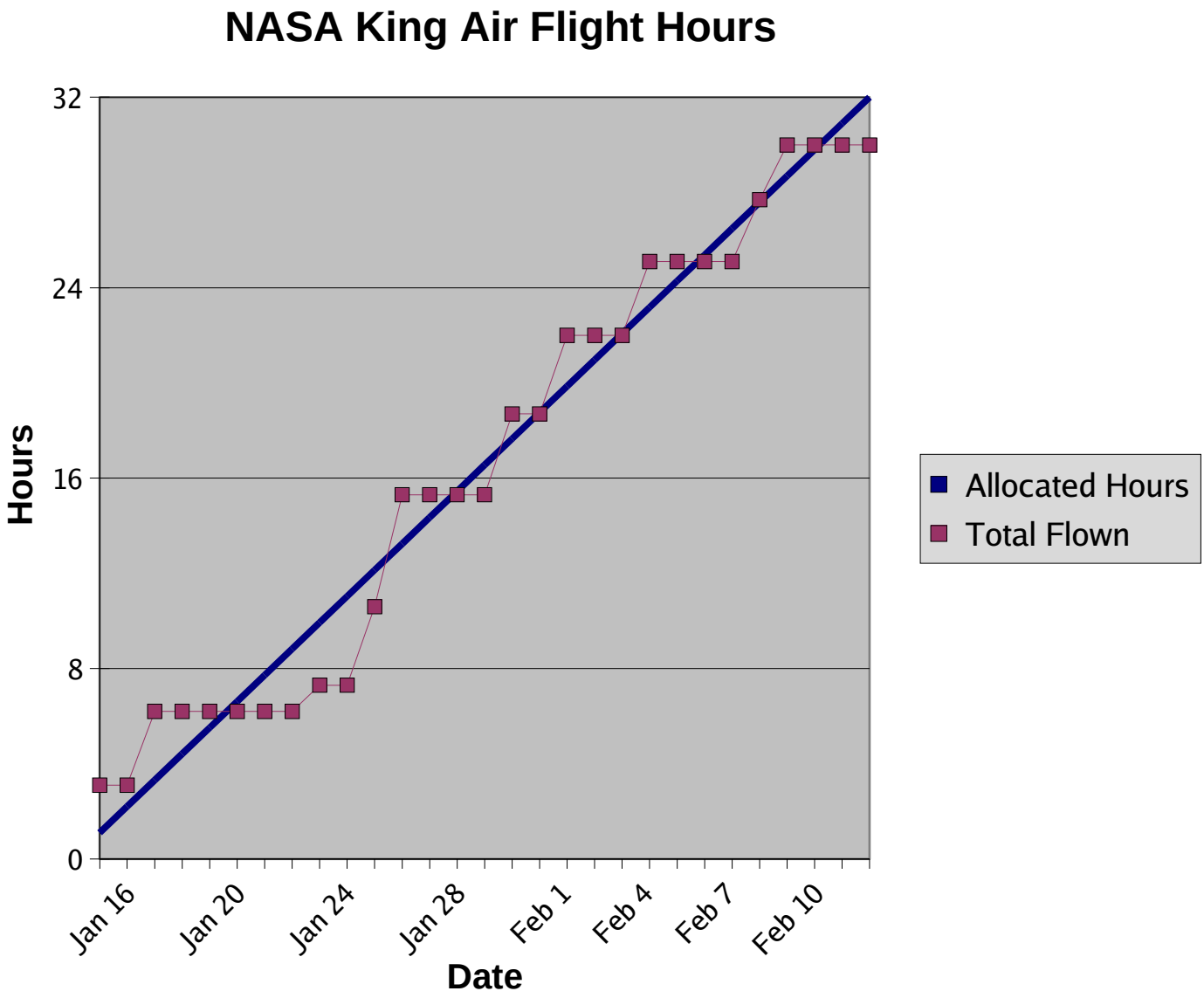
University of Wyoming
NASA 2006

January - February 2006

- Contacts
- Flight Data
- WCR Data
- NCAR RAL MM5 model for Wyoming
- Plot of Flight Hours
- FSSP notes (Jeff French)
- Project reports (Jeff Snider)

Date	Flight # (*.kml)	Status	Times (UTC)	Hours	Reports
07-Sep-2006		Data reprocessed (nasa06_qc2) • Radiometer calibration coefficients. • PCASP flow calibration. • Used the T-REX wind maneuver from Mar 19, 2006. • Fixed a small wind calculation error that is only noticeable in turns. • Moved center point to GLEES. • Added :landmarks attribute that can be used in ncplot.			
10-Feb-2006 (Fri)	9	PCASP and CCN removed. Second (new) FSSP added.	1919-2131	2.3	Bart Geerts (Scientist) Jeff French (4th seat)
9-Feb-2006 (Thu)	8	FSSP data appears good.	2152-0019	2.6	Jeff Snider (Scientist) Binod Pokharel (4th seat)
5-Feb-2006 (Sun)	7a 7b	System crash shortly after take off, two data files. FSSP data suspect.	1321-1600	3.1	Dave Leon (Scientist)
2-Feb-2006 (Thu)	6	CCN 108 replaces CCN 104. Diffusion screens removed from the CPC. FSSP has intermittant high resets.	1854-2207	3.3	Bart Geerts (Scientist) Larry Oolman (3rd seat)
31-Jan-2006 (Tue)	5	FSSP data bad. Diffusion screens added to CPC.	1310-1630	3.4	Dave Leon (Scientist) Jeff French (3rd seat)
					Bart Geerts (Scientist)

27-Jan-2006 (Fri)	4	No upper short wave radiometer data.	2358-0302	3.2	Larry Oolman (3rd seat)
27-Jan-2006 (Fri)	3	CCN tubing kinked. UF near zero for about 1 minute around 2237. Upper short wave radiometer quit at 2149.	2133-2300	1.5	Bart Geerts (Scientist) Larry Oolman (3rd seat)
26-Jan-2006 (Thu)	2	FSSP data bad. Spikes in CCN VDET when valve closes, especially at higher altitudes.	1902-2215	3.4	Dave Leon (Scientist)
24-Jan-2006 (Tue)	TF04	Test flight. Maneuvers were done.	2025-2123	1.1	Jeff Snider (4th seat)
18-Jan-2006 (Wed)	1	No HADS A or B pressure, using PMB. No PCASP data. No SV6 GPS data, Ashtech ok. CCN experienced leaks, especially at higher altitudes.	1957-2258	3.1	Dave Leon (Scientist) Jeff French (3rd seat) Jeff Snider (4th seat)
13-Jan-2006 (Fri)	TF03	Test Flight. Maneuvers were done.	2109-2214	1.2	
10-Jan-2006 (Tue)	TF02	Test Flight.	2224-2328	1.1	
10-Jan-2006 (Tue)	TF01	Test Flight.	2108-2144	0.7	
Total Research Hours (Including Test)				30.0 of 32.0	


NASA King Air Flight Hours
32
24
16
8
0
Hours
Jan 16
Jan 20
Jan 24
Jan 28
Feb 1
Feb 4
Feb 7
Feb 10
Date
Allocated Hours
Total Flown

NASA06
FSSP notes
J French (compiled 2/17/06)

The ‘old’ FSSP (ser# 413-0577-12) was used for the entire NASA06 project (3 test flights, 9 research flights). It was noted early in the experiment that the instrument was exhibiting ‘strange’ behavior during flights. However, attempts to reproduce this behavior on the ground were, generally, unsuccessful.

Problems with the instrument were sporadic and did not affect every flight. Only on a few occasions are data corrupted for an entire flight. In some instances the instrument appeared to work early in a flight but did not work later in the same flight.

Although the exact nature of the problem varied somewhat, in general, when the probe was not working, it reported a high number of total resets while at the same time reporting no strobes. It is believed this behavior resulted from fogging on one of the optic mirrors due to a heater problem. Between the flight on Feb05 and Feb09 corrosion was noted on a connector for the heater in one of the probe arms. The connector was cleaned and the instrument worked well for both remaining flights (Feb09 and Feb10).

Below is a brief synopsis of FSSP status for each flight:

Test flights:
0110b - FSSP working
0110c - FSSP working
0113b - all clear air
0124a - all clear air

Research flights:

0118a:

FSSP worked entire flight, favorable comparisons between LWC devices

0126a:

FSSP not working most (all?) of flight, early in flight (19:31-19:35) penetrated liquid water ~0.2 g m-3 based on PVM and DMT, FSSP showed droplets, but very 'spiky', shortly after this time, rest of flight indicated lots of resets but no strobes, no particles in other regions where PVM & DMT indicated LW ~ 2 g m-3; after flight Don checked with nebulizer, appeared to be working on ground

0127a:

FSSP works well entire flight, DMT turned on ~third way through flight (?...~21:55), maximum LWCs between 0.5 & 1.0 g m-3

0127b:

more difficult to determine, LWCs less than earlier flight on this day, max around 0.2 in PVM, 0.15 in DMT...FSSP picks up most of this, particularly early on, later in flight looks questionable, but LWCs are even less, stobes/resets ~ 0.1, typical for ice??

0131a:

FSSP not working this flight, no strobes, lot of resets, after flight Glenn checked with nebulizer and beads, was not working, cleaned and re-aligned mirror, noted broken heater wire but not sure if breakage occurred during disassembly & cleaning.

0202a:

FSSP is working for the first half to ¾ of the flight. After 2130 it appears that the instrument begins exhibiting problems consistent with the probe not working properly (high # resets, few strobes). However, even after 2130, LWCs computed from the probe show reasonable agreement with the PVM and DMT. I would still judge data taken after this period as 'suspect'. Before 2130 the FSSP appears to be behaving quite well. LWCs computed from FSSP, PVM, and DMT compare favorably.

0205b:

FSSP does not work correctly virtually the entire flight. Within 30 minutes after takeoff, the probe begins reporting high # resets with essentially no strobes. Only in the first ½ of flight do comparisons of LWC between FSSP, DMT, and PVM look reasonable. After this time, FSSP does not even appear to respond to regions of liquid water (as identified using data from the PVM & DMT).

0209a:

FSSP works entire flight

0210a:

During this flight, the 'new' FSSP was also flown (new probe in OBL, while 'old' probe remained in IBL). The old probe appeared to work well entire flight. Comparisons between the new and old probe reveal the new probe reports roughly 2X the number of resets, strobes and gated strobes as does the old probe. Particle size spectra agree quite well, except for number concentration. Consequently, the LWC for the new probe is roughly 2X that reported from the old probe.

Flight Scientist Notes – NASA-06: 10 February, 2006

19:18 – 21:31 UTC

Crew: Kevin Fagerstrom, Bart Geerts, Jon Wolfe, Jeff French.

Ground instruments:

Glees: hotplate and WV-1500 (5-channel) (1 time under our track incl. one circle)

N. Platte Ranch south of Saratoga: WV-1100 (2-channel) and possibly a radiosonde

Wolfe den: hotplate (one overflight at 21:09 UTC, no precip within at least 10 km)

UWKA flight pattern:

We flew one N-S leg at 14 kft over GLEES down to near the CO border, then 4.5 legs at 11 kft across the Laramie Range along the mean wind direction, then a cross leg (normal to the mean wind). The waypoints were LAR-14GLEN14-14GLES14-11PLTNW-11PLTSE-11PLTNW-11PLTSE-11PLTNW-11PLT-11WolfeDen11-11PLTNE11-PLTSW-LAR.

definitions:

- GLEN and GLES are aligned along 347º-167º true over GLEES. The GLEN-GLES leg is ~60 km long. The wind was some 15º more westerly than this track.
- The legs PLTNW-PLTSE and PLTNE-PLTSW are centered over Pilot Hill (N41º16.32', W105º26.38'). The leg PLTNW-PLTSE (320º-140º true) is oriented almost precisely along the flight-level wind (about 15 kts) and ~65 km long, while PLTNE-PLTSW (230º-50º true) is normal to it and ~57 km long.
- The flight levels are shown in kft (14 kft = 4276 m MSL, 11 kft = 3359 m)

The only mini-sounding, collected during take-off heading N (7-14 kft), shows a well-mixed layer in the lowest ~800 m, a stable layer near 10 kft and a 2nd one near 13 kft. The air is most humid between 11-13 kft, and it is very dry above 13 kft. Very little wind shear is present between 7-13 kft.

Weather: we sample the most benign of all snow events in this project. It is a cold day; temperature is ~ -10ºC at the surface, -22ºC at 11 kft, and -27ºC at 14 kft. At 14 kft, all clouds are below flt level in the valley, but over the Snowy Range we clip the highest cloud tops. At 11 kft we seem to

be centered between cloud base and top. The clouds are well-defined and cumuliform, although the edges are fuzzy compared to the 2 Feb case. The lower parts of clouds are very ill-defined as the boundary between light snowfall and cloud is unclear. In cloud, at 11 kft, we can almost always detect the ground below. Surprisingly, some liquid water (up to ~0.2 g/kg) is encountered mainly in clouds upwind of the Laramie Range, and ice up to 0.5 cm thick accumulates on leading edges during this flight. The 2D-P probe picks up some particles, no clear shape stands out.

Weak echoes are present mainly in the eastern part of the Laramie valley throughout the flight, deep enough to be detected from CYS. The echoes are aligned with the wind (320º-140º true). This aligned becomes a bit less evident as echoes break up in cells. The spacing between the main echo bands (some 30-50 km or 20-37 times the HCR depth) is far greater than expected from HCR theory, although some shorter-wavelength bands are poorly detectable in between. The CYS radar indicates that echoes are most prominent during the flight. They first develop some 2 hrs before the flight (10 am MDT) and dissipate some 2 hrs after landing (except east of CYS).

Instruments: No P-CASP, CCN or CN. Instead, two FSSP probes were used. It appears that all systems worked well.

Coordination with WMI Cheyenne aircraft (N234K): none.

WCR data: the only mode used is up-dual-down (ppmag6, 150 range gates). The most interesting WCR data come from the 4.5 along-wind legs across the Laramie Range. They appear to show that snowfall is enhanced orographically. CYS reflectivity animations indicate that echoes are long-lived. Because the flight legs are very-well aligned with the wind, WCR transects may confirm cell longevity and, combined WCR/WKA data may yield insights into kinematic/microphysical processes leading to orographic precip, under very cold conditions over a shallow elongated ridge.

Approximate leg times:

LAR[19:18] – [19:33]14GLEN14[19:34:30] – [19:44:30]14GLES14[19:46] – [19:55]11PLTNW11[19:56] – [20:07]11PLTSE11[20:11] – [20:27]11PLTNW11[20:30] – [20:41]11PLTSE11[20:43] – [20:57:40]11PLTNW[21:00] – [21:04:45]11PLT-11WolfeDen11-11PLTNE11[21:15] – [21:24]PLTSW-LAR

NASA06: 20060210a

Flight notes-Jeff French, 4rd seat

Pilot: Kevin Fagerstrom

Right Seat: Bart Geerts

Third Seat: Jonathon Wolfe

Fourth Seat: Jeff French

Pre-flight:

Instruments:

- This is the last flight of NASA06, before flight all aerosol gear was removed, the second (new) FSSP was mounted

Weather conditions:

- Winds out of the Northwest, shallow clouds over the Snowy Range and Laramie Range, extend up to ~13 kft, clouds look somewhat convective in nature, but capped by strong inversion??

Flight:

- ~1915 wheels up
- 1921 open Nadir port
- 1932 @ 13 kft towards west end of valley to do NW-SE pass over Glees at 14 kft…we appear to be ~1500 to 2000 ft above cloud top with only a few 'turrets' (I use this term loosely) extending to our altitude
- 1937 wind: 331 deg @ 27-30 kts
- 1938 clip cloud top
- 194330 on south end of Snowy Range clipping tops, all probes show some liquid water, lwcs up to ~0.2 g/m3, also shows up in both FSSPs
- 1947 turn east, proceed to Laramie Range, descend to 11 kft
- 1956 checked Cheyenne radar, strongest echoes extend to north and east of Cheyenne, some also along the Laramie range, north and west of

Cheyenne, no apparent banded structure as was seen on NWS radar pre-flight

- 1958-2007 NW to SE track along Laramie Range, ‘spotty clouds’ with liquid water up to 0.2 g m3, FSSP spectra in good agreement re: size, all d’s < 20 um, new FSSP has 2x concentration of old FSSP
- 200930 complete turn at SE end of leg, set up for SE-NW leg
- 2030 end of 2nd leg, begin 3rd NW to SE
- 2033 over ridge on NW end, liquid water up to 0.35 g/m3, all small drops
- 2042 south end of leg turn for next leg
- 2057 end of leg, set up to go south, will proceed ~1/2 of leg then turn to Wolfe’s hotplate site
- 210930 over Wolfe’s site, severe clear, east of precip/clouds over Laramie Range, west of precip lying north and east of Cheyenne
- 2115 set up for cross wind leg over Laramie Range
- 2127 preparation for landing, we shutdown WASP, closed Nadir port, pull DMT breakers just before landing

Post flight:

- All instruments looked good in flight. New FSSP concs 2X concs from old FSSP, PVM LWCs twice as large as DMT

2nd Seat February 9, 2006 Jeff Snider

Four objectives: 1) Aerosol ahead of a N-to-S moving bdry, 2) N-to-S and S-to-N crossings of bdry with WCR in U-DD mode, 3) VAD circles with WCR in DDDS-mirror up mode (30 degree left turning circles with ppt above), 4) CHY missed approach over Wolfe Den.

Navagation points for objective #2 – "A" is Wheatland Reservoir and "B" is about 10 mile south of Douglas WY, about 25 min flight time between

Comment – Using CCN108

2143 – Engine run up

2151 – Take off

2157 – Start aerosol run, technically this is the downwind/crosswind portion of the H-pattern. Flying is crosswind, ~20 mile north of LAR. WCR is UDD mode, recording

2206 – reversing course

2214 – assent to 17 kft, cloud tops at ~15 kft. This sounding in ice but no LWC

2230 – level at 12.3 kft, trf = -15, in-cloud, start S-to-N WCR leg, heading 5 degree magnetic, winds are 300 degree (true), there is a ~60 degree crosswind component

2244 – end of WCR leg, returning to S

2246 – start N-to-S WCR leg, new WCR file started, higher altitude by ~1 kft, now at (~13 kft)

2249 – evidence for plates in 2DC (some holes in images), or are these large water droplets (??), think the former due to irregular shape

2253 – evidence (in hw) for waves, peak vertical speeds 5 m/s

2256 – return to altitude of first S-to-N WCR leg (~12 kft)

2258 – start of S-to-N WCR leg

2305 – start of VAD turns, left-hand, 30 degree bank, WCR configured U-DD mode with mirror in up position

2309 – done with VAD

2314 - start repeat of N-to-S WCR leg at ~13 kft, new WCR file

2324 – new WCR file, heading to CHY, ascent to 15 kft, then missed approach

2330 – new WCR file, DDDS200, mirror in side position

2340 – missed approach at CHY, PVMLWC indicating up to 0.3 g/m^3 during descent

2345 – level now at 640 mb, highest PVM lwc of flight. For got the switch mirror back to vertical position, picking up ice on probes on right-wing hard points, some large stellars ~ 2mm in 2DC and 2DP

2357 – start CCN run, SW of LAR in Laramie valley, could there be contamination from LAR here?

0015 – end CCN run, why would AERI_MF_RAW and AERISPR_RAW increase significantly with shut off of UFN pump??

0020 - Landing

Binod Pokharel

My work in the flight

Date: 02/09/2006

- Changed the pad in CCN at 2:30 pm
- Before starting the flight, the CCN ‘S’ sequence was at 1%
- Flight was started at 2:48 pm
- At 2:55 pm CCN sequence number was set for CCN levels 5

  S = 0.4, 0.8, 1.6, 0.8, 0.4; and CCN was run
- Before running the CCN, I opened the NADIR door and UFN pumped on at 2:54 pm
- Put the water in the pad of CCN at 3:15 pm
- After that the sequence of CCN was set at 1%
- At 3:40 pm the pad was looking dry because VDET value was higher. So I again put water and restart the CCN at 3:45 pm.
- After 4:38 CCN did not work so Perry put water in the pad and CCN started to work at 4:57
- But the CCN sequence was set at 5 levels, i.e., S = 0.4, 0.8, 1.6, 0.8, 0.4
- CCN was turned off at 5:15 pm
- UFN and NADIR door was closed at 5:10 pm.
- The plane was landed at 5:20 pm.

This is the short briefing about my work during the flight. The main thing I worked on CCN only. So it is not the detail about all.

NASA06 – February 5th, 2006. Flight Scientist's notes

Crew: Kevin Fagerstrom (pilot), Heather McIntyre (Tech seat), Perry Wechsler (Aerosol), David Leon (Flight Scientist).

Based on MM5 and other forecasts a 6am takeoff was called for February 5th in order to catch a quickly moving, but poorly times snowstorm that was moving across the state. At 11:30 UTC prior to the flight stars were visible most directions from the Laramie valley and little reflectivity was evident on the Cheyenne WSR in the Snowy Range region. However, there was an impressive line of echoes to the east of Cheyenne near the Nebraska/Wyoming border. The Riverton, WY and Grand Junction, CO WSRs showed high reflectivity bands streaming towards the Southeast and East respectively, however coverage for both of those radars cut out a long way from the Snowy Range. By the time that the aircraft was pulled out of the hangar at about 12 UTC far fewer stars were visible, particularly to the north and west.

Following takeoff the aircraft headed towards the north while climbing to 20kft for a sounding. During the climbout to the north echoes near the surface were apparent almost immediately in the WCR data with solid cloud below being encountered at about 13:05 UTC. Essentially the aircraft (largely inadvertently) passed over the leading edge of the precipitation band that was approaching Laramie from the North-West. The aircraft continued to climb to almost 20kft (extended from the initial climb to 18kft). Data from some of the sounding and the 90-270 at the North end of the leg was lost due to an aircraft data system crash (the gap in the UWKA dat runs from 131116—132104). However, the WCR data from the southbound leg over the leading edge of the precipitation band should be useable.

Following the sounding to 20kft, the UWKA continued southward down the Laramie valley to set up for a 300º leg over GLEES. Due to an error in setting (or selecting) the westernmost end point of the leg (GLEW) this leg was flown far to the south of GLEES. Surprisingly high turbulence levels were encountered on this leg, and the aircraft altitude was changed from 18 kft to 17 kft in an attempt to find a lower turbulence region. Higher cloud tops were visible to the South. Cloud tops had a ragged appearance consistent with the relatively high turbulence levels encountered during this leg. Because of the error in setting up the first leg it was necessary to head North over the Saratoga valley to intercept the correct starting point for the along-wind leg. Echoes encountered on this leg were strong and extended to the surface for most of the leg. This leg was paired with another along-wind leg, this time at 14 kft.

Following these legs, we made a descent into Saratoga for a sounding, and to assess whether we would be able to fly the H-pattern. The aircraft broke out of the cloud layer at about 9kft. However, visibility at that level was far too low to fly the H-pattern. We then climbed to 14 kft for a downwind leg over GLEES. On this leg the clouds appeared to have weakened and thinned considerably. This leg was followed by a longer E-W flight leg from the Laramie valley, over GLEES, and on towards Baggs with a significant kink in the flight track over the Saratoga valley in order to pass over the highest terrain in the Sierra Madre. Both the outbound and return legs were flown @ approximately 14kft. On the return leg, over the Saratoga Valley the King Air accumulated a significant amount of ice on the windshield which was not cleared by the windshield heaters prompting the pilot to climb above cloud-top and to cut short additional legs. A final leg over GLEES was included on the return to Laramie and included a 360 degree turn so that a VAD-based wind profile could be computed over the site. At this time the echoes over GLEES extended only a few hundred

meters above the surface. Despite the relatively fair conditions encountered over the Snowy Range, a considerable amount of low cloud lingered in the Laramie Valley which did not dissipate for a few hours after the end of the flight.

Literal flight notes:

125430 – Taxiing. ASOS reports winds at 260

125720 – Takeoff

125807 – Perry to the back. Wind direction (mag) @ 280

125448 -- Can see cloud base over Laramie.

130108 – Radar on. Recording data. 2 cloud layers above. 1 below to near sfc. Winds 290 mag @ 15.5 kft. Dewpoint depression drops dramatically above ~14 kft.

130558 – Liquid layer @ ~16 kft (?)

130651 – Can see sky to E. Generating heads @ our level. Stars above. Echio very solid below.

130822 – top of sounding. Asking for a few hundred meters more.

131040 – Top of sounding (new). Descending to 18kft

131104 – Winds 310 @ 18 kft.

131117 – 2nd water layer close to 18 kft.

131407 – Data system hang. Re-entering cloud @ 19 kft.

131508 – 90-270 N. of Laramie

131605 – Wisps of cloud @ 18.5 kft. Liquid ?

131715 – Cloud-tops now @ 23kft. Solid echo below.

132204 – Data system back. Don’t know how much data was lost 30s or 10 min.

132331 – Now above cloud top. Cloud tops drop dramatically below.

132449 – Turbulence @ 18 kft.

132715 – Turbulence (stronger) going down to 17 kft.

132826 – Can see to sfc. Cloud tops ragged, some turbulence.

133300 -- Clouds (echoes) stronger below. 1st leg was @ 300 through GLEW not GLEZ.

133500 – Track bringing us into cloud top.

133724 – Cloud top @ our altitude.

133833 – Into cloud. 17 nmi to GLEW. 2D-C and some 2D-P records

134000 – Echoes very solid to surface.

134500 – Near or @ cloud top here. New radar file started.

134900 – Heading N. to correct GLEW for new leg.

135154 – Turn to get onto correct leg.

135417 – Start of new leg. Orientation ~120.

135619 – Some turbulence.

135721 – Out of cloud. Stack of clouds over highest terrain.

135908 – Over GLEZ. Some turbulence . Entering upper (convective ?) cloud layer.

140035 – Clearing. Can see below to Sheep Mtn.

140145 – Can see cloud structure over Sheep Mtn. on radar.

140320 – Up looking WCR image looks like mirror of down.

140435 – Echo does not reach to sfc. Turn @ end of leg.

140655 – Will do next leg @ 14kft.

140837 – (Perry) Up looking PSP hosed.

141124 – Broken liquid clouds over Sheep Mtn.

141200 – Some echoes, barely visible above. Cloud tops lower on this leg ?

141456 – Over GLEES. Re-entering cloud.

142135 – End of leg. New radar file/approach to Saratoga.

142925 – Clouds thicker above now.

143057 – Out of cloud @ 9kft.

143219 – Not enough visibility for H-pattern.

143500 – End of approach. Climbing out.

143803. Funky echo (below ground) on radar. (Reflection off river ?).

143931 – 2D-P problems.

144057 – 2D-P still having problems.

144213 – Start of leg to GLEES.

144623 – Out of cloud ?

144749 – Over GLEEZ. Clouds shallower now. Very little echo above.

144905 – Can see to Sheep Mtn. Some liquid cloud upwind of Sheep Mtn. + upper level stuff.

145328 – Echoes all abvoe us now (over Laramie Valley).

145333 – Echo near sfc (lowest 300-500m)

150158 – In cloud. Past GLEES.

150546 – Over GLEW. Extending leg to W. Change in heading.

151115 – Keeping going over Sierra Madre.

151257 – Cloud layers separate. Just above liquid cloud layer.

151550 – Can see to sfc. Echoes do not reach sfc.

151647 – Passing through convective-like cloud.

151758 – Over highest terrain. Some turbulence.

152020 – End of leg. 90-270.

152349 – New radar file.

153004 – FSSP not working. Power cycled. Some liquid water over Saratoga valley.

153417 – Pilots windshield heater not working. Climbing to 17 kft. Out of cloud.

153916 – Final leg over GLEES. Cloud has distinct, 2-layer structure.

154140 – Bright sunshine in cockpit. Upper level cloud.

154416 – 360 over GLEES.

155152 – Low liquid cloud over Laramie Valley.

Flight Scientist Notes – NASA-06: 2 February, 2006

18:53-22:06 UTC (~noon-3 pm)

Crew: Thomas Drew, Bart Geerts, Larry Oolman, Perry Wechsler.

Ground instruments:

Glees: hotplate and WV-1500 (5-channel) (10 times under our track incl. one circle)

N. Platte Ranch: WV-1100 (2-channel) N41º15'36'', W106º46'42'' (well south of our track)

UWKA flight pattern:

We flew 3 cross legs at 14 kft, then the W part of an H ("WH"), then a sounding over SRT to 17 kft, then across at 17 kft, then the E part of the H ("EH"), then 6 cross-legs at 14 kft. Specifically, the waypoints were: LAR-14GLEE14-14GLEW14-14GLEE14-14GLEW14-9.6WHN8-8WHS8-8GLEW17-17GLEE14-10EHN9-9EHS9-9EHN9-14GLEE14-14GLEW14-14GLEE14-14GLEW14-14GLEE14-14GLEW14-circle over GLEES-14GLEE14-LAR.

definitions:

- GLEE, GLEES, and GLEW are aligned along 111.5º-281.5º true
- GLEE is the eastern end just east of the tree-less ridge north of Centennial (the turn took us across the little Laramie River), 16 km east of GLEES.
- GLEW is 40 km W of GLEES, about 5 km east of Saratoga. We sometimes turned around before reaching GLEW, because of lack of echoes.
- the flight levels are shown in kft (14 kft=4276 m MSL)

Sounding above Saratoga: 19:57-20:06 UTC (8-17 kft)

The wind direction at 14 kft generally was from a slightly northerly direction relative to the flight track: the track was 5-20º counterclockwise relative to the wind. The wind backed about 10º during the 3 hrs of flight. Winds veered with height a bit, from ~270º at 8 kft to ~300º at 17 kft. Wind speed was about 15 kts at 14 kft. Temperature was about -20ºC at 14 kft.

Weather: This is a great case for the study of isolated orographic precip development, and of aerosol modification due to this precip. Clouds formed

on the upwind side as streamers over the hills, and they rapidly grew into cumuli congesti (tops 15-16 kft) with significant liquid water at flight level, possibly in drizzle-size droplets (suggested by FFSP). The development of snow clearly took some time, as cumuli on the upwind side were mostly echo-free and equally vigorous cumuli closer to the crest produced WCR echoes up to 20 dBZ. On the lee side the clouds lost their definition and collapsed, but WCR echoes continued well after the clouds had dissipated, mostly in a shallow layer 1000-500 m above the terrain, thinning towards the east. Cloud tops were deepest above the crest or just upwind of the crest, and for some time (during the last 6 cross legs) a cirrus layer was present at about 17 kft above the peak only, and some cumuli reached this cirrus.

Earlier in the day (mainly 16-18 Z, 3-1 hr before take-off) the Snowy Range had been blanketed by steady light snow from a deep stratiform layer (cold satellite IR and echoes visible from Cheyenne) that had formed some 6 hrs earlier on the cold side of a strong jet (it was not predicted by MM5 or ETA). That band was moving off at the time of arrival. The first 3 flight legs saw this deeper layer of cloud well above flight level. This layer produced a weak echo up to 1200 m above flt level; the sun was readily visible thru it. It was thicker to the southeast, and it drifted off in that direction. The layer clearly seeded the well-defined clouds below, and the echo was continuous. It extended over the SRT valley, esp. the southern end, but echoes did not reach the ground there. The good isolated orographic cumuli only developed later, while doing the H legs.

The H pattern legs suggest that the wind in the upwind valley is complex, possibly channeled around the Snowy Range and into the gap south of Elk Mtn. Soundings had suggested a stable layer at about 10-12 kft MSL but we did not see that. Light turbulence was encountered in the cumuli, slightly stronger turbulence on the E side of the Range.

A stationary, persistent cloud band formed about 20 km north of Elk Mtn, and extended downwind, and towards the end of the flight it was deep enough to produce some snow towards the east, esp. over the Laramie Range.

Instruments: It appears that all systems worked well. Another CCN unit was used for the first time in NASA06, and apparently it performed well. Questions were raised about the FSSP. At the end of the flight, when shutting the nadir port, Perry noted that the WCR turbo was not set correctly.

Coordination with WMI Cheyenne aircraft (N234K): none (they took off at 22 UTC, about the time we landed).

WCR data: Probably the most interesting observation from the WCR was the growth of echoes during the last 6 cross-mountain legs from the upwind side to the crest. Echoes were relatively weak and shallow, max reflectivity mostly ~10 dBZ. Visible cloud contours appeared much more cumuliform than the WCR echoes. The upward + dual-downward looking configuration of the WCR was used exclusively for this flight, even on the H legs. The number of range gates recorded (150 gates or 4.5 km recorded range) was plenty.

NASA flight, 2 February 2006

Larry Oolman, 3rd Seat

Crew: Tom Drew, Bart Geerts, Larry Oolman, Perry Wechsler

CCN 108 replaced CCN 104.
Diffusion screens removed from CPC.
FSSP has intermittent high resets.

1854	Take off
	PSP_U less than PSP_D
185816	UpDualDown.150.pp6
1912	90/270 near Saratoga
192331	New file, Laramie Valley
1939	CCN supersaturations set to 0.4, 0.8, 1.6, 0.8, 0.4%
194303	File break, north end of H pattern over Saratoga Valley at 9600 ft
1947	Cloud bases lower to south, descend to 8600 ft
195710	File break, spiral sounding to 17000 ft, CCN set to 1%
202120	File break, rewet CCN pads, CCN set to 0.4, 0.8, 1.6, 0.8, 0.4%
2025	Start H pattern west of Snowy Range through the Centenial Valley
204442	File break, back to E-W legs at 14000 feet, CCN at 1%
210023	File break near Saratoga
212258	File break near Saratoga
2133	Rewet CCN pads
2140	CCN back on
214732	File break near Saratoga
2156	Circle above GLEES
2159	End radar observations
2207	Land.

NASA06. Flight Scientist's notes. January 31, 2006.

Crew: Tom Drew (pilot). Jeff French (tech seat). Matt Burkhart (aerosol). David Leon (flight scientist).

Based on forecasts that showed a dramatic drying above 700 mb during the day, takeoff was set at 6am. Prior to the flight, strong echoes over the Snowy range were visible on the Cheyenne WSR – the first case for which we could see significant reflectivity.

At takeoff the sky was still almost completely dark, however is was possible to see a variety of mid-level clouds silhouetted against the sky to the east. After takeoff it became slightly lighter and it was possible to see a very-low level cloud layer creeping over Laramie from the North and West.

We climbed to 20 kft over the Laramie valley to get a sounding before heading West over GLEES. From there we followed a flight strategy similar to that used by Bart on the 27th with a long leg out to Baggs followed by shorter legs over the Snowy range. The outbound leg to Baggs was flown at ~17-18 kft and the return leg was flown at 14kft

. The aircraft remained in cloud for both of these legs with strong echoes most of the time. The reflectivity field (particularly above the radar) showed a pattern of generating heads leading into long, nearly-horizontal fallstreaks giving the reflectivity field a very stratified appearance. Little, if any, liquid water was encountered on either of these legs.

The inbound (Eastward) leg from Baggs was extended to GLEES with a 90-270 turn over GLEES so that a vertical profile of the horizontal winds could be calculated over the site using VAD analyses. Following the 90-270 the King Air descended to about 7.5 kft over the Saratoga Valley before climbing to about 8kft for the upwind leg of the H pattern. The flight altitude was chosen to keep the UWKA just below the base of the water clouds that extended into the valley in places. As in previous flights a slight turn Eastward was made near the middle of the flight leg. The leg was cut slightly short on the South end due to lower cloud bases for the upper level cloud towards the southern end of the valley. Towards the northern end of the leg the liquid cloud had a 2-layer structure with the two cloud layers merging over the higher terrain.

Following the completion of the upwind leg of the H, an oval sounding was made to 17 kft before descending to 14kft for the along-wind leg over GLEES. There were solid echoes to the surface on this pass over GLEES and the aircraft remained in cloud until pretty close to Centennial. The Downwind leg of the H was flown at 9kft. There were no traces of liquid cloud much past the high point of the terrain and it appeared that the conditions might be deteriorating rapidly. For much of the downwind leg there was no echo from the upper cloud layer.

Following the completion of the H pattern we decided to make a pair of legs over GLEES at 14kft despite the apparent deterioration in conditions. Conditions over the Snowy range were pretty similar to the previous pass, however there was now a thick layer of liquid cloud over the Saratoga

valley with tops @ ~12kft. This was surprising given the almost complete lack of liquid cloud on the Laramie side of the Snowy range. The return leg at 14kft was very similar to the upwind leg. Some ice was noted on the leading edge of the wing, however this was probably the result of the last two legs. The aircraft broke out of cloud somewhat past GLEES and we were able to see to the surface over Centennial.

After landing, the conditions seemed to improve again with upper level clouds again moving over the Laramie valley and with liquid cloud creeping over the Northern edge of the Snowy range.

Literal flight notes

130119 Preparing to takeoff. Still dark.

130500 Taxiing, still dark.

130856 Takeoff.

131017 Starting spiral sounding. Wind direction @ 11kft: 250 magnetic.

131555 Radar running. No echoes at this time.

131732 Inversion (on sounding) @ 12.5 kft

Low clouds creeping in over town.

132101 Low liquid clouds still present below.

132150 Hints of echo on the radar

132416 Very dry above

132611 Top of sounding @ 20 kft.

Descending to 17 or 18 kft.

132750 Heading towards GLEES. Echoes above us (19.5 nmi to GLES)

133000 Echoes thicker above. Still weak. Some Echoes to near the sfc.

133210 2D-C records (Jeff).

133328 (Tom) Impact snow and light rime on wing.

133400 Echoes stronger below/solid to near 4.5km above us.

133500 Over GLEES. Turn for Baggs.

133728 FSSP problems (only one channel showing data)

134528 Probe heats weren't turned on.

134600 Separate cloud (echo) layer near the surface. Main echo weaker, shallower.

134750 May have encountered some liquid a few minutes ago (Jeff)

134853 Near highest terrain over Sierra Madre.

135000 (Matt) Rosemount Icing probe cycled.

135600 Will do 90-270 @ end of leg to Baggs.

135649 Echoes no longer extend to sfc.

135853 Generating heads @ cloud top.

135930 Starting 90-270

140000 In turn. Can see cloud top very near 17kft

140252 New radar file. @ 14kft dewpt depression small (< 3 C)

140536 Can barely see to sfc.

140627 Cant see to sfc.

140905 Echo near sfc. Again

141009 Over higher terrain, but not yet to GLEW

141326 Can see to sfc pretty well (no echo to sfc here)

141518 (Jeff) Nice dendrites.

141645 Echo filling in to sfc(15+ nmi to GLEES).

141832 Solid, strong echoes to sfc.

142011 Approaching GLEES.

142100 Sun. (thought it was an undersun at first)

142200 Sunrise in cabin (in 90-270 over GLEES)

142500 (Jeff) Liquid water on PVM

142716 Light turbulence @ 14kft.

143005 Descending into Saratoga for soundings, upwind H.

143100 Echo does not reach sfc.

143104 Can see to sfc from 13.5 kft

143400 Clearly out of cloud. More turbulence. Can see liquid cloud layer.

143540 Liquid cloud hugging terrain.

143856 Bottom of descent at 7.5 kft

144102 Passing below base of small liquid clouds.

144427 N. End of H. Echo ~1km above us. Thinner. Can see liquid cloud hugging Sierra Madre.

144700 Cloud above us much thicker.

144800 Adjusting orientation of H to closer to E. edge of valley. Winds in valley 240 magnetic.

145100 Base of upper cloud is lower at S. end of H. Cutting it a bit short.

145245 Turn @ S. end of H.

145330 Can see wave clouds to N.

145622 Echoes lower above us. Almost reaching our level.

150219 Clouds weaker above. Higher. Liquid cloud right above us. Much thicker than before.

150000 Turn @ N. end of H.

150900 Turbulence near center of valley.

150926 Turn to begin mini sounding to 17 kft.

151203 2-layer structure for liquid cloud over Elk mtn.

151334 Echoes to ~4km above. Mulit-layered in reflectivity. Some echoes below us @ 12.5 kft

151708 Cloud base @ 15.5 kft.

151816 @ 17kft. End of sounding. Back to 14kft for along-wind leg.

152146 Liquid cloud layer over the mountains looks broken, thin.

152225 Echoes getting thicker below & more solid above (~ 18nmi to GLEES).

152406 Echo filling in to sfc.

152400 Echoes to 2.5 km above & slanting downward over the mountains (?)

152904 Approach to LAR. Change in heading (want to get into vfr conditions)

153036 Nothing on radar.

153326 Descending to 9 kft for downwind H. Some turbulence. Moving another ~2km away from mountains.

153644 S. end of H.

154210 Midpoint of H northbound. Moving a bit closer to terrain.

154839 Some echoes above. N. end of H.

155100 Strong echoes @ 4-4.5km above.

155404 End of H pattern. Now, pair of legs @ 14kft over GLEES.

155938 Entering Western edge of cloud.

160145 Break in cloud layer above us.

160300 Over GLEES. Echoes to SFC.

160600 9.6 nmi to GLES1. No echo from near sfc.

160953 Out of cloud.

161037 90-270 @ end of leg. Thick liquid cloud below. Many photos.

161300 On final leg.

161600 Bunch of ice on wings

161700 Echo tops lower now. 7.5 nmi W. of GLEES

161646 Over GLEES. Cloud tops dropping dramatically.

162014 Can see to sfc (over Centennial)

162200 End of leg. Returning home.

NASA06: 20060131a

Flight notes-Jeff French, 3rd seat

Pilot: Tom Drew

Right Seat: Dave Leon

Third Seat: Jeff French

Fourth Seat: Matt Burkhart

Pre-flight:

Noted before flight:

- Pre-sunrise takeoff, no clouds overhead, NWS radar indicated snow over Snowy Range

Flight:

- ~1309 wheels up
- 1315: ascend sounding in Laramie valley, all variables look good
- 1332: begin crossing Snowy Range at 17 kft, nice radar echo, some particle on 2DC & P
- 1336: FSSP looks screwy…particles showing up only in 1 bin (I think 5th bin); change to FSSP Range1, still particles only in 5th bin (now a different size)
- 1341: switch back to Range0, no longer seeing any particles
- 1344: Tom notes that probe heats were never turned on, probe heats turned on, no ice visible from inside the plane on probes
- 1400: turn over Baggs WY, descend to 14 kft to setup return to Saratoga valley
- 1416: Beautiful dendritic crystals on 2DC
- 1424: sanity check, all channels look reasonable
- 1426: liquid water on PVM and DMT, nothing on FSSP
- 1430: descending into Saratoga valley

- 1518: some liquid water on DMT and PVM, nothing on FSSP
- 1521: setup for 14 kft pass (west to east) over Snowy Range
- 1530: pass complete, east side of range, setting up for lee-side H at ~9 kft
- 1554: finish downwind H, setup for pass over Snowy Range, complete 2 passes at 14 kft (first east-to-west, second west-to-east), passes completed at ~1621
- 1630: wheels down

Post flight:

- FSSP appeared hosed inflight, Glenn checked on ground and sizing appeared incorrect, will remove from aircraft and check before next flight
- CPC counts very low entire flight (virtually non-existent), Don installed diffusion screens before this flight…perhaps all particles were very small??? (UFN concs ~ 2 Orders Mag. Larger than CPC)

Flight Scientist Notes – NASA-06: January 27, 2006: double cross-leg only mission

Crew: Kevin Fagerstrom, Bart Geerts, Larry Oolman, Perry Wechsler.

two flights:

(a) 21:33-22:59 UTC (~2:30-4 pm) and

(b) 23:58-03:01 UTC (~5-8 pm, only the first ~30 min in daylight)

ground instruments:

Glees: hotplate and WV-1500 (5-channel)

N. Platte Ranch: WV-1100 (2-channel) N41º15'36'', W106º46'42''

Flight (a) 21:33-22:59 UTC

waypoints: LAR-14GLEES14-14BAGS13-13GLEW14-14GLEE-14GLEW14-14GLEE14-LAR (2 long legs at 14/13 kft, and 2 short legs at 14 kft)

where:

- GLEE, GLEES, GLEW, and BAGS are all aligned along 73.5º-253.5º true
- GLEE [N41º24'15'', W106º01'30''] is the eastern end just east of the Snowy Range terrain drop-off (the turn often took us as far as I-80)
- GLEW [N41º16'59'', W106º40'08''] is 9.5 km short of the N Platte ranch site, but we took long turns so the flight track was within a few km of the WV-1100 at each turn at GLEW, and within ~2 km for the long legs down to BAGS
- BAGS: SW-most endpoint, about 10 km NE of the town of Baggs
- the flight levels are shown in kft (13 kft= 3970 m, 14 kft=4276 m MSL)

The wind direction at 14 kft generally was from a southerly direction relative to the flight track: the track was 25-30º clockwise relative to the wind. Wind speed 15-20 kts at 14 kft. Temperature was about -16.5ºC at 14 kft. and -15.0ºC at 13 kft.

Weather: at T/O, light snow over Snowy Range, but Centenial Ridge is visible. A deep cloud producing light snow even over the valley moves to the NE. We intersect the tail end of it on the first Snowy Range traverse. From centennial east, shallow Cu-form clouds dominate, with some WCR echoes, mostly below flt level. Thickening stratiform cloud over Sierra Madre. The sun itself and sundogs are visible. Light snow above and below, especially near the W end (reached at 22:07 UTC). On the way back, the Saratoga is remarkably clear, sun out, and shallow clouds build nicely over the slope of the Snowy Range. The cu-form clouds deepen to flight level near Glees, and the echo intensity increases rapidly along the upslope. The same is observed along the next to flight legs at 14 kft over the Snowy Range, both W-bound and E-bound, although the clouds become more shallow, more broken, and the echoes weaker. Clearly this shallow Cu is NOT seeded from above during the last 3 legs over the Snowy Range. Later, during the LAR ground phase (4-5 pm), some deeper Cu tops are seen poking above the ill-defined stratiform cloud tops (these are shallow or more distant to the W). The flight was generally smooth, with occasional light turbulence in the Cu and in a rotor-like cloud encountered near GLEE just before landing. No liquid water recorded (<0.01 g/kg) except occasionally in the oro-Cu (~0.02 g/kg at most).

Instruments: CCN performance questioned shortly after take-off. At 21:46 UTC it is determined that CCN is not working at all. WC100R data (LWC) are not recorded for a while (till 21:58 UTC?). Al Rodi reported the following GPS issue: PDOPS >3.5 ..."questionable" between 22:10 - 22:24 UTC

Coordination with WMI Cheyenne aircraft (N234K): they took off ~2.5 hrs before us and flew between Baggs and Battle Peak (i.e. east of Sierra Madre). On our long leg out towards BAGS, we fly 1000 ft above them within a few km, at 21:53 UTC. On our return long leg, we fly at 13 kft while N234K moves off to the N and to higher altitude.

17kft. The 17kft altitude was chosen as the approximate top of the solid cloud layer based on the WCR data, although generating heads frequently extended 1km or more above this level. I would also consider including an along-wind, above-cloud pass (if possible) with the radar in dual-downward looking mode to document the flow throughout the cloud layer.

Flight (b) 23:58-03:01 UTC

Waypoints: LAR-14GLEES14-14GLEW13-13BAGS13-13GLEW14-14GLEE-14GLEW14-14GLEE14-14GLEW14-14GLEE17-17GLEW-SRT-14GLEW14-GLEE-LAR (2 long legs at 14/13 kft, and 7 short legs at 14 kft, and 1 short leg at 17 kft).

The points are the same as defined for flight (a). GLEE, GLEES, GLEW, and BAGS are all aligned along 73.5º-253.5º true. SRT is Saratoga approach down to 7800 ft MSL. The track was 20-25º clockwise relative to the wind direction at 14 kft. Wind speed 15-25 kts at 14 kft. Temperature

was about -17.5ºC at 14 kft and -15.5ºC at 13 kft.

Weather: only the first 30 min were in daylight (all 3 hrs of forward video were recorded). Very smooth flight, occasionally some very light turbulence. Very little cloud liquid water (<0.05 g/kg).

1. long leg E-W from GLEE: 00:06-00:33 UTC: very stratified echoes, shallow over GLEES and deep (~19 kft or 6 km) near BAGS. Over SRT valley, upper echo belt persists, precip does not reach ground; near BAGS echoes remain elevated as well. This long leg should show double ridge with shallow echoes over upwind side of both ranges.

2. long leg W-E from BAGS: 00:35-00:57 UTC. Echoes stronger, even at ~600 m AGL, but still do not make it to the ground over SRT valley. Deep echo layer (topping near 6 km MSL now stretches further E, but still just shallow echoes over GLEES.

3. short leg E-W 14 kft: 01:00-01:11 UTC: still mostly shallow echoes, with nice orographic echoes below, and clear echo tops.

4. short leg W-E 14 kft: 01:14-01:23 UTC: echo belt aloft stronger, and snow down to ground over part of the SRT valley. Nice orographic enhancement, LWC up to 0.05 g/kg.

5. short leg E-W 14 kft: 01:26-01:37 UTC. deeper echoes over Snowy Range, SRT valley mostly snowfree at low-levels, upper-level echo belt persists

6. short leg W-E 14 kft: 01:39-01:48 UTC: again nice shallow orographic enhancement on upwind side of Snowy Range., and echo extending further east on lee side.

7. short leg E-W 14 kft: 01:51-02:02 UTC: highly stratified deep echoes over Snowy Range, clearing near GLEW, upper echo band persists.

8. short leg W-E 14 kft: 02:04-02:14 UTC: again nice shallow orographic enhancement on upwind side of Snowy Range, and echo extending further east on lee side. No low-level echo in SRT valley.

9. short leg E-W 17 kft: 02:16-02:25 UTC: solid echo below us, and ~ 200m echo tops above us. The echo tops are not sharply defined, and stars are clearly visible above us. T=-24ºC, wind 20 kts from 228º. No low-level echo in SRT valley.

10. SRT approach: we have a down ramp/turn sounding from 17 kft to 7.8 kft between 02:25:37 UTC- 02:35:50 UTC (about 1000 ft/min), and an up spiral sounding from 7.8-14 kft between 02:35:50 UTC – 02:41:40 UTC.

11. short leg W-E 14 kft: 02:45-02:54 UTC: deep highly stratified precip, again nice shallow orographic enhancement on upwind side of Snowy Range, echoes peter out gradually on E side.

Coordination with N234K: none

Instruments: CCN counter worked, although the air appeared quite clear (except above SRT); very little signal at 1.0 supersaturation; more at 1.5 SS. PSPup (downwelling radiance) did not record. No other problems observed.

WCR data: Probably the most interesting observation from the WCR was the very fine layering of reflectivity, first only in the deeper layer aloft, and later extending to 14 kft and lower. Also remarkable are the persistent, relatively weak upper-level echo belt and the low-level stronger echoes over the upwind side and crest of the mountain ridges. This layer merges with the upper layer over higher terrain but the echo separation at earlier times suggests that seeding may be limited on the upwind side.

The upward + dual-downward looking configuration of the WCR was used exclusively for this flight. The number of range gates recorded (150 gates or 4.5 km recorded range) was overkill for this flight.

NASA flight, 27 January 2006 - B

Larry Oolman, 3rd Seat

Crew: Tom Drew, Bart Geerts, Larry Oolman, Perry Wechsler

2358	Take off
000616	UpDualDown.150.pp6
003523	Baggs, new file.
	Upper PSP is not working.
005943	New file over Laramie Valley
0113	Over Saratoga Valley, no new file.
012259	New file over Laramie Valley
0137	Over Saratoga Valley, no new file.
014808	New file over Laramie Valley
	FSSP calculations give large CONC, NaN LWC
021241	New file over Laramie Valley, climb to 17kft
023633	Sounding into SAA, new file.
0302	Land.

NASA flight, 27 January 2006 - A

Larry Oolman, 3rd Seat

Crew: Tom Drew, Bart Geerts, Larry Oolman, Perry Wechsler

2133	Take off
213658	UpDualDown.150.pp6
214033	Start new file, must have accidently clicked off
	CCN is not working.
2156	LWC100 turned on.
220720	Baggs, new file.
223212	File change over Laramie Valley
2300	Land to repair CCN, hose was pinched

NASA06. January 26, 2006. – Flight scientist's notes

Crew: Tom Drew (pilot), Jeff French (tech seat), Brent Glover (aerosol), Dave Leon (flight scientist)

In the 1-2 hours preceding the scheduled takeoff at 12 noon the clouds developed considerably, with the typical wall of cloud downwind of the Snowy Range and with intermittent high cloud over the Laramie valley.

The King Air took off just after 12 noon and did a spiral climb up to 20kft (?) to obtain a sounding over the Laramie Valley. We then climbed up to ~ 24kft on the E-W leg over GLEES in order to reach (near) the top of the upper cloud layer and to see if there was an obvious reason that the tops of the clouds were so flat. The top of this climb was reached near the GLEES site. At this time there was a slight gap between the upper and lower cloud layers. Brent Glover reported spikes in the CCN Vdet during the ascent – something that was noted intermittently during the rest of the flight.

We then began the descent into the Saratoga valley. Unlike the flight on the 18th there was no well-defined leading edge to the liquid cloud. Instead, broken clouds stretched out over much of the valley. The base of the lower cloud layer sloped steeply downward towards the North. Cloud-base was at 11-12 kft around Medicine Bow peak (only the top of the ridgeline was obscured by the cloud layer) but was at ~9.5 kft upwind of Elk Mtn.

The upwind leg of the H-pattern was flown at an altitude of 9 kft. The aircraft track angle was changed about 1/3 of the way from the Northern end of the leg. The aircraft track angle for the southern end of the leg more closely followed the valley. This deviation allowed us to stay closer to the edge of the cloud layer (to the extent that there was a defined edge). A similar pattern was flown for the Northbound, return leg.

The aircraft then made a short sounding up to about 17kft, during which Jeff F. and I both noted a large # of little plates on the 2D-C including a large # of images with holes. We then flew the along-wind leg over GLEES at 14kft during which the 2D probes showed columsn and some dendrites. The aircraft emerged out of the cloud layer well to the west of GLEES consistent with the WCR cross-sections which showed that the cloud-top sloped dramatically downward from West to East over the Snowy range. Unlike the previous flight (Jan 18th) we encountered relatively little liquid water on this or subsequent passes. Even where liquid water was encountered, it was transient – little wisps rather than extensive layers. Some turbulence was noted downwind of GLEES.

We then descended to 9kft for the downwind leg of the H. Despite comparable winds, this leg was far more turbulent than on the 18th. The upper cloud layer became more broken during this leg, and stack of lenticular clouds that would remain for the rest of the flight became visible over Elk mtn (these may have been present earlier, but obscured by the upper cloud layer).

We then climbed to 17kft for the remaining along-wind legs over the Snowy range (the 14kft flight level seemed marginal as it did not put us into the liquid cloud). Radar echoes over GLEES for the first upwind leg were weak and broken and it appeared that the conditions for the flight were rapidly deteriorating. The liquid cloud over the Snowy range and the Sierra Madre were shallow and broken with distinctly lumpy tops (again in contrast to the solid, smooth-topped liquid cloud layers encountered on the 18th). The downwind leg (also at 18 kft) was similar to the upwind one, but the wave-cloud downwind of the Snowy Range (over Sheep Mtn.) evolved dramatically during this leg and could be seen to fill in rapidly, with a strange vortex near the flight level and dramatic cross-wind undulations along the top of the cloud layer.

We then preformed another pair of legs over the Snow range (both at 17 kft) during which the cloud layer over the Snowy range remained relatively weak while the downwind wave clouds continued to develop.

Overall, the conditions encountered during this were far more complex than for the flight on the 18th and will probably be harder to interpret. The complexity of the upper cloud layer was particularly striking (with up to 4 distinct cloud layers above the aircraft at some times) as was how rapidly the conditions could evolve (evidenced by the rapid development of the downwind wave cloud during a ~2 minute period from when the aircraft passed over GLEES to when it crossed the 1st downwind wave.

Literal flight notes

185107 Preparing for takeoff. Clouds have built up over the past ~2 hours. thick echoes to >3km above.

185432 Engines on.

185848 Taxiing

190025 Takeoff

190134 Off the ground

190212 Brent to back to open port

190352 Starting radar, mode up+dual down.

190442 Spiral climbout

190550 13kft, 10 deg dewpoint depression

190647 Precip over Laramie.

190700 (From Jeff F.) Terry K. will take off @ 2pm and will fly around us to the north.

190733 In cloud over the Snowy's

190814 12+kft in ice cloud. Can barely see to surface. Bumpier than previous day.

190923 Turbulence drops

191041 Radar echo to 3km above. Echo tops are amazingly flat

191130 Touch of ice on leading edge of wing (liquid cloud?).

191152 Sunny. Out of mid-level layer. 16.5 kft.

191310 Echoes more broken above. Sunny in cockpit.

191446 Sounding shows cld base @ < 10kft (?).

191623 Discussion Jeff/Brent. Problems with the CCN. Spikes.

198132 Echo-tops @ 24kft, very well defined.

192023 Heading towards GLEES. Clouds/echoes clear below.

192200 Heading towards GLEES @ 23kft & still climbing slightly.

192625 Starting down again. Over GLEES. Solid echoes below, can't see to sfc.

192803 20kft. Descending

192907 Can see LE of water cloud below (photo)

193116 Entering cloud layer @ 16.8 kft

193208 In cloud. Nice & smooth.

193245 (Jeff F.) liquid water.

193259 (Brent) Lost spike in Vdet on CCN.

193416 More wisps of liquid.

193522 Can see to sfc.

193623 In the Saratoga valley @ ~12kft

193725 Jeff stopping radar file. Crud on 2D-C/P.

193837 Cloud-base @ 9.5 kft.

194036 @ N. end of H. Brent is wetting pads.

Will fly H @ 9kft.

194218 Orbiting near cloud base. Layers above on radar. Weak echo to near sfc.

194317 Waiting for CCN.

194458 Still waiting, Clear above.

194500-194700 (Jeff F) Passed through our exhaust plume.

195154 Change in (track) angle. Now heading down the valley

1954 winds 240 in valley (magnetic)

1955 2-layer structure layer above.

195817 Turn @ S. end of H.

195947 End of turn. Heading north.

200345 Centerpoint of H

200720 In cloud (thin). Cloud base much lower here.

200925 End of leg & into small clouds.

201152 Heading S. to center of leg. in cloud. Did we move to the East ? (probably)

201425 Near liquid cloud wisps.

201608 End of H.

201630 Sounding to 17kft. Then over @ 14kft.

201830 Still in sounding.

202311 Lots o' little plates ? Lots of 2d-c images have holes in them.

202407 Out of cloud. Smooth tops.

202611 End of turn. Coming over GLEES1 @ 14kft.

202935 Columns & dendrites (Jeff F.)

203112 Out of cloud. Cloud-tops @ 14kft.

203245 Over GLEES, can see to Sheep mtn.

203433 Some turbulence

203500 Some virga from upper layer

203600 ~12nmi from GLEES for downwind leg of H

203811 Descending to 9kft for leg

204018 Passing E of Jelm mtn.

204118 Almost looks like mammatus from upper layer to south

204213 Starting H from S. end.

202649 clouds more broken above. Passing N. end of Sheep mtn.

204809 Funky cloud (lenticular) over Elk mtn.

205309 Bumpy approaching N. end of H

205756 Echo to sfc. Blowing snow (?) (Jeff F.)

205942 End of H. Climbing.

210152 Passing over LAR.

210814 Over GLEES, echoes weak. Conditions getting marginal.

213808 Echo separating from ground.

211355 Nice stellars (2D-C)

211551 Edge of water cloud below. Over (Saratoga) valley

211817 90-270 @ end of leg. @ 17kft can barely see to sfc.

211944 Starting E-bound leg/ new radar file started., @17kft again.

212137 Can see cloud tops heading down above us (on radar).

212374 Sunny

212342 Wave cloud downwind & over Elk mtn. (to left)

213152 Turn @ East end of leg

213419 Starting pass over the mountains

214406 Entering cloud.

214835 Upper level cloud still thick. Can see to sfc.

215058 90-270. Starting new radar file

215407 End of leg.

Returning to LAR.

Fourth Seat Notes 20060124 Jeff Snider

202323 - Take off

2024 - Starting CCN at 0.4%

2025 - Forgot to turn off UFN pump for take off. It was sampling during taxi and takeoff

2030 - Climb out at 500 fpm. No spike or detection pulse evident in CCN at S = 0.4%

2031 - CCN to S = 1.6%

2040 - 20 kft and level, 160 kt TAS. Adjusted aerosol inlet valve to give 150 slpm

2045 - Some spiking, delta ~ 2 V in VDET of CCN at TWAIT to FLUSH bdry

2141 - Intercepted wake of King Air, can see particles for ~2 s in CN and UFN

2122 - Landing. Aerosol pump off. UFN pump off. CCN to idle.

Flight Scientists Notes - NASA06. January 18, 2006.

Crew for the flight was: Jeff Snider, Jeff French, Tom Drew and David Leon.

The planned takeoff at noon was delayed by approximately 1 hour due to leak testing the CCN and efforts to fix an apparent leak. During this time the cloud layer over the Snowy Range appeared to deepen considerably and the trailing edge of the cloud layer extended significantly into the Laramie valley.

The aircraft took off just before 20:00 UTC and, helped by the strong winds was able to climb to about 20kft on the westbound leg towards the Snowy Range. The trailing edge of the cloud was encountered at about 15 - 18 nmi downwind of GLEES and with a cloud base at around 10,700 ft (from the altimeter). At about 17kft there was a discernable gap between the upper Altostratus layer and the lower cloud layer with the two layers merging over the higher terrain. There were numerous 2D-C and 2D-P records confirming that these probes were working, however the PCASP was apparently not.

During the climb Jeff French noticed that 'PUSED' was not working, and as a consequence, all variables that depend on pressure were messed up on the display (winds, theta, etc). Jeff F. switched the pressure used to PMB which restored sanity to the displayed winds, etc.

During the first along wind leg the WCR stopped recording data due to a problem communicating with the 'data' drive. This problem was not noticed until near the end of the along-wind leg. During the descent into Saratoga for the initial sounding and for part of the cross-wind leg of the 'H' Jeff F. worked to restart the WCR: first by rebooting wasp without powering off (which was unsuccessful - the reboot stopped at mounting the data disk), and then by powering down the system which was successful.

A well-defined leading edge to the water cloud extending perhaps a few miles over the Saratoga valley was evident with the two cloud layers merging over the higher terrain. The upper level cloud was continuous over the valley. We flew parallel to the edge of the liquid cloud resulting in an aircraft track that differed significantly from 90 from the wind. Several heading adjustments were made during these legs to avoid the leading edge of the cloud layer.

Following the upwind leg of the H, the aircraft flew downwind over the GLEES site at about 14kft. WCR echoes were strong down to the surface with stratiform cloud above. Echoes in may places appeared to approach or exceed the +20dBZ upper limit on the display. Of particular interest was that there was frequently a gap between the upper and lower cloud echoes in the WCR data - a feature that may have become more pronounced during the subsequent flight legs. About 5nmi upwind of GLEES ice started to accumulate on the leading egde of the wing confirming that we had entered the liquid cloud layer. There were numerous records from both the 2D-C and 2D-P.

We then started the cross-wind leg of the H downwind of the Snowy Range. As expected the trailing edge of the cloud layer was considerably more diffuse than the upwind leg. The orientation of this leg of the H was closer to perpendicular the winds, however some course corrections were sill made to maintain separation from the trailing edge of the cloud (the cloud edge protruded farthest into the valley near the center of the H - presumably downwind of the highest terrain. Both north and south of the ends of the flight leg the upper level cloud layer deepened considerably (prior to the flight the Cheyenne WSR had shown echoes over Steamboat).

Following completion of the H pattern, we started to make along-wind passes over the GLEES site at 14kft and 17kft. The 17kft altitude was chosen as the approximate top of the solid cloud layer based on the WCR data, although generating heads frequently extended 1km or more above this level. During the series of along-wind legs the upper level cloud layer weakened considerably, and by the final legs there was a complete break in the cloud layer over the Saratoga valley with a fuzzy trailing edge of the cloud layer over the Sierra Madre much like we are used to in the Laramie valley.

By the final leg we only entered cloud over the highest terrain a few miles before GLEES. Probably the most interesting ovservation from the WCR was the existence of a (frequently) separate echo adjacent to the terrain as it is unclear where ice would have originated in this layer, although it may have been seeded by the upwind cloud over the
Sierra Madre.

The upward + dual-downward looking configuration of the WCR was used almost exclusively for this flight. A single along-wind pass was made with the radar in the side + dual-downward looking configuration of the WCR. For future WCR operations I would consider going to a mode with somewhat fewer range gates (the 4.5km recorded range was overkill for this flight) I would also consider including an along-wind, above-cloud pass (if possible) with the radar in dual-downward looking mode to document the flow throughout the cloud layer. I would also consider adding a 360 degree turn over the GLEES site to document the 3-D wind profile.

Specific entries from notes:

194927 - Engines on. Typical fuzzy cloud over snowy range. Tops @ ?.
Recording data.

195300 - Taxiing
195700 - Takeoff
195847 - Cloud base @ ~10,700 (from altimeter)
200139 - Recording data, PMS problems. Trailing edge of cloud ~18km from GLEES.
200315 - Entering edge of ice cloud. 2DP & 2DC particles.
200708 - In cloud. Break between upper level ice cloud and lower level cloud.
201315 - Now heading twoards Saratoga. TDP @ -36, TRF -27.
201315 - Descending into Saratoga for missed approach.
201700 - Cloud base @ 13kft.
202315 - End of climb following missed approach
202437 - Starting H, paralleling upwind edge of (water) cloud.
202650 - Still nothing on PCASP
203543 - Radar coming up. Disk not mounting.
204112 - Northbound leg of the H
204658 - Over Saratoga. Liquid cloud may have 2-layer structure.
204849 - Turn @ N. end of H. Return to center. Will do leg @ 14kft over the range.
Leading Edge of the liquid cloud.
file started.
205400 - Climb to 14kft for along-wind pass.
weaker, broken.
210000 - Block altitude approved. Will work along the 190
210229 - Starting downwind leg. Solid echoes down to the surface. Lots of 2D data.
210531 - Ice accumulating on LE of wing.
210613 - Over GLEES
210859 - End of along-wind leg.
leg of H @ 10kft. As before significant variability in edge of cloud.

211520 - H southbound leg. Re watering CCN pads. Solid echo to the sfc.
211732 - S. end of H.
212330 - Center point of downwind leg of H
212718 - Getting into N. edge of cloud.
212924 - Turn at N. end of leg.
213227 - Approaching center of leg
213342 - Clouds thicker.
213522 - Turn & climb to 14kft for leg across the snowies (along-wind)
213842 - Start of upwind leg @ 14kft. New radar file started.
214434 - Over GLEES
214904 - over edge of liquid cloud to the left (South).
215214 - End of leg. Next leg @ 250 degrees and 17kft.
215425 - Start of downwind leg.
215752 - In and out of cloud.
220230 - Out of cloud.
220412 - End of leg.
220643 - Start of new leg.
220916 - About to re-enter cloud.
211538 - Over GLEES right @ cloud top.
221944 - Out of cloud. Sunny. Good view of liquid cloud below.
223340 - Sounding into Saratoga
223340 - End of sounding. On sounding a small inversion evident above 12kft.
224224 - Last leg started. Clouds much weaker. Upper level stuff is almost gone.
224335 - Over LE of water cloud.
224657 - Over GLEES
224725 - Out of cloud.
that layer just above the surface ?
225930 - On the ground.

NASA06: 20060118a

Flight notes-Jeff French, 3rd seat

Pilot: Tom Drew
Right Seat: Dave Leon
Third Seat: Jeff French
Fourth Seat: Jeff Snider

Pre-flight:
Noted before flight:

Tech. test of aerosol inlet system indicated leak, decided pre-flight to replace tubing between Y and CCN. Also, Y connector was replaced.

Radar appeared to operate fine before flight, KingAir data system operated OK before flight

Flight:

195200: begin recording data
195700: wheels up
Noticed shortly after takeoff that HADS_A and HADS_B were screwed up, since HADS is used in pressure calc's, several variables also messed up. Called Matt on Sat phone, he stepped through process of changing P_used to PMB (which appeared OK).
Checked radar, CPAS indicated error writing to disk. Initial file only few M, then nothing writing to data disk on radar. Kill CPAS using sudo, restart cpas, radar runs fine until try to write file. Try above 2-3 times. Decide to reboot, do soft reboot, Reboot hangs when trying to recognize data disk. Jeff S. cycles power on WASP for hard reboot, everything comes up. Run CPAS...everything works, can record data fine.
Finally chance to look at other channels, notice than nothing shows up on PCASP, all three PCASP variables are zero. At this time, no longer in cloud (other side of Snowies, doing aerosol runs. No one checked FSSP in cloud, decide to cycle power on PMS-L breaker @202840. Still nothing on PCASP. FSSP does appear to work as we path through small cloud.
Jeff notes aerosol mass flow looks screwy, particular AERIMFC is larger than AERIMF & AERIMFC (reported in slpm) is ~260, well above 180????
Pass back over Snowies, the DMT looks hosed. Note that offset is around negative 0.22???, when rescale the plot, DMT appears to vary with both FLWC and PVM
After lee-side cross-wind aerosol leg, ascend to another pass over Snowies. At higher alt, Jeff S. notes erroneously high concs in CCN (leak with larger p differentials???)

Post flight:

Plane is down following day, apparently tail deicing boot not working
Need to resolve issues with HADS, PCASP, aerosol inlet flow control, CCN leak

Fourth Seat Notes 20060118 Jeff Snider

1957 - Aerosol pump on

2001 - CCN on at S = 1.6%

2009 - Suspect leak in CCN, 5 VDC excursions in CCN concentration detect pulse...this amplitude increasing with increasing King Air altitude up to 450 mb

2028 - Supersaturation sequence changed to 0.2, 0.4, 0.8 and 1.6%

2040 - End of cloud-edge portion of H-pattern

2058 - CCN back to S = 1.6%

2119 - Water added to top pad of CCN, it was wet

2122 - Same CCN sequence as at 2028

2159 - Elevated CN concentrations in ice cloud, that could be interesting

2230 - Adjust AERI_MFC to 175 slpm

2252 - Adjust AERI_MFC to 175 slpm

2259 - NADIR door shut, CCN into idle, aerosol pump offf