The 26 June 2015 Nocturnal Mesoscale Convective System during PECAN

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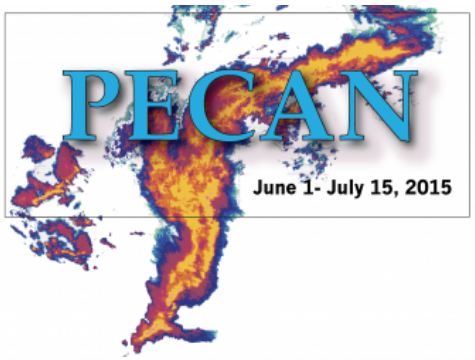
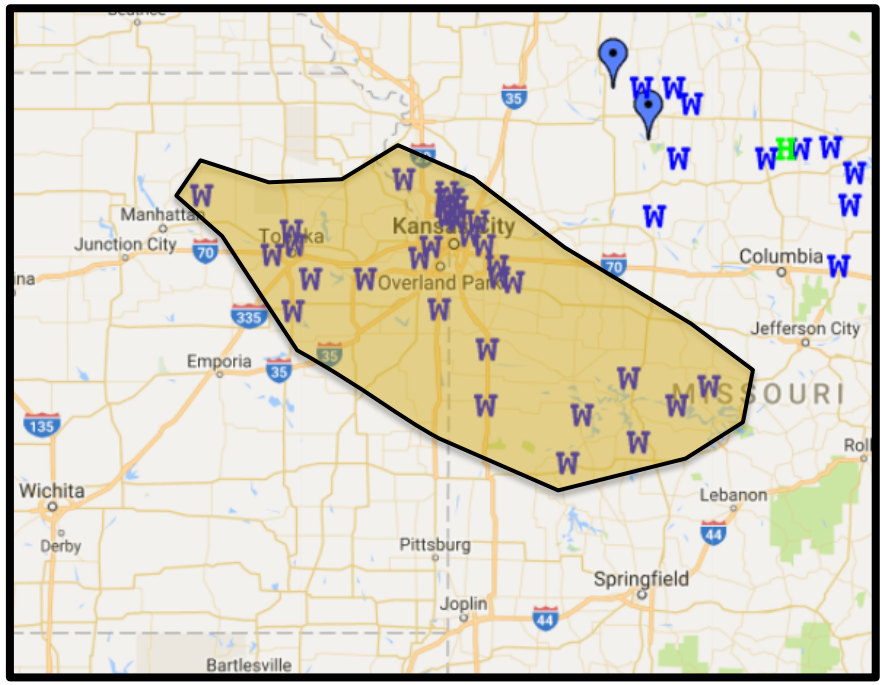
Acknowledgements:

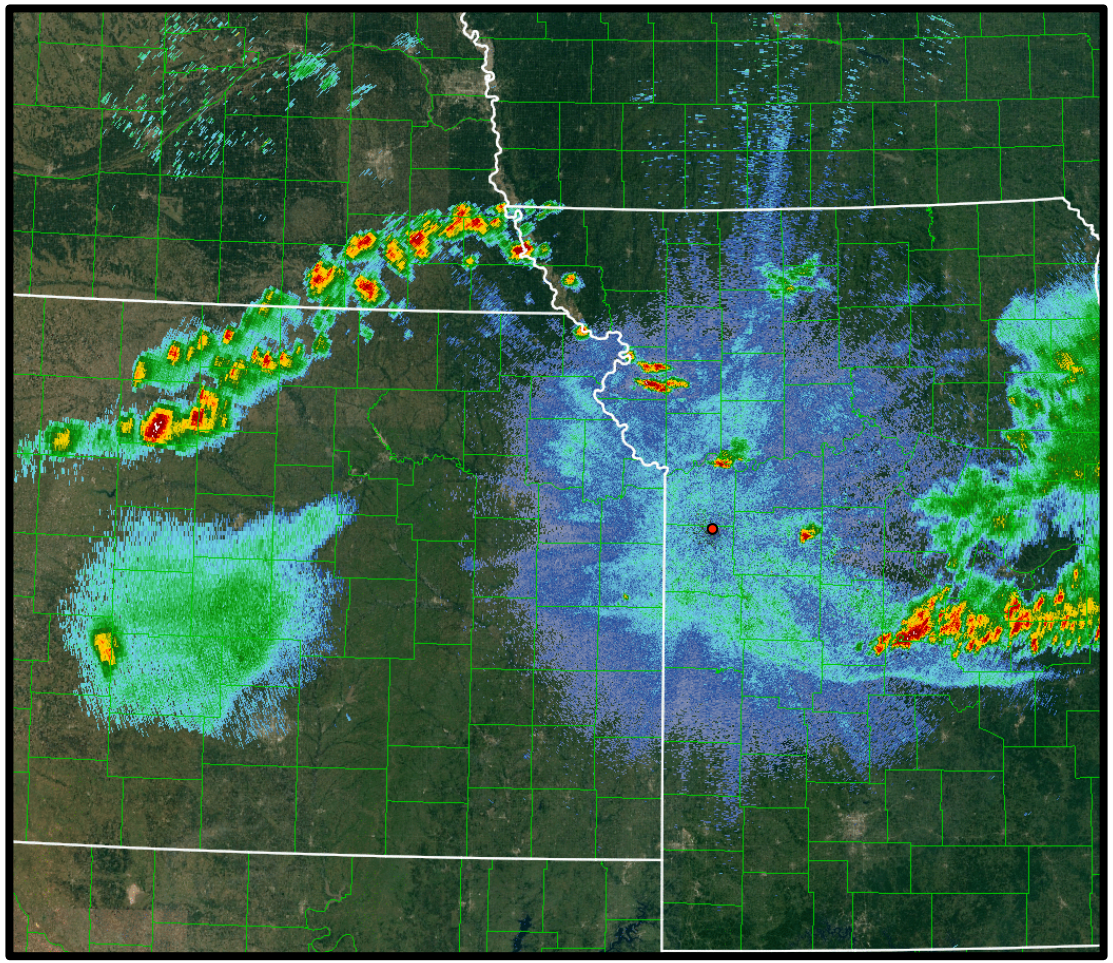
NSF Grant AGS-1259709, Conrad Ziegler, Michael Coniglio, Michael Biggerstaff, Russ Schumacher, Ted Mansell, Terry Schuur, George Bryan



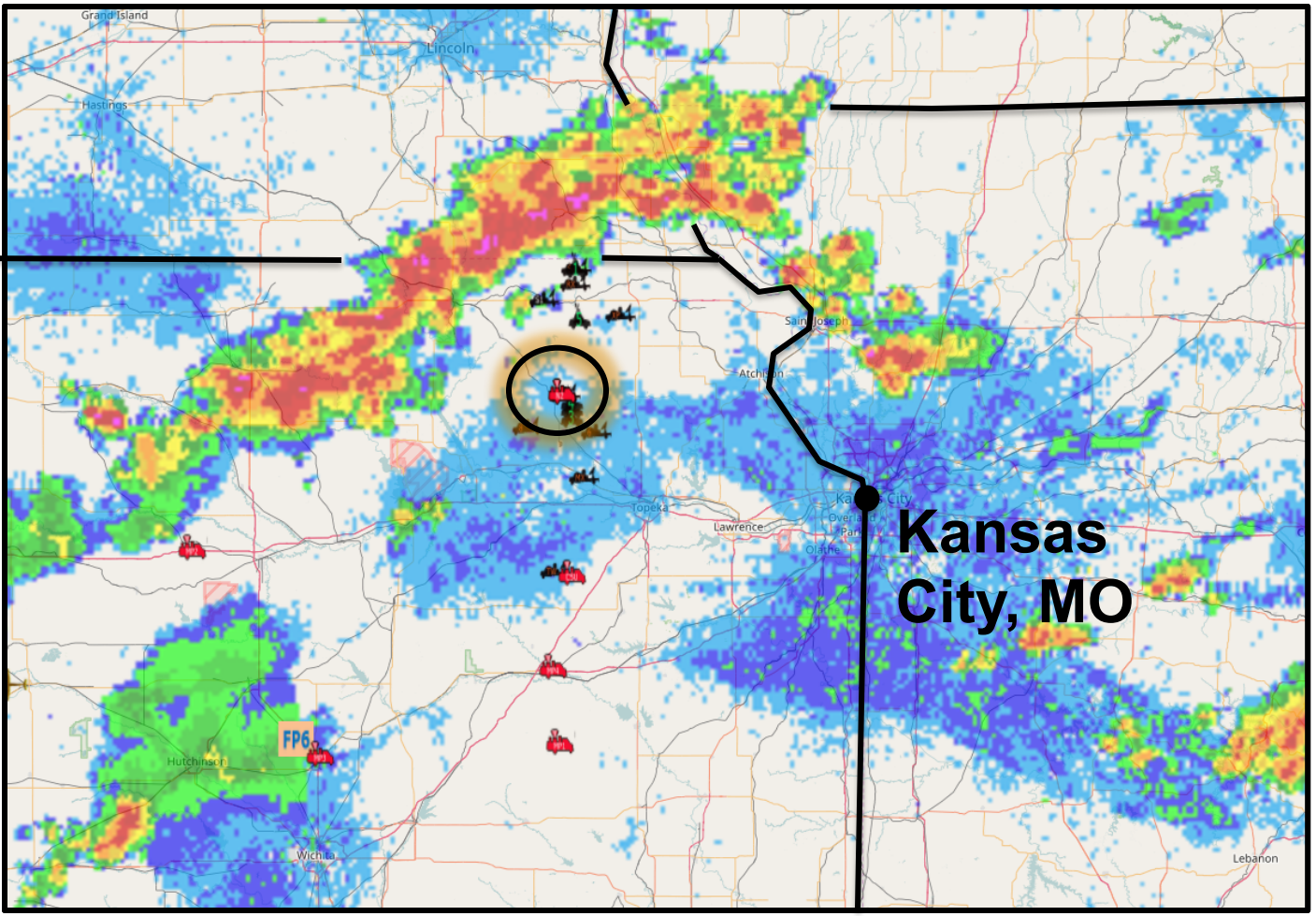
June 25/26 2015: Severe Nocturnal MCS Impacts Kansas City, Missouri and Surrounding Areas

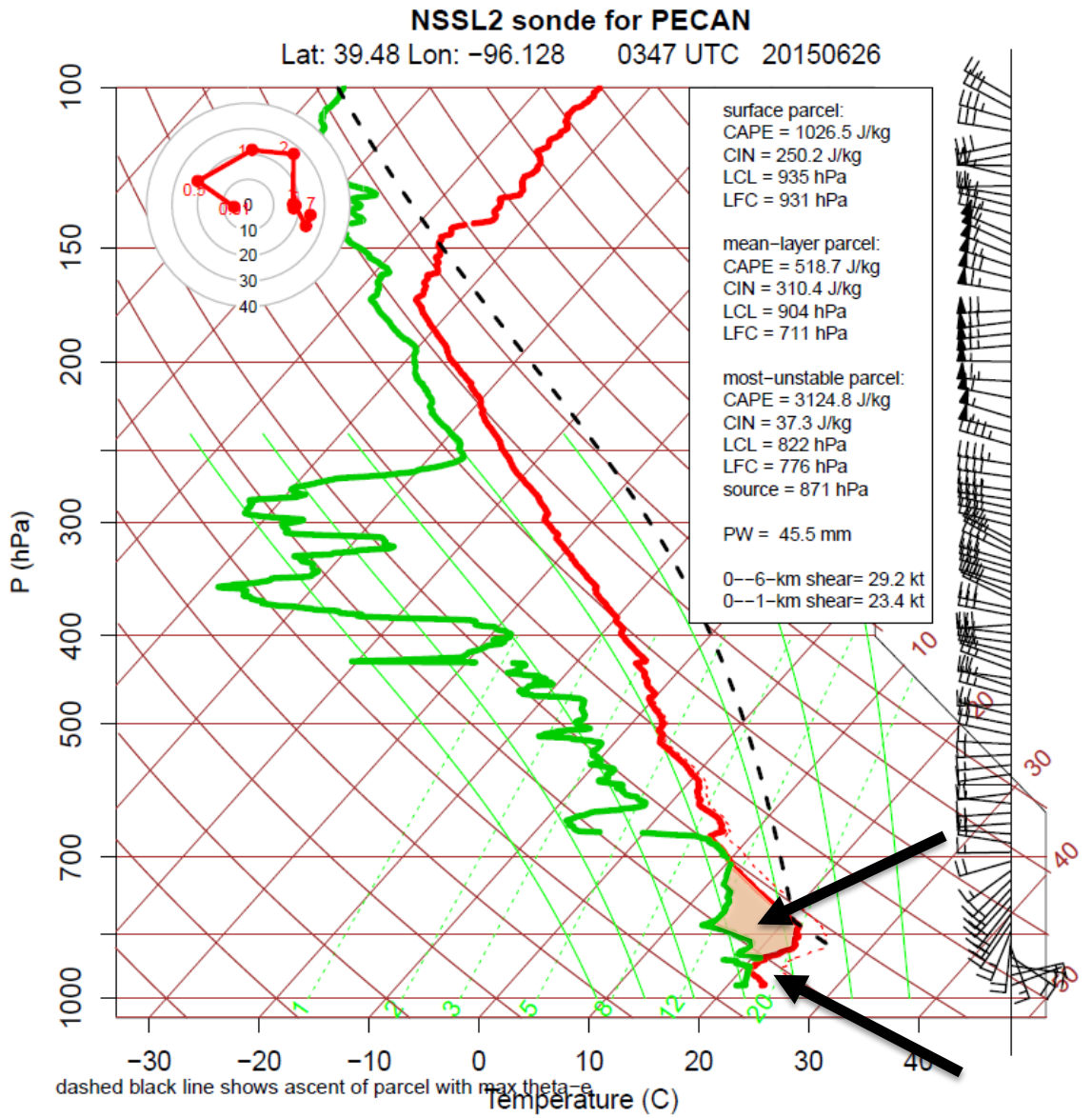
- Thunderstorms developed along cold front, progressed southeast overnight
- Kansas City, MO area hit hard after midnight

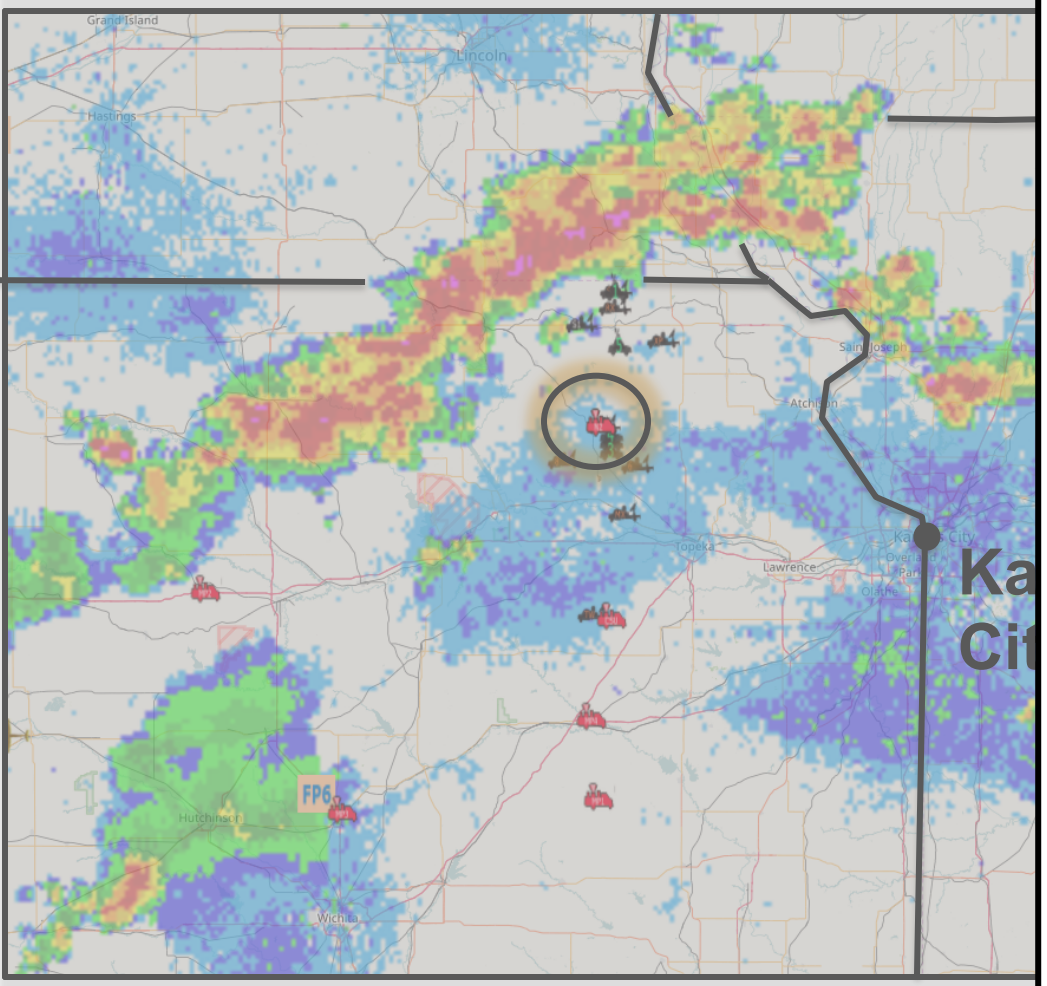




Base-scan reflectivity from KEAX between 0300 - 0900 UTC


Grand Island
Lincoln
Hastings
Atchison
Topeka
Lawrence
Olathe
Hutchinson
Wichita
Lebanon
FP6
Kansas City, MO


NSSL2 sonde for PECAN
Lat: 39.48 Lon: −96.128 0347 UTC 20150626
surface parcel:
CAPE = 1026.5 J/kg
CIN = 250.2 J/kg
LCL = 935 hPa
LFC = 931 hPa
mean−layer parcel:
CAPE = 518.7 J/kg
CIN = 310.4 J/kg
LCL = 904 hPa
LFC = 711 hPa
most−unstable parcel:
CAPE = 3124.8 J/kg
CIN = 37.3 J/kg
LCL = 822 hPa
LFC = 776 hPa
source = 871 hPa
PW = 45.5 mm
0−−6−km shear= 29.2 kt
0−−1−km shear= 23.4 kt
P (hPa)
Temperature (C)
dashed black line shows ascent of parcel with max theta−e



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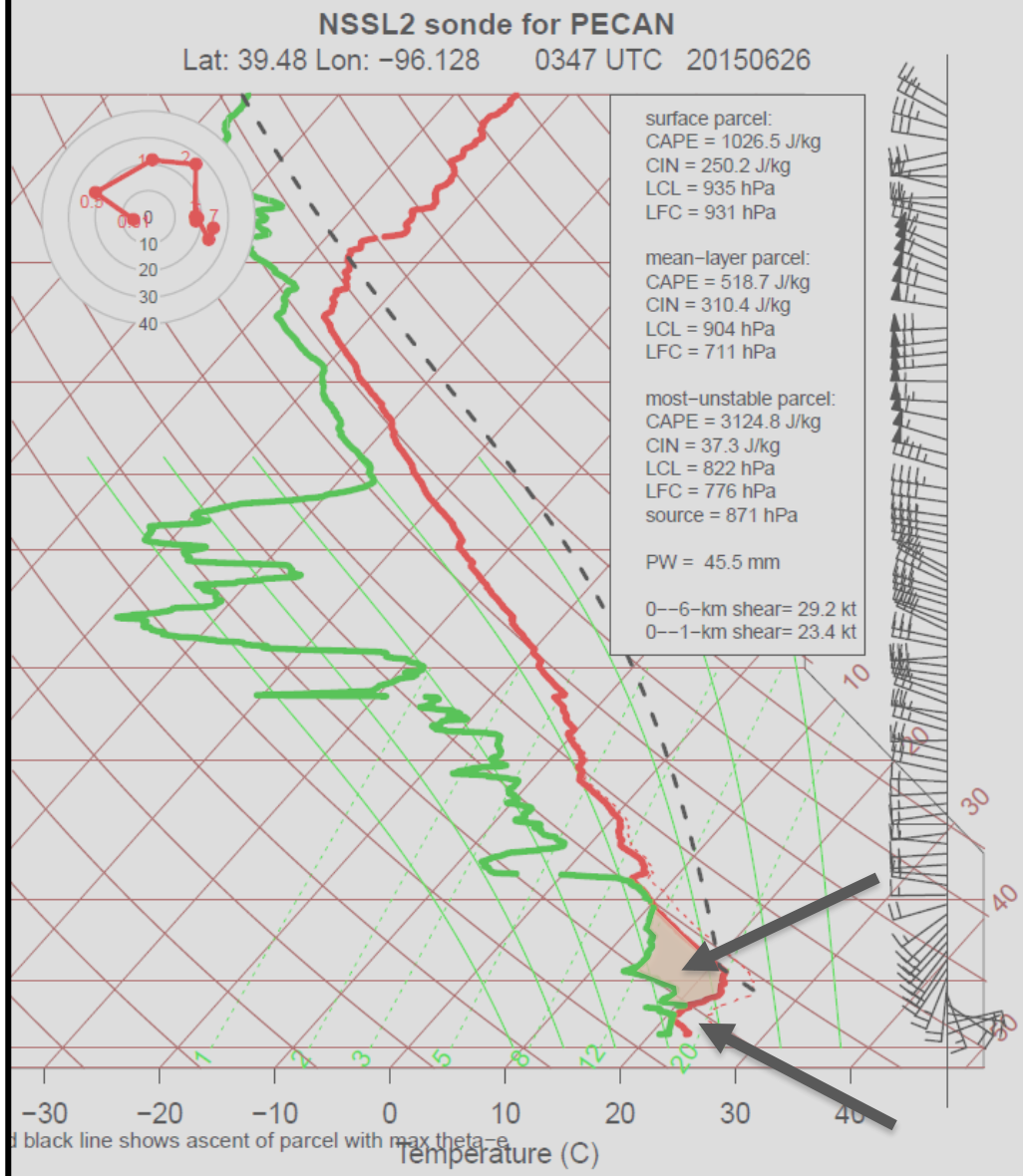

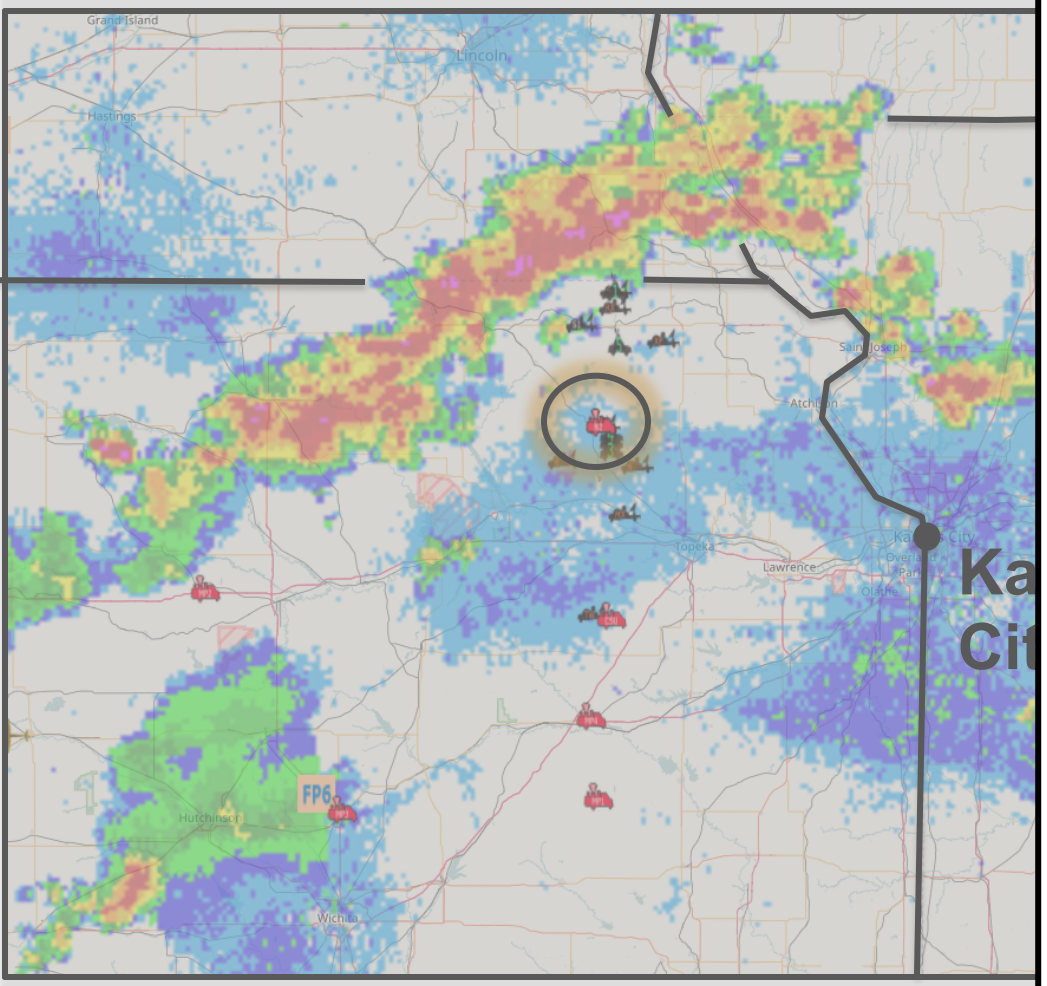

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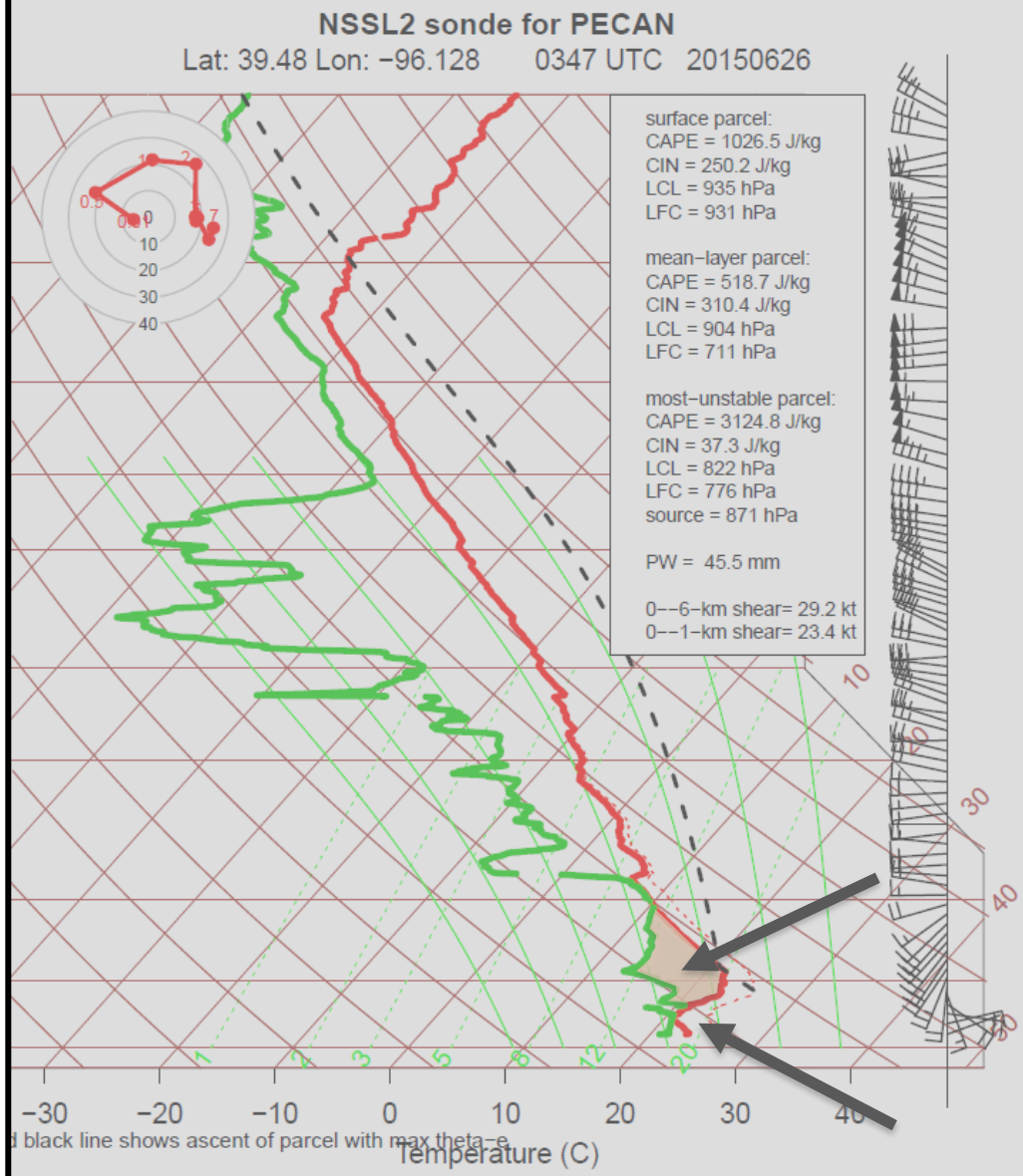

Two Main Research Questions

1. What physically drives the transition of an elevated to surface-based MCS?

2. What are the primary drivers of the severe surface winds?

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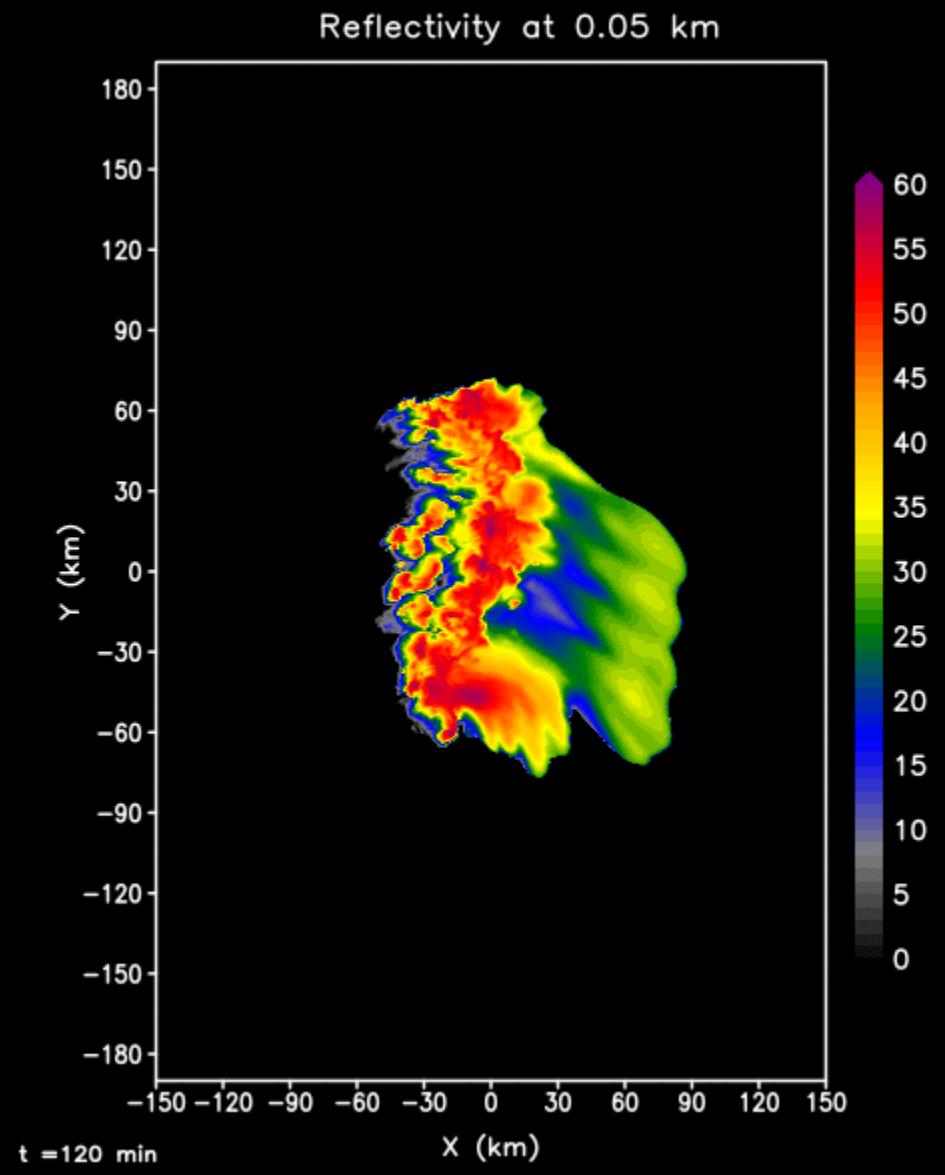
Model Specifications

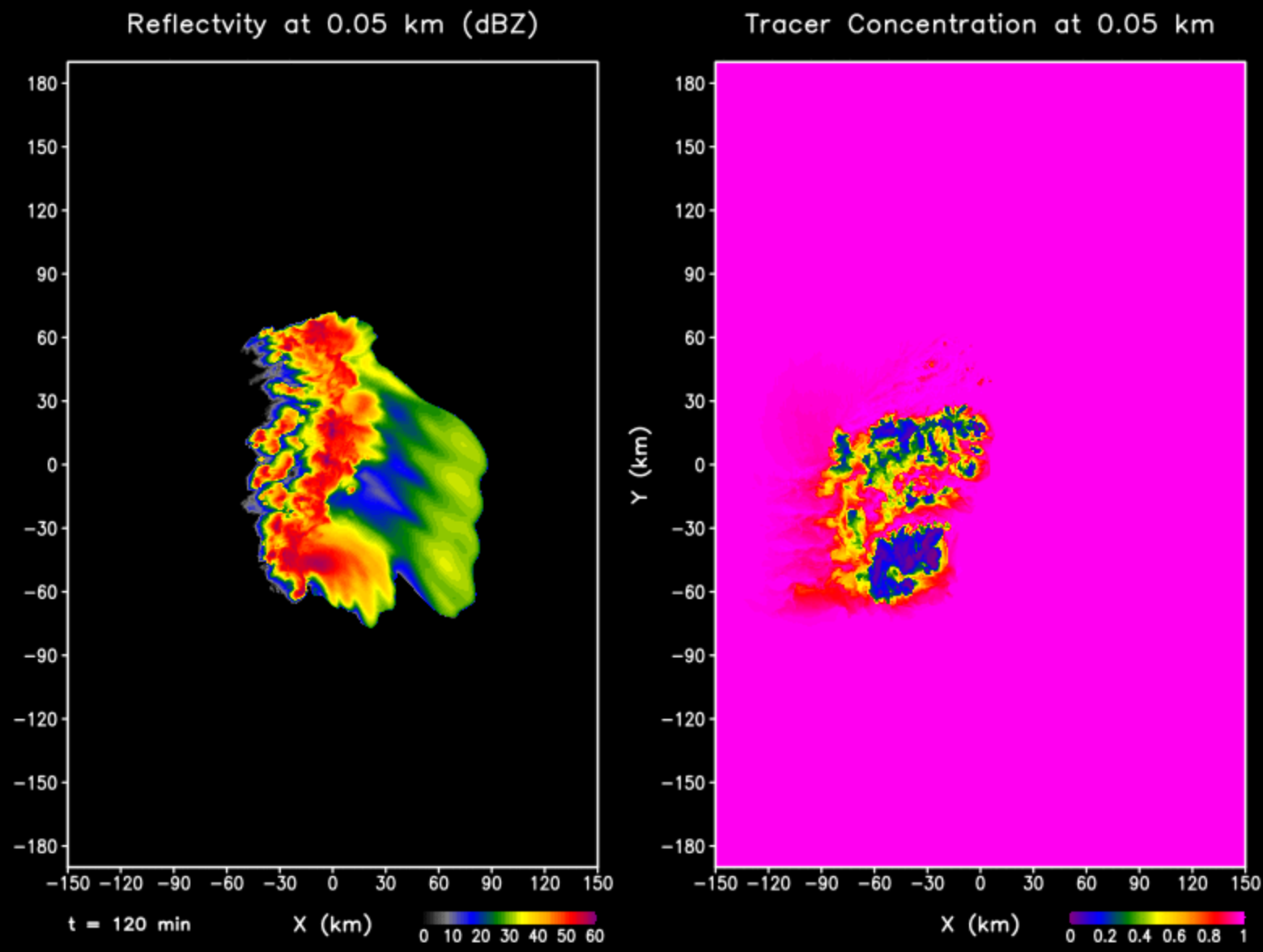
- CM1, Version 17
- 250 m horizontal grid spacing
- 100 to 250 m (stretched) vertical grid spacing
- NAM point sounding close to frontal boundary
- Morrison double-moment moisture scheme
- Initiation via line of warm bubbles
- Free slip upper/lower boundaries
- No Coriolis



Main Points:

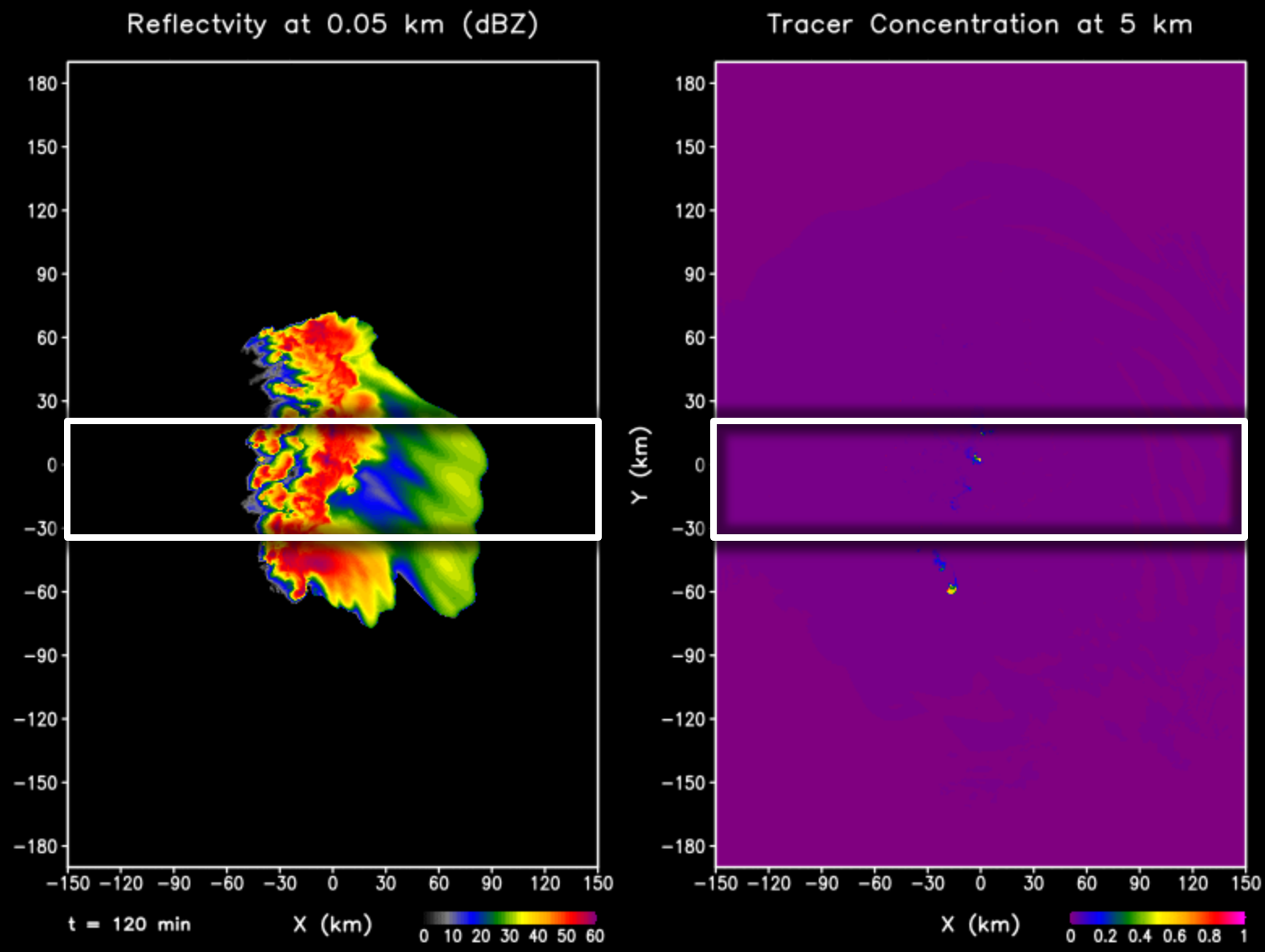
- Passive tracer originates between 0 – 500 m
- Gust front of simulated MCS lifts low-level tracers along majority of leading edge

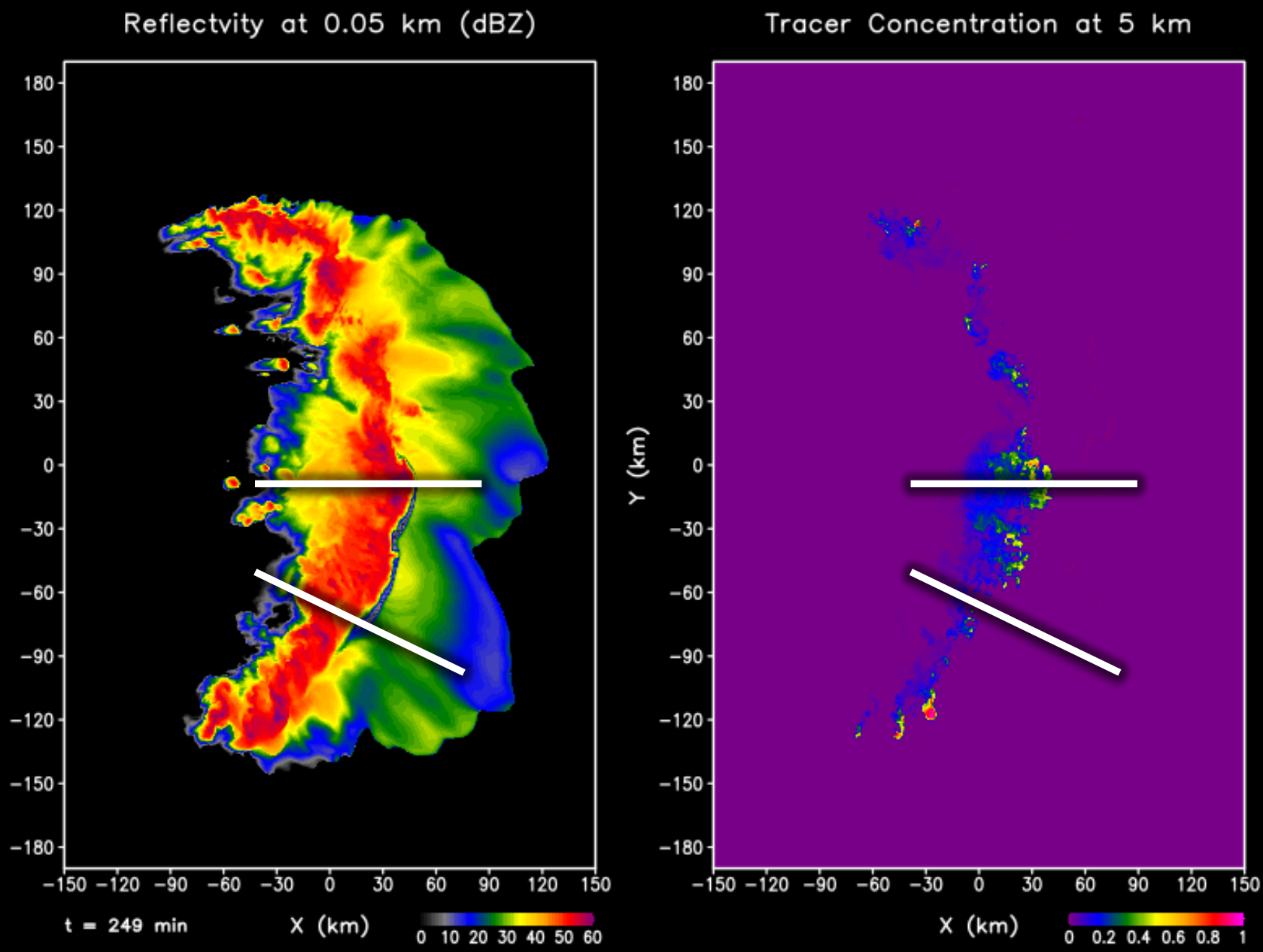
…But not necessarily to parcel LFC

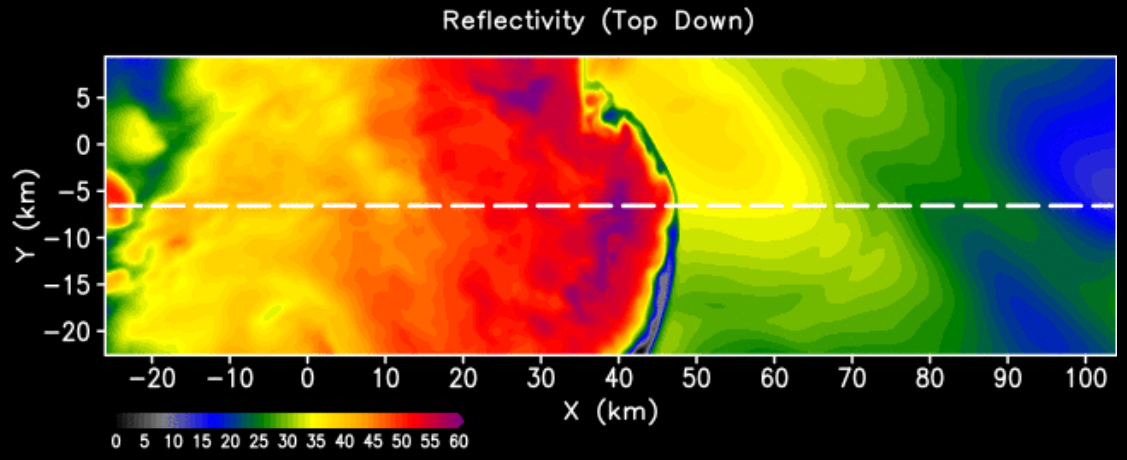


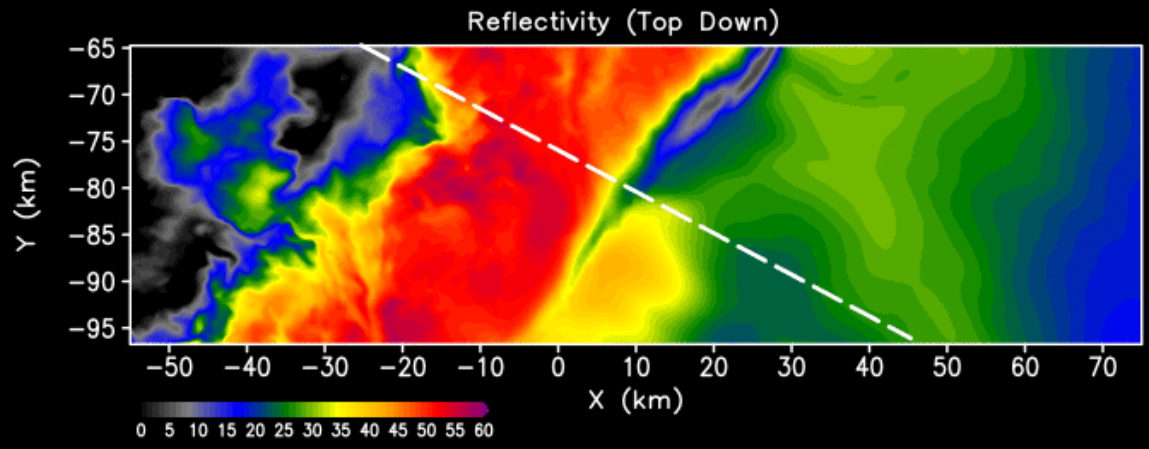
Main Points:

- Tracer originating below 0.5 km at 5 km is an indication of a surface-based updraft
- Bow echo is surface-based while southern segment is elevated
- Trajectory analyses (not shown) confirms the dichotomy




Reflectvity at 0.05 km (dBZ)
Tracer Concentration at 5 km
Y (km)
X (km)
X (km)
t = 249 min
0 10 20 30 40 50 60
0 0.2 0.4 0.6 0.8 1
180
150
120
90
60
30
0
−30
−60
−90
−120
−150
−180
−150 −120 −90 −60 −30 0 30 60 90 120 150


Reflectivity (Top Down)
Y (km)
X (km)
0 5 10 15 20 25 30 35 40 45 50 55 60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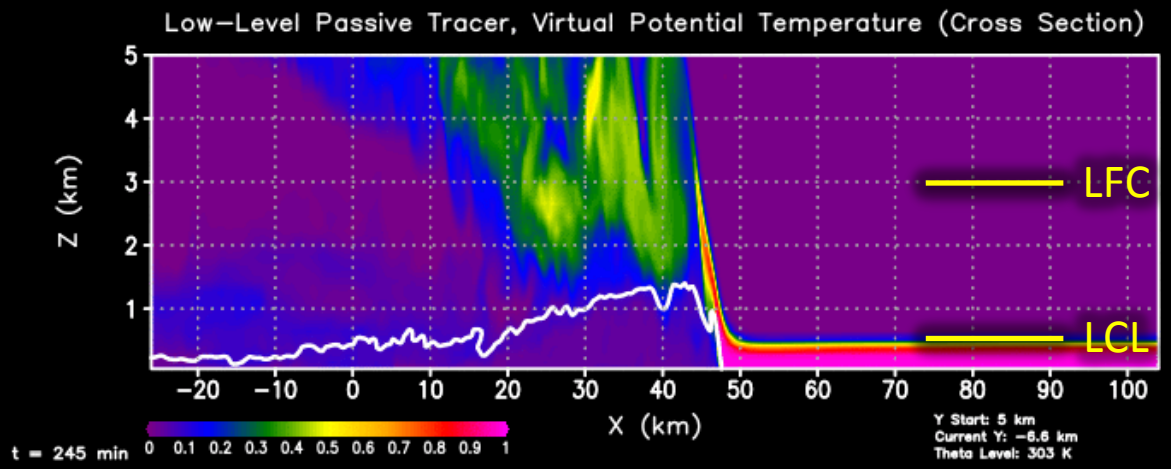
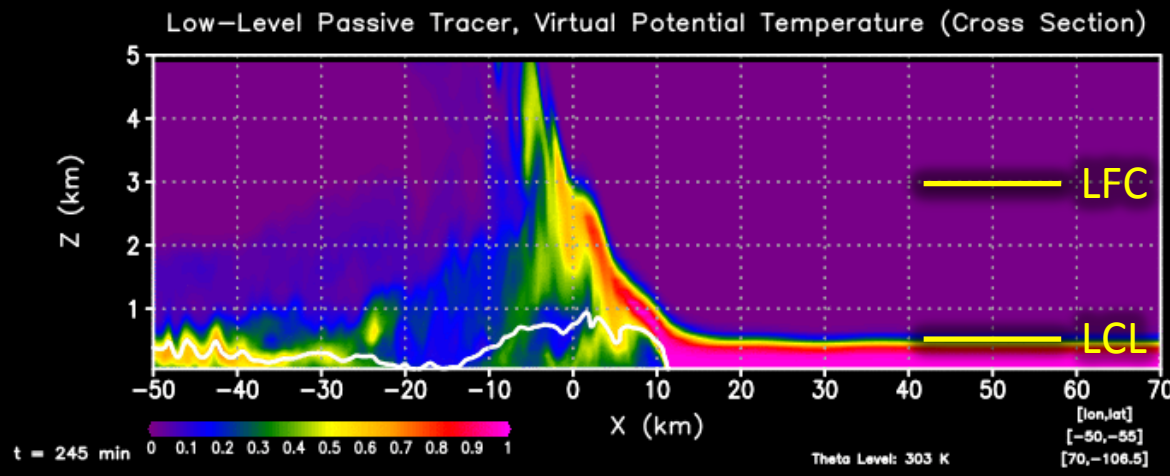
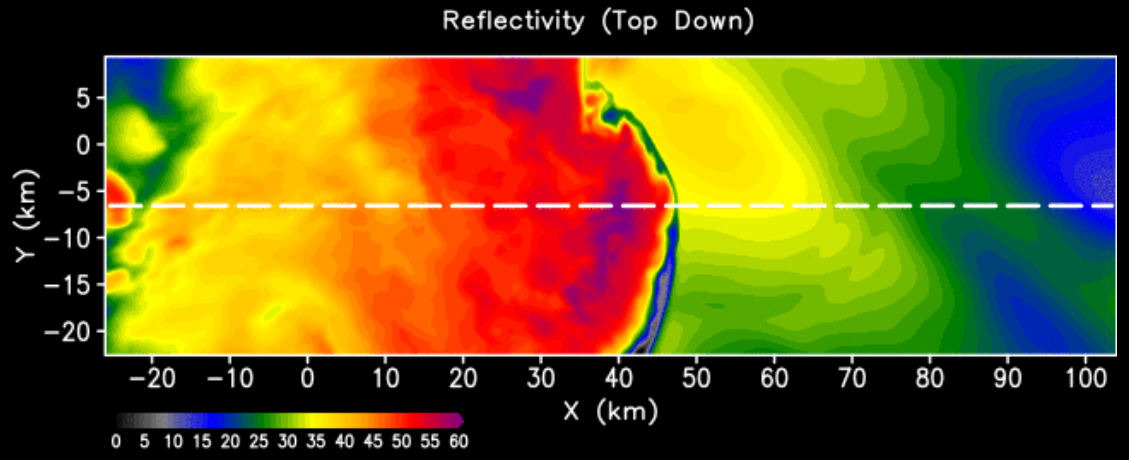
0 5 10 15 20 25 30 35 40 45 50 55 60


Low–Level Passive Tracer, Virtual Potential Temperature (Cross Section)
Z (km)
X (km)
LFC
LCL
t = 245 min
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Y Start: 5 km
Current Y: −8.6 km
Theta Level: 303 K


Low–Level Passive Tracer, Virtual Potential Temperature (Cross Section)
Z (km)
X (km)
LFC
LCL
t = 245 min
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
Theta Level: 303 K
[lon,lat]
[−50,−55]
[70,−106.5]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Y (km)
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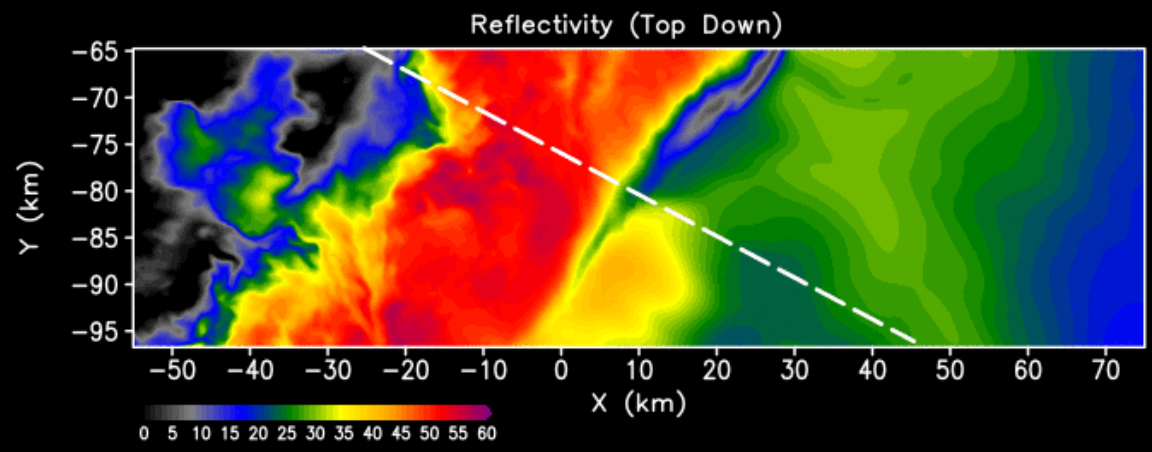
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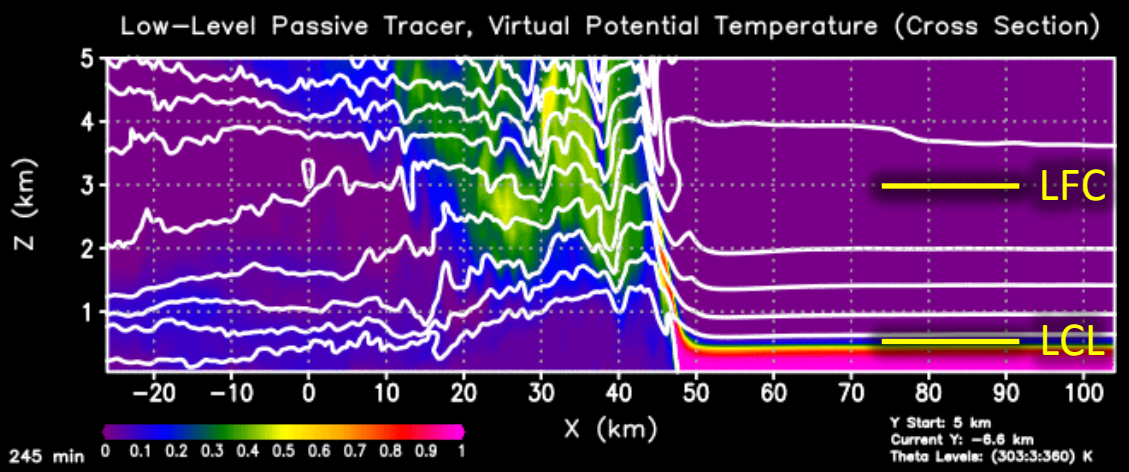
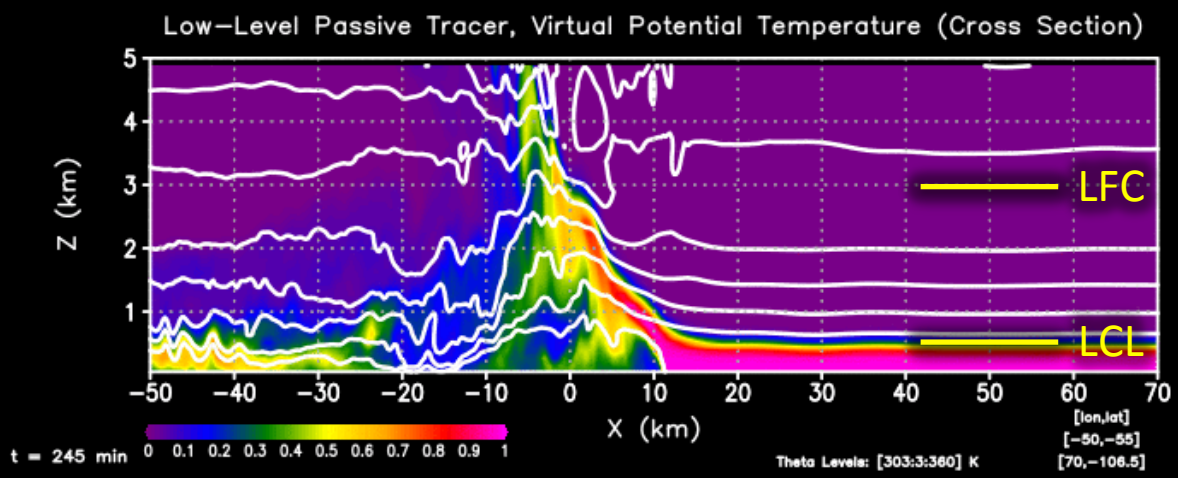

Low–Level Passive Tracer, Virtual Potential Temperature (Cross Section)
Z (km)
X (km)
LFC
LCL
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
t = 245 min
Y Start: 5 km
Current Y: −6.6 km
Theta Levels: (303:3:360) K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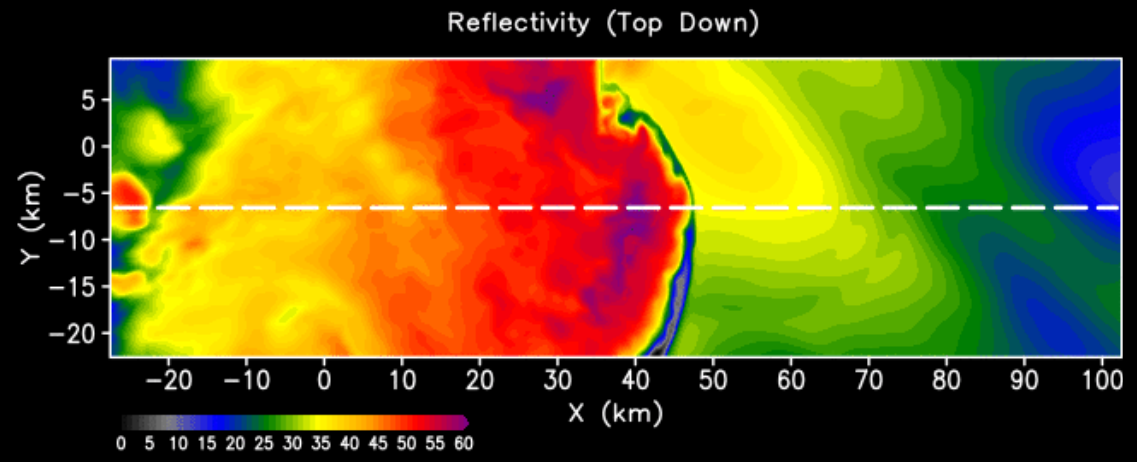
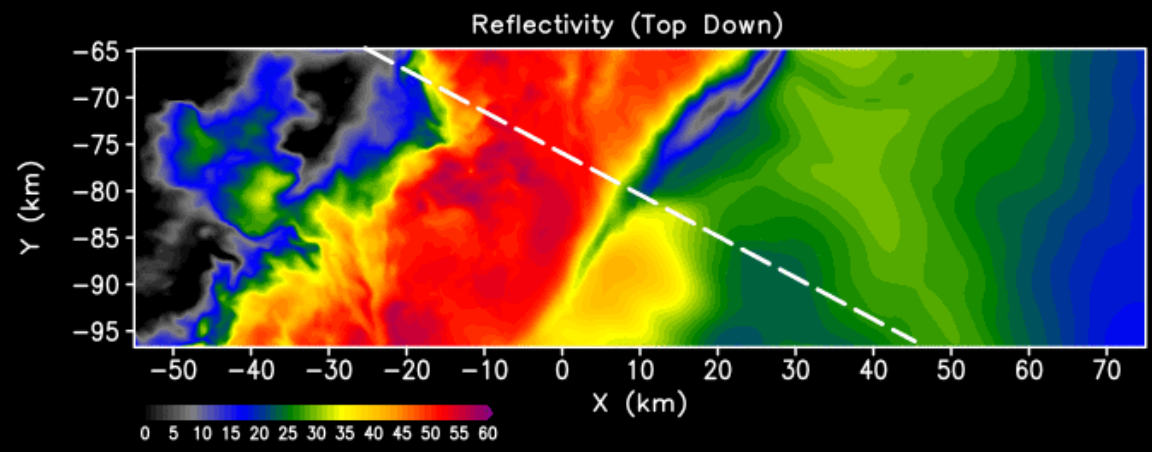
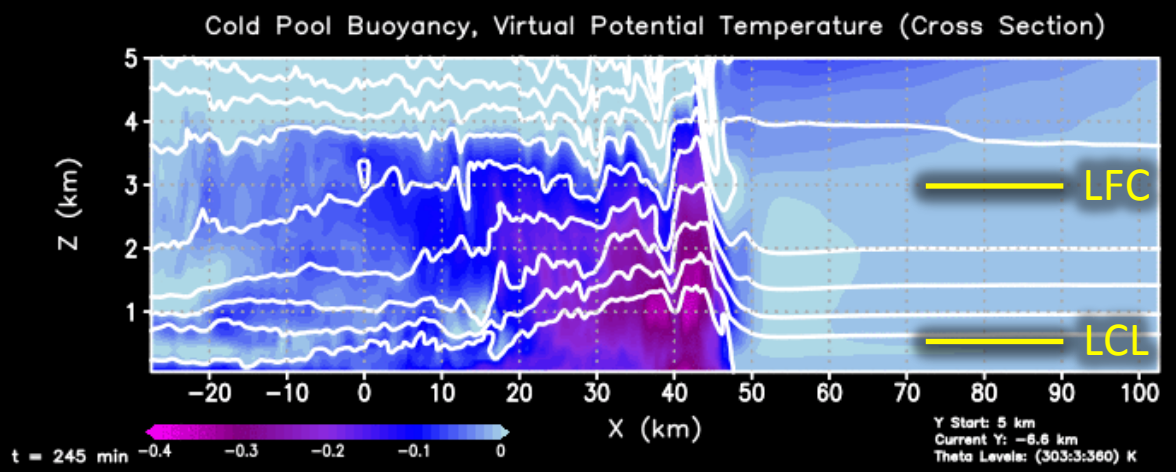
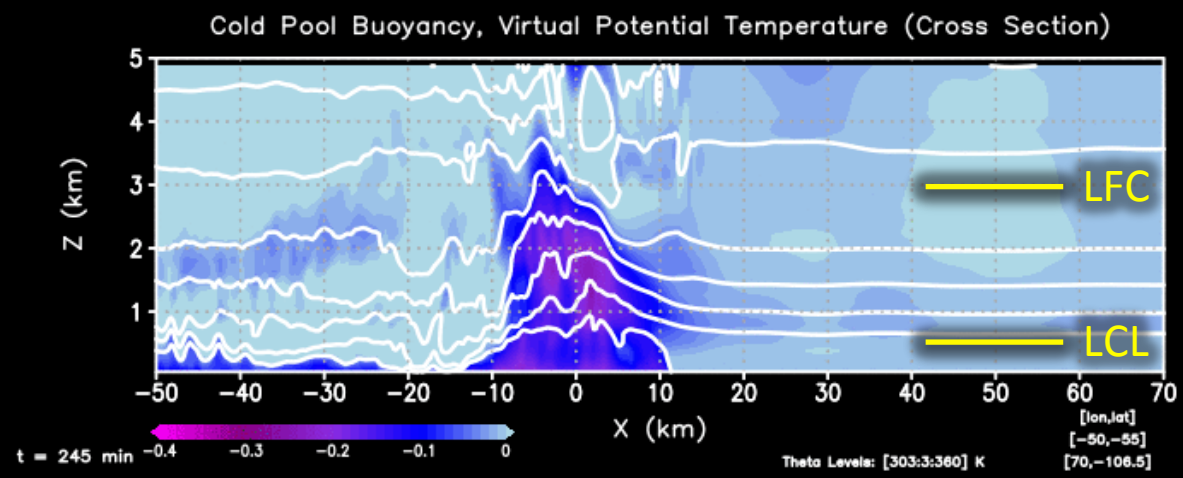
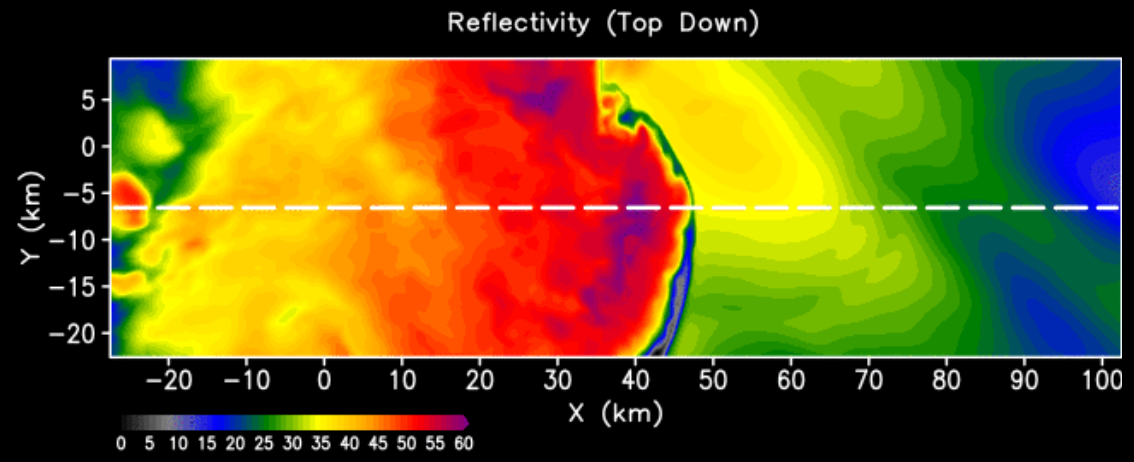


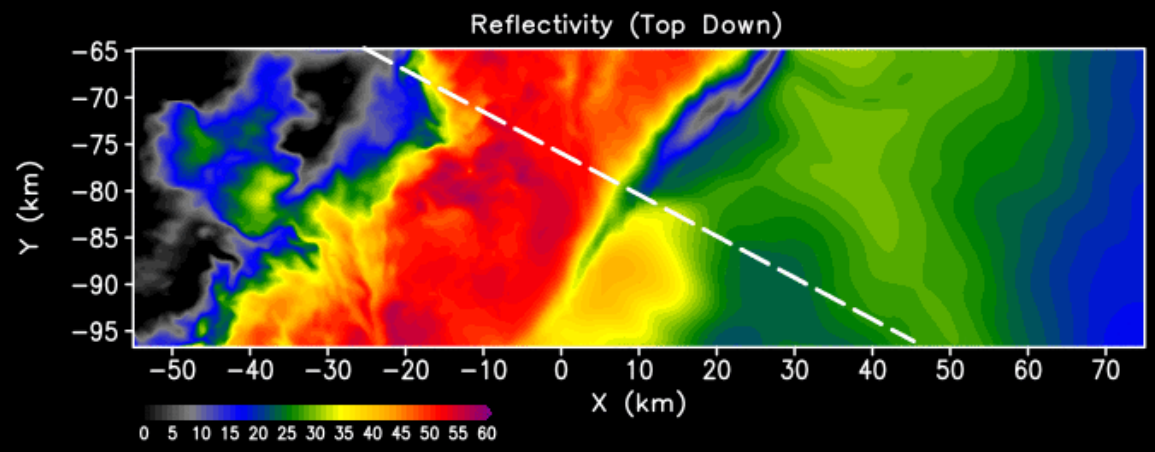


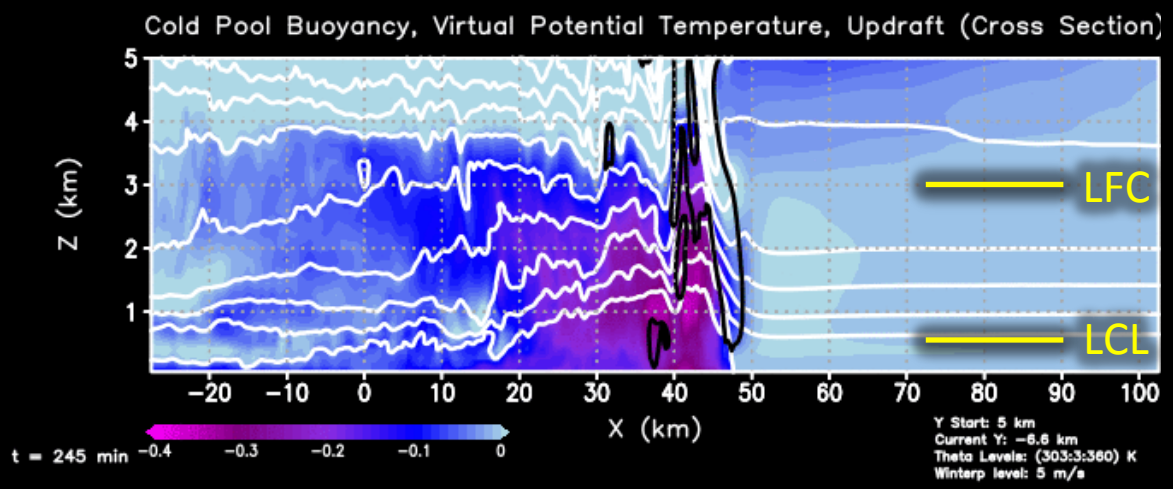


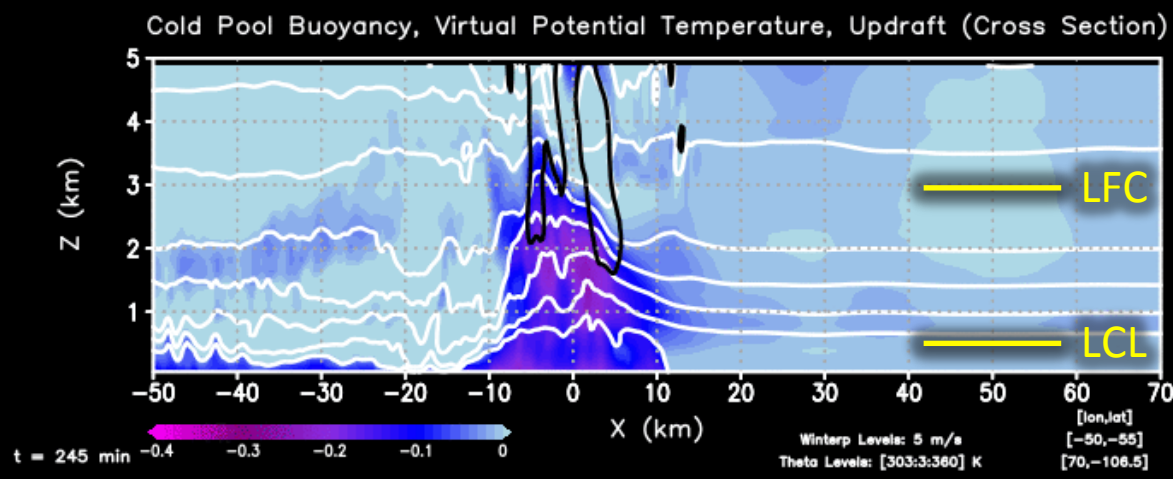


$$B = g\left(\frac{\theta'_v}{\bar{\theta}_v} - r_c\right)$$





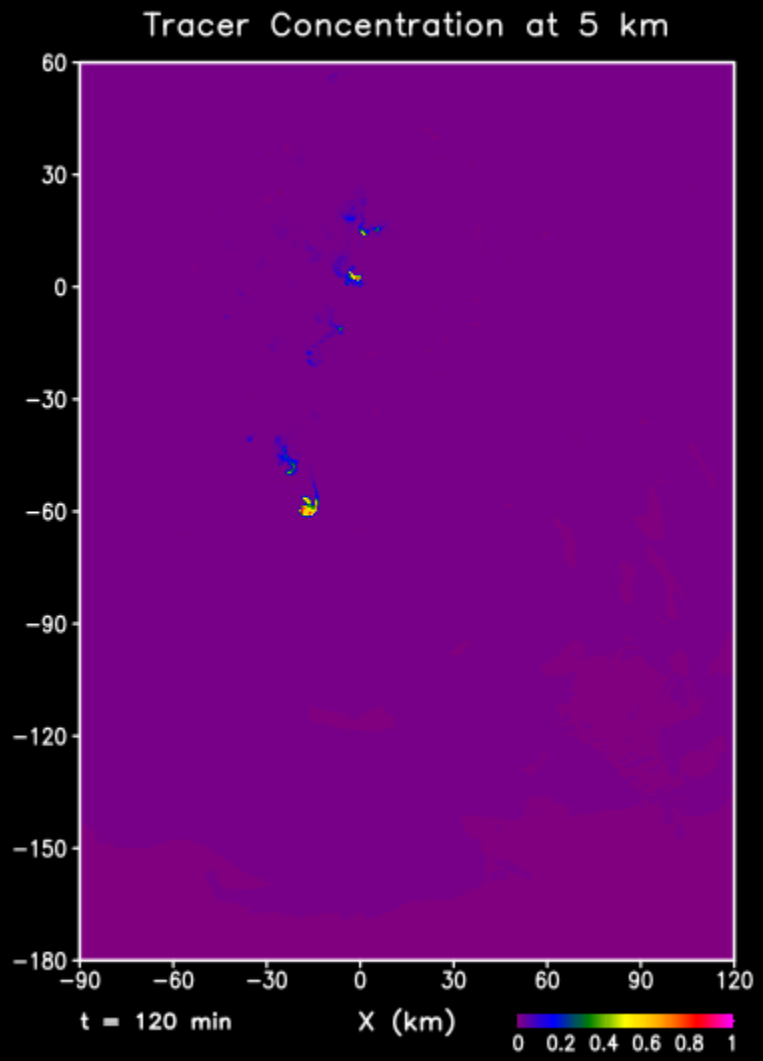


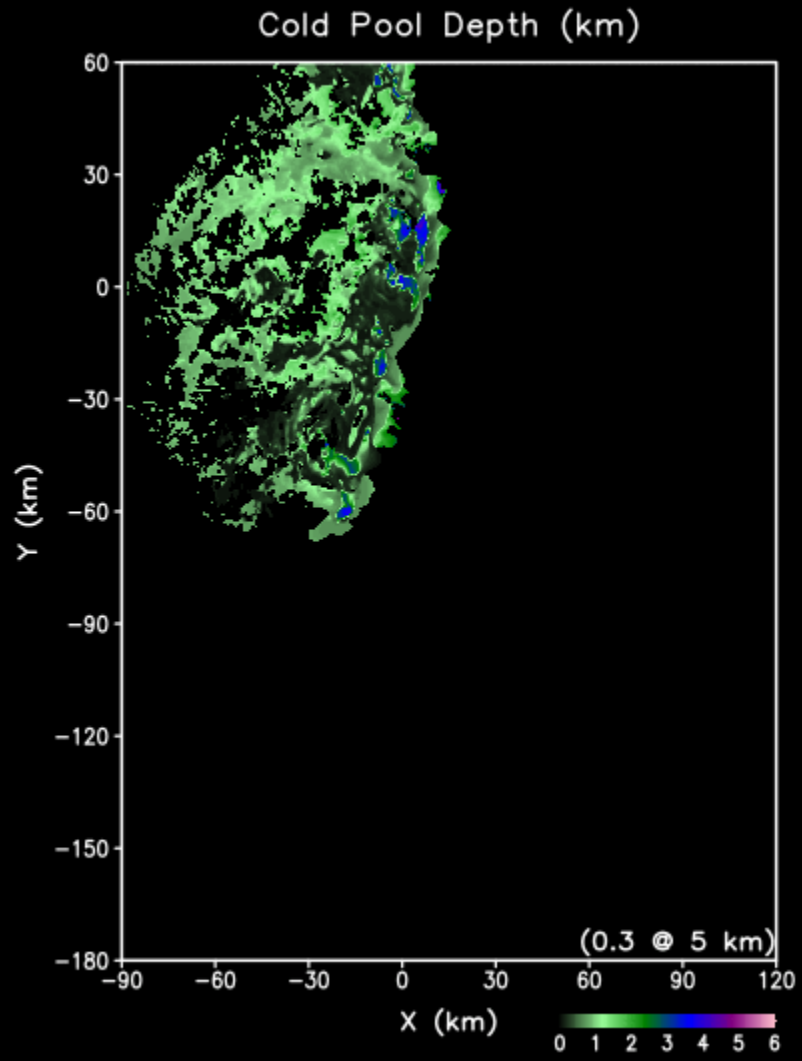


$$B = g\left(\frac{\theta'_v}{\overline{\theta}_v} - r_c\right)$$

When the depth of the cold pool reaches the LFC of surface-based parcels, *the system becomes surface-based*.

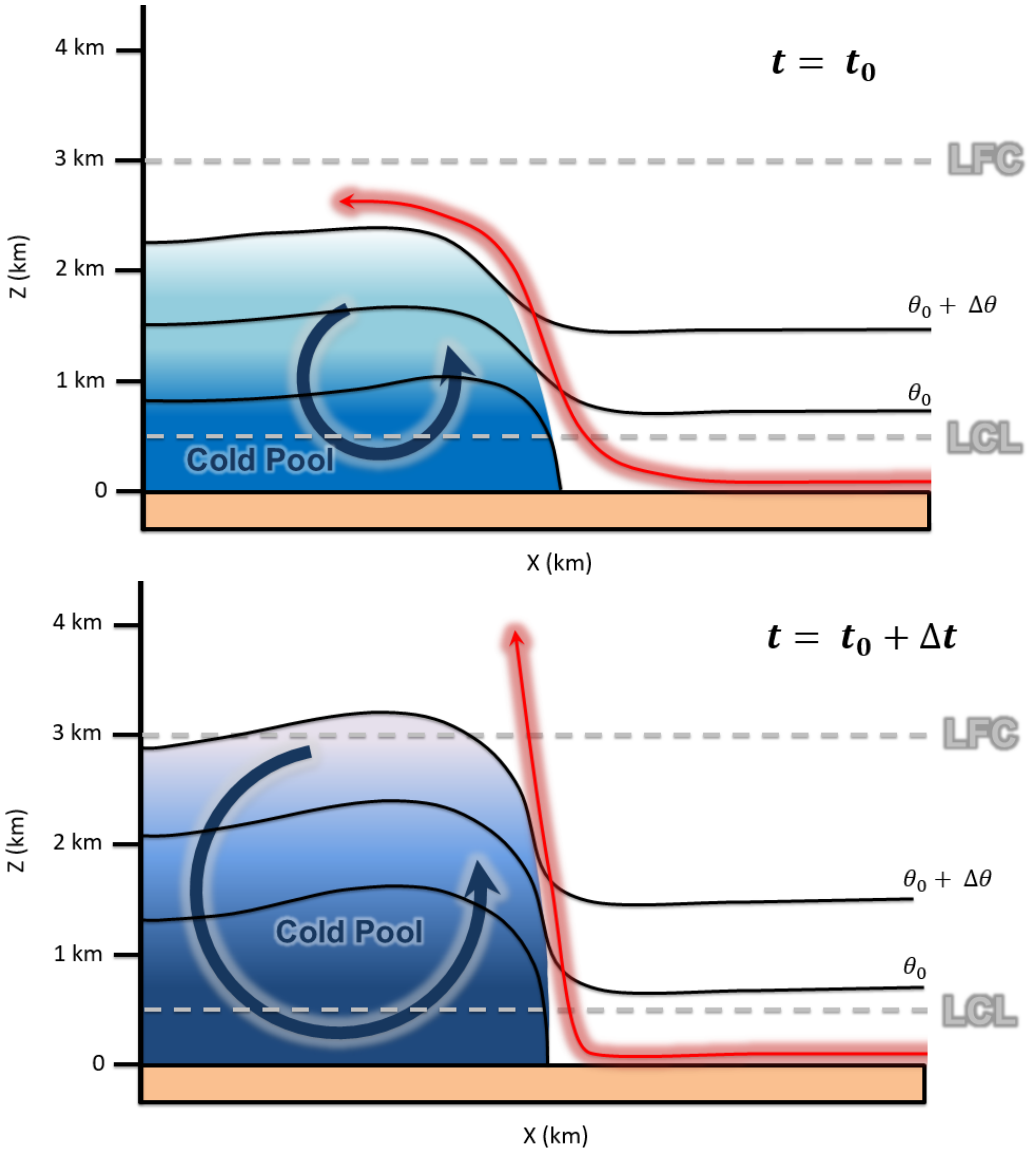
This process *takes time!*





0-3 km shear vectors

Concluding Remarks: Time is the answer!



General Idea:

1. As elevated convection matures, cold pool strengthens & deepens
2. After some time, cold pool depth reaches LFC of surface-based parcels
3. System subsequently strengthens, enabling self-feedback loop

Other Factors:

- Strong line-normal shear may help build cold pool faster (e.g. RKW theory)
- Sensitivities?