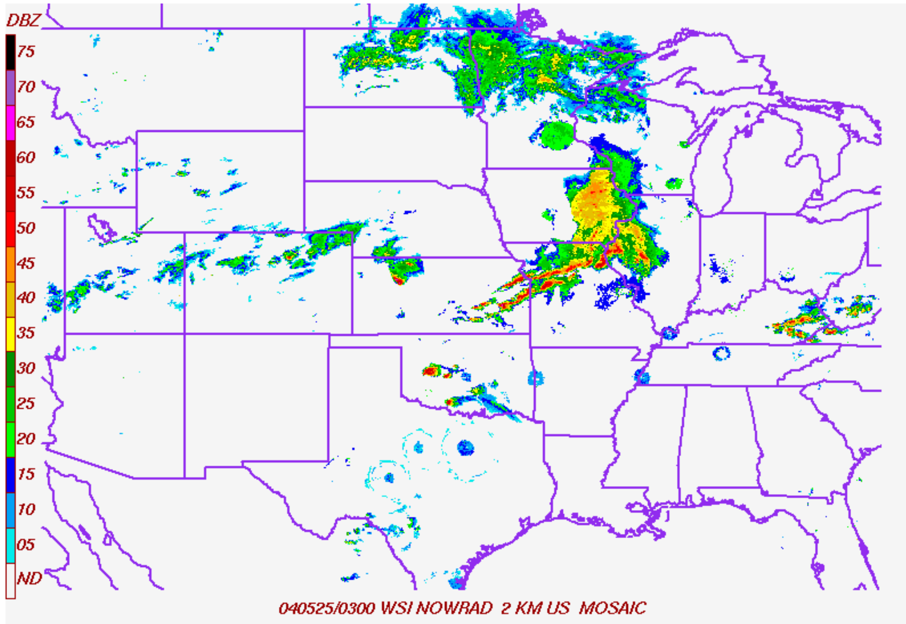
Let’s consider the 24-30 h forecast challenge (i.e., the next diurnal cycle).

How does the 4 km WRF-ARW ‘’guidance’’ compare to the ETA?

May 25, 2004

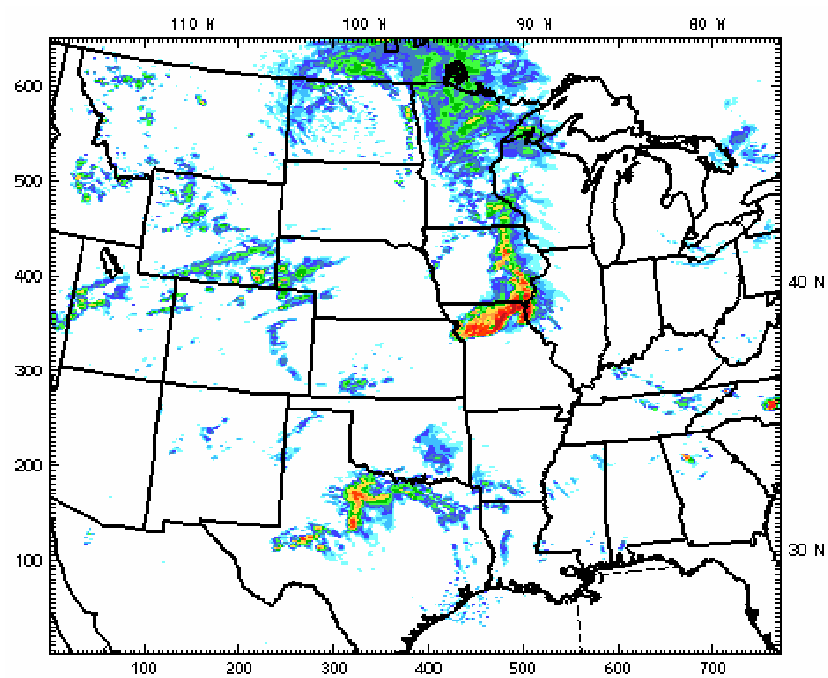
Radar

03 GMT



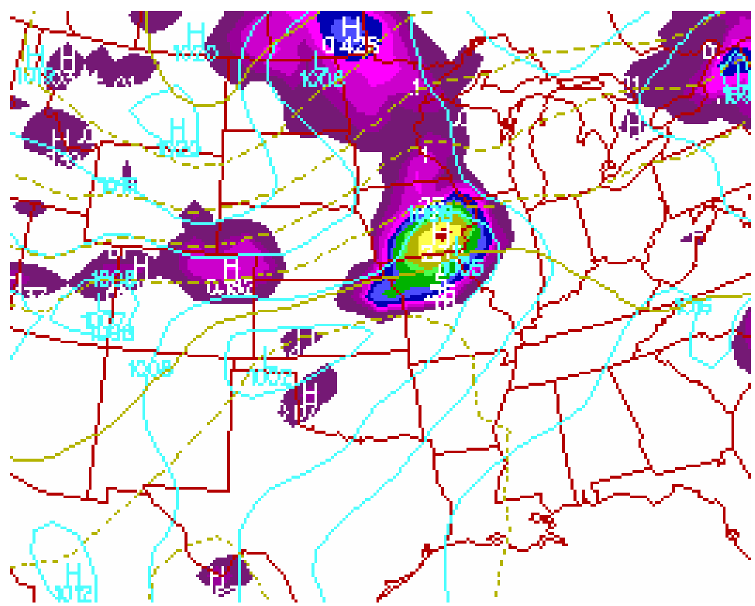
WRF-ARW

03 GMT 27 hr



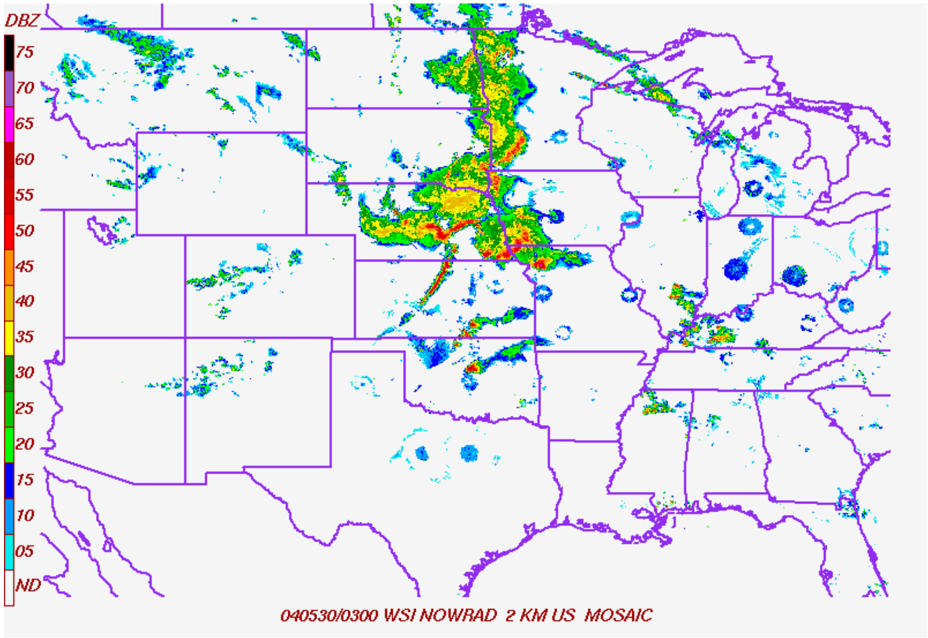
ETA

06 GMT prec. 30 hr



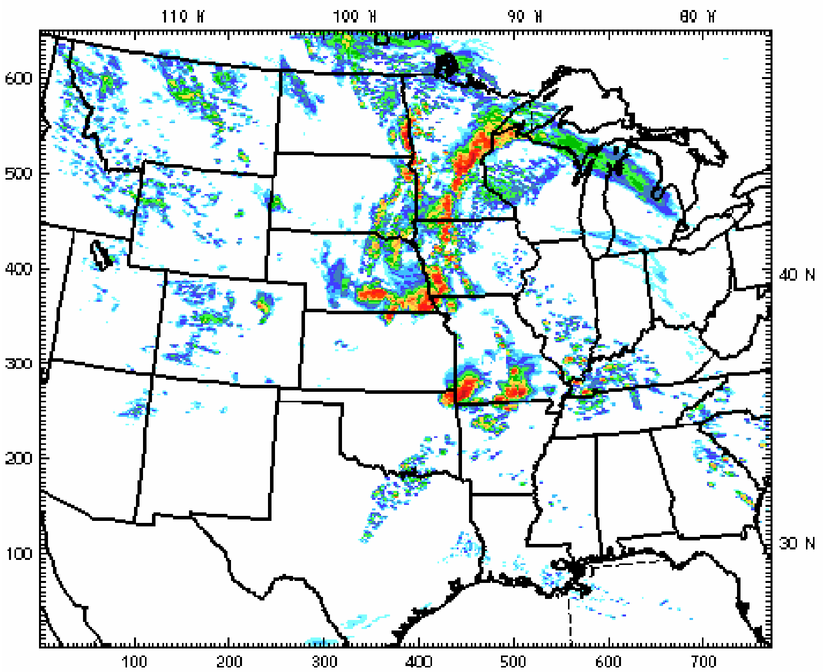
May 30, 2004

Radar
03 GMT



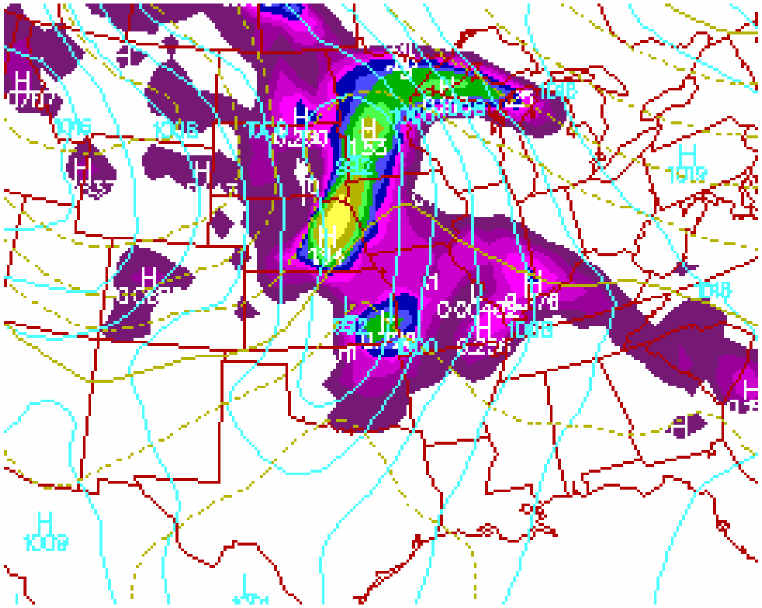
WRF-ARW

03 GMT 27 hr



ETA

06 GMT prec. 30 hr



Introducing: The ``Morris Threat Index''

Considered 24-30 hr Forecast Period:

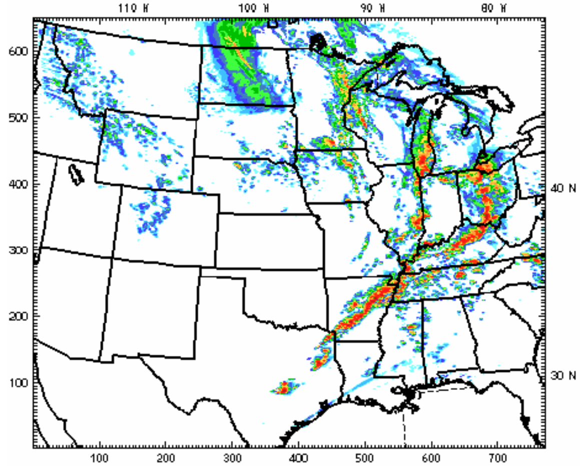
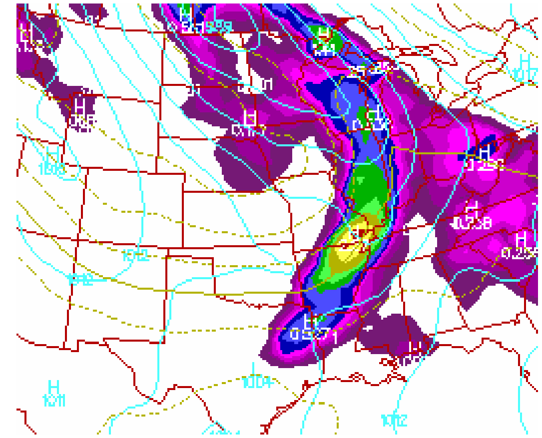
- **Overall Convective Mode/Severity**
- (1) popcorn or no convection (< .25 in)
- (2) organized clusters (.25-1.0 in)
- (3) squall Lines, bow echoes, etc. (> 1 in)

- **Overall Forecast Accuracy**
- (1) no correspondence
- (2) many significant features forecast within ~ 3 h, 300 km
- (3) significant features forecast well

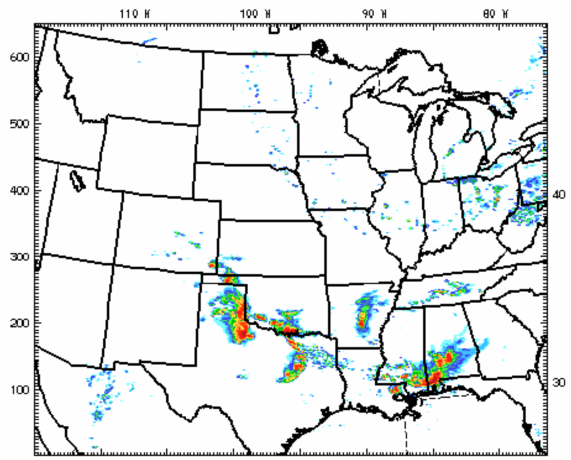
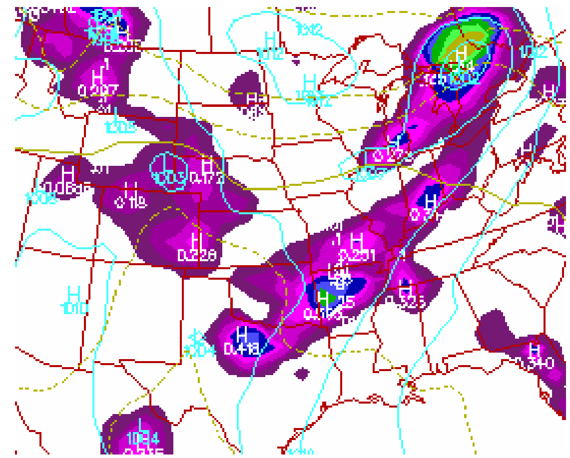
Convective Mode/Intensity

WRF **ETA**

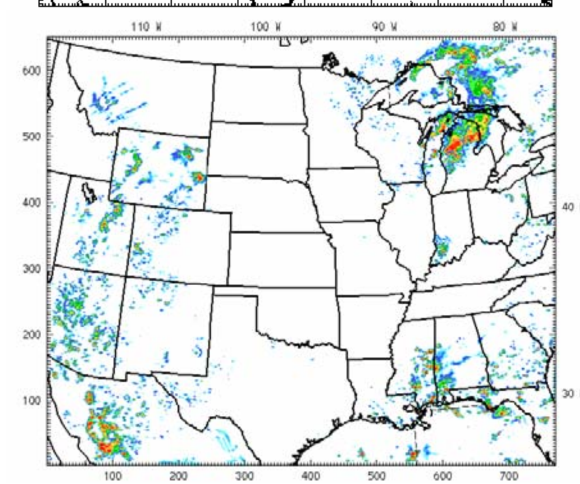
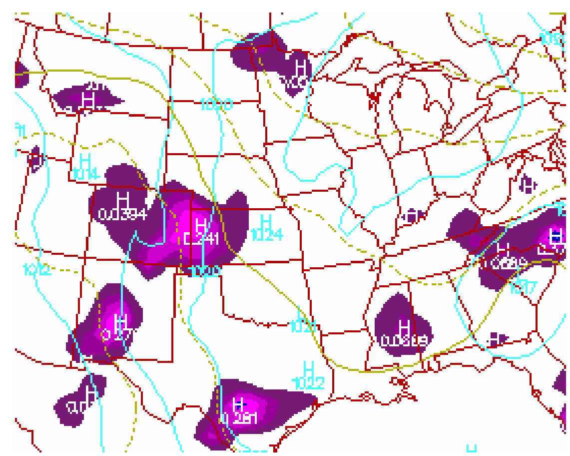
CAT 3: severe, well organized (> 1 in)

CAT 2: some organization (.25-1.0 in)

CAT 1: weak, disorganized (< .25 in)

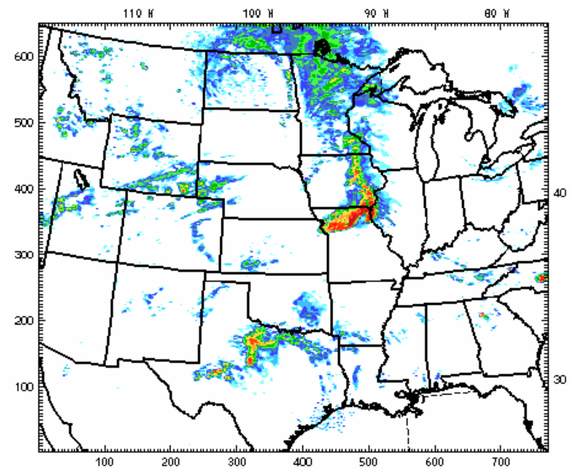
Convective Mode/Intensity			
	3 (severe)	2	1 (weak)
OBS	28	60	49
WRF-ARW	21	73	44
ETA	30	72	31

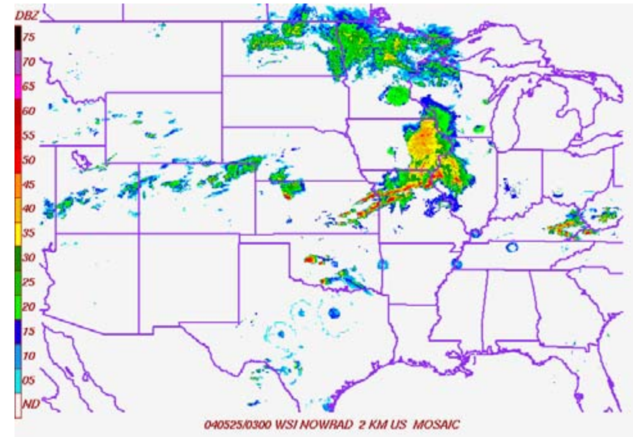
Forecast Mode/Intensity versus OBS				
	weak	under forecast	agree	over forecast
WRF-ARW	28	32	48	30
ETA	23	19	54	36

Overall Forecast

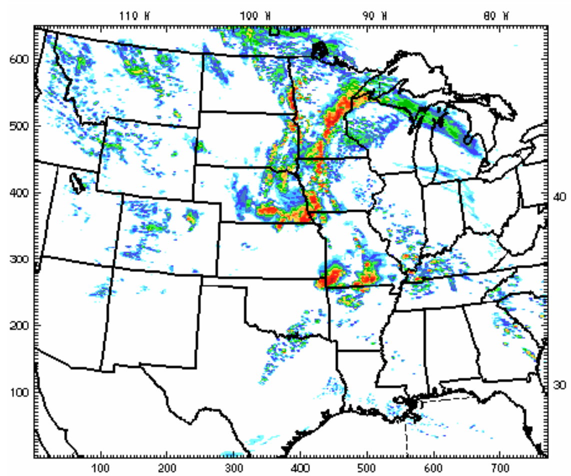
WRF | RADAR

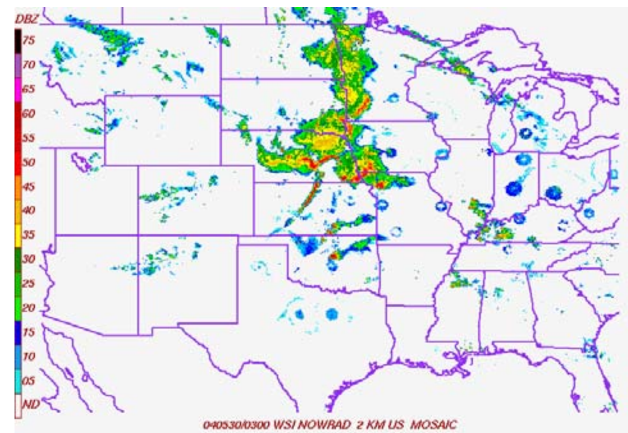
Good:



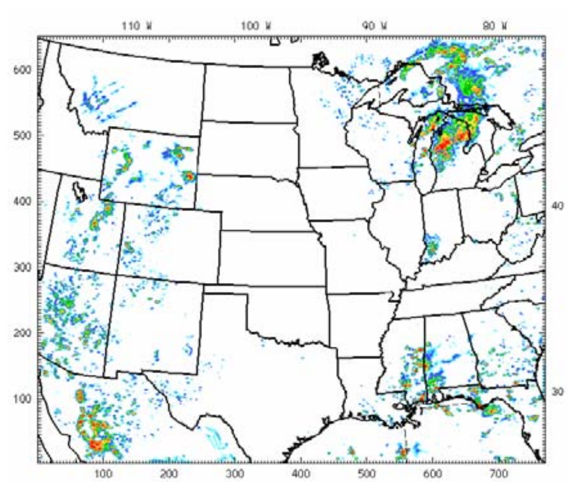


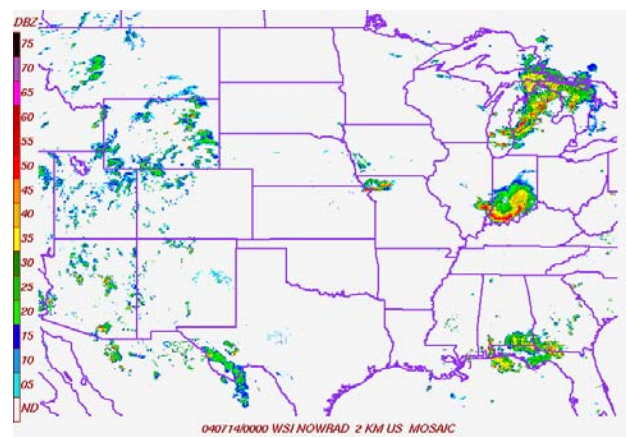
OK:





Bad:





Overall Forecast

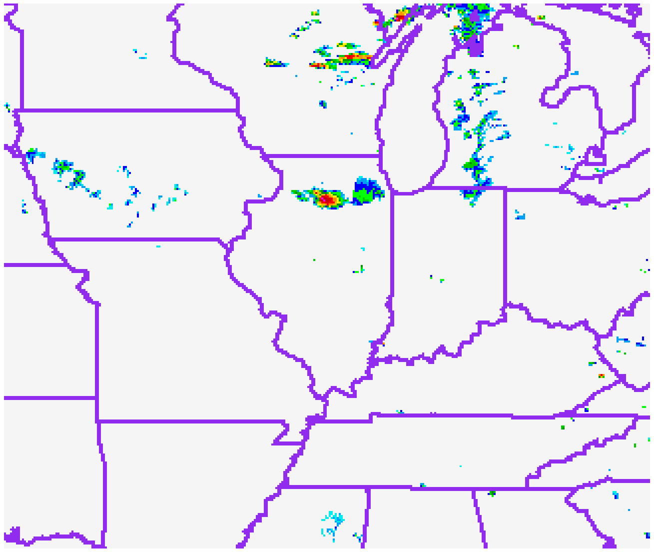
	good	ok	bad
WRF-ARW	**43**	**73**	**22**
ETA	**42**	**76**	**14**

WRF - ARW versus ETA

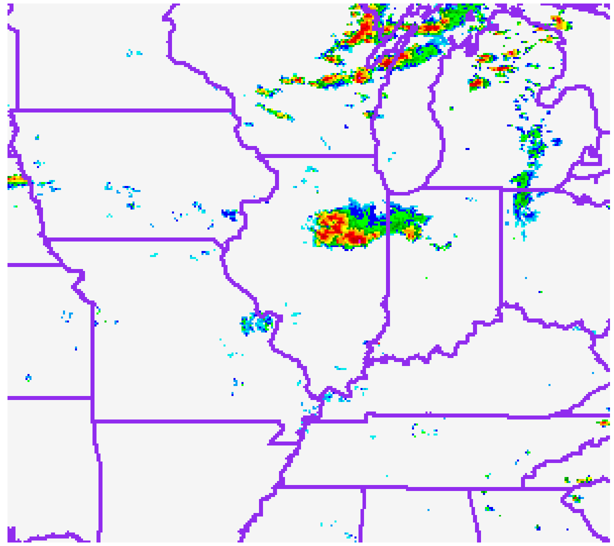
better	agree	worse
27	**72**	**32**

Failure Modes: 13 July 2004

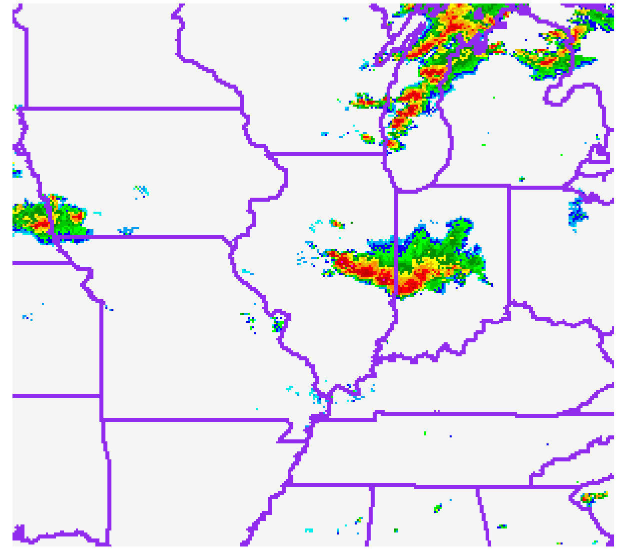
18 GMT



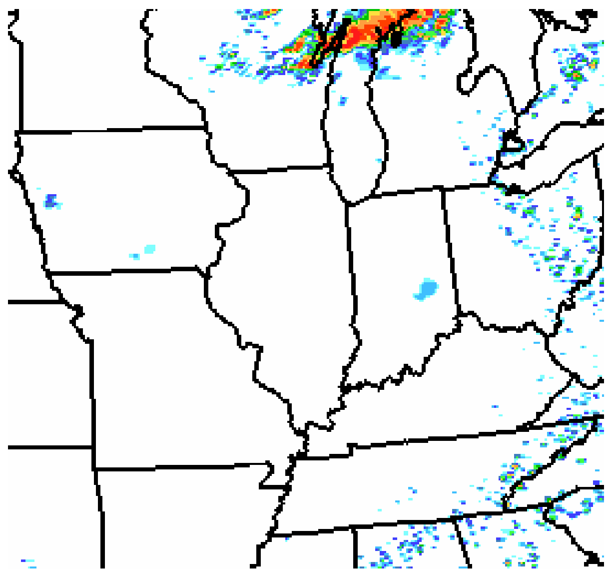
20 GMT



22 GMT

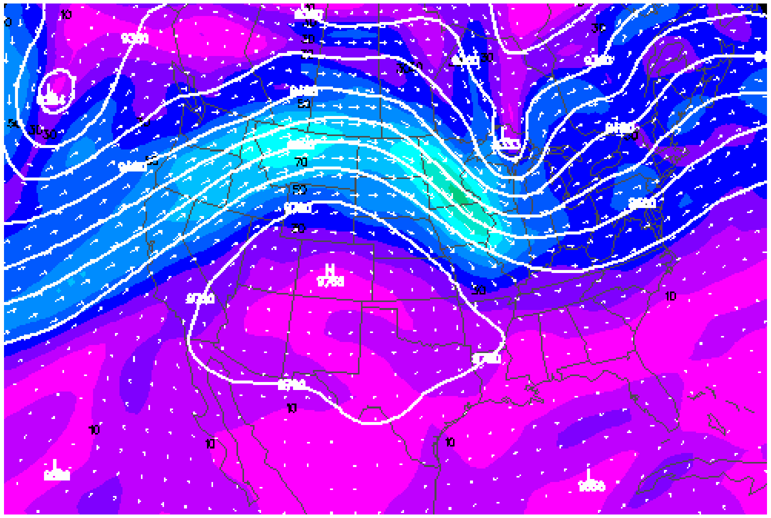


WRF 21 h

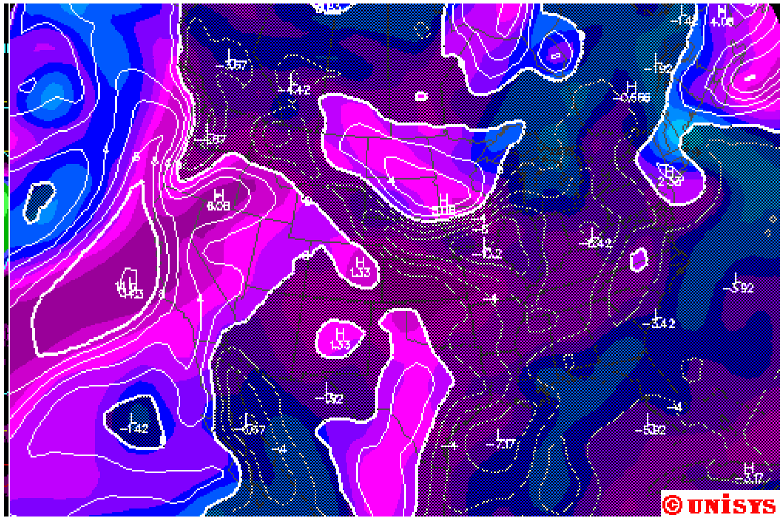


Failure Modes: 13 July 2004

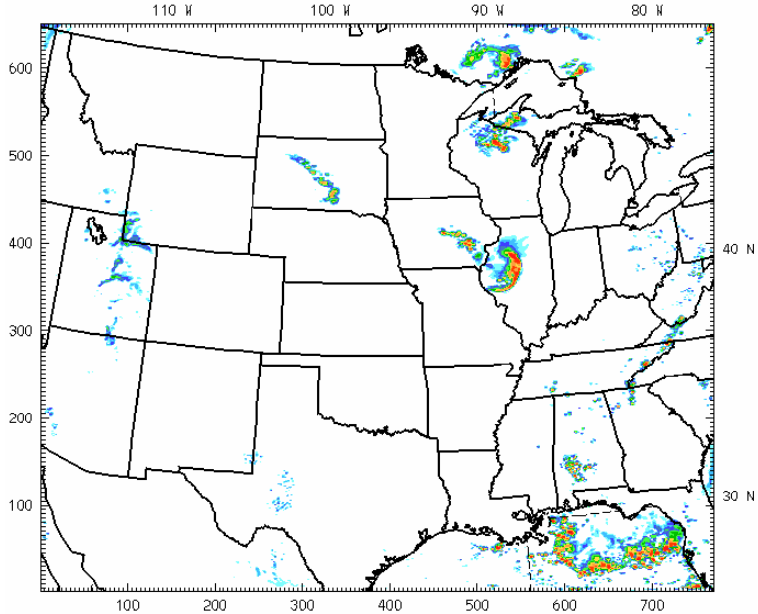
ETA   24 h   300 mb



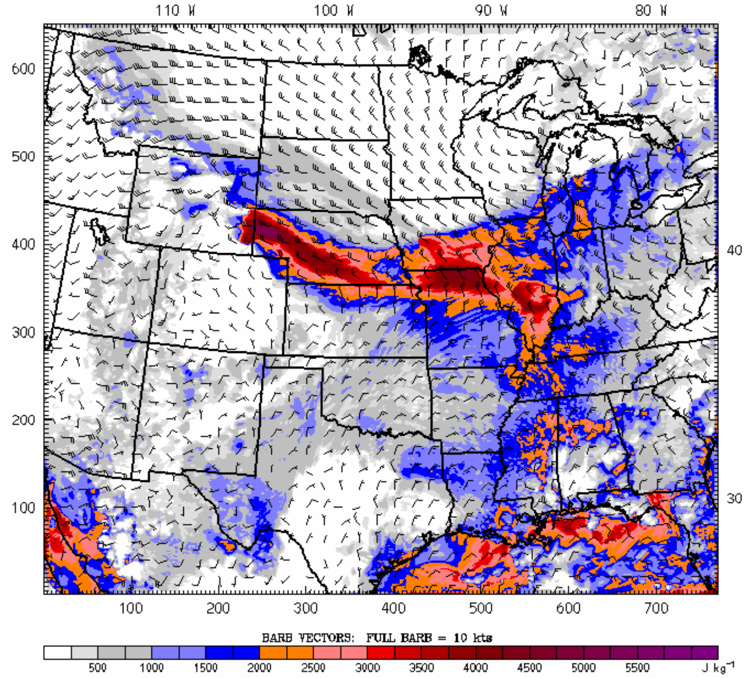
ETA   24 h   LI



WRF 15 h REF



WRF 24 h CAPE

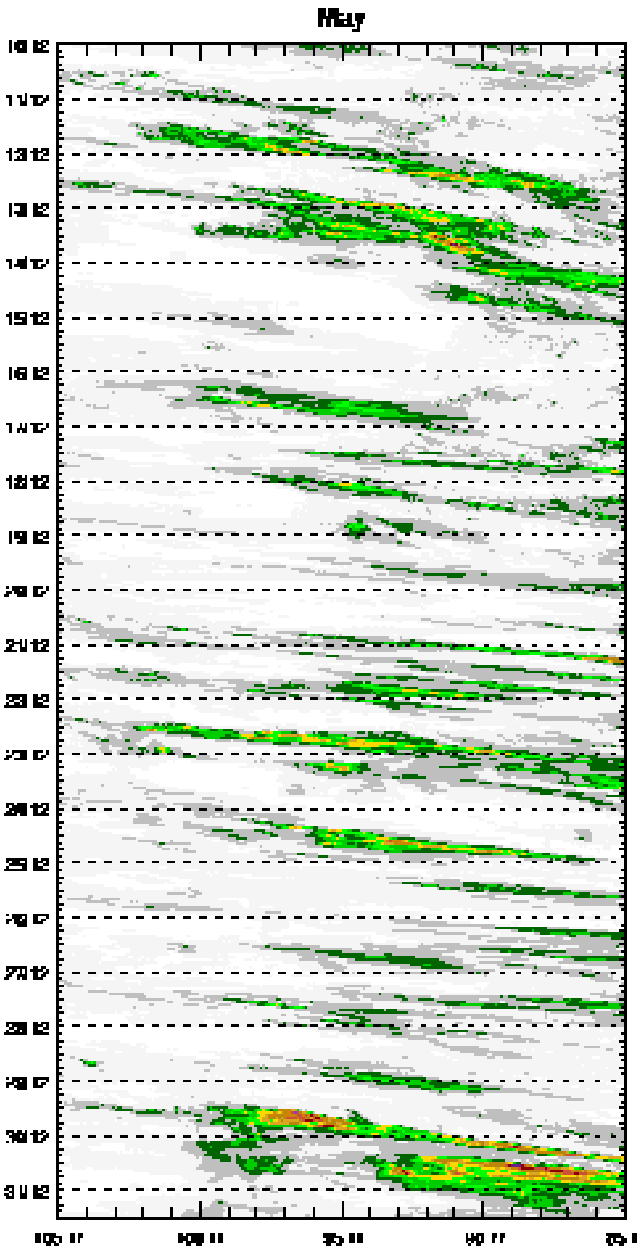


How well does 4-km WRF represent the climatological behavior of convection?

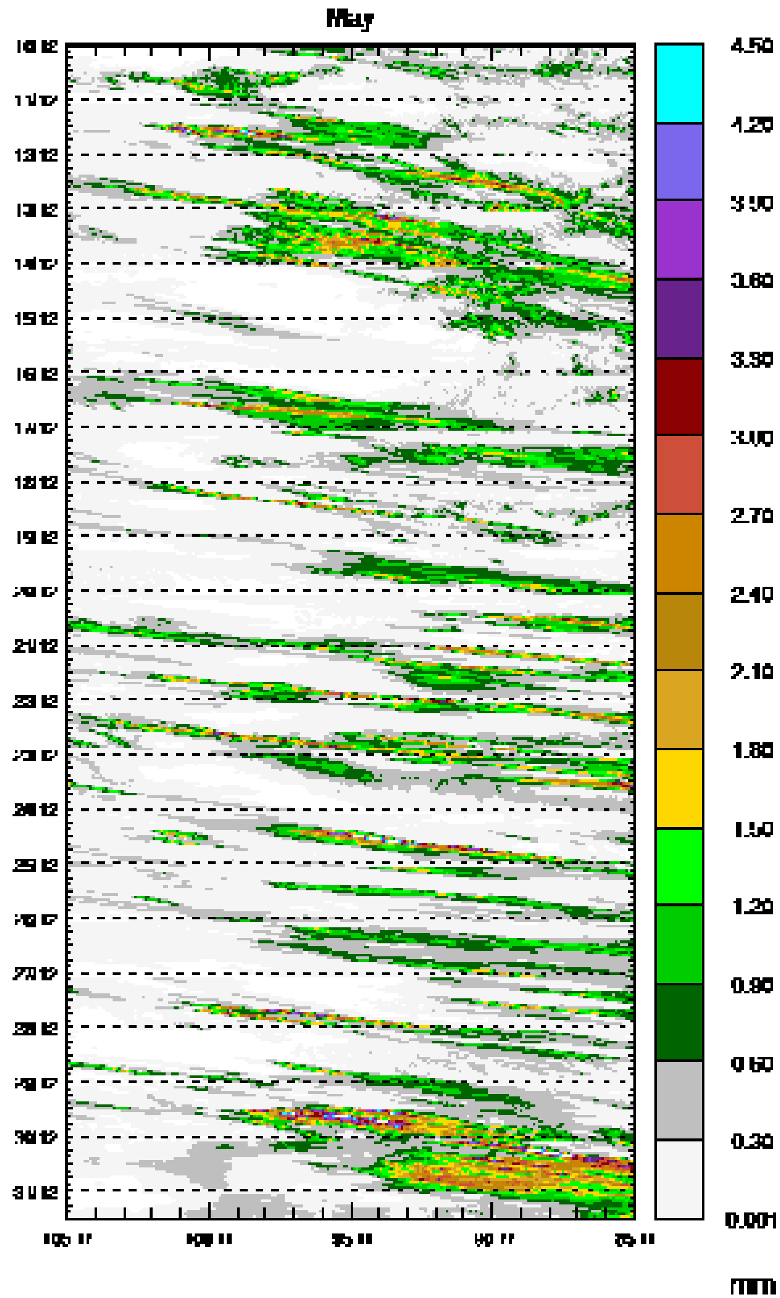
(e.g., diurnal cycle, episodes)

Longitudinal 1 hr Precip. May 10-31, 2004

Stage IV

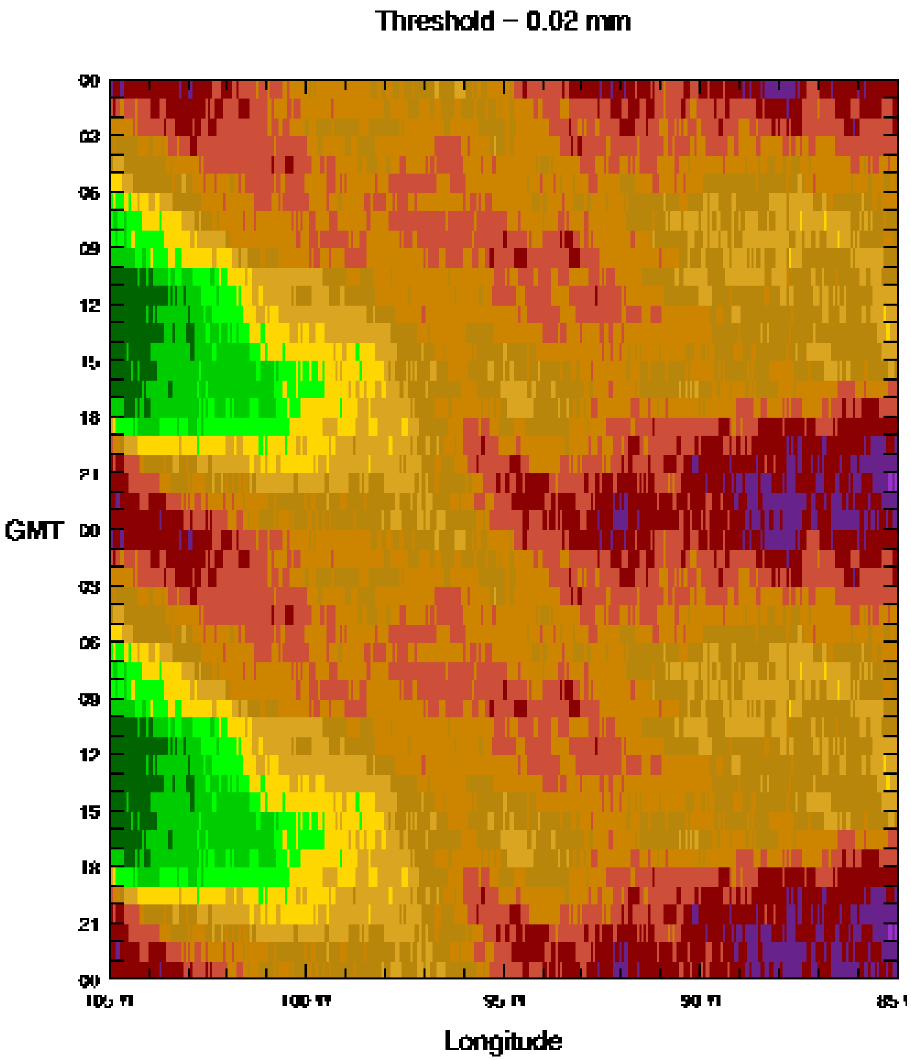


WRF

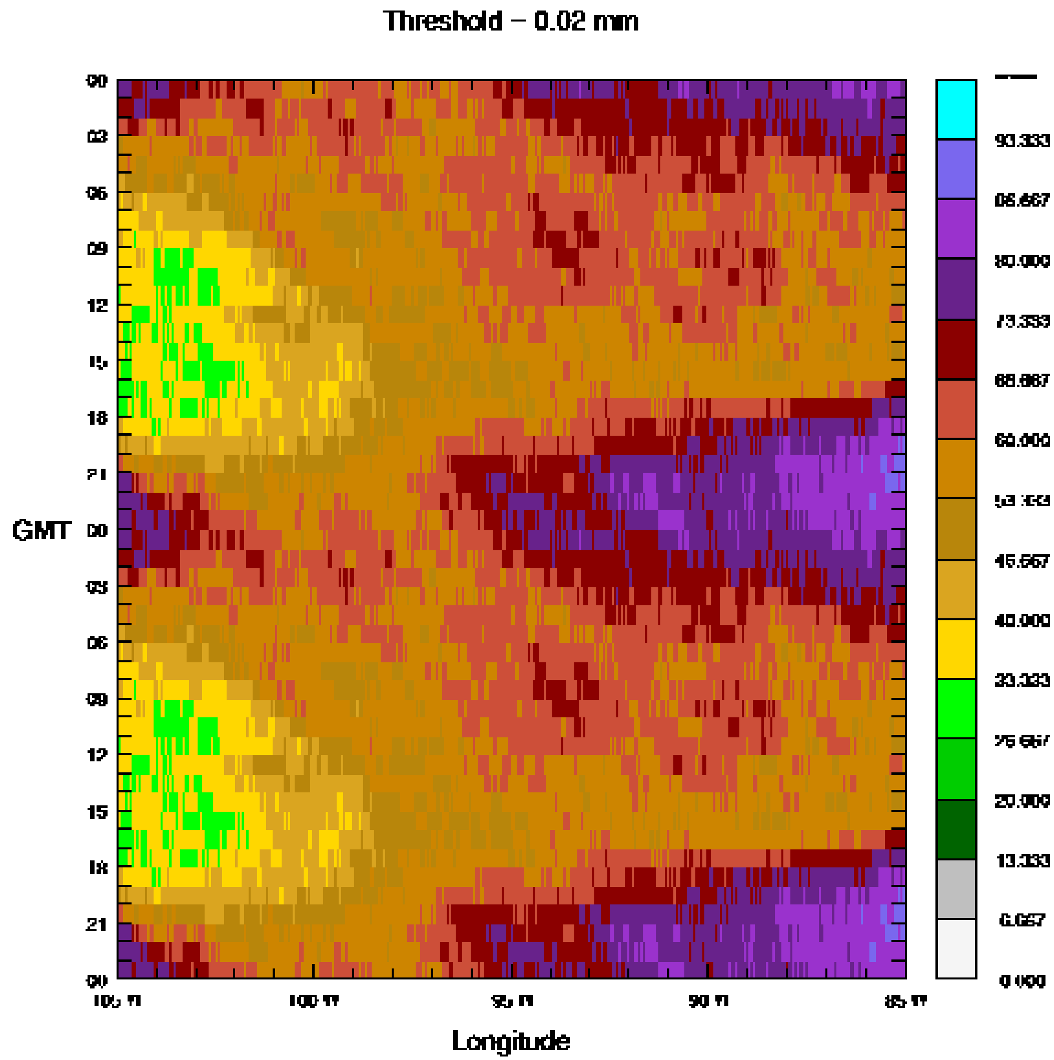


Diurnal Average Frequency: 2004

Stage IV

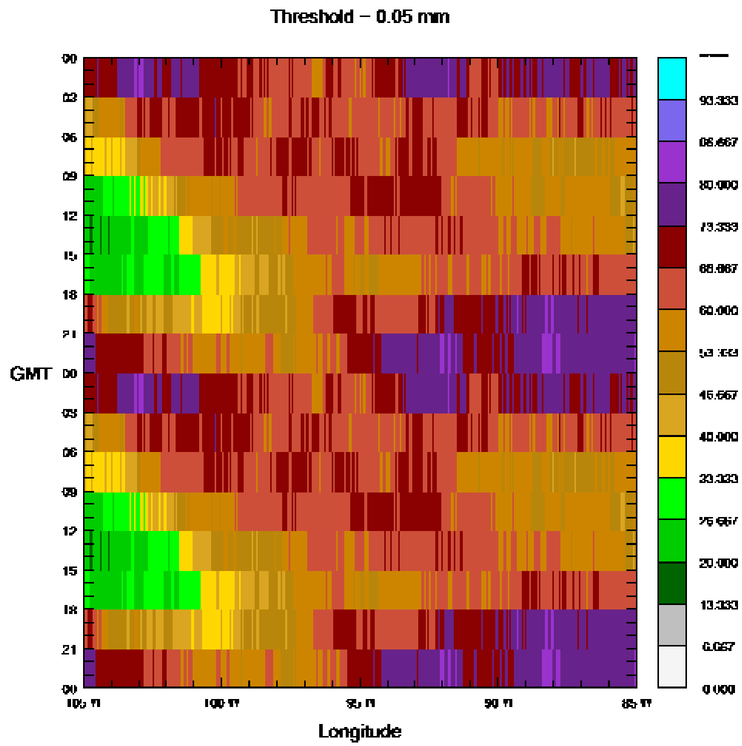


4 km WRF

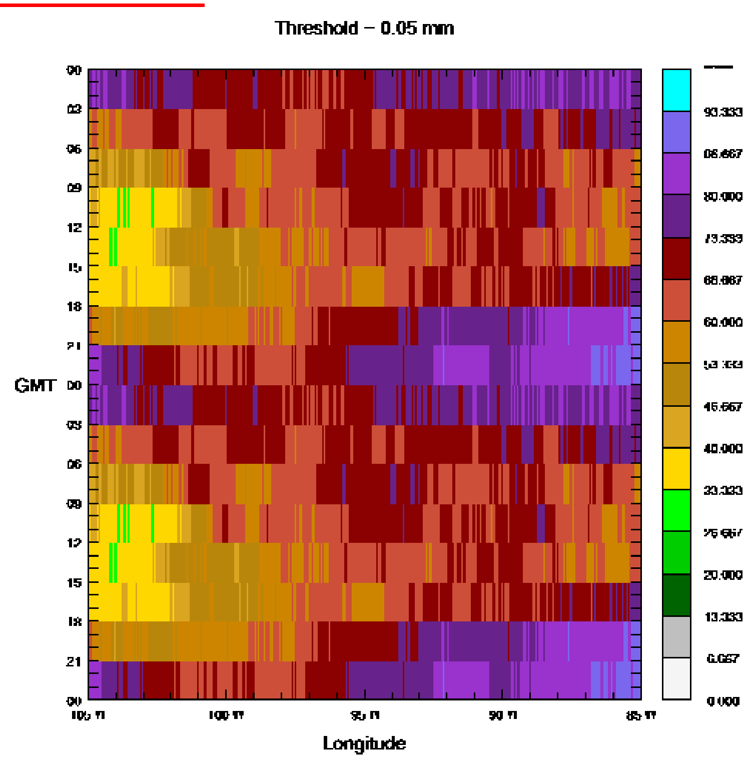


Diurnal Average 3 hr Precip.

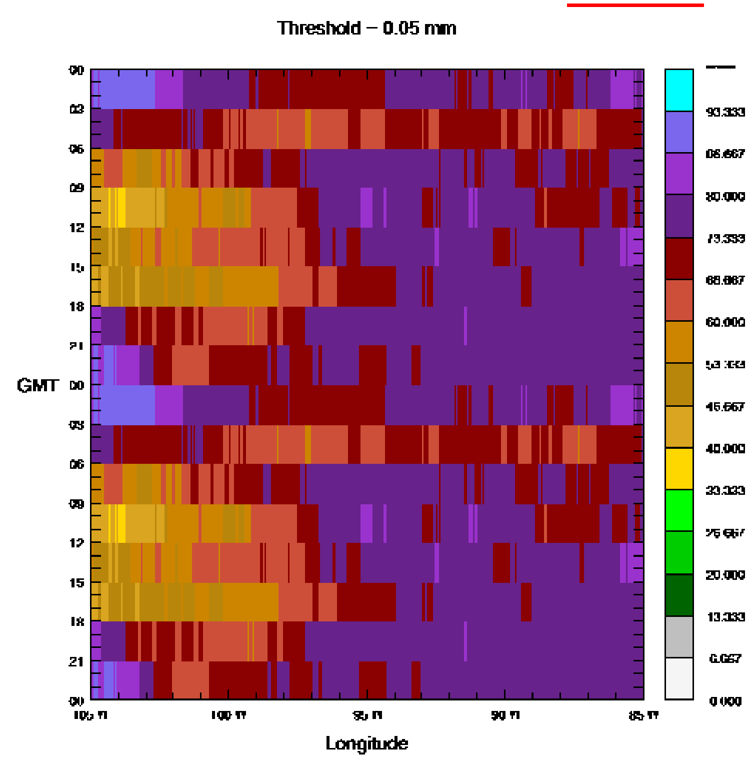
Stage IV



4 km WRF



ETA



Summary

Considering a 24-30 hr forecast:

- 4-km WRF strongly controlled by resolved ETA forcing…. Thus, WRF and ETA offer similar overall guidance as to intensity, timing, and location of significant convection
- 4-km WRF adds valuable information as to MCS mode and propagation (e.g., squall lines, bow echoes, MCVs)
- 4-km WRF more accurately represents diurnal cycle and convective episodes
- Need more investigation of failure modes

WRF-ARW 2005 real-time forecasts can be found at:

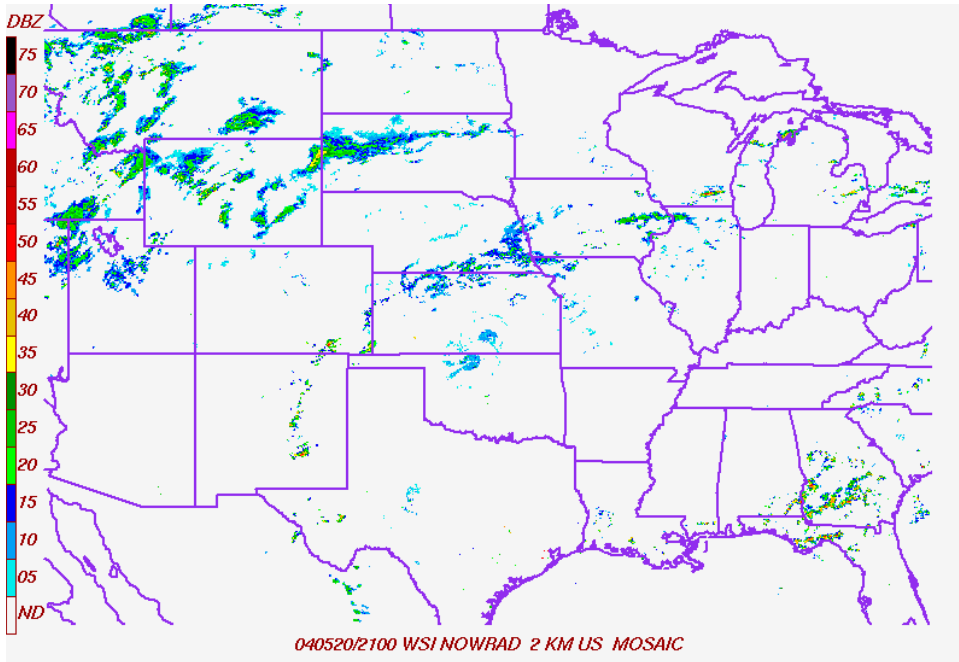
http://box.mmm.ucar.edu/projects/wrf_spring/

http://rain.mmm.ucar.edu/mm5/

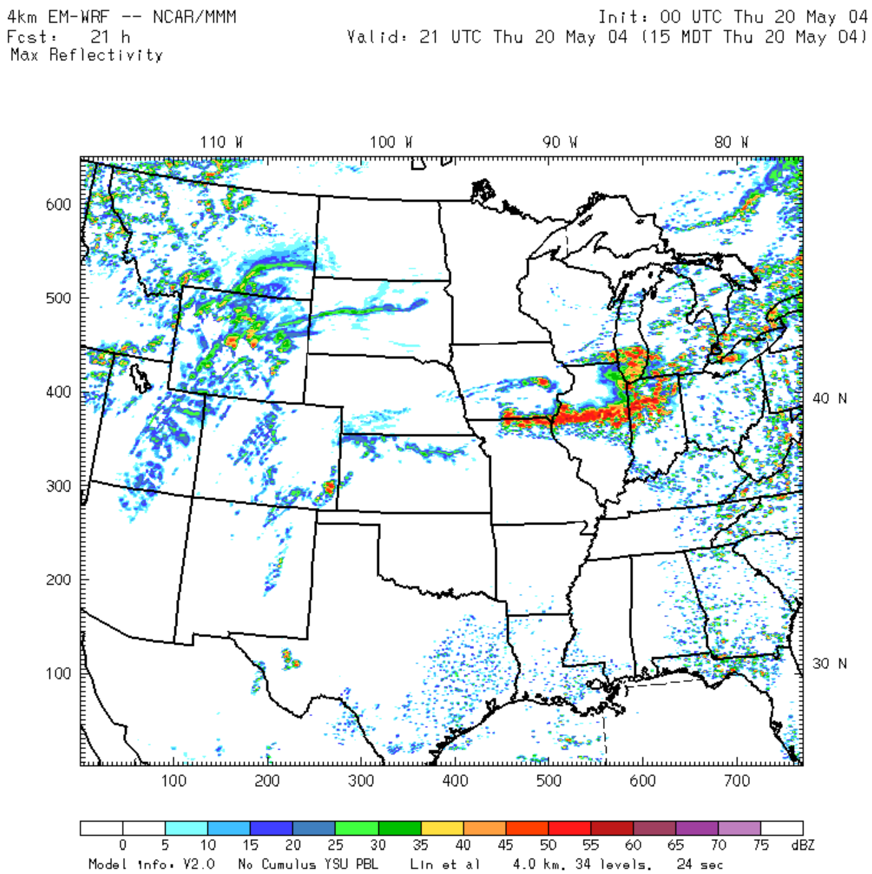
Also archived at:

http://www.joss.ucar.edu/wrf-2004/catalog/
http://www.joss.ucar.edu/wrf-2005/catalog/

May 20 21 UTC



No Diffusion



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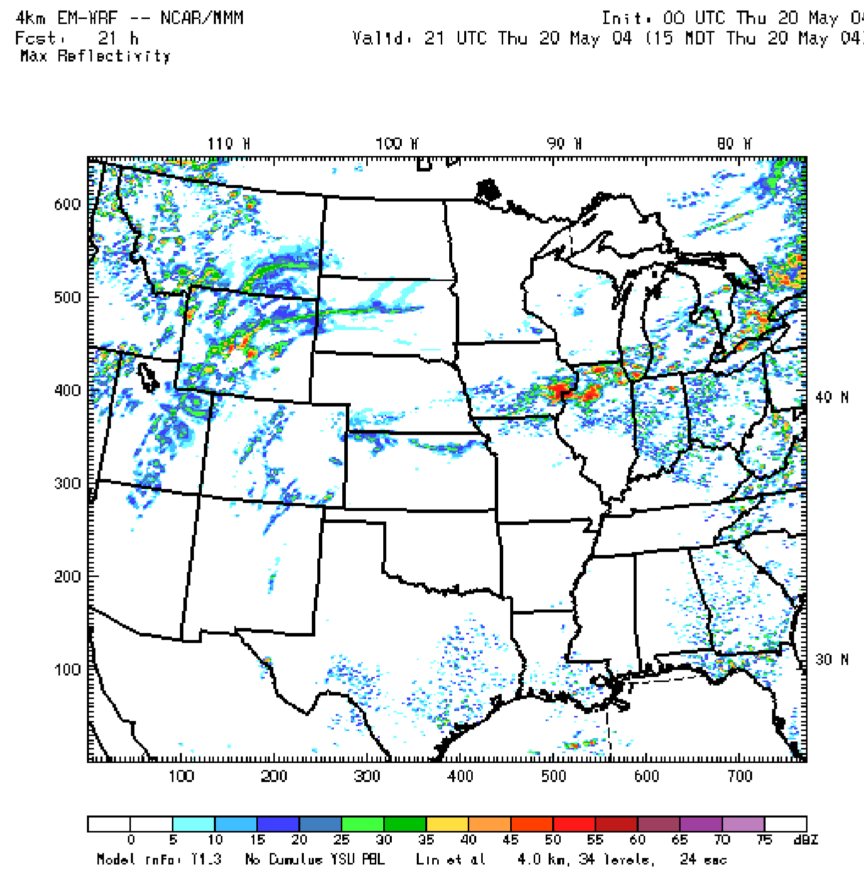
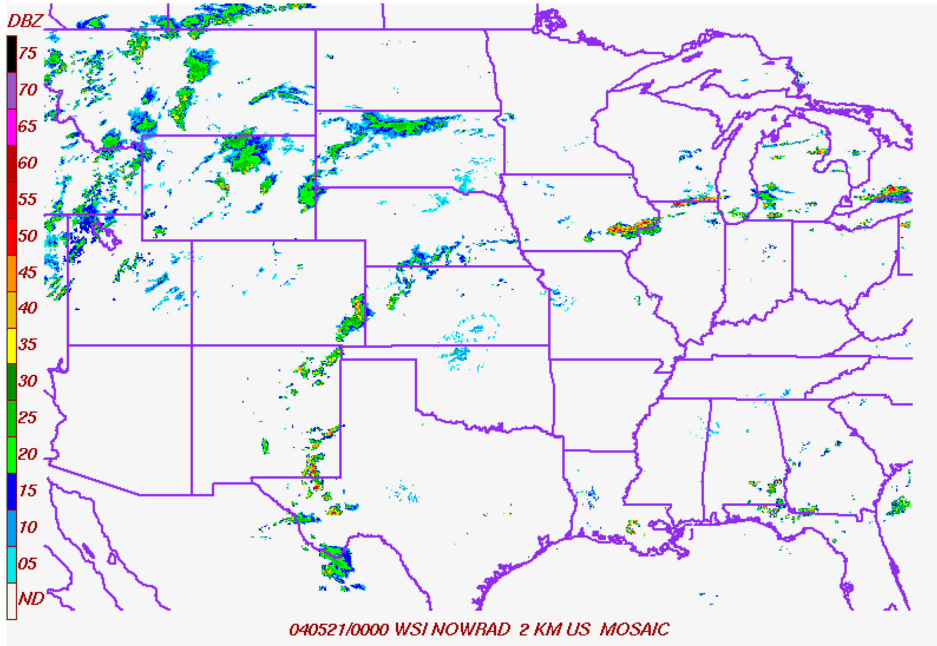
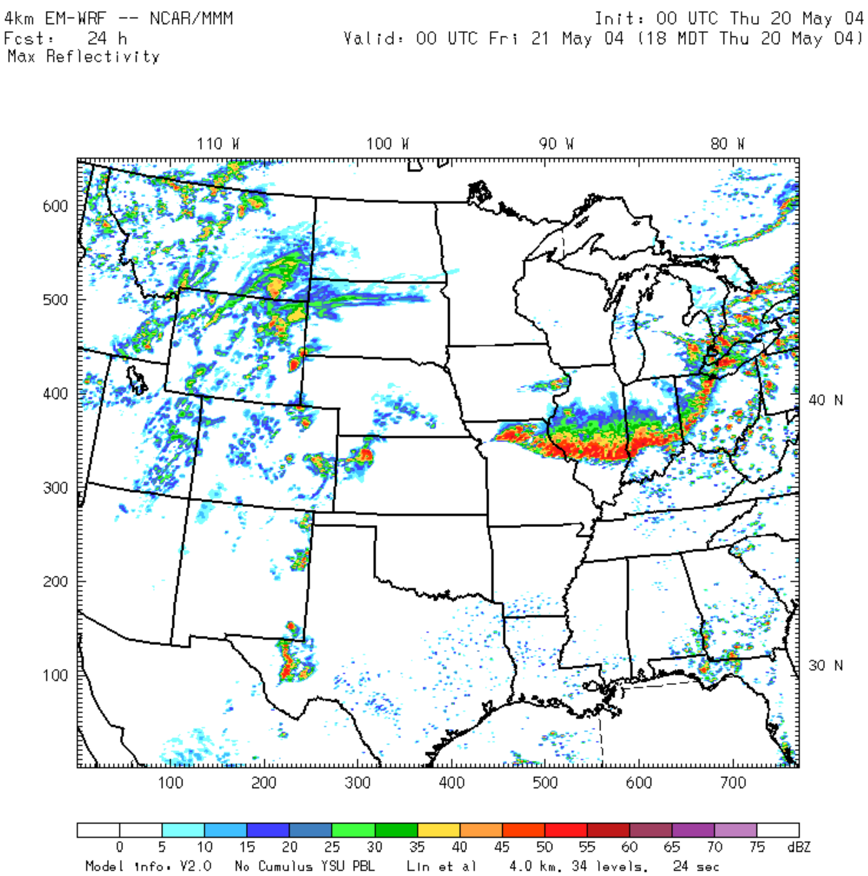


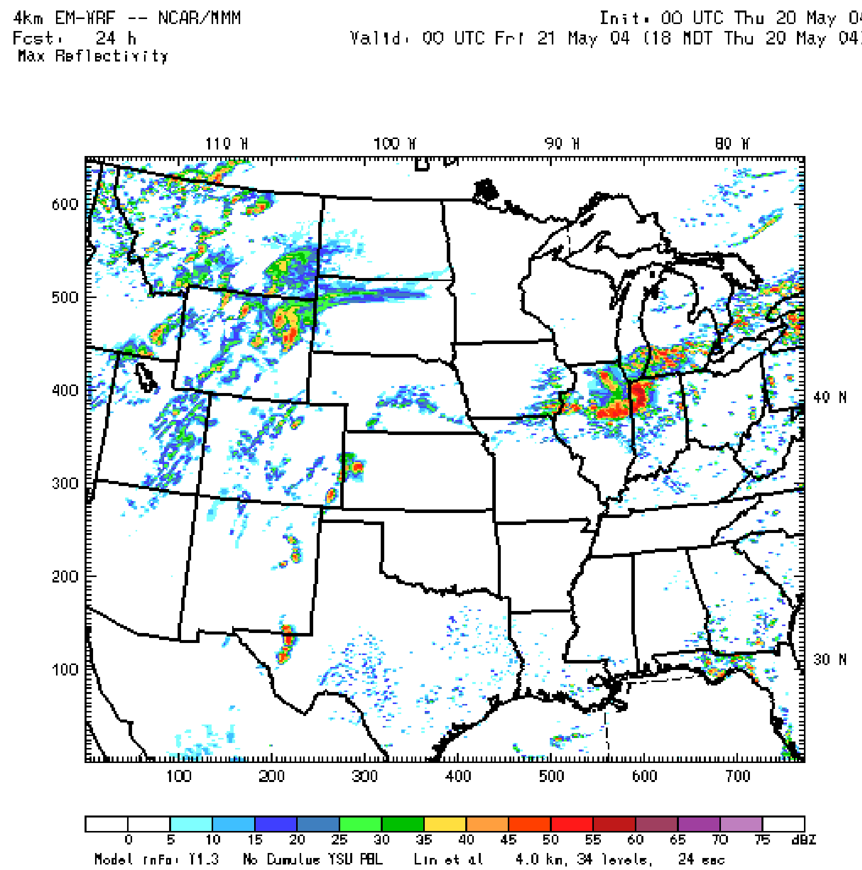
May 21 00 UTC



No Diffusion

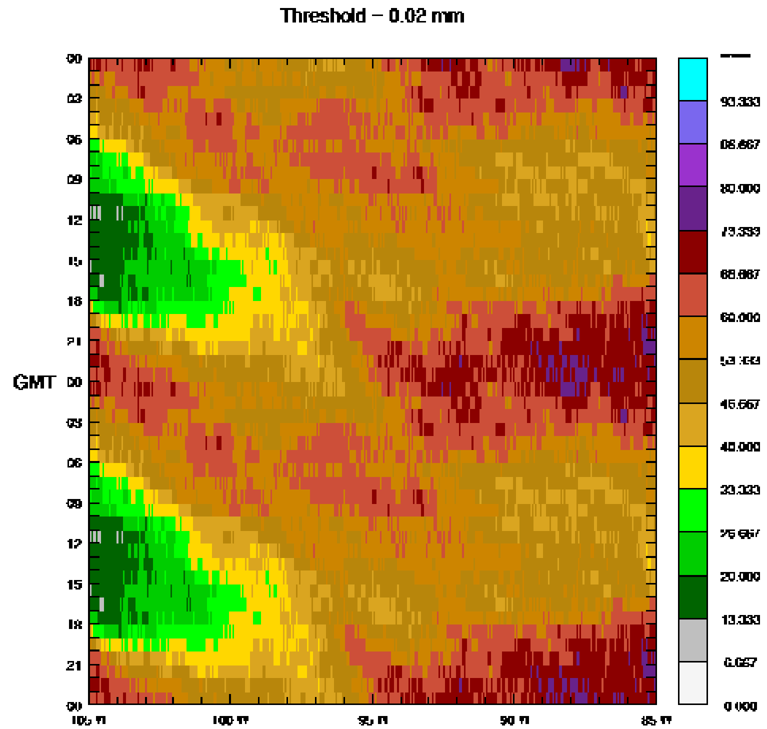
Diffusion





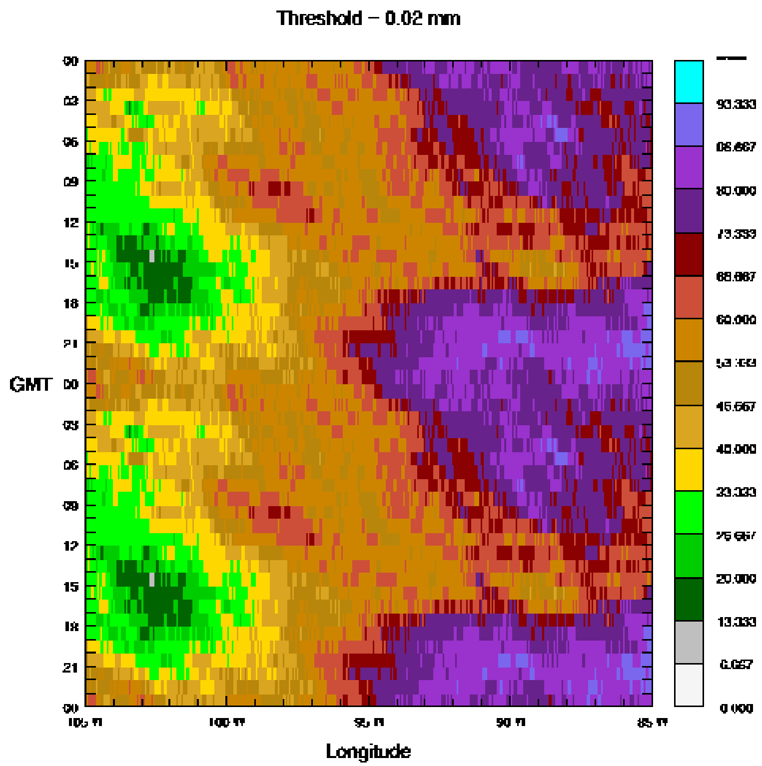
Diurnal Averages

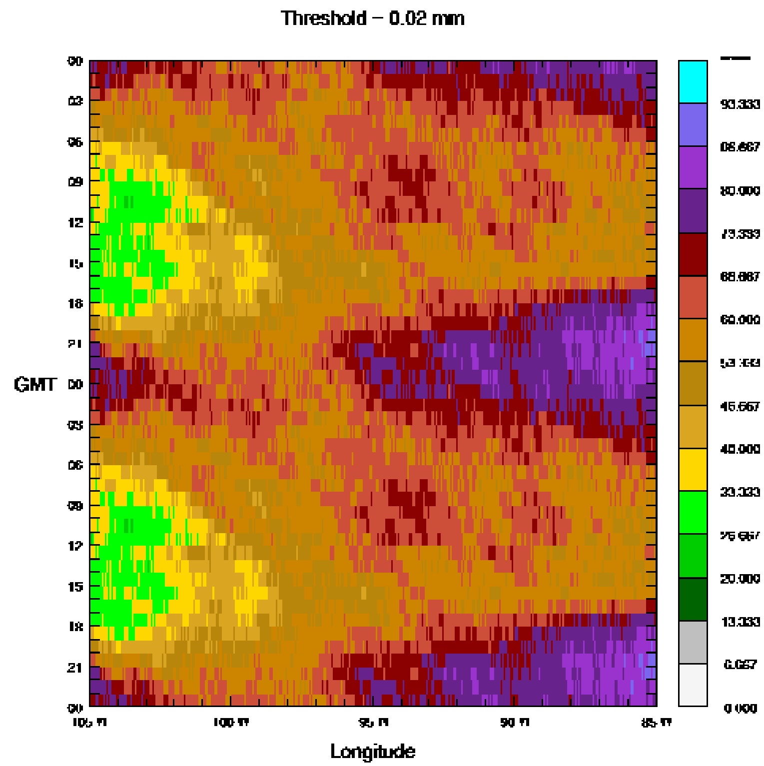
ST4



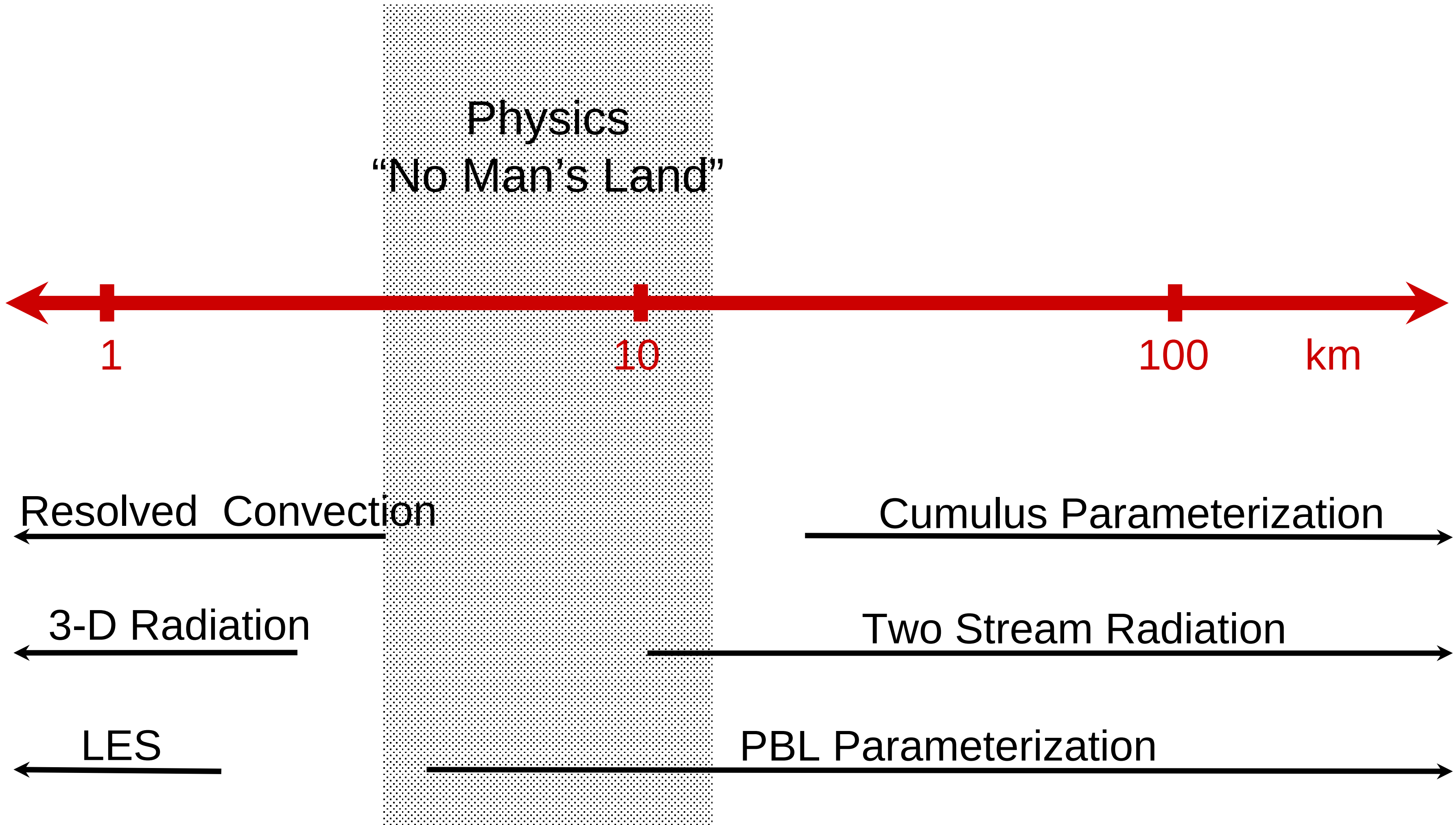
No diffusion

Diffusion





Model Physics in High Resolution NWP



Progress

4 km WRF simulations exhibit:

- A surprising ability to forecast mesoscale convective systems (MCS) out to 36 h
- A demonstrated skill at depicting MCS mode (bow echoes, mesoscale convective vortices, supercell lines)
- An ability to spin-up convective systems within 3-4 h from a cold start.
- Significant improvement in forecast guidance over convective parameterization??

Challenge:

- QPF problematic (too much convective precip)
- Stratiform regions appear too small (microphysics?)
- Convective systems often fail to decay (BL evolution?)
- Initialization (data assimilation)
- Verification methods

For Convective Mode 3 (severe)

WRF-ARW

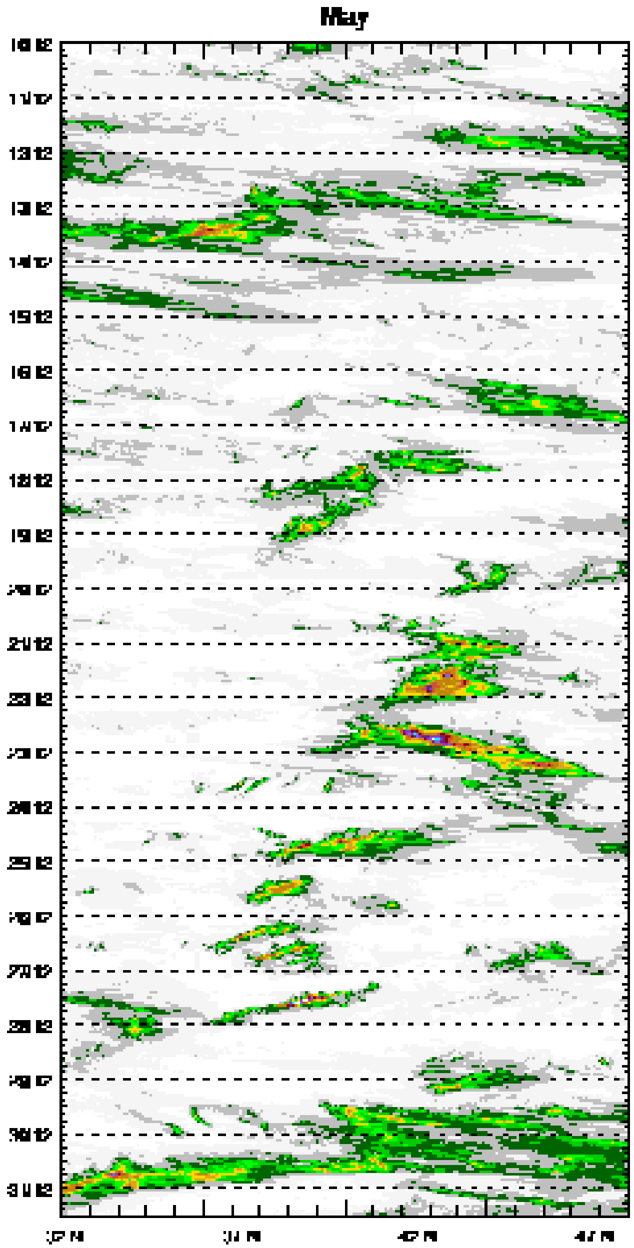
	OBS YES	OBS NO	
YES	**11**	**10**	POD = .39
			FAR = .48
NO	**17**		CSI = .29

ETA

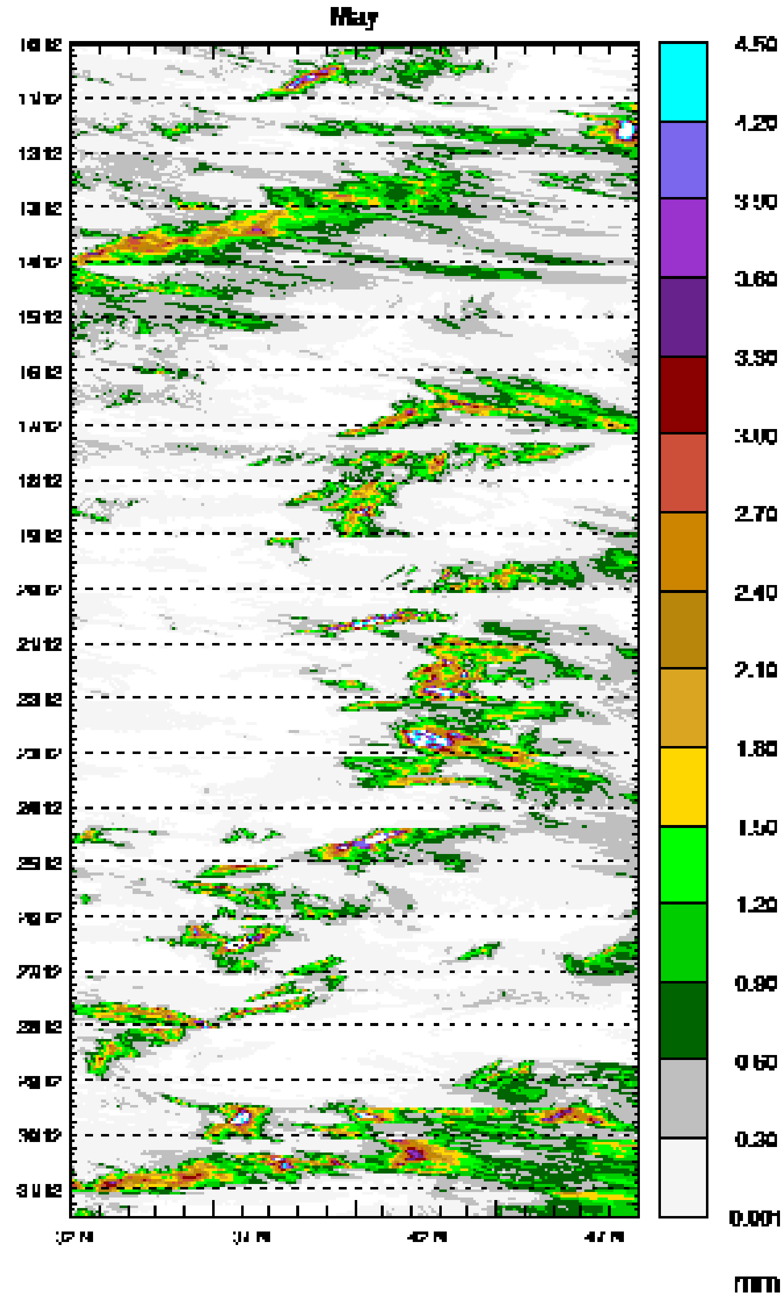
	OBS YES	OBS NO	
YES	**16**	**14**	POD = .57
			FAR = .47
NO	**12**		CSI = .38

Latitudinal 1 hr Precip. May 10-31, 2004

Stage IV

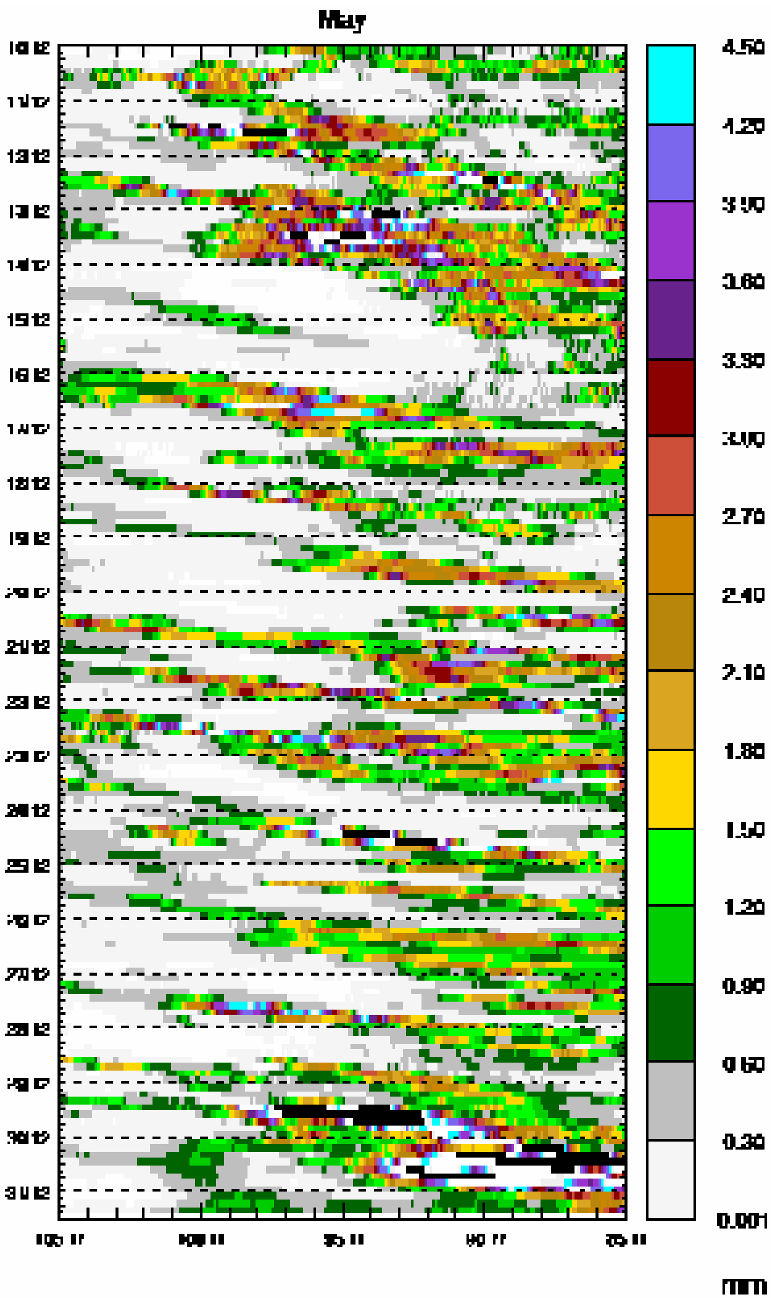


WRF

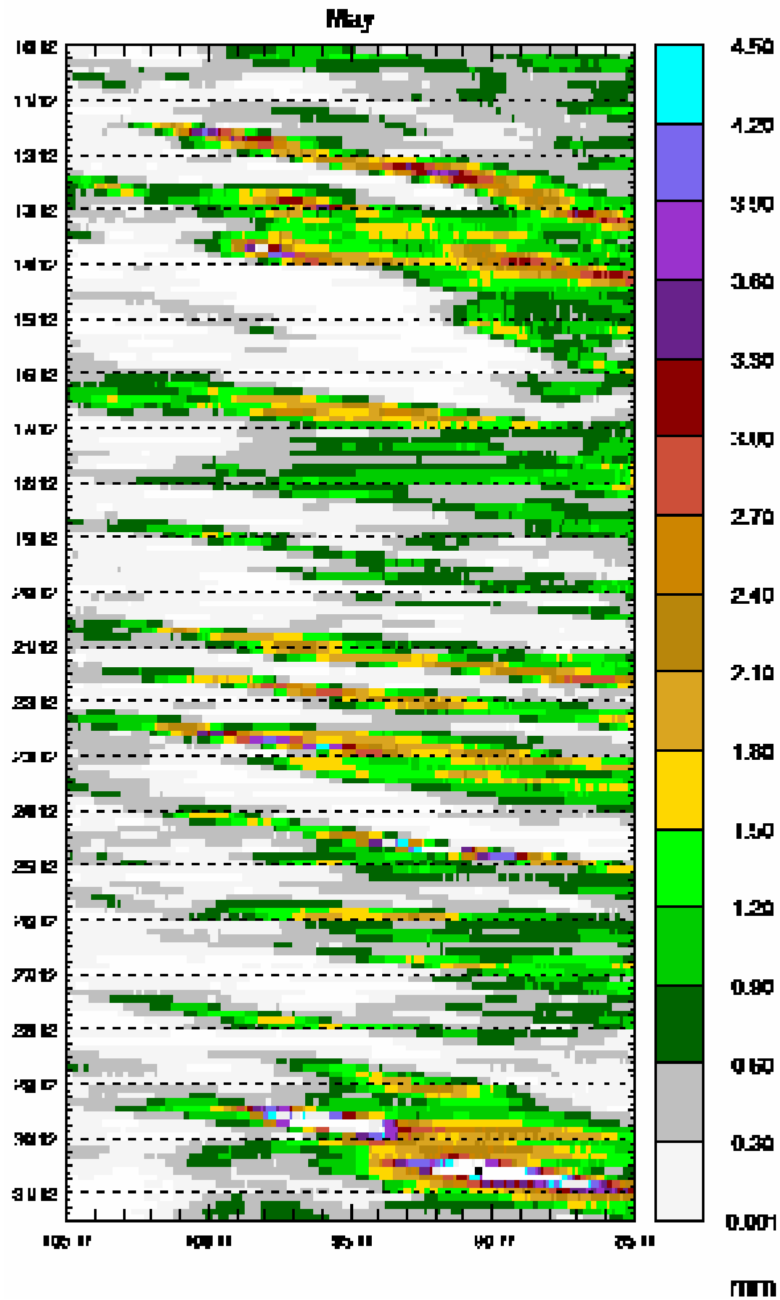


Longitudinal 3 hr Precip. May 10-31, 2004

WRF



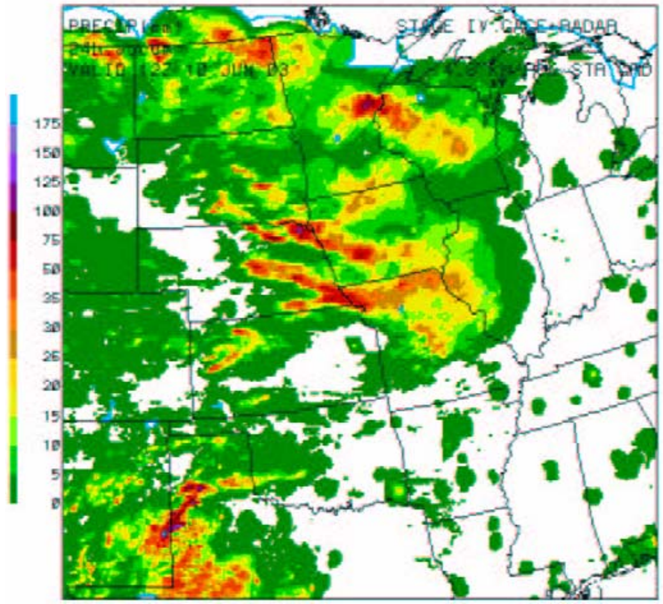
ETA



How About QPF?

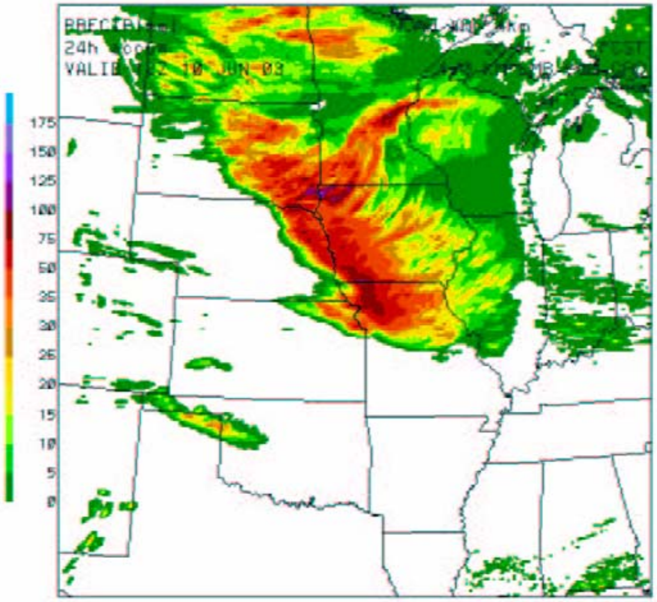
24 hr precipitation verification

OBS

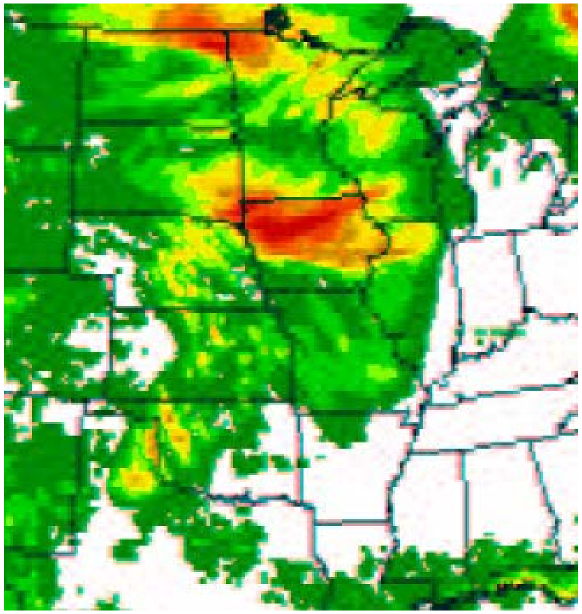


Valid 6/10/03 12 UTC

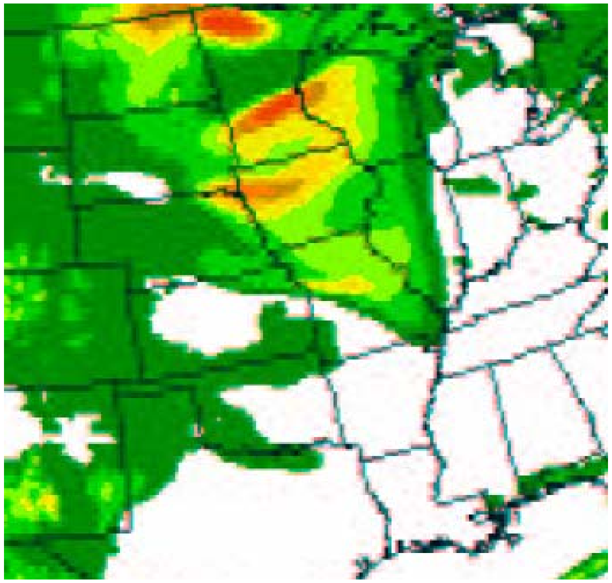
4 km WRF



10 km WRF



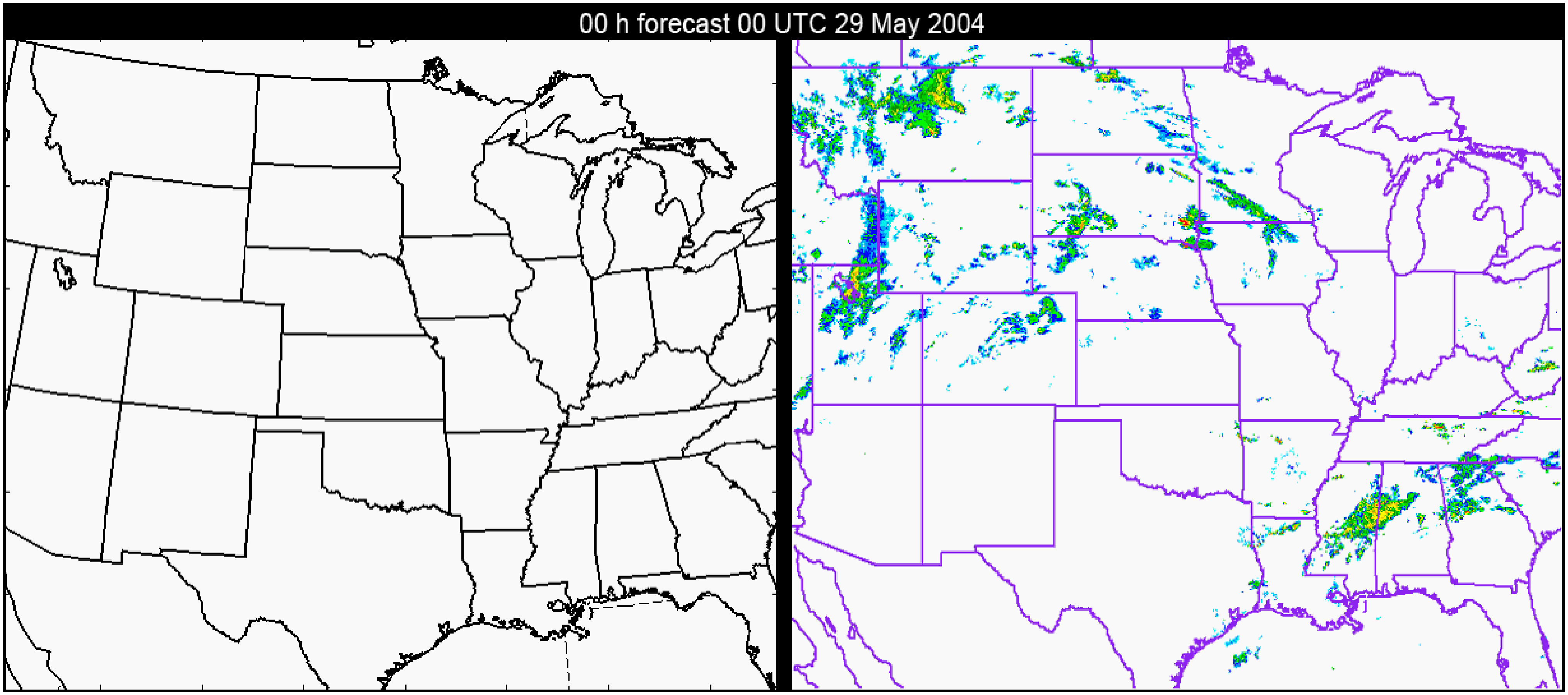
12 km ETA



29 May 2004 00 UTC

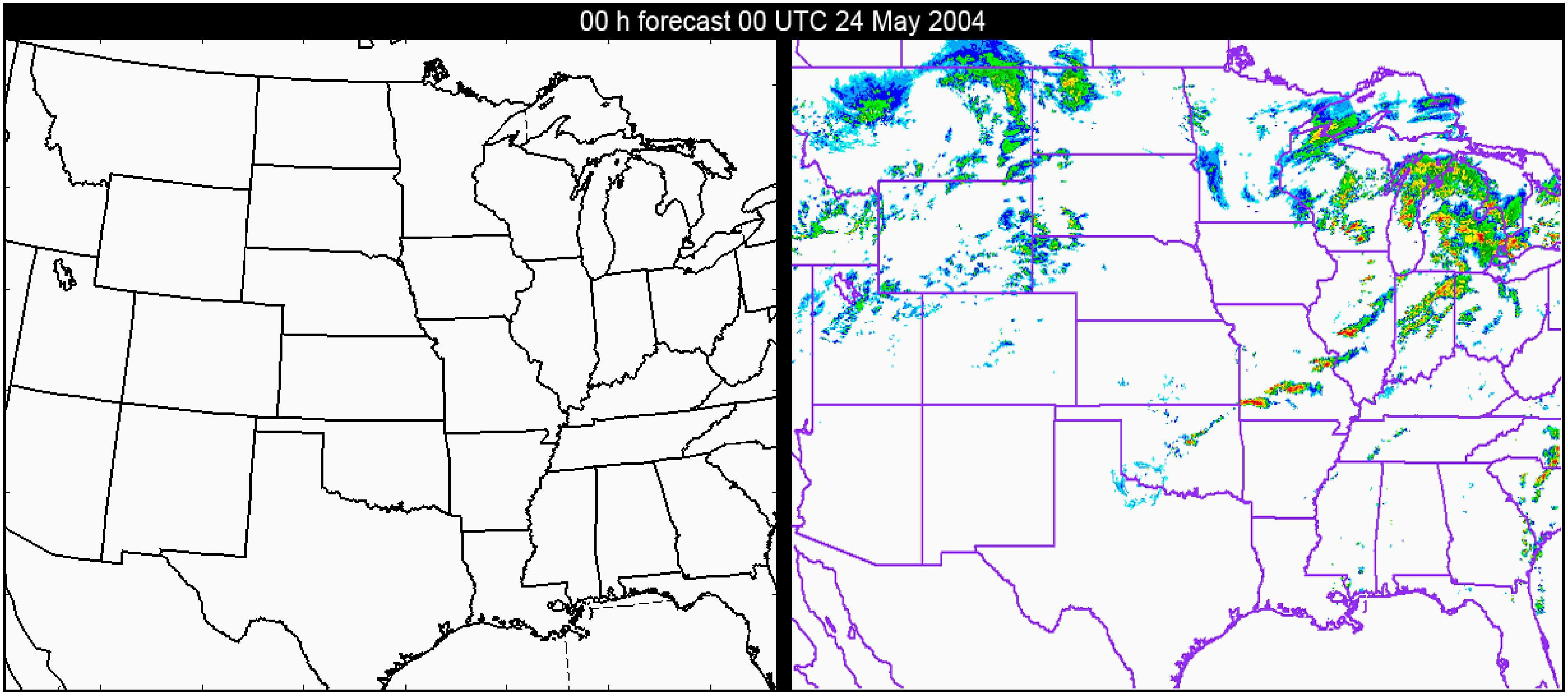
4-km WRF

Radar



24 May 2004 00 UTC

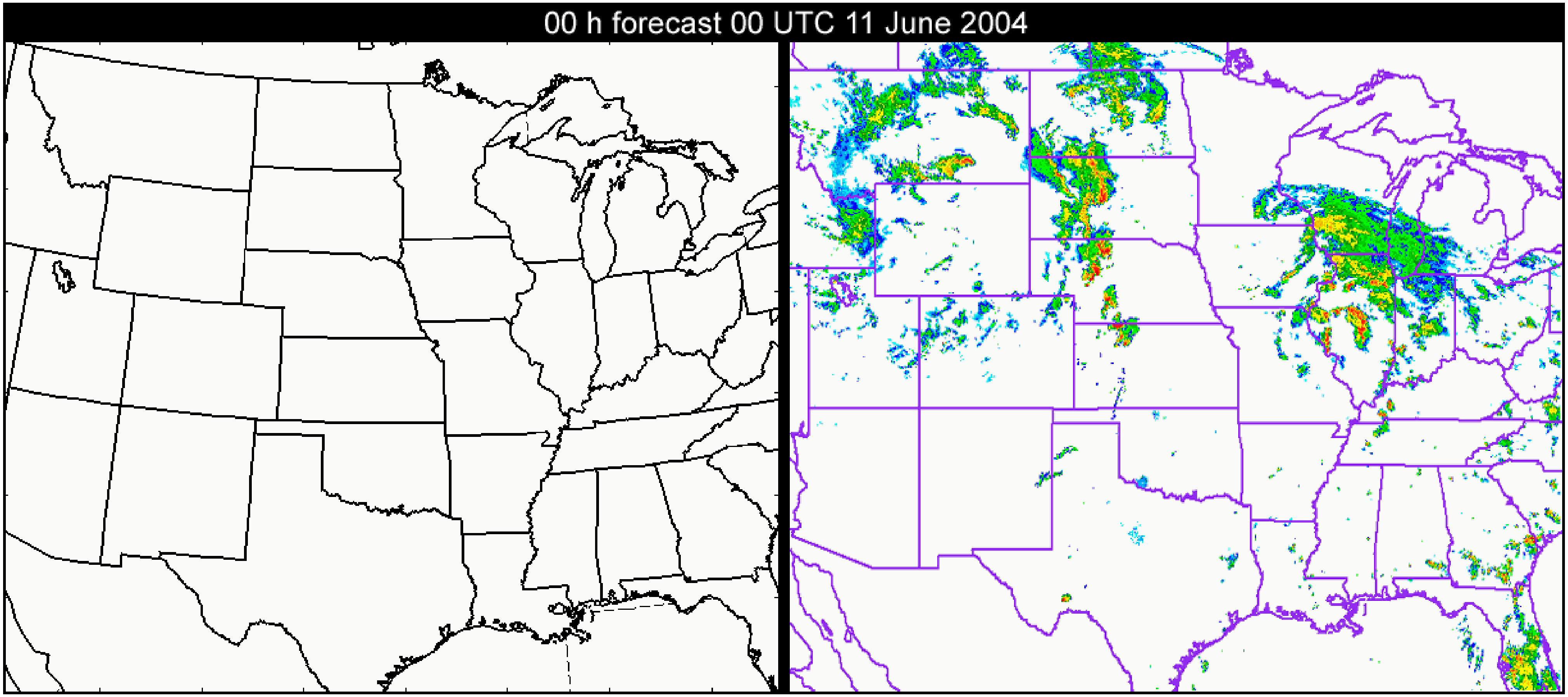
4-km WRF **Radar**



11 June 2004 00 UTC

4-km WRF

Radar

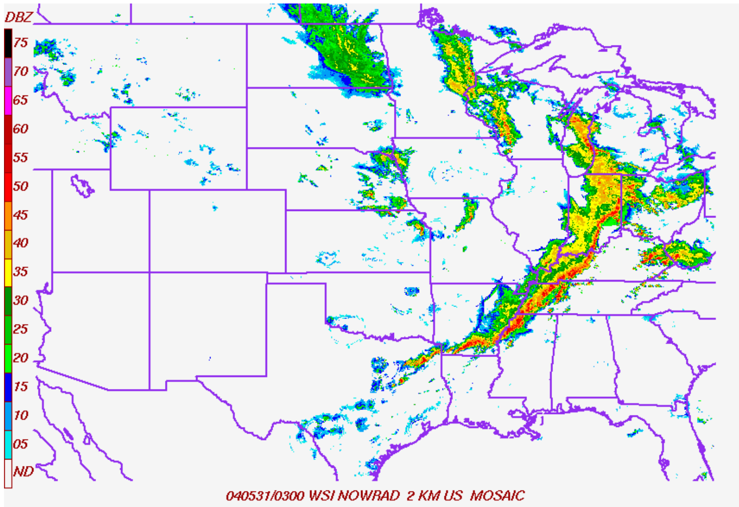


May 31, 2004

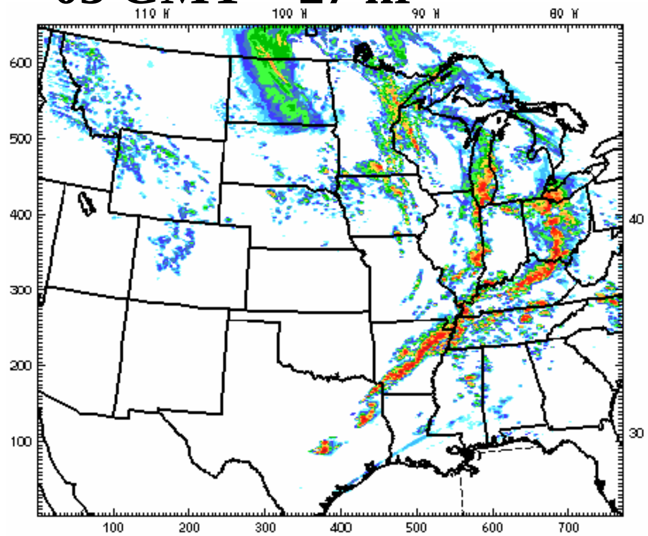
Radar

ETA

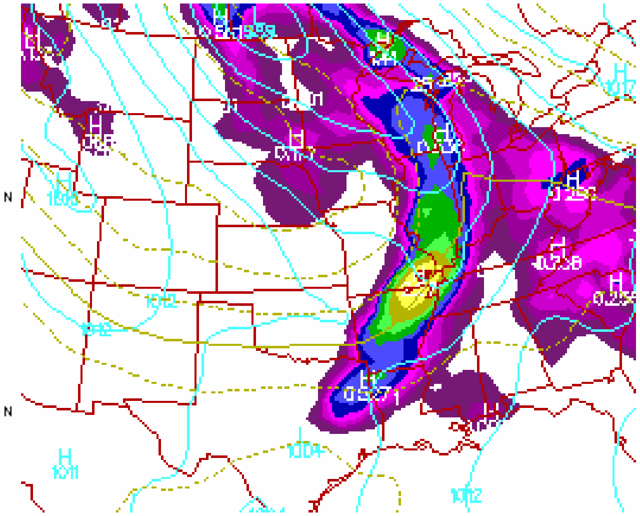
03 GMT



03 GMT 27 hr

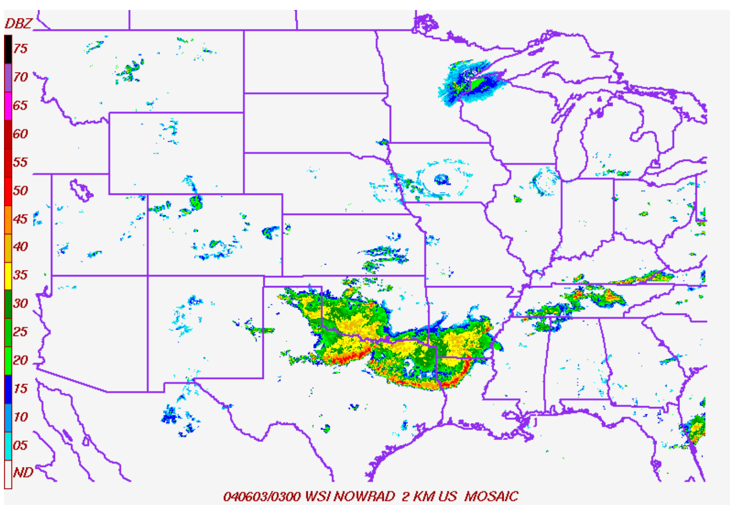


06 GMT prec. 30 hr

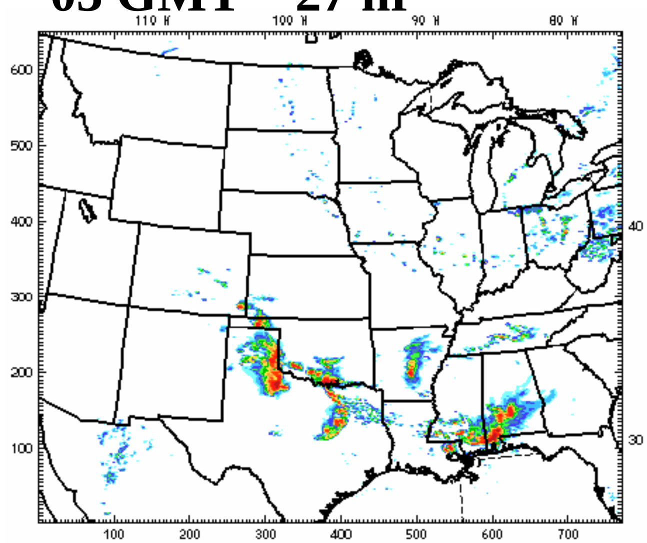


June 3, 2004

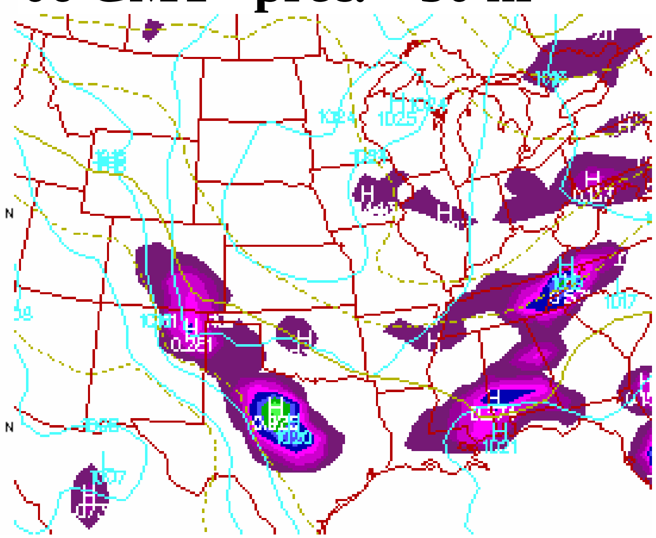
03 GMT



03 GMT 27 hr



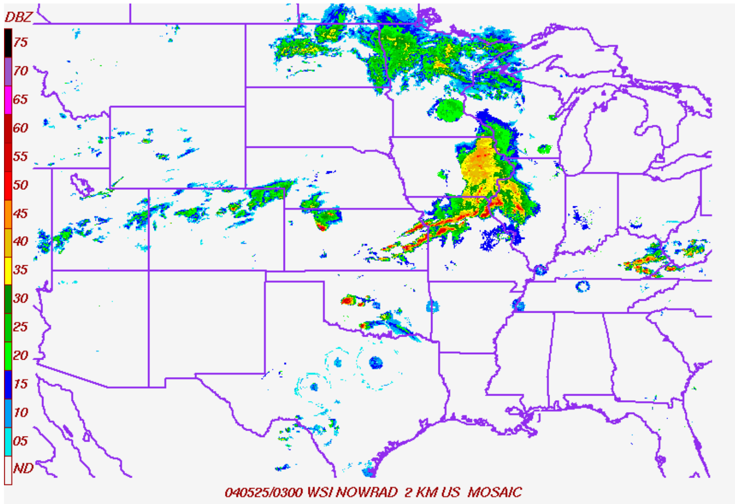
06 GMT prec. 30 hr



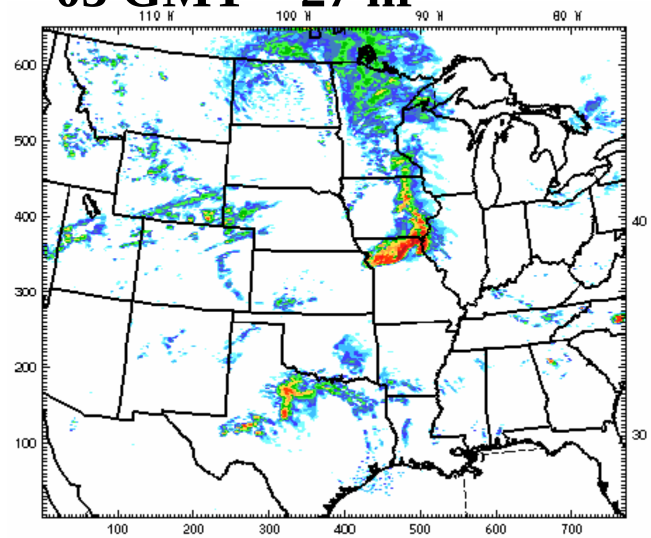
May 25, 2004

Radar | **ETA**

03 GMT



03 GMT 27 hr



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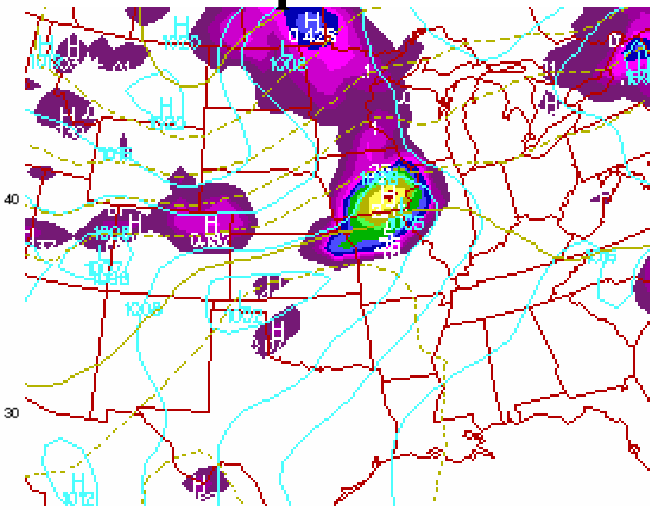
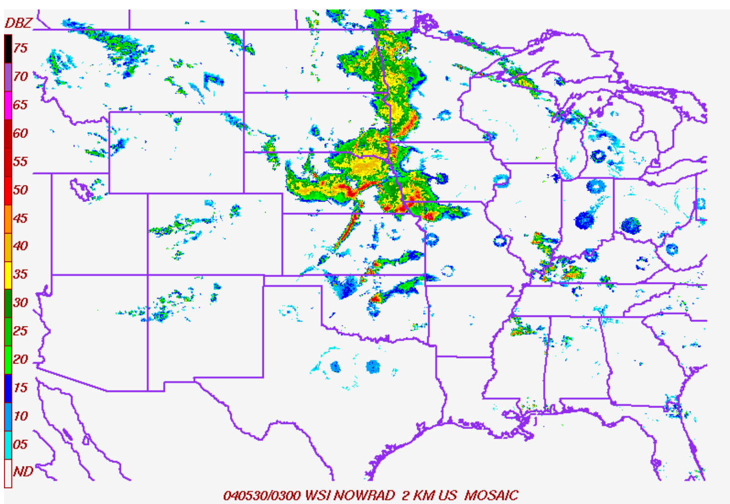


May 30, 2004

03 GMT



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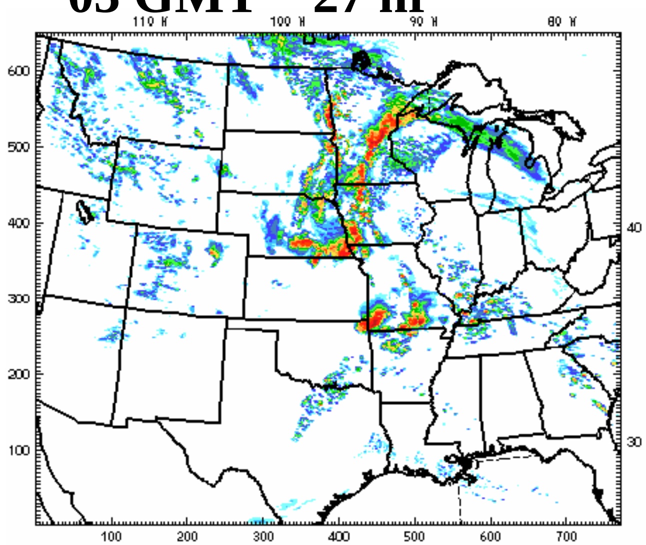

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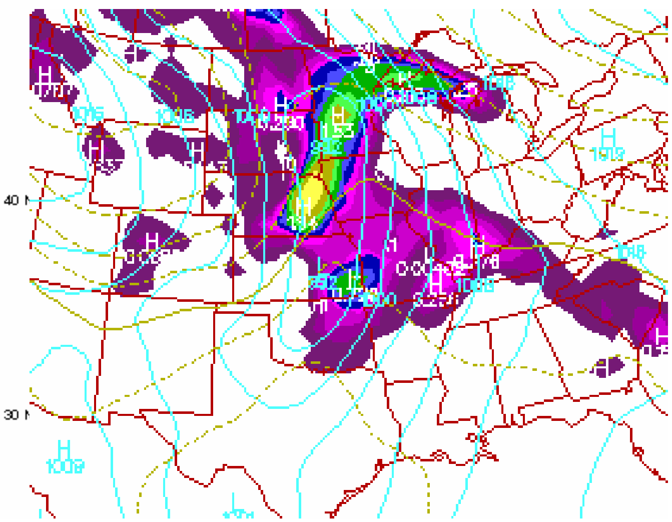
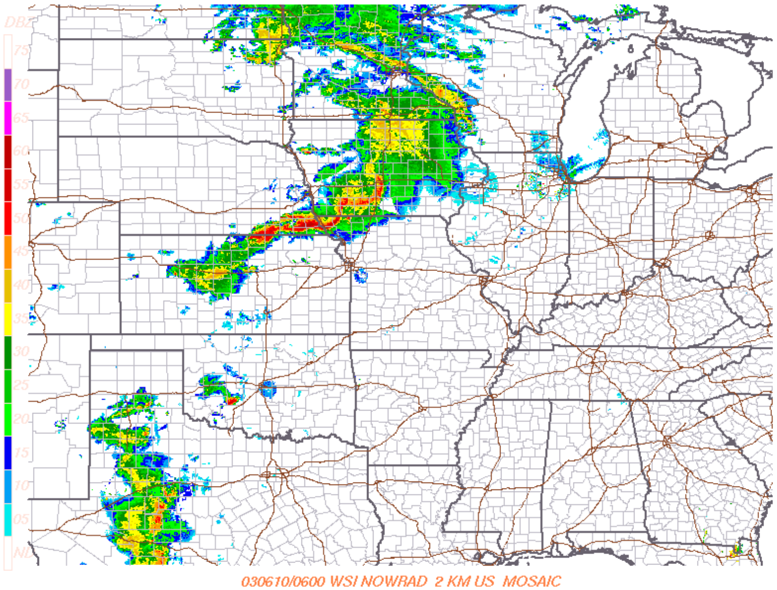


Radar

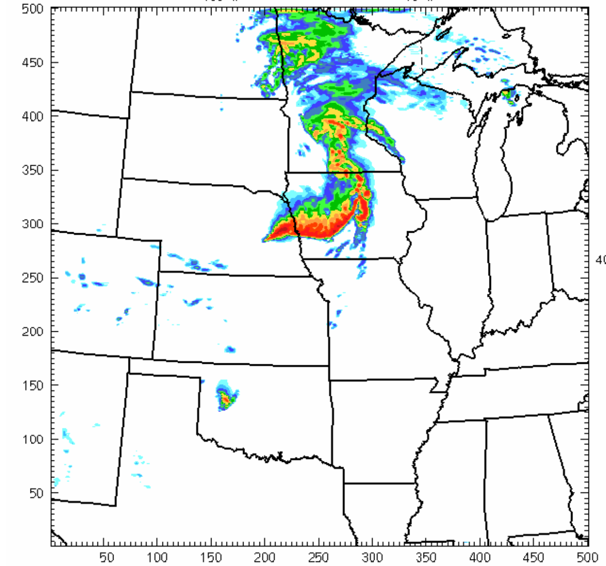
June 10, 2003

ETA

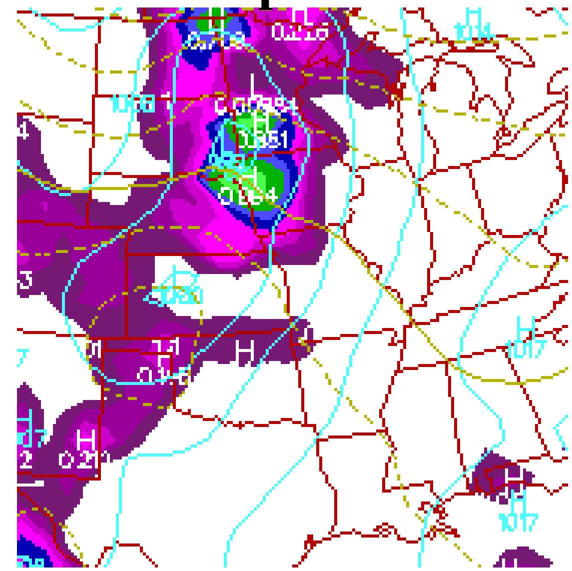
06 GMT



06 GMT 30 hr

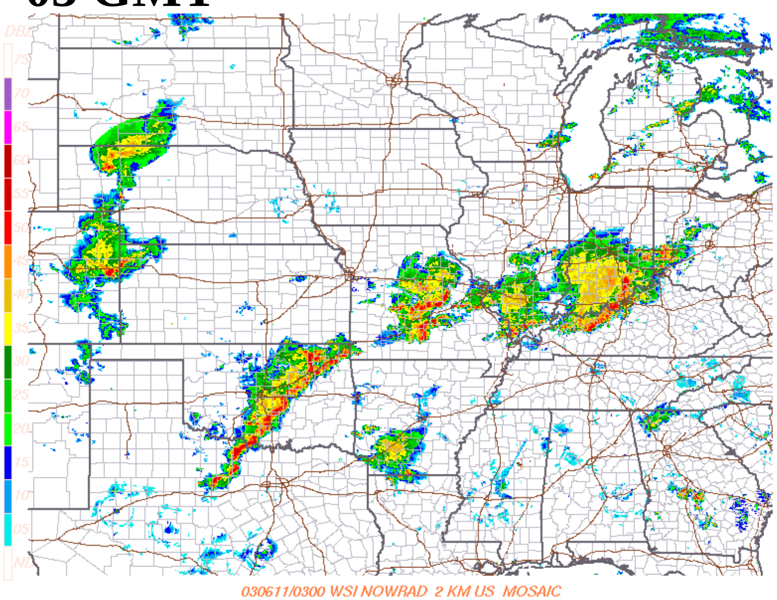


06 GMT prec. 30 hr

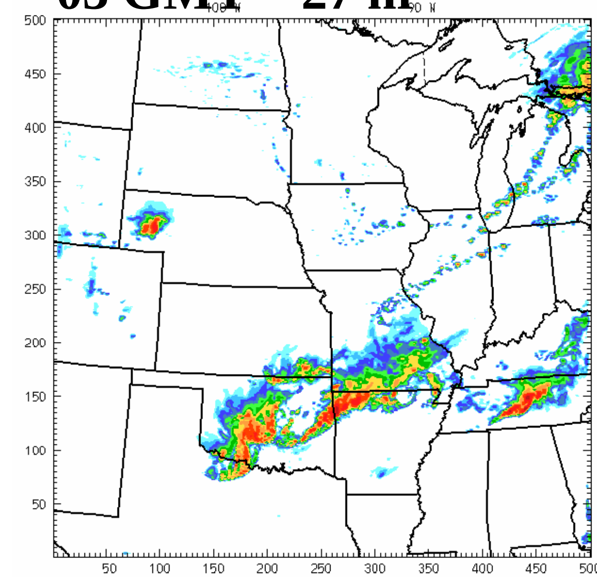


June 11, 2003

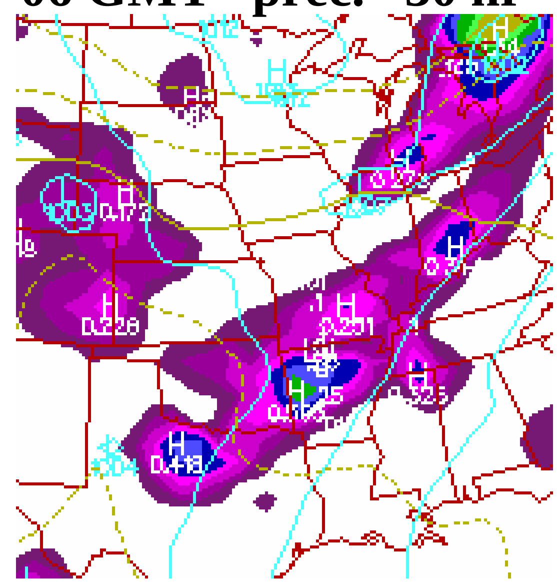
03 GMT



03 GMT 27 hr



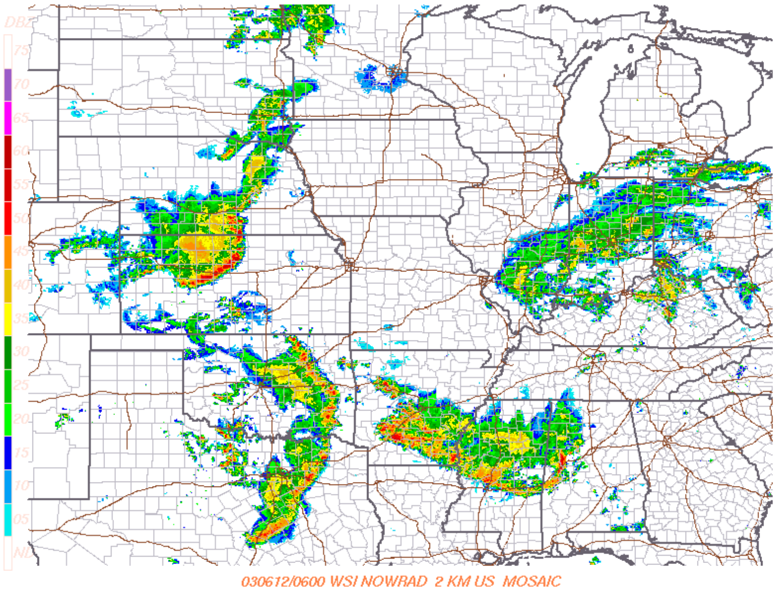
06 GMT prec. 30 hr



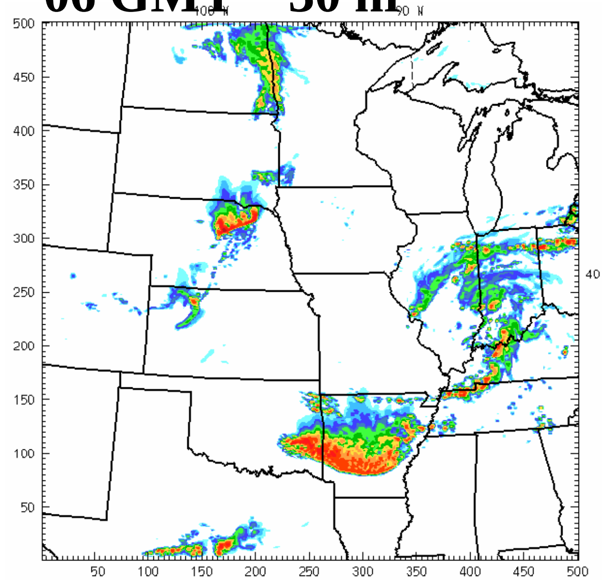
June 12, 2003

Radar

06 GMT

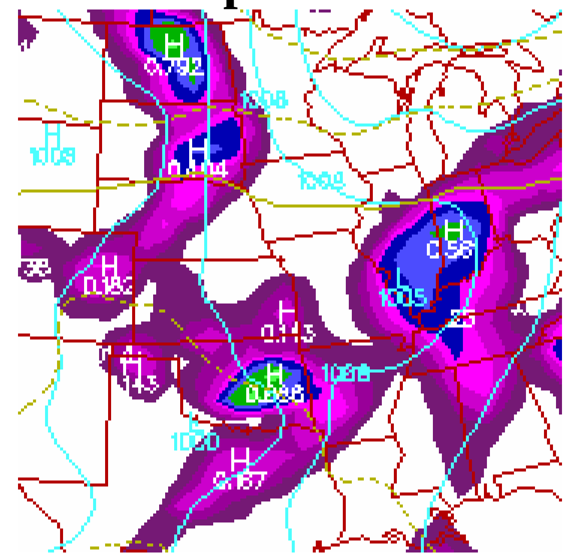


06 GMT 30 hr



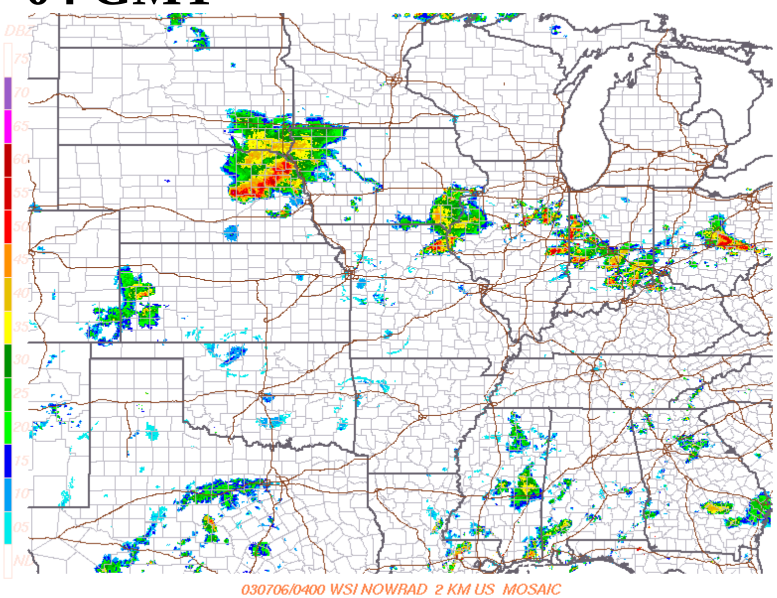
ETA

06 GMT prec. 30 hr

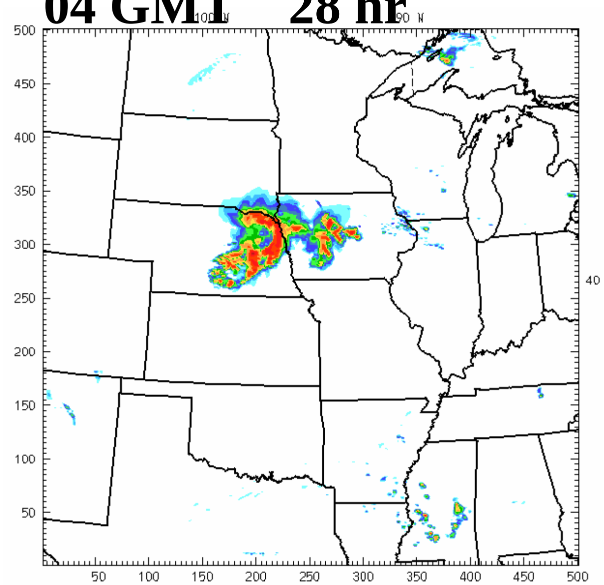


July 6, 2003

04 GMT



04 GMT 28 hr



06 GMT prec. 30 hr