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Models for the Aerosols of the Lower Atmosphere and the Effects of Humidity Variations on Their Optical Properties

ERIC P. SHETTLE
ROBERT W. FENN

20 September 1979

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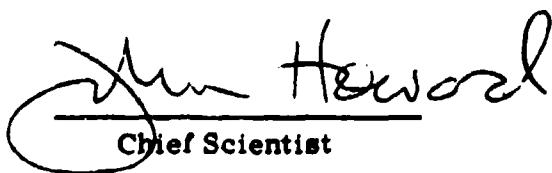
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John Heward
Chief Scientist

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presented together with a review of their experimental basis. The optical properties of these models are discussed and some comparisons of the model with experimental measurements are presented.

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Preface

We would like to thank several individuals who helped with this report, in particular: Fred Volz for his advice on the aerosol refractive indices and his general comments on the aerosol models, Frank Gibson for his work in developing the Fog Models, and Barry Siegel for his assistance with the computer programming.

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Models for the Aerosols of the Lower Atmosphere and the Effects of Humidity Variations on Their Optical Properties

I. INTRODUCTION

Propagation of electromagnetic radiation at optical/infrared frequencies through the atmosphere is affected by absorption and scattering by air molecules and by particulate matter (haze, dust, fog, and cloud droplets) suspended in the air. Scattering and absorption by haze particles or aerosols becomes the dominant factor in the boundary layer near the earth's surface, especially under low visibility conditions.

Atmospheric aerosol particles in the atmosphere vary greatly in their concentration, size, and composition, and consequently in their effects on optical and IR radiation.

There are many scientific and technical reasons why it is necessary to develop models for atmospheric aerosols. They are needed to make estimates of the transmittance, of angular light scattering distribution, of contrast reduction, sky radiance, or other atmospheric optical properties or effects.

Models for the optical properties of aerosols have been developed previously at AFGL and elsewhere.^{1-7*} For the lower layer near the earth's surface, these models define an average continental type aerosol whose concentration can be scaled according to surface visibility.

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*Due to the large number of references cited in this report, they will not be footnoted. See References, pages 89 through 94.

The aerosol properties in these models were based on experimental measurements that were made during and prior to the mid-1960's. At that time there was sufficient experimental data available to define an average aerosol model with some different haze concentrations in the lower troposphere (up to a few km altitude) with exponential vertical decrease in particle concentration.

During the past decade, in this country and elsewhere, extensive additional measurements from ground as well as airborne platforms have been made of aerosol concentrations, their size distribution, and optical properties, to warrant the development of updated aerosol models that also describe some of the temporal and spatial variations in atmospheric aerosol distributions and properties. There are now sufficient experimental data to develop models for several different types of tropospheric aerosols, including the dependence of the aerosol properties on relative humidity.

Such updated models have been developed by Shettle and Fenn⁸ and Toon and Pollack,⁹ except both of these sets of models neglect the effects of relative humidity. The present report describes aerosol models for the lower atmosphere and their optical properties including a discussion of how the aerosol properties change as a function of relative humidity. The optical properties of the models are given for a number of wavelengths between 0.2 and 40 μ m, and for several different relative humidities ranging from 0 to 99 percent. In addition four fog models are given for the droplet-condensation phase.

The models of the atmospheric aerosols and their optical properties presented below are based on a review of the available data on the nature of the aerosols, their sizes, their distribution, and variability. However, it must be emphasized that these models represent only a simple, generalized version of typical conditions. It is not practical to include all the details of natural aerosol distributions nor are existing experimental data sufficient to describe the frequency of occurrence of the different conditions. While these aerosol models were developed to be as representative as possible of different atmospheric conditions, the following point should be kept in mind when using any such model: Given the natural variability of the atmospheric aerosols almost any aerosol model is supported by some measurements and no model (or set of models) will be consistent with all measurements.

2. MODELS FOR THE PHYSICAL PROPERTIES OF THE AEROSOLS

2.1 Model Size Distribution

The size distributions for the different aerosol models are represented by one or the sum of two log-normal distributions:

$$n(r) = \frac{dN(r)}{dr} = \sum_{i=1}^2 \left(\frac{N_i}{\ln(10) \cdot r \cdot \sigma_i \sqrt{2\pi}} \right) \exp \left[-\frac{(\log r - \log r_i)^2}{2\sigma_i^2} \right]^* \quad (1)$$

where $N(r)$ is the cumulative number density of particles of radius r ; σ is the standard deviation; r_i , N_i are the mode radius and the number density with r_i . This form of distribution function represents the multimodal nature of the atmospheric aerosols that has been discussed in various studies.¹⁰⁻¹⁴ While Harris and McCormick¹⁵ have suggested using the sum of four log-normal distributions and Davies¹⁶ has used the sum of as many as seven log-normal distributions to fit a measured aerosol size distribution, Whitby and Cantrell¹⁷ have shown that two modes are generally adequate to characterize the gross features of most aerosol distributions. While a third component is often necessary to represent the Aitken nuclei especially near sources of combustion particulates, their effect on the optical properties is small and will be neglected.

There are measurements showing the composition of the atmospheric particulates depending on their size,^{18, 19} and using a bimodal size distribution offers the possibility of treating the composition of the individual modes separately. However, there is, in general, insufficient experimental data to uniquely define different refractive index models for the different size ranges, along with differing dependence on relative humidity.

For the maritime conditions, there is evidence²⁰ showing that the large particles are almost exclusively of oceanic origin and the smaller particles are predominantly of the same composition as the continental aerosols so that we do not differentiate between the two size ranges in terms of their composition.

Four different aerosol models for the atmospheric boundary layer near the earth's surface have been developed. They differ in particle size distribution and particle refractive index. Table 1 lists the parameters defining the size distributions in accordance with Eq. (1) for these models.

The choices of N in Table 1 are normalized to correspond to 1 particle/cm³. The actual size distributions can be re-normalized to give the correct extinction coefficients for the altitude and for the visibility being used. The continental and oceanic components of the maritime model can be used in various proportions depending on the prevailing winds—particularly in coastal regions. The basis for the characterization of each of the aerosol models is discussed in Sections 2.3 through 2.6.

*Following the usual convention, log is the logarithm to the base 10 and ln is the logarithm to the base e.

Table 1. Characteristics of the Aerosol Models of the Lower Atmosphere

Aerosol Model	Size Distribution			Type
	N_1	r_1^*	σ_1	
RURAL	0.999875	0.03	0.35	Mixture of Water-Soluble and Dust-Like Aerosols
	0.000125	0.5	0.4	
URBAN	0.999875	0.03	0.35	Rural Aerosol Mixture with Soot-Like Aerosols
	0.000125	0.5	0.4	
MARITIME Continental Origin	1.	0.03	0.35	Rural Aerosol Mixture
	1.	0.3	0.4	Sea Salt Solution in Water
TROPOSPHERIC	1.	0.03	0.35	Rural Aerosol Mixture

*These mode radii correspond to moderate humidities (70 to 80%); values of r_1 as function of humidity are given in Table 2.

Table 2. Mode Radii for the Aerosol Models as a Function of Relative Humidity

Relative Humidity	Tropospheric		Rural		Maritime	Urban	
	r_1	r_2	r_1	r_2		r_1	r_2
0%	0.02700	0.02700	0.4300	0.1800	0.02500	0.4000	
50%	0.02748	0.02748	0.4377	0.1711	0.02563	0.4113	
70%	0.02848	0.02848	0.4571	0.2041	0.02911	0.4777	
80%	0.03274	0.03274	0.5477	0.3180	0.03514	0.5805	
90%	0.03884	0.03884	0.6462	0.3803	0.04187	0.7061	
95%	0.04238	0.04238	0.7078	0.4606	0.04904	0.8634	
98%	0.04751	0.04751	0.9728	0.6024	0.05996	1.1691	
99%	0.05215	0.05215	1.1755	0.7505	0.06847	1.4858	

2.2 Effects of Humidity Variations on Aerosol Properties

As the relative humidity increases, water vapor condenses out of the atmosphere onto the particulates suspended in the atmosphere. This condensed water increases the size of the aerosols and changes their composition and their effective refractive index. The resulting effect of the aerosols on the absorption and scattering of light will correspondingly be modified. There have been a number of studies of the change of aerosol properties as a function of relative humidity.²¹⁻²⁸ The most comprehensive of these, especially in terms of the resulting effects on the aerosol optical properties is the work of Hänel.²⁶⁻²⁸

The change in the particulate size is related to the relative humidity by (following H  nel's notation)

$$r(a_w) = r_o \left[1 + \rho \cdot \frac{m_w(a_w)}{m_o} \right]^{1/3} \quad (2)$$

where

r_o is the dry particle radius,
 ρ is the particle density relative to that of water,
 $m_w(a_w)$ is the mass of condensed water,
 m_o is the dry particle mass, and
 a_w is the water activity which is essentially the relative humidity f , corrected for curvature of the particle surface.

$$a_w = f \cdot \exp \left(\frac{-2\sigma V_w}{R_w \cdot T \cdot r} \right) \quad (3)$$

where

σ = surface tension on the wet particle surface,
 V_w = specific volume of water,
 R_w = specific gas constant for water,
 T = absolute temperature (°K).

For room temperature ($T = 298^{\circ}\text{K}$),

$$\frac{2\sigma V_w}{R_w T} \approx 0.001056 \text{ [micron]} \text{ (H  nel, }^{28} \text{ page 126).}$$

Typical atmospheric temperatures are as much as 20 percent lower but, for particle radii $r > 0.01 \mu\text{m}$, this leads to errors of less than 2 percent in curvature effect so Eq. (3) can be rewritten as

$$a_w = f \cdot \exp \left(\frac{-0.001056}{r(a_w)} \right), \quad (4)$$

where r is in μm and where the dependence of r on a_w has been made explicit.

There are a number of studies on change in size or mass of aerosol particles as a function of relative humidity for various electrolytes^{21, 25} and natural atmospheric particulates.^{11, 12, 15, 17, 18, 19, 22, 23, 26, 28, 29, 30} H  nel²⁸ (in his Table IV) has tabulated his and other measurements of $\frac{m_w(a_w)}{m_o}$ vs a_w for various types of

natural aerosols. However, even with this data on the relative mass of condensed water for use in Eq. (2), it is not possible to combine Eq. (2) and (4) into an exact analytic expression giving aerosol radius, r , as an explicit function of relative humidity, because a_w appears on both sides of Eq. (4). Various approximations have been developed.^{25, 28, 31} However, these tend to breakdown for small particle sizes and high humidities.

To avoid the limitations of these approximations, Eq. (2) and (4) were used alternately in an iterative manner until they converged (typically 5 or 6 iterations) starting with a_w^i on the right side of Eq. (2). Starting with $r = r_o$ in Eq. (4) leads to the same result. To interpolate between Hänel's²⁸ data for different water activities, a_w^i and a_w^{i+1} , it was assumed that

$$\frac{m_w(a_w^i)}{m_w(a_w^{i+1})} \approx \left(\frac{1-a_w^i}{1-a_w^{i+1}} \right)^{\nu_1}. \quad (5)$$

Once the wet aerosol particle size is found from Eq. (2) and (4), the effective complex refractive index, n , is simply the volume weighted average of the refractive indexes of the dry aerosol substance, n_o , and water, n_w . Equivalently, this can be written as

$$n = n_w + (n_o - n_w) \cdot \left[\frac{r_o}{r(a_w)} \right]^3. \quad (6)$$

For the refractive index of water, the survey of Hale and Querry³² was used. While there are some minor differences between the optical constants in Hale and Querry's survey and the more recent measurements^{33, 34} these differences are comparable with the experimental errors and are small compared with the other uncertainties in the model parameters. These refractive index data are shown in Figure 1.

2.3 Rural Aerosol Model

The "Rural Model" is intended to represent the aerosol under conditions where it is not directly influenced by urban and/or industrial aerosol sources. The rural aerosols are assumed to be composed of a mixture of 70 percent of water soluble substance (ammonium and calcium sulfate and also organic compounds) and 30 percent dust-like aerosols. The refractive index for these components based on the measurements of Volz^{35, 36} is shown in Figure 2 and tabulated in Table 3. These refractive index data weighted by the mixing ratio of the two components are consistent with other direct measurements,^{37, 38} and with values inferred from in situ measurements.³⁹⁻⁴¹

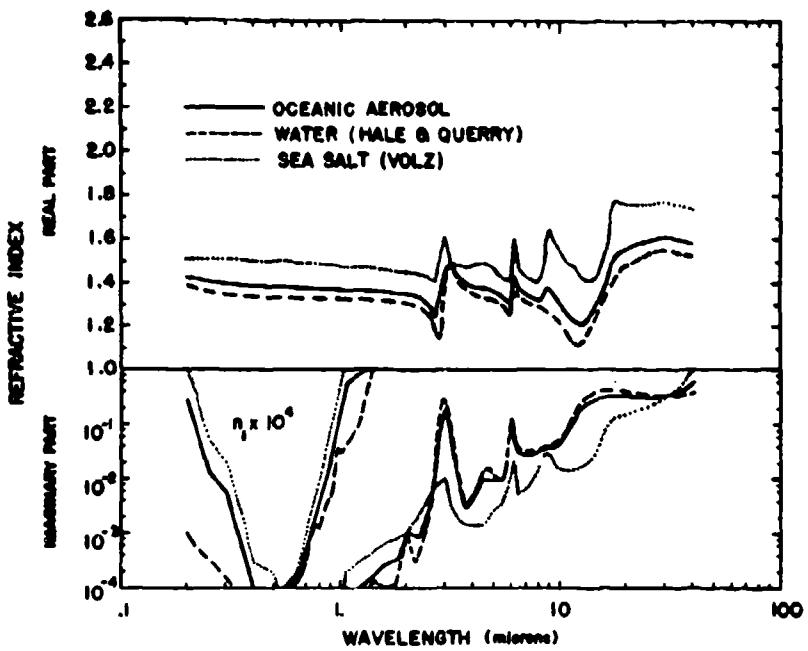


Figure 1. Refractive Index of Oceanic Aerosol, Water, and Sea Salt

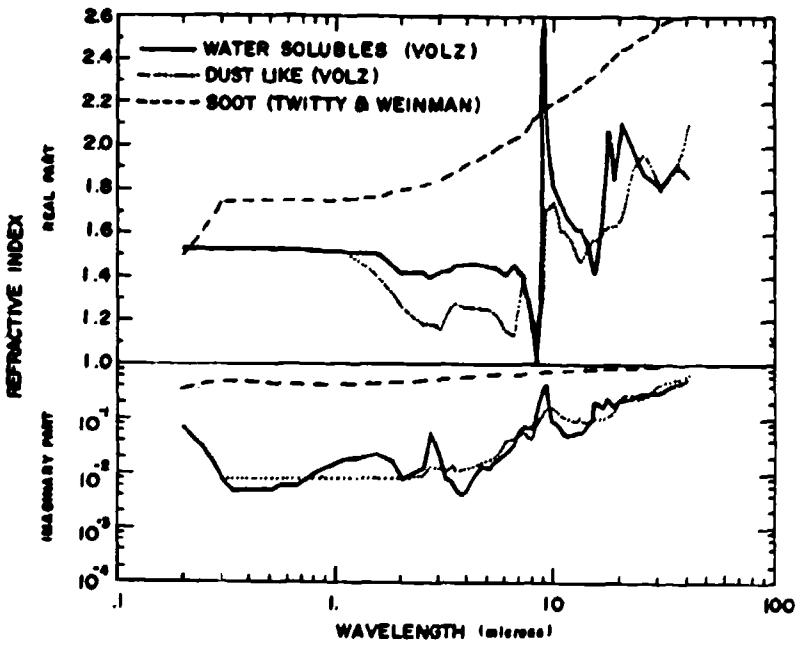


Figure 2. Refractive Index for the Dry Rural and Urban Aerosol Components

Table 3. Refractive Index for the Different Aerosol Components

WAVELENGTH (MICRONS)	WATER SOLUBLE	WATER DUST-LIKE	SODIUM	SEA SALT
0.2000	1.539 -7.00E-02	1.530 -7.00E-02	1.500 -3.50E-02	1.510 -1.00E-01
0.2500	1.539 -3.00E-02	1.530 -3.00E-02	1.526 -4.50E-02	1.530 -5.00E-02
0.3000	1.519 -8.00E-03	1.530 -8.00E-03	1.700 -0.70E-01	1.510 -2.00E-01
0.3500	1.531 -5.00E-03	1.530 -5.00E-03	1.750 -0.67E-01	1.510 -4.00E-01
0.4000	1.530 -5.00E-03	1.530 -5.00E-03	1.750 -0.64E-01	1.510 -4.00E-01
0.4500	1.530 -5.00E-03	1.530 -5.00E-03	1.750 -0.61E-01	1.510 -4.00E-01
0.5000	1.530 -5.00E-03	1.530 -5.00E-03	1.750 -0.58E-01	1.510 -4.00E-01
0.5145	1.530 -5.00E-03	1.530 -5.00E-03	1.750 -0.55E-01	1.510 -4.00E-01
0.5500	1.539 -6.00E-02	1.530 -6.00E-02	1.750 -0.44E-01	1.510 -3.00E-01
0.6000	1.533 -6.00E-02	1.530 -6.00E-02	1.750 -0.34E-01	1.510 -2.00E-01
0.6500	1.530 -7.00E-02	1.530 -7.00E-02	1.750 -0.24E-01	1.510 -1.00E-01
0.6943	1.530 -7.00E-02	1.530 -7.00E-02	1.750 -0.14E-01	1.510 -1.00E-01
0.7600	1.528 -1.20E-02	1.520 -6.00E-03	1.750 -0.04E-01	1.510 -0.40E-01
0.9600	1.520 -1.70E-02	1.520 -6.00E-03	1.750 -0.50E-02	1.510 -0.20E-01
1.2000	1.500 -2.00E-02	1.460 -8.00E-03	1.760 -0.45E-02	1.470 -0.06E-01
1.5316	1.510 -2.30E-02	1.480 -9.00E-03	1.770 -0.40E-02	1.460 -0.02E-01
1.6000	1.460 -1.00E-02	1.350 -6.00E-03	1.790 -0.30E-02	1.450 -0.05E-01
2.0000	1.420 -8.00E-02	1.260 -6.00E-03	1.810 -0.20E-02	1.450 -0.08E-01
2.2500	1.420 -1.00E-02	1.220 -9.00E-03	1.810 -0.10E-02	1.450 -0.06E-01
2.5000	1.420 -1.20E-02	1.180 -9.00E-03	1.820 -0.07E-02	1.450 -0.04E-01
2.7000	1.480 -5.50E-02	1.100 -1.50E-02	1.810 -0.05E-02	1.450 -0.02E-01
3.0000	1.420 -1.20E-02	1.160 -1.20E-02	1.820 -0.03E-02	1.450 -0.01E-01
3.24800	1.430 -8.00E-03	1.220 -1.00E-02	1.830 -0.02E-02	1.450 -0.00E-01
3.39223	1.437 -7.00E-03	1.260 -9.00E-03	1.830 -0.01E-02	1.450 -0.00E-01
3.50000	1.452 -5.00E-03	1.280 -8.00E-03	1.840 -0.01E-02	1.450 -0.00E-01
3.55000	1.452 -6.00E-03	1.270 -8.00E-03	1.840 -0.01E-02	1.450 -0.00E-01
4.00500	1.455 -5.00E-03	1.260 -8.00E-03	1.840 -0.01E-02	1.450 -0.00E-01
4.60000	1.468 -1.30E-02	1.260 -1.60E-02	1.840 -0.01E-02	1.450 -0.00E-01
5.00000	1.450 -1.20E-02	1.220 -1.60E-02	1.850 -0.01E-02	1.450 -0.00E-01
5.50000	1.450 -1.00E-02	1.220 -1.60E-02	1.850 -0.01E-02	1.450 -0.00E-01
6.00000	1.419 -2.70E-02	1.150 -3.70E-02	1.860 -0.01E-02	1.450 -0.00E-01
6.27000	1.430 -2.70E-02	1.140 -3.90E-02	1.860 -0.01E-02	1.450 -0.00E-01
6.60000	1.450 -3.30E-02	1.170 -4.20E-02	1.860 -0.01E-02	1.450 -0.00E-01
7.00700	1.483 -7.00E-02	1.150 -4.50E-02	1.860 -0.01E-02	1.450 -0.00E-01
7.50000	1.200 -6.00E-02	1.150 -4.90E-02	1.870 -0.01E-02	1.450 -0.00E-01
8.20000	1.483 -1.00	1.130 -7.00E-02	1.870 -0.01E-02	1.450 -0.00E-01
8.60000	1.300 -2.25	1.150 -9.00E-02	1.870 -0.01E-02	1.450 -0.00E-01
9.00000	2.400 -2.25	1.150 -9.00E-02	1.870 -0.01E-02	1.450 -0.00E-01
9.20000	2.568 -2.70	1.170 -1.40	1.870 -0.01E-02	1.450 -0.00E-01
9.20000	2.200 -1.40	1.170 -1.40	1.870 -0.01E-02	1.450 -0.00E-01
9.50000	1.952 -1.60	1.130 -1.60	1.870 -0.01E-02	1.450 -0.00E-01
9.80000	1.870 -9.50E-02	1.150 -1.60	1.870 -0.01E-02	1.450 -0.00E-01
10.00000	1.870 -9.50E-02	1.150 -1.60	1.870 -0.01E-02	1.450 -0.00E-01
10.40000	1.870 -9.00E-02	1.150 -1.60	1.870 -0.01E-02	1.450 -0.00E-01
10.50000	1.760 -7.00E-02	1.120 -1.60	1.870 -0.01E-02	1.450 -0.00E-01
11.00000	1.720 -5.00E-02	1.120 -1.00	1.870 -0.01E-02	1.450 -0.00E-01
11.5010	1.673 -7.00E-02	1.150 -1.00	1.870 -0.01E-02	1.450 -0.00E-01
12.50000	1.620 -5.00E-02	1.150 -9.00	1.870 -0.01E-02	1.450 -0.00E-01
13.00000	1.620 -5.00E-02	1.170 -9.00	1.870 -0.01E-02	1.450 -0.00E-01
13.50000	1.568 -7.00E-02	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
14.00000	1.440 -1.00	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
14.50000	1.440 -1.00	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
15.00000	1.420 -1.20	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
16.00000	1.420 -1.20	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
17.25000	2.000 -2.40	1.150 -1.70	1.870 -0.01E-02	1.450 -0.00E-01
21.30000	2.000 -2.40	1.170 -2.00	1.870 -0.01E-02	1.450 -0.00E-01
22.50000	2.000 -2.40	1.170 -2.00	1.870 -0.01E-02	1.450 -0.00E-01
25.00000	1.888 -2.80	1.150 -2.40	1.870 -0.01E-02	1.450 -0.00E-01
27.90000	1.888 -2.80	1.150 -2.40	1.870 -0.01E-02	1.450 -0.00E-01
39.00000	1.820 -3.00	1.150 -2.40	1.870 -0.01E-02	1.450 -0.00E-01
75.00000	1.920 -4.00	1.150 -2.40	1.870 -0.01E-02	1.450 -0.00E-01
86.00000	1.664 -5.00	1.150 -2.40	1.870 -0.01E-02	1.450 -0.00E-01

In the preliminary version of these models,⁸ the water-soluble and dust-like components were treated separately and the results of the Mie scattering calculations on individual components were combined. To reduce the calculations for the current models, which now are done as a function of humidity, the individual aerosol particles were considered to be a homogeneous combination of the different types of substance—as many natural aerosols are.⁴² The resulting refractive index for the composite rural aerosol is given in Table 3. However, Bergstrom⁴³ has argued that using such mean refractive indexes in determining the optical properties will result in errors.

However, it should be noted that using this composite refractive index and Shettle and Fenn's⁸ rural aerosol size distribution and comparing these results for the scattering and absorption coefficients with those based on separate calculations for the different aerosol types, one finds only a 5 percent difference except for the scattering minimum at $8.2 \mu\text{m}$ where the difference was 16 percent.

The parameters for the rural model size distribution given in Table 1 fall within what Whitby and Cantrell¹⁷ give as a typical range of values for the accumulation and coarse particle modes.

The resulting number density distribution, $n_{(r)}$, is shown in Figure 3. While this size distribution approximates a r^{-4} power law for radii between 0.1 and $20 \mu\text{m}$,^{44,45} there are some fluctuations about a slope of -4 because of the bimodal nature of the distribution.⁴⁶ The major change from the earlier version of the rural model⁸ is that the number density of the very small ($r < 0.5 \mu\text{m}$) particles is more accurately represented.

To allow for the dependence of the humidity effects on the size of the dry aerosol, the growth of the aerosol was computed separately for the accumulation and coarse particle components using H  nel's model No. 6 water uptake data. In accounting for the aerosol growth in Eq. (2), changes in the width of the size distribution were assumed negligible so only the mode radius, r_1 , was modified by humidity changes. The effective refractive indexes for the two size components were then computed from Eq. (6) as a function of relative humidity. The cumulative number density and the volume distribution are shown in Figures 4 and 5 respectively for several different relative humidities. The refractive index as a function of wavelength and relative humidity is given in Table 4.

2.4 Urban Aerosol Model

In urban areas the air with a rural aerosol background is primarily modified by the addition of aerosols from combustion products and industrial sources. The urban aerosol model therefore was taken to be a mixture of the rural aerosol with carbonaceous aerosols. The sootlike aerosols are assumed to have the same size distribution as both components of the rural model. The proportions of the sootlike

aerosols and the rural type of aerosol mixture are assumed to be 20 percent and 80 percent respectively. The refractive index of the sootlike aerosols was based on the soot data in Twitty and Weinman's⁴⁷ survey of the refractive index of carbonaceous materials. As with the rural model, a composite urban aerosol refractive index was determined at each wavelength. These values are given in Table 3.

The change in aerosol was based on Hanel's²⁸ urban aerosol data (his Model 5) and is given in Table 2. The resulting refractive indexes as a function of relative humidity are given in Table 5.

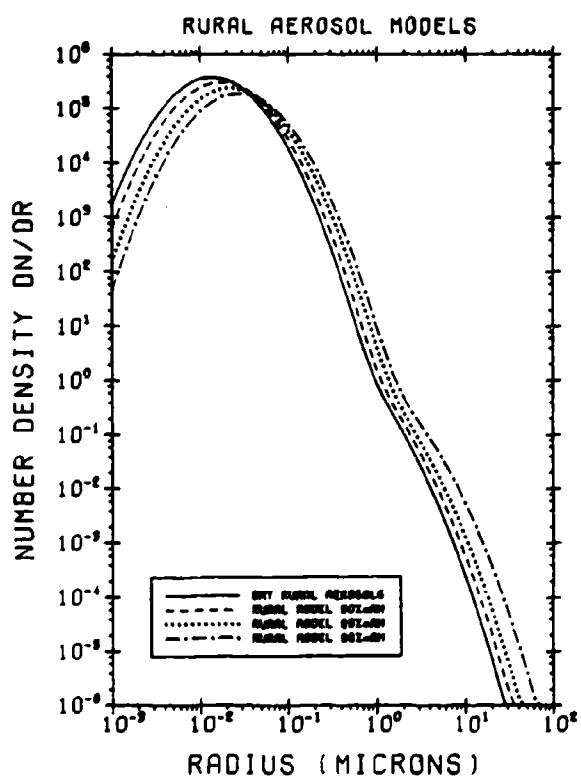


Figure 3. Aerosol Number Distribution ($\text{cm}^{-3} \mu\text{m}^{-1}$) for the Rural Model at Different Relative Humidities With Total Particle Concentrations Fixed at $15,000 \text{ cm}^{-3}$

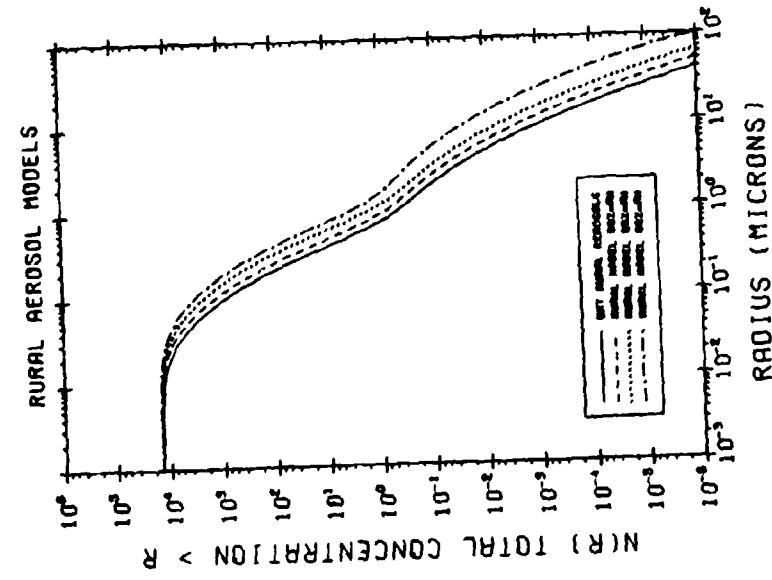


Figure 4. Cumulative Number Density
 $N(R)$ (cm^{-3}) for the Rural Aerosol Model at
 Different Relative Humidities With Total
 Particle Concentration Fixed at
 $15,000 \text{ cm}^{-3}$

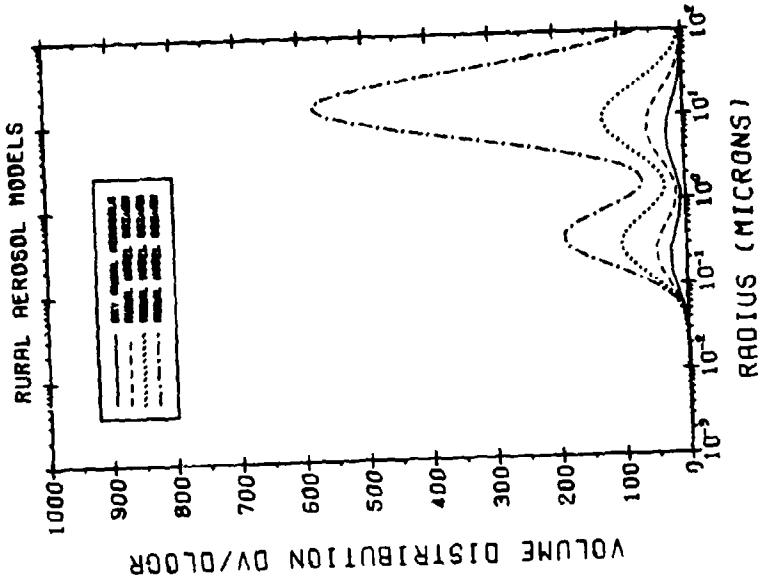


Figure 5. Volume Distribution ($\mu\text{m}^3/\text{cm}^3$) for
 the Rural Aerosol Model at Different Relative
 Humidities With the Total Particle Concentration
 Fixed at $15,000 \text{ cm}^{-3}$

Table 4. Refractive Index of the Rural Model as a Function of Relative Humidity and Wavelength (a) Small Rural Aerosols

Table 4. Refractive Index of the Rural Model as a Function of Relative Humidity and Wavelength, (b) Large Rural Aerosols

NAME	LARGE RURAL LENGTH RH = .92	LARGE RURAL RH = .902	LARGE RURAL RH = .892	LARGE RURAL RH = .882	LARGE RURAL RH = .872	LARGE RURAL RH = .951	LARGE RURAL RH = .932	LARGE RURAL RH = .912
.2800	1.531-7.88E-02	1.523-6.84E-02	1.508-5.03E-02	1.463-3.10E-02	1.425-2.06E-02	1.425-1.52E-02	1.405-6.06E-03	1.405-3.45E-03
.2500	1.530-3.00E-02	1.521-2.04E-02	1.502-2.05E-02	1.463-1.05E-02	1.411-0.45E-02	1.411-0.38E-02	1.377-2.54E-03	1.379-1.47E-03
.3800	1.531-0.63E-03	1.521-0.59E-03	1.508-0.66E-03	1.457-3.67E-03	1.402-2.36E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.3371	1.531-5.98E-03	1.520-5.98E-03	1.508-5.98E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.4800	1.530-5.98E-03	1.520-5.98E-03	1.508-5.98E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.5145	1.530-5.98E-03	1.520-5.98E-03	1.508-5.98E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.5500	1.530-6.60E-03	1.520-6.60E-03	1.508-6.60E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.6320	1.530-6.60E-03	1.520-6.60E-03	1.508-6.60E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.693	1.530-7.38E-03	1.520-7.38E-03	1.508-7.38E-03	1.459-4.10E-03	1.403-2.86E-03	1.399-1.79E-03	1.355-6.93E-04	1.353-3.92E-04
.8660	1.530-1.00E-02	1.510-1.36E-02	1.480-1.19E-02	1.422-5.33E-02	1.365-3.10E-02	1.307-1.40E-02	1.272-2.47E-02	1.251-1.20E-02
1.3000	1.495-1.66E-02	1.486-1.56E-02	1.465-1.37E-02	1.429-9.26E-02	1.390-6.92E-02	1.350-3.49E-02	1.335-7.04E-02	1.325-3.92E-02
1.4760	1.477-1.86E-02	1.469-1.75E-02	1.450-1.54E-02	1.421-9.19E-02	1.383-6.93E-02	1.345-3.43E-02	1.330-7.04E-02	1.320-3.92E-02
3.3923	1.379-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.343-1.19E-02	1.316-6.44E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
.7000	1.379-1.88E-02	1.361-1.46E-02	1.336-1.64E-02	1.349-1.04E-02	1.317-6.02E-02	1.287-2.65E-02	1.254-7.38E-02	1.222-3.92E-02
2.0000	1.376-1.78E-02	1.376-1.22E-02	1.376-1.22E-02	1.349-1.04E-02	1.317-6.02E-02	1.287-2.65E-02	1.254-7.38E-02	1.222-3.92E-02
2.2510	1.362-1.78E-02	1.362-1.22E-02	1.362-1.22E-02	1.349-1.04E-02	1.317-6.02E-02	1.287-2.65E-02	1.254-7.38E-02	1.222-3.92E-02
2.5000	1.362-1.11E-02	1.350-1.06E-02	1.333-1.53E-02	1.303-1.19E-02	1.270-6.27E-02	1.207-4.55E-02	1.165-7.40E-02	1.129-4.06E-02
2.7000	1.354-1.11E-02	1.326-1.12E-02	1.326-1.12E-02	1.303-1.19E-02	1.270-6.27E-02	1.207-4.55E-02	1.165-7.40E-02	1.129-4.06E-02
3.0000	1.342-1.98E-02	1.342-2.16E-02	1.342-2.16E-02	1.307-1.19E-02	1.273-6.38E-02	1.233-4.22E-02	1.199-7.40E-02	1.165-4.06E-02
3.2800	1.367-0.61E-01	1.373-1.29E-02	1.386-2.76E-02	1.347-1.19E-02	1.316-6.02E-02	1.281-4.02E-02	1.250-7.38E-02	1.226-3.92E-02
3.5900	1.379-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
3.7000	1.379-1.88E-02	1.359-1.97E-02	1.356-1.97E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
3.9900	1.397-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
4.0000	1.397-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
4.5000	1.449-1.33E-02	1.387-1.32E-02	1.379-1.32E-02	1.339-1.19E-02	1.303-6.66E-02	1.277-4.72E-02	1.245-7.38E-02	1.226-3.92E-02
6.0000	1.399-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
6.5000	1.399-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
7.2000	1.399-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
7.9000	1.405-5.75E-02	1.395-5.36E-02	1.389-5.36E-02	1.359-4.14E-02	1.327-3.37E-02	1.281-2.36E-02	1.243-5.36E-02	1.215-2.43E-02
8.5000	1.399-1.88E-02	1.371-1.87E-02	1.359-1.88E-02	1.336-1.19E-02	1.307-6.02E-02	1.284-3.06E-02	1.252-7.38E-02	1.226-3.92E-02
9.0000	1.377-1.72E-02	1.379-1.72E-02	1.371-1.72E-02	1.341-1.06E-02	1.312-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
9.2000	1.378-1.72E-02	1.379-1.72E-02	1.371-1.72E-02	1.341-1.06E-02	1.312-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
9.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
10.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
10.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
11.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
12.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
13.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
14.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
14.8000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
15.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
16.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
16.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
17.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
17.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
18.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
18.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
19.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
19.5000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
20.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
21.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
22.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
23.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
24.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
25.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
26.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
27.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
28.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
29.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
30.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
31.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
32.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
33.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
34.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
35.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	1.226-3.92E-02
36.0000	1.376-1.57E-02	1.378-1.57E-02	1.370-1.57E-02	1.340-1.06E-02	1.310-7.2E-03	1.287-4.02E-02	1.255-7.38E-02	

Table 5. Refractive Index of the Urban Model as a Function of Relative Humidity and Wavelength. (a) Small Urban Aerosols

Table 5. Refractive Index of the Urban Model as a Function of Relative Humidity and Wavelength. (a) Large Urban Aerosols

2.5 Maritime Aerosol Model

The aerosol compositions and distributions of oceanic origin are significantly different from continental aerosol types. These aerosols are largely sea-salt particles which are produced by the evaporation of sea-spray droplets and then have grown again due to aggregation of water under high relative humidity conditions. However, even over the ocean there is a more or less pronounced continental aerosol background, which, mixed with the aerosols of oceanic origin, forms a fairly uniform maritime aerosol that is representative for the boundary layer in the lower 2-3 km in the atmosphere over the oceans but that also may occur over the continents in a maritime air mass. This maritime model should be distinguished from the fresh sea-spray aerosol which exists in the lower 10-20 m above the ocean surface and which is strongly dependent on wind speed.

The maritime aerosol model therefore, has been composed of two components: the sea-salt component; and a continental component which was assumed to be identical to the rural aerosol with the exception that the very large particles were eliminated since they will eventually be lost due to fallout as the air masses move across the oceans. This model is similar to the one suggested by Junge^{42,48} based on his measurements.^{49,50} It is also supported by the measurements made by Meszaros and Vissy²⁰ in the South Atlantic and Indian Oceans. They found that the larger particles had a predominantly cubic crystalline structure characteristic of sodium chloride and that the other major constituents were of other crystal types. The smallest particles were a mixture of other aerosol types—the most common identifiable component being ammonium sulphate.

For the size distribution of the oceanic component, a log normal distribution is used with $r_0 = 0.3$ for moderate relative humidities (≈ 80 percent) and $\sigma = 0.4$. This is consistent with the measurements of Woodcock⁵¹ as well as the more recent measurements of Junge and Jaenicke⁵⁰ and the sea-salt type component of the data of Meszaros and Vissy.²⁰ The relative proportions of aerosols of oceanic or continental origins will vary particularly in coastal regions. To account for these variations, the model permits the user to adjust the relative amounts of the oceanic and continental types of aerosol. The size distribution used for the results here has 1 percent of the total number of particles of oceanic origin. The change of particle size with relative humidity is based on Hanel's²⁸ results for a sea-spray aerosol (his Model 2). This number density distribution is shown in Figure 6, with the corresponding cumulative number distribution and volume distributions shown in Figures 7 and 8.

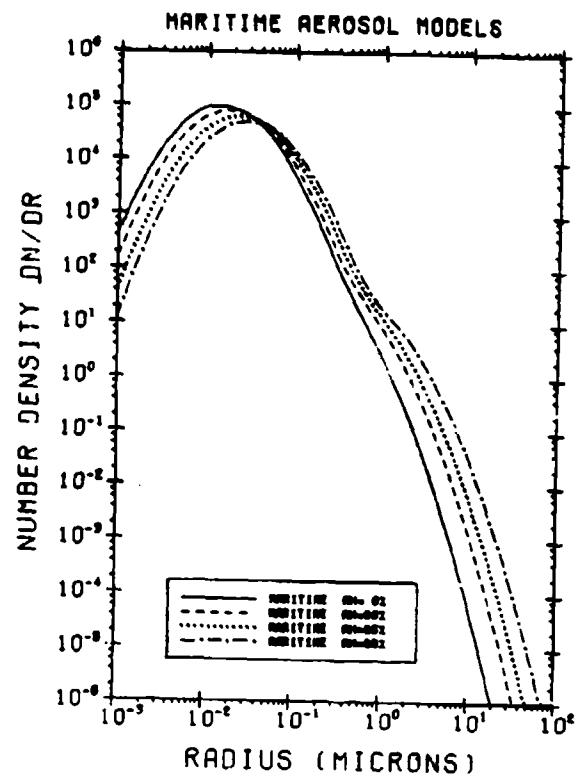


Figure 6. Aerosol Number Distribution ($\text{cm}^{-3} \mu\text{m}^{-1}$) for the Maritime Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

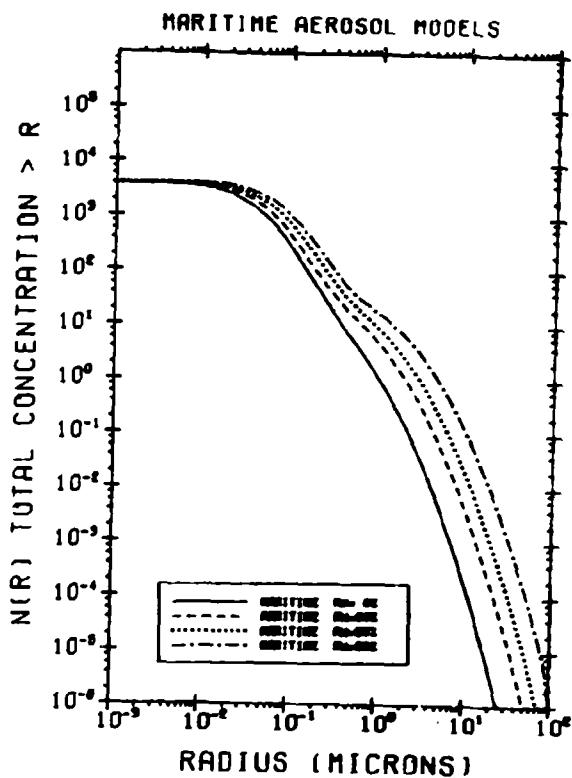


Figure 7. Cumulative Number Density (cm^{-3}) for the Maritime Aerosol Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

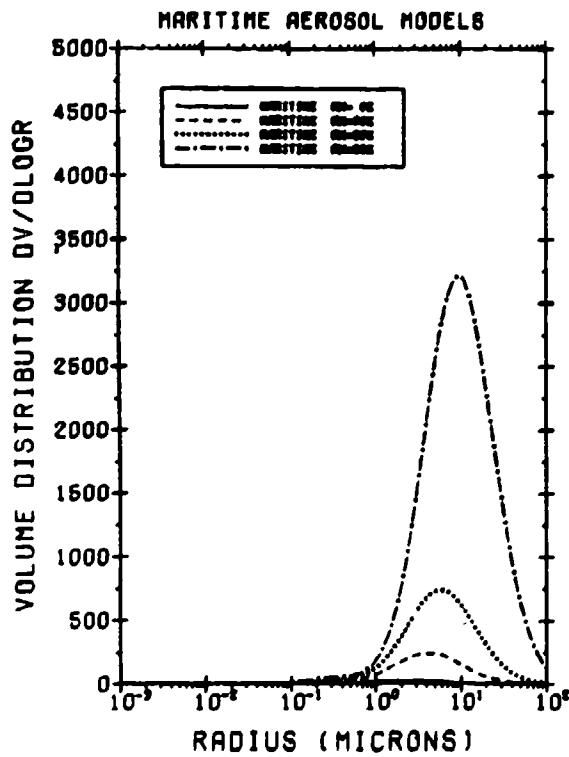


Figure 8. Volume Distribution ($\mu\text{m}^3/\text{cm}^3$) for the Maritime Aerosol Model at Different Relative Humidities With the Total Particle Concentration Fixed at 4000 cm^{-3}

The refractive index is based on that for a solution of sea salt in water, using a weighted average of the refractive indexes of water and sea salt. The relative weighting as a function of the relative humidity is based on Eq. (8). The refractive index of the sea salt is primarily taken from the measurements of Voiz.⁵² His data for the imaginary part were limited to wavelengths longer than $2.5 \mu\text{m}$, but this was extended to $0.2 \mu\text{m}$ by using the difference between absorption measurements for sea water and pure water compiled by Dorsey⁵³ (Table 6).

A similar two-component maritime aerosol model has been developed by Wells et al.⁵⁴ based on the earlier models of Barnhardt and Street⁵⁵ and Hodges⁵⁶. They also have components representing aerosols of continental and marine origin. However their size distributions differ from the present models; they use more simplified refractive index models, and the treatment of humidity neglects the dependence of the relative humidity effects on either the size or composition of the aerosol.

Table 6. Refractive Index of the Oceanic Model as a Function of Relative Humidity and Wavelength

A significant addition by Wells et al.⁵⁴ to these other models is the inclusion of the effects of wind speed on the marine component of the aerosol distributions. They did this by modifying the parameters defining their size distribution as a function of wind, based on Woodcock's⁵¹ data (while they cite Manson⁵⁷ as their source, the data can be traced to Woodcock through Junge^{58,59}). They used a modified Γ size distribution,^{60,61} with $\alpha = 2$,

$$\frac{dN}{dr} = n(r) = A r^\alpha \exp(-br^\gamma) \quad (7)$$

and fit A, which is proportional to the total number of particles, and γ , which is primarily the rate of decrease of the number density for the large particles as a function of wind speed. A simpler way of adding the effects of wind to our maritime model would be based on Lovett's work.^{62,63} Based on his measurements of the concentration of sea-salt in the atmosphere as a function of wind speed, he derived the following empirical relationship

$$\ln \theta = 0.16 v + 1.45 \quad (8)$$

where θ is concentration of sea salt in $\mu g m^{-3}$ and v is the wind speed in m/sec. Making the simplifying assumption that this concentration is proportional to the total number of particles of oceanic origin, it can be shown that

$$N(v) = N(v_0) \cdot \exp[0.16(v - v_0)] \quad (9)$$

where $N(v)$ is the number of sea salt particulates for a wind speed v . Since Lovett's⁶² measurements of relative mass distribution vs aerosol size show no significant dependence on wind speed, the assumption that particle number is proportional to the sea-salt mass is reasonable. It should be noted that the relevant indicator of wind speed is the mean prevailing wind speed, since the lifetime of these aerosols is on the order of a few days.

2.6 Tropospheric Model

The tropospheric aerosol model represents the aerosols within the troposphere above the boundary layer. These aerosols are assumed to have the same composition as the rural model (70 percent water-soluble and 30 percent dust-like). The size distribution is modified from the rural model by eliminating the large (or coarse) particle ($r_i = 0.5$) component of the size distribution because of the longer residence of aerosols above the boundary and the expected differential loss of the larger particles. This leaves the log-normal distribution with the small (or

accumulation) particle component. This is consistent with the changes in aerosol size distribution with altitude suggested by Whitby and Cantrell.¹⁷ The dependence of particle size on relative humidity is the same as for the small particle component of the rural model, and is shown in Figures 9-11.

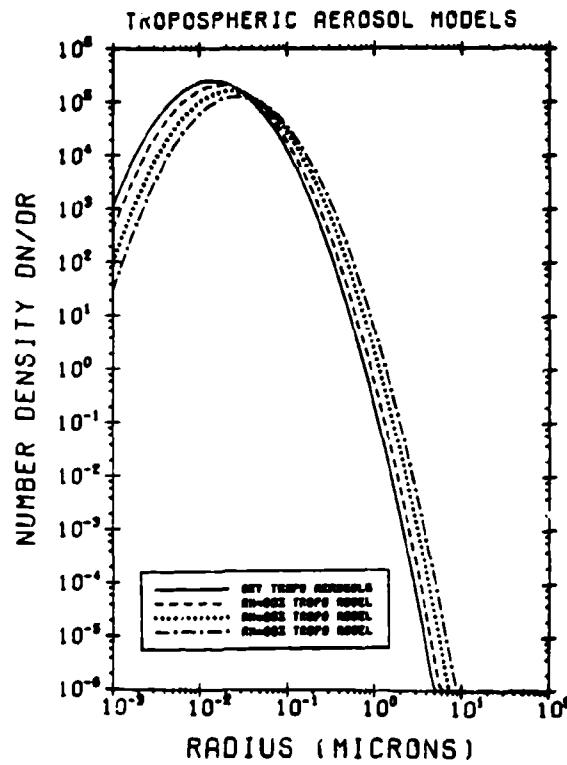


Figure 9. Aerosol Number Distribution ($\text{cm}^{-3} \mu\text{m}^{-1}$) for the Tropospheric Model at Different Relative Humidities With Total Particle Concentrations Fixed at $10,000 \text{ cm}^{-3}$

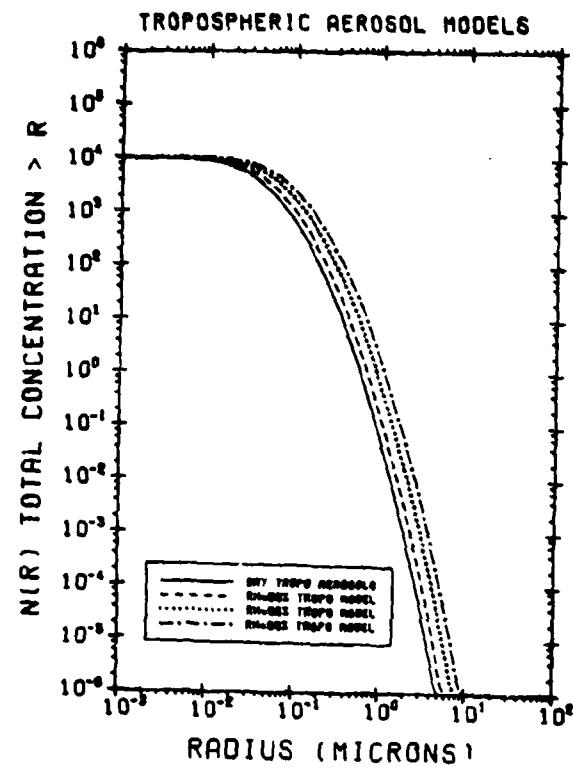


Figure 10. Cumulative Number Density (cm^{-3}) for the Tropospheric Aerosol Model at Different Relative Humidities With Total Particle Concentrations Fixed at $10,000 \text{ cm}^{-3}$

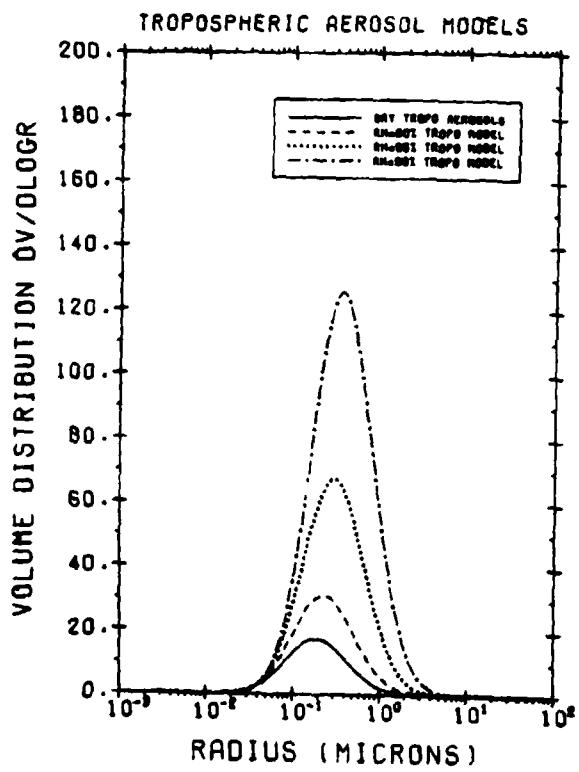


Figure 11. Volume Distribution ($\mu\text{m}^3/\text{cm}^3$) for the Tropospheric Aerosol Model at Different Relative Humidities With the Total Particle Concentrations Fixed at $10,000 \text{ cm}^{-3}$

2.7 Fog Models

When the air becomes nearly saturated with water vapor (relative humidity close to 100 percent), fog can form (assuming sufficient condensation nuclei are present). The air can become saturated in two ways, either by mixing of air masses with different temperatures and/or humidities (advection fogs), or by the air cooling until the air temperature approaches the dew point temperature (radiation fogs).⁶⁴

To represent the range of the different types of fog, we use the fog models presented by Silverman and Sprague,⁶⁵ following the work of Dyachenko.⁶⁶ These were chosen to represent the range of measured size distributions, and correspond to what Silverman and Sprague identified as typical of radiation fogs and advection fogs, although they are also characteristic of developing and mature fogs, respectively. They use a modified gamma size distribution [Eq. (7)] to describe the size distribution.

The values of the parameters, A , α , b , γ are given in Table 7 along with the mode radius and total particle number.

Table 7. Size Distribution Parameters of the Fog Models

Type of Fog	Model	A	α	b	γ	(μ)	
						r_{mode}	$N_0(\text{cm}^{-3})$
Advection Fog	1	0.06592	3	0.3	1	10.0	20
	2	0.027	3	0.375	1	8.0	20
Radiation Fog	3	2.37305	6	1.5	1	4.0	100
	4	607.5	6	3.0	1	2.0	200

Models 1 and 3 represent heavy, and Models 2 and 4 moderate fog conditions for the different types. Generally, measured fog droplet size distributions⁶⁶⁻⁷⁰ fall within the variations represented by these models. For example, extensive measurements of valley fog by Pilie et al^{67,68} have shown that developing fog is characterized by droplet concentrations of 100 to 200 particles per cm^3 in the 1 to 10 μm radius range with mean radius of 2 to 4 μm . As the fog thickens, the droplet concentration decreases to less than 2 particles per cm^3 and mean radius increases from 6 to 12 μm . Droplets less than 3 μm radius were seldom observed in fully developed fog.

It was assumed the refractive index for the fog was that of pure water. While most of the fog droplets have condensation nuclei, the effect on the refractive index was considered to be negligible compared with the other uncertainties in these models. The size distribution for the fog models is shown in Figures 12-14.

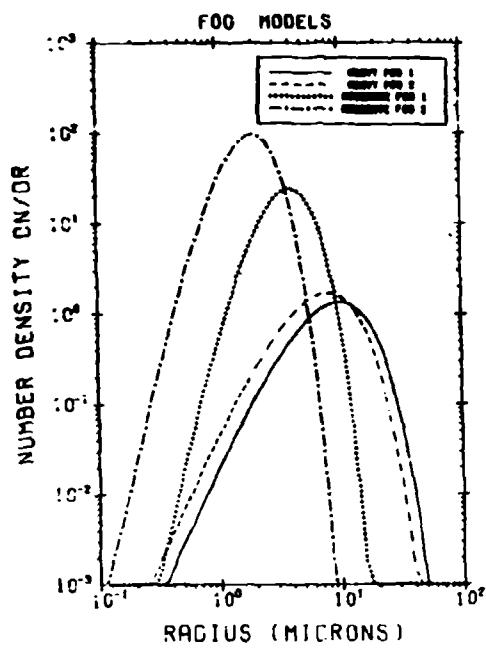


Figure 12. Number Distribution ($\text{cm}^{-3} \mu\text{m}^{-1}$) for the Different Fog Models

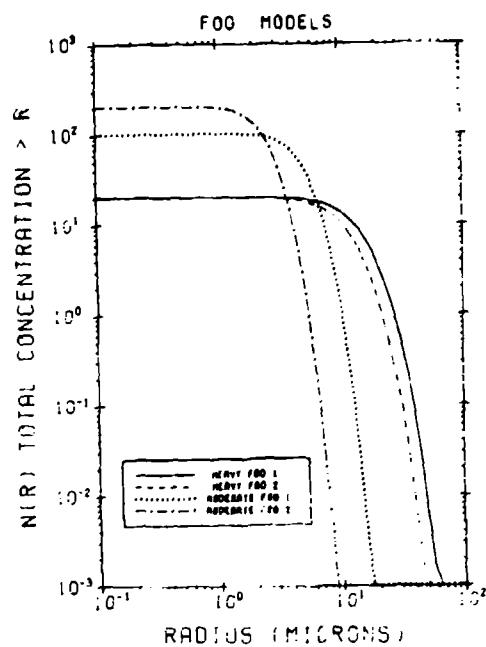


Figure 13. Cumulative Number (cm^{-3}) Distribution for the Different Fog Models

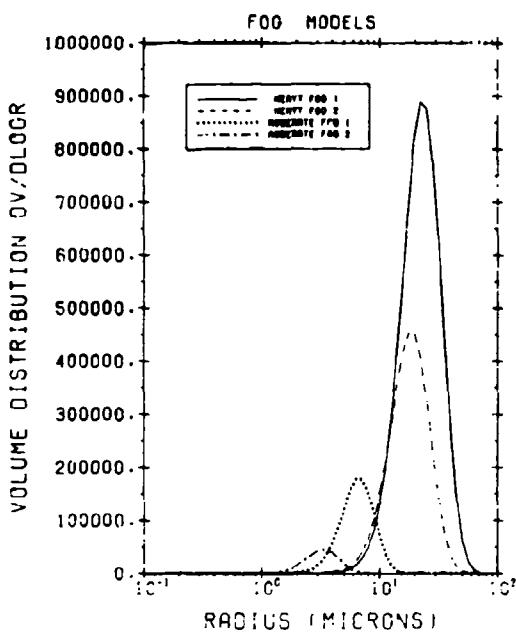


Figure 14. Volume Distribution ($\mu\text{m}^3/\text{cm}^3$) for the Different Fog Models

3. AEROSOL OPTICAL PROPERTIES

3.1 Mie Scattering Calculations

Once the size distribution and refractive index of the aerosol models are specified, the optical properties, such as the scattering or absorption coefficients can be calculated from Mie theory.⁷¹⁻⁷⁴ There are a number of versions of Mie scattering computer codes available for such computations (for example, Dave,⁷⁵ and Hansen and Travis⁷⁶). For the present work, a modified version of a program developed by RRA for AFGL⁷⁷ was used. The most important modification on it was to use downward recursion to calculate the logarithmic derivative of the Riccati-Bessel function used in calculating the Mie coefficients to avoid the numerical instabilities that develop with these calculations for large absorbing particles when upward recursion is used.^{75, 78}

For the Mie scattering calculations the aerosol particles are assumed to be spherical, which is not in general true. While liquid aerosols will be approximately spherical, the dry particles usually are irregularly shaped. However it can be argued that many of the measurements of aerosol size distributions are measuring scattered light⁷⁹⁻⁸² and the size "assigned" to a given particle, is the size of a sphere that has similar scattering properties to the measured particle. Furthermore, the irregular shaped particles are closest to "equivalent" spheres in their

scattering properties in the forward direction generally used for size measurements.^{83, 84} So the resulting size distribution is the size distribution of spheres that have similar optical properties to the actual aerosol particles. Also studies by Chylek⁸³ and Holland and Gagne⁸⁴ indicate that for particles of equal overall dimensions but different shapes, the spherical particle extinction has the highest values.

3.2 Aerosol Model Attenuation

The attenuation coefficients for the rural aerosol model at 50 percent and 95 percent relative humidity are shown in Figures 15 and 16 as a function of wavelength. To show the effect of variations of relative humidity on the aerosol extinction, the rural model extinction has been calculated over a range of humidities for a constant total number density. The resulting extinction vs wavelength is shown in Figure 17 for several relative humidities between 0 and 99 percent where the number density is held fixed at 15,000 particles/cm³, which correspond to a meteorological range of about 25 km for the dry aerosols and about 5 km at 99 percent relative humidity.

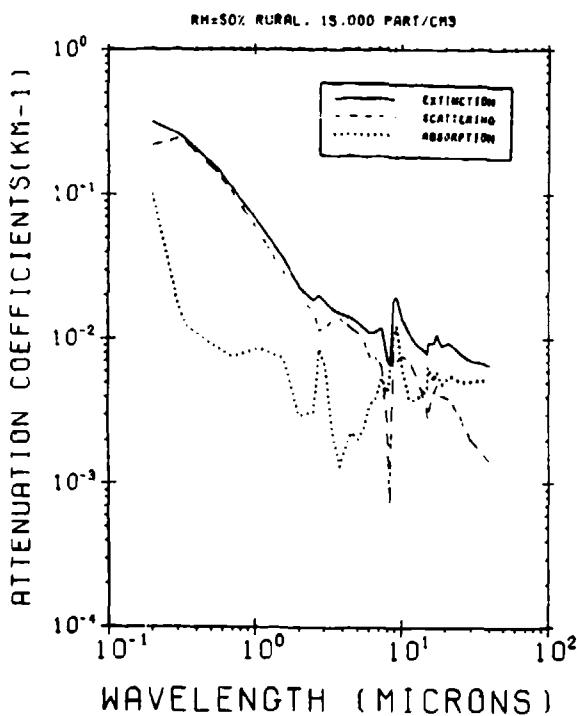


Figure 15. Attenuation Coefficients vs Wavelength for the Rural Aerosols at 50 Percent Relative Humidity

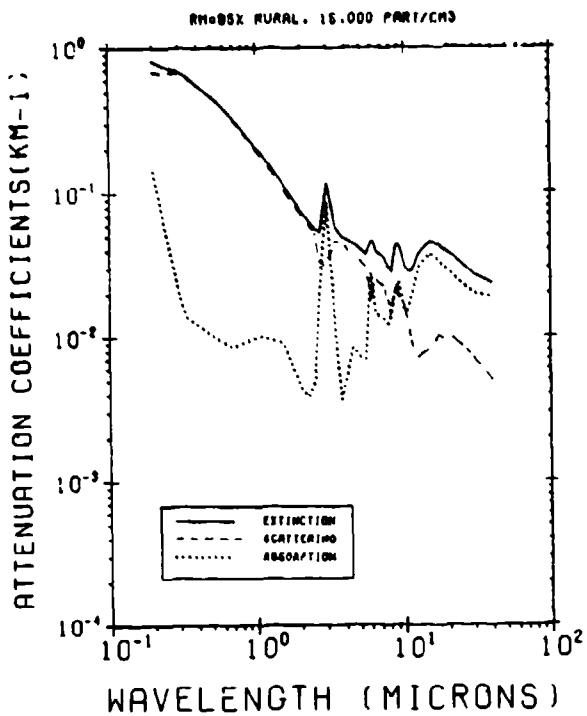


Figure 16. Attenuation Coefficients vs Wavelength for the Rural Aerosol Model at 95 Percent Relative Humidity

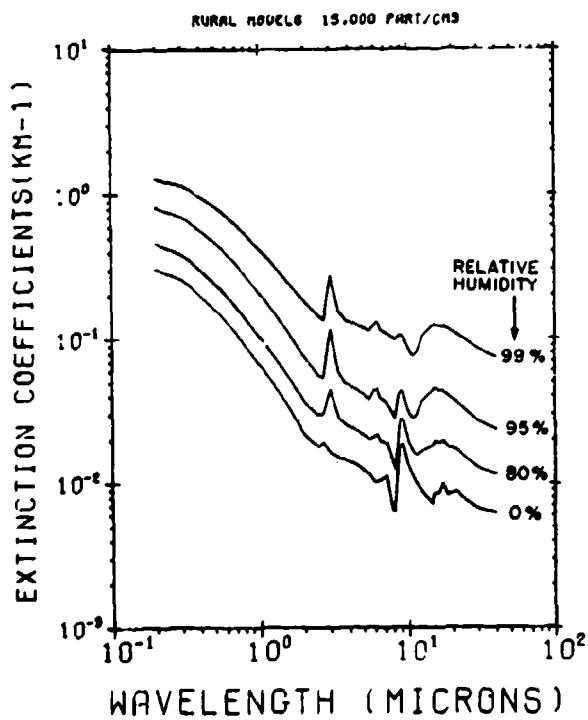


Figure 17. Extinction Coefficients vs Wavelength for the Rural Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

The development of the 3- μm water absorption feature with increasing relative humidity is apparent in these figures. Also apparent from these figures is the masking of the strong dispersion from the 9 μm sulfate in the dry aerosol by the water condensed on the aerosol.

The attenuation coefficients for the urban aerosol model are shown in Figures 18 through 20 as a function of wavelength, for several different humidities. The corresponding results for the maritime and tropospheric aerosol models are shown in Figures 21 through 23 and Figures 24 through 26 respectively.

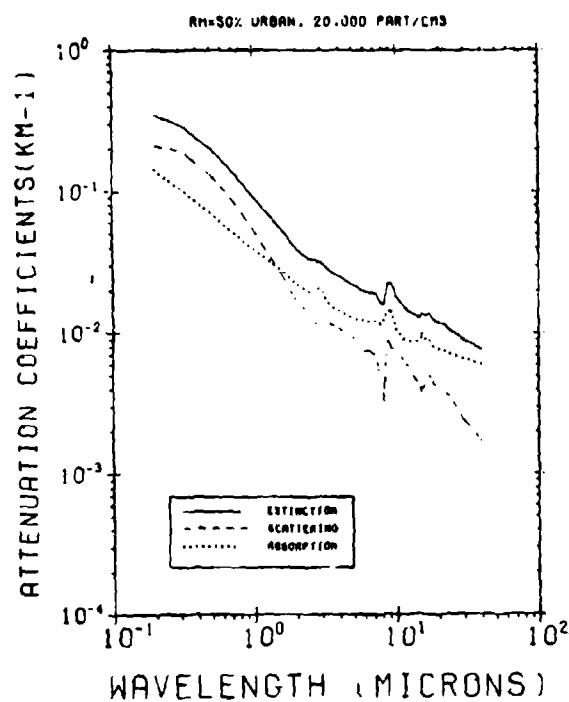


Figure 18. Attenuation Coefficients vs Wavelength for the Urban Aerosols at 50 Percent Relative Humidity

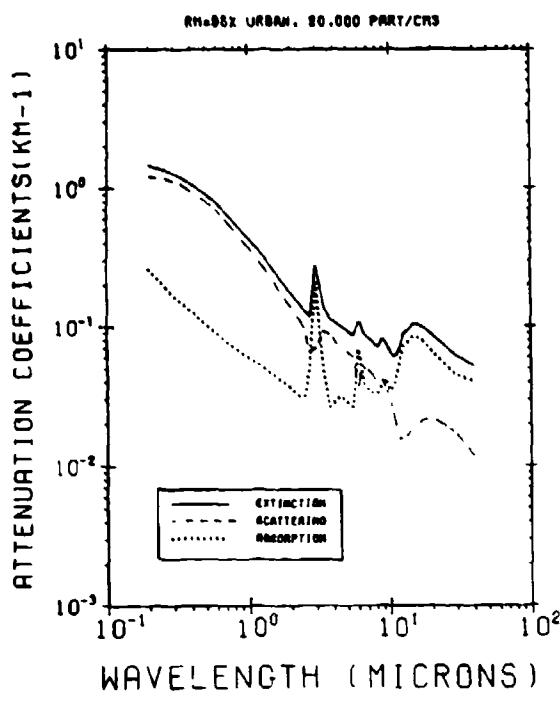


Figure 19. Attenuation Coefficients vs Wavelength for the Urban Aerosols at 95 Percent Relative Humidity

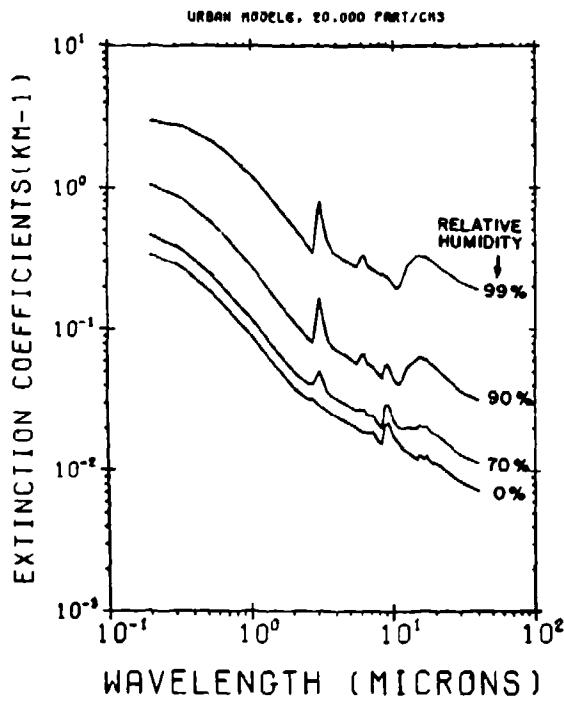


Figure 20. Extinction Coefficients vs Wavelength for the Urban Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

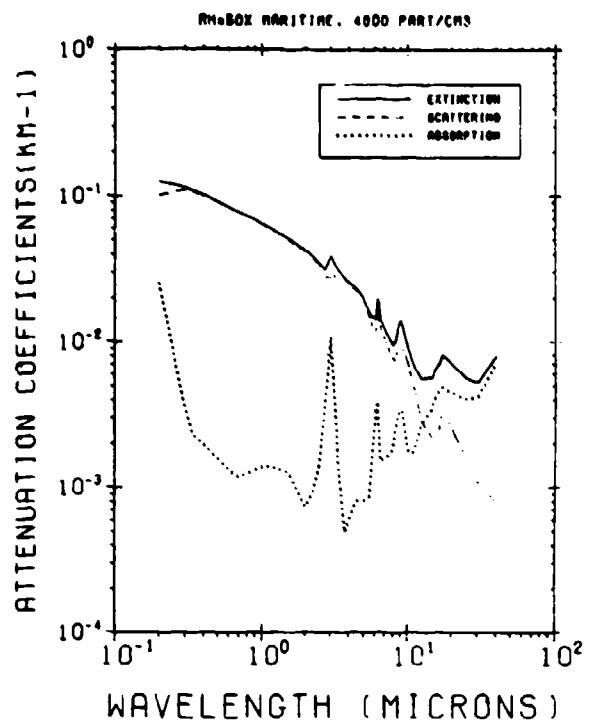


Figure 21. Attenuation Coefficients vs Wavelength for the Maritime Aerosol Model at 50 Percent Relative Humidity

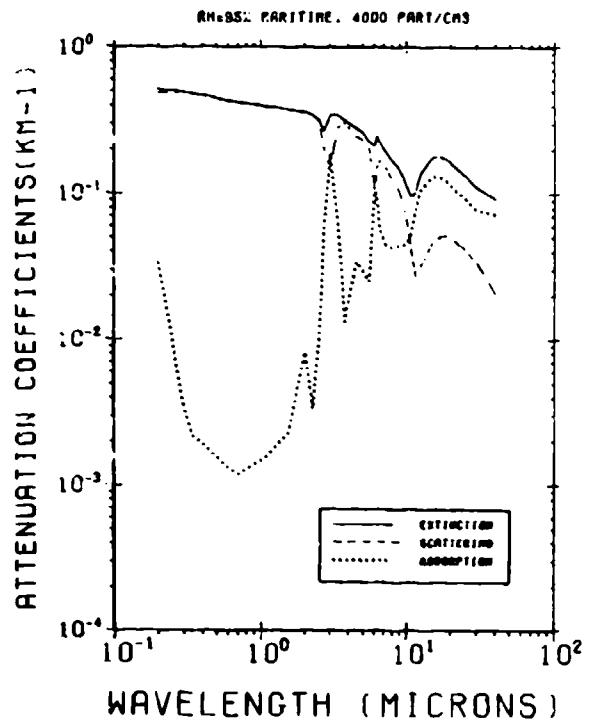


Figure 22. Attenuation Coefficients vs Wavelength for the Maritime Aerosol Model at 95 Percent Relative Humidity

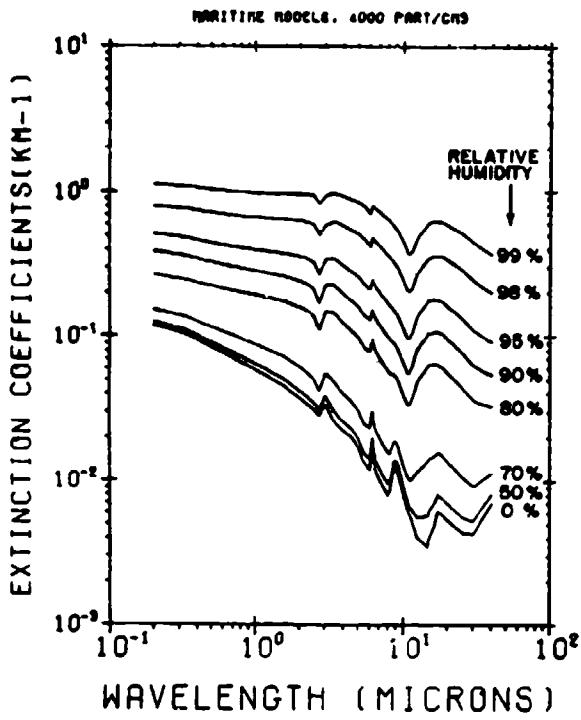


Figure 23. Extinction Coefficients vs Wavelength for the Maritime Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

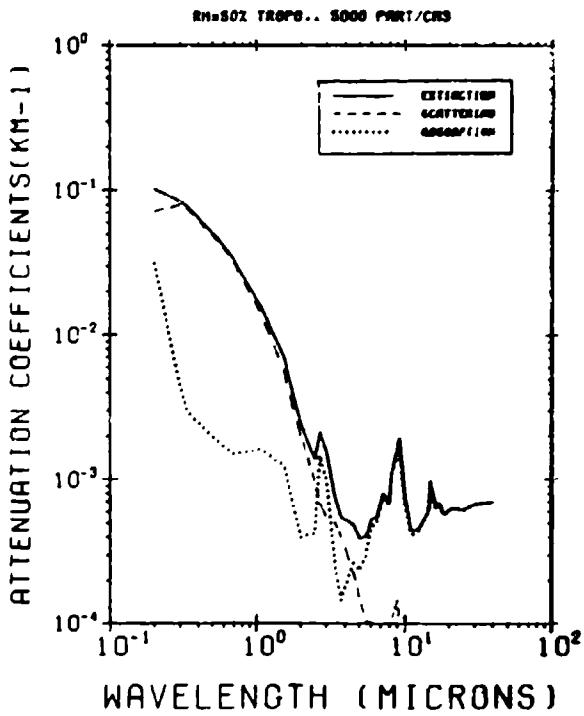


Figure 24. Attenuation Coefficients vs Wavelength for the Tropospheric Aerosol Model at 50 Percent Relative Humidity

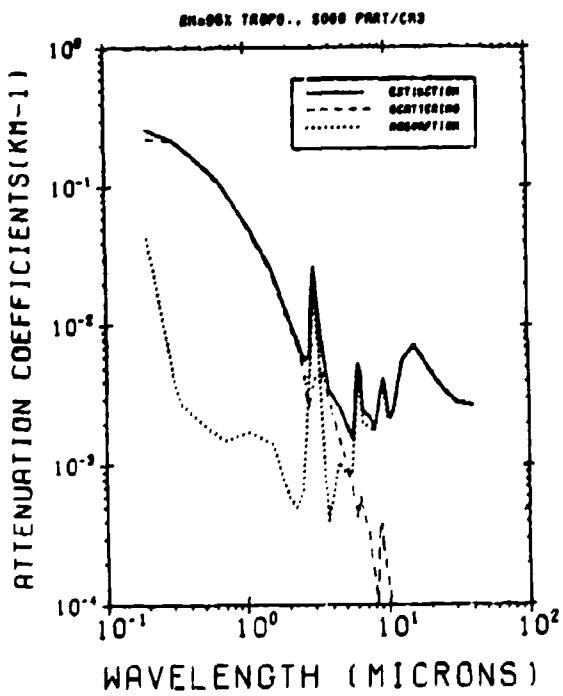


Figure 25. Attenuation Coefficients vs Wavelength for the Tropospheric Aerosol Model at 95 Percent Relative Humidity

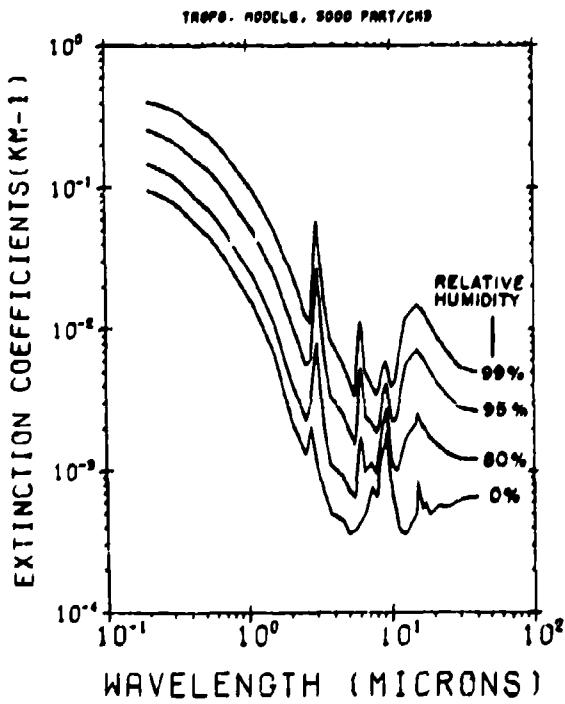


Figure 26. Extinction Coefficients vs Wavelength for the Tropospheric Aerosol Model for Different Relative Humidities and Constant Number Density of Particles

One feature common to all these models is the reduction in the slope of the extinction coefficient vs wavelength with increasing relative humidity. This is due to the growth of the aerosols, which is greatest for the larger particles, and the corresponding increased contribution of scattering to the total extinction, especially in the infrared.

The total number of particles for the components of the different aerosol models are given in Tables 8 through 11 normalized to different meteorological ranges, V, for various relative humidities. Using Koschmieder's law or the visual range formula^{85,86} at a wavelength of 0.55 microns.

$$\underline{V = \frac{1}{\sigma} \ln \frac{1}{\epsilon} = \frac{3.812}{\sigma}}$$
 (10)

where ϵ , the threshold contrast is 2 percent and $\sigma = \sigma_{\text{molecular}} + \sigma_{\text{aerosol}}$ is the total extinction.* The N_1 and N_2 in the tables are the appropriately normalized values of the N_i in Table 1, where $i = 1$ is the small particle component and $i = 2$ the large particle component. It is important to note that caution should be exercised in comparing total numbers of aerosol particles between various models and/or measured number densities. The results depend on the details of the small particle distributions; for models, the total numbers are most sensitive to the assumed distribution of the smallest particles, and for measurements, the total numbers are most sensitive to the small particle cut-off characteristics of the measuring instrument. This can be seen from any of the plots of the aerosol cumulative number density (Figures 4, 7, or 10) where changing the small particle cut-off from 0.1 to 1.0 μm (a representative range for particle counters) will change the total number of aerosol particles counted, by a factor between 100 and 1000. The smallest aerosols (less than 0.1 μm) are usually the least important particles in terms of the optical or IR properties.

* Strictly speaking the extinction should be weighted by the photopic response of the eye, and the effects of absorption neglected in deriving Eq. (10).

Table 8. Total Number Density for the Rural Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =	0.	50.	70.	80.	90.	95.	98.	99.
VISIONALITY = 2. KM.								
N1 =	199538.58	192537.16	176656.13	129603.79	65526.28	60268.62	48675.99	37244.91
N2 =	24.94	24.07	22.33	16.24	10.69	8.53	6.89	4.66
VISIONALITY = 5. KM.								
N1 =	79076.33	76308.75	70803.53	51474.48	33795.07	27052.61	19299.47	14768.60
N2 =	9.69	9.54	8.85	6.44	4.24	3.38	2.41	1.65
VISIONALITY = 10. KM.								
N1 =	36924.51	37561.62	34652.67	25330.05	16684.67	13316.61	9495.64	7265.83
N2 =	6.87	4.70	4.36	3.17	2.09	1.66	1.19	.91
VISIONALITY = 23. KM.								
N1 =	16230.63	15661.76	14532.62	10565.23	6957.06	5552.58	3955.42	3129.65
N2 =	2.63	1.96	1.82	1.32	.87	.69	.49	.36
VISIONALITY = 50. KM.								
N1 =	6803.78	6565.31	6091.98	4428.90	2916.35	2327.61	1659.76	1271.01
N2 =	.85	.82	.76	.55	.36	.29	.21	.16

Table 9. Total Number Density for the Urban Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY =	0.	50.	70.	80.	90.	95.	98.	99.
VISIONALITY = 2. KM.								
N1 =	220039.51	210325.47	161500.19	107935.91	69877.38	45967.45	26535.53	16383.38
N2 =	27.51	26.29	20.65	13.49	8.74	5.75	3.32	2.10
VISIONALITY = 5. KM.								
N1 =	87284.26	83354.47	64828.76	42776.28	27693.23	18217.44	10516.34	7285.55
N2 =	10.90	10.42	8.10	5.35	3.46	2.26	1.31	.91
VISIONALITY = 10. KM.								
N1 =	42925.84	41039.89	31911.62	21856.49	13631.85	8967.44	5176.62	3586.27
N2 =	5.37	5.13	3.99	2.63	1.78	1.12	.65	.45
VISIONALITY = 23. KM.								
N1 =	17698.91	17108.73	13306.28	8779.95	5884.11	3739.10	2150.51	1435.38
N2 =	2.24	2.14	1.66	1.10	.71	.47	.27	.19
VISIONALITY = 50. KM.								
N1 =	7503.11	7171.87	5577.91	3688.59	2382.74	1567.44	984.83	626.05
N2 =	.94	.90	.78	.46	.38	.28	.11	.08

Table 10. Total Number Density for the Maritime Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY = 0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY = 2. KM. N1 = 96516.79 N2 = 974.92	86640.83	70038.09	35076.01	24467.13	17683.12	11033.66	7418.74
	995.36	707.46	356.32	267.14	177.81	111.12	75.14
VISIBILITY = 5. KM. N1 = 36250.75 N2 = 3866.37	35129.41	27756.92	13901.03	9656.61	6976.32	4359.67	2946.06
	254.84	260.37	140.42	97.95	70.67	46.04	29.78
VISIBILITY = 10. KM. N1 = 16620.73 N2 = 198.19	17292.27	13663.20	6843.10	4773.11	3436.06	2146.02	1451.17
	174.67	136.01	69.12	48.21	30.69	21.68	14.66
VISIBILITY = 23. KM. N1 = 7851.07 N2 = 79.38	7210.41	5697.10	2853.39	1996.26	1431.91	984.83	605.13
	72.83	57.55	26.82	20.18	16.46	9.84	6.21
VISIBILITY = 50. KM. N1 = 3291.12 N2 = 33.26	3022.56	2368.22	1196.12	834.30	680.25	375.11	253.65
	38.53	24.12	12.88	8.43	6.86	3.79	2.56

Table 11. Total Number Density for the Tropospheric Aerosol Model as a Function of Relative Humidity and Meteorological Range

RELATIVE HUMIDITY = 0.	50.	70.	80.	90.	95.	98.	99.
VISIBILITY = 2. KM. N1 = 21997.62 N2 = 0.08	212240.41	197103.94	143715.10	93745.27	74441.95	54687.15	42396.01
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY = 5. KM. N1 = 87179.73 N2 = 0.00	64113.38	78114.62	56955.99	37152.36	29522.22	21673.16	16602.04
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY = 10. KM. N1 = 42933.77 N2 = 0.00	41404.36	38451.52	26036.29	18286.05	14522.32	10668.50	8273.72
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY = 23. KM. N1 = 17893.88 N2 = 0.00	17266.50	16033.24	11690.37	7625.62	6055.41	4446.49	3446.66
	0.00	0.00	0.00	0.00	0.00	0.00	0.00
VISIBILITY = 50. KM. N1 = 7501.00 N2 = 0.00	7237.17	6721.03	4900.53	3196.61	2530.35	1966.77	1445.66
	0.00	0.00	0.00	0.00	0.00	0.00	0.00

3.3 Fog Model Attenuation

The attenuation coefficients for the fog models are shown in Figures 27 through 31, using the number densities given in Table 7. The meteorological ranges for these droplet concentrations vary from 130 m for Fog Model 1 (Advection Fog) to 450 m for Fog Model 4 (Radiation Fog). However, the models are representative of heavy fogs with visibilities of less than 50 m, to light fogs with visibilities over 1 km, and can be scaled to visibilities over this range.

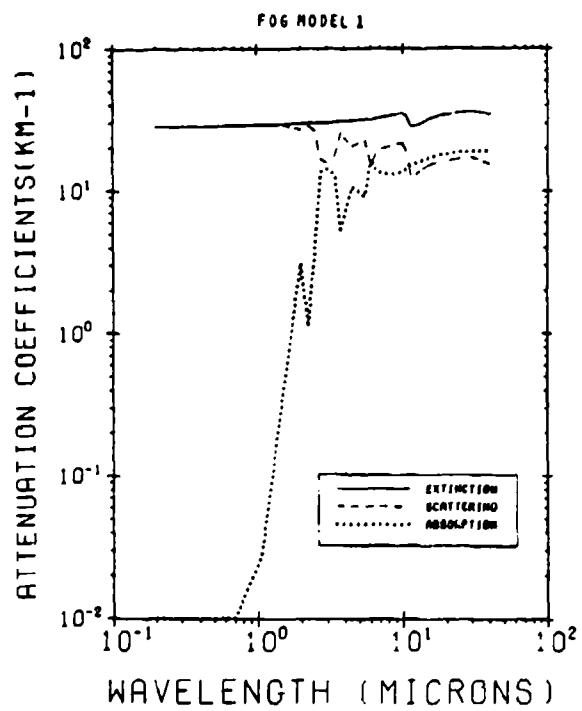


Figure 27. Attenuation Coefficients vs Wavelength; Heavy Advection Fog Model 1

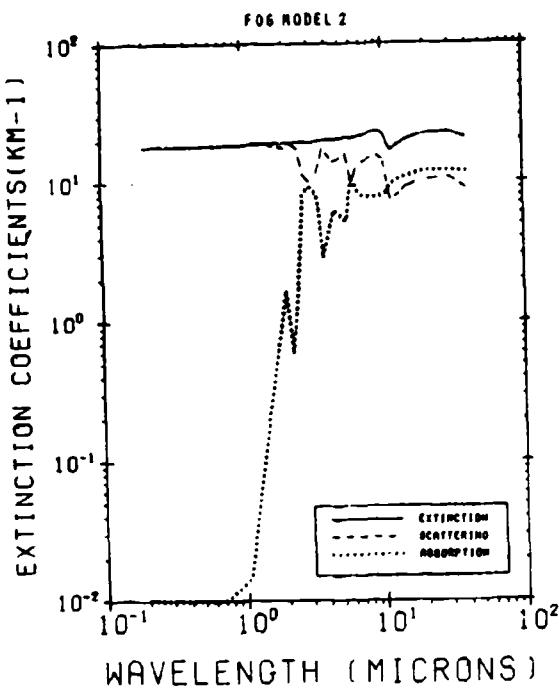


Figure 28. Attenuation Coefficients vs Wavelength; Light to Moderate Advection Fog Model 2

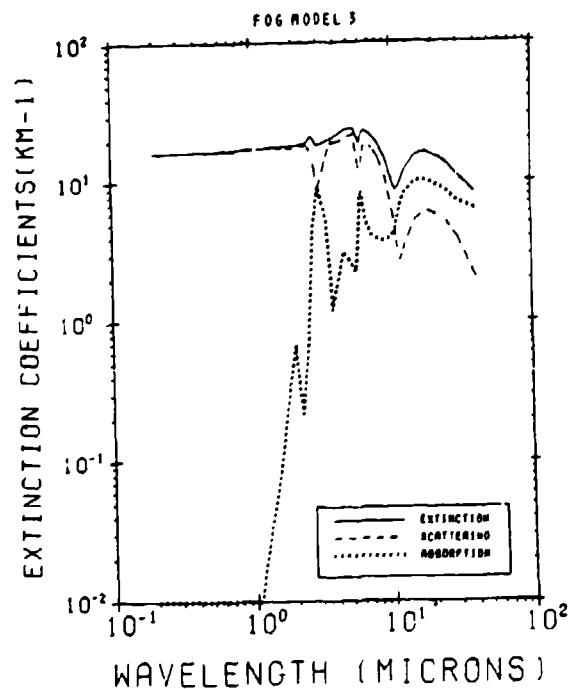


Figure 29. Attenuation Coefficients vs Wavelength; Heavy Radiation Fog, Model 3

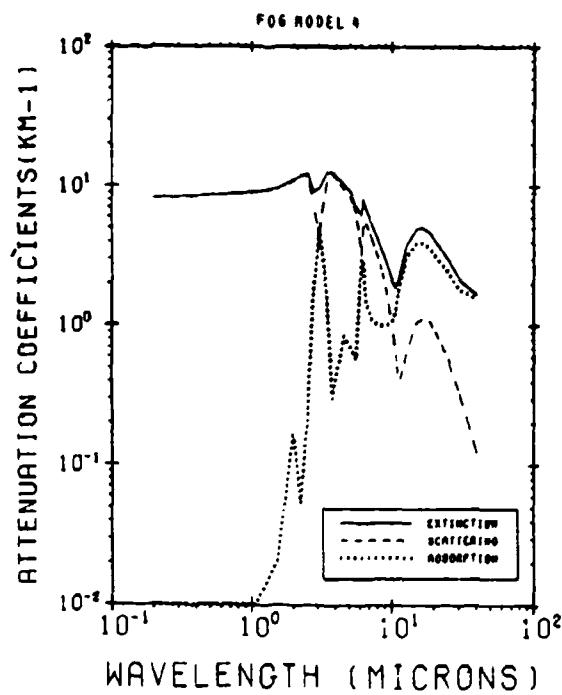


Figure 30. Attenuation Coefficients vs Wavelength; Light to Moderate Radiation Fog, Model 4

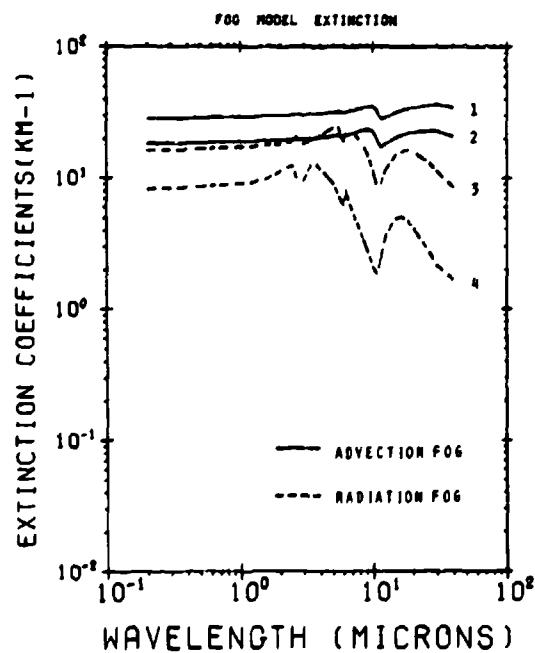


Figure 31. Extinction Coefficients vs Wavelength for the Different Fog Models. Models 1 and 2 are for heavy and light Advection Fog. Models 3 and 4 are for heavy and light Radiation Fog

3.4 Tables of Aerosol Attenuation

The attenuation coefficients for the different aerosol models are given in Tables 12 through 47. These attenuation coefficients in the tables are normalized to different number densities characteristic of the different types of aerosol, with the total number of particles being the same for each of the different humidities, for which the results are tabulated. This permits examination of how the optical properties of a given type of aerosol change with changes in the relative humidity, assuming no other processes, such as nucleation, coagulation, or sedimentation, affect the size distribution.

These tables also include the albedo for single scatter, a , which is the ratio of the scattering to total extinction cross-sections

$$a = \frac{\sigma_{\text{scat}}}{\sigma_{\text{ext}}} = \frac{\sigma_{\text{scat}}}{\sigma_{\text{scat}} + \sigma_{\text{abs}}} \quad (11)$$

Because it provides a convenient one parameter representation for the angular dependence of scattering by the aerosols, the asymmetry parameter, g , also has been given. The asymmetry parameter is defined as the cosine weighted average of the phase function, $P(\theta)$

$$g = \frac{\int_{-1}^{+1} \cos \theta P(\theta) d(\cos \theta)}{\int_{-1}^{+1} P(\theta) d(\cos \theta)} \quad (12)$$

where $P(\theta)$ is the differential probability of scattering at an angle θ .

The asymmetry parameter is particularly useful when multiple scattering effects are significant, and the details of the scattering function are smoothed out; then g characterizes the angular distribution of the radiation field in approximate radiative transfer methods as the Eddington approximation,⁸⁷ the Delta Eddington approximation,⁸⁸ and various forms of the Two-stream approximation.^{89,90} Using the asymmetry parameter with the Henyey-Greenstein⁹¹ phase function

$$P(\theta) = \frac{(1-g^2)}{[1+g^2 - 2g \cos \theta]^{3/2}} \quad (13)$$

reasonably accurate intensities can be determined with the more exact radiative transfer methods.⁹² However, for single scattering calculations this or any other one parameter approximation to the phase function should only be used with extreme caution.

Table 12. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Rural Model

WAVELENGTH (MICROND)	NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3			SCAT.ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	3.050E-01	2.076E-01	9.819E-02	.6789	.7981
.300	2.591E-01	2.377E-01	1.746E-02	.9816	.6709
.337	2.345E-01	2.221E-01	1.243E-02	.9470	.6712
.358	1.661E-01	1.375E-01	8.665E-03	.9407	.6479
.694	1.099E-01	1.024E-01	7.520E-03	.9315	.6342
1.060	6.129E-02	9.279E-02	8.502E-03	.8613	.6176
1.536	3.517E-02	2.706E-02	7.316E-03	.7920	.6334
2.000	2.149E-02	1.862E-02	2.879E-03	.8661	.7063
2.250	1.944E-02	1.661E-02	3.029E-03	.8442	.7271
2.500	1.787E-02	1.480E-02	3.073E-03	.8281	.7463
2.700	1.936E-02	1.110E-02	8.262E-03	.5773	.7768
3.000	1.636E-02	1.229E-02	4.068E-03	.7513	.7707
3.392	1.525E-02	1.332E-02	1.925E-03	.8778	.7424
3.750	1.455E-02	1.320E-02	1.270E-03	.9127	.7312
4.500	1.342E-02	1.129E-02	2.175E-03	.8410	.7642
5.000	1.235E-02	1.043E-02	1.914E-03	.8449	.7516
5.500	1.149E-02	9.114E-03	2.375E-03	.7923	.7662
6.000	1.027E-02	7.326E-03	2.943E-03	.7176	.7940
6.200	1.036E-02	7.199E-03	3.163E-03	.6947	.7886
6.500	1.051E-02	7.053E-03	3.461E-03	.6778	.7797
7.200	1.139E-02	6.215E-03	5.170E-03	.5459	.7664
7.900	6.548E-03	2.419E-03	4.129E-03	.3694	.8525
8.200	6.432E-03	6.445E-04	5.787E-03	.1002	.8700
8.700	1.780E-02	7.098E-03	9.908E-03	.4438	.5846
9.000	1.850E-02	7.050E-03	1.064E-02	.4248	.5570
9.200	1.875E-02	6.885E-03	1.187E-02	.3672	.5992
10.000	1.337E-02	7.478E-03	5.893E-03	.5593	.6159
10.591	1.180E-02	7.165E-03	4.639E-03	.6870	.6271
11.000	1.090E-02	7.164E-03	3.735E-03	.6573	.6257
11.500	1.006E-02	6.637E-03	3.418E-03	.6601	.6374
12.500	8.816E-03	5.634E-03	3.183E-03	.6390	.6546
14.000	7.233E-03	3.397E-03	3.836E-03	.4697	.6061
15.000	8.556E-03	2.799E-03	5.761E-03	.3266	.6859
16.400	8.766E-03	4.212E-03	4.554E-03	.4805	.6120
17.200	1.018E-02	4.773E-03	5.405E-03	.4689	.5570
18.500	8.362E-03	4.041E-03	4.322E-03	.4832	.5813
21.300	8.839E-03	3.727E-03	5.112E-03	.4217	.5341
25.000	7.569E-03	2.834E-03	4.735E-03	.3744	.5284
30.000	6.700E-03	1.893E-03	4.815E-03	.2821	.5137
40.000	6.289E-03	1.354E-03	4.935E-03	.2154	.4346

Table 13. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Rural Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 1.51005E+04 PARTICLES/CMT ³			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	3.172E-01	2.177E-01	9.954E-02	.68F2	.7592
.300	2.641E-01	2.467E-01	1.741E-02	.9341	.6836
.337	2.428E-01	2.303E-01	1.246E-02	.9487	.6762
.350	1.514E-01	1.428E-01	8.641E-03	.9427	.6534
.694	1.139E-01	1.084E-01	7.569E-03	.9326	.6392
1.060	6.361E-02	5.504E-02	8.571E-03	.8651	.6220
1.436	3.653E-02	2.914E-02	7.386E-03	.7974	.6765
2.000	2.241E-02	1.950E-02	2.912E-03	.8711	.7670
2.250	2.026E-02	1.718E-02	3.051E-03	.8602	.7277
2.500	1.856E-02	1.545E-02	3.110E-03	.8324	.7478
2.700	2.009E-02	1.151E-02	8.446E-03	.97E7	.7821
3.000	1.824E-02	1.178E-02	6.459E-03	.6654	.7759
3.392	1.605E-02	1.390E-02	2.148E-03	.8662	.7407
3.750	1.520E-02	1.389E-02	1.311E-03	.9117	.7311
4.500	1.400E-02	1.175E-02	2.247E-03	.8395	.7460
5.000	1.287E-02	1.086E-02	2.039E-03	.8440	.7535
5.500	1.196E-02	9.504E-03	2.455E-03	.7947	.7685
6.000	1.090E-02	7.424E-03	3.490E-03	.6818	.7982
6.200	1.104E-02	7.445E-03	3.595E-03	.6764	.7899
6.500	1.103E-02	7.377E-03	7.686E-03	.6886	.7810
7.200	1.182E-02	6.503E-03	5.322E-03	.5499	.7688
7.900	6.947E-03	2.676E-03	4.272E-03	.38F2	.8519
8.200	6.676E-03	7.442E-04	5.972E-03	.1115	.8719
8.700	1.841E-02	8.192E-03	1.022E-02	.4450	.5924
9.000	1.918E-02	8.156E-03	1.102E-02	.4293	.5652
9.200	1.938E-02	7.124E-03	1.226E-02	.3676	.6074
10.000	1.377E-02	7.693E-03	6.076E-03	.5587	.6249
10.591	1.215E-02	7.315E-03	4.832E-03	.6022	.6374
11.000	1.123E-02	7.244E-03	7.938E-03	.6469	.6376
11.500	1.340E-02	6.633E-03	3.765E-03	.6380	.6504
12.500	9.256E-03	5.508E-03	3.749E-03	.5990	.6604
14.000	7.878E-03	3.756E-03	4.523E-03	.42F9	.6919
15.000	9.229E-03	2.630E-03	6.394E-03	.3068	.6892
16.400	9.362E-03	4.205E-03	5.157E-03	.4492	.6200
17.200	1.074E-02	4.817E-03	5.926E-03	.4464	.5657
18.500	8.919E-03	4.071E-03	4.845E-03	.4566	.5889
21.300	9.319E-03	3.815E-03	5.504E-03	.4094	.5404
25.000	7.909E-03	2.922E-03	5.867E-03	.3658	.5331
30.000	7.062E-03	1.973E-03	5.889E-03	.2794	.5170
40.000	6.683E-03	1.411E-03	5.192E-03	.2137	.4399

Table 14. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Rural Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF (KM-1)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	1.5980E+04 PARTICLES/CM ³ SCAT. ALB.	ASYMMETRY PARAMETER
.200	3.620E-01	2.392E-01	1.020E-01	.6995	.7632	
.300	2.642E-01	2.566E-01	1.765E-02	.9379	.6920	
.337	2.611E-01	2.466E-01	1.292E-02	.9521	.6865	
.550	1.632E-01	1.546E-01	8.777E-03	.9462	.6638	
.694	1.222E-01	1.153E-01	7.641E-03	.9378	.6498	
1.060	6.882E-02	6.031E-02	8.711E-03	.8774	.6314	
1.536	3.970E-02	3.217E-02	7.527E-03	.8114	.6440	
2.000	2.466E-02	2.167E-02	2.986E-03	.8789	.7198	
2.250	2.221E-02	1.911E-02	3.182E-03	.8603	.7303	
2.500	2.029E-02	1.709E-02	3.200E-03	.8423	.7522	
2.700	2.158E-02	1.256E-02	9.817E-03	.5821	.7913	
3.000	2.259E-02	1.143E-02	1.112E-02	.5069	.7814	
3.392	1.807E-02	1.538E-02	2.695E-03	.8509	.7380	
3.750	1.605E-02	1.544E-02	1.413E-03	.9161	.7319	
4.500	1.547E-02	1.294E-02	2.922E-03	.8369	.7518	
5.000	1.424E-02	1.200E-02	2.242E-03	.8426	.7584	
5.500	1.318E-02	1.053E-02	2.652E-03	.7948	.7778	
6.000	1.247E-02	7.745E-03	4.725E-03	.6211	.8171	
6.200	1.273E-02	8.112E-03	4.816E-03	.6373	.7929	
6.500	1.237E-02	8.234E-03	4.135E-03	.6657	.7863	
7.200	1.296E-02	7.266E-03	5.694E-03	.5616	.7747	
7.900	7.997E-03	3.372E-03	4.624E-03	.4217	.8507	
8.200	7.330E-03	1.100E-03	6.290E-03	.1488	.8750	
8.700	1.985E-02	8.946E-03	1.091E-02	.4506	.6112	
9.000	2.079E-02	8.919E-03	1.167E-02	.4290	.5851	
9.200	2.096E-02	7.737E-03	1.312E-02	.3719	.6272	
10.000	1.474E-02	8.237E-03	6.906E-03	.5587	.6466	
10.591	1.299E-02	7.689E-03	5.301E-03	.5919	.6116	
11.000	1.204E-02	7.445E-03	4.600E-03	.6101	.6653	
11.500	1.123E-02	6.639E-03	4.592E-03	.5911	.6798	
12.500	1.033E-02	5.275E-03	5.058E-03	.5105	.6965	
14.000	9.654E-03	3.349E-03	6.199E-03	.3524	.7226	
15.000	1.085E-02	2.965E-03	7.881E-03	.2734	.6960	
16.400	1.003E-02	4.256E-03	6.570E-03	.3928	.6760	
17.200	1.214E-02	4.963E-03	7.180E-03	.4087	.5848	
18.500	1.029E-02	4.200E-03	6.090E-03	.4082	.6027	
21.300	1.051E-02	4.059E-03	6.460E-03	.3056	.5547	
25.000	9.042E-03	3.163E-03	5.879E-03	.3490	.5445	
30.000	7.948E-03	2.192E-03	5.756E-03	.2758	.5274	
40.000	7.379E-03	1.562E-03	5.817E-03	.2117	.4510	

Table 15. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Rural Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	4.649E-01	3.484E-01	1.165E-01	.7494	.7729
.300	3.849E-01	3.063E-01	1.859E-02	.9517	.7240
.337	3.546E-01	3.416E-01	1.306E-02	.9632	.7197
.350	2.245E-01	2.153E-01	9.161E-03	.9592	.6997
.694	1.708E-01	1.628E-01	8.011E-03	.9531	.6858
1.060	9.704E-02	8.771E-02	9.329E-03	.9039	.6650
1.536	5.690E-02	4.877E-02	8.132E-03	.8571	.6702
2.000	3.695E-02	3.355E-02	3.402E-03	.9079	.7181
2.250	3.295E-02	2.962E-02	3.331E-03	.8989	.7378
2.500	2.970E-02	2.604E-02	3.668E-03	.8763	.7651
2.700	3.009E-02	1.824E-02	1.186E-02	.6060	.P168
3.000	4.561E-02	1.407E-02	3.074E-02	.3261	.7661
3.392	2.890E-02	2.330E-02	5.600E-03	.8062	.7286
3.750	2.582E-02	2.394E-02	1.995E-03	.9271	.7716
4.500	2.358E-02	1.948E-02	4.055E-03	.8277	.7654
5.000	2.160E-02	1.825E-02	3.546E-03	.8372	.7775
5.500	2.001E-02	1.625E-02	3.746E-03	.8121	.7910
6.000	2.105E-02	1.023E-02	1.042E-02	.4861	.8303
6.200	2.180E-02	1.200E-02	9.802E-03	.5574	.8025
6.500	1.974E-02	1.298E-02	6.762E-03	.6574	.7957
7.200	1.931E-02	1.159E-02	7.726E-03	.6000	.7946
7.900	1.602E-02	7.448E-03	6.574E-03	.5312	.8468
8.200	1.257E-02	4.323E-03	8.251E-03	.3438	.8734
8.700	2.673E-02	1.278E-02	1.394E-02	.4763	.6831
9.000	2.827E-02	1.276E-02	1.551E-02	.4513	.6619
9.200	2.772E-02	1.093E-02	1.679E-02	.3944	.6994
10.000	1.962E-02	1.088E-02	8.745E-03	.5544	.7250
10.591	1.723E-02	9.450E-03	7.841E-03	.5465	.7449
11.000	1.632E-02	8.427E-03	7.890E-03	.5164	.7547
11.300	1.581E-02	6.903E-03	8.912E-03	.4365	.7665
12.500	1.671E-02	5.162E-03	1.157E-02	.3877	.7644
14.000	1.028E-02	4.273E-03	1.401E-02	.2337	.7265
15.000	1.978E-02	4.197E-02	1.558E-02	.2122	.7170
16.400	1.922E-02	5.300E-03	1.392E-02	.2757	.6769
17.200	2.012E-02	6.169E-03	1.395E-02	.3067	.6404
18.500	1.808E-02	5.478E-03	1.260E-02	.3030	.6442
21.300	1.723E-02	5.530E-03	1.170E-02	.3210	.6031
25.000	1.694E-02	4.605E-03	1.034E-02	.3081	.5854
30.000	1.290E-02	3.687E-03	9.416E-03	.2702	.5646
40.000	1.164E-02	2.451E-03	9.180E-03	.2176	.4977

Table 16. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Rural Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 1.5080E+06 PARTICLES/CM ³			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	6.745E-01	5.419E-01	1.326E-01	.8034	.7759
.300	5.637E-01	5.644E-01	1.973E-02	.9657	.7505
.337	5.260E-01	5.104E-01	1.360E-02	.9740	.7477
.350	3.409E-01	3.314E-01	9.549E-03	.9720	.7311
.694	2.621E-01	2.538E-01	8.334E-03	.9682	.7170
1.060	1.507E-01	1.408E-01	9.905E-03	.9343	.6934
1.536	8.898E-02	7.939E-02	8.694E-03	.9013	.6677
2.000	5.785E-02	5.384E-02	4.010E-03	.9377	.7167
2.250	5.046E-02	4.686E-02	3.631E-03	.9275	.7378
2.500	4.647E-02	4.007E-02	4.400E-04	.9010	.7622
2.700	4.333E-02	2.676E-02	1.647E-02	.6176	.6252
3.000	8.680E-02	2.353E-02	6.327E-02	.2711	.7249
3.392	4.597E-02	3.577E-02	1.020E-02	.7781	.7101
3.750	3.929E-02	3.637E-02	2.924E-03	.9256	.7248
4.500	3.551E-02	2.695E-02	6.586E-03	.8154	.7682
5.000	3.291E-02	2.723E-02	5.680E-03	.8274	.7760
5.500	3.008E-02	2.450E-02	5.580E-03	.8145	.7964
6.000	3.484E-02	1.643E-02	2.041E-02	.4141	.8769
6.200	3.570E-02	1.774E-02	1.796E-02	.4971	.8124
6.500	3.076E-02	1.972E-02	1.134E-02	.6412	.7948
7.200	2.890E-02	1.787E-02	1.103E-02	.6182	.8139
7.900	2.315E-02	1.339E-02	9.758E-03	.5784	.8425
8.200	2.131E-02	9.900E-03	1.141E-02	.4645	.8643
8.700	3.572E-02	1.784E-02	1.788E-02	.4994	.7340
9.000	3.768E-02	1.769E-02	1.999E-02	.4695	.7185
9.200	3.652E-02	1.527E-02	2.125E-02	.4181	.7489
10.000	2.661E-02	1.429E-02	1.233E-02	.5369	.7768
10.591	2.378E-02	1.175E-02	1.233E-02	.4941	.7971
11.000	2.318E-02	9.079E-03	1.330E-02	.4262	.8062
11.500	2.373E-02	7.756E-03	1.597E-02	.3268	.8121
12.500	2.835E-02	6.138E-03	2.221E-02	.2156	.7944
14.000	3.317E-02	6.348E-03	2.682E-02	.1914	.7402
15.000	3.469E-02	6.396E-03	2.829E-02	.1844	.7321
16.400	3.348E-02	7.476E-03	2.600E-02	.2233	.6999
17.200	3.370E-02	8.371E-03	2.533E-02	.2484	.6741
18.500	3.103E-02	7.025E-03	2.320E-02	.2522	.6696
21.300	2.822E-02	7.858E-03	2.036E-02	.2785	.6368
25.000	2.448E-02	6.839E-03	1.764E-02	.2793	.6164
30.000	2.086E-02	5.486E-03	1.538E-02	.2629	.5945
40.000	1.846E-02	3.033E-03	1.467E-02	.2076	.5344

Table 17. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Rural Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM ³	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMTRY PARAMETER
.200	8.142E-01	6.737E-01	1.405E-01	.8274	.7758	
.300	6.894E-01	6.696E-01	1.977E-02	.9717	.7606	
.337	6.436E-01	6.297E-01	1.385E-02	.9785	.7581	
.355	4.271E-01	4.174E-01	9.725E-03	.9772	.7438	
.694	3.315E-01	3.230E-01	5.910E-03	.9743	.7312	
1.060	1.923E-01	1.821E-01	1.018E-02	.9471	.7062	
1.536	1.126E-01	1.036E-01	9.010E-03	.9200	.6956	
2.000	7.427E-02	6.979E-02	4.478E-03	.9307	.7168	
2.250	6.489E-02	6.030E-02	3.792E-03	.9418	.7322	
2.500	5.576E-02	5.081E-02	4.945E-03	.9117	.7625	
2.700	5.331E-02	3.319E-02	2.012E-02	.6225	.8276	
3.000	1.175E-01	3.071E-02	8.684E-02	.2612	.7130	
3.392	5.911E-02	4.545E-02	1.366E-02	.7689	.7014	
3.750	4.952E-02	4.586E-02	3.655E-03	.9262	.7198	
4.500	4.452E-02	3.605E-02	8.472E-03	.8097	.7748	
5.000	4.126E-02	3.395E-02	7.320E-03	.8226	.7753	
5.500	3.766E-02	3.068E-02	6.984E-03	.8146	.7074	
6.000	4.517E-02	1.772E-02	2.746E-02	.7922	.6782	
6.200	4.605E-02	2.207E-02	2.397E-02	.4794	.8012	
6.500	3.903E-02	2.476E-02	1.642E-02	.6347	.7993	
7.200	3.616E-02	2.261E-02	1.355E-02	.6253	.8072	
7.900	3.006E-02	1.787E-02	1.219E-02	.5945	.8407	
8.200	2.806E-02	1.423E-02	1.382E-02	.5074	.8600	
8.700	4.208E-02	2.154E-02	2.054E-02	.5120	.7563	
9.000	4.610E-02	2.125E-02	2.246E-02	.4818	.7441	
9.200	4.263E-02	1.851E-02	2.412E-02	.4342	.7714	
10.000	3.183E-02	1.683E-02	1.500E-02	.5286	.7983	
10.591	2.869E-02	1.350E-02	1.519E-02	.4746	.8185	
11.000	2.844E-02	1.109E-02	1.735E-02	.3898	.8263	
11.500	2.985E-02	8.622E-03	2.123E-02	.2860	.8294	
12.500	3.730E-02	7.217E-03	2.008E-02	.1925	.8056	
14.000	4.434E-02	8.076E-03	3.626E-02	.1822	.7474	
15.000	4.585E-02	8.173E-03	3.767E-02	.1743	.7401	
16.400	4.425E-02	9.291E-03	3.495E-02	.2166	.7106	
17.200	4.403E-02	1.019E-02	3.384E-02	.2315	.6886	
18.500	4.082E-02	9.739E-03	3.108E-02	.2386	.6817	
21.300	3.656E-02	9.715E-03	2.684E-02	.2657	.6528	
25.000	3.174E-02	8.615E-03	2.312E-02	.2714	.6318	
30.000	2.696E-02	7.084E-03	1.907E-02	.2628	.6099	
40.000	2.367E-02	4.953E-03	1.872E-02	.2093	.5529	

Table 18. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Rural Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 1.8000E+04 PARTICLES/CM ³			SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)		
.200	1.0000E+00	0.9998E-01	1.0000E-01	.6907	.7773
.300	9.201E-01	0.9997E-01	2.192E-02	.9767	.7786
.337	8.659E-01	0.9996E-01	1.674E-02	.9939	.7712
.350	8.599E-01	0.9998E-01	1.029E-02	.9929	.7612
.664	6.755E-01	4.669E-01	6.998E-03	.9811	.7908
1.000	2.098E-01	2.789E-01	1.0000E-02	.9924	.7307
1.536	1.001E-01	1.703E-01	0.891E-03	.9452	.7227
2.000	1.270E-01	1.212E-01	6.808E-03	.9446	.7796
2.250	1.127E-01	1.001E-01	6.982E-03	.9501	.7833
2.500	1.001E-01	9.269E-02	7.457E-04	.9825	.7893
2.700	9.412E-02	6.078E-02	3.374E-02	.6657	.8990
3.000	1.942E-01	5.932E-02	1.389E-01	.2048	.7446
3.392	1.074E-01	8.017E-02	2.723E-02	.7465	.7222
3.750	9.202E-02	8.587E-02	7.157E-03	.9229	.7346
4.500	6.543E-02	6.693E-02	1.092E-02	.8020	.7467
5.000	6.098E-02	6.626E-02	1.473E-02	.8181	.7957
5.500	7.556E-02	6.213E-02	1.343E-02	.8227	.8167
6.000	8.532E-02	3.509E-02	5.023E-02	.4113	.6657
6.200	8.833E-02	4.746E-02	4.407E-02	.4926	.8262
6.500	7.790E-02	5.029E-02	2.791E-02	.6668	.8203
7.200	7.237E-02	6.807E-02	2.430E-02	.6642	.8300
7.900	6.510E-02	6.249E-02	2.268E-02	.6591	.8510
8.200	6.262E-02	5.846E-02	2.416E-02	.6162	.8628
8.700	7.200E-02	4.821E-02	3.077E-02	.5778	.8192
9.000	7.467E-02	4.076E-02	3.331E-02	.8503	.8159
9.200	7.101E-02	3.713E-02	7.467E-02	.5171	.8712
10.000	5.774E-02	3.189E-02	2.969E-02	.9919	.8561
10.591	5.196E-02	2.443E-02	2.793E-02	.6772	.8710
11.000	9.143E-02	1.920E-02	3.223E-02	.3737	.8764
11.500	5.433E-02	1.451E-02	3.917E-02	.2790	.8746
12.000	6.923E-02	1.496E-02	5.427E-02	.2161	.8479
14.000	8.346E-02	1.071E-02	6.475E-02	.2242	.7036
15.000	8.904E-02	1.097E-02	6.600E-02	.2237	.7786
16.400	8.190E-02	2.093E-02	6.297E-02	.2459	.7926
17.200	8.266E-02	2.197E-02	6.113E-02	.2605	.7289
18.000	7.670E-02	2.194E-02	5.724E-02	.2730	.7869
21.300	7.127E-02	2.124E-02	5.803E-02	.2907	.7049
25.000	6.371E-02	1.976E-02	6.299E-02	.3151	.6829
30.000	5.532E-02	1.733E-02	3.800E-02	.3132	.5600
40.000	4.786E-02	1.243E-02	3.543E-02	.2590	.6112

Table 19. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Rural Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 1.5000E+04 PARTICLES/CM3			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	1.388E+00	1.188E+00	1.718E-01	.8679	.7770
.250	1.158E+00	1.125E+00	2.227E-02	.9000	.7793
.337	1.097E+00	1.082E+00	1.921E-02	.9881	.7786
.500	7.628E-01	7.724E-01	1.850E-02	.9866	.7717
.694	6.814E-01	6.222E-01	9.156E-03	.9855	.7620
1.066	3.961E-01	3.849E-01	1.125E-02	.9716	.7444
1.926	2.929E-01	2.422E-01	1.038E-02	.9589	.7365
2.000	1.637E-01	1.747E-01	9.016E-03	.9519	.7491
2.250	1.626E-01	1.572E-01	5.473E-03	.9666	.7609
2.500	1.451E-01	1.347E-01	1.040E-02	.9283	.7921
2.750	1.358E-01	8.799E-02	4.780E-02	.6481	.8686
3.000	2.749E-01	8.163E-02	1.933E-01	.2969	.7517
3.392	1.566E-01	1.149E-01	4.169E-02	.7379	.7294
3.750	1.361E-01	1.249E-01	1.121E-02	.9176	.7413
4.500	1.263E-01	1.000E-01	2.633E-02	.7916	.7920
5.000	1.280E-01	9.769E-02	2.307E-02	.8090	.8016
5.500	1.130E-01	9.315E-02	2.078E-02	.8176	.8225
6.000	1.269E-01	5.303E-02	7.390E-12	.4178	.8761
6.250	1.312E-01	6.463E-02	6.660E-12	.4925	.8750
6.500	1.175E-01	7.552E-02	4.187E-02	.6472	.8286
7.200	1.094E-01	7.363E-02	3.623E-02	.6712	.8705
7.500	1.015E-01	6.725E-02	3.429E-02	.6623	.8549
8.200	9.867E-02	6.296E-02	3.967E-02	.6374	.8654
8.700	1.061E-01	6.396E-02	4.212E-02	.6030	.8414
9.000	1.063E-01	6.158E-02	4.474E-02	.5792	.8415
9.200	1.030E-01	5.9740E-02	4.617E-02	.5542	.8527
10.000	8.665E-02	4.860E-02	3.805E-02	.5608	.8740
10.991	7.822E-02	3.711E-02	4.111E-02	.4744	.8943
11.000	7.731E-02	2.902E-02	4.829E-02	.3754	.8952
11.900	8.157E-02	2.338E-02	5.822E-02	.2063	.8923
12.500	1.037E-01	2.421E-02	7.945E-02	.2376	.8611
14.000	1.247E-01	3.059E-02	9.411E-02	.2651	.8233
15.000	1.263E-01	3.092E-02	9.541E-02	.2446	.7989
16.400	1.249E-01	3.303E-02	9.105E-02	.2645	.7758
17.200	1.235E-01	3.421E-02	8.932E-02	.2769	.7632
18.500	1.189E-01	3.461E-02	8.426E-02	.2912	.7508
21.200	1.084E-01	3.414E-02	7.426E-02	.3149	.7314
25.000	9.035E-02	3.237E-02	6.597E-02	.3292	.7091
30.000	8.671E-02	2.918E-02	5.754E-02	.3369	.6867
40.000	7.517E-02	2.148E-02	5.369E-02	.2657	.6419

Table 20. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Urban Model

WAVELENGTH (MICRORID	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM ³			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	3.336E-01	1.958E-01	1.386E-01	.5046	.7705
.300	2.009E-01	1.843E-01	1.042E-01	.6389	.7182
.337	2.003E-01	1.724E-01	9.591E-02	.6626	.7067
.350	1.767E-01	1.627E-01	8.393E-02	.6322	.6617
.694	1.374E-01	8.579E-02	5.163E-02	.6243	.6413
1.060	8.320E-02	4.630E-02	3.690E-02	.5565	.6166
1.536	5.302E-02	2.535E-02	2.766E-02	.4782	.6287
2.000	3.779E-02	1.601E-02	2.178E-02	.4237	.6883
2.250	3.479E-02	1.404E-02	2.025E-02	.4045	.7670
2.500	3.160E-02	1.261E-02	1.899E-02	.3941	.7243
2.700	3.202E-02	1.118E-02	2.084E-02	.3491	.7370
3.000	2.858E-02	1.079E-02	1.771E-02	.3787	.7446
3.392	2.612E-02	1.065E-02	1.547E-02	.4076	.7391
3.750	2.474E-02	1.028E-02	1.646E-02	.4155	.7771
4.500	2.247E-02	9.203E-03	1.326E-02	.4047	.7414
5.000	2.099E-02	8.614E-03	1.237E-02	.4144	.7435
5.500	1.984E-02	7.933E-03	1.191E-02	.3998	.7466
6.000	1.873E-02	7.067E-03	1.166E-02	.3773	.7543
6.200	1.855E-02	6.987E-03	1.157E-02	.3766	.7498
6.500	1.830E-02	6.903E-03	1.140E-02	.3772	.7424
7.200	1.827E-02	6.501E-03	1.177E-02	.3558	.7270
7.900	1.568E-02	4.391E-03	1.109E-02	.2836	.7676
8.200	1.528E-02	3.005E-03	1.228E-02	.1946	.7850
8.700	2.109E-02	8.154E-03	1.293E-02	.3867	.5887
9.000	2.144E-02	8.253E-03	1.319E-02	.3849	.5616
9.200	2.173E-02	7.419E-03	1.431E-02	.3614	.5911
10.000	1.732E-02	7.153E-03	1.016E-02	.4131	.6156
10.591	1.601E-02	6.696E-03	9.311E-03	.4183	.6238
11.000	1.519E-02	6.531E-03	8.656E-03	.4300	.6240
11.500	1.448E-02	6.115E-03	8.365E-03	.4223	.6281
12.500	1.337E-02	5.427E-03	7.939E-03	.4067	.6376
14.000	1.184E-02	3.982E-03	7.054E-03	.3364	.6298
15.000	1.276E-02	3.672E-03	9.064E-03	.2803	.6252
16.400	1.209E-02	4.408E-03	7.645E-03	.3645	.5785
17.200	1.266E-02	4.831E-03	7.046E-03	.3810	.5370
18.500	1.123E-02	4.167E-03	7.059E-03	.3712	.5512
21.300	1.092E-02	3.886E-03	7.032E-03	.3559	.5072
25.000	9.495E-03	3.079E-03	6.415E-03	.3243	.4930
30.000	8.359E-03	2.236E-03	6.123E-03	.2675	.4709
40.000	7.151E-03	1.598E-03	5.554E-03	.2234	.4009

Table 21. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Urban Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+84 PARTICLES/CM ³			SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	3.516E-01	2.091E-01	1.425E-01	.5947	.7811
.300	3.026E-01	1.986E-01	1.883E-01	.6488	.7236
.337	2.813E-01	1.839E-01	9.774E-02	.6525	.7126
.390	1.848E-01	1.199E-01	6.498E-02	.6864	.6605
.494	1.437E-01	9.118E-02	5.252E-02	.6345	.6482
1.060	8.688E-02	4.928E-02	3.761E-02	.5672	.6231
1.536	5.527E-02	2.709E-02	2.822E-02	.4893	.6342
2.000	3.939E-02	1.718E-02	2.222E-02	.4361	.6919
2.250	3.970E-02	1.507E-02	2.064E-02	.4220	.7106
2.500	3.287E-02	1.350E-02	1.937E-02	.4157	.7266
2.700	3.324E-02	1.162E-02	2.142E-02	.3557	.7440
3.000	3.143E-02	1.125E-02	2.016E-02	.3579	.7453
3.392	2.748E-02	1.155E-02	1.593E-02	.4203	.7388
3.750	2.587E-02	1.110E-02	1.477E-02	.4292	.7392
4.500	2.349E-02	9.081E-03	1.361E-02	.4207	.7455
5.000	2.193E-02	9.248E-03	1.264E-02	.4217	.7480
5.500	2.070E-02	8.501E-03	1.220E-02	.4156	.7519
6.000	1.980E-02	7.427E-03	1.237E-02	.3751	.7611
6.200	1.964E-02	7.474E-03	1.217E-02	.3805	.7540
6.500	1.918E-02	7.604E-03	1.170E-02	.3850	.7476
7.200	1.908E-02	6.943E-03	1.213E-02	.3640	.7138
7.900	1.614E-02	4.750E-03	1.139E-02	.2947	.7728
8.200	1.584E-02	3.285E-03	1.258E-02	.2074	.7908
8.700	2.218E-02	6.617E-03	1.356E-02	.3885	.6008
9.000	2.263E-02	6.723E-03	1.391E-02	.3854	.5753
9.200	2.285E-02	7.609E-03	1.504E-02	.3418	.6038
10.000	1.812E-02	7.512E-03	1.060E-02	.4147	.6296
10.591	1.673E-02	6.989E-03	9.742E-03	.4177	.6375
11.000	1.589E-02	6.767E-03	9.127E-03	.4247	.6385
11.500	1.520E-02	6.276E-03	8.925E-03	.4120	.6432
12.500	1.421E-02	5.682E-03	8.724E-03	.3859	.6454
14.000	1.288E-02	4.066E-03	8.899E-03	.3158	.6387
15.000	1.381E-02	3.791E-03	1.002E-02	.2746	.6331
16.400	1.311E-02	4.532E-03	8.574E-03	.3458	.5684
17.200	1.367E-02	4.990E-03	8.672E-03	.3656	.5489
18.500	1.216E-02	4.322E-03	7.847E-03	.3553	.5673
21.300	1.175E-02	4.076E-03	7.676E-03	.3468	.5166
25.000	1.022E-02	3.252E-03	6.969E-03	.3182	.5016
38.000	8.970E-03	2.382E-03	6.588E-03	.2655	.4791
40.000	7.696E-03	1.699E-03	5.997E-03	.2208	.4101

Table 22. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Urban Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM3			SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	4.640E-01	3.000E-01	1.641E-01	.6471	.7906
.300	3.921E-01	2.748E-01	1.173E-01	.7000	.7476
.337	3.630E-01	2.566E-01	1.073E-01	.7049	.7385
.550	2.377E-01	1.670E-01	7.069E-02	.7026	.6998
.694	1.845E-01	1.272E-01	5.721E-02	.6899	.6803
1.060	1.108E-01	6.950E-02	4.135E-02	.6270	.6536
1.536	7.000E-02	3.004E-02	3.125E-02	.5942	.6590
2.000	5.002E-02	2.541E-02	2.461E-02	.5080	.7056
2.250	4.502E-02	2.223E-02	2.279E-02	.4937	.7258
2.500	4.107E-02	1.962E-02	2.145E-02	.4777	.7484
2.700	4.090E-02	1.615E-02	2.475E-02	.3950	.7769
3.000	5.090E-02	1.501E-02	3.589E-02	.2950	.7405
3.392	3.649E-02	1.776E-02	1.873E-02	.4867	.7351
3.750	3.339E-02	1.608E-02	1.651E-02	.5055	.7459
4.500	3.024E-02	1.462E-02	1.562E-02	.4835	.7625
5.000	2.819E-02	1.370E-02	1.449E-02	.4860	.7673
5.500	2.635E-02	1.249E-02	1.386E-02	.4740	.7759
6.000	2.692E-02	9.880E-03	1.704E-02	.3670	.7410
6.200	2.691E-02	1.076E-02	1.616E-02	.3947	.7732
6.500	2.511E-02	1.092E-02	1.419E-02	.4348	.7703
7.200	4.435E-02	1.006E-02	1.430E-02	.4130	.7644
7.500	2.866E-02	7.385E-03	1.328E-02	.3574	.7966
8.200	1.987E-02	5.497E-03	1.438E-02	.2766	.8142
8.700	2.055E-02	1.158E-02	1.697E-02	.4055	.6635
9.000	2.951E-02	1.170E-02	1.781E-02	.3964	.6428
9.200	2.924E-02	1.032E-02	1.891E-02	.3532	.6730
10.000	2.285E-02	9.721E-03	1.313E-02	.4255	.6935
10.591	2.102E-02	8.701E-03	1.232E-02	.4146	.7050
11.000	2.017E-02	8.078E-03	1.299E-02	.4005	.7092
11.500	1.969E-02	7.125E-03	1.257E-02	.3618	.7145
12.500	1.907E-02	5.888E-03	1.399E-02	.2962	.7094
14.000	2.004E-02	4.876E-03	1.516E-02	.2434	.6762
15.000	2.110E-02	4.796E-03	1.635E-02	.2254	.6684
16.400	2.008E-02	5.525E-03	1.456E-02	.2751	.6316
17.200	2.045E-02	6.148E-03	1.430E-02	.3087	.5997
18.500	1.862E-02	5.488E-03	1.313E-02	.2948	.6013
21.300	1.740E-02	5.350E-03	1.205E-02	.3075	.5625
25.000	1.513E-02	4.638E-03	1.069E-02	.2934	.5433
30.000	1.240E-02	3.396E-03	9.680E-03	.2997	.5198
40.000	1.129E-02	2.397E-03	8.892E-03	.2123	.4952

Table 23. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Urban Model

WAVELENGTH MICRONS	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+04 PARTICLES/CM ³			SCAT. ALBD.	ASYMMETRY PARAMETER
	EXTINCTION (CM ⁻¹)	SCATTERING (CM ⁻¹)	ABSORPTION (CM ⁻¹)		
.200	7.075E-01	5.099E-01	1.976E-01	.7200	.7949
.300	5.968E-01	4.872E-01	1.336E-01	.7738	.7713
.400	5.469E-01	4.274E-01	1.215E-01	.7786	.7698
.500	3.682E-01	2.811E-01	7.986E-02	.7805	.7362
.600	2.799E-01	2.150E-01	6.407E-02	.7711	.7162
1.000	1.666E-01	1.199E-01	4.670E-02	.7197	.6673
1.500	1.833E-01	6.784E-02	3.950E-02	.6965	.6820
2.000	7.316E-02	4.905E-02	2.811E-02	.6158	.7131
2.500	6.477E-02	3.886E-02	2.581E-02	.6015	.7312
3.000	5.799E-02	3.353E-02	2.446E-02	.5782	.7503
3.700	5.624E-02	2.548E-02	3.083E-02	.4517	.8030
3.892	5.536E-02	2.463E-02	7.073E-02	.2903	.7171
3.750	4.886E-02	3.144E-02	2.421E-02	.9650	.7185
4.000	4.481E-02	2.971E-02	1.915E-02	.6081	.7400
4.500	4.481E-02	2.486E-02	1.915E-02	.9648	.7698
5.000	4.092E-02	2.332E-02	1.760E-02	.5699	.7778
5.500	3.761E-02	2.116E-02	1.665E-02	.9997	.7923
6.000	4.219E-02	1.692E-02	2.727E-02	.3536	.6142
6.200	4.233E-02	1.746E-02	2.484E-02	.4131	.7864
6.500	3.744E-02	1.838E-02	1.907E-02	.4908	.7867
7.000	3.517E-02	1.679E-02	1.838E-02	.4775	.7891
7.500	3.040E-02	1.336E-02	1.704E-02	.4394	.8147
8.000	2.981E-02	1.091E-02	1.810E-02	.3760	.8298
8.700	3.941E-02	1.719E-02	2.222E-02	.4362	.7276
9.000	4.885E-02	1.718E-02	2.367E-02	.4205	.7136
9.200	3.985E-02	1.517E-02	2.468E-02	.3806	.7361
10.000	3.134E-02	1.372E-02	1.762E-02	.4379	.7590
10.591	2.890E-02	1.163E-02	1.727E-02	.4024	.7729
11.000	2.848E-02	1.019E-02	1.820E-02	.3989	.7783
11.500	2.892E-02	8.519E-03	2.040E-02	.2946	.7608
12.500	3.270E-02	7.110E-03	2.567E-02	.2169	.7624
14.000	3.626E-02	7.114E-03	2.915E-02	.1962	.7094
15.000	3.742E-02	7.129E-03	3.029E-02	.1905	.7022
16.000	3.582E-02	7.985E-03	2.783E-02	.2229	.6714
17.200	3.562E-02	8.784E-03	2.691E-02	.2444	.6480
18.500	3.297E-02	8.171E-03	2.468E-02	.2679	.6417
21.300	2.970E-02	6.021E-03	2.168E-02	.2701	.6104
25.000	2.976E-02	6.993E-03	1.881E-02	.2699	.5887
30.000	2.193E-02	5.595E-03	1.633E-02	.2551	.5651
40.000	1.092E-02	3.984E-03	1.501E-02	.2064	.5058

Table 24. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Urban Model

WAVELENGTH (MICROND)	NORMALIZED TO A NUMBER DENSITY OF 2.0000E+06 PARTICLES/CM3				
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.000E+00	0.1400E+01	2.2000E+01	.7893	.7921
.300	0.651E-01	7.350E-01	1.494E-01	.8311	.7047
.337	0.276E-01	0.921E-01	1.355E-01	.8362	.7807
.390	0.563E-01	4.600E-01	0.781E-02	.8422	.7974
.494	0.381E-01	3.649E-01	7.126E-02	.8366	.7417
1.068	2.604E-01	2.002E-01	5.227E-02	.7993	.7128
1.936	1.595E-01	1.196E-01	3.988E-02	.7900	.6999
2.800	1.119E-01	7.939E-02	3.194E-02	.7146	.7175
2.850	9.744E-02	6.850E-02	2.894E-02	.7030	.7330
2.900	0.551E-02	5.769E-02	2.791E-02	.6747	.7619
2.700	0.862E-02	4.085E-02	3.977E-02	.5867	.8183
3.000	1.667E-01	4.178E-02	1.250E-01	.2516	.6984
3.392	0.728E-02	5.466E-02	3.262E-02	.6262	.7031
3.750	7.397E-02	5.167E-02	2.229E-02	.6986	.7301
4.500	6.622E-02	4.200E-02	2.422E-02	.6347	.7696
5.000	6.153E-02	3.950E-02	2.202E-02	.6421	.7800
5.500	5.649E-02	3.594E-02	2.055E-02	.6363	.7993
6.000	6.691E-02	2.327E-02	4.364E-02	.3478	.8272
6.200	6.724E-02	2.840E-02	3.883E-02	.4224	.7927
6.500	5.786E-02	3.077E-02	2.679E-02	.5346	.7950
7.200	5.292E-02	2.829E-02	2.462E-02	.5347	.8035
7.500	4.682E-02	2.304E-02	2.290E-02	.5892	.8249
8.200	4.682E-02	2.680E-02	2.402E-02	.4641	.8373
8.700	5.313E-02	2.621E-02	2.093E-02	.4753	.7736
9.000	5.655E-02	2.576E-02	3.879E-02	.4556	.7660
9.200	5.687E-02	2.309E-02	3.170E-02	.4208	.7831
10.000	4.434E-02	2.010E-02	2.423E-02	.4534	.8054
10.591	4.110E-02	1.623E-02	2.488E-02	.3948	.8201
11.000	4.136E-02	1.355E-02	2.783E-02	.3272	.8249
11.500	4.382E-02	1.100E-02	3.282E-02	.2510	.8239
12.000	5.412E-02	9.895E-03	4.423E-02	.1828	.7997
14.000	6.271E-02	1.137E-02	5.135E-02	.1812	.7351
15.000	6.389E-02	1.168E-02	5.241E-02	.1797	.7291
16.000	6.157E-02	1.254E-02	4.903E-02	.2037	.7020
17.200	6.049E-02	1.333E-02	4.716E-02	.2203	.6643
18.000	5.668E-02	1.299E-02	4.369E-02	.2300	.6742
21.300	4.988E-02	1.269E-02	3.719E-02	.2544	.6491
25.000	4.332E-02	1.130E-02	3.194E-02	.2627	.6268
30.000	2.668E-02	9.535E-03	2.714E-02	.2608	.6836
40.000	3.199E-02	6.655E-03	2.489E-02	.2110	.5493

Table 25. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Urban Model

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	2.0000E+04 DENSITY OF PARTICLES/CM3	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.473E+00	1.214E+00	2.592E-01	.8241	.7883	
.300	1.206E+00	1.121E+00	1.655E-01	.8713	.7922	
.337	1.213E+00	1.063E+00	1.498E-01	.8765	.7897	
.550	8.457E-01	7.487E-01	9.707E-02	.8852	.7730	
.694	6.731E-01	5.942E-01	7.888E-02	.8826	.7597	
1.060	4.089E-01	3.500E-01	5.003E-02	.8581	.7326	
1.536	2.505E-01	2.061E-01	4.440E-02	.8228	.7160	
2.000	1.751E-01	1.388E-01	3.628E-02	.7928	.7241	
2.250	1.509E-01	1.183E-01	3.219E-02	.7861	.7365	
2.500	1.299E-01	9.807E-02	3.179E-02	.7552	.7650	
2.700	1.194E-01	6.602E-02	5.339E-02	.5529	.6287	
3.000	2.768E-01	7.041E-02	2.042E-01	.2564	.6912	
3.392	1.394E-01	9.271E-02	4.573E-02	.6697	.6946	
3.750	1.144E-01	8.809E-02	2.636E-02	.7697	.7224	
4.500	1.019E-01	6.995E-02	3.199E-02	.6862	.7678	
5.000	9.682E-02	6.604E-02	2.870E-02	.6965	.7790	
5.500	8.699E-02	6.053E-02	2.646E-02	.6958	.8124	
6.000	1.060E-01	3.713E-02	6.889E-02	.3502	.8358	
6.200	1.067E-01	4.603E-02	6.069E-02	.4313	.7967	
6.500	9.014E-02	5.101E-02	3.913E-02	.5659	.8120	
7.200	8.210E-02	4.757E-02	3.453E-02	.5794	.8126	
7.900	7.621E-02	4.171E-02	3.290E-02	.5620	.8318	
8.200	7.149E-02	3.799E-02	3.350E-02	.5313	.8421	
8.700	8.015E-02	4.140E-02	3.875E-02	.5165	.8558	
9.000	8.097E-02	4.009E-02	4.087E-02	.4952	.8033	
9.200	7.662E-02	3.670E-02	4.192E-02	.4668	.8161	
10.000	6.563E-02	3.103E-02	3.460E-02	.4728	.8277	
10.591	6.107E-02	2.419E-02	3.688E-02	.3961	.8527	
11.000	6.242E-02	1.951E-02	4.291E-02	.3125	.8568	
11.500	6.781E-02	1.577E-02	5.234E-02	.2326	.8534	
12.500	8.789E-02	1.544E-02	7.245E-02	.1756	.8200	
14.000	1.040E-01	1.901E-02	8.500E-02	.1028	.7582	
15.000	1.052E-01	1.924E-02	8.596E-02	.1029	.7531	
16.400	1.020E-01	2.068E-02	8.131E-02	.2027	.7267	
17.200	9.973E-02	2.150E-02	7.815E-02	.2163	.7145	
18.500	9.371E-02	2.151E-02	7.220E-02	.2245	.7031	
21.300	8.228E-02	2.096E-02	6.132E-02	.2547	.6825	
25.000	7.191E-02	1.920E-02	5.262E-02	.2642	.6604	
30.000	6.112E-02	1.671E-02	4.441E-02	.2733	.6379	
40.000	5.293E-02	1.182E-02	4.071E-02	.2250	.5063	

Table 28. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Urban Model

WAVELENGTH (NM)	NORMALIZED TD A NUMBER DENSITY OF (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	2.0000E+04 PARTICLES/CM3	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	2.259E+00	1.997E+00	3.023E-01	.8662	.7836	
.300	2.070E+00	1.000E+00	1.906E-01	.9000	.7974	
.337	1.979E+00	1.007E+00	1.722E-01	.9139	.7966	
.550	1.465E+00	1.394E+00	1.114E-01	.9240	.7874	
.694	1.190E+00	1.000E+00	9.033E-02	.9246	.7775	
1.060	7.590E-01	6.929E-01	6.647E-02	.9124	.7550	
1.536	4.745E-01	4.030E-01	5.088E-02	.8926	.7371	
2.000	3.344E-01	2.900E-01	4.433E-02	.8674	.7376	
2.250	2.849E-01	2.476E-01	3.720E-02	.8691	.7661	
2.500	2.424E-01	2.025E-01	3.963E-02	.8357	.7726	
2.700	2.171E-01	1.297E-01	6.731E-02	.5978	.8415	
3.000	5.200E-01	1.434E-01	3.765E-01	.2759	.6986	
3.392	2.679E-01	1.890E-01	7.888E-02	.7046	.6951	
3.750	2.178E-01	1.821E-01	7.555E-02	.8363	.7145	
4.560	1.931E-01	1.609E-01	5.217E-02	.7298	.7682	
5.000	1.605E-01	1.361E-01	4.645E-02	.7427	.7876	
5.500	1.667E-01	1.247E-01	4.198E-02	.7482	.8054	
6.000	2.034E-01	7.412E-02	1.293E-01	.3644	.8472	
6.200	2.055E-01	9.138E-02	1.140E-01	.4449	.8037	
6.500	1.742E-01	1.031E-01	7.106E-02	.5921	.8069	
7.280	1.592E-01	9.865E-02	6.056E-02	.6196	.8227	
7.900	1.476E-01	8.991E-02	5.769E-02	.6091	.8401	
8.200	1.434E-01	8.469E-02	5.853E-02	.5919	.8487	
8.700	1.476E-01	8.380E-02	6.384E-02	.5676	.8365	
9.000	1.465E-01	8.030E-02	6.621E-02	.5481	.8387	
9.280	1.430E-01	7.550E-02	6.744E-02	.5205	.8676	
10.000	1.245E-01	6.283E-02	6.164E-02	.5048	.8687	
10.591	1.158E-01	4.807E-02	6.774E-02	.4151	.8844	
11.000	1.187E-01	3.795E-02	6.871E-02	.3193	.8884	
11.500	1.299E-01	3.100E-02	9.888E-02	.2392	.8839	
12.500	1.714E-01	3.275E-02	1.387E-01	.1910	.8489	
14.000	2.048E-01	4.138E-02	1.634E-01	.2021	.7896	
15.000	2.060E-01	4.185E-02	1.642E-01	.2031	.7856	
16.400	2.019E-01	4.436E-02	1.571E-01	.2262	.7642	
17.200	1.969E-01	4.562E-02	1.513E-01	.2317	.7531	
18.500	1.868E-01	4.621E-02	1.405E-01	.2474	.7415	
21.300	1.652E-01	4.918E-02	1.201E-01	.2734	.7253	
25.000	1.466E-01	4.277E-02	1.041E-01	.2913	.7044	
30.000	1.271E-01	3.856E-02	8.854E-02	.3034	.6829	
40.000	1.099E-01	2.833E-02	8.159E-02	.2577	.6395	

Table 27. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Urban Model

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	2.000E+04 PARTICLES/CM3	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.280	2.997E+00	2.690E+00	3.379E-01	.9869	.7814	
.300	2.830E+00	2.610E+00	2.115E-01	.9253	.7993	
.337	2.730E+00	2.540E+00	1.906E-01	.9302	.7995	
.550	2.115E+00	1.992E+00	1.224E-01	.9421	.7948	
.694	1.769E+00	1.670E+00	9.882E-02	.9441	.7870	
1.060	1.164E+00	1.091E+00	7.237E-02	.9378	.7682	
1.536	7.474E-01	6.918E-01	5.562E-02	.9256	.7751	
2.000	5.340E-01	4.814E-01	3.337E-02	.9072	.7501	
2.250	4.562E-01	4.144E-01	4.177E-02	.9084	.7565	
2.500	3.673E-01	3.375E-01	4.981E-02	.9114	.7629	
2.700	3.429E-01	2.109E-01	1.320E-01	.6150	.6516	
3.000	8.005E-01	2.361E-01	5.644E-01	.2950	.7137	
3.392	4.334E-01	3.106E-01	1.229E-01	.7165	.7039	
3.750	3.924E-01	3.041E-01	4.874E-02	.8628	.7241	
4.500	3.126E-01	2.320E-01	8.094E-02	.7423	.7728	
5.000	2.930E-01	2.221E-01	7.162E-02	.7562	.7846	
5.500	2.737E-01	2.094E-01	5.434E-02	.7649	.8093	
6.000	3.283E-01	1.248E-01	2.035E-01	.3800	.6576	
6.200	3.322E-01	1.512E-01	1.010E-01	.4552	.6125	
6.500	2.897E-01	1.714E-01	1.143E-01	.5999	.6140	
7.200	2.639E-01	1.672E-01	9.677E-02	.6333	.8304	
7.900	2.486E-01	1.557E-01	9.293E-02	.6262	.8472	
8.200	2.430E-01	1.494E-01	9.357E-02	.6153	.8549	
8.700	2.429E-01	1.442E-01	9.976E-02	.5935	.8525	
9.000	2.396E-01	1.383E-01	1.013E-01	.5772	.8569	
9.200	2.349E-01	1.322E-01	1.027E-01	.5627	.8640	
10.000	2.097E-01	1.106E-01	9.914E-02	.5276	.8952	
10.501	1.948E-01	8.524E-02	1.035E-01	.4378	.9017	
11.000	1.977E-01	6.776E-02	1.373E-01	.3679	.9161	
11.500	2.160E-01	5.585E-02	1.941E-01	.2811	.9121	
12.500	2.787E-01	5.995E-02	2.187E-01	.2152	.8685	
14.000	3.319E-01	7.506E-02	2.569E-01	.2261	.8126	
15.000	3.334E-01	7.583E-02	2.576E-01	.2274	.8091	
16.000	3.280E-01	7.985E-02	2.482E-01	.2474	.7997	
17.200	3.214E-01	8.167E-02	2.398E-01	.2341	.7802	
18.500	3.074E-01	8.311E-02	2.243E-01	.2704	.7691	
21.300	2.757E-01	8.177E-02	1.939E-01	.2966	.7550	
25.000	2.492E-01	7.874E-02	1.709E-01	.3159	.7353	
30.000	2.202E-01	7.284E-02	1.473E-01	.3309	.7146	
40.000	1.924E-01	5.595E-02	1.369E-01	.2867	.6754	

Table 28. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³	
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	1.177E-01	9.299E-02	2.472E-02	.7900	.7516
.300	1.058E-01	1.023E-01	3.472E-03	.9672	.6060
.337	1.006E-01	9.834E-02	2.298E-03	.9772	.6926
.550	7.976E-02	7.033E-02	1.435E-03	.9820	.6756
.694	7.030E-02	6.912E-02	1.173E-03	.9873	.6767
1.060	5.607E-02	5.466E-02	1.408E-03	.9749	.6864
1.036	4.505E-02	4.379E-02	1.262E-03	.9720	.6976
2.000	3.669E-02	3.605E-02	6.497E-04	.9823	.7055
2.250	3.354E-02	3.262E-02	9.158E-04	.9727	.7112
2.500	3.056E-02	2.922E-02	1.339E-03	.9562	.7177
2.700	2.798E-02	2.534E-02	2.643E-03	.9055	.7367
3.000	3.371E-02	3.102E-02	2.694E-03	.9211	.6287
3.392	2.575E-02	2.518E-02	5.711E-04	.9778	.6779
3.750	2.298E-02	2.263E-02	3.543E-04	.9846	.6784
4.500	1.987E-02	1.947E-02	3.969E-04	.9800	.6599
5.000	1.690E-02	1.642E-02	4.800E-04	.9716	.6659
5.500	1.335E-02	1.275E-02	5.969E-04	.9551	.6859
6.000	1.188E-02	1.052E-02	1.272E-03	.8921	.6887
6.200	1.717E-02	1.483E-02	2.346E-03	.8674	.6195
6.500	1.203E-02	1.123E-02	7.925E-04	.9341	.6558
7.200	9.517E-03	8.528E-03	1.809E-03	.8858	.6665
7.900	8.005E-03	6.673E-03	1.332E-03	.8376	.6697
8.200	8.537E-03	6.511E-03	2.026E-03	.7627	.6594
8.700	1.202E-02	9.246E-03	2.776E-03	.7691	.5851
9.000	1.249E-02	9.778E-03	2.716E-03	.7826	.5644
9.200	1.168E-02	8.808E-03	2.870E-03	.7542	.5760
10.000	8.156E-03	6.872E-03	1.284E-03	.8425	.5903
10.591	6.674E-03	5.627E-03	1.046E-03	.8432	.5991
11.000	5.802E-03	4.965E-03	9.169E-04	.8441	.6024
11.500	5.465E-03	4.582E-03	8.628E-04	.8415	.5979
12.500	4.029E-03	3.171E-03	8.540E-04	.7878	.6187
14.000	3.491E-03	2.242E-03	1.249E-03	.6422	.5837
15.000	3.957E-03	2.312E-03	1.665E-03	.5843	.5763
16.400	4.914E-03	2.387E-03	2.527E-03	.4857	.5348
17.200	6.146E-03	3.104E-03	3.040E-03	.5052	.4955
18.500	5.770E-03	2.708E-03	2.902E-03	.4831	.4821
21.300	5.024E-03	1.992E-03	3.032E-03	.3965	.4635
25.000	4.372E-03	1.372E-03	3.000E-03	.3138	.4373
30.000	4.248E-03	8.920E-04	3.356E-03	.2100	.3944
40.000	6.971E-03	6.791E-04	6.296E-03	.0960	.2346

Table 29. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.250E-01	1.000E-01	2.499E-02	.8014	.7593
.300	1.136E-01	1.102E-01	3.440E-03	.9897	.7065
.437	1.090E-01	1.067E-01	2.300E-03	.9789	.7005
.550	8.685E-02	8.542E-02	1.432E-03	.9835	.6915
.694	7.746E-02	7.627E-02	1.172E-03	.9849	.6907
1.060	6.284E-02	6.143E-02	1.410E-03	.9776	.6480
1.936	5.096E-02	4.968E-02	1.275E-03	.9750	.7105
2.000	6.187E-02	4.114E-02	7.270E-04	.9826	.227
2.250	3.821E-02	3.728E-02	9.399E-04	.9796	.7289
2.500	3.461E-02	3.320E-02	1.414E-03	.9592	.7381
2.700	3.098E-02	2.754E-02	3.438E-03	.8890	.7642
3.000	3.844E-02	2.766E-02	1.079E-02	.7197	.6957
3.392	3.057E-02	2.915E-02	1.423E-03	.9535	.6907
3.750	2.697E-02	2.648E-02	6.397E-04	.9818	.6919
4.500	2.299E-02	2.218E-02	9.111E-04	.9667	.6808
5.000	1.966E-02	1.885E-02	8.094E-04	.9588	.6851
5.500	1.561E-02	1.475E-02	8.512E-04	.9448	.7132
6.000	1.416E-02	1.104E-02	3.123E-03	.7795	.7123
6.200	1.993E-02	1.606E-02	3.858E-03	.8059	.6382
6.500	1.431E-02	1.280E-02	1.517E-03	.8940	.6748
7.200	1.146E-02	9.856E-03	1.671E-03	.8603	.6633
7.900	9.549E-03	7.754E-03	1.796E-03	.8120	.6457
8.200	9.975E-03	7.501E-03	2.474E-03	.7520	.6768
8.700	1.341E-02	1.015E-02	3.254E-03	.7573	.6127
9.000	1.383E-02	1.0615E-02	3.216E-03	.7674	.6940
9.200	1.233E-02	9.547E-03	3.301E-03	.7375	.6755
10.000	9.199E-03	7.282E-03	1.827E-03	.7904	.6201
10.591	7.492E-03	5.790E-03	1.771E-03	.7729	.6291
11.000	6.727E-03	4.934E-03	1.713E-03	.7335	.6327
11.500	6.401E-03	4.354E-03	2.055E-03	.6786	.6291
12.500	5.559E-03	2.836E-03	2.721E-03	.5102	.6298
14.800	5.691E-03	2.180E-03	3.510E-03	.3831	.5896
15.000	6.193E-03	2.265E-03	3.888E-03	.3681	.5829
16.400	7.025E-03	2.511E-03	4.514E-03	.3574	.5411
17.200	8.107E-03	3.250E-03	4.857E-03	.4029	.5379
18.500	7.635E-03	3.011E-03	4.624E-03	.3943	.4926
21.300	6.583E-03	2.267E-03	4.317E-03	.3447	.4715
25.000	5.853E-03	1.629E-03	6.024E-03	.2881	.4443
30.000	5.249E-03	1.097E-03	4.192E-03	.2089	.4240
40.000	7.979E-03	7.803E-04	7.191E-03	.0984	.2571

Table 30. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)	
.200	1.505E-01	1.266E-01	2.569E-02	.6293 .7738
.300	1.379E-01	1.364E-01	3.439E-03	.9751 .7280
.337	1.326E-01	1.305E-01	2.272E-03	.9829 .7243
.550	1.099E-01	1.065E-01	1.426E-03	.9870 .7214
.694	1.004E-01	9.926E-02	1.169E-03	.9846 .7211
1.060	8.474E-02	8.372E-02	1.413E-03	.9873 .7230
1.336	7.143E-02	7.012E-02	1.313E-03	.9817 .7465
2.000	6.033E-02	5.930E-02	1.026E-03	.9870 .7579
2.250	5.523E-02	5.623E-02	1.073E-03	.9818 .7649
2.500	4.950E-02	4.777E-02	1.730E-03	.9651 .7790
2.700	4.200E-02	3.587E-02	6.127E-03	.8541 .8142
3.000	5.561E-02	2.979E-02	2.542E-02	.9357 .7673
3.392	4.811E-02	4.376E-02	4.344E-13	.9097 .7171
3.750	4.105E-02	4.066E-02	9.926E-14	.9763 .7215
4.500	3.480E-02	3.254E-02	2.264E-03	.9350 .7235
5.000	3.020E-02	2.821E-02	1.995E-03	.9370 .7251
5.500	2.444E-02	2.259E-02	1.829E-03	.9251 .7797
6.000	2.311E-02	1.428E-02	8.821E-03	.6182 .7537
6.200	2.331E-02	2.146E-02	8.844E-03	.7082 .6934
6.500	2.315E-02	1.910E-02	4.044E-03	.8253 .7177
7.200	1.863E-02	1.519E-02	3.451E-03	.6149 - .7193
7.900	1.562E-02	1.211E-02	7.503E-03	.7757 .7206
8.200	1.563E-02	1.149E-02	4.147E-03	.7351 .7151
8.700	1.864E-02	1.366E-02	4.947E-03	.7320 .6732
9.000	1.870E-02	1.379E-02	4.992E-03	.7742 .6620
9.200	1.762E-02	1.246E-02	5.142E-03	.7050 .6696
10.000	1.202E-02	9.079E-03	3.740E-02	.7082 .6921
10.591	1.073E-02	6.758E-03	3.372E-03	.6294 .6995
11.000	1.013E-02	5.371E-03	4.755E-03	.5304 .6898
11.500	1.030E-02	4.362E-03	5.966E-03	.4215 .6819
12.500	1.156E-02	2.982E-03	8.596E-03	.2575 .6556
14.000	1.302E-02	3.122E-03	1.069E-02	.2251 .5925
15.000	1.429E-02	3.234E-03	1.175E-02	.2254 .5869
16.400	1.498E-02	3.718E-03	1.126E-02	.2482 .5811
17.200	1.571E-02	4.676E-03	1.123E-02	.2849 .5284
18.500	1.485E-02	4.350E-03	1.050E-02	.2930 .5124
21.380	1.261E-02	3.555E-03	9.056E-03	.2819 .4912
25.000	1.062E-02	2.747E-03	7.871E-03	.2547 .4648
30.000	9.115E-03	1.961E-03	7.154E-03	.2152 .4302
40.000	1.138E-02	1.263E-03	1.011E-02	.1110 .3124

Table 31. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLEFS/CM ³	
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT.ALB.	ASYMMETRY PARAMETER
.200	2.683E-01	2.397E-01	2.859E-02	.8935	.7956
.300	2.516E-01	2.482E-01	3.415E-02	.9064	.7782
.337	2.455E-01	2.432E-01	2.228E-03	.9979	.7752
.550	2.195E-01	2.181E-01	1.610E-03	.9936	.7717
.694	2.080E-01	2.068E-01	1.170E-03	.9944	.7721
1.060	1.921E-01	1.907E-01	1.452E-03	.9924	.7777
1.536	1.765E-01	1.749E-01	1.579E-03	.9911	.7872
2.000	1.601E-01	1.571E-01	2.927E-13	.9817	.8012
2.250	1.505E-01	1.489E-01	1.604E-03	.9893	.8089
2.500	1.366E-01	1.325E-01	3.972E-03	.9719	.8321
2.700	1.097E-01	8.806E-02	2.159E-02	.8031	.6844
3.000	1.049E-01	6.723E-02	8.192E-02	.4516	.8332
3.392	1.459E-01	1.246E-01	2.129E-02	.0541	.7557
3.750	1.300E-01	1.257E-01	4.316E-03	.9658	.7597
4.500	1.087E-01	9.752E-02	1.123E-02	.8948	.7823
5.000	9.804E-02	8.951E-02	9.534E-03	.9028	.7822
5.500	8.315E-02	7.562E-02	8.133E-03	.9022	.7944
6.000	7.885E-02	4.054E-02	3.831E-02	.5142	.8157
5.200	9.510E-02	5.904E-02	3.614E-02	.6212	.7712
6.500	8.46E-02	6.196E-02	1.928E-02	.7677	.7738
7.200	6.767E-02	5.259E-02	1.510E-02	.7770	.7764
7.900	5.801E-02	4.356E-02	1.445E-02	.7519	.7877
8.200	5.537E-02	4.046E-02	1.491E-02	.7308	.7800
8.700	5.466E-02	3.875E-02	1.591E-02	.7089	.7682
9.000	5.262E-02	3.653E-02	1.609E-02	.6943	.7650
9.200	4.996E-02	3.351E-02	1.635E-02	.6727	.7692
10.000	3.907E-02	2.365E-02	1.541E-02	.6054	.7780
10.591	3.362E-02	1.615E-02	1.767E-02	.4813	.7628
11.000	3.374E-02	1.201E-02	2.173E-02	.2550	.7776
11.500	3.685E-02	9.460E-03	2.739E-02	.2567	.7621
12.500	4.907E-02	9.854E-03	3.922E-02	.2016	.7115
14.800	6.222E-02	1.389E-02	4.832E-02	.2233	.6342
15.000	6.294E-02	1.416E-02	4.878E-02	.2250	.6294
16.400	6.303E-02	1.543E-02	8.39F-02	.2418	.5999
17.200	6.373E-02	1.635E-02	4.739E-02	.2565	.5854
18.300	6.104E-02	1.640E-02	4.464E-02	.2617	.5793
21.300	5.237E-02	1.445E-02	3.792E-02	.2759	.5512
25.000	4.436E-02	1.214E-02	3.221E-02	.2777	.5265
38.000	3.606E-02	9.347E-03	2.671E-02	.2592	.4996
60.000	3.279E-02	5.519E-03	2.727E-02	.1613	.4236

Table 32. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000,			PARTICLES/cm ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	3.844E-01	3.525E-01	3.192E-02	.9170	.8007
.380	3.619E-01	3.519E-01	3.352E-03	.9997	.7922
.537	3.526E-01	3.504E-01	2.216E-03	.9937	.7917
.694	3.146E-01	3.132E-01	1.698E-03	.9988	.7865
1.060	2.769E-01	2.756E-01	1.177E-03	.9941	.7843
1.536	2.579E-01	2.566E-01	1.874E-03	.9924	.7924
2.000	2.390E-01	2.342E-01	4.796E-03	.9799	.9160
2.250	2.272E-01	2.250E-01	2.726E-03	.9912	.8147
2.500	2.084E-01	2.022E-01	6.196E-03	.9745	.8787
2.700	1.689E-01	1.734E-01	3.947E-02	.7900	.8946
3.000	2.259E-01	9.946E-02	1.265E-01	.6423	.8669
3.392	2.240E-01	1.877E-01	3.670E-02	.8390	.7644
3.750	2.033E-01	1.950E-01	7.512E-03	.9670	.7771
4.500	1.731E-01	1.535E-01	1.998E-02	.9859	.7940
5.000	1.587E-01	1.417E-01	1.668E-02	.9946	.7944
5.500	1.369E-01	1.227E-01	1.614E-02	.8945	.8174
6.000	1.205E-01	6.509E-02	6.378E-02	.5067	.8735
6.200	524E-01	9.269E-02	5.974E-02	.5070	.7490
6.500	41E-01	1.010E-01	7.319E-02	.7526	.7497
7.200	3.86E-01	8.779E-02	2.997E-02	.7717	.7445
7.900	2.665E-02	7.791E-02	2.475E-02	.7401	.7771
8.200	3.376E-02	6.870E-02	2.516E-02	.7328	.7022
8.700	8.966E-02	6.348E-02	2.619E-02	.7079	.7921
9.000	8.954E-02	9.914E-02	2.649E-02	.6975	.7918
9.200	9.162E-02	5.642E-02	2.581E-02	.6714	.7044
10.000	6.639E-02	3.875E-02	2.623E-02	.5962	.8134
10.591	5.607E-02	2.623E-02	2.991E-02	.4682	.8288
11.000	5.636E-02	1.945E-02	3.691E-02	.3452	.8739
11.500	6.168E-02	1.597E-02	4.611E-02	.2624	.7587
12.500	8.262E-02	1.754E-02	6.539E-02	.2122	.7764
14.000	1.049E-01	2.503E-02	7.987E-02	.2386	.6589
15.000	1.059E-01	2.566E-02	8.546E-02	.2474	.6941
16.400	1.074E-01	2.746E-02	7.993E-02	.2557	.6246
17.200	1.069E-01	2.658E-02	7.875E-02	.2673	.6121
18.500	1.031E-01	2.881E-02	7.425E-02	.2796	.5066
21.300	8.952E-02	2.584E-02	6.368E-02	.2837	.6777
25.000	7.670E-02	2.220E-02	5.450E-02	.2895	.5577
30.000	6.260E-02	1.752E-02	4.508E-02	.2799	.5277
40.000	5.386E-02	1.067E-02	4.339E-02	.1944	.6452

Table 33. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Maritime Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	9.174E-01	4.060E-01	3.341E-02	.9356	.6079
.300	4.922E-01	4.087E-01	3.342E-02	.9972	.6035
.337	4.818E-01	4.796E-01	2.196E-03	.9956	.6034
.399	4.373E-01	4.359E-01	1.614E-03	.9968	.7986
.694	4.201E-01	4.109E-01	1.104E-03	.9972	.7955
1.060	3.966E-01	3.951E-01	1.939E-03	.9961	.7927
1.536	3.787E-01	3.766E-01	2.271E-03	.9940	.7994
2.000	3.602E-01	3.520E-01	8.192E-03	.9774	.6117
2.250	3.471E-01	3.438E-01	3.331E-03	.9904	.6193
2.500	3.239E-01	3.138E-01	1.014E-02	.9667	.8444
2.700	2.677E-01	2.087E-01	5.901E-02	.7796	.9068
3.080	3.399E-01	1.920E-01	1.679E-01	.4471	.8625
3.392	3.466E-01	2.049E-01	6.170E-02	.8220	.7738
3.750	3.216E-01	3.084E-01	1.379E-02	.9547	.7736
4.500	2.806E-01	2.463E-01	3.430E-02	.8777	.8056
5.000	2.606E-01	2.313E-01	2.941E-02	.8875	.8057
5.500	2.302E-01	2.052E-01	2.449E-02	.8916	.8186
6.000	2.119E-01	1.800E-01	1.079E-01	.5046	.6547
6.200	2.486E-01	1.500E-01	9.656E-02	.6072	.8092
6.500	2.255E-01	1.683E-01	5.722E-02	.7663	.8044
7.200	1.952E-01	1.502E-01	4.596E-02	.7692	.8194
7.900	1.717E-01	1.288E-01	4.291E-02	.7571	.8176
8.200	1.632E-01	1.202E-01	4.298E-02	.7366	.8148
8.700	1.532E-01	1.091E-01	4.408E-02	.7122	.8128
9.000	1.456E-01	1.011E-01	4.647E-02	.6949	.8138
9.200	1.393E-01	9.449E-02	4.496E-02	.6779	.8165
10.000	1.126E-01	6.794E-02	4.507E-02	.5998	.8262
10.591	9.682E-02	4.580E-02	5.102E-02	.4771	.8328
11.000	9.658E-02	3.601E-02	6.256E-02	.3522	.8286
11.500	1.047E-01	2.758E-02	7.707E-02	.2675	.8141
12.500	1.387E-01	3.226E-02	1.065E-01	.2326	.7632
14.000	1.757E-01	4.784E-02	1.299E-01	.2619	.6669
15.000	1.772E-01	4.656E-02	1.337E-01	.2627	.6822
16.400	1.004E-01	4.992E-02	1.305E-01	.2767	.6545
17.200	1.798E-01	5.147E-02	1.263E-01	.2862	.6415
18.500	1.747E-01	5.212E-02	1.222E-01	.2903	.6258
21.300	1.543E-01	4.758E-02	1.067E-01	.3083	.6071
25.000	1.343E-01	4.178E-02	9.254E-02	.3113	.5823
30.000	1.110E-01	3.386E-02	7.713E-02	.3051	.5573
40.000	9.257E-02	2.074E-02	7.178E-02	.2242	.4958

Table 34. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Maritime Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)		
.200	7.895E-01	7.564E-01	3.907E-02	.9556	.8146
.300	7.614E-01	7.581E-01	3.349E-03	.9956	.8102
.337	7.810E-01	7.494E-01	2.191E-03	.9971	.8167
.350	6.990E-01	6.984E-01	1.420E-03	.9980	.8103
.694	6.783E-01	6.771E-01	1.198E-03	.9982	.8082
1.060	6.535E-01	6.518E-01	1.640E-03	.9975	.8011
1.536	6.399E-01	6.364E-01	3.481E-03	.9946	.8051
2.000	6.260E-01	6.088E-01	1.721E-02	.9725	.8167
2.250	6.137E-01	6.073E-01	6.350E-03	.9896	.8237
2.500	5.970E-01	5.660E-01	2.132E-02	.9642	.8405
2.700	5.038E-01	3.851E-01	1.187E-01	.7644	.9167
3.000	5.921E-01	2.704E-01	3.212E-01	.4575	.8816
3.392	6.202E-01	4.949E-01	1.253E-01	.7980	.7862
3.750	5.928E-01	5.678E-01	2.899E-02	.9511	.7802
4.500	5.363E-01	4.637E-01	7.311E-02	.8637	.8168
5.000	5.085E-01	4.454E-01	6.376E-02	.8761	.8177
5.500	4.621E-01	4.080E-01	5.413E-02	.8831	.8203
6.000	4.169E-01	2.155E-01	2.014E-01	.5168	.8712
6.200	4.617E-01	2.883E-01	1.974E-01	.5975	.8359
6.500	4.528E-01	3.338E-01	1.190E-01	.7372	.8212
7.200	4.035E-01	3.064E-01	9.514E-02	.7642	.8265
7.900	3.623E-01	2.715E-01	9.079E-02	.7494	.8317
8.200	3.699E-01	2.555E-01	9.033E-02	.7388	.8370
8.700	3.224E-01	2.312E-01	9.124E-02	.7170	.8355
9.000	3.064E-01	2.146E-01	9.176E-02	.7075	.8379
9.200	2.949E-01	2.022E-01	9.273E-02	.6865	.8415
10.000	2.628E-01	1.6483E-01	9.469E-02	.6111	.8519
10.591	2.079E-01	1.020E-01	1.059E-01	.4903	.8614
11.000	2.037E-01	7.619E-02	1.275E-01	.3740	.8582
11.500	2.160E-01	6.240E-02	1.851E-01	.2884	.8459
12.500	2.787E-01	7.367E-02	2.051E-01	.2643	.7988
14.000	3.501E-01	1.027E-01	2.474E-01	.2973	.7259
15.000	3.529E-01	1.041E-01	2.488E-01	.2951	.7215
16.400	3.614E-01	1.111E-01	2.532E-01	.3075	.6945
17.200	3.614E-01	1.140E-01	2.475E-01	.3154	.6921
18.500	3.552E-01	1.160E-01	2.391E-01	.3267	.6662
21.300	3.215E-01	1.084E-01	2.131E-01	.3371	.6472
25.000	2.666E-01	9.784E-02	1.808E-01	.3414	.6223
30.000	2.425E-01	8.218E-02	1.603E-01	.3389	.5976
40.000	1.993E-01	9.270E-02	1.466E-01	.2644	.5425

Table 35. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Maritime Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 4000.			PARTICLES/CM ³
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	
.200	1.129E+00	1.093E+00	3.632E-02	.9678
.300	1.183E+00	1.100E+00	3.357E-03	.9970
.337	1.093E+00	1.091E+00	2.205E-03	.9980
.550	1.035E+00	1.033E+00	1.472E-03	.9965
.694	1.009E+00	1.008E+00	1.210E-03	.9988
1.060	9.810E-01	9.792E-01	1.704E-03	.9982
1.536	9.749E-01	9.694E-01	5.497E-03	.9944
2.000	9.695E-01	9.575E-01	3.190E-02	.9671
2.250	9.611E-01	9.497E-01	1.137E-02	.9882
2.500	9.356E-01	8.970E-01	3.869E-02	.9517
2.700	8.306E-01	6.225E-01	2.080E-01	.7495
3.000	9.234E-01	4.307E-01	4.927E-01	.4664
3.392	9.776E-01	7.586E-01	2.190E-01	.7760
3.750	9.536E-01	8.994E-01	5.420E-02	.9432
4.500	8.879E-01	7.546E-01	1.334E-01	.8498
5.000	8.548E-01	7.307E-01	1.161E-01	.8642
5.500	7.942E-01	6.940E-01	1.002E-01	.8738
6.000	7.104E-01	3.700E-01	3.395E-01	.5223
6.200	8.094E-01	4.806E-01	3.289E-01	.5937
6.500	7.789E-01	5.666E-01	2.123E-01	.7274
7.200	7.105E-01	5.301E-01	1.724E-01	.7573
7.900	6.491E-01	4.840E-01	1.651E-01	.7457
8.200	6.233E-01	4.594E-01	1.639E-01	.7370
8.700	5.831E-01	4.185E-01	1.646E-01	.7177
9.000	5.560E-01	3.908E-01	1.652E-01	.7028
9.200	5.367E-01	3.707E-01	1.661E-01	.6976
10.000	4.697E-01	2.789E-01	1.700E-01	.6201
10.591	3.830E-01	1.954E-01	1.896E-01	.5075
11.000	3.715E-01	1.468E-01	2.247E-01	.3953
11.500	3.862E-01	1.208E-01	2.654E-01	.3127
12.500	4.849E-01	1.411E-01	3.438E-01	.2979
14.000	6.026E-01	1.924E-01	4.102E-01	.3193
15.000	6.074E-01	1.950E-01	4.124E-01	.3211
16.400	6.266E-01	2.075E-01	4.170E-01	.3323
17.200	6.267E-01	2.129E-01	4.142E-01	.3391
18.500	6.209E-01	2.170E-01	4.039E-01	.3495
21.300	5.733E-01	2.062E-01	3.671E-01	.3597
25.000	5.213E-01	1.901E-01	3.312E-01	.3646
30.000	4.510E-01	1.642E-01	2.868E-01	.3640
40.000	3.720E-01	1.097E-01	2.623E-01	.2949

Table 36. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 0% Tropospheric Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	9.775E-02	6.697E-02	3.679E-02	.6850	.7510
.300	8.075E-02	7.638E-02	4.378E-03	.9458	.6710
.337	7.381E-02	7.091E-02	2.901E-03	.9607	.6638
.358	4.419E-02	4.238E-02	1.011E-03	.9590	.6345
.694	3.288E-02	3.052E-02	1.482E-03	.9537	.6152
1.060	1.558E-02	1.398E-02	1.604E-03	.8971	.5736
1.535	6.732E-03	5.491E-03	1.241E-03	.9157	.5281
2.001	2.282E-03	1.623E-03	7.445E-04	.824	.4440
2.250	1.707E-03	1.711E-03	4.145E-04	.7612	.4711
2.588	1.323E-03	9.122E-04	4.112E-04	.6893	.4467
2.700	2.064E-03	6.437E-04	1.420E-03	.3119	.4204
3.000	1.089E-03	5.195E-04	5.691E-04	.4772	.4028
3.392	6.788E-04	4.914E-04	2.272E-04	.6652	.3777
3.750	9.076E-04	3.680E-04	1.396E-04	.7250	.3563
4.500	4.965E-04	2.094E-04	2.671E-04	.4588	.2150
5.000	3.618E-04	1.425E-04	2.193E-04	.3978	.2919
5.500	3.810E-04	9.575E-05	2.852E-04	.2513	.2695
6.000	4.387E-04	5.661E-05	3.821E-04	.1203	.2465
6.200	4.666E-04	5.399E-05	4.127E-04	.1157	.2422
6.500	5.040E-04	5.078E-05	4.532E-04	.1007	.2313
7.200	7.718E-04	4.346E-05	7.284E-04	.0563	.2101
7.900	6.609E-04	7.467E-06	6.534E-04	.0113	.1760
8.200	1.069E-03	1.621E-06	1.067E-03	.0017	.1532
8.700	1.398E-03	1.239E-04	1.275E-03	.0886	.2091
9.000	1.495E-03	1.376E-04	1.758E-03	.0920	.2079
9.200	1.877E-03	9.636E-05	1.780E-03	.0513	.1447
10.000	7.082E-04	4.703E-05	6.612E-04	.0664	.1811
10.591	5.360E-04	3.208E-05	5.040E-04	.0599	.1687
11.000	4.132E-04	2.620E-05	3.870E-04	.0674	.1626
11.500	3.809E-04	1.985E-05	3.611E-04	.0921	.1526
12.500	3.648E-04	1.232E-05	3.525E-04	.0338	.1356
14.000	5.044E-04	4.623E-06	4.997E-04	.0092	.1030
15.000	8.502E-04	4.443E-06	8.458E-04	.0052	.0962
16.400	5.465E-04	6.121E-06	5.384E-04	.0112	.1024
17.200	5.965E-04	8.113E-06	5.884E-04	.0136	.1086
18.500	4.910E-04	4.610E-06	4.864E-04	.0094	.0928
21.300	3.734E-04	3.746E-06	5.697E-04	.0065	.0836
25.000	5.600E-04	1.036E-06	5.942E-04	.0033	.0643
30.000	6.266E-04	8.150E-07	6.298E-04	.0013	.0451
45.000	6.571E-04	1.576E-07	6.567E-04	.0005	.0290

Table 37. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 50% Tropospheric Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	1.814E-01	7.021E-02	3.116E-02	.6926	.7536
.300	8.357E-02	7.923E-02	6.338E-03	.9681	.6765
.337	7.645E-02	7.353E-02	2.993E-03	.9620	.6685
.550	4.580E-02	4.399E-02	1.805E-03	.9616	.6406
.694	3.319E-02	3.171E-02	1.481E-03	.9554	.6207
1.060	1.610E-02	1.458E-02	1.608E-03	.9006	.5787
1.536	7.008E-03	5.761E-03	1.247E-03	.8220	.5326
2.000	2.412E-03	2.021E-03	3.998E-04	.8379	.4991
2.250	1.796E-03	1.387E-03	4.089E-04	.7723	.4743
2.500	1.384E-03	9.679E-04	4.162E-04	.6993	.4511
2.700	2.131E-03	6.708E-04	1.461E-03	.3147	.4248
3.000	1.566E-03	5.584E-04	1.007E-03	.3566	.4032
3.392	7.536E-04	4.975E-04	2.581E-04	.6611	.3815
3.750	5.435E-04	3.992E-04	1.643E-04	.7343	.3602
4.500	4.068E-04	2.254E-04	2.614E-04	.4629	.3186
5.000	3.867E-04	1.536E-04	2.312E-04	.3991	.2954
5.500	3.986E-04	1.029E-04	2.957E-04	.2582	.2730
6.000	5.254E-04	6.074E-05	4.646E-04	.1156	.2490
6.200	5.365E-04	5.953E-05	4.770E-04	.1110	.2432
6.500	5.363E-04	5.543E-05	4.808E-04	.1034	.2347
7.200	7.970E-04	4.673E-05	7.503E-04	.0545	.2173
7.900	6.811E-04	8.646E-06	6.725E-04	.0127	.1792
8.200	1.087E-03	2.149E-06	1.0045E-03	.0020	.1574
8.700	1.659E-03	1.289E-04	1.331E-03	.0843	.2101
9.000	1.370E-03	1.435E-04	1.427E-03	.0914	.2089
9.200	1.955E-03	1.002E-04	1.055E-03	.0517	.1858
10.000	7.424E-04	4.871E-05	6.937E-04	.0656	.1818
10.591	5.702E-04	3.310E-05	5.371E-04	.0581	.1695
11.000	4.535E-04	2.694E-05	4.265E-04	.0594	.1629
11.500	4.339E-04	2.034E-05	4.136E-04	.0469	.1520
12.500	4.500E-04	1.265E-05	4.373E-04	.0281	.1354
14.000	6.170E-04	4.950E-06	6.120E-04	.0040	.1034
15.000	9.658E-04	4.814E-06	9.610E-04	.0050	.0969
16.400	6.419E-04	6.525E-06	6.350E-04	.0102	.1024
17.200	6.814E-04	8.612E-06	6.728E-04	.0126	.1080
18.500	5.788E-04	4.951E-06	5.658E-04	.0087	.0930
21.300	6.341E-04	4.017E-06	6.301E-04	.0063	.0837
25.000	6.898E-04	1.964E-06	6.079E-04	.0033	.0649
30.000	6.671E-04	8.059E-07	6.662E-04	.0013	.0461
40.000	6.998E-04	3.865E-07	6.955E-04	.0006	.0290

Table 38. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 70% Tropospheric Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 5800.			PARTICLES/CM ³	
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.092E-01	7.710E-02	3.206E-02	.7066	.7571
.300	8.989E-02	8.555E-02	4.336E-03	.9518	.6853
.337	8.214E-02	7.927E-02	2.868E-03	.9651	.6790
.398	4.932E-02	4.752E-02	1.800E-03	.9635	.6910
.694	3.577E-02	3.429E-02	1.476E-03	.9587	.6315
1.060	1.750E-02	1.988E-02	1.617E-03	.9876	.5887
1.336	7.618E-03	6.358E-03	1.260E-03	.8346	.5418
2.000	2.701E-03	2.301E-03	4.003E-04	.8518	.5075
2.250	1.995E-03	1.581E-03	4.141E-04	.7925	.4829
2.500	1.520E-03	1.093E-03	4.270E-04	.7190	.4598
2.780	2.279E-03	7.311E-04	1.548E-03	.3208	.4338
3.000	2.599E-03	6.515E-04	1.947E-03	.2807	.4043
3.392	9.210E-04	6.026E-04	3.190E-04	.6579	.3890
3.750	6.247E-04	4.700E-04	1.547E-04	.7524	.3680
4.580	5.561E-04	2.614E-04	2.927E-04	.4717	.3259
5.000	4.357E-04	1.786E-04	2.571E-04	.4100	.3026
5.500	4.379E-04	1.192E-04	3.183E-04	.2724	.2800
6.000	7.143E-04	7.016E-05	6.441E-04	.0982	.2541
6.200	6.886E-04	7.230E-05	6.164E-04	.1050	.2494
6.500	6.070E-04	6.608E-05	5.410E-04	.1009	.2414
7.200	8.521E-04	5.422E-05	7.979E-04	.0636	.2196
7.900	7.260E-04	1.147E-05	7.146E-04	.0148	.1873
8.200	1.126E-03	3.116E-06	1.123E-03	.0020	.1657
8.700	1.584E-03	1.393E-04	1.445E-03	.081	.2127
9.000	1.724E-03	1.557E-04	1.569E-03	.0903	.2110
9.200	2.113E-03	1.003E-04	2.004E-03	.0512	.1890
10.000	8.148E-04	5.230E-05	7.625E-04	.0642	.1836
10.591	6.439E-04	3.527E-05	6.087E-04	.0548	.1709
11.000	5.422E-04	2.851E-05	5.137E-04	.0526	.1640
11.500	5.510E-04	2.140E-05	5.305E-04	.0388	.1534
12.500	6.406E-04	1.339E-05	6.272E-04	.0209	.1354
14.000	8.644E-04	5.735E-06	8.587E-04	.0056	.1044
15.000	1.219E-03	5.692E-06	1.213E-03	.0047	.0984
16.400	8.570E-04	7.465E-06	8.495E-04	.0087	.1026
17.200	8.715E-04	9.745E-06	8.610E-04	.0112	.1073
18.500	7.676E-04	5.741E-06	7.417E-04	.0077	.0935
21.200	7.602E-04	4.637E-06	7.636E-04	.0060	.1042
25.000	7.192E-04	2.321E-06	7.169E-04	.0072	.1661
30.000	7.352E-04	1.048E-06	7.542E-04	.0014	.0477
40.000	7.797E-04	4.516E-07	7.742E-04	.0016	.0719

Table 39. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 80% Tropospheric Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
.200	1.682E-01	1.125E-01	3.572E-02	.7590	.7667
.300	1.214E-01	1.171E-01	4.307E-03	.9645	.7176
.487	1.112E-01	1.084E-01	2.812E-03	.9767	.7128
.550	6.764E-02	6.586E-02	1.761E-03	.9737	.6879
.694	4.958E-02	4.810E-02	1.476E-03	.9722	.6690
1.060	2.465E-02	2.300E-02	1.652E-03	.9330	.6255
1.536	1.101E-02	9.699E-03	1.309E-03	.8811	.5769
2.000	6.375E-03	3.928E-03	6.469E-04	.8979	.5403
2.250	3.152E-03	2.715E-03	4.379E-04	.8612	.5167
2.500	2.300E-03	1.820E-03	4.802E-04	.7913	.4947
2.700	3.067E-03	1.073E-03	1.994E-03	.3498	.4703
3.000	8.044E-03	1.272E-03	6.672E-03	.1581	.4143
3.392	1.917E-03	1.261E-03	6.552E-04	.5582	.4190
3.750	1.114E-03	9.048E-04	2.094E-04	.8121	.3993
4.500	9.387E-04	4.804E-04	4.583E-04	.5118	.3563
5.000	7.260E-04	3.324E-04	3.936E-04	.4578	.3235
5.500	6.554E-04	2.187E-04	4.366E-04	.3338	.3095
6.000	1.725E-03	1.267E-04	1.596E-03	.0746	.2767
6.200	1.505E-03	1.547E-04	1.358E-03	.1028	.2751
6.500	9.916E-04	1.337E-04	8.579E-04	.1348	.2692
7.200	1.144E-03	1.005E-04	1.043E-03	.0879	.2464
7.900	9.700E-04	3.183E-05	9.351E-04	.0324	.2175
8.200	1.347E-03	1.346E-05	1.333E-03	.0100	.1992
8.700	2.117E-03	1.904E-04	1.926E-03	.0899	.2247
9.000	2.378E-03	2.114E-04	2.166E-03	.0899	.2215
9.200	2.796E-03	1.467E-04	2.609E-03	.0572	.2042
10.000	1.165E-03	7.043E-06	1.099E-03	.0605	.1952
10.591	1.029E-03	4.619E-05	9.784E-04	.0451	.1814
11.000	1.025E-03	3.638E-05	9.889E-04	.0355	.1726
11.500	1.210E-03	2.688E-05	1.193E-03	.0222	.1604
12.500	1.718E-03	1.814E-05	1.700E-03	.0106	.1398
14.000	2.211E-03	1.140E-05	2.200E-03	.0052	.1111
15.000	2.579E-03	1.180E-05	2.567E-03	.0046	.1065
16.400	2.055E-03	1.373E-05	2.041E-03	.0067	.1068
17.200	1.952E-03	1.677E-05	1.935E-03	.0086	.1086
18.500	1.726E-03	1.094E-05	1.719E-03	.0063	.0984
21.300	1.589E-03	8.502E-06	1.500E-03	.0056	.0888
25.000	1.310E-03	4.470E-06	1.305E-03	.0074	.0724
30.000	1.219E-03	2.097E-06	1.217E-03	.0017	.0540
40.000	1.212E-03	8.597E-07	1.211E-03	.0017	.0358

Table 40. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 90% Tropospheric Model!

WAVELENGTH (MICRON)	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	5000. PARTICLES/CM3
				SINGLE SCAT. ALB. ASYMMETRY PARAMETER
.200	2.154E-01	1.795E-01	3.994E-02	.6146 .7708
.300	1.784E-01	1.741E-01	4.234E-03	.6763 .7452
.337	1.651E-01	1.623E-01	2.797E-03	.9831 .7417
.550	1.037E-01	1.019E-01	1.778E-03	.9829 .7222
.694	7.729E-02	7.580E-02	1.446E-03	.9808 .7149
1.060	3.965E-02	3.796E-02	1.698E-03	.9572 .6639
1.536	1.842E-02	1.705E-02	1.377E-03	.92E6 .6159
2.000	8.248E-03	7.716E-03	5.323E-04	.93E5 .5705
2.250	5.861E-03	5.387E-03	4.736E-04	.9192 .5566
2.500	4.112E-03	3.534E-03	5.777E-04	.8505 .5366
2.700	4.699E-03	1.850E-03	2.849E-04	.7937 .5152
3.000	1.084E-02	2.073E-03	1.596E-02	.1925 .4355
3.392	4.292E-03	2.994E-03	1.334E-03	.6883 .4547
3.750	2.328E-03	2.065E-03	3.184E-04	.8671 .4775
4.500	1.822E-03	1.034E-03	7.883E-04	.5677 .3947
5.000	1.390E-03	7.254E-04	6.649E-04	.5218 .3707
5.500	1.142E-03	4.735E-04	6.687E-04	.4146 .3476
6.000	3.762E-03	2.804E-04	3.482E-03	.0745 .3081
6.200	3.179E-03	3.785E-04	2.800E-03	.1101 .3087
6.500	1.800E-03	3.148E-04	1.486E-03	.1748 .3052
7.200	1.739E-03	2.211E-04	1.518E-03	.1271 .2816
7.900	1.478E-03	9.486E-05	1.347E-03	.0642 .2554
8.200	1.822E-03	5.513E-05	1.756E-03	.0373 .2471
8.700	2.695E-03	2.869E-04	2.607E-03	.0991 .2477
9.000	3.284E-03	3.079E-04	2.976E-03	.0978 .2416
9.200	3.622E-03	2.192E-04	3.407E-03	.1625 .2291
10.000	1.794E-03	1.075E-04	1.686E-03	.0599 .2167
10.591	1.755E-03	6.852E-05	1.697E-03	.0301 .2115
11.000	1.997E-03	5.266E-05	1.945E-03	.0264 .1905
11.500	2.559E-03	3.905E-05	2.520E-03	.0151 .1761
12.500	3.956E-03	3.153E-05	3.925E-03	.0081 .1520
14.800	4.936E-03	2.913E-05	4.907E-03	.0059 .1235
15.000	5.304E-03	3.027E-05	5.274E-03	.0057 .1200
16.400	4.524E-03	3.195E-05	4.492E-03	.0071 .1171
17.200	4.225E-03	3.570E-05	4.189E-03	.0044 .1167
18.500	3.740E-03	2.591E-05	3.714E-03	.0069 .11AP
21.300	3.029E-03	1.697E-05	7.017E-03	.0063 .1088
25.000	2.498E-03	1.046E-05	2.488E-03	.0042 .0833
30.000	2.128E-03	5.005E-06	2.123E-03	.0024 .0659
40.000	2.040E-03	1.901E-06	2.038E-03	.0010 .0434

Table 41. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 95% Tropospheric Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)		
.200	2.602E-01	2.184E-01	4.180E-02	.8393	.7709
.300	2.184E-01	2.142E-01	4.214E-03	.9807	.7557
.337	2.031E-01	2.003E-01	2.772E-03	.9863	.7531
.550	1.306E-01	1.280E-01	1.705E-03	.9863	.7159
.694	9.842E-02	9.693E-02	1.495E-03	.9846	.7199
1.060	5.153E-02	4.981E-02	1.723E-03	.9666	.6804
1.536	2.450E-02	2.309E-02	1.403E-03	.9427	.6340
2.000	1.155E-02	1.095E-02	5.946E-04	.9405	.5970
2.250	8.193E-03	7.695E-03	4.980E-04	.9392	.5762
2.500	5.669E-03	5.020E-03	6.493E-04	.8855	.5575
2.700	5.997E-03	2.510E-03	3.487E-03	.4105	.5381
3.000	2.701E-02	4.285E-02	2.272E-02	.1547	.4489
3.392	6.357E-03	6.491E-03	1.866E-03	.7065	.4726
3.750	3.611E-03	3.010E-03	4.017E-04	.8822	.4569
4.500	2.577E-03	1.937E-03	1.040E-03	.5965	.4148
5.000	1.958E-03	1.087E-03	6.711E-04	.5551	.3907
5.500	1.553E-03	7.087E-04	8.439E-04	.4555	.3670
6.000	5.325E-03	4.207E-04	4.934E-03	.0790	.3295
6.200	4.689E-03	5.911E-04	3.898E-03	.1317	.3266
6.500	2.448E-03	4.865E-04	1.961E-03	.1987	.3243
7.200	2.204E-03	3.341E-04	1.874E-03	.1513	.3005
7.900	1.880E-03	1.592E-04	1.720E-03	.0847	.2752
8.200	2.281E-03	1.019E-04	2.099E-03	.0463	.2611
8.700	3.401E-03	3.636E-04	3.038E-03	.1069	.2622
9.000	3.841E-03	3.807E-04	3.460E-03	.0991	.2554
9.200	4.155E-03	2.767E-04	3.878E-03	.0666	.2442
10.000	2.251E-03	1.381E-04	2.113E-03	.0614	.2302
10.591	2.299E-03	8.698E-05	2.212E-03	.0378	.2141
11.000	2.731E-03	6.629E-05	2.665E-03	.0243	.2020
11.500	3.584E-03	4.976E-05	3.574E-03	.0139	.1865
12.500	5.663E-03	4.678E-05	5.618E-03	.0079	.1606
14.000	7.003E-03	4.743E-05	6.956E-03	.0068	.1314
15.000	7.364E-03	6.906E-05	7.314E-03	.0067	.1282
16.400	6.612E-03	5.025E-06	6.352E-03	.0078	.1240
17.200	5.976E-03	5.408E-05	5.922E-03	.0000	.1228
18.500	5.279E-03	4.090E-05	5.239E-03	.0017	.1157
21.300	4.189E-03	2.919E-05	4.160E-03	.0070	.1054
25.000	3.399E-03	1.641E-05	3.383E-03	.0048	.0900
30.000	2.811E-03	8.097E-06	2.803E-03	.0029	.0725
40.000	2.656E-03	3.095E-06	2.653E-03	.0012	.0481

Table 42. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 98% Tropospheric Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	ASYMMETRY PARAMETER
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)		
1.200	3.316E-01	2.877E-01	4.391E-02	.8676	.7702
1.300	2.854E-01	2.812E-01	4.222E-03	.9052	.7659
1.337	2.673E-01	2.645E-01	2.764E-03	.9897	.7642
1.550	1.777E-01	1.760E-01	1.793E-03	.9899	.7507
1.694	1.363E-01	1.346E-01	1.511E-03	.9889	.7365
1.860	7.352E-02	7.176E-02	1.756E-03	.9761	.7000
1.936	3.689E-02	3.464E-02	1.450E-03	.9598	.6561
2.000	1.802E-02	1.732E-02	7.043E-04	.9679	.6202
2.250	1.282E-02	1.229E-02	5.389E-04	.9580	.6000
2.500	8.760E-03	7.992E-03	7.756E-04	.9115	.5841
2.700	6.439E-03	5.818E-03	4.622E-03	.4524	.5677
3.000	4.162E-02	7.095E-03	3.457E-02	.1705	.4681
3.392	1.048E-02	7.654E-03	2.829E-03	.7301	.4955
3.750	5.637E-03	5.085E-03	5.925E-04	.9020	.4819
4.500	4.081E-03	2.587E-03	1.493E-03	.6343	.4411
5.000	3.089E-03	1.867E-03	1.243E-03	.5970	.4172
5.500	2.363E-03	1.205E-03	1.158E-03	.5100	.3948
6.000	8.157E-03	7.162E-04	7.441E-03	.0878	.3494
6.200	6.912E-13	1.046E-03	5.866E-03	.1514	.3506
6.500	3.670E-03	8.555E-04	2.815E-03	.2331	.3497
7.200	3.086E-03	5.762E-04	2.510E-03	.1867	.3260
7.900	2.628E-03	3.043E-04	2.324E-03	.1158	.3015
8.200	2.910E-03	2.126E-04	2.697E-03	.0731	.2886
8.700	4.252E-03	5.124E-04	3.740E-03	.1205	.2834
9.000	4.761E-03	5.182E-04	4.223E-03	.1093	.2756
9.200	5.023E-03	3.882E-04	4.635E-03	.0773	.2659
10.000	3.056E-03	1.988E-04	2.857E-03	.0651	.2499
10.591	3.263E-03	1.236E-04	3.139E-03	.0379	.2327
11.000	4.039E-03	9.360E-05	3.946E-03	.0232	.2192
11.500	5.610E-03	7.195E-05	5.338E-03	.0173	.2022
12.500	8.710E-03	7.418E-05	8.639E-03	.0085	.1736
14.000	1.070E-02	8.911E-05	1.061E-02	.0087	.1431
15.000	1.164E-02	9.152E-05	1.095E-02	.0083	.1402
16.400	9.797E-03	9.143E-05	9.706E-03	.1093	.1345
17.200	9.125E-03	9.469E-05	9.030E-03	.0114	.1325
18.500	8.042E-03	7.474E-05	7.967E-03	.0097	.1260
21.300	6.271E-03	5.198E-05	6.219E-03	.0083	.1154
25.000	5.089E-03	2.987E-05	4.979E-03	.0060	.0998
30.000	4.025E-03	1.500E-05	4.010E-03	.0037	.0820
40.000	3.745E-03	5.631E-06	3.740E-03	.0015	.0551

Table 43. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Relative Humidity = 99% Tropospheric Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 5000.			PARTICLES/CM ³	
	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)		
0.200	4.828E-01	3.876E-01	4.847E-02	.8871	.7695
0.300	3.558E-01	3.508E-01	4.230E-03	.9881	.7719
0.337	3.348E-01	3.319E-01	2.782E-03	.9917	.7710
0.550	2.293E-01	2.275E-01	1.808E-03	.9921	.7606
0.694	1.704E-01	1.769E-01	1.924E-03	.9915	.7478
1.060	9.891E-02	9.713E-02	1.785E-03	.9820	.7142
1.536	4.993E-02	4.643E-02	1.493E-03	.9711	.6727
2.080	2.597E-02	2.315E-02	8.262E-04	.9662	.6391
2.250	1.857E-02	1.799E-02	5.822E-04	.9666	.6291
2.500	1.263E-02	1.171E-02	3.164E-04	.9274	.6150
2.700	1.133E-02	5.444E-03	5.889E-03	.4804	.5912
3.000	5.799E-02	1.055E-02	4.744E-12	.1829	.4849
3.392	1.563E-02	1.170E-02	3.932E-03	.7684	.5137
3.750	8.485E-03	7.763E-03	7.241E-04	.9167	.5019
4.500	5.961E-03	3.953E-03	2.007E-03	.6632	.4625
5.000	4.506E-03	2.864E-03	1.563E-03	.6310	.4789
5.500	3.373E-03	1.861E-03	1.512E-03	.5517	.4169
6.000	1.138E-02	1.104E-03	1.028E-02	.0971	.3696
6.200	9.732E-03	1.653E-03	8.079E-03	.1698	.3707
6.500	9.126E-03	1.350E-03	3.776E-03	.2813	.3706
7.200	4.124E-03	9.004E-04	3.223E-03	.2183	.3473
7.900	3.588E-03	5.064E-04	3.002E-03	.1443	.3232
8.200	3.742E-03	3.719E-04	3.371E-03	.0994	.3112
8.700	5.182E-03	6.974E-04	4.495E-03	.1346	.3122
9.000	5.697E-03	6.856E-04	5.012E-03	.1203	.2938
9.200	5.981E-03	5.269E-04	5.425E-03	.0885	.2150
10.000	3.995E-03	2.757E-04	3.680E-03	.0697	.2675
10.591	4.348E-03	1.700E-04	4.170E-03	.6392	.2494
11.000	5.500E-03	1.286E-04	5.372E-03	.0234	.2347
11.580	7.448E-03	1.010E-04	7.347E-03	.0136	.2165
12.500	1.211E-02	1.147E-04	1.200E-02	.0095	.1957
14.800	1.482E-02	1.477E-04	1.468E-02	.0100	.1536
15.000	1.514E-02	1.510E-04	1.499E-02	.0100	.1519
16.400	1.359E-02	1.490E-04	1.344E-02	.0110	.1441
17.200	1.266E-02	1.508E-04	1.251E-02	.0119	.1416
18.500	1.114E-02	1.223E-04	1.102E-02	.0110	.1354
21.300	6.608E-03	8.383E-05	8.924E-03	.0097	.1245
25.000	6.612E-03	4.694E-05	6.764E-03	.0072	.1368
30.000	5.382E-03	2.491E-05	5.357E-03	.0046	.0905
40.000	4.957E-03	9.265E-06	4.948E-03	.0019	.0614

Table 44. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for the Advection Fog 1 Model

WAVELENGTH (MICRONS)	EXTINCTION (KM ⁻¹)	SCATTERING (KM ⁻¹)	ABSORPTION (KM ⁻¹)	20.00 NUMBER DENSITY OF PARTICLES/CM ³	SINGLE SCAT. ALB. ASYMMETRY PARAMETER
.200	2.031E+01	2.031E+01	3.544E-03	.9999	.8578
.300	2.049E+01	2.049E+01	3.385E-04	1.0000	.8726
.337	2.047E+01	2.047E+01	1.597E-04	1.0013	.8722
.550	2.074E+01	2.074E+01	2.399E-05	1.0000	.8717
.694	2.090E+01	2.090E+01	2.973E-04	1.0013	.8703
1.060	2.024E+01	2.024E+01	2.718E-02	.9991	.8652
1.535	2.065E+01	2.065E+01	4.353E-01	.9853	.8618
2.000	2.092E+01	2.092E+01	3.120E+02	.8957	.8798
2.250	3.009E+01	2.097E+01	1.118E+00	.9628	.8649
2.500	3.027E+01	2.645E+01	3.013E+00	.8740	.8918
2.700	3.043F+01	1.688E+01	1.354E+01	.5843	.9541
3.000	3.014E+01	1.586E+01	1.420E+01	.5263	.9502
3.392	3.070E+01	1.754E+01	1.316E+01	.5714	.9297
3.750	3.098E+01	2.503E+01	5.148E+00	.6379	.8544
4.500	3.140E+01	2.066E+01	1.074E+01	.6580	.8407
5.000	3.171E+01	2.177E+01	9.942E+00	.6845	.8885
5.500	3.209E+01	2.294E+01	9.157E+00	.7147	.8912
6.000	3.173E+01	1.588E+01	1.546E+01	.5013	.9674
6.200	3.200E+01	1.619E+01	1.541E+01	.5059	.9470
6.500	3.284E+01	1.808E+01	1.436E+01	.5573	.9193
7.200	3.304E+01	1.973E+01	1.332E+01	.5970	.9039
7.900	3.368E+01	2.048E+01	1.320E+01	.6080	.9039
8.200	3.399E+01	2.079E+01	1.319E+01	.6118	.9057
8.700	3.452E+01	2.128E+01	1.324E+01	.6164	.9117
9.000	3.485E+01	2.156E+01	1.329E+01	.6187	.9156
9.200	3.504E+01	2.171E+01	1.333E+01	.6196	.9194
10.000	3.525E+01	2.169E+01	1.356E+01	.6153	.9381
10.599	3.321E+01	1.916E+01	1.445E+01	.5769	.9577
11.000	3.037E+01	1.598E+01	1.479E+01	.5120	.9395
11.500	2.824E+01	1.299E+01	1.526E+01	.4598	.9587
12.500	2.906E+01	1.318E+01	1.588E+01	.4635	.9418
14.800	3.107E+01	1.501E+01	1.686E+01	.4711	.9171
15.000	3.203E+01	1.510E+01	1.692E+01	.4716	.9081
16.400	3.295E+01	1.560E+01	1.735E+01	.4736	.8957
17.200	3.340E+01	1.503E+01	1.757E+01	.4779	.8698
18.500	3.406E+01	1.615E+01	1.791E+01	.4742	.8812
21.300	3.494E+01	1.651E+01	1.843E+01	.4726	.8685
25.000	3.581E+01	1.695E+01	1.886E+01	.4774	.8491
30.000	3.665E+01	1.740E+01	1.925E+01	.4775	.8246
40.000	3.463E+01	1.559E+01	1.978E+01	.4490	.7815

Table 45. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for the Advection Fog 2 Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	20.00 PARTICLES/CM3	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.816E+01	1.816E+01	1.839E-03	.9999	.8570	
.300	1.830E+01	1.830E+01	1.786E-04	1.0000	.8715	
.337	1.828E+01	1.828E+01	8.240E-05	1.0000	.8707	
.350	1.849E+01	1.849E+01	1.262E-05	1.0000	.8691	
.694	1.859E+01	1.859E+01	1.591E-04	1.0000	.8676	
1.060	1.886E+01	1.884E+01	1.459E-02	.9992	.8604	
1.536	1.916E+01	1.916E+01	2.319E-01	.9879	.8553	
2.000	1.937E+01	1.7	1.680E+00	.9177	.8705	
2.250	1.949E+01	1.2	5.946E-01	.9695	.8604	
2.500	1.962E+01	1.756E+01	2.066E+00	.8947	.8808	
2.700	1.980E+01	1.146E+01	8.379E+00	.5788	.8543	
3.000	1.950E+01	1.016E+01	9.340E+00	.5210	.8487	
3.392	1.994E+01	1.179E+01	8.154E+00	.5911	.9148	
3.750	2.017E+01	1.732E+01	2.857E+01	.8584	.8378	
4.500	2.052E+01	1.419E+01	6.325E+00	.6917	.8794	
5.000	2.078E+01	1.509E+01	5.778E+00	.7219	.8664	
5.580	2.115F+01	1.591E+01	5.238E+01	.7523	.8616	
6.000	2.078E+01	1.449F+01	1.029E+01	.5069	.9575	
6.200	2.090E+01	1.070E+01	1.029E+01	.5096	.9259	
6.500	2.141E+01	1.251E+01	8.914E+01	.5842	.8999	
7.200	2.202E+01	1.400E+01	6.018E+00	.6359	.8864	
7.900	2.262E+01	1.674E+01	7.876E+00	.6518	.8912	
8.200	2.288E+01	1.503E+01	7.847E+00	.6570	.8951	
8.700	2.325E+01	1.540E+01	7.849E+00	.6624	.9134	
9.000	2.341E+01	1.554E+01	7.864E+00	.6640	.9195	
9.200	2.346E+01	1.558E+01	7.884E+00	.6640	.9117	
10.000	2.284E+01	1.461E+01	8.035E+00	.6462	.9137	
10.590	2.054E+01	1.211E+01	8.433E+00	.5894	.9469	
11.000	1.845E+01	9.377E+00	9.076E+00	.5062	.9515	
11.500	1.718E+01	7.615E+00	9.561E+00	.4477	.9497	
12.500	1.811E+01	7.874E+00	1.024E+01	.6348	.9113	
14.000	2.036E+01	9.280E+00	1.108E+01	.4559	.8966	
15.000	2.048E+01	9.352E+00	1.113E+01	.4567	.8943	
16.400	2.119E+01	9.744E+00	1.144E+01	.4509	.8799	
17.200	2.153E+01	9.927E+00	1.160E+01	.4612	.8729	
18.500	2.201E+01	1.019E+01	1.182E+01	.4631	.8622	
21.300	2.255E+01	1.048E+01	1.207E+01	.4648	.8455	
25.000	2.297E+01	1.075E+01	1.222E+01	.4601	.8212	
30.000	2.297E+01	1.088E+01	1.209E+01	.4735	.7812	
40.000	2.089E+01	9.013E+00	1.188E+01	.4315	.7348	

Table 46. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Radiation Fog 1 Model

WAVELENGTH (MICRON)	NORMALIZED TO A NUMBER DENSITY OF (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	100.0 PARTICLES/CM3	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	1.617E+01	1.617E+01	6.339E-04	1.0800	.6460	
.300	1.631E+01	1.631E+01	5.966E-05	1.0000	.6570	
.337	1.637E+01	1.637E+01	2.784E-05	1.0000	.6591	
.550	1.661E+01	1.661E+01	6.071E-06	1.0010	.6557	
.694	1.668E+01	1.663E+01	5.194E-05	1.0000	.6476	
1.060	1.730E+01	1.730E+01	5.478E-03	.9997	.8340	
1.536	1.773E+01	1.769E+01	8.465E-02	.9952	.8177	
2.000	1.810E+01	1.744E+01	6.688E-01	.9671	.8102	
2.250	1.839E+01	1.817E+01	2.101E-01	.9881	.8115	
2.500	1.939E+01	1.829E+01	8.096E-01	.9581	.8278	
2.700	2.118E+01	1.623E+01	4.952E+00	.7662	.9334	
3.000	1.815E+01	8.912E+00	9.237E+00	.4911	.9220	
3.392	1.921E+01	1.301E+01	5.410E+00	.7185	.8008	
3.750	2.027E+01	1.906E+01	1.206E+00	.9475	.7547	
4.500	2.274E+01	1.960E+01	3.141E+00	.8619	.8273	
5.000	2.387E+01	2.119E+01	2.681E+00	.8877	.8382	
5.500	2.428E+01	2.202E+01	2.255E+00	.9071	.8626	
6.000	1.916E+01	1.091E+01	8.254E+00	.5692	.9125	
6.200	2.187E+01	1.366E+01	8.209E+00	.6247	.8773	
6.500	2.326E+01	1.805E+01	5.218E+00	.7757	.8606	
7.200	2.202E+01	1.791E+01	4.103E+00	.8176	.8657	
7.900	1.982E+01	1.593E+01	3.888E+00	.8028	.8680	
8.200	1.873E+01	1.689E+01	3.876E+00	.7952	.8682	
8.700	1.682E+01	1.301E+01	3.807E+00	.7737	.8676	
9.000	1.550E+01	1.178E+01	3.808E+00	.7556	.8671	
9.200	1.476E+01	1.094E+01	3.822E+00	.7411	.8666	
10.000	1.131E+01	7.324E+00	7.983E+00	.6477	.8641	
10.590	9.065E+00	4.592E+00	4.473E+00	.5066	.8612	
11.000	8.715E+00	3.329E+00	5.385E+00	.3823	.8562	
11.500	9.154E+00	2.752E+00	6.402E+00	.3076	.8455	
12.500	1.173E+01	3.529E+00	8.200E+00	.3009	.8142	
14.000	1.503E+01	5.211E+00	9.818E+00	.3467	.7940	
15.000	1.511E+01	5.298E+00	9.884E+00	.3490	.7495	
16.400	1.593E+01	5.751E+00	1.018E+01	.3609	.7107	
17.200	1.617E+01	5.935E+00	1.024E+01	.3670	.7024	
18.500	1.633E+01	6.146E+00	1.018E+01	.3764	.6777	
21.300	1.529E+01	5.709E+00	9.495E+00	.3790	.6286	
25.000	1.377E+01	5.133E+00	8.634E+00	.3728	.5642	
30.000	1.131E+01	3.902E+00	7.328E+00	.3521	.4835	
40.000	8.476E+00	2.079E+00	6.397E+00	.2453	.3301	

Table 47. Attenuation Coefficients, Single Scatter Albedo, and Asymmetry Parameter for Radiation Fog 2 Model

WAVELENGTH (MICRONS)	NORMALIZED TO A NUMBER DENSITY OF 200.0			PARTICLES/CM ³	
	EXTINCTION (KM-1)	SCATTERING (KM-1)	ABSORPTION (KM-1)	SINGLE SCAT. ALB.	ASYMMETRY PARAMETER
.200	8.220E+00	8.220E+00	1.614E-04	1.0000	.6366
.300	8.346E+00	8.346E+00	1.720E-05	1.0000	.6459
.337	8.417E+00	8.417E+00	8.058E-06	1.0000	.6419
.550	8.672E+00	8.672E+00	1.175E-06	1.0000	.8286
.694	8.754E+00	8.754E+00	1.409E-05	1.0000	.8224
1.060	9.121E+00	9.120E+00	1.351E-03	.9999	.7883
1.536	9.798E+00	9.737E+00	2.129E-02	.9976	.7763
2.000	1.124E+01	1.106E+01	1.723E-01	.9847	.8133
2.250	1.207E+01	1.202E+01	5.371E-02	.9956	.6393
2.500	1.224E+01	1.204E+01	2.014E-01	.9815	.8767
2.700	9.081E+00	7.589E+00	1.492E+00	.8357	.4256
3.000	9.610E+00	4.586E+00	5.024E+00	.4772	.8982
3.392	1.243E+01	1.071E+01	1.718E+00	.8617	.7887
3.750	1.260E+01	1.230E+01	3.013E-01	.9761	.8882
4.500	1.029E+01	9.459E+00	8.357E-01	.9185	.8310
5.000	9.051E+00	8.357E+00	6.937E-01	.9274	.8243
5.500	7.142E+00	6.571E+00	5.711E-01	.9200	.8210
6.000	6.222E+00	3.222E+00	3.000E+00	.5179	.8282
6.200	8.014E+00	5.177E+00	2.836E+00	.6461	.8037
6.500	6.881E+00	5.404E+00	1.476E+00	.7854	.7904
7.200	5.226E+00	4.130E+00	1.096E+00	.7913	.7728
7.900	4.135E+00	3.110E+00	1.025E+00	.7522	.7628
8.200	3.764E+00	2.736E+00	1.008E+00	.7307	.7436
8.700	3.185E+00	2.187E+00	9.989E-01	.6864	.7274
9.000	2.584E+00	1.884E+00	1.001E+00	.6571	.7171
9.200	2.704E+00	1.698E+00	1.076E+00	.6280	.7100
10.000	2.093E+00	1.024E+00	1.069E+00	.4893	.6790
10.590	1.073E+00	6.188E-01	1.255E+00	.3333	.6520
11.000	2.082E+00	4.656E-01	1.616E+00	.2237	.6305
11.500	2.499E+00	4.128E-01	2.086E+00	.1652	.6020
12.500	3.701E+00	6.295E-01	3.071E+00	.1701	.5475
14.800	4.931E+00	1.039E+00	3.892E+00	.216	.4577
15.000	4.966E+00	1.056E+00	3.911E+00	.2125	.4511
16.400	5.036E+00	1.117E+00	3.921E+00	.2216	.4084
17.200	4.997E+00	1.117E+00	3.840E+00	.2254	.3872
18.500	4.784E+00	1.081E+00	3.623E+00	.2298	.3566
21.300	3.614E+00	8.202E-01	2.988E+00	.2171	.2976
25.000	2.999E+00	5.766E-01	2.413E+00	.1929	.2340
38.000	2.168E+00	3.331E-01	1.827E+00	.1542	.1711
40.000	1.673E+00	1.237E-01	1.549E+00	.0740	.0456

4. THE USE OF THE AEROSOL MODELS

4.1 Boundary Layer Models

The aerosol models defined in this report are representative for various general types of environments. Yet, there is no clear answer to the simple question: Which model should be used for what location and weather situation? Some discussion on this point is necessary to give the user some guidance in choosing the optimum model for a given condition.

For the boundary layer of the atmosphere up to 1 - 2 km above the surface, the composition of the aerosol particles is primarily controlled by sources (natural and man-made) at the earth's surface. The aerosol content of the atmosphere at a given location, will therefore depend on the trajectory of the local air mass during the preceding several days, and the meteorological history of the air mass. The amount of mixing in the atmosphere is controlled by the temperature profile and the winds. Precipitation will tend to wash the aerosol out of the atmosphere, although it should be noted that "frontal showers" often mark the boundary between two different air masses with generally different histories and correspondingly different aerosol contents.

The "rural" and the "urban" model are intended to distinguish between aerosol types of natural and man-made origin over a land area. Clearly, the man-made aerosol will be predominantly found in urban-industrial areas. However, it is quite likely that after passage of a cold front, clear polar air also covers an urban area and that therefore the rural aerosol model, which is free of the component of industrial-carbonaceous aerosols, is more applicable. After a few days, as the clean air mass begins to accumulate local pollution however, the urban model will once again become more representative.

Conversely, very often the pollution plume from major urban-industrial areas may, under stagnant weather conditions, diffuse over portions of a continent (for example, Central Europe, Northeastern United States), including its rural sections.

There is also a distinct difference between the composition of aerosols over the ocean and those over land areas due to the different surface-based sources. Aerosols in maritime environments have a very pronounced component of sea-salt particles from the sea water. Sea-salt particles are formed from sea spray from breaking waves. The larger particles fall out, but the smaller particles are transported up with the atmospheric mixing in the boundary layer. In coastal regions the relative proportions of particles of continental and oceanic origins will vary, depending on the strength and direction of the prevailing winds at time of observation.

While changes in visibility are often associated with changes in the relative humidity,⁹³ (as the relative humidity approaches 100 percent the visibility tends to

decrease), it is not possible to define a unique functional relationship between the meteorological range and relative humidity for the free atmosphere. However, for aerosols in a closed system, where aerosol changes can be controlled, such a functional relationship can be developed. Such an expression has been derived empirically by Kasten³¹ and has been used by Hänel^{27,28}

$$\frac{V(f_1)}{V(f_2)} \approx \left(\frac{1-f_1}{1-f_2} \right)^\nu \quad (14)$$

where V is the meteorological range and f is the fractional relative humidity, with $0.7 \leq f_1, f_2 \leq 0.995$, and ν is a model dependent parameter. For the Rural and Tropospheric Models $\nu \approx 0.42$, for the Urban Aerosol Model $\nu \approx 0.57$ and for the Maritime Aerosol Model $\nu \approx 0.58$.

Since the natural atmosphere is not a closed system and changes in the relative humidity do not necessarily take place in isolation from other changes, Eq. (14) should be used with caution. The measurements presented by Filippov and Mirumyants⁹⁴ clearly illustrate the difficulties in defining a simple unique expression relating visibility and relative humidity. Where the changes in the relative humidity are primarily due to changes in the air temperature, with a constant dew point, that is, solar heating during the day or radiational cooling at night, then Eq. (14) can be expected to be approximately valid for relative humidity greater than 70-80 percent.

4.2 Tropospheric Aerosol Model

The Tropospheric Aerosol Model has been developed primarily for application in the troposphere, above the boundary layer, where the aerosols are not as sensitive to local sources or largely controlled by the mixing of the first 1 to 2 km of the atmosphere. However, the Tropospheric Model may be applicable to near ground level for particularly clear and calm conditions (in pollution free areas with visibilities greater than 30 to 40 km), where there has been little turbulent mixing for a period of one to two days, permitting the larger particles to have settled out of the atmosphere without being replaced by dust blown into the air from the surface. (The sedimentation rate of a $10 \mu\text{m}$ radius aerosol particle is approximately 1 km per day.)⁹⁵

4.3 Fog Models

The Fog Models described in Section 2.5 were presented in terms of the atmospheric conditions leading to the development of the fog, so this provides a good basis for deciding which fog model to use. In more general terms, for heavy

fogs the visibilities will be less than 200-250 m and the extinction will be virtually independent of wavelength. For these conditions Fog Model 1 should be used. For light to moderate fogs, the visibility will generally exceed 350 m and there will be a noticeable difference between the extinction for visible wavelengths and in the 8-12 μ m window. For such cases Fog Model 4 should be used. For very light fog conditions where the visibility may be about 1 km, the 99 percent relative humidity aerosol models may represent the wavelength dependence of the atmospheric extinction as well as any of the fog models.

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