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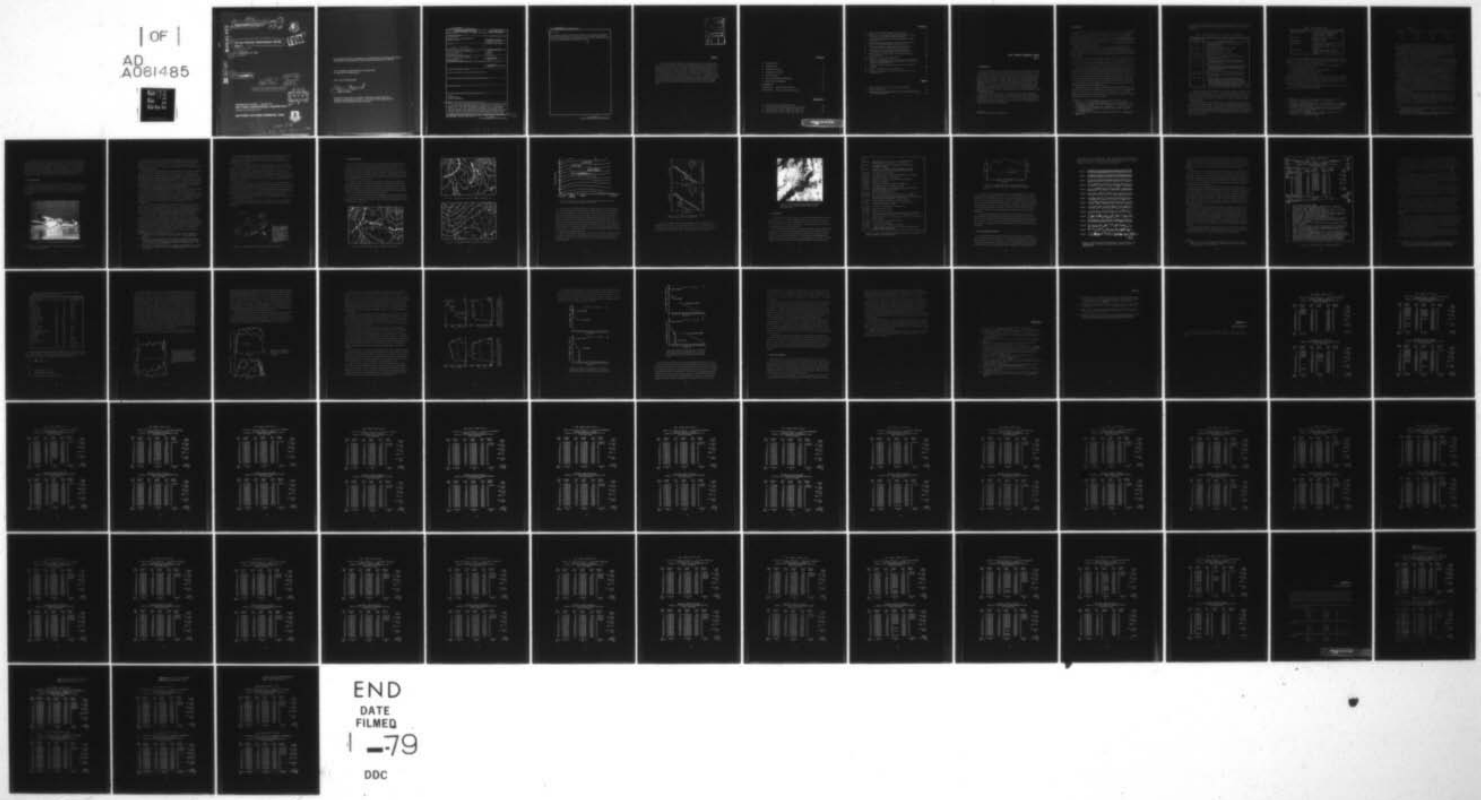

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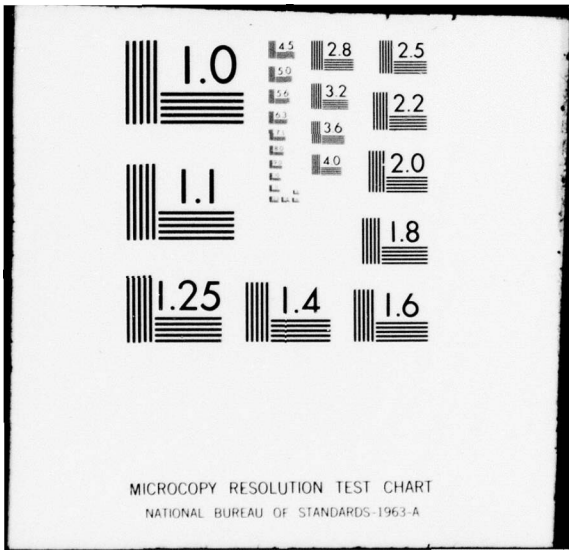
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Cirrus Particle Distribution Study. Part I.

D. J. HARLEY, Lt Col, USAF

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AIR FORCE SYSTEMS COMMAND, USAF

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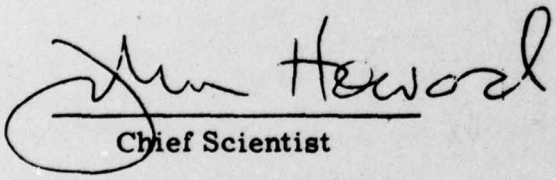

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Cirrus particle distribution data are presented for a flight that was made by the AFGL instrumented MC-130E aircraft near Denver, Colorado on 29 October 1977. The data were gathered in support of an Air Force Weapons Laboratory project. The report briefly describes some previous cirrus research and also outlines the basic cloud physics instrumentation aboard the aircraft, particularly the PMS 1-D and 2-D spectrometer equipment. Data averages are given for consecutive 30-sec periods during a 27-min flight through varying thicknesses of cirrus clouds. Besides tabular data, graphs

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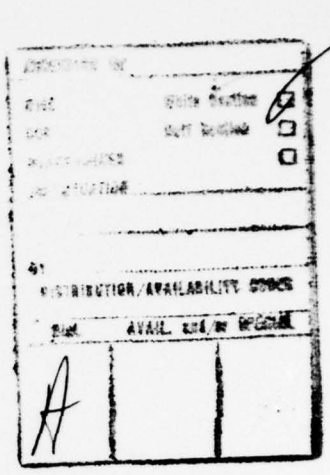
are presented that show the temporal variations of liquid water content and particle concentration as a function of size. The 2-D data indicated most of the cirrus particles were not recognizable according to any standard classification system, although many were bullet rosettes.



Preface

I would like to thank Dr. Robert M. Cunningham for his many helpful suggestions in improving both the technical content and readability of the manuscript. My appreciation is also extended to personnel of Digital Programming Services, Inc., particularly Michael Francis, who devoted many hours to the development of the data presentation format provided herein. Ms. Barbara Main did excellent work in improving the sketches of illustrations that I provided her. Thanks are also due to the mission director, Dr. Arnold A. Barnes, Jr., and the meteorological equipment technicians, MSgt Joseph Arnold, TSgt Marshall Wright and Mr. Anthony Matthews, who were instrumental in obtaining the actual cirrus data presented here.

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Cirrus Particle Distribution Study Part 1

1. INTRODUCTION

A cirrus sampling mission over Colorado was made on 29 October 1977 during a movement of the AFGL instrumented MC-130E aircraft to the West Coast. Particle and other atmospheric data were obtained for the Air Force Weapons Laboratory's Advanced Radiation Technology (ART) program. The purpose of this program is to obtain data that will enable a better definition of typical habit and distribution of particles or ice crystals found in relatively thin cirrus clouds. This information will in turn be used in determining the expected degradation of laser beam energy propagated through this type of cloud form. Ensuing parts of this study will present cirrus particle population and size data that were obtained during other sampling flights.

The following Sections provide: (1) a brief review of previous literature on cirrus data to provide a perspective, (2) a discussion of the cloud physics instrumentation aboard the sampling aircraft, (3) a review of the weather situation at the time of one specific sampling flight, and (4) a description of the generalized data format and of the data for one mission.

(Received for publication 4 August 1978)

2. PERSPECTIVE

The physics and composition of cirrus clouds were not extensively studied until the last few years when improved instrumentation and a better sampling capability provided an impetus for a closer look at these high clouds. Aside from the fact that they are an important mechanism for moisture exchange at subtropopause levels they also contribute to the earth's albedo and tend to restrict incoming solar radiation and light transmittance. These effects are due to the small-sized but numerous ice particles in cirrus type clouds.

Mason,[1] reporting on Weickmann's findings of the 1940's, indicated that at temperatures below -25 C the dominant ice particle form is the hexagonal prism which is indigenous to cirrus and medium-level clouds. Weickmann believed clusters (bullet rosettes) of the prism-shaped crystals about 2 mm were common in isolated cirrus clouds.

Schaefer[2] acquired snowflake replicas in many parts of the world and indicated that cirrus clouds result from spontaneous nucleation, that is, foreign particles are not required to initiate them. According to Schaefer, the crystal types common to cirrus are the hexagonal plate and column and the irregular or asymmetric crystal.

In laboratory tests, aufm Kampe et al[3] found predominantly single crystals to form at temperatures above -20 C. However, around -20 C they were irregular aggregates or "spatial crystals" (or bullet rosettes) with about 100 crystals per cm^3. At -29 C the same spatial crystals were observed, though they seemed to have the characteristics of both plates and columns. Additionally, some single columns were present at this temperature and at temperatures down to about -40 C. This same type of crystal was found in the top of a cirrocumulus cloud, where crystals were just forming. Older crystals, gathered at the base of this type cloud, were of the same type but had grown considerably in size.

Considering ice particles over a wide temperature range Ono[4] pointed out that their basic form exhibits four changes over the range 0 to -32 C. The changes from planar to columnar at -3.5 C and from columnar to planar at -9.5 C are rather sharp (on the temperature scale). However, the transition from planar to columnar crystals below about -22 C is much less sharp.

---

1. Mason, B.J. (1957) The Physics of Clouds, Oxford University Press.
2. Schaefer, F.J. (1951) Snow and its relationship to experimental meteorology, Compendium of Meteor., Bull. Amer. Meteorol. Soc. pp 221-234.
3. aufm Kampe, H.J., Weickmann, H.K., and Kelley, J.J. (1951) The influence of temperature on the shape of ice crystals growing at water saturation, J. Meteorol. 8:168-174.
4. Ono, A. (1970) Growth mode of ice crystals in natural clouds, J. Atmos. Sci. 27:649-658.

Based on an examination of more than 10,000 crystals and the results of others, Ono developed the listing of typical crystal shapes according to the temperature ranges below.

Table 1. Typical Crystal Forms as Function of Temperatures

Temperature (C)	Form of Ice Crystals
≥ -3.5	Simple hexagonal plane ice crystal without any internal structure.
-3.5 to -4	Solid/hollow-type columnar ice crystal.
-4 to -6	Needle-type columnar ice crystal.
-6 to -8	Sheath-type columnar ice crystal.
-8 to -9.5	Solid/hollow-type columnar ice crystal.
-9.5 to -12	Thick plane-type ice crystal with or without hollow structure on prism faces.
-12 to -14	Hexagonal plane ice crystal with internal structure, ribs extending along the a axis over the basal faces of the crystal.
-14 to -17	Stellar type plane ice crystal, including plane crystal with dendritic extension, dendritic plane crystal with sector plane at tops, and plane crystal with dendritic extensions.
-17 to -19	Hexagonal plane ice crystal with internal structure.
-19 to -22	Thick plane-type ice crystal with hollow structure on prism faces.
-22 to -32	Ice crystals seem to have characteristics of both plane and columnar ice crystals. In addition to single columnar or single thick plane ice crystals, irregular aggregates of columns or sectors are common. Scroll, side plane and bullet-type columnar ice crystals are also common crystal forms.

The ratio of diameter to thickness for a given crystal diameter exhibits a maximum value in the neighborhood of -16 C. This is where dendrites and stellars are seen. On the other hand, the ratio of thickness (or length) to diameter in warm columnar crystals goes through a maximum near -5 C where needle and columnar crystals are found.

The large variation of particle types in cirrus temperatures is particularly to be noted in the preceeding table. While warmer temperatures frequently result in one or two given particle types, Ono found that, at temperatures below -22 C, particles have both the characteristics of planar and columnar crystals as well as variations of these. A summary of opinion of findings regarding typical cirrus particle type is given in Table 2.

Table 2. Cirrus Particle Type

Weickmann (1940's)	In convective cirrus: bullet rosettes. In cirrostratus: eroded single bullets, columns and plates.
Schaefer[2]	Hexagonal plates and columns and irregular crystals.
Knollenberg[5]	Bullets and columns.
Heymsfield[6]	In weak uniform cirrus: plates, columns, and some bullet rosettes. In heavy uniform cirrus: mostly bullet rosettes.
Heymsfield[7]	In cirrus uncinus: bullet rosettes, single bullets, banded columns, and plates.

Heymsfield and Knollenberg[8] collected several hours of flight data in cirrus generating cells found in uncinus, cirrostratus, spissatus and thunderstorm anvils. Average values of particle and moisture data were:

(a) Ice crystal concentration: 10,000 - 25,000 m^{-3} (max. 50,000 m^{-3}),

(b) Crystal length: 0.6 - 1.0 mm,

(c) Particle habit: bullet rosettes, columns, and plates,

(d) Ice crystal density: 0.6 - 0.9 gm m^{-3},

(e) Ice water content: 0.15 - 0.25 gm m^{-3}.

They[8] admitted that the mean particle length of 0.6 mm (600 μm) or more that they found was greater than those usually observed in cirrus, but they pointed out that the cirrus generating cell is not a cloud in the usual sense. Rather, it is a mass of growing precipitation elements (ice crystals).

On two particular flights in high clouds, Heymsfield[6] found the total concentrations of crystals at various altitudes as follows:

5. Knollenberg, R. G. (1973) Cirrus-contrail cloud spectra studies with the Sabreliner, Atmos. Tech. (by NCAR), No. 1, pp 52-55.

6. Heymsfield, A. (1974) Ice crystal growth in deep cirrus systems, in Preprints of Conference on Cloud Physics, Bull. Amer. Meteorol. Soc. pp 311-316.

7. Heymsfield, A. (1975) Cirrus uncinus generating cells and the evolution of cirriform clouds. Part I: Aircraft observations of the growth of the ice phase, J. Atmos. Sci. 32:799-808.

8. Heymsfield, A. J., and Knollenberg, R. G. (1972) Properties of cirrus generating cells, J. Atmos. Sci. 29:1358-1366.

Flight No. 1		Flight No. 2	
Altitude (kft)	Concentration (cm^{-3})	Altitude (kft)	Concentration (cm^{-3})
31	0.39	37	0.57
29	1.71	25	1.78
21	4.13	17	2.24

He also pointed out that cirrostratus clouds exhibited lower particle concentrations and ice water contents than did cirrus uncinus clouds. The mean and maximum crystal lengths were found to increase from near the cloud top to the cloud base.

The number of sampling flights through aircraft condensation trails at high altitudes appears to be small. However, Knollenberg[5] has indicated contrails are similar to natural cirrus as concerns crystal size spectra.

In all of his cirrus flights, Heymsfield[6] found a thin (0.5 to 1.0 km) nearly invisible tropopause cirrus layer above a lower cirrus deck. The particle concentration in this high cirrus was of the order of 0.2 to 1.5 cm^{-3}. These layers contained columnar and plate crystals, and occasionally trigonal crystals. The thin cirrus layers were found nearly every day at the tropopause, independent of whether a storm system was below. They apparently formed in the stable layer near the base of the tropopause. The highest concentration of crystals found in Heymsfield's cirrus flights was in the 7 to 15 μm range, whether 20 miles from the edge of an overrunning surface, 150 miles from the edge, or in the thin tropopause layer.

In the Ryan et al[9] single flight through a cirrus layer at 32,000 ft the measured crystal concentration varied between approximately 0.5 and 3.8 cm^{-3} which is near Heymsfield's[6] results. They found nearly equal numbers of particles in each channel in the 5.5 to 50 μm range. Ryan et al[9] point out that only apparent size distributions can be reported for particles detected by spectrometers based on a light scattering mechanism. This is the case since the scattering properties of ice crystals are not known.

Although not directly applicable to the problem of ice clouds Stewart[10] has provided an excellent literature review of the extinction caused by various sized droplets in fogs. The atmospheric extinction of visible wavelengths in some fogs is several times that at a wavelength of 10 μm. She points out that large drops contribute much more to extinction than do small drops.

---

9. Ryan, R.T., Blau, J.H., Jr., von Thuna, P.C., and Cohen, M.L. (1972) Cloud microstructure as determined by an optical cloud particle spectrometer, J. Appl. Meteorol. 11:149-156.

10. Stewart, Dorathy A. (1977) Infrared and Submillimeter Extinction by Fog, Redstone Arsenal Technical Report TR-77-9, 55 pp.

In a study of Alaskan ice fogs below -20 C, Thuman and Robinson[11] found the size of particles decreased as the temperature decreased; however the number of equant solid particles with rudimentary crystal faces, or "droxtals," increased rapidly with decreasing temperature. At low temperatures (< ~ -35 C) they attributed the high incidence of restricted visibility (at the surface, not aloft) to the presence of the droxtals rather than the prisms of hexagons; in fact, below -38 C they found over 90 percent of the particles in the ice fogs to be droxtals.

3. INSTRUMENTATION

The AFGL MC-130E, serial number 40571, shown in Figure 1, is equipped with five optical spectrometer probes for measuring the size and number of particles in different areas of the particle spectrum. These are manufactured by Particle Measuring Systems, Inc. (PMS) and consist of four imaging probes and one scattering probe.

Figure 1. AFGL Instrumented MC-130E Aircraft

11. Thuman, W. C., and Robinson, E. (1954) Studies of Alaskan ice-fog particles, J. Meteorol. 11:151-156.

One-dimensional (1-D) measurements of the largest sizes are made by the "precipitation" probe which records ice particles between approximately 400 and 4700 μm. The "cloud" probe makes 1-D measurements of particles between approximately 26 and 312 μm, while the scattering probe is used to detect particles in the 2 to 30 μm range.

Two-dimensional "shadowgraph" recordings of particles are also made aboard the aircraft by two 2-D spectrometers. These are based on an extension of 1-D technology and are manufactured by the same developer. The 2-D probes contain high speed front end memories enabling each photodiode detector element to encode many bits of shadow information from each particle. As a particle passes through the spectrometer array, slices of the shadow are recorded to develop a two-dimensional image. The range of the 2-D "cloud" probe is approximately 25 to 800 μm, and that for the 2-D "precipitation" probe is about 200 to 6400 μm.

Particles passing through the vertically pointed laser beams of the four imaging probes occlude one or more photodiodes in a line. Large particles therefore occlude more of the diodes than do smaller ones. In the scattering probe, particles also pass through a laser beam, but in this case the size is determined by the amount of light that is forward scattered by the moving particle. More extensive discussions of 1- and 2-D probe capabilities are given by Knollenberg[12, 13] and Heymsfield.[14]

The 1- and 2-D array probes provide a relatively accurate measure of particulate mass spectra for liquid droplets because they are essentially spherical and have a density of one (although there is some difficulty with droplets splashing). In ice clouds the size spectra is also relatively accurate; however, conversion to a mass spectra involves certain assumptions requiring estimates of particle density.

These instruments are among the best presently available, but even better quality ice crystal data would be desirable. Dendrite crystals, for example, are not well sized by the probes because they frequently result in less than a 50 percent reduction in laser light. Also, columnar crystals are underestimated in concentration according to Heymsfield.[14] Plates, plates with extensions, bullet rosettes, and aggregates, however, are sized and counted nearly correctly. To eventually improve the quality of ice particle data, AFGL is pursuing the development and acquisition of a superior cirrus particle detector.

12. Knollenberg, R.G. (1970) The optical array: An alternative to scattering or extinction for airborne particle size determination. J. Appl. Meteorol. 9:86-103.

13. Knollenberg, R.G. (1976) Three new instruments for cloud physics measurements: The 2-D spectrometer, the forward scattering probe, and the active scattering spectrometer, in Preprints of Intnatl. Cld. Physics Conf., Bull Amer. Meteorol. Soc. pp 554-561.

14. Heymsfield, A.J. (1976) Particle size distribution measurement: An evaluation of the Knollenberg optical array probes, Atmos. Tech. (by NCAR) No. 8, pp 17-24.

The MC-130E sampling aircraft is instrumented with an aluminum foil impact sampler to record larger droplets or crystals. Since such large particles are ordinarily rare at cirrus altitudes this device was not used in obtaining the data described in a later section.

A device for collecting particles on a formvar replicator film is ordinarily utilized, although it was not available for the 29 October flight because of mechanical problems. The advantage of formvar for collection is that a permanent replica of particles is made that gives valuable detail on their physical structure. This is more difficult to obtain by optical methods. Optical detection systems and continuous replication are often complementary. The bulk of optical data can be digitally processed, some in real-time, while the formvar data provides greater detail but must be reduced manually.

To obtain a visual estimate of the intensity and type of ice crystals through which the aircraft is passing a metal rod or "snow stick" with a black, flat surface at the end has been fabricated to protrude out the fuselage approximately 17 in. into the airstream. Particles of ice impinge on the flat surface that is perpendicular to the airflow. This provides the meteorological observer a view through his window of a sample of the type, size, and number of crystals being flown through.

The type of instrumentation aboard the aircraft and the location of some of the sensors are shown in Figure 2.

The remainder of this report describes a particular cirrus sampling flight of the MC-130E aircraft on 29 October 1977 and the data that were obtained during the flight.

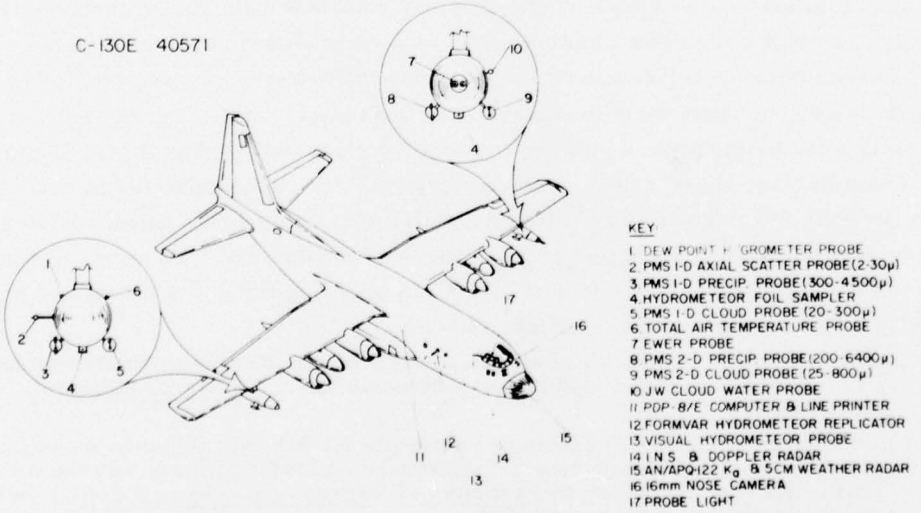

Figure 2. Cloud Physics Instrumentation Aboard Aircraft 40571

4. SYNOPTIC SITUATION

The surface isobaric pattern over the mountain states was relatively weak on 29 October 1977, the day the sampling mission was flown near Denver. The previous day, a north-south oriented cold front had started to move inland over Washington and Oregon. By the morning of the 29th it extended from Central California north into Eastern Washington and was continuing slowly eastward resulting in light rain showers over Oregon, Idaho, and Montana. The small scale features of the 29 October 1200Z synoptic chart are shown in Figure 3 while Figure 4 is the corresponding chart for 24 hr later.

As shown in Figure 5, an upper level trough extended along the coastline of western North America resulting in a southwesterly flow over the western states. The southern portion of the trough near California continued moving to the east, and by the following day it extended northwesterly from New Mexico to the Alaska coastline. The lifting induced by the trough was favorable for the formation of the cirrus clouds through which the sampling aircraft flew.

The vertical pattern of temperature distribution along the flight path is shown in cross-section form in Figure 6. Between 1200 GMT, when the temperatures on the figure were established, and the time of the actual flight, slightly colder air had moved into the sampling area.

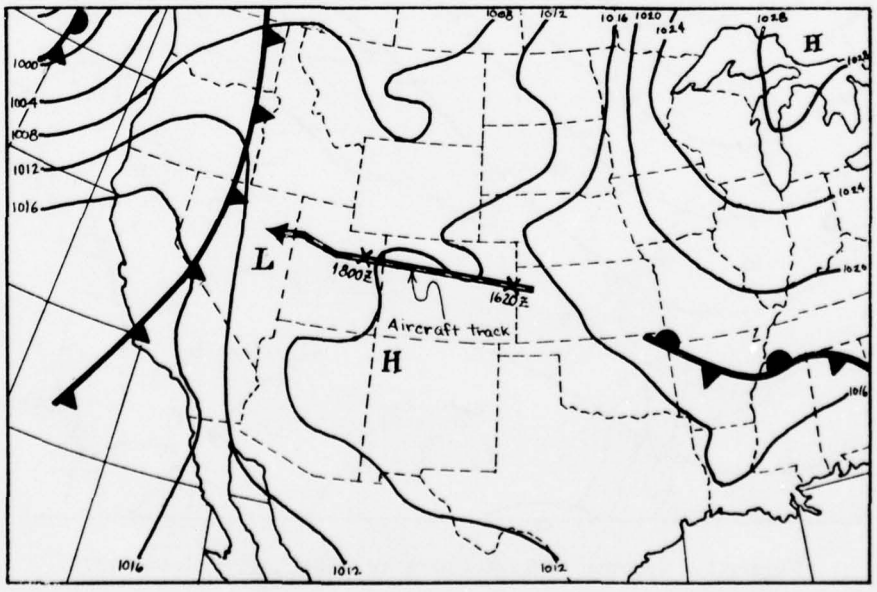

Figure 3. Synoptic Surface Chart for 1200Z, 29 October 1977

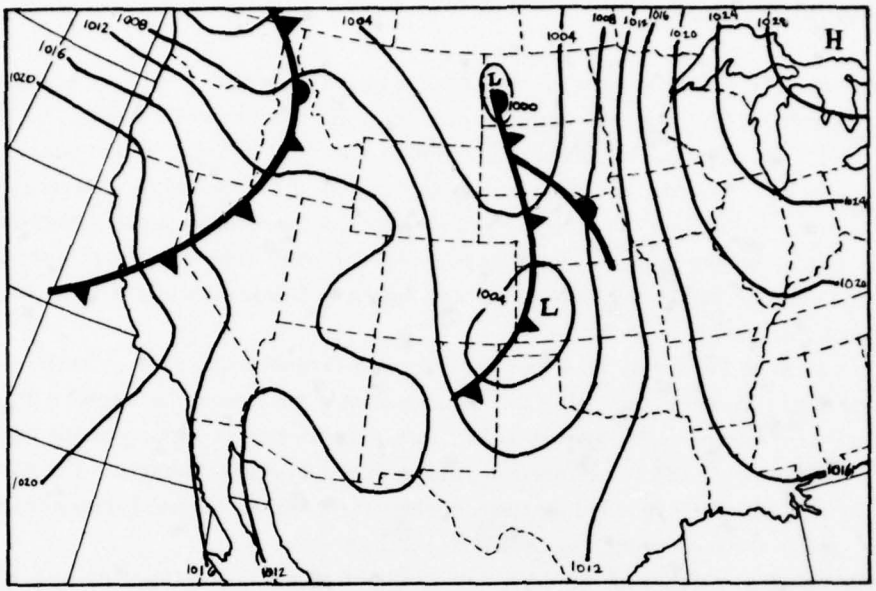

Figure 4. Synoptic Surface Chart for 1200Z, 30 October 1977

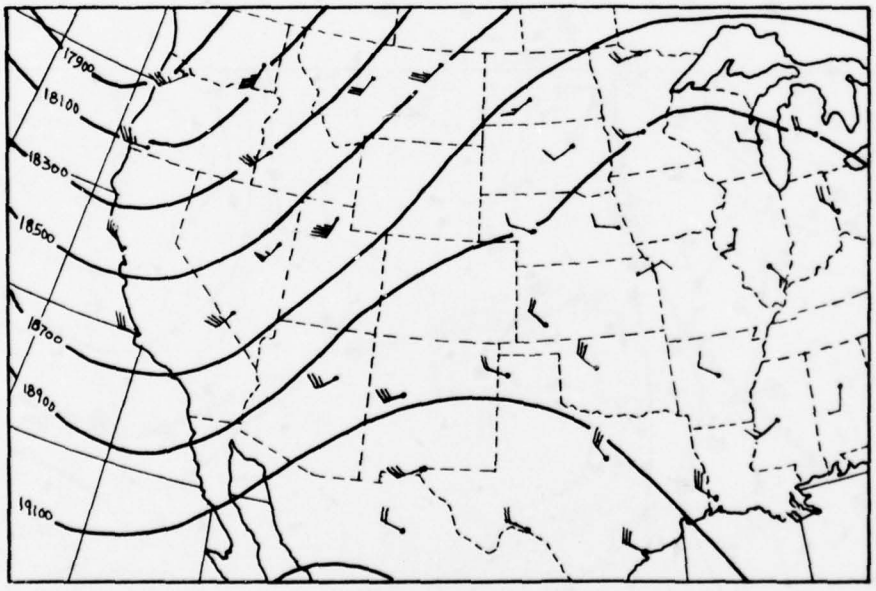

Figure 5. Synoptic 500 mb Chart for 1200Z, 29 October 1977

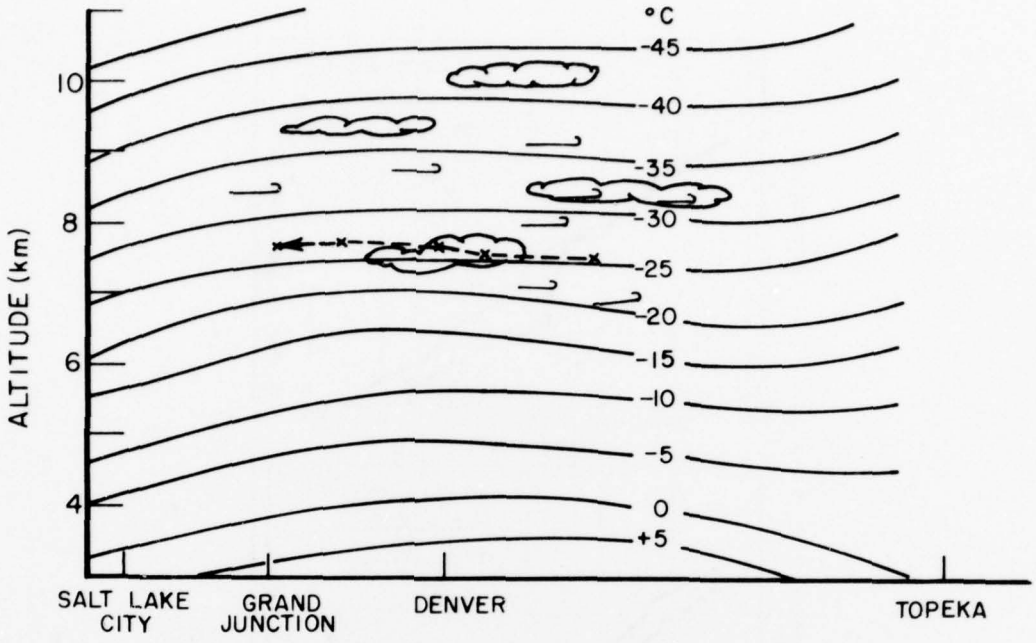

Figure 6. Isotherms (°C) Along General Flight Path 29 October 1977 as Determined From 1200Z Soundings Along Route

Supplemental data indicated broken to overcast skies over most of Colorado with ceilings estimated at 10,000 to 25,000 ft (3050 to 7620 m). The freezing level was near 12,000 ft (3660 m). There were no reports of the heights of cloud tops. Radar reports indicated there were no echoes most of the day in the area except about 1735Z when light rain showers or thunderstorms were reported over the Colorado-Utah border. At the approximate time the aircraft was within a few miles of Denver (and the sampling was in progress) the Denver weather report indicated the bases of overcast clouds were estimated at 25,000 ft (7620 m), the visibility was 40 miles (64 km), the temperature was 65°F (19C) and surface winds were 170° at 5 kts (2.5 m sec^{-1}). Most other stations within at least 100 miles (170 km) reported similar weather conditions at the time.

Figure 7 shows plotted sounding data for 1200Z on 29 October for Grand Junction and Denver, respectively. The former station is about 60 miles (96 km) from the sampling track but it is in a direction from which air was being advected toward the sampled area.

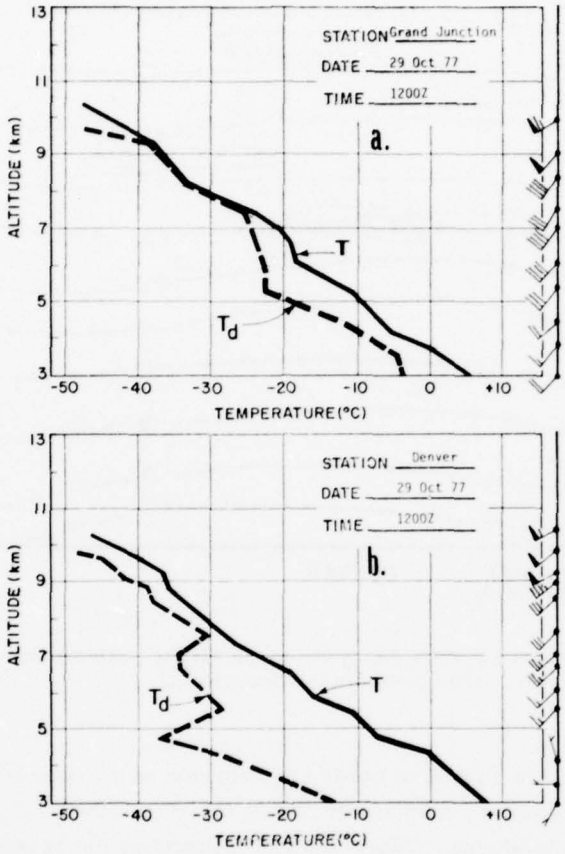

Figure 7. Grand Junction and Denver, Colorado Sounding Data, 1200Z, 29 October 1977

Figure 8 is a Defense Meteorological Satellite Program (DMSP) picture of general cloud conditions over the southwestern portion of the United States at approximately midday on 29 October. The main cloud mass feature is associated with a high level jet extending to the northeast from over Baja, California.

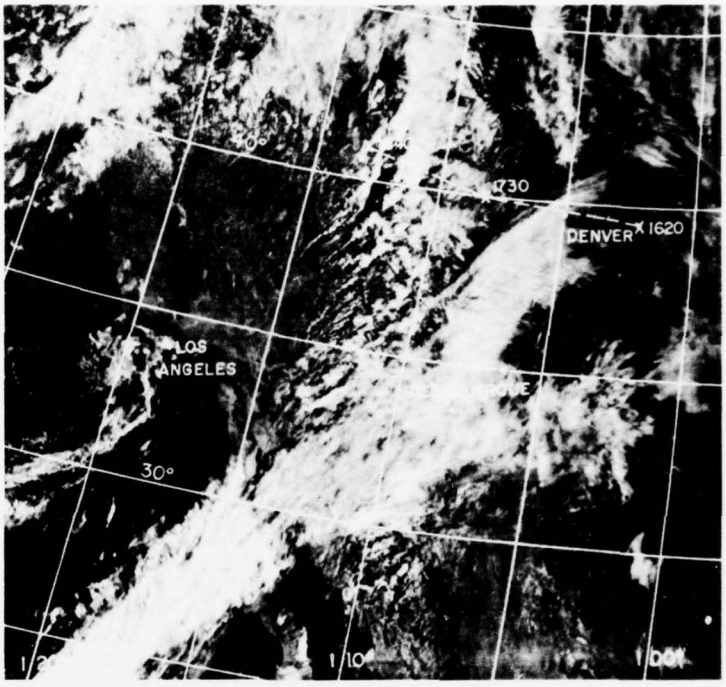

Figure 8. Defense Meteorological Satellite Program Visible Picture of Western United States (Midday 29 October 1977)

5. THE SAMPLING

The generally good visibility reported in the Denver weather observation was also mentioned in a comment recorded at 1644Z in the sampling aircraft. While still a few miles east of Denver at 23,500 ft (7.1 km) the Air Force Academy, some 70 miles (112 km) south could be seen. Other notes from the aircraft voice tape transcript are recorded in Figure 9.

The cirrus sampling considered most significant was begun about 1650Z near Denver and continued for nearly a half-hour as the aircraft continued to the west northwest. The aircraft altitude was between 24,600 ft (7.5 km) and 25,250 ft (7.7 km) MSL during the sampling period. Flight altitude temperatures were between -27 and -31C during this time. Figure 10 shows the variation of aircraft altitude and outside temperature as the flight progressed in the sampling area.

Time	
16:44:00	At 23,500 ft (7162m). In clear. Cirrus all quadrants. Visibility 100 mi. Air Force Academy visible.
16:45:10	Jet contrails above that are below higher cirrus layer. At 24,000 ft (7315m).
16:45:30	A cirrus layer above estimated at 36,000 ft (10,972m). But there is also cirrus all quadrants at lower levels.
16:50:50	Some counts in cloud probe.
16:51:10	At 24,400 ft (7437m). Getting into bottom of a cirrus layer.
16:52:10	At 24,500 ft (7468m). In thin cirrus.
16:54:30	Monitor on cloud probe shows bell curve distribution.
16:56:20	Start the 2-D sampler.
16:58:50	2-D shows particles 100 to 200 μ in diameter.
17:00:00	At 25,000 ft (7620m). Definitely in cloud.
17:01:00	In stratified cloud. Can't see any structure above or below. Not getting anything on snow stick.
17:01:15	Getting many updates on 2-D.
17:01:25	Very small particles visible when snow stick is rotated.
17:02:15	From monitor it's difficult to tell if particles are bullet rosettes, but snow stick indicates single crystals, small.
17:03:35	Larger particles indicated on snow stick and 2-D.
17:06:30	Clouds look thick above and below. Cannot see ground. Can see no structure in clouds.
17:07:00	Can see ground and snow on mountains now.
17:08:50	Some fairly large stellars.
17:10:00	Getting into thicker clouds.
17:11:30	Still no cloud structure, but breaking between layers of clouds. Wing tips have been visible whole time. Breaking out on top.
17:12:30	At 24,900 ft (7589m). On top of one cirrus layer. A higher cirrus layer is above.
17:13:10	Can see snow covered mountains below.
17:14:00	Very few particle updates.
17:14:30	1-D probe does not indicate any particles.
17:15:45	Scattering probe indicates particles across the spectrum, but mainly toward smaller sizes.

Figure 9. Notes Transcribed From Mission Director's Voice Tape Comments During 29 October 1977 Sampling Flight

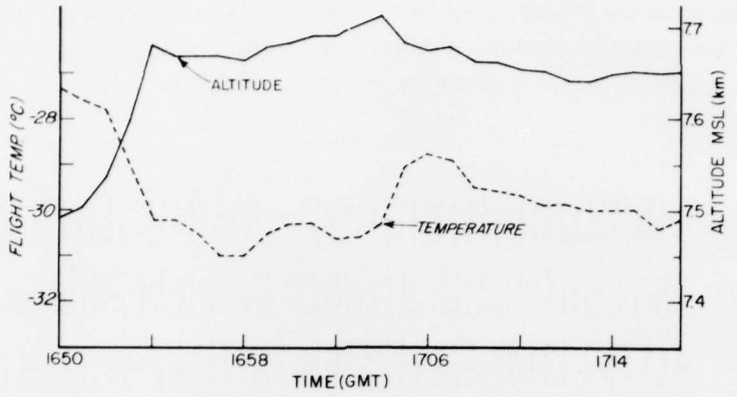

Figure 10. Variation With Time of Aircraft Altitude and Outside Air Temperature During 29 October 1977 Sampling Period

At 1701Z the aircraft was reported to be in a thin stratified cloud. The airborne meteorologist indicated he could see no cloud structure above or below his 25,000 ft (7.6 km) altitude at that time. The ground was visible for one or two brief times during the sampling period. However, at 1712Z the observer indicated the aircraft was briefly above one cirrus layer at 24,900 ft (7.6 km), but that there was another layer still higher. Contrails were occasionally visible above the aircraft, but below the higher cirrus deck. By 1715Z most of cirrus layer being sampled was behind the aircraft although particle counts increased again shortly thereafter.

The smallest particles had been reported at the beginning of the sampling period (1650Z). There had been a gradual increase in particle size seen on the snow stick outside the aircraft as the heaviest (thickest) portion of the cirrus layer was traversed. A 1710Z comment indicated the aircraft was moving into some of the heaviest cloud seen up to that time, but by 1713Z snow-covered mountains were seen below.

6. DATA AND FORMAT DISCUSSION

Several small but representative "shadow graph" samples recorded by the PMS 2-D probe are shown in Figure 11. The vertical bars throughout the samples are each 800 μm in the y-axis direction. Software considerations of the sampling airspeed have insured that a given distance in the x-axis direction (which is also a measure of the time a given particle occludes a photodiode) corresponds with the

same distance in the y-axis direction. Thus, the "shadow" of a given particle in Figure 11 represents an enlarged view of the original shape that passed through the probe. A scale in μm is given on one of the samples.

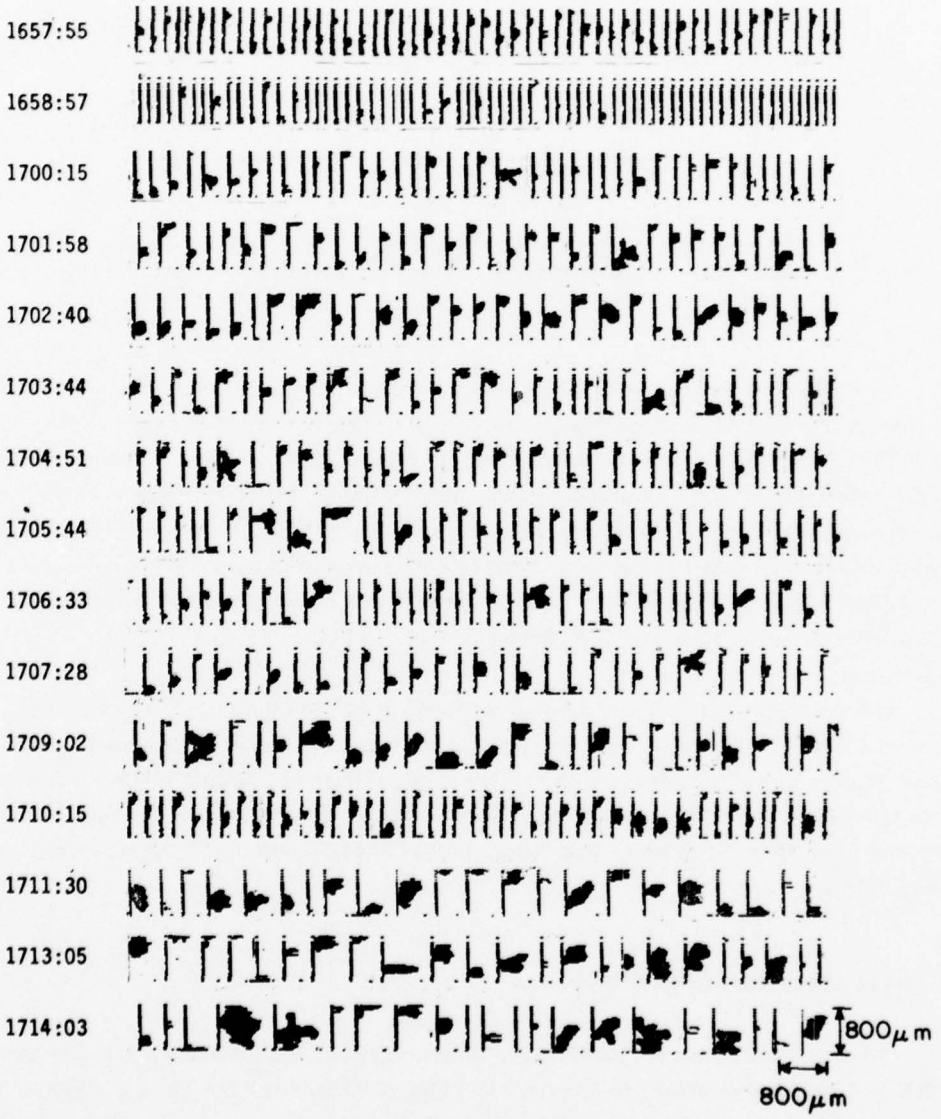

Figure 11. PMS 2-D Particle "Shadowgraphs" During 29 October 1977 Sampling Flight. Each line shows examples recorded at about the indicated time.

The smallest particles that can be recorded by the 2-D cloud probe are ~ 25 μm square. The second line of Figure 11 recorded at 1658:57 contains small particles that appear to be about as small as those possible to record. Note that when cloud particles are as small as these, the vertical bars at the beginning of each recorded particle are necessarily closer together than when larger particles are being recorded.

The sample lines of 2-D shadows on Figure 11, which are in chronological order, provide an overview of the variation of particle size during the sampling flight. As previously mentioned, the smallest particles occurred at the beginning of the data run. They sporadically increased with size reaching 500 to 800 μm in size by the end of the run at about 1714Z. Very shortly after this time no further shadowgraphs were recorded. The horizontal extent of the cloud had apparently been exceeded as the aircraft continued westward.

Based on some of the patterns in Figure 11, and on many others not printed here, it was determined that the predominant crystal form seen in this cirrus sample was "bullet rosettes" or, as termed by Magono and Lee,[15] combination of bullets." The variation of particle forms in the 2-D shapes is readily apparent. Many appear to have an approximately round shape, probably small hexagonal plates; however, the rosette form seemed to predominate. The symetrically shaped, pristine particles outlined in Magono and Lee's excellent ice crystal classification paper were extremely rare in the cirrus clouds encountered on this flight. This is common in our general experience.

Computer processed data from the three PMS 1-D probes are included in Appendices A and B. The bulk of these data are number densities of various sized particles in terms of number per cubic meter per millimeter of bar width. (Bar width will be explained below.) Certain additional flight information such as the aircraft pressure level, altitude, temperature, and true airspeed (TAS) are also included on the right side of each printout sheet. Summarized data for two sample start times, one 30 sec after the initial one, are included on each page. Figure 12 provides an example of the data printout format with the explanations of particular elements.

Although the data printouts in Appendix A are summaries for 30-sec periods, the sampling interval could be changed in the future to provide summarized data for shorter or longer periods. Longer period examples are in Appendix B.

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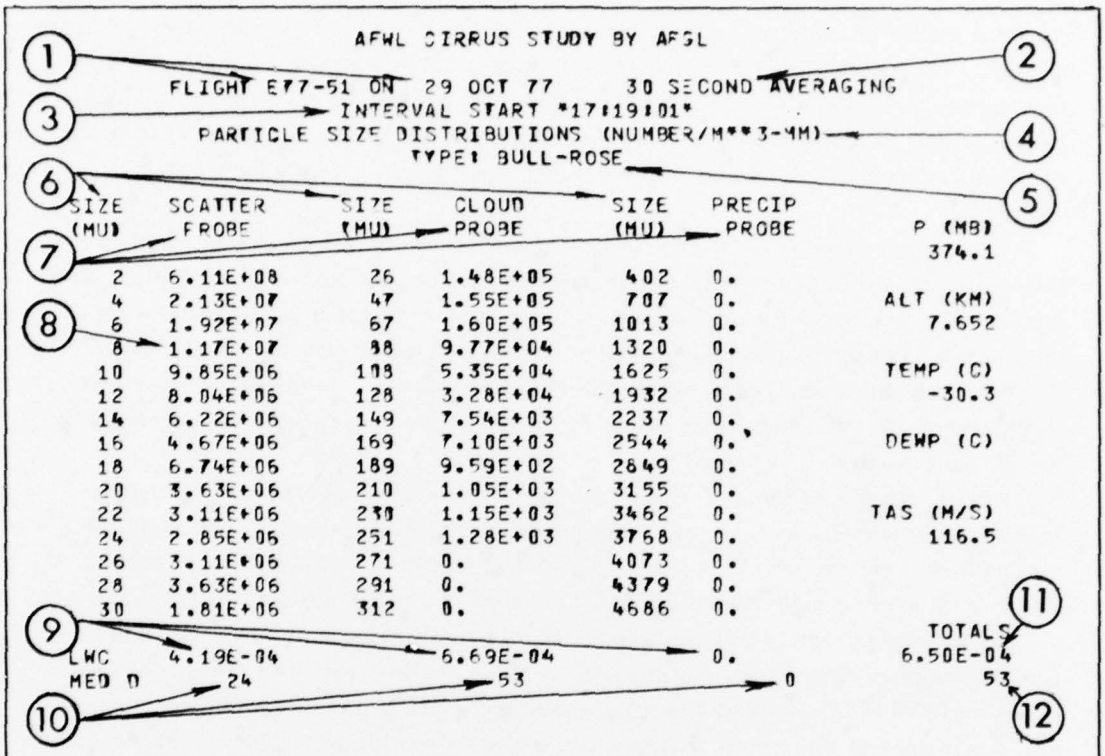
15. Magono, C., and Lee, C.W. (1966) Meteorological classification of natural snow crystals. Jour. Faculty of Sci., Hokkaido Univ., Series VII, VOL. II, 4, pp 321-361.



1. Flight number and date of flight.
2. Length of sample over which particle concentrations are determined.
3. Time sampling began; completed 30 sec later.
4. Concentrations are in number of particles per cubic meter per millimeter bar width (see text for discussion of bar width).
5. Particle type is determined after other data are examined. In this case bullet-rosettes. Other possibilities include rain, plates, small snow, columns, needles, aggregates and rimed dendrites.
6. Mean maximum size of particles in micrometers (see text).
7. "Scattering", "Cloud", and "Precipitation" probes are used in determining concentrations of particles in the size ranges 2-30 μm, 26-312 μm and 402-4686 μm, respectively.
8. Typical concentration: 1.17×10^7 particles per cubic meter per bar width are 8 μm in size.
9. Total liquid water content in grams per cubic meter for each of the three probes. Scatter probe particles are assumed spherical with density =1.
10. Equivalent melted diameter (in μm) of a particle having a mass at the median value of each probe's LWC.
11. Sum of cloud and precipitation probe's LWC, but excludes contribution of the four largest cloud probe channels (i.e., at 251, 271, 291 and 312 μm) that overlap the contribution of the smallest (402 μm) precipitation channel.
12. Equivalent melted diameter (in μm) of a particle having a mass at the median of the combined cloud and precipitation probe's total LWC value. Contributions of the four largest cloud probe channels are excluded.

Figure 12. Description of Cirrus Study Data Format

Each of the three probes records the actual number of particles observed in their sampling categories. Using the geometric properties of the sampling volume (including a consideration of air speed) the actual number of particles is converted to a number per unit volume. Because of large differences in sampling volumes and size class widths between the three probes the raw data must be adjusted to a standard volume and particle bandwidth before combining the data to give the complete spectra.

For this reason the computations of particle concentration have been further normalized by dividing by the width ("bar width") of each channel. This allows a determination of particle number for particles of all sizes per unit distance traveled. It also permits a better comparison of particle concentration without consideration of the width of the channel that recorded the particles.

The actual number of particles in a given channel may be determined by multiplying a specific concentration value in the data tables by the width of the channels. The third scatter probe channel, for example, records particles near the 6 μm value. Its width extends from half the distance to the next lower channel (down to 5 μm) to half the distance to the next higher channel (up to 7 μm), or a total of 2 μm in width.

The total mass or liquid water content (LWC) of the particles recorded by the cloud and precipitation probes is determined by a computer calculation that equivalently "melts" all ice particles in a unit volume (1 m^3). The minute particles recorded by the scattering probe are considered to be round and to have a mass equal to equivalent sized liquid drops. Cunningham[16] has considered the computations to convert frozen particle sizes to melted equivalent diameters for the two larger probes. The power functions used in this procedure at AFGL are given in Table 3.

It is important to realize that the sizes of cloud and precipitation probe particles given in Figure 12, and in the attached data sheets, are the maximum shadow lengths of the actual ice crystals as they pass through the probes. These are determined by the number of diodes occluded by the shadow plus certain geometric corrections. For particles passing through the scattering probe it is assumed that the instrument's calibration for spherical water drops applies.

The computer processing of the raw PMS data produces information on the equivalent melted diameter for each sampling channel, but this is not included in this report—except as a single mean value for each probe and as an overall value for the cloud and precipitation probes combined.

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16. Cunningham, R. M. (1978) Analysis of particle spectral data from optical array (PMS) 1D and 2D sensors, in Preprints of AMS Fourth Symposium on Meteorological Observations and Instrumentation, Denver, Colorado.

Table 3. Equations Used to Correct Particle Size (L) to Melted Diameter (D), $D = AL^B$, Units in mm

Particle Type	A	B	Breakpoint (L)
Rain	1	1	-
Wet Snow	1	1	LE 1 mm
Wet Snow	1	.65	GT 1
Large Snow	.4	.78	LE 1
Large Snow	.4	.88	GT 1
Small Snow	.4	.78	LE .5
Small Snow	.37	.67	GT .5
Bullet Rosettes	.26	.67	LE .2
Bullet Rosettes	.44	1.0	GT .2
Columns	.44	1.0	-
Needles	.26	.67	-
Plate Family	.34	.78	LE 1
Plate Family	.34	.68	GT 1
Aggregates of Plates and Dendrites	.34 .34	.78 .68	LE 1 GT 1
Dendrite Family	.34	.78	-
Graupel	.60	.91	LE .4
Graupel	.49	.68	GT .4
Rimed Dendrite	.85	1.0	LE .2
	.42	.56	> .2 ≤ 2.0
	.31	1.0	GT 2.0

From the equivalent melted diameter information for each channel the liquid water content (LWC) is calculated once per averaging interval using the average particle number density. The equation used for this calculation is

$$LWC = \frac{\pi}{6000} \rho \sum_{i=1}^{15} N_i D_i^3$$

where

ρ = water density (1 g cm^{-3})

N_i = number density for channel i

D_i = center diameter for channel i (in mm).

The LWC (in g/m^3) total is given in the data printouts at the bottom of the data column for each probe. The "Total" LWC (in g/m^3) in the bottom right corner of each printout is the total value for the cloud and precipitation probes less any overlapping range. Because of the deletion of the overlapping amount the "Total" LWC value will occasionally be slightly less than the amounts indicated for either of the probes individually. The median volume diameter of all melted particles is the diameter where the mass (LWC) of all the particles smaller than it, is one-half of the total mass of the sample being considered. It is found by summing the mass of each channel until the sum equals one-half the total mass. The equivalent mean diameter (in μm) of all the particles in one sample is found on the printouts and on Figure 12 at the bottom of the columns applying to each probe. The diameter value under "Total" in the bottom right of each printout is based on the combined cloud and precipitation probes' LWC. Since the overlapping part of the combined LWC value is deleted the "Total" diameter will sometimes be the same or slightly less than corresponding diameters listed for either of the two probes separately. Data from the scattering probe are not used in computations involving the "Total" LWC and diameter values in the bottom right of each printout.

Based on these two "Total" values for each 30-sec sample the plots of their variation with time during the 29 October flight are shown on Figure 13 (a and b).

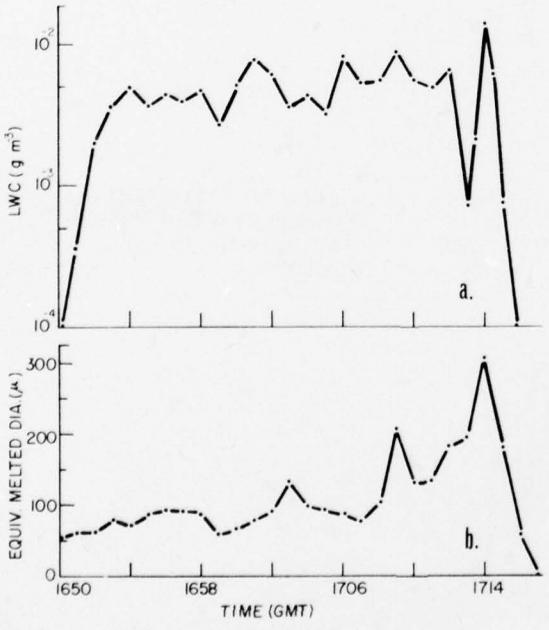


Figure 13. Variation of Liquid Water Content and of Diameter of Particles Having a Mass Equivalent to the Median of the Crystal Particles That Were Actually Observed. Determined from probes recording particles between approximately 26 and 4700 μm

Although one is plotted on a logarithmic scale and the other on a linear scale there is an overall correlation between the two curves as shown in the slight increases in both between approximately 1652 and 1712Z. Also, a peak value occurs in both plots at 1714Z, just before each falls to a minimum. However, the very rapid increase in LWC at 1651 and the valley at 1713Z are not reflected in similar changes in the mean diameter values. The gradual increase of particle size with time that seemed apparent in the Figure 11 2-D shadowgraphs is also reflected in both portions of Figure 13. In general, the LWC plot appears more responsive to actual particle density changes in view of the variations on Figure 13a, although this may be somewhat disguised through use of the logarithmic scale.

Figure 14 (a and b) was developed to show the variation with time of concentrations of particles of a particular size. The specific channel sizes plotted were chosen as representatives of their particular probe. The 16 μm channel is near the midpoint of the scattering probe; the 67 and 251 μm channels are from the cloud probe, and the precipitation probe is represented by the 707 μm channel curve.

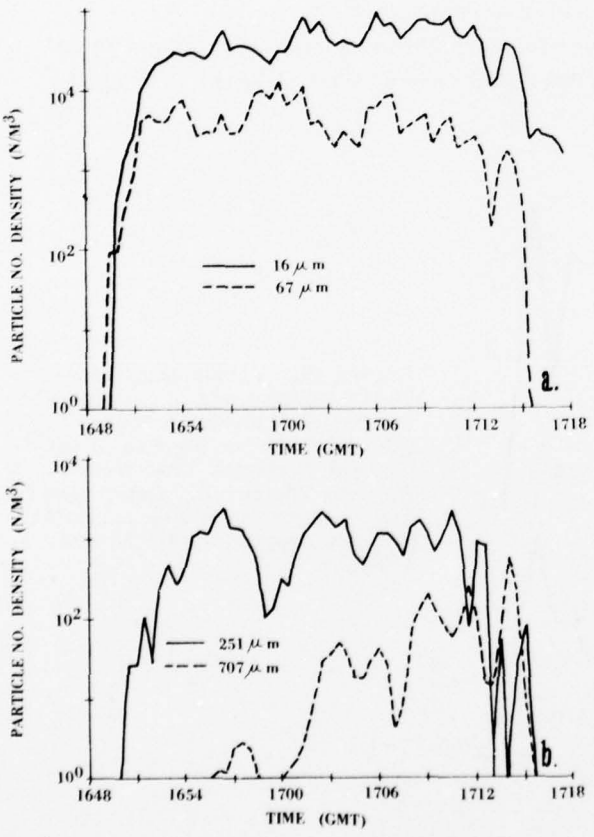


Figure 14. Variation of Particle Concentration of Four Specific Sampling Channels

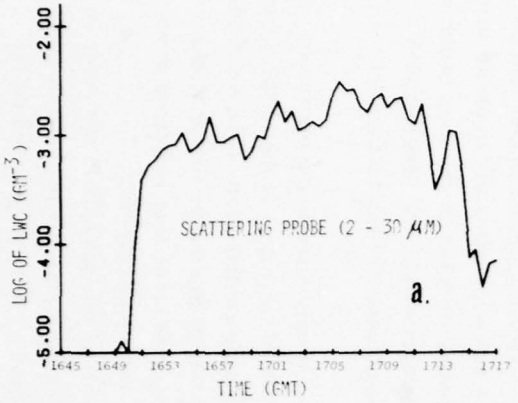
The overall temporal variations of particles in the three smallest channels on Figure 14 (a and b) are similar in that they rise above the zero level at about the same time, remain generally within an order of magnitude of a mean value for about 25 min, and then descend in magnitude to a lower level. The small-interval changes, however, are many, and indicate considerable independence in the up and down trends between the various sized particles. In this sample the smallest sized particles displayed the least variation in density with time. Figure 14 (a and b) shows that as the size of the particles increased from 16 up to 707 μm the amplitude variations became greater (with greater peaks and deeper valleys). It is not known whether this is typical.

The change in concentration of the 707 μm sized particles in Figure 14b appears to be almost completely independent of the variation of smaller particles. It does, however, begin to increase at 1700Z shortly after the 251 μm curve begins to rise, and it also dips significantly at 1713Z when the three other curves show a similar drop. The 1713Z drop in concentration is directly correlated with the drop in LWC seen on Figure 13a at the same time.

The plots in Figure 15 show the variation of liquid water content (LWC) for each of the three probes plus a plot of "Total" values from the cloud and precipitation probes (excluding overlapping channels in the cloud probe). Figure 15d is similar to Figure 13a, but on a slightly different scale. These LWC vs time plots have variations similar to those displayed by the temporal changes of concentration in Figure 14 (a and b). The scatter probe changes are approximately in phase with those of the cloud probe, but the former's contribution of mass is about an order of magnitude less (10^{-3} vs 10^{-2} g/m^3). The LWC determined by the precipitation probe increased markedly from approximately 1652Z until 1714Z and then fell rapidly.

The "Total" LWC curve in Figure 15d increases only slightly during the sampling period reflecting the relatively high contribution of the cloud probe in the initial minutes, then, as it began to decrease, the increasing contribution of the precipitation probe in the final minutes. The increasing LWC of this latter probe at about 1708 to 1710Z appears to correlate well with transcript notes that indicated particles were visible on the snow stick and that the cloud was relatively thick.

Longer term data averages than the 30-sec values of Appendix A are given in Appendix B. The latter appendix contains 1-D data printouts for periods varying from 1 to 18 minutes. The specific periods selected were largely based on the values shown in Figure 15. From another cirrus report being prepared it has been found there is general agreement between periods of reduced visibility and higher values of liquid water content measured by the precipitation probe.



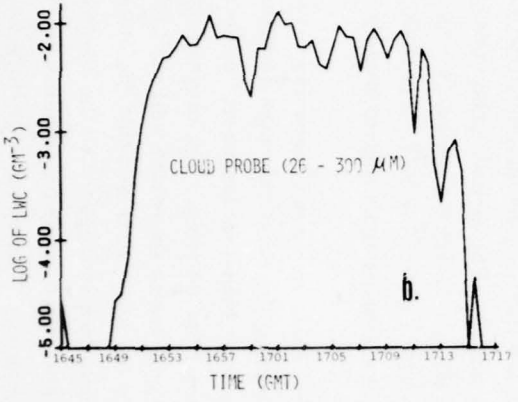
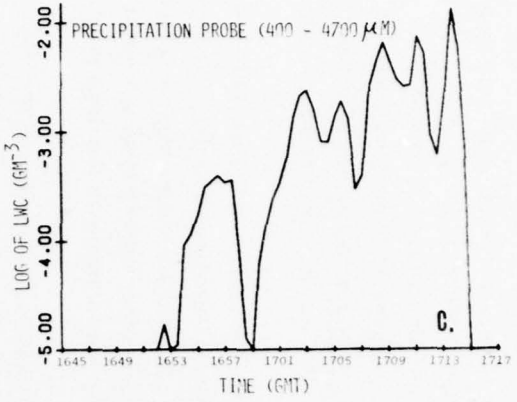


Figure 15. Variation of Liquid Water Content With Time. For scattering probe (a) and cloud probe (b)



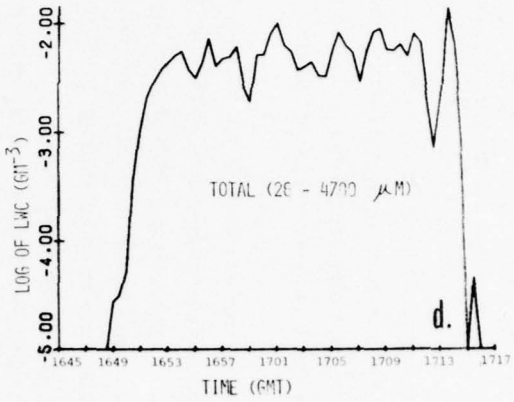


Figure 15. Variation of Liquid Water Content With Time. For precipitation probe (c), and of cloud plus precipitation probe, but not overlapping channels (d)

Some plots of number density as a function of particle size for specific sample times are shown in Figure 16 (a, b, c, and d). These are essentially pictorial representations of some of the tabular data that are given in the Appendix. Data from each of the three probes are plotted if they recorded any particles. In the case of Figure 16 (a and b) there were no particles observed by the precipitation probe, and only data from the other two probes are shown.

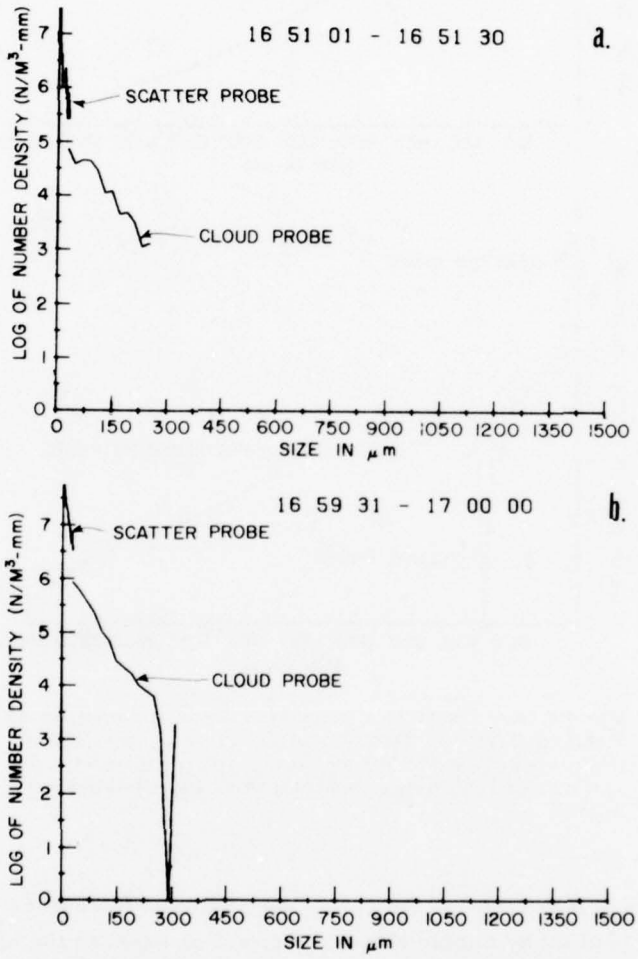


Figure 16. Particle Concentration as a Function of Particle Size for Two Sampling Times. (a) Initial contact with bottom of cirrus layer; (b) into thin cirrus

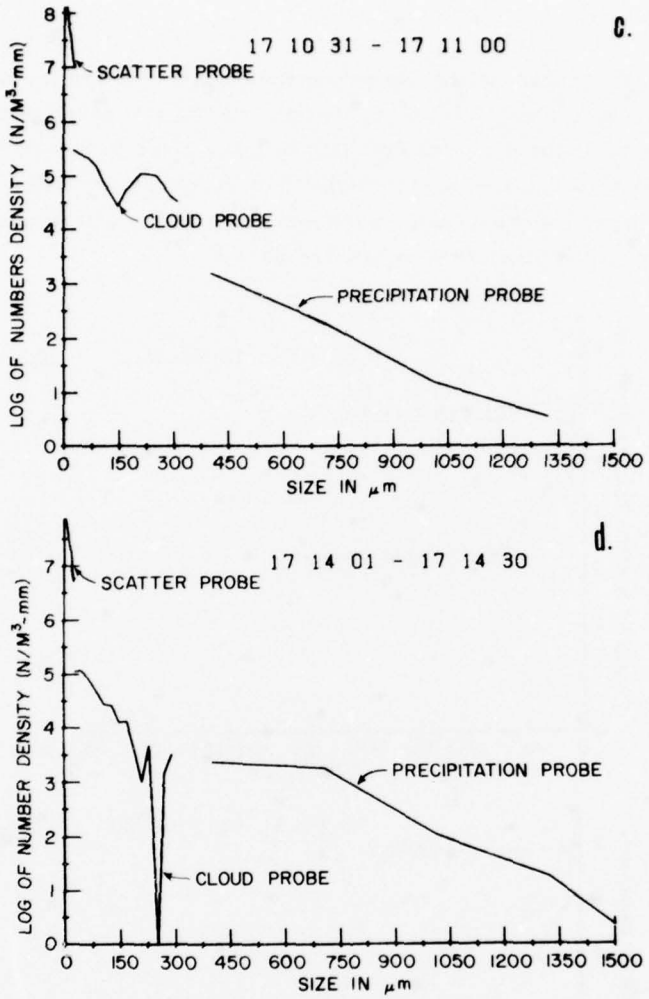


Figure 16. Particle Concentration as a Function of Particle Size for Two Sampling Times. (c) Time when visibility further reduced, (d) time when LWC and median diameter reached peak for the sample period

In most cases it is believed the gaps shown between the curves for the three probes may be bridged by simple linear interpolation between the highest channel of one probe and the lowest channel of the adjoining one. For example, the 350 μm value of number density of the precipitation probe on Figure 16c or d may be linked to the 300 μm value of the cloud probe. Often, however, the data gap in number density between adjoining probes seems excessive. Considerable study has been conducted, and is continuing, on the advisability of making certain processing changes that would reduce the gap between curve segments and lead to a more

smooth transition of concentration values from large to small particle sizes. This may eventually be effected by altering the output values of the smallest one or two channels of the cloud and precipitation probes. Such a change, if effected, should result in only minor revisions of the median diameter and liquid water content values in this report.

Figure 16 (a and b) shows concentration vs size data in a cirrus cloud that became gradually heavier as the flight progressed. A transcript note concurrent with data in Figure 16a indicated the aircraft was just coming into the bottom of the cirrus layer. Visibility was barely reduced at this time. By the time data in Figure 16b were recorded, however, a transcript note indicated the aircraft was definitely in the cirrus layer and visibility was presumably reduced. Particles corresponding in various size classes had increased in number about half an order of magnitude between the times represented by Figure 16a and Figure 16b.

Figure 16c represents data recorded at a time when an aircraft log note indicated that the cirrus was relatively thick. The LWC was also at a relatively high plateau at that time. Although the number concentrations at sizes below 150 μm had not changed appreciably from the time represented by Figure 14b, the concentrations in the cloud probe greater than that size did increase. There was also an increased concentration of larger sized particles recorded by the precipitation probe at the later time.

The greatest total liquid water content value and equivalent melted diameter during the sampling were recorded about 1714Z, shortly before they both decreased rapidly. Figure 16d shows the concentration of particles by size at this time. There was very little difference in scatter and cloud probe data between those in Figures 16b and d; however, the precipitation probe data in the latter figure is significant and correlates well with the large droplets seen at this time in the 2-D output in Figure 11.

7. CONCLUDING COMMENTS

The purpose of this report has been both to describe briefly some previous research in the field of cirrus particles and to present the results of one sampling flight through cirrus by the AFGL instrumented MC-130E aircraft. While previous work in this area has not been extensive, an increasing number of investigators appear to be interested in cirriform clouds. This is partly due to improved instrumentation and also to an increased realization of the importance of this type cloud in the economy of overall cloud cover over the earth.

The cloud-physics instrumentation on our MC-130E permits a variety of environmental measurements to be made and tape recorded for study and evaluation.

For cirrus study the one- and two-dimensional spectrometers are particularly valuable in providing information on the size, concentration, and shape of particles that comprise the visible (and sometimes not visible) cloud mass. From such measurements the liquid water content of the atmosphere can be calculated.

In the 29 October 1977 flight a cirrus cloud of varying density was sampled for slightly less than one-half hour. Particle data averages for 30-sec consecutive periods during the sampling are presented in this report. Plots of the variation with time of liquid water content and of the equivalent melted diameter of particles reflect continual change; however, they are both greatest at approximately the time the aircraft meteorologist indicated visibility was least. The meteorologist's estimation of cloud intensity was best correlated with liquid water content variations recorded by the precipitation probe and much less with those by the cloud probe and scattering probe.

The 2-D probe printout of ice crystal sizes and shapes in the form of "shadowgraphs" showed very few particles to be recognizable according to known classification types. While the majority of those identifiable were bullet rosettes with a few plates and columns, many could only be considered to be in a miscellaneous category that contained an assortment of shapes.

Additional sampling flights through cirrus clouds have recently been conducted by AFGL for the Air Force Weapons Laboratory. Further reports on the cirrus particle spectrum are planned.

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16. Cunningham, R.M. (1978) Analysis of particle spectral data from optical array (PMS) 1D and 2D sensors, in Preprints of AMS Fourth Symposium on Meteorological Observations and Instrumentation, Denver, Colorado.

Appendix A

30-Second Data Averages

Average cirrus particle concentration data are given for consecutive 30-sec periods in the following tabulations for a sampling flight over Colorado on 29 October 1977.

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:49:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 384.2
2	2.53E+08	25	0.	402	0.	
4	2.61E+05	47	0.	707	0.	ALT (KM)
6	2.61E+05	67	0.	1013	0.	7.467
8	5.21E+05	89	0.	1320	0.	
10	0.	108	0.	1625	0.	TEMP (C)
12	0.	128	0.	1932	0.	-26.7
14	0.	149	0.	2237	0.	
16	0.	169	0.	2544	0.	DEWP (C)
18	0.	189	0.	2849	0.	
20	0.	210	0.	3155	0.	
22	0.	230	0.	3462	0.	TAS (M/S)
24	0.	251	0.	3768	0.	115.8
26	0.	271	0.	4073	0.	
28	0.	291	0.	4379	0.	
30	0.	312	0.	4686	0.	
						TOTALS
LWC	2.47E-06		0.		0.	0.
MED D	2		0		0	0

INTERVAL START *16:49:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 383.3
2	2.90E+08	25	0.	402	0.	
4	5.21E+05	47	0.	707	0.	ALT (KM)
6	2.61E+05	67	4.58E+03	1013	0.	7.483
8	2.61E+05	88	5.46E+03	1320	0.	
10	2.61E+05	108	3.71E+03	1625	0.	TEMP (C)
12	0.	128	1.37E+03	1932	0.	-27.1
14	0.	149	0.	2237	0.	
16	0.	169	8.92E+02	2544	0.	DEWP (C)
18	0.	189	0.	2849	0.	
20	0.	210	0.	3155	0.	
22	0.	230	0.	3462	0.	TAS (M/S)
24	0.	251	0.	3768	0.	115.9
26	2.61E+05	271	0.	4073	0.	
28	0.	291	0.	4379	0.	
30	0.	312	0.	4686	0.	
						TOTALS
LWC	7.73E-06		2.78E-05		0.	2.78E-05
MED D	25		56		0	56

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:50:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 383.1
2	3.04E+08	26	0.	402	0.	
4	5.21E+05	47	1.95E+04	707	0.	ALT (KM)
6	2.61E+05	67	4.58E+03	1013	0.	7.485
8	7.82E+05	88	5.46E+03	1320	0.	
10	2.61E+05	108	1.86E+03	1625	0.	TEMP (C)
12	2.61E+05	128	1.37E+03	1932	0.	-27.3
14	0.	149	0.	2237	0.	
16	2.61E+05	169	8.92E+02	2544	0.	DEWP (C)
18	0.	189	0.	2849	0.	
20	0.	210	0.	3155	0.	
22	2.61E+05	230	0.	3462	0.	TAS (M/S)
24	0.	251	0.	3768	0.	115.8
26	2.61E+05	271	0.	4073	0.	
28	0.	291	0.	4379	0.	
30	0.	312	0.	4686	0.	
						TOTALS
LWC	1.26E-05		3.16E-05		0.	3.16E-05
MED D	21		51		0	51

INTERVAL START *16:50:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 382.9
2	2.98E+08	26	0.	402	5.40E-01	
4	2.61E+06	47	9.77E+03	707	0.	ALT (KM)
6	2.08E+06	67	1.83E+04	1013	0.	7.490
8	5.21E+05	88	2.73E+03	1320	0.	
10	2.61E+05	108	3.71E+03	1625	0.	TEMP (C)
12	5.21E+05	128	2.75E+03	1932	0.	-27.3
14	0.	149	3.25E+03	2237	0.	
16	7.82E+05	169	0.	2544	0.	DEWP (C)
18	2.61E+05	189	0.	2849	0.	
20	0.	210	0.	3155	0.	
22	0.	230	0.	3462	0.	TAS (M/S)
24	0.	251	1.28E+03	3768	0.	115.9
26	0.	271	0.	4073	0.	
28	0.	291	0.	4379	0.	
30	0.	312	0.	4686	0.	
						TOTALS
LWC	9.58E-06		6.98E-05		4.72E-07	5.20E-05
MED D	15		65		176	57

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:51:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						382.0
2	2.28E+08	26	7.41E+04	402	1.08E+00	
4	8.07E+06	47	3.90E+04	707	0.	ALT (KM)
6	2.86E+06	67	4.58E+04	1013	0.	7.507
8	4.17E+05	89	4.36E+04	1320	0.	
10	1.04E+06	108	2.97E+04	1625	0.	TEMP (C)
12	1.82E+06	128	1.10E+04	1932	0.	-27.5
14	1.56E+06	149	1.19E+04	2237	0.	
16	1.30E+06	169	4.46E+03	2544	0.	DEWP (C)
18	2.34E+06	189	4.81E+03	2849	0.	
20	7.81E+05	210	3.15E+03	3155	0.	
22	1.04E+06	230	1.16E+03	3462	0.	TAS (M/S)
24	2.60E+05	251	1.28E+03	3768	0.	116.0
26	5.21E+05	271	0.	4073	0.	
28	7.81E+05	291	0.	4379	0.	
30	2.60E+05	312	0.	4686	0.	
						TOTALS
LWC	9.09E-05		3.76E-04		9.43E-07	3.59E-04
MED D	21		62		176	61

INTERVAL START *16:51:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						380.6
2	1.47E+08	26	3.33E+05	402	1.62E+00	
4	1.66E+07	47	2.34E+05	707	0.	ALT (KM)
6	1.56E+07	67	2.01E+05	1013	0.	7.532
8	1.20E+07	88	1.12E+05	1320	0.	
10	1.04E+07	108	8.15E+04	1625	0.	TEMP (C)
12	8.32E+06	128	4.66E+04	1932	0.	-27.7
14	4.68E+06	149	1.08E+04	2237	0.	
16	4.94E+06	169	1.51E+04	2544	0.	DEWP (C)
18	6.50E+05	189	4.81E+03	2849	0.	
20	3.64E+06	210	5.24E+03	3155	0.	
22	2.60E+06	230	4.61E+03	3462	0.	TAS (M/S)
24	1.56E+06	251	5.13E+03	3768	0.	116.1
26	2.86E+06	271	1.44E+03	4073	0.	
28	2.34E+06	291	0.	4379	0.	
30	3.12E+06	312	0.	4686	0.	
						TOTALS
LWC	3.89E-04		1.11E-03		1.41E-06	1.01E-03
MED D	25		58		176	56

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:52:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						380.5
2	6.29E+07	26	4.44E+05	402	2.15E+00	
4	3.14E+07	47	3.02E+05	707	0.	ALT (KM)
6	2.24E+07	67	2.42E+05	1013	0.	7.534
8	2.18E+07	88	1.82E+05	1320	0.	
10	1.87E+07	108	1.44E+05	1625	0.	TEMP (C)
12	1.40E+07	128	9.73E+04	1932	0.	-27.5
14	8.06E+06	149	6.47E+04	2237	0.	
16	8.06E+06	169	3.91E+04	2544	0.	DEWP (C)
18	5.46E+06	189	1.92E+04	2849	0.	
20	4.42E+06	210	1.15E+04	3155	0.	
22	4.42E+06	230	1.27E+04	3462	0.	TAS (M/S)
24	3.90E+06	251	1.28E+03	3768	0.	116.2
26	3.12E+06	271	5.76E+03	4073	0.	
28	4.94E+06	291	0.	4379	0.	
30	1.82E+06	312	1.92E+03	4686	0.	
						TOTALS
LWC	5.20E-04		2.21E-03		1.88E-06	2.04E-03
MED D	23		66		176	63

INTERVAL START *16:52:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						378.8
2	9.48E+07	26	2.96E+05	402	8.60E+00	
4	4.91E+07	47	1.65E+05	707	0.	ALT (KM)
6	3.63E+07	67	1.96E+05	1013	0.	7.565
8	2.78E+07	88	1.11E+05	1320	0.	
10	2.00E+07	108	1.24E+05	1625	0.	TEMP (C)
12	1.48E+07	128	1.33E+05	1932	0.	-28.0
14	1.43E+07	149	1.09E+05	2237	0.	
16	1.09E+07	169	8.89E+04	2544	0.	DEWP (C)
18	9.35E+06	189	6.53E+04	2849	0.	
20	5.71E+06	210	3.56E+04	3155	0.	
22	4.15E+06	230	1.96E+04	3462	0.	TAS (M/S)
24	2.34E+06	251	1.15E+04	3768	0.	116.3
26	2.86E+06	271	7.20E+03	4073	0.	
28	3.89E+06	291	3.29E+03	4379	0.	
30	3.89E+06	312	1.92E+03	4686	0.	
						TOTALS
LWC	6.00E-04		3.32E-03		7.52E-06	2.91E-03
MED D	22		77		176	74

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:53:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						377.1
2	8.12E+07	26	1.48E+05	402	1.93E+01	
4	5.55E+07	47	1.36E+05	707	0.	ALT (KM)
6	3.61E+07	67	1.96E+05	1013	0.	7.596
8	3.81E+07	88	1.22E+05	1320	0.	
10	2.28E+07	108	6.83E+04	1625	0.	TEMP (C)
12	1.37E+07	128	1.40E+05	1932	0.	-28.6
14	1.58E+07	149	1.49E+05	2237	0.	
16	1.24E+07	169	1.20E+05	2544	0.	DEWP (C)
18	1.48E+07	189	9.66E+04	2849	0.	
20	5.71E+06	210	5.44E+04	3155	0.	
22	5.19E+06	230	4.03E+04	3462	0.	TAS (M/S)
24	4.15E+06	251	2.30E+04	3768	0.	116.4
26	5.19E+06	271	1.87E+04	4073	0.	
28	3.89E+06	291	1.15E+04	4379	0.	
30	3.63E+06	312	5.75E+03	4686	0.	
						TOTALS
LWC	7.24E-04		4.77E-03		1.69E-05	3.71E-03
MED D	22		83		176	78

INTERVAL START *16:53:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						375.0
2	6.27E+07	26	2.21E+05	402	5.36E+00	
4	6.76E+07	47	3.01E+05	707	0.	ALT (KM)
6	5.13E+07	67	3.01E+05	1013	0.	7.636
8	4.04E+07	88	1.60E+05	1320	0.	
10	3.00E+07	108	2.21E+05	1625	0.	TEMP (C)
12	2.36E+07	128	2.27E+05	1932	0.	-29.3
14	1.74E+07	149	1.91E+05	2237	0.	
16	1.45E+07	169	1.37E+05	2544	0.	DEWP (C)
18	1.45E+07	189	8.14E+04	2849	0.	
20	6.48E+06	210	4.39E+04	3155	0.	
22	6.48E+06	230	1.38E+04	3462	0.	TAS (M/S)
24	4.40E+06	251	1.28E+04	3768	0.	116.6
26	2.85E+06	271	5.74E+03	4073	0.	
28	5.96E+06	291	8.21E+03	4379	0.	
30	3.37E+06	312	5.75E+03	4686	0.	
						TOTALS
LWC	7.88E-04		4.89E-03		4.69E-06	4.27E-03
MED D	21		74		176	71

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:54:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 372.7
2	8.20E+07	26	3.68E+05	402	9.64E+00	
4	7.81E+07	47	3.20E+05	707	5.61E-01	ALT (KM)
6	5.92E+07	67	3.68E+05	1013	0.	7.679
8	4.86E+07	88	2.38E+05	1320	0.	
10	3.18E+07	108	2.58E+05	1625	0.	TEMP (C)
12	2.46E+07	128	2.88E+05	1932	0.	-30.1
14	1.78E+07	149	2.23E+05	2237	0.	
16	1.34E+07	169	1.37E+05	2544	0.	DEWP (C)
18	1.09E+07	189	8.22E+04	2849	0.	
20	6.98E+06	210	3.75E+04	3155	0.	
22	4.91E+06	230	2.87E+04	3462	0.	TAS (M/S)
24	8.02E+06	251	1.78E+04	3768	0.	116.7
26	5.69E+06	271	7.17E+03	4073	0.	
28	3.10E+06	291	9.83E+03	4379	0.	
30	4.14E+06	312	1.74E+04	4686	0.	
						TOTALS
LWC	8.21E-04		5.93E-03		1.11E-05	4.97E-03
MED D	22		74		197	70

INTERVAL START *16:54:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 372.8
2	4.22E+07	26	1.11E+05	402	1.03E+02	
4	8.44E+07	47	3.10E+05	707	5.61E-01	ALT (KM)
6	7.38E+07	67	2.23E+05	1013	0.	7.676
8	6.11E+07	88	8.67E+04	1320	0.	
10	3.93E+07	108	1.12E+05	1625	0.	TEMP (C)
12	2.85E+07	128	1.39E+05	1932	0.	-30.3
14	2.69E+07	149	1.67E+05	2237	0.	
16	1.53E+07	169	2.00E+05	2544	0.	DEWP (C)
18	1.76E+07	189	1.34E+05	2849	0.	
20	7.77E+06	210	1.02E+05	3155	0.	
22	8.28E+06	230	7.81E+04	3462	0.	TAS (M/S)
24	6.21E+06	251	4.97E+04	3768	0.	116.7
26	8.28E+06	271	3.30E+04	4073	0.	
28	3.37E+06	291	2.79E+04	4379	0.	
30	5.09E+06	312	1.53E+04	4686	0.	
						TOTALS
LWC	1.04E-03		7.71E-03		9.27E-05	5.46E-03
MED D	22		90		178	81

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:55:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 373.2
2	6.32E+07	26	3.69E+04	402	1.25E+02	
4	7.66E+07	47	2.43E+05	707	1.12E+00	ALT (KM)
6	6.24E+07	67	1.27E+05	1013	0.	7.669
8	4.84E+07	88	7.59E+04	1320	0.	
10	3.44E+07	108	4.61E+04	1625	0.	TEMP (C)
12	3.16E+07	128	3.00E+04	1932	0.	-30.2
14	1.97E+07	149	5.59E+04	2237	0.	
16	1.35E+07	169	9.31E+04	2544	0.	DEWP (C)
18	9.58E+06	189	1.17E+05	2849	0.	
20	5.44E+06	210	1.00E+05	3155	0.	
22	3.88E+06	230	7.23E+04	3462	0.	TAS (M/S)
24	6.73E+06	251	6.00E+04	3768	0.	116.6
26	3.37E+06	271	3.88E+04	4073	0.	
28	2.59E+06	291	2.46E+04	4379	0.	
30	2.59E+06	312	1.53E+04	4686	0.	
						TOTALS
LWC	6.93E-04		6.11E-03		1.15E-04	3.70E-03
MED D	20		99		179	87

INTERVAL START *16:55:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 373.1
2	7.04E+07	26	1.47E+05	402	1.98E+02	
4	8.47E+07	47	2.52E+05	707	0.	ALT (KM)
6	6.50E+07	67	1.46E+05	1013	0.	7.671
8	5.75E+07	88	4.07E+04	1320	0.	
10	3.78E+07	108	3.87E+04	1625	0.	TEMP (C)
12	2.30E+07	128	3.28E+04	1932	0.	-30.3
14	1.94E+07	149	1.72E+04	2237	0.	
16	1.19E+07	169	5.32E+04	2544	0.	DEWP (C)
18	1.22E+07	189	7.08E+04	2849	0.	
20	6.73E+06	210	8.46E+04	3155	0.	
22	3.88E+06	230	8.84E+04	3462	0.	TAS (M/S)
24	4.92E+06	251	5.61E+04	3768	0.	116.6
26	5.18E+06	271	3.73E+04	4073	0.	
28	4.66E+06	291	4.27E+04	4379	0.	
30	2.85E+06	312	3.25E+04	4686	0.	
						TOTALS
LWC	7.68E-04		6.27E-03		1.73E-04	3.13E-03
MED D	21		107		176	91

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:56:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 373.3
2	4.77E+07	26	1.11E+05	402	3.28E+02	
4	8.76E+07	47	2.52E+05	707	3.93E+00	ALT (KM)
6	8.42E+07	67	1.46E+05	1013	0.	7.667
8	6.81E+07	88	1.27E+05	1320	0.	
10	4.64E+07	108	9.41E+04	1625	0.	TEMP (C)
12	3.29E+07	128	2.60E+04	1932	0.	-30.4
14	2.56E+07	149	4.41E+04	2237	0.	
16	1.61E+07	169	5.68E+04	2544	0.	DEWP (C)
18	1.68E+07	189	1.08E+05	2849	0.	
20	9.07E+06	210	1.08E+05	3155	0.	
22	6.48E+06	230	1.22E+05	3462	0.	TAS (M/S)
24	4.92E+06	251	8.94E+04	3768	0.	116.6
26	5.44E+06	271	5.31E+04	4073	0.	
28	3.89E+06	291	5.09E+04	4379	0.	
30	2.85E+06	312	2.49E+04	4686	0.	
						TOTALS
LWC	9.05E-04		8.14E-03		3.06E-04	4.40E-03
MED D	19		105		180	91

INTERVAL START *16:56:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 373.4
2	1.94E+07	26	3.32E+05	402	3.72E+02	
4	1.02E+08	47	2.23E+05	707	3.94E+00	ALT (KM)
6	1.11E+08	67	2.41E+05	1013	0.	7.666
8	9.69E+07	88	1.55E+05	1320	0.	
10	7.75E+07	108	7.93E+04	1625	0.	TEMP (C)
12	5.26E+07	128	6.83E+04	1932	0.	-30.6
14	3.03E+07	149	8.61E+04	2237	0.	
16	2.85E+07	169	1.17E+05	2544	0.	DEWP (C)
18	2.15E+07	189	1.84E+05	2849	0.	
20	1.22E+07	210	2.10E+05	3155	0.	
22	1.06E+07	230	1.78E+05	3462	0.	TAS (M/S)
24	5.70E+06	251	1.16E+05	3768	0.	116.5
26	7.26E+06	271	6.18E+04	4073	0.	
28	8.55E+06	291	4.27E+04	4379	0.	
30	8.03E+06	312	4.98E+04	4686	0.	
						TOTALS
LWC	1.46E-03		1.18E-02		3.44E-04	7.11E-03
MED D	21		101		179	90

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:57:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.5
2	8.22E+07	26	3.32E+05	402	4.08E+02	
4	8.58E+07	47	1.94E+05	707	7.88E+00	ALT (KM)
6	6.90E+07	67	1.37E+05	1013	0.	7.663
8	5.58E+07	88	9.51E+04	1320	0.	
10	3.94E+07	108	7.39E+04	1625	0.	TEMP (C)
12	3.09E+07	128	3.01E+04	1932	0.	-30.9
14	1.63E+07	149	4.09E+04	2237	0.	
16	1.58E+07	169	6.48E+04	2544	0.	DEWP (C)
18	1.40E+07	189	1.05E+05	2849	0.	
20	7.00E+06	210	9.73E+04	3155	0.	
22	6.74E+06	230	8.86E+04	3462	0.	TAS (M/S)
24	5.45E+06	251	6.39E+04	3768	0.	116.4
26	4.93E+06	271	6.04E+04	4073	0.	
28	4.41E+06	291	3.78E+04	4379	0.	
30	3.89E+06	312	2.88E+04	4686	0.	
						TOTALS
LWC	8.64E-04		7.20E-03		3.95E-04	3.97E-03
MED D	21		105		183	90

INTERVAL START *16:57:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.6
2	1.07E+08	26	1.85E+05	402	3.37E+02	
4	8.56E+07	47	2.14E+05	707	9.57E+00	ALT (KM)
6	6.93E+07	67	1.46E+05	1013	0.	7.662
8	5.16E+07	88	1.09E+05	1320	0.	
10	4.28E+07	108	4.25E+04	1625	0.	TEMP (C)
12	3.35E+07	128	4.93E+04	1932	0.	-31.1
14	1.97E+07	149	6.79E+04	2237	0.	
16	1.79E+07	169	1.02E+05	2544	0.	DEWP (C)
18	1.12E+07	189	1.29E+05	2849	0.	
20	9.34E+06	210	1.14E+05	3155	0.	
22	7.27E+06	230	9.90E+04	3462	0.	TAS (M/S)
24	4.15E+06	251	6.52E+04	3768	0.	116.4
26	3.89E+06	271	5.47E+04	4073	0.	
28	3.37E+06	291	2.80E+04	4379	0.	
30	4.93E+06	312	2.69E+04	4686	0.	
						TOTALS
LWC	8.65E-04		7.56E-03		3.41E-04	4.63E-03
MED D	20		101		166	88

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:58:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 373.5
2	1.63E+08	26	2.59E+05	402	3.65E+02	
4	9.52E+07	47	2.43E+05	707	7.32E+00	ALT (KM)
6	7.19E+07	67	2.10E+05	1013	0.	7.663
8	6.25E+07	88	1.06E+05	1320	0.	
10	3.81E+07	108	5.17E+04	1625	0.	TEMP (C)
12	2.91E+07	128	7.12E+04	1932	0.	-31.2
14	2.08E+07	149	9.48E+04	2237	0.	
16	1.79E+07	169	1.24E+05	2544	0.	DEWP (C)
18	1.22E+07	189	1.38E+05	2849	0.	
20	6.75E+06	210	1.05E+05	3155	0.	
22	7.53E+06	230	7.94E+04	3462	0.	TAS (M/S)
24	7.27E+06	251	4.73E+04	3768	0.	116.4
26	4.41E+06	271	3.45E+04	4073	0.	
28	6.23E+06	291	4.28E+04	4379	0.	
30	3.89E+06	312	2.30E+04	4686	0.	
						TOTALS
LWC	9.41E-04		7.31E-03		3.54E-04	4.78E-03
MED D	22		97		183	85

INTERVAL START *16:58:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 373.2
2	1.21E+08	26	2.95E+05	402	8.75E+01	
4	7.62E+07	47	4.86E+05	707	1.69E+00	ALT (KM)
6	6.69E+07	67	4.28E+05	1013	0.	7.669
8	5.96E+07	88	2.50E+05	1320	0.	
10	3.84E+07	108	3.25E+05	1625	0.	TEMP (C)
12	2.57E+07	128	3.28E+05	1932	0.	-30.9
14	1.71E+07	149	2.45E+05	2237	0.	
16	1.63E+07	169	1.36E+05	2544	0.	DEWP (C)
18	1.37E+07	189	9.58E+04	2849	0.	
20	7.52E+06	210	5.86E+04	3155	0.	
22	5.70E+06	230	5.29E+04	3462	0.	TAS (M/S)
24	6.22E+06	251	2.56E+04	3768	0.	116.5
26	7.00E+06	271	1.73E+04	4073	0.	
28	6.74E+06	291	1.15E+04	4379	0.	
30	5.70E+06	312	1.15E+04	4686	0.	
						TOTALS
LWC	1.00E-03		7.20E-03		8.46E-05	6.04E-03
MED D	23		75		183	71

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *16:59:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.7
2	1.96E+08	26	8.11E+05	402	1.45E+01	
4	5.07E+07	47	5.05E+05	707	0.	ALT (KM)
6	4.04E+07	67	4.92E+05	1013	0.	7.678
8	3.00E+07	88	3.01E+05	1320	0.	
10	1.89E+07	108	1.77E+05	1625	0.	TEMP (C)
12	1.76E+07	128	1.09E+05	1932	0.	-30.5
14	1.22E+07	149	4.19E+04	2237	0.	
16	1.29E+07	169	4.52E+04	2544	0.	DEWP (C)
18	1.01E+07	189	2.30E+04	2849	0.	
20	6.47E+06	210	1.77E+04	3155	0.	
22	5.44E+06	230	1.26E+04	3462	0.	TAS (M/S)
24	3.62E+06	251	5.10E+03	3768	0.	116.6
26	3.37E+06	271	4.31E+03	4073	0.	
28	2.85E+06	291	3.28E+03	4379	0.	
30	2.33E+06	312	5.74E+03	4686	0.	
						TOTALS
LWC	5.95E-04		3.04E-03		1.27E-05	2.67E-03
MED D	21		62		176	58

INTERVAL START *16:59:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.7
2	2.62E+08	26	8.85E+05	402	8.57E+00	
4	3.52E+07	47	6.01E+05	707	0.	ALT (KM)
6	2.72E+07	67	3.73E+05	1013	0.	7.679
8	2.28E+07	89	2.22E+05	1320	0.	
10	1.94E+07	108	1.07E+05	1625	0.	TEMP (C)
12	1.84E+07	128	6.83E+04	1932	0.	-30.4
14	1.22E+07	149	3.01E+04	2237	0.	
16	1.04E+07	169	2.22E+04	2544	0.	DEWP (C)
18	8.80E+06	189	1.72E+04	2849	0.	
20	6.21E+06	210	1.04E+04	3155	0.	
22	4.40E+06	230	8.04E+03	3462	0.	TAS (M/S)
24	6.47E+06	251	6.38E+03	3768	0.	116.7
26	6.73E+06	271	1.43E+03	4073	0.	
28	3.36E+06	291	0.	4379	0.	
30	3.62E+06	312	1.91E+03	4686	0.	
						TOTALS
LWC	7.08E-04		2.08E-03		7.50E-06	1.92E-03
MED D	23		56		176	54

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:00:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 372.5
2	1.47E+08	26	6.63E+05	402	6.16E+01	
4	8.15E+07	47	4.07E+05	707	1.68E+00	ALT (KM)
6	5.51E+07	67	5.87E+05	1013	0.	7.683
8	4.76E+07	88	3.67E+05	1320	0.	
10	3.60E+07	108	4.11E+05	1625	0.	TEMP (C)
12	2.67E+07	128	2.80E+05	1932	0.	-30.4
14	1.50E+07	149	1.78E+05	2237	0.	
16	1.50E+07	169	9.04E+04	2544	0.	DEWP (C)
18	1.66E+07	189	4.88E+04	2849	0.	
20	8.54E+06	210	2.71E+04	3155	0.	
22	8.60E+06	230	2.87E+04	3462	0.	TAS (M/S)
24	6.21E+06	251	1.40E+04	3768	0.	116.7
26	3.36E+06	271	1.43E+04	4073	0.	
28	7.76E+06	291	6.56E+03	4379	0.	
30	5.17E+06	312	7.65E+03	4686	0.	
						TOTALS
LWC	9.85E-04		5.80E-03		6.19E-05	5.05E-03
MED D	22		68		186	65

INTERVAL START *17:00:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 372.2
2	1.65E+08	26	5.89E+05	402	1.29E+02	
4	7.52E+07	47	3.00E+05	707	4.49E+00	ALT (KM)
6	5.71E+07	67	3.09E+05	1013	0.	7.688
8	4.55E+07	88	2.55E+05	1320	0.	
10	3.08E+07	108	2.78E+05	1625	0.	TEMP (C)
12	2.48E+07	128	2.99E+05	1932	0.	-30.2
14	2.12E+07	149	1.92E+05	2237	0.	
16	1.53E+07	169	1.10E+05	2544	0.	DEWP (C)
18	1.68E+07	189	8.32E+04	2849	0.	
20	7.24E+06	210	5.21E+04	3155	0.	
22	6.46E+06	230	3.21E+04	3462	0.	TAS (M/S)
24	5.69E+06	251	1.27E+04	3768	0.	116.8
26	6.46E+06	271	7.17E+03	4073	0.	
28	4.65E+06	291	1.31E+04	4379	0.	
30	4.65E+06	312	3.82E+03	4686	0.	
						TOTALS
LWC	9.23E-04		5.64E-03		1.34E-04	5.06E-03
MED D	22		73		188	70

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:01:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-UM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 372.1
2	1.27E+08	26	2.95E+05	402	2.34E+02	
4	1.14E+08	47	4.55E+05	707	6.17E+00	ALT (KM)
6	1.01E+08	67	3.73E+05	1013	5.89E-01	7.690
8	7.52E+07	88	2.44E+05	1320	0.	
10	5.97E+07	108	2.96E+05	1625	0.	TEMP (C)
12	3.98E+07	128	3.49E+05	1932	0.	-30.3
14	2.71E+07	149	3.20E+05	2237	0.	
16	2.48E+07	169	2.26E+05	2544	0.	DEWP (C)
18	2.43E+07	189	1.44E+05	2849	0.	
20	1.16E+07	211	1.25E+05	3155	0.	
22	9.82E+06	230	6.65E+04	3462	0.	TAS (M/S)
24	8.02E+06	251	3.44E+04	3768	0.	116.8
26	1.14E+07	271	2.58E+04	4073	0.	
28	8.01E+06	291	1.64E+04	4379	0.	
30	8.27E+06	312	2.10E+04	4686	0.	
						TOTALS
LWC	1.49E-03		9.56E-03		2.42E-04	7.91E-03
MED D	22		80		168	76

INTERVAL START *17:01:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-UM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 372.0
2	4.91E+07	26	3.31E+05	402	3.17E+02	
4	1.30E+08	47	3.97E+05	707	1.18E+01	ALT (KM)
6	1.36E+08	67	5.00E+05	1013	0.	7.691
8	1.06E+08	88	3.03E+05	1320	0.	
10	7.29E+07	108	2.63E+05	1625	0.	TEMP (C)
12	5.66E+07	128	3.22E+05	1932	0.	-30.3
14	4.21E+07	149	3.54E+05	2237	0.	
16	3.85E+07	169	2.91E+05	2544	0.	DEWP (C)
18	3.44E+07	189	2.23E+05	2849	0.	
20	1.68E+07	210	1.70E+05	3155	0.	
22	1.81E+07	230	1.16E+05	3462	0.	TAS (M/S)
24	1.11E+07	251	5.74E+04	3768	0.	116.8
26	1.27E+07	271	4.01E+04	4073	0.	
28	1.27E+07	291	2.46E+04	4379	0.	
30	8.53E+06	312	3.06E+04	4686	0.	
						TOTALS
LWC	2.04E-03		1.25E-02		3.33E-04	9.92E-03
MED D	22		84		189	79

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:02:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-UM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						372.0
2	1.00E+08	26	2.95E+05	402	4.48E+02	
4	1.12E+08	47	2.81E+05	707	3.03E+01	ALT (KM)
6	1.01E+08	67	1.82E+05	1013	5.89E-01	7.691
8	8.43E+07	88	9.75E+04	1320	0.	
10	6.03E+07	108	8.10E+04	1625	0.	TEMP (C)
12	4.66E+07	128	5.73E+04	1932	0.	-30.5
14	3.26E+07	149	5.16E+04	2237	0.	
16	2.48E+07	169	1.32E+05	2544	0.	DEWP (C)
18	2.17E+07	189	1.67E+05	2849	0.	
20	1.01E+07	210	1.54E+05	3155	0.	
22	7.76E+06	230	1.39E+05	3462	0.	TAS (M/S)
24	7.50E+06	251	7.65E+04	3768	0.	116.7
26	6.72E+06	271	6.74E+04	4073	0.	
28	8.54E+06	291	2.29E+04	4379	0.	
30	5.17E+06	312	4.21E+04	4686	0.	
						TOTALS
LWC	1.31E-03		9.53E-03		5.45E-04	6.11E-03
MED D	21		100		202	90

INTERVAL START *17:02:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-UM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						371.8
2	8.77E+07	26	1.84E+05	402	9.93E+02	
4	1.35E+08	47	3.10E+05	707	9.15E+01	ALT (KM)
6	1.24E+08	67	2.00E+05	1013	2.36E+00	7.694
8	1.01E+08	88	1.33E+05	1320	0.	
10	7.66E+07	108	7.92E+04	1625	0.	TEMP (C)
12	4.66E+07	128	4.77E+04	1932	0.	-30.6
14	3.44E+07	149	3.33E+04	2237	0.	
16	3.65E+07	169	6.64E+04	2544	0.	DEWP (C)
18	2.64E+07	189	1.06E+05	2849	0.	
20	1.01E+07	210	1.04E+05	3155	0.	
22	1.27E+07	230	1.11E+05	3462	0.	TAS (M/S)
24	7.50E+06	251	1.03E+05	3768	0.	116.7
26	9.83E+06	271	9.04E+04	4073	0.	
28	8.79E+06	291	5.74E+04	4379	0.	
30	9.31E+06	312	5.35E+04	4686	0.	
						TOTALS
LWC	1.65E-03		9.90E-03		1.34E-03	5.40E-03
MED D	21		110		212	95

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:03:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-4M)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 371.5
2	1.32E+08	26	2.58E+05	402	1.70E+03	
4	1.18E+08	47	1.74E+05	707	1.13E+02	ALT (KM)
6	9.33E+07	67	1.32E+05	1013	2.36E+00	7.701
8	7.50E+07	88	1.14E+05	1320	0.	
10	6.08E+07	108	4.42E+04	1625	0.	TEMP (C)
12	4.45E+07	128	2.59E+04	1932	0.	-30.6
14	2.84E+07	149	1.93E+04	2237	0.	
16	2.09E+07	169	1.15E+04	2544	0.	DEWP (C)
18	2.38E+07	189	2.20E+04	2849	0.	
20	9.57E+06	210	3.44E+04	3155	0.	
22	8.01E+06	230	4.13E+04	3462	0.	TAS (M/S)
24	3.10E+06	251	8.03E+04	3768	0.	116.8
26	5.95E+06	271	6.16E+04	4073	0.	
28	4.91E+06	291	4.26E+04	4379	0.	
30	4.65E+06	312	4.20E+04	4686	0.	
						TOTALS
LWC	1.10E-03		5.91E-03		2.07E-03	3.62E-03
MED D	13		116		201	131

INTERVAL START *17:03:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-4M)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 370.9
2	1.42E+08	26	1.10E+05	402	1.69E+03	
4	1.04E+08	47	1.06E+05	707	1.65E+02	ALT (KM)
6	8.24E+07	67	9.54E+04	1013	5.88E+00	7.713
8	6.61E+07	88	9.47E+04	1320	0.	
10	5.19E+07	108	6.25E+04	1625	0.	TEMP (C)
12	3.16E+07	128	3.41E+04	1932	0.	-30.5
14	2.94E+07	149	1.18E+04	2237	0.	
16	1.78E+07	169	7.96E+03	2544	0.	DEWP (C)
18	1.83E+07	189	1.43E+04	2849	0.	
20	9.81E+06	210	4.27E+04	3155	0.	
22	8.52E+06	230	5.04E+04	3462	0.	TAS (M/S)
24	9.30E+06	251	5.62E+04	3768	0.	116.9
26	5.94E+06	271	4.70E+04	4073	0.	
28	5.17E+06	291	4.42E+04	4379	0.	
30	6.46E+06	312	5.73E+04	4686	0.	
						TOTALS
LWC	1.17E-03		5.86E-03		2.35E-03	3.94E-03
MED D	22		119		215	143

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:04:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						371.0
2	1.31E+08	25	2.21E+05	402	1.11E+03	
4	1.12E+08	47	2.42E+05	707	1.18E+02	ALT (KM)
6	8.08E+07	67	1.50E+05	1013	4.71E+00	7.711
8	6.82E+07	88	1.03E+05	1320	0.	
10	4.98E+07	108	5.70E+04	1625	0.	TEMP (C)
12	3.80E+07	128	3.27E+04	1932	0.	-30.4
14	2.71E+07	149	2.90E+04	2237	0.	
16	2.12E+07	169	3.36E+04	2544	0.	DEWP (C)
18	2.35E+07	189	6.11E+04	2849	0.	
20	1.21E+07	210	9.06E+04	3155	0.	
22	1.21E+07	230	6.42E+04	3462	0.	TAS (M/S)
24	6.71E+06	251	8.15E+04	3768	0.	116.9
26	6.71E+06	271	5.30E+04	4073	0.	
28	8.78E+06	291	4.26E+04	4379	0.	
30	5.42E+06	312	3.44E+04	4686	0.	
						TOTALS
LWC	1.31E-03		6.76E-03		1.60E-03	4.35E-03
MED D	21		110		219	98

INTERVAL START *17:04:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						371.3
2	1.32E+08	25	2.57E+05	402	5.44E+02	
4	8.73E+07	47	5.81E+04	707	6.16E+01	ALT (KM)
6	6.56E+07	67	1.18E+05	1013	2.35E+00	7.705
8	4.70E+07	88	9.73E+04	1320	0.	
10	3.46E+07	108	4.04E+04	1625	0.	TEMP (C)
12	2.87E+07	128	4.90E+04	1932	0.	-30.1
14	2.19E+07	149	5.04E+04	2237	0.	
16	1.91E+07	169	6.81E+04	2544	0.	DEWP (C)
18	1.88E+07	189	4.96E+04	2849	0.	
20	1.27E+07	210	6.87E+04	3155	0.	
22	6.71E+06	230	4.35E+04	3462	0.	TAS (M/S)
24	1.01E+07	251	3.05E+04	3768	0.	116.9
26	6.00E+06	271	2.00E+04	4073	0.	
28	7.49E+06	291	1.64E+04	4379	0.	
30	5.16E+06	312	1.91E+04	4686	0.	
						TOTALS
LWC	1.19E-03		4.13E-03		8.03E-04	3.25E-03
MED D	23		98		222	91

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:05:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.6
2	1.24E+08	26	1.10E+05	402	5.42E+02	
4	9.68E+07	47	8.71E+04	707	5.88E+01	ALT (KM)
6	6.35E+07	67	9.53E+04	1013	1.18E+00	7.681
8	4.52E+07	88	7.03E+04	1320	6.19E-01	
10	3.43E+07	108	5.70E+04	1625	0.	TEMP (C)
12	3.28E+07	128	5.86E+04	1932	0.	-29.3
14	2.74E+07	149	6.65E+04	2237	0.	
16	1.73E+07	169	6.36E+04	2544	0.	DEWP (C)
18	2.40E+07	189	4.87E+04	2849	0.	
20	1.24E+07	210	5.21E+04	3155	0.	
22	1.03E+07	230	4.92E+04	3462	0.	TAS (M/S)
24	8.78E+06	251	2.29E+04	3768	0.	116.9
26	8.00E+06	271	8.59E+03	4073	0.	
28	9.81E+06	291	1.64E+04	4379	0.	
30	6.71E+06	312	1.72E+04	4686	0.	
						TOTALS
LWC	1.35E-03		3.72E-03		7.90E-04	3.19E-03
MED D	23		36		220	91

INTERVAL START *17:05:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.9
2	1.33E+08	26	1.84E+05	402	9.15E+02	
4	1.12E+08	47	2.90E+05	707	9.80E+01	ALT (KM)
6	7.69E+07	67	2.95E+05	1013	5.29E+00	7.676
8	8.00E+07	88	1.38E+05	1320	6.19E-01	
10	6.14E+07	108	1.89E+05	1625	0.	TEMP (C)
12	5.42E+07	128	1.40E+05	1932	0.	-28.9
14	3.38E+07	149	1.38E+05	2237	0.	
16	2.76E+07	169	8.66E+04	2544	0.	DEWP (C)
18	3.15E+07	189	8.49E+04	2849	0.	
20	2.27E+07	210	6.56E+04	3155	0.	
22	1.86E+07	230	6.75E+04	3462	0.	TAS (M/S)
24	1.52E+07	251	3.82E+04	3768	0.	117.0
26	1.73E+07	271	1.72E+04	4073	0.	
28	1.57E+07	291	1.47E+04	4379	0.	
30	1.57E+07	312	1.91E+04	4686	0.	
						TOTALS
LWC	2.38E-03		5.93E-03		1.36E-03	5.58E-03
MED D	24		88		223	86

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:06:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.9
2	1.51E+08	26	4.04E+05	402	1.37E+03	
4	1.19E+08	47	2.90E+05	707	1.33E+02	ALT (KM)
6	9.08E+07	67	2.90E+05	1013	3.53E+00	7.674
8	1.01E+08	88	1.97E+05	1320	0.	
10	8.13E+07	108	1.91E+05	1625	0.	TEMP (C)
12	6.22E+07	128	2.03E+05	1932	0.	-28.8
14	5.42E+07	149	1.85E+05	2237	0.	
16	4.59E+07	169	1.60E+05	2544	0.	DEWP (C)
18	4.75E+07	189	1.31E+05	2649	0.	
20	2.40E+07	210	1.04E+05	3155	0.	
22	1.96E+07	230	1.10E+05	3462	0.	TAS (M/S)
24	1.88E+07	251	5.60E+04	3768	0.	117.0
26	1.83E+07	271	3.72E+04	4073	0.	
28	1.78E+07	291	3.92E+04	4379	0.	
30	2.30E+07	312	2.67E+04	4686	0.	
						TOTALS
LWC	3.01E-03		9.24E-03		1.88E-03	8.05E-03
MED D	24		93		214	87

INTERVAL START *17:06:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						372.8
2	1.25E+08	26	2.94E+05	402	9.85E+02	
4	1.35E+08	47	3.38E+05	707	8.73E+01	ALT (KM)
6	1.08E+08	67	3.95E+05	1013	5.88E-01	7.677
8	8.85E+07	88	2.59E+05	1320	0.	
10	6.37E+07	108	2.35E+05	1625	0.	TEMP (C)
12	5.55E+07	128	1.80E+05	1932	0.	-28.8
14	4.28E+07	149	1.33E+05	2237	0.	
16	3.10E+07	169	1.20E+05	2544	0.	DEWP (C)
18	3.82E+07	189	7.34E+04	2849	0.	
20	2.17E+07	210	7.18E+04	3155	0.	
22	1.78E+07	230	6.64E+04	3462	0.	TAS (M/S)
24	1.44E+07	251	5.60E+04	3768	0.	117.0
26	1.60E+07	271	4.44E+04	4073	0.	
28	1.70E+07	291	2.29E+04	4379	0.	
30	1.83E+07	312	1.53E+04	4686	0.	
						TOTALS
LWC	2.53E-03		7.36E-03		1.29E-03	6.12E-03
MED D	24		90		209	81

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:07:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 372.8
2	1.58E+08	26	5.88E+05	402	2.49E+02	
4	1.31E+08	47	4.83E+05	707	1.40E+01	ALT (KM)
6	1.05E+08	67	4.35E+05	1013	5.88E-01	7.677
8	8.15E+07	88	2.97E+05	1320	0.	
10	6.68E+07	108	2.24E+05	1625	0.	TEMP (C)
12	5.03E+07	128	1.96E+05	1932	0.	-28.8
14	4.23E+07	149	1.39E+05	2237	0.	
16	3.43E+07	169	1.27E+05	2544	0.	DEWP (C)
18	3.69E+07	189	8.49E+04	2849	0.	
20	2.04E+07	210	7.39E+04	3155	0.	
22	1.75E+07	230	5.38E+04	3462	0.	TAS (M/S)
24	1.47E+07	251	4.45E+04	3768	0.	117.0
26	2.19E+07	271	3.00E+04	4073	0.	
28	1.60E+07	291	2.13E+04	4379	0.	
30	1.75E+07	312	1.91E+04	4686	0.	
						TOTALS
LWC	2.58E-03		7.23E-03		2.93E-04	5.35E-03
MED D	24		85		199	75

INTERVAL START *17:07:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 373.1
2	1.45E+08	26	1.84E+05	402	2.51E+02	
4	1.06E+08	47	1.93E+05	707	3.30E+01	ALT (KM)
6	6.87E+07	67	1.41E+05	1013	1.18E+00	7.671
8	5.55E+07	88	7.57E+04	1320	0.	
10	4.34E+07	108	5.33E+04	1625	0.	TEMP (C)
12	3.82E+07	128	4.22E+04	1932	0.	-28.9
14	3.12E+07	149	6.86E+04	2237	0.	
16	2.12E+07	169	5.04E+04	2544	0.	DEWP (C)
18	2.35E+07	189	6.20E+04	2849	0.	
20	1.60E+07	210	5.83E+04	3155	0.	
22	1.34E+07	230	4.58E+04	3462	0.	TAS (M/S)
24	1.39E+07	251	2.93E+04	3768	0.	117.0
26	8.78E+06	271	1.57E+04	4073	0.	
28	1.32E+07	291	9.82E+03	4379	0.	
30	1.37E+07	312	5.73E+03	4686	0.	
						TOTALS
LWC	1.83E-03		3.56E-03		3.94E-04	2.88E-03
MED D	24		92		229	87

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:08:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.7
2	1.00E+08	26	3.32E+05	402	1.30E+03	
4	1.27E+08	47	2.62E+05	707	2.43E+02	ALT (KM)
6	1.12E+08	67	1.73E+05	1013	1.53E+01	7.661
8	7.45E+07	88	1.16E+05	1320	2.48E+00	
10	5.74E+07	108	4.60E+04	1625	0.	TEMP (C)
12	4.47E+07	128	2.59E+04	1932	0.	-29.4
14	3.91E+07	149	3.97E+04	2237	0.	
16	2.74E+07	169	3.90E+04	2544	0.	DEWP (C)
18	2.79E+07	189	6.02E+04	2849	0.	
20	1.35E+07	210	6.47E+04	3155	0.	
22	1.27E+07	230	8.72E+04	3462	0.	TAS (M/S)
24	1.16E+07	251	6.76E+04	3768	0.	116.7
26	7.50E+06	271	7.17E+04	4073	0.	
28	6.47E+06	291	4.26E+04	4379	0.	
30	9.31E+06	312	3.06E+04	4686	0.	
						TOTALS
LWC	1.59E-03		6.91E-03		2.59E-03	5.46E-03
MED D	21		110		261	104

INTERVAL START *17:08:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.8
2	1.05E+08	26	2.21E+05	402	2.11E+03	
4	1.48E+08	47	2.52E+05	707	4.24E+02	ALT (KM)
6	1.31E+08	67	2.05E+05	1013	3.24E+01	7.658
8	1.07E+08	88	1.35E+05	1320	2.48E+00	
10	7.01E+07	108	1.07E+05	1625	0.	TEMP (C)
12	5.98E+07	128	6.01E+04	1932	0.	-29.6
14	3.80E+07	149	4.62E+04	2237	0.	
16	3.73E+07	169	5.23E+04	2544	0.	DEWP (C)
18	3.70E+07	189	1.00E+05	2849	0.	
20	1.91E+07	210	1.01E+05	3155	0.	
22	1.40E+07	230	8.95E+04	3462	0.	TAS (M/S)
24	1.11E+07	251	8.03E+04	3768	0.	116.7
26	1.40E+07	271	7.03E+04	4073	0.	
28	1.47E+07	291	5.41E+04	4379	0.	
30	1.04E+07	312	4.59E+04	4686	0.	
						TOTALS
LWC	2.14E-03		8.69E-03		4.40E-03	8.23E-03
MED D	22		109		266	130

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:09:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.7
2	9.34E+07	26	3.68E+05	402	3.23E+03	
4	1.46E+08	47	2.42E+05	707	6.32E+02	ALT (KM)
6	1.42E+08	67	2.37E+05	1013	3.95E+01	7.661
8	1.23E+08	88	1.33E+05	1320	2.48E+00	
10	8.41E+07	108	8.84E+04	1625	0.	TEMP (C)
12	6.29E+07	128	3.96E+04	1932	0.	-29.6
14	5.56E+07	149	2.58E+04	2237	0.	
16	3.83E+07	169	2.48E+04	2544	0.	DEWP (C)
18	3.60E+07	189	2.10E+04	2849	0.	
20	2.17E+07	210	3.86E+04	3155	0.	
22	1.73E+07	230	7.35E+04	3462	0.	TAS (M/S)
24	1.60E+07	251	5.48E+04	3768	0.	116.7
26	1.63E+07	271	6.17E+04	4073	0.	
28	1.53E+07	291	5.08E+04	4379	0.	
30	8.80E+06	312	4.78E+04	4686	0.	
						TOTALS
LWC	2.36E-03		6.66E-03		6.48E-03	8.80E-03
MED D	22		116		261	207

INTERVAL START *17:09:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.9
2	1.22E+08	26	7.37E+04	402	2.70E+03	
4	1.22E+08	47	2.13E+05	707	3.93E+02	ALT (KM)
6	1.08E+08	67	1.05E+05	1013	1.59E+01	7.655
8	7.94E+07	88	9.48E+04	1320	0.	
10	6.11E+07	108	5.71E+04	1625	0.	TEMP (C)
12	4.74E+07	128	3.14E+04	1932	0.	-29.5
14	3.47E+07	149	6.45E+03	2237	0.	
16	3.29E+07	169	7.97E+03	2544	0.	DEWP (C)
18	3.03E+07	189	9.56E+03	2849	0.	
20	1.40E+07	210	2.40E+04	3155	0.	
22	1.37E+07	230	2.98E+04	3462	0.	TAS (M/S)
24	1.09E+07	251	3.32E+04	3768	0.	116.7
26	1.27E+07	271	4.30E+04	4073	0.	
28	1.04E+07	291	3.44E+04	4379	0.	
30	7.50E+06	312	4.97E+04	4686	0.	
						TOTALS
LWC	1.76E-03		4.56E-03		4.46E-03	5.64E-03
MED D	22		121		235	202

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:10:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.1
2	1.07E+08	26	2.95E+05	402	1.77E+03	
4	1.23E+08	47	2.04E+05	707	2.63E+02	ALT (KM)
6	1.16E+08	67	1.77E+05	1013	1.30E+01	7.653
8	8.46E+07	88	7.59E+04	1320	1.24E+00	
10	7.12E+07	108	5.71E+04	1625	0.	TEMP (C)
12	5.38E+07	128	3.69E+04	1932	0.	-29.5
14	4.32E+07	149	2.58E+04	2237	0.	
16	3.29E+07	169	3.54E+04	2544	0.	DEWP (C)
18	3.57E+07	189	3.83E+04	2849	0.	
20	1.99E+07	210	7.72E+04	3155	0.	
22	1.81E+07	230	6.89E+04	3462	0.	TAS (M/S)
24	1.01E+07	251	5.61E+04	3768	0.	116.7
26	1.42E+07	271	5.02E+04	4073	0.	
28	1.42E+07	291	5.90E+04	4379	0.	
30	7.76E+06	312	4.59E+04	4686	0.	
						TOTALS
LWC	2.06E-03		6.81E-03		3.02E-03	5.56E-03
MED D	22		115		239	130

INTERVAL START *17:10:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.0
2	1.20E+08	26	2.95E+05	402	1.55E+03	
4	1.48E+08	47	2.43E+05	707	1.94E+02	ALT (KM)
6	1.36E+08	67	2.14E+05	1013	1.42E+01	7.654
8	1.03E+08	88	1.49E+05	1320	2.48E+00	
10	7.51E+07	108	7.56E+04	1625	0.	TEMP (C)
12	5.62E+07	128	4.51E+04	1932	0.	-29.8
14	4.84E+07	149	2.69E+04	2237	0.	
16	4.01E+07	169	5.14E+04	2544	0.	DEWP (C)
18	3.34E+07	189	7.56E+04	2849	0.	
20	2.17E+07	210	1.10E+05	3155	0.	
22	1.61E+07	230	1.07E+05	3462	0.	TAS (M/S)
24	1.40E+07	251	9.95E+04	3768	0.	116.6
26	1.32E+07	271	6.75E+04	4073	0.	
28	1.11E+07	291	4.10E+04	4379	0.	
30	1.09E+07	312	3.25E+04	4686	0.	
						TOTALS
LWC	2.16E-03		8.20E-03		2.56E-03	6.32E-03
MED D	22		107		235	181

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:11:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.1
2	1.76E+08	26	2.21E+05	402	9.65E+02	
4	1.19E+08	47	1.07E+05	707	2.81E+02	ALT (KM)
6	9.48E+07	67	9.11E+04	1013	2.48E+01	7.653
8	7.17E+07	88	8.41E+04	1320	2.48E+00	
10	5.23E+07	108	4.43E+04	1625	6.55E-01	TEMP (C)
12	3.24E+07	128	3.55E+04	1932	0.	-29.8
14	3.44E+07	149	2.04E+04	2237	0.	
16	2.49E+07	169	2.84E+04	2544	0.	DEWP (C)
18	2.49E+07	189	4.31E+04	2849	0.	
20	1.01E+07	210	7.21E+04	3155	0.	
22	1.11E+07	230	6.89E+04	3462	0.	TAS (M/S)
24	7.77E+06	251	5.36E+04	3768	0.	116.6
26	8.03E+06	271	4.74E+04	4073	0.	
28	8.03E+06	291	5.09E+04	4379	0.	
30	7.51E+06	312	3.25E+04	4686	0.	
						TOTALS
LWC	1.41E-03		5.97E-03		2.65E-03	4.98E-03
MED D	22		113		291	134

INTERVAL START *17:11:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.4
2	1.81E+08	26	3.69E+04	402	3.24E+03	
4	9.74E+07	47	1.17E+05	707	8.17E+02	ALT (KM)
6	6.58E+07	67	1.05E+05	1013	3.42E+01	7.646
8	4.48E+07	88	5.43E+04	1320	4.97E+00	
10	4.48E+07	108	3.51E+04	1625	0.	TEMP (C)
12	3.14E+07	128	1.50E+04	1932	0.	-29.9
14	2.75E+07	149	1.51E+04	2237	0.	
16	2.20E+07	169	1.77E+03	2544	0.	DEWP (C)
18	1.84E+07	189	7.66E+03	2849	0.	
20	1.04E+07	210	1.05E+03	3155	0.	
22	1.04E+07	230	8.05E+03	3462	0.	TAS (M/S)
24	6.22E+06	251	3.83E+03	3768	0.	116.5
26	7.00E+06	271	4.31E+03	4073	0.	
28	6.22E+06	291	4.93E+03	4379	0.	
30	9.07E+06	312	5.75E+03	4686	0.	
						TOTALS
LWC	1.26E-03		9.46E-04		7.37E-03	7.91E-03
MED D	22		98		272	263

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:12:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.6
2	1.31E+08	26	4.80E+05	402	3.89E+03	
4	1.41E+08	47	2.72E+05	707	3.31E+02	ALT (KM)
6	1.14E+08	67	1.28E+05	1013	1.18E+01	7.642
8	9.23E+07	88	1.09E+05	1320	0.	
10	6.97E+07	108	7.38E+04	1625	0.	TEMP (C)
12	5.16E+07	128	4.10E+04	1932	0.	-29.9
14	4.54E+07	149	2.05E+04	2237	0.	
16	3.08E+07	169	1.51E+04	2544	0.	DEWP (C)
18	3.45E+07	189	1.15E+04	2849	0.	
20	1.56E+07	210	1.46E+04	3155	0.	
22	1.17E+07	230	3.68E+04	3462	0.	TAS (M/S)
24	1.53E+07	251	4.34E+04	3768	0.	116.5
26	1.06E+07	271	5.89E+04	4073	0.	
28	1.06E+07	291	6.90E+04	4379	0.	
30	9.33E+06	312	3.64E+04	4686	0.	
						TOTALS
LWC	1.91E-03		5.68E-03		5.14E-03	6.61E-03
MED D	22		120		210	181

INTERVAL START *17:12:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.7
2	2.54E+08	26	3.69E+04	402	7.84E+02	
4	7.83E+07	47	5.83E+04	707	5.23E+01	ALT (KM)
6	5.16E+07	67	7.75E+04	1013	0.	7.640
8	3.91E+07	88	3.53E+04	1320	0.	
10	3.66E+07	108	1.48E+04	1625	0.	TEMP (C)
12	2.39E+07	128	1.78E+04	1932	0.	-29.9
14	2.59E+07	149	1.40E+04	2237	0.	
16	1.76E+07	169	1.69E+04	2544	0.	DEWP (C)
18	1.40E+07	189	1.73E+04	2849	0.	
20	8.04E+06	210	3.14E+04	3155	0.	
22	7.26E+06	230	2.88E+04	3462	0.	TAS (M/S)
24	5.19E+06	251	3.96E+04	3768	0.	116.5
26	6.48E+06	271	4.46E+04	4073	0.	
28	4.41E+06	291	4.11E+04	4379	0.	
30	3.37E+06	312	3.07E+04	4686	0.	
						TOTALS
LWC	8.96E-04		4.18E-03		9.36E-04	1.99E-03
MED D	21		119		200	103

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:13:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.8
2	4.43E+08	26	0.	402	4.24E+02	
4	3.03E+07	47	2.91E+04	707	4.72E+01	ALT (KM)
6	1.56E+07	67	9.12E+03	1013	0.	7.640
8	1.74E+07	88	1.36E+04	1320	0.	
10	8.62E+06	108	3.69E+03	1625	0.	TEMP (C)
12	4.93E+06	128	4.10E+03	1932	0.	-29.9
14	6.22E+06	149	1.08E+03	2237	0.	
16	5.44E+06	169	8.88E+02	2544	0.	DEWP (C)
18	4.67E+06	189	9.59E+02	2849	0.	
20	2.59E+06	210	3.14E+03	3155	0.	
22	2.07E+06	230	2.30E+03	3462	0.	TAS (M/S)
24	2.07E+06	251	0.	3768	0.	116.5
26	2.33E+06	271	8.63E+03	4073	0.	
28	1.30E+06	291	3.29E+03	4379	0.	
30	2.07E+06	312	5.75E+03	4686	0.	
						TOTALS
LWC	3.13E-04		5.10E-04		5.97E-04	7.21E-04
MED D	23		122		216	194

INTERVAL START *17:13:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.5
2	4.02E+08	26	3.69E+04	402	9.64E+02	
4	3.76E+07	47	2.91E+04	707	2.27E+02	ALT (KM)
6	2.80E+07	67	5.01E+04	1013	3.54E+00	7.644
8	1.97E+07	88	1.63E+04	1320	6.21E-01	
10	1.53E+07	108	3.69E+03	1625	0.	TEMP (C)
12	1.43E+07	128	5.47E+03	1932	0.	-30.0
14	1.06E+07	149	2.15E+03	2237	0.	
16	6.74E+06	169	0.	2544	0.	DEWP (C)
18	7.52E+06	189	0.	2849	0.	
20	4.67E+06	210	2.09E+03	3155	0.	
22	2.33E+06	230	0.	3462	0.	TAS (M/S)
24	2.85E+06	251	2.56E+03	3768	0.	116.5
26	2.85E+06	271	0.	4073	0.	
28	2.85E+06	291	0.	4379	0.	
30	1.81E+06	312	1.92E+03	4686	0.	
						TOTALS
LWC	4.46E-04		2.19E-04		2.00E-03	2.13E-03
MED D	22		72		262	254

AFWL CIRRUS STUDY BY AFGL

FLIGHT EF7-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:14:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 374.3
2	2.53E+08	26	1.11E+05	402	2.33E+03	
4	7.54E+07	47	1.17E+05	707	1.78E+03	ALT (KM)
6	6.27E+07	67	8.20E+04	1013	1.08E+02	7.649
8	4.98E+07	88	4.61E+04	1320	1.80E+01	
10	3.94E+07	108	2.77E+04	1625	1.31E+00	TEMP (C)
12	2.88E+07	129	2.60E+04	1932	2.08E+00	-30.0
14	2.28E+07	149	1.29E+04	2237	1.48E+00	
16	1.92E+07	169	1.33E+04	2544	0.	DEWP (C)
18	1.89E+07	189	3.83E+03	2849	0.	
20	9.59E+06	210	1.04E+03	3155	0.	
22	6.22E+06	230	4.60E+03	3462	0.	TAS (M/S)
24	8.55E+06	251	0.	3768	0.	116.5
26	5.18E+06	271	1.44E+03	4073	0.	
28	5.70E+06	291	3.28E+03	4379	0.	
30	5.96E+06	312	0.	4686	0.	
						TOTALS
LWC	1.07E-03		6.30E-04		1.31E-02	1.37E-02
MED D	22		67		314	310

INTERVAL START *17:14:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 374.2
2	3.64E+08	26	3.69E+04	402	2.69E+03	
4	6.17E+07	47	8.74E+04	707	6.49E+02	ALT (KM)
6	5.13E+07	67	5.92E+04	1013	1.89E+01	7.650
8	4.54E+07	88	3.53E+04	1320	3.11E+00	
10	3.39E+07	108	2.40E+04	1625	0.	TEMP (C)
12	2.70E+07	128	9.57E+03	1932	0.	-30.0
14	2.05E+07	149	1.08E+04	2237	0.	
16	1.68E+07	169	2.66E+03	2544	0.	DEWP (C)
18	1.63E+07	189	2.87E+03	2849	0.	
20	1.19E+07	210	3.14E+03	3155	0.	
22	6.74E+06	230	0.	3462	0.	TAS (M/S)
24	7.26E+06	251	1.28E+03	3768	0.	116.5
26	4.66E+06	271	0.	4073	0.	
28	5.70E+06	291	9.85E+03	4379	0.	
30	6.74E+06	312	9.58E+03	4686	0.	
						TOTALS
LWC	1.05E-03		8.17E-04		5.81E-03	6.13E-03
MED D	22		126		267	260

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:15:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 374.1
2	6.00E+08	26	0.	402	5.50E+02	
4	3.32E+07	47	3.88E+04	707	3.03E+01	ALT (KM)
6	1.87E+07	67	1.82E+04	1013	5.90E-01	7.652
8	1.48E+07	88	1.90E+04	1320	0.	
10	1.45E+07	108	5.53E+03	1625	0.	TEMP (C)
12	1.09E+07	128	4.10E+03	1932	0.	-29.9
14	8.03E+06	149	2.15E+03	2237	0.	
16	5.96E+06	169	8.87E+02	2544	0.	DEWP (C)
18	7.25E+06	189	0.	2849	0.	
20	2.85E+06	210	2.09E+03	3155	0.	
22	2.07E+06	230	1.15E+03	3462	0.	TAS (M/S)
24	4.40E+06	251	3.83E+03	3768	0.	116.6
26	2.33E+06	271	1.44E+03	4073	0.	
28	2.33E+06	291	0.	4379	0.	
30	1.81E+06	312	7.66E+03	4686	0.	
						TOTALS
LWC	4.06E-04		4.14E-04		6.34E-04	7.58E-04
MED D	23		132		197	180

INTERVAL START *17:15:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB) 373.7
2	9.46E+08	26	0.	402	0.	
4	2.33E+06	47	0.	707	0.	ALT (KM)
6	2.85E+06	67	0.	1013	0.	7.659
8	2.33E+06	88	0.	1320	0.	
10	1.04E+06	108	0.	1625	0.	TEMP (C)
12	1.29E+06	128	0.	1932	0.	-30.1
14	1.04E+06	149	0.	2237	0.	
16	1.30E+06	169	0.	2544	0.	DEWP (C)
18	1.55E+06	189	0.	2849	0.	
20	7.77E+05	210	0.	3155	0.	
22	5.18E+05	230	0.	3462	0.	TAS (M/S)
24	2.59E+05	251	0.	3768	0.	116.6
26	7.77E+05	271	0.	4073	0.	
28	2.59E+05	291	0.	4379	0.	
30	2.59E+05	312	0.	4686	0.	
						TOTALS
LWC	7.50E-05		0.		0.	0.
MED D	20		0		0	0

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 30 SECOND AVERAGING
INTERVAL START *17:16:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						374.2
2	8.26E+08	26	3.69E+04	402	5.37E-01	
4	4.41E+06	47	0.	707	0.	ALT (KM)
6	1.82E+06	67	0.	1013	0.	7.650
8	2.33E+06	88	0.	1320	0.	
10	3.11E+06	108	9.23E+03	1625	0.	TEMP (C)
12	1.30E+06	128	1.37E+03	1932	0.	-30.4
14	1.04E+06	149	4.31E+03	2237	0.	
16	1.56E+06	169	0.	2544	0.	DEWP (C)
18	0.	189	0.	2849	0.	
20	7.78E+05	210	0.	3155	0.	
22	0.	230	0.	3462	0.	TAS (M/S)
24	7.78E+05	251	0.	3768	0.	116.4
26	1.04E+06	271	0.	4073	0.	
28	2.59E+05	291	0.	4379	0.	
30	7.78E+05	312	0.	4686	0.	
						TOTALS
LWC	8.90E-05		4.53E-05		4.70E-07	4.58E-05
MED D	25		61		176	61

INTERVAL START *17:16:31*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						374.3
2	1.13E+09	26	0.	402	0.	
4	4.67E+05	47	0.	707	0.	ALT (KM)
6	2.33E+05	67	0.	1013	0.	7.649
8	5.19E+05	88	0.	1320	0.	
10	2.85E+06	108	0.	1625	0.	TEMP (C)
12	5.19E+05	128	0.	1932	0.	-30.5
14	2.59E+05	149	0.	2237	0.	
16	1.30E+06	169	0.	2544	0.	DEWP (C)
18	1.04E+06	189	0.	2849	0.	
20	0.	210	0.	3155	0.	
22	2.59E+05	230	0.	3462	0.	TAS (M/S)
24	2.59E+05	251	0.	3768	0.	116.4
26	0.	271	0.	4073	0.	
28	0.	291	0.	4379	0.	
30	2.59E+05	312	0.	4686	0.	
						TOTALS
LWC	4.11E-05		0.		0.	0.
MED D	15		0		0	0

Appendix B

Data for Long-Period Averages

PMS 1-D printouts of average cirrus data for varying time intervals are given in this appendix. The periods selected were primarily determined after reference to the plotted data in Figure 15c which is believed to be in general agreement with visibility conditions in the aircraft. Specifically, the higher peaks of the precipitation probe LWC curve represent times when visibility from the aircraft was reduced most.

Peaks in the precipitation probe LWC plot are represented in the first three 1-D averages for the following:

Averaging Period	Beginning At	Page
240 sec	1654:01	68
300 sec	1701:01	68
420 sec	1707:01	69

Lower values of precipitation LWC during the flight are found in the following intervals:

180 sec	1657:01	69
120 sec	1706:01	70
60 sec	1712:01	70

Two printouts of longer term averages which include both high and low LWC values are:

1080 sec	1653:01	71
720 sec	1702:01	71

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 240 SECOND AVERAGING
INTERVAL START *16:54:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						373.2
2	6.42E+07	25	2.03E+05	400	2.36E+02	
4	8.55E+07	47	2.52E+05	706	3.45E+00	ALT (KM)
6	7.42E+07	67	1.92E+05	1011	0.	7.669
8	5.10E+07	87	1.16E+05	1316	0.	
10	4.37E+07	108	9.33E+04	1622	0.	TEMP (C)
12	3.22E+07	128	8.31E+04	1927	0.	-30.5
14	2.20E+07	148	8.79E+04	2233	0.	
16	1.65E+07	169	1.03E+05	2538	0.	FROSTPOINT
18	1.42E+07	189	1.16E+05	2843	0.	
20	8.06E+05	209	1.07E+05	3149	0.	
22	6.51E+06	230	9.46E+04	3454	0.	TAS (M/S)
24	5.76E+05	250	6.49E+04	3760	0.	116.6
26	5.50E+06	271	4.34E+04	4065	0.	
28	4.24E+06	291	3.31E+04	4370	0.	
30	4.37E+06	311	2.59E+04	4676	0.	
						TOTALS
LWC	9.27E-04		7.55E-03		2.20E-04	4.65E-03
MED D	21		99		100	86

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 300 SECOND AVERAGING
INTERVAL START *17:01:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						371.5
2	1.1[illegible]E+[illegible]3	25	2.2[illegible]E+0[illegible]	[illegible]00	8.52[illegible]+02	
4	1.12E+[illegible]3	47	2.41E+05	706	7.55[illegible]+01	ALT (KM)
6	9.25[illegible]+07	67	2.14E+05	1011	2.53[illegible]+00	7.695
8	7.4[illegible]E+07	87	1.[illegible]0E+05	1316	1.2[illegible]E-01	
10	5.62[illegible]+07	108	1.17E+05	1622	[illegible].	TEMP (C)
12	4.21E+[illegible]7	128	1.12E+05	1927	0.	-30.2
14	3.04E+07	148	1.0[illegible]E+05	2233	0.	
16	2.43[illegible]+07	169	9.69E+04	2538	0.	FROSTPOINT
18	2.47[illegible]+07	189	9.23E+04	2843	0.	
20	1.2[illegible]E+07	209	9.10E+04	3149	0.	
22	1.13E+07	230	7.50E+0[illegible]	3454	0.	TAS (M/S)
24	8.73E+06	250	5.92E+04	3760	0.	116.8
26	9.25E+06	271	4.25E+04	4065	0.	
28	8.35E+06	291	2.99E+04	4370	0.	
30	7.54E+05	311	3.37E+04	4676	0.	
						TOTALS
LWC	1.50E-03		7.34E-03		1.13E-03	5.30E-03
MED D	27		99		211	88

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 420 SECOND AVERAGING
INTERVAL START *17:07:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						374.0
2	1.81E+08	26	2.27E+05	400	1.68E+03	
4	1.11E+08	47	1.94E+05	706	2.83E+02	ALT (KM)
6	9.21E+07	67	1.54E+05	1011	1.48E+01	7.654
8	7.10E+07	87	9.94E+04	1316	1.38E+00	
10	5.40E+07	108	6.33E+04	1622	4.69E-02	TEMP (C)
12	4.08E+07	128	4.27E+04	1927	0.	-29.6
14	3.45E+07	148	3.23E+04	2233	0.	
16	2.66E+07	169	3.23E+04	2536	0.	FROSTPOINT
18	2.60E+07	189	3.81E+04	2843	0.	
20	1.41E+07	209	4.81E+04	3149	0.	
22	1.20E+07	230	5.01E+04	3454	0.	TAS (M/S)
24	1.01E+07	250	4.35E+04	3760	0.	116.6
26	1.04E+07	271	4.11E+04	4065	0.	
28	9.63E+06	291	3.45E+04	4370	0.	
30	8.50E+06	311	2.79E+04	4676	0.	
						TOTALS
LWC	1.62E-03		4.98E-03		3.04E-03	5.15E-03
MED D	22		110		249	151

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 180 SECOND AVERAGING
INTERVAL START *16:57:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB)
						373.2
2	1.55E+08	26	4.62E+05	400	2.04E+02	
4	7.15E+07	47	3.75E+05	706	4.42E+00	ALT (KM)
6	5.74E+07	67	2.98E+05	1011	0.	7.669
8	4.71E+07	87	1.81E+05	1316	0.	
10	3.28E+07	108	1.30E+05	1622	0.	TEMP (C)
12	2.58E+07	128	1.10E+05	1927	0.	-30.8
14	1.64E+07	148	8.70E+04	2233	0.	
16	1.52E+07	169	8.26E+04	2538	0.	FROSTPOINT
18	1.17E+07	189	8.49E+04	2843	0.	
20	7.22E+06	209	6.73E+04	3149	0.	
22	6.18E+06	230	5.69E+04	3454	0.	TAS (M/S)
24	5.53E+06	250	3.57E+04	3760	0.	116.5
26	5.05E+06	271	2.88E+04	4065	0.	
28	4.49E+06	291	2.06E+04	4370	0.	
30	4.06E+06	311	1.63E+04	4676	0.	
						TOTALS
LWC	8.30E-04		5.70E-03		1.97E-04	3.98E-03
MED D	22		91		183	80

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 120 SECOND AVERAGING
INTERVAL START *17:06:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						372.9
2	1.45E+08	25	3.68E+05	400	7.15E+02	
4	1.23E+08	47	3.27E+05	706	6.70E+01	ALT (KM)
6	9.30E+07	67	3.16E+05	1011	1.47E+00	7.675
8	8.15E+07	87	2.86E+05	1316	0.	
10	6.38E+07	108	1.76E+05	1622	0.	TEMP (C)
12	5.15E+07	123	1.55E+05	1927	0.	-28.8
14	4.26E+07	143	1.32E+05	2233	0.	
16	3.31E+07	169	1.15E+05	2538	0.	FROSTPOINT
18	3.65E+07	189	8.79E+04	2843	0.	
20	2.05E+07	209	7.72E+04	3149	0.	
22	1.71E+07	230	6.91E+04	3454	0.	TAS (M/S)
24	1.55E+07	250	4.65E+04	3760	0.	117.0
26	1.63E+07	271	3.19E+04	4065	0.	
28	1.60E+07	291	2.33E+04	4370	0.	
30	1.81E+07	311	1.67E+04	4676	0.	
						TOTALS
LWC	2.49E-03		6.61E-03		9.56E-04	5.57E-03
MED D	24		90		212	82

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 60 SECOND AVERAGING
INTERVAL START *17:12:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	P (MB)
						374.7
2	1.93E+08	25	2.59E+05	400	2.34E+03	
4	1.10E+08	47	1.65E+05	706	1.92E+02	ALT (KM)
6	8.28E+07	67	1.03E+05	1011	5.92E+00	7.641
8	6.57E+07	87	7.21E+04	1316	0.	
10	5.31E+07	108	4.44E+04	1622	0.	TEMP (C)
12	3.77E+07	123	2.95E+04	1927	0.	-29.9
14	3.56E+07	143	1.73E+04	2233	0.	
16	2.42E+07	169	1.60E+04	2538	0.	FROSTPOINT
18	2.42E+07	189	1.44E+04	2843	0.	
20	1.18E+07	209	2.30E+04	3149	0.	
22	9.46E+06	230	3.28E+04	3454	0.	TAS (M/S)
24	1.02E+07	250	4.16E+04	3760	0.	116.5
26	8.56E+06	271	5.19E+04	4065	0.	
28	7.52E+06	291	5.51E+04	4370	0.	
30	6.35E+06	311	3.76E+04	4676	0.	
						TOTALS
LWC	1.40E-03		4.90E-03		3.01E-03	4.21E-03
MED D	22		120		208	166

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 1080 SECOND AVERAGING
INTERVAL START *16:53:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 373.0
2	1.14E+08	25	3.00E+05	400	7.40E+02	
4	1.02E+08	47	2.81E+05	706	6.95E+01	ALT (KM)
6	8.45E+07	67	2.49E+05	1011	4.49E+01	7.673
8	6.89E+07	87	1.57E+05	1316	3.45E-01	
10	5.06E+07	108	1.31E+05	1622	0.	TEMP (C)
12	3.86E+07	128	1.16E+05	1927	0.	-30.0
14	2.89E+07	148	1.00E+05	2233	0.	
16	2.32E+07	169	9.08E+04	2538	0.	FROSTPOINT
18	2.26E+07	189	8.60E+04	2843	0.	
20	1.22E+07	209	7.94E+04	3149	0.	
22	1.04E+07	230	6.97E+04	3454	0.	TAS (M/S)
24	8.70E+06	250	5.10E+04	3760	0.	116.7
26	8.86E+06	271	3.81E+04	4065	0.	
28	8.37E+06	291	2.88E+04	4370	0.	
30	7.50E+06	311	2.58E+04	4676	0.	
						TOTALS
LWC	1.42E-03		6.75E-03		1.14E-03	5.15E-03
MED D	22		97		227	87

AFWL CIRRUS STUDY BY AFGL

FLIGHT E77-51 ON 29 OCT 77 720 SECOND AVERAGING
INTERVAL START *17:02:01*
PARTICLE SIZE DISTRIBUTIONS (NUMBER/M**3-MM)
TYPE: BULL-ROSE

SIZE (MU)	SCATTER PROBE	SIZE (MU)	CLOUD PROBE	SIZE (MU)	PRECIP PROBE	
						P (MB) 373.2
2	1.58E+08	25	2.29E+05	400	1.41E+03	
4	1.12E+08	47	2.04E+05	706	2.05E+02	ALT (KM)
6	9.06E+07	67	1.71E+05	1011	9.82E+00	7.670
8	7.29E+07	87	1.12E+05	1316	8.55E-01	
10	5.55E+07	108	8.02E+04	1622	2.74E-02	TEMP (C)
12	4.23E+07	128	5.94E+04	1927	0.	-29.7
14	3.39E+07	148	4.88E+04	2233	0.	
16	2.64E+07	169	5.01E+04	2538	0.	FROSTPOINT
18	2.66E+07	189	5.39E+04	2843	0.	
20	1.43E+07	209	6.10E+04	3149	0.	
22	1.21E+07	230	6.02E+04	3454	0.	TAS (M/S)
24	1.01E+07	250	5.09E+04	3760	0.	116.7
26	1.04E+07	271	4.24E+04	4065	0.	
28	9.95E+06	291	3.35E+04	4370	0.	
30	9.12E+06	311	2.99E+04	4676	0.	
						TOTALS
LWC	1.65E-03		5.74E-03		2.35E-03	5.06E-03
MED D	22		107		237	102