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

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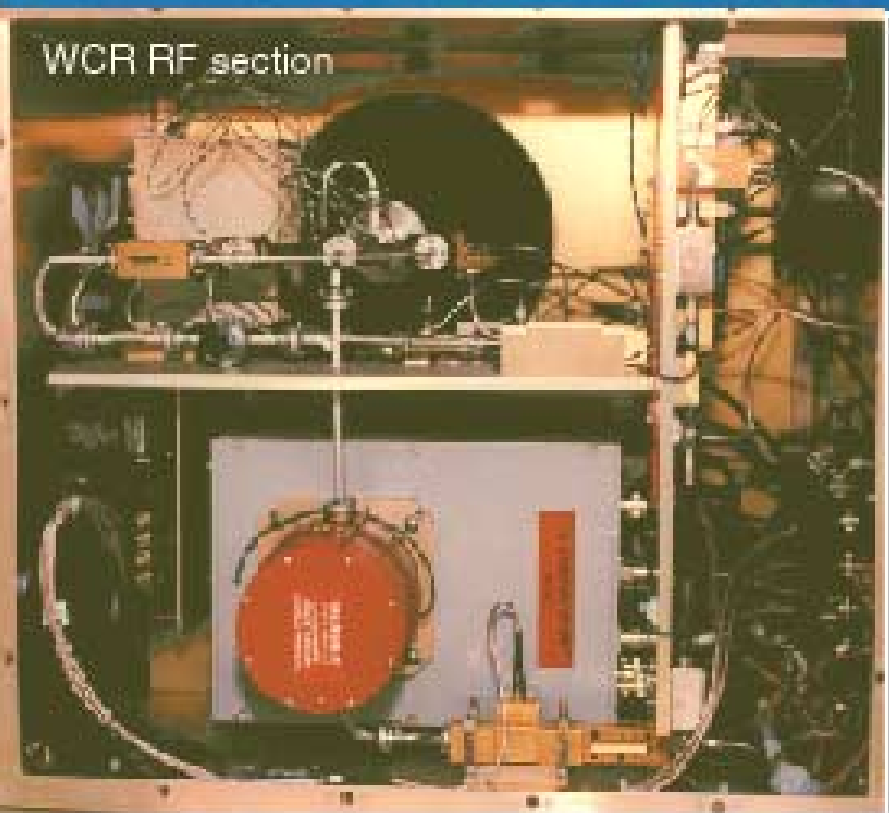
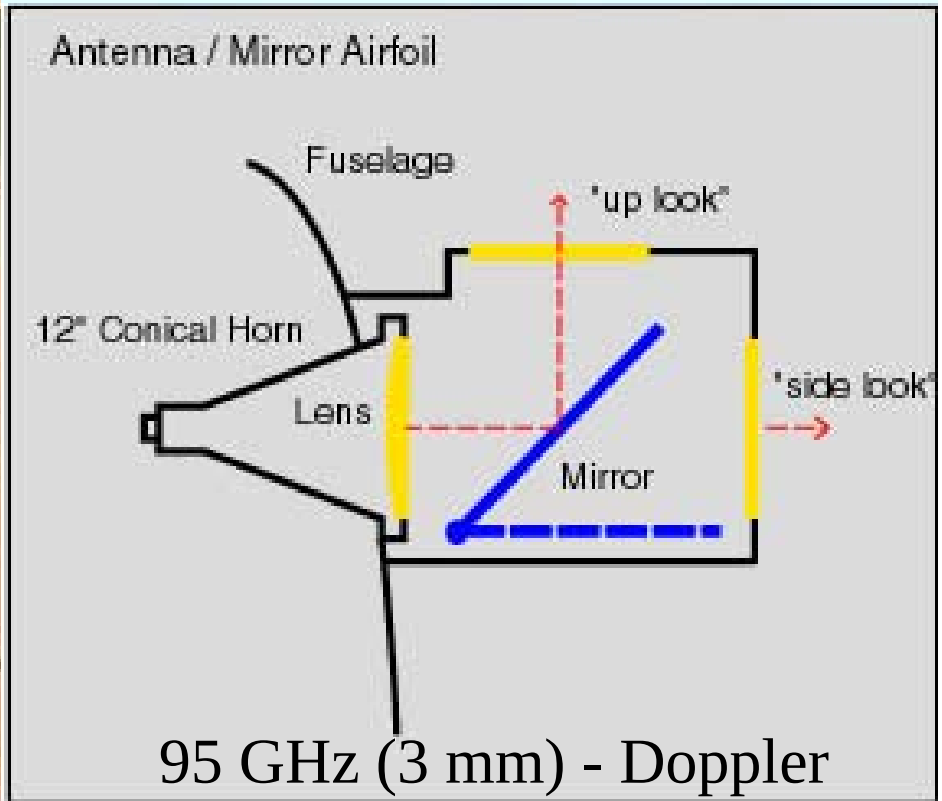
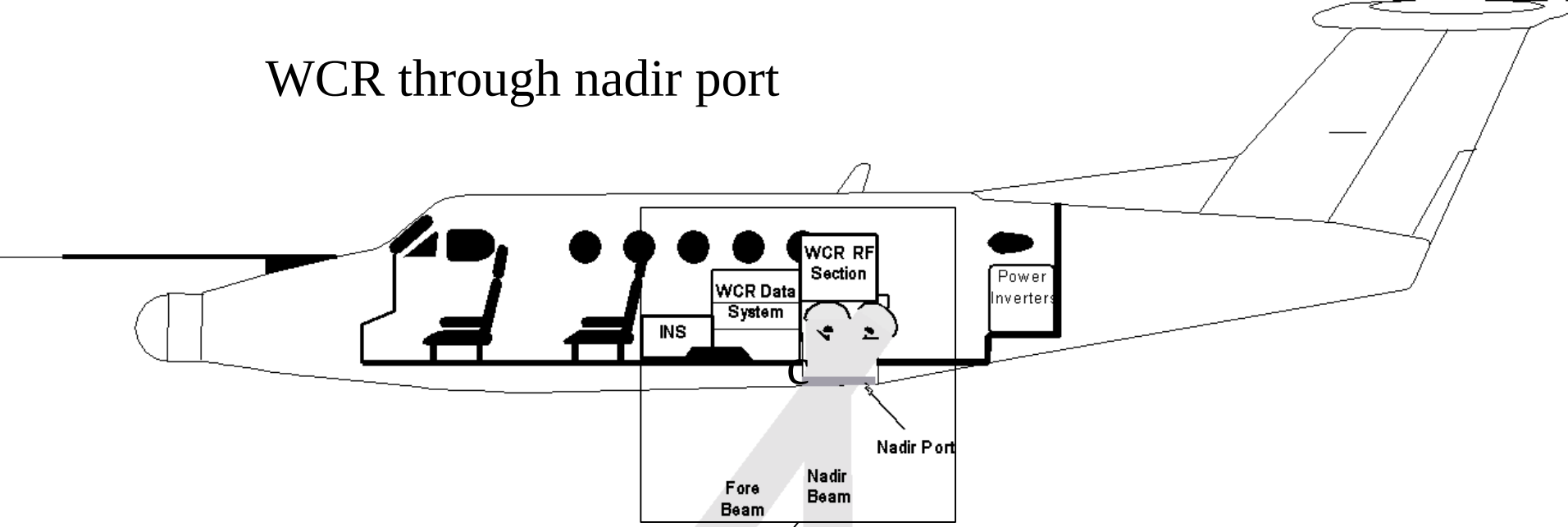
- 95 Ghz (3 mm) airborne radar observations of the optically clear convective boundary-layer
- Quiescent boundary-layer structure
  - Echo
  - Vertical velocity
- Radar fine-lines and the triggering of thunderstorms
  - Analysis of a dryline and cold front

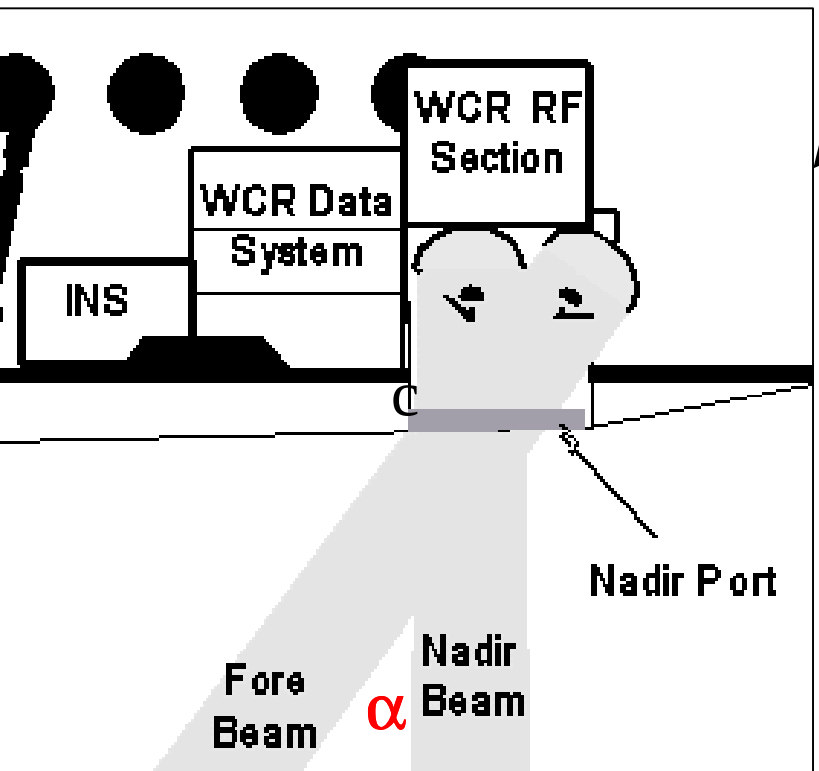




95 GHz (3 mm) - Doppler

WCR through nadir port





Vertical-Plane Dual-Doppler

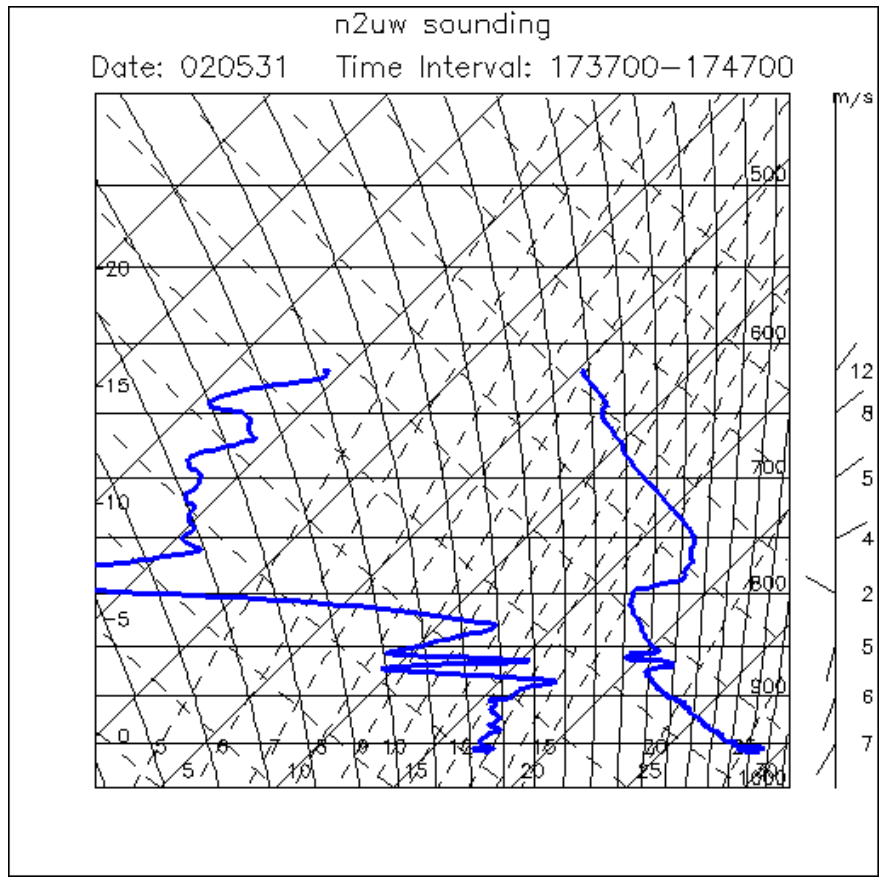
$$w = -V_n - w_{insects}$$

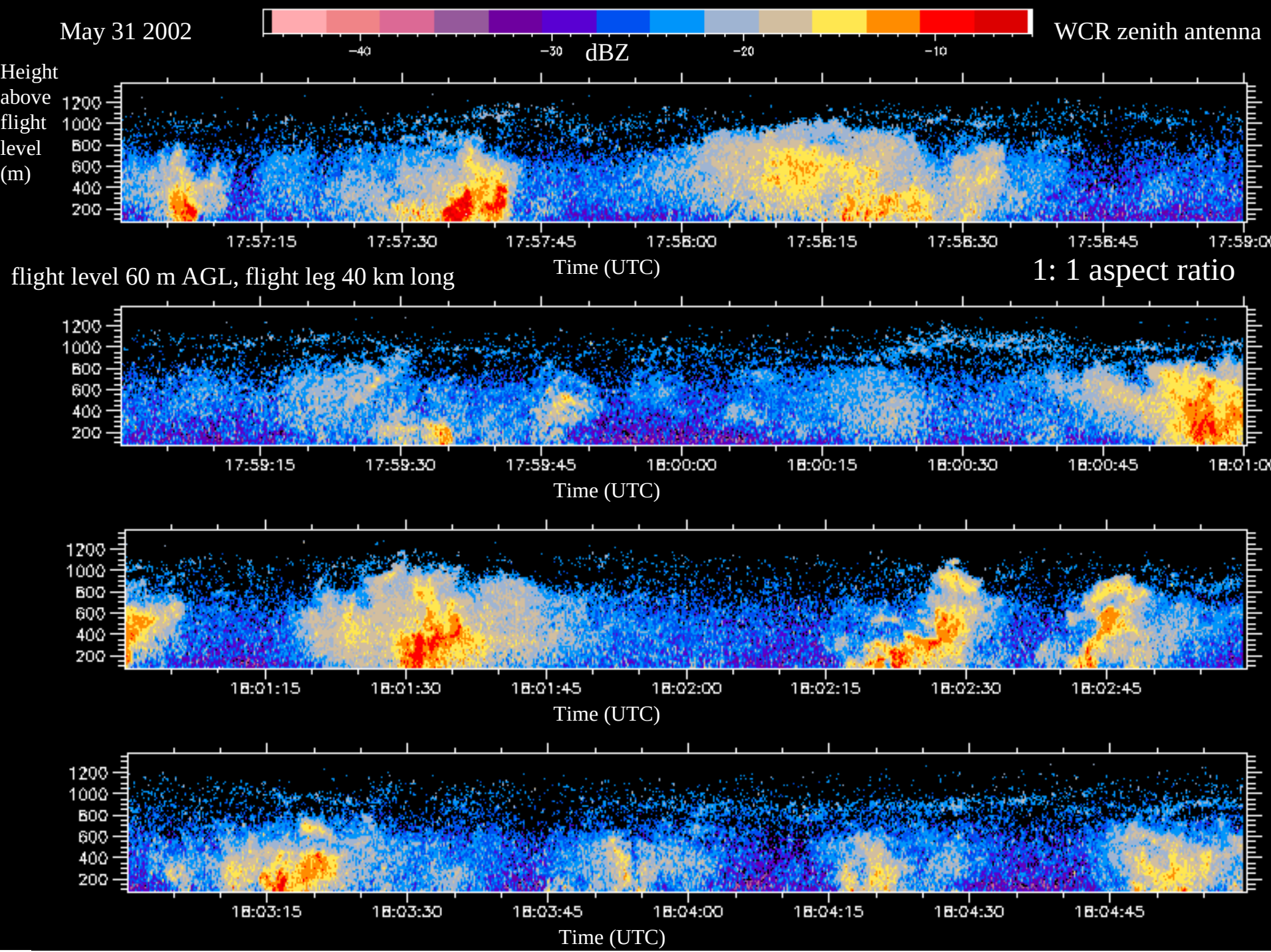
$$u = \frac{V_f}{\sin\alpha} - \frac{V_n}{\tan\alpha} - u_{insects}$$

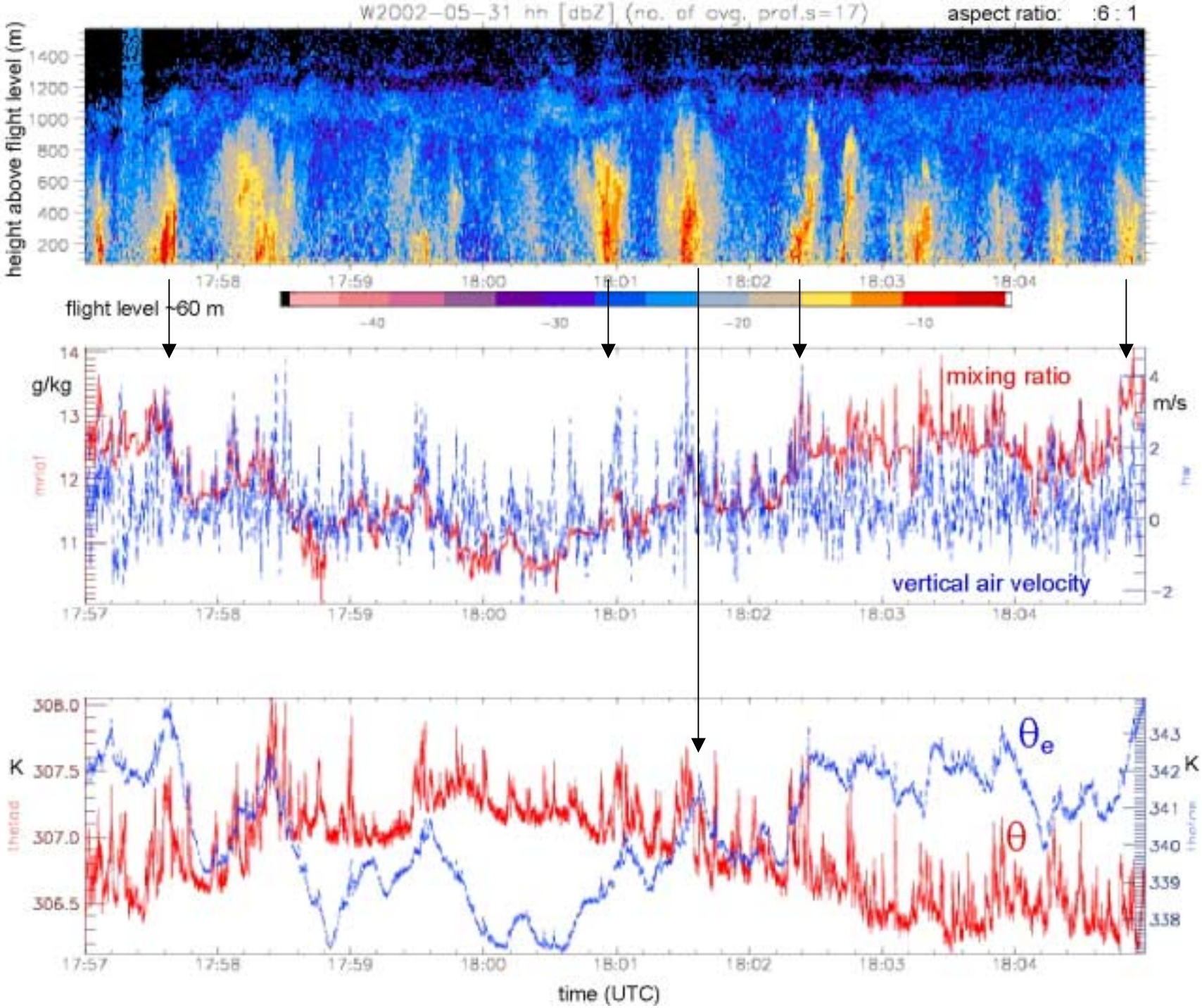
--> extract circulation (u,w) below AC

echoes in the ‘quiescent’ BL

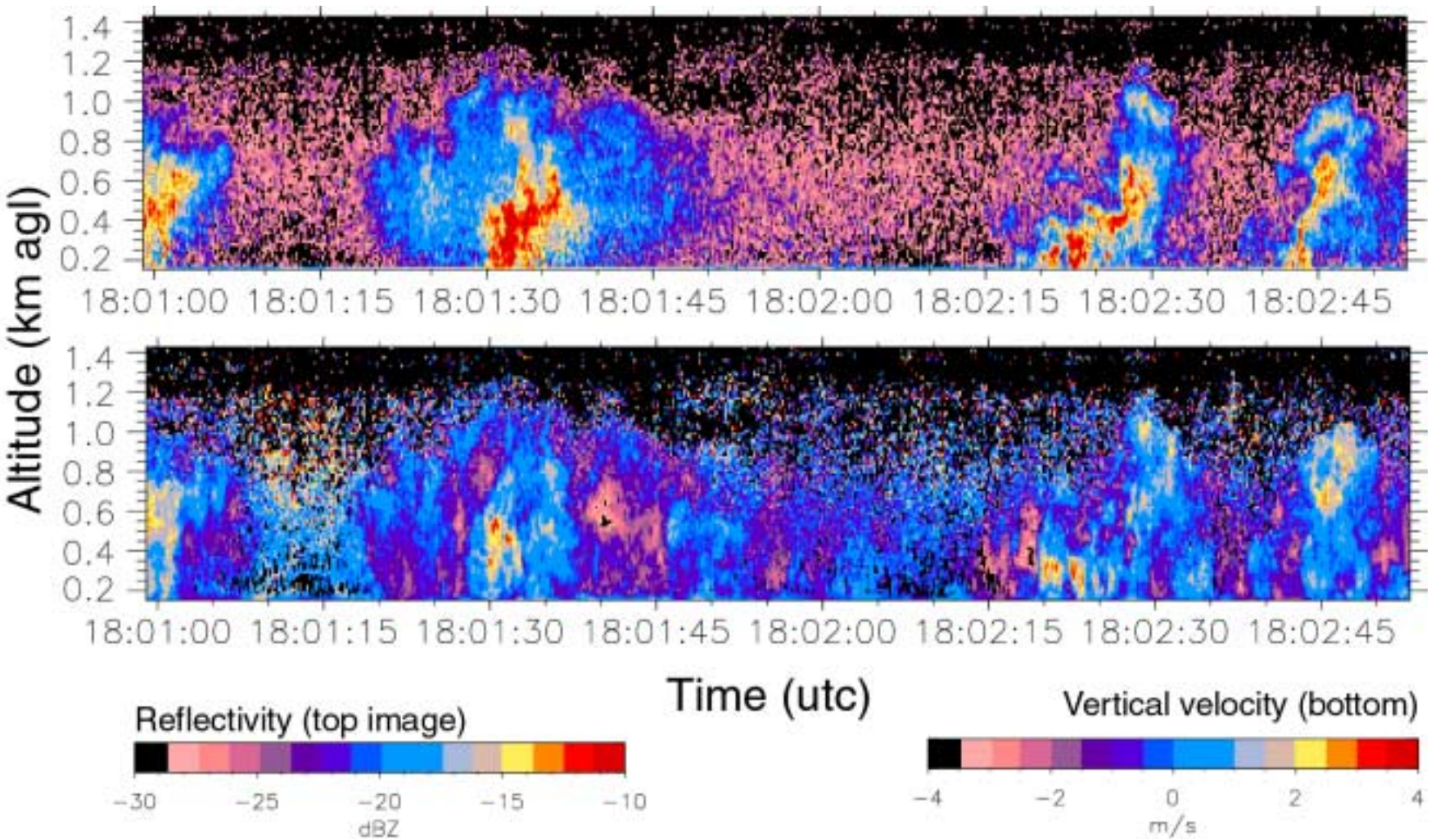
- Clear, warm day in Kansas, 31 May 2002
- Soundings suggest a well-mixed, well-capped BL
- Thin haze layer marks the BL top




May 31 2002
WCR zenith antenna
dBZ
-40
-30
-20
-10
Height above flight level (m)
1200
1000
800
600
400
200
17:57:15
17:57:30
17:57:45
17:58:00
17:58:15
17:58:30
17:58:45
Time (UTC)
flight level 60 m AGL, flight leg 40 km long
1: 1 aspect ratio
17:59:15
17:59:30
17:59:45
18:00:00
18:00:15
18:00:30
18:00:45
18:01:15
18:01:30
18:01:45
18:02:00
18:02:15
18:02:30
18:02:45
18:03:15
18:03:30
18:03:45
18:04:00
18:04:15
18:04:30
18:04:45

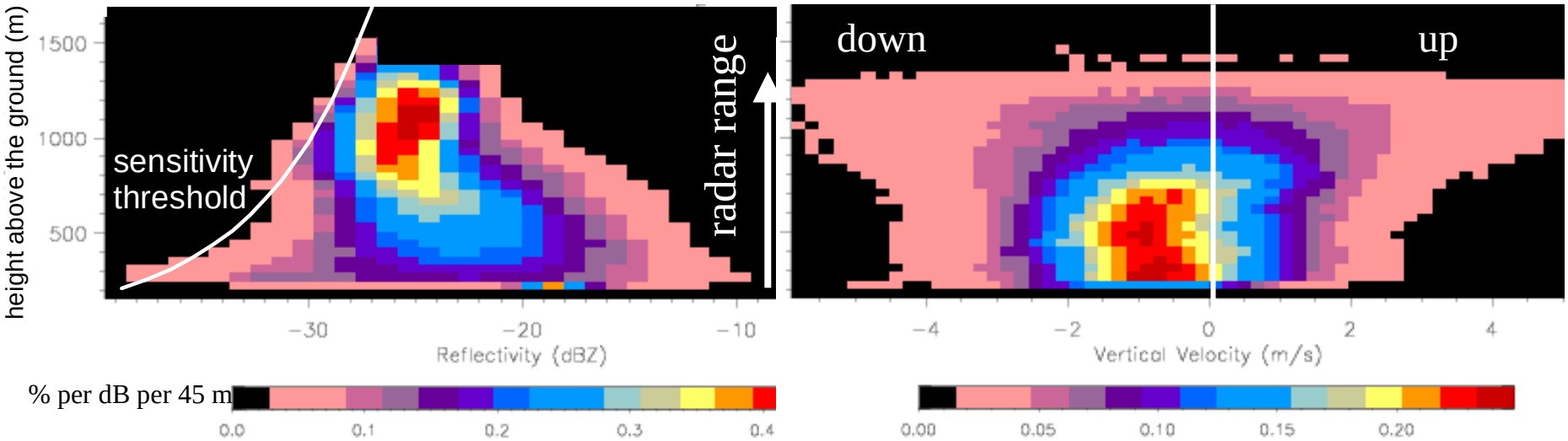

W2002-05-31 hh [dbZ] (no. of ovg. prof.s=17)
aspect ratio: :6 : 1
height above flight level (m)
1400
1200
1000
800
600
400
200
17:58
17:59
18:00
18:01
18:02
18:03
18:04
flight level ~60 m
-40
-30
-20
-10
g/kg
14
13
12
11
mixing ratio
m/s
4
2
0
-2
vertical air velocity
17:57
17:58
17:59
18:00
18:01
18:02
18:03
18:04
K
308.0
307.5
307.0
306.5
θ_e
θ
343
342
341
340
339
338
K
time (UTC)

WCR vertical velocities



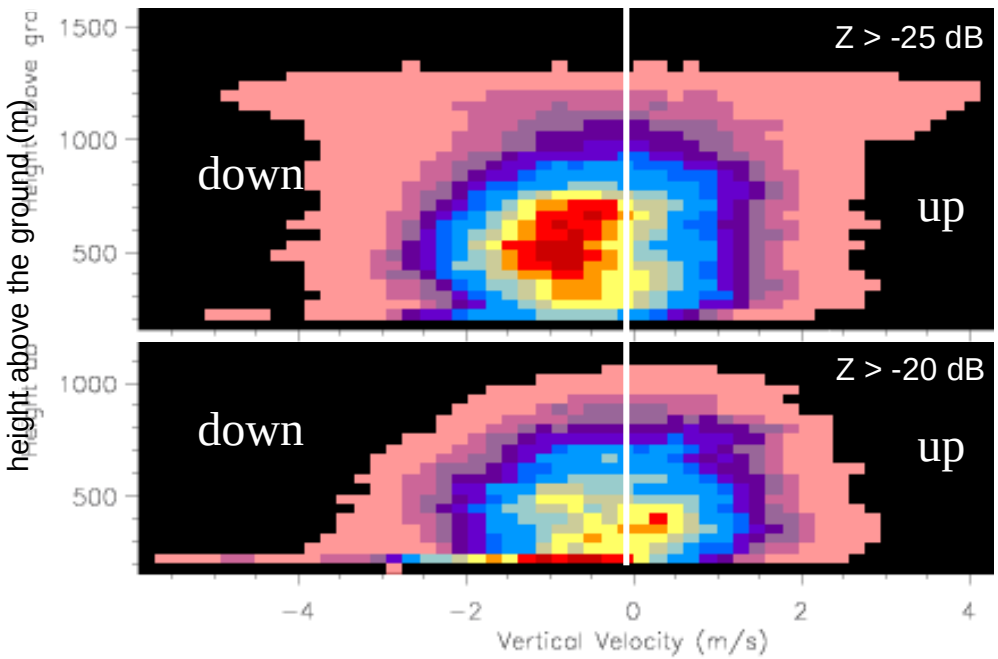
aspect ratio: 2.5:1

Frequency-by-altitude diagram



% per dB per 45 m

% per 0.2 ms^{-1} per 45 m



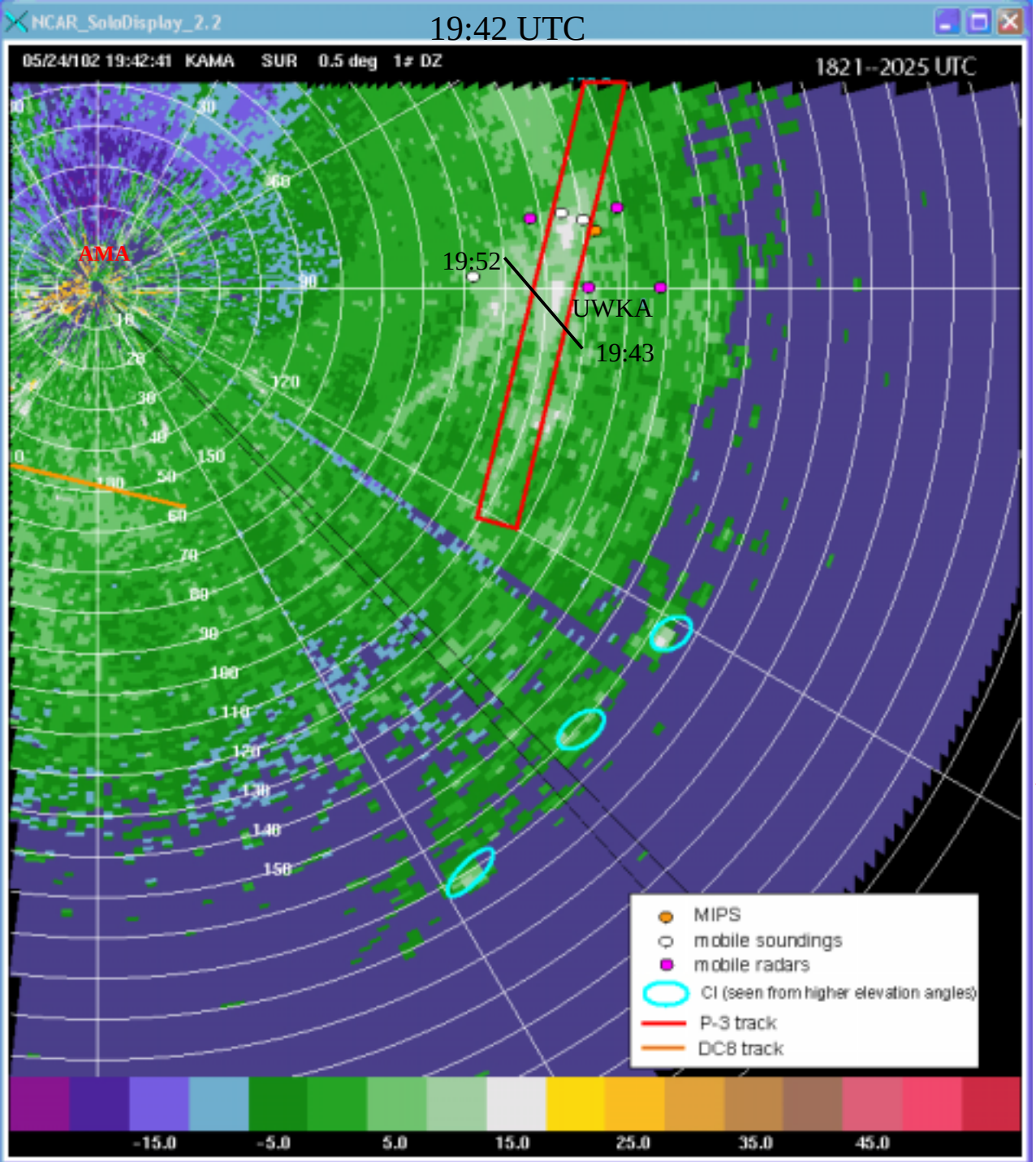
vertical velocity frequency (%) 2002-05-31

reflectivity threshold = -25 dBZ

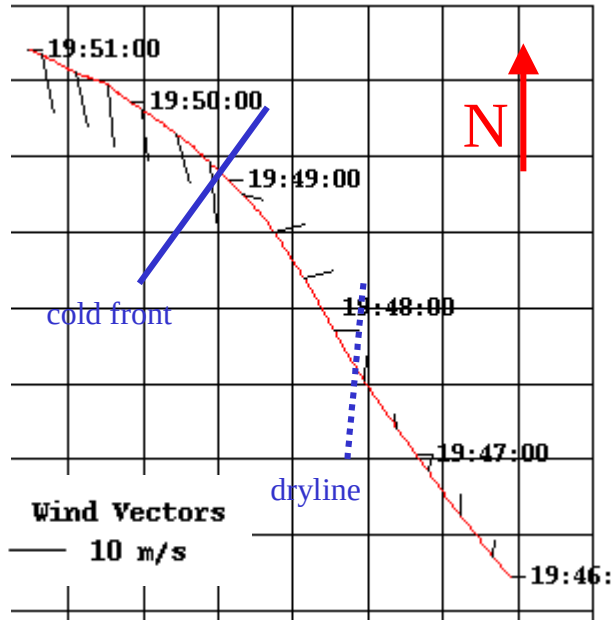
reflectivity threshold = -20 dBZ

% per 0.2 ms^{-1} per 45 m

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

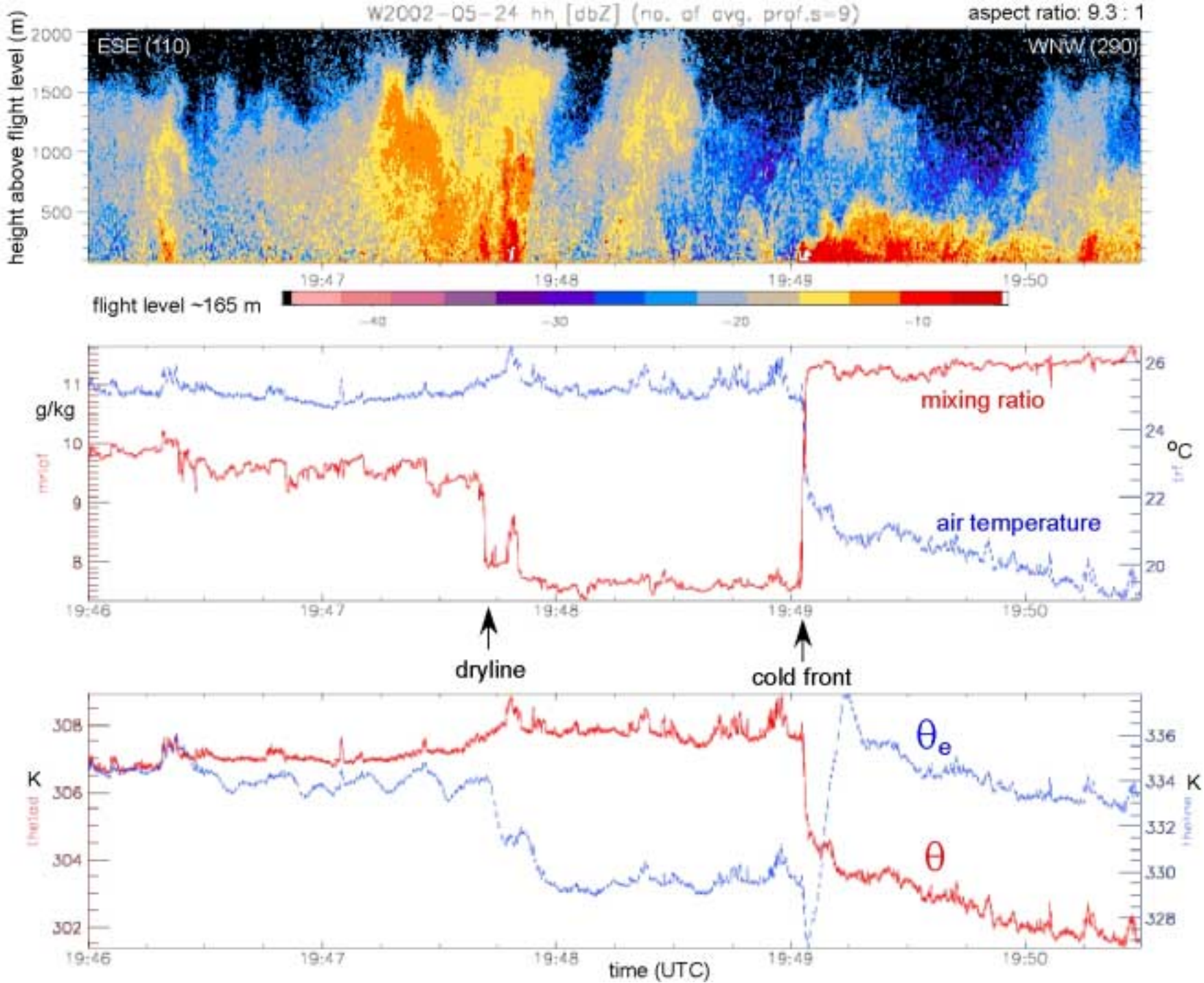


24 May

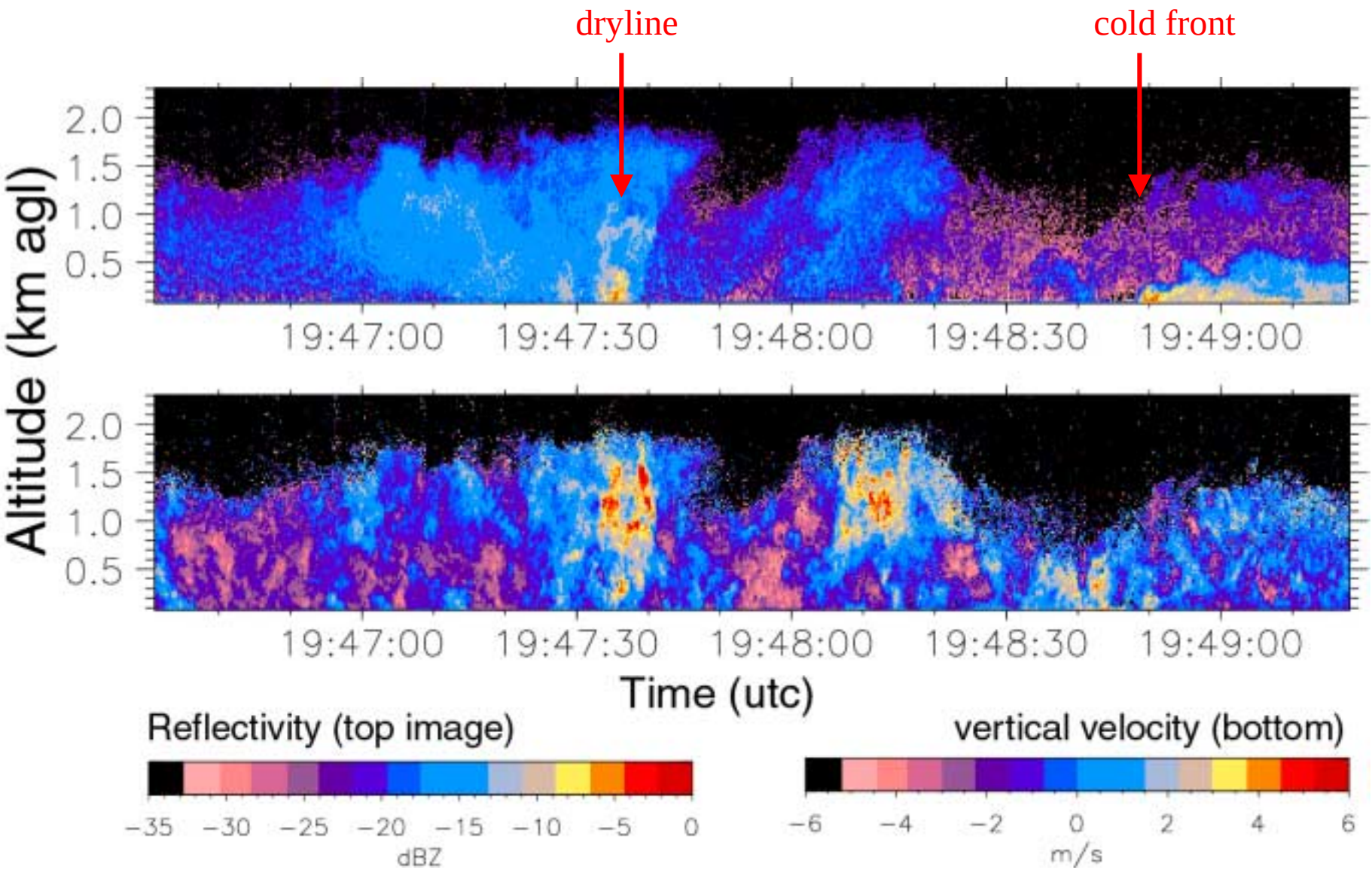


WCR up-looking, flight level 165 m


5/24, 21:07 UTC


W2002-05-24 hh [dbZ] (no. of avg. prof.s=9)
aspect ratio: 9.3 : 1
ESE (110)
WNW (290)
height above flight level (m)
2000
1500
1000
500
19:47
19:48
19:49
19:50
flight level ~165 m
-40
-30
-20
-10
g/kg
11
10
9
8
mixing ratio
air temperature
°C
26
24
22
20
19:46
19:47
19:48
19:49
19:50
dryline
cold front
K
308
306
304
302
θe
θ
336
334
332
330
328
time (UTC)

WCR vertical velocities

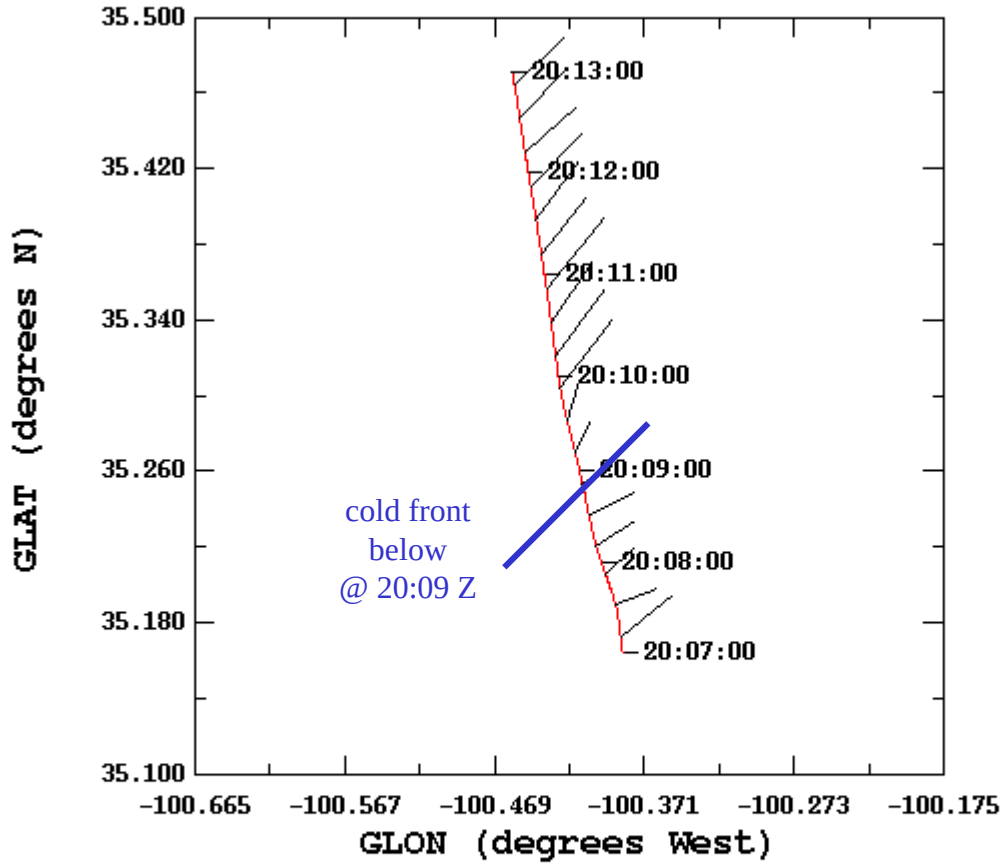


20:10 Z
VPDD

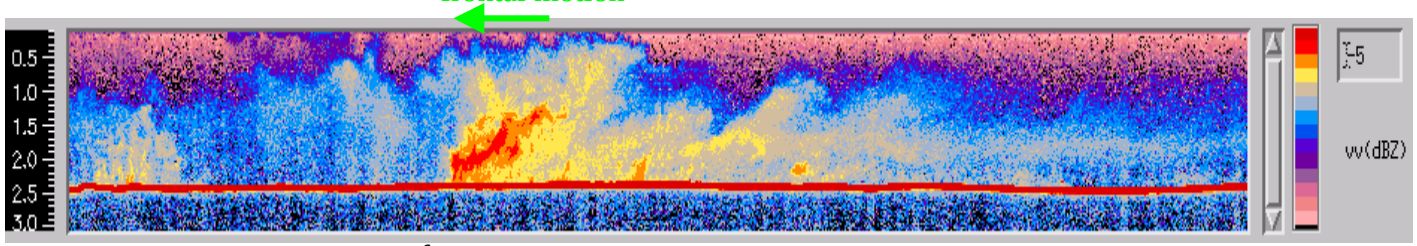
5/24/2002, 20:07:00–20:13:00

cold front and dryline have collapsed

Flight level: ~2300 m AGL



frontal motion



SSE
164

NNW
344

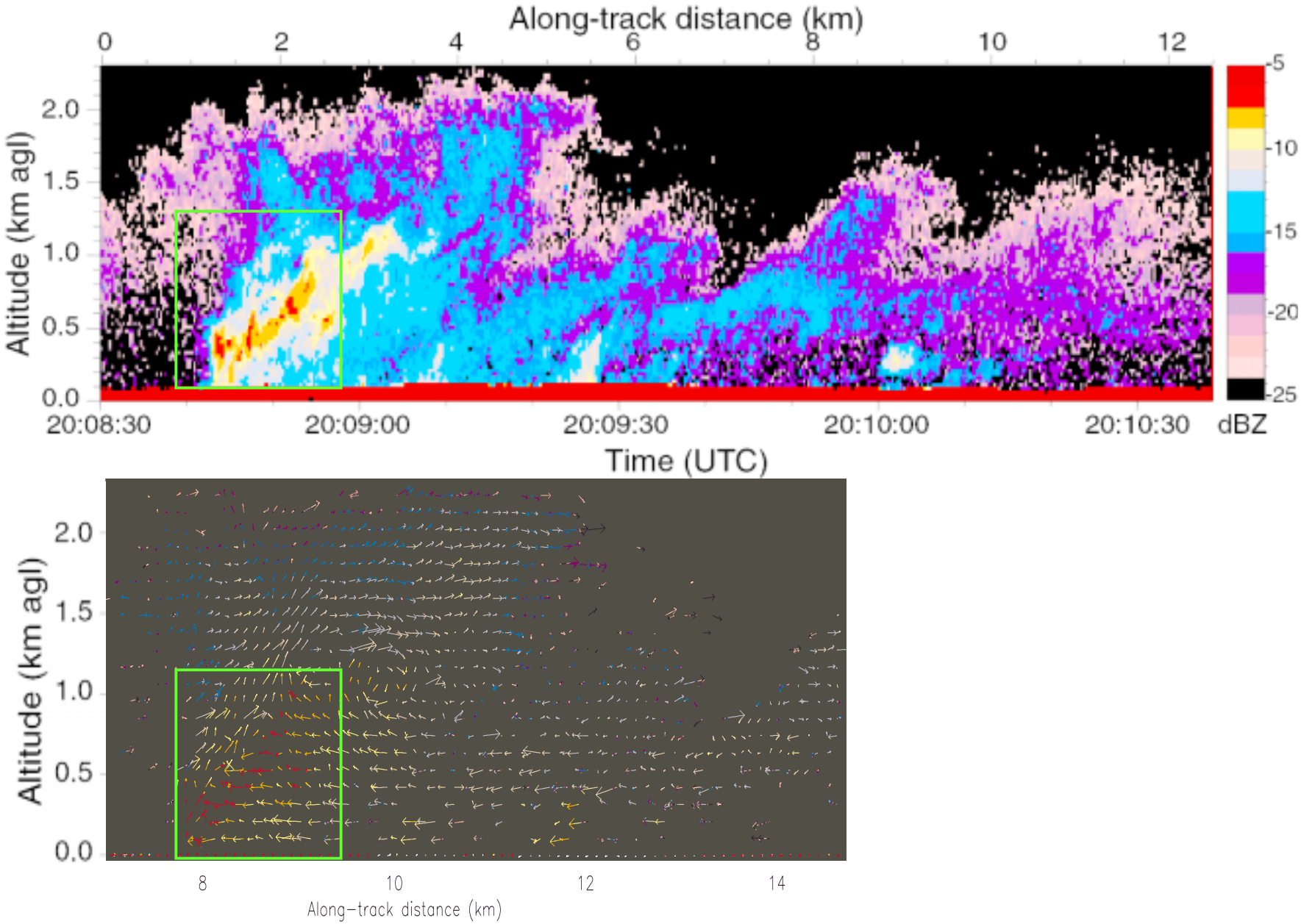
moist air

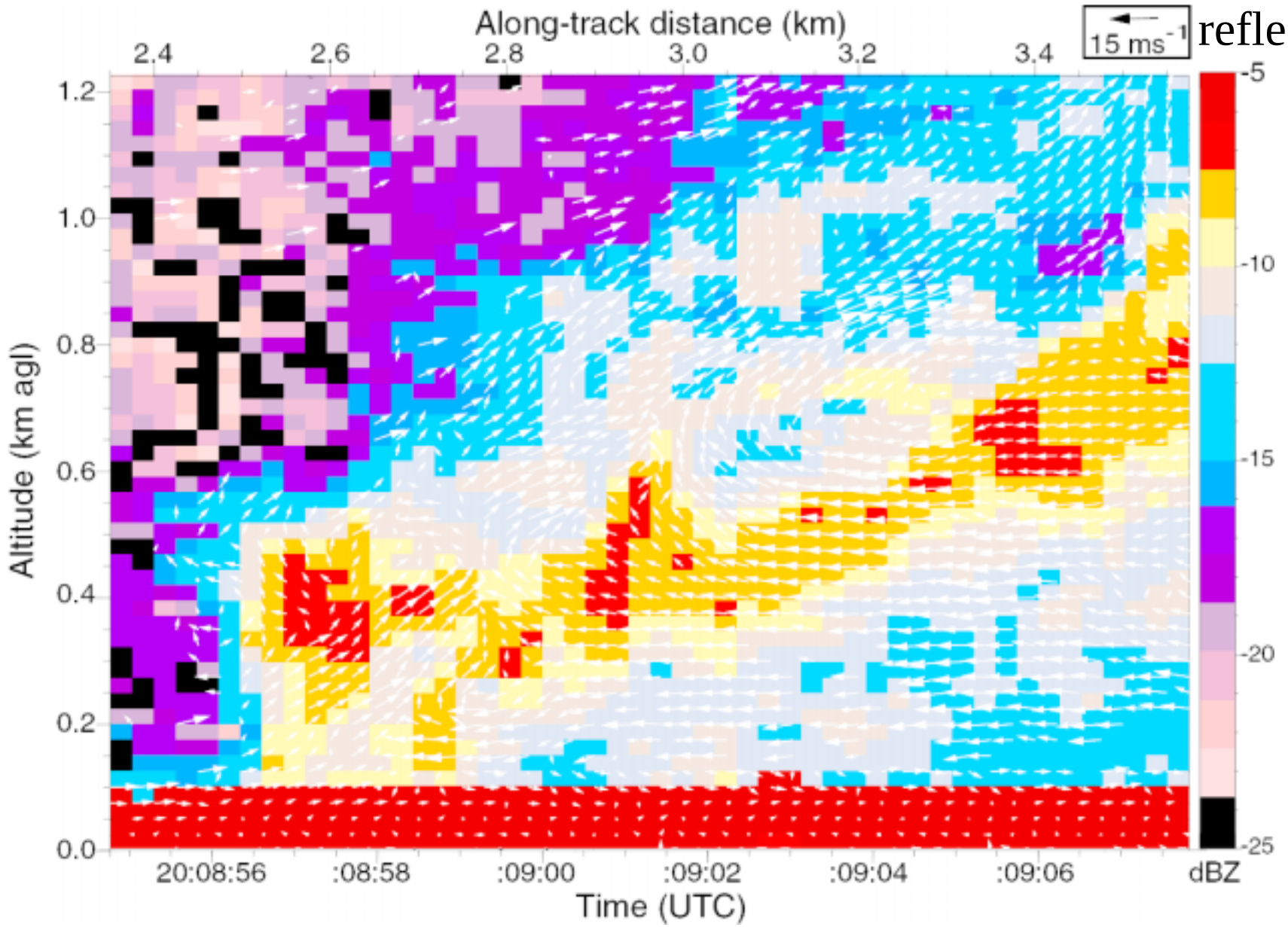
front
& dryline

cold air

Flight level: 2300 m AGL

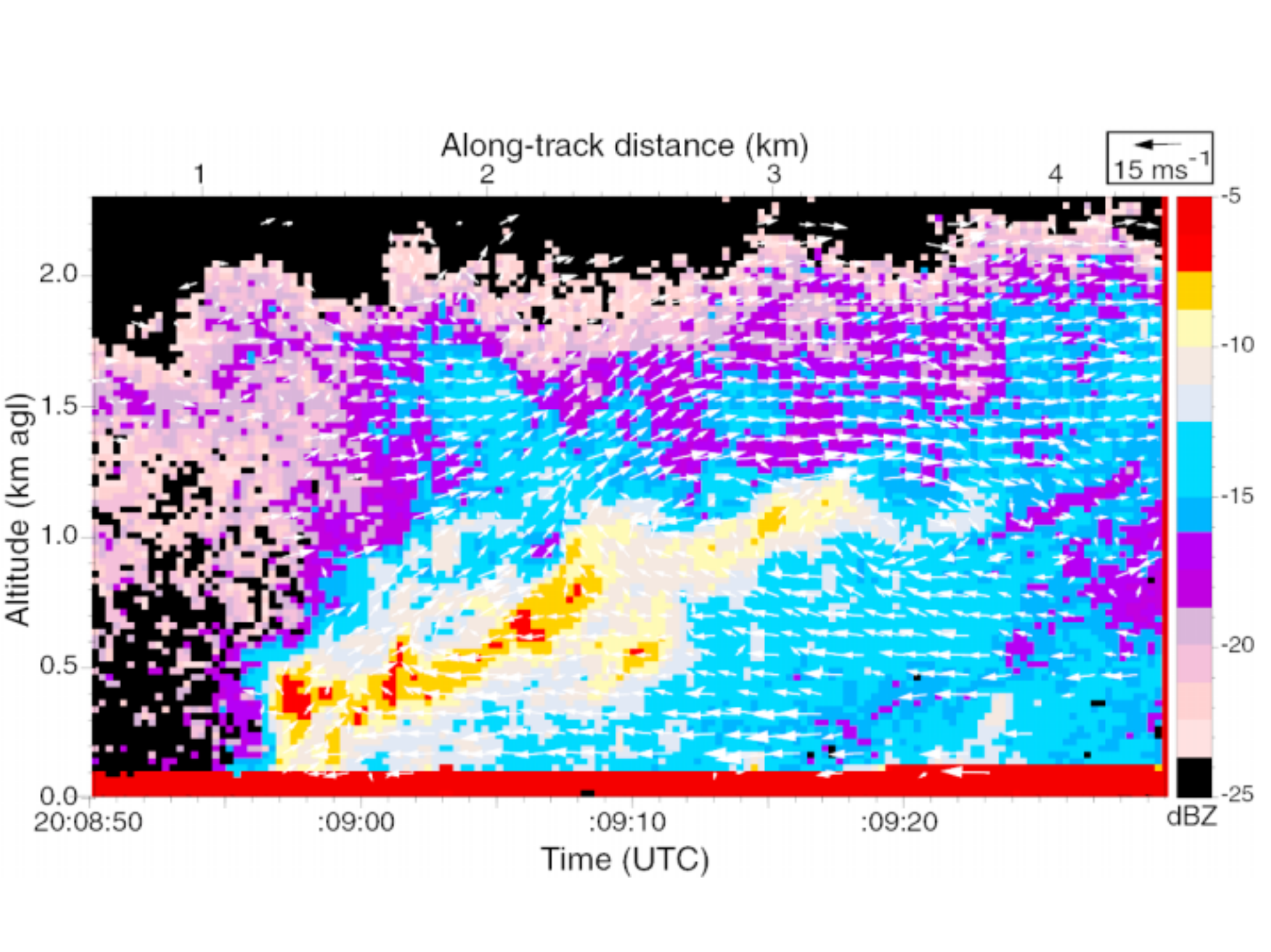
WCR nadir antenna reflectivity

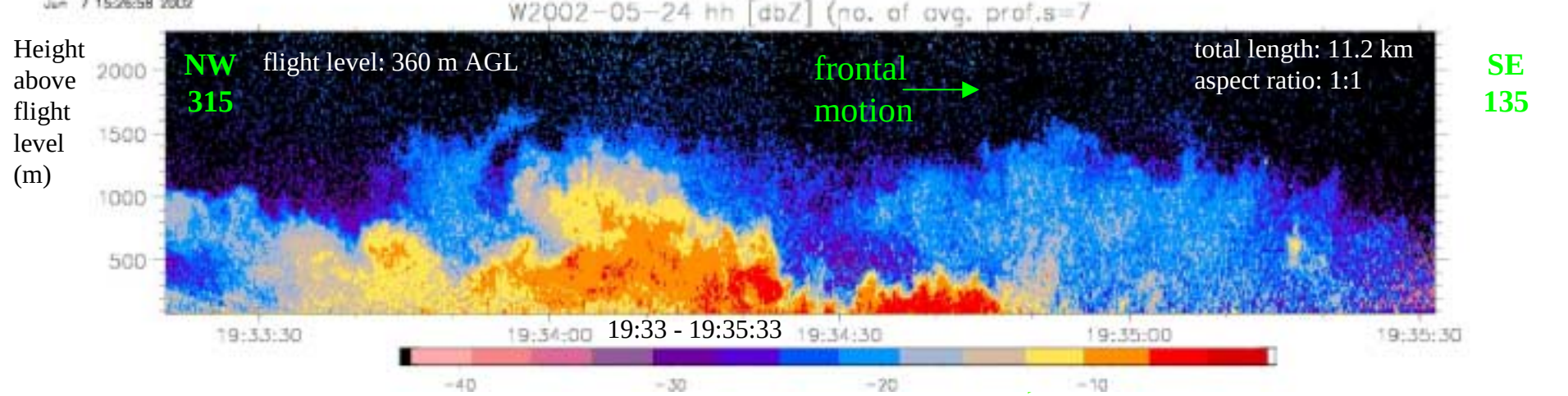


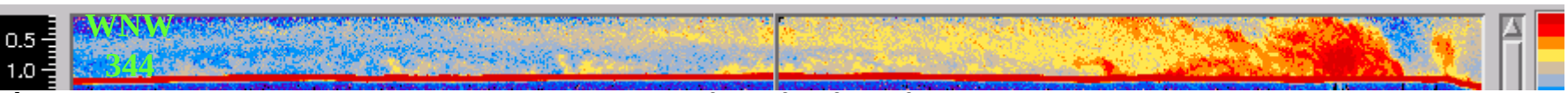


reflectivity

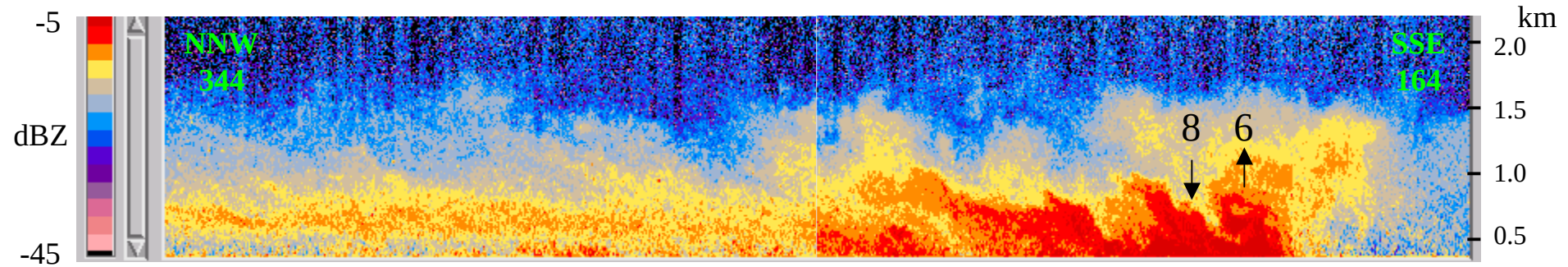
1:1 aspect ratio


Along-track distance (km)
1
2
3
4
15 ms-1
Altitude (km agl)
2.0
1.5
1.0
0.5
0.0
-5
-10
-15
-20
-25
dBZ
20:08:50
:09:00
:09:10
:09:20
Time (UTC)

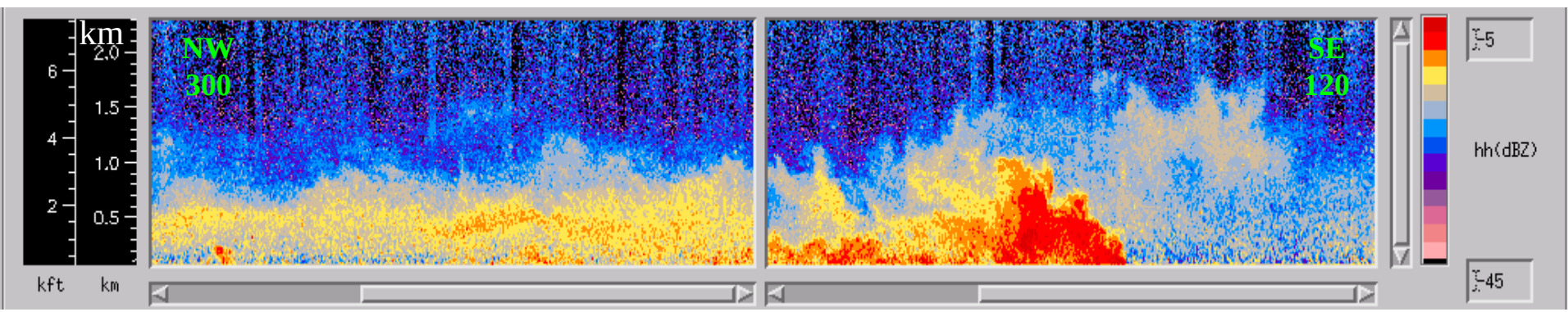




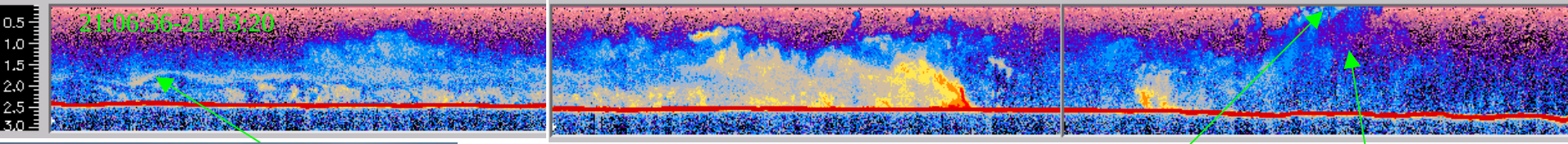
20:21:50 - 20:25:40



20:27:00 - 20:30:48



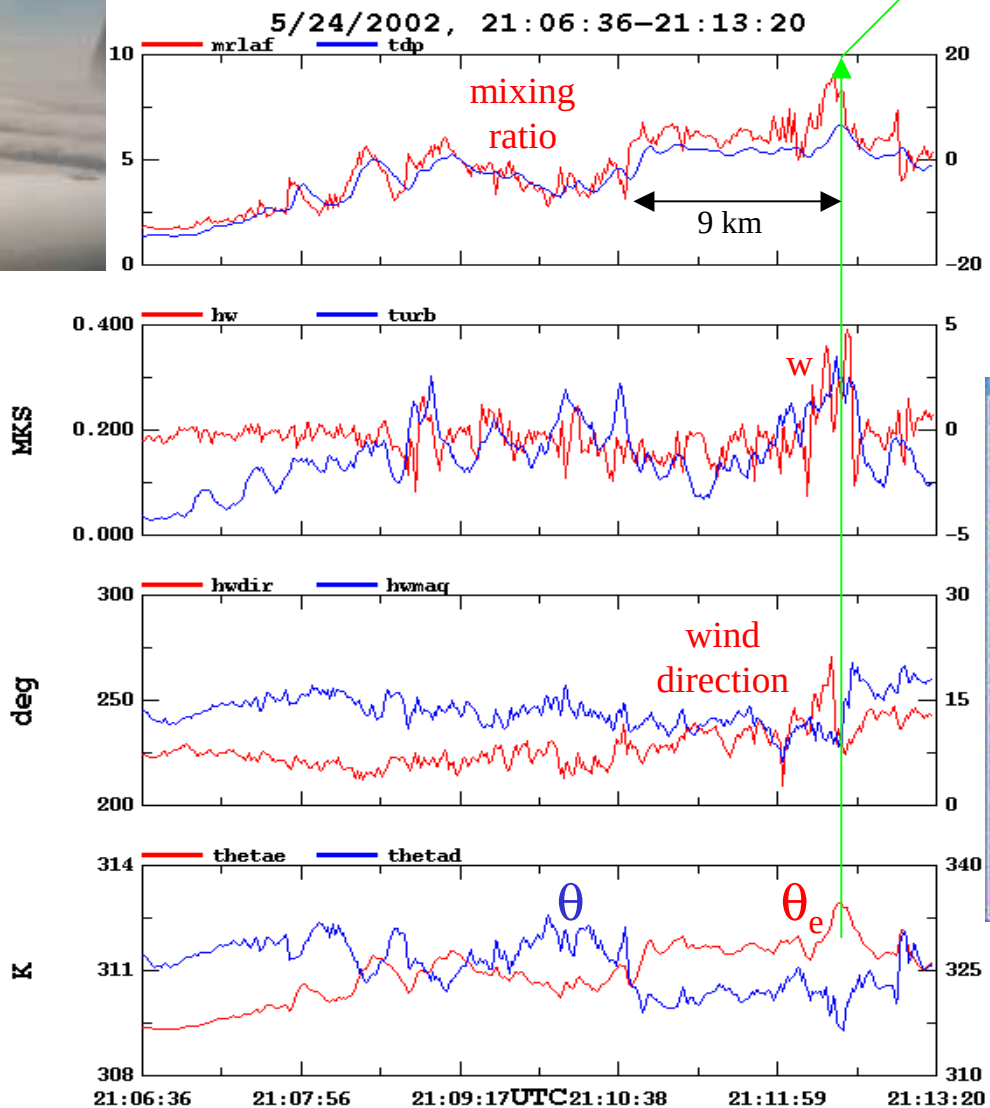
20:42:43 - 20:46:18



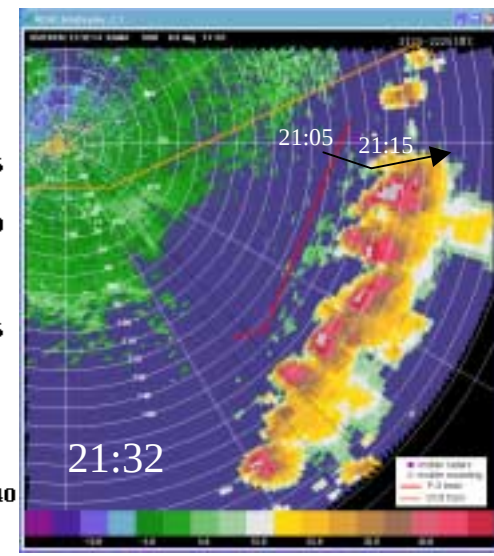
Gravity waves in the cold-frontal stratus

frontal motion

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



WNW
290

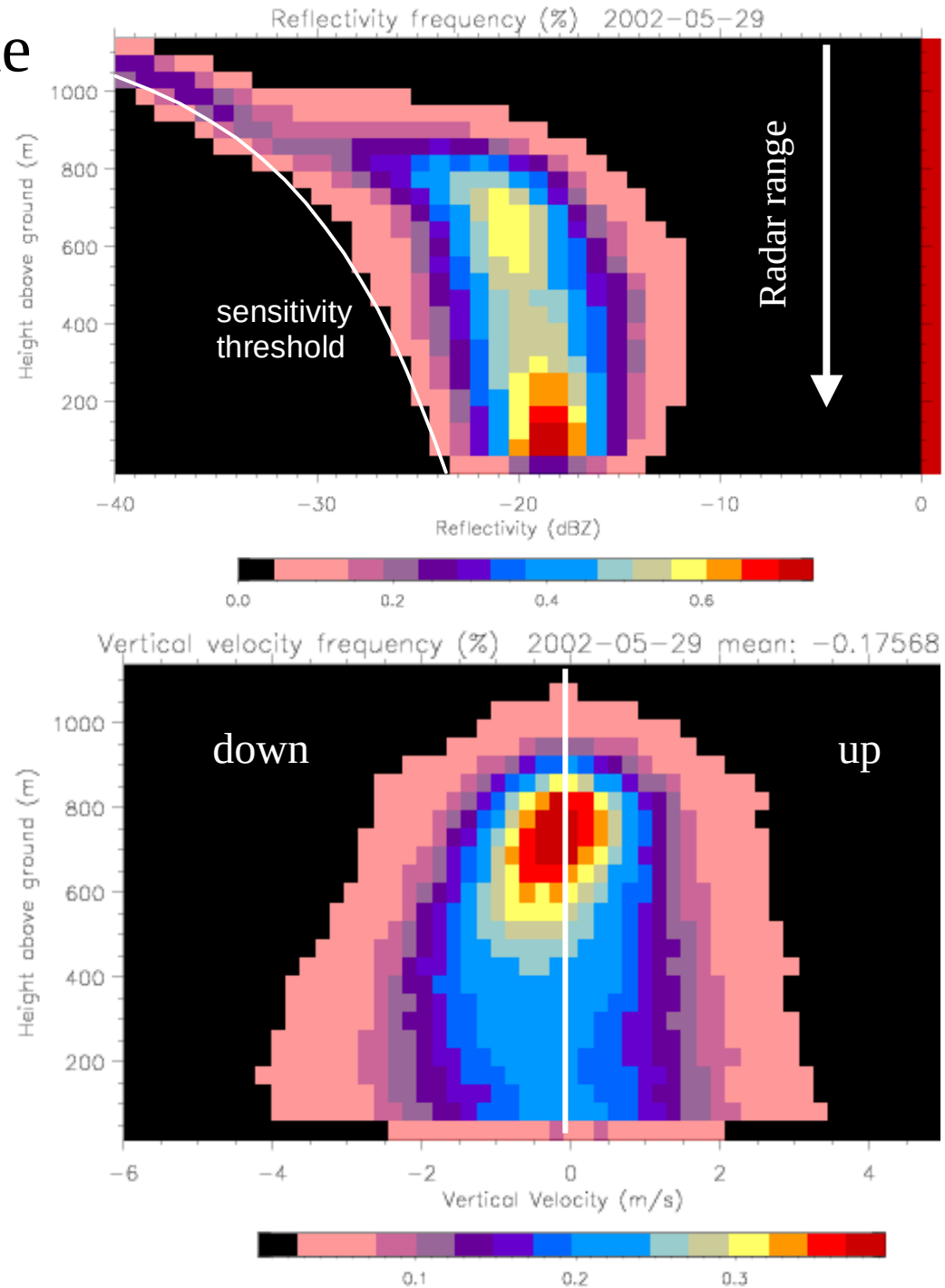
ESE
110

summary

- An airborne W-band radar sampling at 30 Hz can measure echoes in the opticaly-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



5/29/02, 16:42-16:50, sfactor=2