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Profiles of Temperature and Density Based on 1- and 10-Percent Extremes in the Stratosphere and Troposphere

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Vertical profiles of temperature and density have been developed based on 1 and 10 percent warm and cold temperatures and 1 and 10 percent high and low densities occurring at the worst locations in the world (except Antarctica) during the worst month. The profiles, from the surface to 80 km, are based on extremes that occur at 5, 10, 20, 30, and 40 km. For example, one of the temperature profiles developed was based on a 10 percent warm temperature at an altitude of 20 km; thus, it represents meteorological conditions typically associated with this extreme. Ten such warm profiles (5 levels by 2 percentiles) and 10 cold profiles have been constructed from 14 years of rawinsonde and rocketsonde observations. Internally consistent hydrostatic profiles of density associated with these temperature profiles are provided. Twenty analogous density (and associated temperature) profiles also have been developed from extreme densities occurring at these altitudes. Thus, a set of realistic profiles (rather than envelopes) of temperature and density associated with extremes at specified levels in the troposphere and strato- (Contd)

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Preface

The authors are especially grateful for the contributions of Mr. Jim Willand. His data processing methods were accurate and efficient, and enabled the timely completion of this report. We also thank Irving Gringorten and Frank Marcos for their helpful suggestions, and Mrs. Helen Connell for her expedient typing of this manuscript through several drafts.

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1. INTRODUCTION

Information on expected extremes of the thermodynamic properties of the atmosphere is required for the design and operation of systems traversing the atmosphere. Such data are particularly important at altitudes from the surface to approximately 80 km for developing airborne vehicles ranging from helicopters and airplanes to sophisticated aerospace systems.

Several temperature models of regional extremes have been developed for a few selected locations.[1,2,3] They provide temperature profiles based on estimated 1-percent hot and cold temperatures at pressure levels between 850 mb (1.5 km) and 100 mb (16 km). NASA[4] also presents temperature and density

(Received for publication 27 December 1984)

1. Martin, F. L. (1972) Development of Regional Model Atmospheres for Aerothermodynamic Calculations (I), NPS-51MR72101A, Naval Postgraduate School, Monterey, Calif.

2. Martin, F. L. (1973) Development of Regional Extreme Model Atmospheres for Aerothermodynamic Calculations (II), NPS-51MR73071A, Naval Postgraduate School, Monterey, Calif.

3. Martin, F. L. (1974) Oceanic Extreme Model Atmospheres for Aerothermodynamic Calculations, NPS-51MR74091A, Naval Postgraduate School, Monterey, Calif.

4. NASA (1983) Terrestrial Environment (Climatic) Criteria Guidelines for Use in Aerospace Vehicle Development, 1982 Revision, NASA Tech. Memo. 82473, Marshall Space Flight Center, Ala.

envelopes and extreme profiles up to 90 km, but only at several missile ranges.

The Air Force Reference Atmospheres[5] provide monthly mean temperatures, densities, and pressures at 15-degree intervals of latitude from the equator to the pole, including estimated day-to-day variability around the monthly averages. Also available are several reports[6, 7, 8] containing information on the time and space variations of density in the upper stratosphere and lower mesosphere for time periods up to 72 hours and horizontal distances out to nearly 400 km (200 nm). Unfortunately, these do not directly address low probabilities of occurrence.

MIL-STD-210B, Climatic Extremes for Military Equipment,[9] contains envelopes of global extremes (excluding Antarctica) of hot and cold temperatures and of high and low densities and pressures at 2 km increments of altitude below 30 km and 5 km increments above 30 km. However, these envelopes are deficient for many design considerations because the values are unrelated in time and space; that is, values at one altitude may be valid for different locations or for different months from values at other altitudes. Because they are not consistent profiles typical of the vertical distribution of the thermodynamic properties at any one location, these envelopes are unrealistically severe for many engineering and design problems. Low density or high density, for example, cannot occur simultaneously at any given location through a vertical thickness more than a few kilometers, as shown in Figure 1.[5, 10] In this figure, the density profile associated with a warm winter stratosphere in the region near 60° N displays a 5-percent minimum near 30 km and a 5-percent maximum at about 50 km. Conversely, the density profile associated with a cold winter stratosphere shows a 5-percent maximum near 35 km and a 5-percent minimum at 65 km.

In this report, vertical profiles of temperature and density have been developed based on 1- and 10-percent hot and cold temperatures and 1- and 10-percent high and low densities occurring during the most severe month at the

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5. Cole, A.E., and Kantor, A.J. (1978) Air Force Reference Atmospheres, AFGL-TR-78-00051, AD A058505.

6. Kantor, A.J., and Cole, A.E. (1981) Variations of Density and Wind with Time at Altitudes 30 to 60 km, AFGL-TR-81-0281, AD A109804.

7. Kantor, A.J. (1982) Atlas of Northern Hemisphere Density between 30 and 60 km, AFGL-TR-82-0282, AD A125987.

8. Kantor, A.J. (1983) Variability of Atmospheric Density on the Middle Atmosphere, AFGL-TR-83-0079, AD A131985.

9. Department of Defense (1973) Military Standard, Climatic Extremes for Military Equipment, MIL-STD-210B, 15 December 1973, Office of the Under Secretary of Defense, Research and Engineering, Washington, D.C.

10. Kantor, A.J., and Cole, A.E. (1977) Monthly 90° N Atmospheres and High-Latitude Warm and Cold Winter Stratosphere/Mesosphere, AFGL-TR-77-0289, AD A053234.

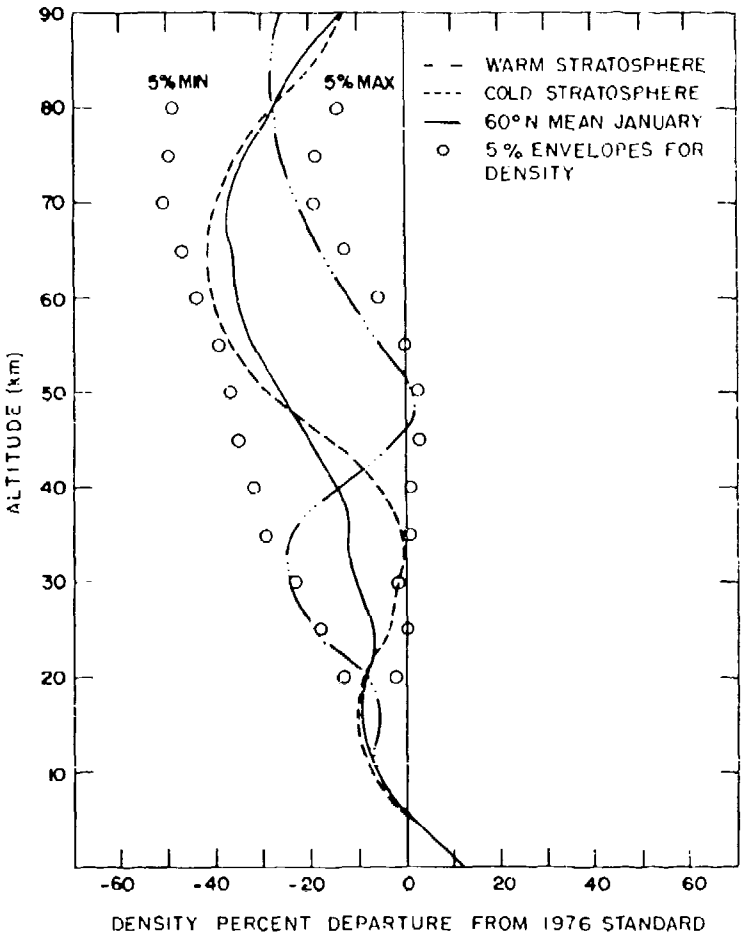

Figure 1. Density Profiles Associated With Extreme Temperatures in the Upper Stratosphere

worst locations for which reliable upper-air data are available. The profiles, from the surface to 80 km, are based on extremes that occur at 5, 10, 20, 30, and 40 km. There are 20 profiles associated with extreme temperatures (5 levels by 4 percentiles), and 20 analogous profiles associated with extreme densities. Consequently, a set of realistic profiles (rather than envelopes) of temperature and density, associated with extremes at each of five specified levels in the troposphere and stratosphere, are now available for altitudes up to 80 km.

2. BASIC ASSUMPTIONS AND EQUATIONS

The atmospheric profiles in this report are defined by temperature-altitude segments in which vertical gradients of temperature are linear with respect to geopotential altitude. For simplicity, gradient changes occur at "breakpoints" of whole and half km of altitude, and the breakpoint temperatures are in whole and half degrees Kelvin. It is assumed that the air is dry, is in hydrostatic equilibrium, and behaves as a perfect gas. The molecular weight of air at sea level, 28.9644 kg/(k-mol), is considered to be constant to 80 km. Dissociation of molecular oxygen begins to take place near 80 km, and molecular weight starts decreasing slowly above that altitude.[5, 11] Consequently, molecular-scale temperatures (T_M) and the ambient kinetic temperatures (T) are identical in this report because $T_M = (M_o/M)T$, and M_o, the sea-level molecular weight, and M, the molecular weight of air at a specific altitude, are equal for altitudes up to 80 km.

Numerical values for the various thermodynamic and physical constants used in computing the tables of temperature and density for these model profiles are the same as those used in the preparation of the U.S. Standard Atmosphere, 1976, with the following two exceptions:

(1) Surface conditions for the profiles are based on sea-level pressures and temperatures for the appropriate month and location rather than on standard conditions.

(2) The accelerations due to gravity at sea level for the specified sites were obtained from the following expression by Lambert[12] in which gravity g (m/sec^2) varies with latitude ϕ :

$$g_\phi = 9.780356\,(1 + 0.0052885 \sin^2\phi - 0.0000059 \sin^2 2\phi). \quad (1)$$

2.1 The Static Atmosphere and Perfect Gas Law

The atmosphere is assumed to be in hydrostatic equilibrium and to satisfy the differential equation

$$dP = -\rho g\, dZ \quad (2)$$

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11. NOAA, NASA, USAF (1976) U.S. Standard Atmosphere, 1976, Government Printing Office, Washington, D.C.

12. List, R.J., Ed. (1968) Smithsonian Meteorological Tables, Smithsonian Inst. Press, Washington, D.C.

which relates air pressure (P) to density (ρ), acceleration of free fall (g), and altitude (Z). The perfect gas law relates air pressure to density and temperature as follows:

$$P = \frac{\rho R^* T_M}{M_o} \tag{3}$$

where R* is the universal gas constant, 8.31432 J/K(k-mol).

2.2 Geopotential

The relationship between geopotential altitude and geometric altitude is the same as that used for the U.S. Standard Atmosphere Supplements, 1966 and the Air Force Reference Atmospheres,

$$H = \left(\frac{r_\phi Z}{r_\phi + Z} \right) \left(\frac{g_\phi}{G} \right) \tag{4}$$

where H is the geopotential altitude in geopotential meters (m'), Z is the geometric altitude in meters, g_ϕ is the sea-level value for acceleration of gravity (m/sec^2) at a specific latitude ϕ as given by Lambert's equation, G is the unit geopotential set equal to 9.80665 m^2/sec^2(m'), and r_ϕ is the effective earth radius in meters (Section IV, Smithsonian Tables[12]). Values of r_ϕ and g_ϕ at the locations selected to develop the model profiles are given in Table 1.

2.3 Computational Equations

Vertical distributions of pressure can be obtained from the appropriate vertical temperature structure and associated sea-level pressures, according to the following two forms of the barometric equation:

$$\frac{P}{P_b} = \left(\frac{T_{Mb}}{T_{Mb} + Lh} \right)^{\frac{GM_o}{R^* L}} \qquad (L \neq 0) \tag{5}$$

$$\frac{P}{P_b} = \exp\left(\frac{-GM_o h}{R^* T_{Mb}} \right) \qquad (L = 0) \tag{6}$$

where $h = H - H_b$; H_b is the geopotential altitude at a base of a particular layer char-

Table 1. Sea-Level Acceleration Due to Gravity and Effective Earth's Radius at Locations Selected to Develop Model Profiles

Location	Sea-Level Gravity	Effective Radius
	g (m/sec^2)	r (km)
Alert, NWT, Canada (82.5N, 62.3W)	983.119	6377.124
Eureka, NWT, Canada (80.0N, 85.9W)	983.051	6376.562
Thule, Greenland (76.6N, 68.8W)	982.929	6375.544
Barrow, Alaska (71.2N, 156.5W)	982.667	6373.366
Norman Wells, NWT, Canada (65.3N, 126.8W)	982.300	6370.330
Poker Flats, Alaska (65.1N, 147.5W)	982.288	6370.227
Coral Harbor, NWT, Canada (64.3N, 83.4W)	982.224	6369.700
Frobisher Bay, NWT, Canada (63.8N, 68.6W)	982.193	6369.432
Ft. Churchill, Manitoba, Canada (58.8N, 94.1W)	981.808	6366.236
China Lake, California (35.4N, 117.4W)	979.766	6349.314
Point Mugu, California (34.1N, 119.1W)	979.656	6348.407
Truk Island (7.5N, 151.7E)	978.123	6335.711
Majuro, Marshall I. (7.1N, 171.1E)	978.113	6335.626
Pago Pago, Tutuila I. (14.2S, 170.4W)	978.344	6337.537
Antofagasta, Chile (23.4S, 70.2W)	978.848	6341.715
Punta Arenas, Chile (53.1S, 70.6W)	981.338	6362.345

acterized by a specific value of L, which is the vertical gradient of molecular-scale temperature with geopotential altitude of (dT_M/dh); and T_{Mb} and P_b are the respective values of temperature and pressure at altitude H_b. Rewriting Eq. (3) for ρ and ρ_b and combining both with Eqs. (5) and (6), yields the two computational expressions for density

$$\frac{\rho}{\rho_b} = \frac{T_{Mb}}{T_{Mb} + Lh}^{1 + \frac{GM_o}{R^*L}} \qquad (L \neq 0) \qquad (7)$$

$$\frac{\rho}{\rho_b} = \exp \frac{-GM_o h}{R^* T_{Mb}} \qquad (L = 0) \qquad (8)$$

3. DATA BASE

The data used in this investigation consist primarily of two types of observations: (1) rawinsonde observations from the surface to approximately 25 km, and (2) Meteorological Rocket Network (MRN) observations for altitudes roughly 25 km to 65 km. The total period of record spans 14 years, from 1969 through 1982.

3.1 Rawinsondes

Rawinsonde data, provided in National Climatic Data Center (NCDC) Tape Deck 5600 format, consist of 00 UT and 12 UT observations of temperatures and pressure altitudes for most areas of the world excluding Eurasia, Africa, and Australia. The effect of excluding these regions is discussed in Section 4.1. Although both NCDC TD 5685 and the USAF/ETAC DATSAV tapes contain the preferred global coverage, these data are considered unreliable for analysis of extremes and low probabilities of occurrence of temperature and density. Consequently, TD 5600 was used for this report instead of TD 5685. TD 5600 contains observations from some 130 locations (United States, Central and South America, and Oceania) for the years 1969 through 1981, and was used in combination with Canadian rawinsonde tapes which also contain twice-daily observations from some 40 Canadian-controlled high-latitude stations for the years 1969 through 1982.

3.2 Meteorological Rockets

MRN tape deck TDF 5850 was used for this report; it provides temperatures and calculated densities at 21 MRN locations for altitudes from approximately

Table 2. Meteorological Rocket Network Stations, Overall Period of Record 1969-1982

Station	Location	Number of Soundings
Thule AFB, Greenland	77N, 69W	896
Poker Flats, Alaska (Ft. Greely)	65N, 147W	861
Ft. Churchill, Manitoba	59N, 94W	1242
Primrose Lake, Alberta	55N, 110W	1076
Shemya, Alaska	53N, 174W	510
Green River, Utah	39N, 110W	3
Wallops Island, Virginia	38N, 76W	1111
El Arenosillo, Spain	37N, 7W	27
Point Mugu, California	34N, 119W	1531
White Sands, New Mexico	32N, 107W	1601
Cape Kennedy, Florida	29N, 81W	1500
Barking Sands, Hawaii	22N, 160W	1318
Antigua, British West Indies	17N, 62W	785
Ft. Sherman, Canal Zone	9N, 80W	919
Kwajalein, Marshall Islands	9N, 168E	1434
Natal, Brazil	6S, 35W	44
Ascension Island	8S, 14W	1181
Mar Chiquita, Argentina	38S, 57W	31

25 km to 65 km for the years 1969 through 1982. Table 2 lists the 18 MRN stations and the number of soundings that were available. They lie mostly in the western hemisphere and are located between latitudes 77° N and 38° S.

3.3 Limitations and Accuracy

Rawinsonde temperature measurement errors vary linearly with altitude

from 0.7 K at the surface to 1.5 K at 30 km.[13] Rocketsonde measurement errors, corrected for a warm bias for altitudes between 30 km and 65 km,[14] also increase linearly with altitude from about 0.5 K at 25 km to 3 K at 65 km. However, temperature data were not used for altitudes above 60 km because thermistor measurements are subject to additional uncertainties above this level.

Density at a given level in the atmosphere, except near the surface, is dependent upon the integrated temperature profile through a substantial layer of the atmosphere rather than from an observed temperature at a specific altitude. Thus, random observational errors in temperature tend to average out in the integration over the entire layer, minimizing the errors in computed densities. The root-mean-square (rms) errors in densities derived from rawinsonde temperature observations vary from 0.1 percent at the surface to 1.5 percent near 30 km. The rms errors in densities derived from rocketsonde temperature measurements have been estimated to vary from 3 percent at 30 km to 4 or 5 percent at 60 km.[13]

4 DATA PROCESSING

Several conversions and mathematical and statistical procedures have been utilized in developing the required vertical profiles of temperature and density from rawinsonde and rocketsonde observations for the 14-year period 1969 to 1982. These are discussed in Section 4.1.

4.1 Rawinsondes

Analysis of available rawinsonde data entailed assimilation of as many as 9000 soundings per station (two per day for 13 years). Computer techniques and analyses produced threshold values of 1-, 10-, 90-, and 99-percent temperatures at 5, 10, and 20 km for the most severe month and location. The resulting threshold temperatures at the indicated locations, months, and altitudes of occurrence, are shown in Table 3. The two temperatures, 241 K and 235 K, that are listed for the 99-percent threshold at 20 km are discussed in Section 5. These 13 values were used to select sets of soundings that meet or exceed the 1- and 10-percent hot and cold temperatures at the appropriate location, month, and altitude. The same procedure provided the threshold densities shown in Table 4, plus those

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13. Meteorological Group, Range Commanders Council (1981) Meteorological Data Error Estimates, Document 110-81, White Sands Missile Range, N. Mex.

14. Krumins, M., and Lyons, W. (1972) Corrections for the Upper Atmosphere Temperatures Using a Thin Film Loop Mount, Naval Ordnance Laboratory, Technical Report 72-152, White Oak, Silver Spring, Md.

Table 3. Rawinsonde Temperature Extremes for the Most Severe Month and Location (With Paired MRN Location)

Percentile	Site Rawin-Month (MRN)	5km Temperature (K)	Site Rawin-Month (MRN)	10km Temperature (K)	Site Rawin-Month (MRN)	20km Temperature (K)
1%	Eureka-Feb. (Thule)	220	Eureka-Mar. (Thule)	199	Alert-Feb. (Thule)	186
10%	Eureka-Feb. (Thule)	224	Alert-Feb. (Thule)	204	Alert-Jan. (Thule)	192
90%	Antofagasta-Feb. (Cape Kennedy-Aug.)	276	Majuro-Jan. (Kwajalein)	243	Alert-June (Thule)	234
99%	Point Mugu-July (Point Mugu)	279	Pago-Pago-Jan. (Kwajalein-July)	245	Alert-Feb. (Thule)	241 (a)
99%					Alert-June (Thule)	235 (b)

soundings that meet or exceed the 1-and 10-percent high and low densities.

All threshold temperatures and densities that were developed for the model profiles are compared with 1973 MIL-STD-210B values in Table 5. The lack of Eurasian, African, and Australasian data is apparent in that the warm extremes are less severe than MIL-STD-210B temperatures at 5 and 10 km. Locations in the Near East, particularly over the Indian subcontinent in summer, undoubtedly would produce warmer 90-and 99-percent temperatures at these levels. Similarly, winter observations over Siberia would produce somewhat colder 1-percent temperatures at 5 km. The inclusion of African and Australasian densities also would produce more extreme 90-and 99-percent densities at 5, 10, and possibly 20 km.

4.2 Rocketsondes

A procedure analogous to that used for rawinsondes was used to analyze MRN temperatures and densities at 30 and 40 km. MRN data from the 18 stations listed in Table 2 were used to produce the desired threshold temperatures and densities. Although the period of record, 1969-1982, is approximately the same as that available for the rawinsonde analysis, MRN observations are limited to locations mostly in the western hemisphere, and both the number of stations and the number of soundings are an order of magnitude smaller than that for the

Table 4. Rawinsonde Density Extremes for the Most Severe Month and Location (With Paired MRN Location)

Percentile	Site Rawin-Month (MRN)	5 km Density (Kg/m^3)	Site Rawin-Month (MRN)	10 km Density (Kg/m^3)	Site Rawin-Month (MRN)	20 km Density (Kg/m^3)
1%	Punta Arenes-Jan. (Wallops I.-July)	6.93-1*	Coral Harbor-Jan. (Churchill)	3.39-1*	Coral Harbor-Feb. (Churchill)	6.73-2*
10%	Point Mugu-Sept. (Point Mugu)	7.04-1	Frobisher Bay-Mar. (Churchill)	3.53-1	Eureka-Feb. (thule)	7.14-2
90%	Barrow-Jan. (Poker Flats)	7.74-1	China Lake-Dec. (Point Mugu)	4.30-1	Truk-Feb. (Kwajalein)	9.71-2
99%	Norman Wells-Jan. (Poker Flats)	7.83-1	Point Mugu-Jan. (Point Mugu)	4.33-1	Truk-Feb. (Kwajalein)	9.93-2

* Power of ten by which preceding numbers should be multiplied.

Table 5. Threshold Temperatures and Densities Determined for the Model Profiles vs Values From MIL-STD-210B

Altitude		Profiles	210B	Profiles	210B	Profiles	210B	Profiles	210B
(km)		1%		10%		90%		99%	
5	T (K)	220	221	224	225	276	281	279	285
	ρ(kg/m^3)	6.93-1*	6.99-1*	7.04-1*	7.03-1*	7.74-1*	7.75-1*	7.83-1*	7.87-1*
10	T (K)	199	199	204	206	243	254	245	260
	ρ(kg/m^3)	3.39-1	3.53-1	3.53-1	3.58-1	4.30-1	4.28-1	4.33-1	4.33-1
20	T (K)	186	189	192	192	234	234	241	236
	ρ(kg/m^3)	6.73-2	7.10-2	7.14-2	7.50-2	9.71-2	1.01-1	9.93-2	1.05-1
30	T (K)	189	193	195	195	244	241	254	243
	ρ(kg/m^3)	1.22-2	1.13-2	1.24-2	1.27-2	2.04-2	2.06-2	2.06-2	2.10-2
40	T (K)	201	203	211	211	273	278	276	298
	ρ(kg/m^3)	2.06-3	2.00-3	2.22-3	2.40-3	4.79-3	5.03-3	4.88-3	5.27-3

* Power of ten by which preceding numbers should be multiplied

Table 6. Rocketsonde Temperature Extremes for the Most Severe Month and Location

Percentile	Site/Month	Temperature 30 km (K)	Site/Month	Temperature 40 km (K)
1%	Churchill Dec.	189	Thule Jan.	201
10%	Thule Dec.	195	Thule Jan.	211
90%	Poker Flats June	244	Poker Flats June	273
99%	Thule July	254	Poker Flats June	276

rawinsondes. Threshold temperatures and densities are shown in Tables 6 and 7, respectively, for 30 and 40 km at the indicated locations and months of occurrence. Those soundings that meet or exceed the 1-and 10-percent hot and cold temperatures and high and low densities were selected for final analysis.

At MRN altitudes, Table 5 shows that threshold temperatures and densities for the profiles are generally comparable to the MIL-STD values, except for the 99 percent temperatures. The profiles were developed from a significantly larger and more stable data base containing more accurate observations than

Table 7. Rocketsonde Density Extremes for the Most Severe Month and Location

Percentile	Site/Month	Density 30 km (kg/m^3)	Site/Month	Density 40 km (kg/m^3)
1%	Thule Jan.	1.22-2*	Thule Feb.	2.06-3*
10%	Thule Jan.	1.24-2	Thule Feb.	2.22-3
90%	Poker Flats July	2.04-2	Poker Flats July	4.79-3
99%	Thule July	2.03-2	Poker Flats July	4.88-3

* Power of ten by which preceding numbers should be multiplied.

those used for the MIL-STD. At 40 km, the warm bias in the early MRN temperature observations used for the MIL-STD was not uniformly corrected and resulted in high temperature estimates, especially at 90 and 99 percent. At 30 km, the much colder 99-percent MIL-STD temperature probably results from the almost exclusive use of rawinsonde data, which are less accurate at this altitude than the MRN data used for the current profiles.

5. ANALYSIS

All soundings that met or exceeded the 40 criteria established for temperature and density as described in Tables 3, 4, 6, and 7, were carefully analyzed for development of model vertical profiles typical of each of the indicated atmospheric conditions. As noted in Section 4, two 99-percent temperatures at 20 km are listed for Alert (see Table 3). These values, 241 K in February and 235 K in June, reflect the existence of an atypical high-latitude winter stratosphere known as a "sudden warming." A sudden warming occurs sufficiently often to produce the more extreme 99 percent temperature in winter rather than summer. For completeness, the alternate June profile, based on the 235 K threshold, also is provided in this report.

Tables of the model profiles are provided in Appendix A for 2 km increments of altitude from sea level to 80 km. Corresponding Standard Atmosphere densities are shown in these tables for convenience and comparison. The temperature-altitude profiles used to generate the models are defined in Appendix B. The temperature gradients between the tabular breakpoints in the Appendix B tables are linear with geopotential altitude.

The sea level pressures used for each profile were derived from analyses of the 40-year monthly means in the Northern Hemisphere[15] and more than 30 years' data in the Southern Hemisphere.[16] Errors introduced by using monthly mean sea level pressures are normally insignificant because the defining element for these models is temperature. For example, an unusually large pressure error of 10 mb at sea level (roughly 1 percent) would remain constant throughout the model, and would result in a density error of no more than 1 percent at any altitude. Exceptions do occur, however, for high-density extremes at low levels. The high density thresholds at 5 km occur during high-latitude winter under the influence

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15. USWB (1952) Normal Weather Charts for the Northern Hemisphere, Tech Paper 21, Washington, D.C.

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of unusually high surface pressure. This is reflected in Table 6, where surface pressure for the 90-and 99-percent 5 km density profiles is 1032 mb rather than the mean January pressure of 1018.5 mb at Barrow and 1021 mb at Norman Wells.

5.1 Rawinsonde Extremes at 5, 10, and 20 km

Twelve temperature-height profiles representative of atmospheric conditions associated with threshold temperatures at 5, 10, and 20 km were derived for the locations and months shown in Table 3 using the equations and ground rules outlined in Section 2. As an example, Figure 2 shows the cumulative frequency distribution of 10 km temperatures at Eureka in March. This location and month was objectively selected for development of the model profile based on the 1-percent temperature threshold at 10 km, 199 K. Figure 3 represents the profile that was subjectively fitted to the appropriate rawinsonde and MRN temperatures at Eureka/Thule in March. The densities associated with that profile were calculated using Eqs. (7) and (8).

For the 12 model profiles based on threshold densities, temperatures in the soundings associated with density criteria at 5, 10, and 20 km were used in the same manner to construct the profiles for the locations and months shown in Table 4; associated densities for all altitudes again were computed from Eqs. (7) and (8). At altitudes above 25-30 km, concomitant values from the most appropriate MRN stations were employed to extend all 24 profiles to approximately 55 km. The MRN stations used to complement the rawinsonde stations are listed in Tables 3 and 4. They were chosen from the 18 usable MRN sites considering proximity, climate, and specific synoptic situation for the dates in question. MRN observations at the selected locations were matched with the corresponding rawinsonde dates ±1 day. For the overlap region, 20-30 km, heavier weight was given to rawinsonde observations below 25 km, and heavier weight was given to MRN observations above 25 km, the altitude regions where the respective data are more reliable.

Three profiles, based on the 90-percent threshold temperature at 5 km, the 99-percent threshold temperature at 10 km, and the 1-percent threshold density at 5 km were developed from observations at Southern Hemisphere rawinsonde locations in combination with observations from the most appropriate MRN stations in the Northern Hemisphere. A 6-month seasonal adjustment was applied to the MRN data as indicated in Tables 3 and 4.

5.2 Rocketsonde Extremes at 30 and 40 km

Eight temperature-height profiles typical of conditions associated with threshold temperatures at 30 and 40 km were developed for the location and months shown in Table 6. For the eight additional profiles based on threshold densities,

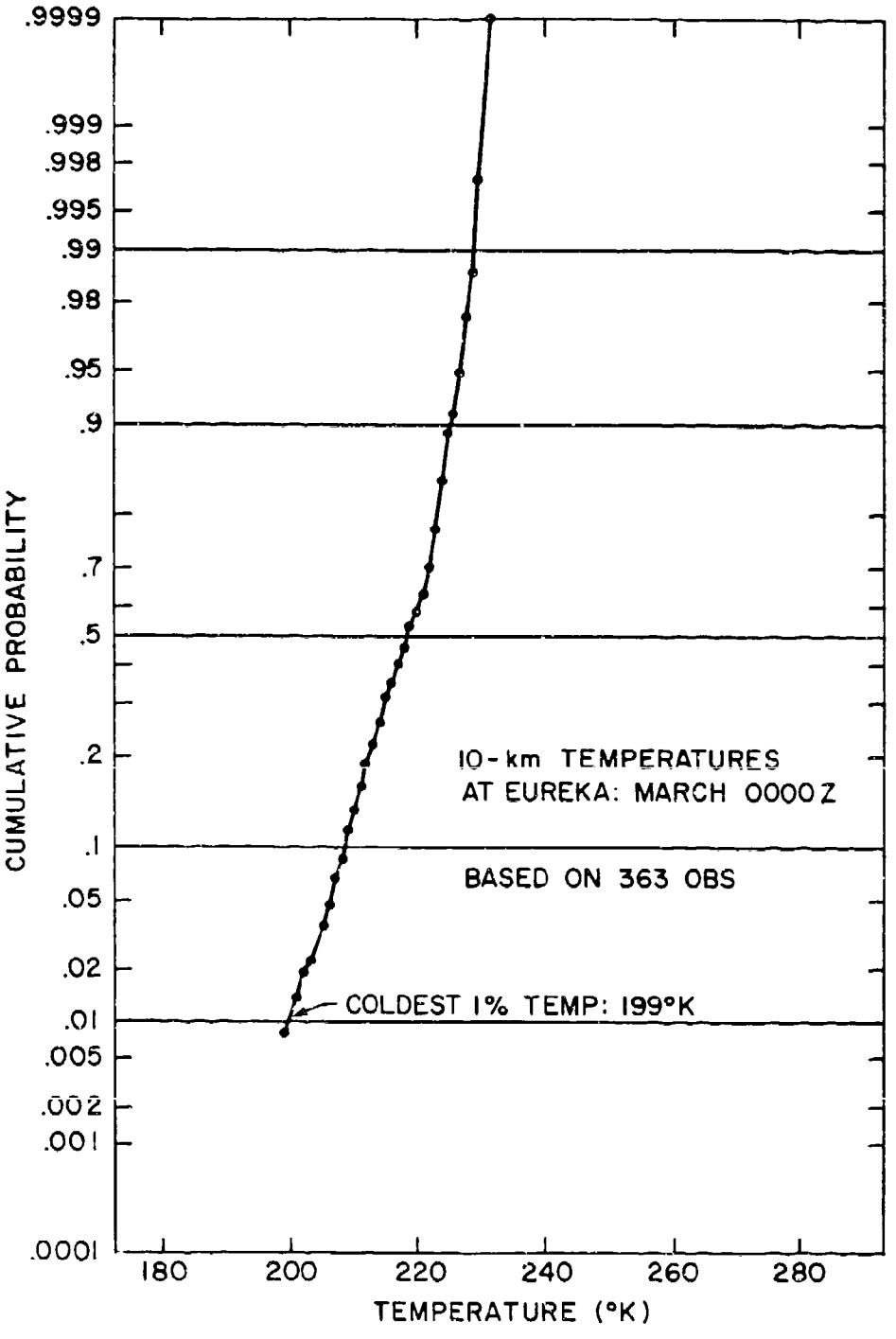

Figure 2. Cumulative Probability for Selection of 1-Percent Temperature at 10 km

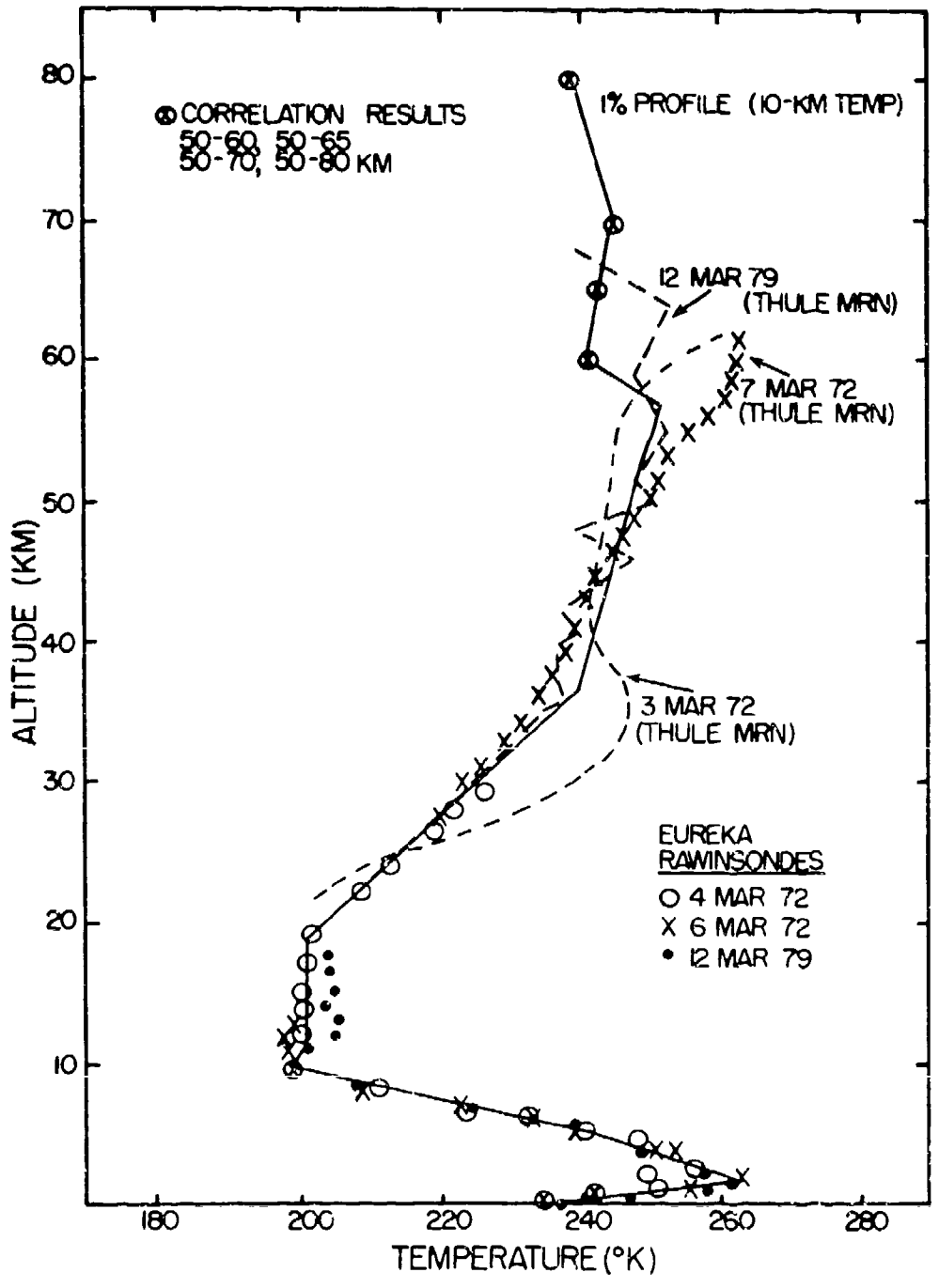

Figure 3. Profile Based on 1-Percent 10-km Threshold Temperature at Eureka and Concomitant Thule MRN Data

temperatures in the soundings associated with the density criteria at 30 and 40 km were used to construct the model profiles for the locations and months shown in Table 7. Concomitant rawinsonde data for all soundings of interest at the selected stations (Tables 6 and 7) were utilized to develop continuous profiles upward from sea level. Again, the model profiles were constructed and computed according to the ground rules and equations provided in Section 2.

5.3 Profiles Above 55 km

The 20 model profiles based on 1- and 10-percent cold temperatures and low densities at the five specified altitudes, 5, 10, 20, 30, and 40 km, are representative of high-latitude winter conditions when there can be rather wide fluctuations of temperature and density near the mesopause (≈80 km). However, information on the temperature structure above 55 km can be derived from the profile values at 50 km. As a result, the portions of these temperature-height profiles above 55 km were based on estimates obtained from interlevel temperature correlations (Table 8) that were developed from data derived from independent rocket grenade and pressure gauge experiments at Fort Churchill during the winters 1957-1972,[10] along with the model profile temperatures adopted at 50 km. The equation used for these calculations is:

$$\hat{T}_2 = \overline{T}_2 + \frac{rS_2}{S_1} (T_1 - \overline{T}_1) \tag{9}$$

where $\overline{T}_1$ and $\overline{T}_2$ are the monthly mean temperatures at lower level 1 and upper level 2, S_1 is the standard deviation of the temperature (T_1), S_2 is the standard deviation of the temperature (T_2), r is the correlation coefficient of temperature between the two levels, and $\hat{T}_2$ is the estimated temperature at level 2. Estimated temperatures for 60, 65, 70, and 80 km were used to develop the appropriate winter profiles above 55 km as shown in Figure 3.

The 20 model profiles based on the 1- and 10-percent hot temperatures and high densities at the same five specified altitudes are generally representative of summer conditions and/or occur at low-latitude locations. During these months (and during all months at low latitudes) the temperature structure in the mesosphere is relatively stable above 60 km. Consequently, these model profiles were extended from 60 to 80 km using the Air Force Reference Atmospheres for the appropriate month and latitude.

Table 8. Interlevel Temperature Correlations for High-Latitude Profiles

Alt (km)	40	45	50	55	60	65	70	75	80
50	0.458	0.583	1.0						
55	0.031	0.144	0.509	1.0					
60	-0.234	-0.176	0.325	0.670	1.0				
65	-0.451	-0.404	-0.342	0.272	0.509	1.0			
70	-0.546	-0.421	-0.483	-0.134	-0.082	0.473	1.0		
75	-0.600	-0.560	-0.330	-0.058	0.151	0.209	0.513	1.0	
80	-0.436	-0.497	-0.561	-0.049	-0.049	0.251	0.446	0.547	1.0

6. DISCUSSION

The model profiles of temperature and density derived for this report represent atmospheric conditions associated with 1- and 10-percent hot and cold temperatures and high and low densities that occur at each of 5 levels (5, 10, 20, 30, and 70 km). Results are presented at 2 km intervals of geometric altitude, from sea level to 80 km, in Tables A1-A5 for temperature and associated density, and in Tables A6-A10 for density and associated temperature. Results are also presented in the form of temperature-altitude profiles with lapse-rate breakpoints in geopotential km as derived from threshold temperatures in Table B1, and from threshold densities in Table B2. They are realistic hydrostatically consistent representations of the temperature and density structure resulting from the extremes that occur at the indicated altitudes.

Four of the 40 temperature-altitude profiles, based on the 1-and 99-percent temperatures at 10 km (Figure 4) and 1-and 99-percent temperatures at 30 km (Figure 5), are compared with the 1973 MIL-STD-210B envelopes. In a similar manner, the 1-percent temperature profiles at 10 and 30 km (Figure 6) and the 99-percent profiles at 10 and 30 km (Figure 7), are compared to the MIL-STD envelopes. In all four examples, it is obvious that the profiles generally are much less extreme than the MIL-STD envelopes at all but the threshold altitudes.

Figures 4 and 5 display a reversal feature of the atmosphere; that is, the hot and cold profiles of the troposphere and lower stratosphere become cold and hot profiles, respectively, above 60 or 65 km. This is particularly clear in Figure 5, which is based on a 30 km threshold temperatures. Figures 6 and 7 show that the 1-percent extremes (Figure 6) and the 99-percent extremes (Figure 7), produce

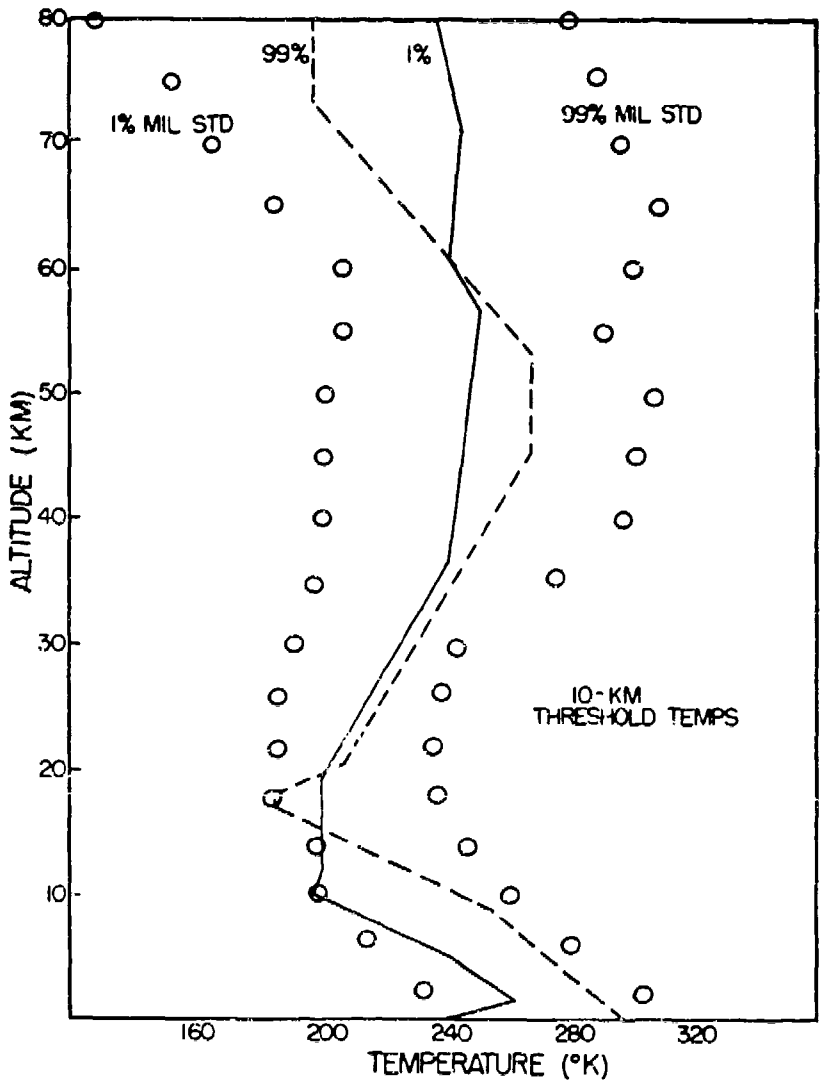

Figure 4. Model Profiles for 10-km Threshold Temperatures, and MIL-STD-210B Envelopes

different estimates of atmospheric structure when based on different threshold altitudes.

The results in this report clearly point out the differences between profiles that are consistent in time and space and envelopes that indicate extremes at each altitude that are unrelated in time and space to those at other altitudes. Each of these presentations of upper air data have their applications. The envelopes can be used to determine low probability conditions at a specific alti-

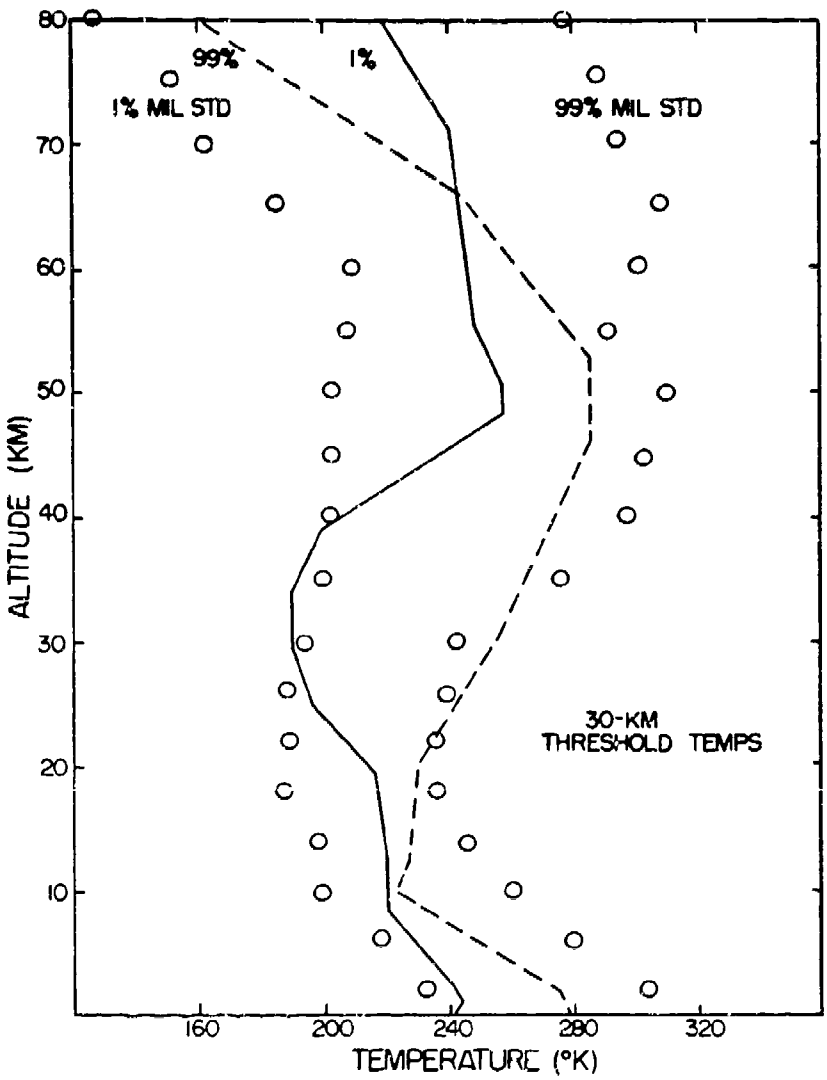

Figure 5. Model Profiles for 30-km Threshold Temperatures, and MIL-STD-210B Envelopes

tude of concern. These would most commonly be applied to design considerations involving constant level flight. The model profiles presented in this report are more appropriate for the design of vehicles traversing the atmosphere, or other considerations for which the total influence of the atmosphere is needed. Each of the 40 profiles in this report should be considered individually to determine which are the most appropriate for a particular application.

The profiles in this report will be included in future revisions of MIL-STD-

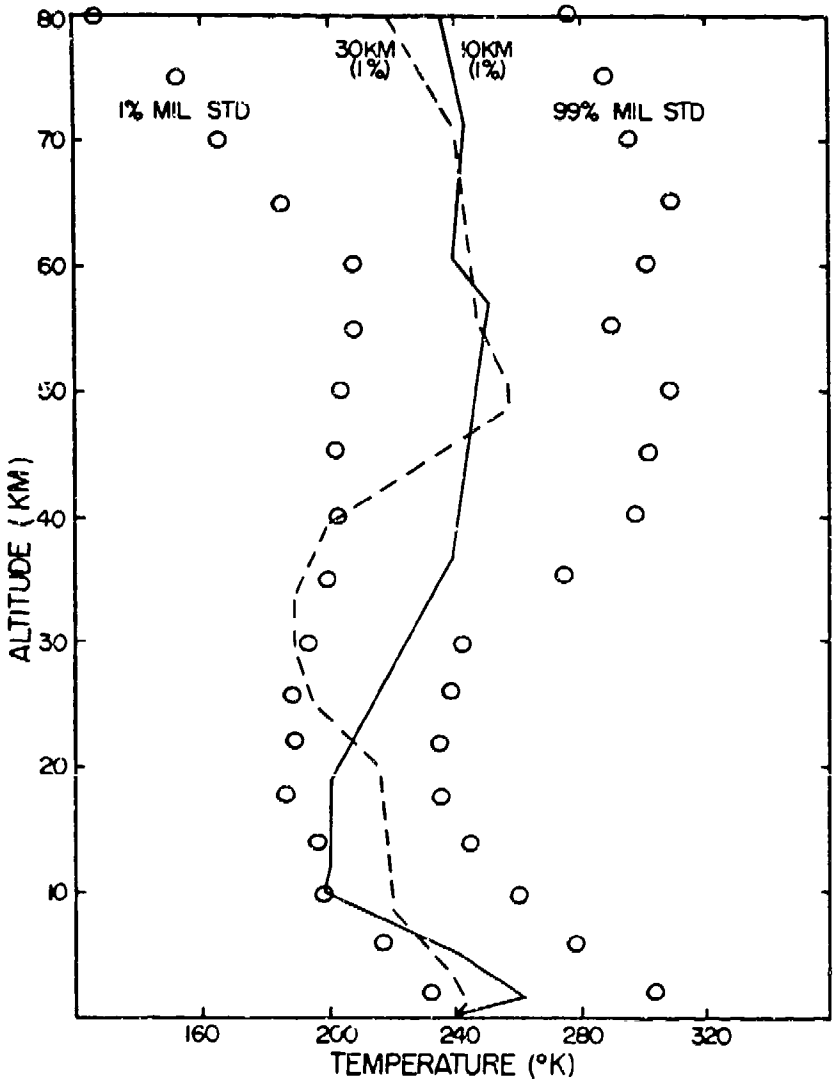

Figure 6. Model Profiles for 1-Percent Threshold Temperatures at 10 and 30 km, and MIL-STD-210B Envelopes

210B and the COSPAR International Reference Atmosphere. Data in this report will also be used to update the envelopes in the revision of MIL-STD-210B at altitudes where more extreme conditions were found.

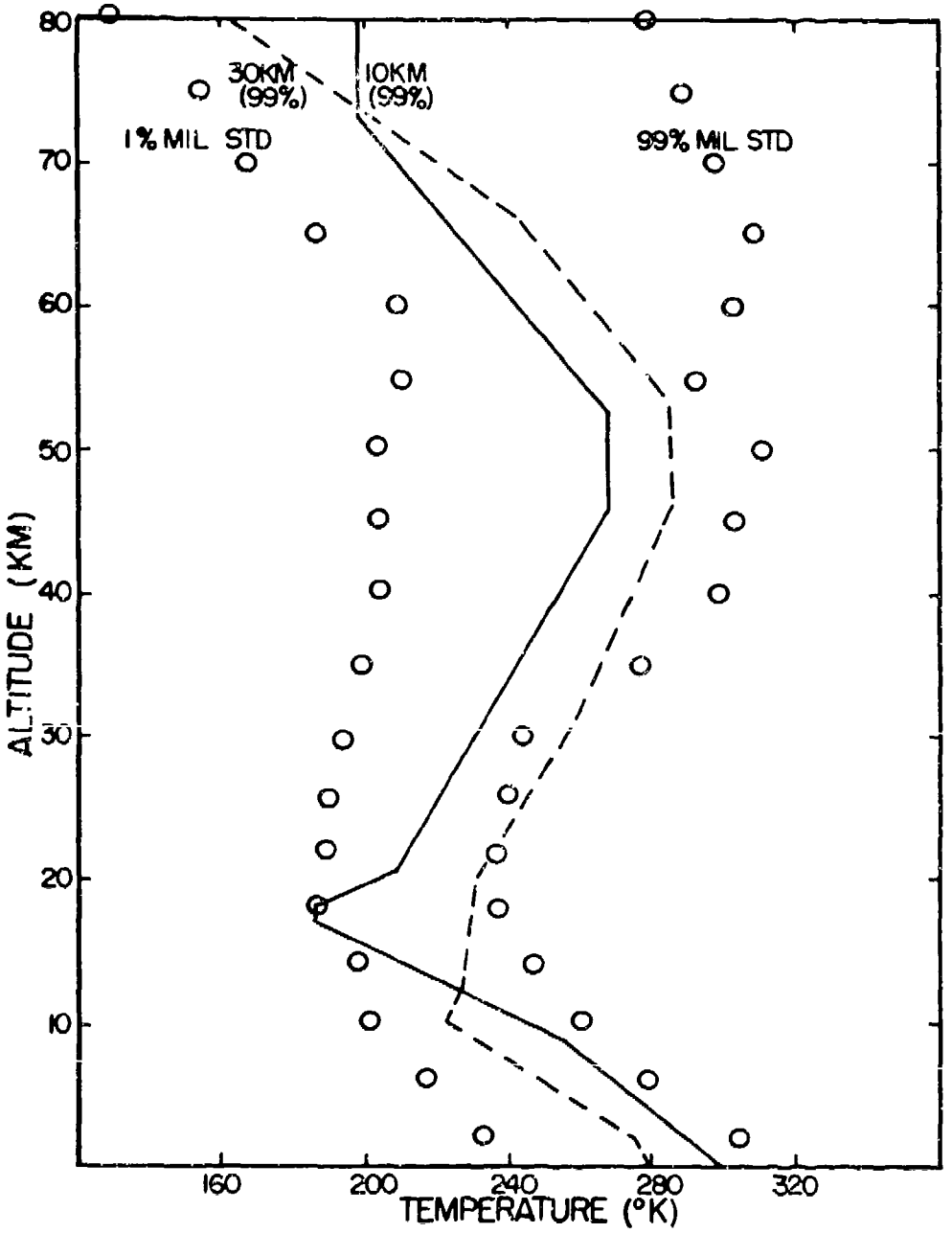

Figure 7. Model Profiles for 99-Percent Threshold Temperatures at 10 and 30 km, and MIL-STD-210B Envelopes

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Appendix A

Temperature and Density Models Based on
1, 10, 90, and 99 Percent Extremes at
5, 10, 20, 30, and 40 km

Table A1. Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 5 km

Geometric Altitude (km)	1 Percent		10 Percent	
	Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)
0	220.150	1.607+0*	229.650	1.541+0*
2	234.142	1.124+0	236.633	1.117+0
4	224.860	8.698-1	228.621	8.620-1
6	216.141	6.628-1	219.105	6.628-1
8	214.141	4.869-1	209.150	5.045-1
10	211.633	3.575-1	209.150	3.640-1
12	207.637	2.631-1	209.137	2.626-1
14	203.643	1.925-1	205.143	1.926-1
16	199.652	1.400-1	202.150	1.397-1
18	199.650	9.958-2	202.150	9.979-2
20	199.650	7.090-2	202.150	7.126-2
22	199.650	5.035-2	206.061	5.000-2
24	207.129	3.474-2	214.023	3.482-2
26	214.688	2.428-2	221.980	2.458-2
28	222.243	1.719-2	229.932	1.757-2
30	229.792	1.231-2	237.879	1.270-2
32	237.337	8.916-3	245.821	9.289-3
34	244.877	6.523-3	252.753	6.886-3
36	250.612	4.850-3	255.727	5.214-3
38	255.567	3.639-3	258.700	3.961-3
40	260.518	2.747-3	261.671	3.019-3
42	265.467	2.084-3	263.889	2.315-3
44	269.650	1.594-3	262.306	1.801-3
46	269.650	1.241-3	260.725	1.400-3
48	268.438	9.706-4	259.144	1.086-3
50	265.279	7.628-4	257.565	8.420-4
52	262.122	5.978-4	255.986	6.516-4
54	258.967	4.672-4	254.409	5.035-4
56	255.814	3.641-4	252.832	3.885-4
58	252.663	2.829-4	251.256	2.993-4
60	249.317	2.193-4	248.101	2.317-4
62	241.646	1.721-4	241.217	1.810-4
64	233.979	1.340-4	234.336	1.405-4
66	230.150	1.019-4	229.150	1.074-4
68	230.150	7.615-5	229.150	8.021-5
70	230.150	5.691-5	229.150	5.987-5
72	228.507	4.281-5	227.781	4.493-5
74	226.155	3.222-5	225.821	3.374-5
76	223.805	2.418-5	223.862	2.527-5
78	221.456	1.810-5	221.905	1.888-5
80	219.109	1.350-5	219.949	1.408-5

* Power of ten by which preceding numbers should be multiplied

Table A1 (Contd). Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 5 km

90 Percent		99 Percent		Std. Atm. Density
Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	(kg/m^3)
291.650	1.209+0*	290.150	1.215+0*	1.2250+0*
291.133	9.571-1	294.163	9.506-1	1.0066
283.190	7.761-1	284.183	7.773-1	8.1935-1
268.276	6.399-1	272.745	6.343-1	6.6011
253.337	5.220-1	256.796	5.209-1	5.2579
238.407	4.206-1	240.858	4.224-1	4.1351
223.496	3.343-1	224.930	3.377-1	3.1194-1
208.575	2.615-1	210.558	2.637-1	2.2786
193.674	2.009-1	201.411	1.982-1	1.6647
196.813	1.393-1	204.873	1.392-1	1.2165
204.751	9.559-2	212.817	9.689-2	8.8910-2
212.683	6.651-2	216.953	6.933-2	6.4510-2
217.607	4.748-2	220.920	4.996-2	4.6938
221.173	3.432-2	224.885	3.622-2	3.4257
224.735	2.494-2	228.847	2.641-2	2.5076
228.296	1.821-2	232.806	1.937-2	1.8410
231.855	1.337-2	236.763	1.428-2	1.3555-2
235.411	9.868-3	240.719	1.059-2	9.8874-3
238.965	7.315-3	244.670	7.885-3	7.2579
242.517	5.447-3	248.620	5.902-3	5.3666
246.066	4.074-3	252.567	4.439-3	3.9957
249.613	3.061-3	256.512	3.354-3	2.9948-3
253.159	2.309-3	260.454	2.546-3	2.2589
256.701	1.749-3	264.394	1.940-3	1.7142
260.150	1.331-3	266.150	1.496-3	1.3167
260.150	1.028-3	266.150	1.162-3	1.0269
260.150	7.945-4	262.796	9.138-4	8.0562-4
260.150	6.139-4	258.473	7.181-4	6.3901
254.522	4.839-4	253.609	5.633-4	5.0445
246.679	3.822-4	246.936	4.425-4	3.9627
238.840	2.996-4	240.268	3.454-4	3.0968
231.006	2.330-4	233.604	2.678-4	2.4071-4
223.177	1.796-4	226.943	2.061-4	1.8605
215.353	1.372-4	220.287	1.574-4	1.4296
210.419	1.025-4	213.636	1.193-4	1.0917
207.489	7.557-5	206.988	8.965-5	8.2829-5
204.560	5.545-5	202.695	6.603-5	6.2374-5
201.634	4.052-5	200.156	4.801-5	4.6386
198.709	2.947-5	197.619	3.478-5	3.4311
195.786	2.134-5	195.084	2.509-5	2.5239
192.864	1.538-5	192.550	1.803-5	1.8458

Table A2. Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 10 km

Geometric Altitude (km)	1 Percent Temperature (K)	1 Percent Density (kg/m^3)	10 Percent Temperature (K)	10 Percent Density (kg/m^3)
0	237.150	1.497+0*	246.150	1.438+0*
2	259.625	1.043+0	258.124	1.048+0
4	247.607	8.349-1	246.105	8.385-1
6	233.074	6.678-1	232.681	6.667-1
8	216.070	5.312-1	217.876	5.256-1
10	199.159	4.147-1	203.150	4.074-1
12	201.150	2.922-1	203.137	2.912-1
14	201.150	2.079-1	199.542	2.112-1
16	201.150	1.482-1	195.950	1.523-1
18	201.150	1.056-1	192.360	1.092-1
20	203.319	7.455-2	188.773	7.790-2
22	207.701	5.241-2	185.187	5.518-2
24	212.080	3.712-2	188.105	3.773-2
26	216.456	2.648-2	191.089	2.595-2
28	220.830	1.903-2	194.071	1.796-2
30	225.201	1.376-2	197.051	1.250-2
32	229.569	1.001-2	202.882	8.638-3
34	233.934	7.338-3	212.010	5.961-3
36	238.297	5.407-3	221.132	4.180-3
38	240.470	4.040-3	230.249	2.973-3
40	241.658	3.036-3	239.361	2.144-3
42	242.846	2.285-3	248.466	1.565-3
44	244.033	1.723-3	257.566	1.156-3
46	245.219	1.301-3	266.660	8.630-4
48	246.404	9.839-4	275.749	6.507-4
50	247.589	7.452-4	279.150	5.045-4
52	248.773	5.652-4	279.150	3.962-4
54	249.956	4.294-4	279.150	3.113-4
56	251.139	3.266-4	279.150	2.445-4
58	248.299	2.526-4	267.802	1.995-4
60	242.394	1.967-4	254.024	1.625-4
62	241.771	1.493-4	240.253	1.309-4
64	242.557	1.127-4	226.491	1.041-4
66	243.343	8.529-5	215.516	8.065-5
68	244.128	6.456-5	212.964	5.967-5
70	244.913	4.892-5	210.413	4.400-5
72	244.055	3.734-5	207.863	3.233-5
74	242.487	2.854-5	205.316	2.367-5
76	240.920	2.177-5	203.150	1.723-5
78	239.354	1.659-5	203.150	1.241-5
80	237.789	1.262-5	203.150	8.925-6

*Power of ten by which preceding numbers should be multiplied

Table A2 (Contd). Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 10 km

90 Percent		99 Percent		Std. Atm. Density
Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	(kg/m^3)
300.650	1.171+0*	299.150	1.173+0*	1.2250+0*
289.682	9.651-1	289.177	9.632-1	1.0066
278.721	7.894-1	279.210	7.850-1	8.1935-1
267.767	6.405-1	269.249	6.351-1	6.6011
256.820	5.153-1	259.295	5.098-1	5.2579
243.005	4.152-1	245.985	4.110-1	4.1351
226.108	3.340-1	229.084	3.315-1	3.1194-1
209.221	2.642-1	212.193	2.630-1	2.2786
195.008	2.024-1	195.314	2.048-1	1.6647
189.610	1.457-1	186.150	1.500-1	1.2165
206.663	9.496-2	202.781	9.710-2	8.8910-2
211.757	6.709-2	211.443	6.729-2	6.4510-2
216.114	4.791-2	216.197	4.795-2	4.6938
220.468	3.445-2	220.948	3.443-2	3.4257
224.819	2.494-2	225.696	2.490-2	2.5076
229.168	1.817-2	230.441	1.814-2	1.8410
233.514	1.332-2	235.183	1.330-2	1.3555-2
237.957	9.825-3	239.922	9.816-3	9.8874-3
242.198	7.286-3	244.659	7.287-3	7.2579
246.535	5.433-3	249.392	5.442-3	5.3666
250.870	4.073-3	254.122	4.087-3	3.9957
255.203	3.069-3	258.849	3.087-3	2.9948-3
259.532	2.324-3	263.574	2.343-3	2.2589
263.859	1.768-3	268.150	1.789-3	1.7142
268.150	1.352-3	268.150	1.392-3	1.3167
268.150	1.052-3	268.150	1.084-3	1.0269
268.150	8.197-4	268.150	8.443-4	8.0562-4
268.150	6.384-4	264.940	6.650-4	6.3901
262.555	5.066-4	258.077	5.284-4	5.0445
256.677	4.004-4	251.217	4.173-4	3.9627
250.803	3.148-4	244.362	3.275-4	3.0968
244.932	2.461-4	237.511	2.552-4	2.4071-4
239.065	1.913-4	230.664	1.975-4	1.8605
233.201	1.478-4	223.822	1.517-4	1.4296
227.893	1.132-4	216.984	1.156-4	1.0917
223.013	8.610-5	210.150	8.736-5	8.2829-5
218.136	6.507-5	203.320	6.541-5	6.2374-5
213.262	4.887-5	198.150	4.811-5	4.6386
208.391	3.647-5	198.150	3.438-5	3.4311
203.523	2.703-5	198.150	2.457-5	2.5239
198.658	1.990-5	198.150	1.756-5	1.8458

Table A3. Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 20 km

Geometric Altitude (km)	1 Percent Temperature (K)	1 Percent Density (kg/m^3)	10 Percent Temperature (K)	10 Percent Density (kg/m^3)
0	236.650	1.496+0*	240.150	1.472+0*
2	250.023	1.072+0	254.130	1.054+0
4	237.604	8.525-1	245.095	8.312-1
6	225.192	6.693-1	230.482	6.629-1
8	212.788	5.183-1	215.877	5.210-1
10	206.650	3.844-1	207.136	3.922-1
12	206.631	2.763-1	204.139	2.855-1
14	201.639	2.027-1	201.144	2.069-1
16	196.650	1.476-1	198.150	1.493-1
18	191.664	1.066-1	195.159	1.072-1
20	186.682	7.637-2	192.169	7.661-2
22	189.619	5.237-2	192.150	5.377-2
24	192.605	3.612-2	192.150	3.774-2
26	198.920	2.471-2	196.068	2.606-2
28	205.282	1.711-2	200.045	1.812-2
30	211.640	1.198-2	204.019	1.270-2
32	217.994	8.484-3	207.990	8.963-3
34	224.344	6.067-3	211.959	6.368-3
36	230.690	4.380-3	219.700	4.488-3
38	237.032	3.191-3	227.628	3.200-3
40	243.370	2.345-3	235.551	2.308-3
42	249.705	1.737-3	243.468	1.684-3
44	256.035	1.297-3	251.381	1.241-3
46	262.362	9.754-4	259.289	9.237-4
48	264.650	7.490-4	264.150	7.012-4
50	264.650	5.805-4	264.150	5.432-4
52	264.650	4.499-4	264.150	4.208-4
54	264.650	3.488-4	264.150	3.261-4
56	263.152	2.719-4	262.977	2.538-4
58	258.622	2.138-4	259.432	1.988-4
60	254.094	1.673-4	255.889	1.552-4
62	245.367	1.325-4	247.055	1.231-4
64	235.537	1.043-4	236.832	9.735-5
66	227.468	8.082-5	228.858	7.543-5
68	224.719	6.080-5	227.679	5.651-5
70	221.971	4.559-5	226.502	4.228-5
72	219.226	3.407-5	223.951	3.177-5
74	216.482	2.537-5	220.815	2.384-5
76	213.740	1.883-5	217.681	1.782-5
78	211.000	1.392-5	214.549	1.327-5
80	208.261	1.025-5	211.420	9.842-6

* Power of ten by which preceding numbers should be multiplied

Table A3 (Contd). Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 20 km

90 Percent		(a) 99 Percent		(b) 99 Percent		Std. Atm. Density
Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	(kg/m^3)
273.150	1.293+0*	228.150	1.552+0*	273.150	1.293+0*	1.2250-0*
263.128	1.040+0	238.650	1.110+0	268.126	1.023+0	1.0066
253.105	8.296-1	231.113	8.575-1	257.101	8.224-1	8.1935-1
241.094	6.603-1	221.103	6.623-1	244.089	6.593-1	6.6011
229.090	5.196-1	216.150	4.947-1	231.085	5.223-1	5.2579
228.701	3.847-1	217.659	3.584-1	218.220	4.080-1	4.1351
234.150	2.802-1	219.657	2.599-1	233.152	2.821-1	3.1194-1
234.150	2.094-1	221.654	1.891-1	233.751	2.101-1	2.2786
234.150	1.565-1	223.650	1.379-1	234.350	1.566-1	1.6647
234.150	1.170-1	232.225	9.855-2	234.948	1.168-1	1.2165
234.150	8.748-2	240.796	7.128-2	235.546	8.727-2	8.8910-2
234.150	6.542-1	243.192	5.336-2	236.144	6.523-2	6.4510-2
234.150	4.893-2	239.210	4.092-2	236.741	4.880-2	4.6938
234.150	3.660-2	235.232	3.124-2	237.338	3.654-2	3.4257
237.071	2.709-2	231.255	2.375-2	238.692	2.731-2	2.5076
240.051	2.013-2	230.150	1.777-2	240.878	2.039-2	1.8410
243.030	1.501-2	230.150	1.323-2	243.062	1.526-2	1.3555-2
247.720	1.117-2	230.150	9.860-3	247.720	1.136-2	9.8874-3
252.480	8.363-3	230.150	7.346-3	252.480	8.503-3	7.2579
257.932	6.277-3	230.150	5.473-3	257.932	6.382-3	5.3666
264.270	4.728-3	230.150	4.079-3	264.270	4.807-3	3.9957
270.605	3.585-3	230.150	3.040-3	270.605	3.645-3	2.9948-3
278.935	2.737-3	230.150	2.267-3	278.935	2.783-3	2.2589
283.262	2.102-3	230.150	1.690-3	283.262	2.138-3	1.7142
287.150	1.638-3	232.791	1.248-3	287.150	1.665-3	1.3167
287.150	1.295-3	235.753	9.242-4	287.150	1.316-3	1.0269
287.150	1.024-3	238.713	6.870-4	287.150	1.041-3	8.0562-4
284.317	8.174-4	241.671	5.126-4	284.317	8.311-4	6.3901
279.587	6.547-4	240.994	3.890-4	279.587	6.656-4	5.0445
274.859	5.224-4	239.615	2.957-4	274.859	5.311-4	3.9627
270.135	4.153-4	238.237	2.244-4	270.135	4.222-4	3.0968
265.414	3.288-4	236.860	1.701-4	265.414	3.343-4	2.4071-4
260.696	2.593-4	235.484	1.287-4	260.696	2.637-4	1.8605
253.933	2.053-4	235.150	9.693-5	253.933	2.087-4	1.4296
240.974	1.649-4	235.150	7.287-5	240.974	1.677-4	1.0917
228.023	1.309-4	235.150	5.480-5	228.023	1.331-4	8.2829-5
215.079	1.026-4	233.501	4.147-5	215.079	1.043-4	6.2374-5
202.144	7.919-5	231.149	3.140-5	202.144	8.052-5	4.6386
189.217	6.009-5	228.799	2.371-5	189.217	6.110-5	3.4311
176.298	4.472-5	226.450	1.786-5	176.298	4.547-5	2.5239
163.387	3.255-5	224.102	1.341-5	163.387	3.310-5	1.8458

Table A4. Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 30 km

Geometric Altitude (km)	1 Percent Temperature (K)	1 Percent Density (kg/m^3)	10 Percent Temperature (K)	10 Percent Density (kg/m^3)
0	241.150	1.462+0*	253.150	1.393+0*
2	241.547	1.101+0	254.374	1.061+0
4	237.242	8.431-1	241.356	8.484-1
6	229.645	6.500-1	228.347	6.702-1
8	222.053	4.969-1	215.345	5.222-1
10	220.150	3.678-1	212.150	3.844-1
12	220.150	2.698-1	212.150	2.786-1
14	219.657	1.984-1	210.648	2.033-1
16	218.661	1.461-1	207.655	1.489-1
18	217.665	1.074-1	204.664	1.085-1
20	216.670	7.893-2	201.675	7.882-2
22	208.851	5.949-2	198.688	5.695-2
24	200.899	4.440-2	195.702	4.096-2
26	195.448	3.236-2	194.150	2.911-2
28	192.867	2.312-2	194.150	2.052-2
30	190.288	1.645-2	194.150	1.446-2
32	190.150	1.153-2	197.074	1.006-2
34	190.150	8.077-3	203.423	6.949-3
36	193.829	5.569-3	209.768	4.855-3
38	197.787	3.863-3	216.109	3.429-3
40	205.328	2.656-3	222.446	2.447-3
42	218.177	1.817-3	228.779	1.763-3
44	231.018	1.270-3	235.108	1.282-3
46	243.851	9.061-4	241.433	9.403-4
48	256.676	6.575-4	247.754	6.954-4
50	258.650	5.028-4	254.071	5.182-4
52	255.536	3.918-4	258.150	3.923-4
54	251.794	3.050-4	258.150	3.022-4
56	248.862	2.358-4	256.356	2.344-4
58	247.878	1.806-4	250.843	1.837-4
60	246.895	1.382-4	245.332	1.432-4
62	245.913	1.057-4	239.825	1.111-4
64	244.932	8.075-5	237.756	8.451-5
66	243.951	6.163-5	238.935	6.346-5
68	242.970	4.699-5	240.113	4.772-5
70	241.990	3.580-5	241.290	3.595-5
72	238.583	2.750-5	238.657	2.751-5
74	233.886	2.113-5	234.346	2.111-5
76	229.192	1.616-5	230.038	1.612-5
78	224.500	1.229-5	225.733	1.225-5
80	219.812	9.296-6	221.430	9.264-6

* Power of ten by which preceding numbers should be multiplied

Table A4 (Contd). Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 30 km

90 Percent		99 Percent		Std. Atm. Density
Temperature (K)	Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	(kg/m^3)
285.150	1.235+0*	279.150	1.262+0*	1.2250+0*
274.135	1.006+0	275.124	1.000+0	1.0066
263.113	8.130-1	262.106	8.137-1	8.1935-1
245.112	6.669-1	249.097	6.552-1	6.6011
227.140	5.388-1	236.095	5.216-1	5.2579
223.652	4.037-1	223.162	4.098-1	4.1351
227.645	2.932-1	226.358	2.982-1	3.1194-1
228.650	2.166-1	227.751	2.195-1	2.2786
228.650	1.608-1	228.549	1.622-1	1.6647
228.650	1.194-1	229.346	1.201-1	1.2165
228.650	8.868-2	230.143	8.899-2	8.8910-2
230.611	6.539-2	235.087	6.502-2	6.4510-2
232.599	4.834-2	240.063	4.782-2	4.6938
234.587	3.584-2	245.035	3.540-2	3.4257
239.651	2.635-2	250.005	2.637-2	2.5076
244.813	1.949-2	254.971	1.976-2	1.8410
249.971	1.451-2	259.386	1.492-2	1.3555-2
255.126	1.087-2	263.156	1.135-2	9.8874-3
260.278	8.200-3	266.923	8.668-3	7.2579
265.427	6.216-3	270.688	6.644-3	5.3666
270.572	4.738-3	274.451	5.113-3	3.9957
275.714	3.630-3	278.211	3.949-3	2.9948-3
280.853	2.796-3	281.969	3.061-3	2.2589
285.989	2.164-3	285.724	2.381-3	1.7142
286.650	1.706-3	286.150	1.878-3	1.3167
286.650	1.349-3	286.150	1.483-3	1.0269
286.650	1.066-3	286.150	1.172-3	8.0562-4
283.813	8.511-4	282.406	9.379-4	6.3901
278.990	6.819-4	276.100	7.538-4	5.0445
273.970	5.443-4	269.799	6.029-4	3.9627
269.054	4.327-4	263.501	4.797-4	3.0968
264.140	3.426-4	257.207	3.796-4	2.4071-4
256.228	2.731-4	250.917	2.988-4	1.8605
245.235	2.184-4	243.303	2.350-4	1.4296
234.248	1.728-4	231.524	1.861-4	1.0917
223.269	1.353-4	219.752	1.457-4	8.2829-5
212.296	1.046-4	207.988	1.125-4	6.2374-5
201.331	7.985-5	196.231	8.565-5	4.6386
190.372	6.002-5	184.481	6.410-5	3.4311
179.420	4.436-5	172.739	4.707-5	2.5239
168.474	3.218-5	161.004	3.383-5	1.8458

Table A5. Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 40 km

Geometric Altitude (km)	1 Percent Temperature (K)	1 Percent Density (kg/m^3)	10 Percent Temperature (K)	10 Percent Density (kg/m^3)
0	253.150	1.396+0*	253.150	1.396+0*
2	255.874	1.057+0	255.874	1.057+0
4	242.856	8.470-1	242.856	8.470-1
6	229.847	6.701-1	229.847	6.701-1
8	216.845	5.230-1	216.845	5.230-1
10	215.157	3.834-1	214.404	3.846-1
12	217.155	2.770-1	215.403	2.786-1
14	216.648	2.029-1	212.647	2.054-1
16	213.655	1.499-1	208.656	1.514-1
18	210.664	1.102-1	204.668	1.110-1
20	207.675	8.079-2	200.683	8.094-2
22	204.688	5.893-2	199.663	5.791-2
24	201.702	4.280-2	198.667	4.137-2
26	200.150	3.073-2	197.673	2.950-2
28	200.150	2.189-2	198.233	2.087-2
30	200.150	1.559-2	198.829	1.478-2
32	200.150	1.111-2	199.424	1.048-2
34	200.150	7.921-3	200.019	7.448-3
36	200.150	5.647-3	200.614	5.295-3
38	200.150	4.026-3	205.305	3.706-3
40	201.835	2.849-3	210.256	2.613-3
42	205.793	2.005-3	215.204	1.857-3
44	212.087	1.407-3	220.148	1.331-3
46	219.599	9.941-4	226.409	9.562-4
48	227.105	7.105-4	234.705	6.883-4
50	234.607	5.135-4	242.997	5.012-4
52	242.104	3.750-4	246.528	3.753-4
54	249.596	2.766-4	249.288	2.828-4
56	252.792	2.092-4	250.189	2.153-4
58	247.082	1.635-4	247.235	1.662-4
60	241.374	1.271-4	244.283	1.280-4
62	242.467	9.578-5	241.333	9.826-5
64	245.415	7.186-5	242.160	7.413-5
66	248.362	5.410-5	244.125	5.580-5
68	251.307	4.088-5	246.088	4.210-5
70	254.249	3.099-5	248.050	3.184-5
72	252.157	2.400-5	245.657	2.453-5
74	247.846	1.868-5	241.346	1.896-5
76	243.538	1.448-5	237.038	1.460-5
78	239.233	1.117-5	232.733	1.118-5
80	234.930	8.587-6	228.430	8.530-6

* Power of ten by which preceding numbers should be multiplied

Table A5 (Contd). Models of Temperature and Associated Density for 1-, 10-, 90-, and 99-Percent Temperatures at 40 km

90 Percent Temperature (K)	90 Percent Density (kg/m^3)	99 Percent Temperature (K)	99 Percent Density (kg/m^3)	Std. Atm. Density (kg/m^3)
283.150	1.244+0*	287.150	1.227+0*	1.2250+0*
271.134	1.015+0	273.131	1.010+0	1.0066
259.125	8.209-1	259.121	8.239-1	8.1935-1
247.124	6.571-1	245.120	6.641-1	6.6011
235.131	5.202-1	231.128	5.287-1	5.2579
226.551	4.011-1	225.651	4.005-1	4.1351
228.148	2.950-1	228.646	2.927-1	3.1194-1
228.150	2.188-1	228.650	2.172-1	2.2786
228.150	1.623-1	228.650	1.613-1	1.6647
228.150	1.204-1	228.650	1.197-1	1.2165
228.150	8.941-2	229.814	8.852-2	8.8910-2
230.503	6.579-2	232.203	6.527-2	6.4510-2
232.889	4.856-2	234.589	4.829-2	4.6938
235.275	3.596-2	236.975	3.584-2	3.4257
238.421	2.664-2	241.209	2.650-2	2.5076
244.376	1.962-2	246.172	1.966-2	1.8410
250.328	1.456-2	251.132	1.467-2	1.3555-2
256.276	1.089-2	256.089	1.101-2	9.8874-3
262.221	8.197-3	262.535	8.275-3	7.2579
268.162	6.210-3	269.664	6.247-3	5.3666
274.099	4.735-3	276.788	4.752-3	3.9957
278.841	3.646-3	283.908	3.641-3	2.9948-3
281.806	2.835-3	284.650	2.864-3	2.2589
284.769	2.211-3	284.650	2.259-3	1.7142
286.650	1.735-3	284.650	1.783-3	1.3167
286.650	1.371-3	282.861	1.415-3	1.0269
285.454	1.088-3	279.904	1.125-3	8.0562-4
281.908	8.697-4	276.948	8.935-4	6.3901
278.363	6.927-4	273.994	7.075-4	5.0445
274.821	5.502-4	271.042	5.588-4	3.9267
271.281	4.358-4	268.092	4.403-4	3.0968
267.743	3.442-4	265.144	3.461-4	2.4071-4
264.207	2.710-4	258.034	2.754-4	1.8605
252.562	2.187-4	246.648	2.209-4	1.4296
240.791	1.748-4	235.270	1.753-4	1.0917
229.027	1.382-4	223.898	1.376-4	8.2829-5
217.271	1.079-4	212.534	1.066-4	6.2374-5
205.522	8.313-5	201.176	8.155-5	4.6386
193.780	6.307-5	189.826	6.138-5	3.4311
182.046	4.704-5	178.483	4.541-5	2.5239
170.319	3.441-5	167.146	3.295-5	1.8458

Table A6. Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 5 km

Geometric Altitude (km)	1 Percent Density (kg/m^3)	1 Percent Temperature (K)	10 Percent Density (kg/m^3)	10 Percent Temperature (K)
0	1.239+0*	281.650	1.219+0*	289.150
2	9.881-1	276.647	9.641-1	289.158
4	7.617-1	280.148	7.757-1	283.170
6	6.285-1	264.162	6.395-1	268.554
8	5.125-1	248.187	5.263-1	251.011
10	4.123-1	232.221	4.272-1	233.479
12	3.267-1	216.265	3.411-1	215.958
14	2.455-1	208.150	2.571-1	207.831
16	1.770-1	208.150	1.883-1	203.650
18	1.268-1	209.592	1.349-1	203.650
20	9.067-2	212.577	9.376-2	211.317
22	6.510-2	215.559	6.661-2	216.912
24	4.697-2	218.539	4.821-2	219.689
26	3.404-2	221.518	3.505-2	222.464
28	2.478-2	224.495	2.558-2	225.238
30	1.812-2	227.470	1.875-2	228.009
32	1.331-2	230.443	1.380-2	230.779
34	9.815-3	233.414	1.019-2	233.548
36	7.195-3	239.116	7.558-3	236.314
38	5.310-3	245.951	5.668-3	241.855
40	3.949-3	250.982	4.126-3	247.776
42	2.957-3	256.910	3.080-3	253.693
44	2.229-3	262.833	2.315-3	259.607
46	1.692-3	268.753	1.752-3	265.516
48	1.307-3	271.150	1.355-3	266.650
50	1.032-3	267.717	1.057-3	265.534
52	8.186-4	261.808	8.321-4	261.601
54	6.458-4	255.903	6.523-4	257.671
56	5.068-4	250.002	5.095-4	253.744
58	3.955-4	244.104	3.965-4	249.818
60	3.068-4	238.209	3.074-4	245.896
62	2.365-4	232.319	2.393-4	239.836
64	1.812-4	226.432	1.857-4	232.784
66	1.378-4	220.548	1.431-4	225.737
68	1.041-4	214.669	1.093-4	218.694
70	7.803-5	208.793	8.282-5	211.655
72	5.802-5	202.920	6.143-5	207.307
74	4.277-5	197.052	4.495-5	204.963
76	3.125-5	191.187	3.278-5	202.622
78	2.261-5	185.325	2.382-5	200.281
80	1.620-5	179.468	1.725-5	197.942

* Power of ten by which preceding numbers should be multiplied

Table A6 (Contd). Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 5 km

90 Percent		99 Percent		Std. Atm. Density
Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	(kg/m^3)
1.509+0*	238.150	1.431+0*	251.150	1.2250+0*
1.104+0	247.129	1.113+0	245.142	1.0066
8.739-1	235.116	8.774-1	234.117	8.1935-1
6.833-1	223.110	6.774-1	224.643	6.6011
5.270-1	211.159	5.055-1	221.652	5.2579
3.772-1	213.957	3.701-1	222.650	4.1351
2.712-1	216.753	2.714-1	223.649	3.1194-1
1.977-1	217.352	1.993-1	224.646	2.2786
1.454-1	215.756	1.469-1	225.150	1.6647
1.067-1	214.161	1.086-1	225.150	1.2165
7.815-2	212.567	8.030-2	225.150	8.8910-2
5.711-2	210.975	5.937-2	225.150	6.4510-2
4.164-2	209.383	4.390-2	225.150	4.6938
3.030-2	207.792	3.247-2	225.150	3.4257
2.199-2	206.202	2.402-2	225.150	2.5076
1.535-2	213.832	1.777-2	225.150	1.8410
1.084-2	221.771	1.295-2	228.812	1.3555-2
7.752-3	229.704	9.354-3	236.941	9.8874-3
5.608-3	237.634	6.829-3	245.065	7.2579
4.101-3	245.558	5.038-3	253.184	5.3666
3.029-3	253.477	3.753-3	261.298	3.9957
2.270-3	260.150	2.854-3	266.150	2.9948-3
1.751-3	260.150	2.215-3	266.150	2.2589
1.354-3	259.310	1.718-3	266.150	1.7142
1.052-3	257.138	1.334-3	266.150	1.3167
8.154-4	254.967	1.050-3	261.917	1.0269
6.307-4	252.797	8.259-4	256.988	8.0562-4
4.868-4	250.629	6.463-4	252.062	6.3901
3.740-4	249.150	5.034-4	247.139	5.0445
2.855-4	249.150	3.902-4	242.219	3.9627
2.180-4	249.150	3.010-4	237.302	3.0968
1.665-4	249.150	2.289-4	234.645	2.4071-4
1.271-4	249.150	1.732-4	232.681	1.8605
9.715-5	249.150	1.308-4	230.718	1.4296
7.423-5	249.150	9.855-5	228.756	1.0917
5.672-5	249.150	7.407-5	226.795	8.2829-5
4.391-5	245.663	5.596-5	222.996	6.2374-5
3.405-5	240.570	4.221-5	218.297	4.6386
2.626-5	235.480	3.165-5	213.600	3.4311
2.014-5	230.393	2.359-5	208.906	2.5239
1.536-5	225.309	1.746-5	204.215	1.8458

Table A7. Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 10 km

Geometric Altitude (km)	1 Percent Density (kg/m^3)	1 Percent Temperature (K)	10 Percent Density (kg/m^3)	10 Percent Temperature (K)
0	1.545+0*	228.150	1.448+0*	243.150
2	1.143+0	229.142	1.102+0	241.338
4	8.676-1	223.165	8.601-1	231.732
6	6.200-1	231.152	6.639-1	222.154
8	4.597-1	232.151	4.838-1	224.553
10	3.413-1	233.150	3.538-1	226.950
12	2.548-1	233.150	2.609-1	228.150
14	1.908-1	232.364	1.935-1	228.150
16	1.440-1	229.174	1.441-1	227.165
18	1.083-1	225.986	1.076-1	225.173
20	8.112-2	222.799	8.018-2	223.182
22	6.052-2	219.615	5.957-2	221.192
24	4.497-2	216.433	4.415-2	219.203
26	3.327-2	213.253	3.264-2	217.215
28	2.421-2	213.150	2.397-2	216.150
30	1.761-2	213.150	1.752-2	216.150
32	1.281-2	213.150	1.280-2	216.150
34	9.328-3	213.150	9.360-3	216.150
36	6.790-3	213.150	6.696-3	221.710
38	4.943-3	213.150	4.826-3	227.650
40	3.548-3	216.777	3.508-3	233.587
42	2.558-3	220.732	2.571-3	239.520
44	1.856-3	224.685	1.899-3	245.449
46	1.354-3	228.636	1.413-3	251.374
48	9.939-4	232.583	1.059-3	257.296
50	7.332-4	236.529	8.132-4	258.150
52	5.438-4	240.472	6.264-4	258.150
54	4.053-4	244.412	4.843-4	257.206
56	3.039-4	248.030	3.766-4	254.252
58	2.337-4	245.668	2.921-4	251.301
60	1.792-4	243.308	2.258-4	248.351
62	1.360-4	243.250	1.741-4	245.403
64	1.024-4	245.410	1.338-4	242.457
66	7.735-5	247.570	1.025-4	239.768
68	5.856-5	249.728	7.800-5	238.002
70	4.445-5	251.884	5.924-5	236.238
72	3.404-5	252.342	4.491-5	234.474
74	2.629-5	250.384	3.398-5	232.712
76	2.027-5	248.427	2.566-5	230.951
78	1.559-5	246.471	1.934-5	229.191
80	1.197-5	244.517	1.455-5	227.432

* Power of ten by which preceding numbers should be multiplied

Table A7 (Contd). Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 10 km

90 Percent		99 Percent		Std. Atm. Density
Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	(kg/m^3)
1.228+0*	289.150	1.203+0*	295.150	1.2250+0*
9.948-1	281.160	9.786-1	287.567	1.0066
8.005-1	273.175	8.035-1	274.792	8.1935-1
6.596-1	256.245	6.668-1	260.756	6.6011
5.365-1	239.298	5.331-1	242.815	5.2579
4.298-1	222.361	4.342-1	224.884	4.1351
3.384-1	205.436	3.442-1	206.965	3.1194-1
2.433-1	205.150	2.491-1	205.673	2.2786
1.747-1	205.150	1.797-1	204.678	1.6647
1.243-1	207.469	1.285-1	205.360	1.2165
8.878-2	209.853	9.144-2	207.942	8.8910-2
6.366-2	212.235	6.532-2	210.522	6.4510-2
4.583-2	214.615	4.686-2	213.101	4.6988
3.311-2	216.994	3.376-2	215.678	3.4257
2.402-2	219.372	2.430-2	219.356	2.5076
1.748-2	221.748	1.751-2	224.503	1.8410
1.277-2	224.122	1.271-2	229.648	1.2555-2
9.366-3	226.495	9.294-3	234.789	9.8874-3
6.891-3	228.867	6.843-3	239.926	7.2579
5.027-3	234.368	5.072-3	245.062	5.3666
3.690-3	240.289	3.784-3	250.192	3.9957
2.730-3	246.207	2.840-3	255.321	2.9948-3
2.034-3	252.121	2.176-3	256.150	2.2589
1.527-3	258.032	1.673-3	256.150	2.2589
1.154-3	263.650	1.287-3	156.150	1.3167
8.949-4	263-650	9.901-4	256.150	1.0269
6.938-4	263.583	7.695-4	253.254	8.0562-4
5.456-4	259.260	5.980-4	249.520	6.3901
4.274-4	254.939	4.630-4	245.789	5.0445
3.334-4	250.621	3.571-4	242.060	3.9627
2.591-4	246.306	2.744-4	238.334	3.0968
2.004-4	241.993	2.100-4	234.609	2.4071-4
1.543-4	237.683	1.601-4	230.888	1.8605
1.183-4	233.276	1.215-4	227.168	1.4296
9.031-5	229.071	9.182-5	223.451	1.0917
6.853-5	224.890	6.907-5	219.736	8.2829-5
5.150-5	221.959	5.125-5	218.150	6.2374-5
3.856-5	219.029	3.775-5	218.150	4.6386
2.876-5	216.102	2.781-5	218.103	3.4311
2.138-5	213.176	2.081-5	214.702	2.5239
1.582-5	210.252	1.548-5	210.304	1.8458

Table A8. Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 20 km

Geometric Altitude (km)	1 Percent Density (kg/m^3)	1 Percent Temperature (K)	10 Percent Density (kg/m^3)	10 Percent Temperature (K)
0	1.502+0*	235.150	1.537+0*	230.150
2	1.093+0	243.632	1.125+0	235.137
4	8.690-1	229.623	8.600-1	229.114
6	6.808-1	215.623	6.627-1	219.105
8	5.052-1	210.154	5.045-1	209.150
10	3.608-1	213.150	3.639-1	209.150
12	2.620-1	213.150	2.626-1	209.137
14	1.903-1	213.150	1.926-1	205.143
16	1.362-1	216.598	1.397-1	202.150
18	9.686-2	223.572	9.979-2	202.150
20	6.741-2	239.403	7.125-2	202.150
22	4.882-2	250.961	5.000-2	206.061
24	3.763-2	247.978	3.482-2	214.023
26	2.891-2	244.997	2.458-2	221.980
28	2.215-2	242.017	1.757-2	229.932
30	1.691-2	239.040	1.270-2	237.879
32	1.277-2	238.150	9.288-3	245.821
34	9.615-3	238.150	6.885-3	252.753
36	7.236-3	238.150	5.213-3	255.727
38	5.447-3	238.150	3.961-3	258.700
40	4.100-3	238.150	3.019-3	261.761
42	3.087-3	238.150	2.315-3	263.889
44	2.311-3	239.685	1.801-3	262.306
46	1.720-3	243.636	1.400-3	260.725
48	1.286-3	247.583	1.086-3	259.144
50	9.663-4	251.529	8.419-4	257.565
52	7.303-4	255.150	6.515-4	255.986
54	5.339-4	255.150	5.034-4	254.409
56	4.349-4	252.590	3.885-4	252.832
58	3.369-4	249.441	2.993-4	251.256
60	2.602-4	246.295	2.317-4	248.101
62	2.003-4	243.150	1.810-4	241.217
64	1.537-4	240.007	1.405-4	234.336
66	1.168-4	238.437	1.074-4	229.150
68	8.855-5	237.456	8.021-5	229.150
70	6.703-5	236.475	5.986-5	229.150
72	5.081-5	234.842	4.493-5	227.781
74	3.849-5	232.884	3.373-5	225.821
76	2.909-5	230.927	2.527-5	223.862
78	2.194-5	228.971	1.888-5	221.905
80	1.651-5	227.017	1.408-5	219.949

* Power of ten by which preceding numbers should be multiplied

Table A8 (Contd). Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 20 km

90 Percent		99 Percent		Std. Atm. Density
Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	(kg/m^3)
1.169+0*	301.150	1.169+0*	301.150	1.2250+0*
9.639-1	290.182	9.609-1	291.179	1.0066
7.886-1	279.221	7.843-1	281.214	8.1935-1
6.401-1	268.267	6.356-1	271.256	6.6011
5.152-1	257.319	5.110-1	261.304	5.2579
4.180-1	241.483	4.160-1	245.483	4.1351
3.345-1	225.580	3.342-1	229.580	3.1194-1
2.634-1	209.687	2.643-1	213.687	2.2786
2.036-1	193.803	2.053-1	197.803	1.6647
1.455-1	189.211	1.475-1	193.482	1.2165
9.795-2	198.134	9.994-2	203.000	8.8910-2
6.710-2	207.052	6.891-2	212.512	6.4510-2
4.711-2	214.014	4.929-2	216.845	4.6938
3.377-2	218.369	3.554-2	220.803	3.4257
2.437-2	222.720	2.578-2	224.759	2.5076
1.770-2	227.069	1.880-2	228.712	1.8410
1.294-2	231.415	1.380-2	232.663	1.3555-2
9.519-3	235.758	1.017-2	236.612	9.8874-3
7.033-3	240.363	7.548-3	240.558	7.2579
5.186-3	247.264	5.603-3	245.514	5.3666
3.857-3	254.161	4.159-3	252.411	3.9957
2.892-3	261.053	3.112-3	259.303	2.9948-3
2.185-3	267.941	2.347-3	266.191	2.2589
1.664-3	274.650	1.795-3	271.150	1.7142
1.303-3	274.650	1.401-3	271.150	1.3167
1.020-3	274.650	1.094-3	271.150	1.0269
8.106-4	270.610	8.710-4	265.321	8.0562-4
6.442-4	265.116	6.899-4	259.435	6.3901
5.096-4	259.627	5.437-4	253.554	5.0445
4.012-4	254.140	4.261-4	247.675	3.9627
3.142-4	248.657	3.321-4	241.801	3.0968
2.448-4	243.178	2.572-4	235.930	2.4071-4
1.897-4	237.702	1.980-4	230.063	1.8605
1.461-4	232.229	1.514-4	224.199	1.4296
1.118-4	226.760	1.150-4	218.339	1.0917
8.514-5	221.294	8.673-5	212.483	8.2829-5
6.468-5	214.624	6.489-5	206.631	6.2374-5
4.893-5	206.826	4.815-5	200.782	4.6386
3.662-5	199.032	3.542-5	194.937	3.4311
2.710-5	191.243	2.582-5	189.095	2.5239
1.911-5	191.549	1.805-5	190.448	1.8458

Table A9. Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 30 km

Geometric Altitude (km)	1 Percent Density (kg/m^3)	1 Percent Temperature (K)	10 Percent Density (kg/m^3)	10 Percent Temperature (K)
0	1.424+0*	248.150	1.430+0*	247.150
2	1.076+0	250.624	1.093+0	245.528
4	8.577-1	237.606	8.613-1	234.312
6	6.749-1	224.597	6.707-1	223.104
8	5.236-1	211.595	5.158-1	211.983
10	3.881-1	205.150	3.772-1	209.139
12	2.810-1	202.892	2.755-1	206.142
14	2.032-1	199.898	2.003-1	203.148
16	1.463-1	196.905	1.450-1	200.155
18	1.048-1	193.914	1.044-1	197.164
20	7.433-2	192.133	7.490-2	194.175
22	5.172-2	194.125	5.344-2	191.188
24	3.613-2	196.115	3.701-2	193.901
26	2.534-2	198.104	2.576-2	196.686
28	1.773-2	201.374	1.789-2	201.164
30	1.226-2	209.121	1.244-2	207.521
32	8.602-3	216.863	8.750-3	213.874
34	6.109-3	224.601	6.218-3	220.223
36	4.390-3	232.334	4.463-3	226.568
38	3.190-3	240.062	3.233-3	232.909
40	2.342-3	247.785	2.363-3	239.246
42	1.736-3	255.504	1.742-3	245.579
44	1.317-3	259.189	1.300-3	250.648
46	1.009-3	260.771	9.764-4	255.590
48	7.760-4	262.150	7.374-4	260.528
50	5.999-4	262.150	5.682-4	261.150
52	4.639-4	262.150	4.389-4	261.150
54	3.661-4	256.305	3.440-4	257.172
56	2.882-4	249.408	2.709-4	250.472
58	2.255-4	242.516	2.120-4	243.777
60	1.752-4	235.628	1.648-4	237.085
62	1.329-4	233.069	1.252-4	234.569
64	1.001-4	231.693	9.452-5	233.193
66	7.534-5	230.318	7.124-5	231.818
68	5.659-5	228.944	5.362-5	230.444
70	4.244-5	227.570	4.029-5	229.070
72	3.192-5	225.109	3.037-5	226.473
74	2.398-5	222.170	2.287-5	223.338
76	1.794-5	219.233	1.715-5	220.205
78	1.338-5	216.297	1.281-5	217.074
80	9.939-6	213.363	9.539-6	213.944

* Power of ten by which preceding numbers should be multiplied

Table A9 (Contd). Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 30 km

90 Percent		99 Percent		Std. Atm. Density
Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	(kg/m^3)
1.204+0*	292.150	1.248+0*	282.150	1.2250+0*
9.916-1	279.333	1.007+0	273.132	1.0066
8.089-1	266.524	8.080-1	264.103	8.1935-1
6.558-1	252.718	6.539-1	250.093	6.6011
5.273-1	237.926	5.229-1	236.091	5.2579
4.181-1	223.151	4.124-1	222.177	4.1351
3.047-1	225.946	2.952-1	229.368	3.1194-1
2.230-1	228.739	2.180-1	231.150	2.2786
1.648-1	230.150	1.623-1	231.150	1.6647
1.226-1	230.150	1.209-1	231.150	1.2165
9.124-2	230.150	9.007-2	231.150	8.8910-2
6.790-2	230.150	6.686-2	232.137	6.4510-2
5.054-2	230.150	4.970-2	233.133	4.6938
3.731-2	232.306	3.700-2	234.127	3.4257
2.756-2	235.285	2.758-2	235.121	2.5076
2.043-2	238.263	2.059-2	236.114	1.8410
1.518-2	241.710	1.527-2	239.208	1.3555-2
1.126-2	247.064	1.127-2	244.764	9.8874-3
6.405-3	252.414	6.388-3	250.315	7.2579
6.313-3	257.760	6.280-3	255.864	5.3666
4.770-3	263.104	4.732-3	261.409	3.9957
3.626-3	268.444	3.587-3	266.950	2.9948-3
2.771-3	273.780	2.735-3	272.488	2.2589
2.129-3	279.114	2.098-3	278.023	1.7142
1.662-3	281.150	1.633-3	280.401	1.3167
1.308-3	281.150	1.276-3	282.375	1.0269
1.029-3	281.150	1.001-3	283.650	8.0562-4
8.156-4	279.221	7.900-4	283.650	6.3901
6.478-4	275.873	6.266-4	281.939	5.0445
5.132-4	272.528	4.982-4	278.985	3.9627
4.054-4	269.185	3.952-4	276.033	3.0968
3.194-4	265.843	3.129-4	272.927	2.4071-4
2.546-4	258.340	2.526-4	263.099	1.8605
2.045-4	246.562	2.023-4	253.277	1.4296
1.626-4	234.791	1.607-4	243.461	1.0917
1.277-4	223.027	1.264-4	233.652	8.2829-5
9.908-5	211.271	9.983-5	220.447	6.2374-5
7.574-5	199.522	7.811-5	205.751	4.6386
5.697-5	187.780	6.003-5	191.064	3.4311
4.208-5	176.046	4.518-5	176.386	2.5239
3.045-5	164.319	3.318-5	161.717	1.8458

Table A10. Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 40 km

Geometric Altitude (km)	1 Percent Density (kg/m^3)	1 Percent Temperature (K)	10 Percent Density (kg/m^3)	10 Percent Temperature (K)
0	1.398+0*	253.150	1.395+0*	253.650
2	1.052+0	257.122	1.054+0	256.626
4	8.468-1	243.103	8.421-1	244.610
6	6.726-1	229.093	6.649-1	232.601
8	5.266-1	215.091	5.185-1	220.599
10	4.055-1	201.150	3.987-1	208.635
12	2.888-1	201.150	2.922-1	204.640
14	2.079-1	198.747	2.128-1	200.647
16	1.495-1	195.555	1.540-1	196.656
18	1.070-1	192.365	1.108-1	192.668
20	7.616-2	189.176	7.919-2	188.683
22	5.315-2	189.150	5.522-2	188.650
24	3.710-2	189.150	3.851-2	188.650
26	2.581-2	189.831	2.653-2	191.226
28	1.782-2	192.813	1.818-2	196.593
30	1.237-2	195.793	1.259-2	201.957
32	8.646-3	198.771	8.805-3	207.317
34	5.945-3	206.639	6.216-3	212.674
36	4.118-3	216.553	4.388-3	220.053
38	2.901-3	226.460	3.108-3	229.960
40	2.075-3	236.362	2.234-3	239.862
42	1.504-3	246.257	1.627-3	249.757
44	1.105-3	256.147	1.200-3	259.647
46	8.218-4	266.030	8.963-4	269.530
48	6.177-4	275.907	6.761-4	279.407
50	4.748-4	282.150	5.293-4	280.650
52	3.737-4	280.753	4.187-4	278.974
54	2.992-4	276.810	3.338-4	274.242
56	2.376-4	272.869	2.652-4	269.513
58	1.880-4	268.930	2.098-4	264.786
60	1.503-4	261.222	1.653-4	260.063
62	1.206-4	250.404	1.307-4	253.382
64	9.584-5	239.594	1.045-4	241.589
66	7.536-5	228.790	8.265-5	229.803
68	5.857-5	217.993	6.456-5	218.024
70	4.496-5	207.202	4.975-5	206.252
72	3.328-5	201.150	3.642-5	202.650
74	2.386-5	201.150	2.617-5	202.650
76	1.711-5	201.150	1.881-5	202.650
78	1.227-5	201.150	1.352-5	202.650
80	8.804-6	201.150	9.728-6	202.650

* Power of ten by which preceding numbers should be multiplied

Table A10 (Contd). Models of Density and Associated Temperature for 1-, 10-, 90-, and 99-Percent Densities at 40 km

90 Percent		99 Percent		Std. Atm. Density
Density (kg/m^3)	Temperature (K)	Density (kg/m^3)	Temperature (K)	(kg/m^3)
1.213+0*	290.150	1.196+0*	294.150	1.2250+0*
9.945-1	278.134	9.874-1	280.932	1.0066
8.084-1	266.125	8.075-1	267.723	8.1935-1
6.544-1	252.718	6.572-1	253.116	6.6011
5.261-1	237.926	5.309-1	237.124	5.2579
4.172-1	223.151	4.225-1	221.151	4.1351
3.041-1	225.946	3.066-1	224.346	3.1194-1
2.225-1	228.739	2.236-1	227.538	2.2786
1.644-1	230.150	1.645-1	229.643	1.6647
1.223-1	230.150	1.218-1	230.639	1.2165
9.104-2	230.150	9.041-2	231.635	8.8910-2
6.775-2	230.150	6.716-2	232.630	6.4510-2
5.030-2	230.779	4.997-2	233.625	4.6938
3.709-2	233.562	3.723-2	234.619	3.4257
2.746-2	236.343	2.758-2	237.367	2.5076
2.040-2	239.122	2.038-2	242.131	1.8410
1.514-2	243.150	1.514-2	246.893	1.3555-2
1.124-2	248.701	1.132-2	251.651	9.8874-3
8.401-3	254.249	8.515-3	256.407	7.2579
6.319-3	259.794	6.437-3	261.159	5.3666
4.782-3	265.335	4.891-3	265.909	3.9957
3.641-3	270.873	3.735-3	270.655	2.9948-3
2.788-3	276.407	2.867-3	275.399	2.2589
2.146-3	281.938	2.210-3	280.140	1.7142
1.686-3	282.650	1.722-3	283.150	1.3167
1.328-3	282.650	1.357-3	283.150	1.0269
1.054-3	280.320	1.077-3	281.054	8.0562-4
8.368-4	277.561	8.574-4	277.508	6.3901
6.625-4	274.805	6.805-4	273.963	5.0445
5.233-4	272.049	5.385-4	270.421	3.9627
4.124-4	269.296	4.249-4	266.881	3.0968
3.243-4	266.544	3.343-4	263.343	2.4071-4
2.585-4	259.340	2.641-4	257.840	1.8605
2.078-4	247.562	2.120-4	246.062	1.4296
1.653-4	235.791	1.684-4	234.291	1.0917
1.300-4	224.027	1.322-4	222.527	8.2829-5
1.009-4	212.271	1.025-4	210.771	6.2374-5
7.730-5	200.522	7.833-5	199.022	4.6386
5.823-5	188.780	5.888-5	187.280	3.4311
4.309-5	177.046	4.346-5	175.546	2.5239
3.123-5	165.319	3.141-5	163.819	1.8458

Appendix B

Temperature-Altitude Profiles From Threshold Temperatures and From Threshold Densities for Extremes of Pressure and of Temperature at Each of Five Levels

Table B1. Temperature-Altitude Profiles in Geopotential km (From Threshold Temperatures)

Threshold Temperatures	Sea Level Pressure (mb)	Breakpoints in Geopotential km and Temperature (K)											
		Alt	K	Alt	K	Alt	K	Alt	K	Alt	K	Alt	K
5 km													
1%	1016.0	S.L.	220.15	1.0	236.15	2.5	233.15	5.5	216.65	9.5	212.65	16.0	199.65
		22.0	199.65	34.5	247.15	43.5	269.65	47.0	269.65	59.5	249.65	64.5	230.1
		70.0	230.15	80.0	218.15								
10%	1016.0	S.L.	229.65	1.5	238.65	4.5	226.65	8.0	209.15	12.0	209.15	15.5	202.15
		21.0	202.15	33.5	252.15	41.5	264.15	59.0	250.15	65.0	229.15	70.0	220.15
		80.0	219.15										
90%	1012.5	S.L.	291.65	1.0	287.15	2.0	291.15	4.0	283.15	16.0	193.15	17.0	193.15
		22.5	215.15	47.5	260.15	54.0	260.15	66.9	212.15	80.0	191.15		
99%	1012.5	S.L.	290.15	0.5	288.15	1.0	299.15	5.5	276.65	13.5	212.65	16.0	201.15
		17.0	201.15	20.0	213.15	46.5	266.15	50.0	266.15	55.0	255.15	70.0	204.15
		80.0	191.15										
10 km													
1%	1019.5	S.L.	237.15	1.5	262.65	5.0	241.65	10.0	199.15	12.0	201.15	19.0	201.15
		36.5	239.65	56.5	251.65	60.0	241.15	70.0	245.15	80.0	237.15		
10%	1016.5	S.L.	246.15	1.5	261.15	5.0	240.15	10.0	203.15	12.0	203.15	22.0	185.15
		31.0	198.65	48.5	279.15	56.0	279.15	65.0	216.15	75.0	203.15	80.0	203.15
90%	1011.0	S.L.	300.65	9.0	251.15	15.0	200.15	17.5	186.15	20.0	207.65	47.5	268.15
		53.5	268.15	66.0	230.65	80.0	195.65						
99%	1008.0	S.L.	299.15	9.0	254.0	17.0	186.15	18.0	186.15	20.5	208.15	45.5	268.15
		52.5	268.15	72.5	198.15	80.0	198.15						

Table B1 (Contd). Temperature-Altitude Profiles in Geopotential km (From Threshold Temperatures)

Threshold Temperatures	Sea Level Pressure (mb)	Breakpoints in Geopotential km and Temperature (K)											
		Alt	K	Alt	K	Alt	K	Alt	K	Alt	K	Alt	K
20 km													
1%	1016.5	S.L.	236.65	1.5	253.15	9.0	206.65	12.0	206.65	20.0	186.65	24.0	192.65
		46.5	264.65	55.0	264.65	60.0	253.15	65.0	228.15	80.0	207.15		
10%	1015.0	S.L.	240.15	2.0	254.15	4.0	245.15	9.0	208.65	20.0	192.15	24.0	192.15
		34.0	212.15	47.0	264.15	55.0	264.15	60.0	255.15	65.0	229.15	70.0	226.15
		80.0	210.15										
90%	1014.5	S.L.	273.15	4.0	253.15	8.0	223.15	11.0	234.15	26.0	234.15	32.0	243.15
		37.0	255.15	47.0	287.15	52.5	287.15	65.0	257.15	80.0	158.15		
(a) 99%	1016.5	S.L.	228.15	1.0	238.65	2.5	238.65	7.0	216.15	8.5	216.15	16.0	223.65
		21.0	245.15	28.5	230.15	40.0	230.15	54.0	242.15	64.0	235.15	70.0	235.15
		80.0	223.15										
(b) 99%	1014.5	S.L.	273.15	2.0	268.15	4.0	257.15	10.0	218.15	12.0	233.15	27.0	237.65
		32.0	243.15	37.0	255.15	47.0	287.15	52.5	287.15	65.0	257.15	80.0	158.15
30 km													
1%	1012.8	S.L.	241.15	1.0	243.15	3.5	239.15	8.5	220.15	13.0	220.15	20.0	216.65
		25.0	196.65	30.0	190.15	34.0	190.15	39.0	200.15	48.0	258.65	50.0	258.65
		55.0	249.15	70.0	241.65	80.0	217.65						
10%	1012.8	S.L.	253.15	1.5	257.65	8.5	212.15	13.0	212.15	25.0	194.15	31.0	194.15
		51.0	258.15	55.0	258.15	62.5	237.15	70.0	241.65	80.0	219.65		
90%	1011.7	S.L.	285.15	4.0	163.15	8.0	227.15	9.5	222.65	12.5	228.65	20.0	228.65
		26.0	234.65	46.0	286.65	52.5	286.65	62.5	261.65	80.0	163.65		
99%	1011.3	S.L.	279.15	2.0	275.15	10.0	223.15	12.5	227.15	20.0	230.15	31.0	257.65
		46.0	286.15	52.5	286.15	65.0	246.15	80.0	156.15				

Table B1 (Contd). Temperature-Altitude Profiles in Geopotential km (From Threshold Temperatures)

Threshold Temperatures	Sea Level Pressure (mb)	Breakpoints in Geopotential km and Temperature (K)							
		Alt	K	Alt	K	Alt	K	Alt	K
40 km									
1%	1014.7	S.L.	253.15	1.5	259.15	8.5	213.65	13.0	218.15
		42.5	207.15	55.0	254.65	60.0	240.15	70.0	255.15
10%	1014.7	S.L.	253.15	1.5	259.15	8.5	213.65	12.5	215.65
		38.0	200.65	45.0	223.15	50.0	244.15	55.0	251.15
		80.0	226.65						
90%	1011.7	S.L.	283.15	9.5	226.15	12.0	228.15	20.0	228.15
		47.0	283.65	51.0	286.65	63.5	264.15	80.0	165.15
99%	1011.7	S.L.	287.15	9.0	224.15	12.0	228.65	19.0	228.65
		42.0	284.65	48.5	284.65	62.5	263.65	80.0	162.15

Table B2. Temperature-Altitude Profiles in Geopotential km (From Threshold Densities)

Percentile Densities	Sea Level Pressure (mb)	Breakpoints in Geopotential km and Temperature (K)											
		Alt	K	Alt	K	Alt	K	Alt	K	Alt	K	Alt	K
5 km													
1%	1002.0	S.L. 34.0	281.65 233.65	1.0 46.5	280.15 271.15	3.0 48.5	273.15 271.15	4.0 80.0	280.15 176.65	13.0	208.15	17.0	208.15
10%	1012.0	S.L. 21.0 80.0	289.15 215.65 196.65	1.0 36.0	292.15 236.65	4.5 46.0	281.65 266.65	12.0 49.0	215.65 266.65	15.0 60.0	203.65 244.65	18.0 70.0	203.65 208.65
90%	1032.0	S.L. 41.5	238.15 260.15	0.5 45.0	250.15 260.15	1.5 55.0	250.15 249.15	8.0 70.0	211.15 249.15	13.0 80.0	218.15 223.15	28.0	206.15
99%	1032.0	S.L. 41.0	251.15 266.15	3.0 48.0	242.15 266.15	5.0 60.0	226.15 236.15	8.0 70.0	221.65 226.15	15.0 80.0	225.15 202.15	31.0	225.15
10km													
1%	1012.0	S.L. 26.0	228.15 213.15	1.0 38.0	232.15 213.15	4.0 55.5	223.15 248.15	6.0 60.5	231.15 242.15	10.0 70.5	233.15 253.15	13.5 80.0	233.15 243.65
10%	1011.0	S.L. 34.0	243.15 216.15	1.0 48.0	246.15 258.15	6.0 53.0	222.15 258.15	11.0 65.0	228.15 240.15	15.0 80.0	228.15 226.65	27.0	216.15
90%	1020.0	S.L. 51.5	289.15 263.65	4.0 69.0	273.15 225.15	12.0 80.0	205.15 208.65	16.0	205.15	36.0	229.15	47.5	263.65
99%	1019.5	S.L. 42.0	295.15 256.15	0.5 50.0	297.15 256.15	5.5 70.0	265.15 218.15	12.0 75.0	208.65 218.15	17.0 80.0	204.15 208.15	27.0	217.15

Table B2 (Contd). Temperature-Altitude Profiles in Geopotential km (From Threshold Densities)

Percentile Densities	Sea Level Pressure (mb)	Breakpoints in Geopotential km and Temperature (K)											
		Alt	K	Alt	K	Alt	K	Alt	K	Alt	K	Alt	K
20 km													
1%	1014.5	S.L.	235.15	1.5	247.15	7.0	208.65	10.0	213.15	15.0	213.15	18.0	223.65
		21.5	251.65	30.5	238.15	43.0	238.15	51.5	255.15	54.0	255.15	64.0	239.15
		70.0	236.15	80.0	226.15								
10%	1016.0	S.L.	230.15	1.0	238.15	4.0	229.15	8.0	209.15	12.0	209.15	15.5	202.15
		21.0	202.15	33.5	252.15	41.5	264.15	59.0	250.15	65.0	229.15	70.0	229.15
		80.0	219.15										
90%	1011.0	S.L.	301.15	8.0	257.15	17.0	185.15	23.0	212.15	35.5	239.65	45.5	274.65
		50.0	274.65	70.0	218.65	77.0	190.65	80.0	192.15				
99%	1011.0	S.L.	301.15	8.0	261.15	17.0	189.15	22.0	213.15	37.0	243.15	45.0	271.15
		49.5	271.15	77.0	188.65	80.0	191.65						
30 km													
1%	1014.7	S.L.	248.15	1.0	257.15	9.0	205.15	10.5	205.15	19.5	191.65	27.5	199.65
		42.5	258.15	47.5	262.15	52.0	262.15	60.0	234.15	70.0	227.15	80.0	212.15
10%	1014.7	S.L.	247.15	1.0	251.15	8.5	209.15	10.0	209.15	22.0	191.15	27.0	198.15
		42.0	246.15	48.0	261.15	52.5	261.15	60.0	235.65	70.0	228.65	80.0	212.65
90%	1010.3	S.L.	292.15	5.0	260.15	10.0	223.15	15.0	230.15	24.5	230.15	31.5	240.65
		46.5	261.15	52.5	281.15	62.5	264.15	80.0	159.15				
99%	1011.3	S.L.	282.15	4.0	264.15	10.0	222.15	12.5	231.15	20.0	231.15	31.0	236.65
		46.0	278.65	51.0	283.65	54.5	283.65	61.5	273.15	70.0	230.65	80.0	155.65

Table B2 (Contd). Temperature-Altitude Profiles in Geopotential km (From Threshold Densities)

Percentile Densities	Sea Level Pressure mb	Breakpoints in Geopotential km and Temperature (K)											
		Alt	K	Alt	K	Alt	K	Alt	K	Alt	K	Alt	K
40 km													
1%	1016.1	S.L.	253.15	2.0	257.15	10.0	201.15	12.5	201.15	20.0	189.15	25.5	189.15
		32.5	199.65	49.0	282.15	51.0	282.15	58.5	267.15	70.5	201.15	80.0	201.15
10%	1016.1	S.L.	253.65	2.0	256.65	10.0	208.65	20.0	188.65	25.0	188.65	35.0	215.65
		48.0	280.65	51.0	280.65	61.0	258.65	70.0	202.65	80.0	202.65		
90%	1010.3	S.L.	290.15	5.0	260.15	10.0	223.15	15.0	230.15	23.5	239.15	31.0	240.65
		46.0	282.65	50.0	282.65	62.5	265.15	80.0	160.15				
99%	1010.3	S.L.	294.15	5.0	261.15	10.0	221.15	15.0	229.15	27.0	235.15	47.0	283.15
		50.5	283.15	63.0	260.65	80.0	159.65						