Interesting observations and research questions from CSU's participation in MPEX

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Research supported by NSF grant AGS-1157425

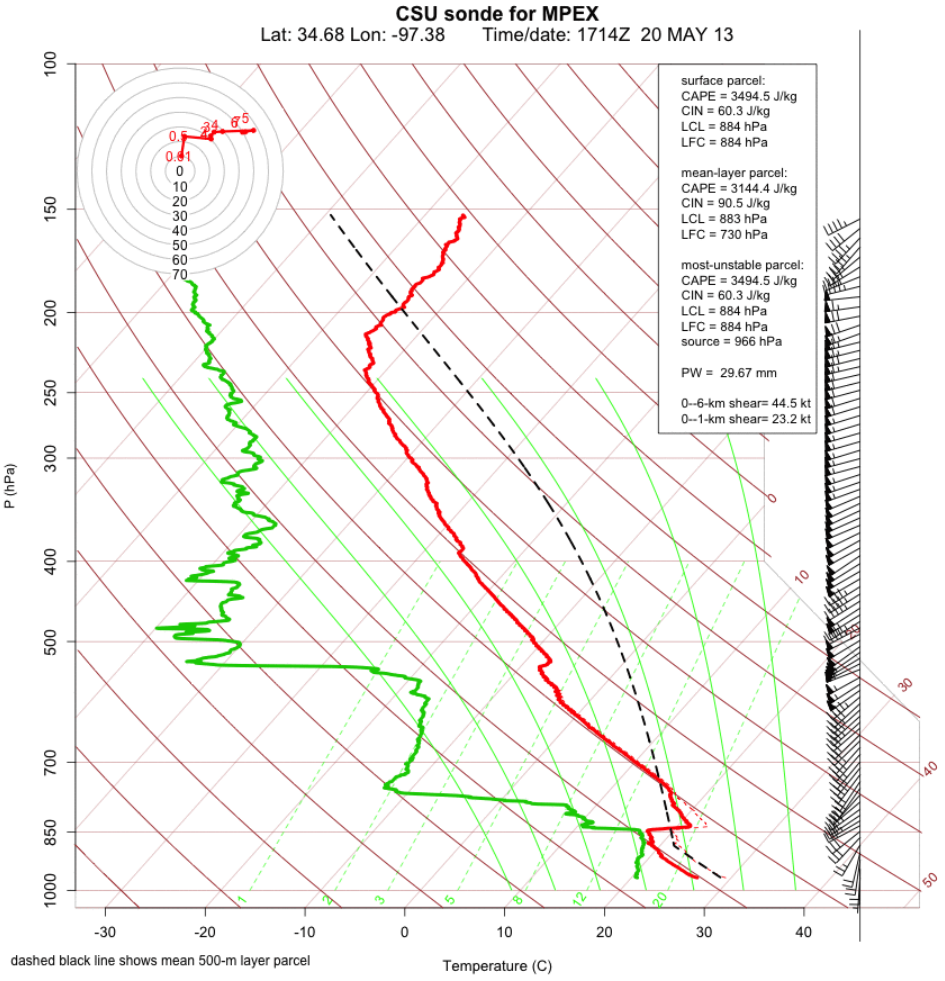
MPEX workshop, 19 November 2013

Overview

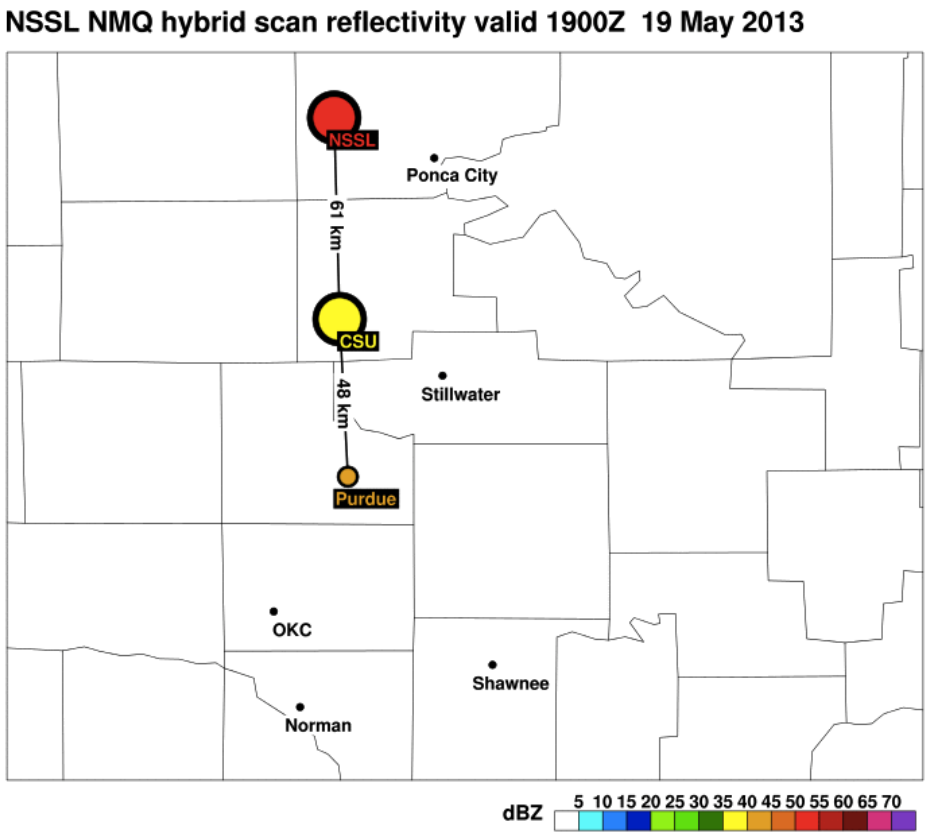
- Four CSU graduate students and myself collected upsonde observations during MPEX
- Was the first time that the CSU sonde system had been used in a non-fixed setup, and was almost completely successful (after some wiring modifications in Colby, KS – thanks to Matt Paulus!)
- 52 successful soundings collected in a variety of pre-convective and convectively disturbed environments (unlike other groups, we could only have 1 sonde in the air at a time)

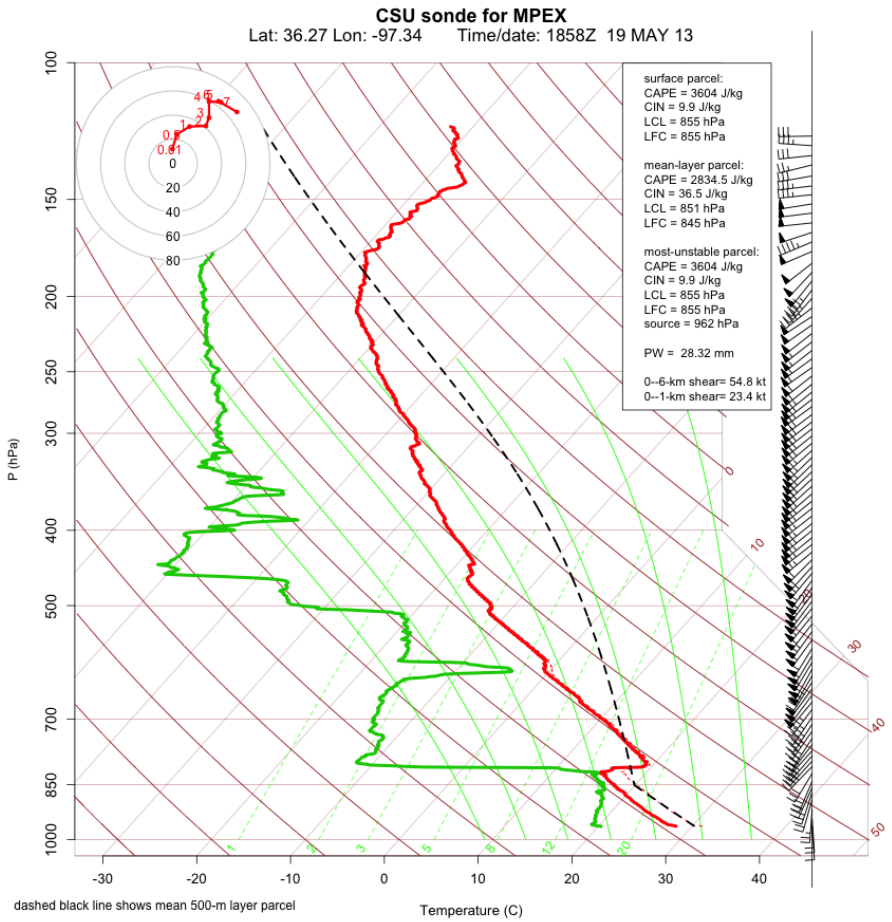
19-20 May tornadic supercells

- Successful coordination of upsonde launches on very difficult (logistically and mentally) severe weather days in central Oklahoma
- ATS 680 class at CSU evaluated PBL parameterizations in WRF in relation to MPEX soundings (following the methods of Coniglio et al. 2013, *WAF*)
- Model initialized from GFS at 1200 UTC 19 May and integrated for 36 hours; 4-km horizontal grid spacing, 51 vertical levels



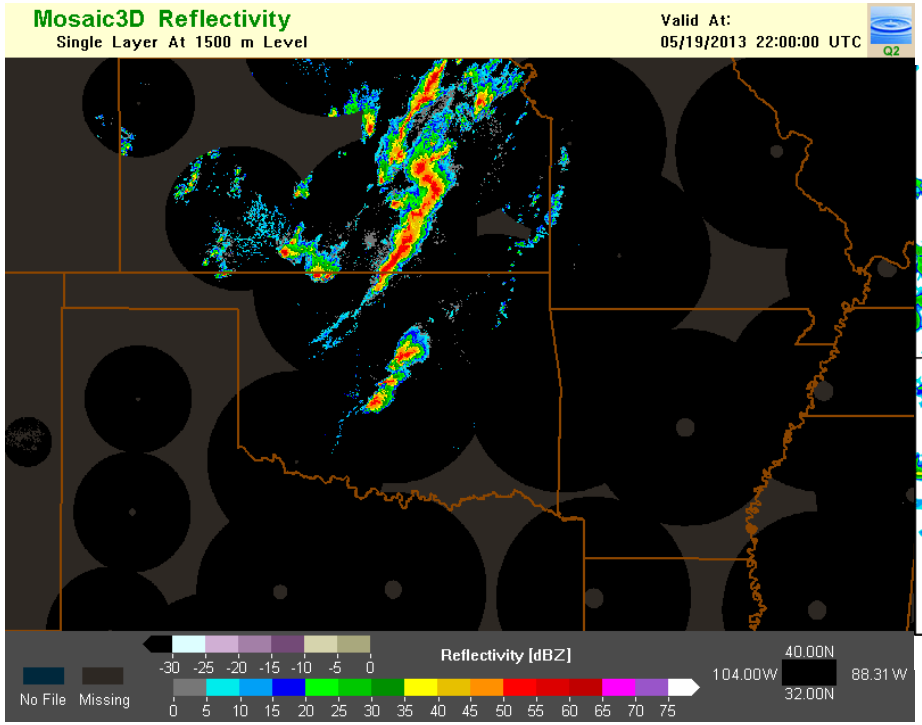
CSU MPEX sounding: 1858 UTC 19 May 2013

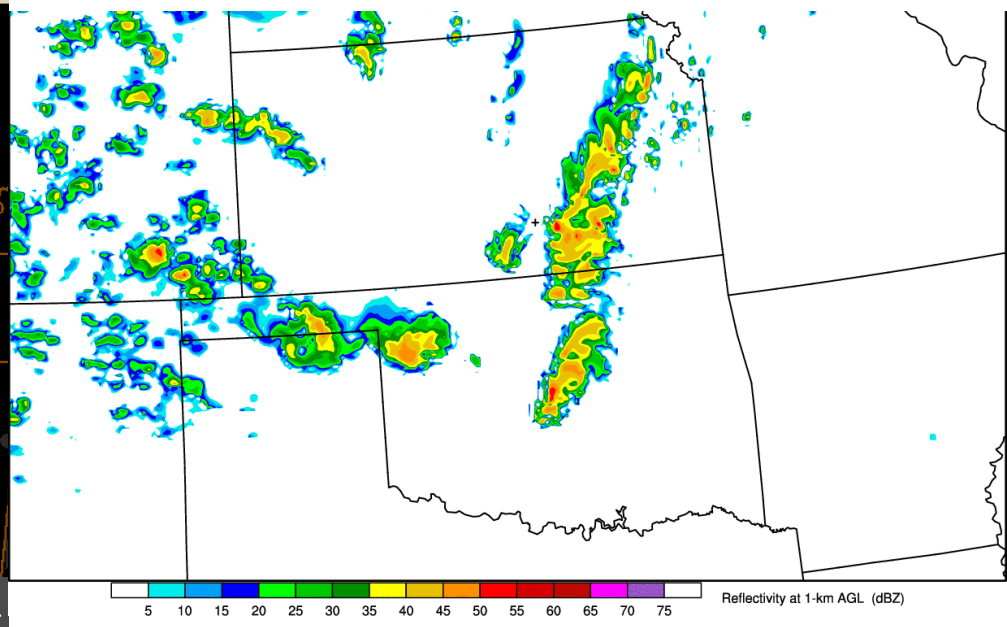




(figure from Mike Coniglio)

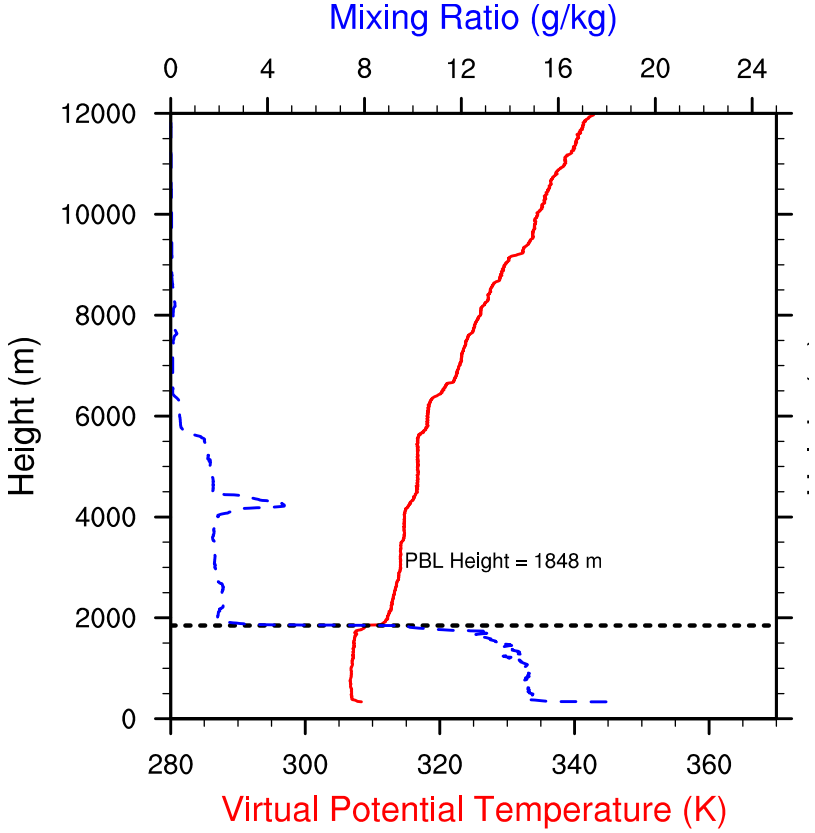
CSU real-time forecast valid 2200 UTC (10-h forecast)



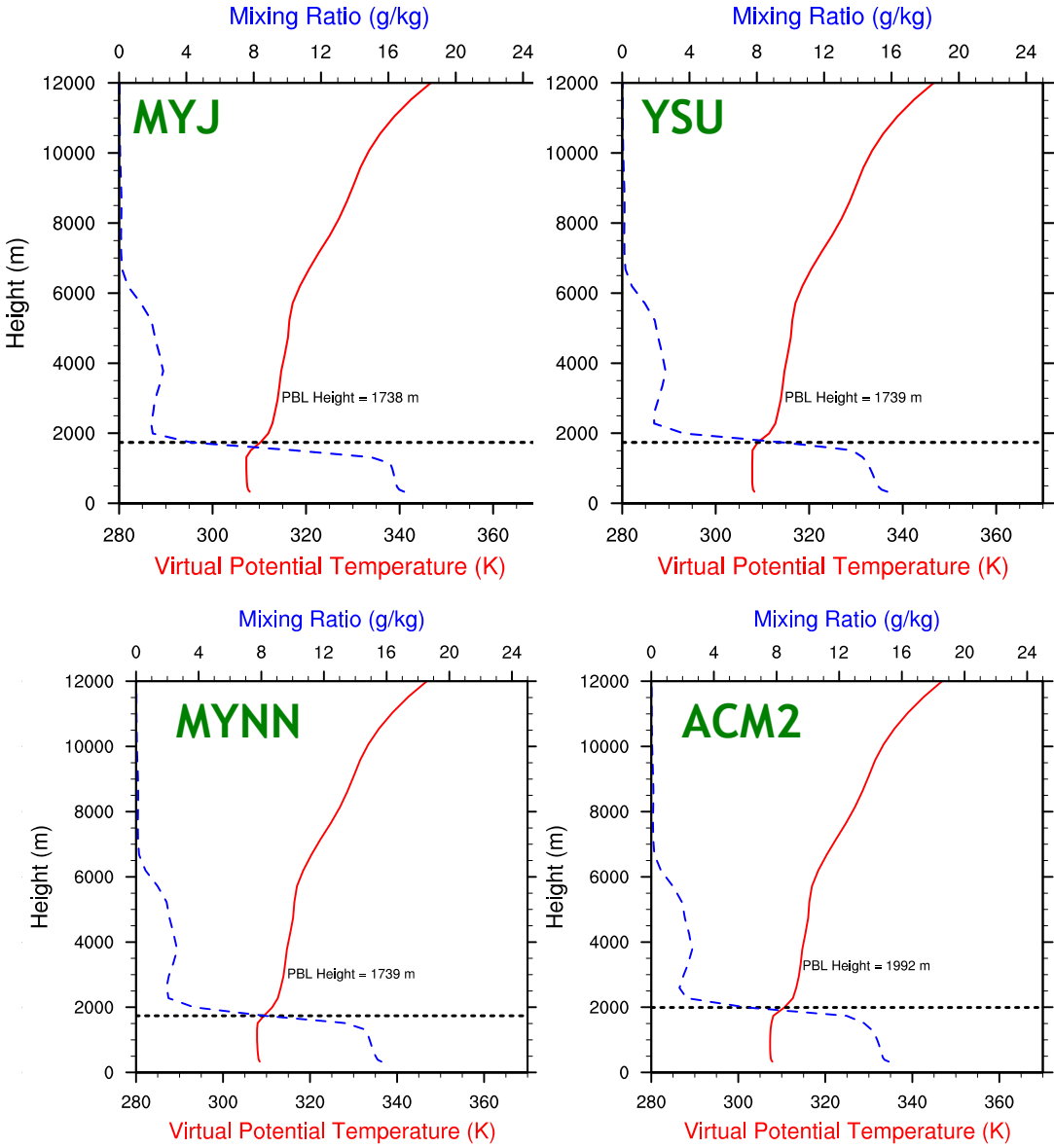


(figure from OU NMQ website)

Observed, 1858 UTC

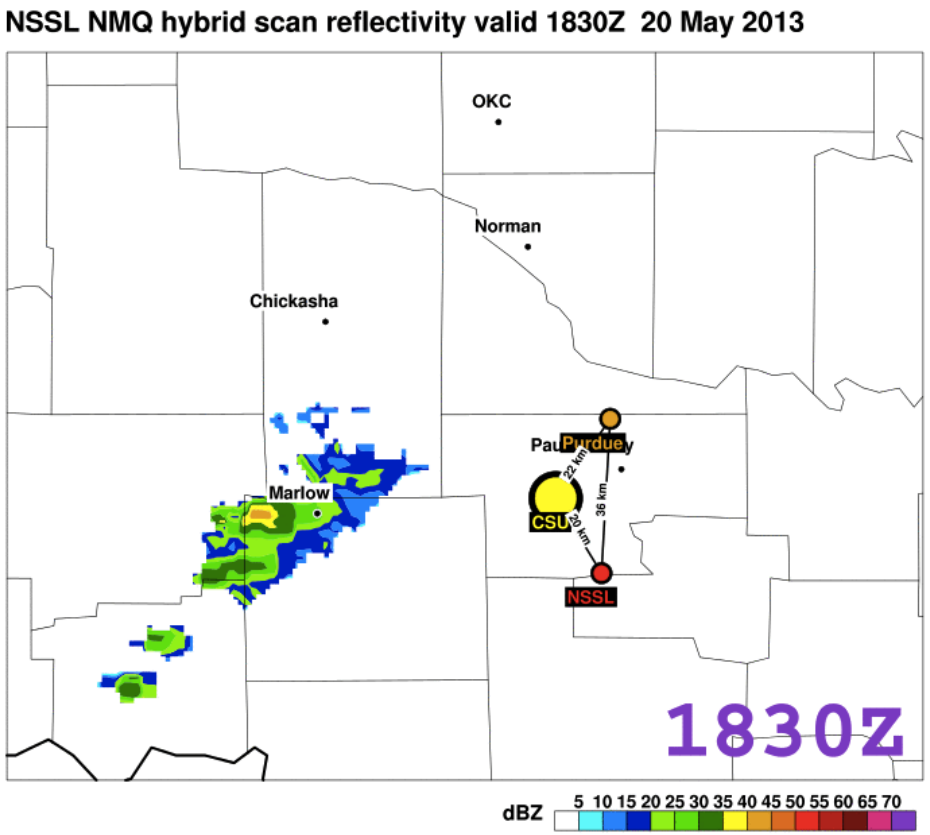


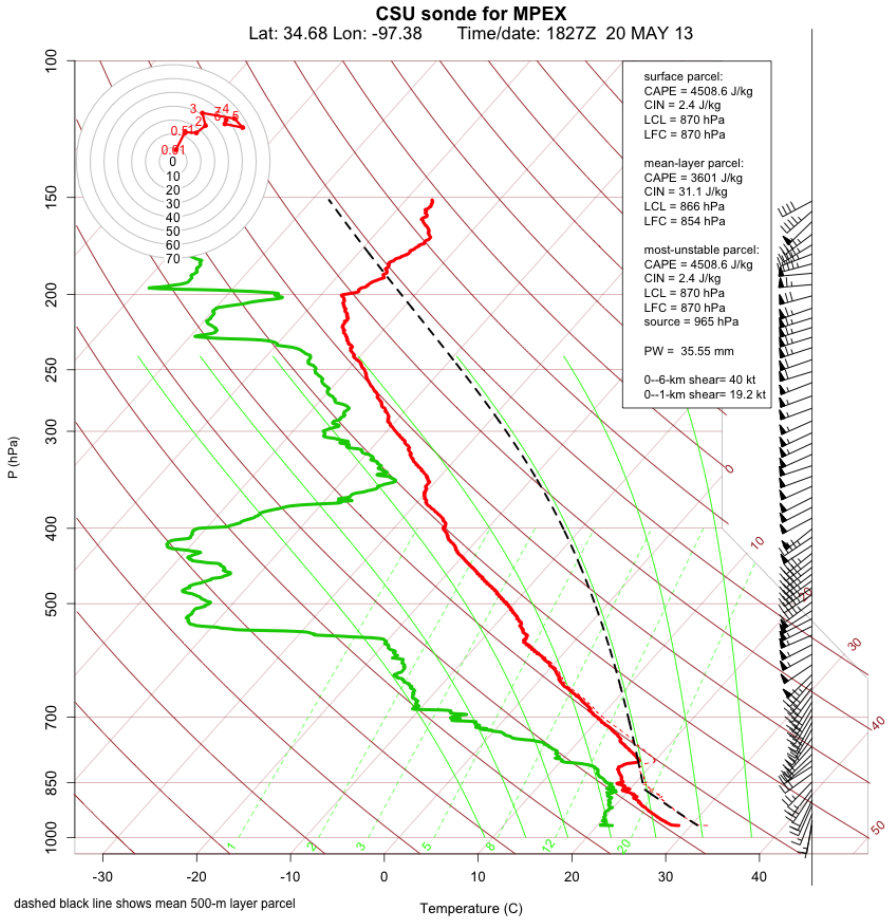
WRF 7-hour forecasts



All PBL schemes generally similar in this short-lead forecast; all underpredict PBL height by ~100 m except ACM2

CSU MPEX sounding: 1827 UTC 20 May 2013

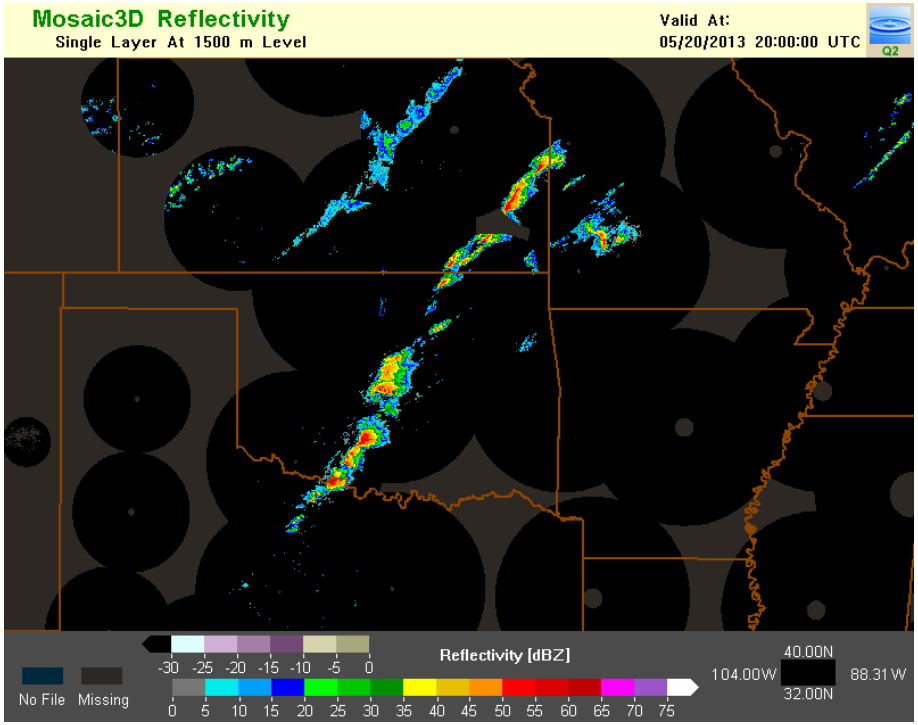


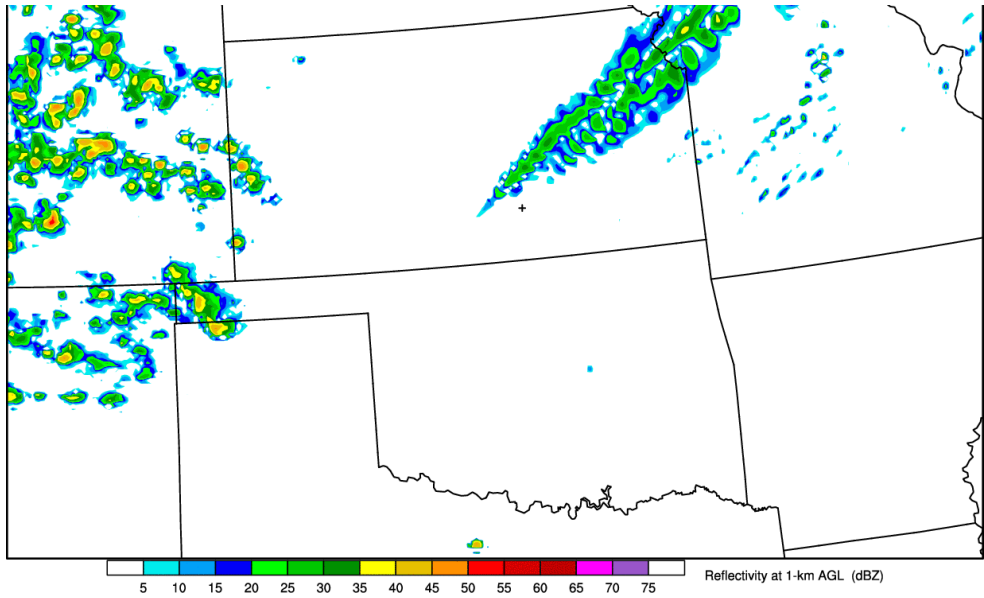


(figure from Mike Coniglio)

PBL has deepened owing to large-scale ascent

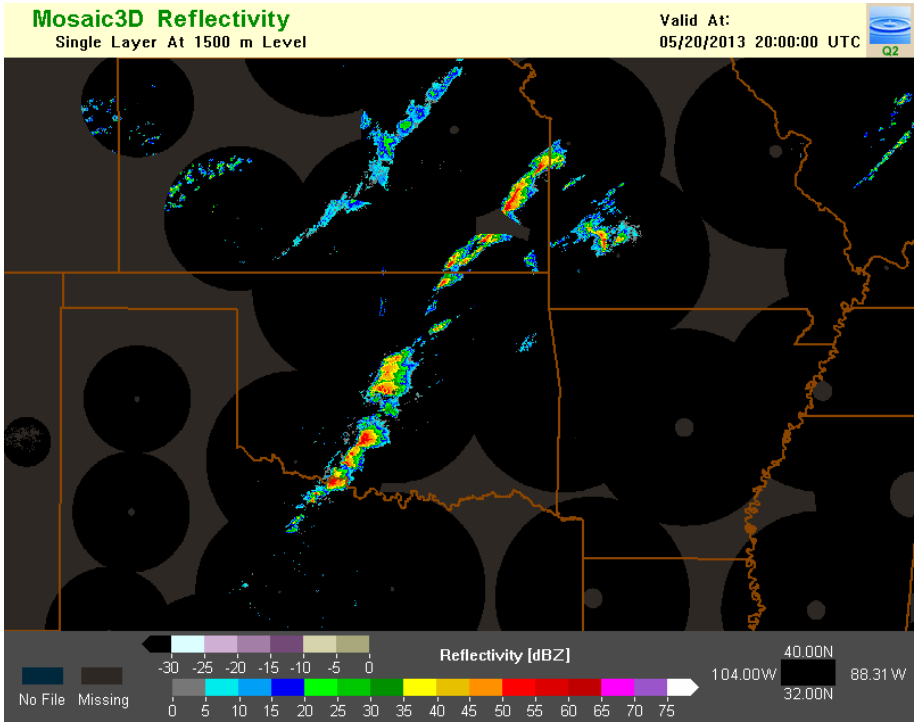
CSU real-time forecast valid 2000 UTC 20 May (32-h forecast)



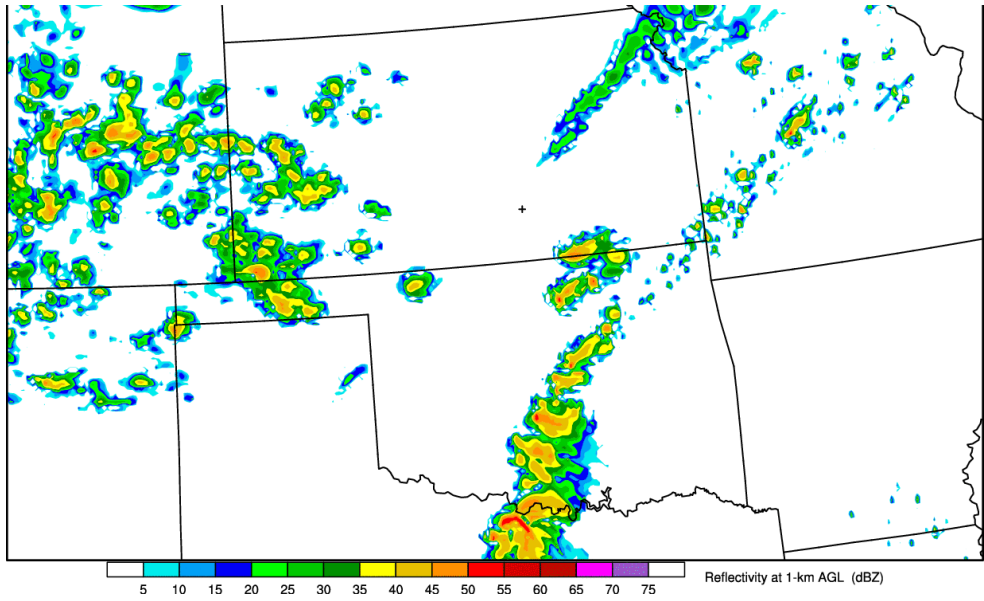


(figure from OU NMQ website)

CSU real-time forecast valid 2200 UTC 20 May (34-h forecast)

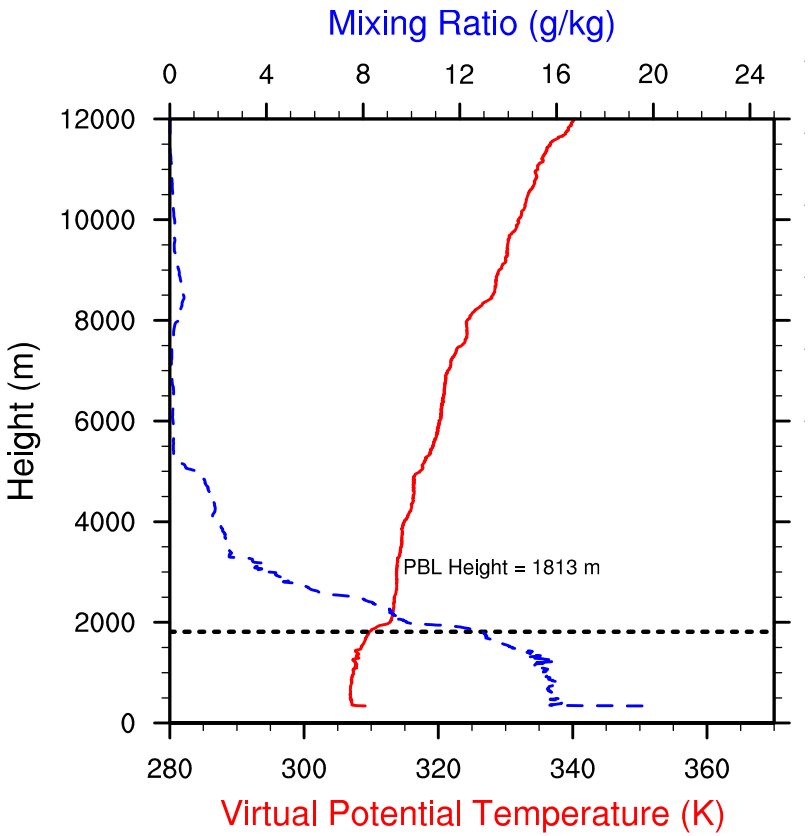


(figure from OU NMQ website)

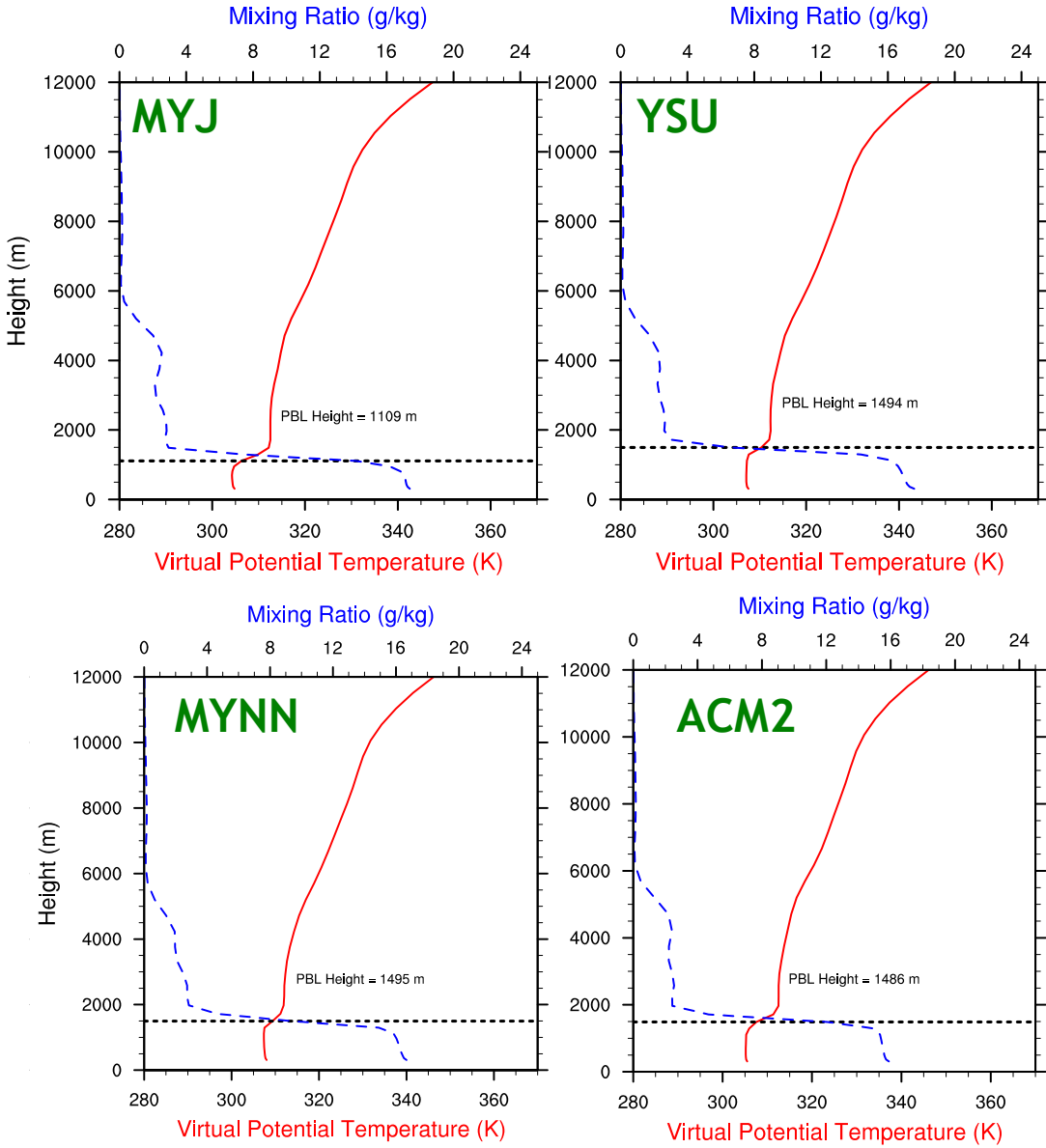


Day-2 forecasts consistently predict convection initation 2-4 hours later than observed

Observed, 1827 UTC



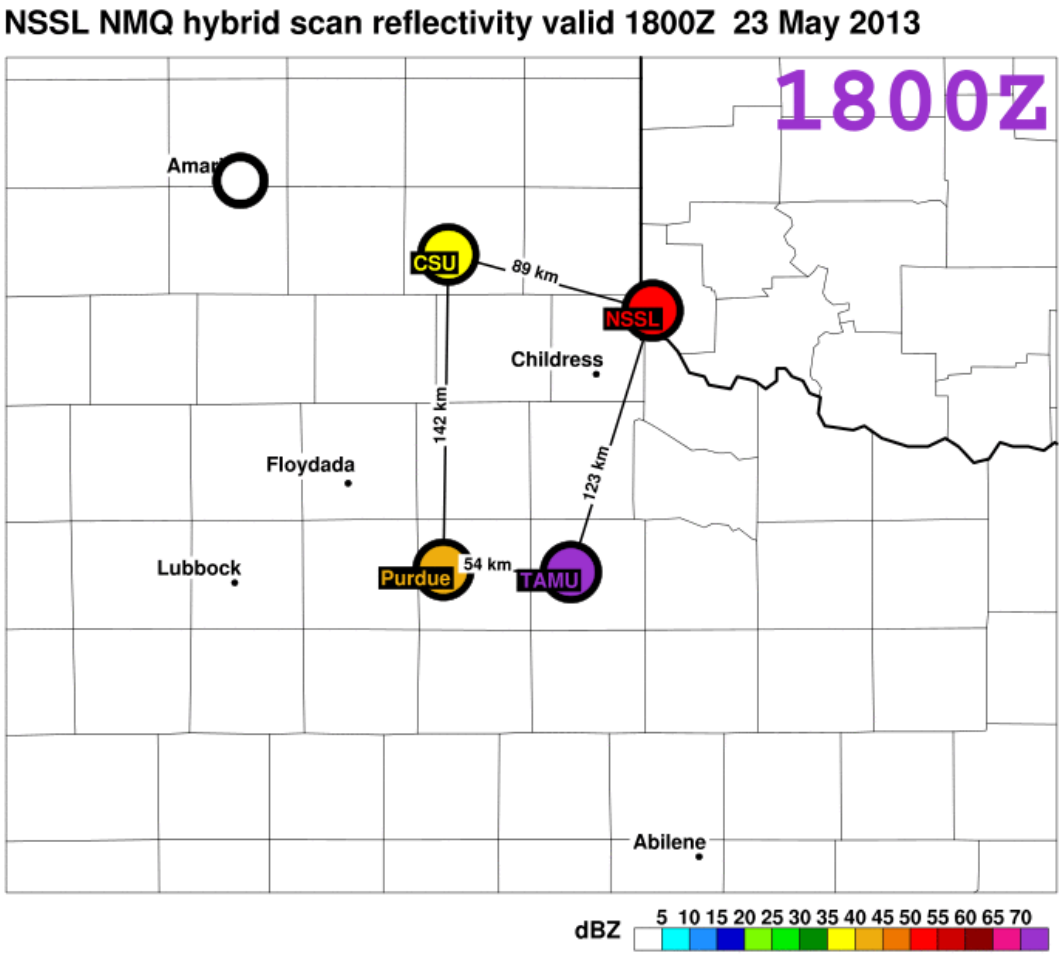
WRF 30-hour forecasts



Usual biases apparent (MYJ moist and shallow, etc.) by day 2 of forecast, but all schemes have PBL too shallow and cap too strong – convection initiates late

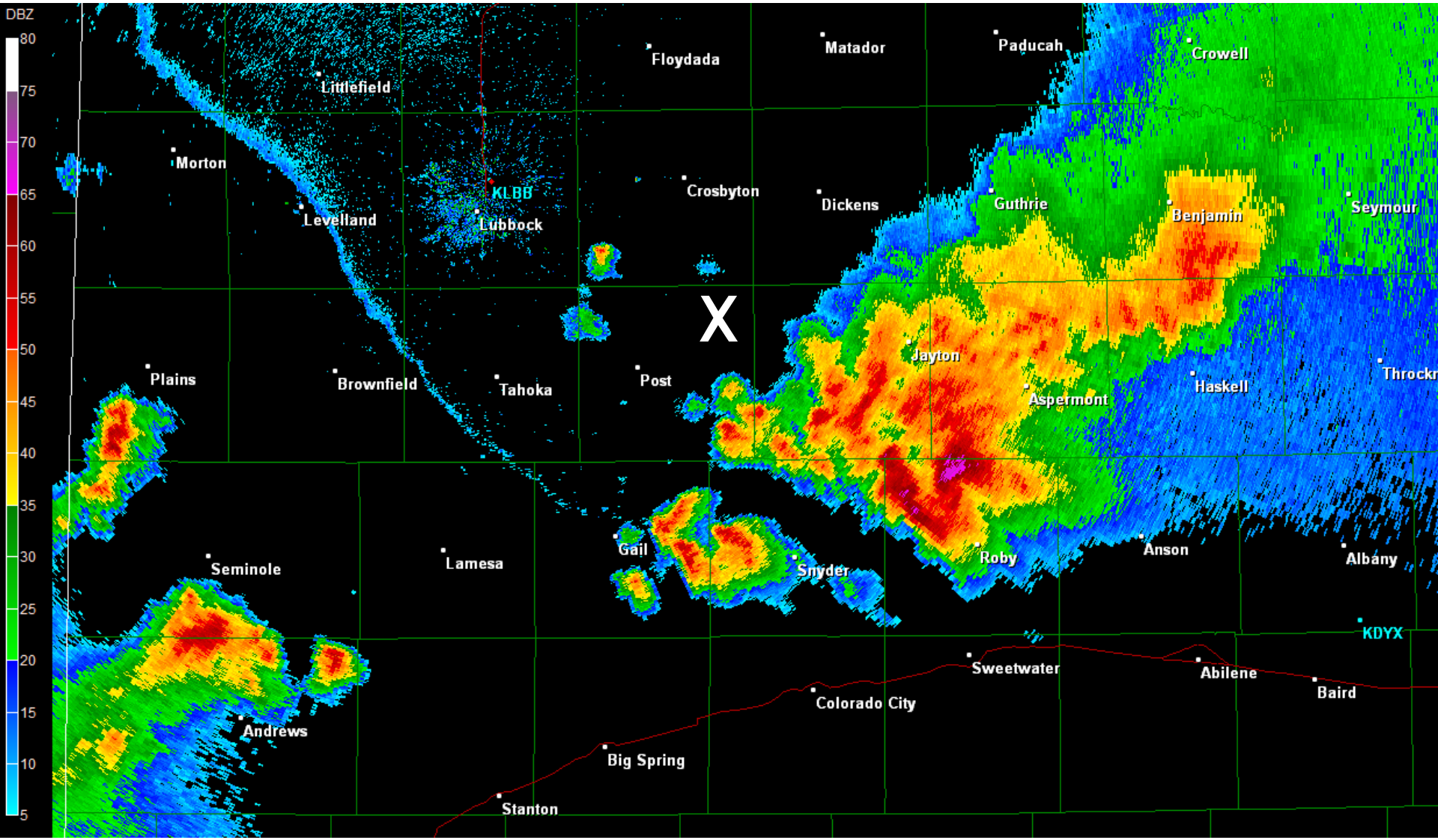
Insufficient synoptic/mesoscale ascent in model?

23 May supercells → squall line

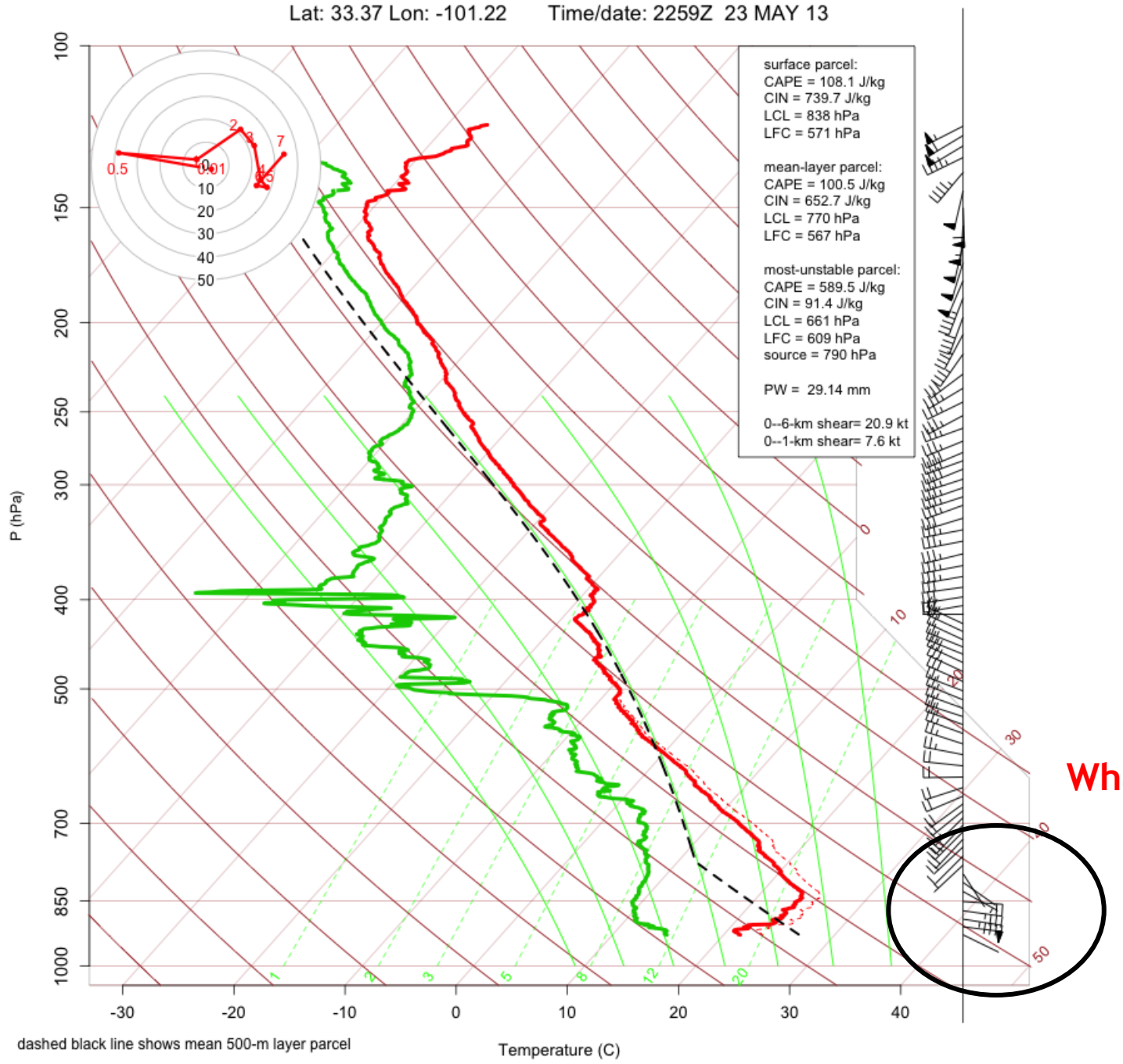


(animation from Mike Coniglio)

2300 UTC 23 May

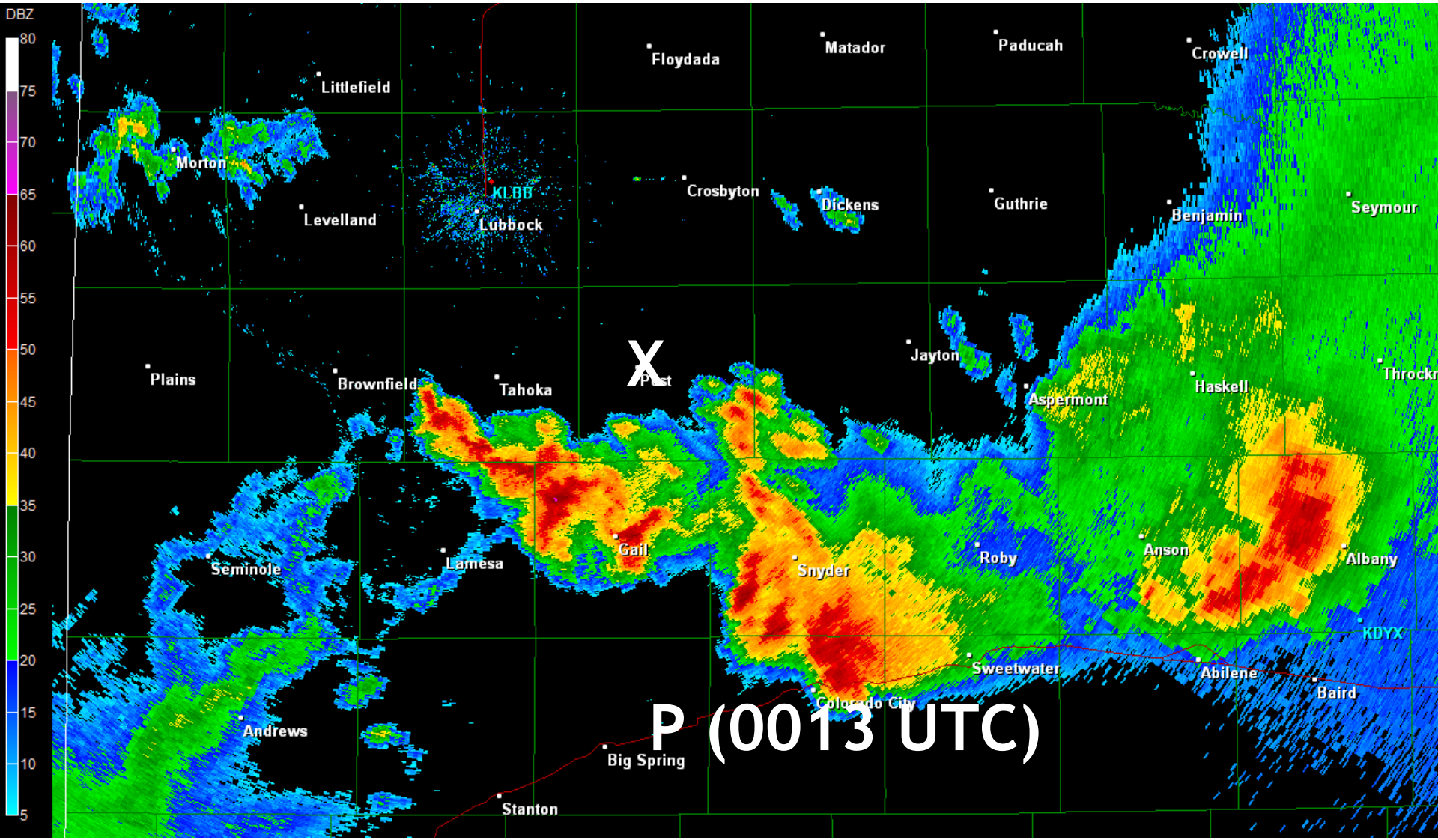


Sounding taken in the cold pool


CSU sonde for MPEX
Lat: 33.37 Lon: -101.22 Time/date: 2259Z 23 MAY 13
surface parcel:
CAPE = 108.1 J/kg
CIN = 739.7 J/kg
LCL = 838 hPa
LFC = 571 hPa
mean-layer parcel:
CAPE = 100.5 J/kg
CIN = 652.7 J/kg
LCL = 770 hPa
LFC = 567 hPa
most-unstable parcel:
CAPE = 589.5 J/kg
CIN = 91.4 J/kg
LCL = 661 hPa
LFC = 609 hPa
source = 790 hPa
PW = 29.14 mm
0--6-km shear= 20.9 kt
0--1-km shear= 7.6 kt
P (hPa)
Temperature (C)
dashed black line shows mean 500-m layer parcel

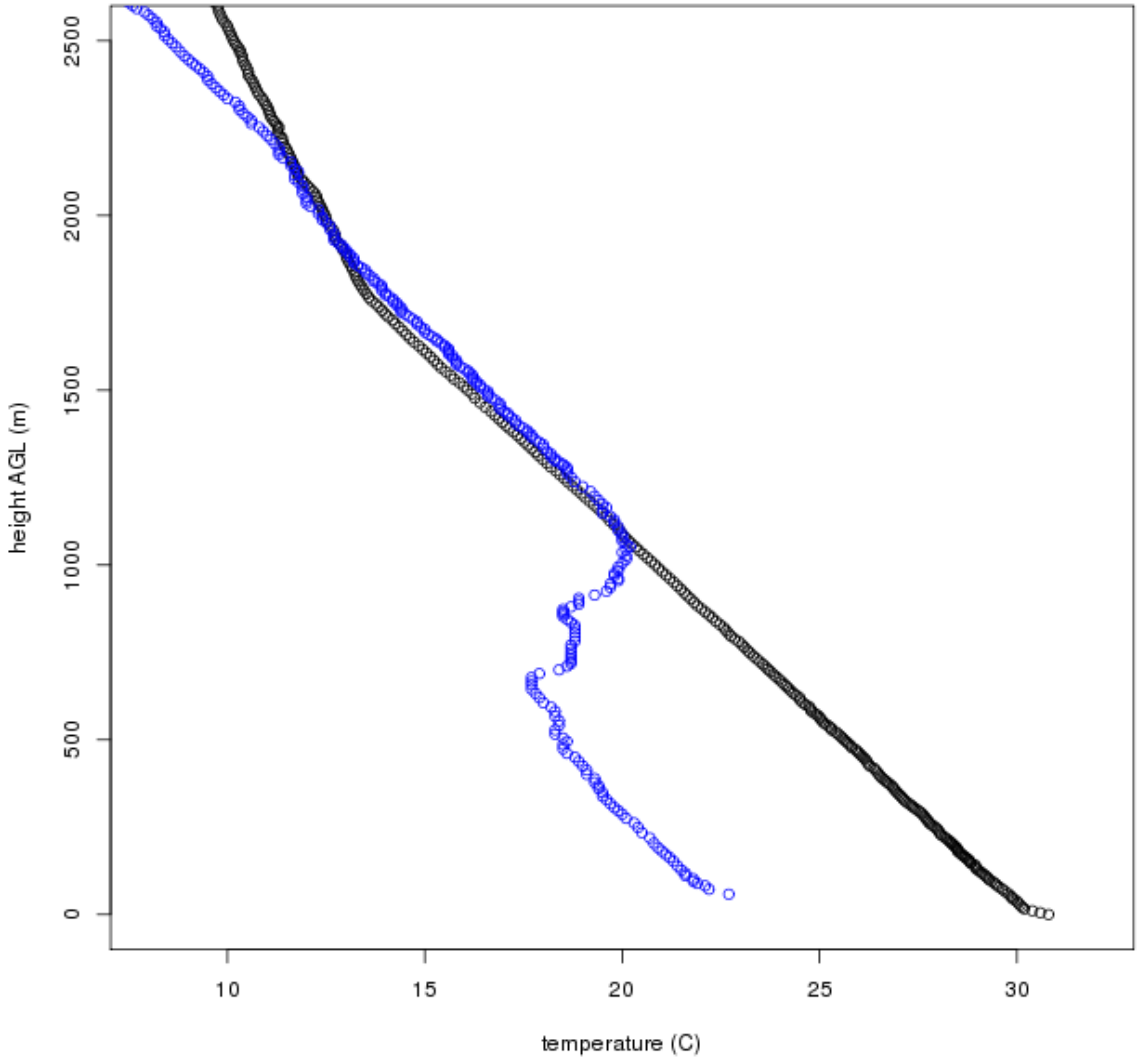
What's this?

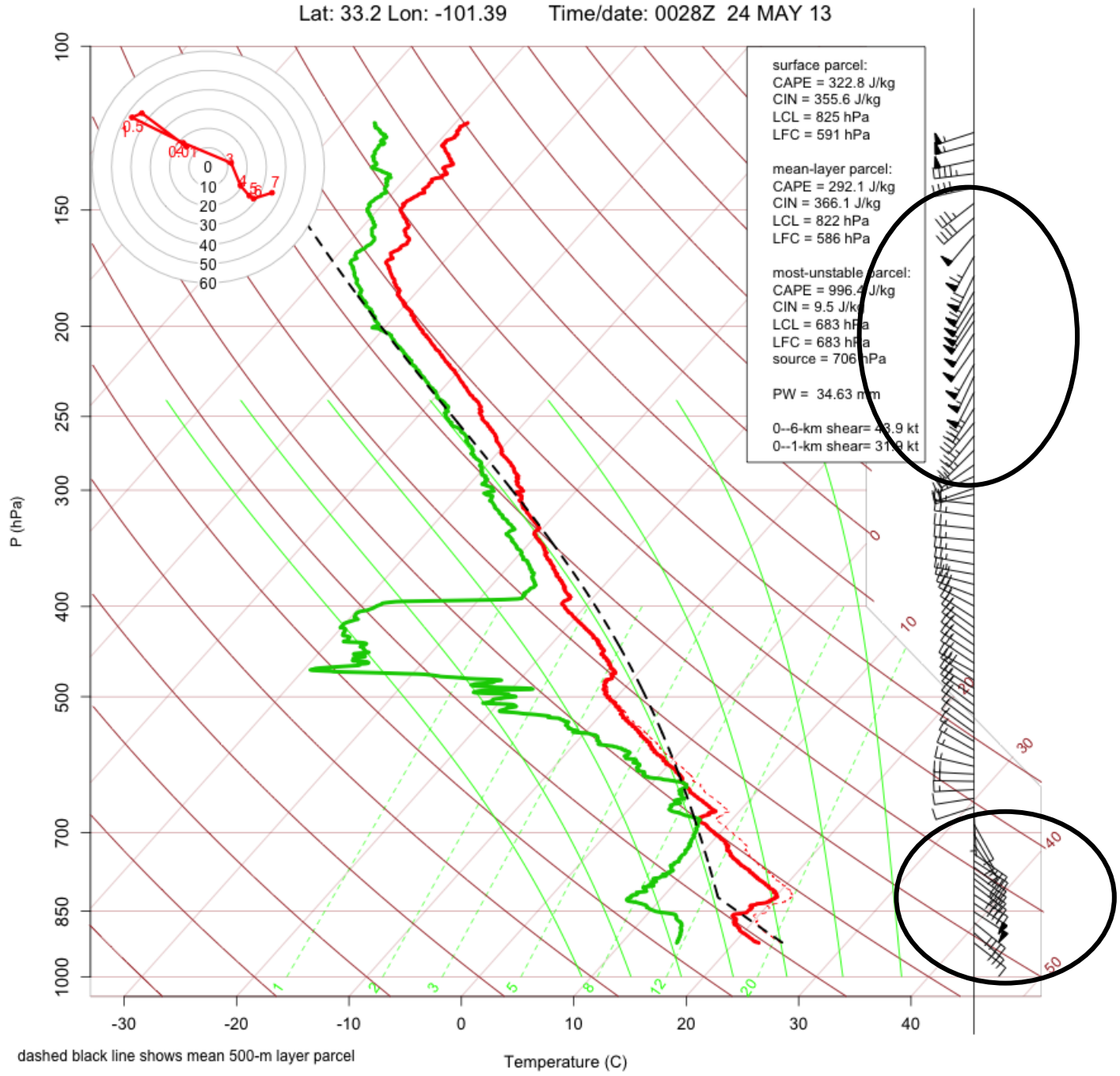
0028 UTC 24 May



Temperature profiles:
Purdue sounding (0013 UTC)
CSU sounding (0028 UTC)

Cold pool approximately
1.2 km deep with
temperature deficit of ~8 K

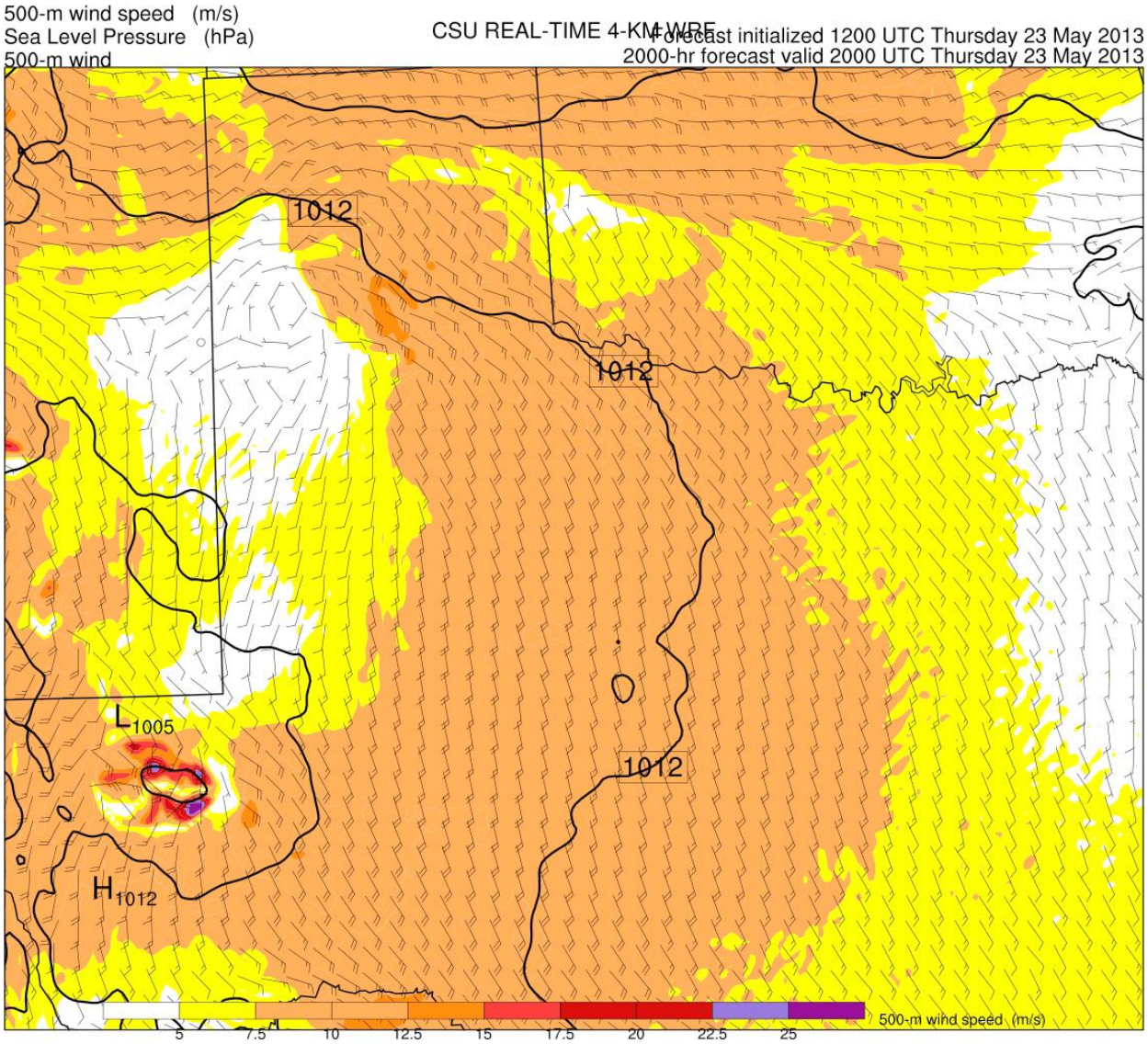



CSU sonde for MPEX
Lat: 33.2 Lon: -101.39 Time/date: 0028Z 24 MAY 13
surface parcel:
CAPE = 322.8 J/kg
CIN = 355.6 J/kg
LCL = 825 hPa
LFC = 591 hPa
mean-layer parcel:
CAPE = 292.1 J/kg
CIN = 366.1 J/kg
LCL = 822 hPa
LFC = 586 hPa
most-unstable parcel:
CAPE = 996.4 J/kg
CIN = 9.5 J/kg
LCL = 683 hPa
LFC = 683 hPa
source = 706 hPa
PW = 34.63 mm
0--6-km shear= 43.9 kt
0--1-km shear= 31.9 kt
P (hPa)
Temperature (C)
dashed black line shows mean 500-m layer parcel

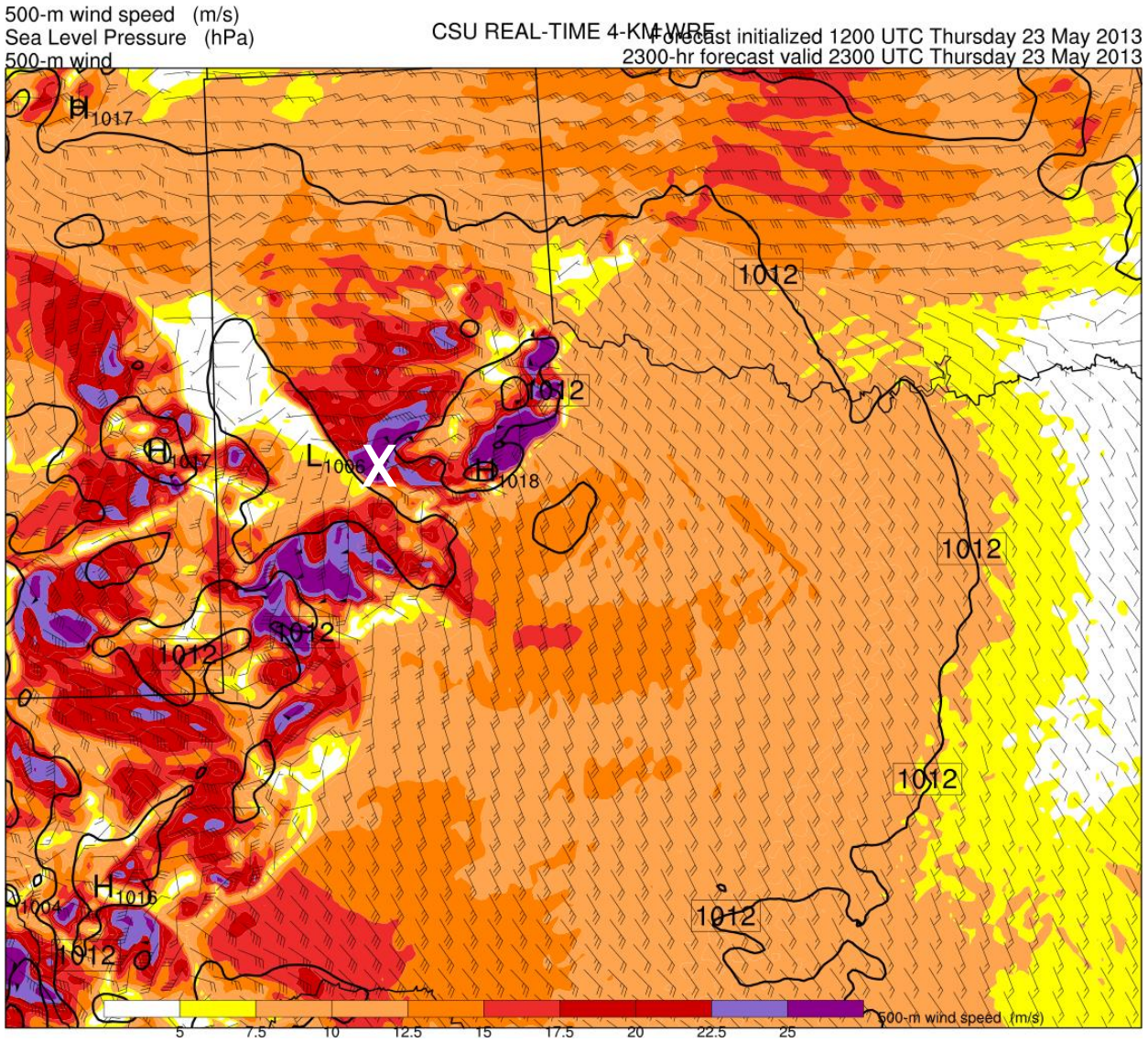
Model indicates very large pressure perturbations (mesohighs) in developing convection (8-10 mb)

Strong winds not only at the leading (downshear) edge of the squall line, but also in the cold pool

West TX mesonet did show a 92-mph surface gust and other 60+ mph gusts



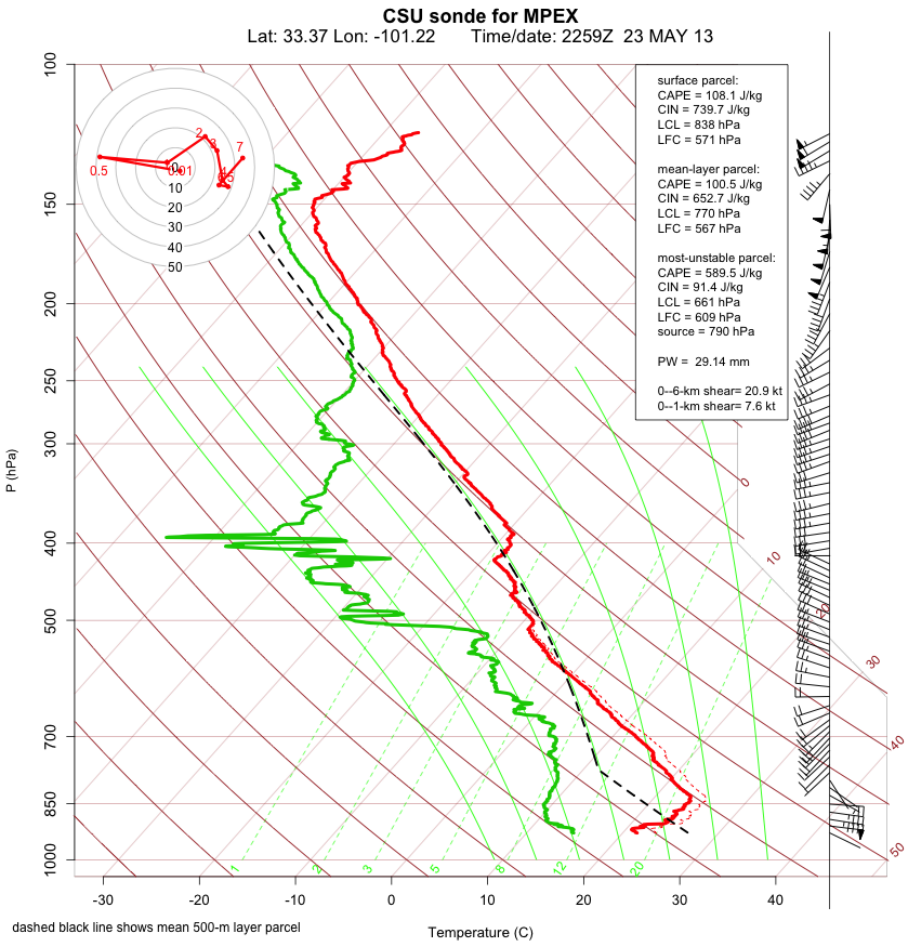
CSU real-time forecast initialized 1200 UTC 23 May: 500-meter AGL wind speed (colors) and MSLP from 2000-0115 UTC



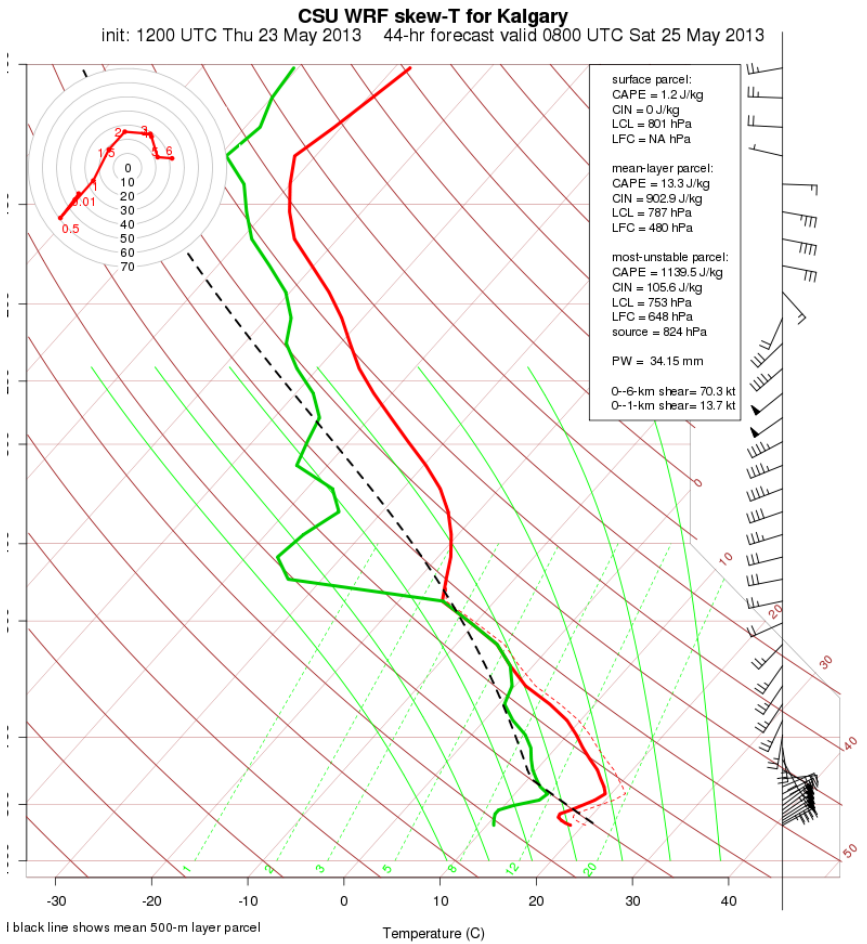
CSU real-time forecast initialized 1200 UTC 23 May: 500-meter AGL wind speed (colors) and MSLP at 2300 UTC

2300 UTC 23 May

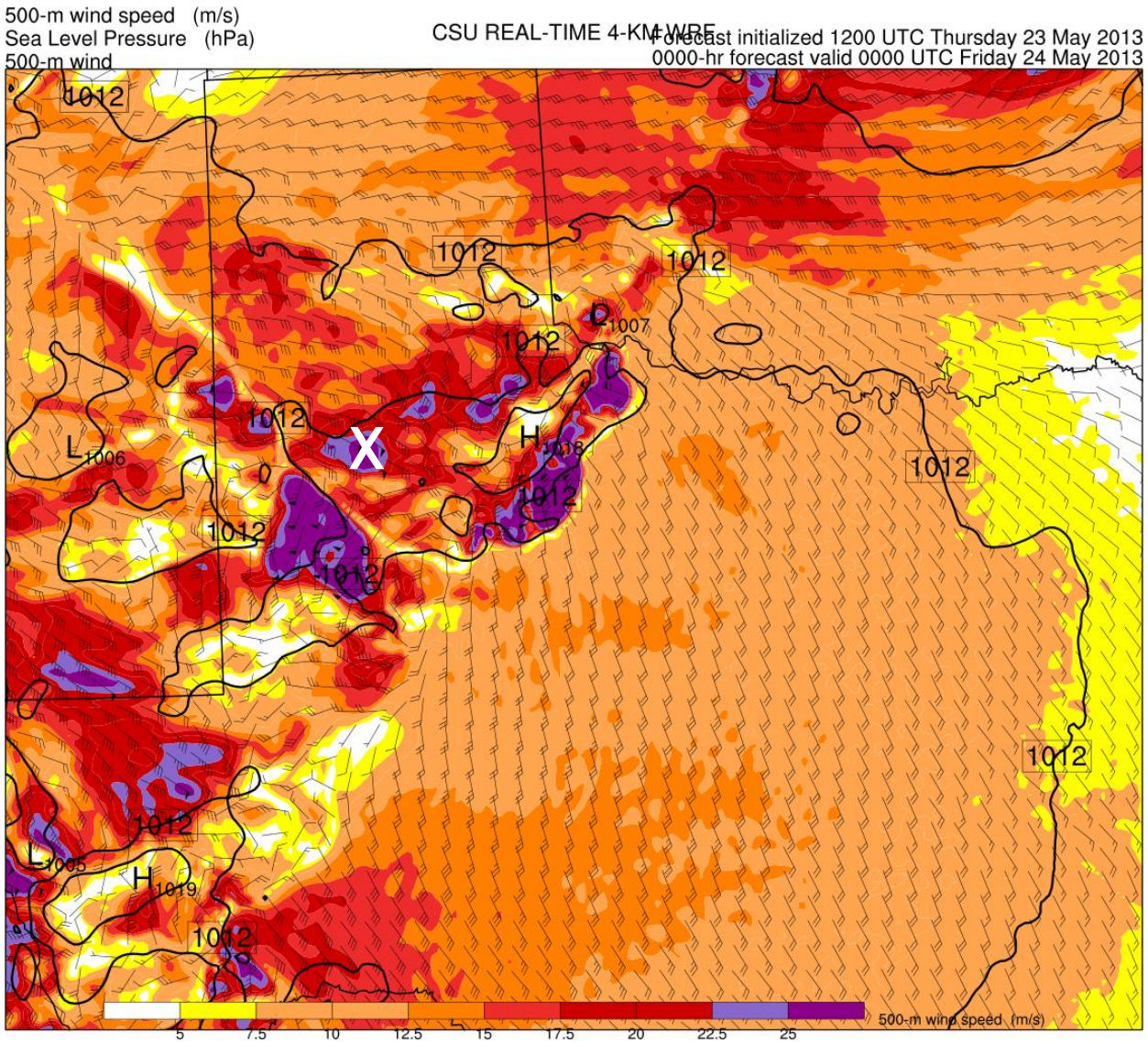
Observation



Model



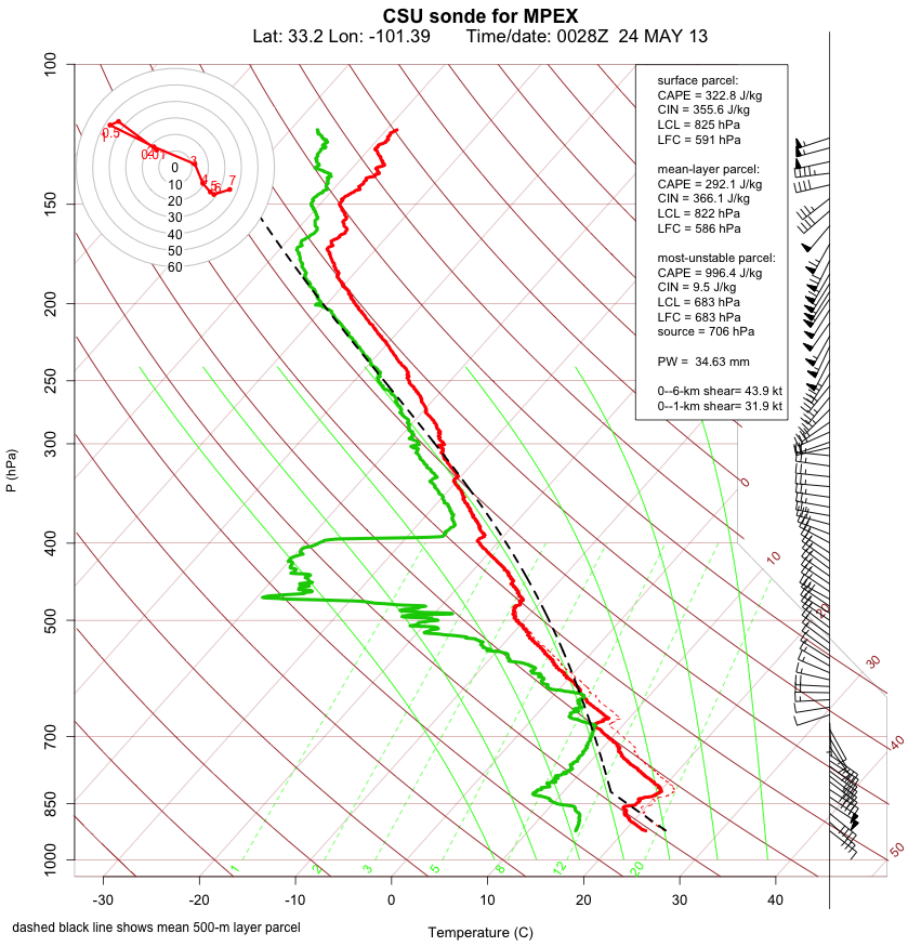
Model captures the general structure of the temperature and wind profile in the cold pool



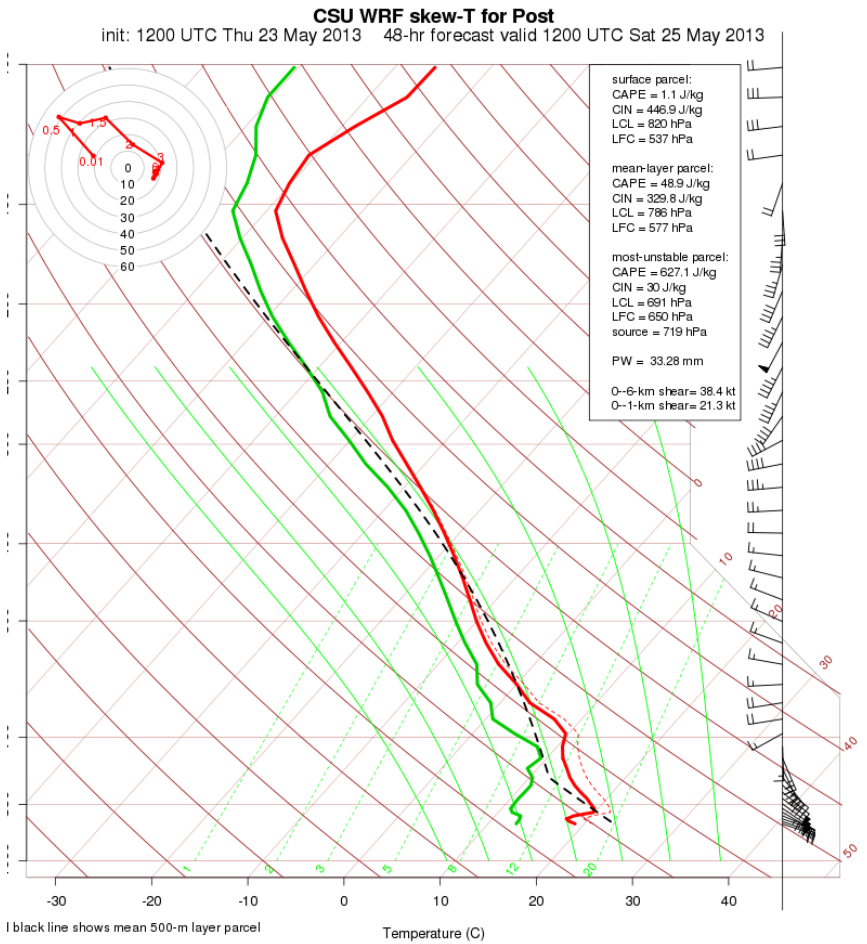
CSU real-time forecast initialized 1200 UTC 23 May: 500-meter AGL wind speed (colors) and MSLP at 0000 UTC

0000 UTC 24 May

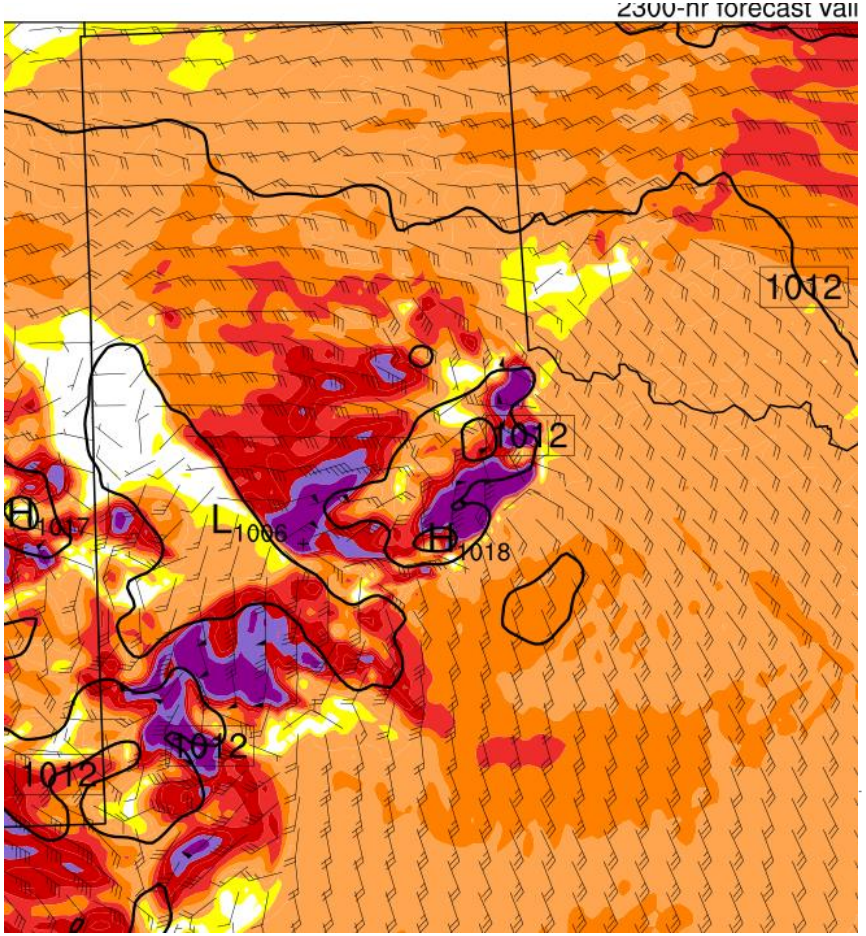
Observation (0028 UTC)

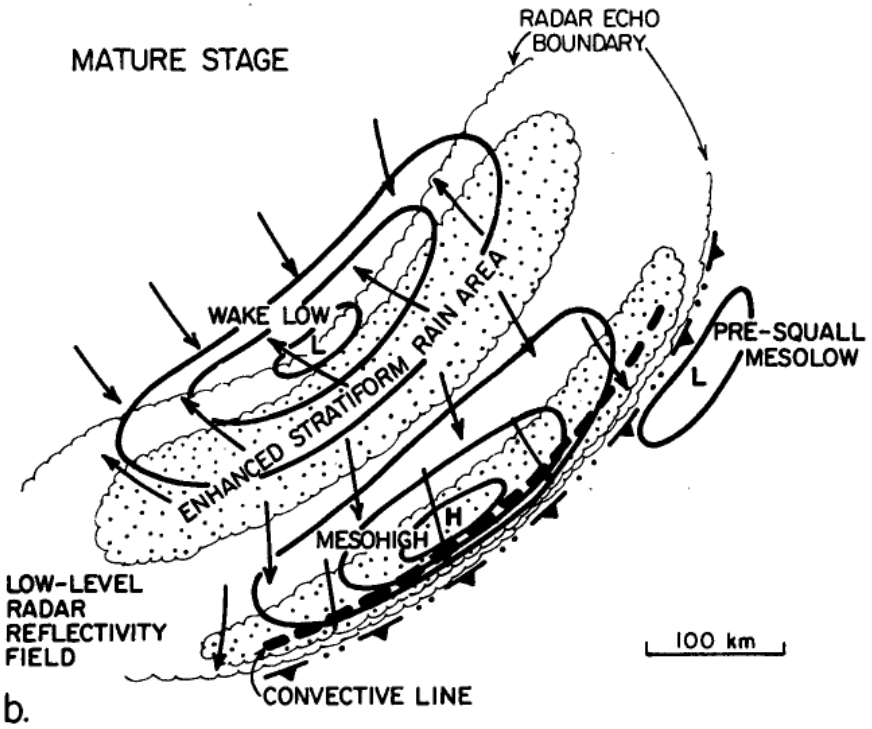


Model (0000 UTC)



Model again shows the “jet” just above the surface within the cold pool

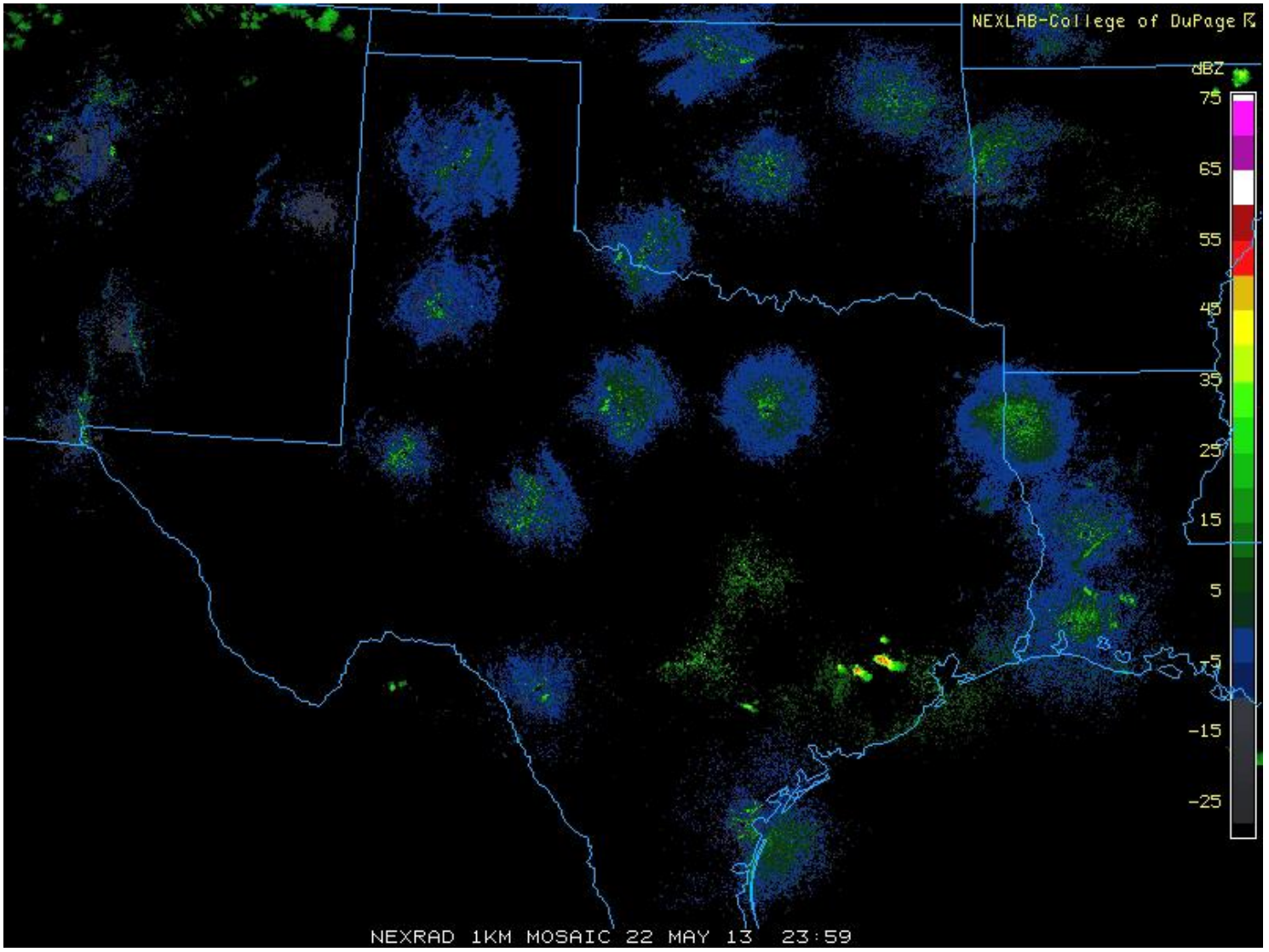




(Johnson and Hamilton 1988)

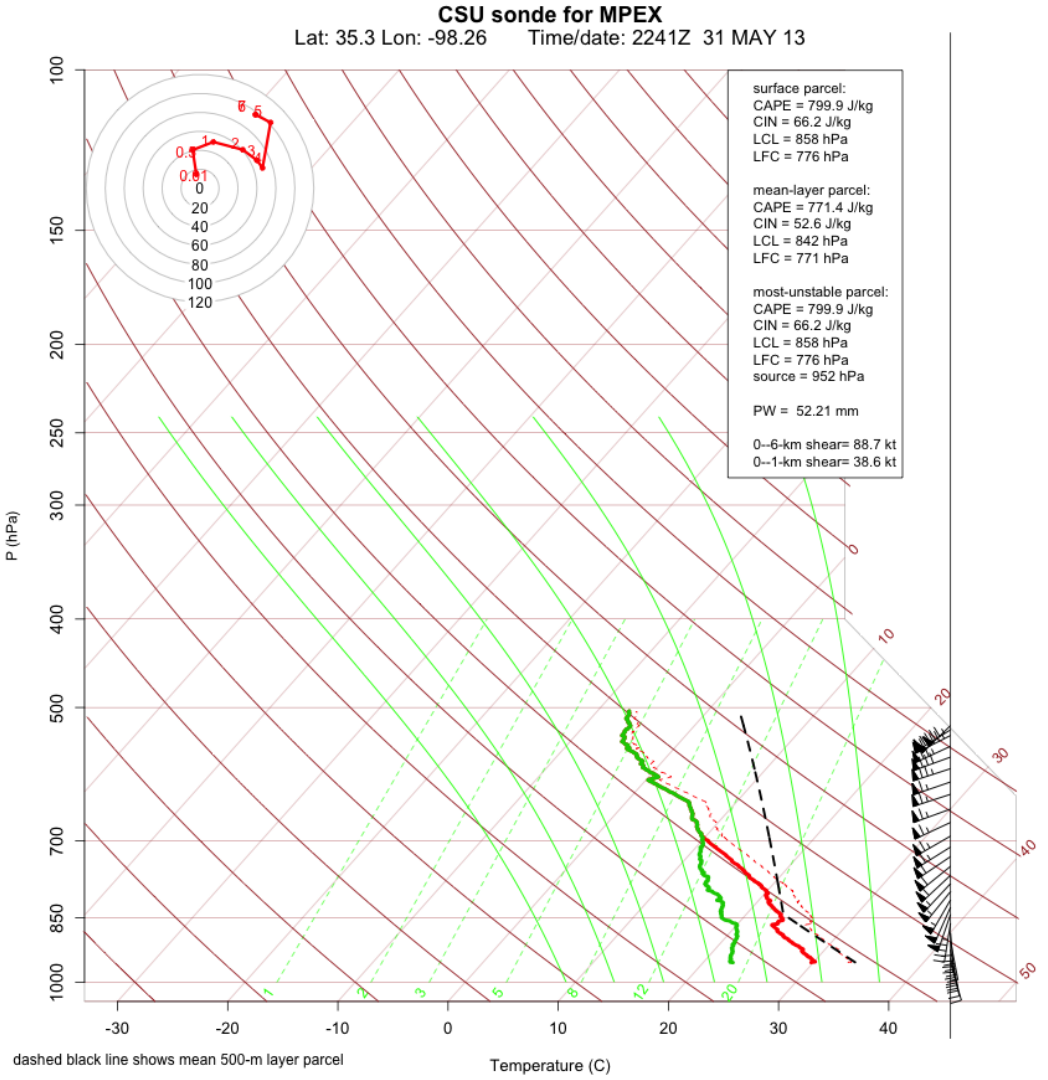
- A vague resemblance to the wind field in the Johnson and Hamilton schematic, but no traditional wake low in this case
- Also note that the model winds here are at 500-m AGL – surface easterlies were substantially weaker

Longer timescale than intended for MPEX, but any chance that dropsondes or upsondes from the 23rd could improve forecast of San Antonio flood on the 25th?

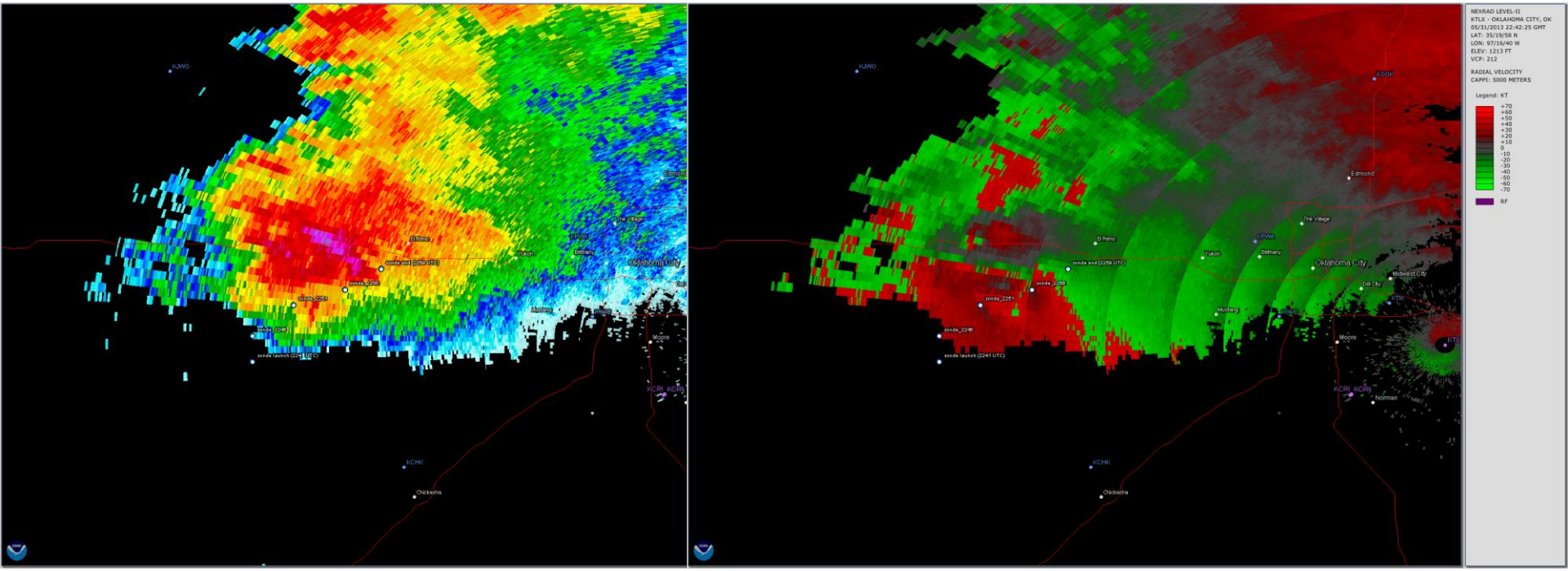


31 May 2013 – El Reno tornado and flash-flood-producing MCS

Sonde apparently entered into mesocyclone of El Reno supercell: maximum wind speed of 102 kt at ~502 mb

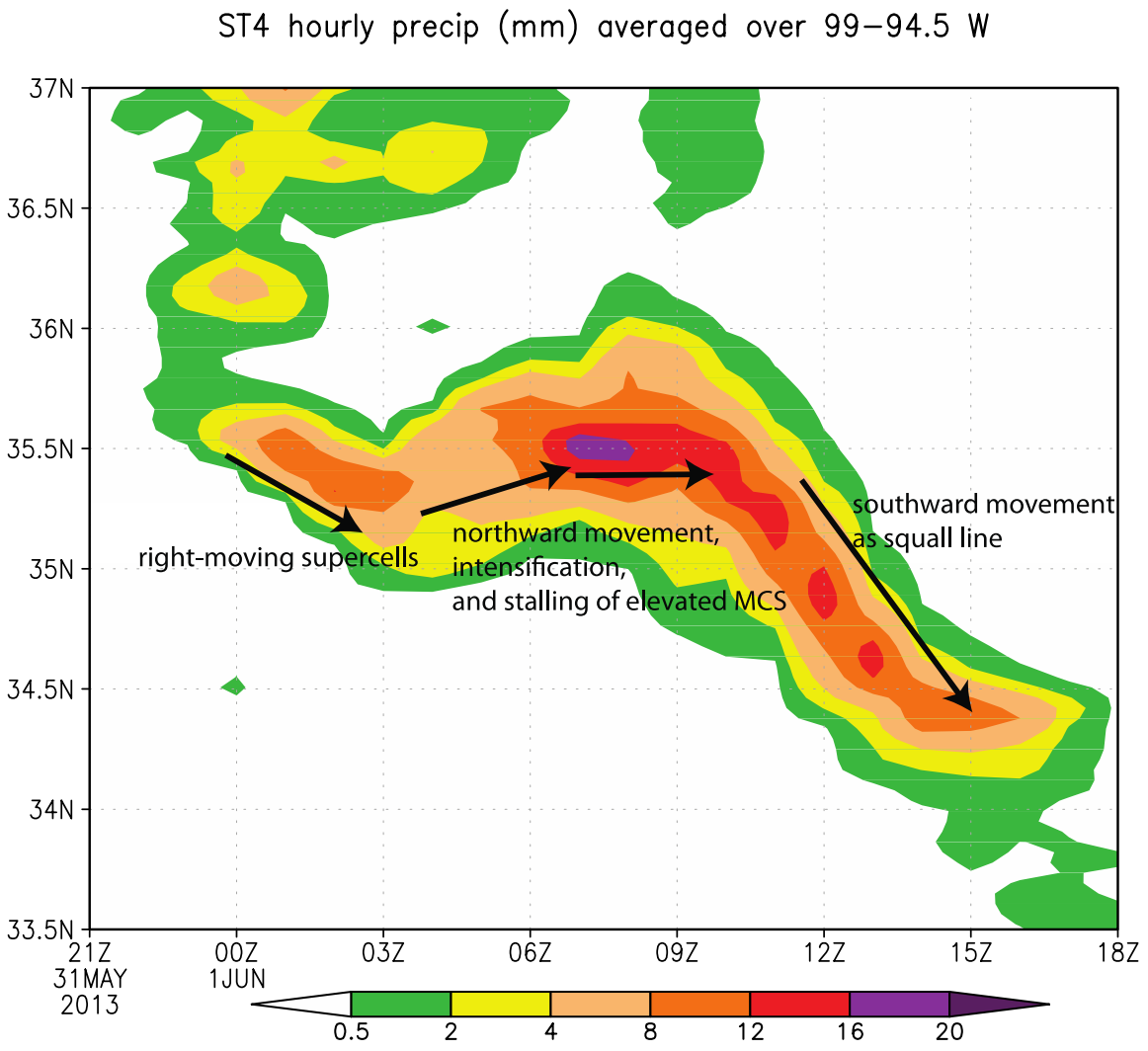


5-km CAPPI from KTLX radar, 2242-2300 UTC

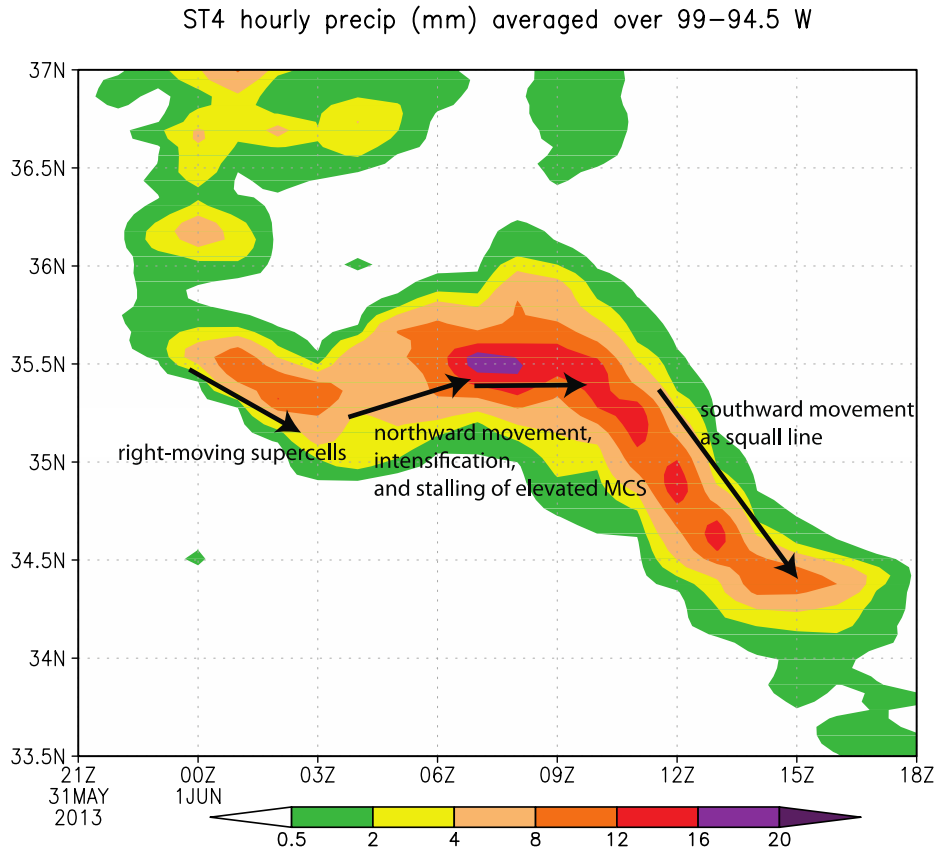


Appears that sonde enters very strong winds in the midlevel mesocyclone

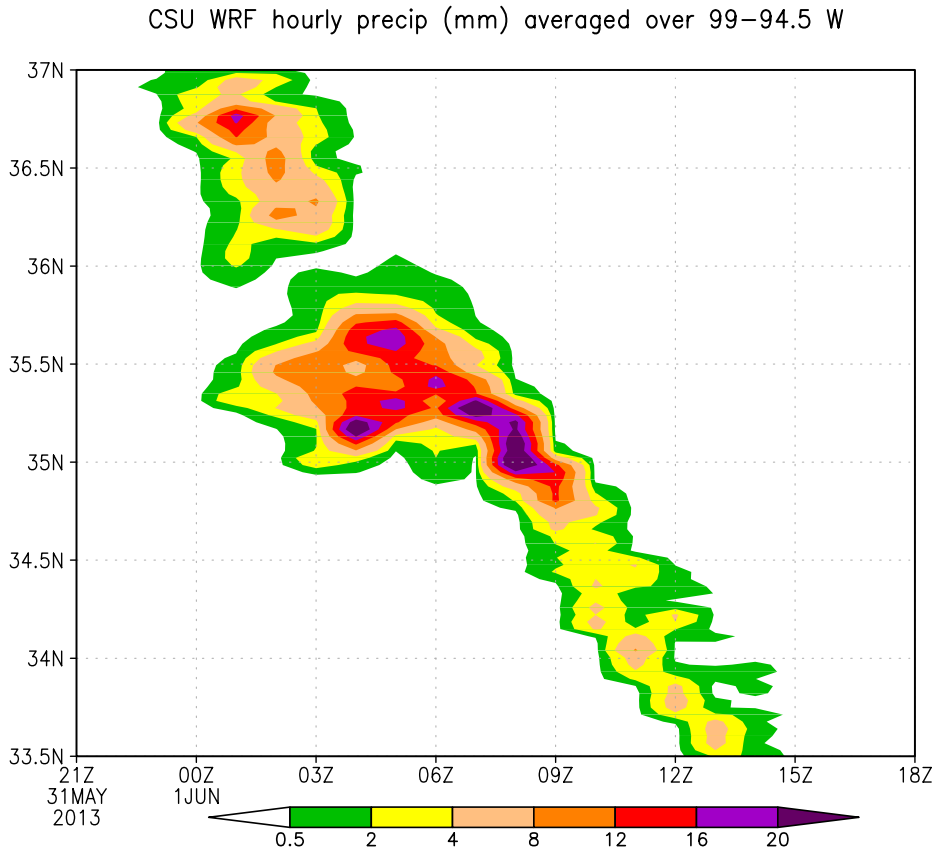
Time-latitude diagram (averaged over the longitudes of OK) shows southward propagation of supercells, then northward motion and stalling of extreme-rain-producing MCS, then southward propagation as squall line



Stage IV



CSU real-time WRF init 1200 UTC 31 May

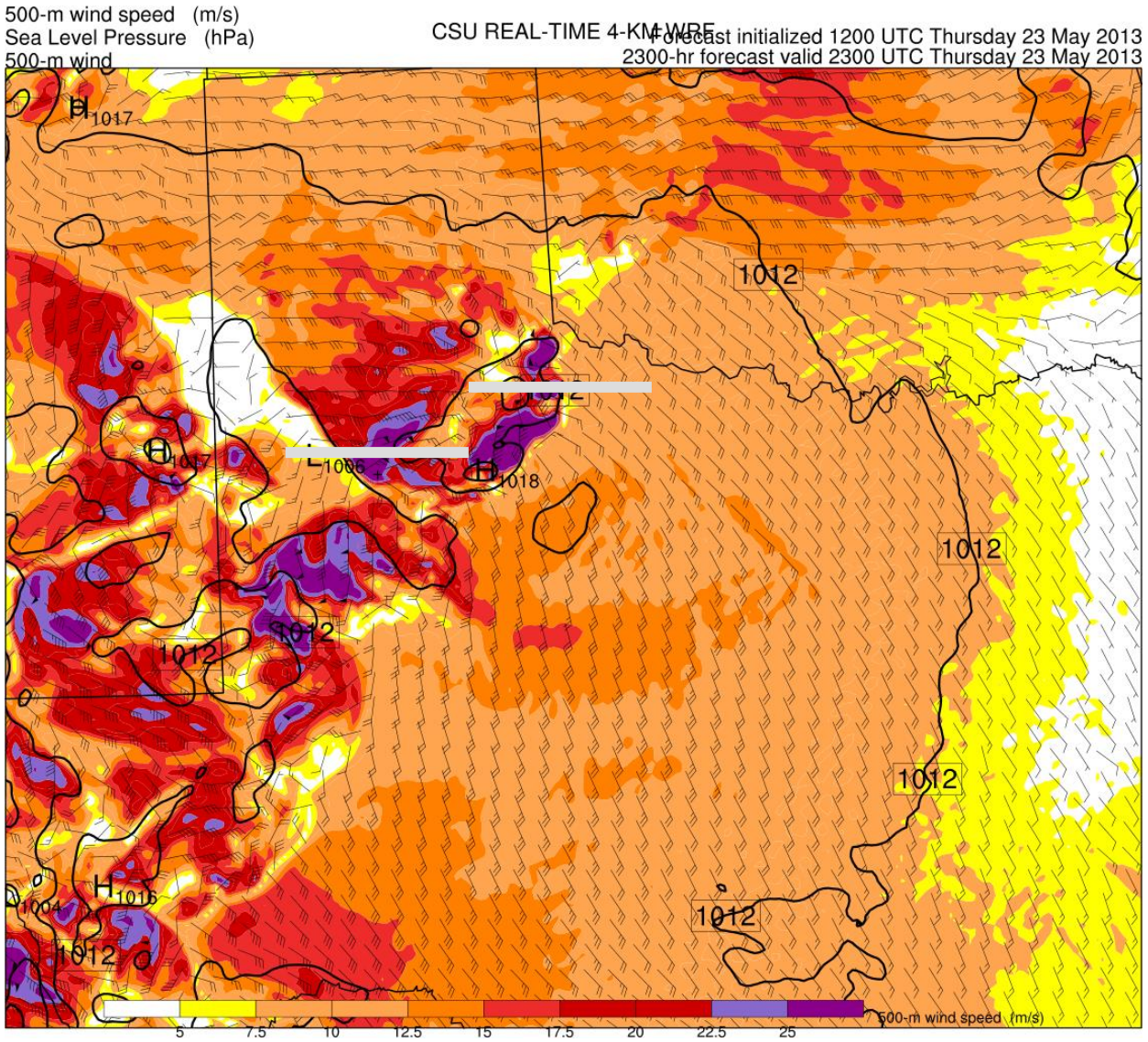


CSU WRF captures general evolution of system, but the MCS doesn't "stall" for as long as the observed system, and moves southward too quickly

Research interests

- Convective evolution, cold-pool behavior, and upscale growth during 23 May 2013 MCS
- Heavy rainfall (processes and predictability) on 31 May-1 June in Oklahoma
- Failed convection initiation on 27 May
- Collaborations regarding assimilation of upsondes and dropsondes and their impact on short-term and long-term forecasts!

John launching at Carhenge



CSU real-time forecast initialized 1200 UTC 23 May: 500-meter AGL wind speed (colors) and MSLP at 2300 UTC

Init: 1200 UTC Thu 23 May 13 Fcst: 11.00 h

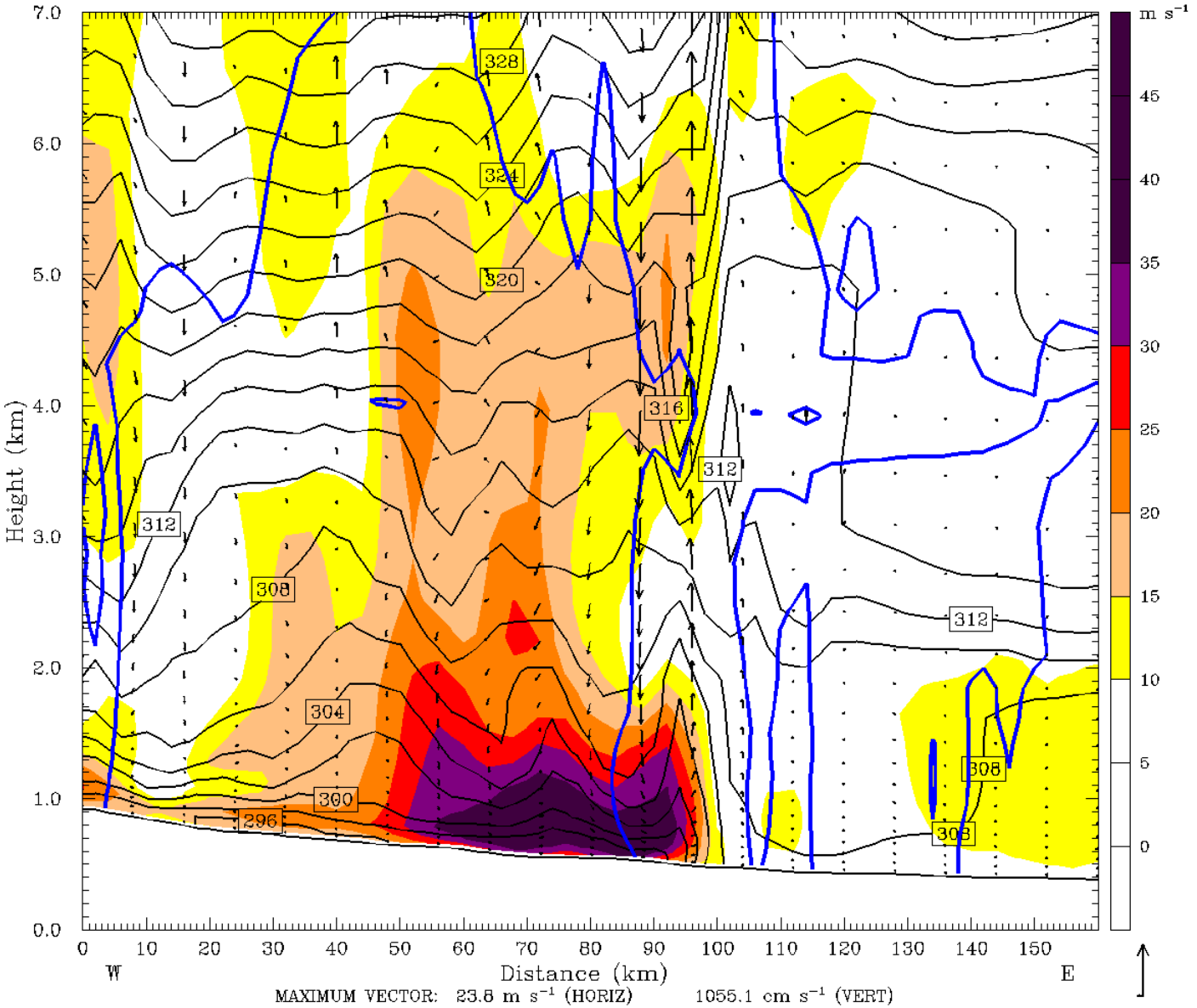
Valid: 2300 UTC Thu 23 May 13 (1700 MDT Thu 23 May 13)

Horizontal wind speed XY= 500.0,190.0 to 540.0,190.0

Potential temperature XY= 500.0,190.0 to 540.0,190.0

Radar reflectivity (lamda = 10 cm) XY= 500.0,190.0 to 540.0,190.0,av= 3

Circulation vectors XY= 500.0,190.0 to 540.0,190.0



MAXIMUM VECTOR: 23.8 m s^{-1} (HORIZ) 1055.1 cm s^{-1} (VERT)

Model Info: V3.4.1 No Cu MYJ PBL Morrison Noah LSM 4.0 km, 50 levels, 25 sec

LW: RRTM SW: RRTMG DIFF: simple KM: 2D Smagor

Init: 1200 UTC Thu 23 May 13 Fcst: 11.00 h

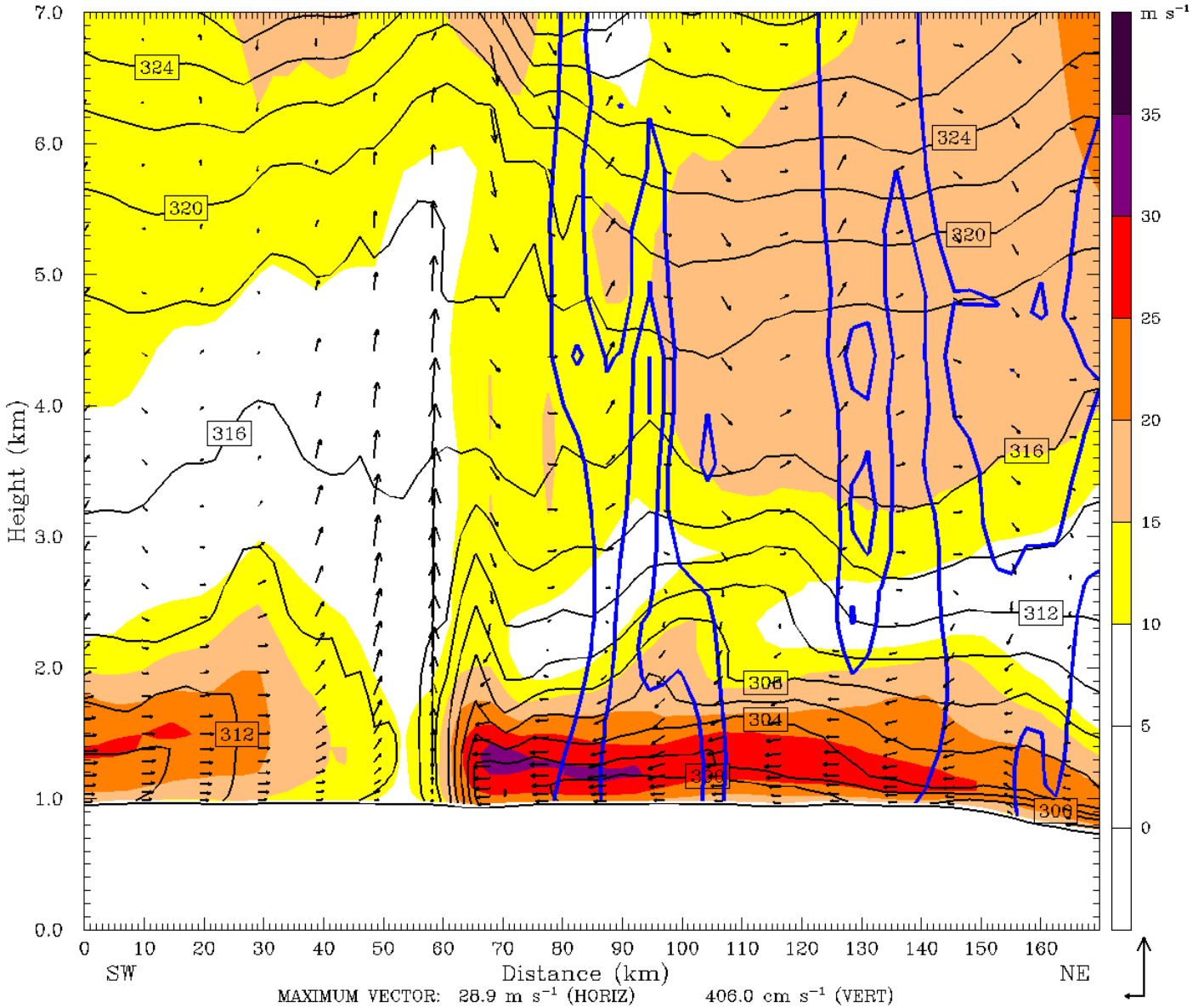
Valid: 2300 UTC Thu 23 May 13 (1700 MDT Thu 23 May 13)

Horizontal wind speed XY= 478.0,165.0 to 502.0,200.0

Potential temperature XY= 478.0,165.0 to 502.0,200.0

Radar reflectivity (lamda = 10 cm) XY= 478.0,165.0 to 502.0,200.0

Circulation vectors XY= 478.0,165.0 to 502.0,200.0



MAXIMUM VECTOR: 28.9 m s^{-1} (HORIZ) 406.0 cm s^{-1} (VERT)

Model Info: V3.4.1 No Cu MYJ PBL Morrison Noah LSM 4.0 km, 50 levels, 25 sec

LW: RRTM SW: RRTMG DIFF: simple KM: 2D Smagor