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FINAL REPORT  
for  
Field Support, Data Analysis  
and  
Associated Research  
for the  
Acoustic Grenade Sounding Program

(7 February 1974 -- 31 October 1976)

Contract No. NAS5-20039

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## ABSTRACT

This report summarizes the field support and data analysis and associated research performed for NASA Goddard Space Flight Center by GUS Manufacturing, Inc. in support of the acoustic grenade sounding program under Contract NAS5-20039 during the period 7 February 1974 through 31 October 1976. As part of NASA's overall Meteorological Rocket Sounding Program, the acoustic grenade technique is utilized to determine temperature and horizontal winds in the 30 to 90 km altitude range of the upper atmosphere.

During the period covered by this contract, a total of 8 acoustic grenade soundings were conducted at two locations: Wallops Island, Virginia and Kourou, French Guiana. Field support provided at these locations included deployment of the large area microphone system, supervision, maintenance and operation of sound-ranging stations; and coordination of activities.

Data analysis efforts included the analysis of field data to determine upper atmospheric meteorological parameters. Profiles for upper atmospheric temperature, wind and density are included in this report in the form of a plot and tables for each of the acoustic grenade soundings conducted during the contract period.

Research efforts were directed toward a systematic comparison of temperature data from acoustic grenade with other meteorological sensor probes in the upper atmosphere. The comparison study is published as a separate report, namely, Comparison of Temperatures Obtained by Acoustic Grenade and Thermistor Soundings of the Upper Atmosphere.



## SECTION 1 INTRODUCTION

### 1.1 GENERAL BACKGROUND AND PURPOSE

This report summarizes the field support, data analysis and associated research performed by GUS Manufacturing, Inc., in support of the acoustic grenade sounding program under Contract NAS5-20039 during the period 7 February, 1974 through 31 October, 1976. As part of NASA's overall Meteorological Rocket Sounding Program, the acoustic grenade technique is the only one which provides simultaneous determination of both horizontal winds and temperature in the 30 to 90 km altitude range of the upper atmosphere. These data are used in determining statistical models of upper atmospheric temperature and wind structure, in investigating gravity wave propagation in the upper atmosphere, and in interpreting and developing theoretical models for stratospheric warmings, as well as serving as ancillary information in support of composition measurements conducted in the upper atmosphere.

The temperature and wind structure in the acoustic grenade technique are determined basically by measuring the propagation properties of acoustic waves and solving the inverse propagation problem to deduce the temperature and winds producing these observed propagation properties. The acoustic waves result from rocketborne grenades which are ejected and exploded one by one at regular predetermined intervals along the upleg portion of the rocket's near vertical trajectory. The fundamental measurements are the burst time and position of each grenade explosion along

with the time at which the resulting acoustic wave arrives at each microphone in a ground-based sound-ranging array. The order of arrival of the acoustic wave at each microphone determines the direction of the associated ray. Tracing the ray path up through the atmosphere to the grenade explosion point enables the calculation of the average sound speed and horizontal wind components in the layers between successive grenade explosions, with the average temperature determined directly from the sound speed. Pressure and density profiles are then extrapolated upward beginning with a known high-altitude pressure measurement via a simultaneous solution of the ideal gas law and the hydrostatic equation, making use of the grenade-determined temperature profile.

## 1.2 SUMMARY OF WORK PERFORMED

The work performed by GUS under this contract is separated into three areas, field support, data analysis, and research. Field support consisted of supervision, maintenance and operation of sound-ranging stations; coordination of activities at field support sites; and deployment of the large area microphone system (LAMS) at the field support sites. Data analysis efforts included the analysis of field data to determine upper atmospheric meteorological parameters; the generation of a plot and associated table for upper atmospheric temperature and wind structure for each of the acoustic grenade sounds conducted during the contract period. A summary table of temperature, wind speed and direction, pressure and density and standard error was

also generated for each sounding. Research efforts were directed toward a systematic comparison of temperature data from acoustic grenade and thermistor soundings.

During the period covered by this contract eight acoustic grenade soundings were conducted at two field support locations:

(1) Wallops Island, Virginia.

Six soundings were conducted; all were successful.

(2) Kourou, French Guiana.

Two soundings were conducted; all were successful.

The large area microphone system (LAMS) was utilized in expanded arrays at Wallops and in the sound-ranging station at Kourou, French Guiana. Since it is a very portable system, the LAMS provides great flexibility in quickly assembling a sound-ranging station at any desired field support site.

The analysis of acoustic grenade data to yield upper atmospheric temperature, winds, pressure, density, and the standard errors associated with temperature and winds, continued to be an important GUS function throughout the contract period. The final results were generated into a format suitable for direct publication by NASA.

The theoretical study performed during this contract period was directed toward conducting a systematic statistical comparison of temperature profiles obtained using acoustic grenade and thermistor soundings to determine their degree of consistency in measuring the temperature of the same parcel of air. This study is an extension of a similar study previously conducted under Contract NAS5-11576 using available data from 1960-1972. The study was prompted in part by the requirement of satellite temperature sensing systems for accurate stratospheric temperatures for calibration purposes.

The comparison report is published as a separate joint paper with NASA. It carries the title Comparison of Temperatures Obtained by Acoustic Grenade and Thermistor Soundings of the Upper Atmosphere by David U. Wright, Jr., NASA and Dan J. Ramsdale, Consultant to GUS Manufacturing, Inc.

An abstract of this paper is included in Section 4.

SECTION 2  
FIELD SUPPORT

2.1 INTRODUCTION

Two field support sites were used during this contract period: (1) a fourteen microphone triple sound-ranging array at NASA Wallops Station, Wallops Island, Virginia; (2) an eight microphone triple sound-ranging array at Guiana Space Center (GSC) at Kourou, French Guiana.

2.2 FIELD SUPPORT

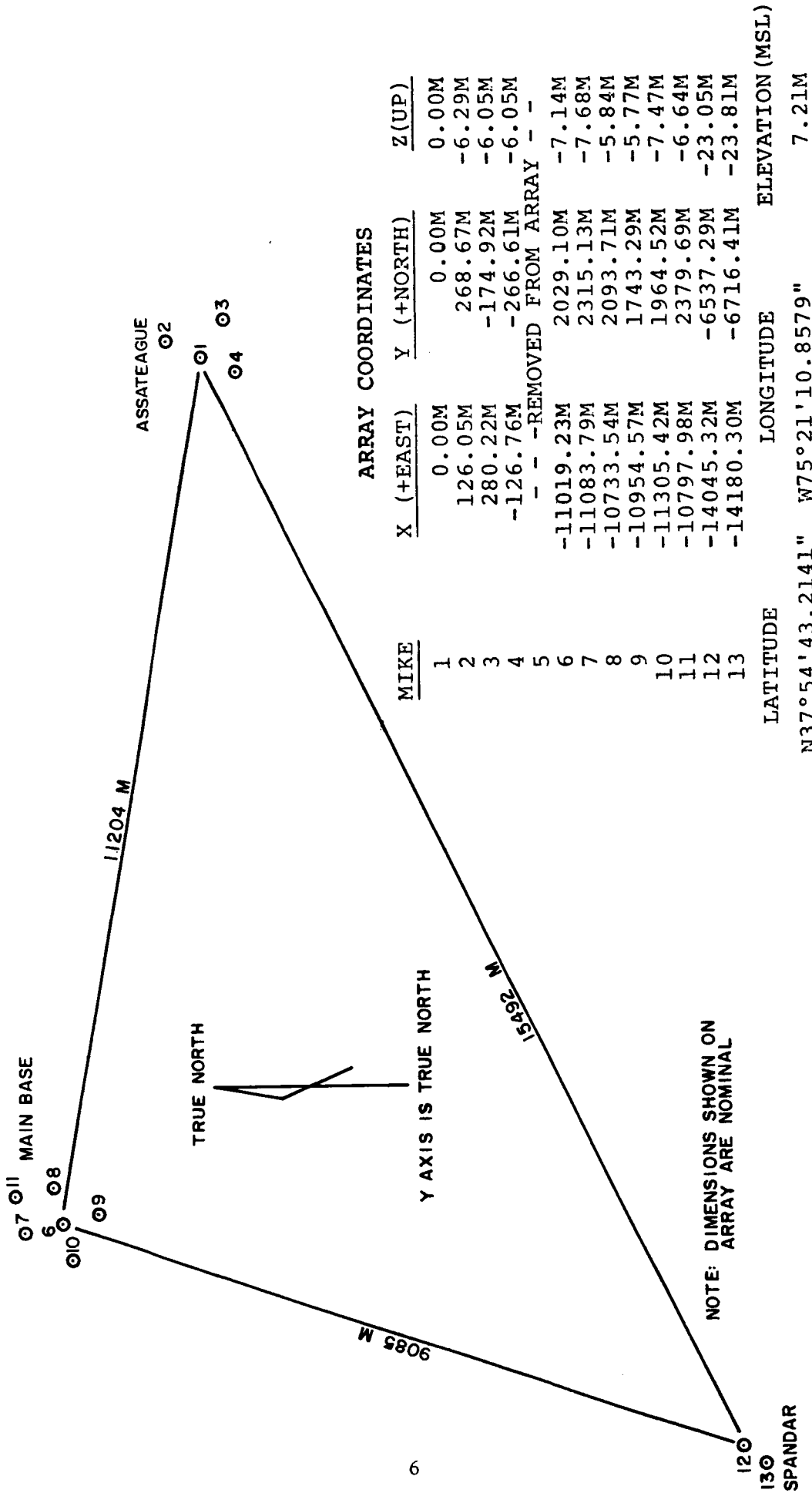
2.2.1 Wallops Island, Virginia

The Wallops triple sound-ranging array is shown in Figure 1 . The three sound-ranging stations comprised the Wallops triple array. The Main Base hotwire array of six microphones were operated and maintained by Wallops personnel, while GUS personnel assumed complete responsibility for the LAMS array. GUS provided advisory personnel for technical consultation as required.

The LAMS array comprised of eight LAMS microphones, four located at Assateaque, two at Spandar and two at Main Base. The two at Main Base were located with two of the hotwire microphones to check the acoustic phasing between the two systems. Very little difference was found in the two systems, making the data compatible.

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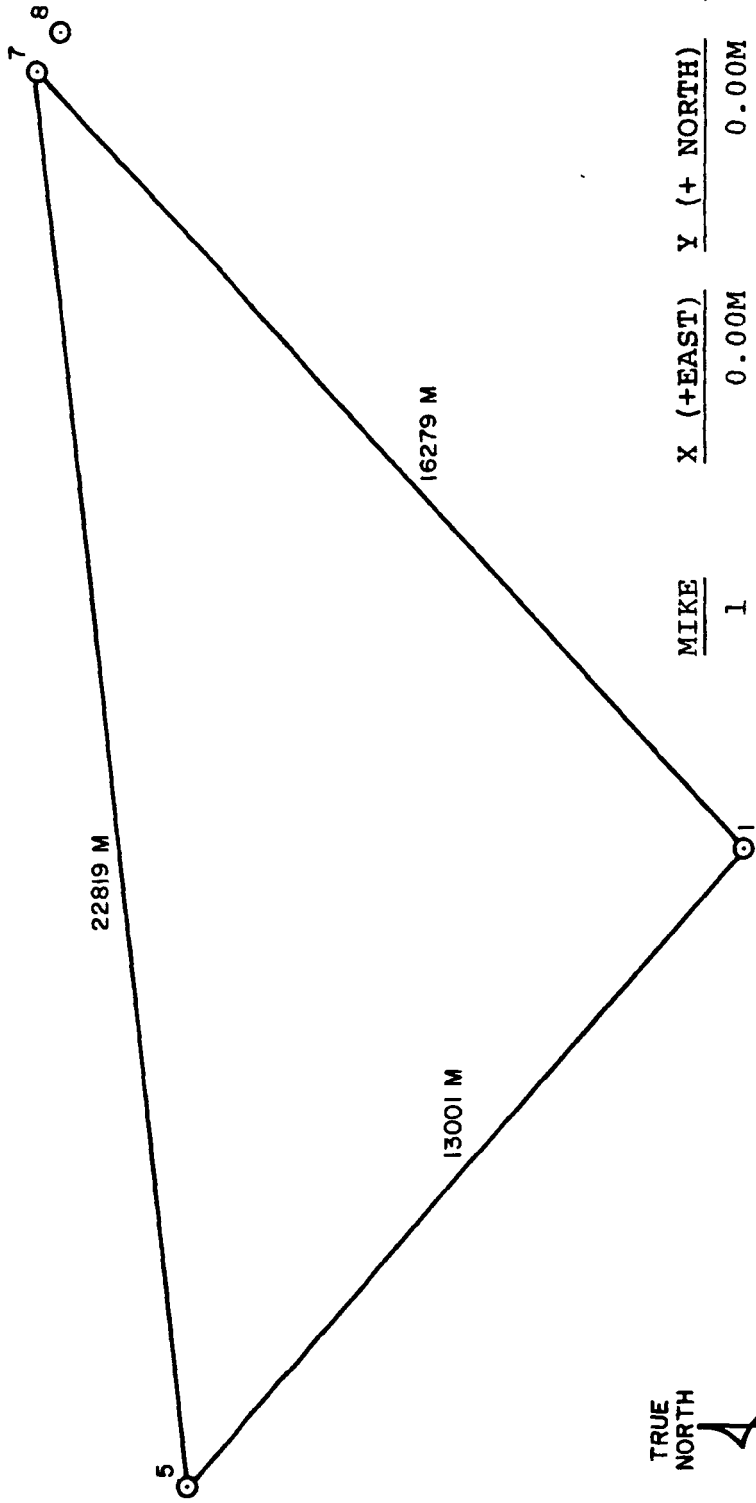




LAUNCHER ● FIGURE 1 WALLOPS TRIPLE SOUND-RANGING ARRAY

### 2.2.2 Kourou, French Guiana

In March 1974 GUS personnel accompanied NASA personnel and other interested parties to the Guiana Space Center (GSC) at Kourou, French Guiana to install the LAMS array and sound-ranging station and recorded two acoustic grenade soundings. The array at Kourou is shown in Figure 2.



MIKE	X (+EAST)	Y (+ NORTH)	Z (UP)
1	0.00M	0.00M	0.00M
2	1072.26M	-1406.96M	-1.01M
3	1230.85M	-3085.27M	-0.51M
4	-1206.61M	-1081.38M	0.66M
5	-10351.17M	7866.46M	-13.51M
6	-11674.96M	7399.90M	-17.47M
7	12295.04M	10669.73M	13.58M
8	12831.87M	10510.62M	-0.99M

LATITUDE                      LONGITUDE                      ELEVATION (MSL)

N 5°11'23.9780"                      W 52°42'6.8167"                      9.75M

NOTE: DIMENSIONS SHOWN ON ARRAY ARE NOMINAL.

FIGURE 2 KOUROU SOUND-RANGING ARRAY

SECTION 3  
DATA ANALYSIS

3.1 INTRODUCTION

The instrumentation and analysis techniques are reported or referenced in Final Report for Field Support, Data Analysis and Associated Research and Development for Acoustic Grenade Sounding Program, January 1974, prepared by GUS Manufacturing, Inc. for Goddard Space Flight Center under Contract NAS5-11576. The same analysis techniques were employed in reducing the data and preparing the following data plots, tables and summary tables for the eight soundings covered by this present contract.

3.2 LIST OF SOUNDINGS

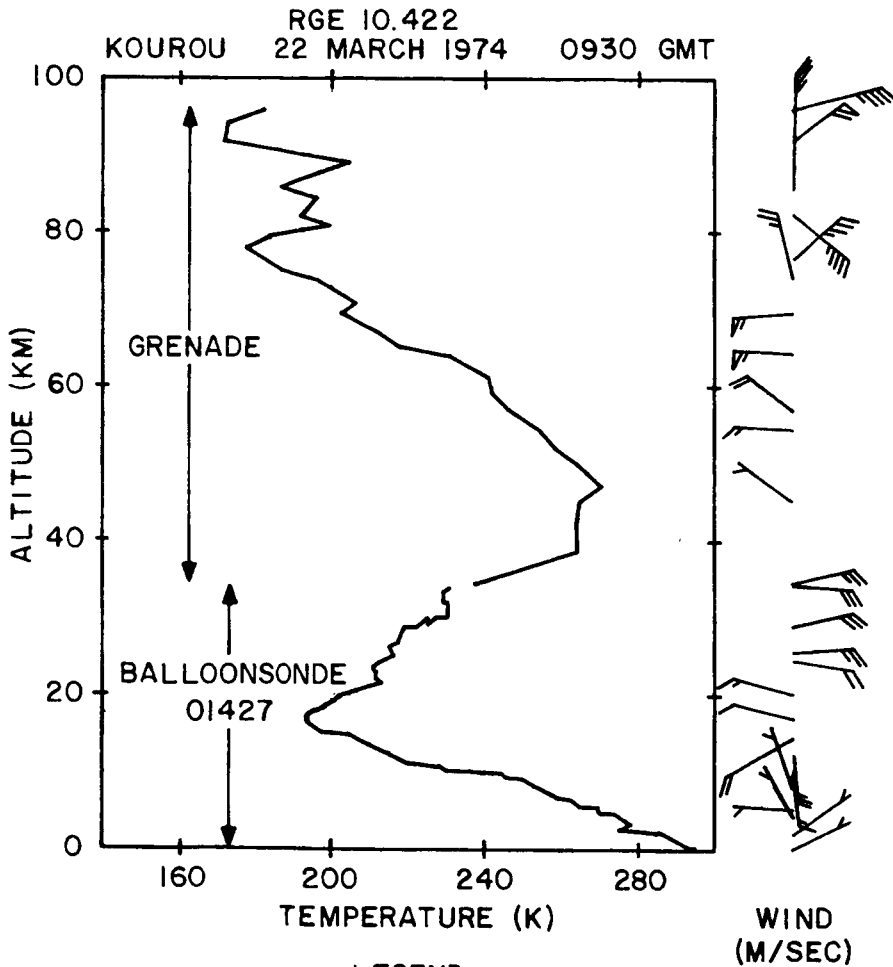
Plots and summaries are included on the next sixteen pages for the following acoustic grenade soundings:

1.	Kourou	RGE 10.421	22 March 1974	0645 GMT
2.	Kourou	RGE 10.422	22 March 1974	0930 GMT
3.	Wallops	RGE 10.413	24 July 1975	0520 GMT
4.	Wallops	RGE 10.407	7 August 1975	1610 GMT
5.	Wallops	RGE 10.415	19 Nov. 1975	1745 GMT
6.	Wallops	RGE 10.423	21 Nov. 1975	0411 GMT
7.	Wallops	RGE 10.424	3 Dec. 1975	1657 GMT
8.	Wallops	RGE 10.410	4 Dec. 1975	0525 GMT

ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
34800.6	237.5	0.2	28.5	0.6	77.4	2.1
38683.3	264.2	0.5	1.3	1.2	280.1	71.3
42477.4	264.0	0.5	3.5	1.4	279.9	33.0
45577.0	265.5	0.8	8.7	2.7	306.0	16.6
47988.5	270.6	0.8	9.2	3.2	346.2	10.8
50354.6	264.9	0.6	3.5	2.2	25.3	29.5
52680.4	258.8	0.5	9.0	1.5	243.5	14.6
54965.0	254.4	0.6	14.7	1.9	273.5	11.2
57211.6	246.4	0.7	24.3	2.8	304.3	6.6
59420.1	242.5	1.3	19.8	2.2	269.2	10.4
61587.1	241.6	1.8	51.2	2.4	269.3	4.2
63708.7	230.3	1.9	59.4	2.8	272.1	4.1
65793.1	217.1	1.9	53.5	3.0	266.5	5.0
67847.5	212.7	2.0	52.6	3.3	254.8	5.6
69850.1	203.4	1.8	57.5	3.1	266.5	4.8
71820.7	206.9	2.1	29.9	3.6	246.9	10.5
73749.1	196.1	1.9	25.9	5.2	347.3	7.1
75639.1	186.2	1.8	31.6	4.7	27.5	7.8
77496.7	177.3	2.2	37.6	4.9	48.1	9.6
79333.4	183.3	1.8	48.3	3.6	96.5	6.5
81117.7	199.6	1.2	38.6	2.9	124.5	4.2
82841.4	192.5	1.6	45.5	4.1	129.6	4.7
84535.0	196.5	1.8	40.3	3.8	111.2	6.6
86180.0	181.5	1.9	37.3	5.9	1.6	5.7
88948.1	204.3	1.1	57.2	3.0	3.3	2.0
92022.7	171.2	1.7	61.5	3.9	53.2	5.2
94227.6	172.9	1.9	46.9	3.9	75.6	8.2
96336.0	181.2	2.2	14.6	7.0	14.5	20.2

WIND COMPONENTS  
M/SEC

ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
36000	-4.3	-18.8
38000	-1.3	-3.9
40000	-0.3	2.0
42000	-0.6	3.2
44000	-2.8	5.2
46000	-5.8	5.9
48000	-7.9	2.2
50000	-4.0	-0.3
52000	1.7	5.2
54000	1.1	11.9
56000	-6.8	17.1
58000	-8.6	20.0
60000	0.0	28.9
62000	-0.1	51.9
64000	-0.9	57.7
66000	4.6	53.4
68000	11.1	52.1
70000	5.8	51.8
72000	4.3	26.2
74000	-23.2	3.0
76000	-27.1	-16.8
78000	-15.7	-33.7
80000	11.4	-41.4
82000	25.4	17.2
84000	17.9	-35.5
86000	-27.5	-8.9
88000	-50.3	-2.5
90000	-50.2	-19.0
92000	-35.8	-44.9
94000	-16.1	-43.1
96000	-13.7	-10.3



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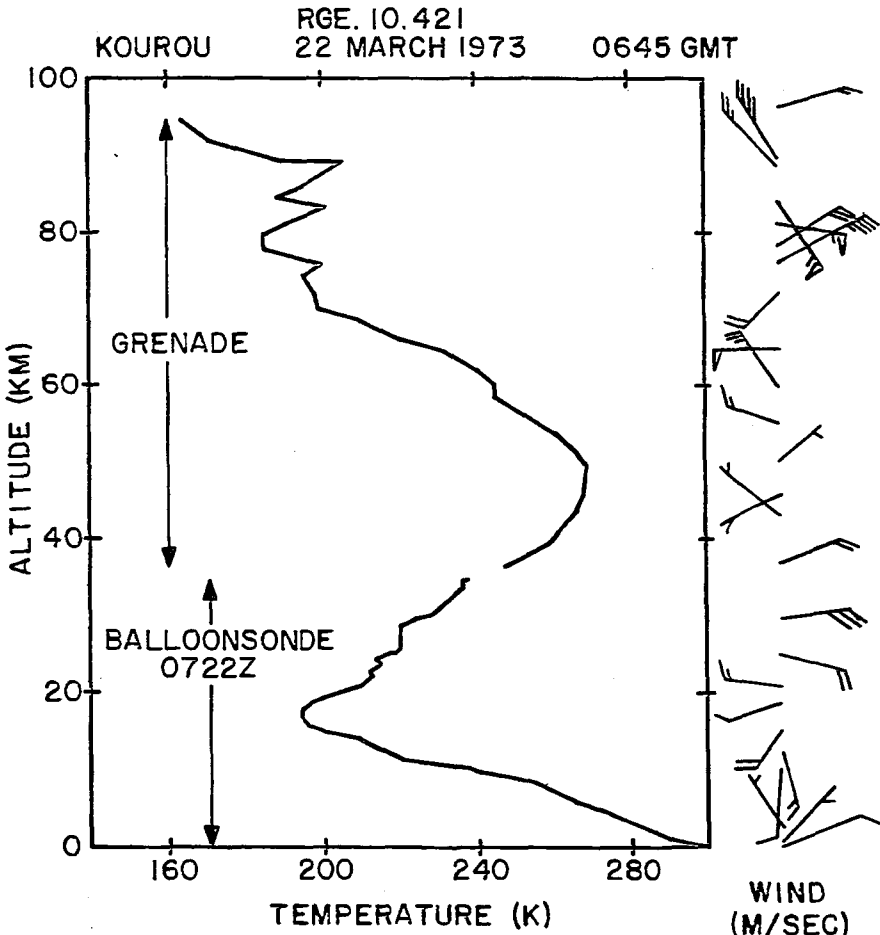
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ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
36173.2	247.1	0.2	23.5	0.6	69.4	2.4
39967.3	259.8	0.2	6.3	0.9	326.1	4.6
43670.1	266.3	0.1	3.3	0.5	308.0	9.0
46710.0	267.3	0.2	6.9	0.7	244.2	8.8
49090.9	268.3	0.3	4.7	0.8	50.8	13.3
51411.2	266.1	0.3	3.4	1.3	176.0	14.2
53688.3	262.7	0.8	9.4	1.5	305.3	9.5
55935.5	254.1	1.0	16.4	1.4	288.6	6.4
58139.4	245.3	1.0	24.2	1.8	285.3	3.2
60301.2	245.2	1.0	27.9	2.0	325.5	3.1
62427.8	241.2	1.0	48.5	1.5	287.1	2.4
64508.1	231.4	1.1	51.1	1.7	269.8	2.9
66551.0	221.8	1.2	43.5	1.9	253.1	3.9
68558.6	210.8	1.0	42.3	1.7	250.7	3.6
70521.9	199.2	0.9	45.1	1.5	250.9	3.0
72444.1	197.1	0.8	23.4	1.8	225.5	5.0
74336.6	195.1	1.0	6.2	1.7	90.5	25.8
76180.8	199.2	2.1	48.7	3.5	62.5	6.5
77976.7	186.0	2.2	62.5	4.1	58.1	5.7
79759.9	185.0	1.7	64.0	3.1	87.3	4.6
81502.0	190.7	1.9	57.7	3.6	100.2	5.2
83186.6	201.7	2.0	48.1	5.2	140.5	4.7
84829.6	188.7	1.3	56.1	3.8	147.2	2.7
86437.4	195.3	1.4	32.9	4.1	164.4	4.3
88006.8	206.3	2.3	24.8	5.4	316.2	10.8
89905.4	189.8	1.6	42.2	4.4	328.6	4.3
92111.6	172.4	2.6	38.5	8.2	351.7	7.7
94250.7	164.5	2.8	19.4	5.7	74.6	28.2

WIND COMPONENTS  
M/SEC

ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
38000	-6.8	-9.7
40000	-5.2	1.8
42000	-3.5	3.0
44000	-1.4	3.1
46000	1.7	5.2
48000	-0.2	0.8
50000	-0.4	-2.3
52000	0.8	1.9
54000	-4.9	8.8
56000	-7.2	14.5
58000	-18.2	13.9
60000	-22.0	17.0
62000	-15.8	39.2
64000	-3.4	49.5
66000	8.9	44.4
68000	13.1	40.6
70000	5.6	42.7
72000	11.7	23.5
74000	2.5	-3.0
76000	-19.2	-37.1
78000	-27.1	-53.3
80000	-2.2	-61.5
82000	18.8	-46.3
84000	41.9	-29.2
86000	34.2	-14.4
88000	-12.2	13.6
90000	-34.3	19.1
92000	-34.8	5.5
94000	-8.9	-15.8



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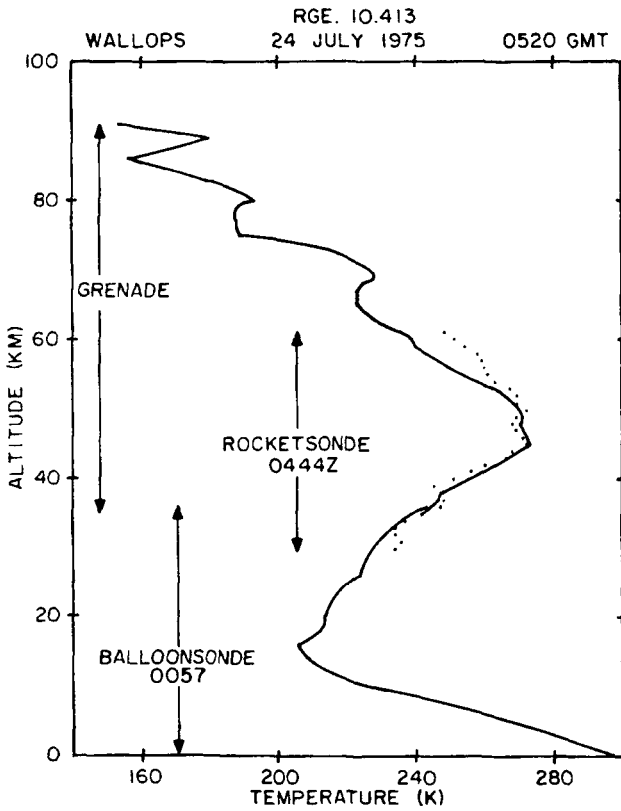
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ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
34310.2	241.7	1.4	31.1	1.1	88.9	3.9
38137.1	247.9	1.4	38.2	1.2	86.9	3.4
41873.5	262.8	1.4	51.4	1.3	92.1	2.7
44939.9	273.3	2.0	47.6	1.6	90.0	4.1
47356.2	270.7	1.7	47.2	1.7	80.2	3.9
49710.6	271.6	1.8	51.4	2.0	73.9	3.9
52019.6	266.5	1.8	55.8	2.4	57.8	3.5
54297.9	257.1	1.8	64.2	2.3	66.6	3.3
56530.4	247.6	1.8	72.6	2.2	79.5	3.3
58722.7	241.2	1.8	80.3	2.3	82.0	3.0
60875.4	237.5	2.0	80.9	2.8	91.8	3.6
62983.5	227.2	1.9	72.8	2.8	95.8	4.0
65059.5	223.4	1.7	113.7	2.6	84.2	2.4
67120.2	223.0	1.9	112.3	3.0	87.4	2.8
69109.1	229.0	2.4	93.4	4.2	67.7	4.1
71032.1	223.6	2.7	30.9	5.2	58.4	14.3
72944.3	215.7	2.7	71.7	8.5	12.4	4.0
74826.1	189.9	1.9	12.7	6.0	138.2	21.3
76666.3	188.3	2.2	85.9	7.2	32.6	4.1
78471.5	187.8	2.2	63.8	7.8	327.8	4.3
80238.0	193.9	1.9	115.5	6.7	327.8	2.0
81948.4	185.3	2.9	96.7	11.0	337.5	3.3
83624.4	174.0	2.6	32.9	9.5	323.1	11.3
86060.3	156.3	1.0	38.6	5.8	177.8	4.5
88804.8	181.9	2.1	63.6	7.7	290.6	8.7
91050.7	153.1	2.5	151.1	14.2	187.3	3.4

WIND COMPONENTS  
M/SEC

ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
36000	-1.2	-34.2
38000	-1.7	-38.2
40000	-0.0	-44.7
42000	1.5	-50.3
44000	0.6	-48.7
46000	-3.5	-47.1
48000	-9.6	-47.4
50000	-16.6	-48.9
52000	-27.5	-48.7
54000	-25.5	-57.5
56000	-16.3	-68.3
58000	-11.7	-76.8
60000	-3.0	-80.3
62000	5.1	-76.3
64000	-1.8	-92.3
66000	-8.5	-112.7
68000	-18.5	-100.8
70000	-26.4	-58.6
72000	-43.4	-42.1
74000	-26.0	-11.7
76000	-41.1	-30.8
78000	-61.2	10.9
80000	-87.6	53.4
82000	-80.1	37.3
84000	-17.4	16.6
86000	26.2	5.8
88000	-3.5	41.3
90000	69.2	38.2



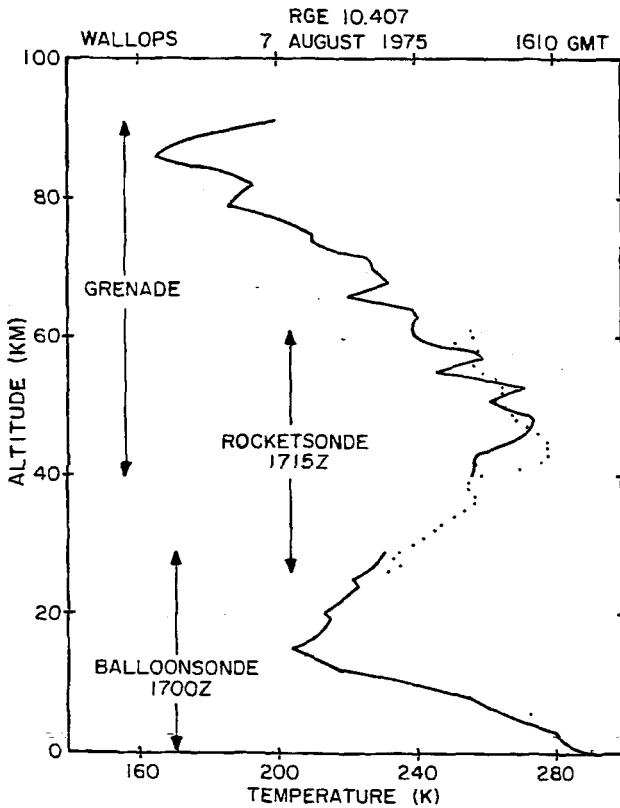
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— 10M/SEC    — DIRECTION OF NORTH WIND ↓

ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
39259.9	256.3	1.0	31.5	1.0	103.2	3.2
42949.8	258.4	1.2	37.2	1.2	95.1	3.4
45969.3	271.4	1.6	41.3	1.7	99.1	4.1
48338.8	275.4	1.6	46.0	1.9	107.7	3.6
50649.1	260.7	1.5	44.4	2.4	126.4	3.3
52921.1	272.7	1.5	49.2	2.1	109.9	3.6
55146.4	245.0	1.7	43.0	2.3	98.0	3.5
57349.0	261.7	1.7	65.0	2.2	84.5	3.7
59527.3	241.9	1.2	76.3	2.0	105.3	2.4
61647.4	238.7	1.5	69.4	2.6	104.9	3.4
63718.3	242.2	1.8	29.9	5.1	8.9	3.5
65753.2	220.3	1.6	36.4	4.7	23.6	5.4
67756.7	232.5	1.7	21.0	5.1	335.3	8.1
69722.6	229.4	1.6	25.5	3.7	224.5	10.0
71641.5	226.0	1.5	27.7	4.5	304.7	9.6
73510.1	210.1	1.3	27.4	3.8	84.3	15.6
75348.2	210.6	1.8	46.1	9.2	22.0	8.4
77152.6	199.2	2.3	43.5	7.3	70.3	17.7
78930.2	186.6	2.1	24.1	6.8	73.0	30.6
80667.8	189.4	1.4	27.9	8.2	198.5	12.0
82351.9	194.5	1.6	30.0	9.7	0.8	9.8
83999.9	184.4	2.4	54.6	10.2	52.3	14.5
85608.8	163.7	2.3	68.9	8.8	92.1	13.7
88296.7	173.3	0.8	48.9	5.2	14.4	3.9
91279.2	200.8	1.4	129.3	7.6	322.2	2.2

WIND COMPONENTS  
M/SEC

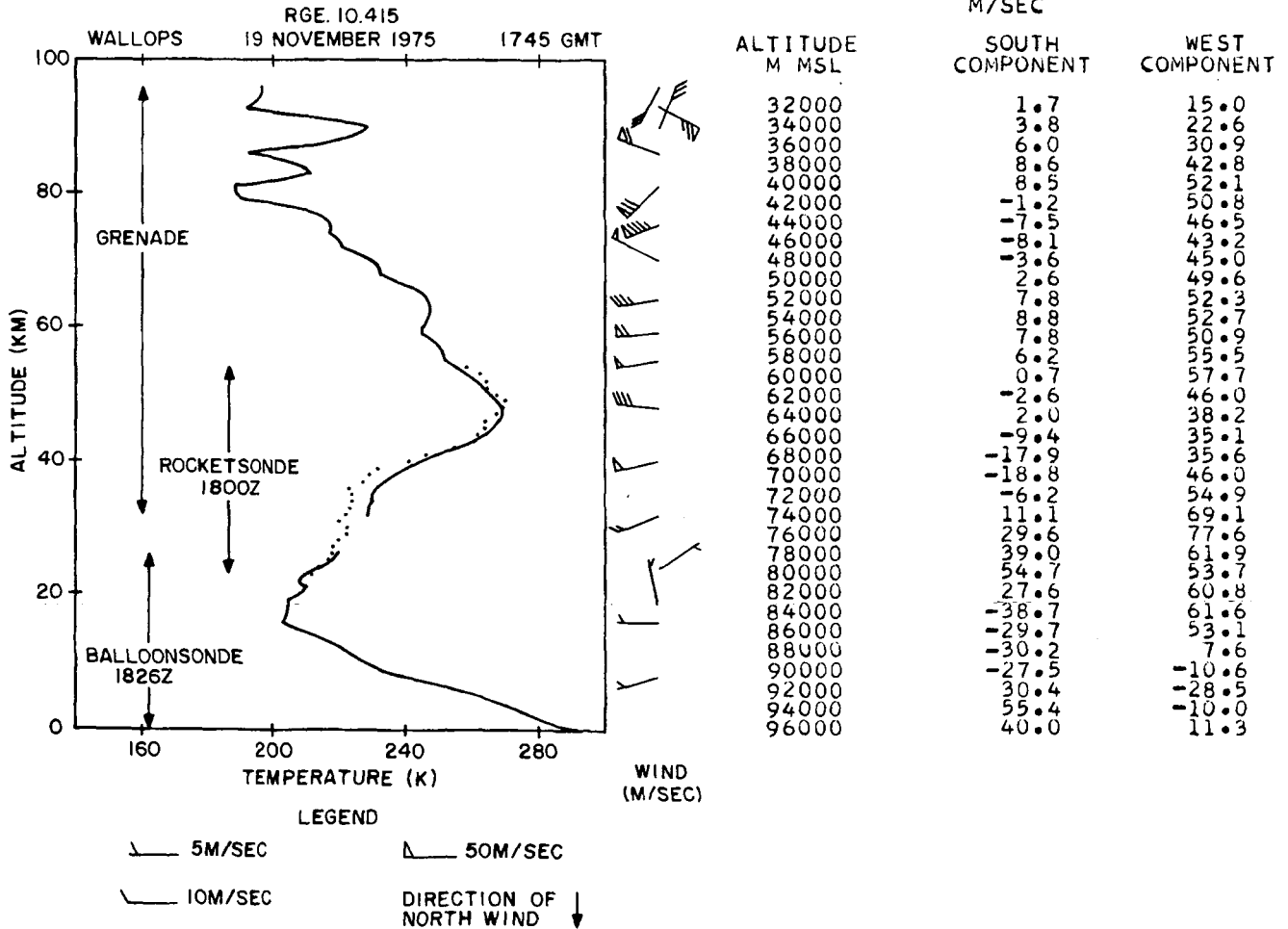


ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
40000	6.4	-31.9
42000	4.3	-35.4
44000	4.4	-38.3
46000	7.1	-40.8
48000	13.2	-42.8
50000	22.6	-38.2
52000	20.6	-42.0
54000	11.5	-44.5
56000	1.3	-51.2
58000	2.2	-67.1
60000	18.8	-71.6
62000	7.5	-53.6
64000	-27.3	-10.5
66000	-30.3	-9.3
68000	-12.8	8.8
70000	8.4	18.3
72000	-10.7	10.1
74000	-15.2	-22.5
76000	-31.5	-26.4
78000	-11.0	-13.4
80000	12.1	-4.0
82000	-14.8	-0.6
84000	-27.2	-40.7
86000	-8.4	-57.2
88000	-41.8	-17.2
90000	-78.7	39.9



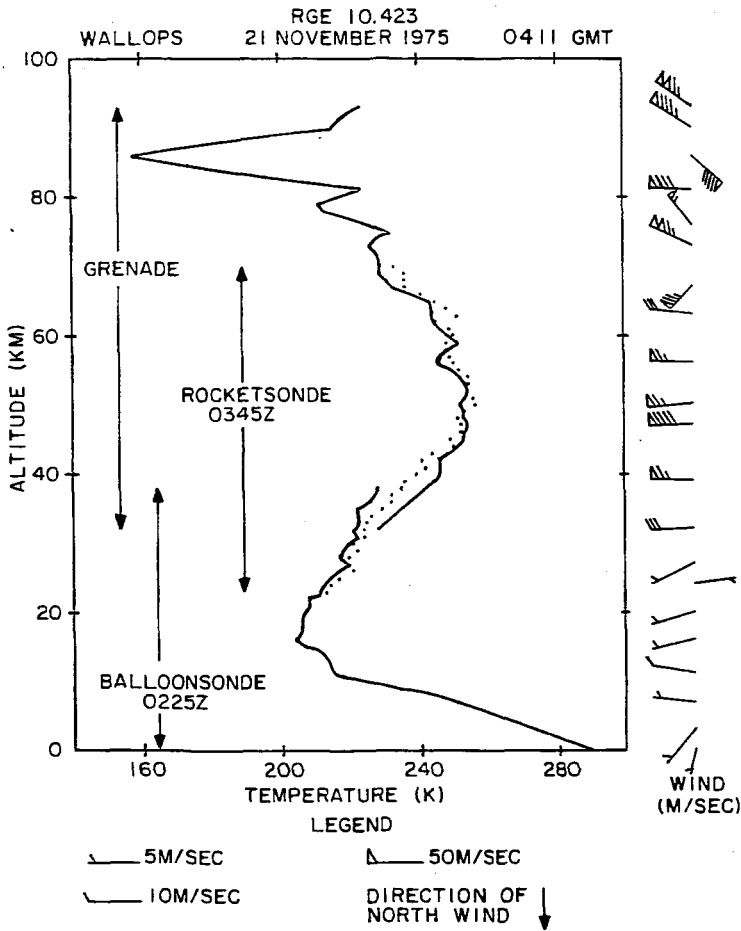
ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
31892.2	229.1	1.0	14.7	0.8	263.7	6.4
35845.3	231.0	1.0	30.1	0.9	259.0	3.3
39687.4	242.6	0.9	54.4	1.0	258.3	2.1
42839.2	261.4	1.2	50.2	2.0	276.4	4.0
45317.0	267.4	1.4	43.8	2.5	282.7	5.2
47734.3	270.2	1.4	44.3	2.4	276.1	5.4
50111.2	265.9	1.3	50.3	2.1	266.3	4.6
52451.3	260.2	1.2	53.8	2.1	260.1	4.2
54748.7	252.7	1.2	53.4	2.2	260.6	4.7
57006.5	250.9	1.2	50.0	2.3	261.6	5.1
59224.7	244.8	1.1	63.1	2.4	265.4	4.0
61392.9	247.1	1.3	49.3	2.9	277.9	5.6
63519.0	247.5	1.4	39.2	2.9	261.1	8.1
65614.2	242.9	1.5	36.5	3.6	282.4	8.8
67662.4	233.1	1.2	36.9	3.6	298.0	6.5
69673.4	230.3	0.9	50.3	2.8	296.0	3.8
71652.3	222.6	1.2	52.7	3.0	279.4	5.2
73591.5	218.0	1.5	66.0	3.6	265.8	5.7
75484.0	217.3	1.6	86.5	3.8	248.7	4.4
77359.2	212.8	1.7	77.5	4.4	248.5	5.7
79195.9	189.2	1.7	72.1	6.7	217.3	5.5
80959.2	188.0	1.6	73.3	5.9	224.7	5.5
82689.6	211.5	2.1	68.6	5.4	259.6	8.3
84382.7	208.4	3.4	85.7	14.9	316.2	7.5
86024.4	192.7	3.1	64.3	10.6	290.3	12.3
88036.0	220.5	1.4	31.4	6.3	357.9	6.0
90381.6	229.7	1.6	33.5	6.1	21.6	7.8
92638.4	190.2	1.4	07.2	6.7	147.2	3.9
94793.4	196.9	2.0	55.3	9.7	185.7	5.9
96869.1	195.5	2.0	33.0	8.6	207.8	12.8

WIND COMPONENTS  
M/SEC



ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
31472.4	226.9	1.0	31.6	0.8	267.1	3.1
35416.0	236.6	0.9	47.2	1.2	275.3	2.4
39252.4	245.7	1.1	67.0	1.4	271.4	1.9
42395.0	247.1	1.5	66.6	1.9	268.9	2.7
44849.3	253.8	1.2	79.4	1.5	267.3	1.8
47259.3	254.0	1.1	92.7	1.5	272.6	1.5
49631.9	252.7	1.3	74.6	1.8	274.7	2.1
51956.8	254.2	1.3	69.3	1.6	263.6	2.2
54249.4	252.6	1.3	81.6	1.6	262.5	1.9
56505.5	245.1	1.3	66.8	1.8	270.8	2.4
58719.7	251.8	1.1	78.9	1.4	259.5	1.8
60889.5	247.0	1.4	56.9	2.2	279.9	3.1
63018.7	244.7	1.6	32.3	2.3	276.2	6.2
65109.9	243.6	1.9	49.1	2.7	235.6	4.9
67165.9	232.3	2.1	77.8	3.4	226.9	3.3
69182.5	229.2	2.1	96.0	3.0	248.0	3.1
71163.1	229.7	2.2	112.1	3.7	272.2	2.7
73103.4	225.9	2.0	116.0	4.3	294.6	2.1
74998.6	231.5	2.2	89.7	5.4	323.1	2.1
76871.5	219.9	2.5	57.8	5.6	307.9	4.6
78704.2	210.2	3.2	44.0	5.9	285.9	9.7
81351.2	225.9	2.0	80.8	3.0	271.8	3.2
83942.7	179.9	2.6	71.1	7.1	182.1	3.6
85606.5	153.7	2.3	93.4	6.9	139.3	3.3
87616.2	177.7	2.3	41.4	6.0	202.0	7.1
89966.7	214.9	3.1	87.2	7.1	302.0	4.2
93310.9	224.3	1.9	115.9	4.7	325.1	1.3

WIND COMPONENTS  
M/SEC

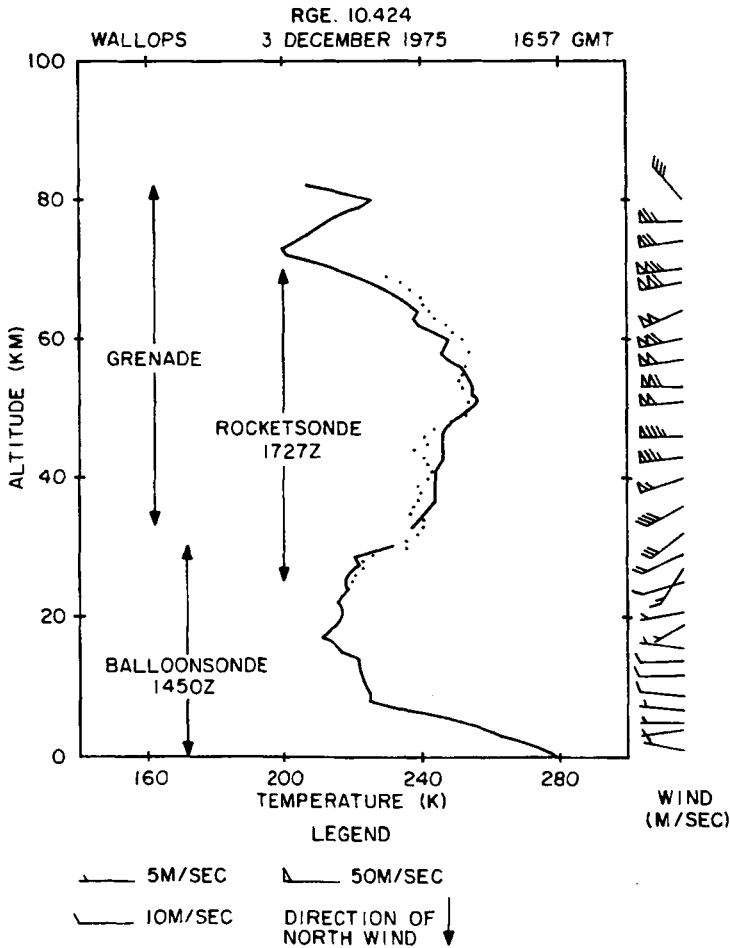


ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
32000	0.8	33.7
34000	-2.2	41.5
36000	-3.8	50.1
38000	-2.6	60.5
40000	-1.0	66.8
42000	0.8	67.1
44000	2.8	74.9
46000	-0.0	85.7
48000	-4.7	86.7
50000	-3.2	74.0
52000	6.7	70.8
54000	9.4	77.9
56000	2.3	70.6
58000	8.9	73.8
60000	0.0	64.9
62000	-6.5	43.6
64000	11.1	36.1
66000	38.7	47.6
68000	45.9	70.2
70000	19.2	98.4
72000	-23.3	109.0
74000	-59.4	-51.4
76000	-52.4	49.4
78000	-21.3	43.9
80000	-7.4	61.1
82000	16.6	59.8
84000	64.7	-1.2
86000	63.1	-38.8
88000	22.6	23.8
90000	-41.8	67.5
92000	-76.0	69.2

ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
32961.5	237.6	1.2	49.2	1.5	236.1	2.6
36882.5	244.4	1.1	43.3	1.5	242.6	3.3
40708.4	244.5	0.7	57.2	0.9	252.4	1.8
43836.5	246.5	1.2	79.2	1.7	264.1	2.5
46287.4	246.1	1.2	88.3	1.9	269.0	2.3
48690.2	251.1	1.2	93.1	1.8	261.7	2.1
51054.0	256.3	1.3	103.2	2.0	265.5	2.0
53373.5	255.1	1.2	112.0	2.0	271.1	1.7
55657.7	252.7	1.4	105.2	2.3	266.5	2.2
57899.5	246.0	1.7	101.8	2.7	262.3	2.8
60107.1	249.1	1.7	113.7	2.7	259.9	2.5
62270.4	238.3	1.7	111.4	2.9	253.9	2.7
64394.2	239.4	1.9	104.4	3.4	247.9	3.3
66482.9	231.6	2.2	111.0	4.3	242.1	3.6
68525.2	224.1	2.0	114.1	3.8	260.5	3.4
70528.9	212.6	1.8	115.8	3.7	264.5	3.2
72495.0	197.9	1.8	99.1	3.7	257.2	3.9
74448.4	206.0	2.1	74.1	4.2	262.9	6.0
77268.4	214.6	1.4	68.1	2.7	269.9	4.0
80004.0	226.4	3.4	44.5	10.2	318.8	9.7
82636.8	201.6	1.8	118.1	6.3	192.7	2.0

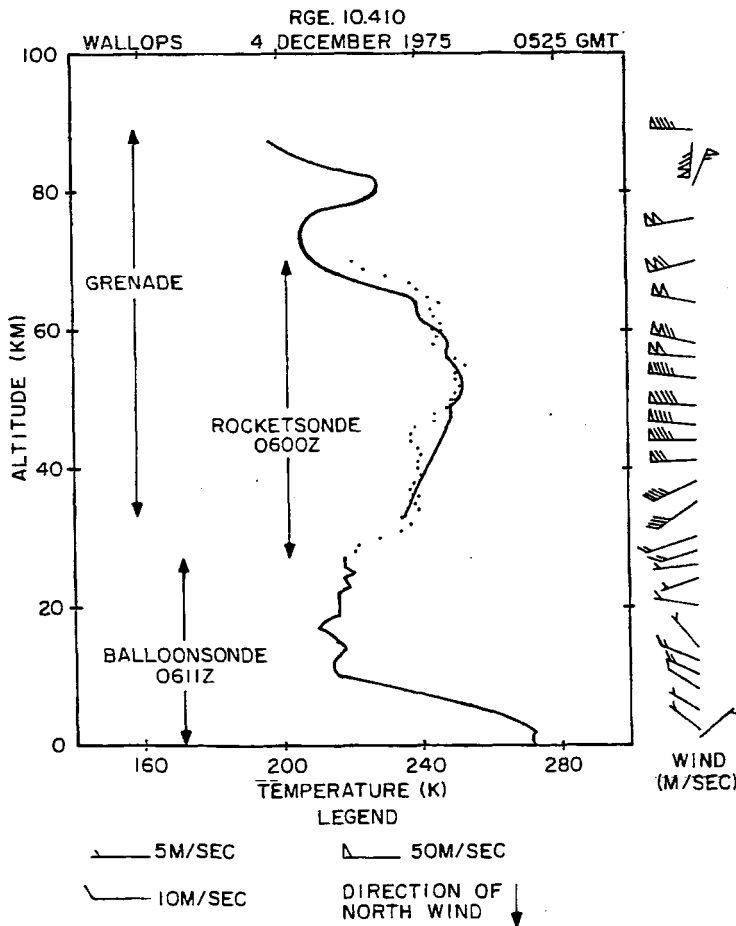
WIND COMPONENTS  
M/SEC

ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
34000	25.4	40.2
36000	21.6	39.0
38000	19.1	43.2
40000	17.7	51.7
42000	13.4	64.6
44000	7.6	78.8
46000	3.2	86.9
48000	9.7	91.1
50000	10.3	98.1
52000	3.8	106.6
54000	0.4	109.8
56000	7.3	104.5
58000	13.8	102.8
60000	19.9	110.0
62000	29.2	107.3
64000	37.8	99.2
66000	47.3	98.3
68000	27.8	108.5
70000	13.6	113.9
72000	18.4	101.2
74000	12.2	79.6
76000	4.1	70.6
78000	-9.0	57.5
80000	-16.3	32.5
82000	79.2	26.8



ALTITUDE M MSL	TEMPERATURE DEG K	ERROR DEG K	WIND SPEED M/SEC	ERROR M/SEC	WIND DIRECTION DEGREES	ERROR DEG
32906.4	235.1	0.6	40.7	0.6	232.6	1.3
38761.2	241.4	1.1	51.4	1.3	247.4	2.7
41923.0	244.4	1.9	74.0	2.4	267.3	3.5
44401.1	246.4	1.9	85.3	2.6	269.5	3.1
46803.9	249.6	1.7	93.4	2.4	275.3	2.5
49168.4	248.9	1.5	93.2	2.2	276.3	2.1
51500.6	253.3	1.7	101.8	2.6	276.9	2.2
53786.4	251.6	2.0	98.1	3.0	276.8	2.8
56037.7	248.6	1.8	104.1	2.7	274.8	2.4
58258.6	249.2	1.8	115.6	3.1	282.8	2.1
61488.7	240.5	1.0	109.3	1.5	270.5	1.3
64644.8	239.0	2.0	106.0	3.3	278.5	2.7
66692.9	224.0	1.8	107.3	2.8	263.3	2.6
68705.9	213.5	1.9	102.1	3.0	247.5	2.9
70673.7	208.7	2.1	111.8	3.3	255.6	3.1
73557.7	205.8	1.2	100.5	2.0	266.8	2.0
76395.7	208.7	2.3	109.2	3.9	260.5	3.5
78221.6	223.6	2.4	103.0	3.7	264.9	3.4
79997.3	228.5	2.8	55.4	4.6	236.2	7.3
81733.9	228.7	3.1	56.8	7.3	24.9	5.8
84253.0	208.5	1.4	40.9	4.1	336.6	3.1
87106.6	197.1	1.8	118.0	5.2	185.2	1.5

WIND COMPONENTS  
M/SEC



ALTITUDE M MSL	SOUTH COMPONENT	WEST COMPONENT
34000	23.7	35.1
36000	22.0	40.3
38000	20.2	45.6
40000	13.3	57.8
42000	4.2	73.4
44000	0.9	83.3
46000	-5.5	90.4
48000	-9.4	92.8
50000	-10.9	95.6
52000	-12.1	99.4
54000	-11.2	98.7
56000	-10.9	103.9
58000	-21.6	111.0
60000	-12.4	110.9
62000	-4.2	108.5
64000	-12.1	105.8
66000	2.8	105.8
68000	29.2	98.9
70000	31.5	103.3
72000	17.4	104.6
74000	8.3	101.9
76000	15.3	106.2
78000	12.6	98.8
80000	15.8	43.8
82000	-42.8	-12.1
84000	-32.1	9.6
86000	57.4	12.8
88000	70.6	40.6

SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.421

KOUROU

ARRAY NUMBER 23

LAUNCH TIME 0645Z

DATE 22 MARCH 1974

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/5Q M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
37000	249.9	0.429E 03	-0.7	0.599E-02	-3.8
38000	253.2	0.375E 03	-0.5	0.516E-02	-3.8
39000	256.6	0.329E 03	0.1	0.447E-02	-3.3
40000	259.9	0.289E 03	0.8	0.387E-02	-3.3
41000	261.6	0.254E 03	1.2	0.338E-02	-2.0
42000	263.3	0.223E 03	1.5	0.295E-02	-1.2
43000	265.1	0.196E 03	2.0	0.258E-02	-0.4
44000	266.4	0.173E 03	2.4	0.227E-02	0.5
45000	266.7	0.153E 03	2.6	0.199E-02	1.6
46000	267.1	0.134E 03	2.7	0.176E-02	2.6
47000	267.4	0.119E 03	2.7	0.155E-02	3.5
48000	267.8	0.104E 03	2.6	0.136E-02	3.6
49000	268.2	0.926E 02	2.5	0.120E-02	3.4
50000	267.4	0.817E 02	2.4	0.106E-02	3.6
51000	266.5	0.721E 02	2.3	0.942E-03	3.9
52000	265.2	0.635E 02	2.1	0.834E-03	4.2
53000	263.7	0.560E 02	1.9	0.739E-03	4.1
54000	261.5	0.493E 02	1.6	0.656E-03	4.0
55000	257.7	0.433E 02	1.4	0.586E-03	4.5
56000	253.9	0.380E 02	0.9	0.521E-03	4.8
57000	249.9	0.333E 02	0.5	0.464E-03	5.2
58000	245.8	0.290E 02	-0.1	0.412E-03	5.4
59000	245.3	0.253E 02	-0.8	0.360E-03	4.1
60000	245.2	0.221E 02	-1.4	0.314E-03	2.8
61000	243.9	0.193E 02	-1.8	0.275E-03	2.0
62000	242.0	0.168E 02	-2.3	0.242E-03	1.2
63000	238.5	0.146E 02	-2.7	0.214E-03	0.7
64000	233.8	0.127E 02	-3.2	0.189E-03	0.6
65000	229.1	0.110E 02	-3.7	0.167E-03	0.4
66000	224.4	0.950E 01	-4.3	0.147E-03	0.3
67000	219.4	0.818E 01	-5.0	0.129E-03	0.2
68000	213.9	0.701E 01	-5.7	0.114E-03	0.2
69000	208.2	0.599E 01	-6.6	0.100E-03	0.1
70000	202.3	0.509E 01	-7.7	0.876E-04	0.1
71000	198.7	0.430E 01	-9.0	0.755E-04	-1.1
72000	197.6	0.364E 01	-10.0	0.641E-04	-3.5
73000	196.5	0.307E 01	-10.9	0.545E-04	-5.7
74000	195.5	0.259E 01	-11.6	0.462E-04	-7.7
75000	196.6	0.218E 01	-12.1	0.387E-04	-10.5
76000	198.8	0.185E 01	-12.1	0.324E-04	-13.2
77000	193.2	0.156E 01	-11.6	0.282E-04	-12.0
78000	185.9	0.131E 01	-11.9	0.245E-04	-10.7
79000	185.4	0.109E 01	-11.8	0.205E-04	-12.3
80000	185.8	0.915E 00	-11.6	0.171E-04	-14.1
81000	189.1	0.766E 00	-11.0	0.141E-04	-15.0
82000	194.0	0.644E 00	-10.1	0.115E-04	-16.2
83000	200.5	0.544E 00	-8.6	0.946E-05	-17.6
84000	195.2	0.462E 00	-6.7	0.824E-05	-13.7
85000	189.4	0.387E 00	-5.9	0.713E-05	-10.3
86000	193.5	0.326E 00	-4.9	0.586E-05	-11.3
87000	199.3	0.275E 00	-3.6	0.480E-05	-12.6
88000	206.2	0.233E 00	-1.5	0.394E-05	-13.7
89000	197.7	0.198E 00	0.4	0.349E-05	-8.1
90000	189.0	0.166E 00	1.4	0.307E-05	-3.0
91000	181.1	0.140E 00	2.2	0.269E-05	3.6
92000	173.2	0.115E 00	1.0	0.232E-05	8.8
93000	169.1	0.954E-01	-0.5	0.196E-05	11.5
94000	165.4	0.782E-01	-3.0	0.164E-05	12.8

ORIGINAL PAGE IS  
OF POOR QUALITY

SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.422

KOUROU

ARRAY NUMBER 23

LAUNCH TIME 0930Z

DATE 22 MARCH 1974

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
35000	238.9	0.554E 03	-3.4	0.808E-02	-4.4
36000	245.7	0.481E 03	-3.4	0.682E-02	-6.0
37000	252.6	0.419E 03	-3.2	0.577E-02	-7.3
38000	259.5	0.368E 03	-2.1	0.495E-02	-7.7
39000	264.1	0.324E 03	-1.2	0.428E-02	-7.4
40000	264.1	0.285E 03	-0.3	0.377E-02	-5.6
41000	264.1	0.251E 03	0.2	0.332E-02	-3.9
42000	264.1	0.221E 03	0.7	0.292E-02	-2.3
43000	264.3	0.195E 03	1.1	0.257E-02	-1.0
44000	264.7	0.171E 03	1.3	0.226E-02	0.0
45000	265.2	0.151E 03	1.5	0.199E-02	1.1
46000	266.4	0.133E 03	1.5	0.174E-02	1.1
47000	268.5	0.117E 03	1.4	0.152E-02	1.9
48000	270.6	0.103E 03	1.5	0.133E-02	1.9
49000	268.8	0.917E 02	1.5	0.119E-02	2.5
50000	269.3	0.809E 02	1.4	0.106E-02	3.2
51000	263.2	0.712E 02	1.1	0.943E-03	4.0
52000	260.6	0.627E 02	0.7	0.838E-03	4.6
53000	258.2	0.551E 02	0.2	0.749E-03	4.6
54000	256.6	0.483E 02	-0.1	0.657E-03	4.1
55000	254.3	0.424E 02	-0.7	0.581E-03	3.6
56000	250.7	0.371E 02	-1.2	0.516E-03	3.8
57000	247.2	0.324E 02	-1.9	0.457E-03	3.7
58000	245.0	0.283E 02	-2.6	0.403E-03	3.1
59000	243.2	0.247E 02	-3.3	0.354E-03	2.3
60000	242.2	0.215E 02	-4.0	0.309E-03	1.2
61000	241.8	0.187E 02	-4.7	0.270E-03	0.0
62000	239.4	0.163E 02	-5.2	0.237E-03	-0.0
63000	234.0	0.141E 02	-5.8	0.211E-03	-0.5
64000	228.4	0.122E 02	-6.5	0.187E-03	-0.5
65000	222.1	0.106E 02	-7.4	0.166E-03	-0.2
66000	216.5	0.909E 01	-8.5	0.146E-03	-0.6
67000	214.5	0.779E 01	-9.5	0.126E-03	-2.3
68000	212.0	0.666E 01	-10.3	0.109E-03	-3.9
69000	207.3	0.568E 01	-11.3	0.955E-04	-4.4
70000	203.7	0.482E 01	-12.5	0.825E-04	-5.6
71000	205.4	0.410E 01	-13.3	0.695E-04	-9.0
72000	205.9	0.349E 01	-13.7	0.590E-04	-11.2
73000	200.3	0.296E 01	-14.0	0.515E-04	-10.8
74000	194.8	0.250E 01	-14.7	0.447E-04	-10.7
75000	189.6	0.210E 01	-15.3	0.387E-04	-10.6
76000	184.5	0.176E 01	-16.2	0.332E-04	-10.8
77000	179.7	0.146E 01	-17.1	0.284E-04	-11.2
78000	179.0	0.121E 01	-18.1	0.237E-04	-13.8
79000	182.2	0.101E 01	-18.5	0.193E-04	-17.5
80000	189.4	0.845E 00	-18.4	0.155E-04	-22.2
81000	198.5	0.713E 00	-17.2	0.125E-04	-24.7
82000	196.0	0.603E 00	-15.7	0.107E-04	-22.3
83000	192.9	0.508E 00	-14.7	0.917E-05	-20.1
84000	195.3	0.428E 00	-13.6	0.764E-05	-20.1
85000	192.3	0.361E 00	-12.2	0.655E-05	-17.6
86000	183.2	0.302E 00	-11.6	0.576E-05	-12.9
87000	188.3	0.252E 00	-11.5	0.467E-05	-15.1
88000	196.5	0.214E 00	-9.5	0.380E-05	-16.9
89000	203.8	0.182E 00	-7.6	0.312E-05	-18.0
90000	193.0	0.155E 00	-5.5	0.280E-05	-11.5
91000	182.2	0.131E 00	-3.8	0.251E-05	-3.1
92000	171.5	0.108E 00	-5.2	0.220E-05	3.1
93000	172.0	0.894E-01	-6.7	0.181E-05	2.7
94000	172.7	0.738E-01	-8.4	0.148E-05	2.0
95000	176.0	0.610E-01	-10.2	0.120E-05	-0.2
96000	179.9	0.507E-01	-11.7	0.981E-06	-2.6

ORIGINAL PAGE IS  
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SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.413

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 0520Z

DATE 24 July 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
35000	242.8	0.597E 03	3.9	0.856E-02	1.2
36000	244.5	0.519E 03	4.2	0.740E-02	2.0
37000	246.1	0.453E 03	4.5	0.641E-02	2.8
38000	247.7	0.395E 03	4.8	0.556E-02	3.6
39000	251.3	0.345E 03	4.9	0.478E-02	3.3
40000	255.3	0.301E 03	4.9	0.411E-02	2.8
41000	259.3	0.264E 03	5.5	0.355E-02	2.9
42000	263.2	0.233E 03	5.9	0.308E-02	2.9
43000	266.6	0.205E 03	6.2	0.267E-02	3.0
44000	270.1	0.180E 03	6.5	0.232E-02	3.1
45000	273.3	0.159E 03	7.1	0.203E-02	3.5
46000	272.2	0.141E 03	7.5	0.180E-02	5.4
47000	271.1	0.124E 03	7.6	0.160E-02	7.0
48000	270.9	0.110E 03	7.6	0.141E-02	7.5
49000	271.3	0.973E 02	7.7	0.124E-02	7.4
50000	270.9	0.859E 02	7.7	0.110E-02	7.6
51000	268.7	0.759E 02	7.8	0.984E-03	8.5
52000	266.5	0.669E 02	7.6	0.875E-03	9.2
53000	262.4	0.590E 02	7.4	0.783E-03	10.3
54000	258.3	0.518E 02	6.9	0.699E-03	10.7
55000	254.1	0.455E 02	6.4	0.623E-03	11.2
56000	249.9	0.398E 02	5.7	0.555E-03	11.5
57000	246.3	0.347E 02	4.9	0.491E-03	11.5
58000	243.4	0.303E 02	4.1	0.434E-03	11.0
59000	240.8	0.264E 02	3.1	0.382E-03	10.4
60000	239.0	0.229E 02	2.2	0.334E-03	9.4
61000	236.8	0.199E 02	1.3	0.293E-03	8.5
62000	232.0	0.173E 02	0.4	0.260E-03	8.6
63000	227.2	0.149E 02	-0.8	0.229E-03	7.8
64000	225.4	0.129E 02	-1.8	0.199E-03	5.8
65000	223.5	0.111E 02	-2.9	0.173E-03	3.8
66000	223.2	0.956E 01	-3.7	0.149E-03	1.4
67000	223.1	0.823E 01	-4.3	0.128E-03	-0.7
68000	225.7	0.708E 01	-4.7	0.109E-03	-4.0
69000	228.7	0.612E 01	-4.5	0.932E-04	-6.7
70000	226.5	0.529E 01	-4.1	0.813E-04	-7.0
71000	223.7	0.456E 01	-3.6	0.709E-04	-7.1
72000	219.6	0.392E 01	-3.0	0.622E-04	-6.4
73000	214.9	0.336E 01	-2.5	0.543E-04	-5.7
74000	201.2	0.287E 01	-2.0	0.497E-04	-5.7
75000	189.8	0.241E 01	-3.0	0.442E-04	2.1
76000	188.9	0.202E 01	-3.8	0.373E-04	-0.0
77000	188.2	0.169E 01	-4.3	0.313E-04	-2.1
78000	187.9	0.142E 01	-4.5	0.263E-04	-4.2
79000	189.6	0.119E 01	-4.3	0.218E-04	-6.9
80000	193.1	0.100E 01	-3.5	0.180E-04	-9.7
81000	190.1	0.842E 00	-2.2	0.154E-04	-7.1
82000	185.0	0.704E 00	-1.6	0.132E-04	-3.9
83000	178.2	0.587E 00	-1.4	0.114E-04	-0.1
84000	171.2	0.485E 00	-2.0	0.987E-05	3.2
85000	164.0	0.396E 00	-3.9	0.841E-05	5.8
86000	156.7	0.320E 00	-6.5	0.712E-05	7.6
87000	165.1	0.259E 00	-9.2	0.546E-05	-0.6
88000	174.4	0.211E 00	-10.8	0.422E-05	-7.6
89000	179.4	0.176E 00	-10.7	0.342E-05	-10.0
90000	166.5	0.146E 00	-10.7	0.306E-05	-3.2
91000	153.7	0.118E 00	-13.7	0.267E-05	3.0

SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.407

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 1610Z

DATE 7 August 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
40000	256.7	0.313E 03	9.3	0.426E-02	6.6
41000	257.2	0.275E 03	9.6	0.372E-02	7.8
42000	257.8	0.241E 03	9.8	0.326E-02	8.9
43000	258.6	0.212E 03	9.8	0.289E-02	9.9
44000	262.9	0.186E 03	9.8	0.244E-02	9.1
45000	267.2	0.163E 03	9.7	0.213E-02	8.4
46000	271.5	0.144E 03	10.1	0.185E-02	8.2
47000	273.1	0.127E 03	10.1	0.162E-02	8.7
48000	274.8	0.113E 03	10.4	0.143E-02	8.7
49000	271.2	0.100E 03	10.7	0.123E-02	10.4
50000	264.8	0.882E 02	10.5	0.116E-02	12.9
51000	262.6	0.775E 02	10.0	0.102E-02	13.4
52000	267.9	0.682E 02	9.7	0.887E-03	10.8
53000	271.8	0.603E 02	9.8	0.773E-03	8.8
54000	259.3	0.533E 02	10.0	0.717E-03	13.3
55000	246.8	0.465E 02	8.9	0.657E-03	17.1
56000	251.5	0.406E 02	7.8	0.596E-03	13.0
57000	259.0	0.356E 02	7.5	0.479E-03	8.6
58000	255.8	0.313E 02	7.6	0.427E-03	9.3
59000	246.7	0.274E 02	7.2	0.387E-03	12.0
60000	241.2	0.238E 02	6.3	0.345E-03	12.8
61000	239.7	0.207E 02	5.5	0.302E-03	11.7
62000	239.3	0.180E 02	4.7	0.263E-03	9.9
63000	241.0	0.157E 02	4.2	0.227E-03	6.8
64000	239.2	0.136E 02	4.0	0.199E-03	5.8
65000	229.4	0.118E 02	3.7	0.181E-03	8.6
66000	221.8	0.102E 02	2.6	0.160E-03	8.9
67000	227.9	0.878E 01	2.0	0.134E-03	3.6
68000	232.1	0.761E 01	2.2	0.114E-03	0.1
69000	230.5	0.658E 01	2.6	0.995E-04	0.4
70000	228.9	0.569E 01	3.2	0.866E-04	0.9
71000	227.1	0.492E 01	3.9	0.754E-04	1.2
72000	222.9	0.424E 01	4.8	0.663E-04	0.3
73000	214.4	0.364E 01	5.5	0.592E-04	2.3
74000	210.2	0.311E 01	5.9	0.515E-04	2.7
75000	210.5	0.265E 01	6.6	0.439E-04	1.3
76000	206.5	0.226E 01	7.6	0.382E-04	2.3
77000	200.1	0.192E 01	8.4	0.334E-04	4.2
78000	193.2	0.162E 01	9.2	0.293E-04	6.6
79000	186.7	0.136E 01	9.4	0.253E-04	8.0
80000	188.3	0.113E 01	9.8	0.210E-04	5.4
81000	190.4	0.953E 00	10.8	0.174E-04	5.1
82000	193.5	0.803E 00	12.1	0.144E-04	4.6
83000	190.5	0.677E 00	13.6	0.123E-04	7.6
84000	184.4	0.566E 00	14.2	0.107E-04	11.9
85000	171.5	0.471E 00	14.2	0.956E-05	20.2
86000	165.1	0.384E 00	12.1	0.811E-05	22.6
87000	168.7	0.316E 00	10.8	0.652E-05	18.6
88000	172.2	0.261E 00	9.9	0.527E-05	15.2
89000	179.8	0.215E 00	9.1	0.417E-05	9.6
90000	189.0	0.178E 00	8.2	0.328E-05	3.4
91000	198.2	0.150E 00	9.6	0.263E-05	1.5

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SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.415

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 1745Z

DATE 19 NOVEMBER 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
32000	*****	0.849E 03	-4.4	0.129E-01	-4.7
33000	229.5	0.732E 03	-4.5	0.111E-01	-3.8
34000	230.0	0.632E 03	-4.7	0.957E-02	-3.1
35000	230.5	0.546E 03	-4.9	0.825E-02	-2.4
36000	231.4	0.471E 03	-5.3	0.710E-02	-2.1
37000	234.4	0.407E 03	-5.8	0.605E-02	-2.8
38000	237.4	0.352E 03	-6.4	0.517E-02	-3.5
39000	240.4	0.307E 03	-6.6	0.444E-02	-3.8
40000	244.3	0.267E 03	-6.9	0.380E-02	-4.6
41000	250.3	0.232E 03	-7.4	0.323E-02	-6.3
42000	256.3	0.203E 03	-7.6	0.276E-02	-7.8
43000	261.7	0.178E 03	-7.4	0.237E-02	-8.5
44000	264.2	0.157E 03	-7.3	0.207E-02	-8.3
45000	266.6	0.138E 03	-7.1	0.180E-02	-8.0
46000	268.2	0.122E 03	-7.0	0.158E-02	-7.5
47000	269.3	0.107E 03	-7.0	0.139E-02	-6.9
48000	269.7	0.950E 02	-7.0	0.122E-02	-6.7
49000	267.9	0.839E 02	-7.0	0.109E-02	-6.1
50000	266.1	0.739E 02	-7.2	0.968E-03	-5.6
51000	263.7	0.652E 02	-7.4	0.861E-03	-5.0
52000	261.3	0.573E 02	-7.8	0.764E-03	-4.5
53000	258.4	0.504E 02	-8.2	0.679E-03	-4.3
54000	255.1	0.442E 02	-8.7	0.604E-03	-4.3
55000	252.5	0.387E 02	-9.3	0.534E-03	-4.6
56000	251.7	0.339E 02	-9.9	0.469E-03	-5.6
57000	250.9	0.296E 02	-10.4	0.412E-03	-6.6
58000	248.2	0.259E 02	-10.8	0.364E-03	-6.7
59000	245.4	0.226E 02	-11.4	0.321E-03	-7.0
60000	245.6	0.197E 02	-12.0	0.280E-03	-8.3
61000	246.7	0.172E 02	-12.4	0.243E-03	-9.8
62000	247.2	0.150E 02	-12.6	0.212E-03	-11.3
63000	247.4	0.131E 02	-12.7	0.185E-03	-12.8
64000	246.4	0.114E 02	-12.6	0.162E-03	-13.7
65000	244.3	0.100E 02	-12.4	0.143E-03	-14.2
66000	241.1	0.873E 01	-12.0	0.126E-03	-14.1
67000	236.3	0.760E 01	-11.7	0.112E-03	-13.5
68000	232.6	0.658E 01	-11.5	0.985E-04	-13.5
69000	231.2	0.570E 01	-11.1	0.859E-04	-14.0
70000	229.0	0.493E 01	-10.6	0.750E-04	-14.2
71000	225.1	0.426E 01	-10.0	0.659E-04	-13.7
72000	221.8	0.366E 01	-9.4	0.576E-04	-13.4
73000	219.4	0.315E 01	-8.6	0.500E-04	-13.4
74000	217.8	0.270E 01	-7.8	0.432E-04	-13.7
75000	217.5	0.232E 01	-6.7	0.371E-04	-14.2
76000	216.1	0.199E 01	-5.3	0.321E-04	-14.0
77000	213.7	0.170E 01	-3.7	0.277E-04	-13.3
78000	204.6	0.145E 01	-1.9	0.248E-04	-9.7
79000	191.7	0.123E 01	-1.0	0.223E-04	-4.8
80000	188.7	0.103E 01	-0.4	0.190E-04	-4.6
81000	188.5	0.864E 00	0.3	0.159E-04	-3.8
82000	202.1	0.726E 00	1.4	0.125E-04	-9.3
83000	211.0	0.621E 00	4.1	0.102E-04	-10.8
84000	209.2	0.530E 00	6.9	0.883E-05	-7.6
85000	202.5	0.452E 00	9.6	0.777E-05	-2.2
86000	192.9	0.381E 00	11.2	0.689E-05	4.1
87000	206.2	0.322E 00	12.9	0.544E-05	-1.0
88000	220.0	0.277E 00	16.7	0.439E-05	-4.1
89000	224.3	0.238E 00	20.7	0.370E-05	-2.7
90000	228.2	0.206E 00	25.4	0.314E-05	-0.7
91000	218.9	0.178E 00	30.3	0.284E-05	9.3
92000	201.3	0.152E 00	33.0	0.263E-05	23.2
93000	191.3	0.127E 00	33.3	0.232E-05	32.1
94000	194.5	0.107E 00	33.4	0.192E-05	32.1
95000	196.8	0.909E-01	33.7	0.161E-05	32.9
96000	196.1	0.768E-01	33.7	0.136E-05	35.4

SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.423

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 0411Z

DATE 21 NOVEMBER 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
32000	228.2	0.813E 03	-8.5	0.124E 01	-8.4
33000	230.7	0.700E 03	-8.6	0.105E 01	-8.5
34000	233.1	0.609E 03	-8.7	0.904E 02	-8.4
35000	235.6	0.525E 03	-8.6	0.776E 02	-8.2
36000	238.0	0.455E 03	-8.6	0.666E 02	-8.1
37000	240.4	0.394E 03	-8.8	0.572E 02	-8.2
38000	242.8	0.343E 03	-8.9	0.492E 02	-8.1
39000	245.1	0.299E 03	-8.9	0.425E 02	-8.0
40000	246.1	0.261E 03	-9.0	0.369E 02	-7.5
41000	246.5	0.227E 03	-9.3	0.321E 02	-6.9
42000	246.9	0.198E 03	-9.7	0.280E 02	-6.4
43000	248.8	0.173E 03	-10.2	0.242E 02	-6.6
44000	251.3	0.151E 03	-10.6	0.209E 02	-7.1
45000	253.8	0.132E 03	-11.0	0.181E 02	-7.4
46000	253.9	0.116E 03	-11.5	0.159E 02	-7.0
47000	254.0	0.101E 03	-12.2	0.139E 02	-6.7
48000	253.6	0.891E 02	-12.8	0.122E 02	-7.0
49000	253.0	0.780E 02	-13.6	0.107E 02	-7.6
50000	252.9	0.683E 02	-14.3	0.940E 03	-8.3
51000	253.6	0.598E 02	-15.0	0.821E 03	-9.3
52000	254.1	0.524E 02	-15.7	0.718E 03	-10.3
53000	253.4	0.459E 02	-16.4	0.631E 03	-11.1
54000	252.8	0.402E 02	-17.0	0.554E 03	-12.2
55000	250.1	0.352E 02	-17.6	0.490E 03	-12.5
56000	246.8	0.307E 02	-18.3	0.434E 03	-12.7
57000	246.6	0.268E 02	-19.0	0.378E 03	-14.1
58000	249.6	0.234E 02	-19.5	0.326E 03	-16.3
59000	251.2	0.205E 02	-19.8	0.286E 03	-17.7
60000	249.0	0.179E 02	-20.0	0.251E 03	-17.9
61000	246.9	0.156E 02	-20.3	0.221E 03	-18.1
62000	245.8	0.136E 02	-20.6	0.193E 03	-18.9
63000	244.7	0.119E 02	-20.8	0.169E 03	-20.0
64000	244.2	0.104E 02	-20.8	0.148E 03	-21.1
65000	243.6	0.907E 01	-20.7	0.129E 03	-22.1
66000	238.7	0.791E 01	-20.3	0.111E 03	-22.5
67000	233.3	0.685E 01	-20.3	0.102E 03	-20.9
68000	231.0	0.594E 01	-20.2	0.895E 04	-21.4
69000	229.5	0.513E 01	-19.9	0.779E 04	-22.0
70000	229.4	0.444E 01	-19.5	0.674E 04	-22.9
71000	229.6	0.383E 01	-18.9	0.582E 04	-23.8
72000	228.0	0.332E 01	-18.0	0.507E 04	-23.8
73000	226.1	0.286E 01	-17.0	0.441E 04	-23.7
74000	228.5	0.247E 01	-15.8	0.376E 04	-24.8
75000	231.5	0.214E 01	-14.0	0.322E 04	-25.7
76000	225.3	0.185E 01	-11.9	0.282E 04	-23.3
77000	219.2	0.159E 01	-10.1	0.252E 04	-21.2
78000	213.9	0.136E 01	-8.1	0.222E 04	-19.0
79000	211.9	0.116E 01	-6.2	0.191E 04	-18.4
80000	217.9	0.999E 00	-3.5	0.159E 04	-20.0
81000	223.8	0.862E 00	0.1	0.134E 04	-19.2
82000	214.4	0.744E 00	3.8	0.120E 04	-12.4
83000	196.7	0.643E 00	7.8	0.111E 04	-0.9
84000	179.0	0.536E 00	8.2	0.104E 04	9.1
85000	163.2	0.443E 00	7.3	0.945E 05	18.8
86000	158.4	0.356E 00	4.0	0.784E 05	18.5
87000	170.3	0.292E 00	2.4	0.597E 05	8.6
88000	183.8	0.242E 00	2.1	0.459E 05	0.3
89000	196.6	0.202E 00	2.5	0.353E 05	-7.2
90000	215.0	0.173E 00	5.5	0.288E 05	-11.3
91000	217.8	0.148E 00	8.5	0.237E 05	-8.4
92000	220.6	0.128E 00	11.9	0.202E 05	-5.2
93000	223.4	0.110E 00	15.2	0.172E 05	-2.1

ORIGINAL PAGE IS  
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SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.424

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 1657Z

DATE 3 DECEMBER 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/SQ M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
33000	237.7	0.772E 03	0.7	0.113E-01	-2.1
34000	239.4	0.670E 03	1.0	0.975E-02	-1.3
35000	241.1	0.581E 03	1.2	0.840E-02	-0.6
36000	242.9	0.506E 03	1.6	0.726E-02	0.1
37000	244.4	0.441E 03	1.9	0.629E-02	0.8
38000	244.4	0.384E 03	1.9	0.547E-02	2.0
39000	244.4	0.334E 03	1.8	0.477E-02	3.1
40000	244.5	0.291E 03	1.6	0.415E-02	4.0
41000	244.7	0.254E 03	1.2	0.361E-02	4.7
42000	245.3	0.221E 03	0.6	0.314E-02	5.0
43000	246.0	0.193E 03	0.0	0.273E-02	5.2
44000	246.5	0.168E 03	-0.6	0.238E-02	5.3
45000	246.3	0.146E 03	-1.4	0.207E-02	5.7
46000	246.1	0.128E 03	-2.3	0.181E-02	5.8
47000	247.6	0.111E 03	-3.5	0.157E-02	5.0
48000	249.7	0.976E 02	-4.5	0.136E-02	3.4
49000	251.8	0.854E 02	-5.4	0.118E-02	1.6
50000	254.0	0.747E 02	-6.3	0.102E-02	-0.1
51000	256.1	0.655E 02	-6.9	0.891E-03	-1.6
52000	255.8	0.575E 02	-7.5	0.783E-03	-2.2
53000	255.3	0.504E 02	-8.2	0.687E-03	-3.1
54000	254.5	0.442E 02	-8.8	0.605E-03	-4.1
55000	253.4	0.387E 02	-9.3	0.532E-03	-5.0
56000	251.7	0.339E 02	-9.9	0.465E-03	-5.6
57000	248.7	0.296E 02	-10.4	0.415E-03	-5.7
58000	246.2	0.259E 02	-11.0	0.366E-03	-6.2
59000	247.5	0.226E 02	-11.6	0.318E-03	-8.0
60000	248.9	0.197E 02	-12.0	0.276E-03	-9.5
61000	244.6	0.172E 02	-12.2	0.246E-03	-8.9
62000	239.7	0.150E 02	-12.8	0.218E-03	-8.7
63000	238.7	0.130E 02	-13.3	0.190E-03	-10.3
64000	239.2	0.113E 02	-13.6	0.165E-03	-12.2
65000	237.2	0.987E 01	-13.7	0.145E-03	-12.9
66000	233.4	0.856E 01	-13.8	0.127E-03	-13.0
67000	229.7	0.741E 01	-13.8	0.112E-03	-13.2
68000	226.0	0.640E 01	-13.9	0.986E-04	-13.4
69000	221.4	0.551E 01	-14.0	0.868E-04	-13.1
70000	215.6	0.473E 01	-14.1	0.765E-04	-12.5
71000	209.1	0.404E 01	-14.4	0.674E-04	-11.7
72000	201.6	0.344E 01	-15.0	0.594E-04	-10.7
73000	200.0	0.290E 01	-15.8	0.506E-04	-12.5
74000	204.1	0.246E 01	-16.0	0.420E-04	-16.1
75000	207.7	0.209E 01	-15.7	0.351E-04	-18.8
76000	210.7	0.179E 01	-14.9	0.295E-04	-20.8
77000	213.8	0.153E 01	-13.5	0.249E-04	-22.2
78000	217.8	0.131E 01	-11.7	0.209E-04	-23.6
79000	222.1	0.112E 01	-9.6	0.176E-04	-24.9
80000	226.4	0.969E 00	-6.5	0.149E-04	-25.3
81000	217.0	0.835E 00	-3.0	0.134E-04	-19.3
82000	207.6	0.708E 00	-1.1	0.118E-04	-14.0

SUMMARY OF ROCKET GRENADE DATA

EXPERIMENT 10.410

WALLOPS

ARRAY NUMBER 19

LAUNCH TIME 0525Z

DATE 4 DECEMBER 1975

ALTITUDE M MSL	TEMPERATURE DEG K	PRESSURE NT/50 M	DEVIATION PER CENT	DENSITY KG/CU M	DEVIATION PER CENT
33000	235.2	0.7599 03	-0.9	0.112E-01	-2.7
34000	236.3	0.6588 03	-0.7	0.970E-02	-1.8
35000	237.3	0.5700 03	-0.7	0.836E-02	-1.1
36000	238.4	0.4933 03	-0.9	0.721E-02	-0.5
37000	239.5	0.4288 03	-1.1	0.622E-02	-0.1
38000	240.6	0.3722 03	-1.1	0.538E-02	0.4
39000	241.6	0.3233 03	-1.5	0.466E-02	0.8
40000	242.6	0.2811 03	-1.9	0.404E-02	1.1
41000	243.5	0.2444 03	-2.4	0.350E-02	1.3
42000	244.5	0.2113 03	-2.9	0.304E-02	1.5
43000	245.3	0.1855 03	-3.6	0.264E-02	1.5
44000	246.1	0.1623 03	-4.3	0.229E-02	1.6
45000	247.2	0.1411 03	-5.1	0.199E-02	1.3
46000	248.6	0.1233 03	-5.9	0.173E-02	0.9
47000	249.6	0.1077 03	-6.8	0.150E-02	0.6
48000	249.6	0.9433 02	-7.7	0.131E-02	0.0
49000	249.9	0.8243 02	-8.7	0.115E-02	-0.8
50000	250.0	0.7200 02	-9.7	0.100E-02	-2.5
51000	252.4	0.6300 02	-10.5	0.869E-03	-4.0
52000	252.9	0.5511 02	-11.3	0.760E-03	-5.1
53000	252.2	0.4833 02	-12.0	0.667E-03	-6.0
54000	251.3	0.4233 02	-12.7	0.586E-03	-7.1
55000	250.0	0.3700 02	-13.4	0.515E-03	-8.0
56000	248.8	0.3233 02	-14.1	0.452E-03	-8.9
57000	248.9	0.2822 02	-14.7	0.395E-03	-10.3
58000	249.1	0.2466 02	-15.2	0.345E-03	-11.6
59000	247.2	0.2155 02	-15.6	0.304E-03	-12.0
60000	244.4	0.1888 02	-16.2	0.268E-03	-12.3
61000	241.3	0.1633 02	-16.8	0.235E-03	-12.7
62000	240.0	0.1422 02	-17.4	0.206E-03	-13.6
63000	239.8	0.1233 02	-17.8	0.180E-03	-15.2
64000	239.3	0.1077 02	-18.0	0.156E-03	-16.7
65000	236.4	0.9377 01	-18.1	0.138E-03	-17.1
66000	229.9	0.8122 01	-18.2	0.123E-03	-16.0
67000	222.4	0.6999 01	-18.7	0.109E-03	-15.4
68000	217.2	0.6001 01	-19.1	0.964E-04	-15.3
69000	212.8	0.5144 01	-19.8	0.842E-04	-15.7
70000	210.3	0.4399 01	-20.3	0.727E-04	-16.8
71000	208.4	0.3744 01	-20.8	0.626E-04	-18.0
72000	207.4	0.3188 01	-21.2	0.535E-04	-19.5
73000	206.1	0.2711 01	-21.4	0.457E-04	-20.8
74000	206.2	0.2330 01	-21.4	0.389E-04	-22.3
75000	207.3	0.1966 01	-21.2	0.329E-04	-23.9
76000	208.3	0.1677 01	-20.6	0.279E-04	-25.2
77000	213.7	0.1422 01	-19.6	0.232E-04	-27.6
78000	221.8	0.1222 01	-17.8	0.192E-04	-30.1
79000	225.7	0.1005 01	-15.3	0.162E-04	-30.7
80000	228.5	0.9100 00	-12.2	0.138E-04	-30.5
81000	228.6	0.7877 00	-8.6	0.119E-04	-27.8
82000	226.6	0.6880 00	-3.0	0.104E-04	-24.3
83000	218.6	0.5885 00	-1.8	0.932E-05	-18.9
84000	210.6	0.4988 00	0.6	0.825E-05	-13.7
85000	205.5	0.4255 00	3.1	0.720E-05	-9.3
86000	201.5	0.3622 00	5.6	0.626E-05	-5.3
87000	197.5	0.3066 00	7.3	0.540E-05	-1.8
88000	223.1	0.2588 00	8.9	0.400E-05	-12.5
89000	256.4	0.2225 00	14.2	0.306E-05	-19.5

ORIGINAL PAGE IS  
OF POOR QUALITY

SECTION 4  
COMPARISON OF TEMPERATURES  
OBTAINED BY ACOUSTIC GRENADE AND  
THERMISTOR SOUNDINGS OF THE UPPER ATMOSPHERE

ABSTRACT

The measurement of upper atmospheric temperature using a rocket borne thermistor is routinely performed at numerous locations daily all over the world. The temperatures measured by the thermistor suffer from many errors (for example, radiative, frictional and ohmic heating) and must be corrected to obtain the true ambient air temperature. These corrections must be determined theoretically for each type of thermistor payload since they are quite dependent on the properties of the thermistor and the way it is placed in the payload. As part of an effort to provide ground truth data for satellite flyovers, a series of Datasonde thermistor payloads was launched at NASA Wallops Island nearly concurrently with acoustic grenade payloads so that the temperature of the same parcel of the atmosphere could be determined by the three techniques at nearly the same time. Both day and night launches were carried out to isolate the effect of solar radiation on the thermistor payload. This report details the results of the comparison of both the uncorrected and corrected Datasonde temperatures with those obtained by the acoustic grenade technique, a method whose temperature accuracy is nominally  $\pm 2$  Kelvin degrees over the altitude range covered by the Datasonde. The comparison data sets were

supplemented with archival sets in which the grenade and Datasonde payloads were launched very closely together in time. The corrected Datasonde temperatures compared well statistically with the grenade temperatures; the differences between the two were scattered about zero. Since the Datasonde correction technique applies to altitudes below 70 km only, the uncorrected data was used to estimate an empirical correction scheme for data above 70 km, using the grenade data as the true temperature. The results showed that at NASA Wallops Island the Datasonde temperatures at 80 km are approximately 130 and 45 Kelvin degrees too warm for day and night launches, respectively. Similar analyses are presented for Churchill Datasonde/grenade launches and for uncorrected Arcasonde/grenade launches at NASA Wallops Island.