# Advancing Storm-Scale Forecasts over Nested Domains for High-Impact Weather

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# Objectives

Assess the ability of the North American Model (NAM) 4 km Conus Nest to provide realistic and accurate forecasts of severe convective weather (capability and accuracy)

Determine if the 1.33 km Fire Wx Nest has added value beyond that provided by the 4 km Conus NAM

Develop useful diagnostics for forecasters and model developers

# Strategy and Focus

Focus evaluation on supercells and convection initiation (CI) as key phenomena

In-depth study of two cases

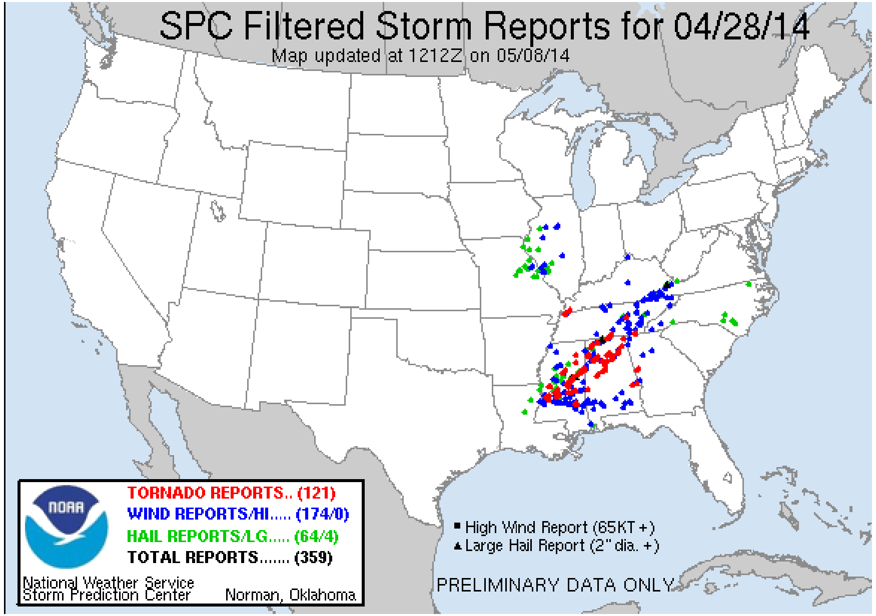
Examine model output *every 5 minutes* and compare forecast storms and CI with observations (Doppler radar, Mesonet, surface, soundings, satellite, etc). Examine the physical processes of supercells and CI in the model – in line with observations and current knowledge?

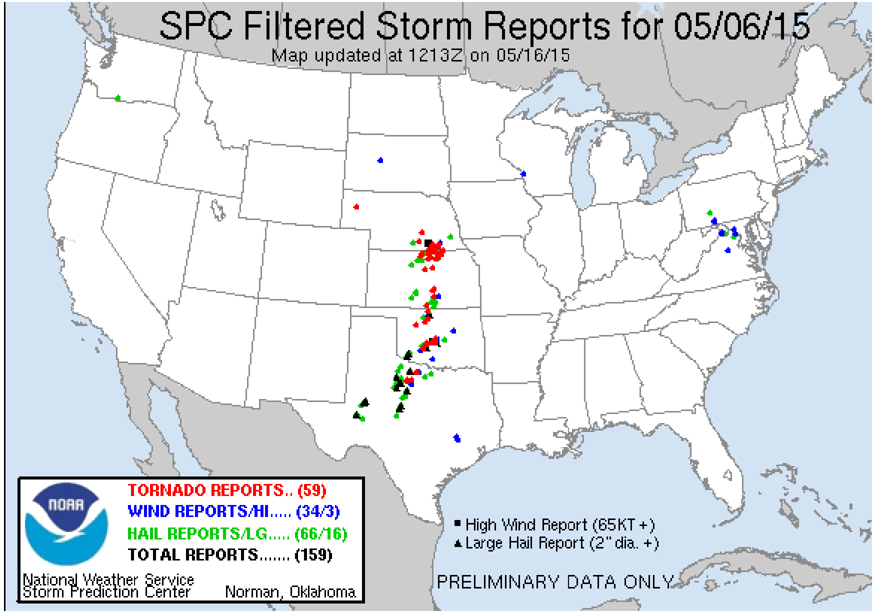
How accurate are the nest predictions? Changes between 4 and 1.33 km nests?

Develop diagnostics to help assess supercell and CI behaviors quickly and easily

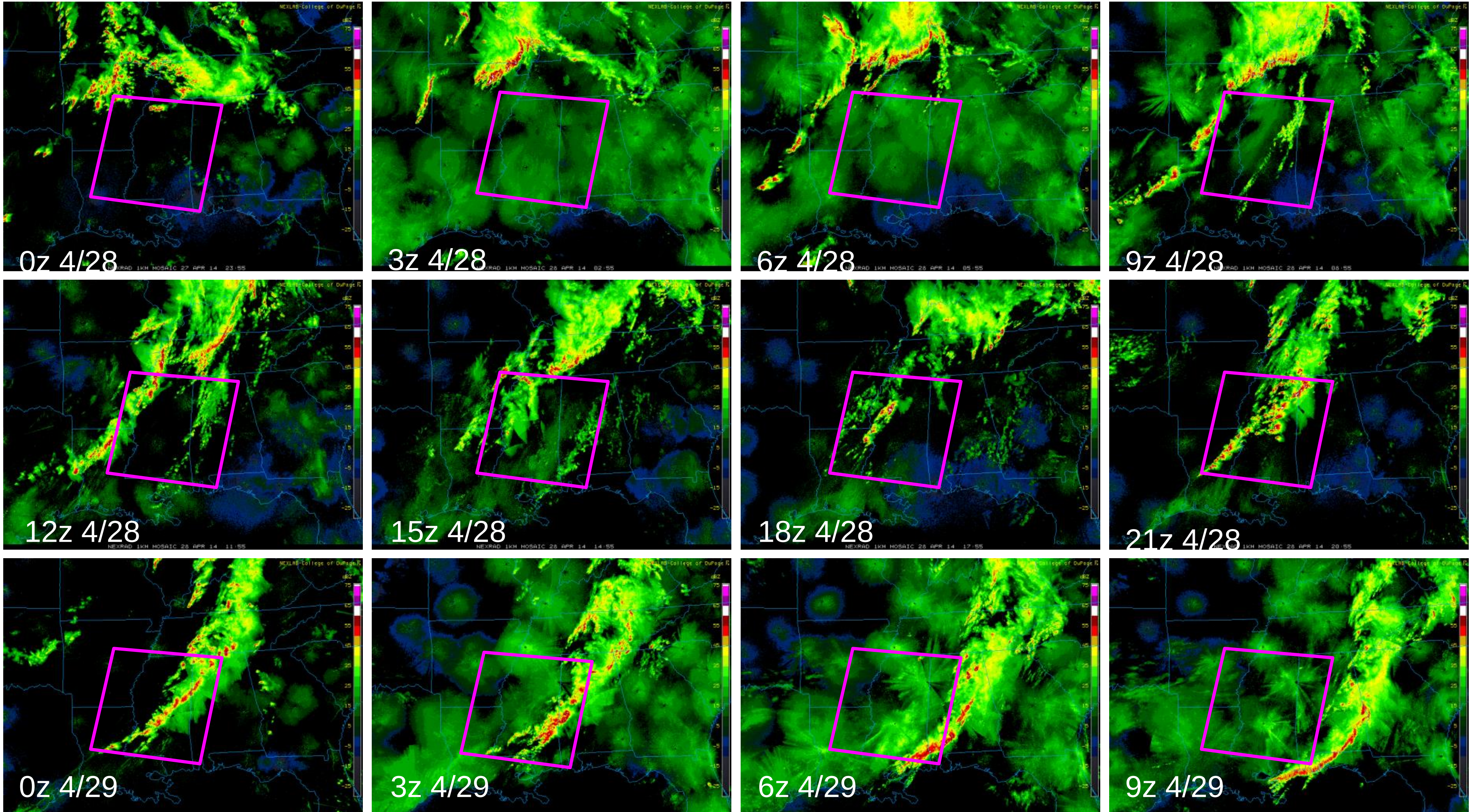
Evaluate the ability of the current physical parameterizations to produce realistic storm and CI behaviors

Severe Reports for the 2 cases:
28 April 2014
6 May 2015

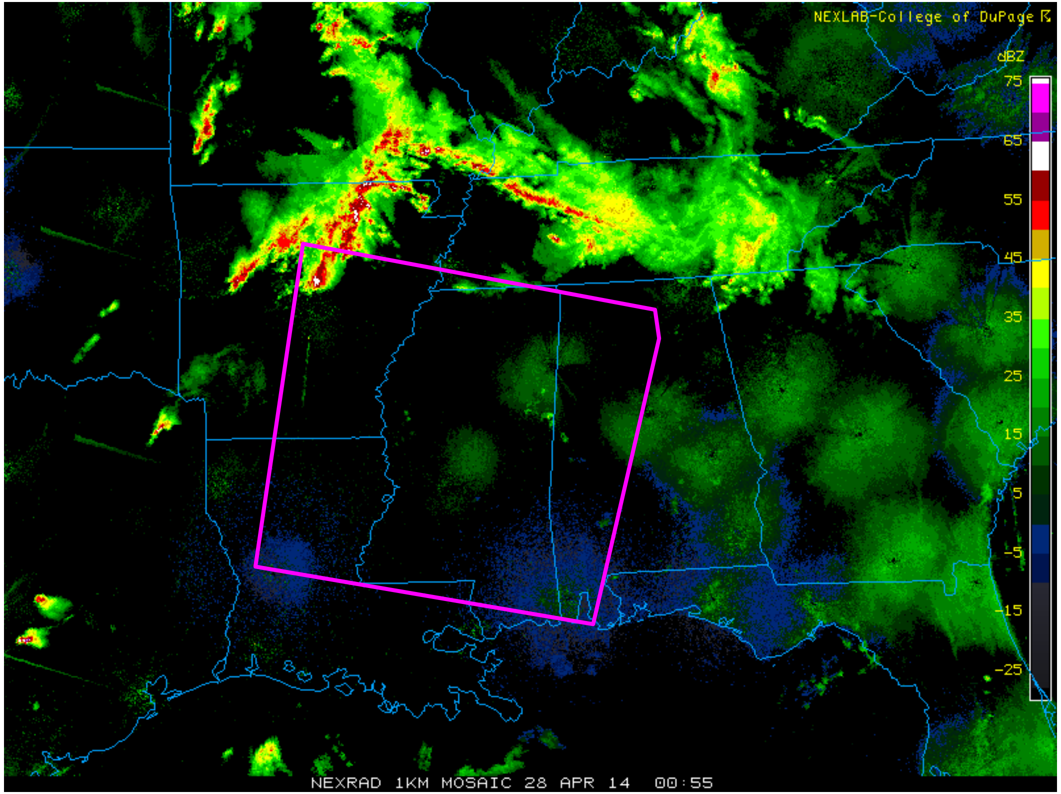


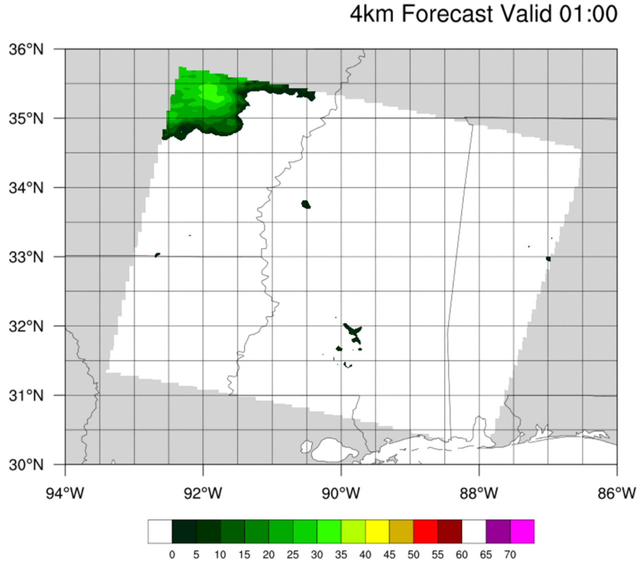



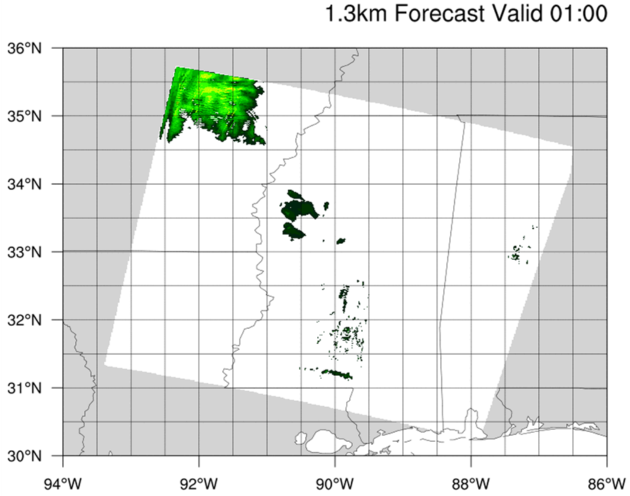
# Observed Reflectivity Mosaics – 28 April 2014



# 1km AGL Reflectivity



# General Evaluation

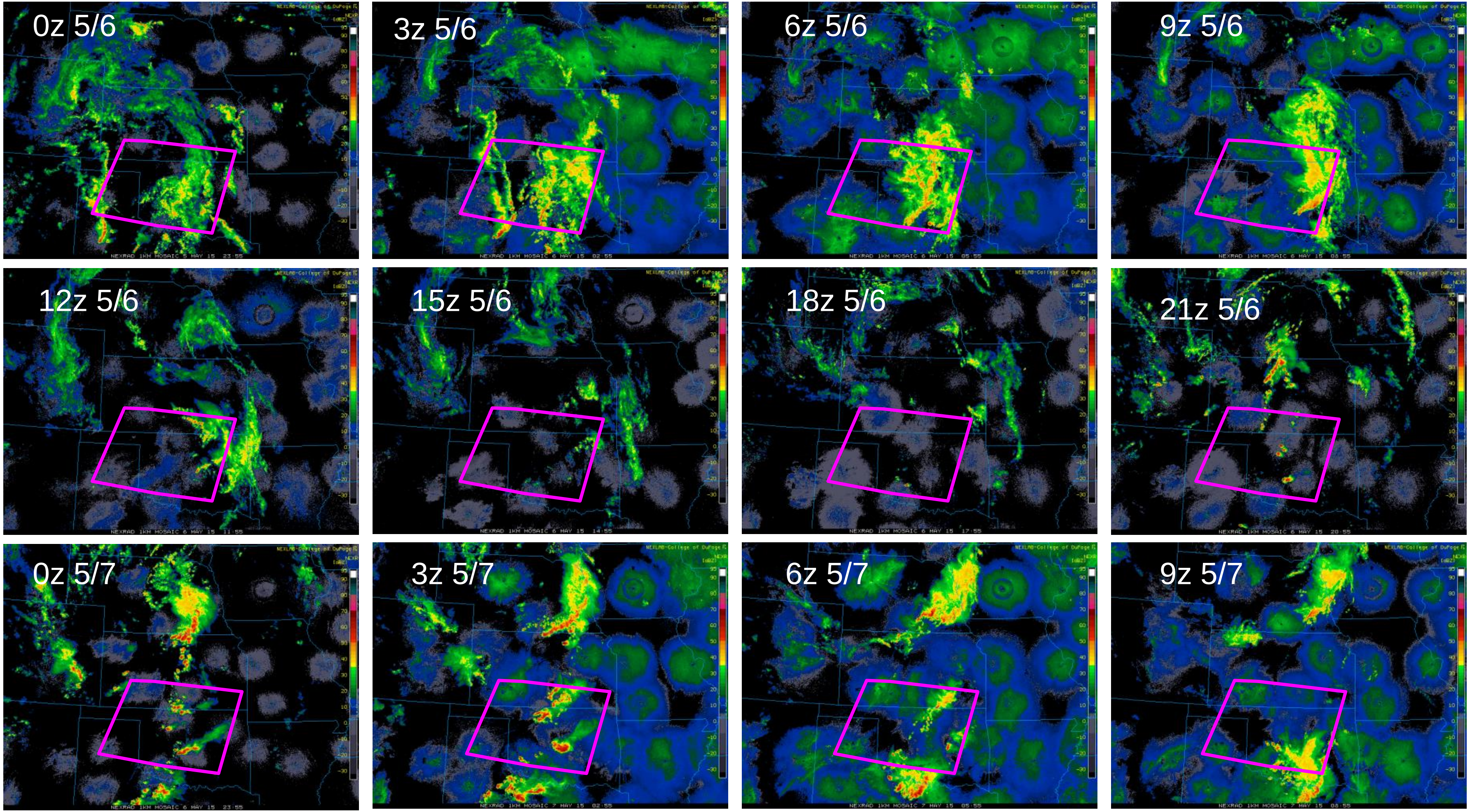
Timing of CI near 1800 UTC is good, but model convection is too widespread

Squall line moves a little too fast to the north

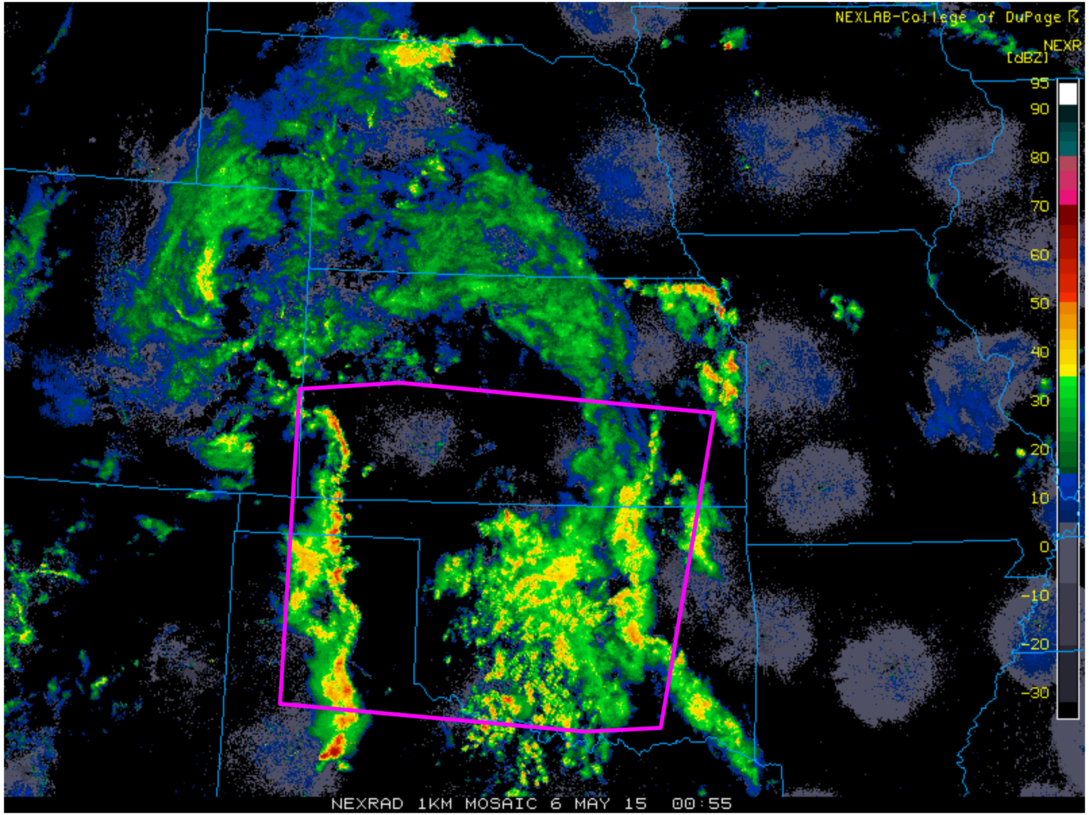
Southern extent of squall line too little, line stalls compared to observations

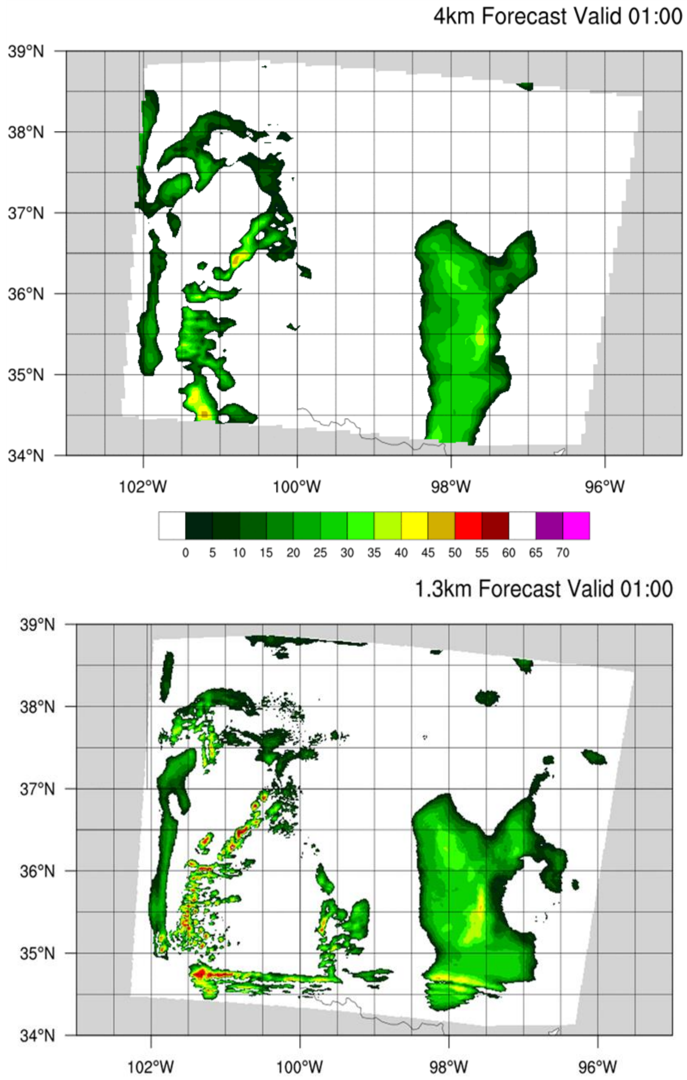
Overall convective evolution in conus and firewx nests very similar

# Observed Reflectivity Mosaics – 6 May 2015



# 1km AGL Reflectivity



# General Evaluation

Initial convection pretty good

Bowing convective line only in firewx nest – clear capability improvement compared to 4 km CONUS nest

Daytime CI not predicted well.  Only a few short-lived storms, compared to observed long-lived supercells.

# What have we learned?

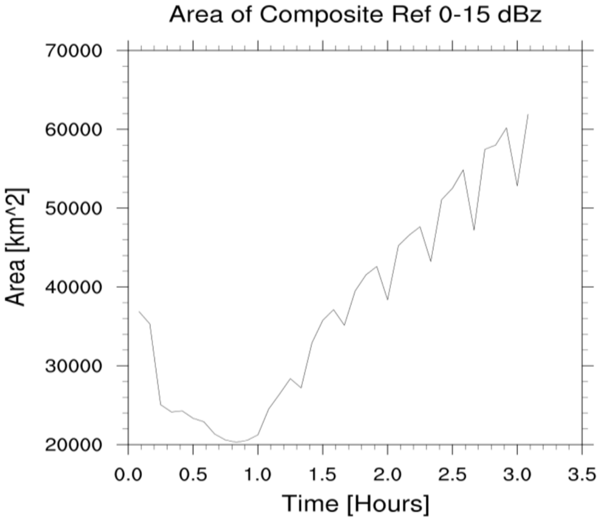
# “Pulsing” in low-dBz Reflectivity

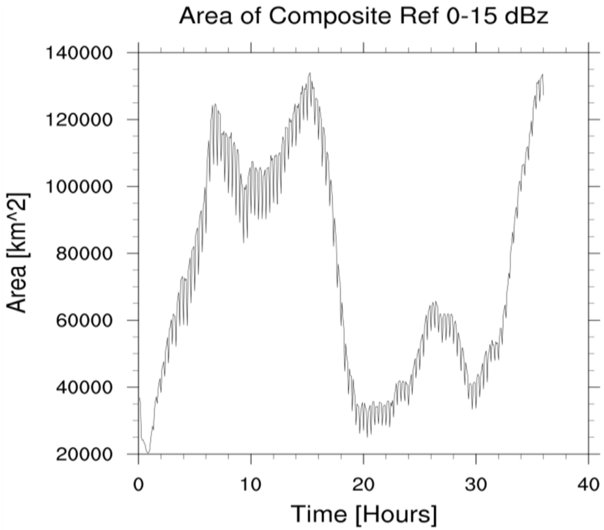
- Decrease in 0-15 dBz coverage every 4th timestep (20 minutes)

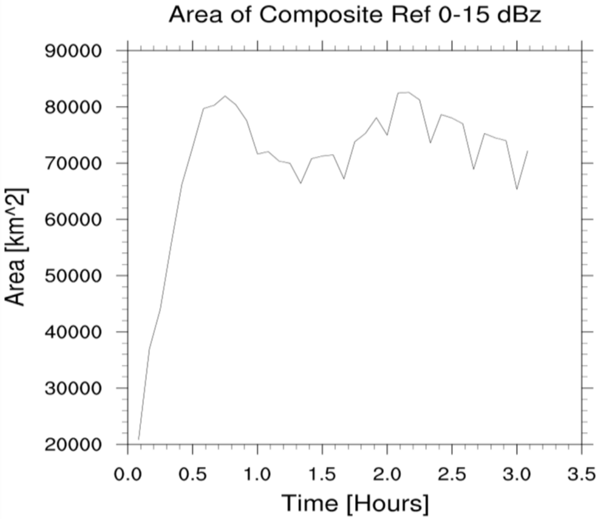
- Exists in 4 km NAM but **not** in the 1.3 km firewx nest

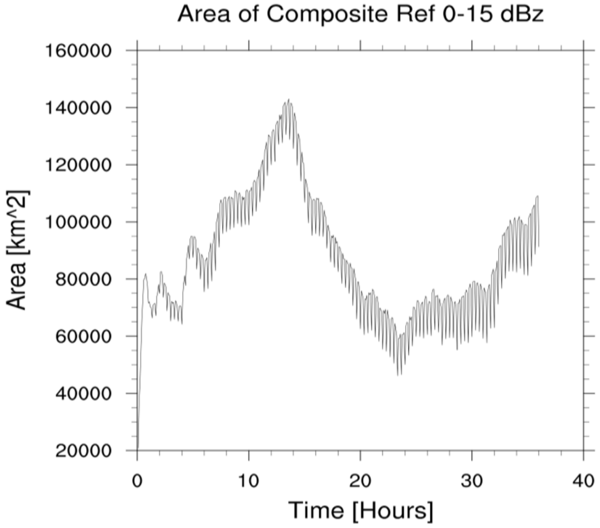
- Correlated with radiation scheme being called every 20 minutes?

-Eric Aligo’s new NAM run eliminates this!

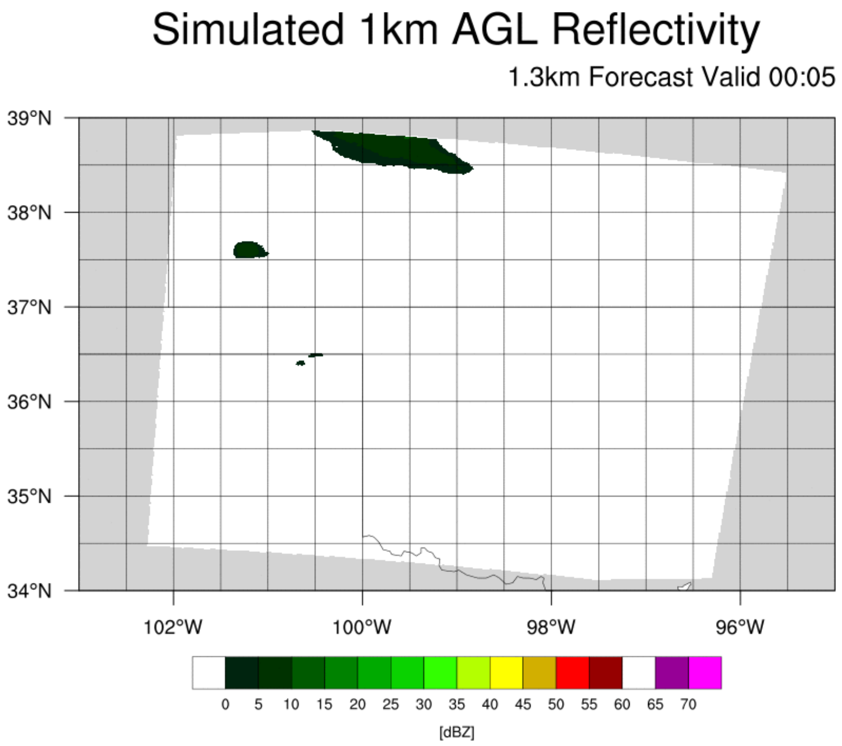


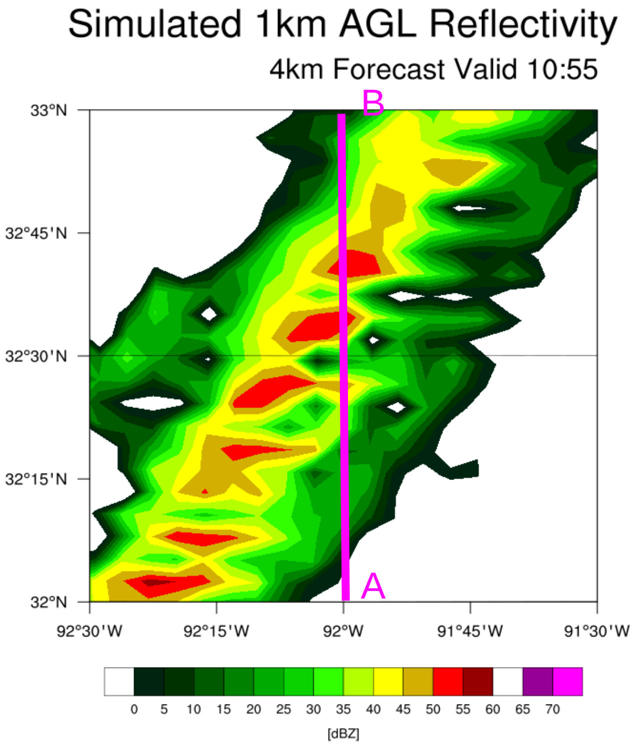



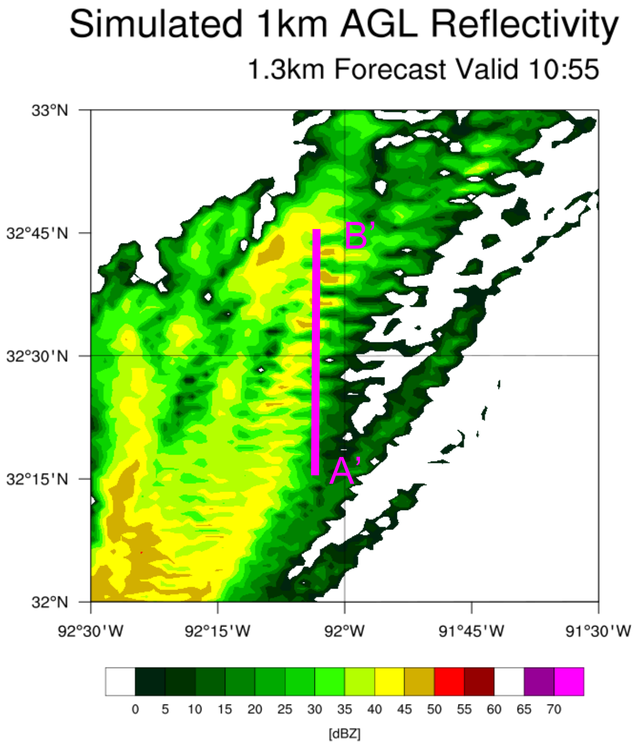



Value of 5-minute model output!



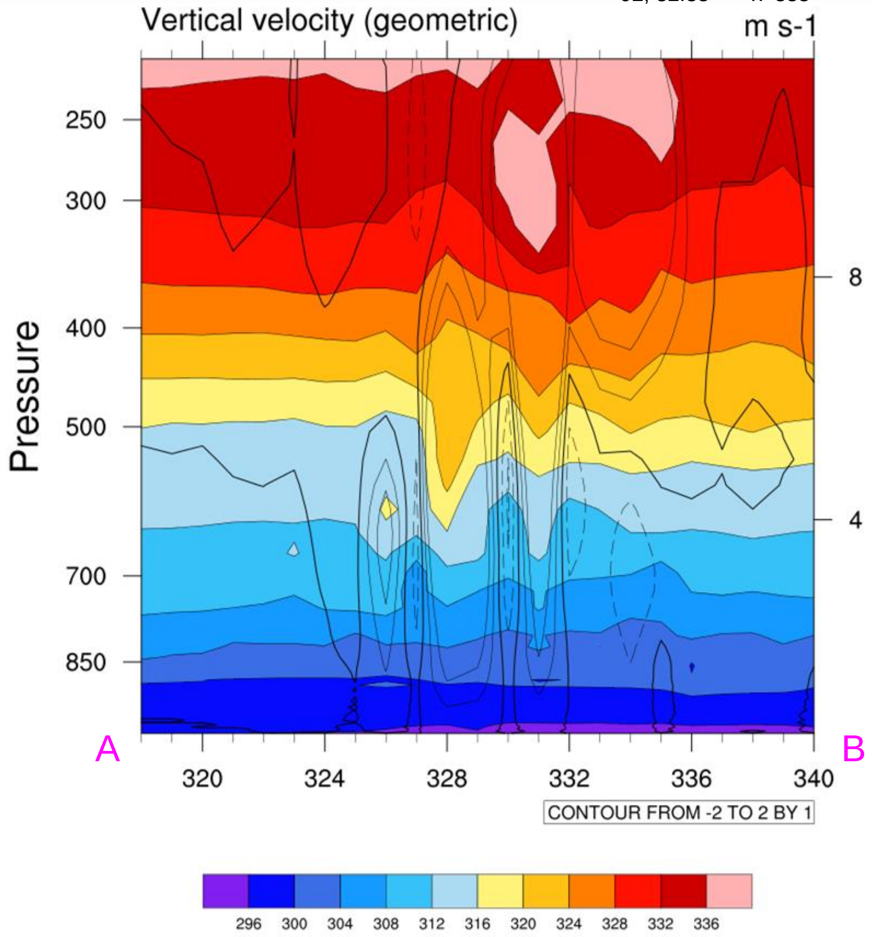
# 4Δx waves in convective regions



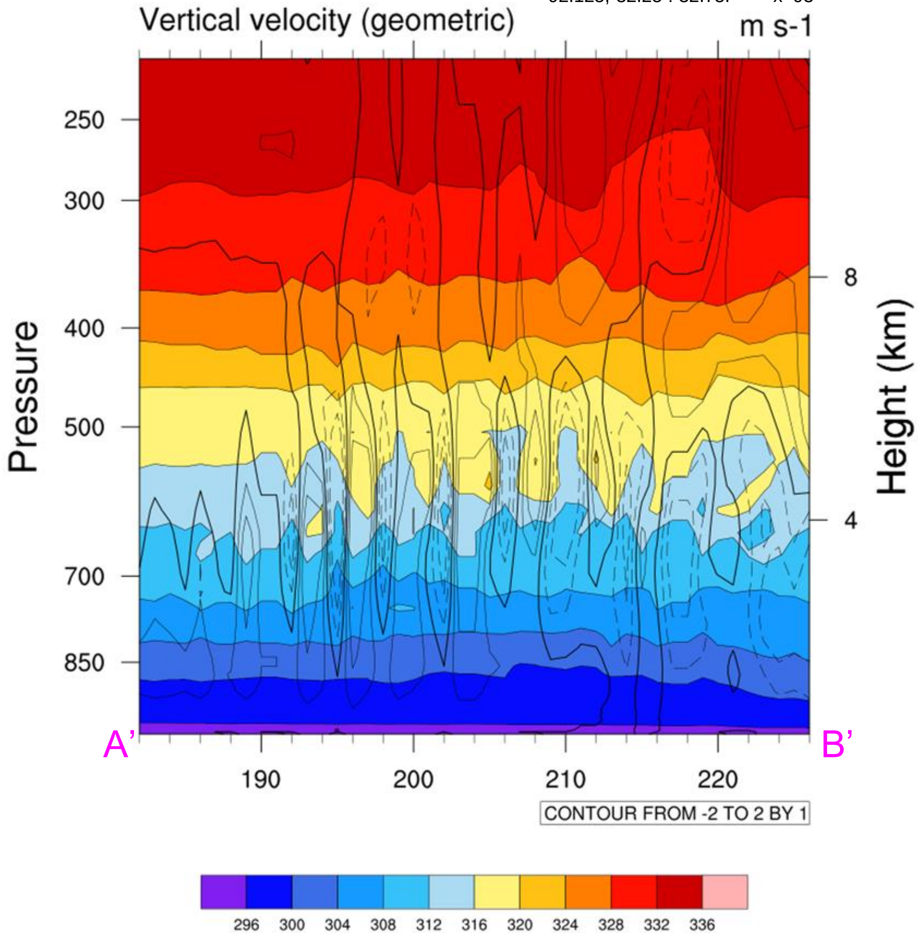



Potential Temp (shaded) and vertical velocity (contoured)

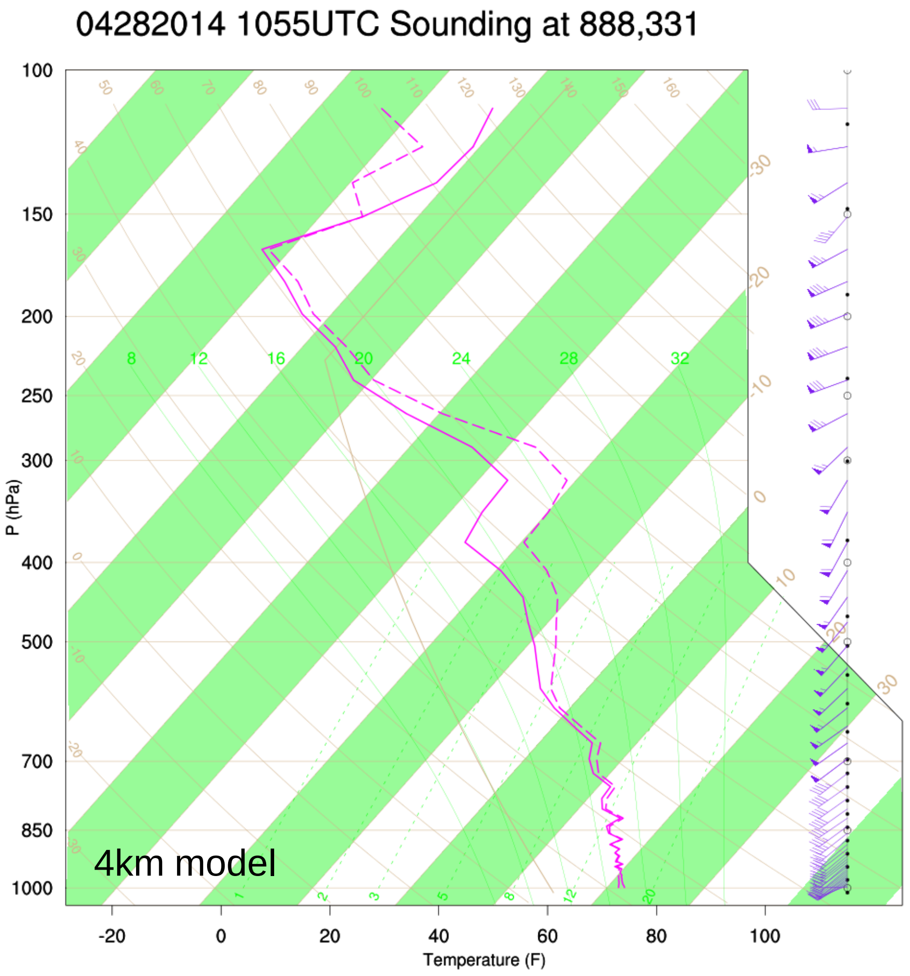
-92, 32:33 x=888




-92.125, 32.25 : 32.75. x=93



Model soundings show *super*saturation within convective regions in upper levels



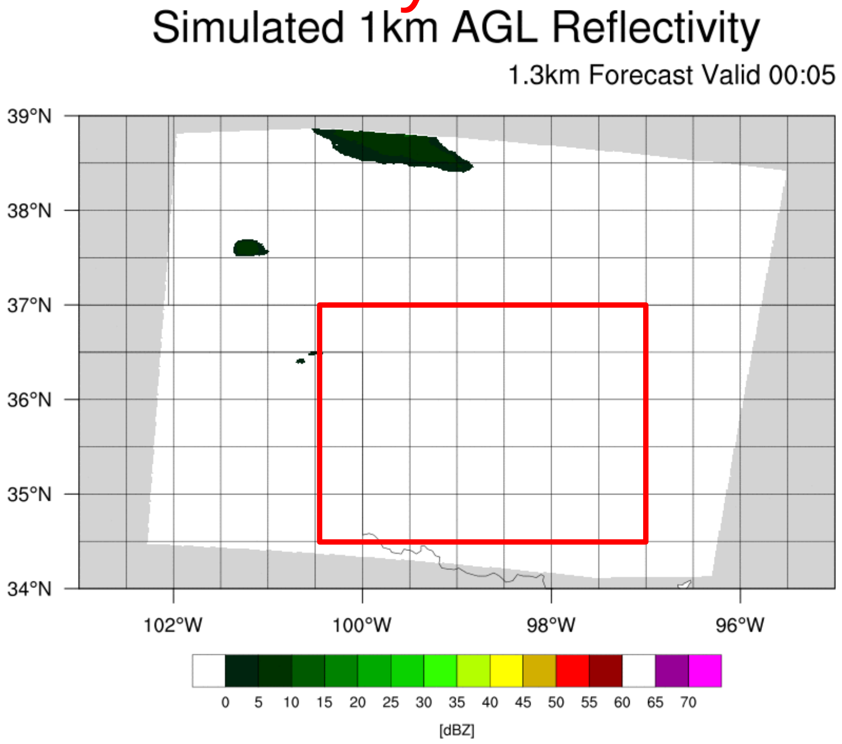
# Convective Behaviors

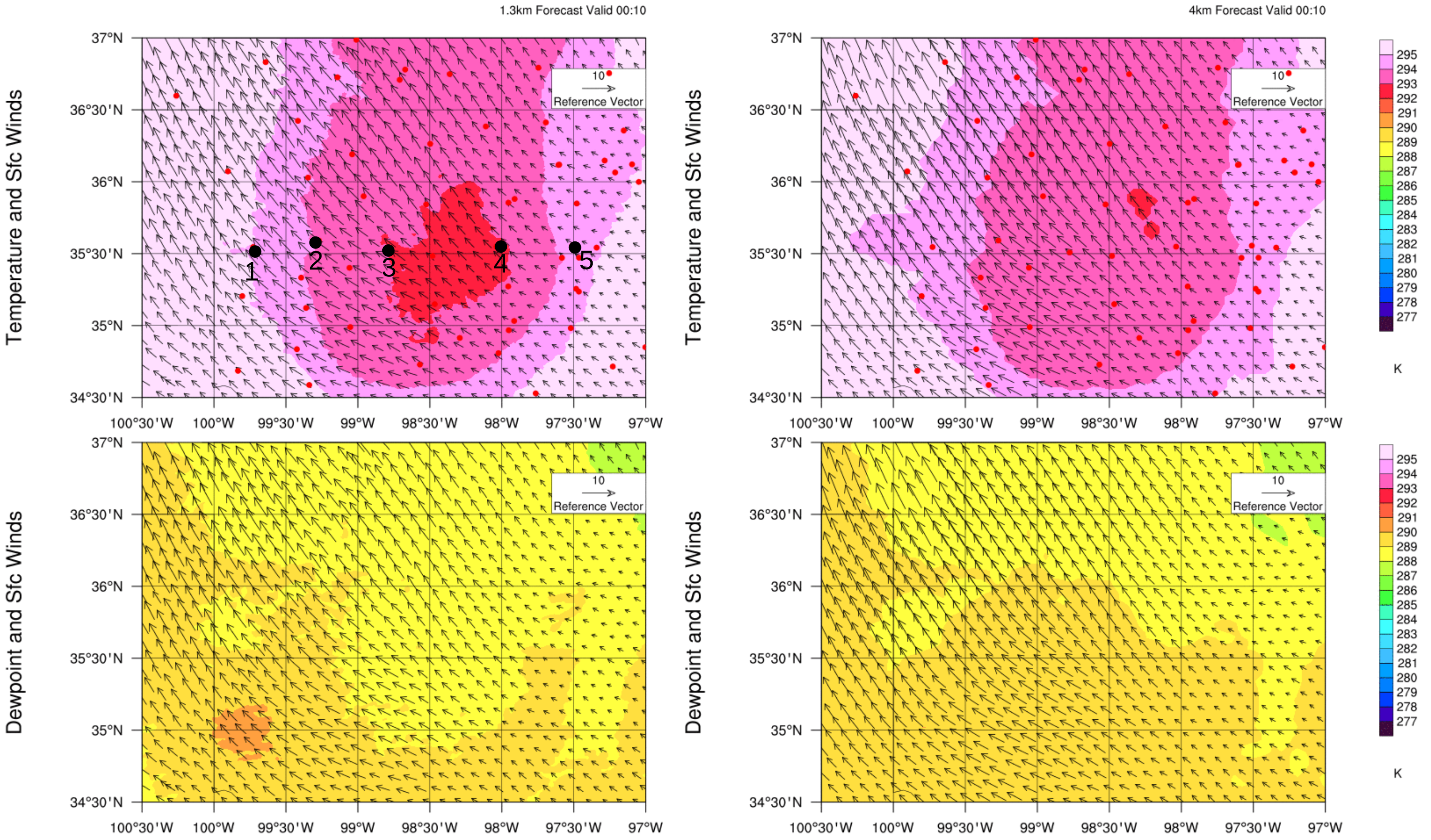
# Bowing Convective Line in 6 May case

A similar feature is apparent in the 1.33-km fire-weather nest (right)

The 4-km NAM did not show this feature (not shown)

Notice southward propagating reflectivity ahead of bow (will revisit later)




1.3km Forecast Valid 00:10
4km Forecast Valid 00:10
Temperature and Sfc Winds
Dewpoint and Sfc Winds
10
Reference Vector
1
2
3
4
5
37°N
36°30'N
36°N
35°30'N
35°N
34°30'N
100°30'W
100°W
99°30'W
99°W
98°30'W
98°W
97°30'W
97°W
295
294
293
292
291
290
289
288
287
286
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284
283
282
281
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277
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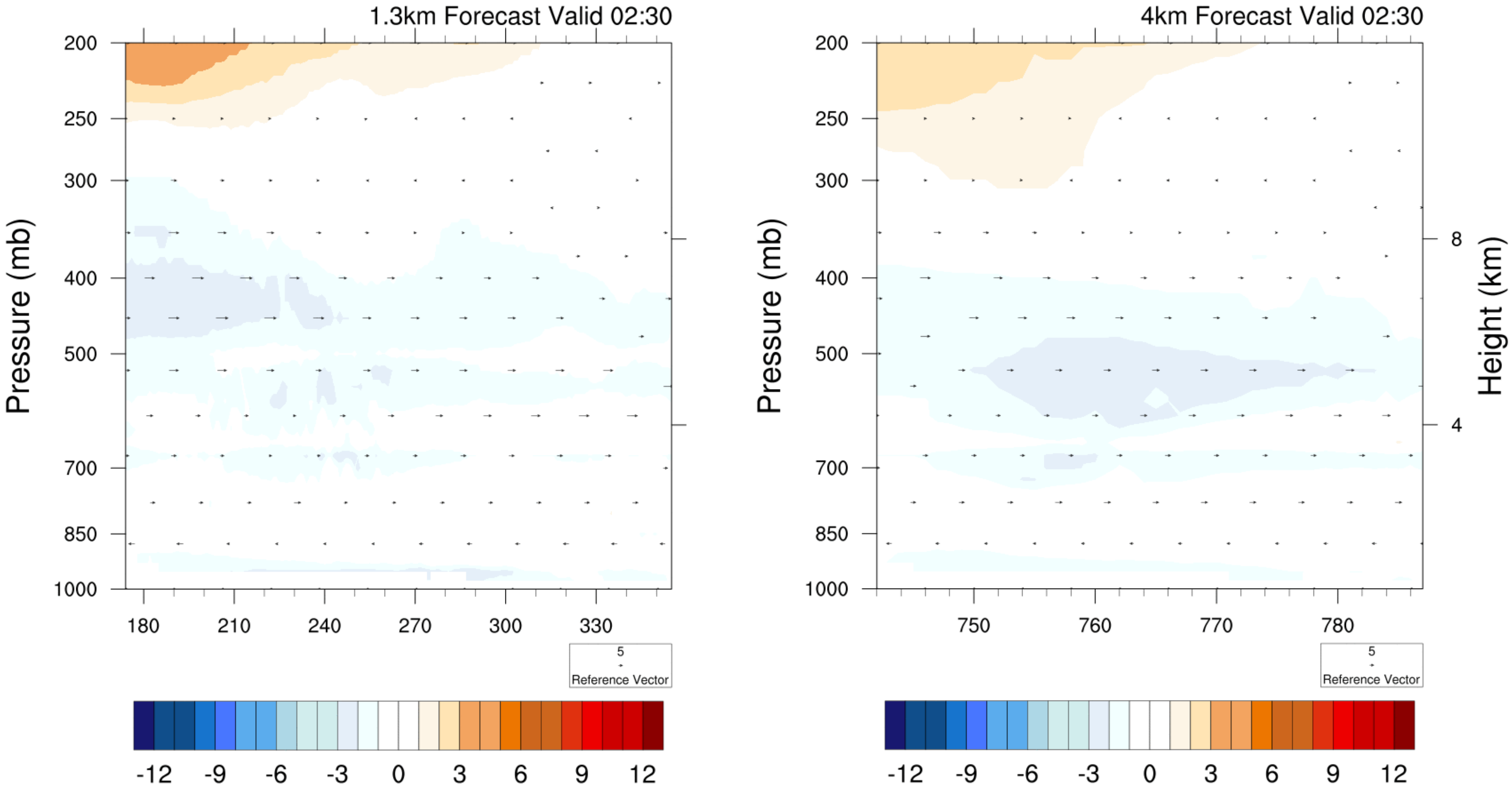
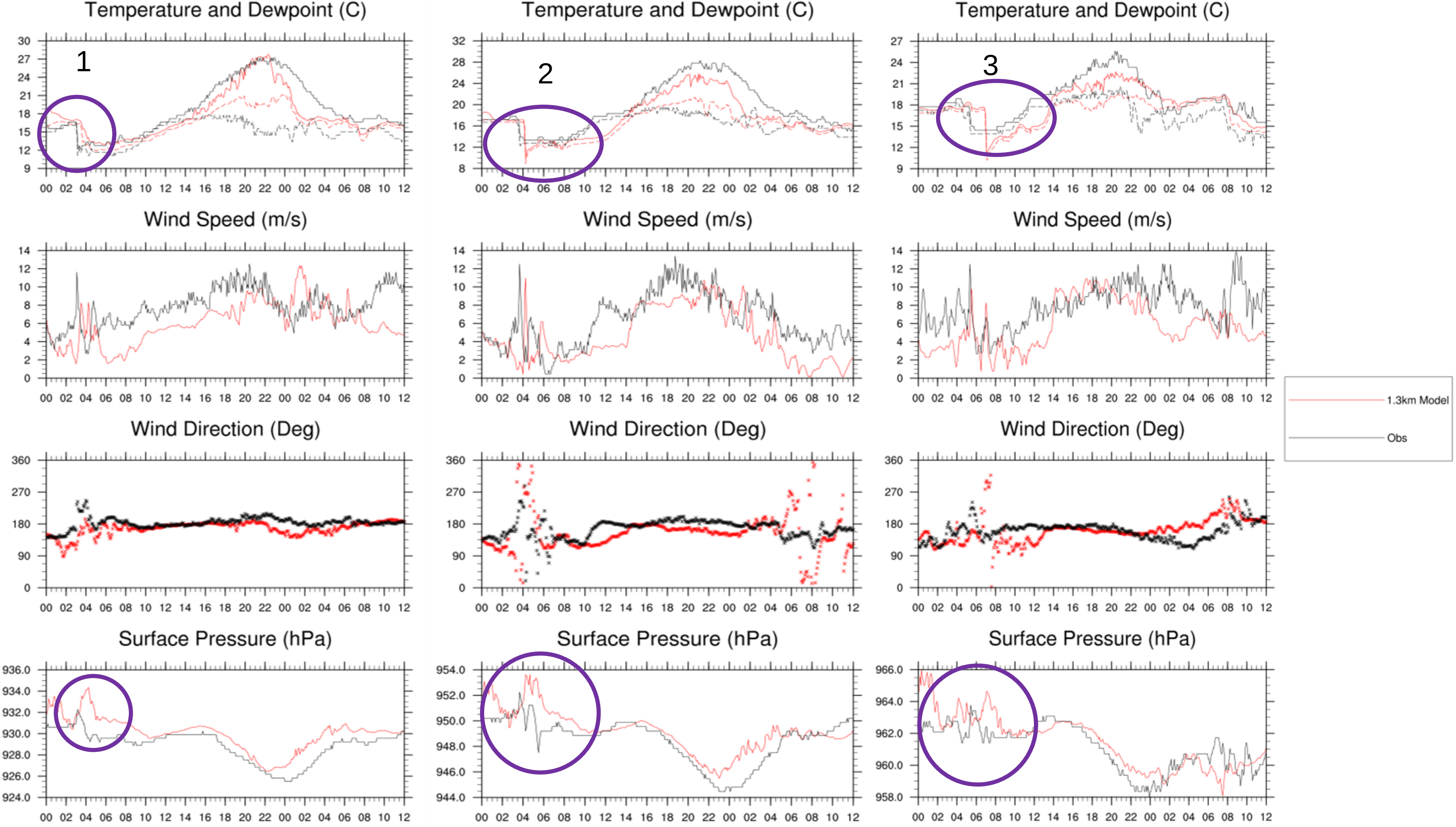
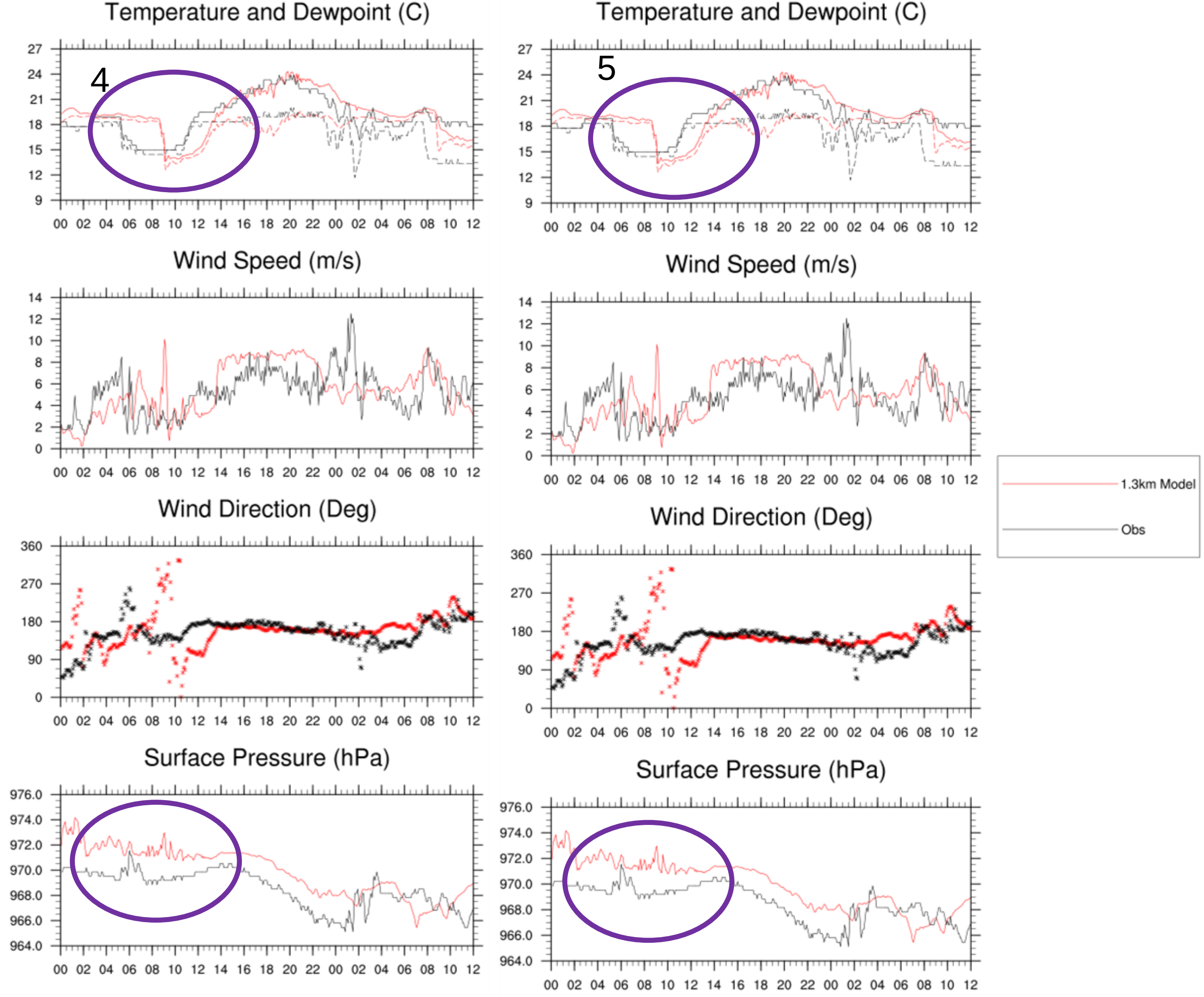
# Theta prime (color) showing the propagation of the outflow in the bow




Temperature and Dewpoint (C)
Temperature and Dewpoint (C)
Temperature and Dewpoint (C)
1
2
3
Wind Speed (m/s)
Wind Speed (m/s)
Wind Speed (m/s)
Wind Direction (Deg)
Wind Direction (Deg)
Wind Direction (Deg)
Surface Pressure (hPa)
Surface Pressure (hPa)
Surface Pressure (hPa)
1.3km Model
Obs



Temperature and Dewpoint (C)
4
Wind Speed (m/s)
Wind Direction (Deg)
Surface Pressure (hPa)
Temperature and Dewpoint (C)
5
Wind Speed (m/s)
Wind Direction (Deg)
Surface Pressure (hPa)
1.3km Model
Obs

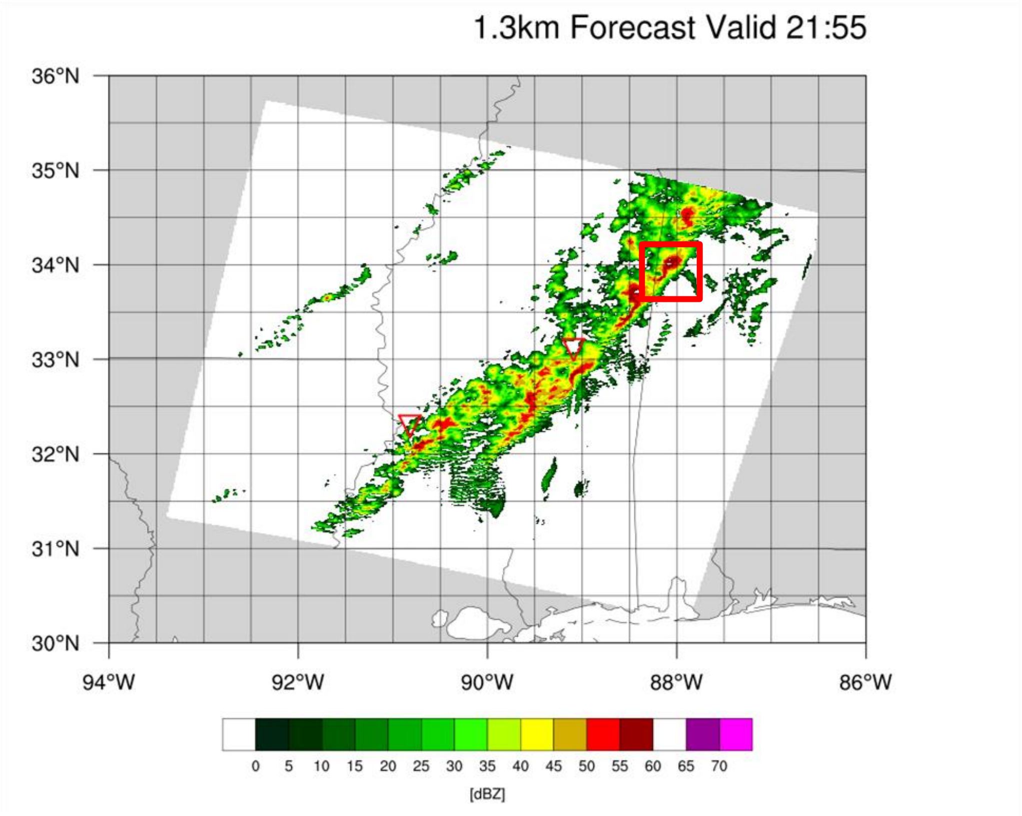
# Evaluation

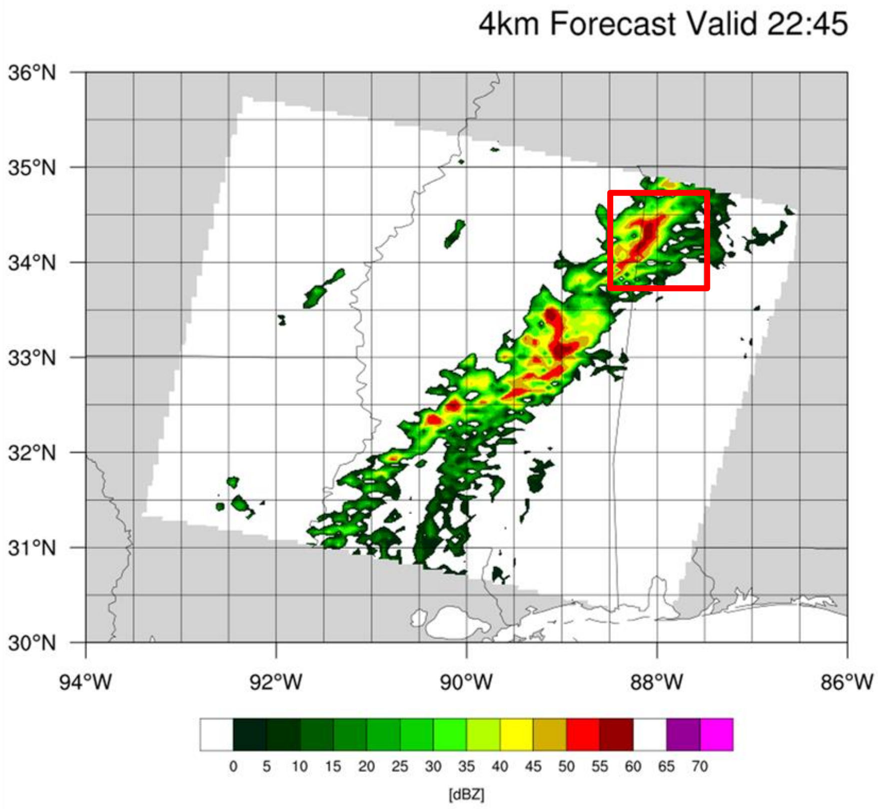
Bowing convective line only in 1.33 km firewx nest – missing in 4 km nest

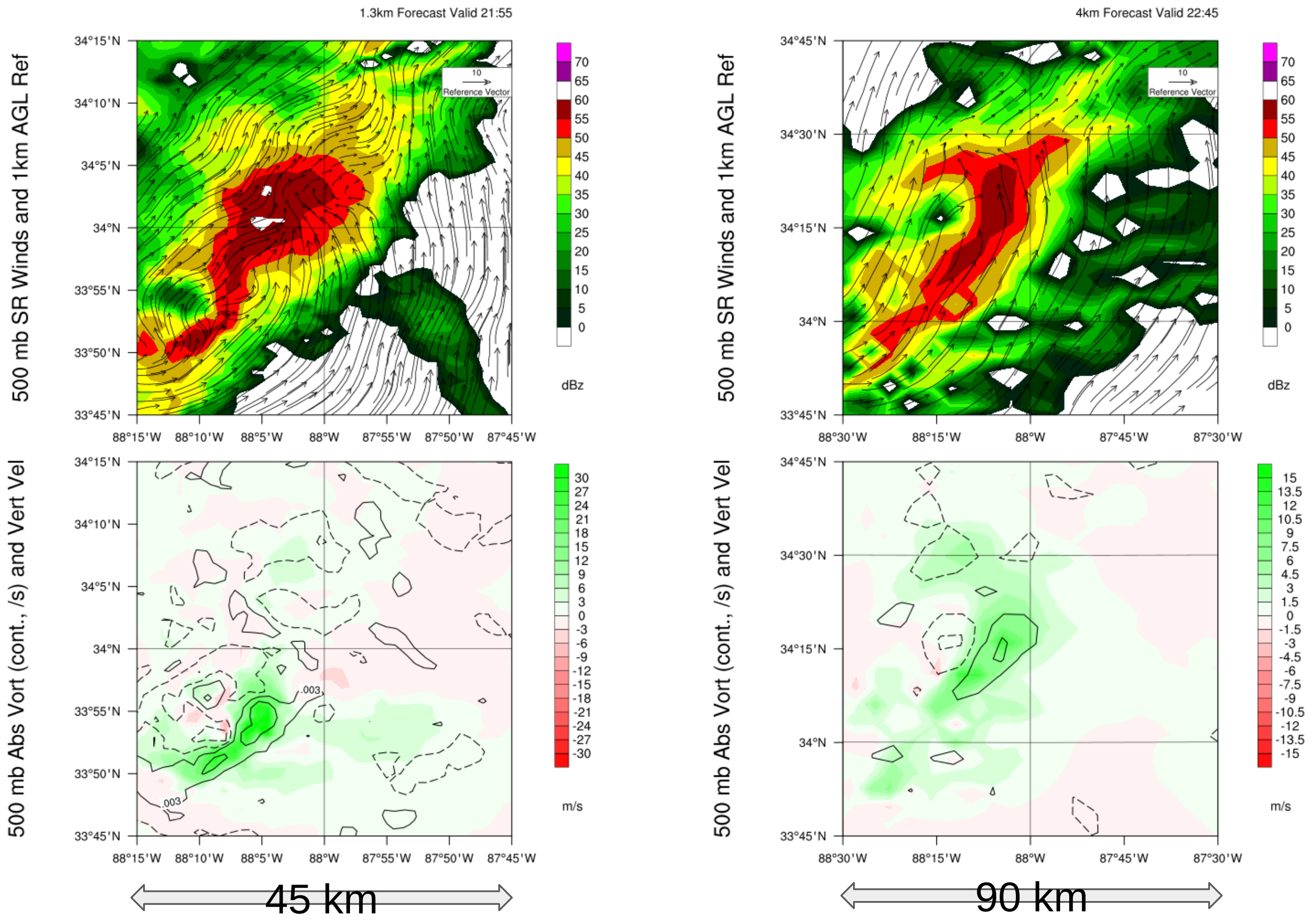
Firewx nest

- Cold pool cooler than observations, yet pressure rise earlier is greater than observations and later is less than observations – cold pool becomes too shallow over time. Collision with other outflow also may influence evolution.
- Cold pool west-east extent smaller than suggested by observations
- Cold pool moves eastward slower than observations, which supports assessment that cold pool is too shallow (pressure rise too small)

# Rotating Storm in the 28 April Case

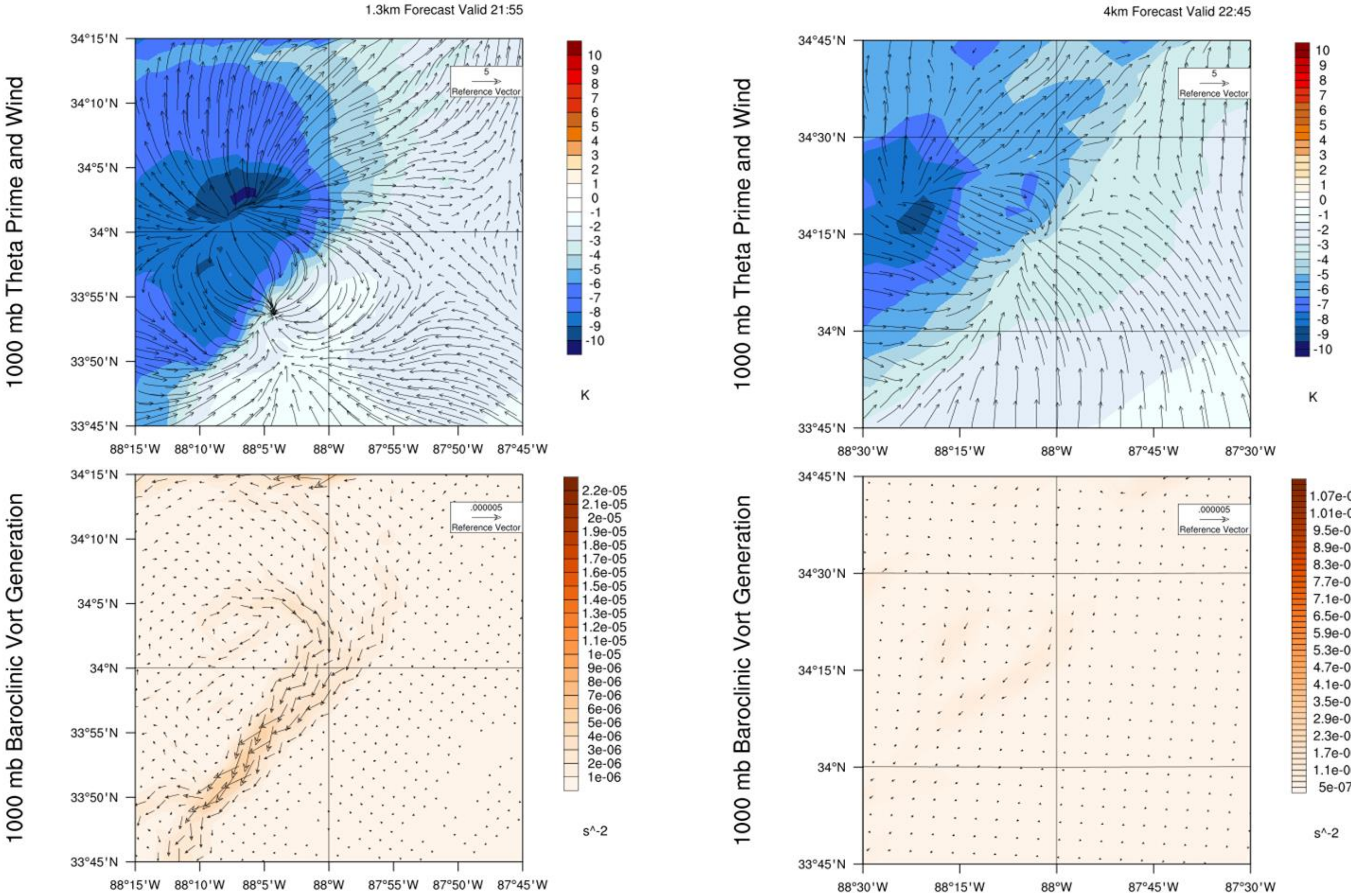


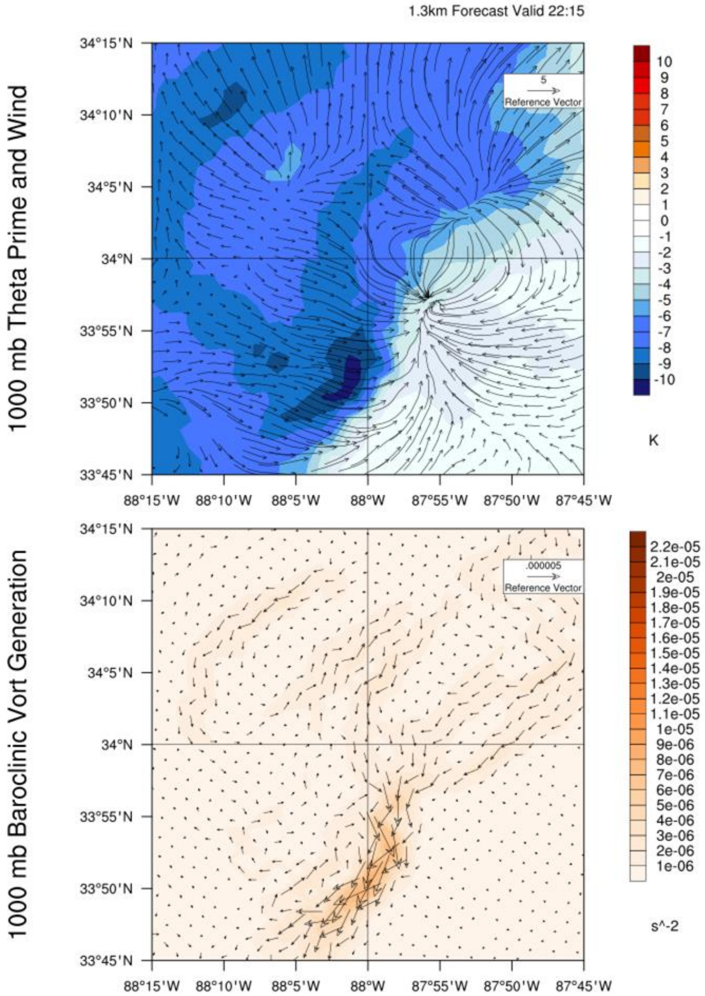


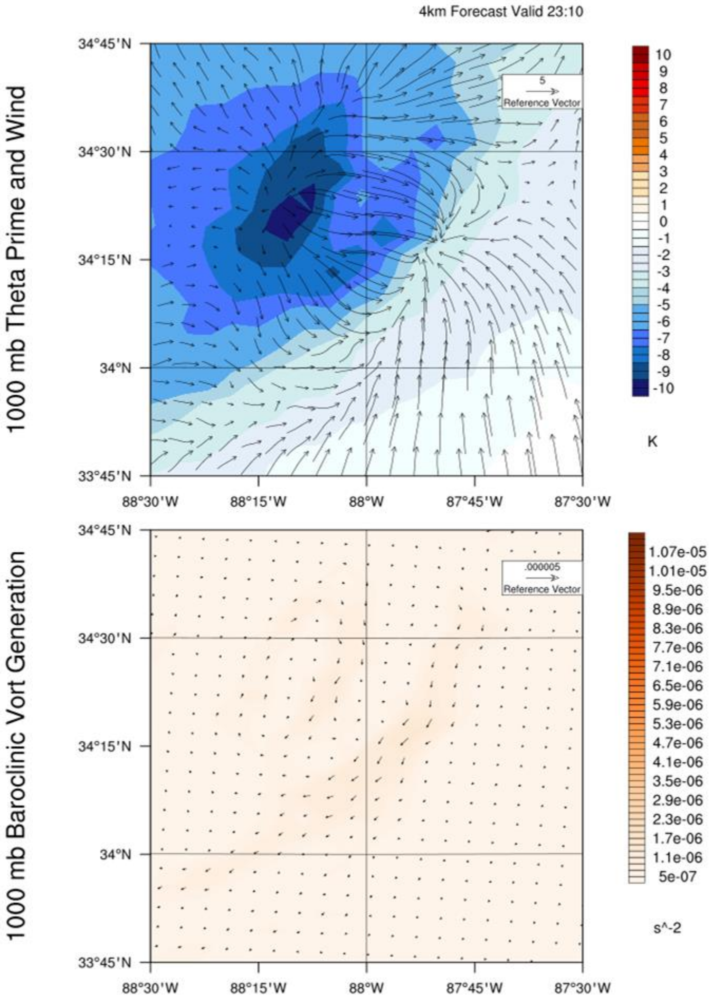

Conus storm appears to be ~twice as large as firewx nest storm

Conus storm lacks classic supercell hook echo, while firewx nest storm has classic supercell hook

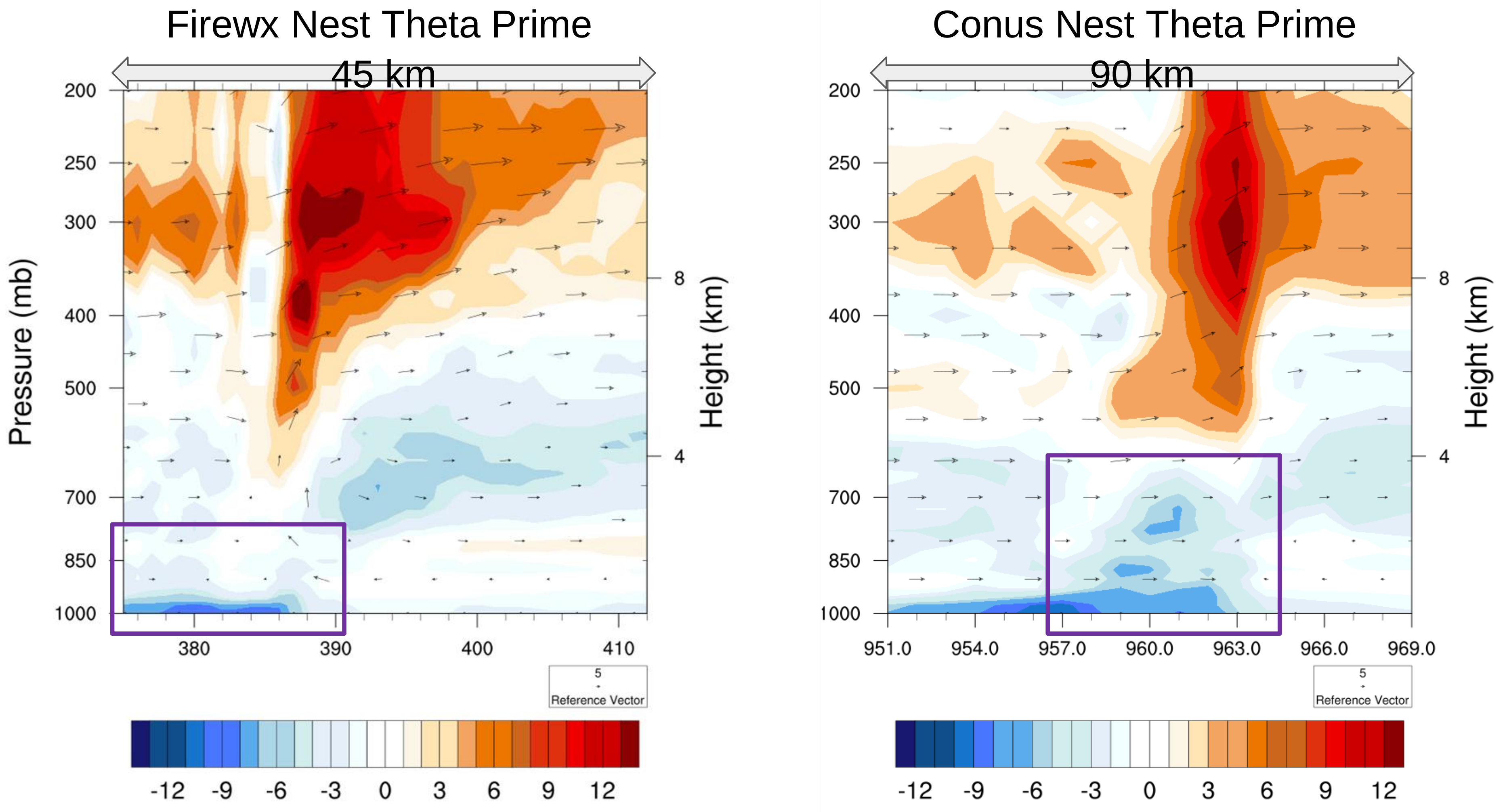



Temperature gradients are much weaker in conus storm, leading to baroclinic vorticity generation being much weaker




20 minutes later, a RFD appears in the firewx nest and leads to increased low-level baroclinic vorticity generation. This is not seen in the 4 km run.



Firewx Nest Theta Prime
45 km
Pressure (mb)
Height (km)
200
250
300
400
500
700
850
1000
8
4
380
390
400
410
5
Reference Vector
-12
-9
-6
-3
0
3
6
9
12
Conus Nest Theta Prime
90 km
951.0
954.0
957.0
960.0
963.0
966.0
969.0

# Evaluation

Both 4 km nest and 1.33 km firewx nest produce storms with rotating updrafts

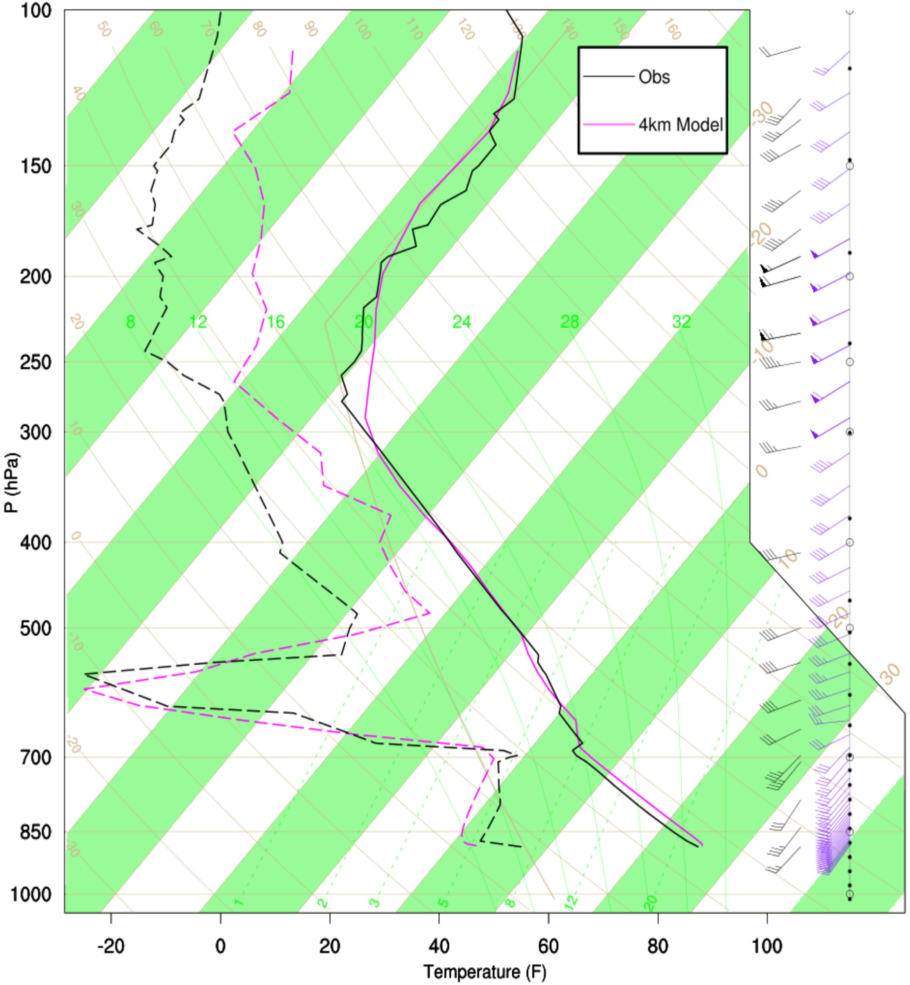
Classic supercell structures apparent in firewx nest, not so in 4 km nest

- Hook echo
- Rear flank downdraft
- Strong temperature contrasts and baroclinic generation of vorticity in low levels

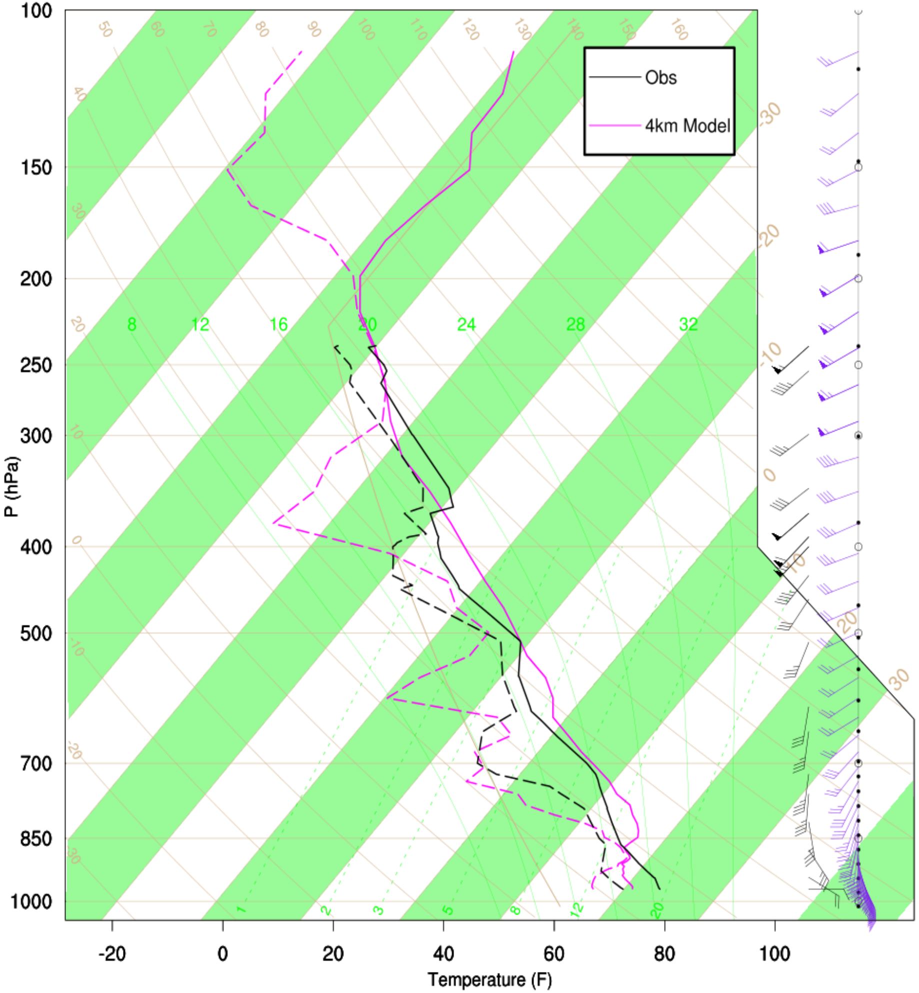
Cold pools again appear to be too shallow, especially in firewx nest

# Convection Initiation – 6 May 2015

# 05072015 0000UTC Sounding at AMA

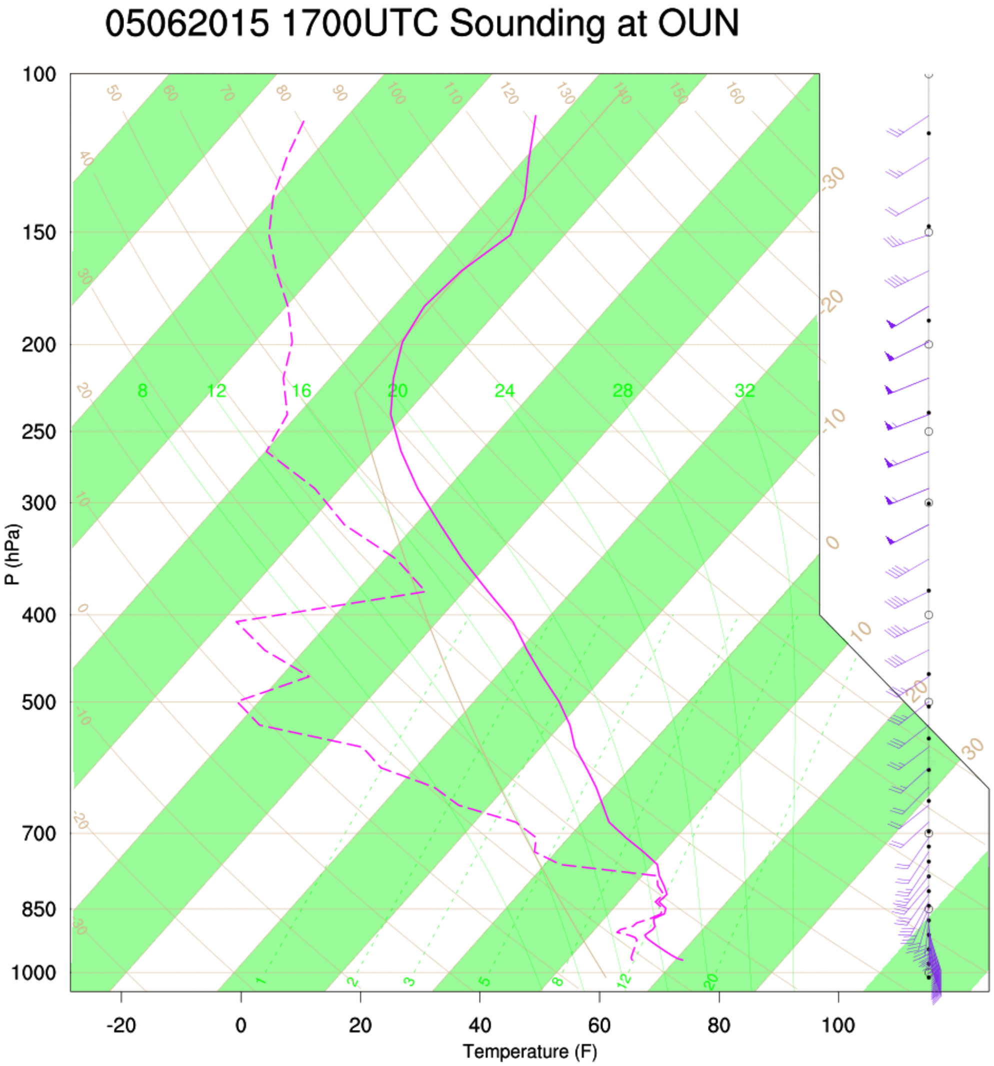



# 05072015 0000UTC Sounding at OUN



FIREWX sounding evolution at KOUN from 1700UTC on May 6 to 0000UTC on May 7

Presence of low level clouds could contribute to cool surface temperatures



Top:

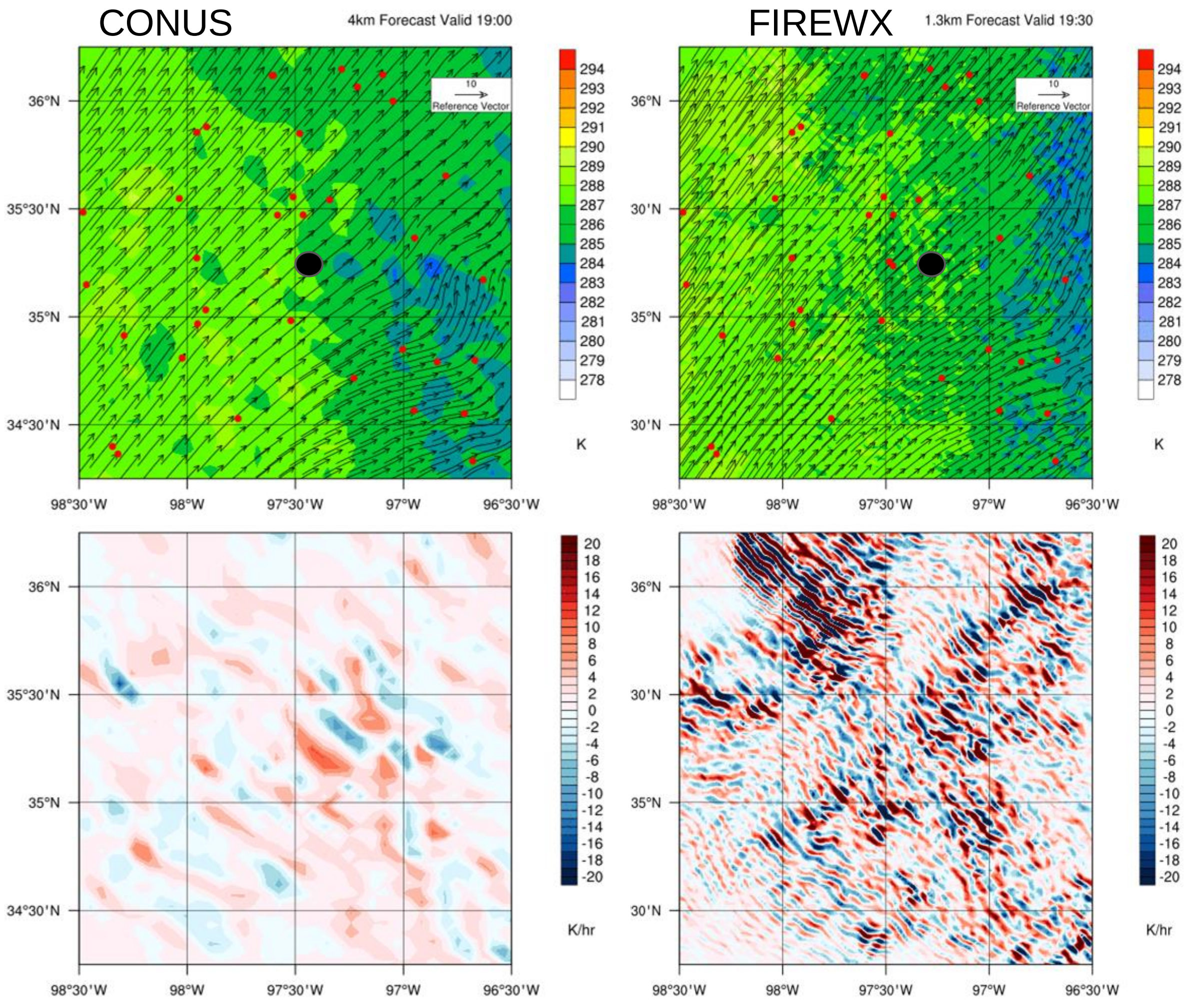
800 mb Temp (color)
800 mb Winds (vector)
OK Mesonet Stations (red dots)
KOUN (black dot)

Bottom:

800 mb Temperature Advection (WAA-red, CAA-blue)

CONUS 800 mb Temp change due to advection at KOUN from 19Z to 24Z:
Total= -0.17 K
Average= -0.003 K/5 min

Firewx 800 mb Temp change due to advection at KOUN from 19Z to 24 Z:
Total= 2.9 K
Average = 0.04 K/5 min



# Evaluation

CI did not occur during the daytime for the 6 May event due to capping inversion that was too strong

Combination of subsidence and horizontal warm advection aloft led to warmer inversion temperatures while low-level clouds below kept PBL too cool and too shallow

Both nests have persistent wave structures at 800 hPa

- Roughly perpendicular to flow
- Approximately 8 dx wavelength and waves move northeastward at same speed

# Future Work

- Analyze more storm evolution and CI samples in both cases
- Compare model storm structure to NEXRAD data
- Modify ARL's HYSPLIT to read in NAM data (grib2, hybrid sigma-pressure levels, 5 minute output) and then calculate back-trajectories in the vicinity of fronts and throughout simulated storms
- Compare forecast low-level clouds to satellite

# NGGPS Nesting/Convective Systems Summary

**Major Accomplishment in FY16:**

Identified added value of FireWx nest compared to CONUS nest for convective storms

Identified areas where improvement is needed:  pulsing of weak reflectivity, cold pool depth, low-level clouds, numerical waves, supersaturation in convective region.  Several already corrected.

Showed value of 5-minute model output when exploring model behaviors

**Priority Focus for FY17**

Continue in-depth evaluation of model CI and supercells to identify key diagnostics

**Key Issue**

Physical process parameterization schemes need improvement – community issue

# Thank You!

- NOAA/NWS/NCEP/NGGPS for sponsoring our project
- Bill Lapenta, Geoff DiMego, Genene Fisher, and UCAR contacts for support of students visiting this summer
- Eric Rogers and Eric Aligo for running the cases using the NAM
- Everyone at EMC who provided guidance and been so helpful to Eli Dennis and Michael Colbert during their 10 weeks here
- Glenn Rolph and Barbara Stunder from ARL for helping to modify HYSPLIT