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EXTREME ATMOSPHERE MODELS, 1973

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HOUSTON, TEXAS 77058

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16 Abstract

The results of a study that used radiosonde soundings to select the extreme atmospheric conditions in the continental United States are presented.

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EXTREME ATMOSPHERE MODELS, 1973

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EXTREME ATMOSPHERE MODELS, 1973

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SUMMARY

In planning any remote-sensing experiment, it is desirable to know the range of atmospheric conditions that may occur. This report presents the results of a study that used radiosonde soundings to select the extreme atmospheric conditions in the continental United States.

INTRODUCTION

In analyzing all Earth resources data obtained by remote-sensing techniques, the effect of the atmosphere between the target and the sensor must be considered. The atmospheric effect is dependent on the meteorological conditions (i.e., pressure, humidity, aerosol content, etc.) existing at the time the observations are made and on the wavelength of the observations. Therefore, in planning remote-sensing experiments or devising new instruments or techniques to account for the atmospheric effect, it is desirable to know the extreme range of conditions that might occur so that an adequate assessment of the effects can be made.

This report describes an effort to determine the extreme cases of meteorological conditions over the United States. Selections of extreme conditions were made from National Weather Service radiosonde reports on the basis of water content and temperature structure of the atmosphere. Cases were chosen for conditions of hot/dry, cold/dry, hot/wet, and cold/wet with other cases chosen for location of the water in the atmosphere. A computer model of the atmosphere was then used to evaluate attenuation effects of the air.

The "U.S. Standard Atmosphere Supplements, 1966" (ref. 1) was also processed by the same computer model as a comparison with measured conditions. These models are average conditions for latitude regions of 15° N, 30° N, 45° N, 60° N, and 75° N and for the seasons of summer and winter. These models were evaluated in conjunction with the extreme cases because they are often used in that capacity and are readily available in most laboratories.

SELECTION OF CASES

Radiosonde reports for the continental United States were obtained from the Space Flight Meteorology Group, National Oceanic and Atmospheric Administration (NOAA), for the period June 1972 through February 1973. During this period, test dates were selected at intervals of approximately 5 days. The reports from the selected data were then visually scanned for evidence of possible extreme conditions at any of the reporting stations.

The National Severe Storms Laboratory, NOAA, provided radiosonde data for central Oklahoma. These data points represented severe weather conditions for May and June 1966 and May 1968.

The reported data for the selected stations were integrated with a calculator program written to compute the precipitable water in the air. Extreme cases were selected on the basis of calculator output because water vapor is a highly variable constituent of the lower atmosphere and has a large attenuation effect in many spectral regions (figs. 1 to 4).

PRECIPITABLE WATER CALCULATIONS

Precipitable water is defined as the amount of water that can be precipitated out of a column of air between two layers. By designating the two layers as a and b (where $b > a$), precipitable water may be calculated by the method described in reference 2 of

$$\text{precipitable water} = \frac{1}{\rho_{\text{liquid}}} \int_a^b \rho r \, dz \tag{1}$$

where ρ_{liquid} is the density of liquid water, ρ is the density of the ambient atmosphere, r is the mixing ratio of water in the air (grams/kilogram), and z is the altitude. By using the hydrostatic equation

$$\frac{\partial P}{\partial z} = -\rho G \tag{2}$$

where P is pressure and G is acceleration due to gravity, equation (1) can be simplified by

$$\text{precipitable water} = -\frac{1}{G} \int_{P_a}^{P_b} r \, dP \tag{3}$$

Assuming r to be a constant, $\bar{r}$, over the interval P_a to P_b

$$\text{precipitable water} \approx \frac{(P_a - P_b)\bar{r}}{G} \tag{4}$$

At a given level, the mixing ratio (ref. 3) can be approximated by

$$r = \frac{0.62197e}{P - e} \times 10^3 \frac{g}{kg} \tag{5}$$

where P is the atmospheric pressure at the level and e is the vapor pressure of water, which can be estimated (ref. 2) by the empirical formula

$$e = 6.11 \times 10^{\left(7.5T_d/T_d+237.3\right)} \tag{6}$$

where T_d is the dewpoint temperature in degrees Celsius.

Thus, the precipitable water can be calculated by using pressure and dewpoint temperature as input data. This information is obtained from radiosonde data for levels of the atmosphere to 10 kilometers or above for 0000 G.m.t. and 1200 G.m.t. for approximately 80 stations in the United States.

A calculator was programed to accept pressure, temperature, and dewpoint depression (from radiosonde readings) as input data. Precipitable water in centimeters (between layers and summed for the entire atmosphere) was fed to a typewriter unit.

RESULTS

The extreme cases, chosen by the method described earlier, are given in table I. The column headed "Precipitable water" gives the total amount in centimeters of precipitable water in the atmosphere between the ground level and the highest level for which dewpoint information was provided by the radiosonde reports. Appendix A gives the complete calculator output for these cases and the radiosonde data from which calculations were made. The same information is provided for the severe storm cases in table II and appendix B. These data are included because the maximum potential instability that these cases represent occurs when the lower atmosphere is wet and hot and the upper atmosphere is cold and dry. Conditions behind the front are moderate in water content.

Table III is a summary of the calculator output for the standard atmospheres for purposes of comparison. It presents the averages of theoretical measurements. Appendix C gives the input and complete output for these cases. The input was made to conform to the format of the radiosonde readings.

CONCLUDING REMARKS

The range of water content for the extreme atmosphere cases was 0.131 to 5.85 centimeters, whereas the "U.S. Standard Atmosphere Supplements, 1966" provided a range of 0.214 to 4.376 centimeters and the severe storm cases provided a range of 1.769 to 3.2 centimeters.

It is hoped that the extreme atmospheric conditions discussed in this report will allow an accurate assessment of the effect of water content variation in the atmosphere on atmospheric transmission.

Lyndon B. Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas, February 26, 1974
951-16-00-00-72

REFERENCES

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2. Saucier, Walter J.: Principles of Meteorological Analysis. University of Chicago Press, 1955.

3. List, Robert J., ed.: Smithsonian Meteorological Tables. Sixth ed., Vol. 114 of Smithsonian Misc. Collections, Pub. 4014, Smithsonian Institution, 1966.

TABLE I.- EXTREME CASES

Date	Time, G.m.t.	Station	Surface temperature, °C	Surface dewpoint, °C	Precipitable water, cm	Comments
July 17, 1972	0000	Key West, Fla.	28.4	25.6	5.851	High moisture in lower levels (below 850 mbar)
Sept. 5, 1972	0000	Lake Charles, La.	28.8	24.1	5.30	High moisture in middle levels (approximately 800 mbar), surface temperature inversion
Oct. 20, 1972	1200	Brownsville, Tex.	22.6	19.9	4.793	High moisture in lower levels (below 850 mbar), surface temperature inversion
Nov. 10, 1972	1200	Boothville, La.	31.4	29.7	4.003	High extreme surface dewpoint, temperature inversion at 750 mbar
Dec. 10, 1972	1200	New York, N.Y.	-7.7	-7.7	3.377	High level moisture (550 to 880 mbar)
June 30, 1972	0000	Tucson, Ariz.	39.4	-7.6	1.278	High extreme surface temperature
Jan. 10, 1973	1200	Caribou, Maine	-34.5	-38.6	.276	Low extreme surface temperature and dewpoint at surface and 800 mbar
Jan. 30, 1973	1200	Albany, N.Y.	-16.3	-27.3	.202	Low surface moisture and maximum moisture at 850 mbar
Dec. 5, 1972	1200	Ely, Nev.	-22.3	-24.6	.166	Low surface moisture and maximum moisture at 700 mbar, surface temperature inversion
Jan. 10, 1972	1200	Rapid City, S. Dak.	-19.5	-28.5	.131	Low moisture at 750 and 500 mbar, surface temperature inversion

TABLE II.- SEVERE STORM CASES

Date	Time, G.m.t.	Station	Surface temperature, °C	Surface dewpoint, °C	Precipitable water, cm	Comments
May 15, 1968	1701	Rush Springs, Okla.	25.8	22.3	3.028	Before dry line passage
May 15, 1968	1801	Ft. Sill, Okla.	28.8	15.8	1.912	During dry line passage
May 15, 1968	1900	Hinton, Okla.	27.4	13.4	2.263	After dry line passage
June 8, 1966	1648	Chickasha, Okla.	28.2	15.2	2.809	Ahead of front
June 8, 1966	2000	Cordell, Okla.	33.0	2.0	1.857	Behind front
June 5, 1966	2000	Tinker AFB, Okla.	30.2	11.2	2.044	Before front
June 9, 1966	1700	Pauls Valley, Okla.	17.4	7.4	3.200	Behind front
May 24, 1966	1700	Sheppard AFB, Tex.	24.4	4.4	1.769	Behind front (overrunning)

TABLE III.- STANDARD ATMOSPHERES

Month	North latitude, deg.	Surface temperature, °C	Surface dewpoint, °C	Precipitable water, cm
Annual[a]	15	26.5	21.8	4.067
July	30	28.0	24.3	4.376
January	30	14.0	10.6	2.272
July	45	21.0	16.5	2.972
January	45	-1.0	-4.5	.854
July	60	14.0	9.7	2.115
January	60	-16.0	-18.6	.417
July	75	5.0	2.7	1.540
January	75	-24.0	-26.4	.214

[a]Theoretical measurement was calculated only once for the equatorial region.

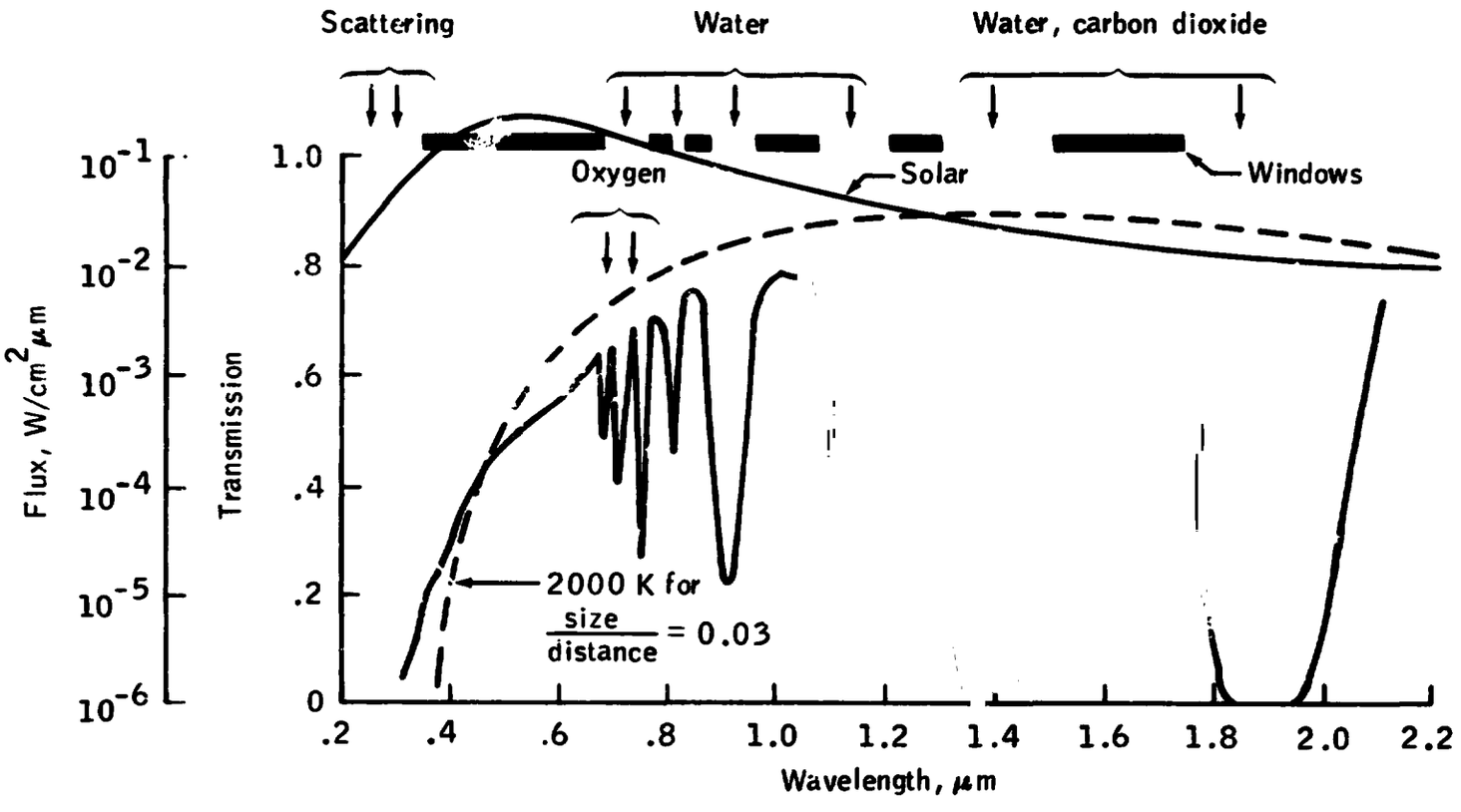

Figure 1.- Atmospheric transmission along a vertical path of two airmasses.

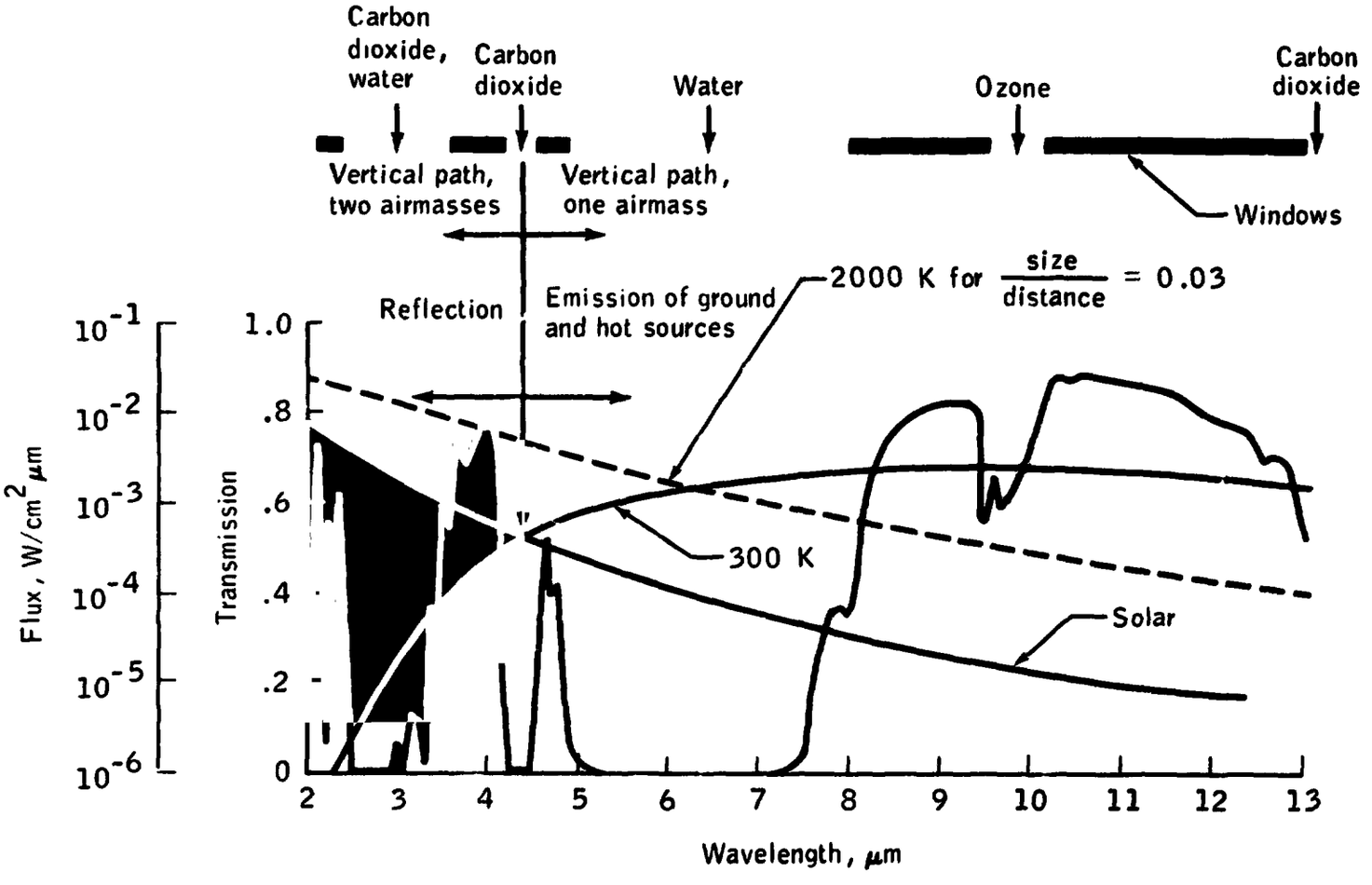

Figure 2.- Atmospheric transmission.

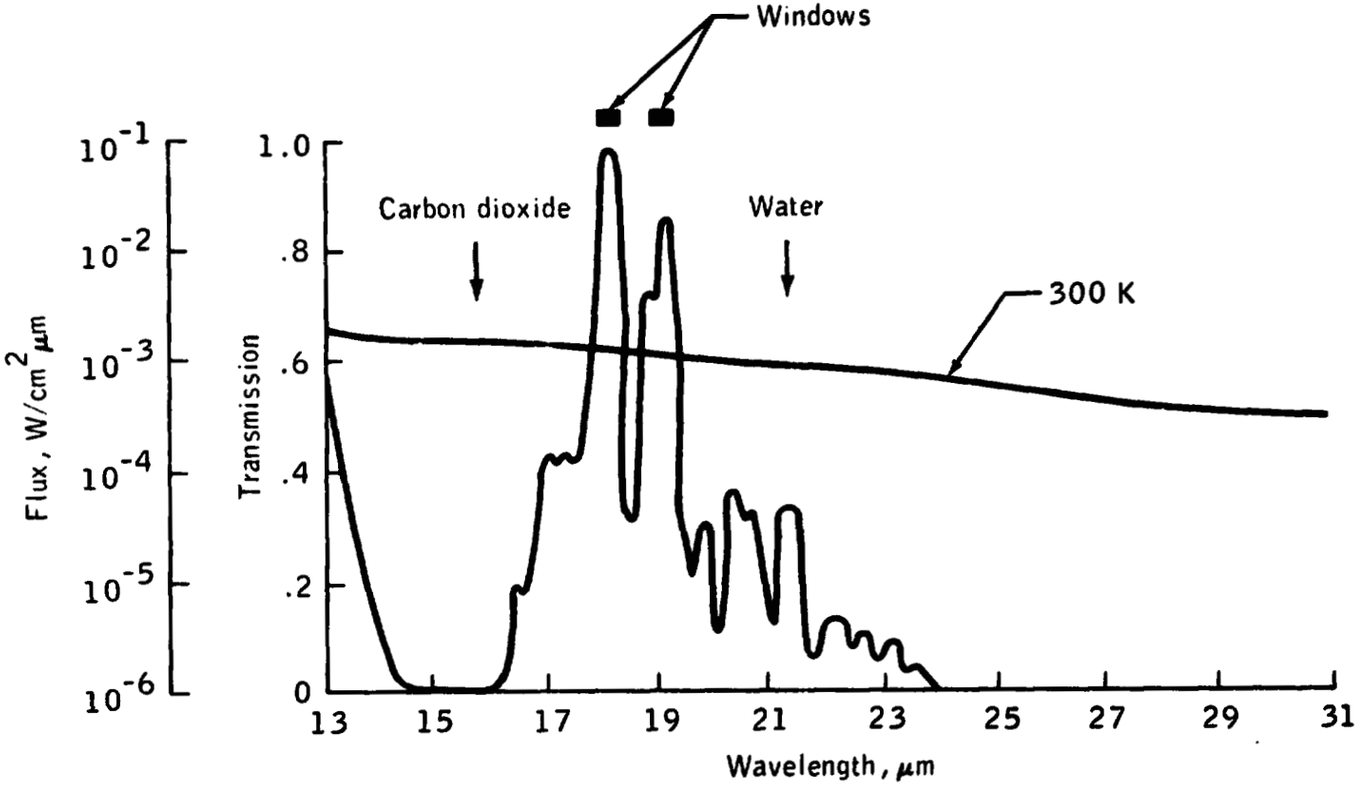

Figure 3.- Atmospheric transmission along a vertical path of one airmass.

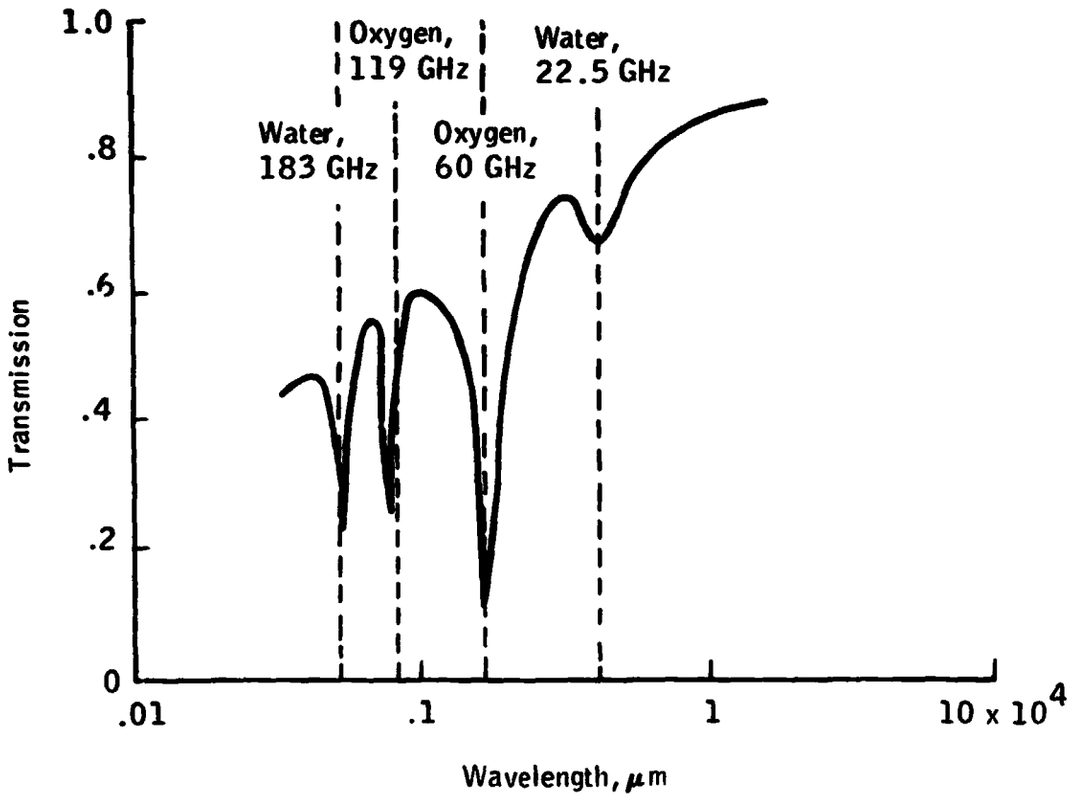

Figure 4.- Microwave atmospheric transmission.

APPENDIX A

EXTREME ATMOSPHERIC CASES

The top half of each page contains the radiosonde data used as input to the calculator program. The first line is organized as follows: five-digit station number, date, time (G.m.t.), and station location. The remaining lines are the data from the significant levels in the atmosphere. The first three digits represent the pressure in millibars. If the pressure is greater than 1000 millibars, only the last three digits are given. The next three digits are the temperature in degrees Celsius to one-tenth of a degree (XX.X). The third digit of this group indicates whether the temperature is positive or negative; an even digit denotes positive values and an odd digit signifies temperatures below zero. The last two digits on each line are the dewpoint depression information. Numbers less than 50 should be divided by 10 and numbers greater than 55 should be decreased by 50 to obtain the dewpoint depression in degrees Celsius.

The lower portion of each page contains the calculator output for the particular case. Pressure is given in millibars, and temperature and dewpoint are in degrees Celsius. The column headed "CM H2O" is the quantity in centimeters of precipitable moisture between the level of pressure listed on the same line with the precipitable moisture and the preceding pressure. The column headed "SUM" gives the cumulative total of precipitable water.

72201 7/17/72 0000 Key West, Fla.

017 28428	475 10350
000 26419	468 11530
850 16220	412 17330
700 07421	400 19719
642 04422	352 25508
591 00128	300 34534
558 02949	279 38944
542 04529	250 44900
500 07929	200 57100
496 07819	174 64700

STATION NO. 72201
DATE 71772
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1017	28.4	25.6		
1000	26.4	24.5	.351166	.351166
850	16.2	14.2	2.435161	2.786328
700	[illegible]	5.3	1.538496	4.324825
642	4.4	2.2	.444892	4.769717
591	-.1	-2.9	.318304	5.088522
558	-2.9	-7.8	.152320	5.240843
542	-4.5	-7.4	.064145	5.304988
500	-7.9	-10.8	.158609	5.463598
496	-8.7	-10.6	.013856	5.477455
475	-10.3	-10.3	.076196	5.553653
468	-11.5	-14.5	.022593	5.576247
412	-17.3	-20.5	.127357	5.703604
400	-19.7	-21.6	.021411	5.725015
352	-25.5	-26.3	.072169	5.797185
300	-34.5	-37.9	.045972	5.843157
279	-38.9	-43.3	.008191	5.851349

72240 9/05/72 0000 LAKE CHARLES, LA.

013 28847	421 14559
000 28857	400 17368
931 23024	381 19569
774 13246	367 21958
718 09417	345 24973
666 06450	309 31169
620 02820	300 33158
594 01240	295 33750
566 01328	283 35171
548 02359	267 38970
536 03156	223 49500
528 03369	150 66100
500 06567	127 70700
478 08576	123 69700
436 12969	111 72500

STATION NO. 72240
DATE 9572
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H20	SUM
1013	28.8	24.1		
1000	28.8	21.8	.236684	.236684
931	23.0	20.6	1.173529	1.410214
774	13.2	8.6	2.063681	3.473895
718	9.4	7.7	.524469	3.998365
666	6.4	1.4	.414459	4.412824
620	2.8	.8	.303768	4.716593
594	1.2	-2.8	.156712	4.873305
566	-1.?	-4.1	.146362	5.019668
548	-2.3	-11.3	.072863	5.092531
536	-3.1	-9.1	.039916	5.132447
528	-3.3	-22.3	.019526	5.151974
500	-6.5	-23.5	.033478	5.185452
478	-8.5	-34.5	.017537	5.202990
436	-12.9	-31.9	.021823	5.224814
421	-14.5	-23.5	.014942	5.239756
400	-17.3	-35.3	.019505	5.259262
381	-19.5	-38.5	.007920	5.267182
367	-21.9	-29.9	.008657	5.275840
345	-24.9	-47.9	.011221	5.287062
309	-31.1	-50.1	.004788	5.291851
300	-33.1	-41.1	.002118	5.293969
295	-33.7	-[illegible].7	.002004	5.295973
283	-35.1	-56.1	.003119	5.299092
267	-38.9	-58.9	.000910	5.300003

72250 10/20/72 1200 BROWNSVILLE, TEX.

016 22627	506 06956
000 25232	500 07161
850 16232	471 09775
818 14445	444 13168
796 12415	420 16756
781 11643	400 17768
742 08600	332 28937
700 07000	300 34361
633 02800	265 40170
624 01457	250 43900
611 02865	200 55500
586 00878	150 68700
522 05374	100 77900

STATION NO. 72250
DATE 102072
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1016	22.6	19.9		
1000	25.2	22.0	.256808	.256808
850	16.2	13.0	2.147096	2.403904
818	14.4	9.9	.335956	2.739861
796	12.4	10.9	.222018	2.961879
781	11.6	7.3	.142477	3.104357
742	8.6	8.6	.353540	3.457898
700	7.0	7.0	.397425	3.855323
633	2.8	2.8	.562819	4.418143
624	1.4	-5.6	.052662	4.470805
611	2.8	-12.2	.043026	4.513831
586	.8	-27.2	.040090	4.553922
522	-5.3	-29.3	.043558	4.597481
506	-6.9	-12.9	.028043	4.625525
500	-7.1	-18.1	.014164	4.639689
471	-9.7	-34.7	.033303	4.672993
444	-13.1	-31.1	.014501	4.687494
420	-16.7	-22.7	.025629	4.713123
400	-17.7	-35.7	.019451	4.732575
332	-28.9	-32.6	.040905	4.773480
300	-34.3	-45.3	.015474	4.788955
265	-40.1	-60.1	.004579	4.793534

72232 11/10/72 1200 BOOTHVILLE, LA.

013 31417
000 23228
781 10602
767 07602
747 13281
588 02559
553 05177
500 12361
442 15143
400 21725
372 24765
289 39156
250 47700
200 58100
150 63700
116 73700
100 71100

STATION NO.	72232
DATE	111072
TIME (GMT)	1200

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1013	31.4	29.7		
1000	23.2	20.4	.278515	.278515
781	10.6	10.4	2.848154	3.126669
767	7.6	7.4	.133419	3.260089
747	13.2	-17.8	.099212	3.359302
588	-2.5	-11.5	.320443	3.679745
553	-5.1	-32.1	.056341	3.736086
500	-12.3	-23.3	.043890	3.779977
442	-16.1	-20.4	.084649	3.864626
400	-21.7	-24.2	.065111	3.929737
372	-24.7	-30.7	.030363	3.960101
289	-39.1	-45.1	.042961	4.003062

74486 12/10/72 1200 J.F.K., NEW YORK

016 07701
000 06001
912 07401
889 10651
558 08301
500 13329
458 18125
420 22301
400 24727
384 27750
318 37543
300 39334
250 51100
200 63700
181 68500
157 72700
150 69300
123 63700
107 64100
100 66700
-1.

STATION NO. 74486
DATE 121072
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H20	SUM
1016	-7.7	-7.7		
1000	6.0	6.0	.065109	.065109
912	7.4	7.4	.582673	.647783
889	10.6	10.6	.189877	.837661
558	-8.3	-8.3	2.151410	2.989071
500	-13.3	-16.2	.172086	3.161158
458	-18.1	-20.6	.080633	3.241791
420	-22.3	-22.3	.060559	3.302350
400	-24.7	-27.4	.025624	3.327974
384	-27.7	-32.7	.013270	3.341245
318	-37.5	-41.8	.031141	3.372386
300	-39.3	-42.7	.005367	3.377753
250				

72274 6/30/72 0000 TUCSON, ARIZ.

922 39497	400 18572
907 35881	300 34167
850 31081	275 39567
700 16077	250 46100
578 01672	216 49300
526 05168	200 52900
500 06970	159 62900
474 10772	150 64700
458 10774	100 72500

STATION NO. 72274
DATE 63072
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
922	39.4	-7.6		
907	35.8	4.8	.063471	.063471
850	31.0	.0	.304206	.367678
700	16.0	-11.0	.524782	.892461
578	1.6	-20.4	.227336	1.119797
526	-5.1	-23.1	.064267	1.184065
500	-6.9	-26.9	.026009	1.210074
474	-10.7	-32.7	.017834	1.227908
458	-10.7	-34.7	.007665	1.235574
400	-18.5	-40.5	.020808	1.256382
300	-34.1	-51.1	.019527	1.275910
275	-39.5	-56.5	.002211	1.278122

72712 1/10/73 1200 CARIBOU, ME.

987 34541	617 29505
979 22530	530 34344
966 20929	471 39350
910 24109	400 48600
898 24301	337 57900
850 23704	323 58700
804 22701	176 50700
745 23113	150 53100
700 24914	100 54900
672 25931	

STATION NO. 72712
DATE 11073
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H20	SUM
987	-34.5	-38.6		
979	-22.5	-25.5	.002531	.002531
966	-20.9	-23.8	.007031	.009562
910	-24.1	-25.0	.032037	.041600
898	-24.3	-24.4	.006932	.048532
850	-23.7	-24.1	.029894	.078426
804	-22.7	-22.7	.032787	.111214
745	-23.1	-24.4	.044168	.155382
700	-24.9	-26.3	.030698	.186080
672	-25.9	-29.0	.016323	.202404
617	-29.5	-30.0	.028556	.230961
530	-34.3	-38.7	.033480	.264441
471	-39.3	-44.3	.012074	.276516

72518 1/30/73 1200 ALBANY, N.Y.

008 16361	568 27972
000 15959	500 35167
959 16358	459 39766
932 16731	379 50100
915 17156	352 49100
871 17725	300 51700
832 19325	281 49500
797 20557	205 49100
775 19357	181 42100
735 21765	172 42100
721 22565	134 50900
700 23370	114 47500
665 26359	106 50700
649 25972	100 49500

STATION NO. 72518
DATE 13073
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1008	-16.3	-27.3		
959	-16.3	-24.3	.023815	.023815
915	-17.1	-23.1	.026909	.050725
832	-19.3	-21.8	.061099	.111824
775	-19.3	-26.3	.039766	.151591
721	-22.5	-37.5	.021393	.172984
665	-26.3	-35.3	.013881	.186865
649	-25.9	-47.9	.002888	.189754
500	-35.1	-52.1	.010133	.199887
459	-39.7	-55.7	.002101	.201989

72486 12/05/72 1200 ELY, NEV.

798 22323	412 40161
795 17350	400 40700
781 16150	332 45900
754 16215	274 47300
690 20541	232 44700
679 20360	109 48100
592 27164	163 45300
532 32363	138 51300
500 32563	100 49500

STATION NO. 72486
DATE 12572
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H2O	SUM
798	-22.3	-24.6		
795	-17.3	-22.3	.002211	.002211
781	-16.1	-21.1	.012153	.014365
754	-16.3	-17.8	.029591	.043956
690	-20.5	-24.6	.065080	.109037
679	-20.3	-30.3	.006708	.115746
592	-27.1	-41.1	.027498	.143245
532	-32.3	-45.3	.008995	.152240
500	-32.5	-45.5	.004046	.156287
412	-40.1	-51.1	.009296	.165583

72662 1/10/73 1200 RAPID CITY, S. DAK.

907 19559
893 12364
864 10567
836 12168
729 13970
700 16168
670 16968
651 18567
630 17369
500 29967
400 40164
300 54500
267 58900
250 58700
178 53700
131 52300
121 55300
115 54300
100 56300

STATION NO. 72662
DATE 11073
TIME (GMT) 1200

PRESSURE	TEMP	DEW PT	CM H2O	SUM
907	-19.5	-28.5		
893	-12.3	-26.3	.006370	.006370
864	-10.5	-27.5	.014093	.020463
836	-12.1	-30.1	.011825	.032288
729	-13.9	-33.9	.036216	.068504
700	-16.1	-34.1	.008769	.077274
670	-16.9	-34.9	.009004	.086279
651	-18.5	-35.5	.005513	.091793
630	-17.3	-36.3	.005857	.097651
500	-29.9	-46.9	.024859	.122511
400	-40.1	-54.1	.008467	.130978

APPENDIX B

SEVERE STORM CASES

Data are presented in the same manner as in appendix A except that station numbers are not given and the times listed with the radiosonde data are central standard time.

5/15/68 1101 RUSH SPRINGS, OKLA.

961 25835	700 09270
924 22824	696 09072
879 19010	672 07062
864 16856	646 05677
850 14662	600 00469
834 12870	500 11558
821 11480	454 17957
808 17057	437 19570
760 14259	429 19556
718 10063	400 23158

STATION NO.
DATE 51568
TIME (GMT) 1701

PRESSURE	TEMP	DEW PT	CM H2O	SUM
961	25.8	22.3		
924	22.8	20.4	.651325	.651325
879	19.0	18.0	.723858	1.375184
864	16.8	10.8	.186963	1.562147
850	14.6	2.6	.106485	1.668633
834	12.8	-7.2	.066154	1.734788
821	11.4	-18.6	.024761	1.759549
808	17.0	10.0	.070761	1.830311
760	14.2	5.2	.414561	2.244872
718	10.0	-3.0	.248542	2.493415
700	9.2	-10.8	.061199	2.554615
696	9.0	-13.0	.008990	2.563605
672	7.0	-5.0	.072703	2.636309
646	5.6	-21.4	.066168	2.702478
600	.4	-18.6	.059272	2.761750
500	-11.5	-19.5	.157407	2.919158
454	-17.9	-24.9	.064094	2.983252
437	-19.5	-39.5	.012003	2.995256
429	-19.5	-25.5	.005657	3.000913
400	-23.1	-31.1	.026821	3.027734

5/15/68 1210 FT. SILL, OKLA.

966 28863	628 03675
910 24062	594 00072
877 20459	578 02359
850 19260	500 11163
833 19494	482 12557
802 17298	466 14357
737 12478	457 14771
700 10077	444 16359
689 09477	414 20760
666 06663	400 22359

STATION NO.
DATE 51568
TIME (GMT) 1810

PRESSURE	TEMP	DEW PT	CM H20	SUM
966	28.8	15.8		
910	24.0	12.0	.614861	.614861
877	20.4	11.4	.327503	.942365
850	19.2	9.2	.252755	1.195120
833	19.4	-24.6	.080276	1.275397
802	17.2	-30.8	.015507	1.290905
737	12.4	-15.6	.062819	1.353724
700	10.0	-17.0	.056043	1.409768
689	9.4	-17.6	.015833	1.425601
666	6.6	-6.4	.057988	1.483590
628	3.6	-21.4	.090157	1.573748
594	.0	-22.0	.038025	1.611773
578	-2.3	-11.3	.031694	1.643467
500	-11.1	-24.1	.153847	1.797315
482	-12.5	-19.5	.025396	1.822711
466	-14.3	-21.3	.025905	1.848616
457	-14.7	-35.7	.008631	1.857248
444	-16.3	-25.3	.009834	1.867082
414	-20.7	-30.7	.027517	1.894600
400	-22.3	-31.3	.009969	1.904570

5/15/68 1300 HINTON, OKLA.

949 27464
907 22662
892 21863
868 20265
850 19666
715 14867
700 08666
647 04663
600 00161
500 12354
471 14947
462 15760
400 22362

STATION NO.
DATE 51568
TIME (GMT) 1900

PRESSURE	TEMP	DEW PT	CM H20	SUM
949	27.4	13.4		
907	22.6	10.6	.410109	.410109
892	21.8	8.8	.129298	.539407
868	20.2	5.2	.176416	.715824
850	19.6	3.6	.112475	.828299
715	14.8	-2.2	.716093	1.544392
700	8.6	-7.4	.058810	1.603203
647	4.6	-8.4	.169324	1.772528
600	-.1	-11.1	.140478	1.913006
500	-12.3	-17.7	.235773	2.148780
471	-14.9	-19.6	.053327	2.202107
462	-15.7	-25.7	.012491	2.214599
400	-22.3	-34.3	.048251	2.262850

6/8/66 1048 CHICKASHA, OKLA.

968 28263	750 16271
954 27660	739 15670
938 25859	700 13073
891 21056	600 02271
850 18056	500 09569
818 17458	489 09971
805 16460	472 11764
792 16457	464 11768
780 17863	400 21167

STATION NO.
DATE 60866
TIME (GMT) 1648

PRESSURE	TEMP	DEW PT	CM H20	SUM
968	28.2	15.2		
954	27.6	17.6	.176518	.176518
938	25.8	16.8	.215208	.391727
891	21.0	15.0	.601766	.993493
850	18.0	12.0	.472305	1.465799
818	17.4	9.4	.319026	1.784826
805	16.4	6.4	.110245	1.895072
792	16.4	9.4	.112257	2.007329
780	17.8	4.8	.100061	2.107391
750	16.2	-4.8	.160801	2.268193
739	15.6	-4.4	.040974	2.309167
700	13.0	-10.0	.125020	2.434187
600	2.2	-18.8	.203397	2.637585
500	-9.5	-28.5	.110059	2.747644
489	-9.9	-30.9	.007333	2.754978
472	-11.7	-25.7	.013671	2.768649
464	-11.7	-29.7	.006869	2.775519
400	-21.1	-38.1	.034045	2.809565

6/8/66 1400 CORDELL, OKLA.

951 33081	672 07072
938 31478	648 05677
915 29274	622 02871
901 28473	549 05974
862 24070	540 06568
850 23069	500 10375
843 22468	460 12975
803 18264	444 15365
751 12661	433 17362
738 11259	400 21768
700 07858	

STATION NO.
DATE 60866
TIME (GMT) 2000

PRESSURE	TEMP	DEW PT	CM H20	SUM
951	33.0	2.0		
938	31.4	3.4	.065431	.065431
915	29.2	5.2	.132455	.197886
901	28.4	5.4	.088068	.285954
862	24.0	4.0	.242395	.528350
850	23.0	4.0	.073078	.601428
843	22.4	4.4	.043733	.645162
803	18.2	4.2	.259019	.904181
751	12.6	1.6	.323403	1.227584
738	11.2	2.2	.078442	1.306027
700	7.8	-.2	.222775	1.528803
672	7.0	-15.0	.102361	1.631164
648	5.6	-21.4	.034642	1.665807
622	2.8	-18.2	.033423	1.699230
549	-5.9	-29.9	.075740	1.774970
540	-6.5	-24.5	.007070	1.782041
500	-10.3	-35.3	.027287	1.809328
460	-12.9	-37.9	.013922	1.823251
444	-15.3	-30.3	.008116	1.831368
433	-17.3	-29.3	.008169	1.839537
400	-21.7	-39.7	.017972	1.857509

6/5/66 1400 TINKER AFB, OKLA.

963 30269	788 21488
956 29067	700 13087
915 24460	600 01679
850 18456	540 05178
818 15238	530 06776
802 16258	500 10376
790 20477	400 22375

STATION NO.
DATE 60566
TIME (GMT) 2000

PRESSURE	TEMP	DEW PT	CM H20	SUM
963	30.2	11.2		
956	29.0	12.0	.064208	.064208
915	24.4	14.4	.431388	.495597
850	18.4	12.4	.732258	1.227856
818	15.2	11.4	.345246	1.573102
802	16.2	8.2	.154913	1.728015
790	20.4	-6.6	.070415	1.798431
788	21.4	-16.6	.004354	1.802785
700	13.0	-24.0	.094161	1.896947
600	1.6	-27.4	.073679	1.970626
540	-5.1	-33.1	.033488	2.004114
530	-6.7	-32.7	.004503	2.008618
500	-10.3	-36.3	.012096	2.020715
400	-22.3	-47.3	.023736	2.044451

6/9/66 1100 PAULS VALLEY, OKLA.

984 17460	579 02161
963 15457	554 05356
918 12656	524 08952
910 15852	521 09159
872 14807	515 09174
850 15016	511 08561
828 15025	500 09365
824 14858	492 09972
802 18268	487 10377
700 10441	437 15165
595 00362	400 20168

STATION NO.
DATE 60966
TIME (GMT) 1700

PRESSURE	TEMP	DEW PT	CM H2O	SUM
984	17.4	7.4		
963	15.4	8.4	.147684	.147684
918	12.6	6.6	.318696	.466380
910	15.8	10.6	.063429	.529810
872	14.8	14.1	.398599	.928409
850	15.0	13.4	.259916	1.188326
828	15.0	12.5	.253065	1.441391
824	14.8	6.8	.038035	1.479426
802	18.2	.2	.139152	1.618578
700	10.4	6.3	.699855	2.318434
595	-.3	-12.3	.594517	2.912951
579	-2.1	-13.1	.039974	2.952925
554	-5.3	-11.3	.067707	3.020633
524	-8.9	-14.1	.081915	3.102549
521	-9.1	-18.1	.006433	3.108982
515	-9.1	-33.1	.006755	3.115738
511	-8.5	-19.5	.004159	3.119897
500	-9.3	-24.3	.014873	3.134770
492	-9.9	-31.9	.006491	3.141262
487	-10.3	-37.3	.002144	3.143406
437	-15.1	-30.1	.026023	3.169430
400	-20.1	-28.1	.031031	3.200461

5/24/66 1100 SHEPPARD AFB, TEX.

983 24470
967 20870
878 13076
850 16275
836 16272
800 15264
15
771 13271
735 10258
700 06456
595 01361
500 13159
400 24571

STATION NO.
DATE 52466
TIME (GMT) 1700

PRESSURE	TEMP	DEW PT	CM H20	SUM
983	24.4	4.4		
967	20.8	.8	.077814	.077814
878	13.0	-13.0	.262809	.340623
850	16.2	-8.8	.055750	.396374
836	16.2	-5.8	.037648	.434022
800	15.2	1.2	.150396	.584419
771	13.2	-7.8	.118039	.702458
735	10.2	2.2	.162948	.865406
700	6.4	.4	.209973	1.075380
595	-1.3	-12.3	.435774	1.511154
500	-13.1	-22.1	.183581	1.694735
400	-24.5	-45.5	.074020	1.768755

APPENDIX C

U.S. STANDARD ATMOSPHERE, 1966

Data from the "U.S. Standard Atmosphere Supplements, 1966" were reformatted and are presented in a manner similar to that of the previous appendixes. The three columns at the top of each page are pressure in millibars, temperature in degrees Celsius, and dewpoint depression in degrees Celsius, respectively.

ANNUAL READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION FOR THE EQUATOR

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1013.25	26.5	4.65
903.9	20.5	4.47
804.3	14.5	4.3
780.9	13.0	4.35
758.0	13.8	15.0
632.3	3.75	13.94
491.1	-9.65	12.57
376.4	-23.05	12.8
284.3	-36.45	15.0

STATION NO. 15
DATE 15
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1013	26.5	21.8		
903	20.5	16.0	1.635246	1.635246
804	14.5	10.2	1.147196	2.782442
780	13.0	8.6	.224940	3.007383
758	13.8	-1.2	.159941	3.167324
632	3.7	-10.1	.475100	3.642425
491	-9.6	-22.2	.294218	3.936644
376	-23.0	-35.8	.103571	4.040216
284	-36.4	-51.4	.027238	4.067454

JULY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION
FOR LATITUDE 30° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1013.5	28.0	3.56
904.4	20.5	6.65
804.8	15.0	7.57
714.3	9.5	7.28
632.5	4.0	9.4
492.0	-7.0	11.27
378.1	-21.0	10.05
286.1	-35.0	11.51

STATION NO. 30
DATE 7
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1013	28.0	24.3		
904	20.5	13.8	1.690477	1.690477
804	15.0	7.4	.973889	2.664367
714	9.5	2.2	.664314	3.328681
632	4.0	-5.4	.432040	3.760721
492	-7.0	-18.2	.421468	4.182190
378	-21.0	-31.0	.150050	4.332240
286	-35.0	-46.5	.044349	4.376589

JANUARY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION FOR LATITUDE 30° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1021.0	14.0	3.34
906.4	11.0	5.2
803.5	8.0	5.07
710.7	1.5	10.57
626.8	-5.0	13.05
482.8	-18.0	13.36
366.8	-31.0	11.93
274.4	-44.0	10.59

STATION NO. 30
DATE 1
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1021	14.0	10.6		
906	11.0	5.8	.837001	.837001
803	8.0	2.9	.645186	1.482188
710	1.5	-9.0	.407063	1.889252
626	-5.0	-18.5	.176132	2.065385
482	-18.0	-31.3	.145396	2.210781
366	-31.0	-42.9	.047145	2.257926
274	-44.0	-54.5	.014526	2.272452

JULY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION FOR LATITUDE 45° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1013.5	21.0	4.5
902.2	16.5	6.48
801.5	12.0	8.64
710.3	6.0	10.94
627.8	0.0	11.92
486.3	-12	14.04
371.8	-25	12.58
280.3	-38	11.19

STATION NO. 45
DATE 7
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1013	21.0	16.5		
902	16.5	10.0	1.154873	1.154873
801	12.0	3.3	.754731	1.909604
710	6.0	-4.9	.457006	2.366611
627	.0	-11.9	.259549	2.626160
486	-12.0	-26.0	.243241	2.869402
371	-25.0	-37.5	.077586	2.946988
280	-38.0	-49.1	.025445	2.972433

JANUARY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION
FOR LATITUDE 45° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1018.0	-1.0	3.5
897.3	-4.5	4.62
789.6	-8.0	5.4
693.7	-11.5	7.22
607.9	-17.5	7.93
462.4	-29.5	8.17
346.8	-41.5	9.51
256.2	-53.5	9.62

STATION NO. 45
DATE
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H20	SUM
1018	-1.0	-4.5		
897	-4.5	-9.1	.296586	.296586
789	-8.0	-13.4	.211440	.508026
693	-11.5	-18.7	.145203	.653230
607	-17.5	-25.4	.089233	.742463
462	-29.5	-37.6	.081933	.824396
346	-41.5	-51.0	.024353	.848750
256	-53.5	-63.1	.005790	.854541

JULY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION
FOR LATITUDE 60° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1010.0	14.0	4.3
896.1	8.6	5.11
793.1	3.2	4.90
700.2	-2.2	5.75
616.6	-7.6	6.4
541.5	-13.0	7.12
474.1	-20.0	7.85
359.2	-34.0	8.95
267.6	-48.0	10.18

STATION NO. 60
DATE 7
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H20	SUM
1010	14.0	9.7		
896	8.6	3.4	.755347	.755347
793	3.2	-1.7	.512601	1.267949
700	-2.2	-7.9	.343934	1.611883
657	-4.9	-53.9	.066390	1.678274
616	-7.6	-14.0	.044239	1.722514
541	-13.0	-20.1	.134669	1.857183
474	-20.0	-27.8	.076616	1.933800
359	-34.0	-42.9	.061003	1.994803
267	-48.0	-58.1	.013316	2.008120

JANUARY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION
FOR LATITUDE 60° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1013.5	-16	2.65
887.9	-14	4.27
777.7	-17.2	4.16
680.0	-20.4	4.87
635.4	-22	5.67
593.4	-25.4	5.5
446.9	-39.0	6.54
330.8	-52.6	7.47

STATION NO. 60
DATE 1
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H20	SUM
1013	-16.0	-18.6		
887	-14.0	-18.2	.120213	.120213
777	-17.2	-21.3	.106930	.227143
680	-20.4	-25.2	.079806	.306950
635	-22.0	-27.6	.030197	.337147
593	-25.4	-30.9	.023479	.360627
446	-39.0	-45.5	.046627	.407255
330	-52.6	-60.0	.010293	.417548

JULY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION
FOR LATITUDE 75° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1012.5	5.0	2.29
895.2	2.4	3.95
790.6	-0.2	3.68
742.6	-1.5	5.68
613.0	-11.25	7.23
469.1	-24.25	8.57
353.9	-37.25	9.89
283.5	-47.0	10.28
262.9	-46.5	13.58

STATION NO. 75
DATE 7
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1012	5.0	2.7		
895	2.4	-1.5	.503182	.503182
841	1.1	-47.9	.106227	.609410
790	-.2	-3.8	.095526	.704936
742	-1.5	-7.1	.162330	.867266
697	-4.7	-53.7	.070295	.937562
613	-11.2	-18.4	.063579	1.001142
469	-24.2	-32.8	.143344	1.144486
353	-37.2	-47.1	.038536	1.183023
283	-47.0	-57.2	.007312	1.190335
262	-46.5	-60.0	.001014	1.191350

JANUARY READINGS OF PRESSURE, TEMPERATURE, AND DEWPOINT DEPRESSION FOR LATITUDE 75° N

Pressure, mbar	Temperature, °C	Dewpoint depression, °C
1013.5	-24.0	2.47
884.4	-21.0	4.84
826.7	-19.5	5.79
772.5	-22.2	5.66
673.2	-27.7	6.28
584.8	-33.2	6.90
436.9	-44.2	7.12
321.8	-55.2	7.27

STATION NO. 75
DATE 1
TIME (GMT)

PRESSURE	TEMP	DEW PT	CM H2O	SUM
1013	-24.0	-26.4		
884	-21.0	-25.8	.062602	.062602
826	-19.5	-25.2	.032608	.095211
772	-22.2	-27.9	.029840	.125052
673	-27.7	-34.0	.040845	.165897
584	-33.2	-40.1	.022891	.188789
436	-44.2	-51.3	.020199	.208989
321	-55.2	-62.5	.005766	.214755