Airborne Doppler radar observations of convective plumes and radar ‘fine-lines’

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• 95 Ghz (3 mm) airborne radar observations of the optically clear convective boundary-layer

• Quiescent boundary-layer structure
  – Echo
  – Vertical velocity

• Radar fine-lines and the triggering of thunderstorms
  – Analysis of a dryline and cold front
Wyoming Cloud Radar

95 GHz (3 mm) - Doppler
WCR through nadir port

Vertical-Plane Dual-Doppler

\[
w = -V_n - w_{\text{insects}}
\]

\[
u = \frac{V_f - V_n}{\sin\alpha} - u_{\text{insects}} \tan\alpha
\]

--> extract circulation \((u,w)\) below AC
echoes in the ‘quiescent’ BL

- Clear, warm day in Kansas, 31 May 2002
- Soundings suggest a well-mixed, well-capped BL
- Thin haze layer marks the BL top
WCR vertical velocities

aspect ratio: 2.5:1
Frequency-by-altitude diagram

- Reflectivity threshold = -25 dBZ
- Reflectivity threshold = -20 dBZ

5/31/02, 17:57-18:05, sfactor=2
24 May

WCR up-looking, flight level 165 m
WCR vertical velocities

dryline

cold front
Flight level: ~2300 m AGL

20:10 Z
VPDD

cold front and dryline have collapsed

5/24/2002, 20:07:00–20:13:00

Flight level: ~2300 m AGL

cold front below @ 20:09 Z

cold front & dryline have collapsed

frontal motion
Flight level: 2300 m AGL

WCR nadir antenna reflectivity
20:21:50 - 20:25:40

Frontal motion

20:42:43 - 20:46:18

ESE 164

19:33 - 19:35:33

SE 135

20:27:00 - 20:30:48

Frontal motion

total length: 11.2 km
aspect ratio: 1:1

Flight level: 360 m AGL
Total length: 11.2 km
Aspect ratio: 1:1

Height above flight level (m)

-45 dBZ

20:27:00 - 20:30:48

-5 km

20:27:00 - 20:30:48

-45 dBZ

20:27:00 - 20:30:48

-5 km

20:27:00 - 20:30:48

-45 dBZ
This is a cloud whose towering tops had grown well above 4 km AGL, part of a line of storm cells aligned with the cold front.

Deep convection develops 9 km ahead of sfc cold front.

Gravity waves in the cold-frontal stratus.
summary

• An airborne W-band radar sampling at 30 Hz can measure echoes in the optically-clear warm-season convective boundary-layer.
• Dual-Doppler synthesis at close range is feasible.
• The quiescent BL contains well-defined plumes,
  – about as wide as they are deep
  – originate near the surface
  – buoyant, positive moisture anomalies
  – tend to be subsident, except for the stronger plumes (bug bias?)
• The WCR echo and velocity transects have been used to describe the detailed vertical structure of radar ‘fine lines’, confirming kinematic aspects of a cold front that have been simulated in the lab and by hi-res numerical models, but have never been observed before.
Frequency-by-altitude diagram

nadir antenna