

King Air N2UW flight report for December 19, 2004

Crew: Fagerstrom, Vali, Oolman, Glover

Plan: This was to be the first early morning flight, after the near-standard 11 am takeoff of the earlier days. Once again, King Air was to take off one hour after the C130, so as to overlap with its cloud work after the circles.

In-cloud intercomparison was to be included after the first set of circles by the C130. King Air to select cloud and lead.

General comments: Heavy rain was noted (in Dickenson Bay area) overnight, at around 3 am. and again 5:30 am. SPol echoes overnight also showed considerable activity in the region, and the flight also encountered deeper clouds and substantial rain. Definitely, the day falls on the rainy end of the spectrum so far sampled in RICO.

Cloud sampling emphasized the rain, since that was the most prominent feature of the day. Sampling was done at various altitudes, from 3.3 km to near the surface. Not randomly, but still covering a large area; repeat passes were done in several examples to observe the structure and its changes. The aircraft nose radar was used in the latter part of the flight to sample NRE (nose radar echoes).



Photo (PC190375) on left is a view from 10,000' at 1233 UTC, looking toward the ESE. Deeper clouds emerge from large areas of small clouds. Patches of thin As are also seen.

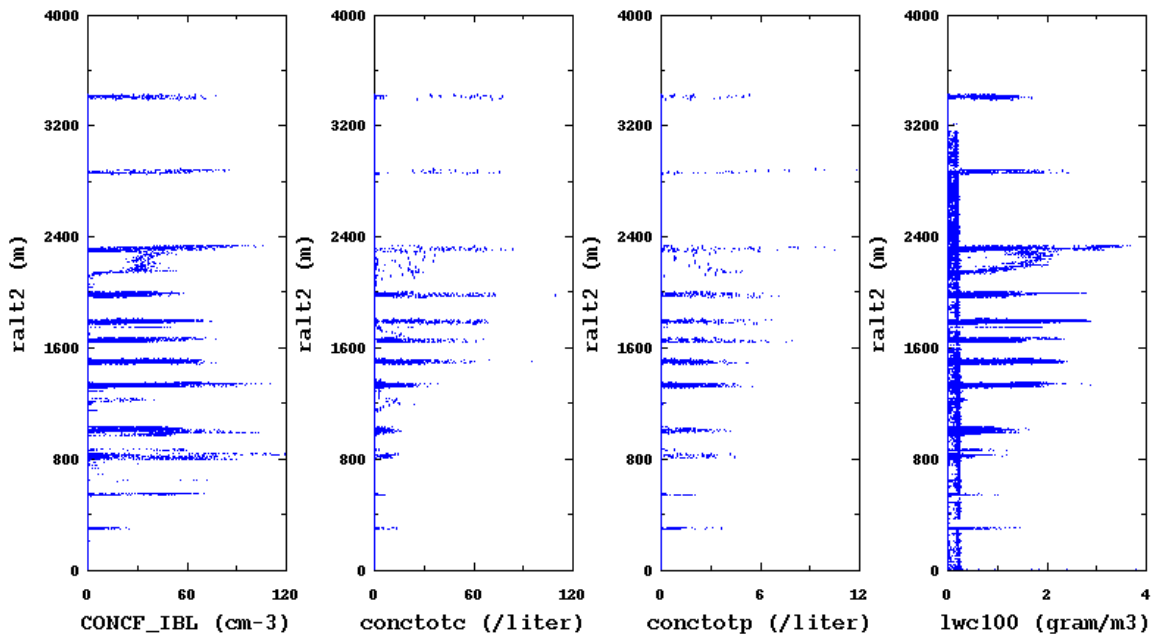


The second photo (PC190377) was taken at 1244.



A view from near cloud base altitude (PC190424 taken at 1505) shows that the general character of the clouds didn't change much over the period (3+ hours) of the King Air flight. Rain is clearly visible, and appears to originate from parts of the cloud where older cloud mass is intermingled with the vigorous new turrets.

Cloud microphysics. Droplet concentrations of 40-60 cm^{-3} were the rule, and peak vertical velocities up to 6 m s^{-1} were encountered near cloud tops. LWC over 2 g m^{-3} were frequently detected and in one pass 3 g m^{-3} or more was recorded (see Section C below). Vertical profiles shown below indicate a slight decrease in peak droplet concentrations with altitude and an increase in LWC. The concentrations of drops in the 2D- C and 2D-P size ranges have higher values above about 1500 m than below that, which is indicative, I think, of the transport of large drops upward by updrafts, in addition to the expected reductions due to coalescence.



A. During the initial phase of the flight, at 10,000 ft, rain was frequently encountered before entering cloud, in bright sunlight, and with no cloud noted overhead. This was further emphasized by the numerous occasions when rainbows were observed ‘on the sides’

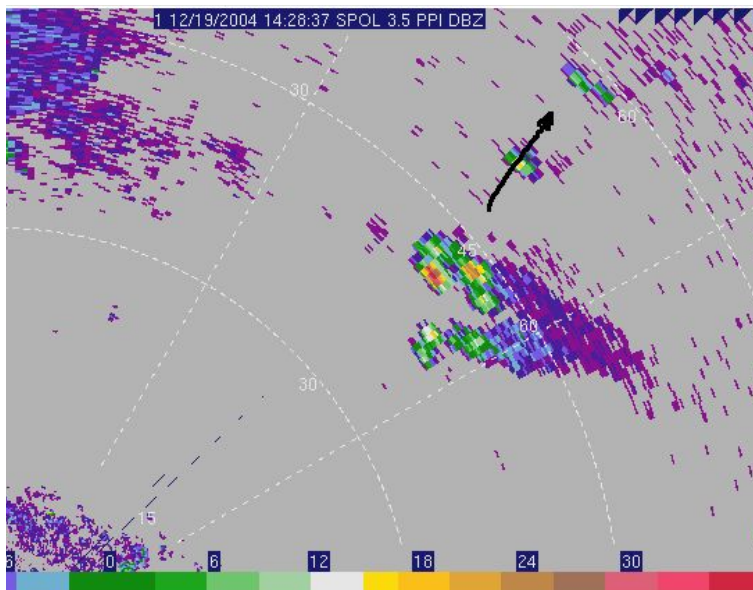


of clouds, as shown in the example here (PC190390 taken at 1258). Note that the rainbow does not extend past the cloud edge, and (while hard to prove) there is no cloud overhead from which the rain could be falling. Rather, the impression is that the rainbow is formed by larger drops that are still present after the smaller ones that make the cloud visible have evaporated.

B. One of the cloud top passes caught a fresh thermal. Flying at 2340 m altitude, the top of the turret had a lively appearance – the photo here was taken 24 s before cloud entry.

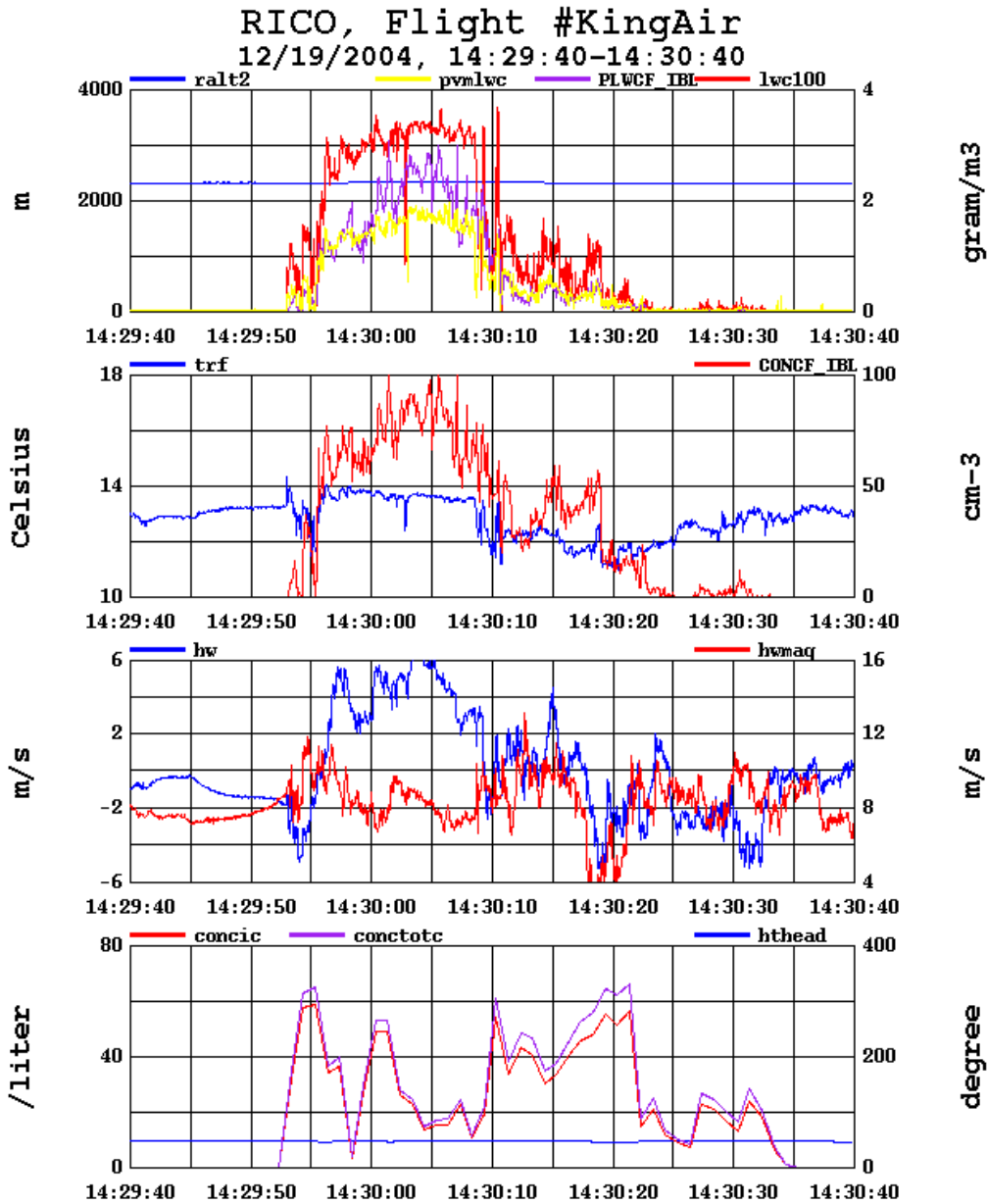


Satellite images show this cloud to be at the SW end of a line of about 40 km length, oriented SW-NE and moving toward WNW, but changing with time to a longer line of W-E orientation.



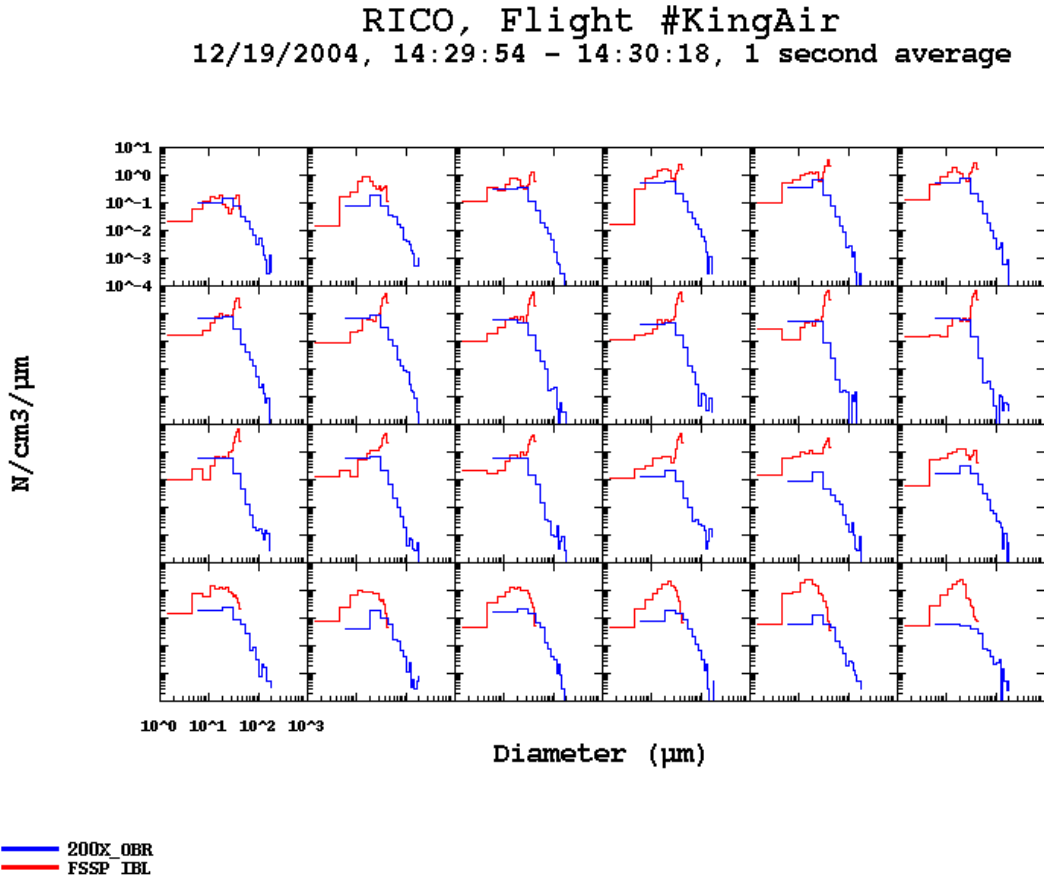
SPol shows a small cell at flight level with about 12 dBZ intensity. Motion of the cell was from about 100° so that the transect was oriented nearly perpendicular to the direction of translation.

After a short pulse of downdraft at the edge, a fairly steady updraft of a little over 1 km extent and 5-7 m s⁻¹ intensity was found. The nearly top-hat LWC was 2.7 g m⁻³ from the FSSP integral, and 3.5 g m⁻³ from the hot-wire probe. Adiabatic LWC (for cloud base at 950 mb and 22°C -- rough numbers at this point) would be 3.7 g m⁻³. Time traces and spectra are shown below.



What certainly looks like an entrainment event can be seen at 14:30:03 -- LWC measured by all of the probes dropped to about half the nearby values, and there was a temperature dip of about 1°C. There was also a noticeable change in the vertical and horizontal winds. The duration of the event was something close to 0.2 s. Remarkably, it is directly adjacent to the the peak updraft velocity.

The droplet spectra peak near $40\ \mu\text{m}$ (uncomfortably close to the upper end of the FSSP size range), and the peaks have total widths of only about $10\ \mu\text{m}$. Nonetheless, the 1D-C probe indicates the spectra extending to $200\ \mu\text{m}$ and the 2D-C registered perfect images of about $600\ \mu\text{m}$ right in the peak updraft.

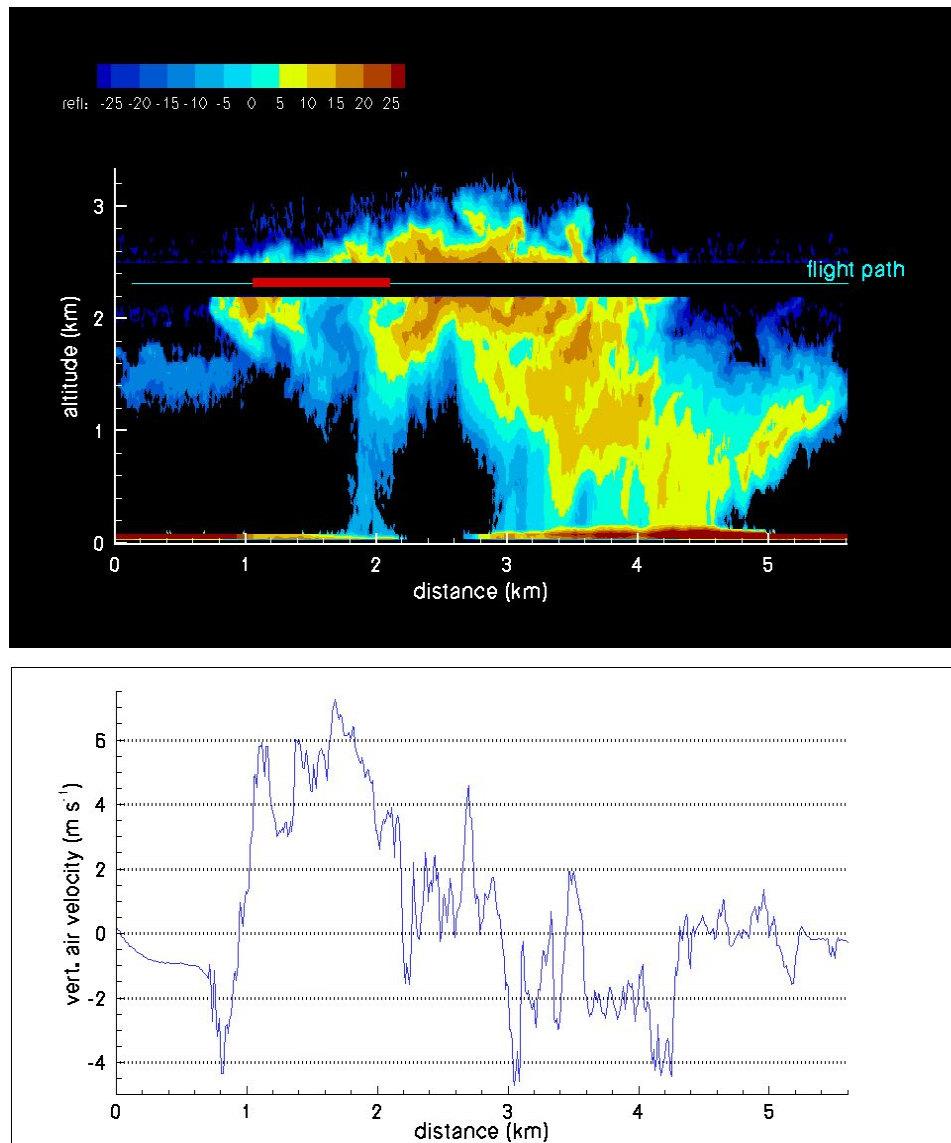


The WCR vertical section adds more flavor to the data already shown. Perhaps the main point, clearly demonstrated by this image, is that at this stage, with cloud top about 1800 m above the base, the updraft is already surrounded by drizzle/rain and also contains substantial drizzle/rain even though it may be as close as 80+ % of adiabatic LWC.

Other structural features are harder to ascertain. New growth in this instant is on the SW side, neither upwind nor downwind with respect to the part of the cloud that developed earlier. This has to be viewed in the context of the evolution of the pattern seen on the satellite images.

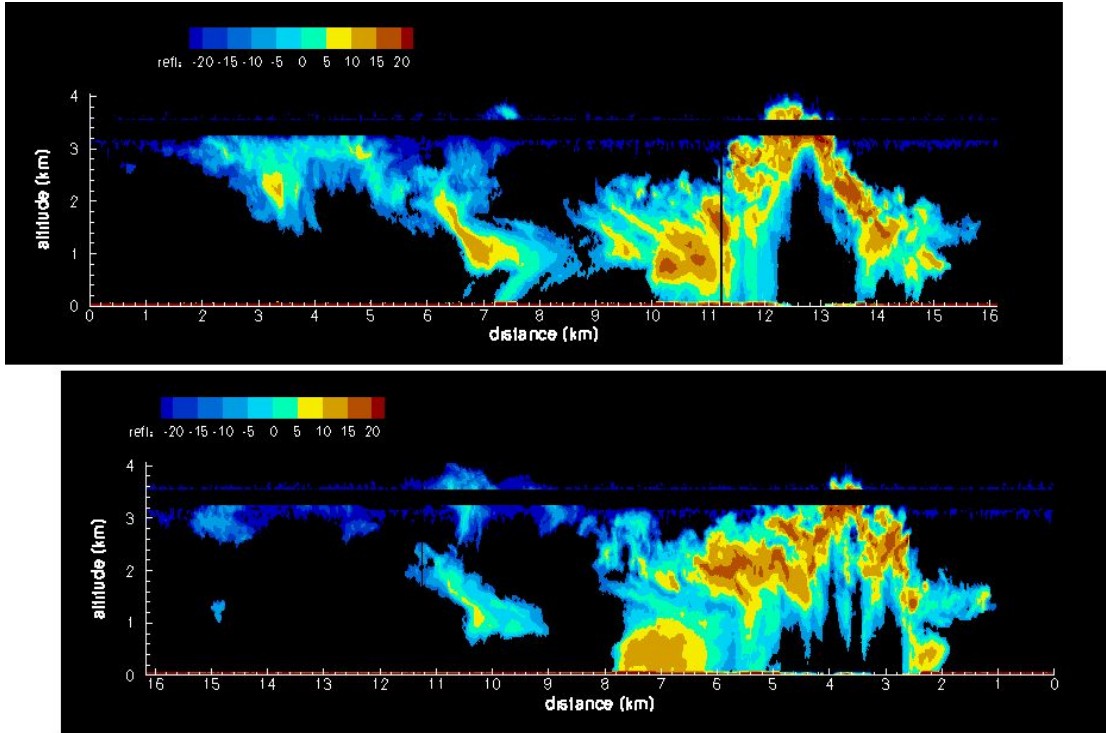
(As it is obvious from the image, there is considerable attenuation and hence a reduction in the signal to below the noise level in much of the lower part of the precipitation region.)

Two more passes were made in this cloud and provide material to be explored later.



C. A nice extension of the situation just described is provided by sampling done about 20 min earlier at a higher altitude. Two passes were made through a newly emerging turret at 3.3 km. Vertical velocities of up to 8 m s^{-1} were encountered, but LWC was only about 1 g m^{-3} , and drizzle/rain concentrations were up to $40 - 80 \text{ L}^{-1}$ in the updraft. Only the WCR images are included here; I have the other supporting material ready to look if anyone wishes.

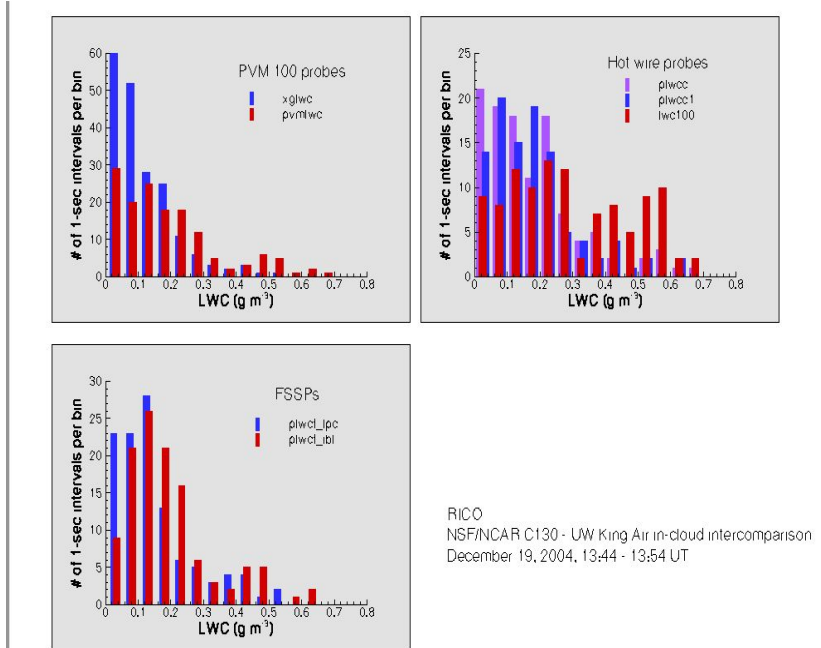
The radar images show, once again, that new growth emerges through older clouds, though to establish the overall structure in three dimensions will need more analysis.



The two images shown here are for passes made 4 minutes apart; the panels are lined up with each other to give a reasonable approximation of stationarity in space. Given that, the highest echo, and the location of the updraft have shifted toward the right (to the NNW).

D. Intercomparison results

Data from the in-cloud intercomparison of measurements from the C130 and the King Air have been distributed separately and will be the subject of other reports. Only one chart is included here, and it is fairly self-explanatory:



Flight notes:

10:40 Strong echo line, tangent to 40-km circle at 045 radial; movement seems along the line. Quick review of the overnight radar data shows fascinating lines (cell boundaries??) forming and passing the region.

1213 engines started; 1222 taxi

1228 T/O

1238 AT 10 kft, heading to 030/80. Will take a brief look at clouds, with an eye to select region suitable for in-cloud intercomparison.

1246 top and later a weaker top; 40 cm-3; 40 L-1

1302 several passes, mostly with rain; one without

1309 bright sun and rain before cloud entry
rainbows everywhere !!!

1310 target 300 heading

1312 pointer set on W side of group and will use it to target a harder turret to the right – guessing 0.5 km.

1316 at pointer – no NRE (nose radar echo)

1317 5 m/s up in strong NRE

1318 using 1-km offset from previous NRE, now SD mode

1322 to left of ptr

1323 heading to 030/80 for intercomparison, down to 5500'

1327 edge of cloud – photo – trail behind evaporating puff

1330 pilots taking over to get lined up for intercomparison; left turn for us, small deviation and climb for C130; going well

1340 C130 is now behind

1344 first cloud pass on 180 heading

1346 passing wisp if dark cloud

1349 heading to smaller cloud with C130 still behind – 3 nm by TCAS

1354 broke off formation – intercomparison done

1357 one more cloud pass at 5000'; climb to 10 kft after

1411 turret on nose at 10 kft; good 5 m/s; pointer set

1416 back at pointer – only trace of cloud left

1423 new plan, down to 7000'

1431 out on W side, 8 nm from pointer that was set in first turret

1433 down to 6000'; toward pointer with 90/270

1436 bit to left (SE) of ptr; down to 5000'
fuzzy cloud; 90/270 to pointer

144122 at ptr, no cld left
1450 aiming for NRE line; turn before reaching the end of it
1455 SD mode for next run
1458 picking up the line on NRE
1503 down to 1500', head back to NRE below cld base
1506 touching cld base; 60 cm-3 at 1500'
1511 crossing NRE line at 800' on N heading
1515 up to 3000' for pass to W
30 cm-3; 0.4 g m-3; rain
1520 SD mode (?); 0.6 gm-3
1523 scan of photos S to E
1528 last cld, SD mode at 4000'
1550 L/D