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UPPER AIR DENSITIES AND TEMPERATURES MEASURED BY THE FALLING SPHERE METHOD

Results from 13 Flights between 1952 and 1958

Reviewed and Summarized in 1961

by

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INTRODUCTION

Between 1952 and 1958 a series of 13 measurements of upper-air density and temperature were carried out by the University of Michigan Department of Aeronautical and Astronautical Engineering using the falling-sphere technique. The flights took place at White Sands, Wallops Island, at sea and at Ft. Churchill. The results were published in the following references:

1. Bartman, F. L. and L. M. Jones, "Density and Temperature of the Upper Atmosphere as Measured by the Falling-Sphere Method", Univ. of Mich. E.R.I. Report 2299-1-F, 1955.
2. Bartman, F. L., L. W. Chaney, L. M. Jones and V. C. Liu, "Upper-Air Density and Temperature by the Falling Sphere Method", Jour. App. Phys. 27, 7, 1956.
3. Jones, L. M. and F. L. Bartman, "A Simplified Falling Sphere Method for Upper-Air Density", Univ. of Mich., E. R. I. Report 2215-10-T, 1956.
4. Jones, L. M., J. W. Peterson, E. J. Schaefer and H. F. Schulte, "Upper Air Densities and Temperatures from Eight IGY Rocket Flights by the Falling Sphere Method", Nat. Acad. Sci. IGY Rocket Report Series No. 5, 1959.
5. Jones, L. M., J. W. Peterson, E. J. Schaefer and H. F. Schulte, "Upper Air Density and Temperature: Some Variations and an Abrupt Warming in the Mesosphere", Jour. Geoph. Res. 64, 12, 1959.

In this report the tabulated results of all of the flights are gathered together in a consistent series for two purposes:

1. To be available for use in the preparation of standard atmospheres. Two such models are now being prepared: the COSPAR International Reference Atmosphere and the Extension to the ICAO Standard Atmosphere.

2. To publish revisions in the density and temperature results from six of the flights. The revisions result from the use of new sphere drag coefficient data recently published. The changes are nominal, being perhaps 15% at the highest altitudes, 5% at 60 kilometers and zero at 40 kilometers. Seven of the flights are unaffected. The geophysical significance of the results as discussed in reference 5 are unaffected.

In addition to the tabulations from all of the flights, we have included revised versions of some of the plotted curves of reference 5. The new curves show the following:

1. Revised density and temperature values using new C_D values.
2. The ARDC Model Atmosphere 1959 as reference rather than the 1956 version.
3. Individual temperature points instead of averages for the flights AM 6.02, 3, 5, and SM 2.10 which took place at Ft. Churchill and which show an example of "explosive warming" at rocket altitudes as discussed in reference 5.

The falling sphere technique is limited at low altitudes as well as at very high altitudes. In the later case accelerometer sensitivity or precision of tracking is a difficulty. A few of the high altitude scattered points are not plotted. At low altitudes the aerodynamics of spheres are such that an unsteady condition of flow can be expected accompanied by variable drag force and uncertain drag coefficient data. Data from all the spheres show scatter at low altitudes, some more than others. Low altitude data are not shown when drag coefficients were believed to be unreliable. The sphere derived densities and temperatures agreed rather well with balloonsonde measurements except in the case of SM 2.10. A satisfactory explanation for the scatter in the data of SM 2.10 below 27 kilometers has not been found so that in this region the balloon points should be used.

ERRORS

The main source of error of the density results is believed to be the uncertainty in the drag coefficient data. The derived density is inversely proportional to the assumed drag coefficient. This error is estimated to be 2% except at very low Reynolds numbers which correspond to altitudes greater than 70 kilometers where the error is estimated to be 5%. At higher altitudes the threshold of accelerometer sensitivity or precision of tracking is finally reached which varies from one sphere to another. The threshold effect can be estimated by observing the scatter of the density data. In all cases the data analysis has been continued into the threshold area where the scatter is 100 per cent. This occurs in the 80 to 90 kilometer range in the group of accelerometer spheres and 60 to 70 kilometer in the group of tracked spheres (SC numbers). The error in the

absolute temperature is similar to the error in the density except that errors due to drag coefficient tend to cancel. This is because the derived temperature is proportional to ratio of pressure to density and pressure is found by integrating density.

ACKNOWLEDGEMENT

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SC-23 14 May 1952

18:16 MST, WSPG, New Mexico, 32.4°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
50.38	.00116	269
50.66	.00111	270
50.94	.00107	272
51.23	.00103	274
51.51	.000984	274
51.80	.000938	278
52.08	.000897	281
52.37	.000861	
52.65	.000814	
52.93	.000819	
53.22	.000819	
53.50	.000778	
53.78	.000747	
54.06	.000706	
54.34	.000758	
54.62	.000670	
54.89	.000675	
55.17	.000680	
55.45	.000639	
55.72	.000644	
56.00	.000511	
56.27	.000655	
56.54	.000567	
56.81	.000572	

SC-23 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
57.08	.000429	
57.35	.000434	
57.62	.000444	
57.88	.000449	
58.15	.000454	
58.41	.000459	
58.67	.000412	
58.93	.000360	
59.18	.000365	
59.44	.000370	
59.69	.000434	
59.95	.000380	
60.19	.000446	
60.44	.000394	
60.69	.000463	
60.94	.000405	
61.18	.000289	
61.42	.000225	
61.66	.000165	
61.90	.000236	
62.13	.000241	
62.37	.000244	

SC-23 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
62.60	.000248	
62.83	.000256	
63.05	.000260	
63.28	.000264	
63.50	.000270	
63.72	.000358	
63.94	.000369	
64.16	.000287	
64.37	.000296	
64.59	.000213	
64.80	.000133	
65.01	.0000469	
65.42	.000145	
65.62	.0000515	
65.82	.000154	
66.02	.0000541	
66.21	.000164	
66.40	.000170	
66.59	.000287	
66.78	.000293	
66.97	.000412	
67.15	.000190	

SC-29 11 December 1952

16:47 MST, WSPG, New Mexico, 32.4°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
34.07	.00984	222
34.22	.0104	206
34.37	.0102	205
34.52	.0102	200
34.68	.0104	191
34.84	.0102	188
35.01	.00953	196
35.18	.00902	201
35.35	.00825	214
35.53	.00763	225
35.72	.00722	231
35.91	.00732	222
36.10	.00747	211
36.30	.00644	237
36.50	.00588	253
36.71	.00613	235
36.92	.00577	243
37.14	.00526	259
37.37	.00521	254
37.60	.00567	225
37.84	.00582	211
38.08	.00536	222
38.33	.00497	229
38.59	.00466	236
38.86	.00412	257
39.13	.00372	275
39.41	.00341	290

SC-29 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{O}Kelvin)
39.70	.00341	281
39.99	.00377	244
40.29	.00391	224
40.59	.00364	230
40.90	.00312	257
41.22	.00271	285
41.55	.00279	265
41.88	.00290	245
42.22	.00264	256
42.57	.00222	292
42.92	.00210	297
43.27	.00213	281
43.63	.00209	274
43.99	.00221	247
44.36	.00235	238
44.74	.00217	225
45.13	.00169	275
45.51	.00144	308
45.91	.00148	287
46.30	.00156	260
46.70	.00162	235
47.10	.00163	220
47.52	.00154	219
47.93	.00141	225
48.35	.00107	281
48.77	.000804	357
49.19	.000964	285
49.62	.000979	267

SC-29 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
50.05	.000850	291
50.48	.000783	301
50.91	.000680	331
51.34	.000794	271
51.78	.000897	226
52.21	.000758	251
52.65	.000655	275
53.09	.000598	286
53.53	.000521	311
53.97	.000508	305
54.41	.000492	300
54.85	.000464	303
55.29	.000421	318
55.74	.000407	314
56.17	.000465	261
56.62	.000521	219
57.06	.000541	197
57.50	.000588	182
57.94	.000588	167
58.38	.000488	185
58.83	.000458	182
59.27	.000457	167
59.71	.000442	158
60.16	.000384	165
60.60	.000274	214
61.04	.000230	239
61.48	.000263	195
61.93	.000278	170

SC-29 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
62.37	.000220	
62.80	.000104	
63.24	.0000460	
63.67	.0000460	
64.11	.0000184	
65.39	.0000804	
65.81	.000142	
66.23	.000127	
66.65	.000128	
67.07	.000147	
67.48	.000131	
67.90	.0000840	
68.31	.0000691	
68.72	.000116	
69.13	.000169	
69.53	.000136	
69.94	.0000861	
70.34	.000122	
70.74	.000157	
71.14	.000141	
71.54	.000107	
71.94	.0000727	
72.33	.0000207	
74.26	.0000221	
74.64	.00000562	
75.02	.00000572	
75.39	.0000435	

SC-30 23 April 1953

12:33 MST, WSPG, New Mexico, 32.4°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
36.78	.00526	274
37.04	.00515	271
37.30	.00521	259
37.58	.00490	266
37.86	.00477	263
38.15	.00457	265
38.44	.00420	278
38.75	.00403	279
39.06	.00399	271
39.39	.00368	282
39.72	.00338	296
40.05	.00333	288
40.40	.00338	272
40.75	.00333	264
41.11	.00326	257
41.49	.00303	264
41.87	.00270	283
42.25	.00251	291
42.65	.00249	279
43.05	.00244	272
43.46	.00224	281
43.88	.00200	300
44.30	.00199	273

SC-30 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
44.73	.00183	296
45.17	.00162	321
45.60	.00176	280
46.05	.00170	276
46.51	.00157	283
46.96	.00164	255
47.43	.00147	260
47.90	.00133	278
48.38	.00137	255
48.86	.00130	254
49.34	.00108	285
49.83	.00105	276
50.33	.00104	264
50.83	.000912	282
51.33	.000866	280
51.83	.000892	255
52.34	.000783	272
52.85	.000624	322
53.36	.000655	290
53.87	.000768	231
54.39	.000701	235
54.91	.000639	240
55.43	.000567	274

SC-30 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{O}Kelvin)
55.95	.000462	290
56.47	.000472	266
57.00	.000447	263
57.52	.000403	274
58.04	.000424	242
58.57	.000389	246
59.09	.000311	289
59.62	.000300	279
60.14	.000256	308
60.66	.000208	359
61.19	.000269	263
61.71	.000291	226
62.22	.000269	226
62.75	.000258	218
63.27	.000258	201
63.73	.000271	174
64.31	.000177	244
64.82	.0000722	
65.34	.0000850	
65.85	.000121	
66.36	.000147	
66.88	.000159	
67.39	.000111	

SC-30 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
67.89	.0000758	
68.40	.000138	
68.90	.000125	
69.40	.0000639	
69.90	.0000644	
70.40	.0000655	
70.90	.000105	
71.39	.000118	
71.89	.0000660	
72.38	.0000412	
72.87	.0000294	
73.35	.0000546	
73.84	.000123	
74.32	.0000164	
75.28	.0000430	
75.75	.000102	
76.23	.0000747	
77.64	.0000588	
78.57	.0000168	
79.03	.0000313	
79.94	.0000171	
80.39	.0000475	
80.84	.0000321	

SC-31 29 September 1953

13:50 MST, WSPG, New Mexico, 32.4°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
31.31	.0162	225
31.39	.0157	230
31.46	.0155	237
31.54	.0157	224
31.62	.0151	230
31.70	.0145	235
31.78	.0159	212
31.85	.0155	213
31.93	.0145	229
32.02	.0152	215
32.10	.0148	218
32.18	.0127	250
32.26	.0138	228
32.34	.0164	194
32.42	.0144	213
32.51	.0128	237
32.59	.0126	240
32.68	.0132	223
32.76	.0149	195
32.85	.0137	208
32.94	.00959	296
33.03	.00964	292
33.11	.0122	227
33.20	.0129	218
33.29	.0132	209
33.38	.0113	230
33.47	.0109	242
33.56	.0118	221

SC-31 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
33.66	.00902	283
33.75	.00840	298
33.84	.0108	234
33.94	.00995	246
34.03	.00830	294
34.12	.00881	274
34.22	.0118	202
34.31	.0134	177
34.41	.0108	213
34.52	.00727	314
34.61	.00665	340
34.71	.00794	282
34.81	.00912	242
34.91	.00964	226
35.01	.00933	230
35.11	.00835	252
35.22	.00758	272
35.32	.00804	256
35.43	.00819	246
35.53	.00747	266
35.64	.00716	276
35.75	.00722	268
35.85	.00722	266
35.96	.00727	261
36.07	.00716	261
36.18	.00680	268
36.30	.00691	263
36.41	.00696	255

SC-31 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
36.52	.00608	289
36.64	.00588	293
36.75	.00655	262
36.87	.00618	273
36.98	.00680	245
37.10	.00634	258
37.22	.00428	375
37.34	.00608	262
37.46	.00593	263
37.58	.00562	275
37.70	.00613	250
37.82	.00546	274
37.95	.00443	329
38.07	.00562	259
38.19	.00577	246
38.32	.00417	
38.45	.00376	
38.58	.00428	
38.70	.00536	
38.83	.00572	
38.96	.00479	
39.09	.00432	
39.22	.00466	
39.36	.00450	
39.49	.00441	
39.63	.00442	
39.76	.00388	
39.90	.00403	

SC-31 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
40.04	.00414	
40.18	.00410	
40.32	.00415	
40.46	.00365	
40.60	.00349	
40.74	.00336	
40.88	.00326	
41.03	.00348	
41.17	.00344	
41.32	.00352	
41.46	.00314	
41.61	.00277	
41.75	.00344	
41.90	.00416	
42.05	.00354	
42.20	.00293	
42.35	.00282	
42.50	.00226	
42.66	.00269	
42.81	.00352	
42.96	.00320	
43.11	.00259	
43.27	.00305	
43.42	.00301	
43.58	.00259	
43.74	.00326	
43.90	.00305	
44.06	.00245	

SC-31 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
44.22	.00296	
44.38	.00222	
44.54	.00160	
44.70	.00287	
44.87	.00303	
45.03	.00259	
45.20	.00270	
45.36	.00234	
45.53	.00237	
45.70	.00244	
45.87	.00185	
46.04	.00208	
46.21	.00196	
46.38	.00138	
46.55	.00190	
46.72	.00229	
46.89	.00195	
47.06	.00187	
47.23	.00231	
47.40	.00218	
47.58	.00157	
47.75	.00150	
47.92	.00162	
48.10	.00112	
48.27	.00105	
48.44	.00182	
48.61	.00194	
48.78	.00141	

SC-31 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
48.95	.00126	
49.12	.00191	
49.30	.00186	
49.47	.00105	
49.64	.00128	
49.81	.00132	
49.98	.000598	
50.15	.000907	
50.31	.00160	
50.48	.00165	
50.65	.00109	
50.81	.00112	
50.97	.00188	
51.14	.00118	
51.30	.000546	
51.46	.00116	
51.62	.000866	
51.78	.000381	
51.94	.00107	
52.10	.00142	
52.25	.00103	
52.40	.000778	
52.56	.00116	
52.71	.00125	
52.86	.000371	
53.01	.000464	
53.15	.000809	

SC-31 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
46.42	.00159	
46.76	.00144	
47.09	.00160	
47.40	.00150	
47.70	.00136	
48.00	.00147	
48.28	.00143	
48.55	.00140	
48.82	.00148	
49.08	.00112	
49.33	.000876	
49.58	.000923	
49.82	.00110	
50.06	.00141	
50.29	.00126	
50.51	.000923	
50.72	.000876	
50.94	.000789	
51.15	.00100	
51.35	.00137	
51.55	.00110	
51.74	.000701	
51.93	.000402	
52.12	.000335	
52.30	.00102	
52.48	.00180	
52.66	.00171	
52.83	.000979	
53.00	.000500	
53.16	.000835	
53.32	.00103	
53.47	.000768	
53.63	.000423	

DAN 2 24 June 1955

13:04 EST, Wallops Is. 37.9°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
30.52	.0180	219
31.07	.0164	222
32.22	.0122	251
32.79	.0111	255
33.99	.00969	249
35.22	.00902	224
36.49	.00644	262
37.13	.00670	231
37.78	.00551	256
38.44	.00446	292
39.11	.00498	240
39.81	.00475	227
40.46	.00350	283
41.13	.00320	286
41.79	.00281	301
42.48	.00338	230
43.13	.00276	257
43.80	.00233	279
44.50	.00222	270
45.15	.00197	279
45.82	.00207	243
47.14	.00150	283
47.80	.00137	287
48.47	.00151	239
49.11	.00132	249

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
49.75	.00123	245
50.41	.00101	275
51.07	.000979	261
51.71	.000984	238
52.35	.000825	261
52.99	.000758	262
53.62	.000665	276
54.25	.000644	263
54.88	.000572	273
55.50	.000551	262
56.12	.000521	257
56.74	.000485	254
57.35	.000456	249
57.96	.000417	251
58.56	.000384	251
59.18	.000385	231
59.77	.000331	247
60.37	.000300	252
60.91	.000318	220
61.54	.000255	251
62.14	.000251	234
62.72	.000239	226
63.29	.000206	241
63.86	.000209	219
64.43	.000178	236

DAN 2 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
64.98	.000162	241
65.55	.000164	218
66.11	.000151	217
66.65	.000129	235
67.21	.000123	228
67.77	.000118	219
68.83	.000101	216
69.36	.0000866	233
70.43	.0000716	
70.94	.0000742	
71.46	.0000665	
71.96	.0000557	
72.49	.0000716	
72.98	.0000567	
73.49	.0000541	
73.98	.0000504	
74.48	.0000403	
74.96	.0000349	
75.45	.0000434	
75.91	.0000279	
76.42	.0000390	
76.89	.0000301	
77.34	.0000234	
77.82	.0000302	
78.27	.0000247	

DAN 2 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
61.14	.000298	
61.76	.000279	
62.35	.000213	
62.96	.000219	
63.56	.000198	
64.15	.000187	
64.74	.000173	
65.31	.000157	
65.90	.000140	
66.47	.000145	
67.06	.000125	
67.58	.000115	
68.14	.000118	
68.69	.000100	
69.26	.0000964	
69.83	.0000886	
70.36	.0000819	

DAN 2 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
70.90	.0000727	
71.44	.0000747	
71.97	.0000680	
73.01	.0000526	
73.54	.0000515	
74.07	.0000456	
74.59	.0000414	
75.08	.0000387	
75.61	.0000342	
76.12	.0000347	
76.56	.0000319	
77.08	.0000274	
77.58	.0000294	
78.08	.0000265	
78.55	.0000249	
79.02	.0000253	
79.50	.0000224	

AM 6.01 6 July 1956

13:00 EST, Wallops Is., 37.9°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
49.03	.00148	279
50.93	.00121	270
52.82	.000941	276
55.61	.000691	267
56.52	.000675	241
57.43	.000615	232
58.32	.000479	
60.11	.000407	
61.00	.000367	
61.87	.000326	
62.75	.000305	
63.62	.000251	
64.48	.000231	
65.34	.000203	
66.20	.000178	
67.04	.000161	
67.90	.000135	
68.73	.000125	
70.41	.000105	
72.06	.0000800	
72.90	.0000839	

AM 6.01 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
61.47	.000247	
62.42	.000312	
64.29	.000165	
65.20	.000201	
67.01	.000174	
67.93	.0000761	
68.79	.000119	
69.62	.000191	
70.52	.000138	
71.39	.000110	
72.25	.0000823	
73.13	.0000631	
73.94	.0000699	
74.79	.0000505	
76.44	.0000431	
77.26	.0000394	
78.10	.0000292	
79.71	.0000188	
80.49	.0000207	
81.26	.0000239	
82.03	.0000249	
85.20	.00000880	
86.67	.00000836	

AM 6.09 2 November 1956
15:40 Z3T, At Sea, 49°N, 48.4°W

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
19.42	.106	197
19.76	.100	196
20.13	.0922	201
20.52	.0861	201
20.96	.0800	201
21.93	.0664	206
22.48	.0621	201
23.05	.0545	208
23.65	.0487	212
24.28	.0445	209
24.96	.0401	208
25.70	.0348	213
26.48	.0306	214
29.10	.0200	217
30.04	.0174	215
30.99	.0144	224
31.97	.0124	224
32.98	.0107	224
33.99	.00904	228
35.02	.00770	230
36.06	.00656	232
37.12	.00551	237
38.17	.00470	239
39.25	.00401	241
40.30	.00344	243
41.36	.00294	245
42.44	.00256	243

AM 6.09 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
43.51	.00218	246
44.58	.00185	252
45.65	.00158	255
46.73	.00137	254
48.85	.00106	249
49.90	.000923	247
50.96	.000789	251
52.00	.000705	244
53.05	.000580	258
54.08	.000492	266
55.09	.000423	273
56.11	.000383	265
57.11	.000337	266
58.13	.000293	269
59.13	.000288	239
61.12	.000207	
62.10	.000190	
63.09	.000186	
64.03	.000174	
65.01	.000122	
65.96	.000111	
67.84	.0000772	
68.76	.0000642	
70.59	.0000392	
71.52	.0000486	
72.44	.0000708	
75.12	.0000355	

AM 6.09 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
64.45	.0000940	
71.45	.0000449	
75.24	.0000365	
79.69	.0000236	
80.57	.0000152	
81.39	.0000203	

AM 6.10 4 November 1956

15:54 Z3T, At Sea, 57.8°N, 46.7°W

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
19.14	.117	195
19.48	.111	194
19.84	.105	192
20.24	.0994	190
20.67	.0922	189
21.14	.0856	187
26.85	.0304	203
27.81	.0247	214
28.78	.0212	213
29.80	.0190	202
30.89	.0156	205
31.97	.0124	216
34.28	.00857	219
36.60	.00592	222
37.79	.00488	225
39.00	.00394	233
40.22	.00318	243
41.42	.00261	251
42.64	.00229	243
43.85	.00189	249
45.07	.00160	250
46.28	.00135	252
47.52	.00114	253
48.74	.000934	263
49.94	.000775	273
51.16	.000684	265
52.38	.000578	269

AM 6.10 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
53.63	.000488	274
54.87	.000571	195
56.09	.000396	231
57.31	.000318	242
58.51	.000307	210
59.72	.000205	265
60.92	.000184	252
62.13	.000179	219
63.33	.000158	205
64.52	.000131	203
65.71	.0000870	257
66.87	.0000797	240
68.06	.0000703	230
70.39	.0000490	236
71.57	.0000463	209
72.74	.0000459	
73.87	.0000256	
75.03	.0000254	
76.18	.0000186	
78.54	.0000152	
79.74	.0000160	
81.79	.00000863	
82.76	.00000536	
84.78	.00000538	
85.79	.00000520	
87.77	.00000470	

AM 6.10 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
79.50	.0000126	
80.77	.00000827	
81.95	.00000852	
83.23	.00000527	
84.37	.00000597	
85.58	.00000544	
86.78	.00000389	
87.90	.00000470	
89.02	.00000510	
90.23	.00000285	

AM 6.12 10 November 1956
11:17 Z4T, At Sea, 65.6°N, 58°W

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
18.05	.111	203
18.41	.106	200
18.82	.0978	202
19.27	.0913	200
19.76	.0840	201
20.28	.0753	205
22.91	.0485	208
26.52	.0270	207
28.60	.0190	209
29.75	.0158	209
30.96	.0128	213
32.20	.0104	215
33.44	.00835	221
34.68	.00664	231
35.93	.00564	226
37.22	.00455	232
38.54	.00369	236
39.84	.00308	235
41.17	.00252	237
42.48	.00211	235
43.81	.00172	238
45.15	.00140	244
46.46	.00122	231
47.80	.000965	243
49.11	.000774	253

AM 6.12 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
50.41	.000668	246
51.70	.000548	252
52.99	.000452	258
54.25	.000396	249
55.53	.000311	269
58.04	.000245	246
59.29	.000211	240
62.97	.000120	
64.18	.000109	
65.41	.0000955	
66.61	.0000812	
71.33	.0000398	
72.50	.0000382	
73.59	.0000282	
74.80	.0000242	
75.97	.0000287	
77.09	.0000186	
79.37	.0000208	
80.49	.0000217	
81.60	.0000207	
83.75	.0000167	
84.70	.00000611	
85.80	.00000848	
86.85	.00000812	
89.96	.00000742	

AM 6.12 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
65.06	.000119	
66.44	.0000788	
67.77	.0000638	
69.10	.0000535	
71.68	.0000431	
74.19	.0000312	
75.45	.0000232	
76.68	.0000152	
77.91	.0000180	
79.12	.0000142	

AM 6.02 25 January 1958

13:12 CST, Ft. Churchill, 58.7°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
18.44	.113	208
18.84	.106	207
19.27	.101	203
20.27	.0827	211
20.83	.0736	217
21.44	.0684	211
22.86	.0543	212
23.67	.0481	210
24.54	.0422	208
28.75	.0220	198
29.97	.0176	201
31.24	.0141	203
33.89	.00895	206
35.25	.00693	214
36.64	.00552	216
38.04	.00434	222
39.46	.00352	220
40.86	.00278	226
42.33	.00220	229
43.66	.00176	236
45.07	.00140	243
46.50	.00115	244
47.90	.000908	255
49.29	.000792	242
50.68	.000652	243
52.09	.000535	244
53.44	.000430	253
54.80	.000344	265

AM 6.02 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
56.15	.000287	267
57.47	.000247	263
58.80	.000211	260
60.10	.000174	267
61.44	.000153	256
62.75	.000128	258
64.04	.000106	263
65.33	.0000979	240
66.60	.0000779	255
69.12	.0000621	225
70.35	.0000474	248
71.60	.0000418	236
72.82	.0000381	217
74.03	.0000276	252
75.25	.0000241	
76.48	.0000229	
77.64	.0000158	
78.84	.0000148	
80.01	.0000128	
81.17	.00000913	
82.35	.0000101	
83.49	.00000914	
84.56	.00000554	
85.72	.00000647	
86.84	.00000605	
87.87	.00000337	
89.04	.00000432	
90.13	.00000364	

AM 6.02 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
57.28	.000243	272
60.02	.000181	257
61.38	.000152	258
64.05	.000110	250
65.36	.0000946	244
67.95	.0000681	236
69.23	.0000550	244
70.49	.0000514	218
71.75	.0000409	227
74.25	.0000321	
75.50	.0000245	
77.94	.0000168	
79.19	.0000128	
80.38	.0000106	
81.56	.00000982	
82.75	.00000739	
83.88	.00000780	
85.10	.00000604	
86.26	.00000517	
87.46	.00000335	

SM 2.10 27 January 1958

12:48 CST, Ft. Churchill, 58.7°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
19.16	.108	181
19.70	.0904	195
20.31	.0995	157
21.00	.0797	170
22.66	.0546	180
23.62	.0451	183
24.69	.0377	179
25.83	.0294	185
27.06	.0246	176
29.71	.0128	212
32.54	.00835	206
34.02	.00665	202
35.50	.00474	225
36.99	.00379	225
39.99	.00222	250
41.49	.00182	249
42.99	.00147	253
44.50	.00123	246
45.99	.000997	248
47.46	.000799	254
48.94	.000683	243
50.41	.000550	247
51.85	.000450	248

SM 2.10 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{O}Kelvin)
53.30	.000364	252
58.98	.000175	243
60.39	.000141	250
63.13	.000101	240
64.51	.0000894	222
65.85	.0000709	229
67.20	.0000591	226
69.84	.0000394	230
71.13	.0000342	218
72.43	.0000293	207
73.70	.0000229	218
74.96	.0000172	241
76.20	.0000140	
77.45	.0000121	
78.68	.0000109	
79.90	.00000988	
81.11	.00000852	
83.46	.00000526	
84.62	.00000461	
85.80	.00000454	
86.96	.00000421	
88.07	.00000321	
89.20	.00000215	
90.33	.00000172	

AM 6.03 29 January 1958

13:06 CST, Ft. Churchill, 58.7°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
18.18	.106	229
18.63	.103	220
19.12	.0969	217
19.66	.0870	222
20.94	.0721	220
21.69	.0646	219
22.52	.0569	219
24.44	.0442	207
26.76	.0316	197
28.06	.0247	202
29.44	.0185	215
30.90	.0150	210
32.42	.0112	223
33.97	.00848	233
37.18	.00473	271
38.81	.00368	287
40.44	.00299	292
42.09	.00252	286
43.74	.00205	289
45.38	.00169	291
47.04	.00140	288
48.68	.00118	283
50.33	.000978	280
51.98	.000849	262
53.59	.000712	253

AM 6.03 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
55.22	.000585	248
56.83	.000479	243
58.42	.000376	249
60.03	.000297	255
61.60	.000241	255
63.17	.000203	245
64.74	.000172	232
69.35	.0000902	227
70.86	.0000706	233
72.34	.0000529	253
73.84	.0000414	267
75.31	.0000334	276
76.78	.0000297	258
78.23	.0000267	236
79.68	.0000228	223
81.07	.0000142	300
82.50	.0000119	308
85.27	.00000860	
86.66	.00000798	
88.05	.00000799	
89.35	.00000509	
90.68	.00000380	
93.37	.00000414	
97.29	.00000341	
98.50	.00000220	
99.77	.00000225	

AM 6.03 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
69.59	.0000845	229
74.38	.0000474	
77.54	.0000237	
82.16	.0000124	
85.21	.00000776	
86.69	.00000727	

AM 6.05 4 March 1958

13:30 CST, Ft. Churchill, 58.7°N

Descending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
17.94	.125	195
18.86	.0962	218
19.39	.0893	216
19.97	.0787	224
20.62	.0714	224
22.14	.0579	219
23.00	.0513	217
23.98	.0440	216
25.03	.0369	219
27.40	.0261	214
28.71	.0209	218
31.52	.0131	227
33.01	.0104	229
34.55	.00835	227
36.10	.00650	232
37.70	.00494	244
39.31	.00413	232
40.92	.00305	251
42.55	.00242	255
44.17	.00194	257
45.81	.00156	259
47.44	.00126	259
49.06	.00103	255

AM 6.05 (continued)

Altitude (kilometers)	Density (kg/cu meter)	Temperature (^{o}Kelvin)
50.69	.000835	254
52.29	.000686	250
53.89	.000564	245
55.50	.000448	248
57.08	.000365	246
58.68	.000293	246
63.38	.000162	230
64.91	.000130	229
66.44	.000101	236
67.97	.0000834	230
69.48	.0000643	241
72.44	.0000362	295
73.94	.0000347	256
75.41	.0000311	234
78.30	.0000184	
81.13	.0000113	
82.58	.0000127	
83.97	.00000983	
85.40	.0000108	
86.75	.00000714	
88.14	.00000875	
89.36	.00000306	
90.79	.00000425	

AM 6.05 (continued)

Ascending Trajectory Data

Altitude (kilometers)	Density (kg/cu meter)	Temperature (°Kelvin)
57.15	.000348	243
58.83	.000277	242
60.49	.000220	242
62.15	.000181	
63.76	.000144	
65.38	.000114	
68.58	.0000691	
70.18	.0000571	
73.32	.0000372	
76.43	.0000220	
79.25	.0000172	
82.23	.0000126	
85.16	.00000745	