

King Air N2UW flight report for December 17, 2004

Crew: Fagerstrom, Vali, Oolman, Glover

A 100-km wide, curved band of nearly cloud-free area passed over the area during the day. The clouds we studied were near the eastern boundary of this band (behind it). At the beginning of the flight, not far from the leading edge of the cloudy area (the eastern boundary arc of the clear band) Cu extended to somewhat over 3.5 km altitude. Later on, and as that eastern boundary of the clear band passed over Barbuda, the leading edge had smaller clouds and a considerable clear space developed behind that. As a result, the later part of the flight sampled smaller clouds, some not producing drizzle, and a few doing so.



The photo on the left (PC 170295 taken at 15:04:27 from 10,000' and looking toward the NE from about 40 km NNE off ANU) shows part the “clear” band in the foreground and the cloudy area further to the E.



This photo is of one the larger cloud groups at just behind the clear arc. At 16:55 it was located about 25 km N and 28 km E of SPol.



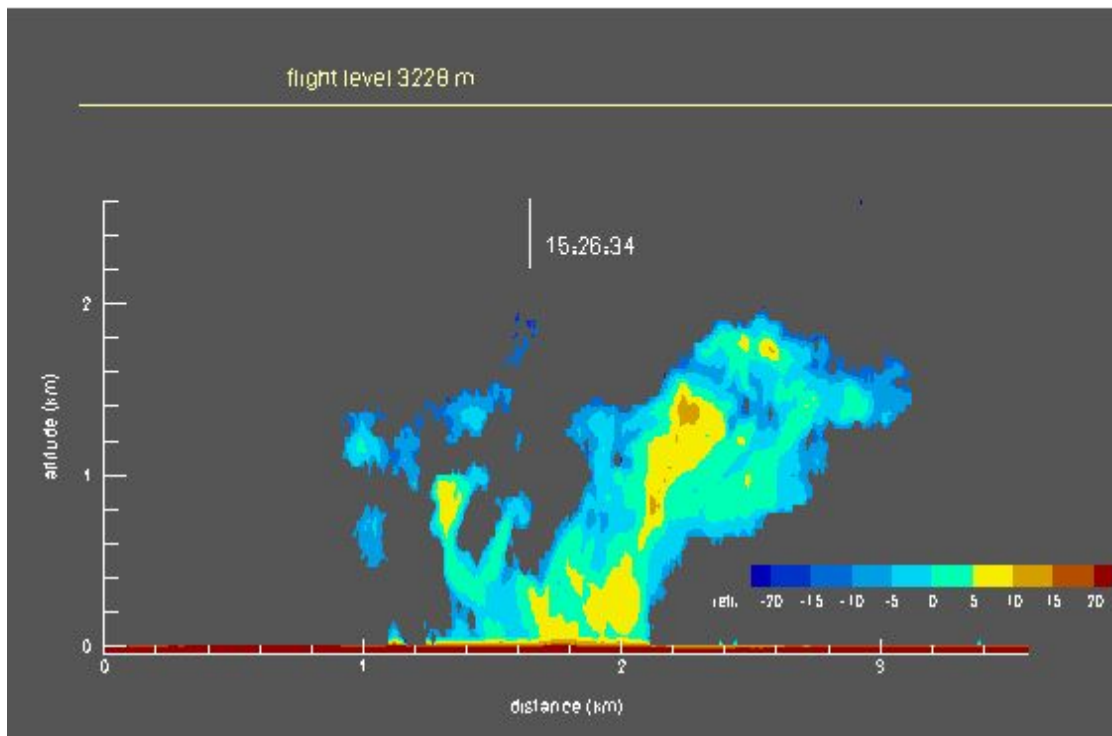
This photo (PC170337 taken at 16:57:44 from position 30 km E and 28 km N of SPol, looking roughly to the N) shows the thin layer of patchy cloud that persisted in the mostly clear area behind the cloud band passing Barbuda at this time.

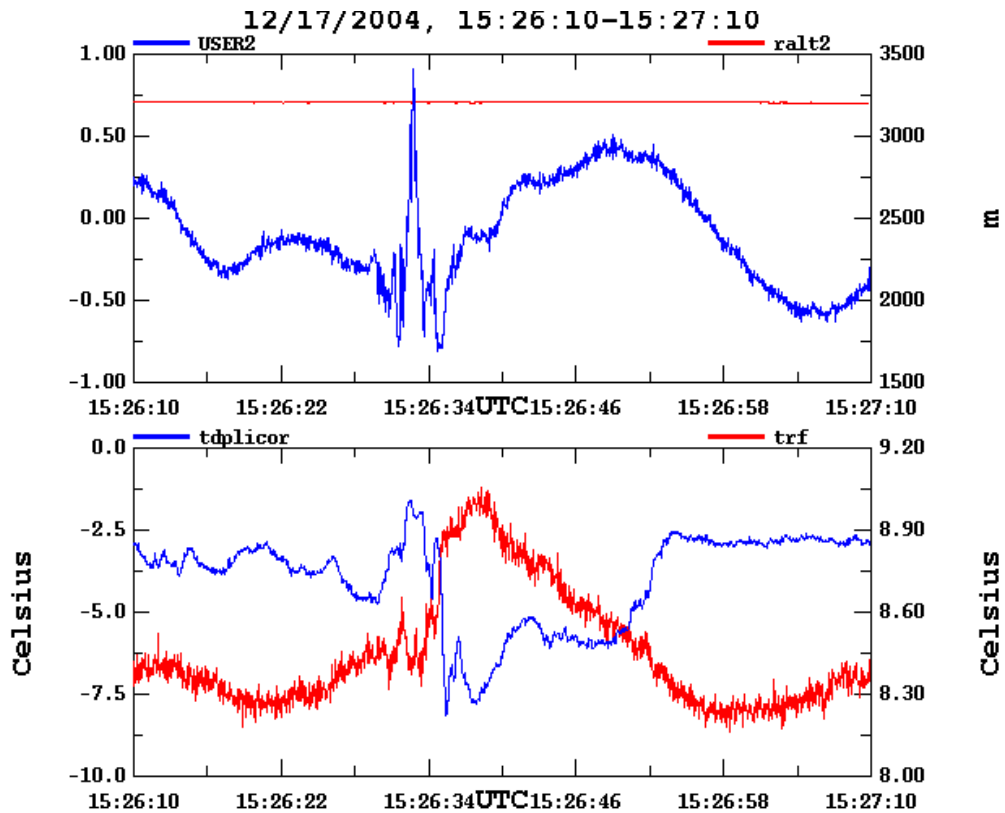
General impression was that clouds were quite ragged, vertical motions weak (mostly 2 m s^{-1} and less, instead of the often seen values of 5 m s^{-1} and more) and rain, while not absent, was also sparse. SPol statistics would be worth looking at to check on this.

Five sets of repeat passes were performed, starting at 1614, 1627, 1643, 1657 and 1757. In the hour between the last two sets, the flight was just above and then below cloud base.

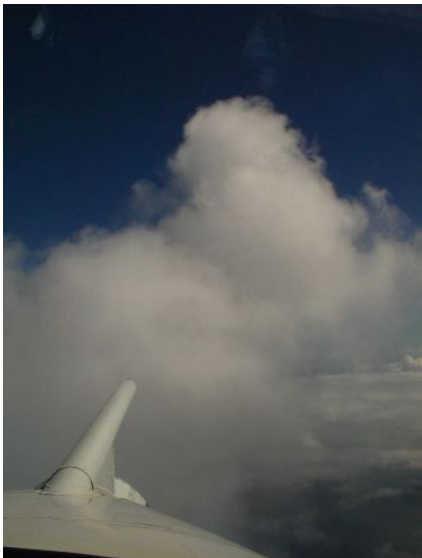
In the following, I describe some highlights of the data to guide further analyses and to help direct data collection in the time remaining of the field project.

A. The first observation of interest was the unexpected encounter with an updraft about 1 km above a Cu detected by the WCR. It was first noticed as a sudden motion of the aircraft, then it was noted that it coincided with the radar echo below. This event is illustrated with the time traces and the radar echo shown below. The vertical velocity trace is the blue one in the top panel.



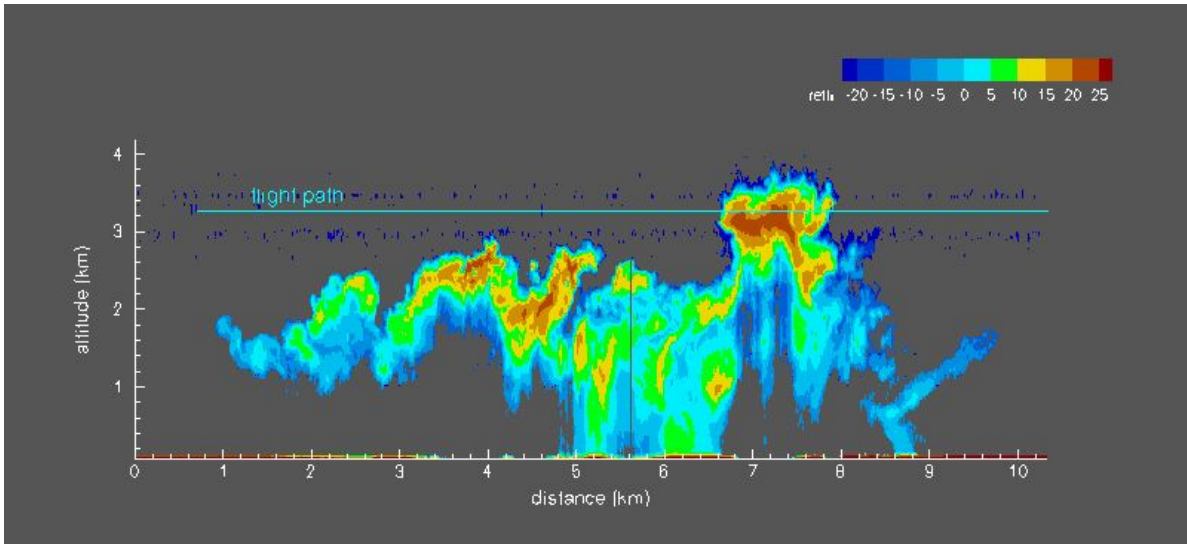


Most surprising in this event is the small horizontal extent of the updraft (about 300 m) and sharp gradients on both sides of it. For all appearance it resembles an updraft within a cumulus, including the downdrafts on either side. However, the absence of detectable cloud droplets (FSSP count of 0), or any visual clue to the presence of this perturbation, plus the clear indication by the cloud radar of a cloud 1 km (!) below the flight level make the phenomenon specially puzzling.



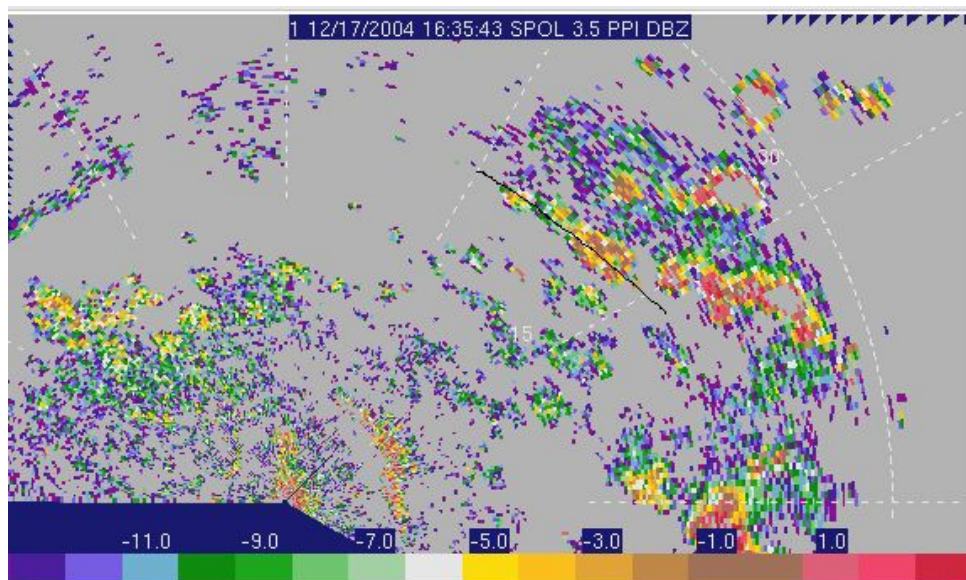
B. A second set of somewhat unusual observations was made while penetrating the top of a cloud early in the flight, in the region of deeper clouds. Aircraft heading was to the East. The penetration was at 10,000'. A photo (PC170309) taken just before cloud entry is shown here. The cloud had very soft appearance, and indeed the maximum LWC encountered was 0.5 g m^{-3} coincident with 2 m s^{-1} updraft, with about 3/4 of the pass having downdrafts and near zero LWC. Yet, both SPol and WCR registered about +15 dBZ reflectivity values. Those measurements are in concert with the detection, at flight level, of drops of up to 1 mm in diameter (2D-C data) and in concentrations to about 80 L^{-1} . The shape of

the WCR echo – see below – as well as the visual appearance are strongly suggestive of an isolated, bubble, with no further supply from below. Although it is possible that the bubble has risen through previous parcels, it may be that it is close to having characteristics that are the result of a simple rise from the condensation level, as altered by entrainment and by evolution of the drop spectra.



C. One of the sequences of penetrations was in a group of small clouds and one of those passes provided a set of data closest to what one expects to find in a freshly formed cloud. This is the only such event noted so far in the project.

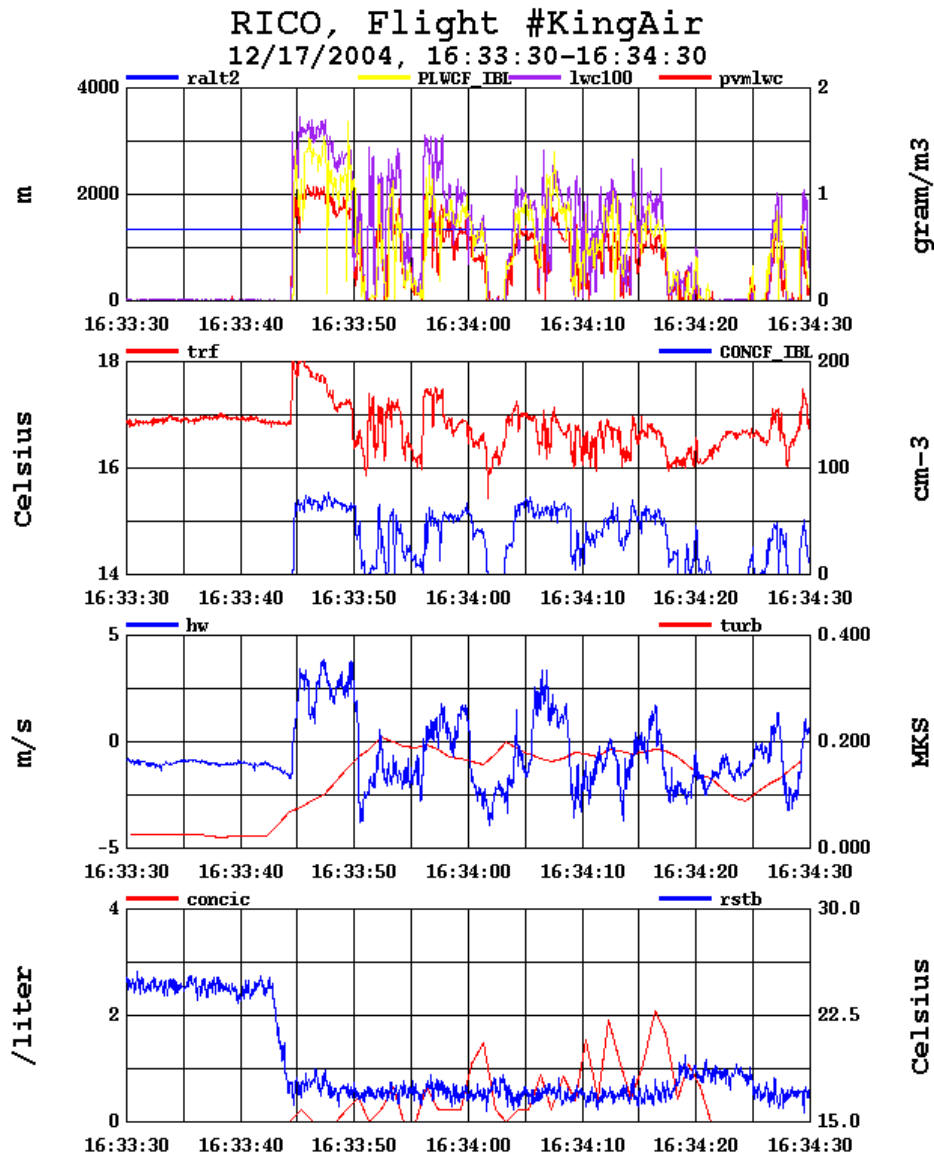
The cloud group shows on SPol as a -5 dBZ patch of 3×5 km oriented SE-NW and centered 16 km E and 12 km N of the radar (at 16:35:43) on the 3.5° elevation scan. No co-located echo is seen on 0.5 and 1.3° scans.



The King Air passes were flown at 1,328 m altitude, approximately 4-500 m above cloud base. A thin line in the image above shows the approximate flight path.

In all passes, the peak LWC observed were near 1.5 g m^{-3} (depending on which probe one believes) and thus quite close to the adiabatic value. Peak droplet concentrations were near 70 cm^{-3} ; peak updrafts in Passes #1, 3 and 4 were 2, 4 and 5 m s^{-1} (Pass #2 was to the side of the cloud to look with a horizontal radar beam).

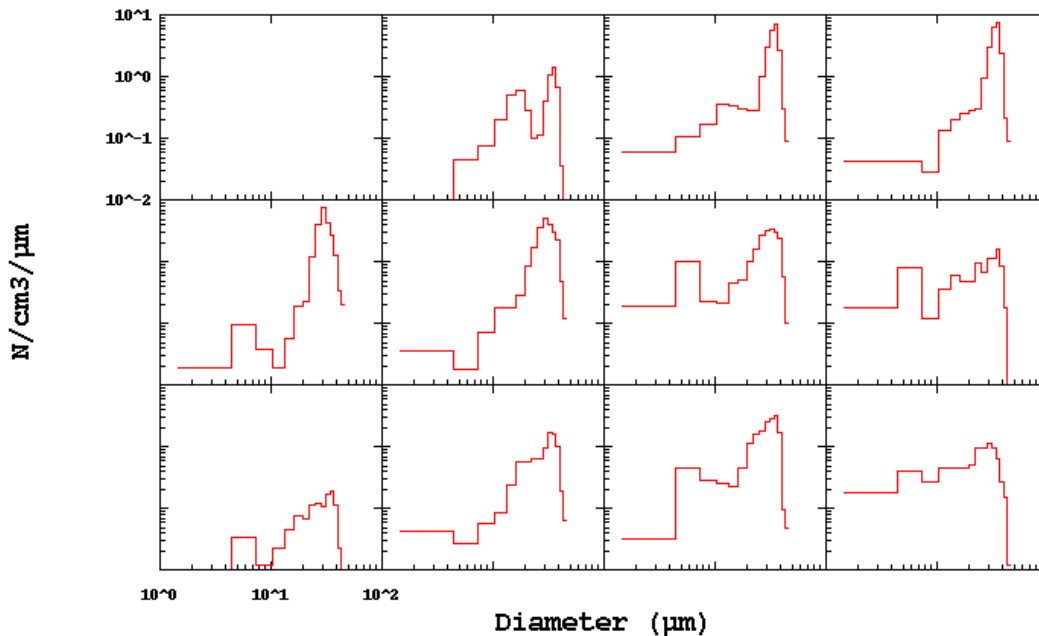
The most interesting turned out to be Pass #3 – these were the data that called attention to this event in the first place. A photo of the cloud taken as the aircraft was turning toward it is shown on page 7. (This is photo PC170322 taken at 16:32:45; the identification of the cloud should be confirmed by viewing the on-board video). Immediately on entry into the cloud, an updraft of 3 m s^{-1} and about 500 m wide was encountered (trace “hw” in the graph). A 1°C positive temperature perturbation at the edge



decreased with time (due to wetting??). Droplet concentration, vertical velocity and LWC had nearly top hat profiles coincident with this updraft.

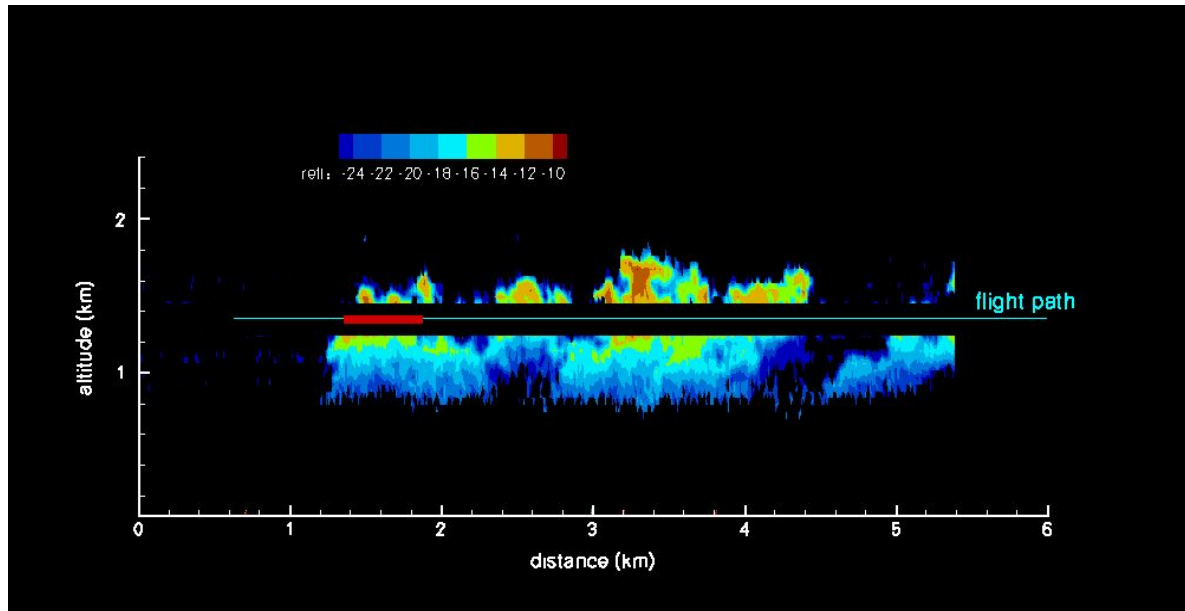
Most striking in these data (in comparison with what has been so far in other clouds) is the narrowness of the droplet spectra in the updraft, as shown below. Nearly monodisperse FSSP spectra, with 30-40 μm diameter are indicated over about a 300-m distance.

RICO, Flight #KingAir
12/17/2004, 16:33:44 – 16:33:56, 1 second average



In the WCR vertical section shown below, the updraft region is highlighted with a thick red line. Almost everywhere, but most distinctly in the updraft area, this echo shows the upward gradient of reflectivity that would be expected for a non-precipitating cloud. The fine detail of three minor peaks in the vertical air velocity trace are marked by three vertical lumps in the echo (slightly tilted toward the right). The echo tops here are about 300 m above flight level; with a 3 m s⁻¹ updraft, this yields a time scale of 100 s growth past the flight level. The total echo depth is about 800 m to 1 km.

There is some indication of slight precipitation near the 3.3 km mark under the highest echo patch. Just past the initial updraft (at 16:33:50 and 16:33:53) the 2D-C probe registered two drops of about 120 μm diameter; the maximum size through the pass was 300 μm (the cockpit video can provide additional info about drops on the window).



D. Much more to look at later on.

Flight notes:

- 1443 engines started; 1455 T/O
- 1500 C130 is doing random sampling at CB+
- 1503 10,000' dvel. Ragged, small clouds, some clusters – one close to 030/80 target point.
- 1514 45 bank circles for resolving range vs. power dependence of WCR velocity
- 1525 fuzzy-looking target reaching to 10k, will pass, then down to 6k
- 1526 bump from echo below; WCR echo top is ~ 1 km below !!!
- 1530 down to 6kft, the thin wispy layer is just below this
- 1539 pass at 6kft near cloud top

only Cu- - on W side.

1543 Ops report of good target a 040/40
1545 to 4kft - 60 cm-3; heading to 040/40
1614 pointer set in moderate cld – idea is to follow its evolution
90/270 turns several times
1623 negotiating with ANU control & C130
1627 pointer set .../38 ANU; 1 km offset
163048 at offset ptr; then reset to 0 km
163350(?) at pointer, UD mode; followed by 90/270
163732 at pointer; will move NE from here
1641 target on our left; C130 seen there
1643 pointer set, echo to surface
164509 at pointer; 90/270 after; add 1 km offset
164855 at offset pointer; resetting to 0 km
165248 at pointer; seems to be between clouds
1653 new target
1657 ptr set in new target
1658 photo to NE
1700 90/270
170040 at pointer; change to 1 km offset
1704 at offset pointer; doesn' seem right – else cloud changes way too fast
1705 VFR; to 2000'.
At 2300' 30 cm-3, no vertical vel., no drizzle
1720 cloud over Barbuda
1729 360 heading; C130 out of there
1734 sort of a line
1738 50 cm-3, narrow spectra
1742 to 1500' , low CB
1750 report of 1050/60 echo
1757 in precip; pointer set
1800 back @ 800'; visually not the heaviest of precip
180307 visual to core of precip, not using pointer
180509 again, on NW side
will do 270 turn and climb; cell on W end; weak by now
180807 at pointer set earlier; climbing; 40 nm to Barbuda
1810 climb to 9000' and head home
1840 L/D

