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AIR FORCE CAMBRIDGE RESEARCH LABORATORIES
L. G. HANSCOM FIELD, BEDFORD, MASSACHUSETTS

UV, Visible, and IR Attenuation for Altitudes to 50 km, 1968

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OFFICE OF AEROSPACE RESEARCH
United States Air Force

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Abstract

An atmospheric attenuation model for the ultraviolet, visible, and infrared was developed in 1964, based on scattering (molecules and aerosols) and ozone absorption. Since then more measurements have been made and our knowledge of aerosol attenuation has widened. These circumstances result in attenuation model changes which are relatively unimportant for most exploratory calculations. They can be significant, however, for long slant-path high-altitude applications entailing large zenith angles, factors which characterize, for example, the measurement geometries of rockets and satellites. Accordingly, a revision of the 1964 Attenuation Model is warranted.

In this paper the optical parameters are computed spectrally and with altitude as follows: (1) pure air attenuation parameters are determined by utilizing Rayleigh scattering cross sections with molecular number densities from the standard atmosphere; (2) ozone absorption parameters are derived based on Vigroux's coefficients applied to a representative atmospheric ozone distribution; (3) seven sets of aerosol measurements are compared and a profile of aerosol attenuation coefficients vs altitude is developed. Attenuation coefficients and optical thickness due to molecular, aerosol, and ozone attenuation are computed and tabulated individually so that the influence of each can be compared. The newly derived tabulations permit various exploratory calculations, including horizontal, vertical, and slant-path transmission at kilometer intervals to an altitude of 50 km, individually for each attenuating component or for overall atmospheric extinction (molecular + ozone + aerosol).

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Symbols

A_v	Vigroux ozone absorption coefficient (cm^{-1})
D_3	Ozone concentration (cm/km)
d	Horizontal path length (km)
H_p	Aerosol scale height (km)
h	Altitude (km)
K	Mie scattering efficiency
m	Aerosol index of refraction
m_s	Index of refraction at sea level, air at 1013 mb and 15°C
N_3	Ozone number density (cm^{-3})
N_p	Aerosol number density (cm^{-3})
N_r	Molecular number density (cm^{-3})
N_s	Molecular number density at sea level (cm^{-3})
r	Particle radius (microns)
t_p	Turbidity (β_p/β_r)
T	Temperature °K
T_h	Horizontal transmission
T_{0-h}	Transmission between sea level and altitude h
$T_{h-\infty}$	Transmission between h and space
$T_{\Delta h}$	Transmission between two altitudes above sea level
β_3	Atmospheric ozone absorption coefficient (km^{-1})
β_p	Aerosol attenuation coefficient (km^{-1})
$\overline{\beta}_p(h, \lambda_1)$	Mean of 79 profiles for λ_1 = 0.55 microns (km^{-1})

β_r	Rayleigh attenuation coefficient (km^{-1})
β_{ext}	Extinction coefficient (km^{-1})
δ	Depolarization factor
θ	Zenith angle
λ	Wavelength (microns or cm)
λ_1	Wavelength 0.55 microns
σ_r	Rayleigh scattering cross section (cm^2)
τ_3	Ozone optical thickness from sea level to altitude h (0-h)
τ_3'	Ozone optical thickness from altitude h to space ($h-\infty$)
τ_p	Aerosol optical thickness from sea level to altitude h, (0-h)
τ_p'	Aerosol optical thickness from altitude h to space, ($h-\infty$)
τ_r	Rayleigh optical thickness from sea level to altitude h, (0-h)
τ_r'	Rayleigh optical thickness from altitude h to space, ($h-\infty$)
τ_{ext}	Extinction optical thickness (molecular + ozone + aerosol) from sea level to altitude h, (0-h)
τ_{ext}'	Extinction optical thickness (molecular + ozone + aerosol) from altitude h to infinity, ($h-\infty$)
ψ	Aerosol size distribution function

UV, Visible, and IR Attenuation for Altitudes to 50 km, 1968*

1. INTRODUCTION

In 1964, an atmospheric attenuation model was published (Elterman, 1964) which has been useful for a variety of exploratory calculations. Now a revision is warranted for reasons given in the abstract and Section 4 of this report. In this revision most of the earlier material is presented in summary form. The section on attenuation by Rayleigh scattering, however, is retained because the content leading to the derivation of the Rayleigh parameters is useful. In one instance, due to existing interest, the material is expanded, i.e., the tabulations which comprise the attenuation model now include aerosol and ozone optical thickness so that a comparison can be made of the relative importance of each attenuating component for vertical and slant paths.

The shortest wavelength considered is 0.27 microns. The use of shorter wavelengths would require a treatment of O_2 absorption. Also, attenuation is sufficiently severe so that interest in the shorter wavelength region for purposes of ultraviolet transmission below 50 km probably is limited. The longest wavelength used is 4.0 microns. Calculations for longer wavelengths are complicated by the presence of absorption bands of H_2O, CO_2, and their wings. In between, a total of 22 wavelengths is chosen (Table 1) within the atmospheric windows and for the ultraviolet region where ozone absorption is important.

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Conceptually, the attenuation model starts with molecular densities from the latest published U.S. Standard Atmosphere (1962) followed by the addition of ozone and aerosol components. The meteorological range (M. R.) at sea level corresponds to about 25 km at 0.55μ wavelength. This choice serves a useful function because it permits including some important measurements conducted at λ = 0.55μ . In addition, this wavelength customarily represents the phototopic region.

Table 1. Model Parameters as a Function of Wavelength

λ (microns)	m_s	σ_r (cm^2)	A_v (cm^{-1})
0.27	1.00029668	8.960×10^{-26}	2.10×10^{2}
0.28	1.00029475	7.646×10^{-26}	1.06×10^{2}
0.30	1.00029156	5.677×10^{-26}	1.01×10^{1}
0.32	1.00028902	4.310×10^{-26}	8.98×10^{-1}
0.34	1.00028699	3.334×10^{-26}	6.40×10^{-2}
0.36	1.00028531	2.622×10^{-26}	1.80×10^{-3}
0.38	1.00028392	2.091×10^{-26}	0
0.40	1.00028275	1.689×10^{-26}	0
0.45	1.00028052	1.038×10^{-26}	3.50×10^{-3}
0.50	1.00027896	6.735×10^{-27}	3.45×10^{-2}
0.55	1.00027782	4.563×10^{-27}	9.20×10^{-2}
0.60	1.00027697	3.202×10^{-27}	1.32×10^{-1}
0.65	1.00027630	2.314×10^{-27}	6.20×10^{-2}
0.70	1.00027578	1.714×10^{-27}	2.30×10^{-2}
0.80	1.00027503	9.990×10^{-28}	1.00×10^{-2}
0.90	1.00027451	6.213×10^{-28}	0
1.06	1.00027397	3.216×10^{-28}	0
1.26	1.00027357	1.606×10^{-28}	0
1.67	1.00027315	5.189×10^{-29}	0
2.17	1.00027292	1.817×10^{-29}	0
3.50	1.00027272	2.681×10^{-30}	0
4.00	1.00027269	1.571×10^{-30}	0

λ – Wavelength

m_s – Index of refraction (1013 mb, 15°C)

σ_r – Rayleigh scattering cross section

A_v – Absorption coefficient after Vigroux for pure O_3, smoothed values (1013 mb, 18°C)

2. RAYLEIGH PARAMETERS

A fundamental requirement for generating an accurate series of Rayleigh parameters is an exact determination of the index of refraction for the wavelengths of interest. With this known, the Rayleigh cross sections can be computed. This in turn permits computation of the Rayleigh attenuation coefficient and its variation with altitude as well as corresponding optical thickness values.

The index of refraction for a standard atmosphere (1013 mb, 15°C) specifically for the desired wavelengths used is determined by Edlen's (1953) expression

$$(m_s - 1)10^{-8} = 6432.8 + \frac{2949810}{146 - (\lambda^{-2})} + \frac{25540}{41 - (\lambda^{-2})} , \tag{1}$$

where m_s = refractive index ,

λ = wavelength (microns) .

Penndorf's (1957) computations using Eq. (1) demonstrate that the effect of water vapor can be neglected and the derived m_s values have negligible error for the spectral range from 0.2 to 20.0 microns.

The Rayleigh cross section is expressed by

$$\sigma_r(\lambda) = \frac{8\pi^3(m_s^2 - 1)^2}{3\lambda^4 N_s^2} \cdot \frac{6 + 3\delta}{6 - 7\delta} \tag{2}$$

where

σ_r = the Rayleigh scattering cross section (cm^2),

λ = the wavelength (cm),

m_s = the index of refraction of air at 15°C and 1013 mb pressure,

N_s = the molecular number density at sea level for a standard atmosphere (cm^{-3}),

δ = the depolarization factor.

The term $(6 + 3\delta)/(6 - 7\delta)$ accounts for the degree of depolarization attributable to the anisotropy of the atmospheric molecule. The depolarization factor has been determined by calculation and by laboratory measurement. The latest work of Gucker and Basu (1953) yields $\delta = 0.035$. The wavelengths of interest with the indices of refraction and Rayleigh cross sections [computed from Eqs. (1) and (2)] are listed in Table 1, and plotted in Figures 1 and 2.

Using the scattering cross sections, the Rayleigh coefficients are obtained with

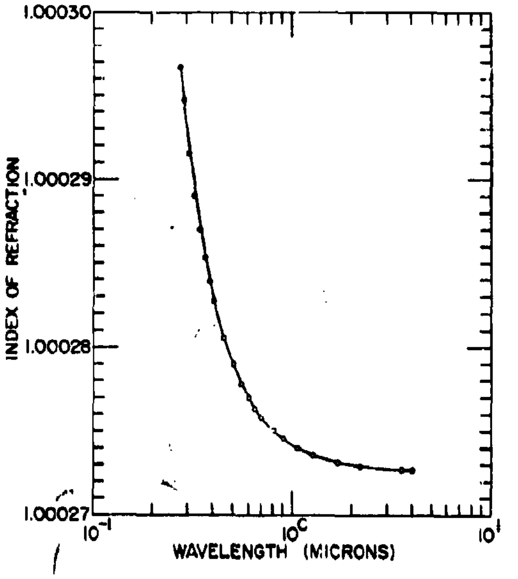

Figure 1. Index of Refraction for 1013 mb and 15°C (Table 1), oooo Represent Attenuation Model Wavelengths

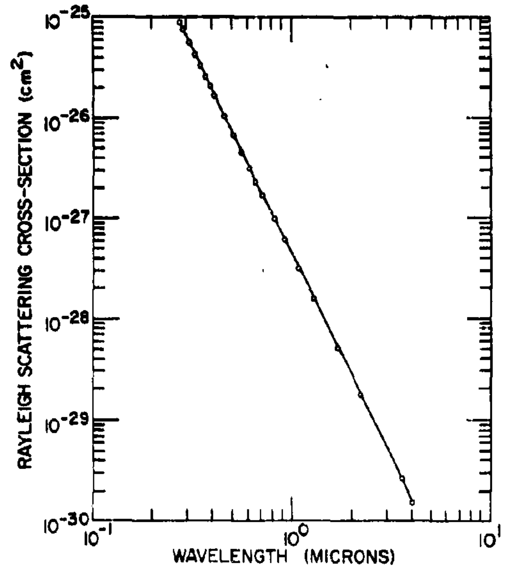

Figure 2. Rayleigh Cross Section vs Wavelength (Table 1), oooo Represent Attenuation Model Wavelengths

$$\beta_r(h,\lambda) = \sigma_r(\lambda) \cdot N_r(h) \cdot (10^5 \text{ cm/km}) \quad , \tag{3}$$

where

β_r = the Rayleigh attenuation coefficient (km^{-1}) ,
σ_r = the Rayleigh scattering cross section (cm^2),
N_r = the molecular number density (cm^{-3}) .

The values of $N_r(h)$ needed for Eq. (3) were obtained from the U.S. Standard Atmosphere and are listed in Table 2. This expression is used to compute an array of Rayleigh attenuation coefficients as a function of altitude for each wavelength.

With the Rayleigh attenuation coefficients determined, the optical thicknesses from sea level to some altitude h are computed by

$$\tau_r(h,\lambda) = \sum_0^h \bar{\beta}_r(h,\lambda)\, \Delta h \quad , \tag{4}$$

where

τ_r = Rayleigh optical thickness (0 - h) ,
$\bar{\beta}_r$ = mean of the Rayleigh attenuation coefficients (km^{-1}) for each altitude increment,
Δh = altitude increment chosen as one km for these calculations.

The Rayleigh optical thickness for altitude h to space is obtained by the relationship

$$\tau_r'(h,\lambda) = \tau_r(\infty,\lambda) - \tau_r(h,\lambda) \quad , \tag{5}$$

where

$\tau_r'(h)$ = Rayleigh optical thickness $(h - \infty)$,
$\tau_r(\infty)$ = Rayleigh optical thickness $(0 - \infty)$.

The term $\tau_r(\infty)$ was obtained by using Eq. (4) with the limits set between 0 and 80 km. Above 80 km, Stergis' (1966) calculations, based on N_2, O_2, and O as the principal atmospheric constituents, yield

$$\int_{80}^{\infty} \beta_r(h,\lambda)\, dh = \begin{cases} 3.6 \times 10^{-6} , & \lambda = 0.4\,\mu \\ 6.7 \times 10^{-7} , & \lambda = 0.6\,\mu \\ 2.1 \times 10^{-7} , & \lambda = 0.8\,\mu \end{cases} .$$

These values approximate a constant 10^{-5}, that of the Rayleigh optical thickness for unity air mass. For our purposes then the integral can be neglected because the constant is small and applies to all wavelengths of interest.

Table 2. Model Parameters as a Function of Altitude

h (km)	N_r (cm^{-3})	D_3 (cm/km)
0	2.547×10^{19}	3.56×10^{-3}
1	2.311	3.26
2	2.093	2.93
3	1.891	2.50
4	1.704	2.26
5	1.531	2.21
6	1.373	2.16
7	1.227	2.23
8	1.093	2.28
9	9.712×10^{18}	2.81
10	8.598	3.50
11	7.585	4.60
12	6.486	6.21
13	5.543	8.45
14	4.738	9.57
15	4.049	9.94
16	3.461	1.03×10^{-2}
17	2.959	1.11
18	2.529	1.22
19	2.162	1.42
20	1.849	1.64
21	1.574	1.84
22	1.341	1.97
23	1.144	1.98
24	9.760×10^{17}	1.93
25	8.335	1.80
26	7.123	1.63
27	6.092	1.41
28	5.214	1.23
29	4.466	1.07
30	3.828	9.03×10^{-3}
31	3.283	7.93
32	2.818	6.82
33	2.406	5.82
34	2.056	4.85
35	1.760	4.31
36	1.509	3.61
37	1.296	3.02
38	1.116	2.53
39	9.620×10^{16}	2.17
40	8.308	1.86
41	7.187	1.52
42	6.227	1.19
43	5.404	9.30×10^{-4}
44	4.697	7.44
45	4.088	5.76
46	3.564	4.46
47	3.112	3.53
48	2.738	2.79
49	2.418	2.23
50	2.135	1.86

h – Altitude; N_r – Molecular number density;
D_3 – Ozone equivalent thickness

3. ABSORPTION PARAMETERS FOR ATMOSPHERIC OZONE

This section is a summary of the material used in the 1964 Attenuation Model.

The parameter for determining O_3 absorption as a function of altitude is the atmospheric ozone absorption coefficient expressed by:

$$\beta_3(h,\lambda) = A_v(\lambda)\, D_3(h) \quad , \tag{6}$$

β_3 = atmospheric ozone absorption coefficient (km^{-1}),

A_v = the pure ozone absorption coefficient (cm^{-1}) after Vigroux,

D_3 = the ozone equivalent thickness (cm/km).

Thus, the Vigroux coefficients (1953) listed in Table 1 in conjunction with the ozone concentrations, Table 2 and Figure 3, permit the computation of an array of atmospheric ozone absorption coefficients to 50 km for each of the desired wavelengths.

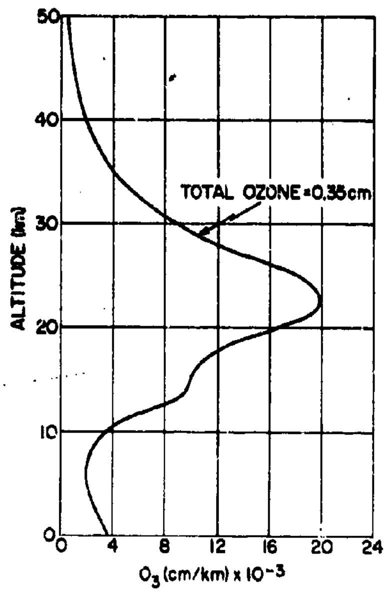

Figure 3. Representative Atmospheric Ozone Concentration Profile (Table 2). Values for:
0 to 30 km, based on Handbook of Geophysics and Space Environment (1965)
30 to 40 km, interpolated
40 to 50 km, based on London, Ooyama, and Prabhakara (1962)

The ozone optical thickness from sea level to altitude h, $\tau_3(h,\lambda)$, and the ozone optical thickness from some altitude h to space, $\tau'_3(h,\lambda)$, are included in the model tabulations. The expressions for deriving these parameters have the same form as Eqs. (4) and (5).

4. AEROSOL ATTENUATION

Of the various methods used to investigate aerosol attenuation, for the present we will consider optical techniques only because they are suited to this type of study. In this country, Newkirk and Eddy (1964) used solar aureole photometry; Penndorf (1954) analyzed solar radiation measurements from aircraft altitudes; Elterman's results (1966a,b), with searchlight probing, comprise a substantial number of profiles acquired in New Mexico for altitudes to about 34 km. In Australia, Crosby and Koerber (1962) used a balloon-borne integrating nephelometer. In the U.S.S.R., Kondratiev, et al. (1967), conducted balloon solar transmission measurements; Feoktistov (1965) analyzed photographs of the earth's horizon from the spacecraft Voschod; Rozenberg, et al. (1960) (1966), acquired their results with searchlight probing. The various results, as shown in Figure 4, were made comparable at $\lambda_1 = 0.55\mu$ by using the empirical relationship that the aerosol attenuation coefficient is inversely proportional to wavelength. For reasons of clarity, a substantial body of results was not included in Figure 4, as for example the twilight measurements by Rozenberg (1965), Volz and Goody (1962), the searchlight measurements by Spankuch (1967), analysis of twilight aureole photographs from the spacecraft Vostok-6 by Driving (1966), the aircraft measurements of sky brightness by Sandomirski, Al'tovskaia and Trifonova (1964), and aircraft nephelometry by Waldram (1945). Also, interesting results in the form of relative values have been obtained with optical techniques: the twilight measurements by Bigg (1964), the laser beam backscatter by Collis and Ligda (1966), by Clemeshaw, Kent, and Wright (1967), and by Grams and Fiocco (1967).

A consideration of all results shows, as does Figure 4, that the aerosol attenuation coefficient is a strongly fluctuating parameter and that average values based on an adequate number of measurements are necessary in order to establish a representative profile. The recent searchlight probing measurements (Elterman, 1966a and 1966b) appear representative based on several considerations. First, each profile was acquired by continuous measurement through both troposphere and stratosphere and with an altitude resolution approximating one km. In addition, a total of 119 profiles comprising absolute values of aerosol attenuation coefficients were determined for various times throughout the year. This represents a substantially larger sample than previously published. Further, such a quantity of

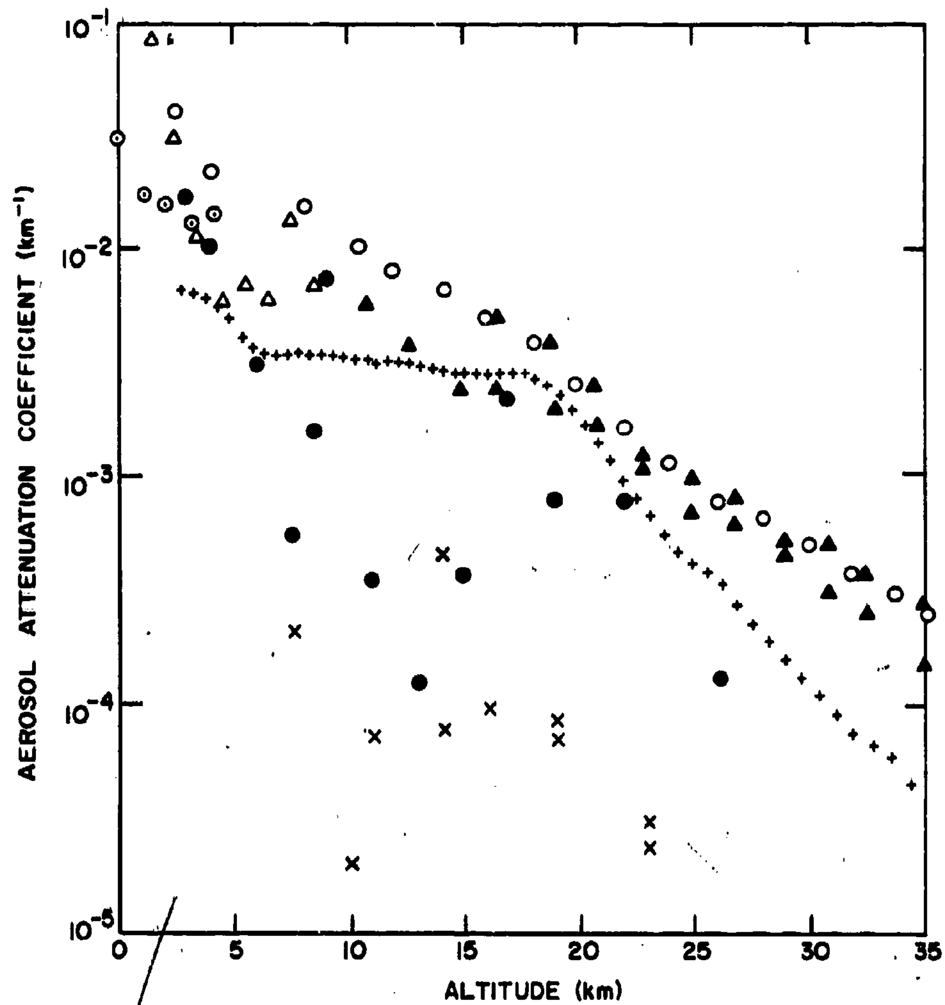

Figure 4. Aerosol Attenuation Coefficients vs Altitude at $\lambda_i = 0.55\mu$. Comparison of results:

X X X X solar aureole, 2 balloon flights, Newkirk and Eddy (1964);
△ △ △ △ solar radiation measured from aircraft, mean of 8 flights, Penndorf (1954);
+ + + + searchlight probing, mean of 105 profiles, Elterman (1966a) and (1966b);
⊙ ⊙ ⊙ ⊙ balloon integrating nephelometer, mean of 14 flights, Crosby and Koerber (1962);
● ● ● ● solar radiation measured from balloons, mean of 3 flights, Kondratiev et al. (1967);
▲ ▲ ▲ ▲ spacecraft horizon photography, analysis of 4 frames, Rozenberg (1966), Feoktistov (1965);
○ ○ ○ ○ searchlight probing, mean for 5 nights, Rozenberg (1966)

results readily permits statistical treatment. Finally, we note that the mean of the 119 profiles falls reasonably well within the values determined by other researchers, a circumstance which tends to provide a measure of comfort.

In considering the suitability of the 119 profiles, extensive averaging is required and this tends to wash out features easily noted in the individual profile. We present, therefore, in Figure 5 a single profile, chosen because its properties are readily evident and also because it is similar to the overall average. The features can be made to emerge more prominently if the aerosol coefficients are used to compute a turbidity profile, $t_p(h,\lambda_1) = \beta_p(h,\lambda_1)/\beta_r(h,\lambda_1)$, where β_p and β_r are the aerosol and Rayleigh coefficients respectively and $\lambda_1 = 0.55\mu$ (Figure 6).

Since volcanic dust in the atmosphere can have a residence time of several years, the effects of the Mt. Agung eruption (March 1963) must be considered. The direct measurements of Junge, Chagnon, and Manson (1961), Friend (1965), Mossop (1964), and Rosen (1968), collectively considered, before and after this event, show evidence of change in the stratospheric aerosol content. The observations of the twilight sky by Volz (1965) and Meinel and Meinel (1964) also show augmentation of stratospheric particulates. Since the searchlight probing measurements yielded absolute values of aerosol attenuation coefficients, the most suitable parameter to use for examining this feature quantitatively is the stratospheric aerosol optical thickness for the altitude region between the tropopause and 25 km. The reason for choosing the latter altitude limit will be discussed later. Accordingly, all profiles were placed in time-sequential groups determined by the similarity of the stratospheric dust feature. Then the optical thickness was computed by

$$\tau = \frac{1}{n} \sum_{i=1}^{n} \sum_{h_1}^{h_2} \bar{\beta}'(h)\, \Delta h \quad , \tag{7}$$

where n is the number of profiles in the group, h_1 is the altitude of the tropopause, h_2 the 25 km altitude, $\bar{\beta}'$ the mean aerosol attenuation coefficient (within each profile) for the altitude interval, and Δh the altitude intervals used for computing the profiles. The results of this computation are presented in Table 3. The tabulation demonstrates a relatively high level of stratospheric dust for the December 1963 to March 1964 period. Beginning with April 1964, dust abatement and a generally stabilized level are in evidence. The mean optical thickness of Group (B+C+D) is 26 percent less than that of Group A. Since Group A entails a period of abnormally high aerosol content, its profiles are <u>not</u> representative. These results are in satisfactory agreement with the findings from the direct measurements of the authors mentioned.

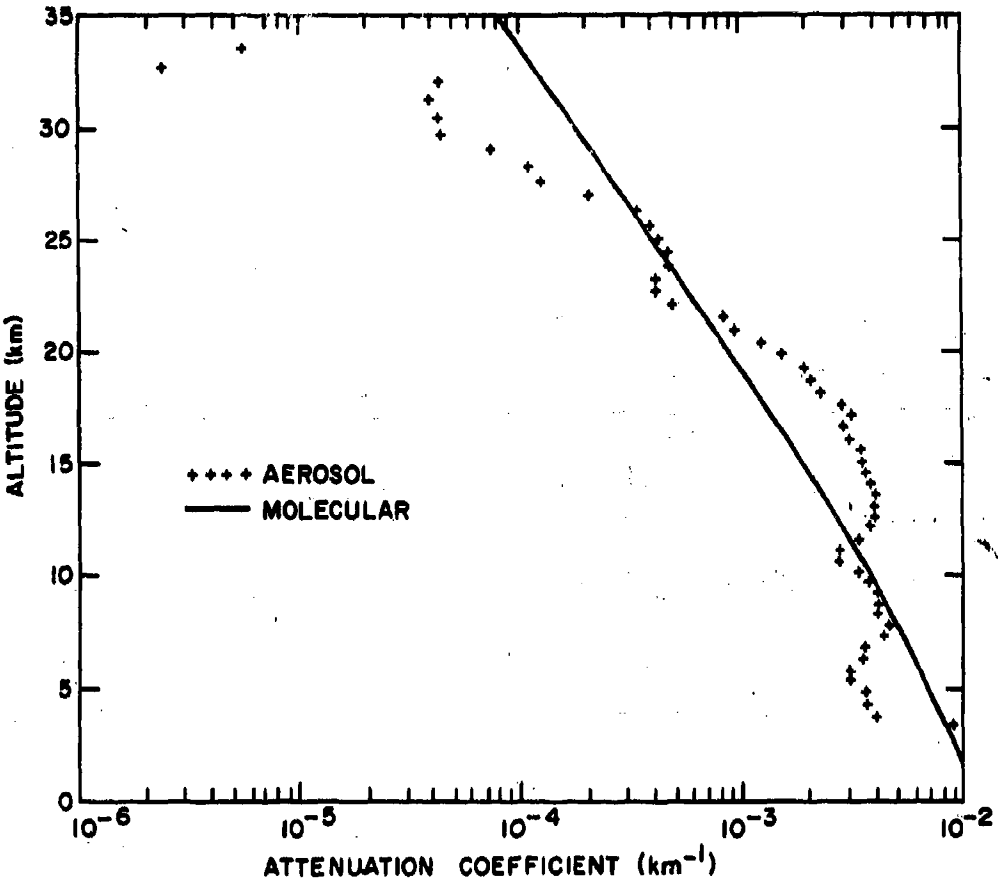

Figure 5. Single Profile $\beta_p(h, \lambda_1)$ for 11 April 1964 at 02:00 MST, Similar to Mean of 79 Profiles, $\lambda_1 = 0.55\mu$.
Surface to 5 km – convective region;
5 to 11.7 km – troposphere dust layer;
11.7 to 23.8 km – stratosphere dust layer;
25.6 km – upper altitude maximum
+ + + + aerosol (measurements)
——— molecular (computed)

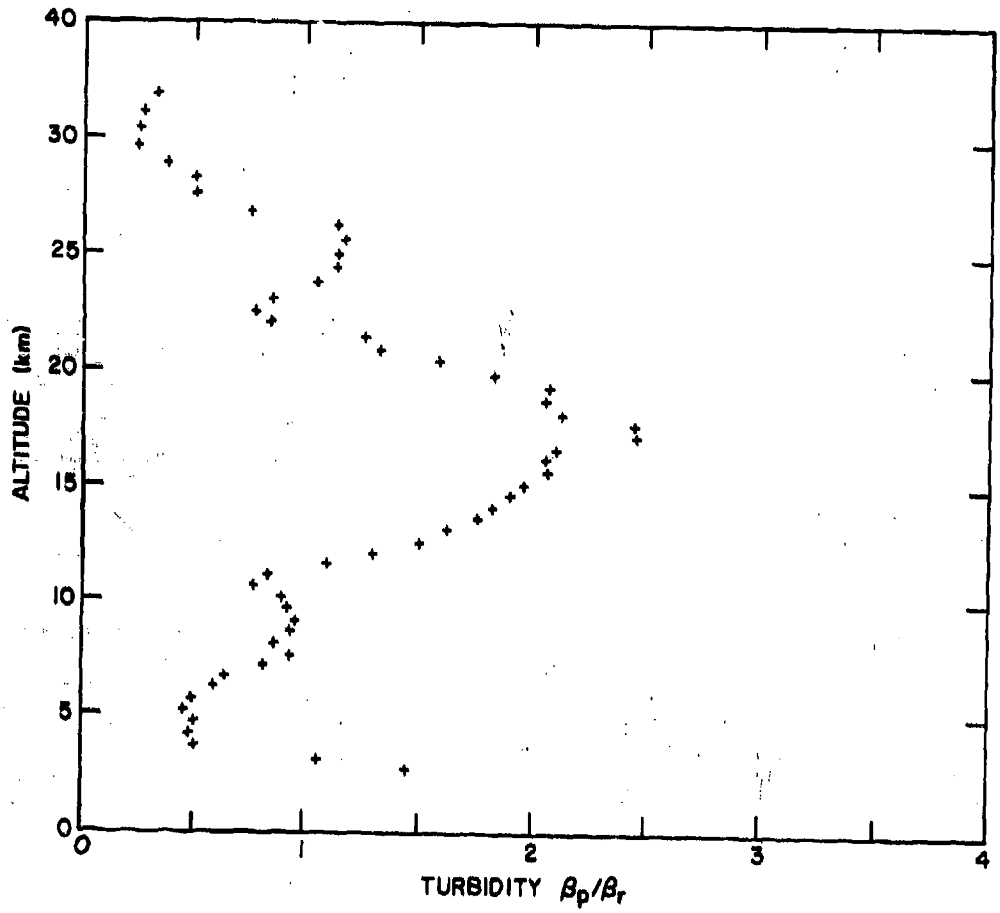

Figure 6. Single Turbidity Profile $\beta_p(h, \lambda_1)/\beta_r(h, \lambda_1)$ for 11 April at 0200 MST.
+++++ Measurements
(See caption pertaining to Figure 5)

Table 3. Aerosol Optical Thickness as a Measure of Volcanic Dust, $\lambda_1 = 0.55\mu$

Group	Period (Inclusive)	Number of Profiles	Mean Optical Thickness (approx. 12-25 km)
A	Dec 1963 – Mar 1964	40	3.1×10^{-2}
B	Apr 1964 – Sep 1964	50	2.2
C	Oct 1964 – Nov 1964	10	2.7
D	Dec 1964 – Apr 1965	19	2.4
B+C+D	Apr 1964 – Apr 1965	79	2.3

The considerations discussed above justify the selection of the Group (B+C+D) profiles as a basis for developing representative aerosol attenuation parameters. It will be convenient to designate the 7ø profile average for $\lambda_1 = 0.55\mu$ as $\bar{\beta}_p(h, \lambda_1)$ (Figure 7). This profile can be extended to encompass a larger altitude range by using the scale height relationship,

$$\bar{\beta}_p(h_2, \lambda_1) = \bar{\beta}_p(h_1, \lambda_1) \exp\left[-\frac{(h_2 - h_1)}{H_p}\right] . \tag{8}$$

Penndorf's study (1954) shows that for the lowest 5 km, the aerosol coefficients fall off exponentially with a scale height $0.97 < H_p < 1.4$ km. We resort to the use of his mean value, $H_p = 1.2$ km, to extend the $\bar{\beta}_p(h, \lambda_1)$ profile from 3.7 km to sea level. This results in aerosol coefficients which are identical to those of the 1964 Attenuation Model for altitudes 0 to 3 km (Table 4.11).

Above the convective region, up to the tropopause the aerosol coefficients show a moderate gradient which is in close agreement with Penndorf's analysis (1954) of the vertical distribution of aerosols in the troposphere. Also, this section of the profile is based on high signal to noise measurements and extensive averaging, factors which contribute to its reliability. Additionally, this altitude region, being above the convective layer, is characterized by aerosol conditions which tend to be independent of surface terrain. These considerations suggest that the shape and values of the $\bar{\beta}_p(h, \lambda_1)$ profile for this altitude region are realistic.

Above the tropopause, up to 25 km, the coefficients are larger than those derived for the 1964 Attenuation Model by a factor of about 20 (at 20 km for $\lambda_1 = 0.55\mu$). This difference may be attributed in part to the intrinsic difficulties of converting a size distribution to an optical parameter, that is, establishing the radii limits, particle shape, chemistry, and index of refraction. Relative to profile shape, a turbidity maximum dominates at about 19 km (Figure 8). The measurements of Rosen (1968) and those of Volz (1968) for 1964 to 1968 are in satisfactory agreement

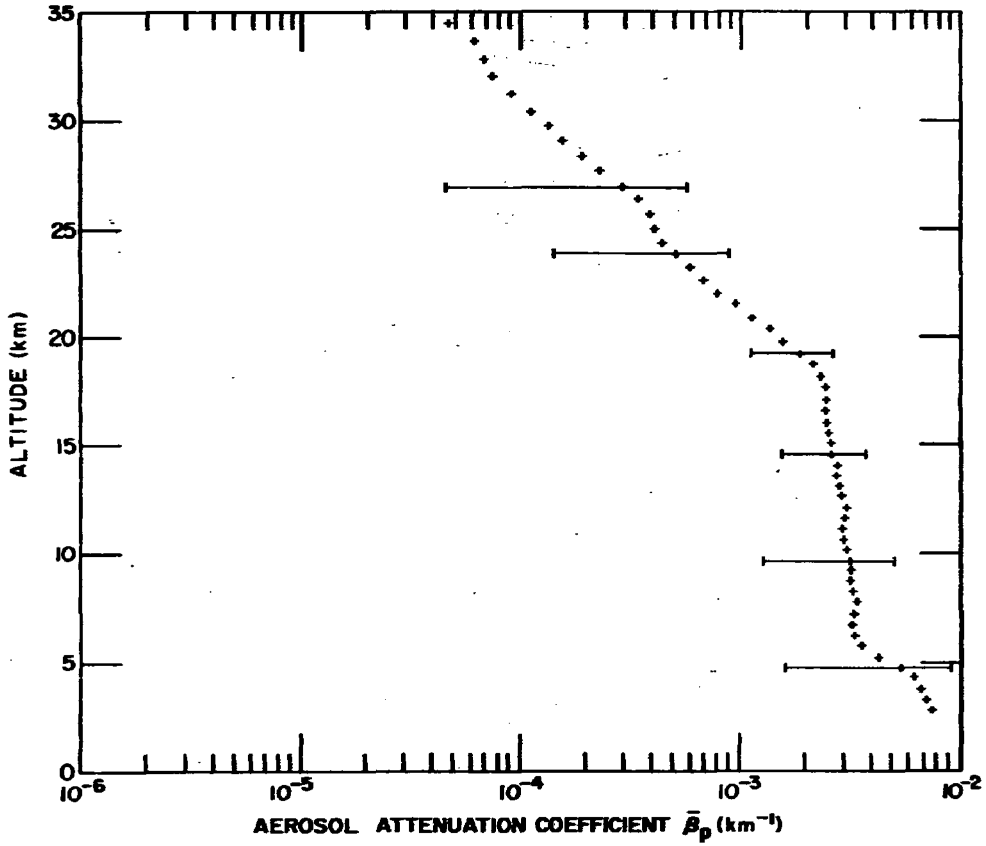

Figure 7. Mean of 79 Low Stratospheric Dust Profiles (Table 3) for April 1964 to April 1965. Aerosol attenuation coefficients, $\bar{\beta}_p(h, \lambda_1)$; standard deviation limits attributable to error and atmospheric variations; $\lambda_1 = 0.55\mu$; +++++ measurements with searchlight probing

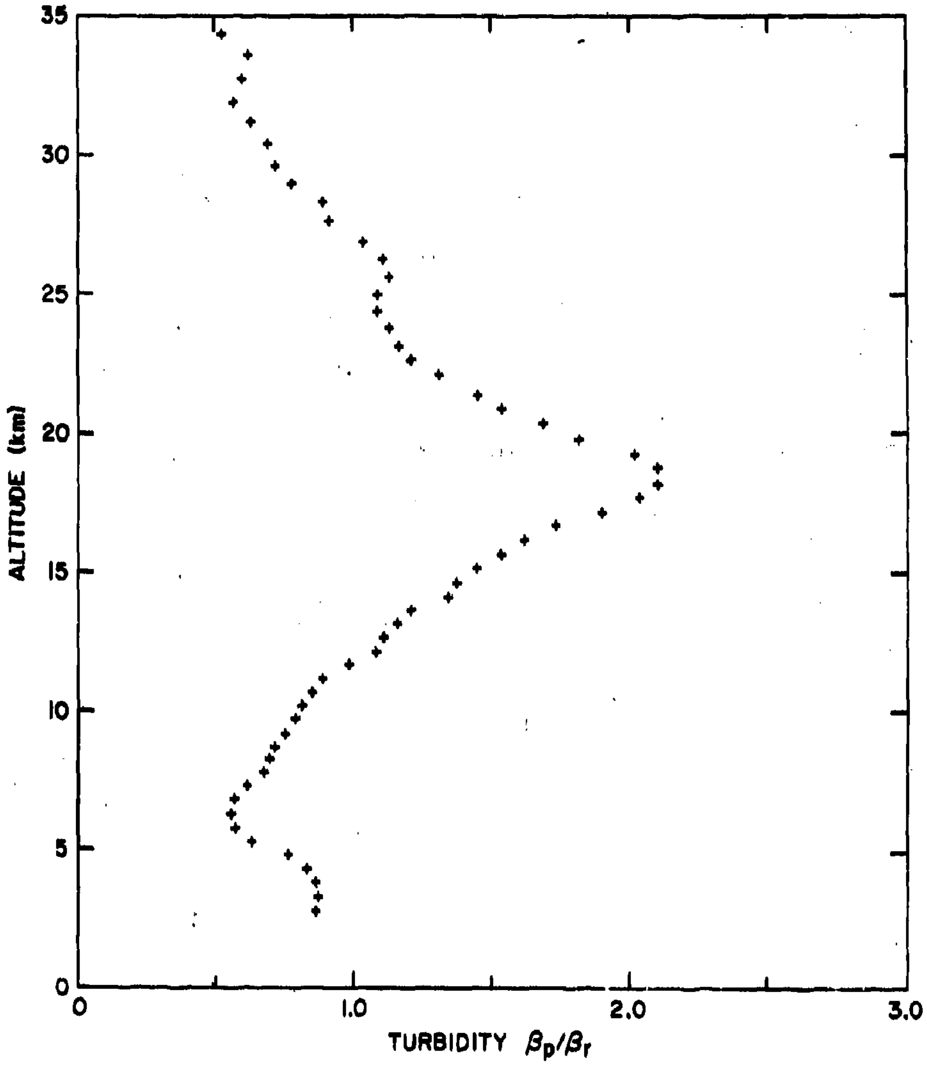

Figure 8. Mean Turbidity Profile, $\bar{\beta}_p(h,\lambda_1)/\beta_r(h,\lambda_1)$
(See caption for Figure 7)

with the mean optical thickness and shape of the Group (B+C+D) profiles, Table 3. Also their results show that the stratospheric dust level has remained approximately constant from 1964 to the time of this writing. The $\bar{\beta}_p(h,\lambda_1)$ curve (Figure 7) shows this dust feature as the knee of the profile rather than a massive layer feature indicated by the turbidity profile. This conceptual relationship suggests that over-emphasis is possible when dealing only with turbidity profiles.

The turbidity profile shows an upper stratospheric maximum with its lower terminus at 25 km. This altitude then, was the basis for choosing the upper stratospheric dust limit in Eq. (7). The maximum at 26 km occurs with sufficient frequency to be easily identified in the turbidity profile. The existence of such an aerosol concentration above 20 km is supported by the analysis of satellite photography reported by Mateer, Dave, Dunkelman, and Evans (1967).

To establish upper altitude aerosol coefficients, a least square fit was computed for $\bar{\beta}_p(h,\lambda_1)$ from 26 to 32 km (Figure 9). The result, H_p = 3.75 km (in effect derived from 790 measurement points), was used in Eq. (8) to extend the values to 50 km. Miller (1967) obtained H_p = 3.25 km from a thorough analysis of rocket measurements acquired in 1964 for this altitude region. The overall profile from sea level to 50 km is presented in Figure 10 (Table 4.11). Since the

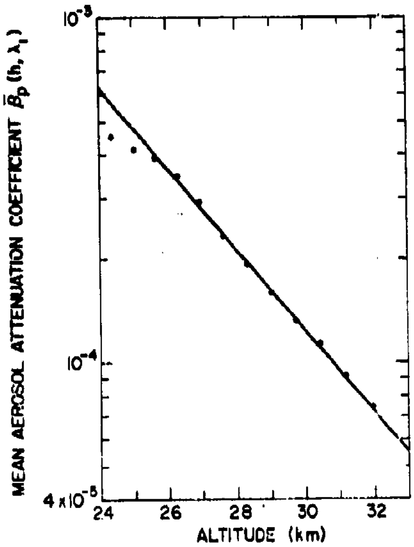

Figure 9. Expanded Scale for 26 to 32 km Altitude Region Showing H_p = 3.75 km for 79 Profile Mean; Aerosol Attenuation Coefficients, $\beta_p(h,\lambda_1)$ vs Altitude; Least Square Fit Used to Extrapolate to 50 km; λ_1 = 0.55μ

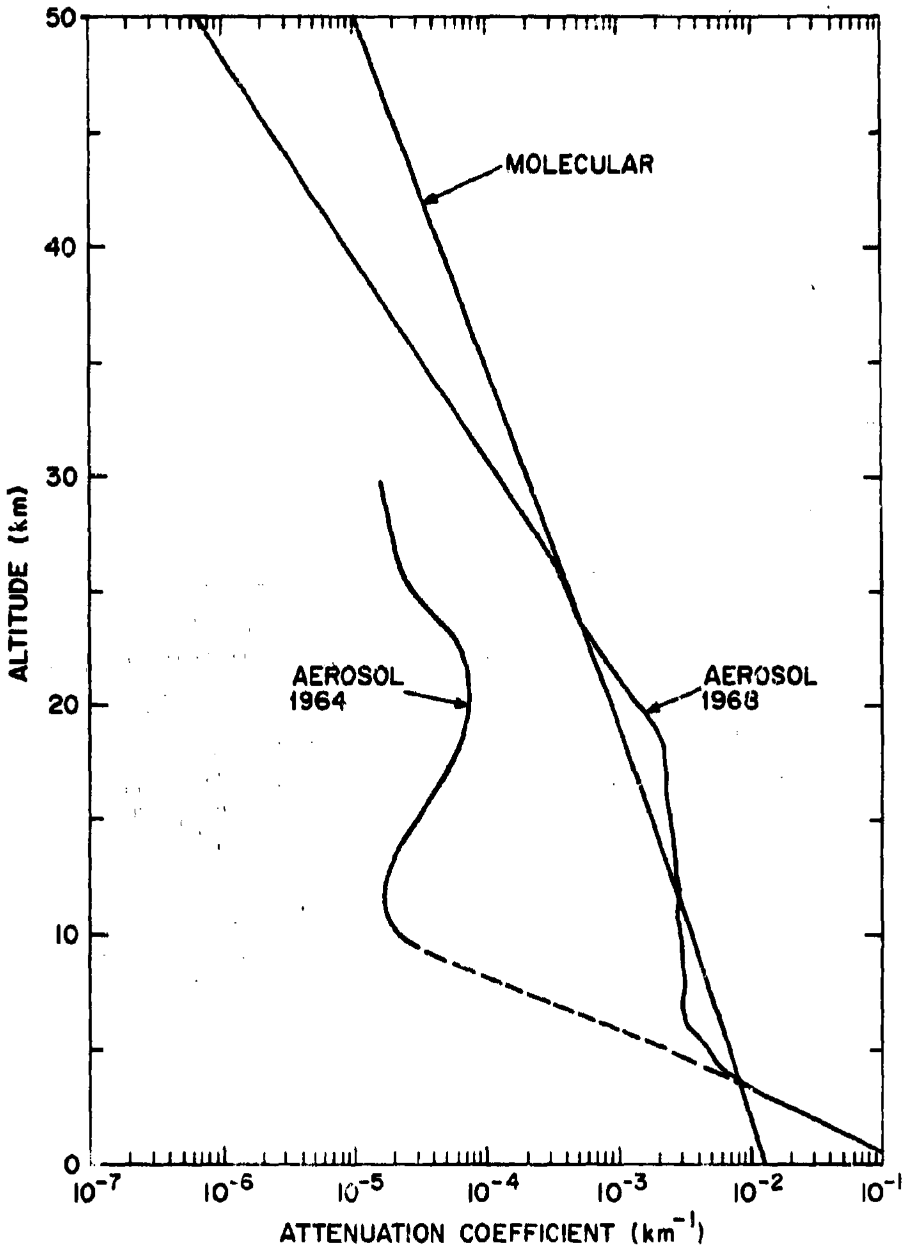

Figure 10. Comparison of Profiles. Aerosol attenuation coefficients $\beta_p(h, \lambda_1)$, with molecular $\beta_r(h, \lambda_1)$. The 1964 profile shows interpolation between 5 to 10 km; $\lambda_1 = 0.55\mu$

turbidity is proportional to the mixing ratio, the diminishing values for the extrapolation imply the aerosol source exists below 30 km. Should the source be of meteoric origin, the mixing ratio would tend to be constant or increase for altitudes 30 to 50 km.

Thus far we have selected a set of measurements for $\lambda_1 = 0.55\mu$ and provided reasons for its use. It would be in order now to examine some expressions leading to corresponding aerosol profiles for other wavelengths. If we consider a real atmosphere, the aerosol sizes within unit volume can be described by a size distribution function, $\psi(r)$. Various size distribution functions are in use: the Junge type power law (1963) with a choice of exponents discussed in detail by Bullrich (1964), a similar distribution modified by gaps observed by Fenn (1964), a log-Gaussian distribution used by Foitzik (1965), a composite distribution with components from several types. The optical-particle size relationship utilizes $\psi(r)$ such that

$$\beta_p(m, r, \lambda) = \int_{N_{r2}}^{N_{r1}} \sigma_p(m, r, \lambda)\, dN_p(r) \quad , \tag{9}$$

$$dN_p = N_o\, \psi(r)\, dr \quad , \tag{10}$$

$$N_o(h) = C\, N_p(h) \quad . \tag{11}$$

β_p is the aerosol attenuation coefficient, m is the index of refraction, N_{r_1} and N_{r_2} are the aerosol number density limits established by the radii limits r_1 and r_2, σ_p is the aerosol cross section for each particle, N_p is the total number of particles between r_1 and r_2. For a given altitude, N_o actually is proportional to the particle number density between r_1 and r_2. Since the same size distribution function applies to all altitudes (an assumption), Eqs. (9), (10), and (11) are combined

$$\beta_p(h, \lambda) = C\, N_p(h) \int_{r_1}^{r_2} \sigma_p(r, \lambda)\, \psi(r)\, dr \quad . \tag{12}$$

Here, $C\, N_p(h)$ is placed outside the integral which now contains only factors that are independent of altitude; also, m is removed because subsequent considerations will pertain to particles without any distinction in refractive index. If Eq. (12) is normalized to sea level conditions, the integral cancels out. Then generally for the various wavelengths λ, and specifically for $\lambda_1 = 0.55\mu$, we have

$$\frac{\beta_p(h,\lambda)}{\beta_p(0,\lambda)} = \frac{\beta_p(h,\lambda_1)}{\beta_p(0,\lambda_1)} \simeq \frac{N_p(h)}{N_p(0)} \tag{13}$$

or

$$\beta_p(h,\lambda) = \frac{\beta_p(0,\lambda)}{\beta_p(0,\lambda_1)} \cdot \beta_p(h,\lambda_1) \quad . \tag{14}$$

Equation (13) has been derived in this manner to demonstrate its compatibility with particle size considerations. Sea level conditions have been researched extensively by Curcio and Durbin (1959), Curcio, Knestrick, and Cosden (1961), Knestrick, Cosden, and Curcio (1961), Dunkelman (1952), Baum and Dunkelman (1955). The $\beta_p(0,\lambda)$ values for a 25 km M.R., based on the results of these authors, are shown in Figure 11 (see also Elterman, 1964). Utilizing these results, in conjunction with the $\bar{\beta}_p(h,\lambda_1)$ profile (Table 4.11), all requirements for the right-hand side of Eq. (14) are satisfied and an array of aerosol attenuation coefficients can be computed for all altitudes and wavelengths of interest.

The aerosol optical thickness from sea level to altitude h, $\tau_p(h,\lambda)$, and the aerosol optical thickness from some altitude h to space, $\tau_p'(h,\lambda)$, are included in the model tabulations. The expressions for deriving these parameters have the same form as Eqs. (4) and (5).

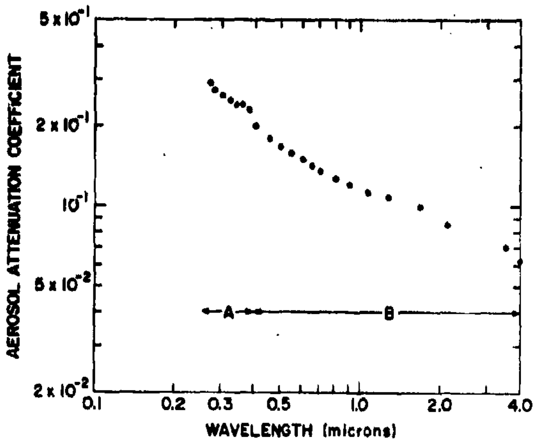

Figure 11. Aerosol Attenuation Coefficients $\beta_p(0,\lambda)$ vs Wavelength at Sea Level for a Meteorological Range Approximating 25 km.
A – derived from Baum and Dunkelman (1955)
B – contained in Curcio, Knestrick, and Cosden (1961)

5. ATMOSPHERIC EXTINCTION

In this section, three sets of extinction parameters are considered: extinction coefficient, extinction optical thickness from sea level to a desired altitude, and extinction optical thickness from a desired altitude to space.

The atmospheric extinction coefficient β_{ext} is the sum of all the attenuating components:

$$\beta_{ext}(h,\lambda) = \beta_r(h,\lambda) + \beta_3(h,\lambda) + \beta_p(h,\lambda) \quad . \tag{15}$$

The extinction optical thickness from sea level to altitude h , $\tau_{ext}(h,\lambda)$, and the extinction optical thickness from some altitude h to space, $\tau'_{ext}(h,\lambda)$, are included in the tabulations of the attenuation model. The expression for deriving these parameters has the same form as Eqs. (4) and (5).

6. EXPLORATORY TRANSMISSION CALCULATIONS

Using the derived tabulations that follow, some exploratory calculations with extinction parameters (for any of the wavelengths) are demonstrated. Rayleigh, aerosol, and ozone parameters can be used similarly.

For horizontal transmission (T_h) over a path (d) at any altitude (h) , the extinction coefficient

$$T_h = \exp\left[- \beta_{ext}(h,\lambda) \cdot d \right] \quad . \tag{16}$$

For vertical and slant-path transmission from sea level to a given altitude, at zenith angle θ for all wavelengths of interest

$$T_{o-h} = \exp\left[- \tau_{ext}(h) \cdot \sec\theta \right] \quad . \tag{17}$$

For vertical and slant-path transmission between two altitudes above sea level

$$T_{\Delta h} = \exp - \left[\tau_{ext}(h_2) - \tau_{ext}(h_1) \right] \cdot \sec\theta \quad . \tag{18}$$

For vertical and slant-path transmission from a given altitude out into space

$$T_{h-\infty} = \exp\left[- \tau'_{ext}(h) \sec\theta \right] \quad . \tag{19}$$

7. CONCLUDING REMARKS

The procedure for developing the aerosol attenuation profile is summarized as follows:

(1) Various studies were compared and of these a set of measurements selected.

(2) The choice of measurements (comprising 119 profiles from 2.76 to 34.4 km) was examined statistically. This resulted in the elimination of 40 profiles (December 1963 to March 1964 inclusive) characterized by a high volcanic dust component.

(3) The mean of the 79 remaining profiles was extended to sea level and to 50 km respectively by reasonably supported extrapolations.

(4) The overall profile then was developed laterally to obtain 21 additional profiles for the wavelengths of interest.

A significant aspect of the procedure is that the wavelength-height array of parameters was derived independently of the assumptions associated with conversion of a size distribution to an optical parameter.

For most purposes, calculations using the new parameters will be affected only moderately. For example at $\lambda_1 = 0.55\mu$, the 1964 Attenuation Model provides an extinction optical thickness, $\tau_{ext} = 0.331$, for a vertical air mass. The new parameters yield $\tau_{ext} = 0.379$, resulting in a transmission change of about 3-1/2 percent. However, for long path horizontal transmission calculations above 5 km and for long slant-path calculations entailing large zenith angles, the new aerosol parameters can function more significantly.

As mentioned previously, the Rayleigh and ozone parameters are unchanged.

8. TABULATION OF PARAMETERS

Tables 4.1 to 4.22, which follow, comprise the atmospheric attenuation model. Exponents are in computer notation; for example, read 2.86-3 = 2.86×10^{-3} and 2.86 3 as 2.86×10^{3}.

Table 4.1 Parameters at 0.27 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	2.282 -1	.000	1.928	2.90 -1	.000	.458	7.48 -1	.000	70.955	1.27 0	.000	73.346
1	2.071 -1	.217	1.710	1.29 -1	.209	.250	6.85 -1	.716	70.243	1.02 0	1.143	72.203
2	1.875 -1	.414	1.513	5.51 -2	.300	.158	6.15 -1	1.356	69.590	8.58 -1	2.081	71.265
3	1.694 -1	.593	1.335	2.31 -2	.339	.119	5.25 -1	1.936	69.023	7.18 -1	2.869	70.477
4	1.526 -1	.753	1.174	1.22 -2	.357	.102	4.75 -1	2.436	58.520	6.39 -1	3.547	69.799
5	1.372 -1	.895	1.030	9.21 -3	.358	.091	4.64 -1	2.905	58.051	6.11 -1	4.172	69.174
6	1.230 -1	1.028	.900	6.50 -3	.375	.083	4.54 -1	3.364	57.592	5.83 -1	4.769	68.577
7	1.099 -1	1.144	.783	6.04 -3	.382	.077	4.69 -1	3.825	57.131	5.84 -1	5.353	67.993
8	9.795 -2	1.248	.680	6.22 -3	.388	.071	4.79 -1	4.299	56.658	5.83 -1	5.936	67.410
9	8.701 -2	1.340	.587	5.97 -3	.394	.065	5.90 -1	4.833	56.123	6.83 -1	6.569	66.777
10	7.703 -2	1.422	.505	5.82 -3	.400	.059	7.35 -1	5.496	55.461	8.18 -1	7.320	66.026
11	6.796 -2	1.495	.433	5.45 -3	.405	.053	9.65 -1	6.346	64.610	1.04 0	8.248	65.097
12	5.811 -2	1.558	.370	5.73 -3	.411	.047	1.30 0	7.481	63.475	1.37 0	9.452	63.894
13	4.967 -2	1.611	.317	5.29 -3	.417	.042	1.77 0	9.021	61.935	1.83 0	11.051	62.295
14	4.245 -2	1.657	.271	5.18 -3	.422	.037	2.01 0	10.913	60.044	2.06 0	12.994	60.352
15	3.623 -2	1.696	.231	4.86 -3	.427	.032	2.09 0	12.961	57.995	2.13 0	15.087	58.259
16	3.101 -2	1.730	.198	4.53 -3	.432	.027	2.16 0	15.086	55.870	2.20 0	17.251	56.095
17	2.651 -2	1.759	.169	4.57 -3	.436	.022	2.33 0	17.333	53.623	2.36 0	19.531	53.815
18	2.265 -2	1.783	.145	4.42 -3	.441	.018	2.56 0	19.780	51.175	2.59 0	22.007	51.339
19	1.937 -2	1.804	.124	3.73 -3	.445	.014	2.98 0	22.552	48.404	3.01 0	24.804	48.542
20	1.656 -2	1.822	.106	2.73 -3	.448	.010	3.44 0	25.755	45.191	3.46 0	28.038	45.308
21	1.410 -2	1.837	.091	1.98 -3	.450	.008	3.86 0	29.419	41.537	3.88 0	31.710	41.636
22	1.202 -2	1.850	.078	1.40 -3	.452	.006	4.14 0	33.419	37.537	4.15 0	35.725	37.621
23	1.025 -2	1.861	.066	1.14 -3	.453	.005	4.15 0	37.557	33.389	4.17 0	39.885	33.461
24	8.744 -3	1.871	.057	9.05 -4	.454	.004	4.05 0	41.672	29.284	4.06 0	44.001	29.345
25	7.447 -3	1.879	.049	7.62 -4	.455	.003	3.78 0	45.589	25.367	3.79 0	47.926	25.420
26	6.382 -3	1.886	.042	6.64 -4	.456	.003	3.42 0	49.190	21.765	3.43 0	51.536	21.810
27	5.458 -3	1.892	.036	5.08 -4	.457	.002	2.96 0	52.382	18.574	2.97 0	54.734	18.612
28	4.672 -3	1.897	.031	3.30 -4	.457	.001	2.58 0	55.154	15.802	2.59 0	57.512	15.834
29	4.001 -3	1.901	.027	2.39 -4	.457	.001	2.25 0	57.569	13.387	2.25 0	59.931	13.415
30	3.430 -3	1.905	.023	2.29 -4	.458	.001	1.90 0	59.641	11.315	1.90 0	62.007	11.339
31	2.942 -3	1.908	.020	1.75 -4	.458	.001	1.67 0	61.422	9.534	1.67 0	63.791	9.555
32	2.525 -3	1.911	.017	1.34 -4	.458	.001	1.43 0	62.971	7.985	1.43 0	65.343	8.003
33	2.155 -3	1.913	.015	1.03 -4	.458	.000	1.22 0	64.298	6.659	1.22 0	66.672	6.674
34	1.842 -3	1.915	.013	7.37 -5	.458	.000	1.02 0	65.418	5.539	1.02 0	67.795	5.551
35	1.577 -3	1.917	.011	6.04 -5	.458	.000	9.05 -1	66.380	4.576	9.07 -1	68.758	4.588
36	1.352 -3	1.918	.010	4.63 -5	.458	.000	7.58 -1	67.212	3.745	7.59 -1	69.591	3.754
37	1.162 -3	1.919	.008	3.54 -5	.458	.000	6.34 -1	67.908	3.049	6.35 -1	70.289	3.057
38	9.998 -4	1.921	.007	2.72 -5	.458	.000	5.31 -1	68.490	2.466	5.32 -1	70.873	2.473
39	8.619 -4	1.921	.006	2.07 -5	.458	.000	4.56 -1	68.984	1.972	4.57 -1	71.367	1.979
40	7.444 -4	1.922	.005	1.59 -5	.458	.000	3.91 -1	69.407	1.549	3.91 -1	71.791	1.555
41	6.439 -4	1.923	.005	1.22 -5	.458	.000	3.19 -1	69.762	1.194	3.20 -1	72.147	1.199
42	5.579 -4	1.924	.004	9.32 -6	.458	.000	2.50 -1	70.047	.910	2.50 -1	72.432	.914
43	4.842 -4	1.924	.004	7.14 -6	.458	.000	1.95 -1	70.269	.687	1.96 -1	72.655	.691
44	4.208 -4	1.925	.003	5.47 -6	.458	.000	1.56 -1	70.445	.511	1.57 -1	72.831	.515
45	3.663 -4	1.925	.003	4.19 -6	.458	.000	1.21 -1	70.584	.373	1.21 -1	72.970	.376
46	3.193 -4	1.925	.003	3.21 -6	.458	.000	9.37 -2	70.691	.265	9.40 -2	73.078	.268
47	2.788 -4	1.926	.002	2.46 -6	.458	.000	7.41 -2	70.775	.182	7.44 -2	73.162	.184
48	2.453 -4	1.926	.002	1.89 -6	.458	.000	5.85 -2	70.841	.115	5.88 -2	73.229	.117
49	2.166 -4	1.926	.002	1.44 -6	.458	.000	4.68 -2	70.894	.062	4.70 -2	73.282	.064
50	1.913 -4	1.926	.002	1.10 -6	.458	.000	3.91 -2	70.937	.020	3.93 -2	73.325	.021

Table 4.2 Parameters at 0.28 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	1.948 -1	.000	1.545	2.70 -1	.000	.427	3.77 -1	.000	35.815	8.42 -1	.000	37.891
1	1.767 -1	.195	1.350	1.19 -1	.194	.232	3.45 -1	.361	35.455	6.41 -1	.742	37.149
2	1.600 -1	.354	1.291	5.13 -2	.279	.147	3.11 -1	.690	35.125	5.22 -1	1.323	36.568
3	1.444 -1	.506	1.139	2.15 -2	.316	.111	2.65 -1	.977	34.839	4.31 -1	1.800	36.091
4	1.303 -1	.643	1.002	1.14 -2	.332	.095	2.40 -1	1.230	34.586	3.81 -1	2.206	35.685
5	1.171 -1	.767	.879	8.58 -3	.342	.085	2.34 -1	1.457	34.350	3.60 -1	2.576	35.315
6	1.050 -1	.877	.768	6.05 -3	.350	.077	2.29 -1	1.698	34.119	3.40 -1	2.926	34.965
7	9.380 -2	.977	.559	5.52 -3	.355	.071	2.36 -1	1.931	33.885	3.36 -1	3.264	34.627
8	8.359 -2	1.065	.580	5.79 -3	.361	.066	2.42 -1	2.170	33.645	3.31 -1	3.598	34.293
9	7.426 -2	1.144	.501	5.55 -3	.367	.060	2.98 -1	2.440	33.376	3.78 -1	3.952	33.939
10	6.574 -2	1.214	.431	5.42 -3	.372	.055	3.71 -1	2.774	33.042	4.42 -1	4.362	33.529
11	5.800 -2	1.274	.370	5.08 -3	.377	.049	4.88 -1	3.203	32.613	5.51 -1	4.858	33.033
12	4.959 -2	1.329	.316	5.33 -3	.383	.044	6.58 -1	3.776	32.040	7.13 -1	5.490	32.401
13	4.238 -2	1.375	.270	4.92 -3	.388	.039	8.95 -1	4.553	31.263	9.43 -1	6.318	31.573
14	3.623 -2	1.414	.231	4.82 -3	.393	.034	1.01 0	5.508	30.308	1.06 0	7.317	30.574
15	3.095 -2	1.449	.197	4.53 -3	.397	.029	1.05 0	6.542	29.274	1.09 0	8.390	29.501
16	2.647 -2	1.476	.169	4.31 -3	.402	.025	1.09 0	7.615	28.201	1.12 0	9.496	28.395
17	2.262 -2	1.501	.144	4.26 -3	.406	.021	1.18 0	8.749	27.067	1.20 0	10.659	27.232
18	1.934 -2	1.522	.123	4.12 -3	.410	.017	1.29 0	9.984	25.832	1.32 0	11.919	25.972
19	1.653 -2	1.540	.105	3.47 -3	.414	.013	1.51 0	11.383	24.433	1.53 0	13.340	24.551
20	1.414 -2	1.555	.090	2.55 -3	.417	.010	1.74 0	13.005	22.811	1.76 0	14.980	22.911
21	1.204 -2	1.568	.077	1.35 -3	.419	.008	1.95 0	14.850	20.966	1.96 0	16.839	21.052
22	1.026 -2	1.579	.066	1.39 -3	.421	.006	2.09 0	15.859	18.947	2.10 0	18.872	19.019
23	8.745 -3	1.589	.057	1.05 -3	.422	.005	2.10 0	13.952	16.854	2.11 0	20.976	16.915
24	7.462 -3	1.597	.049	8.42 -4	.423	.004	2.05 0	21.035	14.781	2.05 0	23.057	14.834
25	6.373 -3	1.603	.042	7.09 -4	.424	.003	1.91 0	23.012	12.804	1.92 0	25.042	12.849
26	5.446 -3	1.609	.035	6.19 -4	.424	.002	1.73 0	24.829	10.987	1.73 0	26.866	11.025
27	4.658 -3	1.614	.031	4.73 -4	.425	.002	1.49 0	26.441	9.375	1.50 0	28.483	9.408
28	3.987 -3	1.619	.026	3.62 -4	.425	.001	1.30 0	27.840	7.976	1.31 0	29.887	8.004
29	3.415 -3	1.622	.023	2.79 -4	.426	.001	1.13 0	29.059	6.757	1.14 0	31.110	6.781
30	2.927 -3	1.626	.020	2.14 -4	.426	.001	9.57 -1	30.105	5.711	9.60 -1	32.159	5.732
31	2.511 -3	1.629	.017	1.63 -4	.426	.001	8.41 -1	31.003	4.813	8.43 -1	33.061	4.830
32	2.155 -3	1.631	.015	1.25 -4	.426	.000	7.23 -1	31.785	4.031	7.25 -1	33.845	4.046
33	1.840 -3	1.633	.013	9.57 -5	.426	.000	6.17 -1	32.455	3.361	6.19 -1	34.517	3.374
34	1.572 -3	1.634	.011	7.33 -5	.427	.000	5.14 -1	33.021	2.795	5.16 -1	35.084	2.807
35	1.346 -3	1.636	.009	5.62 -5	.427	.000	4.57 -1	33.506	2.310	4.58 -1	35.571	2.320
36	1.154 -3	1.637	.008	4.31 -5	.427	.000	3.83 -1	33.926	1.890	3.84 -1	35.994	1.899
37	9.913 -4	1.638	.007	3.30 -5	.427	.000	3.20 -1	34.277	1.539	3.21 -1	36.345	1.546
38	8.532 -4	1.639	.006	2.53 -5	.427	.000	2.68 -1	34.571	1.245	2.69 -1	36.640	1.251
39	7.356 -4	1.640	.005	1.93 -5	.427	.000	2.30 -1	34.820	.936	2.31 -1	36.890	1.001
40	6.353 -4	1.640	.005	1.48 -5	.427	.000	1.97 -1	35.034	.782	1.98 -1	37.104	.787
41	5.495 -4	1.641	.004	1.13 -5	.427	.000	1.61 -1	35.213	.603	1.62 -1	37.284	.607
42	4.751 -4	1.642	.004	8.68 -6	.427	.000	1.26 -1	35.357	.459	1.27 -1	37.428	.463
43	4.132 -4	1.642	.003	6.65 -6	.427	.000	9.86 -2	35.469	.347	9.90 -2	37.541	.350
44	3.591 -4	1.642	.003	5.09 -6	.427	.000	7.89 -2	35.558	.258	7.92 -2	37.630	.261
45	3.126 -4	1.643	.002	3.90 -6	.427	.000	6.11 -2	35.628	.188	6.14 -2	37.700	.191
46	2.725 -4	1.643	.002	2.99 -6	.427	.000	4.73 -2	35.682	.134	4.76 -2	37.755	.136
47	2.379 -4	1.643	.002	2.29 -6	.427	.000	3.74 -2	35.724	.092	3.77 -2	37.797	.094
48	2.093 -4	1.644	.002	1.76 -6	.427	.000	2.96 -2	35.758	.058	2.98 -2	37.831	.060
49	1.849 -4	1.644	.001	1.34 -6	.427	.000	2.36 -2	35.784	.032	2.38 -2	37.858	.033
50	1.633 -4	1.644	.001	1.03 -6	.427	.000	1.97 -2	35.806	.010	1.99 -2	37.880	.011

Table 4.3 Parameters at 0.30 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. ((0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	1.446 -1	.000	1.222	2.60 -1	.000	.411	3.60 -2	.000	3.413	4.41 -1	.000	5.047
1	1.312 -1	.138	1.084	1.14 -1	.187	.224	3.29 -2	.034	3.373	2.79 -1	.360	4.686
2	1.188 -1	.263	.959	4.34 -2	.269	.142	2.96 -2	.066	3.347	1.98 -1	.598	4.450
3	1.073 -1	.376	.846	2.07 -2	.304	.107	2.52 -2	.093	3.320	1.53 -1	.773	4.274
4	9.672 -2	.477	.744	1.10 -2	.320	.091	2.28 -2	.117	3.295	1.31 -1	.915	4.132
5	8.693 -2	.569	.652	8.26 -3	.330	.081	2.23 -2	.140	3.273	1.18 -1	1.039	4.008
6	7.792 -2	.651	.570	5.83 -3	.337	.074	2.18 -2	.162	3.251	1.06 -1	1.151	3.897
7	6.965 -2	.725	.496	5.41 -3	.342	.069	2.25 -2	.184	3.229	9.76 -2	1.252	3.795
8	6.207 -2	.791	.431	5.58 -3	.348	.063	2.30 -2	.207	3.205	9.07 -2	1.346	3.701
9	5.513 -2	.849	.372	5.35 -3	.353	.058	2.84 -2	.232	3.180	8.89 -2	1.436	3.611
10	4.881 -2	.901	.320	5.22 -3	.358	.053	3.53 -2	.264	3.148	8.94 -2	1.525	3.522
11	4.306 -2	.947	.274	4.89 -3	.364	.047	4.65 -2	.305	3.107	9.44 -2	1.617	3.430
12	3.682 -2	.987	.235	5.13 -3	.369	.042	6.27 -2	.360	3.053	1.05 -1	1.717	3.331
13	3.147 -2	1.021	.201	4.74 -3	.373	.038	8.53 -2	.434	2.979	1.22 -1	1.830	3.218
14	2.690 -2	1.050	.171	4.64 -3	.378	.033	9.67 -2	.525	2.888	1.28 -1	1.955	3.093
15	2.299 -2	1.075	.147	4.36 -3	.383	.028	1.00 -1	.623	2.789	1.28 -1	2.083	2.965
16	1.965 -2	1.096	.125	4.15 -3	.387	.024	1.04 -1	.726	2.697	1.28 -1	2.210	2.837
17	1.680 -2	1.114	.107	4.10 -3	.391	.020	1.12 -1	.834	2.579	1.33 -1	2.341	2.707
18	1.436 -2	1.130	.092	3.97 -3	.395	.016	1.23 -1	.951	2.461	1.42 -1	2.478	2.569
19	1.228 -2	1.143	.078	3.34 -3	.399	.012	1.43 -1	1.085	2.328	1.59 -1	2.628	2.419
20	1.050 -2	1.154	.067	2.45 -3	.402	.009	1.66 -1	1.239	2.173	1.79 -1	2.797	2.250
21	8.937 -3	1.164	.057	1.78 -3	.404	.007	1.86 -1	1.415	1.998	1.97 -1	2.985	2.063
22	7.615 -3	1.172	.049	1.34 -3	.405	.006	1.99 -1	1.607	1.805	2.08 -1	3.187	1.860
23	6.433 -3	1.179	.042	1.02 -3	.406	.005	2.00 -1	1.807	1.606	2.07 -1	3.395	1.653
24	5.541 -3	1.185	.036	8.11 -4	.407	.004	1.95 -1	2.004	1.408	2.01 -1	3.599	1.448
25	4.732 -3	1.191	.031	6.83 -4	.408	.003	1.82 -1	2.193	1.220	1.87 -1	3.793	1.254
26	4.044 -3	1.195	.027	5.96 -4	.409	.002	1.65 -1	2.366	1.047	1.69 -1	3.972	1.076
27	3.458 -3	1.199	.023	4.56 -4	.409	.002	1.42 -1	2.519	.893	1.46 -1	4.129	.918
28	2.960 -3	1.202	.020	3.49 -4	.410	.001	1.24 -1	2.653	.760	1.28 -1	4.266	.781
29	2.535 -3	1.205	.017	2.68 -4	.410	.001	1.08 -1	2.769	.644	1.11 -1	4.386	.662
30	2.173 -3	1.207	.015	2.06 -4	.410	.001	9.12 -2	2.858	.544	9.36 -2	4.488	.560
31	1.864 -3	1.209	.013	1.57 -4	.410	.001	8.01 -2	2.954	.459	8.21 -2	4.576	.472
32	1.600 -3	1.211	.011	1.20 -4	.411	.000	6.89 -2	3.029	.384	7.06 -2	4.652	.395
33	1.366 -3	1.212	.009	9.22 -5	.411	.000	5.88 -2	3.092	.320	6.02 -2	4.717	.330
34	1.167 -3	1.213	.008	7.06 -5	.411	.000	4.90 -2	3.146	.266	5.02 -2	4.773	.275
35	9.990 -4	1.214	.007	5.41 -5	.411	.000	4.35 -2	3.193	.220	4.46 -2	4.820	.227
36	8.567 -4	1.215	.006	4.15 -5	.411	.000	3.65 -2	3.233	.180	3.74 -2	4.861	.186
37	7.300 -4	1.216	.005	3.18 -5	.411	.000	3.05 -2	3.266	.147	3.13 -2	4.895	.152
38	6.335 -4	1.217	.005	2.44 -5	.411	.000	2.56 -2	3.294	.119	2.62 -2	4.924	.123
39	5.461 -4	1.217	.004	1.86 -5	.411	.000	2.19 -2	3.318	.095	2.25 -2	4.948	.099
40	4.717 -4	1.218	.004	1.43 -5	.411	.000	1.88 -2	3.338	.075	1.93 -2	4.969	.078
41	4.080 -4	1.218	.003	1.09 -5	.411	.000	1.54 -2	3.355	.057	1.58 -2	4.987	.061
42	3.535 -4	1.219	.003	8.36 -6	.411	.000	1.20 -2	3.369	.044	1.24 -2	5.001	.046
43	3.068 -4	1.219	.002	6.40 -6	.411	.000	9.39 -3	3.380	.033	9.71 -3	5.012	.035
44	2.666 -4	1.219	.002	4.90 -6	.411	.000	7.51 -3	3.388	.025	7.79 -3	5.021	.027
45	2.321 -4	1.220	.002	3.75 -6	.411	.000	5.82 -3	3.395	.018	6.05 -3	5.028	.020
46	2.023 -4	1.220	.002	2.88 -6	.411	.000	4.50 -3	3.400	.013	4.71 -3	5.033	.014
47	1.767 -4	1.220	.001	2.21 -6	.411	.000	3.57 -3	3.404	.009	3.74 -3	5.037	.010
48	1.554 -4	1.220	.001	1.69 -6	.411	.000	2.82 -3	3.407	.006	2.98 -3	5.041	.007
49	1.373 -4	1.220	.001	1.29 -6	.411	.000	2.25 -3	3.410	.003	2.39 -3	5.043	.004
50	1.212 -4	1.221	.001	9.91 -7	.411	.000	1.88 -3	3.412	.001	2.00 -3	5.045	.002

Table 4.4 Parameters at 0.32 microns

Alt. (km)	Rayleigh atten. coeff. (km^{-1})	Rayleigh optical thick. (0-h)	Rayleigh optical thick. (h-∞)	Aerosol atten. coeff. (km^{-1})	Aerosol optical thick. (0-h)	Aerosol optical thick. (h-∞)	Ozone absorp. coeff. (km^{-1})	Ozone optical thick. (0-h)	Ozone optical thick. (h-∞)	Ext. coeff. (km^{-1})	Ext. optical thick. (0-h)	Ext. optical thick. (h-∞)
h	β_r	τ_r	τ_r'	β_p	τ_p	τ_p'	β_3	τ_3	τ_3'	β_{ext}	τ_{ext}	τ_{ext}'
0	1.099 -1	.000	.927	2.50 -1	.000	.395	3.20 -3	.000	.303	3.63 -1	.000	1.628
1	9.962 -2	.105	.823	1.10 -1	.180	.215	2.93 -3	.003	.300	2.13 -1	.288	1.340
2	9.020 -2	.199	.728	4.75 -2	.259	.136	2.63 -3	.006	.298	1.40 -1	.464	1.163
3	8.148 -2	.285	.642	1.39 -2	.292	.103	2.24 -3	.008	.295	1.04 -1	.586	1.041
4	7.342 -2	.362	.565	1.05 -2	.308	.088	2.03 -3	.010	.293	8.60 -2	.681	.947
5	6.599 -2	.432	.495	7.94 -3	.317	.078	1.98 -3	.012	.291	7.59 -2	.762	.866
6	5.915 -2	.495	.433	5.60 -3	.324	.072	1.94 -3	.014	.289	6.67 -2	.833	.794
7	5.287 -2	.550	.377	5.21 3	.329	.066	2.00 -3	.016	.287	6.01 -2	.897	.731
8	4.712 -2	.600	.327	5.36 -3	.334	.061	2.05 -3	.018	.285	5.45 -2	.954	.674
9	4.185 -2	.645	.283	5.14 -3	.340	.056	2.52 -3	.021	.283	4.95 -2	1.006	.622
10	3.705 -2	.684	.243	5.02 -3	.345	.051	3.14 -3	.024	.280	4.52 -2	1.053	.574
11	3.269 -2	.719	.208	4.70 -3	.350	.046	4.13 -3	.027	.276	4.15 -2	1.097	.531
12	2.795 -2	.749	.178	4.94 -3	.354	.041	5.58 -3	.032	.271	3.85 -2	1.137	.491
13	2.383 -2	.775	.152	4.50 -3	.359	.036	7.59 -3	.039	.265	3.60 -2	1.174	.454
14	2.042 -2	.797	.130	4.46 -3	.364	.032	8.59 -3	.047	.257	3.35 -2	1.209	.419
15	1.745 -2	.816	.111	4.19 -3	.358	.027	8.93 -3	.055	.248	3.06 -2	1.241	.387
16	1.492 -2	.832	.095	3.99 -3	.372	.023	9.25 -3	.065	.239	2.82 -2	1.270	.358
17	1.275 -2	.846	.081	3.94 -3	.376	.019	9.97 -3	.074	.229	2.67 -2	1.297	.330
18	1.090 -2	.858	.070	3.81 -3	.380	.015	1.10 -2	.085	.219	2.57 -2	1.324	.304
19	9.319 -3	.868	.060	3.21 -3	.383	.012	1.28 -2	.096	.207	2.53 -2	1.349	.279
20	7.967 -3	.876	.051	2.36 -3	.386	.009	1.47 -2	.110	.193	2.51 -2	1.374	.253
21	6.785 -3	.884	.044	1.71 -3	.388	.007	1.65 -2	.126	.178	2.50 -2	1.399	.228
22	5.781 -3	.890	.037	1.29 -3	.390	.006	1.77 -2	.143	.161	2.48 -2	1.424	.203
23	4.929 -3	.895	.032	9.84 -4	.391	.004	1.78 -2	.161	.143	2.37 -2	1.448	.179
24	4.206 -3	.900	.027	7.80 -4	.392	.003	1.73 -2	.178	.125	2.23 -2	1.471	.156
25	3.592 -3	.904	.024	6.57 -4	.392	.003	1.62 -2	.195	.108	2.04 -2	1.493	.135
26	3.070 -3	.907	.020	5.73 -4	.393	.002	1.46 -2	.210	.093	1.83 -2	1.512	.115
27	2.625 -3	.910	.017	4.38 -4	.394	.002	1.27 -2	.224	.079	1.57 -2	1.529	.098
28	2.247 -3	.912	.015	3.35 -4	.394	.001	1.10 -2	.236	.068	1.36 -2	1.544	.084
29	1.925 -3	.914	.013	2.58 -4	.394	.001	9.61 -3	.246	.057	1.18 -2	1.557	.071
30	1.650 -3	.916	.011	1.98 -4	.394	.001	8.11 -3	.255	.048	9.96 -3	1.567	.060
31	1.415 -3	.918	.010	1.51 -4	.395	.001	7.12 -3	.263	.041	8.69 -3	1.577	.051
32	1.215 -3	.919	.008	1.16 -4	.395	.000	6.12 -3	.269	.034	7.45 -3	1.585	.043
33	1.037 -3	.920	.007	8.86 -5	.395	.000	5.23 -3	.275	.028	6.35 -3	1.592	.036
34	8.860 -4	.921	.006	6.79 -5	.395	.000	4.36 -3	.280	.024	5.31 -3	1.598	.030
35	7.594 -4	.922	.005	5.21 -5	.395	.000	3.87 -3	.284	.020	4.68 -3	1.602	.025
36	6.504 -4	.923	.005	3.99 -5	.395	.000	3.24 -3	.287	.016	3.93 -3	1.607	.021
37	5.537 -4	.923	.004	3.05 -5	.395	.000	2.71 -3	.290	.013	3.30 -3	1.610	.017
38	4.809 -4	.924	.003	2.34 -5	.395	.000	2.27 -3	.293	.011	2.78 -3	1.613	.014
39	4.146 -4	.924	.003	1.79 -5	.395	.000	1.95 -3	.295	.008	2.38 -3	1.616	.012
40	3.580 -4	.925	.003	1.37 -5	.395	.000	1.67 -3	.297	.007	2.04 -3	1.618	.009
41	3.097 -4	.925	.002	1.05 -5	.395	.000	1.36 -3	.298	.005	1.69 -3	1.620	.007
42	2.684 -4	.925	.002	8.04 -6	.395	.000	1.07 -3	.300	.004	1.35 -3	1.622	.006
43	2.329 -4	.925	.002	6.16 -6	.395	.000	8.35 -4	.300	.003	1.07 -3	1.623	.005
44	2.024 -4	.926	.002	4.72 -6	.395	.000	6.68 -4	.301	.002	8.75 -4	1.624	.004
45	1.762 -4	.926	.001	3.61 -6	.395	.000	5.17 -4	.302	.002	6.97 -4	1.625	.003
46	1.536 -4	.926	.001	2.77 -6	.395	.000	4.01 -4	.302	.001	5.57 -4	1.625	.002
47	1.341 -4	.926	.001	2.12 -6	.395	.000	3.17 -4	.303	.001	4.53 -4	1.626	.002
48	1.180 -4	.926	.001	1.63 -6	.395	.000	2.51 -4	.303	.000	3.70 -4	1.626	.001
49	1.042 -4	.926	.001	1.24 -6	.395	.000	2.00 -4	.303	.000	3.06 -4	1.626	.001
50	9.202 -5	.927	.001	9.53 -7	.395	.000	1.67 -4	.303	.000	2.60 -4	1.627	.001

Table 4.5 Parameters at 0.34 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	8.492 -2	.000	.717	2.40 -1	.000	.379	2.28 -4	.000	.022	3.25 -1	.000	1.120
1	7.707 -2	.081	.636	1.66 -1	.173	.207	2.09 -4	.000	.021	1.83 -1	.254	.866
2	6.978 -2	.154	.563	4.56 -2	.248	.131	1.88 -4	.000	.021	1.16 -1	.403	.717
3	6.303 -2	.221	.497	1.91 -2	.281	.099	1.60 -4	.001	.021	8.23 -2	.502	.618
4	5.680 -2	.280	.437	1.01 -2	.295	.084	1.45 -4	.001	.021	6.71 -2	.577	.543
5	5.105 -2	.334	.383	7.63 -3	.304	.075	1.41 -4	.001	.021	5.88 -2	.640	.480
6	4.576 -2	.383	.335	5.38 -3	.311	.069	1.38 -4	.001	.021	5.13 -2	.695	.425
7	4.090 -2	.426	.292	5.00 -3	.316	.063	1.43 -4	.001	.020	4.60 -2	.743	.376
8	3.645 -2	.464	.253	5.15 -3	.321	.058	1.46 -4	.001	.020	4.17 -2	.787	.332
9	3.238 -2	.499	.219	4.94 -3	.326	.053	1.80 -4	.001	.020	3.75 -2	.827	.293
10	2.867 -2	.529	.188	4.82 -3	.331	.049	2.24 -4	.002	.020	3.37 -2	.863	.257
11	2.529 -2	.556	.161	4.51 -3	.336	.044	2.94 -4	.002	.020	3.01 -2	.894	.225
12	2.162 -2	.580	.138	4.74 -3	.340	.039	3.97 -4	.002	.019	2.68 -2	.923	.197
13	1.848 -2	.600	.118	4.37 -3	.345	.035	5.41 -4	.003	.019	2.34 -2	.948	.172
14	1.580 -2	.617	.101	4.28 -3	.349	.030	6.12 -4	.003	.018	2.07 -2	.970	.150
15	1.350 -2	.631	.086	4.03 -3	.353	.026	6.36 -4	.004	.018	1.82 -2	.989	.130
16	1.154 -2	.644	.074	3.83 -3	.357	.022	6.59 -4	.005	.017	1.60 -2	1.007	.113
17	9.865 -3	.654	.063	3.78 -3	.361	.018	7.10 -4	.005	.016	1.44 -2	1.022	.098
18	8.433 -3	.664	.054	3.66 -3	.365	.015	7.81 -4	.006	.016	1.29 -2	1.035	.084
19	7.209 -3	.671	.046	3.08 -3	.368	.011	9.09 -4	.007	.015	1.12 -2	1.047	.072
20	6.164 -3	.678	.039	2.26 -3	.371	.009	1.05 -3	.008	.014	9.48 -3	1.058	.062
21	5.249 -3	.684	.034	1.64 -3	.373	.007	1.18 -3	.009	.013	8.07 -3	1.067	.053
22	4.472 -3	.689	.029	1.23 -3	.374	.005	1.26 -3	.010	.011	6.97 -3	1.074	.046
23	3.813 -3	.693	.025	9.45 -4	.375	.004	1.27 -3	.011	.010	6.03 -3	1.081	.039
24	3.254 -3	.696	.021	7.49 -4	.376	.003	1.24 -3	.013	.009	5.24 -3	1.086	.034
25	2.779 -3	.699	.018	6.30 -4	.377	.003	1.15 -3	.014	.008	4.56 -3	1.091	.029
26	2.375 -3	.702	.016	5.50 -4	.377	.002	1.04 -3	.015	.007	3.97 -3	1.095	.024
27	2.031 -3	.704	.013	4.21 -4	.378	.002	9.02 -4	.016	.006	3.35 -3	1.099	.021
28	1.738 -3	.706	.012	3.22 -4	.378	.001	7.87 -4	.017	.005	2.85 -3	1.102	.018
29	1.489 -3	.707	.010	2.48 -4	.378	.001	6.85 -4	.018	.004	2.42 -3	1.105	.015
30	1.276 -3	.709	.009	1.90 -4	.379	.001	5.78 -4	.018	.003	2.04 -3	1.107	.013
31	1.095 -3	.710	.007	1.45 -4	.379	.001	5.08 -4	.019	.003	1.75 -3	1.109	.011
32	9.397 -4	.711	.006	1.11 -4	.379	.000	4.36 -4	.019	.002	1.49 -3	1.110	.009
33	8.023 -4	.712	.005	8.51 -5	.379	.000	3.72 -4	.020	.002	1.26 -3	1.112	.008
34	6.854 -4	.713	.005	6.52 -5	.379	.000	3.10 -4	.020	.002	1.06 -3	1.113	.007
35	5.867 -4	.713	.004	5.00 -5	.379	.000	2.76 -4	.020	.001	9.13 -4	1.114	.006
36	5.031 -4	.714	.004	3.83 -5	.379	.000	2.31 -4	.020	.001	7.72 -4	1.115	.005
37	4.323 -4	.714	.003	2.93 -5	.379	.000	1.93 -4	.021	.001	6.55 -4	1.116	.004
38	3.720 -4	.715	.003	2.25 -5	.379	.000	1.62 -4	.021	.001	5.56 -4	1.116	.004
39	3.207 -4	.715	.002	1.72 -5	.379	.000	1.39 -4	.021	.001	4.77 -4	1.117	.003
40	2.770 -4	.715	.002	1.32 -5	.379	.000	1.19 -4	.021	.000	4.09 -4	1.117	.003
41	2.396 -4	.716	.002	1.01 -5	.379	.000	9.73 -5	.021	.000	3.47 -4	1.117	.002
42	2.076 -4	.716	.002	7.72 -6	.379	.000	7.62 -5	.021	.000	2.91 -4	1.118	.002
43	1.802 -4	.716	.001	5.91 -6	.379	.000	5.95 -5	.021	.000	2.46 -4	1.118	.002
44	1.566 -4	.716	.001	4.53 -6	.379	.000	4.76 -5	.021	.000	2.09 -4	1.118	.001
45	1.363 -4	.716	.001	3.46 -6	.379	.000	3.69 -5	.022	.000	1.77 -4	1.118	.001
46	1.188 -4	.716	.001	2.66 -6	.379	.000	2.85 -5	.022	.000	1.50 -4	1.119	.001
47	1.037 -4	.717	.001	2.04 -6	.379	.000	2.26 -5	.022	.000	1.28 -4	1.119	.001
48	9.128 -5	.717	.001	1.56 -6	.379	.000	1.79 -5	.022	.000	1.11 -4	1.119	.001
49	8.051 -5	.717	.001	1.19 -6	.379	.000	1.43 -5	.022	.000	9.61 -5	1.119	.001
50	7.119 -5	.717	.001	9.14 -7	.379	.000	1.19 -5	.022	.000	8.40 -5	1.119	.001

Table 4.6 Parameters at 0.36 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	6.678 -2	.000	.564	2.40 -1	.000	.379	6.41 -6	.000	.001	3.07 -1	.000	.945
1	6.060 -2	.064	.501	1.06 -1	.173	.207	5.87 -6	.000	.001	1.66 -1	.236	.709
2	5.487 -2	.121	.443	4.56 -2	.248	.131	5.27 -6	.000	.001	1.00 -1	.370	.575
3	4.957 -2	.173	.391	1.91 -2	.281	.099	4.50 -6	.000	.001	6.87 -2	.454	.491
4	4.467 -2	.220	.344	1.01 -2	.295	.084	4.07 -6	.000	.001	5.48 -2	.516	.429
5	4.015 -2	.263	.301	7.63 -3	.304	.075	3.98 -6	.000	.001	4.78 -2	.567	.378
6	3.599 -2	.301	.263	5.38 -3	.311	.069	3.83 -6	.000	.001	4.14 -2	.612	.333
7	3.216 -2	.335	.229	5.00 -3	.316	.063	4.01 -6	.000	.001	3.72 -2	.651	.294
8	2.866 -2	.365	.199	5.15 -3	.321	.058	4.10 -6	.000	.001	3.38 -2	.687	.258
9	2.546 -2	.392	.172	4.94 -3	.326	.053	5.06 -6	.000	.001	3.04 -2	.719	.226
10	2.254 -2	.416	.148	4.82 -3	.331	.049	6.30 -6	.000	.001	2.74 -2	.748	.197
11	1.989 -2	.437	.127	4.51 -3	.336	.044	8.28 -6	.000	.001	2.44 -2	.774	.172
12	1.701 -2	.456	.108	4.74 -3	.340	.039	1.12 -5	.000	.001	2.18 -2	.797	.148
13	1.453 -2	.471	.093	4.37 -3	.345	.035	1.52 -5	.000	.001	1.89 -2	.817	.128
14	1.242 -2	.485	.079	4.28 -3	.349	.030	1.72 -5	.000	.001	1.67 -2	.835	.110
15	1.062 -2	.496	.068	4.03 -3	.353	.026	1.79 -5	.000	.000	1.47 -2	.851	.095
16	9.075 -3	.506	.058	3.83 -3	.357	.022	1.85 -5	.000	.000	1.29 -2	.864	.081
17	7.758 -3	.515	.050	3.78 -3	.361	.018	2.00 -5	.000	.000	1.16 -2	.877	.069
18	6.632 -3	.522	.042	3.66 -3	.365	.015	2.20 -5	.000	.000	1.03 -2	.888	.058
19	5.669 -3	.528	.036	3.08 -3	.368	.011	2.56 -5	.000	.000	8.78 -3	.897	.046
20	4.847 -3	.533	.031	2.26 -3	.371	.009	2.95 -5	.000	.000	7.14 -3	.905	.040
21	4.127 -3	.538	.026	1.64 -3	.373	.007	3.31 -5	.000	.000	5.80 -3	.911	.034
22	3.517 -3	.541	.023	1.23 -3	.374	.005	3.55 -5	.000	.000	4.79 -3	.917	.028
23	2.999 -3	.545	.019	9.45 -4	.375	.004	3.56 -5	.000	.000	3.98 -3	.921	.024
24	2.559 -3	.547	.017	7.49 -4	.376	.003	3.47 -5	.000	.000	3.34 -3	.925	.020
25	2.185 -3	.550	.014	6.30 -4	.377	.003	3.24 -5	.000	.000	2.85 -3	.928	.017
26	1.867 -3	.552	.012	5.50 -4	.377	.002	2.93 -5	.000	.000	2.45 -3	.931	.015
27	1.597 -3	.554	.011	4.21 -4	.378	.002	2.54 -5	.000	.000	2.04 -3	.933	.012
28	1.367 -3	.555	.009	3.22 -4	.378	.001	2.21 -5	.000	.000	1.71 -3	.935	.010
29	1.171 -3	.556	.008	2.48 -4	.378	.001	1.93 -5	.000	.000	1.44 -3	.936	.009
30	1.004 -3	.557	.007	1.90 -4	.379	.001	1.63 -5	.001	.000	1.21 -3	.938	.008
31	8.609 -4	.558	.006	1.45 -4	.379	.001	1.43 -5	.001	.000	1.02 -3	.939	.006
32	7.389 -4	.559	.005	1.11 -4	.379	.000	1.23 -5	.001	.000	8.62 -4	.940	.005
33	6.309 -4	.560	.004	8.51 -5	.379	.000	1.05 -5	.001	.000	7.26 -4	.940	.005
34	5.390 -4	.560	.004	6.52 -5	.379	.000	8.73 -6	.001	.000	6.13 -4	.941	.004
35	4.614 -4	.561	.003	5.00 -5	.379	.000	7.76 -6	.001	.000	5.19 -4	.942	.003
36	3.957 -4	.561	.003	3.83 -5	.379	.000	6.50 -6	.001	.000	4.40 -4	.942	.003
37	3.399 -4	.562	.002	2.93 -5	.379	.000	5.44 -6	.001	.000	3.75 -4	.943	.003
38	2.926 -4	.562	.002	2.25 -5	.379	.000	4.55 -6	.001	.000	3.20 -4	.943	.002
39	2.522 -4	.562	.002	1.72 -5	.379	.000	3.91 -6	.001	.000	2.73 -4	.943	.002
40	2.178 -4	.563	.002	1.32 -5	.379	.000	3.35 -6	.001	.000	2.34 -4	.943	.002
41	1.884 -4	.563	.001	1.01 -5	.379	.000	2.74 -6	.001	.000	2.01 -4	.944	.001
42	1.633 -4	.563	.001	7.72 -6	.379	.000	2.14 -6	.001	.000	1.73 -4	.944	.001
43	1.417 -4	.563	.001	5.91 -6	.379	.000	1.67 -6	.001	.000	1.49 -4	.944	.001
44	1.231 -4	.563	.001	4.53 -6	.379	.000	1.34 -6	.001	.000	1.29 -4	.944	.001
45	1.072 -4	.563	.001	3.46 -6	.379	.000	1.06 -6	.001	.000	1.12 -4	.944	.001
46	9.345 -5	.563	.001	2.56 -6	.379	.000	8.03 -7	.001	.000	9.69 -5	.944	.001
47	8.158 -5	.563	.001	2.04 -6	.379	.000	6.35 -7	.001	.000	8.43 -5	.944	.001
48	7.178 -5	.564	.001	1.56 -6	.379	.000	5.02 -7	.001	.000	7.38 -5	.945	.001
49	6.339 -5	.564	.001	1.19 -6	.379	.000	4.01 -7	.001	.000	6.50 -5	.945	.001
50	5.598 -5	.564	.000	9.14 -7	.379	.000	3.35 -7	.001	.000	5.72 -5	.945	.000

Table 4.7 Parameters at 0.38 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	5.327 -2	.000	.450	2.30 -1	.000	.364	0.	.000	.000	2.83 -1	.000	.814
1	4.834 -2	.051	.399	1.01 -1	.166	.198	0.	.000	.000	1.50 -1	.216	.598
2	4.377 -2	.097	.353	4.37 -2	.238	.126	0.	.000	.000	8.74 -2	.335	.480
3	3.954 -2	.138	.312	1.83 -2	.269	.095	0.	.000	.000	5.79 -2	.408	.407
4	3.563 -2	.176	.274	9.69 -3	.283	.081	0.	.000	.000	4.53 -2	.459	.355
5	3.202 -2	.210	.240	7.31 -3	.292	.072	0.	.000	.000	3.93 -2	.501	.313
6	2.871 -2	.240	.210	5.15 -3	.298	.066	0.	.000	.000	3.39 -2	.538	.276
7	2.566 -2	.267	.183	4.79 -3	.303	.061	0.	.000	.000	3.04 -2	.570	.244
8	2.286 -2	.291	.159	4.93 -3	.308	.056	0.	.000	.000	2.78 -2	.599	.215
9	2.031 -2	.313	.137	4.73 -3	.312	.051	0.	.000	.000	2.50 -2	.626	.189
10	1.798 -2	.332	.118	4.61 -3	.317	.046	0.	.000	.000	2.26 -2	.650	.165
11	1.586 -2	.349	.101	4.32 -3	.322	.042	0.	.000	.000	2.02 -2	.671	.143
12	1.356 -2	.364	.086	4.54 -3	.326	.038	0.	.000	.000	1.81 -2	.690	.124
13	1.159 -2	.376	.074	4.19 -3	.330	.033	0.	.000	.000	1.58 -2	.707	.107
14	9.908 -3	.387	.063	4.11 -3	.335	.029	0.	.000	.000	1.40 -2	.722	.092
15	8.469 -3	.396	.054	3.86 -3	.339	.025	0.	.000	.000	1.23 -2	.735	.079
16	7.239 -3	.404	.046	3.67 -3	.342	.021	0.	.000	.000	1.09 -2	.747	.068
17	6.188 -3	.410	.039	3.62 -3	.346	.018	0.	.000	.000	9.81 -3	.757	.057
18	5.290 -3	.416	.034	3.51 -3	.349	.014	0.	.000	.000	8.80 -3	.766	.048
19	4.522 -3	.421	.029	2.96 -3	.353	.011	0.	.000	.000	7.48 -3	.775	.040
20	3.866 -3	.425	.025	2.17 -3	.355	.008	0.	.000	.000	6.04 -3	.781	.033
21	3.292 -3	.429	.021	1.57 -3	.357	.006	0.	.000	.000	4.86 -3	.787	.028
22	2.805 -3	.432	.018	1.18 -3	.359	.005	0.	.000	.000	3.99 -3	.791	.023
23	2.392 -3	.434	.016	9.05 -4	.360	.004	0.	.000	.000	3.30 -3	.795	.020
24	2.041 -3	.437	.013	7.18 -4	.360	.003	0.	.000	.000	2.76 -3	.798	.017
25	1.743 -3	.439	.011	6.04 -4	.361	.003	0.	.000	.000	2.35 -3	.800	.014
26	1.490 -3	.440	.010	5.27 -4	.362	.002	0.	.000	.000	2.02 -3	.803	.012
27	1.274 -3	.442	.008	4.03 -4	.362	.002	0.	.000	.000	1.68 -3	.804	.010
28	1.090 -3	.443	.007	3.09 -4	.362	.001	0.	.000	.000	1.40 -3	.806	.008
29	9.340 -4	.444	.006	2.37 -4	.363	.001	0.	.000	.000	1.17 -3	.807	.007
30	8.006 -4	.445	.005	1.82 -4	.363	.001	0.	.000	.000	9.83 -4	.808	.006
31	6.867 -4	.445	.005	1.39 -4	.363	.001	0.	.000	.000	8.26 -4	.809	.005
32	5.894 -4	.446	.004	1.06 -4	.363	.000	0.	.000	.000	6.96 -4	.810	.004
33	5.033 -4	.447	.003	8.15 -5	.363	.000	0.	.000	.000	5.85 -4	.811	.004
34	4.300 -4	.447	.003	6.24 -5	.363	.000	0.	.000	.000	4.92 -4	.811	.003
35	3.680 -4	.447	.003	4.79 -5	.363	.000	0.	.000	.000	4.16 -4	.812	.003
36	3.156 -4	.448	.002	3.67 -5	.363	.000	0.	.000	.000	3.52 -4	.812	.002
37	2.711 -4	.448	.002	2.81 -5	.363	.000	0.	.000	.000	2.99 -4	.812	.002
38	2.334 -4	.448	.002	2.15 -5	.364	.000	0.	.000	.000	2.55 -4	.813	.002
39	2.012 -4	.449	.001	1.64 -5	.364	.000	0.	.000	.000	2.18 -4	.813	.002
40	1.738 -4	.449	.001	1.26 -5	.364	.000	0.	.000	.000	1.86 -4	.813	.001
41	1.503 -4	.449	.001	9.67 -6	.364	.000	0.	.000	.000	1.60 -4	.813	.001
42	1.302 -4	.449	.001	7.39 -6	.364	.000	0.	.000	.000	1.38 -4	.813	.001
43	1.130 -4	.449	.001	5.66 -6	.364	.000	0.	.000	.000	1.19 -4	.814	.001
44	9.823 -5	.449	.001	4.34 -6	.364	.000	0.	.000	.000	1.03 -4	.814	.001
45	8.550 -5	.449	.001	3.32 -6	.364	.000	0.	.000	.000	8.88 -5	.814	.001
46	7.454 -5	.449	.001	2.55 -6	.364	.000	0.	.000	.000	7.71 -5	.814	.001
47	6.508 -5	.449	.001	1.95 -6	.364	.000	0.	.000	.000	6.70 -5	.814	.001
48	5.726 -5	.450	.000	1.50 -6	.364	.000	0.	.000	.000	5.88 -5	.814	.000
49	5.056 -5	.450	.000	1.14 -6	.364	.000	0.	.000	.000	5.17 -5	.814	.000
50	4.465 -5	.450	.000	8.76 -7	.364	.000	0.	.000	.000	4.55 -5	.814	.000

Table 4.8 Parameters at 0.40 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick (h-∞) τ_{ext}'
0	4.303 -2	.000	.354	2.00 -1	.000	.316	0.	.000	.000	2.43 -1	.000	.680
1	3.905 -2	.041	.323	8.80 -2	.144	.172	0.	.000	.000	1.27 -1	.185	.495
2	3.536 -2	.073	.285	3.80 -2	.207	.109	0.	.000	.000	7.33 -2	.285	.395
3	3.194 -2	.112	.252	1.59 -2	.234	.082	0.	.000	.000	4.79 -2	.346	.335
4	2.878 -2	.142	.221	8.43 -3	.246	.070	0.	.000	.000	3.72 -2	.388	.292
5	2.587 -2	.169	.194	6.35 -3	.254	.063	0.	.000	.000	3.22 -2	.423	.257
6	2.319 -2	.194	.170	4.48 -3	.259	.057	0.	.000	.000	2.77 -2	.453	.227
7	2.073 -2	.216	.148	4.15 -3	.263	.053	0.	.000	.000	2.49 -2	.479	.201
8	1.847 -2	.235	.128	4.29 -3	.267	.049	0.	.000	.000	2.28 -2	.503	.177
9	1.641 -2	.253	.111	4.11 -3	.272	.044	0.	.000	.000	2.05 -2	.525	.156
10	1.453 -2	.268	.095	4.01 -3	.276	.040	0.	.000	.000	1.85 -2	.544	.136
11	1.281 -2	.282	.082	3.76 -3	.280	.037	0.	.000	.000	1.66 -2	.562	.118
12	1.096 -2	.294	.070	3.95 -3	.283	.033	0.	.000	.000	1.49 -2	.578	.103
13	9.365 -3	.304	.060	3.65 -3	.287	.029	0.	.000	.000	1.30 -2	.592	.089
14	8.004 -3	.312	.051	3.57 -3	.291	.025	0.	.000	.000	1.16 -2	.604	.076
15	6.841 -3	.320	.044	3.35 -3	.294	.022	0.	.000	.000	1.02 -2	.615	.066
16	5.848 -3	.326	.037	3.19 -3	.298	.019	0.	.000	.000	9.04 -3	.624	.056
17	4.999 -3	.332	.032	3.15 -3	.301	.015	0.	.000	.000	8.15 -3	.633	.047
18	4.273 -3	.336	.027	3.05 -3	.304	.012	0.	.000	.000	7.32 -3	.641	.040
19	3.653 -3	.340	.023	2.57 -3	.307	.009	0.	.000	.000	6.22 -3	.647	.033
20	3.123 -3	.344	.020	1.89 -3	.309	.007	0.	.000	.000	5.01 -3	.653	.027
21	2.660 -3	.346	.017	1.37 -3	.311	.006	0.	.000	.000	4.03 -3	.658	.023
22	2.266 -3	.349	.015	1.03 -3	.312	.004	0.	.000	.000	3.30 -3	.661	.019
23	1.932 -3	.351	.013	7.87 -4	.313	.003	0.	.000	.000	2.72 -3	.664	.016
24	1.649 -3	.353	.011	6.24 -4	.313	.003	0.	.000	.000	2.27 -3	.667	.013
25	1.408 -3	.354	.009	5.25 -4	.314	.002	0.	.000	.000	1.93 -3	.669	.011
26	1.203 -3	.356	.008	4.58 -4	.314	.002	0.	.000	.000	1.60 -3	.671	.010
27	1.029 -3	.357	.007	3.51 -4	.315	.001	0.	.000	.000	1.38 -3	.672	.008
28	8.809 -4	.358	.006	2.68 -4	.315	.001	0.	.000	.000	1.15 -3	.673	.007
29	7.545 -4	.358	.005	2.06 -4	.315	.001	0.	.000	.000	9.61 -4	.675	.005
30	6.467 -4	.359	.004	1.58 -4	.316	.001	0.	.000	.000	8.05 -4	.675	.005
31	5.547 -4	.360	.004	1.21 -4	.316	.000	0.	.000	.000	6.76 -4	.676	.004
32	4.762 -4	.360	.003	9.25 -5	.316	.000	0.	.000	.000	5.69 -4	.677	.004
33	4.065 -4	.361	.003	7.09 -5	.316	.000	0.	.000	.000	4.77 -4	.677	.003
34	3.473 -4	.361	.002	5.43 -5	.316	.000	0.	.000	.000	4.02 -4	.678	.003
35	2.973 -4	.361	.002	4.16 -5	.316	.000	0.	.000	.000	3.39 -4	.678	.002
36	2.549 -4	.362	.002	3.19 -5	.316	.000	0.	.000	.000	2.87 -4	.678	.002
37	2.190 -4	.362	.002	2.44 -5	.316	.000	0.	.000	.000	2.43 -4	.679	.002
38	1.885 -4	.362	.001	1.87 -5	.316	.000	0.	.000	.000	2.07 -4	.679	.001
39	1.625 -4	.362	.001	1.43 -5	.316	.000	0.	.000	.000	1.77 -4	.679	.001
40	1.404 -4	.362	.001	1.10 -5	.316	.000	0.	.000	.000	1.51 -4	.679	.001
41	1.214 -4	.363	.001	8.41 -6	.316	.000	0.	.000	.000	1.30 -4	.679	.001
42	1.052 -4	.363	.001	6.43 -6	.316	.000	0.	.000	.000	1.12 -4	.680	.001
43	9.129 -5	.363	.001	4.92 -6	.316	.000	0.	.000	.000	9.62 -5	.680	.001
44	7.935 -5	.363	.001	3.77 -6	.316	.000	0.	.000	.000	8.31 -5	.680	.001
45	6.907 -5	.363	.001	2.89 -6	.316	.000	0.	.000	.000	7.20 -5	.680	.001
46	6.021 -5	.363	.000	2.22 -6	.316	.000	0.	.000	.000	6.24 -5	.680	.000
47	5.257 -5	.363	.000	1.70 -6	.316	.000	0.	.000	.000	5.43 -5	.680	.000
48	4.625 -5	.363	.000	1.30 -6	.316	.000	0.	.000	.000	4.76 -5	.680	.000
49	4.085 -5	.363	.000	9.95 -7	.316	.000	0.	.000	.000	4.18 -5	.680	.000
50	3.607 -5	.363	.000	7.62 -7	.316	.000	0.	.000	.000	3.68 -5	.680	.000

Table 4.9 Parameters at 0.45 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	2.644 -2	.000	.223	1.80 -1	.000	.285	1.25 -5	.000	.001	2.06 -1	.000	.509
1	2.400 -2	.025	.198	7.92 -2	.130	.155	1.14 -5	.000	.001	1.03 -1	.155	.355
2	2.173 -2	.046	.175	3.42 -2	.186	.098	1.03 -5	.000	.001	5.59 -2	.234	.275
3	1.963 -2	.069	.155	1.44 -2	.211	.074	8.75 -6	.000	.001	3.40 -2	.279	.230
4	1.769 -2	.087	.136	7.59 -3	.222	.063	7.91 -6	.000	.001	2.53 -2	.309	.201
5	1.590 -2	.104	.119	5.72 -3	.228	.056	7.73 -6	.000	.001	2.16 -2	.332	.177
6	1.425 -2	.119	.104	4.03 -3	.233	.052	7.56 -6	.000	.001	1.83 -2	.352	.157
7	1.274 -2	.133	.091	3.75 -3	.237	.048	7.80 -6	.000	.001	1.65 -2	.370	.140
8	1.135 -2	.145	.079	3.86 -3	.241	.044	7.98 -6	.000	.001	1.52 -2	.386	.124
9	1.008 -2	.155	.068	3.70 -3	.245	.040	9.83 -6	.000	.001	1.38 -2	.400	.109
10	8.926 -3	.165	.059	3.61 -3	.248	.036	1.22 -5	.000	.001	1.25 -2	.413	.096
11	7.874 -3	.173	.050	3.38 -3	.252	.033	1.61 -5	.000	.001	1.13 -2	.425	.084
12	6.733 -3	.180	.043	3.55 -3	.255	.029	2.17 -5	.000	.001	1.03 -2	.436	.074
13	5.755 -3	.187	.037	3.28 -3	.259	.026	2.96 -5	.000	.001	9.07 -3	.446	.064
14	4.918 -3	.192	.031	3.21 -3	.262	.023	3.35 -5	.000	.001	8.16 -3	.454	.055
15	4.204 -3	.197	.027	3.02 -3	.265	.020	3.48 -5	.000	.001	7.26 -3	.462	.047
16	3.593 -3	.200	.023	2.87 -3	.268	.017	3.60 -5	.000	.001	6.50 -3	.469	.041
17	3.072 -3	.204	.020	2.84 -3	.271	.014	3.88 -5	.000	.001	5.95 -3	.475	.034
18	2.626 -3	.207	.017	2.75 -3	.274	.011	4.27 -5	.000	.001	5.41 -3	.481	.029
19	2.265 -3	.209	.014	2.31 -3	.276	.009	4.97 -5	.000	.001	4.61 -3	.486	.024
20	1.919 -3	.211	.012	1.70 -3	.278	.007	5.74 -5	.000	.001	3.67 -3	.490	.020
21	1.634 -3	.213	.010	1.23 -3	.280	.005	6.44 -5	.000	.001	2.93 -3	.493	.016
22	1.393 -3	.214	.009	9.26 -4	.281	.004	6.89 -5	.001	.001	2.39 -3	.496	.014
23	1.187 -3	.216	.008	7.09 -4	.281	.003	6.93 -5	.001	.001	1.97 -3	.498	.011
24	1.013 -3	.217	.007	5.62 -4	.282	.003	6.75 -5	.001	.000	1.64 -3	.500	.010
25	8.652 -4	.218	.006	4.73 -4	.283	.002	6.30 -5	.001	.000	1.40 -3	.501	.008
26	7.394 -4	.219	.005	4.12 -4	.283	.002	5.70 -5	.001	.000	1.21 -3	.503	.007
27	6.324 -4	.219	.004	3.16 -4	.283	.001	4.93 -5	.001	.000	9.97 -4	.504	.006
28	5.413 -4	.220	.004	2.42 -4	.284	.001	4.30 -5	.001	.000	8.26 -4	.505	.005
29	4.636 -4	.220	.003	1.86 -4	.284	.001	3.74 -5	.001	.000	6.87 -4	.505	.004
30	3.974 -4	.221	.003	1.42 -4	.284	.001	3.16 -5	.001	.000	5.71 -4	.506	.003
31	3.409 -4	.221	.002	1.09 -4	.284	.000	2.78 -5	.001	.000	4.77 -4	.507	.003
32	2.926 -4	.221	.002	8.33 -5	.284	.000	2.39 -5	.001	.000	4.00 -4	.507	.002
33	2.499 -4	.222	.002	6.38 -5	.284	.000	2.04 -5	.001	.000	3.34 -4	.507	.002
34	2.134 -4	.222	.001	4.89 -5	.284	.000	1.70 -5	.001	.000	2.79 -4	.508	.002
35	1.827 -4	.222	.001	3.75 -5	.284	.000	1.51 -5	.001	.000	2.35 -4	.508	.001
36	1.567 -4	.222	.001	2.87 -5	.284	.000	1.26 -5	.001	.000	1.98 -4	.508	.001
37	1.346 -4	.222	.001	2.20 -5	.284	.000	1.06 -5	.001	.000	1.67 -4	.508	.001
38	1.158 -4	.223	.001	1.69 -5	.284	.000	8.85 -6	.001	.000	1.42 -4	.509	.001
39	9.987 -5	.223	.001	1.29 -5	.284	.000	7.59 -6	.001	.000	1.20 -4	.509	.001
40	8.625 -5	.223	.001	9.87 -6	.285	.000	6.51 -6	.001	.000	1.03 -4	.509	.001
41	7.461 -5	.223	.001	7.56 -6	.285	.000	5.32 -6	.001	.000	8.75 -5	.509	.001
42	6.464 -5	.223	.000	5.79 -6	.285	.000	4.16 -6	.001	.000	7.46 -5	.509	.001
43	5.610 -5	.223	.000	4.43 -6	.285	.000	3.25 -6	.001	.000	6.38 -5	.509	.000
44	4.876 -5	.223	.000	3.39 -6	.285	.000	2.60 -6	.001	.000	5.48 -5	.509	.000
45	4.244 -5	.223	.000	2.60 -6	.285	.000	2.02 -6	.001	.000	4.71 -5	.509	.000
46	3.700 -5	.223	.000	1.99 -6	.285	.000	1.56 -6	.001	.000	4.06 -5	.509	.000
47	3.230 -5	.223	.000	1.53 -6	.285	.000	1.24 -6	.001	.000	3.51 -5	.509	.000
48	2.842 -5	.223	.000	1.17 -6	.285	.000	9.76 -7	.001	.000	3.06 -5	.509	.000
49	2.510 -5	.223	.000	8.95 -7	.285	.000	7.80 -7	.001	.000	2.68 -5	.509	.000
50	2.217 -5	.223	.000	6.86 -7	.285	.000	6.51 -7	.001	.000	2.35 -5	.509	.000

Table 4.10 Parameters at 0.50 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	1.716 -2	.000	.145	1.67 -1	.000	.264	1.23 -4	.000	.012	1.84 -1	.000	.421
1	1.557 -2	.016	.129	7.35 -2	.120	.144	1.12 -4	.000	.012	8.91 -2	.137	.284
2	1.410 -2	.031	.114	3.17 -2	.173	.091	1.01 -4	.000	.011	4.59 -2	.204	.217
3	1.273 -2	.045	.100	1.33 -2	.195	.069	8.63 -5	.000	.011	2.61 -2	.240	.181
4	1.148 -2	.057	.088	7.04 -3	.206	.058	7.80 -5	.000	.011	1.86 -2	.263	.158
5	1.031 -2	.068	.077	5.31 -3	.212	.052	7.62 -5	.000	.011	1.57 -2	.280	.141
6	9.245 -3	.077	.068	3.74 -3	.216	.048	7.45 -5	.001	.011	1.31 -2	.294	.127
7	8.263 -3	.086	.059	3.48 -3	.220	.044	7.69 -5	.001	.011	1.18 -2	.307	.114
8	7.364 -3	.094	.051	3.58 -3	.223	.041	7.87 -5	.001	.011	1.10 -2	.318	.103
9	6.541 -3	.101	.044	3.44 -3	.227	.037	9.69 -5	.001	.011	1.01 -2	.329	.092
10	5.791 -3	.107	.038	3.35 -3	.230	.034	1.21 -4	.001	.011	9.26 -3	.338	.083
11	5.109 -3	.112	.033	3.14 -3	.233	.031	1.59 -4	.001	.011	8.41 -3	.347	.074
12	4.369 -3	.117	.028	3.30 -3	.237	.027	2.14 -4	.001	.010	7.88 -3	.355	.066
13	3.734 -3	.121	.024	3.04 -3	.240	.024	2.92 -4	.001	.010	7.07 -3	.363	.058
14	3.191 -3	.125	.020	2.98 -3	.243	.021	3.30 -4	.002	.010	6.50 -3	.369	.051
15	2.728 -3	.128	.017	2.80 -3	.246	.018	3.43 -4	.002	.010	5.87 -3	.376	.045
16	2.331 -3	.130	.015	2.66 -3	.249	.015	3.55 -4	.002	.009	5.35 -3	.381	.040
17	1.993 -3	.132	.013	2.63 -3	.251	.013	3.83 -4	.003	.009	5.01 -3	.386	.034
18	1.704 -3	.134	.011	2.55 -3	.254	.010	4.21 -4	.003	.008	4.67 -3	.391	.030
19	1.456 -3	.136	.009	2.15 -3	.256	.008	4.90 -4	.004	.008	4.09 -3	.396	.025
20	1.245 -3	.137	.008	1.57 -3	.258	.006	5.66 -4	.004	.007	3.39 -3	.399	.021
21	1.060 -3	.138	.007	1.14 -3	.259	.005	6.35 -4	.005	.007	2.84 -3	.403	.018
22	9.035 -4	.139	.006	8.59 -4	.260	.004	6.80 -4	.005	.006	2.44 -3	.405	.016
23	7.703 -4	.140	.005	6.57 -4	.261	.003	6.83 -4	.006	.005	2.11 -3	.407	.013
24	6.574 -4	.141	.004	5.21 -4	.262	.002	6.66 -4	.007	.005	1.84 -3	.409	.011
25	5.614 -4	.141	.004	4.39 -4	.262	.002	6.21 -4	.007	.004	1.62 -3	.411	.010
26	4.798 -4	.142	.003	3.83 -4	.263	.001	5.62 -4	.008	.004	1.42 -3	.413	.008
27	4.103 -4	.142	.003	2.93 -4	.263	.001	4.86 -4	.009	.003	1.19 -3	.414	.007
28	3.512 -4	.143	.002	2.24 -4	.263	.001	4.24 -4	.009	.003	1.00 -3	.415	.006
29	3.008 -4	.143	.002	1.72 -4	.263	.001	3.69 -4	.009	.002	8.42 -4	.416	.005
30	2.578 -4	.143	.002	1.32 -4	.264	.000	3.12 -4	.010	.002	7.01 -4	.417	.004
31	2.212 -4	.143	.001	1.01 -4	.264	.000	2.74 -4	.010	.002	5.96 -4	.417	.003
32	1.898 -4	.144	.001	7.73 -5	.264	.000	2.35 -4	.010	.001	5.02 -4	.418	.003
33	1.621 -4	.144	.001	5.92 -5	.264	.000	2.01 -4	.011	.001	4.22 -4	.418	.002
34	1.385 -4	.144	.001	4.53 -5	.264	.000	1.67 -4	.011	.001	3.51 -4	.419	.002
35	1.185 -4	.144	.001	3.48 -5	.264	.000	1.49 -4	.011	.001	3.02 -4	.419	.002
36	1.016 -4	.144	.001	2.66 -5	.264	.000	1.25 -4	.011	.001	2.53 -4	.419	.001
37	8.732 -5	.144	.001	2.04 -5	.264	.000	1.04 -4	.011	.001	2.12 -4	.420	.001
38	7.516 -5	.144	.001	1.56 -5	.264	.000	8.73 -5	.011	.000	1.78 -4	.420	.001
39	6.480 -5	.144	.000	1.19 -5	.264	.000	7.49 -5	.011	.000	1.52 -4	.420	.001
40	5.596 -5	.145	.000	9.15 -6	.264	.000	6.42 -5	.011	.000	1.29 -4	.420	.001
41	4.841 -5	.145	.000	7.02 -6	.264	.000	5.24 -5	.011	.000	1.08 -4	.420	.001
42	4.194 -5	.145	.000	5.37 -6	.264	.000	4.11 -5	.012	.000	8.84 -5	.420	.000
43	3.640 -5	.145	.000	4.11 -6	.264	.000	3.21 -5	.012	.000	7.26 -5	.420	.000
44	3.153 -5	.145	.000	3.15 -6	.264	.000	2.57 -5	.012	.000	6.05 -5	.420	.000
45	2.754 -5	.145	.000	2.41 -6	.264	.000	1.99 -5	.012	.000	4.98 -5	.421	.000
46	2.401 -5	.145	.000	1.85 -6	.264	.000	1.54 -5	.012	.000	4.12 -5	.421	.000
47	2.096 -5	.145	.000	1.42 -6	.264	.000	1.22 -5	.012	.000	3.46 -5	.421	.000
48	1.844 -5	.145	.000	1.09 -6	.264	.000	9.63 -6	.012	.000	2.92 -5	.421	.000
49	1.628 -5	.145	.000	8.31 -7	.264	.000	7.69 -6	.012	.000	2.48 -5	.421	.000
50	1.438 -5	.145	.000	6.36 -7	.264	.000	6.42 -6	.012	.000	2.14 -5	.421	.000

Table 4.11 Parameters at 0.55 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	1.162 -2	.000	.098	1.58 -1	.000	.250	3.28 -4	.000	.031	1.70 -1	.000	.379
1	1.055 -2	.011	.087	6.95 -2	.114	.136	3.00 -4	.000	.031	8.03 -2	.125	.254
2	9.550 -3	.021	.077	3.00 -2	.163	.086	2.70 -4	.001	.030	3.98 -2	.185	.194
3	8.627 -3	.030	.068	1.26 -2	.185	.065	2.30 -4	.001	.030	2.15 -2	.215	.163
4	7.774 -3	.038	.060	6.66 -3	.194	.055	2.08 -4	.001	.030	1.46 -2	.234	.145
5	6.987 -3	.046	.052	5.02 -3	.200	.049	2.03 -4	.001	.030	1.22 -2	.247	.132
6	6.263 -3	.052	.046	3.54 -3	.205	.045	1.99 -4	.001	.030	1.00 -2	.258	.121
7	5.598 -3	.058	.040	3.29 -3	.208	.042	2.05 -4	.002	.029	9.09 -3	.268	.111
8	4.989 -3	.064	.035	3.39 -3	.211	.038	2.10 -4	.002	.029	8.59 -3	.277	.102
9	4.431 -3	.068	.030	3.25 -3	.215	.035	2.59 -4	.002	.029	7.94 -3	.285	.094
10	3.923 -3	.072	.026	3.17 -3	.218	.032	3.22 -4	.002	.029	7.42 -3	.293	.086
11	3.461 -3	.076	.022	2.97 -3	.221	.029	4.23 -4	.003	.028	6.85 -3	.300	.079
12	2.960 -3	.079	.019	3.12 -3	.224	.026	5.71 -4	.003	.028	6.65 -3	.307	.073
13	2.529 -3	.082	.016	2.88 -3	.227	.023	7.77 -4	.004	.027	6.19 -3	.313	.066
14	2.162 -3	.084	.014	2.82 -3	.230	.020	8.80 -4	.005	.026	5.86 -3	.319	.060
15	1.848 -3	.086	.012	2.65 -3	.233	.017	9.14 -4	.006	.025	5.41 -3	.325	.054
16	1.579 -3	.088	.010	2.52 -3	.235	.015	9.48 -4	.007	.024	5.05 -3	.330	.049
17	1.350 -3	.090	.009	2.49 -3	.238	.012	1.02 -3	.008	.023	4.86 -3	.335	.044
18	1.154 -3	.091	.007	2.41 -3	.240	.010	1.12 -3	.009	.022	4.69 -3	.340	.040
19	9.867 -4	.092	.006	2.03 -3	.242	.007	1.31 -3	.010	.021	4.32 -3	.344	.035
20	8.435 -4	.093	.005	1.49 -3	.244	.006	1.51 -3	.011	.020	3.84 -3	.348	.031
21	7.183 -4	.094	.005	1.08 -3	.245	.004	1.69 -3	.013	.018	3.49 -3	.352	.027
22	6.121 -4	.094	.004	8.13 -4	.246	.003	1.81 -3	.015	.016	3.24 -3	.355	.024
23	5.219 -4	.095	.003	6.22 -4	.247	.003	1.82 -3	.016	.015	2.97 -3	.358	.021
24	4.453 -4	.095	.003	4.93 -4	.248	.002	1.78 -3	.018	.013	2.71 -3	.361	.018
25	3.803 -4	.096	.002	4.15 -4	.248	.002	1.66 -3	.020	.011	2.45 -3	.364	.015
26	3.250 -4	.096	.002	3.62 -4	.248	.001	1.50 -3	.022	.010	2.19 -3	.366	.013
27	2.780 -4	.096	.002	2.77 -4	.249	.001	1.30 -3	.023	.008	1.85 -3	.368	.011
28	2.379 -4	.097	.002	2.12 -4	.249	.001	1.13 -3	.024	.007	1.58 -3	.370	.009
29	2.038 -4	.097	.001	1.63 -4	.249	.001	9.84 -4	.025	.006	1.35 -3	.371	.008
30	1.747 -4	.097	.001	1.25 -4	.249	.000	8.31 -4	.026	.005	1.13 -3	.373	.007
31	1.498 -4	.097	.001	9.55 -5	.249	.000	7.30 -4	.027	.004	9.75 -4	.374	.006
32	1.285 -4	.097	.001	7.31 -5	.249	.000	6.27 -4	.028	.003	8.29 -4	.375	.005
33	1.098 -4	.097	.001	5.60 -5	.250	.000	5.35 -4	.028	.003	7.01 -4	.375	.004
34	9.381 -5	.098	.001	4.29 -5	.250	.000	4.46 -4	.029	.002	5.83 -4	.376	.003
35	8.030 -5	.098	.001	3.29 -5	.250	.000	3.97 -4	.029	.002	5.10 -4	.377	.003
36	6.886 -5	.098	.000	2.52 -5	.250	.000	3.32 -4	.029	.002	4.26 -4	.377	.002
37	5.916 -5	.098	.000	1.93 -5	.250	.000	2.78 -4	.030	.001	3.56 -4	.377	.002
38	5.092 -5	.098	.000	1.48 -5	.250	.000	2.33 -4	.030	.001	2.98 -4	.378	.002
39	4.390 -5	.098	.000	1.13 -5	.250	.000	2.00 -4	.030	.001	2.55 -4	.378	.001
40	3.791 -5	.098	.000	8.66 -6	.250	.000	1.71 -4	.030	.001	2.18 -4	.378	.001
41	3.279 -5	.098	.000	6.64 -6	.250	.000	1.40 -4	.031	.001	1.79 -4	.378	.001
42	2.841 -5	.098	.000	5.08 -6	.250	.000	1.09 -4	.031	.000	1.43 -4	.379	.001
43	2.406 -5	.098	.000	3.89 -6	.250	.000	8.56 -5	.031	.000	1.14 -4	.379	.001
44	2.143 -5	.098	.000	2.98 -6	.250	.000	6.84 -5	.031	.000	9.29 -5	.379	.000
45	1.866 -5	.098	.000	2.28 -6	.250	.000	5.30 -5	.031	.000	7.39 -5	.379	.000
46	1.626 -5	.098	.000	1.75 -6	.250	.000	4.10 -5	.031	.000	5.90 -5	.379	.000
47	1.420 -5	.098	.000	1.34 -6	.250	.000	3.25 -5	.031	.000	4.80 -5	.379	.000
48	1.249 -5	.098	.000	1.03 -6	.250	.000	2.57 -5	.031	.000	3.92 -5	.379	.000
49	1.103 -5	.098	.000	7.86 -7	.250	.000	2.05 -5	.031	.000	3.23 -5	.379	.000
50	9.743 -6	.098	.000	6.02 -7	.250	.000	1.71 -5	.031	.000	2.75 -5	.379	.000

Table 4.12 Parameters at 0.60 microns

Alt. (km)	Rayleigh atten. coeff. (km^{-1})	Rayleigh optical thick. (0 - h)	Rayleigh optical thick. (h - ∞)	Aerosol atten. coeff. (km^{-1})	Aerosol optical thick. (0 - h)	Aerosol optical thick. (h - ∞)	Ozone absorp. coeff. (km^{-1})	Ozone optical thick. (0 - h)	Ozone optical thick. (h - ∞)	Ext. coeff. (km^{-1})	Ext. optical thick. (0 - h)	Ext. optical thick. (h - ∞)
h	β_r	τ_r	τ_r'	β_p	τ_p	τ_p'	β_3	τ_3	τ_3'	β_{ext}	τ_{ext}	τ_{ext}'
0	8.156 -3	.000	.069	1.50 -1	.000	.237	4.70 -4	.000	.045	1.59 -1	.000	.351
1	7.401 -3	.008	.061	6.60 -2	.108	.129	4.30 -4	.000	.044	7.38 -2	.116	.235
2	6.701 -3	.015	.054	2.85 -2	.155	.082	3.87 -4	.001	.044	3.56 -2	.171	.180
3	6.054 -3	.021	.048	1.20 -2	.175	.062	3.30 -4	.001	.043	1.83 -2	.198	.153
4	5.455 -3	.027	.042	6.32 -3	.185	.053	2.98 -4	.002	.043	1.21 -2	.213	.136
5	4.903 -3	.032	.037	4.77 -3	.190	.047	2.92 -4	.002	.043	9.96 -3	.224	.127
6	4.395 -3	.037	.032	3.36 -3	.194	.043	2.85 -4	.002	.042	8.04 -3	.233	.118
7	3.928 -3	.041	.028	3.12 -3	.197	.040	2.94 -4	.002	.042	7.35 -3	.241	.110
8	3.501 -3	.045	.024	3.22 -3	.201	.037	3.01 -4	.003	.042	7.02 -3	.248	.103
9	3.110 -3	.048	.021	3.09 -3	.204	.033	3.71 -4	.003	.042	6.57 -3	.255	.096
10	2.753 -3	.051	.018	3.01 -3	.207	.030	4.62 -4	.003	.041	6.22 -3	.261	.090
11	2.429 -3	.053	.015	2.82 -3	.210	.027	6.07 -4	.004	.041	5.86 -3	.267	.084
12	2.077 -3	.056	.013	2.96 -3	.213	.025	8.20 -4	.005	.040	5.86 -3	.273	.078
13	1.775 -3	.058	.011	2.73 -3	.215	.022	1.12 -3	.006	.039	5.62 -3	.279	.072
14	1.517 -3	.059	.010	2.68 -3	.218	.019	1.26 -3	.007	.038	5.46 -3	.284	.066
15	1.297 -3	.061	.008	2.52 -3	.221	.016	1.31 -3	.008	.036	5.12 -3	.290	.061
16	1.108 -3	.062	.007	2.39 -3	.223	.014	1.36 -3	.009	.035	4.86 -3	.295	.056
17	9.474 -4	.063	.006	2.36 -3	.226	.012	1.47 -3	.011	.034	4.78 -3	.299	.051
18	8.099 -4	.064	.005	2.29 -3	.228	.009	1.61 -3	.012	.032	4.71 -3	.304	.047
19	6.924 -4	.064	.004	1.93 -3	.230	.007	1.87 -3	.014	.030	4.49 -3	.309	.042
20	5.919 -4	.065	.004	1.41 -3	.232	.005	2.16 -3	.016	.028	4.17 -3	.313	.038
21	5.041 -4	.066	.003	1.03 -3	.233	.004	2.43 -3	.018	.026	3.96 -3	.317	.034
22	4.295 -4	.066	.003	7.72 -4	.234	.003	2.60 -3	.021	.024	3.80 -3	.321	.030
23	3.662 -4	.067	.002	5.91 -4	.234	.003	2.61 -3	.024	.021	3.57 -3	.325	.026
24	3.125 -4	.067	.002	4.68 -4	.235	.002	2.55 -3	.026	.018	3.33 -3	.328	.023
25	2.669 -4	.067	.002	3.94 -4	.235	.002	2.38 -3	.029	.016	3.04 -3	.331	.019
26	2.281 -4	.067	.001	3.44 -4	.236	.001	2.15 -3	.031	.014	2.72 -3	.334	.016
27	1.951 -4	.068	.001	2.63 -4	.236	.001	1.86 -3	.033	.012	2.32 -3	.337	.014
28	1.670 -4	.068	.001	2.01 -4	.236	.001	1.62 -3	.035	.010	1.99 -3	.339	.012
29	1.430 -4	.068	.001	1.55 -4	.237	.001	1.41 -3	.036	.008	1.71 -3	.341	.010
30	1.226 -4	.068	.001	1.19 -4	.237	.000	1.19 -3	.037	.007	1.43 -3	.342	.008
31	1.051 -4	.068	.001	9.07 -5	.237	.000	1.05 -3	.039	.006	1.24 -3	.344	.007
32	9.025 -5	.068	.001	6.94 -5	.237	.000	9.00 -4	.040	.005	1.06 -3	.345	.006
33	7.705 -5	.068	.001	5.32 -5	.237	.000	7.68 -4	.040	.004	8.98 -4	.346	.005
34	6.583 -5	.068	.000	4.07 -5	.237	.000	6.40 -4	.041	.003	7.47 -4	.347	.004
35	5.635 -5	.068	.000	3.12 -5	.237	.000	5.69 -4	.042	.003	6.57 -4	.347	.003
36	4.832 -5	.069	.000	2.39 -5	.237	.000	4.77 -4	.042	.002	5.49 -4	.348	.003
37	4.151 -5	.069	.000	1.83 -5	.237	.000	3.99 -4	.043	.002	4.58 -4	.348	.002
38	3.573 -5	.069	.000	1.41 -5	.237	.000	3.34 -4	.043	.002	3.84 -4	.349	.002
39	3.080 -5	.069	.000	1.07 -5	.237	.000	2.86 -4	.043	.001	3.28 -4	.349	.002
40	2.660 -5	.069	.000	8.22 -6	.237	.000	2.46 -4	.044	.001	2.80 -4	.350	.001
41	2.301 -5	.069	.000	6.30 -6	.237	.000	2.01 -4	.044	.001	2.30 -4	.350	.001
42	1.994 -5	.069	.000	4.82 -6	.237	.000	1.57 -4	.044	.001	1.82 -4	.350	.001
43	1.730 -5	.069	.000	3.69 -6	.237	.000	1.23 -4	.044	.000	1.44 -4	.350	.001
44	1.504 -5	.069	.000	2.83 -6	.237	.000	9.82 -5	.044	.000	1.16 -4	.350	.000
45	1.309 -5	.069	.000	2.16 -6	.237	.000	7.60 -5	.044	.000	9.13 -5	.350	.000
46	1.141 -5	.069	.000	1.66 -6	.237	.000	5.89 -5	.044	.000	7.19 -5	.350	.000
47	9.963 -6	.069	.000	1.27 -6	.237	.000	4.66 -5	.044	.000	5.78 -5	.351	.000
48	8.766 -6	.069	.000	9.78 -7	.237	.000	3.68 -5	.045	.000	4.66 -5	.351	.000
49	7.742 -6	.069	.000	7.46 -7	.237	.000	2.94 -5	.045	.000	3.79 -5	.351	.000
50	6.837 -6	.069	.000	5.72 -7	.237	.000	2.46 -5	.045	.000	3.20 -5	.351	.000

Table 4.13 Parameters at 0.65 microns

Alt. (km)	Rayleigh atten. coeff. (km⁻¹)	Rayleigh optical thick. (0-h)	Rayleigh optical thick. (h-∞)	Aerosol atten. coeff. (km⁻¹)	Aerosol optical thick. (0-h)	Aerosol optical thick (h-∞)	Ozone absorp. coeff. (km⁻¹)	Ozone optical thick. (0-h)	Ozone optical thick. (h-∞)	Ext. coeff. (km⁻¹)	Ext. optical thick. (0-h)	Ext. optical thick. (h-∞)
h	β_r	τ_r	τ_r'	β_p	τ_p	τ_p'	β_3	τ_3	τ_3'	β_{ext}	τ_{ext}	τ_{ext}'
0	5.893 -3	.000	.050	1.42 -1	.000	.224	2.21 -4	.000	.021	1.48 -1	.000	.295
1	5.349 -3	.006	.044	6.25 -2	.102	.122	2.02 -4	.000	.021	6.80 -2	.108	.187
2	4.842 -3	.011	.039	2.70 -2	.147	.078	1.82 -4	.000	.021	3.20 -2	.158	.137
3	4.374 -3	.015	.034	1.13 -2	.166	.058	1.55 -4	.001	.020	1.59 -2	.182	.113
4	3.942 -3	.019	.030	5.99 -3	.175	.050	1.40 -4	.001	.020	1.01 -2	.195	.100
5	3.543 -3	.023	.027	4.51 -3	.180	.044	1.37 -4	.001	.020	8.19 -3	.204	.091
6	3.176 -3	.027	.023	3.18 -3	.184	.041	1.34 -4	.001	.020	6.49 -3	.211	.084
7	2.838 -3	.030	.020	2.96 -3	.187	.038	1.38 -4	.001	.020	5.93 -3	.216	.078
9	2.529 -3	.032	.018	3.05 -3	.190	.035	1.41 -4	.001	.020	5.72 -3	.223	.072
9	2.247 -3	.035	.015	2.92 -3	.193	.032	1.74 -4	.001	.020	5.34 -3	.229	.066
10	1.989 -3	.037	.013	2.85 -3	.196	.029	2.17 -4	.002	.019	5.06 -3	.234	.061
11	1.755 -3	.039	.011	2.67 -3	.199	.026	2.85 -4	.002	.019	4.71 -3	.239	.056
12	1.501 -3	.040	.010	2.80 -3	.201	.023	3.85 -4	.002	.019	4.69 -3	.244	.052
13	1.282 -3	.042	.008	2.59 -3	.204	.021	5.24 -4	.003	.018	4.39 -3	.248	.047
14	1.096 -3	.043	.007	2.53 -3	.207	.018	5.93 -4	.003	.018	4.22 -3	.253	.043
15	9.369 -4	.044	.006	2.38 -3	.209	.015	6.16 -4	.004	.017	3.93 -3	.257	.039
16	8.008 -4	.045	.005	2.26 -3	.211	.013	6.39 -4	.004	.016	3.70 -3	.261	.035
17	6.846 -4	.045	.004	2.24 -3	.214	.011	6.88 -4	.005	.016	3.61 -3	.264	.031
18	5.852 -4	.046	.004	2.17 -3	.216	.009	7.56 -4	.006	.015	3.51 -3	.268	.028
19	5.003 -4	.047	.003	1.82 -3	.218	.007	8.80 -4	.007	.014	3.21 -3	.271	.024
20	4.277 -4	.047	.003	1.34 -3	.219	.005	1.02 -3	.008	.013	2.78 -3	.274	.021
21	3.642 -4	.047	.002	9.71 -4	.220	.004	1.14 -3	.009	.012	2.48 -3	.277	.019
22	3.103 -4	.048	.002	7.31 -4	.221	.003	1.22 -3	.010	.011	2.26 -3	.279	.016
23	2.646 -4	.048	.002	5.59 -4	.222	.002	1.23 -3	.011	.010	2.05 -3	.281	.014
24	2.258 -4	.048	.001	4.43 -4	.222	.002	1.20 -3	.012	.009	1.87 -3	.283	.012
25	1.928 -4	.049	.001	3.73 -4	.223	.002	1.12 -3	.013	.007	1.68 -3	.285	.010
26	1.648 -4	.049	.001	3.25 -4	.223	.001	1.01 -3	.015	.006	1.50 -3	.287	.009
27	1.409 -4	.049	.001	2.49 -4	.224	.001	8.74 -4	.015	.005	1.26 -3	.288	.007
28	1.206 -4	.049	.001	1.91 -4	.224	.001	7.63 -4	.016	.005	1.07 -3	.289	.006
29	1.033 -4	.049	.001	1.45 -4	.224	.001	6.63 -4	.017	.004	9.13 -4	.290	.005
30	8.856 -5	.049	.001	1.12 -4	.224	.000	5.60 -4	.018	.003	7.61 -4	.291	.004
31	7.597 -5	.049	.001	8.58 -5	.224	.000	4.92 -4	.018	.003	6.53 -4	.292	.004
32	6.521 -5	.049	.000	6.57 -5	.224	.000	4.23 -4	.019	.002	5.54 -4	.292	.003
33	5.567 -5	.049	.000	5.03 -5	.224	.000	3.61 -4	.019	.002	4.67 -4	.293	.003
34	4.757 -5	.049	.000	3.86 -5	.224	.000	3.01 -4	.019	.002	3.87 -4	.293	.002
35	4.071 -5	.049	.000	2.96 -5	.224	.000	2.67 -4	.020	.001	3.38 -4	.294	.002
36	3.491 -5	.050	.000	2.26 -5	.224	.000	2.24 -4	.020	.001	2.81 -4	.294	.001
37	3.000 -5	.050	.000	1.73 -5	.224	.000	1.87 -4	.020	.001	2.35 -4	.294	.001
38	2.582 -5	.050	.000	1.33 -5	.224	.000	1.57 -4	.020	.001	1.96 -4	.294	.001
39	2.226 -5	.050	.000	1.02 -5	.224	.000	1.35 -4	.020	.001	1.67 -4	.295	.001
40	1.922 -5	.050	.000	7.78 -6	.224	.000	1.15 -4	.020	.000	1.42 -4	.295	.001
41	1.663 -5	.050	.000	5.97 -6	.224	.000	9.42 -5	.021	.000	1.17 -4	.295	.000
42	1.441 -5	.050	.000	4.57 -6	.224	.000	7.38 -5	.021	.000	9.28 -5	.295	.000
43	1.250 -5	.050	.000	3.50 -6	.224	.000	5.77 -5	.021	.000	7.37 -5	.295	.000
44	1.087 -5	.050	.000	2.68 -6	.224	.000	4.61 -5	.021	.000	5.97 -5	.295	.000
45	9.459 -6	.050	.000	2.05 -6	.224	.000	3.57 -5	.021	.000	4.72 -5	.295	.000
46	8.246 -6	.050	.000	1.57 -6	.224	.000	2.77 -5	.021	.000	3.75 -5	.295	.000
47	7.199 -6	.050	.000	1.20 -6	.224	.000	2.19 -5	.021	.000	3.03 -5	.295	.000
48	6.334 -6	.050	.000	9.26 -7	.224	.000	1.73 -5	.021	.000	2.46 -5	.295	.000
49	5.594 -6	.050	.000	7.06 -7	.224	.000	1.38 -5	.021	.000	2.01 -5	.295	.000
50	4.940 -6	.050	.000	5.41 -7	.224	.000	1.15 -5	.021	.000	1.70 -5	.295	.000

Table 4.14 Parameters at 0.70 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	4.355 -3	.000	.037	1.35 -1	.000	.213	8.19 -5	.000	.008	1.39 -1	.000	.258
1	3.951 -3	.004	.033	5.94 -2	.097	.116	7.50 -5	.000	.008	6.34 -2	.101	.157
2	3.586 -3	.008	.029	2.56 -2	.140	.074	6.74 -5	.000	.008	2.93 -2	.143	.110
3	3.240 -3	.011	.026	1.08 -2	.158	.056	5.75 -5	.000	.008	1.41 -2	.169	.089
4	2.919 -3	.014	.022	5.69 -3	.166	.047	5.20 -5	.000	.008	8.66 -3	.181	.077
5	2.624 -3	.017	.020	4.29 -3	.171	.042	5.08 -5	.000	.007	6.96 -3	.189	.069
6	2.352 -3	.020	.017	3.02 -3	.175	.039	4.97 -5	.000	.007	5.43 -3	.195	.063
7	2.102 -3	.022	.015	2.81 -3	.178	.036	5.13 -5	.000	.007	4.96 -3	.200	.058
8	1.873 -3	.024	.013	2.90 -3	.181	.033	5.24 -5	.000	.007	4.82 -3	.205	.053
9	1.664 -3	.026	.011	2.78 -3	.183	.030	6.46 -5	.001	.007	4.51 -3	.210	.049
10	1.473 -3	.027	.010	2.71 -3	.186	.027	8.05 -5	.001	.007	4.26 -3	.214	.044
11	1.300 -3	.029	.008	2.54 -3	.189	.025	1.06 -4	.001	.007	3.94 -3	.218	.040
12	1.111 -3	.030	.007	2.67 -3	.191	.022	1.43 -4	.001	.007	3.92 -3	.222	.036
13	9.499 -4	.031	.006	2.46 -3	.194	.019	1.94 -4	.001	.007	3.61 -3	.226	.032
14	8.119 -4	.032	.005	2.41 -3	.196	.017	2.20 -4	.001	.007	3.44 -3	.229	.029
15	6.939 -4	.032	.004	2.26 -3	.199	.015	2.29 -4	.001	.006	3.19 -3	.233	.026
16	5.931 -4	.033	.004	2.15 -3	.201	.013	2.37 -4	.002	.006	2.98 -3	.236	.022
17	5.070 -4	.034	.003	2.13 -3	.203	.010	2.55 -4	.002	.006	2.89 -3	.239	.019
18	4.334 -4	.034	.003	2.06 -3	.205	.008	2.81 -4	.002	.006	2.77 -3	.241	.017
19	3.705 -4	.035	.002	1.73 -3	.207	.006	3.27 -4	.002	.005	2.43 -3	.244	.014
20	3.168 -4	.035	.002	1.27 -3	.209	.005	3.77 -4	.003	.005	1.97 -3	.246	.012
21	2.698 -4	.035	.002	9.23 -4	.210	.004	4.23 -4	.003	.005	1.62 -3	.248	.010
22	2.299 -4	.035	.001	6.95 -4	.210	.003	4.53 -4	.004	.004	1.38 -3	.250	.009
23	1.960 -4	.036	.001	5.31 -4	.211	.002	4.55 -4	.004	.004	1.18 -3	.251	.007
24	1.672 -4	.036	.001	4.21 -4	.212	.002	4.44 -4	.005	.003	1.03 -3	.252	.006
25	1.423 -4	.036	.001	3.55 -4	.212	.001	4.14 -4	.005	.003	9.11 -4	.253	.005
26	1.221 -4	.036	.001	3.09 -4	.212	.001	3.75 -4	.005	.002	8.06 -4	.254	.004
27	1.044 -4	.036	.001	2.37 -4	.213	.001	3.24 -4	.006	.002	6.65 -4	.255	.004
28	8.935 -5	.036	.001	1.81 -4	.213	.001	2.83 -4	.006	.002	5.53 -4	.255	.003
29	7.653 -5	.036	.001	1.39 -4	.213	.001	2.46 -4	.006	.001	4.62 -4	.256	.003
30	6.550 -5	.036	.000	1.07 -4	.213	.000	2.08 -4	.007	.001	3.80 -4	.256	.002
31	5.627 -5	.036	.000	8.16 -5	.213	.000	1.82 -4	.007	.001	3.20 -4	.256	.002
32	4.830 -5	.037	.000	6.25 -5	.213	.000	1.57 -4	.007	.001	2.68 -4	.257	.001
33	4.124 -5	.037	.000	4.78 -5	.213	.000	1.34 -4	.007	.001	2.23 -4	.257	.001
34	3.523 -5	.037	.000	3.67 -5	.213	.000	1.12 -4	.007	.001	1.83 -4	.257	.001
35	3.016 -5	.037	.000	2.81 -5	.213	.000	9.91 -5	.007	.001	1.57 -4	.257	.001
36	2.585 -5	.037	.000	2.15 -5	.213	.000	8.30 -5	.007	.000	1.30 -4	.257	.001
37	2.222 -5	.037	.000	1.65 -5	.213	.000	6.95 -5	.007	.000	1.08 -4	.256	.001
38	1.912 -5	.037	.000	1.26 -5	.213	.000	5.82 -5	.008	.000	9.00 -5	.258	.000
39	1.649 -5	.037	.000	9.66 -6	.213	.000	4.99 -5	.008	.000	7.61 -5	.258	.000
40	1.424 -5	.037	.000	7.40 -6	.213	.000	4.28 -5	.008	.000	6.44 -5	.258	.000
41	1.232 -5	.037	.000	5.67 -6	.213	.000	3.50 -5	.008	.000	5.29 -5	.258	.000
42	1.067 -5	.037	.000	4.34 -6	.213	.000	2.74 -5	.008	.000	4.24 -5	.258	.000
43	9.250 -6	.037	.000	3.32 -6	.213	.000	2.14 -5	.008	.000	3.40 -5	.258	.000
44	8.048 -5	.037	.000	2.55 -6	.213	.000	1.71 -5	.008	.000	2.77 -5	.258	.000
45	7.006 -5	.037	.000	1.95 -6	.213	.000	1.32 -5	.008	.000	2.22 -5	.258	.000
46	6.108 -6	.037	.000	1.50 -6	.213	.000	1.03 -5	.008	.000	1.79 -5	.258	.000
47	5.332 -6	.037	.000	1.14 -6	.213	.000	8.12 -6	.008	.000	1.46 -5	.258	.000
48	4.691 -6	.037	.000	8.80 -7	.213	.000	6.42 -6	.008	.000	1.20 -5	.258	.000
49	4.143 -6	.037	.000	6.72 -7	.213	.000	5.13 -6	.008	.000	9.94 -6	.258	.000
50	3.659 -6	.037	.000	5.14 -7	.213	.000	4.28 -6	.008	.000	8.45 -6	.258	.000

Table 4.15 Parameters at 0.80 microns

Alt. (km)	Rayleigh atten. coeff. (km⁻¹)	Rayleigh optical thick (0-h)	Rayleigh optical thick. (h-∞)	Aerosol atten. coeff. (km⁻¹)	Aerosol optical thick. (0-h)	Aerosol optical thick. (h-∞)	Ozone absorp. coeff. (km⁻¹)	Ozone optical thick. (0-h)	Ozone optical thick. (h-∞)	Ext. coeff. (km⁻¹)	Ext. optical thick. (0-h)	Ext. optical thick. (h-∞)
h	β_r	τ_r	τ_r'	β_p	τ_p	τ_p'	β_3	τ_3	τ_3'	β_{ext}	τ_{ext}	τ_{ext}'
0	2.544 -3	.000	.021	1.27 -1	.000	.201	3.56 -5	.000	.003	1.30 -1	.000	.226
1	2.309 -3	.002	.019	5.59 -2	.091	.109	3.26 -5	.000	.003	5.82 -2	.094	.132
2	2.091 -3	.005	.017	2.41 -2	.131	.069	2.93 -5	.000	.003	2.62 -2	.136	.090
3	1.883 -3	.007	.015	1.01 -2	.149	.052	2.50 -5	.000	.003	1.20 -2	.155	.070
4	1.702 -3	.009	.013	5.35 -3	.155	.044	2.26 -5	.000	.003	7.08 -3	.165	.061
5	1.530 -3	.010	.011	4.04 -3	.161	.040	2.21 -5	.000	.003	5.59 -3	.171	.055
6	1.371 -3	.011	.010	2.85 -3	.164	.036	2.16 -5	.000	.003	4.24 -3	.176	.050
7	1.225 -3	.013	.009	2.54 -3	.167	.034	2.23 -5	.000	.003	3.89 -3	.180	.046
8	1.092 -3	.014	.008	2.72 -3	.170	.031	2.28 -5	.000	.003	3.84 -3	.184	.042
9	9.702 -4	.015	.007	2.61 -3	.173	.028	2.81 -5	.000	.003	3.61 -3	.188	.038
10	8.539 -4	.016	.006	2.55 -3	.175	.026	3.50 -5	.000	.003	3.44 -3	.191	.034
11	7.577 -4	.017	.005	2.39 -3	.178	.023	4.60 -5	.000	.003	3.19 -3	.195	.031
12	6.479 -4	.017	.004	2.51 -3	.180	.021	6.21 -5	.000	.003	3.22 -3	.198	.028
13	5.538 -4	.018	.004	2.31 -3	.182	.018	8.45 -5	.000	.003	2.95 -3	.201	.025
14	4.733 -4	.018	.003	2.27 -3	.185	.016	9.57 -5	.001	.003	2.84 -3	.204	.022
15	4.045 -4	.019	.003	2.13 -3	.187	.014	9.94 -5	.001	.003	2.63 -3	.206	.019
16	3.453 -4	.019	.002	2.03 -3	.189	.012	1.03 -4	.001	.003	2.47 -3	.209	.017
17	2.956 -4	.020	.002	2.00 -3	.191	.010	1.11 -4	.001	.003	2.41 -3	.211	.014
18	2.527 -4	.020	.002	1.94 -3	.193	.008	1.22 -4	.001	.002	2.31 -3	.214	.012
19	2.160 -4	.020	.001	1.53 -3	.195	.006	1.42 -4	.001	.002	1.99 -3	.216	.010
20	1.847 -4	.020	.001	1.20 -3	.196	.005	1.64 -4	.001	.002	1.55 -3	.218	.008
21	1.573 -4	.020	.001	8.08 -4	.197	.004	1.34 -4	.001	.002	1.21 -3	.219	.007
22	1.340 -4	.021	.001	6.53 -4	.198	.003	1.97 -4	.002	.002	9.84 -4	.220	.005
23	1.143 -4	.021	.001	5.00 -4	.199	.002	1.98 -4	.002	.002	8.12 -4	.221	.005
24	9.750 -5	.021	.001	3.96 -4	.199	.002	1.93 -4	.002	.001	6.87 -4	.222	.004
25	8.326 -5	.021	.001	3.34 -4	.199	.001	1.80 -4	.002	.001	5.97 -4	.223	.003
26	7.115 -5	.021	.000	2.91 -4	.200	.001	1.63 -4	.002	.001	5.25 -4	.223	.003
27	6.036 -5	.021	.000	2.23 -4	.200	.001	1.41 -4	.002	.001	4.25 -4	.224	.002
28	5.209 -5	.021	.000	1.70 -4	.200	.001	1.23 -4	.003	.001	3.45 -4	.224	.002
29	4.451 -5	.021	.000	1.31 -4	.200	.000	1.07 -4	.003	.001	2.83 -4	.224	.001
30	3.824 -5	.021	.000	1.00 -4	.200	.000	9.03 -5	.003	.001	2.29 -4	.225	.001
31	3.230 -5	.021	.000	7.68 -5	.200	.000	7.93 -5	.003	.000	1.89 -4	.225	.001
32	2.815 -5	.021	.000	5.88 -5	.201	.000	6.82 -5	.003	.000	1.55 -4	.225	.001
33	2.404 -5	.021	.000	4.50 -5	.201	.000	5.62 -5	.003	.000	1.27 -4	.225	.001
34	2.054 -5	.021	.000	3.45 -5	.201	.000	4.85 -5	.003	.000	1.04 -4	.225	.001
35	1.758 -5	.021	.000	2.64 -5	.201	.000	4.31 -5	.003	.000	8.71 -5	.225	.000
36	1.508 -5	.021	.000	2.03 -5	.201	.000	3.61 -5	.003	.000	7.14 -5	.225	.000
37	1.295 -5	.021	.000	1.55 -5	.201	.000	3.02 -5	.003	.000	5.87 -5	.225	.000
38	1.115 -5	.021	.000	1.19 -5	.201	.000	2.53 -5	.003	.000	4.83 -5	.225	.000
39	9.610 -6	.021	.000	9.08 -6	.201	.000	2.17 -5	.003	.000	4.04 -5	.225	.000
40	8.300 -6	.021	.000	6.96 -6	.201	.000	1.86 -5	.003	.000	3.39 -5	.226	.000
41	7.179 -6	.021	.000	5.34 -6	.201	.000	1.52 -5	.003	.000	2.77 -5	.226	.000
42	6.221 -6	.021	.000	4.08 -6	.201	.000	1.19 -5	.003	.000	2.22 -5	.226	.000
43	5.398 -6	.021	.000	3.13 -6	.201	.000	9.30 -6	.003	.000	1.78 -5	.226	.000
44	4.692 -6	.021	.000	2.40 -6	.201	.000	7.44 -6	.003	.000	1.45 -5	.226	.000
45	4.084 -6	.021	.000	1.83 -6	.201	.000	5.76 -6	.003	.000	1.17 -5	.226	.000
46	3.561 -6	.021	.000	1.41 -6	.201	.000	4.43 -6	.003	.000	9.43 -6	.226	.000
47	3.106 -6	.021	.000	1.08 -6	.201	.000	3.53 -6	.003	.000	7.72 -6	.226	.000
48	2.735 -6	.021	.000	8.28 -7	.201	.000	2.79 -6	.003	.000	6.35 -6	.226	.000
49	2.415 -6	.021	.000	6.32 -7	.201	.000	2.23 -6	.003	.000	5.28 -6	.226	.000
50	2.133 -6	.021	.000	4.84 -7	.201	.000	1.86 -6	.003	.000	4.48 -6	.226	.000

Table 4.16 Parameters at 0.90 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	1.593 -3	.000	.013	1.20 -1	.000	.190	0.	.000	.000	1.22 -1	.000	.203
1	1.436 -3	.002	.012	5.29 -2	.036	.103	0.	.000	.000	5.42 -2	.088	.115
2	1.300 -3	.003	.010	2.28 -2	.124	.056	0.	.000	.000	2.41 -2	.127	.076
3	1.175 -3	.004	.009	9.57 -3	.140	.049	0.	.000	.000	1.07 -2	.144	.059
4	1.059 -3	.005	.008	5.06 -3	.148	.042	0.	.000	.000	6.12 -3	.153	.050
5	9.514 -4	.006	.007	3.31 -3	.152	.038	0.	.000	.000	4.70 -3	.158	.045
6	8.528 -4	.007	.006	2.59 -3	.155	.034	0.	.000	.000	3.54 -3	.162	.041
7	7.622 -4	.008	.005	2.50 -3	.158	.032	0.	.000	.000	3.26 -3	.166	.037
8	6.733 -4	.009	.005	2.57 -3	.160	.029	0.	.000	.000	3.25 -3	.169	.034
9	6.034 -4	.009	.004	2.47 -3	.163	.027	0.	.000	.000	3.07 -3	.172	.031
10	5.342 -4	.010	.004	2.41 -3	.165	.024	0.	.000	.000	2.94 -3	.175	.028
11	4.713 -4	.010	.003	2.26 -3	.168	.022	0.	.000	.000	2.73 -3	.176	.025
12	4.030 -4	.011	.003	2.37 -3	.170	.020	0.	.000	.000	2.77 -3	.181	.022
13	3.444 -4	.011	.002	2.19 -3	.172	.017	0.	.000	.000	2.53 -3	.184	.020
14	2.944 -4	.011	.002	2.14 -3	.175	.015	0.	.000	.000	2.44 -3	.186	.017
15	2.515 -4	.012	.002	2.01 -3	.177	.013	0.	.000	.000	2.26 -3	.188	.015
16	2.151 -4	.012	.001	1.91 -3	.179	.011	0.	.000	.000	2.13 -3	.191	.013
17	1.838 -4	.012	.001	1.89 -3	.180	.009	0.	.000	.000	2.07 -3	.193	.010
18	1.572 -4	.012	.001	1.93 -3	.182	.007	0.	.000	.000	1.99 -3	.195	.008
19	1.344 -4	.013	.001	1.54 -3	.184	.006	0.	.000	.000	1.68 -3	.197	.007
20	1.149 -4	.013	.001	1.13 -3	.185	.004	0.	.000	.000	1.25 -3	.198	.005
21	9.781 -5	.013	.001	8.20 -4	.186	.003	0.	.000	.000	9.18 -4	.199	.004
22	8.334 -5	.013	.001	6.17 -4	.187	.003	0.	.000	.000	7.01 -4	.200	.003
23	7.105 -5	.013	.000	4.72 -4	.188	.002	0.	.000	.000	5.43 -4	.201	.003
24	6.054 -5	.013	.000	3.74 -4	.188	.002	0.	.000	.000	4.35 -4	.201	.002
25	5.179 -5	.013	.000	3.15 -4	.188	.001	0.	.000	.000	3.67 -4	.201	.002
26	4.425 -5	.013	.000	2.75 -4	.189	.001	0.	.000	.000	3.19 -4	.202	.001
27	3.785 -5	.013	.000	2.10 -4	.189	.001	0.	.000	.000	2.48 -4	.202	.001
28	3.240 -5	.013	.000	1.61 -4	.189	.001	0.	.000	.000	1.93 -4	.202	.001
29	2.775 -5	.013	.000	1.24 -4	.189	.000	0.	.000	.000	1.52 -4	.202	.001
30	2.378 -5	.013	.000	9.49 -5	.189	.000	0.	.000	.000	1.19 -4	.203	.001
31	2.040 -5	.013	.000	7.25 -5	.189	.000	0.	.000	.000	9.29 -5	.203	.000
32	1.751 -5	.013	.000	5.55 -5	.189	.000	0.	.000	.000	7.30 -5	.203	.000
33	1.495 -5	.013	.000	4.25 -5	.190	.000	0.	.000	.000	5.75 -5	.203	.000
34	1.277 -5	.013	.000	3.26 -5	.190	.000	0.	.000	.000	4.54 -5	.203	.000
35	1.093 -5	.013	.000	2.50 -5	.190	.000	0.	.000	.000	3.59 -5	.203	.000
36	9.376 -6	.013	.000	1.91 -5	.190	.000	0.	.000	.000	2.85 -5	.203	.000
37	8.055 -6	.013	.000	1.47 -5	.190	.000	0.	.000	.000	2.27 -5	.203	.000
38	6.933 -6	.013	.000	1.12 -5	.190	.000	0.	.000	.000	1.82 -5	.203	.000
39	5.977 -6	.013	.000	8.58 -6	.190	.000	0.	.000	.000	1.46 -5	.203	.000
40	5.162 -6	.013	.000	6.58 -6	.190	.000	0.	.000	.000	1.17 -5	.203	.000
41	4.465 -6	.013	.000	5.04 -6	.190	.000	0.	.000	.000	9.51 -6	.203	.000
42	3.867 -6	.013	.000	3.86 -6	.190	.000	0.	.000	.000	7.73 -6	.203	.000
43	3.353 -6	.013	.000	2.95 -6	.190	.000	0.	.000	.000	6.31 -6	.203	.000
44	2.919 -6	.013	.000	2.26 -6	.190	.000	0.	.000	.000	5.18 -6	.203	.000
45	2.540 -6	.013	.000	1.73 -6	.190	.000	0.	.000	.000	4.27 -6	.203	.000
46	2.214 -6	.013	.000	1.33 -6	.190	.000	0.	.000	.000	3.54 -6	.203	.000
47	1.933 -6	.013	.000	1.02 -6	.190	.000	0.	.000	.000	2.95 -6	.203	.000
48	1.701 -6	.013	.000	7.82 -7	.190	.000	0.	.000	.000	2.48 -6	.203	.000
49	1.502 -6	.013	.000	5.97 -7	.190	.000	0.	.000	.000	2.10 -6	.203	.000
50	1.327 -6	.013	.000	4.57 -7	.190	.000	0.	.000	.000	1.78 -6	.203	.000

Table 4.17 Parameters at 1.06 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	8.192 -4	.000	.007	1.13 -1	.000	.179	0.	.000	.000	1.14 -1	.000	.186
1	7.434 -4	.001	.006	4.97 -2	.081	.097	0.	.000	.000	5.04 -2	.082	.103
2	6.731 -4	.001	.005	2.15 -2	.117	.062	0.	.000	.000	2.21 -2	.118	.067
3	6.081 -4	.002	.005	9.01 -3	.132	.046	0.	.000	.000	9.32 -3	.134	.051
4	5.480 -4	.003	.004	4.75 -3	.139	.040	0.	.000	.000	5.31 -3	.142	.044
5	4.925 -4	.003	.004	3.59 -3	.143	.035	0.	.000	.000	4.08 -3	.146	.039
6	4.415 -4	.004	.003	2.53 -3	.146	.032	0.	.000	.000	2.97 -3	.150	.036
7	3.945 -4	.004	.003	2.35 -3	.149	.030	0.	.000	.000	2.75 -3	.153	.033
8	3.516 -4	.004	.002	2.42 -3	.151	.028	0.	.000	.000	2.78 -3	.155	.030
9	3.123 -4	.005	.002	2.32 -3	.153	.025	0.	.000	.000	2.64 -3	.158	.027
10	2.765 -4	.005	.002	2.27 -3	.156	.023	0.	.000	.000	2.54 -3	.161	.025
11	2.440 -4	.005	.002	2.12 -3	.158	.021	0.	.000	.000	2.37 -3	.163	.022
12	2.036 -4	.006	.001	2.23 -3	.160	.018	0.	.000	.000	2.44 -3	.166	.020
13	1.733 -4	.006	.001	2.06 -3	.162	.016	0.	.000	.000	2.24 -3	.168	.017
14	1.524 -4	.006	.001	2.02 -3	.164	.014	0.	.000	.000	2.17 -3	.170	.015
15	1.302 -4	.006	.001	1.90 -3	.166	.012	0.	.000	.000	2.03 -3	.172	.013
16	1.113 -4	.006	.001	1.80 -3	.168	.010	0.	.000	.000	1.91 -3	.174	.011
17	9.517 -5	.006	.001	1.73 -3	.170	.009	0.	.000	.000	1.88 -3	.176	.009
18	8.135 -5	.006	.001	1.72 -3	.172	.007	0.	.000	.000	1.80 -3	.178	.007
19	6.955 -5	.006	.000	1.45 -3	.173	.005	0.	.000	.000	1.52 -3	.180	.006
20	5.946 -5	.007	.000	1.07 -3	.175	.004	0.	.000	.000	1.13 -3	.181	.004
21	5.053 -5	.007	.000	7.72 -4	.175	.003	0.	.000	.000	8.23 -4	.182	.003
22	4.314 -5	.007	.000	5.81 -4	.176	.002	0.	.000	.000	6.25 -4	.183	.003
23	3.673 -5	.007	.000	4.45 -4	.177	.002	0.	.000	.000	4.82 -4	.183	.002
24	3.139 -5	.007	.000	3.53 -4	.177	.002	0.	.000	.000	3.84 -4	.184	.002
25	2.681 -5	.007	.000	2.97 -4	.177	.001	0.	.000	.000	3.24 -4	.184	.001
26	2.291 -5	.007	.000	2.59 -4	.178	.001	0.	.000	.000	2.82 -4	.184	.001
27	1.959 -5	.007	.000	1.38 -4	.178	.001	0.	.000	.000	2.18 -4	.185	.001
28	1.677 -5	.007	.000	1.52 -4	.178	.001	0.	.000	.000	1.68 -4	.185	.001
29	1.436 -5	.007	.000	1.17 -4	.178	.000	0.	.000	.000	1.31 -4	.185	.001
30	1.231 -5	.007	.000	8.94 -5	.178	.000	0.	.000	.000	1.02 -4	.185	.000
31	1.056 -5	.007	.000	6.83 -5	.178	.000	0.	.000	.000	7.89 -5	.185	.000
32	9.055 -6	.007	.000	5.23 -5	.178	.000	0.	.000	.000	6.13 -5	.185	.000
33	7.740 -6	.007	.000	4.01 -5	.178	.000	0.	.000	.000	4.78 -5	.185	.000
34	6.612 -6	.007	.000	3.07 -5	.179	.000	0.	.000	.000	3.73 -5	.185	.000
35	5.660 -6	.007	.000	2.35 -5	.179	.000	0.	.000	.000	2.92 -5	.185	.000
36	4.854 -6	.007	.000	1.80 -5	.179	.000	0.	.000	.000	2.29 -5	.185	.000
37	4.170 -6	.007	.000	1.38 -5	.179	.000	0.	.000	.000	1.80 -5	.185	.000
38	3.583 -6	.007	.000	1.36 -5	.179	.000	0.	.000	.000	1.42 -5	.185	.000
39	3.094 -6	.007	.000	8.08 -6	.179	.000	0.	.000	.000	1.12 -5	.186	.000
40	2.672 -6	.007	.000	6.19 -6	.179	.000	0.	.000	.000	8.87 -6	.186	.000
41	2.311 -6	.007	.000	4.75 -6	.179	.000	0.	.000	.000	7.05 -6	.186	.000
42	2.003 -6	.007	.000	3.63 -6	.179	.000	0.	.000	.000	5.54 -6	.186	.000
43	1.736 -6	.007	.000	2.78 -6	.179	.000	0.	.000	.000	4.52 -6	.186	.000
44	1.511 -6	.007	.000	2.13 -6	.179	.000	0.	.000	.000	3.64 -6	.186	.000
45	1.315 -6	.007	.000	1.63 -6	.179	.000	0.	.000	.000	2.95 -6	.186	.000
46	1.145 -6	.007	.000	1.25 -6	.179	.000	0.	.000	.000	2.40 -6	.186	.000
47	1.001 -6	.007	.000	9.56 -7	.179	.000	0.	.000	.000	1.96 -6	.186	.000
48	8.805 -7	.007	.000	7.37 -7	.179	.000	0.	.000	.000	1.62 -6	.186	.000
49	7.776 -7	.007	.000	5.62 -7	.179	.000	0.	.000	.000	1.34 -6	.186	.000
50	6.867 -7	.007	.000	4.31 -7	.179	.000	0.	.000	.000	1.12 -6	.186	.000

Table 4.18 Parameters at 1.26 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0 - h) τ_r	Rayleigh optical thick. (h - ∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0 - h) τ_p	Aerosol optical thick. (h - ∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0 - h) τ_3	Ozone optical thick. (h - ∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0 - h) τ_{ext}	Ext. optical thick. (h - ∞) τ_{ext}'
0	4.091 -4	.000	.003	1.08 -1	.000	.171	0.	.000	.000	1.08 -1	.000	.174
1	3.713 -4	.000	.003	4.75 -2	.078	.093	0.	.000	.000	4.79 -2	.078	.096
2	3.352 -4	.001	.003	2.05 -2	.112	.059	0.	.000	.000	2.08 -2	.113	.062
3	3.037 -4	.001	.002	8.51 -3	.125	.044	0.	.000	.000	8.92 -3	.127	.047
4	2.737 -4	[illegible]	.002	4.55 -3	.133	.038	0.	.000	.000	4.83 -3	.134	.040
5	2.450 -4	.002	.002	3.43 -3	.137	.034	0.	.000	.000	3.68 -3	.139	.036
6	2.205 -4	.002	.002	2.42 -3	.140	.031	0.	.000	.000	2.64 -3	.142	.033
7	1.971 -4	.002	.001	2.25 -3	.142	.029	0.	.000	.000	2.45 -3	.144	.030
8	1.755 -4	.002	.001	2.32 -3	.144	.026	0.	.000	.000	2.49 -3	.147	.026
9	1.560 -4	.002	.001	2.22 -3	.147	.024	0.	.000	.000	2.38 -3	.149	.025
10	1.381 -4	.003	.001	2.17 -3	.149	.022	0.	.000	.000	2.30 -3	.151	.023
11	1.213 -4	.003	.001	2.03 -3	.151	.020	0.	.000	.000	2.15 -3	.154	.021
12	1.042 -4	.003	.001	2.13 -3	.153	.018	0.	.000	.000	2.24 -3	.156	.018
13	8.904 -5	.003	.001	1.97 -3	.155	.016	0.	.000	.000	2.06 -3	.158	.016
14	7.610 -5	.003	.000	1.93 -3	.157	.014	0.	.000	.000	2.00 -3	.160	.014
15	5.504 -5	.003	.000	1.81 -3	.159	.012	0.	.000	.000	1.88 -3	.162	.012
16	5.560 -5	.003	.000	1.72 -3	.161	.010	0.	.000	.000	1.78 -3	.164	.010
17	4.753 -5	.003	.000	1.70 -3	.162	.008	0.	.000	.000	1.75 -3	.166	.009
18	4.063 -5	.003	.000	1.65 -3	.164	.007	0.	.000	.000	1.69 -3	.167	.007
19	3.473 -5	.003	.000	1.39 -3	.156	.005	0.	.000	.000	1.42 -3	.169	.005
20	2.969 -5	.003	.000	1.02 -3	.157	.004	0.	.000	.000	1.05 -3	.170	.004
21	2.529 -5	.003	.000	7.38 -4	.168	.003	0.	.000	.000	7.64 -4	.171	.003
22	2.155 -5	.003	.000	5.56 -4	.168	.002	0.	.000	.000	5.77 -4	.172	.003
23	1.837 -5	.003	.000	4.25 -4	.169	.002	0.	.000	.000	4.44 -4	.172	.002
24	1.558 -5	.003	.000	3.37 -4	.169	.002	0.	.000	.000	3.53 -4	.173	.002
25	1.339 -5	.003	.000	2.34 -4	.170	.001	0.	.000	.000	2.97 -4	.173	.001
26	1.144 -5	.003	.000	2.47 -4	.170	.001	0.	.000	.000	2.59 -4	.173	.001
27	9.785 -6	.003	.000	1.89 -4	.170	.001	0.	.000	.000	1.99 -4	.173	.001
28	8.375 -6	.003	.000	1.45 -4	.170	.001	0.	.000	.000	1.55 -4	.174	.001
29	7.173 -6	.003	.000	1.11 -4	.170	.000	0.	.000	.000	1.19 -4	.174	.000
30	6.149 -6	.003	.000	8.54 -5	.170	.000	0.	.000	.000	9.16 -5	.174	.000
31	5.274 -6	.003	.000	5.53 -5	.170	.000	0.	.000	.000	7.06 -5	.174	.000
32	4.527 -6	.003	.000	5.30 -5	.171	.000	0.	.000	.000	5.45 -5	.174	.000
33	3.855 -6	.003	.000	3.33 -5	.171	.000	0.	.000	.000	4.21 -5	.174	.000
34	3.302 -6	.003	.000	2.93 -5	.171	.000	0.	.000	.000	3.25 -5	.174	.000
35	2.627 -6	.003	.000	2.25 -5	.171	.000	0.	.000	.000	2.53 -5	.174	.000
36	2.424 -6	.003	.000	1.72 -5	.171	.000	0.	.000	.000	1.95 -5	.174	.000
37	2.082 -6	.003	.000	1.32 -5	.171	.000	0.	.000	.000	1.53 -5	.174	.000
38	1.792 -6	.003	.000	1.01 -5	.171	.000	0.	.000	.000	1.19 -5	.174	.000
39	1.545 -6	.003	.000	7.72 -6	.171	.000	0.	.000	.000	9.27 -6	.174	.000
40	1.334 -6	.003	.000	5.92 -6	.171	.000	0.	.000	.000	7.25 -6	.174	.000
41	1.154 -6	.003	.000	4.54 -6	.171	.000	0.	.000	.000	5.69 -6	.174	.000
42	1.003 -6	.003	.000	3.47 -6	.171	.000	0.	.000	.000	4.47 -6	.174	.000
43	8.683 -7	.003	.000	2.58 -6	.171	.000	0.	.000	.000	3.53 -6	.174	.000
44	7.544 -7	.003	.000	2.04 -6	.171	.000	0.	.000	.000	2.79 -6	.174	.000
45	6.557 -7	.003	.000	1.56 -6	.171	.000	0.	.000	.000	2.22 -6	.174	.000
46	5.725 -7	.003	.000	1.20 -6	.171	.000	0.	.000	.000	1.77 -6	.174	.000
47	4.993 -7	.003	.000	9.16 -7	.171	.000	0.	.000	.000	1.42 -6	.174	.000
48	4.393 -7	.003	.000	7.04 -7	.171	.000	0.	.000	.000	1.14 -6	.174	.000
49	3.854 -7	.003	.000	5.37 -7	.171	.000	0.	.000	.000	9.26 -7	.174	.000
50	3.430 -7	.003	.000	4.11 -7	.171	.000	0.	.000	.000	7.54 -7	.174	.000

Table 4.19 Parameters at 1.67 microns

Alt (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0 - h) τ_r	Rayleigh optical thick. (h - ∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0 - h) τ_p	Aerosol optical thick. (h - ∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0 - h) τ_3	Ozone optical thick. (h - ∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0 - h) τ_{ext}	Ext. optical thick. (h - ∞) τ_{ext}'
0	1.322 -4	.000	.001	9.30 -2	.000	.155	0.	.000	.000	9.81 -2	.000	.156
1	1.199 -4	.000	.001	4.31 -2	.071	.084	0.	.000	.000	4.32 -2	.071	.085
2	1.085 -4	.000	.001	1.35 -2	.101	.054	0.	.000	.000	1.87 -2	.102	.054
3	9.810 -5	.000	.001	7.32 -3	.115	.040	0.	.000	.000	7.91 -3	.115	.041
4	8.841 -5	.000	.001	4.13 -3	.121	.034	0.	.000	.000	4.22 -3	.121	.035
5	7.945 -5	.001	.001	3.11 -3	.124	.031	0.	.000	.000	3.19 -3	.125	.031
6	7.122 -5	.001	.001	2.20 -3	.127	.028	0.	.000	.000	2.27 -3	.127	.029
7	6.365 -5	.001	.000	2.04 -3	.129	.026	0.	.000	.000	2.10 -3	.130	.026
8	5.675 -5	.001	.000	2.10 -3	.131	.024	0.	.000	.000	2.15 -3	.132	.024
9	5.039 -5	.001	.000	2.02 -3	.133	.022	0.	.000	.000	2.07 -3	.134	.022
10	[illegible] -5	.001	.000	1.97 -3	.135	.020	0.	.000	.000	2.01 -3	.136	.020
11	[illegible] -5	.001	.000	1.84 -3	.137	.018	0.	.000	.000	1.89 -3	.138	.018
12	3.365 -5	.001	.000	1.74 -3	.139	.016	0.	.000	.000	1.77 -3	.140	.016
13	2.975 -5	.001	.000	1.79 -3	.141	.014	0.	.000	.000	1.82 -3	.142	.014
14	2.459 -5	.001	.000	1.75 -3	.143	.012	0.	.000	.000	1.77 -3	.143	.012
15	2.101 -5	.001	.000	1.64 -3	.144	.011	0.	.000	.000	1.65 -3	.145	.011
16	1.796 -5	.001	.000	1.55 -3	.146	.009	0.	.000	.000	1.55 -3	.147	.009
17	1.535 -5	.001	.000	1.54 -3	.147	.008	0.	.000	.000	1.56 -3	.148	.008
18	1.313 -5	.001	.000	1.49 -3	.149	.006	0.	.000	.000	1.51 -3	.150	.006
19	1.122 -5	.001	.000	1.26 -3	.150	.005	0.	.000	.000	1.27 -3	.151	.005
20	9.593 -6	.001	.000	9.24 -4	.151	.004	0.	.000	.000	9.34 -4	.152	.004
21	8.159 -6	.001	.000	6.70 -4	.152	.003	0.	.000	.000	6.78 -4	.153	.003
22	6.951 -6	.001	.000	5.04 -4	.153	.002	0.	.000	.000	5.11 -4	.154	.002
23	5.935 -6	.001	.000	3.86 -4	.153	.002	0.	.000	.000	3.92 -4	.154	.002
24	5.054 -6	.001	.000	3.06 -4	.154	.001	0.	.000	.000	3.11 -4	.155	.001
25	4.325 -6	.001	.000	2.57 -4	.154	.001	0.	.000	.000	2.62 -4	.155	.001
26	3.696 -6	.001	.000	2.25 -4	.154	.001	0.	.000	.000	2.28 -4	.155	.001
27	3.151 -6	.001	.000	1.72 -4	.154	.001	0.	.000	.000	1.75 -4	.155	.001
28	2.705 -6	.001	.000	1.31 -4	.154	.000	0.	.000	.000	1.34 -4	.155	.001
29	2.317 -6	.001	.000	1.01 -4	.155	.000	0.	.000	.000	1.03 -4	.156	.000
30	1.983 -6	.001	.000	7.75 -5	.155	.000	0.	.000	.000	7.95 -5	.155	.000
31	1.704 -6	.001	.000	5.92 -5	.155	.000	0.	.000	.000	6.09 -5	.156	.000
32	1.453 -6	.001	.000	4.53 -5	.155	.000	0.	.000	.000	4.68 -5	.155	.000
33	1.249 -6	.001	.000	3.47 -5	.155	.000	0.	.000	.000	3.60 -5	.156	.000
34	1.067 -6	.001	.000	2.66 -5	.155	.000	0.	.000	.000	2.77 -5	.156	.000
35	9.132 -7	.001	.000	2.04 -5	.155	.000	0.	.000	.000	2.13 -5	.155	.000
36	7.831 -7	.001	.000	1.56 -5	.155	.000	0.	.000	.000	1.64 -5	.156	.000
37	6.728 -7	.001	.000	1.20 -5	.155	.000	0.	.000	.000	1.26 -5	.156	.000
38	5.790 -7	.001	.000	9.13 -6	.155	.000	0.	.000	.000	9.70 -6	.156	.000
39	4.992 -7	.001	.000	7.01 -6	.155	.000	0.	.000	.000	7.51 -6	.156	.000
40	4.311 -7	.001	.000	5.37 -6	.155	.000	0.	.000	.000	5.80 -6	.155	.000
41	3.729 -7	.001	.000	4.12 -6	.155	.000	0.	.000	.000	4.49 -6	.155	.000
42	3.231 -7	.001	.000	3.15 -6	.155	.000	0.	.000	.000	3.47 -6	.155	.000
43	2.804 -7	.001	.000	2.41 -6	.155	.000	0.	.000	.000	2.69 -6	.155	.000
44	2.437 -7	.001	.000	1.85 -6	.155	.000	0.	.000	.000	2.09 -6	.155	.000
45	2.122 -7	.001	.000	1.41 -6	.155	.000	0.	.000	.000	1.63 -6	.155	.000
46	1.849 -7	.001	.000	1.09 -6	.155	.000	0.	.000	.000	1.27 -6	.156	.000
47	1.615 -7	.001	.000	8.31 -7	.155	.000	0.	.000	.000	9.93 -7	.156	.000
48	1.421 -7	.001	.000	6.39 -7	.155	.000	0.	.000	.000	7.81 -7	.155	.000
49	1.235 -7	.001	.000	4.88 -7	.155	.000	0.	.000	.000	6.13 -7	.156	.000
50	1.103 -7	.001	.000	3.73 -7	.155	.000	0.	.000	.000	4.84 -7	.156	.000

Table 4.20 Parameters at 2.17 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0 - h) τ_r	Rayleigh optical thick (h - ∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0 - h) τ_p	Aerosol optical thick. (h - ∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0 - h) τ_3	Ozone optical thick. (h - ∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0 - h) τ_{ext}	Ext. optical thick. (h - ∞) τ_{ext}'
0	4.629 -5	.000	.000	8.50 -2	.000	.134	0.	.000	.000	8.50 -2	.000	.135
1	4.200 -5	.000	.000	3.74 -2	.051	.073	0.	.000	.000	3.74 -2	.061	.074
2	3.803 -5	.000	.000	1.51 -2	.083	.046	0.	.000	.000	1.62 -2	.088	.047
3	3.436 -5	.000	.000	6.78 -3	.099	.035	0.	.000	.000	6.81 -3	.100	.035
4	3.096 -5	.000	.000	3.58 -3	.105	.030	0.	.000	.000	3.61 -3	.105	.030
5	2.783 -5	.000	.000	2.70 -3	.108	.027	0.	.000	.000	2.73 -3	.108	.027
6	2.494 -5	.000	.000	1.90 -3	.110	.024	0.	.000	.000	1.93 -3	.110	.025
7	2.229 -5	.000	.000	1.77 -3	.112	.022	0.	.000	.000	1.79 -3	.112	.023
8	1.987 -5	.000	.000	1.82 -3	.114	.021	0.	.000	.000	1.84 -3	.114	.021
9	1.765 -5	.000	.000	1.75 -3	.115	.019	0.	.000	.000	1.77 -3	.116	.019
10	1.562 -5	.000	.000	1.71 -3	.117	.017	0.	.000	.000	1.72 -3	.117	.017
11	1.378 -5	.000	.000	1.60 -3	.119	.016	0.	.000	.000	1.61 -3	.119	.016
12	1.179 -5	.000	.000	1.68 -3	.120	.014	0.	.000	.000	1.69 -3	.121	.014
13	1.007 -5	.000	.000	1.55 -3	.122	.012	0.	.000	.000	1.56 -3	.122	.012
14	8.609 -6	.000	.000	1.52 -3	.124	.011	0.	.000	.000	1.53 -3	.124	.011
15	7.359 -6	.000	.000	1.43 -3	.125	.009	0.	.000	.000	1.43 -3	.125	.009
16	6.290 -6	.000	.000	1.36 -3	.126	.008	0.	.000	.000	1.36 -3	.127	.008
17	5.377 -6	.000	.000	1.34 -3	.128	.007	0.	.000	.000	1.34 -3	.128	.007
18	4.598 -6	.000	.000	1.30 -3	.129	.005	0.	.000	.000	1.30 -3	.130	.005
19	3.929 -6	.000	.000	1.09 -3	.130	.004	0.	.000	.000	1.10 -3	.131	.004
20	3.359 -6	.000	.000	8.02 -4	.131	.003	0.	.000	.000	8.05 -4	.132	.003
21	2.851 -6	.000	.000	5.31 -4	.132	.002	0.	.000	.000	5.34 -4	.132	.002
22	2.433 -6	.000	.000	4.37 -4	.132	.002	0.	.000	.000	4.40 -4	.133	.002
23	2.073 -6	.000	.000	3.35 -4	.133	.001	0.	.000	.000	3.37 -4	.133	.002
24	1.774 -6	.000	.000	2.55 -4	.133	.001	0.	.000	.000	2.57 -4	.134	.001
25	1.515 -6	.000	.000	2.23 -4	.133	.001	0.	.000	.000	2.25 -4	.134	.001
26	1.294 -6	.000	.000	1.95 -4	.134	.001	0.	.000	.000	1.95 -4	.134	.001
27	1.107 -6	.000	.000	1.49 -4	.134	.001	0.	.000	.000	1.50 -4	.134	.001
28	9.475 -7	.000	.000	1.14 -4	.134	.000	0.	.000	.000	1.15 -4	.134	.000
29	8.115 -7	.000	.000	8.77 -5	.134	.000	0.	.000	.000	8.85 -5	.134	.000
30	6.956 -7	.000	.000	6.72 -5	.134	.000	0.	.000	.000	6.79 -5	.135	.000
31	5.937 -7	.000	.000	5.14 -5	.134	.000	0.	.000	.000	5.20 -5	.135	.000
32	5.122 -7	.000	.000	3.93 -5	.134	.000	0.	.000	.000	3.98 -5	.135	.000
33	4.373 -7	.000	.000	3.01 -5	.134	.000	0.	.000	.000	3.06 -5	.135	.000
34	3.735 -7	.000	.000	2.31 -5	.134	.000	0.	.000	.000	2.35 -5	.135	.000
35	3.193 -7	.000	.000	1.77 -5	.134	.000	0.	.000	.000	1.80 -5	.135	.000
36	2.742 -7	.000	.000	1.35 -5	.134	.000	0.	.000	.000	1.38 -5	.135	.000
37	2.356 -7	.000	.000	1.04 -5	.134	.000	0.	.000	.000	1.06 -5	.135	.000
38	2.023 -7	.000	.000	7.96 -6	.134	.000	0.	.000	.000	8.15 -6	.135	.000
39	1.748 -7	.000	.000	6.08 -6	.134	.000	0.	.000	.000	6.25 -6	.135	.000
40	1.510 -7	.000	.000	4.65 -6	.134	.000	0.	.000	.000	4.81 -6	.135	.000
41	1.305 -7	.000	.000	3.57 -6	.134	.000	0.	.000	.000	3.70 -6	.135	.000
42	1.132 -7	.000	.000	2.73 -6	.134	.000	0.	.000	.000	2.85 -6	.135	.000
43	9.820 -8	.000	.000	2.09 -6	.134	.000	0.	.000	.000	2.19 -6	.135	.000
44	8.535 -8	.000	.000	1.60 -6	.134	.000	0.	.000	.000	1.69 -6	.135	.000
45	7.429 -8	.000	.000	1.23 -6	.134	.000	0.	.000	.000	1.30 -6	.135	.000
46	6.477 -8	.000	.000	9.41 -7	.134	.000	0.	.000	.000	1.01 -6	.135	.000
47	5.654 -8	.000	.000	7.21 -7	.134	.000	0.	.000	.000	7.77 -7	.135	.000
48	4.975 -8	.000	.000	5.54 -7	.134	.000	0.	.000	.000	6.04 -7	.135	.000
49	4.304 -8	.000	.000	4.23 -7	.134	.000	0.	.000	.000	4.67 -7	.135	.000
50	3.930 -8	.000	.000	3.24 -7	.134	.000	0.	.000	.000	3.63 -7	.135	.000

Table 4.21 Parameters at 3.50 microns

Alt. (km) h	Rayleigh atten. coeff. (km^{-1}) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km^{-1}) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km^{-1}) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km^{-1}) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	6.829 -6	.000	.000	7.00 -2	.000	.111	0.	.000	.000	7.00 -2	.000	.111
1	6.197 -6	.000	.000	3.08 -2	.050	.060	0.	.000	.000	3.09 -2	.050	.060
2	5.611 -6	.000	.000	1.33 -2	.072	.038	0.	.000	.000	1.33 -2	.072	.038
3	5.069 -6	.000	.000	5.56 -3	.082	.029	0.	.000	.000	5.59 -3	.082	.029
4	4.553 -6	.000	.000	2.95 -3	.086	.025	0.	.000	.000	2.96 -3	.086	.025
5	4.106 -6	.000	.000	2.22 -3	.089	.022	0.	.000	.000	2.23 -3	.089	.022
6	3.690 -6	.000	.000	1.57 -3	.091	.020	0.	.000	.000	1.57 -3	.091	.020
7	3.289 -6	.000	.000	1.45 -3	.092	.019	0.	.000	.000	1.46 -3	.092	.019
8	2.931 -6	.000	.000	1.50 -3	.094	.017	0.	.000	.000	1.50 -3	.094	.017
9	2.604 -6	.000	.000	1.44 -3	.095	.016	0.	.000	.000	1.44 -3	.095	
10	2.335 -6	.000	.000	1.40 -3	.097	.014	0.	.000	.000	1.41 -3	.097	
11	2.034 -6	.000	.000	1.32 -3	.098	.013	0.	.000	.000	1.32 -3	.098	
12	1.739 -6	.000	.000	1.38 -3	.099	.011	0.	.000	.000	1.38 -3	.099	.011
13	1.486 -6	.000	.000	1.28 -3	.101	.010	0.	.000	.000	1.28 -3	.101	.010
14	1.270 -6	.000	.000	1.25 -3	.102	.009	0.	.000	.000	1.25 -3	.102	.009
15	1.085 -6	.000	.000	1.17 -3	.103	.008	0.	.000	.000	1.18 -3	.103	.008
16	9.291 -7	.000	.000	1.12 -3	.104	.006	0.	.000	.000	1.12 -3	.104	.006
17	7.933 -7	.000	.000	1.10 -3	.105	.005	0.	.000	.000	1.10 -3	.105	.005
18	6.782 -7	.000	.000	1.07 -3	.106	.004	0.	.000	.000	1.07 -3	.106	.004
19	5.798 -7	.000	.000	8.99 -4	.107	.003	0.	.000	.000	9.00 -4	.107	.003
20	4.957 -7	.000	.000	6.50 -4	.108	.003	0.	.000	.000	6.51 -4	.108	.003
21	4.221 -7	.000	.000	4.75 -4	.109	.002	0.	.000	.000	4.73 -4	.109	.002
22	3.590 -7	.000	.000	3.50 -4	.109	.002	0.	.000	.000	3.51 -4	.109	.002
23	3.065 -7	.000	.000	2.75 -4	.109	.001	0.	.000	.000	2.76 -4	.109	.001
24	2.617 -7	.000	.000	2.18 -4	.110	.001	0.	.000	.000	2.19 -4	.110	.001
25	2.235 -7	.000	.000	1.84 -4	.110	.001	0.	.000	.000	1.84 -4	.110	.001
26	1.910 -7	.000	.000	1.60 -4	.110	.001	0.	.000	.000	1.61 -4	.110	.001
27	1.633 -7	.000	.000	1.23 -4	.110	.000	0.	.000	.000	1.23 -4	.110	.000
28	1.398 -7	.000	.000	9.39 -5	.110	.000	0.	.000	.000	9.41 -5	.110	.000
29	1.197 -7	.000	.000	7.22 -5	.110	.000	0.	.000	.000	7.23 -5	.110	.000
30	1.025 -7	.000	.000	5.54 -5	.110	.000	0.	.000	.000	5.55 -5	.111	.000
31	8.904 -8	.000	.000	4.23 -5	.110	.000	0.	.000	.000	4.24 -5	.111	.000
32	7.557 -8	.000	.000	3.24 -5	.111	.000	0.	.000	.000	3.25 -5	.111	.000
33	6.452 -8	.000	.000	2.48 -5	.111	.000	0.	.000	.000	2.49 -5	.111	.000
34	5.512 -8	.000	.000	1.90 -5	.111	.000	0.	.000	.000	1.91 -5	.111	.000
35	4.718 -8	.000	.000	1.40 -5	.111	.000	0.	.000	.000	1.40 -5	.111	.000
36	4.046 -8	.000	.000	1.12 -5	.111	.000	0.	.000	.000	1.12 -5	.111	.000
37	3.476 -8	.000	.000	8.55 -6	.111	.000	0.	.000	.000	8.59 -6	.111	.000
38	2.992 -8	.000	.000	6.55 -6	.111	.000	0.	.000	.000	6.59 -6	.111	.000
39	2.579 -8	.000	.000	5.01 -6	.111	.000	0.	.000	.000	5.03 -6	.111	.000
40	2.228 -8	.000	.000	3.84 -6	.111	.000	0.	.000	.000	3.85 -6	.111	.000
41	1.927 -8	.000	.000	2.94 -6	.111	.000	0.	.000	.000	2.96 -6	.111	.000
42	1.670 -8	.000	.000	2.25 -6	.111	.000	0.	.000	.000	2.27 -6	.111	.000
43	1.449 -8	.000	.000	1.72 -6	.111	.000	0.	.000	.000	1.74 -6	.111	.000
44	1.259 -8	.000	.000	1.32 -6	.111	.000	0.	.000	.000	1.33 -6	.111	.000
45	1.095 -8	.000	.000	1.01 -6	.111	.000	0.	.000	.000	1.02 -6	.111	.000
46	9.555 -9	.000	.000	7.75 -7	.111	.000	0.	.000	.000	7.85 -7	.111	.000
47	8.343 -9	.000	.000	5.94 -7	.111	.000	0.	.000	.000	6.02 -7	.111	.000
48	7.340 -9	.000	.000	4.55 -7	.111	.000	0.	.000	.000	4.54 -7	.111	.000
49	6.432 -9	.000	.000	3.49 -7	.111	.000	0.	.000	.000	3.55 -7	.111	.000
50	5.725 -9	.000	.000	2.67 -7	.111	.000	0.	.000	.000	2.72 -7	.111	.000

Table 4.22 Parameters at 4.00 microns

Alt. (km) h	Rayleigh atten. coeff. (km⁻¹) β_r	Rayleigh optical thick. (0-h) τ_r	Rayleigh optical thick. (h-∞) τ_r'	Aerosol atten. coeff. (km⁻¹) β_p	Aerosol optical thick. (0-h) τ_p	Aerosol optical thick. (h-∞) τ_p'	Ozone absorp. coeff. (km⁻¹) β_3	Ozone optical thick. (0-h) τ_3	Ozone optical thick. (h-∞) τ_3'	Ext. coeff. (km⁻¹) β_{ext}	Ext. optical thick. (0-h) τ_{ext}	Ext. optical thick. (h-∞) τ_{ext}'
0	4.002 -5	.000	.000	6.30 -2	.000	.100	0.	.000	.000	6.30 -2	.000	.100
1	3.532 -5	.000	.000	2.77 -2	.045	.054	0.	.000	.000	2.77 -2	.045	.054
2	3.283 -5	.000	.000	1.20 -2	.065	.034	0.	.000	.000	1.20 -2	.065	.034
3	2.971 -6	.000	.000	5.02 -3	.074	.026	0.	.000	.000	5.03 -3	.074	.026
4	2.677 -6	.000	.000	2.55 -3	.078	.022	0.	.000	.000	2.55 -3	.078	.022
5	2.405 -5	.000	.000	2.00 -3	.080	.020	0.	.000	.000	2.00 -3	.080	.020
6	2.157 -6	.000	.000	1.41 -3	.082	.018	0.	.000	.000	1.41 -3	.082	.018
7	1.923 -6	.000	.000	1.31 -3	.083	.017	0.	.000	.000	1.31 -3	.083	.017
8	1.713 -6	.000	.000	1.35 -3	.084	.015	0.	.000	.000	1.35 -3	.084	.015
9	1.526 -6	.000	.000	1.30 -3	.086	.014	0.	.000	.000	1.30 -3	.086	.014
10	1.351 -6	.000	.000	1.25 -3	.087	.013	0.	.000	.000	1.27 -3	.087	.013
11	1.192 -5	.000	.000	1.18 -3	.088	.012	0.	.000	.000	1.19 -3	.088	.012
12	1.019 -6	.000	.000	1.24 -3	.089	.010	0.	.000	.000	1.25 -3	.089	.010
13	8.710 -7	.000	.000	1.15 -3	.090	.009	0.	.000	.000	1.15 -3	.091	.009
14	7.445 -7	.000	.000	1.12 -3	.092	.008	0.	.000	.000	1.13 -3	.092	.008
15	6.363 -7	.000	.000	1.06 -3	.093	.007	0.	.000	.000	1.06 -3	.093	.007
16	5.439 -7	.000	.000	1.00 -3	.094	.006	0.	.000	.000	1.01 -3	.094	.006
17	4.543 -7	.000	.000	9.93 -4	.095	.005	0.	.000	.000	9.93 -4	.095	.005
18	3.974 -7	.000	.000	9.51 -4	.096	.004	0.	.000	.000	9.61 -4	.096	.004
19	3.393 -7	.000	.000	8.09 -4	.097	.003	0.	.000	.000	8.10 -4	.097	.003
20	2.905 -7	.000	.000	5.94 -4	.097	.002	0.	.000	.000	5.94 -4	.097	.002
21	2.474 -7	.000	.000	4.31 -4	.098	.002	0.	.000	.000	4.31 -4	.098	.002
22	2.108 -7	.000	.000	3.24 -4	.098	.001	0.	.000	.000	3.24 -4	.098	.001
23	1.797 -7	.000	.000	2.49 -4	.098	.001	0.	.000	.000	2.48 -4	.099	.001
24	1.534 -7	.000	.000	1.97 -4	.099	.001	0.	.000	.000	1.97 -4	.099	.001
25	1.310 -7	.000	.000	1.55 -4	.099	.001	0.	.000	.000	1.60 -4	.099	.001
26	1.119 -7	.000	.000	1.44 -4	.099	.001	0.	.000	.000	1.44 -4	.099	.001
27	9.572 -8	.000	.000	1.10 -4	.099	.000	0.	.000	.000	1.11 -4	.099	.000
28	8.193 -8	.000	.000	9.45 -5	.099	.000	0.	.000	.000	8.45 -5	.099	.000
29	7.017 -8	.000	.000	6.50 -5	.099	.000	0.	.000	.000	6.51 -5	.099	.000
30	6.015 -8	.000	.000	4.35 -5	.099	.000	0.	.000	.000	4.39 -5	.099	.000
31	5.159 -8	.000	.000	3.81 -5	.099	.000	0.	.000	.000	3.81 -5	.099	.000
32	4.429 -8	.000	.000	2.91 -5	.099	.000	0.	.000	.000	2.92 -5	.100	.000
33	3.731 -8	.000	.000	2.23 -5	.100	.000	0.	.000	.000	2.24 -5	.100	.000
34	3.230 -8	.000	.000	1.71 -5	.100	.000	0.	.000	.000	1.71 -5	.100	.000
35	2.765 -8	.000	.000	1.31 -5	.100	.000	0.	.000	.000	1.31 -5	.100	.000
36	2.371 -8	.000	.000	1.00 -5	.100	.000	0.	.000	.000	1.01 -5	.100	.000
37	2.037 -8	.000	.000	7.70 -6	.100	.000	0.	.000	.000	7.72 -6	.100	.000
38	1.753 -8	.000	.000	5.90 -6	.100	.000	0.	.000	.000	5.92 -6	.100	.000
39	1.512 -8	.000	.000	4.51 -6	.100	.000	0.	.000	.000	4.52 -6	.100	.000
40	1.305 -8	.000	.000	3.45 -6	.100	.000	0.	.000	.000	3.47 -6	.100	.000
41	1.127 -8	.000	.000	2.65 -6	.100	.000	0.	.000	.000	2.65 -6	.100	.000
42	9.784 -9	.000	.000	2.03 -6	.100	.000	0.	.000	.000	2.04 -6	.100	.000
43	8.491 -9	.000	.000	1.55 -6	.100	.000	0.	.000	.000	1.56 -6	.100	.000
44	7.380 -9	.000	.000	1.19 -6	.100	.000	0.	.000	.000	1.20 -6	.100	.000
45	6.424 -9	.000	.000	9.09 -7	.100	.000	0.	.000	.000	9.16 -7	.100	.000
46	5.600 -9	.000	.000	6.94 -7	.100	.000	0.	.000	.000	7.03 -7	.100	.000
47	4.889 -9	.000	.000	5.34 -7	.100	.000	0.	.000	.000	5.39 -7	.100	.000
48	4.302 -9	.000	.000	4.11 -7	.100	.000	0.	.000	.000	4.15 -7	.100	.000
49	3.733 -9	.000	.000	3.13 -7	.100	.000	0.	.000	.000	3.17 -7	.100	.000
50	3.355 -9	.000	.000	2.40 -7	.100	.000	0.	.000	.000	2.43 -7	.100	.000

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13. ABSTRACT

An atmospheric attenuation model for the ultraviolet, visible, and infrared was developed in 1964, based on scattering (molecules and aerosols) and ozone absorption. Since then more measurements have been made and our knowledge of aerosol attenuation has widened. These circumstances result in attenuation model changes which are relatively unimportant for most exploratory calculations. They can be significant, however, for long slant-path high-altitude applications entailing large zenith angles, factors which characterize, for example, the measurement geometries of rockets and satellites. Accordingly, a revision of the 1964 Attenuation Model is warranted.

In this paper the optical parameters are computed spectrally and with altitude as follows: (1) pure air attenuation parameters are determined by utilizing Rayleigh scattering cross sections with molecular number densities from the standard atmosphere; (2) ozone absorption parameters are derived based on Vigroux's coefficients applied to a representative atmospheric ozone distribution; (3) seven sets of aerosol measurements are compared and a profile of aerosol attenuation coefficients vs altitude is developed. Attenuation coefficients and optical thickness due to molecular, aerosol, and ozone attenuation are computed and tabulated individually so that the influence of each can be compared. The newly derived tabulations permit various exploratory calculations, including horizontal, vertical, and slant-path transmission at kilometer intervals to an altitude of 50 km, individually for each attenuating component or for overall atmospheric extinction (molecular + ozone + aerosol).

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	ROLE	WT	ROLE	WT	ROLE	WT
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Visible atmospheric transmission						
IR atmospheric transmission						
Aerosol atmospheric attenuation						
Transmission in troposphere and stratosphere						
Aerosol attenuation in troposphere and stratosphere						
Model atmosphere						
Light scattering						

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