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RESEARCH AND DEVELOPMENT TECHNICAL REPORT
ECOM-5345

METEOROLOGICAL INFLUENCE OF A SOLAR ECLIPSE ON THE STRATOSPHERE

By
J. S. Randhawa
B. H. Williams
M. D. Kays

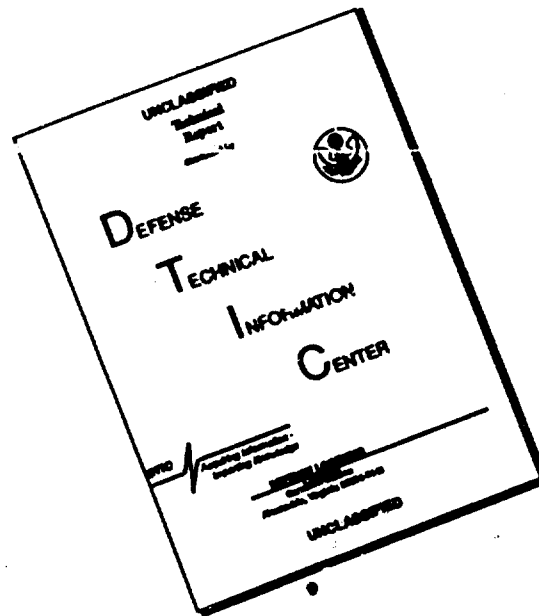
December 1970

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METEOROLOGICAL INFLUENCE OF A SOLAR ECLIPSE ON THE STRATOSPHERE

By

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December 1970

DA Task No. IT061102B53A-18

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U. S. Army Electronics Command

Fort Monmouth, New Jersey

ABSTRACT

An experiment to study the influence of a solar eclipse on the earth's lower atmosphere was conducted at Eglin Air Force Base, Florida, where a solar eclipse occurred on 7 March 1970. Three temperature-ozone-sondes and eight Arcasondes were deployed into the upper stratosphere and lower mesosphere at times prior to, during, and after the total eclipse. In addition, two electrochemical ozonesondes were flown on balloons on 5 and 6 March. Resulting temperature, wind and ozone data are presented. No measurements were made during the totality. An increase in ozone was measured during and several hours after the partial eclipse. Higher temperatures and a perturbation in the zonal wind field were observed in the middle stratosphere during the partial eclipse.

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INTRODUCTION

During the last two decades, a significant amount of research has gone into intriguing problems involving the structure and dynamics of the stratosphere and mesosphere. Ozone is an important constituent of that region and, because of its strong absorption of solar ultraviolet radiation, plays a special role in the radiative thermal budget. It thus helps to develop some of the characteristics of the general circulation of the upper stratosphere and mesosphere.

When solar radiation is denied to the earth's atmosphere during an eclipse of the sun, marked changes occur in its state, particularly in the ionosphere where the effects can be studied by means of radio waves. At lower elevations, the denial of solar radiation also affects the ozonosphere where it is found to produce increased ozone concentration due to the absence of photochemical reactions. Measurements of total ozone content in a vertical column during partial eclipses have been reported by Stranz [1] and Bojkov [2] who show an increase in the total amount shortly after the maximum phase of the eclipse. Ozone observations were made using a rocket-borne ozonesonde by Randhawa [3] during a total eclipse on 12 November 1966. An increase in the ozone concentration was noted as the sonde passed through the total eclipse shadow between 60 and 54 km altitude.

The stratospheric circulation in Northern Hemisphere lower midlatitudes has been shown to exhibit a strong diurnal response to solar heating in the 45-55 km altitude region [4, 5]. This diurnal tidal motion is characterized by wind variations of the order of 20 mps in a layer centered near the stratopause level. Rocket sounding data indicate a well-developed meridional variation, with the circulation directed away from the equator during the morning hours and toward the equator during the afternoon and evening. The zonal diurnal variation in March is less definite but generally indicates a weakening flow during the day and strengthening (more westerly) at night.

The introduction of an eclipse shadow into the stratospheric solar heat input provides an opportunity for inspection of a new mode of stratospheric response to a change in solar heat input. The progress of the eclipse shadow is significantly different from sunset-sunrise perturbations and provides unique conditions in which to study the response times of the region.

An experiment to study these effects was performed at Lulin Air Force Base (29°41'N, 85°20'W) during the total solar eclipse which occurred on 7 March 1970. Meteorological sensors to measure temperature, ozone and wind before, during and after the total eclipse were deployed near 60 km altitude by Arcaś rockets.

EXPERIMENT

The path of totality moved northeastward over the Gulf of Mexico, across the Florida Panhandle and along the east coast of the United States. The duration of complete darkness at the center line was 190 seconds, starting at 1313 EST. The launch site, indicated as D-3 in Figure 1, was located about 10 km northwest of the path of totality. The sensors were rocket-launched into the totality at an azimuth of 129 degrees. Arcas meteorological rockets were utilized to carry the sensors, parachutes and transmitters to an altitude of 55-60 km. After ejection, the sensors descended on radar-reflective parachutes (4.5m diameter). The transmitted signals were pulse modulated and received by a GMD receiver on a carrier frequency of 1680 MHz. FPS-16 radars were used for tracking the parachutes and provided the altitude of the instrument with time. The three types of sensors used during this experiment were:

A. STS-Ozonesonde: This is a dual-channel rocket-borne ozonesonde [6] which incorporated a temperature-sensing bead thermistor on a time-sharing basis with an ozone sensor. Ozone is detected by the chemiluminescent principle and the sensor consists of Rhodamine B adsorbed on silica gel. Each instrument was calibrated before launch by use of an ozone generator [7] for the absolute measurement of ozone concentration in the atmosphere. Ozonized air of known concentration was injected into the sampling bottle at a known flow rate, and instrument sensitivity was set in the proper range. Figure 2 shows this dual sensor.

B. Temperaturesonde: This is a single-channel temperature instrument [8] which also has a bead thermistor as its sensing element.

C. Electrochemical Ozonesonde: During the course of this experiment two electrochemical ozonesondes (Mast type) [9] were attached with AMT-12 Radiosondes and flown on balloons, one on 5 March and the other on 6 March 1970. The objective of these balloon flights was to study the low-level ozone distribution and to compare the data derived from the two systems at overlap levels.

Surface weather conditions for several days prior to the eclipse were in general humid with occasional rain. The day of the eclipse, 7 March 1970, was quite cloudy with intermittent rain during the morning hours and heavy rain during eclipse time. A low-pressure system was moving northeastward from the Gulf of Mexico across western Florida.

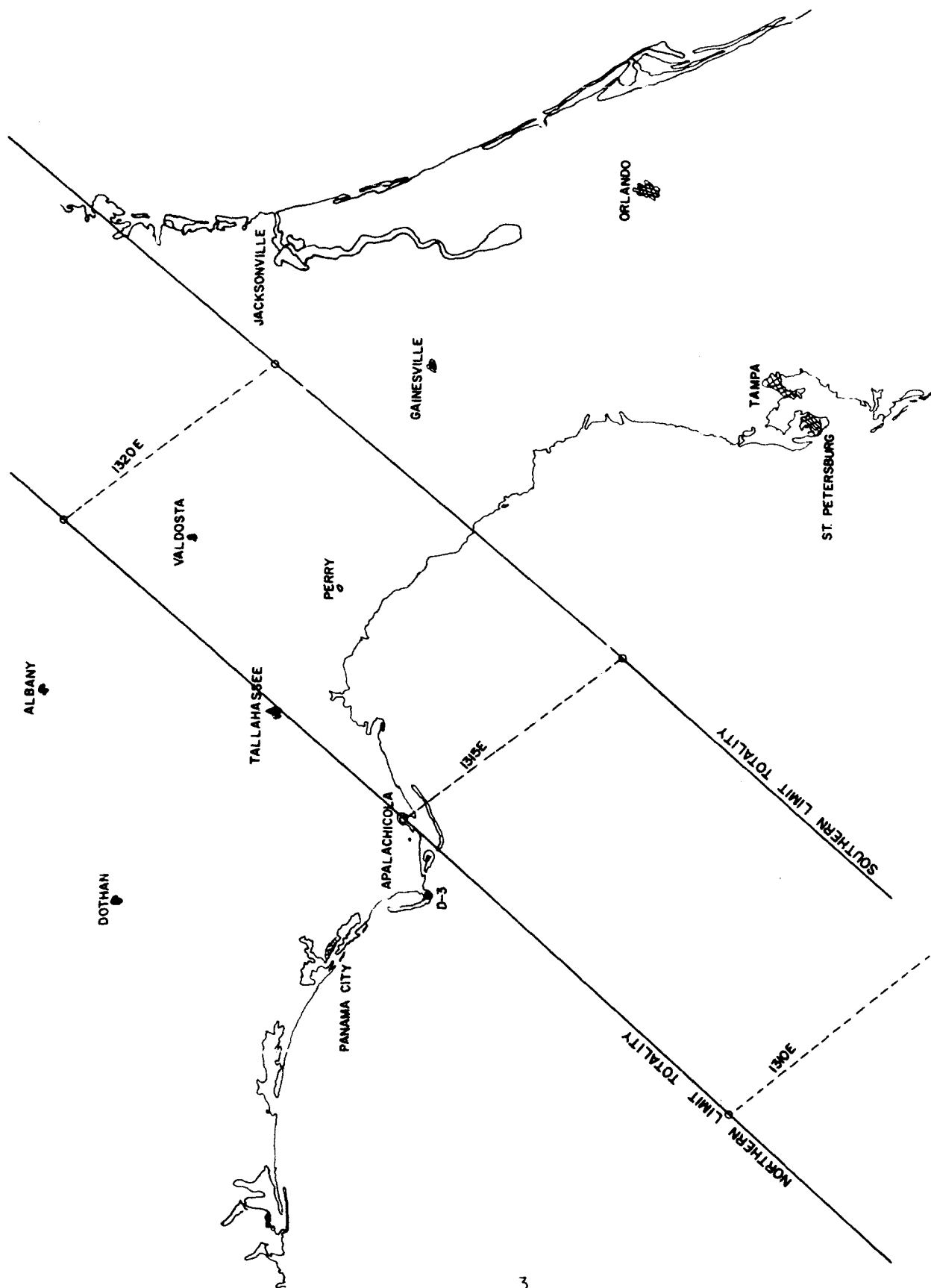
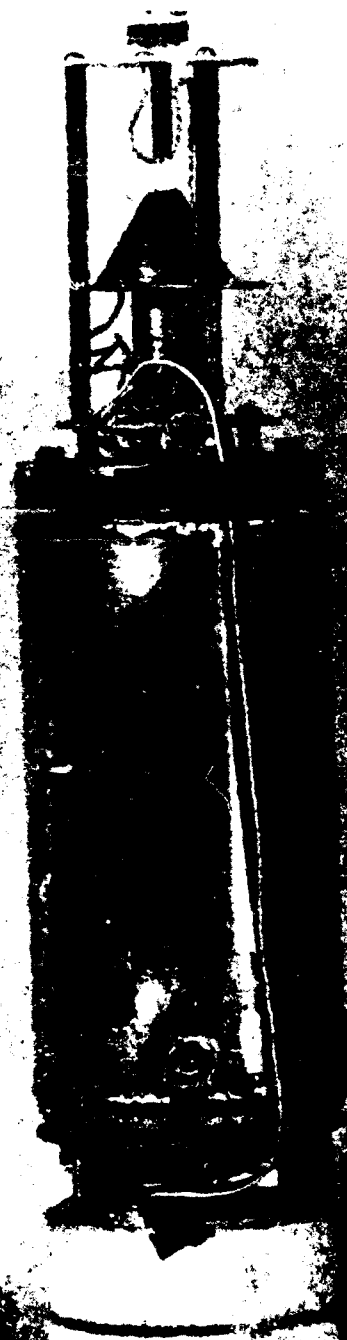


Figure 1. Path of Eclipse Shadow.



STS-OZONESONDE

RESULTS AND DISCUSSION

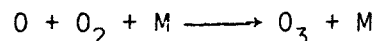
Eleven rockets were launched at the times given in Table I. Three soundings produced temperature, ozone, and wind data, six produced temperature and wind data, and two produced wind data only. All these data are presented in Appendix A in tabular and graphical form. Total ozone measured with a Dobson spectrophotometer at Tallahassee, Florida (30°23'N, 84°22'W) is given in Table II. Skies during daylight hours at Tallahassee on 5 and 6 March were partly cloudy and on 7 March were overcast with high clouds. No precipitation was recorded during this period.

Ozone

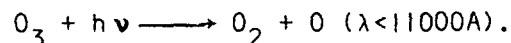
Two Mast electrochemical ozonesondes were flown, one on 5 March and the other on 6 March; the data received are presented in Figures 3 and 4. There are no marked differences in the two distributions except for a small increase near 18 km and a slight decrease at 10 km altitude on 6 March. Total ozone measured at Tallahassee on the same days also showed no large variation.

On the day of the eclipse, three ozone soundings (Figure 5) were made: one at 1404 EST (partial eclipse), the second at 1815 EST (one hour before sunset), and the third at 2015 EST (one hour after sunset). The eclipse sounding showed a higher than expected ozone concentration above 35 km. This higher concentration was also measured by the 1815 EST sounding which was made nearly four hours after the last contact. The night sounding (2015 EST) showed normal ozone distribution with two peaks, one near 25 km and the other near 19 km altitude.

As the photodissociation of ozone is gradually cut off during the eclipse, an increasing amount of ozone is formed through the three-body reaction



where M is the other oxygen molecule or is a nitrogen molecule. On the other hand, ozone can be destroyed by the following reaction as the solar radiation becomes available:



According to theory, maximum enhancement occurs after totality; thereafter a rapid decrease occurs as compared to build-up time [10]. As evidenced from these observations, ozone concentration did not decrease for a long time, even after the fourth contact. The increase measured during partial eclipse at some levels is more than 100 percent as

TABLE 1

<u>Date</u>	<u>Launch Time (EST)</u>	<u>Measured Parameter</u>
6 Mar 70	1339	Wind
6 Mar 70	1610	Temperature-Wind
7 Mar 70	1121	Wind
7 Mar 70	1310.5	Temperature-Wind
7 Mar 70	1311.5	Temperature-Wind
7 Mar 70	1404	Temp-Ozone-Wind
7 Mar 70	1600	Temperature-Wind
7 Mar 70	1815	Temp-Ozone-Wind
7 Mar 70	1820	Temperature-Wind
7 Mar 70	2015	Temp-Ozone-Wind
7 Mar 70	2020	Temperature-Wind

TABLE II

TOTAL OZONE MEASURED WITH A DOBSON SPECTROPHOTOMETER AT
TALLAHASSEE, FLORIDA (30°23'N, 84°22'W)

<u>Date</u>	<u>Time (EST)</u>	<u>Total (m-atm-cm)</u>
5 Mar 70	10-50-30	320
5 Mar 70	10-51-30	326
5 Mar 70	11-58-45	324
5 Mar 70	12-01-45	320
5 Mar 70	15-21-00	342
5 Mar 70	15-23-30	342
6 Mar 70	10-00-00	341
6 Mar 70	10-01-00	340
6 Mar 70	12-16-30	343
6 Mar 70	12-18-45	343
6 Mar 70	15-30-00	336
6 Mar 70	15-32-30	336
7 Mar 70	10-19-00	375
7 Mar 70	10-20-00	375
7 Mar 70	12-00-30	375
7 Mar 70	12-03-00	375
7 Mar 70	14-13-00	414
7 Mar 70	14-39-00	414
9 Mar 70	12-16-15	372
10 Mar 70	12-01-00	350

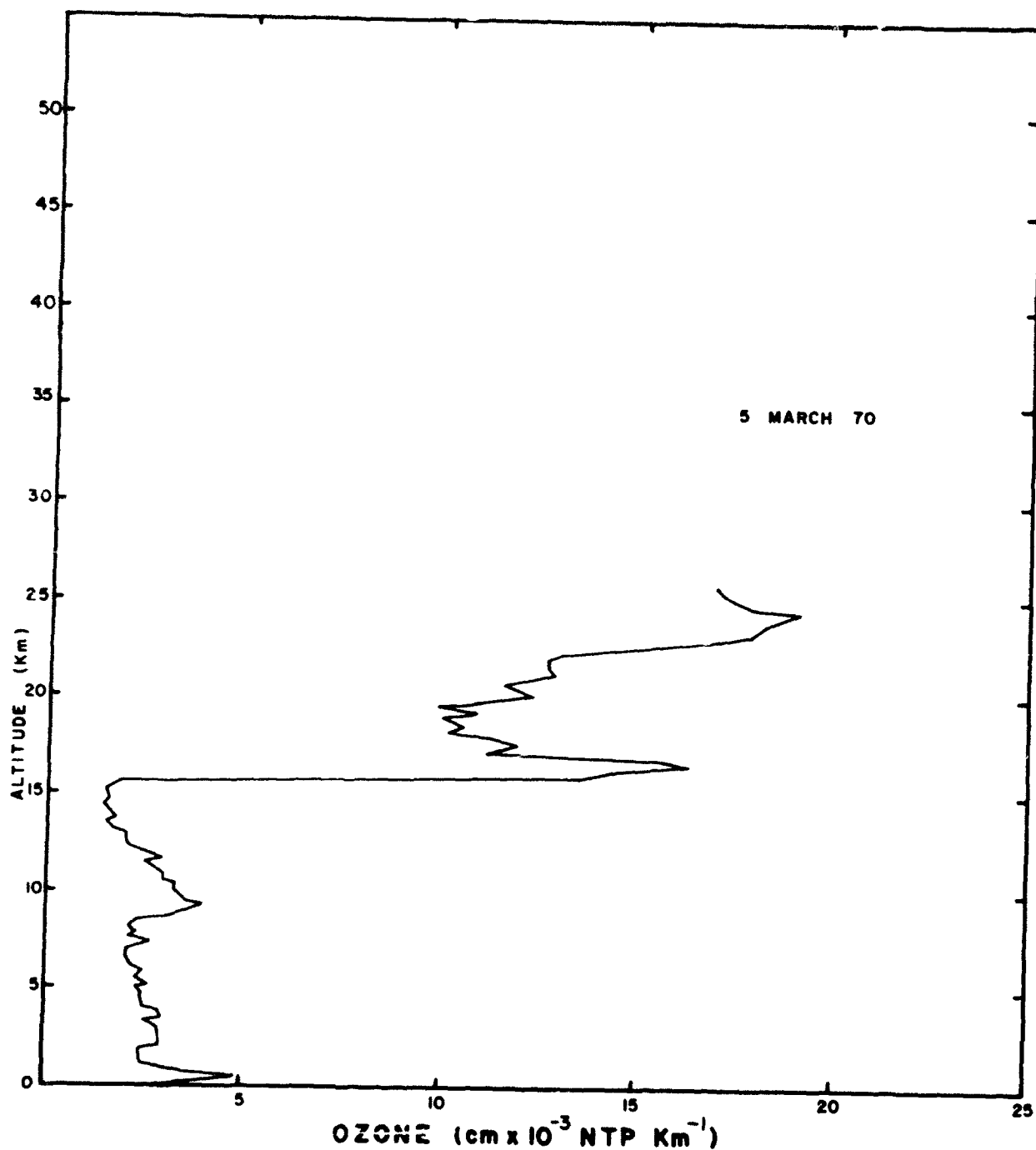


Figure 3. Ozone Concentration Obtained from the Mast Electrochemical Ozone-sonde Flown on 5 March 1970, 1600 EST.

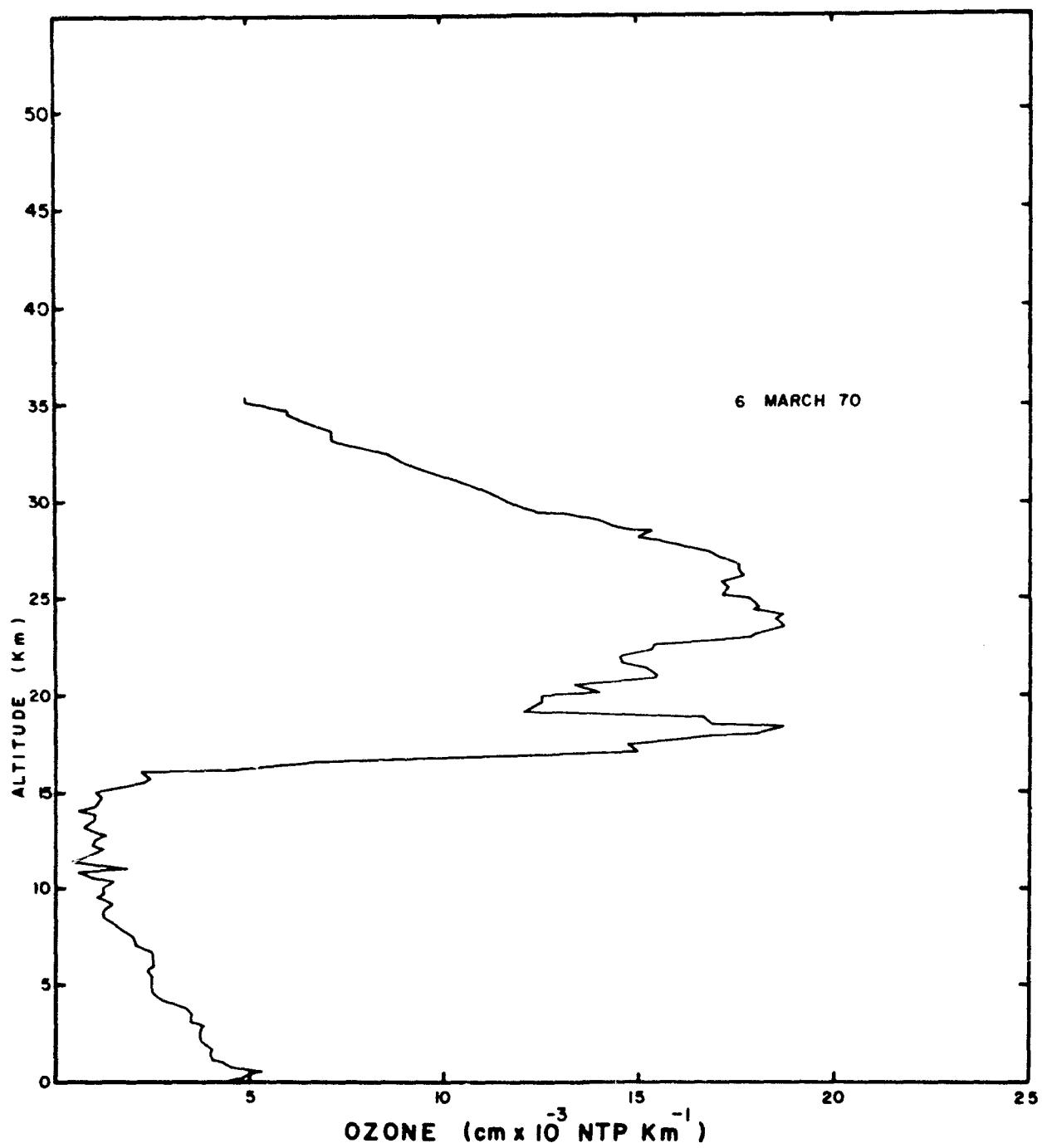


Figure 4. Ozone Concentration Obtained from the Mast Electrochemical Ozone-sonde Flown on 6 March 1970, 1800 EST.

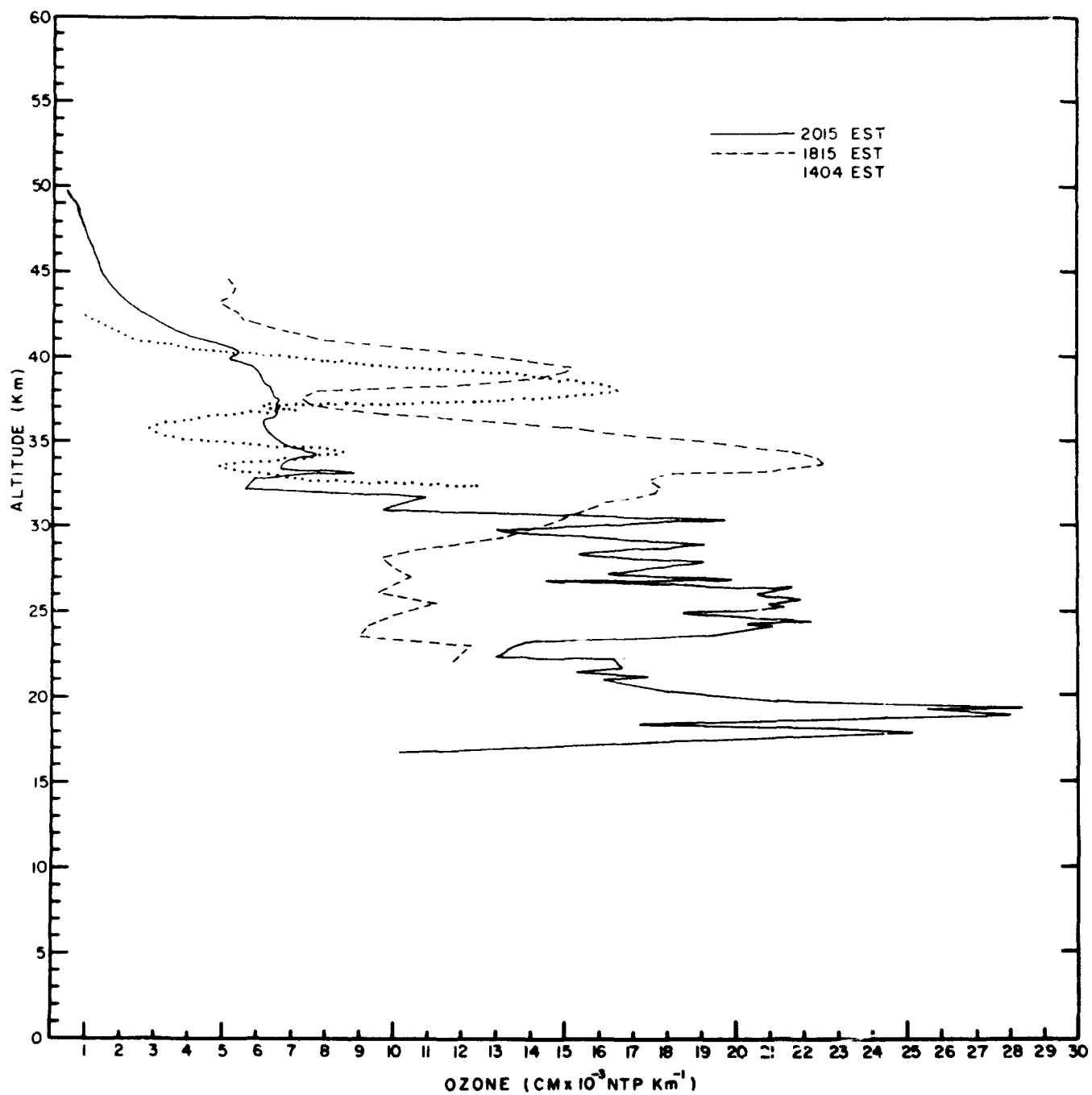


Figure 5. Ozone Concentration with Altitude as Obtained from Three Rocket Soundings on 7 March 1970.

compared to the 2015 EST sounding. The measurements made for the total ozone at Tallahassee during that week (Table II) show some variation from day to day. On 7 March, before the first contact, total ozone measured was 375 m-atm-cm, and just after the fourth contact it was measured to be 414 m-atm-cm, showing an increase of more than 10 percent. This is the first time so much increase in total ozone has been reported from measurements with a Dobson spectrophotometer due to a solar eclipse.

Temperature and Wind

Temperatures recorded on the day of the eclipse are shown in Figures 6 and 7. The thermal field shown in Figure 8 was analyzed from temperature values measured by the Arcasonde system. These analyses indicate that a marked warming was observed in the stratosphere during the partial solar eclipse. The temperatures observed near the time of totality in the lower and middle stratosphere are considerably higher than those observed during the previous afternoon. For example, the temperature difference is 9.1°C at 25 km, 12.4°C at 30 km, and 14.8°C at 35 km.

Several influences appear to be effective in altering the thermal structure during this time frame. A small portion of the heating can be attributed to the diurnal variation of the temperature. Beyers, Miers, and Reed [11] report that the time of maximum temperature over White Sands Missile Range, New Mexico, at 40 km in February is 1400 MST and the amplitude is only 2°C. Thus an increase of 12°C at 40 km during the partial eclipse cannot be ascribed to the diurnal variation.

The appearance of a weak anticyclone over the southeastern states on 7 March accounts for the relatively weak and disorganized circulation at the 10 mb level (Figure 10). Horizontal divergence along with warm air advection which is associated with this synoptic-scale system could well have been responsible for additional heating. Figures 9, 10, and 11 show the movement of this anticyclone at 10 mb from the Gulf of Mexico across southeastern United States.

Unfortunately, temperature and wind observations were not available above the stratopause level during the totality due to the effect of heavy rains on the radar acquisition of Arcasonde payloads and weak signals received by the ground-based GMD's. However, a similar experiment was conducted at Wallops Island, Virginia, during the eclipse [12]. Their temperature analyses showed cooling between 45 and 55 km altitude which they associated with the eclipse. It is reasonable to assume that this cooling existed at the same levels over Eglin AFB, Florida. There is thus the implication that this cooling gen-

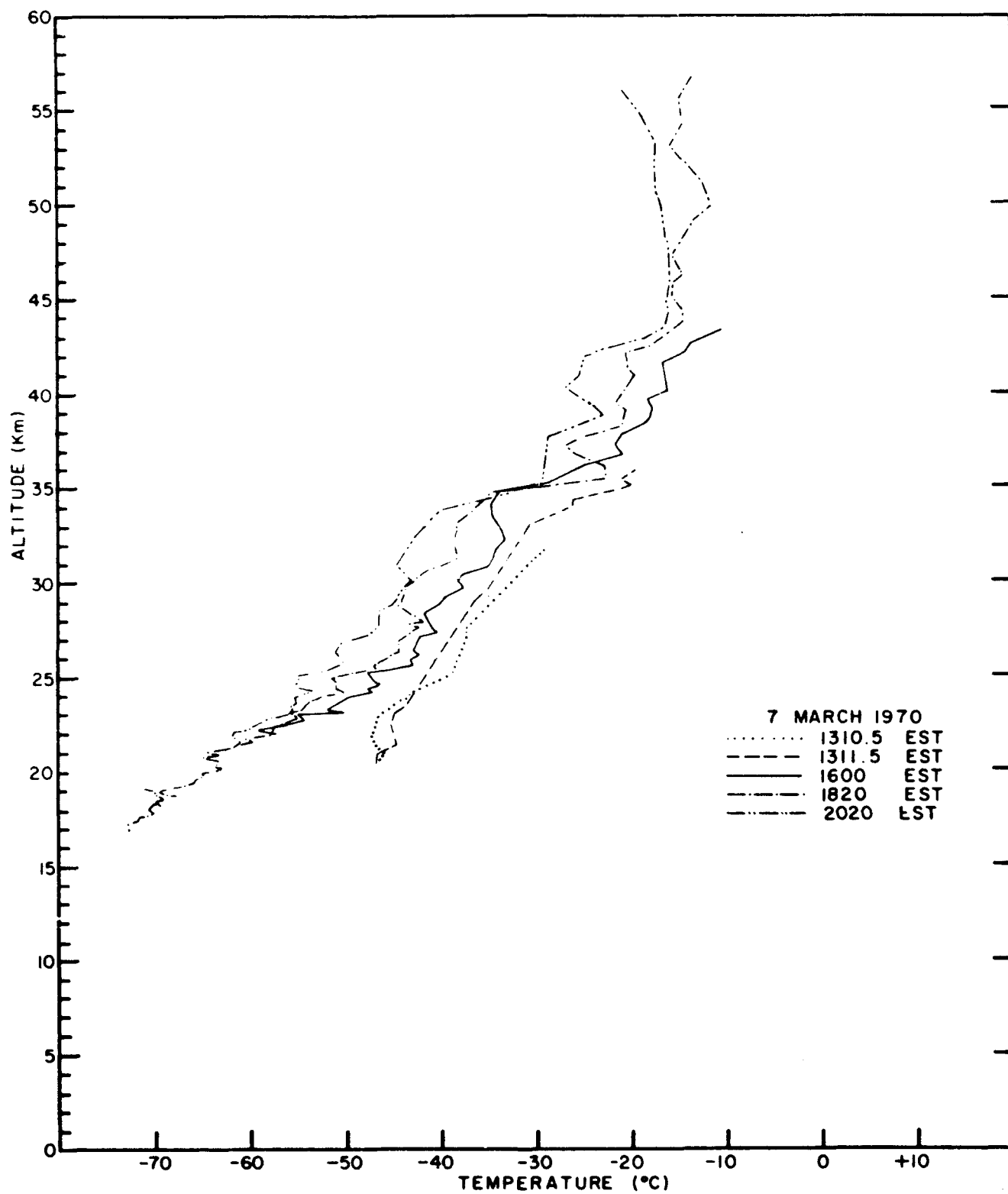


Figure 6. Temperature Data Obtained from Arcasonde 1A on 7 March 1970.

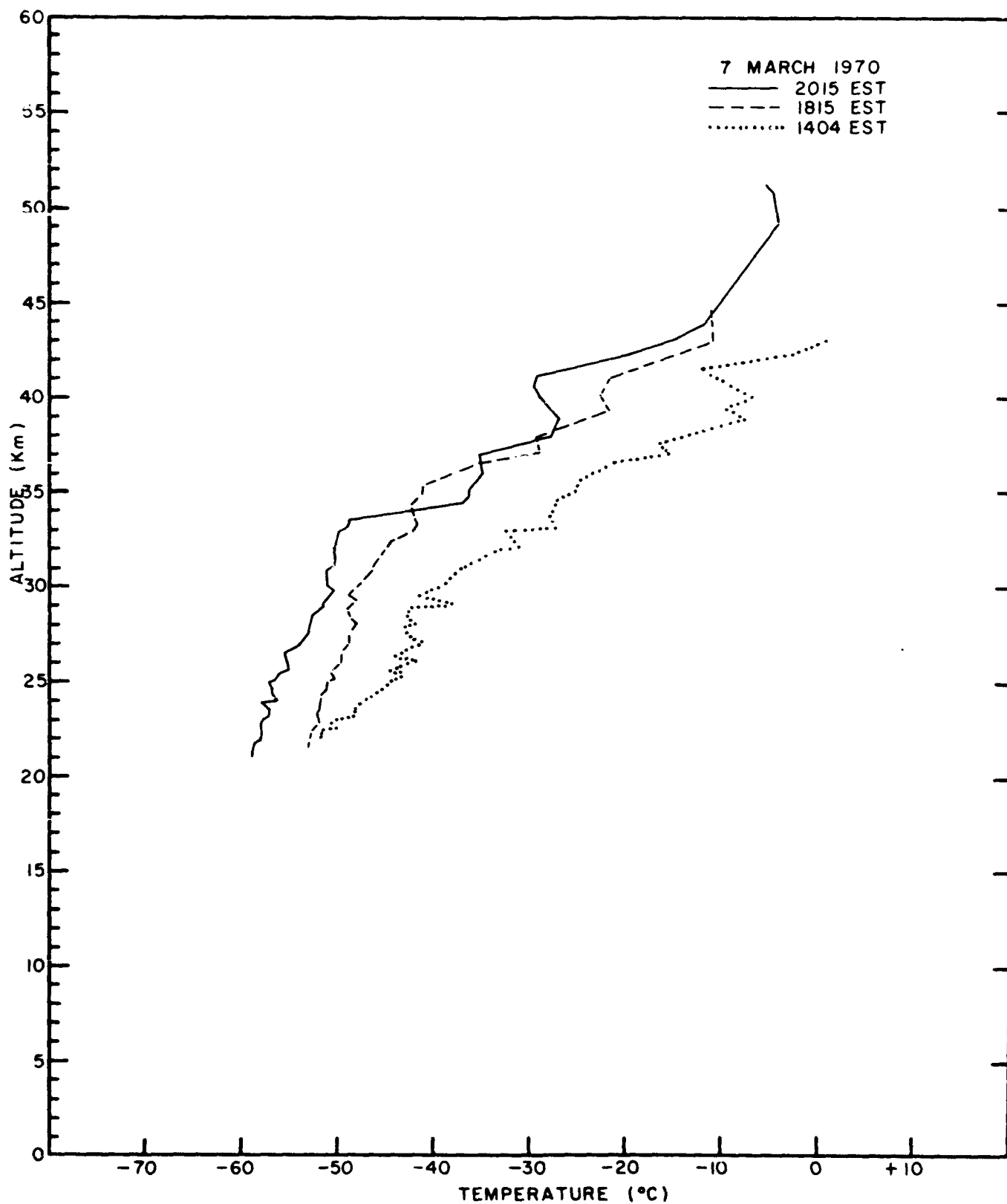


Figure 7. Temperature Data Obtained from STS-Ozone Sensor on 7 March 1970.

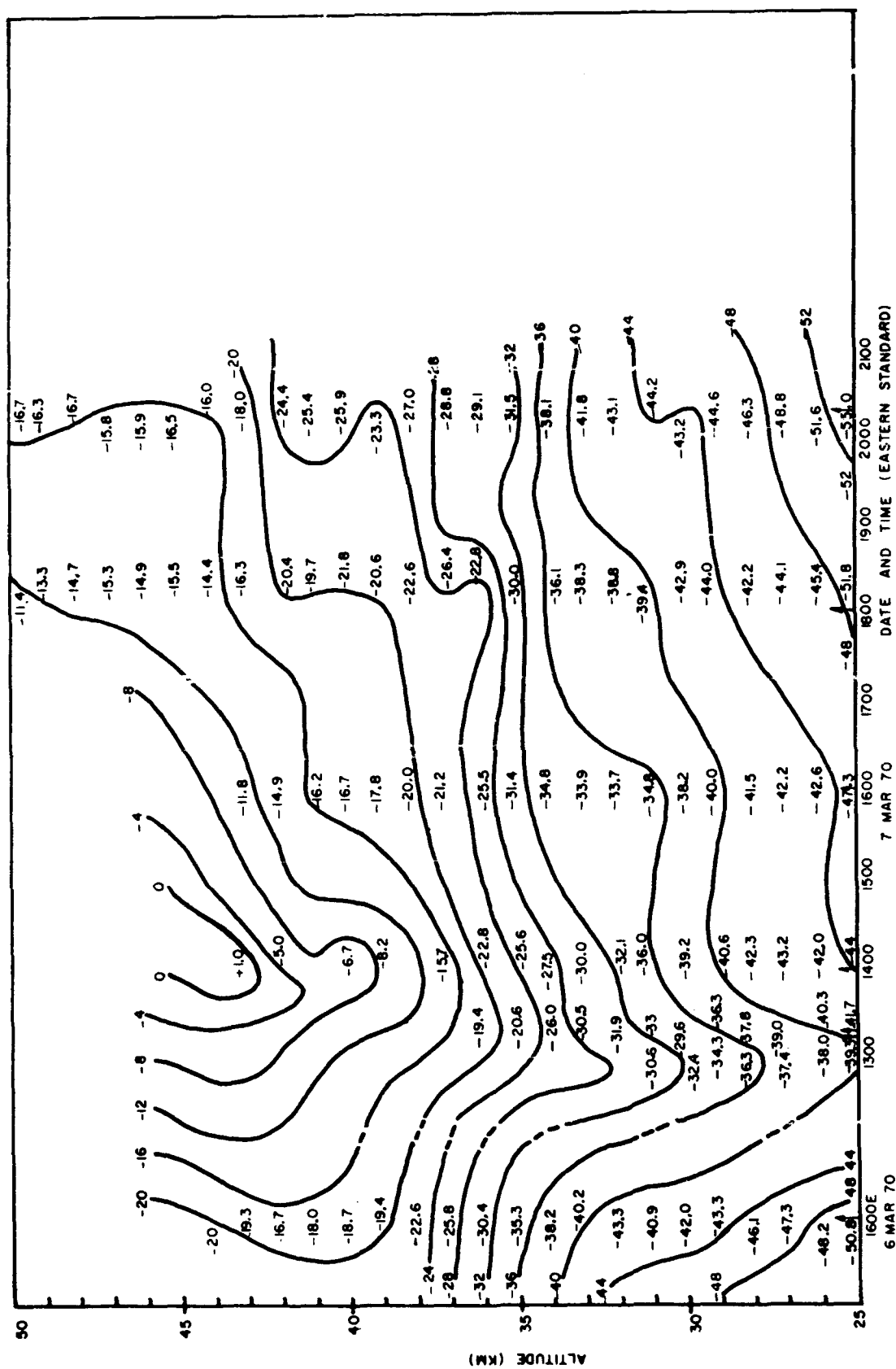


Figure 8. Isothermal Analysis of Temperature Data. Isotherms are drawn for intervals of 4°C. Only Arcasonde temperatures are included in this analysis.

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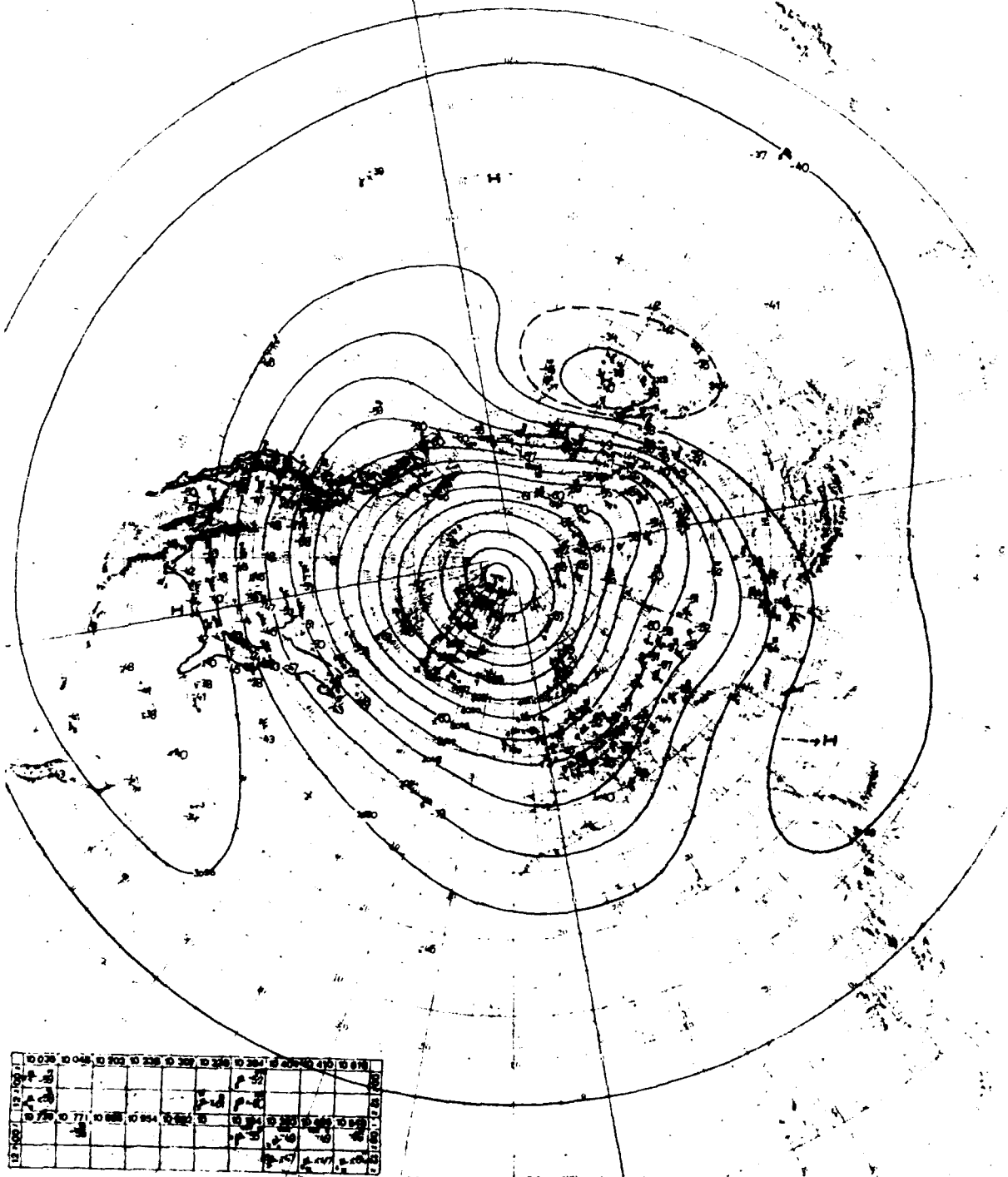
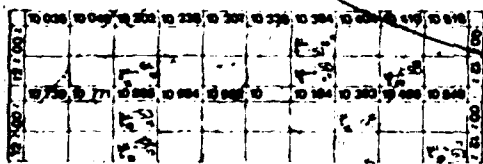


Figure 9. Ten Millibar Constant Pressure Analysis Provided by the Free University of Berlin for 6 March 1970.

16



17

erated downward motion and subsequent compressional heating in the upper and middle stratosphere (below 45 km).

In general, the zonal wind components (Figure 12) and meridional wind components (Figure 13) are characterized by a weak and variable flow during 6 and 7 March. The mean component winds for March at Cape Kennedy, Florida, based on a five-year period, 1964-1968, show south and west winds prevailing throughout the stratosphere [13]. The only apparent correlation between changes in the wind field and the solar eclipse was the occurrence of a marked minimum in the west winds during the partial eclipse from 36 to 40 km.

CONCLUSIONS

The experimental study made at Eglin Air Force Base, Florida, indicates that the solar eclipse produced a significant perturbation in the stratosphere. The observations obtained during this period show that there was an appreciable increase in temperature, decrease in zonal wind field, and increase in ozone concentration. This ozone concentration increase persisted for at least four hours. A comparatively large increase in total ozone appears to have resulted due to the eclipse.

ACKNOWLEDGMENTS

The authors wish to acknowledge the help received from the personnel of Schellenger Research Laboratories, the University of Texas at El Paso, who contributed to the success of this study. Special thanks are due Mr. John Frei for instrument development and Mr. John Sisson for data reduction.

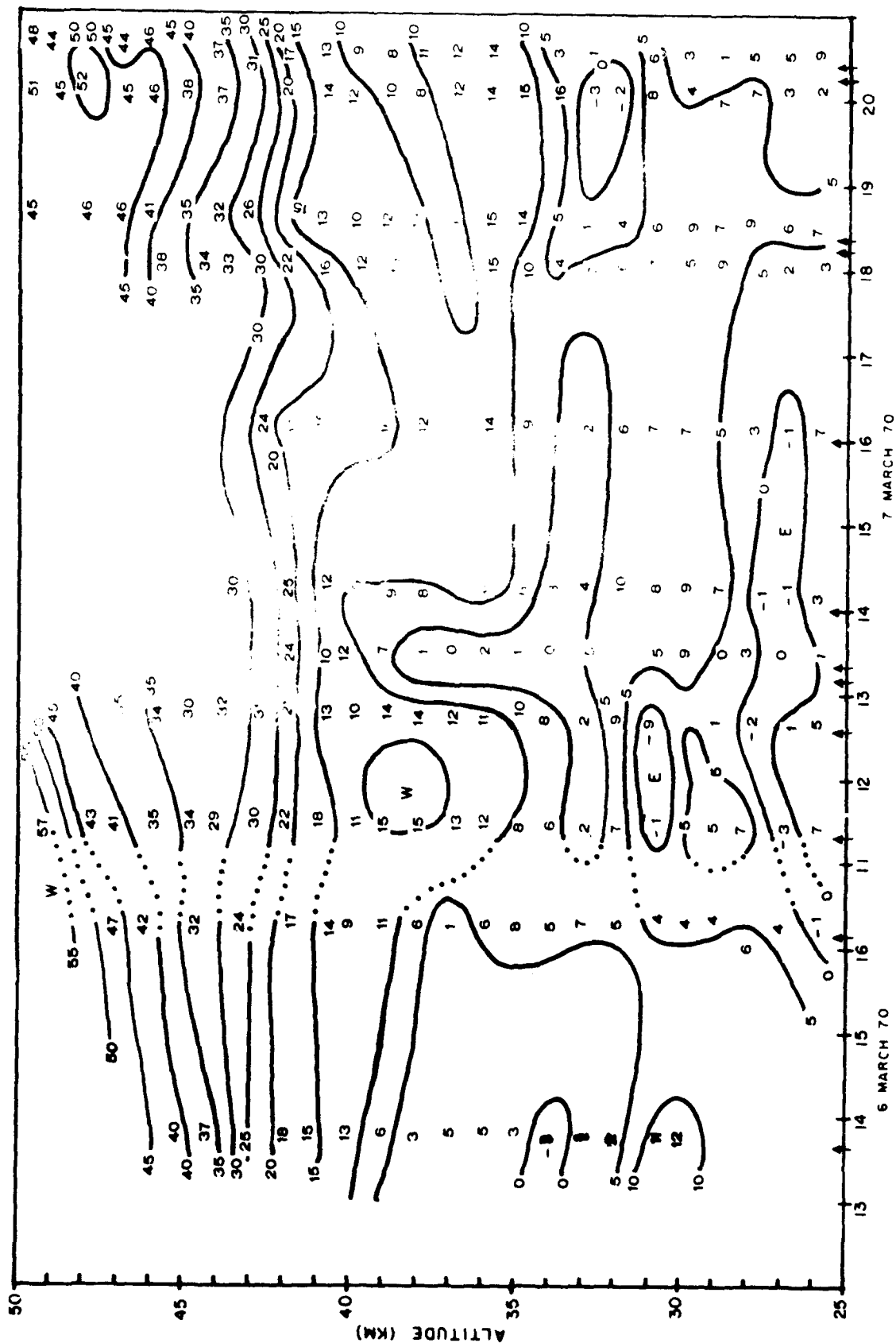


Figure 12. Zonal Wind Component (m sec^{-1}). Position of arrows represents approximate time (EST) of rocket observation.

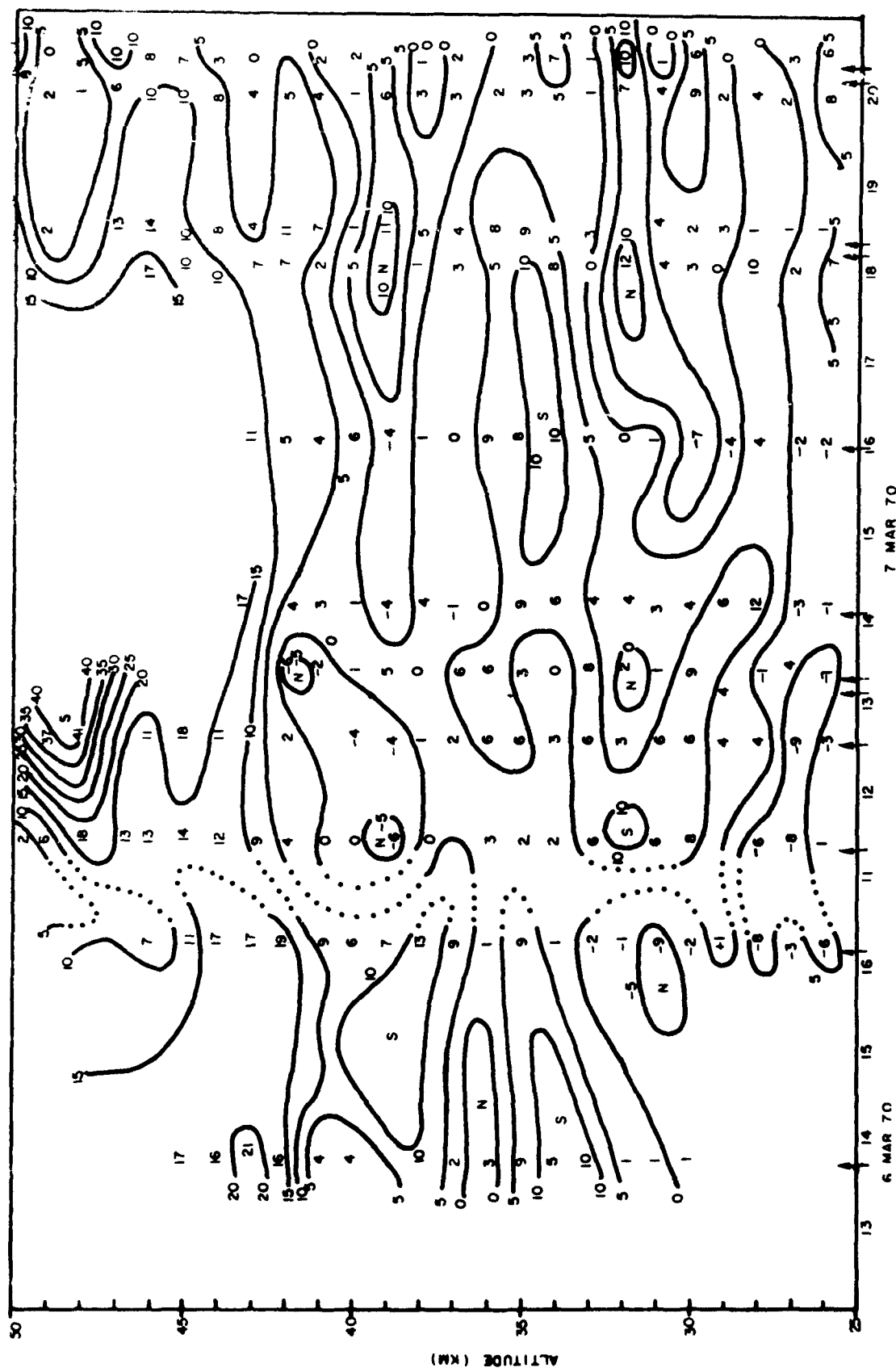


Figure 13. Meridional Wind Component (m sec^{-1}). Position of arrows represents approximate time (EST) of rocket observation.

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A P P E N D I X A

METEOROLOGICAL ROCKET SOUNDING DATA

METEOROLOGICAL ROCKET SOUNDING DATA

EDLIN AFB, FLORIDA

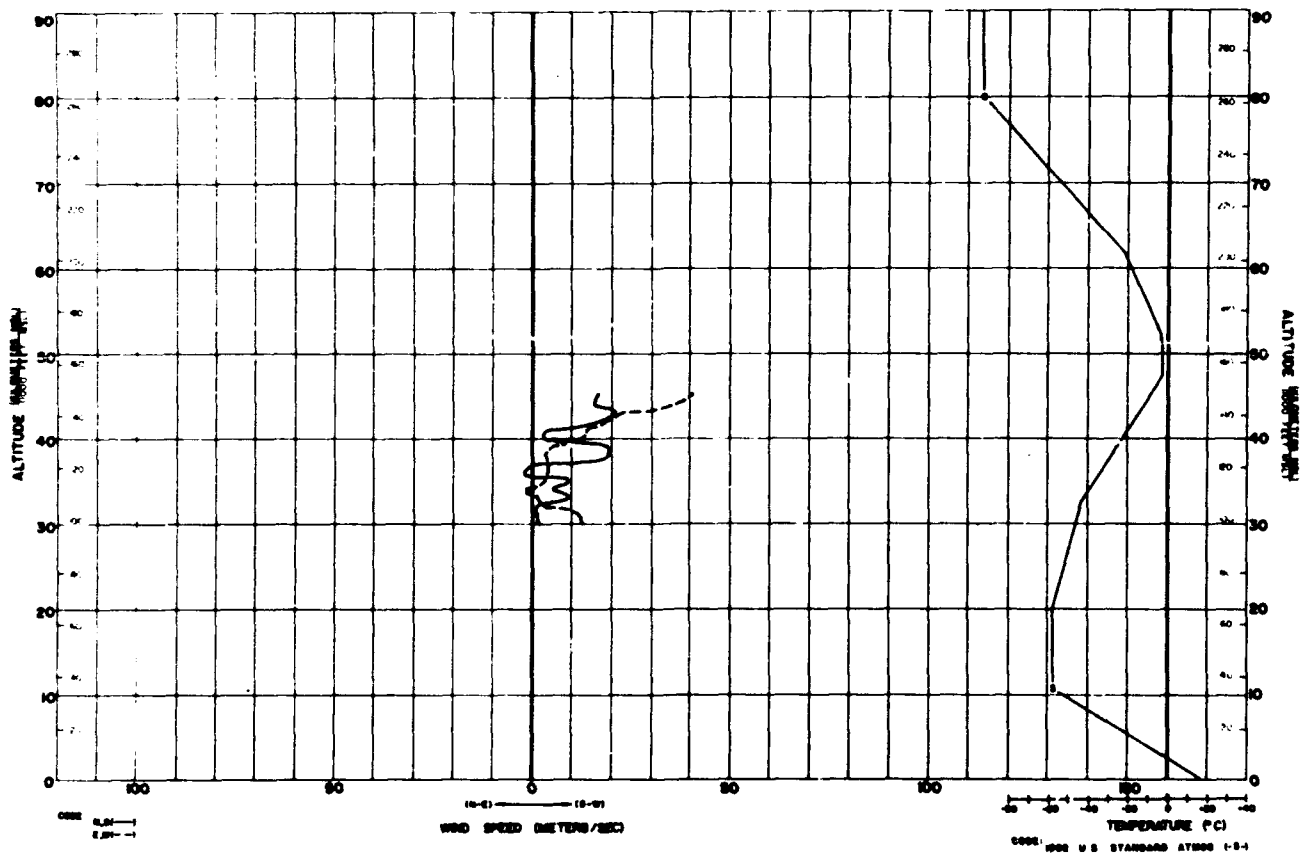
ARCAS 1

6 MARCH 1971

1339 EST

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43.00	11.11	35.58	
42.00	15.5X	18.56	
41.00	4.15	14.71	
40.00	4.11	15.45	
39.00	4.55	5.75	
38.00	9.85	5.74	
37.00	1.5	4.19	
36.00	-2.54	4.66	
35.00	9.15	5.45	
34.00	6.55	-1.7	
33.00	9.75	1.5	
32.00	1.52	1.8	
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METEOROLOGICAL ROCKET SOUNDING DATA

WLEH AFB, FLORIDA

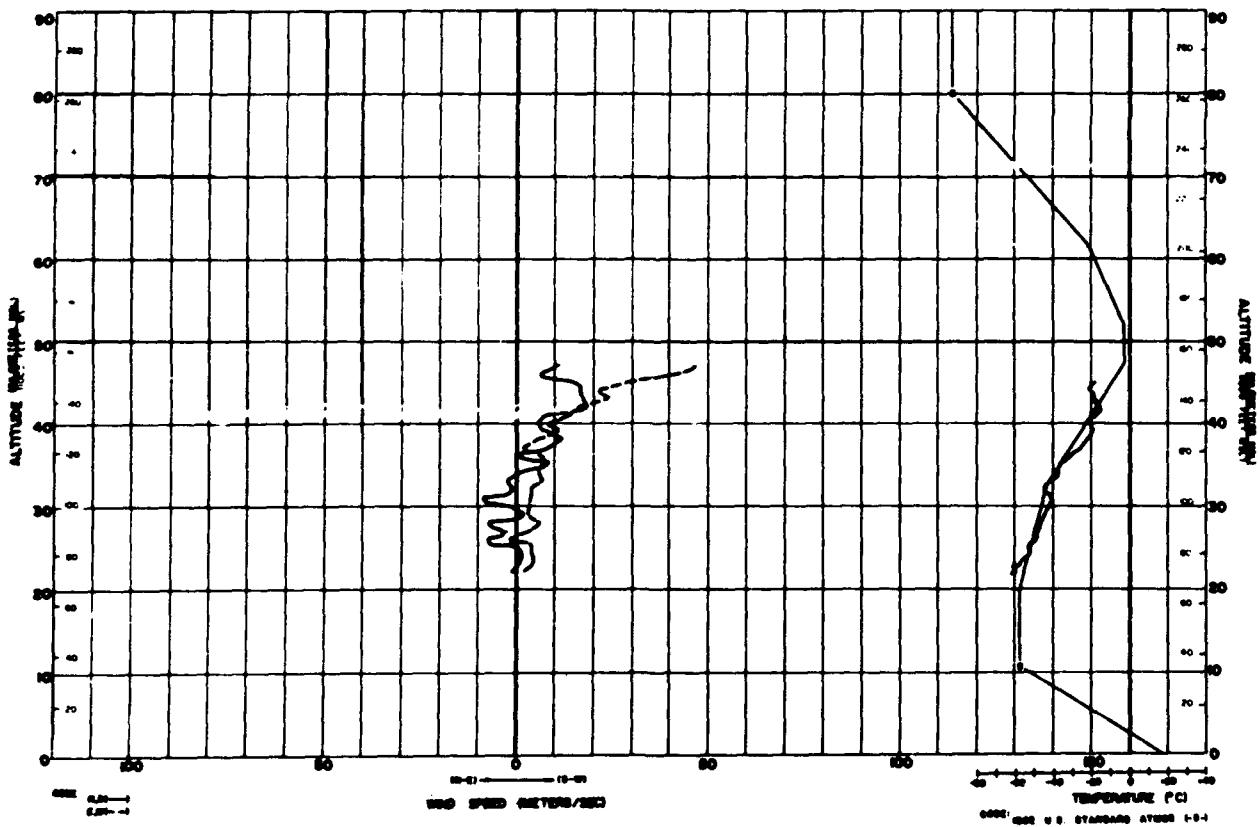
ARCAS 2

6 MARCH 1970

1610 HRT

ARCABORDE

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46.00	6.54	42.68	
45.00	11.43	30.13	
44.00	17.38	22.08	
43.00	17.44	24.90	-70.0
42.00	18.94	17.51	-39.5
41.00	8.92	14.00	-16.7
40.00	5.81	9.08	-18.0
39.00	6.51	10.55	-20.0
38.00	14.52	5.79	-19.2
37.00	9.51	1.17	-45.0
36.00	.45	6.05	-26.0
35.00	8.55	7.91	-30.6
34.00	1.51	5.26	-55.1
33.00	-2.46	6.55	-58.5
32.00	-4.44	4.80	-40.2
31.00	-8.56	4.45	-45.1
30.00	-4.18	5.96	-41.1
29.00	1.15	5.64	-45.7
28.00	-6.76	5.75	-45.0
27.00	-5.50	4.06	-47.1
26.00	-6.15	-1.59	-48.7
25.00	-7.70	4.57	-51.5
24.00	.51	4.65	-54.9
23.00	.26	4.96	-56.8
22.00	-7.75	2.98	-59.5



METEOROLOGICAL ROCKET SOUNDING DATA

RAJAH AFB, FLORIDA

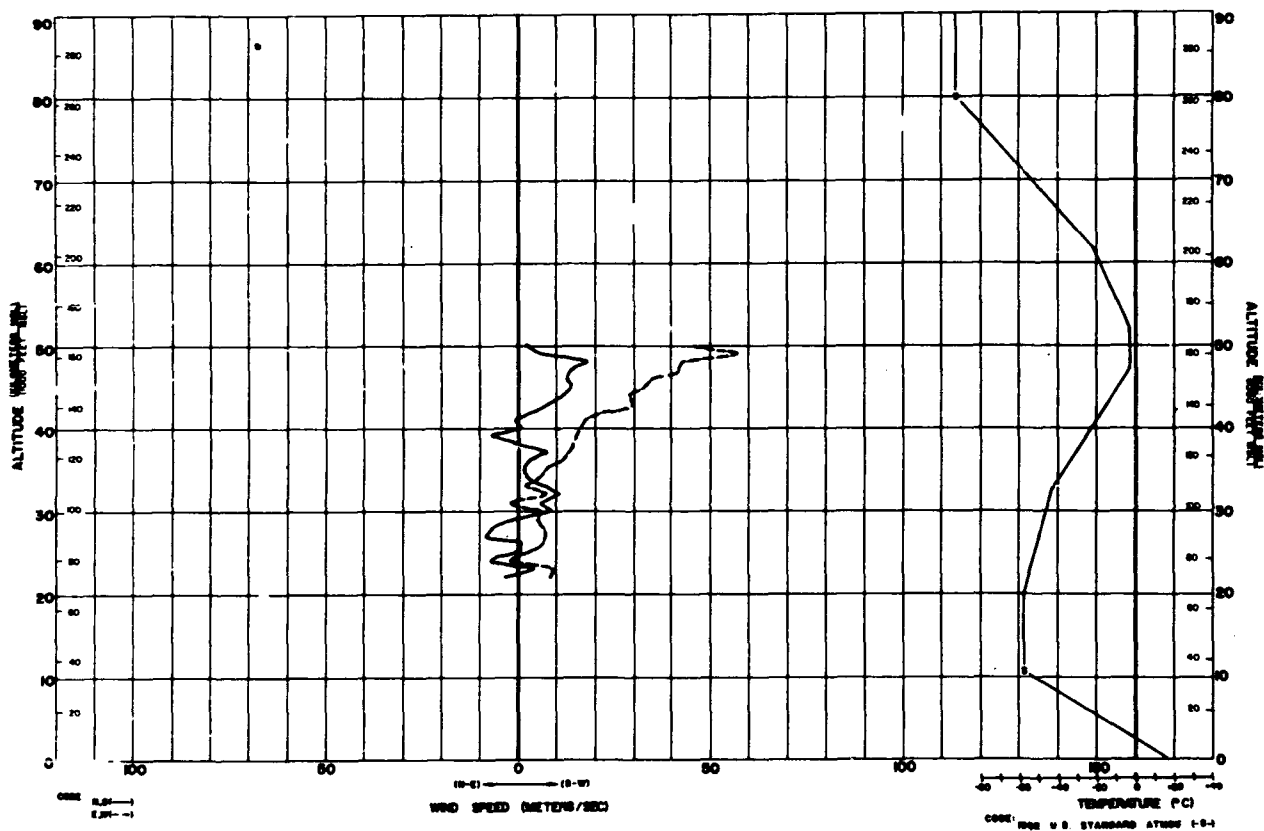
ARCAS 1

7 MARCH 1970

1121 HNW

ARCASOMDE

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49.00	5.85	57.15	
48.00	17.85	42.95	
47.00	13.84	42.25	
46.00	12.94	35.39	
45.00	14.28	33.59	
44.00	12.07	29.25	
43.00	8.57	29.91	
42.00	4.01	22.16	
41.00	-1.18	17.98	
40.00	.19	10.63	
39.00	-6.15	15.13	
38.00	-.08	14.57	
37.00	7.20	13.25	
36.00	3.20	11.63	
35.00	1.73	7.92	
34.00	2.01	5.64	
33.00	6.30	1.91	
32.00	10.21	7.31	
31.00	6.45	-1.35	
30.00	8.08	5.47	
29.00	-1.32	5.01	
28.00	-6.50	6.74	
27.00	-8.56	-3.01	
26.00	.55	6.50	
25.00	.41	4.12	
24.00	-6.94	-1.76	
23.00	4.64	9.46	
22.00	-5.94	9.25	



METEOROLOGICAL ROCKET SOUNDING DATA

WILKIN AFB, FLORIDA

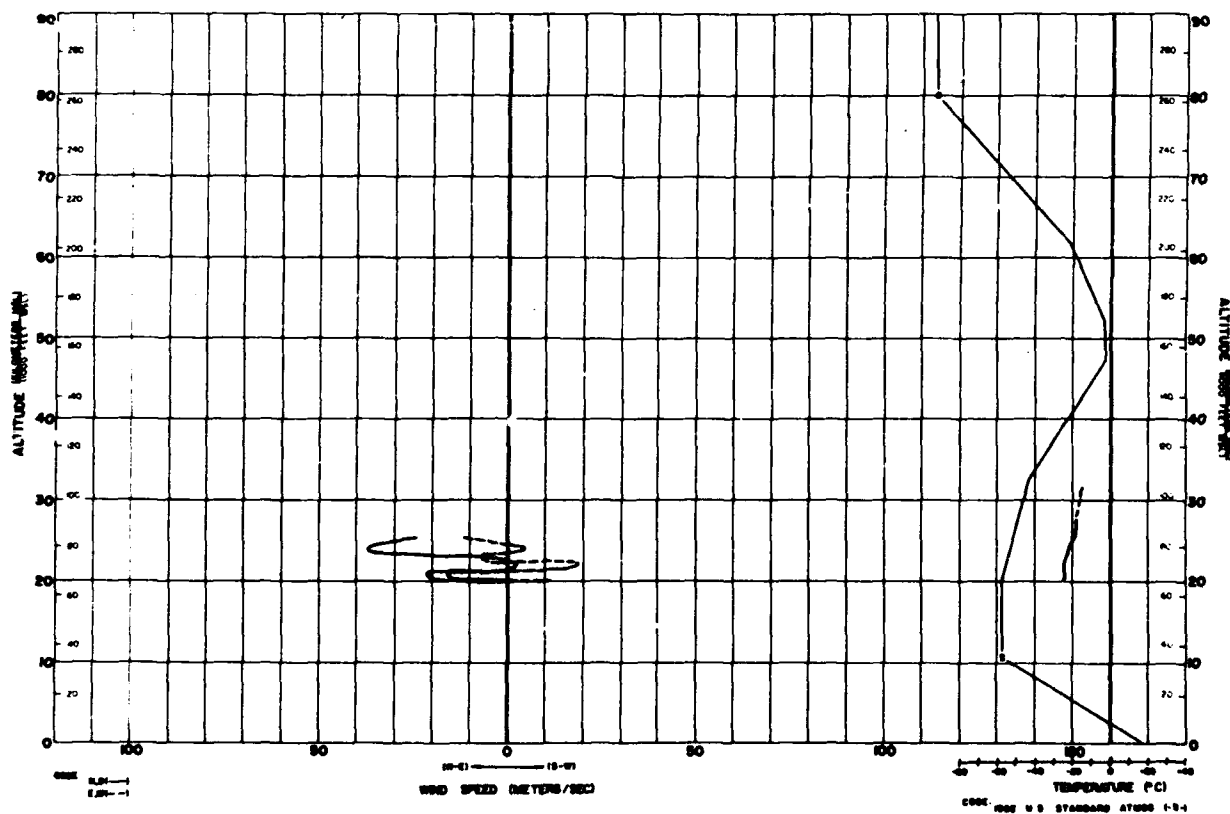
ARCAS 2

7 MARCH 1970

1310.5 HNF

ARCASOMDE

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24.00	-27.35	4.96	-15.3
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22.00	2.84	18.70	-17.2
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METEOROLOGICAL ROCKET SOUNDING DATA

EGLIN AFB, FLORIDA

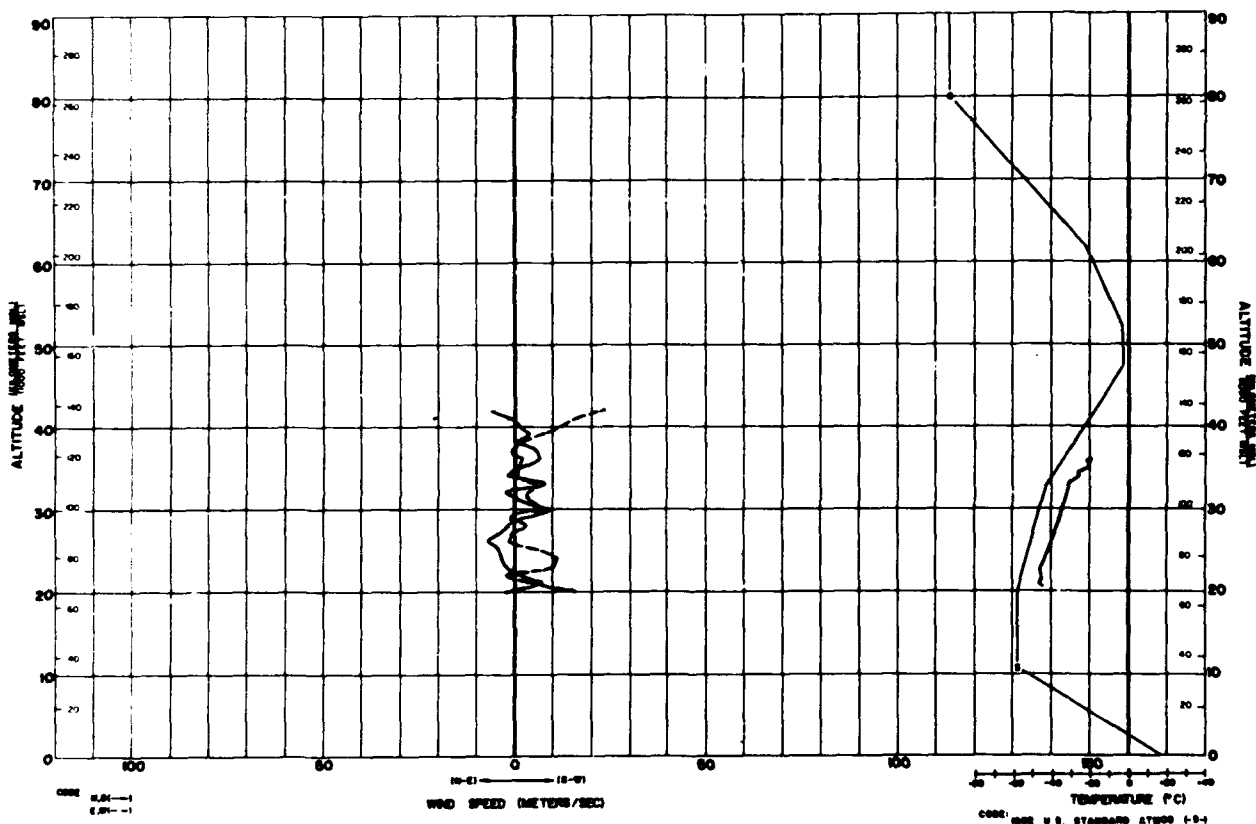
ARCAS 5

7 MARCH 1970

1311.5 EST

ARCASOWDE

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40.00	.86	12.08	
39.00	4.69	7.17	
38.00	.19	1.18	
37.00	5.81	-1.18	
36.00	6.35	1.50	
35.00	2.96	1.17	-20.5
34.00	-1.17	.14	-26.4
33.00	7.79	5.19	-30.5
32.00	-1.98	4.22	-31.9
31.00	.87	4.54	-33.1
30.00	9.25	9.16	-34.7
29.00	4.23	-1.27	-36.2
28.00	-1.12	3.26	-37.8
27.00	-4.12	-1.23	-39.0
26.00	-6.84	-1.71	-40.1
25.00	-4.74	4.42	-41.5
24.00	-5.84	11.78	-42.9
23.00	-2.31	10.16	-45.0
22.00	.63	-2.17	-44.9
21.00	6.97	1.57	-46.5
20.00	-1.58	16.56	



METEOROLOGICAL ROCKET SOUNDING DATA

EGLIN AFB, FLORIDA

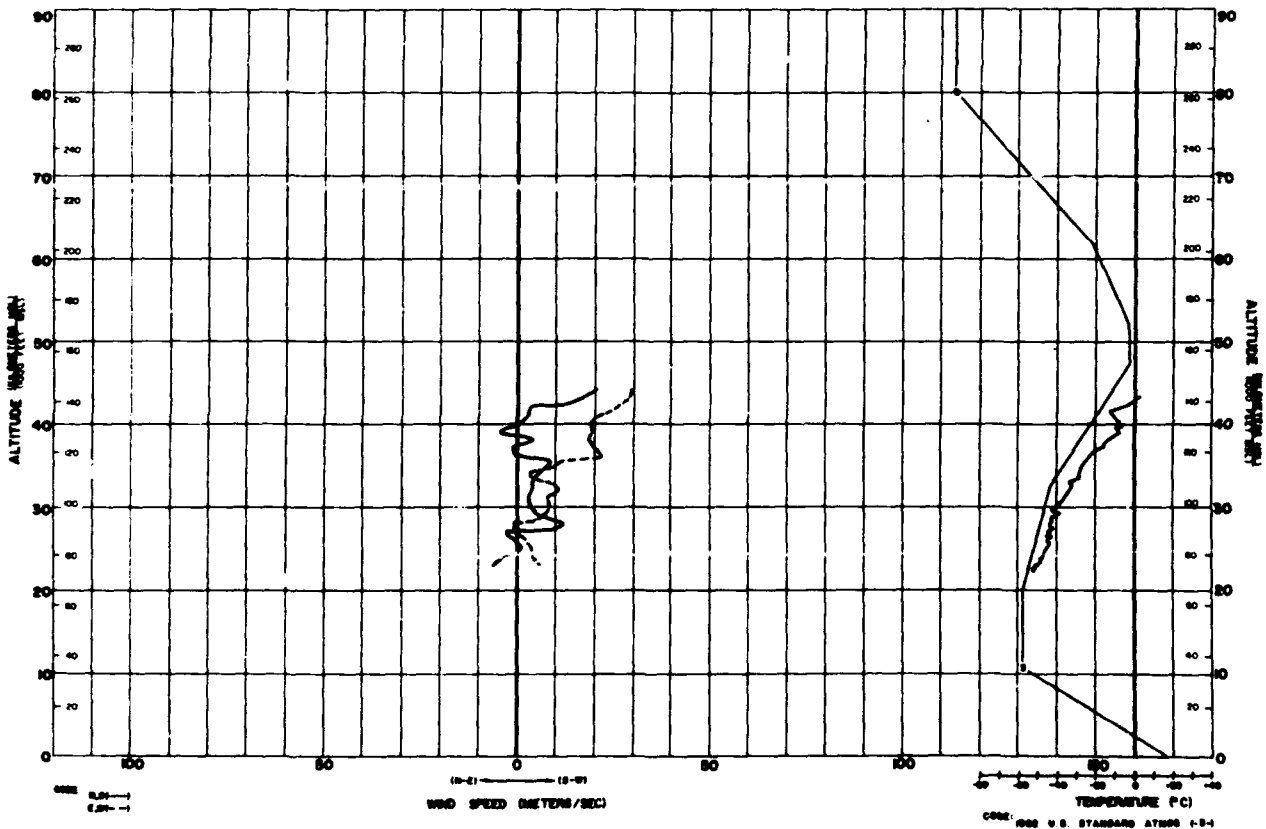
ARCAS 4

7 MARCH 1970

1404 EST

STS-OZONESONDE

ALTITUDE KM	-W + S VELOCITY M/SEC	-S + W VELOCITY M/SEC	TEMPERATURE °C	OZONE O ₃ /KM X 10 ⁻³
42.29	10.00	28.00	-2.3	.95
41.84	3.35	24.02	-7.0	1.38
42.42	3.20	18.00	-11.9	1.87
40.98	2.25	11.80	-10.5	2.34
40.56	2.75	10.10	-8.8	3.21
40.16	2.05	9.51	-8.0	5.00
39.76	.00	9.06	-8.0	7.39
39.37	-1.95	9.15	-9.0	9.89
38.99	-4.30	9.12	-8.1	13.00
38.62	-3.90	9.00	-8.7	14.42
38.25	1.00	8.58	-11.5	16.19
37.91	4.00	8.50	-14.4	16.53
37.57	2.00	8.85	-16.0	15.43
37.40	1.61	9.02	-16.4	14.09
37.24	.50	9.42	-16.3	12.59
36.91	-9.96	9.95	-16.0	6.11
36.72	-9.98	10.00	-17.9	7.05
36.59	-9.99	9.31	-20.9	6.38
36.29	-8.80	10.97	-22.2	4.37
35.99	-9.48	11.15	-23.0	3.23
35.55	2.60	8.94	-24.9	2.82
35.12	5.85	6.00	-25.0	3.01
34.70	7.75	4.59	-26.0	4.81
34.28	6.70	3.60	-27.3	8.39
33.88	5.50	3.30	-27.7	7.15
33.49	5.00	3.05	-27.8	4.97
33.12	4.86	4.00	-27.5	5.16
32.77	4.18	5.36	-32.5	7.45
32.11	4.05	8.80	-31.7	12.63



METEOROLOGICAL ROCKET SOUNDING DATA

EGLIN AFB, FLORIDA

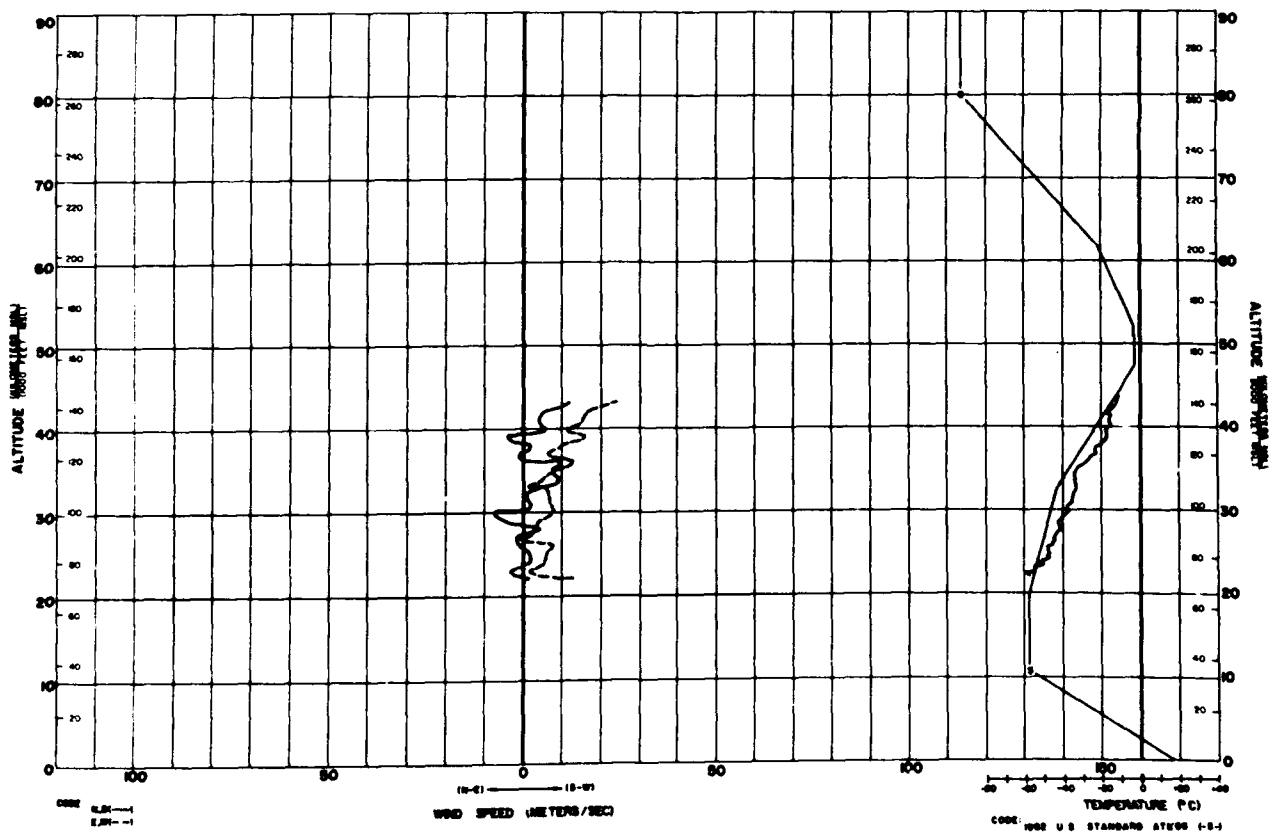
ARCAS 5

7 MARCH 1970

1600 EST

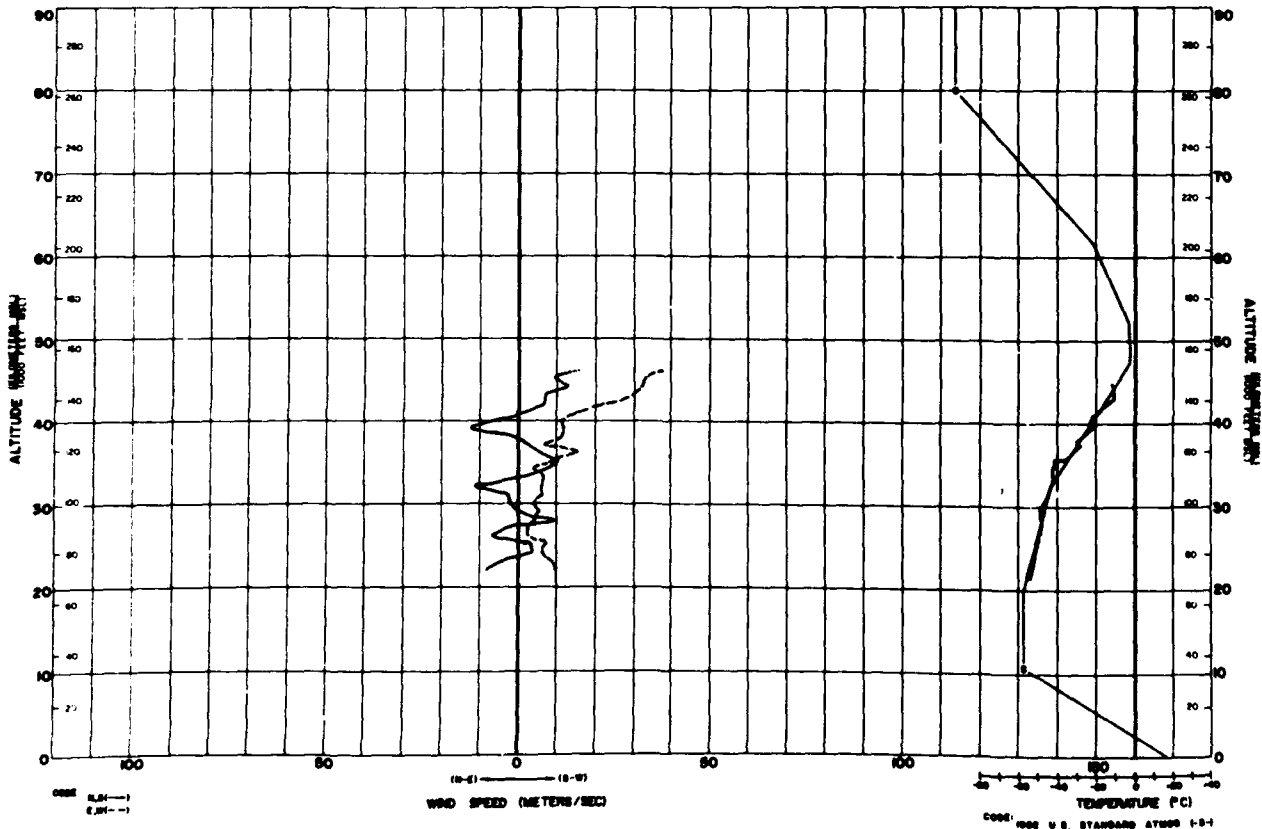
ARCASOWDE

ALTITUDE KM	-H +S VELOCITY M/SEC	-E +W VELOCITY M/SEC	TEMPERATURE °C
45.00	11.51	24.19	-11.7
42.00	5.04	17.04	-14.9
41.00	4.48	15.09	-16.2
40.00	5.65	11.64	-16.7
39.00	4.05	15.53	-17.8
38.00	.79	11.74	-20.0
37.00	-36	7.21	-21.0
36.00	9.07	13.55	-25.6
35.00	7.94	8.72	-30.0
34.00	9.78	5.16	-34.9
33.00	5.04	1.73	-35.9
32.00	.05	6.32	-35.7
31.00	1.28	6.96	-35.0
30.00	-7.53	7.28	-38.0
29.00	-4.96	4.86	-40.1
28.00	4.28	2.65	-41.5
27.00	-2.46	-1.27	-42.1
26.00	-2.16	7.17	-43.0
25.00	1.27	6.74	-47.2
24.00	1.51	5.80	-49.0
23.00	-5.27	2.51	-50.0
22.00	.93	13.33	-57.8



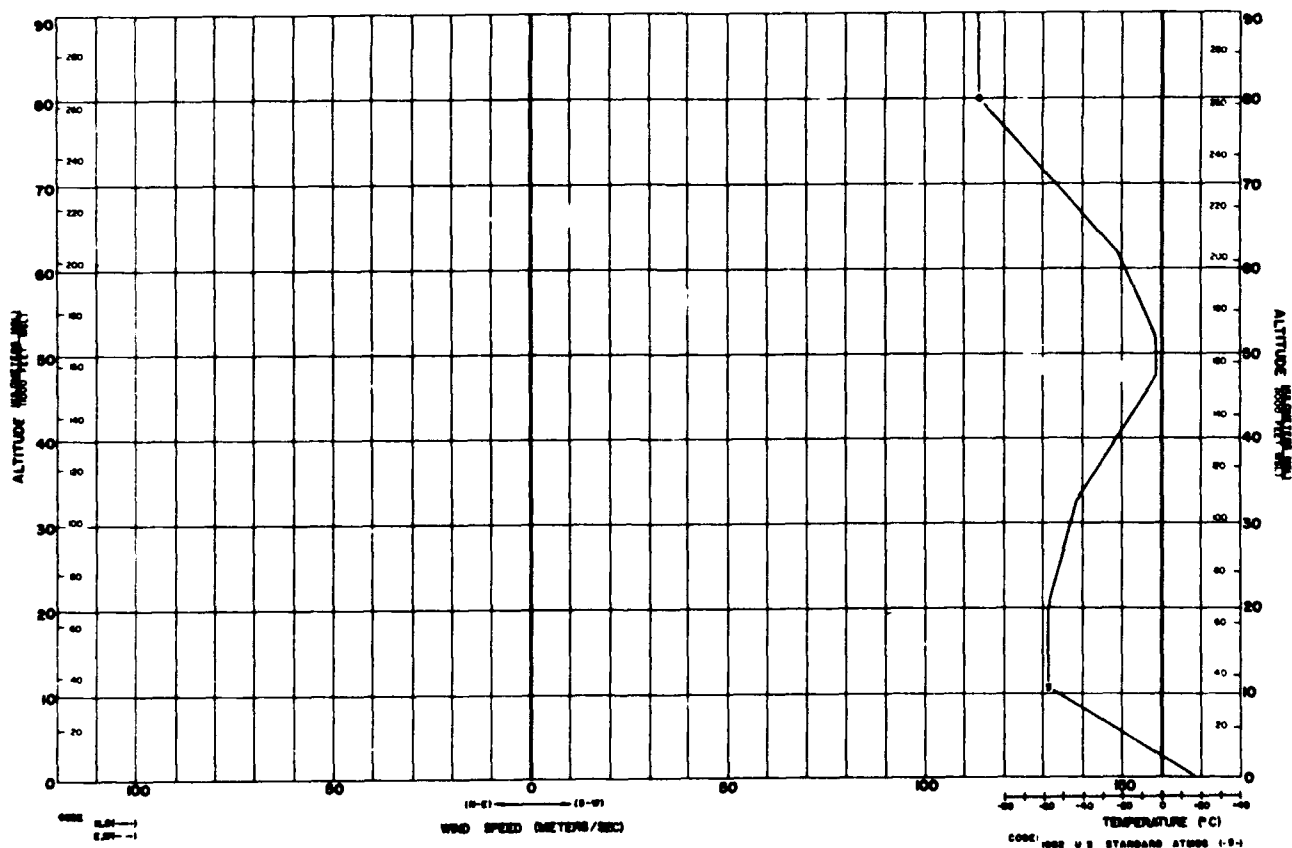
METEOROLOGICAL ROCKET SOUNDING DATA

RAJIN APB, FLORIDA	ARCAS 6	7 MARCH 1970	1815 HRP	STS-OZONESONDE
ALTITUDE KM	-E + S VELOCITY M/SEC	-E + W VELOCITY M/SEC	TEMPERATURE °C	OZONE cm ² /km x 10 ⁻⁸
44.31	12.05	33.19	-11.0	5.02
44.00	13.15	32.98	-11.0	5.18
43.69	12.69	32.50	-10.9	5.18
43.39	10.50	31.01	-10.8	5.14
43.09	8.85	30.14	-10.8	5.06
42.81	7.25	29.00	-10.7	4.80
42.52	7.20	25.00	-12.9	5.18
42.25	7.19	23.02	-14.0	5.36
41.98	7.00	21.30	-16.0	5.44
41.71	6.00	20.00	-17.0	5.85
41.45	4.10	18.03	-19.0	6.22
41.19	3.19	17.00	-20.2	6.68
40.69	.11	15.00	-21.8	7.12
40.20	-4.30	12.99	-22.4	10.12
39.75	-8.56	12.25	-22.1	12.26
39.28	-11.58	12.76	-21.6	14.21
38.98	-12.30	12.95	-23.0	15.11
38.84	-11.96	12.90	-24.0	15.11
38.41	-8.09	12.87	-26.0	14.14
37.99	-2.00	12.66	-28.7	11.44
37.58	1.99	11.00	-29.3	7.65
37.20	1.99	9.10	-29.0	7.24
36.82	2.87	7.30	-31.0	7.58
36.45	3.75	10.50	-35.4	9.26
36.10	4.25	11.89	-37.5	10.80
35.75	5.23	14.25	-39.0	12.38
35.42	7.01	11.61	-40.7	15.00
35.08	9.13	9.13	-41.1	15.94
34.76	9.85	8.00	-41.6	17.66
34.45	9.00	6.25	-42.0	19.58
34.22	8.50	5.00	-42.4	20.70
33.92	7.00	4.10	-42.1	21.75
33.65	5.51	4.75	-42.0	22.28
33.28	7.21	6.25	-44.4	22.50
32.95	-1.85	7.29	-42.0	20.96
32.62	-2.75	6.99	-42.8	18.08
32.30	-6.90	6.29	-44.5	17.44
31.98	-11.00	6.30	-44.9	17.74
31.67	-9.50	6.52	-45.3	17.62
31.38	-6.00	6.50	-45.6	02



ARCAS 6 7 MARCH 1970
(CONTINUED)

ALTITUDE KM	-W + S VELOCITY M/SEC	-E + V VELOCITY M/SEC	TEMPERATURE °C	OZONE O ₃ /km X 10 ⁻³
31.09	-3.79	6.50	-46.1	16.09
30.54	-3.32	5.11	-46.9	15.52
30.00	-3.28	4.57	-47.9	14.70
29.50	-1.85	5.09	-48.8	13.99
29.03	-1.27	5.75	-48.4	13.16
28.58	4.00	5.80	-48.8	11.59
28.14	8.20	4.92	-48.0	10.35
27.70	9.00	3.90	-48.3	9.56
27.27	3.93	3.93	-48.4	9.82
26.66	-3.98	2.50	-49.0	10.42
25.76	-4.00	2.75	-49.9	9.45
25.10	2.00	5.32	-50.4	11.10
24.45	3.13	6.90	-51.3	9.79
23.85	3.20	6.25	-51.7	9.15
23.28	-2.60	7.21	-52.0	8.96
22.57	-5.96	8.99	-52.1	12.15
21.89			-52.9	11.62



METEOROLOGICAL ROCKET SOUNDING DATA

MILIN AFB, FLORIDA

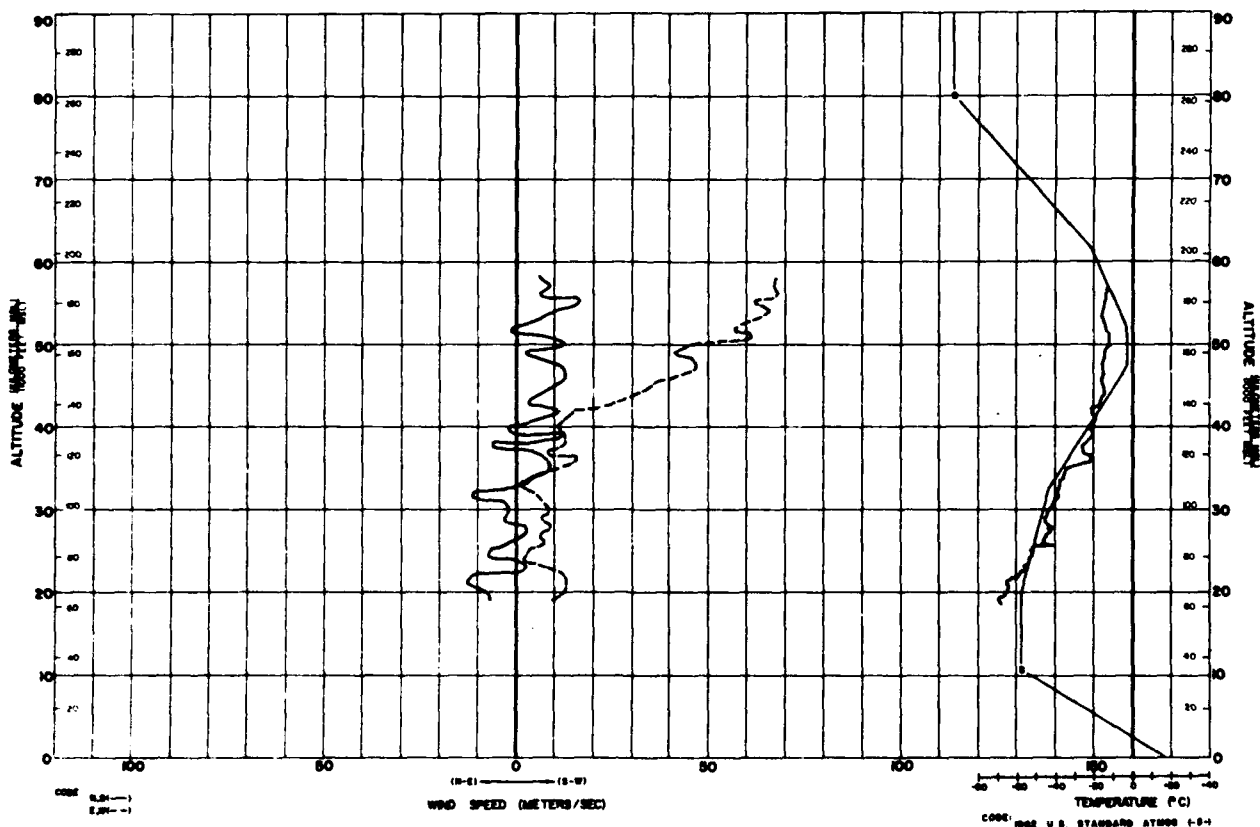
ARCAS 7

7 MARCH 1970

1800 HRT

ARCASOMDE

ALTITUDE KM	-U + S VELOCITY M/SEC	-E + W VELOCITY M/SEC	TEMPERATURE °C
58.00	5.61	67.91	
57.00	9.15	67.26	
56.00	5.90	67.56	-14.1
55.00	15.92	62.49	-14.7
54.00	10.98	65.18	-14.8
53.00	6.67	61.06	-15.6
52.00	-2.24	56.10	-14.0
51.00	5.62	60.51	-12.3
50.00	12.68	45.00	-11.7
49.00	2.19	40.80	-13.1
48.00	7.28	45.59	-14.9
47.00	13.29	46.41	-15.0
46.00	13.69	40.90	-15.3
45.00	10.29	35.41	-15.3
44.00	7.60	32.29	-14.6
43.00	4.38	26.21	-16.7
42.00	11.28	15.02	-20.5
41.00	7.21	12.97	-19.8
40.00	-6.60	10.13	-20.8
39.00	-11.52	11.89	-20.6
38.00	-5.29	12.61	-23.1
37.00	5.98	8.66	-26.4
36.00	7.81	15.24	-22.8
35.00	9.26	13.64	-30.0
34.00	5.41	5.04	-36.0
33.00	3.09	.96	-38.2
32.00	-10.29	3.94	-38.4
31.00	-4.09	6.40	-39.6
30.00	-2.17	8.92	-43.0
29.00	-3.41	7.21	-44.1
28.00	1.28	9.38	-42.1
27.00	1.28	6.38	-43.6
26.00	-7.79	7.02	-45.4
25.00	-6.46	4.47	-51.5
24.00	-5.18	1.79	-52.2
23.00	3.49	7.56	-55.2
22.00	-10.45	13.07	-57.7
21.00	-12.76	13.97	-64.8
20.00	-7.19	13.52	-64.3
19.00	-6.89	14.54	-69.3



METEOROLOGICAL ROCKET SOUNDING DATA

WGLIN AFB, FLORIDA

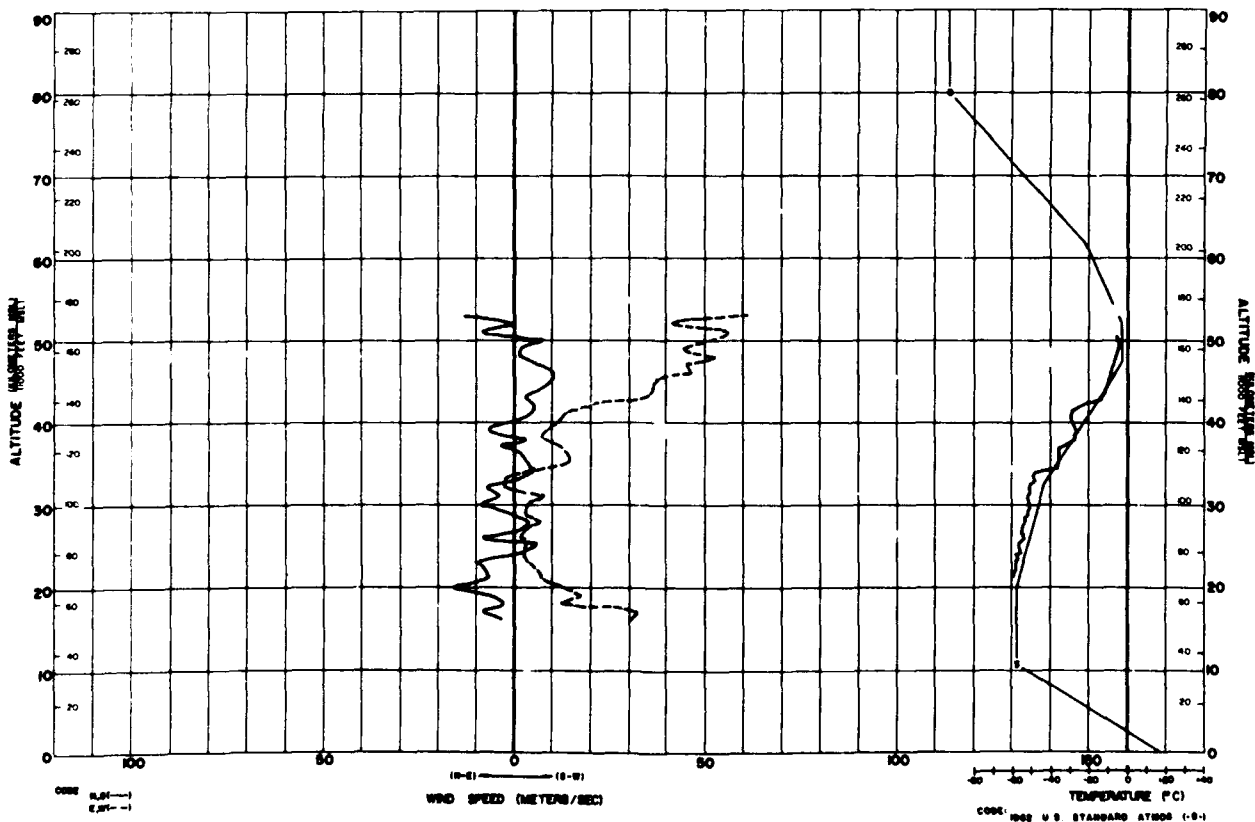
ARCAS 8

7 MARCH 1970

2015

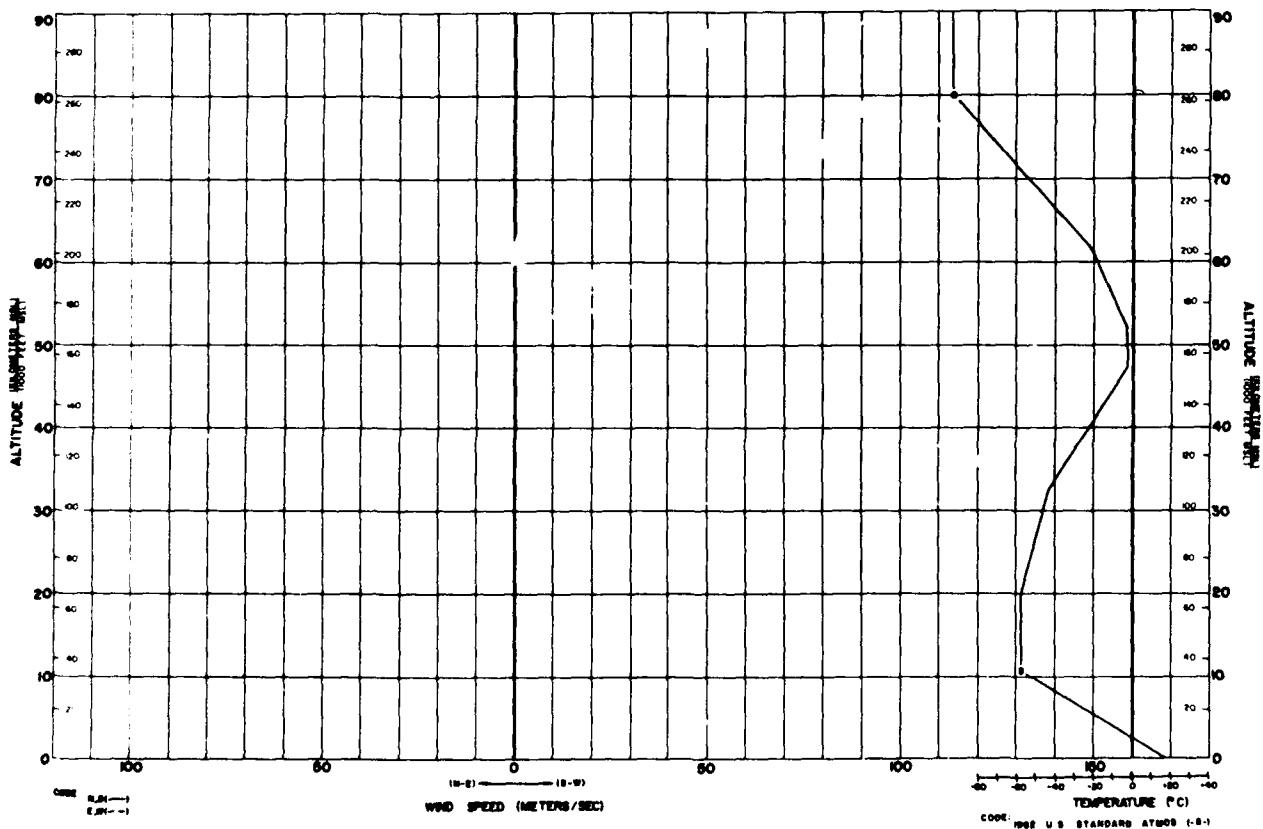
STS-OZONESONDE

ALTITUDE KM	-N + S VELOCITY M/SEC	-E + W VELOCITY M/SEC	TEMPERATURE °C	OZONE O ₃ /KM X 10 ⁻³
49.71	5.95	49.48	-4.1	.35
49.35	2.27	46.91	-4.0	.49
49.00	1.54	44.95	-4.0	.58
48.66	1.25	47.00		.70
44.75	9.48	37.51		1.48
44.21	8.12	36.75		1.60
43.70	6.78	36.10	-12.2	1.83
43.22	4.11	35.11	-14.0	2.09
42.75	4.00	32.66	-15.5	2.46
42.50	5.13	26.00	-19.0	2.78
41.85	5.56	18.24	-22.5	3.22
41.42	5.00	15.14	-26.5	3.77
41.00	4.78	14.00	-29.2	4.26
40.60	5.11	12.98	-29.4	4.84
40.20	1.00	12.11	-29.0	5.39
39.82	-2.00	11.10	-28.6	5.08
39.44	-4.12	10.09	-27.9	5.89
39.07	5.99	9.91	-27.5	5.94
38.70	6.14	8.84	-27.0	6.06
38.35	-1.00	8.00	-27.2	6.21
38.00	5.17	7.83	-27.7	6.35
37.67	1.31	8.12	-29.1	6.44
37.56	-1.85	10.53	-31.2	6.61
37.05	-3.00	10.98	-34.4	6.50
36.74	-5.00	13.00	-35.0	6.55
36.44	-4.47	14.00	-35.0	6.44
36.15	1.13	14.44	-34.8	6.15
35.88	2.00	14.72	-34.9	6.15
35.42	2.72	14.85	-35.7	6.26
35.00	5.00	14.91	-36.3	6.52
34.58	5.92	13.00	-36.6	6.87
34.18	4.98	6.12	-40.7	7.68
33.80	4.77	5.98	-44.5	6.84
33.44	2.97	.72	-48.8	6.61
33.08	2.00	-1.97	-49.1	8.82
32.74	-1.11	-2.47	-50.0	5.94
32.06	-7.10	-2.45	-50.5	5.51
31.55	-6.00	1.54	-50.1	10.90
30.99	-3.98	7.41	-50.6	9.63
30.41	-7.00	4.43	-51.0	19.72



ARCAS 8 7 MARCH 1971
(CONTINUED)

ALTITUDE KM	N + S VELOCITY M/SEC	E + W VELOCITY M/SEC	TEMPERATURE °C	Ozone cmO ₃ /km X 10 ⁻³
29.64	-7.11	5.91	-51.0	12.99
28.95	-7.95	4.12	-51.0	19.05
28.57	5.00	6.55	-50.6	15.34
27.85	4.14	6.74	-50.8	19.00
27.16	1.15	4.17	-53.8	16.21
26.95	-1.12	5.05	-54.0	19.78
26.77	-1.84	2.98	-54.0	14.44
26.42	-4.18	1.98	-55.5	21.69
26.00	-7.82	1.80	-55.5	20.59
25.62	-6.28	1.99	-55.1	21.95
25.48	-2.00	2.16	-55.5	20.91
25.25	5.00	2.46	-56.2	21.37
24.90	5.79	5.00	-57.0	18.44
24.55	2.84	5.92	-56.7	22.21
24.11	1.51	4.18	-56.5	20.27
24.01	1.00	4.25	-56.5	21.05
23.50	-5.96	5.09	-57.1	19.26
23.09	-9.00	5.99	-57.4	14.18
22.95	-9.61	6.18	-57.7	15.46
22.41	-8.15	7.10	-58.0	12.99
22.05	-7.50	7.63	-58.0	16.38
21.54	-7.21	9.11	-58.8	16.65
21.50	-6.52	11.56	-58.8	15.30
21.14	-6.25	11.98	-58.9	17.37
20.97	-6.52	14.00	-58.9	16.12
20.29	-11.71	14.56		17.78
19.66	-12.97	16.72		21.20
19.29	-8.00	15.91		28.30
19.14	-7.14	15.00		25.61
18.97	-6.00	12.80		27.96
18.44	-5.64	24.11		17.20
18.15	-4.91	29.85		22.59
17.72	-4.00	32.00		25.08
17.41	-6.45	31.05		17.63
16.65	-6.00			10.15
16.36	-4.51			15.98



METEOROLOGICAL ROCKET SOUNDING DATA

EGLE AFB, FLORIDA

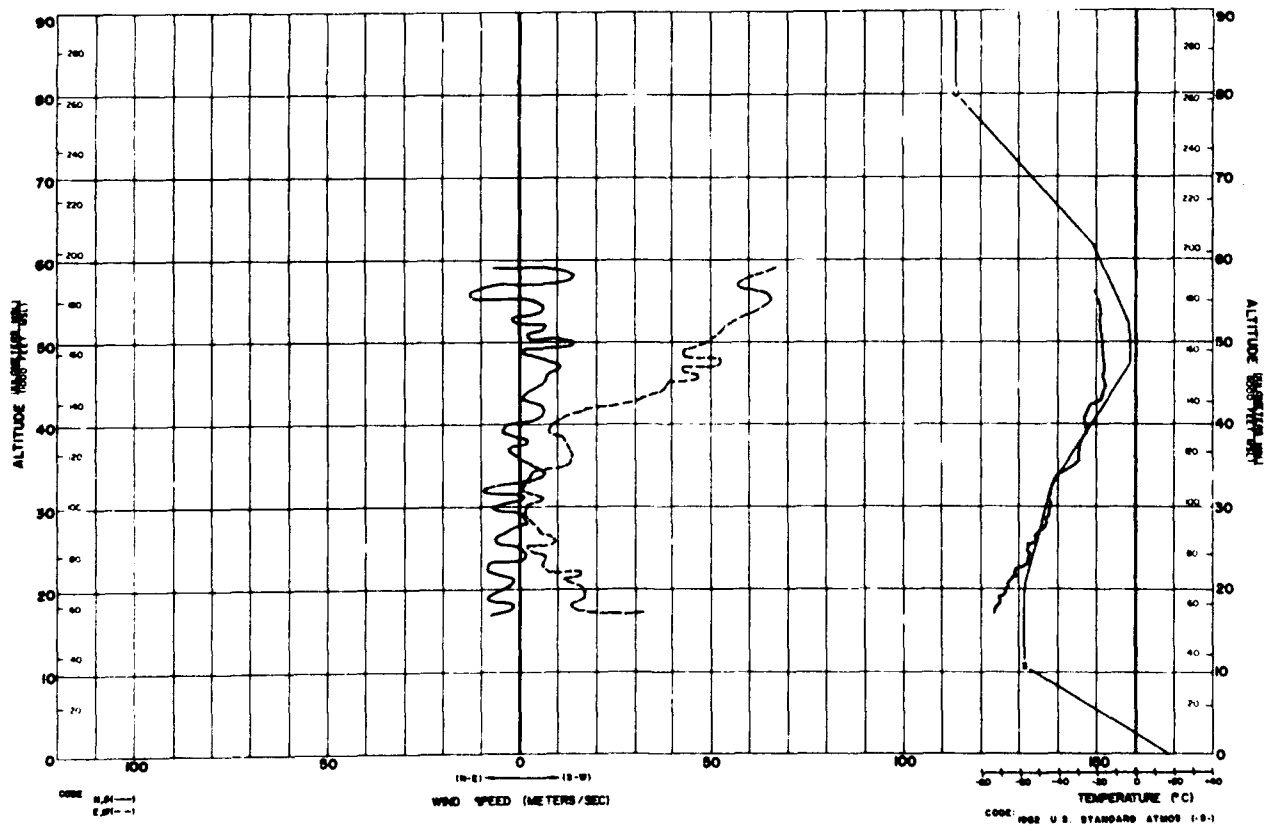
ARCAS 9

1 MARCH 1970

2020 1897

ARCASONDE

ALTITUDE KM	-H + S VELOCITY M/SEC	-E + W VELOCITY M/SEC	TEMPERATURE °C
59.00	-7.57	67.96	
58.00	14.45	66.24	
57.00	-4.03	57.08	
56.00	-13.60	62.20	
55.00	1.70	65.28	-19.1
54.00	5.61	65.17	-18.0
53.00	-1.47	64.66	-17.1
52.00	6.36	64.00	-17.3
51.00	2.51	61.04	-17.1
50.00	14.35	48.25	-16.7
49.00	.43	43.58	-16.3
48.00	5.43	51.68	-16.0
47.00	10.07	43.78	-15.9
46.00	7.88	46.03	-15.9
45.00	6.00	39.96	-16.0
44.00	1.40	57.29	-16.0
43.00	.04	30.87	-18.0
42.00	5.86	17.49	-24.5
41.00	5.34	12.77	-25.5
40.00	-2.42	8.53	-26.0
39.00	-4.69	7.50	-25.2
38.00	1.27	11.34	-27.0
37.00	-2.27	12.53	-28.9
36.00	-1.18	14.19	-29.0
35.00	2.84	13.07	-31.0
34.00	6.61	5.38	-38.0
33.00	.50	.97	-41.8
32.00	-9.67	.01	-45.1
31.00	.61	6.07	-44.1
30.00	-6.73	2.56	-45.1
29.00	.31	.73	-44.6
28.00	1.23	4.53	-46.2
27.00	-3.36	5.09	-49.0
26.00	-5.79	9.23	-50.6
25.00	-2.24	2.16	-55.0
24.00	.94	7.05	-55.0
23.00	-8.04	6.85	-55.9
22.00	-7.55	15.83	-61.8
21.00	-1.47	11.79	-64.8
20.00	-12.97	15.84	-66.0
19.00	-8.97	16.17	-70.5
18.00	-1.95	14.13	-70.5
17.00	-6.03	31.88	-72.9



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1. ORIGINATING ACTIVITY (Corporate author) Atmospheric Sciences Laboratory White Sands Missile Range, New Mexico		2a. REPORT SECURITY CLASSIFICATION Unclassified	
		2b. GROUP	
3. REPORT TITLE METEOROLOGICAL INFLUENCE OF A SOLAR ECLIPSE ON THE STRATOSPHERE			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates)			
5. AUTHOR(S) (First name, middle initial, last name) J. S. Randhawa M. D. Kays B. H. Williams			
6. REPORT DATE December 1970		7a. TOTAL NO. OF PAGES 36	7b. NO. OF REFS 13
8a. CONTRACT OR GRANT NO.		8b. ORIGINATOR'S REPORT NUMBER(S) ECOM-5345	
a. PROJECT NO.			
c. DA Task No. IT061102B53A-18		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.			
10. DISTRIBUTION STATEMENT This document has been approved for public release and sale; its distribution is unlimited.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY U. S. Army Electronics Command Fort Monmouth, New Jersey	
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