King Air N2UW flight report for December 13, 2004
Crew: Drew, Vali, Oolman, Glover

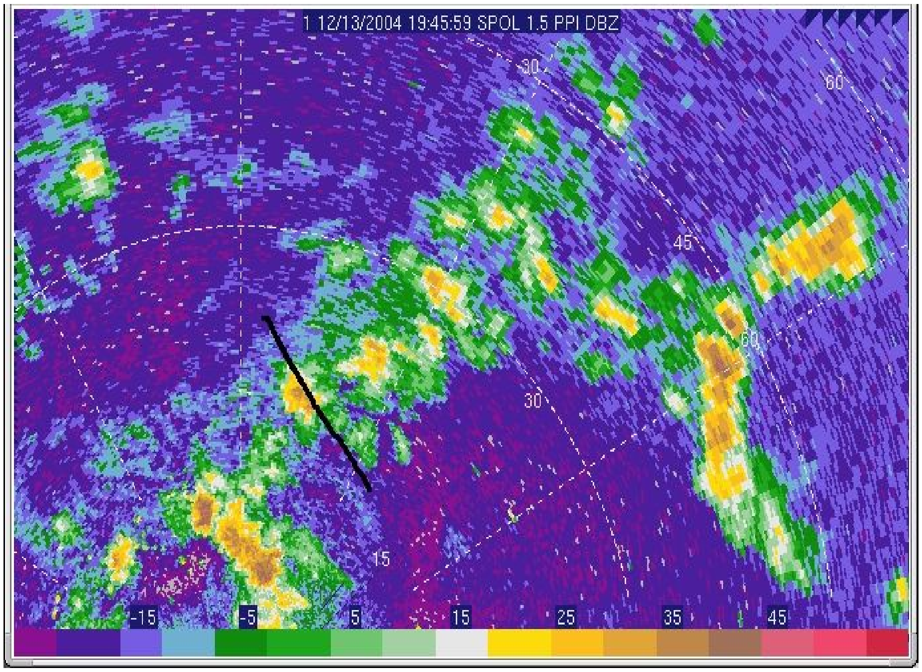
After repair of the air conditioner on the aircraft, a test flight was needed and was to be transformed into a research flight should it a/c work all right. That turned out to be the case. However, the flight was late in the day and not specifically coordinated with C130 activities, nor with the overall pattern of clouds. As luck would have it, interesting clouds did prevail in an area readily accessible, so that a productive flight resulted.

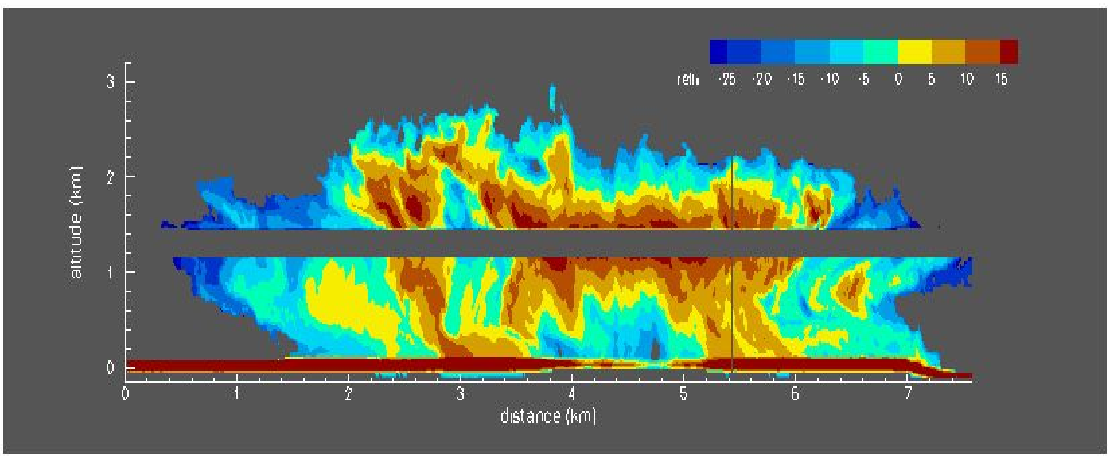
The main activity was monitoring of several cells, some large and deep, some smaller. There were several large Cb in the area; we worked in the spaces between the largest cells.

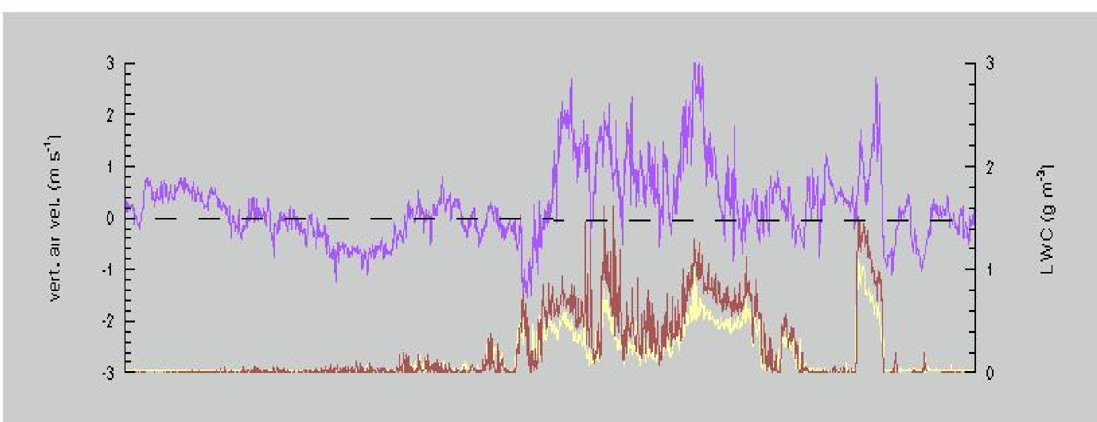
A . The first set of repeat sampling (19:42 – 19:56) was done roughly 20 N of SPOL. This *cluster of deeper clouds* was sampled at 1300 m along a SE – NW line, with both UD (up-down) radar configuration and then with offset (side-down) configuration. (This is why the passes appear unevenly spaced in the plotted track.) The photo below gives an idea of what the cluster looked like, though it may not be exactly the part we penetrated.

The cell was part of a line of echoes on SPol that moved off to the NE with time, forming an arc by about 20:25. The max. echo top was 3.5 km. Reflectivities reached 35 dBZ in the turret sampled and decreased with time to about 24 dBZ in its upper part. Echoes at 1.5° elevation (about cloud base for the echo in question) are shown below, along with a line indicating the general direction of the aircraft passes.

Four passes were made. The WCR image and in situ data on the next page are from the first pass, heading to the NW. The SPol image shows about 1 km greater horizontal extent at the flight line than the WCR or in situ data indicate; this is very like due to Bragg scattering (mistake in locating the flight path would seem to have a minor effect).


1 12/13/2004 19:45:59 SPOL 1.5 PPI DBZ
-15 -5 5 15 25 35 45

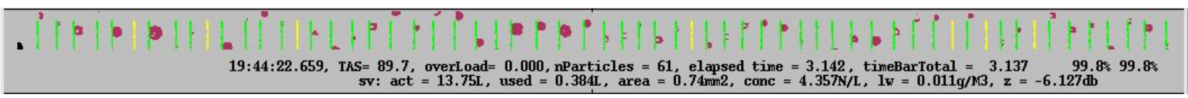

refl
-25 -20 -15 -10 -5 0 5 10 15
altitude (km)
distance (km)


vert. air vel. (m s-1)
LWC (g m-3)

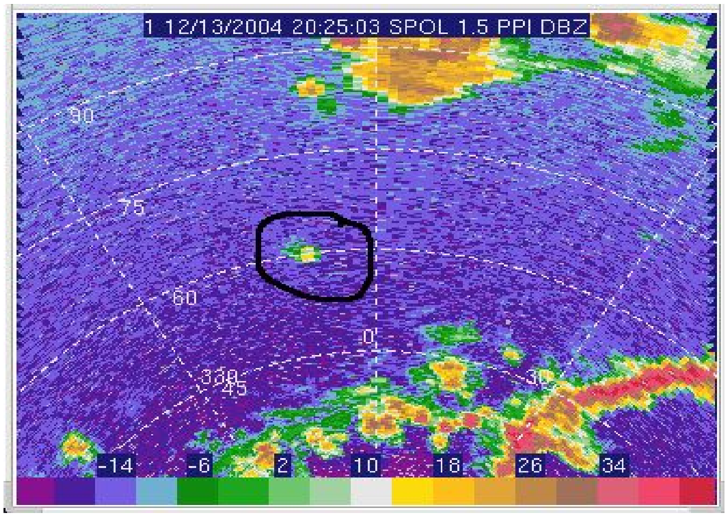
The WCR and in situ data on the previous page is from the pass 19:43:10 – 19:44:30. The echo structure is clearly indicative of multiple cells in the cluster. Strong reflectivities at flight level near the middle of the pass resulted in attenuation of the signal, so that the echoes on both sides of the flight path probably extended further than depicted. Precipitation at the ocean surface certainly extended from one end to the other.

The left (NW) side of the echo, between 2 and 4 km on the horizontal scale extends to about 3.6 km but appears to be collapsing, i.e. there are no updrafts and no LWC at flight level. There is a sharp transition from this to the SE half of the echo (between 3.8 and 5.5 km on the horizontal scale), where the top is lower but there is growth indicated by the flight-level data (updrafts of 1-2 m s^{-1} and LWC of 0.6-1 g m^{-3}). Nonetheless, this SE portion has high reflectivities near the flight altitude and to perhaps 200 m on either side (this is where attenuation is most evident).

In the strong echo region drops to 2 mm diameter were detected by the 2D probes. Notably, the pulse of updraft at 6.5-6.7 km is also located above a strong patch of echo and in this same updraft there were drops of up to 300 µm diameter. These are shown in the 2D-C images below.



B. The second focus on this day was a *small isolated cloud*, located further to the NW of the previous set of passes, at a location 10 km west and 60 km N of SPol. This cloud was studied from 20:16 to 20:38 UTC. The photo below shows the appearance of this cloud; it was taken at 20:26. Traverses were made at 1.0, 0.4 and 0.2 km altitude. Echo top was observed to 2 km. Cloud base was not clearly established; both the PVM and the FSSP recorded cloud droplets and LWC even during the pass at 200 m altitude, but this is certainly an artifact.

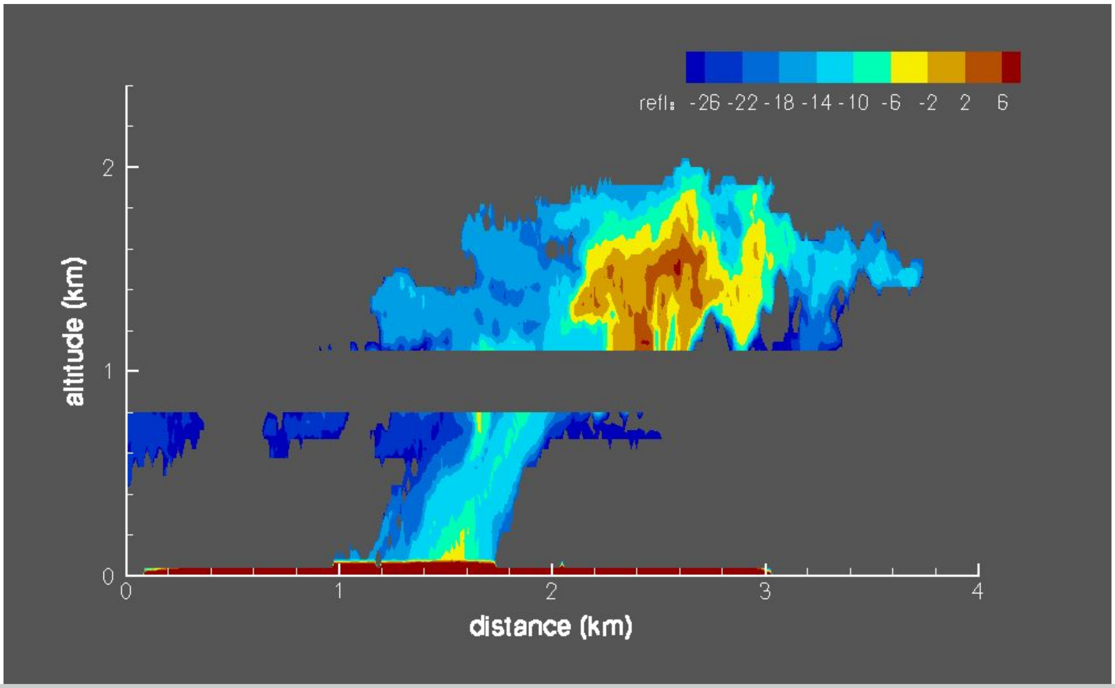


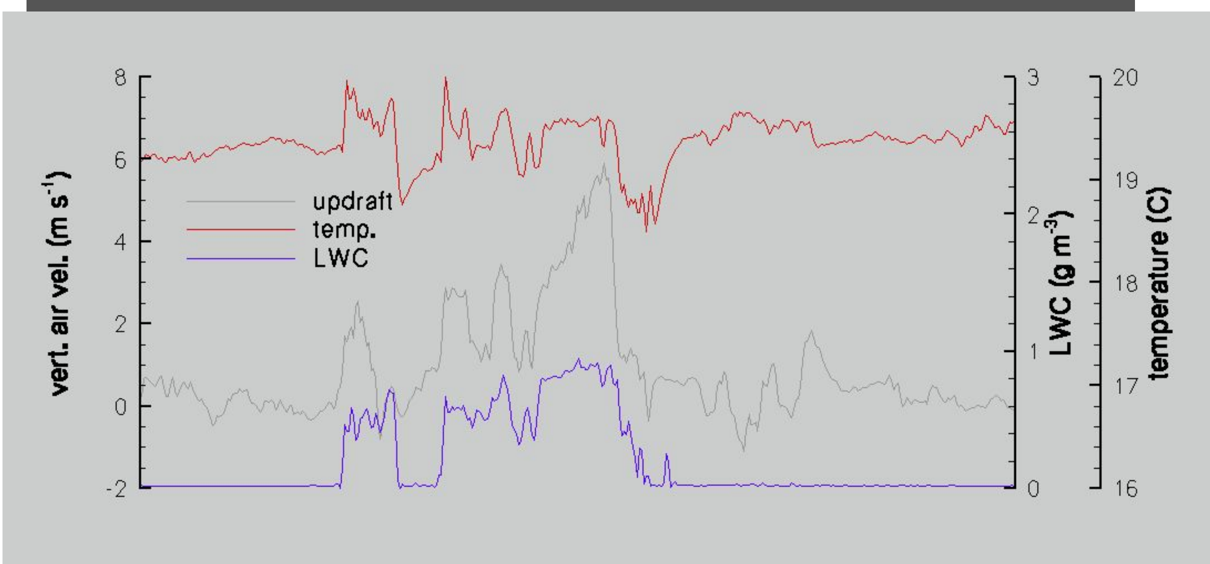
The SPol image shows that indeed the cloud was isolated, with no echoes within at least 30 km. Much larger and deeper clouds were located to the N, and to the S. Photographs show that there were other smaller clouds nearby, and that there was also a deck of high Ac/As present, but these were not registered by SPol.

The small echo we studied can be traced back to its formation at about 19:49 to the NE of SPol and it remained detectable until 20:55, i.e. a little over an hour. Considering the small size of the cloud, this is quite remarkable. From the WCR data, cloud top reached just a little over 2 km and stayed fairly constant. The horizontal dimension of the WCR echo is also about 2 km, again smaller than the SPol echo (perhaps due to Bragg effects ?).

WCR and in situ data from the first pass are shown in the figure on the next page. The flight line is in the middle of the dark band, at 1 km altitude. This pass was along a 015° heading, roughly perpendicular to the mean winds but nearly coincident with the shear vector between the penetration level and the surface. This may account for the rather unusual pattern revealed by the figure: the major udraft is tucked in between the precipitation shaft on the left and the strong echoes overhead on the right. In fact, the precipitation reaching the surface is falling entirely through the updraft area, with the stronger echoes descending into a no-updraft area. Also noteworthy is the strong temperature pattern, well synchronized with the updraft.

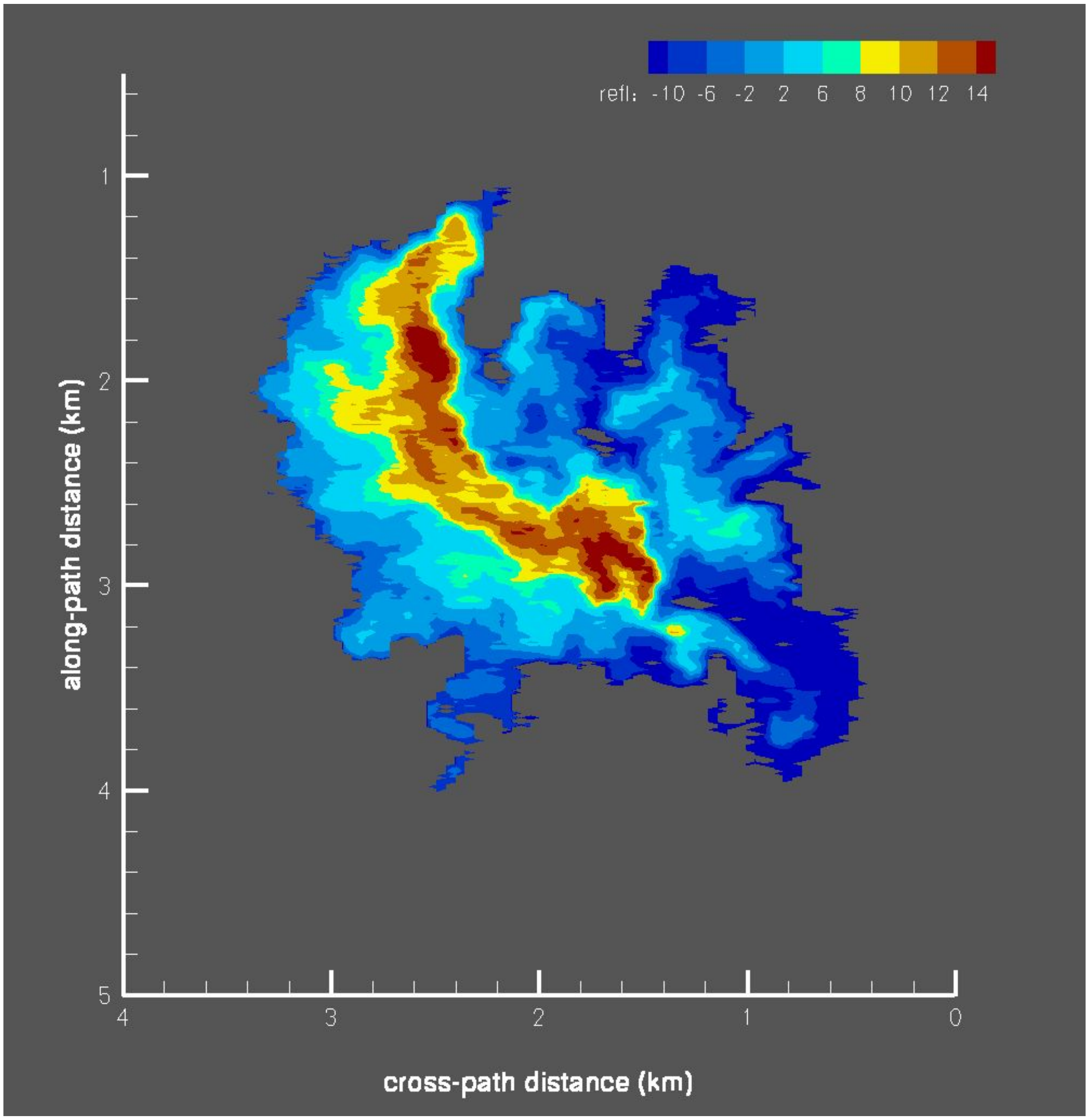
The top figure on page 6 is a horizontal section across the cloud, still at 1 km altitude, taken 2 minutes after the previous pass. The reflectivity scale is shifted to higher values than in the vertical section. The ordinate of this figure is the direction of the flight path, a heading of 195°**.** The intention was to pass 1-km to the side of the pointer set in the first pass, on a reverse heading, thus the path of that pass is (more or less) along a vertical line at the 1-km abscissa value in this figure. This indicates that the first pass was a little to the East of the most intense echo, but even the 2-min time difference between the two passes could make such comparisons uncertain.

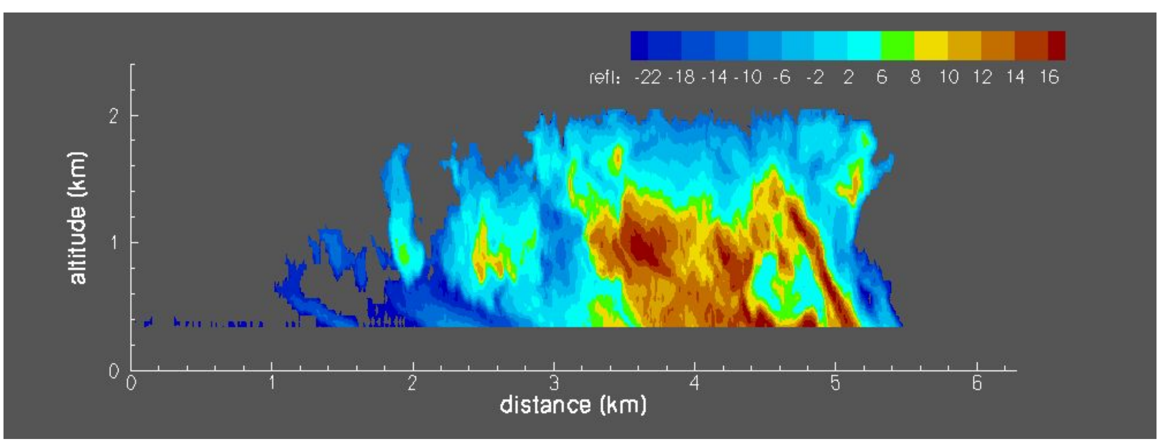




During five minutes past the second pass, the horizontal echo area shrank to about 1.8 km maximum dimension (still at 1 km altitude). That was followed by growth during which the evolution was monitored from passes below cloud base, down to 180 m above the surface. This phase is illustrated with the lower image on page 6. At that time drops to 2 mm diameter were recorded. On the pass following that 4-mm drops were recorded.

All told, there were 10 passes made through the cloud and through the precipitation falling from it over a period of 22 minutes. The complexity of cloud structure and its rapid evolution are clearly evident in the observations. In some ways this is in remarkable contrast with the long life and clear continuity of the echo in the SPol data.


refl: -10 -6 -2 2 6 8 10 12 14
along-path distance (km)
1
2
3
4
5
4
3
2
1
0
cross-path distance (km)


refl: -22 -18 -14 -10 -6 -2 2 6 8 10 12 14 16
altitude (km)
0
1
2
0
1
2
3
4
5
6
distance (km)

Flight Notes:

1839	engines up
1854	T/O
1900	rain ahead
1915	went through tall, tilted cloud at 10000', then down to 7000' for smaller clouds
1917	cloud indistinct
1923	series of turrets
1926	down to 4000' on NE side of clouds
1933	echo on nose radar ("NRE")
1944	UD beams through NRE; set 1.5 km offset pointer; clear in the area past this cloud
1948	SD beams at 1.5 km, then return to zero offset pointer
1951	UD at pointer, then 90/270
1955	UD again
1956	270 to go along the long axis of the cluster perpendicular to previous passes
1956+	data system down
2004	C130 shown on TCAS to be just below us; no visual contact
2009	system back up; new target
2021	third pass on small cloud; did UD, 1-km SD, UD again
2023	90/270
2024	pointer disagrees with visual, got to the side and switched to SD
2025	UD, then to 1000'
2031	at 500' pointer, second pass; will do butterfly pattern based on visual track of precip.
2037	3000' same cloud visually
2042	3000' circles over water for beam calibration
2048	to Barbuda; crossing line with red NRE
2057	beam calibration circles
2117	L/D