

**STERAO-CITATION****Chart Log Notes (BAR)**

Times are approximate, but should be good within 10-15 seconds, times are MDT

UT= MDT + 6 hr

**June 26/96 Flight**

165540: pulling out of hagar

take off time: 171646

1734-38: leak check on big inlet

175500: are and have been in clear skies, but appears quite hazy below

1809: climbing from 21 to 29 kft

1816: level at 29 kft

181930: clear out left side, some cirrus? right side

1842: still at 29 kft, continuing wind checks etc, but soon to head for a storm

184930: bumpy

1853: climbing to 39 kft

185900: another aircraft not far off left side, and below us

1907: near cloud/storm-particles

191050: in/near top of anvil-bumpy

191130-191230: in/out of cloud

191309: clear air, turning a bit right

191500: still in clear air, going to descent 2 kft.

1919: lining up for pass 2 at 33 kft

19250: in cloud/storm, bumpy, wisps left side

192230: out of cloud, then right back in, break out of cloud about 193000; very smooth  
this pass until a few light bumps 192830 to out of cloud, not real bright light,  
"dull grey"

193130: we are downwind of cloud/storm at 33kft, will do another pass closer to the  
main cell

193530: storm is on our right (?)

193700: turning into cloud, cloud is thin as look up, not much sun, dull grey

1939: few bumps, and brighter light, smoother at 194130

1943: still in cloud  
194530: still in cloud and very bumpy  
194730: heading into sun, bright sun out front, by 1949 clear out left side, still in cloud right side, break out of storm at about 194940  
195200: in clear air  
195330: in clear air but bumpy  
195430: in cloud for pass 3, bumpy, by 195630 dull grey light, then a min later seems darker still, 200000 a few bumps but not bad, then smoother, by 2002 getting much brighter and smoother, out of cloud near 200350, then climb  
200500: seem to be back in cloud, 37 kft, 2007-2009 very bumpy, out of cloud about 200945, climbing to 38 kft, but really likely in thin cloud near top, very bright light, 2013: going to do another pass  
201330: very bumpy, in immediate clear air? but clouds left and right, 2015-2016 very bumpy  
201730: in clearer air, clear?, will descend 3 kft.  
202030: bumpy for short period then smooth  
202230: in clear air  
2026: going to land quickly

### June 27/96 Flight

1458: pulling out of hangar  
bit of a wait for take off  
152432: take off  
1530: just before a big spike in NO (1-2 sec wide roughly)  
1535: ozone is 34 ppbv, have been climbing slowly  
153445: another narrow large spike in NO  
1537: thin clouds above  
1541: still thin cloud above  
1544: climbing  
1545: ozone about 42 ppbv, in thin cloud, 1546, still thin cloud but bright, 1547 not in thin cloud, but still thin cloud above  
1551: mostly clear and bright above

1552: over big expanse of solid cloud below, bright above  
155530: ozone 45 ppbv  
1556: in clear air, but over heavy clouds below, turret popping up thro' off right side  
155930: turrets etc now off left side at 10-11 o'clock, still solid cloud below  
160600: in clear skies still, well above solid clouds at 34-35 kft  
161100: ozone 37 ppbv  
161730: "our storm" may be at 10-11 o'clock  
1620: still solid cloud below  
162400: big turret off left side, perpendicular to us, way off  
162830: "storm to work is about 25 miles ahead"  
163030: heading for storm, in clear air, but some spikes in NO just as made slight right turn  
163130: solid clouds below, beautiful blue all about above, big anvil ahead, another short spike in NO  
1633: have to descend to 33 kft 'cause of traffic  
163430: in "bubbles", very bumpy, 163450-in cloud, descending, pretty smooth  
1637: in cloud but it is not thick-ie. quite bright light  
1638: ozone 33 ppbv, CO 0.1 to 0.08  
163840: still in cloud  
163940±: out of cloud right side, at 33 kft  
164130: cloud/storm is off left  
164330: in cloud?, ATC won't give clearance to go higher  
164400: bumpy  
1645: ozone 35 ppb, CO 0.1 to 0.09  
164630: boring, still in cloud, bright white in cloud, not bumpy, not seeing elevated NO  
164900: ozone 36, CO .1 to .09, just out of cloud, big other storm almost direct ahead  
1651: heading for other storm?, ozone 36 ppb in clear air  
165130: in cloud, few bumps, out by 165245--no enhancements--this a new storm?  
165330: climbing  
165430: in clear air at 35 kft  
165645: in cloud, no enhancement, out just after 165730, then climb for 37 kft

165830: small spikes in No in clear air  
1700: in clear air still, clouds all around well below  
170225: in cloud, ozone 37 ppb, CO 0.1, pass bumpy , out at 170400±, smooth, then climb for 39 kft.  
170620: in clear air, still climbing  
170750: back in cloud, smooth, some NO enhancement, out 171020  
1712: going to 41 kft  
1714: still in clear air, level at 41 at 1715, CO .08,.09,.11; ozone 28-29 ppbv  
171700: in cloud, but very thin, out in about 40 seconds  
1719: cryogenic hygrometer out of LN<sub>2</sub>  
172315: in clear air and climbing to 42.5 kft  
172400: in cloud, out in about 1 min 25 sec, only small NO enhancement  
172810: back in cloud, going down the axis, see larger enhancement, smooth, then start to descend a bit, had to descend at request of ATC, out of cloud about 173030 as descended, bright light in the cloud  
173130: in clear air still  
173515: in cloud, out about 173740:--all of above was passing along axis of anvil at about 39 kft. Not very exciting at all re NO.  
rest of flight essentially clear air, thin cloud above after 181300, 1828: bumpy on approach to Jeffco.

### June 28 Flight

1520: pulling out of hangar, not raining now, but rain again on taxi, this is flight where returned to hangar re data system and INS logging, cabin quite warm before take off  
162519: take off  
1629: clouds above us, by 1632 in low clouds, remained in cloud much of ascent until about 164320  
163630-163730: still climbing in clouds, bumpy  
1640-1641: in lighter cloud, clearer air  
164330: just out of tops, left side  
164510: clouds all around, 164620: in clear air, cloud top left/right side  
164630: in clear air well above the low clouds ~ 25.6 kft

165325: bumpy, still in clear air above clouds, our storm at 2 o'clock  
165430: light clouds off right, well above solid deck on left side  
1656: oxone 53, CO 0.16  
170400: still in bright sun, clear skies, solid cloud below, looking for storm  
170450: we are near cloud tops left side  
170550: clear air bumps, then spike in NO  
1700830: "may be something to go through at one o'clock"  
1711: Ozone 38, CO 0.14-0.16  
1715: ozone 46, CO 0.14-0.15, at 30 kft  
171730: no storm around except a small one to about 29 kft just on N end of  
interferometer, descent to pass through  
171800: went thro cloud, some NO enhancement, CO 0.2-0.15, ozone 59 ppbv  
172030: clear left, cloud on right  
172115: bubble on right side  
1722: coming up to larger cloud  
172255: pass into, very bumpy, spikes in NO, out in about 30 seconds  
172510: back in, very bumpy, out in about 30 sec  
172550: back in again, out in about 25 seconds (each pass sees small NO enhancement),  
and each pass very bumpy  
172715: just passed bubble on left  
172815: passed through what appeared to be a smallish bubble--incredible bump--  
computer off ceiling onto floor.  
went home after this--nothing around within the CHILL and Interferometer network.

### June 29 Flight

First intercomparison with P3 instruments

1359: pulling out of hangar

140923: take off

1417: at 15 kft, mostly clear, scattered clouds above, very hazy below, very smooth

1423: no clouds above right, about 50% left (thinnish clouds)

1426: ozone 82 ppb  
1427: ozone 90  
1428: very smooth  
143130: turning left, ozone 100, CO .22, very bright, few clouds  
1434: P3 below, back, left side  
1437: ozone 96, CO .17-.19  
1439: ozone 99, CO .18-.2  
1440: P3 righ beside, left  
1443: ozone 93  
144530: bit of higher cloud left and right side, very bright  
1450: Ozone 94, CO .15-.19  
1453: ozone 89  
145606: few small spikes in NO, begin descent to 13.5 kft  
1502: scattered clouds above, very bright  
150330: few light bumps  
150430±: through small cloud, bumpy, there are a few small clouds at our level, ozone  
63, CO 0.17, saw P3 avoid going thro a small cloud  
1505: P3 in closer, it had moved away some  
1507: some bumpiness, not as smooth as higher altitude leg  
1509: ozone 60, CO 0.15-0.2, bumpy (not great)  
1513: ozone 60  
1517-1518: turning, P3 in synch, going to go to 7.5 kft  
1520: very bumpy, ozone 62, CO 0.21  
1527: bumpy  
1529: ozone 64, CO 0.21-0.23  
1532: crossing a river, smoother  
153620: left turn for P3--it is going to do a 500 Ft leg, we are climbing to higher altitude  
to save fuel, P3 too heavy for 21 kft  
we are going "home"

### July 5 Flight

145227: take off, heading for 9 kft  
1459: clouds above but bright  
1500: ozone 69 ppbv, cabin is warm  
150130: big rain shaft off left side, close  
1502: can sample taken  
1503: rain just left  
1504-05: in rain, very hazy left, dull light left side, brighter on right  
1506: ozone 60 ppbv  
150740: another rain shaft right side  
150830, fairly smooth, dull light  
150920: in rain, mostly right side  
1511: dull sky, we are below clouds, out of rain now, we are still at 9 kft, OPS is directing us to storm farther east, Jeff estimates we are 2-3 kft below bases of clouds/storms (not the storm we eventually study)  
1514: bumpy  
1515: scattered clouds left, overcast on right side  
1517: ozone 75 ppbv  
1518: just about under the storm of interest  
1519±: second can sample  
1520: ozone 66 ppb, "we are in updraft region "  
152030: fairly smooth then into some bumps by 152120  
1522: going to 24 kft, to climb to anvil region  
152330: clouds above us, puffy cumulus right side ~ 1/2 mile  
152430: we are climbing at edge of our storm which is on the left side  
1525: much brighter, ascending in clear air  
1526: at 16.5 kft we are above lower level cumulus  
152630: in clear air, smooth, about cloud tops left side at 1527  
152830: our anvil above, left side  
152910: in and almost immed. out of our cloud, can sample taken about this time  
1531: at 22 kft in clear air, anvils don't look very thick, there are several in view.

1534: in thin cloud (our storm), smooth, out at about 153515, another can sample, no enhanced NO

153630: above lower cloud layer, not far below

1537: puffy cumulus off left

1538: another aircraft off left that appears to be going very close to storm on left side, looks like it went into it?

153945: can sample started/taken, in cloud/storm, can see sun disc, not bumpy, out about 154015

1541: through cloud wisps

1542: climbing in clear air, but then ATC stopped us at 24 kft

154230: "our storm has collapsed", but have been watching big storms left, behind for some time?????????

154450: in cloud, same one we have been working, will then go to other storm, out of cloud at 154605 or so

1546: another aircraft above left

154630: deep convective cumulus just left, below

154720: clouds above us, not really bright light

1549: climb to go thro' larger anvil of the other storm (always looked like a much better one to me)

154920: just in the cloud/storm and climbing, ozone 82 ppb

1551: at 28 kft, at base of anvil of the larger storm

1552: are not in cloud/storm, but anvil above us, fairly bright light

155330: in brighter sun, we are almost out of the "shade" of the anvil above us

155420: bright sun, clouds below

155530: "next pass will be at 29 kft", turning right

1557: about to make another pass, then turn a bit left

1558: "explosive" growth off left, below annvil

1559: ozone 84 ppbv

160130: in cloud, 1602 still in cloud, can sample, very smooth, bright grey light, not seeing much NO enhancement

160330: still in cloud, ozone 90 ppb,

1604: still in, climb to 31 kft, small NO enhancement

1605: ozone 87 ppbv, climbing in the anvil, have not left it, smooth flying, fairly bright



1610: 31 kft still, smooth, have not been out of cloud in quite a while  
1613: asked Jeff if we can leave cloud to get clear air contrast  
161310: out of cloud, another can sample  
1615: in clear air, but anvil above us on left side  
161600: bright sun, out of anvil shadow, clouds below left, clearer to ground right side  
161730: climbing to 33 kft in clear air, ozone 77 ppb, can see to surface left side  
1619: in clear air, but some spikes in NO and then signal stays at higher level--altitude variation?  
1620: level at 33 kft for next pass, ozone 78 ppbv  
1622±: in cloud, quite bright scattered light  
1623: another can sample  
1625: climbing in cloud to 35 kft  
1626: smooth with a few little bumps, still in cloud  
162630: start to see larger enhancements in NO just before levelling out at 35 kft, ozone 75 ppbv  
1628: bit bumpy but light, another can sample  
162930: NO over 10 kcps, scattered light about dull  
1634: still in anvil, have not left it, climbing, only few small bumps, NO high, fairly bright scattered light  
163730: still in storm  
1638±: another can sample  
1640: ozone 69 ppbv, we are still in storm at 38 kft, few bumps but relatively smooth  
1642±: another can sample while still in cloud, quite bright, smooth  
164340: can see sun through cloud  
164530: still in cloud, bright scatter, had to turn south 'cause of traffic  
1646: going to 41 kft, and still in anvil  
164830: ozone 71 ppbv, NO<sub>2</sub> 0.76  
1651: still in anvil, high NO, smooth  
165230: bright scattered light, few bumps, then bumpier, then at 165405 larger NO still in narrow spike, Jeff said in bit of updraft. At 41 Kft--had been climbing slowly since about 1645. Took can sample shortly after updraft, ozone 76--but can sample pump motor may have problem  
1657: still in cloud, bright scatter, smooth, NO still large

1701: still in cloud and high NO  
170130: back through same maximum as before  
1703: few bumps  
170530: ozone 76 ppb  
170610: lost 60 hz ac power to some instruments, NO on different inverter, still in storm  
1711: still in cloud  
1712: in thin anvil, brighter, "anvil is up to 45 kft"  
171250±: out of anvil, in wisps, on top of anvil, NO still high (likely still particles)  
171515: direct sunlight  
1717: in clear air above massive anvil (NO dropped some then up again  
1719-1720: can sample, ozone 66 ppb, at 43 kft  
172430: ozone 74 ppb  
1727: looks like in cloud top, wispy, hazy/foggy--we are in anvil again--turned and flying  
back over main axis  
1730-31: can sample  
1732: descending in storm (where?), few bumps  
1734: ozone 77 ppbv, NO<sub>2</sub> 0.55  
1737: ozone 76 ppb, NO<sub>2</sub> 0.63, smooth  
1738: still in cloud  
1741: bright scatter, ozone 72, NO<sub>2</sub> .54  
174245: descending, going home, but still in cloud, will be fast descent to 21 kft  
174420: out of cloud at 30- 31 kft  
1749: ozone 61 ppb, NO<sub>2</sub> 0.12, level at 12 kft  
1752: bright sunny, lot of high clouds, beautiful, ozone 60, NO<sub>2</sub> 0.09  
1757: passing over DIA  
1758: few bumps, signals up a bit, ozone 58, NO<sub>2</sub>.15  
1802: close file

### **July 9 Flight #1**

1339: moving out of hangar  
CO instrument in zero mode for take-off  
140425: take off

1406: bumpy and in low clouds  
140815: above low level clouds, higher clouds above us  
141330: passing cumulus tower right side, very cloudy left, but bright  
1415: complete clouds left and right but bright  
141720: still in upper layer of clouds, bright, smooth  
1418: ozone 50 ppb, flow 1.82  
1420: still appear to be in light cloud, bright, layer of clouds visible below  
142030: now clearer, blue right, some cloudiness left  
142120: NO<sub>2</sub> zero (switch), about 40 sec later NO<sub>2</sub> pump zero  
1422: very smooth, at 24-25 kft  
142335: ozone 57 ppbv  
142530: bright, cloud tops to our level right side, bright blue skies  
142630: right turn, going to 35 kft, can sample start, ozone 34-36, flow 1.78  
1428: very smooth, in bright blue skies above cloud tops, clouds/bubbles big and bright,  
all around  
142910±: big spike on NO  
143130: ozone 37 ppbv, flow 1.78, CO 0.18-0.17, start second can sample  
142320: in cloud pass starts-in/out top of cloud, first bit bumpy then smoother, as go thro  
tops, clear air low NO, in cloud is higher, bright scatter.  
143630: start can sample, still in tops, going "down anvil axis"  
143830: still grazing top, start another can sample  
143930: just at top, bright blue above  
144130: ozone 41 ppbv, CO 0.19-0.21  
144230: almost clear sky to me?, smooth, bright, apparently still at top of anvil  
1444: "can't get out of anvil, will turn south to get clear air" Me: if in anvil then in very  
thin anvil  
144430: out of anvil, start can sample  
1446±: NO<sub>2</sub> switch zero followed by pump zero, also CO zero followed shortly be a cal,  
ozone 43 ppbv  
144730: some bumps, well above clouds to left and right, in clear air  
1448: "we are downwind of anvil in clear air", will go back closer to anvil and spiral  
down  
1452: change of plans? going back into cloud

145320: something strange on CO instrument, recycled power  
1453-1455: we are in clear air, but NO is elevated in bright clear air, are over anvil?  
1456: ozone 43 ppbv, CO 0.16; we are still in lower anvil (doesn't make sense now, but this is what I had on the chart), about 2 min's before spiral, see Jeff's drawing  
1457: start another can sample  
145730: a few bumps  
145850: in cloud top again, out sort of about 30 sec later, then into wisps and bumpy  
150000: ozone 46 ppbv, in wisp, then into thicker cloud/anvil, bright  
1501: bumpy but not bad, starting the spiral down?  
150230: at 34 kft  
1503: start can sample, ozone 45, CO 0.21  
1504: 32 kft, have been seeing some larger NO but not above a ppb  
150430: some bumpiness but not bad  
1506: start another can sample, bright scatter in cloud, fairly smooth  
1508: still spiralling in anvil, quite smooth, quite bright scatter  
150825: ozone 42, CO 0.19, some bumps again  
1509: another can sample at about 28 kft  
150920: NO down quite a bit  
1511: CO 0.14-0.2, ozone 43, quite smooth, still in anvil, bright, about 27 kft  
151420: another can sample  
1515±: CO zero, NO<sub>2</sub> switch zero followed by pump off zero, ozone 38 ppb  
151630: few light bumps, are still in low anvil  
1517: in clear air out of anvil  
1518: can sample in clear air, ozone 42, smooth clear air, bright, clouds below  
1519: going around cloud/storm on outside, get into light cloud parts once in awhile, NO low  
1522: clear air left, heading home  
152430: at 24 kft?, bright skies  
1526±: ozone 44, CO 0.22, then NO<sub>2</sub> switch zero followed by pump off zero  
1530: ozone 45, CO 0.22  
1531: flying in clear air, thin cloud above, solid layer below  
153400: few bumps

153530: duller light, ozone 48, CO 0.22  
1537: 20 kft and descending, coming up to lower cloud layer tops  
153830: bright, are in light cloud, smooth mostly  
1541: ozone 43, CO 0.37-0.38  
1542±: NO<sub>2</sub> switch zero followed by pump off zero, ozone zero is zero, ozone 41 ppb  
1544: still in cloud, bright fog  
1545: ozone 39, CO 0.24-0.25  
1546: still in clouds, 10-15 mins until landing  
154730-4830: bumpy, mostly thro' cloud layer, another one below us  
155340: coming up to lowest level cloud tops, ozone 42 ppbv  
155430: NO<sub>2</sub> switch zero followed by pump off zero  
1555: in cloud  
155730: log closed, going to do a second flight.  
instrument power off about 15 mins for fueling.

### **July 9 - Second Flight**

171438: take off heading for 12 kft  
1719-1930: bumpy  
1720: ozone 36, CO 0.3, 'foogy'like, near tops of lower clouds  
1723: in cloud still, fuzzy, smooth  
1724: ozone 38, NO<sub>2</sub> switch zero followed by pump off zero, start climbing for 23 kft,  
still in cloud  
1728: still in low clouds, "grey" light, ozone 41, CO 0.3  
1730: level, NO starts up some large spikes, some bumps  
1731: ozone 39, CO 0.29, still in cloud  
1733: getting very bumpy, NO is off scale (ie. larger than a ppbv)  
173450: huge spike in NO, over 100 kcps, ozone 44, CO 0.3, "grey bright light"  
173730: still in cloud, but brighter  
173830 brighter, still in clouds  
174030: ozone 47, CO 0.28, still in clouds

174440: NO<sub>2</sub> switch zero followed by pump off zero, "we are north of main storm" (in retrospect, ATC vectored between two storms--July 30 meeting with J. Dye)

1747: smooth flying

1750: start can sample, ozone 48 ppb, still in clouds, relatively smooth

1752 "grey light"

1754: sill in cloud, we have never been out since just after take-off

175530: bumpy, make turn shortly after this

175720: NO<sub>2</sub> switch zero followed by pump off zero

175840: NO getting highe, ozone 45, CO 0.26

1800: brighter, can see some sun left side, NO still high

1802: still in cloud, NO moderate but dropping smooth, 30 kft, bright grey

180230: ozone 43, CO 0.24

1803: start can sample no. 2, going to go to 34 kft and back into storm

1807: ozone 42, CO 0.25, brighter light, NO starts up again

180920: quite bright right side, NO still over 1 ppbv (increase in NO partly sunshine)

181045: seem to be in clear air above clouds mostly

181120: back in top of cloud

181140: bright, smooth

1813: we are in tip of anvil, smooth, bright, NO is quite highe

181325-1814: some bumpiness, NO is over 2 ppbv, O<sub>3</sub> 34, C) 0.22

181445: brighter, almost clear air, NO is down to moderate

181530: going to go to 35 kft for clear air samples

181730: still seem to be in bright fog

181830: CO instrument, flow impeded, well above clouds right side but not left side

182240: we are away from anvil, is off our left, in bright sun, NO<sub>2</sub>zero followed by pump zero, although in clear air-NO increased to about a ppbv, to almost 2 ppb again by 182430. Where are we???? We descended some--likely back into cloud top region, or evaporated region????

1824: going to go to 33 kft to pass thro'

182630: ??apparently crossing anvil, very smooth, bright sun, NO is over 2 ppb

182815: seems to me to be in clear air above anvil???? ozone 35--Jeff-anvil slopes down

1831: bright sun, smooth

182130: still bright sun, but in cloud  
183330: in fuzzy stuff, bright NO still high  
183630: NO has dropped to low, "we are going to 30 kft in search of high blob of nitrogen"  
183830: in cloud, grey--NO has not increase  
184230: nothing down here, anvil may have sunk some, going to see if it is above visible anvil, we start to climb  
184330: ozone 48, CO 0.29--but may not be working properly  
184515: bright sun again, although in light cloud  
184630: we are climbing in a spiral, NO is low  
184930: Jeff says in anvil--but looks like we are above it?????  
1851: "we are above anvil", ozone 42, can sample  
185230: are downwind of anvil--NO has increased starting at 184930, ie. is increasing as climb  
1855: very smooth, climb some more  
185640: NO<sub>2</sub> zero followed by pump zero  
1857-58: start to feel some bumps, NO up even higher--approaching 2 ppb  
185930: nothing but cloud horizon to horizon  
1901: some bumps, light, NO up to moderate and variable, we are waiting for clearance to go higher  
1908: finally clearance to go higher--aiming for 39 kft  
1909: bright sun still, nothing but cloud deck (anvils?) below  
191330: Ryan found loose fitting on grab sample rack manifold--tightened fitting  
1914: 35 kft--we are climbing downwind of storm--NO has remained low  
1915: can sample, ozone 43  
1917: we are still downwind of storm  
191940: ozone 33, NO<sub>2</sub> switch zero followed by pump off zero  
1922: bright blue skies, clouds below everywhere  
1923: descending  
1925: few bumps, light, NO starts increasing as go down, remains large until 1927.  
???At 192630: "in clear air above anvil at 34 kft--if so seeing high NO  
1927: ozone 31 ppbv, can sample collection

193530: still in clear air above anvil or the general horizon to horizon cloud layer/anvils.  
NO is moderate, and variable

193930: broad peak in NO, then falls to low values. Don't know where we are relative  
to storm/clouds

1942: will be penetrating a bubble soon

194330: in cloud, near cloud/anvil tops, bubble

194510: out of cloud, clear air, NO dropped to low

1946: in clear air, storms left and right, we are at 30 kft

1948: ozone 37 ppbv, solid clods below, storm cloud well left

1949-50: can sample, zero on NO<sub>2</sub>, followed by pump off zero

1952: seem to be heading for storm????

1955: are under anvil of storm, thin its the one that was off left side, smooth

195610: in cloud, bumps

1957: still in and descend some more--not seeing any NO

195920: still in cloud, dull grey light, about 23 kft

200040: bumpy

200250: very bumpy, ozone 39

200330: still in cloud, very bumpy, not seeing any NO

2004: smoother, ozone 38 ppb, still descending

200530: descending, very bumpy

200800: still in cloud on descenc, moderate bumps, quite dark, dull dull grey

2010: NO log closed

2013±: NO<sub>2</sub> zero, followed by pump off zero

201520: have broken through clods--still more close to surface, complete overcast above,  
ie. little light

2017: very bumpy on approach to Jeffco

### **July 10 Flight**

1602: moving out of hangar

161300: take off, bright skies with TS's around, e.g. N of Boulder etc, heading for 23 kft



161640: NO<sub>2</sub> zero followed by pump off zero, storm clouds above left side  
1617: bright skies/sun  
161800: in foggy haze, clouds just above, ozone 39 ppbv, CO 0.33  
1619: in brighter skies, just above some scattered low level clouds  
162130: bright with some cloud above left  
1624: ozone 31, CO 0.28, we are heading direct for storm, big storm way off left side  
1628: still climbing since take-off, bright skies, ozone 29 ppb  
1631: ~ 27.5 kft, heading direct for storm, it is not far, scattered cumulus below  
163220: very bright, can see downwind end of anvil out right side  
1633: ozone up to 72, CO 0.32,  
1634: ozone up to 90 then 99 about 40 sec later, then 78 ppb near 1635  
163430: "here we go", on edge of anvil, just below, upwind part of anvil, NO low  
163630: few bumps accompanied by good increase in NO, out from under edge at  
163710, ozone 65, CO 0.27. DID WE CLIMB ABOVE THE HIGH OZONE OR  
WAS IT ASSOCIATED WITH THE STORM???

163730: in clear bright air  
163820: it is only a small storm--it is just left as turn or circle around core?  
163915: NO<sub>2</sub> zero followed by pump off zero  
163950: climbing in cloud a bit--see spike in NO, then in hazy air (ie cloud?)  
164045: in cloud, bumpy, NO up some, out of cloud in about 30 sec, penetrated left of  
main cell  
164230: ozone 70-76, CO 0.29; in clear air below anvil?  
164340: in clear air below anvil, climbing  
164500: 34 kft, climbing to 35 kft  
164535: coming up to cloud, NO starts up to moderate, dull grey in cloud, few bumps--  
1648: ozone 55, CO 0.33 in cloud  
164930: in cloud, turning, ozone 79, CO 0.3  
1650: turning left, appear to be in clear air now???, ozone 67  
1651: back in anvil? if so can see sun  
165220: few bumps, small increase in NO  
1653: still in cloud, NO low, smooth  
1654: climb a bit, smooth, still in cloud, NO low, smooth, ozone 70, CO 0.3

165440: still in cloud, small spike in NO  
165520: ozone 66-67, CO 0.29, must be in low(can't be)and thin part of anvil, can see through to clouds below  
165630: 36 kft, bew bumps, break into clear air, storm and anvil to our left  
165830: ozone 122-117!!!!!!!, at this time seem to be at altitude near or just above top of anvil  
165930: ozone 110-99, spike in NO  
170025: ozone 91, CO 0.26, going into upstream end of anvil at 37 kft  
170050: in cloud, bright, bumpy, only small increase in NO  
1701-1702: in very light cloud, passing a solid bubble off left side  
170225: Ozone 130! 132 at 1703, CO 0.38 (higher), bubble just left  
170350: in cloud, just in at very top, out at 170445, then back in  
170520: chart says out of cloud, if so important because at 170515 NO starts up and surpasses 1 ppb shortly thereafter  
170630: must be near top, quite bright, some bumps  
1708: still in anvil, NO drops  
1709: still in anvil, NO not large, much brighter  
1710: still in  
171050: still in I guess, but can see surface below  
171115: "out"  
1714: seem to be in thin cloud, bright, NO up some, another pass 30 miles downwind of the former pass  
171525: still in, very bright white scatter, ozone 117, CO 0.26  
1718: in clear air, NO dropped  
1720: we are climbing in clear air away from storm, NO2 zero followed by pump zero, ozone 143, ozone zero is 6-7 ppb  
162350: back in cloud, ozone 123, CO 0.27-0.29, NO up some but not large  
162530: ozone 119, bright, must be near top  
162625: brighter still  
162715: still in thin, can see surface below--i.e. almost out, ozone 113, CO 0.26  
1629: sure is a beautiful storm out left and forward, classic shape  
173030: ozone 100, CO 0.17, 0.18 (smaller) out of cloud  
173140: in thin cloud, very smooth, do not see increase in NO until about 1733

1733: cryo out of LN2  
1735: ozone 61, CO 0.27 while in cloud and NO high--note ozone lower, CO higher in the cloud, grey white light  
1736: getting brighter  
173725: mostly out of cloud  
173930: ozone 122 - higher out of cloud; cal CO, NO2 zero followed by pump off zero  
174220: coming up to cloud, but in what I would call clear air--start to see NO up considerably by 1743 while in wispy stuff, bright sun  
174340: in storm but see NO drop, ozone 65, CO 0.31/0.32  
174630: ozone 55, NO still high but drops off by 174710  
174740: ozone 64, CO 0.26, very smooth, dull grey light  
174820: can see surface below on left side  
174855: mostly out of cloud, but a narrow spike in NO  
174930: seems that most of anvil above us--were we in the lower part????  
175320: coming up for pass at 32 kft, ozone 65, CO 0.28/.29  
1755: in cloud, dull grey, no increase in NO  
175630: NO up a bit, mostly smooth, ozone 55, CO 0.27  
175700: getting brighter  
175820: ozone 51, CO 0.30  
175930: ozone 48, CO 0.29  
180030: still in cloud, smooth, grey  
1801: ozone 62, CO 0.25, grey  
1802: duller still, NO drops  
180320: can see surface below, left side  
180420: can see two storm cores off left  
180530: ozone 65, NO2 switch zero followed by pump off zero  
180630: in cloud again, dull grey shortly after  
181000: still in cloud, brighter grey, 29 kft, NO on this pass only up a bit  
1811: ozone 81, CO 0.29  
181230: can see surface below  
181430: ozone 70, CO 0.3, lining up for another pass at 27 kft  
181520: few bumps but not bad

1817: still in cloud, dull grey, only small increase in NO--probably all NO<sub>2</sub>, a short term spike in NO

181835: can see surface left side, ozone 47, CO 0.32

181925: in clear air below anvil-no direct sun

182030: right turn, anvil all above us

182140: dull light

182245: "going to go back into cloud and spiral up"

182320: in cloud, brighter in cloud than when below the anvil, slow ascent

182420: smooth, ozone 67, CO 0.37 (high)

182545: bumps

182620: smooth

182740: dull grey light

182830: spikes in NO

182855: getting brighter

183045: ozone 62, CO 0.36 still in cloud, not exciting re NO

1832: bright grey

183330: ozone 58, CO 0.34, 35 kft, brighter-can see solar disc, NO up some

1835: 36 kft, ozone 56, CO 0.35, larger NO but only about 500 pptv

183600: bright sun, must be near top

183630: quite bright, still in thin cloud, ozone 77, CO 0.35 (have lots more ozone readings about this time--quite variable)

183730: ozone 100, in clear air, direct sun

183820: ozone 85, cloud horizon to horizon again

1839: 39 kft, ozone 97-100 ppbv

1840: ozone 104-122 variable and high

1842: 39 kft, bumps, we are in cirrus or something (anvil??)

184320: ozone 150, now clear of cirrus, bright direct sun

1844: ozone 180 (stratospheric component?)

1845: ozone 160, CO 0.29/0.3

1846: 40.8 kft, ozone down to 59-49

1847: ozone 68

1848: ozone back up to 157, increases to 180 by 1849

1849: NO2 switch zero, then pump off zero  
185130: still clear air above, all direct sun, clouds below horizon to horizon  
1852: "we are heading back along axis of storm/anvil"  
185320: back in cloud, thin cloud, bright, don't know if our original storm  
1854: CO up to 0.37, Ozone 161--going back towards main cell  
185440-1855: ozone 171, CO 0.33, still in thin cloud, right at tops almost clear air, just a little increase in NO  
185545: some bumps, then smooth again  
185625: ozone 195, CO 0.35  
185730: going into tops  
1858: bumps and spike in NO<sub>x</sub> went through "bubble"  
1859: clouds are maybe 200-500 ft below us  
1900: ozone 140  
190030: few bumps, coming up to clouds again, then more bumps and small increase in NO, ozone 90, then 75, 60 etc NO up some while ozone down  
190130: bumps  
1902: ozone 130 then 95, 67 as get into some very bumpy air at 190230, NO up as well while ozone down  
1903: still very bumpy, NO up ozone down to 67. At 190320: smooth and NO drops and ozone up to 115  
190330: bumpy, then smooth, then a bump with small spike in NO--in and out of thin tops, then out of cloud?  
190540: NO<sub>2</sub> zeros, clear air  
1908: in clear air ozone 180 or 80??, CO 0.49 (high?)  
191130: start descent  
191140: ozone 56, have been in clear air for awhile  
181350: ozone 125  
1915: coming down hard and fast  
1916: ozone 30  
1917: bright and clear  
191720: ozone 40  
1918: our storm very nice off left side  
191950: ozone 48, CO 0.37

191840: ~ 15 kft

1923: ozone 45

192630: log closed

192839: touch down

### July 12/96 Flight

- 1612: pulling out of hangar, CO temp = 48.5
- 163000: take off
- 163230: just below lower clouds
- 163330: in hazy clouds, low altitude, cabin very warm
- 163530: still in/out of low level clouds, at 10 kft constant alt
- 1636: dull left, brighter right, still at 10 kft, ozone 41, CO 0.5 but zero was high to start
- 1637: NO<sub>2</sub> zero followed by pump off zero
- 163740: start climbing to 24 kft
- 163840: at tops of low level clouds, big storm left forward and high
- 1639: bright skies
- 1640: ozone 41, CO 0.49
- 164130: dark left side, bright right, CO flow 4.0 volts
- 164140: climbing thro' cloud/storm??????
- 1644: cabin warm, ozone 40, CO 0.47, still climbing through cloud, bright grey light, ~  
20 kft
- 164445: break in/out of cloud, under anvil???? to left
- 164520: circling storm, another in front and left
- 164750: at 23 kft, ozone 47
- 164825: NO<sub>2</sub> switch zero followed by pump off zero
- 164930: dark--close to storm left and front, bright right side
- 165030: start can sample, cabin still very warm
- 165120: in cloud, lower part of anvil?, bright grey, start to see increase in NO--eaks  
about 1653, quite variable or spikey, ozone 41, CO 0.46
- 1653: ozone 43, NO up, NO<sub>2</sub> also way up
- 165330±: just had lightning flash
- 1654: smooth flying in cloud
- 1655: CO 0.45, ozone 36, quite dull grey
- 165540: few bumps,
- 165620: can see surface below, ie breaking out, NO and NO<sub>2</sub> dropped off, start second  
can sample
- 1657: on north side of anvil in clear air, bright but no direct sun as it is blocked by anvil

165822: turning, shortly after an NO<sub>2</sub> switch then pump zero  
1659: third can sample start  
170010: back in cloud???, can still see surface but barely  
1602: quite bright scattered light, smooth, starting to spiral up, NO is up but just a bit  
1703: ozone 40, CO 0.43, smooth, bright scatter, still in cloud/storm  
1704: CHILL estimates storm top at 50 kft  
170430: bright--are we spiralling up on the edge????  
1705: start another can sample, at about 27 kft, bright  
1707: smooth flying, ozone 43, CO 0.44  
17080: Jeff says he thinks we are about 20 mi downwind of the core, quite bright light  
171020: another can sample start, ozone 43, CO 0.47  
1712: quite bright scatter, ozone 42, CO 0.45, NO is increasing  
171250: few bumps, at about 32 kft, still in spiral, NO is up moderately  
171345: ozone 42, CO 0.45  
171410: some bumps, bright scatter  
171530: getting even brighter, can see sun disc thro', right side, ozone 41, CO 0.45, NO  
up moderate  
171730: brighter  
171830: CO temp = 48.6, ozone 41, CO 0.45, still in  
1720: at ~ 35 kft, almost direct sun, i.e., near top???? How can we be near top of anvil  
only 20 miles from core, if radar says top at 50 kft?????  
172040: CO 0.45, ozone 42--has changed very little on ascent  
1723: still in cloud, ozone 40, CO 0.46, filled LN<sub>2</sub> on cryo, quite bright  
172505: are out of anvil, smooth, bright blue above, all can see is cloud below (horizon  
to horizon?), Ozone 38  
172630: NO<sub>2</sub> switch and then pump off zero  
172940: bright blue with very white clouds below (ie anvil), ozone 46, CO in zero mode  
~ 0.37  
173015: few bumps, anvil wisps off left  
1731: "coming into some anvil" NO up in spikes  
173150: heading west, bumpy, in thin stuff at anvil top, NO up and spikey  
173240: bright grey, in anvil again



173330: few bumps  
173420: bumpy, ozone 39, CO 0.44, very bright, just in top,  
173500: into clear air, clouds all below  
1736: turning right, core bubble top of our storm is just left  
173630: another storm way left and front  
173720: ozone 43, down to 33 about 20 seconds later, CO 0.44  
1739: in clear air still, very bright, direct sun, we are above anvil  
1740±: NO<sub>2</sub> switch zero followed by pup zero  
174100: still in bright clear air above anvil, two other storms way left  
1742: 60 hz power problems start about this time  
1752: running ozone, luminols, NO, CO off due to power problem  
1754: descending a bit, clear to surface left side--ie no anvil, clouds below  
1756: still in bright blue sky, going to do cuts through the anvil  
175650: few bumps--in clear air????  
175730: ozone 32  
175830: coming up to anvil at 35 kft  
175920: in storm, NO increased rapidly to over 1 ppbv  
1801: very bright scatter, smooth, few little bumps, ozone 39  
1803: bright scatter  
180350: ozone 38  
180500: in very thin cloud, breaking thro' other side, NO down but not low, still see wisps, crystal  
1806: direct sun, are out, cloud below, but NO is still relatively high (moderate)  
1807: ozone 37, going down to 33 kft  
180730: we are in cloud particle again, NO up shortly after to about a ppbv  
1809: still in cloud, bright scatter  
181100: ozone 40, bright scatter, can see solar disc, few bumps  
181150: smooth, NO dropping  
181330: can sample (should have gotten a bit earlier), out of cloud mostly  
1815: still in a bit of cloud or not ?????  
181550: direct sun  
181630: looks like clear air but are we still in cloud particles??

1817: ozone 37, can see surface below through fuzz, NO up, direct sun???are we in storm or not???????

181800: NO down to low

1819: going to take clear air can sample, ozone 31

1820: descend in clear air, bright sun

182120: good view of our storm off left, clear to surface below, but low level clouds left side

1823: still in clear air, approaching our storm at 31 kft, NO<sub>2</sub> switch followed by pump zero

182640: back in cloud, bright, NO up, Ozone 35 just on edge

182830: deeper in cloud, NO up ozone 40, still very bright scatter, can see sun disc, smooth

182940: start can sample

183040: bright, ozone 39

183100: NO off first scale

1831: still in cloud, very bright scatter, ozone 39

183330: still smooth flying, still in storm

183520: still in, NO around 1ppbv, variable

1836: NO off first scale again

1837: Jeff says we are out of anvil, NO moderate, might we still be in cloud remnants????

183750: turning around, can sample start.

183855: back in storm as descend some--heading for 27 kft???--NO high then moderate

1840: ozone 39

184130: still in cloud, smooth, can look at solar disc thro' anvil, is duller than previous passes, bright grey

184230: ozone 40, NO dropping to low but NO<sub>2</sub> still high, then NO back up strongly again to over 1 ppb

184335: NO down to low, NO<sub>2</sub> also to 0.25, by 184330 coming out of storm, direct bright sun

184445: could still be in very thin cloud

1846: ozone 39, climbing in cloud again but little change in NO, bright sun right side--are we really in cloud/storm?????

1848: "climbing to 31 kft" might be in very thin anvil cloud???

184920: right turn

1850: ozone 37, heading west along axis, in evaporated anvil?????

185120: looks like in cloud left side, clear right side, NO is up a bit

185140: "get ready for rough ride", ozone 36

185225: in cloud wisps, corresponding large increase in NO

1853: in cloudstill, grey, NO up above 1 ppbv, high NO<sub>2</sub> also-few bumps but really quite smooth

185420: bright grey--getting waves in NO data

1856: NO moderate, NO<sub>2</sub> 0.4

1857: getting much brighter, few bumps, start can sample

185730: almost direct sun right side

185825: not completely out of cloud yet, turn, ozone 29

1859: ozone 26

185930: "coming up to our storm again, back in cloud--no NO change (appears to be wrong re in cloud)

190040: looks like in cloud on left side but not right side, NO<sub>2</sub> 0.1

190125: now in the storm, NO up

190220: grey light

190245: brighter and increasing brightness

1903: few light bumps

190325: appear out on right side, close to cloud on left side

1904: in clear air but storm is just off left side

190530: in clear air--but our storm is just off left

190620: "we are over CHILL or close", another beautiful storm at 11 o'clock

190830: asked for straight and level for calcs, but could not get, we are descending

191030: ozone 25, NO<sub>2</sub> switch zero followed by pump zero

191250: bumps, into some cloud tops, bright

191330: descending on way home--coming up to lower cloud tops, bumps expected

191520: very bumpy, grey light

1917: still descending, puffy very pretty, lots of low level cumulus about

191820: another storm just 20 mi or so left in amongst cumulus

1919: in clds/out  
191930 very bumpy until 192020, grey light  
192130: dull in the clouds, clouds above and scattered, etc  
192230: ozone 37  
1925: log closed  
1926: NO2 switch then pump zero  
192757: touchdown

### July 13/96 Flight

1500: pulling out of hangar, CO temp is 47.1  
151130: CO pumps connected  
1514: "lightning has saturated the interferometer"  
151542: take off, bright sun, higher clouds about, will climb to 8 kft  
1519: very hazy at our altitude-water haze???  
152015: in/out of clouds  
152130: cabin very warm, we are near base of lower clouds, in/out  
152220: ozone 45  
1523: leaving 8 for 15, climbing throu clouds  
152340: very bumpy--see spike in NO-convection  
1524: in clouds, very bumpy, CO 0.68, ozone 40  
1525: still in clouds, very bumpy, dull grey, bumps continue until 152630, then smooth  
152630: in clearer air, large high clouds above, no direct sun  
152745: in thick cloud, dull grey, ozone 38  
152840: still in cloud, then NO2 switch followed by pump zeros  
153009: larger short term spikes in NO, climbing to 23 kft  
1531: still in clouds, smoother  
1532: level flight  
1533: cabin very warm, still in cloud, dull grey  
1534: CO temp is 51.1  
1536: in clear air below anvil, no direct sun  
153730 "going to go in under anvil", can see surface below, ozone 46

1539: start can sample, dull grey, in fuzz etc, no increase in NO  
1540: ozone 33, CO 0.57  
154045: NO2 0.35, gues we are passing under anvil in clouds???  
1542: NO starts up bu tnever very large, NO2 to 0.67, light bumps, bright grey light  
1544: bright grey, ozone 37, we are at 23 kft and have been for a while  
154425: ozone 37  
154530: bumpy, NO up, start can sample  
154620: start spiral up through anvil, NO high and variable  
154730: bright grey, ozone 45, CO 0.47  
1548: at 24.5 kft, smooth to light bups NO to 1 ppbv but lots of variability  
155030: at 27 kft, still in sprial, ozone 37, CO 0.48  
155130: brighter still, quite bright  
1552: NO over a ppbv, 28 kft  
1553: ozone 41, few bumps,  
155400: at 29 kft, bright scattered light  
155530: at 30 kft, still in spiral, NO over 1 ppbv  
155730: 31 kft, still in, few bumps, NO still over a ppbv  
155840: ozone 43, CO 0.49, bright scattered light  
1600: at 32.7 kft, still in spiral, NO over a ppbv  
160125: **lost 60 hz power**  
1609: back on line in measure mode, at 34 kft, bright scatter,  
1610: NO has dropped off  
161130: ozone 42  
161230: unbelievable, we are going to another storm that the P3 is working, we never  
finished the first storm????????!!!!!!!!!!!!!!  
1615±: working on can sample pump so no notes--lines frozen up--have to change can  
sample inlet  
1623: very bumpy,  
1624: clear air left side, still working on can sampler  
1628: "ok, can sampler venting to cabin"  
162930: NO2 switch then pump zeros

163000: in clear air, puffy cumulus just left and to about same altitude, are at 35 kft and have been since about 1625

163230: direct sun, has been awhile--then we see some large increase in NO to over 1 ppbv--think in clear air--if so very important--are we approaching another storm--from what direction/winds???

163450: coming up to second storm anvil (NO has been around 1 ppbv)

163520: bright, can look at solar disc (NO high but not as high)

1636: NO up to 1.5-2 ppbv

163730: **Ryan and I though lightning hit the airplane (thump and flash)--not so**

163940: NO has dropped to low

1641: out, can see surface, we are out of anvil, but also anvil above us

1643-164430: **interesting spike in NO to about a ppbv, clear air left, bright sun?????, ozone 41**

1645: seem to be in cloud, but NO remains low, going to 39 kft

1646: "cirrus all over, hard to find anvil"

1647: don't know where we are relative to storm, but large increase in NO to over 1 ppbv and remains high

1649: bright scatter, smooth, ozone 52

165025: 39 kft, in cloud, ozone 45

1652: still in, NO dropping, ozone 45

1653: NO2 switch then pump zero

1655: don't know if still in anvil, still in cloud, cloud everywhere, NO low

165545: bumpy, NO low

165625: going to go to 41 kft

1657: can see patches of blue sky left, but cloud/cirrus/anvil just above us??

1658: in clear air????, ozone 28 ppb at 165820

165900: bright sun to very bright scatter

170020: "we are back in cloud/storm"

170230: clearer air but still appear to be cloud particles around

170330: ozone 50, start can sample, bright, NO just went up

170600 very bright

170625: out of anvil, blue sky, cloud just below horizon to horizon

1707: bumpy

170810: quite bumpy clear air  
170920: still quite bumpy, ozone 55, start or take can sample, direct sun plus albedo  
from clouds below  
170950: NO2 switch then pump off zero  
171250: cal NOstart, we are still in clear air, bright sun plus albedo, at 41 kft  
171845: can was supposed to be in clear air, but a bit late as just started spiral descent  
through anvil from 41 kft, ozone 36,  
171910: we are in anvil I guess?????, but no increase in NO  
172030: start to see some no increase at 39 kft  
1722: bright scatter, ozone 34  
172320: 36.5 kft  
1725: Jeff balancing dew pt, NO is just under a ppbv  
1726: 34.5 kft  
172630: ozone 45, fairly bright scatter, NO just under a ppbv  
172820: ozone 46, NO over a ppbv  
1729: smooth, bright grey  
172930: ozone 41-42  
173030: 30.5 kft, NO still high  
173120: grey, ozone 44, coming up to 29 kft  
173230: grey  
173430: ozone 45, NO dropping, NO2 0.8-0.9, smooth, near 26 kft  
1736: NO2 0.63, ozone 42, then NO2 up to 0.9 while NO also up a bit (still low)  
1737: bumpy  
173730: NO2 0.8-0.9, ozone 46, coming up to 24 kft, dull grey  
173830: NO2 1.0-0.9, stay at 24 kft for couple of minutes  
173930: NO2 0.5, ozone 39, grey  
174030: can see cumulus, bright, forward--breaking out  
174210: big storm just left are descending again  
174350: NO2 switch then pump zero  
1755: gright sun, clear to surface, scattered cumulus and storms  
1747: big storm left rear, we are above cloud base  
1750: bright sunny, beautiful skies

175230: passing over Stapleton, starting to get bumpy

175530: on approach

175640: log closed

175920: touchdown

### **July 15/96 Flight**

1600: pulling out of hangar

161620: take off

1619: ozone 40, NO<sub>2</sub> switch then pump off zero, going to 12kft, some direct sun, lots clouds around and above

1622: in bright sun, clear air, ozone 38,

1623: climbing to 23 kft, in bright sun

1626: still bright sun, clear air

1628: still in bright sun, clear above-higher cloud way left and way right, ozone 35, NO<sub>2</sub> switch followed by pump off zero

1630: 21 kft, ATC won't let us go higher yet, ozone 42 ppbv

1632-33: Jeff balancing water

1634: still in bright clear skies, big storms off at 10-11 o'clock, ozone 43

163520: turning right, has been very smooth whole flight, so far

1636: can sample start

163730: ozone 42, NO<sub>2</sub> switch then pump off zero

164015: still in very bright skies, clear air, ozone 42

1643: still flyin around in bright blue, big storms at 10-11 o'clock, ozone 39

1645: ATC won't let us go to storm, we are over Greely

1647: looks like may be heading to storm

164820: NO<sub>2</sub> switch then pump zero

164920: ozone 43

1650: can sample, still in bright blue, clear skies

165110: "hyge storm direct ahead"



1652: big anvil-widespread at 10-11 o'clock  
165230-165310: in and out of cloud, another big storm at 3 o'clock  
1654: we are descending to go below storm base  
165440: ozone 39, bright, direct sun still, big puffy cumulus just right, part of the storm  
165530: bumps  
165610: we are bit below or very near base of fairweather clouds, bumpy  
1659: at 10.7 kft, not far below base altitude  
170000: cloud of course above, but bright light, ozone 38  
1701: can sample, dull towards right, bright to left, below base of storm (edge) may be in  
rain shaft off left side  
170220: cloud/storm base quite dark colour, ozone 38  
174330: still below base, quite dark/dull light now  
1704: turning left, Jeff "buckle down"  
170430: bright left, dull right, relatively smooth flying  
170520: ozone 37, rain shaft very dark off right side  
170545: brighter sky, closer to edge of storm base  
170610 very large rain shaft (I do not say which side??)  
170630: some direct sun, bright sun left (see NO up a bit with sunlight)  
170720: left turn, bumpy  
170930: we are away from edge of base of storm in bright cloudy skies, just before this  
an NO<sub>2</sub> switch then pump off zero, ozone 37 ppb (little change from below base)  
1711: it is quite a storm, lots of dark rain? below, large  
171140: climbing in clear air, direct sun, bright, etc  
171330: still climbing in bright sun, clear air/skies, big convective parts of cloud/storm  
just left, gorgeous  
1715: ozone 37  
1717: still climbing in clear air next to storm  
1718: ozone 43  
171840: ozone has just jumped to 52, near 24 kft heading for 25  
1721: few bumps, cloud/storm just left, we are in very bright skies  
172200: can sample, ozone 52, left wing just in puffy cumulus, 172230: bump as in/out  
of cloud, corresponding small spike in NO

1723: we have not really been in the storm cloud yet except for item just above  
1724: bright/direct sun skies  
1725: ozone 50, still in clear air near edge of storm, very bright  
1727: we are just above some of puffy cumulus on side of storm, at 29 kft, ATC won't let us go higher  
1729: ozone 47  
173045: on edge (right side) of strom, anvil outflow above us, ozone 51  
173130: all grey right side, clear left with anvil above us  
1732: slight left turn away from storm, climbing  
173410: in anvil-bottom-can still see puffy cumulus below-no increase in NO, bright  
173515: out of anvil????-i.e., clear view to cumulus below  
173540: sun disc through cloud straight off right side  
173645: ozone 50, clear skies right, storm left  
173830: ozone 52  
173910: **fairly sharp NO spike about 15 sec wide, to 500-700 pptv--as trun away from storm---???clear air spike??????**  
1740: ozone 49, bright sun, mostly clear skies  
174230: dull bright right side, puffy cumulus just below  
1744±15: in cloud/strom short time-very rough ride, NO up a little  
174420: mostly out or on edge again  
174500: puffy tower to our level just left, we are under anivl, no direct sun  
1747: clear air I think, ozone 48, at 28 kft  
174840: clear right side view to surface, cloud(s) above both side  
175030: very bright sky, don't know why we are not climbing through anvil--Jeff: ATC won' allow  
175145: are in very bright sky, storm off our left wing  
1753: ozone 50  
1755: still in very bright skies, NO is has been very small, really boring courtesy of ATC  
175630: ozone 48, on edge of storm, NO sitll low  
1758: ATC still will not allow a climb  
180000: anvil clouds just left, still on upwind side

180100: ozone 46-56 variable, in cloud, grey bright--see strong spikes in NO to over 1 ppbv--ie. there is lots in the storm, if only we could get into it, 170150: out again, as out mamma clouds just left-can see to surface

180230: at 29 kft

180330: back in cloud for short time--large increase in NO

180400: ozone 56-60, still in cloud??? if so can see to surface and NO has dropped

180440: ??in anvil, will climb to 33 kft

180520: ozone 49, NO small

1806-180630: few bumps, NO up to just under ppbv but spikey, bright grey

180710: 31 kft

180820: ozone 57, NO up quite a bit to almost a ppbv, NO2 0.4, bright grey

181000: can sample, NO is dropping, NO2 0.39

1811: ozone 58, NO small again

181150: out of cloud, into bright skies, ozone 55, we descended some as out

1813: "will be at this altitude for 10 min--heading home"

182130: just after start descending, ozone 47

182230: hazy left, but in clear skies, bright direct sun with lots of low clouds right side, clearer left

1824: 23.5 kft, ozone 43-47

1827: 17.5 kft, ozone 37

1829: bright skies

1831: ozone 40

1833 ozone 41

1834 hazy scatterd light by clouds, no direct sun

183520: NO2 switch then pump off zero

1838: 8 kft, clouds overhead

183930: ozone 42

1842: NO2 1.55

184230: ozone 50, NO2 0.63

1844 NO2 0.4, ozone 42

**July 16/96 Flight 1 Intercomparison with p3 on its way to Florida**

1140: pulling out of hangar, CO temp is 51 C  
115610: take off, heading for 15 kft  
115630: bumpy, ozone 39, CO 0.22  
120000: bright/sunny left side, more clouds on right side, ozone 40, NO2 0.23, Co 0.32  
1202: bright sun, ozone 40, no2 .23, CO 0.33  
1204: level at 15 kft?, ozone 39, no2 0.20, CO 0.32  
1206: Jeff balancing water inst.  
1208: hazy below left side and right  
1210: very bright, few scattered clouds, still at 15 kft, ozone 39, no2 0.2, co 0.36  
1212: very hazy left and right, we appear to be above haze, CN 1700/cc  
171330: very bright skies, ozone 36, no2 0.19, co0.35  
1716: are descending, P3 want to do first leg at 9.5 kft--do as they say!!!!  
121730: CN 2300, ozone 41, no2 0.22, co 0.38  
1220: at 9.5 k, CN was off scale, by 122040 CN at 7200, no2 0.31, ozone 42  
122230: no2 zeros, P3 farther away this time and behind left side  
1224: ozone 41-42, no2 0.26, co 0.38, cn 2600  
1226: P3 farther behind, P3 seems to be a bit higher than we are  
1228000: ozone 43, no2 0.23, cn 2300, co 0.37  
1229: P3 now closer like last time, very bright skies  
123030: climbing to 13.5 kft, NO2 zeros  
123340: at 13.5 kft , very smooth, bright sunny  
123430: no2 switch, then pump off zero  
123530: cn 1750  
1237: ozone 34, cn 1990, no2 0.37, co 0.37. P3 is nicely close and just behind  
1240: asked Jeff to ask P3 to do low alt leg 500-100 AGL so we might see some higher  
NOx  
1242: still at 13.5 kft, vderly bright skies, ozone 35, co 0.38, cn 2200, no2 0.31  
1243: P3 is closer still, very smooth and has been  
1245: no clouds abuve us in this area, hazy below  
1246: ozone 34, cn 2150, co (zero) 0.27, NO2 switch then pump zero  
124830: ozone 34, co 0.42, no2 0.13, cn 2200

125130: P3 has been on right side for a while  
1253: descending to 1 kft AGL, we are over farmland as usual  
1256: still descending, ozone 59, co 0.4, no2 0.22, cn 1300  
1258: starting to get bumpy, CN is up  
1300: level flight, cabin warm, bumpy  
130130: no2 zeros  
1304: ozone 59, CO 0.4, NO2 0.42, cn off scale  
130630: not as bumpy, NO2 zeros  
130730: climbing  
1310: filled dry ice on CO inst, ozone 67, co 0.43, no2 0.13, cn 1200  
1312: no2 0.08, ozone 49, co 0.44, cn 1700  
131330: no2 0.01, co 0.44, ozone 40  
1315: ozone 45, co 0.42, cn 0.9???, no2 0.03 to -0.03 (during switch then pump zero)  
1316: at 21 kft heading for 26  
1318: CO temp 51.7, cabin is cooling off, ozone 65, cn 1400, no2 .15, co (zero mode)  
0.36-0.37  
1320 clear, very bright skies  
1321: at 26 kft for a while, no2 switch then pump zero  
1323: calcs on NO and CO start  
1327: ozone 69, no2 0.24, cn 2000, CO cal 0.58-0.59  
133020: ozone 58, co 0.39, no2 0.18, cn 1600  
1333: no2 switch then pump zeros  
133630: ozone 60, co 0.38, no2 0.20  
133820: right turn  
1340: ozone zero = 12 (**high**), NO2 switch and pump zeros  
1341: some small bumps and small peaks in NO, co zero is now 0.27  
134230: big storm is on left side, but it is south of Denver, some cirrus clouds not far  
above us, ozone 57, no2 0.18, cn small  
1344: near thin cirrus just above (streaks)  
1346: clouds just to our level  
134640: cirrus just above or at our level right side  
134830: some light bumps and corresponding very small spikes in NO

134930: ozone 41, co 0.35, no2 0.18  
1351: are some clouds not far below now as approach Denver, few seconds later tops are just below us  
1352-53: in/out of cloud layer, turn, see nothing on NO, start descending--i.e. we pass through cloud layer on descent  
1356: cumulus clouds, fairweather, left side tops well below us  
1357: CO temp is 48.7, ozone 44, co 0.36, no2 0.1, then NO2 zeros  
1358: we are below cloud layer, no direct sun, but is bright  
140050: in/out of clouds, almost back to Jeffco-clouds from/against foothills, still very bright  
140225: incloud, bright white--some increase (small) in NO, ozone 48  
1305, on descent still, bright sies, direct sun, scattered clouds  
140630, on descent, DIA off left wing, ozone 49, co 0.40, no2 0.23  
1408: almost complete cloud above us now (have descended thro"), getting bumpy  
141030: log closed  
141640: touchdown

### July 16/96 Flight 2

1450± power back on  
1522: CO temperature 53.9  
1545: cabin very warm CO temp 56.1  
154730: still taxiing, Co zero is 0.6 (v. high), NO2 switch then pump off zero  
155047: take off, cabin very warm  
1553: bumpy, scattered clouds, bright sun  
1554: start of large spike in NO, lasts until 155425, off scale  
1555: ozone 55, co 0.88, no2 1.3  
155740: ozone 42, no2 0.049, co 0.82  
1559: Jeff attending to water inst.  
160020: ozone 56 (zero is about 16), co 0.82 (zero is about 0.6), no2 0.057  
1601: no2 switch zero (-0.22), pump off zero (-0.22 to -0.23)

1603: scattered clouds, very bright, we are at an altitude just below base of fairweather cumulus (big long water reservoir left against foothills)

160450: ozone 61-63, co 0.86, no2 0.071, storm ahead and bit right, we are near 13 kft

160650: very bright left side, dark right side and below, skirting edge of base of storm

160800: dark, just below base, no2 1.04, ozone 66, small increase in NO

160850: bright sun, gap in base, NO up in response, CO 0.91 (higher), NO higher below base than in external air, so is NO2

160910: bright left side, no2 1.2

160930: few bumps, few seconds later, not under base any more

161020: no2 0.5-0.6, ozone 69 minus 16

161030: our storm is just left

161140: no2 0.76, ozone 67-16

1612: below base again, dark, note; in both passes we are just below base (few hundred feet or less??)

1613: gettin brighter, turning left, 161340: still below cloud, circling

161420: slight right turn, no2 0.81, co 0.86 minus 0.6, ozone 69 minus 16

1615: comin up to brighter air,

161530: darker right side, almost direct sun on left side

1616: outside of base of storm

161630: descending for lower altitude pass below storm

161720: Jeff says we are over a coal fired power plant

161810: large spike in NO, in bright sun (is it from the plant???????)

161940: no2 0.37, ozone 66 minus 16, CO 0.88 minus 0.6 or so

162030: spiralling up outside of cloud, bright, on upwind or north side

162240: NO2 switch then pump zero

162335: I do not see anvil, just puffy bubbles, storm is just left, NO2 0.01, co 0.73 minus 0.6, ozone 62 minus 16

162520: 19 kft, looks to me like a developing storm

162640: ozone inst zero is up to 20 now.

162730: we are in bright and direct sun, clear skies still, storm now left side

162830: no2 switch zero is -.25, pump off zero is 0.26, cabin is quite warm, CO temp 56.6

163030: in bright, direct sun

1631: ozone 62 minus 20, co 0.84 minus 0.6 or more, no2 -0.060????, storm direct ahead

163210: in storm, small increase in NO, bright white scatter, ozone 62 minus 20, no2 0.2, co 0.9 minus 0.6 or so

163330±: out of storm into brights sunny clear skies, storm is close left side at 163410

163515: approach then in storm, NO up only a bit, not very bumpy at all, by 162610 out into clear bright air, 1637: storm just left--i.e.--very short passes--developing storm????, we are climbing now

163810: climbing, back into storm at 163810, bright grey, large increases and variable NO, out of storm at 163945 into bright sun, by end of pass at 24 kft

164030: no2 minus 0.07, co 0.84 minus ?, ozone 59 minus 20

1641: back in edge of storm, bright scatter, not very bumpy at all, strong increase in NO by 164145 ( at about 27 kft) and spike continues as we climb until 164300. We remain in storm but NO drops off, quite bright scattered light

We are spiralling up thro anvil

164410: bumpy

1645: bright, bumpy, no2 0.26, ozone 68 minus 20, CO 0.9 minus at least 0.6

1646: still in storm, bright scatter, NO moderate

1647: at 31 kft, still in, only small bumps, NO low

164730: getting even brighter scatter, still in, small bumps

1648: still in and climbing, NO small to moderate, no2 0.22

1649: 32 kft, NO is up and variable, very bright scattered light

164955: out of storm at about 32.5 kft?, NO dropped quickly, highest NO near cloud top

165155: back into cloud, NO up, at 33 kft, "cloud top is still above us", smooth, very bright

165245: ozone 71 minus 20, no2 0.34, co 0.9 minus 0.6?

165330: are still in cloud, cabin very warm??????

165510: out of cloud, clear sky right side, then back in/out, or into cloud wisps etc--still seeing enhance NO

165640: out of cloud, are above top or just at top, at 35 kft

170000: in thin stuff, "descend a bit (did not) to go along axis of storm"

1701: no2 0.29, ozone 81 minus 22 (now)

170140: over edge of anvil, not middle

170210: clear to surface right side, ozone 85 minus 22



170240: not over middle of anvil, barely over edge, bright and direct sun

1705: Jeff says in evaporated anvil. Mostly clear air, can see surface below left, wisps once in awhile, NO unremarkable if really evaporated anvil

1708: **start spiral down, well downwind of visible anvil**

170945: no2 is -0.02, ozone is 71 minus 22, in bright clear skies, can see right to surface (i.e. few clouds below)

1711: about 30 kft

1713: about 27 kft--not seeing any high NO, big storm at 11 o'clock (ours????)

1714: about 25 kft, ozone 62 minus 22, NO2 -0.11, co 0.75 minus about 0.6

1716: getting back closer to our storm at about 25 kft, have been at 25 since 171430

1717: under anvil, still bright

171730: very near cloud, probably in it

1718: NO2 switch zero is -0.34, pump off zero is -0.32

171840: slight right turn

1771950: looks like in thicker cloud left side, shortly after light is grey

172045: bumpy and stays bumpy thro' 172130, still in, not much NO  
we are apparently going towards the core in lower part of the anvil at 25 kft

172245: getting brighter

172330: bright scattered light, smoothish

1724: mostly out left side, still grey white light right side

172425: bright sun

172530: turning, no2 -0.05, ozone 71 minus 22, leaving 25 kft for 28 kft and will reverse course in anvil

172630: in direct sun, storm is behind us

172845: approaching storm, then into thin stuff

1729: in cloud, no2 0.36, ozone 70 minus 22, co 0.8 minus 0.6 or so

172930: still in at 28 kft--aw large increase in NO for a bit then dropped off

173030: smooth and has been, bright grey, can see sun disc, NO2 0.14

173110: few bumps and NO up some, stays that way until 1732 when exit. It is not a big storm, we are doing perpendicular passes now

1733: clear to surface left side, climb a bit to 29 kft

1735: in bright clear skies

173530: coming up to cloud again, climbing to 31 kft  
173630: bright clear right, cloud left  
173708: in edge, then few seconds later a few bumps, small  
173830: still in, bright scatter  
173945: mostly out of cloud-yes  
174030: clear and bright left, storm right  
1741: turning right towards storm  
174130: in cloud, no2 0.23, ozone 72 minus 22, climbin a bit in cloud  
174245: in this pass can see low clouds below  
1743: mostly out and at about 33 kft  
174340: in cirrus type stuff, but bright sun left side  
174430: wisps, -near top on right side???, then a right turn  
174540: in cloud wisps, ozone 69 minus 20, CO 0.65 minus ?, NO2 0.256  
174620: in wisps/thin top  
1748: descent starts, into cloud top shortly after, bright scattered light  
175010: bumps, spiralling down thro', no2 0.17, NO is low  
175120: ozone 65 minus 22, CO 0.75 minus?, 31 kft, grey, NO2 0.15  
175230: some small increases in NO, about 30 kft, bright scatter, can see solar disc at  
10-11 o'clock  
1753: sun elevation is about even with left wing, no2 0.15, ozone 65 minus 22, co 0.77  
minus ?  
175330: bright, ozone zero is now 19  
175440: fast descent  
175530: mostly out, see clouds and surface below  
1756: no2 switch zero is -0.34, pump off zero is -0.35  
1758: puffy cumuls tops just below us left and right, we are heading for 10 kft  
175930: passing thro clouds (low level clouds)  
180240: in bright skies, few to zero clouds overhead  
180430: bumpy, at 10 kft, have been at 10 since about 1801  
1805: ozone 60 minus 19, no2 -0.05, then switch zero is 0.33 pump off zero is -0.35  
1808: CO temp is 49.6, ozone 61 minus 19, no2 -0.021, CO 0.82 minus?  
1814: no2 0.32, ozone 68 minus 19

1819: log closed

182030: no2 switch and then pump zero

182225: touch down