Systematic Boundary-layer Biases in the WRF-ARW Real-time Convective Forecasts

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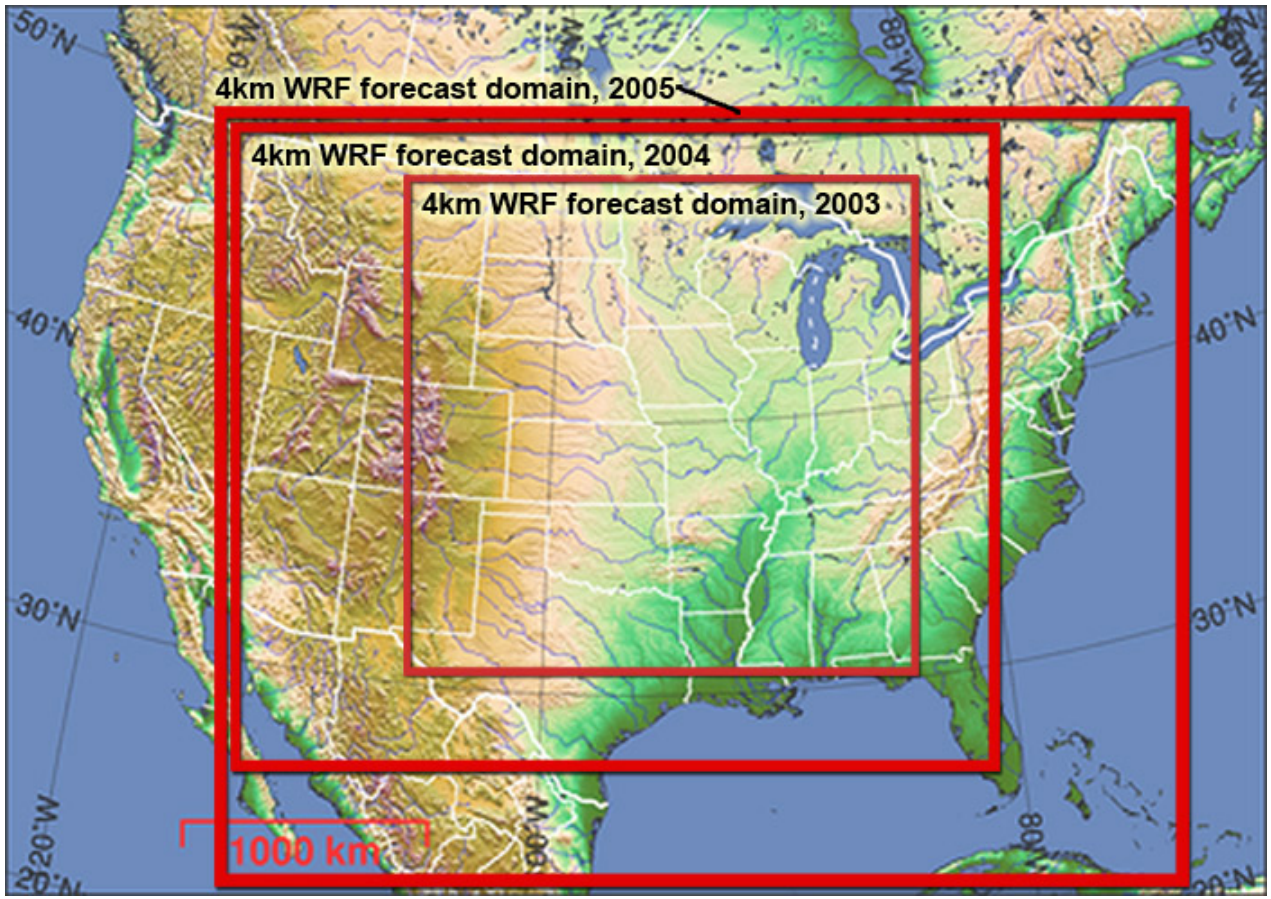
(Wei Wang, Jim Dudhia, Kevin Manning)

WRF Workshop

June 19, 2006

WRF Realtime Convective Forecasting



May 1 – July 31 4 km 00 UTC -- 36h

2003, 2004, 2005

WRF Real-time Forecasts: 2004, 2005, 2006

- 4-km from 0000 UTC - 36 h (plus: 12 UTC -18h)
- Version 1.3 (2.0.3.1) (2.1.2)
- NAM initial and boundary conditions (40 km)
- Physics:

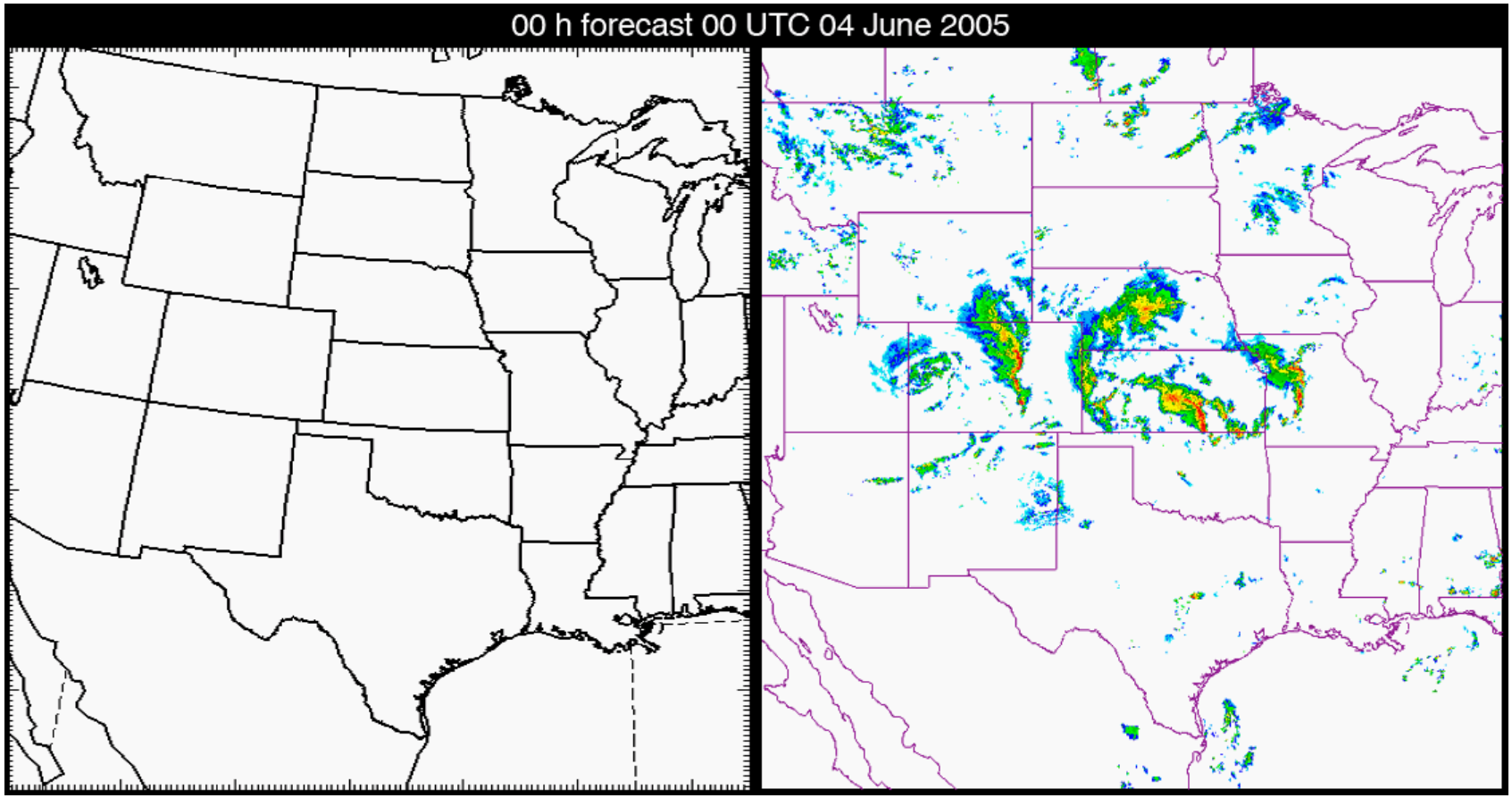
  Lin et al. microphysics (WSM6), (WSM6)

  YSU PBL (first-order closure) (MYJ)

  Noah LSM (HRLDAS) (no HRLDAS)
- 2000 km X 2000 km domain / 2800 km X 2600 km domain….

Real-time WRF 4 km Forecast

Initialized 04 June 2005 00 UTC

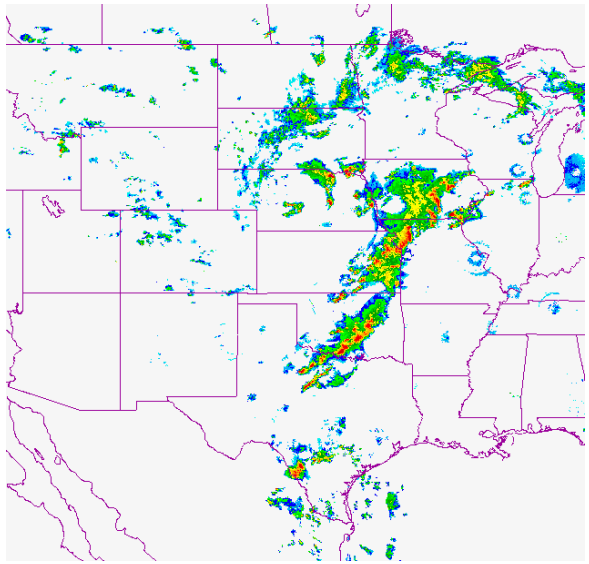


Reflectivity forecast

Composite NEXRAD Radar

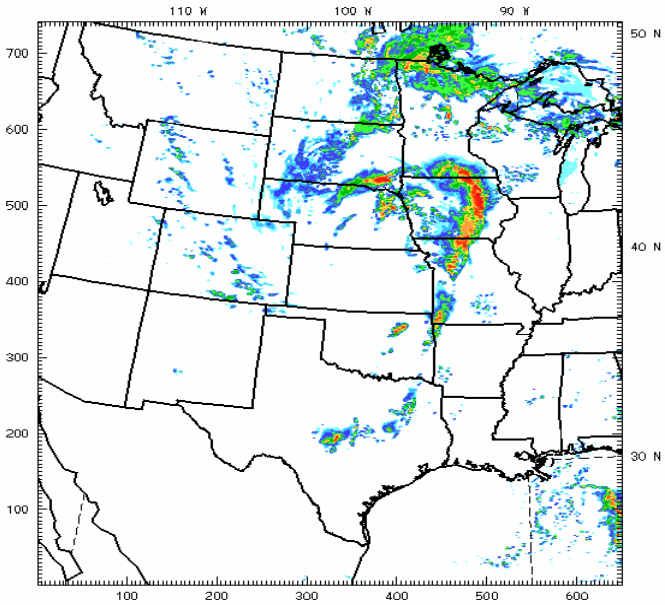
5 June 2005 03 UTC

Radar



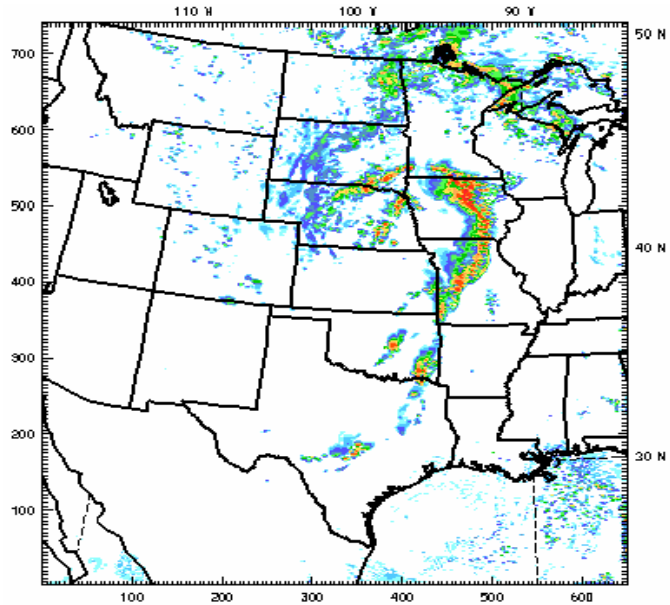
YSU PBL

(27h)



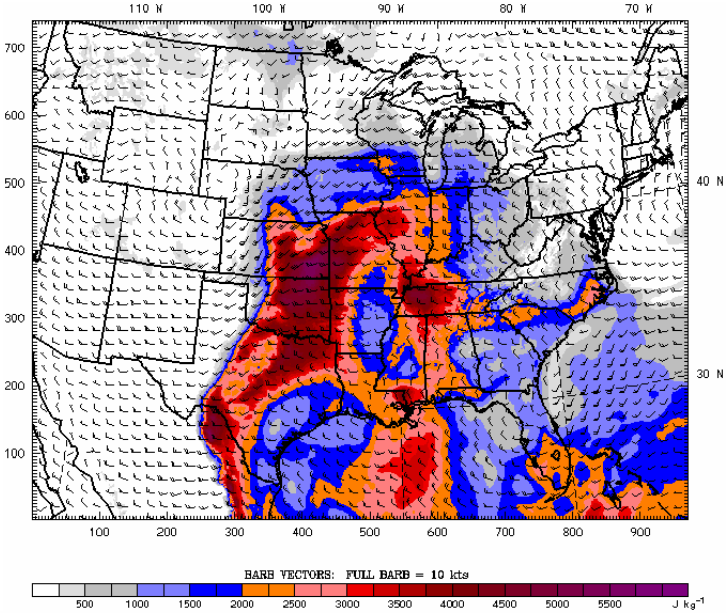
MYJ PBL

(27h)

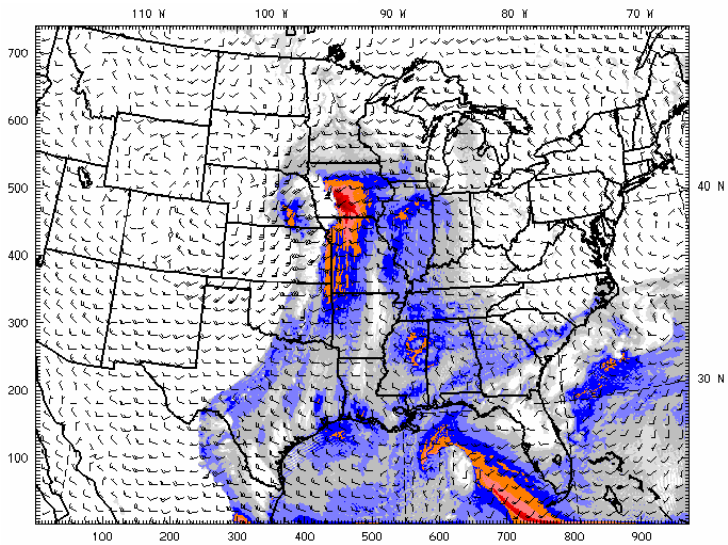


CAPE 05 June 2005 00 UTC

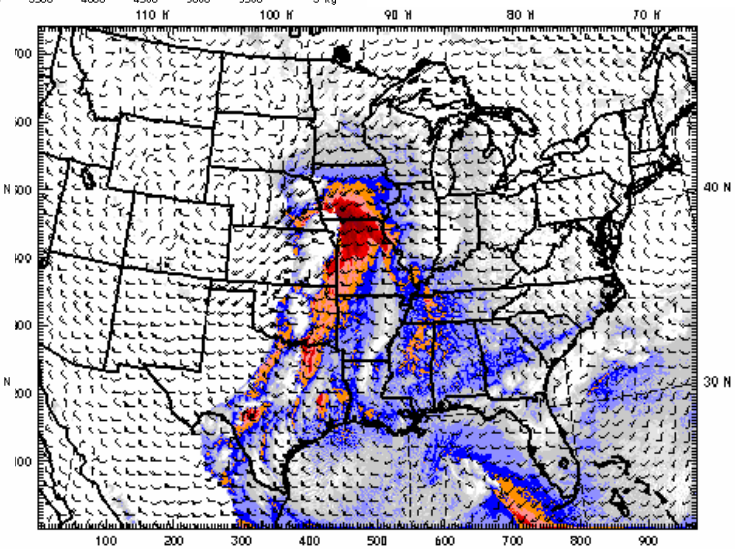
NAM Analysis



YSU PBL (24h)



MYJ PBL (24h)

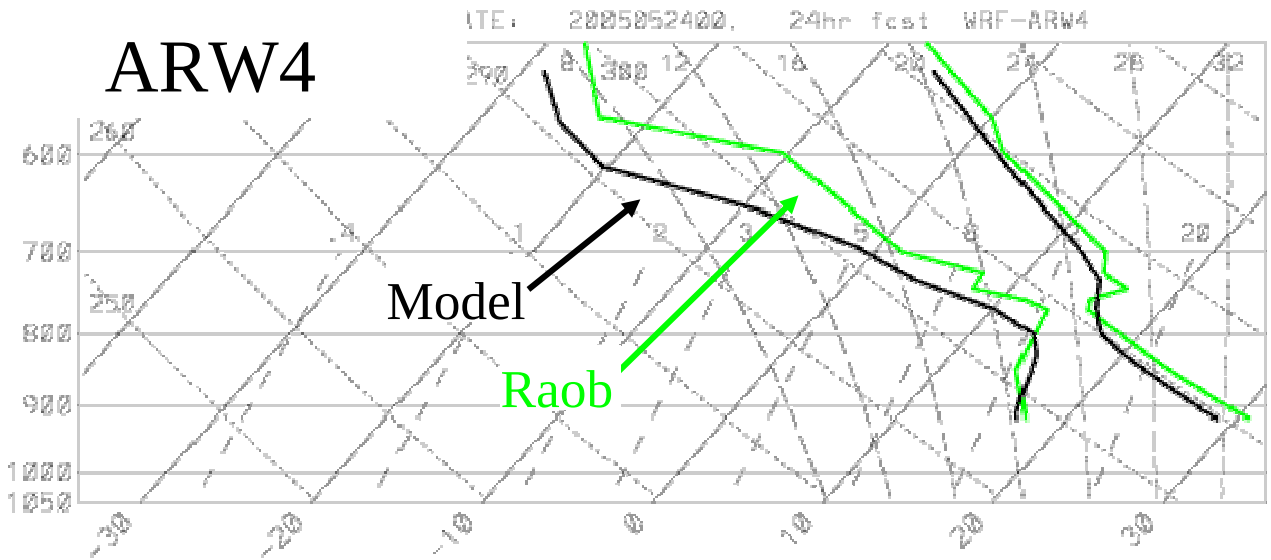


PBL sensitivities:

-**YSU** scheme: mixes across depth of boundary layer

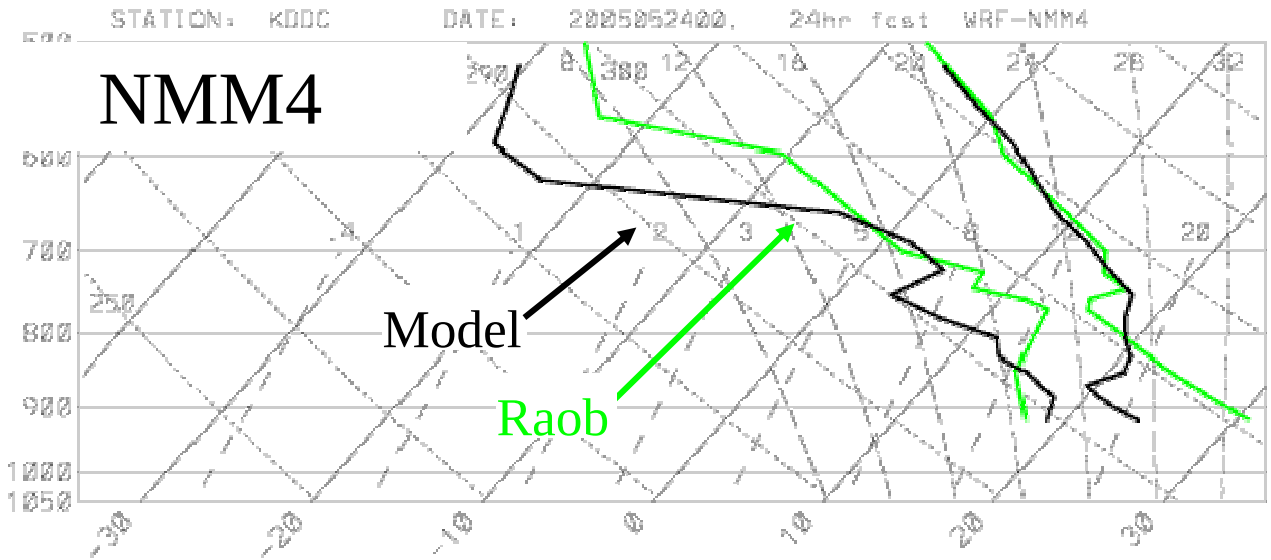
-**MYJ** scheme: mixes based on local turbulence

Sounding comparison: 24h forecast valid 00Z 24 May at DDC



YSU

Good forecast…

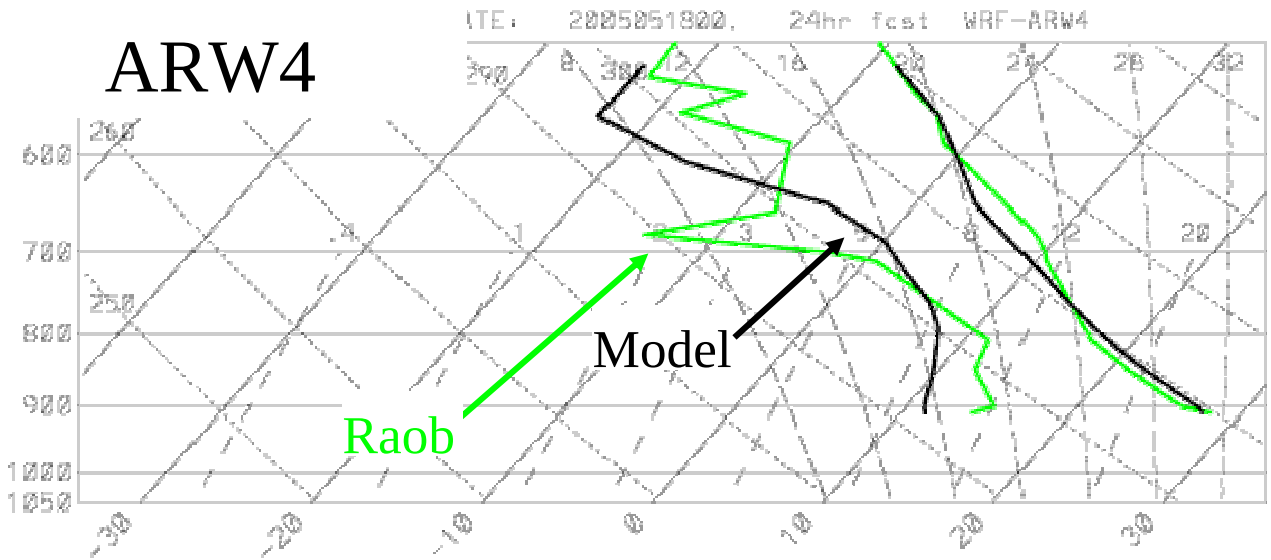


MYJ

PBL too shallow, cold, & moist… clouds just broke up!

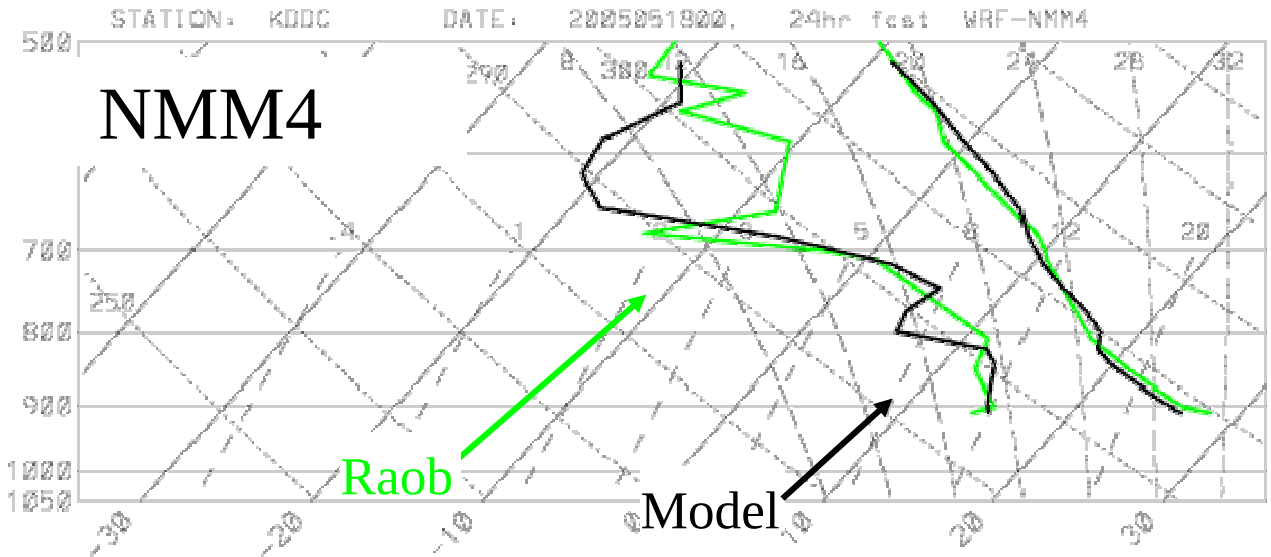
(Jack Kain, NSSL)

Sounding comparison: 24h forecast valid 00Z 18 May at DDC



YSU

Too dry in PBL, too moist above; Where is the PBL top?



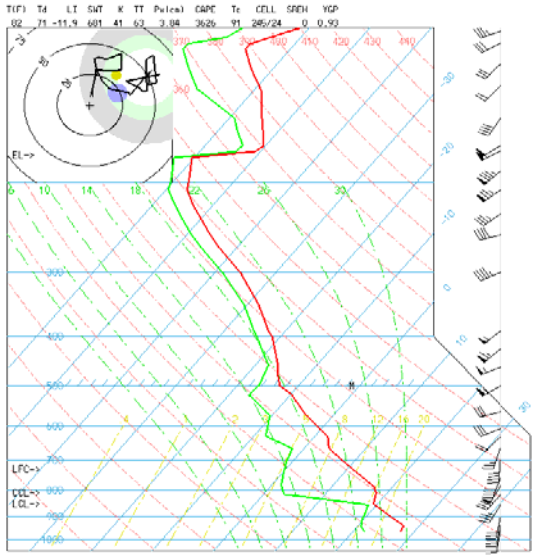
MYJ

Good forecast…

(Jack Kain, NSSL)

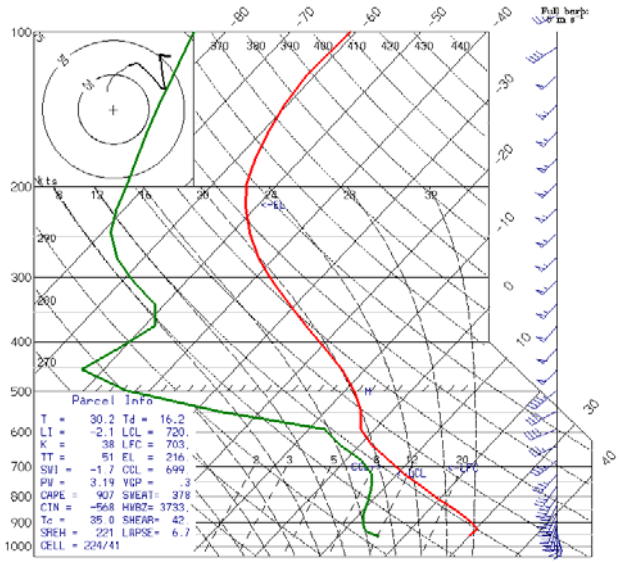
OUN 05 June 2005 00 UTC

OBS



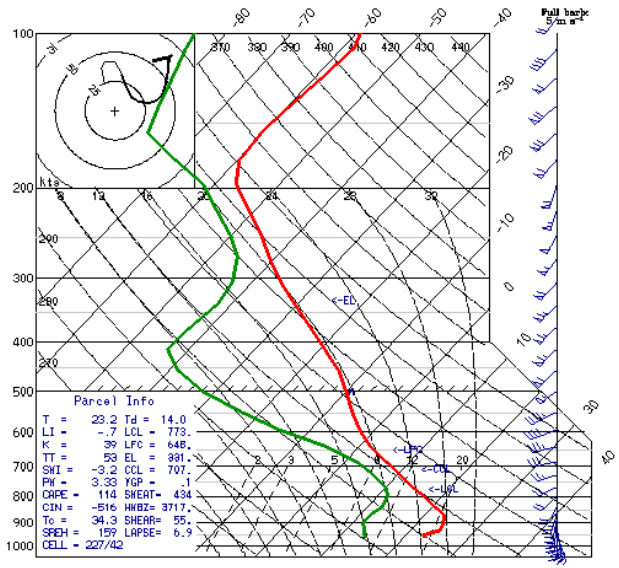
YSU PBL

(24h)



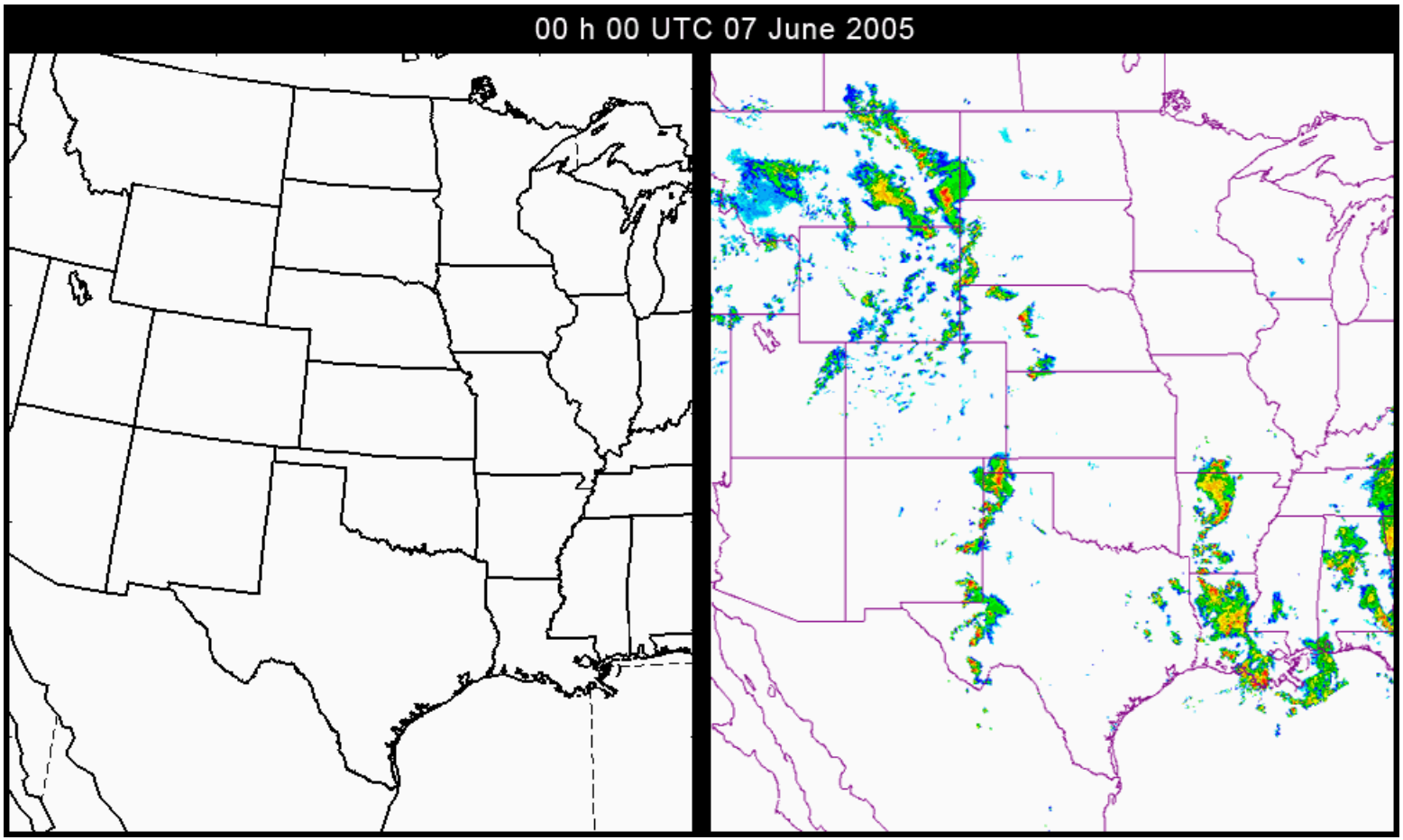
MYJ PBL

(24h)



Real-time WRF 4 km Forecast

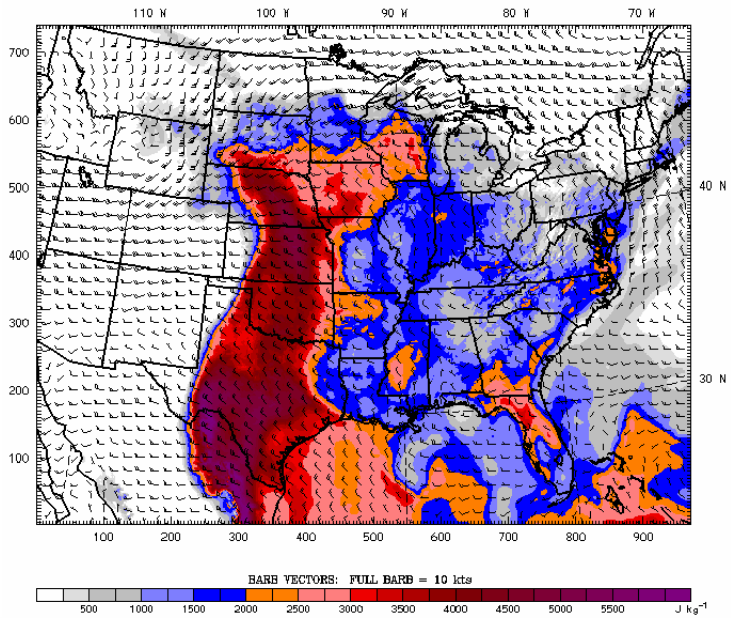
Initialized 07 June 2005 00 UTC



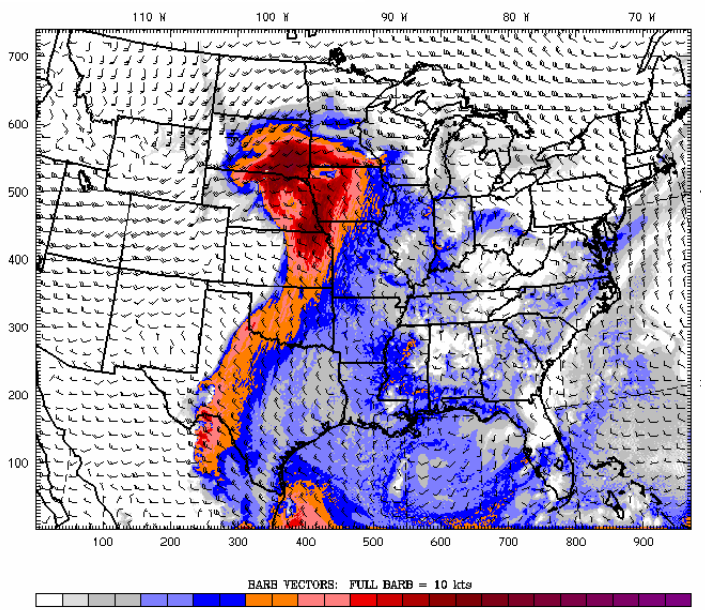
Reflectivity forecast **Composite NEXRAD Radar**

CAPE 08 June 2005 00 UTC

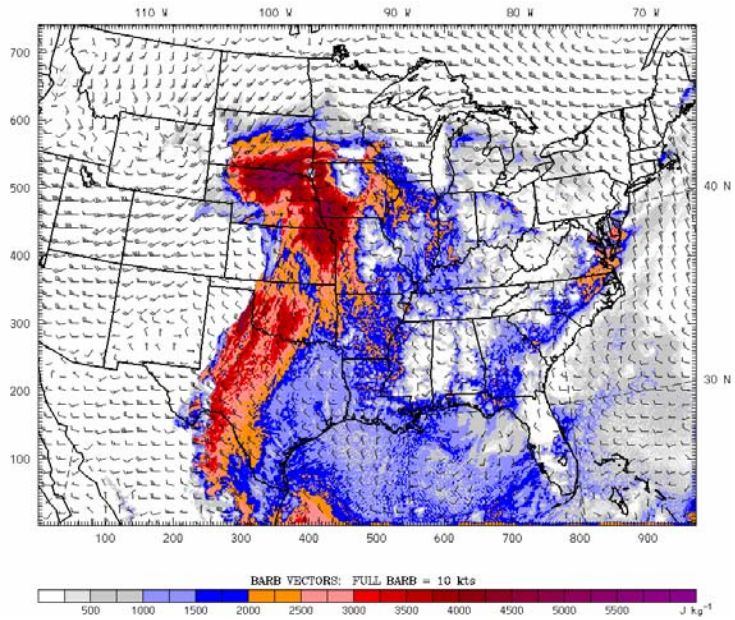
NAM Analysis



YSU PBL (24h)

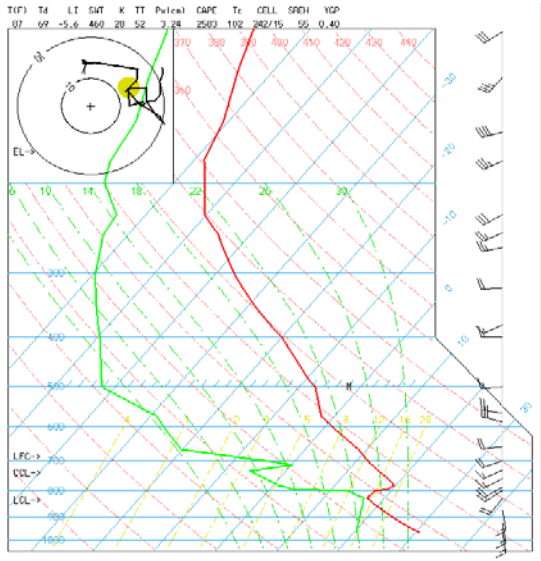


MYJ PBL (24h)

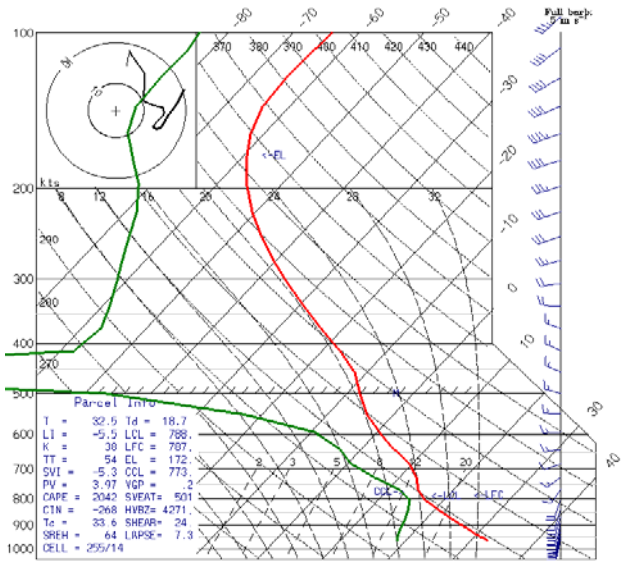


OUN 08 June 2005 00 UTC

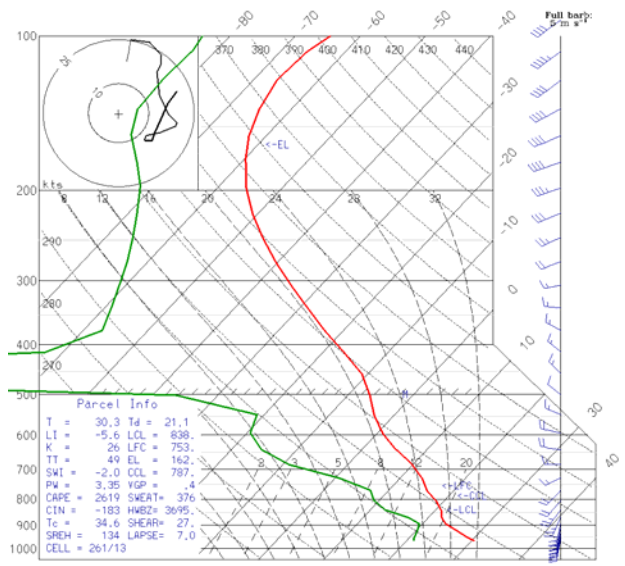
OBS



YSU PBL
(24h)

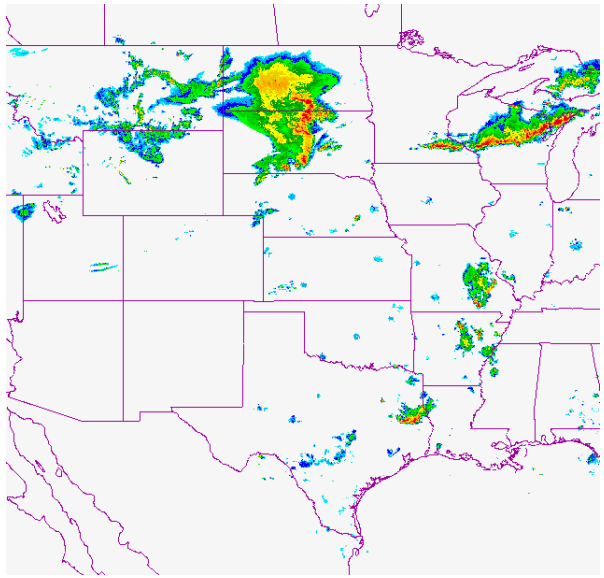


MYJ PBL
(24h)

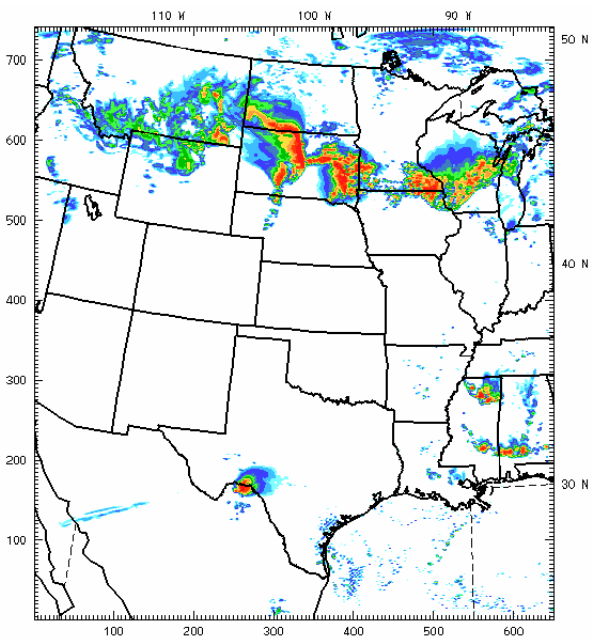


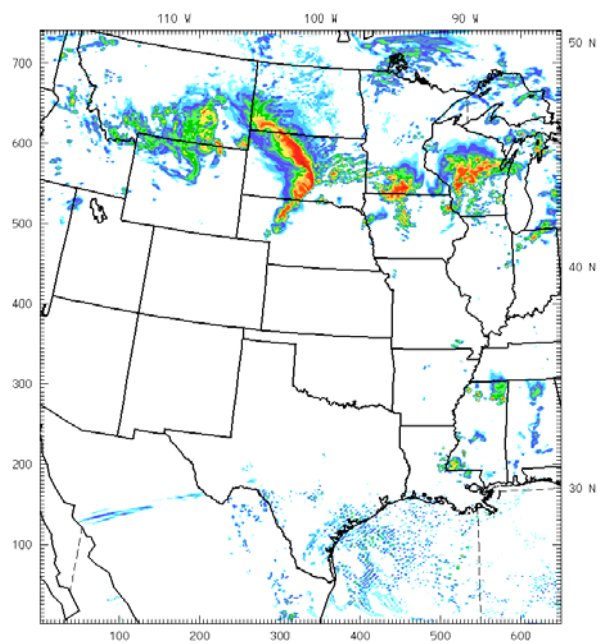
Reflectivity 08 June 2005 03 UTC

Radar



YSU PBL
(27h)



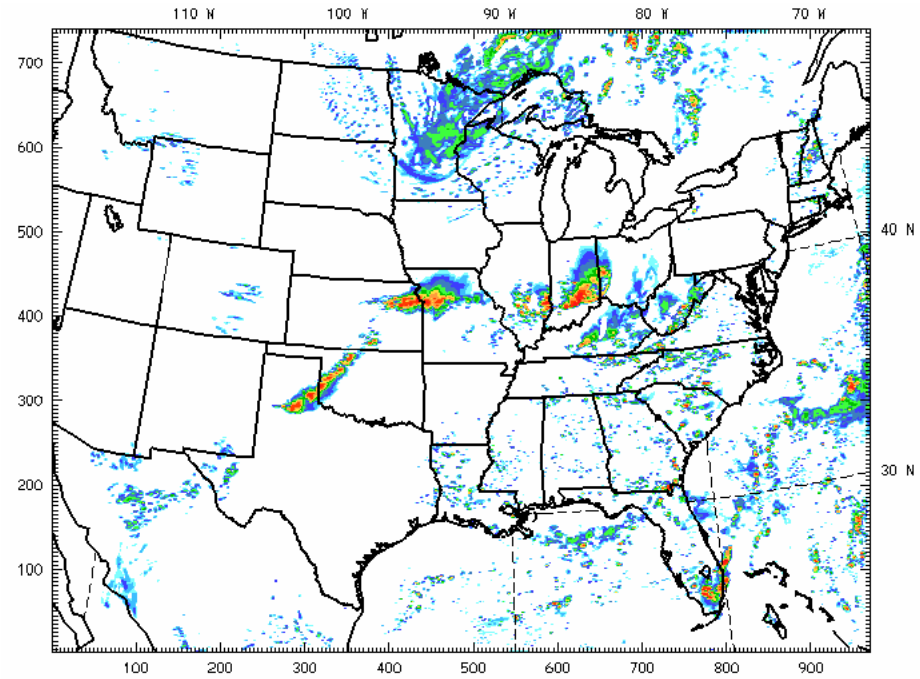


MYJ PBL
(27h)

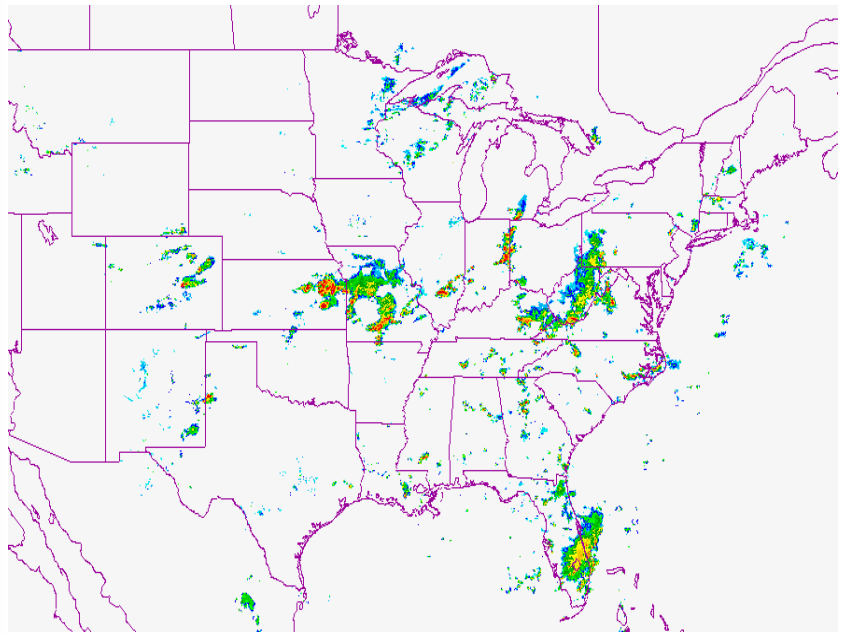
Real-time WRF 4 km Forecast

Initialized 30 July 2005 00 UTC

24 h Forecast



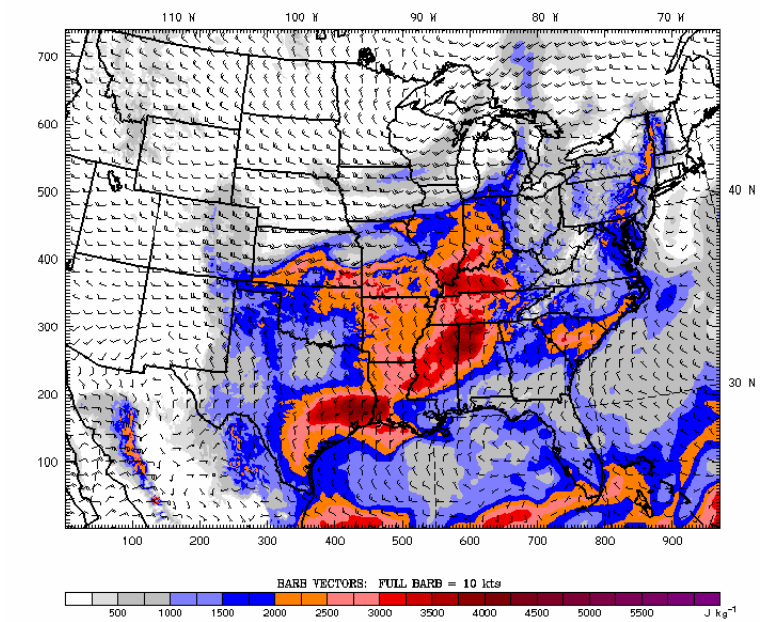
Reflectivity forecast



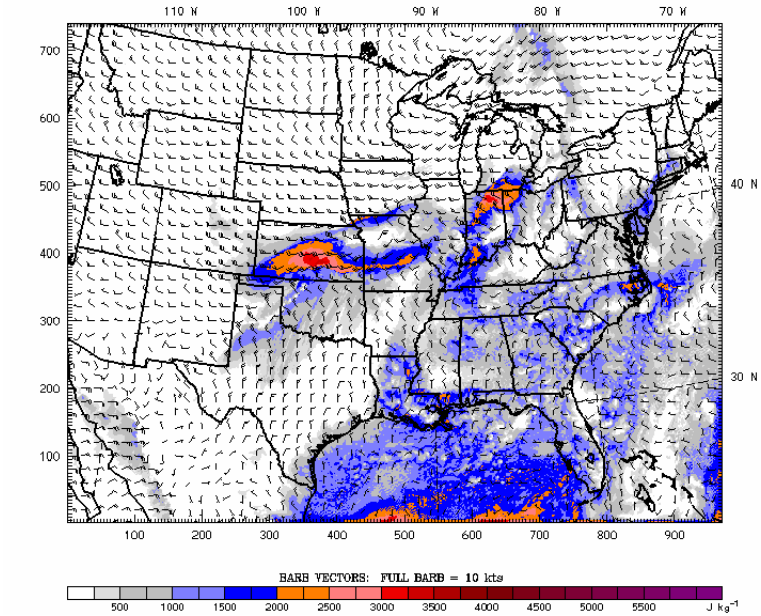
Composite NEXRAD Radar

CAPE 01 July 2005 00 UTC

NAM Analysis

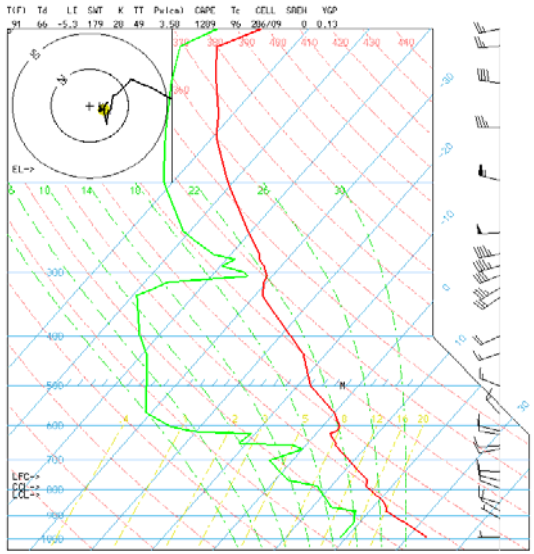


YSU PBL (24h)

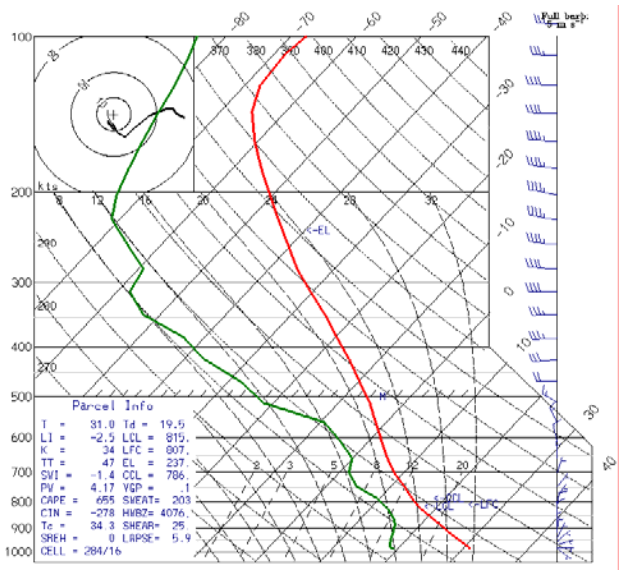


BNA 01 July 2005 00 UTC

OBS



YSU PBL (24h)



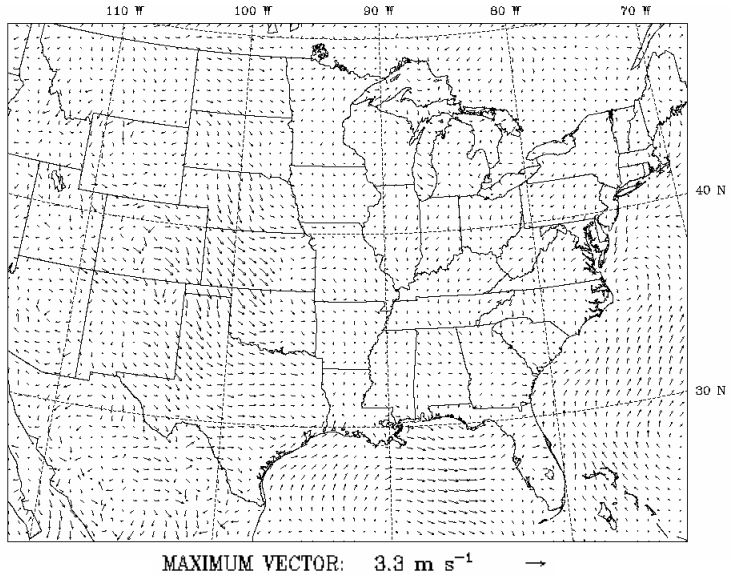
Are there systematic errors?

(YSU, HRLDAS)

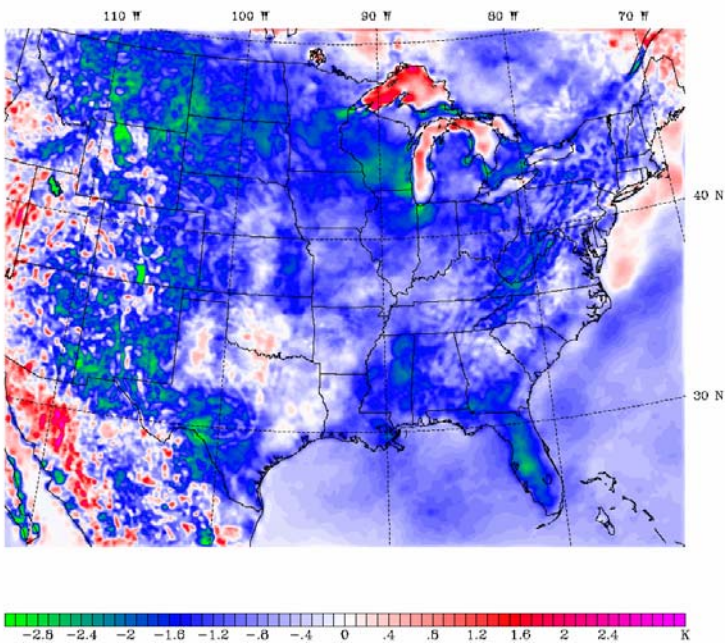
40 Day Average
May 1-June 10 2005

24h forecast - 00 UTC NAM Analysis

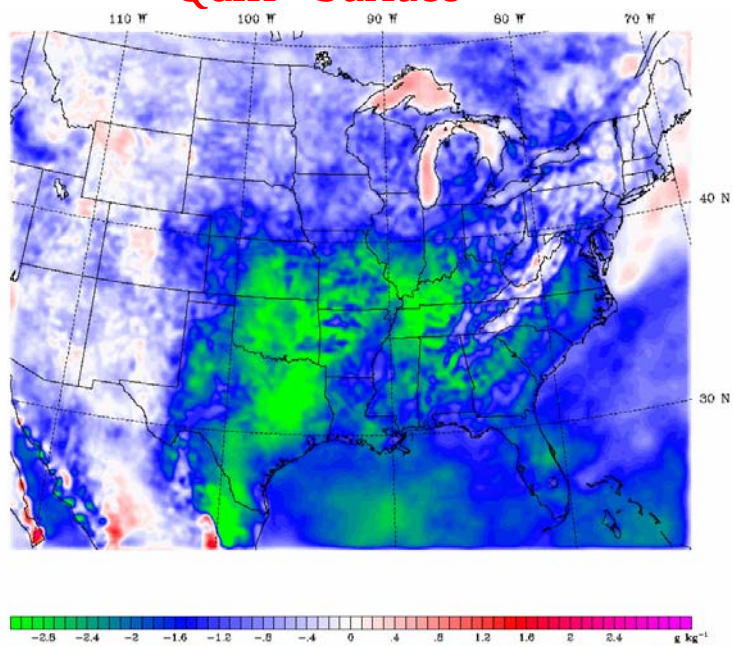
WINDdiff Surface



Tdiff Surface



Qdiff Surface



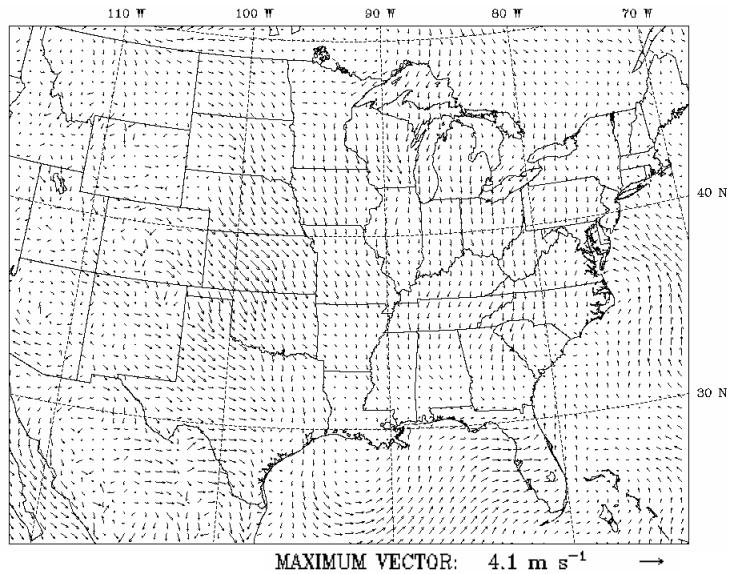
Are there systematic errors?

(YSU, HRLDAS)

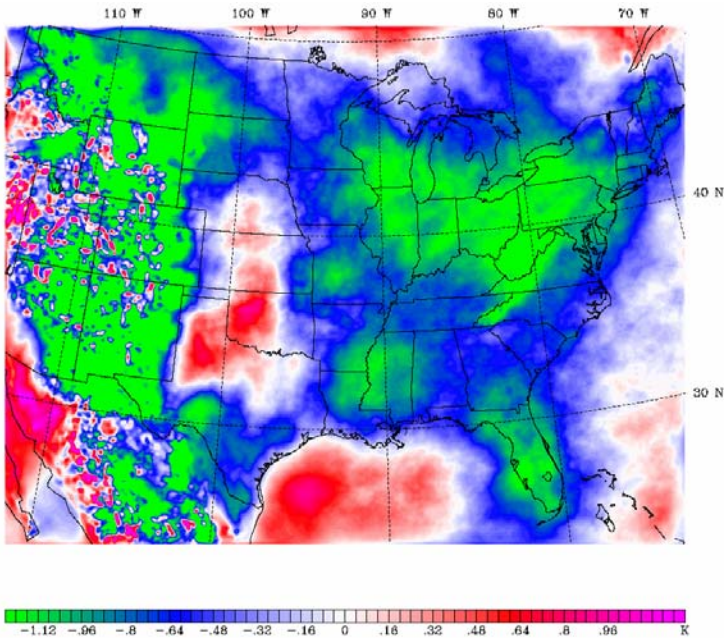
40 Day Average
May 1-June 10 2005

24h forecast - 00 UTC NAM Analysis

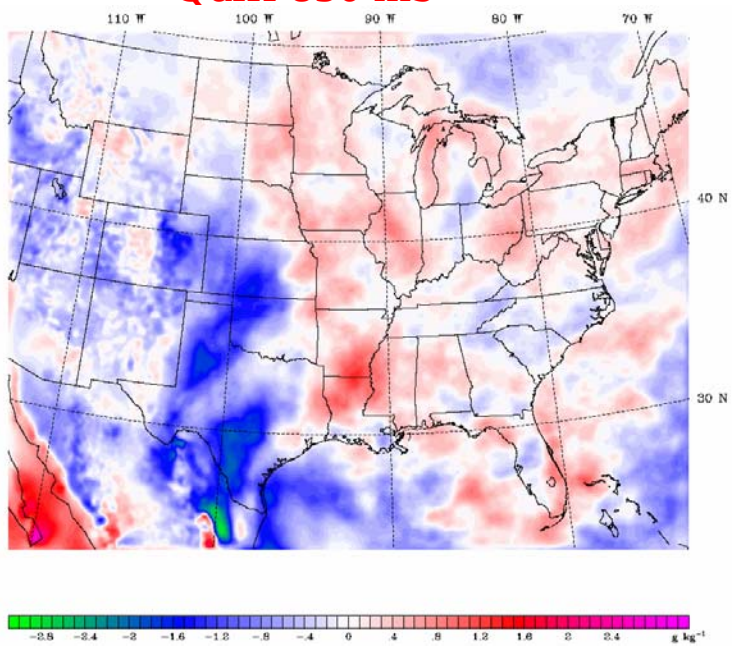
WINDdiff 850 mb



Tdiff 850 mb



Qdiff 850 mb



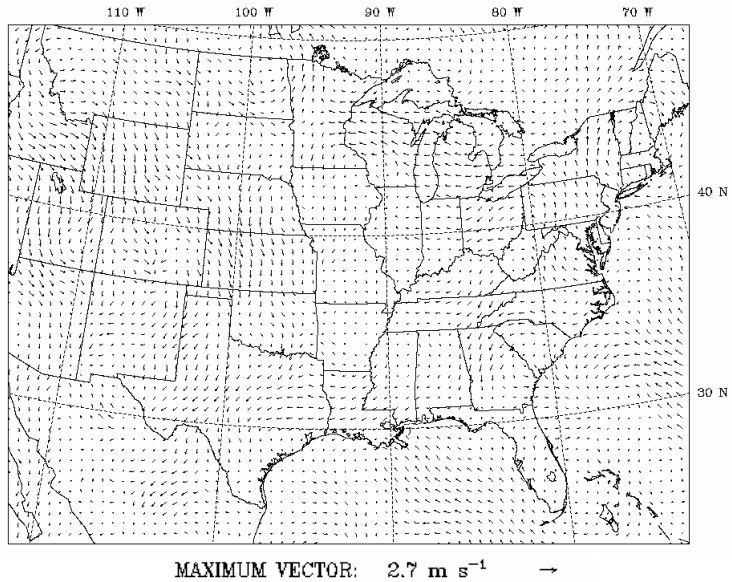
Are there systematic errors?

(YSU, HRLDAS)

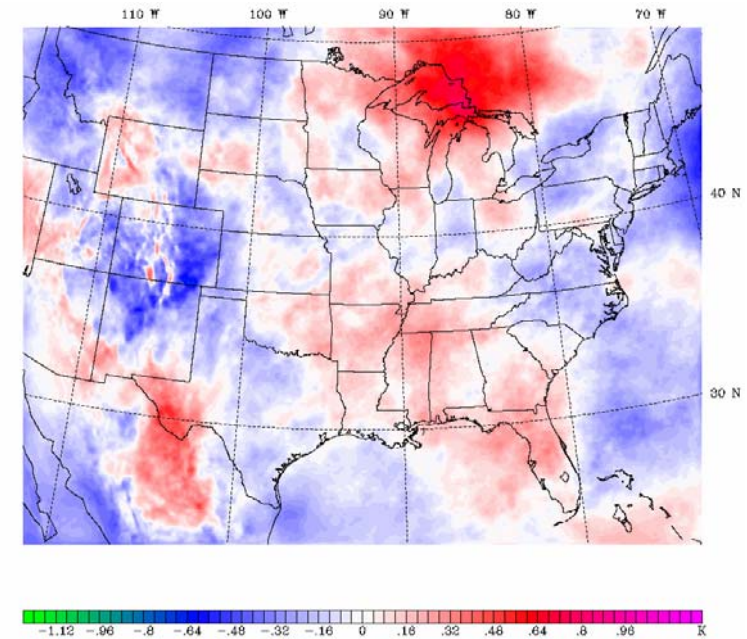
40 Day Average
May 1-June 10 2005

24h forecast - 00 UTC NAM Analysis

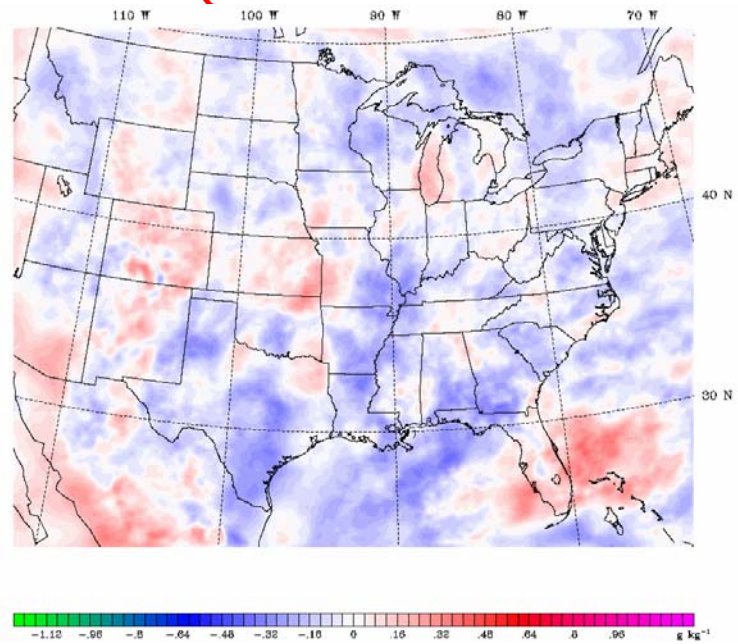
WINDdiff 500 mb



Tdiff 500 mb



Qdiff 500 mb

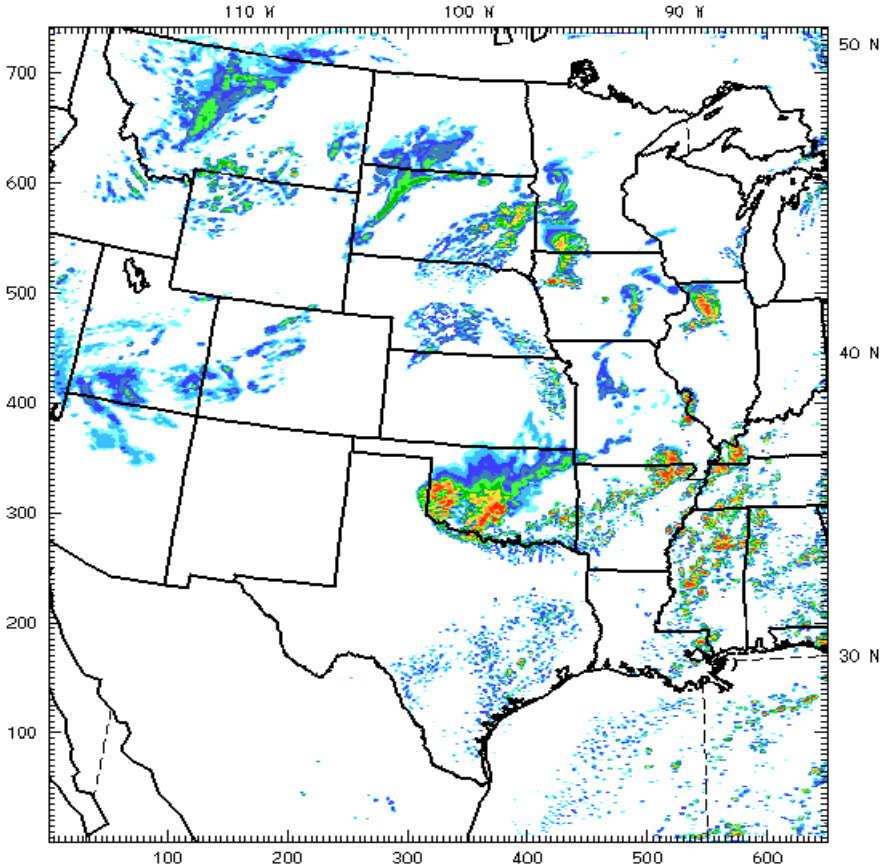


Summary:

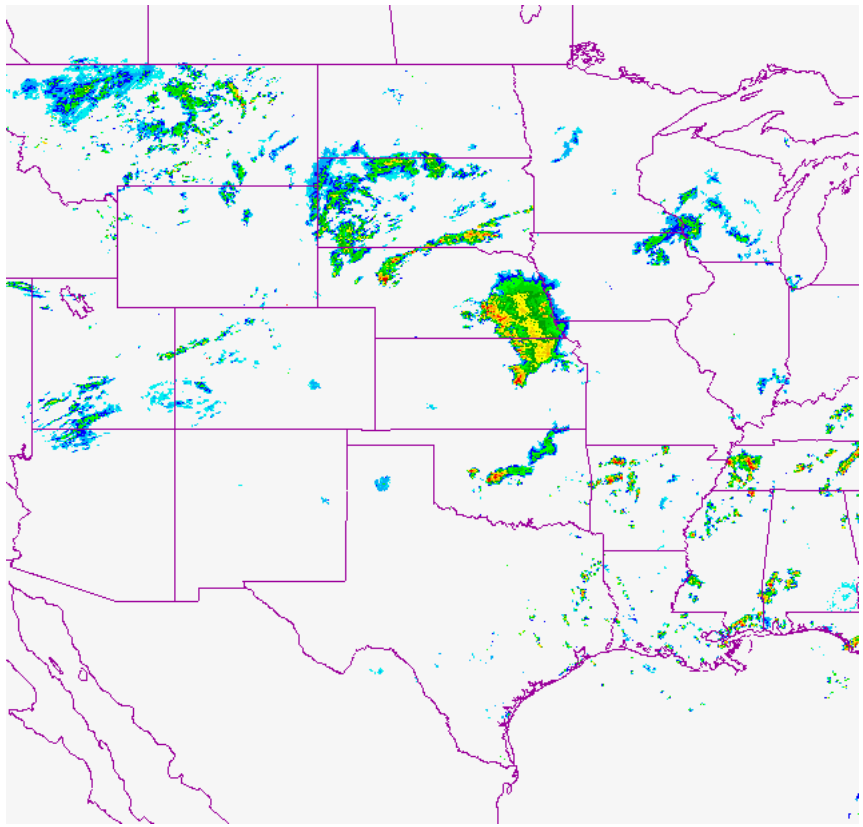
1) Afternoon PBL too deep and dry with YSU scheme for a 24 h forecast, resulting in significantly reduced CAPE

2) MYJ scheme better at preserving CAPE and sounding structures, resulting in overall better convective forecasts.

09 June 2005 18 UTC



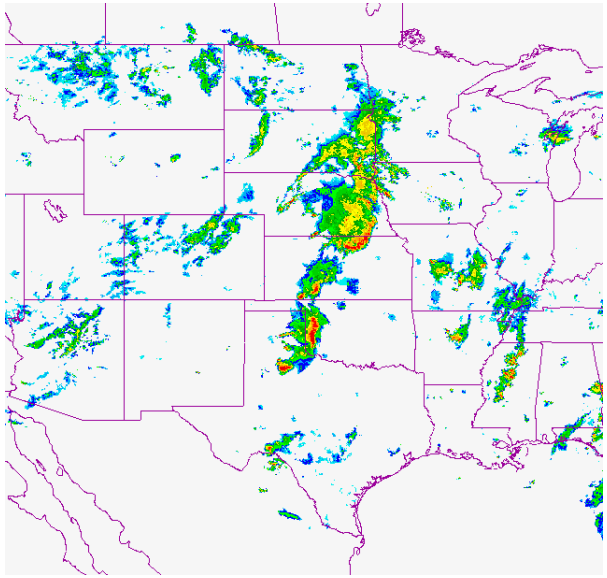
Reflectivity forecast



Composite NEXRAD Radar

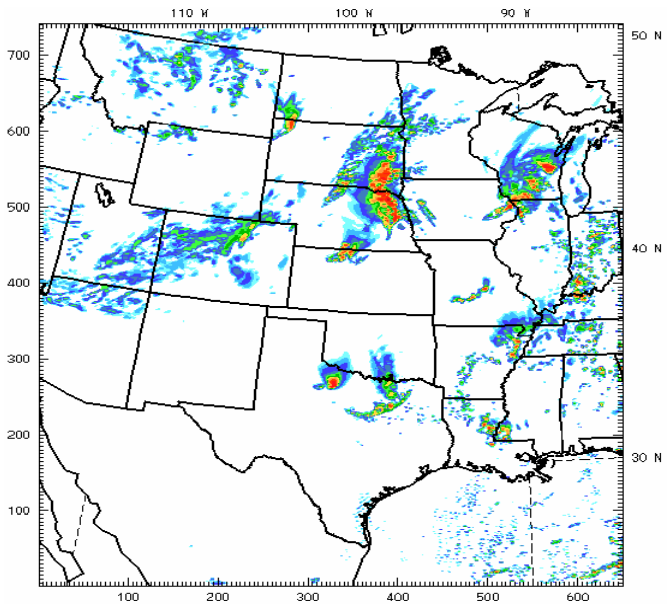
10 June 2005 03 UTC

Radar



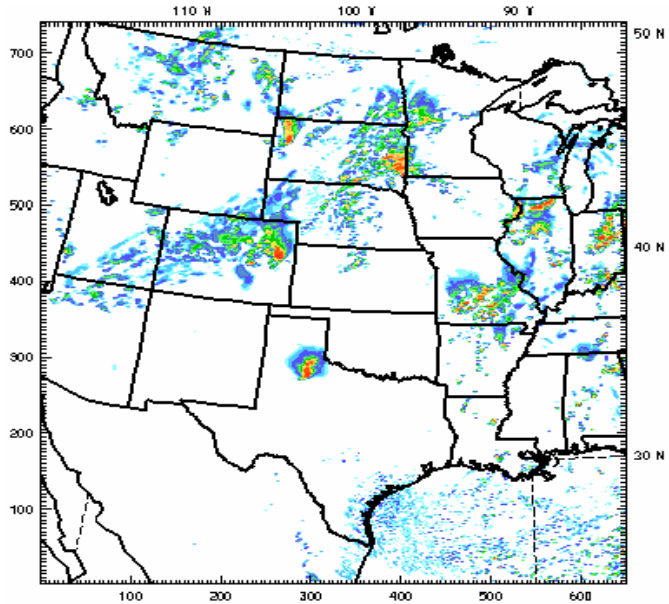
YSU PBL

(27h)



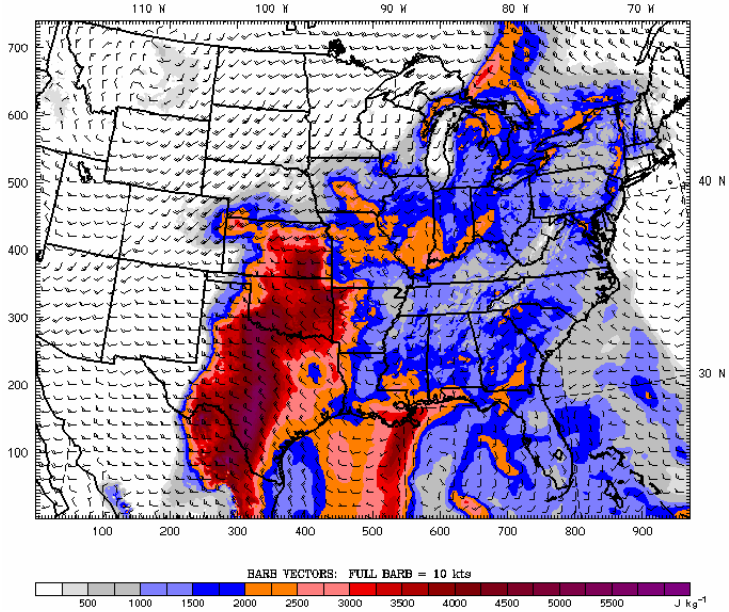
MYJ PBL

(27h)

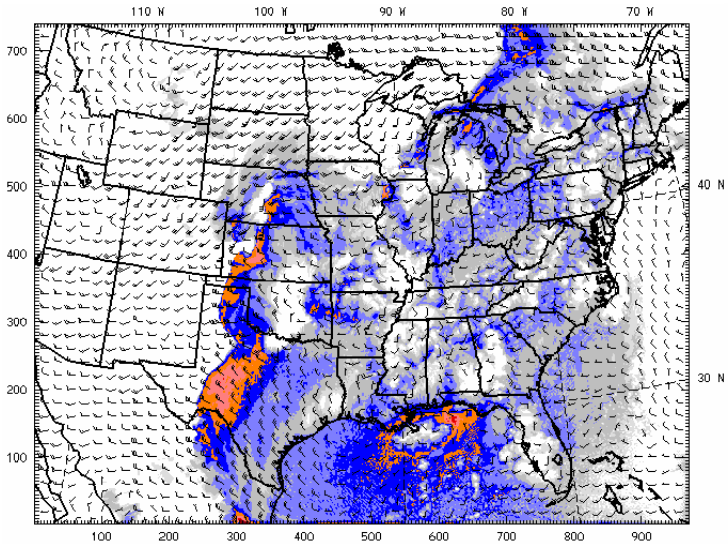


CAPE 10 June 2005 00 UTC

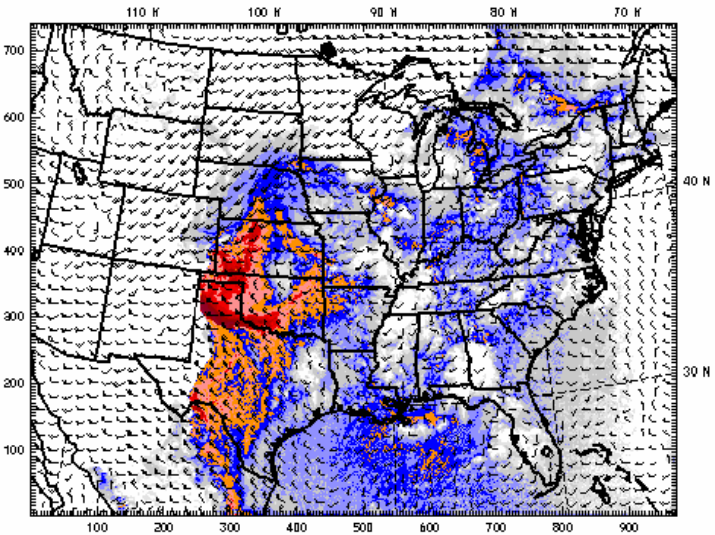
NAM Analysis



YSU PBL (24h)

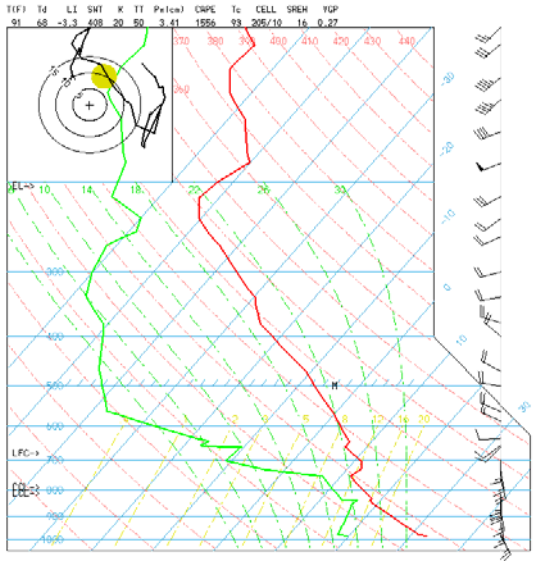


MYJ PBL (24h)

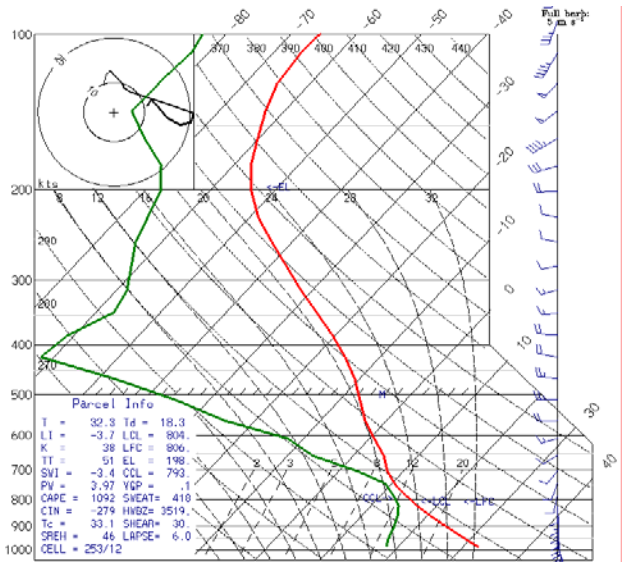


DFW 10 June 2005 00 UTC

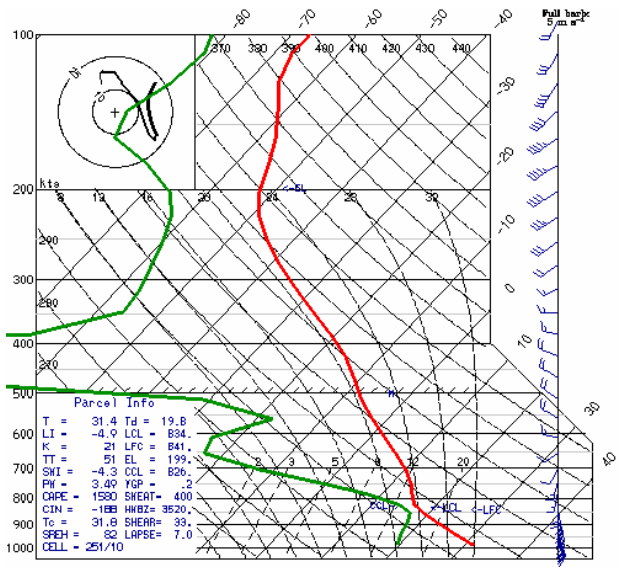
OBS



YSU PBL
(24h)

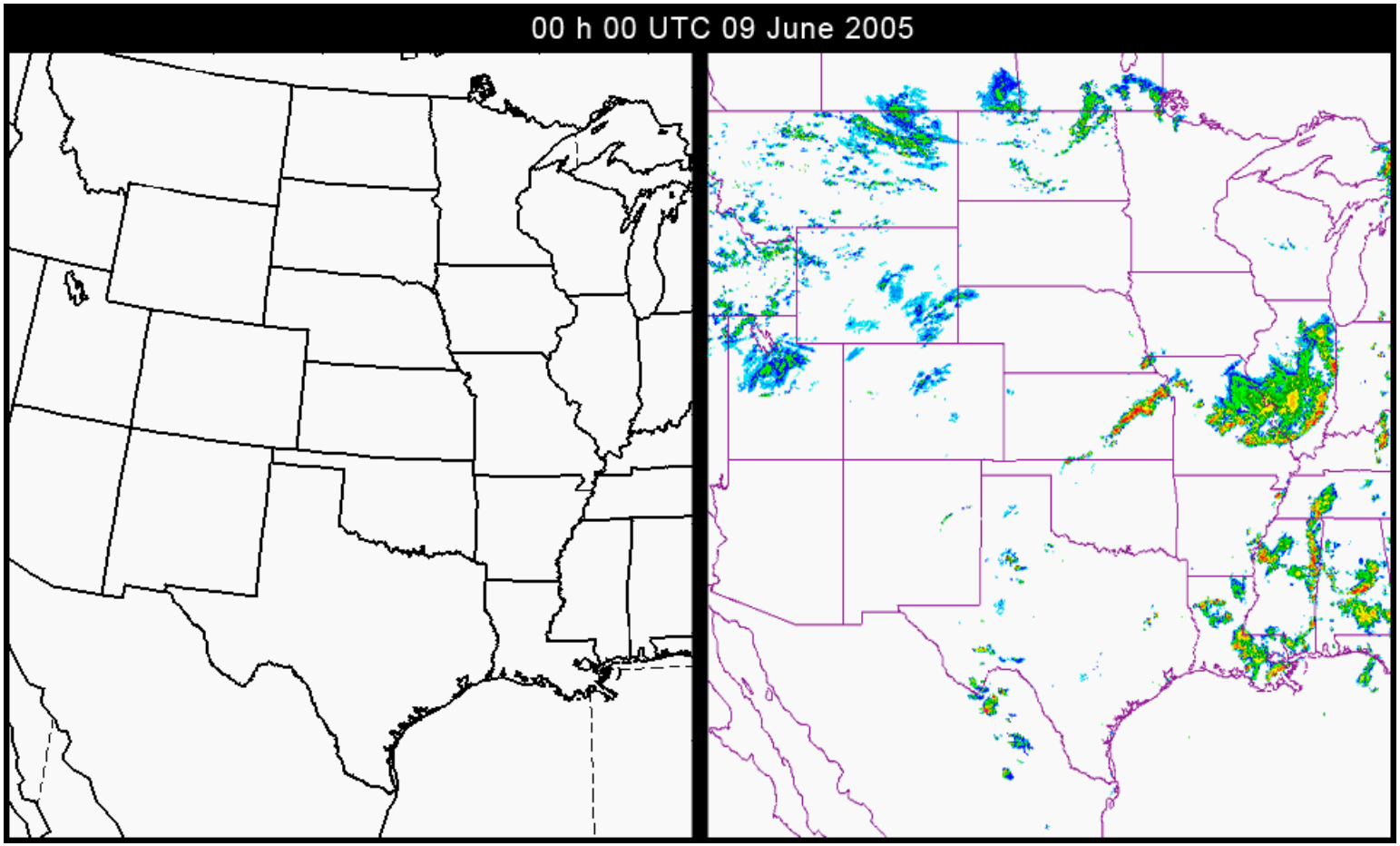


MYJ PBL
(24h)



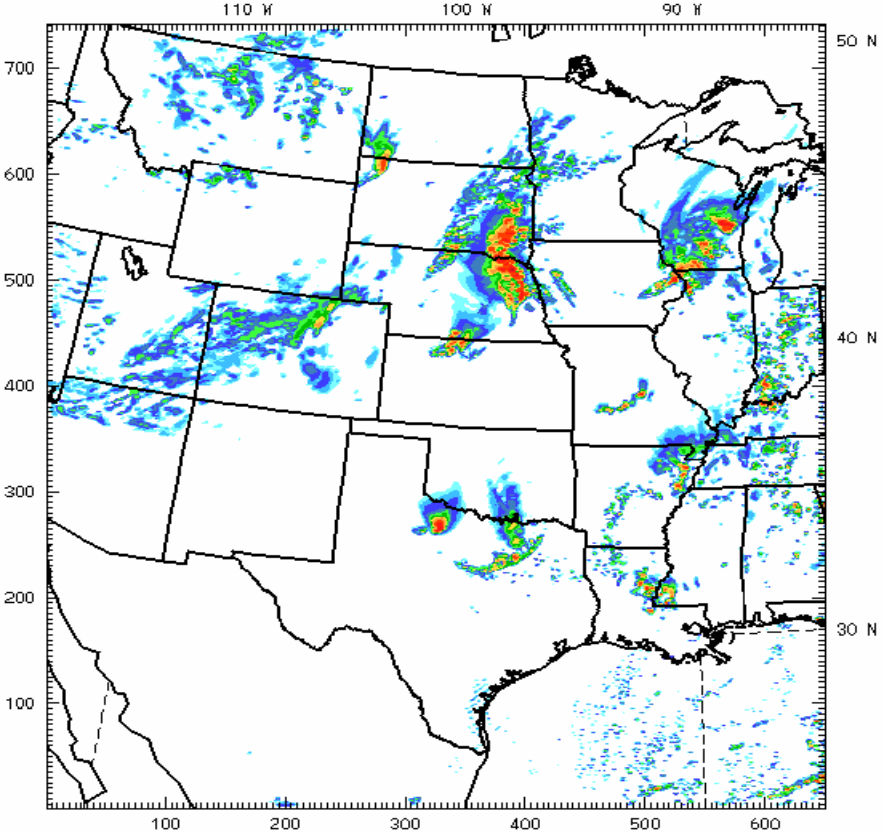
Real-time WRF 4 km Forecast

Initialized 09 June 2005 00 UTC

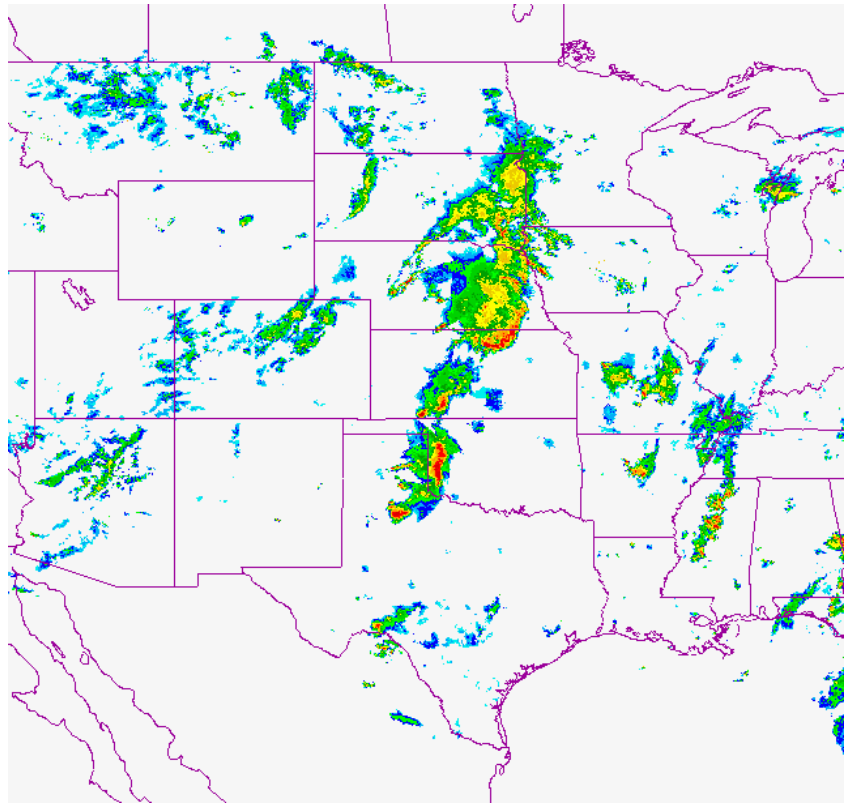


Reflectivity forecast **Composite NEXRAD Radar**

10 June 2005 03 UTC



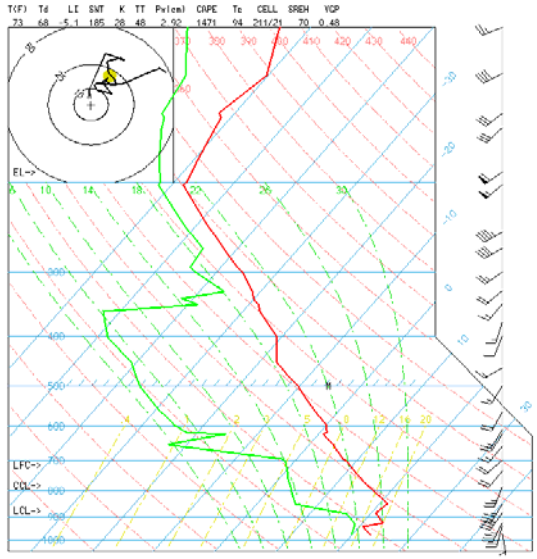
Reflectivity forecast



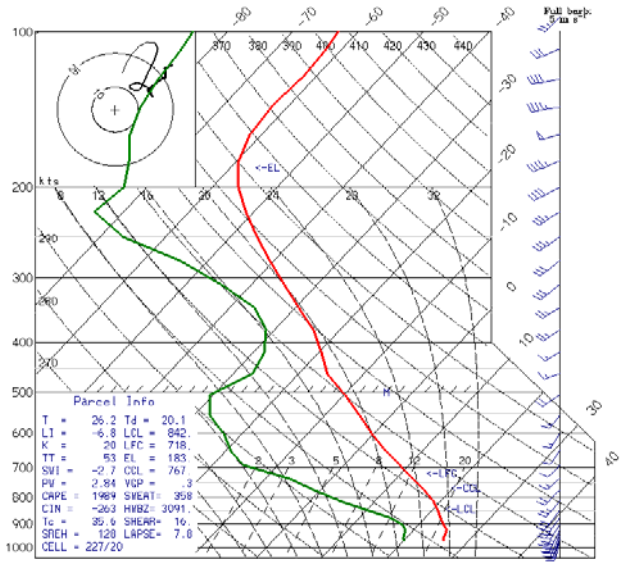
Composite NEXRAD Radar

TOP 07 June 2005 12 UTC

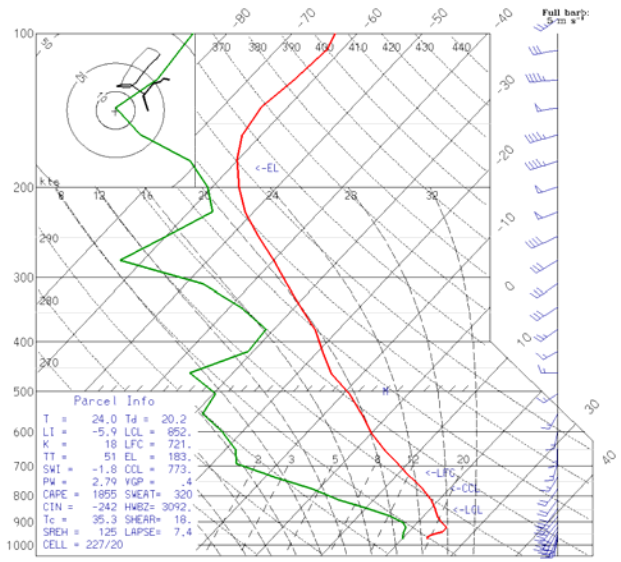
OBS



YSU PBL
(12 h)

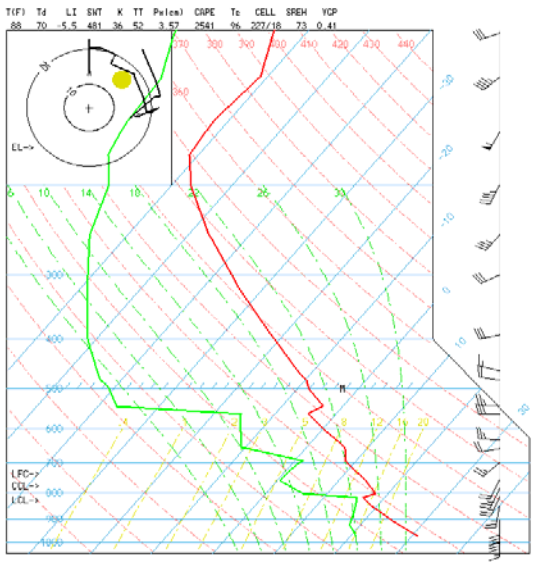


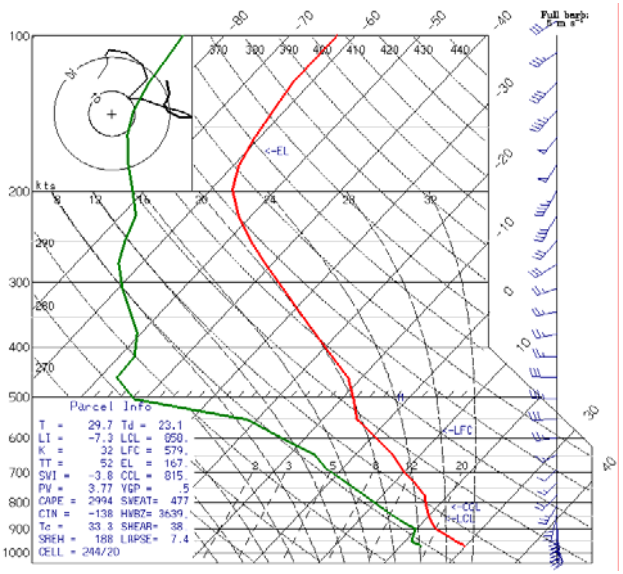
MYJ PBL
(12 h)



TOP 08 June 2005 00 UTC

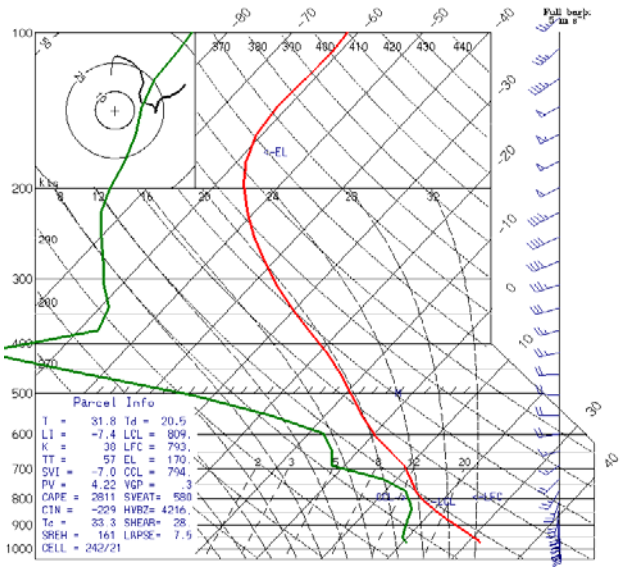
OBS

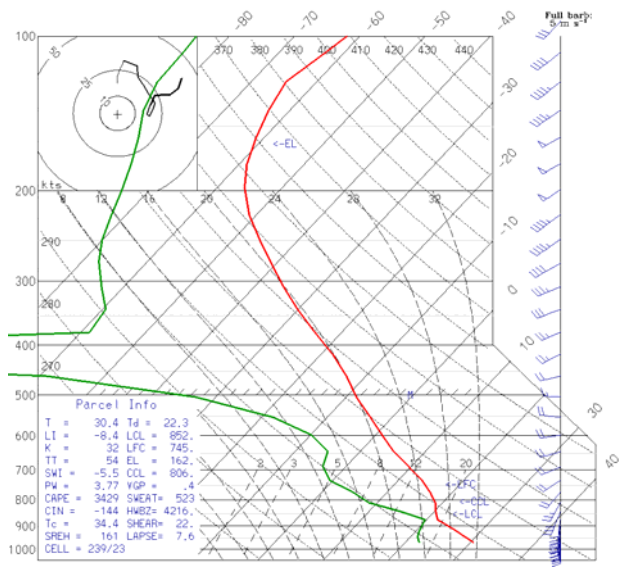




(00h)

YSU PBL
(24h)

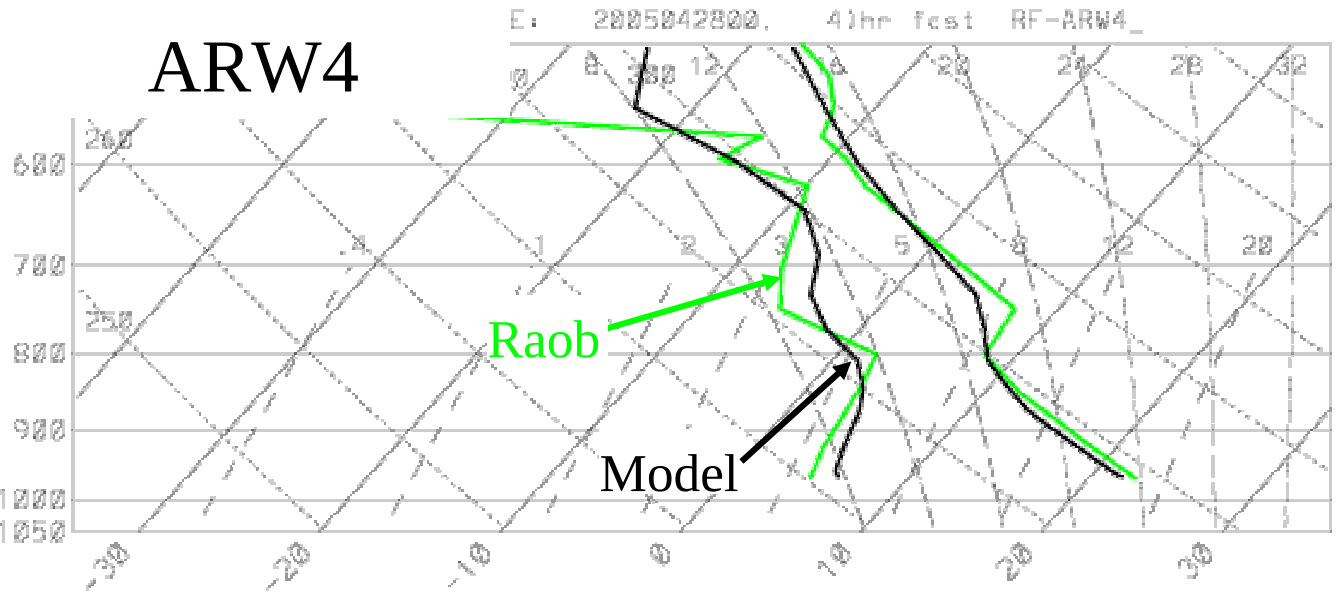




MYJ PBL
(24h)

Sounding comparison: 24h forecast valid 00Z 28 April at OUN

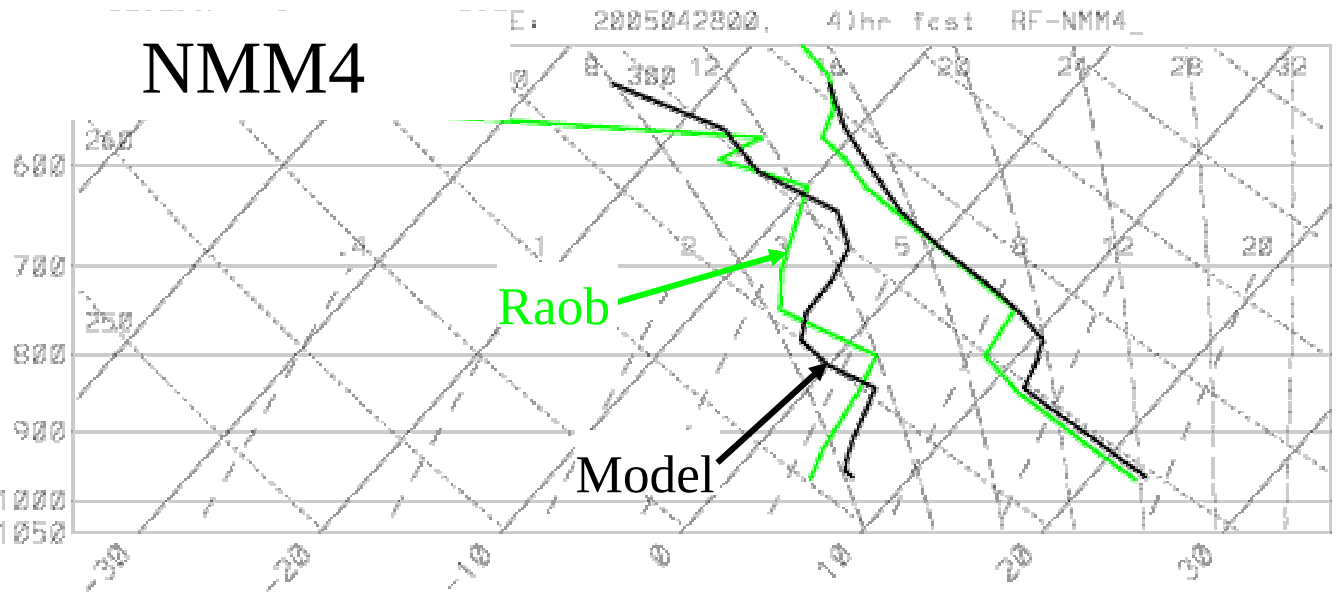
ARW4



YSU

Good in PBL, but CIN layer is washed out

NMM4

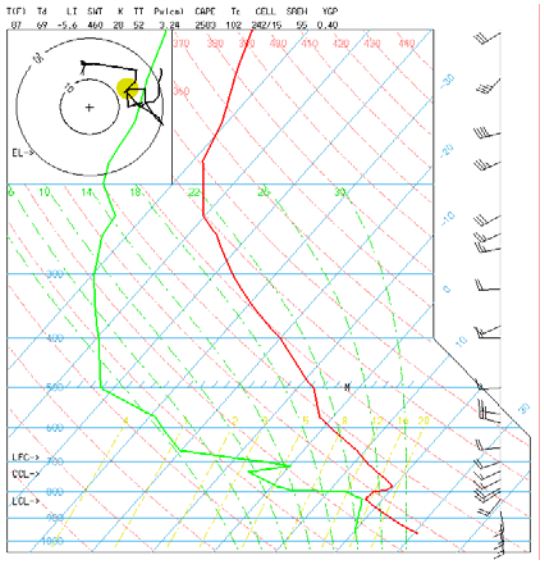


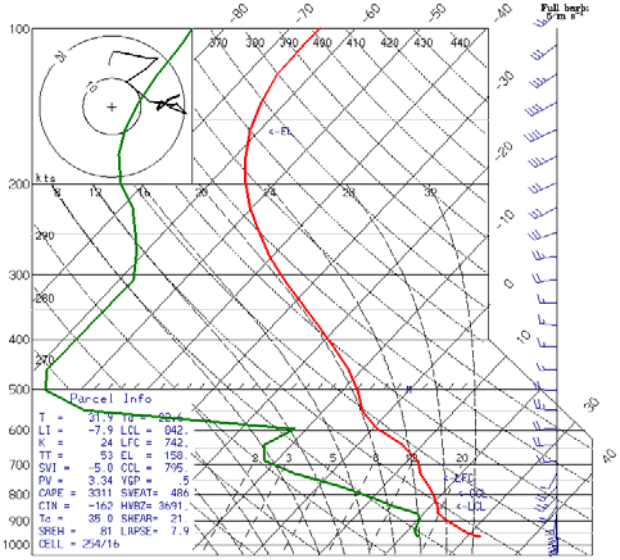
MYJ

PBL too shallow and moist, but CIN layer looks good

OUN 08 June 2005 00 UTC

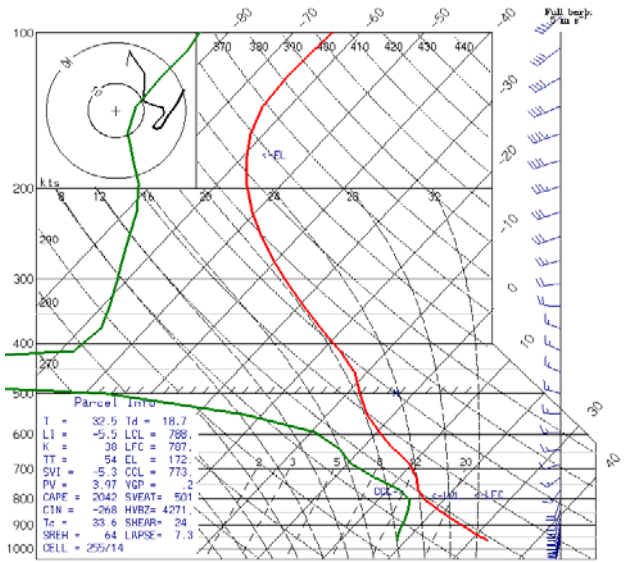
OBS

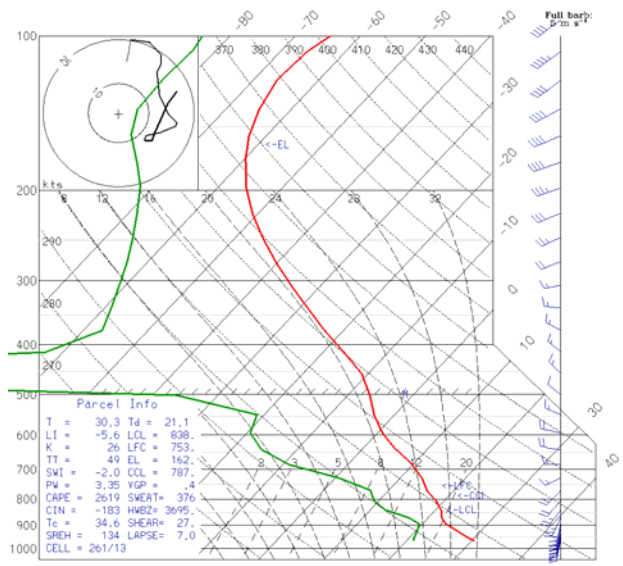




(00h)

YSU PBL
(24h)

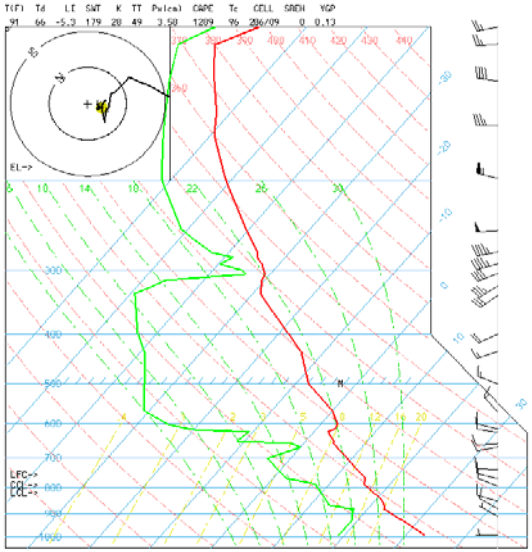


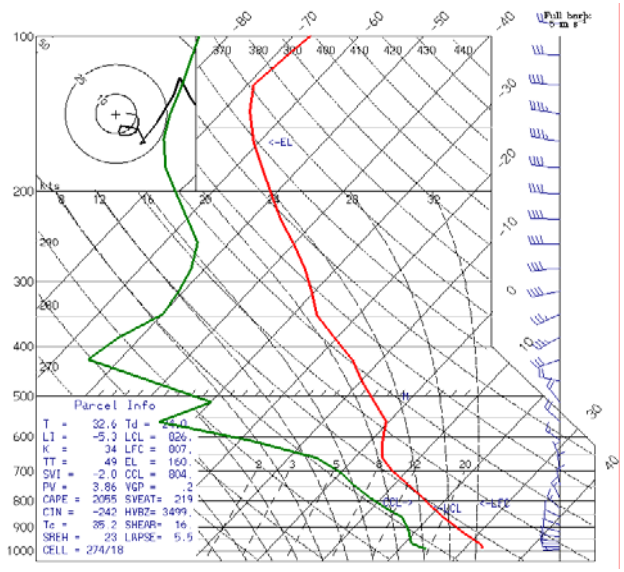


MYJ PBL
(24h)

BNA 01 July 2005 00 UTC

OBS





(00h)

YSU PBL
(24h)