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A Balloon-Borne Integrating Nephelometer

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A BALLOON-BORNE INTEGRATING NEPHELOMETER

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September 1990

ABSTRACT

A balloon-borne integrating nephelometer has been sucessfully developed and flown by Sandia National Laboratories and Radiance Research. This report details instrument design, calibration and data conversion procedure. Free and tethered balloon transport and telemetry systems are described. Data taken during March 1989 South-central New Mexico free flight ascents are presented as vertical profiles of atmospheric particle scattering coefficient, temperature and balloon heading. Data taken during December 1989 Albuquerque, New Mexico tethered flights are also presented as vertical profiles. Data analysis shows superior instrument performance.

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ACKNOWLEDGEMENTS

We are thankful to Dr. Dennis Garvey of the Army Atmospheric Sciences Lab for his generous help in funding the balloon-borne nephelometer development. We recognize the efforts of Chuck Keady in asssisting with logistic problems encountered during field tests. We also acknowledge the encouragement and assistance of Dr. Bernard Zak in his role as Applied Atmospheric Research Program Coordinator.

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1.0 INTRODUCTION

Need for light weight, low power, low cost, expendable aerosol spectrometer, utilizing a balloon lift system, was identified by the Applied Atmospheric Research Group at Sandia National Labs. A high altitude, low concentration aerosol spectrometer was designed and successfully flown by Brown and Weiss (1990). The aerosol spectrometer development led directly to the design of a balloon-borne integrating nephelometer sufficiently sensitive to measure scattering coefficient profiles to high altitudes. Balloon-borne integrating nephelometer development was funded by the Army Atmospheric Sciences Lab of White Sands Missle Range, NM.

System free flight tests (non-tethered expansible 3000 g balloon system) were conducted in the Alamogordo, NM area in March 1989. The balloon telemetry system transmitted temperature, pressure, relative humidity and aerosol scattering data from 1280 m MSL (surface) to approximately 7,000 m MSL.

System tethered flight tests (7 m^3 aerodynamic balloon system) were conducted in the Albuquerque, NM area in December 1989. Balloon system telemetry included the same variables as the free flight system with the addition of wind direction. Data were collected between the surface and 150 m AGL during a mild air pollution episode.

The purpose of the balloon-borne nephelometer flight program was to test and evaluate instrument response throughout the expected environmental extremes found between the surface and 10,000 m. Instrument response to a wide range of aerosol concentrations was also evaluated.

This report describes the balloon-borne integrating nephelometer design and the free and tethered balloon systems. Collected data are presented in plots and tables, and instrument performance is evaluated.

2.0 NEPHELOMETER DESIGN

2.1 Specific Characteristics

The balloon-borne integrating nephelometer is a continuous monitoring instrument which measures extinction coefficient of atmospheric gases and aerosols by light scattering (Buettel and Brewer, 1949). The instrument integrates over scattering angle and measures light scattered from approximately 10° to 170° solid angle. The spectral response is centered near 475 nm, similar to commercial flashlamp nephelometers. Instrument background is at or below air Rayleigh, allowing for sensitive measurement of scattering coefficient.

The balloon-borne nephelometer is designed to operate from ground level to a minimum altitude of 20,000 m MSL, weighs 1500 g, and uses less than 300 ma of current at 9 vdc. Scattering coefficient measurement sensitivity is a fraction of air Rayleigh with 10 second averaging.

2.2 Optical Assembly

The scattering chamber is a 500 cm^3 plastic box with 3.75 cm diameter inlet/outlet tubes. A photomultiplier tube (PMT) is located at one end of a 3 cm diameter aluminum tube looking through the scattering chamber into a light trap at

the opposite end. The PMT field of view is defined by a series of collimating apertures located along the axis of the connecting tube. Overall length of the optical assembly is approximately 50 cm (Fig. 1).

The balloon-borne nephelometer utilizes a xenon flash lamp light source, operated at 0.1 joule/flash, for illumination. The xenon flash lamp has a broad spectral output shifted to the blue end of the visible spectrum and effectively centered at 475 nm. The light source operates at a 16.8 hz flash rate with a 0.03 percent duty cycle. Two reference light paths are used to increase instrument stability: (1) a direct light path to a reference solid-state photodetector located in the scattering chamber and (2) a chopper interrupted light path coupled by fiber optic link to the PMT. The reference photodetector output is used to normalize the flash lamp output to a constant illumination brightness. The chopper interrupted path provides an upscale span calibration at five second intervals. The span calibration and stabilization is especially important in balloon applications to correct for PMT drift, due to the low temperatures encountered on balloon ascent.

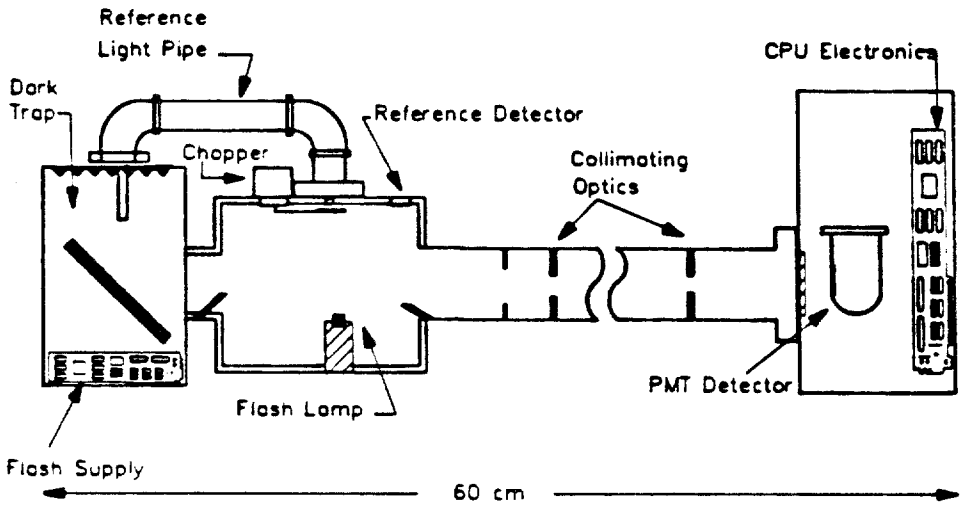

Figure 1. Balloon-borne integrating nephelometer system configuration.

2.3 Signal Processing

A Motorola 63A03 single chip microprocessor controls instrument operation and signal processing. Code is written in 6800 assembler language and stored in an 8kx8 EPROM. The microprocessor controls all essential aspects of instrument operation including flash rate, chopper synchronization, analog to digital conversions, digital to analog conversions, dark current and background corrections, as well as signal averaging and provides digital or analog output of scattering coefficient. The electronics are contained on two circuit boards. The main circuit board contains the microprocessor, photomultiplier tube (PMT), high voltage supply, and the input/output (I/O) circuitry. The main board is located in the PMT enclosure found at the detector end of the instrument. The second board contains the flash lamp supply and triggering circuitry and is located in the dark trap enclosure, away from the PMT and processor to reduce noise. All high voltage locations, including the flash lamp are potted for low pressure operation.

At power up, the flash lamp begins to flash at 16.8 hz. If the instrument power supply voltage is low, the device will continue to operate at a lower flash rate. Prior to each

flash, the voltage on the flash lamp storage capacitor is tested. If adequate, the microprocessor fires the flash lamp, otherwise it waits until there is sufficient charge. This allows for continued instrument operation in the event battery supply voltage becomes inadequate for normal operation.

During a flash, the currents produced from the PMT and reference detector are used to pull down charged integration capacitors. The time to recharge each capacitor to a fixed voltage is a measure of the integrated light from the detector. Using internal timers and comparators, the digitized output from each detector is stored in an internal register. Prior to each flash, the charge on the integration capacitor is adjusted for dark current effects. This effectively eliminates dark current offset from the total detected light output. The PMT integrated output is divided by the reference signal to normalize the output to constant chamber illumination. This value is then stored in a data register. The microprocessor averages outputs as two stage, 10 second averages. The output changes at 12 db/octave for computed values very much different from the current average, and at 6 db/octave for values near the current average. This provides for a fast, yet smooth, response to rapid changes in light scattering. The outputs are refreshed at approximately a 100 hz rate.

The balloon-borne nephelometer has four analog output channels: (1) incremental flash count, (2) scattering coefficient (1 Mm^{-1} to 100 Mm^{-1} range), (3) scattering coefficient (100 Mm^{-1} to 10000 Mm^{-1} range) and (4) calibrator value. The incremental flash count channel gives verification of flash lamp operation and is a 0-1 volt dc linear output. The scattering coefficient channels are 0-1 volt dc log scale output with 0.5 volts dc per decade. The calibrator channel is 0-1 volt dc log scale output with 0.5 vdc per decade. An RS-232 serial output port is also available.

2.4 Calibration

The balloon-borne nephelometer is calibrated using filtered air to obtain a zero air scattering voltage, and freon-12 (CCL_2F_2) to obtain an upscale scattering voltage, following the method described by Ruby and Waggoner (1981). The scattering coefficient to voltage conversion factor and instrument background can be calculated using the equations:

Given that

$$Vz = f\ (bz + Bbg) \tag{1}$$

and

$$Vf12 = f\ (bf12 + Bbg) \tag{2}$$

where

Vz = zero air voltage
Vf12 = freon-12 voltage
bz = zero air scattering coefficient (Mm^{-1})
bf12 = freon-12 scattering coefficient (Mm^{-1})
Bbg = background scatter (Mm^{-1})
f = scattering coefficient to voltage conversion factor

simultaneously solving eq.(1) and eq.(2) gives

$$f = (Vf12 - Vz)/(bf12 - bz) \tag{3}$$

substituting f into eq.(1) gives

$$Bbg = (Vz/f) - bz$$

then

$$bscat = (Vout \times (Vcal0/Vcal)/f) - Bbg$$

where

bscat = scattering coefficient
Vout = nephelometer scattering output voltage

Vcal0 = nephelometer calibrator filtered air output voltage
Vcal = nephelometer calibrator output voltage.

2.5 Comparison to Standard Nephelometer

The balloon-borne integrating nephelometer was evaluated in a side by side comparison with a model 1550 nephelometer modified to photon counting. The modified 1550 is optically similar to the commercial 1590 series, operating at the same 525 nm wavelength. The spectral response of the balloon-borne nephelometer is similar to the unmodified 1550 flashlamp nephelometer, which is broad band and centered at a wavelength near 475 nm. The scattering coefficients for the two spectral responses are expected to be highly correlated, provided the volume mean diameter of the particle size distribution is not highly variable during the sampling period.

The comparison measurements were of ambient air at an EPA site near Durham, NC. The 2.5 day sample period occured during October, 1989. High ambient relative humidity at the site (typically > 90 percent) required heating of the inlet air by about 17°C to eliminate liquid water associated with the particles. The inlet air was split through a bifurcated sample line, after the inlet heater, and sampled in parallel by each instrument. Particle free reference air was measured automatically for 15 minutes every 4 hours. The internal chopper controlled span of the balloon-borne nephelometer was

inserted into the scattering volume for 1 second of every 5 seconds to correct for span variability. Under control of an external computer the internal span of the 1550 was inserted during the last 6 minutes of each clean air cycle.

An Apple based data aquisition system recorded 3 minute averages of ambient temperature, scattering coefficients, and internal span values for each nephelometer.

The feasibility of using the balloon-borne nephelometer to measure scattering extinction based on this comparison is shown in Figure 2. The upper curve, 2A, shows ambient temperature and internal span values for each instrument. The modified 1550 shows a marked sensitivity to ambient temperature changes. These internal span values were used to correct the output of the 1550. The coefficients shown in the time series (Fig. 2B) represent scattering by particles only (b_{sp}). Particle only scattering coefficient is obtained by subtracting air Rayleigh scattering coefficient and instrument background from total measured scattering coefficient. B_{sp} during the sampling period ranged from about 10 Mm^{-1} to about 100 Mm^{-1}, with peak values near noon of each day. The correlation of 3 minute averages between the two instruments was 0.93 with an average scattering ratio of 1550 to balloon-borne nephelometer of about 0.75. The ratio of 0.75 is reasonable for a scattering wavelength dependence of 2 (Angstrom exponent = 2), which is typical for ambient urban/rural aerosol (Ruby and Waggoner, 1981).

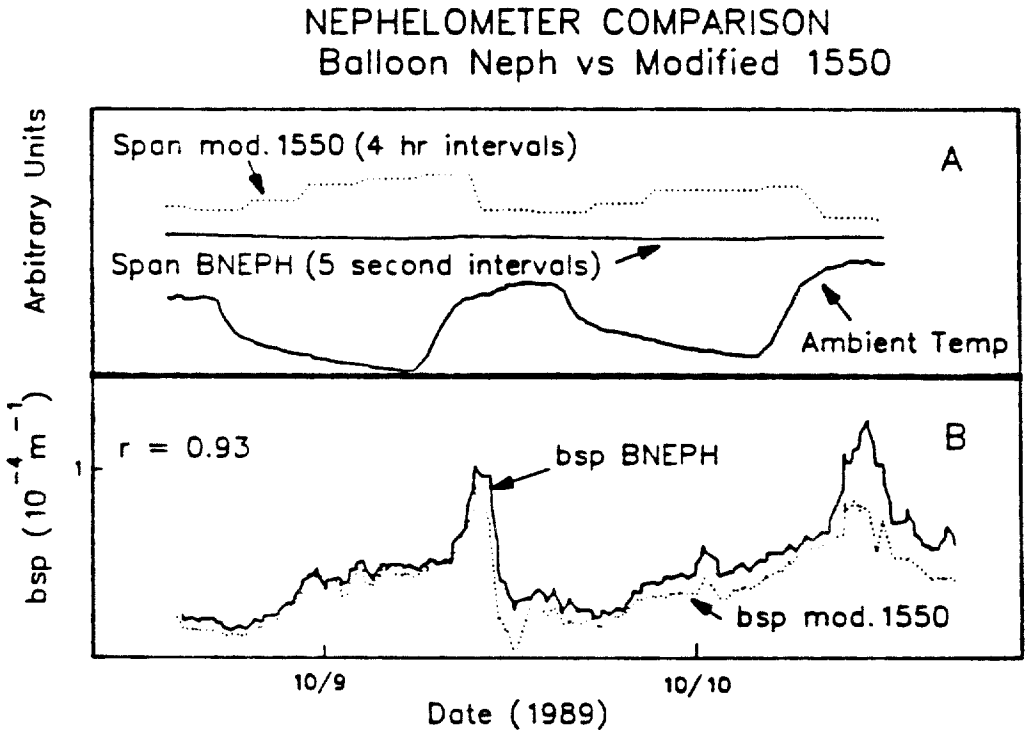

Figure 2. Comparison of the balloon-borne nephelometer, BNEPH, (lambda = 475 nm) and a modified Model 1550 nephelometer (lambda = 525 nm). The upper curve (A) shows the effect of ambient temperature on the internal span of each instrument. The lower curve (B) shows bsp as a function of time for each instrument.

3.0 BALLOON SYSTEMS

3.1 Free Flight Balloon Train

The free flight system utilizes a 3000 g latex expansible balloon, inflated with sufficient helium gas to provide 1000 g of free lift. The balloon envelope is inflated through a modified inflation/cutdown collar as first described by Mastenbrook (1966). For this test series the cutdown mechanism was activated by an electronic timer device set for 30 minutes flight time. The nephelometer/radiosonde package was attached to the balloon collar by a 50 m nylon tether line.

The nephelometer was housed in a 2.54 cm thick, high density styrofoam package. A 0.5 watt thermostatically controlled resistance heater was placed inside the package to maintain rough temperature control. An Atmospheric Instrumentation Research Inc. TS-3A-SPX radiosonde was attached to the exterior of the nephelometer package and electronically interconnected by ribbon cable to the nephelometer output.

Airflow through the instrument was provided by ram air during ascent. An ascent rate of 2 m/s provides a volume exchange rate of approximately 250 cm^3/s.

3.2 Tethered Balloon Train

The tethered flight system utilizes a 7 m^3 aerodynamic balloon providing 1500 g of free lift. The nephelometer/-radiosonde package is attached to the balloon nylon rigging line 3 m below the balloon envelope by a carabiner and loop arrangement. The balloon is attached to an electric winch by 3000 m of plastic coated kevlar tether line. The winch speed is electronically controlled from 0 m/s to 5 m/s.

The nephelometer is housed in a high density cardboard enclosure. An Atmospheric Instrumentation Research Inc. TS-3A-SP tethersonde is attached to the exterior and electronically connected by ribbon cable to the nephelometer output.

Instrument aspiration is provided by a brushless dc biscuit fan, giving a volume exchange rate of approximately 75 cm^3/s.

3.3 Data Telemetry

Data telemetry is provided by Atmospheric Instrumentation Research Inc. TS-3A- SPX radiosondes for the free flight system and TS-3A-SP tethersondes for the tethered flight system. Both sondes transmit 16 channels of data. The data

are transmitted in a time multiplexed format with each channel sharing equal time. Each channel is switched into an oscillator circuit through electronic commutation. The oscillator output frequency is dependent on a resistive, capacitive or voltage input value. The generated frequency is used to modulate a 403.5 Mhz radio frequency carrier which is broadcast to an Atmospheric Instrumentation Research Inc. Atmospheric Data Aquisition System (ADAS) ground station. The modulation frequency range is 50 hz to 550 hz. This modulation range translates into a 2 mv resolution on the nephelometer voltage input channels.

The ADAS ground station receives the transmitted RF signal and decodes the modulating frequency. The frequency coded data are then converted back into electrical values, through the use of reference values and known oscillator characteristics. The resistive and capacitive values are then converted into standard meteorological values of temperature, pressure, and humidity. The voltage channels are output as raw voltages. The TS-3A-SP used in tethered operations also outputs wind direction and wind speed.

All data channels are output at 10 second intervals. Meteorological and voltage data are logged by an HP-85 computer, stored on cassette tape, and output to a printer for hard copy. Data are later transferred from HP-85 cassette tape to PC for analysis.

4.0 FREE FLIGHT DATA SUMMARY

The balloon-borne nephelometer free flight series was flown from Alamogordo Airpark, Alamogordo, NM with a field elevation of 1250 m MSL. The release site was 16 km west of the Sacramento Mountains and 20 km east of White Sands National Monument.

The TS-3A-SPX radiosonde utilizes a carbon hygristor element for relative humidity measurement. The relative humidity value was converted to mixing ratio by computer alogorithm. The balloon flight paths were tracked by a recording optical theodolite.

4.1 Flight 0306

On March 6, 1989, the surface temperature was 13°C at the balloon release time of 1250 MST. Surface winds were less than 1 m/s from the northwest. The skies were clear with visibility of 100 km. Barometric pressure was 876.5 mb and steady.

Upon release the balloon system headed in a southeasterly direction to an altitude of 500 m AGL. At that point the balloon slowly came around to a southerly heading at 1800 m

AGL. The balloon continued to climb on the same heading until system cutdown at 6923 m AGL (Fig. 3)

The boundary layer height (BLH) was estimated from the temperature profile to be 1800 m AGL (Fig. 4). The particle scattering coefficient was relatively constant with altitude up to the BLH as was expected with a well mixed boundary layer. Above the boundary layer a sharp decrease in aerosol concentration is noted (Fig. 5). Flight 0306 data are presented in Appendix A.

4.2 Flight 0307

On March 7, 1989 the temperature was 10°C at the balloon release time of 0930 MST. Surface winds were from the south at 3 m/s. The skies were clear with visibility of 100 km. Barometric pressure was 877.4 mb and steady.

Following release, the balloon headed in a northerly direction to an altitude of 1600 m AGL. At that point the balloon slowly came around to a southeasterly heading at 2100 m AGL. The balloon continued to climb on that heading until system cutdown at 5819 m AGL (Fig. 6)

The BLH was estimated from temperature profile data to be 2100 m AGL (Fig. 7). The change in particle scattering coefficient with altitude up to the BLH was not nearly as

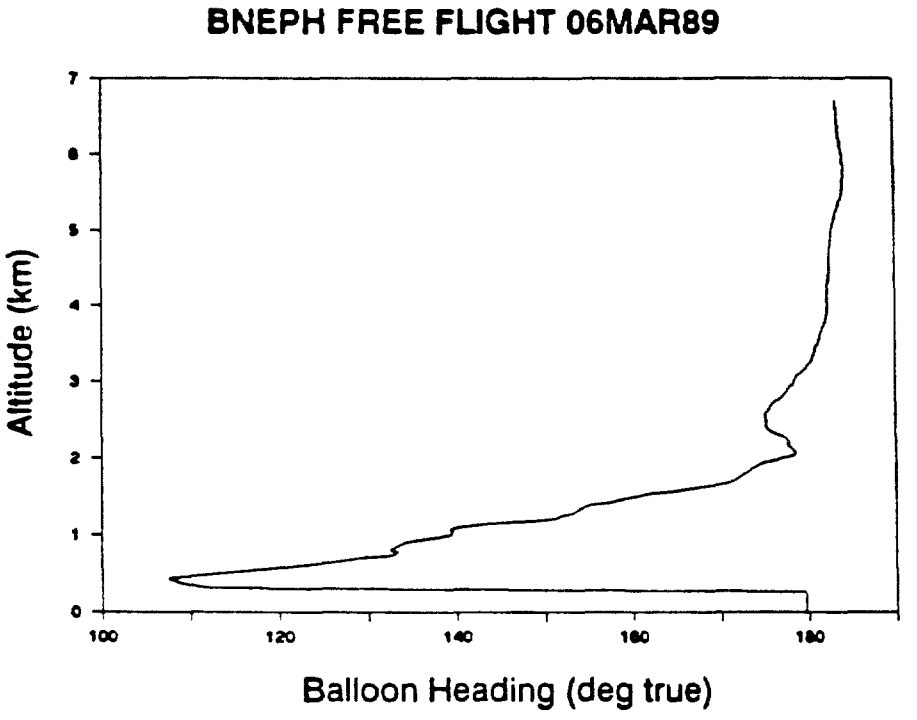

Figure 3. Vertical profile of balloon heading March 6, 1989 free flight.

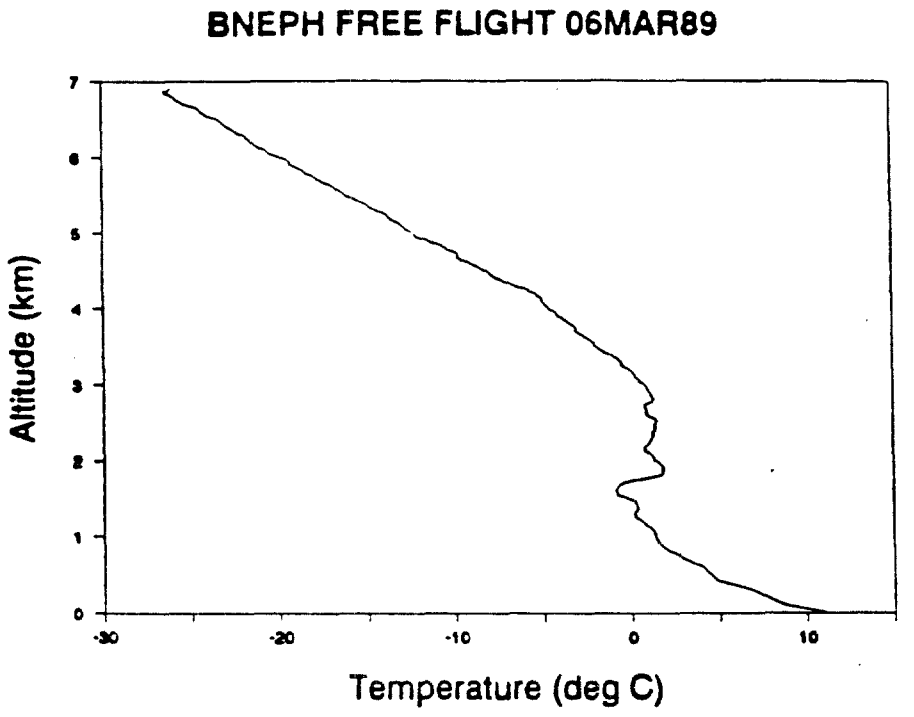

Figure 4. Vertical profile of ambient temperature March 6, 1989 free flight.

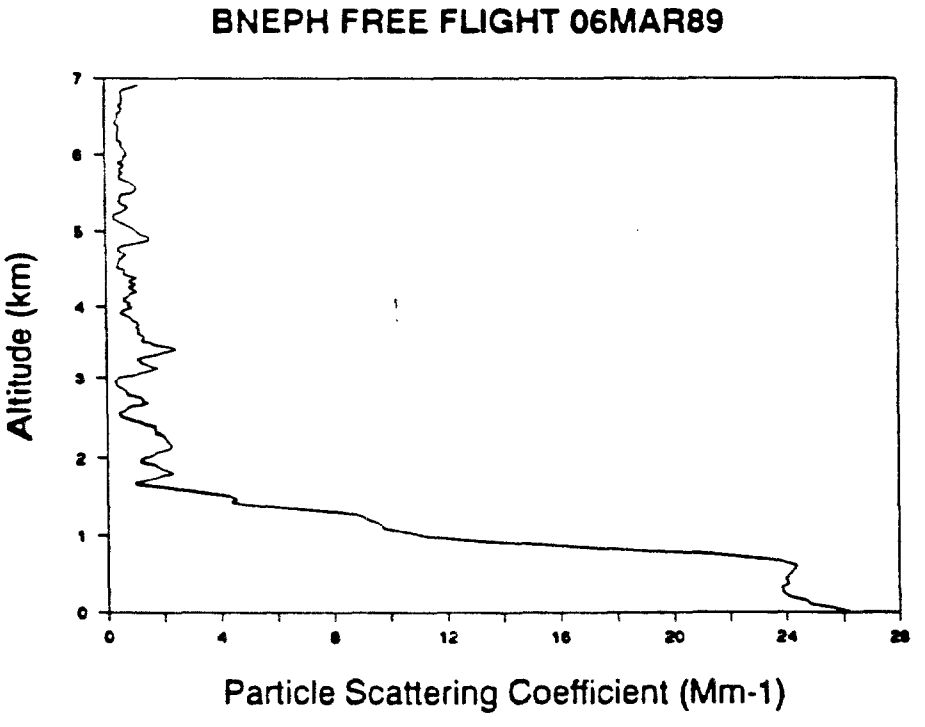

Figure 5. Vertical profile of particle scattering coefficient March 6, 1989 free flight.

constant as observed in flight 0306. Three shallow but distinct temperature inversions are present below 2100 m, located at 650 m, 1450 m, and 1850 m. Each inversion level delineates a different aerosol concentration with an overall decrease in concentration with increasing altitude. As in flight 0306 there is a sharp decrease in aerosol concentration above 2100 m AGL (Fig. 8). Flight 0307 data are presented in Appendix A.

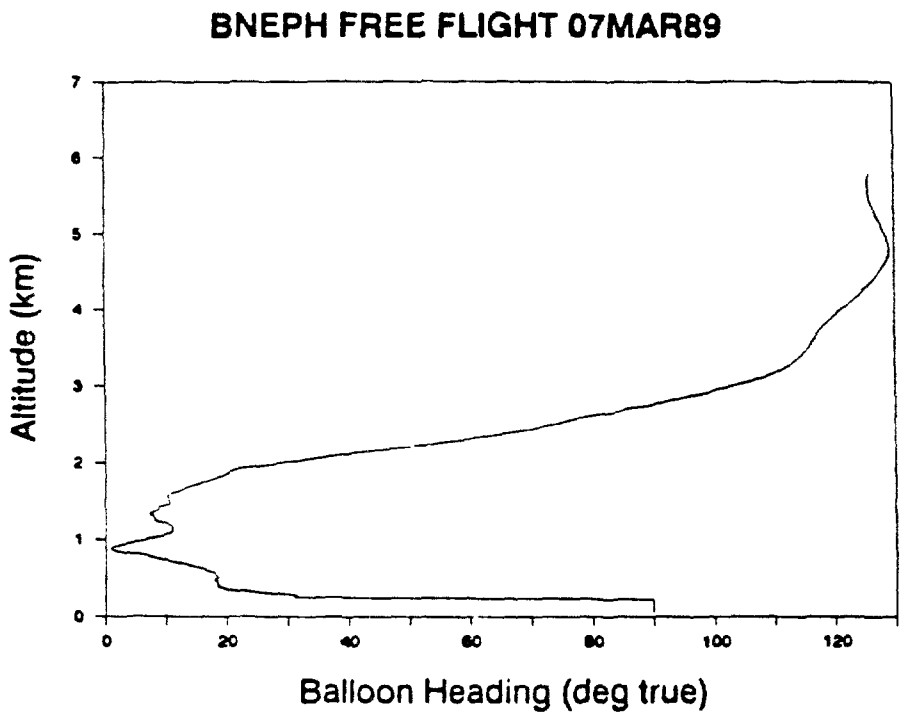

Figure 6. Vertical profile of balloon heading March 7, 1989 free flight.

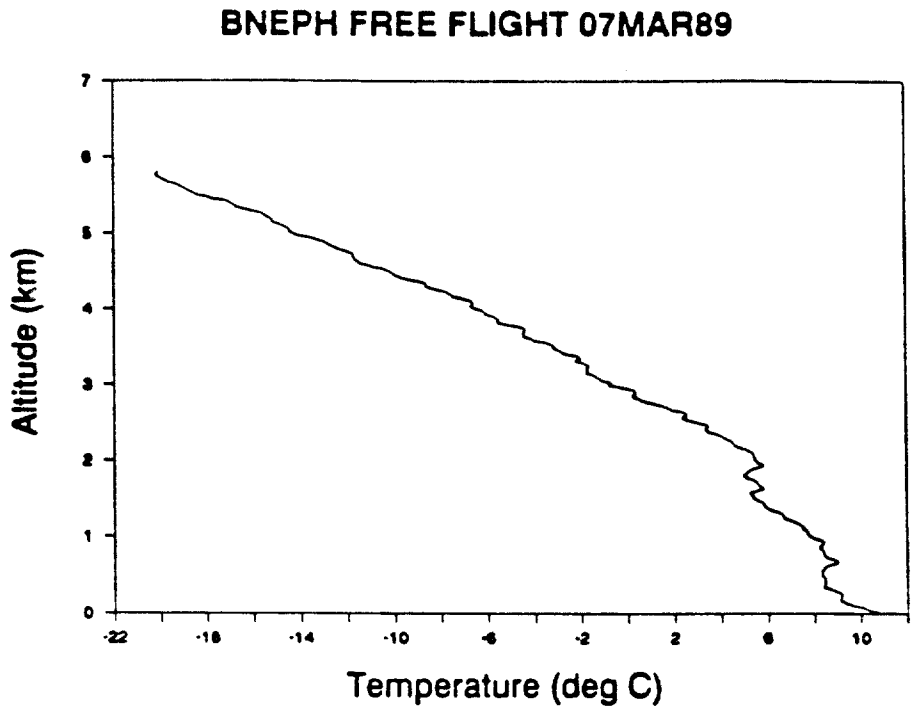

Figure 7. Vertical profile of ambient temperature March 7, 1989 free flight.

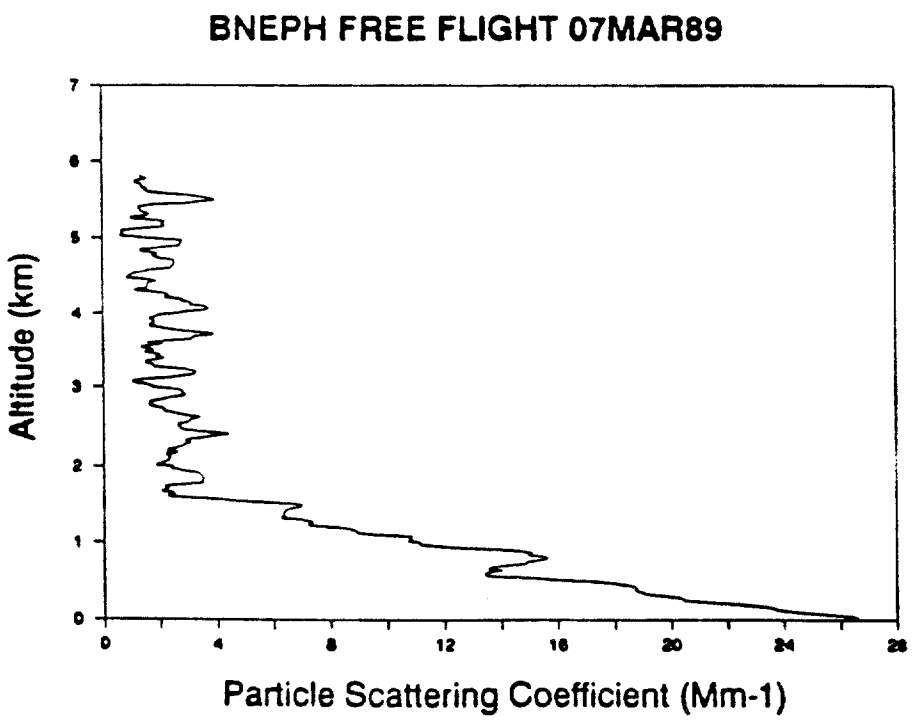

Figure 8. Vertical profile of particle scattering coefficient March 7, 1989 free flight.

5.0 TETHERED FLIGHT DATA SUMMARY

The balloon-borne nephelometer tethered flights were conducted at a site near the intersection of I-40 and I-25 in Albuquerque, NM. Site elevation is 1610 m MSL.

The TS-3A-SP tethersonde utilizes a wet bulb temperature and a dry bulb temperature to compute mixing ratio. Wind direction is measured by an electronically locking magnetic compass and corrected for magnetic deviation to report true direction. Wind speed, when implemented, is measured by a spinning cup anemometer and converted to a frequency by light chopper. The winch speed was set to give an ascent rate of 0.3 m/s on all flights.

Due to FAA restrictions under FAR 101, tethered balloon flights are altitude limited to 150 m AGL. Under certain conditions noted by Zak et al (1985), the winter boundary layer height in Albuquerque could be as low as 100 m. On cold clear nights in the Albuquerque area, a cold air mass drains from the west slope of the Sandia Mountains into the river valley. With high barometric pressure conditions, winds are usually very light. These common meteorological conditions create surface temperature inversions as the ground surface loses heat to the night sky, trapping locally generated pollutants below the inversion level.

On December 19, 1989, the conditions for a shallow stagnant air mass were met. Tethered balloon-borne nephelometer flights were conducted to characterize the aerosol concentration relative to altitude and time within the polluted air mass between 0620 and 0950 MST.

5.1 Flight 0620

The first flight time was chosen to characterize the inversion layer prior to significant traffic flow and the susequent increase in auto emissions. The night of December 18 and the morning of December 19 were designated "no burn" periods in the Albuquerque area. Consequently, wood smoke aerosols were not expected to be a major factor in particle light scattering.

The temperature vs. altitude plot for the 0620 MST flight shows a significant inversion through the 160 m level (Fig. 9). The inversion height is above the altitude limit of this flight. The particle scattering coefficient is relatively constant with respect to altitude, having a ratio of 1.1 between the surface and 150 m (Fig. 10). The particle scattering coefficient arithmetic mean, measured over the altitude range, is 40.8 Mm^{-1}, with a standard deviation of 4.6 Mm^{-1}. Flight 0620 data are presented in Appendix B.

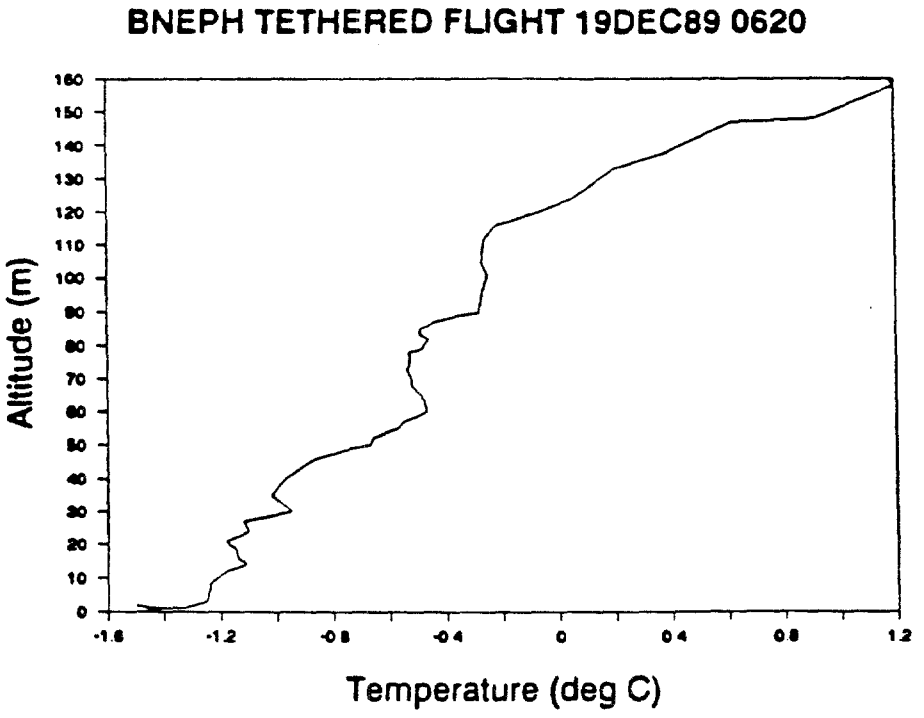

Figure 9. Vertical profile of ambient temperature 0620 MST December 19, 1989 tethered flight.

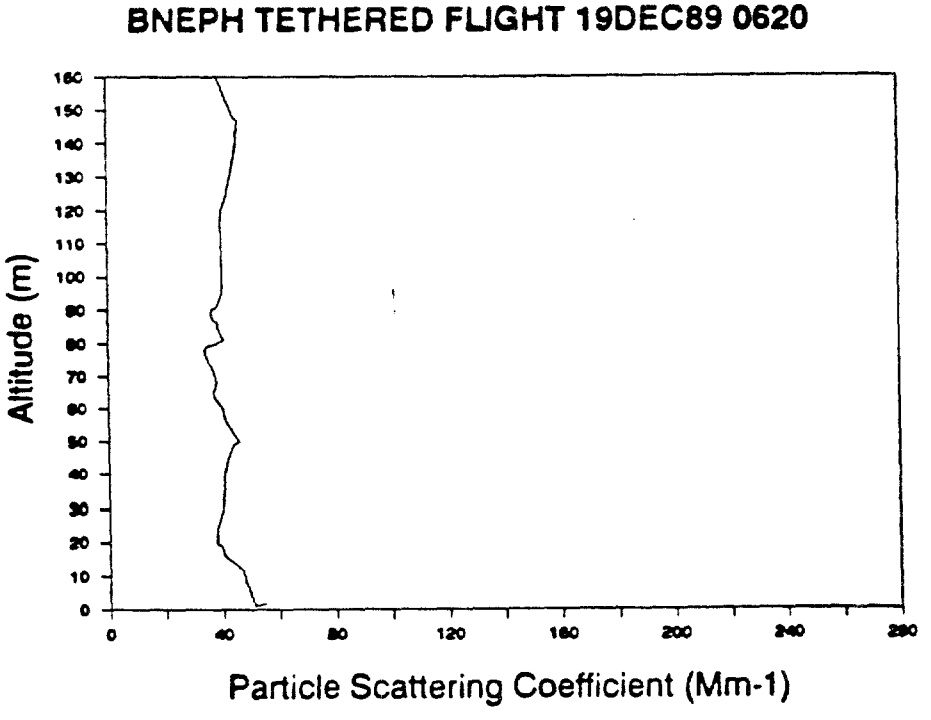

Figure 10. Vertical profile of particle scattering coefficient 0620 MST December 19, 1989 tethered flight.

5.2 Flight 0725

The temperature vs. altitude plot for the 0725 MST flight is similar to the 0620 flight (Fig. 11). The particle scattering coefficient is again relatively constant with respect to altitude, a ratio of 1.4 between the surface and 150 m, but with an overall increase in particle concentration, due to increased auto emissions (Fig. 12). The particle scattering coefficient arithmetic mean, measured over the altitude range, is 58.0 Mm^{-1}, with a standard deviation of 8.8 Mm^{-1}. Flight 0725 data are presented in Appendix B.

5.3 Flight 0800

The temperature vs. altitude plot for the 0800 MST flight shows the inversion layer beginning to break up. The 0800 MST flight followed a 0725 MST sunrise by 35 minutes. Surface warming by 0800 MST has initiated the inversion layer break up (Fig. 13). The particle scattering coefficient is again relatively constant with respect to altitude, a ratio of 1.2 between the surface and 150 m, but with an overall increase in particle concentration (Fig. 14). The particle scattering coefficient arithmetic mean, over the altitude range, is 75.2 Mm^{-1}, with a standard deviation 6.7 Mm^{-1}. Flight 0800 data are presented in Appendix B.

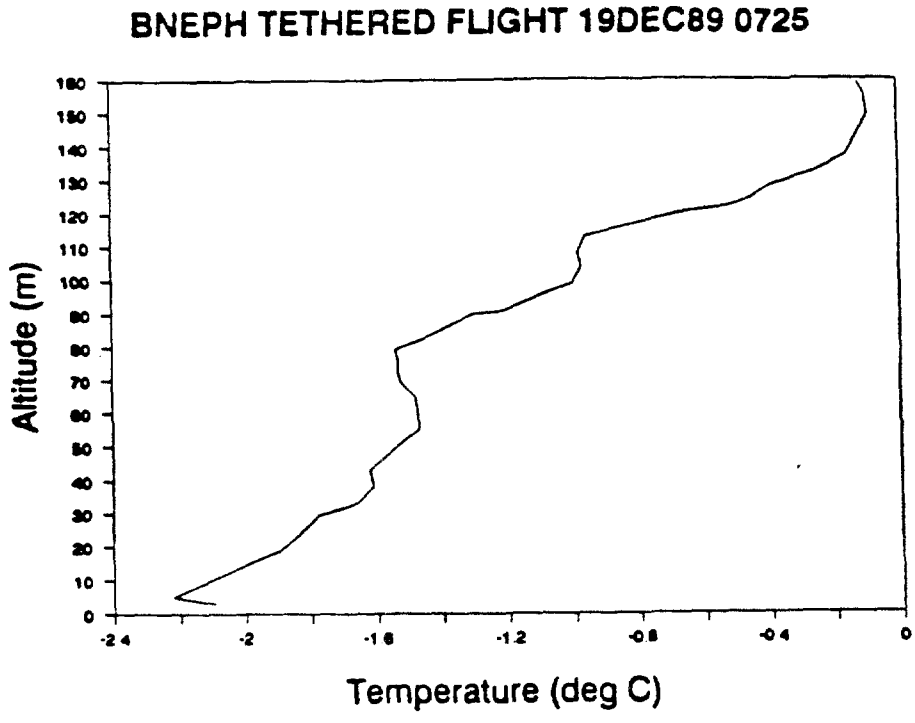

Figure 11. Vertical profile of ambient temperature 0725 MST December 19, 1989 tethered flight.

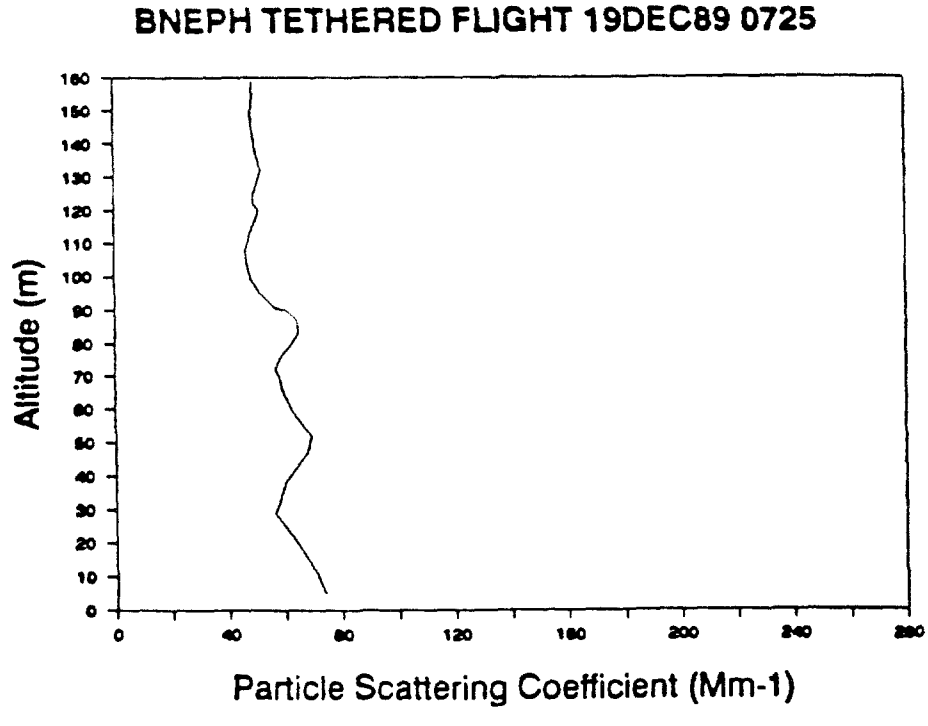

Figure 12. Vertical profile of particle scattering coefficient 0725 MST December 19, 1989 tethered flight.

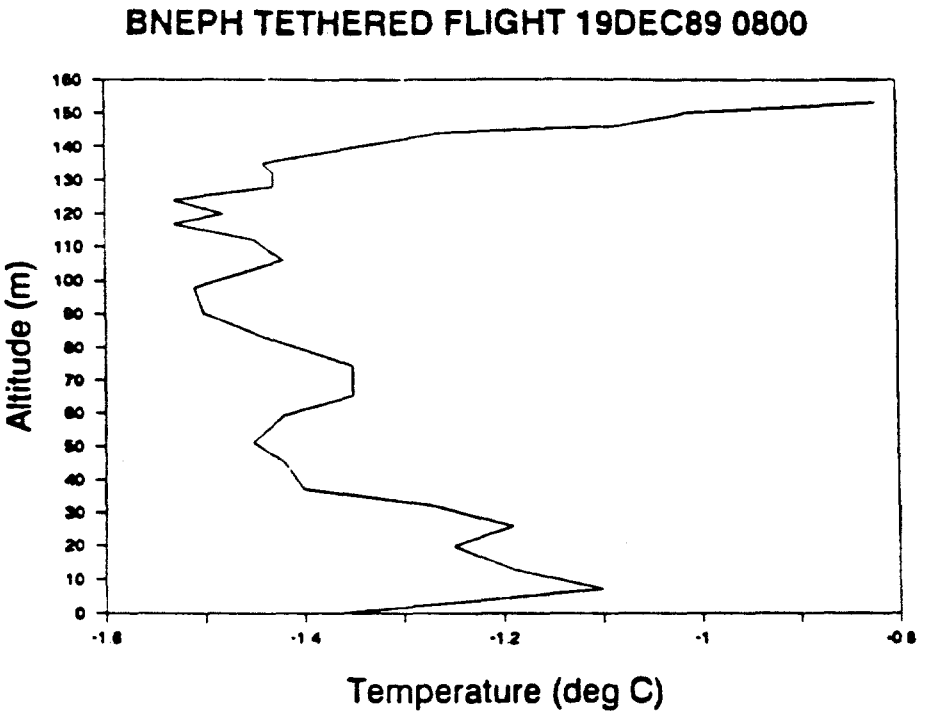

Figure 13. Vertical profile of ambient temperature 0800 MST December 19, 1989 tethered flight.

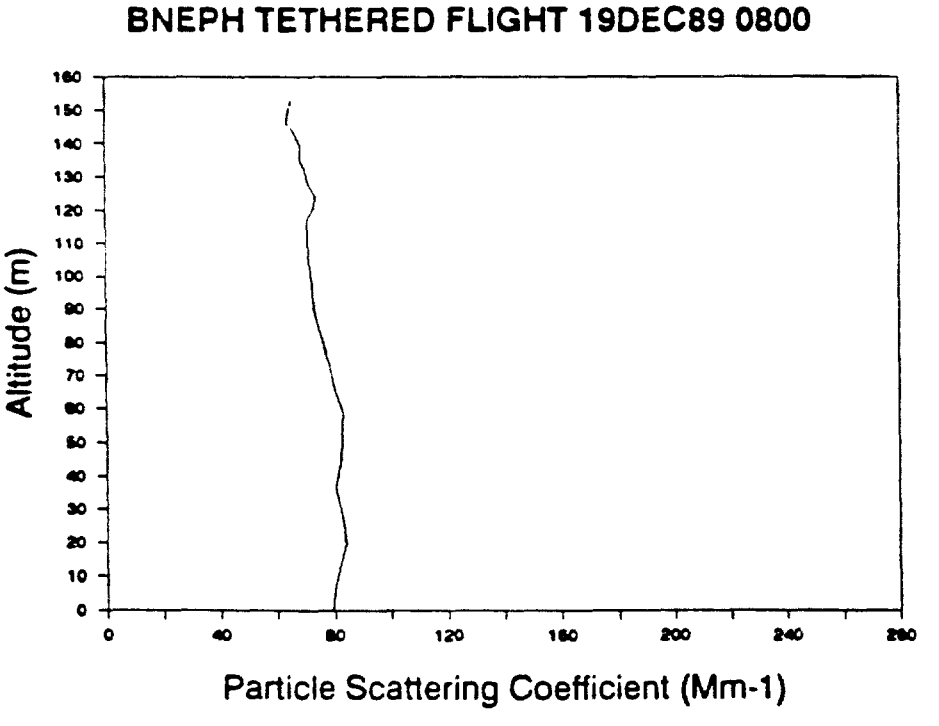

Figure 14. Vertical profile of particle scattering coefficient 0800 MST December 19, 1989 tethered flight.

5.4 Flight 0820

The temperature vs. altitude plot for the 0820 MST flight shows an almost complete dispersion of the inversion layer. A negative lapse rate of 0.008°C m^{-1} as been established. The temperature inversion, however, does reform at approximately 140 m (Fig. 15). The particle scattering coefficient is relatively constant with respect to altitude, a ratio of 1.1 between the surface and 150 m, with an overall increase in particle concentration (Fig. 16). The particle scattering coefficient arithmetic mean for the flight is 87.7 Mm^{-1}, with a standard deviation of 5.2 Mm^{-1}. Flight 0820 data are presented in Appendix B.

5.5 Flight 0845

The temperature vs. altitude plot for the 0845 MST flight shows a steep 0.15°C m^{-1} inversion between the 40 m and 50 m levels (Fig. 17). This low level temperature inversion contributes to an increase by a factor of 3 in particle scattering coefficient over the 0820 MST flight. The ratio of the particle scattering coefficient below the inversion to the particle scattering coefficient above the inversion is 2.63 (Fig. 18). The particle scattering coefficient arithmetic mean for the flight is 131.4 Mm^{-1}, with a standard deviation of 73.6 Mm^{-1}. Flight 0845 data are presented in Appendix B.

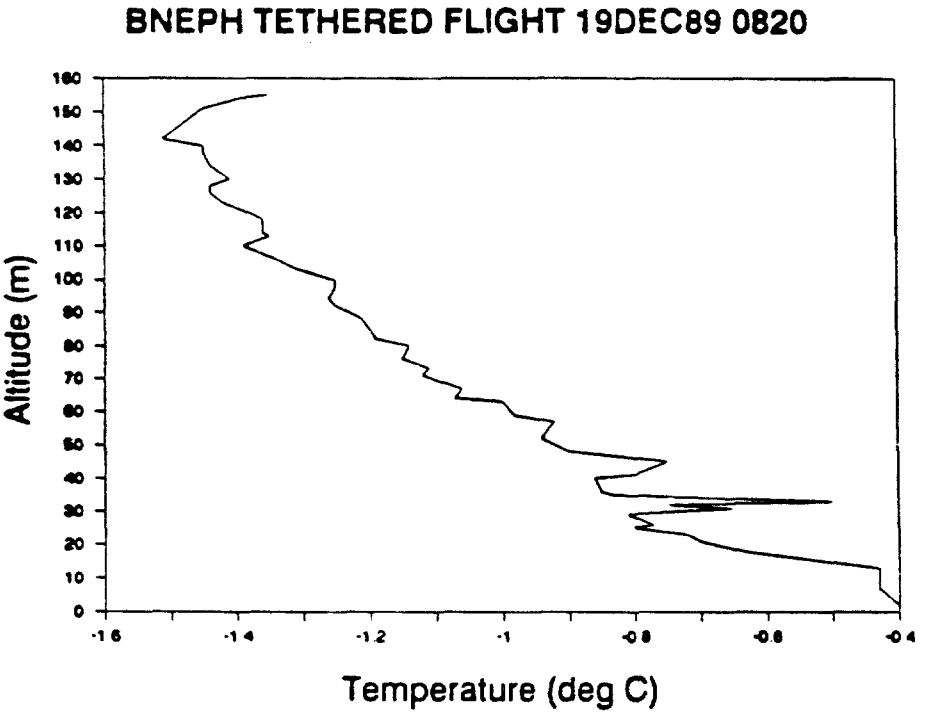

Figure 15. Vertical profile of ambient temperature 0820 MST December 19, 1989 tethered flight.

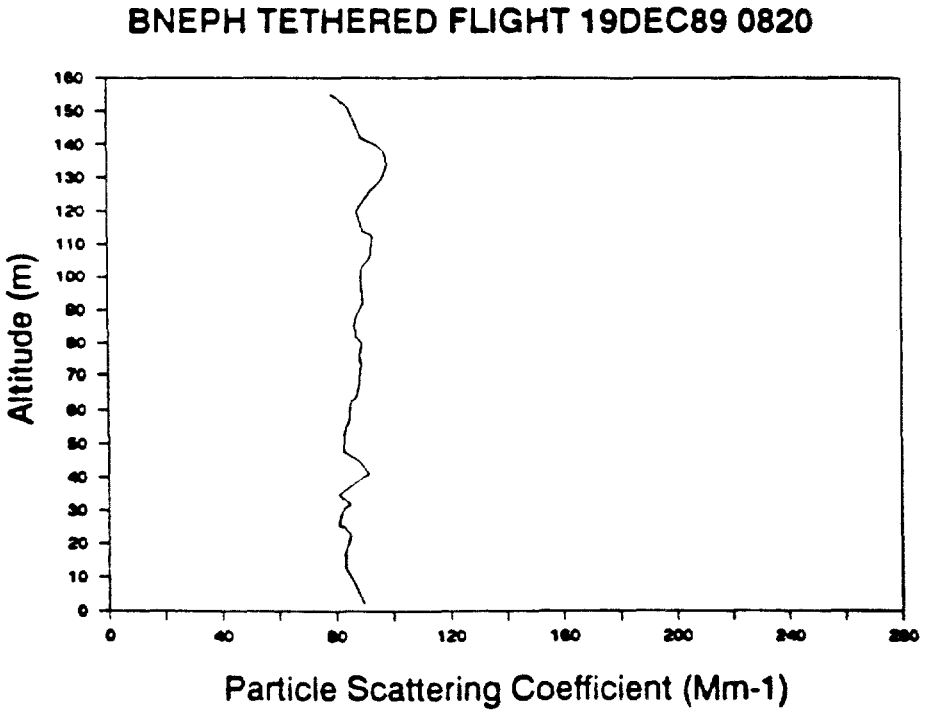

Figure 16. Vertical profile of particle scattering coefficient 0820 MST December 19, 1989 tethered flight.

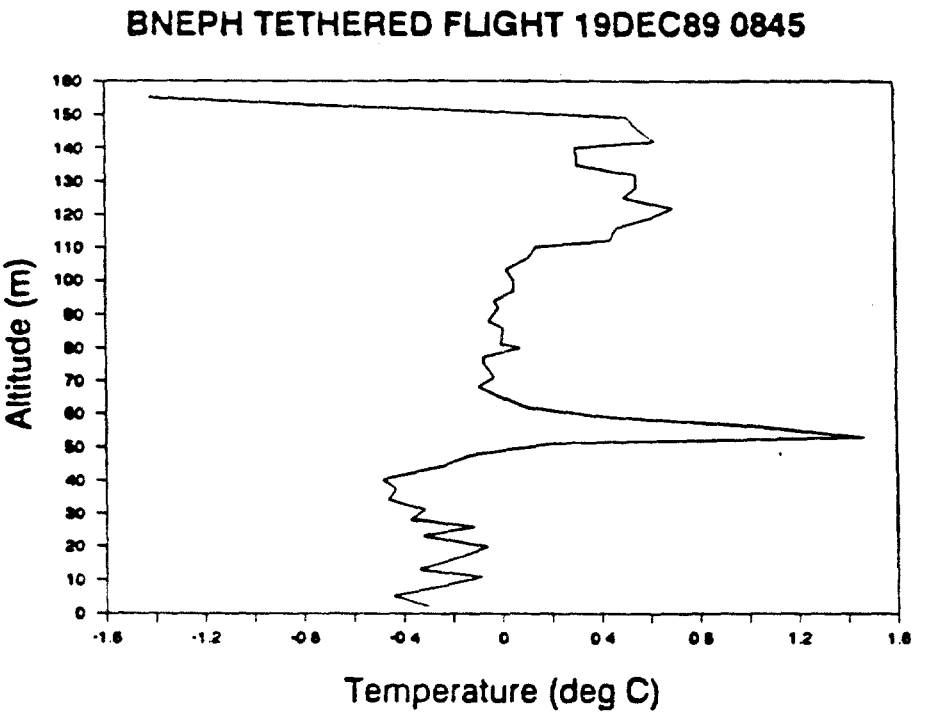

Figure 17. Vertical profile of ambient temperature 0845 MST December 19, 1989 tethered flight.

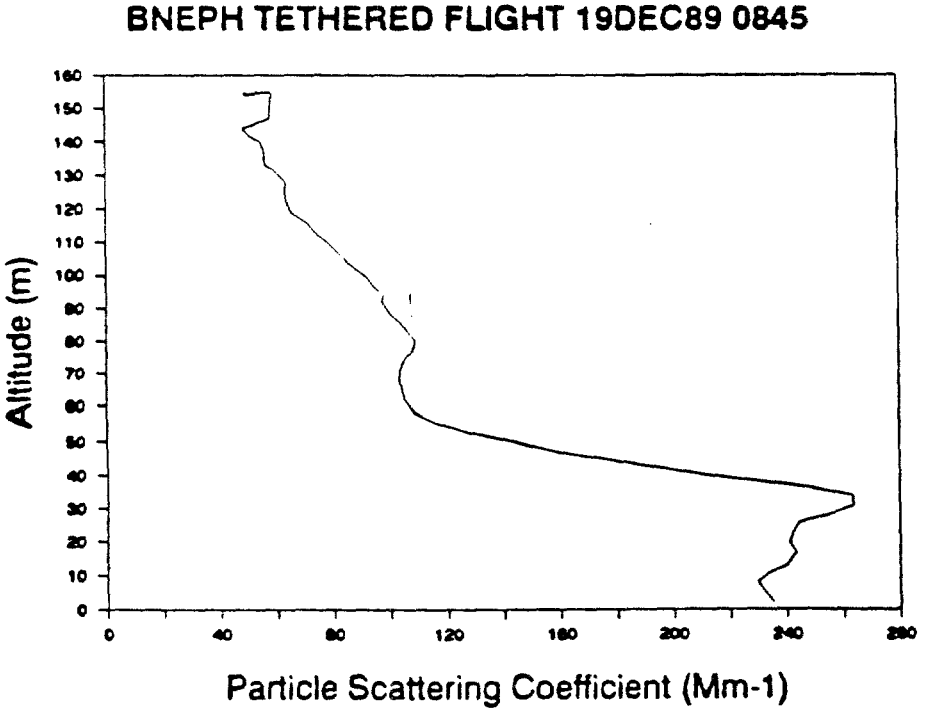

Figure 18. Vertical profile of particle scattering coefficient 0845 MST December 19, 1989 tethered flight.

5.6 Flight 0920

The temperature vs. altitude plot for the 0920 flight shows a 0.038°C m^{-1} inversion at 65 m (Fig. 19). The ratio of particle scattering coefficient below the inversion to the particle scattering coefficient above the inversion is 3.5. The overall particle concentration is lower than observed during the 0845 flight (Fig. 20). The particle scattering coefficient arithmetic mean for the flight is 99.2 Mm^{-1}, with a standard deviation of 54.1 Mm^{-1}. Flight 0920 data are presented in Appendix B.

5.7 Flight 0945

The temperature vs. altitude plot for the 0945 MST flight shows several inversion levels between the surface and 150 m (Fig. 21). Particle concentration changes roughly correlate with inversion level changes (Fig. 22). The overall particle scattering coefficient ratio between the surface and 150 m is 1.9 with decreasing concentrations at the higher altitudes. The particle scattering coefficient arithmetic mean is 90.7 Mm,$^{-1}$ with a standard deviation of 19.7 Mm^{-1}. Flight 0945 data are presented in Appendix B.

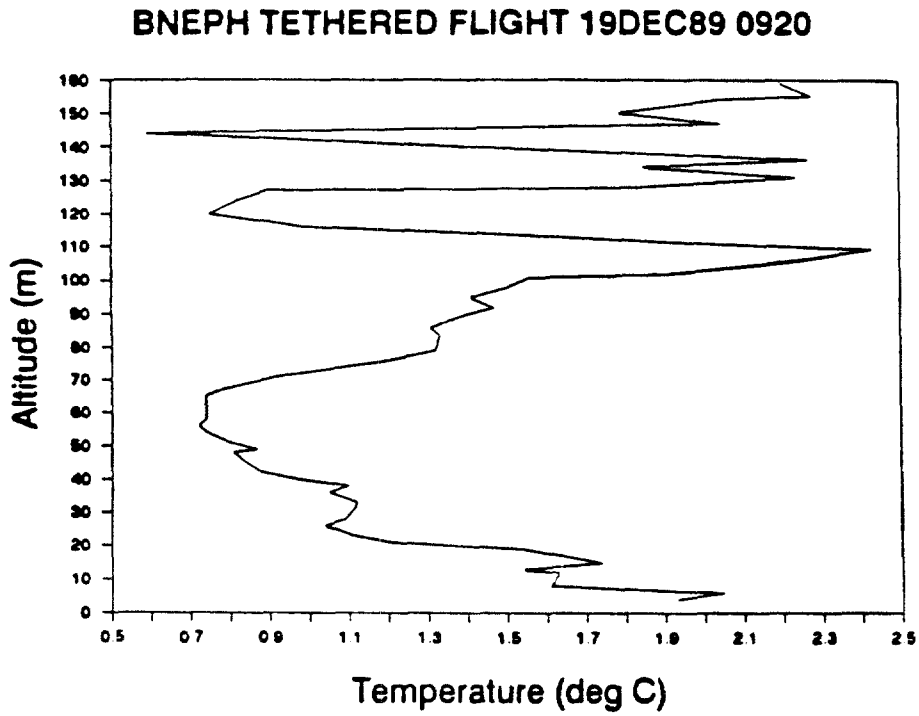

Figure 19. Vertical profile of ambient temperature 0920 MST December 19, 1989 tethered flight.

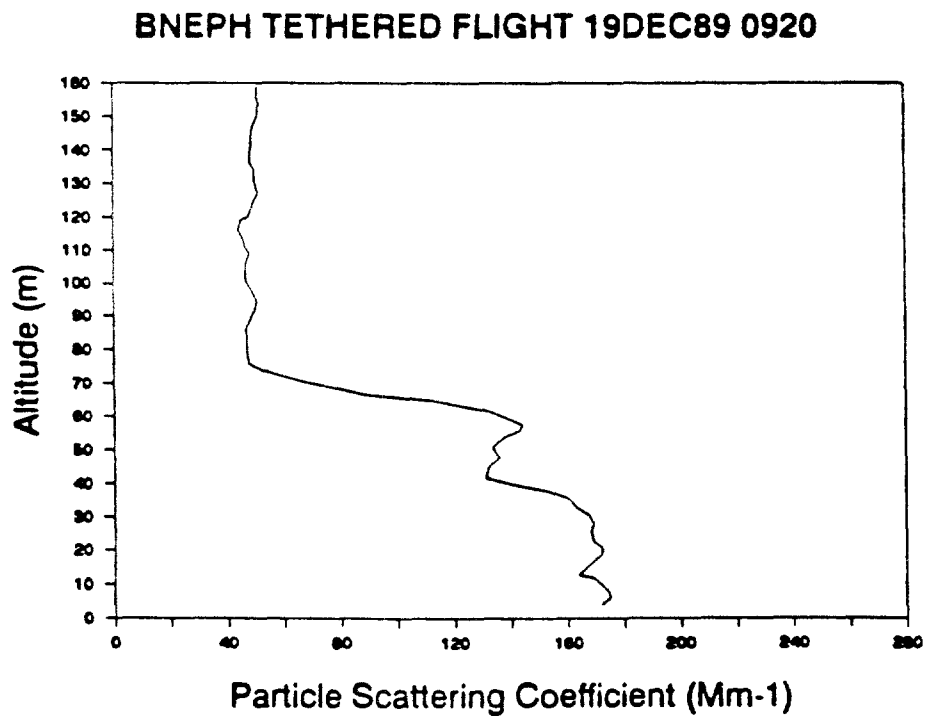

Figure 20. Vertical profile of particle scattering coefficient 0920 MST December 19, 1989 tethered flight.

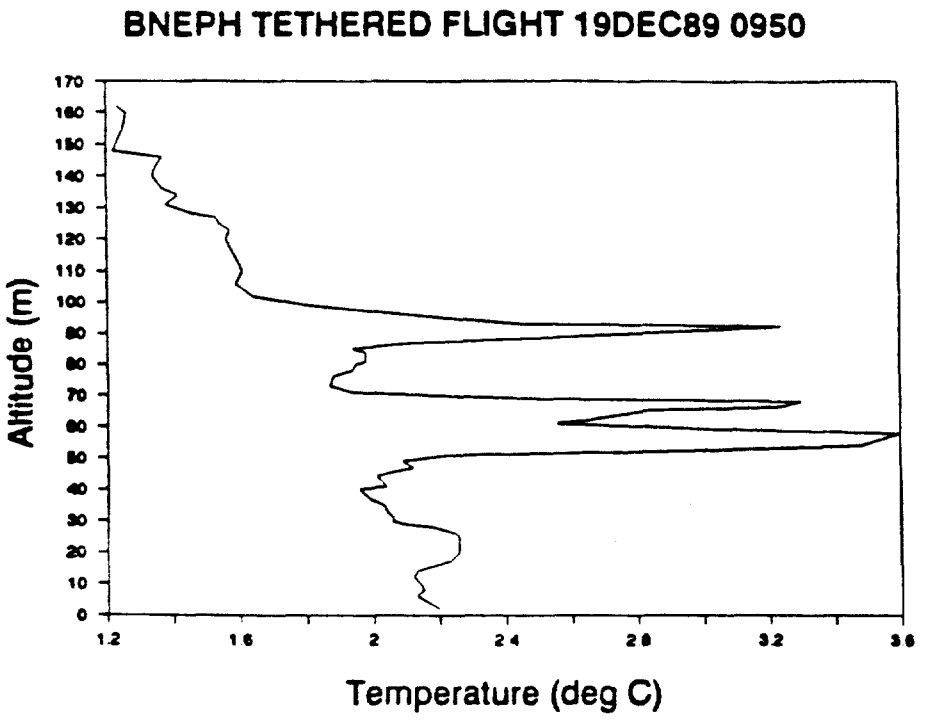

Figure 21. Vertical profile of ambient temperature 0950 MST December 19, 1989 tethered flight.

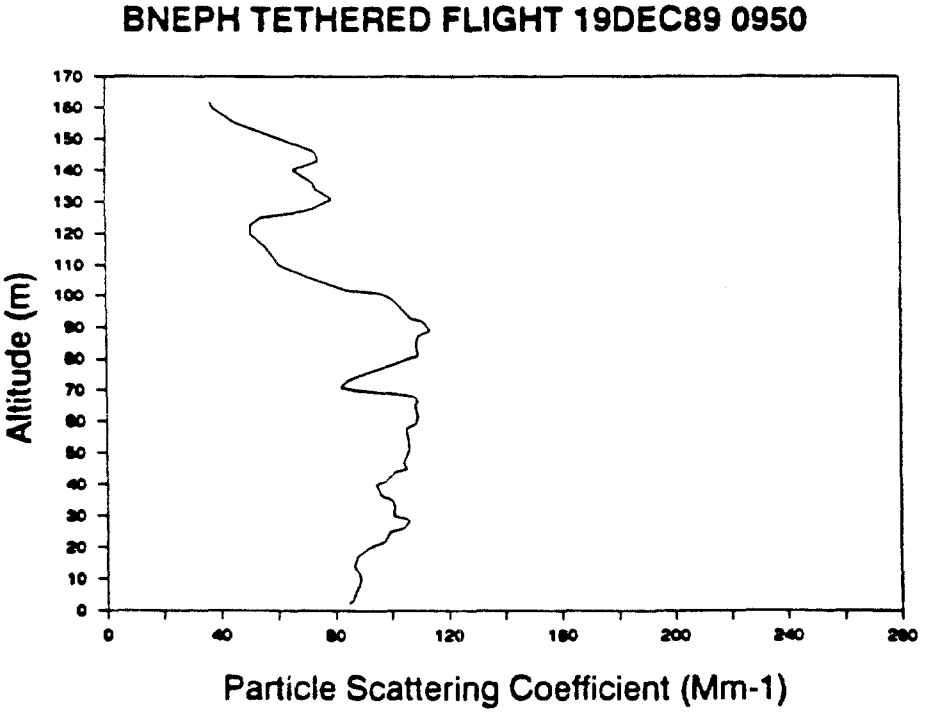

Figure 22. Vertical profile of particle scattering coefficient 0950 MST December 19, 1989 tethered flight.

6.0 BALLOON-BORNE NEPHELOMETER PERFORMANCE EVALUATION

The capability of the balloon-borne nephelometer to make an uninterrupted aerosol concentration measurement from the surface to 7000 m AGL, with 30 m resolution, was demonstrated during the free flight series. Scattering coefficients from surface values of 30 Mm^{-1} to expected air Rayleigh values at altitude were measured. Pressure and temperature extremes, 360 mb and -25°C respectively, encountered by the balloon-borne nephelometer produced no instrument malfunction. Balloon-borne aerosol instrumentation measurement capability, by a similar electronic system, from the surface to 30,000 m and -65°C has been demonstrated by Brown and Weiss (1990).

The tethered flight series demonstrated balloon-borne nephelometer measurement capability during a mild urban air pollution episode. Scattering coefficients between 20 Mm^{-1} and 265 Mm^{-1} were measured with an altitude resolution of 3 m. Continuous monitoring of light scattering with altitude over an extended time period recorded the rapid changes in an urban aerosol environment.

7.0 CONCLUSION

The free flight balloon system has the capability of measuring atmospheric scattering coefficient from the surface to 30,000 m MSL. The tethered system has the capability of micro-structure measurement from the surface to 3000 m AGL, giving detailed observations in the boundary layer. In addition, both systems measure and report the standard atmospheric variables of temperature, relative humidity and pressure. These balloon systems give a cost effective alternative for atmospheric measurement programs.

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APPENDIX A

Free Flight Data Tables

FREE FLIGHT 0306

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
890306	125018	15	876.4	12.75	2.56	47.5	28.3
890306	125028	66	871.1	10.96	2.49	46.1	26.8
890306	125038	108	866.7	9.29	2.50	44.7	25.4
890306	125048	156	861.7	8.69	2.62	44.8	25.6
890306	125057	202	856.9	8.25	2.67	44.1	25.0
890306	125107	258	851.1	7.64	2.64	43.8	24.8
890306	125117	315	845.2	7.13	2.66	42.3	23.4
890306	125127	373	839.3	6.79	2.65	43.3	24.5
890306	125136	434	833.0	6.03	2.61	41.4	22.7
890306	125205	601	816.1	4.52	2.65	42.3	23.8
890306	125215	645	811.7	3.94	2.64	43.0	24.7
890306	125225	696	806.6	3.52	2.63	43.1	24.8
890306	125235	728	803.4	3.07	2.61	42.1	23.9
890306	125244	770	799.2	2.70	2.56	42.9	24.7
890306	125254	807	795.6	2.75	2.40	40.2	22.2
890306	125304	839	792.4	2.41	2.33	40.2	22.1
890306	125314	888	787.6	1.85	2.18	38.3	20.3
890306	125323	923	784.2	1.62	2.13	34.9	17.0
890306	125333	961	780.5	1.57	1.96	32.6	14.8
890306	125343	1000	776.8	1.57	1.96	29.9	12.2
890306	125353	1034	773.5	1.19	1.94	29.6	11.9
890306	125402	1066	770.5	1.32	1.83	29.0	11.4
890306	125412	1101	767.1	1.47	1.76	27.9	10.4
890306	125422	1144	763.0	0.98	1.66	27.4	9.9
890306	125431	1176	760.0	1.09	1.65	27.4	10.0
890306	125441	1205	757.2	0.72	1.63	27.1	9.8
890306	125451	1243	753.7	0.48	1.56	26.1	8.8
890306	125501	1266	751.5	0.63	1.59	27.0	9.8
890306	125510	1306	747.8	0.09	1.56	26.4	9.3
890306	125520	1333	745.2	0.04	1.48	25.7	8.6
890306	125530	1359	742.8	0.33	1.32	25.7	8.6
890306	125540	1387	740.2	0.35	1.29	25.2	8.2
890306	125549	1409	738.2	0.61	1.26	23.6	6.7
890306	125559	1447	734.7	-0.04	1.12	21.0	4.1
890306	125609	1471	732.5	0.33	1.20	20.4	3.6
890306	125619	1496	730.3	0.34	1.23	21.5	4.8
890306	125628	1524	727.7	0.17	1.25	21.4	4.7
890306	125638	1561	724.3	-0.57	1.22	21.3	4.7
890306	125648	1590	721.6	-0.77	1.21	21.3	4.7
890306	125658	1629	718.1	-1.06	1.29	20.7	4.1
890306	125707	1653	716.0	-0.75	1.73	19.6	3.2
890306	125717	1681	713.4	-0.85	1.76	17.4	1.0
890306	125727	1708	711.1	-0.81	1.82	17.3	1.0
890306	125737	1733	708.8	-0.50	1.70	17.4	1.1
890306	125746	1759	706.6	-0.17	1.59	17.1	0.8
890306	125756	1784	704.3	0.54	1.31	17.1	1.0
890306	125806	1804	702.6	1.39	1.19	18.7	2.6
890306	125816	1826	700.7	1.70	1.15	18.3	2.4

FREE FLIGHT B0306

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
890306	125825	1852	698.4	1.74	1.13	18.1	2.1
890306	125835	1877	696.3	1.79	1.12	17.4	1.6
890306	125845	1904	694.0	1.86	1.12	18.3	2.4
890306	125855	1931	691.6	1.78	1.12	18.9	3.1
890306	125904	1951	689.9	1.79	1.16	17.4	1.7
890306	125914	1975	687.9	1.75	1.20	16.5	0.8
890306	125924	1999	685.8	1.53	1.19	16.7	1.1
890306	125934	2022	683.8	1.60	1.21	17.1	1.5
890306	125944	2043	682.1	1.35	1.23	16.7	1.2
890306	125953	2076	679.2	0.94	1.38	16.8	1.3
890306	130003	2104	676.9	1.66	1.28	16.9	1.4
890306	130013	2141	673.8	0.90	1.16	17.5	2.1
890306	130023	2175	670.9	0.70	1.08	17.5	2.1
890306	130032	2195	669.3	0.77	1.13	17.2	1.8
890306	130042	2220	667.2	0.72	1.28	17.6	2.3
890306	130102	2286	661.7	1.36	1.73	17.9	2.8
890306	130111	2313	659.5	0.99	1.76	17.5	2.4
890306	130121	2333	657.9	1.22	1.89	17.0	1.9
890306	130131	2352	656.3	1.44	2.05	16.6	1.6
890306	130141	2376	654.4	1.21	2.12	16.3	1.4
890306	130150	2398	652.6	1.14	2.25	17.4	2.5
890306	130200	2421	650.7	1.18	2.33	16.0	1.1
890306	130210	2445	648.8	1.69	2.45	16.6	1.8
890306	130220	2469	646.8	1.27	2.50	16.5	1.7
890306	130229	2490	645.1	1.42	2.53	16.1	1.4
890306	130239	2525	642.3	1.29	2.63	15.2	0.5
890306	130249	2547	640.6	1.45	2.61	14.1	0.5
890306	130259	2571	638.7	1.76	2.61	14.4	0.2
890306	130308	2605	636.0	1.10	2.62	13.9	0.6
890306	130318	2635	633.7	1.02	2.77	14.1	0.4
890306	130328	2654	632.1	0.82	2.87	15.0	0.6
890306	130338	2678	630.3	0.76	3.00	15.8	1.4
890306	130347	2698	628.7	1.15	3.03	14.9	0.6
890306	130357	2720	627.0	0.75	2.94	15.6	1.3
890306	130407	2740	625.4	0.70	2.91	16.6	2.3
890306	130417	2761	623.7	0.83	2.91	16.1	1.8
890306	130427	2782	622.1	0.89	2.82	14.6	0.4
890306	130436	2806	620.3	1.18	2.78	14.8	0.6
890306	130446	2830	618.5	1.50	2.72	15.3	1.1
890306	130456	2852	616.7	1.16	2.62	15.2	1.1
890306	130506	2881	614.6	1.19	2.53	13.7	0.3
890306	130515	2902	612.9	1.14	2.50	13.7	0.3
890306	130525	2929	610.9	0.97	2.44	13.5	0.5
890306	130535	2952	609.2	1.02	2.46	14.5	0.6
890306	130545	2971	607.7	0.94	2.45	14.0	0.1
890306	130554	3005	605.2	0.87	2.40	14.0	0.1
890306	130604	3025	603.6	0.91	2.37	13.4	0.4
890306	130614	3049	601.8	0.60	2.28	13.7	0.1
890306	130624	3080	599.5	0.60	2.23	14.5	0.8

FREE FLIGHT 0306

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
890306	130633	3101	597.9	0.33	2.15	14.4	0.7
890306	130643	3127	596.0	0.23	2.11	14.7	1.0
890306	130653	3149	594.3	0.23	2.02	15.9	2.3
890306	130703	3175	592.4	0.31	2.00	14.9	1.3
890306	130712	3202	590.4	-0.06	1.95	15.6	2.1
890306	130722	3229	588.4	0.10	1.95	14.8	1.3
890306	130732	3253	586.7	-0.10	1.92	15.6	2.1
890306	130742	3278	584.9	-0.58	1.91	14.7	1.2
890306	130752	3309	582.6	-0.44	1.96	13.8	0.4
890306	130801	3335	580.7	-0.54	2.02	14.3	0.9
890306	130811	3358	579.0	-0.35	2.03	14.8	1.5
890306	130821	3384	577.1	-1.06	1.95	14.6	1.3
890306	130831	3410	575.2	-0.67	2.03	15.6	2.3
890306	130840	3429	573.9	-1.24	1.97	15.2	1.9
890306	130850	3455	572.1	-1.43	1.98	15.4	2.2
890306	130900	3476	570.5	-1.57	1.95	15.8	2.6
890306	130910	3495	569.2	-1.68	1.95	15.6	2.4
890306	130919	3523	567.2	-1.96	1.91	16.4	3.2
890306	130929	3549	565.3	-2.05	1.89	14.1	1.0
890306	130939	3572	563.6	-2.20	1.82	13.8	0.7
890306	130949	3595	562.0	-1.90	1.86	13.9	0.9
890306	131008	3638	559.0	-2.31	1.77	15.0	2.1
890306	131018	3666	557.0	-2.48	1.65	14.6	1.7
890306	131028	3690	555.3	-2.64	1.62	13.9	1.0
890306	131038	3711	553.9	-2.94	1.58	14.0	1.1
890306	131047	3731	552.4	-3.06	1.57	12.5	0.3
890306	131057	3750	551.2	-3.17	1.55	14.1	1.3
890306	131107	3773	549.6	-3.11	1.50	14.6	1.8
890306	131117	3798	547.8	-2.99	1.50	14.0	1.3
890306	131126	3829	545.7	-3.16	1.46	13.2	0.6
890306	131136	3850	544.2	-3.62	1.41	13.5	0.8
890306	131146	3878	542.3	-3.83	1.39	13.9	1.3
890306	131156	3897	541.0	-3.37	1.42	14.1	1.6
890306	131205	3920	539.4	-4.16	1.34	13.0	0.5
890306	131215	3946	537.6	-4.22	1.33	12.9	0.3
890306	131225	3969	536.1	-4.05	1.31	12.9	0.4
890306	131235	3994	534.4	-4.21	1.28	13.1	0.6
890306	131244	4021	532.6	-4.55	1.26	11.8	0.7
890306	131254	4035	531.6	-4.63	1.26	11.9	0.5
890306	131304	4065	529.6	-4.74	1.24	13.6	1.2
890306	131314	4089	528.0	-4.76	1.23	14.1	1.8
890306	131324	4119	526.0	-5.03	1.21	12.1	0.2
890306	131333	4137	524.8	-4.97	1.19	12.4	0.1
890306	131343	4164	523.0	-5.14	1.14	13.2	0.9
890306	131353	4184	521.6	-4.94	1.14	12.0	0.2
890306	131403	4211	519.8	-5.12	1.12	13.6	1.5
890306	131412	4244	517.6	-5.92	1.07	13.1	1.0
890306	131422	4269	516.0	-5.01	1.16	12.6	0.5
890306	131432	4289	514.7	-6.26	1.08	13.2	1.1

FREE FLIGHT 0306

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
890306	131442	4314	513.0	-6.10	1.09	13.6	1.5
890306	131451	4339	511.4	-6.58	1.08	12.4	0.4
890306	131501	4357	510.2	-6.93	1.06	11.7	0.3
890306	131511	4387	508.2	-6.83	1.07	13.7	1.8
890306	131521	4409	506.8	-7.33	1.05	13.3	1.4
890306	131531	4440	504.8	-7.64	1.04	12.0	0.1
890306	131540	4462	503.4	-7.72	1.03	12.7	0.8
890306	131550	4493	501.4	-7.89	1.03	13.4	1.5
890306	131600	4518	499.8	-8.02	1.03	12.3	0.5
890306	131610	4535	498.7	-8.21	1.01	11.9	0.1
890306	131619	4575	496.1	-8.69	0.98	11.9	0.1
890306	131629	4594	494.9	-8.38	0.99	12.8	1.1
890306	131639	4637	492.2	-8.89	0.94	11.7	0.0
890306	131649	4644	491.7	-9.27	0.92	12.3	0.6
890306	131658	4664	490.4	-9.40	0.93	11.8	0.1
890306	131708	4696	488.4	-9.68	0.92	11.1	0.5
890306	131718	4717	487.1	-9.84	0.92	10.5	1.1
890306	131728	4738	485.7	-9.82	0.92	12.2	0.6
890306	131738	4768	483.8	-9.45	0.94	11.9	0.4
890306	131747	4784	482.9	-9.97	0.91	10.6	0.9
890306	131757	4809	481.3	-10.38	0.87	11.5	0.0
890306	131807	4831	479.9	-10.59	0.87	11.8	0.3
890306	131817	4863	477.9	-10.28	0.89	11.6	0.2
890306	131826	4890	476.2	-10.96	0.87	12.4	1.0
890306	131836	4918	474.5	-11.29	0.86	12.6	1.3
890306	131846	4935	473.5	-11.60	0.85	13.6	2.3
890306	131856	4962	471.8	-11.64	0.86	13.2	1.9
890306	131925	5038	467.1	-11.93	0.85	12.5	1.3
890306	131935	5082	464.4	-12.91	0.79	12.1	0.9
890306	131945	5106	463.0	-12.69	0.78	12.3	1.2
890306	131954	5123	462.0	-12.97	0.75	11.9	0.8
890306	132004	5143	460.7	-12.98	0.75	11.8	0.7
890306	132014	5171	459.0	-13.23	0.73	11.5	0.4
890306	132024	5187	458.1	-13.23	0.74	11.2	0.1
890306	132033	5216	456.3	-13.48	0.72	11.5	0.4
890306	132043	5239	455.0	-13.79	0.68	11.1	0.1
890306	132053	5263	453.5	-13.76	0.67	11.1	0.2
890306	132103	5284	452.3	-13.76	0.67	10.6	0.3
890306	132113	5308	450.8	-14.15	0.65	11.4	0.5
890306	132122	5336	449.2	-14.18	0.64	12.2	1.3
890306	132132	5360	447.7	-14.68	0.62	11.8	1.0
890306	132142	5391	445.9	-14.93	0.61	11.0	0.2
890306	132152	5412	444.7	-14.92	0.61	11.7	0.9
890306	132201	5438	443.2	-15.08	0.60	10.4	0.3
890306	132211	5479	440.7	-15.56	0.58	11.0	0.3
890306	132221	5499	439.6	-15.84	0.57	11.2	0.5
890306	132231	5527	438.0	-16.01	0.57	11.1	0.4
890306	132241	5558	436.1	-16.20	0.56	11.7	1.0
890306	132250	5587	434.5	-16.42	0.56	11.2	0.6

FREE FLIGHT 0306

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
890306	132300	5624	432.4	-16.69	0.55	12.4	1.8
890306	132310	5646	431.1	-16.77	0.55	11.8	1.2
890306	132320	5674	429.4	-17.01	0.54	11.4	0.8
890306	132329	5696	428.2	-17.23	0.53	11.2	0.7
890306	132339	5729	426.3	-17.54	0.52	10.8	0.3
890306	132349	5764	424.3	-17.74	0.51	9.4	1.0
890306	132359	5786	423.1	-18.00	0.50	10.7	0.3
890306	132409	5819	421.2	-18.26	0.49	10.5	0.1
890306	132418	5850	419.5	-18.38	0.48	10.9	0.6
890306	132428	5876	418.0	-18.75	0.47	11.5	1.2
890306	132438	5900	416.7	-18.90	0.46	10.5	0.2
890306	132448	5926	415.2	-19.05	0.45	10.6	0.3
890306	132457	5951	413.8	-19.25	0.44	11.1	0.9
890306	132507	5982	412.1	-19.64	0.44	9.8	0.4
890306	132517	5988	411.8	-19.15	0.45	10.5	0.3
890306	132527	6028	409.5	-19.67	0.44	11.3	1.2
890306	132537	6066	407.5	-20.23	0.43	10.6	0.5
890306	132546	6089	406.2	-20.54	0.42	10.8	0.7
890306	132556	6125	404.2	-20.66	0.42	11.2	1.2
890306	132606	6132	403.8	-20.64	0.42	10.0	0.0
890306	132616	6160	402.3	-20.95	0.41	11.1	1.0
890306	132626	6189	400.7	-21.23	0.41	10.0	0.1
890306	132635	6217	399.2	-21.52	0.40	10.4	0.4
890306	132645	6250	397.4	-21.34	0.41	10.9	1.0
890306	132655	6260	396.9	-21.72	0.39	10.4	0.5
890306	132705	6303	394.6	-21.74	0.39	9.9	0.1
890306	132715	6304	394.5	-21.83	0.39	10.1	0.3
890306	132724	6347	392.2	-22.23	0.38	10.3	0.5
890306	132734	6372	390.9	-22.41	0.37	10.5	0.7
890306	132744	6398	389.5	-22.55	0.37	10.4	0.7
890306	132754	6414	388.6	-22.67	0.36	9.7	0.2
890306	132803	6454	386.5	-22.88	0.36	9.7	0.0
890306	132823	6489	384.7	-23.00	0.35	10.5	0.8
890306	132833	6520	383.1	-23.33	0.34	9.6	0.4
890306	132843	6540	382.0	-23.29	0.35	9.6	0.2
890306	132852	6552	381.4	-23.80	0.33	10.1	0.5
890306	132902	6596	379.1	-23.99	0.33	9.5	0.2
890306	132912	6607	378.5	-24.27	0.32	10.5	0.9
890306	132922	6644	376.6	-24.33	0.32	9.5	0.2
890306	132932	6661	375.7	-24.48	0.31	10.4	1.0
890306	132941	6676	375.0	-24.45	0.33	10.0	0.5
890306	132951	6711	373.1	-25.13	0.31	9.4	0.3
890306	133001	6742	371.5	-25.39	0.31	9.7	0.3
890306	133011	6754	370.9	-25.61	0.30	10.1	0.7
890306	133021	6776	369.8	-25.67	0.30	10.3	1.0
890306	133030	6815	367.9	-26.00	0.30	10.0	0.6
890306	133040	6845	366.3	-25.83	0.30	9.3	0.0
890306	133050	6882	364.4	-26.51	0.29	9.3	0.6
890306	133100	6923	362.4	-26.99	0.29	9.2	0.5

FREE FLIGHT 0307

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat 10-6/m	Bsp 10-6/m
890307	93138	7	876.8	11.39	3.21	44.9	25.6
890307	93148	40	873.3	10.80	3.05	51.5	32.2
890307	93159	74	869.7	10.37	3.02	47.5	28.4
890307	93209	97	867.4	10.05	2.99	44.5	25.4
890307	93220	124	864.5	9.99	3.06	43.2	24.1
890307	93230	163	860.4	9.29	2.86	42.2	23.1
890307	93240	195	857.1	9.06	2.84	44.7	25.7
890307	93251	221	854.4	9.08	2.73	43.5	24.6
890307	93301	247	851.7	9.30	2.69	40.6	21.7
890307	93312	279	848.5	9.06	2.52	41.0	22.2
890307	93322	306	845.7	9.30	2.51	38.0	19.3
890307	93332	344	841.8	8.61	2.35	38.1	19.4
890307	93343	386	837.5	8.28	2.29	38.3	19.7
890307	93353	424	833.7	8.37	2.24	39.9	21.3
890307	93404	446	831.5	8.72	2.37	37.7	19.2
890307	93414	479	828.1	8.31	2.32	34.2	15.8
890307	93424	500	826.0	8.41	2.33	36.0	17.6
890307	93435	519	824.2	8.50	2.35	38.1	19.8
890307	93445	545	821.6	8.06	2.32	38.3	20.0
890307	93456	569	819.2	8.58	2.46	34.7	16.5
890307	93506	596	816.5	8.31	2.59	31.6	13.4
890307	93516	626	813.6	8.30	2.67	29.7	11.6
890307	93527	646	811.6	8.71	2.60	31.9	13.9
890307	93537	667	809.6	8.88	2.69	30.8	12.9
890307	93548	687	807.6	9.15	2.68	33.1	15.2
890307	93558	709	805.5	9.09	2.59	32.1	14.3
890307	93608	729	803.4	8.72	2.52	32.0	14.2
890307	93619	752	801.2	8.68	2.53	28.9	11.1
890307	93629	774	799.1	8.40	2.49	31.6	13.9
890307	93640	799	796.7	8.33	2.53	35.1	17.4
890307	93650	822	794.5	8.61	2.62	35.1	17.5
890307	93700	849	791.9	8.32	2.58	32.4	14.8
890307	93711	869	789.9	8.23	2.58	30.7	13.1
890307	93721	896	787.4	8.22	2.64	33.0	15.5
890307	93732	920	785.1	8.30	2.73	34.4	16.9
890307	93742	943	782.9	8.61	2.82	31.8	14.4
890307	93752	962	781.1	8.43	2.86	32.9	15.6
890307	93803	985	779.0	8.28	2.85	28.3	10.9
890307	93813	1007	776.8	8.14	2.86	28.3	11.0
890307	93824	1028	774.9	7.81	2.80	27.2	10.0
890307	93834	1063	771.6	7.53	2.89	28.8	11.6
890307	93844	1085	769.5	8.00	3.12	29.4	12.3
890307	93855	1107	767.5	7.55	3.11	27.8	10.7
890307	93905	1135	764.9	7.59	3.27	26.1	9.1
890307	93916	1169	761.8	7.46	3.22	27.3	10.3
890307	93926	1202	758.7	7.65	3.25	28.8	11.9
890307	93937	1233	755.9	7.03	3.17	22.8	6.0
890307	93947	1260	753.3	6.78	3.12	24.1	7.2

FREE FLIGHT 0307

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat 10-6/m	Bsp 10-6/m
890307	93957	1283	751.2	6.77	3.05	25.7	8.9
890307	94008	1308	749.0	6.69	3.20	25.0	8.3
890307	94018	1329	747.0	6.60	3.39	22.6	5.9
890307	94029	1350	745.1	6.51	3.35	22.6	5.9
890307	94039	1371	743.2	6.19	3.30	24.7	8.1
890307	94100	1413	739.4	5.86	3.29	23.1	6.5
890307	94110	1439	737.0	6.05	3.46	21.3	4.8
890307	94121	1468	734.5	5.68	3.38	23.2	6.7
890307	94131	1489	732.6	5.95	3.44	22.1	5.7
890307	94141	1514	730.3	5.39	3.30	24.6	8.2
890307	94152	1533	728.6	5.34	3.25	23.5	7.2
890307	94202	1552	726.9	5.58	3.21	23.2	6.9
890307	94213	1579	724.5	5.25	3.30	23.4	7.1
890307	94223	1599	722.8	5.42	3.12	21.7	5.4
890307	94234	1621	720.9	5.11	3.13	19.3	3.0
890307	94244	1639	719.3	5.93	3.27	17.8	1.7
890307	94254	1664	717.1	5.84	3.20	18.8	2.7
890307	94305	1681	715.6	5.88	3.13	17.1	1.0
890307	94315	1703	713.6	5.50	2.98	18.8	2.8
890307	94326	1723	711.9	5.70	3.19	20.2	4.2
890307	94336	1745	710.0	5.53	3.19	17.5	1.5
890307	94346	1768	708.0	5.48	3.22	16.5	0.6
890307	94357	1787	706.3	5.39	3.37	17.8	1.9
890307	94407	1815	703.9	5.01	3.44	19.0	3.2
890307	94418	1847	701.2	4.93	3.57	19.2	3.4
890307	94428	1893	697.2	5.09	3.57	20.6	4.9
890307	94439	1922	694.7	5.36	3.57	19.8	4.2
890307	94449	1945	692.8	5.65	3.61	17.1	1.6
890307	94459	1965	691.1	6.05	3.65	19.0	3.6
890307	94510	1984	689.5	5.86	3.59	18.4	2.9
890307	94520	2008	687.5	5.52	3.56	19.9	4.5
890307	94531	2027	685.9	5.36	3.52	17.2	1.8
890307	94541	2050	684.0	5.74	3.58	16.2	0.8
890307	94552	2073	682.1	5.23	3.39	17.1	1.8
890307	94602	2093	680.4	5.48	3.43	18.8	3.5
890307	94612	2114	678.7	5.55	3.42	16.6	1.4
890307	94623	2134	676.9	5.16	3.31	18.1	2.9
890307	94633	2156	675.1	5.44	3.37	16.5	1.4
890307	94644	2180	673.2	4.92	3.26	17.8	2.7
890307	94654	2196	671.9	4.99	3.28	18.3	3.2
890307	94704	2218	670.1	4.62	3.23	16.8	1.7
890307	94715	2241	668.1	4.51	3.19	17.1	2.1
890307	94725	2265	666.2	4.69	3.18	18.7	3.7
890307	94736	2284	664.7	4.45	3.08	15.7	0.7
890307	94746	2308	662.6	4.32	3.03	18.2	3.3
890307	94756	2333	660.6	4.18	3.08	18.2	3.3
890307	94807	2351	659.2	4.05	3.03	18.2	3.3
890307	94817	2374	657.3	3.95	2.94	18.7	3.8
890307	94828	2400	655.2	3.55	2.94	16.6	1.8

FREE FLIGHT 0307

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat 10-6/m	Bsp 10-6/m
890307	94838	2423	653.3	3.48	2.92	16.9	2.1
890307	94849	2435	652.4	3.36	2.96	19.5	4.7
890307	94859	2458	650.6	3.22	2.88	20.0	5.3
890307	94909	2482	648.6	3.54	2.95	20.0	5.3
890307	94920	2504	646.9	3.71	2.99	19.3	4.6
890307	94930	2542	643.8	3.07	2.89	16.1	1.5
890307	94941	2567	641.8	2.47	2.82	15.3	0.7
890307	94951	2601	639.2	2.23	2.94	16.4	1.8
890307	95001	2630	636.8	2.43	3.01	19.3	4.8
890307	95012	2651	635.2	2.99	3.17	18.5	4.1
890307	95022	2676	633.3	2.14	2.96	17.8	3.4
890307	95043	2711	630.5	1.93	3.03	15.5	1.2
890307	95054	2741	628.1	1.69	2.97	17.9	3.6
890307	95104	2766	626.2	1.45	2.96	16.5	2.2
890307	95114	2790	624.3	1.16	2.85	17.1	2.8
890307	95125	2814	622.5	0.63	2.76	15.0	0.8
890307	95135	2836	620.8	0.66	2.82	15.7	1.5
890307	95146	2863	618.7	0.28	2.76	15.7	1.5
890307	95156	2884	617.1	0.31	2.85	15.6	1.5
890307	95207	2912	614.9	0.09	2.82	17.1	3.0
890307	95217	2936	613.1	0.73	2.96	16.4	2.4
890307	95227	2960	611.2	0.12	2.85	17.1	3.1
890307	95238	2981	609.7	0.24	2.90	17.4	3.5
890307	95248	3005	607.8	-0.79	2.70	16.7	2.8
890307	95259	3032	605.8	-0.62	2.74	16.1	2.2
890307	95309	3051	604.3	-0.92	2.64	16.4	2.5
890307	95319	3073	602.7	-0.42	2.72	14.7	0.9
890307	95330	3101	600.5	-1.58	2.53	13.4	0.4
890307	95340	3119	599.2	-1.29	2.64	15.9	2.1
890307	95351	3148	597.0	-0.91	2.69	13.3	0.4
890307	95401	3167	595.6	-1.77	2.54	12.5	1.3
890307	95412	3189	593.9	-1.65	2.50	16.9	3.2
890307	95422	3213	592.2	-1.67	2.43	17.2	3.5
890307	95432	3237	590.4	-1.78	2.40	18.9	5.3
890307	95443	3259	588.8	-1.73	2.36	16.0	2.5
890307	95453	3279	587.3	-1.60	2.36	15.4	1.9
890307	95504	3303	585.5	-1.48	2.33	16.5	3.0
890307	95514	3329	583.6	-2.23	2.19	14.9	1.4
890307	95525	3348	582.2	-1.88	2.16	12.1	1.4
890307	95535	3372	580.5	-2.52	2.06	14.5	1.1
890307	95545	3387	579.3	-1.49	2.19	15.3	2.0
890307	95556	3410	577.7	-2.20	2.08	14.8	1.4
890307	95606	3438	575.7	-2.63	2.06	15.5	2.2
890307	95617	3456	574.3	-2.88	2.07	16.2	2.9
890307	95627	3480	572.6	-2.93	2.10	15.8	2.5
890307	95638	3495	571.5	-2.79	2.08	13.5	0.2
890307	95648	3521	569.7	-3.34	1.95	15.5	2.3
890307	95658	3548	567.7	-3.38	1.95	14.4	1.3
890307	95709	3572	566.0	-2.59	2.04	14.1	1.1

FREE FLIGHT 0307

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat 10-6/m	Bsp 10-6/m
890307	95719	3595	564.3	-3.90	1.87	17.2	4.1
890307	95730	3608	563.4	-4.15	1.85	12.9	0.2
890307	95740	3634	561.6	-3.87	1.86	13.0	0.1
890307	95750	3650	560.4	-4.06	1.83	16.9	3.9
890307	95801	3673	558.8	-4.55	1.70	15.3	2.3
890307	95811	3699	557.0	-4.67	1.66	14.3	1.3
890307	95822	3719	555.5	-4.17	1.63	16.7	3.8
890307	95832	3743	553.9	-4.62	1.55	17.1	4.2
890307	95843	3769	552.0	-4.38	1.47	16.8	4.0
890307	95853	3784	551.0	-4.21	1.44	16.0	3.1
890307	95903	3808	549.2	-4.53	1.39	17.0	4.2
890307	95914	3835	547.4	-5.24	1.33	16.8	4.0
890307	95924	3847	546.6	-5.71	1.31	14.0	1.2
890307	95935	3882	544.1	-5.59	1.33	13.8	1.1
890307	95945	3894	543.2	-5.36	1.33	13.1	0.4
890307	95956	3923	541.3	-5.51	1.28	15.9	3.2
890307	100006	3940	540.1	-5.91	1.22	15.0	2.3
890307	100027	3986	537.0	-5.94	1.25	14.5	1.9
890307	100037	4007	535.5	-6.19	1.29	13.8	1.3
890307	100048	4032	533.8	-6.27	1.27	12.5	0.0
890307	100058	4054	532.3	-6.58	1.26	15.1	2.6
890307	100109	4076	530.8	-6.74	1.28	16.7	4.2
890307	100119	4103	528.9	-6.79	1.27	17.5	5.1
890307	100129	4126	527.4	-6.27	1.37	14.7	2.3
890307	100140	4151	525.7	-6.80	1.31	16.3	3.9
890307	100150	4172	524.3	-7.02	1.31	15.6	3.3
890307	100201	4192	522.9	-7.49	1.29	15.8	3.5
890307	100211	4218	521.2	-7.82	1.34	14.7	2.4
890307	100222	4247	519.3	-7.25	1.38	14.7	2.5
890307	100232	4270	517.7	-8.00	1.36	14.4	2.2
890307	100242	4290	516.4	-8.34	1.33	15.9	3.7
890307	100253	4312	515.0	-8.61	1.28	12.3	0.1
890307	100303	4339	513.2	-8.62	1.30	9.0	3.2
890307	100314	4361	511.7	-8.71	1.32	10.1	2.0
890307	100324	4386	510.0	-8.49	1.35	12.0	0.0
890307	100335	4414	508.2	-9.29	1.29	12.2	0.2
890307	100345	4437	506.7	-9.76	1.26	14.5	2.5
890307	100355	4458	505.3	-9.91	1.23	15.2	3.2
890307	100406	4481	503.8	-10.02	1.21	13.8	1.8
890307	100416	4514	501.7	-10.06	1.23	12.3	0.4
890307	100427	4535	500.3	-10.08	1.14	13.5	1.6
890307	100437	4562	498.6	-10.80	1.11	11.7	0.2
890307	100448	4586	497.0	-10.50	1.23	11.6	0.3
890307	100458	4602	495.9	-11.24	1.16	11.8	2.4
890307	100509	4633	493.9	-11.37	1.15	12.9	1.1
890307	100519	4659	492.3	-11.40	1.12	14.8	3.1
890307	100529	4683	490.7	-11.69	1.10	13.8	2.0
890307	100540	4710	489.0	-11.88	1.09	15.0	3.2
890307	100550	4740	487.1	-11.54	1.10	14.5	2.8

FREE FLIGHT 0307

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat 10-6/m	Bsp 10-6/m
890307	100601	4773	485.0	-11.81	1.08	12.9	1.3
890307	100611	4791	483.9	-11.76	1.09	14.8	3.2
890307	100622	4828	481.5	-12.66	1.06	13.6	2.1
890307	100632	4843	480.6	-12.55	1.10	10.6	0.9
890307	100642	4874	478.6	-12.44	1.10	10.2	1.3
890307	100653	4902	476.8	-13.07	1.04	14.0	2.5
890307	100703	4921	475.7	-12.95	1.06	11.7	0.2
890307	100714	4949	473.9	-13.12	1.04	13.1	1.7
890307	100724	4969	472.7	-13.67	1.00	16.2	4.8
890307	100735	4993	471.2	-13.96	0.97	16.1	4.7
890307	100745	5022	469.4	-14.41	0.92	13.6	2.2
890307	100756	5033	468.7	-14.16	0.90	11.8	0.4
890307	100806	5064	466.8	-14.47	0.85	11.3	2.0
890307	100817	5091	465.1	-14.70	0.83	11.2	0.1
890307	100827	5115	463.7	-14.23	0.86	11.5	0.3
890307	100837	5144	461.9	-14.97	0.81	11.4	0.2
890307	100848	5170	460.3	-15.26	0.79	10.2	1.0
890307	100858	5189	459.2	-15.16	0.78	11.1	1.7
890307	100909	5224	457.0	-15.26	0.78	14.2	3.1
890307	100919	5236	456.3	-15.27	0.79	16.0	5.0
890307	100930	5268	454.4	-15.69	0.76	11.0	0.1
890307	100940	5291	453.0	-15.49	0.76	11.6	0.6
890307	100951	5311	451.8	-15.58	0.75	13.3	2.3
890307	101011	5357	449.0	-16.61	0.71	11.9	1.0
890307	101022	5396	446.7	-16.77	0.71	12.0	1.1
890307	101032	5409	445.9	-16.93	0.71	13.2	2.3
890307	101043	5438	444.2	-17.03	0.71	12.6	1.8
890307	101053	5459	443.0	-17.03	0.71	11.4	0.5
890307	101104	5493	441.0	-17.67	0.68	10.0	0.8
890307	101114	5500	440.5	-18.37	0.66	11.7	0.9
890307	101125	5527	439.0	-18.23	0.69	16.2	5.4
890307	101135	5561	437.0	-18.45	0.69	17.5	6.8
890307	101146	5589	435.3	-18.85	0.69	15.5	4.8
890307	101156	5609	434.1	-18.90	0.71	12.9	2.2
890307	101207	5634	432.7	-19.11	0.70	10.9	0.2
890307	101217	5658	431.3	-19.21	0.69	12.6	2.0
890307	101227	5671	430.5	-19.32	0.69	11.9	1.3
890307	101238	5715	428.0	-19.60	0.68	13.2	2.6
890307	101248	5736	426.8	-19.84	0.67	12.0	1.4
890307	101259	5756	425.6	-20.10	0.66	11.1	0.5
890307	101309	5774	424.6	-20.14	0.66	11.6	1.1
890307	101320	5801	423.1	-20.26	0.65	10.5	1.3
890307	101330	5819	422.0	-20.23	0.65	11.7	1.3
890307	101341	5812	422.4	-19.70	0.67	12.3	1.9
890307	101351	5767	425.0	-20.52	0.63	12.9	2.4
890307	101402	5721	427.7	-20.37	0.64	11.0	0.4
890307	101412	5644	432.1	-19.84	0.67	11.2	0.6
890307	101423	5581	435.8	-19.33	0.71	11.6	0.9
890307	101433	5510	440.0	-19.05	0.71	12.3	1.5

APPENDIX B

Tethered Flight Data Tables

TETHERED FLIGHT 0620

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
891219	61838	1	843.0	-1.50	65.7	67.6	48.1
891219	61849	3	842.8	-1.44	65.0	71.8	52.3
891219	61859	7	842.4	-1.46	65.0	72.3	52.8
891219	61909	8	842.3	-1.33	63.5	65.1	45.7
891219	61919	9	842.2	-1.25	63.3	66.9	47.5
891219	61929	12	841.9	-1.24	63.4	69.9	50.5
891219	61939	14	841.7	-1.24	63.8	65.1	45.7
891219	61949	15	841.6	-1.23	63.9	63.5	44.1
891219	61959	16	841.4	-1.18	63.2	60.8	41.4
891219	62009	19	841.2	-1.11	62.5	60.8	41.4
891219	62019	20	841.0	-1.12	62.8	58.1	38.8
891219	62029	21	840.9	-1.14	62.8	58.1	38.7
891219	62039	24	840.6	-1.15	63.0	55.4	36.0
891219	62049	27	840.3	-1.17	63.2	58.0	38.6
891219	62100	30	840.0	-1.18	63.6	58.6	39.3
891219	62110	35	839.5	-1.10	62.7	59.3	40.0
891219	62120	40	839.0	-1.12	63.1	60.1	40.8
891219	62140	45	838.4	-0.95	62.6	61.0	41.7
891219	62150	49	838.0	-1.02	63.7	59.4	40.1
891219	62200	50	837.8	-0.97	63.1	65.3	46.0
891219	62210	52	837.7	-0.88	62.5	65.1	45.8
891219	62220	55	837.3	-0.74	62.1	66.4	47.1
891219	62230	57	837.1	-0.67	61.6	59.7	40.5
891219	62240	60	836.9	-0.66	62.5	58.9	39.7
891219	62250	61	836.7	-0.57	61.8	62.6	43.3
891219	62301	64	836.5	-0.55	61.9	57.9	38.6
891219	62311	65	836.3	-0.47	61.2	55.5	36.3
891219	62321	68	836.0	-0.47	61.6	56.4	37.2
891219	62331	70	835.8	-0.48	61.7	58.0	38.8
891219	62341	73	835.5	-0.49	62.0	58.5	39.3
891219	62351	74	835.4	-0.52	62.3	54.5	35.3
891219	62401	76	835.1	-0.52	62.4	54.4	35.2
891219	62411	78	835.0	-0.54	62.6	55.3	36.1
891219	62421	79	834.8	-0.53	62.3	52.2	33.0
891219	62431	80	834.7	-0.53	62.6	52.2	33.0
891219	62441	81	834.7	-0.53	62.5	58.8	39.6
891219	62512	82	834.5	-0.48	62.0	63.1	44.0
891219	62522	83	834.4	-0.48	62.1	58.9	39.7
891219	62602	85	834.2	-0.47	62.2	55.9	36.7
891219	62612	86	834.1	-0.46	61.9	61.1	41.9
891219	62632	87	834.0	-0.49	62.1	56.1	36.9
891219	62642	89	833.8	-0.49	62.6	58.2	39.0
891219	62713	90	833.7	-0.46	61.9	54.1	34.9
891219	62723	91	833.6	-0.44	61.9	55.2	36.1
891219	62733	95	833.2	-0.36	61.0	57.9	38.8
891219	62743	101	832.5	-0.28	61.0	60.1	41.0
891219	62753	105	832.1	-0.28	61.6	60.5	41.4
891219	62803	112	831.4	-0.27	61.9	58.4	39.3

TETHERED FLIGHT 0620

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Mix Rat g/kg	Bscat Mm-1	Bsp Mm-1
891219	62813	116	831.0	-0.25	61.9	59.3	40.2
891219	62823	120	830.6	-0.27	62.2	60.5	41.5
891219	62833	124	830.1	-0.26	61.7	57.8	38.7
891219	62843	128	829.8	-0.22	61.6	60.4	41.4
891219	62853	133	829.2	-0.07	60.2	65.6	46.6
891219	62903	138	828.7	0.05	59.6	60.3	41.3
891219	62914	147	827.8	0.12	59.7	64.2	45.2
891219	62924	148	827.6	0.20	59.3	68.9	49.9
891219	62934	158	826.6	0.39	57.9	63.2	44.3
891219	62944	163	826.1	0.62	56.8	59.1	40.2
891219	63004	168	825.6	0.92	56.0	55.5	36.6
891219	63014	170	825.4	1.20	55.9	52.7	33.8
891219	63024	173	825.1	1.16	56.4	51.7	32.9

TETHERED FLIGHT 0725

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	72323	3	843.6	-2.09	70.1	94.6	75.1
891219	72343	5	843.4	-2.22	70.1	96.7	77.2
891219	72353	1	842.6	-2.04	68.3	90.2	70.7
891219	72403	19	841.9	-1.89	67.1	92.4	72.9
891219	72413	26	841.2	-1.81	66.8	85.0	65.5
891219	72423	29	840.8	-1.78	66.9	76.2	56.7
891219	72434	33	840.4	-1.66	66.1	74.9	55.5
891219	72444	38	839.9	-1.61	65.9	75.5	56.1
891219	72454	43	839.4	-1.62	66.2	82.0	62.6
891219	72504	47	839.0	-1.57	65.7	80.9	61.6
891219	72514	52	838.5	-1.51	65.7	87.8	68.5
891219	72524	55	838.2	-1.47	65.4	92.9	73.5
891219	72534	60	837.6	-1.47	65.5	84.6	65.3
891219	72544	65	837.1	-1.48	65.8	80.8	61.5
891219	72554	69	836.7	-1.52	66.2	79.8	60.5
891219	72604	72	836.3	-1.53	66.4	76.1	56.8
891219	72615	76	835.9	-1.53	66.2	77.0	57.8
891219	72625	79	835.6	-1.54	66.4	75.1	55.8
891219	72635	83	835.2	-1.44	65.5	81.6	62.3
891219	72645	87	834.7	-1.36	65.4	86.8	67.5
891219	72655	90	834.5	-1.30	65.0	83.9	64.7
891219	72705	91	834.4	-1.21	64.6	80.3	61.1
891219	72715	95	834.0	-1.11	63.7	75.5	56.3
891219	72725	99	833.6	-1.00	63.0	71.2	52.0
891219	72735	104	833.0	-0.97	63.1	65.8	46.6
891219	72745	108	832.6	-0.98	63.4	66.2	47.1
891219	72755	113	832.1	-0.96	63.2	66.5	47.4
891219	72806	117	831.6	-0.80	61.8	64.7	45.5
891219	72816	120	831.3	-0.67	61.0	70.8	51.7
891219	72826	122	831.1	-0.52	60.3	72.3	53.2
891219	72836	124	830.9	-0.46	60.5	67.8	48.7
891219	72846	128	830.5	-0.39	60.2	65.6	46.5
891219	72856	132	830.1	-0.26	59.3	71.3	52.2
891219	72906	137	829.5	-0.16	59.2	72.1	53.0
891219	72916	144	828.9	-0.12	59.3	69.4	50.4
891219	72926	149	828.3	-0.09	59.3	67.3	48.3
891219	72936	155	827.7	-0.10	59.8	67.7	48.7
891219	72946	159	827.3	-0.12	60.1	67.6	48.6

TETHERED FLIGHT 0800

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	80013	0	844.0	-1.36	67.3	99.1	79.7
891219	80023	7	843.3	-1.10	64.6	99.2	79.8
891219	80033	13	842.6	-1.19	65.7	97.3	77.9
891219	80043	20	841.9	-1.25	66.7	101.3	81.9
891219	80053	26	841.3	-1.19	65.6	105.3	85.9
891219	80104	32	840.6	-1.27	66.6	103.7	84.3
891219	80114	37	840.1	-1.40	67.7	98.8	79.5
891219	80124	45	839.3	-1.42	67.4	100.3	81.0
891219	80134	51	838.6	-1.45	67.3	100.5	81.2
891219	80144	59	837.8	-1.42	66.7	104.0	84.7
891219	80154	65	837.1	-1.35	65.9	101.7	82.4
891219	80204	74	836.2	-1.35	66.1	101.3	82.0
891219	80214	83	835.3	-1.44	67.0	96.2	77.0
891219	80224	90	834.5	-1.50	67.6	95.1	75.9
891219	80234	98	833.7	-1.51	67.1	91.5	72.2
891219	80244	106	832.9	-1.42	66.1	89.8	70.6
891219	80254	112	832.2	-1.45	66.5	93.6	74.4
891219	80305	117	831.7	-1.53	67.2	87.2	68.0
891219	80315	120	831.4	-1.48	66.1	89.5	70.3
891219	80325	124	830.9	-1.53	66.6	93.3	74.1
891219	80335	128	830.5	-1.43	65.3	93.2	74.0
891219	80345	132	830.1	-1.43	65.3	92.9	73.7
891219	80355	135	829.8	-1.44	65.6	84.6	65.4
891219	80405	139	829.4	-1.36	64.5	89.8	70.7
891219	80415	144	828.9	-1.26	63.3	88.2	69.1
891219	80425	146	828.7	-1.08	62.2	85.1	66.0
891219	80435	150	828.3	-1.01	62.4	81.9	62.8
891219	80445	153	828.0	-0.82	61.4	81.1	62.1

TETHERED FLIGHT 0820

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	81823	2	843.9	-0.40	63.2	109.1	89.7
891219	81833	7	843.4	-0.43	63.9	111.0	91.7
891219	81843	13	842.7	-0.43	63.9	107.1	87.7
891219	81853	18	842.2	-0.63	65.8	100.6	81.2
891219	81903	21	841.9	-0.70	66.1	99.9	80.5
891219	81913	23	841.7	-0.72	65.5	107.3	87.9
891219	81923	25	841.4	-0.80	66.3	104.5	85.1
891219	81933	26	841.4	-0.77	65.7	102.2	82.8
891219	81943	29	841.0	-0.81	65.7	101.4	82.1
891219	81953	31	840.9	-0.65	63.5	98.7	79.4
891219	82003	32	840.7	-0.75	65.1	103.2	83.9
891219	82013	33	840.6	-0.50	62.9	105.3	85.9
891219	82034	35	840.4	-0.83	66.1	105.0	85.7
891219	82044	36	840.3	-0.85	65.9	98.3	78.9
891219	82054	40	839.9	-0.86	65.7	97.9	78.6
891219	82104	41	839.8	-0.80	65.1	109.9	90.5
891219	82114	45	839.4	-0.75	64.5	117.2	97.9
891219	82124	48	839.0	-0.90	66.3	105.1	85.8
891219	82134	52	838.6	-0.94	66.0	99.9	80.6
891219	82144	55	838.3	-0.93	65.7	101.1	81.8
891219	82154	57	838.1	-0.92	65.4	105.8	86.5
891219	82204	59	837.9	-0.98	65.7	101.1	81.8
891219	82215	63	837.5	-1.00	65.9	104.8	85.5
891219	82225	64	837.4	-1.07	66.4	106.7	87.4
891219	82235	67	837.0	-1.06	66.2	102.4	83.1
891219	82245	71	836.7	-1.12	66.4	109.6	90.3
891219	82255	73	836.4	-1.11	66.1	109.4	90.1
891219	82305	76	836.1	-1.15	66.2	104.7	85.4
891219	82315	80	835.7	-1.14	66.3	109.9	90.7
891219	82325	82	835.4	-1.19	66.7	108.2	88.9
891219	82335	85	835.2	-1.20	66.3	106.8	87.6
891219	82345	88	834.9	-1.21	66.5	103.0	83.8
891219	82355	92	834.4	-1.25	66.9	108.1	88.8
891219	82405	94	834.2	-1.26	66.6	107.9	88.7
891219	82416	98	833.8	-1.25	66.2	110.2	91.0
891219	82426	100	833.6	-1.25	66.0	107.5	88.2
891219	82436	103	833.3	-1.31	66.9	107.5	88.3
891219	82446	106	832.9	-1.34	66.9	109.1	89.9
891219	82456	110	832.6	-1.39	67.3	108.4	89.2
891219	82506	113	832.3	-1.35	66.5	115.9	96.8
891219	82516	114	832.2	-1.36	66.5	110.7	91.5
891219	82526	118	831.7	-1.36	66.5	109.7	90.5
891219	82536	120	831.5	-1.38	66.7	105.6	86.4
891219	82546	123	831.2	-1.42	66.9	107.0	87.9
891219	82556	126	830.9	-1.44	67.1	107.6	88.4
891219	82607	128	830.7	-1.44	66.9	112.5	93.4
891219	82617	130	830.4	-1.41	66.4	114.3	95.2
891219	82627	134	830.0	-1.44	66.4	114.8	95.7

TETHERED FLIGHT 0820

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	82637	138	829.7	-1.45	66.8	118.1	99.0
891219	82647	140	829.4	-1.45	67.1	119.6	100.4
891219	82657	142	829.2	-1.51	67.2	111.0	91.9
891219	82717	151	828.3	-1.45	66.3	111.2	92.1
891219	82727	154	828.0	-1.39	65.6	103.1	84.0
891219	82737	155	827.8	-1.35	65.1	97.6	78.6

TETHERED FLIGHT 0850

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	84607	2	844.4	-0.30	60.9	251.0	231.6
891219	84617	5	844.1	-0.44	62.8	258.5	239.1
891219	84627	8	843.8	-0.25	60.5	254.1	234.7
891219	84637	11	843.4	-0.08	58.9	242.7	223.4
891219	84647	13	843.2	-0.34	61.3	250.1	230.8
891219	84657	17	842.9	-0.16	59.4	267.4	248.0
891219	84707	20	842.5	-0.06	59.1	259.9	240.6
891219	84717	23	842.2	-0.32	62.3	260.6	241.2
891219	84727	26	841.8	-0.11	60.1	259.9	240.6
891219	84737	28	841.7	-0.37	62.8	264.4	245.1
891219	84747	31	841.3	-0.31	61.8	267.1	247.8
891219	84757	34	841.0	-0.46	62.5	290.0	270.7
891219	84808	37	840.7	-0.43	62.0	291.5	272.2
891219	84818	40	840.3	-0.48	62.1	266.8	247.5
891219	84828	44	840.0	-0.24	60.2	232.4	213.1
891219	84838	47	839.7	-0.13	60.0	203.0	183.7
891219	84848	51	839.3	0.21	57.7	175.7	156.4
891219	84858	53	839.0	1.47	48.4	160.1	140.9
891219	84908	56	838.7	1.05	55.3	144.5	125.3
891219	84918	59	838.4	0.41	62.0	134.8	115.6
891219	84928	62	838.1	0.10	64.4	125.3	106.0
891219	84938	65	837.7	-0.01	64.4	123.0	103.8
891219	84948	68	837.4	-0.09	64.0	124.6	105.4
891219	84958	71	837.2	-0.03	63.2	122.3	103.0
891219	85009	75	836.7	-0.07	63.4	121.0	101.8
891219	85019	77	836.6	-0.07	63.0	125.1	105.9
891219	85029	80	836.2	0.08	61.7	127.8	108.6
891219	85039	81	836.1	0.00	62.7	128.9	109.7
891219	85049	86	835.5	0.01	62.4	127.6	108.5
891219	85059	88	835.4	-0.05	62.7	124.7	105.5
891219	85109	92	835.0	-0.01	62.3	116.0	96.9
891219	85119	94	834.7	-0.03	62.0	118.9	99.7
891219	85129	97	834.4	0.05	61.2	114.8	95.6
891219	85139	100	834.1	0.05	61.2	117.5	98.3
891219	85149	103	833.8	0.02	61.5	108.1	88.9
891219	85159	107	833.3	0.11	61.2	107.0	87.9
891219	85209	110	833.1	0.14	61.0	101.0	81.9
891219	85220	112	832.8	0.44	58.8	95.9	76.8
891219	85230	116	832.5	0.47	59.6	94.7	75.7
891219	85240	119	832.2	0.61	58.4	91.8	72.7
891219	85250	122	831.8	0.70	58.3	84.5	65.5
891219	85310	125	831.5	0.50	60.1	76.9	57.9
891219	85320	128	831.2	0.55	59.6	87.8	68.7
891219	85330	132	830.8	0.55	59.6	82.9	63.9
891219	85340	133	830.7	0.46	60.3	77.2	58.2
891219	85350	135	830.5	0.31	61.4	73.3	54.2
891219	85400	137	830.3	0.31	60.9	76.9	57.8
891219	85421	140	829.9	0.30	60.3	75.8	56.8

TETHERED FLIGHT 0850

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	85431	141	829.9	0.48	57.7	73.0	54.0
891219	85441	142	829.8	0.63	56.3	73.4	54.4
891219	85451	144	829.5	0.59	57.0	69.7	50.7
891219	85501	147	829.3	0.54	57.2	67.1	48.1
891219	85511	149	829.0	0.52	57.6	65.8	46.8
891219	82747	155	827.9	-1.42	66.1	98.4	79.3

TETHERED FLIGHT 0920

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	92756	127	831.3	0.90	57.3	70.8	51.7
891219	92806	128	831.2	1.83	48.9	70.7	51.7
891219	92816	131	830.9	2.24	48.4	69.9	51.0
891219	92826	134	830.6	1.85	53.5	68.8	49.9
891219	92836	136	830.4	2.27	50.2	67.9	49.0
891219	85451	144	829.5	0.59	57.0	69.7	50.7
891219	92916	147	829.2	2.05	53.6	65.1	46.2
891219	92926	150	829.0	1.79	55.4	68.4	49.5
891219	92936	154	828.6	2.05	52.4	71.4	52.6
891219	92946	155	828.5	2.28	51.3	69.5	50.6
891219	92957	158	828.1	2.22	52.2	70.7	51.8
891219	93007	159	828.0	2.20	52.5	69.7	50.8

TETHERED FLIGHT 0920

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	91952	1	844.4	2.01	52.6	186.4	167.2
891219	92002	4	844.1	1.93	54.2	191.2	172.0
891219	92012	6	843.9	2.05	53.9	186.6	167.4
891219	92022	8	843.6	1.61	58.0	194.8	175.6
891219	92032	12	843.3	1.63	57.2	201.6	182.4
891219	92042	13	843.1	1.54	57.5	184.2	164.9
891219	92053	15	843.0	1.74	55.5	179.8	160.6
891219	92103	19	842.5	1.54	57.5	185.0	165.8
891219	92113	21	842.3	1.21	60.4	192.6	173.4
891219	92123	23	842.1	1.11	60.4	196.4	177.1
891219	92133	26	841.8	1.04	60.1	185.7	166.5
891219	92143	28	841.5	1.09	59.1	182.4	163.2
891219	92153	31	841.3	1.11	58.5	194.3	175.1
891219	92203	33	841.0	1.12	58.4	188.6	169.3
891219	92213	36	840.8	1.05	58.7	177.8	158.6
891219	92223	38	840.5	1.10	58.3	181.2	162.0
891219	92233	40	840.3	0.97	59.5	179.5	160.3
891219	92243	42	840.1	0.88	59.8	155.3	136.0
891219	92253	45	839.8	0.84	59.6	146.2	127.0
891219	92303	48	839.6	0.81	59.7	150.3	131.1
891219	92314	49	839.4	0.87	58.7	157.3	138.1
891219	92324	51	839.1	0.80	58.9	157.5	138.3
891219	92334	54	838.9	0.74	59.3	149.1	129.9
891219	92344	56	838.6	0.72	59.4	152.0	132.9
891219	92354	58	838.5	0.74	58.8	169.7	150.5
891219	92404	62	838.1	0.74	58.7	165.7	146.5
891219	92414	65	837.7	0.74	58.5	154.8	135.7
891219	92424	67	837.5	0.78	58.0	134.3	115.2
891219	92434	71	837.2	0.92	56.6	108.1	88.9
891219	92444	74	836.8	1.10	55.5	80.5	61.4
891219	92454	76	836.6	1.20	54.6	66.5	47.4
891219	92504	79	836.2	1.32	54.1	68.4	49.3
891219	92514	84	835.7	1.33	54.9	65.8	46.7
891219	92525	86	835.5	1.31	55.2	65.2	46.1
891219	92535	90	835.2	1.40	54.4	67.4	48.3
891219	92545	92	834.9	1.47	54.1	64.9	45.8
891219	92555	95	834.6	1.41	54.7	71.2	52.1
891219	92605	98	834.3	1.50	54.2	71.4	52.4
891219	92615	101	834.0	1.56	54.0	66.4	47.3
891219	92625	102	833.8	1.91	51.2	65.6	46.6
891219	92635	106	833.5	2.26	49.7	65.5	46.6
891219	92645	109	833.2	2.43	48.7	66.2	47.3
891219	92655	111	832.9	2.01	53.4	65.4	46.4
891219	92705	114	832.7	1.48	57.9	69.5	50.5
891219	92715	116	832.4	0.99	61.5	62.1	43.1
891219	92725	119	832.1	0.80	61.8	62.8	43.7
891219	92735	120	832.0	0.75	61.0	65.5	46.5
891219	92746	124	831.7	0.82	59.0	64.3	45.3

TETHERED FLIGHT 0950

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	95036	2	844.3	2.20	56.8	102.1	82.9
891219	95046	3	844.2	2.18	56.9	103.1	83.9
891219	95056	6	843.8	2.13	57.2	104.7	85.5
891219	95106	8	843.6	2.15	56.8	107.7	88.5
891219	95116	10	843.4	2.14	56.7	107.0	87.8
891219	95126	12	843.3	2.12	56.7	107.9	88.7
891219	95136	14	843.0	2.13	56.8	109.4	90.2
891219	95146	17	842.8	2.23	55.5	104.2	85.0
891219	95156	20	842.4	2.26	54.8	103.7	84.5
891219	95206	22	842.2	2.26	55.0	113.1	94.0
891219	95216	25	841.9	2.26	55.4	117.1	97.9
891219	95226	26	841.7	2.25	55.7	119.2	100.0
891219	95236	28	841.6	2.18	56.6	118.9	99.7
891219	95246	29	841.5	2.09	57.0	131.2	112.0
891219	95257	30	841.3	2.06	56.9	125.7	106.5
891219	95307	31	841.2	2.06	56.4	117.7	98.6
891219	95317	33	841.1	2.04	56.5	116.9	97.7
891219	95327	35	840.8	2.03	56.9	124.5	105.4
891219	95337	37	840.6	1.99	57.0	119.0	99.8
891219	95347	40	840.3	1.96	57.1	115.1	96.0
891219	95357	41	840.2	2.04	56.3	111.9	92.7
891219	95407	44	839.9	2.01	56.5	113.7	94.6
891219	95417	45	839.8	2.04	56.0	124.5	105.4
891219	95427	47	839.6	2.12	55.2	123.6	104.5
891219	95437	49	839.4	2.09	55.9	126.7	107.5
891219	95447	51	839.1	2.23	55.3	119.7	100.6
891219	95457	52	839.1	2.86	50.2	127.4	108.4
891219	95507	54	838.8	3.48	47.1	129.3	110.3
891219	95528	58	838.5	3.60	50.1	119.3	100.3
891219	95538	59	838.3	3.06	54.8	126.4	107.4
891219	95548	61	838.1	2.56	58.5	126.7	107.7
891219	95558	62	838.0	2.65	57.2	129.2	110.2
891219	95608	65	837.7	2.84	54.9	128.7	109.7
891219	95618	66	837.6	3.23	52.3	126.7	107.7
891219	95628	68	837.4	3.30	52.6	125.9	106.9
891219	95638	69	837.3	2.53	59.0	132.4	113.3
891219	95648	70	837.2	2.20	59.6	123.1	104.1
891219	95658	71	837.1	1.94	59.1	106.1	87.0
891219	95708	73	836.9	1.87	57.4	88.9	69.8
891219	95718	76	836.5	1.88	56.7	109.5	90.4
891219	95728	78	836.4	1.94	56.1	112.7	93.6
891219	95739	80	836.1	1.95	56.3	117.3	98.2
891219	95749	81	836.0	1.98	56.0	129.0	109.9
891219	95759	84	835.7	1.98	56.3	128.2	109.2
891219	95809	85	835.6	1.94	56.1	128.5	109.4
891219	95819	87	835.5	2.13	55.2	127.6	108.5
891219	95829	89	835.2	2.60	52.1	127.8	108.8
891219	95859	92	834.9	3.24	51.5	129.8	110.8

TETHERED FLIGHT 0950

Date	Time	Altitude Metres	Pressure Mb	Temp Deg C	Rel Hum %	Bscat Mm-1	Bsp Mm-1
891219	95909	93	834.8	2.46	57.1	140.9	121.9
891219	95929	99	834.2	1.81	59.9	119.4	100.4
891219	95939	101	833.9	1.70	59.8	117.3	98.2
891219	100000	102	833.9	1.64	57.5	121.2	102.2
891219	100010	106	833.4	1.59	56.9	107.9	88.9
891219	100020	110	833.0	1.61	55.7	82.8	63.8
891219	100030	116	832.4	1.58	56.4	81.0	62.0
891219	100040	120	832.0	1.56	56.3	76.6	57.6
891219	100050	123	831.7	1.57	55.5	66.8	47.9
891219	100100	125	831.5	1.54	55.5	65.6	46.6
891219	100110	127	831.2	1.53	55.7	77.6	58.6
891219	100120	128	831.2	1.47	55.2	77.1	58.1
891219	100140	131	830.9	1.38	55.4	109.4	90.4
891219	100150	134	830.6	1.42	54.3	89.0	70.1
891219	100210	136	830.3	1.37	54.5	97.0	78.0
891219	100231	140	830.0	1.34	54.3	91.4	72.5
891219	100241	143	829.7	1.35	54.0	87.1	68.1
891219	100251	146	829.3	1.37	53.6	76.1	57.1
891219	100311	148	829.2	1.22	54.9	118.2	99.3
891219	100321	155	828.4	1.25	54.3	82.8	63.8
891219	100331	160	827.9	1.26	53.9	60.0	41.1
891219	100341	162	827.6	1.23	54.2	52.8	33.9

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