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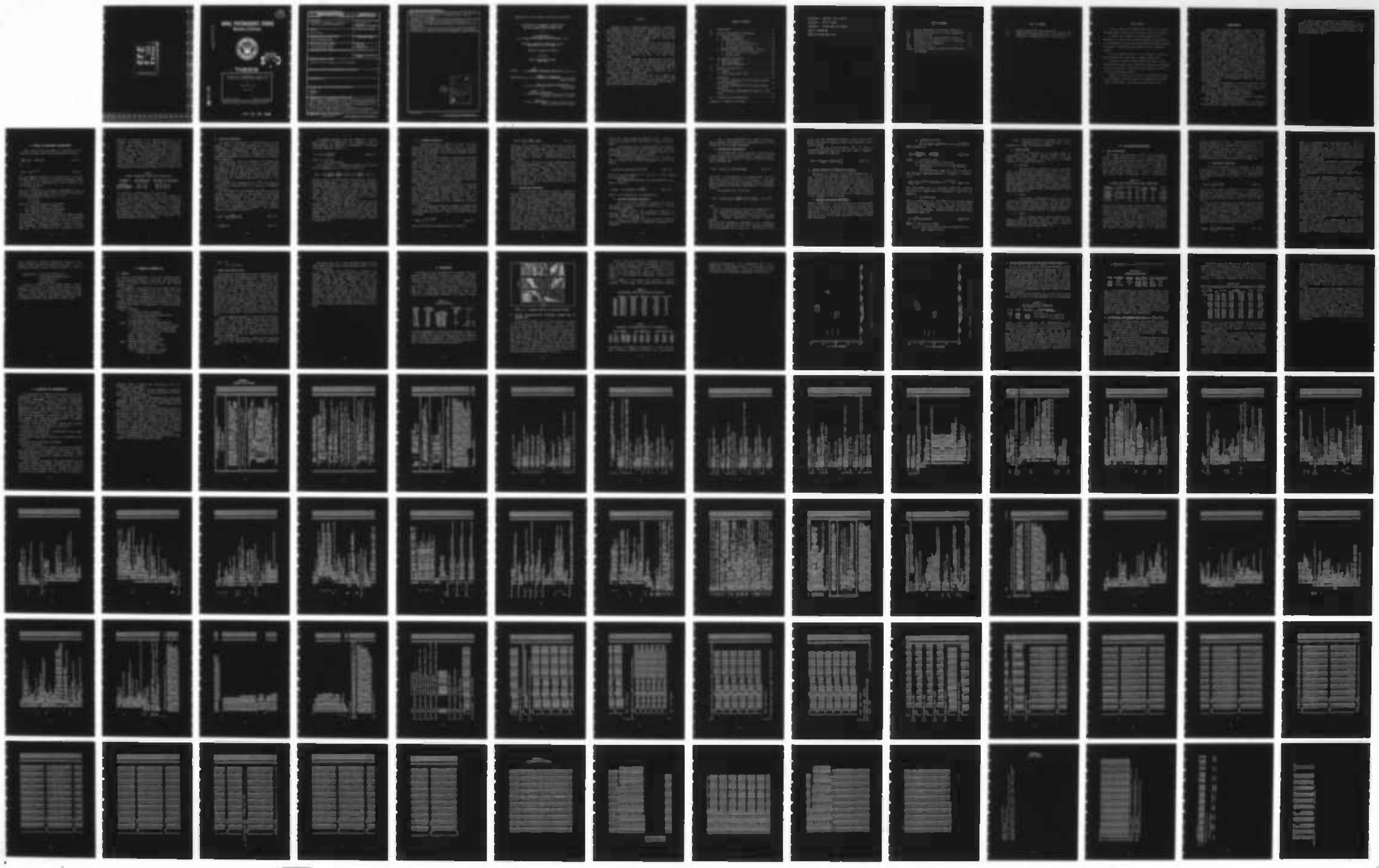

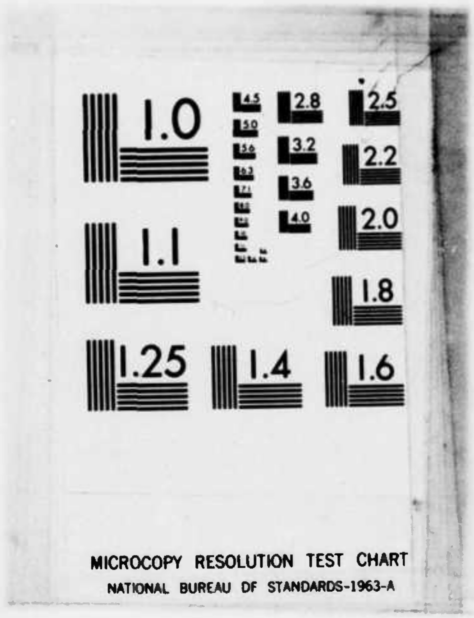
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NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

CALCULATION OF ATMOSPHERIC TRANSMITTANCE
BY IBM 3033 COMPUTER CODE LOWTRAN IIIB

by

Moon-Sik Shin

June 1983

Thesis Advisor: Alfred W. Cooper

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Due to compiler storage limitation in the IBM computer, the atmospheric data are read into common storage at the beginning of the program. The two

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LOWTRAN IIIB is presently available as a method of predicting atmospheric transmittance at low resolutions at NPS and is suitable for incorporation in simulations and studies of electro-optic weapon/sensor systems performance.

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Calculation of Atmospheric Transmittance
by
IBM 3033 Computer Code LOWTRAN IIIB

by

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Submitted in partial fulfillment of the
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LOWTRAN IIIB is a FORTRAN computer program for prediction of atmospheric optical transmittance, developed at the U.S. Air Force Geophysics Laboratory (AFGL). LOWTRAN IIIB was received in the modified form developed by Naval Weapon Center China Lake for use on the UNIVAC 1110 computer [Ref. 1], and has now been interfaced to the IBM 3033 computer.

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I. INTRODUCTION

LOWTRAN IIIB is a FORTRAN computer program, developed at the U.S.Air Force Geophysics Laboratory (AFGL), which was received in the modified form developed by Naval Weapon Center. It calculates the transmittance of the earth's atmosphere in the spectral region from 0.25 to 28.57 micrometers (350 to 40,000 cm-1) at 20 cm-1 spectral resolution on a linear wavenumber scale. Six atmospheric models, which are tropical, midlatitude summer and winter, subartic summer and winter, and the U.S. 1962 standard atmosphere, covering seasonal and latitudinal variations from sea level to 100 km are available, in addition to a capability of allowing the user to input atmospheric parameters of his own choosing. The program includes four aerosol models which are average continental, urban, rural, and maritime, and either hazy (5 km visibility) or clear (23 km visibility) haze conditions can be selected in addition to the capability of selecting a particular visibility of the user's choosing. The model accounts for molecular absorption, molecular scattering, and aerosol extinction, plus atmospheric refraction and earth curvature effects.

LOWTRAN IIIB is presently an available method for predicting atmospheric transmittance at low resolution at NPS and may be incorporated in simulations and studies of electro-optic weapon/sensor systems performance.

Basically, this thesis describes a program to

a) Develop a computer code to calculate atmospheric transmittance for particular wavelengths.

b) Develop a code to give transmittance and molecular absorptance with bandwidth appropriate to grey-body sorces.

c) Apply these to prediction of transmittance over a marine optical path, based on the available meteorological data base for the area, for conditions appropriate to the optical propagation experimental measurement program at the Naval Postgraduate School.

II. THEORY OF ATMOSPHERIC TRANSMITTANCE

Beer's law for linear propagation of monochromatic radiation in the linear regime can be expressed as follows;

$$\frac{d}{dz}\left[I(\nu)\right] = -\mu(\nu) I(\nu) \qquad \text{(eqn 2.1)}$$

or

$$I(z) = I(0)\, e^{-\mu z} \qquad \text{(eqn 2.2)}$$

The ratio $\frac{I(z)}{I(0)}$ is defined as the transmittance T of the path of length z, and u is the total extinction coefficient which is the sum of the coefficients for total absorption and non-forward scattering

$$\mu = \mu_a + \mu_s$$

Both the scattering and absorption coefficients can be divided into components due to the molecules of the air and the aerosol particles suspended in it; i.e.

$$\mu_a = k_m + k_a$$

$$\mu_s = \sigma_m + \sigma_a$$

where k_m = molecular absorption coefficient

k_a = aerosol absorption coefficient

σ_m = molecular scattering coefficient

σ_a = aerosol scattering coefficient

The relative values of the four coefficients depend strongly on the density and molecular composition of the atmosphere and the composition, number density and size distribution of the aerosols. The order of importance in each of the important atmospheric transmission windows is shown in Table I [Ref. 2]. We note from this that scattering by both molecules and aerosols is of greater importance in the visible, and absorption in the infrared (particularly 8 to 14 um). Since devices are designed to operate throughout these windows, it is important to predict the transmittance of the atmosphere as a function of wavelength and weather conditions. This prediction becomes a complex problem of computer modelling. The problem requires a definition of the composition, density and pressure of the atmospheric gases, together with the frequencies, line strengths and line widths of all the spectroscopic transitions of the gas molecules and the aerosol constituents, and the number, size

TABLE I

Optical Atmospheric Attenuation Coefficient

Atmospheric window	Wavelength for EO systems (µm)	Attenuation Coefficients in order of importance
Visible	0.4 - 0.7	σ_a, σ_m, K_a
Near Infrared	0.7 - 1.2	σ_a, K_a, σ_m, K_m
Middle Infrared	3.0 - 5.0	K_m, σ_a, K_a, σ_m
Far Infrared	8.0 - 12.0	K_m, K_a, σ_a

and composition distributions of the particles.

Over the entire wavelength range from visible to infrared the absorption by molecules, scattering by aerosols and absorption by aerosols are the dominant extinction mechanisms, and should be considered. In the "window" regions of good transmittance, the molecular line absorption is relatively small, and may in some regions be ignored. The remaining extinction in these regions is due to aerosol scattering (which varies only slowly with wavelength) and "continuum absorption" by the molecules.

A. MOLECULAR ABSORPTION

To compute the monochromatic transmittance of the atmosphere, we must first obtain accurate data describing the frequencies, intensity and line shape of all absorption lines affecting the attenuation. These should be developed a compilation based on certain constraints dictated by atmospheric abundances if we need to develop this monochromatic capability.

The approach by AFGL is to calculate the transmittance at given wavelength for each transition having finite absorption at that wavelength for each of the molecules. The summation over all the molcules gives a monochromatic transmittance which is appropriate directly for laser propagation, but must be degraded by integration over finite bandwidth for low resolution predictions suitable to non-laser sources.

To calculate the transmittance $T = e^{-K_m z}$, the absorption coefficient K_m should be known as a function of frequency for each line.

The four essential line parameters for each line are the resonant frequency, ν_0 (cm-1), the intensity per absorbing molecule, S(cm-1/molecule cm-2), the Lorentz line width parameter, α_0 (cm-1/atm), the energy of the lower state, E"(cm-1), and the line half-with at half maximum, α, which is proportional to the pressure. The frequency, ν_0, is independent of both temperature and pressure. The molecular absorption coefficient is given by

$$K_m(\nu) = \frac{S\alpha}{\pi\left[(\nu-\nu_0)^2 - \alpha^2\right]} \qquad \text{(eqn 2.3)}$$

$$S = \int K_m(\nu)\, d\nu \qquad \text{(eqn 2.4)}$$

The pressure broadened line width depends in a complicated fashion on temperature; for computation this is approximated by the assumption of temperature - independent collision diameters, leading to

$$\alpha = \alpha(P_o, T_s)\,\frac{P}{P_o}\left(\frac{T_s}{T}\right)^{\frac{1}{2}} \qquad \text{(eqn 2.5)}$$

where P = 1 atm, and

T = 296 degrees Kelvin.

The intensity, S, is pressure-independent and its temperature dependance can be calculated from E" and

$$S(T) = S(T_s)\,\frac{Q_v(T_s)}{Q_v(T)} \times \frac{Q_r(T_s)}{Q_r(T)} \times \exp\left[1.439\ E''\left(\frac{T-T_s}{TT_s}\right)\right] \qquad \text{(eqn 2.6)}$$

where Q_v and Q_r are vibrational and rotational partition functions respectively. At lower pressure the collision broadening diminishes and Doppler broadening becomes important. In the intermediate pressure range the Voigt profile obtained by convolving the two profiles is used. Once Doppler broadening dominates the Gaussian profile may be used. Lorentz linewidths are typically .001 to .01 cm-1, while the Doppler width may be 0.0003 cm-1.

The AFCRL calculations [Ref. 14] are based on the Absorption Line Parameters Compilation, which originally listed ν_o, S(T), α(Ps, Ts) and E" for 130,000 lines in the range beyond 1 µm, for each one of the species water, carbon dioxide, ozone, nitrous oxide, carbon monoxide, methane and oxygen. A new version of the compilation including over 139,000 lines between 0.2 µm and 30 µm was recently reported by AFGL [Ref. 3].

B. CONTINUUM ABSORPTION

Continuum absorption occurs as a result of collisional interactions between molecules; that is, collisions between two H_2O molecules and those of other gases (principally H_2O: N_2 collision, since nitrogen comprises approximately 80 % of the air)

In wavelength regions between the absorption bands some attenuation occurs of a continuous nature which is attributed to water vapor. The mechanism of water vapor continuum extinction lacks a complete theoretical explanation. At present, it is believed that it results from the accumulated attenuations of the distant wings of H_2O absorption lines, occurring principally in the far infrared part of the spectrum. Other postulates, such as that the phenomenon is caused by other absorption mechanisms involving H_2O dimers, remain possibilities yet to be proved.

However, all that we can do at present is to account for the water vapor continuum phenomenon empirically, based on what limited experimental measurements we have to go on, until better line shape theories become available. It should be emphasized that further accurate and well controlled measurements are urgently required in order to account for this phenomenon in real atmospheric situations with confidence.

A common formulation used (for example in LOWTRAN IIIB) to account for the water vapor continuum attenuation at a fixed temperature has been to define the transmittance $\bar{T}(\nu)$ as follows;

$$\bar{T}(\nu) = e^{-K(\nu) \times \text{range}} \qquad \text{(eqn 2.7)}$$

where the attenuation coefficient $k(\nu)$ is given by

$$K(\nu) = C_S \left[P_{H_2O} + \frac{C_N}{C_S}(P_T - P_{H_2O}) \right] \omega \qquad \text{(eqn 2.8)}$$

where P_{H_2O} and P_T refer to the water vapor partial pressure and ambient pressure respectively (atm), and ω defines the quantity of water vapor per unit pathlength (gm cm-2 km-1). The quantities C_S and C_N are generally referred to as the self and foreign (nitrogen) broadening coefficients for water vapor.

Values for C_S and C_N/C_S have been obtained empirically from laboratory measurements. In LOWTRAN versions I through III, the quantity C_N/C_S is assumed to remain constant over a given wavelength interval. However, a major addition in LOWTRAN IIIB has been to account for the temperature dependence of Cs and this will be discussed in the 8-14 μm H_2O continuum region. The H_2O continuum radiation in the 3.5-4.2 μm region is of much less importance and will not be futher discussed here.

1. Temperature Dependence

The water vapor continuum attenuation coefficient has been found to have a significant temperature dependence, which was not accounted for in the previous LOWTRAN computer codes. Based on the laboratory measurements using samples of water vapor at elevated temperatures, an approximate empirical expression was obtained by Roberts et al [Ref. 6] for the temperature dependence which is given in Eqn 2.9 below. It was found that the attenuation coefficient due to the water vapor continuum increases as the temperature decreases. That is, for a fixed amount of water vapor in a given path, one would expect more absorption at lower temperatures and less absorption at higher temperatures. This is a somewhat unusual phenomenon. In practice one finds less water vapor in the atmosphere under cold conditions, therefore, the effect of temperature on the attenuation in the 8-14 μm region plays two competing roles, through the total water content of the path and the attenuation coefficient.

The empirical fits to the wavelength and temperature dependence of the water vapor continuum described in Roberts et al [Ref. 6] have been used in LOWTRAN IIIB with the appropriate conversion of units as follows.

The attenuation coefficient C_s in $gm^{-1}\ cm^{2}\ atm^{-1}$ at 296 K is given by the following expression in the 8-14 μm region:

$$C_s(\nu, 296) = 4.18 + 5578 \exp(-7.87 \times 10^{-3} \nu) \qquad \text{(eqn 2.9)}$$

where ν is the wavenumber in cm^{-1} (note that $= 10^4/\lambda$, where λ is the wavelength in μm).

The temperature dependence of the coefficient C_s was found to vary as:

$$C_s(\nu, T) = C_s(\nu, 296) \exp 6.08 \left(\frac{296}{T} - 1\right) \qquad \text{(eqn 2.10)}$$

where T is the temperature in degrees Kelvin.

2. Nitrogen Broadened Coefficient

C_N/C_s in the above Equation represents the ratio of the foreign (nitrogen) broadening coefficient to the self broadening coefficient.

In LOWTRAN IIIB we use a value of 0.002 for the parameter C_N/C_s based on the measurements presented by Supplement LOWTRAN IIIB [Ref. 7].

Here, it is assumed that C_N/C_s (at 296 K) does not vary with temperature (since no supporting measurements are available).

Thus, further measurements are needed to determine more accurately the magnitude of the parameter C_N/C_S and its temperature and wavelength dependence.

3. <u>Transmission Calculations</u>

The transmittance due to the water vapor continuum in the 8-14 μm region is calculated for a horizontal path of length RANGE(km) at altitude z using the following expression in LOWTRAN IIIB:

$$T(\nu) = \exp\left[-C\ (\nu, 296) \times W(z) \times RANGE\right] \qquad \text{(eqn 2.11)}$$

where W(z) is the effective H_2O absorber amount per unit path length (in gm · cm^{-2}atm km^{-1}) at altitude z, and $C_S(\nu, 296)$ is the water vapor (self broadened) attenuation coefficient obtained from laboratory measurements at a temperature of 296 K.

The quantity W(z) is given by:

$$W(z) = w(z)\left[P_{H_2O} \exp\left[6.08\left(\frac{296}{T(z)}-1\right)+0.002\left(P_T-P_{H_2O}\right)\right]\right] \qquad \text{(eqn 2.12)}$$

where

w(z) = gm cm-2/km of H2O in the path at temperature T,

P_{H_2O} = H2O partial pressure (atm) at altitude z,

P_T = ambient (total) pressure (atm) at altitude z, and

T(z) = ambient temperature at altitude z (degrees Kelvin).

Note that the temperature dependence of the attenuation coefficient $C_S(\nu,T)$ given in Eqn 2.10, has been incorporated into the expression for W in Eqn 2.12. The reason for this is so that the temperature variation over a given atmospheric slant path is weighted equally with the water content along the path.

It may be worth contrasting Eqn 2.12 with the corresponding expression which has been used in LOWTRAN I through LOWTRAN III, that is:

$$W(z) = w(z)\left[P_{H_2O} + 0.005(P_T - P_{H_2O})\right] \qquad \text{(eqn 2.13)}$$

C. AEROSOL EXTINCTION COEFFICIENT & MODELS.

Scattering of radiation occurs from molecules in the air, from aerosol particles suspended in the air, and from water droplets in fog, rain or hail. The attenuation of a beam depends on the size and number density distribution and the refractive index of the particles. Atmospheric transmission may be strongly influenced or even dominated by scattering from aerosol particles. The major parameter determining the interaction is the ratio of particle radius to the wavelegth of the radiation.

1. Aerosol extinction coefficient

Aerosol extinction is sum of the absorption and scattering by aerosol particles. Although scattering by aerosol particles whose radius is smaller than about 0.03 times the wavelength of the light may be calculated by Rayleigh theory, for the whole range of particle radius Mie theory must be applied.

a. Rayleigh Scattering

The Rayleigh volume total scattering coefficient may be written as

$$\sigma_m = \frac{8\pi^3(n^2-1)^2}{3N\lambda^2}\left(\frac{6+3P}{6-7P}\right) \qquad \text{(eqn 2.14)}$$

where n ; refractive index

N ; the number density of molecules

P ; depolarization factor due to some molecular anisotropy.

Following Penndorf [Ref. 8] it can be written in the following form which depends on pressure and temperature.

$$\sigma_m = 9.807\times10^{-20}(273/T)(P/1013)\,\nu^{4.0117}\ \mathrm{Km}^{-1} \qquad \text{(eqn 2.15)}$$

The strong dependence on wavelength means that Rayleigh scattering is a small effect for wavelengths longer than the visible.

b. Mie scattering

This is appropriate for the condition of particle size comparable to wavelength; i.e., for large molecules and small droplets. This is the most important mechanism for atmospheric scattering. McCartney gives the scattering coefficient [Ref. 9].

$$\sigma = \pi\int r^2 N_T(r)\,K(\alpha, n)\,dr \qquad \text{(eqn 2.16)}$$

where r ; the particle radius

$N_T(r)$; the total number density of particles in the size range dr about r

$K(\alpha, n)$; the area scattering coefficient, the ratio of effective area to geometrical area, which depends on $\alpha = 2\pi r/\lambda$ and refractive index n.

2. Aerosol Model

The range of conditions in the boundary layer is represented by three diffent aerosol models, which are rural, urban or maritime. The first two are grouped together as " averaged continental ".

a. Maritime

Maritime aerosol composition and size distributions are significantly different from rural and urban aerosol types. The maritime aerosol component is due to salt particles which are caused by the evaporation of seaspray a droplets. The concentration of particles near the surface is strongly dependent on wind speed (above 7 m/sec) and the size distribution is also dependent on relative humidity. This salt-particle number-density decreases rapidly above about 500 m [Ref. 10].

b. Rural

Rural aerosol background is partly the product of reactions between various gases in the atmosphere and partly due to dust particles picked up from the earth surface. The particle concentration is largely dependent on the history of the airmass carrying the aerosol particles.

c. Urban

Urban aerosols contain certain additives from combustion products and from industry. Shettle and Fenn assumed an addition of 35% soot-like particles of similiar distribution to the rural aerosol [Ref. 11].

III. LOW RESOLUTION MODELLING

A. MODEL ATMOSPHERES

The LOWTRAN code provides a choice of six atmospheric models. These include the 1962 U. S. Standard Atmosphere plus five supplementary models. Surface level conditions for the supplementary models are given in Table II [Ref. 1]. There are also two conditional haze models - corresponding to sea level visual ranges of 5 and 23 km - provided as basic input data for LOWTRAN III. Aerosol attenuation for other visual ranges is calculated using an interpolation/

TABLE II
Surface Level Condition for Model Atmospheres

Model atmosphere	Latitude & month	Pressure (mb)	Temp. (K)	Air density (g/m3)	Water vapor (g/m3)	Ozone (g/m3)
Subartic						
winter	60 N,Jan	1013	257	1372	1.2	4.1E-05
summer	60 N,July	1010	287	1220	9.1	4.9E-05
Midlatitude						
winter	45 N,Jan	1018	272	1301	3.5	6.0E-05
summer	45 N,July	1013	294	1191	14.0	6.0E-05
Tropical	15 N	1013	300	1167	19.0	5.6E-05

extrapolation procedure which utilizes these two models. In addition to the model atmospheres the user has the option of inserting his own model atmosphere, or of building another model by combining various parts of the six standard models.

Provisions are made in the LOWTRAN program for inserting radiosonde data. There are limits on the accuracy of LOWTRAN transmittance calculations when the input is radiosonde data alone. Radiosondes provide vertical profiles of the synoptic meteorological parameters of temperature, pressure, humidity, and wind. Information on micrometeorological parameters (i.e., aerosol size distributions, local oxidant concentrations, etc.) is also needed as input. In the absence of micrometeorological inputs LOWTRAN relies on its model atmospheres for that information; this may not necessarily be applicable to a specific location. For further discussion on optical parameters see [Ref. 12].

B. CALCULATION MODELLING

In the application it is impossible to measure transmittance at a single frequency. Instead one measures the transmittance T (ν) averaged over the spectral bandwidth, $\overline{T}_{\Delta\nu}(\nu)$, accepted by the receiver, as indicated in the equation

$$\overline{T}_{\Delta\nu}(\nu) = \frac{1}{\Delta\nu}\int T(\nu)\,d\nu \qquad \text{(eqn 3.1)}$$

where ν is the central frequency in the interval, $\Delta\nu$. Consequently for many applications one is interested in knowing the transmittance of the atmosphere averaged over a relatively wide spectral interval, that is, for low resolution.

Thus the term transmittance is somewhat ambiguous unless it is qualified by some indication of the spectral resolution, $\Delta\nu$, over which it is averaged. This is particularly true in the case of molecular absorption, since the absorption coefficient K_m is a rapidly varying function of frequency. It is because of the rapid variation of K_m with frequency that the averaged tranmittance $\overline{T}$ does not, in general, obey the simple exponential law. That is,

$$\overline{T}_{\Delta\nu}(\nu) = \frac{1}{\Delta\nu}\int_{\Delta\nu} \exp\left[-K_m(\nu)\Delta m\right] \qquad \text{(eqn 3.2)}$$

where K_m represents the net monochromatic molecular absorption coefficient. On the other hand the molecular scattering coefficient (σ_m) and the aerosol scattering and absorption coefficients(σ_a and K_a) are slowly varying functions of frequency, and the average transmittance obeys the simple exponential law provided only the direct transmitted beam is being observed

There are four basic approaches to obtaining a low resolution transmittance value for a given path through the atmosphere due to molecular absorption. These are;

(1) direct measurements over the required path,

(2) measurements in the laboratory under simulated conditions,

(3) line-by-line (monochromatic) calculations based on detailed knowledge of spectroscopic line parameters which are then averaged over the required spectral interval, and

(4) calculations based on band model techniques (which use available laboratory and/or field transmittance measurements or actual line data as a basis).

From the point of view of computations, method 3 involves a considerable amount of work and computer time, and consequently method 4 has been used most frequently.

Basically, it involves a graphical or computerized "curve fitting" technique for accessing the stored transmittance data for the appropriate absorber and scatterer amounts computed from the input atmospheric path conditions. The predetermined variations of transmittance with frequency are stored for the various atmospheric constituents, for standard path conditions.

For a given set of meteorological conditions and selected path, the appropriate absorber and scatterer amounts in the required path are computed for each component and the results used to correct the transmittances for these components. The transmittances for the separate processes (line absorption, continuum absorption, molecular scattering, aerosol scattering and aerosol absorption) are then multiplied together to give the overall absorption. That is :

$$T_{\Delta\nu}(\nu)(\text{total}) = T_{\Delta\nu}(\nu)(\text{line absorption}) \times T_{\Delta\nu}(\nu)(\text{continuum absorption}) \times T_{\Delta\nu}(\nu)(\text{Rayleigh}) \times T_{\Delta\nu}(\nu)(\text{aerosol}).$$

It should be noted that the LOWTRAN computer code is designed to calculate the transmittance for spectral bands. It should not be used to calculate transmission for laser lines. Suitable techniques for computing atmospheric transmission for laser lines or extremely narrow spectral bands are described in [Ref. 13], [Ref. 14], and [Ref. 15].

IV. EXAMPLE OF PROGRAM USE

A. PROBLEM

As a check on the performance of the code a sample calculation was carried out using the same input data described by Shlanta and Cornette [Ref. 1], for which they provide computed output.

The example is the calculation of the transmittance from 2350 to 2450 cm-1 in steps of 5 cm-1 for a slant path from 2.5km to 8.5 km at a zenith angle of 65 degree, for a subartic winter model atmosphere, and a 23 km visual range.

The program is initiated with data input on 4 cards (lines) defining the conditions of the computation, and user directions are given at the beginning of the program listing (Appendix A).

```
CARD 1  **5**1**1
        5 ; Sub-artic winter atmosphere
        1 ; An average continental aerosol model
        1 ; For 23 km visible range
        0 ; For normal operation, etc.
CARD 2  **2**0*********2.500*****8.500****65.000
        2 ; Vertical & slant path between two altitudes
        0 ; For normal operation of the program which
            selects the shorter path when applicable
        2.500 ; Observer altitude (km)
        8.500 ; Source altitude (km)
        65.000 ; Zenith angle at H1 (deg.).
CARD 3  **2350.000**2450.000*****5.000
        2350.000 ; Initial frequency (cm-1)
        2450.000 ; Final frequency   ( "  )
        5.000 ; Frequency intervals at which
                transmittance is printed.
```

CARD 4 **0

0 ; To end data.

B. OUTPUT FROM LOWTRAN IIIB.

The output for this problem is given in Appendix C. The parameters defining the atmospheric path, model atmospheres and frequency range are first printed out. Following tabulations give the absorber amounts for horizontal and vertical path. At the heading HORIZONTAL PROFILES there are 13 columns. The first column gives a running integer associated with each level. The second column gives the level altitude in km. The next 8 columns give the equivalent absorber amounts per km for the following absorbing species: water vapor, uniformly mixed gas, ozone, nitrogen continuum, water vapor continuum (10 μm), molecular scattering, aerosol extinction and UV ozone, respectively. The next three columns give the mean refractive index modulus from that level to the level above, the equivalent absorber amounts per km for the water vapor continuum (4 μm) and for nitric acid.

A heading VERTICAL PROFILES is then printed followed by 15 columns. The first and second columns give the integer associated with the levels traversed by the path and the height of the level. Then follow 8 columns which give the integrated equivalent absorber amounts from the initial altitude to the level above (in the same order as indicated above). The next 4 columns are labelled PSI, PHI, BETA, and THETA (see Appendix D).

The total equivalent absorber amounts for each absorber species are then summarized below in their appropriate units.

The second line in the total equivalent absorber amount table gives the water vapor continuum amount (4 μm) and the nitric acid amount.

A transmittance table, containing 12 columns, now follows. The first 3 columns give the frequency (cm-1) wavelength (μm), and total transmittance. The next 7 columns show the individual transmittances due to water vapor, uniformly mixed gases, ozone, nitrogen (4 μm) continuum, total water vapor continuum, molecular scattering, and aerosol extinction. The last 2 columns give absorption due to aerosols and the cumulative integrated absorption. The latter quantity can be used to determine the average transmittance over any given spectral interval within the spectral range covered by the calculation. Finally, the total integrated absorption from V1 to V2 is printed out together with the average transmittance over the band.

V. APPLICATION

The purpose of this implementation of LOWTRAN IIIB is to present a simple method of predicting atmospheric transmittance (at low resolution) which is applicable over a wide spectral interval and for a wide range of atmospheric path.

In this study the bandwidths of the computations have been chosen to match the transmission bands of the filters used by the atmospheric optics measurement group at NPS [Ref. 16]. These filters have been used with grey - body sources to give wavelength resolution in a number of transmittance measurements at Monterey and elsewhere. Figure 5.1 shows the passbands of the grey-body source filters superimposed on curves of atmospheric transmittance for a 1000 ft, path at sea level containing 5.7 mm of precipitable water at 79°F. The filter bands are shown as Table III.

TABLE III

Broadband System

center wave-length (μm)	filter bandwidth at 1/2 ht (μm)	" (CM-1)	grey-body source temp. (K)	detector
0.49	.010	20619-21053	2800	Si
0.63	.010	15748-16000	"	"
0.84	.010	11834-11976	"	"
1.03	.010	9662-9756	"	"
1.06	.010	9390-9479	"	"
1.60	.098	6064-6447	"	"
2.15	.097	4549-4759	"	Ge
3.80	.400	2500-2778	1800	InSb, 77K
3.835	.110	2571-2646	"	"
10.66	2.850	827-1083	"	HgCdTe, 77K
11.02	.710	879-938	"	"

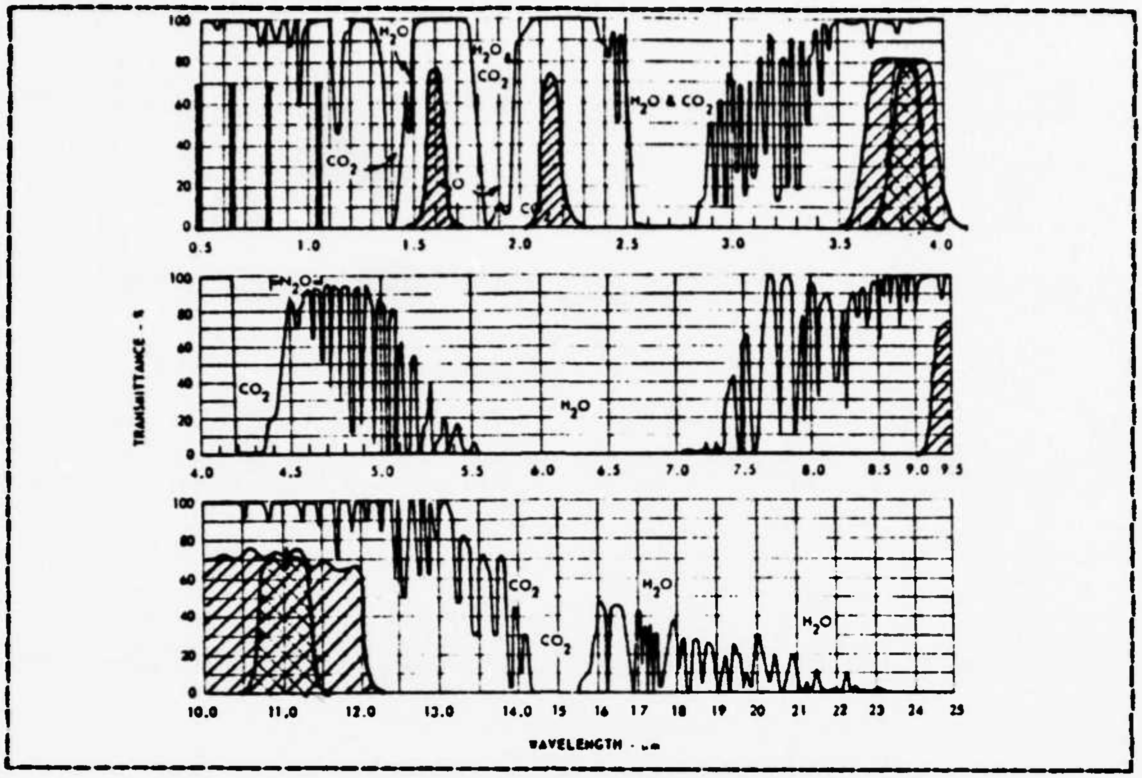

Figure 5.1 Bandpass Regions for Grey-body Source.

A. LOWTRAN CALCULATIONS FOR THE MONTHLY AVERAGE DATA OF MONTEREY BAY

Calculations intended for use in the propagation studies in the Monterey Bay Area make use of the known range of conditions and three different relative humidities, 70, 80, and 90 %, taking into account the monthly and yearly averages of air pressure, air temperature, dewpoint temperature, water vapor density, and relative humidity. These monthly and yearly averages are taken from the thesis by Guner [Ref. 4], and ozone density is translated from that source to 6.00E-05 gm/m3, consistent with the midlatitude model in Table II. In this Table IV the average temperature is used which is the mean value of maximum and minimum average temperatures corresponding to day/night conditions.

Table V shows the calculated atmospheric transmittance for 3 different cases of relative humidities and temperatures for selected wavebands of the broadband system at sea level(1.60, 2.15, 3.80, 3.835, 10.66, 11.02 µm), 13.16 km range, and with typical May conditions. Figure 5.2 and Figure 5.3 also represent the atmospheric transmittance of Table V.

By comparing the numbers for different relative humidity, it can be seen that increasing relative humidity

TABLE IV
Monterey Bay Area Average Weather Condition

	mean pr. (mbars)	mean temp. (deg.)	mean dew. (deg.)	H2O den. (gm/M)	rel. hum. (%)
JAN.	1020.0	10.03	6.12	7.37	77
FEB.	1020.0	10.57	6.68	7.67	76
MAR.	1017.5	10.84	6.68	7.67	78
APR.	1018.0	11.68	8.34	8.53	77
MAY.	1017.0	13.34	9.45	9.11	77
JUN.	1015.0	14.45	11.12	10.16	79
JUL.	1017.0	14.73	11.68	10.55	83
AUG.	1017.5	15.29	10.23	10.92	84
SEP.	1013.5	15.84	14.73	10.55	79
OCT.	1017.5	14.73	10.01	9.40	75
NOV.	1019.0	12.79	7.23	7.95	72
DEC.	1018.0	11.12	6.12	7.37	73
YEAR.	1017.5	13.07	8.89	8.82	77

TABLE V
Comparison of Transmittance by R.H & Temperature

	wavenumber µm	cm-1	Rel. Humidity 70 %	80 %	90 %	temperature(°C) 0.0	13.3	30.0
(1)	1.60	6064-6447	.823	.823	.823	.823	.823	.823
(2)	2.15	4549-4759	.834	.832	.831	.833	.833	.833
(3)	3.80	2500-2778	.803	.797	.791	.794	.799	.803
(4)	3.835	2571-2646	.813	.808	.803	.806	.810	.814
(5)	10.66	827-1083	.836	.815	.793	.801	.821	.839
(6)	11.02	879-938	.856	.833	.808	.818	.840	.860

decreases the atmospheric transmittance. We can also see that increasing temperature increases the transmittance;

significant differences of the transmittance occur due to temperature. The numbers from the 8-14 µm region are much larger than the other band. This point is consistent with the theory of the temperature dependence from chapter II.

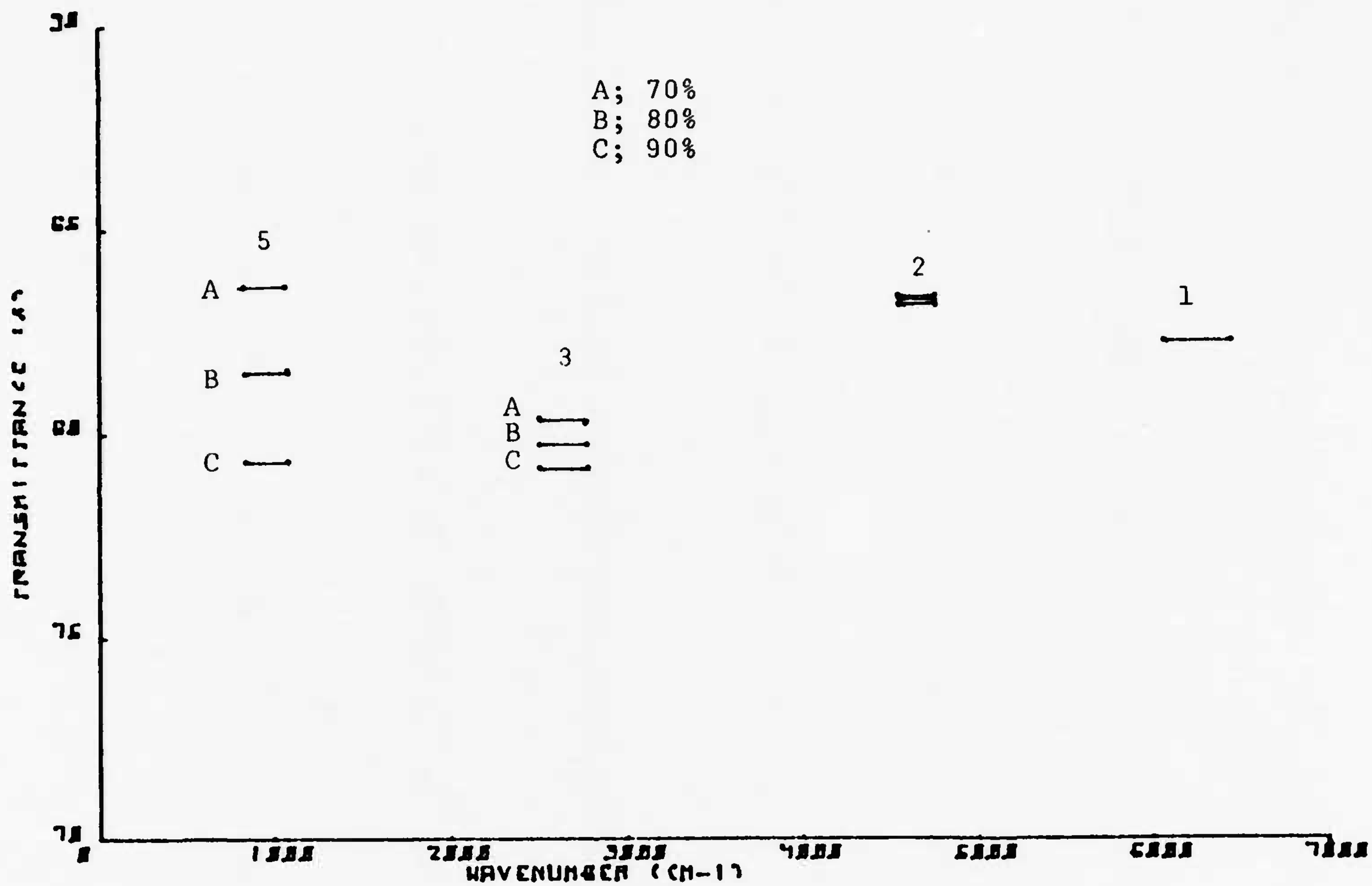

Figure 5.2 Comparison of Transmittance due to Relative Humidity.

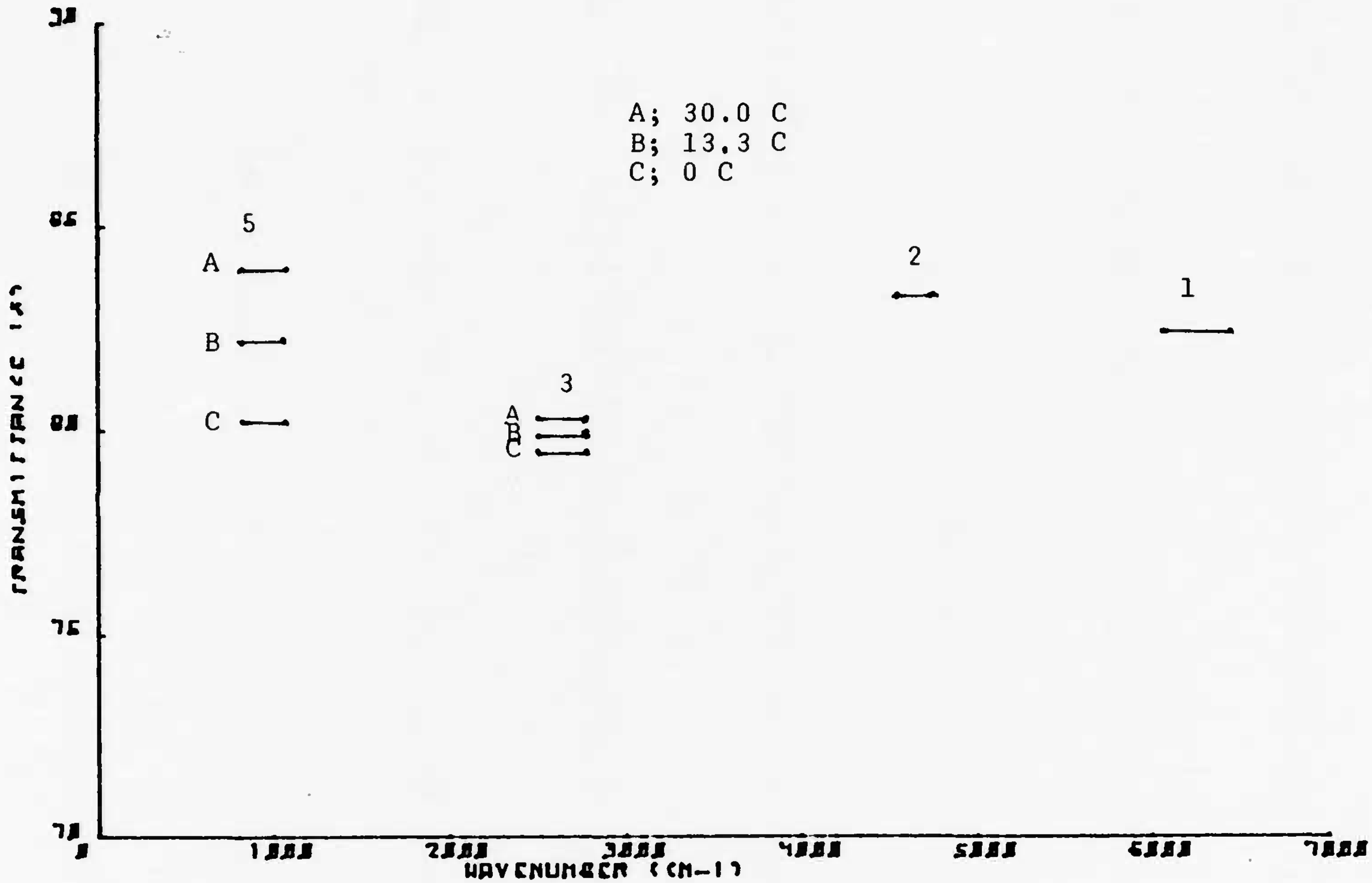

Figure 5.3 Comparison of Transmittance due to Temperature.

B. OPTICAL TRANSMISSION AT SAN NICOLAS ISLAND, CEWCOM-78.

In May 1978 the NPS Optical Physics and Micrometeorology Groups participated in a Cooperative Experiment, West Coast, Oceanography and Meteorology, 1978 (CEWCOM-78) in cooperation with the measurement program OSP-III run by the USN Optical Signatures Program on San Nicolas Island. Optical transmittance measurements from the R/V ACANIA to shore and micrometeorological measurements on the R/V ACANIA were made by NPS measurement group, and other meteorological data were monitored in the OSP experiment. Weather conditions limited the data obtained.

The measured transmittance of the optical path from the R/V ACANIA to site A on the northwest tip of San Nicolas

TABLE VI

San Nicolas Data, CEWCOM-78

Date	Time	Range(m)	Broadband(μm) 3.6-4.0	9.0-12.0
5/15	1126		63.0 %(94.99)	
"	1458	2192		45.2 %(96.14)
"	1633	2200	57.8 %(95,31)	
"	1649	2200		49.8 %(96.63)

Island is listed in Table VI. The transmittances are the observed values, uncorrected for the molecular absorption, measured with filter selection from a grey-body source.

The micrometeorological data taken by the NPS Meteorology Team during the CEWCOM-78 experiment [Ref. 16] and the Daily Statistical Summary of Meteorological Data [Ref. 17] are used to find interpolated temperature, relative humidity, and visibility. The numbers in parentheses represent LOWTRAN predictions of transmittance, including both molecules and aerosol extinction based on these meteorological input data.

The comparison is given for the one day for which suffi-

TABLE VII

Meteorological Data

Time	Broadband (μm)	Press. (mbar)	Temp. (deg.)	Dew T. (deg.)	R.H. (%)	Water vapor (g/m3)
1126	3.6-4.0	1013.2	14.52	10.0	81.0	9.8
1633	"	"	14.99	10.9	66.7	"
1458	9.0-12.0	"	14.80	10.9	74.67	9.7
1649	"	"	14.93	10.0	65.69	9.5

cient meteorological data are available (Table VII). This comparison shows the LOWTRAN predicted transmittance for these conditions to be much higher than the measurements. The overestimation of transmittance by LOWTRAN suggests that the particle model included in the code may be inadequate, or that the model's total particle number density may be underestimated by the code. Calibration errors in the measurement equipment have been investigated and are considered an unlikely source of the discrepancy.

C. EXPERIMENTAL MEASUREMENT FROM MARINA TO POINT PINOS

The current modelling effort was undertaken in support of an experimental progam of transmittance measurement of total extinction on ranges over Monterey Bay from Marina to Point Pinos (June 1979) using laser and broadband (thermal) sources. The optical extinction was measured at 0.4880, 0.6328, 1.03, 1.06, and 11.05 μm.

The calculational program has therefore been directed to computation of molecular absorption and aerosol extinction coefficients for sea level propagation under a range of weather conditions statistically typical of Monterey. This has been done for a variety of wavelengths appropriate to the measurements, and averaged over the filter bandwidths for the broadband sources used (see Table III.).

The aerosol particle spectrum was measured on board the ACANIA with a Knollenberg counter. This information was used to predict a scattering extinction coefficient, based on one point measurement of the particle size spectrum.

For comparison of data it is necessary to subtract the effects of molecular absorption from the total optical

TABLE VIII

Extinction Coefficient from Optical Measurement and LOWTRAN

date	time	(μm)	optical (a)	LOWTRAN total (b)	LOWTRAN molecular (c)	diff. (a-c)	aerosol (d)
6/6	1734	1.60	22.5	2.47	0.072	22.4	31.6
	1714	1.06	21.7	2.68	0.165	21.5	32.4
	1718	1.03	19.4	2.69	2.63	16.8	32.8
	1720	0.84	22.1	2.75	0.196	21.9	32.8
	1721	0.63	22.5	2.83	0.066	22.4	32.8
6/7	1406	11.02	19.17	1.84	1.52	17.7	7.62
	1404	10.6	12.1	2.01	1.49	10.6	7.72
	1423	1.06	35.5	2.45	0.16	35.3	48.7
	1434	1.03	43.9	4.87	2.56	41.3	49.5
	1555	11.02	20.0	1.73	1.25	18.8	7.83
	1558	10.6	10.6	1.77	1.26	9.34	7.71
	1615	1.6	35.3	2.17	0.07	35.2	49.2
	1628	1.06	38.3	2.43	0.15	38.2	50.5
	1632	1.03	35.0	4.69	2.4	32.6	51.4
	1634	0.84	40.1	2.52	0.18	39.9	51.0
	1636	0.63	43.2	2.45	0.067	43.13	53.0

extinction. This is done using LOWTRAN. The value of relative humidity and water vapor content have been obtained from Prof. Schacher and Dr. Fairall who made the aerosol measurements [Ref. 18].

The results are presented in Table VIII. The extinction in units of E-02 km-1 as measured optically, the LOWTRAN prediction of total extinction, the molecular contribution computed by LOWTRAN, total measured minus LOWTRAN molecular, and the values calculated from aerosol spectra are shown.

By the comparison seen by the Table VIII, optical extinction computed from the aerosol spectra is much higher than the LOWTRAN total extinction, and is very often higher than the measured optical extinction. This may be due to the fact that aerosol extinction was not measured over the whole path but at only one point. It was measured on board the ACANIA meteorological mast at a height of approximately 10 m above mean sea level, at approximately the centerpoint of the optical path. The optical path in this experiment ranged from 18.3 m above sea level at Marina to almost sea level at the ACANIA, due to earth curvature over the 13.16 km path.

Total aerosol extinction from LOWTRAN is much less than the extinction calculated from the measured aerosol spectrum. Subtracting the calculated molecular component of the LOWTRAN from the optically measured extinction yields the aerosol extinction ("diff."), which is much greater than the LOWTRAN aerosol component but somewhat less than that predicted from the aerosol spectra. i.e., agreement of aerosol extinction is much better with aerosol spectrum measurement than with the LOWTRAN aerosol extinction. It appears probable that the LOWTRAN model consistently underestimates the severity of aerosol extinction in the marine environment.

VI. CONCLUSION AND RECOMMENDATION

The comparisons of LOWTRAN IIIB predictions with optical measurements and with computations from particle size distribution measurements show considerable differences. The differences could conceivably arise from measurement errors in the optical transmittance and the particle measurements; the two physical measurements give results reasonably close to each other but in both cases differ markedly from LOWTRAN IIIB. In view of the consideration give to both measurement techniques it seems most likely that LOWTRAN IIIB consistently underestimates the aerosol attenuation in the infrared wavebands

It must first be realized that LOWTRAN IIIB contains limitations. It does not include the effects of

1. clouds, fog or precipitation
2. refraction, scintillation or distortion of the propagating beam due to turbulence
3. background interference from direct or scattered solar radiation
4. surface level reflections and masking
5. multiple scattering

In addition the models of refraction and earth curvature are simplified and the atmosphere is considered to be horizontally homogeneous and stable with no inversion. These limitations mean that at best LOWTRAN IIIB results are of "moderate" accuracy.

Some of these limitations have been removed in the continuing evolution of LOWTRAN. LOWTRAN IV (Feb. 1978) in addition to using improved empirical transmittance functions for gases of small absorber amount, includes the effects of nitric acid as an absorber and emitter, and incorporates a "radiance mode" to compute the radiance from the earth surface and the atmosphere.

LOWTRAN V (Feb, 1980) has been upgraded to include new aerosol models dependent on altitude and relative humidity, and a model for fog attenuation.

It may be expected that implementation of these codes (preferbly LOWTRAN V) may give better agreement between experiment and compution and allow better validation of aerosol extinction calculation methods.

LOWTRAN IV and LOWTRAN V are not currently available at NPS in card or tape form, and considerable modification will be required to adapt them to use on the IBM 3033 system. In the absence of later forms of LOWTRAN, the IIIB version may still be used to compare transmittances under different conditions. In addition, little change has been made in the absorption in later versions, so that the use of IIIB to compute the atmospheric absorption is valid. This allows its use to compute aerosol extinction from total optical extinction by subtraction of the calculated absorpton.

It is recommended that an effort should be made to adapt LOWTRAN V for the NPS IBM computer system.

APPENDIX A

LOWTRAN IIIB PROGRAM

```
C***********************************************************************
C*            NAVAL PCSTGRADUATE SCHOOL MODIFICATION                   *LL
C*                   OF AFGL LOWTRAN 3B                                *LL
C*               (1 OCTOBER 1976 VERSION)                              *LL
C*                                                                     *LL
C*                  MAJ. MOON-SIK SHIN                                 *LL
C*                   AIR FORCE KOREA                                   *LL
C*                                                                     *LL
C***********************************************************************LL
C*                                                                     *LL
C*    PRCGRAM LOWTRAN 3B CALCULATES THE TRANSMITTANCE OF THE ATMOS-    *LL
C*    PHERE FROM 350 CM-1 TO 40000 CM-1 (0.25 TO 28.57 MICRONS) AT     *LL
C*    20 CM-1 SPECTRAL RESOIUTION ON A LINEAR WAVENUMBER SCALE.        *LL
C*    REFRACTION AND EARTH-S CURVATURE EFFECTS ARE INCLUDED.           *LL
C*    THE ATMOSPHERE IS LAYERED IN ONE KILOMETER INTERVALS BETWEEN     *LL
C*    GRCUND LEVEL AND 25 KM., 5 KM. INTERVALS TO 50 KM., A TWENTY     *LL
C*    KM. INTERVAL TC 70 KM., AND A THIRTY KM. INTERVAL TO 100 KM.     *LL
C*                                                                     *LL
C***********************************************************************LL
C*                                                                     *LL
C*    PRCGRAM ACTIVATED BY SUBMISSION OF FOUR CARD SEQUENCE'           *LL
C*                                                                     *LL
C**** CARD 1' MODEL,IAERO,IHAZE,JP,IM,M1,M2,M3,ML,RO,VIS               *LL
C*                                   ------FORMAT(9I3,3X,2F10.3) *****LL
C*                                                                     *LL
C*    MODEL SELECTS CNE OF THE FOLLOWING MODEL ATMOSPHERE'             *LL
C*       MODEL = 0 FCR HORIZ. PATH WHEN METEOROL. DATA USED'           *LL
C*          INSTEAD OF CARD 2, READ H1,P(MB),T(DEG C),DEW PT.TEMP      *LL
C*          (DEG C), REL. HUMIDITY(%),H2O DENSITY(GM.M-3),O3 DENSITY   *LL
C*          (GM.M-3), RANGE(KM)                                        *LL
C*          ----------- FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3).         *LL
C*       MODEL = 1 SPECIFIES A TROPICAL ATMOSPHERE.                    *LL
C*       MODEL = 2 SPECIFIES A MIDLATITUDE SUMMER ATMOSPHERE.          *LL
C*       MODEL = 3 SPECIFIES A MIDLATITUDE WINTER ATMOSPHERE.          *LL
C*       MODEL = 4 SPECIFIES A SUB-ARCTIC SUMMER ATMOSPHERE.           *LL
C*       MODEL = 5 SPECIFIES A SUB-ARCTIC WINTER ATMOSPHERE.           *LL
C*       MODEL = 6 SPECIFIES A 1962 US STANDARD ATMOSPHERE.            *LL
C*       MODEL = 7 FOR NEW MODEL ATMOSPHERE (E.G., RADIOSCNDE DATA)'   *LL
C*          READ BETWEEN CARDS 1 AND 2, ALTITUDE(KM),P(MB),T(DEG C),   *LL
C*          DEW PT.TEMP(DEG C),REL. HUMIDITY (%),H2O DENSITY(GM.M-3),  *LL
C*          O3 DENSITY(GM.M-3), AEROSOL NO. DENSITY(CM-3)              *LL
C*          ------------- FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3)        *LL
C*          NOTE EITHER DEW PT.TEMP, REL. HUM., OR H2O DENSITY         *LL
C*          CAN BE USED.                                               *LL
C*                                                                     *LL
C*    IAERO SELECTS THE TYPE OF AEROSOL ATTENUATION'                   *LL
C*       IAERO = 1 SPECIFIES AN AVERAGE CONTINENTAL AEROSOL MODEL.     *LL
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C*          IAERO = 2 SPECIFIES A RURAL AEROSOL MODEL.                     *LL 00470
C*          IAERO = 3 SPECIFIES AN URBAN AEROSOL MODEL.                    *LL 00480
C*          IAERO = 4 SPECIFIES A MARITIME AEROSOL MODEL.                  *LL 00490
C*                                                                         *LL 00500
C*       IHAZE SELECTS THE DEGREE OF AEROSOL ATTENUATION'                  *LL 00510
C*          IF IHAZE=0 NC AEROSOL SCATTERING IS COMPUTED.                  *LL 00520
C*          IF IHAZE = 1 AND VIS IS NON-ZERO, THEN AEROSOL ATTENUATION     *LL 00530
C*             FOR THE VISIBLE RANGE IS USED.                              *LL 00540
C*          IF IHAZE = 1 OR 2 AND VIS IS ZERO, THEN AEROSOL ATTENUATION    *LL 00550
C*             FOR 23 KM AND 5 KM VISIBLE RANGES, RESPECTIVELY,            *LL 00560
C*             IS USED.                                                    *LL 00570
C*                                                                         *LL 00580
C*       JP SELECTS THE PRINT OPTION'                                      *LL 00590
C*          JP = 0 FOR NORMAL OPERATION.                                   *LL 00600
C*          JP = 1 TO SUPPRESS THE PRINTING OF THE TRANSMITTANCE TABLE.    *LL 00610
C*                                                                         *LL 00620
C*       IM DETERMINES WHEN RADIOSONDE DATA IS TO BE READ IN'              *LL 00630
C*          IM = 0 FOR NORMAL OPERATION.                                   *LL 00640
C*          IM = 1 FOR INITIALIZING RADIOSONDE OR METEOROLOGICAL           *LL 00650
C*             DATA.                                                       *LL 00660
C*                                                                         *LL 00670
C*       M1, M2, AND M3 ARE USED TO CHANGE TEMP, H2O, AND O3 ALTITUDE      *LL 00680
C*          PROFILES, RESPECTIVELY, TO ANOTHER MODEL VALUE.                *LL 00690
C*                                                                         *LL 00700
C*       ML IS THE NUMBER OF LEVELS OF RADIOSONDE DATA FOR MODEL = 7.      *LL 00710
C*                                                                         *LL 00720
C*       RO IS THE INPUT VALUE FOR THE RADIUS OF THE EARTH.  IF RO IS      *LL 00730
C*          ZERO THEN THE PROGRAM USES STORED VALUES.                      *LL 00740
C*                                                                         *LL 00750
C*       VIS IS THE VISUAL RANGE AT SEA LEVEL (KM)                         *LL 00760
C*                                                                         *LL 00770
C**** CARD 2' ITYPE,LEN,H1,H2,ANGLE,RANGE,BETA---FORMAT(2I3,4X,5F10.3) **LL 00780
C*                                                                         *LL 00790
C*       ITYPE INDICATES THE TYPE OF ATMOSPHERIC PATH'                     *LL 00800
C*          ITYPE = 1, CORRESPONDS TO A HORIZONTAL (CONSTANT PRESSURE)     *LL 00810
C*             PATH.  READ H1 AND RANGE.                                   *LL 00820
C*          ITYPE = 2, VERTICAL OR SLANT PATH BETWEEN TWO ALTITUDES.       *LL 00830
C*             READ H1 AND TWO OTHER GEOMETRIC PARAMETERS (E.G., H2 AND    *LL 00840
C*             ANGLE).                                                     *LL 00850
C*          ITYPE = 3, VERTICAL OR SLANT PATH TO SPACE.                    *LL 00860
C*             READ H1 AND ANGLE.                                          *LL 00870
C*                                                                         *LL 00880
C*       LEN SELECTS THE TYPE OF RAY PATH TO BE USED'                      *LL 00890
C*          LEN = 0 FOR NORMAL OPERATION OF THE PROGRAM WHICH SELECTS      *LL 00900
C*             THE SHORTER PATH WHEN APPLICABLE.                           *LL 00910
C*          LEN = 1 TO SELECT THE LONGER PATH WHEN APPLICABLE.             *LL 00920
C*                                                                         *LL 00930
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C*     H1       =    OBSERVER ALTITUDE (KM)                                *LL 00940
C*     H2       =    SOURCE  ALTITUDE (KM)                                 *LL 00950
C*     ANGLE    =    ZENITH ANGLE AT H1 (DEGREES)                          *LL 00960
C*     RANGE    =    PATH LENGTH (KM)                                      *LL 00970
C*     BETA     =    EARTH CENTRE ANGLE (DEGREES)                          *LL 00980
C*                                                                         *LL 00990
C**** CARD 3' V1,V2,DV-------------------------------FORMAT(3F10.3)********LL 01000
C*                                                                         *LL 01010
C*     V1 = INITIAL FREQUENCY (WAVENUMBER CM-1) INTEGER VALUE              *LL 01020
C*     V2 = FINAL FREQUENCY(WAVENUMBER CM-1) INTEGER VALUE                 *LL 01030
C*     DV = FREQUENCY INTERVALS AT WHICH TRANSMITTANCE IS PRINTED          *LL 01040
C*        NOTE' DV MUST BE A MULTIPLE OF 5 CM-1                            *LL 01050
C*                                                                         *LL 01060
C**** CARD 4' IXY-----------------------------------FORMAT(I3)************LL 01070
C*                                                                         *LL 01080
C*     IXY IS THE CYCLING INDICATOR'                                       *LL 01090
C*        IXY = 0 TO END DATA                                              *LL 01100
C*        IXY = 1 FOR NEW CARD 3 ONLY                                      *LL 01110
C*        IXY = 2 TO CCNTINUE DATA                                         *LL 01120
C*        IXY = 3 FOR NEW CARD 2 ONLY                                      *LL 01130
C*        IXY = 4 FOR NEW CARD 1 ONLY (PLUS RADIOSONDE OR                  *LL 01140
C*           METEOROLCGICAL DATA, IF DESIRED)                              *LL 01150
C*                                                                         *LL 01160
C*************************************************************************LL 01170
C                                                                           LL 01180
C                                                                           LL 01190
C   DATA SETSC3/C4/C5/C7/C7A/C207-09/ ARE READ IN AT BEGINNING              LL 01200
C     CF FRORRAM TO CCMMON STORAGE DUE TO COMPILER STORAGE LIMITATIONS      LL 01210
C     WITH NFS COMPUTER.                                                    LL 01220
C                                                                           LL 01230
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),       LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),      LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),         LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),      LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),         LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),          LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),          LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),        LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),             LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),                LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)                   LL 01390
      DIMENSION          TX(10),VH(10),E(10),AHZ1(34),AHZ2(34),W(10),       LL 01400
     *                   P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45),        LL 01410
     *                   C7(4,45),C7A(4,45),C1(2580),C2(1575)
C                                                                           LL 01420
      LOGICAL            CKZERO                                             LL 01430
      CKZERO(X)=ABS(X).LT.1.E-20                                            LL 01440
```

```
C
C       INPUT SPECTRAL DATA  FOR OZONE
C
        DO 6 J=1,540,10
        K=J+9
     50 FORMAT(8X,10(1X,F5.2))
      6 READ(5,50)  (C3(I),I=J,K)
C
CC      WRITE(6,69)
     69 FORMAT(8X,/,1X,'SPECTRAL DATA OZONE',/)
CC      WRITE(6,51)
     51 FORMAT(7X,/,1X,'C301 DATA ',/)
CC      WRITE(6,50)  (C3(I),I=1,190)
C
CC      WRITE(6,52)
     52 FORMAT(7X,/,1X,'C302 DATA ',/)
CC      WRITE(6,50)  (C3(I),I=191,380)
C
CC      WRITE(6,53)
     53 FORMAT(7X,/,1X,'C303 DATA ',/)
CC      WRITE(6,50)  (C3(I),I=381,540)
C
C   **** INPUT SPECTRAL DATA FOR N2 CONTINUIUM
          READ(5,72)  (C4(I),I=1,5)
     72 FORMAT(8X,5(1X,1PE8.2))
C
        L=0
        DO 7 J=1,18
        L=L+6
        M=L+6
        READ(5,55)  (C4(I),I=L,M)
     55 FORMAT(8X,7(1X,E8.2))
        L=L+1
      7 CONTINUE
C
        READ(5,73)  (C4(I),I=132,133)
     73 FORMAT(8X,2(1X,1PE8.2))
C
CC      WRITE(6,54)
     54 FORMAT(7X,/,1X,'C4 SPECTRAL DATA- N2 CONTINUIUM',/)
CC      WRITE(6,72)  (C4(I),I=1,5)
CC      WRITE(6,14)  (C4(I),I=6,131)
     14 FORMAT(1X,7(1X,1PE8.2))
CC      WRITE(6,73)  (C4(I),I=132,133)
C
C
C *** SPECTRAL DATA'  H2O CONTINUUM (4 MICRON REGION DATA)
```

```
C                                                                       LL 01970
C       NOTE - IN LOWTRAN 3, THE H2O CONTINUUM DATA WAS FOR THE         LL 01980
C            10 MICRON REGION.  IN LOWTRAN 3B, THIS DATA IS REPLACED    LL 01990
C            BY AN EMPIRICAL EQUATION.                                  LL 02000
C                                                                       LL 02010
C                                                                       LL 02020
      READ(5,56)  (C5(I),I=1,15)                                        LL 02030
   56 FORMAT(1X,F5.3)                                                   LL 02040
CC    WRITE(6,57)                                                       LL 02050
   57 FORMAT(7X,/,1X,'SPECTRAL DATA H2O CONTINUM (4 MICRON REGION',/)   LL 02060
CC    WRITE(6,56)  (C5(I),I=1,15)                                       LL 02070
C                                                                       LL 02090
C     INPUT AVERAGE CONTINENTAL AEROSOL MODEL.  DATA IS INPUTED 4 GROUPS LL 02100
C        OF 45 EACH TO ALLOW  IDENTIFICATION OF SPECIFIC BLOCKS OF DATA. LL 02110
C                                                                       LL 02120
C     CONTINENTAL AEROSCL MODEL                                         LL 02130
C                                                                       LL 02140
      DO 58 J=1,42,7                                                    LL 02150
      K=J+6                                                             LL 02160
   59 FORMAT(8X,7(1X,F7.5))                                             LL 02170
      READ(5,59)  (C701(I), I=J,K)                                      LL 02180
   58 CONTINUE                                                          LL 02190
      READ(5,62)  (C701(I),I=43,45)                                     LL 02200
   62 FORMAT(8X,3(1X,F7.5))                                             LL 02210
C                                                                       LL 02220
CC    WRITE(6,60)                                                       LL 02230
   60 FORMAT(8X,//,1X,'SPECTRAL DATA AEROSOL EXTINCTION                 LL 02240
     *   AVG CONTINENTAL AEROSOL MODEL',/)                              LL 02250
CC    WRITE(6,61)  (C701(J),J=1,45)                                     LL 02260
   61 FORMAT(1X,7(1X,F7.5))                                             LL 02270
C                                                                       LL 02280
C     INPUT RURAL AEROSCL MODEL                                         LL 02290
C                                                                       LL 02300
      DO 63 J=1,42,7                                                    LL 02310
      K=J+6                                                             LL 02320
   63 READ(5,59)  (C702(I),I=J,K)                                       LL 02330
      READ(5,62)  (C702(I),I=43,45)                                     LL 02340
C                                                                       LL 02350
CC    WRITE(6,64)                                                       LL 02360
   64 FORMAT(8X,/,1X,'RURAL AEROSOL MODEL',/)                           LL 02370
CC    WRITE(6,61)  (C702(J),J=1,45)                                     LL 02380
C                                                                       LL 02390
C *** URBAN AEROSOL MODEL                                               LL 02400
C                                                                       LL 02410
      DO 65 J=1,42,7                                                    LL 02420
      K=J+6                                                             LL 02430
   65 READ(5,59)  (C703(I),I=J,K)                                       LL 02440
```

```
      READ(5,62)  (C703(I),I=43,45)                                     LL 02450
C                                                                       LL 02460
CC    WRITE(6,66)                                                       LL 02470
   66 FORMAT(8X,/,1X,'URBAN  AEROSOL MODEL',/)                          LL 02480
CC    WRITE(6,61)  (C703(I),I=1,45)                                     LL 02490
C                                                                       LL 02500
C *** MARITIME AEROSCI MODEL                                             LL 02510
C                                                                       LL 02520
      DO 67 J=1,42,7                                                    LL 02530
      K=J+6                                                             LL 02540
   67 READ(5,59)  (C704(I),I=J,K)                                       LL 02550
      READ(5,62)  (C704(I),I=43,45)                                     LL 02560
C                                                                       LL 02570
CC    WRITE(6,68)                                                       LL 02580
   68 FORMAT(8X,/,1X,'MARITIME AEROSOL MODEL',/)                        LL 02590
CC    WRITE(6,61)  (C704(I), I=1,45)                                    LL 02600
C                                                                       LL 02630
C *** SPECTRAL DATA'  AEROSOL ABSORPTION                                LL 02640
C                                                                       LL 02650
C *** AVERAGE CONTINENTAL AEROSOL MODEL                                 LL 02660
C                                                                       LL 02680
      DO 16 J=1,42,7                                                    LL 02690
      K=J+6                                                             LL 02700
   16 READ(5,59)  (C7A01(I),I=J,K)                                      LL 02710
      READ(5,62)  (C7A01(I),I=43,45)                                    LL 02720
CC    WRITE(6,17)                                                       LL 02730
   17 FORMAT(8X,/,1X,'SPECTRAL DATA AEROSOL ABSORBTION  *** AVERAGE     LL 02740
     *CONTINENTAL AERCSOL MCDEL',/)                                     LL 02750
CC    WRITE(6,61)  (C7A01(I),I=1,45)                                    LL 02760
C                                                                       LL 02770
C *** RURAL AEROSOL MODEL                                               LL 02780
C                                                                       LL 02790
      DO 70 J=1,42,7                                                    LL 02800
      K=J+6                                                             LL 02810
   70 READ(5,59)  (C7A02(I),I=J,K)                                      LL 02820
      READ(5,62)  (C7A02(I),I=43,45)                                    LL 02830
CC    WRITE(6,71)                                                       LL 02840
   71 FORMAT(8X,/,1X,'RURAL AEROSOL MODEL',/)                           LL 02850
CC    WRITE(6,61)  (C7A02(I),I=1,45)                                    LL 02860
C                                                                       LL 02870
C *** URBAN AEROSOL MCDEL                                               LL 02880
C                                                                       LL 02890
      DO 74 J=1,42,7                                                    LL 02900
      K=J+6                                                             LL 02910
   74 READ(5,59)  (C7A03(I),I=J,K)                                      LL 02920
      READ(5,62)  (C7A03(I),I=43,45)                                    LL 02930
CC    WRITE(6,75)                                                       LL 02940
```

```
   75 FORMAT(8X,/,1X,'URBAN AEROSOL MODEL ',/)                       LL 02950
CC    WRITE(6,61) (C7A03(I),I=1,45)                                   LL 02960
C                                                                     LL 02970
C *** MARITIME AEROSOL MODEL                                           LL 02980
C                                                                     LL 02990
      DO 76 J=1,42,7                                                  LL 03000
      K=J+6                                                           LL 03010
   76 READ(5,59) (C7A04(I),I=J,K)                                     LL 03020
      READ(5,62) (C7A04(I),I=43,45)                                   LL 03030
CC    WRITE(6,77)                                                     LL 03040
   77 FORMAT(8X,/,1X,'MARATIME AEROSOL MODEL',/)                      LL 03050
CC    WRITE(6,61) (C7A04(I),I=1,45)                                   LL 03060
C                                                                     LL 03070
C *** SPECTRAL DATA'  OZONE - UV AND VISIBLE                          LL 03100
C                                                                     LL 03110
      READ(5,72) (C8(I),I=1,5)                                        LL 03120
      L=0                                                             LL 03130
      DO 78 J=1,13                                                    LL 03140
      L=L+6                                                           LL 03150
      M=L+6                                                           LL 03160
      READ(5,55) (C8(I),I=L,M)                                        LL 03170
      L=L+1                                                           LL 03180
   78 CONTINUE                                                        LL 03190
      READ(5,79) (C8(I),I=97,102)                                     LL 03200
   79 FORMAT(8X,6(1X,E8.2))                                           LL 03210
C                                                                     LL 03220
CC    WRITE(6,80)                                                     LL 03230
   80 FORMAT(8X,/,1X,'SPECTRAL DATA-- OZONE - UV AND VISIBLE',/)      LL 03240
CC    WRITE(6,72) (C8(I),I=1,5)                                       LL 03250
CC    WRITE(6,14) (C8(I),I=6,102)                                     LL 03260
C                                                                     LL 03280
C *** INPUT PARTIAL AMT OF C2 DATA                                    LL 03290
C                                                                     LL 03310
      DO 83 J=951,1570,10                                             LL 03320
      K=J+9                                                           LL 03330
   83 READ(5,50) (C2(I),I=J,K)                                        LL 03340
      READ(5,50) (C2(I),I=1571,1575)                                  LL 03350
C                                                                     LL 03360
CC    WRITE(6,84)                                                     LL 03370
   84 FORMAT(8X,/,1X,'SPECTRAL DATA*** UNIFORMLY MIXED GASES C206 DATA',LL 03380
     */)                                                              LL 03390
CC    WRITE(6,50) (C2(I),I=951,1140)                                  LL 03400
C                                                                     LL 03410
CC    WRITE(6,85)                                                     LL 03420
   85 FORMAT(8X,/,1X,'C207 DATA',/)                                   LL 03430
CC    WRITE(6,50) (C2(I),I=1141,1330)                                 LL 03440
CC    WRITE(6,81)                                                     LL 03450
```

```
   81 FORMAT(8X,/,1X,'C208 DATA',/)                                    LL 03460
CC    WRITE(6,50) (C2(I),I=1331,1520)                                  LL 03470
C                                                                      LL 03480
CC    WRITE(6,82)                                                      LL 03490
   82 FORMAT(8X,/,1X,'C209 DATA',/)                                    LL 03500
CC    WRITE(6,50) (C2(I),I=1521,1575)                                  LL 03510
C                                                                      LL 03520
C  BEGIN MAIN CODE                                                     LL 03550
C***********************************************************************LL 03650
      CALL ARRAY (P,T,WH,WO,VX,C1,C2,C7,C7A)                           LL 01470
      IXY=2                                                            LL 03670
      IP=1                                                             LL 03680
      NL1=NL-1                                                         LL 03690
      DO 208 ITER=1,10000                                              LL 03700
         IF (IXY.LE.0.OR.IXY.GE.5) GO TO 209                           LL 03710
         IF (IXY.EQ.1) GO TO 107                                       LL 03720
         IF (IXY.EQ.3) GO TO 105                                       LL 03730
C                                                                      LL 03740
         READ(5,400) MODEL,IAERO,IHAZE,JP,IM,M1,M2,M3,ML,RO,VIS         LL 03750
         IF (MODEL.EQ.1) WRITE(6,410)                                  LL 03760
         IF (MODEL.EQ.2) WRITE(6,411)                                  LL 03770
         IF (MODEL.EQ.3) WRITE(6,412)                                  LL 03780
         IF (MODEL.EQ.4) WRITE(6,413)                                  LL 03790
         IF (MODEL.EQ.5) WRITE(6,414)                                  LL 03800
         IF (MODEL.EQ.6) WRITE(6,415)                                  LL 03810
         IF (M1.NE.0) WRITE(6,444) M1                                  LL 03820
         IF (M2.NE.0) WRITE(6,445) M2                                  LL 03830
         IF (M3.NE.0) WRITE(6,446) M3                                  LL 03840
         IF (IAERO.EQ.1) WRITE(6,447)                                  LL 03850
         IF (IAERO.EQ.2) WRITE(6,448)                                  LL 03860
         IF (IAERO.EQ.3) WRITE(6,449)                                  LL 03870
         IF (IAERO.EQ.4) WRITE(6,450)                                  LL 03880
         IF (IHAZE.EQ.0) WRITE(6,426)                                  LL 03890
         IF (IHAZE.EQ.1.AND.CKZERO(VIS)) VIS=23.                       LL 03900
         IF (IHAZE.EQ.2.AND.CKZERO(VIS)) VIS=5.                        LL 03910
         IF (.NOT.CKZERO(VIS)) WRITE(6,417) VIS                        LL 03920
         IF (VIS.GT.0.0.AND.VIS.LT.2.0) WRITE(6,442)                   LL 03930
         IF (MODEL.EQ.0) M=7                                           LL 03940
         IF (MODEL.NE.0) M=MODEL                                       LL 03950
         IF (MODEL.EQ.0) NLP=1                                         LL 03960
         IF (MODEL.NE.0.AND.MODEL.NE.7) NLP=NL                         LL 03970
         IF (MODEL.EQ.7) NLP=MAX0(ML,1)                                LL 03980
            IF (ML.GT.NL) WRITE(6,451) ML,NL                           LL 03990
            IF (ML.GT.NL) STOP                                         LL 04000
C                                                                      LL 04010
         DO 101 I = 1,NL                                               LL 04020
            IF (M.NE.7) AHZ1(I)=HZ1(I)                                 LL 04030
```

```
            IF  (M.NE.7)  AHZ2(I)=HZ2(I)
            IF  (M.NE.7)  Z(I)=Z0(I)
  101       CONTINUE
         IF  (     CKZERO(RO))  RE=REARTH(M)
         IF  (.NOT.CKZERO(RO))  RE=RO
         IF  (M.NE.7.OR.IM.EQ.0)  GO TO 104
C
C**** READ IN RADIOSCNDE (MODEL = 7) OR METEOROLOGICAL (MODEL = 0) DATA
C
  100    CONTINUE
          DC 103 K = 1,NLP
            IF  (MODEL.EQ.0)  READ(5,429)  Z(K),P(7,K),TMP,DP,RH,WH(7,K),
     *        WO(7,K),RANGE
            IF  (MODEL.EQ.7)  READ(5,429)  Z(K),P(7,K),TMP,DP,RH,WH(7,K),
     *        WO(7,K),AHZ1(K)
            IF  (MODEL.EQ.0)  AHZ1(K)=0.0
            IF  (MODEL.EQ.0)  H1=Z(K)
            DO  102 I = 1,NL1
  102         IF  (Z(K).GE.Z0(I))  J=I
            FAC=(Z(K)-Z0(J))/(Z0(J+1)-Z0(J))
            T(7,K)=TMP+273.15
            IF  (M1.NE.0)  T(7,K)=T(M1,J)*(T(M1,J+1)/T(M1,J))**FAC
            IF  (.NOT.CKZERO(RH))  TT=273.15/T(7,K)
            IF  (.NOT.CKZERO(DP))  TT=273.15/(273.15+DP)
            IF  (CKZERO(WH(7,K)))  WH(7,K)=EXP(18.9766-14.9595*TT-2.43882
     *        *TT**2)*TT
            IF  (.NOT.CKZERO(RH))  WH(7,K)=0.01*RH*WH(7,K)
            IF  (M2.NE.0)  WH(7,K)=WH(M2,J)*(WH(M2,J+1)/WH(M2,J))**FAC
            IF  (M3.NE.0)  WO(7,K)=WO(M3,J)*(WO(M3,J+1)/WO(M3,J))**FAC
            IF  (CKZERO(AHZ1(K)))  AHZ2(K)=HZ2(J)*(HZ2(J+1)/HZ2(J))**FAC
            IF  (.NOT.CKZERO(AHZ1(K)))  AHZ2(K)=AHZ1(K)
            IF  (CKZERO(AHZ1(K)))  AHZ1(K)=HZ1(J)*(HZ1(J+1)/HZ1(J))**FAC
            IF  (MODEL.EQ.0)  WRITE(6,430)  Z(K),P(7,K),TMP,DP,RH,WH(7,K),
     *        WO(7,K),RANGE
            IF  (MODEL.EQ.7)  WRITE(6,429)  Z(K),P(7,K),TMP,DP,RH,WH(7,K),
     *        WO(7,K),AHZ1(K)
  103       CONTINUE
C
  104    CONTINUE
         IF  (M1.EQ.0)  M1=M
         IF  (M2.EQ.0)  M2=M
         IF  (M3.EQ.0)  M3=M
         IF  (MODEL.EQ.0)  ITYPE=1
         IF  (MODEL.EQ.0)  GO TO 107
         IF  (IXY.EQ.4)  GO TO 108
C
  105    CONTINUE
```

```
C         IF(MODEL.EQ.0) GO TO 100
          READ(5,406) ITYPE,LEN,H1,H2,ANGLE,RANGE,BETA                   LL 04500
          X1=RE+H1                                                       LL 04510
          IFIND=0                                                        LL 04520
          IF (CKZERO(RANGE).AND.((ITYPE.EQ.2.AND..NOT.CKZERO(BETA))     LL 04530
     *       .OR.(ITYPE.EQ.3.AND.H2.LT.H1.AND.H2.GT.0.0))) IFIND=1     LL 04540
          IF (ITYPE.EQ.1.OR.ITYPE.EQ.3) GO TO 106                        LL 04550
          ITYPE=2                                                        LL 04560
          IF (.NOT.CKZERO(ANGLE).AND..NOT.CKZERO(BETA)) H2=              LL 04570
     *      X1*ABS((SIN(ANGLE*CA)/SIN((ANGLE-BETA)*CA)))-RE              LL 04580
          IF (.NOT.CKZERO(ANGLE).AND..NOT.CKZERO(RANGE)) H2=             LL 04590
     *      X1*SQRT(1.+(RANGE/X1)**2+2.*(RANGE/X1)*COS(ANGLE*CA))-RE     LL 04600
          IF (.NOT.CKZERO(BETA).AND..NOT.CKZERO(RANGE)) H2=              LL 04610
     *      X1*ABS(COS(BETA*CA)+SQRT((RANGE/X1)**2-SIN(BETA*CA)**2))-RE LL 04620
          X2=RE+H2                                                       LL 04630
          IF (.NOT.CKZERO(RANGE)) ANGLE=ARCOS(((X2/X1)*(X2/RANGE)-       LL 04640
     *      (X1/RANGE)-(RANGE/X1))/2.)/CA                                LL 04650
          IF (.NOT.CKZERO(BETA*CA)) ANGLE=ATAN(X2*SIN(BETA*CA)/(X2*     LL 04660
     *      COS(BETA*CA)-X1))/CA                                         LL 04670
          IF (ANGLE.LT.0.0) ANGLE=ANGLE+180.                             LL 04680
          IF (CKZERO(RANGE)) RANGE=X1*ABS(SQRT((X2/X1)**2-SIN(ANGLE*CA) LL 04690
     *      **2)-COS(ANGLE*CA))                                          LL 04700
          IF (CKZERO(BETA)) BETA=ARSIN((RANGE/X2)*SIN(ANGLE*CA))/CA     LL 04710
  106     CONTINUE                                                       LL 04720
          WRITE(6,428) H1,H2,ANGLE,RANGE,BETA                            LL 04730
          IF (ITYPE.EQ.1) WRITE(6,407) H1,RANGE                          LL 04740
          IF (ITYPE.EQ.2) WRITE(6,408) H1,H2,ANGLE                       LL 04750
          IF (ITYPE.EQ.3) WRITE(6,409) H1,ANGLE                          LL 04760
          IF (ITYPE.EQ.3) H2=Z(NLP)                                      LL 04770
C                                                                        LL 04780
  107     CONTINUE                                                       LL 04790
          IF (IXY.EQ.3.OR.IXY.EQ.4) GO TO 108                            LL 04800
          READ(5,405) V1,V2,DV                                           LL 04810
          WL2=10000./V1                                                  LL 04820
          WL1=10000./V2                                                  LL 04830
          IF (IXY.LE.2) WRITE(6,418) V1,V2,DV,WL1,WL2                    LL 04840
          WL=SQRT(WL1*WL2)                                               LL 04850
          CO=77.46 +0.459/WL**2                                          LL 04860
          CW=43.487-0.3473/WL**2                                         LL 04870
          IF (IXY.EQ.1) GO TO 49                                         LL 04880
C                                                                        LL 04890
  108     CONTINUE                                                       LL 04900
          IF (IFIND.EQ.1) CALL ANGL (H1,H2,ANGLE,BETA,LEN,NLP)           LL 04910
          IF (IFIND.EQ.1) GO TO 110                                      LL 04920
          IF (JP.EQ.0) WRITE(6,427)                                      LL 04930
          IF (ITYPE.EQ.1) GO TO 1100                                     LL 04940
          DO 109 K = 1,10                                                LL 04950
```

```
109         VH(K)=0.0
      EETA=0.0
      SR=0.0
C
C**** NOW DEFINE CONSTANT PRESSURE PATH QUANTITIES EH(1-8)
C
      SPHI=SIN(ANGLE*CA)
      R1=(RE+H1)*SPHI
      IF (H1.LE.Z(NLP)) GO TO 110
      X=(RE+Z(NLP))/(RE+H1)
      IF (SPHI.GT.X) HMIN=R1-RE
      IF (SPHI.GT.X) WRITE(6,433) HMIN
      IF (SPHI.GT.X) GO TO 209
      H1=Z(NLP)
      J1=NLP
      SPHI=SPHI/X
      ANGLE=180.-ARSIN(SPHI)/CA
 110  CONTINUE
      R1=(RE+H1)*SPHI
1100  CONTINUE
      DO 112 I = 1,NLP
         PS=P(M,I)/1013.0
         TS=273.15/T(M1,I)
         TS1=(296.0/273.15)*TS
         X=PS*TS
         PT=PS*SQRT(TS)
         D=0.1*WH(M2,I)
         PPW=4.56E-6*T(M1,I)*WH(M2,I)
C
C   ***  THIS DEFINITION OF HAZE WHEN VIS = 0.0 MAY BE IN ERROR.
C
         IF (CKZERO(VIS)) HAZE=0.0
         IF (.NOT.CKZERO(VIS)) HAZE=115.*((AHZ2(I)-AHZ1(I))/VIS+
     *      AHZ1(I)/5.0-AHZ2(I)/23.0)/18.
         EH(1,I)=D*PT**0.9
         EH(2,I)=X*PT**0.75
         EH(3,I)=46.667*WO(M3,I)*PT**0.4
         EH(4,I)=0.8*PT*X
         EH(5,I)=D*(PPW*EXP(6.08*(TS1-1.0))+0.002*(PS-PPW))
         EH(6,I)=X
         EH(7,I)=3.5336E-4*AMAX1(HAZE,0.0)
         EH(8,I)=46.667*WO(M3,I)
         EH(9,I)=0.0
         EH(10,I)=D*(0.12*PS+0.88*PPW)*EXP(4.56*(TS1-1.0))
         REF=CO*P(M,I)/T(M1,I)-4.56E-6*CW*WH(M2,I)*T(M1,I)
         IF (I.EQ.NLP) GO TO 111
         PPW=4.56E-6*T(M1,I+1)*WH(M2,I+1)
```

```
      EH(9,I)=0.5E-6*(REF+CO*P(M,I+1)/T(N1,I+1)-PPW*CW)
      IF (IPIND.EQ.0.CR.JP.EQ.0) WRITE(6,434) I,Z(I),
     *   (EH(K,I),K=1,10),REF
111   CONTINUE
      IF (H1.GE.Z(I)) J1=I
      EH(9,I)=EH(9,I) +1.0
112   CONTINUE
      IF (MODEL.NE.0) CALL POINT (H1,YN1,J1,NP1,E,IP)
      TX1=E(9)
      IF (ITYPE.EQ.1) GO TO 47
C
C**** DOWNWARD TRAJECTORY
C
      IF (ANGLE.LE.90.) GO TO 19
      K2=0
      IF (NP1.EQ.1) J1=J1-1
      J2=J1+1
      JP1=J1+1
      IF ((H2.GT.Z(J1+1) .OR.CKZERO(H2-H1)).OR.(NP1.EQ.1.AND.
     *   H2.GE.Z(J1+1))) GO TO 30
      CALL POINT (H2,YN2,J2,NP2,W,IP)
      TX2=W(9)
      IF (H2.LT.H1) H=H2
      IF (J1.EQ.J2) TX2=TX1+YN2-EH(9,N)
      IF (H2.GT.H1) TX1=TX2
      IF (J1.EQ.J2.AND.H2.LT.H1) YN1=TX2
30    A0=(RE+H1)*SPHI*YN1
      IF (H2.GE.H1) YN2=YN1
      DO 31 I = 1,J1
         IF (I.NE.J1) HMIN=A0/EH(9,I)-RE
         IF (I.EQ.J1) HMIN=A0/YN1-RE
         IF (HMIN.LE.Z(I+1)) GO TO 32
31       CONTINUE
32    X=HMIN
      IF (HMIN.LE.0.00) GO TO 34
C
C    ***  THE USE OF YN BELCW MAY POSSIBLY BE IN ERROR
C          SHOULD BE YN1 OR YN2
C
      CALL POINT (HMIN,YN,JMIN,NP,TX,IP)
      TX3=TX(9)
      IF (J2.EQ.JMIN.OR.J1.EQ.JMIN) TX3=YN2+TX(9)-EH(9,N)
      IF (J1.EQ.JMIN.AND.H2.GE.H1) GO TO 33
      HMIN=A0/TX3-RE
      IF (ABS(X-HMIN).GT.0.0001) GO TO 32
33    IF (J1.EQ.JMIN.AND.H2.GE.H1) YN1=TX3
      IF (J2.EQ.JMIN.AND.J1.NE.J2) YN2=TX3
```

```
      IF (H2.GE.H1) TX2=TX3
      IF (H2.GE.H1) J2=JMIN
      IF (H2.GE.H1.OR.H2.LT.HMIN) H=HMIN
      WRITE(6,436) HMIN
      IF (H2.LT.HMIN) WRITE(6,440) HMIN
      GO TO 35
C
   34 WRITE(6,436) HMIN
      IF (H2.LT.H1) GO TO 35
      IF (ITYPE.EQ.3.OR.H2.GE.H1) WRITE(6,437)
      ITYPE=2
      TX2=EH(9,1)
      JMIN=0
      J2=1
      H2=0.0
      H=0.0
C
C**** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-8)
C
   35 IF (JP.EQ.0) WRITE(6,420)
      DO 135 ITES = 1,10000
         IF (K2.EQ.0) REF=YN1
         IF (K2.EQ.1) REF=YN2
         X1=H1
         J=JP1+1
   38    CONTINUE
         J=J-1
         X2=Z(J)
         IF (J.EQ.J2.AND.K2.EQ.0) X2=H
         IF (J.EQ.JMIN.AND.K2.EQ.1) X2=HMIN
         HM=(RE+X1)*SPHI-RE
         IF (HM.GT.Z(J).AND.HM.GT.X2) X2=HM
         RX=(RE+X1)/(RE+X2)
         DS=X1-X2
         ALP=90.0
         THET=ARSIN(SPHI)/CA
         SALP=RX*SPHI
         IF (ABS(X2-HM).GT.1.E-5) ALP=ARSIN(SALP)/CA
         BET=ALP-THET
         IF (SPHI.GT.1.E-10) DS=(RE+X2)*SIN(BET*CA)/SPHI
         THETA=180.-THET
         BETA=BETA+BET
         PSI=BETA-ALP-ANGLE+180.
         SR=SR+DS
         DO 39 K = 1,10
            AJ=EH(K,J)
            BJ=EH(K,J+1)
```

```
      IF (J.EQ.J1)  BJ=E(K)
      IF (J.EQ.J2.AND.H2.LT.H1.AND.H2.GT.0.0)  AJ=W(K)
      IF (J.EQ.JMIN.AND.H2.GE.H1)  AJ=TX(K)
      IF (J.EQ.JMIN.AND.ABS(H2-HM).LT.1.E-5)  AJ=TX(K)
      IF (K2.NE.0.AND.J.EQ.J2)  BJ=W(K)
      IF (K2.NE.0.AND.J.EQ.JMIN)  AJ=TX(K)
      IF (CKZERO(AJ).OR.CKZERO(BJ))  EV=0.0
      IF (CKZERO(AJ-BJ))  EV=DS*AJ
      IF (.NCT.CKZERO(AJ).AND..NOT.CKZERO(BJ).ANC.
     *   .NOT.CKZERO(AJ-BJ))  EV=DS*(AJ-BJ)/ALOG(AJ/BJ)
      VH(K)=VH(K)+EV
39    CONTINUE
     IF (JP.EQ.0)  WRITE(6,435)  J,X1,(VH(L),L=1,8),PSI,ALP,
     *  BETA,THETA,SR
     IF (J.EQ.J2.AND.H2.GE.H1)  GO TO 45
     IF (J.EQ.JMIN.AND.K2.EQ.1)  GO TO 43
     IF (J.NE.1)  RN=REF/EH(9,J-1)
     IF (J.EQ.J2+1)  RN=REF/TX2
     IF (J.EQ.J2.AND.K2.EQ.0)  RN=REF/YN2
     IF (J.EQ.(JMIN+1).AND.K2.EQ.1)  RN=REF/TX3
     IF (SALP.GE.RN)  RN=1.0
     SPHI=SALF*RN
     REF=EH(9,J)
     IF (J.EQ.J2+1.AND.K2.EQ.0)  REF=TX2
     X1=X2
     IF (J.NE.1.AND.(J.NE.J2.OR.K2.NE.0))  GO TO 38
     IF (HMIN.LE.0.0)  GO TO 47
     IF (LEN.EQ.0)  WRITE(6,438)
     IF (LEN.EC.0)  GO TO 47
     WRITE(6,439)
     K2=1
     IF (ABS(X1-HMIN).LE.0.001)  GO TO 47
     H=HMIN
     JP1=J2+1
     IF (NP2.EQ.1)  JP1=JP1-1
     B=BETA
     PH=180.-ARSIN(SPHI)/CA
     TS=SR
     PS=PSI
     DO 42 K = 1,10
42      E(K)=VH(K)
135  CONTINUE
43  BETA=2.*BETA-B
    PSI=2.*PSI-PS
    SR=2.*SR-TS
C
C****  LCNG PATH  TAKEN
```

```
C
      PHI=PH
      DO 44 K = 1,10
44       VH(K)=2.*VH(K)-E(K)
      GO TO 47
C
45    CONTINUE
      DO 46 K = 1,10
46       VH(K)=2.0*VH(K)
      BETA=2.0*BETA
      SR=2.0*SR
      IF (CKZERO(H2-H1)) GO TO 47
      RN=TX1/YN1
      SPHI=SIN(ANGLE*CA)
      IF (SPHI.LT.RN) SPHI=SPHI/RN
C
C**** UPWARD TRAJECTORY
C
19    IF (ANGLE.GT.90..AND.NP1.GT.0) J1=J1+1
      IF (ITYPE.EQ.3) J2=NLP
      IF (ITYPE.EQ.2) CALL POINT(H2,YN2,J2,NP,TX,IP)
      IF (ITYPE.EQ.2.AND.NP.EQ.1) J2=J2-1
      EH(10,J1)=E(10)
      DO 21 K = 1,8
         IF (ITYPE.EQ.3) EH(K,J1)=E(K)
         IF (ITYPE.EQ.2) EH(K,J2+1)=TX(K)
21       CONTINUE
      IF (ITYPE.EQ.2) EH(10,J2+1)=TX(10)
      IF (J1.EQ.J2) TX1=TX1+YN2-EH(9,J1)
C
C**** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-8)
C
      IF (JP.EQ.0) WRITE(6,420)
      X1=H1
      DO 25 I = J1,J2
         X2=Z(I+1)
         IF (I.EQ.J2) X2=H2
         DZ=X2-X1
         IF (I.EQ.NLP) DZ=Z(I)-Z(I-1)
         RX=(RE+X1)/(RE+X2)
         THETA=ARSIN(SPHI)/CA
         PHI=ARSIN(SPHI*RX)/CA
         BET=THETA-PHI
         SALP=RX*SPHI
         IF (SPHI.GT.1.E-10) DZ=(RE+X2)*SIN(BET*CA)/SPHI
         BETA=BETA+BET
         PSI=BETA+PHI-ANGLE
```

```
      PHI=180.-PHI
      SR=SR+DZ
      IO=MAX0(MIN0(I,NLP-1),1)
      DO 24 K = 1,10
         IF (CKZERO(EH(K,IO)).OR.CKZERO(EH(K,IO+1)).OR.
     *       CKZERO(EH(K,IO)-EH(K,IO+1)))
     *       EV=DZ*AMIN1(EH(K,IO),EH(K,IO+1))
         IF (.NOT.CKZERO(EH(K,IO)).AND..NOT.CKZERO(EH(K,IO+1))
     *       .AND..NOT.CKZERO(EH(K,IO)-EH(K,IO+1)).AND.I.NE.NLP)
     *       EV=DZ*(EH(K,IO)-EH(K,IO+1))/ALOG(EH(K,IO)/
     *       EH(K,IO+1))
         IF (.NOT.CKZERO(EH(K,IO)).AND..NOT.CKZERO(EH(K,IO+1))
     *       .AND..NOT.CKZERO(EH(K,IO)-EH(K,IO+1)).AND.I.EQ.NLP)
     *       EV=DZ*EH(K,IO+1)/ALOG(EH(K,IO)/EH(K,IO+1))
         VH(K)=VH(K)+EV
 24      CONTINUE
      IF (JP.EQ.0) WRITE(6,435) I,X1,(VH(L),L=1,8),PSI,PHI,BETA,
     *   THETA,SR
      IF (I.EQ.NLP) GO TO 25
      IF (I.EQ.J2-1)  EH(9,I+1)=YN2
      IF (I.EQ.J1)  EH(9,I)=TX1
      RN=EH(9,I+1)/EH(9,I)
      SPHI=SPHI*RX/RN
      IF (SALP.GE.RN)  SPHI=SALP
      X1=X2
 25   CONTINUE
 47   CONTINUE
      IF (ITYPE.NE.1) WRITE(6,443) HM
      DO 48 K = 1,10
      IF (ITYPE.EQ.1.AND.MODEL.NE.0)  W(K)=RANGE*E(K)
      IF (ITYPE.EQ.1.AND.MODEL.EQ.0)  W(K)=RANGE*EH(K,1)
      IF (ITYPE.NE.1)  W(K)=VH(K)
 48   CONTINUE
 49   WRITE(6,419)
      WRITE(6,421)  (W(I),I=1,8),W(10)
C
C**** BEGINNING OF TRANSMITTANCE CALCULATIONS
C
      IV1=MAX0(5*IFIX(V1/5.0),350)
      IV2=MIN0(5*IFIX(V2/5.0+0.99),50000)
      DV=AMAX1(DV,5.0)
      IDV=IFIX(DV)
      SUM=0.0
      DO 206  IV = IV1,IV2,IDV
      IF  (IV.GE.  350.AND.IV.LT. 9875)  I=(IV-  350)/5+    1
      IF  (IV.GE. 9875.AND.IV.LT.12800)  I=(IV- 9875)/5+ 1771
      IF  (IV.GE.12800.AND.IV.LT.13400)  I=(IV-12800)/5+ 2491
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      IF (IV.GE.13400.AND.IV.LE.14500) I=(IV-13400)/5+ 2356
      IF (IV.GT.14500.AND.IV.LE.50000) I=(IV-14500)/5+ 2831
      IF (IV.GE.  500.AND.IV.LT. 8060) J=(IV-  500)/5+    1
      IF (IV.GT.12970.AND.IV.LT.13190) J=(IV-12970)/5+ 1520
      K=(IV-575)/5+1
      IF ((IV.GE.  350.AND.IV.LT.12800).OR.
     *    (IV.GE.13400.AND.IV.LE.14500))
     *    WS1=ALOG10(AMAX1(W(1),1.0E-20))+C1(I)
      IF ((IV.LT.  350.OR. IV.GE.12800).AND.
     *    (IV.LT.13400.OR. IV.GT.14500))  WS1=FW(1)-1.0
      IF ((IV.GE.  500.AND.IV.LT. 8060).OR.
     *    (IV.GT.12970.AND.IV.LT.13190))
     *    WS2=ALOG10(AMAX1(W(2),1.0E-20))+C2(J)
      IF ((IV.LT.  500.OR. IV.GE. 8060).AND.
     *    (IV.LE.12970.OR. IV.GE.13190))  WS2=FW(1)-1.0
      IF ( IV.GE.  575.AND.IV.LE. 3270)
     *    WS3=ALOG10(AMAX1(W(3),1.0E-20))+C3(K)
      IF ( IV.LT.575.OR. IV.GT. 3270) WS3=FO(1)-1.0
      NS1=0
      NS2=0
      NS3=0
      DO 202 L = 1,67
         IF (WS1.GE.FW(L))  NS1=L
         IF (WS2.GE.FW(L))  NS2=L
         IF (WS3.GE.FO(L))  NS3=L
 202     CONTINUE
C
C******* WATER VAPOR
C
      IF (NS1.EQ.0) TX(1)=1.0
      IF (NS1.GT.0.AND.NS1.LT.67) TX(1)=TR(NS1+1)+
     *    (TR(NS1)-TR(NS1+1))*(FW(NS1+1)-WS1)/(FW(NS1+1)-FW(NS1))
      IF (NS1.EQ.67)  TX(1)=0.0
C
C******* UNIFORMLY MIXED GASES
C
      IF (NS2.EQ.0) TX(2)=1.0
      IF (NS2.GT.0.AND.NS2.LT.67) TX(2)=TR(NS2+1)+
     *    (TR(NS2)-TR(NS2+1))*(FW(NS2+1)-WS2)/(FW(NS2+1)-FW(NS2))
      IF (NS2.EQ.67)  TX(2)=0.0
C
C******* OZONE
C
      IF (NS3.EQ.0) TX(3)=1.0
      IF (NS3.GT.0.AND.NS3.LT.67) TX(3)=TR(NS3+1)+
     *    (TR(NS3)-TR(NS3+1))*(FO(NS3+1)-WS3)/(FO(NS3+1)-FO(NS3))
      IF (NS3.EQ.67)  TX(3)=0.0
```

```
C                                                                  LL 08250
C******* NITROGEN CONTINUUM                                        LL 08260
         K=(IV- 2080)/5+    1                                      LL 08280
         IF (IV.LT.2080.OR.IV.GE.2740) TX(4)=0.0                   LL 08290
         IF (IV.GE. 2080.AND.IV.LT. 2740) TX(4)=C4(K)*W(4)         LL 08300
C                                                                  LL 08310
C******* WATER VAPOR CONTINUUM                                     LL 08320
         XI=FLOAT(IV-2350)/50.0                                    LL 08340
         NH=IFIX(XI)                                               LL 08350
         TX(5)=0.0                                                 LL 08360
C                                                                  LL 08370
C*******   10 MICRON REGION                                        LL 08380
         IF (IV.GE.  670.AND.IV.LE. 1350) TX(5)=(4.18+5578.0*      LL 08400
     *      EXP(-7.87E-3*FLOAT(IV)))*W(5)                          LL 08410
C                                                                  LL 08420
C*******   4 MICRON REGION                                         LL 08430
         IF (IV.GE.2350.AND.IV.LE.3000) TX(5)=(C5(NH)+(XI-FLOAT(NH)) LL 08450
     *      *(C5(NH+1)-C5(NH)))*W(10)                              LL 08460
C                                                                  LL 08470
C******* MOLECULAR SCATTERING                                      LL 08480
         IF (IV.LT.2740) TX(6)=0.0                                 LL 08500
         IF (IV.GE. 2740.AND.IV.LE.50000)                          LL 08510
     *      TX(6)=9.807E-20*(FLOAT(IV)**4.0117)*W(6)               LL 08520
C                                                                  LL 08530
C******* AEROSOL EXTINCTION                                        LL 08540
         WL=10000./FLOAT(IV)                                       LL 08560
         XX=0.0                                                    LL 08570
         YY=0.0                                                    LL 08580
         TX(7)=0.0                                                 LL 08590
         TX(10)=0.0                                                LL 08600
         IF (IHAZE.EQ.0) GO TO 204                                 LL 08610
         NS=0                                                      LL 08620
         DO 203 L = 1,44                                           LL 08630
 203        IF (WL.GE.VX(IAERO,L)) NS=L                            LL 08640
         IF (NS.GT.0.AND.NS.LT.44) XX=C7 (IAERO,NS+1)+             LL 08650
     *      (C7 (IAERO,NS)-C7 (IAERO,NS+1))*(VX(IAERO,NS+1)-WL)/   LL 08660
     *      (VX(IAERO,NS+1)-VX(IAERO,NS))                          LL 08670
         IF (NS.GT.0.AND.NS.LT.44) YY=C7A(IAERO,NS+1)+             LL 08680
     *      (C7A(IAERO,NS)-C7A(IAERO,NS+1))*(VX(IAERO,NS+1)-WL)/   LL 08690
     *      (VX(IAERO,NS+1)-VX(IAERO,NS))                          LL 08700
 204     CONTINUE                                                  LL 08710
         TX(7)=XX*W(7)                                             LL 08720
         TX(10)=YY*W(7)                                            LL 08730
C                                                                  LL 08740
C******* UV OZONE                                                  LL 08750
         IF (IV.GE.13000.AND.IV.LE.23400) XI=FLOAT(IV-13000)/200.+ 1.LL 08770
         IF (IV.GE.27500.AND.IV.LE.50000) XI=FLOAT(IV-27500)/500.+57.LL 08780
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      N=IFIX(XI)+1
      IF ((IV.GE.13000.AND.IV.LE.23400).OR.
     *    (IV.GE.27500.AND.IV.LE.50000))
     *    TX(8)=W(8)*(C8(N)+(XI-FLOAT(N))*C8(N-1))
      IF ((IV.LT.13000.OR.IV.GT.23400).AND.
     *    (IV.LT.27500.OR.IV.GT.50000)) TX(8)=0.0
C
      TX(9)=0.0
      IF (IV.GE. 2080.AND.IV.LT. 2740) TX(9)=TX(9)+TX(4)
      IF (IV.GT.  670.AND.IV.LT. 3000) TX(9)=TX(9)+TX(5)
      IF (IV.GE. 2740.AND.IV.LT.50000) TX(9)=TX(9)+TX(6)
      TX(9)=TX(9)+TX(7)
      IF ((IV.GE.13000.AND.IV.LE.23400).OR.
     *    (IV.GE.27500.AND.IV.LE.50000)) TX(9)=TX(9)+TX(8)
      DO 205 L = 4,10
  205    TX(L)=EXP(-TX(L))
      TX(10)=1.0-TX(10)
      TX(9)=TX(1)*TX(2)*TX(3)*TX(9)
      IF (IV.GE.13000.AND.IV.LE.50000) TX(3)=TX(8)
      IF (JP.EQ.3) TX(9)=TX(7)
      AB=1.0-TX(9)
      IF (IV.EQ.IV1.OR.IV.EQ.IV2) AB=0.5*AB
      SUM=SUM+AB*FLOAT(IDV)
      IF (JP.EQ.0.AND.IABS(MOD(IV-IV1,50*IDV)).EQ.0) WRITE(6,422)
      IF (JP.EQ.0) WRITE(6,423) IV,WL,TX(9),(TX(L),L=1,7),TX(10),
     *    SUM
  206 CONTINUE
    AB=1.-SUM/FICAT(IV2-IV1)
    WRITE(6,424) IV1,IV2,SUM,AB
    READ(5,400) IXY
  208 CONTINUE
  209 CONTINUE
      STCF
C
  400 FORMAT(9I3,3X,2F10.3)
  405 FORMAT(3F10.3)
  406 FORMAT(2I3,4X,5F10.3)
  407 FORMAT(/10X,29H HORIZONTAL PATH, ALTITUDE = , F7.3,13H KM, RANGE
     * ,F7.3,3H KM)
  408 FORMAT(//10X,51H SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1
     * ,F7.3,9H KM H2 = ,F7.3,20H KM, ZENITH ANGLE = ,F7.3,8H DEGREES)
  409 FORMAT(//10X,40H SLANT PATH TO SPACE FROM ALTITUDE H1 = ,F7.3,19H
     *KM, ZENITH ANGLE =,F7.3,8H DEGREES)
  410 FORMAT('1'/10X,41H TROPICAL (15 DEG. LAT.) MODEL ATMOSPHERE)
  411 FORMAT('1'/10X,51H MIDLATITUDE (45 DEG. LAT.) SUMMER MODEL ATMOSP
     *ERE)
  412 FORMAT('1'/10X,51H MIDLATITUDE (45 DEG. LAT.) WINTER MODEL ATMOSP
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     *ERE)                                                             LL 09260
413   FORMAT('1'/10X,50H SUB-ARCTIC (60 DEG. LAT.) SUMMER MODEL ATMOSPHELL 09270
     *RE)                                                              LL 09280
414   FORMAT('1'/10X,50H SUB-ARCTIC (60 DEG. LAT.) WINTER MODEL ATMOSPHELL 09290
     *RE)                                                              LL 09300
415   FORMAT('1'//10X,36H 1962 U.S. STANDARD ATMOSPHERE MODEL)         LL 09310
417   FORMAT(/10X,14H HAZE MODEL = ,F5.1,29H KM VISUAL RANGE AT SEA LEVELL 09320
     *L/)                                                              LL 09330
418   FORMAT(/10X,22H FREQUENCY RANGE V1 = ,F7.1,14H CM-1 TO V2 = ,F7.1,LL 09340
     *15H CM-1 FOR DV = ,F6.1,9H CM-1   (,F6.2,3H - ,F5.2,9H MICRONS)//)LL 09350
419   FORMAT(/10X,38H EQUIVALENT SEA LEVEL ABSORBER AMOUNTS//21X,110HWATLL 09360
     *ER VAPOR       CO2 ETC.      OZONE     NITROGEN (CONT)   H2O (CONT) LL 09370
     *    MOL  SCAT        AEROSOL      OZONE(U-V)/24X,7HGM CM-2,10X,2HKM, LL 09380
     *10X,6HATM CM,10X,2HKM,9X,7HGM CM-2,10X,2HKM,13X,2HKM,10X,6HATM CM)LL 09390
420   FORMAT('1'///10X,21H  VERTICAL PROFILES   ,63X,3HPSI,4X,3HPHI,6X,  LL 09400
     *4HBETA,4X,13HTHETA     RANGE)                                    LL 09410
421   FORMAT(/8X,10H W(1-8) = ,8(1PE14.3)/74X,1PE14.3/)                LL 09420
422   FORMAT('1'/10X,32H  FREQ WAVELENGTH  TOTAL       H2O,5X,4HCO2+,5X,  LL 09430
     *64HCZCNE  N2 CCNT  H2O CONT MOL SCAT  AEROSOL  AEROSOL   INTEGRATELL 09440
     *D /11X,14H CM-1  MICRONS,8(4X,5HTRANS),4X,20H ABS       ABSORPTION )LL 09450
423   FORMAT(10X,I6,10F9.4,F12.2)                                      LL 09460
424   FORMAT(/27H INTEGRATED ABSORPTION FROM ,I5,4H TO ,I5,8H CM-1 = ,  LL 09470
     *F10.2,26H, AVERAGE TRANSMITTANCE = ,F6.4)                        LL 09480
426   FCRMAT(/20X,42HAEROSOL SCATTERING NOT COMPUTED, IHAZE = 0)       LL 09490
427   FORMAT('1'///10X,20H HORIZONTAL PROFILES)                        LL 09500
428   FORMAT(/10X,6H H1 = ,F7.3,10H KM, H2 = ,F7.3,13H KM, ANGLE = ,  LL 09510
     *F8.4,14H GEOM. RANGE = ,F7.2,12H KM, BETA = ,F8.5,4H DEG)        LL 09520
429   FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3)                            LL 09530
430   FORMAT(10X,26HINPUT METEOROLOGICAL DATA /10X,4HZ = ,F7.2,9H KM, P LL 09540
     *= ,F7.2,9H MB, T = ,F5.1,18H C, DEW PT.TEMP = ,F5.1,19H C, REL HUMLL 09550
     *IDITY = ,F5.1,18H %, H2O DENSITY = ,1PE9.2,7H GM.M-3/10X,17H OZONELL 09560
     * DENSITY = ,1PE9.2,17H GM.M-3, RANGE = ,F10.3,3H KM)             LL 09570
433   FORMAT(71H TRAJECTORY MISSES EARTH-S ATMOSPHERE. CLOSEST DISTANCE LL 09580
     *OF APPROACH IS ,F10.2/19H END OF CALCULATION)                    LL 09590
434   FORMAT(10X,I4,F6.1,11(1PE10.3))                                  LL 09600
435   FORMAT(I3,F6.1,8(1PE10.3),4(0PF9.4),F6.1)                        LL 09610
436   FORMAT(8H HMIN = ,F10.3)                                         LL 09620
437   FORMAT(64H PATH INTERSECTS EARTH - PATH CHANGED TO TYPE 2 WITH H2 LL 09630
     *= 0.0 KM)                                                        LL 09640
438   FORMAT(85H CHOICE OF TWO PATHS FOR THIS CASE - SHORTER PATH TAKEN LL 09650
     *  FOR LONGER PATH SET LEN = 1)                                   LL 09660
439   FORMAT(85H CHOICE OF TWO PATHS FOR THIS CASE - LONGER PATH TAKEN. LL 09670
     * FOR SHORTER PATH SET LEN = 0)                                   LL 09680
440   FORMAT(70H H2 WAS SET LESS THAN HMIN AND HAS BEEN RESET EQUAL TO  LL 09690
     *MIN I.E., H2 = ,F10.3)                                           LL 09700
441   FORMAT(24H  MODEL ATMOSPHERE NO. 7/23H    Z (KM)    P (MB)    ,  LL 09710
     * 49HT (C) DEW PT _RH  H2O(GM.M-3) O3(GM.M-3) NO. DEN.)           LL 09720
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442   FORMAT(61H  FOG CONDITIONS MAY EXIST AT SEA LEVEL FOR THIS VISUAL LL 09730
     *RANGE/93H  IF SO THEN ASSUME THE TRANSMITTANCE DUE TO FOG IS GIVENLL 09740
     *BY THE TRANSMITTANCE AT 0.55 MICRONS)                              LL 09750
443   FORMAT(//5X,29HESTIMATED TANGENT ALTITUDE = ,F10.3,3H KM//)       LL 09760
444   FORMAT(15X,41HTEMPERATURE PROFILE FOR MODEL ATMOSPHERE ,I5)       LL 09770
445   FORMAT(15X,41HWATER VAPOR PROFILE FOR MODEL ATMOSPHERE ,I5)       LL 09780
446   FORMAT(15X,41HOZONE       PROFILE FOR MODEL ATMOSPHERE ,I5)       LL 09790
447   FORMAT(/10X,26H CONTINENTAL AEROSOL MODEL)                        LL 09800
448   FORMAT(/10X,20H RURAL AEROSOL MODEL)                              LL 09810
449   FORMAT(/10X,20H URBAN AEROSOL MODEL)                              LL 09820
450   FORMAT(/10X,23H MARITIME AEROSOL MODEL)                           LL 09830
451   FORMAT(10H1   ***   ,I5,37H INPUT LEVELS EXCEEDS MODEL LIMIT OF , LL 09840
     *I5)                                                                LL 09850
      END                                                                LL 09860
      SUBROUTINE POINT (X,YN,N,NP,TX,IP)                                 LL 09870
C                                                                        LL 09880
C***********************************************************************LL 09890
C*                                                                     *LL 09900
C*    SUBROUTINE POINT COMPUTES THE MEAN REFRACTIVE INDEX ABOVE AND    *LL 09910
C*    BELOW A GIVEN ALTITUDE AND INTERPOLATES EXPONENTIALLY TO DETER-  *LL 09920
C*    MINE THE EQUIVALENT ABSORBER AMOUNTS AT THAT ALTITUDE.           *LL 09930
C*                                                                     *LL 09940
C***********************************************************************LL 09950
C*                                                                     *LL 09960
C*    X IS THE GIVEN ALTITUDE IN KM.                                   *LL 09970
C*    TX(9) AND YN ARE THE MEAN REFRACTIVITY ABOVE AND BELOW X,        *LL 09980
C*       RESPECTIVELY.                                                 *LL 09990
C*    N IS THE INTEGER CORRESPONDING TO THE ATMOSPHERIC LEVEL AT       *LL 10000
C*       OR BELOW X.                                                   *LL 10010
C*    IF X COINCIDES WITH THE ATMOSPHERE LEVEL, NP = 1,                *LL 10020
C*       OTHERWISE NP = 0.                                             *LL 10030
C*    TX(1-8) ARE ABSORBER AMOUNTS PER KM AT X.                        *LL 10040
C*    IP IS AN INDICATOR'  IP = 0 IMPLIES A CALCULATION OF REFRACTIVE  *LL 10050
C*      INDEX ONLY.  OTHERWISE, THE EQUIVALENT ABSORBER AMOUNTS ARE    *LL 10060
C*      ALSO CALCULATED.                                               *LL 10070
C*                                                                     *LL 10080
C***********************************************************************LL 10090
C                                                                        LL 10100
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),   LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),  LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),     LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),  LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),     LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),      LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),      LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),    LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),         LL 01280
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     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),          LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)             LL 01390
C                                                                     LL 10240
      DIMENSION       TX(10),P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45)LL 10250
     *                ,C7(4,45),C7A(4,45),C1(2580),C2(1575)
      LOGICAL         CKZERO                                          LL 10260
C                                                                     LL 10270
      REF(X,Y,Z)=CO*X/Y-4.56E-6*Z*Y*CW                                LL 10280
      CKZERO(X)=ABS(X).LT.1.E-20                                      LL 10290
C                                                                     LL 10300
      CALL ARRAY(P,T,WH,WO,VX,C1,C2,C7,C7A)                           LL 01470
      N=0                                                             LL 10310
      X=AMAX1(X,0.0)                                                  LL 10320
      NL1=NL-1                                                        LL 10330
      DO 101  I = 1,NL1                                               LL 10340
  101     IF  (X.GT.Z(I))  N=I                                        LL 10350
      IF  (.NOT.CKZERO(X-Z(N+1)))  NP=0                               LL 10360
      IF  (     CKZERO(X-Z(N+1)))  NP=1                               LL 10370
      IF  (N.EQ.0.OR.NP.EQ.1)  GO TO 102                              LL 10380
      FAC=AMIN1((X-Z(N))/(Z(N+1)-Z(N)),1.)                            LL 10390
      PX1=P(M,N)*(P(M,N+1)/P(M,N))**FAC                               LL 10400
      TX1=T(M,N)*(T(M,N+1)/T(M,N))**FAC                               LL 10410
      WX1=WH(M,N)*(WH(M,N+1)/WH(M,N))**FAC                            LL 10420
      TX(9)=(REF(P(M,N+1),T(M,N+1),WH(M,N+1))+REF(PX1,TX1,WX1))/2.    LL 10430
      YN=(REF(P(M,N),T(M,N),WH(M,N))+REF(PX1,TX1,WX1))/2.             LL 10440
      GO TO 103                                                       LL 10450
C                                                                     LL 10460
  102 CONTINUE                                                        LL 10470
      TX(9)=(EH(9,N+1)-1.)*1.E+06                                     LL 10480
      IF  (N.EQ.0)  YN=0.0                                            LL 10490
      IF  (N.NE.0)  YN=(EH(9,N)-1.)*1.E+06                            LL 10500
  103 CONTINUE                                                        LL 10510
C                                                                     LL 10520
      IF  (IP.EQ.0)  GO TO 105                                        LL 10530
      DO 104 K = 1,10                                                 LL 10540
          IF  ((N.EQ.0.OR.     CKZERO(EH(K,N))).AND.K.NE.9)  TX(K)=0.0 LL 10550
          IF  ((N.NE.0.AND..NOT.CKZERO(EH(K,N))).AND.K.NE.9)  TX(K)=  LL 10560
     *        EH(K,N)*(EH(K,N+1)/EH(K,N))**FAC                        LL 10570
  104     CONTINUE                                                    LL 10580
      WRITE(6,1)  X,N,NP,TX(9),YN,(TX(K),K=1,8)                       LL 10590
  105 CONTINUE                                                        LL 10600
      TX(9)=1.+TX(9)*1.E-06                                           LL 10610
      YN   =1.+YN*1.E-06                                              LL 10620
      RETURN                                                          LL 10630
    1 FORMAT(/,10X,'FROM POINT - HEIGHT =',F10.4,9H KM, N = ,I3,7H, NP LL 10640
     * = ,I2,35H, REFRACTIVITY ABOVE AND BELOW X = ,2(1PE10.3)//10X,   LL 10650
     *40H EQUIVALENT ABSORBER AMOUNTS PER KM AT X//20X,8(1PE10.3))    LL 10660
```

```
      END                                                               LL 10670
C
C
C
      SUBROUTINE ANGL (H1,H2,ANGLE,BETA,LEN,ML)                         LL 10680
C                                                                       LL 10690
C***********************************************************************LL 10700
C*                                                                     *LL 10710
C*    THIS SUBROUTINE CALCULATES THE INITIAL ZENITH ANGLE (ANGLE)      *LL 10720
C*    TAKING INTO ACCOUNT REFRACTION EFFECTS GIVEN H1,H2, AND BETA     *LL 10730
C*    (WHERE BETA IS THE EARTH CENTRE ANGLE SUBTENDED BY H1 AND H2 ),  *LL 10740
C*    ASSUMING THE REFRACTIVE INDEX TO BE CONSTANT IN A GIVEN LAYER.   *LL 10750
C*    FOR GREATER ACCURACY INCREASE THE NUMBER OF LEVELS IN THE MODEL  *LL 10760
C*    ATMOSPHERE.                                                      *LL 10770
C*                                                                     *LL 10780
C*    THIS SUBROUTINE CAN BE REMOVED FROM THE PROGRAM IF NOT REQUIRED. *LL 10790
C*                                                                     *LL 10800
C***********************************************************************LL 10810
C                                                                       LL 10820
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),   LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),  LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),     LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),  LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),     LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),      LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),      LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),    LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),         LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),            LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)               LL 01390
C                                                                       LL 10960
      DIMENSION        TX(10) .                                         LL 10970
      LOGICAL          CKZERO                                           LL 10980
C                                                                       LL 10990
      CKZERO(X)=ABS(X).LT.1.E-20                                        LL 11000
C                                                                       LL 11010
      IP=99                                                             LL 11020
      X1=RE+H1                                                          LL 11030
      X2=RE+H2                                                          LL 11040
      LEN=0                                                             LL 11050
      BETA=BETA*CA                                                      LL 11060
      IF (CKZERO(BETA)) BETA=ARCOS(X2/X1)                               LL 11070
      TANG=X2*SIN(BETA)/(X2*COS(BETA)-X1)                               LL 11080
      THET=ATAN(TANG)                                                   LL 11090
      IF (THET.LT.0.0) THET=THET+PI                                     LL 11100
      SPHI=SIN(THET)                                                    LL 11110
      ANG=THET/CA                                                       LL 11120
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      TN=THET
      TM=TN-0.5*CA
      DO 101 ITER =  1,10
         ANGLE=THET
         FBT=0.0
         B1=0.0
         BET1=0.0
         BET2=0.0
         FBT1=0.0
         FBT2=0.0
         FBT3=0.0
         IF  (BETA.LE.0.0) GO TO 2
         IF  (2.*THET-PI.GT.1.E-8)  GO  TO  9
         IF  (IP.EQ.100)  GO  TO  6
         XMIN=X2*COS(BETA)-RE
         IF  (XMIN.LT.H1)  GO  TO  8
         IF  (XMIN.GE.H1)  GO  TO  4
 2       HMIN=H2
         H2=H1
         H1=HMIN
 3       ANGLE=0.5*PI
         THET=ANGLE
         SPHI=1.0
         ANG=ANGLE/CA
 4       IP=100
         CALL POINT  (H1,YN,J1,NE,TX,IP)
         TX1=TX(9)
 5       CALL POINT  (H2,YN,J2,NE,TX,IP)
         IF  (NP.EQ.1)  J2=J2-1
         IF  (J1.EQ.J2)  TX1=TX1+YN-EH(9,J1)
 6       CONTINUE
         X1=RE+H1
         FBT=-TAN(THET)
         DO 7 J = J1,J2
            IF  (J.NE.J2)  X2=RE+Z(J+1)
            IF  (J.EQ.J2)  X2=RE+H2
            SALP=X1*SPHI/X2
            ALP=ARSIN(SALP)
            RN=EH(9,J+1)/EH(9,J)
            IF  ((J+1).EQ.J2)  RN=YN/EH(9,J)
            IF  (J.EQ.J1)  RN=EH(9,J+1)/TX1
            IF  ((J+1).EQ.J2.AND.J.EQ.J1)  RN=YN/TX1
            FBT=FBT+TAN(THET)-TAN(ALP)
            B1=B1+THET-ALP
            TH1=THET/CA
            C=ALP/CA
            IF  (CKZERO(X2-(RE+H2)))  C=PI-ALP
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      IF  (SALP.GE.RN)  RN=1.                                        LL 11600
      SPHI=SALE/RN                                                   LL 11610
      THET=ARSIN(SPHI)                                               LL 11620
      X1=X2                                                          LL 11630
7     CONTINUE                                                       LL 11640
   IF  (BETA.LE.0.0)  THET=C                                         LL 11650
   IF  (BETA.LE.0.0)  GO TO 28                                       LL 11660
   GO TO 26                                                          LL 11670
8  CONTINUE                                                          LL 11680
   TANG=-TANG                                                        LL 11690
   ANGLE=PI-ANGLE                                                    LL 11700
   TN=ANGLE                                                          LL 11710
   ANG=ANGLE/CA                                                      LL 11720
   IF  (H1.LE.0.0)  GO TO 3                                          LL 11730
9  CONTINUE                                                          LL 11740
   IP=101                                                            LL 11750
   CALL POINT  (H1,YN1,J1,NP1,TX,IP)                                 LL 11760
   TX1=TX(9)                                                         LL 11770
   IF  (NP1.EQ.1)  J1=J1-1                                           LL 11780
   J2=ML                                                             LL 11790
   IF  (H2.GE.H1)  GO TO 13                                          LL 11800
   CALL POINT  (H2,YN2,J2,NP2,TX,IP)                                 LL 11810
   TX2=TX(9)                                                         LL 11820
   IF  (J1.EQ.J2)  TX2=YN1+TX(9)-EH(9,J1)                            LL 11830
   J2P=J2-1                                                          LL 11840
   DO 102 J = J1,J2P                                                 LL 11850
      X1=RE+Z(J+1)                                                   LL 11860
      X2=RE+Z(J)                                                     LL 11870
      IF  (J.EQ.J1)  X1=RE+H1                                        LL 11880
      IF  (J.EQ.J2)  X2=RE+H2                                        LL 11890
      SALP=X1*SPHI/X2                                                LL 11900
      HMIN=X1*SPHI-RE                                                LL 11910
      IF  (SALP.LE.1.0)  GO TO 11                                    LL 11920
      SALP=SPHI                                                      LL 11930
      IF  (HMIN.GT.H2)  GO TO 18                                     LL 11940
11    ALP=ARSIN(SALP)                                                LL 11950
      THET=ARSIN(SPHI)                                               LL 11960
      BET=ALP-THET                                                   LL 11970
      BET1=BET1+BET                                                  LL 11980
      FB=TAN(ALP)                                                    LL 11990
      IF  (J.NE.J1)  FB=FB-TAN(THET)                                 LL 12000
      FBT1=FBT1+FB                                                   LL 12010
      TH1=THET/CA                                                    LL 12020
      BE=BET/CA                                                      LL 12030
      AL=ALP/CA                                                      LL 12040
      IF  (CKZERO(X2-(RE+H2)))  C=PI-ALP                             LL 12050
      REF=EH(9,J)                                                    LL 12060
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```
            IF  (J.EQ.J1)  REF=YN1
            IF  (J.EQ.J2)  REF=TX2
            IF  (J.EQ.1)  GO TO 12
            RN=EH(9,J)/EH(9,J-1)
            IF  (J.EQ.J1)  RN=YN1/EH(9,J-1)
            IF  (J.EQ.J2+1)  RN=REF/TX2
            IF  (J.EQ.J2)  RN=REF/YN2
            IF  (SALP.GE.RN)  RN=1.
            SPHI=SALP*RN
            IF  (Z(J).LE.H2)  GO TO 12
102         CONTINUE
12        X1=X2
          IF  (ABS(Z(J)-H2).GE.1.0E-10.OR.J.EQ.1)  GO TO 14
13        J=J-1
          X1=RE+Z(J+1)
          IF  (J.EQ.J1)  X1=RE+H1
          IF  (J.EQ.J2.AND.J.NE.J1)  X1=RE+H2
14        X2=RE+Z(J)
          HMIN=X1*SPHI-RE
          IF  (HMIN.LE.0.0)  B1=BET1
          IF  (HMIN.LE.0.0)  LEN=0
          IF  (HMIN.LE.0.0)  FBT=FBT1
          IF  (HMIN.LE.0.0)  GO TO 26
          IF  (Z(J).LT.HMIN)  GO TO 18
          REF=EH(9,J)
          IF  (J.EQ.J2)  REF=YN
          SALP=X1*SPHI/X2
      ALP=ARSIN(SALP)
      THET=ARSIN(SPHI)
          BET=ALP-THET
          FB=TAN(ALP)-TAN(THET)
          FBT2=FBT2+FB
          BET2=BET2+BET
          BMIN=BET1+BET2
          AL=ALP/CA
          TH1=THET/CA
          RN=REF/EH(9,J-1)
          IF  (SALP.GE.RN)  RN=1.0
          SPHI=SALP*RN
          GO TO 13
17        TX3=YN1+TX(9)-EH(9,J1)
          YN1=TX3
          IF  (ABS(H2-Z(J+1)).LE.1.0E-5)  YN1=TX(9)
          IF  (ABS(H1-Z(J+1)).LE.1.0E-5)  YN1=TX(9)
          RN=1.0
          GO TO 19
18        CALL POINT  (HMIN,YN,J2,NP,TX,IP)
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```
      IP=102
      TX3=TX(9)
      IF (J.EQ.J1.AND.H2.GE.H1) GO TO 17
      IF (J.EQ.J1.OR.J.EQ.J2) TX3=YN2+TX(9)-EH(9,J)
      IF (HMIN.GT.H2) TX3=TX(9)
      IF (J.EQ.J1.AND.HMIN.GT.H2) GO TO 17
      RN=REF/TX3
      IF (SALP.GE.FN) RN=1.
      SPHI=SALP*RN
      X=X1*SPHI-RE
      DIF=ABS(HMIN-X)
      HMIN=X
      IF (DIF.GT.1.0E-5) GO TO 18
19    X2=RE+HMIN
         THET=ARSIN(SPHI)
      IF (CKZERO(RN)) FBT3=-TAN(THET)
      IF (CKZERO(RN)) GO TO 20
      DNX=(TX3-1.0)*ALOG((TX3-1.0)/(REF-1.0))/(X2-X1)
      FBT3=-TAN(THET)*(1.0-1.0/(1.0+TX3/(X2*DNX)))
20    BET=0.5*PI-THET
      BET2=BET2+BET
      BMIN=BET1+BET2
      IF (H2.GE.H1) GO TO 23
      BET=BET1+2.*BET2
      DB1=BETA-BET1
      DB2=BET-BETA
      DB3=ABS(BMIN-BETA)
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) B1=BET1
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) LEN=0
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) FBT=FBT1
      IF ((DB3.LE.DB1.OR.DB2.LE.DB1).AND.DB3.LE.DB1) B1=BET1+BET2
      IF ((DB3.LE.DB1.OR.DB2.LE.DB1).AND.DB3.LE.DB1) FBT=FBT1+FBT2+
     *   FBT3
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) B1=BET
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) LEN=1
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) FBT=FBT1+2.*(FBT2+FBT3)
      GO TO 26
23    B1=2.0*(BET1+BET2)
      LEN=1
      FBT=2.0*(FBT1+FBT2+FBT3)
      WRITE(6,401) J,B1,FBT,FBT1,FBT2,FBT3,TX1,YN1
      IF (CKZERO(H2-H1)) GO TO 26
      IP=103
      IF (NP1.EQ.1) J1=J1+1
      SPHI=SIN(ANGLE)
      IF (Z(J1+1).LE.H2) CALL POINT(H2,YN,N,NP,TX,IP)
      IF (Z(J1+1).LE.H2) J2=J1
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      RN=TX1/YN1                                                       LL 13010
      IF (SPHI.GE.RN) RN=1.                                            LL 13020
      SPHI=SPHI/RN                                                     LL 13030
         THET=ARSIN(SPHI)                                              LL 13040
      GO TO 5                                                          LL 13050
 26   THET=ANGLE+(BETA-B1)/(1.+FBT/TANG)                               LL 13060
      DB1=B1/CA                                                        LL 13070
      E=BET1/CA                                                        LL 13080
      TH1=THET/CA                                                      LL 13090
      WRITE(6,404) E1,DB1,FBT,TH1,TANG                                 LL 13100
      IF (THET.GT.TN.OR.THET.LT.TM) THET=(TN+TM)/2.                    LL 13110
      TH1=THET/CA                                                      LL 13120
      WRITE(6,404) BET1,B,FBT,TH1                                      LL 13130
      TN1=TN/CA                                                        LL 13140
      TM1=TM/CA                                                        LL 13150
      WRITE(6,405) TN,TM,TN1,TM1                                       LL 13160
      SPHI=SIN(THET)                                                   LL 13170
      TANG=TAN(THET)                                                   LL 13180
      IF (ABS(BETA-B1).LT.1.E-7.OR.ABS(ANGLE-THET).LT.1.E-7) GO TO 28LL 13190
101   CONTINUE                                                         LL 13200
     THET=(ANGLE+THET)/2.                                              LL 13210
 28  ANGLE=THET/CA                                                     LL 13220
     IF (BETA.LE.0.0) H1=H2                                            LL 13230
     WRITE(6,406) ANGLE,ITER                                           LL 13240
     RETURN                                                            LL 13250
C                                                                      LL 13260
401  FORMAT (I6,1PE16.7,8(0PF13.8))                                    LL 13270
404  FORMAT (14H TOTAL BETA = ,1PE14.6,0PF15.6,7H, FBT = ,1PE14.6,8H THLL 13280
    *ET = ,0PF10.6,8H TANG = ,F10.6,15H TOTAL RANGE = ,F10.1)          LL 13290
405  FORMAT (5F12.6)                                                   LL 13300
406  FORMAT (8X/15HZENITH ANGLE = ,F7.3,53H DEGREES - RECOMPUTED FROM SLL 13310
    *UBROUTINE ANGL (ITERATION,I3,1H))                                 LL 13320
     END                                                               LL 13330
C
C
C
     SUBROUTINE ARRAY(P,T,WH,WO,VX,C1,C2,C7,C7A)                       LL 13340
C
     COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),   LL 01270
    *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),  LL 01280
    *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),     LL 01280
    *WHC6(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),  LL 01280
    *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),     LL 01280
    *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),      LL 01280
    *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),      LL 01280
    *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),    LL 01280
    *C7C2(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),         LL 01280
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     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),              LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)                 LL 01390
      DIMENSION P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45),              LL 13480
     *          C1(2580),C2(1575),C7(4,45),C7A(4,45)
C
C
      DO 10 I=1,34                                                         LL 13490
      P(1,I)=P01(I)                                                        LL 13500
      P(2,I)=P02(I)                                                        LL 13510
      P(3,I)=P03(I)                                                        LL 13520
      P(4,I)=P04(I)                                                        LL 13530
      P(5,I)=P05(I)                                                        LL 13540
      P(6,I)=P06(I)                                                        LL 13550
      T(1,I)=T01(I)                                                        LL 13570
      T(2,I)=T02(I)                                                        LL 13580
      T(3,I)=T03(I)                                                        LL 13590
      T(4,I)=T04(I)                                                        LL 13600
      T(5,I)=T05(I)                                                        LL 13610
      T(6,I)=T06(I)                                                        LL 13620
      WH(1,I)=WH01(I)                                                      LL 13640
      WH(2,I)=WH02(I)                                                      LL 13650
      WH(3,I)=WH03(I)                                                      LL 13660
      WH(4,I)=WH04(I)                                                      LL 13670
      WH(5,I)=WH05(I)                                                      LL 13680
      WH(6,I)=WH06(I)                                                      LL 13690
      WO(1,I)=WO01(I)                                                      LL 13710
      WO(2,I)=WO02(I)                                                      LL 13720
      WO(3,I)=WO03(I)                                                      LL 13730
      WC(4,I)=WO04(I)                                                      LL 13740
      WO(5,I)=WO05(I)                                                      LL 13750
      WO(6,I)=WO06(I)                                                      LL 13760
   10 CONTINUE                                                             LL 13780
      DC 20 I=1,45
        VX(1,I)=VX01(I)
        VX(2,I)=VX02(I)
        VX(3,I)=VX03(I)
        VX(4,I)=VX04(I)
   20   CONTINUE
      DO 30 I=1,45
      C7(1,I)=C701(I)                                                      LL 13640
      C7(2,I)=C702(I)                                                      LL 13650
      C7(3,I)=C703(I)                                                      LL 13660
      C7(4,I)=C704(I)                                                      LL 13670
      C7A(1,I)=C7A01(I)                                                    LL 13640
      C7A(2,I)=C7A02(I)                                                    LL 13650
      C7A(3,I)=C7A03(I)                                                    LL 13660
      C7A(4,I)=C7A04(I)                                                    LL 13670
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   30 CONTINUE
      DO 40 I=1,190
      C1(I)=C101(I)                                                      LL 13640
      C1(I+190)=C102(I)                                                  LL 13650
      C1(I+380)=C103(I)                                                  LL 13660
      C1(I+570)=C104(I)                                                  LL 13670
      C1(I+760)=C105(I)                                                  LL 13680
      C1(I+950)=C106(I)                                                  LL 13690
      C1(I+1140)=C107(I)                                                 LL 13700
      C1(I+1330)=C108(I)                                                 LL 13710
      C1(I+1520)=C109(I)                                                 LL 13720
      C1(I+1710)=C110(I)                                                 LL 13730
      C1(I+1900)=C111(I)                                                 LL 13740
      C1(I+2090)=C112(I)                                                 LL 13750
      C1(I+2280)=C113(I)                                                 LL 13760
      C2(I)=C201(I)                                                      LL 13640
      C2(I+190)=C202(I)                                                  LL 13650
      C2(I+380)=C203(I)                                                  LL 13660
      C2(I+570)=C204(I)                                                  LL 13670
      C2(I+760)=C205(I)                                                  LL 13670
   40 CONTINUE                                                           LL 13780
      DO 50 I=1,110
      C1(I+2470)=C114(I)
   50 CONTINUE
      RETURN                                                             LL 13790
      END                                                                LL 13800
C
      BLCCK DATA                                                         LL 13810
C                                                                        LL 13820
C***********************************************************************LL 13830
C*    THE SPECTRAL AND TRANSMITTANCE DATA FOR LOWTRAN IIIB.             *LL 13850
C***********************************************************************LL 13870
C                                                                        LL 13880
      CCMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),    LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),   LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),      LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),   LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),      LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),       LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),       LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),     LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),          LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),             LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)                LL 01390
C                                                                        LL 14020
C *** THE VALUE FOR PI                                                   LL 14170
C                                                                        LL 14180
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      DATA              PI /3.14159265358979/                             LL 14190
C                                                                         LL 14200
C *** THE CCNVERSION FROM DEGREES TO RADIANS.                              LL 14210
C                                                                         LL 14220
      DATA              CA /0.017453292519943/                            LL 14230
C                                                                         LL 14240
C *** THE MEAN RADIUS OF THE EARTH (INTERNATIONAL SPHERIOD) IN KM.        LL 14250
C                                                                         LL 14260
      DATA              REBAR /6371.299315/                               LL 14270
C                                                                         LL 14280
C *** THE POLAR RADIUS OF THE EARTH (INTERNATIONAL SPHEROID) IN KM.       LL 14290
C                                                                         LL 14300
      DATA              REPOL /6356.911946/                               LL 14310
C                                                                         LL 14320
C *** THE EQUATORIAL RADIUS OF THE EARTH (INTERNATIONAL SPHEROID) IN KM.LL 14330
C                                                                         LL 14340
      DATA              REEQU /6378.388000/                               LL 14350
C                                                                         LL 14360
C *** VALUES OF THE RADIUS CF THE EARTH FOR THE MODEL ATMCSPHERES IN KM.LL 14370
C                                                                         LL 14380
      DATA              REARTH(1) /6376.951637/                           LL 14390
      DATA              REARTH(2) /6367.659029/                           LL 14400
      DATA              REARTH(3) /6367.659029/                           LL 14410
      DATA              REARTH(4) /6362.287754/                           LL 14420
      DATA              REARTH(5) /6362.287754/                           LL 14430
      DATA              REARTH(6) /6367.659029/                           LL 14440
      DATA              REARTH(7) /6371.299315/                           LL 14450
C                                                                         LL 14460
C *** NUMBER OF TYPES OF MODEL ATMOSPHERES                                LL 14470
C                                                                         LL 14480
      DATA              IATM /6/                                          LL 14490
C                                                                         LL 14500
C *** NUMBER OF LEVELS IN MODEL ATMOSPHERE DATA                           LL 14510
C                                                                         LL 14520
      DATA              NL /34/                                           LL 14530
C                                                                         LL 14540
C *** HAZE MODEL'  23 KM. VISIBLE RANGE                                   LL 14550
C                                                                         LL 14560
      DATA              HZ1 /2.830E+03,1.245E+03,5.374E+02,2.257E+02,     LL 14570
     *  1.193E+02,8.992E+01,6.341E+01,5.893E+01,6.073E+01,5.822E+01,     LL 14580
     *  5.679E+01,5.320E+01,5.589E+01,5.159E+01,5.052E+01,4.747E+01,     LL 14590
     *  4.514E+01,4.460E+01,4.317E+01,3.636E+01,2.669E+01,1.935E+01,     LL 14600
     *  1.456E+01,1.114E+01,8.831E+00,7.434E+00,2.239E+00,5.893E-01,     LL 14610
     *  1.551E-01,4.084E-02,1.078E-02,5.553E-05,1.970E-08,0.000E+00/     LL 14620
C                                                                         LL 14630
C *** HAZE MODEL'   5 KM. VISIBLE RANGE                                   LL 14640
C                                                                         LL 14650
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      DATA            HZ2  /1.379E+04,5.034E+03,1.845E+03,6.735E+02,    LL 14660
     *  2.454E+02,8.992E+01,6.341E+01,5.893E+01,6.073E+01,5.822E+01,    LL 14670
     *  5.679E+01,5.320E+01,5.589E+01,5.159E+01,5.052E+01,4.747E+01,    LL 14680
     *  4.514E+01,4.460E+01,4.317E+01,3.636E+01,2.669E+01,1.935E+01,    LL 14690
     *  1.456E+01,1.114E+01,8.831E+00,7.434E+00,2.239E+00,5.893E-01,    LL 14700
     *  1.551E-01,4.084E-02,1.078E-02,5.553E-05,1.970E-08,0.000E+00/    LL 14710
C                                                                       LL 14720
C *** ALTITUDE (KM.) AT LEVEL I                                         LL 14730
C                                                                       LL 14740
      DATA            Z0 / 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0,LL 14750
     *     9.0,10.0,11.0,12.0,13.0,14.0,15.0,16.0,17.0,18.0,19.0,20.0, LL 14760
     *    21.0,22.0,23.0,24.0,25.0,30.0,35.0,40.0,45.0,50.0,70.0,      LL 14770
     *    100.0,99999.0/                                                LL 14780
C                                                                       LL 14790
C *** PRESSURE (MB.) AT LEVEL I FOR THE MODEL ATMOSPHERES               LL 14800
C                                                                       LL 14810
      DATA            P01              /1.013E+03,9.040E+02,8.050E+02,  LL 14820
     *    7.150E+02,6.330E+02,5.590E+02,4.920E+02,4.320E+02,3.780E+02,  LL 14830
     *    3.290E+02,2.860E+02,2.470E+02,2.130E+02,1.820E+02,1.560E+02,  LL 14840
     *    1.320E+02,1.110E+02,9.370E+01,7.890E+01,6.660E+01,5.650E+01,  LL 14850
     *    4.800E+01,4.090E+01,3.500E+01,3.000E+01,2.570E+01,1.220E+01,  LL 14860
     *    6.000E+00,3.050E+00,1.590E+00,8.540E-01,5.790E-02,3.000E-04,  LL 14870
     *    0.000E+00/                                                    LL 14880
      DATA            P02              /1.013E+03,9.020E+02,8.020E+02,  LL 14890
     *    7.100E+02,6.280E+02,5.540E+02,4.870E+02,4.260E+02,3.720E+02,  LL 14900
     *    3.240E+02,2.810E+02,2.430E+02,2.090E+02,1.790E+02,1.530E+02,  LL 14910
     *    1.300E+02,1.110E+02,9.500E+01,8.120E+01,6.950E+01,5.950E+01,  LL 14920
     *    5.100E+01,4.370E+01,3.760E+01,3.220E+01,2.770E+01,1.320E+01,  LL 14930
     *    6.520E+00,3.330E+00,1.760E+00,9.510E-01,6.710E-02,3.000E-04,  LL 14940
     *    0.000E+00/                                                    LL 14950
      DATA            P03              /1.018E+03,8.973E+02,7.897E+02,  LL 14960
     *    6.938E+02,6.081E+02,5.313E+02,4.627E+02,4.016E+02,3.473E+02,  LL 14970
     *    2.992E+02,2.568E+02,2.199E+02,1.882E+02,1.610E+02,1.378E+02,  LL 14980
     *    1.178E+02,1.007E+02,8.610E+01,7.350E+01,6.280E+01,5.370E+01,  LL 14990
     *    4.580E+01,3.910E+01,3.340E+01,2.860E+01,2.430E+01,1.110E+01,  LL 15000
     *    5.180E+00,2.530E+00,1.290E+00,6.820E-01,4.670E-02,3.000E-04,  LL 15010
     *    0.000E+00/                                                    LL 15020
      DATA            P04              /1.010E+03,8.960E+02,7.929E+02,  LL 15030
     *    7.000E+02,6.160E+02,5.410E+02,4.730E+02,4.130E+02,3.590E+02,  LL 15040
     *    3.107E+02,2.677E+02,2.300E+02,1.977E+02,1.700E+02,1.460E+02,  LL 15050
     *    1.250E+02,1.080E+02,9.280E+01,7.980E+01,6.860E+01,5.890E+01,  LL 15060
     *    5.070E+01,4.360E+01,3.750E+01,3.227E+01,2.780E+01,1.340E+01,  LL 15070
     *    6.610E+00,3.400E+00,1.810E+00,9.870E-01,7.070E-02,3.000E-04,  LL 15080
     *    0.000E+00/                                                    LL 15090
      DATA            P05              /1.013E+03,8.878E+02,7.775E+02,  LL 15100
     *    6.798E+02,5.932E+02,5.158E+02,4.467E+02,3.853E+02,3.308E+02,  LL 15110
     *    2.829E+02,2.418E+02,2.067E+02,1.766E+02,1.510E+02,1.291E+02,  LL 15120
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     *     1.103E+02,9.431E+01,8.050E+01,6.882E+01,5.875E+01,5.014E+01,  LL 15130
     *     4.277E+01,3.647E+01,3.109E+01,2.649E+01,2.256E+01,1.020E+01,  LL 15140
     *     4.701E+00,2.243E+00,1.113E+00,5.719E-01,4.016E-02,3.000E-04,  LL 15150
     *     0.000E+00/                                                    LL 15160
      DATA           P06                /1.013E+03,8.986E+02,7.950E+02,  LL 15170
     *     7.012E+02,6.166E+02,5.405E+02,4.722E+02,4.111E+02,3.565E+02,  LL 15180
     *     3.080E+02,2.650E+02,2.270E+02,1.940E+02,1.658E+02,1.417E+02,  LL 15190
     *     1.211E+02,1.035E+02,8.850E+01,7.565E+01,6.467E+01,5.529E+01,  LL 15200
     *     4.729E+01,4.047E+01,3.467E+01,2.972E+01,2.549E+01,1.197E+01,  LL 15210
     *     5.746E+00,2.871E+00,1.491E+00,7.978E-01,5.520E-02,3.008E-04,  LL 15220
     *     0.000E+00/                                                    LL 15230
C                                                                        LL 15240
C                                                                        LL 15250
C     DATA   P07 /34*0.0/                                                LL 15260
C                                                                        LL 15270
C                                                                        LL 15280
C                                                                        LL 15290
C *** TEMPERATURE (K) AT LEVEL I FOR THE MODEL ATMOSPHERES               LL 15300
C                                                                        LL 15310
      DATA           T01                /300.0,294.0,288.0,284.0,277.0,  LL 15320
     *     270.0,264.0,257.0,250.0,244.0,237.0,230.0,224.0,217.0,210.0,  LL 15330
     *     204.0,197.0,195.0,199.0,203.0,207.0,211.0,215.0,217.0,219.0,  LL 15340
     *     221.0,232.0,243.0,254.0,265.0,270.0,219.0,210.0,210.0/        LL 15350
      DATA           T02                /294.0,290.0,285.0,279.0,273.0,  LL 15360
     *     267.0,261.0,255.0,248.0,242.0,235.0,229.0,222.0,216.0,216.0,  LL 15370
     *     216.0,216.0,216.0,216.0,217.0,218.0,219.0,220.0,222.0,223.0,  LL 15380
     *     224.0,234.0,245.0,258.0,270.0,276.0,218.0,210.0,210.0/        LL 15390
      DATA           T03                /272.2,268.7,265.2,261.7,255.7,  LL 15400
     *     249.7,243.7,237.7,231.7,225.7,219.7,219.2,218.7,218.2,217.7,  LL 15410
     *     217.2,216.7,216.2,215.7,215.2,215.2,215.2,215.2,215.2,215.2,  LL 15420
     *     215.2,217.4,227.8,243.2,258.5,265.7,230.7,210.2,210.0/        LL 15430
      DATA           T04                /287.0,282.0,276.0,271.0,266.0,  LL 15440
     *     260.0,253.0,246.0,239.0,232.0,225.0,225.0,225.0,225.0,225.0,  LL 15450
     *     225.0,225.0,225.0,225.0,225.0,225.0,225.0,225.0,225.0,226.0,  LL 15460
     *     228.0,235.0,247.0,262.0,274.0,277.0,216.0,210.0,210.0/        LL 15470
      DATA           T05                /257.1,259.1,255.9,252.7,247.7,  LL 15480
     *     240.9,234.1,227.3,220.6,217.2,217.2,217.2,217.2,217.2,217.2,  LL 15490
     *     217.2,216.6,216.0,215.4,214.8,214.1,213.6,213.0,212.4,211.8,  LL 15500
     *     211.2,216.0,222.2,234.7,247.0,259.3,245.7,210.0,210.0/        LL 15510
      DATA           T06                /288.1,281.6,275.1,268.7,262.2,  LL 15520
     *     255.7,249.2,242.7,236.2,229.7,223.2,216.8,216.6,216.6,216.6,  LL 15530
     *     216.6,216.6,216.6,216.6,216.6,216.6,217.6,218.6,219.6,220.6,  LL 15540
     *     221.6,226.5,236.5,253.4,264.2,270.6,219.7,210.0,210.0/        LL 15550
C                                                                        LL 15560
C                                                                        LL 15570
C                                                                        LL 15580
C     DATA   T07 /34*0.0/                                                LL 15590
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C                                                                         LL 15600
C                                                                         LL 15610
C *** WATER VAPOR DENSITY (GM.M-3) AT LEVEL I FOR THE MODEL ATMOSPHERES   LL 15620
C                                                                         LL 15630
      DATA          WH01                /1.9E+01,1.3E+01,9.3E+00,         LL 15640
     *    4.7E+00,2.2E+00,1.5E+00,8.5E-01,4.7E-01,2.5E-01,1.2E-01,        LL 15650
     *    5.0E-02,1.7E-02,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,        LL 15660
     *    5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,        LL 15670
     *    6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,        LL 15680
     *   1.4E-07,1.0E-09,0.0E+00/                                         LL 15690
      DATA          WH02                /1.4E+01,9.3E+00,5.9E+00,         LL 15700
     *    3.3E+00,1.9E+00,1.0E+00,6.1E-01,3.7E-01,2.1E-01,1.2E-01,        LL 15710
     *    6.4E-02,2.2E-02,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,        LL 15720
     *    5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,        LL 15730
     *    6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,        LL 15740
     *    1.4E-07,1.0E-09,0.0E+00/                                        LL 15750
      DATA          WH03                /3.5E+00,2.5E+00,1.8E+00,         LL 15760
     *    1.2E+00,6.6E-01,3.8E-01,2.1E-01,8.5E-02,3.5E-02,1.6E-02,        LL 15770
     *    7.5E-03,6.9E-03,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,        LL 15780
     *    5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,        LL 15790
     *    6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,        LL 15800
     *    1.4E-07,1.0E-09,0.0E+00/                                        LL 15810
      DATA          WH04                /9.1E+00,6.0E+00,4.2E+00,         LL 15820
     *    2.7E+00,1.7E+00,1.0E+00,5.4E-01,2.9E-01,1.3E-01,4.2E-02,        LL 15830
     *    1.5E-02,9.4E-03,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,        LL 15840
     *    5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,        LL 15850
     *    6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,        LL 15860
     *    1.4E-07,1.0E-09,0.0E+00/                                        LL 15870
      DATA          WH05                /1.2E+00,1.2E+00,9.4E-01,         LL 15880
     *    6.8E-01,4.1E-01,2.0E-01,9.8E-02,5.4E-02,1.1E-02,8.4E-03,        LL 15890
     *    5.5E-03,3.8E-03,2.6E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,        LL 15900
     *    5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,        LL 15910
     *    6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,        LL 15920
     *    1.4E-07,1.0E-09,0.0E+00/                                        LL 15930
      DATA          WH06                /5.9E+00,4.2E+00,2.9E+00,         LL 15940
     *    1.8E+00,1.1E+00,6.4E-01,3.8E-01,2.1E-01,1.2E-01,4.6E-02,        LL 15950
     *    1.8E-02,8.2E-03,3.7E-03,1.8E-03,8.4E-04,7.2E-04,6.1E-04,        LL 15960
     *    5.2E-04,4.4E-04,4.4E-04,4.4E-04,4.8E-04,5.2E-04,5.7E-04,        LL 15970
     *    6.1E-04,6.6E-04,3.8E-04,1.6E-04,6.7E-05,3.2E-05,1.2E-05,        LL 15980
     *    1.5E-07,1.0E-09,0.0E+00/                                        LL 15990
C                                                                         LL 16000
C                                                                         LL 16010
C     DATA   WH07 /34*0.0/                                                LL 16020
C                                                                         LL 16030
C                                                                         LL 16040
C                                                                         LL 16050
C *** OZONE DENSITY (GM.M-3) AT LEVEL I FOR THE MODEL ATMOSPHERES         LL 16060
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C                                                                       LL 16070
      DATA         W001               /5.6E-05,5.6E-05,5.4E-05,         LL 16080
     *   5.1E-05,4.7E-05,4.5E-05,4.3E-05,4.1E-05,3.9E-05,3.9E-05,       LL 16090
     *   3.9E-05,4.1E-05,4.3E-05,4.5E-05,4.5E-05,4.7E-05,4.7E-05,       LL 16100
     *   6.9E-05,9.0E-05,1.4E-04,1.9E-04,2.4E-04,2.8E-04,3.2E-04,       LL 16110
     *   3.4E-04,3.4E-04,2.4E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,       LL 16120
     *   8.6E-08,4.3E-11,0.0E+00/                                       LL 16130
      DATA         W002               /6.0E-05,6.0E-05,6.0E-05,         LL 16140
     *   6.2E-05,6.4E-05,6.6E-05,6.9E-05,7.5E-05,7.9E-05,8.6E-05,       LL 16150
     *   9.0E-05,1.1E-04,1.2E-04,1.5E-04,1.8E-04,1.9E-04,2.1E-04,       LL 16160
     *   2.4E-04,2.8E-04,3.2E-04,3.4E-04,3.6E-04,3.6E-04,3.4E-04,       LL 16170
     *   3.2E-04,3.0E-04,2.0E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,       LL 16180
     *   8.6E-06,4.3E-11,0.0E+00/                                       LL 16190
      DATA         W003               /6.0E-05,5.4E-05,4.9E-05,         LL 16200
     *   4.9E-05,4.9E-05,5.8E-05,6.4E-05,7.7E-05,9.0E-05,1.2E-04,       LL 16210
     *   1.6E-04,2.1E-04,2.6E-04,3.0E-04,3.2E-04,3.4E-04,3.6E-04,       LL 16220
     *   3.9E-04,4.1E-04,4.3E-04,4.5E-04,4.3E-04,4.3E-04,3.9E-04,       LL 16230
     *   3.6E-04,3.4E-04,1.9E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,       LL 16240
     *   8.6E-08,4.3E-11,0.0E+00/                                       LL 16250
      DATA         W004               /4.9E-05,5.4E-05,5.6E-05,         LL 16260
     *   5.8E-05,6.0E-05,6.4E-05,7.1E-05,7.5E-05,7.9E-05,1.1E-04,       LL 16270
     *   4.3E-04,1.8E-04,2.1E-04,2.6E-04,2.8E-04,3.2E-04,3.4E-04,       LL 16280
     *   3.9E-04,4.1E-04,4.1E-04,3.9E-04,3.6E-04,3.2E-04,3.0E-04,       LL 16290
     *   2.8E-04,2.6E-04,1.4E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,       LL 16300
     *   8.6E-08,4.3E-11,0.0E+00/                                       LL 16310
      DATA         W005               /4.1E-05,4.1E-05,4.1E-05,         LL 16320
     *   4.3E-05,4.5E-05,4.7E-05,4.9E-05,7.1E-05,9.0E-05,1.6E-04,       LL 16330
     *   2.4E-04,3.2E-04,4.3E-04,4.7E-04,4.9E-04,5.6E-04,6.2E-04,       LL 16340
     *   6.2E-04,6.2E-04,6.CE-04,5.6E-04,5.1E-04,4.7E-04,4.3E-04,       LL 16350
     *   3.6E-04,3.2E-04,1.5E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,       LL 16360
     *   8.6E-08,4.3E-11,0.0E+00/                                       LL 16370
      DATA         W006               /5.4E-05,5.4E-05,5.4E-05,         LL 16380
     *   5.0E-05,4.6E-05,4.6E-05,4.5E-05,4.9E-05,5.2E-05,7.1E-05,       LL 16390
     *   9.0E-05,1.3E-04,1.6E-04,1.7E-04,1.9E-04,2.1E-04,2.4E-04,       LL 16400
     *   2.8E-04,3.2E-04,3.5E-04,3.8E-04,3.8E-04,3.9E-04,3.8E-04,       LL 16410
     *   3.6E-04,3.4E-04,2.0E-04,1.1E-04,4.9E-05,1.7E-05,4.0E-06,       LL 16420
     *   8.6E-08,4.3E-11,0.0E+00/                                       LL 16430
C                                                                       LL 16440
C                                                                       LL 16450
C     DATA   W007 /34*0.0/                                              LL 16460
C                                                                       LL 16470
C                                                                       LL 16480
C *** SPECTRAL DATA'  AEROSOLS                                          LL 16490
C                                                                       LL 16500
C *** AVERAGE CONTINENTAL AEROSCL MODEL                                 LL 16510
C                                                                       LL 16520
      DATA     VX01                  /0.20,0.25,0.31,0.34,0.49,LL 16530
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     *      0.51, 0.63, 0.69, 0.86, 1.06, 1.54, 2.00, 2.50, 2.70, 3.00,LL 16540
     *      3.20, 3.39, 3.50, 3.75, 4.00, 4.50, 5.50, 6.00, 6.50, 7.20,LL 16550
     *      7.90, 8.20, 8.50, 8.70, 9.00, 9.20, 9.50,10.00,10.59,11.00,LL 16560
     *     13.00,14.80,15.00,17.20,18.50,20.00,25.00,27.90,30.00, 0.00/LL 16570
C                                                                      LL 16580
C *** RURAL AEROSOL MODEL                                              LL 16590
C                                                                      LL 16600
      DATA  VX02                         /0.20, 0.25, 0.30, 0.40, 0.48,LL 16610
     *      0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16620
     *      3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16630
     *      9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16640
     *     14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.00, 0.00/LL 16650
C                                                                      LL 16660
C *** URBAN AEROSOL MCDEL                                              LL 16670
C                                                                      LL 16680
      DATA  VX03                         /0.20, 0.25, 0.30, 0.40, 0.49,LL 16690
     *      0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16700
     *      3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16710
     *      9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16720
     *     14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.00, 0.00/LL 16730
C                                                                      LL 16740
C *** MARITIME AEROSCI MODEL                                           LL 16750
C                                                                      LL 16760
      DATA  VX04                         /0.20, 0.25, 0.30, 0.40, 0.49,LL 16770
     *      0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16780
     *      3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16790
     *      9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16800
     *     14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.0, 0.00/ LL 16810
C                                                                      LL 16820
C *** TRANSMITTANCE FUNCTIONS                                          LL 16830
C                                                                      LL 16840
      DATA            TR /0.999,0.998,0.996,0.994,0.992,0.990,0.980,   LL 16850
     *   0.970,0.960,0.950,0.940,0.930,0.920,0.910,0.900,0.880,0.860,   LL 16860
     *   0.840,0.820,0.800,0.780,0.760,0.740,0.720,0.700,0.680,0.660,   LL 16870
     *   0.640,0.620,0.600,0.580,0.560,0.540,0.520,0.500,0.480,0.460,   LL 16880
     *   0.440,0.420,0.400,0.380,0.360,0.340,0.320,0.300,0.280,0.260,   LL 16890
     *   0.240,0.220,0.200,0.180,0.160,0.140,0.120,0.100,0.080,0.060,   LL 16900
     *   0.040,0.030,0.020,0.015,0.010,0.008,0.006,0.004,0.002,0.001/   LL 16910
C                                                                      LL 16920
C *** TRANSMITTANCE FUNCTION FOR H2O                                   LL 16930
C                                                                      LL 16940
      DATA            FW      /-2.3468,-2.0362,-1.6990,-1.4815,-1.3279,LL 16950
     *  -1.2007,-0.7825,-0.5229,-0.3468,-0.1938, 0.0655, 0.0414, 0.1553,LL 16960
     *   0.2430, 0.3324, 0.4342, 0.6128, 0.7243, 0.8261, 0.9191, 1.0000,LL 16970
     *   1.0792, 1.1461, 1.2122, 1.2672, 1.3284, 1.3892, 1.4409, 1.4955,LL 16980
     *   1.5441, 1.5966, 1.6435, 1.6857, 1.7340, 1.7782, 1.8261, 1.8692,LL 16990
     *   1.9191, 1.9638, 2.0086, 2.0607, 2.1038, 2.1461, 2.1875, 2.2304,LL 17000
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     *   2.2788, 2.3263, 2.3717, 2.4183, 2.4698, 2.5159, 2.5740, 2.6284,LL 17010
     *   2.6952, 2.7559, 2.8261, 2.9031, 3.0000, 3.0607, 3.1461, 3.2041,LL 17020
     *   3.2718, 3.3054, 3.3444, 3.3979, 3.4914, 3.5682/                LL 17030
C                                                                       LL 17040
C *** TRANSMITTANCE FUNCTION FOR OZONE                                  LL 17050
C                                                                       LL 17060
      DATA         FO      /-1.6778,-1.3980,-1.1192,-0.9508,-0.8239,LL 17070
     *  -0.7258,-0.4318,-0.2366,-0.1074,-0.0000, 0.0969, 0.1761, 0.2304,LL 17080
     *   0.3010, 0.3522, 0.4624, 0.5563, 0.6435, 0.7243, 0.7924, 0.8573,LL 17090
     *   0.9191, 0.9731, 1.0253, 1.0719, 1.1173, 1.1614, 1.2095, 1.2480,LL 17100
     *   1.2900, 1.3263, 1.3617, 1.3979, 1.4393, 1.4698, 1.4983, 1.5314,LL 17110
     *   1.5682, 1.6021, 1.6335, 1.6721, 1.7076, 1.7482, 1.7924, 1.8325,LL 17120
     *   1.8865, 1.9395, 2.0000, 2.0607, 2.1206, 2.1903, 2.2552, 2.3385,LL 17130
     *   2.4313, 2.5185, 2.6435, 2.7853, 2.9777, 3.1072, 3.2553, 3.3617,LL 17140
     *   3.4771, 3.5563, 3.6233, 3.7076, 3.8325, 3.9345/                LL 17150
C                                                                       LL 17160
C *** SPECTRAL DATA' H2O                                                LL 17170
C                                                                       LL 17180
      DATA     C101                                                     LL 17190
     *  / 3.93, 3.72, 3.54, 3.42, 3.37, 3.37, 3.36, 3.33, 3.25, 3.13,   LL 17200
     *    3.02, 2.96, 2.97, 3.00, 3.08, 3.12, 3.08, 3.03, 3.00, 3.01,   LL 17210
     *    3.03, 3.07, 3.05, 3.01, 2.94, 2.83, 2.71, 2.62, 2.58, 2.57,   LL 17220
     *    2.62, 2.67, 2.72, 2.71, 2.60, 2.46, 2.35, 2.26, 2.22, 2.23,   LL 17230
     *    2.19, 2.17, 2.17, 2.20, 2.26, 2.34, 2.42, 2.39, 2.20, 2.01,   LL 17240
     *    1.92, 1.83, 1.78, 1.79, 1.81, 1.84, 1.83, 1.80, 1.71, 1.51,   LL 17250
     *    1.39, 1.30, 1.25, 1.18, 1.19, 1.18, 1.21, 1.33, 1.47, 1.53,   LL 17260
     *    1.54, 1.36, 1.12, 0.89, 0.69, 0.49, 0.60, 0.71, 0.79, 0.99,   LL 17270
     *    0.86, 0.73, 0.53, 0.43, 0.51, 0.52, 0.67, 0.73, 0.80, 0.83,   LL 17280
     *    0.80, 0.63, 0.47, 0.32,-0.08,-0.21,-0.29,-0.21,-0.01, 0.08,   LL 17290
     *    0.16, 0.09,-0.03,-0.21,-0.37,-0.35,-0.30,-0.31,-0.37,-0.42,   LL 17300
     *   -0.48,-0.42,-0.40,-0.39,-0.43,-0.77,-0.83,-0.88,-0.79,-0.60,   LL 17310
     *   -0.50,-0.42,-0.39,-0.38,-0.37,-0.40,-0.51,-0.67,-0.82,-0.58,   LL 17320
     *   -0.40,-0.32,-0.21,-0.09,-0.18,-0.16,-0.19,-0.28,-0.33,-0.35,   LL 17330
     *   -0.28,-0.22,-0.10,-0.05,-0.11,-0.13,-0.27,-0.27,-0.18,-0.06,   LL 17340
     *    0.11, 0.23, 0.26, 0.19, 0.11,-0.00,-0.09, 0.02, 0.08, 0.12,   LL 17350
     *    0.22, 0.28, 0.39, 0.54, 0.68, 0.75, 0.79, 0.79, 0.71, 0.69,   LL 17360
     *    0.76, 0.88, 1.01, 1.16, 1.18, 1.14, 1.05, 1.02, 1.11, 1.23,   LL 17370
     *    1.41, 1.75, 1.83, 1.99, 2.05, 2.03, 2.00, 1.96, 1.90, 1.86/   LL 17380
C                                                                       LL 17390
      DATA     C102                                                     LL 17400
     *  / 1.91, 2.08, 2.24, 2.41, 2.63, 2.68, 2.67, 2.73, 2.79, 2.81,   LL 17410
     *    2.91, 2.93, 3.02, 3.16, 3.23, 3.30, 3.34, 3.43, 3.57, 3.59,   LL 17420
     *    3.59, 3.58, 3.57, 3.61, 3.71, 3.71, 3.69, 3.64, 3.60, 3.68,   LL 17430
     *    3.80, 3.95, 4.05, 4.05, 4.02, 3.99, 3.96, 4.01, 4.13, 4.22,   LL 17440
     *    4.35, 4.40, 4.58, 4.62, 4.63, 4.61, 4.57, 4.56, 4.56, 4.53,   LL 17450
     *    4.49, 4.48, 4.40, 4.20, 4.14, 3.92, 3.63, 3.35, 3.16, 3.10,   LL 17460
     *    3.24, 3.47, 3.66, 3.80, 3.93, 4.00, 4.04, 4.15, 4.23, 4.31,   LL 17470
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     *    4.35, 4.31, 4.23, 4.20, 4.24, 4.28, 4.35, 4.42, 4.42, 4.44,  LL 17480
     *    4.46, 4.40, 4.30, 4.22, 4.13, 4.07, 4.12, 4.19, 4.22, 4.23,  LL 17490
     *    4.16, 4.04, 3.99, 3.94, 3.93, 3.91, 3.86, 3.83, 3.80, 3.78,  LL 17500
     *    3.70, 3.54, 3.40, 3.30, 3.31, 3.42, 3.52, 3.52, 3.49, 3.41,  LL 17510
     *    3.21, 3.14, 3.10, 3.08, 3.11, 2.98, 2.88, 2.78, 2.74, 2.76,  LL 17520
     *    2.72, 2.76, 2.82, 2.85, 2.86, 2.75, 2.64, 2.60, 2.61, 2.64,  LL 17530
     *    2.56, 2.49, 2.37, 2.25, 2.14, 2.08, 2.11, 2.20, 2.31, 2.28,  LL 17540
     *    2.15, 2.06, 1.98, 2.03, 2.05, 1.96, 1.84, 1.72, 1.64, 1.59,  LL 17550
     *    1.57, 1.57, 1.60, 1.63, 1.51, 1.38, 1.07, 0.91, 0.87, 0.92,  LL 17560
     *    1.04, 1.01, 0.92, 0.84, 0.92, 0.97, 1.01, 1.06, 1.10, 1.06,  LL 17570
     *    1.01, 0.91, 0.79, 0.55, 0.47, 0.41, 0.39, 0.38, 0.34, 0.33,  LL 17580
     *    0.36, 0.43, 0.48, 0.45, 0.38, 0.27, 0.21, 0.22, 0.29, 0.37/  LL 17590
C                                                                      LL 17600
      DATA     C103                                                    LL 17610
     *  / 0.38, 0.37, 0.29, 0.19, 0.13, 0.11, 0.03,-0.05,-0.12,-0.24,  LL 17620
     *   -0.31,-0.39,-0.43,-0.50,-0.59,-0.68,-0.73,-0.80,-0.92,-1.06,  LL 17630
     *   -1.14,-1.22,-1.27,-1.28,-1.33,-1.32,-1.43,-1.51,-1.63,-1.74,  LL 17640
     *   -1.82,-1.98,-2.09,-2.21,-2.21,-2.24,-2.27,-2.36,-2.51,-2.65,  LL 17650
     *   -2.70,-2.63,-2.57,-2.56,-2.59,-2.67,-2.69,-2.67,-2.68,-2.62,  LL 17660
     *   -2.52,-2.42,-2.29,-2.14,-2.00,-1.87,-1.71,-1.51,-1.39,-1.27,  LL 17670
     *   -1.12,-1.01,-0.89,-0.75,-0.68,-0.57,-0.47,-0.42,-0.32,-0.27,  LL 17680
     *   -0.26,-0.19,-0.13,-0.11,-0.01, 0.05, 0.08, 0.17, 0.25, 0.31,  LL 17690
     *    0.41, 0.43, 0.44, 0.43, 0.36, 0.35, 0.31, 0.25, 0.25, 0.22,  LL 17700
     *    0.21, 0.33, 0.49, 0.65, 0.76, 0.71, 0.51, 0.30, 0.13, 0.10,  LL 17710
     *    0.17, 0.24, 0.31, 0.38, 0.45, 0.51, 0.56, 0.60, 0.63, 0.62,  LL 17720
     *    0.63, 0.64, 0.66, 0.69, 0.76, 0.75, 0.74, 0.70, 0.62, 0.53,  LL 17730
     *    0.46, 0.39, 0.38, 0.37, 0.38, 0.42, 0.47, 0.50, 0.58, 0.69,  LL 17740
     *    0.67, 0.62, 0.64, 0.68, 0.76, 0.90, 1.11, 1.13, 1.10, 0.97,  LL 17750
     *    0.98, 1.17, 1.38, 1.52, 1.70, 1.76, 1.84, 1.92, 1.90, 1.87,  LL 17760
     *    1.91, 2.02, 2.13, 2.10, 2.18, 2.22, 2.25, 2.03, 2.01, 1.77,  LL 17770
     *    1.93, 2.19, 2.28, 2.14, 2.15, 2.22, 2.01, 2.14, 2.26, 2.36,  LL 17780
     *    2.51, 2.66, 2.73, 2.68, 2.69, 2.64, 2.22, 1.95, 1.61, 1.11,  LL 17790
     *    0.88, 0.83, 0.89, 1.20, 1.62, 1.82, 1.99, 2.01, 2.14, 2.16/  LL 17800
C                                                                      LL 17810
      DATA     C104                                                    LL 17820
     *  / 2.21, 2.30, 2.33, 2.42, 2.50, 2.51, 2.49, 2.46, 2.42, 2.37,  LL 17830
     *    2.37, 2.33, 2.31, 2.43, 2.56, 2.61, 2.63, 2.60, 2.50, 2.38,  LL 17840
     *    2.41, 2.34, 2.31, 2.32, 2.40, 2.27, 2.32, 2.22, 2.09, 2.08,  LL 17850
     *    2.17, 2.41, 2.77, 2.68, 2.49, 2.29, 2.23, 2.42, 2.61, 2.58,  LL 17860
     *    2.49, 2.40, 2.39, 2.51, 2.60, 2.68, 2.68, 2.70, 2.82, 2.83,  LL 17870
     *    2.82, 2.81, 2.84, 2.86, 2.91, 2.96, 3.03, 3.08, 3.21, 3.30,  LL 17880
     *    3.40, 3.52, 3.49, 3.46, 3.51, 3.54, 3.56, 3.55, 3.57, 3.61,  LL 17890
     *    3.71, 3.80, 3.92, 3.99, 4.06, 4.02, 4.06, 4.12, 4.28, 4.30,  LL 17900
     *    4.22, 4.32, 4.42, 4.53, 4.64, 4.55, 4.40, 4.28, 4.32, 4.38,  LL 17910
     *    4.37, 4.24, 4.13, 4.14, 4.20, 4.25, 4.32, 4.35, 4.31, 4.27,  LL 17920
     *    4.25, 4.27, 4.31, 4.36, 4.41, 4.52, 4.59, 4.71, 4.79, 4.81,  LL 17930
     *    4.73, 4.61, 4.42, 4.28, 4.08, 4.00, 3.88, 3.86, 3.92, 3.98,  LL 17940
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     *    4.12, 4.18, 4.31, 4.37, 4.42, 4.50, 4.53, 4.58, 4.59, 4.61,    LL 17950
     *    4.61, 4.59, 4.53, 4.49, 4.44, 4.41, 4.40, 4.34, 4.30, 4.26,    LL 17960
     *    4.09, 3.98, 3.87, 3.78, 3.77, 3.79, 3.75, 3.72, 3.62, 3.56,    LL 17970
     *    3.51, 3.48, 3.32, 3.18, 3.07, 2.96, 2.87, 2.80, 2.68, 2.58,    LL 17980
     *    2.59, 2.51, 2.59, 2.57, 2.50, 2.42, 2.32, 2.20, 2.12, 2.00,    LL 17990
     *    1.92, 1.79, 1.63, 1.60, 1.69, 1.78, 2.04, 2.00, 1.81, 1.70,    LL 18000
     *    1.63, 1.61, 1.60, 1.49, 1.14, 1.35, 1.64, 1.69, 1.70, 1.59/    LL 18010
C                                                                       LL 18020
      DATA     C105                                                     LL 18030
     *  / 1.45, 1.29, 1.19, 1.08, 1.02, 1.04, 1.10, 1.16, 1.20, 1.23,    LL 18040
     *    1.22, 1.08, 1.08, 1.06, 0.89, 0.93, 0.73, 0.58, 0.54, 0.77,    LL 18050
     *    0.81, 0.74, 0.71, 0.57, 0.49, 0.43, 0.38, 0.12, 0.10, 0.20,    LL 18060
     *    0.41, 0.37, 0.31, 0.11,-0.13,-0.21,-0.32,-0.36,-0.39,-0.33,    LL 18070
     *   -0.39,-0.45,-0.50,-0.56,-0.62,-0.68,-0.77,-0.84,-0.91,-1.00,    LL 18080
     *   -1.11,-1.19,-1.28,-1.31,-1.39,-1.43,-1.48,-1.52,-1.57,-1.60,    LL 18090
     *   -1.61,-1.60,-1.58,-1.51,-1.42,-1.32,-1.26,-1.16,-1.00,-0.83,    LL 18100
     *   -0.71,-0.61,-0.52,-0.43,-0.36,-0.30,-0.21,-0.19,-0.17,-0.15,    LL 18110
     *   -0.13,-0.17,-0.19,-0.12,-0.06,-0.01, 0.00,-0.11,-0.23,-0.32,    LL 18120
     *   -0.44,-0.51,-0.48,-0.47,-0.42,-0.40,-0.40,-0.39,-0.37,-0.35,    LL 18130
     *   -0.48,-0.75,-1.13,-1.58,-1.80,-1.66,-1.52,-1.35,-1.19,-1.02,    LL 18140
     *   -0.88,-0.66,-0.65,-0.63,-0.62,-0.66,-0.73,-0.79,-0.88,-0.84,    LL 18150
     *   -0.70,-0.59,-0.43,-0.39,-0.50,-0.61,-0.74,-0.79,-0.76,-0.69,    LL 18160
     *   -0.62,-0.59,-0.52,-0.48,-0.48,-0.42,-0.39,-0.38,-0.33,-0.29,    LL 18170
     *   -0.26,-0.23,-0.22,-0.28,-0.37,-0.50,-0.60,-0.60,-0.51,-0.46,    LL 18180
     *   -0.42,-0.43,-0.45,-0.35,-0.24,-0.14,-0.08,-0.08, 0.00, 0.11,    LL 18190
     *    0.32, 0.43, 0.42, 0.32, 0.23, 0.22, 0.28, 0.45, 0.55, 0.62,    LL 18200
     *    0.65, 0.71, 0.75, 0.80, 0.83, 0.85, 0.87, 0.90, 0.93, 1.00,    LL 18210
     *    1.04, 1.15, 1.22, 1.32, 1.31, 1.32, 1.33, 1.48, 1.78, 1.87/    LL 18220
C                                                                       LL 18230
      DATA     C106                                                     LL 18240
     *  / 2.01, 1.92, 1.86, 1.89, 1.92, 1.98, 2.03, 2.39, 2.31, 2.48,    LL 18250
     *    2.70, 2.71, 2.76, 2.78, 2.70, 2.77, 3.08, 2.94, 3.05, 2.94,    LL 18260
     *    3.23, 3.20, 3.19, 3.32, 3.11, 3.41, 3.31, 3.36, 3.46, 3.36,    LL 18270
     *    3.39, 3.50, 3.41, 3.22, 3.19, 2.98, 2.78, 2.98, 3.02, 2.82,    LL 18280
     *    2.98, 2.86, 2.92, 2.92, 3.05, 3.22, 3.60, 3.78, 3.81, 3.96,    LL 18290
     *    3.76, 3.62, 3.34, 3.08, 3.31, 3.16, 3.37, 3.41, 3.30, 3.33,    LL 18300
     *    3.33, 3.51, 3.48, 3.43, 3.52, 3.31, 3.40, 3.58, 3.61, 3.49,    LL 18310
     *    3.46, 3.42, 3.19, 3.18, 3.30, 3.00, 2.99, 3.21, 3.11, 3.14,    LL 18320
     *    3.10, 2.72, 2.81, 2.95, 2.69, 2.73, 2.72, 2.47, 2.51, 2.60,    LL 18330
     *    2.42, 2.37, 2.73, 1.91, 1.87, 1.81, 1.78, 1.53, 1.51, 1.62,    LL 18340
     *    1.59, 1.50, 1.42, 1.32, 1.22, 1.12, 1.08, 1.02, 0.97, 0.92,    LL 18350
     *    0.90, 0.87, 0.84, 0.82, 0.79, 0.78, 0.76, 0.75, 0.72, 0.71,    LL 18360
     *    0.71, 0.70, 0.69, 0.67, 0.61, 0.59, 0.52, 0.48, 0.41, 0.39,    LL 18370
     *    0.38, 0.33, 0.32, 0.30, 0.30, 0.30, 0.29, 0.28, 0.27, 0.26,    LL 18380
     *    0.25, 0.23, 0.22, 0.21, 0.20, 0.18, 0.14, 0.13, 0.06, 0.01,    LL 18390
     *   -0.03,-0.07,-0.11,-0.16,-0.21,-0.24,-0.29,-0.32,-0.38,-0.41,    LL 18400
     *   -0.45,-0.50,-0.54,-0.61,-0.69,-0.76,-0.84,-0.90,-0.97,-1.01,    LL 18410
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     *    -1.10,-1.13,-1.19,-1.22,-1.28,-1.30,-1.33,-1.36,-1.39,-1.43,    LL 18420
     *    -1.48,-1.50,-1.52,-1.57,-1.61,-1.66,-1.70,-1.72,-1.78,-1.81/    LL 18430
C                                                                         LL 18440
      DATA      C107                                                      LL 18450
     *   /-1.89,-1.92,-2.00,-2.08,-2.16,-2.24,-2.31,-2.40,-2.48,-2.54,    LL 18460
     *    -2.61,-2.71,-2.83,-2.95,-3.10,-5.00,50.00,-5.00,-5.00,-5.00,    LL 18470
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18480
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18490
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18500
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18510
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18520
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18530
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18540
     *    -3.78,-3.33,-3.01,-2.82,-2.68,-2.49,-2.30,-2.13,-2.00,-1.81,    LL 18550
     *    -1.60,-1.41,-1.13,-0.90,-0.79,-0.63,-0.48,-0.36,-0.28,-0.16,    LL 18560
     *    -0.06, 0.08, 0.20, 0.28, 0.41, 0.54, 0.69, 0.80, 0.92, 1.04,    LL 18570
     *     1.19, 1.19, 1.01, 0.98, 1.02, 1.19, 1.29, 1.30, 1.29, 1.38,    LL 18580
     *     1.19, 1.39, 1.42, 1.43, 1.70, 1.62, 1.54, 1.41, 1.53, 1.86,    LL 18590
     *     1.96, 1.97, 2.02, 2.01, 1.94, 1.94, 1.83, 2.03, 2.21, 2.42,    LL 18600
     *     2.30, 2.16, 2.02, 2.02, 2.02, 2.13, 1.90, 1.71, 2.01, 1.56,    LL 18610
     *     1.56, 1.51, 1.30, 1.63, 1.64, 1.67, 1.70, 2.22, 2.39, 2.38,    LL 18620
     *     2.30, 1.93, 2.39, 2.49, 2.52, 2.57, 2.21, 2.18, 2.40, 2.41,    LL 18630
     *     2.45, 2.51, 2.23, 2.49, 2.30, 2.61, 2.72, 2.52, 2.63, 2.56/    LL 18640
C                                                                         LL 18650
      DATA      C108                                                      LL 18660
     *   / 2.51, 2.70, 2.62, 2.62, 2.80, 2.74, 2.79, 2.74, 2.70, 2.88,    LL 18670
     *     2.81, 2.72, 2.76, 2.84, 2.92, 2.98, 2.88, 2.88, 3.02, 3.08,    LL 18680
     *     3.26, 3.03, 3.14, 3.28, 3.03, 3.11, 3.15, 3.30, 3.31, 3.22,    LL 18690
     *     3.00, 3.06, 3.34, 3.40, 3.37, 3.32, 3.08, 3.09, 3.09, 3.01,    LL 18700
     *     3.07, 3.07, 3.31, 3.21, 3.31, 3.67, 3.58, 3.79, 3.70, 3.49,    LL 18710
     *     3.39, 3.11, 3.13, 3.01, 3.10, 3.01, 3.18, 3.32, 3.43, 3.35,    LL 18720
     *     3.40, 3.39, 3.39, 3.51, 3.54, 3.42, 3.50, 3.67, 3.59, 3.63,    LL 18730
     *     3.66, 3.48, 3.39, 3.29, 3.31, 3.41, 3.23, 3.32, 3.12, 2.91,    LL 18740
     *     2.91, 2.75, 2.78, 2.72, 2.62, 2.58, 2.32, 2.22, 2.00, 1.97,    LL 18750
     *     1.68, 1.62, 1.64, 1.53, 1.56, 1.51, 1.52, 1.48, 1.42, 1.42,    LL 18760
     *     1.40, 1.41, 1.43, 1.56, 1.52, 1.51, 1.52, 1.39, 1.39, 1.30,    LL 18770
     *     1.09, 1.16, 1.21, 1.20, 1.22, 1.20, 1.18, 1.20, 1.19, 1.17,    LL 18780
     *     1.10, 1.10, 1.09, 1.10, 1.11, 1.04, 0.98, 0.90, 0.86, 0.90,    LL 18790
     *     0.90, 0.90, 0.86, 0.71, 0.79, 0.70, 0.71, 0.67, 0.62, 0.53,    LL 18800
     *     0.42, 0.31, 0.20, 0.01,-0.08,-0.17,-0.26,-0.35,-0.44,-0.53,    LL 18810
     *    -0.63,-0.73,-0.83,-0.93,-1.04,-1.14,-1.24,-1.34,-1.44,-1.54,    LL 18820
     *    -1.64,-1.74,-1.84,-1.94,-2.04,-2.14,-2.24,-2.34,-2.44,-2.54,    LL 18830
     *    -2.64,-2.74,-2.84,-2.94,-3.04,-3.14,-3.24,-3.34,-3.44,-3.54,    LL 18840
     *    -3.64,-3.74,-3.84,-3.94,-4.04,-5.00,-5.00,-5.00,-5.00,-5.00/    LL 18850
C                                                                         LL 18860
      DATA      C109                                                      LL 18870
     *   /-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18880
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     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18890
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18900
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18910
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18920
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18930
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 18940
     *    -4.15,-4.06,-3.97,-3.88,-3.79,-3.70,-3.61,-3.52,-3.43,-3.34,     LL 18950
     *    -3.25,-3.16,-3.07,-2.98,-2.98,-2.80,-2.71,-2.62,-2.53,-2.44,     LL 18960
     *    -2.35,-2.26,-2.18,-2.09,-2.00,-1.91,-1.82,-1.73,-1.64,-1.55,     LL 18970
     *    -1.46,-1.37,-1.28,-1.19,-1.10,-1.01,-0.92,-0.83,-0.74,-0.65,     LL 18980
     *    -0.56,-0.47,-0.38,-0.29,-0.20,-0.14,-0.09,-0.02, 0.03, 0.10,     LL 18990
     *     0.17, 0.22, 0.30, 0.35, 0.41, 0.45, 0.42, 0.40, 0.43, 0.46,     LL 19000
     *     0.50, 0.59, 0.71, 0.84, 0.93, 1.01, 1.06, 1.07, 1.02, 1.01,     LL 19010
     *     1.12, 1.23, 1.24, 1.28, 1.34, 1.43, 1.52, 1.56, 1.59, 1.56,     LL 19020
     *     1.51, 1.61, 1.50, 1.70, 1.82, 1.92, 1.94, 1.89, 1.81, 1.45,     LL 19030
     *     1.30, 1.28, 1.43, 1.50, 1.49, 1.55, 1.48, 1.32, 1.39, 1.53,     LL 19040
     *     1.82, 2.23, 2.61, 2.51, 2.20, 1.86, 1.61, 1.19, 1.32, 1.52,     LL 19050
     *     1.70, 1.90, 2.01, 1.92, 1.91, 2.12, 2.10, 2.01, 2.18, 1.99/     LL 19060
C                                                                       LL 19070
      DATA     C110                                                     LL 19080
     *   / 2.11, 2.28, 2.21, 2.13, 2.00, 1.91, 1.92, 1.97, 1.88, 1.91,     LL 19090
     *     1.91, 1.92, 1.93, 1.74, 1.61, 1.58, 1.27, 1.20, 1.18, 1.11,     LL 19100
     *     0.99, 0.86, 0.71, 0.60, 0.44, 0.31, 0.19, 0.03,-0.07,-0.21,     LL 19110
     *    -0.35,-0.49,-0.64,-0.79,-0.94,-1.11,-1.24,-1.41,-1.57,-1.73,     LL 19120
     *    -1.91,-2.09,-2.27,-2.45,-2.63,-2.81,-2.99,-3.18,-3.37,-3.56,     LL 19130
     *    -3.75,-3.94,-4.13,-4.31,-4.49,-4.66,-4.83,-4.99,-5.14,-5.28,     LL 19140
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.68,-4.26,     LL 19150
     *    -3.89,-3.57,-3.32,-3.11,-2.91,-2.89,-2.79,-2.74,-2.63,-2.47,     LL 19160
     *    -2.29,-2.20,-2.17,-2.23,-2.27,-2.32,-2.12,-2.08,-2.07,-2.07,     LL 19170
     *    -2.07,-1.98,-1.77,-1.70,-1.63,-1.60,-1.59,-1.43,-1.21,-1.15,     LL 19180
     *    -1.09,-1.13,-1.29,-1.19,-0.98,-0.93,-0.87,-0.91,-0.88,-0.71,     LL 19190
     *    -0.62,-0.59,-0.58,-0.63,-0.58,-0.39,-0.22,-0.14,-0.06,-0.01,     LL 19200
     *    -0.01,-0.08,-0.20,-0.16,-0.02, 0.18, 0.32, 0.42, 0.37, 0.23,     LL 19210
     *     0.12, 0.15, 0.28, 0.43, 0.59, 0.58, 0.53, 0.44, 0.39, 0.38,     LL 19220
     *     0.35, 0.23, 0.26, 0.19, 0.08, 0.10, 0.18, 0.27, 0.38, 0.43,     LL 19230
     *     0.32, 0.37, 0.58, 0.64, 0.87, 0.98, 1.00, 1.02, 1.13, 1.08,     LL 19240
     *     1.08, 1.16, 1.16, 1.30, 1.41, 1.40, 1.32, 1.32, 1.37, 1.42,     LL 19250
     *     1.50, 1.42, 1.38, 1.36, 1.38, 1.49, 1.63, 1.62, 1.62, 1.70,     LL 19260
     *     1.68, 1.60, 1.56, 1.56, 1.63, 1.64, 1.56, 1.49, 1.49, 1.52/     LL 19270
C                                                                       LL 19280
      DATA     C111                                                     LL 19290
     *   / 1.58, 1.62, 1.62, 1.61, 1.61, 1.62, 1.63, 1.71, 1.72, 1.70,     LL 19300
     *     1.70, 1.67, 1.62, 1.66, 1.70, 1.67, 1.56, 1.49, 1.42, 1.38,     LL 19310
     *     1.26, 1.20, 1.13, 1.14, 1.19, 1.29, 1.50, 1.72, 1.86, 1.78,     LL 19320
     *     1.82, 1.88, 1.82, 1.89, 1.99, 2.00, 2.14, 2.04, 2.02, 2.02,     LL 19330
     *     1.98, 1.90, 1.83, 1.81, 1.72, 1.69, 1.59, 1.50, 1.36, 1.20,     LL 19340
     *     0.98, 0.63, 0.43, 0.29, 0.16, 0.05, 0.02, 0.03, 0.03, 0.01,     LL 19350
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     *    -0.08,-0.18,-0.20,-0.11,-0.06,-0.03,-0.14,-0.21,-0.08,-0.06,    LL 19360
     *     0.10, 0.18, 0.11, 0.32, 0.42, 0.44, 0.38, 0.28, 0.42, 0.43,    LL 19370
     *     0.41, 0.33, 0.32, 0.41, 0.50, 0.46, 0.31, 0.18, 0.08, 0.20,    LL 19380
     *     0.21, 0.34, 0.36, 0.28, 0.35, 0.39, 0.42, 0.38, 0.32, 0.30,    LL 19390
     *     0.16,-0.01,-0.23,-0.41,-0.52,-0.48,-0.58,-0.61,-0.48,-0.23,    LL 19400
     *    -0.03, 0.21, 0.36, 0.39, 0.47, 0.44, 0.40, 0.51, 0.59, 0.53,    LL 19410
     *     0.69, 0.57, 0.48, 0.52, 0.62, 0.59, 0.55, 0.50, 0.32, 0.26,    LL 19420
     *     0.11,-0.08,-0.10,-0.16,-0.43,-0.62,-0.88,-1.09,-1.16,-1.31,    LL 19430
     *    -1.45,-1.49,-1.78,-1.91,-2.01,-1.97,-1.97,-1.97,-1.97,-2.26,    LL 19440
     *    -2.20,-2.01,-1.99,-2.00,-2.04,-2.37,-2.49,-2.44,-2.35,-2.32,    LL 19450
     *    -2.19,-2.10,-2.25,-2.16,-2.36,-2.44,-2.40,-2.49,-2.48,-2.43,    LL 19460
     *    -2.40,-2.36,-2.40,-2.49,-2.59,-2.68,-2.89,-3.28,-3.51,-3.74,    LL 19470
     *    -2.97,-4.20,-4.43,-4.66,-4.89,-5.00,-5.00,-5.00,-5.00,-5.00/    LL 19480
C                                                                         LL 19490
      DATA     C112                                                       LL 19500
     *   /-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19510
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19520
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19530
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19540
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19550
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-3.71,-3.56,-3.40,-3.21,-3.06,    LL 19560
     *    -2.90,-2.74,-2.60,-2.46,-2.32,-2.17,-2.03,-1.87,-1.79,-1.74,    LL 19570
     *    -1.83,-1.82,-1.71,-1.59,-1.49,-1.46,-1.46,-1.49,-1.49,-1.25,    LL 19580
     *    -1.24,-1.08,-0.90,-1.06,-0.91,-0.91,-1.01,-0.99,-0.87,-0.92,    LL 19590
     *    -0.79,-0.42,-0.54,-0.38,-0.42,-0.48,-0.34,-0.27,-0.17,-0.28,    LL 19600
     *    -0.38,-0.22,-0.30,-0.08,-0.01,-0.20, 0.06, 0.10, 0.06, 0.14,    LL 19610
     *    -0.12,-0.02,-0.02,-0.13,-0.11,-0.10,-0.06,-0.05,-0.04,-0.10,    LL 19620
     *    -0.04,-0.06,-0.21,-0.38,-0.61,-0.40,-0.31,-0.42,-0.58,-0.57,    LL 19630
     *    -0.54,-0.24, 0.11, 0.51, 0.81, 0.79, 0.62, 0.26,-0.31,-0.67,    LL 19640
     *    -0.80,-0.88,-0.50,-0.39,-0.10, 0.09, 0.06, 0.08, 0.16, 0.21,    LL 19650
     *     0.13, 0.32, 0.35, 0.51, 0.60, 0.51, 0.51, 0.40, 0.40, 0.43,    LL 19660
     *     0.42, 0.33, 0.43, 0.34, 0.22, 0.13,-0.11,-0.31,-0.31,-0.41,    LL 19670
     *    -0.41,-0.39,-0.53,-0.69,-0.84,-0.88,-1.01,-1.10,-1.19,-1.29,    LL 19680
     *    -1.45,-1.49,-1.67,-1.67,-1.51,-1.66,-1.60,-1.69,-1.83,-1.51/    LL 19690
C                                                                         LL 19700
      DATA     C113                                                       LL 19710
     *   /-1.42,-1.40,-1.24,-1.38,-1.31,-1.30,-1.30,-1.28,-1.39,-1.33,    LL 19720
     *    -1.40,-1.35,-1.37,-1.39,-1.41,-1.49,-1.48,-1.56,-1.47,-1.46,    LL 19730
     *    -1.41,-1.42,-1.48,-1.41,-1.31,-1.15,-1.13,-1.20,-1.41,-1.88,    LL 19740
     *    -2.08,-2.08,-2.22,-2.35,-2.35,-1.98,-1.92,-1.78,-1.57,-1.69,    LL 19750
     *    -1.70,-1.70,-1.66,-1.84,-1.50,-1.56,-1.42,-1.29,-1.38,-1.28,    LL 19760
     *    -1.48,-1.58,-1.44,-1.53,-1.48,-1.48,-1.58,-1.58,-1.69,-1.79,    LL 19770
     *    -2.00,-2.16,-1.99,-2.23,-2.04,-2.04,-2.39,-2.74,-3.09,-3.44,    LL 19780
     *    -3.79,-4.14,-4.49,-4.84,-5.19,-2.46,-2.26,-1.99,-2.01,-2.14,    LL 19790
     *    -2.31,-2.15,-2.01,-1.99,-2.14,-2.41,-2.12,-1.99,-1.84,-1.79,    LL 19800
     *    -1.71,-1.78,-1.72,-1.68,-1.78,-1.52,-1.38,-1.29,-1.22,-0.91,    LL 19810
     *    -0.90,-1.01,-0.76,-0.90,-0.90,-0.90,-1.19,-1.00,-0.79,-0.68,    LL 19820
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     *   -0.68,-0.73,-0.85,-0.85,-0.61,-0.61,-0.48,-0.51,-0.92,-0.83,    LL 19830
     *   -0.61,-0.41,-0.29,-0.29,-0.61,-0.74,-0.19,-0.18, 0.00, 0.19,    LL 19840
     *   -0.10, 0.20, 0.20, 0.02, 0.20,-0.01, 0.18, 0.28, 0.11, 0.00,    LL 19850
     *   -0.37,-0.10, 0.02, 0.16, 0.20, 0.00, 0.00, 0.00, 0.00, 0.07,    LL 19860
     *    0.22, 0.11, 0.11, 0.21, 0.09, 0.21, 0.20, 0.37, 0.28, 0.07,    LL 19870
     *    0.09,-0.29,-0.69,-0.69,-0.74,-0.88,-1.01,-0.86,-0.54,-0.19,    LL 19880
     *    0.19, 0.23, 0.21, 0.29, 0.28, 0.29, 0.52, 0.54, 0.51, 0.60,    LL 19890
     *    0.40, 0.49, 0.48, 0.46, 0.49, 0.27, 0.06,-0.33,-0.81,-1.17/    LL 19900
C                                                                        LL 19910
      DATA     C114                                                      LL 19920
     *  /-1.11,-1.37,-1.52,-1.54,-1.94,-2.06,-2.06,-2.14,-1.96,-2.00,    LL 19930
     *   -2.00,-2.08,-2.23,-2.31,-2.31,-2.53,-2.31,-2.31,-2.31,-2.28,    LL 19940
     *   -2.34,-2.34,-1.91,-1.82,-1.69,-1.56,-1.84,-1.91,-1.75,-1.83,    LL 19950
     *   -1.76,-1.54,-1.98,-1.80,-1.68,-1.69,-1.56,-1.60,-1.71,-1.36,    LL 19960
     *   -1.36,-1.44,-1.48,-1.40,-1.48,-1.36,-1.45,-1.49,-1.85,-1.39,    LL 19970
     *   -1.23,-1.18,-1.18,-1.34,-1.36,-1.23,-1.23,-1.37,-1.30,-1.40,    LL 19980
     *   -1.28,-1.27,-1.37,-1.32,-1.32,-1.22,-1.28,-1.38,-1.69,-2.07,    LL 19990
     *   -2.42,-2.58,-2.58,-2.80,-2.58,-2.43,-1.88,-1.60,-1.26,-1.16,    LL 20000
     *   -1.23,-1.10,-1.23,-1.10,-0.83,-0.80,-0.80,-0.80,-0.98,-0.97,    LL 20010
     *   -0.97,-0.91,-0.92,-1.13,-1.24,-1.50,-1.98,-2.18,-2.32,-2.63,    LL 20020
     *   -3.91,-4.20,-4.49,-4.78,-5.07,-5.07,-5.07,-5.07,-5.07,-5.07/    LL 20030
C                                                                        LL 20040
C *** SPECTRAL DATA'  UNIFORMLY MIXED GASES                              LL 20050
C                                                                        LL 20060
      DATA     C201                                                      LL 20070
     *  /-4.25,-3.70,-3.20,-2.75,-1.90,-1.73,-1.51,-1.29,-1.11,-0.91,    LL 20080
     *   -0.71,-0.51,-0.30,-0.60, 0.22, 0.49, 0.76, 1.08, 1.29, 1.56,    LL 20090
     *    1.76, 1.91, 2.08, 2.23, 2.36, 2.51, 2.72, 2.90, 3.12, 3.37,    LL 20100
     *    3.56, 3.69, 3.79, 3.86, 3.88, 3.86, 3.73, 3.58, 3.38, 3.17,    LL 20110
     *    2.86, 2.73, 2.52, 2.31, 2.17, 2.01, 1.89, 1.77, 1.63, 1.47,    LL 20120
     *    1.21, 0.92, 0.53, 0.23,-0.17,-0.53,-0.74,-0.81,-0.84,-0.88,    LL 20130
     *   -1.00,-1.18,-1.42,-1.61,-1.86,-2.10,-2.29,-2.51,-2.72,-2.91,    LL 20140
     *   -3.14,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20150
     *   -5.00,-2.68,-2.47,-2.19,-1.97,-1.71,-1.50,-1.32,-2.12,-1.13,    LL 20160
     *   -1.09,-1.11,-1.10,-1.09,-1.01,-1.01,-1.11,-1.33,-1.66,-2.13,    LL 20170
     *   -2.51,-2.83,-2.71,-2.39,-2.09,-1.78,-1.59,-1.33,-1.18,-1.01,    LL 20180
     *   -0.96,-0.91,-0.90,-0.87,-0.80,-0.79,-0.86,-1.07,-1.28,-1.69,    LL 20190
     *   -2.11,-2.74,-3.09,-3.50,-3.03,-2.58,-2.23,-1.89,-1.54,-1.28,    LL 20200
     *   -1.13,-1.11,-1.16,-1.20,-1.23,-1.21,-1.17,-1.12,-1.15,-1.19,    LL 20210
     *   -1.20,-1.17,-1.02,-0.89,-0.68,-0.42,-0.24,-0.01, 0.18, 0.40,    LL 20220
     *    0.57, 0.77, 0.96, 1.07, 1.13, 1.11, 1.08, 1.15, 1.27, 1.33,    LL 20230
     *    1.44, 1.40, 1.13, 0.89, 0.63, 0.54, 0.65, 0.78, 0.81, 0.86,    LL 20240
     *    0.82, 0.68, 0.47, 0.14,-0.12,-0.48,-0.92,-1.43,-1.89,-2.32,    LL 20250
     *   -2.81,-5.00,-5.00,-5.00,-3.14,-2.47,-2.00,-1.71,-1.59,-1.61/    LL 20260
C                                                                        LL 20270
      DATA     C202                                                      LL 20280
     *  /-1.69,-1.82,-1.87,-1.90,-1.94,-2.04,-2.10,-2.23,-2.32,-2.48,    LL 20290
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     *    -2.71,-2.88,-3.09,-2.99,-2.43,-2.00,-1.69,-1.42,-1.38,-1.49,    LL 20300
     *    -1.70,-2.01,-2.41,-2.64,-2.63,-2.49,-2.38,-2.27,-2.16,-2.05,    LL 20310
     *    -1.94,-1.83,-1.76,-1.71,-1.70,-1.72,-1.81,-1.92,-2.03,-2.27,    LL 20320
     *    -2.61,-3.21,-4.01,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20330
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20340
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20350
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.30,-3.42,-3.17,-2.98,    LL 20360
     *    -2.83,-2.71,-2.67,-2.67,-2.68,-2.58,-2.33,-2.01,-1.64,-1.32,    LL 20370
     *    -0.97,-0.76,-0.63,-0.59,-0.60,-0.63,-0.69,-0.87,-1.08,-1.26,    LL 20380
     *    -1.53,-1.87,-1.91,-1.93,-2.02,-2.21,-2.48,-2.80,-3.08,-3.11,    LL 20390
     *    -3.09,-2.93,-2.76,-2.39,-2.01,-1.69,-1.36,-0.99,-0.63,-0.28,    LL 20400
     *     0.00, 0.08, 0.11, 0.12, 0.12, 0.07, 0.01,-0.08,-0.23,-0.40,    LL 20410
     *    -0.51,-0.53,-0.57,-0.60,-0.61,-0.73,-0.81,-0.95,-1.05,-1.02,    LL 20420
     *    -0.91,-0.68,-0.41,-0.09, 0.18, 0.41, 0.76, 1.00, 1.18, 1.39,    LL 20430
     *     1.51, 1.58, 1.68, 1.71, 1.80, 1.91, 2.02, 2.18, 2.32, 2.50,    LL 20440
     *     2.61, 2.69, 2.81, 2.89, 2.96, 3.04, 3.14, 3.27, 3.41, 3.55,    LL 20450
     *     3.72, 3.90, 4.03, 4.22, 4.42, 4.61, 4.71, 4.73, 4.65, 4.63,    LL 20460
     *     4.72, 4.78, 4.79, 4.50, 3.62, 3.28, 2.79, 2.30, 1.85, 1.35/    LL 20470
C                                                                         LL 20480
      DATA     C203                                                       LL 20490
     *   / 0.62,-0.24,-1.69,-2.18,-2.01,-1.79,-1.53,-1.32,-1.20,-1.15,    LL 20500
     *    -1.12,-1.18,-1.25,-1.26,-1.20,-1.17,-1.20,-1.32,-1.54,-1.84,    LL 20510
     *    -2.16,-2.30,-2.26,-2.01,-1.71,-1.36,-1.06,-0.81,-0.61,-0.49,    LL 20520
     *    -0.45,-0.47,-0.49,-0.46,-0.37,-0.31,-0.34,-0.49,-0.75,-1.11,    LL 20530
     *    -1.43,-2.01,-2.60,-2.89,-2.87,-2.74,-2.51,-2.42,-2.38,-2.39,    LL 20540
     *    -2.42,-2.46,-2.48,-2.49,-2.43,-2.43,-2.46,-2.53,-2.68,-2.74,    LL 20550
     *    -2.82,-2.87,-2.83,-2.82,-2.79,-2.71,-2.66,-2.49,-2.40,-2.32,    LL 20560
     *    -2.26,-2.23,-2.20,-2.09,-2.02,-1.96,-1.88,-1.84,-1.86,-1.86,    LL 20570
     *    -1.87,-1.83,-1.79,-1.73,-1.68,-1.67,-1.69,-1.74,-1.79,-1.87,    LL 20580
     *    -1.78,-1.63,-1.50,-1.37,-1.21,-1.00,-0.83,-0.69,-0.53,-0.41,    LL 20590
     *    -0.30,-0.19,-0.09,-0.04, 0.02, 0.10, 0.16, 0.18, 0.23, 0.26,    LL 20600
     *     0.27, 0.26, 0.24, 0.22, 0.17, 0.12, 0.07,-0.01,-0.07,-0.09,    LL 20610
     *     0.32, 0.72, 0.91, 1.12, 1.03, 0.67, 0.18,-0.11,-0.38,-0.29,    LL 20620
     *    -0.17,-0.08,-0.00, 0.09, 0.13, 0.18, 0.24, 0.27, 0.29, 0.30,    LL 20630
     *     0.29, 0.26, 0.23, 0.21, 0.13, 0.09, 0.02,-0.04,-0.18,-0.32,    LL 20640
     *    -0.51,-0.72,-0.98,-1.18,-1.50,-1.62,-1.81,-2.04,-2.29,-2.49,    LL 20650
     *    -2.62,-2.87,-3.03,-3.21,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20660
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.01,-3.38,-3.01,-2.63,    LL 20670
     *    -2.32,-2.09,-1.98,-1.94,-2.00,-2.14,-2.26,-2.20,-2.02,-1.82/    LL 20680
C                                                                         LL 20690
      DATA     C204                                                       LL 20700
     *   /-1.59,-1.43,-1.38,-1.46,-1.64,-1.90,-2.09,-2.54,-2.91,-3.28,    LL 20710
     *    -3.61,-3.72,-3.64,-3.50,-3.41,-3.37,-3.30,-3.16,-3.01,-2.76,    LL 20720
     *    -2.51,-2.20,-1.80,-1.49,-1.22,-0.97,-0.72,-0.49,-0.20, 0.03,    LL 20730
     *     0.20, 0.36, 0.51, 0.61, 0.67, 0.83, 1.00, 1.22, 1.38, 1.56,    LL 20740
     *     1.70, 1.86, 2.01, 2.20, 2.31, 2.47, 2.61, 2.76, 2.92, 3.01,    LL 20750
     *     3.05, 3.02, 2.98, 2.98, 3.01, 3.03, 2.97, 2.78, 2.44, 2.13,    LL 20760
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     *    1.83, 1.59, 1.49, 1.50, 1.67, 1.84, 2.22, 2.50, 2.71, 2.93,     LL 20770
     *    3.12, 3.18, 3.17, 3.15, 3.21, 3.26, 3.19, 2.98, 2.59, 2.14,     LL 20780
     *    1.70, 1.22, 0.55,-0.27,-1.09,-2.54,-3.00,-2.94,-2.78,-2.68,     LL 20790
     *   -2.61,-2.60,-2.63,-2.60,-2.57,-2.53,-2.57,-2.64,-2.77,-3.04,     LL 20800
     *   -3.38,-3.98,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20810
     *   -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20820
     *   -5.00,-4.00,-3.73,-3.62,-3.59,-3.53,-3.56,-3.57,-3.53,-3.51,     LL 20830
     *   -3.45,-3.37,-3.26,-3.21,-3.18,-3.27,-3.36,-3.60,-3.96,-5.00,     LL 20840
     *   -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20850
     *   -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20860
     *   -5.00,-5.00,-5.00,-5.00,-4.62,-4.07,-3.89,-3.76,-3.67,-3.56,     LL 20870
     *   -3.42,-3.35,-3.26,-3.18,-3.14,-3.11,-3.09,-3.10,-3.12,-3.23,     LL 20880
     *   -3.30,-3.38,-3.37,-3.29,-3.14,-3.08,-3.00,-2.93,-2.89,-2.91/     LL 20890
C                                                                         LL 20900
      DATA     C205                                                       LL 20910
     *  /-3.00,-3.08,-3.16,-3.31,-3.48,-3.71,-3.98,-5.00,-5.00,-5.00,     LL 20920
     *   -5.00,-4.52,-3.98,-3.69,-3.42,-3.18,-2.95,-2.77,-2.61,-2.48,     LL 20930
     *   -2.41,-2.41,-2.40,-2.38,-2.34,-2.27,-2.21,-2.31,-2.48,-2.73,     LL 20940
     *   -3.21,-4.13,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20950
     *   -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,     LL 20960
     *   -5.00,-5.00,-4.13,-4.02,-3.99,-3.96,-3.87,-3.73,-3.51,-3.29,     LL 20970
     *   -3.13,-2.99,-2.84,-2.73,-2.69,-2.68,-2.69,-2.65,-2.62,-2.59,     LL 20980
     *   -2.57,-2.62,-2.81,-3.04,-3.21,-3.39,-3.42,-3.36,-3.21,-3.03,     LL 20990
     *   -2.93,-2.80,-2.64,-2.52,-2.37,-2.28,-2.20,-2.13,-2.07,-2.02,     LL 21000
     *   -1.96,-1.88,-1.78,-1.63,-1.44,-1.31,-1.20,-1.08,-0.98,-0.94,     LL 21010
     *   -0.86,-0.76,-0.52,-0.31,-0.08, 0.13, 0.30, 0.37, 0.36, 0.36,     LL 21020
     *    0.35, 0.35, 0.39, 0.46, 0.48, 0.41, 0.23,-0.08,-0.38,-0.67,     LL 21030
     *   -0.88,-0.96,-0.98,-0.87,-0.67,-0.36,-0.12, 0.14, 0.44, 0.68,     LL 21040
     *    0.90, 1.11, 1.19, 1.24, 1.25, 1.26, 1.27, 1.51, 1.59, 1.50,     LL 21050
     *    1.28, 0.71, 0.11,-0.28,-0.67,-1.32,-1.61,-1.58,-1.42,-1.18,     LL 21060
     *   -0.91,-0.59,-0.27,-0.06, 0.29, 0.57, 0.73, 0.92, 0.81, 0.73,     LL 21070
     *    0.79, 0.91, 1.01, 1.03, 0.88, 0.72, 0.63, 0.38, 0.12,-0.21,     LL 21080
     *   -0.47,-0.67,-1.23,-1.67,-2.31,-2.76,-3.24,-3.49,-3.51,-3.47,     LL 21090
     *   -3.39,-3.37,-3.43,-3.53,-3.50,-3.36,-3.18,-3.07,-2.96,-3.08/     LL 21100
      END                                                                 LL 21120
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APPENDIX B

CCNTINUED DATA PACKAGE

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-4.15,-3.51,-3.00,-2.54,-2.12,-1.76,-1.50,-1.21,-0.86,-0.49,
-0.29,-0.10, 0.02, 0.12, 0.24, 0.32, 0.43, 0.52, 0.58, 0.65,
 0.72, 0.79, 0.76, 0.72, 0.68, 0.64, 0.68, 0.79, 0.83, 0.83,
 0.80, 0.78, 0.68, 0.56, 0.49, 0.42, 0.34, 0.26, 0.14, 0.02,
-0.14,-0.35,-0.51,-0.74,-0.88,-1.17,-1.40,-1.58,-2.11,-2.47,
-2.83,-3.24,-3.59,-3.94,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-4.46,-4.00,-3.50,-3.14,-2.78,
-2.41,-2.10,-1.78,-1.49,-1.20,-0.20, 0.15, 0.35, 0.57, 0.78,
 0.95, 1.20, 1.40, 1.65, 1.80, 1.97, 2.10, 2.21, 2.31, 2.38,
 2.40, 2.42, 2.58, 2.52, 2.20, 2.48, 2.54, 2.45, 2.30, 2.00,
 1.20, 0.95, 0.92, 0.90, 0.90, 0.89, 0.90, 0.92, 0.94, 0.95,
 0.96, 0.95, 0.90, 0.80, 0.68, 0.55, 0.40, 0.30, 0.19, 0.08,
-0.02,-0.11,-0.22,-0.41,-0.56,-0.71,-0.89,-1.03,-1.18,-1.33,
-1.60,-1.76,-1.90,-2.02,-2.21,-2.46,-2.59,-2.79,-3.00,-3.22,
-3.61,-4.16,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00
-5.00,-5.00,-5.00,-5.00,-4.16,-3.91,-3.66,-3.41,-3.05,-2.69,
-2.44,-2.19,-2.03,-1.86,-1.71,-1.56,-1.48,-1.39,-1.26,-1.13,
-0.97,-0.81,-0.65,-0.48,-0.35,-0.22,-0.14,-0.06,-0.02,-0.09,
-0.18,-0.14, 0.06, 0.26,-0.02,-0.42,-0.60,-0.82,-0.80,-0.74,
-0.74,-0.79,-0.84,-0.89,-0.85,-0.81,-0.76,-0.70,-0.68,-0.64,
-0.65,-0.66,-0.72,-0.78,-0.84,-0.90,-1.02,-1.14,-1.24,-1.33,
-1.47,-1.61,-1.77,-1.92,-1.98,-2.04,-2.08,-2.09,-2.06,-2.03,
-1.98,-1.93,-1.87,-1.82,-1.76,-1.71,-1.65,-1.59,-1.51,-1.44,
-1.36,-1.28,-1.18,-1.08,-0.98,-0.88,-0.78,-0.69,-0.59,-0.49,
-0.37,-0.25,-0.18,-0.10, 0.00, 0.16, 0.27, 0.38, 0.57, 0.75,
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 1.49, 1.23, 0.66, 0.38,-0.33,-0.71,-0.66,-0.58,-0.49,-0.44,
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-3.07,-3.28,-3.50,-3.72,-3.94,-5.00,-5.00,-5.00,-5.00,-5.00,
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-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
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-0.81,-0.77,-0.72,-0.68,-0.63,-0.58,-0.53,-0.48,-0.41,-0.34,
-0.26,-0.19,-0.17,-0.18,-0.19,-0.46,-0.79,-1.12,-1.45,-1.75,
-2.38,-2.97,-3.57,-4.16,-5.00,-5.00,-5.00,-4.16,-3.90,-3.63,
-3.37,-3.10,-2.79,-2.47,-2.15,-1.84,-1.73,-1.63,-1.52,-1.41,
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1.34E-03,1.25E-03,1.06E-03,9.06E-04,7.53E-04,6.41E-04,5.09E-04,
4.04E-04,3.36E-04,2.86E-04,2.32E-04,1.94E-04,1.57E-04,1.31E-04,
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0.147
0.117
0.097
0.087
0.100
0.120
0.147
0.174
0.200
0.240
0.280
0.330
0.000
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9.75E+01,7.65E+01,6.04E+01,4.62E+01,3.46E+01,2.52E+01,2.00E+01,
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-1.08,-0.89,-0.68,-0.54,-0.71,-0.79,-0.78,-0.66,-0.49,-0.54,
-0.86,-1.37,-2.08,-2.44,-3.46,-3.72,-3.74,-3.59,-3.22,-2.98,
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-4.93,-4.46,-3.99,-3.45,-2.99,-2.63,-2.30,-2.09,-2.02,-2.12,
-2.18,-2.13,-2.04,-1.78,-1.83,-2.08,-2.28,-2.81,-3.01,-3.15,
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-1.57,-1.66,-1.80,-1.91,-2.04,-2.18,-2.33,-2.47,-2.61,-2.78,
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-5.00,-5.00,-5.00,-5.00,-5.00
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APPENDIX C

SAMPLE OUTPUT

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SUB-ARCTIC (60 DEG. LAT.) WINTER MODEL ATMOSPH RE
CONTINENTAL AEROSOL MODEL
HAZE MODEL =  23.0 KM VISUAL RANGE AT SEA LEV L

H1 =   2.500 KM, H2 =   8.500 KM, ANGLE =  65.0000 GEOM. RANGE =  14.15 KM, BETA =  0.11537 DEG

SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1     2.500 KM H2 =   8.500 KM, ZENITH ANGLE =  65.000 DEGREES
FREQUENCY RANGE V1 =  2350.0 CM-1 TO V2 =  2450.0 CM-1 FOR DV =    5.0 CM-1   (  4.08 -  4.26 MICRONS)
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HORIZONTAL PROFILES

1	0.0	1.233E-01	1.087E+00	1.937E-03	6.761E-01	6.632E-04	1.062E+00	1.000E+00	1.913E-03	2.853E-04	2.900E-02	3.052E+02
2	1.0	1.051E-01	8.536E-01	1.834E-03	6.651E-01	6.144E-04	9.239E-01	4.399E-01	1.913E-03	2.504E-04	2.445E-02	2.654E+02
3	2.0	7.625E-02	6.884E-01	1.744E-03	5.197E-01	4.114E-04	8.193E-01	1.899E-01	1.913E-03	2.219E-04	1.768E-02	2.354E+02
4	3.0	4.918E-02	5.538E-01	1.738E-03	4.045E-01	2.422E-04	7.254E-01	7.975E-02	2.007E-03	1.970E-04	1.206E-02	2.084E+02
5	4.0	2.647E-02	4.484E-01	1.729E-03	3.177E-01	1.101E-04	6.458E-01	4.216E-02	2.100E-03	1.757E-04	7.051E-03	1.855E+02
6	5.0	1.153E-02	3.646E-01	1.717E-03	2.504E-01	3.801E-05	5.773E-01	3.177E-02	2.193E-03	1.569E-04	3.479E-03	1.655E+02
7	6.0	5.027E-03	2.950E-01	1.700E-03	1.961E-01	1.376E-05	5.145E-01	2.241E-02	2.287E-03	1.396E-04	1.735E-03	1.479E+02
8	7.0	2.457E-03	2.372E-01	2.335E-03	1.525E-01	6.006E-06	4.571E-01	2.062E-02	3.313E-03	1.238E-04	9.790E-04	1.313E+02
9	8.0	4.423E-04	1.692E-01	2.802E-03	1.175E-01	8.156E-07	4.043E-01	2.146E-02	4.200E-03	1.086E-04	2.049E-04	1.162E+02
10	9.0	2.555E-04	1.470E-01	4.693E-03	8.799E-02	5.326E-07	3.512E-01	2.057E-02	7.467E-03	9.359E-05	1.473E-04	1.009E+02
11	10.0	1.680E-04	1.117E-01	6.611E-03	6.428E-02	2.898E-07	3.002E-01	2.007E-02	1.120E-02	8.000E-05	8.240E-05	8.626E+01
12	11.0	1.008E-04	8.490E-02	8.279E-03	4.697E-02	1.681E-07	2.566E-01	1.880E-02	1.493E-02	6.837E-05	4.867E-05	7.374E+01
13	12.0	5.984E-05	6.446E-02	1.045E-02	3.429E-02	9.673E-08	2.192E-01	1.975E-02	2.007E-02	5.844E-05	2.843E-05	6.300E+01
14	13.0	3.598E-05	4.901E-02	1.072E-02	2.507E-02	5.657E-08	1.875E-01	1.823E-02	2.193E-02	4.996E-05	1.084E-05	5.387E+01
15	14.0	1.738E-05	3.725E-02	1.050E-02	1.832E-02	2.639E-08	1.663E-01	1.765E-02	2.287E-02	4.270E-05	7.996E-06	4.606E+01
16	15.0	1.145E-05	2.829E-02	1.127E-02	1.338E-02	1.707E-08	1.369E-01	1.677E-02	2.613E-02	3.654E-05	5.194E-06	3.935E+01
17	16.0	8.366E-06	2.159E-02	1.173E-02	9.820E-03	1.229E-08	1.174E-01	1.595E-02	2.893E-02	3.131E-05	3.654E-06	3.374E+01
18	17.0	6.371E-06	1.642E-02	1.101E-02	7.184E-03	9.194E-09	1.005E-01	1.576E-02	2.893E-02	2.682E-05	2.891E-06	2.888E+01
19	18.0	4.946E-06	1.253E-02	1.035E-02	5.273E-03	7.033E-09	8.615E-02	1.525E-02	2.893E-02	2.298E-05	2.245E-06	2.476E+01
20	19.0	4.205E-06	9.538E-03	9.406E-03	3.859E-03	5.918E-09	7.375E-02	1.265E-02	2.800E-02	1.967E-05	1.912E-06	2.119E+01
21	20.0	3.357E-06	7.260E-03	8.245E-03	2.824E-03	4.657E-09	6.315E-02	9.431E-03	2.613E-02	1.683E-05	1.530E-06	1.815E+01
22	21.0	3.301E-06	5.515E-03	7.045E-03	2.062E-03	4.571E-09	5.399E-02	6.838E-03	2.380E-02	1.439E-05	1.361E-06	1.552E+01
23	22.0	2.863E-06	4.189E-03	6.099E-03	1.506E-03	3.942E-09	4.617E-02	5.145E-03	2.193E-02	1.230E-05	1.303E-06	1.327E+01
24	23.0	2.625E-06	3.180E-03	5.238E-03	1.099E-03	3.624E-09	3.947E-02	3.936E-03	2.007E-02	1.052E-05	1.197E-06	1.134E+01
25	24.0	2.533E-06	2.413E-03	4.115E-03	8.012E-04	3.528E-09	3.372E-02	3.121E-03	1.680E-02	8.984E-06	1.154E-06	9.691E+00
26	25.0	2.451E-06	1.829E-03	3.432E-03	5.836E-04	3.481E-09	2.880E-02	2.627E-03	1.493E-02	5.969E-06	1.117E-06	8.277E+00
27	30.0	6.381E-07	4.420E-04	1.166E-03	1.153E-04	8.463E-10	1.273E-02	7.912E-04	7.000E-03	2.649E-06	2.555E-07	3.659E+00
28	35.0	9.587E-08	1.096E-04	5.216E-04	2.348E-05	1.113E-10	5.765E-03	2.082E-04	4.293E-03	1.190E-06	2.766E-08	1.639E+00
29	40.0	1.875E-08	2.784E-05	1.710E-04	4.924E-06	2.001E-11	2.577E-03	5.481E-05	1.913E-03	5.448E-07	3.700E-09	7.405E-01
30	45.0	4.317E-09	7.615E-06	4.056E-05	1.123E-06	4.311E-12	1.215E-03	1.443E-05	6.067E-04	2.600E-07	6.191E-10	3.492E-01
31	50.0	7.652E-10	2.221E-06	1.018E-05	2.757E-07	7.224E-13	5.547E-04	3.809E-06	2.007E-04	9.178E-08	8.355E-11	1.709E-01
32	70.0	1.604E-12	2.291E-08	7.112E-08	1.474E-09	1.118E-15	4.407E-05	1.962E-08	4.013E-06	6.388E-09	1.694E-13	1.267E-02
33	100.0	1.459E-16	5.397E-12	5.175E-12	1.041E-13	6.038E-20	3.852E-07	6.961E-12	2.007E-09	5.535E-11	2.300E-17	1.107E-04

FROM FCINT - FEIGHT = 2.5000 KM, N = 3, NP = 0, REFRACTIVITY ABOVE AND BELOW X = 2.150E+02 2.284E+02

EQUIVALENT ABSCREER AMOUNTS PER KM AT X

6.125E-02 6.174E-01 1.741E-03 4.587E-01 3.157E-04 7.709E-01 1.231E-01 1.959E-03

FROM POINT - FEIGHT = 8.5000 KM, N = 9, NP = 0, REFRACTIVITY ABOVE AND BELOW X = 1.046E+02 1.122E+02

EQUIVALENT AESCREER AMOUNTS PER KM AT X

3.615E-04 1.668E-01 3.626E-03 1.017E-01 6.591E-07 3.768E-01 2.101E-02 5.600E-03

VERTICAL PROFILES

										PSI	PHI	BETA	THETA	RANGE
3	2.5	7.276E-02	7.290E-01	2.051E-03	5.419E-01	3.763E-04	9.090E-01	1.456E-01	2.309E-03	-0.0001	115.0097	0.0096	84.9999	1.2
4	3.0	1.595E-01	1.910E+00	6.150E-03	1.352E+00	7.726E-04	2.528E+00	2.851E-01	7.164E-03	0.0021	115.0268	0.0287	84.9925	3.5
5	4.0	2.016E-01	2.665E+00	1.021E-02	2.059E+00	9.324E-04	3.969E+00	3.756E-01	1.222E-02	0.0046	115.0435	0.0481	84.9757	5.9
6	5.0	2.203E-01	3.641E+00	1.425E-02	2.583E+00	9.887E-04	5.256E+00	4.389E-01	1.751E-02	0.0069	115.0604	0.0674	84.9568	8.3
7	6.0	2.288E-01	4.261E+00	1.697E-02	2.992E+00	1.011E-03	6.402E+00	4.900E-01	2.405E-02	0.0090	115.0776	0.0860	84.9417	10.6
8	7.0	2.316E-01	4.766E+00	2.500E-02	3.308E+00	1.017E-03	7.415E+00	5.397E-01	3.285E-02	0.0110	115.0946	0.1058	84.9244	13.0
9	8.0	2.320E-01	4.977E+00	2.878E-02	3.438E+00	1.018E-03	7.876E+00	5.648E-01	3.860E-02	0.0124	115.1031	0.1154	84.9066	14.2

ESTIMATED TANGENT ALTITUDE = 920763.250 KM

EQUIVALENT SEA LEVEL ABSORBER AMOUNTS

	WATER VAPOUR GM CM-2	CO2 ETC. KM	OZONE ATM CM	NITROGEN (CONT) KM	H2O (CONT) GM CM-2	MOL SCAT KM	AEROSOL KM	OZONE(U-V) ATM CM
W(1-8) =	2.220E-01	4.977E+00	2.878E-02	3.438E+00	1.018E-03 6.013E-02	7.876E+00	5.648E-01	3.860E-02

FREQ CM-1	WAVELENGTH MICRONS	TOTAL TRANS	H2O TRANS	CO2+ TRANS	OZONE TRANS	N2 CONT TRANS	H2O CONT TRANS	MOL SCAT TRANS	AEROSOL TRANS	AEROSOL ABS	INTEGRATED ABSORPTION
2350	4.2553	0.0	0.9964	0.0	1.0000	0.6552	1.0000	1.0000	0.9902	0.0011	2.50
2355	4.2463	0.0	0.9969	0.0	1.0000	0.6642	0.9986	1.0000	0.9902	0.0011	7.50
2360	4.2373	0.0	0.9972	0.0	1.0000	0.6711	0.9972	1.0000	0.9902	0.0011	12.50
2365	4.2283	0.0	0.9573	0.0	1.0000	0.6758	0.9959	1.0000	0.9902	0.0011	17.50
2370	4.2194	0.0	0.9976	0.0	1.0000	0.6804	0.9945	1.0000	0.9901	0.0011	22.50
2375	4.2105	0.0	0.9975	0.0	1.0000	0.6804	0.9931	1.0000	0.9901	0.0011	27.50
2380	4.2017	0.0014	0.9981	0.0021	1.0000	0.6823	0.9917	1.0000	0.9901	0.0011	32.49
2385	4.1929	0.0272	0.9963	0.0406	1.0000	0.6828	0.9904	1.0000	0.9901	0.0011	37.33
2390	4.1841	0.1127	0.9987	0.1693	1.0000	0.6804	0.9890	1.0000	0.9901	0.0011	41.79
2395	4.1754	0.2546	1.0000	0.3853	1.0000	0.6758	0.9876	1.0000	0.9901	0.0011	45.52
2400	4.1667	0.4527	1.0000	0.6637	1.0000	0.6781	0.9863	1.0000	0.9901	0.0010	48.25
2405	4.1580	0.5831	1.0000	0.8775	1.0000	0.6804	0.9865	1.0000	0.9900	0.0010	50.34
2410	4.1494	0.6616	1.0000	0.9850	1.0000	0.6875	0.9868	1.0000	0.9900	0.0010	52.03
2415	4.1408	0.6724	1.0000	0.9940	1.0000	0.6922	0.9870	1.0000	0.9900	0.0010	53.67
2420	4.1322	0.6826	1.0000	0.9918	1.0000	0.7042	0.9873	1.0000	0.9900	0.0010	55.26
2425	4.1237	0.6869	1.0000	0.9874	1.0000	0.7115	0.9875	1.0000	0.9900	0.0010	56.62
2430	4.1152	0.6922	1.0000	0.9812	1.0000	0.7214	0.9878	1.0000	0.9900	0.0010	58.30
2435	4.1068	0.6951	1.0000	0.9739	1.0000	0.7339	0.9881	1.0000	0.9900	0.0010	59.87
2440	4.0984	0.7041	1.0000	0.9689	1.0000	0.7428	0.9863	1.0000	0.9899	0.0010	61.35
2445	4.0900	0.7131	1.0000	0.9660	1.0000	0.7543	0.9886	1.0000	0.9899	0.0010	62.73
2450	4.0816	0.7256	1.0000	0.9643	1.0000	0.7687	0.9888	1.0000	0.9899	0.0010	63.47

INTEGRATED ASORPTION FROM 2350 TO 2450 CM-1 = 63.47, AVERAGE TRANSMITTANCE = 0.3653

AD-A132 123 CALCULATION OF ATMOSPHERIC TRANSMITTANCE BY IBM 3033 COMPUTER CODE LOWTRAN IIIB(U) NAVAL POSTGRADUATE SCHOOL MONTEREY CA M SHIN JUN 83 2/2

UNCLASSIFIED F/G 20/6 NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX D

DEFINITIONS AND SYMBOLS

AB	Absorption at frequency V; also average transmittance
AHZ1, AHZ2	Aerosol number density
AJ	Equivalent absorber amount per km at level J
ALP	Angle of arrival at adjacent level
ANGLE	Input zenith angle (degree)
BET	Angle subtended at the earth's center as path traverses adjacent levels
BETA	Total angle subtended path at earth's center
BJ	Equivalent absorber amount per km at level J+1
CA	Conversion factor from degree to radians
CO	Wavelength dependent coefficient used in refractive index expression
Cw	Wavelength dependent coefficient used in refractive index expression
C1	Log absorption coefficient for water vapor
C2	Log absorption coefficient for uniformly mixed gas
C3	Log absorption coefficient for ozone
C4	Absorption cofficient for nitrogen
C5	Absorption cofficient for water vapor continuum
C6	Extinction coefficient for molecular scattering
C7	Extinction coefficient for aerosol models
C7A	Aerosol absorption coefficient
C8	Absorption coefficient for ozone (UV and visible region)
D	water vapor amount (pr.cm/km) at level I
DP	Dew point temperature (C)
Ds	Path length from level I to level I + 1
DV	Wave number increment at which transmittance is calculated
DZ	Height increment from level I to I + 1
E(K)	Equivalent absorber amount per km at height H1
EH(1,I)	Equivalent absorber amount per km for water vapor at level Z(I)
EH(2,I)	Equivalent absorber amount per km for carbon dioxide, etc. at level Z(I)
EH(3,I)	Equivalent absorber amount per km for ozone at level Z(I)
EH(4,I)	Equivalent absorber amount per km for nitrogen at level Z(I)
EH(5,I)	Equivalent absorber amount per km for water vapor continuum at level Z(I)
EH(6,I)	Equivalent absorber amount per km for molecular scattering at level Z(I)
EH(7,I)	Equivalent absorber amount per km for waerosol extinction at level Z(I)
EH(8,I)	Equivalent absorber amount per km for ozone (UV and visible) at level Z(I)
EH(9,I)	Mean refractive index of layer above level Z(I)
EV	Integrated absorber amount from level I to I + 1
FAC	Factor for exponential and linear interpolation
FO	Transmission function logarithmic absorber amount scale for ozone
FW	Transmission function logarithmic absorber amount scale for water vapor and uniformly mixed gases
H	Altitude (km)
H1	Initial Altitude (km)
H2	Final Altitude (km)

HAZE Aerosol number density (no. cm-3)

HM Estimated tangent height (km)

HMIN Minimum altitude of path trajectory (km)

HZ| Aerosol number density (no. cm-3) for 23 km visual range

HZ| Aerosol number density (no. cm-3) for 5 km visual range

I Running integer used as altitude indicator

IAERO Indicator for type of aerosol model

IATOM Number of levels in model atmosphere

IDV Frequency increment (cm-1)

IFIND Indicator for using subroutine ANGL

IHAZE Aerosol model indicator

IM Parameter used when reading in a new atmospheric model

IP Indicator for using subroutine POINT to calculate reference index only (IP = 0)

IR Card printer number

ITER,ITES Iteration counters

ITYPE Indicator for type of atmospheric path

IV Frequency at which transmittance is calculated

IV1 Starting frequency

IV2 Last frequency

IW Line printer number

IXY Parameter for terminating program and cycling indicator

J Running integer for altitude identification

JMIN Altitude indicator for minimum height of path

JP Print option for altitude H1

J1 Level indicator for altitude H1

J2 Level indicator for altitude H2

K Absorber indicator, K=1, 2, 3, etc., corresponds to water vapor, uniformly mixed gases, ozone, etc., respectively

K2 Cycling parameter for downward looking paths

L Frequency indicator for ozone transmittance calculation

LEN Parameter used for defining longest of two paths

M Integer used to identify required model atmosphere

ML Number of levels in radiosonde data input (MODEL7)

MODEL Integer used to identify required model atmosphere

M1 Integer for selecting temperature altitude profile for (M=M1)

M2 Integer for selecting water vapor altitude profile for (M=M2)

M3 Integer for selecting ozone altitude profile for (M=M3)

N Indicator for level below given input altitude used in POINT subroutine

NL,NLP Number of levels in model atmosphere data

NP Indicator for determining whether H1 or H2 coincide with levels in the model atmosphere

NP1 Value of NP for altitude H1

NP2 Value of NP for altitude H2

NS1,NS2 Counters corresponding to WS1, WS2

P(M,1) Pressure (mb) at level I for model atmosphere M

PHI Angle of arrival at H2

PPW Partial pressure of water vapor (in atmosphere)

PS Total pressure in atmospheres

PSI Angular deviation of path from initial direction

PT Product of total pressure (atm) and the square root of 273/T(M,I)

RANGE Path length (km)

RE,REATH Earth radius (km)

REP Refractive index of air at level I

RH Relative humidity (%)

RN Ratio of refractive indices of air above and below a given level

RX	Ratio of earth center distances between adjacent levels
RO	Earth radius (km) read in as input (=RE)
R1	The product of the sine of the initial zenith angle and the earth center distance to starting altitude
SALP	Sine of angle of arrival at adjacent level
SPHI	Sine of the local zenith angle at a given level
SR	Slant range (km)
SUM	Accumlated absorption
T(M,I)	Temperature (K) for model atmosphere M at level I
THET	Zenith angle at a given level (in radians)
THETA	Zenith angle at a given level (in degrees)
TMP	Ambient temperature (C)
TR	Transmittance scales for transmission functions
TS	Ratio of standard temperature (273.15 K) to temperature level I
TS1	Ratio of 296 K to temperature at level I
TT	Ratio 273.15/(TMP + 273.15)
TX(K)	Equivalent absorber amounts per km at a given altitude obtained from POINT; also transmittance values at a given wavelength for each absorber type (K = 1,8)
TX(9)	Total transmittance at frequency IV
TX(10)	Absorption due to aerosol only at frequency IV
TX1	Refractive index of layer above initial alt. H1
TX2	Refractive index of layer above final alt. H2
TX1	Refractive index of layer above minimum alt. HMIN
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
VIS	Visual range (km) at sea level
VX	Wavelength at which aerosol coefficients are read in (micrometer)
V1	Initial frequency for transmittance calculation
V2	Final frequency for transmittance calculation
W(K)	Total equivalent absorber amount for entire path
WH(M,I)	Water vapor density for atmospheric model M at level I (gm m-3)
WL,WL1,WL2	Wavelength in microns
WO(M,I)	Ozone density for atmospheric model M at level I
WS1	Transmission function scaling factor for water vapor at given wavelength
WS2	Transmission function scaling factor for carbon dioxide, etc., at given wavelength
WS3	Transmission function scaling factor for ozone at given wavelength
X	Input height to POINT subroutine
XI	Wavenumber interpolation parameter
XX	Wavenumber identification parameter for UV ozone transmittance calculation
X1	Earth center distance of level I
X2	Earth center distance of level I + 1
YN	Refractive index of layer below input height from POINT subroutine
YN1	Refractive index of layer below initial alt. H1
YN2	Refractive index of layer below final alt. H2
YY	Aerosol absorption coefficient at frequency V
Z(I),ZO(I)	Altitude at level I in km

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