University of Wyoming King Air and Cloud Radar.

Airborne millimeter radar research since 1992.

Marine stratus off the coast of Oregon (1995, 1999) ---- *J. Atmos. Sci.*, **55**, 3540-3564, 1998.

Small cumulus, Florida (1995) ---- *Atmos. Res.* **52.** 143-165, 1999
Q. J. Roy. Meteor. Soc., **126**, 415-443, 2000.

Winter Ns, Ac lent., … , Wyoming (1992, 1997, 2000) ---- to appear *J. Atmos. Sci.*, Apr. 2001

Marine Sc, E. Pacific (DYCOMS, 2001) ---- coming in July 2001

URL : //www-das.uwyo.edu/wcr

Pending proposal : "***Improvements to spaceborne cloud profiling, based on aircraft and radar observations of cloud structure***."

- insights into cloud processes of relevance to CloudSat
- improvements to algorithms for cloud profiling

Pixel size:

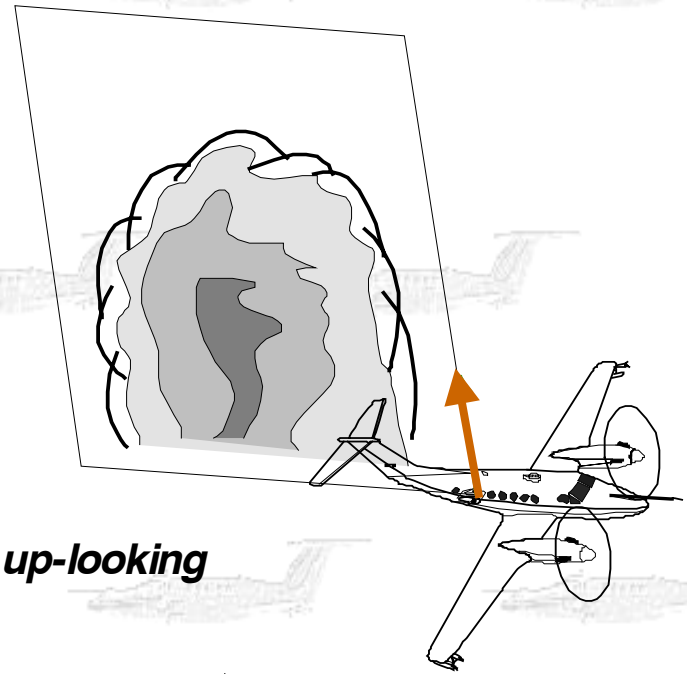
WCR: $10^2 \times \pi \times 30 \approx 10^4$ m^3

CloudSat: 3×10^9 m^3

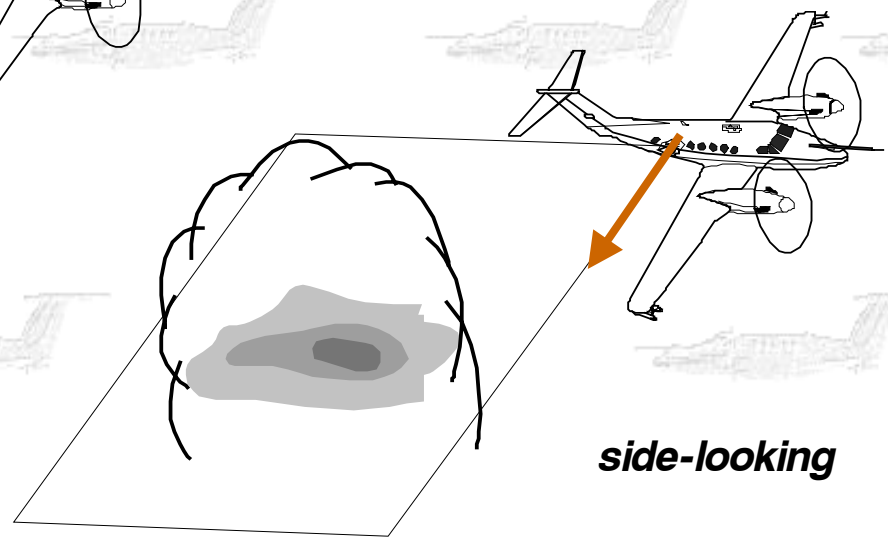
Time to cover 50 km:

WCR: **10 minutes**

CloudSat: **7.5 seconds**



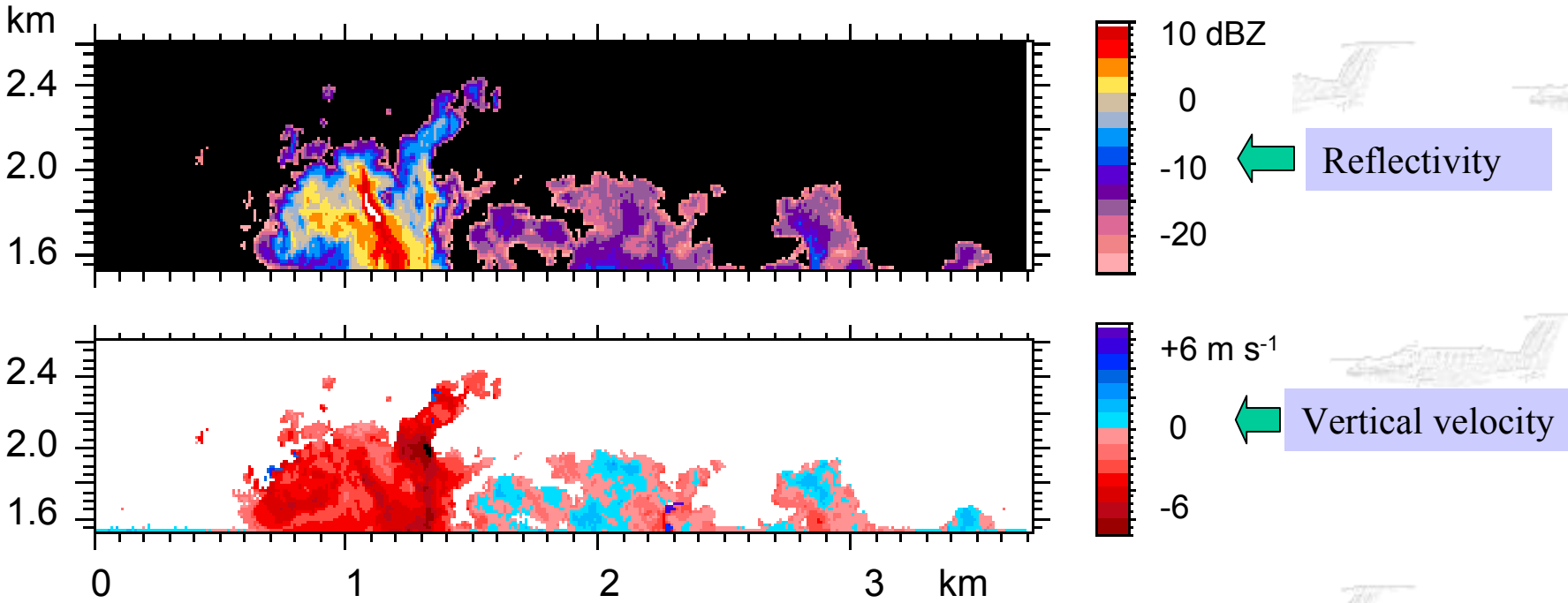
up-looking



side-looking

Cumulus in dissipating stage

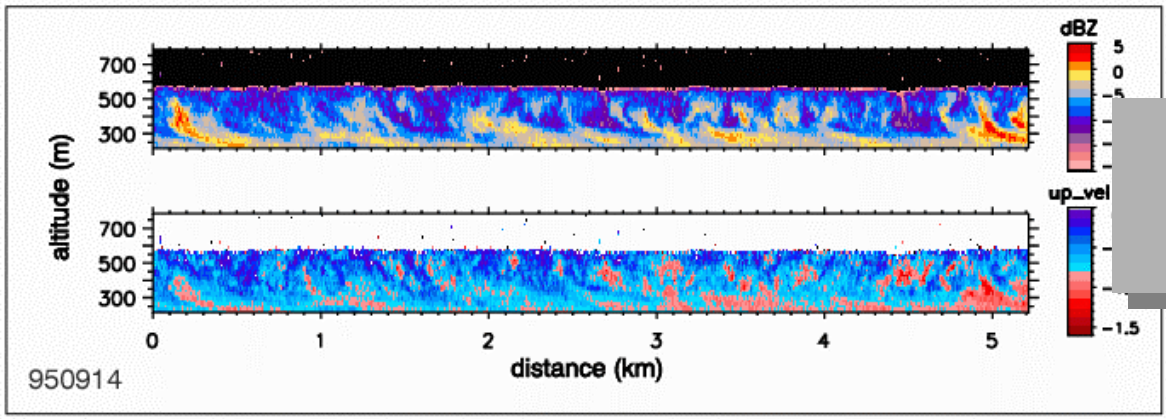
Florida, 10 August 1995

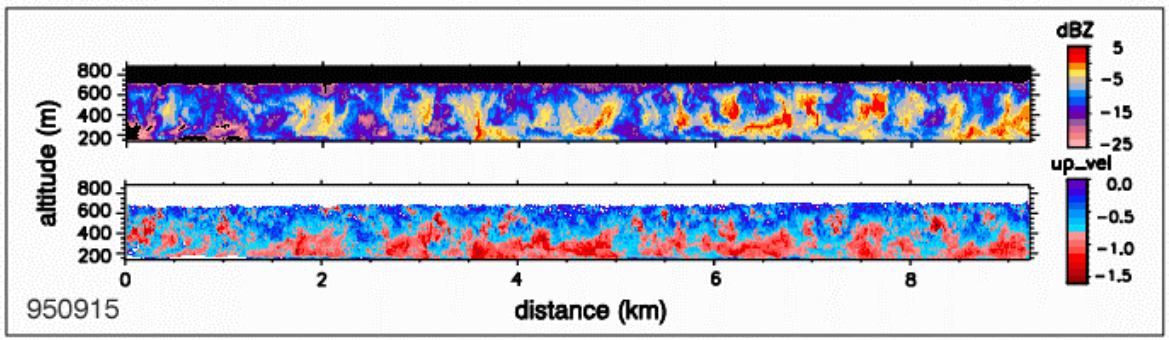


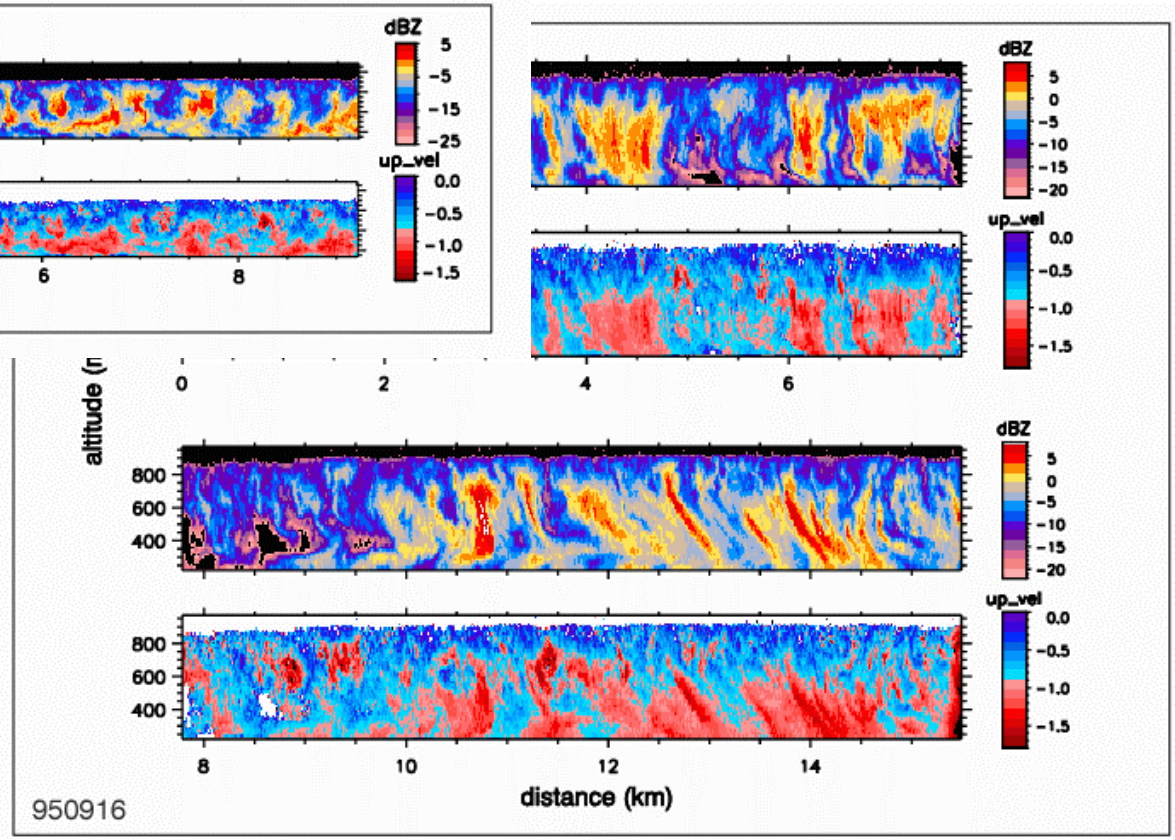
The cloud located at 1 km has reached the dissipation stage, with all of the cloud volume moving downward. At the flight level, the temperature was 18.5°C, the liquid water content 0.7 g m^{-3} and very light drizzle with drops 200 µm diameter was recorded. The total cloud droplet concentration was about 150 cm^{-3}. The reflectivity field indicates the presence of 3 precipitation shafts above 1.8 km altitude. These merge into one main core of precipitation. Smaller clouds at 2 and 2.9 km have some weak updraft regions.

Coastal stratus

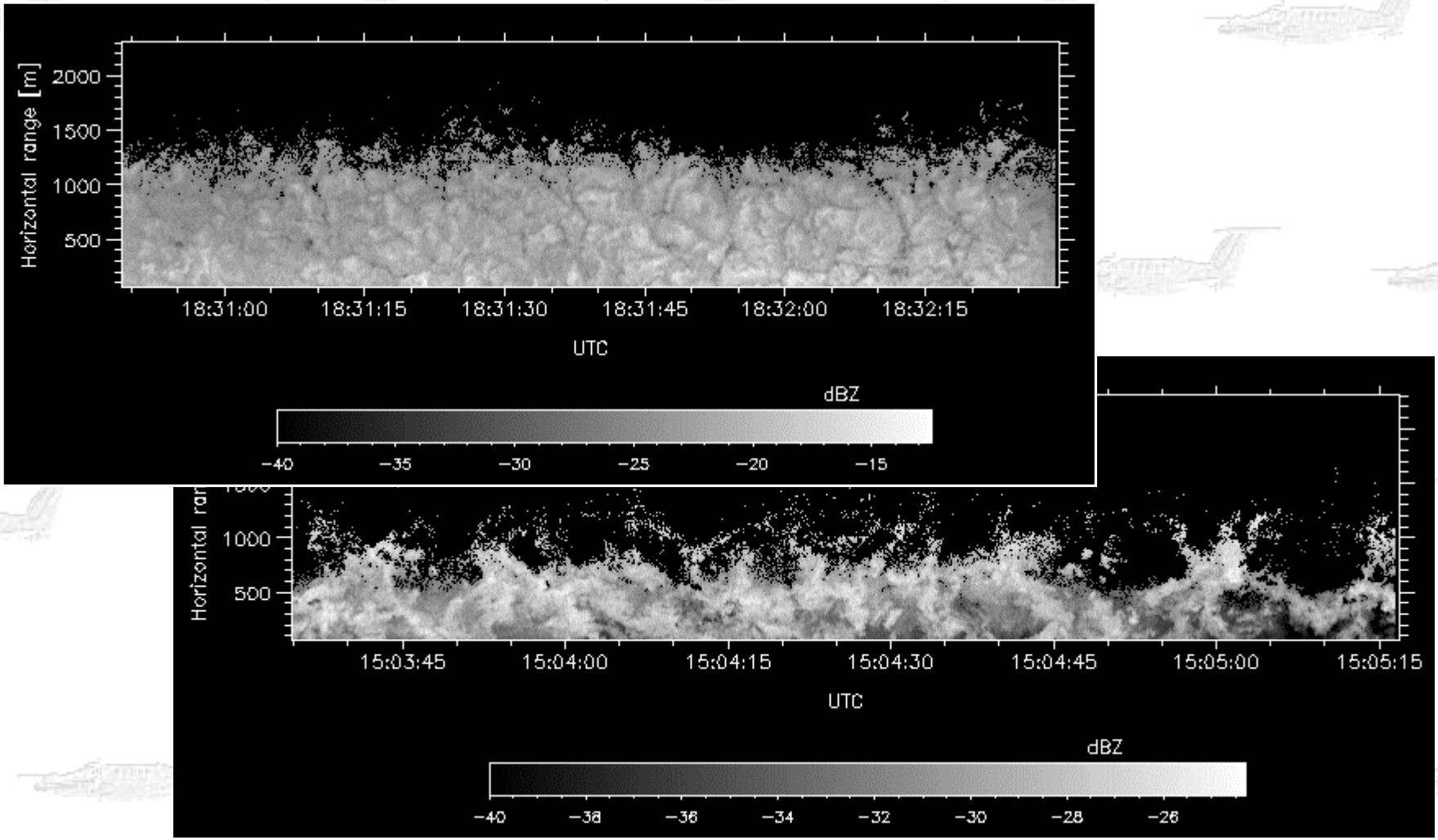
Oregon, 1995





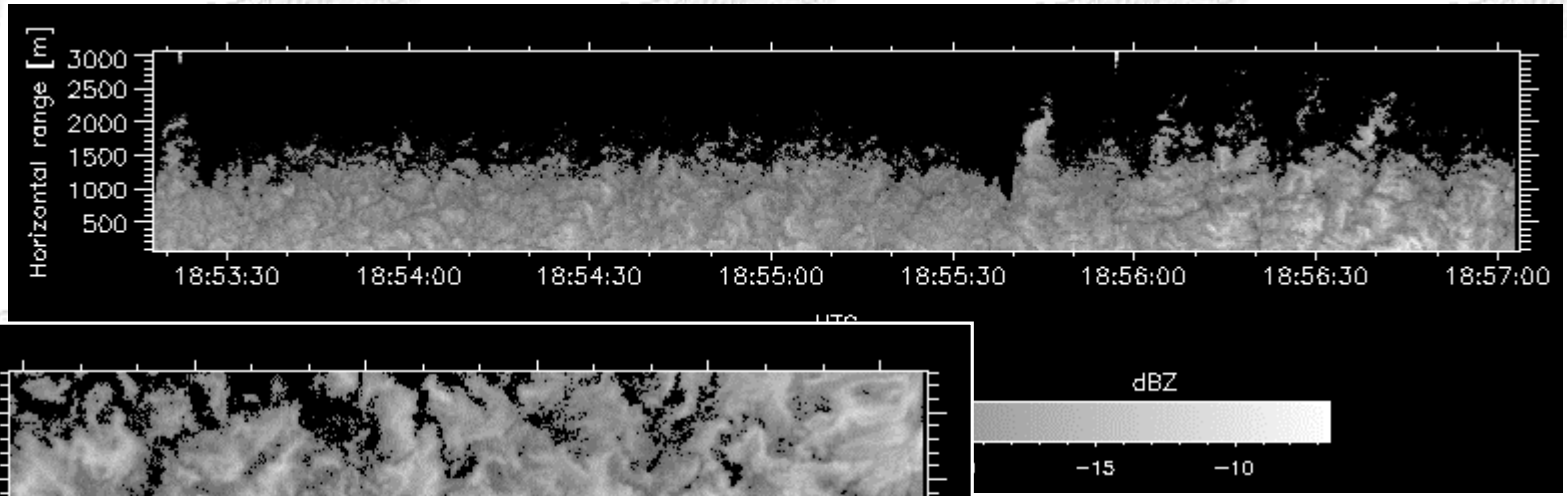


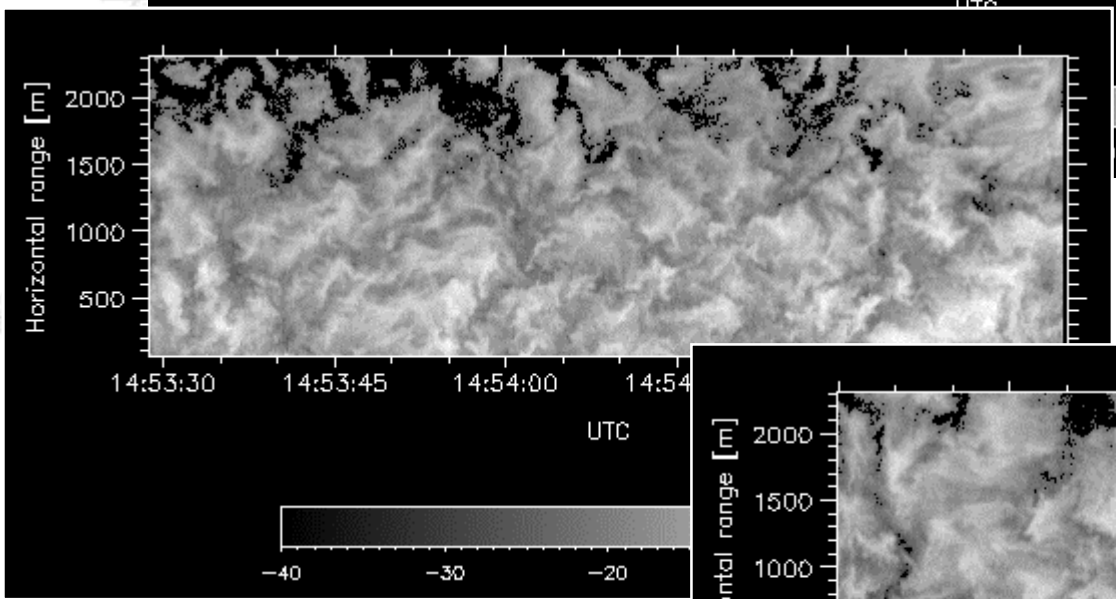
Vertical sections of reflectivity and of vertical velocity. The horizontal and vertical scales of the images are 1:1.



Horizontal sections of various coastal stratus cases. **Attenuation correction has been applied, but signal to noise ratio limits the range of detection. These images demonstrate large variety in the scales and textures of reflectivity fields.**

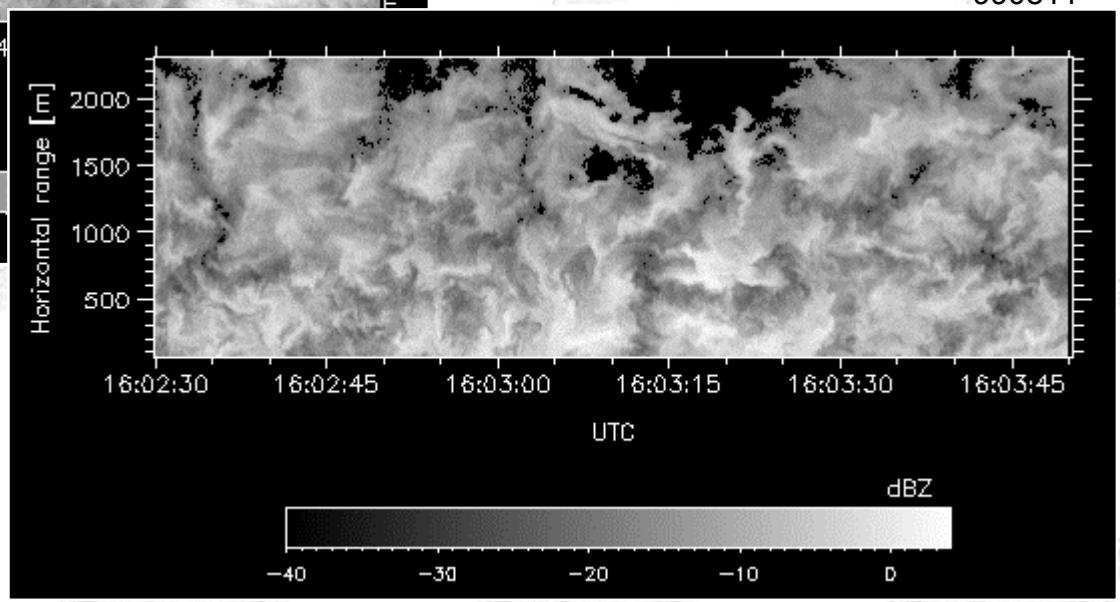
990809

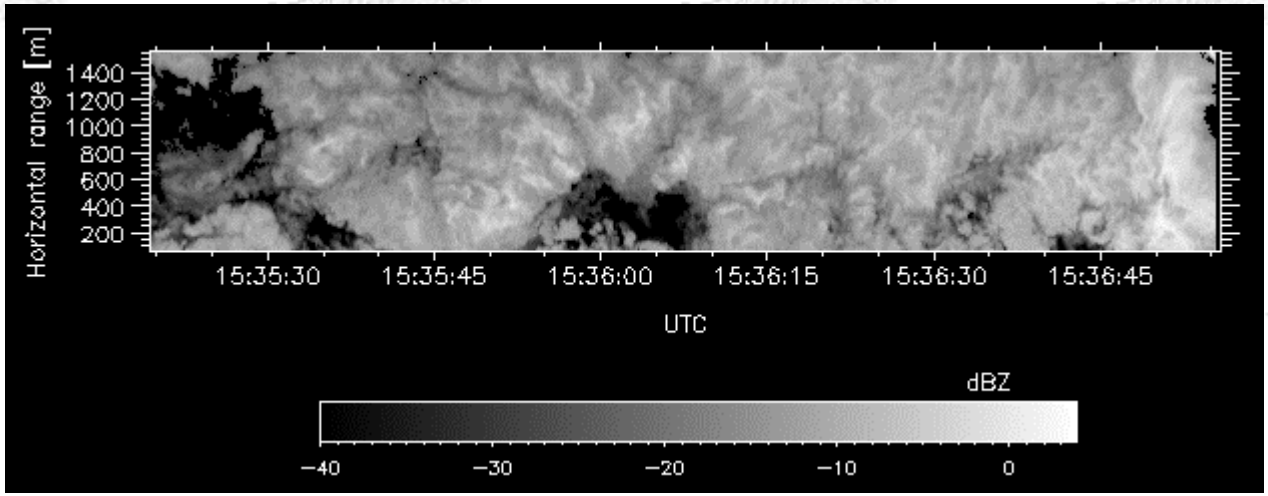


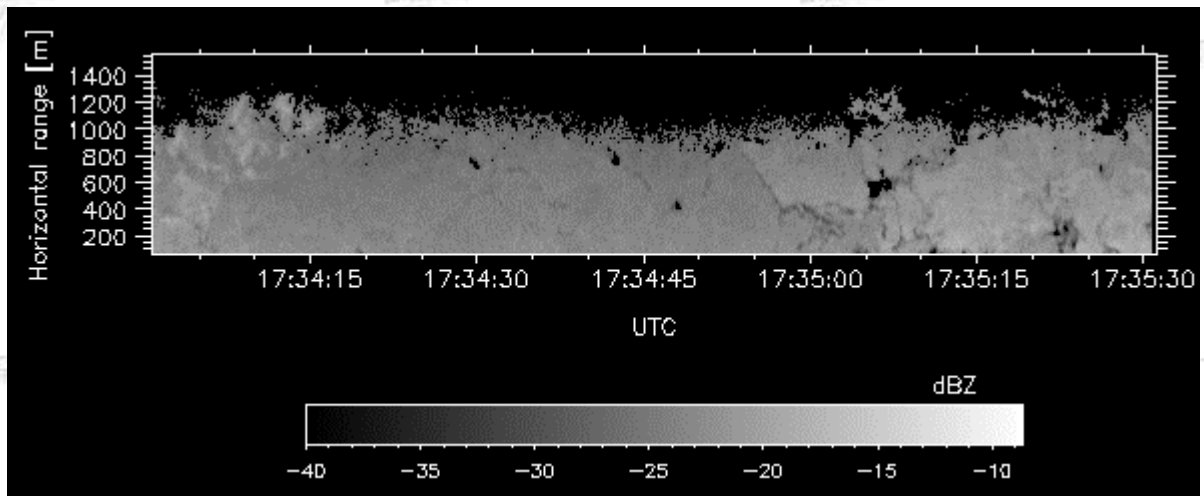


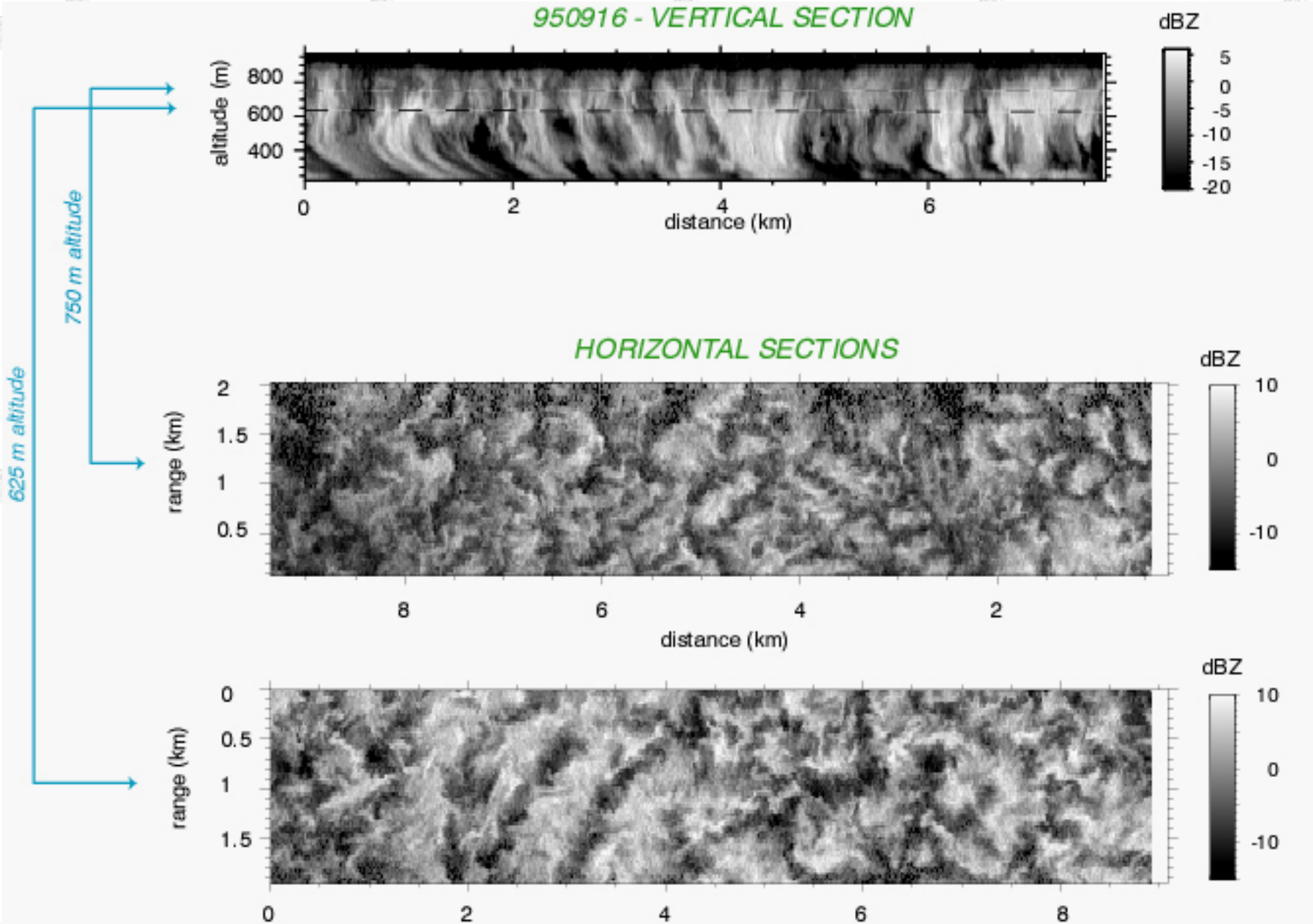
990811

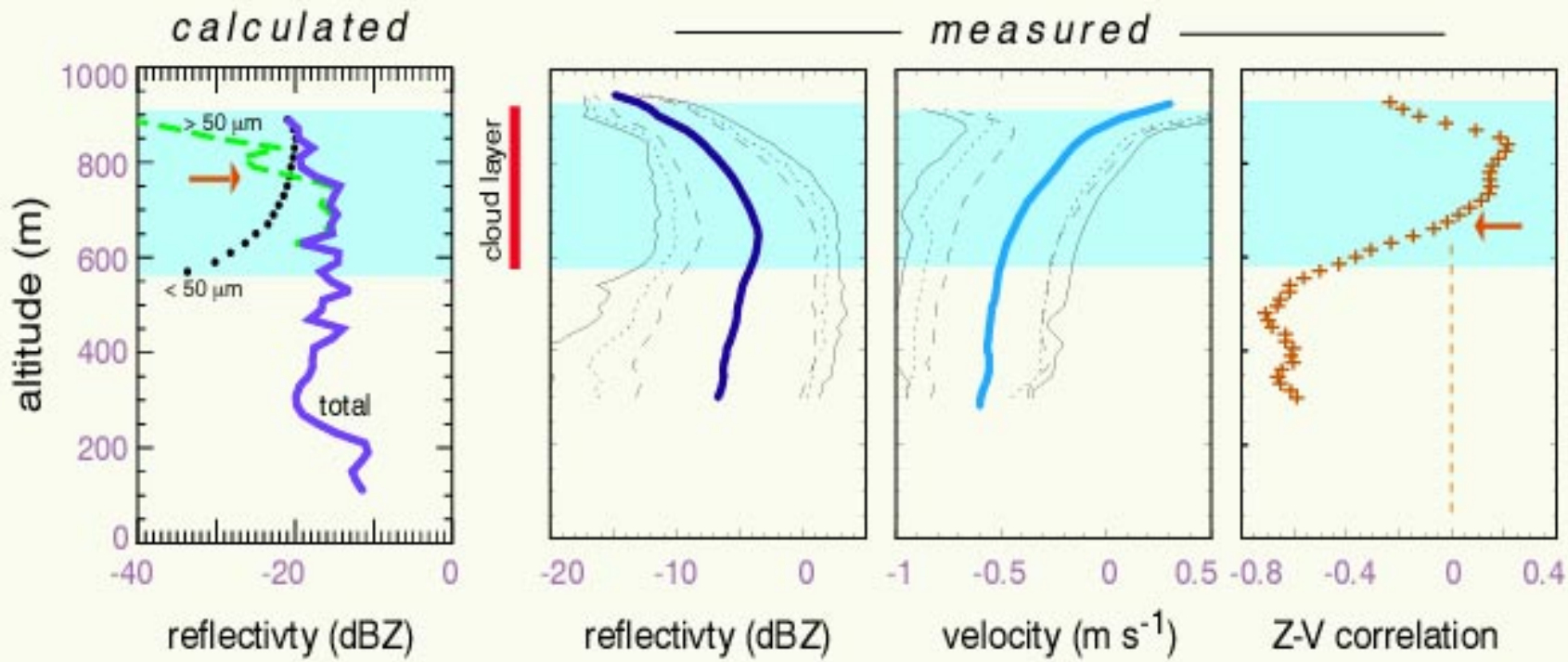
990811

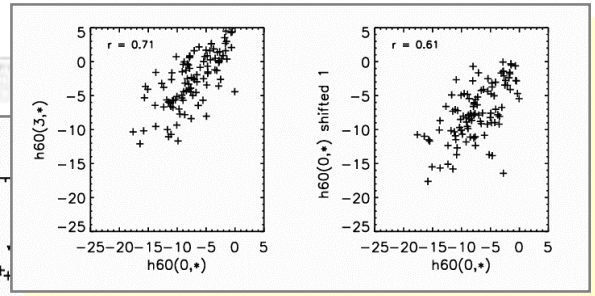



Horizontal range [m]
1400
1200
1000
800
600
400
200
15:35:30
15:35:45
15:36:00
15:36:15
15:36:30
15:36:45
UTC
dBZ
−40
−30
−20
−10
0

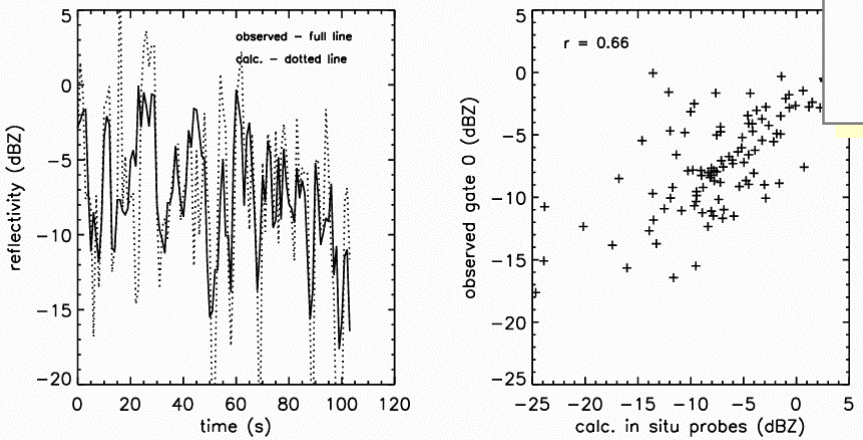

Horizontal range [m]
1400
1200
1000
800
600
400
200
17:34:15
17:34:30
17:34:45
17:35:00
17:35:15
17:35:30
UTC
dBZ
−40
−35
−30
−25
−20
−15
−10


950916 - VERTICAL SECTION
dBZ
altitude (m)
800
600
400
0
2
4
6
distance (km)
5
0
-5
-10
-15
-20
750 m altitude
625 m altitude
HORIZONTAL SECTIONS
dBZ
range (km)
2
1.5
1
0.5
8
6
4
2
distance (km)
10
0
-10
dBZ
range (km)
0
0.5
1
1.5
0
2
4
6
8
10
0
-10

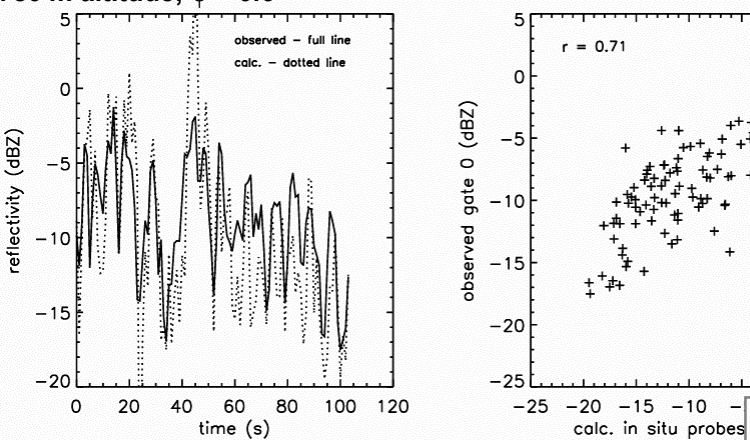

calculated
measured
altitude (m)
1000
800
600
400
200
0
> 50 µm
< 50 µm
total
-40
-20
0
reflectivty (dBZ)
cloud layer
-20
-10
0
reflectivty (dBZ)
-1
-0.5
0
0.5
velocity (m s-1)
-0.8
-0.4
0
0.4
Z-V correlation
950916



630 m altitude; ϕ = 0.15

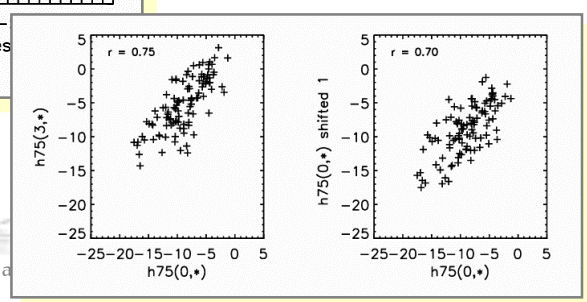


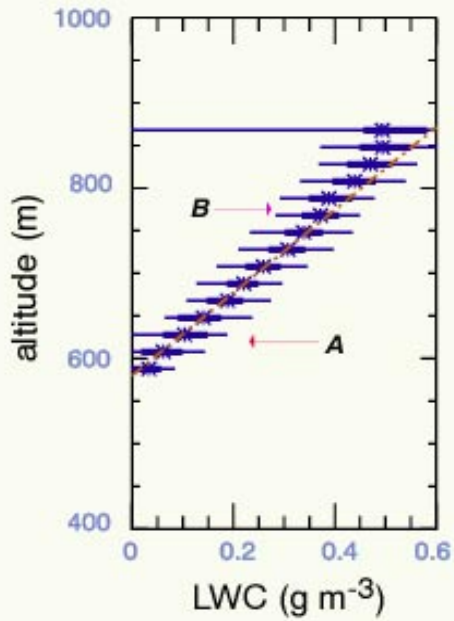
780 m altitude; ϕ = 0.6

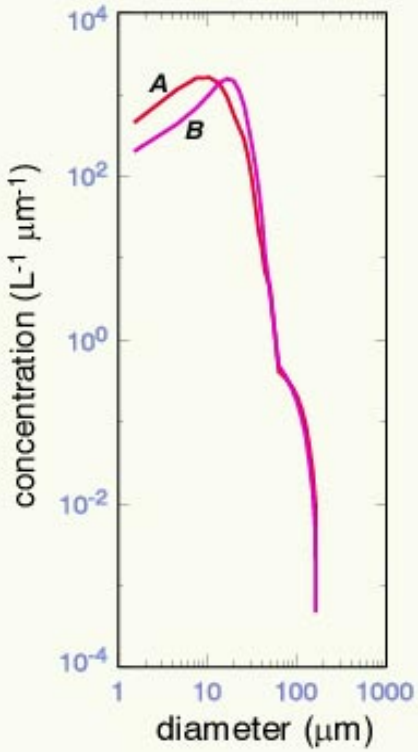


The correlation between Z_{calc} (derived from in situ data along the flight path) and Z_{obs} (radar measurement 90 m to the side of the aircraft), is very similar to that between radar ranges separated by a similar distance.

Interpretation of reflectivity patterns in terms of spectral characteristics is possible.



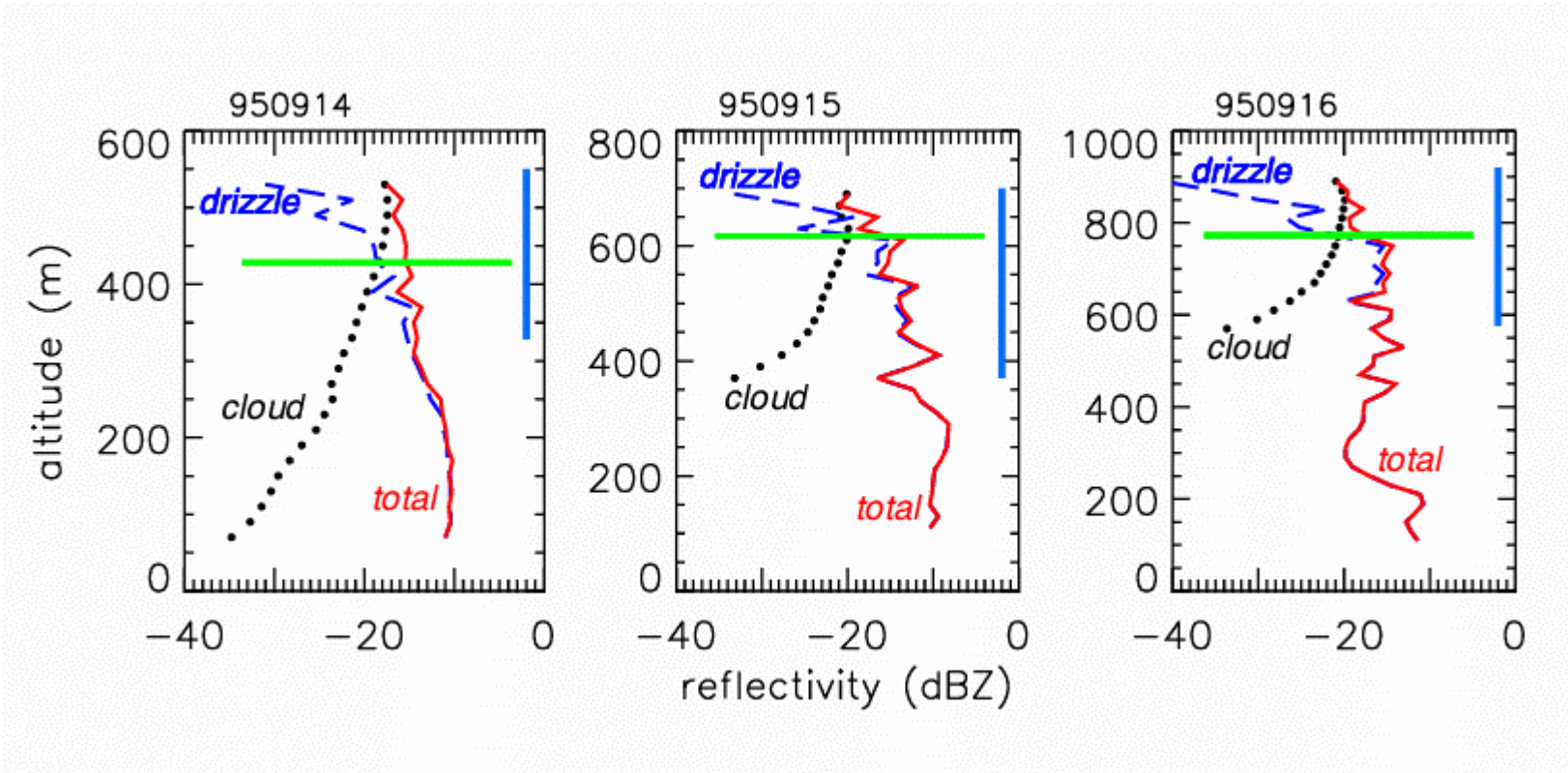

1000
800
600
400
altitude (m)
B
A
0
0.2
0.4
0.6
LWC (g m-3)

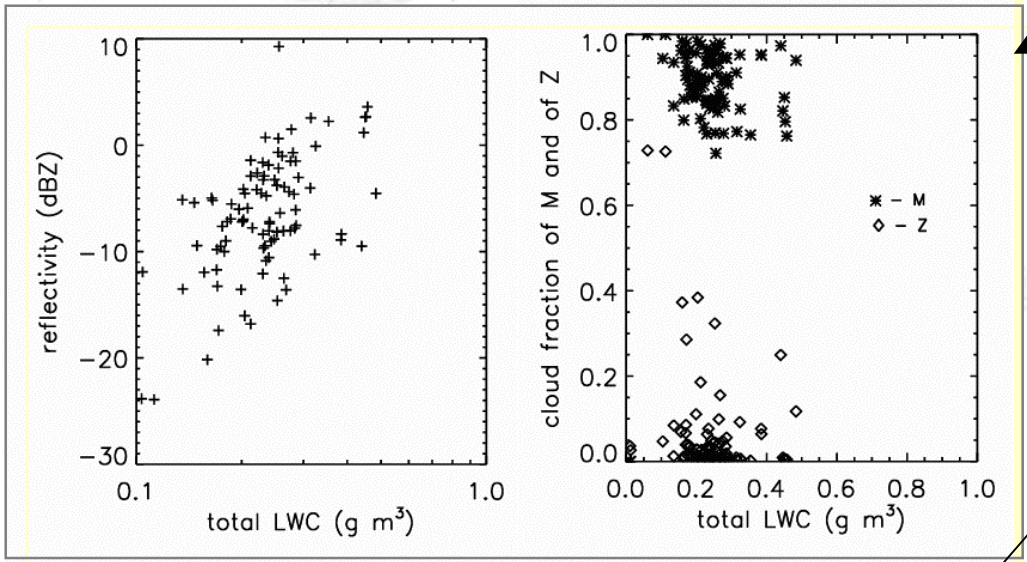

10^4
10^2
10^0
10^-2
10^-4
concentration (L-1 μm-1)
A
B
1
10
100
1000
diameter (μm)

950916

Conclusion from observations of Oregon coastal stratus:

Reflectivity is dominated by drizzle through the major part of the cloud depth.



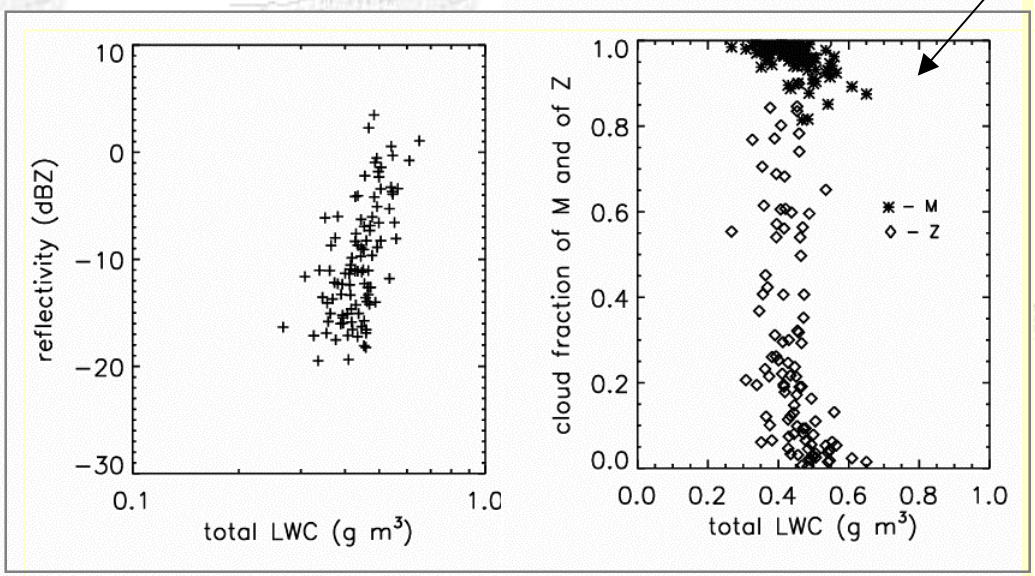


630 m altitude; $\phi = 0.15$

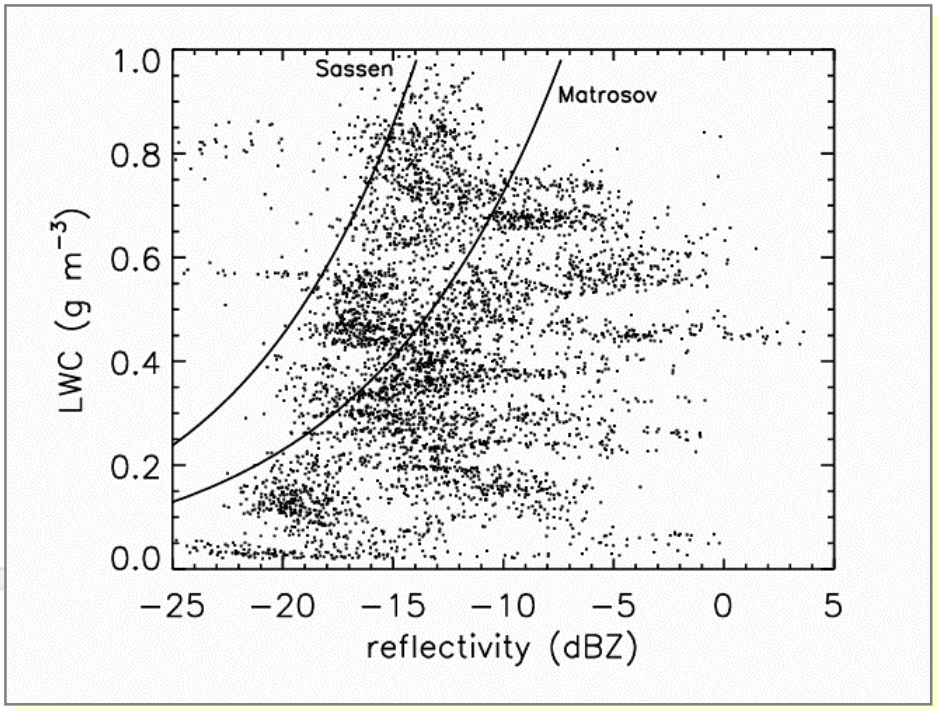
Mass and reflectivity are correlated, but range of Z for given M is large. Over 80% of total mass is in cloud droplet sizes (< 50 μm), whereas these droplet contribute small fractions of the reflectivity.

780 m altitude; $\phi = 0.6$

Mass and reflectivity are better correlated, but range of Z for given M is still large. Over 90% of total mass is in cloud droplet sizes (< 50 μm), and these droplet now contribute varying fractions of the reflectivity.



Mass - reflectivity (Z - M) relationship is complex. Simple rule would be unreliable.

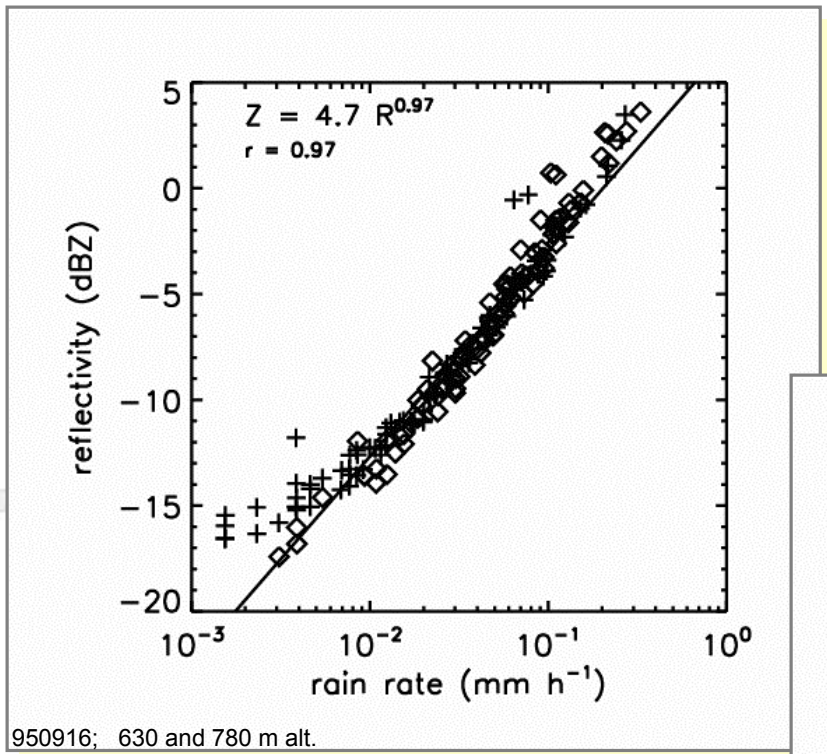


990817 flight

The use of M - Z relationships based on cloud droplet spectra, without the inclusion of drizzle, will seriously overestimate LWC from radar data.

Attenuation correction is quite straightforward when mass and reflectivity are decoupled.

on the other hand ...

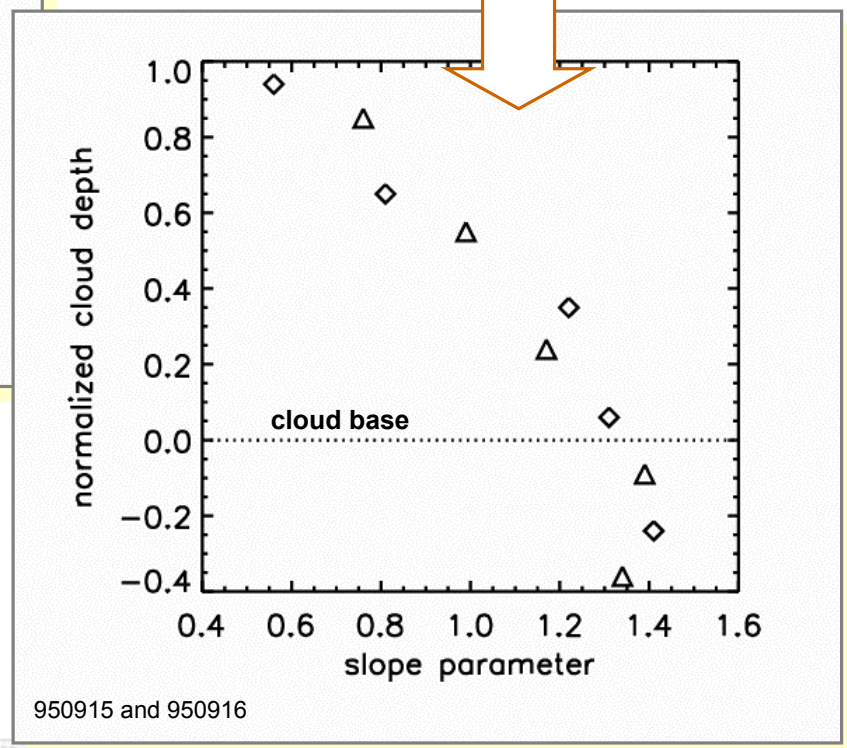


950916; 630 and 780 m alt.

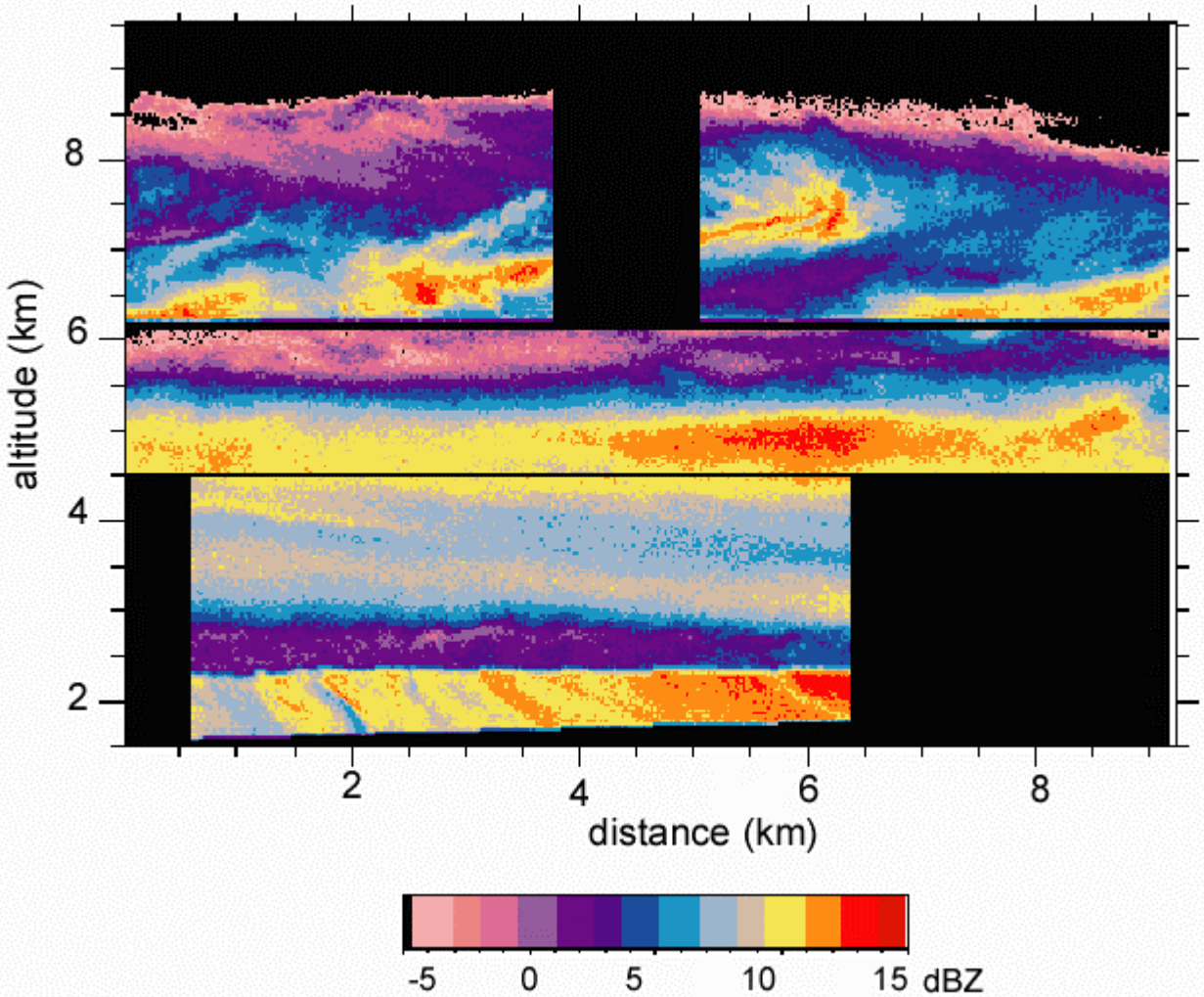
reflectivity and precipitation rate show strong correlations, justifying the use of power-law equations, like

$$Z = 4.8\ R^{0.97}$$

but slope parameter is altitude dependent.



950915 and 950916



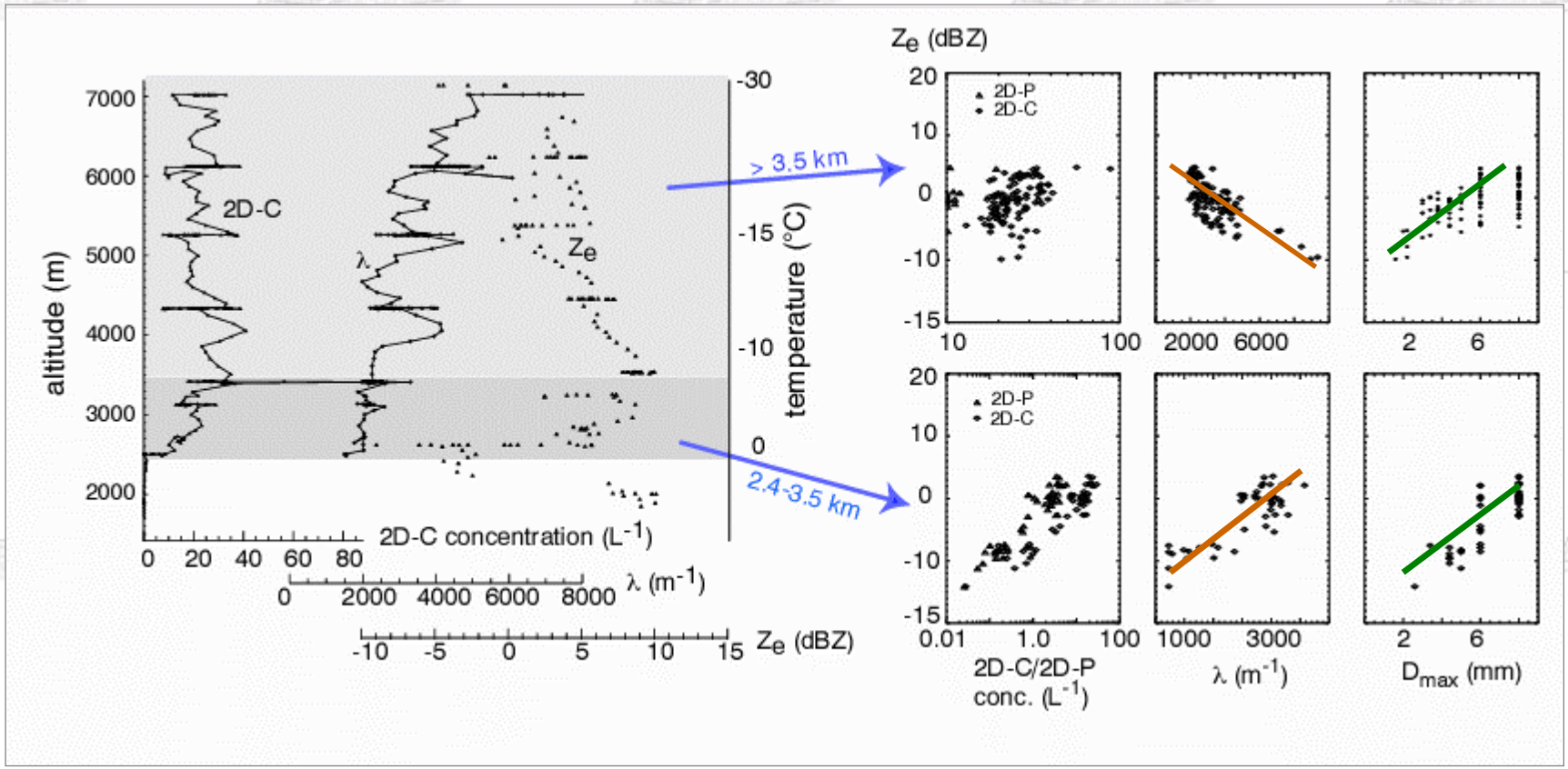
generating cells

stratified region

melting layer

October 31, 1992 **Ns,** Wyoming-Nebraska border

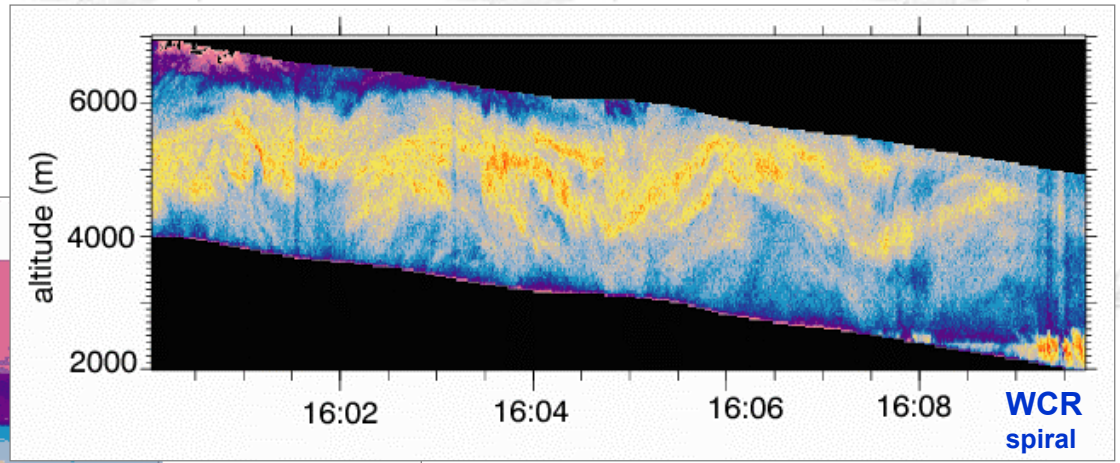
October 31, 1992 **Ns,** Wyoming-Nebraska border

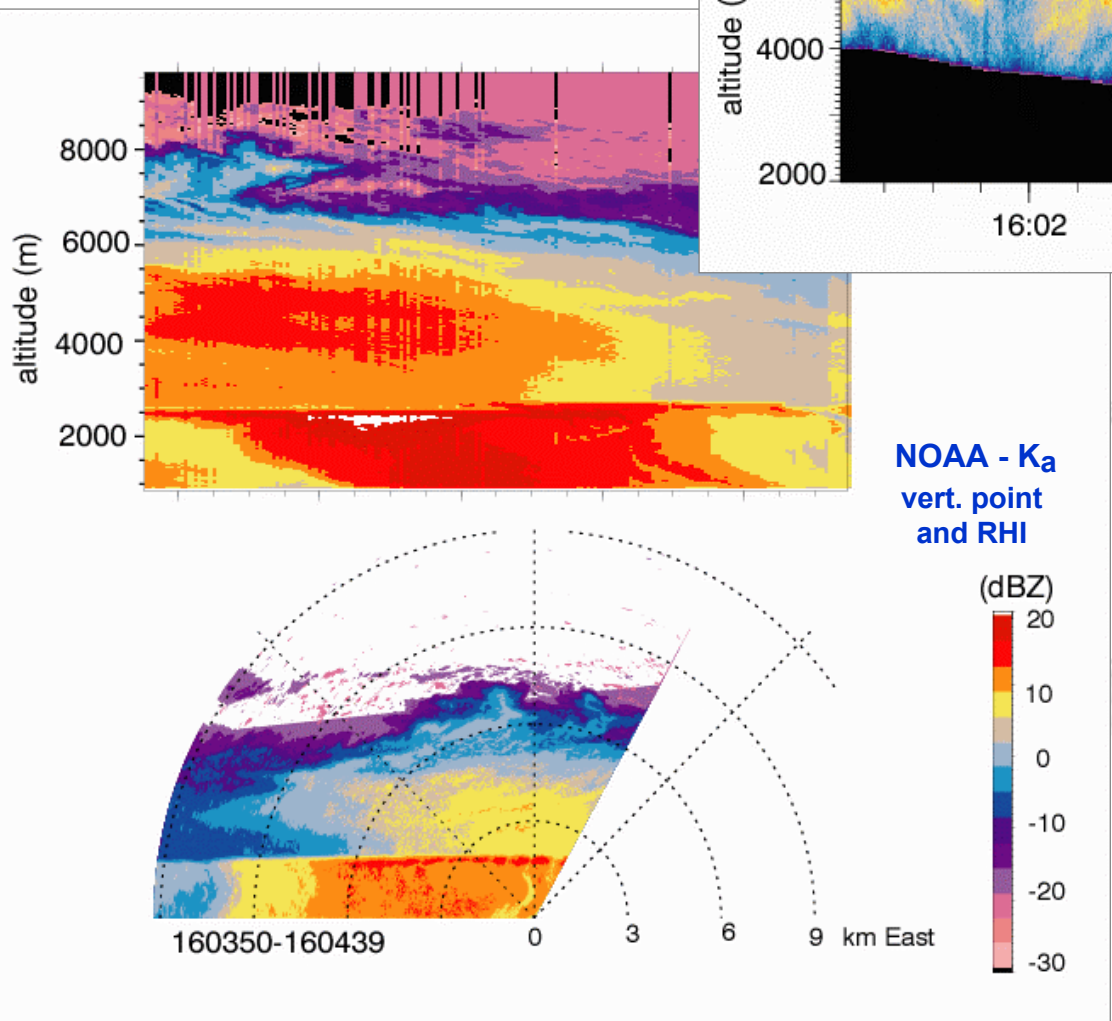


Z vs. λ relationship is reversed through cloud region above the melting layer

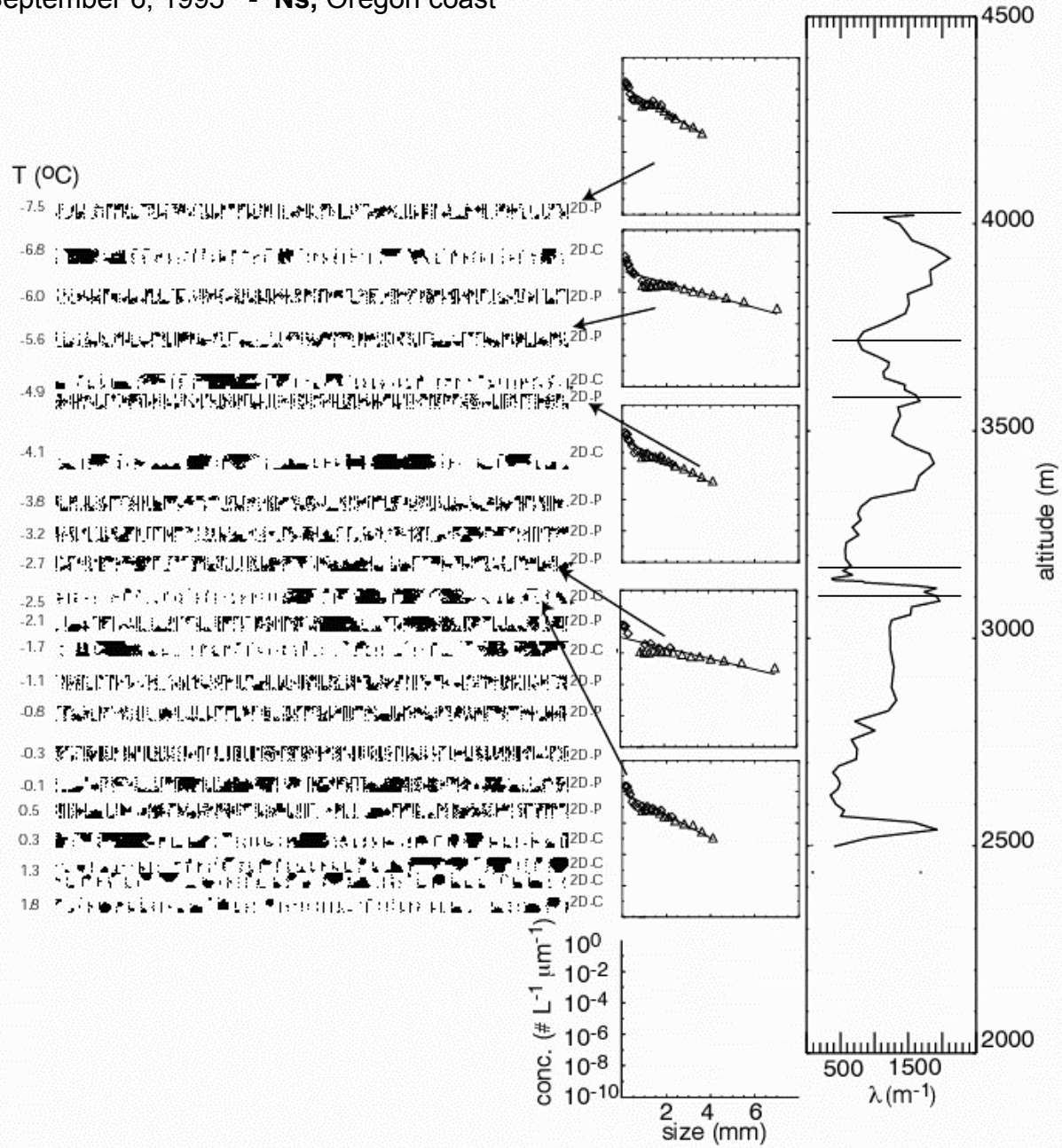
Z_e vs. D_{max} relationship appears to be more robust

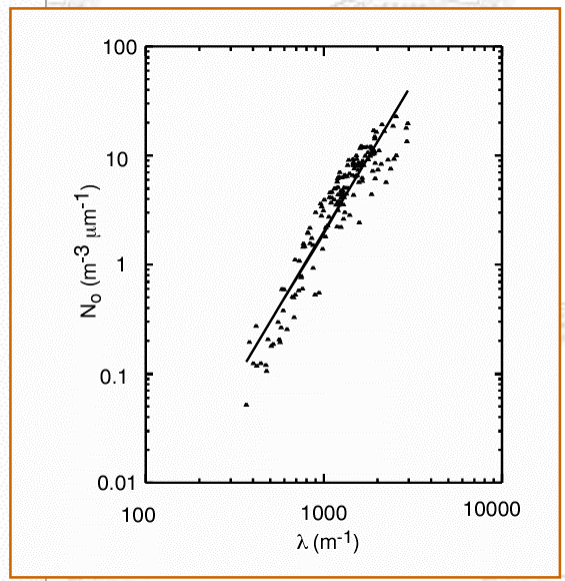
September 6, 1995 - **Ns,** Oregon coast

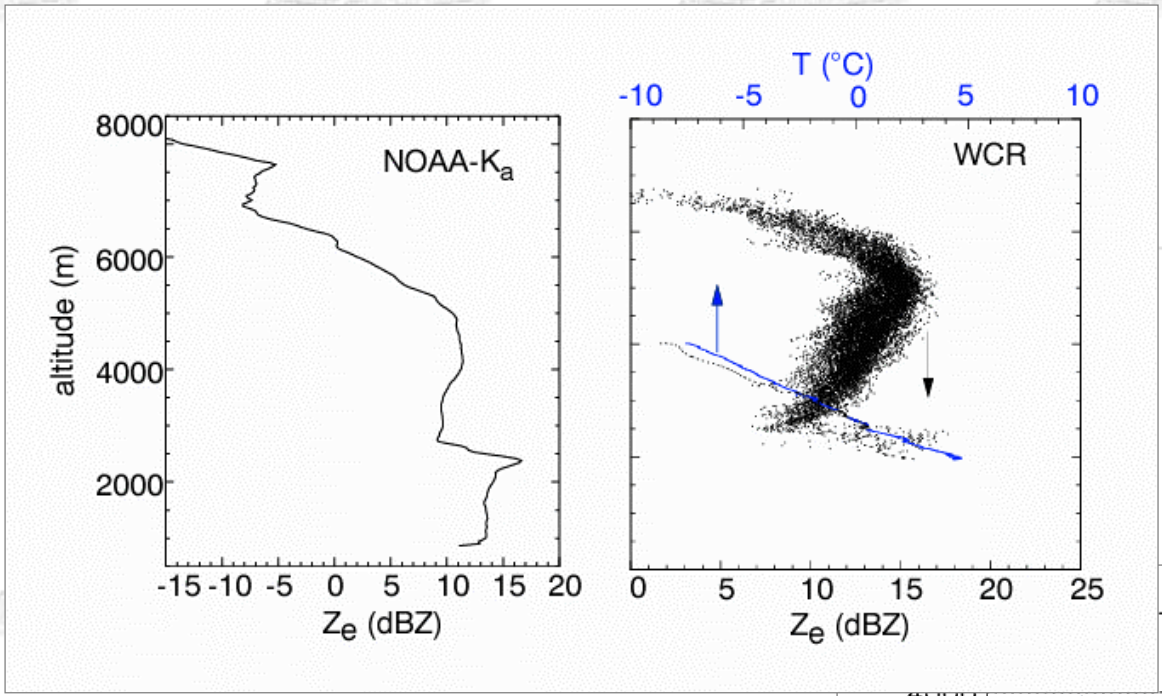


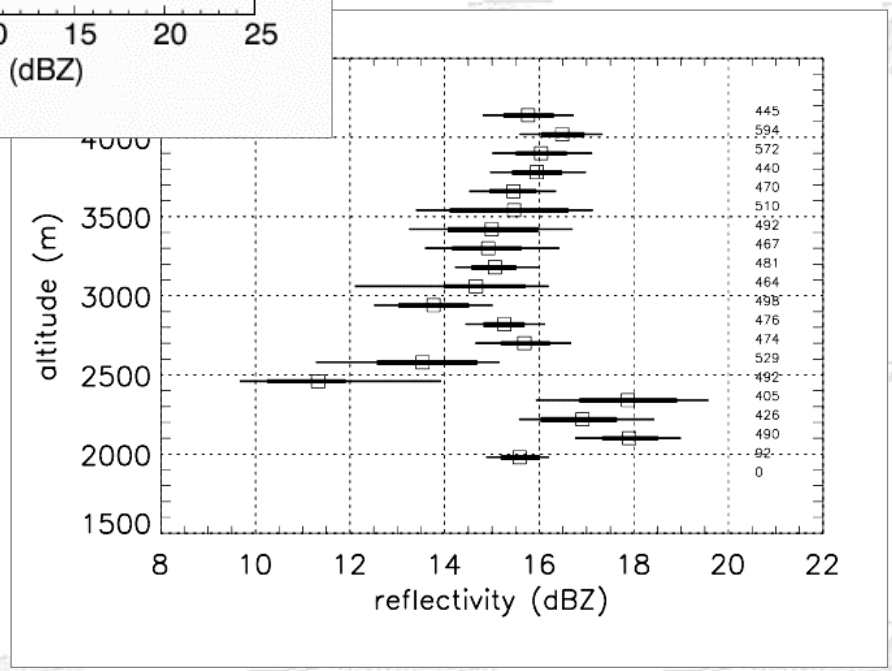


September 6, 1995 - **Ns,** Oregon coast

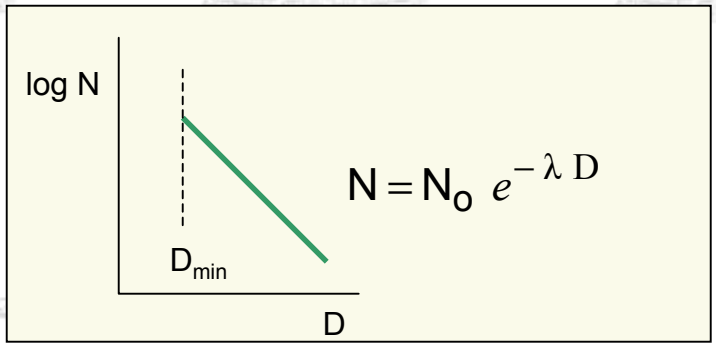








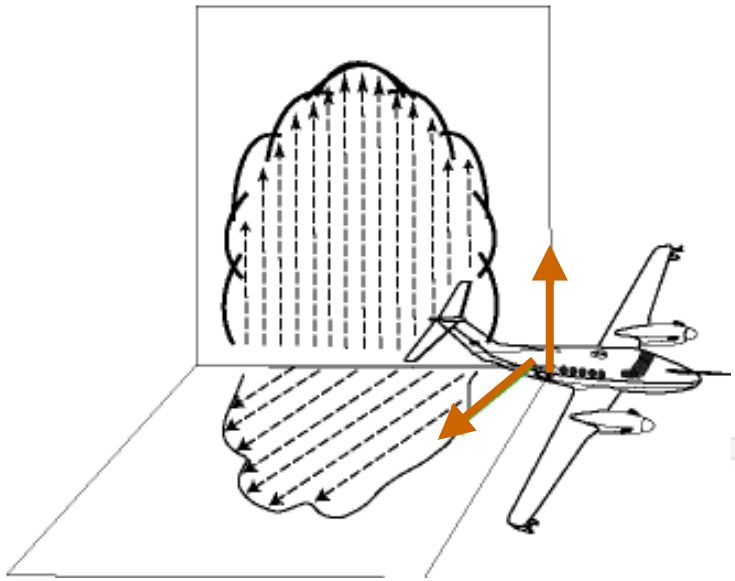
September 6, 1995 - **Ns,** Oregon coast



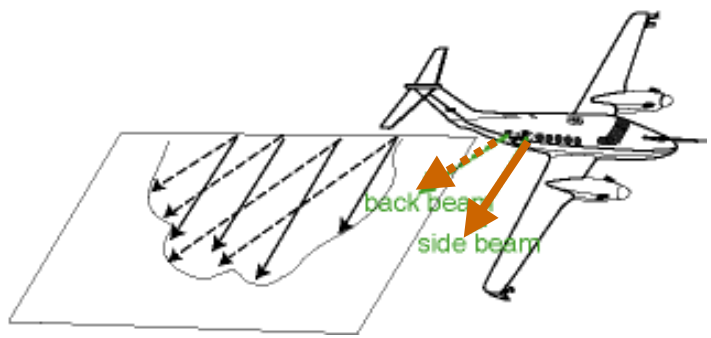
$$N_o = a\left(\frac{\lambda}{1000}\right)^b$$

Case/author	D_{min} (: m)	a	b	r	λ (H10^3) m^{-1}
September 06, 1995 (Ns over Oregon)	100	3.3	2.74	0.93	3.7 - 30
October 31, 1992 (Ns over Wyoming)	100	1.88	2.32	0.91	1.5 - 9.3
October 31, 1992 (Ns over Wyoming)	900	0.68	2.41	0.91	1.2 - 3.7
Altostratus cloud (Field 1999)	800	1.54	2.89	0.7	1.9 - 5.8
Winter cyclonic storm (Lo and Passarelli 1982)	300	1.07	1.85		1.0 - 8.0
Rainband (Gordon and Marwitz 1986)	500	0.13	2.26	0.9	1.1 - 10.7

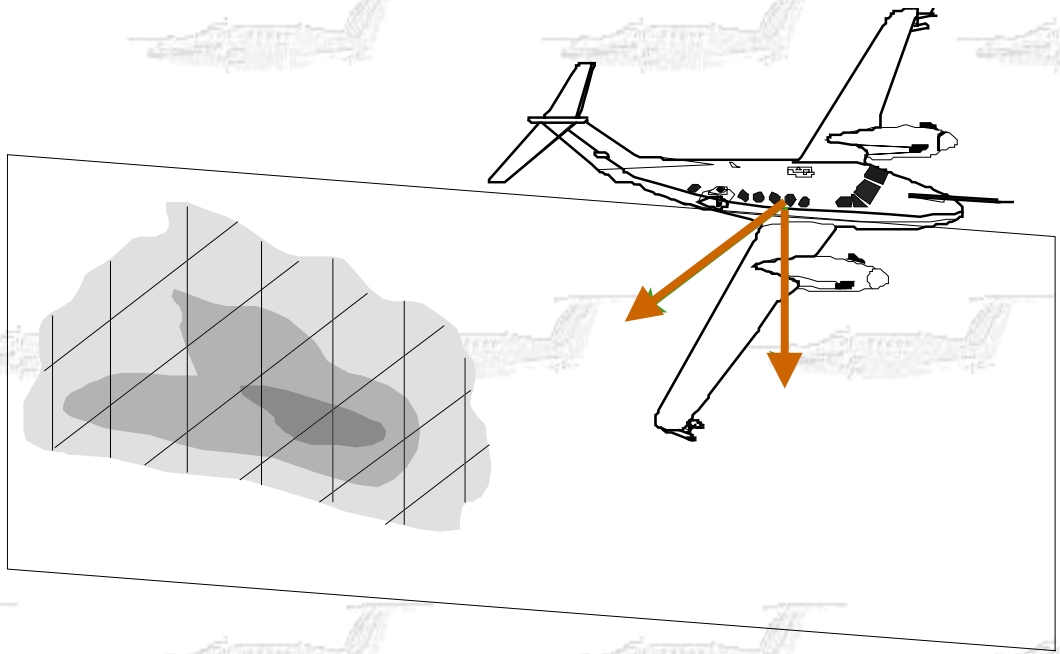
dual-direction configuration

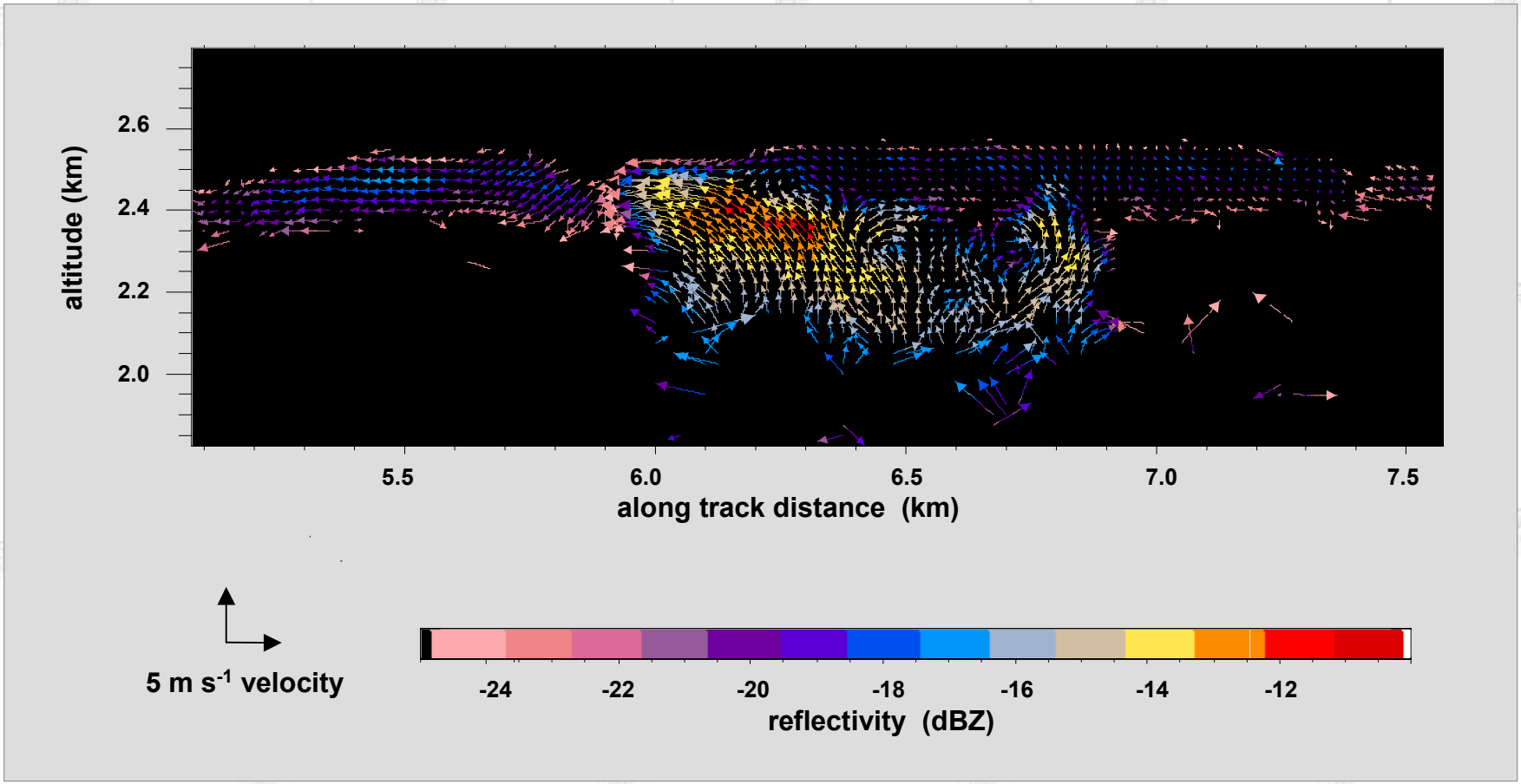


horizontal dual-beam configuration



vertical plane dual_Doppler





vertical plane dual-Doppler analysis

TRAC98 980625 13:50:50 - 13:51:23