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A. HIGH ALTITUDE INFRARED RADIANCE MODEL

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20. Abstract continued

computes infrared radiances for an earth's limb viewing geometry. The nominal spectral region of this study lies between 2.7 and 25 micrometers and emphasis is placed on radiation originating at altitudes between 70 and 500 km. The physical model is described, with emphasis on the changes required in extending its usefulness. Application of the computer program is described. Model predictions are compared with radiance data obtained in the ICECAP auroral studies program. This comparison is used to illustrate uncertainties in results due to assumptions made in the model and lack of data on actual atmospheric composition.

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1.0 INTRODUCTION

The research reported here has had as its major objective the development and improvement of infrared radiance and transmission models of the atmosphere. These models are designed to simulate the radiative properties of the atmosphere to provide predictions for Air Force and other Department of Defense design and surveillance programs. Comparison with available experimental measurements provides greater understanding of the atmosphere and serves to check the adequacy of the models.

The main areas of effort have been

1. Extension of the applicability of a current model on non-equilibrium atmospheric infrared radiance between 2.5 and 25 microns.
2. Development and improvement of thermal equilibrium models of the infrared transmission and radiance for the earth's lower atmosphere.

The goal of the first area has been the further development of a computer program to simulate the natural infrared radiance background of the earth's upper atmosphere. The nominal spectral region under study lies between 2.7 and 25 micrometers and emphasis is placed on radiation originating at altitudes between 70 and 500 kilometers. The general problem area is of interest for systems design, military surveillance and the advancement of knowledge about physical processes in the upper atmosphere. The immediate application of this work is to aid in developing optimum infrared background measurements programs and in interpreting the results of such measurements.

This work is an extension of the study of Corbin, et al (1969) and Degges (1972, 1974). The former investigated the natural infrared background of the earth in 5 to 25 micrometer spectral region, with the goal of estimating earth limb viewing radiances for tangent heights from the surface to 500 km altitude. For convenience, their study divided the atmosphere into two regions with a division at 70 km. Below 70 km the atmosphere was assumed to be in thermal equilibrium. Above 70 km explicit calculations were made of processes which excite and de-excite molecular vibrational and rotational levels which are the source of infrared radiation.

Their study concentrated on radiation from water vapor, carbon dioxide, ozone, nitric oxide and nitrous oxide, which are principal radiating species in the spectral region considered. In addition, nitric acid was included in the lower atmosphere work and estimates were made of radiation to be expected from particulate matter suspended in the atmosphere.

Corbin, et al (1969), presented models for the lower atmosphere for a wide range of seasonal and latitudinal conditions. This was not possible for the abundances of most minor neutral species. More data has since become available, particularly for nitric oxide and the hydroxyl radical, but at present it appears that the best means of estimating abundances of important infrared emitting species is chemical rate equation integrations including molecular diffusion and eddy mixing. Even calculations involving transport properties cannot always be accepted because the values of eddy mixing coefficients are to a large extent only informed guesses and published calculations often use outdated rate coefficients. Degges (1972) reported a computer program with which to determine diurnal variations in abundances of minor species, to investigate the effects of changes in assumed eddy mixing coefficients, and to estimate the effects of new determinations of chemical rate coefficients.

A second area of study necessary to improve the radiance model includes the physical processes that control the population of infrared emitting states of atmospheric molecules. Except for the pure rotational radiation from molecules such as water, the degree of excitation of vibrational levels determines the radiation from infrared emitting molecules. The most important mechanisms are collisional excitation and de-excitation and absorption and re-emission of electromagnetic radiation.

In the troposphere and lower stratosphere, collisional processes are rapid enough to control the population of vibrational levels. Above 30 to 50 km, however, collisional excitation becomes less efficient and radiative processes become important. The combined effects of collisional and radiative processes must therefore be considered. Below an altitude of about 90 km molecular nitrogen and oxygen are the most important collision partners. Above that altitude, atomic oxygen becomes important, both in exciting nitric oxide and in determining molecular oxygen and nitrogen vibrational temperatures.

In determining the effects of radiation on the populations of vibrational levels of infrared active molecules, it is necessary to separate the radiation of a single change in vibrational quantum numbers from the rest of the radiation field. The previously reported studies did this by assuming a Doppler line shape for the individual rotational lines of a band and were able to obtain adequate numerical approximations for radiative transfer functions appropriate to single bands of linear molecules, and less accurately, for water vapor and ozone bands lying in the spectral region of interest.

The principal areas of research and program revision reported by Degges (1974) included a further study of band radiance modelling and the effects of the line shape on radiance computations. In addition to some exploratory calculations using a Voigt line profile instead of a Doppler line shape, some asymptotic analytical results were obtained which provide an estimate of the accuracy of the numerically obtained band functions at large optical thicknesses. It was found that when a Voigt profile is used, the connection between the band models and functions for a single line is more readily seen than when a Doppler line shape is used. This basic material on radiative transport is reviewed in Section 2, and additional results are presented.

The status of current knowledge of atmospheric composition is reviewed in Section 3. Recent measurements of chemical rate coefficients have resulted in changes in estimates of abundances of some molecular species. An attempt is made to set upper and lower bounds for mixing ratios at high altitudes.

Results of calculations are given in Section 4. We discuss the effects of changes made in the program and compare model predictions with ICECAP radiance measurements. This experimental data permits us to better assess the validity and limitations of the model.

In Section 5 we review the limitations of low altitude models which assume thermal equilibrium for vibrational populations and estimate the altitudes below which such models are valid.

In Section 6 we discuss the high resolution line-by-line program. This is treated more fully in a separate scientific report. The computer programs are documented in Section 7.

2.0 RADIATIVE PROCESSES AND MODELLING

2.1 Introduction

The physical processes and assumptions used in developing a model for transport of infrared radiation in the upper atmosphere are discussed below, beginning with a general overview and discussion of a simpler problem. Next, the interaction of electromagnetic radiation with an isolated atom or molecule is described. An understanding of the basic processes involved is the first step in any computation of the radiation from a gas or mixture of gases. Subsequently, absorption from a continuum source, a spectrally varying source and fluorescent processes are treated. The effects of optical thickness when the path of the radiation includes a large number of molecules of the same species is considered for spectral lines with a Voigt profile, which includes Doppler (Gaussian) and Lorentz shapes as limiting cases. Finally, a model for the transport of radiation for a single vibration-rotation band is described, and the effects of temperature estimated.

Figure 1 illustrates the geometry employed in the current modelling study. A molecule at Point P absorbs radiation from three sources: (1) a collimated beam from the sun, (2) the lower boundary which radiates as a black body, and (3) other molecules between the lower and upper boundaries. Radiative transfer functions are needed to compute the effects of absorption of radiation by other molecules between each of the sources and the molecule at Point P.

In the absence of collisional excitation and de-excitation, the simplest integral equation that may be written to describe radiative transport in a finite plane parallel atmosphere is

$$J(\tau) = \frac{1}{2} \int_0^{\tau_{\max}} K_1(|\tau - t|) J(t) dt + S(\tau) \quad (1)$$

This equation assumes that there is only one radiative transition involved and that the radiation emitted by a molecule after absorption is independent of the direction of incidence. Here τ is a measure of the optical path length

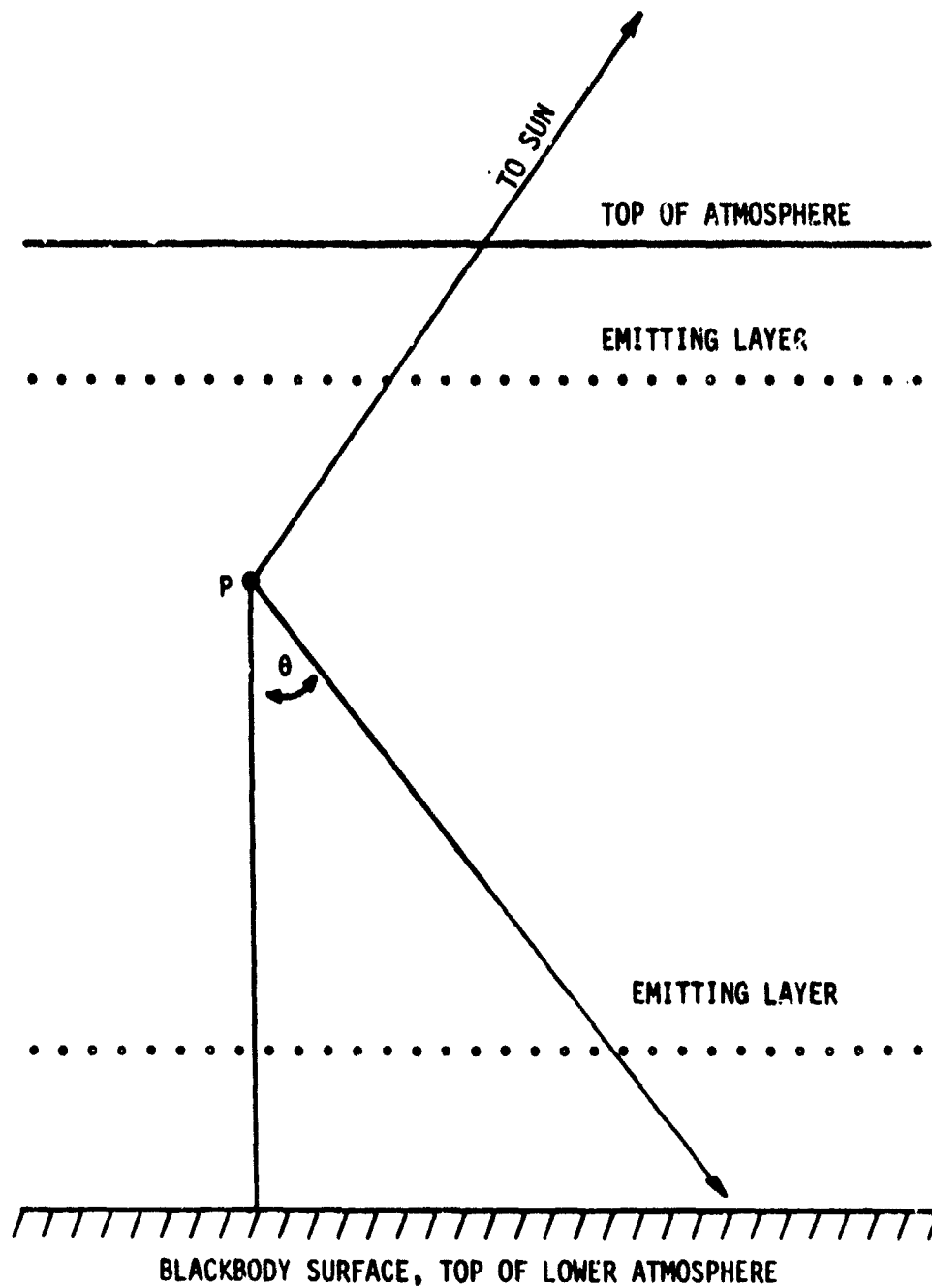


Figure 1. Geometry assumed in deriving the radiative transfer functions.

in the vertical direction. $J(\tau)$ is a dimensionless measure of the population of the upper, emitting molecular state. $K_1(\tau)$ is the radiative transfer function which accounts for absorption of radiation emitted by molecules at a vertical path length τ distant from the absorbing molecule. $S(\tau)$ is an auxiliary function which includes the effects of radiation originating outside the atmosphere. If there is only a blackbody source located at the lower boundary from which optical path length is measured ($\tau = 0$ at the lower boundary) then

$$S(\tau) = \frac{1}{2} N_0 K_2(\tau) \quad (2)$$

Here N_0 is the radiance of the lower boundary in arbitrary units such as watts $\text{cm}^{-2}\text{-ster}^{-1}$ or the spectral radiance in units such as watts $\text{cm}^{-2} \text{ cm}^{-2}\text{-ster}^{-1}$ (wavelength interval) $^{-1}$.

In the gray or spectrally independent case, when Equation (2) holds, the kernel function $K_1(\tau)$ is the first exponential integral $E_1(\tau)$ and the function $K_2(\tau)$ describing the absorption from the blackbody source is the second exponential integral $E_2(\tau)$. These functions are described in detail in such works as Kourganoff (1963). A complete analytic solution is available and the auxiliary functions required for a numerical solution have been tabulated by King (1956). Figure 2 plots the solution of Equation (1) when Equation (2) holds for the gray case for values of total optical thickness $\tau_{\text{max}} = 0, 0.1, 1.0, \text{ and } \infty$. When the total optical thickness is small, the effective excitation of the molecule at any point in the atmosphere is half that of a molecule at the (vibrational) temperature of the blackbody. As the total optical thickness increases, the excitation of the molecules near the blackbody increases, while that of molecules near the top of the atmosphere decreases. This occurs because as the optical thickness increases, molecules near the lower boundary absorb an increasing amount of radiation reradiated from molecules above them. At the same time, less radiation penetrates to higher altitude. The physics of the problem require that if a second blackbody of the same temperature be placed at the top of the atmosphere, the population of radiators at all points would be uniformly that corresponding

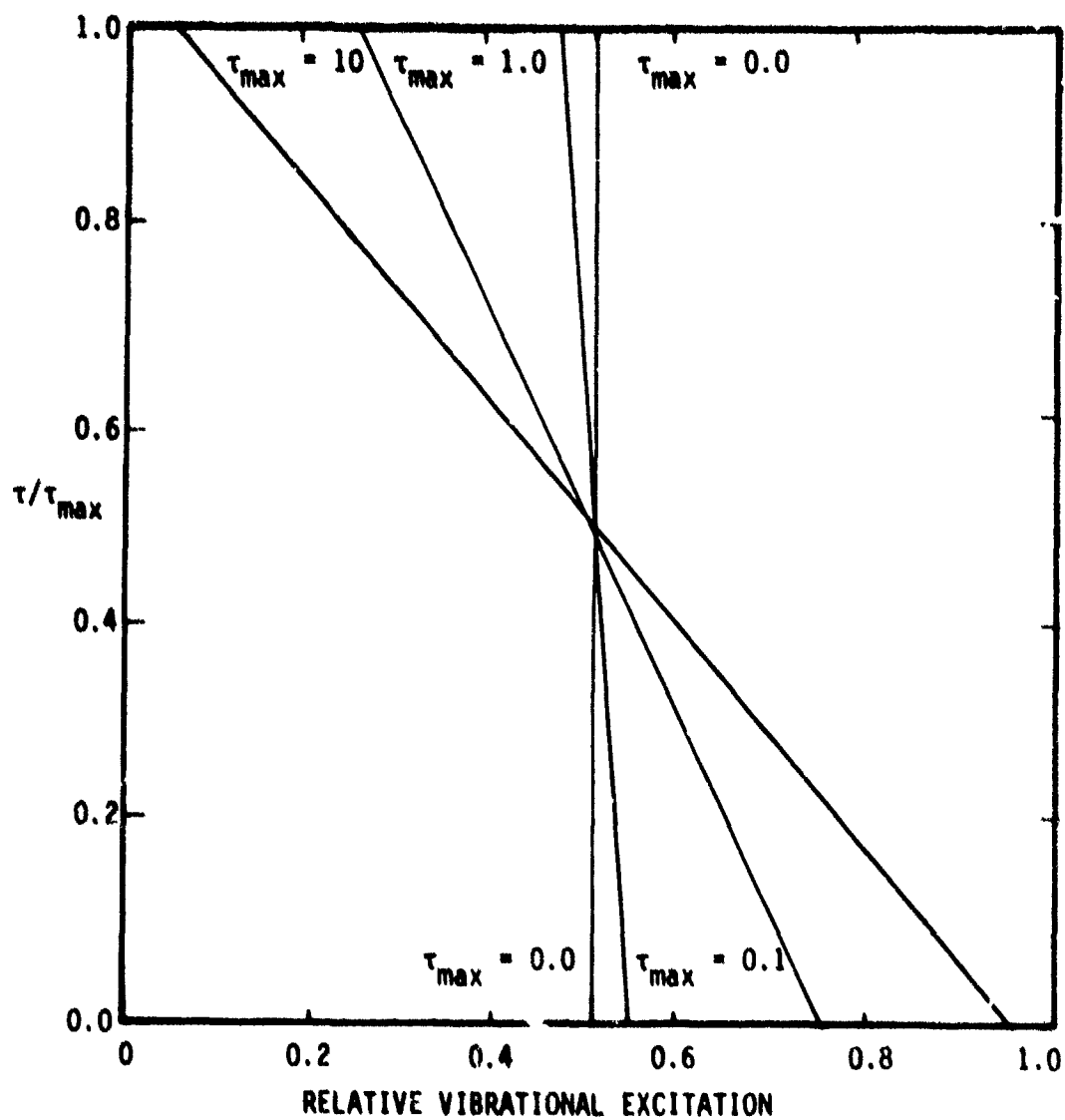


Figure 2: Effect of optical thickness on relative vibrational excitation of atmosphere illuminated from below by black body source (Gray Case).

to the blackbody temperature. This symmetry and the linear character of the integral Equation (1) results in the relation $J(\tau) + J(\tau_{\max} - \tau) = N_0$.

When a collimated beam of light is incident on the top of the atmosphere, another term must be added to the function $S(\tau)$ in Equations (1) and (2) to account for this. If the flux is incident at a zenith angle with cosine μ and has an intensity in arbitrary units such as πF watts cm^{-2} normal to its direction, the term added to $S(\tau)$ has the form $FM_1[(\tau_{\max} - \tau)/\mu]$. In the gray case, $M_1(\tau)$ is simply $\exp(-\tau)$. The corresponding functions for individual spectral lines and bands will be described after a closer look at the interaction of electromagnetic radiation with a single molecule.

2.2 Interaction of Radiation With A Single Molecule

When treating a problem in which the number of photons emitted or absorbed by an atom or molecule must be considered rather than total energy emitted, it is convenient to examine the physics of the interaction of radiation with matter through use of the Einstein A and B coefficients. In treating a radiative problem such as the current study of high altitude infrared radiances which also involves transfer of energy between molecules through collisions, this approach is a necessity. In the following discussion, cgs units are used except where explicitly stated.

The Einstein A_{ul} coefficient is the rate at which an atom or molecule in an excited state spontaneously emits radiation. It has the units photons/sec-molecule. In an assemblage of molecules all in a state which can radiate, the average rate of radiation is given by the Einstein A_{ul} coefficient for the particular radiative transition from a state of higher energy (subscript u) to one of lower energy (subscript l).

In addition to spontaneous emission, two other processes occur. These are absorption, characterized by the Einstein coefficient for absorption B_{lu} , and induced emission, characterized by the Einstein coefficient for induced emission B_{ul} . In a blackbody radiation field with spectral density, $\rho(\nu_{lu})$, the probability that an atom or molecule absorbs a quantum of radiation in unit time is $B_{lu}\rho(\nu_{lu})$. When radiation density is expressed cgs units, ergs $\text{sec}^{-1} \text{cm}^{-1}$, the coefficient B_{lu} has units $\text{cm}^1/\text{ergs sec}$. Similarly, an atom or molecule in a radiation field with the above spectral

density and in an excited state emits radiation at the rate $B_{ul}\rho(\nu_l)$ in addition to that characterized by the coefficient A_{ul} . The Einstein coefficients are properties of an atom or molecule. If one coefficient is known, the others may be determined by the relations

$$A_{ul} = 8\pi h B_{ul} / \lambda^3 \quad (3)$$

and

$$g_l B_{lu} = g_u B_{ul} \quad (4)$$

Thus, it is possible to treat the problem knowing only the Einstein A_{ul} coefficient.

Experimental determinations of the interaction of infrared radiation with gases are usually made by measurements of light absorption. Experimental results may be expressed as integrated absorption from a continuum source,

$$S'_{lu} = N_l \frac{A_{ul} \lambda_{lu}^2}{8\pi} \frac{g_u}{g_l} \left[1 - \exp\left(-\frac{hc}{\lambda_{lu} kT}\right) \right] \quad (5)$$

or as line or band strengths

$$S_{lu} = S'_{lu}/p \quad (6)$$

where p is the pressure.

In the visible and ultraviolet regions of the spectrum, it is customary to use oscillator strengths to characterize the interaction of radiation and matter. In this case, the defining equation is

$$S'_{lu} = \frac{\pi e^2}{mc} N_l f_{lu} \left[1 - \exp\left(-\frac{hc}{\lambda_{lu} kT}\right) \right] \quad (7)$$

The results of theoretical computations of the interaction of matter with radiation are frequently expressed as dipole moments, μ_{ul} . These are related to the Einstein A coefficient by

$$A_{ul} = \frac{64\pi^4}{3h\lambda^3} \frac{g_l}{g_u} |\mu_{ul}|^2 \quad (8)$$

The rate at which a single atom or molecule absorbs and reradiates light from a parallel beam from a continuum source at a wavelength λ_0 corresponding to a resonance transition is (Mitchell and Zemansky, 1961):

$$G = \frac{\pi e^2}{mc^2} I_0 f_0 \lambda_0^2 \quad (\text{photons/sec}) \quad (9)$$

$$= 8.852 \times 10^{-13} I_0 f_0 \lambda_0^2 \quad (\text{photons/sec})$$

where I_0 is the continuum source flux and f_0 is the oscillator strength. If the incident flux is expressed in photons/cm²- μm , and oscillator strength is replaced by the equivalent line or band strength S expressed as cm⁻²atm⁻¹, then

$$G = 3.72 \times 10^{-24} I_0 S \lambda^2 \quad (10)$$

Implicit in this expression is the convenient relation between the Einstein A_{ul} coefficient and line or band strength with wavelength dimensions μm

$$A_{ul} = 2.804S (\text{cm}^{-2}\text{atm}^{-1})/\lambda^2 (\mu\text{m}) \quad (11)$$

When the source is an extended blackbody surface with a spectral radiance N_λ , the G factor is obtained by integration over the solid angle subtended by the source. For radiation from a plane parallel surface of infinite extent,

$$G = 1.169 \times 10^{-23} N_{\lambda} S \lambda^2 \quad (12)$$

Another purely radiative mechanism of importance in upper atmosphere radiance computations is fluorescence. A striking example occurs for the weak 10.4 μm CO_2 band. Absorption of solar radiation by CO_2 4.3 μm band maintains the ν_3 vibrational mode at a vibrational temperature of about 290 K. During the day, this leads to an enhancement of emission in the 10.4 μm band by as much as two orders of magnitude when viewed along the earth's limb from outside the atmosphere.

Fluorescence occurs when the upper state of the resonance transition reradiates into other than the initial states. The relative probability of a radiative transition to a lower state, n from the upper state, u when there are k possible lower state is:

$$P_{un} = \frac{A_{un}}{\sum_{j=1}^k A_{uj}} \quad (13)$$

where the A_{uj} are the Einstein A coefficients for the spontaneous emission probabilities for a transition from the upper state to the j th lower state.

In the case of molecular resonance-fluorescent scattering at low temperature, only the lowest vibrational level ($v'' = 0$) in the ground electronic state is populated significantly. Absorption of a photon excites the molecule to a vibrational level, v' in the same or a higher electronic state. Radiation is possible from this state to the initial level ($v'' \neq 0$) or other vibrational levels ($v'' = 0$) in the ground electronic state. The rate of resonance fluorescent scattering in a given electronic vibrational transition may be obtained by combining Equations (9) and (13) and introducing appropriate subscripts:

$$G_{v',v''} = 8.853 \times 10^{-17} I_{v',0} f_{v',0}^2 2_{v',0} \frac{A_{v',v''}}{\sum_{v''} A_{v',v''}} \quad (14)$$

Here the subscript $v'v''$ refers to a transition from an upper state with vibrational level v' to a lower state with vibrational level v'' . The subscript $v'o$ refers to absorption of a photon by a molecule in the lowest vibrational level of the ground state, exciting the molecule to a vibrational level v' in the same or higher electronic state.

2.3 Radiative Transfer Functions for Lines and Bands

In developing a realistic model of the interaction of radiation with matter, it is necessary to take into account the details of absorption. Line shape must be considered because it determines the amount of radiation escaping from an optically thick layer of gas. Thus, for large optical thickness (greater than a magnitude of about 10), the total emission from an isolated spectral line with Lorentz shape is proportional to the square root of the optical thickness, while that from a line with Doppler shape is proportional to the square root of the logarithm of the optical thickness. In addition, absorption of radiation emitted at one place in the gas by a molecule at another location cannot be computed without knowledge of the line shape.

At high altitudes, the profile of the spectral absorption curve of an individual line in a vibration-rotation band is predominantly due to velocity or Doppler broadening. Kuhn and London (1969), who investigated the heat budget of the atmosphere between 30 and 110 km, report that radiative transfer calculations require the use of the Voigt profile (including both collisional and Doppler broadening) at altitudes between 20 and 70 km. Alternatively, the Doppler profile is adequate at higher altitudes where the Doppler shape is the largest contributor to line broadening. The original computational model therefore assumed a Doppler profile.

The discussion below assumes a Voigt profile for a single line, and it will be shown that for small optical thicknesses and low pressures, the difference between calculations with Doppler and Voigt profiles is small. Asymptotic values for large optical thicknesses are quite different, however.

The radiative transfer functions required to treat transfer of resonance radiation in a single line are well known for the Voigt profile and its two limiting cases, the Doppler and Lorentz profiles. Avrett and

and Hummer (1965) review the properties of four of these functions, giving series expansions for small values of optical thickness and asymptotic expressions for large values of the optical thickness. The notation used for these functions varies widely. That used here is adapted from that used by Ivanov and Shcherbakov (1965 a,b) in their tabulation of functions for the Doppler profile.

The best known of these functions is probably that relating to the equivalent width of a line in absorption or to the total radiation emitted in a line from a source in thermal equilibrium at a constant temperature, the integrated absorptance, defined as

$$L(a, \tau) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} (1 - e^{-\tau f(a, x)}) dx \quad (15)$$

Here $f(a, x)$ is used to denote the Voigt profile,

$$f(a, x) = \frac{a}{\pi} \int_{-\infty}^{\infty} \frac{dt e^{-t^2}}{(t-x)^2 + a^2} \quad (16)$$

The parameter a is proportional to the ratio of the Lorentz half width at half maximum b_L and the Doppler half width at half maximum b_D ,

$$a = \frac{b_L}{b_D} (\ln 2)^{1/2} \quad (17)$$

The parameter x is proportional to the difference between the spectral frequency of the line center ν_0 and that at any other point in the line profile, ν

$$x = \frac{2(\nu - \nu_0)}{b_D} (\ln 2)^{1/2} \quad (18)$$

The quantity τ is the optical thickness at the center of a line with Doppler

broadening alone,

$$\tau = \frac{2\pi e^2}{mc} \frac{Nfl}{b_D} (\ln 2)^{1/2} \quad (19)$$

where N is the number density of ground state molecules and l is the path length. The actual optical thickness at the center of a line with Voigt profile is the product of the τ of Equation (19) and $\exp(a^2)$ times the co-error function of the parameter a , $\text{erfc}(a)$. In general, Equation (15) must be evaluated numerically. For small values of τ , a series expansion may be obtained in the form

$$L(a, \tau) = - \sum_{n=1}^{\infty} \frac{(-\tau)^n}{n!} \phi_n(a) \quad (20)$$

where

$$\phi_n(a) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} [f(a, x)]^n dx \quad (21)$$

For all values of a , $\phi_1(a)$ is one. When $\phi_n(a)$ is divided by $\text{erfc } a$, a smooth variation between $a = 0$ (Doppler profile) and $a = \infty$ (Lorentz profile) is obtained as shown in Figure 3 for small n . For large values of τ , asymptotic series are available, as given for example by van Trigt (1968).

$$L(0, \tau) \approx 2 \left(\frac{\ln \tau}{\pi} \right)^{1/2} \left[1 + \frac{.2886}{\ln \tau} + \dots \right] \quad (22a)$$

$$L(a \neq 0, \tau) \frac{2(a\tau)^{1/2}}{(\pi)^{1/4}} \left[1 + \frac{\sqrt{\pi}}{8} \frac{3 - 2a^2}{a\tau} + \dots \right] \quad (22b)$$

Equation (10) gives the rate at which a single molecule absorbs radiation from a parallel beam. If the molecule is located within an optically thick medium, the rate of absorption of radiation is reduced by a factor which

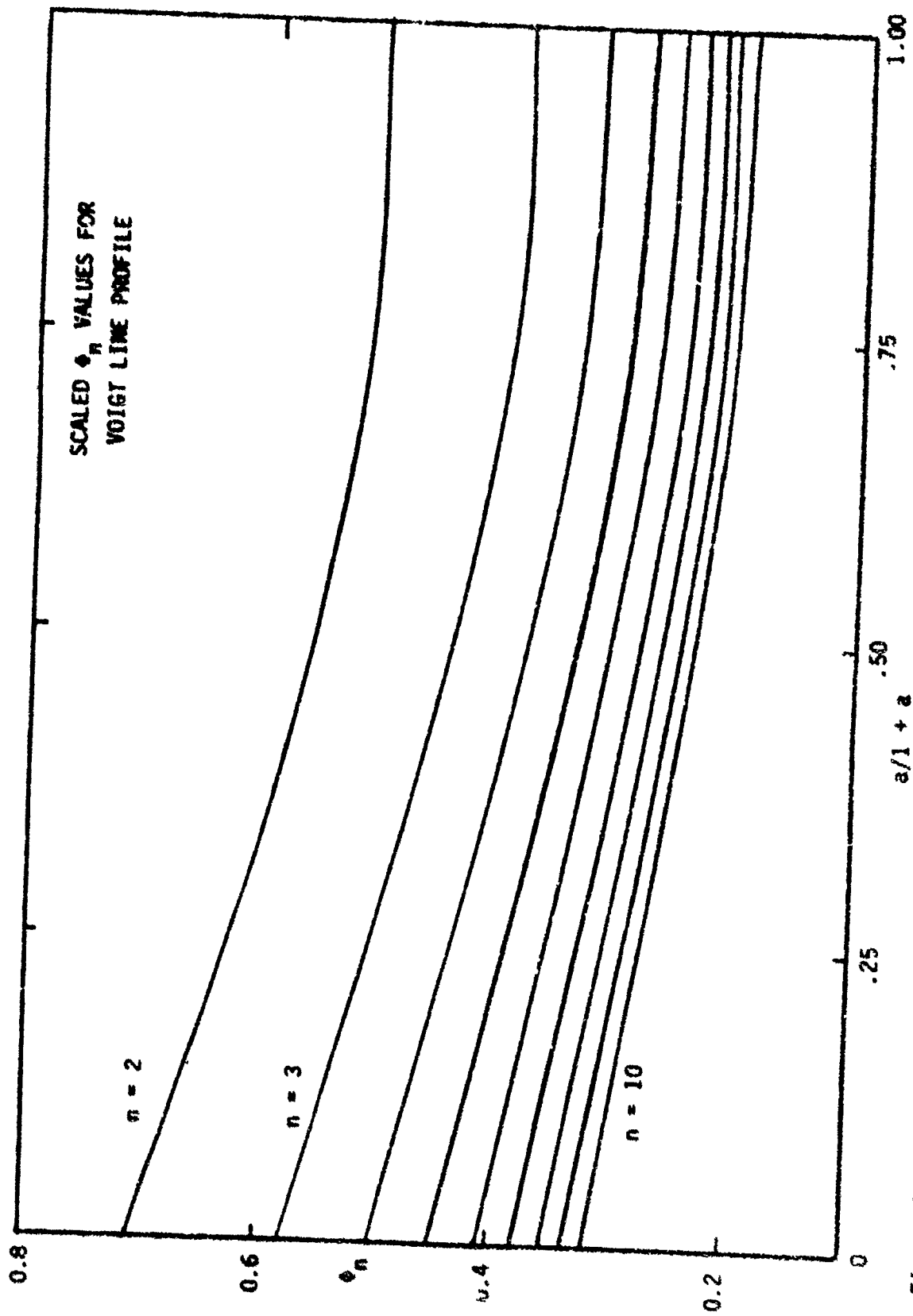


Figure 3: Scaled ϕ_n values for Voigt line profile.

depends on the optical thickness,

$$M_1(a, \tau) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} f(a, x) e^{-\tau f(a, x)} dx \quad (23)$$

For small values of τ , a series expansion is

$$M_1(a, \tau) = \sum_{n=0}^{\infty} \frac{(-\tau)^n}{n!} \phi_{n+1}(a) \quad (24)$$

Asymptotic expressions for large values of τ are

$$M_1(0, \tau) \approx \frac{1}{\sqrt{\pi} \tau \sqrt{k \tau}} \left[1 - \frac{0.2886}{k \tau} + \dots \right] \quad (25a)$$

where

$$M_1(a=0, \tau) \approx \frac{1}{\pi^{1/4}} \sqrt{\frac{a}{\tau}} \left[1 - \frac{\sqrt{\pi}}{8} \frac{3 - 2a^2}{a \tau} + \dots \right] \quad (25b)$$

The function M_1 is the derivative with respect to τ of the function L . In addition to its use in modifying the G factor of Equation (10), it gives the probability of escape of a photon in a direction with optical thickness τ .

A third function is defined as

$$M_2(a, \tau) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} f(a, x)^2 e^{-\tau f(a, x)} dx \quad (26)$$

and has a series expansion

$$M_2(a, \tau) = \sum_{n=0}^{\infty} \frac{(-\tau)^n}{n!} \phi_{n+2}(a) \quad (27)$$

This function is proportional to the rate at which a molecule absorbs radiation from another molecule at a optical distance τ . This function would be used as the kernel function K_1 in Equation (1) if one dimensional radiative transport were being treated. It is included here because of its use in generating the kernel function for a plane parallel geometry.

When the source of radiation is an infinitely extended plane blackbody, the function which is used to determine the rate at which a molecule absorbs radiation is given by

$$N_{12}(a, \tau) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} f(a, x) E_2 [\tau f(a, x)] dx \quad (28a)$$

$$= \tau \int_{\tau}^{\infty} M_1(t) \frac{dt}{t^2} \quad (28b)$$

$$= \int_0^{\pi/2} M_1 \left(\frac{\tau}{\cos \theta} \right) \sin \theta d\theta \quad (28c)$$

The series expansion for this function is given by

$$N_{12}(a, \tau) = \phi_1(a) + (\gamma\tau - \tau + \tau \ln \tau) \phi_2(a) \quad (29)$$

$$+ \tau \phi_L(a) - \sum_{n=2}^{\infty} \frac{(-\tau)^n}{(n-1)n!} \phi_{n+1}$$

Here a new integral is defined,

$$\phi_L(a) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} [f(a, x)]^2 \ln f(a, x) dx$$

and γ is the Euler-Mascheroni constant 0.5772... The asymptotic expansions

$$N_{12}(0, \tau) \sim \frac{1}{\sqrt{\pi} \tau \sqrt{\ln \tau}} \left(0.5 - \frac{0.2693}{\ln \tau} + \dots \right) \quad (30a)$$

$$N_{12}(a \neq 0, \tau) \sim \frac{1}{\pi^{1/4}} \left(\frac{a}{\tau} \right)^{1/2} \left(\frac{2}{3} + \dots \right) \quad (30b)$$

may be obtained from Equations (29b) and (25).

The kernel function for plane parallel geometry is given by

$$N_{21}(a, \tau) = \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\infty} [f(a, x)]^2 E_1[f(a, x)] dx \quad (31a)$$

$$= \int_{\tau}^{\infty} M_2(t) \frac{dt}{t} \quad (31b)$$

$$= \int_0^{\pi/2} M_2 \frac{\tau}{\cos \theta} \frac{\sin \theta d\theta}{\cos \theta} \quad (31c)$$

The series expansion useful for small τ is

$$N_{21}(a, \tau) = -(\gamma + \ln \tau) \phi_2 - \phi_L - \sum_{n=1}^{\infty} \frac{(-\tau)^n}{n \cdot n!} \phi_{n+2} \quad (32)$$

and the asymptotic expansions are

$$N_{21}(0, \tau) \sim \frac{1}{\sqrt{\pi}} \frac{1}{\tau^2} \frac{1}{\sqrt{\ln \tau}} \left(0.5 - \frac{0.0193}{\ln \tau} + \dots \right) \quad (33a)$$

$$N_{21}(a \neq 0, \tau) \sim \frac{a^{1/2}}{\pi^{1/4} \tau^{3/2}} \left(\frac{1}{3} + \dots \right) \quad (33b)$$

The recurrence relation

$$N_{kn}(a, \tau) = \frac{1}{n-1} \left[M_k(a, \tau) - \tau N_{k+1, n-1}(a, \tau) \right] \quad (34)$$

carries over into the corresponding band functions and provides a partial check on numerical calculations.

In extending this treatment of radiative transfer to a vibration-rotation band, in addition to assuming that each line has the same Voigt profile shape, the following assumptions are made:

1. Rotational levels within a vibrational level remain in equilibrium with the translational temperature. This is valid up to at least 150 km according to Goody (1964).
2. There is complete redistribution of frequency within a single line following absorption of radiation.
3. There is complete redistribution of absorbed energy among all rotational levels.
4. Line strengths are used as if each line were at the band center, neglecting wavelength variation across a band.
5. There is no overlap of adjacent lines.
6. Temperature variations at different levels do not affect the radiative transfer.

Let g_j be the fraction of total band strength associated with a single line so that

$$\sum_j g_j = 1 \quad (35)$$

and the sum over j may involve complete summation over rotational quantum number for two or more branches. The optical thickness at the center of a single line will be given by τg_j , where τ is the optical thickness that would result if the entire band strength were in a single line. Then the radiative transfer functions for a band may be defined as functions of radiative transfer functions for a single line. First,

$$L^b(a, \tau) = \sum_j L(a, \tau g_j) \quad (36)$$

where the superscript b refers to an entire band.

In order that the correct derivative relations

$$M_1^b(a, \tau) = \frac{d}{d\tau} L^b(a, \tau) \quad (37a)$$

$$M_2^b(a, \tau) = - \frac{d}{d\tau} M_1^b(a, \tau) \quad (37b)$$

and the integral relations of Equations (28b) and (31b) hold,

$$M_1^b(a, \tau) = \sum_j g_j M_1(a, \tau g_j) \quad (38a)$$

$$M_2^b(a, \tau) = \sum_j g_j^2 M_2(a, \tau g_j) \quad (38b)$$

$$N_{12}^b(a, \tau) = \sum_j g_j N_{12}(a, \tau g_j) \quad (38c)$$

$$N_{21}^b(a, \tau) = \sum_j g_j^2 N_{21}(a, \tau g_j) \quad (38d)$$

While these functions must be evaluated numerically, it is possible to perform this evaluation in two different ways for small values of τ . Making the definitions

$$G_n = \sum_j g_j^n \quad (39)$$

$$G_l = \sum_j g_j^2 \ln g_j \quad (39b)$$

The following series expansions are obtained:

$$L^b(a, \tau) = - \sum_{n=1}^{\infty} \frac{(-\tau)^n}{n!} G_n \phi_n(a) \quad (40a)$$

$$M_1^b(a, \tau) = \sum_{n=1}^{\infty} \frac{(-\tau)^n}{n!} G_{n+1} \phi_{n+1}(a) \quad (40b)$$

$$M_2^b(a, \tau) = \sum_{n=0}^{\infty} \frac{(-\tau)^n}{n!} G_{n+2} \phi_{n+2}(a) \quad (40c)$$

$$L_3^b(a, \tau) = G_1 \phi_1(a) \tau + \frac{1}{2} \left[\left(\ln \tau + \gamma - \frac{3}{2} \right) G_2 \phi_2(a) + G_L \phi_2(a) + G_2 \phi_L(a) \right] \tau^2 + \sum_{n=3}^{\infty} \frac{(-\tau)^n}{(n-2)!} G_n \phi_n(a) \quad (40d)$$

$$N_{12}^b(a, \tau) = G_1 \phi_1(a) + G_2 \phi_2(a) \tau \ln \tau + \left[G_L \phi_2(a) + (\gamma - 1) G_2 \phi_2(a) + G_2 \phi_L(a) \right] \tau - \sum_{n=2}^{\infty} \frac{(-\tau)^n}{(n-1)!} G_{n+1} \phi_{n+1}(a) \quad (40e)$$

$$N_{21}^b(a, \tau) = - \left[\gamma \phi_2(a) + \phi_L(a) \right] G_2 - G_2 \phi_2(a) \ln \tau - G_L \phi_2(a) - \sum_{n=1}^{\infty} \frac{(-\tau)^n}{n!} G_{n+2} \phi_{n+2}(a) \quad (40f)$$

For large values of the optical thickness parameter τ , there is a sharp distinction between the asymptotic expansions for Doppler line

shape. When Doppler line shape is assumed, the asymptotic forms for the functions discussed above differ from those for a single line by a factor proportional to $(\ln \tau)^{1/2}$ in the case of bands for a linear molecule. The numerical results suggest that the asymptotic expansions for an asymmetric rotor are multiplied by an additional factor proportional to $\ln \tau$. In the case of a Voigt profile, there is no such change in the asymptotic form. The L functions retain their $\tau^{1/2}$ dependence, N_{12} functions retain the $\tau^{1/2}$ dependence, and the M_2 and N_{21} functions retain the $\tau^{-3/2}$ dependence. The chief complication with the functions for Voigt profiles is that for intermediate values of τ the behavior is similar to that for a Doppler profile, while at some value of τ dependent on the parameter a , the functions begin to tend toward the asymptotic form. Similar behavior has been found by Malkmus (1967, 1968) for curves of growth for various random band models.

A strict derivation of the asymptotic expansions for the Doppler profile functions has not been obtained. In the high rotational temperature limit, the first term in the expansions for parallel and perpendicular bands of linear molecules appear to be

Parallel	Perpendicular	
$L^b(0, \tau) \sim \sqrt{\pi \epsilon} Q_R \ln \tau$	$\frac{3}{2} \sqrt{\pi \epsilon} Q_R \ln \tau$	(41a)
$M_1^b(0, \tau) \sim \sqrt{\pi \epsilon} Q_R / \tau$	$\frac{3}{2} \sqrt{\pi \epsilon} Q_R / \tau$	(41b)
$M_2^b(0, \tau) \sim \sqrt{\pi \epsilon} Q_R / \tau^2$	$\frac{3}{2} \sqrt{\pi \epsilon} Q_R / \tau^2$	(41c)
$L_3^b(0, \tau) \sim \frac{1}{2} \sqrt{\pi \epsilon} \lambda_R \ln \tau$	$\frac{3}{4} \sqrt{\pi \epsilon} Q_R \ln \tau$	(41d)
$N_{12}^b(0, \tau) \sim \frac{1}{2} \sqrt{\pi \epsilon} Q_R / \tau$	$\frac{3}{4} \sqrt{\pi \epsilon} Q_R / \tau$	(41e)
$N_{21}^b(0, \tau) \sim \frac{1}{2} \sqrt{\pi \epsilon} Q_R / \tau^2$	$\frac{3}{4} \sqrt{\pi \epsilon} Q_R / \tau^2$	(41f)

Here Q_R is the rotational partition function and ϵ is the hcB_v/kT , the dimensionless ratio of rotational quantum energy to kinetic temperature.

The first term in the asymptotic expansions for Voigt profile band functions is easily obtained, as is illustrated for the $L^b(a, \tau)$ function. At large optical paths, $L(a, \tau)$ for a single line is from Equation (21b) approximately $2\pi^{1/4}(a\tau)^{1/2}$. Since the optical thickness at the center of a band is simply $g_J\tau$, then

$$L^b(a, \tau) \sim 2\pi^{-1/4} a^{1/2} \sum_J (\tau g_J)^{1/2}$$

or, denoting $\sum_J g_J^{1/2}$ by $G_{1/2}$

$$L^b(a, \tau) \sim \frac{2}{\pi^{1/4}} (a\tau)^{1/2} G_{1/2} \quad (42a)$$

and

$$M_1^b(a, \tau) \sim \frac{(a/\tau)^{1/2}}{\pi^{1/4}} G_{1/2} \quad (42b)$$

$$M_2^b(a, \tau) \sim \frac{a^{1/2} G_{1/2}}{2\pi^{1/4} \tau^{3/4}} \quad (42c)$$

$$L_3^b(a, \tau) \sim \frac{4(a\tau)^{1/2}}{3\pi^{1/2}} G_{1/2} \quad (42d)$$

$$N_{12}^b(a, \tau) \sim \frac{2}{3\pi^{1/4}} \left(\frac{a}{\tau}\right)^{1/2} G_{1/2} \quad (42e)$$

$$N_{21}^b(a, \tau) \sim \frac{a^{1/2}}{3\pi^{1/4} \tau^{3/2}} G_{1/2} \quad (42f)$$

In order to simplify programming, a single set of functions is used for all parallel bands of linear molecules and a single set is used for perpendicular bands. These functions vary with the rotational temperature and in the program, in order to partially account for temperature variation, the parameter τ is not used, but rather a derived parameter τ_0 , which is the optical thickness at the center of the strongest line in the band. This is either an R branch line for a parallel band or a Q branch line for a perpendicular band.

In practice, rather than formally integrate a modified Equation (1) including a τ dependent λ to account for collisional de-excitation, and an additional source term to account for collisional excitation, the computer program sets an initial vibrational population at each altitude and computes the total radiative excitation at each level which results from the sum of radiation from the earth and lower atmosphere, the sun and other levels in the atmosphere.

The band functions are used to determine the effects of absorption between a molecule at a given altitude and the various sources of radiation affecting a given band in the following way. The vertical optical paths to the lower boundary and to each level in the atmosphere are computed and, for daytime conditions, the optical path to the assumed top of the atmosphere in the direction of the sun using the secant of the solar zenith angle as a multiple. The effective radiation from the lower boundary is determined by multiplying the surface radiance by the appropriate N_b^{12} function. The effective radiation from the sun is determined by use of the proper M_1^b function. The effective radiation from the other levels of the atmosphere may be obtained by integrating the product of emission at each level and the band function N_{12}^b .

$$S_{atm}(\tau_p) = \int_0^{\tau} J(\tau_p - t) N_{21}^0(a, \tau_p - t) dt + \int_{\tau_p}^{\tau} J(t - \tau_p) N_{21}^b(a, t - \tau_p) dt \quad (43)$$

Numerical integration is avoided for contributions from nearby atmospheric layers by assuming that the relative vibrational population between two points varies linearly with optical thickness. The integral relations between the band functions are used in the form

$$\begin{aligned} \int_{\tau_1}^{\tau_2} J(t) N_{21}^b(a, t) dt &= \int_{\tau_1}^{\tau_2} (A + Bt) N_{21}^b(a, t) dt \\ &= J(\tau_1) N_{12}^b(a, \tau_1) - J(\tau_2) N_{12}^b(a, \tau_2) \\ &\quad + \frac{J(\tau_2) - J(\tau_1)}{\tau_2 - \tau_1} \left[L_3^b(a, \tau_1) - L_3^b(a, \tau_2) \right] \end{aligned} \quad (44)$$

At large optical thicknesses, where the contribution to excitation is small, the radiative transfer functions used in the programs are not accurate enough for the subtractions in Equation (44) to yield meaningful results and Equation (43) is evaluated by the trapezoidal rule.

Vibrational populations are determined by balancing collisional and radiative excitation and de-excitation rates. Total band intensities at an observation point inside or outside the atmosphere are computed by determining the optical path from each level to the observation point and integrating the product of local emission rate and the band function $M_1^b(a, \tau)$. This integration also uses a semi-analytical form for atmospheric layers close to the assumed detector location with the relation

$$\begin{aligned} \int_{\tau_1}^{\tau_2} J(t) M_1^b(a, t) dt &= \int_{\tau_1}^{\tau_2} (A + Bt) M_1^b(a, t) dt \\ &= J(\tau_1) L^b(a, \tau_1) - J(\tau_2) L^b(a, \tau_2) \\ &\quad + \frac{J(\tau_2) - J(\tau_1)}{\tau_2 - \tau_1} \left[L_1^b(a, \tau_1) - L_1^b(a, \tau_2) \right] \end{aligned} \quad (45)$$

where

$$L_1^b(a, \tau) = \int_0^{\tau} L^b(a, t) dt \quad (46)$$

Again, trapezoidal integration is used for layers far away from the detector.

The spectral distribution of radiation is determined by finding a mean effective temperature and line-of-sight column density for the radiating molecules, computing intensity for each line in the band with the line function $L(a, \tau)$, summing the line emission rates and scaling each line emission rate so that the total band intensity is obtained.

The above analysis has been presented for the general Voigt profile. Actual use of the radiative transfer functions in the programs has been restricted to the Doppler profile. This restriction is adequate for the water vapor and ozone bands which in the concentrations used in the program have a maximum vertical optical thickness at line center less than three. For limb viewing of carbon dioxide bands the Voigt profile should be used. Efforts to find a general way of setting up the radiative transfer functions to use a Voigt profile that varies with altitude have not been successful. Exploratory calculations show that the computed radiance values for strongest bands at a tangent height of 60 kilometers may be in error by 20 - 50 percent. In view of the uncertainties in chemical abundances, this error is not felt to be serious.

The same radiative transfer functions have been used for the non-linear molecules as were used for the linear molecules. The match between radiative transfer functions has been made by determining a single "effective" rotational constant for the non-linear tri-atomic molecules. This was done by computing actual radiative transfer functions for a limited range of optical thicknesses adequate to cover that needed in the model. The computed functions were compared with those for the linear molecules and the effective rotational constant needed to produce an approximate match at optical thickness at line center of about two was used.

3.0 ATMOSPHERIC COMPOSITION

There have been relatively few measurements of the variation with altitude of infrared emitting species at altitudes above 40 km, the limit of direct sampling by balloons. While ozone measurements by different workers agree reasonably well with each other and with theoretical computations at altitudes up to 100 km, and nitric oxide profiles appear reasonably well known between about 80 and 150 km at middle latitudes, corresponding data are less abundant for other species which are important. There is in some cases, indirect data available which when combined with computational models can yield limits to concentrations. Thus, Anderson (1971a) has been able to put an upper limit on total hydroxyl radical abundance above 60 km from measurement of resonance fluorescence and with this result computes possible water vapor profiles between 50 and 100 km using a photochemical model that includes vertical transport by eddy diffusion. In a later paper, Anderson (1971 b) gives a measured altitude profile for hydroxyl with error limits ± 120 percent.

At present, then, estimates of chemical abundances of minor species required to predict infrared radiation require the use of photochemical computations. Even with the inclusion of best estimates of the effects of such transport processes as eddy mixing, these computations must be used with caution, even when they appear to agree with the limited concentration determinations that are available. Wofsy and McElroy (1973) give a discussion of methane concentrations in the stratosphere which illustrates the interplay of experiment and modelling studies, showing how estimates of eddy mixing coefficients may be obtained.

While previous work (Degges, 1972, 1974) made use of a chemistry program which included one-dimensional diffusive transport, the current contract relies on published calculations to obtain estimates of the abundance of infrared emitting species in the atmosphere. The U.S. Standard Atmosphere, 1976 has been used as the source of abundances of the major atmospheric species N_2 , O_2 and O . We discuss H_2O , NO , O_3 and CO_2 abundances below.

Water vapor abundances are not well known, even in the stratosphere.

Balloon measurements are limited to altitudes below 40 km and are subject to considerable uncertainty as to the amount of water vapor carried to high altitude by the balloon. Direct measurements put lower and upper limits of the volume mixing ratio at two and ten parts per million in the upper stratosphere. A recent optical measurement from a balloon has been made by Goldman, et al (1973) who observed thermal emission from the rotational spectrum near 25 micrometers. Near and below 30 km, the volume mixing ratio is nearly three parts per million. In the region between 30 and 36 km, above the peak altitude reached by the balloon, the mixing ratio appears to be two or three times as large. Radford, et al (1977) have used ground based microwave soundings to determine mesospheric water vapor concentrations. They obtain 10 ppm at 50 km with a maximum of 15 ppm at 60 km. Rogers, et al (1977a) have analyzed radiance measurements obtained from the AFGL/DNA ICECAP Program to infer a water vapor mixing ratio of 3.5 ppmV between 50 and 70 km during late winter at Fairbanks, Alaska. They discuss other measurements and calculations. At present, we adopt 5 ppmV as a reasonable mixing ratio, as shown in Figure 4.

A large number of measurements of nitric oxide concentrations are available. Representative mid-latitude concentrations are shown in Figure 5, which is based on the twilight measurements of Baker, et al (1977) and on the calculations of Oran, et al (1975).

While ozone abundances below about 50 km must take into account lateral transport as well as vertical transport by eddy mixing and molecular diffusion, photochemical models are adequate above that altitude, and agree with observations obtained by measuring absorption of solar and stellar ultraviolet radiation and those deduced from measurements of the molecular oxygen 1.27 μ m infrared atmospheric band. The exact profile depends on assumed eddy diffusion coefficients, however, principally through atomic hydrogen and oxygen concentration. O_3 abundances used here are shown in Figure 6. Below 60 km, we use the ozone model in the U.S. Standard Atmosphere, 1976. These curves rely heavily on measurements by Llewellyn and Witt (1977) and Hays and Roble (1973). The calculations of Thomas and Bowman (1972) have been used as a guide to predict diurnal variations in abundances. Diffusive equilibrium is assumed above 100 km.

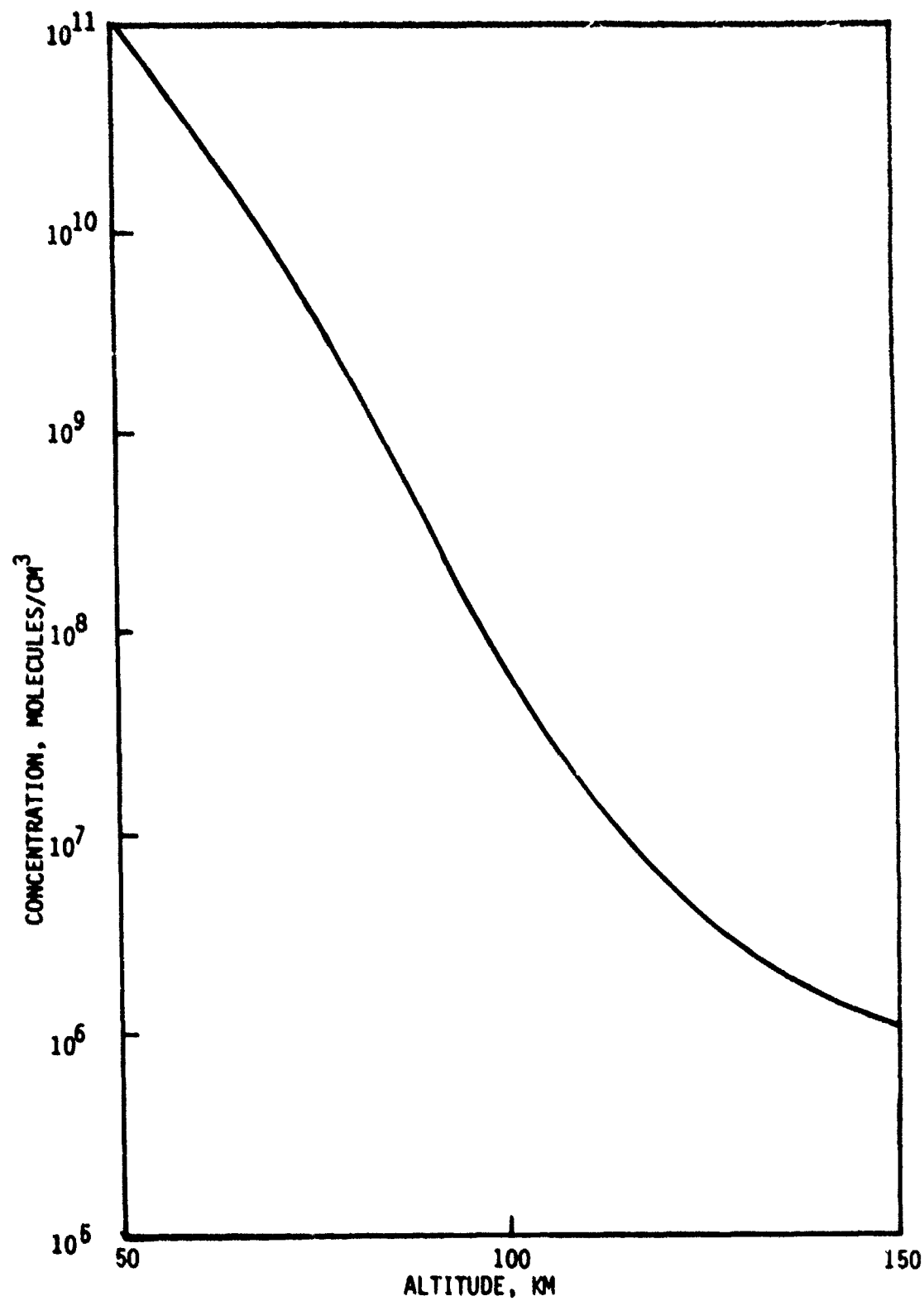


Figure 4: Water vapor concentration profile

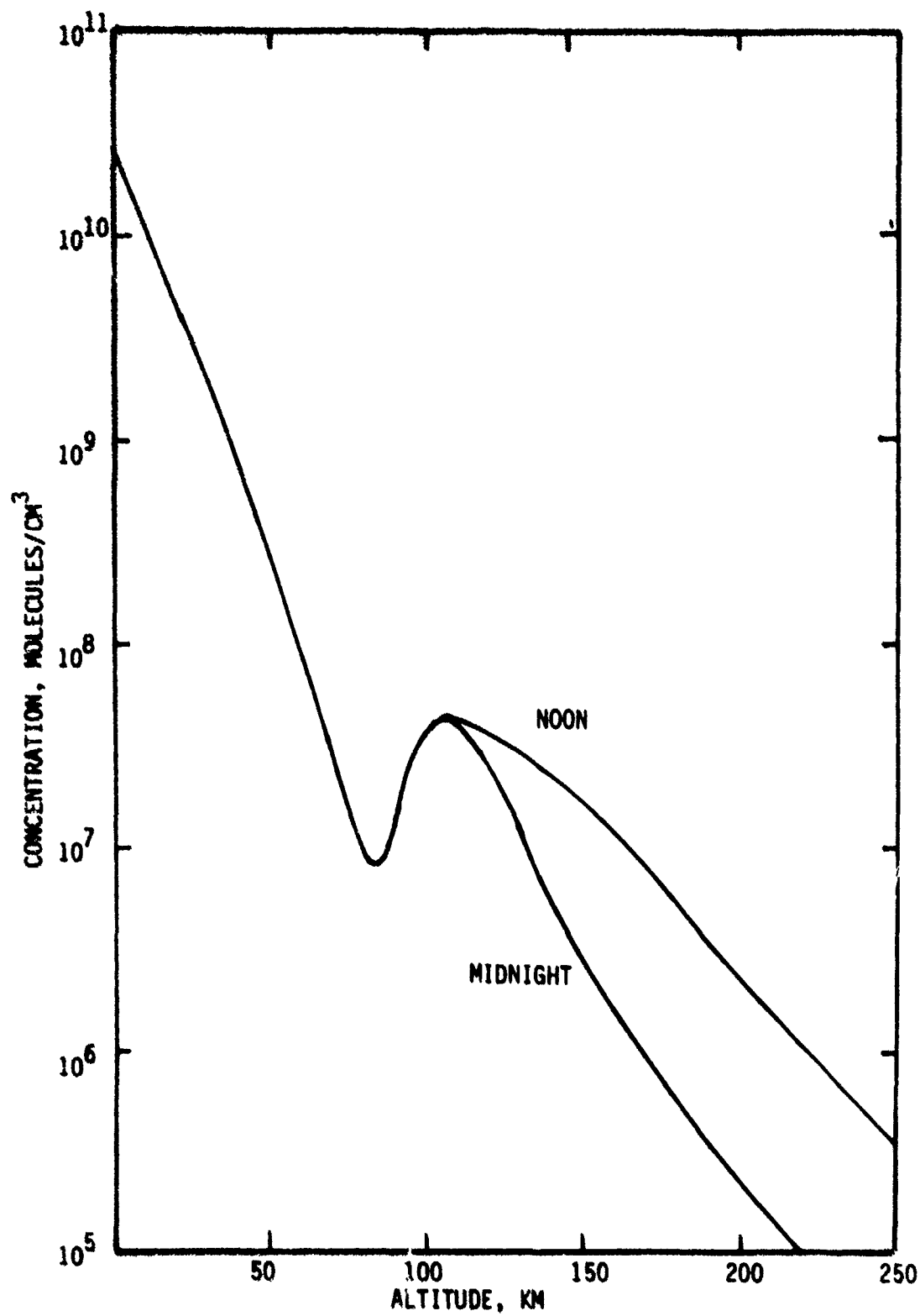


Figure 5: Nitric oxide concentration values

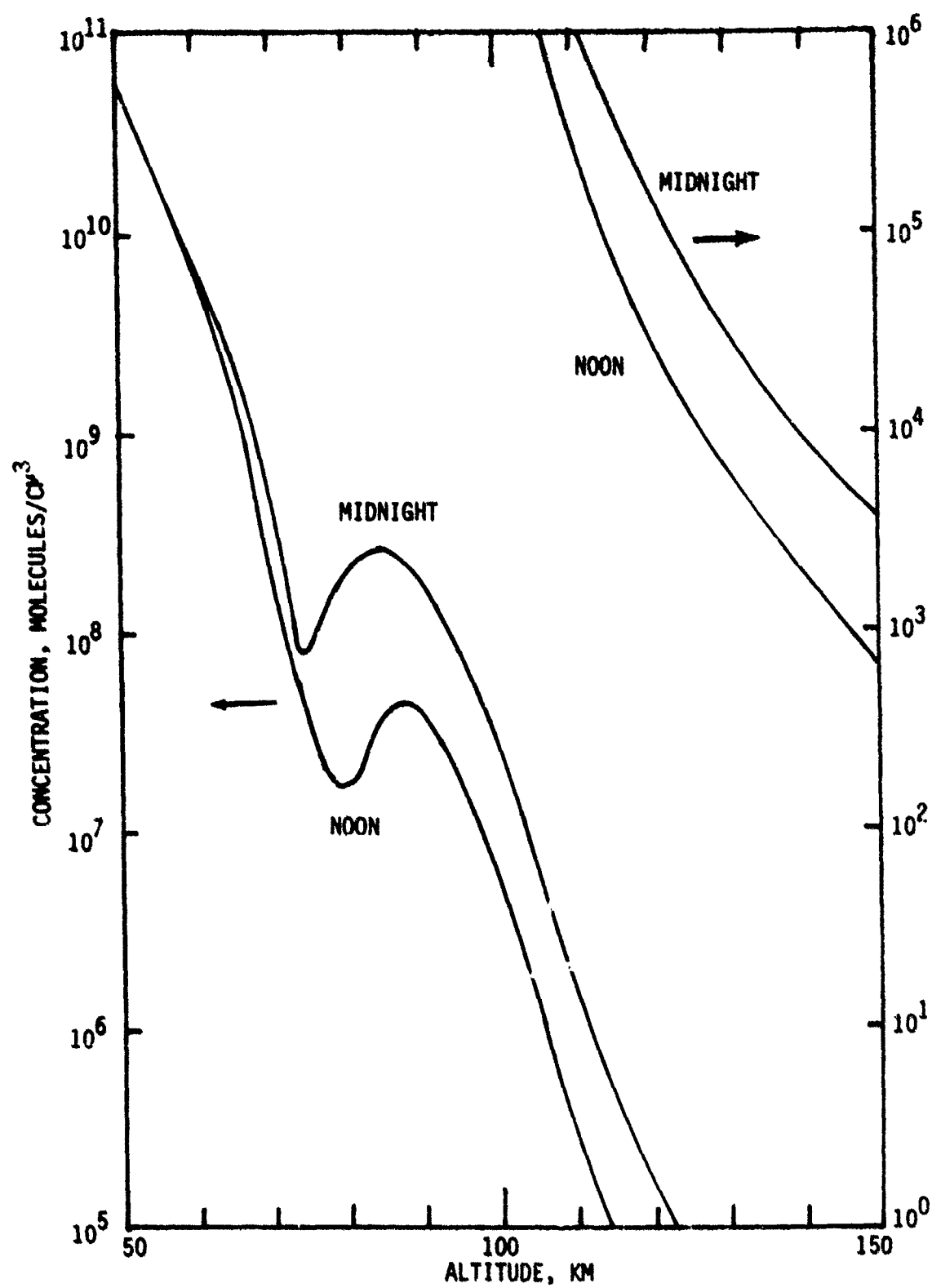


Figure 6: Ozone concentration profiles

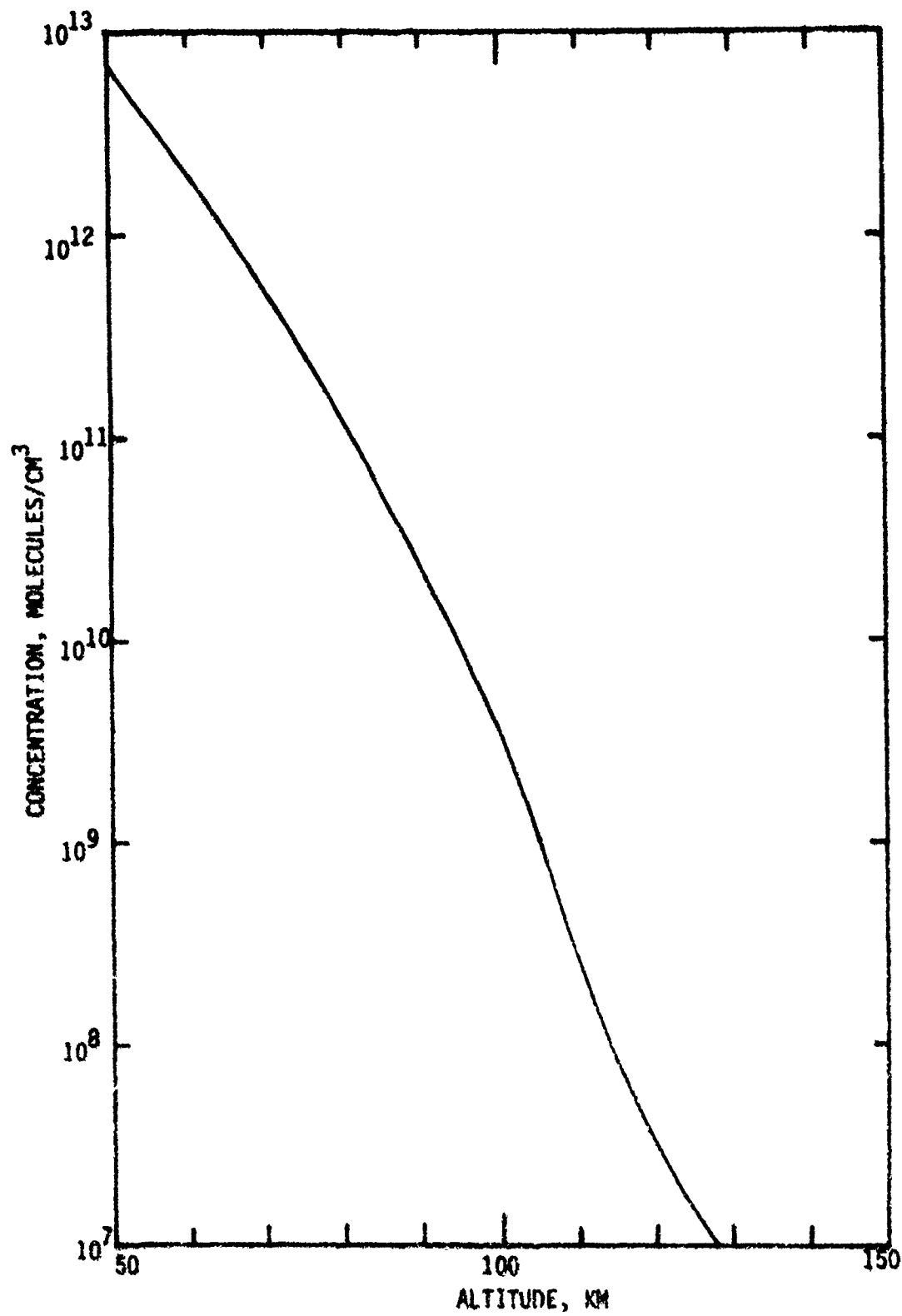


Figure 7: Carbon dioxide concentration profile

Carbon dioxide has a lifetime of about ten days at the top of the atmosphere, where it is dissociated by solar radiation. It is well shielded by molecular oxygen below about 120 km, however, and should remain well mixed below 100 km. The only good measurement above 100 km remains that of Offerman and von Zahn (1971), who find that between 120 and 140 km the mixing ratio is not more than 50 percent less than the tropospheric value. Above 140 km, molecular diffusion is rapid enough compared to photodissociation to maintain diffusive equilibrium. Figure 7 gives our current estimate of CO₂ concentrations.

4.0 RESULTS FROM COMPUTATIONAL MODEL

4.1 Introduction

The revised high altitude spectral radiance programs can produce spectral radiance profiles for wavelengths between 2.5 and 25 micrometers or between 400 and 4000 wave numbers. Results are presented here based on estimated abundance profiles of the four species CO_2 , H_2O , O_3 and NO . The temperature and pressure profiles used were taken from U.S. Standard Atmosphere, 1976. Upwelling terrestrial radiances are assumed to be those corresponding to a black body source at the ground level temperature.

4.2 Limb-Viewing Spectral Radiances

Representative limb viewing radiance profiles are shown in Figures 8 through 19. These are based on the concentration profiles of Section 3. The temperatures and number densities used are those of the U.S. Standard Atmosphere, 1976.

Comparison of day and night profiles for a given tangent height shows that the low energy (small wave number and long wavelength) band radiances do not vary appreciably during the day. The high altitude high energy bands, however, do vary in intensity by as much as two orders of magnitude as the result of resonant and fluorescent emission following absorption of solar radiation. This is shown clearly in the CO_2 4.3 micrometer bands and in the water vapor complex at 2.7 micrometers.

4.3 Individual Band Radiances

For some purposes it may be more convenient to have available the total radiance of an individual band rather than the spectrum of the region where the band is located. This may aid in making allowances for species abundances different from those assumed in a computation or in assigning an experimentally observed radiance value to one species rather than another.

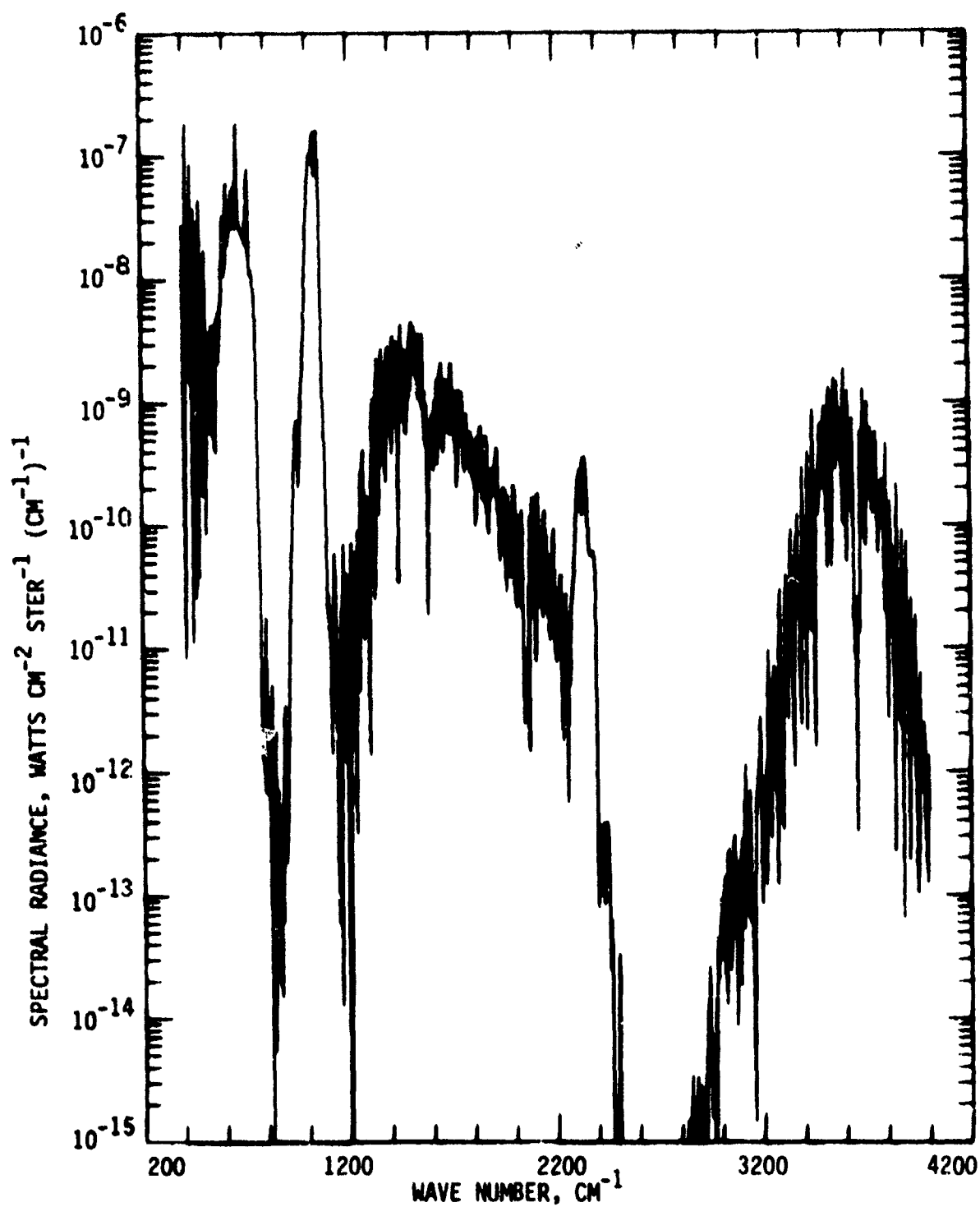


Figure 8: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 60 km tangent height.

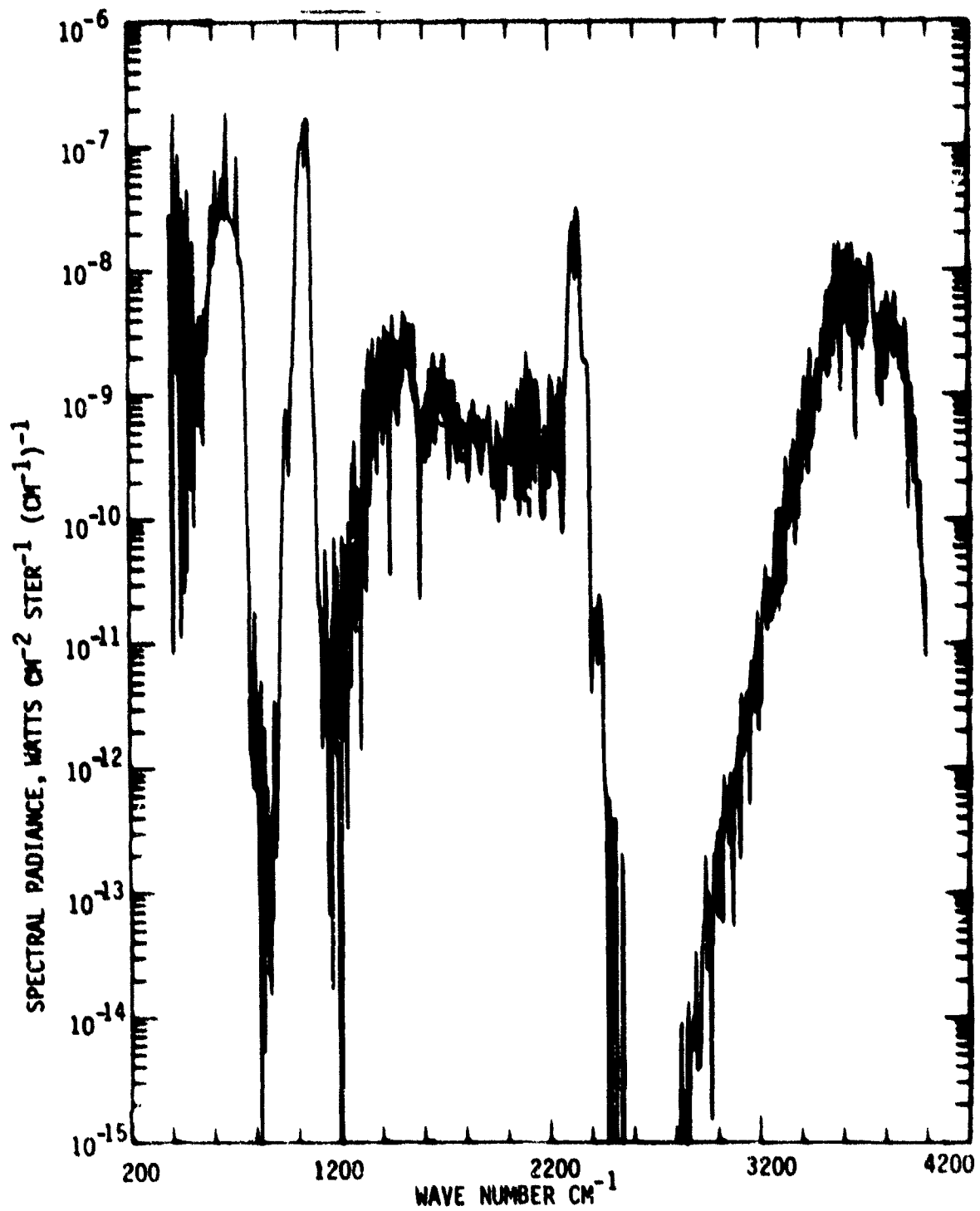


Figure 9: Day limb viewing spectral radiance, 400 to 4000 cm⁻¹, 60 km tangent height.

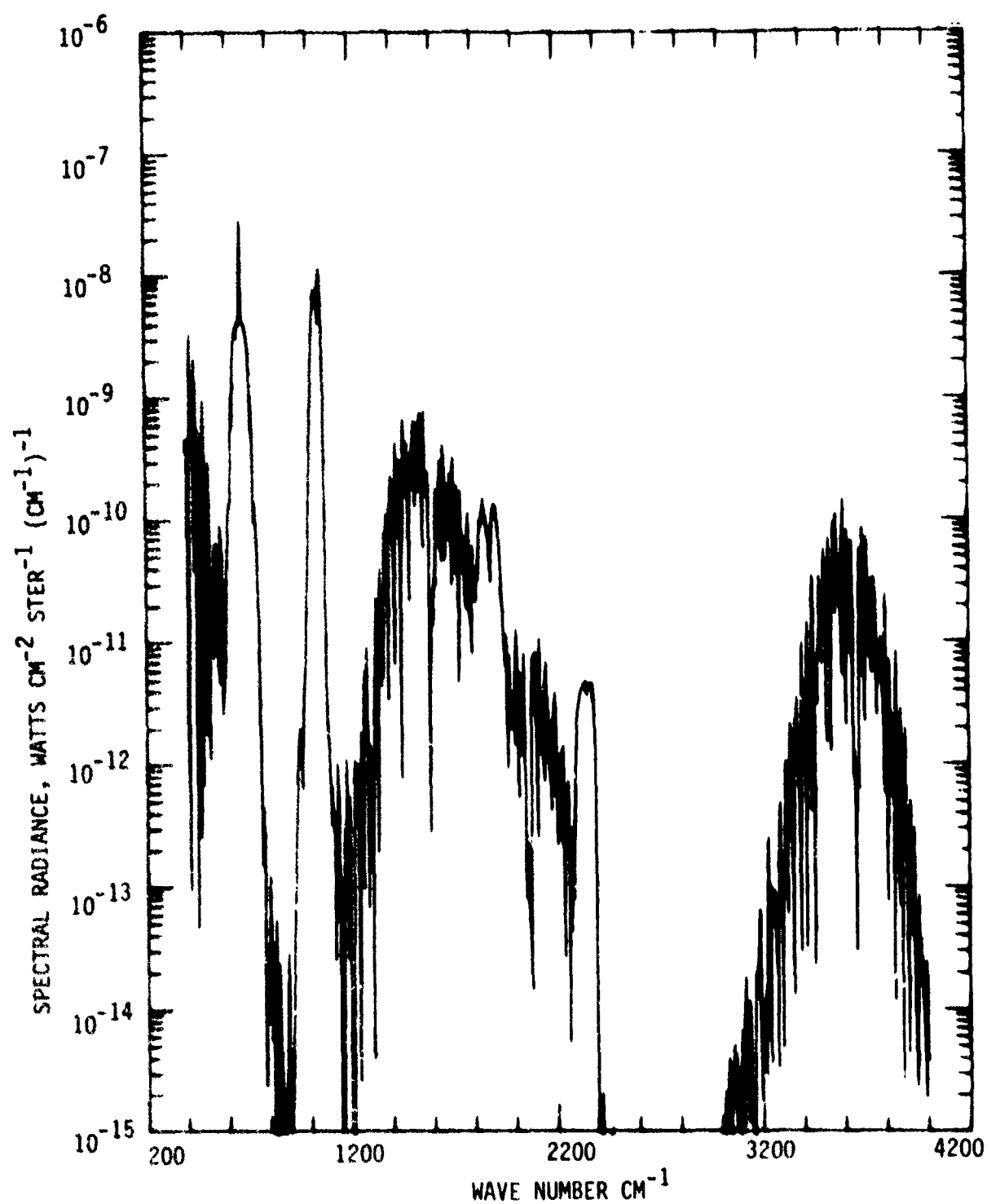


Figure 10: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 80 km tangent height.

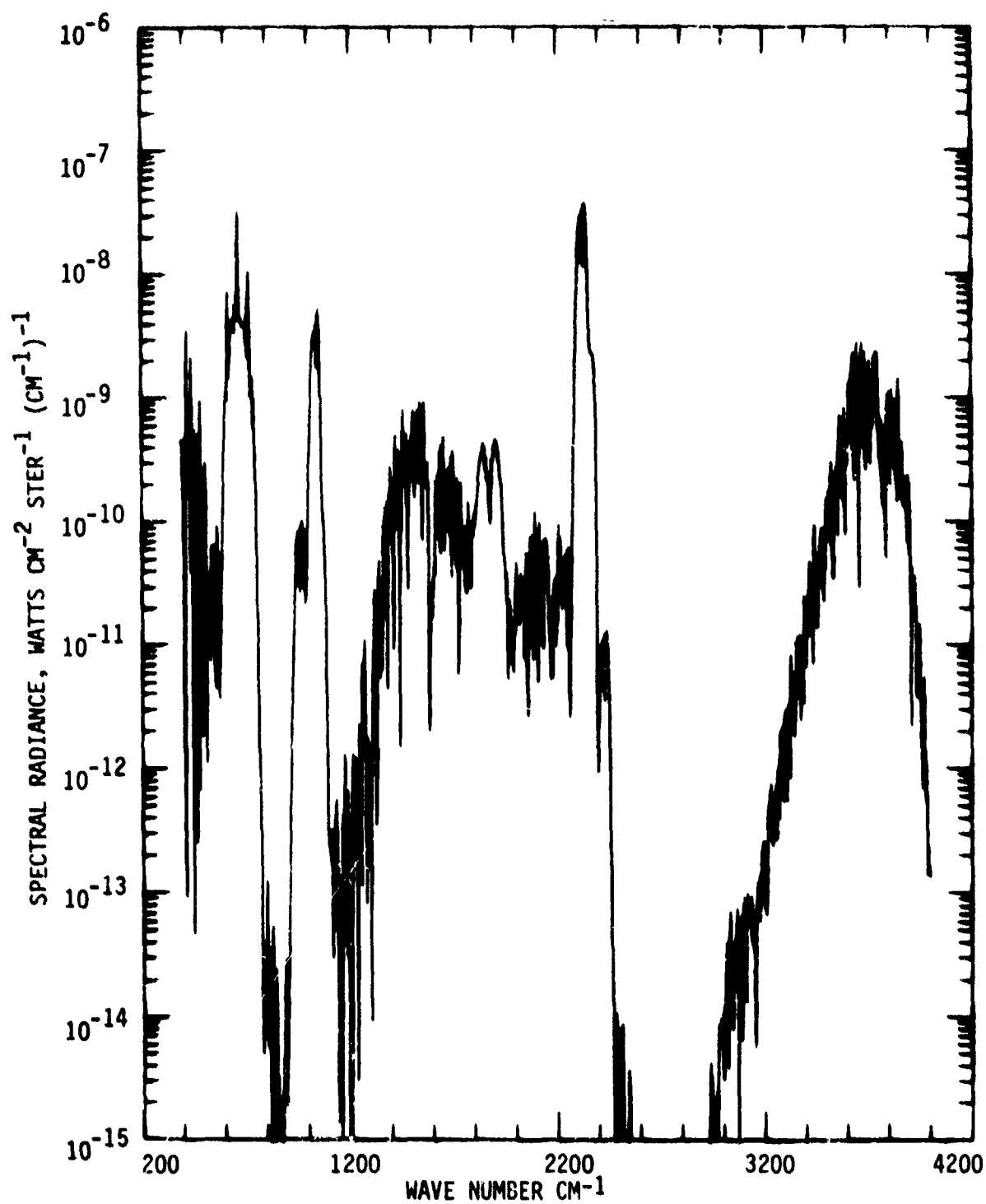


Figure 11: Day limb viewing spectral radiance, 400 to 4000 cm^{-1} , 80 km tangent height.

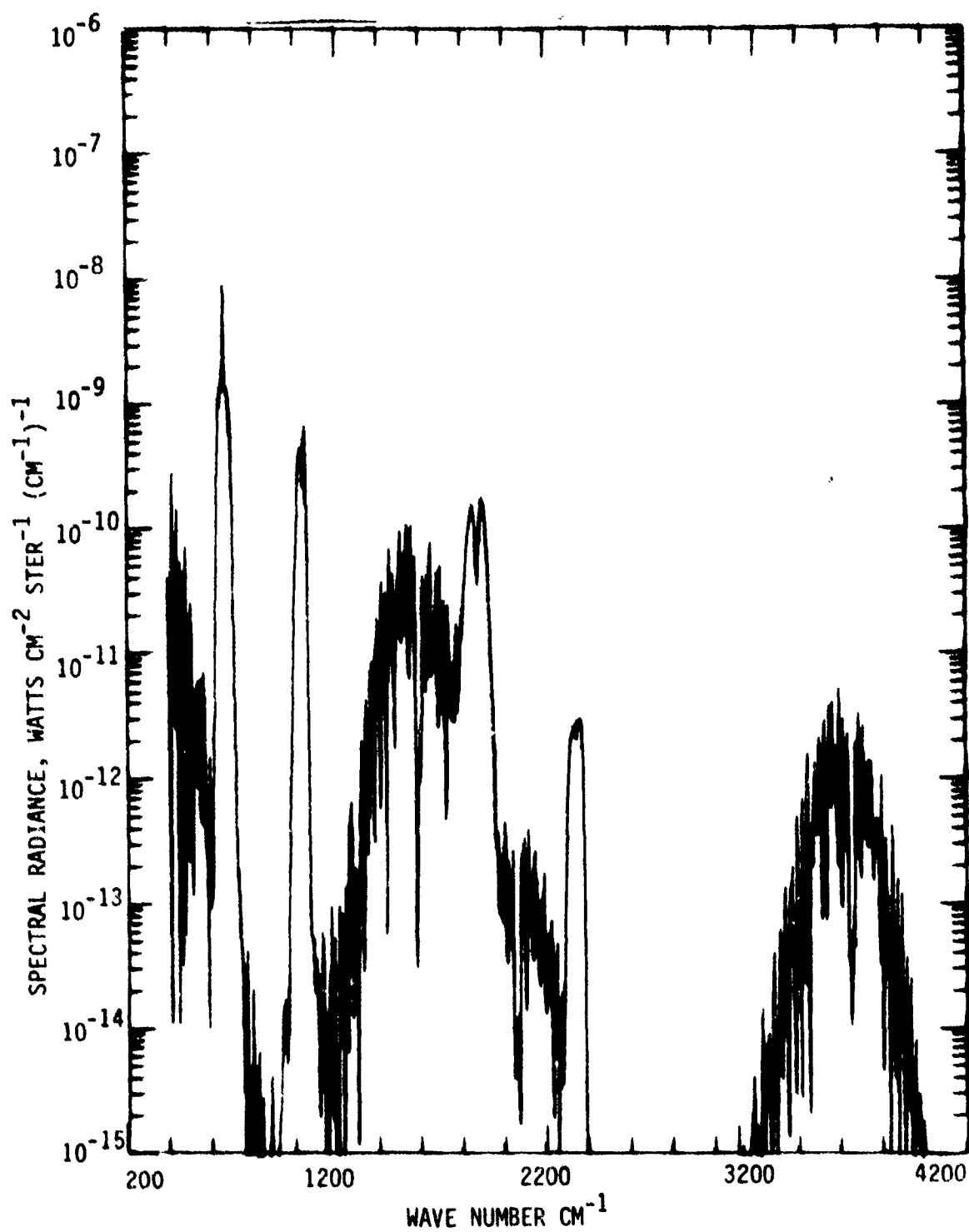


Figure 12: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 100 km tangent height.

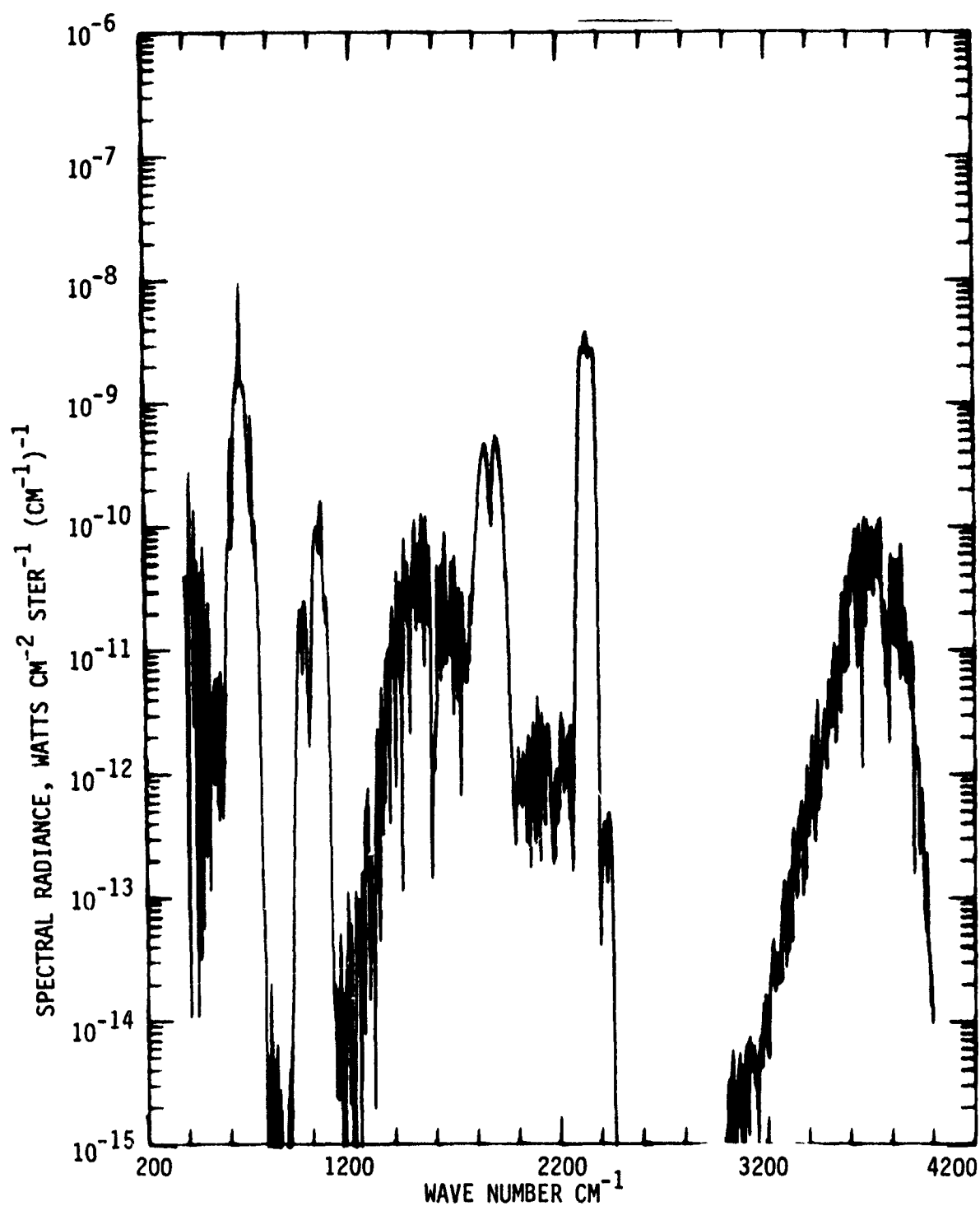


Figure 13: Day limb viewing spectral radiance, 400 to 4000 cm⁻¹, 100 km tangent height.

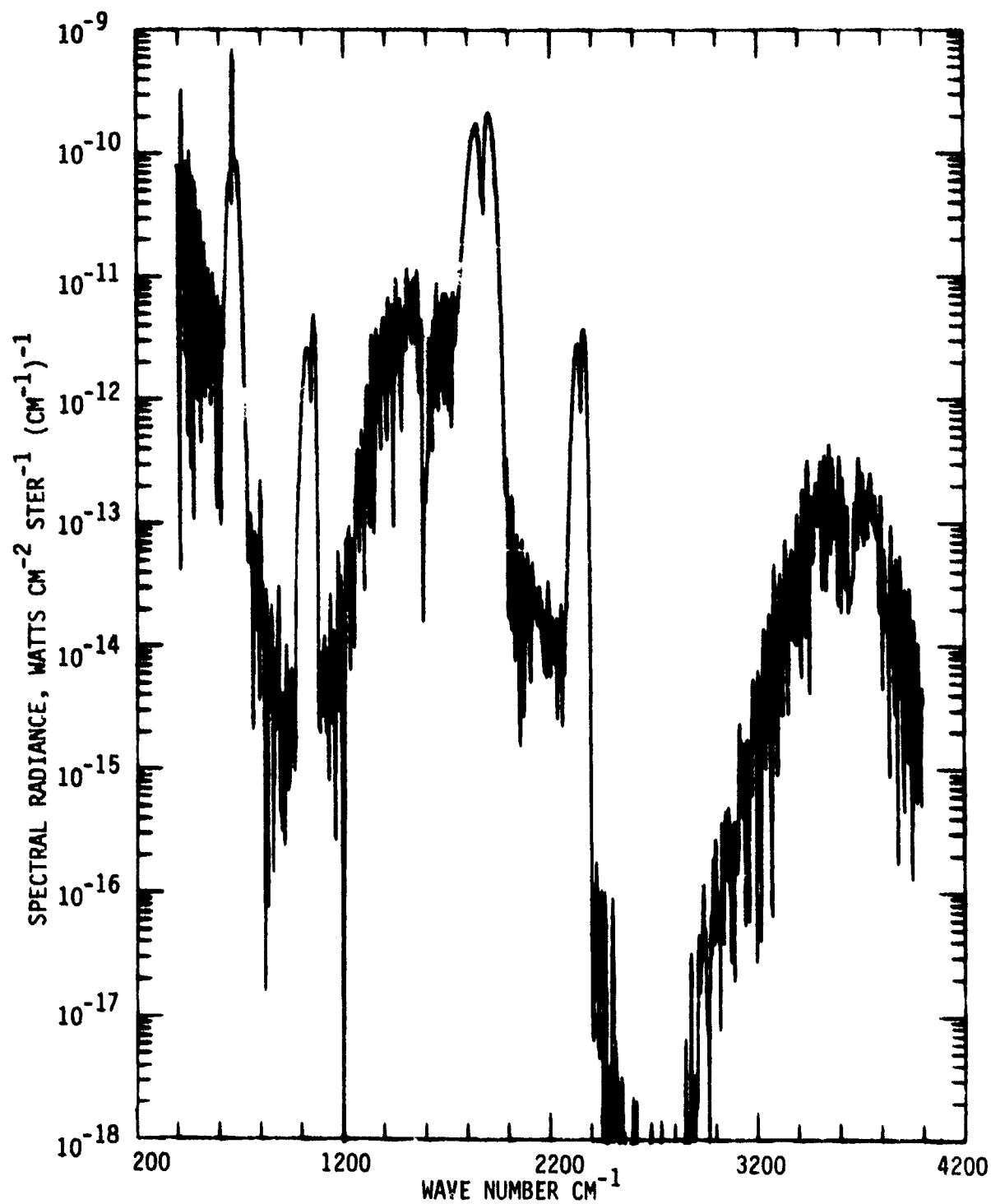


Figure 14: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 120 km tangent height.

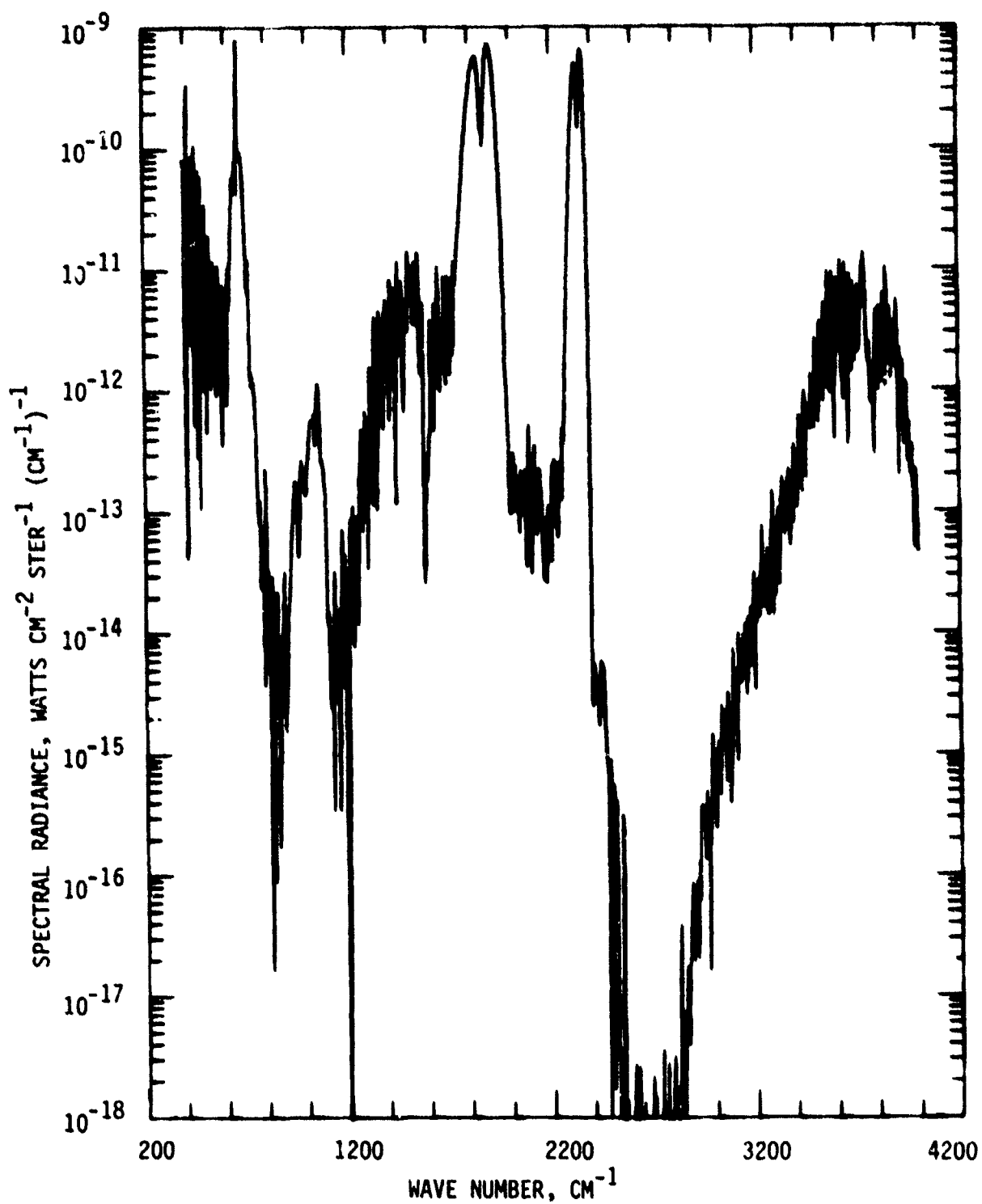


Figure 15: Day limb viewing spectral radiance, 400 to 4000 cm^{-1} , 120 km tangent height.

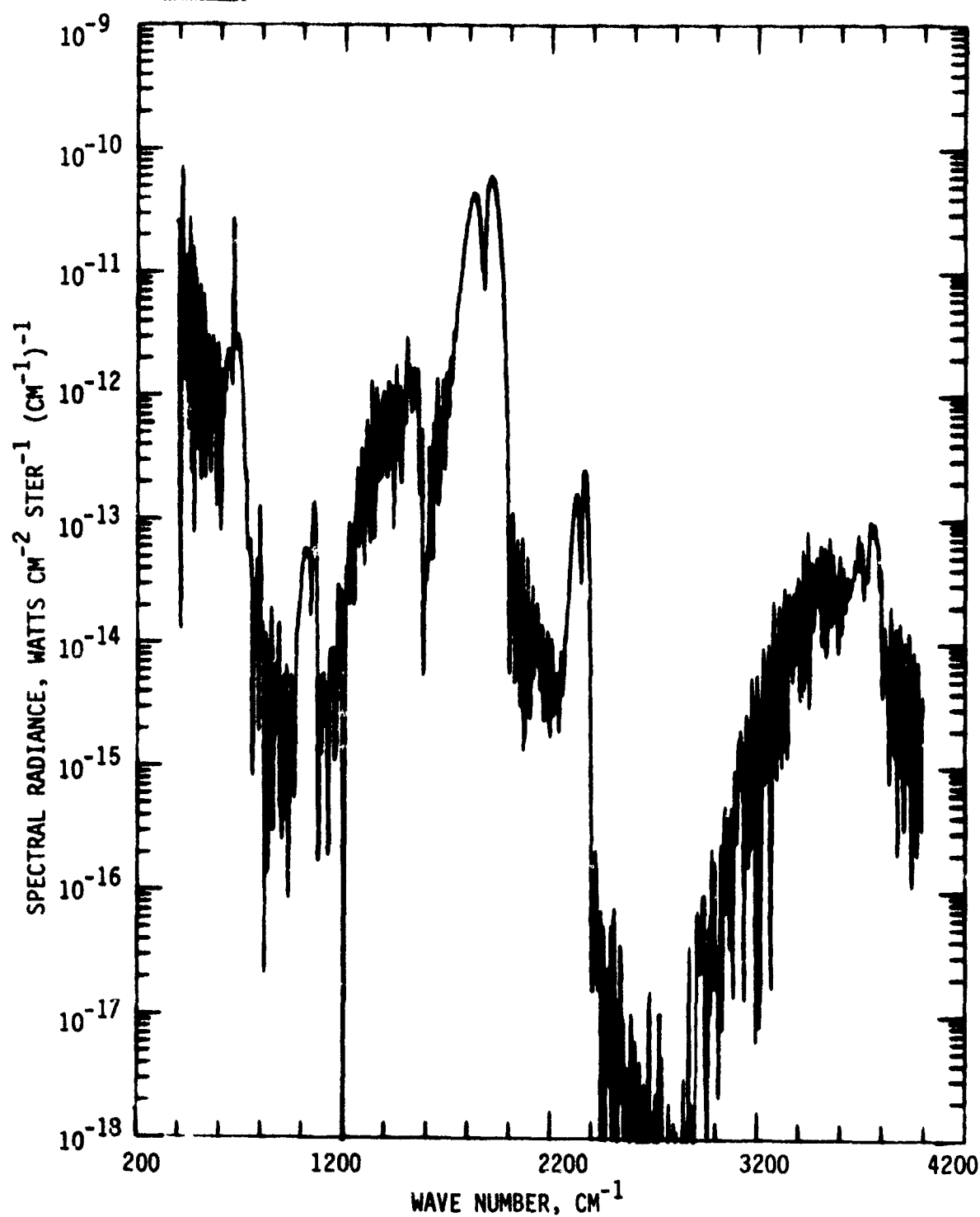


Figure 16: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 150 km tangent height.

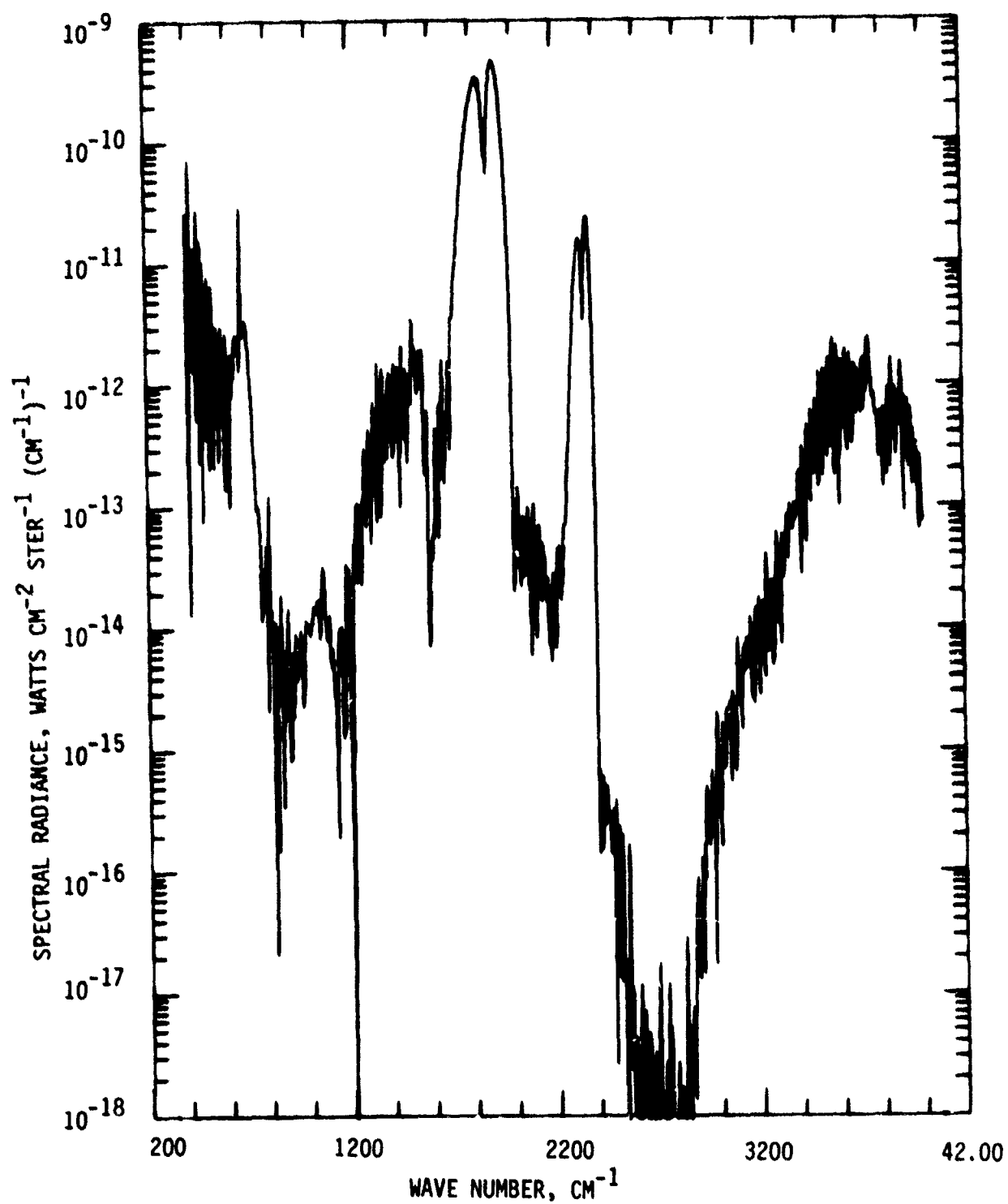


Figure 17: Day limb viewing spectral radiance, 400 to 4000 cm⁻¹, 150 km tangent height.

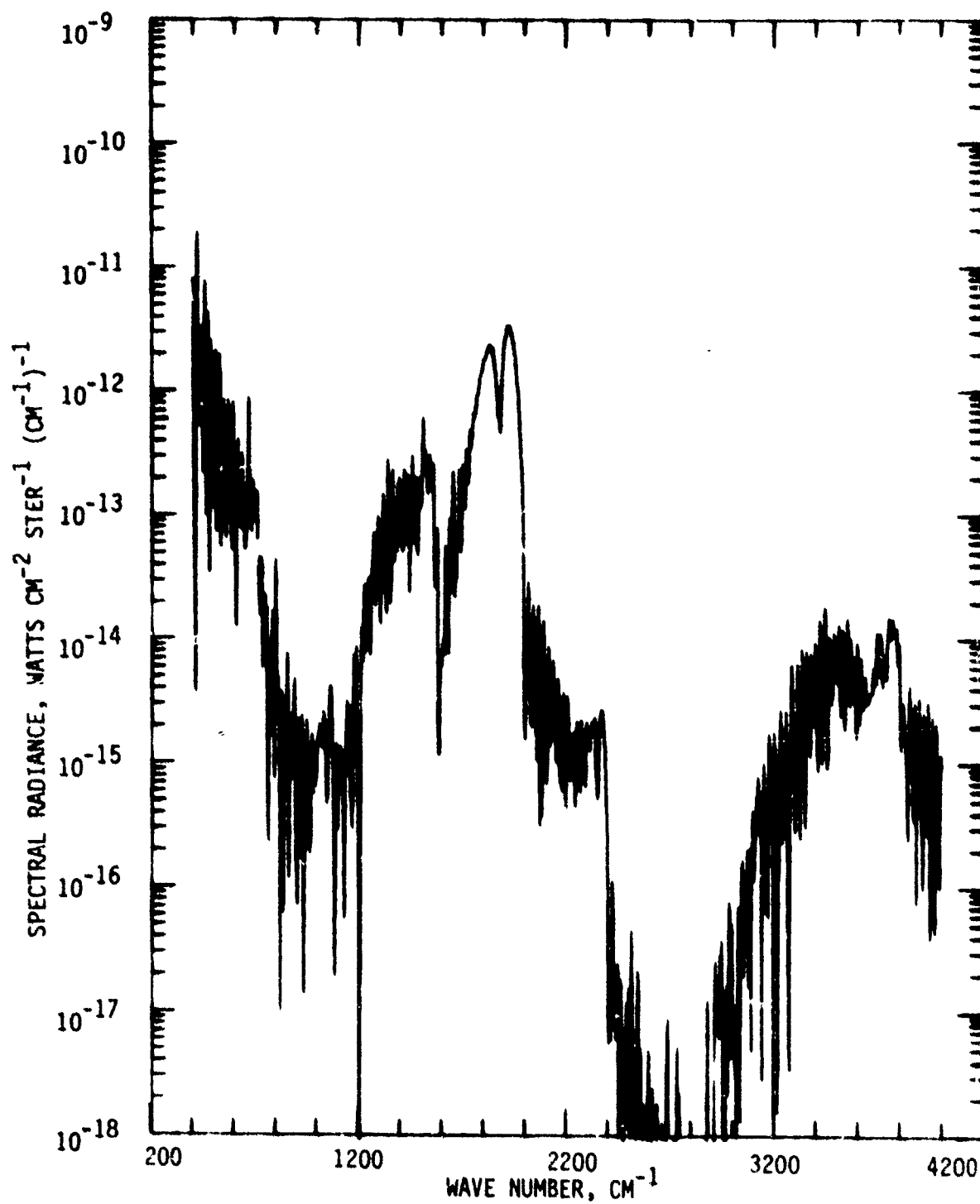


Figure 18: Night limb viewing spectral radiance, 400 to 4000 cm⁻¹, 200 km tangent height.

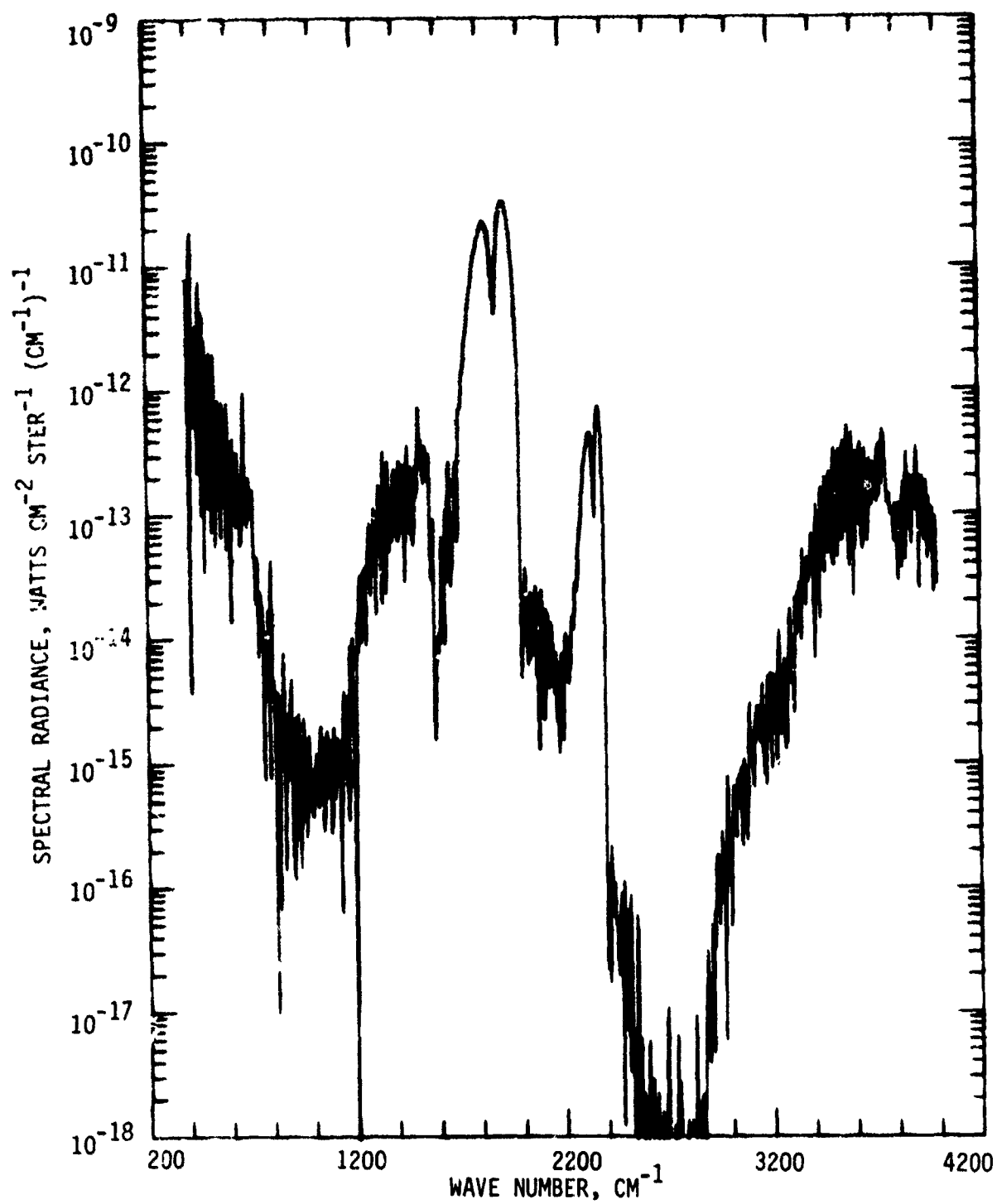


Figure 19: Day limb viewing spectral radiance, 400 to 4000 cm⁻¹, 200 km tangent height.

Figures 20 and 21 show the night and day total band radiances for the ten water vapor bands included in the spectra of Figures 8 through 13. The 6.3 micrometer ν_2 band is the strongest, day and night. During the day, the ν_3 band at 2.66 micrometers strongly absorbs solar radiation and becomes almost as bright at a tangent height near 90 km. At night this band is nearly four orders of magnitude fainter.

Figures 22 and 23 show night and day limb radiance values for seven bands of the CO_2 15 micrometer band complex, the 4.3 micrometer ν_3 band and the two fluorescent bands originating from the ν_3 state, the 10.42 micrometer 00011-10001 band and the 9.60 micrometer 00011. The 15 micrometer band radiances vary little between day and night. During the day, however, the radiance of the 4.3 micrometer band rises from its night value of between 10^{-9} and 10^{-8} watts/cm²-ster to a value of between 10^{-8} and 2×10^{-7} watts/cm²-ster. This band is thick in the limb viewing geometry, and most of the increase is due to increased vibrational temperatures at altitudes above 90 km. The 10.41 and 9.60 micrometer bands, which have much lower optical thickness, give a better indication of the altitudes at which the solar excitation is important. The 60 km value is about 4×10^{-8} watts/cm²-ster day or night. Figures 24 through 27 show night and day band radiances for nitric oxide and ozone.

4.4 Comparison With Observations

A limited amount of data from the ICECAP Program is available for comparison with the results of the radiance computer program. Figure 28 compares peak spectral radiance values for the 15 micrometer band reported by Stair et al (1974, 1975) and Rogers et al (1976, 1977b) with those computed by the present model and concentrations of Section 3 (Model I) and the previous Model (Model II) using the U.S. Standard Atmosphere, 1962 temperature profile with 180 K mesopause temperature and uniform mixing of CO_2 at all altitudes. The differences between the models is due principally to differing temperature profiles and assumed CO_2 mixing ratios. A part of the difference between the data and the model can be resolved by using a temperature profile obtained at the observation site near the times of the flights. Complete resolution of the differences will require an

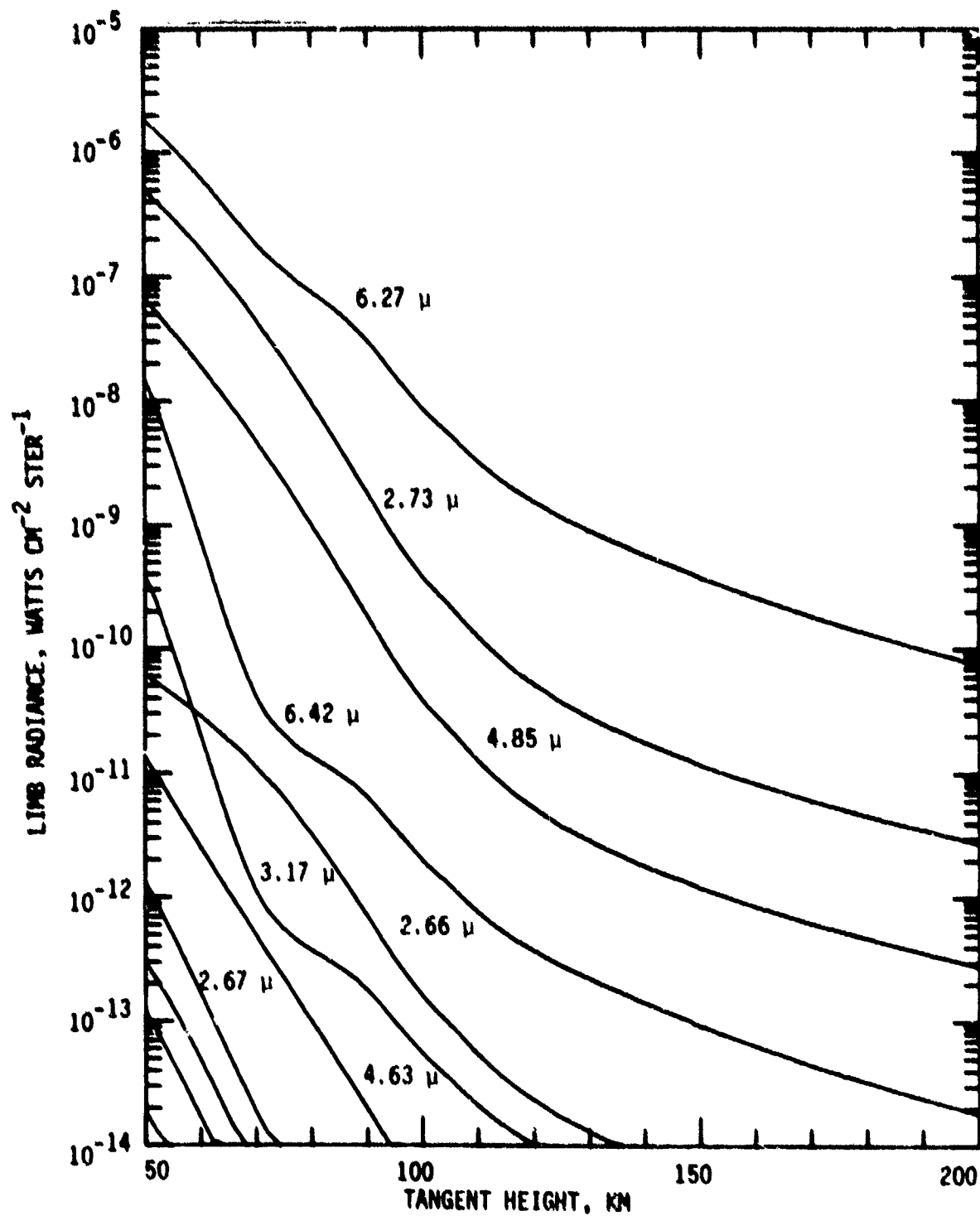


Figure 20: Night limb viewing total band radiance values for water vapor bands.

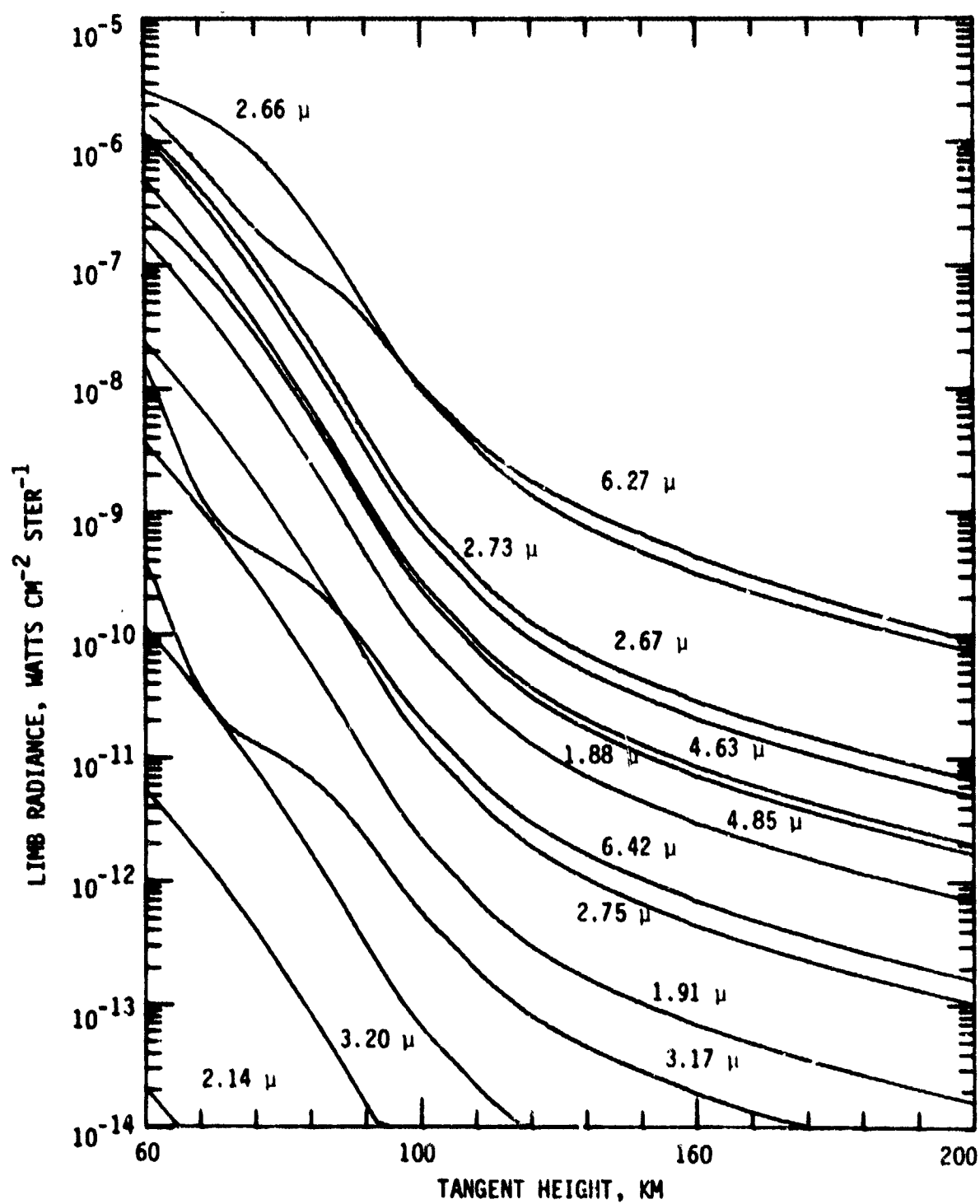


Figure 21: Day limb viewing total radiance values for water vapor bands.

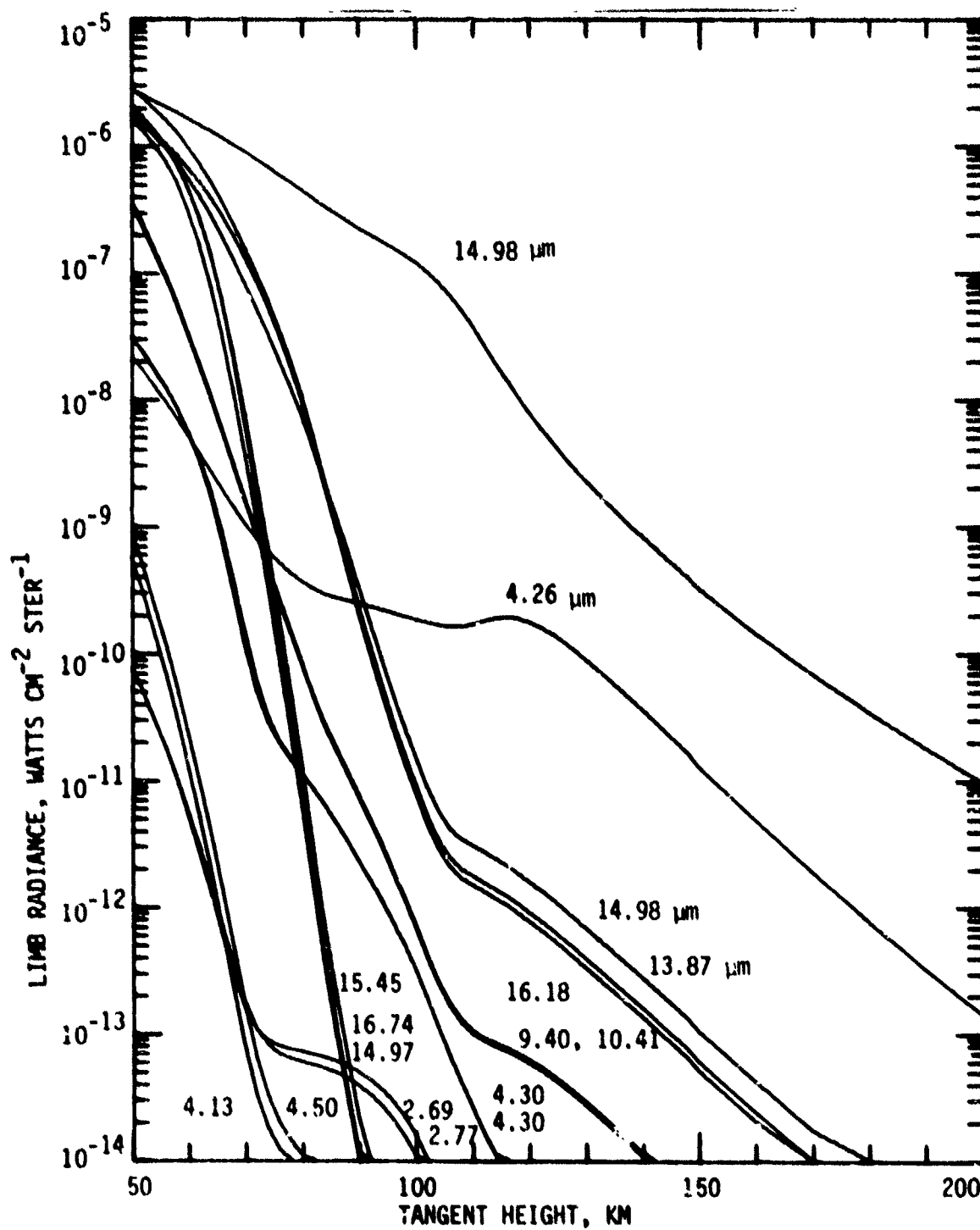


Figure 22: Night limb viewing total radiance values for carbon dioxide bands.

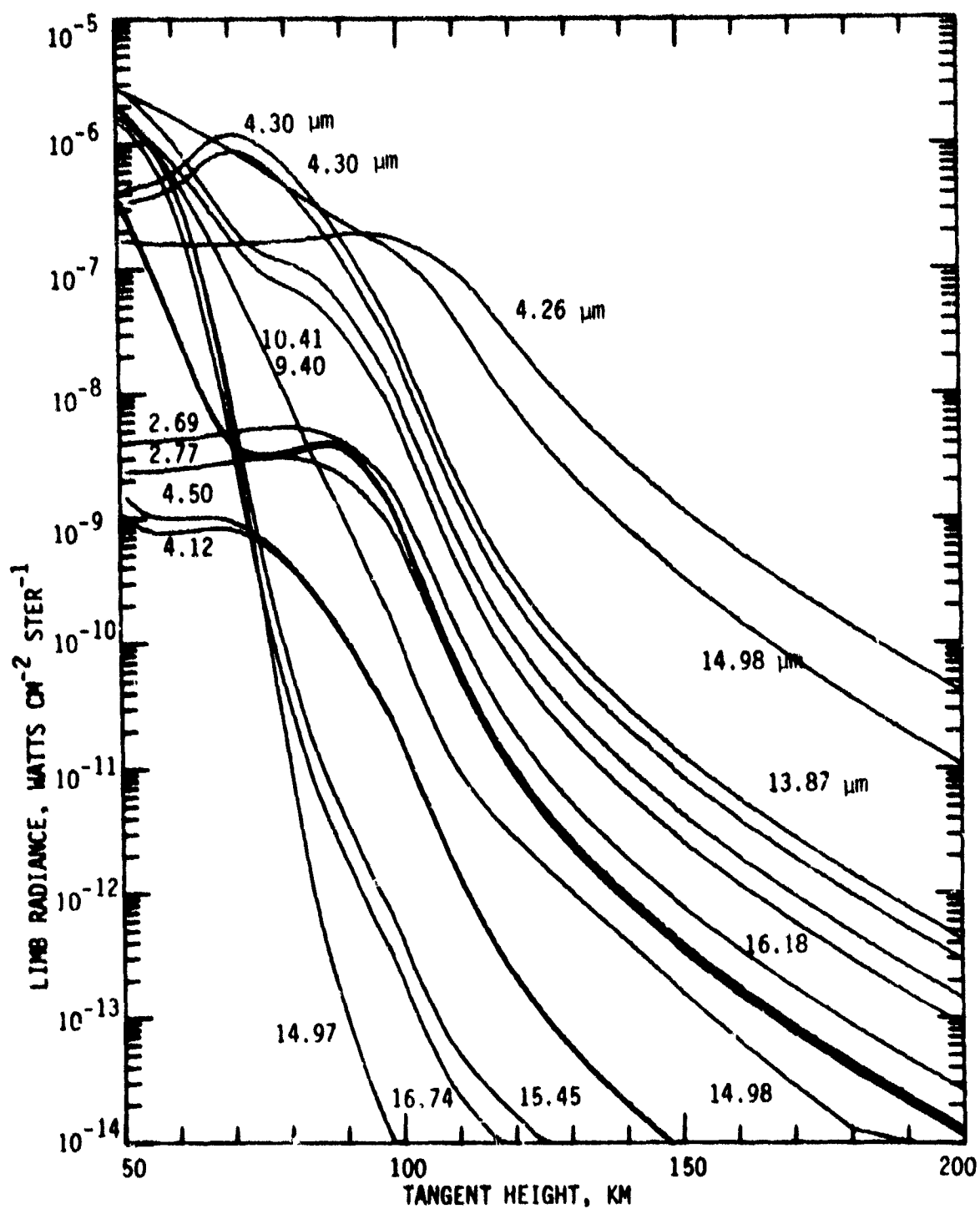


Figure 23: Day limb viewing total radiance values for carbon dioxide bands.

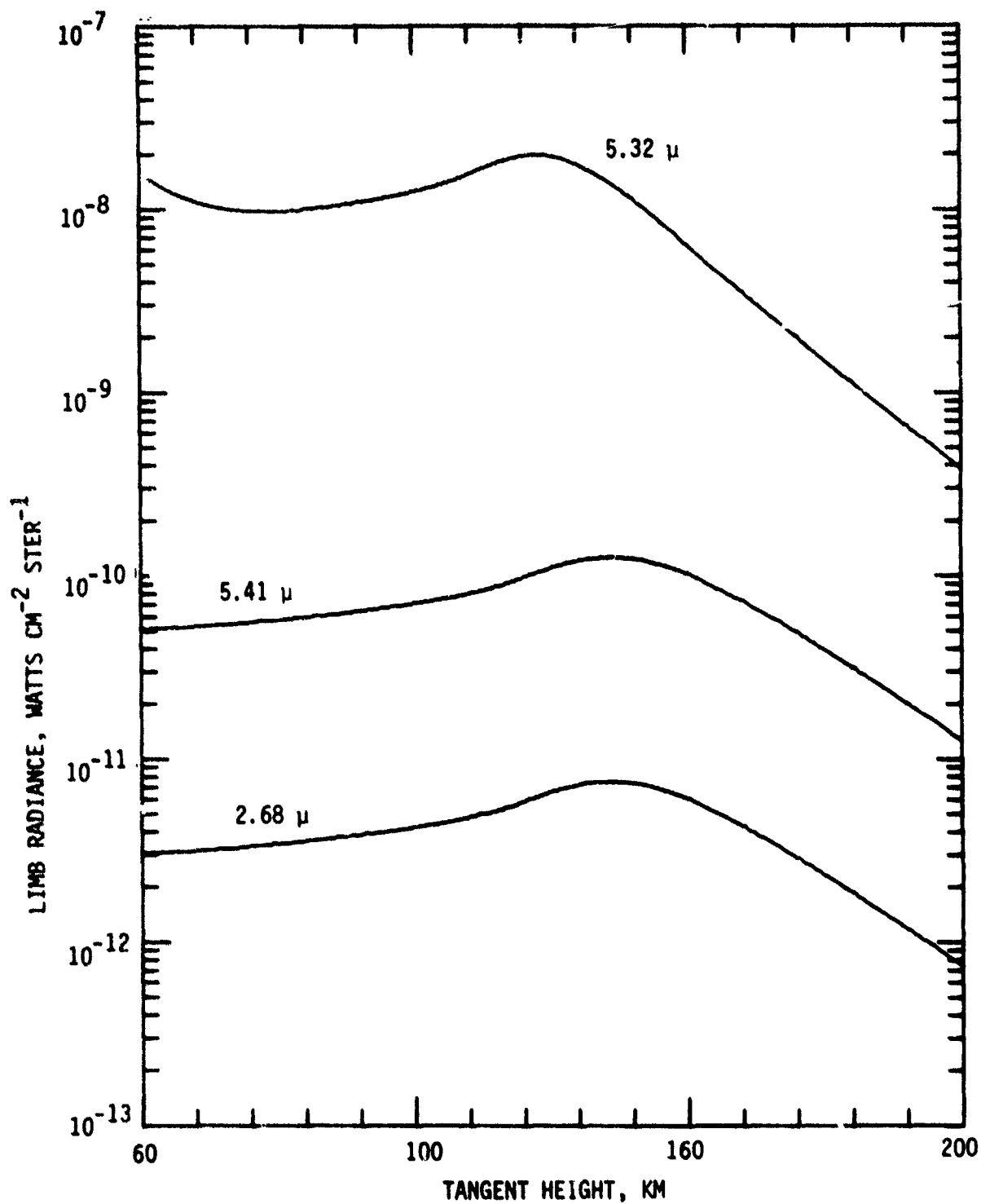


Figure 24: Night limb viewing total radiance values for nitric oxide bands.

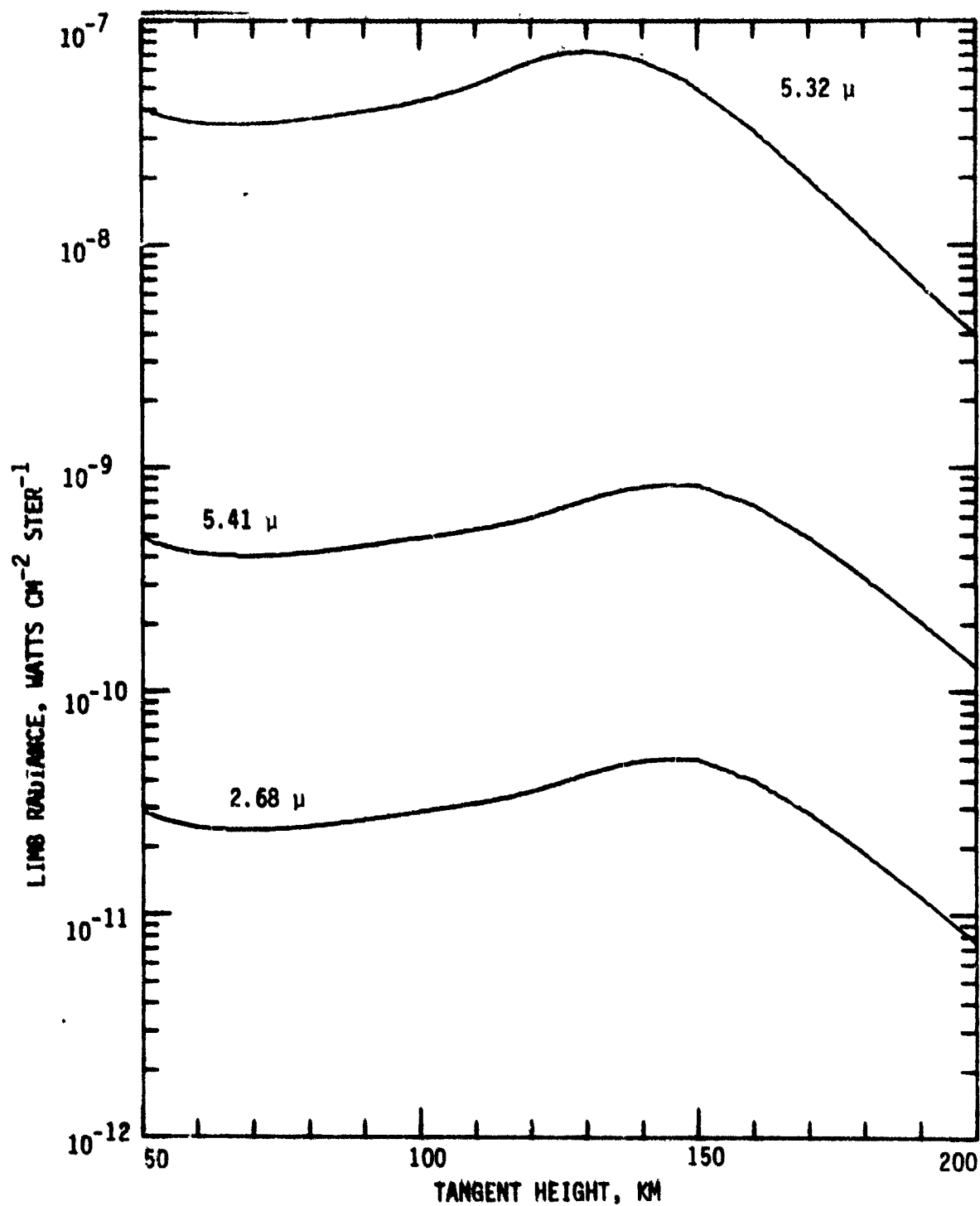


Figure 25: Day limb viewing total radiance values for nitric oxide bands.

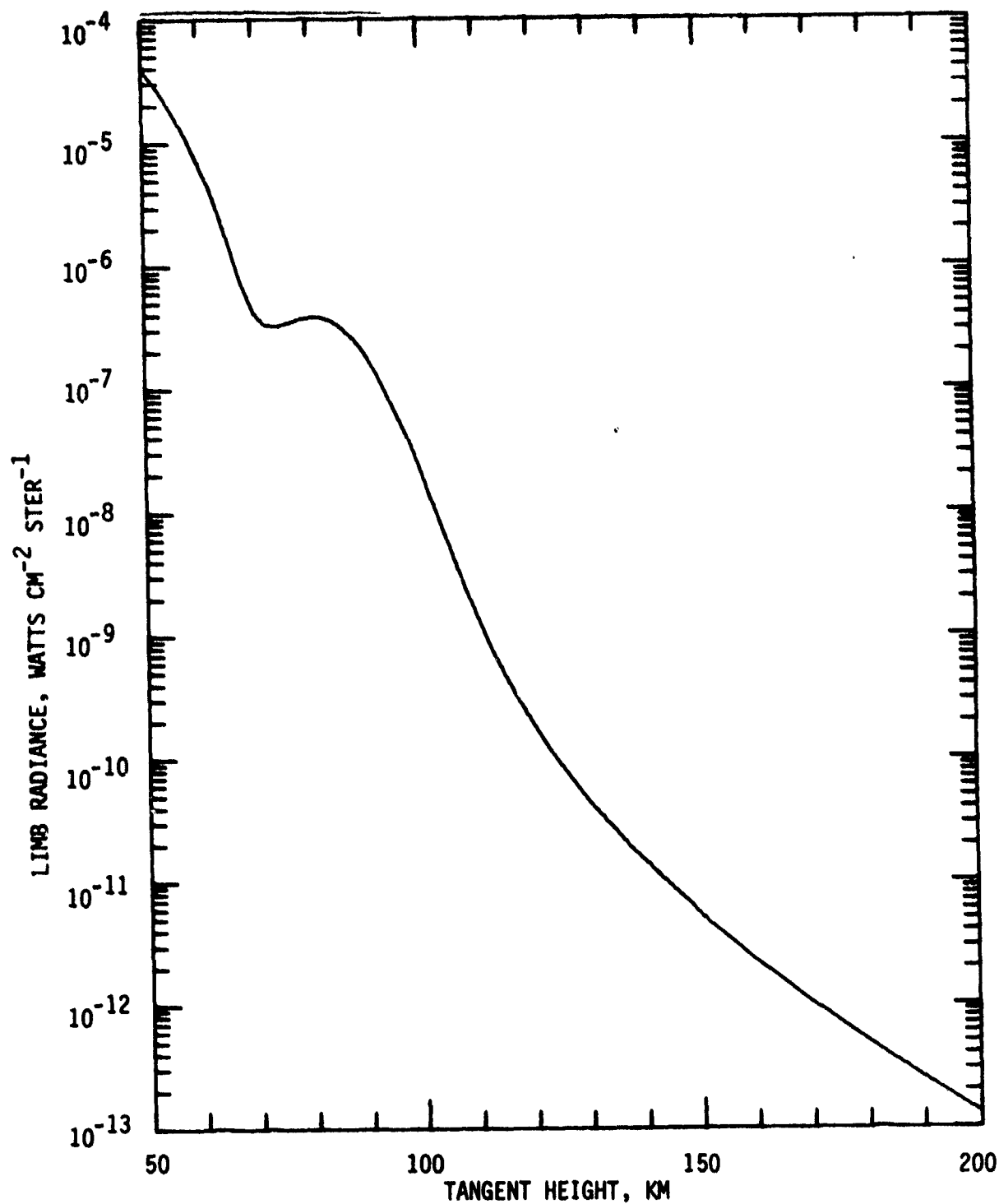


Figure 26: Night limb viewing total radiance value for ozone.

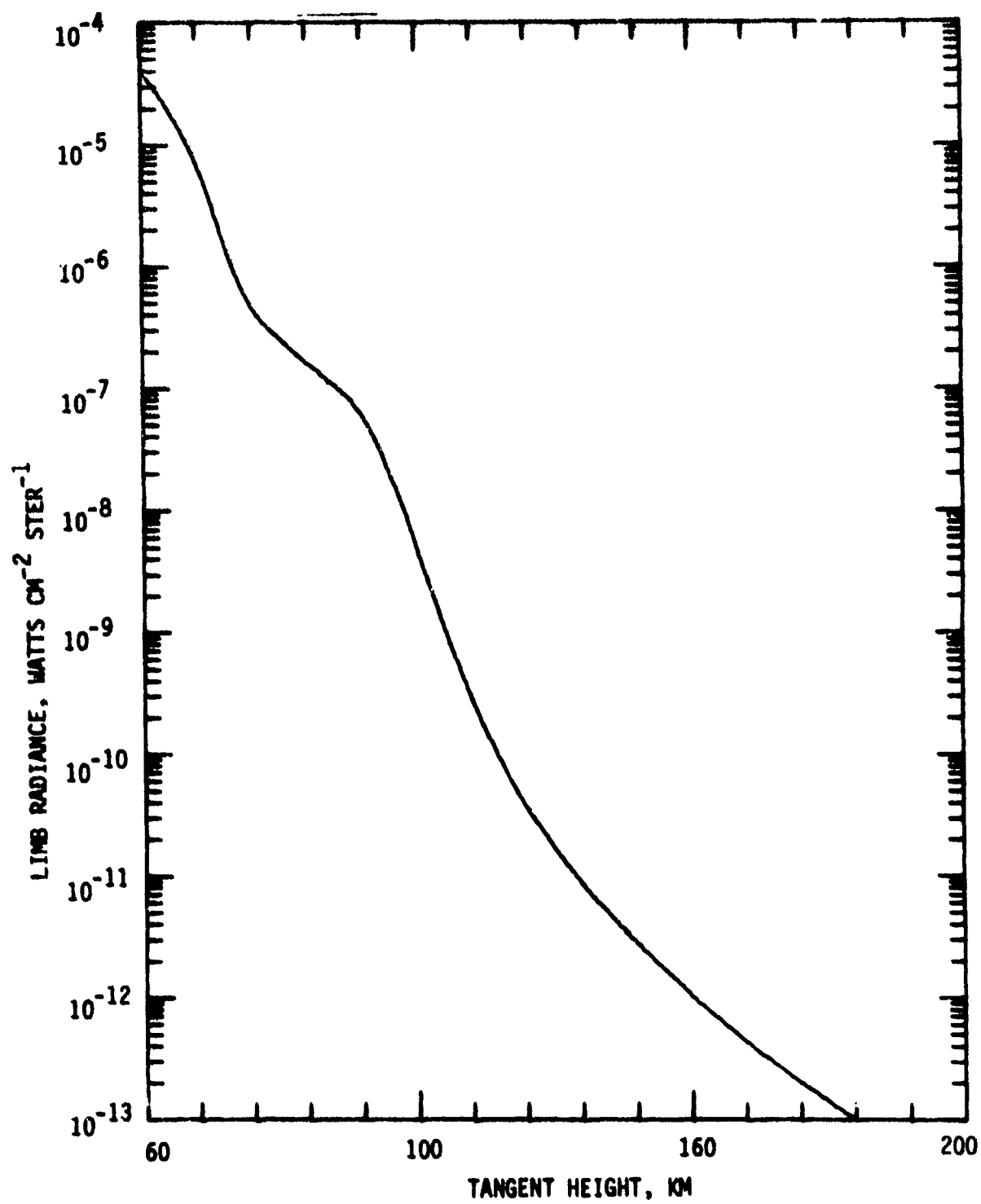


Figure 27: Day limb viewing total radiance value for ozone.

improved model which takes into account the variation of line width and band shape with temperature in the region of the mesopause.

Figure 29 compares the radiance model prediction for the ozone 9.6 micrometer band with data from the same sources as for CO₂. The amount of ozone used in the calculation is relatively optically thin in the upward direction, and doubling the concentrations will approximately double the computed radiance. The model calculation agrees with observation to within a factor of three for the 1973 measurement, and can be fit quite well simply by increasing concentrations above 80 km by a factor of three, with a smooth increase in concentration between 50 and 80 km. The shape of the observed radiance curve supports the qualitative features of the measurement by Hays and Roble (1973) and their interpretation (Roble and Hays, 1974) that the observed ultraviolet absorption is due to ozone and not a mesospheric aerosol layer.

4.5 Model Evaluation

The most important general area of investigation in this research effort has been the improvement of models for the transport of infrared radiation.

Figures 28 and 29 demonstrate that the radiance program results are in fair agreement with a small amount of observational data. The agreement with the carbon dioxide radiance model of James and Kumer (1973), is believed to be satisfactory. The model in its present state must be considered incomplete, however. For example, space and running time restrict the number of bands included, and further work is required to select a reasonable set of carbon dioxide isotopic bands for inclusion.

The program results are highly dependent on the atmospheric temperature and concentrations used, as is evident from Figure 28. Uncertainties in atmospheric composition, which commonly range from factors of two to orders of magnitude, are reflected in the computational results, and produce the greatest uncertainty at high altitudes. Uncertainties in the rates of collisional excitation mechanisms also affect the calculations.

The program for computing band radiances is now slightly faster than the 1974 mode. The most time consuming process is now the

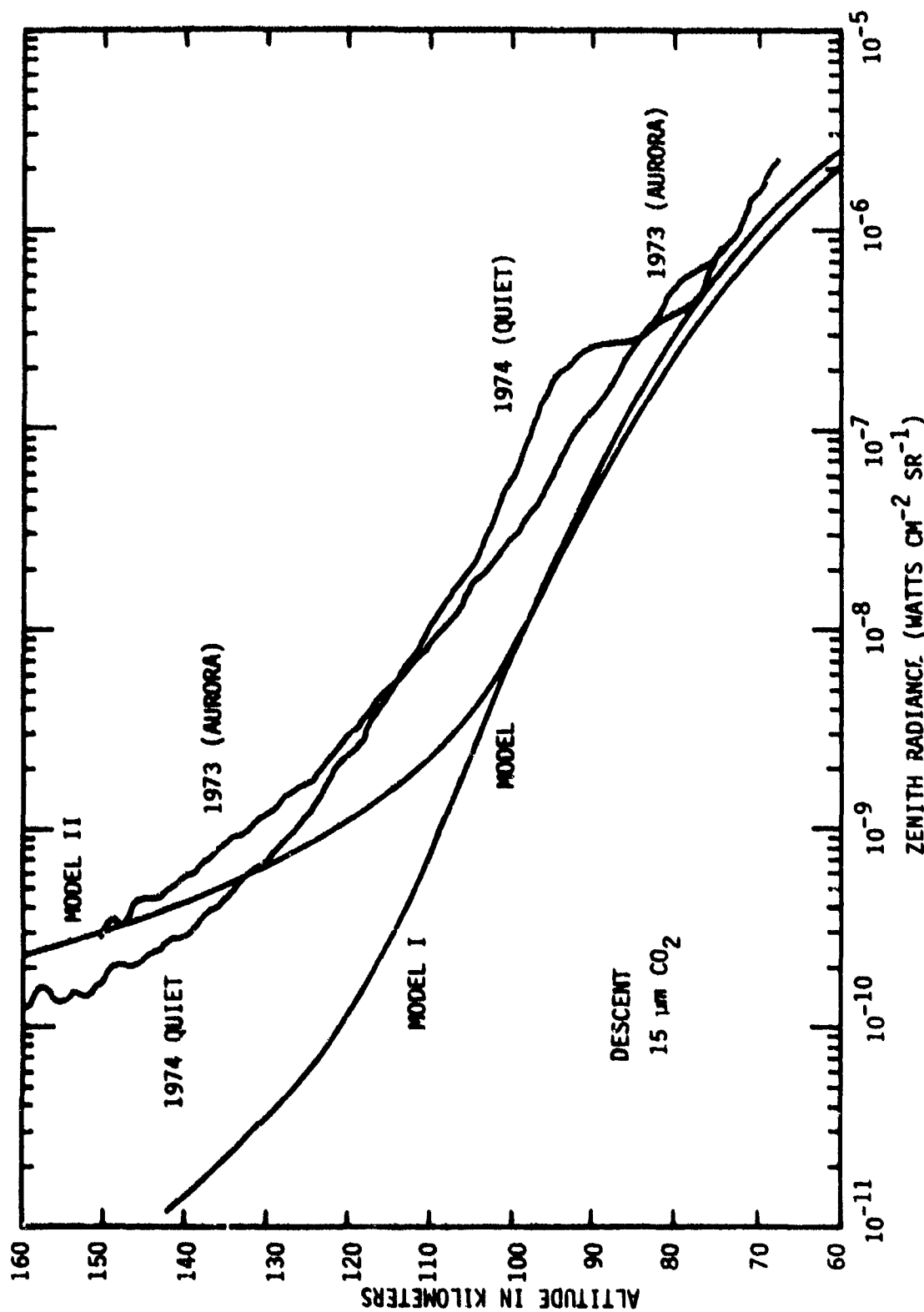


Figure 28: Comparison of the zenith radiance altitude profiles at 15 μm during quiet conditions (1974) and an aurora (1973).

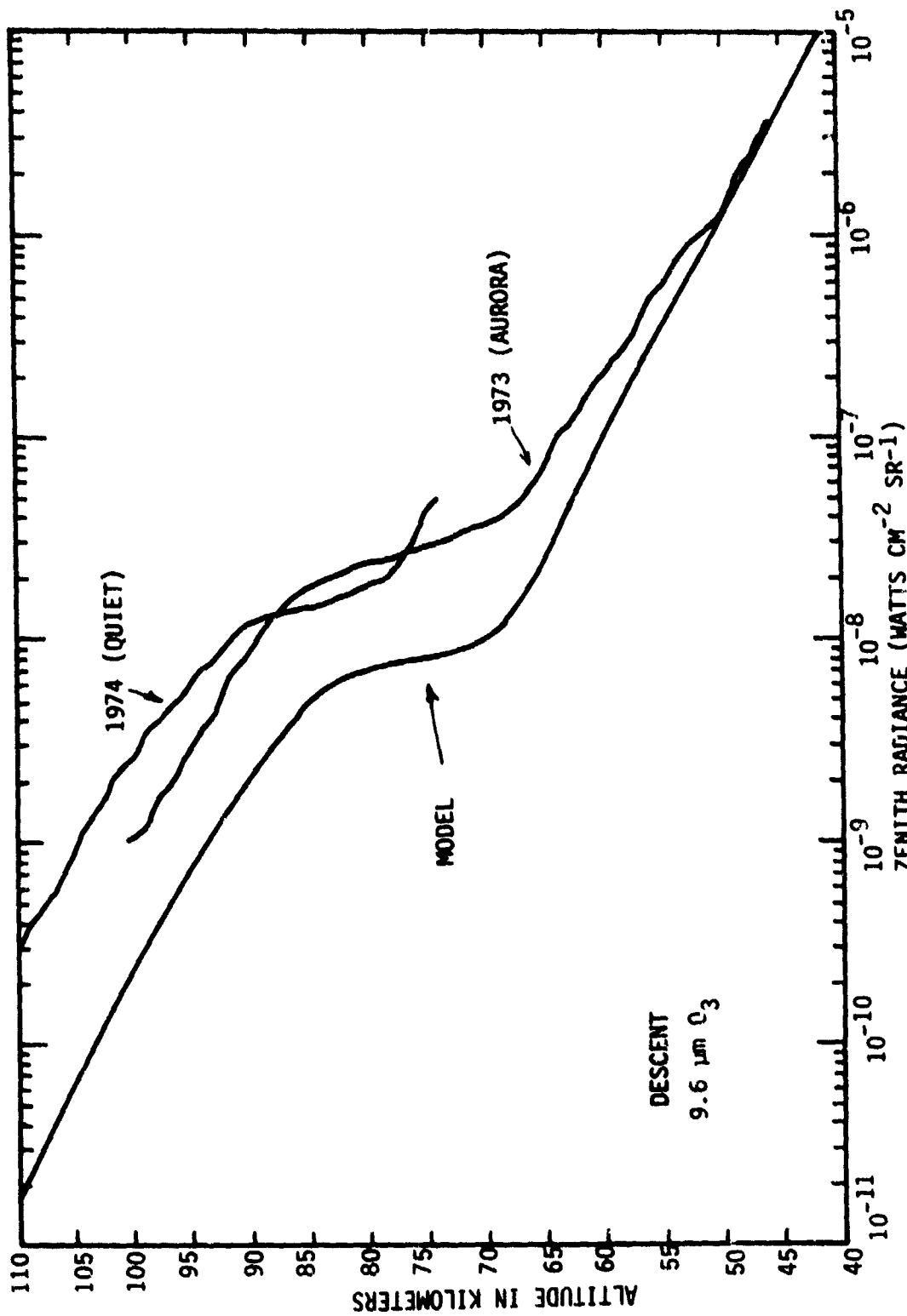


Figure 29: Comparison of the zenith radiance altitude profiles at 9.6 μm during quiet conditions (1974) and an aurora (1973).

integration of band radiances. The spectrum generated by the program in its current form does not properly represent line intensities for bands where a warm emitting region is overlaid by a cooler absorbing region. Future work will include use of the FASCODE algorithm, described in Section 6, to improve the calculation of both the radiative transfer near the mesopause and the spectral calculations. As in the past, results of future radiance measurements will guide in program modification.

5.0 VIBRATIONAL TEMPERATURES

The recognition that vibrational temperatures at high altitude are not the same as the local translational temperatures is one of the most important reasons for the development of radiance models such as this one and that of James and Kumer (1973). The present program has been adapted to provide vibrational populations and temperatures at altitudes between ground level and 700 km. No one set of radiative transfer functions is adequate to compute outgoing radiances for the full range of altitudes, but even the Doppler profile can be used to estimate departures of vibrational temperatures from kinetic temperatures.

Figures 30 through 33 present vibrational temperatures for one or two of the lowest excited vibrational states of carbon dioxide, water vapor, ozone and nitric oxide.

Figure 30 shows day and night vibrational temperatures for the $01101 \nu_2$ mode excited level and for the $00011 \nu_3$ mode excited levels. The ν_2 mode remains close to thermal equilibrium up to about 75 km altitude. The ν_3 mode temperature remains close to that of molecular nitrogen at altitudes up to about 70 km. Kumer and James (1974) have shown that the nitrogen and the ν_3 mode vibrational temperatures depart from kinetic temperatures above 50 km, while remaining closely coupled to each other. The $10001 \nu_1$ mode level (not shown) is not in thermal equilibrium above 30 km, and higher vibrational levels depart from thermal equilibrium faster than the lower levels.

Figure 31 shows temperature for the water vapor ν_2 mode with radiation near 6.3 micrometers. Thermal equilibrium is maintained to near 70 km. Resonant absorption of sunlight raises the daytime vibration temperature a few degrees above the nighttime temperature above 70 km.

Figure 32 shows temperatures for the ozone ν_3 mode, which remains in thermal equilibrium up to 60 km. The peak in the daytime temperature comes from the chemiluminescent formation of ozone by the three body reaction of atomic and molecular oxygen. The rate constant used is that of Garvin and Hampson (1974).

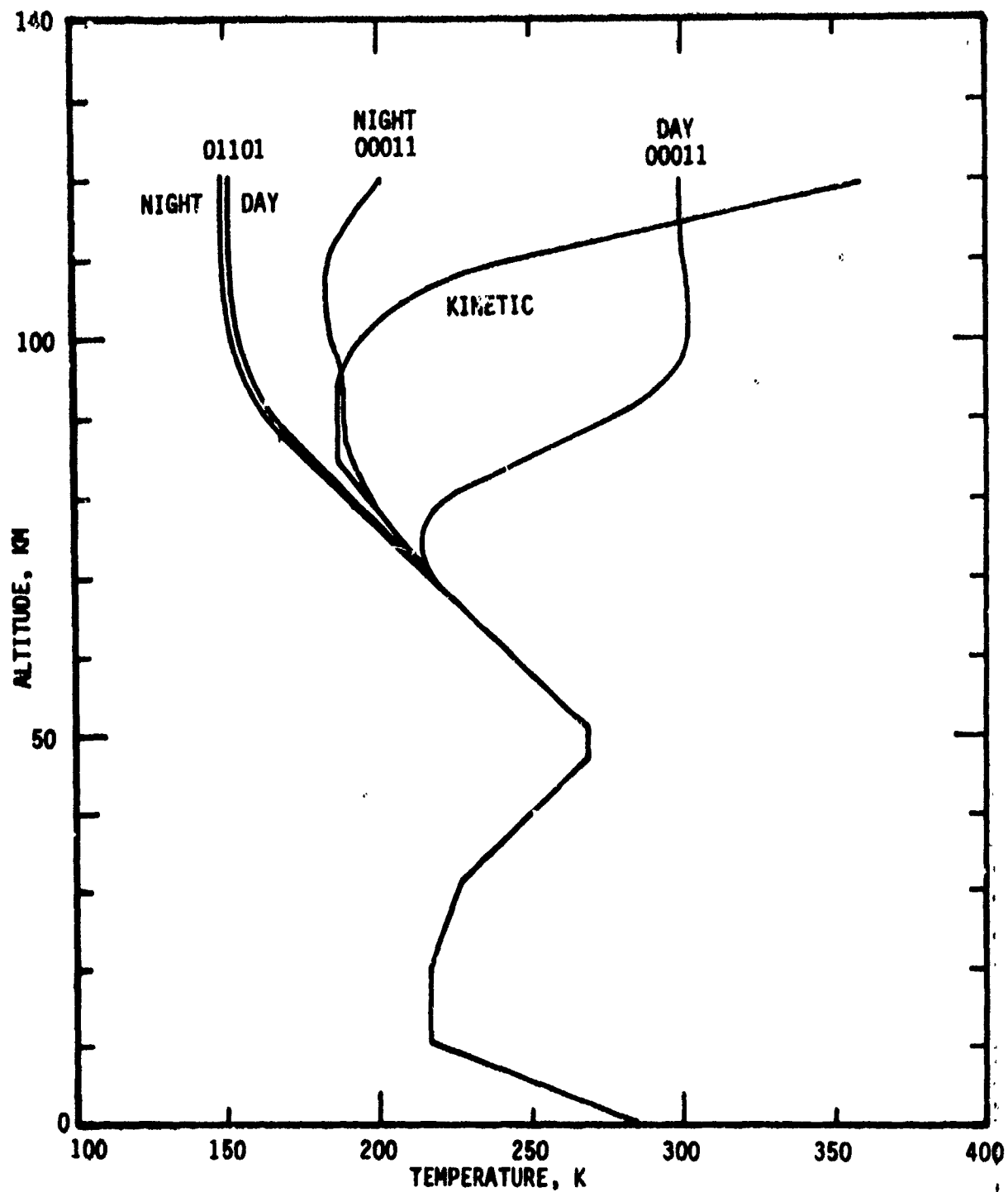


Figure 30: Carbon dioxide vibration temperatures

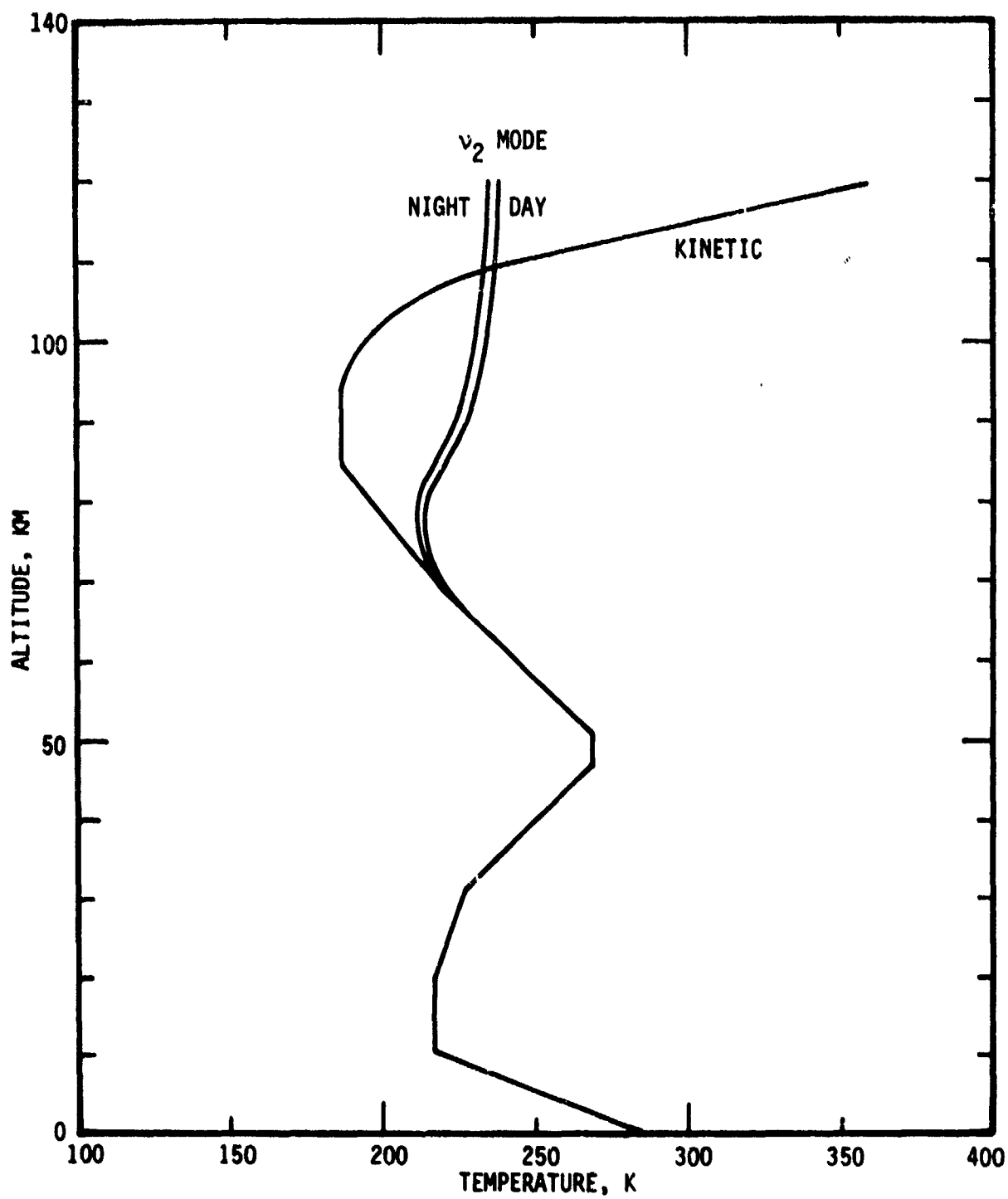


Figure 31: Water vapor v_2 mode vibrational temperatures

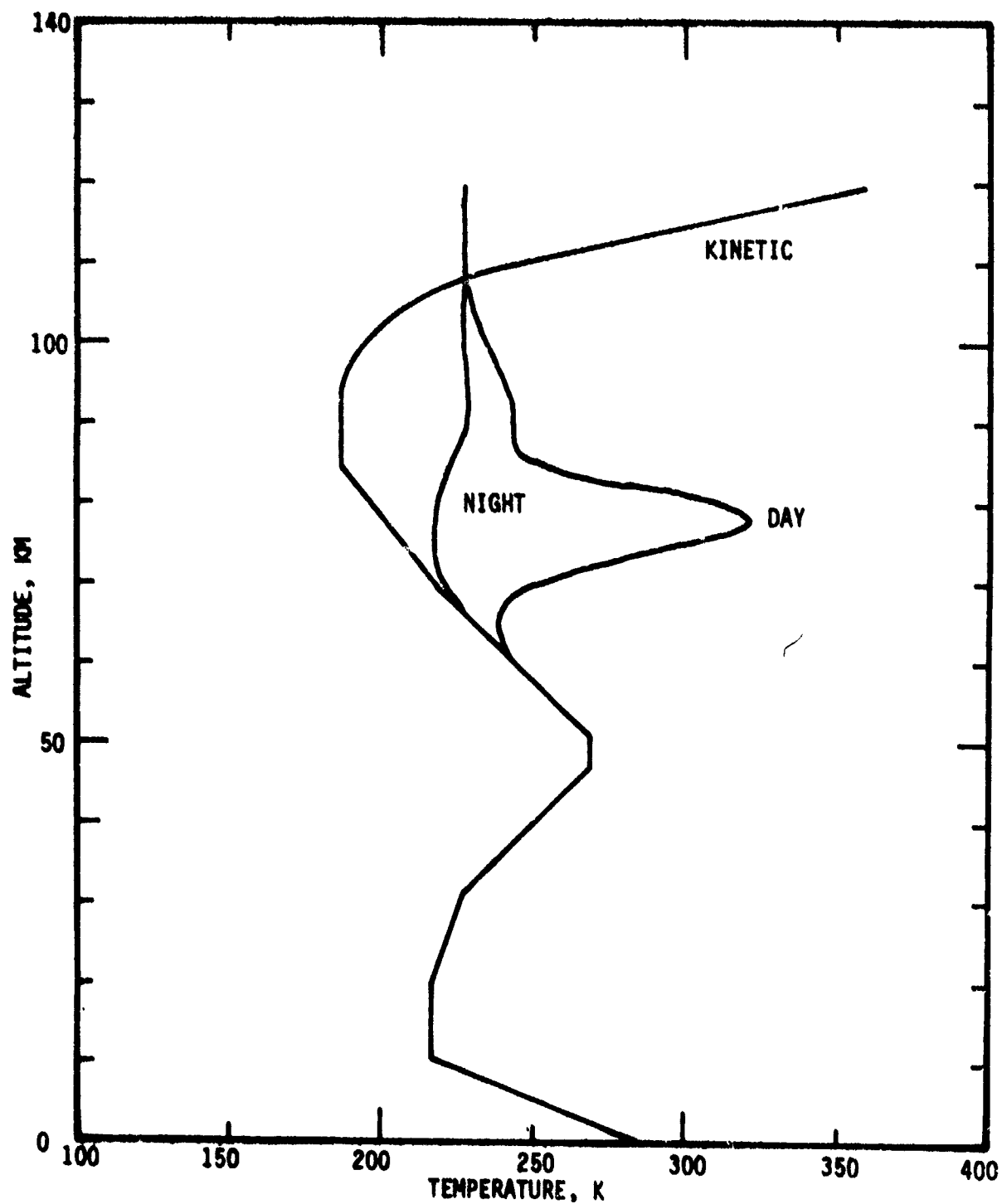


Figure 32: Ozone ν_3 mode vibrational temperatures

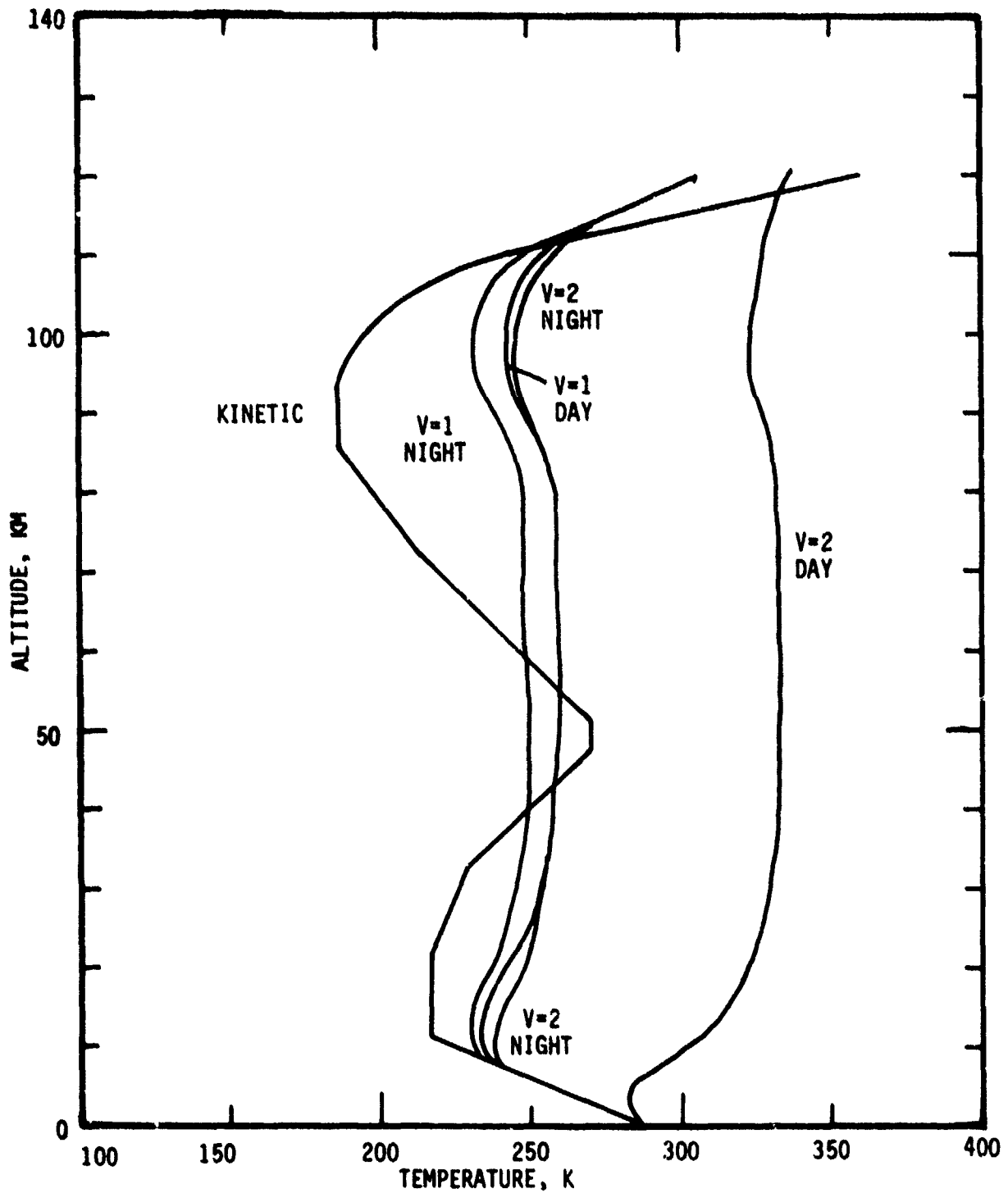


Figure 33: Nitric oxide vibrational temperatures

Figure 33 shows nitric oxide vibrational temperatures. Vibrational levels are not in thermal equilibrium above about 10 km. The temperatures between 10 and 30 km may not be correct. The concentrations used in the calculation are only estimates and no attempt was made to differentiate between day and night concentrations at low levels. The vibrational excitation rates used in the calculations are taken from Taylor's (1974, 1975) compilations, except for the use of Glänzer and Troe's (1975) and Quack and Troe's (1975) rates for excitation of nitric oxide by atomic oxygen. The results using these rates appear to confirm the suggestion made by Degges (1971) that atomic oxygen should be an important collision partner above the mesopause.

A related computer program (Hurd, et al, 1977) has been developed to follow the time history of vibrational populations of the CO_2 v_3 mode (the 0011 level) and molecular nitrogen and oxygen vibrational temperatures. This gives more accurate populations than the BGND Program can because BGND must assume steady state conditions and does not allow for the possibility of nitrogen vibrational temperature variation. In addition to its time history capability, use of matrix solution of the radiative transfer problem has been investigated using NORAD, with the conclusion that execution of the BGND Program will be more efficient using nitrogen vibrational populations computed by NORAD.

6.0 FASCODE — A LINE-BY-LINE ATMOSPHERIC TRANSMISSION AND EMISSION COMPUTER PROGRAM

A line-by-line computer program, FASCODE, for the calculation of atmospheric transmission and emission has been developed. This has involved the extension of the HIRACC algorithm developed at AFGL for the rapid line-by-line calculation of atmospheric infrared spectral absorption coefficients at a given temperature, pressure and composition assuming a Lorentz shape for the spectral line profile. A complete description and documentation will be found in an accompanying scientific report, Smith et al (1978).

The Lorentz shape is not appropriate at higher altitudes where Doppler broadening becomes dominant. To enable the use of the code at all altitudes a Voigt profile version of the HIRACC algorithm was developed. This program yields a line shape smoothly varying from nearly Lorentz at lower altitudes to purely Doppler at altitudes ≥ 50 kms. In addition, the domain of the line shape function was extended from 48 to 64 half-widths. With these new features the extended HIRACC algorithm required only a moderate increase in running time over the Lorentz profile version.

Using a layered atmospheric model, the spectral absorption properties of each layer are different. To compute spectral absorption coefficients over a given path through these layers requires a careful treatment since the line widths and/or shape for each spectral line will, in general, change with altitude. The HIRACC algorithm applied at two different altitudes will produce results at different spectral sampling intervals requiring an appropriate method of merging these results in order to produce an absorption coefficient for the given path. Since one needs a coarser sampling interval at the lowest altitudes of the sight path chosen, the merger algorithm is started at this point. The HIRACC algorithm is exercised and the results are written to mass storage. Using criteria established for sampling intervals which can be handled by the merging algorithms, the resolution for the next level is chosen and the HIRACC algorithm is exercised. The results at this level are then merged with the previous level (at a coarser sampling interval) by interpolating the previous results into the new. This procedure is followed until all levels have been completed.

The resulting spectral absorption signature is then available for use for the particular path calculated. For convenience a plotting program has been included within the FASCODE structure. We note here that the merged absorption coefficient obtained is valid for a path proceeding ("looking") in either direction.

The emission along a given path may also be calculated if one assumes thermodynamic equilibrium along a path. Using this assumption an option has been included in FASCODE for the calculation of emission as well as transmission. Emission calculations require a new feature however, since emission along a path looking up is not in general equal to the emission along the same path looking down. In order to reduce calculation time, the emission calculation proceeds from the lowest level (coarsest spectral interval) upward to the highest level (finest spectral interval) regardless of the direction of sight along the path, but the algorithm for the emission calculation is different for the upward and downward looking cases. Merging of the results for the layers is done in the same manner as for the absorption, except that for this case the transmission is calculated instead of the absorption and both the transmission and the emission are produced.

The results of the programs have been tested for internal self-consistency and compared with results from other line-by-line calculations, in particular the work of Kyle and Goldman (1975). Satisfactory agreement has been obtained in all cases tested. The interested reader is referred to the detailed scientific report describing the method, Smith et al (1978).

7.0 HIGH ALTITUDE RADIANCE PROGRAMS

This section lists and describes the main programs revised or written for this contract, BCKGND and SPCTRA.

BCKGND computes vibrational populations and total band radiances for an earth's limb viewing geometry at 2 km intervals between 0 and 150 and at 10 km intervals between 150 and 700 km.

SPCTRA computes spectral radiances corresponding to the total band radiances output by BCKGND. Control information is read from TAPE 5 = INPUT. Permanent data is read from TAPE 1 and the results of the BCKGND computation are read from TAPE 3. Output data is sent to TAPE 6 = OUTPUT for printing and to TAPE 4 for use by a plotting program. Optional output of unfiltered spectral radiances may be placed on TAPE 7 and saved for later use.

Listings of two auxiliary programs, INTERP and NORAD are included for information, but are not documented further.

INTERP produces molecular concentrations for N_2 , O_2 and O consistent with the U.S. Standard Atmosphere, 1976. The ozone concentrations of Figure 6 are included in DATA statements for arrays O3DAY and O3NITE in Subroutine O3. The original version of INTERP was used by Corbin, et al (1969) to generate model atmospheres for low altitude limb radiance calculations. Part of the output from INTERP is used as input to Program BCKGND. The subroutine with the same name is no longer needed in BCKGND.

NORAD is used to compute time dependent vibrational populations of N_2 and the CO_2 v_3 mode. Its use in auroral calculations is illustrated in Hurd, et al (1977).

PROGRAM BCKGND (BGND)

Purpose: The main Program BCKGND (short for BACKGROUND) serves primarily to control the operation of subroutines which compute vibrational populations and radiative rates. BCKGND reads and checks the input data, and transfers control to Subroutine BANRAD which computes vibrational populations, local optical thicknesses and volume radiances for all included bands of a single molecular species. When control is returned, BCKGND computes and outputs integrated band radiances for limb viewing (exo-atmospheric) and seven endo-atmospheric viewing angles at selected tangent heights or endo-atmospheric altitudes.

Program Flow: The initial step in operation of BCKGND is the reading of all input data. The number IGAS of molecular species including total number density is read in. Then in the DO range ending with Statement 170, the following operations are performed. The title card, containing alphanumeric identification, an index check number and maximum altitude considered for the species is read in and its check number checked against the index of the DO range. If the check succeeds, altitude and number densities are read into arrays ALT and STORE until an altitude corresponding to the maximum altitude is found. When this altitude is found, the logarithm of input number densities is formed in the DO range ending with Statement 130 and control is passed to Subroutine INTERP which interpolates to form values at 1 km intervals up to 160 km and at 5 km intervals at higher altitudes. The interpolated values are converted to number densities in the DO range ending with Statement 160. In the DO range ending with Statement 175, total atmosphere number densities are stored in array TOTDEN. Temperature data are

then read in similarly in the DO range ending with Statement 245 and interpolated values found by Subroutine INTERP. The complete set of number densities and temperatures is then printed out. Next, vibrational level and band constants are read in for each species in the DO range ending with Statement 331. The first card for each species contains an alphanumeric identification, number of vibrational levels NLEV, number of bands NBAN, molecular mass AMAS, and two vibrational energy transfer coefficients DEX and DEXB. The alphabetic code is checked and if it is a valid code stored in array DATATY, these constants are transferred to the appropriate arrays. In the DO range ending with Statement 313, constants for each vibrational level are read in, and card sequence numbers checked. In the DO range ending with Statement 316, constants for each band are read in and card sequence numbers checked. For CO₂ and H₂O, tabular values of temperatures and associated vibrational energy exchange coefficients are read before the level and molecular band data.

The computation of molecular band radiances then proceeds in the following manner. The outer DO range index NLTE and ending with Statement 900 controls the factors considered in a complete set of calculations for any of five possible sets. The corresponding DO statement may be varied depending on what factors are desired. See the description of Subroutine BANRAD for the effect of different values of the index NLTE. Each cycle through the nested DO range with Index I and ending with Statement 850 results in the computation of band radiance values for a single molecule. Action within this DO range is as follows.

Subroutine BANRAD is called and returns volume emission radiance values in array RAD and local optical thickness values in array TAU. Then for each band, line-of-sight band radiances are computed in the DO range ending with Statement 840. Within this DO range, the value of NLTE is examined and appropriate headings are printed. Then trapezoidal rule integration is performed to determine the radiance arising along each of the eight lines-of-sight, including the modification necessary for the effects of optical thickness along the line-of-sight. The DO range ending with Statement 830 controls the integration for each tangent height and endo-atmospheric viewing level. In the current version, radiance values are computed at 5 km intervals of tangent height up to 150 km and at 25 km intervals above this level. The integration of radiance values is performed for each endo-atmospheric viewing level in the DO range ending with Statement 810. The integration begins at the viewing altitude. At each point on the line-of-sight, the contribution of the local volume emission rate to that received at the viewing point is computed by Subroutine SMI, which takes into account the effects of optical thickness between the emitting point and the viewing point. The equivalent integration for the limb viewing case is performed in the DO ranges ending with Statements 815 and 818. Upon completion of the integration for each tangent height and endo-atmospheric viewing level, band radiances for that level are punched and printed. This punched output, together with that produced by Subroutine BANRAD, is used as input data to the special radiance Program SPECTRA.

Tables 7.1 through 7.4 list the molecular bands and related physical data now included in the programs. Band strengths for water vapor, carbon dioxide and ozone are those used in the AFGL absorption line atlas described by McClatchey, et al (1973). Band strengths for nitric oxide are approximately those of Abels and Shaw (1966) and Schurin and Ellis (1966). Infrared solar fluxes at band centers are interpolated from the tabulation of Johnson (1965). The tables are followed by descriptions of the subroutines, the Program Listing and Sample Input Data.

TABLE 7.1: WATER VAPOR BAND DATA

Vibrational Transition		Band Center Wavelength (μm)	Band Strength at 296 K ($\text{mol}^{-1} \text{ cm}^2 \text{ cm}^{-1}$)	Solar Flux Band Center (photons $\text{cm}^{-2} \mu\text{m}^{-1}$)
Upper State	Lower State			
010	000	6.27	1.06(-17)*	5.60(15)
020	000	3.17	6.58(-20)	3.50(16)
100	000	2.73	3.62(-19)	5.10(16)
001	000	2.66	7.99(-18)	5.40(16)
020	010	6.42	8.61(-21)	5.70(15)
100	010	4.85	8.90(-23)	1.20(16)
001	101	4.63	4.90(-22)	1.50(16)
030	010	3.26	7.99(-23)	3.30(16)
110	010	2.75	1.50(-22)	5.00(16)
011	010	2.68	3.30(-21)	5.40(16)
030	020	6.60	7.00(-24)	4.90(15)
030	000	2.14	2.00(-22)	9.30(16)
110	000	1.91	1.83(-20)	1.20(17)
011	000	1.88	9.16(-19)	1.25(17)

*Number in parentheses is power of ten.

TABLE 7.2: CARBON DIOXIDE BAND DATA

Vibrational Transition		Band Center Wavelength (μm)	Band Strength at 296 K ($\text{mol}^{-1} \text{cm}^2 \text{cm}^{-1}$)	Solar Flux Band Center (photons $\text{cm}^{-2} \mu\text{m}^{-1}$)
Upper State	Lower State			
01101	00001	14.98	8.26(-18)	4.60(14)
10002	01101	16.18	1.44(-19)	3.70(14)
02201	01101	14.98	6.49(-19)	4.60(14)
11102	10002	15.45	2.22(-20)	4.20(14)
11102	02201	16.74	5.21(-21)	3.35(14)
03301	02201	14.97	3.82(-20)	4.60(14)
10001	01101	13.87	1.85(-19)	5.80(14)
00011	10001	10.41	4.91(-22)	1.31(15)
00011	00001	4.26	9.60(-17)	1.60(16)
00011	10002	9.40	6.32(-22)	1.78(15)
10012	00001	2.77	1.04(-18)	4.95(16)
10011	00001	2.69	1.50(-18)	5.35(16)
10012	10002	4.30	1.93(-19)	1.60(16)
10011	10002	4.12	1.06(-22)	1.75(16)
10012	10001	4.50	1.27(-22)	1.39(16)
10011	10001	4.30	1.18(-19)	1.60(16)

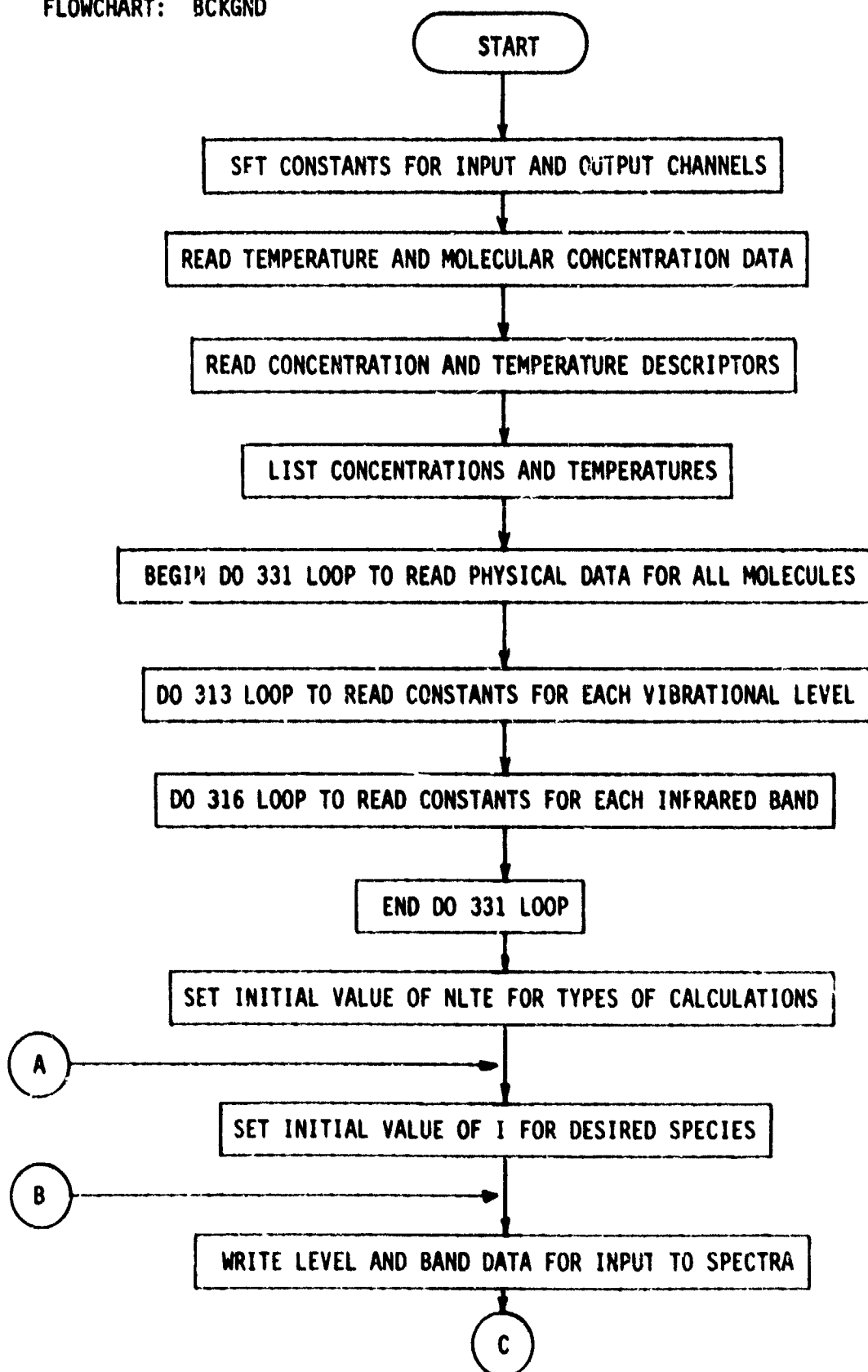
TABLE 7.3: NITRIC OXIDE BAND DATA

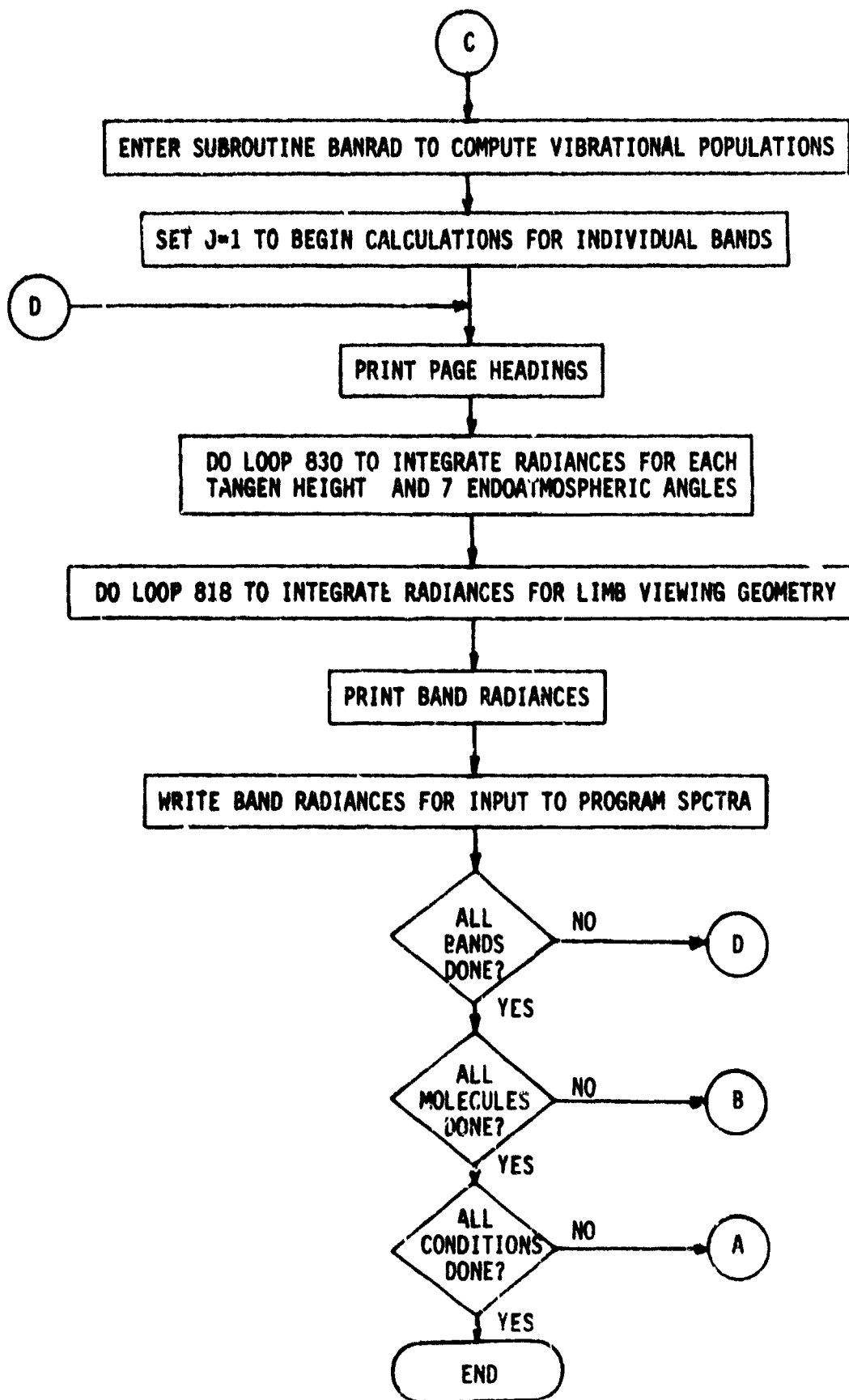
Vibrational Transition		Band Center Wavelength (μm)	Band Strength at 296 K ($\text{mol}^{-1} \text{cm}^2 \text{cm}^{-1}$)	Solar Flux Band Center (photons $\text{cm}^{-2} \mu\text{m}^{-1}$)
Upper State	Lower State			
1	0	5.32	5.0×10^{-18}	8.7×10^{15}
2	0	2.68	8.5×10^{-20}	5.4×10^{16}
2	1	5.41	1.27×10^{-21}	8.4×10^{15}

TABLE 7.4: OZONE BAND DATA

Vibrational Transition		Band Center Wavelength (μm)	Band Strength at 296 K ($\text{mol}^{-1} \text{cm}^2 \text{cm}^{-1}$)	Solar Flux Band Center (photons $\text{cm}^{-2} \mu\text{m}^{-1}$)
Upper State	Lower State			
001	000	9.60	1.29(-17)	1.7(-1)

FLOWCHART: BCKGND





Subroutine BANRAD

Purpose: BANRAD computes the population of vibrational levels of infrared active species, including the effects of collisional excitation; absorption of radiation from the lower atmosphere, sun and molecules radiating at high altitude. The values returned to the main program are volume radiance and unit optical thickness at each altitude for each band included in the computation.

Method: Subroutine BANRAD computes the population of vibrational levels of infrared active species, including the effects of collisional excitation and absorption radiation from the lower atmosphere, sun and molecules radiating at high altitude. The values returned to the main program are volume radiance and unit optical thickness at each altitude for each band included in the computation.

The collisional processes which are assumed to effect the vibrational state of a molecule are (1) translational-vibrational (T-V) interactions in which translation energy is transformed into vibrational energy or vice-versa during a collision, (2) intermolecular vibrational exchange (V-V) in which a molecule of one species exchanges a quantum of vibrational energy with a molecule of another species, and (3) intramolecular vibrational exchange of polyatomic molecules in which a collision transfers the energy in one mode of vibration into another mode within the same molecule.

When a molecule in the ground state collides with another molecule there is a finite probability P_{TV} that a portion of the relative translational energy will be transformed to vibrational energy if the translational energy is equal

to or exceeds the vibrational energy. Similarly, if the molecule is in an excited vibrational state, there is a finite probability P_{VT} that the vibrational energy will be converted to relative translational energy during the collision. For a Boltzmann distribution of translational energies at a given temperature

$$P_{TV} = P_{VT} = \frac{g_u}{g_l} \exp \left(- \frac{hc}{\lambda_0 kT} \right)$$

where g_u and g_l are the statistical weights of the upper and lower vibrational levels, h is Planck's constant (6.6256×10^{-27} erg-sec), c is the velocity of light (2.9979×10^{10} cm/sec), k is the Boltzmann constant (1.38054×10^{-16} erg/K), T is absolute temperature (K) and λ_0 is the wavelength (cm) corresponding to the energy difference of the two vibrational levels. Similar expressions hold for intermolecular and intramolecular V-V transfer.

The rate at which a vibrational level of a single molecule is excited (K_{TV}) or de-excited (K_{VT}) is given by the product of the collision frequency Z and the transition probability. The subroutine uses temperature dependent rate coefficients k_{TV} , k_{VT} , etc., such that if $[M]$ is the concentration of the collision partner, $K_{VT} = k_{VT}[M]$, etc.

The radiative processes which are assumed to affect the vibrational state of a molecule are (1) absorption of solar radiation, (2) absorption of radiation from the lower atmosphere, (3) absorption of radiation emitted by molecules in the upper atmosphere and (4) spontaneous emission at a rate $A_{ul}(\text{sec}^{-1})$, the Einstein A coefficient. Because absorbing molecules are present between each source of radiation

and the molecule for which the vibrational state is to be computed, radiative transfer functions must be used to take into account the effects of absorption. The model assumes that individual lines have a Doppler (thermal velocity broadened) spectral contour.

At a given altitude, there will be N_1 molecules/cm³ in the ground vibrational state of a molecule and N_u molecules/cm³ in an upper state. Molecular nitrogen and oxygen are assumed to be the only collision partners effective in transfer of vibrational quanta, and their concentrations are used to determine total vibrational excitation rates K_{TV} , K_{VT} , etc. The treatment below refers to a two-state molecule.

In unit volume, molecules in the ground state are excited to the upper state by:

- (1) Collisional T-V excitation at a rate $N_1 k_{TV}$
- (2) Collisional V-V excitation at a rate $N_1 K_{MV}$ (the subscript MV is used for excitation, VM for de-excitation, by transfer of vibrational quanta).
- (3) Absorption of solar flux at a rate $N_1 I_0 G' M_1^b$ (k_s) where G' is molecular cross section for absorption of radiative flux.
- (4) Absorption of lower atmospheric radiance at a rate $N_1 N_{\lambda,t} G' N_{12}^b (k_t)$
- (5) Absorption of radiance emitted at other levels of the atmosphere at a rate $N_1 \int N_{\lambda,D} G' N_{21}^b (k_D) dz$

Molecules in the upper state are de-excited by:

- (1) Collisional V-T de-excitation at a rate $N_u K_{VT}$
- (2) Collisional V-V de-excitation at a rate $N_u K_{VM}$
- (3) Spontaneous radiative de-excitation at a rate $N_u A_{u1}$

Excitation rates are assumed to balance de-excitation rates and the equation

$$\begin{aligned} \frac{dN_u}{dt} = & N_1 (k_{TV} + k_{MV} + I_0 G' M_1^b(k_s)) + N_{\lambda,t} G' N_{12}^b(k_t) \\ & + \int N_{\lambda,D} G' N_{21}^b(k_D) dZ - N_u (K_{VT} + K_{VM} + A_{u1}) = 0 \end{aligned}$$

is solved by iteration to determine N_u and N_1 at all altitudes.

Program Flow: The first step in the computation is determination of the thermal equilibrium populations of vibrational levels. This is performed in the DO range ending with Statement 130. Each passage through this DO range computes populations for one altitude. Within this DO range are two others. The DO range ending with Statement 110 computes the vibrational population of each level relative to the ground vibrational population of each level relative to the ground vibrational level, using the energies (wave number) stored in WAVE and the statistical weights stored temporarily in real array VIBPOP. The sum of relative populations is stored in SUM. The final ground state population is then computed by dividing total concentration by SUM, and stored in real array GNDSTE. The DO range ending with Statement 120 then computes

the vibrational population of each level by multiplying total concentration by relative concentration divided by SUM.

The DO range ending with Statement 135 selects the vibrational level which is coupled with the first excited nitrogen vibrational level.

The DO range ending with Statement 160 computes the rate at which a single molecule in a given level is excited or de-excited by collisions at each altitude.

The outer DO range ending with Statement 180 computes wavelengths (BNDLAM), Einstein A coefficients (EA), rates for absorption of radiation from the sun (GDOWN) and from the earth and lower atmosphere (GUP) and the G factor used in computing radiative transfer within the upper atmosphere (GFAC). The inner DO range ending with Statement 180 computes the unit optical thicknesses for each band at each altitude using Function TAUMAX, and stores the result in array BNDTAU. In addition, it computes the volume radiances and stores them in array BNDRAD.

At this point, if NLTE is 1, computation for thermal equilibrium is complete and control is transferred to Statement 900. If NLTE is not 1, the computation for non-equilibrium is performed iteratively in the DO range ending with Statement 400. The DO range ending with Statement 190 computes various integrated optical thicknesses for each band. The DO range ending Statement 182 computes the total thickness between each two altitudes in their vertical direction and stores the values in array TTH.

The DO range ending with Statement 184 (1) computes the optical thickness between the base altitude and each other

altitude, storing the result in array TTUP and (2) computes the total optical thickness between the top altitude and each other altitude, storing the results in array TTDOWN. If the computation is not for daytime conditions, the DO range ending with Statement 186 sets the values in TTDOWN equal to 0.0, for efficiency in the later computations. If the computation is for the effects of collisional excitation only, the DO range ending with Statement 188 sets the values in TTUP equal to 0.0.

The computation of vibrational populations now begins.

Control is transferred to

Statement 210 if I is 1, CH₄

Statement 220 if I is 2, CO₂

Statement 230 if I is 3, H₂O

Statement 240 if I is 4, NO

Statement 250 if I is 5, N₂O

Statement 230 if I is 6, pre-dawn Ozone

Statement 230 if I is 7, noon Ozone

Following each of these statements is a DO range in which vibrational populations are computed. A discussion of two statements in the computation for CO₂ will illustrate the computational details. First, look at the statement in the DO range immediately following Statement 221 that begins VIBPOP(NZ,8) = which computes the population of the first level of the ν_3 vibrational mode. This vibrational level is coupled to the nitrogen first vibrational level by collision, to the upward flux from the earth and lower atmosphere, to solar flux, and to lower vibrational levels by radiation. Excitation by absorption of radiation from within the upper atmosphere is neglected for this level. A ground state molecule is excited by collision with nitrogen at the rate VVNSIG(NZ) (collision exchange), by absorption of solar

flux at a rate $GDOWN(9)*SM1(KB(9), TDOWN2(NZ))$ (equals $I_0 G'M_1^b(k_s)$) and by absorption of flux from the earth and lower atmosphere at a rate $GUP(9)*SLM2(KB(9), TTUP2(NZ))$ (equals $N_{\lambda,t} G'N_1^b(k_t)$). An excited molecule is de-excited by radiation at the rate $EA(9)$ (other Einstein A coefficients are negligible), by vibrational exchange with nitrogen at a rate $VVRSIG(NZ)$, and by transfer of vibrational energy to other modes within the CO_2 molecule at a rate $VVDSIG(NZ)$. The vibrational population is then the ground state population times the ratio of excitation and de-excitation rates. Second, look at the statement beginning $POP2 = \dots$, which computes the vibrational population of Level 2, the first excited level of the v_2 vibrational mode. This level is excited from the ground state by collisional excitation at a rate $TVS = TVSIG$, by absorption of radiation from the lower atmosphere and earth at a rate $GUP(1)*SLM1(KB(1), TTUP(NZ1))$ (equals $N_{\lambda,t} G'N_1^b(k_t)$), by absorption of radiation from other points in the upper atmosphere in the $15.0 \mu m$ fundamental band at a rate $2\pi GFAC(1)*(XFER(VIBPOP(1,2), TTH(1,1), NZ, 1, 1, KB(1)) + XFER(VIBPOP(NZ,2), TTH(NZ,1), NALT, NZ, 2, KB(1)))*EA(1)$ (equals $\int N_{\lambda,D} G'N_2^b(k_D) dz$) and by absorption of solar radiation at the rate $GDOWN(1)*SM1(KB(1), TTDOWN(NZ,1))$ (equals $I_0 G'M_1^b(k_s)$). It is excited from Levels 3, 4 and 7 by collisional excitation VTS and by radiation $EA(2)$, $EA(3)$ and $EA(7)$. De-excitation occurs by radiation $EA(1)$, and by collisional de-excitation to the ground state at a rate $VTS = VTSIG(NZ)$, and by collisional excitation to higher states at a rate TVS . The approximate vibrational population is then the ratio of the sums of population rates times higher state populations divided by the sum of de-excitation rates for single molecule.

After each set of vibrational populations is completed, new

values for volume band radiances are computed in the nested DO ranges ending with Statement 360. After three iterations to compute vibrational populations, control is returned to the main program.

Inputs: NLEVEL, NBAND, NALT, CDEXT, CDEXB, RM, LSC, LCC, I, LBC, LBU, BV, STR, WAVE, CONC, SFLUX, TFLUX, KCHEM, NR, NP, NW, NLTE, TEMP, BNDLAM, DENTOT, NBAND1.

Outputs: VIBPOP, BNDAU, BNDRAD

MNEMONIC VARIABLES

AA	intermediate factor in computing vibrational populations
AAA	quantity used in NO chemiluminescence calculation in original Subroutine BANRAD application; it has no effect at present
BNDL	wavelength of current interest (μm)
BNDLAM	wavelength array (μm)
BNDRAD	volume radiance
BNDAU	unit optical thickness
B''	rotational constant (cm^{-1})
CDEXB	rate coefficient at 300 K for vibrational de-excitation of lowest NO vibrational level ($\text{cm}^3 \text{sec}^{-1}$)
CDEXT	rate coefficient at 300 K for vibrational exchange of NO with N_2 or O_2 for the most significant vibrational level ($\text{cm}^3 \text{sec}^{-1}$)
CHEML	currently inactive
CONC	array of NO concentrations (cm^{-3})
CO ₂	real array used to store reduced temperature value and rate coefficients to generate vibrational energy exchange rates for CO ₂ : currently inactive
DENTOT	array of total number densities at altitude mesh (cm^{-3})
EA	array of Einstein A coefficients

FAC	used as temporary storage
FACTOR	temporary storage in computing vibrational exchange
GDOWN	real array in which are stored rates of absorption of solar radiation, $I_0 G'$ for each band
GFAC	real array in which are stored values of G' for each band
GNDSTE	real array in which are stored ground state vibrational populations, equivalenced to VIBPOP(1,1)
GUP	real array in which are stored rates of absorption from the lower atmosphere, $2\pi N_{\lambda,t}^b G'$ for each band
I	index of species of interest (equals 4 for NO)
ITER	integer used as index in iterative computation of vibrational level population
IX	index for altitude level
JF	index for final vibrational level in band transition
JI	index for initial vibrational level in a band transition
JL	integer used to compute JI, JF
JX	index for vibrational level
KB	integer array used to store band types
KBN	index of band type
KCHEM	chemiluminescence index; currently has no effect
KL	integer array storing level types
KLN	current level type
LBC	integer array containing information on which levels produce a band
LBU	integer array containing band type information
LCC	integer array containing vibrational level coupling go N_2 or O_2
LSC	integer array containing level type information
NALT	number of altitudes for which results are to be returned
NB	index for band number
NBAND	number of bands for this species
NBAND1	equal to NBAND
NBC	temporary storage index

NBX	temporary storage index
NF	temporary storage index
NI	temporary storage index
NL	level number index
NLEVEL	number of vibrational levels for this species
NLTE	integer variable used to indicate conditions of computation, 1 for local thermodynamic equilibrium, 2 for collisional excitation only, 3 for night conditions, 4 for noon conditions, 5 to include high vibrational temperature for nitrogen
NMIN	integer variable storing (NALT - 1)
NP	output device index
NR	input device index
NW	output device index
NY, NZ	index for altitude level
POP2, POP3, POP4, POP5, POP6, POP7, POP8	real variables used temperature storage for vibrational populations
POWER	real array in which are stored conversion factors between emission rates in photons $\text{cm}^{-3} \text{sec}^{-1}$ and watts $\text{cm}^{-3} \text{ster}^{-1}$ for each band
RM	molecular mass for this molecule (g/mole)
SFLUX	array of solar flux values for each band
SNB	temporary storage of band strength ($\text{cm}^{-1}(\text{atm-cm})^{-1}$)
STR	array of band strength for each band ($\text{cm}^{-1}(\text{atm-cm})^{-1}$)
SUM	used to store partial sums
TDOWN2	real array equivalenced to TTDOWN(1,9)
TEMP	array containing temperature profile (K)
TFLUX	array containing fluxes for lower altitudes for each band
TMP	temporary storage for temperature (K)
TNNV	nitrogen vibrational temperature (K)
TTDOWN	array storing values of total optical thickness from top of atmosphere for each band

TTH	array storing values of total optical thickness between adjacent altitudes for each band
TTUP	array storing values of total optical thickness from bottom of upper atmosphere for each band
TiUP2	array equivalenced to TTU(9,1)
TVS	used to store local value of TVSIG
TVSIG	array storing values of vibrational populations of each state for each altitude
VIEPOP	array storing values of vibrational populations of each state for each altitude
VTs	local value of VTSIG
VTSIG	array of vibrational de-excitation rates at each altitude
VVDSIG	array of estimated values of transfer of vibrational energy (downward)
VVNSIG	array of rates of transfer of vibrational energy from N ₂ to this molecule
VVRSIG	array of rates of transfer of vibrational energy to N ₂
VVUSIG	array of estimated values of rate of transfer of vibrational exchange (upward)
VVWAVE	difference between N ₂ vibrational energy and a molecular vibrational energy
WATVA	array storing reduced temperature values and rate coefficients to generate vibrational energy exchange rates for CO ₂
WAVE	array containing energy level of each band (cm ⁻¹)
XYM	temporary storage variables
XYMM	temporary storage variable
XYN	temporary storage variable

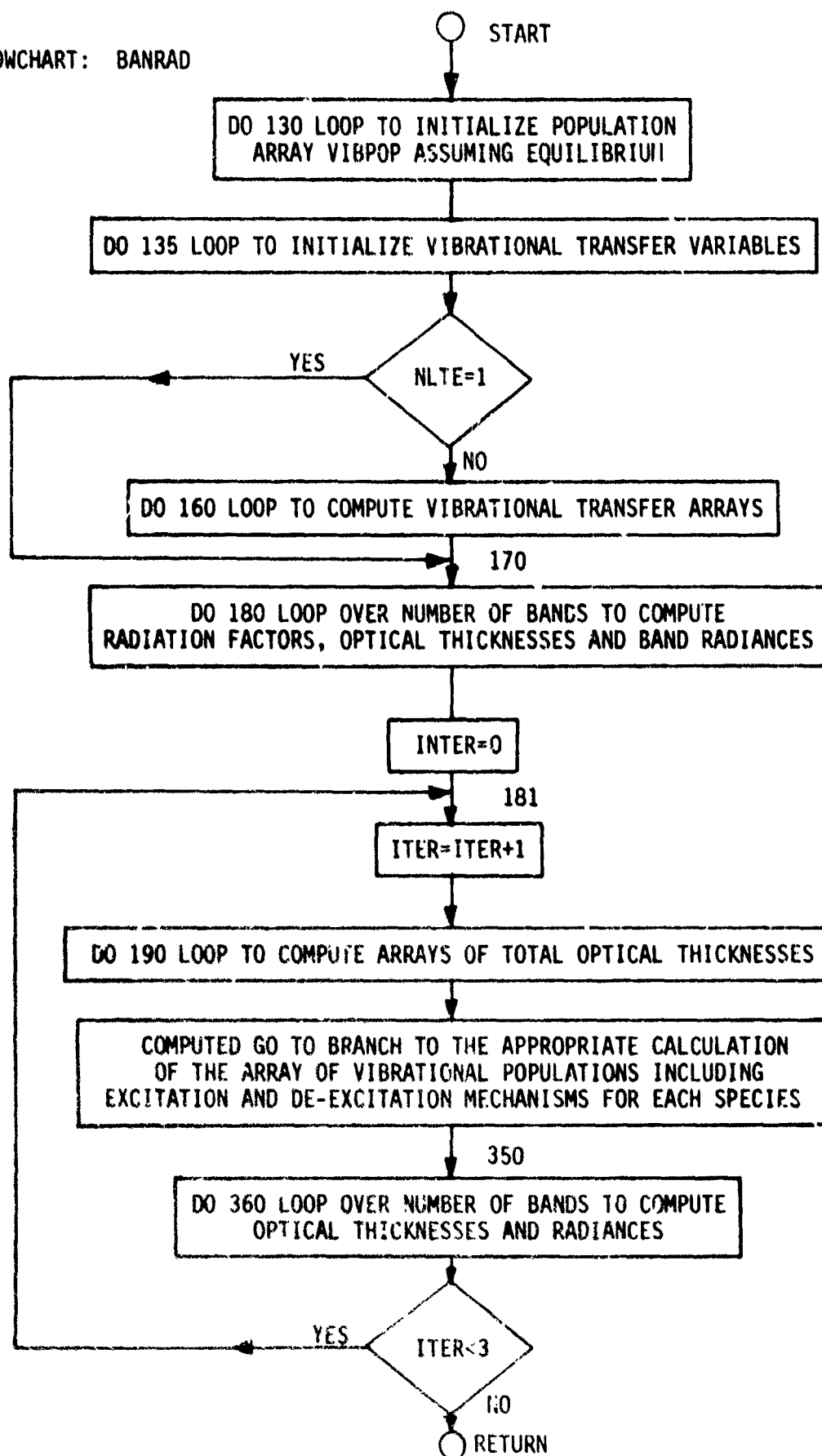
Non-Library
Externals:

EVAL, SIMP, SLM1, SM1, TAUMAX, XFER

Called by:

BCKGND

FLOWCHART: BANRAD



Function XFER

Purpose: Function XFER is used to compute the excitation of a vibrational level caused by molecules radiating in a given band.

Method: Function XFER computes the contribution to the source function from the radiation received in a given vibration-rotation band by a molecule at a given altitude. A single entry to Function XFER computes this number for radiation received from molecules located either below or above this altitude. Equation (44) is summed over each altitude interval involved.

Program Flow: Function XFER assumes that the values in RAD(1) and TTH(1) are the values corresponding to the lowest altitude over which the integration is to be performed. Thus, when called from Subroutine BANRAD to determine the effect of molecules above a given altitude with index NZ, the calling argument list has the form (VIBPOP(NZ,2), TTH(NZ,1), NALT, NZ, 2,KB(1)) for a band transition between vibrational Levels 1 and 2 and band number 1.

Upon entry to Function XFER, the number of altitude intervals is found from the difference of NTOP and NBOT, and stored in NINT. If NTOP=NBOT, the value 1.0 is returned by Function XFER. Otherwise, K is tested and control transferred to the appropriate part of the function.

When K is one, XFER computes the radiative contribution to excitation from layers below the altitude level for which the computation is made. When K is two, the contribution from layers above is computed.

The computation from a single level is found in each passage through the loop ending with Statement 120 (if K is one) or Statement 220 (if K is two). Before entry to either loop, RA is set to one, TB to zero, and EA3 to zero. RFAC, the ratio of ground state to upper state vibrational populations is computed and SUM is set to one-half. Within the appropriate loop, TB is incremented by the optical thickness obtained from array TTH. $1/2 N_{12}(\tau)$ for the band is obtained from Function SLM1 and the value stored in EB2. The band function $1/2 L_3(\tau)$ is computed from the value of $L_0(\tau)$ obtained by a call to Function SL3 and $1/2 N_{12}(\tau)$ through use of the recurrence relation

$$\frac{1}{2} L_3(\tau) = \frac{1}{4} [L_0(\tau) + N_{12}(\tau)]$$

Equation (44) is then applied and the result added to the value in SUM.

MNEMONIC VARIABLES

EA3	temporary storage for value of the band function L_3 for the nearer of two adjacent integration points
EB2	temporary storage for value of the band function $1/2 N_{12}$ for farther away of two adjacent integration points
EB3	temporary storage for value of the band function L_3 for the farther away of two adjacent integration points
K	integer parameter used to choose appropriate section of this function
KB	integer parameter used to choose appropriate sections of Functions SLM1 and SL3
NBOT NTOP	indices in altitude array of top and bottom altitudes in layer of interest

NF	index used to select values from array VIBPOP
NINT	(NTOP - NBOT), number of intervals
NPL	(NINT+1)
NY	index for altitude level
NZ	index for altitude level
RA	relative vibrational population of nearer altitude point
RAD	real array containing vibrational population of an upper state
RB	relative vibrational population of farther altitude point
RFAC	ratio of ground state population to upper vibrational level population
SUM	immediate result of integration
TB	optical distance from level for which calculation is being made to farther of two levels
TM	increment of optical thickness between two adjacent levels
TTH	real array storing incremental optical thicknesses
VIBPOP	real array storing vibrational populations of ground and excited levels of a molecule

Non-Library

Externals: SLM1, SL3

Called by: BANRAD

Function SL3

Purpose: This function yields the total absorption of radiation from a continuum source passing through a line absorbing medium. The result of this computation is used by Function XFER to compute the band function $L_3^b(\tau)$.

Method: SL3 computes the function $L^b(\tau)$ for parallel and perpendicular transitions in linear molecules. The algorithm uses a polynomial approximation to values of $L^b(\tau)$ computed for a reduced rotational temperature $hcB_v/kT = 0.002$. The values computed by SL3 are within five percent of the correct values for any reduced rotational temperature encountered in running the program.

Program Flow: Upon entry, the absolute value of the argument TAU is defined as T. Some logic then is used to choose the appropriate polynomial curve fit to the function which is computed and return is executed.

Inputs: K, TAU

Output: SLM1

MNEMONIC VARIABLES:

K	input parameter used to choose appropriate branch of the function, K equals 1 for parallel band, K equals 2 for perpendicular band
SL3	computed value of $L^b(\tau)$
T	absolute value of argument of TAU
TAU	input variable, optical depth k_t

X argument used to compute curve fit
Y natural logarithm of T

Non-Library

Externals: None

Called by: XFER

MNEMONIC VARIABLES:

BV	rotational constant (cm^{-1})
DEN	columnar number density of molecule (cm^{-2})
FLAM	wavelength (μm)
KB	integer parameter
KL	integer parameter
RM	mass of molecule (gm/mole)
S	band strength ($\text{cm}^{-1}(\text{atm-cm})^{-1}$)
SIG	the quantity hcB_v/kT
T	temperature (K)
TAUMAX	value of optical thickness returned by function

Non-Library

Externals: SJMAX

Called by: BANRAD

Function TAUMAX

Purpose: The purpose of this function is to compute the optical thickness of the strongest line in an infrared vibrational-rotational band.

Method: Function TAUMAX computes the optical thickness k_0 at the center of the strongest line of a vibrational-rotational band of a linear molecule, assuming Doppler line shape.

Program Flow: The optical thickness at the center of a line with Doppler shape is

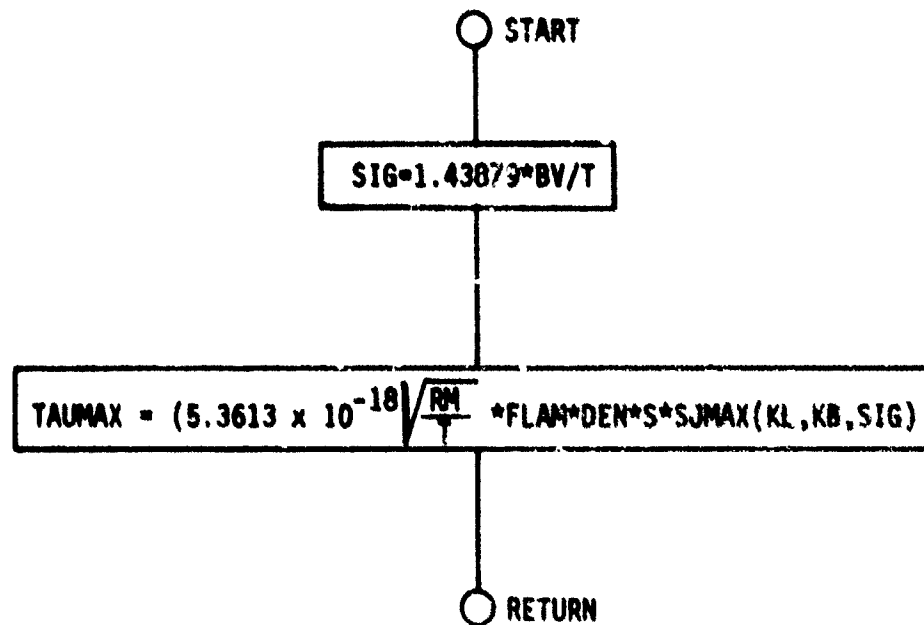
$$k_0 = 5.3612 \times 10^{-18} \sqrt{\frac{M}{T}} N_{1c} \lambda_0 S_{lu}^{\text{line}}$$

where M is the molecular mass (gm/mole), T is the absolute temperature (K), N_{1c} is the columnar number density (molecules/cm²), λ_0 is the line center wavelength (μm) and S_{lu}^{line} is the line strength in absorption (cm⁻¹ (atm-cm)⁻¹ at 300 K. Function TAUMAX computes the reduced rotational temperature hcB_v/kT and transmits this as an argument to Function SJMAX which computes the fraction of total band strength in the strongest line $S_{j_{\text{max}}}/S_{lu}^{\text{band}}$. TAUMAX then computes the optical thickness at the center of the strongest line, using $S_{j_{\text{max}}}$ in place of S_{lu}^{line} in the above expression.

Inputs: KL, KB, RM, BV, T, FLAM, S, DEN

Output: TAUMAX

FLOWCHART: TAUMAX



Function SJMAX

Purpose: The purpose of this function is to compute relative line strengths.

Method: Function SJMAX computes the relative strength of the strongest line in a parallel or perpendicular band of a linear molecule, assuming that all parallel bands are $1\sum - 1\sum$ transitions and all perpendicular bands are $1\pi - 1\sum$ transitions. The effect of neglecting the actual transition involved is negligible for the uses of Function SJMAX.

Program Flow: Function SJMAX computes the J values of the strongest line in the band, computes the strength from the appropriate Hönl-London formula, and divides this by the rotational partition function returned by Function QJPART.

Inputs: KL, KB, SIG

Output: SJMAX

MNEMONIC VARIABLES:

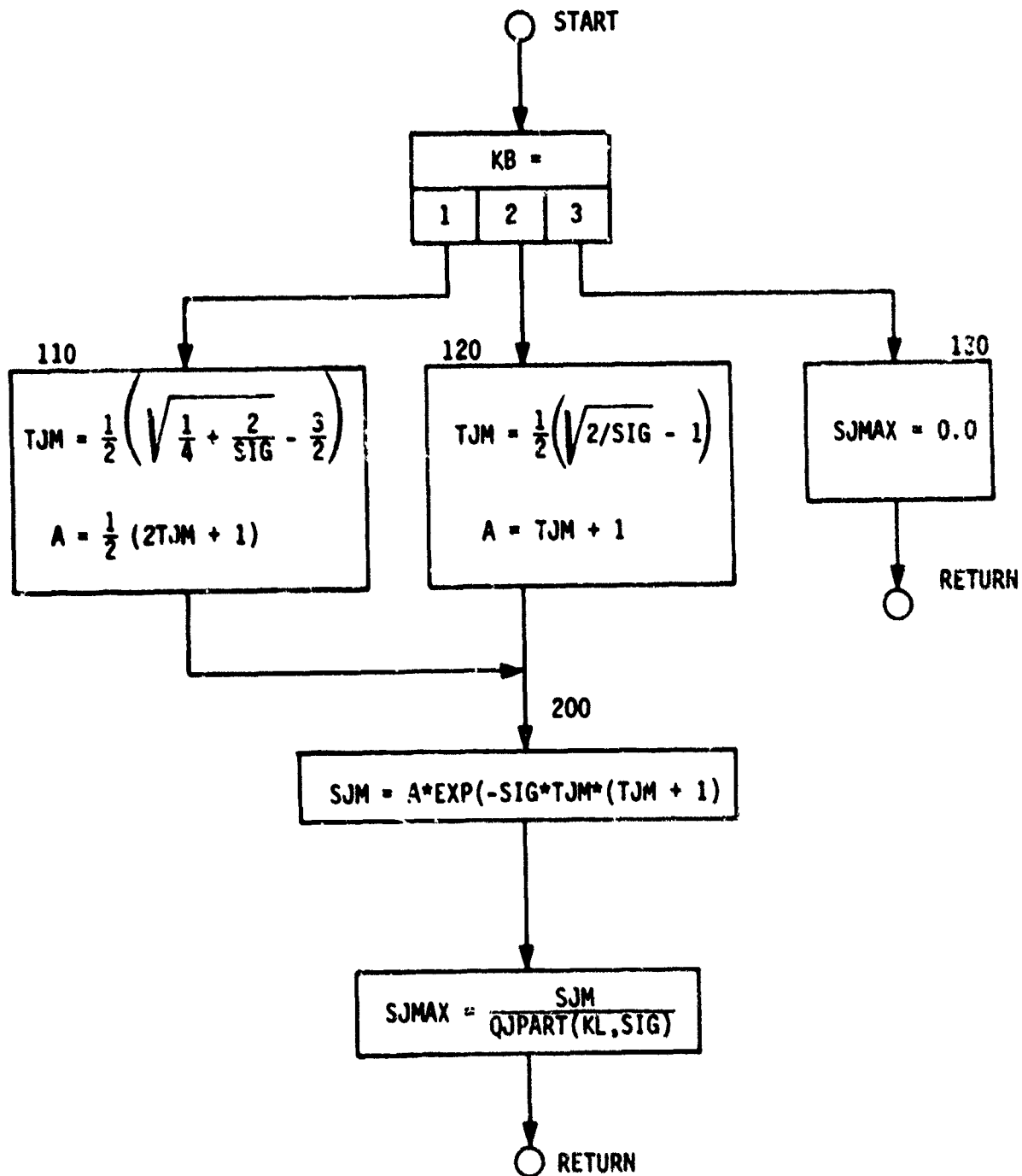
A	intermediate result in calculation
KB	parameter to choose type of transition (KB = 1 $\sum$ - $\sum$ transition) (KB = 2 π - $\sum$ transition)
KL	parameter passed to QJPART
SIG	the quantity $(hcB_v)/kT$
SJM	strength of strongest line in band
SJMAX	relative strength of strongest line in band
TJM	effective rotational quantum number

Non-Library

Externals: QJPART

Called by: TAUMAX

FLOWCHART: SJMAX



Function QJPART

Purpose: The purpose of this function is to compute rotational partition functions for linear molecules. Refer to Subroutine BANRAD for definition of symbols.

Method: Function QJPART computes the rotational partition function of a single vibrational level of a rigid linear molecule, assuming that the energy E_J of a rotational state with quantum number J is

$$E_J = hcB_v J(J + 1)$$

Provision is made for computing the rotational partition functions for vibrational levels in which rotational states with only even or odd J values are present.

Program Flow: If $K = 1$, all rotational levels are assumed populated. If $K = 2$, only even rotational levels are assumed populated. If $K = 3$, only odd rotational levels are assumed populated.

The computation uses polynomial approximates to the partition function

$$Q_J = \sum_J (2J + 1) \exp(-E_J/kT)$$

with SIG as the parameter. The range of applicability is limited to values of SIG less than 0.2, and the largest value of SIG encountered for the molecules presented included is 0.015.

Inputs: K, SIG

Outputs: QJPART

MNEMONIC VARIABLES:

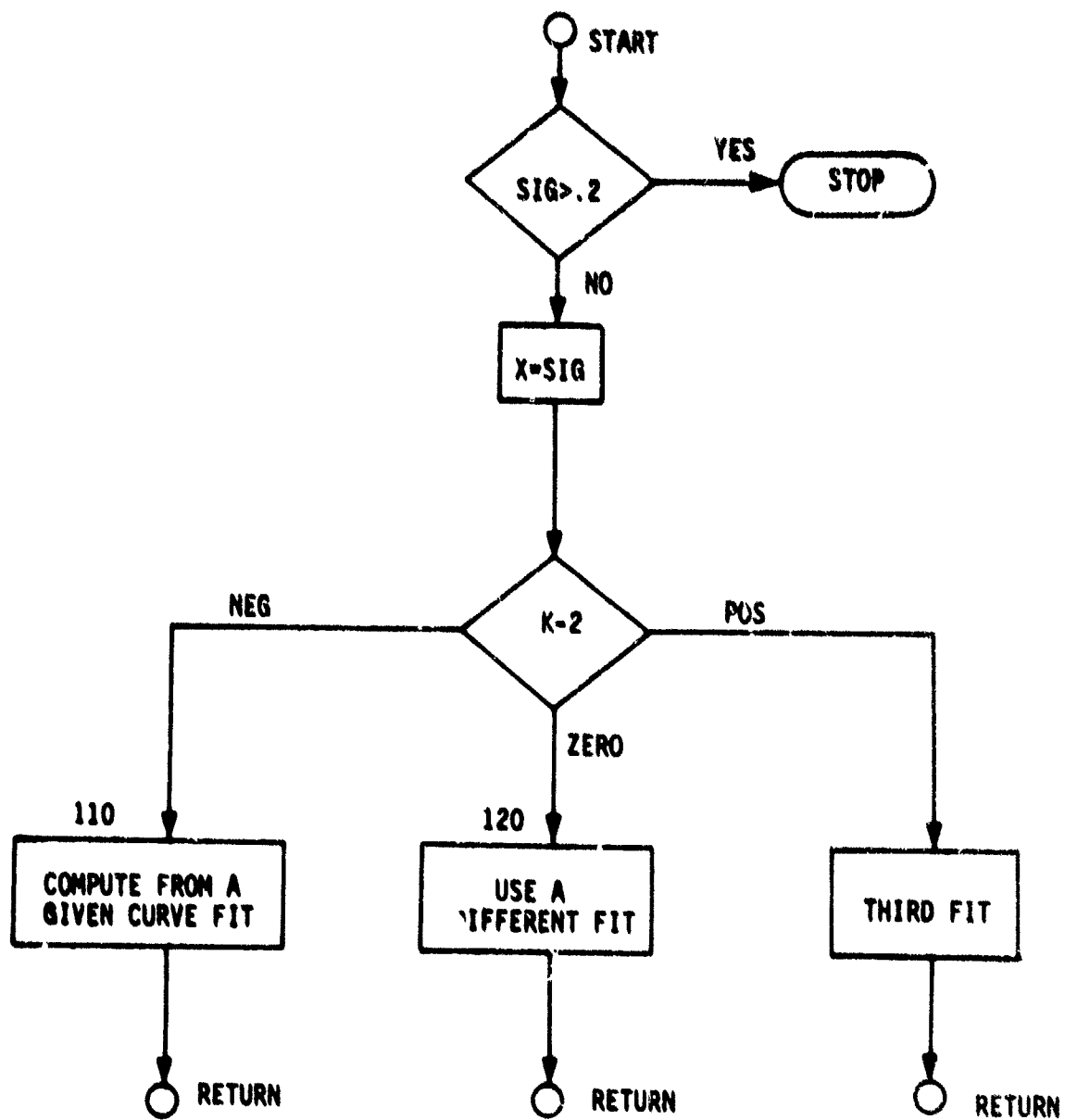
K	parameter used to choose appropriate fit
QJPART	value of rotational partition function
SIG	the quantity (hcB_v/kT)
X	the value of SIG, defined for convenience in the curve fit

Non-Library

Externals: None

Called by: SJMAX

FLOWCHART: QJPART



Function SIMP

Purpose: The purpose of this function is to compute an integral using Simpson's rule.

Method: Function SIMP computes the integral of a function between any two of three equally spaced points. Simpson's rule integration is used.

Program Flow: Upon entry, the value of K is tested to choose the appropriate branch of the function with the following results:

$$K < 2 \quad \text{SIMP} = (h/12) (8A(2) + 5A(1) - A(3))$$

$$K = 2 \quad \text{SIMP} = (h/12) (8A(2) + 5A(3) - A(1))$$

$$K > 2 \quad \text{SIMP} = (h/3) (4A(2) + A(1) + A(3))$$

Inputs: A, H, K

Output: SIMP

MNEMONIC VARIABLES:

A array of values to be integrated

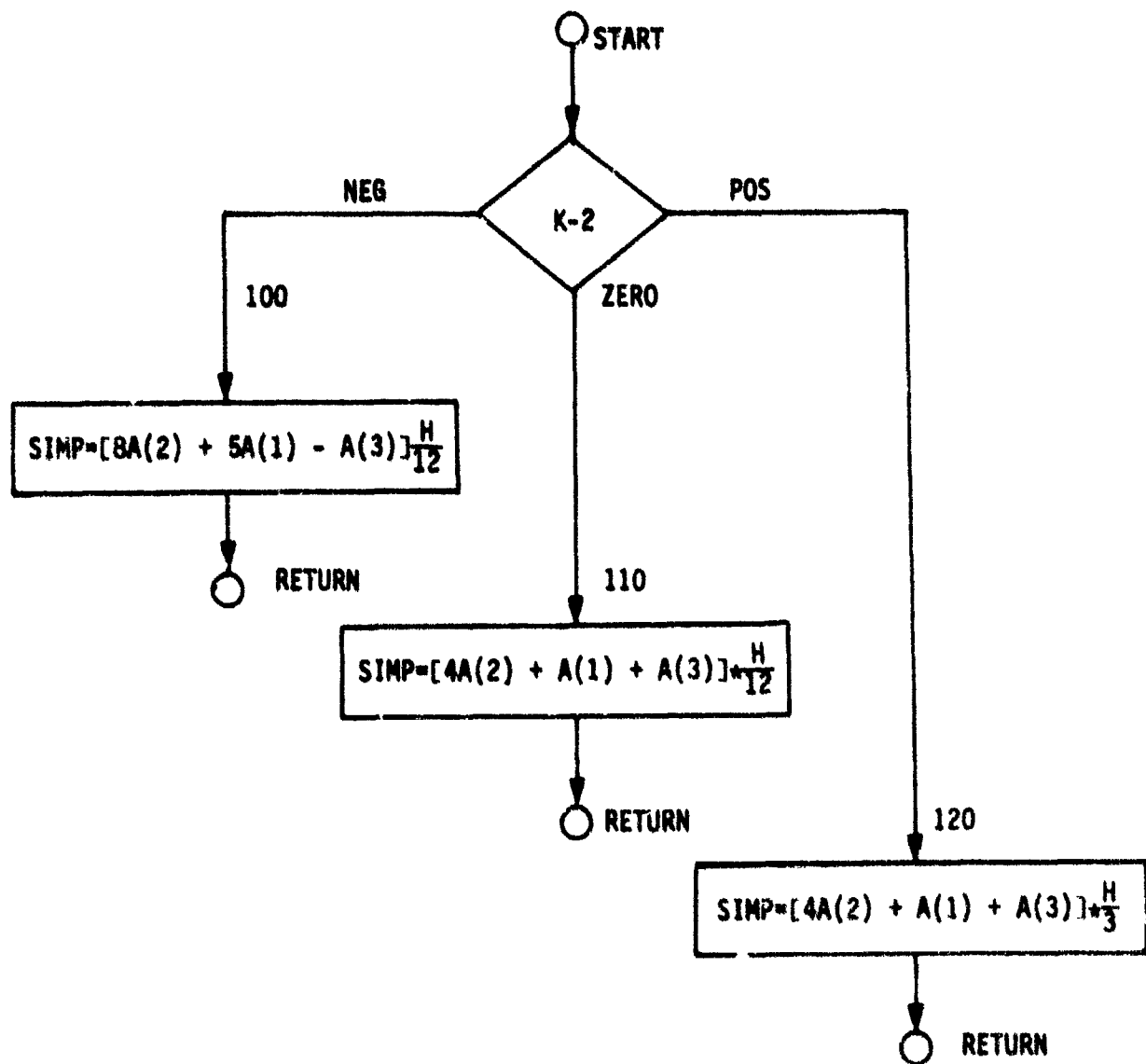
H integration step size

K parameter to choose method desired

Non-Library
Externals: None

Called by: BANRAD, XFER

FLOWCHART: SIMP



X argument used to compute curve fit
Y natural logarithm of T

Non-Library

Externals: None

Called by: BANRAD

Function SM1

Purpose: This function yields a factor needed to compute the true rate of absorption at an optical depth, k_0 , of radiation (from a spectrally constant source) in a resonant medium. Refer to Subroutine BANRAD for further explanation and definition of symbols used below.

Method: SM1 computes the function $M_1^b(k_0)$ for parallel and perpendicular transitions in linear molecules. The algorithm employs a polynomial approximation to values of $M_1^b(k_0)$ computed at a reduced rotational temperature $hcB_v/kT = 0.002$.

Program Flow: Upon entry the absolute value of the argument TAU is defined as T. Some logic then is used to choose the appropriate polynomial curve fit to the function which is computed and return is executed.

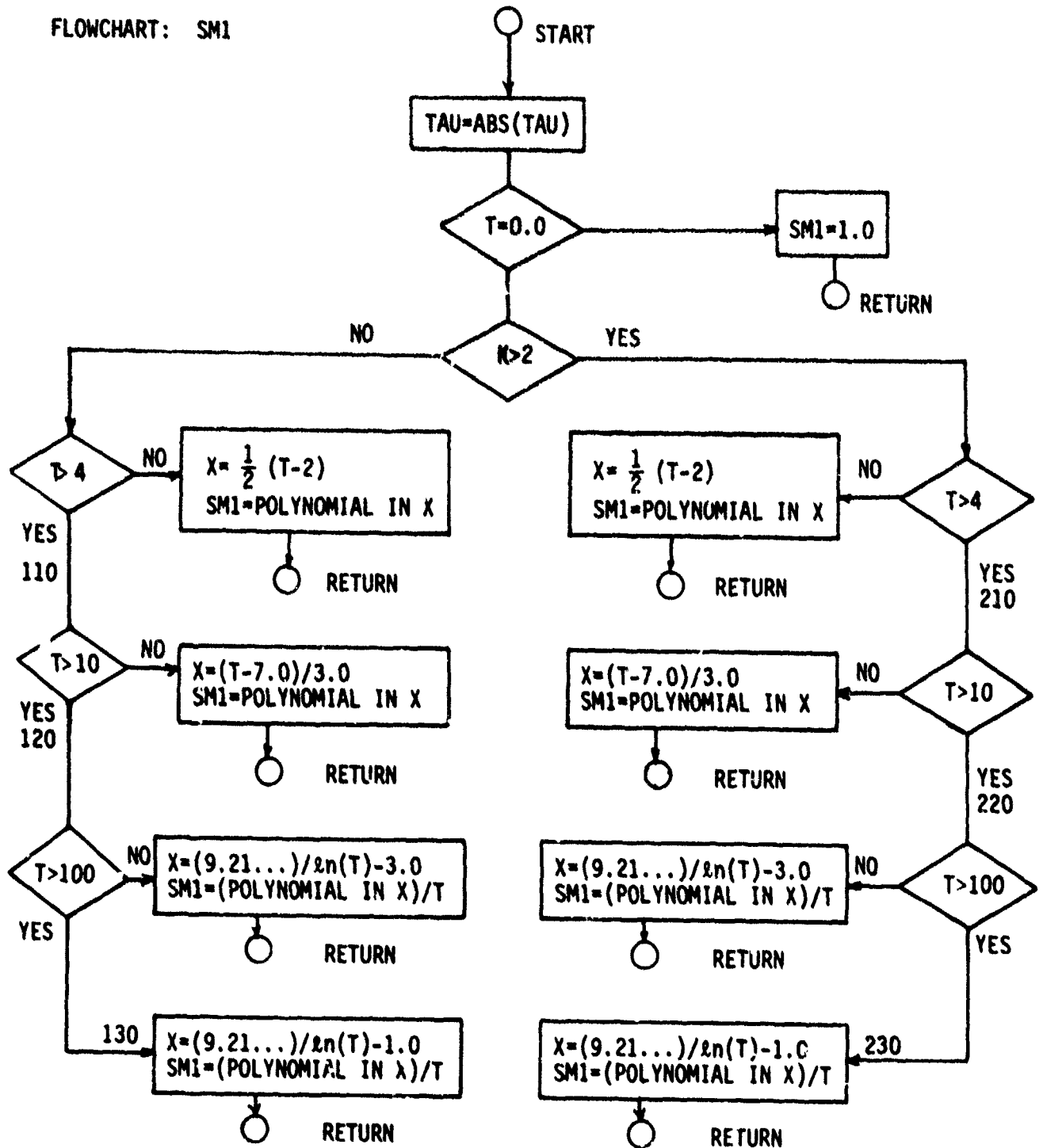
Inputs: K, TAU

Output: SM1

MNEMONIC VARIABLES:

K	input parameter used to choose appropriate branch of the function; K equals 1 for parallel band, K equals 2 for perpendicular band
SM1	rate of absorption at optical thickness k_0 , relative to zero optical thickness
T	absolute value of argument TAU
TAU	input variable - optical depth k_0

FLOWCHART: SM1



Function SLM1

Purpose: This function yields the factor used to obtain the actual absorption of radiation from an extended black body surface passing through a resonant medium. Refer to Subroutine BANRAD for further explanation and definition of symbols used below.

Method: SLM1 computes the function $\frac{1}{2\pi} N_1^b(k_t)$ for parallel and perpendicular transitions in linear molecules. The algorithm uses a polynomial approximation to values of $\frac{1}{2\pi} N_1^b(k_t)$ computed for a reduced rotational temperature $hcB_v/kT = 0.002$. The values computed by SLM1 are within five percent of the correct values for any reduced rotational temperature encountered in running the program.

Program Flow: Upon entry the absolute value of the argument TAU is defined as T. Some logic then is used to choose the appropriate polynomial curve fit to the function which is computed and return is executed.

Inputs: K, TAU

Output: SLM1

MNEMONIC VARIABLES:

K	input parameter used to choose appropriate branch of the function, K equals 1 for parallel band, K equals 2 for perpendicular band
SLM1	computed value of $\frac{1}{2\pi} N_1^b(k_t)$
T	absolute value of argument TAU
TAU	input variable, optical depth k_t

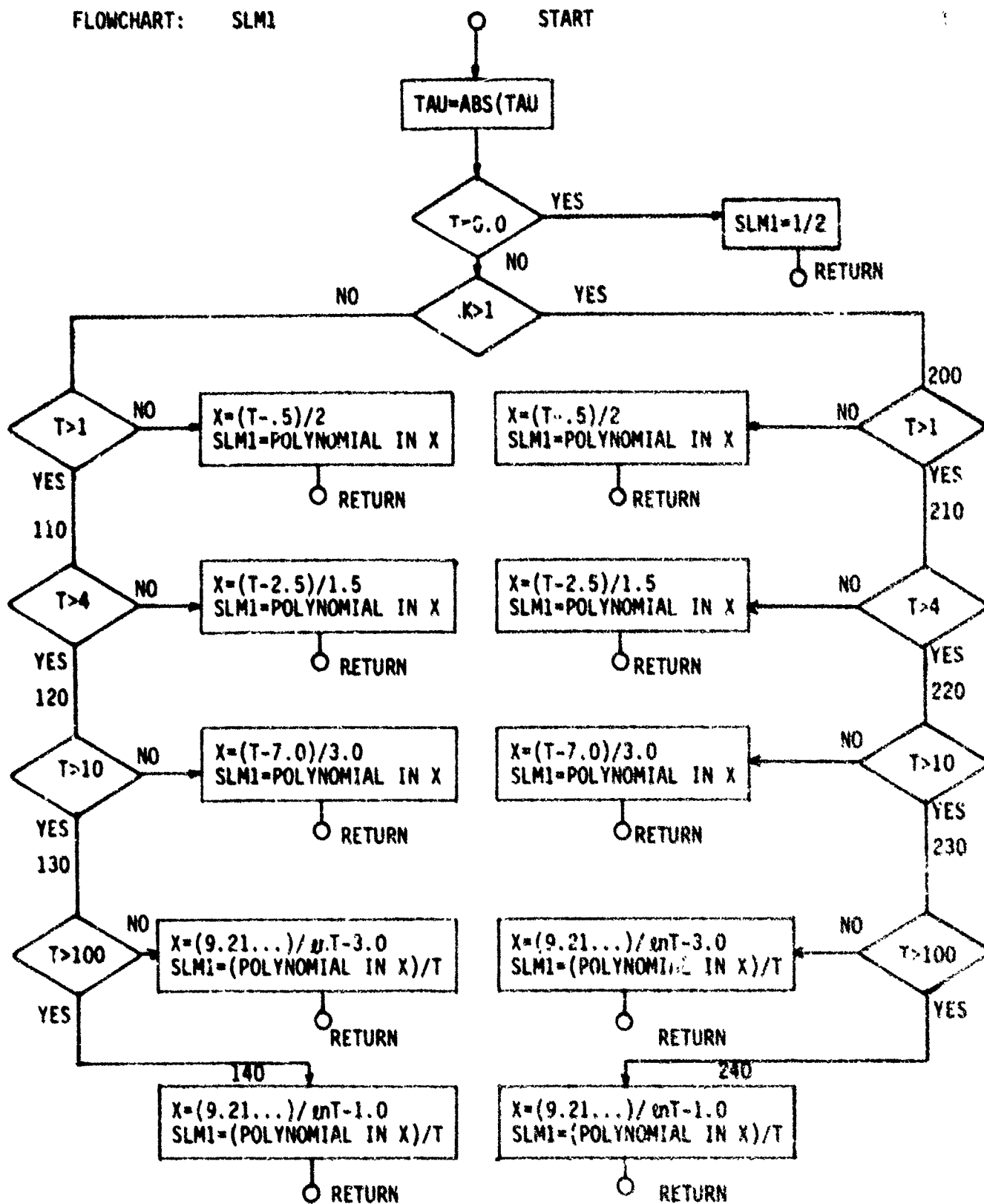
X argument used to compute curve fit
X natural logarithm of T

Non-Library

Externals: None

Called by: BANRAD

FLOWCHART: SLM1



```

C
C
C
C
C
C
PROGRAM BOND (INPUT,OUTPUT,TAPE 3,TAPE 5,PRINT,TAPE 4,OUTPUT)
EFFICIENT VERSION OF BOND.
131 ALTITUDES.
DEVELOPMENTAL VERSION. MATRIX ROUTINES.

DIMENSION XID(4,25),XIDI(4),ALT(30),STORE(30),IAL(25)
DIMENSION DATAT(25),CDEXI(25),CDEXB(25),NLEVEL(25),NRAND(25)
DIMENSION ISC(25,25),LCC(25,25),RIM(25,25),BV(25,25),AMASS(25)
DIMENSION ZANG(7),STAU(7),SEAL(8),SDM(8),RATIO(8)
DIMENSION PR(25,25),LAW(25,25),SIF(25,25),SFUX(25,25),PLUX(25,
125,3)
DIMENSION CO2(18,2),WATV4(12,2)
DIMENSION CONN2(131),CONN2(131),CONG(131)
DIMENSION CONCH4(131),CONN2(131),CONH20(131)
DIMENSION CONNO(131),CONN2(131),CONH3(131)
DIMENSION CONCO(131)
REAL LAMBDA
EQUIVALENCE (CONN2(1),CONC(1,8)),(CONN2(1),CONC(1,9))
EQUIVALENCE (CONO(1),CONC(1,10)),(CONCH4(1),CONC(1,11))
EQUIVALENCE (CONCO2(1),CONC(1,12)),(CONH20(1),CONC(1,13))
EQUIVALENCE (CONNO(1),CONC(1,14)),(CONN20(1),CONC(1,15))
EQUIVALENCE (CONO3(1),CONC(1,16)),(CONCO(1),CONC(1,17))
COMMON /VBRCON/ I,CO2,WATVA,CDEXI,CDEXB
COMMON /TEGLUM/ NLTE
COMMON/INOUT/NR,NP,NW
COMMON CONC(131,10),TAU(131,25),RAD(131,25),I(131),LAMBDA(25),
1TOTDEN(131)
DATA(ZANG(1),1-1,7)/0.0,20 0,40.0,60.0,70.0,80.0,90.0/
DATA(DATAT(1),I=1,25)/8HMETHANE ,8HCARBON D,8HWATER VA,8HNITRIC O
1,8HNITROUS ,8HOZONE PR,8HOZONE NO,18*8H
NR = 5
NP = 3
NTX = 6

```

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NW = 6
READ (NR,6) Y
READ (NR,6) CONN2
READ (NR,6) CONO2
READ (NR,6) CONO
READ (NR,6) CONCH4
READ (NR,6) CONCO2
READ (NR,6) CONH2O
READ (NR,6) CONNO
READ (NR,6) CONN2O
READ (NR,6) CONO3
READ (NR,6) CONCO
6  FORMAT (1X,1P6E11.4)
   READ (NR,10) IGAS
10  FORMAT (I2)
20  FORMAT(1H1,22NUMBER OF GAS PROFILES, I3)
   WRITE(NW,20) IGAS
   IGAS=IGAS+1
   DO 170 J=1,IGAS
30  FORMAT (4A6,I3,F7.0)
   READ(NR,30)(XID(K,J), K=1,4), ICHK,ALTM
   IF(J.EQ.ICHK) GO TO 50
40  FORMAT ( 7HID CARD, A6, 20HOUT OF ORDER FOR GAS, I3)
   WRITE(NW,40)(XID(K,J),K=1,4), J
50  CONTINUE
120 CONTINUE
   IF(ALTM.GT.150.) GO TO 140
   IALT(J) = ALTM/2.0 + 1.0
   GO TO 150
140 IALT(J) = 76.0 + (ALTM - 150.0)/10.0
150 CONTINUE
   I1=IALT(J)
170 CONTINUE
   DO 175 J=1,131

```

```

175 TOTDEN(J) = CONC(J,8) + CONC(J,9) + CONC(J,10)
    CONTINUE
180 READ(NR,30) (XIDI(K),K = 1,4), ICHK, KCHK
    IF(ICHK.EQ.1) GO TO 190
190 FORMAT( 7HID CARD, 4A6,26HOUT OF ORDER FOR TEMP DATA)
    WRITE(NW,180) (XIDI(K),K=1,4)
200 CONTINUE
210 CONTINUE
220 FORMAT (1X,IS,1P9E12.4)
230 WRITE(NW,261) (J,(CONC(J,I),I=1,IGAS), T(J),J = 1,131)
    IGAS=IGAS-1
    DO 331 I=1,IGAS
240 READ(NR,310)TYPE,NLEV ,NRAN ,AMAS ,DEXT,DEXB
250 FORMAT (A8,22X,I2,3X,I2,3X,F6.2,4X,2(E12.4,3X))
    DO 311 J=1,25
260 IF(TYPE.EQ.DATATY(J)) GO TO 312
    CONTINUE
270 WRITE(NW,370)
280 FORMAT(36HTHE GAS IS NOT LISTED IN THE PROGRAM)
    STOP 1
290 NSP=J
    NLEVEL(NSP)=NLEV
    NBAND(NSP)=NBAN
    AMASS(NSP)=AMAS
    CDEXT(NSP)=DEXT
    CDEXB(NSP)=DEXB
300 IF(NSP.EQ.2)READ(NR,320) (CO2(I,1),CO2(I,2),I=1,18)
    FORMAT (6(F5.2,F8.2))
310 IF(NSP.EQ.3)READ(NR,320) (WATVA(I,1),WATVA(I,2),I=1,18)
    ILEV=0
    DO 313 IJ=1,NLEV
    ILEV=ILEV+1
    READ(NR,330)LSC(IJ,NSP),LCC(IJ,NSP),RCM(IJ,NSP),BV(IJ,NSP),JGAS,
    1JLEVEL

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```

330 FORMAT (2I6,2E12.4,36X,2I3)
    IF(NSP.EQ.JGAS) GO TO 314
    WRITE(NW,340) NSP
340 FORMAT(64HTHE CODE ON THE DATA DOES NOT AGREE WITH THE FIRST CARD
    1WHICH IS,I3)
C   STOP 2
314 IF(ILEVL.EQ.JLEVEL) GO TO 313
    WRITE (NW,350) NSP
350 FORMAT(42HTHERE IS A CARD OUT OF SEQUENCE IN GAS NO.,I3)
C   STOP 3
313 CONTINUE
    ILEVEL=0
    DO 316 IJ=1,NBAN
        ILEVEL=ILEVL+1
        READ(NR,360)LBC(IJ,NSP):LBU(IJ,NSF),STR(IJ,NSP),SFLUX(IJ,NSP),
        1(TFLUX(IJ,NSP,J),J=1,3),JGAS,JLEVEL
        STR(IJ,NSP) = 2.479ZE+19*STR(IJ,NSP)
360 FORMAT (2I6,1P5E12.4,2I3)
362 FORMAT (2I6,1PE12.4,2I3,1X,4A6)
    IF(NSP.EQ.JGAS) GO TO 322
    WRITE (NW,340) NSP
C   STOP 4
322 IF(ILEVL.EQ.JLEVEL) GO TO 316
    WRITE (NW,350) NSP
C   STOP 5
316 CONTINUE
331 CONTINUE
    WRITE (NP,378) T
378 FORMAT (1P6E12.4)
    DO 900 NLTE = 1, 3, 2
        NSFTOT = 4
        WRITE (NP,360) NSPTOT,NLTE
        DO 850 I = 4, 4
            IF ((I.EQ. 6) .AND. (NLTE.EQ. 4)) GO TO 850

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C      IF (I.EQ. 7) .AND. (NLTE.EQ. 3) GO TO 850
      IF (I.EQ. 5) GO TO 850
      WRITE (NP,360) I,NLTE
      WRITE (NP,362) NLTE,EL(I),NBAND(I),AMASS(I)
      1  ,I,NLTE,XID(K,I), K = 1, 4)
      NLEV = NLEVEL(I)
      NBND = NBAND(I)
      DO 381 IJ = 1, NLEV
        WRITE (NP,360) LSC(IJ,I),LCC(IJ,I),RCM(IJ,I),BV(IJ,I)
      381 CONTINUE
      DO 382 IJ = 1, NBND
        WRITE (NP,360) LBC(IJ,I),LBU(IJ,I),STR(IJ,I)
      382 CONTINUE
      JALT = (IALT(I) - 1)/5
      WRITE (NP,360) IALT(I),JALT
      CALL BARRAD (NLEVEL(I),NBAND(I),IALT(I),CDEXB(I),
      1  AMASS(I),LSC(I,I),LCC(I,I),LBC(I,I),LBU(I,I),BV(I,I),STR(I,I),
      2  RCM(I,I),CONC(I,I),SFLUX(I,I),IFLUX(I,I),
      KK=IALT(I)
      JSET=NBAND(I)
      DO 840 J=1,JSET
      700 FORMAT(1H1,4A6,8HBAND NO.,I3,5X,7HLMADA =,F6.2,7HMICRO M,4X,4A6//)
      WRITE(NW,700)(XID(K,I),K=1,4),J,LAMDA(J),(XIDT(K),K=1,4)
      IF (NLTE.GT. 1) GO TO 707
      704 FORMAT(40H ASSUMES LOCAL THERMODYNAMIC EQUILIBRIUM/)
      705 WRITE(NW,704)
      GO TO 715
      706 FORMAT (28H LACK OF THERMAL EQUILIBRIUM ,I6/)
      707 WRITE (NW,706) NLTE
      710 FORMAT(118H EXOATMOSPHERIC VIEWING $$ - - - - - E N D
      1  O A T M O S P H E R I C   V I E W I N G - - - - - )
      715 WRITE (NW,710)
      720 FORMAT(118H TAN HT LIMB BAND RAD $$ ALTID - - - - - BAND RADI
      1  ANCE AS A FUNCTION OF ZENITH ANGLE (WATTS/CM2-STER)- - - - - )

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WRITE (NU,720)
730 FORMAT(118H (KM) (WATTS/CM2-STER) $$ (KM) 0 DEG - UP 20 DEG
1 40 DEG 60 DEG 70 DEG 80 DEG 90 DEG-HORZ )
WRITE (NU,730)
740 FORMAT (F5.0,1PE14.4,OPF12.0,1X,1P7E12.4)
KTAU = MOD(LBU(J,1),10)
KSET=IALT(1)-1
DO 830 K = 1, KSET
IF (K.GT.76) GO TO 750
HT = 2KK - 2
GO TO 760
750 HT=150+(K-76)*10
760 B1=HT+ 6371.
DO 810 L=1,7
M1=K+1
PHI=ZANG(L)*.017453292
SAVTAU=0.0
STAU(L)=0.0
SL1B = 0.0
SLOB = 0.0
SRAD(L)=0.0
ABSUM = 0.0
SSUM = 0.0
TSUM = 0.0
RANG=0.0
MSET=IALT(1)
DO 790 N=M1,MSET
SL1A = SL1B
SLOA = SLOB
IF (M.GT.76) GO TO 770
D2=2*M - 2 + 6371
GO TO 78C
770 D2=150+(M-76)*10+ 6371
780 ANG=ASIN(SIN(PHI)*D1/D2)

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```

DS=SQRT(D1*D1+D2*D2-2.*D1*D2*COS(PHI-ANG))
DELS=(DS-RANG)*1.0E+05
RANG=DS
DELTAU = DELS*(0.5*(TAU(M,J)+TAU(M-1,J)))
SAVTAU = STAU(L)
STAU(L) = STAU(L) + DELTAU
SL1B = SL1(KTAU,STAU(L))
SLOB = SLO(KTAU,STAU(L))
RADA = RAD(M-1,J)/TAU(M-1,J)
RADB = RAD(M,J)/TAU(M,J)
SFAC = (RADB - RADA)/DELTAU
SRAD(L) = SRAD(L) + SFAC*(SL1A - SL1B)
ADDEND = SLOB*RADB - SLOA*RADA
1 - (SL1B - SL1A)*SFAC
1 NADIST = 0
IF ((SL1B - SL1A) .LT. 1.0E-4*SL1B) NADIST = 1
IF ((SLOB - SLOA) .LT. 1.0E-4*SLOB) NADIST = 1
IF (DELTAU .LT. 1.0E-6*SAVTAU) NADIST = 1
IF (NADIST .EQ. 1) ADDEND =
1 0.5*DELTAU*(RADB*SM1(KTAU,STAU(L))
2 + RADA*SM1(KTAU,SAVTAU))
IF (ADDEND .LT. 0.0) WRITE (NW,*) J,K,M1,M,L,ADDEND
ABSUM = ABSUM + ABS(ADDEND)
SSUM = SSUM + ADDEND
TSUM = TSUM + AMAX1(ADDEND,0.0)
IF (NLTE .EQ. 1) GO TO 790
IF (L .NE. 7) GO TO 790
IF (J .EQ. 1) GO TO 790
IF (K .GT. 10) GO TO 790
WRITE (NW,*) J,K,M1,M,D2,ANG,DS,DELS
WRITE (NW,*) J,K,M1,M,DELTAU,SAVTAU,STAU(L),SL1A,SL1B
WRITE (NW,*) J,K,M1,M,RAD(M-1,J),RAD(M,J),RADA,RADB,SFAC,SRAD(L)
WRITE (NW,*) J,K,M1,M,SLOA,SLOB,ADDEND,ABSUM,TSUM,SSUM
790 CONTINUE

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```

SRAD(L) = SPAD(L) + ABS(RADB*SLO(KTAU,STAU(L)))
SRAD(L) = SSUM
810 CONTINUE
SAVTAU=0.0
STAU(7)=0.0
SL1B = 0.0
SLOB = 0.0
VRANG = 0.0
SRAD(8)=0.0
SSUM = 0.0
TSUM = 0.0
MSET=IALT(I)
DO 815 M=K,MSET
  SL1A = SL1B
  SLOA = SLOB
  L=MSET-M+K
  IF(L.GT.76) GO TO 811
  D2=2*L - 2 + 6371
  GO TO 812
811 D2=150+(L-76)*10+ 6371
812 DS=SQRT(D2*D2-D1*D1)
  D3 = D2 - 6371.
  IF(L.LT.MSET) GO TO 813
  RANG=DS
  GO TO 815
813 DELS=(RANG-DS)*1.0E+05
  VRANG = VRANG + DELS
  RANG=DS
  SAVTAU = STAU(7)
  DELTAU = DELS*(0.5*(TAU(L,J)+TAU(L+1,J)))
  STAU(7) = STAU(7) + DELTAU
  SL1B = SL1(KTAU,STAU(7))
  SLOB = SLO(KTAU,STAU(7))
  RADB = RAD(L,J)/TAU(L,J)

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RADA = RAD(L+1,J)/TAU(L+1,J)
SFAC = (RADB - RADA)/DELTAU
SRAD(8) = SRAD(8) + SFAC*(SL1A - SL1B)
ADDEND = SLOB*RADB - SLOA*RADA
1  - (SL1B - SL1A)*SFAC
   NADTST = 0
   IF ((SL1B - SL1A) .LT. 1.0E-4*SL1B) NADTST = 1
   IF ((SLOB - SLOA) .LT. 1.0E-4*SLOB) NADTST = 1
   IF (DELTAU .LT. 1.0E-6*SAVTAU) NADTST = 1
   IF (NADTST .EQ. 1) ADDEND =
1  0.5*DELTAU*(RADB*SM1(KTAU,STAU(7))
2  + RADA*SM1(KTAU,SAVTAU))
   IF (ADDEND .LT. 0.0) WRITE (NW,*) J,M,L,K,M,ADDEND
   SSUM = SSUM + ADDEND
   TSUM = TSUM + AMAX1(ADDEND,0.0)
   SL1A = SL1B
C 815 CONTINUE
   M1=K+1
   RANG=0.0
   MSET=IALT(1)
   DO 818 M=M1,MSET
     SL1A = SL1B
     SLOA = SLOB
     IF (M.GT.76) GO TO 816
     D2=2*M - 2 + 6371
     GO TO 817
816 D2=150+(M-76)*10+ 6371
817 DS=SQRT(D2*D2-D1*D1)
     D3 = D2 - 6371.
     DELS=(DS-RANG)*1.0E+05
     VRANG = VRANG + DELS
     RANG=DS
     SAVTAU = STAU(7)
     DELTAU = DF (0.5*(TAU(M,J)+TAU(M-1,J)))

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```

      STAU(7) = STAU(7) + DELTAU
      SL1B = SL1(KTAU,STAU(7))
      SLOB = SLO(KTAU,STAU(7))
      RADA = RAD(M-1,J)/TAU(M-1,J)
      RADB = RAD(M,J)/TAU(M,J)
      SFAC = (RADB - RADA)/DELTAU
      SRAD(8) = SRAD(8) + SFAC*(SL1A - SL1B)
      ADDEND = SLOB*RADB - SLOA*RADA
1    - (SL1B - SL1A)*SFAC
      NADTST = 0
      IF ((SL1B - SL1A) .LT. 1.0E-4*SL1B) NADTST = 1
      IF ((SLOB - SLOA) .LT. 1.0E-4*SLOB) NADTST = 1
      IF (DELTAU .LT. 1.0E-6*SAVTAU) NADTST = 1
      IF (NADTST .EQ. 1) ADDEND =
1    0.5*DELTAU*(RADB*SM1(KTAU,STAU(7))
2    + RADA*SM1(KTAU,SAVTAU))
      IF (ADDEND .LT. 0.0) WRITE (NW,*) J,K,M1,M,ADDEND
      SSUM = SSUM + ADDEND
      TSUM = TSUM + AMAX1(ADDEND,0.0)
      SL1A = SL1B
C    818 CONTINUE
      SRAD(8) = SRAD(8) + ABS(RADB*SLO(KTAU,STAU(7)))
      SRAD(8) = SSUM
      WRITE (NP,740) HT,SRAD(8),HT,(SRAD(M), M = 1, 7)
      WRITE(NW,740) HT,SRAD(8), HT,(SRAD(M), M= 1,7)
830 CONTINUE
840 CONTINUE
850 CONTINUE
900 CONTINUE
      STOP 77
      END

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SUBROUTINE BANRAD (NLEVEL,NBAND,NALT,TEXCO,VEXCO,RM,LSC,LCC,
1  LBC,LBU,BV,STR,WAVE,CONC,SFLUX,TFLUX)
C
THIS SECTION COMPUTES POPULATION OF VIBRATIONAL LEVELS.
DIMENSION EA(25),POWER(25),KB(25),KL(25)
DIMENSION EAHALF(25),TFLUX(25),SFLUX(25)
DIMENSION GUP(25),GDOWN(25),GFAC(25)
DIMENSION TR2(131),TTH2(131),TDOWN2(131),TTUP2(131)
DIMENSION TTH(131,25),TTUP(131,25),TIDOWN(131,25)
DIMENSION CONC(131)
DIMENSION TVSIG(131),VTSIG(131)
DIMENSION VVUSIG(131),VVDSIG(131)
DIMENSION VVNSIG(131),VVRSIG(131)
DIMENSION WAVE(250),LSC(250),LCC(250),LBC(250),LBU(250),STR(250)
DIMENSION GNDSTE(131)
DIMENSION CO2(18,2),WATVA(18,2)
DIMENSION CDEXT(25),CDEXB(25)
DIMENSION CHEML(131)
COMMON /VBRCOM/ I,CO2,WATVA,CDEXT,CDEXB
COMMON /ITRCOM/ ITER
COMMON /POPCOM/ VIBPOP(131,25)
COMMON/INOUT/NR,NP,NW
EQUIVALENCE (TDOWN2(1),TIDOWN(1,9)),(TTUP2(1),TTUP(1,9))
EQUIVALENCE (GNDSTE(1),VIBPOP(1,1))
COMMON /TEQCOM/ NLTE
COMMON ZDEN(131,10),BNDTAU(131,25),BNDRAD(131,25),TEMP(131)
1  ,BNDLAM(25),DENTOT(131)
DATA ZFAC /1.0/
DATA CHEML /131*0.0/
RTFUN(NUS,NBS) =
1  (XFER(VIBPOP(1,NUS),TTH(1,NBS),NZ,1,1,KB(NBS)))
2  + XFER(VIBPOP(NZ,NUS),TTH(NZ,NBS),NALT,NZ,2,KB(NBS))) * EA(NBS)
3  + GDOWN(NBS) * SM1(KB(NBS),ZFAC * TIDOWN(NZ,NBS))
4  + GUP(NBS) * SN12(KB(NBS),TTUP(NZ,NBS))
AAA = 0.0

```

```

50  FORMAT (6E12.4)
DO 130 NZ = 1, NALT
  SUM = 0.0
  TMP = TEMP(NZ)
DO 110 NL = 2, NLEVEL
  XYN = MOD(LSC(NL)/10,10)
  AA = EXP(-1.43879*WAVE(NL)/TMP)*XYN
  VIBPOP(NZ,NL) = AA
  SUM = SUM + AA
110 CONTINUE
  SUM = SUM + 1.0
  GNDSTE(NZ) = CONC(NZ)/SUM
DO 120 NL = 2, NLEVEL
  VIBPOP(NZ,NL) = CONC(NZ)*VIBPOP(NZ,NL)/SUM
120 CONTINUE
130 CONTINUE
DO 135 NL = 2, NLEVEL
  IF (LCC(NL).EQ. 1) VVWAVE = 2331.- WAVE(NL)
  IF (LCC(NL).EQ. 2) VVWAVE = 1556.4 - WAVE(NL)
  FAC = 2331.0
  IF (LCC(NL).EQ. 2) FAC = 1556.4
135 CONTINUE
  IF (MLTE.EQ.1) GO TO 170
DO 160 NZ = 1,NALT
  TEMPNZ = TEMP(NZ)
  TEMP13 = EXP(ALOG(TEMPNZ)/3.0)
  IF (I.EQ. 6) CHEML(NZ) = 6.6E-35*EXP(510.0/TEMPNZ)
  1  % (1.6*ZDEN(NZ,8) + 1.7*ZDEN(NZ,9))
  2  *ZDEN(NZ,9)*ZDEN(NZ,10)
  IF (I.EQ. 3) GO TO 136
  IF (I.NE. 2) GO TO 140
  VTSIG(NZ) = 6.69E-10*EXP(-84.0~/TEMP13)
  VVRSIG(NZ) = 1.71E-6*EXP(-175.3/TEMP13)
  1  + 6.07E-14*EXP(15.27/TEMP13)

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VVDSIG(NZ) = 1.0E-15 + 5.16E-11*EXP(-76.75/TEMP13)
VVNSIG(NZ) = VVRSIG(NZ)/EXP(1.43879/TEMP(NZ)*18.0)
VVUSIG(NZ) = VVDSIG(NZ)*VIBPOP(NZ,8)/VIRPOP(NZ,5)
GO TO 150
136 CONTINUE
FAC = 0.0
VVNSIG(NZ) = 4.0E-13
VTSIG(NZ) = 5.37E-10*EXP(-70.0/TEMP13)
VVRSIG(NZ) = VVNSIG(NZ)*EXP(-1.43879/TEMP(NZ)*1594.736)
GO TO 150
140 CONTINUE
VTSIG(NZ) = CTEXT(1)
IF (I.EQ. 4) VTSIG(NZ) =
1 6.75E-07*EXP(-182.83/TEMP13)
VVNSIG(NZ) = CDEXB(1)
IF (I.EQ. 4) VVNSIG(NZ) =
1 4.22E-10*EXP(-86.35/TEMP13)
VVRSIG(NZ) = VVNSIG(NZ)*EXP(-1.43879/TEMP(NZ)*VVUWAVE)
150 CONTINUE
TVSIG(NZ) = VTSIG(NZ)/GNDSTE(NZ)*VIBPOP(NZ,2)
VTSIG(NZ) = VTSIG(NZ)*DENTOT(NZ)
TVSIG(NZ) = TVSIG(NZ)*DENTOT(NZ)
TNNV = TEMP(NZ)
IF (NLTE.LT. 5) GO TO 154
IF (NZ.GT. 41.AND. NZ.LT. 51) TNNV = TEMP(NZ)+FLOAT(NZ-41)
1 *280.0
IF (NZ.GE. 51) TNNV = 3000.0
154 CONTINUE
FACTOR = EXP(-1.43879*FAC/TNNV)
VVNSIG(NZ) = VVNSIG(NZ)*ZDEN(NZ,8)*FACTOR/(1.0 + FACTOR)
VVRSIG(NZ) = VVRSIG(NZ)*ZDEN(NZ,8)/(1.0 + FACTOR)
160 CONTINUE
DO 166 NZ = 1, NALT
SUM = 0.0

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```

TMP = 180.0
DO 162 ML = 2, NLEVEL
  XYM = MOD(LSC(NL)/10,10)
  AA = EXP(-1.43879*WAVE(NL)/TMP)**XYM
  VIBPOP(NZ,ML) = AA
  SUM = SUM + AA
162 CONTINUE
  SUM = SUM + 1.0
  GNDSTE(NZ) = CONC(NZ)/SUM
DO 164 ML = 2, NLEVEL
  VIBPOP(NZ,ML) = CONC(NZ)*VIBPOP(NZ,ML)/SUM
164 CONTINUE
166 CONTINUE
170 CONTINUE
DO 180 NB = 1, NBAND
  NBC = LBC(NB)
  NI = MOD(NBC/100,100)
  NF = MOD(NBC,100)
  KL(NB) = MOD(LBU(NB)/10,10)
  KB(NB) = MOD(LBU(NB),10)
  TWAVE = WAVE(NI) - WAVE(NF)
  BNDLAM(NB) = 1.0E+4/TWAVE
  IF (TFLUX(NB).EQ. 0.0) TFLUX(NB) =
1 5.997E+6*TWAVE**4/(EXP(1.43879*TWAVE/TEMP(1)) - 1.0)
  XYM = MOD(LSC(NF)/10,10)
  XYHM = MOD(LSC(NI)/10,10)
  ZA(NB) = STR(NB)*2.804/BNDLAM(NB)**2*XYM
1  *EXP(1.43879*WAVE(NF)/296.0)/XYHM
  POWER(NB) = 1.58065E-20/BNDLAM(NB)
  GFAC(NB) = 3.72E-24*STR(NB)*BNDLAM(NB)**2
1  *EXP(1.43879*WAVE(NF)/296.0)
  GUP(NB) = GFAC(NB)*TFLUX(NB)*1E-4864
  IF (NLTE.LT. 3) GUP(NB) = 0.0
  GDOWN(NB) = GFAC(NB)*SFUX(NB)

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IF (NLTE .LT. 4) GDOWN(NB) = 0.0
KBN = KB(NB)
KLN = KL(NB)
BNDL = BNDLAM(NB)
FAC = POWER(NB)*EA(NB)
SNB = STR(NB)*EXP(1.43879*WAVE(NF)/296.0)
DO 180 NZ = 1, NALT
  BNDTAU(NZ,NB) = TAUMAX(KLN,KBN,RM,BU,TEMP(NZ),PNIL,SNB,
    1 VIBPOP(NZ,NF))
  IF (NLTE .GT. 1) GO TO 180
  BNDRAD(NZ,NB) = VIBPOP(NZ,NI)*FAC
180 CONTINUE
C IF (NLTE .EQ. 1) GO TO 900
  ITHAX = 4
  IF (I .EQ. 2) ITHAX = 10
  ITER = 0
181 ITER = ITER + 1
  NMIN = NALT - 1
  DO 190 NB = 1, NBAND
    TTDOWN(NALT,NB) = 0.0
    TTUP(1,NB) = 0.0
    TTH(1,NB) = SIMP(BNDTAU(1,NB)*2.0E+5,1)
    DO 182 NZ = 2, NMIN
      TTH(NZ,NB) = SIMP(BNDTAU(NZ - 1,NB)*2.0E+5,2)
182 CONTINUE
    DO 184 NZ = 2, NMIN
      NY = NALT - NZ + 1
      TTUP(NZ,NB) = TTUP(NZ - 1,NB) + TTH(NZ - 1,NB)
      TTDOWN(NY,NB) = TTDOWN(NY + 1,NB) + TTH(NY,NB)
184 CONTINUE
      TTDOWN(1,NB) = TTDOWN(2,NB) + TTH(1,NB)
      TTUP(NALT,NB) = TTUP(NMIN,NB) + TTH(NMIN,NB)
      IF (NLTE .GT. 3) GO TO 190
      IF (NLTE .EQ. 1) GO TO 190

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DO 186 NZ = 1, NALT
  TTDOWN(NZ,NB) = 0.0
186  CONTINUE
  IF (NLTE .GT. 2) GO TO 190
  DO 188 NZ = 1, NALT
    TTUP(NZ,NB) = 0.0
188  CONTINUE
190  CONTINUE
  IF (NLTE .EQ. 1) GO TO 900
200  CONTINUE
  GO TO (210,220,230,240,250,260,260), I
210  CONTINUE
  DO 215 NZ = 1, NALT
    VIBPOP(NZ,3) = GNDSTE(NZ)*(GUP(2)*SN12(KB(2),TTUP(NZ,2))
1    + GDOWN(2)*SM1(K(2),TTDOWN(NZ,2)))/(EA(2) + EA(4))
    VIBPOP(NZ,2) = (EA(1)*VIBPOP(NZ,3) + GNDSTE(NZ)
1    *(GUP(1)*SN12(KB(1),TTUP(NZ,1))
2    + GDOWN(1)*SM1(KB(1),TTDOWN(NZ,1))
3    + TVSIG(NZ) + 0.75*VVUNSIG(NZ)))
4    /(EA(1) + VTSIG(NZ) + 0.75*VVUNSIG(NZ))
    VIBPOP(NZ,4) = GNDSTE(NZ)*(0.25*VVUNSIG(NZ)
1    + GUP(3)*SN12(KB(3),TTUP(NZ,3))
2    + GDOWN(3)*SM1(KB(3),TTDOWN(NZ,3))
3    /(EA(3) + 0.25*VVUNSIG(NZ))
215  CONTINUE
    GO TO 350
220  CONTINUE
    NZ = 0
221  NZ = NZ + 1
    VIBPOP(NZ,8) = GNDSTE(NZ)*(VVUNSIG(NZ) + RTFUN(8,9))
2    /(VVUNSIG(NZ) + EA(9) + VVDSIG(NZ))
    TVS = TVSIG(NZ)
    VTS = VTSIG(NZ)
    POP3 = VIBPOP(NZ,3)

```

```

POP4 = VIBPOP(NZ,4)
POP7 = VIBPOP(NZ,7)
POP2 = ((TVS + RTFUN(2,1))*GNDSTL(NZ)
1 + POP3*(EA(2) + VTS) + POP4*(EA(3) + VTS)
2 + POP7*(EA(7) + VTS))/(VTS + EA(1) + TVS)
VIBPOP(NZ,2) = POP2
POP8 = VIBPOP(NZ,8)
POP7 = ((TVS*0.25 + GUP(7)*SN12(KB(7),TTUP(NZ,7))
1 + GDOWN(7)*SM1(KB(7),TTDOWN(NZ,7)))*POP2
2 + EA(8)*POP8 + EA(15)*VIBPOP(NZ,9) + EA(16)*VIBPOP(NZ,10))
3 /(EA(7) + VTS)
VIBPOP(NZ,7) = POP7
POP5 = VIBPOP(NZ,5)
POP6 = VIBPOP(NZ,6)
POP3 = (POP2*(0.25*TVS + GUP(2)*SN12(KB(2),TTUP(NZ,2))
1 + GDOWN(2)*SM1(KB(2),TTDOWN(NZ,2)) + POP5*(EA(4) + VTS)
2 + EA(10)*POP8 + EA(13)*VIBPOP(NZ,9) + EA(14)*VIBPOP(NZ,10))
3 /(EA(2) + VTS + TVS)
VIBPOP(NZ,3) = POP3
POP4 = (POP2*(0.5*TVS + GUP(3)*SN12(KB(3),TTUP(NZ,3))
1 + GDOWN(3)*SM1(KB(3),TTDOWN(NZ,3)) + POP5*(EA(5)
2 + POP6*(EA(6) + VTS))/(EA(3) + VTS + TVS)
VIBPOP(NZ,4) = POP4
POP5 = (POP3*(TVS + GUP(4)*SN12(KB(4),TTUP(NZ,4))
1 + GDOWN(4)*SM1(KB(4),TTDOWN(NZ,4))
2 + POP4*(GUP(5)*SN12(KB(5),TTUP(NZ,5))
3 + GDOWN(5)*SM1(KB(5),TTDOWN(NZ,5)) + POP8*VVDSIG(NZ))
4 /(EA(4) + EA(5) + VTS + VVDSIG(NZ))
VIBPOP(NZ,5) = POP5
POP6 = (POP4*(0.5*TVS + GUP(6)*SN12(KB(6),TTUP(NZ,6))
1 + GDOWN(6)*SM1(KB(6),TTDOWN(NZ,6)))/(EA(6) + VTS)
VIBPOP(NZ,6) = POP6
VIBPOP(NZ,9) = (VIBPOP(NZ,3)*(VVNSIG(NZ) + RTFUN(9,13))
1 + GNDSTL(NZ)*RTFUN(9,11) + VIBPOP(NZ,7)*RTFUN(9,15))

```

```

2  /VURSIG(NZ) + EA(11) + EA(17) + EA(15)
VIBPOP(NZ,10) = (VIBPOP(NZ,7) + VUNSIG(NZ) + RTFUN(10,16))
1  + VIBPOP(NZ,3) * RTFUN(10,14) + GNDSTE(NZ) * RTFUN(10,12))
2  /VURSIG(NZ) + EA(12) + EA(14) + EA(16))
GNDSTE(NZ) = CONC(NZ) - (POP8 + POP6 + POP5 + POP7 + POP4
1  + POP3 + POP2)
IF (GNDSTE(NZ) .LE. 0.0) GNDSTE(NZ) = 0.05 * CONC(NZ)
225 IF (NZ.LT.NALT) GO TO 221
GO TO 350
230 CONTINUE
DO 235 NZ = 1, NALT
VIBPOP(NZ,2) = ((VUSIG(NZ) + VURSIG(NZ)
1  + RTFUN(2,1)) * GNDSTE(NZ) + VIBPOP(NZ,3) * EA(5))
2  / (VUSIG(NZ) + EA(1) + VUNSIG(NZ))
VIBPOP(NZ,3) = ((VUSIG(NZ) + VURSIG(NZ)
1  + RTFUN(3,5)) * VIBPOP(NZ,2) +
2  RTFUN(3,2) * GNDSTE(NZ) + VIBPOP(NZ,6) * EA(11))
3  / (EA(2) + EA(5) + VUSIG(NZ) + VUNSIG(NZ))
VIBPOP(NZ,4) = (RTFUN(4,3) * GNDSTE(NZ)
1  + RTFUN(4,6) * GNDSTE(NZ)) / (EA(3) + EA(6))
VIBPOP(NZ,5) = (RTFUN(5,4) * GNDSTE(NZ)
1  + RTFUN(5,7) * VIBPOP(NZ,2)) / (EA(4) + EA(7))
VIBPOP(NZ,6) = (RTFUN(6,8) * VIBPOP(NZ,8)
1  + RTFUN(6,12) * GNDSTE(NZ)) / (EA(8) + EA(11))
2  + EA(12))
VIBPOP(NZ,7) = (RTFUN(7,9) * VIBPOP(NZ,2)
1  + RTFUN(7,13) * GNDSTE(NZ)) / (EA(9) + EA(13))
VIBPOP(NZ,8) = (RTFUN(8,10) * VIBPOP(NZ,2)
1  + RTFUN(8,14) * GNDSTE(NZ)) / (EA(10) + EA(14))
235 CONTINUE
GO TO 350
240 CONTINUE
DO 245 NZ = 1, NALT
CR10 = 3.6E-11 * ZDEN(NZ,10)

```

```

CR21 = 1.8E-11*ZDEN(NZ,10)
CR20 = 2.7E-11*ZDEN(NZ,10)
TEMPNZ = TEMP(NZ)
XP10 = EXP(-1.43879*WAVE(2)/TEMPNZ)
XP20 = EXP(-1.43879*WAVE(3)/TEMPNZ)
XP21 = XP20/XP10
XPDIF = XP21/XP10
CR01 = CR10*XP10
CR12 = CR21*XP21
CR02 = CR20*XP20
VIBPOP(NZ,2) = ((TVSIG(NZ) + VVNSIG(NZ)
1 + GUP(1)*SN12(KB(1),TTUP(NZ,1)) + CR01
2 + XFER(VIBPOP(1,2),TTH(1,1),NZ,1,1,KB(1))
3 + XFER(VIBPOP(NZ,2),TTH(NZ,1),NALT,NZ,2,KB(1))*EA(1)
4 + GDOWN(1)*SM1(KB(1),TTDOWN(NZ,1))*GNDSTE(NZ)
5 + (EA(3) + CR21 + VVRSIG(NZ) + VTSIG(NZ))*VIBPOP(NZ,3)
6 + AAA*CHEML(NZ))/(EA(1) + CR10 + CR12
7 + VTSIG(NZ) + VVRSIG(NZ) + XPDIF*(TVSIG(NZ) + VVNSIG(NZ)))
VIBPOP(NZ,3) = ((XPDIF*(TVSIG(NZ) + VVNSIG(NZ))
1 + RTFUN(3,3) + CR12)*VIBPOP(NZ,2)
2 + (RTFUN(3,2) + CR02)*GNDSTE(NZ)
3 + AAA*CHEML(NZ))/(EA(2) + EA(3) + VTSIC(NZ)
4 + CR21 + CR20 + VVRSIG(NZ))
GNDSTE(NZ) = CGFC(NZ) - VIBPOP(NZ,2) - VIBPOP(NZ,3)
245 CONTINUE
GO TO 350
250 CONTINUE
DO 255 NZ = 1, NALT
VIBPOP(NZ,6) = GNDSTE(NZ)*(VVNSIG(NZ)
1 + GDOWN(3)*SM1(KB(3),TTDOWN(NZ,3))
2 + GUP(3)*SN12(KB(3),TTUP(NZ,3))
3 / (VVRSIG(NZ)*1.5 + EA(3))
VIBPOP(NZ,5) = (VIBPOP(NZ,6)*VVRSIG(NZ)*0.5
1 + TVSIG(NZ)*VIBPOP(NZ,4))/(VTSIG(NZ) + 5.0*EA(1))

```

```

VIBPOP(NZ,4) = (VIBPOP(NZ,5)*VTSIG(NZ) + 5.0*EA(1))
1 + TVSIG(NZ)*VIBPOP(NZ,3)
2 /(TVSIG(NZ) + VTSIG(NZ) + 4.0*EA(1))
VIBPOP(NZ,3) = (VIBPOP(NZ,4)*VTSIG(NZ) + 4.0*EA(1))
1 + TVSIG(NZ)*VIBPOP(NZ,2)/(TVSIG(NZ) + VTSIG(NZ) + 3.0*EA(1))
VIBPOP(NZ,2) = (VIBPOP(NZ,3)
1 + GNDSTE(NZ)*(GUP(2)*SN12(KB(2),TTUP(NZ,2))
2 + GDOWN(2)*SM1(KB(2),TTDOWN(NZ,2)))/EA(2)
VIBPOP(NZ,2) = (GNDSTE(NZ)*VTSIG(NZ)
1 + GUP(1)*SN12(KB(1),TTUP(NZ,1))
2 + GDOWN(1)*SM1(KB(1),TTDOWN(NZ,1))
3 + VIBPOP(NZ,3)*(3.0*EA(1) + VTSIG(NZ)))
4 /(VTSIG(NZ) + VTSIG(NZ) + EA(1))
255 CONTINUE
GO TO 350
260 CONTINUE
DO 265 NZ = 1, NALT
VIBPOP(NZ,2) = ((VTSIG(NZ) + VVNSIG(NZ)
1 + GUP(1)*SN12(KB(1),TTUP(NZ,1))
2 + XFER(VIBPOP(1,2),TTH(1,1),NZ,1,1,KB(1))
3 + XFER(VIBPOP(NZ,2),TTH(NZ,1),NALT,NZ,2,KB(1)))*EA(1)
4 + GDOWN(1)*SM1(KB(1),TTDOWN(NZ,1))*GNDSTE(NZ)
5 + CHEML(NZ))
6 /(VTSIG(NZ) + EA(1) + VVRSIG(NZ))
265 CONTINUE
GO TO 350
350 CONTINUE
DO 360 NB = 1, NBAND
FAC = POWER(NB)*EA(NB)
NBC = LBC(NB)
NI = MOD(NBC/100,100)
NF = MOD(NBC,100)
KLN = KL(NB)
KBN = KB(NB)

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```

      BNDL = BNDLAM(NB)
      SNB = STR(NB)*EXP(1.43879*WAVE(NF)/296.0)
      DO 360 NZ = 1, NALT
        BNDRAD(NZ,NB) = VIBPOF(NZ,NI)*FAC
        BNDTAU(NZ,NB) = TAUMAX(KLN,KBN,RM,BU,TEMP(NZ),BNDL,SNB,
          1 VIBPOF(NZ,NF))
      360 CONTINUE
      DO 850 IX = 1, NALT
      850 CONTINUE
      400 CONTINUE
      IF (ITER .LT. ITMAX) GO TO 181
      CONTINUE
      WRITE (NW,15)
      WRITE (NW,36)
      IALT = 999
      WRITE (NW,16) IALT,(EA(NB),NB=1,NBAND)
      WRITE (NW,15)
      DO 905 NZ = 1, NALT
      IF (MOD(NZ,12) .EQ. 0 .AND. NZ .NE. 0) WRITE (NW,36)
      IF (NZ .LE. 76) IALT = 2*NZ - 2
      IF (NZ .GE. 76) IALT = 10*NZ - 610
      WRITE (NW,16) IALT,(BNDTAU(NZ,NB),NB=1,NBAND)
      IALT = IALT + 1000
      WRITE (NW,16) IALT,(TTH(NZ,NB),NB=1,NBAND)
      IALT = IALT + 1000
      WRITE (NW,16) IALT,(TTDOWN(NZ,NB),NB=1,NBAND)
      IALT = IALT + 1000
      WRITE (NW,16) IALT,(TTUP(NZ,NB),NB=1,NBAND)

```

```

905      IALT = IALT + 1000
        WRITE (NW,16) IALT,(BNDRAD(NZ,NB),NB=1,NBAND)
        CONTINUE
        WRITE (NW,15)
        WRITE (NW,36)
        DO 910 NZ = 1, NALT

910      IF (NZ .LE. 76) IALT = 2*NZ - 2
        IF (NZ .GE. 76) IALT = 10*NZ - 610
        WRITE (NP,8) (VIBPOP(NZ,NL), NL = 1, NLEVEL)
        WRITE (NW,16) IALT,(VIBPOP(NZ,NL),NL=1,NLEVEL)
        CONTINUE
        WRITE (NW,15)
        WRITE (NW,36)
        DO 930 NZ = 1, NALT
        DO 920 NL = 2, NLEVEL
          XYN = MOD(LSC(NL)/10,10)
          AA = ALOG(VIBPOP(NZ,1)*XYN/VIBPOP(NZ,NL))
          CHEML(NL) = 1.43879*WAVE(NL)/AA
        CONTINUE
920      IF (NZ .LE. 76) IALT = 2*NZ - 2
        IF (NZ .GE. 76) IALT = 10*NZ - 610
        WRITE (NW,17) IALT,TEMP(NZ),(CHEML(NL),NL=2,NLEVEL)
        CONTINUE
930      WRITE (NW,15)
        RETURN
      8    FORMAT (1P7E11.4)
      15    FORMAT (1X)
      16    FORMAT (1X,I4,1P10E12.4,2X,2X/(5X,1P10E12.4))
      17    FORMAT (1X,I4,12F9.2)
      26    FORMAT (6X,7I8)
      36    FORMAT (1H1)
        END

```

```

FUNCTION XFER ( IAD, ITH, NTOP, NBOT, K, K2)
COMMON /POPC)/ V13POP(131,25)
DIMENSION RA(1:1), ITH(1:1)
NINT = NTOP - N BOT
NPL = NINT + 1
IF (NINT .GT. 0) GO TO 100
XFER = 0.0
RETURN

100 CONTINUE
I3 = 1.0
EA3 = 0.0
IF (K .GT. 1) GO TO 200
NF = NTOP
RA = 2A7(NF)/I3POP(NF,1)
SUM = 7.5*PA
DO 120 N2 = 1, NINT
N2 = NINT - 47 - 1
I4 = ITH(N2)
I2 = I3 + I4
F33 = 5.03(K3,I2)
NF = NF - 1
I2 = 2A7(N2)/I3POP(NF,1)
SUM = SUM + (I2 - PA)*(E33 - FA3)/I4
RA = I3
EA3 = E33
CONTINUE
XFER = 335(SJ4 - 23*CN12(K3,I2))
RETURN

200 CONTINUE
NF = NBOT
PA = 2A7(1)/I3POP(NF,1)
SUM = 7.5*PA
DO 220 N2 = 2, NPL
I4 = ITH(N2 - 1)

```

```

307540
307550
307560
307570
307580
307590
307500
307510
307520
307530
307540
307550
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307570
307580
307590
307700
307710
307720
307730
307740
307750
307760
307770
307780
307790
307300
307810
307820
307830
307840
307850
307860
307870

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```

220
Y0 = Y0 + Y4
F93 = S_03(K3,Y0)
NF = NF + 1
04 = 2A)(NZ)/I POP(NF,1)
S14 = S14 + (2R - 2A)*(EP1 - FA1)/Y4
04 = 23
EA1 = E11
CONTINUE
XFER = 13S(S14 . 03*SN12(K3,Y3))
RETURN
END

```

```

007980
007990
007300
007310
007320
007330
007340
007350
007360
007370
007380

```

```

C
C
C
C
C
C
FUNCTION SLOS(K,TAU)
      COMPUTE ONE-HALF THE VALUE OF THE FUNCTION L SUB NOIGHT THREE.
      K=EN. 1, PARALLEL 3AND
      K=EN. 2, PERPENDICULAR BAND
      Y = ABS(TAU)
      IF (Y .EQ. 0.0) GO TO 300
      IF (K .EQ. 2) GO TO 200
      IF (Y .GT. 1.0) GO TO 110
      X = (Y - 0.5)*2.0
      QLO3 = (((2.59374-4)*X - 6.0149E-3)*X - 0.1027233)*X
      1 + 0.12338821*ACOS(Y)*Y + 0.4035533)*Y
      RETURN
110 CONTINUE
      IF (Y .GT. 4.0) GO TO 120
      X = (Y - 2.5)/1.5
      QLO3 = (((((17.685E-4 - 3.516E-4)*X)*X - 1.0464E-3)*X
      1 + 2.7618E-3)*X - 7.96629E-3)*X + 0.0219502)*X
      2 - 0.1626558)*X + 0.1975702)*Y
      RETURN
120 CONTINUE
      IF (Y .GT. 18.0) GO TO 130
      X = (Y - 7.0)/3.0
      QLO3 = (((((1.495E-4)*X - 4.9991E-4)*X + 0.0011377)*X
      1 - 0.0933493)*X + 0.01800861)*X - 0.03090774)*X
      2 + 0.10486302)*Y
      RETURN
130 CONTINUE
      Y = A COS(Y)
      IF (Y .GT. 130.0) GO TO 140
      X = 9.21034037176/Y - 3.0
      QLO3 = (((((3.9E-5 - 9.76E-5)*X)*X + 2.455E-4)*X
      1 - 0.0012058)*X + 0.0340297)*X + 0.3210431)*Y

```

```

140 RETURN
    CONTINUE
    IF (T.GT. 1.990E0) GO TO 150
    Y = 27.53152111977Y - 5.0
    SL03 = (((0.35X - 2.01E-5X) * X - 1.963E-4) * X
1      + 0.9129309) * X + 0.2729744) * Y
    RETURN
150 CONTINUE
    X = 13.91551155067Y - 1.0
    SL03 = (((((15.496E-4 * X - 0.0915938) * X + 0.0016303) * X
1      - 0.0001371) * X - 0.0027757) * X + 0.0791741) * X
2      + 0.7915939) * Y
    RETURN
200 CONTINUE
    IF (T.GT. 1.3) GO TO 210
    Y = (Y - 0.5) * 2.0
    SL03 = (((1.517E-4 * X - 4.0569E-3) * X - 0.0000005) * X
1      + 0.997407331 * (LOG(Y) * Y + 0.4161293) * Y
    RETURN
210 CONTINUE
    IF (T.GT. 4.9) GO TO 220
    X = (Y - 2.5) * 1.5
    SL03 = (((((15.904E-4 - 2.794E-4 * X) * X - 9.069E-4) * X
1      + 2.2244E-3) * X - 5.6504E-3) * X + 0.0197235) * X
2      - 0.0531552) * X + 0.2307133) * Y
    RETURN
220 CONTINUE
    IF (T.GT. 10.0) GO TO 230
    Y = (Y - 7.0) / 3.0
    SL03 = (((((1.576E-4 * X - 4.291E-4) * X + 1.0472E-3) * X
1      - 3.3166E-3) * X + 0.0107584) * X - 0.0356259) * X
2      + 0.1319360) * Y
    RETURN
230 CONTINUE

```

```

Y = A-0.5(T)
IF (Y .GT. 110.) GO TO 240
X = 9.21034037176/Y - 3.0
SL03 = (((((6.285E-4 - (2.131E-4)*X + 3.79E-5)*X)*X) * (
1 + 7.79E-5)*X + 9.04E-5)*X - 0.0922063)*Y
2 + 0.8337889)*Y + 0.4187794)*Y
RETURN
240 CONTINUE
IF (Y .GT. 110.) GO TO 250
X = 27.5310211193/Y - 5.0
SL03 = (((1.55E-5)*X - 3.642E-4)*X + 0.0134767)*X
1 + 0.3770989)*Y
RETURN
250 CONTINUE
X = 13.91551755796/Y - 1.0
SL03 = (((((1.1049E-3 - 4.412E-4)*X) * X - 5.441E-4)*X
1 + 9.451E-4)*X + 3.4768E-3)*X + 9.0335987)*X
2 + 0.3254546)*Y
RETURN
300 CONTINUE
SL03 = 0.0
RETURN
END

```

```

008579
008580
008590
008700
008710
008720
008730
008740
008750
008760
008770
008780
008790
008900
008910
008920
008930
008940
008950
008960
008970
008980
008990

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```

FUNCTION SLN (K,TAU)
  T = ABS (TAU)
  IF (K.EQ. 2) GO TO 200
  IF (T.EQ. 4.0) GO TO 110
  Y = (T - 2.0)*.5
  QLO = (((((0.08411)*X - 0.0010436)*X + 0.0060379)*X
1 - 0.0246050)*X + 0.0792553)*X - 0.2301023)*X + 0.5559377)*X
  RETURN
110 CONTINUE
  IF (T.EQ. 13.0 GO TO 120
  Y = (T - 7.0)*.3
  QLO = (((((0.001915)*X - 0.0007254)*X + 0.0023079)*X
1 - 0.0099348)*X + 0.0274065)*X - 0.0942082)*X + 0.3539235)*X
  RETURN
120 CONTINUE
  Y = A.05(T)
  IF (T.EQ. 198.0) GO TO 130
  X = 9.210340371776/Y - 3.0
  QLO = (((((0.000069)*X - 0.0001537)*X - 0.0001490)*X
1 + 0.0013943)*X - 0.0063060)*X + 0.0037963)*X + 1.1415534)*X
  RETURN
130 CONTINUE
  X = 9.210340371776/Y - 1.0
  QLO = (((((0.0007142 - 0.00622)*X) + 0.005211)*X
1 - 0.004995)*X + 0.005477)*X + 0.007743)*X - 0.015300)*X
2 + 0.122528)*X - 0.940111)*X
  RETURN
200 CONTINUE
  IF (T.EQ. 4.0) GO TO 210
  Y = (T - 2.0)*.5
  QLO = (((((0.002431)*X - 0.0010331)*X + 0.0041030)*X
1 - 0.0150764)*X + 0.0501769)*X - 3.2013270)*X + 0.7100944)*X
  RETURN
210 CONTINUE

```

009240
009250
009260
009270
009280
009290
009300
009310
009320
009330
009340
009350
009360

```

IF (T - 6T - 12.0) 50 70 220
X = (r - 7.0)/3.0
SL0 = (((((0.0101169*X - 0.0704539)*X + 0.0016637)*X
1 - 0.0065345)*X + 0.0255562)*X - 0.1003592)*X + 0.4282944)*T
OF TUDY
220 CONTINUE
Y = A.0G(T)
X = 4.60517019518809/Y - 1.0
SL0 = (((((0.035431 - 0.035896*X)*X + 0.062211)*X
1 - 0.056995)*X + 0.046618)*X + 0.045072)*X + 0.003249)*X
2 - 0.0000887)*X + 0.052059)*X + 0.163319)*X + 1.393769)*Y
RETURN
END

```

```

009370
009380
009390
009400
009410
009420
009430
009440
009450
009460
009470
009480
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009620
009630
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009660
009670
009680
009690
009700

FUNCTION SN12 (C,TAU)
  T = ABS(TAU)
  IF (T.EQ. 0.) GO TO 300
  IF (K.EQ. 1) GO TO 200
  IF (T.EQ. 1.) GO TO 110
  T = 25.26760337*T
  SN12 = (((((15.54E-16)*T - 1.3747E-13)*T + 3.11017E-11)*T
1 - 5.434609E-3)*T + 1.24762E-5)*T - 2.5E-26E-4)*T
2 - 0.88254245 + 0.01984964*ALOG(T))*T + 1.0)*0.5
  RETURN

110 CONTINUE
  IF (T.EQ. 4.0) GO TO 120
  X = (T - 2.5)/1.5
  SN12 = (((((13.00591E-3 - 1.41455E-3*X)*X - 3.88035E-3)*X
1 + 9.48736E-3)*X - 0.0239407)*X + 0.0523008)*X
2 - 0.1045984)*X + 0.8862743)*0.5
  RETURN

120 CONTINUE
  IF (T.EQ. 13.0) GO TO 130
  X = (T - 7.0)/3.0
  SN12 = (((((15.08470E-4 - 1.90191E-4*X)*X - 9.27534E-4)*X
1 + 2.24274E-3)*X - 5.54296E-3)*X + 0.01290804)*X
2 - 0.82339935)*X + 0.06552257)*0.5
  RETURN

130 CONTINUE
  IF (T.GT. 103.0) GO TO 140
  Y = A_05(T)
  X = 9.240340371/76/Y - 3.0
  SN12 = (((((17.0836E-4*X - 1.5101E-3)*X + 9.0129E-4)*X
1 - 5.0499E-4)*X - 1.8632E-3)*X + 0.0149364)*X
2 + 0.437027)*0.5/T
  RETURN

140 CONTINUE
  Y = A_05(T)

```

```

      Y = 3.210348371 76/Y - 1.0
      SW12 = (((5.07 6E-3 - 4.681E-4)*X - 1.5849E-3)*X
1      + 0.9147526)*X + 0.1079074)*0.5/Y
      RETURN
200  CONTINUE
      IF (T .GT. 1.0) GO TO 210
      T = 25.9729135
      SW12 = (((((2 071E-16)*Y - 6.9372E-14)*T + 1.58314E-11)*Y
1      - 3.39973E-3)*Y + 7.01818E-7)*T - 1.51594E-4)*Y
2      - 0.0655453 + 1.01494384*ALOG(T))*T + 1.0)*0.5
      RETURN
210  CONTINUE
      IF (T .GT. 4.0) GO TO 220
      Y = (T - 2.5)/1.5
      SW12 = (((((2 72E-3 - 1.1203E-3)*X)*X - 3.0489E-3)*X
1      + 7.2345E-3)*X - 1.0213281)*X + 0.0521586)*X
2      - 0.1213660)*X + 0.2508902)*0.5
      RETURN
220  CONTINUE
      IF (T .GT. 10.0 GO TO 230
      Y = (T - 7.0)/3.0
      SW12 = (((((4. 27E-4)*X - 1.2459E-3)*X + 2.5263E-3)*X
1      - 6.7323E-3)*X + 0.7174769)*X - 0.0421443)*X
2      + 0.8958415)*0.5
      RETURN
230  CONTINUE
      IF (T .GT. 110.0 GO TO 240
      Y = A_05(T)
      X = 3.210348371 76/Y - 1.0
      SW12 = (((9.1E-5)*X - 1.9096E-3)*X - 1.9059E-3)*X
1      + 0.3253129)*X + 0.6392594)*0.5/Y
      RETURN
240  CONTINUE
      Y = A_05(T)

```

```

009710
009720
009730
009740
009750
009760
009770
009780
009790
009800
009810
009820
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009840
009850
009860
009870
009880
009890
009900
009910
009920
009930
009940
009950
009960
009970
009980
009990
010000
010010
010020
010030
010040

```

```

X = 3.210340379 4517 - 1.0
C412 = (((6.44 4E-4) + 3.453E-4) * X - 5.099E-4) * Y
1 + 0.9215109) * X + 0.591852) * 0.5 / T
DE TIR4
CONTINUE
C412 = 9.5
DE TIR4
END

```

```

010050
010067
010070
010089
010090
010103
010110
010120

```

```

FUNCTION TAU48Y (KL,K9,RM,AV,T,FLAM,S,DEN)
SIG = 1.43873e-4/T
TAUMAY = 5.3513'-10*SQRT(DEN/T)*FLAM*DEN*SIG*MAX(KL,K9,SIG)
END

```

010130
 010140
 010150
 010160
 010170

```

C
C
C
      FUNCTION CJMAX (KL,K2,SIG)
      CJMAX COMPUTES THE RELATIVE STRENGTH OF THE STRONGEST LINE
      IF K1 = 1, SIGMA-SIGMA TRANSITION
      IF K1 = 2, SIGMA-PI TRANSITION
      GO TO (110,120,130), K2
110 CONTINUE
      TSM = 0.5*(S2RT 0.25 + 2.0/SIG) - 1.5)
      A = 0.5*(TSM + CJM + 1.0)
      GO TO 200
120 CONTINUE
      TSM = 0.5*(S2RT (2.0/SIG) - 1.0)
      A = TSM + 1.1
      GO TO 200
130 CONTINUE
      CJMAX = 0.0
      RETURN
200 CONTINUE
      SJM = A*EXP(-SI*VTJW*ITJM + 1.0))
      SJMAX = SJM/2*PI*(KL,SIG)
      RETURN
      END
010180
010190
010200
010210
010220
010230
010240
010250
010260
010270
010280
010290
010300
010310
010320
010330
010340
010350
010360
010370
010380

```

```

C      FUNCTION QJPAR (K, SIG)
C      QJPAR COMPUTES THE ROTATIONAL PARTITION FUNCTION FOR A
C      DIGIT ROTATION, SIG = LE. 0.2.
C      K = 1, ALL LEVELS POPULATED
C      K = 2, EVEN LEVELS POPULATED
C      K = 3, ODD LEVELS POPULATED
C      IF (SIG .GT. 1.) STOP
C      Y = SIG
C      IF (K - 2) 110, 120, 130
C      COEFFICIENTS ARE FROM RUN "ALTE-EX"
C      110 CONTINUE
C      QJPAR = (((10.0396500232857 * SIG + 0.0125718835471) * X
C      1 + 0.9556756164730) * X + 0.333333133379) * X + 1.00000000017) / SIG
C      RETURN
C      120 CONTINUE
C      QJPAR = (((((62.5879214103 * SIG - 29.5697177637) * SIG
C      1 + 5.4953267119) * SIG - 0.502572215608) * SIG
C      2 + 0.129737813346) * SIG + 0.0328350303506) * SIG
C      3 + 0.16657022970) * SIG + 0.499999399435) / SIG
C      RETURN
C      130 CONTINUE
C      QJPAR = (((((29.5713117676 - 52.5874596502 * SIG) * SIG
C      1 - 5.4957937336) * SIG + 0.505750342701) * SIG
C      2 - 0.117839755176) * SIG + 0.0338315983069) * SIG
C      3 + 0.166563112347) * SIG + .500000010544) / SIG
C      RETURN
C      END

```

```

010390
010400
010410
010420
010430
010440
010450
010460
010470
010480
010490
010500
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010520
010530
010540
010550
010560
010570
010580
010590
010600
010610
010620
010630
010640
010650

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010560
010570
010580
010590
010700
010710
010720
010730
010740
010750
010760
010770
010780

```

100 FUNCTION SIMP (G,H,K)
    DIMENSION A(4)
    IF (K - 2) 170/110,120
    CONTINUE
    SIMP = (9.0*1(2) + 5.0*1(1) - A(3))*H/12.0
    RETURN
110 CONTINUE
    SIMP = (8.0*1(2) + 5.0*1(3) - A(1))*H/12.0
    RETURN
120 CONTINUE
    SIMP = (4.0*1(2) + A(1) + A(3))*H/3.0
    RETURN
END

```

```

FUNCTION S41 (K,TAU)
  T = A35(TAU)
  IF (T .EQ. 0.0) GO TO 100
  IF (K .EQ. 2) GO TO 200
  IF (T .EQ. 4.0) GO TO 110
  Y = (T - 2.0) * 0.25
  S41 = (((2.35 * 10E-03 * X - 8.90515E-03) * X + 2.55223E-02) * X
    1 - 7.37377E-12) * X + 1.63735E-01) * X - 3.91749E-01) * X + 9.426645
  RETURN
110 CONTINUE
  IF (T .EQ. 10.0) GO TO 120
  Y = (T - 7.0) * 0.3
  S41 = (((5.32 * 10E-04 * X - 1.79043E-03) * X + 4.05103E-03) * X
    1 - 1.34749E-12) * X + 2.59109E-02) * X - 6.01708E-02) * X + 0.134123
  RETURN
120 CONTINUE
  IF (T .EQ. 110.0) GO TO 130
  Y = A.05(T)
  Y = 3.210340371 * 76/Y - 3.0
  S41 = ((((-3.2 * 10E-04 * X - 6.79778E-04) * X + 2.95590E-03) * X
    1 - 1.29130E-03) * X - 6.31784E-03) * X + 3.75904E-02) * X
    2 + 8.30441E-11) * X
  RETURN
130 CONTINUE
  Y = A.05(T)
  X = 3.210340371 * 76/Y - 1.0
  S41 = ((((-5.1 * 10E-04 * X - 2.93474E-04) * X - 4.35153E-04) * X
    1 + 1.30137E-12) * X - 3.80089E-04) * X + 3.23441E-02) * X
    2 + 8.17407E-11) * X
  RETURN
200 CONTINUE
  IF (T .EQ. 4.0) GO TO 210
  Y = (T - 2.0) * 0.5
  S41 = (((1.39 * 10E-03 * X - 5.29314E-03) * X + 1.58249E-02) * X

```

```

010790
010800
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010880
010890
010900
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010920
010930
010940
010950
010960
010970
010980
010990
011000
011010
011020
011030
011040
011050
011060
011070
011080
011090
011100
011110
011120

```

```

1 - 4.74033E-02)*Y + 1.26175E-01)*X - 2.06333E-01)*X + 0.51757*
RETURN
210 CONTINUE
IF (Y .GT. 13.0) GO TO 220
X = (Y - 7.0)/3.0
SW1 = (((3.7670E-04)*X - 1.25334E-03)*Y + 3.41153E-03)*X
1 - 1.95360E-03)*X + 3.07476E-02)*X - 9.14709E-02)*X + 9.1941308
RETURN
220 CONTINUE
IF (Y .GT. 180.0) GO TO 230
Y = A206(T)
X = 9.21034037176/Y - 3.0
SW1 = (((-7.53425E-03)*X - 0.97124E-03)*Y + 6.62199E-02)*X
1 + 1.304245)/Y
RETURN
230 CONTINUE
Y = A206(T)
X = 9.21034037176/Y - 1.0
SW1 = (((1.33077E-03 - 5.82519E-04)*X)*X + 1.99563E-03)*X
1 + 1.21174E-03)*X + 4.76165E-02)*X + 1.18445)/Y
RETURN
300 CONTINUE
SW1 = 1.0
RETURN
END

```

```

011130
011140
011150
011160
011170
011180
011190
011200
011210
011220
011230
011240
011250
011260
011270
011280
011290
011300
011310
011320
011330
011340
011350
011360
011370

```

```

C
C
C
C
FUNCTION SL1 (K,TAU)
  IF (K.EQ. 1) C MPJTE FUNCTION VALUE FOR PARALLEL 3AND.
  IF (K.EQ. 2) C MPJTE FUNCTION VALUE FOR PEPPENDICULAP 3AND.

  Y = A35(TAU)
  IF (K.EQ. 2) GO TO 200
  IF (T.GT.1.3) GO TO 110
  Y = (T - 0.5)*2.0
  SL1 = (((1.13E-5)*X - 1.94E2E-4)*X + 0.0276149)*X
  1 - 0.0356373)*Y + 0.46139471)*Y*Y
  RETURN

110 CONTINUE
  IF (T.GT. 4.0) GO TO 120
  X = (T - 2.5)/1.5
  SL1 = (((((3.49E-4 - 5.49E-5*X)*X - 2.0320E-3)*X
  1 + 0.0114037)*X - 0.0613564)*X + 0.3531337)*Y*Y
  RETURN

120 CONTINUE
  IF (T.GT. 18.0) GO TO 130
  X = (T - 7.0)/2.0
  SL1 = (((((7.77E-4 - 1.036E-4*X)*X - 2.9392E-3)*X
  1 + 0.0120034)*X - 0.0501136)*X + 0.2354310)*Y*Y
  RETURN

130 CONTINUE
  IF (T.GT. 110.0) GO TO 140
  Y = A_05(T)
  X = 3.210340371/76/Y - 3.0
  SL1 = (((((6.67E-5*X - 6.7E6E-4)*X + 0.0021934)*X
  1 + 0.0011841)*X - 0.0098382)*X + 0.0530E69)*Y*Y
  RETURN

140 CONTINUE
  IF (T.GT. 1000.0) GO TO 150
  Y = A_05(T)

```

011380
 011390
 011400
 011410
 011420
 011430
 011440
 011450
 011460
 011470
 011480
 011490
 011500
 011510
 011520
 011530
 011540
 011550
 011560
 011570
 011580
 011590
 011600
 011610
 011620
 011630
 011640
 011650
 011660
 011670
 011680
 011690
 011700
 011710

011720
011730
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011800
011810
011820
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011890
011900
011910
011920
011930
011940
011950
011960
011970
011980
011990
012000
012010
012020
012030
012040
012050

```

X = 27.53102111'93/V - 5.0
SL1 = (((1.636E-4)*Y - 1.5604E-3)*X + 1.6992E-3)*X
1 * 0.9615796)*Y*Y
      RETURN
150 CONTINUE
Y = ALOG(T)
X = 13.91551155*Y6/V - 1.0
SL1 = (((((2.8E-4)*X + 2.309E-3)*Y - 7.500E-3)*X
1 * 6.317E-3)*X - 2.37E-4)*X - 1.799E-2)*Y
2 * 0.030724)*X - 0.030671)*Y*Y
      RETURN
200 CONTINUE
IF (Y .GT. 1.0) GO TO 210
X = (Y - 0.5)*2.0
SL1 = (((((7.33E-6)*X - 1.2125E-4)*X + 1.07580E-3)*X
1 - 0.32932252)*Y + 0.46967333)*Y*Y
      RETURN
210 CONTINUE
IF (Y .GT. 4.0) GO TO 220
X = (Y - 2.5)/1.5
SL1 = (((((2.14E-4 - 3.26E-5*Y)*X - 1.3290E-3)*X
1 * 5.2413E-3)*X - 0.0538254)*X + 3.3901694)*Y*Y
      RETURN
220 CONTINUE
IF (Y .GT. 18.0) GO TO 230
X = (Y - 7.0)/3.0
SL1 = (((((15.23E-4 - 1.152E-4*Y)*X - 2.2120E-3)*X
1 * 7.3132527)*X - 0.0494252)*X + 3.2718101)*Y*Y
      RETURN
230 CONTINUE
IF (Y .GT. 130.0) GO TO 240
Y = A.05(Y)
X = 3.210340371*Y6/V - 3.7
SL1 = (((((1.96E-4)*X - 1.3224E-3)*X + 2.5304E-3)*X

```

012060
 012070
 012080
 012090
 012100
 012110
 012120
 012130
 012140
 012150
 012160
 012170
 012180
 012190
 012200
 012210
 012220

```

1  + 8.1940E-3)*Y - 5.60820E-2)*X + 1.057741)*Y*X
240 RETURN
CONTINUE
IF (Y.GT. 1.0000) GO TO 250
Y = A_05(T)
X = 27.6310211193/Y - 5.0
SL1 = ((2.654E.4)*X - 2.2012E-3)*X
1 - 7.7131506)*Y + 1.1466715)*Y*X
250 RETURN
CONTINUE
Y = A_05(T)
X = 13.3155115596/Y - 1.0
SL1 = ((1.14.49E-4)*X - 2.2191E-3)*X + 3.6173E-3)*X
1 - 2.3417E-3)*X + 3.3462E-3)*X - 0.9192525)*X
2 + 3.6151E-3)*X + 1.1747922)*Y*X
RETURN
END

```

2.0015E+02	2.7517E+00	2.0220E+02	2.4922E+02	2.3624E+02	2.0327E+02	016520
2.1655E+02	2.1665E+00	2.1655E+02	2.1655E+02	2.1655E+02	2.1857E+02	016530
2.2754E+02	2.2754E+00	2.2754E+02	2.2754E+02	2.2754E+02	2.3374E+02	016540
2.4480E+02	2.4480E+00	2.4480E+02	2.4480E+02	2.4480E+02	2.4692E+02	016550
2.7065E+02	2.7065E+00	2.7065E+02	2.7065E+02	2.7065E+02	2.5255E+02	016560
2.4157E+02	2.4157E+00	2.4157E+02	2.4157E+02	2.4157E+02	2.1959E+02	016570
2.1035E+02	2.1035E+00	2.1035E+02	2.1035E+02	2.1035E+02	1.9470E+02	016580
1.0660E+02	1.0660E+00	1.0660E+02	1.0660E+02	1.0660E+02	1.8837E+02	016590
1.9220E+02	1.9220E+00	1.9220E+02	1.9220E+02	1.9220E+02	2.1352E+02	016700
2.4000E+02	2.4000E+00	2.4000E+02	2.4000E+02	2.4000E+02	3.7609E+02	016710
2.9289E+02	2.9289E+00	2.9289E+02	2.9289E+02	2.9289E+02	4.4945E+02	016720
5.0541E+02	5.0541E+00	5.0541E+02	5.0541E+02	5.0541E+02	5.7458E+02	016730
5.7449E+02	5.7449E+00	5.7449E+02	5.7449E+02	5.7449E+02	7.4757E+02	016740
6.2386E+02	6.2386E+00	6.2386E+02	6.2386E+02	6.2386E+02	9.1449E+02	016750
9.4133E+02	9.4133E+00	9.4133E+02	9.4133E+02	9.4133E+02	9.7062E+02	016760
9.7882E+02	9.7882E+00	9.7882E+02	9.7882E+02	9.7882E+02	9.9006E+02	016770
9.9237E+02	9.9237E+00	9.9237E+02	9.9237E+02	9.9237E+02	9.9617E+02	016780
9.9685E+02	9.9685E+00	9.9685E+02	9.9685E+02	9.9685E+02	9.9822E+02	016790
9.9890E+02	9.9890E+00	9.9890E+02	9.9890E+02	9.9890E+02	9.9935E+02	016800
9.9942E+02	9.9942E+00	9.9942E+02	9.9942E+02	9.9942E+02	9.9957E+02	016810
9.9964E+02	9.9964E+00	9.9964E+02	9.9964E+02	9.9964E+02	9.9979E+02	016820
9.9986E+02	9.9986E+00	9.9986E+02	9.9986E+02	9.9986E+02	9.9997E+02	016830
1.9880E+19	1.9880E+11	1.3302E+19	1.0717E+19	9.5372E+18	5.7150E+19	016840
5.0779E+18	3.7033E+11	2.7101E+18	1.9804E+18	1.4475E+18	1.0504E+19	016850
7.6429E+17	5.5793E+11	4.0835E+17	2.991E+17	2.2075E+17	1.6106E+17	016860
1.1823E+17	8.7424E+11	6.5093E+16	4.8789E+16	3.6799E+16	2.7925E+16	016870
2.1438E+16	1.5720E+11	1.3111E+16	1.0393E+16	8.2094E+15	5.4499E+15	016880
5.0401E+15	3.9179E+11	3.0205E+15	2.3272E+15	1.7774E+15	1.3487E+15	016890
1.0154E+15	7.5547E+11	5.5825E+14	4.1117E+14	3.0067E+14	2.1659E+14	016900
1.5792E+14	1.1375E+11	7.9416E+13	5.5637E+13	3.4926E+13	2.7199E+13	016910
1.9044E+13	1.3252E+11	9.2738E+12	6.5347E+12	4.6444E+12	3.2934E+12	016920
2.3441E+12	1.5618E+11	1.1719E+12	8.5284E+11	5.3618E+11	4.8524E+11	016930
3.7715E+11	2.9876E+11	2.3991E+11	1.9544E+11	1.6121E+11	1.3415E+11	016940
1.1317E+11	9.5008E+11	6.1952E+10	7.8735E+10	5.0674E+10	5.2859E+10	016950

4.6218E+10	4.0549E+11	3.5292E+10	3.1514E+10	1.7893E+10	1.0793E+10	019360
6.6135E+03	4.4294E+00	2.9484E+05	2.0112E+03	1.3660E+09	3.5737E+09	018370
6.8370E+08	4.8581E+00	3.4872E+08	2.5139E+08	1.8203E+08	1.3247E+08	018980
9.6658E+07	7.0874E+00	5.2062E+07	3.8312E+07	2.8247E+07	2.0859E+07	018990
1.5452E+07	1.1462E+00	8.5125E+06	6.3299E+06	4.7124E+06	3.5150E+06	019000
2.6244E+06	1.3613E+00	1.4672E+06	1.0936E+06	8.2336E+05	5.1767E+05	019010
4.6380E+05	3.4854E+00	2.6223E+05	1.9751E+05	1.4868E+05	1.1232E+05	019020
8.4908E+04	6.4088E+00	4.8469E+04	3.6697E+04	2.7791E+04	2.1070E+04	019030
1.5987E+04	1.2140E+00	9.2258E+03	7.0159E+03	5.3411E+03	4.0687E+03	019040
3.1019E+03	2.3666E+00	1.8071E+03	1.3893E+03	1.0560E+03		019050
5.2354E+18	4.3838E+11	3.5695E+18	2.8751E+19	2.2903E+19	1.8014E+18	019060
1.3622E+18	9.9588E+11	7.2783E+17	5.3133E+17	3.8833E+17	2.8178E+17	019070
2.0504E+17	1.4965E+11	1.0955E+17	8.0423E+16	5.9220E+16	4.3207E+16	019080
3.1718E+16	2.3453E+11	1.7463E+16	1.3093E+16	9.6720E+15	7.4913E+15	019090
5.7511E+15	4.4854E+11	3.5172E+15	2.7837E+15	2.2023E+15	1.7301E+15	019100
1.3521E+15	1.0510E+11	3.1245E+14	6.2433E+14	4.7682E+14	3.5181E+14	019110
2.7251E+14	2.0267E+11	1.4992E+14	1.1023E+14	8.0661E+13	5.8641E+13	019120
4.2366E+13	3.0409E+11	2.1305E+13	1.4930E+13	1.0443E+13	7.2967E+12	019130
5.1090E+12	3.5552E+11	2.4879E+12	1.6745E+12	1.1386E+12	7.7238E+11	019140
5.2737E+11	3.5933E+11	2.4454E+11	1.7217E+11	1.2463E+11	3.2436E+10	019150
6.9997E+10	5.4113E+11	4.2468E+10	3.3854E+10	2.7354E+10	2.2320E+10	019160
1.8470E+10	1.5392E+11	1.2911E+10	1.0895E+10	9.2457E+09	7.9281E+09	019170
6.8257E+09	5.9991E+00	5.1168E+09	4.4537E+09	2.3641E+09	1.3406E+09	019180
7.9866E+08	4.9131E+00	3.1833E+08	2.0117E+08	1.3194E+08	3.7795E+07	019190
6.9141E+07	4.0111E+00	2.7591E+07	1.8933E+07	1.3117E+07	9.1309E+06	019200
6.3754E+06	4.4747E+00	3.1471E+06	2.2190E+06	1.5663E+06	1.1083E+06	019210
7.8694E+05	5.5953E+00	3.9839E+05	2.8406E+05	2.0282E+05	1.4511E+05	019220
1.0394E+05	7.4527E+00	5.3497E+04	3.8444E+04	2.7656E+04	1.9915E+04	019230
1.4358E+04	1.0362E+00	7.4864E+03	5.4153E+03	3.9216E+03	2.8423E+03	019240
2.0620E+03	1.4973E+00	1.0883E+03	7.9175E+02	5.7655E+02	4.2023E+02	019250
3.0657E+02	2.2386E+00	1.6361E+02	1.1953E+02	6.7633E+01	5.4222E+01	019260
4.7107E+01	3.4585E+00	2.5417E+01	1.8691E+01	1.3759E+01		019270
1.0000E-05	2.5119E-00	6.3896E-06	1.5843E-05	3.9811E-05	1.0000E-04	019280
2.5110E-04	6.3096E-00	1.5849E-03	3.9811E-03	1.0000E-02	2.5119E-02	019290

6.3794E-02	1.5849E+02	3.9811E-01	1.0897E+00	2.5119E+00	3.7995E+00	019300
1.5849E+01	3.9811E+00	1.0897E+02	2.5113E+02	6.7096E+02	1.5849E+01	019310
3.9811E+03	1.5800E+00	2.5119E+04	6.7095E+04	1.5849E+05	3.9811E+05	019320
1.0000E+06	2.5119E+00	6.7096E+06	1.5849E+07	3.9811E+07	1.0000E+08	019330
2.5119E+08	6.7096E+00	1.5849E+09	3.9811E+09	1.0000E+10	2.0488E+10	019340
6.1976E+10	3.6000E+10	1.5100E+11	2.4499E+11	3.4300E+11	4.1600E+11	019350
4.4700E+11	4.8900E+11	4.3000E+11	4.0197E+11	3.6200E+11	3.1900E+11	019360
2.7500E+11	2.3000E+11	1.8900E+11	1.5600E+11	1.3000E+11	1.1000E+11	019370
9.2800E+10	7.3983E+11	6.8765E+10	5.9812E+10	5.2567E+10	4.6200E+10	019380
4.1344E+10	3.6998E+11	3.3303E+10	3.0153E+10	2.7300E+10	2.4951E+10	019390
2.2803E+10	2.8334E+11	1.9303E+10	1.7807E+10	1.2400E+10	3.0000E+09	019400
6.7500E+09	5.1800E+00	4.8500E+09	3.2357E+09	2.5845E+09	2.0863E+09	019410
1.7032E+09	1.3900E+00	1.1471E+09	9.4659E+08	7.8444E+08	5.5265E+08	019420
5.4300E+05	4.5528E+00	3.8173E+08	3.2005E+08	2.6835E+08	2.2500E+08	019430
1.8968E+08	1.5990E+00	1.3490E+08	1.1364E+08	9.5800E+07	5.1080E+07	019440
6.8621E+07	5.8077E+00	4.9153E+07	4.1680E+07	3.5338E+07	3.0018E+07	019450
2.5699E+07	2.1661E+00	1.8400E+07	1.5677E+07	1.3358E+07	1.1381E+07	019460
9.6971E+06	8.2622E+00	7.0397E+06	5.9990E+06	5.1105E+06	4.3543E+06	019470
3.7100E+06	3.1759E+00	2.7197E+06	2.3273E+06	1.9923E+06	1.7055E+06	019480
1.4600E+05	1.2498E+00	1.0699E+06	9.1594E+05	7.8400E+05		019490
2.3789E+17	1.9566E+11	1.5911E+17	1.2813E+17	1.0212E+17	9.0321E+16	019500
6.0738E+16	4.4368E+11	3.2417E+16	2.3699E+16	1.7315E+16	1.2564E+16	019510
9.1421E+15	6.5724E+11	4.8845E+15	3.5861E+15	2.6405E+15	1.9265E+15	019520
1.4142E+15	1.0457E+11	7.7861E+14	5.4357E+14	4.4017E+14	3.3402E+14	019530
2.5647E+14	1.9909E+11	1.5642E+14	1.2433E+14	9.8195E+13	7.7139E+13	019540
6.0287E+13	4.6863E+11	3.6225E+13	2.7837E+13	2.1260E+13	1.6132E+13	019550
1.2151E+13	9.0365E+11	6.6846E+12	4.9174E+12	3.5965E+12	2.6146E+12	019560
1.8999E+12	1.3559E+11	3.4994E+11	6.6579E+11	4.6561E+11	3.2534E+11	019570
2.2780E+11	1.5852E+11	1.1893E+11	6.8111E+10	4.2340E+10	2.6333E+10	019580
1.6553E+10	1.0438E+11	6.6058E+09	4.3543E+09	2.9682E+09	2.0919E+09	019590
1.4966E+09	1.1022E+00	8.2630E+08	6.3073E+08	4.8914E+08	3.8375E+08	019600
3.0584E+08	2.4580E+00	1.9908E+08	1.6243E+08	1.3342E+08	1.1864E+08	019610
9.2534E+07	7.7606E+00	6.5873E+07	5.5293E+07	2.5667E+07	1.2867E+07	019620
6.8292E+06	3.7646E+00	2.1409E+06	1.2537E+06	7.4486E+05	4.5009E+05	019630

2.7594E+05	1.7049E+00	1.0667E+05	5.7105E+04	4.2501E+04	2.7076E+04	019640
1.7315E+04	1.1139E+00	7.1826E+03	4.6430E+03	3.0101E+03	1.9560E+03	019650
1.2759E+07	4.3373E+00	5.4575E+02	3.5745E+02	2.3507E+02	1.5478E+02	019660
1.0205E+02	6.7376E+00	4.6544E+01	2.9490E+01	1.9549E+01	1.2977E+01	019670
8.6259E+04	5.7413E+01	3.8264E+00	2.5542E+00	1.7070E+00	1.1421E+00	019680
7.6508E-01	5.1312E-00	3.4454E-01	2.3151E-01	1.5588E-01	1.0503E-01	019690
7.0850E-02	4.7840E-00	3.2350E-02	2.1877E-02	1.4838E-02	1.0066E-02	019700
6.8367E-03	4.6494E-01	3.1640E-03	2.1561E-03	1.4708E-03		019710
7.9976E+15	6.5712E+10	5.3491E+15	4.3093E+15	3.4331E+15	2.7003E+15	019720
2.0420E+15	1.4916E+10	1.0898E+15	7.9640E+14	5.8210E+14	4.2239E+14	019730
3.0735E+14	2.2432E+10	1.6471E+14	1.2055E+14	8.8770E+13	6.4766E+13	019740
4.7545E+13	3.5156E+10	2.6176E+13	1.9613E+13	1.4798E+13	1.1229E+13	019750
8.6200E+12	6.7235E+10	5.2722E+12	4.1819E+12	3.3012E+12	2.5933E+12	019760
2.0268E+12	1.5755E+10	1.2178E+12	9.3535E+11	7.1474E+11	5.4235E+11	019770
4.0849E+11	3.9380E+10	2.2473E+11	1.6532E+11	1.2091E+11	9.7901E+10	019780
6.3505E+10	4.5582E+10	3.1936E+10	2.2390E+10	1.5653E+10	1.0938E+10	019790
7.6583E+09	5.3292E+10	3.7293E+09	2.1945E+09	1.2974E+09	7.7209E+08	019800
4.6510E+08	2.8160E+00	1.7191E+05	1.0959E+03	7.2428E+17	4.9374E+07	019810
3.4567E+07	2.4830E+00	1.8184E+07	1.3573E+07	1.0310E+07	7.9278E+06	019820
6.1979E+05	4.0897E+00	3.8904E+06	3.1191E+06	2.5203E+06	2.0602E+06	019830
1.6930E+06	1.3993E+00	1.1604E+06	9.6737E+05	6.1924E+05	1.9734E+05	019840
9.8735E+04	5.1460E+00	2.7734E+04	1.5421E+04	8.7105E+03	5.0104E+03	019850
2.9259E+03	1.7245E+01	1.0296E+03	6.1852E+02	3.7423E+02	2.2785E+02	019860
1.3931E+02	8.5706E+00	5.2876E+01	3.2713E+01	2.0296E+01	1.2627E+01	019870
7.8870E+00	4.9361E+00	3.0952E+00	1.9446E+00	1.2241E+00	7.7245E-01	019880
4.8820E-01	3.0901E-00	1.9589E-01	1.2435E-01	7.9069E-02	5.0347E-02	019890
3.2106E-02	2.9503E-00	1.3113E-02	8.4005E-03	5.3887E-03	3.4612E-03	019900
2.2261E-03	1.4335E-00	9.2436E-04	5.9680E-04	3.8581E-04	2.4973E-04	019910
1.6185E-04	1.0503E-00	6.8238E-05	4.4392E-05	2.8915E-05	1.8857E-05	019920
1.2313E-05	8.0499E-00	5.2692E-06	3.4533E-05	2.2659E-05		019930
1.2735E+14	1.0466E+10	8.5177E+13	6.8627E+13	5.4667E+13	4.2998E+13	019940
3.2515E+13	2.3752E+11	1.7354E+13	1.2682E+13	9.2691E+12	5.7259E+12	019950
4.8941E+12	3.5729E+10	2.6148E+12	1.9199E+12	1.4135E+12	1.0323E+12	019960
7.5708E+11	5.5981E+12	4.1681E+11	3.1240E+11	2.3563E+11	1.7881E+11	019970

1. 3727E+11	1. 9775E+10	0. 3952E+10	6. 6503E+10	5. 2560E+10	4. 1295E+10	019980
3. 2273E+10	2. 5047E+10	1. 9402E+10	1. 4912E+10	1. 1301E+10	1. 6361E+10	019990
6. 5046E+09	4. 3376E+09	3. 5705E+09	2. 6374E+09	1. 9253E+09	1. 3997E+09	020000
1. 0112E+09	7. 2503E+08	5. 0053E+08	3. 5617E+08	2. 4925E+08	1. 7416E+08	020010
1. 2195E+08	4. 4060E+08	5. 9304E+07	4. 6944E+07	3. 7398E+07	2. 9547E+07	020020
2. 3347E+07	1. 0248E+07	1. 4094E+07	1. 1134E+07	0. 9644E+06	7. 3349E+06	020030
6. 0857E+06	5. 1240E+06	4. 3592E+06	3. 7492E+06	3. 2575E+06	2. 9400E+06	020040
2. 5181E+06	2. 2366E+06	1. 9950E+06	1. 7354E+06	1. 4856E+06	1. 4556E+06	020050
1. 3230E+05	1. 2954E+05	1. 1008E+05	1. 0075E+05	6. 7719E+05	4. 7700E+05	020060
7. 4921E+05	2. 5909E+05	1. 9741E+05	1. 5301E+05	1. 1940E+05	3. 4140E+05	020070
7. 4287E+04	5. 9006E+04	4. 8168E+04	3. 8033E+04	3. 1528E+04	2. 5646E+04	020080
2. 0902E+04	1. 7103E+04	1. 4011E+04	1. 1437E+04	9. 4360E+03	7. 7560E+03	020090
6. 3533E+03	5. 2737E+03	4. 3575E+03	3. 5953E+03	2. 9739E+03	2. 4626E+03	020100
2. 0495E+03	1. 5910E+03	1. 4035E+03	1. 1531E+03	9. 6775E+02	3. 0432E+02	020110
6. 6069E+02	5. 5650E+02	4. 6744E+02	3. 4671E+02	3. 2202E+02	2. 6864E+02	020120
2. 2423E+02	1. 9726E+02	1. 5647E+02	1. 3041E+02	1. 0941E+02	3. 1565E+01	020130
7. 6670E+01	6. 4229E+01	5. 3035E+01	4. 5145E+01	3. 7079E+01	3. 1798E+01	020140
2. 6706E+01	2. 2441E+01	1. 8067E+01	1. 5070E+01	1. 7355E+01		020150
2. 5000E+01	2. 1047E+01	1. 7720E+01	1. 4919E+01	1. 2559E+01	1. 0574E+01	020160
9. 9019E+00	7. 4945E+00	6. 3096E+00	5. 3127E+00	4. 4721E+00	3. 7651E+00	020170
7. 1698E+00	2. 5556E+00	2. 2457E+00	1. 8915E+00	1. 5924E+00	1. 3407E+00	020180
1. 1207E+00	9. 5024E+00	6. 0000E+00	6. 4293E+00	5. 1600E+00	4. 1537E+00	020190
3. 3305E+00	2. 5833E+00	2. 1567E+00	1. 7334E+00	1. 3932E+00	1. 1190E+00	020200
9. 9900E+00	7. 2000E+00	5. 0000E+00	4. 6000E+00	3. 7000E+00	2. 9000E+00	020210
2. 3000E+00	1. 9000E+00	1. 4000E+00	1. 1500E+00	9. 5000E+00	3. 7000E+00	020220
4. 2900E+00	4. 7000E+00	1. 0500E+00	1. 4000E+00	1. 5000E+00	2. 3000E+00	020230
8. 0000E+00	3. 6000E+00	4. 0000E+00	4. 2000E+00	4. 4000E+00	4. 5000E+00	020240
4. 4000E+00	4. 2000E+00	3. 9000E+00	3. 5000E+00	3. 1000E+00	2. 7000E+00	020250
2. 3000E+00	2. 0341E+00	1. 0059E+00	1. 5855E+00	1. 3794E+00	1. 2000E+00	020260
1. 0447E+00	3. 9443E+00	7. 9170E+00	6. 8922E+00	5. 8000E+00	5. 2058E+00	020270
4. 5147E+00	3. 9188E+00	3. 4001E+00	2. 9591E+00	1. 5000E+00	3. 5917E+00	020280
5. 7500E+00	3. 5759E+00	2. 7500E+00	1. 6011E+00	1. 0909E+00	7. 6322E+00	020290
5. 0637E+00	3. 4500E+00	2. 4475E+00	1. 7307E+00	1. 2259E+00	3. 5823E+00	020300
6. 1500E+00	4. 4464E+00	3. 2147E+00	2. 3247E+00	1. 6804E+00	1. 2149E+00	020310

4.74375+02	5.75953+00	4.59145+02	3.31355+02	2.40005+02	1.76373+02	020720
1.20555+02	3.51843+00	5.90335+01	5.13815+01	3.77505+01	2.77363+01	020730
2.03745+01	1.69723+00	1.10005+01	8.16575+00	5.03115+00	4.46575+00	020740
3.30675+00	2.64853+00	1.01305+00	1.34245+00	9.04025+01	7.34035+01	020750
5.45005+01	4.37423+00	3.05175+01	2.28735+01	1.70885+01	1.27875+01	020760
9.56825+02	7.15983+00	5.35775+02	4.00975+02	3.00005+02		020770
2.54705+04	2.09275+01	1.70335+04	1.37255+04	1.09335+04	3.59975+03	020780
5.50305+03	4.75045+01	3.47075+01	2.57225+01	1.85385+01	1.34525+01	020790
9.74815+02	7.14393+01	5.22945+02	3.67235+02	2.82715+02	2.06255+02	020800
1.51425+02	1.11953+01	8.33635+01	6.24815+01	4.71275+01	3.57625+01	020810
2.74555+01	2.14123+01	1.57985+01	1.33195+01	1.05145+01	3.25905+01	020820
5.45475+04	5.91753+01	3.87955+01	2.98145+01	2.27625+01	1.72725+01	020830
1.70095+08	3.57513+00	7.15705+09	5.26435+09	3.50655+09	2.79945+09	020840
2.02255+03	1.45173+00	1.01715+09	7.12745+09	4.98515+09	3.68335+09	020850
2.47905+08	1.59723+00	1.18775+08	8.18335+07	5.68835+07	3.94355+07	020860
2.74925+07	1.31123+00	1.38375+07	9.67135+06	5.96225+06	3.23665+06	020870
4.01745+05	3.14333+00	2.49595+06	2.01125+06	1.64205+06	1.35305+06	020880
1.13075+06	3.59513+00	8.04275+05	6.84455+05	5.85635+05	3.06175+05	020890
4.39175+05	3.92413+00	3.34155+05	2.92935+05	1.60815+05	3.48545+04	020900
5.76795+04	3.64713+00	2.36525+04	1.57235+04	1.05775+04	7.20815+03	020910
4.97195+03	3.45143+00	2.42145+03	1.70595+03	1.20825+03	3.59925+02	020920
6.13795+02	4.60333+00	3.16585+02	2.27335+02	1.64465+02	1.18895+02	020930
8.62235+01	5.20173+00	4.55745+01	3.31555+01	2.41735+01	1.76595+01	020940
1.29145+01	9.45333+00	6.92725+00	5.08135+00	3.73115+00	2.74245+00	020950
2.01775+00	1.48613+00	1.09555+00	8.08575+00	5.07455+00	4.41755+00	020960
3.26595+01	2.42213+00	1.75545+01	1.33255+01	3.89755+02	7.35745+02	020970
5.47395+02	4.07613+00	3.03785+02	2.26535+02	1.69165+02	1.26395+02	020980
2.65175+03	7.07393+00	5.29875+03	3.97235+03	2.58045+03		020990
6.80005+01	5.49993+01	5.28005+01	5.70995+01	6.50005+01	1.13005+01	021000
2.02205+02	2.35903+01	2.95005+02	4.04995+02	4.77905+02	4.86905+02	021010
4.54995+02	4.13003+01	3.24005+02	2.52995+02	2.03905+02	1.58895+02	021020
1.22805+02	8.73093+01	5.07905+01	3.99995+01	2.74095+01	1.69995+01	021030
1.03005+01	6.64003+01	3.04005+01	2.55995+01	1.61995+01	1.12005+01	021040
7.33095+03	4.31993+01	7.17005+09	1.89995+03	8.70095+09	3.60895+06	021050

1.6000E+04	1.9970E+00	1.6000E+00	1.5000E+03	2.1000E+08	2.5000E+08	020650
2.8000E+08	2.6000E+00	2.2000E+00	1.9000E+03	1.3000E+03	3.2000E+07	020570
6.2000E+07	4.0000E+00	2.6000E+00	1.4500E+07	3.2570E+06	4.7053E+05	020630
2.7100E+05	1.5000E+00	9.3200E+05	5.7000E+05	3.5855E+05	2.4437E+05	020590
1.6600E+05	1.1600E+00	8.3620E+04	6.1100E+04	4.5440E+04	3.4266E+04	020700
2.6200E+04	2.9366E+00	1.5922E+04	1.2550E+04	9.9766E+03	3.8259E+03	020710
6.4900E+03	5.2843E+00	4.3213E+03	3.5512E+03	1.4388E+03	6.3664E+02	020720
3.0000E+02	1.4820E+00	7.5011E+01	4.0053E+01	2.1533E+01	1.1801E+01	020730
6.6721E+00	3.5973E+00	2.1064E+00	1.7103E+00	7.0017E-01	4.0776E-01	020740
2.8056E-01	1.4060E-00	8.2979E-02	4.9154E-02	2.9210E-02	1.7417E-02	020750
1.0424E-02	6.2544E-04	3.7699E-03	2.2650E-03	1.7673E-03	3.2762E-04	020760
6.0170E-04	3.0472E-05	1.0536E-04	1.1293E-04	6.8910E-05	4.2126E-05	020770
2.5701E-05	1.5015E-00	9.7133E-06	5.9755E-06	3.6826E-05	2.2724E-06	020780
1.4042E-06	9.5090E-00	5.3044E-07	3.3412E-07	2.0702E-07	1.2923E-07	020790
8.0500E-03	5.0234E-00	3.1780E-04	1.9633E-03	1.2305E-03	7.7197E-09	020800
4.0497E-09	3.0500E-00	1.9217E-09	1.2121E-03	7.6555E-10		020810
2.5470E+12	2.8027E+10	1.7035E+12	1.3725E+12	1.0933E+12	3.5997E+11	020820
6.5030E+11	7.7504E+10	3.4707E+11	2.5363E+11	1.6538E+11	1.3452E+11	020830
9.7001E+10	7.1439E+10	5.2296E+10	3.8395E+10	2.8271E+10	2.0625E+10	020840
1.5142E+10	1.1196E+10	8.3363E+09	6.2491E+09	4.7127E+09	3.5762E+09	020850
2.7655E+09	2.1412E+09	1.6790E+09	1.3313E+09	1.0514E+09	3.2590E+08	020860
6.4547E+08	5.0175E+00	7.0705E+08	2.9804E+09	2.2762E+08	1.7272E+08	020870
1.3009E+08	3.6751E+00	7.1570E+07	5.2649E+07	3.8506E+07	2.7994E+07	020880
2.0225E+07	1.4517E+00	1.0171E+07	7.1274E+06	4.9051E+06	3.4033E+06	020890
2.4790E+06	1.6972E+00	1.1077E+06	3.3719E+05	5.9535E+05	4.2101E+05	020900
3.0070E+05	2.1275E+00	1.5011E+05	1.8913E+05	3.1492E+04	3.2159E+04	020910
4.8313E+04	7.9272E+00	3.0733E+04	2.5837E+04	2.9653E+04	1.7197E+04	020920
1.4494E+04	1.2300E+00	1.0499E+04	9.0112E+03	7.7735E+03	5.7724E+03	020930
5.9215E+03	5.1953E+00	4.5730E+03	4.0371E+03	2.2926E+03	1.3670E+03	020940
2.7310E+02	3.5749E+00	3.7705E+02	2.5775E+02	1.7763E+02	1.2406E+02	020950
9.7670E+01	5.2260E+00	4.4690E+01	3.2212E+01	2.3334E+01	1.6901E+01	020960
1.2391E+01	9.8060E+00	6.6745E+00	4.9113E+00	3.6211E+00	2.5743E+00	020970
1.2013E+00	1.4659E+00	1.0915E+00	8.117E-01	6.0430E-01	4.5075E-01	020980
7.2656E-01	2.5153E-00	1.6017E-01	1.4030E-01	1.0560E-01	7.3223E-02	020990

5.9449E-02	4.4712E-01	3.3637E-02	2.5335E-02	1.9099E-02	1.4403E-02	021000
1.0880E-02	8.2219E-01	6.2183E-03	4.7039E-03	3.5657E-03	2.7034E-03	021010
2.0517E-03	1.5577E-01	1.1838E-02	9.0031E-04	6.6539E-14	5.2212E-04	021020
3.9806E-04	3.0372E-01	2.3192E-04	1.7722E-04	1.3553E-04		021030
						021040
METHANE - CH4		1	120.			021050
CARBON DIOXIDE - CO2		2	700.			021060
WATER VAPOR - H2O		3	700.			021070
NITRIC OXIDE - NO		4	700.			021080
NITROUS OXIDE - N2O		5	150.			021090
OZONE - O3		6	700.			021100
OZONE - O3 MOON		7	700.			021110
MOL NO DEN - IC80 ST AM		8	700.			021120
TEMP - TC80 STD. ATMO.		1	700.			021130
METHANE - CH4		94	4	15.30	1.0000E-15	021140
		11				021150
		31				021160
		31				021170
		21				021180
		201				021190
		301				021200
		401				021210
		302				021220
CARBON MONOXIDE - CO		10	16	44.0		021230
		08				021240
		0.				021250
		09				021260
		12				021270
		21				021280
		12				021290
		22				021300
		21				021310
		21				021320
		12				021330

501	11	7.9940E-18	5.4000E+16			021580
302	11	5.6101E-11	5.2000E+15			021530
402	11	5.9001E-13	1.2000E+16			021710
502	11	4.9000E-12	1.5000E+16			021710
602	11	7.9300E-15	3.3000E+16			021720
702	11	1.5000E-12	5.0000E+16			021730
802	11	3.3001E-11	5.4000E+16			021740
603	11	7.0000E-14	4.9000E+15			021750
601	11	2.0000E-12	9.3000E+16			021760
701	11	1.8381E-10	1.2000E+17			021770
601	11	3.0600E-13	1.2500E+17			021780
				30.00	4.0000E-15	2.000021790
NITRIC OXIDE - NO						
11		0.0001E+10	1.6961E+00			021800
11	1	1.8700E+13	1.6792E+00			021810
11		3.7270E+13	1.6605E+00			021820
201	11	5.0001E-18	8.7000E+15			021830
301	11	5.5001E-10	5.4000E+16			021840
302	11	1.2701E-11	8.4000E+15			021850
NITROUS OXIDE - N2O						
11		0.0001E+10	4.1901E-01		1.0000E-15	2.500021860
21		5.0000E+12	4.0000E-01			021870
31		1.1730E+13	4.0000E-01			021880
41		1.7581E+13	4.0000E-01			021890
51		2.3365E+13	4.0000E-01			021900
11	1	2.2235E+13	4.0000E-01			021910
11		1.2850E+13	4.0000E-01			021920
201	12	3.7000E+11	3.4000E+14	2.5000E+16		021930
701	11	2.6080E+12	3.8000E+15	1.3000E+16		021940
601	11	1.8561E+13	1.6000E+16	1.3000E+14		021950
OZONE PRE-PAWN - O3						
11		0.0000E+10	3.0000E-04	49.00	2.4000E-14	1.000021970
11	2	1.0421E+13	3.0000E-04			021980
201	11	1.2901E-17	1.6880E+15			021990
OZONE NOON - O3 - O3						
				49.30	2.4000E-14	1.000022010

11	0.0000E+00	3.0000E-04	2.7517E+00	2.6220E+02	2.4922E+02	2.3624E+02	2.2327E+02	022020
11	1.0421E+03	3.0000E-04	2.1665E+00	2.1665E+02	2.1665E+02	2.1665E+02	2.1857E+02	022030
201	1.2903E-07	1.6890E+15	2.2254E+00	2.2452E+02	2.2651E+02	2.2849E+02	2.3374E+02	022040
			2.4490E+00	2.5033E+02	2.5585E+02	2.6139E+02	2.6692E+02	022050
			2.7065E+02	2.6903E+02	2.6354E+02	2.5804E+02	2.5255E+02	022060
			2.4706E+02	2.4157E+00	2.3053E+02	2.2509E+02	2.1959E+02	022070
			2.1426E+02	2.1035E+00	2.0252E+02	1.9861E+02	1.9470E+02	022080
			1.9070E+02	1.8687E+00	1.8687E+02	1.8736E+12	1.8833E+02	022090
			1.0911E+02	1.9500E+02	2.0070E+02	2.0531E+02	2.1352E+02	022100
			2.2398E+02	2.6400E+02	2.8807E+02	3.1200E+02	3.3600E+02	022110
			3.6800E+02	4.0578E+02	4.2754E+02	4.4845E+02	4.6927E+02	022120
			4.8734E+02	5.0541E+00	5.2749E+02	5.4963E+02	5.7159E+02	022130
			5.8953E+02	6.0449E+00	6.3435E+02	6.6299E+02	6.9275E+02	022140
			7.0820E+02	8.2386E+00	8.5456E+02	8.9714E+02	9.4093E+02	022150
			9.2751E+02	9.4133E+00	9.8492E+02	9.6523E+02	9.7062E+02	022160
			9.7601E+02	9.7012E+00	9.8163E+02	9.8725E+02	9.9805E+02	022170
			9.9121E+02	9.9237E+00	9.9352E+02	9.9583E+02	9.9617E+02	022180
			9.9651E+02	9.9685E+00	9.9719E+02	9.9788E+02	9.9822E+02	022190
			9.9856E+02	9.9890E+00	9.9924E+02	9.9931E+02	9.9935E+02	022200
			9.9939E+02	9.9942E+00	9.9946E+02	9.9953E+02	9.9957E+02	022210
			9.9966E+02	9.9964E+00	9.9968E+02	9.9975E+02	9.9979E+02	022220
			9.9992E+02	9.9986E+00	9.9990E+02	9.9997E+02	9.9999E+02	022230
			1.0888E+13	1.5341E+1	1.3302E+19	1.0717E+19	5.7150E+18	022240
			5.0778E+15	3.7093E+1	2.7101E+18	1.9806E+15	1.4675E+18	022250
			7.6429E+17	5.2703E+1	6.0835E+17	2.9911E+17	2.2075E+17	022260
			1.1923E+17	8.7424E+1	6.5093E+16	4.8793E+15	3.6799E+15	022270
			2.1430E+16	1.5720E+1	1.3111E+16	1.0323E+15	8.2094E+15	022280
			5.0401E+15	3.9179E+1	3.0285E+15	2.3277E+15	1.7774E+15	022290
			1.0154E+15	7.5547E+1	5.5885E+14	4.1110E+14	3.0867E+14	022300
							2.1859E+14	022310
							1.0504E+18	022320
							1.6106E+17	022330
							2.7925E+16	022340
							5.4489E+15	022350
							1.3487E+15	022360
							2.1859E+14	022370

1.5792E+14	1.1335E+1	7.9416E+13	5.5633E+13	3.8926E+13	2.7199E+13	022370
1.9644E+13	1.3252E+1	9.2739E+12	6.5352E+12	4.6484E+12	3.2934E+12	022380
2.2441E+12	1.5510E+1	1.1719E+12	8.5243E+11	6.3618E+11	4.8523E+11	022390
2.7715E+11	2.9876E+1	2.3991E+11	1.9544E+11	1.5121E+11	1.3415E+11	022400
1.1313E+11	9.6009E+1	8.1952E+10	7.0735E+10	6.0674E+10	5.2859E+10	022410
4.6218E+10	4.9549E+1	3.5692E+10	3.1514E+10	1.7893E+10	1.0793E+10	022420
6.8135E+09	4.4244E+0	2.9484E+09	2.0112E+09	1.3860E+09	9.6797E+08	022430
5.8779E+06	4.9541E+0	3.4872E+08	2.5130E+08	1.8203E+08	1.3247E+08	022440
9.6655E+07	7.9874E+0	5.2062E+07	3.8312E+07	2.8243E+07	2.0859E+07	022450
1.5452E+07	1.1462E+0	8.5125E+05	6.3293E+05	4.7124E+06	3.5150E+05	022460
2.6244E+05	1.3613E+0	1.4672E+06	1.0985E+05	8.2336E+05	5.1767E+05	022470
4.6330E+05	2.4858E+0	2.6223E+05	1.9751E+05	1.4888E+05	1.1232E+05	022480
8.4808E+04	6.4088E+0	4.8469E+04	3.6687E+04	2.7791E+04	2.1070E+04	022490
1.5987E+04	1.2140E+0	9.2258E+03	7.0153E+03	5.3411E+03	4.0687E+03	022500
3.1019E+03	2.3666E+0	1.8071E+03	1.3893E+03	1.0560E+03		022510
5.7354E+19	4.3839E+1	3.5685E+18	2.8751E+18	2.2903E+18	1.8014E+18	022520
1.3622E+18	9.9598E+1	7.2703E+17	5.3130E+17	3.8833E+17	2.9178E+17	022530
2.0504E+17	1.4965E+1	1.0955E+17	8.0423E+16	5.9220E+16	4.3207E+16	022540
2.1738E+15	2.3453E+1	1.7463E+16	1.3093E+15	9.8720E+15	7.4913E+15	022550
5.7211E+15	4.4854E+1	3.5172E+15	2.7897E+15	2.2023E+15	1.7301E+15	022560
1.3521E+15	1.0510E+1	8.1245E+14	6.2433E+14	4.7682E+14	3.6181E+14	022570
2.7251E+14	2.0267E+1	1.4992E+14	1.1023E+14	9.0651E+13	5.8641E+13	022580
4.2366E+13	3.0409E+1	2.1305E+13	1.4930E+13	1.0443E+13	7.2967E+12	022590
5.1090E+12	3.5552E+1	2.4879E+12	1.6745E+12	1.1386E+12	7.7238E+11	022600
5.2737E+11	3.5933E+1	2.4454E+11	1.7212E+11	1.2463E+11	3.2436E+10	022610
6.9997E+10	5.4113E+1	4.2468E+10	3.3854E+11	2.7354E+10	2.2320E+10	022620
1.8470E+10	1.5392E+1	1.2911E+10	1.0825E+10	9.2457E+09	7.9281E+09	022630
4.8257E+09	5.9991E+0	5.1168E+09	4.4537E+09	2.3641E+09	1.3406E+09	022640
7.9864E+03	4.3131E+0	3.1033E+08	2.0117E+09	1.3194E+08	3.7795E+07	022650
5.9141E+07	4.0111E+0	2.7501E+07	1.4933E+07	1.3117E+07	3.1309E+06	022660
6.3758E+05	4.4747E+0	3.1471E+06	2.2191E+05	1.5663E+05	1.1083E+05	022670
7.8694E+05	5.5353E+0	3.9839E+05	2.8405E+05	2.0282E+05	1.4511E+05	022680
1.0394E+05	7.4527E+0	5.3437E+04	3.8444E+04	2.7656E+04	1.9916E+04	022690
1.6358E+04	1.0362E+0	7.4864E+03	5.6153E+03	3.9216E+03	2.4423E+03	022700

2.0520E+02	1.4973E+00	1.0803E+03	7.9175E+02	5.7655E+02	4.2023E+02	022710
2.0557E+02	2.2386E+00	1.6761E+02	1.1953E+02	3.7633E+01	5.4222E+01	022720
4.7107E+01	3.4595E+00	2.5413E+01	1.8631E+01	1.3759E+01	1.0000E+04	022730
1.0000E+02	2.5119E+00	6.3096E+02	1.5843E+03	3.9811E+03	2.5113E+06	022740
2.5119E+04	6.3096E+00	1.5849E+05	3.9811E+05	1.0000E+06	3.8981E+08	022750
6.3096E+05	1.5849E+00	3.9811E+07	1.0000E+09	1.9744E+09	5.4039E+09	022760
7.6961E+04	1.5195E+00	3.0000E+09	3.6502E+03	6.4613E+09	1.1065E+10	022770
6.5750E+09	8.0000E+00	6.6758E+09	9.4095E+03	1.0203E+10	2.0000E+10	022780
1.2000E+10	1.3291E+10	1.4720E+10	1.6394E+10	1.8058E+10	6.7650E+10	022790
2.4915E+10	3.1037E+10	7.8664E+10	4.0154E+10	6.0000E+10	4.1607E+11	022800
7.6275E+10	3.5000E+10	1.5100E+11	2.4400E+11	3.4300E+11	3.1902E+11	022810
4.4700E+11	4.4000E+10	4.3000E+11	4.9100E+11	3.6200E+11	1.1000E+11	022820
2.7500E+11	2.3000E+11	1.0900E+11	1.5600E+11	1.3000E+11	4.6200E+10	022830
9.2800E+10	7.9883E+10	6.8755E+10	5.9812E+10	5.2587E+10	2.4951E+10	022840
4.1344E+10	3.6999E+10	3.3070E+10	3.0153E+10	2.7300E+10	3.0000E+09	022850
2.2803E+10	2.0934E+10	1.9307E+10	1.7800E+10	1.2400E+10	2.0869E+09	022860
6.7500E+09	5.1800E+09	4.0560E+09	3.2353E+09	2.5845E+09	5.5265E+08	022870
1.7032E+09	1.3990E+09	1.1471E+09	9.4659E+08	7.8444E+08	2.2500E+08	022880
5.4300E+08	4.5529E+08	3.0173E+08	3.2065E+08	2.6635E+08	3.1080E+07	022890
1.8968E+08	1.5990E+08	1.3480E+08	1.1354E+08	9.5800E+07	3.9018E+07	022900
6.8621E+07	5.9077E+07	4.9153E+07	4.1500E+07	3.5338E+07	1.1381E+07	022910
2.5499E+07	2.1651E+07	1.8400E+07	1.5677E+07	1.3358E+07	4.3543E+06	022920
9.6971E+05	8.2622E+07	7.0397E+06	5.9900E+06	5.1105E+06	1.7055E+06	022930
7.7100E+05	3.1759E+07	2.7187E+06	2.3273E+05	1.9923E+05	3.0321E+16	022940
1.4600E+05	1.2498E+07	1.0699E+06	9.1584E+05	7.8400E+05	1.2564E+16	022950
2.3789E+17	1.3546E+10	1.5911E+17	1.2813E+17	1.0212E+17	1.9265E+15	022960
6.0738E+16	4.4368E+17	3.2417E+16	2.3699E+16	1.7315E+16	3.7402E+14	022970
9.1421E+15	6.5724E+16	4.6845E+15	3.5831E+15	2.6405E+15	7.7139E+13	022980
1.4142E+15	1.0457E+16	7.7861E+14	5.0357E+14	4.4817E+14	1.6132E+13	022990
2.5647E+14	1.9999E+16	1.5692E+14	1.2433E+14	9.8196E+13	2.6146E+12	023000
6.0287E+13	4.6863E+16	3.8225E+13	2.7837E+13	2.1260E+13	3.2534E+11	023010
1.2151E+13	9.0365E+16	6.6846E+12	4.9174E+12	3.5965E+12	2.6338E+10	023020
1.8890E+12	1.3558E+16	9.4994E+11	6.6570E+11	4.6561E+11	2.6338E+10	023030
2.2780E+11	1.5955E+16	1.1093E+11	8.6103E+10	4.2340E+10		023040

1.6553F+10	1.0430E+1	6.6058E+09	4.3543E+03	2.9682E+03	2.0819E+03	023050
1.4968F+09	1.1022E+0	8.2630E+08	6.3073E+08	4.8914E+03	3.8375E+08	023060
3.0584E+09	2.4580E+0	1.9908E+08	1.6243E+03	1.3342E+03	1.1084E+08	023070
9.2533E+07	7.7506E+0	6.5373E+07	5.5293E+07	2.5667E+07	1.2867E+07	023080
6.8292E+06	3.7546E+0	2.1478E+06	1.2537E+05	7.4485E+05	4.5009E+05	023090
2.7584E+05	1.7049E+0	1.0667E+05	6.7105E+04	4.2501E+04	2.7076E+04	023100
1.7315F+04	1.1138E+0	7.1826E+03	4.6433E+03	3.0101E+03	1.9560E+03	023110
1.2759E+03	4.3373E+0	5.4575E+02	3.5745E+02	2.5507E+02	1.5476E+02	023120
1.0205E+02	6.7375E+0	4.4544E+01	2.9438E+01	1.9549E+01	1.2977E+01	023130
8.6259F+00	5.7413E+0	3.8264E+00	2.5522E+00	1.7070E+00	1.1421E+00	023140
7.6508E-01	5.1312E-0	3.4454E-01	2.3151E-01	1.5588E-01	1.0503E-01	023150
7.0850E-02	4.7848E-0	3.2350E-02	2.1837E-02	1.4838E-02	1.0066E-02	023160
6.8367E-03	4.6484E-0	3.1540E-03	2.1551E-03	1.4708E-03		023170
7.9976E+15	6.5712E+1	5.3491E+15	4.3093E+15	3.4331E+15	2.7003E+15	023180
2.0420E+15	1.4916E+1	1.0898E+15	7.9649E+14	5.8210E+14	4.2239E+14	023190
3.0735E+14	2.2432E+1	1.6421E+14	1.2055E+14	8.8770E+13	5.4766E+13	023200
4.7545E+13	3.5156E+1	2.6176E+13	1.9619E+13	1.4798E+13	1.1229E+13	023210
8.6208E+12	6.7235E+1	5.2722E+12	4.1813E+12	3.3012E+12	2.5933E+12	023220
2.0268E+12	1.5755E+1	1.2178E+12	9.3585E+11	7.1474E+11	5.4235E+11	023230
4.0849E+11	3.0380E+1	2.2473E+11	1.6532E+11	1.2091E+11	8.7901E+10	023240
6.3505E+10	4.5582E+1	3.1936E+10	2.2330E+10	1.5653E+10	1.0938E+10	023250
7.6583E+09	5.3292E+0	3.7293E+09	2.1845E+09	1.2974E+09	7.7209E+09	023260
4.6510E+08	2.8160E+0	1.7191E+08	1.0959E+08	7.2428E+07	4.9374E+07	023270
3.4567E+07	2.4830E+0	1.8184E+07	1.3579E+07	1.0310E+07	7.3278E+06	023280
6.1979E+06	4.8897E+0	3.8904E+06	3.1193E+06	2.5203E+06	2.0602E+06	023290
1.6930E+05	1.3983E+0	1.1604E+06	9.5737E+05	4.1924E+05	1.9734E+05	023300
9.8735F+04	5.1460E+0	2.7734E+04	1.5421E+04	8.7105E+03	5.0104E+03	023310
2.9259E+03	1.7245E+0	1.8296E+03	6.1852E+02	3.7423E+02	2.2785E+02	023320
1.3931F+02	8.5796E+0	5.2876E+01	3.2713E+01	2.0296E+01	1.2627E+01	023330
7.8970E+00	4.3361E+0	3.0952E+00	1.9445E+00	1.2241E+00	7.7245E-01	023340
4.8820E-01	3.0901E-0	1.9589E-01	1.2435E-01	7.9069E-02	5.0347E-02	023350
3.2106E-02	2.0503E-0	1.3113E-02	8.4095E-03	5.2887E-03	3.4612E-03	023360
2.2241E-03	1.4335E-0	5.2436E-04	5.9649E-04	3.9581E-04	2.4973E-04	023370
1.6185E-04	1.0503E-0	6.8238E-05	4.4392E-05	2.8915E-05	1.8857E-05	023380

2.8691E+07	2.7438E+07	2.6241E+07	2.5095E+07	2.4000E+07	2.2783E+07	023730
2.1627E+07	2.0530E+07	1.9439E+07	1.8509E+07	1.7509E+07	1.6105E+06	023740
5.7580E+06	3.5759E+06	2.7500E+06	1.6011E+06	1.0909E+06	7.4322E+05	023750
5.0637E+05	3.4590E+05	2.4436E+05	1.7308E+05	1.2259E+05	5.5829E+04	023760
6.1500E+04	4.4466E+04	3.2147E+04	2.3242E+04	1.5804E+04	1.2149E+04	023770
9.7637E+03	5.3505E+03	4.5914E+03	3.3135E+03	2.4000E+03	1.7633E+03	023780
1.2955E+03	9.5144E+02	6.9933E+02	5.1331E+02	3.7750E+02	2.7736E+02	023790
2.0278E+02	1.4972E+02	1.1000E+02	8.1450E+01	6.0311E+01	4.4657E+01	023800
3.7067E+01	2.4485E+01	1.8170E+01	1.3424E+01	9.9402E+00	7.3603E+00	023810
5.4500E+00	4.0792E+00	3.0517E+00	2.2875E+00	1.7008E+00	1.2787E+00	023820
9.5682E-01	7.1598E-01	5.3577E-01	4.0091E-01	3.0000E-01		023830
2.5470E+14	2.0927E+14	1.7035E+14	1.3725E+14	1.0933E+14	3.5597E+13	023840
6.5038E+13	4.7504E+13	3.4707E+13	2.5363E+13	1.9538E+13	1.3452E+13	023850
9.7881E+12	7.1439E+12	5.2296E+12	3.8395E+12	2.8271E+12	2.0626E+12	023860
1.5142E+12	1.1196E+12	8.3363E+11	6.2491E+11	4.7127E+11	3.5762E+11	023870
2.7455E+11	2.1412E+11	1.6790E+11	1.3313E+11	1.0514E+11	3.2590E+10	023880
6.4547E+10	5.0175E+10	3.8795E+10	2.9894E+10	2.2762E+10	1.7272E+10	023890
1.3009E+10	9.6751E+09	7.1570E+09	5.2643E+09	3.8506E+09	2.7994E+09	023900
2.0225E+09	1.4517E+09	1.0171E+09	7.1274E+08	4.9851E+08	3.4833E+08	023910
2.4290E+08	1.5372E+08	1.1077E+08	8.1807E+07	5.6883E+07	3.9435E+07	023920
2.7492E+07	1.9182E+07	1.3237E+07	9.4713E+06	6.9622E+06	5.2366E+06	023930
4.0174E+06	3.1438E+06	2.4958E+06	2.0112E+06	1.6420E+06	1.3530E+06	023940
1.1203E+06	9.5051E+05	8.0427E+05	6.8446E+05	5.8563E+05	5.0617E+05	023950
6.3917E+05	3.9241E+05	3.3415E+05	2.9233E+05	1.6081E+05	3.4054E+04	023960
5.7679E+04	3.5471E+04	2.3652E+04	1.5724E+04	1.0573E+04	7.2081E+03	023970
4.9719E+03	3.4515E+03	2.4214E+03	1.7059E+03	1.2982E+03	3.5992E+02	023980
5.1279E+02	4.4033E+02	3.1650E+02	2.2733E+02	1.6446E+02	1.1888E+02	023990
8.6223E+01	6.2617E+01	4.5574E+01	3.3155E+01	2.4173E+01	1.7659E+01	024000
1.2914E+01	9.4533E+00	6.9272E+00	5.0813E+00	3.7311E+00	2.7424E+00	024010
2.0177E+00	1.4361E+00	1.0955E+00	8.0867E-01	5.9745E-01	4.4179E-01	024020
3.2698E-01	2.4221E-01	1.7959E-01	1.3325E-01	9.8975E-02	7.3574E-02	024030
5.4739E-02	4.0761E-02	3.0378E-02	2.2653E-02	1.6916E-02	1.2639E-02	024040
9.4517E-03	7.0739E-03	5.2987E-03	3.9722E-03	2.9804E-03		024050
6.8000E+11	6.9000E+11	5.8000E+11	5.7000E+11	5.5000E+11	1.1300E+12	024060

2.0200E+12	2.2500E+11	2.9500E+12	4.0400E+12	4.7700E+12	4.8500E+12	024070
4.5400E+12	4.0300E+11	3.2400E+12	2.5200E+12	2.8300E+12	1.5800E+12	024080
1.2200E+12	9.7300E+11	6.0700E+11	3.9000E+11	2.7400E+11	1.6900E+11	024090
1.0300E+11	6.6400E+11	3.8400E+10	2.5500E+10	1.6100E+10	1.1200E+10	024100
7.3300E+09	4.4000E+00	2.4000E+09	1.1000E+03	5.2000E+05	2.0000E+02	024110
9.0000E+07	4.6000E+00	2.7000E+07	1.0000E+07	1.0000E+07	2.2000E+07	024120
7.8000E+07	4.5000E+00	4.5000E+07	3.0000E+07	2.0000E+07	2.0000E+07	024130
1.4000E+07	9.0000E+00	5.0000E+06	2.7000E+05	1.5000E+05	3.0400E+05	024140
5.2200E+05	3.0400E+00	1.7920E+05	1.1050E+05	7.0600E+04	4.6900E+04	024150
3.2000E+04	2.2400E+00	1.6000E+04	1.1750E+04	9.7400E+03	6.5800E+03	024160
5.0550E+03	3.3160E+00	3.0610E+03	2.4140E+03	1.9100E+03	1.5430E+03	024170
1.2400E+03	1.0160E+00	9.3100E+02	6.8200E+02	2.7600E+02	1.2240E+02	024180
5.7800E+01	2.0510E+00	1.4570E+01	7.7000E+00	4.1400E+00	2.2690E+00	024190
1.2600E+00	7.1100E+00	4.0540E+01	2.3270E+01	1.3460E+01	7.8410E+02	024200
4.0000E+02	7.7010E+00	1.5950E+02	9.4540E+03	5.6100E+03	3.3490E+03	024210
2.0000E+03	1.2020E+00	7.2300E+04	4.3550E+04	2.6290E+04	1.5910E+04	024220
9.6400E+05	5.8600E+00	3.5640E+05	2.1710E+05	1.3250E+05	3.1010E+05	024230
4.9500E+05	3.0410E+00	1.8670E+06	1.1430E+06	7.0820E+07	4.3700E+07	024240
2.7000E+07	1.6710E+00	1.0350E+07	6.4250E+03	3.9920E+08	2.4840E+08	024250
1.5400E+09	9.5600E+00	6.0360E+09	3.7750E+03	2.3660E+03	1.4840E+09	024260
9.3200E+10	5.8660E+11	3.6950E+10	2.3310E+10	1.4720E+10		024270
2.5400E+12	2.0920E+11	1.7030E+12	1.3720E+12	1.0930E+12	3.5990E+11	024280
6.5000E+11	4.7500E+12	3.4700E+11	2.5360E+11	1.0530E+11	1.3450E+11	024290
9.7800E+10	7.1430E+11	5.2290E+10	3.8190E+10	2.8270E+10	2.0620E+10	024300
1.5140E+10	1.1190E+11	8.3360E+09	6.2400E+09	4.7120E+09	3.5760E+09	024310
2.7450E+09	2.1410E+00	1.6790E+09	1.3300E+09	1.0510E+09	3.2590E+08	024320
6.4540E+08	5.0170E+00	3.8700E+06	2.9800E+03	2.2700E+08	1.7270E+08	024330
1.3000E+03	9.5750E+00	7.1570E+07	5.2600E+07	3.8500E+07	2.7990E+07	024340
2.0220E+07	1.4510E+00	1.0170E+07	7.1270E+06	4.9850E+06	3.4830E+06	024350
2.4390E+06	1.6970E+00	1.1870E+06	8.3710E+05	5.9530E+05	4.2180E+05	024360
3.0020E+05	2.1270E+00	1.5010E+05	1.0910E+05	3.1490E+04	5.2150E+04	024370
4.8310E+04	3.9270E+00	3.0730E+04	2.5000E+04	2.0650E+04	1.7180E+04	024380
1.4490E+04	1.2300E+00	1.0490E+04	9.0110E+03	7.7730E+03	5.7720E+03	024390
5.9210E+03	5.1950E+00	4.5730E+03	4.0370E+03	2.2920E+03	1.3830E+03	024400

8.7310E+02	5.5749E+00	7.7735E+02	2.5775E+02	1.7763E+02	1.7408E+02	024410
8.7630E+01	6.2268E+00	4.4598E+01	3.2212E+01	2.3334E+01	1.5981E+01	024420
1.2391E+01	3.0860E+00	6.6745E+00	4.9113E+00	3.6211E+00	2.5743E+00	024430
1.9813E+00	1.4697E+01	1.0915E+00	8.1157E-01	5.0430E-01	4.5076E-01	024440
3.3656E-01	2.5153E-02	1.6817E-01	1.4037E-01	1.0560E-01	7.9223E-02	024450
5.9489E-02	4.4712E-03	3.3537E-02	2.5335E-02	1.3099E-02	1.4409E-02	024460
1.0480E-02	8.2219E-04	6.2183E-03	4.7063E-03	3.5657E-03	2.7034E-03	024470
2.0513E-03	1.5577E-04	1.1838E-03	9.0041E-04	5.9539E-04	5.2212E-04	024480
3.9806E-04	3.0372E-05	2.3102E-04	1.7722E-04	1.3553E-04		024490
7						024500
METHANE - C44		1	120.			024510
CARBON MONOXIDE - CO2		2	700.			024520
WATER VAPOR - H2O		3	700.			024530
NITRIC OXIDE - NO		4	700.			024540
NITROUS OXIDE - N2O		5	150.			024550
OTONE - O3 PRE-PA44		6	700.			024560
OTONE - O3 NOON		7	700.			024570
MOL NO DEN - ICAO ST A		8	700.			024580
TEMP - ICAO STD. AT401		1	700.			024590
METHANE - CH4			04	15.10	1.0000E-15	024600
51	8.0000E+10					024610
31	1.3062E+13					024620
31	3.0184E+13					024630
21	1.5268E+13					024640
201	1.8500E+12			1.5000E+16		024650
301	3.2000E+12			4.0000E+13		024660
401	2.4000E+10			3.5000E+15		024670
302	1.0000E-12			1.9000E+15		024680
CARBON MONOXIDE - CO2			18	44.0		024690
06	-12.70	.10	-14.59	.12	-14.21	.14
0.	-12.07	400.	-13.32	800.	-12.471230.	-12.222000.
09	-12.53	.11	-14.02	.13	-14.44	.15
12					-14.80	.17
21					-15.05	.19
						024730
						024740

11	5.2353E+13	3.0000E-02	025090
11	5.3331E+13	3.0000E-02	025100
201	1.0610E-27	5.6000E+15	025110
301	5.5903E-70	3.5000E+16	025120
401	3.6200E-19	5.1000E+16	025130
501	7.9940E-28	5.4000E+16	025140
302	3.6190E-31	5.2000E+15	025150
402	3.9090E-34	1.2000E+16	025160
502	4.9000E-32	1.5000E+16	025170
602	7.7903E-33	3.3000E+16	025180
702	1.5000E-32	5.0000E+15	025190
802	3.3003E-31	5.4000E+16	025200
603	7.0000E-34	4.9000E+15	025210
601	2.0000E-32	9.3000E+16	025220
701	1.8300E-30	1.2000E+17	025230
801	3.0600E-39	1.2500E+17	025240
NITRIC OXIDE - NO			2.0000E+15
11	0.0000E+10	1.6961E+00	025260
11	1.6790E+13	1.6792E+00	025270
11	3.7270E+13	1.6605E+00	025280
201	5.0000E-28	6.7000E+15	025290
301	3.5003E-30	5.4000E+16	025300
302	1.2703E-31	8.4000E+15	025310
NITROUS OXIDE - N2O			2.5000E+15
11	0.0000E+10	4.1901E-01	025330
21	5.8890E+12	4.0000E-01	025340
31	1.1730E+13	4.0000E-01	025350
41	1.7583E+13	4.0000E-01	025360
51	2.3395E+12	4.0000E-01	025370
11	2.2235E+13	4.0000E-01	025380
11	1.2650E+13	4.0000E-01	025390
201	3.3000E+11	3.4000E+16	025400
701	2.6000E+12	3.0000E+15	025410
601	1.3560E+13	1.6000E+16	025420
2.5000E+16			
1.3000E+15			
1.3000E+14			

PROGRAM SPCTRA

Purpose: SPCTRA computes the spectral radiances in the 5 to 25 μm interval corresponding to the band radiances computed by BCKGND. The input data to SPCTRA are the molecular band line constants used by, and vibrational population and band radiance data generated by BCKGND. In its present form, SPCTRA computes spectral radiances between 2.5 and 25 μm for limb views and endo-atmospheric zenith angles of 0 and 90 degrees at 5 km intervals between 60 and 200 km.

Program Flow: When program execution begins, values are assigned to the integer variables NOUT, NLN and NALT and the Subroutine ROTATE, which reads in data for the molecular lines, is called. The outer DO range ending with Statement 500 is entered. The DO parameters are fixed at present to produce two sets of spectra, using night and day input from Program BCKGND. The program may be made more flexible by reading in DO parameters prior to execution of the DO statement. The variable BLAM is set to 5.0 and the outer DO range ending with Statement 105 is entered. The effect of the first two statements is to set up a table of wave numbers at 2 cm^{-1} intervals between 2.5 and 25 μm in real array AVLAM. These are the finest wave numbers at which spectral radiances may be printed out. The inner DO range ending with Statement 105 sets the values of output spectral radiances equal to zero.

The DO range ending with Statement 110 sets temperature values in array TEMP to those corresponding to the U.S. Standard Atmosphere, 1962. Temperature values may also be read in prior to execution of the first DO statement. Following final execution of this DO range, temperatures are printed out.

Next, the number of molecular species is read in and stored in integer variable NSPTOT. The outer DO range ending with Statement 400 is entered and executed NSPTOT times. Within this DO range, molecular vibrational level and band data and vibrational population data are read in and mean temperatures and total number of molecules per unit area in the vertical and horizontal directions are computed for each vibrational state. Total band radiances corresponding to limb viewing and vertical and horizontal endo-atmospheric viewing are read in. Relative line radiances are computed and normalized to the total band radiances. The spectra corresponding to the normalized line radiances are computed and stored in arrays SPECA, SPECB and SPECC. Details of these computations are given below.

The code number of the species ISP is read in. The number of vibrational levels NLEVEL, the number of bands NBAND and the molecular weight RM are read in. In the DO range ending with Statement 210, the level description codes LSC and LCC, the energy and the mean rotational constant for each vibrational level are read in. In the DO range ending with Statement 220, the band description codes LBC and LBU and the band strength for each band are read in. The number of altitudes NALT for which vibrational populations are computed for the species and the number of altitudes NRLEV for which band radiances are computed by BCKGND are read in. Vibrational level populations are read in and stored in array CON.

The mean temperatures and total number of molecules per square centimeter in the vertical and horizontal directions at 5 km intervals between 60 and 200 km are determined in the DO range ending with Statement 129. The product of temperature and vibrational level population is computed in the DO range ending with Statement 112.

The integrals of total number of molecules and the product of temperature and number density in the vertical direction are computed in the DO range ending with Statement 120. Simpson's rule integration is used. The total number of molecules in a given vibrational level above a given altitude is stored in array COLCNT. The corresponding mean temperatures, obtained by dividing the integral of the product of temperature and number density by the integral of number density, are stored in array AVTEMP. After exit from DO range, the column counts and temperatures are printed out.

The DO range ending with Statement 128 performs a similar computation for column counts and mean temperatures in the horizontal direction. The integrations required are performed in Function QINT. Upon exit from this DO range, column counts stored in array HORCNT and mean temperatures stored in array BVTEMP are printed out.

The inner DO range ending with Statement 400 is now entered and executed for each band. This DO range controls the computation of the spectra.

The altitude HT, the limb band radiance RADC, and endo-atmospheric radiances RADA (upward direction) and RADB (horizontal direction) are read in the DO range ending with Statement 230. Band information is computed from band and level constants. A test is made on the species code ISP to determine whether the molecule is linear or non-linear.

Following the test of ISP, if the molecule is linear and is not in McClatchey's tabulation, line positions are computed in Subroutine ROTPOS. The DO range ending with Statement 250 is entered and executed for each of the twenty altitudes for which spectra are computed. Line

radiances are computed in Subroutine ROTSTR for vertical endo-atmospheric viewing. Successive calls to Subroutine FILTER compute the spectral contributions from lines in the P, Q and R branches. The sequence of calls to ROTSTR and FILTER is repeated for endo-atmospheric viewing in the horizontal direction and for limb viewing. Upon exit from this DO range, control is transferred to Statement 280.

If the test on ISP determines that the molecular line data is available, control is transferred to Statement 250 and the DO range ending with Statement 270 is executed for each of the 28 altitudes for which spectra are computed. Spectra are generated from the line radiances by calls to Subroutine WATSTR and FILTER, for each of the three viewing conditions.

Following the final execution of the DO ranges ending with Statement 400, the spectra are printed out in the order endo-atmospheric viewing in the upward direction, endo-atmospheric viewing in the horizontal direction and limb viewing.

Upon final execution of the DO range ending with Statement 500, the program halts with a STOP statement.

Mnemonic Variables:

AVLAM	real array in which output wave numbers are stored
AVTEMP	real array in which mean temperatures in the vertical direction are stored
BV	real array in which rotational constants for each vibrational level are stored
BVTEMP	real array in which mean temperatures in the horizontal direction are stored

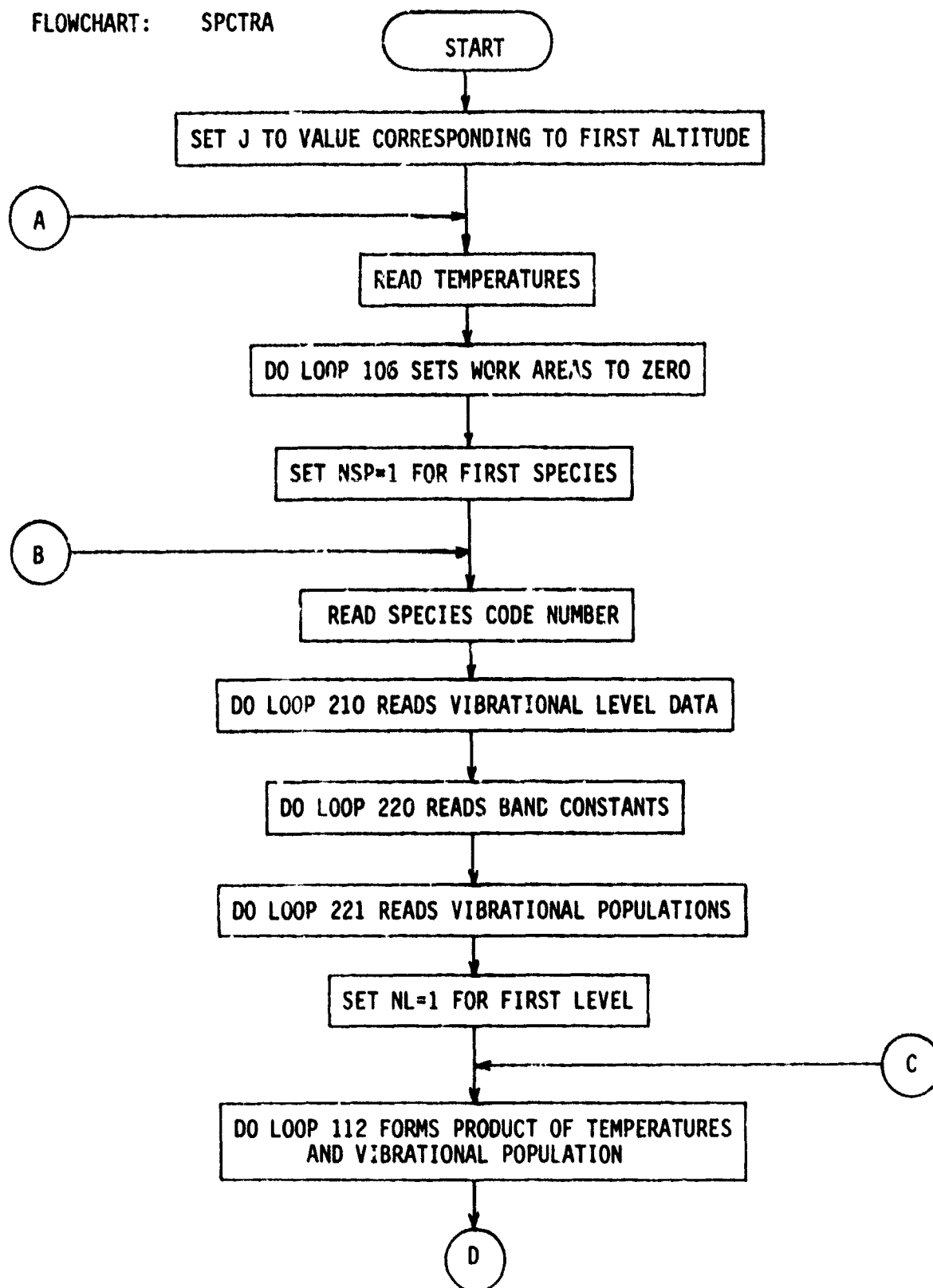
COLCNT	real array in which total number of molecules per square centimeter above 60, 65, ... 200 km in each vibrational level are stored
CON	real array in which number densities for each vibrational level are stored
HHOLAM	real array in which wave numbers of band lines are stored
HHOLSE	real array in which lower state energies of band lines are stored
HHOSTR	real array in which strengths of lines are stored
HORCNT	real array in which total number of molecules per square centimeter in each vibrational level in the horizontal direction at altitudes 60, 65, ... 200 km are stored.
HRAD	real array in which line radiances are stored
P	real array in which wavelengths of P branch of linear molecule are returned by Subroutine ROTPOS
PRAD	real array in which products of number density and temperature are stored
PS	real array in which P branch line radiances are returned by Subroutine ROTSTR
Q	real array in which Q branch line wavelengths are returned by Subroutine ROTPOS
QS	real array in which Q branch line radiances are returned by Subroutine ROTSTR
R	real array in which R branch line wavelengths are returned by Subroutine ROTPOS
RADA	real array into which vertical direction and endo-atmospheric band radiances are read
RADB	real array into which horizontal direction endo-atmospheric band radiances are read
RADC	real array in which limb view band radiances are read
RCM	real array into which vibrational level energies are read
ROTEA	real array used by Subroutines ROTATE and WATSTR, stores factors needed to compute line radiances in water vapor pure rotational spectrum

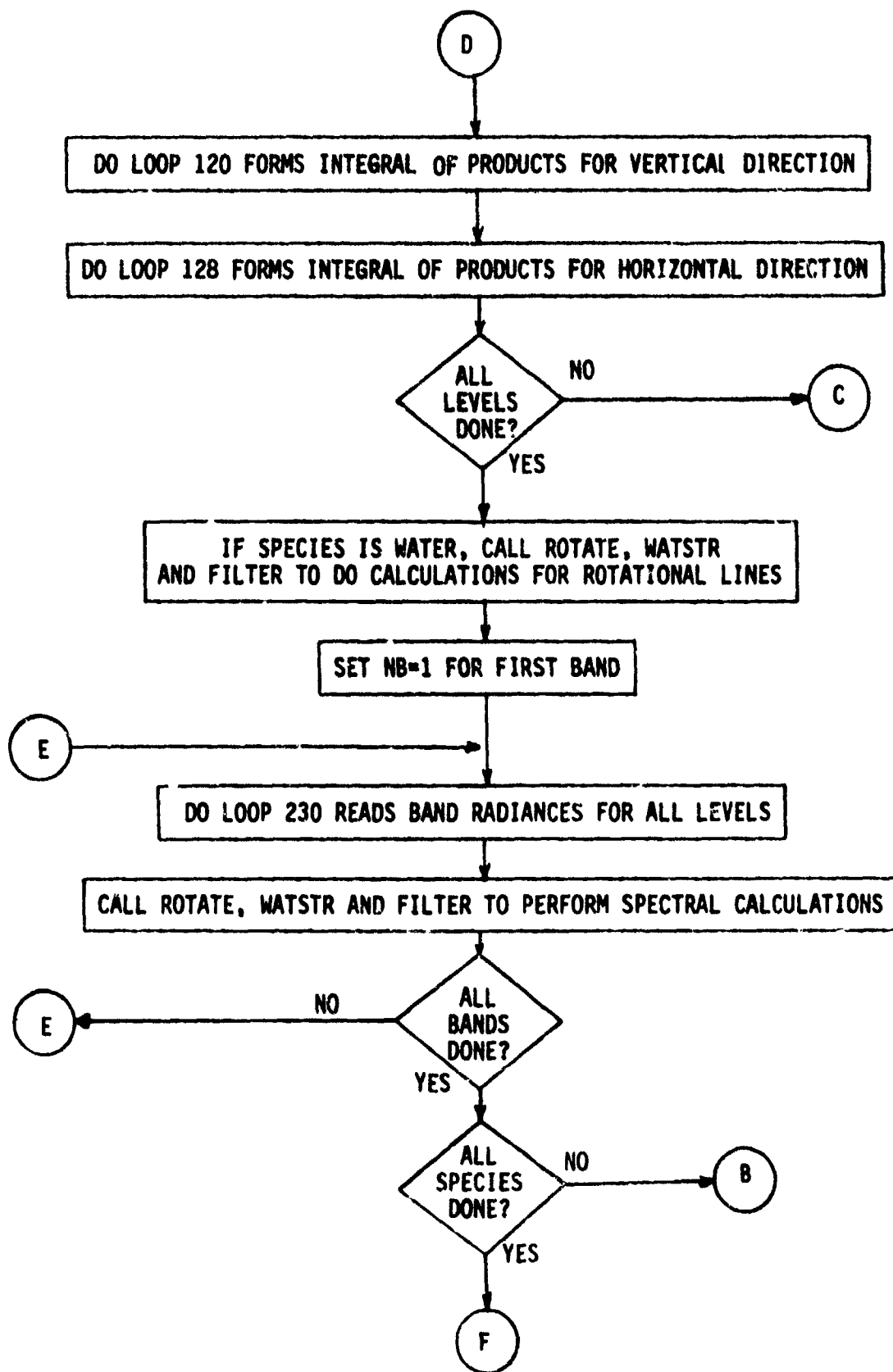
ROTLAM	real array in which water vapor pure rotational line wavelengths are stored
ROTLSE	real array in which lower state energies of water vapor pure rotational lines are stored
ROTST	real array in which absorption strengths of water vapor pure rotational lines are stored
RS	real array in which R branch line radiances are returned by Subroutine ROTSTR
SPECA	real array in which spectral radiances for vertical viewing endo-atmospheric geometry are generated
SPECB	real array in which spectral radiances for endo-atmospheric horizontal viewing are generated
SPECC	real array in which spectral radiances for limb viewing are generated
STR	real array used to store band strengths
TEMP	real array used to store atmospheric temperatures
BLAM	real variable used as temporary storage during generation of values in array AVLAM
CENTER	real variable used to store wave number of band center
HT	real variable into which altitudes at which band radiances are computed by BCKGND are read
H1, H2, H3, H4, H5	real variables used to store distance increments used in computing total column counts and mean temperatures in the horizontal direction
RBASE	real variable used to store distance of base altitude from center of earth in computing horizontal column counts
RB2	real variable used to store value of $RBASE^{**2}$
RM	real variable used to store value of molecular weight
RTOP	real variable used to store distance from center of earth of given altitude level
SNB	real variable used to store current value of band strength
STH	real variable used as temporary storage in computing horizontal column counts

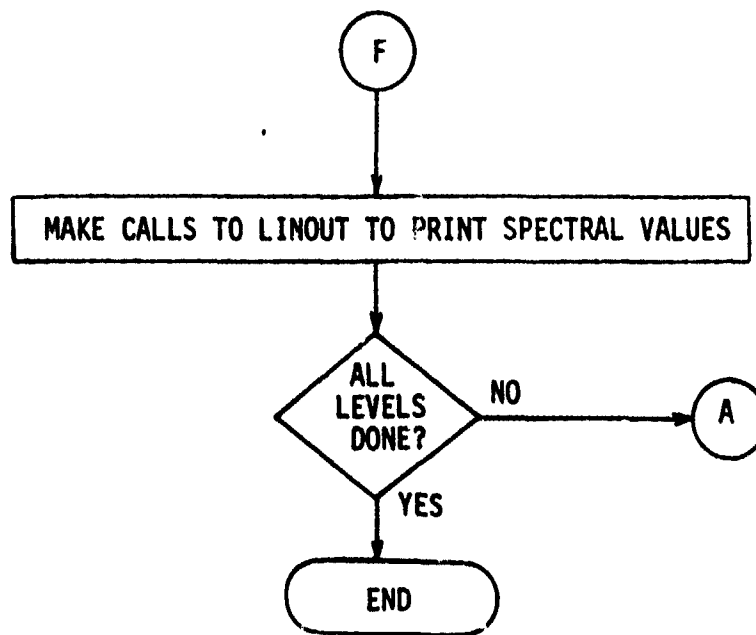
SVH	real variable used as temporary storage in computing horizontal column counts
TC	real variable used to accumulate integral of number density in computing vertical column counts
TCH	real variable used to accumulate integral of number density in computing horizontal column counts
TP	real variable used to accumulate integral of product of temperature in the vertical direction
TPH	real variable used to accumulate integral of product of temperature and number density in computing mean temperature in the horizontal direction
LBC	integer array storing level numbers of initial and final states of a band
LBU	integer array storing band type and symmetry information
LCC	integer array storing vibrational level information
LSC	integer array storing vibrational level information
I	integer variable used as index in DO loops
ISP	integer variable into which species identification code is read (2 for CO ₂ , 3 for H ₂ O, 4 for NO, 5 for N ₂ O and 6 or 7 for ozone)
J	integer variable used as index in DO loops
K	integer variable (set equal to 28 in current program) used as final parameter in DO statement controlling computation of column counts and mean temperatures. The value of K is the number of altitudes for which spectra are computed
KB	integer variable used to store band type code
KK	integer variable used as final parameter in DO range ending with Statement 125, computed from K and I
KL	integer variable used to store band symmetry code
NA	integer variable used as altitude level index in computing horizontal column counts
NALT	integer variable storing total number of altitude levels

NB	integer variable used as index for number of current band
NBAND	integer variable storing total number of bands considered for a given species
NBC	integer variable used to store current value of LBC
NCASES	integer variable used as index for spectrum set
NF	integer variable used as index for lower vibrational state of band
NI	integer variable used as index for upper vibrational state of band
NL	integer variable used as index for vibrational level number
NLEVEL	integer variable in which is stored total number of vibrational levels for a molecular species
NLN	integer variable controlling number of lines treated in each branch of a band of a linear molecule, set to 100 in current program
NRLEV	integer variable into which is read number of altitudes at which band radiances for a given species are computed by BCKGND
NSP	integer variable used as index for DO range executed NSPTOT times
NSPTOT	integer variable into which is read total number of species to be included in a spectrum
NZ	integer variable used as altitude index in DO loops

FLOWCHART: SPCTRA







Subroutine FILTER

Purpose: FILTER computes the contribution to spectral radiance from each line in a band or sub-band, in the interval 2.5 μm to 25 μm . Provision is made for varying resolution in either wavelength or wave number space. Sufficient storage is provided to compute radiances at two wave number intervals with triangular slit resolution of five wave numbers.

Method: FILTER searches an array of emission line strengths and assigns a weighted strength to an output wave number or wavelength.

Program Flow: The outer DO range ending with Statement 150 controls the distribution of spectral radiance from the Ith of N given lines, and computes the indexes JS and JF of the first and last output points in array SPEC to which a given line contributes. The inner DO range ending with Statement 120 computes the contribution of a given line to spectral radiance at output wavelengths or wave numbers.

Inputs: RAD, WVLTH, N, KOMPUT

Output: SPEC

MNEMONIC VARIABLES

SPEC	real array into which spectra radiances are added at regular intervals between 2.5 and 25 μm or 400 and 4000 wave numbers.
RAD	real array containing radiances of individual lines
WVLTH	real array containing wavelengths of individual lines

N	integer variable containing number of lines in band or sub-band for which spectral radiance is to be computed
KOMPUT	integer variable which determines number of output spectral points and whether wavelength or wave number output is made
RADT	real variable used as temporary storage for radiance value of a single line
RLAM	real variable used as temporary storage for wavelength value at which spectral radiance is computed
RT	real variable used as temporary storage for wavelength of a single line
I	integer variable used as index for outer DO loop which treats each line in turn
J	integer variable used as index for inner DO loop which assigns spectral contribution of each line to output wavelength
JF	integer variable used as final parameter in inner DO loop, index of greatest output wavelength for a given line
JS	integer variable used as initial parameter in inner DO loop, index for shortest output wavelength for a given line

Subroutine ROTATE

Purpose: Subroutine ROTATE is used to read in spectral line data from the compilation of McClatchey, et al. The input data consists of line positions and strengths for vibrational - rotational bands of water, carbon dioxide, ozone and nitrous oxide, and for the pure rotational spectrum of water. This data is processed for use by other subroutines.

Program Flow: The DO range ending with Statement 110 reads in data on the strongest lines in a vibration - rotation band. This data consists of the wave number of the line, the line strength at 296 K and the wave number of the lower rotational state. ROTATE converts the wave number to wavelength in μm stored in array HHOLAM, converts the line strength to units $\text{cm}^{-1}/\text{atm-cm}$ at 273.15 K stored in array HHOSTR and stores the wave number of the lower state in array HHOLSE.

The rotational partition function for water vapor is computed next if water vapor data is being read. The DO range ending at Statement 130 is used only for water vapor pure rotational lines and computes the wavelength (stored in array ROTLAM), Einstein A coefficient (stored in array IA), relative line strength in absorption at 273.15 K (stored in array ROTST), relative line strength in emission at 273.15 K (stored in array ROTEA) and the wave number of the lower rotational state (stored in array ROTLSE).

MNEMONIC VARIABLES

EA	real variable used to store Einstein A coefficient for water vapor pure rotational spectrum line
EALC	real variable used to store intermediate results in computing pure rotational line strengths in emission
EALP	real variable used to store intermediate results in computing pure rotational line strengths in absorption
ENERGY	real variable into which is read wave numbers of pure rotational lines
ENL	real variable into which is read wave numbers of lower states of pure rotational lines
ENV	real variable into which is read wave number of upper state of pure rotational line
HHOLAM	real array in which wavelengths of vibration - rotation band lines are stored
HHOLSE	real array in which wave numbers of lower states of vibration - rotation band are stored
HHUSTR	real array in which line strengths of vibration - rotation band are stored ($\text{cm}^{-2}\text{-}\mu\text{m}^{-1}$ STP)
ROTEA	real array in which pure rotational line strengths in emission (273.15 K) are stored
ROTLAM	real array in which pure rotational line wavelengths are stored
ROTLSE	real array in which lower state wave number of pure rotational lines are stored
ROTST	real array in which pure rotational line strengths in absorption are stored
WVLTH	real array in which wavelengths of vibration - rotation band lines are stored (redundant)
EAFAC	real variable used to store pre-factor in computing Einstein A coefficients for pure rotational lines
QR	real variable in which is stored approximate rotational partition function for water vapor molecule

QRFAC	real variable into which is read pre-factor for computing rotational partition function
RA	real variable into which is stored first water vapor rotational constant
RB	real variable into which is stored second water vapor rotational constant
RC	real variable into which is stored third water vapor rotational constant
TEFAC	real variable in which is stored exponential factor used in converting line intensities at 296 K to line strengths at 273.15 k
TRFAC	real variable in which is stored factor relating rotational function at 296 K to that at 273.15 k
I	integer variable used as index in DO loop
NLINES	integer variable into which is read number of lines included in pure rotational spectrum and in any single vibration - rotation band

Subroutine WATSTR

Purpose: WATSTR computes the radiances of individual lines in vibration - rotation bands and in the pure rotational spectrum of water vapor. The radiances are computed with the assumption that the atmosphere in the line-of-sight may be treated as having uniform temperature. The radiances computed for the vibration - rotation bands are scaled to match the total band radiances produced by the BACKGROUND Program. Absolute radiance values are computed for the water vapor pure rotational spectrum.

Program Flow: Upon entry to WATSTR, a conversion factor TQFAC is computed for later use in computing the effect of charging rotational partition function with temperature. Control is then transferred to the appropriate part of the subroutine as determined by the value of N.

For computation of the radiances of lines in the water vapor pure rotational spectrum ($N=1$), control is transferred to Statement 100. A radiance factor RADFAC and an optical thickness factor TAUFAC are computed. Then the optical thickness and radiance values corrected for optical thickness and induced emission are computed for each line in the DO range ending with Statement 110. Control is returned to the main program. Line constants generated by Subroutine ROTATE are available in the arrays of common area ROTCOM. Radiance values are returned in array HRAD.

Control is transferred to Statement 200 for computation of radiances of lines in the other bands. An optical thickness factor TAUFAC and factor TEFAC used in computing populations of rotational states at temperature T

are computed. The variable SUM, used to accumulate the sum of relative radiances, is set to zero. In the DO range ending with Statement 210, the optical thickness of each line is computed and the relative radiance value, corrected for optical thickness, is computed and stored in array HRAD. The sum relative radiances is accumulated in SUM. Upon exit from this DO range, the total radiance RAD is divided by SUM and stored in RADFAC. In the DO range ending with Statement 220, absolute radiance values are obtained and stored in array HRAD. Control is then returned to the main program.

MNEMONIM VARIABLES

RAD	real variable containing total band strength for vibration - rotation band
RM	real variable containing molecular weight of molecule
T	real variable containing value of temperature
DEN	real variable containing total number of ground state molecules per square centimeter in line-of-sight
N	integer variable determining whether entry to WATSTR re- sults in computation for water vapor pure rotational spectrum (N=1) or other band (N=2).
HHO:AM	real array, values as in ROTATE
HHOLSE	real array, values as in ROTATE
HHOSTR	real array, values as in ROTATE
HRAD	real array used to return radiance values of individual lines
ROTEA	real array, values as in ROTATE
ROTLAM	real array, values as in ROTATE
ROTLSE	real array, values as in ROTATE
ROTST	real array, values as in ROTATE
HSTR	real variable used as temporary storage in computing optical thickness

RADFAC	real variable in which is stored pre-factor used in computing radiance values
SUM	real variable in which partial sums of relative radiances are accumulated
TAU	real variable in which optical thickness at line center is generated
TAUFAC	real variable in which pre-factor for optical thickness is stored
TEFAC	real variable in which factor used in computing rotational populations is stored
TQFAC	real variable in which factor converting rotational partition function is stored

Subroutine ROTSTR

Purpose: Subroutine ROTSTR computes the relative radiances of lines in the vibration - rotation bands of those linear molecules, which are not included in the line parameter compilation of McClatchey, et al. The radiances are corrected for effects of optical thickness, and absolute values then determined by normalizing to total band radiances computed by the BACKGROUND Program. As for non-linear molecules, a single temperature is assumed for the molecules in the line-of-sight.

Program Flow: Upon entry to ROTSTR, the reduced rotational temperature SIG is computed, relative strengths of the P, Q and R lines for $J=0$ are assigned and values assigned to the increment of J values DJ and the variable J value AJ. Depending on the value of NP, relative strengths of rotational lines are computed in either the DO range ending with Statement 110 (parallel transition) or the DO range ending with Statement 120 (perpendicular transition). Control is transferred to Statement 300 and the pre-factor TAU_FAC used in computing optical thickness is evaluated. The variable SUM which accumulates the sum of relative radiances is set to zero. In the DO range ending with Statement 310, optical thicknesses for lines in P, Q and R branches and relative radiances for these lines, corrected for the effects of optical thickness, are computed. In the DO range ending with Statement 320, absolute line radiances normalized to the total band radiance RAD are computed. Control is then returned to the main program.

MNEMONIC VARIABLES

RAD	real variable containing total band strength
RM	real variable containing molecular weight of molecule
BVPP	real variable containing mean rotational constant of lower vibrational state
AJ	real variable containing varying value of rotational quantum number J of lower vibrational state
DJ	real variable containing value of increment of rotational quantum number
T	real variable containing mean temperature of emitting layer
DEN	real variable containing number of molecules in lower state per square centimeter in line-of-sight
STR	real variable containing band strength at 300 K
PS	real array in which radiances of lines in P branch are returned
QS	real array in which radiances of lines in Q branch are returned
RS	real array in which radiances of lines in R branch are returned
NP	integer variable determining whether band is parallel (NP=1) or perpendicular (NP=2)
ND	integer variable determining whether all lines are present (ND=1) or alternate lines are missing (ND=2)
P	real array containing wavelengths of lines in P branch
Q	real array containing wavelengths of lines in Q branch
R	real array containing wavelengths of lines in R branch
FAC	real variable used to store exponential factor in computation of line strengths
PTAU	real variable storing optical thickness in a P branch line
QTAU	real variable storing optical thickness in a Q branch line
RTAU	real variable storing optical thickness of R branch line

SIG	real variable storing reduced rotational temperature
SUM	real variable which accumulates sum of relative line radiance
TAUFAC	real variable storing pre-factor used in computing optical thickness at line centers

Subroutine ROTPOS

Purpose: ROTPOS computes the wavelength of lines in the P, Q and R branches of the infrared vibrational - rotational bands of linear molecules neglecting spin and Λ or ℓ doubling. It is used for bands not included in the compilation of McClatchey, et al.

Method: The line positions are computed using Equations (IV, 19), (IV, 20) and (IV, 22) of Herzberg (1945). It should be noted that use of these simple formulae results in an error in line positions which may approach 0.1 μm for large J values in transitions between doublet states.

Program Flow: Upon entry to ROTPOS, the auxiliary values BDIF, BSUM, RCENT and TRI used in the computation are computed from the band center position and the rotational constants. The initial J value is set to zero and provisions made for omitting alternate lines by setting DJ equal to ND. This latter starting condition means that the alternate lines omitted are always those with odd J values. The wavelengths of 100 lines in each branch in units μm are then computed in the DO range ending with Statement 110. The wavelengths are printed out and control returned to the main program.

MNEMONIC VARIABLES

AJ	real variable in which current rotational quantum number J is stored
BDIF	real variable storing difference of rotational constants BVP and BVPP
BSUM	real variable storing sum of rotational constants

DJ	real variable storing increment of rotational quantum number
RCENT	real variable containing constant used in computing R branch line positions
TRI	real variable containing constant used in computing R branch line positions
CENTER	real variable giving the wave number of the band center
BVP	real variable giving the mean rotational constant of the upper vibrational state
BVPP	real variable giving the mean rotational constant of the lower vibrational state
P	real array in which wavelengths of the P branch are returned
Q	real array in which wavelengths of the Q branch are returned
R	real array in which wavelengths of the R branch are returned
ND	integer variable determining whether all lines in a band are present (ND=1) or whether alternate lines are missing (ND=2)

[illegible]

```

DO 221 NZ = 1, NALT
  READ (1,42) (CON(NZ,NL), NL = 1, NLEVEL)
221 CONTINUE
  C      COMPUTE MEAN TEMPERATURES AND COLUMN COUNTS
    K = NRLEV
    DO 129 NL = 1, NLEVEL
      DO 112 I = 1, NALT
        PROD(I) = CON(I,NL)*TEMP(I)
112 CONTINUE
        NA = NALT
        DO 120 I = 1, K
          IF (I.EQ. 1) TP = SIMP(PROD(NA-2),2.0E+5,2)
          IF (I.GT. 1) TP = TP + SIMP(PROD(NA-1),2.0E+5,1)
          IF (I.EQ. 1) TC = SIMP(CON(NA-2,NL),2.0E+5,2)
          IF (I.GT. 1) TC = TC + SIMP(CON(NA-1,NL),2.0E+5,1)
          COLCNT(K - I + 1,NL) = TC
          AVTEMP(K - I + 1,NL) = TP/TC
          NA = NA - 1
120 CONTINUE
          HORCNT(I,NL) = 0.0
          RBASE = 6.431E+8
          DO 128 I = 1, K
            NA = NALT
            RB2 = RBASL RBASE
            RTOP = 6.431E+8 + NALT*2.0E+5
            SVH = SQRT(RTOP*RTOP - RB2)
            KK = K - I + 1
            DO 125 JK = 1, KK
              RTOP = RTOP - 2.0E+5
              STH = SQRT(RTOP*RTOP - RB2)
              H5 = SVH - STH
              SVH = STH
              RTOP = RTOP - 2.0E+5
              STH = SQRT(RTOP*RTOP - RB2)

```

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000990
001000
001010
001020
001030

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C
H4 = SVH - STM
SVH = STM
IF (JK .EQ. 1) TP4 = JINT(PPOD(NA-2), H4, H5, 2)
IF (JK .GT. 1) TPR = TPR + JINT(PPOD(NA-1), H4, H5, 1)
IF (JK .EQ. 1) TCH = JINT(CCN(NA-2, NL), H4, H5, 2)
IF (JK .GT. 1) TCH = TCH + JINT(CCN(NA-1, NL), H4, H5, 1)
NA = NA - 1
RTP = RTP + 2.0E+5
CONTINUE
HORCNT(I, NL) = TCH
BVTEMP(I, NL) = TPR/TCH
RBASE = PRASE + 2.0E+5
CONTINUE
CONTINUE
IF (ISP .NE. 3) GO TO 225
CNTR = 2.0*HORCNT(J, 1)
CALL POTATE (5, LINES)
POTATE WILL READ FROM TAPES
CALL WATSTR (RADC(J), RM, BVTEMP(J, 1), CNTR, 1, LINES)
CALL FILTER (SPEC, HRAD, WVNUM, LINES)
CALL WATSTR (RADA(J), RM, BVTEMP(J, 1), COLCNT(J, 1), 1, LINES)
CALL FILTER (SPEC, HRAD, WVNUM, LINES)
CALL WATSTR (RADB(J), RM, BVTEMP(J, 1), HORCNT(J, 1), 1, LINES)
CALL FILTER (SPEC, HRAD, WVNUM, LINES)
CONTINUE
DO 400 NB = 1, NBAND
PO 230 I = 1, NRLEV
READ (1, 43) HT, RACC(I), RADA(I), RADP(I)
CONTINUE
NBO = LBO(NB)
NI = MOD(NBO/100, 100)
NF = MOD(NBO, 100)
PRINT *, J, ISP, NB, NI, NF, BVTEMP(J, NF), HORCNT(J, NF)
IF (NB .GT. 10 .AND. ISP .EQ. 3) GO TO 400

```

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001280
001290
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001370
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001390
001400

```

CALL ROTATE (5,LINES)	001410
CALL MATSTR (RADC(J),RM,BVTEMP(J,NF),2.0*HORCNT(J,NF),2,LINES)	001420
CALL FILTER (SPEC,HRAD,WVNUM,LINES)	001430
CALL MATSTR (RADA(J),RM,AVTEMP(J,NF),COLCNT(J,NF),2,LINES)	001440
CALL FILTER (SPEC,HRAD,WVNUM,LINES)	001450
CALL MATSTR (RADB(J),RM,BVTEMP(J,NF),HORCNT(J,NF),2,LINES)	001460
CALL FILTER (SPEC,HRAD,WVNUM,LINES)	001470
CONTINUE	001480
WRITE (2,16)	001490
CALL LINCUT (SPEC,4,KALT,1801)	001510
CALL LINCUT (SPEC,5,KALT,1801)	001540
CALL LINCUT (SPEC,7,KALT,1801)	001570
CALL SECCND (SECB)	001600
SFCC = SECB - SECA	001610
WRITE (2,*) SECC,SECA,SECB	001620
CONTINUE	001630
STOP	001640
FORMAT (E16)	001650
FORMAT (1PE11.3)	001660
FORMAT (1X)	001670
FORMAT (1PE12.4)	001680
FORMAT (1H1)	001690
FORMAT (2I6,5E12.4)	001700
FORMAT (1P7E11.4)	001710
FORMAT (F5.0,1PE14.4,13X,E12.4,60X,F12.4)	001720
END	001730

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001870

```

FUNCTION SIMP (A,H,K)
  DIMENSION A(3)
  IF (K - 2) 100,110,120
  CONTINUE
  SIMP = (8.0*A(2) + 5.0*A(1) - A(3))*H/12.0
  RETURN
  CONTINUE
  SIMP = (8.0*A(2) + 5.0*A(3) - A(1))*H/12.0
  RETURN
  CONTINUE
  SIMP = (4.0*A(2) + A(1) + A(3))*H/3.0
  RETURN
END
100
110
120

```

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001970
001980
001990
002000
002010
002020
002030
002040
002050

```

FUNCTION QINT (A,H1,H2,K)
  DIMENSION A(3)
  IF (H1*H2 .EQ. 0.0) STOP "QINT"
  HS = H1 + H2
  IF (K - 2) 100,110,120
100 CONTINUE
  QINT = ((A(2)*HS - A(1)*H2 - A(3)*H1)*H1/(6.0*H2*HS)
    1 + (A(1) + A(2))*0.5)*H1
    RETURN
110 CONTINUE
  QINT = ((A(2)*HS - A(1)*H2 - A(3)*H1)*H2/(6.0*H1*HS)
    1 + (A(2) + A(3))*0.5)*H2
    RETURN
120 CONTINUE
  QINT = (A(2)*HS - A(1)*H2 - A(3)*H1)*(H1**3 + H2**3)
    1 / (6.0*HS*H1*H2) + (A(1)*H1 + A(2)*HS + A(3)*H2)*0.5
    RETURN
  END

```

```

SUBROUTINE WATSTR (RAD,RM,T,DEN,N,LINES)
COMMON /ISFCOM/ ISP
COMMON WVNUM(2500),ENLS(2500),STP(2500),HRAC(2500)
TQFAC = (296.0/T)**1.5
IF (ISP.EQ. 2) TQFAC = 296.0/T
IF (ISP.EQ. 4) TQFAC = 296.0/T
GO TO (100,200,300), N
100 CONTINUE
RADFAC = 1.58765E-20*DEN*TQFAC
TAUFAC = 4.8815E-18*SQRT(RM/T)*TQFAC*DEN
DO 110 I = 1, LINES
  HHCLAM = 1.0E+4/WVNUM(I)
  TAU = TAUFAC*STR(I)*EXP(-1.43879*ENLS(I)/T)
  1 *((1.0 - EXP(-14387.9/(HHCLAM*T)))
  ROYEA = 2.0*STR(I)/HHCLAM**2
  HRAD(I) = RADFAC*ROTEA*SFUN(TAU)
  1 *EXP(-1.43879*(1.0E+4/HHCLAM + ENLS(I))/T)
110 CONTINUE
RETURN
200 CONTINUE
TAUFAC = 4.8815E-18*SQRT(RM/T)*DEN
TEFAC = (T - 296.0)/(T*296.0)*1.43879
SUM = 0.0
DO 210 I = 1, LINES
  HSTR = TQFAC*STR(I)*EXP(TEFAC*ENLS(I))
  HHCLAM = 1.0E+4/WVNUM(I)
  TAU = TAUFAC*HHCLAM*HSTR
  HRAD(I) = TAU*SFUN(TAU)*EXP(-14387.9/(HHCLAM*T))
  1 /HHCLAM**4
  SUM = SUM + HRAD(I)
210 CONTINUE
RADFAC = RAD/SUM
DO 220 I = 1, LINES
  HRAD(I) = HRAD(I)*RADFAC

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002350
002360
002370
002380
002390

```

002400
002410
002420
002430
002440

220 CONTINUE
RETURN
300 CONTINUE
RETURN
END

```

FUNCTION SFUN (TAU)
T = ARS(TAU)
IF (T .GT. 4.0) GO TO 110
X = (T - 2.0)*0.5
SFUN = (((0.301361)*X - 0.004288)*X + 0.013686)*X - 0.042491)
1 *X + 0.114932)*X - 0.267057)*X + 0.556485
RETURN
110 CONTINUE
IF (T .GT. 10.0) GO TO 120
X = (T - 7.0)/3.0
SFUN = (((0.000347)*X - 0.001167)*X + 0.003148)*X - 0.009545)
1 *X + 0.028249)*X - 0.081972)*X + 0.247900
RETURN
120 CONTINUE
Y = ALOG(T)
X = 1.0/Y
SFUN = (((0.067876)*X - 0.268698)*X + 0.264568)*X
1 - 0.269167)*X + 0.325368)*X + 1.128379)*SQRT(Y)/T
RETURN
END

```

```

00245J
00246J
00247C
00248J
00249J
00250C
00251J
00252C
00253C
00254C
00255J
00256J
00257C
00258J
00259C
00260J
00261C
00262C
00263J
00264C

```

```

C      SUBROUTINE FILTER (SPEC,RAD,WVNUM,N)
C      FIVE WAVENUMBER RESOLUTION, TWO WAVENUMBER INTERVAL
C      RES IS (FULL) WIDTH AT HALF MAXIMUM OF TRIANGULAR SLIT FUNCTION.
C      STEP IS INTERVAL BETWEEN POINTS.
C      START IS LOWER END OF SPECTRAL RANGE.
C
C      DIMENSION SPEC(1801),RAD(450),WVNUM(450)
C      COMMON /ISFCOM/ ISP
C
C      DATA RES,STEP,START /5.0,2.0,400.0/
C
C      RESOI = RES**(-2)
C      DO 150 I = 1, N
C      PT = WVNUM(I)
C      RADT = RAD(I)
C      JS = (PT - START - RES)/STEP + 2.0
C      JF = (PT - START + RES)/STEP + 1.0
C      IF (JS .LT. 1) JS = 1
C      IF (JF .GT. 1801) JF = 1801
C      IF (JS .GT. JF) GO TO 150
C      DO 120 J = JS, JF
C      RNUM = (J - 1)*STEP + START
C      SPEC(J) = SPEC(J) + (RES - ABS(RNUM - PT))*RADT*RESOI
C      CONTINUE
C      CONTINUE
C      RETURN
C      END
120
150

```

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```

SUBROUTINE ROTATE (NIN,LINES)
COMMON /ISPCOM/ ISP
COMMON WVNUM(2500),ENLS(2500),STR(2500),HRAD(2500)
READ (NIN,2) LINES
DO 120 I = 1, LINES
  READ (NIN,4) WVNUM(I),STR(I),ENLS(I)
  STR(I) = 2.4793E+19*STR(I)
120 CONTINUE
  RETURN
2  FORMAT (1X,I8)
4  FORMAT (F10.3,1PE10.3,5X,0PF10.3)
  END

```

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002940
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002980
002990
003000
003010
003020
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003040
003050

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```

C
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C
C
SUBROUTINE LINOIT (ARRAY,NP,KALT,LINES)
LINOIT PRINTS OUT RESULTS FROM PROGRAM SPCTPA.
DIMENSION ARRAY(LINES)
WRITE (2,10)
NUM = 400
NLOW = 1
NHAI = 6
CONTINUE
NLIN = MIN0(NHAI,LINES)
WRITE (NP,12) NP,KALT,NUM,(ARRAY(I),I=NLOW,NLIN)
WRITE (2,12) NP,KALT,NUM,(ARRAY(I),I=NLOW,NLIN)
NLOW = NLOW + 5
NHAI = NHAI + 5
NUM = NUM + 12
IF (NLOW .LE. LINES) GO TO 120
RETURN
FORMAT (14,I5,I6,1P6E10.3)
12 FORMAT (1H1)
15 END
120

```

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PROGRAM INTERP (TAPE2, TAPE5, TAPE9, OUTPUT)

THIS PROGRAM INTERPOLATES VALUES FOR TEMPERATURE, WATER VAPOUR, OZONE, CARBON DIOXIDE, NITROUS OXIDE, AND IT CALCULATES THE PRESSURES FROM THE HYDROSTATIC EQUATION. THE VALUES OF OZONE ABOVE 35KM, AND NITROUS OXIDE ABOVE 40KM ARE ALSO CALCULATED.

THE DATA REQUIRED TO OPERATE THIS PROGRAM ARE,

- 1) THE INCREMENT OF ALTITUDE FOR INTERPOLATION, AND THE FINAL ALTITUDE AT WHICH THIS INCREMENT IS USED. ANOTHER INCREMENT AND FINAL VALUE CAN BE USED UP TO A MAXIMUM OF 50. FORMAT IS 16F5.1.
- 2) THE NEXT CARD HAS THE TYPE OF DATA TO BE READ IN COLUMNS 1 TO 4, WITH LATITUDE IN COLUMNS 6 AND 7. IN COLUMNS 9 TO 14 WE HAVE A DESCRIPTOR OF THE DATA, AND AN S OR T IN COLUMN 16 TO SIGNIFY FOR THE WATER VAPOUR WHETHER IT CORRESPOND TO LOW OR HIGH ALTITUDES. IN COLUMNS 18 AND 19 WE HAVE A CODE TO IDENTIFY THE DATA.
- 3) WE NOW READ THE VALUES OF OUR PARAMETERS, AT THE ALTITUDES AT WHICH THEY WERE MEASURED. THE FORMAT IS 4(F4.1, 1X, E7.2, 3X). FOR THE PRESSURE PROFILE, WE READ IN ONLY THE SURFACE PRESSURE IN A F10.0 FORMAT. AFTER THE OZONE VALUES TO 35KM HAVE BEEN READ, WE READ THE CONSTANTS REQUIRED TO PERFORM THE CALCULATIONS, AND THE MAXIMUM ALTITUDE AT WHICH THEY CAN BE USED. N2O DATA IS READ UP TO AN ALTITUDE OF 40KM, AND CALCULATED THEREAFTER. THE FORMAT IS 1(2F5.0).
- 4) THE NEXT CARD RESTARTS THE SEQUENCE OF CARDS 2 AND 3 FOR A NEW PROFILE. IF NO MORE PROFILES FOLLOW, WE HAVE THE WORD DONE PUNCHED ON THE CARD.
- 5) ONCE ALL THE PROFILES HAVE BEEN READ AND INTERPOLATED, WE READ

```

C      A CAPD WITH THE COMBINATION OF PROFILES WHICH WE WANT TO      000690
C      FABRICATE. THE ORDER OF THE CODES ARE, TEMP. H2O, UPPERA MOSPHERE 000691
C      H2O, OZONE, CO2, AND N2O. THE FORMAT IS 615.                      000692
C                                                                           000693
C      DIMENSION TY(2),TEM(5),ALT(50),DELZ(50),ZMAX(50),INTERA(3)      000694
C      DIMENSION T(11,131),WAT(11,131),WATH(3,50),OZONE(11,131)      000695
C      DIMENSION CAPOX(1,131),NITOX(5,131),P(11,131),ALTZ(132),ALTH(3,50) 000696
C      REAL NITOX                                                         000697
C      COMMON T,WAT,WATH,OZONE,CAPOX,NITOX,P,ALTZ,DEL7,ZMAX,NUM,ALTMAX 000698
C      COMMON/INCUT/ NR,NF,NM                                           000699
C      DATA (TY(I),I=1,6)                                              000700
C      1 /6HTEMP,6HWHIX,6HWHIX,6HCO2M,6HN2OM,6HNPRES,6H04TM,      000701
C      1 6HNO2O/                                                         000702
C      DATA OZONE/6H00NE/                                              000703
C      CALL SECOND (SECA)                                              000704
C      NR = 2                                                            000705
C      NW = 5                                                            000706
C      NW = 9                                                            000707
C      REWIND 2                                                         000708
C                                                                           000709
C      ALTMAY IS THE MAXIMUM ALTITUDE AT WHICH THE PROFILE IS EVALUATED. 000800
C                                                                           000801
C      ALTMAY=700000.3                                                 000802
C                                                                           000803
C      READ IN INTERVALS AT WHICH PROFILES ARE TO BE EVALUATED.      000804
C                                                                           000805
C      DO 41 I=1,50,4                                                  000806
C      I4=I*7                                                           000807
C      READ(NF,I4) (DELZ(J),J=I,I4)                                     000808
C      FORMAT (12F6.1)                                                 000809
C      DO 131 J=I,I4                                                   000810
C      DELZ(J)=DELZ(J)*1000.                                           000811
C      ZMAX(J)=ZMAX(J)*1000.                                           000812
C      131 CONTINUE                                                    000813

```

```

00 61 J=I,I4
IF (ZMAX(J).GE.ALTHAX) GO TO 33
61 CONTINUE
41 CONTINUE
33 INTER=J
C
C
C
READ THE HEADER CARD
24 READ(NR,10) TYPE, LAT,(TEM(I) ,I=1,6),A,ID
10 FORMAT ( A4,I4,I2,I4,6A1,I4,A1,I4,I2)
IF (TYPE .EQ. NONE) GO TO 26
00 11 I=1,6
IF (TYPE .EQ. TYPE) GO TO 12
11 CONTINUE
12 ITYPE=I
C
C
C
SELECT THE SUBROUTINE CORRESPONDING TO THE DATA BEING READ IN.
GO TO(13,14,15,16,17,18,19,21),ITYPE
13 CALL TEMP(IC,LEVEL)
GO TO 24
14 CALL WATER(ID,A,LEVFLA,INTERP(IC),ALTH)
GO TO 24
15 CALL O3(ID)
GO TO 24
16 CALL CO2(ID)
GO TO 24
17 CALL N2O(ID)
GO TO 24
18 CALL PRES(IC)
GO TO 24
19 CALL OATHM(ID)
GO TO 24
21 CALL NCNO (IC)

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00 71 J=1,LEVEL,6
J5=J+5
47 IF (J6-LEVEL)48,48,49
49 J6=J6-1
GO TO 47
48 WRITE(NP,50) (P(IT,I),I=J,J6),KOUNT
50 FORMAT (1P6E12.4,5X,I3)
WRITE(NW,50) (P(IT,I),I=J,J6),KOUNT
KOUNT=KOUNT+1
71 CONTINUE
INT=-5
WRITE(NP,30) LEVEL,INT,XMULT,SUPF,KOUNT
30 FORMAT (4HTEMP,6X,2I5,1P2E10.3,37X,I3)
WRITE(NW,30) LEVEL,INT,XMULT,SUPF,KOUNT
KOUNT=KOUNT+1
00 81 J=1,LEVEL,6
J6=J+5
57 IF (J6-LEVEL)58,58,59
59 J6=J6-1
GO TO 57
58 WRITE(NP,50) (T(IT,I),I=J,J6),KOUNT
WRITE(NW,50) (T(IT,I),I=J,J6),KOUNT
KOUNT=KOUNT+1
81 CONTINUE
WRITE(NP,80) LEVEL,INT,XMULT,KOUNT
80 FORMAT (4PHMIX,5X,2I5,1P2E10.3,47X,I3)
WRITE(NW,80) LEVEL,INT,XMULT,KOUNT
KOUNT=KOUNT+1

C
C
C
INTERPOLATE STRATOSPHERIC H2O WITH TRAPEZOIDAL H2O
I=1
J=LEVEL
WATH(IH20H,1)=WAT(IH20,J-1)

```

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001950

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001960      ALTH(IH20H,I)=ALTZ(J-1)
001970      INA=INTERA(IH20H)
001980      DO 51 L=2,INA
001990          ALTZ(J)=ALTZ(J-1)+DELZ(I)
002000          IF(ALTZ(J)-ALTMX(I))53,63,52
002010          IF(ALTZ(J)-ZMAX(I))52,52,54
002020          IF(ALTZ(J)-ALTH(IH20H,L))55,55,51
002030          WAT(IH20,J)=(ALTH(IH20H,L)-ALTZ(J))/(ALTH(IH20H,L)-ALTH(IH20H,L-1))
002040          WAT(IH20,J)=- (ALOG(WATH(IH20H,L))-ALOG(WATH(IH20H,L-1)))+WAT(IH20H,L-1)
002050          J=J+1
002060          WAT(IH20,J)=EXP(WAT(IH20,J))
002070          J=J+1
002080          GO TO 53
002090          I=I+1
002100          GO TO 53
002110          51 CONTINUE
002120          52 CONTINUE
002130          DO 91 J=1,LEVEL,6
002140              J6=J+5
002150              IF(J6-LEVEL)68,58,69
002160              J6=J6-1
002170              GO TO 67
002180              68 WRITE(NP,50) (WAT(IH20,I),I=J,J6),KOUNT
002190              WRITE(NW,50) (WAT(IH20,I),I=J,J6),KCOUNT
002200              KOUNT=KOUNT+1
002210              91 CONTINUE
002220              WRITE(NP,90) LEVEL,INT ,XMULT,KOUNT
002230              FORMAT (4HOPX,5X,2I5,1PE10.3,47X,I3)
002240              WRITE(NW,90) LEVEL,INT ,XMULT,KOUNT
002250              KOUNT=KOUNT+1
002260              DO 101 J=1,LEVEL,6
002270              J6=J+5
002280              IF(J6-LEVEL)78,78,79
002290

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```

79 J6=J6-1
GO TO 77
78 WRITE(NP,50) (OZONE(IOZON,I),I=J,J6),KOUNT
WRITE(NW,50) (OZONE(IOZON,I),I=J,J6),KOUNT
KOUNT=KOUNT+1
101 CONTINUE
C
C IF C02 PROFILE IS NOT DESIRED, LET IC02 EQUAL 0.
C
IF(IC02)112,112,113
113 WRITE(NP,100) LEVEL,INT ,XMULT,KOUNT
100 FORMAT (4HCC2M,5X,2I5,1PE10.3,47X,I3)
WRITE(NW,100) LEVEL,INT ,XMULT,KOUNT
KOUNT=KOUNT+1
DO 111 J=1,LEVEL,6
J5=J+5
87 IF(J6-LEVEL)88,88 ,89
89 J6=J6-1
GO TO 87
88 WRITE(NP,50) (CAROX(IC02,I),I=J,J6),KOUNT
WRITE(NW,50) (CAROX(IC02,I),I=J,J6),KOUNT
KOUNT=KOUNT+1
111 CONTINUE
C
C IF N2O IS NOT DESIRED, LET IN2O EQUAL 0.
C
C
112 IF(IN20)114,114,115
115 WRITE(NP,110) LEVEL,INT ,XMULT,KOUNT
110 FORMAT (4HN2OM,5X,2I5,1PE10.3,47X,I3)
WRITE(NW,110) LEVEL,INT ,XMULT,KOUNT
KOUNT=KOUNT+1
DO 121 J=1,LEVEL,6
J6=J+5
97 IF(J6-LEVEL)98,98,99

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99 J6=J6-1
GO TO 97
98 WRITE(NP,50) (NITOX(IN20,I),I=J,J6),KOUNT
WRITE(NW,50) (NITOX(IN20,I),I=J,J6),KOUNT
KOUNT=KOUNT+1
121 CONTINUE
114 WRITE(NP,120) LEVEL,INTER,XMULT,SURF,KOUNT
120 FORMAT (4HZOUT,6X,2I5,1P2E10.3,37X,I3)
WRITE(NW,120) LEVEL,INTER,XMULT,SURF,KOUNT
KOUNT=KOUNT+1
WRITE(NP,40) (DELZ(I),ZMAX(I),I=1,INTER)
WRITE(NW,40) (DELZ(I),ZMAX(I),I=1,INTER)
KOUNT=KOUNT+1
WRITE(NP,140) KOUNT
140 FORMAT (4HCAIC,73X,I3)
WRITE(NW,140) KOUNT
GO TO 25
27 WRITE(NP,150)
150 FORMAT (4HDCNE)
WRITE(NW,150)
PEWIND 2
CALL SECOND (SECB)
SECC = SECB - SECA
WRITE (NW,50) SECA,SECB,SECC
REWIND 9
STOP 77
END

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002910      SUBROUTINE TEMP (ID,LEVEL)
002920      DIMENSION T(11,131),WAT(11,131),WATH(3,50),OZONE(11,131)
002930      DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(50)
002940      DIMENSION ZMAX(50) ,ALT(50),TE(50)
002950      REAL NITOX
002960      COMMON/INOUT/ NR,NF,NM
002970      COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,NUM,ALTMAX
002980      DO 21 I=1,50,4
002990      I4=I+3
003000
003010      READ ALTITUDES AND TEMPERATURE
003020
003030      READ(NR,10) (ALT(J),TE(J) ,J=I,I4)
003040      FORMAT (8F8.2)
003050      DO 11 J=I,I4
003060      ALT(J)=ALT(J)*1000.
003070      IF(ALT(J).GE.ALTMAX ) GO TO 12
003080
003090      11 CONTINUE
003100      21 CONTINUE
003110      12 INTERP=J
003120      T(ID,1)=TE(1)
003130      ALT7(1)=0.0
003140      I=1
003150      J=2
003160
003170      BEGINNING OF INTERPOLATION LOOP
003180
003190      DO 51 L=2,INTER
003200      ALTZ(J)=ALT7(J-1)+DELZ(I)
003210      IF(ALTZ(J)-ALTMAX)63,63,62
003220      63 IF(ALTZ(J)-ZMAX(I))52,52,54
003230      52 IF(ALTZ(J)-ALT(L))55,55,51
003240      55 T(ID,J)=TE(L)-(ALT(L)-ALTZ(J))*(TE(L)-TE(L-1))/(ALT(L)-ALT(L-1))
      J=J+1

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54 GQ TO 53
I=I+1
51 GO TO 57
51 CONTINUE
62 CONTINUE
NUM=J-1
LEVEL=NUM
PETURN
END

```

SUBROUTINE WATER (ID,A,LEVELA,INTERA,ALTM)
DIMENSION T(11,131),WAT(11,131),WATH(3,50),OZONE(11,131)
DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALT7(132),DELZ(50)
DIMENSION 7MAX(50),ALTH(3,50),ALT(50),H2O(50)
REAL NITOX
COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALT,Z,DELZ,ZMAX,NUM,ALTMAX
COMMON/INCUT/ NR,NP,NW
DATA B/1HT/

CHECK IF WATER VAPOR IS FROM TROPOSPHERE OR STRATOSPHERE

IF(A.NE.B) GO TO 18
DO 11 I=1,50,4
I4=I+3

READ TROPOSPHERE WATER VAPOR

READ(NR,10) (ALT(J),H2O(J),J=I,I4)
10 FORMAT (4(F4.1,1X,E7.2,3X))
DO 11 J=I,I4
ALT(J)=ALT(J)*1000.
H2O(J)=(H2O(J)*1.225)*.00003001
IF(ALT(J).GE.10000.) GO TO 12
11 CONTINUE
12 INTER=J
WAT(ID,1)=H2O(1)
ALTZ(1)=0.0
I=1
J=2

BEGINNING OF LOGARITHMIC INTERPOLATION LOOP

DO 51 L=2,INTER
51 ALT7(J)=ALTZ(J-1)+DELZ(I)

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IF (ALTZ(J)-ALTMX) 63,63,62
63 IF (ALTZ(J)-ZMAX(I)) 52,52,54
52 IF (ALTZ(J)-ALT(L)) 55,55,51
55 WAT(ID,J)=(ALT(L)-ALTZ(J))/(ALT(L)-ALT(L-1))
WAT(ID,J)=-WAT(ID,J)*(ALOG(H2O(L))-ALOG(H2O(L-1))) +ALOG(H2O(L))
WAT(ID,J)=EXP(WAT(ID,J))
J=J+1
GO TO 53
54 I=I+1
GO TO 53
51 CONTINUE
52 CONTINUE
LEVELA=J
RETURN
18 DO 61 I=2,50,4
I4=I+3
READ STRATOSPHERIC WATER VAPOF
READ(NR,I4) (ALTH(ID,J),WATH(ID,J),J=I,I4)
DO 61 J=I,I4
ALTH(ID,J)=ALTH(ID,J)*1000.
WATH(ID,J)=(WATH(ID,J)*1.225E-7)
IF (ALTH(I,J).GE.ALTMX) GO TO 72
61 CONTINUE
72 INTERP=J
RETURN
END

```

C
C
C

```

SUBROUTINE CO2 (ID)
DIMENSION I(1,131),WAT(11,131),WATH(3,50),OZONE(11,131)
DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(5)
DIMENSION ZMAX(50),ALT(50),CD(50)
REAL NITOX
COMMON I,WAT,WATH,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,NUM,ALTMAX
COMON/INCUT/ NR,NP,NW
DO 11 I=1,50,4
I4=I+3
10 FORMAT (4(F4.1,1X,E7.2,3X))
DO 11 J=I,I4
ALT(J)=ALT(J)*1000.
CD(J)=CD(J)*100.
IF (ALT(J).GE.ALTMAX) GO TO 12
11 CONTINUE
12 INTERP=J
CAROX(ID,1)=CD(1)
ALTZ(1)=0.0
I=1
J=2
BEGINNING OF INTERPOLATION LOOP
DO 51 L=2,INTER
53 ALT7(J)=ALT7(J-1)+DELZ(I)
IF (ALT7(J)-ALTMAX) 63,63,62
53 IF (ALT7(J)-ZMAX(I)) 52,52,54
52 IF (ALT7(J)-ALT(L)) 55,55,51
55 CAROX(ID,J)=CD(L)-(ALT(L)-ALTZ(J))*(CD(L)-CD(L-1))/(ALT(L)-ALT(L-1))
1)

```

003960
003970
003980
003990
004000
004010
004020
004030
004040
004050
004060
004070
004080
004090
004100
004110
004120
004130
004140
004150
004160
004170
004180
004190
004200
004210
004220
004230
004240
004250
004260
004270
004280
004290

C
C
C

C
C
C

004300
004310
004320
004330
004340
004350
004360
004370

J=J+1
GO TO 53
I=I+1
GO TO 53
51 CONTINUE
52 CONTINUE
RETURN
END

```

SUBROUTINE N2O (I9)
  DIMENSION I(11,131),WAT(11,131),WATP(3,50),OZONE(11,131)
  DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(50)
  DIMENSION ZMAX(50),ALT(50),NIT(50)
  REAL NITOX,NIT
  COMMON I,WAT,WATP,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,NUM,ALTMAX
  COMMON/INPUT/ NR,NP,NW
  DO 11 I=1,50,4
    I4=I+3
    FEAD ALTITUDE AND N2O CONCENTRATIONS UP TO 40KM

    READ(NR,10) (ALT(J),NIT(J),J=1,I4)
    10 FORMAT (4(F4.1,1X,E7.2,3X))
    DO 11 J=1,I4
      ALT(J)=ALT(J)*1000.
      NIT(J)=NIT(J)*100.
      IF(ALT(J).GE.40000.) GO TO 12
    11 CONTINUE
    12 INTER=J
    NITOX(10,1)=NIT(1)
    ALTZ(1)=0.0
    I=1
    J=2
    BEGINNING OF INTERPOLATION LOOP

    DO 51 L=2,INTER
      53 ALTZ(J)=ALTZ(J-1)+DELZ(1)
      IF(ALTZ(J)-ALTMAX)63,63,62
      63 IF(ALTZ(J)-ZMAX(1))52,52,54
      52 IF(ALTZ(J)-ALT(L))55,55,51
      55 NITOX(ID,J)=NIT(L)-(ALT(L)-ALTZ(J))*(NIT(L)-NIT(L-1)), (ALT(L)-ALT(
      1L-1))

```

```

J=J+1
GO TO 53
54 I=I+1
GO TO 53
51 CONTINUE
52 CONTINUE
LEVEL=J

```

```

C
C
C      CALCULATION OF A20 CONCENTRATIONS ABOVE 40KM

```

```

DO 61 J=LEVEL,NUM
NITOX(ID,J)=NITOX(ID,LEVEL-1)*(EXP((-0.0024*(ALTZ(J)-40000.)))
61 CONTINUE
RETURN
END

```

```

004720
004730
004740
004750
004760
004770
004780
004790
004800
004810
004820
004830
004840
004850
004860

```

```

SUBROUTINE PRES (ID)
DIMENSION: T(11,131),WAT(11,171),WATH(3,50),OZONE(11,131)
DIMENSION CAPOX(1,131),NITOX(5,131),P(11,131),ALIZ(132),DELZ(50)
DIMENSION ZMAX(50)
DIMENSION AFAC(10)
REAL NITOX
COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALIZ,DEL7,ZMAX,NUM,ALTHAX
COMMON /O3CON/ O3DAY(131),O3NITE (71)
COMMON/INOUT/ NP,NP,NM

READ SURFACE PRESSURE IN MILLIBARS

READ(NP,1F) P(ID,1)
10 FORMAT (F10.2)

PMOL = 28.9564

FAC1 = 2.5470E+19/P(1,1)*T(1,1)
PM2 = 0.78084*FAC1
PC2 = 0.209475*FAC1
RA = 0.20934*FAC1
RC22 = 0.005314*FAC1
PM2C = 5.0E-06*FAC1
PMO = 1.0E-05*FAC1
PO3 = 1.0E-06*FAC1
POC = 1.0E-07*FAC1

AFAC(2) = 28.0134/PMOL
AFAC(3) = 31.9388/PMOL
AFAC(4) = 39.548/RMOL
AFAC(5) = 44.0095/PMOL
AFAC(6) = 18.31534/RMOL
AFAC(7) = 30.9361/PMOL

```

```

AFAC(8) = 47.9982/RMOL
AFAC(9) = 28.01055/PMOL

      BNUM = 2.5470E+19
      P(2,1) = 5.78084*BNUM
      P(3,1) = 0.209476*BNUM
      P(4,1) = 0.00934*BNUM
      P(5,1) = 0.000314*BNUM
      P(6,1) = 5.0E-05*BNUM
      P(7,1) = 1.0E-05*BNUM
      P(8,1) = 1.0E-06*BNUM
      P(9,1) = 1.0E-07*BNUM

      DO 50 I=2,NUM
      G=980.665/(1.+(ALTZ(I)/100.)/6356.766)**2
      ALPHA=(T(ID,I-1)-T(ID,I))/((ALTZ(I)-ALTZ(I-1))*100.)
      IF (ALPHA) 32,33,32

      CALCULATION OF PRESSURE USING HYDROSTATIC EQUATIONS

33  P(ID,I)=P(ID,I-1)*EXP(-G*((ALTZ(I)-ALTZ(I-1))*100.)/(2.87E6*T(ID,
1-1)))
      GO TO 51

32  P(ID,I)=P(ID,I-1)+((T(ID,I)/T(ID,I-1))**(G/(ALPHA*2.87E6)))

51  CONTINUE
      IF (I.GT. 51) GO TO 54
      FAC1 = S(1,I)/T(1,I)
      P(2,I) = PA2*FAC1
      P(3,I) = PC2*FAC1
      P(4,I) = PA*FAC1
      P(5,I) = PC2*FAC1

```

```

005210
005220
005230
005240
005250
005260
005270
005280
005290
005300
005310
005320
005330
005340
005350
005360
005370
005380
005390
005400
005410
005420
005430
005440
005450
005460
005470
005480
005490
005500
005510
005520
005530
005540

```

005550
005560
005570
005580
005590
005600
005610
005620
005630
005640
005650
005660
005670
005680
005690
005700
005710
005720
005730
005740
005750
005760
005770
005780
005790
005800
005810
005820
005830
005840
005850
005860
005870
005880

```

P(6,I) = R420*FAC1
P(7,I) = R40*FAC1
P(8,I) = R43*FAC1
P(9,I) = R40*FAC1
GO TO 5A
54 CONTINUE
PAT = T(10,I)/T(10,I-1)
DO 56 J = 2, 9
P(J,I) = P(J,I-1)*(PAT**((G*AFAC(J)/(ALPHA*2.87E6))))
55 CONTINUE
58 CONTINUE
DO 50 J = 2, 9
TFAC = T(1,51)
DO 50 I = 52, NUM
P(J,I) = P(J,I)*TFAC/T(1,I)
50 CONTINUE
C
PRINT 6, (T(1,I), I=1, NUM)
PRINT 6, (P(2,I), I=1, NUM)
PRINT 6, (F(3,I), I=1, NUM)
PRINT 6, (F(4,I), I=1, NUM)
PRINT 6, (P(5,I), I=1, NUM)
PRINT 6, (P(6,I), I=1, NUM)
PRINT 6, (F(7,I), I=1, NUM)
PRINT 6, (P(8,I), I=1, NUM)
PRINT 6, (P(9,I), I=1, NUM)
FACN = O3NITE(51)/P(8,51)
FACD = O3DAY(51)/P(8,51)
DO 62 I = 52, NUM
O3NITE(I) = FACN*P(8,I)
O3DAY(I) = FACD*P(8,I)
C

```

```

62  CONTINUE
    PRINT 6, (O3NITE(I), I=1, NUM)
    PRINT 6, (O3DAY(I), I=1, NUM)
    RETURN
C
    6  FORMAT (1X,1P5E11.4)
    END

```

```

005890
005900
005910
005920
005930
005940
005950

```

```

SUBROUTINE O3 (IO)
  DIMENSION T(11,131),WAT(11,131),WAT(13,50),OZONE(11,131)
  DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(50)
  DIMENSION ZMAX(50), AN(4), ALT(50),OZ(50)
  COMMON /C7COM/ O3DAY(131),O3NITE(131)
  REAL NITOX
  COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,NUM,ALTMAX
  COMMON/INCUT/ NR,NF,NW

  DATA O3DAY /6.8E11,6.8E11,5.8E11,5.7E11,6.5E11,1.13E12,2.02E12,
1 2.35E12,2.95E12,4.04E12,4.77E12,4.86E12,4.54E12,4.03E12,
2 3.24E12,2.52E12,2.03E12,1.58E12,1.22E12,8.73E11,6.07E11,
3 3.08E11,2.74E11,1.69E11,1.03E11,6.54E10,3.84E10,2.55E10,
4 1.61E10,1.12E10,7.33E9,4.4E9,2.4E9,1.1E9,5.2E8,2.0E8,
5 9.0E7,4.6E7,2.7E7,1.9E7,1.8E7,2.2E7,3.8E7,4.5E7,4.5E7,
6 3.8E7,2.8E7,2.0E7,1.4E7,9.0E6,5.0E6,80*0.0/

  DATA O3NITE /6.8E11,6.8E11,5.8E11,5.7E11,6.5E11,1.13E12,2.02E12,
1 2.35E12,2.95E12,4.04E12,4.77E12,4.86E12,4.54E12,4.03E12,
2 3.24E12,2.52E12,2.03E12,1.58E12,1.22E12,8.73E11,6.07E11,
3 3.08E11,2.74E11,1.69E11,1.03E11,6.54E10,3.84E10,2.55E10,
4 1.61E10,1.12E10,7.33E9,4.4E9,2.4E9,1.1E9,5.2E8,3.8E8,
5 1.5E8,9.0E7,1.0E8,1.5E8,2.1E8,2.5E8,2.8E8,2.2E8,
6 1.8E8,1.7E8,9.2E7,6.2E7,4.0E7,2.6E7,80*0.0/
  DO 11 I=1,50,4
    I4=I+3
  PEAD ALTITUDE AND OZONE CONCENTRATIONS UP TO 35KM

  READ(NR,10) (ALT(J),OZ(J),J=1,I4)
  10 FORMAT (4(F4.1,X,E7.2,3X))
  DO 11 J=1,I4
    ALT(J)=ALT(J)*1000.
    OZ(J)=(OZ(J)/1.66)*.0001

```

```

IF (ALT(J).GE.ALTMAX) GO TO 12
11 CONTINUE
12 INTER=J
OZONE(ID,1)=OZ(1)
ALTZ(1)=0.0
I=1
J=2
C
C BEGINNING OF INTERPOLATION LOOP
C
DO 51 L=2,INTER
53 ALTZ(J)=ALTZ(J-1)+DELZ(I)
IF (ALTZ(J)-ALTMAX) 53,53,52
53 IF (ALTZ(J)-ZMAX(I)) 52,52,54
52 IF (ALTZ(J)-ALT(L)) 55,55,51
55 OZONE(ID,J)=OZ(L)-(ALT(L)-ALTZ(J))*(OZ(L)-OZ(L-1))/(ALT(L)-ALT(L-1))
J=J+1
GO TO 57
54 I=I+1
GO TO 57
51 CONTINUE
52 CONTINUE
LEVELP=J
C
C READ CONSTANTS USED IN THE CALCULATIONS AND THE ALTITUDES
C TO WHICH THEY ARE TO BE USED
C
READ(NP,40) (AM(IK),ALT(IK),IK=1,4)
40 FORMAT (4(2F5.1))
DO 51 IK=1,4
ALT(IK)=ALT(IK)*1000.
51 CONTINUE
IK=1
006300
006310
006320
006330
006340
006350
006360
006370
006380
006390
006400
006410
006420
006430
006440
006450
006460
006470
006480
006490
006500
006510
006520
006530
006540
006550
006560
006570
006580
006590
006600
006610
006620
006630

```

006640
006650
006660
006670
006680
006690
006700
006710
006720
006730
00674
006750
006760

```

LAST=LEVEL8-1
DO 71 K=LEVEL6,NUM
35 IF(ALT7(K)-ALT(IK)) 34,34,33
33 IK=IK+1
LAST=K-1
GO TO 35

      OZONE CALCULATION

34 OZONE(ID,K)=OZONE(ID,LAST)*((P( 1,K)/P( 1,LAST))**AN(IK))
71 CONTINUE
RETURN
END

```

```

SUBROUTINE OATH (ID)
  DIMENSION T(11,131),WAT(11,131),WATP(3,50),OZONE(11,131)
  DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(50)
  DIMENSION ZMAX(50)
  DIMENSION ODAY(131),ONITE(131)
  DIMENSION ATM0(131,2)
  REAL NITOX
  COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,NUM,ALTMAX
  COMMON/INPUT/ NP,NP,NW
  EQUIVALENCE (ATM0(1,1),ONITE(1)),(ATM0(1,2),ODAY(1))
  DATA B/1MT/

  DO 11 I=1,50,4
    I4=I+3

    READ(NR,10) (ALT(J),H20(J),J=1,I4)
    10 FORMAT (4(0PF6.1,1PE9.2))
    DO 11 J=1,I4
      ALT(J)=ALT(J)*1000.
      IF (ALT(J).GE. ALTMAX) GO TO 12
    11 CONTINUE
    12 INTER=J
    ATM0(1,ID)=H20(1)
    ALTZ(1)=0.0
    I=1
    J=2

    BEGINNING OF LOGARITHMIC INTERPOLATION LOOP

    DO 51 L=2,INTER
      ALTZ(J)=ALTZ(J-1)+DELZ(I)
      IF (ALTZ(J)-ALTMAX) 53,53,52
      53 IF (ALTZ(J)-ZMAX(I)) 52,52,54
    51 CONTINUE

```

```

006770
006780
006790
006800
006810
006820
006830
006840
006850
006860
006870
006880
006890
006900
006910
006920
006930
006940
006950
006960
006970
006980
006990
007000
007010
007020
007030
007040
007050
007060
007070
007080
007090
007100

```

```

52 IF (ALTZ(J)-ALT(L))55,55,51
55 ATMO(J,IO)=(ALT(L)-ALTZ(J))/(ALT(L)-ALT(L-1))
   ATMO(J,IO)=-ATMO(J,IO)*(ALOG(H2O(L))-ALOG(H2O(L-1))) + ALOG(H2O(L))
   ATMO(J,IO)=EXP(ATMO(J,IO))
   J=J+1
   GO TO 53
54 I=I+1
   GO TO 53
51 CONTINUE
52 CONTINUE
   LEVELA=J
   PRINT 6, (ATMO(I,IO),I=1,NUM)
   RETURN
6  FORMAT (1X,1P6E11.4)
   END

```

```

007110
007120
007130
007140
007150
007160
007170
007180
007190
007200
007210
007220
007230
007240
007250

```

```

SURROUTINE NONO (ID)
DIMENSION T(11,131),WAT(11,131),WATH(3,50),OZONE(11,131)
DIMENSION CAROX(1,131),NITOX(5,131),P(11,131),ALTZ(132),DELZ(50)
DIMENSION 7MAX(50),ALTH(3,50),ALT(50),H2O(50)
DIMENSION ONAY(131),ONITE(131)
DIMENSION ATM2(131,2)
REAL NITOX
COMMON T,WAT,WATH,OZONE,CAROX,NITOX,P,ALTZ,DELZ,ZMAX,HUM,ALTMAX
COMMON/INOUT/ NR,NF,NW
EQUIVALENCE (ATMO(1,1),ONITE(1)),(ATMO(1,2),ODAY(1))
DATA B/147/

DO 11 I=1,50,4
I4=I+3

READ(NR,10) (ALT(J),H2O(J),J=I,I4)
10 FORMAT (4(0PF6.1,1PE9.2))
DO 11 J=I,I4
ALT(J)=ALT(J)*100.
IF (ALT(J).GE. ALTMAX) GO TO 12
11 CONTINUE
12 INTER=J
ATMO(1,10)=H2O(1)
ALT7(1)=0.0
I=1
J=2

BEGINNING OF LOGARITHMIC INTERPOLATION LOOP

DO 51 L=2,INTER
53 ALT7(J)=ALTZ(J-1)+DELZ(I)
IF (ALT7(J)-ALTMAX) 53,63,62
63 IF (ALT7(J)-7MAX(I)) 52,52,54

```

C

C

C

C

C

C

```

52 IF (ALTZ(J)-ALT(L))55,55,51
55 ATMO(J, ID) = (ALT(L) - ALTZ(J)) / (ALT(L) - ALT(L-1))
   ATMO(J, ID) = -ATMO(J, ID) * (ALOG(H2O(L)) - ALOG(H2O(L-1))) + ALOG(H2O(L))
   ATMO(J, ID) = EXP(ATMO(J, ID))
   J=J+1
   GO TO 53
54 I=I+1
55 GO TO 53
51 CONTINUE
52 CONTINUE
   LEVELA=J
   PRINT 6, (ATMO(I, ID), I=1, NUM)
   RETURN
6  FORMAT (1X, 1P5E11.4)
   END

```

```

007600
007610
007620
007630
007640
007650
007660
007670
007680
007690
007700
007710
007720
007730
007740

```

2.0 150.0 10.0 700.0		U.S. STD. ATM. 1976		
TEMP 45 STDATM 01				
0.00	288.15	11.02	216.65	216.65
47.35	270.65	51.41	270.65	214.65
91.00	186.87	95.00	183.31	195.08
107.00	217.63	109.00	230.33	110.00
125.00	417.23	130.00	460.27	140.00
150.00	696.29	170.00	747.57	185.00
225.00	917.76	250.00	941.33	275.00
350.00	990.06	400.00	995.63	500.00
PPFS 45 STDATM 01				
1013.25				
STANDARD ATMOSPHERE TROPOSPHERE				
0.0 6.24E03	6.0 4.95E02	10.0 6.00E01		
STANDARD ATMOSPHERE STRATOSPHERE				
10.0 4.30E00	18.0 4.10E00	26.0 1.26E01	35.0 1.54E01	
50.0 7.50E00	80.0 5.33E-1	90.0 5.73E-1	700.0 1.00E-5	
OATM 45 STDATM 01				
0.0 1.00E-06	60.0 1.30E+06	70.0 1.00E+08	80.0 1.00E+10	
86.0 8.60E+10	88.0 1.51E+11	90.0 2.44E+11	92.0 3.43E+11	
94.0 4.16E+11	96.0 4.47E+11	98.0 4.48E+11	100.0 4.30E+11	
102.0 4.01E+11	104.0 3.62E+11	106.0 3.19E+11	108.0 2.75E+11	
110.0 2.70E+11	112.0 1.89E+11	114.0 1.56E+11	116.0 1.30E+11	
118.0 1.10E+11	120.0 9.28E+10	125.0 5.38E+10	130.0 4.62E+10	
135.0 7.50E+10	140.0 2.73E+10	145.0 2.18E+10	150.0 1.78E+10	
160.0 1.24E+10	170.0 9.00E+09	180.0 6.75E+09	190.0 5.18E+09	
200.0 4.05E+09	225.0 2.31E+09	250.0 1.39E+09	275.0 8.60E+08	
300.0 5.43E+08	350.0 2.25E+08	400.0 3.58E+07	450.0 4.16E+07	
500.0 1.84E+07	600.0 3.71E+06	700.0 7.84E+05		
OATM 45 STDATM 02				
0.0 1.00E+02	20.0 1.00E+05	30.0 1.00E+08	40.0 3.00E+09	
50.0 8.00E+09	60.0 1.20E+10	70.0 2.00E+10	80.0 6.00E+10	
86.0 8.60E+10	88.0 1.51E+11	90.0 2.44E+11	92.0 3.43E+11	
94.0 4.16E+11	96.0 4.47E+11	98.0 4.48E+11	100.0 4.30E+11	

102.0	4.01E+11	104.0	3.62E+11	106.0	3.19E+11	108.0	2.75E+11	008100
110.0	2.30E+11	112.0	1.89E+11	114.0	1.56E+11	116.0	1.30E+11	008110
118.0	1.10E+11	120.0	9.28E+10	122.0	6.38E+10	124.0	4.62E+10	008120
135.0	3.50E+10	140.0	2.73E+10	145.0	2.18E+10	150.0	1.78E+10	008130
160.0	1.24E+10	170.0	9.00E+09	180.0	6.75E+09	190.0	5.13E+09	008140
200.0	4.05E+09	225.0	2.31E+09	250.0	1.39E+09	275.0	8.60E+08	008150
300.0	5.43E+08	350.0	2.25E+08	400.0	9.58E+07	450.0	4.16E+07	008160
500.0	1.84E+07	600.0	3.71E+06	700.0	7.84E+05			008170
NONO 45 STDATM 01								008180
0.0	2.50E+10	40.0	8.30E+08	60.0	9.00E+07	62.0	7.20E+07	008190
64.0	5.80E+07	66.0	4.60E+07	68.0	3.70E+07	70.0	2.90E+07	008200
72.0	2.30E+07	74.0	1.80E+07	76.0	1.40E+07	78.0	1.15E+07	008210
80.0	9.60E+06	82.0	8.70E+06	84.0	8.20E+06	86.0	8.70E+06	008220
88.0	1.05E+07	90.0	1.40E+07	92.0	1.20E+07	94.0	2.30E+07	008230
96.0	3.00E+07	98.0	3.60E+07	100.0	4.00E+07	102.0	4.20E+07	008240
104.0	4.40E+07	106.0	4.50E+07	108.0	4.40E+07	110.0	4.20E+07	008250
112.0	3.90E+07	114.0	3.50E+07	116.0	3.10E+07	118.0	2.70E+07	008260
120.0	2.30E+07	125.0	1.70E+07	130.0	1.20E+07	140.0	6.80E+06	008270
150.0	2.95E+05	160.0	1.60E+06	180.0	5.75E+05	200.0	2.27E+05	008280
250.0	3.45E+24	300.0	6.15E+03	400.0	2.40E+02	500.0	1.18E+01	008290
600.0	5.45E-01	700.0	3.00E-02					008300
NONO 45 STDATM 02								008310
0.0	2.50E+10	40.0	8.30E+08	60.0	9.00E+07	62.0	7.20E+07	008320
64.0	5.80E+07	66.0	4.60E+07	68.0	3.70E+07	70.0	2.90E+07	008330
72.0	2.30E+07	74.0	1.80E+07	76.0	1.40E+07	78.0	1.15E+07	008340
80.0	9.60E+06	82.0	8.70E+06	84.0	8.20E+06	86.0	8.70E+06	008350
88.0	1.05E+07	90.0	1.40E+07	92.0	1.20E+07	94.0	2.30E+07	008360
96.0	3.00E+07	98.0	3.60E+07	100.0	4.00E+07	102.0	4.20E+07	008370
104.0	4.40E+07	106.0	4.50E+07	108.0	4.40E+07	110.0	4.20E+07	008380
112.0	4.20E+07	114.0	4.10E+07	116.0	3.90E+07	118.0	3.70E+07	008390
120.0	3.60E+07	125.0	3.30E+07	130.0	3.00E+07	140.0	2.40E+07	008400
150.0	1.85E+07	160.0	1.35E+07	180.0	5.75E+06	200.0	2.35E+06	008410
250.0	3.45E+05	300.0	6.15E+04	400.0	2.40E+03	500.0	1.18E+02	008420
600.0	5.45E-00	700.0	3.00E-01					008430

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TEMP 45 STDATM 01				
0.00	268.15	11.02	215.65	20.06 216.65
47.35	270.65	51.41	270.65	71.80 214.65
91.00	185.87	95.00	189.31	100.00 195.08
137.00	217.53	109.00	230.33	110.00 240.00
125.00	417.23	133.00	469.27	140.00 559.63
160.00	696.29	173.00	747.57	185.00 808.51
225.00	917.78	250.00	941.33	275.00 962.54
350.00	990.06	400.00	995.83	500.00 999.24
PRES 45 STDATM 01				
1013.25				
HMTX 45 STDATM T 01				
0.0	6.24E02	6.0	4.95E02	10.0 6.00E01
HMTX 45 STDATM S 01				
15.0	4.30E00	18.0	4.10E00	26.0 1.86E01
50.0	7.60E00	80.0	6.33E-1	90.0 6.33E-1
OATM 45 STDATM 01				
0.0	1.00E-06	60.0	1.00E+06	70.0 1.00E+08
86.0	8.50E+10	88.0	1.51E+11	90.0 2.44E+11
94.0	4.16E+11	96.0	4.47E+11	98.0 4.48E+11
102.0	4.01E+11	104.0	3.52E+11	106.0 3.19E+11
110.0	2.30E+11	112.0	1.89E+11	114.0 1.56E+11
118.0	1.10E+11	120.0	9.28E+10	125.0 6.38E+10
125.0	3.50E+10	140.0	2.73E+10	145.0 2.18E+10
160.0	1.24E+10	170.0	9.70E+09	180.0 6.75E+09
200.0	4.05E+09	225.0	2.31E+09	250.0 1.39E+09
300.0	5.43E+08	350.0	2.25E+08	400.0 9.58E+07
500.0	1.84E+07	600.0	3.71E+06	700.0 7.84E+05
OATM 45 STDATM 02				
0.0	1.00E+02	20.0	1.00E+06	30.0 1.00E+08
50.0	8.00E+09	60.0	1.20E+10	70.0 2.00E+10
80.0	8.60E+10	88.0	1.51E+11	90.0 2.44E+11
100.0	4.16E+11	105.0	4.47E+11	100.0 4.48E+11

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STANDARD ATMOSPHERE TROPOSPHERE
STANDARD ATMOSPHERE STRATOSPHERE

80.0 1.00E+10
92.0 3.43E+11
100.0 4.30E+11
108.0 2.75E+11
116.0 1.30E+11
120.0 4.62E+10
150.0 1.78E+10
190.0 5.18E+09
275.0 8.61E+08
450.0 4.16E+07

40.0 3.00E+09
80.0 5.00E+10
92.0 3.43E+11
100.0 4.30E+11

102.0	2.01E+11	104.0	3.62E+11	106.0	3.19E+11	108.0	2.75E+11	00934
110.0	2.30E+11	112.0	1.89E+11	114.0	1.56E+11	116.0	1.30E+11	009350
118.0	1.10E+11	120.0	9.28E+10	125.0	6.38E+10	130.0	4.62E+10	009360
135.0	3.50E+10	140.0	2.73E+10	145.0	2.18E+10	150.0	1.78E+10	009370
160.0	1.24E+10	170.0	9.19E+09	180.0	6.75E+09	190.0	5.18E+09	009380
200.0	4.05E+09	225.0	2.31E+09	250.0	1.39E+09	275.0	8.63E+08	009390
300.0	5.43E+08	350.0	2.25E+08	400.0	9.58E+07	450.0	4.16E+07	009400
500.0	1.84E+07	600.0	3.71E+06	700.0	7.84E+05			009410
DONE								009420
1	1	1	1	1				009430
999	2	1	2	3	0			009440
2	3	1	3	4	0			009450
3	4	1	4	5	0			009460
4	5	1	5	6	0			009470
5	6	1	6	7	0			009480
6	7	1	7	8	0			009490
7	8	1	8	9	0			009500
8	9	1	9	10	0			009510
9	10	1	10	11	0			009520
10	11	1	11	12	0			009530
2	12	1	12	13	0			009540
2	13	1	13	14	0			009550
4	14	1	14	15	0			009560
4	15	1	15	16	0			009570
3	16	1	16	17	0			009580
6	17	1	17	18	0			009590
6	18	1	18	19	0			009600
5	19	1	19	20	0			009610
5	20	1	20	21	0			009620
10	21	3	21	22	0			009630
10	22	3	22	23	0			009640
9	23	2	23	24	0			009650
1	24	3	24	25	0			009660
	25	1	25	26	0			009670

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2.8815E+02	2.7517E+02	2.6220E+02	2.4922E+02	2.3624E+02	2.2327E+02	009980
2.1665E+02	2.1665E+02	2.1665E+02	2.1665E+02	2.1665E+02	2.1857E+02	009990
2.2056E+02	2.2254E+02	2.2452E+02	2.2651E+02	2.2849E+02	2.3374E+02	010000
2.3927E+02	2.4480E+02	2.5033E+02	2.5586E+02	2.6139E+02	2.6692E+02	010100
2.7065E+02	2.7065E+02	2.6903E+02	2.6354E+02	2.5804E+02	2.5255E+02	010110
2.4706E+02	2.4157E+02	2.3607E+02	2.3058E+02	2.2509E+02	2.1959E+02	010120
2.1426E+02	2.1035E+02	2.0643E+02	2.0252E+02	1.9861E+02	1.9470E+02	010130
1.9078E+02	1.8687E+02	1.8687E+02	1.8687E+02	1.8736E+02	1.8833E+02	010140
1.8931E+02	1.9220E+02	1.9508E+02	2.0020E+02	2.0531E+02	2.1352E+02	010150
2.2398E+02	2.4000E+02	2.6400E+02	2.8800E+02	3.1200E+02	3.3600E+02	010160
3.6000E+02	3.8289E+02	4.0578E+02	4.2764E+02	4.4845E+02	4.6927E+02	010170
4.8734E+02	5.0541E+02	5.2349E+02	5.4156E+02	5.5963E+02	5.7458E+02	010180
5.8953E+02	6.1449E+02	6.1944E+02	6.3439E+02	6.4929E+02	6.6424E+02	010190
7.8820E+02	8.2386E+02	8.5456E+02	8.7525E+02	8.9714E+02	9.1449E+02	010200
9.2791E+02	9.4133E+02	9.4981E+02	9.5830E+02	9.6523E+02	9.7062E+02	010210
9.7601E+02	9.7882E+02	9.8163E+02	9.8444E+02	9.8725E+02	9.9006E+02	010220
9.9121E+02	9.9237E+02	9.9352E+02	9.9468E+02	9.9583E+02	9.9617E+02	010230
9.9651E+02	9.9685E+02	9.9719E+02	9.9753E+02	9.9788E+02	9.9822E+02	010240
9.9856E+02	9.9890E+02	9.9924E+02	9.9958E+02	9.9993E+02	9.9997E+02	010250
9.9939E+02	9.9942E+02	9.9946E+02	9.9950E+02	9.9953E+02	9.9957E+02	010260
9.9960E+02	9.9964E+02	9.9968E+02	9.9971E+02	9.9975E+02	9.9979E+02	010270
9.9982E+02	9.9986E+02	9.9990E+02	9.9993E+02	9.9997E+02	9.9997E+02	010280
1.9888E+19	1.6341E+19	1.3302E+19	1.0717E+19	8.5372E+18	6.7150E+18	010290
5.0778E+16	3.7093E+18	2.7101E+18	1.9804E+18	1.4475E+18	1.1504E+18	010300
7.6423E+17	5.5783E+17	4.0835E+17	2.9981E+17	2.2075E+17	1.6116E+17	010310
1.1823E+17	8.7424E+16	5.5093E+16	4.8768E+16	3.6799E+16	2.7925E+16	010320
2.1438E+16	1.6720E+16	1.3111E+16	1.0399E+16	8.2094E+15	6.4489E+15	010330
5.0401E+15	3.9179E+15	3.0285E+15	2.3272E+15	1.7774E+15	1.3487E+15	010340
1.0158E+15	7.5547E+14	5.5885E+14	4.1110E+14	3.0067E+14	2.1859E+14	010350
1.5792E+14	1.1335E+14	7.9416E+13	5.5653E+13	3.8926E+13	2.7199E+13	010360
1.9044E+13	1.3252E+13	9.2738E+12	6.5362E+12	4.6484E+12	3.2934E+12	010370
2.7441E+12	1.6610E+12	1.1719E+12	8.5246E+11	6.3618E+11	4.8524E+11	010380
3.7715E+11	2.9876E+11	2.3991E+11	1.9544E+11	1.6121E+11	1.3415E+11	010390
1.1313E+11	9.6008E+10	8.1952E+10	7.0336E+10	6.0674E+10	5.2859E+10	010400

4.6218E+10	4.0549E+10	3.5692E+10	3.1514E+10	1.7093E+10	1.7793E+10	010320
6.8135E+09	4.4284E+09	2.9484E+09	2.0112E+09	1.3860E+09	9.6797E+08	010330
6.8770E+08	4.8581E+08	3.4872E+08	2.5130E+08	1.8203E+08	1.3247E+08	010340
9.6659E+07	7.0874E+07	5.2062E+07	3.8312E+07	2.8243E+07	2.0858E+07	010350
1.5452E+07	1.1462E+07	8.5125E+06	5.3298E+06	4.7124E+06	3.5150E+06	010360
2.6244E+06	1.9613E+06	1.4672E+06	1.0986E+06	8.2336E+05	5.1767E+05	010370
4.6380E+05	3.4858E+05	2.6223E+05	1.9751E+05	1.4888E+05	1.1232E+05	010380
8.4808E+04	6.4088E+04	4.8409E+04	3.6687E+04	2.7791E+04	2.1070E+04	010390
1.5987E+04	1.2140E+04	9.2258E+03	7.0169E+03	5.3411E+03	4.0687E+03	010400
3.1019E+03	2.3666E+03	1.8071E+03	1.3809E+03	1.0560E+03		010410
5.3354E+18	4.3838E+18	3.5685E+18	2.8751E+18	2.2903E+18	1.8014E+18	010420
1.7622E+18	9.9508E+17	7.2703E+17	5.3130E+17	3.8833E+17	2.8178E+17	010430
2.0504E+17	1.4965E+17	1.0955E+17	8.0429E+16	5.9220E+16	4.3207E+16	010440
3.1718E+16	2.3453E+16	1.7463E+16	1.3088E+16	9.8720E+15	7.4913E+15	010450
5.7511E+15	4.4854E+15	3.5172E+15	2.7897E+15	2.2023E+15	1.7301E+15	010460
1.3521E+15	1.0510E+15	8.1245E+14	6.2433E+14	4.7662E+14	3.6181E+14	010470
2.7251E+14	2.0267E+14	1.4992E+14	1.1029E+14	8.0661E+13	5.8641E+13	010480
4.2366E+13	3.0409E+13	2.1305E+13	1.4930E+13	1.0443E+13	7.2967E+12	010490
5.1099E+12	3.5552E+12	2.4879E+12	1.6745E+12	1.1386E+12	7.7238E+11	010500
5.2737E+11	3.5233E+11	2.4454E+11	1.7212E+11	1.2463E+11	9.2436E+10	010510
4.9997E+10	5.4117E+10	4.2468E+10	3.7854E+10	2.7354E+10	2.2320E+10	010520
1.8470E+10	1.5392E+10	1.2911E+10	1.0895E+10	9.2457E+09	7.9281E+09	010530
6.8257E+09	5.8991E+09	5.1168E+09	4.4537E+09	2.3641E+09	1.3406E+09	010540
7.9866E+08	4.9131E+08	3.1033E+08	2.0117E+08	1.3194E+08	8.7795E+07	010550
5.9141E+07	4.0111E+07	2.7501E+07	1.8939E+07	1.3117E+07	9.1308E+06	010560
6.3754E+06	4.4747E+06	3.1471E+06	2.2180E+06	1.5663E+06	1.1083E+06	010570
7.8694E+05	5.5953E+05	3.9839E+05	2.8406E+05	2.0282E+05	1.4511E+05	010580
1.0394E+05	7.4527E+04	5.3497E+04	3.8444E+04	2.7656E+04	1.9916E+04	010590
1.4258E+04	1.0362E+04	7.4864E+03	5.4158E+03	3.9216E+03	2.8423E+03	010600
2.0620E+03	1.4973E+03	1.0883E+03	7.9176E+02	5.7655E+02	4.2023E+02	010610
3.0457E+02	2.2386E+02	1.6361E+02	1.1969E+02	8.7633E+01	6.4222E+01	010620
4.7107E+01	3.4585E+01	2.5413E+01	1.8691E+01	1.3759E+01		010630
2.3789E+17	1.9546E+17	1.5911E+17	1.2819E+17	1.0212E+17	8.1321E+16	010640
6.0738E+16	4.4768E+16	3.2417E+16	2.3689E+16	1.7315E+16	1.2564E+16	010650

9.1421E+15	6.6724E+15	4.8845E+15	3.5861E+15	2.6405E+15	1.9265E+15	010660
1.4142E+15	1.0457E+15	7.7861E+14	5.8357E+14	4.4017E+14	3.3402E+14	010670
2.5643E+14	1.9999E+14	1.5682E+14	1.2439E+14	9.8196E+13	7.7139E+13	010680
6.0287E+13	4.6863E+13	3.6225E+13	2.7837E+13	2.1263E+13	1.6132E+13	010690
1.2151E+13	9.0365E+12	6.6846E+12	4.9174E+12	3.5965E+12	2.6146E+12	010700
1.8890E+12	1.3558E+12	9.4994E+11	6.6570E+11	4.6561E+11	3.2534E+11	010710
2.2780E+11	1.5852E+11	1.1093E+11	6.8103E+10	4.2340E+10	2.6338E+10	010720
1.6553E+10	1.0430E+10	6.6058E+09	4.3543E+09	2.9682E+09	2.1819E+09	010730
1.4968E+09	1.1022E+09	8.2630E+08	6.3079E+08	4.6914E+08	3.8375E+08	010740
3.0584E+08	2.4580E+08	1.9908E+08	1.6243E+08	1.3342E+08	1.1084E+08	010750
9.2533E+07	7.7606E+07	6.5373E+07	5.5299E+07	2.5667E+07	1.2867E+07	010760
6.8292E+06	3.7646E+06	2.1408E+06	1.2537E+06	7.4486E+05	4.5009E+05	010770
2.7584E+05	1.7049E+05	1.0667E+05	6.7106E+04	4.2501E+04	2.7076E+04	010780
1.7315E+04	1.1138E+04	7.1826E+03	4.6439E+03	3.1011E+03	1.9560E+03	010790
1.2759E+03	8.3373E+02	5.4575E+02	3.5786E+02	2.3507E+02	1.5478E+02	010800
1.0205E+02	6.7376E+01	4.4544E+01	2.9490E+01	1.9549E+01	1.2977E+01	010810
8.6259E+00	5.7413E+00	3.8264E+00	2.5542E+00	1.7070E+00	1.1421E+00	010820
7.6508E-01	5.1312E-01	3.4454E-01	2.3161E-01	1.5588E-01	1.1503E-01	010830
7.0850E-02	4.7848E-02	3.2350E-02	2.1897E-02	1.4838E-02	1.0066E-02	010840
6.8367E-03	4.6484E-03	3.1640E-03	2.1561E-03	1.4708E-03		010850
7.9976E+15	6.5712E+15	5.3491E+15	4.3098E+15	3.4331E+15	2.7003E+15	010860
2.0420E+15	1.4916E+15	1.0898E+15	7.9640E+14	5.8210E+14	4.2239E+14	010870
3.0735E+14	2.2432E+14	1.6421E+14	1.2056E+14	8.8770E+13	6.4766E+13	010880
4.7545E+13	3.5156E+13	2.6176E+13	1.9619E+13	1.4798E+13	1.1229E+13	010890
8.6208E+12	6.7235E+12	5.2722E+12	4.1818E+12	3.3012E+12	2.5933E+12	010900
2.0268E+12	1.5755E+12	1.2178E+12	9.3586E+11	7.1474E+11	5.4235E+11	010910
4.0849E+11	3.0380E+11	2.2473E+11	1.6532E+11	1.2091E+11	8.7901E+10	010920
6.3505E+10	4.5582E+10	3.1936E+10	2.2380E+10	1.5653E+10	1.0938E+10	010930
7.6583E+09	5.3292E+09	3.7293E+09	2.1845E+09	1.2974E+09	7.7209E+08	010940
4.6510E+08	2.8160E+08	1.7191E+08	1.0958E+08	7.2428E+07	4.9374E+07	010950
3.4567E+07	2.4830E+07	1.8184E+07	1.3578E+07	1.0310E+07	7.9278E+06	010960
6.1079E+06	4.8897E+06	3.8904E+06	3.1198E+06	2.5203E+06	2.0602E+06	010970
1.6930E+06	1.3983E+06	1.1604E+06	9.6737E+05	4.1924E+05	1.9734E+05	010980
9.8735E+04	5.1460E+04	2.7734E+04	1.5421E+04	8.7105E+03	5.0104E+03	010990

2.9259E+03	1.7245E+03	1.0296E+03	6.1852E+02	3.7423E+02	2.2785E+02	011100
1.3931E+02	8.5706E+01	5.2876E+01	3.2713E+01	2.0296E+01	1.2627E+01	011110
7.8870E+00	4.9361E+00	3.0952E+00	1.9446E+00	1.2241E+00	7.7245E-01	011120
4.8820E-01	3.0901E-01	1.9589E-01	1.2436E-01	7.9069E-02	5.3347E-02	011130
3.2106E-02	2.0507E-02	1.3113E-02	8.4006E-03	5.3887E-03	3.4612E-03	011140
2.2261E-03	1.4335E-03	9.2436E-04	5.9580E-04	3.8581E-04	2.4973E-04	011150
1.6185E-04	1.0503E-04	6.8238E-05	4.4392E-05	2.8915E-05	1.8857E-05	011160
1.2313E-05	8.0499E-06	5.2692E-06	3.4533E-06	2.2659E-06		011170
1.2735E+14	1.0464E+14	8.5177E+13	6.8627E+13	5.4667E+13	4.2998E+13	011180
3.2515E+17	2.3752E+13	1.7354E+13	1.2682E+13	9.2691E+12	6.7259E+12	011190
4.8941E+12	3.5720E+12	2.6148E+12	1.9198E+12	1.4135E+12	1.313E+12	011100
7.5708E+11	5.5981E+11	4.1681E+11	3.1240E+11	2.3563E+11	1.7881E+11	011110
1.3727E+11	1.0706E+11	8.3952E+10	6.6589E+10	5.2568E+10	4.1295E+10	011120
3.2273E+10	2.5087E+10	1.9392E+10	1.4902E+10	1.1381E+10	8.5361E+09	011130
6.5046E+09	4.8376E+09	3.5785E+09	2.6324E+09	1.9253E+09	1.3997E+09	011140
1.0112E+09	7.2583E+08	5.0853E+08	3.5637E+08	2.4925E+08	1.7416E+08	011150
1.2195E+08	8.4860E+07	5.9384E+07	4.5984E+07	3.7398E+07	2.9547E+07	011160
2.3342E+07	1.8248E+07	1.4094E+07	1.1134E+07	8.9644E+06	7.3349E+06	011170
6.0857E+06	5.1248E+06	4.2592E+06	3.7499E+06	3.2575E+06	2.8480E+06	011180
2.5181E+06	2.2366E+06	1.9050E+06	1.7864E+06	1.6056E+06	1.4556E+06	011190
1.2230E+06	1.2054E+06	1.1008E+06	1.0075E+06	6.7719E+05	4.7700E+05	011200
3.4821E+05	2.5980E+05	1.9741E+05	1.5300E+05	1.1940E+05	9.4140E+04	011210
7.4887E+04	5.9806E+04	4.8168E+04	3.8893E+04	3.1528E+04	2.5648E+04	011220
2.0902E+04	1.7103E+04	1.4011E+04	1.1492E+04	9.4360E+03	7.7568E+03	011230
6.3973E+03	5.2737E+03	4.3535E+03	3.5968E+03	2.9739E+03	2.4626E+03	011240
2.0405E+03	1.6918E+03	1.4035E+03	1.1651E+03	9.6775E+02	8.0432E+02	011250
6.5889E+02	5.5660E+02	4.6344E+02	3.8621E+02	3.2202E+02	2.6864E+02	011260
2.2423E+02	1.8726E+02	1.5647E+02	1.3081E+02	1.0941E+02	9.1566E+01	011270
7.6670E+01	6.4229E+01	5.3835E+01	4.5146E+01	3.7879E+01	3.1798E+01	011280
2.6706E+01	2.2441E+01	1.8867E+01	1.5870E+01	1.3355E+01		011290
1.0300E-06	2.5119E-06	5.3095E-06	1.5849E-05	3.9811E-05	1.5000E-04	011300
2.5119E-04	6.3096E-04	1.5849E-03	3.9811E-03	1.0000E-02	2.5119E-02	011310
6.3096E-02	1.5849E-01	3.9811E-01	1.0000E+00	2.5119E+00	6.3096E+00	011320
1.5849E+01	7.0811E+01	1.0000E+02	2.5119E+02	6.3096E+02	1.5849E+03	011330

3.9811E+03	1.0000E+04	2.5119E+04	6.3096E+04	1.5849E+05	3.9811E+05	011340
1.0000E+04	2.5119E+04	6.3096E+04	1.5849E+04	3.9811E+07	1.5849E+08	011350
2.5119E+04	6.3096E+04	1.5849E+04	3.9811E+09	1.0000E+10	2.0488E+10	011360
4.1976E+10	8.6000E+10	1.5100E+11	2.4430E+11	3.4300E+11	4.1600E+11	011370
4.4700E+11	4.4800E+11	4.3000E+11	4.0100E+11	3.6200E+11	3.1900E+11	011380
2.7500E+11	2.3000E+11	1.8900E+11	1.5000E+11	1.3000E+11	1.1000E+11	011390
9.2800E+10	7.9800E+10	6.0765E+10	5.9812E+10	5.2567E+10	4.6200E+10	011400
4.1344E+10	3.6998E+10	3.3303E+10	3.0153E+10	2.7300E+10	2.4951E+10	011410
2.2803E+10	2.0934E+10	1.9303E+10	1.7800E+10	1.2400E+10	9.2000E+09	011420
6.7500E+09	5.1800E+09	4.0500E+09	3.2353E+09	2.5845E+09	2.0869E+09	011430
1.7032E+09	1.3900E+09	1.1471E+09	9.4668E+08	7.8444E+08	6.5265E+08	011440
5.4300E+08	4.5526E+08	3.8173E+08	3.2006E+08	2.6835E+08	2.2500E+08	011450
1.8968E+08	1.5990E+08	1.3480E+08	1.1364E+08	9.5800E+07	8.1080E+07	011460
6.8621E+07	5.8077E+07	4.9153E+07	4.1600E+07	3.5338E+07	3.0018E+07	011470
2.5493E+07	2.1661E+07	1.8400E+07	1.5677E+07	1.3358E+07	1.1381E+07	011480
9.6971E+06	8.2622E+06	7.0397E+06	5.9980E+06	5.1105E+06	4.3543E+06	011490
3.7100E+06	3.1759E+06	2.7187E+06	2.3273E+06	1.9923E+06	1.7055E+06	011500
1.4600E+06	1.2498E+06	1.0699E+06	9.1584E+05	7.8400E+05		011510
1.0000E+02	2.5119E+02	6.3096E+02	1.5849E+03	3.9811E+03	1.0000E+04	011520
2.5119E+04	6.3096E+04	1.5849E+05	3.9811E+05	1.0000E+06	2.5119E+06	011530
6.3096E+06	1.5849E+07	3.9811E+07	1.0000E+08	1.9744E+08	3.8381E+08	011540
7.6961E+08	1.5195E+09	3.0000E+09	3.6502E+09	4.4413E+09	5.4938E+09	011550
6.5750E+09	8.0000E+09	8.6758E+09	9.4086E+09	1.0203E+10	1.1065E+10	011560
1.2000E+10	1.3291E+10	1.4720E+10	1.6304E+10	1.8058E+10	2.0000E+10	011570
2.4915E+10	3.1037E+10	3.8664E+10	4.8164E+10	6.0000E+10	6.7650E+10	011580
7.6275E+10	8.6000E+10	1.5100E+11	2.4400E+11	3.4300E+11	4.1600E+11	011590
4.4700E+11	4.4800E+11	4.3000E+11	4.0100E+11	3.6200E+11	3.1900E+11	011600
2.7500E+11	2.3000E+11	1.8900E+11	1.5600E+11	1.3000E+11	1.1000E+11	011610
9.2800E+10	7.9800E+10	6.0765E+10	5.9812E+10	5.2567E+10	4.6200E+10	011620
4.1344E+10	3.6998E+10	3.3303E+10	3.0153E+10	2.7300E+10	2.4951E+10	011630
2.2803E+10	2.0934E+10	1.9303E+10	1.7800E+10	1.2400E+10	9.2000E+09	011640
6.7500E+09	5.1800E+09	4.0500E+09	3.2353E+09	2.5845E+09	2.0869E+09	011650
1.7032E+09	1.3900E+09	1.1471E+09	9.4668E+08	7.8444E+08	6.5265E+08	011660
5.4300E+08	4.5526E+08	3.8173E+08	3.2006E+08	2.6835E+08	2.2500E+08	011670

1.8968E+08	1.5990E+08	1.3480E+08	1.1364E+08	9.5803E+07	8.1080E+07	011580
6.8621E+07	5.8077E+07	4.9153E+07	4.1600E+07	3.5338E+07	3.0918E+07	011690
2.5499E+07	2.1661E+07	1.8400E+07	1.5677E+07	1.3358E+07	1.1381E+07	011700
9.6971E+06	8.2622E+06	7.0397E+06	5.9980E+06	5.1105E+06	4.3543E+06	011710
3.7100E+06	3.1759E+06	2.7187E+06	2.3273E+06	1.9923E+06	1.7055E+06	011720
1.4600E+06	1.2498E+06	1.0699E+06	9.1584E+05	7.8400E+05		011730

C	COMMON TVN2, TVC2, VVNC, VVON, TVN20, TVO20	000440
	COMMON DUMMY(1989)	000450
C	COMMON /ABCD/ H, DELTS, EPS, NDIM, NTRY, KCASE, N1, N2	000460
		000470
C	COMMON /ECFCOM/ SCC2, SCC2V	000480
	COMMON /GIFCOM/ QIP	000490
	COMMON /FANCOM/ EACOE, KBN, GUP, GUPAN	000500
	COMMON /YMTCOM/ XMAT(51,51), XFEP	000510
C		000520
C		000530
C	READ DO LOOP CONTROL PARAMETERS FOR LOOPS 450 AND 400	000540
C		000550
C		000560
C	READ (3,14) KSTRT, KEND, KTSTRT, NTIME	000570
		000580
C	READ (3,21) ARCFAC	000590
	READ (3,21) DRZFAC	000600
C	N1 = 0	000610
	N2 = 0	000620
C		000630
C	TFAC = 10.0**0.25	000640
	EPS = 1.0E-5	000650
	NDIM = 153	000660
	H = 1.0E-3	000670
C		000680
C	NALT = 51	000690
C	KN2V = 1	000700
C	KC2V = 2	000710
	KCC2V = 3	000720
	NSPS = 1	000730
		000740
		000750
		000760
		000770

NSPF = 3
NSFM = 3

C
C
C
C

CONSTANTS REQUIRED FOR CO2 NU-3 BAND

WVNUM = 2349.16
BNCL = 1.0E+4/WVNUM
SFLUY = 1.60E+16
PM = 44.0
BV = 0.39021
KLN = 1
KBN = 1
EACOFF = 400.0
STP = 2585.0
SNE = STP
GFAC = 3.72E-24*STR*BNCL**2
GDCWN = GFAC*SFLUX

C
C
C

GOSAVE = GDCWN
GDCWN = 0.0

READ (3,26) TEMP
READ (3,26) SN2
READ (3,26) SO2
READ (3,26) SCC2
READ (3,26) SO

C
C

WRITE (6,16)

TIMEA = 0.0
WRITE (6,21) TIMEA
WRITE (6,17)

000785
000790
000800
000810
000820
000830
000840
00085
000860
000870
000880
000890
000900
000910
000920
000930
000940
000950
000960
000970
000980
000990
001000
001010
001020
001030
001040
001050
001060
001070
001080
001090
001100
001110

```

C
TIMEB = 1.0E-3/TFAC
IF (TIMEA - NE. 0.0) TIMEB = TIMEA

C
DO 120 I = 1, NALT
  READ (5,5) SN2(I), SN2(I), SO(I), SOC2(I)
  QIP(I,1) = 0.0
  QIP(I,2) = 0.0
  QIP(I,3) = 0.0
  QIP(I,4) = 0.0
  QIP(I,5) = 0.0
  QIP(I,6) = 0.0
  IF (I .GT. 15)
    1 READ (4,5) QIP(I,4), QIP(I,5)
  QIP(I,4) = DEFAC*QIP(I,4)
  QIP(I,5) = ARCFAC*QIP(I,5)
  TEMP(I) = TMEL(FLOCAT(2*I + 48))
  TMP = TEMP(I)
  TMF13 = TMCM*(-3.3333*333333333333E-1)
  V1N2(I) = 6.53E-7*EXP(-273.1*TMP13)
  TVN2(I) = VTN2(I)*EXP(-1.43879/TMP*2330.72)
  VTC2(I) = 4.81E-8*EXP(-169.6*TMP13)
  TVC2(I) = VT02(I)*EXP(-1.43879/TMP*1556.39)
  VVCN(I) = 1.71E-6*EXP(-175.3*TMP13)
  1 + 6.07E-14*EXP(15.27*TMP13)
  VVFC(I) = VVCN(I)*EXP(-1.43879/TMP*18.43)
  VVNO(I) = 1.74E-10*EXP(-124.0*TMP13)
  VVCN(I) = VVNO(I)*EXP(-1.43879/TMP*774.33)
  VTN20(I) = 1.07E-10*EXP(-69.9*TMP13)
  TVN20(I) = VTN20(I)*EXP(-1.43879/TMP*2330.72)
  VTC20(I) = 6.88E-9*EXP(-76.7*TMP13)
  TVC20(I) = VT020(I)*EXP(-1.43879/TMP*1556.39)

C
SN2V(I) = 1.0E-8*SN2(I)
C
SC2V(I) = 1.0E-9*SOC2(I)
C

```

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001120
001130
001140
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001170
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001190
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001430
001440
001450

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```

C
DO 125 N7 = 2, NMIN
  TTP(NZ) = SIMP(BNCTAU(NZ-1),2.0E+5,2)
125 CONTINUE
C
DO 130 NZ = 2, NMIN
  NY = NALT - NZ + 1
  TTUP(NZ) = TTUP(NZ-1) + TTH(NZ-1)
  TTDOWN(NY) = TTDOWN(NY+1) + TTH(NY)
130 CONTINUE
C
  TTDOWN(1) = TTDOWN(2) + TTH(1)
  TTUP(NALT) = TTUP(NALT-1) + TTH(NALT)
C
  UPWELLING FLUX FROM LOWER ATMOSPHERE
C
  TFLUX = 5.097E+6*WVNUM**4/
1  (EXP(1.43879*WVNUM/TEMP(1)) - 1.0)
  GUF = 12.4664*GFAC*TFLUX
C
C
DO 150 NZ = 1, NALT
  TCY(1,NZ) = SN2V(NZ)
  TCY(2,NZ) = SO2V(NZ)
  TCY(3,NZ) = SCC2V(NZ)
150 CONTINUE
C
DO 160 NZ = 1, 51
DO 170 NP = 1, 51
  XWAT(NP,NZ) = 7.0
170 CONTINUE
  AFEP = 0.0
  CALL XFEF (SCC2V,TTH,NZ,1,1,NBN)
  AFEP = AFEP + YFEF

```

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001800
001810
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0 185
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001960
001970
001980
001990
002000
002010
002020
002030
002040
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002070
002080
002090
002100
002110
002120
002130

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```

CALL XFEP (SC02V(NZ),TTH(NZ),NALT,NZ,2,KEN)
AFEP = AFEP + YFEP
BFEP = 0.0
DO 175 NR = 1, 51
  BFEP = BFEP + XMAT(NP,NZ)*SC02V(NR)
  175 CONTINUE
  WRITE (6,13) NZ,NZ,AFEP,BFEP
  WRITE (6,23) (XMAT(NR,NZ), NR = 1, 51)
  180 CONTINUE
C
DO 450 KCASE = KSIRT, KEND
  GDOWN = 0.0
  IF (MOD(KCASE,2) .EQ. 1) GDOWN = GDSAVE
  IF (KCASE .EQ. 5) GDOWN = 0.0
  CALL FILL (TCX,VCX,DCX,SCX)
  CALL FLT (TCX,VCX,DCX,SCX)
  DO 400 KTIME = KTSIRT, NTIME
    IF (KTIME .EQ. 1) NTRY = 0
    IF (KTIME .LE. 29) TIMEB = TFAC*TIMEB
    IF (KTIME .GT. 29) TIMEB = TIMEB + 0300.0
    DELTS = TIMEB - TIMEA
    TIMEA = TIMEB
    WRITE (6,16)
    WRITE (6,21) TIMEA
    WRITE (6,17)
    IF (MOD(KTIME,2) .EQ. 1) WRITE (1,16)
    IF (MOD(KTIME,2) .EQ. 1) WRITE (1,21) TIMEA
  C
  C
  CALL SPK (TCX,VCX)
  C
  C
  C
  DO 370 NZ = 1, NALT

```

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002140
002150
002160
002170
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002190
002200
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002470

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```

C      ALT = 2*NZ + 40
      ALT = 2*NZ - 2
      TMFA = 1.43879/ALOG(SN2(NZ)/TCX(1,NZ))*2320.72
      TMFB = 1.43879/ALOG(SO2(NZ)/TCX(2,NZ))*1555.39
      TMFC = 1.43879/ALOG(SCO2(NZ)/TCX(3,NZ))*2349.15

C      WRITE (6,25) ALT,(TCX(I,NZ), I = 1, 3),TMFA,TMFB,TMPC
      IF (MOD(KTIME,2) .EQ. 1)
1      WRITE (1,25) ALT,(TCX(I,NZ), I = 1, 3),TMFA,TMPE,TMPC

C      SN2V(NZ) = TCX(1,NZ)
      SO2V(NZ) = TCX(2,NZ)
      SCC2V(NZ) = TCX(3,NZ)

C      370  CCNTINUE

C      WRITE (6,17)
      CALL SECOND (SECA)
      WRITE (6,6) H
      WRITE (6,9) N2,N1,SECA
      IF (MOD(KTIME,2) .EQ. 1) WRITE (1,9) N2,N1,SECA

C      SAVE VARIABLES IN CASE OF TIME LIMIT.

C      KTFPLUS = KTIME + 1
      WRITE (2,*) KCASE,KEND,KTFPLUS,KTIME
      WRITE (2,*) TFAC,TIMEA,TIMEB
      WRITE (2,*) SN2V
      WRITE (2,*) SO2V
      WRITE (2,*) SCC2V
      WRITE (2,*) XMAT
      REWIND 2
      ENDDFILE 6
      ENDDFILE 1

```

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002480
002490
002500
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002780
002790
002800
002810

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```

C      400      CONTINUE
C      CALL FILL (TCX,VCX,DCX,SCX)
C      CALL PUT (TCX,VCX,DCX,SCX)
C      TIMEA = 0.0
C      TIMEB = 1.0E-3/TFAC
C      KTSTPT = 1
C      CCNTINUE
C      STOP
C      5  FORMAT (EX,1P4E11.4)
C      6  FORMAT (7X,1P7E18.9)
C      7  FORMAT (1X,2I3,1P7E10.3)
C      8  FORMAT (1X,F8.3,1X,F8.3)
C      9  FORMAT (7X,2I8,2(1X,F8.3))
C      10 FORMAT (/1X,1PE10.3)
C      11 FORMAT (4X,1PE5.2,7E17.9)
C      12 FORMAT (43X,1P5E18.2)
C      13 FORMAT (1X,2I3,1F4E18.9)
C      14 FORMAT (1X,4I3)
C      16 FORMAT (1H1)
C      17 FORMAT (1X)
C      21 FORMAT (1X,1P12E10.3)
C      22 FORMAT (7X,1P8E10.2)
C      23 FORMAT (1X,1P12E10.2)
C      24 FORMAT (EX,12(A4,7X)/5X,12(A4,7X)/)
C      25 FORMAT (1X,F10.2,1P3E10.3,0P3F10.3)
C      26 FORMAT (1X,1P6E11.4)
C      END

```

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002990
003000
003010
003020
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003080
003090

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```

SUBROUTINE DER (TCX,VCX,8TX,CJX)
C
C THIS PROGRAM COMPUTES VIBRATIONAL PCPULATIONS
C OF N2, O2, AND CO2.
C
C 51 ALTITUDES, 50 (2) 150 KM.
C
C DIMENSION SN2(51),SO2(51),SO(51),SCO2(51)
C DIMENSION SN2V(51),SO2V(51),SCO2V(51)
C
C ARRAY SPACE FOR THE VIBRATIONAL ENERGY TRANSFER RATES
C
C DIMENSION VTN2(51),VT02(51),VVCN(51),VVNO(51)
C DIMENSION VTN2O(51),VT02O(51),TVN2(51),TV02(51)
C DIMENSION VVNC(51),VVON(51),TVN2O(51),TV02O(51)
C DIMENSION GIF(51,6)
C
C DIMENSION TCX(3,51),VCX(3,51)
C DIMENSION PTX(3,51),OJX(3,51)
C
C ARRAYS REQUIRED FOR RADIATIVE TRANSPORT
C
C COMMON BN0TAU(51),ORAD(51),PCX(51)
C COMMON TILF(51),TICOWN(51),TTH(51)
C
C
C COMMON SN2,SO2,SO,SN2V,SO2V
C COMMON VTN2,VT02,VVCN,VVNO,VTN2O,VT02O
C COMMON TVN2,TV02,VVNC,VVON,TVN2O,TV02O
C COMMON CUMMY(1989)
C COMMON /APCD/ H,DELTS,EPS,NDIM,NTRY,KCASE,N1,N2

```

C	COMMON /FOPCOM/ SC02,SC02V	003440
C	COMMON /CIFCOM/ OIP	003450
		003460
	COMMON /PANCOM/ EACOEFF,KBN,GUF,GDCMN	003470
	COMMON /XMTCOM/ XMAT(51,51),YFER	003480
		003490
		003500
		003510
		003520
	NALT = 51	003530
	KN2V = 1	003540
	K02V = 2	003550
	KCC2V = 3	003560
	NSPS = 1	003570
	NSPF = 3	003580
	NSFM = 3	003590
		003600
		003610
	VN2FAC = 10.0	003620
	VO2FAC = 1.0	003630
	OC02V = 0.0	003640
	ZFAC = 4.0	003650
		003660
		003670
	N1 = N1 + 1	003680
		003690
		003700
	DO 190 NZ = 1, NALT	003710
	RCX(NZ) = TCX(3,NZ)	003720
	190 CONTINUE	003730
		003740
		003750
		003760
		003770

PADIATIVE CONTRIBUTION TO C02 NU-3 EXCITATION

```

00 200 NZ = 1, NALT
SUM = 0.0
00 195 NR = 1, NALT
SUM = SUM + XMAT(NR,NZ)*RCX(NR)
155 CCNTINUE
QRAD(NZ) = GUP*SN12(K8N,TTUP(NZ))*SC02(NZ)
1 + SCC2(NZ)*SUP*EACOE
3 + GDOWN*SP1(K8N,ZFAC*TTDCWH(NZ))*SC02(NZ)
200 CCNTINUE
C
C
00 260 NZ = 1, NALT
Q2V = VA2FAC*QIP(NZ,KCASE)
Q02V = VC2FAC*QIP(NZ,KCASE)
C
XM = SN2(NZ) + S02(NZ) + SC02(NZ)
TN2V = TCX(1,NZ)
T02V = TCX(2,NZ)
TC02V = TCX(3,NZ)
QJX(KA2V,NZ) = GN2V + (TC02V*VVNC(NZ) +
1 TC02V*VVON(NZ) + XM*TVN2(NZ) +
2 SO(NZ)*TVN20(NZ))*SN2(NZ)
BTX(KA2V,NZ) = SC02(NZ)*VVNC(NZ) + S02(NZ)*VVNO(NZ) +
2 XM*VTN2(NZ) + SC(NZ)*VTN20(NZ)
QJX(K02V,NZ) = Q02V + (TN2V*VV40(NZ) +
1 XM*TV02(NZ) + SO(NZ)*TV020(NZ))*SC2(NZ)
BTX(K02V,NZ) = SN2(NZ)*VVON(NZ) + XM*VT02(NZ) +
1 SC(NZ)*VTC2C(NZ)
QJX(KC02V,NZ) = GC02V + QRAD(NZ) + SC02(NZ)*TN2V*VVNC(NZ)
BTX(KC02V,NZ) = EACOE + SN2(NZ)*VVON(NZ)
VCX(1,NZ) = QJX(1,NZ) - BTX(1,NZ)*TCX(1,NZ)
VCX(2,NZ) = QJX(2,NZ) - BTX(2,NZ)*TCX(2,NZ)
C

```

VCX(3,NZ) = OJX(3,NZ) - HTX(3,NZ)*TCX(3,NZ)

C

C

260

CONTINUE

C

C

RETUPN

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004120
004130
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004190

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C
C
C
C
SUBROUTINE SPK (Y, YDER)
EXPERIMENTAL STIFF INTEGRATION METHCD
T. C. DEGGES, VISIDYNF, INC. 1975 JULY 14-18

DIMENSION Y(153), YDER(153), P(153), FDER(153)
DIMENSION C(153), CDER(153)
DIMENSION YBET(153), YQ(153), FBET(153), PQ(153)
DIMENSION CBET(153), QQ(153), AA(153), F4(153)
DIMENSION EPP(153)
COMMON /ABCD/ H, XEND, EPS, NDIR, NTRY, KCASE, N1, N2
COMMON DUMMY(1173)
COMMON P, PDER, Q, QDER, YBET, YQ, PEET, FQ, QBET, GC, AA, F4, FRR

STATEMENT FUNCTION TO COMPUTE (1.0 - EXP(-X))
EXPM(X) = (((0.000333333*X - 0.041666667)*X +
1 0.166666667)*X - 0.5)*X + 1.0)*X

STATEMENT FUNCTION TO PREVENT OVERFLOW IN EXP
CHEKXP(X) = AMAX1(-575.0, AMIN1(X, 675.0))

WRITE (6,12) NTRY, KCASE, H, XEND
X = (.0
IF (H .GT. XEND) H = XEND
IF (NTRY .NE. 0) GO TO 20
NTRY = 1
HSAV = H
CALL DEP (Y, YDER, YBET, YQ)
FAC = 2.0
DO 10 J = 1, NDIR
  AA(J) = 0.0
10 CONTINUE
20 CONTINUE
30 CONTINUE

```

```

H2 = H/2.0
H4 = H/4.0
DO 40 J = 1, NDIM
  IF (YBET(J) .LE. 0.0) GO TO 34
  FACB = H*YBET(J)
  EFAC = EXP(-CHEKXP(FACB))
  FACM = 1.0 - EFAC
  IF (FACB .LT. 0.01) FACM = EXPM(FACB)
  P(J) = EFAC*Y(J) + FACM*(YQ(J)/YBET(J) -
1  AA(J)/YPET(J)**2) + H*AA(J)/YPET(J)
  GO TO 40
34 CONTINUE
P(J) = (H2*AA(J) + YQ(J))*H + Y(J)
40 CONTINUE
CALL CDR (F,POER,FBET,PQ)
SUM = 0.0
DO 50 J = 1, NDIM
  BETA = (YBET(J) + PBET(J))*0.5
  IF (BETA .LE. 0.0) GO TO 44
  AA(J) = (PC(J) - YC(J))/H
  FACB = H*BETA
  EFAC = EXP(-CHEKXP(FACB))
  FACM = 1.0 - EFAC
  IF (FACB .LT. 0.01) FACM = EXPM(FACB)
  Q(J) = EFAC*Y(J) + FACM*(YC(J)/BETA -
1  AA(J)/BETA**2) + H*AA(J)/BETA
  GO TO 47
44 CONTINUE
Q(J) = (YQ(J) + PQ(J))*H2 + Y(J)
47 CONTINUE
SUM = AMAX1(SUM,ABS(Q(J) - P(J))/(C(J) + P(J) + 1.0E-2))
50 CONTINUE
IF (SUM .LT. EPS) GO TO 80
CALL CDR (C,ODER,CRAFT,ON)
C

```

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004680
004690
004700
004710
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004740
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004760
004770
004780
004790
004800
004810
004820
004830
004840
004850
004860
004870

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C 70 SUM = AMAX1(SUM,ABS(P(J) - Q(J)))/(F(J) + Q(J) + 1.0E-2)
C CONTINUE
C IF (SUM .LT. EPS/2.5) GO TO 80
C FAC = 1.1
C WRITE (6,12) N1,N2,SUM,H
C H = H2
C HSAV = H
C GO TO 70
C 80 CONTINUE
C DO 90 J = 1, NDIM
C Y(J) = Q(J)
C CONTINUE
C GO TO 130
C 100 CONTINUE
C DO 110 J = 1, NDIM
C Y(J) = P(J)
C CONTINUE
C 120 CONTINUE
C 12 FORMAT (2X,2I6,1P2E10.3)
C N2 = N2 + 1
C CALL DER (Y,YDER,YBET,YO)
C WRITE (6,12) N1,N2,SUM,H
C X = Y + H
C IF (ABS((XEND - X)/XEND) .LT. 1.0E-10) RETURN
C IF (SUM .LT. EPS/5.0 .AND. H .EQ. HSAV) HSAV = FAC*H
C H = HSAV
C IF (Y + H .GT. XEND) H = XEND - X
C GO TO 30
C END

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005220
005230
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005290
005300
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005330
005340
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005360
005370
005380
005390
005400
005410
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005430
005440
005450
005460
005470
005480
005490
005500


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005860
005870
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005900
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005990
006000
006010
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006070
006080
006090
006100
006110
006120
006130
006140
006150
006160
006170
006180
006190

FUNCTION SLO (K,TAU)
T = ABS (TAU)
IF (K .EQ. 2) GO TO 200
IF (T .GT. 4.0) GO TO 110
X = 1 - 2.0*T*.5
SLO = (((0.0004110*X - 0.0018456)*X + 0.0068378)*X
1 - 0.0224656)*X + 0.0792553)*X - 0.2301123)*X + 0.6569377)*T
RETURN
110 CONTINUE
IF (T .GT. 10.0) GO TO 120
X = (T - 7.0)/3.0
SLO = (((0.0001916*X - 0.0007254)*X + 0.0023078)*X
1 - 0.0080348)*X + 0.0274855)*X - 0.0942082)*X + 0.3539295)*T
RETURN
120 CONTINUE
Y = ALOG(T)
IF (T .GT. 100.0) GO TO 130
X = 9.210340371976/Y - 3.0
SLO = (((0.0000869*X - 0.0001530)*X - 0.0001490)*X
1 + 0.0013943)*X - 0.0063060)*X + 0.0837063)*X + 1.1415564)*Y
RETURN
130 CONTINUE
X = 0.210340371976/Y - 1.0
SLO = (((0.0007142 - 0.006222*X) + 0.005211)*X
1 - 0.004896)*X - 0.005477)*X + 0.007743)*X - 0.015900)*X
2 + 0.122526)*X + 0.940111)*Y
RETURN
200 CONTINUE
IF (T .GT. 4.0) GO TO 210
X = (T - 2.0)*.5
SLO = (((0.0002431*X - 0.0010991)*X + 0.0041830)*X
1 - 0.00160764)*X + 0.0501769)*X - 0.2013270)*X + 0.7188944)*T
RETURN
210 CONTINUE

```

006200
006210
006220
006230
006240
006250
006260
006270
006280
006290
006300
006310
006320

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IF (T.GT. 10.0) GO TO 220
X = (T - 7.0)/3.0
SLQ = (((((0.0001159*X - 0.0014695)*X + 0.0016637)*X
1 - 0.0065345)*X + 0.0255562)*X - 0.1003592)*X + 0.4282944)*T
RETURN
220 CONTINUE
Y = ALOG(T)
X = 4.60517018592809/Y - 1.0
SLQ = ((((((0.035431 - 0.035666*X)*X + 0.162211)*X
1 - 0.0056895)*X - 0.046818)*X + 0.045072)*X + 0.009249)*X
2 - 0.000887)*X - 0.062059)*X + 0.163319)*X + 1.399769)*Y
RETURN
END

```

```

FUNCTION SN12 (K,TAU)
T = ABS(TAU)
IF (T.EQ. 0.0) GO TO 300
IF (K.GT. 1) GO TO 200
IF (T.GT. 1.0) GO TO 110
T = 25.2676037*T
SN12 = (((((5.54E-16*T - 1.3747E-13)*T + 3.11017E-11)*T
1 - 0.434609E-9)*T + 1.24762E-6)*T - 2.57626E-4)*T
2 - 0.08264246 + 0.01984964*ALOG(T))*T : 1.0)*0.5
RETURN
110 CONTINUE
IF (T.GT. 4.0) GO TO 120
X = (T - 2.5)/1.5
SN12 = (((((3.00591E-3 - 1.4146E-3*X)*X - 3.88085E-3)*X
1 + 9.48736E-3)*X - 0.0239407)*X + 0.0523028)*X
2 - 0.1045984)*X + 0.1862743)*0.5
RETURN
120 CONTINUE
IF (T.GT. 10.0) GO TO 130
X = (T - 7.0)/3.0
SN12 = (((((5.08470E-4 - 1.90181E-4*X)*X - 9.27594E-4)*X
1 + 2.24274E-3)*X - 5.54298E-3)*X + 0.01200804)*X
2 - 0.02939935)*X + 0.06552257)*0.5
RETURN
130 CONTINUE
IF (T.GT. 100.0) GO TO 140
Y = ALOG(T)
X = 0.210340371976/Y - 3.0
SN12 = (((((7.836E-4*X - 1.5181E-3)*X + 9.0128E-4)*X
1 - 6.438E-4)*X - 1.0632E-3)*X + 0.0149364)*X
2 + 0.4378273)*0.5/T
RETURN
140 CONTINUE
Y = ALOG(T)

```

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006330
006340
006350
006360
006370
006380
006390
006400
006410
006420
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006460
006470
006480
006490
006500
006510
006520
006530
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006550
006560
006570
006580
006590
006600
006610
006620
006630
006640
006650
006660

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```

X = 9.210340371976/Y - 1.0
SN12 = ((5.0746E-3 - 4.681E-4*X)*X - 1.5848E-3)*X
1 + 0.0147526)*X + 0.4079074)*0.5/T
    RETURN
200 CONTINUE
    IF (T.GT. 1.0) GO TO 210
    T = 2F.0729185*T
    SN12 = (((2.71E-16*T - 6.8372E-14)*T + 1.58314E-11)*T
1 - 3.39873E-9)*T + 7.01818E-7)*T - 1.61584E-4)*T
2 - 0.0656453 + 0.01494384*ALOG(T))*T + 1.0)*0.5
    RETURN
210 CONTINUE
    IF (T.GT. 4.0) GO TO 220
    X = (T - 2.5)/1.5
    SN12 = (((2.32E-3 - 1.1203E-3*X)*X - 3.0489E-3)*X
1 + 7.9345E-3)*X - 0.0213281)*X + 0.052158E)*X
2 - 0.1213660)*X + 0.2508902)*0.5
    RETURN
220 CONTINUE
    IF (T.GT. 10.0) GO TO 230
    X = (T - 7.0)/3.0
    SN12 = (((4.727E-4*X - 1.2459E-3)*X + 2.5263E-3)*X
1 - 6.7323E-3)*X + 0.0174769)*X - 0.0421443)*X
2 + 0.0958415)*0.5
    RETURN
230 CONTINUE
    IF (T.GT. 100.0) GO TO 240
    Y = ALOG(T)
    X = 9.210340371976/Y - 3.0
    SN12 = ((9.1E-5*X - 1.9096E-3)*X - 1.8059E-3)*X
1 + 1.0263129)*X + 0.6392594)*0.5/T
    RETURN
240 CONTINUE
    Y = ALOG(T)

```

```

006670
006680
006690
006700
006710
006720
006730
006740
006750
006760
006770
006780
006790
006800
006810
006820
006830
006840
006850
006860
006870
006880
006890
006900
006910
006920
006930
006940
006950
006960
006970
006980
006990
007000

```

007 10
007020
007030
007040
007050
007060
007070
007080

X = 9.21034037976/Y - 1.0
 SN12 = ((15.44+E-4)*X + 3.453E-4)*X - 5.099E-4)*X
 + 0.0216100)*X + 0.591052)*0.5/Y
 1 RETURN
 300 CCNTIRUF
 SN12 = 0.5
 RETURN
 END

007090
007100
007110
007120
007130

FUNCTION TAUMAX (KL,KB,RM,BV,T,FLAP,S,DEN)
SIG = 1.43879*BV/T
TAUMAX = 5.3613E-18*SQRT(RM/T)*FLAP*DEN*S*SJMAX(KL,KB,SIG)
RETURN
END

```

C
C
C
      FUNCTION SJMAX (KL,KB,SIG)
      SJMAX COMPUTES THE RELATIVE STRENGTH OF THE STRONGEST LINE
      IF KB = 1, SIGMA-SIGMA TRANSITION
      IF KB = 2, SIGMA-PI TRANSITION
      GO TO (110,120,130), KB
110 CONTINUE
      TJM = 0.5*(SORT(0.25 + 2.0/SIG) - 1.5)
      A = 0.5*(TJM + TJM + 1.0)
      GO TO 200
120 CONTINUE
      TJM = 0.5*(SORT(2.0/SIG) - 1.0)
      A = TJM + 1.0
      GO TO 200
130 CONTINUE
      SJMAX = 0.0
      RETURN
200 CONTINUE
      SUM = 1*EXP(-SIG*TJM*(TJM + 1.0))
      SJMAX = SUM/OJFAP1(KL,SIG)
      RETURN
      END
007140
007150
007160
007170
007180
007190
007200
007210
007220
007230
007240
007250
007260
007270
007280
007290
007300
007310
007320
007330
007340

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0007350
0007360
0007370
0007380
0007390
0007400
0007410
0007420
0007430
0007440
0007450
0007460
0007470
0007480
0007490
0007500
0007510
0007520
0007530
0007540
0007550
0007560
0007570
0007580
0007590
0007600
0007610

007620
007630
007640
007650
007660
007670
007680
007690
007700
007710
007720
007730
007740

```

FUNCTION SIMP (A,H,K)
  DIMENSION A(3)
  IF (K - 2) 100,110,120
100 CONTINUE
  SIMP = (6.0*A(2) + 5.0*A(1) - A(3))*H/12.0
  RETURN
110 CONTINUE
  SIMP = (8.0*A(2) + 5.0*A(3) - A(1))*H/12.0
  RETURN
120 CONTINUE
  SIMP = (4.0*A(2) + A(1) + A(3))*H/3.0
  RETURN
  ENC

```

```

FUNCTION SM1 (K,TAU)
T = ABS(1AU)
IF (T .GT. 0.0) GO TO 300
IF (K .GE. 2) GO TO 200
IF (T .GT. 4.0) GO TO 110
X = (T - 2.0)*0.5
SM1 = (((12.35490E-03)*X - 8.90535E-03)*X + 2.56223E-02)*X
1 - 7.07877E-02)*X + 1.53735E-01)*X - 3.01749E-01)*X + 0.426845
RETURN
110 CONTINUE
IF (T .GT. 10.0) GO TO 120
X = (T - 7.0)/3.0
SM1 = (((5.32297E-04)*X - 1.79043E-03)*X + 4.05109E-03)*X
1 - 1.04749E-02)*X + 2.59109E-02)*X - 6.01708E-02)*X + 0.134123
RETURN
120 CONTINUE
IF (T .GT. 100.0) GO TO 130
Y = ALOG(T)
X = 9.21034037197E/Y - 3.0
SM1 = ((((-6.24516E-04)*X - 6.79378E-04)*X + 2.98590E-03)*X
1 - 1.28190E-03)*X - 6.31784E-03)*X + 3.78904E-02)*X
2 + 8.90441E-01)/T
RETURN
130 CONTINUE
Y = ALOG(T)
X = 9.21034037197E/Y - 1.0
SM1 = (((6.12038E-04)*X - 2.93434E-04)*X - 4.36163E-04)*X
1 + 1.30037E-02)*X - 3.80088E-04)*X + 3.23441E-02)*X
2 + 8.17407E-01)/T
RETURN
200 CONTINUE
IF (T .GT. 4.0) GO TO 210
X = (T - 2.0)*0.5
SM1 = (((1.39071E-03)*X - 5.29904E-03)*X + 1.58249E-02)*X

```

```

1 - 4.74039E-02)*X + 1.26175E-01)*X - 2.86233E-01)*X + 0.517573
  RETURN
210 CONTINUE
  IF (T.GT. 10.0) GO TO 220
  X = (T - 7.0)/1.0
  SM1 = (((3.76429E-04*X - 1.25384E-03)*X + 3.41168E-03)*X
1 - 1.35360E-02)*X + 3.07476E-02)*X - 8.14765E-02)*X + 0.1941308
  RETURN
220 CONTINUE
  IF (T.GT. 100.0) GO TO 230
  Y = ALOG(T)
  X = 9.210340371976/Y - 3.0
  SM1 = (((-7.53415E-03*X - 8.87124E-03)*X + 6.62199E-02)*X
1 + 1.304245)/T
  RETURN
230 CONTINUE
  Y = ALOG(T)
  X = 9.210340371976/Y - 1.0
  SM1 = (((1.99767E-03 - 5.82519E-04*X)*X + 1.99669E-03)*X
1 + 1.21174E-03)*X + 4.76165E-02)*X + 1.18445)/T
  RETURN
300 CONTINUE
  SM1 = 1.0
  RETURN
  END

```

0 8 9
 008100
 008110
 008120
 008130
 008140
 008150
 008160
 008170
 008180
 008190
 0 820
 008210
 008220
 008230
 008240
 008250
 008260
 008270
 008280
 008290
 008300
 008310
 008320
 008330

```

SUBROUTINE XFER (RAD,TTH,NTOP,NBOT,K-KB)
COMMON /FCFCOM/ VIBPOP(51,2)
DIMENSION RAD(161),TTH(161)
COMMON /XMTCOM/ XMAT(51,51),YFER
NINT = NTCF - NBOT
MPL = NINT + 1
IF (NINT .GT. 0) GO TO 100
YFEP = 0.0
RETURN
100 CONTINUE
RA = 1.0
TR = 0.0
EA3 = 0.0
IF (K .GT. 1) GO TO 200
K = 0.1, INTEGRATE DOWNWARD FROM ALTITUDE NTOP.
XMAT(NTOP,NTOP) = XMAT(NTOP,NTOP) + 0.5/VIBPOP(NTOP,1)
NF = NTOP
RFAC = VIBPOP(NF,1)/RAD(NF)
SUM = 0.5*RA
DO 120 NZ = 1, NINT
  NY = NINT - NZ + 1
  TM = TTH(NY)
  TR = TR + TM
  EB3 = SL03(KB,TR)
  NF = NF - 1
  RB = RFAC*RAD(NY)/VIBPOP(NF,1)
  SUM = SUM + (RB - RA)*(EB3 - EA3)/TM
  XMAT(NF+1,NTOP) = XMAT(NF+1,NTOP) -
    1 (EB3 - EA3)/TM/VIBPOP(NF+1,1)
  XMAT(NF,NTOP) = XMAT(NF,NTOP) +
    1 (EB3 - EA3)/TM/VIBPOP(NF,1)
  RA = RB

```

```

003340
008350
008360
008370
008380
008390
008400
008410
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008430
008440
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008470
008480
008490
008500
008510
008520
008530
008540
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008560
008570
008580
008590
008600
008610
008620
008630
008640
008650
008660
008670

```

C
C
C

```

120  EA3 = ER3
      CONTINUE
      XMAT(1,NTOP) = XMAT(1,NTOP) - SN12(KB,TB)/VIRPOP(1,1)
      YFER = ABS(SUM - RB*SN12(KB,TB))/RFAC
      RETURN
200  CCCONTINUE

      C
      C
      C
      K .EQ. 2, INTEGRATE UPWARD FROM ALTITUDE NROTI.

      XMAT(NROTI,NROTI) = XMAT(NBOT,NBOT) + 0.5/VIRPOP(NBOT,1)
      NF = NBOT
      RFAC = VIRPOP(NF,1)/RAD(1)
      SUM = 0.5*RA
      DO 220 N7 = 2, NPL
        TM = TTH(NZ - 1)
        TB = TB + TM
        EP3 = SL03(KB,TB)
        NF = NF + 1
        XMAT(NF-1,NBOT) = XMAT(NF-1,NBOT) -
1      (ER3 - EA3)/TM/VIRPOP(NF-1,1)
        XMAT(NF,NBOT) = XMAT(NF,NBOT) +
1      (EB3 - EA3)/TM/VIRPOP(NF,1)
        RB = RFAC*RAD(NZ)/VIRPOP(NF,1)
        SUM = SUM + (RB - RA)*(EB3 - EA3)/TM
        RA = RB
      EA3 = EB3
      CONTINUE
      XMAT(NTOP,NBOT) = XMAT(NTOP,NBOT) -
1      SN12(KB,TB)/VIRPOP(NTOP,1)
      YFER = ABS(SUM - RB*SN12(KB,TB))/RFAC
      RETURN
      END

```

```

008680
008690
008700
008710
008720
008730
008740
008750
008760
008770
008780
008790
008800
008810
008820
008830
008840
008850
008860
008870
008880
008890
008900
008910
008920
008930
008940
008950
008960
008970
008980
008990

```

```

C
C
C
C
C
FUNCTION SL03(K,TAU)
COMPUTE ONE-HALF THE VALUE OF THE FUNCTION L SUB NOUGHT THREE.
K .EQ. 1, PARALLEL BAND
K .EQ. 2, PERPENDICULAR BAND
T = ABS(TAU)
IF (T .EQ. 0.0) GO TO 300
IF (K .GE. 2) GO TO 200
IF (T .GT. 1.0) GO TO 110
X = (T - 0.5)*2.0
SL03 = (((2.583E-4)*X - 6.0149E-3)*X - 0.1027233)*X
1 + 0.12538821*ALOG(T)*T + 0.4035503)*T
RETURN
110 CONTINUE
IF (T .GT. 4.0) GO TO 120
X = (T - 2.5)/1.5
SL03 = (((((7.686E-4 - 3.516E-4)*X)*X - 1.0464E-3)*X
1 + 2.7618E-3)*X - 7.96629E-3)*X + (.0219502)*X
2 - 0.0626550)*X + 0.1975702)*X
RETURN
120 CONTINUE
IF (T .GT. 10.0) GO TO 130
X = (T - 7.0)/3.0
SL03 = (((((1.7495E-4)*X - 4.9991E-4)*X + 0.00113772)*X
1 - 0.00324538)*X + 0.01009861)*X - 0.03090774)*X
2 + 0.10486302)*T
RETURN
130 CONTINUE
Y = ALOG(T)
IF (T .GT. 100.0) GO TO 140
X = 9.210340371976/Y - 3.0
SL03 = (((((8.93E-5 - 9.78E-5)*X)*X + 2.458E-4)*X
1 - 0.0012858)*X + 0.0347297)*X + 0.3210431)*Y

```

```

009110
009010
009020
009130
009040
009050
009160
009170
009080
009090
009100
009110
009120
009130
009140
009150
009160
009170
009180
009190
009200
009210
009220
009230
009240
009250
009260
009270
009280
009290
009300
009310
009320
009330

```

```

140      RETURN
      CONTINUE
      IF (T.GT. 1000.0) GO TO 150
      X = 27.6210211593/Y - 5.0
      SL03 = (((8.3E-6 - 2.01E-5*X)*X - 1.843E-4)*X
1      + 0.0129309)*X + 0.2729344)*Y
      RETURN
150      CONTINUE
      X = 13.81551055796/Y - 1.0
      SL03 = (((5.396E-4*X - 0.0015838)*X + 0.0016309)*X
1      - 0.0001371)*X - 0.0723757)*X + 0.0301341)*X
2      + 0.2315830)*Y
      RETURN
200      CONTINUE
      IF (T.GT.1.0) GO TO 210
      X = (T - 0.5)*2.0
      SL03 = (((1.607E-4*X - 4.0569E-3)*X - 0.080885)*X
1      + 0.097407381*ALOG(T)*T + 0.4161293)*T
      RETURN
210      CONTINUE
      IF (T.GT. 4.0) GO TO 220
      X = (T - 2.5)/1.5
      SL03 = (((5.904E-4 - 2.794E-4*X)*X - 8.069E-4)*X
1      + 2.2244E-3)*X - 6.6504E-3)*X + 0.0197235)*X
2      - 0.0631562)*X + 0.2307133)*T
      RETURN
220      CONTINUE
      IF (T.GT. 10.0) GO TO 230
      X = (T - 7.0)/3.0
      SL03 = (((1.476E-4*X - 4.291E-4)*X + 1.0472E-3)*X
1      - 3.7166E-3)*X + 0.0107584)*X - 0.0356259)*X
2      + 0.1310343)*T
      RETURN
230      CONTINUE

```

```

009340
009350
009360
009370
009380
009390
009400
009410
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009430
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009480
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009670

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0 9551
009590
009720
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009720
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009770
009780
009790
009800
009810
009820
009830
009840
009850
009860
009870
009880
009890
009900

```

Y = ALG(Y)
IF (T.GT. 100.0) GO TO 240
Y = 9.21740271975/Y - 3.2
Z1 = ((1.14.185E-6 - (2.131E-6)*Y + 2.79E-5)*Y)*X
+ 7.79E-5)*Y + 9.04E-5)*Y - 0.0022059)*Y
+ 0.0330859)*Y + 0.4197794)*Y
RETURN
240 CONTINUE
IF (T.GT. 100.0) GO TO 250
Y = 22.67221153/Y - 5.0
Z2 = ((1.1.5E-5)*Y - 2.642E-4)*Y + 0.0124767)*Y
+ 0.0720989)*Y
RETURN
250 CONTINUE
Y = 12.24251055795/Y - 1.0
Z3 = ((1.1.0049E-3 - 4.42E-4)*Y - 9.44E-4)*Y
+ 9.051E-4)*Y - 3.4768E-3)*Y + 0.0330859)*Y
+ 0.0328465)*Y
RETURN
260 CONTINUE
Z4 = 0.0
RETURN
END

```

[illegible]

8.6209E+12	6.7235E+12	5.2722E+12	4.1812E+12	3.3912E+12	2.5933E+12	016650
2.0268E+12	1.5755E+12	1.2173E+12	9.3525E+11	7.1474E+11	5.4235E+11	016660
4.0843E+11	3.0387E+11	2.2473E+11	1.6932E+11	1.2091E+11	8.7901E+10	016670
6.3505E+10	4.5582E+10	3.1936E+10	2.2327E+10	1.5653E+10	1.0970E+10	016680
7.6547E+09	5.7292E+09	3.7293E+09	2.1845E+09	1.2974E+09	7.7209E+08	016690
1.7007E+02	2.5119E+02	6.3096E+02	1.5249E+03	3.9811E+03	1.0000E+04	016700
2.5119E+04	6.3096E+04	1.5249E+05	3.9811E+05	1.0000E+06	2.5119E+06	016710
6.3096E+06	1.5249E+07	3.9811E+07	1.0000E+08	1.9744E+08	3.9931E+08	016720
7.6961E+08	1.5195E+09	7.0000E+09	3.6502E+09	6.4413E+09	9.4038E+09	016730
6.5750E+09	8.0000E+09	2.6758E+09	9.4086E+09	1.0223E+10	1.1765E+10	016740
1.2071E+10	1.3291E+10	1.4720E+10	1.6304E+10	1.8058E+10	2.1000E+10	016750
2.4015E+10	3.1037E+10	3.8664E+10	4.8164E+10	6.0000E+10	6.7650E+10	016760
7.6275E+10	8.6000E+10	1.5107E+11	2.4600E+11	3.4300E+11	4.1670E+11	016770
4.4709E+11	4.4800E+11	4.3000E+11	4.07100E+11	3.6200E+11	3.19.0E+11	016780

CAY

1 1 1 1

1.000F-00	2.7517E+02	2.6220E+02	2.4922E+02	2.3624E+02	2.2327E+02
1.000E-00	2.1655E+02	2.1655E+02	2.1655E+02	2.1655E+02	2.1655E+02
2.0815E+02	2.2254E+02	2.2452E+02	2.2651E+02	2.2849E+02	2.3047E+02
2.1555E+02	2.4480E+02	2.5033E+02	2.5586E+02	2.6139E+02	2.6692E+02
2.2055E+02	2.7065E+02	2.6903E+02	2.6354E+02	2.5804E+02	2.5255E+02
2.3927E+02	2.4157E+02	2.3607E+02	2.3050E+02	2.2509E+02	2.1959E+02
2.7065E+02	2.1035E+02	2.0643E+02	2.0252E+02	1.9861E+02	1.9470E+02
2.1426E+02	1.8687E+02	1.8687E+02	1.8687E+02	1.8736E+02	1.8833E+02
1.9078E+02	1.9220E+02	1.9508E+02	2.0020E+02	2.0531E+02	2.1042E+02
1.8931E+02	1.6341E+02	1.3302E+02	1.0717E+02	8.5372E+01	6.7150E+01
1.9888E+02	3.7093E+01	2.7101E+01	1.9804E+01	1.4475E+01	1.0504E+01
5.7778E+01	5.5783E+01	4.0835E+01	2.9981E+01	2.2075E+01	1.6116E+01
7.6429E+01	8.7424E+01	6.5093E+01	4.8788E+01	3.6799E+01	2.7925E+01
1.1523E+01	1.6720E+01	1.3111E+01	1.0399E+01	8.2094E+01	6.4489E+01
2.1478E+01	3.9179E+01	3.0285E+01	2.2272E+01	1.7774E+01	1.3487E+01
5.0401E+01	7.5547E+01	5.5685E+01	4.1110E+01	3.0067E+01	2.1859E+01
1.0158E+01	1.1335E+01	7.9416E+01	5.5653E+01	3.8926E+01	2.7199E+01
1.5792E+01	1.7252E+01	5.2738E+01	6.5362E+01	4.6484E+01	3.2934E+01
1.9044E+01	4.3838E+01	3.5685E+01	2.8751E+01	2.2903E+01	1.8014E+01
5.3354E+01	9.9508E+01	7.2703E+01	5.7170E+01	3.8833E+01	2.8178E+01
1.3622E+01	1.4865E+01	1.0955E+01	8.0429E+01	5.9220E+01	4.3207E+01
2.0504E+01	2.3453E+01	1.7453E+01	1.7088E+01	9.8720E+01	7.4913E+01
3.1718E+01	4.4854E+01	3.5172E+01	2.7897E+01	2.2023E+01	1.7301E+01
5.7511E+01	1.0510E+01	8.1245E+01	6.2473E+01	4.7682E+01	3.6181E+01
1.7521E+01	2.0287E+01	1.4992E+01	1.1329E+01	8.0661E+01	5.8641E+01
2.7251E+01	7.0419E+01	2.1305E+01	1.4930E+01	1.0443E+01	7.2967E+01
4.2366E+01	3.5552E+01	2.4879E+01	1.5745E+01	1.1386E+01	7.7238E+01
5.1509E+01	6.5712E+01	5.3491E+01	4.3398E+01	3.4331E+01	2.7003E+01
7.9976E+01	1.4916E+01	1.0898E+01	7.9640E+01	5.8210E+01	4.2239E+01
2.0420E+01	2.2432E+01	1.6421E+01	1.2056E+01	8.8770E+01	6.4766E+01
3.0735E+01	3.5156E+01	2.6176E+01	1.9519E+01	1.4798E+01	1.1229E+01
4.7545E+01					

8.6208E+12	6.7235E+12	5.2722E+12	4.1818E+12	3.3012E+12	2.5933E+12
2.0269E+12	1.8755E+12	1.2178E+12	5.3588E+11	7.1474E+11	5.4235E+11
4.0849E+11	3.0380E+11	2.2473E+11	1.6532E+11	1.2091E+11	8.7901E+10
6.3505E+10	4.5582E+10	3.1936E+10	2.2380E+10	1.5653E+10	1.0938E+10
7.6583E+09	5.3292E+09	3.7293E+09	2.1045E+09	1.2974E+09	7.7209E+08
1.0000E+07	2.5119E+02	6.3096E+02	1.5849E+03	3.9811E+03	1.0000E+04
2.5119E+04	6.3096E+04	1.5849E+05	3.9811E+05	1.0000E+06	2.5119E+06
6.3096E+06	1.5849E+07	3.9811E+07	1.0000E+08	1.9744E+08	3.9981E+08
7.6961E+08	1.5195E+09	3.0000E+09	3.6502E+09	4.4413E+09	5.4038E+09
6.5750E+09	8.0000E+09	2.6758E+09	9.4022E+09	1.0203E+10	1.1065E+10
1.2000E+10	1.3291E+10	1.4720E+10	1.6304E+10	1.8058E+10	2.0000E+10
2.4915E+10	3.1077E+10	3.8664E+10	4.8164E+10	6.0000E+10	6.7650E+10
7.6275E+10	8.6000E+10	1.5100E+11	2.4400E+11	3.4300E+11	4.1600E+11
4.4700E+11	4.4800E+11	4.3000E+11	4.0100E+11	3.6200E+11	3.19.0E+11

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