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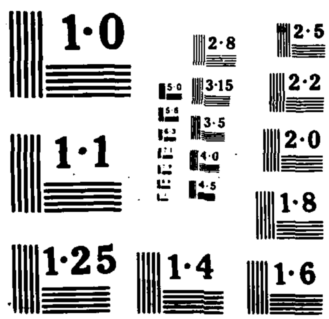
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AD-A172 556

Update of an Efficient Computer Code (NLTE) to Calculate Emission and Transmission of Radiation Through Non-Equilibrium Atmospheres

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20 September 1985

INFRARED TECHNOLOGY DIVISION
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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

NLTE computer code for calculation of Emission and Transmission of Infrared Radiation Through Non-Equilibrium Atmospheres (AFGL-TR-83-0168) has been streamlined and updated. The newer version has several new functions and is at least an order of magnitude faster than the previous version. Instructions on how to use the code, sample runs, and program listings are also given.

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Update of an Efficient Computer Code (NLTE) to Calculate Emission and Transmission of Radiation Through Non-Equilibrium Atmospheres

1. INTRODUCTION

The Air Force Geophysics Laboratory (AFGL) is in the process of developing comprehensive FORTRAN codes for calculating the radiance due to infrared-active species in the upper atmosphere. The objective of this work is to improve the understanding of the physics and chemistry of the upper atmosphere. In particular, the codes deal with atmospheric conditions in which local thermodynamic equilibrium (LTE) cannot be assumed; that is, conditions under which the populations of ro-vibrational states cannot (necessarily) be given by a Boltzmann distribution with the kinetic temperature.

This report describes program NLTE, which is a general line-by-line code predicting the infrared radiance from individual molecular species at an observing site located within the upper atmosphere or in limb geometry viewing from outside the atmosphere. The present version of the program assumes that lines do not overlap to an appreciable extent and that there are no lateral variations in the atmosphere. It operates in a stand-alone mode and also is being incorporated into a larger package for use in iterative or repetitive applications. Emphasis has been placed upon (1) achieving accurate results at all steps of this detailed calcu-

(Received for publication 16 September 1985)

lation, and (2) making the program easy to use and transportable. Since its first release,[1] NLTE has undergone substantial revisions which make it much faster and give it more capabilities, and which, therefore, necessitate a new release and this accompanying report.

The program output consists of the total radiance (watt/cm^2-ster) for a specified vibrational band for a set of viewing paths, and also the spectral radiance (watt/cm^2-ster-μm or watt/cm^2-ster-cm^{-1}) if an instrumental resolution parameter is provided. The band radiance is just the sum of the integrated radiance for all the individual lines. If a single ro-vibrational transition, rather than an entire band, is requested, the program gives the integrated line radiance and also many intermediate results, including the detailed spectral radiance profile for the line.

NLTE requires the user to prepare three input files. They specify (1) the molecule, isotope, and band under consideration, and the viewing geometry; (2) the atmospheric profile; and (3) an appropriate subset of the AFGL Atmospheric Absorption Line Parameters Compilation.[2,3,4] In the case of the second file, the quantities required for an altitude range sufficient to complete the calculation are

(a) the kinetic temperature, T,

(b) the total number density and a vibrational temperature characterizing the the upper level of the band under consideration (and, for hot bands, the lower level as well) or equivalent information, and

(c) a vibrational temperature for the lowest-lying excited state for use in calculating the vibrational partition function, or equivalent information. "Equivalent information" for both (b) and (c) consists of number densities of lower and upper vibrational levels. The third file is necessary because it provides the properties of the individual ro-vibrational transitions, which are needed to determine the absorption and reradiation of energy by each line in the wavelength region under consideration.

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1. Sharma, R.D., Siani, R., Bullitt, M., and Wintersteiner, P.P. (1983) A Computer Code to Calculate Emission and Transmission of Infrared Radiation Through a Non-Equilibrium Atmosphere, AFGL-TR-83-0168, AD A137162.

2. McClatchey, R.A., Benedict, W.S., Clough, S.A., Burch, D.E., Calfee, R.F., Fox, K., Rothman, L.S., and Garing, J.S. (1973) AFCRL Atmospheric Absorption Line Parameters Compilation, AFCRL-TR-73-0096, AD 762904.

3. Rothman, L.S., Gamache, R.R., Barbe, A., Goldman, A., Gillis, J.R., Brown, L.R., Toth, R.A., Flaud, J.M., and Camy-Payret, C. (1983) AFGL atmospheric absorption line parameters compilation:1982 edition, Appl. Opt. 22:2247.

4. Rothman, L.S., Goldman, A., Gillis, J.R., Gamache, R.R., Pickett, H.M., Poynter, R.L., Husson, N., and Chedin, A. (1983) AFGL trace gas compilation: 1982 edition, Appl. Opt. 22:26[illegible]

Section 2 of this report gives the formulation of the problem and the algorithms employed in its solution. Section 3 describes how to use the code, and Section 4 gives examples of some of the results obtained to date. The appendixes contain the source code and sample program output.

2. FORMULATION

2.1 Radiative Transfer Problem

The problem of radiative transport along a viewing path within an absorbing and emitting medium is formulated most generally[5] in terms of the equation of transfer,

$$\frac{1}{k_\nu(s)\rho(s)} \frac{dI_\nu(s)}{ds} = J_\nu(s) - I_\nu(s) \tag{1}$$

and whatever boundary conditions are appropriate. In this equation, both I_ν, which is the specific intensity of radiation at wavenumber ν, and J_ν, the source function, have units of watts/(cm^2-ster-cm^{-1}) or equivalent units (for example, photons/sec instead of watts, micrometers instead of cm^{-1}). The viewing path is parameterized by the position variable, s. The absorption coefficient (cm^2 /molecule) and the total number density (molecules/cm^3) of the molecular specie in question are, respectively, k_ν and ρ. Furthermore, the optical depth between an observation point s and a reference point s' is defined by a line integral over the viewing path:

$$\tau_\nu(s, s') = \int_{s'}^{s} k_\nu(s'')\,\rho(s'')\,ds'' \tag{2}$$

In the problem we are presently considering, the only processes of interest within the atmosphere are stimulated and spontaneous emission from molecules in the excited state of the transition in question, and absorption by molecules in the corresponding lower state. That is, scattering into and out of the beam is neglected. The equation of transfer for this case can thus be derived directly from the three Einstein coefficients and the populations of the upper and lower

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5. Chandrasekhar, S. (1960) Radiative Transfer, Dover, New York.

radiating states. Using the relations between these coefficients,[6] we arrived at[1]

$$\frac{dI_\nu(s)}{ds} \quad \frac{h\nu_o}{c} B_{\ell u} f_\nu(s) n_\ell(s) \left[2c\nu_o^2 \gamma(s) - I_\nu(s)(1 - \gamma(s)) \right] \tag{3}$$

where the position-dependence is written explicitly and the frequency-dependence is indicated by the subscript ν. In this equation, n_ℓ is the lower-state number density, f_ν is the normalized lineshape of the absorption coefficient, $B_{\ell u}$ is the Einstein coefficient for absorption, ν_o is the resonant frequency in wave-numbers, h is Planck's constant, c is the speed of light, and γ is given by

$$\gamma(s) = \frac{g_\ell n_u(s)}{g_u n_\ell(s)} \tag{4}$$

where the g's are statistical weights of the upper (u) and lower (ℓ) radiating states and the n's are the number densities. The $(1 - \gamma)$ factor in Eq. (3) accounts for stimulated emission.

By "normalized lineshape," we mean that f_ν satisfies

$$\int_{-\infty}^{\infty} f_\nu \, d\nu = 1 \tag{5}$$

In NLTE, the Voigt profile is used for f_ν, although the user can specify a Doppler lineshape if necessary.

The correspondence between Eqs. (1) and (3) reveals that the absorption coefficient is given by

$$k_\nu(s) = \frac{h\nu_o}{c} B_{\ell u} f_\nu(s) \frac{n_\ell(s)}{\rho(s)} (1 - \gamma(s)) \tag{6}$$

and the source function by

$$J_\nu(s) = 2c\nu_o^2 \frac{\gamma(s)}{1 - \gamma(s)} \tag{7}$$

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6. Penner, S.S. (1959) Quantitative Molecular Spectroscopy and Gas Emissivities, Addison-Wesley, London.

The absence of an explicit frequency-dependence is proper for this particular source function. The emission coefficient, $j\nu$, which has the same units as the absorption coefficient and plays an analagous role, contains the frequency-dependence and is given by

$$j_\nu = k_\nu J_\nu \tag{8}$$

The boundary conditions for the problem can be determined from the allowed viewing paths, which are shown in Figure 1. Since the paths begin above the atmosphere, the intensity $I_\nu(s')$ must be zero for all frequencies unless the line-of-sight intersects the sun, or else some other zodiacal contribution is not negligible. In either case, this contribution can be separated completely from the atmospheric emission and treat ' ~- .mple attenuation problem, so we do not discuss it further in this dc ..ment.

2.2 Formal Solution

With this particular boundary constraint, the formal solution of Eq. (1) for the line-of-sight path extending from s' to the observer at s can be written as

$$I_\nu(s) = \int_{s'}^{s} J_\nu(s'') k_\nu(s'') \rho(s'') e^{-\tau_\nu(s,s'')} ds'' \tag{9}$$

With the help of Eqs. (4-8) and the relation between $B_{\ell u}$ and the Einstein A coefficient,

$$A = 8\pi h \nu_o^3 \frac{g_\ell}{g_u} B_{\ell u} \tag{10}$$

it is transformed to

$$I_\nu(s) = \int_{s'}^{s} j_\nu(s'') \rho(s'') e^{-\tau_\nu(s,s'')} ds'' \tag{11}$$

$$= \frac{A}{4\pi} \int_{s'}^{s} n_u(s'') f_\nu(s'') e^{-\tau_\nu(s,s'')} ds''$$

The first form of Eq. (11) expresses the facts that (1) an amount of radiant energy,

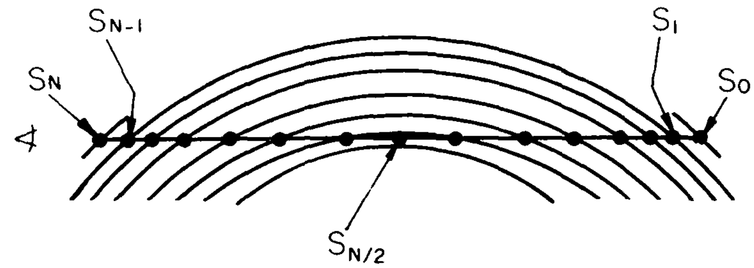

Figure 1a. Limb Viewing Path in a Layered Atmosphere. s_o is the beginning of the path, $s_N/2$ is the tangent point, and s_N is the location of the observer. In the text, s_o and s_N are referred to as s' and s, respectively

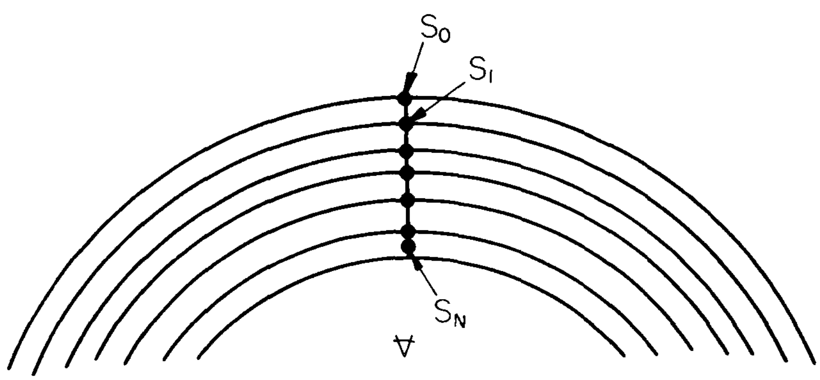

Figure 1b. Zenith Viewing Path in a Layered Atmosphere

j_ν, emitted per molecule at frequency ν at the point s'' along the path (per cm^{-1} per ster) is reduced by an amount (the exponential) determined by the optical depth between that point and the observer at s; and (2) that the total radiance due to all points s'' between s' and s is just the total (integral) contribution from all such points weighted by the total number of emitters. The second integral expresses the same thing in slightly different terms: the volume emission rate (photons/sec - cm^3 - ster - cm^{-1}) is simply $An_u f_\nu / 4\pi$.

Bullitt et al[7] have further transformed the formal solution into expressions that make it easy to visualize how the complicated single-line radiance profiles

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7. Bullitt, M.K., Bakshi, P.M., Picard, R.H., and Sharma, R.D. (1985) Numerical and analytical study of high-resolution limb spectral radiance from non-equilibrium atmospheres, J. Quant. Spectrosc. and Rad. Transfer, 34:33.

evolve, and that also lead to some useful analytical approximations. They make the definitions

$$F_\nu(s, s'') = k_\nu(s'') \, \rho(s'') e^{-\tau_\nu(s, s'')} \tag{12}$$

$$R(s) = 2c\nu_o^2 \frac{\gamma(s)}{1 - \gamma(s)} . \tag{13}$$

R is just the source function, and F_ν serves as a weighting function for the path when the radiance at the observation point is written as

$$I_\nu(s) = \int_{s'}^{s} R(s'') F_\nu(s, s'') \, ds'' . \tag{14}$$

This form is intrinsically no simpler than the others; we introduce it because we later make use of arguments which most easily are expressed in terms of the quantity R.

2.3 NLTE Algorithm

2.3.1 LAYERING

Our prescription for solving for the radiance relies upon the assumption that a stratified model atmosphere consisting of homogeneous concentric layers (see Figure 1) can be made into a sufficiently accurate representation of the actual atmosphere to produce correct results. In NLTE, the altitude grid is defined by whatever altitudes are read on the atmospheric profile data file. The properties of the layers are then determined from the pairs of grid points bounding each of them. *In the case of temperatures, the average value is used;* in the case of number densities, the mean square value is used. For example, for the ith layer

$$T_i = \frac{1}{2} \left| T(s_i) + T(s_{i+1}) \right| \tag{15a}$$

$$\rho_i = \left| \rho(s_i) \, \rho(s_{i+1}) \right|^{1/2} \tag{15b}$$

It is understood that each position s along the viewing path is associated with an altitude, h, which is really the correct parameter for the physical properties of the atmosphere.

2.3.2 OPTICAL DEPTH

The optical depth at frequency ν is obviously an important quantity for the radiance calculation. In order to calculate it numerically, we must correlate the Einstein absorption coefficient with the information contained in the AFGL database,[2] namely the line strength $S(T_s)$ evaluated under conditions of LTE at the standard temperature, $T_s = 296$ K. For arbitrary conditions, the line strength S satisfies

$$S f_\nu = k_\nu \tag{16}$$

and in fact is equal to the absorption coefficient integrated over ν. The connection with the Einstein absorption coefficient is made through Eq. (6), in which the ratio n_ℓ/ρ is simply the probability, P_ℓ, that the lower ro-vibrational state be occupied under the specified conditions. It follows that

$$\frac{h\nu_o}{c} B_{\ell u} = \frac{S(T_s)}{P_\ell(T_s, T_s)} \left(1 - e^{-c_2 \nu_o / T_s}\right)^{-1} \tag{17}$$

where S, P_ℓ, and $(1-\gamma)$ are evaluated for conditions of LTE at the temperature T_s. c_2 is the second radiation constant.[6] Then, for arbitrary conditions, one can plug Eq. (17) into Eq. (6) and use Eq. (16) in Eq. (2) to derive the optical depth along the path within the ith homogeneous layer as

$$\tau_\nu(s_{i+1}, s_i) \equiv \Delta\tau_{\nu i}$$

$$= S(T_s) \frac{P_\ell(T_i, T_{vi})}{P_\ell(T_s, T_s)} \frac{1 - \gamma_i}{1 - \exp(-c_2 \nu_o / T_s)} f_{\nu i} \rho_i \Delta s_i \tag{18}$$

The notation we have adopted here is that the subscript i on each quantity replaces the independent variable, s, and implies a constant value within the ith layer. Also, $\Delta s = s_{i+1} - s_i$. For general conditions, the probability that the lower state be occupied depends on the vibrational and rotational temperatures, T_v'' and T_R'', for the state in question. We regard all rotational temperatures as equal to the kinetic temperature, however, so, in general

$$P_\ell(T, T_v'') = \alpha_i g_\ell \frac{\exp(-c_2 E_v''/T_v'')}{Q_v(T_v'')} \frac{\exp(-c_2 E_R''/T)}{Q_R(T)} \tag{19}$$

where E_v'' and E_R'' are the vibrational and rotational energies of the lower state in wavenumbers, T_v'' and T are the vibrational and rotational temperatures describing the lower state, Q_v and Q_R are the vibrational and rotational partition functions, c_2 is the second radiation constant, and α_I is the isotopic abundance expressed as a fraction of the total, so that

$$\sum_I \alpha_I = 1. \tag{20}$$

The partition functions are, of course, evaluated for the conditions at hand. The particular band vibrational temperature, T_v'', may not be sufficient to determine Q_v, however. We defer a discussion of the means of approximating them until Section 2.3.7.

2.3.3 RADIANCE

Division of the viewing path into segments (s_i, s_{i+1}) as indicated in Figure 1 does not alter the exact nature of the solution in Eq. (14):

$$I_\nu(s) = \sum_{i=o}^{N-1} \int_{s_i}^{s_{i+1}} R(s'') F_\nu(s, s'') ds'' \tag{21}$$

The first approximation is to let R(s'') be a constant over each segment, in accordance with our assumption of homogeneous layers. Then

$$I_\nu(s) \cong \sum_{i=o}^{N-1} R_i \int_{s_i}^{s_{i+1}} F_\nu(s, s'') ds'' \tag{22}$$

However, by the definitions made in Eq. (12) and Eq. (2), F_ν is a perfect differential equal to

$$F_\nu(s, s'') = - \frac{d\tau_\nu(s, s'')}{ds''} e^{-\tau_\nu(s, s'')} = \frac{d}{ds''} \left[e^{-\tau_\nu(s, s'')} \right] \tag{23}$$

This leads to

$$I_\nu(s) \cong \sum_{i=o}^{N-1} R_i e^{-\tau_\nu (s, s_{i+1})} \left[1 - \exp(-\Delta\tau_{\nu i})\right] \tag{24}$$

with $\Delta\tau_{\nu i}$ given by Eq. (18). Moreover, the fact that the optical depth along the path segments is additive, so that

$$\tau_\nu (s, s_{i+1}) = \sum_{j=i+1}^{N-1} \Delta\tau_{\nu j}, \tag{25}$$

leads to the result

$$I_\nu(s) \cong \sum_{i=o}^{N-1} R_i \left[1 - \exp(-\Delta\tau_{\nu i})\right] \exp\left[-\sum_{j=i+1}^{N-1} \Delta\tau_{\nu j}\right] \tag{26}$$

The only approximations involved here are taking R, F_ν, and n_u to be constants within each layer.

One can see that one series is embedded within the other in Eq. (26). It is not necessary, however, to separately evaluate two series for each frequency. One can obtain the desired sum starting with $i = 0$ (the farthest layer) with the following algorithm:

Define $E_i = \exp(-\Delta\tau_{\nu i})$
$X_i = R_i[1 - E_i]$

Calculate $P_o = X_o$
$P_i = X_i + P_{i-1}E_i \qquad i = 1, 2, \ldots, N-1$

Set $I_\nu(s) = P_{N-1}$

E_i represents the amount by which a unit of radiation is attenuated in passing completely through layer i, and X_i is the amount of radiation from the ith layer alone appearing on the observer's side of that layer. The P's represent the total radiation appearing at each boundary. An alternative but completely equivalent algorithm is given by

Define $E_i = \exp(-\Delta\tau_{\nu i})$
$X_i = R_i[1 - E_i]$
$Q_{N-1} = 1$

Calculate $Q_{i-1} = Q_i E_i$
$P_i = Q_i X_i$

Evaluate $I_\nu(s) = \sum_{i=N-1}^{0} P_i$

The only difference in these two approaches is the order in which the atmospheric layers are treated. In the second algorithm, Q_i is the total transmittance from the near side of the ith layer to the observer and P_i is the contribution at the observer's location from the ith layer alone. The advantage of this approach is that one can cut off the summation whenever the attenuation becomes severe enough to negate contributions from ever more distant layers. That is, the summation need not be carried as far as $i = 0$. Obviously, such a truncation is not possible in the first algorithm. The second algorithm, which is especially useful when the observer is within the atmosphere (for example, zenith-look) has been incorporated into NLTE.

2.3.4 INTEGRATED RADIANCE

The quantity which is the main objective of these calculations is obtained by integrating the radiance profiles over frequency. For each line, one evaluates

$$I(s) = \int_{-\infty}^{\infty} I_\nu(s)\, d\nu \qquad (27)$$

For a band, NLTE sums the results over individual lines.

Figure 2 gives some typical single-line radiance profiles for limb geometry, using lines from the ν_2 fundamental of CO_2 near $15\mu m$. Several of the lines are severely self-absorbed along this path, which has a tangent height of 70 km. The weakest lines mimic Doppler lines; stronger lines decrease monotonically from the center but have much more pronounced wings; and the strongest lines have maxima and possibly minima away from the line center, as well as wings where the function decreases smoothly and monotonically, but very slowly, over a very large range of frequencies.

Figure 3 gives the vibrational and kinetic temperatures used in the calculation of these profiles.

For each line, NLTE evaluates Eq. (27) using an analytical approximation which is valid only when the path optical depth is less than unity at the line center. This approximation may be accepted as an appropriate value for I(s) if a "thin-line" criterion, described in Section 2.3.4.2, is satisfied. Otherwise, the integral is evaluated numerically using the "thick-line" procedure described in Section 2.3.4.1. Because of the heavy computational requirements of the thick-line procedures, the program bypasses it whenever the thin-line approximation is sufficiently accurate.

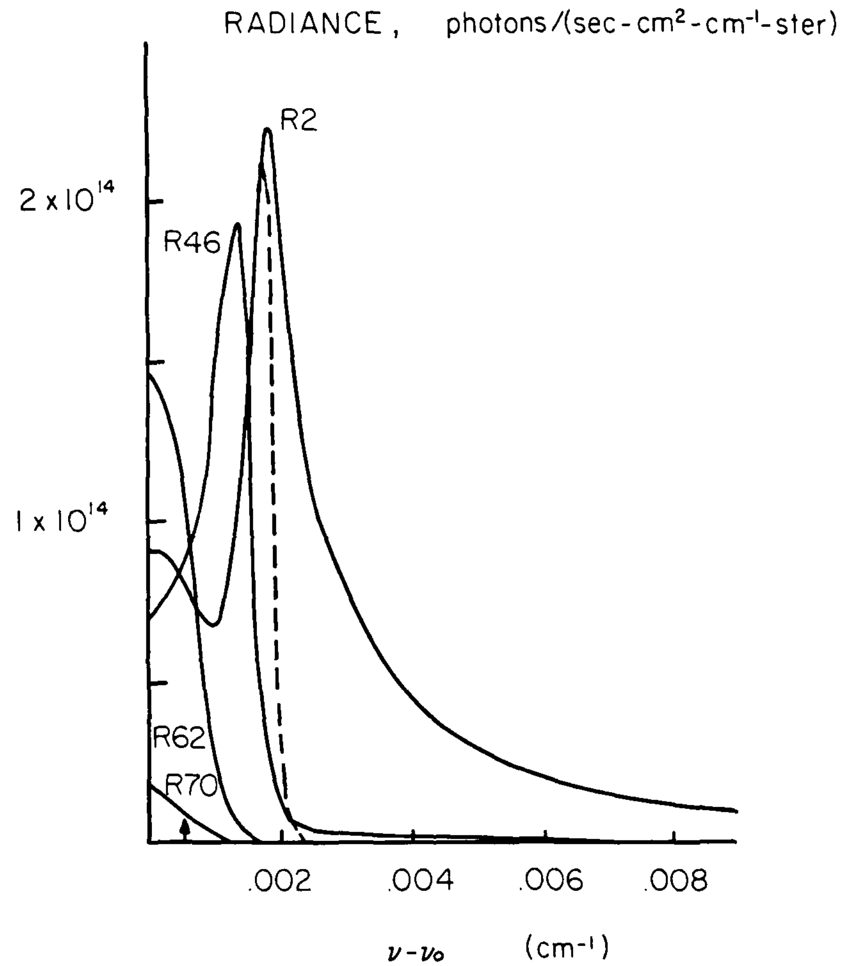

Figure 2. Radiance Profiles of Four Lines of the R Branch of the CO_2 (ν_2) Fundamental, Using Limb Geometry and a Tangent Height of 70 km. The dotted line is the R2 profile assuming a Doppler rather than Voigt lineshape. The arrow indicates the Doppler linewidth at 70 km.

2.3.4.1 Thick-Line Algorithm

When the thin-line approximation is unacceptable, Eq. (27) is evaluated numerically over a range between ν_o and a certain cutoff frequency ν_c, and the contribution from the region between ν_c and infinity is approximated by an analytical expression. Since I_ν is symmetrical about ν_o, the desired value for each line is twice the sum of these two quantities.

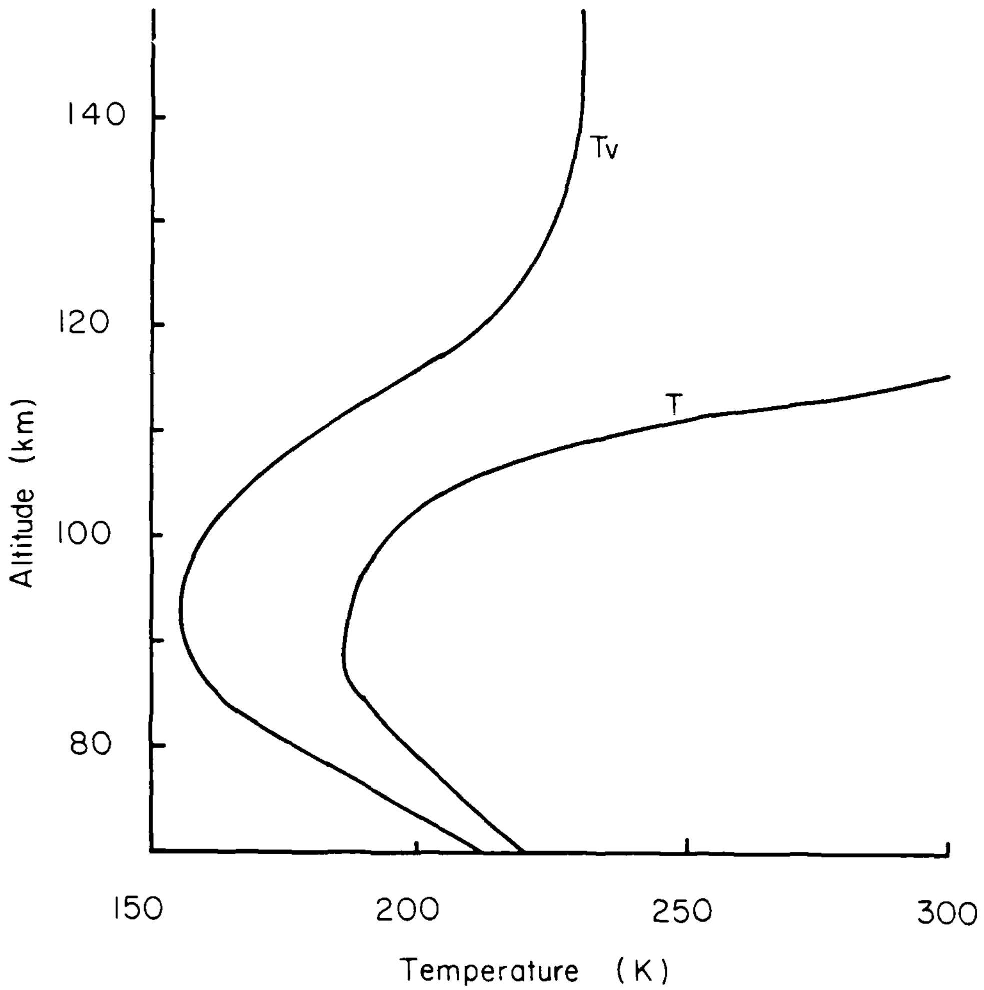

Figure 3. Kinetic and Vibrational Temperature Profiles Used to Calculate the Curves in Figure 2

The numerical integration procedure was designed to use the minimum number of integration points to obtain the desired accuracy. To accomodate the great variety of possible integrands, a semi-adaptive scheme is used. The region ν_o to ν_c is divided into sections, or panels, and the contribution to the total integral from each panel is evaluated separately using Gauss-Legendre quadrature. The panels are taken in order, starting at the line center with a fixed panel-width. At a certain point ν_B, beyond which the radiance profile is determined to be "smooth," the panels are allowed to increase in width so as to cut down on the total number of integration points. The cutoff point ν_c and the panel-expansion point ν_B both depend on the radiance profile being considered, and they are determined as the integration progresses from panel to panel.

Each panel is integrated with the same fixed number of points. The default is four points, but two points per panel often give excellent results and of course require less computation.

The initial panel-width is one "standard Doppler width" (SDW). This is defined to be the half width at half maximum of a Doppler line with a frequency equal to that at the center of the band in question. The kinetic temperature used to define SDW is the lowest encountered in the atmospheric profile.

(1) Numerical Integration

The application of Gauss quadrature over panels of fixed width is a straightforward exercise. In our case, once the integration has progressed into the smooth wing of the radiance profile--that is, past all extrema which might appear in I_ν --the panel widths are doubled in each successive panel. The condition used to establish that the function is smooth by this definition is that τ_ν be less than 0.5 at the end of the last panel previously considered. That is, ν_B is chosen to be the end of the panel within which the path optical depth first drops below one-half.

The rationale behind this criterion for smoothness is that, for a fixed number of points, the absolute accuracy of any numerical integration algorithm is generally worst in intervals within which the integrand has maxima and minima. The validity of the corresponding choice for ν_B is demonstrated in the following manner. One rewrites Eq. (14) as

$$I_\nu(s) = \langle R \rangle [1 - \exp(-\tau_\nu(s, s'))] \quad (28)$$

by making use of the definition

$$\langle R \rangle = \int_{s'}^{s} R(s) F_\nu(s, s'') ds'' \Big/ \int_{s'}^{s} F_\nu(s, s'') ds'' \quad (29)$$

and the integrability of $F_\nu(s, s')$, as in Eq. (23). $\langle R \rangle$ is a function of ν. One sees that I_ν is the product of a weighted average of R and the absorptivity over the entire path. Bullitt et al[7] show that $\langle R \rangle$ asymptotically approaches a limiting value, $\langle R \rangle_\infty$, for large $|\nu - \nu_0|$, and that the departure from this limiting value is very modest whenever $\tau_\nu < 1$. On the other hand, the absorptivity rapidly departs from its limiting value of unity only when $\tau_\nu > 1$. Moreover, because of its functional form and because τ_ν decreases monotonically with increasing ν, the absorptivity factor cannot by itself induce extrema in the radiance profile. One can then say that the functional form of the thick-line radiance profile is dominated by $\langle R \rangle$ near the line-center and by the absorptivity in the wings, and that the extrema in I_ν must therefore be limited to the frequency range for which $\tau_\nu > 1$. To be conservative, we take $\tau_\nu \sim 0.5$ as the criterion for determining ν_B; in fact, we find that the outermost maxima in I_ν usually occur at frequencies for which $2 < \tau_\nu < 5$.

(2) Analytical Approximation After Cutoff

We cut off the numerical integration at ν_c only when it has passed into the region $\tau_\nu << 1$. The contribution from this "tail" of the radiance profile is

$$T(\nu_c, s) = 2\int_{\nu_c}^{\infty} I_\nu(s)\, d\nu \tag{30}$$

From Eq. (11), this can be written as

$$T(\nu_c, s) = \frac{A}{2\pi} \int_{s}^{s} n_u(s'') \left[\int_{\nu_c}^{\infty} f_\nu(s'')\, d\nu \right] ds''. \tag{31}$$

If the lineshape is a Voigt function, its functional form in the tail can be approximated by a Lorentz function, an asymptotic expansion of the Voigt integral, or some other means (see Section 2.3.5). One can then evaluate the ν-integral in Eq. (31), with the result that

$$T(\nu_c, s) = \frac{A}{2\pi^2} \frac{1}{\nu_c - \nu_o} \int_{s'}^{s} n_u(s'')\alpha_L(s'')\, ds'' \tag{32}$$

where α_L is the Lorentz width due to the collision-broadening component of f_ν. In NLTE, of course, the integral is a sum over homogeneous layers. When this conversion is made and the Einstein absorption coefficient is used to replace A, with Eq. (10), the result is

$$T(\nu_c, s) = \frac{2}{\pi} \frac{1}{\nu_c - \nu_o} \sum_i \left\{ \left[2c\nu_o^2 \frac{g_\ell}{g_u} n_u(s_i) \right] \left[\frac{h\nu_o}{c} B_{\ell u} \right] \alpha_L(s_i) \Delta s_i \right\} \tag{33}$$

After substituting Eqs. (4) and (13) for the first quantity in square brackets and

Eqs. (17) and (18) for the second, most factors cancel, and one is left with a result expressed in simple terms:

$$T(\nu_c, s) = \frac{2}{\pi} \frac{1}{\nu_c - \nu_o} \sum_i R_i \alpha_L(s_i) \left[\frac{\Delta\tau_{\nu i}}{f_{\nu i}}\right] \tag{34}$$

In this equation, the term in square brackets and the other factors in the sum are independent of frequency [since, according to Eq. (18), the frequency-dependence of the optical depth is entirely contained in the lineshape]. The sum therefore needs to be evaluated only once for each line, say at ν_o. It is then a simple matter, after the completion of the integration of each successive panel, to determine the approximate residual contribution from the entire region beyond that panel.

The more panels that are taken, the more accurate this residual term will be. The difficult part is determining just how accurate it is. Our procedure for determining ν_c, which is likely to be refined in the future, is based on empirical tests which show that if a quantity κ, defined as

$$\kappa = 6\,\varepsilon\, I_c / \tau_{\nu_c} \tag{35}$$

is greater than $T(\nu_c, s)$, the fractional error introduced in I(s) by cutting off the numerical integration and adding T to the previous result will be less than ε. In Eq. (35), I_c is the cumulative integrated radiance in the panels treated so far, τ_{ν_c} is the optical depth for the path at the end of the last panel, and ε is the desired accuracy of the integrated radiance in the line, expressed as a fractional error. The optically thickest path is used to evaluate κ. This approximation is accurate enough to correctly evaluate the integral over a range contributing several percent to the total result in typical cases, and thus can eliminate numerical treatment of many panels in the far wing of the radiance profile.

If a Doppler, rather than Voigt, lineshape is selected, a different residual term is used in place of Eq. (34).

In order to evaluate Eq. (34), the collision-broadening linewidth $\alpha_L(s_i)$ must be computed for all relevant layers. For each line, the AFGL database contains a standard collision linewidth, α_o, calculated or measured for STP. This quantity is corrected for temperature and pressure to yield

$$\alpha_L(s_i) = \alpha_o P_i \left(\frac{T_s}{T_i}\right)^x \tag{36}$$

where P_i and T_i are the pressure (in atmospheres) and the kinetic temperature in the ith layer, respectively. The exponent, x, to which the temperature ratio is raised, is equal to 0.50 for all molecules except CO_2, for which a value of 0.75 is used.[2]

2.3.4.2 Thin-Line Approximation

In the event that the path optical depth at the line center (and hence at all frequencies) is much less than unity, the integrated radiance can be computed analytically. In effect, one ignores absorption along the path and integrates the volume emission rate for the whole line along the path. If one takes Eq. (11) and sets the exponential equal to unity, only f_ν contains a ν-dependence. Upon inserting the result into Eq. (27), interchanging the order of integration, and using Eq. (5), one quickly arrives at

$$I(s) = \frac{A}{4\pi} \int_{s'}^{s} n_u(s'')\,ds'' \tag{37}$$

After this integral is converted into a sum over homogeneous layers, one follows steps which are almost identical to those used to derive Eq. (34) from Eq. (32) to obtain

$$I(s) = \sum_i R_i \left[\frac{\Delta\tau_{\nu i}}{f_{\nu i}}\right] \tag{38}$$

This sum can be evaluated in a single loop through the atmosphere and therefore requires much less computational effort than the numerical integration.

The criterion that we use to determine whether Eq. (38) is an acceptable approximation to Eq. (27) is based on the value of the total path optical depth at the line center. For lines with

$$\tau_{\nu_o}(s, s') < 3\varepsilon \tag{39}$$

NLTE bypasses the thick-line algorithm. ε is the quantity introduced below Eq. (35).

2.3.4.3 Accuracy

The NLTE algorithm has been designed to perform a detailed calculation and produce accurate results in a reasonable amount of computation time. The accuracy of the calculation depends on the correctness of the input data, the physical approximations built into the algorithm, and the mathematical approximations used to implement it.

The greatest source of error in simulating a particular experiment will generally be due to uncertainties in the quantities contained in the atmospheric profile. For example, errors of a few degrees in a vibrational temperature profile can change the volume emission rate by significant amounts, especially for higher-energy transitions, with an ultimate effect that depends on the thickness of the lines in question and the altitudes at which the errors are most pronounced. Since one cannot anticipate the magnitude of errors of this sort, we focus on inaccuracies that could be induced by the algorithm.

(1) Layering Approximation

The principal physical approximation incorporated into this work is, of course, that of the homogeneous atmospheric layers. The magnitude of the errors induced depends on the (geometrical) thickness of the layers used, the gradients in temperature and number density, the degree of self-absorption along the path, and the path geometry itself. We estimate that with 1-km atmospheric layers, total errors in the integrated radiance will be less than 2 percent for any single line for most realistic atmospheric profiles. For bands containing both thick and thin lines, the error is likely to be much less than this. In both cases, the error will be in the direction of predicting too little radiance.

These conclusions are based on some hand calculations and also on the use of a contrived atmospheric profile. Since the number densities have a nonzero gradient at all altitudes and change by orders of magnitude over the range of the viewing paths, one's attention is first drawn to the approximation represented by Eq. (15b). Suppose that all number densities can be characterized by a local scale height everywhere--that is, these functions are truly exponential within each layer. Then, assuming "correct" values $\rho(s_i)$ and $\rho(s_{i+1})$, Eq. (15b) gives the actual path-average number density only for zenith geometry. For limb geometry, greater distances are encountered in the lower part of each layer--particularly near the tangent point--and this formula underestimates the path average by a small amount. As a result, both the optical depth and the volume emission rate are a little too small. From Eq. (11), one can see that, in general, these two errors tend to cancel, but the degree of cancellation depends on the optical depth. Intuitively, one suspects that the worst-case fractional error results for thin lines because the attenuation term, which in general compensates for the understated volume emission rate, is small.

To verify these conclusions, we used a contrived atmospheric configuration for which the correct path optical depth and the radiance, as well as the values that would be obtained by our algorithm, could be calculated analytically. The assumptions were that of an equilibrium isothermal atmosphere, an exponential emitter density, and a Doppler lineshape. The correct integrated radiance for a single line under these conditions is

$$I(s) = R \int_0^\infty [1 - \exp(-\tau_\nu (s, s'))] d\nu \tag{40}$$

and the two limiting values for I(s) are

$$I(s) \sim R \frac{\tau_{\nu_o}}{f_{\nu_o}} \qquad \tau_{\nu_o} << 1 \tag{41a}$$

$$I(s) \sim R \frac{\alpha_D}{\sqrt{\ell n\, 2}} \sqrt{\ell n\, \tau_{\nu_o}} \qquad \tau_{\nu_o} >> 1 \tag{41b}$$

where τ_{ν_o} is the path optical depth at the line center. Eq. (41b) results from an asymptotic expansion[8] of the integrated absorptivity and is valid for the Doppler lineshape. The Doppler halfwidth, α_D, is given in Eq. (44) below.

With our simplifications, R is independent of altitude, and the NLTE result for I(s) is in error only because of the error in the optical depth. The value of the optical depth obtained by NLTE, $\bar{\tau}_{\nu_o}$, differs from the correct value by a small amount:

$$\bar{\tau}_{\nu_o} = \tau_{\nu_o} (1-\delta) \tag{42}$$

The error term, δ, depends on the assumed scale height and is calculated analytically. Taking 1 km for the layer thickness and 5 km for the scale height, δ is 0.019 for limb geometry and 0.002 for zenith geometry; for an 8-km scale height, the values are 0.010 and 0.0007, respectively. From Eq. (41a), one can see that the worst-case single-line fractional error in I(s) is just δ and is associated with thin lines and limb geometry. For very thick lines, the fractional error is $1/2\ \delta / \ell n(\tau_{\nu_o})$ and is thus much smaller. Since most bands are dominated by the thick-line contributions, it follows that worst-case fractional errors in the band radiance

8. Van Trigt, C. (1968) Asymptotic expansions of the integrated absorptance for simple spectral lines and lines with hyperfine structure and isotope shifts, J. Opt. Soc. Am. 58:669.

due to the layering scheme are much less than δ, which is to say, for 1-km layers and typical atmospheric profiles, less than 1 percent.

These estimates, of course, ignore the effects of temperature gradients on the error induced by the layering approximation, but we believe that they are unimportant. Consider the approximation of the upper state vibrational temperature, T_v, by Eq. (15a). This quantity determines the volume emission rate and thus affects the radiance calculation. One can see that, in regions where T_v has a sharp maximum Eq. (15a) understates it. (For limb-look, however, the path-average temperature is different from the layer-average, as before.) The error will be a factor of approximately exp $(c_2 E\Delta/T_v)$, where E is the vibrational energy of the state and Δ is the error in T_v. A change in the vibrational temperature gradient equal to 0.5 K/km^2, which is quite steep, gives a value of Δ on the order of 0.1 K for 1-km layers and 0.5 K for 2-km layers. For 1-km layers and a 2.7μm transition, the volume emission rate would err by, at worst, 1 percent in a few layers near the extremum. (For a lower-energy transition, the error would be much less.) In the very worst case, the extremum is a sharp maximum near the tangent point, and there is little attenuation at higher altitudes. In this case, the error adds to that discussed earlier; under most circumstances, however, it is considerably smaller, and the general estimates given earlier remain valid.

In extreme cases, inaccuracies due to the layering approximation can, of course, be reduced by using thinner layers, especially at the lowest levels.

(2) High-Altitude Cutoff

A second physical approximation is that all effects due to layers above a certain altitude can be ignored. For an arbitrary atmospheric profile and arbitrary line strengths, it is difficult to say, a priori, how many layers are needed. Generally, 50 1-km layers are adequate for bands dominated by thick lines.

One realization resulting from the tests we performed on NLTE is that, for lines quite far from the band center, the optical depth per layer may increase with increasing altitude, rather than the reverse, if the calculations extend into the lower thermosphere. This comes about because the elevated temperatures in the upper layers increase the lower rotational-state populations dramatically for such lines. This more than offsets the effect of decreasing total number density, and it means that many layers may be necessary if the precise contributions from such lines are needed. Because these lines are weak, their contribution to the radiance from a whole band is almost always negligible.

One can, of course, extend one's model atmosphere as high as is necessary to eliminate any possible error from this source.

(3) Overlap

The third physical approximation inherent in NLTE is that the lines are independent of each other--that is, that overlap is not a relevant consideration.

For the bands in the high-altitude non-LTE regions we usually consider, the lines are spaced sufficiently far apart--even in the Q branches--so that the numerical integration regions do not, in fact, run into each other. Since the numerical integration is cut off only when $\tau_{\nu} << 1$, as described in Section (2), the error induced by ignoring overlap is completely negligible for these cases. Of course, for very strong closely spaced lines and low-altitude viewing paths, overlap may be a relevant consideration. We have made no quantitative estimates of its effect on the integrated radiance, but it is clear that the error would be in the direction of predicting too much radiance.

(4) Mathematical Approximations

Several mathematical approximations employed in NLTE have been described earlier. They include use of numerical integration to evaluate Eq. (27) [(1) in Section 2.3.4.1], the thin-line approximation (Section 2.3.4.2), and the tail cutoff approximation [(2) in Section 2.3.4.1]. Also, the use of the Voigt function (Section 2.3.5) implies mathematical approximations as well as the physical assumption that that function is appropriate for the absorption cross-section. Last of all, approximations used to calculate the partition functions are discussed in Section 2.3.7.

In the case of the numerical integration, one can only check the accuracy by comparing results using different numbers of integration points per panel. In all cases we have tested, the difference between using four points and using eight points is on the order of 0.01 percent or less, and thus negligible.

Two other approximations are scaled to the nominal desired accuracy, ε, and thus can be made as small as necessary. The thin-line approximation produces a worst-case fractional error of almost exactly ε. That is, if the line falls just below the thin-line threshold, the error is ε times the computed intensity and is positive (too much radiance). Weaker lines produce smaller errors, so using the default value $\varepsilon = 0.01$, the error induced in the integrated band radiance by this approximation alone will be less than 1 percent even if there are few contributions from thick lines to be added in.

In a single-line run, NLTE ignores the thin-line criterion and calculates the radiance numerically even for very weak lines.

Similar considerations apply to the analytical tail approximation. The worst-case error for a single line is approximately ε, but the average error is considerably less, and the resultant effect on the band radiance is thus quite small.

The Voigt algorithm is discussed in the next section. It is so accurate that it does not contribute to the error in I(s). The partition function approximations also contribute a negligible amount to the final error.

(5) Summary

The algorithm has been refined to the point where the uncertainties in the atmospheric profile used as input must be regarded as the dominant source of error in the integrated radiance calculated by NLTE. The only exceptions to this would come if a very coarse altitude grid were used, or possibly if extremely disturbed atmospheric conditions (for which we have not checked our approximations) were assumed.

2.3.5 VOIGT ALGORITHM

It is very important to account for collision-broadening in the absorption cross section, even in high-altitude regions where collisions are relatively infrequent and the ratio of the collision linewidth to the Doppler linewidth is very small. This is true because many lines may be severely self-absorbed in the line center even for paths traversing only very high-altitude regions. In such cases, the contribution in the wings, where the collision component dominates, constitutes a large part of the total radiance profile. It is, therefore, necessary to have an accurate representation of the lineshape in the wings, which is to say that the Voigt rather than Doppler profile must be used. Errors of 50 percent to 100 percent can easily be made by neglecting collision-broadening.

The Voigt function, which is the convolution of a Lorentz function and a Gaussian, can be specified by two parameters: the linewidth ratio, y, and the normalized frequency, x:

$$y = \sqrt{\ell n\, 2}\;\frac{\alpha_L}{\alpha_D} \tag{43a}$$

$$x = \sqrt{\ell n\, 2}\;\frac{\nu - \nu_o}{\alpha_D} \tag{43b}$$

α_L and α_D are the collision-broadened and Doppler linewidths, respectively, and are functions of altitude. α_L is given in Eq. (36) and α_D is

$$\alpha_D = \nu_o \left(\frac{2\ell n 2\, kT}{Mc^2}\right)^{1/2} \tag{44}$$

where M is the mass of the molecule, k is Boltzmann's constant, and c is the speed of light.

We originally used a very accurate Voigt routine due to Rybicki[9] (VWERF),

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9. A method due to Rybicki, described in Emission, Absorption, and Transfer of Radiation in Heated Atmospheres (1972), B.H. Armstrong and R.W. Nichols, Pergamon, New York.

which correctly gives eight significant figures over the entire x-y plane. An algorithm due to Pierluissi et al[10] (ZVOIGT, which pieces together three formulas to cover the plane) runs considerably faster but is inaccurate in the near wings ($x \sim 3$) for an important range of values of y. To speed our calculations, we rewrote Pierluissi's algorithm so that it gives results which are accurate to at least 0.1 percent in the line center ($x < 1.25$) and 0.5 percent everywhere else except where $y < 10^{-6}$. To accomplish this, we checked the accuracy and speed of routines using different representations of the Voigt function throughout the x-y plane. We then pieced them together in such a way that the fastest routines occupy as much of the plane as possible, and the calls to the routines and the logical branches to the different regions use as little compute time as possible. A detailed description of our routine, ZVGTC, will be given elsewhere; in this section, we mentioned only a few points which are relevant for NLTE.

In the previous paragraph, we indicated the minimum accuracy criterion for ZVGTC. In fact, it is only near the boundaries between regions where these limits are approached. Over much of the plane, especially in the line center with $y > 0.001$, its accuracy is six figures or better. We have tested NLTE with both VWERF and ZVGTC and have found no differences in the final results for the radiance. The advantage of ZVGTC is that it runs in less than one third of the time required by VWERF.

Figure 4 shows the division of the x-y plane into the four regions used in ZVGTC. Region 1 is treated using Pierluissi's series expansion[10] modified to deal with an extended range in x. Regions 2 and 3 use 6- and 2-point Gauss-Hermite quadrature, respectively.[11] These formulas involve only rational functions and are very fast. For thick lines, a large fraction of the function evaluations fall in these regions. In Region 4, we substitute the Dopple profile for the actual Voigt function, in the interest of speed.

The arithmetic used for Regions 2-4 is fast enough so that branching operations encountered in the subroutine actually begin to compete with the function evaluations for computation time. The peculiar shape of Region 1 results from a need to avoid transcendental function evaluations in the branches. For similar reasons, we avoid repeated entries to the routine by evaluating the Voigt function for many

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10. Pierluissi, J.H., Vanderwood, P.C., and Gomez, R.B. (1974) Fast calculational algorithm for the Voigt profile, J. Quant. Spectrosc. and Rad. Transfer 18:555.

11. Kalshoven, J.E., Jr., and Walden, H. (1983) Laser bandwidth and frequency stability effects on remote sensing of atmospheric pressure as applied to a horizontal path measurement, paper presented at topical meeting on Optical Techniques for Remote Probing of the Atmosphere, Incline Village, Nev.

layers all at once, using a loop within the subroutine rather than one in the main program.

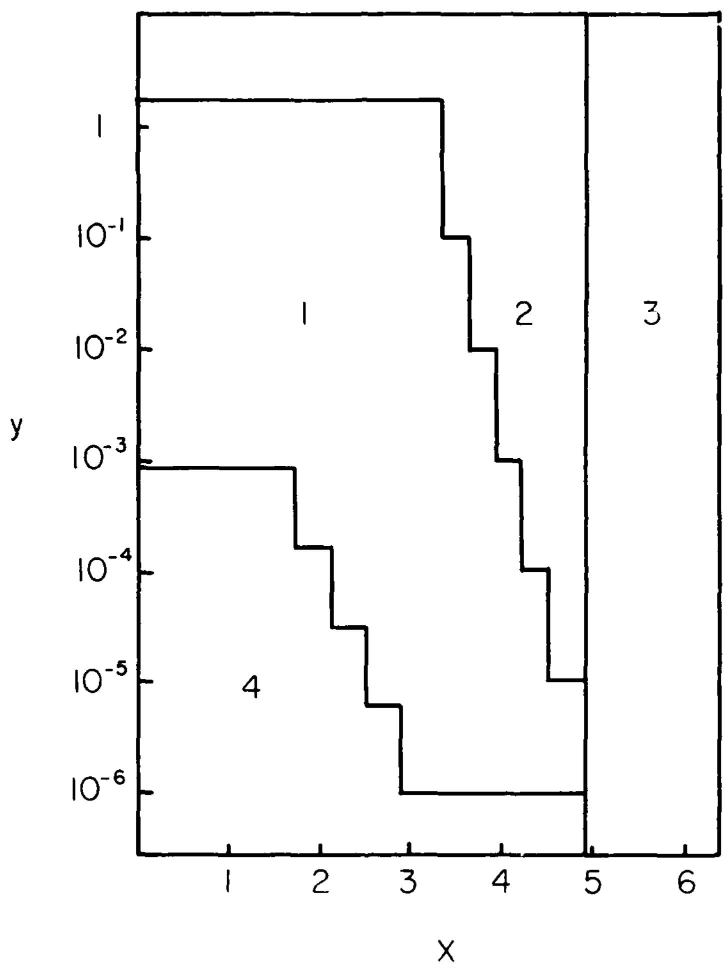

Figure 4. Segments of the x-y Plane Allocated by the Voigt Routine ZVGTC. In Region 1, the Voigt function is evaluated using the ZVOIGT series.[10] In Regions 2 and 3, 6- and 2-point Gauss-Hermite quadrature are used, respectively. In Region 4, the Doppler profile is substituted

2.3.6 SYNTHETIC SPECTRUM

To simulate the imperfect resolution of a real detector, NLTE evaluates a simple sum that approximates the convolution of the calculated spectral radiance with an instrumental scanning function.

In general, if $I_j(\nu - \nu_o)$ represents the radiance profile of the jth line at wavenumber ν, and $g(\nu - \nu')$ is the scanning function--the pattern through which the intensity at ν' is redistributed to ν by the instrument--the contribution to the observed spectrum due to this line is

$$G_j(\nu) = \int I_j(\nu' - \nu_o)\, g(\nu - \nu')\, d\nu' \qquad (45)$$

g must be normalized to unity. Observe that our notation is slightly altered: The quantity in the integrand is what we previously called $I_\nu(s)$.

In NLTE, calculation of this synthetic spectrum is simplified by two assumptions. First, we take the instrument function to be triangular in shape:

$$g(\nu - \nu_o) = [\Delta - |\nu - \nu_o|]/\Delta^2 \qquad |\nu - \nu_o| \leqq \Delta \qquad (46a)$$

$$g(\nu - \nu_o) = 0 \qquad |\nu - \nu_o| > \Delta \qquad (46b)$$

where Δ is, by definition, the full width at half maximum of the function. Second, we assume that g is much broader than the width of the individual-line radiance profiles, and that the latter may therefore be approximated by delta functions:

$$I_j(\nu - \nu_o) \sim I_j\, \delta(\nu - \nu_o) \qquad (47)$$

where I_j is the integrated radiance determined by NLTE. The convolution is then trivial, and the spectral radiance is given by a sum over lines:

$$G(\nu) = \sum_j G_j(\nu) = \sum_j I_j \frac{\Delta - |\nu - \nu_{oj}|}{\Delta^2} \qquad (48)$$

By requiring the intensity to be "located" at each line's center, this procedure, of course, obscures any details of the individual radiance profiles.

2.3.7 PARTITION FUNCTIONS

In order to calculate the optical depth in the various layers via Eqs. (18) and (19), one uses the vibrational and rotational partition functions, Q_V and Q_R. It happens that these appear only in ratios: the partition function for conditions pertinent to a particular layer divided by the partition function for LTE conditions at the standard temperature, T_S.

We take the vibrational partition function to be similar to the harmonic-oscillator partition function,

$$Q_v(T_v) \sim [1 - \exp(-c_2 E_o / T_v)]^{-D} \tag{49}$$

where E_o is the energy of the oscillator fundamental, T_v is the vibrational temperature, and D is the degeneracy of the excited states. For diatomic molecules, this is an approximation in that it assumes equally spaced levels and a single vibrational temperature giving the populations of all the states. For triatomic molecules, we assume that E_o refers to the lowest-lying ladder of states, and thus make the additional approximation of not counting the states in the other ladders. (For example, in CO_2 we take $E_o = 667.379\ cm^{-1}$ and D=2, corresponding to the ν_2 fundamental, and thereby neglect the ν_1 states, the ν_3 states, and the combination states. A better approximation in this case would be to use the product of three such functions, but this still neglects the combination states.

In fact, these approximations are excellent ones. At normal temperatures, neglect of the ν_1 and ν_3 states reduces Q_V by about 0.1 percent and 0.002 percent, respectively, for CO_2. The differences due to anharmonicity are similarly small. The fact that Q_V appears as a ratio further dilutes the effect of these errors. The uncertainties associated with any vibrational temperature profile clearly dominate the errors caused by these approximations.

For CH_4, the energy levels are more complicated, but Q_V can be approximated to about 1 percent[12] by taking empirical values of $1370\ cm^{-1}$ and 5 for E_o and D, respectively.

For O_2, several transitions in the near infrared are electronic transitions, but NLTE treats them as if they were vibrational transitions. In this case, Eq. (49) is, of course, wrong in principal. The levels are so high-lying, however, that Q_V is practically identical to unity, and, in practice, Eq. (49) is perfectly adequate.

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12. Bullitt, M.K. Private Communication.

The temperature dependence of the rotational partition function is approximated by

$$\frac{Q_R(T)}{Q_R(T_s)} = \left(\frac{T}{T_s}\right)^j \tag{50}$$

where the exponent, j, is unity for linear molecules, and 1.5 for nonlinear molecules.[2]

3. USE OF THE PROGRAM

3.1 Introduction

NLTE is written in FORTRAN'77. It requires about 106000 (decimal) words to compile and load on the CYBER 750 at AFGL. A high-optimization option should be selected at compile time (OPT=2 on the FTN5 compiler) if a full band is being run. Each run requires about 2 seconds to perform all the initialization steps, and then a fraction of a second for each line considered. The exact amount of time required, of course, depends on the amount of computation to be done--that is, on the optical depth of the line, the number of atmospheric layers, the number of integration points selected, and so on--but it is typically about 0.25 sec. per line on the CYBER.

NLTE requires information from three data files, which are associated with units 1, 2, and 3. These files contain general program directives, an atmospheric profile, and a coded AFGL line file, respectively. We reiterate that program NLTE, in its stand-alone form, deals with single vibrational bands. As such, the program input on units 1 and 2 is specific to the band in question. (In fact, unit 1 identifies the band.) To obtain the total radiance from several overlapping bands, it is necessary to run the program several times. On unit 3, data pertaining to bands other than the one of interest are ignored.

NLTE prints output on units 4, 5, and 6, with unit 4 being used for the principal results and units 5 and 6 containing supplementary and diagnostic information. If a synthetic spectrum is calculated--that is, if an instrumental scanning function is specified (see Section 2.3.6), NLTE writes the spectral radiance to unit 7 as well as to unit 4. To obtain the total spectral radiance of overlapping bands, the program must be run once for each band. On the first run, a new file is associated with unit ; on succeeding runs, the earlier file is read, the results for the new bands are added in, and the same file is rewritten so that the cumulative results are available. This is all done automatically, provided that the original file is available and the instrumental scanning function and certain other parameters are the same.

The present version of NLTE is written so that an optional file associated with unit 9 can be created for use in interactive mode. This feature is discussed in Section 3.3.5.

On the CYBER 750, the default filenames TAPE1-TAPE6 are used for the files associated with units 1-6. Unit 7, if selected, is associated with file SPECF. Unit 9 is associated with OUTPUT on the CYBER.

Units 2 and 3 are rewound before they are read; unit 1 is not. One can thus put program directives for several runs on (separate records of) unit 1 if the runs are to be done consecutively. Unit 7, if it is used, is also rewound before it is read. Except for unit 9, all files to which NLTE writes output are rewound before normal termination of the program.

Appendix C contains the source listing for NLTE. Appendixes A and B give sample program input and output for two separate jobs--one which calculates the radiance from an entire band, and another which gives the results for a single ro-vibrational transition. They also contain the command sequences used to run these jobs on the CYBER.

3.2 Input Requirements

Unit 1 contains general program directives and physical parameters describing the transition(s) being considered. It is read with list-directed reads, which allows for flexible input formatting and makes it easy to use defaults. In fact, many of the quantities, particularly the program directives, have built-in defaults which do not need to be changed by the user in most circumstances.

Units 2 and 3 are each read in fixed formats, described below. In general, there are no default values for the quantities read from these files; however, on unit 2, the program will, as discussed in Section 3.2.2.3, interpret the input fields in a way which varies with the circumstances.

All three input files may begin with header cards containing alphanumeric information to identify their contents. Header cards are identified by the character C in the first column. Any number of header cards may be included at the beginning of the files, but after the first actual data are read, all information is interpreted as data. That is, "comment cards" cannot appear in the bodies of the input files.

Sections 3.2.1-3.2.3, below, describe the input information for the three required data files.

3.2.1 UNIT 1: GENERAL PROGRAM DIRECTIVES

Table 1 lists the program input obtained from unit 1. The list-directed read allocates one field, of arbitrary length and delimited by commas or blanks, for each variable. Variables corresponding to null fields--defined, for example, by consecutive commas--are unchanged from their previously-set default values. A slash (/) after any field terminates the read operation and defines the remaining fields as nulls. It is thus necessary to provide numerical or character input only for those quantities for which no default is listed in Table 1. For list-directed reads, all character variables must be enclosed in single quotes ('), as indicated.

Appendixes A.1 and B.1 contain sample input for two different jobs. Sections 3.2.1.1 - 3.2.1.5, below, discuss the information read from the four or five card-images comprising file TAPE1.

3.2.1.1 1A: Line Directives

Information on the line directives card identifies the transitions under consideration. The molecule code is a character variable corresponding to one of the first eight infrared-active molecules included in the AFGL database--that is, 'H2O', 'CO2', 'O3', 'N2O', 'CO', 'CH4', 'O2', or 'NO' should be read. The isotope code and the designation of the vibrational states are standard AFGL notation.[2] For linear molecules only, within the band identified by UST and LST, one may consider only the P, Q, or R branches, or else all branches (default). For the branch(es) considered, one may choose a single rotational quantum line--identified by NRL, the J quantum number of the lower rotational state--or all the lines (default).

3.2.1.2 1B: Viewing Path Parameters

The viewing path parameters define the line-of-sight of the observer. NLTE can handle limb- or zenith-look geometry. In limb-look, the path is parameterized by a single quantity, the tangent height. The observer is presumed to be above the atmosphere and the path extends from space to space through the tangent point. In zenith-look, the sensor looks directly upwards from some point within the atmosphere. The path is parameterized by this observation height.

NLTE is capable of calculating the radiance over many--but not more than 50--viewing paths in a single run. The viewing path parameters are defined by a range (TANI-TANF) and spacing interval (SPAC) rather than a set of discrete values. Limb- and zenith-look geometry are distinguished by the sign of SPAC. If SPAC is positive, NLTE assumes limb-look; if SPAC is negative, NLTE computes the radiance in the zenith. For example, if card 1B contains "70, 85, -5", observation heights of 70, 75, 80, and 85 km are assumed for the zenith calculation. If a band-radiance calculation involves more than 500 lines, only five viewing paths can be run at once.

Table 1. Program Input on Unit 1

Variable	Description	Units	Type	Example	Default
CARD 1A: Line Directives					
MOL	Molecule code	—	Char	'CO2'	—
ISO	Isotope code	—	Integer	626	—
UST	Upper vib level	—	Char	'01101'	—
LST	Lower vib level	—	Char	'00001'	—
BR	Branch (P, Q, R, A)	—	Char	'Q'	'A'
NRL	Rot'l Line number	—	Integer	14	999
CARD 1B: Viewing Paths					
TANI	Lowest tang or observ ht	km	Real	70	—
TANF	Highest tang or observ ht	km	Real	85	TANI
SPAC	Interval	km	Real	5	+1
CARD 1C: Program Directives					
HMAX	Top of atmosphere	km	Real	130	see text
ACC	Accuracy	—	Real	0.05	0.01
NPTS	Integ pts per panel	—	Integer	2	4
NDP	Lineshape code	—	Integer	0	0
VMIN	Low end, freq range	cm^{-1}	Real	600	0
VMAX	High end, freq range	cm^{-1}	Real	800	20,000
CARD 1D: Synthetic Spectrum Parameters					
FWHM	Width of scanning fn	cm^{-1}, μm	Real	20.1	0
DEL	Spacing of points	cm^{-1}, μm	Real	2	1
UNIT	Units of FWHM and DEL	—	Char	'CM-1'	'CM-1'
CARD 1E: Band parameters**					
VIBE	Vib energy of transition	cm^{-1}	Peal	667.379	—
VIBL	Vib energy of lower state	cm^{-1}	Real	0.0	—
VIBQ	Vib quantum in part'n fn	cm^{-1}	Peal	667.379	—
GL	Statistical wgt, lower st	—	Integer	1	—
GU	Statistical wgt, upper st	—	Integer	2	—

**Note that card 1E is sometimes superfluous (see text)

3.2.1.3 1C: Program Parameters

HMAX is the highest altitude to be considered in performing the calculation--that is, the "top" of the atmosphere. It should be sufficiently greater than TANF so that the radiance contributions from higher (neglected) altitudes are of little consequence. It defaults to the highest altitude in the profile read on unit 2.

ACC is the nominal accuracy of the integrated radiance computed for each individual line, expressed as a fractional error. It was introduced as ε in Section 2.3.4. Except for the numerical integration, all the mathematical (as opposed to physical) approximations are designed to contribute errors in the end results which are smaller than this amount.

NPTS is the number of integration points per panel in the numerical integration over frequency. Acceptable values are 2, 4, and 8. We know of no way to assess the accuracy of the integration procedure except to increase this parameter. However, for most cases we tested, using the default value (4) instead of the maximum value (8) introduces errors of less than those allowed by specifying ACC = 0.001.

The lineshape code, NDP, can have the values -1, 0, and 1. The default value, 0, selects the new Voigt routine ZVGTC. A value of +1 gives the Doppler lineshape. A value of -1 accesses Voigt function VWERF, which is very accurate but much slower than ZVGTC. We have not found any case in which the older routine gives significantly different results.

VMIN and VMAX define the range of line positions to be searched on unit 3 for transitions to be considered. Default is to search the entire file.

3.2.1.4 1D: Synthetic Spectrum Parameters

If a synthetic spectrum is desired, a positive number must be read for FWHM; otherwise the default condition (no synthetic spectrum) is assumed. The result is in units of watt/(cm^2-ster-cm^{-1}) or watt/(cm^2-ster-μm), depending on UNIT. Possible values of UNIT are 'CM-1' and 'UM'. If spectra from previous runs are being added in, FWHM, DEL, and UNIT, as well as TANI, TANF, and SPAC, must all be exactly the same as the earliest values. No more than 12 synthetic spectra will be generated, even if the number of viewing paths is greater.

3.2.1.5 1E: Band Parameters

In order to perform the radiance calculation, NLTE uses five parameters which represent properties of the vibrational levels under consideration. In order to ease the input requirements, these properties of many important levels of two important molecules, CO_2 and NO, have been stored in BLOCK DATA MOLPAR for automatic retrieval by the program. For other molecules and for CO_2 and NO levels not included in this database, however, it is necessary to read in these quantities. The fifth data card must then be included on unit 1.

The three energies needed are VIBE, the energy of the vibrational transition, which is needed to calculate γ ; VIBL, the vibrational energy of the lower state, needed for P_ℓ and also for other purposes; and VIBQ, the energy of the lowest lying vibrational state, needed to calculate the vibrational partition function. The statistical weights of the upper and lower states are used to calculate the populations of the vibrational levels. Table 2 gives the list of vibrational levels for which the necessary information is stored. Card 1E can be omitted if the radiative transition connects any two of these vibrational states.

3.2.2 UNIT 2: ATMOSPHERIC PROFILE

3.2.2.1 Requirements for the Atmospheric Profile

The information contained on unit 2 defines the model atmosphere. Since NLTE provides no means of determining the populations of the radiating states independently, it is necessary to read a sufficient amount of data to enable such a calculation for all altitudes of interest. The information read pertains to vibrational levels, not ro-vibrational levels. (The ro-vibrational populations are derived using a rotational temperature equal to the kinetic temperature). The vibrational partition function, Q_V, is also needed and information used to evaluate it is contained on unit 2.

We distinguish between regular bands, in which the lower vibrational state is the ground vibrational state, and hot bands in which the lower vibrational state is not ground. In general, we regard each vibrational state as having its own vibrational temperature, even though, in practice, strongly-coupled levels may be described by the same temperature profile. Because the vibrational temperature of the ground state is not meaningful, less input information is required for regular bands than for hot bands.

Since the vibrational levels may be described in alternate but equivalent ways, NLTE provides different input options for users with model atmospheres expressed in terms of different quantities. For regular bands, the populations of the upper and lower radiating vibrational state s may be calculated from the total number density and the upper-state vibrational temperature, or conversely. For hot bands, the total number density is required, but one may specify either the number densities or the vibrational temperatures of the upper and lower radiating vibrational states. NLTE allows for input in various combinations, and it distinguishes them automatically according to criteria discussed in Section 3.2.2.3.

For the partition function, the approximation discussed in Section 2.3.7 requires the vibrational temperature of the lowest vibrational level of the molecule. This can be read directly or calculated from the number density of this

Table 2. CO_2 and NO Vibrational Levels Included in MOLPAR

CO_2 levels								NO levels			
iso / level	626	636	628	627	638	637	828	level	46	56	48
00001	x	x	x	x	x	x	x	0	x	x	x
01101	x	x	x	x	x	x	x	1	x	x	x
10002	x	x	x	x	x	x	x	2	x	x	x
02201	x	x	x	x	x	x	x	3	x		
10001	x	x	x	x	x	x	x	4	x		
11102	x	x	x	x				5	x		
03301	x	x	x	x				6	x		
11101	x	x	x	x							
00011	x	x	x	x	x	x	x				
20003	x	x	x	x							
12202	x	x	x	x							
20002	x	x	x	x							
04401	x	x	x	x							
12201	x	x	x	x							
20001	x	x	x	x							
01111	x	x	x	x							
10012	x	x	x	x							
02211	x	x	x	x							
10011	x	x	x	x							
11112	x	x	x	x							
03311	x	x	x								
11111	x	x	x	x							
00021	x	x	x	x							
20013	x	x	x	x							
12212	x	x	x								
04411	x	x	x								
20012	x	x	x	x							
12211	x	x	x								
20011	x	x	x	x							

level and that of the ground state. NLTE automatically distinguishes between these two possibilities, also.

3.2.2.2 Input Format

Unit 2 is read using a formatted read which is the same for all options. Following the header, the card-images each contain all the information pertaining to a single altitude. They are ordered according to increasing altitude. No more than 250 altitudes, corresponding to 249 layers, can be read. The format is (F5.1, F10.3, 5E12.5, A15), where the first two fields are reserved for the altitude and temperature, and the next five are for the various allowed combinations of number densities and vibrational temperatures. The character field is used for overriding the default interpretations of the input data. (See Sections 3.2.2.3 and 3.2.2.4.)

The variables which can be read from unit 2 are defined in Table 3. The last three variables are used only for approximating the partition function. There are 11 options for reading the data, each involving a different combination of these quantities. Six options pertain to regular bands, four to hot bands, and the last implies LTE conditions and is therefore useful for both regular and hot bands. The combinations are listed in Table 4.

Table 3. Variables Read from Unit 2

* ALT -----	the altitude (km) (required)
* TRTMP--	the translational temperature (K) (required)
* RHO -----	the total number density (molecules/cm^3). This includes all isotopes.
* TVL -----	vibrational temperature of the lower level (K). (Hot bands only.)
* TVU -----	vibrational temperature of the upper level (K)
* NL-------	number density of the lower vibrational level (molecules/cm^3). Unlike RHO, this refers only to the isotope under consideration.
* NU-------	like NL, but for the upper vibrational level
* TVQ -----	vibrational temperature of lowest excited state (K)
* NO-------	number density of the ground vibrational state (molecules/cm^3), for the isotope under consideration
* N1 -------	like NO, but for the lowest excited vibrational state

Appendixes A.2 and B.2 contain sample atmospheric profiles using two different input options. A.2 illustrates the use of vibrational temperatures on input (option 7). B.2 illustrates the use of number densities for both the radiative transition and the vibrational partition function.

Table 4. Possible Combinations of Input Data on Unit 2.

Option
Regular Bands:
1. ALT, TRTMP, RHO, TVU, TVQ
2. ALT, TRTMP, RHO, TVU, NO, N1
3. ALT, TRTMP, NL, NU, TVQ
4. ALT, TRTMP, NL, NU, NO, N1
5. ALT, TRTMP, RHO, TVU
6. ALT, TRTMP, NL, NU
Hot Bands:
7. ALT, TRTMP, RHO, TVL, TVU, TVQ
8. ALT, TRTMP, RHO, TVL, TVU, NO, N1
9. ALT, TRTMP, RHO, NL, NU, TVQ
10. ALT, TRTMP, RHO, NL, NU, NO, N1
LTE Conditions:
11. ALT, TRTMP, RHO

With options 1-4, a redundancy is implied if the radiative transition connects the ground and first excited states because, for example, TVU and TVQ are identical. In this case, option 5 or 6 can be used. If, on the other hand, the radiative transition connects a higher state, use of option 5 will require that the vibrational partition function be calculated with the vibrational temperature appropiate for the radiating states rather than that for the lowest lying levels. This leads to errors in the radiance calculation which will be quite small for most quiescent conditions. For option 6, the radiance will be correct, although quantities which are printed but not used will be slightly in error.

For options 7 and 8, a blank field, or zero, in place of TVU will cause the program to equate TVL and TVU--that is, use the same profile for both vibrational temperatures.

3.2.2.3 Default Interpretations

NLTE automatically distinguishes among the 11 allowed combinations. It does so by interpreting the data on the first card-image--that is, the data describing the lowest altitude included on the file--according to the numerical values appearing in special fields. These special fields are the fourth and fifth fields for regular bands, and the fourth and sixth fields for hot bands. The numbers in them can either be zero (blank fields) or can represent a vibrational temperature or a number density.

Vibrational temperatures generally have numerical values between 100 and 500, while number densities are usually much larger. The default criteria for distinguishing among options are: (1) A nonpositive numerical value in a special field indicates unavailable data; (2) A positive value below 1000 indicates a vibrational temperature; (3) A value above 1000 indicates a number density. For regular bands, for example, reference to Table 4 shows that options 1 and 3 differ from options 2 and 4 because the partition function may be calculated directly from TVQ or indirectly from NO and N1. The value of the quantity appearing in the fifth data field identifies it as either NO or TVQ, and the range of possibilities is narrowed accordingly. Similarly, the quantity in the fourth field is either NU or TVU. Its value distinguishes between options 1 and 3 or between options 2 and 4. A blank in field 5 implies option 5 or 6. A blank in field 4 implies option 11: no vibrational temperatures are available, so the translational temperature is used to calculate all populations.

3.2.2.4 Override Code

NLTE provides an override capability for the default interpretations, to allow for possible ambiguities. For example, data intended to be read with an option 9 interpretation might be mistakenly read with option 7 if the upper radiating state is only populated to the extent of a few hundred molecules/cm^3. In that case it would be necessary to read a character variable, CODE (only on the lowest-altitude card-image), to orient the program properly.

CODE should appear as three consecutive characters anywhere in columns 76-90 of the lowest altitude data card. It should not be delimited with quotes. Table 5 gives the proper override codes and the options which they force into effect.

Table 5. Override Codes

CODE	Action
	default interpretation
LTE	LTE conditions prevail
T, T	requires option 1 or 7
T, N	requires option 2 or 8
N, T	requires option 3 or 9
N, N	requires option 4 or 10

3.2.3 UNIT 3: LINEFILE

3.2.3.1 Requirements for the Linefile

The properties of the lines used in the radiance calculation are taken from unit 3. This is a coded linefile, a subset of the AFGL Atmospheric Absorption Line Parameters Compilation[2,3,4] maintained by personnel at AFGL/OPI. The quantities read by NLTE are given in Table 6, as is the format determined by the larger database.

Table 6. Line-File Data for Each Ro-Vibrational Transition

Format	Symbol	Line-file Datum
F10.4	ν_o	Resonant Frequency (cm^{-1})
E10.3	$S(T_s)$	Line Intensity (LTE, 296 K) ($cm^{-1}/mol\text{-}cm^2$)
F5.4	α_o	Lorentz half-width (1 atm) (cm^{-1}/atm)
F10.3	E"	Energy of the lower state (cm^{-1})
2A8, A10, A9		Quantum numbers, line identifiers
I3		Entry code for these data
I4	ISO	Isotope code
I3	MOL	Molecule code

The physical data in Table 6 have been discussed earlier. The total lower-state energy, E'', is needed to obtain the rotational energy, E_R'' for the calculation of Eq. (19). The entry code and the molecule code are not checked by NLTE. The isotope code is the same as the variable ISO read from unit 1. The quantum numbers and line identifiers are different for different molecules.[2] In fact, the corresponding formats are different as well. NLTE reads each file in a format appropriate for the molecule being considered.

Appendices A.3 and B.3 give examples of coded linefiles appropriate for input to NLTE.

3.2.3.2 Obtaining the Linefile

The AFGL Atmospheric Absorption Line Parameters Compilations has been described in many publications.[2,3,4] At AFGL, it resides on a disk pack to which it was written in buffered binary form. Dr. L.S. Rothman, who is responsible for the compilation, has prepared a Cyber Control Language procedure, WRITE, for obtaining coded subsets of the database.

Users who do not have access to Dr. Rothman's disk pack can obtain the linefile information from magnetic tape. The data format and a possible approach to acquiring files from this medium have been discussed in the report[1] accompanying the first release of NLTE, and we refer readers to that publication for this information.

Example 1 gives a control-card sequence which obtains, saves, and lists all ozone lines between 2000 and 2020 cm^{-1} using WRITE. The GET command locates the file containing the procedure and the BEGIN command invokes it. The latter contains optional parameters, described in Table 7, which determine the disposition of the information acquired from the compilation. The data card(s) following the end-of-record provide the information the procedure requires to identify the desired lines.

EXAMPLE 1 Use of the Procedure WRITE

```
JOB. . .
USER. . .
CHARGE. . .
GET, P= PROCEDU/UN=ROTHMAN.
BEGIN, WRITE, P, PFN=OZONELN, COPFIL=YES.
---EOR--
2000, 2020, 'O3', , , , , 'PFILE'
```

(1) Identifying the Lines

The information to be taken from the data cards is listed in Table 8. Each card is read with a list-directed read, which means that the data fields (eight in

Table 7. Parameters for the Procedure, WRITE

KEYWORD	VALUE	DEFAULT
PFN	Permanent File Name	No save is done even if PFILE is specified on some data cards
COPFIL	YES	NO (no list of TAPE8)
SORTM	YES	NO (no SORT/MERGE)

number) should be separated by comma delimeters and no attention need be paid to the columns used for each field. Default values result from blank fields (consecutive commas). After the last field containing a nondefault value, a slash (/) can be used to terminate data input for that card. Either the slash or a sufficient number of commas to define each field must be used. All input data of type character must be surrounded by single quotes. Leading blanks inside the quotes will give unpredictable results. Anywhere else, blanks are irrelevant. Any number of cards can be included.

Table 8. Input Data for the Procedure, WRITE

DATUM	QUANTITY	TYPE	DEFAULT
V1, V2	Frequency Range (cm^{-1})	Integer, Real	None
MOL	Molecular Formula	Character	All molecules
ISO	Isotope Code	Integer	All isotopes
UST, LST	Band quantum numbers	Character	All bands
SCRIT	Threshold Strength	Real	All strengths
DISPOS	File Disposition Code	Character	List only

V1 and V2 must be specified, as there is no default. MOL is the alphanumeric symbol giving the molecular formula. ISO is the isotope code. UST and LST are the upper- and lower-state quantum numbers for the vibrational bands desired. The quantum numbers are different for different molecules, and their meaning is discussed by McClatchey et al.[2] For the purposes of WRITE, one enters consecutive digits inside quotes, for example, '11101.'

SCRIT is the intensity threshold. Lines which are weaker than this threshold are ignored. Because of the small magnitudes involved, an E descriptor should be used.

The data selected by the procedure can be either listed on OUTPUT or written to TAPE8, which is defined as a direct-access permanent file. DISPOS is a code used to select the desired disposition. Entering 'PFILE' in this field causes TAPE8 to be written. Anything else invokes the list option. One can list some data and save other data by entering different disposition codes on different cards.

Lines satisfying the requirements of each separate data card are frequency-ordered on whichever file they are directed to. However, lines from one data card will always follow those from preceding cards. If the frequency ranges are increasing and do not overlap, frequency-ordering is preserved. Otherwise, for TAPE8, only, a SORT/MERGE option can be specified on the BEGIN card to restore frequency-ordering. Frequency-ordering is not necessary for NLTE.

(2) Parameters for WRITE

The BEGIN card invokes the procedure WRITE (which is found on logical file P in our example). It allows up to three optional parameters which are used for separate purposes: to preserve the frequency-ordering on TAPE 8, as mentioned above; to give the permanent file name; and to cause the information on TAPE8 to be copied to OUTPUT. The form of each of these parameters is KEYWORD=VALUE where KEYWORD is fixed and VALUE is supplied by the user. Table 7 describes these parameters. The parameters can be entered in any order following the logical file name. Parameters which are omitted assume default values, the effect of which is given in Table 7.

3.3 Program Output

Appendixes A.4-A.7 and B.4-B.6 contain program output for Sample Runs 1 and 2. In general, each of the output files (units 4, 5, and 6, and also 7 if it is used) must be copied to a printer or some other device after the program terminates so they will not be lost. Sections 3.3.1 - 3.3.5 describe the information written to the different output files.

The program functions differently in some respects when only one line, rather than an entire band, is being considered. In particular, the thin-line bypass option is suppressed so that the full calculation is performed regardless of the optical depth along the path. With one line, no synthetic spectrum can be generated. However, the detailed radiance profile is printed out (along with the path optical depth) as a function of frequency as the numerical integration proceeds outwards, panel by panel, from the resonant frequency. Note that because of both the Gaussian integration and the panel-width adjustment for the wings (see Section 2.3.4.1), these points are not equally-spaced in frequency. There are other ways in which the printed output on units 4 and 5 differs as well.

3.3.1 UNIT 4: PRINCIPAL PROGRAM OUTPUT

The principal program output is written to unit 4. Examples appear in Appendixes A.4 and B.4.

NLTE first repeats the program input found in files TAPE1, TAPE2, and TAPE3, and also writes some subsidiary information. In the case of the atmospheric profile, the first seven variables in Table 3 are all printed as a function of altitude for the altitude range used in the calculations, even though one or two of them will have been calculated rather than read directly. It also prints the atmospheric pressure used to evaluate the Voigt lineshape (taken from a program database derived from the U.S. Standard Atmosphere, the vibrational temperature TVQ used to calculate the vibrational partition function, and the partition function itself.

When an entire band is considered, the integrated radiance is printed for each line and each viewing path. Two quantities are given: the result of the numerical integration over the radiance profile, under the heading "thick"; and the result which would be obtained if there were no absorption along the path ("thin"). Note that, for very thin lines, the latter is taken as the proper result and the thick calculation is bypassed. The principal results, the sum of the integrated radiance for all the lines, is then printed as "total band radiance." If a synthetic spectrum is generated, that is the last information written to unit 4.

Note that if there are more than five viewing paths, the program loops through them in groups of five, putting out the results sequentially. The synthetic spectrum for all paths still comes at the end.

As noted above, the program output for single-line runs is more detailed. The radiance and path optical depth are printed as a function of frequency, and the results of the integration over successive panels (designated P1, P2, etc.) are also written. The contribution from the tail of the radiance profile--the region from the last integration panel to infinity--also appears. Differences in the output between single-line runs and band runs can be seen by comparing Appendixes A.4 and B.4.

3.3.2 UNIT 5: SUBSIDIARY PROGRAM OUTPUT

The output on unit 5 is quite detailed information--some of it physical and some of it just program parameters and indices--which can be used in various ways. Examples appear in Appendixes A.5 and B.5.

For a full band, the cumulative program execution time is given for each line. In addition, for each path, the cumulative band radiance and the path optical depth at the center of each line are printed. The latter is useful for estimating the effects of self-absorption along the paths. In addition, the indices LB, LL, and KM are printed. They are, respectively, the number of the first expanded integration panel, the number of the last panel used, and the index of the highest-altitude layer used. LB is the same for all paths for a given line; the others may be different. LB and LL are zero for thin lines.

For single-line runs, two sets of altitude-dependent quantities are printed. Among them (in the first set) are the volume emission rate, the adjusted line strength KT, the Doppler width, the Lorentz-to-Doppler linewidth ratio RAT [y in Eq. (43)], and the Voigt function at the line center, f_{ν_0}. In the second set are, for each path, the physical distance (in km) through each layer, the optical depth at the line center within each layer, and the contribution to the total observed radiance at the line center from each layer. The last two of these are useful for extimating the range of altitudes "observed" from the end of the path--that is, the depths from which radiation escapes along the viewing path, and the altitudes at which emission from deeper layers is effectively trapped. For limb-look, however, only the near half of the viewing path is evaluated for this purpose.

3.3.3 UNIT 6: DIAGNOSTIC INFORMATION

The information written to unit 6 is for diagnostic purposes only. Examples appear in Appendixes A.6 and B.6.

If peculiar program input is encountered, potential problems may be noted on unit 6. In normal operation, the headers on each of the input files are echoed, as is the first data card-image. Dummy format fields are juxtaposed for help in locating the faulty input. In the case of unit 2, the program's interpretation of the quantities on the lowest-altitude data card is given, in order to eliminate confusion about the input options and to identify the logical path taken by the atmospheric profile setup routine, ATMPR.

NLTE may also write other special messages, usually to make note of a change in some program parameter or procedure that might be needed to avoid an execution-time error. For example, if the synthetic spectrum array is in danger of being overfilled, NLTE issues a warning and only calculates points falling within the allotted space. (In this particular case, the user can rerun the job with a larger value of DEL if important information is lost.)

3.3.4 UNIT 7: SYNTHETIC SPECTRUM

Unit 7, file SPECF, is read and written only when a synthetic spectrum is generated. The information on it is also written to unit 4; its purpose on output is to provide a file that can be saved and used as input to another program. "Another" program might be NLTE operating on an overlapping band (as discussed in Section 3.1), or it might be a program to read and plot the results of the final calculation.

The format of SPECF is such that NLTE can read it automatically. It starts with a header card-image identifying the type of information on the file (band radiance). This is followed by header card-images identifying the molecule, isotope, band, and branch, with one card for each band contributing to the spectral radiance on the file. Each of these header cards also contains the date and time of the NLTE run that calculated that band's contribution.

The first data card-image gives the synthetic-spectrum and viewing path parameters used to generate the spectra contained on the file. It is there for NLTE to check parameters for consistency, but can be ignored by plot programs.

The second card-image gives the number of bands contributing to the spectra on the file, and the total integrated radiance due to all these bands.

The spectral radiance curves start at the third data card-image. For each wavelength or wavenumber (depending on the units used), there is one card-image giving this quantity followed by up to 12 radiance values, 1 for each viewing path. The format is (F10.3, 1X, 12E10.3).

An example of unit 7 output appears in Appendix A.7.

3.3.5 UNIT 9: OUTPUT FOR INTERACTIVE USAGE

NLTE is a batch-oriented code in the sense that it requires input files to be prepared ahead of time. Since these files can be local, however, one often runs interactively. In such cases, it is useful to have output sent directly to the user, but the quantity of information written to unit 4 precludes the association of TAPE4 with OUTPUT, or at least makes the outcome less than satisfactory.

To surmount this difficulty, NLTE optionally defines an output file, unit 9, which is associated with the terminal (OUTPUT, on the CYBER). The information written to this file is a very limited subset of that written to unit 4. It includes enough information to identify successive stages of execution--specifically, reading the different input files--and also gives the principal output, the integrated radiance.

The procedure for making this feature optional relies upon a conditional-compile facility--using C$ directives--which is available on the CYBER under NOS 2.3. It is invoked by using the DS parameter on the FTN5 control card. Under NOS, omission of this parameter results in no output to unit 9. Other compilers, however, will regard the C$ directives as FORTRAN comments, with the result that unit 9 will be identified and used.

3.4 Transportability

In addition to extensive tests on the CYBER 750 on which the code was developed, NLTE test runs have been completed on a CRAY 1-A supercomputer and on a VAX 11/750 with a floating-point accelerator using VMS.

One set of modifications which is necessary in order for NLTE to run on other systems involves replacing the calls to the CYBER system functions DATE, TIME, and SECOND. DATE and TIME are called in subroutine LINES, and the results are carried into SPECTRM. SECOND, which gives the elapsed processor time, appears in three places in the main program.

The limited dynamic range of FORTRAN variables which is imposed by some 32-bit machines can cause an overflow problem while evaluating the series representation of the Voigt function in region 1 of ZVGTC. (See Section 2.3.5.) The largest number which can appear there is approximately 10^{66}; on the VAX, the default range is only about $10^{\pm 38}$. This problem can be avoided by using VWERF instead of ZVGTC (set NDP = -1; see Section 3.2.1.3). Alternatively, with a VAX, one can use the /G_FLOATING option in ZVGTC to extend the dynamic range for the variables (AN, FNR, FNI, FPR, FPI) which require it, resulting in slower arithmetic for Region 1. If the /G_FLOATING format is implemented in software rather than hardware, the slowdown is considerable, and it is best to use VWERF or find some other alternative.

If underflow messages appear in the output, setting the symbolic constant EXPL equal to the largest argument the EXP function can handle without overflowing may eliminate them. For the VAX, we use EXPL =88.

The OPEN statements for units 1-6 (in subroutine LINES) do not contain the FILE= parameter. One uses job control language to associate input files with the logical units (e.g., GET on the CYBER under NOS 2.3, ASSIGN on the VAX and Cray). For unit 9, if it is used, the FILE= parameter must be set to terminal output (OUTPUT on the CYBER, SYS$OUTPUT on the VAX).

The conditional-compile facility which activates unit 9 can be implemented on a VAX using the /D_LINES qualifier on the FORTRAN command, provided that the proper lines of code are prefixed with a D in column 1. These lines are the ones appearing between the lines prefixed with C$ in NLTE, LINES, SPECTRM, and HEADER.

In our tests, NLTE ran approximately four times as fast on the Cray as on the CYBER, and seven times slower on the VAX than on the CYBER. In the latter comparison, VWERF rather than ZVGTC was used for the Voigt function. Fast-execute optimizations were utilized in all tests.

4. RESULTS

NLTE has been applied to many problems involving infrared transmission in the upper atmosphere, and has been used to simulate the SPIRE experiment[13] and other experiments. In this section, we illustrate the usefulness of the code by citing results from our model of solar-pumped emission from the CO_2 $\nu_1 + \nu_3$ combination bands near 2.7μm.[14]

The most important physical mechanisms involved in this model are

(1) solar pumping of the 101 and 201 levels from ground at 2.7 and 2.0μm, and of the 111 levels from the low-lying 010 level at 2.7μm;

(2) collisional reorientation reactions which redistribute the populations among the directly-excited high-lying Fermi resonance split levels (e.g., 20011, 20012, 20013) and also to adjacent levels with different symmetry which are themselves not strongly pumped (12211, 12212);

(3) V-V collisions with nitrogen molecules, the net effect of which is usually to quench the radiating levels; and

(4) spontaneous emission.

Details, including assumed reaction rates and an energy level diagram, can be found in Sharma and Wintersteiner.[14]

We first used a solar-flux absorption code, SABS, which is similar in design to NLTE, to calculate the excitation rates at altitudes between 40 and 160 km due to absorption in all important infrared bands of CO_2. We then assumed steady state conditions and equated the total radiative and collisional excitation rates with the total radiative and collisional de-excitation rates to get the number densities of all the high-lying states that emit at 2.7μm. Finally, we used NLTE to predict the observed radiance on limb paths between 50 and 100 km. Using an independent estimate of radiance due to water vapor,[14] we compared these results to the SPIRE database. Because the rate constants for the collisional reorientation reactions are poorly known, we also recalculated the radiance using adjusted values for these constants in order to identify the errors they might cause and set limits on their possible values.

Figure 5 gives, as a function of tangent height, the total CO_2 radiance in the 2.6 to 2.9μm region (solid squares) and the breakdown according to sets of contributing bands. The most important sets are the one with the resonant 10012-00001

---

13. Stair, A.T., Jr., Sharma, R.D., Nadile, R.M., Baker, D.J., and Grieder, W.F. (1985) Observations of limb radiance with cryogenic Spectral Infrared Rocket Experiment (SPIRE), J. Geophys. Res. 90:9763.

14. Sharma, R.D., and Wintersteiner, P.P. (1985) CO_2 component of daytime Earth limb emission at 2.7 micrometers, J. Geophys. Res. 90:9789.

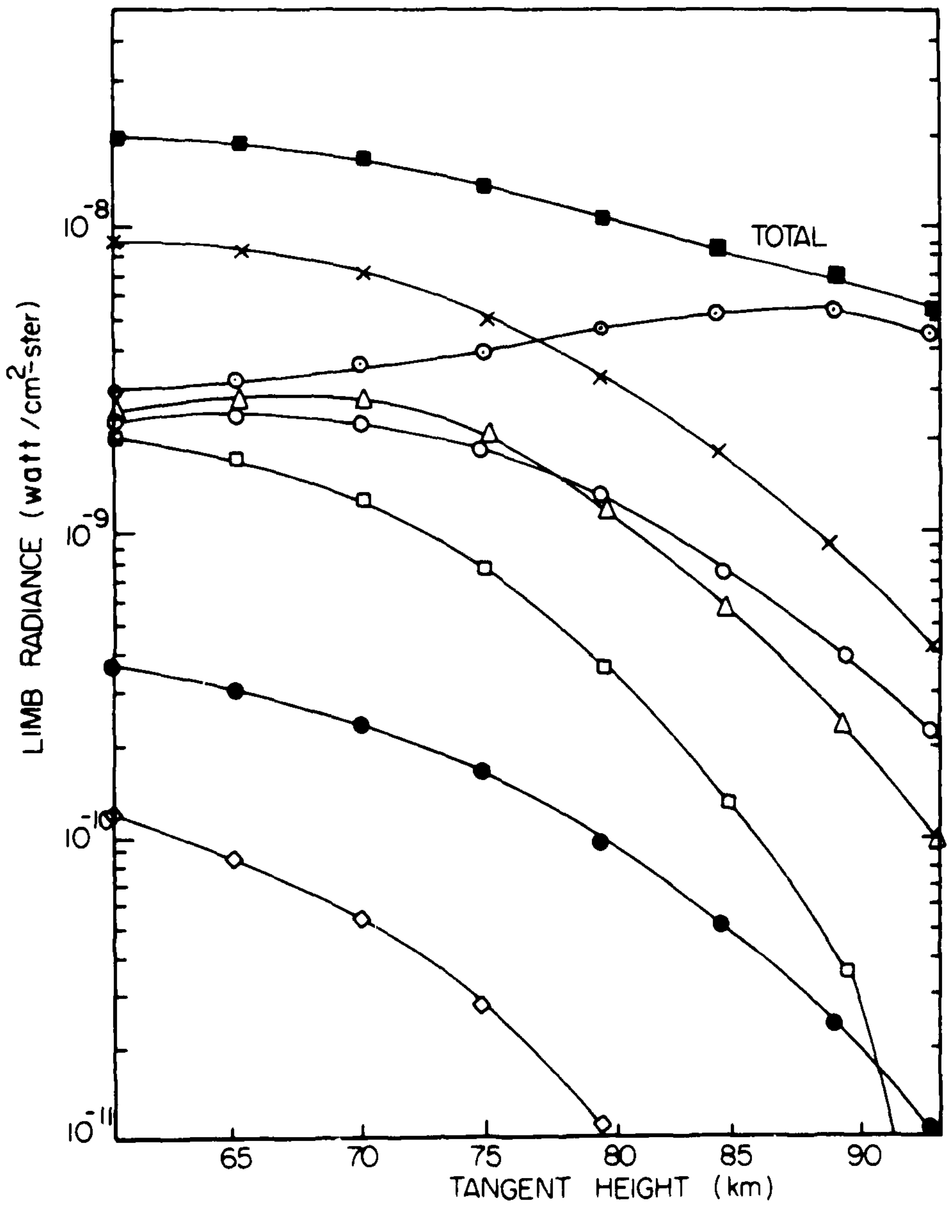

Figure 5. Predicted CO_2 Band Radiance in the 2.6 to 2.9μm Range as a Function of Tangent Height. Circled dots represent the major-isotope resonant bands; crosses, the bands originating in the 201 levels; triangles, the bands originating in the 111 levels; open circles, minor-isotope resonant bands; open squares, bands originating in the 121 levels; solid circles, bands originating in the 301 levels; and diamonds, bands originating in the 221 levels

and 10011-00001 transitions (⊙) and the one with the transitions originating in the 20011, 20012, and 20013 levels (x). Lines in the resonant bands are very strongly self-absorbed on the lower viewing paths, in contrast to lines of the 2.7μm hot bands originating in the 201 levels, most of which are thin. For this reason, the latter group of bands provides the greatest contribution to the total radiance for viewing paths extending below 75 km. Above this altitude, the self-absorption is less and the resonant bands dominate. Groups of more weakly contributing bands in Figure 5 are discussed in Sharma and Wintersteiner.[14]

Figures 6 and 7 give the spectral radiance as a function of wavelength. A triangular scanning function with a full width at half maximum of 0.038μm was used to produce these curves.

In Figure 6, the total radiance is plotted for different tangent paths. These curves are the summed output produced automatically on unit 7 by consecutive NLTE runs for all the contributing bands.

Figure 7 gives, for a tangent path of 75 km, the breakdown of the spectral radiance according to the groups of bands whose integrated contributions are shown in Figure 5. These curves are also summed output from unit 7, but selected differently.

Figure 8 gives the total spectral radiance for the 75 km tangent path, calculated using different assumptions about the collisional reorientation reaction rates. The basic model is the same curve as in Figure 7. "MOD1" decouples some of the high-lying levels, and "MOD2" is the extreme case of decoupling all these levels. (Other modifications involved coupling that was somewhat weaker, or somewhat stronger, than that of the basic model.) One can see that the NLTE radiance predictions are quite distinct--distinct enough, in fact, that a comparison with the SPIRE experiment allows us to rule out the more extreme modifications completely and to put lower limits on the principal rate constants.

The comparison with the experiment is given in Figures 9 and 10. Although the spectral fit is not perfect, the discrepancies together with a detailed examination of the physical mechanisms involved indicate the direction in which the coupling may be adjusted. In general, it is true that most of the conclusions derived from this and other similar modeling efforts rely upon comparing the total predicted radiance with experimental values. In this way--by use of an accurate and efficient radiance code, like NLTE--one can obtain a great deal of information about the physical processes involved in exchange of energy among excited vibrational levels of one or more molecular types.

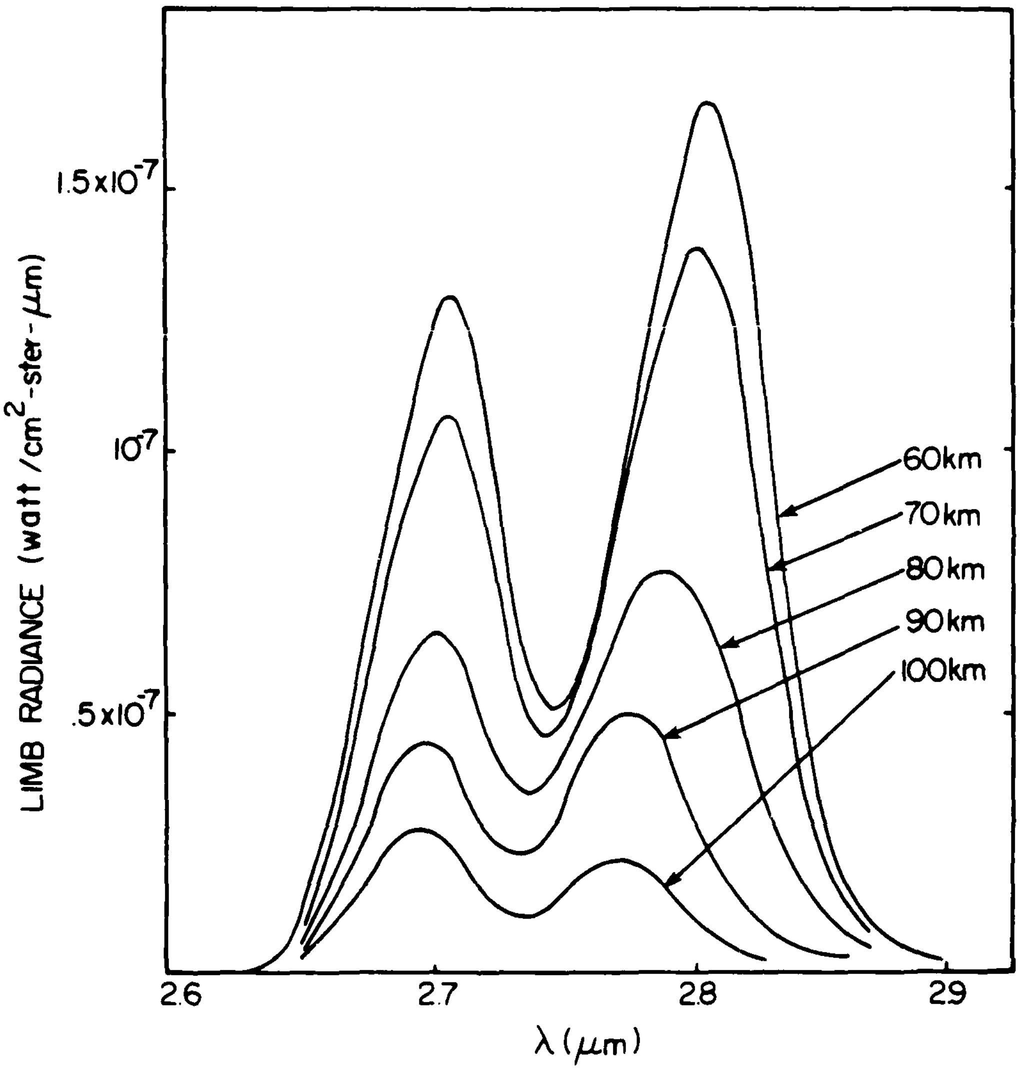

Figure 6. Spectral Distribution of CO_2 Limb Radiance for Tangent Heights Between 60 and 100 km

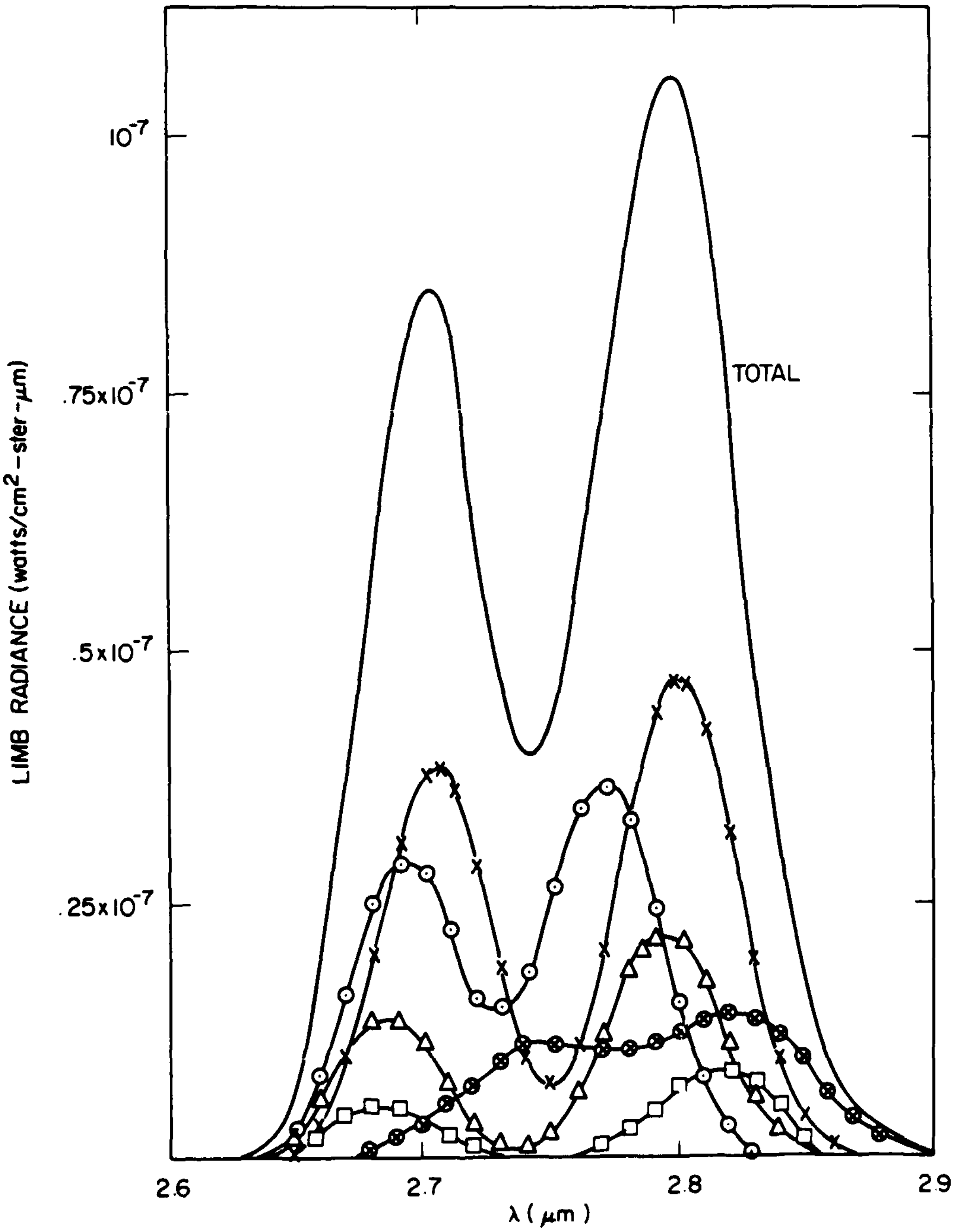

Figure 7. Spectral Distribution of CO_2 Limb Radiance, Components, for the Path With a Tangent Height of 75 km

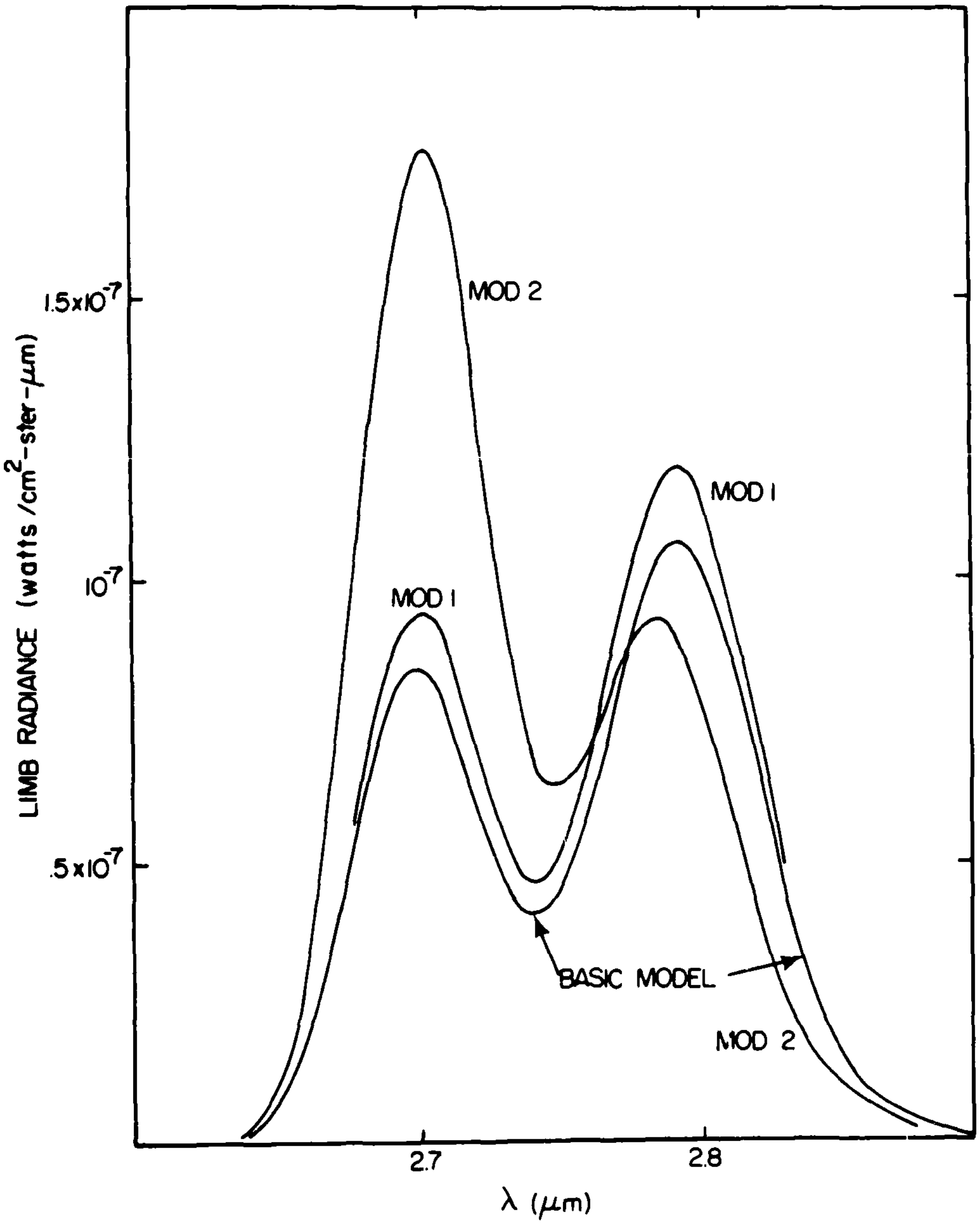

Figure 8. Spectral Distribution of Limb Radiance, From the Basic Model and From Two Modifications, for a Path With a Tangent Height of 75 km

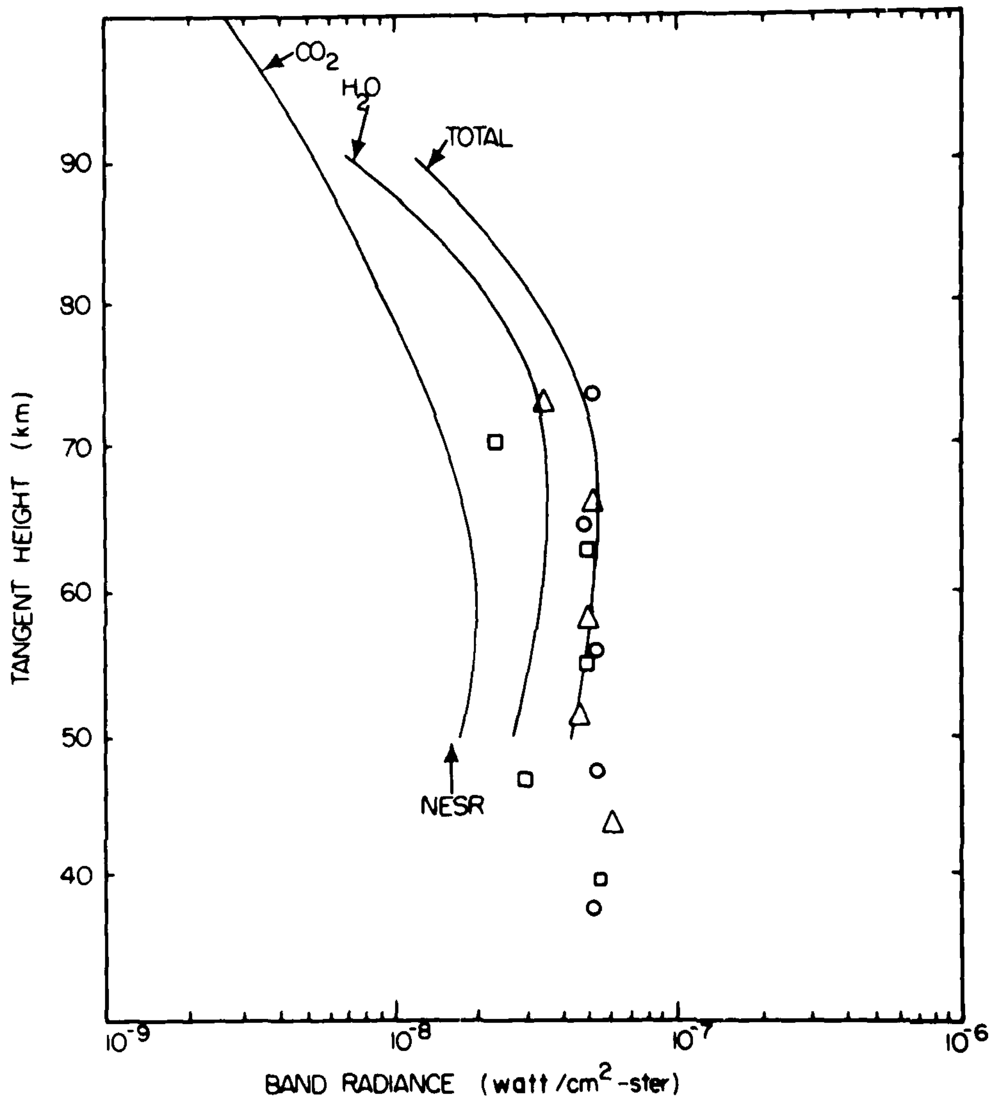

Figure 9. Comparison of Predicted and Experimental Band Radiance, 2.5 to 2.9μm, From SPIRE; and the Results of the CO_2 Model,[14] the H_2O Model, and Their Total. The detector noise limit is indicated by the arrow

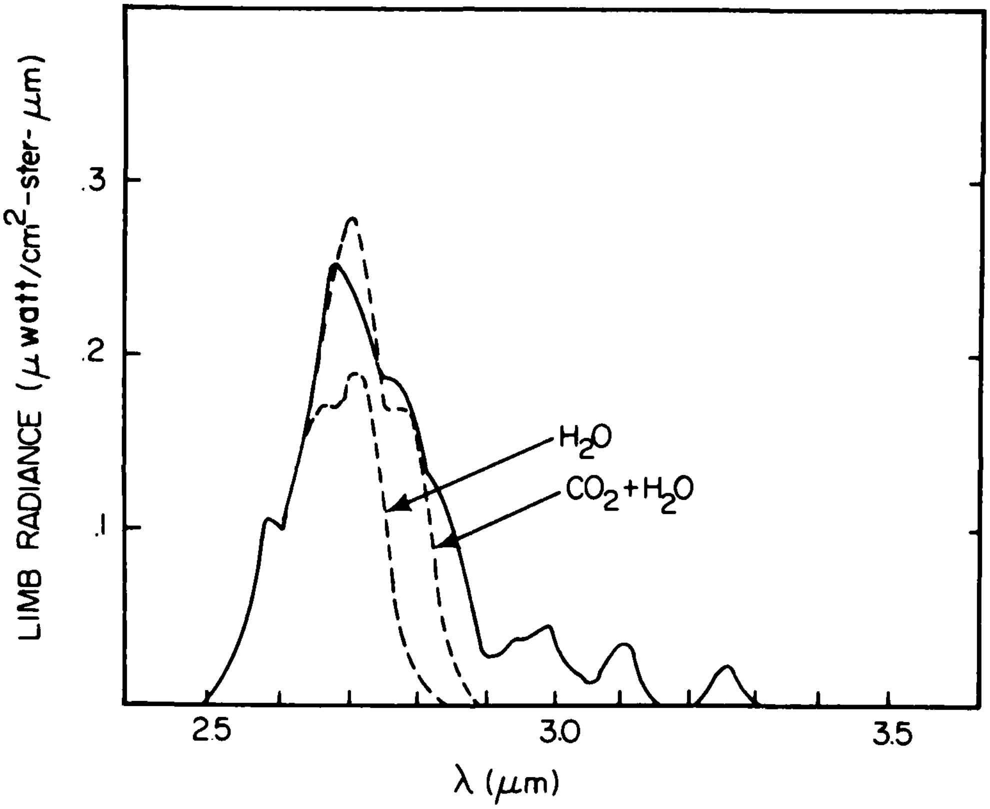

Figure 10. Comparison of Predicted and Experimental Spectral Radiance From the SPIRE Experiment (Solid Line) With Predictions of Contributions From CO_2 and H_2O, for a Tangent Path of 73 km

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14. Sharma, R.D., and Wintersteiner, P.P. (1985) CO_2 Component of daytime Earth limb emission at 2.7 micrometers, J. Geophys. Res. 90:9789.

Appendix A

Sample Run 1: Band Radiance

Appendix A contains Sample Run 1, in which the limb radiance due to the low lying 02201-01101 hot band of CO_2 is calculated for five viewing paths with tangent heights between 70 and 90 km. The "top" of the atmosphere was assumed to be at 150 km, and a maximum of 80 layers was used. The program required a fractional error of 1 percent or less for each line, used two integration points per panel, and ran in 17 sec on the CYBER 750 at AFGL. (Using four integration points per panel, the same job takes 28 sec.) Synthetic spectra were generated for each of the viewing paths and were added to spectra previously calculated and stored on a permanent file, due to the ν_2 fundamental (01101-00001) from the 626, 636, and 628 isotopes.

The results for the total band radiance for the five paths differ from those of a similar run specifying much greater accuracy and eight integration points per panel by 0.14 percent, 0.09 percent, 0.41 percent, 0.87 percent, and 1.01 percent. This indicates that (for this example, at least) the mathematical approximations utilized in the code perform properly.

The physical approximation introduced by the homogeneous atmospheric layers is, of course, not addressed by this comparison. However, as discussed in Section 2.3.4.3, we expect the resultant errors to be on the order of, or less than, the values given above.

A1. Unit 1: Input for Sample Run 1

```
'CO2', 626, '02201', '01101'/
70, 90, 5
150, .01, 2/
.27, .05, 'UM'
```

A2. Unit 2: Input for Sample Run 1

The beginning of the file defining the atmospheric profile used for Sample Run 1 is given below. The file contained data for altitudes between 65 and 249 km, but was only read to 150 km. The first five altitudes were also ignored (because the lowest tangent height was 70 km) except that the input option was determined from the 65-km data. Option 7 was used because the fifth and sixth data fields both contain vibrational temperatures.

```
CA0402S  ATMOS PROFILE 7/16/85
C        ALT,TRTMP,RHO,TVL,TVU,TVQ---ALL TVS SAME AS ON A0201S
C        VIB TEMPS FROM BULLITT'S NU2 MODELLING USING O QUENCHING
CCO2      02201    01101   65-249 KM
   65    233.294  .10397E+13  .22829E+03  .22829E+03  .22829E+03
   66    230.554  .90856E+12  .22482E+03  .22482E+03  .22482E+03
   67    227.814  .79397E+12  .22136E+03  .22136E+03  .22136E+03
   68    225.074  .69383E+12  .21783E+03  .21783E+03  .21783E+03
   69    222.334  .60632E+12  .21424E+03  .21424E+03  .21424E+03
   70    219.590  .52965E+12  .21176E+03  .21176E+03  .21176E+03
   71    217.350  .45791E+12  .20853E+03  .20853E+03  .20853E+03
   72    215.110  .39589E+12  .20522E+03  .20522E+03  .20522E+03
   73    212.870  .34227E+12  .20184E+03  .20184E+03  .20184E+03
   74    210.630  .29591E+12  .19839E+03  .19839E+03  .19839E+03
   75    208.381  .25561E+12  .19487E+03  .19487E+03  .19487E+03
   76    206.421  .21893E+12  .19146E+03  .19146E+03  .19146E+03
   77    204.461  .18752E+12  .18804E+03  .18804E+03  .18804E+03
   78    202.501  .16061E+12  .18460E+03  .18460E+03  .18460E+03
   79    200.541  .13756E+12  .18119E+03  .18119E+03  .18119E+03
   80    198.558  .11759E+12  .17780E+03  .17780E+03  .17780E+03
   81    196.618  .10004E+12  .17445E+03  .17445E+03  .17445E+03
   82    194.678  .85113E+11  .17122E+03  .17122E+03  .17122E+03
   83    192.738  .72413E+11  .16814E+03  .16814E+03  .16814E+03
   84    190.798  .61608E+11  .16525E+03  .16525E+03  .16525E+03
   85    188.886  .52136E+11  .16256E+03  .16256E+03  .16256E+03
   86    188.606  .43675E+11  .16082E+03  .16082E+03  .16082E+03
   87    188.326  .36587E+11  .15933E+03  .15933E+03  .15933E+03
```

A3. Unit 3: Input for Sample Run 1

The beginning of the file containing the transitions needed for Sample Run 1 is given below. That data corresponding to isotopes other than the one of interest are ignored.

```
LL020010 CO2 ALL    02201    01101 08/15/85 15UM NU2 HOT BAND
 590.07000 3.750E-27.0550  3054.161   02201   01101                 P 78 482 636   2
 591.51830 6.585E-27.0550  2933.382   02201   01101                 P 76 482 636   2
 592.96930 1.138E-26.0560  2815.695   02201   01101                 P 74 482 636   2
 594.42310 1.936E-26.0560  2701.102   02201   01101                 P 72 482 636   2
 594.74740 5.111E-27.0550  2989.619   02201   01101                 P 77 482 636   2
 595.87980 3.242E-26.0570  2589.604   02201   01101                 P 70 482 636   2
 595.98850 8.892E-27.0560  2870.575   02201   01101                 P 75 482 636   2
 597.23860 1.523E-26.0560  2754.619   02201   01101                 P 73 482 636   2
 597.33930 5.342E-26.0580  2481.203   02201   01101                 P 68 482 636   2
 598.49760 2.567E-26.0570  2641.754   02201   01101                 P 71 482 636   2
 598.80170 8.663E-26.0580  2375.902   02201   01101                 P 66 482 636   2
 599.48690 4.198E-27.0500  4005.001   02201   01101                 P 92 482 626   2
 599.76550 4.258E-26.0570  2531.980   02201   01101                 P 69 482 636   2
 600.26700 1.383E-25.0590  2273.702   02201   01101                 P 64 482 636   2
 600.88860 8.220E-27.0510  3862.635   02201   01101                 P 90 482 626   2
 601.04240 6.952E-26.0580  2425.300   02201   01101                 P 67 482 636   2
 601.73530 2.171E-25.0590  2174.605   02201   01101                 P 62 482 636   2
 602.29400 1.585E-26.0520  3723.345   02201   01101                 P 88 482 626   2
 602.32810 1.117E-25.0590  2321.715   02201   01101                 P 65 482 636   2
 603.20650 3.354E-25.0600  2078.612   02201   01101                 P 60 482 636   2
 603.62260 1.766E-25.0590  2221.227   02201   01101                 P 63 482 636   2
 603.70290 3.009E-26.0520  3587.135   02201   01101                 P 86 482 626   2
 604.68080 5.098E-25.0610  1985.725   02201   01101                 P 58 482 636   2
 604.92600 2.748E-25.0600  2123.838   02201   01101                 P 61 482 636   2
 605.11550 5.623E-26.0530  3454.005   02201   01101                 P 84 482 626   2
 605.26200 6.092E-27.0510  3928.332   02201   01101                 P 91 482 626   2
 606.15810 7.622E-25.0610  1895.946   02201   01101                 P 56 482 636   2
 606.23810 4.207E-25.0600  2029.549   02201   01101                 P 59 482 636   2
 606.42940 4.214E-27.0620  1659.591   02201   01101                 P 52D482 638   2
 606.44940 1.182E-26.0510  3787.723   02201   01101                 P 89 482 626   2
 606.53180 1.035E-25.0530  3323.959   02201   01101                 P 82 482 626   2
 607.11760 4.980E-27.0630  1621.271   02201   01101                 P 51D482 638   2
 607.55910 6.336E-25.0610  1938.362   02201   01101                 P 57 482 636   2
 607.63840 1.121E-24.0620  1809.275   02201   01101                 P 54 482 636   2
 607.64490 2.258E-26.0520  3650.186   02201   01101                 P 87 482 626   2
 607.80700 5.862E-27.0630  1583.686   02201   01101                 P 50D482 638   2
 607.92410 4.257E-27.0620  1658.075   02201   01101                 P 52C482 638   2
 607.95170 1.875E-25.0540  3196.999   02201   01101                 P 80 482 626   2
 608.49780 6.872E-27.0630  1546.836   02201   01101                 P 49D482 638   2
 608.55660 5.029E-27.0630  1619.813   02201   01101                 P 51C482 638   2
 608.84850 4.248E-26.0530  3515.725   02201   01101                 P 85 482 626   2
 608.88880 9.386E-25.0620  1850.279   02201   01101                 P 55 482 636   2
 609.12170 1.621E-24.0620  1725.716   02201   01101                 P 52 482 636   2
 609.18980 8.023E-27.0640  1510.720   02201   01101                 P 48D482 638   2
 609.19150 5.917E-27.0630  1582.284   02201   01101                 P 50C482 638   2
 609.37520 3.343E-25.0550  3073.127   02201   01101                 P 78 482 626   2
 609.82870 6.934E-27.0630  1545.488   02201   01101                 P 49C482 638   2
 609.88310 9.330E-27.0640  1475.339   02201   01101                 P 47D482 638   2
 610.06040 7.866E-26.0530  3384.342   02201   01101                 P 83 482 626   2
```

A1. Unit 1: Output From Sample Run 1

The principal program output from Sample Run 1 is given on the following 15 pages.

```
PROGRAM NLTE FOR INFRARED RADIANCE
DATE = 85/09/04.  TIME =  09.21.02.

*******************************************      **************
TAPE1
TESTP12---SAMPLE RUN 1, TAPE1---CO2 NU2 15UM 626 HOT BAND

1A- -LINE DIRECTIVES:

MOL = MOLECULE CODE =    CO2
ISO = ISOTOPE  CODE =    626
USI = UPPER VIB LVL = 02201
LSI = LOWER VIB LVL = 01101
BR  = RO-VIB BRANCH =      A
NRL = ROT'L  LINE # =    999

1B---VIEWING PATH PARAMETERS:

TANI = LOWEST  TANGENT HEIGHT (KM) =  70.00
TANF = HIGHEST TANGENT HEIGHT (KM) =  90.00
SPAC = EXAMINATION  INTERVAL  (KM) =   5.00
LOOK = 0;  LOOKING GEOMETRY CHOSEN =   LIMB

1C---PROGRAM PARAMETERS:

HMAX = ASSUMED TOP OF ATMOSPHERE (KM) =  150
ACC  = ACCURACY (INTEG'D RADIANCE)  = .01000
NPTS = NUMBER OF INTEG POINTS PER PANEL =  2
NDP  = 0; LINESHAPE OPTION SELECTED =  VOIGT
VMIN = LOWER END, LINE SEARCH (CM-1) =     0
VMAX = UPPER END, LINE SEARCH (CM-1) = 20000

1D---SYNTHETIC SPECTRUM PARAMETERS:

FWHM = WIDTH OF TRIANGULAR SCANNING FN  (UM  ) =    .270
DEL  = SPACING OF PTS IN SYNTH SPECTRM  (UM  ) =    .050

1E---BAND PARAMETERS:  (FOUND IN MOLPAR)

VIBE = VIB ENERGY OF THE  TRANSITION (CM-1) =  667.7500
VIBL = VIB ENERGY OF THE LOWER STATE (CM-1) =  667.3790
VIBU = QUANTUM FOR THE PARTITION  FN (CM-1) =  667.3790
GL   = STATISTICAL WEIGHT,  LOWER VIBRATIONAL STATE = 2
GU   = STATISTICAL WEIGHT,  UPPER VIBRATIONAL STATE = 2

QUANTITIES RETURNED FROM MOLEC:

WGT  = MOLECULAR  WEIGHT  =  44
AI   = ISOTOPIC  ABUND = .98414
DEGV (EXPLAINED IN MOLEC) =    2
FROT (EXPLAINED IN MOLEC) = 1.0
TEXP (EXPLAINED IN MOLEC) = .25

FORMAT FOR THE SEARCH OF THE LINETAPE IS
(I2,F10.4,F10.7,F5.4,F10 3,2A8,14X,A1,I3,4X,I4)

**************************************************************
```

****

TAPE2

A04025 ATMOS PROFILE 7/16/85
ALT,TRTMP,RHO,TVL,TVU,TVQ-- ALL TVS SAME AS ON A02015
VIB TEMPS FROM BULLITT'S NO2 MODELLING USING O QUENCHING AND SPIRE DATA
CO2 02201 01101 65-249 KM

INPUT OPTION # 7; NVP = 1, NPF = 1, VIBL > 0; (SEE COMMENTS IN ATMPR)

THE LOWER AND UPPER-STATE POPULATIONS REFLECT AN ABUNDANCE OF .98414 W.R.T. TOTAL CO2

	ALT (KM)	TR TEMP (K)	TVL (K)	TVU (K)	TOT PRESS (ATMOS)	CO2 DENSITY (CM-3)	LOWER STATE (CM-3)	UPPER STATE (CM-3)	VB TEMP (1)	PART FN
1	70.00	219.590	211.760	211.760	5.1528E-05	5.2965E+11	1.0949E+10	1.1720E+08	211.760	1.02181
2	71.00	217.350	208.530	208.530	4.4168E-05	4.5791E+11	8.8368E+09	8.8174E+07	208.530	1.02031
3	72.00	215.110	205.220	205.220	3.7861E-05	3.9589E+11	7.1033E+09	6.5802E+07	205.220	1.01884
4	73.00	212.870	201.840	201.840	3.2350E-05	3.4227E+11	5.6864E+09	4.8704E+07	201.840	1.01740
5	74.00	210.630	198.390	198.390	2.7642E-05	2.9591E+11	4.5321E+09	3.5733E+07	198.390	1.01600
6	75.00	208.381	194.870	194.870	2.3552E-05	2.5561E+11	3.5919E+09	2.5948E+07	194.870	1.01465
7	76.00	206.421	191.460	191.460	2.0067E-05	2.1893E+11	2.8214E+09	1.8669E+07	191.460	1.01340
8	77.00	204.461	188.040	188.040	1.7762E-05	1.8752E+11	2.2085E+09	1.3339E+07	188.040	1.01222
9	78.00	202.501	184.600	184.600	1.5721E-05	1.6061E+11	1.7218E+09	9.4546E+06	184.600	1.01111
10	79.00	200.541	181.190	181.190	1.2779E-05	1.3756E+11	1.3385E+09	6.6643E+06	181.190	1.01006
11	80.00	198.558	177.800	177.800	1.0387E-05	1.1759E+11	1.0353E+09	4.6587E+06	177.800	1.00909
12	81.00	196.618	174.450	174.450	8.7689E-06	1.0004E+11	7.9469E+08	3.2236E+06	174.450	1.00819
13	82.00	194.678	171.220	171.220	7.4028E-06	8.5113E+10	6.0992E+08	2.2300E+06	171.220	1.00738
14	83.00	192.738	168.140	168.140	6.2288E-06	7.2413E+10	4.6859E+08	1.5459E+06	168.140	1.00665
15	84.00	190.798	165.250	165.250	5.2410E-06	6.1608E+10	3.6100E+08	1.0777E+06	165.250	1.00602
16	85.00	188.886	162.560	162.560	4.3947E-06	5.2136E+10	2.7764E+08	7.5282E+05	162.560	1.00546
17	86.00	188.606	160.820	160.820	3.6850E-06	4.3675E+10	2.1826E+08	5.5514E+05	160.820	1.00512
18	87.00	188.326	159.330	159.330	3.0852E-06	3.6587E+10	1.7296E+08	4.1601E+05	159.330	1.00484
19	88.00	188.046	158.100	158.100	2.5831E-06	3.0650E+10	1.3829E+08	3.1737E+05	158.100	1.00462
20	89.00	187.766	157.120	157.120	2.1634E-06	2.5676E+10	1.1156E+08	2.4651E+05	157.120	1.00445
21	90.00	187.538	156.410	156.410	1.8119E-06	2.1199E+10	8.9596E+07	1.9256E+05	156.410	1.00433
22	91.00	187.838	156.050	156.050	1.5181E-06	1.7584E+10	7.3277E+07	1.5527E+05	156.050	1.00427
23	92.00	188.138	155.920	155.920	1.2719E-06	1.4585E+10	6.0469E+07	1.2748E+05	155.920	1.00424
24	93.00	188.438	156.010	156.010	1.0662E-06	1.2098E+10	5.0336E+07	1.0649E+05	156.010	1.00426
25	94.00	188.738	156.290	156.290	8.9375E-07	1.0034E+10	4.2209E+07	9.0289E+04	156.290	1.00431
26	95.00	189.250	156.810	156.810	7.4997E-07	8.1052E+09	3.4794E+07	7.5961E+04	156.810	1.00440
27	96.00	190.250	157.280	157.280	6.2932E-07	6.6304E+09	2.9021E+07	6.4529E+04	157.280	1.00448
28	97.00	191.250	157.850	157.850	5.2900E-07	5.4370E+09	2.4297E+07	5.5228E+04	157.850	1.00458
29	98.00	192.250	158.500	158.500	4.4468E-07	4.4531E+09	2.0400E+07	4.7543E+04	158.500	1.00469
30	99.00	193.250	159.230	159.230	3.7482E-07	3.6472E+09	1.7177E+07	4.1158E+04	159.230	1.00483
31	100.00	195.600	160.510	160.510	3.1593E-07	2.7949E+09	1.3808E+07	3.4717E+04	160.510	1.00506
32	101.00	198.800	161.910	161.910	2.6863E-07	2.2142E+09	1.1517E+07	3.0495E+04	161.910	1.00533
33	102.00	202.000	163.340	163.340	2.2841E-07	1.7542E+09	9.6075E+06	2.6796E+04	163.340	1.00562
34	103.00	205.200	164.820	164.820	1.9508E-07	1.3898E+09	8.0219E+06	2.3587E+04	164.820	1.00593
35	104.00	208.400	166.330	166.330	1.6661E-07	1.1010E+09	6.6980E+06	2.0765E+04	166.330	1.00625
36	105.00	213.470	168.370	168.370	1.4310E-07	8.6644E+08	5.6504E+06	1.8787E+04	168.370	1.00670
37	106.00	220.410	170.850	170.850	1.2291E-07	6.7728E+08	4.7952E+06	1.7320E+04	170.850	1.00729
38	107.00	227.350	173.260	173.260	1.0632E-07	5.2941E+08	4.0507E+06	1.5822E+04	173.260	1.00788
39	108.00	234.290	175.580	175.580	9.1970E-08	4.1383E+08	3.4049E+06	1.4310E+04	175.580	1.00848
40	109.00	241.230	177.830	177.830	8.0301E-08	3.2348E+08	2.8505E+06	1.2839E+04	177.830	1.00910
41	110.00	250.140	180.740	180.740	7.0113E-08	2.5474E+08	2.4466E+06	1.2021E+04	180.740	1.00993
42	111.00	261.020	184.250	184.250	6.1997E-08	2.0211E+08	2.1456E+06	1.1666E+04	184.250	1.01100
43	112.00	271.900	187.580	187.580	5.4821E-08	1.6035E+08	1.8653E+06	1.1126E+04	187.580	1.01207
44	113.00	282.780	190.720	190.720	4.9053E-08	1.2722E+08	1.6084E+06	1.0437E+04	190.720	1.01314
45	114.00	293.660	193.650	193.650	4.3892E-08	1.0093E+08	1.3756E+06	9.6333E+03	193.650	1.01419
46	115.00	305.150	196.870	196.870	3.9661E-08	8.1713E+07	1.2063E+06	9.1620E+03	196.870	1.01541
47	116.00	317.250	200.370	200.370	3.5817E-08	6.7508E+07	1.0837E+06	8.9637E+03	200.370	1.01679

48	117.00	329.350	203.700	203.700	3.2652E-08	5.5772E+07	9.6698E+05	8.6501E+03	203.700	1.01818
49	118.00	341.450	206.860	206.860	2.9750E-08	4.6077E+07	8.5738E+05	8.2427E+03	206.860	1.01956
50	119.00	353.550	209.850	209.850	2.7299E-08	3.8067E+07	7.5576E+05	7.7628E+03	209.850	1.02092
51	120.00	365.860	212.380	212.380	2.5050E-08	3.1889E+07	6.6780E+05	7.2438E+03	212.380	1.02211
52	121.00	378.380	214.400	214.400	2.3127E-08	2.7087E+07	5.9135E+05	6.6939E+03	214.400	1.02309
53	122.00	390.900	216.210	216.210	2.1352E-08	2.3008E+07	5.2104E+05	6.1234E+03	216.210	1.02399
54	123.00	403.420	217.820	217.820	1.9816E-08	1.9544E+07	4.5700E+05	5.5501E+03	217.820	1.02480
55	124.00	415.940	219.240	219.240	1.8391E-08	1.6601E+07	3.9914E+05	4.9879E+03	219.240	1.02553
56	125.00	428.520	220.580	220.580	1.7145E-08	1.4264E+07	3.5196E+05	4.5170E+03	220.580	1.02624
57	126.00	441.160	221.850	221.850	1.5983E-08	1.2398E+07	3.1343E+05	4.1241E+03	221.850	1.02691
58	127.00	453.800	222.950	222.950	1.4957E-08	1.0776E+07	2.7814E+05	3.7388E+03	222.950	1.02750
59	128.00	466.440	223.910	223.910	1.3997E-08	9.3665E+06	2.4614E+05	3.3704E+03	223.910	1.02803
60	129.00	479.080	224.730	224.730	1.3143E-08	8.1412E+06	2.1722E+05	3.0213E+03	224.730	1.02848
61	130.00	491.510	225.530	225.530	1.2341E-08	7.1419E+06	1.9338E+05	2.7309E+03	225.530	1.02892
62	131.00	503.730	226.350	226.350	1.1623E-08	6.3235E+06	1.7381E+05	2.4926E+03	226.350	1.02938
63	132.00	515.950	227.050	227.050	1.0947E-08	5.5988E+06	1.5586E+05	2.2646E+03	227.050	1.02978
64	133.00	528.170	227.660	227.660	1.0337E-08	4.9572E+06	1.3952E+05	2.0503E+03	227.660	1.03012
65	134.00	540.390	228.180	228.180	9.7614E-09	4.3891E+06	1.2469E+05	1.8501E+03	228.180	1.03042
66	135.00	552.230	228.640	228.640	9.2397E-09	3.9134E+06	1.1209E+05	1.6773E+03	228.640	1.03069
67	136.00	563.690	229.070	229.070	8.7459E-09	3.5137E+06	1.0141E+05	1.5296E+03	229.070	1.03093
68	137.00	575.150	229.430	229.430	8.2962E-09	3.1549E+06	9.1641E+04	1.3913E+03	229.430	1.03114
69	138.00	586.610	229.720	229.720	7.8696E-09	2.8327E+06	8.2704E+04	1.2623E+03	229.720	1.03131
70	139.00	598.070	229.960	229.960	7.4795E-09	2.5434E+06	7.4572E+04	1.1431E+03	229.960	1.03145
71	140.00	609.030	230.140	230.140	7.1087E-09	2.2969E+06	6.7558E+04	1.0390E+03	230.140	1.03156
72	141.00	619.490	230.270	230.270	6.7682E-09	2.0863E+06	6.1504E+04	9.4812E+02	230.270	1.03163
73	142.00	629.950	230.370	230.370	6.4440E-09	1.8950E+06	5.5963E+04	8.6426E+02	230.370	1.03169
74	143.00	640.410	230.420	230.420	6.1453E-09	1.7212E+06	5.0875E+04	7.8540E+02	230.420	1.03172
75	144.00	650.870	230.440	230.440	5.8604E-09	1.5634E+06	4.6227E+04	7.1481E+02	230.440	1.03173
76	145.00	660.810	230.430	230.430	5.5970E-09	1.4268E+06	4.2180E+04	6.5212E+02	230.430	1.03173
77	146.00	670.230	230.380	230.380	5.3454E-09	1.3083E+06	3.8543E+04	5.9690E+02	230.380	1.03170
78	147.00	679.650	230.320	230.320	5.1121E-09	1.1997E+06	3.5398E+04	5.4618E+02	230.320	1.03166
79	148.00	689.070	230.230	230.230	4.8890E-09	1.1001E+06	3.2408E+04	4.9923E+02	230.230	1.03161
80	149.00	698.490	230.120	230.120	4.6815E-09	1.0088E+06	2.9661E+04	4.5600E+02	230.120	1.03155
81	150.00	707.380	229.980	229.980	4.4828E-09	9.2646E+05	2.7173E+04	4.1669E+02	229.980	1.03146

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TAPE1

CO2OO1O CO2 ALL 02201 01101 08/15/85 15UM NU2 HOT BAND

AFGL LINE FILE FOR SELECTED TRANSITION: CO2 626 02201 01101

BR	LINE	FREQUENCY (CM-1)	STRENGTH	WIDTH (CM-1)	LS ENERGY (CM-1)
P	92	599.4869	.420E-26	.050	4005.0010
P	90	600.8886	.822E-26	.051	3862.6350
P	88	602.2940	.159E-25	.052	3723.3450
P	86	603.7029	.301E-25	.052	3587.1350
P	84	605.1155	.562E-25	.053	3454.0050
P	91	605.2620	.609E-26	.051	3928.3320
P	89	606.4494	.118E-25	.051	3787.7230
P	82	606.5318	.104E-24	.053	3323.9590
P	87	607.6449	.226E-25	.052	3650.1860
P	80	607.9517	.188E-24	.054	3196.9990
P	85	608.8485	.425E-25	.053	3515.7250
P	78	609.3752	.334E-24	.055	3073.1270
P	83	610.0604	.787E-25	.053	3384.3420
P	76	610.8025	.587E-24	.055	2952.3440
P	81	611.2804	.143E-24	.054	3256.0380
P	74	612.2334	.101E-23	.056	2834.6530
P	79	612.5088	.258E-24	.054	3130.8180
P	72	613.6680	.173E-23	.056	2720.0580
P	77	613.7451	.455E-24	.055	3008.6790
P	75	614.9898	.792E-24	.056	2889.6280
P	70	615.1064	.289E-23	.057	2608.5550
P	73	616.2429	.136E-23	.056	2773.6650
P	68	616.5484	.476E-23	.058	2500.1520
P	71	617.5043	.228E-23	.057	2660.7920
P	66	617.9941	.772E-23	.058	2394.8470
P	69	618.7740	.379E-23	.057	2551.0100
P	64	619.4435	.123E-22	.059	2292.6440
P	67	620.0521	.619E-23	.058	2444.3230
P	62	620.8966	.193E-22	.059	2193.5440
P	65	621.3386	.994E-23	.059	2340.7310
P	60	622.3535	.299E-22	.060	2097.5490
P	63	622.6335	.157E-22	.059	2240.2370
P	58	623.8140	.454E-22	.061	2004.6590
P	61	623.9367	.245E-22	.060	2142.8410
P	59	625.2485	.374E-22	.060	2048.5460
P	56	625.2783	.679E-22	.061	1914.8780
P	57	626.5686	.564E-22	.061	1957.3530
P	54	626.7462	.998E-22	.062	1828.2050
P	55	627.8972	.835E-22	.062	1869.2640
P	52	628.2179	.144E-21	.062	1744.6440
P	53	629.2343	.122E-21	.062	1784.2800
P	50	629.6932	.205E-21	.063	1664.1940
P	51	630.5798	.174E-21	.063	1702.4020
P	48	631.1723	.287E-21	.064	1586.8570
P	49	631.9338	.246E-21	.063	1623.6330
P	46	632.6550	.394E-21	.064	1512.6360
P	47	633.2963	.340E-21	.064	1547.9720
P	44	634.1414	.533E-21	.065	1441.5300
P	45	634.6673	.463E-21	.065	1475.4220
P	42	635.6315	.707E-21	.065	1373.5410
P	41	636.0468	.620E-21	.065	1405.9840

P	40	637.1253	.922E-21	.066	1308.6710
P	41	637.4347	.815E-21	.066	1339.6580
P	38	638.6227	.118E-20	.067	1246.9200
P	39	638.8312	.105E-20	.066	1276.4470
P	36	640.1238	.149E-20	.067	1188.2890
P	37	640.2362	.134E-20	.067	1216.3500
P	34	641.6285	.183E-20	.068	1132.7800
P	35	641.6496	.166E-20	.068	1159.3700
P	33	643.0716	.203E-20	.068	1105.5060
P	32	643.1369	.222E-20	.068	1080.3930
P	31	644.5020	.243E-20	.069	1054.7600
P	30	644.6488	.263E-20	.069	1031.1290
P	29	645.9409	.286E-20	.069	1007.1330
P	28	646.1644	.306E-20	.070	984.9890
P	27	647.3883	.328E-20	.070	962.6250
P	26	647.6836	.348E-20	.070	941.9730
P	25	648.8442	.369E-20	.071	921.2380
P	24	649.2063	.387E-20	.071	902.0830
P	23	650.3085	.405E-20	.071	882.9710
P	22	650.7326	.420E-20	.071	865.3200
P	21	651.7812	.434E-20	.072	847.8260
P	20	652.2624	.444E-20	.072	831.6830
P	19	653.2624	.453E-20	.072	815.8030
P	18	653.7958	.457E-20	.073	801.1730
P	17	654.7521	.458E-20	.073	786.9030
P	16	655.3327	.454E-20	.073	773.7910
P	15	656.2501	.447E-20	.074	761.1250
P	14	656.8730	.435E-20	.074	749.5370
P	13	657.7565	.419E-20	.074	738.4720
P	12	658.4169	.398E-20	.074	728.4120
P	11	659.2713	.372E-20	.075	718.9420
P	10	659.9641	.342E-20	.075	710.4160
P	9	660.7945	.307E-20	.075	702.5360
P	8	661.5149	.269E-20	.076	695.5500
P	7	662.3260	.226E-20	.076	689.2550
P	6	663.0690	.181E-20	.076	683.8120
P	5	663.8658	.134E-20	.077	679.0990
P	4	664.6265	.852E-21	.077	675.2050
P	3	665.4139	.385E-21	.077	672.0680
Q	2	667.7540	.195E-20	.077	669.7280
Q	4	667.7598	.462E-20	.077	675.2050
Q	3	667.7638	.338E-20	.077	672.0680
Q	6	667.7689	.678E-20	.076	683.8120
Q	8	667.7812	.855E-20	.075	695.5500
Q	5	667.7824	.575E-20	.076	679.0990
Q	10	667.7969	.992E-20	.075	710.4160
Q	7	667.8091	.771E-20	.076	689.2550
Q	12	667.8159	.109E-19	.074	728.4120
Q	14	667.8382	.114E-19	.074	749.5370
Q	9	667.8441	.929E-20	.075	702.5360
Q	16	667.8637	.116E-19	.073	773.7910
Q	11	667.8873	.105E-19	.075	718.9420
Q	18	667.8926	.114E-19	.072	801.1730
Q	20	667.9246	.109E-19	.072	831.6830
Q	13	667.9387	.112E-19	.074	738.4720
Q	22	667.9600	.102E-19	.071	865.3200
Q	15	667.9983	.116E-19	.073	761.1250
Q	24	667.9985	.926E-20	.071	902.0830
Q	25	668.0404	.825E-20	.070	941.9730
Q	17	668.0661	.115E-19	.073	786.9030
Q	28	668.0854	.721E-20	.069	984.9890
Q	30	668.1336	.616E-20	.069	1031.1290
Q	19	668.1421	.112E-19	.072	815.8030

Q	32	668.1850	.517E-20	.068	1080.3930
Q	21	668.2262	.106E-19	.072	847.8260
Q	34	668.2398	.426E-20	.068	1132.7800
Q	36	668.2974	.344E-20	.067	1188.2890
Q	23	668.3185	.975E-20	.071	882.9710
Q	38	668.3583	.273E-20	.066	1246.9200
Q	25	668.4190	.879E-20	.070	921.2380
Q	40	668.4223	.213E-20	.066	1308.8710
Q	42	668.4894	.163E-20	.065	1373.5410
Q	27	668.5276	.776E-20	.070	962.6250
Q	44	668.5596	.123E-20	.065	1441.5300
Q	46	668.6328	.907E-21	.064	1512.6360
Q	29	668.6444	.670E-20	.069	1007.1330
Q	48	668.7091	.659E-21	.063	1586.8570
Q	31	668.7692	.568E-20	.069	1054.7600
Q	50	668.7884	.472E-21	.063	1664.1940
Q	52	668.8708	.332E-21	.062	1744.8440
Q	33	668.9022	.472E-20	.068	1105.5080
Q	54	668.9558	.229E-21	.062	1828.2050
Q	35	669.0432	.386E-20	.067	1159.3700
Q	56	669.0440	.158E-21	.061	1914.8780
Q	58	669.1350	.105E-21	.060	2004.8590
Q	37	669.1922	.309E-20	.067	1216.3500
Q	60	669.2290	.688E-22	.060	2097.5490
R	1	669.3202	.355E-20	.077	668.1610
Q	62	669.3257	.446E-22	.059	2193.5440
Q	39	669.3493	.243E-20	.066	1276.4470
Q	64	669.4253	.284E-22	.059	2292.6440
Q	41	669.5144	.188E-20	.066	1339.6580
Q	66	669.5277	.178E-22	.058	2394.8470
Q	68	669.6328	.110E-22	.057	2500.1520
Q	43	669.6875	.143E-20	.065	1405.9840
Q	70	669.7406	.670E-23	.057	2608.5550
Q	72	669.8511	.401E-23	.056	2720.0560
Q	45	669.8685	.107E-20	.064	1475.4220
Q	74	669.9643	.236E-23	.056	2834.6530
Q	47	670.0575	.782E-21	.064	1547.9720
Q	76	670.0800	.137E-23	.055	2952.3440
R	2	670.1040	.332E-20	.077	669.7280
Q	78	670.1983	.780E-24	.054	3073.1270
Q	49	670.2543	.564E-21	.063	1623.6130
Q	80	670.3192	.438E-24	.054	3196.9290
Q	82	670.4425	.242E-24	.053	3323.3530
Q	51	670.4591	.401E-21	.063	1702.4020
Q	84	670.5683	.132E-24	.053	3454.0050
Q	53	670.6717	.280E-21	.062	1784.2800
Q	86	670.6965	.707E-25	.052	3587.1150
Q	88	670.8270	.373E-25	.051	3723.3450
Q	55	670.8921	.192E-21	.061	1868.2640
R	3	670.8971	.437E-20	.077	672.0680
Q	90	670.9599	.194E-25	.051	3862.6350
Q	92	671.0950	.993E-26	.050	4005.0010
Q	57	671.1203	.130E-21	.061	1957.3530
Q	94	671.2323	.500E-26	.050	4150.4410
Q	59	671.3563	.862E-22	.060	2048.5460
Q	61	671.5999	.563E-22	.060	2142.8410
R	4	671.6764	.483E-20	.077	675.2050
Q	63	671.8513	.363E-22	.059	2240.2370
Q	65	672.1103	.230E-22	.058	2340.3310
Q	67	672.3769	.141E-22	.058	2444.3230
R	5	672.4823	.527E-20	.076	679.0390
Q	69	672.6512	.877E-23	.057	2551.0100
Q	71	672.9379	.530E-23	.057	2660.7920

Q	73	673.2221	.315E-23	.056	2773.6650
R	6	673.2520	.568E-20	.076	683.8120
Q	75	673.5188	.184E-23	.055	2889.6280
Q	77	673.8229	.106E-23	.055	3008.6790
R	7	674.0755	.606E-20	.076	689.2550
Q	79	674.1344	.601E-24	.054	3130.8160
Q	81	674.4531	.335E-24	.054	3256.0380
Q	83	674.7792	.184E-24	.053	3384.3420
R	8	674.8309	.640E-20	.075	695.5500
Q	85	675.1125	.996E-25	.052	3515.7250
Q	87	675.4530	.531E-25	.052	3650.1860
R	9	675.6769	.669E-20	.075	702.5360
Q	89	675.8005	.278E-25	.051	3787.7230
Q	91	676.1552	.144E-25	.051	3928.3320
R	10	676.4129	.692E-20	.075	710.4160
Q	93	676.5169	.731E-26	.050	4072.0130
R	11	677.2863	.711E-20	.074	718.9420
R	12	677.9981	.724E-20	.074	728.4120
R	13	678.9038	.733E-20	.074	738.4720
R	14	679.5864	.736E-20	.074	749.5370
R	15	680.5293	.735E-20	.073	761.1250
R	16	681.1777	.727E-20	.073	773.7910
R	17	682.1628	.717E-20	.073	786.9030
R	18	682.7722	.702E-20	.072	801.1730
R	19	683.8043	.684E-20	.072	815.8030
R	20	684.3696	.661E-20	.072	831.6830
R	21	685.4536	.638E-20	.071	847.8260
R	22	685.9700	.609E-20	.071	865.3200
R	23	687.1108	.582E-20	.071	882.9710
R	24	687.5734	.550E-20	.071	902.0830
R	25	688.7758	.520E-20	.070	921.2380
R	26	689.1797	.486E-20	.070	941.9730
R	27	690.4486	.456E-20	.070	962.6250
R	28	690.7889	.422E-20	.069	984.9890
R	29	692.1292	.392E-20	.069	1007.1330
R	30	692.4009	.359E-20	.069	1031.1290
R	31	693.8174	.330E-20	.068	1054.7800
R	32	694.0156	.300E-20	.068	1080.3930
R	33	695.5133	.274E-20	.068	1105.5060
R	34	695.6332	.246E-20	.068	1132.7800
R	35	697.2167	.222E-20	.067	1159.3700
R	36	697.2535	.198E-20	.067	1188.2890
R	38	698.8764	.157E-20	.066	1246.9200
R	37	698.9278	.178E-20	.067	1216.3500
R	40	700.5019	.122E-20	.066	1308.6710
R	39	700.6463	.140E-20	.066	1276.4470
R	42	702.1301	.933E-21	.065	1373.5410
R	41	702.3722	.108E-20	.065	1339.6580
R	44	703.7608	.702E-21	.065	1441.5300
R	43	704.1056	.817E-21	.065	1405.9840
R	46	705.3940	.519E-21	.064	1512.6360
R	45	705.8463	.609E-21	.064	1475.4220
R	48	707.0296	.377E-21	.063	1586.8570
R	47	707.5943	.447E-21	.064	1547.9720
R	50	708.6676	.269E-21	.063	1664.1940
R	49	709.3495	.322E-21	.063	1623.6330
R	52	710.3080	.190E-21	.062	1744.6440
R	51	711.1118	.229E-21	.062	1702.4020
R	54	711.9507	.131E-21	.062	1828.2050
R	53	712.8813	.160E-21	.062	1784.2800
R	56	713.5957	.892E-22	.061	1914.8780
R	55	714.6578	.110E-21	.061	1869.2640
R	58	715.2429	.597E-22	.060	2004.6590

R	57	716.4413	.741E-22	.081	1957.3530
R	60	716.8922	.394E-22	.060	2097.5490
R	59	718.2318	.493E-22	.060	2048.5460
R	62	718.5436	.255E-22	.059	2193.5440
R	61	720.0291	.322E-22	.059	2142.8410
R	64	720.1971	.163E-22	.059	2292.6440
R	63	721.8331	.207E-22	.059	2240.2370
R	66	721.8525	.102E-22	.058	2394.8470
R	68	723.5099	.632E-23	.057	2500.1520
R	65	723.6439	.131E-22	.058	2340.7310
R	70	725.1892	.384E-23	.057	2608.5550
R	67	725.4814	.820E-23	.058	2444.3230
R	72	726.8304	.230E-23	.056	2720.0560
R	69	727.2854	.503E-23	.057	2551.0100
R	74	728.4933	.136E-23	.056	2834.6530
R	71	729.1160	.304E-23	.056	2660.7920
R	76	730.1579	.787E-24	.055	2952.3440
R	73	730.9530	.181E-23	.058	2773.6650
R	78	731.8241	.450E-24	.054	3073.1270
R	75	732.7964	.106E-23	.055	2889.6280
R	80	733.4920	.253E-24	.054	3196.9990
R	77	734.6460	.610E-24	.055	3008.6790
R	82	735.1614	.140E-24	.053	3323.9590
R	79	736.5019	.346E-24	.054	3130.8160
R	84	736.8322	.764E-25	.053	3454.0050
R	81	738.3639	.194E-24	.053	3256.0380
R	86	738.5045	.410E-25	.052	3587.1350
R	88	740.1781	.217E-25	.051	3723.3450
R	83	740.2320	.106E-24	.053	3384.3420
R	90	741.8530	.113E-25	.051	3862.6350
R	85	742.1060	.577E-25	.052	3515.7250
R	92	743.5291	.578E-26	.050	4005.0010
R	87	743.9860	.308E-25	.052	3650.1860
R	89	745.8718	.162E-25	.051	3787.7230
R	91	747.7633	.835E-26	.050	3928.3320
R	93	749.6604	.425E-26	.050	4072.0130

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UNIT 7 HEADER:

XXXXXXX BAND RADIANCE ---NLTE OUTPUT
CO2 626 01101 00001 A --- 85/09/04. 08.53.33.
CO2 636 01101 00001 A --- 85/09/04. 08.55.01.
CO2 628 01101 00001 A --- 85/09/04. 08.55.53.

SUBROUTINE SPECTRM RECOGNIZES FILE WITH PREVIOUSLY-CALCULATED BAND RADIANCES; WILL ADD TO THIS DATA-BASE

LMAX = 88. RANGE = 13.050 TO 17.400 UM
LMAX = 88. RANGE = 13.050 TO 17.400 UM

TMIN - TEMPERATURE USED FOR STDW = 188
STD DOPP WIDTH = STDW (CM-1) = .49441E-03
2 PT GAUSS QUADRATURE USED FOR NU-INTEG

EXEC TIME FOR INITIALIZATION = 3.19 SEC; 276 LINES

GROUP # 1 WITH 5 VIEWING PATHS

PATH # 1. TANGENT HT = 70.00 KM. USE LAYERS 1 THRU 80 (ALTITUDES 70.00 THRU 149.00 KM) 80 LAYERS
PATH # 2. TANGENT HT = 75.00 KM. USE LAYERS 6 THRU 80 (ALTITUDES 75.00 THRU 149.00 KM) 75 LAYERS
PATH # 3. TANGENT HT = 80.00 KM. USE LAYERS 11 THRU 80 (ALTITUDES 80.00 THRU 149.00 KM) 70 LAYERS
PATH # 4. TANGENT HT = 85.00 KM. USE LAYERS 16 THRU 80 (ALTITUDES 85.00 THRU 149.00 KM) 65 LAYERS
PATH # 5. TANGENT HT = 90.00 KM. USE LAYERS 21 THRU 80 (ALTITUDES 90.00 THRU 149.00 KM) 60 LAYERS

INTEGRATED RADIANCE (WATT/(CM2*STR) FOR VARIOUS LINE-OF-SIGHT PATHS

LINE		70.00 KM (THIN)	70.00 KM (THICK)	75.00 KM (THIN)	75.00 KM (THICK)	80.00 KM (THIN)	80.00 KM (THICK)	85.00 KM (THIN)	85.00 KM (THICK)	90.00 KM (THIN)	90.00 KM (THICK)
P	92	1.5309E-15		1.2326E-15		1.2592E-15		1.3181E-15		1.3838E-15	
P	90	2.5625E-15		1.7669E-15		1.7748E-15		1.8539E-15		1.9501E-15	
P	88	4.5745E-15		2.5571E-15		2.4933E-15		2.6002E-15		2.7363E-15	
P	86	8.7017E-15		3.7681E-15		3.4938E-15		3.6315E-15		3.8230E-15	
P	84	1.7436E-14		5.7186E-15		4.8902E-15		5.0508E-15		5.3180E-15	
P	91	2.0328E-15		1.5250E-15		1.5467E-15		1.6163E-15		1.6998E-15	
P	89	3.5066E-15		2.1913E-15		2.1731E-15		2.2684E-15		2.3867E-15	
P	82	3.6200E-14		9.0593E-15		6.8587E-15		7.0028E-15		7.3719E-15	
P	87	6.4572E-15		3.1912E-15		3.0438E-15		3.1699E-15		3.3365E-15	
P	80	7.6513E-14		1.5127E-14		9.6700E-15		9.6789E-15		1.0178E-14	
P	85	1.2616E-14		4.7591E-15		4.2567E-15		4.4127E-15		4.6459E-15	
P	78	1.6243E-13		2.6714E-14		1.3784E-14		1.3340E-14		1.4001E-14	
P	83	2.5749E-14		7.3561E-15		5.9524E-15		6.1176E-15		6.4410E-15	
P	76	3.4322E-13		4.9641E-14		2.0030E-14		1.8378E-14		1.9210E-14	
P	81	5.3954E-14		1.1933E-14		8.3514E-15		8.4530E-15		8.8956E-15	
P	74	7.1708E-13		9.5788E-14		2.9929E-14		2.5341E-14		2.6292E-14	
P	79	1.1435E-13		2.0476E-14		1.1819E-14		1.1655E-14		1.2248E-14	
P	72	1.4764E-12		1.8917E-13		4.6424E-14		3.5098E-14		3.5953E-14	
P	77	2.4213E-13		3.7093E-14		1.6971E-14		1.6038E-14		1.6805E-14	
P	75	5.0846E-13		7.0287E-14		2.4948E-14		2.2073E-14		2.2999E-14	
P	70	2.9867E-12		3.7697E-13		7.5145E-14		4.8989E-14		4.9167E-14	
P	73	1.0534E-12		1.3727E-13		3.7890E-14		3.0447E-14		3.1415E-14	
P	68	5.9290E-12		7.5019E-13		1.2697E-13		6.9286E-14		6.7380E-14	
P	71	2.1478E-12		2.7240E-13		5.9942E-14		4.2259E-14		4.2899E-14	
P	66	1.1537E-11		1.4796E-12		2.2255E-13		9.9843E-14		9.2750E-14	
P	69	4.3008E-12		5.4255E-13		9.9076E-14		5.9279E-14		5.8656E-14	
P	64	2.1994E-11		2.8772E-12		4.0039E-13		1.4736E-13		1.2859E-13	
P	67	8.4471E-12		1.0743E-12		1.7046E-13		8.4452E-14		8.0428E-14	
P	62	4.1040E-11		5.5022E-12		7.3136E-13		2.2380E-13		1.8028E-13	
P	65	1.6242E-11		2.1028E-12		3.0285E-13		1.2297E-13		1.1096E-13	
P	60	7.4989E-11		1.0321E-11		1.3412E-12		3.4982E-13		2.5625E-13	
P	63	3.0609E-11		4.0530E-12		5.4934E-13		1.8389E-13		1.5450E-13	
P	58	1.3410E-10	1.3172E-10	1.8986E-11		2.4490E-12		5.6126E-13		3.7077E-13	
P	61	5.6456E-11		7.6676E-12		1.0053E-12		2.8299E-13		2.1773E-13	
P	59	1.0197E-10		1.4225E-11		1.8397E-12		4.4807E-13		3.1169E-13	
P	56	2.3468E-10	2.2851E-10	3.4116E-11		4.4247E-12		9.1894E-13		5.4445E-13	
P	57	1.8023E-10	1.7632E-10	2.5842E-11		3.3407E-12		7.2817E-13		4.5391E-13	
P	54	4.0176E-10	3.8550E-10	6.0019E-11		7.8734E-12		1.5231E-12		8.1379E-13	
P	55	3.1165E-10	3.0141E-10	4.5929E-11		5.9868E-12		1.1962E-12		6.7240E-13	
P	52	6.7284E-10	6.3053E-10	1.0325E-10	1.0092E-10	1.3759E-11		2.5360E-12		1.2333E-12	
P	53	5.2741E-10	5.0052E-10	7.9858E-11	7.8256E-11	1.0554E-11		1.9880E-12		1.0119E-12	
P	50	1.1019E-09	9.9675E-10	1.7355E-10	1.6801E-10	2.3558E-11		4.2097E-12		1.8864E-12	
P	51	8.7230E-10	8.0473E-10	1.3562E-10	1.3191E-10	1.8236E-11		3.3034E-12		1.5396E-12	
P	48	1.7645E-09	1.5095E-09	2.8504E-10	2.7196E-10	3.9465E-11		6.9264E-12		2.8973E-12	
P	49	1.4117E-09	1.2437E-09	2.2520E-10	2.1654E-10	3.0869E-11		5.4592E-12		2.3597E-12	
P	46	2.7629E-09	2.1795E-09	4.5735E-10	4.2651E-10	6.4633E-11	6.2837E-11	1.1245E-11		4.4452E-12	
P	47	2.2135E-09	1.8383E-09	3.6527E-10	3.4481E-10	5.1092E-11	4.9798E-11	8.9192E-12		3.6217E-12	
P	44	[illegible]	2.9794E-09	7.1615E-10	6.4555E-10	1.0334E-10	9.9619E-11	1.7940E-11		6.7753E-12	
P	45	3.4552E-09	2.5815E-09	5.7076E-10	5.3107E-10	8.2630E-11	8.0014E-11	1.4352E-11		5.5385E-12	

P	42	6.3221E-09	3.8385E-09	1.0957E-09	9.4058E-10	1.8132E-10	1.5358E-10	2.8069E-11		1.0220E-11	
P	43	5.2228E-09	3.4229E-09	8.9513E-10	7.8862E-10	1.3046E-10	1.2506E-10	2.2663E-11		8.3952E-12	
P	40	9.2358E-09	4.6560E-09	1.6354E-09	1.3108E-09	2.4562E-10	2.2967E-10	4.2965E-11	4.1729E-11	1.5197E-11	
P	41	7.7148E-09	4.2720E-09	1.3516E-09	1.1227E-09	2.0101E-10	1.8976E-10	3.5057E-11	3.4173E-11	1.2560E-11	
P	38	1.3177E-08	5.3384E-09	2.3814E-09	1.7427E-09	3.6461E-10	3.3212E-10	6.4248E-11	6.1996E-11	2.2183E-11	
P	39	1.1135E-08	5.0256E-09	1.9921E-09	1.5278E-09	3.0212E-10	2.7900E-10	5.3031E-11	5.1350E-11	1.8522E-11	
P	36	1.8356E-08	5.8481E-09	3.3823E-09	2.2055E-09	5.2753E-10	4.6372E-10	9.3753E-11	8.9587E-11	3.1784E-11	3.0958E-11
P	37	1.5683E-08	5.6178E-09	2.8623E-09	1.9798E-09	4.4237E-10	3.9623E-10	7.8275E-11	7.5183E-11	2.6773E-11	
P	34	2.4961E-08	6.2016E-09	4.6845E-09	2.6578E-09	7.4368E-10	6.2410E-10	1.3339E-10	1.2573E-10	4.4545E-11	4.3181E-11
P	35	2.1571E-08	6.0509E-09	4.0119E-09	2.4414E-09	6.3135E-10	5.4265E-10	1.1272E-10	1.0701E-10	3.7911E-11	3.6842E-11
P	33	2.8946E-08	6.3275E-09	5.4803E-09	2.8693E-09	8.7740E-10	7.1564E-10	1.5813E-10	1.4776E-10	5.2468E-11	5.0704E-11
P	32	3.3089E-08	6.4355E-09	6.3183E-09	3.0565E-09	1.0199E-09	8.0754E-10	1.8470E-10	1.7101E-10	6.0931E-11	5.8780E-11
P	31	3.7886E-08	6.5177E-09	7.2940E-09	3.2306E-09	1.1870E-09	9.0771E-10	2.1597E-10	1.9777E-10	7.0877E-11	6.8098E-11
P	30	4.2776E-08	6.5819E-09	8.3015E-09	3.3793E-09	1.3614E-09	1.0050E-09	2.4891E-10	2.2533E-10	8.1300E-11	7.7779E-11
P	29	4.8317E-08	6.6408E-09	9.4494E-09	3.5101E-09	1.5614E-09	1.1073E-09	2.8682E-10	2.5623E-10	9.3284E-11	8.8797E-11
P	28	5.3858E-08	6.6830E-09	1.0612E-08	3.6201E-09	1.7663E-09	1.2037E-09	3.2597E-10	2.8728E-10	1.0581E-10	1.0001E-10
P	27	5.9983E-08	6.7127E-09	1.1904E-08	3.7118E-09	1.8954E-09	1.3012E-09	3.6994E-10	3.2139E-10	1.1943E-10	1.1261E-10
P	26	6.5980E-08	6.7431E-09	1.3185E-08	3.7886E-09	2.2252E-09	1.3904E-09	4.1438E-10	3.5453E-10	1.3335E-10	1.2499E-10
P	75	7.2466E-08	6.7598E-09	1.4578E-08	3.8501E-09	2.4764E-09	1.4780E-09	4.6318E-10	3.9000E-10	1.4862E-10	1.3839E-10
P	24	7.8596E-08	6.7704E-09	1.5912E-08	3.9015E-09	2.7202E-09	1.5551E-09	5.1092E-10	4.2324E-10	1.6351E-10	1.5150E-10
P	23	8.5019E-08	6.7791E-09	1.7318E-08	3.9400E-09	2.9784E-09	1.6283E-09	5.6173E-10	4.5770E-10	1.7933E-10	1.6501E-10
P	27	9.0875E-08	6.7801E-09	1.8620E-08	3.9730E-09	3.2208E-09	1.6907E-09	6.0985E-10	4.8887E-10	1.9427E-10	1.7785E-10
P	21	9.6762E-08	6.7834E-09	1.9937E-08	3.9960E-09	3.4677E-09	1.7476E-09	6.5911E-10	5.2003E-10	2.0954E-10	1.9052E-10
P	20	1.0179E-07	6.7777E-09	2.1085E-08	4.0157E-09	3.6867E-09	1.7940E-09	7.0331E-10	5.4717E-10	2.2318E-10	2.0198E-10
P	19	1.0655E-07	6.7717E-09	2.2182E-08	4.0269E-09	3.8979E-09	1.8344E-09	7.4620E-10	5.7214E-10	2.3639E-10	2.1294E-10
P	18	1.1019E-07	6.7652E-09	2.3051E-08	4.0371E-09	4.0698E-09	1.8652E-09	7.8171E-10	5.9270E-10	2.4727E-10	2.2159E-10
P	17	1.1315E-07	6.7552E-09	2.3777E-08	4.0419E-09	4.2169E-09	1.8891E-09	8.1252E-10	6.1003E-10	2.5666E-10	2.2925E-10
P	16	1.1478E-07	6.7459E-09	2.4222E-08	4.0434E-09	4.3140E-09	1.9040E-09	8.3374E-10	6.2129E-10	2.6302E-10	2.3411E-10
P	15	1.1542E-07	6.7368E-09	2.4454E-08	4.0409E-09	4.3725E-09	1.9118E-09	8.4743E-10	6.2869E-10	2.6704E-10	2.3738E-10
P	14	1.1446E-07	6.7243E-09	2.4342E-08	4.0344E-09	4.3685E-09	1.9098E-09	8.4889E-10	6.2945E-10	2.6722E-10	2.3759E-10
P	13	1.1225E-07	6.7087E-09	2.3955E-08	4.0231E-09	4.3139E-09	1.8992E-09	8.4034E-10	6.2468E-10	2.6428E-10	2.3496E-10
P	12	1.0832E-07	6.6925E-09	2.3189E-08	4.0069E-09	4.1891E-09	1.8771E-09	8.1789E-10	6.1225E-10	2.5700E-10	2.2919E-10
P	11	1.0295E-07	6.6806E-09	2.2104E-08	3.9844E-09	4.0047E-09	1.8432E-09	7.8353E-10	5.9237E-10	2.4602E-10	2.2038E-10
P	10	9.5858E-08	6.6576E-09	2.0836E-08	3.9557E-09	3.7487E-09	1.7933E-09	7.3484E-10	5.6425E-10	2.3057E-10	2.0783E-10
P	9	8.7253E-08	6.6331E-09	1.8829E-08	3.9111E-09	3.4285E-09	1.7243E-09	6.7323E-10	5.2732E-10	2.1112E-10	1.9152E-10
P	8	7.7107E-08	6.6026E-09	1.6675E-08	3.8506E-09	3.0427E-09	1.6301E-09	5.9839E-10	4.8036E-10	1.8755E-10	1.7176E-10
P	7	6.5614E-08	6.5519E-09	1.4216E-08	3.7569E-09	2.5988E-09	1.5027E-09	5.1177E-10	4.2250E-10	1.6033E-10	1.4846E-10
P	6	5.2885E-08	6.4699E-09	1.1476E-08	3.6034E-09	2.1013E-09	1.3305E-09	4.1428E-10	3.5358E-10	1.2974E-10	1.2164E-10
P	5	3.9297E-08	6.3326E-09	8.5390E-09	3.3332E-09	1.5655E-09	1.0996E-09	3.0895E-10	2.7356E-10	9.6720E-11	9.1918E-11
P	4	2.5184E-08	6.0151E-09	5.4782E-09	2.8131E-09	1.0054E-09	7.9340E-10	1.9857E-10	1.8290E-10	6.2149E-11	5.9830E-11
P	3	1.1425E-08	4.9514E-09	2.4872E-09	1.7751E-09	4.5684E-10	4.0694E-10	9.0276E-11	8.6414E-11	2.8250E-11	2.7583E-11
O	2	5.7924E-08	6.4702E-09	1.2610E-08	3.6585E-09	2.3162E-09	1.4048E-09	4.5770E-10	3.8446E-10	1.4323E-10	1.3354E-10
O	4	1.3572E-07	6.6276E-09	2.9490E-08	4.0264E-09	5.4067E-09	2.0251E-09	1.0670E-09	7.3575E-10	3.3403E-10	2.8862E-10
O	3	9.9799E-08	6.5987E-09	2.1709E-08	3.9354E-09	3.9843E-09	1.8251E-09	7.8688E-10	5.9260E-10	2.4628E-10	2.2029E-10
O	6	1.9585E-07	6.5833E-09	4.2433E-08	4.1022E-09	7.7571E-09	2.2104E-09	1.5276E-09	9.2155E-10	4.7856E-10	3.9178E-10
O	8	2.4176E-07	6.7086E-09	5.2171E-08	4.1298E-09	9.4995E-09	2.2897E-09	1.8653E-09	1.0279E-09	5.8495E-10	4.6028E-10
O	5	1.6760E-07	6.6398E-09	3.6370E-08	4.0708E-09	6.6592E-09	2.1386E-09	1.3129E-09	8.4187E-10	4.1114E-10	3.4482E-10
O	10	2.7309E-07	6.7390E-09	5.8636E-08	4.1447E-09	1.0623E-08	2.3276E-09	2.0785E-09	1.0853E-09	6.5251E-10	5.0182E-10
O	7	2.2066E-07	6.6991E-09	4.7719E-08	4.1190E-09	8.7073E-09	2.2575E-09	1.7124E-09	9.8269E-10	5.3670E-10	4.7992E-10
O	12	2.8392E-07	6.7570E-09	6.1869E-08	4.1533E-09	1.1142E-08	2.3433E-09	2.1703E-09	1.1076E-09	6.8255E-10	5.1490E-10
O	14	2.9312E-07	6.7747E-09	6.2104E-08	4.1597E-09	1.1105E-08	2.3436E-09	2.1521E-09	1.1539E-09	6.7817E-10	5.1688E-10
O	9	2.5934E-07	6.7244E-09	5.5832E-08	4.1383E-09	1.0142E-08	2.3122E-09	1.9881E-09	1.0614E-09	6.2381E-10	4.8390E-10
O	16	2.8418E-07	6.7796E-09	5.9716E-08	4.1635E-09	1.0591E-08	2.3305E-09	2.0407E-09	1.0760E-09	6.4459E-10	4.9767E-10
O	11	2.8351E-07	6.7523E-09	6.0694E-08	4.1496E-09	1.0965E-08	2.3378E-09	2.1407E-09	1.1005E-09	6.7267E-10	5.1326E-10
O	18	2.6597E-07	6.7804E-09	5.5372E-08	4.1641E-09	9.7302E-09	2.3040E-09	1.8627E-09	1.0284E-09	5.9010E-10	4.6437E-10
O	20	2.4060E-07	6.7884E-09	4.9574E-08	4.1611E-09	8.6227E-09	2.2611E-09	1.6389E-09	9.6006E-10	5.2103E-10	4.2076E-10
O	13	2.9323E-07	6.7662E-09	6.2360E-08	4.1560E-09	1.1191E-08	2.3450E-09	2.1747E-09	1.1093E-09	6.8457E-10	5.2064E-10
O	22	2.1120E-07	6.7909E-09	4.3020E-08	4.1498E-09	7.3987E-09	2.1978E-09	1.3954E-09	8.7501E-10	4.4548E-10	3.7011E-10
O	15	2.9018E-07	6.7731E-09	6.1237E-08	4.1605E-09	1.0906E-08	2.3384E-09	2.1078E-09	1.0928E-09	6.6495E-10	5.0907E-10
O	24	1.8004E-07	6.7711E-09	3.6219E-08	4.1230E-09	6.1527E-09	2.1064E-09	1.1508E-09	7.7440E-10	3.6925E-10	3.1574E-10
O	26	1.4931E-07	6.7804E-09	2.9612E-08	4.0866E-09	4.9671E-09	1.9814E-09	9.2085E-10	6.6478E-10	2.9729E-10	2.8126E-10
O	17	2.7641E-07	6.7827E-09	5.7822E-08	4.1638E-09	1.0209E-08	2.3189E-09	1.9609E-09	1.0555E-09	6.2027E-10	4.8293E-10
O	28	1.2058E-07	6.7820E-09	2.3583E-08	4.0761E-09	3.8960E-09	1.8159E-09	7.1582E-10	5.5154E-10	2.3281E-10	2.0967E-10

Q	30	9.4899E-08	6.7718E-09	1.8271E-08	3.9288E-09	2.9732E-09	1.6093E-09	5.4098E-10	4.4188E-10	1.7754E 10	1.6351E-10
Q	19	2.5431E-07	6.7833E-09	5.2678E-08	4.1620E-09	9.2109E-09	2.2847E-09	1.7571E-09	9.9712E-10	5.5758E-10	4.4443E-10
Q	32	7.7825E-08	6.7270E-09	1.3788E-08	3.7709E-09	2.2074E-09	1.3694E-09	3.9783E-10	3.4092E-10	1.3200E-10	1.2382E-10
Q	21	2.2664E-07	6.7911E-09	4.6438E-08	4.1562E-09	8.0327E-09	2.2324E-09	1.5210E-09	9.1996E-10	4.8451E-10	3.9835E-10
Q	34	5.4536E-08	6.6407E-09	1.0143E-08	3.5333E-09	1.5962E-09	1.1140E-09	2.8497E-10	2.5402E-10	9.5847E-11	9.1056E-11
Q	36	3.9853E-08	6.4922E-09	7.2736E-09	3.1903E-09	1.1241E-09	8.6397E-10	1.9891E-10	1.8276E-10	6.8033E-11	6.5445E-11
Q	23	1.9607E-07	6.7939E-09	3.9696E-08	[illegible].1397E-09	6.7860E-09	2.1565E-09	1.2746E-09	8.2719E-10	4.0790E-10	3.4348E-10
Q	38	2.8449E-08	6.2580E-09	5.0898E-09	2.7407E-09	7.7192E-10	6.3967E-10	1.3550E-10	1.2727E-10	4.7323E-11	4.5881E-11
Q	25	1.6492E-07	6.7706E-09	3.2956E-08	4.1056E-09	5.5620E-09	2.0493E-09	1.0358E-09	7.2183E-10	3.3331E-10	2.8869E-10
Q	40	1.9836E-08	5.8846E-09	3.4753E-09	2.2221E-09	5.1687E-10	4.5301E-10	9.0137E-11	8.6105E-11	3.2315E-11	3.1507E-11
Q	42	1.3515E-08	5.3252E-09	2.3164E-09	1.6960E-09	3.3760E-10	3.0808E-10	5.8647E-11	5.6677E-11	2.1725E-11	
Q	27	1.3500E-07	6.7818E-09	2.6600E-08	4.0572E-09	4.4276E-09	1.9051E-09	8.1710E-10	6.0963E-10	2.6472E-10	2.3570E-10
Q	44	8.9988E-09	4.5598E-09	1.5073E-09	1.2210E-09	2.1522E-10	2.0194E-10	3.7378E-11	3.6346E-11	1.4424E-11	
Q	46	5.8549E-09	3.6454E-09	9.5752E-10	8.3339E-10	1.3393E-10	1.2805E-10	2.3381E-11		9.4938E-12	
Q	29	1.0766E-07	6.7770E-09	2.0893E-08	3.9823E-09	3.4264E-09	1.7191E-09	6.2643E-10	4.9708E-10	2.0461E-10	1.8838E-10
Q	48	3.7263E-09	2.7131E-09	5.9444E-10	5.4314E-10	8.1481E-11	7.8834E-11	1.[illegible]410E-11		6.2287E-12	
Q	31	8.3696E-08	6.7523E-09	1.5981E-08	3.8601E-09	2.5799E-09	1.4948E-09	4.6718E-10	3.9083E-10	1.5412E-10	1.4328E-10
Q	50	2.3187E-09	1.8888E-09	3.6051E-10	3.3993E-10	4.8475E-11	4.7248E-11	8.7810E-12		4.0925E-12	
Q	52	1.4114E-09	1.2407E-09	2.1371E-10	2.0544E-10	2.8245E-11		5.3202E-12		2.7081E-12	
Q	33	6.3472E-08	6.6878E-09	1.1912E-08	3.6652E-09	1.8910E-09	1.2451E-09	3.3919E-10	2.9662E-10	1.1327E-10	1.0704E-10
Q	54	8.4052E-10	7.7523E-10	1.2387E-10	1.2046E-10	1.6146E-11		3.2282E-12		1.8135E-12	
Q	35	4.6983E-08	6.5728E-09	8.6572E-09	3.3785E-09	1.3503E-09	9.9000E-10	2.3997E-10	2.1730E-10	8.1355E-11	7.7724E-11
Q	56	4.8971E-10	4.6583E-10	7.0218E-11		9.0772E-12		1.9730E-12		1.2334E-12	
Q	58	2.7921E-10	2.7056E-10	3.8952E-11		5.0375E-12		1.2287E-12		8.5347E-13	
Q	37	3.3948E-08	6.3887E-09	6.1352E-09	2.9811E-09	9.3937E-10	7.5077E-10	1.6553E-10	1.5386E-10	5.7178E-11	5.5229E-11
Q	60	1.5574E-10	1.5253E-10	2.1151E-11		2.7731E-12		7.8062E-13		8.0060E-13	
R	1	1.0526E-07	6.5896E-09	2.2915E-08	3.9477E-09	4.2090E-09	1.8610E-09	8.3174E-10	6.1699E-10	2.6027E-10	2.3147E-10
Q	62	8.5056E-11		1.1263E-11		1.5265E-12		5.1101E-13		4.2932E-13	
Q	39	2.3963E-08	6.0983E-09	4.2431E-09	2.4930E-09	6.3728E-10	5.4382E-10	1.1148E-10	1.0572E-10	3.9418E-11	3.8326E-11
Q	64	4.5495E-11		5.8904E-12		8.4834E-13		3.4446E-13		3.1080E-13	
Q	41	1.6520E-08	5.6406E-09	2.8631E-09	1.9632E-09	4.2155E-10	3.7744E-10	7.3347E-11	7.0446E-11	2.6705E-11	
Q	66	2.3833E-11		3.0327E-12		4.8123E-13		2.3841E-13		2.2705E-13	
Q	68	1.2227E-11		1.5425E-12		2.8188E-13		1.6853E-13		1.6676E-13	
Q	43	1.1136E-08	4.9798E-09	1.8871E 09	1.4564E-09	2.7223E-10	2.5205E-10	4.7259E-11	4.5826E-11	1.7848E-11	
Q	70	6.1591E-12		7.8114E-13		1.7189E-13		1.2118E-13		1.2302E-13	
Q	72	3.0449E-12		3.9676E-13		1.0952E-13		8.8003E-14		9.0801E-14	
Q	45	7.3321E-09	4.1264E-09	1.2137E-09	1.0211E-09	1.7152E-10	1.6248E-10	2.9841E-11		1.1796E-11	
Q	74	1.4808E-12		2.0469E-13		7.2655E-14		6.4282E-14		6.8979E-14	
Q	47	4.7230E-09	3.1887E-09	7.6295E-10	6.8139E-10	1.0563E-10	1.0164E-10	1.8539E-11		7.7550E-12	
Q	76	7.1085E-13		1.0890E-13		4.9823E-14		4.7086E-14		4.9337E-14	
R	2	1.1567E-07	6.5937E-09	2.5162E-08	3.9729E-09	4.6180E-09	1.9222E-09	9.1203E-10	6.5919E-10	2.8545E-10	2.5129E-10
Q	78	3.3833E-13		6.0581E-14		3.4968E-14		3.4483E-14		3.6238E-14	
Q	49	2.9742E-09	2.2967E-09	4.6845E-10	4.3530E-10	6.3587E-11	6.1768E-11	1.1363E-11		5.0917E-12	
Q	80	1.6096E-13		3.5599E-14		2.4915E-14		2.5218E-14		2.6539E-14	
Q	82	7.7426E-14		2.2120E-14		1.7899E-14		1.8398E-14		1.9368E-14	
Q	51	1.8318E-09	1.5536E-09	2.8109E-10	2.6783E-10	3.7460E-11		6.9044E-12		3.3577E-12	
Q	84	3.8227E-14		1.4421E-14		1.2898E-14		1.3371E-14		1.4077E-14	
Q	53	1.1038E-09	9.9486E-10	1.6489E-10	1.5947E-10	2.1631E-11		4.1846E-12		2.2358E-12	
Q	86	1.9730E-14		9.7505E-15		9.3003E-15		9.6857E-15		1.0195E-14	
Q	88	1.0801E-14		6.7497E-15		6.6934E-15		6.9872E-15		7.3514E-15	
Q	55	6.5067E-10	6.1015E-10	9.4588E-11	9.2251E-11	1.7268E-11		2.5478E-12		1.5095E-12	
R	3	1.2803E-07	6.6006E-09	2.7820E-08	3.9990E-09	5.1005E-09	1.9837E-09	1.0068E-09	7.0594E-10	3.1512E-10	2.7412E-10
Q	90	6.3117E-15		4.7351E-15		4.8023E-15		5.0185E-15		5.2776E-15	
Q	97	3.9182E-15		3.3428E-15		3.4329E-15		3.5888E-15		3.7724E-15	
Q	57	3.7531E-10	3.6061E-10	5.3080E-11		6.8540E-12		1.5708E-12		1.0363E-12	
Q	94	2.5497E-15		2.3638E-15		2.4438E-15		2.5548E-15		2.6843E-15	
Q	59	2.1178E-10	2.0643E-10	2.9148E-11		3.7879E-12		9.8795E-13		7.2371E-13	
Q	61	1.1700E 10	1.1495E-10	1.5686E-11		2.0850E-12		6.3802E-13		5.1394E-13	
R	4	1.4075E-07	6.6019E-09	3.0458E-08	4.0171E-09	5.5767E-09	2.0350E-09	1.0995E-09	7.4899E-10	3.4431E-10	2.9603E-10
Q	61	6.3287E-11		8.2875E-12		1.1526E-12		4.2422E-13		3.7017E-13	
Q	65	3.3523E-11		4.2993E-12		6.4665E-13		2.9011E-13		2.6950E-13	
Q	67	1.7298E-11		2.2013E-12		3.7757E-13		2.0331E-13		1.9772E-13	
[illegible]	6	1.5186E-07	6.5970E-09	3.2902E-08	4.0293E-09	6.0148E-09	2.0752E-09	1.1845E-09	7.8658E-10	3.7108E-10	3.1583E-10

Q	69	8.8544E-12		1.1176E-12		2.2277E-13		1.4523E-13		1.4576E-13	
Q	71	4.4218E-12		5.6656E-13		1.3904E-13		1.0511E-13		1.0768E-13	
Q	73	2.1700E-12		2.8987E-13		9.0569E-14		7.6685E-14		7.9564E-14	
R	6	1.6210E-07	6.5992E-09	3.5055E-08	4.0398E-09	6.3965E-09	2.1057E-09	1.2579E-09	8.1681E-10	3.9427E-10	3.3269E-10
Q	75	1.0487E-12		1.5187E-13		6.1198E-14		5.6151E-14		5.8695E-14	
Q	77	5.0168E-13		8.2511E-14		4.2574E-14		4.1202E-14		4.3248E-14	
R	7	1.7084E-07	6.6285E-09	3.6867E-08	4.0517E-09	6.7129E-09	2.1288E-09	1.3182E-09	8.4051E-10	4.1336E-10	3.4617E-10
Q	79	2.3867E-13		4.7185E-14		3.0164E-14		3.0185E-14		3.1749E-14	
Q	81	1.1410E-13		2.8554E-14		2.1618E-14		2.2072E-14		2.3235E-14	
Q	83	5.5560E-14		1.8223E-14		1.5583E-14		1.6095E-14		1.6947E-14	
R	8	1.7788E-07	6.6259E-09	3.8295E-08	4.0559E-09	6.9564E-09	2.1442E-09	1.3636E-09	8.5753E-10	4.2787E-10	3.5619E-10
Q	85	2.8018E-14		1.2133E-14		1.1249E-14		1.1693E-14		1.2309E-14	
Q	87	1.4887E-14		8.3214E-15		8.1138E-15		8.4617E-15		8.9047E-15	
R	9	1.8323E-07	6.6271E-09	3.9341E-08	4.0584E-09	7.1277E-09	2.1536E-09	1.3945E-09	8.6921E-10	4.3787E-10	3.6298E-10
Q	89	8.4317E-15		5.8137E-15		5.8397E-15		6.0999E-15		6.4164E-15	
Q	91	5.0923E-15		4.1002E-15		4.1885E-15		4.3781E-15		4.6031E-15	
R	10	1.8667E-07	6.6289E-09	3.9963E-08	4.0598E-09	7.2195E-09	2.1579E-09	1.4095E-09	8.7423E-10	4.4291E-10	3.6678E-10
Q	93	3.2462E-15		2.9013E-15		2.9911E-15		3.1271E-15		3.2863E-15	
R	11	1.8848E-07	6.6238E-09	4.0222E-08	4.0568E-09	7.2432E-09	2.1575E-09	1.4110E-09	8.7411E-10	4.4373E-10	3.6716E-10
R	12	1.8836E-07	6.6250E-09	4.0057E-08	4.0553E-09	7.1889E-09	2.1527E-09	1.3969E-09	8.6839E-10	4.3974E-10	3.6424E-10
R	13	1.8676E-07	6.6244E-09	3.9570E-08	4.0516E-09	7.0754E-09	2.1436E-09	1.3713E-09	8.5814E-10	4.3210E-10	3.5877E-10
R	14	1.8340E-07	6.6252E-09	3.8703E-08	4.0488E-09	6.8929E-09	2.1303E-09	1.3321E-09	8.4336E-10	4.2026E-10	3.5084E-10
R	15	1.7890E-07	6.6186E-09	3.7594E-08	4.0415E-09	6.6674E-09	2.1126E-09	1.2847E-09	8.2413E-10	4.0581E-10	3.4046E-10
R	16	1.7286E-07	6.6193E-09	3.6160E-08	4.0348E-09	6.3843E-09	2.0907E-09	1.2263E-09	8.0001E-10	3.8789E-10	3.2750E-10
R	17	1.6605E-07	6.6195E-09	3.4571E-08	4.0244E-09	6.0749E-09	2.0830E-09	1.1630E-09	7.7272E-10	3.6842E-10	3.1368E-10
R	18	1.5802E-07	6.6154E-09	3.2731E-08	4.0144E-09	5.7231E-09	2.0302E-09	1.0918E-09	7.4158E-10	3.4645E-10	2.9733E-10
R	19	1.4964E-07	6.6150E-09	3.0832E-08	3.9994E-09	5.3628E-09	1.9918E-09	1.0193E-09	7.0757E-10	3.2405E-10	2.8076E-10
R	20	1.4034E-07	6.5870E-09	2.8754E-08	3.9791E-09	4.9738E-09	1.9458E-09	9.4178E-10	6.6945E-10	3.0000E-10	2.6218E-10
R	21	1.3110E-07	6.5824E-09	2.6704E-08	3.9590E-09	4.5927E-09	1.8944E-09	8.6617E-10	6.3083E-10	2.7653E-10	2.4409E-10
R	22	1.2124E-07	6.5857E-09	2.4545E-08	3.9349E-09	4.1960E-09	1.8346E-09	7.8812E-10	5.8847E-10	2.5222E-10	2.2483E-10
R	23	1.1177E-07	6.5785E-09	2.2485E-08	3.9058E-09	3.8197E-09	1.7683E-09	7.1441E-10	5.4615E-10	2.2923E-10	2.0617E-10
R	24	1.0197E-07	6.5778E-09	2.0377E-08	3.8724E-09	3.4391E-09	1.6925E-09	6.4043E-10	5.0208E-10	2.0609E-10	1.8693E-10
R	25	9.2830E-08	6.5656E-09	1.8423E-08	3.8265E-09	3.0881E-09	1.6109E-09	5.7251E-10	4.5894E-10	1.8483E-10	1.6917E-10
R	26	8.3584E-08	6.5578E-09	1.6469E-08	3.7758E-09	2.7413E-09	1.5193E-09	5.0589E-10	4.1512E-10	1.6390E-10	1.5137E-10
R	27	7.5167E-08	6.5390E-09	1.4701E-08	3.7127E-09	2.4292E-09	1.4241E-09	4.4621E-10	3.7389E-10	1.4512E-10	1.3490E-10
R	28	6.6808E-08	6.5167E-09	1.2965E-08	3.6365E-09	2.1263E-09	1.3201E-09	3.8875E-10	3.3219E-10	1.2698E-10	1.1895E-10
R	29	5.9363E-08	6.4760E-09	1.1429E-08	3.5415E-09	1.8598E-09	1.2157E-09	3.3841E-10	2.9443E-10	1.1106E-10	1.0475E-10
R	30	5.2105E-08	6.4371E-09	9.9492E-09	3.4304E-09	1.6061E-09	1.1052E-09	2.9084E-10	2.5750E-10	9.5948E-11	9.1080E-11
R	31	4.5761E-08	6.3801E-09	8.6638E-09	3.3008E-09	1.3871E-09	9.9838E-10	2.4998E-10	2.2464E-10	8.2948E-11	7.9040E-11
R	32	3.9664E-08	6.3155E-09	7.4438E-09	3.1435E-09	1.1817E-09	8.8869E-10	2.1196E-10	1.9318E-10	7.0783E-11	6.7794E-11
R	33	3.4428E-08	6.2306E-09	6.4030E-09	2.9715E-09	1.0076E-09	7.8672E-10	1.7990E-10	1.6590E-10	6.0507E-11	5.8194E-11
R	34	2.9470E-08	6.1187E-09	5.4303E-09	2.7706E-09	8.4696E-10	6.8533E-10	1.5052E-10	1.4034E-10	5.1030E-11	4.9268E-11
R	35	2.5294E-08	5.9889E-09	4.8164E-09	2.5816E-09	7.1346E-10	5.9469E-10	1.2624E-10	1.1875E-10	4.3179E-11	4.1816E-11
R	36	2.1394E-08	5.8306E-09	3.8665E-09	2.3293E-09	5.9200E-10	5.0755E-10	1.0432E-10	9.8915E-11	3.6034E-11	3.5055E-11
R	38	1.5175E-08	5.3917E-09	2.6871E-09	1.8581E-09	4.0358E-10	3.6137E-10	7.0596E-11	6.7741E-11	2.4363E-11	
R	37	1.8158E-08	5.6297E-09	3.2487E-09	2.0996E-09	4.9269E-10	4.3201E-10	8.6483E-11	8.2523E-11	3.0205E-11	2.9449E-11
R	40	1.0523E-08	4.7746E-09	1.8237E-09	1.4057E-09	2.6851E-10	2.4819E-10	4.6720E-11	4.5253E-11	1.7010E-11	
R	39	1.2745E-08	5.1108E-09	2.2330E-09	1.6328E-09	3.3208E-10	3.0231E-10	5.7917E-11	5.5893E-11	2.0754E-11	
R	42	7.1275E-09	4.0035E-09	1.2078E-09	1.0102E-09	1.7424E-10	1.6470E-10	3.0248E-11	2.9485E-11	1.1423E-11	
R	41	8.7366E-09	4.4163E-09	1.4974E-09	1.2043E-09	2.1824E-10	2.0410E-10	3.7912E-11	3.6817E-11	1.4044E-11	
R	44	4.7216E-09	3.1506E-09	7.8157E-10	6.9323E-10	1.1045E-10	1.0599E-10	1.9218E-11		7.5965E-12	
R	43	5.8560E-09	3.5920E-09	9.8089E-10	8.4611E-10	1.4006E-10	1.3341E-10	2.4324E-11		9.3867E-12	
R	46	3.0586E-09	2.3258E-09	4.9408E-10	4.5587E-10	6.8409E-11	6.6334E-11	1.2006E-11		5.0221E-12	
R	45	3.8382E-09	2.7404E-09	6.2770E-10	5.6827E-10	8.7800E-11	8.4745E-11	1.5327E-11		6.2236E-12	
R	48	1.9374E-09	1.6188E-09	3.0515E-10	2.8915E-10	4.1470E-11		7.4017E-12		3.3167E-12	
R	47	2.4602E-09	1.9655E-09	3.9247E-10	3.6731E-10	5.3798E-11	5.2344E-11	9.5143E-12		4.1125E-12	
R	50	1.2003E-09	1.0701E-09	1.8419E-10	1.7765E-10	2.4546E-11		4.5242E-12		2.2002E-12	
R	49	1.5422E-09	1.3334E-09	2.3977E-10	2.2948E-10	3.2240E-11		5.8401E-12		2.7219E-12	
R	52	7.2789E-10	6.7617E-10	1.0874E-10	1.0590E-10	1.4265E-11		2.7595E-12		1.4744E-12	
R	51	9.4596E-10	8.6140E-10	1.4323E-10	1.3889E-10	1.8930E-11		3.5657E-12		1.8150E-12	
R	54	4.3177E-10	4.1214E-10	6.2767E-11		8.1406E-12		1.6907E-12		1.0017E-12	
R	53	5.6760E-10	5.3500E-10	8.3649E-11	8.1686E-11	1.0903E-11		2.1786E-12		1.2247E-12	
R	56	2.5052E-10	2.4315E-10	3.5430E-11		4.5750E-12		1.0485E-12		6.9162E-13	

R	55	3.3336E-10	3.2108E-10	4.7800E-11	6.1792E-12	1.3431E-12	8.3959E-13
R	58	1.4210E-10	1.3948E-10	1.9585E-11	2.5452E-12	6.6382E-13	4.8627E-13
R	57	1.9148E-10	1.8685E-10	2.6713E-11	3.4548E-12	8.4131E-13	5.8532E-13
R	60	7.9128E-11		1.0609E-11	1.4101E-12	4.3150E-13	3.4758E-13
R	59	1.0768E-10		1.4625E-11	1.9175E-12	5.3975E-13	4.1528E-13
R	62	4.3073E-11		5.6370E-12	7.8446E-13	2.8872E-13	2.5193E-13
R	61	5.9292E-11		7.8511E-12	1.0641E-12	3.5622E-13	2.9927E-13
R	64	2.2970E-11		2.9459E-12	4.4309E-13	1.9879E-13	1.8466E-13
R	63	3.1964E-11		4.1384E-12	5.9602E-13	2.4201E-13	2.1836E-13
R	66	1.1995E-11		1.5177E-12	2.5688E-13	1.4018E-13	1.3632E-13
R	68	6.1446E-12		7.7554E-13	1.5460E-13	1.0079E-13	1.0115E-13
R	65	1.6881E-11		2.1481E-12	3.4085E-13	1.6887E-13	1.6082E-13
R	70	3.0876E-12		3.9562E-13	9.7088E-14	7.3397E-14	7.5191E-14
R	67	8.7407E-12		1.1027E-12	2.0136E-13	1.2048E-13	1.1921E-13
R	72	1.5248E-12		2.0369E-13	6.3642E-14	5.3886E-14	5.5909E-14
R	69	4.4372E-12		5.6275E-13	1.2383E-13	8.7301E-14	8.8625E-14
R	74	7.4232E-13		1.0736E-13	4.3320E-14	3.9747E-14	4.1548E-14
R	71	2.2123E-12		2.8828E-13	7.9573E-14	6.3941E-14	6.5974E-14
R	76	3.5713E-13		5.8737E-14	3.0307E-14	2.9330E-14	3.0785E-14
R	73	1.0851E-12		1.5000E-13	5.3241E-14	4.7105E-14	4.9082E-14
R	78	1.7104E-13		3.3816E-14	2.1617E-14	2.1633E-14	2.2753E-14
R	75	5.2545E-13		8.0497E-14	3.6829E-14	3.4806E-14	3.6469E-14
R	80	8.2299E-14		2.0596E-14	1.5593E-14	1.5921E-14	1.6760E-14
R	77	2.5217E-13		4.5154E-14	2.6063E-14	2.5702E-14	2.7010E-14
R	82	4.0318E-14		1.3224E-14	1.1308E-14	1.1680E-14	1.2297E-14
R	79	1.2101E-13		2.8762E-14	1.8731E-14	1.8958E-14	1.9951E-14
R	84	2.0470E-14		8.8643E-15	8.2189E-15	8.5429E-15	8.9933E-15
R	81	5.8709E-14		1.8772E-14	1.3572E-14	1.3949E-14	1.4686E-14
R	86	1.0946E-14		6.1185E-15	5.9658E-15	6.2217E-15	6.5474E-15
R	88	6.2379E-15		4.3010E-15	4.3203E-15	4.5128E-15	4.7470E-15
R	83	2.9230E-14		1.1026E-14	9.8825E-15	1.0224E-14	1.0764E-14
R	90	3.7898E-15		3.0515E-15	3.1172E-15	3.2583E-15	3.4258E-15
R	85	1.5222E-14		7.5228E-15	7.1754E-15	7.4727E-15	7.8655E-15
R	92	2.4329E-15		2.1744E-15	2.2417E-15	2.3435E-15	2.4629E-15
R	87	8.4045E-15		5.2521E-15	5.2084E-15	5.4369E-15	5.7203E-15
R	89	4.9548E-15		3.7171E-15	3.7699E-15	3.9396E-15	4.1430E-15
R	91	3.1028E-15		2.6472E-15	2.7185E-15	2.8420E-15	2.9873E-15
R	93	2.0167E-15		1.8881E-15	1.9521E-15	2.0408E-15	2.1442E-15

TOTAL BAND RADIANCE:

WATT/(CM2*STR):	8.8204E-07	4.4439E-07	1.8601E-07	8.304FE-08	2.5413E-08
PH/(SEC*CM2*STR):	6.4949E+13	3.3475E+13	1.4005E+13	4.7440E+12	1.9117E+12

276 LINES
171 THICK

SUBROUTINE SPECTRM:

CUMULATIVE RADIANCE FOR 5 VIEWING PATHS AND 4 CO2 BANDS

INTEGRATED RADIANCE (WATT/CM2*STER)
SYNTHETIC SPECTRUM (WATT/CM2*STER*UM)

FWHM FOR TRIANGULAR SCANNING FUNCTION = .270 UM DEL = .050 UM

WL(UM)	70.00 KM	75.00 KM	80.00 KM	85.00 KM	90.00 KM
(INTEG'TD)	3.171E-06	1.514E-06	7.420E-07	4.029E-07	2.798E-07
13.050	4.242E-15	4.356E-15	4.531E-15	4.733E-15	4.965E-15
13.100	3.992E-14	4.070E-14	4.231E-14	4.421E-14	4.639E-14
13.150	1.444E-13	1.446E-13	1.502E-13	1.570E-13	1.647E-13
13.200	3.786E-13	3.652E-13	3.778E-13	3.947E-13	4.145E-13
13.250	8.678E-13	7.791E-13	7.996E-13	8.352E-13	8.775E-13
13.300	2.075E-12	1.593E-12	1.600E-12	1.668E-12	1.754E-12
13.350	5.234E-12	3.096E-12	2.955E-12	3.065E-12	3.222E-12
13.400	1.419E-11	6.058E-12	5.229E-12	5.359E-12	5.630E-12
13.450	4.517E-11	1.335E-11	9.378E-12	9.290E-12	9.730E-12
13.500	1.382E-10	3.168E-11	1.687E-11	1.565E-11	1.626E-11
13.550	4.422E-10	8.802E-11	3.329E-11	2.702E-11	2.750E-11
13.600	1.325E-09	2.521E-10	7.173E-11	4.734E-11	4.616E-11
13.650	3.648E-09	7.097E-10	1.683E-10	8.685E-11	7.852E-11
13.700	9.222E-09	1.979E-09	4.324E-10	1.740E-10	1.395E-10
13.750	1.961E-08	4.807E-09	1.064E-09	3.599E-10	2.521E-10
13.800	3.698E-08	1.068E-08	2.631E-09	8.189E-10	4.962E-10
13.850	6.097E-08	1.989E-08	5.562E-09	1.746E-09	9.628E-10
13.900	9.288E-08	3.353E-08	1.075E-08	3.694E-09	1.970E-09
13.950	1.312E-07	5.072E-08	1.802E-08	6.824E-09	3.714E-09
14.000	1.750E-07	7.137E-08	2.769E-08	1.163E-08	8.703E-09
14.050	2.241E-07	9.433E-08	3.911E-08	1.792E-08	1.095E-08
14.100	2.786E-07	1.190E-07	5.179E-08	2.579E-08	1.680E-08
14.150	3.402E-07	1.464E-07	6.517E-08	3.471E-08	2.397E-08
14.200	4.102E-07	1.770E-07	7.930E-08	4.430E-08	3.224E-08
14.250	4.890E-07	2.127E-07	9.491E-08	5.435E-08	4.117E-08
14.300	5.796E-07	2.543E-07	1.128E-07	6.490E-08	5.052E-08
14.350	6.799E-07	3.015E-07	1.336E-07	7.616E-08	6.002E-08
14.400	7.909E-07	3.542E-07	1.578E-07	8.831E-08	6.952E-08
14.450	9.095E-07	4.109E-07	1.853E-07	1.017E-07	7.912E-08
14.500	1.031E-06	4.686E-07	2.149E-07	1.160E-07	8.843E-08
14.550	1.150E-06	5.266E-07	2.459E-07	1.313E-07	9.778E-08
14.600	1.257E-06	5.803E-07	2.759E-07	1.463E-07	1.063E-07
14.650	1.357E-06	6.371E-07	3.052E-07	1.609E-07	1.143E-07
14.700	1.514E-08	7.135E-07	3.485E-07	1.837E-07	1.280E-07
14.750	2.050E-06	9.619E-07	4.769E-07	2.585E-07	1.829E-07
14.800	2.596E-08	1.209E-06	6.039E-07	3.345E-07	2.399E-07
14.850	3.217E-08	1.496E-06	7.471E-07	4.161E-07	2.990E-07
14.900	3.862E-08	1.798E-06	8.972E-07	5.010E-07	3.601E-07
14.950	4.427E-06	2.059E-06	1.028E-06	5.771E-07	4.158E-07
15.000	4.384E-06	2.046E-06	1.020E-06	5.709E-07	4.084E-07
15.050	3.979E-08	1.883E-06	9.354E-07	5.146E-07	3.606E-07
15.100	3.491E-06	1.682E-06	8.366E-07	4.534E-07	3.110E-07
15.150	2.859E-06	1.393E-06	6.941E-07	3.730E-07	2.532E-07
15.200	2.303E-06	1.151E-06	5.783E-07	3.078E-07	2.049E-07
15.250	1.881E-08	9.742E-07	4.935E-07	2.593E-07	1.686E-07
15.300	1.828E-06	9.529E-07	4.867E-07	2.597E-07	1.714E-07
15.350	1.762E-06	9.216E-07	4.723E-07	2.558E-07	1.715E-07
15.400	1.767E-06	9.326E-07	4.779E-07	2.610E-07	1.751E-07
15.450	1.642E-06	8.632E-07	4.373E-07	2.398E-07	1.619E-07
15.500	1.474E-06	[illegible]	[illegible]	2.090E-07	1.424E-07

15.550	1.301E-06	8.829E-07	3.258E-07	1.806E-07	1.236E-07
15.600	1.113E-06	5.539E-07	2.696E-07	1.514E-07	1.041E-07
15.650	9.242E-07	4.464E-07	2.158E-07	1.224E-07	8.440E-08
15.700	7.829E-07	3.699E-07	1.791E-07	1.015E-07	6.884E-08
15.750	6.816E-07	3.236E-07	1.601E-07	9.031E-08	5.947E-08
15.800	5.902E-07	2.842E-07	1.429E-07	7.874E-08	4.978E-08
15.850	5.096E-07	2.506E-07	1.263E-07	6.878E-08	4.012E-08
15.900	4.399E-07	2.205E-07	1.090E-07	5.448E-08	3.085E-08
15.950	3.825E-07	1.933E-07	9.225E-08	4.310E-08	2.294E-08
16.000	3.323E-07	1.660E-07	7.511E-08	3.258E-08	1.631E-08
16.050	2.856E-07	1.384E-07	5.868E-08	2.358E-08	1.113E-08
16.100	2.414E-07	1.117E-07	4.408E-08	1.643E-08	7.376E-09
16.150	1.981E-07	8.640E-08	3.154E-08	1.096E-08	4.738E-09
16.200	1.566E-07	6.382E-08	2.161E-08	7.082E-09	2.984E-09
16.250	1.192E-07	4.516E-08	1.423E-08	4.427E-09	1.833E-09
16.300	8.642E-08	3.039E-08	8.926E-09	2.647E-09	1.086E-09
16.350	6.017E-08	1.974E-08	5.455E-09	1.561E-09	6.422E-10
16.400	4.003E-08	1.223E-08	3.180E-09	8.840E-10	3.684E-10
16.450	2.513E-08	7.116E-09	1.749E-09	4.764E-10	2.038E-10
16.500	1.511E-08	3.993E-09	9.373E-10	2.530E-10	1.125E-10
16.550	8.691E-09	2.168E-09	4.916E-10	1.332E-10	6.221E-11
16.600	4.706E-09	1.115E-09	2.458E-10	6.751E-11	3.373E-11
16.650	2.389E-09	5.402E-10	1.163E-10	3.303E-11	1.810E-11
16.700	1.209E-09	2.637E-10	5.587E-11	1.685E-11	1.018E-11
16.750	5.932E-10	1.250E-10	2.640E-11	8.662E-12	5.800E-12
16.800	2.764E-10	5.628E-11	1.207E-11	4.447E-12	3.304E-12
16.850	1.211E-10	2.397E-11	5.357E-12	2.308E-12	1.900E-12
16.900	5.418E-11	1.052E-11	2.499E-12	1.249E-12	1.105E-12
16.950	2.377E-11	4.563E-12	1.180E-12	6.810E-13	6.359E-13
17.000	9.953E-12	1.908E-12	5.566E-13	3.706E-13	3.609E-13
17.050	3.937E-12	7.681E-13	2.634E-13	2.003E-13	2.011E-13
17.100	1.557E-12	3.171E-13	1.304E-13	1.098E-13	1.125E-13
17.150	6.327E-13	1.416E-13	7.173E-14	6.547E-14	6.792E-14
17.200	2.462E-13	6.311E-14	3.871E-14	3.726E-14	3.893E-14
17.250	8.992E-14	2.731E-14	1.960E-14	1.952E-14	2.047E-14
17.300	2.905E-14	1.073E-14	8.700E-15	8.843E-15	9.293E-15
17.350	8.673E-15	3.710E-15	3.215E-15	3.299E-15	3.469E-15
17.400	1.528E-15	7.298E-16	6.577E-16	6.784E-16	7.137E-16

A5. Unit 5: Output From Sample Run 1

Subsidiary program output from Sample Run 1 begins on the next page.

PROGRAM NLTE FOR INFRARED RADIANCE
DATE - 85/09/04. TIME = 09 21 02.

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TAPE5

CUMULATIVE INTEGRATED RADIANCE (WATT/CM2*STR) AND TOTAL OPTICAL DEPTH (AT LINE CENTER) FOR VARIOUS LINE-OF-SIGHT PATHS

EXEC TIME		LINE			70.00 KM				75.00 KM				80.00 KM				85.00 KM				90.00KM	
			LB	LL	KM	RADIANCE	OP DPTH	LL	KM	RADIANCE	OP DPTH	LL	KM	RADIANCE	OP DPTH	LL	KM	RADIANCE	OP DPTH	LL	KM	RADIANCE	OP DPTH
3.23	P	92	0	0	80	.153E-14	.243E-06	0	80	.123E-14	.169E-06	0	80	.128E-14	.187E-06	0	80	.132E-14	.174E-06	0	80	.138E-14	.183E-06
3.25	P	90	0	0	80	.409E-14	.444E-06	0	80	.300E-14	.250E-06	0	80	.303E-14	.237E-06	0	80	.317E-14	.248E-06	0	80	.333E-14	.259E-06
3.27	P	88	0	0	80	.867E-14	.865E-06	0	80	.556E-14	.383E-06	0	80	.553E-14	.337E-06	0	80	.577E-14	.347E-06	0	80	.807E-14	.365E-06
3.28	P	86	0	0	80	.174E-13	.178E-05	0	80	.932E-14	.612E-06	0	80	.902E-14	.482E-06	0	80	.940E-14	.488E-06	0	80	.989E-14	.513E-06
3.30	P	84	0	0	80	.348E-13	.380E-05	0	80	.150E-13	.104E-05	0	80	.139E-13	.697E-06	0	80	.145E-13	.687E-06	0	80	.152E-13	.720E-06
3.32	P	91	0	0	80	.368E-13	.333E-06	0	80	.166E-13	.208E-06	0	80	.155E-13	.202E-06	0	80	.161E-13	.210E-06	0	80	.189E-13	.221E-06
3.33	P	89	0	0	80	.403E-13	.630E-06	0	80	.188E-13	.313E-06	0	80	.176E-13	.288E-06	0	80	.183E-13	.296E-06	0	80	.193E-13	.312E-06
3.35	P	82	0	0	80	.785E-13	.825E-05	0	80	.278E-13	.187E-05	0	80	.245E-13	.103E-05	0	80	.253E-13	.968E-06	0	80	.267E-13	.101E-05
3.37	P	87	0	0	80	.830E-13	.127E-05	0	80	.310E-13	.489E-06	0	80	.275E-13	.408E-06	0	80	.285E-13	.417E-06	0	80	.300E-13	.439E-06
3.39	P	80	0	0	80	.180E-12	.180E-04	0	80	.481E-13	.360E-05	0	80	.372E-13	.157E-05	0	80	.382E-13	.137E-05	0	80	.402E-13	.142E-05
3.40	P	85	0	0	80	.172E-12	.266E-05	0	80	.509E-13	.805E-06	0	80	.415E-13	.586E-06	0	80	.426E-13	.586E-06	0	80	.448E-13	.616E-06
3.42	P	78	0	0	80	.335E-12	.390E-04	0	80	.778E-13	.722E-05	0	80	.552E-13	.249E-05	0	80	.559E-13	.196E-05	0	80	.588E-13	.199E-05
3.44	P	83	0	0	80	.360E-12	.574E-05	0	80	.850E-13	.141E-05	0	80	.612E-13	.855E-06	0	80	.621E-13	.825E-06	0	80	.653E-13	.863E-06
3.46	P	76	0	0	80	.704E-12	.835E-04	0	80	.135E-12	.149E-04	0	80	.812E-13	.419E-05	0	80	.804E-13	.285E-05	0	80	.845E-13	.281E-05
3.47	P	81	0	0	80	.757E-12	.125E-04	0	80	.147E-12	.264E-05	0	80	.896E-13	.128E-05	0	80	.889E-13	.116E-05	0	80	.934E-13	.121E-05
3.49	P	74	0	0	80	.147E-11	.176E-03	0	80	.242E-12	.311E-04	0	80	.120E-12	.744E-05	0	80	.114E-12	.424E-05	0	80	.120E-12	.401E-05
3.51	P	79	0	0	80	.159E-11	.272E-04	0	80	.283E-12	.519E-05	0	80	.131E-12	.200E-05	0	80	.126E-12	.166E-05	0	80	.132E-12	.170E-05
3.53	P	72	0	0	80	.307E-11	.365E-03	0	80	.452E-12	.650E-04	0	80	.178E-12	.139E-04	0	80	.161E-12	.655E-05	0	80	.168E-12	.579E-05
3.55	P	77	0	0	80	.331E-11	.586E-04	0	80	.489E-12	.106E-04	0	80	.195E-12	.327E-05	0	80	.177E-12	.239E-05	0	80	.185E-12	.239E-05
3.56	P	75	0	0	80	.382E-11	.124E-03	0	80	.559E-12	.220E-04	0	80	.220E-12	.565E-05	0	80	.199E-12	.351E-05	0	80	.208E-12	.339E-05
3.58	P	70	0	0	80	.880E-11	.743E-03	0	80	.936E-12	.135E-03	0	80	.295E-12	.268E-04	0	80	.248E-12	.105E-04	0	80	.257E-12	.855E-05
3.60	P	73	0	0	80	.786E-11	.260E-03	0	80	.107E-11	.460E-04	0	80	.333E-12	.103E-04	0	80	.279E-12	.532E-05	0	80	.288E-12	.486E-05
3.61	P	68	0	0	80	.138E-10	.148E-02	0	80	.182E-11	.275E-03	0	80	.460E-12	.527E-04	0	80	.348E-12	.177E-04	0	80	.356E-12	.130E-04
3.63	P	71	0	0	80	.159E-10	.533E-03	0	80	.210E-11	.957E-04	0	80	.520E-12	.196E-04	0	80	.390E-12	.837E-05	0	80	.399E-12	.710E-05
3.65	P	66	0	0	80	.275E-10	.289E-02	0	80	.358E-11	.552E-03	0	80	.742E-12	.104E-03	0	80	.490E-12	.310E-04	0	80	.491E-12	.207E-04
3.67	P	69	0	0	80	.318E-10	.107E-02	0	80	.412E-11	.197E-03	0	80	.841E-12	.382E-04	0	80	.549E-12	.138E-04	0	80	.550E-12	.106E-04
3.68	P	64	0	0	80	.538E-10	.553E-02	0	80	.700E-11	.109E-02	0	80	.124E-11	.206E-03	0	80	.697E-12	.559E-04	0	80	.679E-12	.326E-04
3.70	P	67	0	0	80	.622E-10	.211E-02	0	80	.807E-11	.398E-03	0	80	.141E-11	.756E-04	0	80	.781E-12	.237E-04	0	80	.759E-12	.153E-04
3.72	P	62	0	0	80	.103E-09	.103E-01	0	80	.138E-10	.210E-02	0	80	.214E-11	.403E-03	0	80	.100E-11	.103E-03	0	80	.939E-12	.542E-04
3.74	P	65	0	0	80	.119E-09	.408E-02	0	80	.157E-10	.792E-03	0	80	.245E-11	.150E-03	0	80	.113E-11	.421E-04	0	80	.105E-11	.259E-04
3.75	P	60	0	0	80	.194E-09	.190E-01	0	80	.260E-10	.397E-02	0	80	.379E-11	.775E-03	0	80	.148E-11	.191E-03	0	80	.131E-11	.922E-04
3.77	P	63	0	0	80	.225E-09	.771E-02	0	80	.300E-10	.154E-02	0	80	.434E-11	.294E-03	0	80	.166E-11	.770E-04	0	80	.146E-11	.475E-04
3.82	P	58	3	4	10	.357E-09	.340E-01	0	80	.490E-10	.734E-02	0	80	.679E-11	.146E-02	0	80	.222E-11	.355E-03	0	80	.183E-11	.159E-03
3.84	P	61	0	0	80	.413E-09	.143E-01	0	80	.567E-10	.294E-02	0	80	.779E-11	.569E-03	0	80	.251E-11	.142E-03	0	80	.205E-11	.715E-04
3.86	P	59	0	0	80	.515E-09	.258E-01	0	80	.709E-10	.550E-02	0	80	.961E-11	.109E-02	0	80	.295E-11	.265E-03	0	80	.236E-11	.123E-03
3.91	P	56	3	4	10	.744E-09	.596E-01	0	80	.105E-09	.133E-01	0	80	.141E-10	.271E-02	0	80	.387E-11	.653E-03	0	80	.291E-11	.277E-03
3.96	P	57	3	4	10	.920E-09	.458E-01	0	80	.131E-09	.100E-01	0	80	.174E-10	.203E-02	0	80	.460E-11	.489E-03	0	80	.336E-11	.213E-03
4.02	P	54	3	4	10	.131E-08	.102E+00	0	80	.191E-09	.234E-01	0	80	.253E-10	.491E-02	0	80	.612E-11	.118E-02	0	80	.417E-11	.481E-03
4.07	P	55	3	4	10	.161E-08	.794E-01	0	80	.237E-09	.179E-01	0	80	.313E-10	.371E-02	0	80	.732E-11	.893E-03	0	80	.485E-11	.370E-03
4.12	P	52	3	4	10	.224E-08	.172E+00	4	17	.338E-09	.105E-01	0	80	.450E-10	.870E-02	0	80	.985E-11	.211E-02	0	80	.808E-11	.829E-03
4.18	P	53	3	4	10	.274E-08	.135E+00	4	17	.416E-09	.313E-01	0	80	.556E-10	.664E-02	0	80	.118E-10	.161E-02	0	80	.709E-11	.640E-03
4.23	P	50	3	4	11	.373E-08	.282E+00	4	16	.584E-09	.683E-01	0	80	.791E-10	.150E-01	0	80	.161E-10	.369E-02	0	80	.898E-11	.141E-02
4.29	P	51	3	4	11	.454E-08	.223E+00	4	16	.716E-09	.533E-01	0	80	.974E-10	.116E-01	0	80	.194E-10	.283E-02	0	80	.105E-10	.110E-02
4.34	P	48	3	4	11	.805E-08	.453E+00	4	16	.988E-09	.113E+00	0	80	.137E-09	.254E-01	0	80	.263E-10	.630E-02	0	80	.134E-10	.237E-02
4.40	P	49	3	4	11	.729E-08	.362E+00	4	16	.120E-08	.888E-01	0	80	.168E-09	.198E-01	0	80	.317E-10	.489E-02	0	80	.158E-10	.185E-02
4.46	P	46	3	4	11	.947E-08	.712E+00	4	16	.163E-08	.181E+00	4	45	.231E-09	.413E-01	0	80	.430E-10	.105E-01	0	80	.202E-10	.390E-02
4.52	P	47	3	4	11	.113E-07	.575E+00	4	16	.198E-08	.145E+00	4	47	.290E-09	.331E-01	0	80	.519E-10	.826E-02	0	80	.238E-10	.308E-02
4.59	P	44	3	4	11	.143E-07	.109E+01	4	16	.262E-08	.285E+00	4	39	.380E-09	.673E-01	0	80	.698E-10	.172E-01	0	80	.306E-10	.629E-02
4.65	P	45	3	4	11	.169E-07	.891E+00	4	16	.315E-08	.230E+00	4	42	.450E-09	.538E-01	0	80	.842E-10	.136E-01	0	80	.362E-10	.501E-02
4.71	P	42	3	4	12	.207E-07	.164E+01	4	17	.409E-08	.437E+00	4	34	.614E-09	.106E+00	0	80	.112E-09	.273E-01	0	80	.464E-10	.911E-02
4.77	P	41	3	4	12	.241E-07	.135E+01	4	17	.488E-08	.357E+00	4	17	.739E-09	.853E-01	0	80	.135E-09	.219E-01	0	80	.548E-10	.799E-02

4.84	P	40	3	4	12	.288E-07	.240E+01	4	17	.819E-08	.654E+00	4	32	.968E-09	.162E+00	4	58	.177E-09	.424E-01	0	80	.700E-10	.153E-01
4.92	P	41	3	4	12	.331E-07	.200E+01	4	17	.732E-08	.540E+00	4	33	.116E-08	.132E+00	4	58	.211E-09	.344E-01	0	80	.825E-10	.124E-01
4.99	P	38	3	4	13	.384E-07	.343E+01	4	17	.906E-08	.955E+00	4	30	.149E-08	.241E+00	4	54	.273E-09	.640E-01	0	80	.105E-09	.229E-01
5.06	P	39	3	4	13	.434E-07	.289E+01	4	17	.106E-07	.798E+00	4	31	.177E-08	.199E+00	4	55	.324E-09	.527E-01	0	80	.123E-09	.189E-01
5.14	P	36	3	4	14	.493E-07	.479E+01	4	18	.128E-07	.136E+01	4	29	.223E-08	.350E+00	4	52	.414E-09	.942E-01	4	61	.154E-09	.336E-01
5.20	P	37	3	4	14	.549E-07	.409E+01	4	18	.148E-07	.115E+01	4	30	.263E-08	.293E+00	4	53	.489E-09	.784E-01	0	80	.181E-09	.280E-01
5.28	P	34	3	4	15	.611E-07	.653E+01	4	18	.174E-07	.189E+01	4	29	.323E-08	.495E+00	4	50	.615E-09	.135E+00	4	59	.224E-09	.479E-01
5.35	P	35	3	4	14	.671E-07	.564E+01	4	18	.199E-07	.162E+01	4	29	.380E-08	.420E+00	4	51	.722E-09	.114E+00	4	60	.261E-09	.405E-01
5.43	P	33	3	4	16	.735E-07	.758E+01	4	19	.227E-07	.222E+01	4	29	.451E-08	.585E+00	4	49	.869E-09	.161E+00	4	58	.312E-09	.570E-01
5.50	P	32	3	4	16	.799E-07	.867E+01	4	19	.258E-07	.256E+01	4	29	.532E-08	.681E+00	4	48	.104E-08	.188E+00	4	58	.370E-09	.686E-01
5.58	P	31	3	4	17	.864E-07	.995E+01	4	20	.290E-07	.296E+01	4	29	.623E-08	.794E+00	4	47	.124E-08	.221E+00	4	57	.439E-09	.780E-01
5.65	P	30	3	4	16	.930E-07	.112E+02	4	20	.324E-07	.337E+01	4	29	.723E-08	.912E+00	4	46	.146E-08	.255E+00	4	56	.516E-09	.899E-01
5.72	P	29	3	4	18	.996E-07	.127E+02	4	21	.359E-07	.384E+01	4	29	.834E-08	.105E+01	4	45	.172E-08	.294E+00	4	55	.605E-09	.104E+00
5.80	P	28	3	4	19	.106E-06	.142E+02	4	21	.395E-07	.432E+01	4	29	.954E-08	.119E+01	4	44	.201E-08	.335E+00	4	54	.705E-09	.118E+00
5.86	P	27	3	4	20	.113E-06	.158E+02	4	22	.432E-07	.485E+01	4	29	.108E-07	.134E+01	4	44	.233E-08	.381E+00	4	54	.818E-09	.134E+00
5.93	P	26	3	4	20	.120E-06	.174E+02	4	22	.470E-07	.538E+01	4	29	.122E-07	.150E+01	4	43	.268E-08	.428E+00	4	53	.943E-09	.150E+00
6.00	P	25	3	4	21	.127E-06	.192E+02	4	23	.509E-07	.596E+01	4	29	.137E-07	.167E+01	4	43	.307E-08	.479E+00	4	52	.108E-08	.168E+00
6.07	P	24	3	4	22	.133E-06	.208E+02	4	23	.548E-07	.651E+01	4	29	.153E-07	.184E+01	4	42	.350E-08	.530E+00	4	52	.123E-08	.186E+00
6.14	P	23	3	4	22	.140E-06	.225E+02	4	24	.587E-07	.710E+01	4	30	.169E-07	.202E+01	4	42	.395E-08	.584E+00	4	51	.140E-08	.205E+00
6.22	P	22	3	4	23	.147E-06	.241E+02	4	24	.627E-07	.764E+01	4	30	.186E-07	.218E+01	4	41	.444E-08	.634E+00	4	51	.158E-08	.222E+00
6.29	P	21	3	4	23	.154E-06	.257E+02	4	25	.667E-07	.819E+01	4	30	.203E-07	.235E+01	4	41	.496E-08	.687E+00	4	50	.177E-08	.241E+00
6.37	P	20	3	4	24	.160E-06	.271E+02	4	25	.707E-07	.867E+01	4	30	.221E-07	.251E+01	4	41	.551E-08	.734E+00	4	50	.197E-08	.257E+00
6.44	P	19	3	4	24	.167E-06	.284E+02	4	26	.747E-07	.913E+01	4	30	.240E-07	.265E+01	4	40	.608E-08	.780E+00	4	50	.218E-08	.273E+00
6.52	P	18	3	4	25	.174E-06	.293E+02	4	26	.788E-07	.950E+01	4	30	.258E-07	.277E+01	4	40	.667E-08	.819E+00	4	49	.240E-08	.286E+00
6.59	P	17	3	4	25	.181E-06	.302E+02	4	26	.828E-07	.981E+01	4	30	.277E-07	.288E+01	4	40	.728E-08	.852E+00	4	49	.263E-08	.298E+00
6.66	P	16	3	4	25	.187E-06	.306E+02	4	26	.869E-07	.100E+02	4	30	.296E-07	.295E+01	4	39	.791E-08	.876E+00	4	48	.287E-08	.305E+00
6.73	P	15	3	4	25	.194E-06	.308E+02	4	26	.909E-07	.101E+02	4	30	.315E-07	.299E+01	4	39	.853E-08	.892E+00	4	48	.310E-08	.311E+00
6.80	P	14	3	4	25	.201E-06	.306E+02	4	26	.949E-07	.101E+02	4	30	.334E-07	.299E+01	4	39	.916E-08	.894E+00	4	48	.334E-08	.312E+00
6.87	P	13	3	4	25	.208E-06	.300E+02	4	26	.990E-07	.993E+01	4	30	.353E-07	.296E+01	4	39	.979E-08	.887E+00	4	47	.358E-08	.310E+00
6.94	P	12	3	4	25	.214E-06	.290E+02	4	26	.103E-06	.982E+01	4	30	.372E-07	.288E+01	4	39	.104E-07	.864E+00	4	47	.381E-08	.302E+00
7.02	P	11	3	4	24	.221E-06	.276E+02	4	26	.107E-06	.918E+01	4	30	.391E-07	.275E+01	4	38	.110E-07	.829E+00	4	47	.403E-08	.289E+00
7.09	P	10	3	4	24	.228E-06	.257E+02	4	25	.111E-06	.858E+01	4	29	.409E-07	.258E+01	4	38	.116E-07	.778E+00	4	47	.423E-08	.272E+00
7.16	P	9	3	4	23	.234E-06	.234E+02	4	25	.115E-06	.784E+01	4	29	.428E-07	.236E+01	4	38	.121E-07	.714E+00	4	46	.442E-08	.249E+00
7.23	P	8	3	4	22	.241E-06	.207E+02	4	24	.119E-06	.695E+01	4	29	.442E-07	.210E+01	4	38	.128E-07	.636E+00	4	46	.460E-08	.222E+00
7.30	P	7	3	4	21	.247E-06	.176E+02	4	23	.122E-06	.593E+01	4	28	.457E-07	.180E+01	4	37	.130E-07	.544E+00	4	46	.474E-08	.190E+00
7.36	P	6	3	4	20	.254E-06	.142E+02	4	22	.126E-06	.479E+01	4	28	.470E-07	.145E+01	4	37	.133E-07	.441E+00	4	46	.487E-08	.154E+00
7.43	P	5	3	4	18	.260E-06	.106E+02	4	21	.129E-06	.357E+01	4	27	.481E-07	.108E+01	4	37	.136E-07	.330E+00	4	46	.496E-08	.115E+00
7.50	P	4	3	4	16	.266E-06	.679E+01	4	20	.132E-06	.229E+01	4	27	.489E-07	.697E+00	4	37	.138E-07	.212E+00	4	45	.502E-08	.739E-01
7.57	P	3	3	4	14	.271E-06	.308E+01	4	18	.134E-06	.104E+01	4	26	.493E-07	.317E+00	4	38	.139E-07	.965E-01	4	45	.505E-08	.337E-01
7.63	Q	2	3	4	21	.278E-06	.157E+02	4	22	.138E-06	.529E+01	4	28	.507E-07	.161E+01	4	37	.143E-07	.491E+00	4	46	.518E-08	.171E+00
7.71	Q	4	3	4	27	.284E-06	.367E+02	4	28	.142E-06	.124E+02	4	31	.528E-07	.376E+01	4	38	.150E-07	.115E+01	4	46	.547E-08	.399E+00
7.78	Q	3	3	4	24	.291E-06	.270E+02	4	26	.146E-06	.911E+01	4	30	.546E-07	.277E+01	4	38	.156E-07	.845E+00	4	46	.569E-08	.294E+00
7.87	Q	6	4	5	30	.298E-06	.529E+02	5	31	.150E-06	.178E+02	5	33	.568E-07	.540E+01	5	39	.165E-07	.164E+01	5	47	.608E-08	.572E+00
7.96	Q	8	4	5	32	.304E-06	.653E+02	5	33	.154E-06	.219E+02	5	34	.591E-07	.661E+01	5	40	.175E-07	.200E+01	5	47	.654E-08	.698E+00
8.04	Q	5	3	4	28	.311E-06	.453E+02	4	29	.158E-06	.153E+02	4	32	.612E-07	.464E+01	4	39	.184E-07	.141E+01	4	46	.689E-08	.491E+00
8.14	Q	10	4	5	33	.318E-06	.737E+02	5	34	.162E-06	.246E+02	5	35	.636E-07	.739E+01	5	41	.195E-07	.223E+01	5	48	.739E-08	.778E+00
8.23	Q	7	4	5	31	.324E-06	.596E+02	5	32	.166E-06	.200E+02	5	34	.658E-07	.606E+01	5	40	.205E-07	.184E+01	5	47	.782E-08	.641E+00
8.32	Q	12	4	5	33	.331E-06	.782E+02	5	34	.170E-06	.259E+02	5	36	.682E-07	.775E+01	5	41	.216E-07	.233E+01	5	48	.834E-08	.812E+00
8.41	Q	14	4	5	34	.338E-06	.790E+02	5	35	.174E-06	.260E+02	5	36	.705E-07	.772E+01	5	42	.227E-07	.231E+01	5	49	.885E-08	.805E+00
8.50	Q	9	4	5	32	.345E-06	.700E+02	5	33	.179E-06	.234E+02	5	35	.728E-07	.706E+01	5	40	.237E-07	.213E+01	5	47	.934E-08	.744E+00
8.60	Q	16	4	5	33	.351E-06	.765E+02	5	34	.183E-06	.250E+02	5	36	.752E-07	.736E+01	5	42	.248E-07	.219E+01	5	50	.983E-08	.764E+00
8.69	Q	11	4	5	33	.358E-06	.765E+02	5	34	.187E-06	.254E+02	5	36	.775E-07	.7[illegible]3E+01	5	41	.259E-07	.230E+01	5	48	.103E-07	.801E+00
8.79	Q	18	4	5	33	.365E-06	.715E+02	5	34	.191E-06	.231E+02	5	36	.798E-07	.675E+01	5	43	.269E-07	.199E+01	5	50	.108E-07	.697E+00
8.88	Q	20	4	5	32	.372E-06	.646E+02	5	33	.195E-06	.207E+02	5	35	.821E-07	.598E+01	5	43	.279E-07	.175E+01	5	51	.112E-07	.614E+00
8.98	Q	13	4	5	33	.379E-06	.790E+02	5	35	.199E-06	.261E+02	5	36	.844E-07	.778E+01	5	42	.290E-07	.233E+01	5	49	.118E-07	.814E+00
9.08	Q	22	4	5	31	.385E-06	.567E+02	5	32	.204E-06	.179E+02	5	35	.866E-07	.513E+01	5	44	.299E-07	.149E+01	5	52	.121E-07	.522E+00
9.17	Q	15	4	5	33	.392E-06	.782E+02	5	35	.208E-06	.256E+02	5	36	.889E-07	.758E+01	5	42	.310E-07	.226E+01	5	49	.128E-07	.792E+00
9.25	Q	24	3	4	29	.399E-06	.482E+02	4	3[illegible]	.212E-06	.151E+02	4	34	.910E-07	.426E+01	4	44	.317E-07	.123E+01	4	53	.129E-07	.431E+00
9.33	Q	25	3	4	27	.406E-06	.400E+02	4	28	.216E-06	.123E+02	4	33	.930E-07	.344E+01	4	45	.324E-07	.980E+00	4	54	.132E-07	.345E+00
9.42	Q	1[illegible]	4	5	33	.412E-06	.744E+02	5	34	.220E-06	.242E+02	5	36	.953E-07	.709E+01	5	43	.335E-07	.210E+01	5	50	.137E-07	.734E+00
9.50	Q	28	3	4	25	.419E-06	.322E+02	4	26	.224E-06	.980E+01	4	32	.972E-07	.269E+01	4	48	.340E-07	.760E+00	4	55	.139E-07	.268E+00
9.58	Q	30	3	4	23	.426E-06	.253E+02	4	24	.228E-06	.758E+01	4	32	.988E-07	.205E+01	4	48	.345E-07	.573E+00	4	57	.141E-07	.202E+00
9.66	Q	19	4	5	32	.433E-06	.684E+02	5	34	.232E-06	.220E+02	5	36	.101E-06	.639E+01	5	43	.355E-07	.188E+01	5	51	.145E-07	.650E+00

9.75	Q	32	3	4	21	.439E-06	.194E+02	4	23	.236E-06	.571E+01	4	31	.102E-06	.152E+01	4	49	.358E-07	.420E+00	4	59	.148E-07	.149E+00
9.85	Q	21	4	5	31	.446E-06	.609E+02	5	32	.240E-06	.194E+02	5	35	.105E-06	.557E+01	5	43	.367E-07	.163E+01	5	51	.150E-07	.570E+00
9.93	Q	34	3	4	19	.453E-06	.145E+02	4	21	.244E-06	.420E+01	4	31	.106E-06	.110E+01	4	51	.370E-07	.300E+00	4	60	.151E-07	.106E+00
10.00	Q	36	3	4	17	.459E-06	.106E+02	4	19	.247E-06	.300E+01	4	31	.107E-06	.772E+00	4	53	.372E-07	.208E+00	4	63	.152E-07	.741E-01
10.10	Q	23	4	5	30	.466E-06	.526E+02	5	31	.251E-06	.166E+02	5	34	.109E-06	.470E+01	5	44	.380E-07	.136E+01	5	52	.155E-07	.477E+00
10.18	Q	38	3	4	15	.472E-06	.754E+01	4	18	.254E-06	.210E+01	4	32	.109E-06	.529E+00	4	55	.381E-07	.141E+00	4	65	.156E-07	.503E-01
10.25	Q	25	3	4	28	.479E-06	.442E+02	4	29	.258E-06	.137E+02	4	34	.111E-06	.385E+01	4	45	.388E-07	.110E+01	4	53	.159E-07	.388E+00
10.33	Q	40	3	4	14	.485E-06	.525E+01	4	18	.260E-06	.143E+01	4	34	.112E-06	.353E+00	4	58	.389E-07	.926E-01	4	67	.159E-07	.334E-01
10.41	Q	42	3	4	13	.490E-06	.357E+01	4	17	.262E-06	.951E+00	4	38	.112E-06	.230E+00	4	61	.390E-07	.595E-01	0	80	.159E-07	.216E-01
10.48	Q	27	3	4	26	.497E-06	.381E+02	4	28	.266E-06	.111E+02	4	33	.114E-06	.306E+01	4	46	.396E-07	.870E+00	4	55	.162E-07	.306E+00
10.56	Q	44	3	4	12	.502E-06	.237E+01	4	17	.267E-06	.618E+00	4	43	.114E-06	.146E+00	4	63	.396E-07	.372E-01	0	80	.162E-07	.136E-01
10.62	Q	46	3	4	11	.505E-06	.154E+01	4	17	.268E-06	.397E+00	4	48	.114E-06	.905E-01	0	80	.396E-07	.228E-01	0	80	.162E-07	.842E-02
10.70	Q	29	3	4	24	.512E-06	.288E+02	4	25	.272E-06	.868E+01	4	32	.116E-06	.237E+01	4	47	.401E-07	.665E+00	4	58	.164E-07	.235E+00
10.77	Q	48	3	4	11	.515E-06	.978E+00	4	17	.272E-06	.243E+00	4	52	.116E-06	.547E-01	0	80	.402E-07	.136E-01	0	80	.164E-07	.510E-02
10.84	Q	31	3	4	22	.522E-06	.223E+02	4	23	.276E-06	.663E+01	4	31	.118E-06	.178E+01	4	48	.405E-07	.495E+00	4	58	.165E-07	.175E+00
10.90	Q	50	3	4	11	.524E-06	.607E+00	4	17	.277E-06	.147E+00	4	56	.118E-06	.323E-01	0	80	.406E-07	.792E-02	0	80	.165E-07	.303E-02
10.96	Q	52	3	4	11	.525E-06	.369E+00	4	17	.277E-06	.868E-01	0	80	.118E-06	.186E-01	0	80	.406E-07	.452E-02	0	80	.165E-07	.178E-02
11.04	Q	33	3	4	20	.531E-06	.169E+02	4	22	.280E-06	.494E+01	4	31	.119E-06	.130E+01	4	50	.409E-07	.358E+00	4	60	.166E-07	.127E+00
11.09	Q	54	3	4	10	.532E-06	.219E+00	4	18	.281E-06	.501E-01	0	80	.119E-06	.105E-01	0	80	.409E-07	.253E-02	0	80	.166E-07	.103E-02
11.17	Q	35	3	4	18	.539E-06	.125E+02	4	20	.284E-06	.358E+01	4	31	.120E-06	.929E+00	4	52	.411E-07	.252E+00	4	61	.167E-07	.896E-01
11.22	Q	56	3	4	10	.539E-06	.127E+00	0	80	.284E-06	.283E-01	0	80	.120E-06	.578E-02	0	80	.411E-07	.139E-02	0	80	.167E-07	.590E-03
11.27	Q	58	3	4	10	.540E-06	.725E-01	0	80	.284E-06	.156E-01	0	80	.120E-06	.312E-02	0	80	.411E-07	.755E-03	0	80	.167E-07	.339E-03
11.34	Q	37	3	4	16	.546E-06	.901E+01	4	19	.287E-06	.253E+01	4	32	.121E-06	.645E+00	4	54	.412E-07	.173E+00	4	64	.168E-07	.617E-01
11.40	Q	60	3	4	10	.546E-06	.404E-01	0	80	.287E-06	.844E-02	0	80	.121E-06	.165E-02	0	80	.412E-07	.406E-03	0	80	.168E-07	.198E-03
11.47	R	1	3	4	25	.553E-06	.285E+02	4	26	.291E-06	.964E+01	4	30	.123E-06	.294E+01	4	38	.419E-07	.895E+00	4	46	.170E-07	.312E+00
11.49	Q	62	0	0	80	.553E-06	.220E-01	0	80	.291E-06	.446E-02	0	80	.123E-06	.854E-03	0	80	.419E-07	.218E-03	0	80	.170E-07	.115E-03
11.57	Q	39	3	4	14	.559E-06	.635E+01	4	18	.294E-06	.175E+01	4	33	.123E-06	.437E+00	4	57	.420E-07	.115E+00	4	66	.170E-07	.414E-01
11.59	Q	64	0	0	80	.559E-06	.117E-01	0	80	.294E-06	.231E-02	0	80	.123E-06	.436E-03	0	80	.420E-07	.118E-03	0	80	.170E-07	.691E-04
11.66	Q	41	3	4	13	.565E-06	.437E+01	4	17	.295E-06	.118E+01	4	36	.124E-06	.288E+00	4	59	.420E-07	.750E-01	0	80	.171E-07	.271E-01
11.68	Q	66	0	0	80	.565E-06	.612E-02	0	80	.295E-06	.117E-02	0	80	.124E-06	.221E-03	0	80	.420E-07	.654E-04	0	80	.171E-07	.428E-04
11.69	Q	68	0	0	80	.565E-06	.313E-02	0	80	.295E-06	.581E-03	0	80	.124E-06	.111E-03	0	80	.420E-07	.373E-04	0	80	.171E-07	.273E-04
11.77	Q	43	3	4	12	.570E-06	.294E+01	4	17	.297E-06	.775E+00	4	40	.124E-06	.185E+00	4	62	.421E-07	.476E-01	0	80	.171E-07	.173E-01
11.79	Q	70	0	0	80	.570E-06	.157E-02	0	80	.297E-06	.284E-03	0	80	.124E-06	.564E-04	0	80	.421E-07	.222E-04	0	80	.171E-07	.180E-04
11.80	Q	72	0	0	80	.570E-06	.771E-03	0	80	.297E-06	.137E-03	0	80	.124E-06	.292E-04	0	80	.421E-07	.138E-04	0	80	.171E-07	.122E-04
11.87	Q	45	3	4	12	.574E-06	.193E+01	4	17	.298E-06	.498E+00	4	45	.124E-06	.116E+00	0	80	.421E-07	.295E-01	0	80	.171E-07	.108E-01
11.88	Q	74	0	0	80	.574E-06	.371E-03	0	80	.298E-06	.655E-04	0	80	.124E-06	.156E-04	0	80	.421E-07	.892E-05	0	80	.171E-07	.842E-05
11.95	Q	47	3	4	11	.577E-06	.124E+01	4	17	.299E-06	.312E+00	4	50	.124E-06	.713E-01	0	80	.421E-07	.178E-01	0	80	.171E-07	.664E-02
11.97	Q	76	0	0	80	.577E-06	.176E-03	0	80	.299E-06	.313E-04	0	80	.124E-06	.880E-05	0	80	.421E-07	.598E-05	0	80	.171E-07	.590E-05
12.03	R	2	3	4	26	.584E-06	.313E+02	4	27	.303E-06	.106E+02	4	30	.126E-06	.323E+01	4	38	.428E-07	.983E+00	4	46	.174E-07	.343E+00
12.05	Q	78	0	0	80	.584E-06	.820E-04	0	80	.303E-06	.152E-04	0	80	.126E-06	.523E-05	0	80	.428E-07	.411E-05	0	80	.174E-07	.417E-05
12.12	Q	49	3	4	11	.586E-06	.781E+00	4	17	.303E-06	.191E+00	4	54	.126E-06	.427E-01	0	80	.428E-07	.105E-01	0	80	.174E-07	.399E-02
12.13	Q	80	0	0	80	.586E-06	.378E-04	0	80	.303E-06	.754E-05	0	80	.126E-06	.328E-05	0	80	.428E-07	.287E-05	0	80	.174E-07	.297E-05
12.15	Q	82	0	0	80	.586E-06	.173E-04	0	80	.303E-06	.393E-05	0	80	.126E-06	.215E-05	0	80	.428E-07	.203E-05	0	80	.174E-07	.211E-05
12.21	Q	51	3	4	11	.587E-06	.480E+00	4	17	.303E-06	.114E+00	0	80	.126E-06	.249E-01	0	80	.428E-07	.607E-02	0	80	.174E-07	.235E-02
12.23	Q	84	0	0	80	.587E-06	.796E-05	0	80	.303E-06	.217E-05	0	80	.126E-06	.146E-05	0	80	.428E-07	.144E-05	0	80	.174E-07	.151E-05
12.28	Q	53	3	4	10	.588E-06	.289E+00	4	17	.303E-06	.870E-01	0	80	.126E-06	.142E-01	0	80	.428E-07	.343E-02	0	80	.174E-07	.137E-02
12.30	Q	86	0	0	80	.588E-06	.373E-05	0	80	.303E-06	.128E-05	0	80	.126E-06	.101E-05	0	80	.428E-07	.102E-05	0	80	.174E-07	.107E-05
12.31	Q	88	0	0	80	.588E-06	.181E-05	0	80	.303E-06	.799E-06	0	80	.126E-06	.704E-06	0	80	.428E-07	.724E-06	0	80	.174E-07	.762E-06
12.37	Q	55	3	4	10	.589E-06	.170E+00	4	18	.304E-06	.383E-01	0	80	.126E-06	.792E-02	0	80	.428E-07	.191E-02	0	80	.174E-07	.789E-03
12.44	R	3	3	4	26	.596E-06	.347E+02	4	27	.308E-06	.117E+02	4	31	.128E-06	.357E+01	4	38	.435E-07	.109E+01	4	46	.176E-07	.379E+00
12.46	Q	90	0	0	80	.596E-06	.927E-06	0	80	.308E-06	.522E-06	0	80	.128E-06	.494E-06	0	80	.435E-07	.513E-06	0	80	.176E-07	.540E-06
12.49	Q	92	0	0	80	.596E-06	.508E-06	0	80	.308E-06	.352E-06	0	80	.128E-06	.348E-06	0	80	.435E-07	.363E-06	0	80	.176E-07	.381E-06
12.51	Q	57	3	4	10	.596E-06	.977E-01	0	80	.308E-06	.214E-01	0	80	.128E-06	.432E-02	0	80	.435E-07	.104E-02	0	80	.176E-07	.453E-03
12.55	Q	94	0	0	80	.596E-06	.299E-06	0	80	.308E-06	.241E-06	0	80	.128E-06	.245E-06	0	80	.435E-07	.255E-06	0	80	.176E-07	.269E-06
12.60	Q	59	3	4	10	.596E-06	.550E-01	0	80	.308E-06	.117E-01	0	80	.128E-06	.231E-02	0	80	.435E-07	.562E-03	0	80	.176E-07	.261E-03
12.65	Q	61	3	4	10	.596E-06	.303E-01	0	80	.308E-06	.625E-02	0	80	.128E-06	.121E-02	0	80	.435E-07	.302E-03	0	80	.176E-07	.152E-03
12.72	R	4	3	4	27	.603E-06	.380E+02	4	28	.312E-06	.128E+02	4	31	.130E-06	.390E+01	4	38	.443E-07	.119E+01	4	46	.179E-07	.414E+00
12.74	Q	63	0	0	80	.603E-06	.164E-01	0	80	.312E-06	.327E-02	0	80	.130E-06	.622E-03	0	80	.443E-07	.163E-03	0	80	.179E-07	.900E-04
12.76	Q	65	0	0	80	.603E-06	.865E-02	0	80	.312E-06	.168E-02	0	80	.130E-06	.316E-03	0	80	.443E-07	.891E-04	0	80	.179E-07	.548E-04
12.78	Q	67	0	0	80	.603E-06	.447E-02	0	80	.312E-06	.842E-03	0	80	.130E-06	.160E-03	0	80	.443E-07	.499E-04	0	80	.179E-07	.345E-04
12.85	R	5	3	4	28	.610E-06	.412E+02	4	29	.316E-06	.139E+02	4	31	.132E-06	.422E+01	4	39	.451E-07	.128E+01	4	46	.183E-07	.447E+00
12.87	Q	69	0	0	80	.610E-06	.227E-02	0	80	.316E-06	.415E-03	0	80	.132E-06	.806E-04	0	80	.451E-07	.290E-04	0	80	.183E-07	.224E-04
[illegible]	Q	71	0	0	80	.610E-06	.113E-02	0	80	.316E-06	.202E-03	0	80	.132E-06	.412E-04	0	80	.451E-07	.116E-04	0	80	.183E-07	.150E-04

12.91	Q	73	0	0	80	.610E-06	.548E-03	0	80	.318E-06	.969E-04	0	80	.132E-06	.217E-04	0	80	.451E-07	.112E-04	0	80	.183E-07	.102E-04
12.98	R	8	3	4	28	.616E-06	.440E+02	4	29	.320E-06	.148E+02	4	32	.134E-06	.449E+01	4	39	.459E-07	.136E+01	4	47	.186E-07	.475E+00
13.00	Q	75	0	0	80	.616E-06	.262E-03	0	80	.320E-06	.463E-04	0	80	.134E-06	.119E-04	0	80	.459E-07	.737E-05	0	80	.186E-07	.712E-05
13.02	Q	77	0	0	80	.616E-06	.123E-03	0	80	.320E-06	.223E-04	0	80	.134E-06	.685E-05	0	80	.459E-07	.501E-05	0	80	.186E-07	.502E-05
13.11	R	7	4	5	29	.623E-06	.464E+02	5	30	.324E-06	.158E+02	5	32	.137E-06	.471E+01	5	39	.467E-07	.143E+01	5	47	.189E-07	.498E+00
13.13	Q	79	0	0	80	.623E-06	.571E-04	0	80	.324E-06	.109E-04	0	80	.137E-06	[illegible]	0	80	.467E-07	.347E-05	0	80	.189E-07	.356E-05
13.14	Q	81	0	0	80	.623E-06	.263E-04	0	80	.324E-06	.552E-05	0	80	.137E-06	.268E-05	0	80	.467E-07	.244E-05	0	80	.189E-07	.253E-05
13.16	Q	83	0	0	80	.623E-06	.120E-04	0	80	.324E-06	.295E-05	0	80	.137E-06	.179E-05	0	80	.467E-07	.173E-05	0	80	.189E-07	.181E-05
13.25	R	8	4	5	29	.629E-06	.483E+02	5	30	.328E-06	.162E+02	5	32	.139E-06	.489E+01	5	39	.476E-07	.148E+01	5	47	.193E-07	.516E+00
13.27	Q	85	0	0	80	.629E-06	.558E-05	0	80	.328E-06	.168E-05	0	80	.139E-06	.122E-05	0	80	.476E-07	.123E-05	0	80	.193E-07	.129E-05
13.29	Q	87	0	0	80	.629E-06	.265E-05	0	80	.328E-06	.102E-05	0	80	.139E-06	.852E-06	0	80	.476E-07	.870E-06	0	80	.193E-07	.916E-06
13.38	R	9	4	5	29	.636E-06	.498E+02	5	30	.332E-06	.166E+02	5	33	.141E-06	.502E+01	5	40	.484E-07	.152E+01	5	47	.197E-07	.529E+00
13.40	Q	89	0	0	80	.636E-06	.132E-05	0	80	.332E-06	.653E-06	0	80	.141E-06	.597E-06	0	80	.484E-07	.618E-06	0	80	.197E-07	.650E-06
13.42	Q	91	0	0	80	.636E-06	.696E-06	0	80	.332E-06	.434E-06	0	80	.141E-06	.420E-06	0	80	.484E-07	.437E-06	0	80	.197E-07	.460E-06
13.51	R	10	4	5	29	.643E-06	.507E+02	5	30	.336E-06	.169E+02	5	33	.143E-06	.509E+01	5	40	.493E-07	.153E+01	5	48	.200E-07	.535E+00
13.53	Q	93	0	0	80	.643E-06	.394E-06	0	80	.336E-06	.295E-06	0	80	.143E-06	.296E-06	0	80	.493E-07	.309E-06	0	80	.200E-07	.325E-06
13.61	R	11	4	5	29	.649E-06	.512E+02	5	31	.340E-06	.170E+02	5	33	.145E-06	.511E+01	5	40	.502E-07	.154E+01	5	48	.204E-07	.536E+00
13.71	R	12	4	5	29	.656E-06	.512E+02	5	31	.344E-06	.170E+02	5	33	.147E-06	.507E+01	5	40	.511E-07	.152E+01	5	48	.207E-07	.532E+00
13.80	R	13	4	5	29	.663E-06	.508E+02	5	31	.348E-06	.168E+02	5	33	.149E-06	.500E+01	5	40	.519E-07	.150E+01	5	48	.211E-07	.523E+00
13.89	R	14	4	5	29	.669E-06	.499E+02	5	30	.352E-06	.164E+02	5	33	.152E-06	.487E+01	5	41	.528E-07	.146E+01	5	49	.215E-07	.508E+00
13.98	R	15	4	5	29	.676E-06	.487E+02	5	30	.356E-06	.160E+02	5	33	.154E-06	.472E+01	5	41	.536E-07	.141E+01	5	49	.218E-07	.491E+00
14.07	R	16	4	5	29	.682E-06	.470E+02	5	30	.360E-06	.154E+02	5	33	.156E-06	.452E+01	5	41	.544E-07	.134E+01	5	49	.221E-07	.469E+00
14.16	R	17	4	5	28	.689E-06	.452E+02	5	30	.364E-06	.147E+02	5	33	.158E-06	.431E+01	5	41	.552E-07	.128E+01	5	50	.224E-07	.446E+00
14.25	R	18	4	5	28	.696E-06	.430E+02	5	29	.368E-06	.139E+02	5	32	.160E-06	.406E+01	5	42	.559E-07	.120E+01	5	50	.227E-07	.419E+00
14.34	R	19	4	5	27	.702E-06	.408E+02	5	29	.372E-06	.131E+02	5	32	.162E-06	.381E+01	5	42	.566E-07	.112E+01	5	51	.230E-07	.392E+00
14.41	R	20	3	4	27	.709E-06	.382E+02	4	28	.376E-06	.122E+02	4	32	.164E-06	.353E+01	4	42	.573E-07	.104E+01	4	51	.233E-07	.362E+00
14.49	R	21	3	4	26	.715E-06	.357E+02	4	27	.380E-06	.114E+02	4	32	.166E-06	.327E+01	4	43	.579E-07	.953E+00	4	52	.235E-07	.334E+00
14.56	R	22	3	4	25	.722E-06	.330E+02	4	27	.384E-06	.105E+02	4	31	.168E-06	.299E+01	4	43	.585E-07	.868E+00	4	52	.237E-07	.304E+00
14.63	R	23	3	4	25	.729E-06	.305E+02	4	26	.388E-06	.958E+01	4	31	.169E-06	.272E+01	4	43	.590E-07	.787E+00	4	53	.240E-07	.276E+00
14.70	R	24	3	4	24	.735E-06	.278E+02	4	25	.392E-06	.868E+01	4	31	.171E-06	.245E+01	4	44	.595E-07	.706E+00	4	53	.241E-07	.248E+00
14.78	R	25	3	4	23	.742E-06	.253E+02	4	25	.396E-06	.786E+01	4	31	.173E-06	.220E+01	4	44	.600E-07	.632E+00	4	54	.243E-07	.222E+00
14.85	R	26	3	4	22	.748E-06	.228E+02	4	24	.400E-06	.702E+01	4	30	.174E-06	.198E+01	4	45	.604E-07	.558E+00	4	55	.245E-07	.196E+00
14.93	R	27	3	4	21	.755E-06	.205E+02	4	23	.403E-06	.628E+01	4	30	.176E-06	.174E+01	4	46	.608E-07	.493E+00	4	55	.246E-07	.173E+00
15.00	R	28	3	4	20	.761E-06	.182E+02	4	22	.407E-06	.553E+01	4	30	.177E-06	.152E+01	4	46	.611E-07	.429E+00	4	56	.247E-07	.151E+00
15.07	R	29	3	4	20	.768E-06	.162E+02	4	22	.410E-06	.488E+01	4	30	.178E-06	.133E+01	4	47	.614E-07	.374E+00	4	57	.248E-07	.132E+00
15.15	R	30	3	4	19	.774E-06	.142E+02	4	21	.414E-06	.425E+01	4	30	.179E-06	.115E+01	4	48	.617E-07	.321E+00	4	58	.249E-07	.113E+00
15.22	R	31	3	4	18	.781E-06	.125E+02	4	20	.417E-06	.370E+01	4	30	.180E-06	.994E+00	4	49	.619E-07	.276E+00	4	58	.250E-07	.975E-01
15.30	R	32	3	4	17	.787E-06	.108E+02	4	20	.420E-06	.318E+01	4	30	.181E-06	.846E+00	4	50	.621E-07	.234E+00	4	59	.251E-07	.827E-01
15.37	R	33	3	4	16	.793E-06	.938E+01	4	19	.423E-06	.274E+01	4	30	.182E-06	.723E+00	4	51	.623E-07	.198E+00	4	60	.251E-07	.703E-01
15.45	R	34	3	4	16	.799E-06	.803E+01	4	19	.426E-06	.232E+01	4	30	.183E-06	.607E+00	4	52	.624E-07	.166E+00	4	61	.252E-07	.588E-01
15.52	R	35	3	4	15	.805E-06	.689E+01	4	18	.429E-06	.198E+01	4	30	.183E-06	.512E+00	4	53	.625E-07	.139E+00	4	62	.252E-07	.494E-01
15.60	R	36	3	4	14	.811E-06	.583E+01	4	18	.431E-06	.165E+01	4	31	.184E-06	.424E+00	4	54	.626E-07	.114E+00	4	64	.252E-07	.407E-01
15.67	R	38	3	4	13	.817E-06	.413E+01	4	17	.433E-06	.115E+01	4	32	.184E-06	.289E+00	4	56	.627E-07	.769E-01	0	80	.253E-07	.275E-01
15.75	R	37	3	4	14	.822E-06	.495E+01	4	18	.435E-06	.139E+01	4	31	.184E-06	.354E+00	4	55	.628E-07	.947E-01	4	65	.253E-07	.338E-01
15.82	R	40	3	4	13	.827E-06	.286E+01	4	17	.436E-06	.780E+00	4	35	.185E-06	.193E+00	4	59	.628E-07	.505E-01	0	80	.253E-07	.182E-01
15.89	R	39	3	4	13	.832E-06	.347E+01	4	17	.438E-06	.956E+00	4	33	.185E-06	.239E+00	4	58	.629E-07	.630E-01	0	80	.253E-07	.226E-01
15.97	R	42	3	4	12	.836E-06	.194E+01	4	17	.439E-06	.517E+00	4	40	.185E-06	.125E+00	4	62	.629E-07	.323E-01	0	80	.253E-07	.117E-01
16.04	R	41	3	4	12	.840E-06	.238E+01	4	17	.440E-06	.641E+00	4	37	.185E-06	.157E+00	4	60	.629E-07	.408E-01	0	80	.254E-07	.147E-01
16.10	R	44	3	4	11	.844E-06	.128E+01	4	17	.441E-06	.334E+00	4	45	.186E-06	.790E-01	0	80	.629E-07	.201E-01	0	80	.254E-07	.737E-02
16.16	R	43	3	4	12	.847E-06	.159E+01	4	17	.442E-06	.420E+00	4	42	.186E-06	.100E+00	0	80	.630E-07	.258E-01	0	80	.254E-07	.939E-02
16.22	R	46	3	4	11	.850E-06	.832E+00	4	16	.442E-06	.211E+00	4	50	.186E-06	.488E-01	0	80	.630E-07	.123E-01	0	80	.254E-07	.454E-02
16.28	R	45	3	4	11	.852E-06	.105E+01	4	16	.443E-06	.269E+00	4	48	.186E-06	.629E-01	0	80	.630E-07	.159E-01	0	80	.254E-07	.585E-02
16.33	R	48	3	4	11	.854E-06	.527E+00	4	16	.443E-06	.130E+00	0	80	.186E-06	.294E-01	0	80	.630E-07	.729E-02	0	80	.254E-07	.274E-02
16.40	R	47	3	4	11	.856E-06	.670E+00	4	16	.443E-06	.168E+00	4	52	.186E-06	.384E-01	0	80	.630E-07	.958E-02	0	80	.254E-07	.357E-02
16.45	R	50	3	4	11	.857E-06	.326E+00	4	17	.444E-06	.787E-01	0	80	.186E-06	.173E-01	0	80	.630E-07	.424E-02	0	80	.254E-07	.163E-02
16.50	R	49	3	4	11	.858E-06	.420E+00	4	17	.444E-06	.103E+00	0	80	.186E-06	.229E-01	0	80	.630E-07	.564E-02	0	80	.254E-07	.214E-02
16.56	R	52	3	4	10	.859E-06	.198E+00	4	17	.444E-06	.464E-01	0	80	.186E-06	.997E-02	0	80	.630E-07	.242E-02	0	80	.254E-07	.949E-03
16.61	R	51	3	4	10	.860E-06	.257E+00	4	17	.444E-06	.613E-01	0	80	.186E-06	.133E-01	0	80	.630E-07	.325E-02	0	80	.254E-07	.126E-02
16.66	R	54	3	4	10	.860E-06	.117E+00	0	80	.444E-06	.268E-01	0	80	.186E-06	.560E-02	0	80	.630E-07	.135E-02	0	80	.254E-07	.548E-03
16.72	R	53	3	4	10	.861E-06	.154E+00	4	17	.444E-06	.358E-01	0	80	.186E-06	.759E-02	0	80	.630E-07	.183E-02	0	80	.254E-07	.731E-03
16.77	R	56	3	4	10	.861E-06	.679E-01	0	80	.444E-06	.151E-01	0	80	.186E-06	.308E-02	0	80	.630E-07	.740E-03	0	80	.254E-07	.314E-03
16.82	R	55	3	4	10	.861E-06	.906E-01	0	80	.444E-06	.204E-01	0	80	.186E-06	.422E-02	0	80	.630E-07	.107E-02	0	80	.254E-07	.420E-03
16.87	R	58	3	4	10	.861E-06	.386E-01	0	80	.444E-06	.831E-02	0	80	.186E-06	.166E-02	0	80	.630E-07	.401E-03	0	80	.254E-07	.180E-03

16.92	R	57	3	4	10	.862E-06	.520E-01	0	80	.444E-08	.114E-01	0	80	.186E-08	.230E-02	0	80	.630E-07	.553E-03	0	80	.254E-07	.241E-03
16.94	R	60	0	0	80	.862E-06	.214E-01	0	80	.444E-08	.448E-02	0	80	.186E-08	.873E-03	0	80	.630E-07	.215E-03	0	80	.254E-07	.104E-03
16.95	R	59	0	0	80	.862E-06	.293E-01	0	80	.444E-08	.821E-02	0	80	.186E-08	.122E-02	0	80	.630E-07	.298E-03	0	80	.254E-07	.138E-03
16.97	R	62	0	0	80	.862E-06	.117E-01	0	80	.444E-08	.236E-02	0	80	.186E-08	.452E-03	0	80	.630E-07	.115E-03	0	80	.254E-07	.608E-04
16.99	R	61	0	0	80	.862E-06	.181E-01	0	80	.444E-08	.331E-02	0	80	.186E-08	.640E-03	0	80	.630E-07	.160E-03	0	80	.254E-07	.803E-04
17.00	R	64	0	0	80	.862E-06	.821E-02	0	80	.444E-08	.122E-02	0	80	.186E-08	.231E-03	0	80	.630E-07	.625E-04	0	80	.254E-07	.365E-04
17.02	R	63	0	0	80	.862E-06	.867E-02	0	80	.444E-08	.173E-02	0	80	.186E-08	.329E-03	0	80	.630E-07	.861E-04	0	80	.254E-07	.476E-04
17.04	R	66	0	0	80	.862E-06	.324E-02	0	80	.444E-08	.817E-03	0	80	.186E-08	.118E-03	0	80	.630E-07	.345E-04	0	80	.254E-07	.276E-04
17.05	R	68	0	0	80	.862E-06	.165E-02	0	80	.444E-08	.306E-03	0	80	.186E-08	.588E-04	0	80	.630E-07	.197E-04	0	80	.254E-07	.144E-04
17.07	R	65	0	0	80	.862E-06	.457E-02	0	80	.444E-08	.885E-03	0	80	.186E-08	.187E-03	0	80	.630E-07	.470E-04	0	80	.254E-07	.289E-04
17.09	R	70	0	0	80	.862E-06	.827E-03	0	80	.444E-08	.150E-03	0	80	.186E-08	.297E-04	0	80	.630E-07	.117E-04	0	80	.254E-07	.948E-05
17.11	R	67	0	0	80	.862E-06	.236E-02	0	80	.444E-08	.444E-03	0	80	.186E-08	.841E-04	0	80	.630E-07	.263E-04	0	80	.254E-07	.187E-04
17.12	R	72	0	0	80	.862E-06	.408E-03	0	80	.444E-08	.720E-04	0	80	.186E-08	.153E-04	0	80	.630E-07	.724E-05	0	80	.254E-07	.641E-05
17.14	R	69	0	0	80	.862E-06	.120E-02	0	80	.444E-08	.219E-03	0	80	.186E-08	.424E-04	0	80	.630E-07	.153E-04	0	80	.254E-07	.118E-04
17.16	R	74	0	0	80	.862E-06	.195E-03	0	80	.444E-08	.344E-04	0	80	.186E-08	.821E-05	0	80	.630E-07	.468E-05	0	80	.254E-07	.442E-05
17.17	R	71	0	0	80	.862E-06	.593E-03	0	80	.444E-08	.106E-03	0	80	.186E-08	.217E-04	0	80	.630E-07	.927E-05	0	80	.254E-07	.787E-05
17.19	R	76	0	0	80	.862E-06	.923E-04	0	80	.444E-08	.164E-04	0	80	.186E-08	.481E-05	0	80	.630E-07	.313E-05	0	80	.254E-07	.309E-05
17.21	R	73	0	0	80	.862E-06	.288E-03	0	80	.444E-08	.509E-04	0	80	.186E-08	[illegible]4E-04	0	80	.630E-07	.587E-05	0	80	.254E-07	.537E-05
17.23	R	78	0	0	80	.862E-06	.430E-04	0	80	.444E-08	.794E-05	0	80	.186E-08	.[illegible]4E-05	0	80	.630E-07	.215E-05	0	80	.254E-07	.219E-05
17.24	R	75	0	0	80	.862E-06	.138E-03	0	80	.444E-08	.243E-04	0	80	.186E-08	.[illegible]23E-05	0	80	.630E-07	.387E-05	0	80	.254E-07	.374E-05
17.26	R	80	0	0	80	.862E-06	.198E-04	0	80	.444E-08	.395E-05	0	80	.186E-08	.172E-05	0	80	.630E-07	.150E-05	0	80	.254E-07	.155E-05
17.28	R	77	0	0	80	.862E-06	.647E-04	0	80	.444E-08	.117E-04	0	80	.186E-08	.359E-05	0	80	.630E-07	.262E-05	0	80	.254E-07	.263E-05
17.29	R	82	0	0	80	.862E-06	.906E-05	0	80	.444E-08	.205E-05	0	80	.186E-08	.112E-05	0	80	.630E-07	.106E-05	0	80	.254E-07	.110E-05
17.31	R	79	0	0	80	.862E-06	.300E-04	0	80	.444E-08	.570E-05	0	80	.186E-08	.219E-05	0	80	.630E-07	.182E-05	0	80	.254E-07	.186E-05
17.33	R	84	0	0	80	.862E-06	.416E-05	0	80	.444E-08	.113E-05	0	80	.186E-08	.781E-06	0	80	.630E-07	.750E-06	0	80	.254E-07	.787E-06
17.35	R	81	0	0	80	.862E-06	.138E-04	0	80	.444E-08	.289E-05	0	80	.186E-08	.140E-05	0	80	.630E-07	.128E-05	0	80	.254E-07	.132E-05
17.36	R	86	0	0	80	.862E-06	.195E-05	0	80	.444E-08	.667E-06	0	80	.186E-08	.525E-06	0	80	.630E-07	.532E-06	0	80	.254E-07	.559E-06
17.38	R	88	0	0	80	.862E-06	.944E-06	0	80	.444E-08	.416E-06	0	80	.186E-08	.367E-06	0	80	.630E-07	.377E-06	0	80	.254E-07	.397E-06
17 [illegible]0	R	83	0	0	80	.862E-06	.630E-05	0	80	.444E-08	.154E-05	0	80	.186E-08	.934E-06	0	80	.630E-07	.901E-06	0	80	.254E-07	.943E-06
17.42	R	90	0	0	80	.862E-06	.483E-06	0	80	.444E-08	.272E-06	0	80	.186E-08	.257E-06	0	80	.630E-07	.267E-06	0	80	.254E-07	.281E-06
17.43	R	85	0	0	80	.862E-06	.292E-05	0	80	.444E-08	.878E-06	0	80	.186E-08	.639E-06	0	80	.630E-07	.640E-06	0	80	.254E-07	.672E-06
17.45	R	92	0	0	80	.862E-06	.265E-06	0	80	.444E-08	.183E-06	0	80	.186E-08	.181E-06	0	80	.630E-07	.189E-06	0	80	.254E-07	.199E-06
17.47	R	87	0	0	80	.862E-06	.138E-05	0	80	.444E-08	.532E-06	0	80	.186E-08	.444E-06	0	80	.630E-07	.454E-06	0	80	.254E-07	.478E-06
17.49	R	89	0	0	80	.862E-05	.687E-06	0	80	.444E-08	.340E-05	0	80	.186E-08	.311E-06	0	80	.630E-07	.322E-06	0	80	.254E-07	.339E-06
17.50	R	91	0	0	80	.862E-06	.362E-06	0	80	.444E-08	.226E-[illegible]	0	80	.186E-08	.219E-06	0	80	.630E-07	.228E-06	0	80	.254E-07	.240E-06
17.52	R	93	0	0	80	.862E-06	.205E-06	0	80	.444E-08	.154E-06	0	80	.186E-08	.154E-06	0	80	.630E-07	.161E-06	0	80	.254E-07	.169E-06

A6. Unit 6: Output From Sample Run 1

Diagnostic program output from Sample Run 1 is given on the next page. No extraordinary conditions were encountered; therefore, this output is confined to listing headers and card-images from the four input files.

```
PROGRAM NLTE FOR INFRARED RADIANCE
DATE = 85/09/04.   TIME =  09.21.02.

*****************************************  ***********************
TAPE6

PRINT THE HEADERS AND FIRST DATA CARD-IMAGES FOUND ON INPUT UNITS


UNIT 1:
CIC3TP12---SAMPLE RUN 1, TAPE1---CO2 NU2 15UM 626 HOT BAND                                          (HEADER)
111111111122722222222233333333333444444444455555555556666666666777777777778888888888                (FORMAT)
'CO2', 626, '02201','01101'/                                                                        (DATA)

UNIT 2:
CA04025  ATMOS PROFILE 7/16/85                                                                      (HEADER)
C         ALT,TRTMP,RHO,TVL,TVU,TVQ---ALL TVS SAME AS ON A0201S                                     (HEADER)
C         VIB TEMPS FROM BULLITT'S NU2 MODELLING USING O QUENCHING AND SPIRE DATA                   (HEADER)
CCO2       02201     01101  65-249 KM                                                               (HEADER)
AAAAABBBBBBBBBBCCCCCCCCCCCCDDDDDDDDDDDDEEEEEEEEEEEEFFFFFFFFFFFFGGGGGGGGGGGG---------------          (FORMAT)
   65    233.294   .10397E+13   .22829E+03   .22829E+03   .22829E+03                                (DATA)
 ALT      TR TEMP   TOT # DENS   LST V TEMP   UST V TEMP   1ST V TEMP                               (INTERP)

UNIT 3:
CL020010 CO2 ALL    02201     01101 08/15/85 15UM NU2 HOT BAND                                      (HEADER)
1111111111222222222223333333333344444444445555555555666666666677777777777888888888                  (FORMAT)
 590.07000 3.750E-27.0550   3054.161    02201    01101                     P 78 482 636  2          (DATA)


UNIT 7:
CXXXXXXX BAND RADIANCE       ---NLTE OUTPUT                                                         (HEADER)
CCO2 626    01101    00001 A --- 85/09/04. 08.53.33.                                                (HEADER)
CCO2 636    01101    00001 A --- 85/09/04. 08.55.01.                                                (HEADER)
CCO2 628    01101    00001 A --- 85/09/04. 08.55.53.                                                (HEADER)
111111111122222222222333333333334444444444555555555566666666666777777777778888888888                (FORMAT)
     .270     .050 UM       LIMB LOOK; HTS (KM) =  70.00  75.00  80.00  85.00  90.00                (DATA)
```

A7. Unit 7: Output From Sample Run 1

The unit 7 output from Sample Run 1 is given below. Note that the information, although not given in the same format, is the same as that given at the end of unit 4.

```
CXXXXXXX BAND RADIANCE       ---NLTE OUTPUT
 CCO2  626   01101    00001 A --- 85/09/04. 08.53.33.
 CCO2  636   01101    00001 A --- 85/09/04. 08.55.01.
 CCO2  628   01101    00001 A --- 85/09/04. 08.55.53.
 CCO2  626   02201    01101 A --- 85/09/04. 09.21.02.
       270   .050 UM        LIMB LOOK: HTS (KM) =  70.00   75.00   80.00   85.00   90.00
   4         3.171E-06 1.514E-06 7.420E-07 4.029E-07 2.798E-07
     13.050  4.242E-15 4.356E-15 4.531E-15 4.733E-15 4.965E-15
     13.100  3.992E-14 4.070E-14 4.231E-14 4.421E-14 4.639E-14
     13.150  1.444E-13 1.446E-13 1.502E-13 1.570E-13 1.647E-13
     13.200  3.786E-13 3.652E-13 3.778E-13 3.947E-13 4.145E-13
     13.250  8.678E-13 7.791E-13 7.996E-13 8.352E-13 8.775E-13
     13.300  2.075E-12 1.593E-12 1.600E-12 1.668E-12 1.754E-12
     13.350  5.234E-12 3.096E-12 2.955E-12 3.065E-12 3.222E-12
     13.400  1.419E-11 6.058E-12 5.229E-12 5.359E-12 5.630E-12
     13.450  4.517E-11 1.335E-11 9.378E-12 9.290E-12 9.730E-12
     13.500  1.382E-10 3.168E-11 1.687E-11 1.565E-11 1.626E-11
     13.550  4.422E-10 8.802E-11 3.329E-11 2.702E-11 2.750E-11
     13.600  1.325E-09 2.521E-10 7.173E-11 4.734E-11 4.616E-11
     13.650  3.648E-09 7.097E-10 1.683E-10 8.685E-11 7.852E-11
     13.700  9.222E-09 1.979E-09 4.324E-10 1.740E-10 1.395E-10
     13.750  1.961E-08 4.807E-09 1.064E-09 3.599E-10 2.521E-10
     13.800  3.698E-08 1.068E-08 2.631E-09 8.189E-10 4.962E-10
     13.850  6.097E-08 1.989E-08 5.562E-09 1.746E-09 9.626E-10
     13.900  9.288E-08 3.353E-08 1.075E-08 3.694E-09 1.970E-09
     13.950  1.312E-07 5.072E-08 1.802E-08 6.824E-09 3.714E-09
     14.000  1.750E-07 7.137E-08 2.769E-08 1.163E-08 6.703E-09
     14.050  2.241E-07 9.433E-08 3.911E-08 1.792E-08 1.095E-08
     14.100  2.786E-07 1.190E-07 5.179E-08 2.579E-08 1.680E-08
     14.150  3.402E-07 1.464E-07 6.517E-08 3.471E-08 2.392E-08
     14.200  4.102E-07 1.770E-07 7.930E-08 4.430E-08 3.224E-08
     14.250  4.890E-07 2.127E-07 9.491E-08 5.435E-08 4.117E-08
     14.300  5.796E-07 2.543E-07 1.128E-07 6.490E-08 5.052E-08
     14.350  6.799E-07 3.015E-07 1.336E-07 7.616E-08 6.002E-08
     14.400  7.909E-07 3.542E-07 1.578E-07 8.831E-08 6.952E-08
     14.450  9.095E-07 4.109E-07 1.853E-07 1.017E-07 7.912E-08
     14.500  1.031E-06 4.686E-07 2.149E-07 1.160E-07 8.843E-08
```

14.550	1.150E-06	5.266E-07	2.459E-07	1.313E-07	9.778E-08
14.600	1.257E-06	5.803E-07	2.759E-07	1.463E-07	1.063E-07
14.650	1.357E-06	6.321E-07	3.052E-07	1.609E-07	1.143E-07
14.700	1.514E-06	7.135E-07	3.485E-07	1.837E-07	1.280E-07
14.750	2.050E-06	9.619E-07	4.769E-07	2.585E-07	1.829E-07
14.800	2.596E-06	1.209E-06	6.039E-07	3.345E-07	2.399E-07
14.850	3.217E-06	1.496E-06	7.471E-07	4.161E-07	2.990E-07
14.900	3.862E-06	1.798E-06	8.972E-07	5.010E-07	3.601E-07
14.950	4.427E-06	2.059E-06	1.028E-06	5.771E-07	4.158E-07
15.000	4.384E-06	2.046E-06	1.020E-06	5.709E-07	4.084E-07
15.050	3.979E-06	1.883E-06	9.354E-07	5.146E-07	3.606E-07
15.100	3.491E-06	1.682E-0[illegible]	8.366E-07	4.534E-07	3.110E-07
15.150	2.859E-06	1.393E-06	[illegible].941E-07	3.730E-07	2.532E-07
15.200	2.303E-06	1.151E-06	5.783E-07	3.078E-07	2.049E-07
15.250	1.881E-06	9.742E-07	4.935E-07	2.593E-07	1.686E-07
15.300	1.828E-06	9.529E-07	4.867E-07	2.597E-07	1.714E-07
15.350	1.762E-06	9.216E-07	4.723E-07	2.558E-07	1.715E-07
15.400	1.767E-06	9.326E-07	4.779E-07	2.610E-07	1.751E-07
15.450	1.642E-06	8.632E-07	4.373E-07	2.398E-07	1.619E-07
15.500	1.474E-06	7.655E-07	3.815E-07	2.098E-07	1.424E-07
15.550	1.301E-06	6.629E-07	3.258E-07	1.806E-07	1.236E-07
15.600	1.113E-06	5.539E-07	2.696E-07	1.514E-07	1.041E-07
15.650	9.242E-07	4.464E-07	2.158E-07	1.224E-07	8.440E-08
15.700	7.829E-07	3.699E-07	1.791E-07	1.015E-07	6.884E-08
15.750	6.816E-07	3.236E-07	1.601E-07	9.031E-08	5.947E-08
15.800	5.902E-07	2.842E-07	1.429E-07	7.874E-08	4.978E-08

15.850	5.096E-07	2.506E-07	1.263E-07	6.678E-08	4.012E-08
15.900	4.399E-07	2.205E-07	1.090E-07	5.448E-08	3.085E-08
15.950	3.825E-07	1.933E-07	9.225E-08	4.310E-08	2.294E-08
16.000	3.323E-07	1.660E-07	7.511E-08	3.258E-08	1.631E-08
16.050	2.856E-07	1.384E-07	5.868E-08	2.358E-08	1.113E-08
16.100	2.414E-07	1.117E-07	4.408E-08	1.643E-08	7.376E-09
16.150	1.981E-07	8.640E-08	3.154E-08	1.096E-08	4.738E-09
16.200	1.566E-07	6.382E-08	2.161E-08	7.082E-09	2.984E-09
16.250	1.192E-07	4.516E-08	1.423E-08	4.427E-09	1.833E-09
16.300	8.642E-08	3.039E-08	8.926E-09	2.647E-09	1.086E-09
16.350	6.017E-08	1.974E-08	5.455E-09	1.561E-09	6.422E-10
16.400	4.003E-08	1.223E-08	3.180E-09	8.840E-10	3.684E-10
16.450	2.513E-08	7.116E-09	1.749E-09	4.764E-10	2.038E-10
16.500	1.511E-08	3.993E-09	9.373E-10	2.530E-10	1.125E-10
16.550	8.691E-09	2.168E-09	4.916E-10	1.332E-10	6.221E-11
16.600	4.706E-09	1.115E-09	2.458E-10	6.751E-11	3.373E-11
16.650	2.389E-09	5.402E-10	1.163E-10	3.303E-11	1.810E-11
16.700	1.209E-09	2.637E-10	5.587E-11	1.685E-11	1.018E-11
16.750	5.932E-10	1.250E-10	2.640E-11	8.662E-12	5.800E-12
16.800	2.764E-10	5.628E-11	1.207E-11	4.447E-12	3.304E-12
16.850	1.211E-10	2.397E-11	5.357E-12	2.308E-12	1.900E-12
16.900	5.418E-11	1.052E-11	2.499E-12	1.249E-12	1.105E-12
16.950	2.377E-11	4.563E-12	1.180E-12	6.810E-13	6.359E-13
17.000	9.953E-12	1.908E-12	5.566E-13	3.706E-13	3.609E-13
17.050	3.937E-12	7.681E-13	2.634E-13	2.003E-13	2.011E-13
17.100	1.557E-12	3.171E-13	1.304E-13	1.098E-13	1.125E-13
17.150	6.327E-13	1.416E-13	7.173E-14	6.547E-14	6.792E-14
17.200	2.462E-13	6.311E-14	3.871E-14	3.726E-14	3.893E-14
17.250	8.992E-14	2.731E-14	1.960E-14	1.952E-14	2.047E-14
17.300	2.905E-14	1.073E-14	8.700E-15	8.843E-15	9.293E-15
17.350	8.673E-15	3.710E-15	3.215E-15	3.299E-15	3.469E-15
17.400	1.528E-15	7.298E-16	6.577E-16	6.784E-15	7.137E-16

A8. Command File for Sample Run 1

The following CYBER commands access permanent files (containing the NLTE binary and the input data), run the program, and copy the results to a line printer. The commands following EXIT allow for abnormal termination.

```
JOB...
USER...
CHARGE...
COMMENT.
COMMENT.    NLTE SAMPLE RUN 1       AUGUST 1985
COMMENT.    CO2 626 02201-01101  HOT BAND 15UM
COMMENT.    ADD SYNTH SPECTRA FROM NU2 FUND'LS
COMMENT.
GET,BIN=NLTEBIN.
GET,TAPE1=TC3TP12,TAPE2=A0402S,TAPE3=L020010,SPECF=SAMP2DP.
BIN.
COPYCF(TAPE4,OUTPUT)
COPYCF(TAPE5,OUTPUT)
COPYCF(TAPE6,OUTPUT)
COPYSBF(SPECF,OUTPUT)
EXIT.
REWIND(TAPE4,TAPE5,TAPE6,SPECF)
COPYCF(TAPE4,OUTPUT)
COPYCF(TAPE5,OUTPUT)
COPYCF(TAPE6,OUTPUT)
COPYSBF(SPECF,OUTPUT)
```

Appendix B

Sample Run 2: Single Line

Appendix B contains Sample Run 2, in which the limb radiance due to a single ro-vibrational transition in one of the 101 combination bands of CO_2 near 2.7μm is evaluated. Four viewing paths with tangent heights between 70 and 100 km are considered. The line chosen is one of the thickest lines in the band. The job ran in 2.6 seconds on the CYBER 750. Devault values were used for all program parameters. The errors for the radiance (determined as in Appendix A) are 0.10%, .057%, 0.06%, and 0.41% for the four viewing paths.

B1. Unit 1: Input for Sample Run 2

```
'CO2', 626, '10012', '00001', 'R', 14
70, 100, 10
/
/
```

PRECEDING PAGE BLANK-NOT FILMED

B2. Unit 2: Input for Sample Run 2

The beginning of the file defining the atmospheric profile used for Sample Run 2 is given below. The file contained data from 40 to 160 km; only that at 70 km or above was used, except that the input option was determined from the 40-km data. Input option 3 was used in this case because the information in fields 3-6 consists of number densities.

```
CA1701    ATMOS PROFILE 06/10/85
C         ALT,TRTMP,NL,NU,NO,N1---DATA FROM VSIM, IRR---FORMERLY AT101G1
CCO2 626    10012    00001   40-160 KM
   40    251.060  .25034E+14  .25415E+05  .25034E+14  .10925E+13
   41    253.435  .21636E+14  .26519E+05  .21636E+14  .97831E+12
   42    255.810  .18700E+14  .27670E+05  .18700E+14  .87605E+12
   43    258.185  .16213E+14  .28737E+05  .16213E+14  .78596E+12
   44    260.560  .14056E+14  .29846E+05  .14056E+14  .70513E+12
   45    262.150  .12230E+14  .29159E+05  .12230E+14  .62725E+12
   46    263.740  .10641E+14  .28487E+05  .10641E+14  .55797E+12
   47    265.225  .93127E+13  .27679E+05  .93127E+13  .49831E+12
   48    266.710  .81506E+13  .26893E+05  .81506E+13  .44503E+12
   49    266.930  .71968E+13  .24042E+05  .71968E+13  .39409E+12
   50    267.150  .63547E+13  .21494E+05  .63547E+13  .34899E+12
   51    265.555  .56342E+13  .16974E+05  .56342E+13  .30273E+12
   52    263.960  .49955E+13  .13404E+05  .49955E+13  .26260E+12
   53    261.210  .44582E+13  .98753E+04  .44582E+13  .22544E+12
   54    258.460  .39787E+13  .72756E+04  .39787E+13  .19354E+12
   55    255.705  .35421E+13  .54637E+04  .35421E+13  .16544E+12
   56    252.950  .31535E+13  .41031E+04  .31535E+13  .14142E+12
   57    250.200  .28003E+13  .32335E+04  .28003E+13  .12038E+12
   58    247.450  .24867E+13  .25482E+04  .24867E+13  .10247E+12
   59    244.700  .22024E+13  .21592E+04  .22024E+13  .86823E+11
   60    241.950  .19506E+13  .18295E+04  .19506E+13  .73564E+11
   61    239.200  .17228E+13  .16620E+04  .17228E+13  .62027E+11
   62    236.450  .15215E+13  .15098E+04  .15215E+13  .52299E+11
   63    233.695  .13399E+13  .14565E+04  .13399E+13  .43868E+11
   64    230.940  .11800E+13  .14051E+04  .11800E+13  .36796E+11
   65    228.190  .10360E+13  .14114E+04  .10360E+13  .30704E+11
   66    225.440  .90964E+12  .14178E+04  .90964E+12  .25620E+11
   67    222.690  .79611E+12  .14649E+04  .79611E+12  .21262E+11
   68    219.940  .69675E+12  .15135E+04  .69675E+12  .17645E+11
   69    218.050  .60752E+12  .16079E+04  .60752E+12  .14807E+11
   70    216.160  .52972E+12  .17081E+04  .52972E+12  .12425E+11
```

B3. Unit 3: Input for Sample Run 2

The beginning of the file containing the 10012-00001 transitions needed for Sample Run 2 is given below. Ro-vibrational lines corresponding to bands or isotopes which are not needed are ignored. In fact, since this is a single-line run, the file could consist of just the one card-image corresponding to the transition under consideration.

```
CL101000  CO2 ALL     10012      00001 06/21/85  2.7UM REGULAR 101 COMBINATION BANDS
C                     10011      00001
 3434.7011 3.807E-27.0590  1482.576    10012    00001                  P 63 482 638  2
 3435.7364 4.693E-27.0590  1436.304    10012    00001                  P 62 482 638  2
 3436.7667 5.763E-27.0600  1390.763    10012    00001                  P 61 482 638  2
 3437.7919 7.050E-27.0600  1345.952    10012    00001                  P 60 482 638  2
 3438.8120 8.591E-27.0600  1301.873    10012    00001                  P 59 482 638  2
 3439.8272 1.043E-26.0610  1256.525    10012    00001                  P 58 482 636  2
 3440.8373 1.261E-26.0610  1215.908    10012    00001                  P 57 482 636  2
 3441.8423 1.519E-26.0610  1174.024    10012    00001                  P 56 482 636  2
 3442.8424 1.623E-26.0620  1132.871    10012    00001                  P 55 482 636  2
 3443.8375 2.179E-26.0620  1092.450    10012    00001                  P 54 482 638  2
 3444.8277 2.595E-26.0620  1052.761    10012    00001                  P 53 482 638  2
 3445.8128 3.078E-26.0620  1013.804    10012    00001                  P 52 482 638  2
 3446.0415 3.974E-27.0530  2779.506    10012    00001                  P 84 482 636  2
 3446.7930 3.636E-26.0630   975.580    10012    00001                  P 51 482 638  2
 3447.7683 4.278E-26.0630   938.089    10012    00001                  P 50 482 638  2
 3448.4041 7.293E-27.0530  2649.787    10012    00001                  P 82 482 636  2
 3448.7386 5.014E-26.0630   901.330    10012    00001                  P 49 482 638  2
 3449.7041 5.854E-26.0640   865.304    10012    00001                  P 48 482 638  2
 3450.6646 6.806E-26.0640   830.011    10012    00001                  P 47 482 638  2
 3450.7441 1.318E-26.0540  2523.146    10012    00001                  P 80 482 636  2
 3451.6202 7.882E-26.0640   795.451    10012    00001                  P 46 482 638  2
 3452.5709 9.091E-26.0650   761.625    10012    00001                  P 45 482 638  2
 3453.0616 2.344E-26.0550  2399.586    10012    00001                  P 78 482 636  2
 3453.5168 1.044E-25.0650   728.532    10012    00001                  P 44 482 638  2
 3454.4577 1.195E-25.0650   696.172    10012    00001                  P 43 482 638  2
 3455.3568 4.105E-26.0550  2279.108    10012    00001                  P 76 482 636  2
 3455.3938 1.361E-25.0650   664.547    10012    00001                  P 42 482 638  2
 3456.3251 1.545E-25.0660   633.655    10012    00001                  P 41 482 638  2
 3457.2515 1.745E-25.0660   603.497    10012    00001                  P 40 482 638  2
 3457.6298 7.076E-26.0560  2161.715    10012    00001                  P 74 482 636  2
 3458.1731 1.964E-25.0660   574.072    10012    00001                  P 39 482 638  2
 3459.0898 2.200E-25.0670   545.383    10012    00001                  P 38 482 638  2
 3459.8808 1.201E-25.0560  2047.408    10012    00001                  P 72 482 636  2
 3460.0018 2.455E-25.0670   517.427    10012    00001                  P 37 482 638  2
 3460.9089 2.727E-25.0670   490.206    10012    00001                  P 36 482 638  2
 3461.6569 3.841E-27.0620  1082.728    10012    00001                  P 53 482 637  2
 3461.8112 3.017E-25.0680   463.719    10012    00001                  P 35 482 638  2
 3462.1101 2.006E-25.0570  1936.190    10012    00001                  P 70 482 636  2
 3462.6553 4.580E-27.0620  1042.662    10012    00001                  P 52 482 637  2
 3462.7087 3.322E-25.0680   437.966    10012    00001                  P 34 482 638  2
 3463.6014 3.642E-25.0680   412.949    10012    00001                  P 33 482 638  2
 3463.6486 5.439E-27.0630  1003.350    10012    00001                  P 51 482 637  2
 3464.3178 3.298E-25.0580  1828.062    10012    00001                  P 68 482 636  2
 3464.4894 3.975E-25.0680   388.666    10012    00001                  P 32 482 638  2
 3464.6371 6.434E-27.0630   964.791    10012    00001                  P 50 482 637  2
```

B4. Unit 4: Output From Sample Run 2

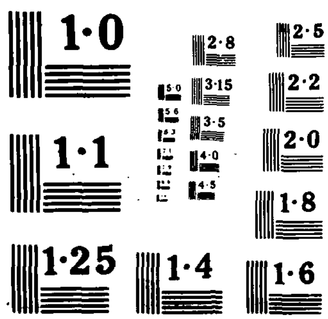
Principal program output from Sample Run 2 is given on the following five pages.

```
PROGRAM NLTE FOR INFRARED RADIANCE
DATE = 85/09/04.   TIME =  10.13.36.

*********************************************************************
TAPE1


1A---LINE DIRECTIVES:

MOL  = MOLECULE CODE =    CO2
ISO  = ISOTOPE  CODE =    626
UST  = UPPER VIB LVL =  10012
LST  = LOWER VIB LVL =  00001
BR   = RO-VIB BRANCH =      R
NRL  = ROT'L  LINE # =     14


1B---VIEWING PATH PARAMETERS:

TANI = LOWEST  TANGENT HEIGHT (KM) =  70.00
TANF = HIGHEST TANGENT HEIGHT (KM) = 100.00
SPAC = EXAMINATION  INTERVAL  (KM) =  10.00
LOOK = 0:  LOOKING GEOMETRY CHOSEN =   LIMB


1C---PROGRAM PARAMETERS:

HMAX = ASSUMED TOP OF ATMOSPHERE (KM) =  150
ACC  = ACCURACY (INTEG'D RADIANCE)  = .01000
NPTS = NUMBER OF INTEG POINTS PER PANEL =  4
NDP  = 0: LINESHAPE OPTION SELECTED =  VOIGT
VMIN = LOWER END, LINE SEARCH (CM-1) =     0
VMAX = UPPER END, LINE SEARCH (CM-1) = 20000


1D---SYNTHETIC SPECTRUM PARAMETERS:

FWHM = 0.  SYNTHETIC SPECTRUM NOT GENERATED


1E---BAND PARAMETERS:  (FOUND IN MOLPAR)

VIBE = VIB ENERGY OF THE  TRANSITION (CM-1) = 3612.8420
VIBL = VIB ENERGY OF THE LOWER STATE (CM-1) =     .0000
VIBQ = QUANTUM FOR THE PARTITION  FN (CM-1) =  667.3790
GL   = STATISTICAL WEIGHT,  LOWER VIBRATIONAL STATE = 1
GU   = STATISTICAL WEIGHT,  UPPER VIBRATIONAL STATE = 1


QUANTITIES RETURNED FROM MOLEC:

WGT  = MOLECULAR  WEIGHT  =  44
AI   = ISOTOPIC  ABUND = .99414
DEGV (EXPLAINED IN MOLEC) =   2
PROT (EXPLAINED IN MOLEC) = 1.0
TEXP (EXPLAINED IN MOLEC) = .25

FORMAT FOR THE SEARCH OF THE LINETAPE IS
(BZ,F10.4,E10.3,F5.4,F10.3,2A8,14X,A1,I3,4X,I4)

*********************************************************************
```

AD-A172 556 UPDATE OF AN EFFICIENT COMPUTER CODE (NLTE) TO CALCULATE EMISSION AND TRA..(U) AIR FORCE GEOPHYSICS LAB HANSCOM AFB MA P P WINTERSTEINER ET AL. 20 SEP 85 2/2

UNCLASSIFIED AFGL-TR-85-0240 F/G 9/2 NL

END
DATE
FILMED
11-86
DTIC


1·0
2·8
2·5
3·15
2·2
3·5
2·0
1·1
4·0
4·5
1·8
1·25
1·4
1·6

••

TAPE2

A1701 ATMOS PROFILE 06/10/85
ALT,TRTMP,NL,NU,ND,NI---DATA FROM VSIM, IRR---FORMERLY AT101G1, CO2MODATMOSPROF78(CV3)
CO2 626 10012 00001 40-160 KM

INPUT OPTION # 4; NVP = 2, NPF = 2, VIBL = 0; (SEE COMMENTS IN ATMPR)

THE LOWER- AND UPPER-STATE POPULATIONS REFLECT AN ABUNDANCE OF .98414 W.R.T. TOTAL CO2

	ALT (KM)	TR TEMP (K)	VB TEMP (K)	TOT PRESS (ATMOS)	CO2 DENSITY (CM-3)	LOWER STATE (CM-3)	UPPER STATE (CM-3)	VB TEMP (1)	PART FN
1	70.00	216.160	265.861	5.1526E-05	5.5111E+11	5.2972E+11	1.7081E+03	215.989	1.02387
2	71.00	214.690	268.821	4.4168E-05	4.7829E+11	4.6006E+11	1.8399E+03	214.485	1.02313
3	72.00	213.220	271.848	3.7861E-05	4.1510E+11	3.9956E+11	1.9819E+03	213.000	1.02241
4	73.00	211.745	275.058	3.2350E-05	3.5798E+11	3.4482E+11	2.1380E+03	211.494	1.02169
5	74.00	210.270	278.346	2.7642E-05	3.0871E+11	2.9757E+11	2.3065E+03	210.011	1.02099
6	75.00	208.795	281.716	2.3552E-05	2.6552E+11	2.5611E+11	2.4821E+03	208.474	1.02029
7	76.00	207.320	285.169	2.0067E-05	2.2837E+11	2.2043E+11	2.6710E+03	206.960	1.01960
8	77.00	205.850	288.633	1.7762E-05	1.9587E+11	1.8919E+11	2.8531E+03	205.376	1.01891
9	78.00	204.380	292.183	1.5721E-05	1.6799E+11	1.6237E+11	3.0477E+03	203.820	1.01823
10	79.00	202.905	295.632	1.2779E-05	1.4367E+11	1.3896E+11	3.2098E+03	202.151	1.01753
11	80.00	201.430	299.163	1.0387E-05	1.2287E+11	1.1892E+11	3.3805E+03	200.509	1.01685
12	81.00	199.960	302.454	8.7689E-06	1.0476E+11	1.0146E+11	3.4844E+03	198.741	1.01614
13	82.00	198.490	305.816	7.4028E-06	8.9323E+10	8.6568E+10	3.5914E+03	196.999	1.01546
14	83.00	197.015	308.795	6.2288E-06	7.5920E+10	7.3630E+10	3.5990E+03	195.150	1.01475
15	84.00	195.540	311.834	5.2410E-06	6.4531E+10	6.2626E+10	3.6067E+03	193.330	1.01408
16	85.00	194.070	314.387	4.3947E-06	5.4670E+10	5.3091E+10	3.5009E+03	191.472	1.01341
17	86.00	192.600	316.983	3.6850E-06	4.6317E+10	4.5008E+10	3.3983E+03	189.650	1.01277
18	87.00	191.125	319.066	3.0852E-06	3.8769E+10	3.7694E+10	3.1676E+03	187.990	1.01221
19	88.00	189.650	321.177	2.5831E-06	3.2451E+10	3.1568E+10	2.9526E+03	186.360	1.01167
20	89.00	188.895	322.740	2.1634E-06	2.7165E+10	2.6436E+10	2.6743E+03	185.152	1.01128
21	90.00	188.140	324.319	1.8119E-06	2.2740E+10	2.2138E+10	2.4222E+03	183.961	1.01091
22	91.00	188.300	325.405	1.5181E-06	1.9018E+10	1.8518E+10	2.1374E+03	183.298	1.01070
23	92.00	188.460	326.498	1.2719E-06	1.5905E+10	1.5490E+10	1.8861E+03	182.641	1.01050
24	93.00	188.615	327.179	1.0662E-06	1.3296E+10	1.2951E+10	1.6301E+03	182.118	1.01034
25	94.00	188.770	327.863	8.9375E-07	1.1115E+10	1.0828E+10	1.4088E+03	181.600	1.01018
26	95.00	189.355	328.211	7.4997E-07	9.2997E+09	9.0608E+09	1.1989E+03	181.279	1.01009
27	96.00	189.940	328.561	6.2932E-07	7.7815E+09	7.5823E+09	1.0203E+03	180.960	1.00999
28	97.00	190.945	328.639	5.2900E-07	6.4912E+09	6.3253E+09	8.5438E+02	180.830	1.00996
29	98.00	191.950	328.718	4.4468E-07	5.4149E+09	5.2767E+09	7.1544E+02	180.700	1.00992
30	99.00	192.955	328.609	3.7482E-07	4.5298E+09	4.4143E+09	5.9539E+02	180.570	1.00988
31	100.00	193.960	328.500	3.1593E-07	3.7893E+09	3.6929E+09	4.9548E+02	180.440	1.00984
32	101.00	197.050	328.241	2.6863E-07	3.1637E+09	3.0825E+09	4.0845E+02	181.201	1.01007
33	102.00	200.140	327.982	2.2841E-07	2.6414E+09	2.5730E+09	3.3670E+02	181.970	1.01030
34	103.00	203.225	327.669	1.9508E-07	2.2157E+09	2.1579E+09	2.7814E+02	182.657	1.01050
35	104.00	206.310	327.358	1.6661E-07	1.8586E+09	1.8097E+09	2.2977E+02	183.349	1.01072
36	105.00	211.335	327.020	1.4310E-07	1.5563E+09	1.5147E+09	1.8918E+02	184.744	1.01115
37	106.00	216.360	326.680	1.2291E-07	1.3033E+09	1.2679E+09	1.5576E+02	186.158	1.01160
38	107.00	223.320	326.367	1.0632E-07	1.0940E+09	1.0636E+09	1.2868E+02	188.174	1.01227
39	108.00	230.280	326.051	9.1970E-08	9.1842E+08	8.9228E+08	1.0630E+02	190.229	1.01297
40	109.00	237.240	325.784	8.0301E-08	7.1463E+08	6.9391E+08	8.1595E+01	191.817	1.01353
41	110.00	244.200	325.518	7.0113E-08	5.5608E+08	5.3964E+08	6.2632E+01	193.430	1.01411
42	111.00	254.975	325.294	6.1997E-08	4.3446E+08	4.2120E+08	4.8353E+01	196.112	1.01512
43	112.00	265.750	325.071	5.4821E-08	3.3947E+08	3.2876E+08	3.7329E+01	198.870	1.01619
44	113.00	276.525	324.914	4.9053E-08	2.7102E+08	2.6224E+08	2.9546E+01	201.114	1.01710
45	114.00	287.300	324.755	4.3892E-08	2.1639E+08	2.0918E+08	2.3385E+01	203.410	1.01806
46	115.00	298.685	324.644	3.9661E-08	1.7592E+08	1.6991E+08	1.8891E+01	205.497	1.01896
47	116.00	310.070	324.534	3.5837E-08	1.4303E+08	1.3801E+08	1.5261E+01	207.629	1.01990
48	117.00	322.075	324.458	3.2652E-08	1.1808E+08	1.1384E+08	1.2541E+01	209.651	1.02083

49	118.00	334.080	324.379	2.9750E-08	9.7499E+07	9.3906E+07	1.0305E+01	211.711	1.02179
50	119.00	346.080	324.334	2.7299E-08	8.1577E+07	7.8516E+07	8.5969E+00	213.219	1.02251
51	120.00	358.080	324.289	2.5050E-08	6.8258E+07	6.5648E+07	7.1720E+00	214.752	1.02326
52	121.00	370.490	324.266	2.3127E-08	5.7849E+07	5.5597E+07	6.0669E+00	216.254	1.02401
53	122.00	382.900	324.242	2.1352E-08	4.9029E+07	4.7085E+07	5.1321E+00	217.782	1.02478
54	123.00	395.315	324.217	1.9816E-08	4.1959E+07	4.0272E+07	4.3840E+00	218.898	1.02536
55	124.00	407.730	324.192	1.8391E-08	3.5907E+07	3.4444E+07	3.7450E+00	220.031	1.02595
56	125.00	420.200	324.175	1.7145E-08	3.1028E+07	2.9749E+07	3.2318E+00	220.986	1.02645
57	126.00	432.670	324.158	1.5983E-08	2.6812E+07	2.5694E+07	2.7889E+00	221.949	1.02696
58	127.00	445.195	324.148	1.4957E-08	2.3362E+07	2.2378E+07	2.4278E+00	222.797	1.02742
59	128.00	457.720	324.137	1.3997E-08	2.0357E+07	1.9491E+07	2.1134E+00	223.651	1.02788
60	129.00	470.250	324.128	1.3143E-08	1.7852E+07	1.7087E+07	1.8519E+00	224.228	1.02820
61	130.00	482.780	324.118	1.2341E-08	1.5655E+07	1.4979E+07	1.6227E+00	224.809	1.02852
62	131.00	494.870	324.114	1.1623E-08	1.3841E+07	1.3240E+07	1.4340E+00	225.387	1.02884
63	132.00	506.960	324.109	1.0947E-08	1.2238E+07	1.1703E+07	1.2672E+00	225.969	1.02917
64	133.00	519.055	324.106	1.0337E-08	1.0870E+07	1.0392E+07	1.1251E+00	226.356	1.02939
65	134.00	531.150	324.100	9.7614E-09	9.6551E+06	9.2288E+06	9.9885E-01	226.740	1.02960
66	135.00	542.850	324.096	9.2397E-09	8.6121E+06	8.2307E+06	8.9064E-01	226.991	1.02974
67	136.00	554.550	324.092	8.7459E-09	7.6818E+06	7.3406E+06	7.9416E-01	227.241	1.02989
68	137.00	565.860	324.087	8.2962E-09	6.8791E+06	6.5730E+06	7.1097E-01	227.381	1.02996
69	138.00	577.170	324.084	7.8696E-09	6.1601E+06	5.8856E+06	6.3650E-01	227.520	1.03004
70	139.00	588.480	324.079	7.4795E-09	5.5367E+06	5.2899E+06	5.7195E-01	227.538	1.03005
71	140.00	599.790	324.074	7.1087E-09	4.9764E+06	4.7545E+06	5.1394E-01	227.560	1.03007
72	141.00	610.110	324.070	6.7682E-09	4.4992E+06	4.2988E+06	4.6459E-01	227.492	1.03003
73	142.00	620.430	324.065	6.4440E-09	4.0680E+06	3.8869E+06	4.1997E-01	227.420	1.02999
74	143.00	630.745	324.060	6.1453E-09	3.6878E+06	3.5239E+06	3.8065E-01	227.267	1.02990
75	144.00	641.060	324.056	5.8604E-09	3.3430E+06	3.1947E+06	3.4501E-01	227.121	1.02982
76	145.00	650.840	324.050	5.5970E-09	3.0381E+06	2.9037E+06	3.1350E-01	226.895	1.02969
77	146.00	660.620	324.045	5.3454E-09	2.7610E+06	2.6392E+06	2.8487E-01	226.671	1.02956
78	147.00	669.860	324.039	5.1121E-09	2.5152E+06	2.4046E+06	2.5947E-01	226.396	1.02941
79	148.00	679.100	324.033	4.8890E-09	2.2913E+06	2.1909E+06	2.3634E-01	226.120	1.02925
80	149.00	688.340	324.027	4.6815E-09	2.0920E+06	2.0007E+06	2.1576E-01	225.800	1.02907
81	150.00	697.580	324.020	4.4828E-09	1.9102E+06	1.8271E+06	1.9697E-01	225.478	1.02889

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*****************************************************************
TAPE3

L101000 CO2 ALL    10012   00001 06/21/85  2.7UM REGULAR 101 COMBINATION BANDS
                   10011   00001

AFGL LINE FILE FOR SELECTED TRANSITION:   CO2   626   10012   00001

 BR  LINE    FREQUENCY   STRENGTH   WIDTH   LS ENERGY
              (CM-1)               (CM-1)    (CM-1)

 R    14     3623.8933   .396E-19   .074     81.9400
*****************************************************************

TMIN = TEMPERATURE  USED  FOR  STDW = 188
STD DOPP WIDTH = STDW (CM-1) = .26750E-02
4-PT  GAUSS QUADRATURE  USED FOR NU-INTEG

EXEC TIME FOR INITIALIZATION =  2.18 SEC;      1 LINES
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GROUP # 1 WITH 4 VIEWING PATHS

PATH # 1. TANGENT HT = 70.00 KM. USE LAYERS 1 THRU 80 (ALTITUDES 70.00 THRU 149.00 KM) 80 LAYERS
PATH # 2. TANGENT HT = 80.00 KM. USE LAYERS 11 THRU 80 (ALTITUDES 80.00 THRU 149.00 KM) 70 LAYERS
PATH # 3. TANGENT HT = 90.00 KM. USE LAYERS 21 THRU 80 (ALTITUDES 90.00 THRU 149.00 KM) 60 LAYERS
PATH # 4. TANGENT HT = 100.00 KM. USE LAYERS 31 THRU 80 (ALTITUDES 100.00 THRU 149.00 KM) 50 LAYERS

RADIANCE (PHOTONS/CM2*STR*SEC*CM-1) AND TOTAL OPTICAL DEPTH VS FREQUENCY (CM-1 FROM THE LINE CENTER) FOR VARIOUS LINE-OF-SIGHT PATHS
INTD RAD (PHOTONS/CM2*STR*SEC) WITHIN SUCCESSIVE INTEGRATION PANELS FOR LINE R 14. FOR CONVERSION TO WATTS, MULTIPLY BY .71987E-19

	FREQ	RADIANCE 70.00 KM	TAU 70.00 KM	RADIANCE 80.00 KM	TAU 80.00 KM	RADIANCE 90.00 KM	TAU 90.00 KM	RADIANCE 100.00 KM	TAU 100.00 KM
1	.000186	8.4589E+10	2.337E+02	8.8079E+10	5.290E+01	9.3091E+10	9.756E+00	7.3241E+10	1.496E+00
2	.000883	8.3575E+10	2.192E+02	8.7307E+10	4.941E+01	9.2809E+10	9.086E+00	7.1112E+10	1.399E+00
3	.001792	7.9916E+10	1.780E+02	8.4461E+10	3.954E+01	9.1771E+10	7.203E+00	6.3801E+10	1.126E+00
4	.002489	7.4763E+10	1.378E+02	8.0327E+10	3.008E+01	9.0193E+10	5.417E+00	5.4568E+10	8.623E-01
P 1	0- 1	4.33487E+08		4.56350E+08		4.92545E+08		3.54281E+08	
5	.002861	7.0989E+10	1.163E+02	7.7222E+10	2.507E+01	8.8809E+10	4.481E+00	4.8563E+10	7.222E-01
6	.003558	6.1805E+10	7.928E+01	6.9440E+10	1.665E+01	8.3729E+10	2.924E+00	3.6246E+10	4.846E-01
7	.004467	4.6308E+10	4.247E+01	5.5821E+10	8.533E+00	6.7086E+10	1.458E+00	2.1081E+10	2.532E-01
8	.005164	3.3438E+10	2.394E+01	4.4691E+10	4.616E+00	4.6749E+10	7.686E-01	1.2260E+10	1.396E-01
P 2	1- 2	2.85772E+08		3.31957E+08		3.89232E+08		1.56603E+08	
9	.005536	2.6982E+10	1.705E+01	3.9207E+10	3.208E+00	3.5647E+10	5.262E-01	8.7937E+09	9.820E-02
10	.006233	1.6764E+10	8.486E+00	2.8530E+10	1.517E+00	1.8649E+10	2.409E-01	4.3637E+09	4.763E-02
11	.007142	8.4273E+09	3.026E+00	1.3760E+10	5.002E-01	6.3610E+09	7.580E-02	1.5200E+09	1.640E-02
12	.007839	4.9448E+09	1.258E+00	6.0742E+09	1.935E-01	2.4183E+09	2.813E-02	6.1348E+08	6.610E-03
P 3	2- 3	7.36531E+07		1.15910E+08		7.90500E+07		1.90174E+07	
13	.008211	3.4900E+09	7.669E-01	3.6615E+09	1.127E-01	1.3841E+09	1.600E-02	3.6608E+08	3.948E-03
14	.008908	1.5378E+09	2.915E-01	1.2863E+09	3.860E-02	4.5158E+08	5.190E-03	1.3121E+08	1.421E-03
15	.009817	4.3648E+08	8.227E-02	2.9225E+08	8.824E-03	9.2581E+07	1.062E-03	3.0982E+07	3.382E-04
16	.010514	1.7425E+08	3.543E-02	9.4897E+07	2.940E-03	2.5927E+07	2.975E-04	9.5685E+06	1.053E-04
P 4	3- 4	6.85371E+06		6.24908E+06		2.26133E+06		6.32481E+05	
17	.011071	9.8239E+07	2.147E-02	4.3770E+07	1.403E-03	9.6165E+06	1.107E-04	3.6198E+06	4.013E-05
18	.012466	4.8592E+07	1.154E-02	1.6045E+07	5.482E-04	1.8077E+06	2.117E-05	3.1738E+05	3.565E-06
19	.014284	3.4189E+07	8.166E-03	1.0930E+07	3.766E-04	1.0642E+06	1.254E-05	4.1627E+04	4.457E-07
20	.015679	2.7881E+07	6.653E-03	8.9185E+06	3.073E-04	8.6549E+05	1.020E-05	2.7841E+04	2.920E-07
P 5	4 6	5.23536E+05		1.92167E+05		2.95270E+04		8.04086E+03	
TAIL CONTRIB:									
PH/SEC*CM2*SR		8.1093E+05		2.5948E+05		2.5238E+04		7.9541E+02	
WATT/CM2*SR		5.8377E-14		1.8679E-14		1.8168E-15		5.7260E-17	

INTEGRATED RADIANCE (WATT/(CM2*STR) FOR VARIOUS LINE-OF-SIGHT PATHS

LINE	70.00 KM (THIN)	70.00 KM (THICK)	80.00 KM (THIN)	80.00 KM (THICK)	90.00 KM (THIN)	90.00 KM (THICK)	100.00 KM (THIN)	100.00 KM (THICK)
R 14	8.1697E-10	5.7669E-11	8.0950E-10	6.5575E-11	3.5227E-10	6.9334E-11	6.0958E-11	3.8192E-11

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B5. Unit 5: Output From Sample Run 2

Subsidiary program output from Sample Run 2 is given on the following three pages.

PROGRAM NLTE FOR INFRARED RADIANCE
DATE = 85/09/04. TIME = 10.13.36.

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TAPE5

ALTITUDE-DEPENDENT QUANTITIES FOR LINE R 14:

VOLUME EMISSION RATE IN PHOTONS/(SEC*CM3*CM-1*STER) (SPECTRAL, AT LINE CENTER)
OR PHOTONS/(SEC*CM3*STER) (INTEGRATED OVER LINE)
R IS GIVEN IN UNITS OF PHOTONS/(SEC*CM2*CM-1*STER)
KT IS GIVEN IN UNITS OF CM-1/MOLECULE-CM2

ALT (KM)	R	DWID (CM-1)	KT	RAT	VGT(O) (CM)	V.E.R.
70.00	.26280E+10	.28722E-02	.49635E-19	.12986E-02	.16330E+03	.10936E+10
71.00	.32578E+10	.28624E-02	.49824E-19	.11228E-02	.16389E+03	.11853E+10
72.00	.40545E+10	.28525E-02	.50014E-19	.96922E-03	.16449E+03	.12858E+10
73.00	.50658E+10	.28426E-02	.50203E-19	.83540E-03	.16524E+03	.13970E+10
74.00	.63301E+10	.28327E-02	.50393E-19	.71908E-03	.16582E+03	.15144E+10
75.00	.79104E+10	.28227E-02	.50582E-19	.61811E-03	.16641E+03	.16396E+10
76.00	.98621E+10	.28127E-02	.50772E-19	.54157E-03	.16700E+03	.17686E+10
77.00	.12268E+11	.28027E-02	.50961E-19	.48365E-03	.16760E+03	.19007E+10
78.00	.15173E+11	.27926E-02	.51151E-19	.41395E-03	.16820E+03	.20282E+10
79.00	.18662E+11	.27824E-02	.51342E-19	.33954E-03	.16882E+03	.21492E+10
80.00	.22740E+11	.27723E-02	.51533E-19	.28385E-03	.16943E+03	.22527E+10
81.00	.27456E+11	.27621E-02	.51725E-19	.24184E-03	.17006E+03	.23362E+10
82.00	.32732E+11	.27519E-02	.51916E-19	.20573E-03	.17069E+03	.23886E+10
83.00	.38542E+11	.27416E-02	.52108E-19	.17473E-03	.17133E+03	.24084E+10
84.00	.44733E+11	.27313E-02	.52299E-19	.14815E-03	.17198E+03	.23897E+10
85.00	.51188E+11	.27210E-02	.52488E-19	.12541E-03	.17263E+03	.23339E+10
86.00	.57743E+11	.27106E-02	.52675E-19	.10609E-03	.17329E+03	.22335E+10
87.00	.64226E+11	.27002E-02	.52860E-19	.89682E-04	.17396E+03	.20948E+10
88.00	.70427E+11	.26922E-02	.53002E-19	.75652E-04	.17447E+03	.19336E+10
89.00	.76147E+11	.26869E-02	.53102E-19	.63678E-04	.17482E+03	.17569E+10
90.00	.81322E+11	.26847E-02	.53148E-19	.53448E-04	.17496E+03	.15726E+10
91.00	.85795E+11	.26859E-02	.53142E-19	.44733E-04	.17488E+03	.13867E+10
92.00	.89596E+11	.26870E-02	.53135E-19	.37449E-04	.17481E+03	.12102E+10
93.00	.92622E+11	.26881E-02	.53127E-19	.31360E-04	.17474E+03	.10453E+10
94.00	.94980E+11	.26907E-02	.53094E-19	.26237E-04	.17457E+03	.89501E+09
95.00	.96618E+11	.26949E-02	.53037E-19	.21931E-04	.17430E+03	.75980E+09
96.00	.97653E+11	.27006E-02	.52957E-19	.18323E-04	.17393E+03	.63927E+09
97.00	.98066E+11	.27077E-02	.52852E-19	.15301E-04	.17348E+03	.53307E+09
98.00	.98037E+11	.27148E-02	.52748E-19	.12796E-04	.17302E+03	.44313E+09
99.00	.97567E+11	.27218E-02	.52643E-19	.10716E-04	.17257E+03	.36723E+09
100.00	.96789E+11	.27362E-02	.52420E-19	.89530E-05	.17167E+03	.30157E+09
101.00	.95708E+11	.27577E-02	.52079E-19	.74648E-05	.17033E+03	.24542E+09
102.00	.94510E+11	.27791E-02	.51739E-19	.62398E-05	.16902E+03	.19994E+09
103.00	.93204E+11	.28003E-02	.51400E-19	.52291E-05	.16774E+03	.16307E+09
104.00	.91886E+11	.28279E-02	.50952E-19	.43701E-05	.16610E+03	.13226E+09
105.00	.90546E+11	.28617E-02	.50397E-19	.36436E-05	.16414E+03	.10667E+09
106.00	.89297E+11	.29015E-02	.49738E-19	.30340E-05	.16189E+03	.85856E+08
107.00	.88132E+11	.29471E-02	.48979E-19	.25242E-05	.15938E+03	.68963E+08
108.00	.87067E+11	.29920E-02	.48231E-19	.21123E-05	.15699E+03	.53411E+08
109.00	.86107E+11	.30362E-02	.47498E-19	.17779E-05	.15471E+03	.39887E+08
110.00	.85279E+11	.30916E-02	.46578E-19	.14931E-05	.15193E+03	.29664E+08
111.00	.84572E+11	.31576E-02	.45486E-19	.12524E-05	.14876E+03	.21976E+08
112.00	.83987E+11	.32223E-02	.44428E-19	.10589E-05	.14577E+03	.16498E+08
113.00	.83524E+11	.32857E-02	.43406E-19	.90245E-06	.14296E+03	.12551E+08
114.00	.83149E+11	.33496E-02	.42391E-19	.77330E-06	.14023E+03	.96438E+07

115.00	.82864E+11	.34141E-02	.41387E-19	.66623E-06	.13758E+03	.74844E+07
116.00	.82643E+11	.34791E-02	.40394E-19	.57667E-06	.13501E+03	.58573E+07
117.00	.82479E+11	.35445E-02	.39414E-19	.50150E-06	.13252E+03	.46225E+07
118.00	.82369E+11	.36088E-02	.38477E-19	.43841E-06	.13016E+03	.36789E+07
119.00	.82316E+11	.36719E-02	.37580E-19	.38523E-06	.12792E+03	.29529E+07
120.00	.82302E+11	.37350E-02	.36704E-19	.33979E-06	.12576E+03	.23872E+07
121.00	.82325E+11	.37981E-02	.35849E-19	.30084E-06	.12367E+03	.19438E+07
122.00	.82336E+11	.38602E-02	.35030E-19	.26741E-06	.12168E+03	.15919E+07
123.00	.82338E+11	.39213E-02	.34247E-19	.23863E-06	.11979E+03	.13111E+07
124.00	.82351E+11	.39816E-02	.33494E-19	.21365E-06	.11797E+03	.10862E+07
125.00	.82374E+11	.40411E-02	.32771E-19	.19192E-06	.11624E+03	.90502E+06
126.00	.82407E+11	.40999E-02	.32074E-19	.17290E-06	.11457E+03	.75789E+06
127.00	.82446E+11	.41579E-02	.31403E-19	.15621E-06	.11297E+03	.63786E+06
128.00	.82483E+11	.42152E-02	.30760E-19	.14151E-06	.11143E+03	.53898E+06
129.00	.82520E+11	.42718E-02	.30143E-19	.12852E-06	.10996E+03	.45723E+06
130.00	.82562E+11	.43266E-02	.29558E-19	.11707E-06	.10857E+03	.38999E+06
131.00	.82607E+11	.43798E-02	.29004E-19	.10694E-06	.10725E+03	.33443E+06
132.00	.82653E+11	.44323E-02	.28470E-19	.97889E-07	.10598E+03	.28762E+06
133.00	.82693E+11	.44843E-02	.27956E-19	.89782E-07	.10475E+03	.24807E+06
134.00	.82727E+11	.45348E-02	.27468E-19	.82539E-07	.10358E+03	.21463E+06
135.00	.82762E+11	.45839E-02	.27005E-19	.76051E-07	.10247E+03	.18628E+06
136.00	.82795E+11	.46317E-02	.26565E-19	.70218E-07	.10141E+03	.16214E+06
137.00	.82825E+11	.46783E-02	.26146E-19	.64964E-07	.10040E+03	.14154E+06
138.00	.82853E+11	.47243E-02	.25740E-19	.60191E-07	.99426E+02	.12383E+06
139.00	.82877E+11	.47699E-02	.25347E-19	.55849E-07	.98475E+02	.10858E+06
140.00	.82899E+11	.48132E-02	.24983E-19	.51943E-07	.97590E+02	.95636E+05
141.00	.82917E+11	.48540E-02	.24645E-19	.48420E-07	.96769E+02	.84599E+05
142.00	.82931E+11	.48946E-02	.24317E-19	.45189E-07	.95967E+02	.74958E+05
143.00	.82945E+11	.49348E-02	.23998E-19	.42222E-07	.95186E+02	.66524E+05
144.00	.82957E+11	.49736E-02	.23695E-19	.39513E-07	.94443E+02	.59162E+05
145.00	.82965E+11	.50111E-02	.23408E-19	.37034E-07	.93736E+02	.52723E+05
146.00	.82971E+11	.50473E-02	.23136E-19	.34762E-07	.93063E+02	.47077E+05
147.00	.82973E+11	.50822E-02	.22878E-19	.32677E-07	.92424E+02	.42118E+05
148.00	.82975E+11	.51169E-02	.22626E-19	.30743E-07	.91797E+02	.37732E+05
149.00	.82975E+11	.51514E-02	.22379E-19	.28948E-07	.91183E+02	.33848E+05

OPTICAL DEPTHS (LINE CENTER) GEOMETRICAL DISTANCES (KM) AND RADIANCE CONTRIBUTIONS (PH/SEC*CM2*SR*CM-1 AT LINE CENTER) FOR EACH LAYER

ALT	DIS	O.D.	RAD	DIS	O.D.	RAD	DIS	O.D.	RAD	DIS	O.D.	RAD
70.0	113.42	.4720E+02	.106E-20									
71.0	46.99	.1710E+02	.349E-13									
72.0	36.06	.1143E+02	.402E-08									
73.0	30.40	.8384E+01	.220E-04									
74.0	26.79	.6408E+01	.166E-01									
75.0	24.22	.5020E+01	.313E+01									
76.0	22.28	.3995E+01	.210E+03									
77.0	20.74	.3213E+01	.633E+04									
78.0	19.48	.2604E+01	.102E+06									
79.0	18.42	.2122E+01	.996E+06									
80.0	17.53	.1736E+01	.645E+07	113.50	.1124E+02	.518E+04						
81.0	16.75	.1425E+01	.298E+08	47.02	.4001E+01	.336E+06						
82.0	16.07	.1172E+01	.104E+09	36.08	.2633E+01	.527E+07						
83.0	15.46	.9661E+00	.290E+09	30.42	.1901E+01	.380E+08						
84.0	14.92	.7970E+00	.662E+09	26.81	.1432E+01	.165E+09						
85.0	14.43	.6580E+00	.128E+10	24.24	.1105E+01	.502E+09						
86.0	13.99	.5411E+00	.216E+10	22.29	.8623E+00	.116E+10						
87.0	13.58	.4431E+00	.320E+10	20.75	.6768E+00	.216E+10						
88.0	13.21	.3628E+00	.429E+10	19.49	.5352E+00	.341E+10						
89.0	12.87	.2970E+00	.527E+10	18.44	.4254E+00	.472E+10						
90.0	12.55	.2428E+00	.602E+10	17.54	.3392E+00	.587E+10	113.59	.2197E+01	.483E+10			
91.0	12.26	.1982E+00	.645E+10	16.76	.2709E+00	.670E+10	47.06	.7606E+00	.653E+10			

92.0	11.99	.1619E+00	.659E+10	16.08	.2172E+00	.715E+10	36.11	.4878E+00	.805E+10			
93.0	11.73	.1324E+00	.645E+10	15.47	.1746E+00	.722E+10	30.45	.3436E+00	.884E+10			
94.0	11.49	.1083E+00	.610E+10	14.93	.1407E+00	.698E+10	26.83	.2528E+00	.897E+10			
95.0	11.26	.8857E-01	.560E+10	14.44	.1136E+00	.851E+10	24.26	.1908E+00	.859E+10			
96.0	11.05	.7234E-01	.501E+10	14.00	.9164E-01	.588E+10	22.31	.1460E+00	.786E+10			
97.0	10.85	.5897E-01	.438E+10	13.59	.7390E-01	.517E+10	20.77	.1129E+00	.694E+10			
98.0	10.66	.4817E-01	.377E+10	13.22	.5977E-01	.447E+10	19.51	.8818E-01	.599E+10			
99.0	10.48	.3943E-01	.321E+10	12.88	.4848E-01	.381E+10	18.45	.6945E-01	.508E+10			
100.0	10.30	.3211E-01	.269E+10	12.56	.3915E-01	.319E+10	17.55	.5469E-01	.422E+10	113.68	.3542E+00	.194E+11
101.0	10.14	.2600E-01	.222E+10	12.27	.3146E-01	.263E+10	16.77	.4301E-01	.345E+10	47.09	.1208E+00	.824E+10
102.0	9.98	.2112E-01	.182E+10	12.00	.2538E-01	.215E+10	16.09	.3404E-01	.280E+10	36.14	.7646E-01	.568E+10
103.0	9.84	.1721E-01	.149E+10	11.74	.2054E-01	.176E+10	15.48	.2709E-01	.227E+10	30.47	.5331E-01	.417E+10
104.0	9.69	.1395E-01	.121E+10	11.50	.1655E-01	.142E+10	14.94	.2151E-01	.182E+10	26.85	.3865E-01	.312E+10
105.0	9.56	.1126E-01	.975E+09	11.27	.1328E-01	.114E+10	14.45	.1703E-01	.145E+10	24.28	.2860E-01	.235E+10
106.0	9.43	.9063E-02	.782E+09	11.06	.1063E-01	.912E+09	14.01	.1347E-01	.114E+10	22.33	.2147E-01	.178E+10
107.0	9.30	.7278E-02	.624E+09	10.86	.8495E-02	.726E+09	13.61	.1065E-01	.904E+09	20.78	.1626E-01	.136E+10
108.0	9.18	.5631E-02	.480E+09	10.67	.6543E-02	.557E+09	13.23	.8118E-02	.687E+09	19.52	.1198E-01	.100E+10
109.0	9.06	.4199E-02	.356E+09	10.48	.4857E-02	.411E+09	12.89	.5972E-02	.504E+09	18.47	.8555E-02	.716E+09
110.0	8.95	.3114E-02	.262E+09	10.31	.3587E-02	.302E+09	12.57	.4374E-02	.367E+09	17.57	.6110E-02	.510E+09
111.0	8.85	.2298E-02	.193E+09	10.15	.2637E-02	.221E+09	12.28	.3191E-02	.267E+09	16.79	.4362E-02	.363E+09
112.0	8.74	.1717E-02	.143E+09	9.99	.1963E-02	.164E+09	12.01	.2358E-02	.196E+09	16.10	.3163E-02	.263E+09
113.0	8.64	.1299E-02	.108E+09	9.84	.1479E-02	.123E+09	11.75	.1765E-02	.146E+09	15.50	.2329E-02	.193E+09
114.0	8.54	.9910E-03	.820E+08	9.70	.1125E-02	.931E+08	11.51	.1335E-02	.110E+09	14.95	.1734E-02	.143E+09
115.0	8.45	.7633E-03	.630E+08	9.56	.8639E-03	.713E+08	11.28	.1019E-02	.841E+08	14.46	.1306E-02	.108E+09
116.0	8.36	.5926E-03	.488E+08	9.43	.6686E-03	.551E+08	11.07	.7844E-03	.646E+08	14.02	.9937E-03	.818E+08
117.0	8.27	.4637E-03	.382E+08	9.31	.5216E-03	.429E+08	10.87	.6089E-03	.501E+08	13.62	.7631E-03	.627E+08
118.0	8.19	.3657E-03	.301E+08	9.19	.4103E-03	.337E+08	10.67	.4767E-03	.392E+08	13.24	.5915E-03	.486E+08
119.0	8.11	.2908E-03	.239E+08	9.07	.3254E-03	.267E+08	10.49	.3764E-03	.309E+08	12.90	.4628E-03	.380E+08
120.0	8.03	.2328E-03	.191E+08	8.96	.2599E-03	.214E+08	10.32	.2994E-03	.246E+08	12.58	.3650E-03	.300E+08
121.0	7.95	.1877E-03	.154E+08	8.85	.2090E-03	.172E+08	10.16	.2398E-03	.197E+08	12.29	.2902E-03	.239E+08
122.0	7.87	.1522E-03	.125E+08	8.75	.1691E-03	.139E+08	10.00	.1933E-03	.159E+08	12.01	.2323E-03	.191E+08
123.0	7.80	.1242E-03	.102E+08	8.65	.1377E-03	.113E+08	9.85	.1569E-03	.129E+08	11.76	.1872E-03	.154E+08
124.0	7.73	.1020E-03	.839E+07	8.55	.1128E-03	.928E+07	9.71	.1280E-03	.105E+08	11.52	.1519E-03	.125E+08
125.0	7.66	.8417E-04	.693E+07	8.46	.9292E-04	.765E+07	9.57	.1052E-03	.866E+07	11.29	.1240E-03	.102E+08
126.0	7.59	.6984E-04	.575E+07	8.37	.7695E-04	.634E+07	9.44	.8682E-04	.715E+07	11.08	.1019E-03	.839E+07
127.0	7.53	.5824E-04	.480E+07	8.28	.6406E-04	.528E+07	9.31	.7207E-04	.594E+07	10.87	.8412E-04	.693E+07
128.0	7.46	.4878E-04	.402E+07	8.19	.5355E-04	.442E+07	9.19	.6008E-04	.495E+07	10.68	.6980E-04	.576E+07
129.0	7.40	.4101E-04	.338E+07	8.11	.4495E-04	.371E+07	9.08	.5030E-04	.415E+07	10.50	.5818E-04	.480E+07
130.0	7.34	.3468E-04	.286E+07	8.03	.3794E-04	.313E+07	8.97	.4235E-04	.350E+07	10.33	.4879E-04	.403E+07
131.0	7.28	.2948E-04	.244E+07	7.96	.3221E-04	.266E+07	8.86	.3586E-04	.296E+07	10.16	.4115E-04	.340E+07
132.0	7.22	.2514E-04	.208E+07	7.88	.2742E-04	.227E+07	8.75	.3047E-04	.252E+07	10.01	.3483E-04	.288E+07
133.0	7.17	.2151E-04	.178E+07	7.81	.2342E-04	.194E+07	8.65	.2596E-04	.215E+07	9.86	.2957E-04	.245E+07
134.0	7.11	.1846E-04	.153E+07	7.74	.2007E-04	.166E+07	8.56	.2220E-04	.184E+07	9.72	.2521E-04	.208E+07
135.0	7.06	.1589E-04	.131E+07	7.67	.1726E-04	.143E+07	8.46	.1905E-04	.158E+07	9.58	.2156E-04	.178E+07
136.0	7.01	.1372E-04	.114E+07	7.60	.1488E-04	.123E+07	8.37	.1640E-04	.136E+07	9.45	.1850E-04	.153E+07
137.0	6.96	.1189E-04	.984E+06	7.53	.1287E-04	.107E+07	8.29	.1416E-04	.117E+07	9.32	.1593E-04	.132E+07
138.0	6.91	.1032E-04	.855E+06	7.47	.1116E-04	.925E+06	8.20	.1226E-04	.102E+07	9.20	.1375E-04	.114E+07
139.0	6.86	.8984E-05	.745E+06	7.41	.9706E-05	.804E+06	8.12	.1064E-04	.882E+06	9.09	.1190E-04	.986E+06
140.0	6.81	.7855E-05	.651E+06	7.35	.8476E-05	.703E+06	8.04	.9274E-05	.769E+06	8.97	.1035E-04	.858E+06
141.0	6.76	.6899E-05	.572E+06	7.29	.7436E-05	.617E+06	7.96	.8123E-05	.673E+06	8.87	.9045E-05	.750E+06
142.0	6.72	.6070E-05	.503E+06	7.23	.6535E-05	.542E+06	7.89	.7128E-05	.591E+06	8.76	.7919E-05	.657E+06
143.0	6.67	.5350E-05	.444E+06	7.17	.5754E-05	.477E+06	7.81	.6266E-05	.520E+06	8.66	.6947E-05	.576E+06
144.0	6.63	.4726E-05	.392E+06	7.12	.5077E-05	.421E+06	7.74	.5521E-05	.458E+06	8.56	.6108E-05	.507E+06
145.0	6.58	.4184E-05	.347E+06	7.07	.4490E-05	.373E+06	7.67	.4876E-05	.405E+06	8.47	.5383E-05	.447E+06
146.0	6.54	.3711E-05	.308E+06	7.01	.3979E-05	.330E+06	7.61	.4315E-05	.358E+06	8.38	.4755E-05	.395E+06
147.0	6.50	.3299E-05	.274E+06	6.96	.3534E-05	.293E+06	7.54	.3827E-05	.318E+06	8.29	.4209E-05	.349E+06
148.0	6.46	.2937E-05	.244E+06	6.91	.3143E-05	.261E+06	7.48	.3400E-05	.282E+06	8.21	.3732E-05	.310E+06
149.0	6.42	.2618E-05	.217E+06	6.86	.2799E-05	.232E+06	7.41	.3024E-05	.251E+06	8.12	.3314E-05	.275E+06
TOTAL		.2344E+03	.846E+11		.5308E+02	.881E+11		.9804E+01	.924E+11		.1508E+01	.497E+11

B6. Unit 6: Output From Sample Run 2

Diagnostic output from Sample Run 2 is given on the next page.

```
PROGRAM D.    OR INFRARED RADIANCE
DATE = 85/../04.   TIME =  10.13.36.

*****************************************************************
TAPE6

PRINT THE HEADERS AND FIRST DATA CARD-IMAGES FOUND ON INPUT UNITS


UNIT 1:
11111111112222222222333333333344444444445555555555666666666677777777778888888888                 (FORMAT)
'CO2', 626, '10012','00001', 'R', 14                                                              (DATA)

UNIT 2:                                                                                           (HEADER)
CA1701   ATMOS PROFILE 06/10/85                                                                   (HEADER)
C        ALT,TRTMP,NL,NU,NO,NI---DATA FROM VSIM, IRR---FORMERLY AT101G1, CO2MODATMOSPROF78(CY3)  (HEADER)
CO2 626   10012   00001  40-160 KM                                                                (FORMAT)
AAAAABBBBBBBBBBBCCCCCCCCCCCCDDDDDDDDDDDDEEEEEEEEEEEEFFFFFFFFFFFFGGGGGGGGGGGG-------------        (DATA)
   40   251.060  .25034E+14  .25415E+05  .25034E+14  .10925E+13                                  (INTERP)
 ALT     TR TEMP  LST # DENS  UST # DENS  GST # DENS  1ST # DENS

UNIT 3:                                                                                           (HEADER)
 1101000 CO2 ALL    10012    00001 06/21/85  2.7UM REGULAR 101 COMBINATION BANDS                  (HEADER)
                    10011    00001                                                                (FORMAT)
11111111112222222222333333333344444444445555555555666666666677777777778888888888                 (DATA)
 1414 7011 3.807E-27.9590  1482.576   10012   00001              P 63 482 638  2
```

Appendix C

NLTE Program and Subroutine Listings

PRECEDING PAGE BLANK-NOT FILMED

```
      PROGRAM NLTE
C     ******************************************************************
C
C                              PROGRAM NLTE
C
C             PREPARED FOR AIR FORCE GEOPHYSICS LABORATORY
C                        HANSCOM AFB, MA, 01730
C
C                                   BY
C
C                        PETER P. WINTERSTEINER
C                          ARCON  CORPORATION
C                          260  BEAR HILL RD.
C                          WALTHAM, MA, 02154
C
C
C     ******************************************************************
C
C     PROGRAM NLTE: LINE-BY-LINE CALCULATION OF INFRARED AIRGLOW FROM
C     NON-LTE REGIONS OF THE ATMOSPHERE. COMPONENT OF A.F.G.L. ATMOS-
C     PHERIC RADIANCE CODE (ARC).
C
C     ******************************************************************
C
      REAL KT,INU,NU,EXPL
      INTEGER RQL,DNU,PFAC,DIML
      LOGICAL CMPL,FLAG
      PARAMETER(DIML=500,CMPL=.FALSE.,EXPL=674.)
      CHARACTER*2 BR(DIML),BL
      CHARACTER*24 AST
      DIMENSION ALT(250),TRTMP(250),ALCOR(250),RHO(250),TVL(250)
      DIMENSION QRAT(250),ZZ(250,5),R(250),DWID(250),VGT(250)
      DIMENSION KT(250),TVU(250),STORE(DIML,5),CUM(250)
      DIMENSION RAT(250),HGTS(50)
      DIMENSION V(DIML),STS(DIML),ALF(DIML),EDP(DIML),RQL(DIML)
      DIMENSION RAD(5),RAW(5),SUMRD(5),SUMPH(5),HTS(5),THR(5),TOD(5)
      DIMENSION SUM(5),K1(5),KM(5),TRN(5),LMAX(5)
      DIMENSION INU(8,5),OD(8,5),CC(8),W(4),C4(2),C8(4),W4(2),W8(4)
      DIMENSION NU(8)
      EQUIVALENCE (V(1),STORE(1,1))
C
      COMMON/A/ALT,TRTMP,ALCOR,RHO,TVL,TVU,QRAT,ZZ,KT,
     1         KMAX,C2,BST,TMIN
      COMMON/B/V,STS,ALF,EDP,RQL,NRL,HGTS,ACC,NPTS,NDP,
     1         WGT,LOOK,NREPS,IMXX,JMAX,FWHM
      COMMON/C/RAT,DWID,VGT
C
      DATA FLAG/.FALSE./
      DATA AST/'************************'/
      DATA (C4(I),I=1,2)/.43056815579703,  .16999052179243/
      DATA (W4(I),I=1,2)/.17392742256873,  .32607257743127/
      DATA (C8(I),I=1,4)/.48014492824877,  .39833323870681,
     1                   .26276620495816, .091717321247825/
      DATA (W8(I),I=1,4)/.050614268145188, .11119051722669,
     1                   .15685332293894,  .18134189168918/
C
  100 FORMAT(//)
  101 FORMAT(1X)
  103 FORMAT(/,' EXEC TIME FOR INITIALIZATION =',F6.2,' SEC;',I7,
     1' LINES',//)
```

```
 104 FORMAT(///,' RADIANCE (PHOTONS/CM2*STR*SEC*CM-1) AND TOTAL',
    1' OPTICAL DEPTH VS FREQUENCY (CM-1 FROM THE LINE CENTER)',
    2' FOR VARIOUS LINE-OF-SIGHT PATHS',/,
    3' INTD RAD (PHOTONS/CM2*STR*SEC) WITHIN SUCCESSIVE INTEGRATION',
    4' PANELS FOR LINE ',A2,I4,
    5'. FOR CONVERSION TO WATTS, MULTIPLY BY',E11.5,
    6//,8X,'FREQ ',5(A1,3X,'RADIANCE',5X,'TAU',3X))
 105 FORMAT(I4,F9.6,1P,5(E13.4,E10.3))
 106 FORMAT(3X,'ALT',8X,'R',9X,'DWID',9X,'KT',10X,'RAT',7X,'VGT(0)',
    16X,'V.E.R.',/,3X,'(KM)',16X,'(CM-1)',31X,'(CM)',/)
 107 FORMAT(1X,F6.2,6E12.5)
 108 FORMAT(//,' OPTICAL DEPTHS (LINE CENTER) GEOMETRICAL DIS',
    1'TANCES (KM) AND RADIANCE CONTRIBUTIONS (PH/SEC*CM2*SR*CM-1',
    2' AT LINE CENTER) FOR EACH LAYER',//,
    33X,'ALT',5(A1,'  DIS',5X,'O.D.',6X,'RAD',2X))
 109 FORMAT(1X,F5.1,5(F7.2,E10.4,E9.3))
 110 FORMAT(1X,'TOTAL',5(E17.4,E9.3))
 111 FORMAT(1X,A2,I5,1P,5(1X,E11.4,12X))
 112 FORMAT(1H+,6X,1P,5(13X,E11.4))
 113 FORMAT(/,' INTEGRATED RADIANCE (WATT/(CM2*STR) FOR VARIOUS LINE',
    1'-OF-SIGHT PATHS',//,1X,'LINE',2X,5(F10.2,' KM',F8.2,' KM'))
 114 FORMAT(3X,'TIME',7X,'LB',5(A1,'LL KM RADIANCE  OP DPTH'))
 115 FORMAT(//,'   CUMULATIVE INTEGRATED RADIANCE (WATT/CM2*STR) AND ',
    1'TOTAL OPTICAL DEPTH (AT LINE CENTER) FOR VARIOUS LINE-OF-SIGHT ',
    2'PATHS',//,3X,'EXEC  LINE',5X,4(F11.2,' KM',10X),F11.2,'KM')
 116 FORMAT(1X,F6.2,1X,A2,2I3,5(2[illegible]))
 117 FORMAT(//,' TOTAL BAND RA[illegible])
 118 FORMAT(/,I5,' LINES',/,I5,' THICK',/)
 119 FORMAT(/,3X,'WATT/(CM2*STR): ',1P,4(E11.4,13X),E11.4)
 120 FORMAT(' PH/(SEC*CM2*STR): ',1P,4(E11.4,13X),E11.4)
 121 FORMAT(11X,5(A1,'(THIN)',5X,'(THICK)',5X))
 122 FORMAT(/,' TMIN = TEMPERATURE  USED  FOR  STDW =',I4,
    1/,' STD DOPP WIDTH = STDW (CM-1) =',E11.5,
    2/,I2,'-PT  GAUSS QUADRATURE  USED FOR NU-INTEG')
 123 FORMAT(' WATT/CM2*SR  ',1P,5(E12.4,11X))
 124 FORMAT(12X,5(F16.2,' KM',4X))
 125 FORMAT(/,' TAIL CONTRIB:',/,' PH/SEC*CM2*SR',1P,5(E12.4,11X))
 126 FORMAT(/,' P',I2,I5,'-',I3,1P,5(E13.5,10X))
 127 FORMAT(' $$$$$ CAUTION: LINE ',A2,I4,' IS VERY THICK, TOD(0) =',
    1E9.3,' FOR',F7.2,' KM PATH, TAIL APPROXIMATION MAY BE IN ERROR',
    2' $$$$$')
 128 FORMAT(//,' ALTITUDE-DEPENDENT QUANTITIES FOR LINE ',A2,I4,':',//,
    1' VOLUME EMISSION RATE IN PHOTONS/(SEC*CM3*CM-1*STER) (SPECTRAL',
    2', AT LINE CENTER)',/,21X,
    3' OR PHOTONS/(SEC*CM3*STER)          (INTEGRATED OVER LINE)',/,
    4' R  IS GIVEN IN UNITS OF PHOTONS/(SEC*CM2*CM-1*STER)',/,
    5' KT IS GIVEN IN UNITS OF CM-1/MOLECULE-CM2',//)
 129 FORMAT(' ******',5(A24))
 130 FORMAT(//,' $$$$$ CAUTION---BECAUSE JMAX >',I4,', NLTE CANNOT',
    1' HANDLE MORE THAN 5 VIEWING PATHS IN ONE RUN.',/,17X,'RERUN ',
    2' NLTE TO HANDLE THE HIGHER-ALTITUDE PATHS $$$$$',//)
 990 FORMAT(///,' ***** REQUESTED LINES NOT FOUND *****',////)
C
C     *******************************************************************
C
C     PARAMETER STATEMENTS APPEAR IN NLTE, LINES, AND SPECTRM. THEY SHOULD
C     BE MADE CONSISTENT  WITH EACH OTHER.  THE PURPOSE OF CMPL IS TO PRO-
C     VIDE AN OPTION TO LIST LIMITED PROGRAM OUTPUT TO UNIT 9, WHICH IS E-
C     QUIVALENT TO OUTPUT.  THIS IS FOR USE IN INTERACTIVE PROCESSING  AND
C     IS INVOKED BY INCLUDING THE  DS  PARAMETER ON THE FTN5 CONTROL CARD.
```

```
C     (CDC CYBER MACHINES). DEFAULT IS TO PRINT NOTHING TO UNIT 9.
C
C     EXPL IS THE OVERFLOW OR UNDERFLOW LIMIT FOR THE EXPONENTIAL FUNCTION
C
C     ******************************************************************
C
C     DEFINE ALL CONSTANTS AND INITIAL VALUES:
C
C        EARTHR = EARTH'S RADIUS (KM)
C        BOLTZ = BOLTZMANN'S CONSTANT (ERGS/DEG)
C        TS = STANDARD LINE STRENGTH TEMPERATURE (K) FOR AFGL TAPE
C        C2 = 2ND RADIATION CONSTANT (DEG/CM-1). THIS FACTOR IS NEEDED
C             EXPRESSIONS LIKE  EXP(-H*C*V/(BOLTZ*T))  WHERE V IS IN CM-1
C             AND T IS SOME TEMPERATURE.   LATER THE TEMPERATURE PROFILES
C             ARE PREMULTIPLIED BY 1/C2 TO SAVE SOME OPERATIONS.
C        BST = BOLTZ*TS/(H*C)
C        C =  SPEED OF LIGHT (CM/SEC)
C        H =  PLANCK'S CONSTANT (ERG-SEC)  AFTER ITS INITIAL USE MULTIPLY
C             BY 10**-7 TO GET MKS UNITS,  WHICH GIVES THE EVENTUAL RADI-
C             ANCES IN TERMS OF WATTS RATHER THAN ERGS/SEC.
C
      A2 = SQRT(ALOG(2.0))
      EARTHR = 6361.
      TS = 296.0
      BOLTZ = 1.380622E-16
      PI = 3.1415926535898
      C = 2.9979E+10
      H = 6.6262E-27
      C2 = H*C/BOLTZ
      BST = TS/C2
      H = H*1.0E-07
      TZ = SECOND()
      BL = ' '
C
C     ******************************************************************
C
C     AT THIS POINT SUBROUTINE LINES IS CALLED TO READ IN THE DATA REQUIRED
C     TO RUN THE PROGRAM, AND  PERFORM SOME INITIAL MANIPULATION OF ARRAYS.
C     THE ATMOSPHERIC PROFILE IS ACTUALLY READ IN SUBROUTINE ATMPR,  CALLED
C     BY LINES.  THE DATA REQUIREMENTS ARE GIVEN IN THE COMMENTS IN SUBROU-
C     TINES LINES AND ATMPR.
C
C     SUBROUTINE LINES---PURPOSE:
C                                   PERFORMS INITIALIZATION STEPS
C                                   READS UNIT 1 (PROGRAM DATA)
C                                   CALLS SUBROUTINE ATMPR
C                                   READS UNIT 3 (AFGL LINEFILE)
C                                   SETS CONTENTS OF COMMON/B/
C                                   CALLS SPECTRM, IF NECESSARY
C                                   RETURNS CERTAIN  INITIAL PARAMETER VALUES
C     SUBROUTINE ATMPR---PURPOSE:
C                                   READS UNIT 2 (ATMOSPHERIC PROFILE)
C                                   SETS UP PROFILE FOR DESIRED BAND
C                                   SETS CONTENTS OF COMMON/A/
C
C     ******************************************************************
C
      CALL LINES(VIBE,VIBL,BR)
C
C     ******************************************************************
```

```
C
C
C     AT THIS POINT THE DATA HAVE ALL BEEN READ IN AND STORED IN THE PROPER
C     ARRAYS.  NOW DO SOME FURTHER INITIALIZATION AND THEN PROCEED WITH THE
C     LOOPS WHICH PERFORM THE ACTUAL CALCULATIONS.
C
C     STDW IS THE STANDARD DOPPLER WIDTH WHICH IS USED TO DEFINE PANELS FOR
C     THE NU-INTEGRATION. THE CC DEFINE THE INTEGRATION POINTS, AND THE W'S
C     ARE THE WEIGHTS.  NPTS (WHICH CAN BE 2, 4, OR 8) IS THE NUMBER OF IN-
C     TEGRATION POINTS PER PANEL.
C
C     ***********************************************************************
C
      IF(JMAX.EQ.0)GO TO 998
      DOPP = A2*SQRT(2.0*BOLTZ*C2/(WGT*C*C))
      STDW = DOPP*SQRT(TMIN/C2)*VIBE
      IF(NPTS.EQ.2)THEN
          CC(1) = -.288675134595*STDW
          CC(2) = -CC(1)
          W(1) = .50
      ELSE IF(NPTS.EQ.4)THEN
          DO 202 I = 1,2
          CC(I)   = -C4(I)*STDW
          CC(5-I) = C4(I)*STDW
  202     W(I)    = W4(I)
      ELSE
          DO 203 I = 1,4
          CC(I)   = -C8(I)*STDW
          CC(9-I) = C8(I)*STDW
  203     W(I)    = W8(I)
      END IF
      I = TMIN
      WRITE(4,122)I,STDW,NPTS
C
C     THE TOTAL NUMBER OF DIFFERENT  LINE-OF-SIGHT  PATHS TO BE CONSIDERED
C     IN ALL IS IMX, (FIXED IN LINES).   THESE CASES ARE DONE IN GROUPS OF
C     FIVE (POSSIBLY LESS, IN THE CASE OF THE LAST GROUP) IN ORDER TO MAKE
C     THE PRINTED OUTPUT MANAGEABLE AND ALSO TO REDUCE THE SIZE OF CERTAIN
C     ARRAYS.  THE LOOP  DO 500 IS ENTERED ONCE FOR EACH GROUP.  THE ARRAY
C     HGTS STORES THE HEIGHTS (IN KM) WHICH PARAMETERIZE EACH PATH.  NREPS
C     (ALSO FIXED IN LINES) IS THE NUMBER OF GROUPS WHICH MUST BE HANDLED.
C
C     NOTE THAT  IF THERE ARE MORE THAN 500 LINES IN THE BAND UNDER CONSI-
C     DERATION ONLY 5 VIEWING PATHS CAN BE PROCESSED IN ONE RUN.
C
      TS = SECOND() - TZ
      WRITE(4,103)TS,JMAX
C$    IF(CMPL)
      WRITE(9,103)TS,JMAX
C$    ENDIF
      IF(JMAX.GT.DIML)THEN
          JMAX = DIML
          IF(NREPS.GT.1)THEN
              NREPS = 1
              WRITE(4,130)DIML
              WRITE(6,130)DIML
          END IF
      END IF
C
C**********************************************************************
```

```
C*
C*    LOOP TO SELECT GROUPS OF (5 OR LESS) LINE-OF-SIGHT PATHS. CALCULATE
C*    THESE CASES ALL AT ONCE. WHEN THIS LOOP ENDS, EXECUTION TERMINATES.
C*    SUBROUTINE PATH RETURNS IMAX, THE NUMBER OF PATHS IN THE GROUP SPE-
C*    CIFIED BY THE INDEX NR AND STACKS IMAX VALUES OF HGTS INTO THE VEC-
C*    TOR HTS.  IT ALSO DETERMINES THE LOWER-ALTITUDE INDEX, K1, FOR EACH
C*    PATH.
C*
      DO 500 NR = 1,NREPS
      LCNT = 1
      JCNT = 0
      IF(JMAX.EQ.1)FLAG = .TRUE.
      CALL PATH(ALT,HGTS,IMXX,HTS,IMAX,NR,KMAX,LOOK,K1)
C*
C*    SUMRD AND SUMPH ARE ARRAYS THAT STORE THE SUM OF RADIANCES FROM RO-
C*    TATIONAL TRANSITIONS FOR THE ITH LINE-OF-SIGHT PATH.   PRESET THESE
C*    ARRAYS TO ZERO.  ALSO CALCULATE THE ARRAY OF PATH LENGTHS, ZZ,  FOR
C*    EACH LAYER (K) AND EACH PATH (I) IN THIS GROUP.   THE FACTOR  10**5
C*    CONVERTS KM TO CM,  AND THE FACTOR RHO(K) CONVERTS ZZ TO THE COLUMN
C*    DENSITY.
C*
      DO 220 I = 1,IMAX
      SUMPH(I) = 0.0
      SUMRD(I) = 0.0
      DO 220 K = K1(I),KMAX
      IF(LOOK.EQ.1)THEN
          Z2 = ALT(K+1) - ALT(K)
          IF(K.EQ.K1(I))Z2 = ALT(K+1) - HTS(I)
      ELSE
          Z1 = ALT(K) - HTS(I)
          IF(Z1.LT.0.0)Z1 = 0.0
          Z1 = SQRT(Z1*(2.0*EARTHR + ALT(K) + HTS(I)))
          Z2 = SQRT((ALT(K+1)-HTS(I))*(2.0*EARTHR+ALT(K+1)+HTS(I))) - Z1
      END IF
  220 ZZ(K,I) = RHO(K)*Z2*1.0E+05
C*
      IF(FLAG.AND.NR.EQ.1)THEN
          WRITE(5,128)BR(1),RQL(1)
          WRITE(5,106)
      END IF
C*
C* ***********************************************************************
C**
C**   LOOP TO PERFORM CALCULATIONS ON ALL THE ROTATIONAL LINES SELECTED.
C**   LINES ARE READ FROM TAPE3 IN BATCHES OF 500, MAXIMUM. IF THERE ARE
C**   MORE THAN 500 LINES ON THE LINEFILE THIS LOOP IS ENTERED MORE THAN
C**   ONCE. (SYMBOLIC CONSTANT DIML IS SET TO 500 FOR THIS PURPOSE.)  IF
C**   THERE ARE MORE THAN  500  LINES, A MAXIMUM OF FIVE L-O-S PATHS CAN
C**   BE RUN.
C**
C**   QQ CORRECTS FOR THE STIMULATED EMISSION AT TS (296 K).
C**
  225 DO 400 J = 1,JMAX
      VINIT = V(J)
      ALFL = ALF(J)
      QQ = 1.0 - EXP(-VINIT/BST)
C**
C**   *********************************************************************
C** *
C** * THE LOOP DO 230 CALCULATES THOSE PATH-INDEPENDENT QUANTITIES WHICH
```

```
C** * DEPEND ONLY ON  ALTITUDE.  ALTITUDES RUN FROM  THE LOWEST REQUIRED
C * * FOR THE FIRST (LOWEST) LINE-OF-SIGHT PATH TO THE  HIGHEST REQUIRED
C * * FOR THE LAST PATH IN THE CURRENT GROUP.
C
C * * GAM  = (GL*NU)/(GU*NL)
C * * R       SIMILAR TO NOTATION IN BULLITT ET AL,  JQSRT (T.B.P., 1985)
C * * DWID = DOPPLER WIDTH (CM-1)
C * * RAT  = LORENTZ TO DOPPLER  LINEWIDTH RATIO  FOR THE VOIGT FUNCTION
C * * KT   = CORRECTED LINE STRENGTH.  QRAT*EXP(ARG)  IS JUST  THE RATIO
C * *         PL(TVL,T)/PL(TS,TS) WHERE PL(T1,T2) IS THE PROBABILITY THAT
C * *         THE LOWER RO-VIB STATE IS OCCUPIED AT THE VIBRATIONAL TEMP-
C * *         ERATURE T1 AND THE ROTATIONAL TEMPERATURE T2.
C * *
      DO 230 K = K1(1),KMAX
      ARG = (VIBE-VINIT)/TRTMP(K) - (VIBL+VIBE)/TVU(K) + VIBL/TVL(K)
      GAM = EXP(ARG)
      R(K) = (GAM/(1.0-GAM))*2.0*C*VINIT*VINIT
      ARG = EDP(J)/BST - (EDP(J)-VIBL)/TRTMP(K) - VIBL/TVL(K)
      KT(K) = STS(J)*QRAT(K)*(1.0 - GAM)*EXP(ARG)/QQ
      DWID(K) = DOPP*SQRT(TRTMP(K))*VINIT
  230 RAT(K) = A2*ALFL*ALCOR(K)/DWID(K)
      DV = 0.0
      IF(NDP.LT.0)THEN
         DO 231 K = K1(1),KMAX
  231    VGT(K) = VWERF(DV,RAT(K))/DWID(K)
      ELSE
         CALL ZVGTC(DV,K1(1),KMAX)
      END IF
C
      IF(FLAG.AND.NR.EQ.1)THEN
C
         DO 232 K = K1(1),KMAX
         TAU = KT(K)*VGT(K)*RHO(K)*1.0E+05*R(K)
  232    WRITE(5,107)ALT(K),R(K),DWID(K),KT(K),RAT(K),VGT(K),TAU
      END IF
C * *
C *   **********************************************************************
C *
C *   **********************************************************************
C * *
C * * THE LOOP  DO 240 I=1,IMAX CALCULATES THE RADIANCE, THR, FOR EACH PATH
C * * ON THE ASSUMPTION THAT THE LINE IS "THIN". IT ALSO CALCULATES THE TO-
C * * TAL OPTICAL DEPTH AT THE LINE CENTER,  AND THEN DECIDES WHETHER TO GO
C * * THROUGH THE "THICK" CALCULATION  ON THE BASIS  OF ITS VALUE.  INUM IS
C * * THE NUMBER OF PATHS IN THE CURRENT GROUP  FOR WHICH TO DO THE "THICK"
C * * CALCULATION. ALSO, FOR EACH PATH, THE ARRAY TRN  USED TO EVALUATE THE
C * * TAIL OF THE RADIANCE PROFILES IS CALCULATED.  LBND AND LMAX ARE INDI-
C * * CES  SPECIFYING THE  INTEGRATION PANELS  AT WHICH THE  PANEL-WIDTH IS
C * * FIRST AUGMENTED AND AFTER WHICH THE NUMERICAL INTEGRATION IS CUT OFF,
C * * RESPECTIVELY. ALSO, INITIALIZE THE RADIANCE ARRAYS WITH THE THIN-LINE
C * * RESULTS,  AND CHOOSE KM(I),  THE MAXIMUM ALTITUDE  NEEDED FOR THE ITH
C * * VIEWING PATH.
C * *
      INUM = 0
      KLAR = 0
      LBND = 0
      MTAU = 1
      DO 240 I = 1,IMAX
      LMAX(I) = 0
      TOD(I) = 0.0
```

```
      THR(I) = 0.0
      TRN(I) = 0.0
      SUM(I) = 0.0
      KM(I) = KMAX
      IF(LOOK.EQ.0)THEN
          KI = KMAX
          KF = K1(I)
          KD = -1
      ELSE
          KI = K1(I)
          KF = KMAX
          KD = 1
      END IF
      QK = 1.0
      DO 235 K = KI,KF,KD
        TAU = KT(K)*ZZ(K,I)
        THR(I) = THR(I) + R(K)*TAU
        TRN(I) = TRN(I) + R(K)*TAU*ALCOR(K)*ALFL
        TAU = TAU*VGT(K)
        TOD(I) = TOD(I) + TAU
        IF(TOD(I).LE.EXPL)THEN
            EK = EXP(-TAU)
            Z2 = QK*(1.0 - EK)*R(K)
            SUM(I) = SUM(I) + Z2
            CUM(K) = SUM(I)
            QK = QK*EK
        ELSE
            Z2 = EXP(-EXPL)
            CUM(K) = 0.0
        END IF
        IF(FLAG)THEN
            L = K - K1(1) + 2
            STORE(L,I) = TAU
            STORE(L+KMAX,I) = Z2
        END IF
235   CONTINUE
      IF(NDP.EQ.1)THEN
          TRN(I) = THR(I)*DWID(K1(I))/(A2*SQRT(PI))
      ELSE
          TRN(I) = TRN(I)*2.0/PI
      END IF
      IF(LOOK.EQ.0)THEN
          THR(I) = 2.0*THR(I)
          TOD(I) = 2.0*TOD(I)
          TRN(I) = 2.0*TRN(I)
      END IF
      RAD(I) = THR(I)
      THR(I) = THR(I)*H*C*VINIT
      RAW(I) = THR(I)
      IF(TOD(I).GT.TOD(MTAU))MTAU = I
      IF(TOD(I).GT.(3.0*ACC).OR.FLAG)THEN
          INUM = I
          RAD(I) = 0.0
          IF(LOOK.EQ.0)THEN
              Z2 = SUM(I)*ACC
              DO 238 K = KMAX,K1(I),-1
              IF(CUM(K).GT.Z2)GO TO 240
              KM(I) = K
238           CONTINUE
          ELSE
```

```
            Z2 = (1.0 - ACC)*SUM(I)
            DO 239 K = KMAX,K1(I),-1
            IF(CUM(K).LT.Z2)GO TO 240
  239       KM(I) = K
         END IF
      END IF
  240 IF(KLAR.LT.KM(I))KLAR = KM(I)
C * *
C *  ***********************************************************************
C *
C *  ***********************************************************************
C * *
C * * IF THERE IS ONLY ONE LINE UNDER CONSIDERATION....
C * *     WRITE SOME INFORMATION TO TAPE5
C * *     WRITE A HEADER TO TAPE4
C * *     RESET INUM SO THE "THICK" CALCULATION IS PERFORMED REGARDLESS OF
C * *     THE OPTICAL DEPTH
C * *
      IF(FLAG)THEN
         INUM = IMAX
         ARG = H*C*VINIT
         WRITE(4,104)BR(1),RQL(1),ARG,(BL,I=1,INUM)
         WRITE(4,124)(HTS(I),I=1,INUM)
         WRITE(4,101)
         WRITE(5,108)(BL,I=1,IMAX)
         WRITE(5,101)
         DO 245 K = K1(1),KMAX
         L = K - K1(1) + 2
         DO 244 I = 1,IMAX
         IF((K1(I)-K1(1)+2).GT.L)GO TO 244
         LL = I
         CUM(I) = 1.0E-05*ZZ(K,I)/RHO(K)
  244    CONTINUE
  245    WRITE(5,109)ALT(K),(CUM(I),STORE(L,I),STORE(L+KMAX,I),I=1,LL)
         WRITE(5,101)
         WRITE(5,110)(TOD(I),SUM(I),I=1,IMAX)
      END IF
C * *
C *  ***********************************************************************
C *
C *   SET ICUR,  THE NUMBER OF PATHS PRESENTLY UNDER CONSIDERATION  FOR THE
C *   "THICK" CALCULATION.  INITIALIZE THE PANEL-WIDTH FACTOR,  PFAC (INTE-
C *   GER) AND THE NU-INDEX, DNU (INTEGER).  (DNU GIVES THE NUMBER OF STAN-
C *   DARD DOPPLER WIDTHS  FROM THE LINE-CENTER  TO THE END  OF THE CURRENT
C *   INTEGRATION PANEL.)  JCNT IS THE NUMBER OF "THICK" LINES ENCOUNTERED.
C *
      IF(INUM.EQ.0)GO TO 360
      JCNT = JCNT + 1
      PFAC = 1
      DNU  = 0
      ICUR = INUM
C *
C *
C * ***********************************************************************
C **
C **  THE LOOP  DO 350 LL = 1,50  SELECTS  THE PANELS  (OF WIDTH STDW*PFAC)
C **  WITHIN WHICH TO PERFORM NPTS-PT GAUSS-LEGENDRE QUADRATURE OVER FREQU-
C **  ENCY. THE LOOP DO 300 L = 1,NPTS  EVALUATES THE INTEGRAND AT THE NPTS
C **  CHOSEN FREQUENCIES FOR EACH L-O-S PATH,  AND THE INTEGRALS THEMSELVES
C **  ARE EVALUATED AT  STATEMENT 305.  THE INTEGRAND IS THE RADIANCE INTE-
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```
C **  GRATED ALONG THE L-O-S PATH---THAT IS THE INTEGRAL OVER Z. THIS Z-IN-
C **  TEGRATION  IS THEREFORE  CARRIED OUT COMPLETELY  FOR THE FIRST OF THE
C **  NPTS POINTS  (THE FIRST FREQUENCY) FOR ALL L-O-S PATHS BEFORE THE SE-
C **  COND IS CONSIDERED.
C **
C **  FOR LIMB-LOOK, THE Z-INTEGRATION IS DONE IN TWO PIECES  (LOOPS ENDING
C **  AT 260 AND 265).  FOR ZENITH-LOOK, ONLY THE SECOND PIECE IS REQUIRED.
C **
C **
      DO 350 LL = 1,50
C **
      DNU = DNU + PFAC
      CPAN = STDW*DNU - STDW*PFAC/2.0
      DO 300 L = 1,NPTS
        DV = CPAN + CC(L)*PFAC
C **
C ** ***********************************************************************
C ***
C ***   LINESHAPE:       CALCULATE, FOR ALL ALTITUDES REQUIRED, THE VALUES
C ***   OF THE VOIGT PROFILE AT THE "DISTANCE" FROM THE CENTER OF THE LINE
C ***   DETERMINED  BY THE CURRENT VALUES OF  L AND LL---THAT IS,  DV CM-1
C ***   FROM THE CENTER.  THE DOPPLER OPTION IS INCLUDED IN ZVGTC. RESULTS
C ***   ARE STORED IN ARRAY VGT.
C ***
        IF(NDP.LT.0)THEN
            DO 251 K = K1(1),KLAR
            Z2 = DV/DWID(K)
  251       VGT(K) = VWERF(Z2,RAT(K))/DWID(K)
        ELSE
            CALL ZVGTC(DV,K1(1),KLAR)
        END IF
C ***
C ** ***********************************************************************
C **
C ** ***********************************************************************
C ***
C ***   THE LOOP  DO 270 I = 1,ICUR  SELECTS DIFFERENT LINE-OF-SIGHT PATHS.
C ***   SUM IS  (TEMPORARILY)  THE OPTICAL DEPTH ALONG THE PATH AT THE CUR-
C ***   RENT FREQUENCY. INU (REAL) IS THE RADIANCE.
C ***
        DO 270 I = 1,ICUR
            SUM(I) = 0.0
            INU(L,I) = 0.0
C ***
C ***       START THE Z-INTEGRATION ALONG THE  LINE-OF-SIGHT  AT THE TOP OF
C ***       THE ATMOSPHERE.  THE LOOP  DO 260  CARRIES THE CALCULATION FROM
C ***       THE OBSERVER TO THE TANGENT POINT FOR LIMB-LOOK GEOMETRY.  THIS
C ***       LOOP IS BYPASSED FOR ZENITH-LOOK.
C ***
            QK = 1.0
            IF(LOOK.EQ.1)GO TO 263
            DO 260 K = KM(I),K1(I),-1
                TAU = KT(K)*ZZ(K,I)*VGT(K)
                SUM(I) = SUM(I) + TAU
                IF(SUM(I).GT.EXPL)GO TO 260
                EK = EXP(-TAU)
                INU(L,I) = INU(L,I) + QK*(1.0 - EK)*R(K)
                QK = QK*EK
  260       CONTINUE
            IF(SUM(I).LT.EXPL)GO TO 263
```

```
            SUM(I) = 2.0*SUM(I)
            GO TO 268
C ***
C ***       FOR LIMB-LOOK, COMPLETE THE Z-INTEGRATION BY CARRYING IT FROM
C ***       THE TANGENT  POINT THROUGH ALL SLABS TO THE FAR HORIZON.  FOR
C ***       ZENITH-LOOK  THIS LOOP DOES THE COMPLETE CALCULATION FROM THE
C ***       THE OBSERVER TO TOP OF THE ATMOSPHERE.
C ***
  263       DO 265 K = K1(I),KM(I)
                TAU = KT(K)*ZZ(K,I)*VGT(K)
                SUM(I) = SUM(I) + TAU
                IF(SUM(I).GT.EXPL)GO TO 265
                EK = EXP(-TAU)
                INU(L,I) = INU(L,I) + QK*(1.0 - EK)*R(K)
                QK = QK*EK
  265       CONTINUE
  268       NU(L) = DV
            OD(L,I) = SUM(I)
  270   CONTINUE
C ***
C ** ***********************************************************************
C **
  300 CONTINUE
C **
C **  PERFORM 2-, 4-, OR 8-PT GAUSSIAN INTEGRATION  OVER THE CURRENT PANEL,
C **  AND ADD THE RESULT TO THE ACCUMULATING SUMS STORED IN RAD.
C **
      TAU = SUM(MTAU)
      DO 310 I = 1,ICUR
      LMAX(I) = LL
      SUM(I) = 0.0
      DO 305 K = 1,NPTS/2
  305 SUM(I) = SUM(I) + W(K)*(INU(K,I) + INU(NPTS+1-K,I))
      SUM(I) = 2.0*SUM(I)*STDW*PFAC
  310 RAD(I) = RAD(I) + SUM(I)
C **
C **  IF THERE IS ONLY ONE LINE, PRINT THE LINESHAPE AND THE RESULTS OF THE
C **  INTEGRATION OVER SUCCESSIVE PANELS AS THEY ARE PROCESSED.
C **
      IF(FLAG)THEN
          DO 320 L = 1,NPTS
          K = (LL-1)*NPTS + L
  320     WRITE(4,105)K,NU(L),(INU(L,I),OD(L,I),I=1,ICUR)
          K = DNU - PFAC
          WRITE(4,126)LL,K,DNU,(SUM(I),I=1,ICUR)
          WRITE(4,101)
      END IF
C **
C **  CHECK TO SEE IF THE NUMERICAL INTEGRATION CAN BE CUT OFF. IF SO, ADD
C **  IN THE ANALYTICAL RESULT FOR THE TAIL  AND DECREMENT ICUR.  SKIP OUT
C **  OF THE FREQUENCY LOOPS IF ALL PROFILES ARE CUT OFF.
C **
      IF(DNU.GE.5)THEN
          L = 0
          DO 330 I = ICUR,1,-1
          Z1 = 1.0
          IF(NDP.EQ.1)THEN
              Z1 = DNU*STDW*A2/DWID(K1(I))
              Z1 = EXP(-Z1*Z1)
          END IF
```

```
            S = Z1*TRN(I)/(DNU*STDW)
            Z2 = 6.0*ACC*RAD(I)/OD(NPTS,I)
            IF(S.LT.Z2)THEN
                L = L + 1
                TRN(I) = S*(1. + (DWID(K1,I))/(DNU*STDW))**2/(2.*A2*A2))
                IF(NDP.EQ.1)TRN(I) = S
                RAD(I) = RAD(I) + TRN(I)
            END IF
  330       CONTINUE
            ICUR = ICUR - L
        END IF
        IF(ICUR.LE.0)GO TO 360
C **
C **    CHECK TO SEE IF THE PANEL WIDTH CAN BE EXPANDED TO PERFORM THE NUMER-
C **    ICAL INTEGRATION IN THE TAIL MORE QUICKLY. THE PATH WITH THE GREATEST
C **    OPTICAL DEPTH TRIGGERS THE EXPANSION FOR ALL PATHS.
C **
        IF(LL.GE.3.AND.TAU.LT..5)THEN
            IF(LBND.EQ.0)LBND = LL
            IF(PFAC.LT.500)PFAC = 2*PFAC
        END IF
  350 CONTINUE
C **
C **    END  THE LOOP (INDEX LL)  THAT SELECTS  THE INTEGRATION  PANELS.  THE
C **    INTEGRATION IS NOW COMPLETE FOR ALL L-O-S PATHS FOR THE PRESENT LINE,
C **    EXCEPT POSSIBLY FOR THE TAIL CONTRIBUTION,  ADDED IN AT STATEMENT 355
C **    FOR THE MOST EXTREME THICK-LINE CASES. (NORMALLY, EXECUTION WILL SKIP
C **    OUT OF THE LOOP DO 350 TO STATEMENT 360.  IF THE LINE IS SO EXTREMELY
C **    THICK THAT THE  PANEL-EXPANSION  PROCEDURE HAS NOT EVEN BEEN INVOKED,
C **    A DIAGNOSTIC MESSAGE  IS WRITTEN TO UNIT 6  BECAUSE THE APPROXIMATION
C **    FOR THE TAIL  CONTRIBUTION  MAY BE IN ERROR.  GENERALLY  THE 50-PANEL
C **    RANGE OF THE LOOP DO 350 IS SUFFICIENT TO AVOID THIS DIFFICULTY.)
C **
C * *********************************************************************
C *
        S = DNU*STDW
        DO 355 I = 1,ICUR
        IF(NDP.EQ.1)THEN
            Z1 = S*A2/DWID(K1(I))
            TRN(I) = EXP(-Z1*Z1)*TRN(I)/S
        ELSE
            TRN(I) = (TRN(I)/S)*(1.0 + (DWID(K1(I))/S)**2/(2.*A2*A2))
        END IF
  355 RAD(I) = RAD(I) + TRN(I)
        IF(PFAC.EQ.1)WRITE(6,127)BR(J),RQL(J),TOD(1),HTS(1)
C *
C *  ********************************************************************
C * *
C * * ADD THE CONTRIBUTIONS FROM THE CURRENT LINE TO THE CUMULATIVE RESULT.
C * *
  360 DO 370 I = 1,IMAX
        IF(I.LE.INUM)THEN
            RAW(I) = RAD(I)*H*C*VINIT
            SUM(I) = TRN(I)*H*C*VINIT
        END IF
        SUMPH(I) = SUMPH(I) + RAD(I)
  370 SUMRD(I) = SUMRD(I) + RAW(I)
C * *
C *  ********************************************************************
C *
```

```
C *    IF ONLY ONE LINE IS CALCULATED, PRINT THE APPROXIMATE RESULT USED FOR
C *    THE TAIL OF THE RADIANCE PROFILE.
C *
       IF(FLAG)THEN
           WRITE(4,125)(TRN(I),I=1,INUM)
           WRITE(4,123)(SUM(I),I=1,INUM)
           WRITE(4,100)
       END IF
C *
C *    PRINT OUT THE RADIANCE---BOTH THE THIN-LINE APPROXIMATION AND THE RE-
C *    SULT OF THE FULL CALCULATION, WHENEVER IT IS PERFORMED. THE FORMER IS
C *    USED ONLY WHEN THE LATTER IS BYPASSED.
C *
       IF(J.EQ.1.AND.LCNT.EQ.1)THEN
           WRITE(4,113)(HTS(I),HTS(I),I=1,IMAX)
           WRITE(4,121)(BL,I=1,IMAX)
           WRITE(4,101)
       END IF
       WRITE(4,111)BR(J),RQL(J),(THR(I),I=1,IMAX)
       IF(INUM.GT.0)WRITE(4,112)(RAW(I),I=1,INUM)
       IF(FLAG)THEN
           WRITE(4,100)
           DO 399 I = 1,3
  399      WRITE(4,129)(AST,K=1,IMAX)
           GO TO 400
       END IF
C**
C**    PRINT OUT THE TOTAL OPTICAL DEPTHS AT THE LINE CENTERS AND THE ACCUM-
C**    ULATING RADIANCE (SUMRD) FOR EACH PATH.  ALSO PRINT THE CPU TIME USED
C**    AND THE INTEGRATION-PANEL INDICES. ALL THIS GOES TO UNIT 5.
C**
       IF(J.EQ.1.AND.LCNT.EQ.1)THEN
           WRITE(5,115)(HTS(I),I=1,IMAX)
           WRITE(5,114)(BL,I=1,IMAX)
           WRITE(5,101)
       END IF
       TS = SECOND() - TZ
       WRITE(5,116)TS,BR(J),RQL(J),LBND,(LMAX(I),KM(I),SUMRD(I),TOD(I),
      1I=1,IMAX)
C**
C**    IF SPECTRAL RADIANCE IS BEING CALCULATED, CALL SPEC1 TO ADD THE CON-
C**    TRIBUTION FROM THE CURRENT LINE  TO THE RESULTS PREVIOUSLY OBTAINED.
C**
       NNN = NR
       IF(FWHM.GT.0.0.AND.NNN.LE.3)CALL SPEC1(FWHM,VINIT,NNN,IMAX,RAW)
C**
  400  CONTINUE
C**
C**    END THE LOOP (INDEX J) THAT CHOOSES DIFFERENT LINES
C**
C* ***********************************************************************
C*
C*     IF MORE THAN 500 LINES ARE USED,  BRANCH TO LINES3 TO REREAD THE NEXT
C*     BATCH, AND THEN ENTER THE LOOP DO 400 ONCE AGAIN.  LCNT IS THE NUMBER
C*     OF TIMES THIS LOOP IS ENTERED.
C*
       IF(JMAX.LT.DIML)GO TO 490
       CALL LINES3(LCNT)
       LCNT = LCNT + 1
       IF(JMAX.EQ.0)GO TO 490
```

```
      FLAG = .FALSE.
      GO TO 225
C*
C*    WRITE THE  FINAL RESULTS FOR THE BAND RADIANCE  FOR THE CURRENT GROUP
C*    OF PATHS.
C*
  490 IF(FLAG)GO TO 500
      WRITE(4,100)
      DO 491 I = 1,3
  491 WRITE(4,129)(AST,K=1,IMAX)
      WRITE(4,117)
      WRITE(4,119)(SUMRD(I),I=1,IMAX)
      WRITE(4,120)(SUMPH(I),I=1,IMAX)
      JMAX = JMAX + DIML*(LCNT-1)
      WRITE(4,118)JMAX,JCNT
C$    IF(CMPL)
      DO 492 I = 1,3
  492 WRITE(9,129)(AST,K=1,IMAX)
      WRITE(9,117)
      WRITE(9,119)(SUMRD(I),I=1,IMAX)
      WRITE(9,120)(SUMPH(I),I=1,IMAX)
      WRITE(9,118)JMAX,JCNT
      DO 498 I = 1,3
  498 WRITE(9,129)(AST,K=1,IMAX)
C$    ENDIF
      DO 499 I = 1,3
  499 WRITE(4,129)(AST,K=1,IMAX)
C
      WRITE(4,100)
  500 CONTINUE
C*
C*    END THE LOOP (INDEX NR) SELECTING DIFFERENT GROUPS OF VIEWING PATHS
C*
C **********************************************************************
C
C     IF SPECTRAL RADIANCE IS BEING CALCULATED, CALL SPEC2 TO WRITE IT TO
C     UNITS 4 AND 7.
C
      IF(FWHM.GT.0.0)CALL SPEC2(FWHM)
C
C     ******************************************************************
C
  998 IF(JMAX.EQ.0)THEN
          WRITE(4,990)
          WRITE(6,990)
      END IF
      CLOSE(1)
      CLOSE(2)
      CLOSE(3)
      REWIND(4)
      REWIND(5)
      REWIND(6)
      CLOSE(4)
      CLOSE(5)
      CLOSE(6)
      END
```

```
      SUBROUTINE LINES(VIBE,VIBL,BRNCH)
C
C     ********************************************************************
C
C     THE PURPOSE OF SUBROUTINE LINES IS TO PERFORM INITIALIZATION STEPS
C                                             READ UNIT 1
C                                             CALL ATMPR
C                                             READ UNIT 3
C                                             CALL SPECTRM
C                                             SET COMMON/B/
C
C     ********************************************************************
C
      INTEGER RQL,DEGV,GL,GU,DIML
      LOGICAL CMPL,FLAG
      PARAMETER(DIML=500,CMPL=.FALSE.)
      CHARACTER*2 BR,BRNCH(DIML),BCH
      CHARACTER*3 MOL
      CHARACTER*4 UNIT
      CHARACTER*8 UST,LST,US,LS
      CHARACTER*10 MES(2),DATE,TIME
      CHARACTER*47 FMT,MSG
C
      DIMENSION V(DIML),STS(DIML),ALF(DIML),EDP(DIML),RQL(DIML),HGTS(50)
      COMMON/B/V,STS,ALF,EDP,RQL,NRL,HGTS,ACC,NPTS,NDP,
     1         WGT,LOOK,NREPS,IMXX,JMAX,FWHM
      SAVE UST,LST,ISO,BR,VMIN,VMAX,JNUM,FMT
C
   97 FORMAT(1H1,'PROGRAM NLTE FOR INFRARED RADIANCE',
     1/,' DATE =',A10,'  TIME = ',A10,/)
   98 FORMAT(1H1)
   99 FORMAT(' ***************************************************',
     1'******************',A2,/,' TAPE',I1)
  100 FORMAT(//,' 1A---LINE DIRECTIVES:',/,
     1/,' MOL = MOLECULE CODE =',3X,A3,
     2/,' ISO = ISOTOPE  CODE =',I6,
     3/,' UST = UPPER VIB LVL = ',A8,
     4/,' LST = LOWER VIB LVL = ',A8,
     5/,' BR  = RO-VIB BRANCH = ',4X,A2,
     6/,' NRL = ROT''L  LINE # =',I6)
  101 FORMAT(//,' 1B---VIEWING PATH PARAMETERS:',/,
     1/,' TANI = LOWEST  ',A7,' HEIGHT (KM) =',F7.2,
     2/,' TANF = HIGHEST ',A7,' HEIGHT (KM) =',F7.2,
     3/,' SPAC = EXAMINATION  INTERVAL  (KM) =',F7.2,
     4/,' LOOK =',I2,';  LOOKING GEOMETRY CHOSEN =',A7)
  102 FORMAT(//,' 1C---PROGRAM PARAMETERS:     ',/,
     1/,' HMAX = ASSUMED TOP OF ATMOSPHERE (KM) =',I5,5X,A16,
     2/,' ACC  = ACCURACY (INTEG''D RADIANCE)  =',F7.5,
     3/,' NPTS = NUMBER OF INTEG POINTS PER PANEL =',I3,
     4/,' NDP  =',I2,'; LINESHAPE OPTION SELECTED =',A22,
     5/,' VMIN = LOWER END, LINE SEARCH (CM-1) =',I6,
     6/,' VMAX = UPPER END, LINE SEARCH (CM-1) =',I6)
  103 FORMAT(//,' 1E---BAND PARAMETERS:  ',A47,/,
     1/,' VIBE = VIB ENERGY OF THE  TRANSITION (CM-1) =',F10.4,
     2/,' VIBL = VIB ENERGY OF THE LOWER STATE (CM-1) =',F10.4,
     3/,' VIBQ = QUANTUM FOR THE PARTITION  FN (CM-1) =',F10.4,
     4/,' GL   = STATISTICAL WEIGHT,  LOWER VIBRATIONAL STATE =',I2,
     5/,' GU   = STATISTICAL WEIGHT,  UPPER VIBRATIONAL STATE =',I2)
  104 FORMAT(//,' QUANTITIES RETURNED FROM MOLEC:',/,
```

```
     1/,' WGT  = MOLECULAR  WEIGHT  =',I4,
     2/,' AI   = ISOTOPIC  ABUND =',F7.5,
     3/,' DEGV (EXPLAINED IN MOLEC) =',I4,
     4/,' PROT (EXPLAINED IN MOLEC) =',F4.1,
     5/,' TEXP (EXPLAINED IN MOLEC) =',F4.2)
  105 FORMAT(/,' FORMAT FOR THE SEARCH OF THE LINETAPE IS',/,1X,A47,/)
  106 FORMAT(//,' $$$$$   CARD 1E NEEDED BUT NOT FOUND,',
     1' RESULTS UNPREDICTABLE $$$$$',//)
  107 FORMAT(//,' AFGL LINE FILE FOR SELECTED TRANSITION:',
     13X,A3,I6,2X,2(1X,A8),/)
  108 FORMAT(2X,'BR  LINE     FREQUENCY    ',
     1'STRENGTH   WIDTH   LS ENERGY',/,
     216X,'(CM-1)',14X,'(CM-1)      (CM-1)',/)
  109 FORMAT(2X,A2,I5,F14.4,E11.3,F7.3,F12.4)
  110 FORMAT(//,' PRINT THE HEADERS AND FIRST DATA CARD-IMAGES FOUND ',
     1'ON INPUT UNITS',/)
  111 FORMAT(//,' 1D---SYNTHETIC SPECTRUM PARAMETERS:',/,
     1/,' FWHM = WIDTH OF TRIANGULAR SCANNING FN  (',A4,') =',F7.3,
     2/,' DEL  = SPACING OF PTS IN SYNTH SPECTRM  (',A4,') =',F7.3)
  112 FORMAT(//,' 1D---SYNTHETIC SPECTRUM PARAMETERS:',/,
     1/,' FWHM = 0,  SYNTHETIC SPECTRUM NOT GENERATED')
  113 FORMAT(//,' $$$$  NOTE: ONLY 50 L-O-S PATHS CAN BE RUN',/)
C
C     *********************************************************************
C
C     INITIALIZATION--UNITS 1-6 ARE ASSOCIATED WITH LOCAL FILES TAPE1-TAPE6
C
      OPEN(1)
      OPEN(2)
      OPEN(3)
      OPEN(4)
      OPEN(5)
      OPEN(6)
      REWIND(2)
      REWIND(3)
      MES(1) = DATE()
      MES(2) = TIME()
      WRITE(4,97)MES(1),MES(2)
      WRITE(5,97)MES(1),MES(2)
      WRITE(6,97)MES(1),MES(2)
      BCH = '  '
      I = 1
      WRITE(4,99)BCH,I
C$    IF(CMPL)
      OPEN(9,FILE='OUTPUT')
      WRITE(9,97)MES(1),MES(2)
      WRITE(9,99)BCH,I
C$    ENDIF
      I = 5
      WRITE(5,99)BCH,I
      I = 6
      WRITE(6,99)BCH,I
      WRITE(6,110)
C
C     *********************************************************************
C
C
C     READ IN MODELLING DATA FROM CARDS---UNIT 1
C
C**** CARD 1A  LINE DIRECTIVES CARD---LIST-DIRECTED READ
```

```
C
C        MOL  = MOLECULE CODE (INPUT AS 'CO2', ETC. INCLUDING QUOTES)
C        ISO  = ISOTOPE  CODE (INTEGER)
C        UST  = UPPER VIB STATE (AFGL LINE FILE NOTATION; INCLUDE QUOTES)
C        LST  = LOWER VIB STATE (AFGL LINE FILE NOTATION; INCLUDE QUOTES)
C        BR   = BRANCH (P, Q, OR R) (INPUT AS 'P', ETC.)
C        NRL  = ROTATIONAL LINE NUMBER  (INTEGER)
C
C     WHEN BR  = 'A', THE P, Q, AND R  BRANCHES ARE ALL EVALUATED (DEFAULT)
C     WHEN NRL = 999 ALL LINES IN THE CHOSEN BRANCH ARE EVALUATED (DEFAULT)
C     INDIVIDUAL LINES CAN BE SELECTED BY SETTING BR TO  'P',  'Q',  OR 'R'
C     AND SETTING NRL EQUAL TO THE DESIRED LINE NUMBER.
C
C
C**** CARD 1B  VIEWING PATH PARAMETERS CARD---LIST-DIRECTED READ
C
C        TANI = SMALLEST TANGENT HEIGHT OR OBSERVATION HEIGHT (KM)
C        TANF = GREATEST TANGENT HEIGHT OR OBSERVATION HEIGHT (KM)
C        SPAC = EXAMINATION INTERVAL (KM)  (DEFAULT = +1 KM)
C
C     IN LIMB-LOOKING GEOMETRY THE LINE-OF-SIGHT PATH IS PARAMETERIZED BY A
C     TANGENT HEIGHT (LOOK = 0);  IN ZENITH-LOOK  GEOMETRY IT IS PARAMETER-
C     IZED BY AN OBSERVATION HEIGHT (LOOK = 1). IF SPAC > 0, LIMB-LOOK GEO-
C     METRY IS ASSUMED;  IF SPAC < 0, ZENITH-LOOK IS ASSUMED. IN THE LATTER
C     CASE, ABS(SPAC) IS USED FOR THE EXAMINATION INTERVAL.
C
C
C**** CARD 1C  PROGRAM PARAMETERS CARD---LIST-DIRECTED READ
C
C        HMAX = ALTITUDE, "TOP" OF USEFUL ATMOSPHERE  (KM;  DEFAULT = 1001)
C        ACC  = FRACTIONAL ERROR ALLOWABLE,  INTEGRATED INTENSITY IN A LINE
C                                          (DEFAULT = .01; MAXIMUM = .05)
C        NPTS = NUMBER OF INTEGRATION PTS PER PANEL (NU-INTEG; DEFAULT = 4)
C        NDP  = LINESHAPE CODE: VOIGT (NDP = 0; DEFAULT)  OR DOPP (NDP = 1)
C        VMIN = LOWER END, FREQUENCY RANGE SEARCHED FOR RO-VIB LINES (CM-1)
C        VMAX = UPPER END, FREQUENCY RANGE SEARCHED FOR RO-VIB LINES (CM-1)
C
C     ANY VALUE OF HMAX FALLING BETWEEN TANF AND THE LARGEST ALTITUDE FOUND
C     IN THE ATMOSPHERIC PROFILE IS ACCEPTABLE. IF HMAX IS NOT WITHIN THESE
C     LIMITS, THE PROGRAM ADJUSTS IT AND PRINTS A MESSAGE.
C
C     ACC DETERMINES WHETHER TO ACCEPT THE THIN-LINE APPROXIMATION  FOR THE
C     INTEGRATED RADIANCE OF THE INDIVIDUAL LINES, OR NOT. (IF ACCEPTED THE
C     MAIN CALCULATION IS BYPASSED  AND THE RESULT IS OBTAINED A GREAT DEAL
C     MORE QUICKLY.) THE CRITERION FOR ACCEPTANCE IS BASED ON THE EMPIRICAL
C     OBSERVATION  THAT THE FRACTIONAL ERROR IS ABOUT  TAU/3,  WHERE TAU IS
C     THE OPTICAL DEPTH  AT LINE CENTER ALONG THE  L-O-S  PATH. (THIS HOLDS
C     FOR TAU < .5.) ACC ALSO DETERMINES WHERE TO CUT OFF THE NUMERICAL IN-
C     TEGRATION AND SUBSTITUTE THE ANALYTICAL  EXPRESSION FOR THE CONTRIBU-
C     TION IN THE TAIL OF THE RADINCE PROFILE,  WHEN THE THICK-LINE CALCUL-
C     ATION IS PERFORMED.
C
C     POSSIBLE VALUES OF NPTS ARE 2, 4, AND 8. THE PROGRAM CHANGES UNACCEP-
C     TABLE VALUES TO ONE OF THESE.
C
C     VMIN AND VMAX  LIMIT THE LINE-FILE SEARCH  TO A CERTAIN RANGE OF LINE
C     POSITIONS. DEFAULT IS TO SEARCH THE ENTIRE FILE.
C
C
C**** CARD 1D  SYNTHETIC SPECTRUM CARD---LIST-DIRECTED READ
```

```
C
C          FWHM = FULL WIDTH HALF MAX OF TRIANG SCAN FN (CM-1 OR UM: DEF = 0)
C          DEL  = SPACING OF PTS IN SYNTH SPECTRUM (CM-1 OR UM: DEF = 1 CM-1)
C          UNIT = 'CM-1' OR 'UM  ': ENERGY OR WAVELENGTH UNITS (DEF = 'CM-1')
C
C       WHEN FWHM > 0,  SUBROUTINE SPECTRM  IS CALLED TO GENERATE A SYNTHETIC
C       SPECTRUM, USING A TRIANGULAR SCANNING FUNCTION. THE ALGORITHM ASSUMES
C       THAT FWHM IS MUCH GREATER THAN THE BREADTH OF THE INDIVIDUAL RADIANCE
C       PROFILES.  ONLY 3 PLACES AFTER THE DECIMAL ARE RETAINED IN THE VALUES
C       OF FWHM AND DEL.
C
C
C
C**** CARD 1E  BAND PARAMETERS CARD---LIST DIRECTED READ
C
C          VIBE = VIBRATIONAL ENERGY  (CM-1) OF THE RADIATIVE TRANSITION
C          VIBL = VIBRATIONAL ENERGY  (CM-1) OF THE LOWER STATE
C          VIBQ = VIBRATIONAL QUANTUM (CM-1) IN THE PARTITION FUNCTION
C          GL   = STATISTICAL WEIGHT OF THE LOWER VIBRATIONAL STATE
C          GU   = STATISTICAL WEIGHT OF THE UPPER VIBRATIONAL STATE
C
C          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
C          X                                                                X
C          X  IMPORTANT NOTE:                                               X
C          X                                                                X
C          X  CARD 1E IS SUPERFLUOUS FOR CERTAIN TRANSITIONS OF CO2 AND NO  X
C          X  BECAUSE THE ENERGIES  AND STATISTICAL WEIGHTS OF MANY VIBRA-  X
C          X  TIONAL LEVELS ARE STORED IN  BLOCK DATA  MOLPAR. IF THE PRO-  X
C          X  GRAM  LOCATES THE PROPER  QUANTITIES, THIS CARD IS NOT READ;  X
C          X  OTHERWISE IT IS READ. IF THE USER IS UNCERTAIN ABOUT WHETHER  X
C          X  THE TRANSITION WILL BE FOUND IT IS BETTER TO INCLUDE IT, BE-  X
C          X  CAUSE 1E IS THE LAST  CARD-IMAGE ON TAPE1  AND NO SUBSEQUENT  X
C          X  INFORMATION CAN BE MISREAD IF THIS CARD IS NOT NEEDED.        X
C          X                                                                X
C          XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
C
C
C     ********************************************************************
C
C     SET DEFAULT VALUES FOR SOME PARAMETERS READ IN ON CARDS 1A-1D
C
      BR = 'A'
      NRL = 999
      TANF = -1.0
      SPAC =  1.0
      HMAX =  1001
      ACC  = .01
      NPTS = 4
      NDP  = 0
      FWHM = 0.0
      VMIN = 0.0
      VMAX = 20000.
      DEL = 1.0
      UNIT = 'CM-1'
      CALL HEADER(1)
C
C****1A
C*****
      READ(1,*)MOL,ISO,UST,LST,BR,NRL
      WRITE(4,100)MOL,ISO,UST,LST,BR,NRL
```

```
C
C****1B
C*****
      READ(1,*)TANI,TANF,SPAC
      IF(TANF.LT.TANI)TANF = TANI
      IF(SPAC.GE.0.0)THEN
          LOOK = 0
          MSG(1:7)  = '   LIMB'
          MSG(8:14) = 'TANGENT'
          IF(SPAC.EQ.0.0)SPAC = 1.0
      ELSE
          LOOK = 1
          MSG(1:7)  = ' ZENITH'
          MSG(8:14) = 'OBSERV.'
          SPAC = ABS(SPAC)
      END IF
      WRITE(4,101)MSG(8:14),TANI,MSG(8:14),TANF,SPAC,LOOK,MSG(1:7)
C
C     SET PARAMETERS RELATED TO L-O-S PATHS---HGTS, IMXX, NREPS
C
      DO 170 I = 1,50
      HGTS(I) = TANI + (I-1)*SPAC
      IF(HGTS(I).GT.TANF)GO TO 175
  170 IMXX = I
      WRITE(4,113)
      WRITE(6,113)
  175 NREPS = IMXX/5
      IF((5*NREPS).NE.IMXX)NREPS = NREPS + 1
C
C****1C
C*****
      READ(1,*)HMAX,ACC,NPTS,NDP,VMIN,VMAX
      MSG(32:47) = '                '
      I = HMAX
      IF(I.EQ.1001)MSG(32:47) = '(RESET IN ATMPR)'
      HMAX = I
      IF(ACC.GT..05)ACC = .05
      IF(NPTS.GT.4)THEN
          NPTS = 8
      ELSE IF(NPTS.LT.4)THEN
          NPTS = 2
      END IF
      MSG(1:22) = '  VOIGT
      IF(NDP.EQ.1)MSG(1:7) = 'DOPPLER'
      IF(NDP.LT.0)MSG(12:22) = '(USE VWERF)'
      IF(FWHM.LT.0.0)FWHM = 0.0
      JMAX = INT(VMIN)
      N = INT(VMAX)
      WRITE(4,102)I,MSG(32:47),ACC,NPTS,NDP,MSG(1:22),JMAX,N
C
C****1D
C*****
      READ(1,*)FWHM,DEL,UNIT
      IF(FWHM.GT.0.0)THEN
          FWHM = INT(1000.*FWHM + 0.5)/1000.
          DEL  = INT(1000.*DEL  + 0.5)/1000.
          WRITE(4,111)UNIT,FWHM,UNIT,DEL
      ELSE
          WRITE(4,112)
      END IF
```

```
C
C     CALL MOLEC  TO ESTABLISH VALUES OF QUANTITIES AND PROGRAM PARAMETERS
C     UNIQUELY ASSOCIATED WITH THE RADIATING MOLECULE, AND TO SEE IF IT IS
C     NECESSARY TO READ CARD 1E.
C
      CALL MOLEC(MOL,ISO,UST,LST,I,DEGV,PROT,TEXP,VIBE,VIBL,VIBQ,
     1           GL,GU,AI,FMT,FLAG)
C
      WGT = FLOAT(I)/6.02486E+23
      MSG = '(FOUND IN MOLPAR)'
      IF(FLAG)THEN
C
C****1E
C*****
          READ(1,*,END=190)VIBE,VIBL,VIBQ,GL,GU
          MSG = '(READ IN)'
      END IF
      GO TO 195
  190 MSG = '$$$$$ NEITHER IN MOLPAR NOR READ IN $$$$$'
      WRITE(4,106)
      WRITE(6,106)
  195 WRITE(4,103)MSG,VIBE,VIBL,VIBQ,GL,GU
C
C     PRINT SOME OF THE PARAMETERS RETURNED FROM MOLEC
C
      WRITE(4,104)I,AI,DEGV,PROT,TEXP
      WRITE(4,105)FMT
      WRITE(4,99)
      WRITE(4,98)
C
      I = 2
      WRITE(4,99)BCH,I
C$    IF(CMPL)
      WRITE(9,109)
      WRITE(9,99)BCH,I
C$    ENDIF
C
C     *********************************************************************
C
C     CALL SUBROUTINE ATMPR TO READ IN AND PREPARE THE ATMOSPHERIC PROFILE.
C     SEE INPUT REQUIREMENTS IN THE COMMENTS IN ATMPR.
C
C     *********************************************************************
C
      CALL ATMPR(MOL,AI,VIBE,VIBL,VIBQ,GL,GU,DEGV,PROT,TEXP,TANI,TANF,
     1HMAX)
C
C     *********************************************************************
C
C     *********************************************************************
C
C     CARD 3   AFGL  LINE FILE CARDS---UNIT 3
C
C     THIS SECTION  READS THE AFGL LINE FILE  AND SELECTS LINES OF INTEREST
C     BASED ON THE CRITERIA  SPECIFIED IN OF THE VARIABLES READ ON CARD 1A.
C     MOST OF THE VARIABLES  READ IN  (VINIT, ST, AL, ED...)  ARE STORED IN
C     ARRAYS (V, STS, ALF, EDP...)
C
C             VINIT (V) = FREQUENCY OF VIBRATIONAL TRANSITION (CM-1)
C             ST  (STS) = LINE INTENSITY         (CM-1/MOLECULE-CM2)
```

```
C             AL  (ALF) = LORENTZ HALF-WIDTH  AT 296 K  AND  1 ATMOS
C                                                        (CM-1/ATMOS)
C             ED  (EDP) = ENERGY OF THE LOWER RO-VIB'L STATE  (CM-1)
C             US, LS    = UPPER AND LOWER STATE QUANTUM DESIGNATIONS
C             BCH (BRNCH) = BRANCH (P, Q, OR R)
C             N   (RQL) = ROTATIONAL LINE NUMBER
C             I = ISOTOPE CODE
C
C     **********************************************************************
C
C     PRINT HEADERS
C
      I = 3
      WRITE(4,98)
      WRITE(4,99)BCH,I
C$    IF(CMPL)
      WRITE(9,109)
      WRITE(9,99)BCH,I
C$    ENDIF
      WRITE(4,109)
      CALL HEADER(I)
      WRITE(6,109)
      WRITE(4,107)MOL,ISO,UST,LST
      WRITE(4,108)
C
C     SHIFT UST AND LST TO RIGHT-JUSTIFIED CHARACTER VARIABLES. SET FLAG.
C
      CALL SHFT(UST,US)
      CALL SHFT(LST,LS)
      FLAG = (MOL.EQ.'H2O').OR.(MOL.EQ.'O3 ').OR.(MOL.EQ.'CH4')
C
C     JMAX COUNTS THE TOTAL NUMBER OF LINES TO BE USED
C     JNUM COUNTS THE TOTAL NUMBER OF LINES READ, USING J
C
      HMAX = VMIN
      TEXP = VMAX
      JMAX = 0
      J = 0
C
C**** 3
C*****
  200 READ(3,FMT,END=998)VINIT,ST,AL,ED,US,LS,BCH,N,I
      J = J + 1
C
C     CHECK THE LINEFILE FOR THE CORRECT ISOTOPE AND BAND,  AND POSSIBLY
C     FOR THE CORRECT BRANCH AND LINE.   IF THE DOPPLER LINESHAPE OPTION
C     (NDP = 1)  IS SELECTED,  THE LORENTZ  LINEWIDTHS  ARE SET TO ZERO.
C     READ THE WHOLE FILE ON THE FIRST CALL. IF THERE ARE MORE THAN DIML
C     LINES,  THE END OF THE FILE WILL BE REREAD FROM  ENTRY LINES3 WHEN
C     IT IS NEEDED.  JMAX  IS THE TOTAL  NUMBER OF LINES SELECTED.  J IS
C     THE TOTAL READ.
C
      IF(VINIT.LT.VMIN)GO TO 200
      IF(VINIT.GT.VMAX)GO TO 200
      IF(ISO.NE.I) GO TO 200
      IF(UST.NE.US)GO TO 200
      IF(LST.NE.LS)GO TO 200
      IF(BR.NE.'A'.AND.BR.NE.BCH) GO TO 200
      IF(NRL.NE.N.AND.NRL.NE.999) GO TO 200
C
```

```
      JMAX = JMAX + 1
      IF(FLAG)THEN
          BCH = '# '
          N = JMAX
      END IF
      WRITE(4,109)BCH,N,VINIT,ST,AL,ED
      IF(VINIT.LT.TEXP)TEXP = VINIT
      IF(VINIT.GT.HMAX)HMAX = VINIT
      IF(JMAX.GT.DIML)GO TO 200
      JNUM = J
      V(JMAX) = VINIT
      STS(JMAX) = ST
      ALF(JMAX) = AL
      IF(NDP.EQ.1)ALF(JMAX) = 0.0
      EDP(JMAX) = ED
      BRNCH(JMAX) = BCH
      RQL(JMAX) = N
      GO TO 200
C
  998 VMIN = TEXP
      VMAX = HMAX
      WRITE(4,109)
      WRITE(4,99)
C
C     CALL SPECTRM TO INITIALIZE FILES AND ARRAYS FOR THE  SYNTHETIC SPEC-
C     TRUM, IF NECESSARY. THEN RETURN TO NLTE.
C
      IF(JMAX.LE.1)FWHM = 0.0
      IF(FWHM.GT.0.0)CALL SPECTRM(VMIN,VMAX,DEL,FWHM,UNIT,
     1                            MOL,ISO,UST,LST,BR,HGTS,IMXX,LOOK,MES)
      RETURN
C
C     *********************************************************************
C
C     ENTRY TO REREAD THE PART OF THE LINEFILE PAST THE FIRST DIML LINES
C
      ENTRY LINES3(LCNT)
C
C     SKIP PAST THE HEADER AND THE LINES ALREADY READ
C
      CALL REWND(3)
      DO 295 J = 1,JNUM
  295 READ(3,109)BCH
C
C     REREAD THE NEXT BATCH OF LINES
C
      JMAX = 0
C
  300 READ(3,FMT,END=999)VINIT,ST,AL,ED,US,LS,BCH,N,I
      JNUM = JNUM + 1
      IF(VINIT.LT.VMIN)GO TO 300
      IF(VINIT.GT.VMAX)GO TO 300
      IF(ISO.NE.I) GO TO 300
      IF(UST.NE.US)GO TO 300
      IF(LST.NE.LS)GO TO 300
      IF(BR.NE.'A'.AND.BR.NE.BCH) GO TO 300
      IF(NRL.NE.N.AND.NRL.NE.999) GO TO 300
C
      JMAX = JMAX + 1
      V(JMAX) = VINIT
```

```
      STS(JMAX) = ST
      ALF(JMAX) = AL
      IF(NDP.EQ.1)ALF(JMAX) = 0.0
      EDP(JMAX) = ED
      BRNCH(JMAX) = BCH
      RQL(JMAX) = N
      IF(FLAG)THEN
          BRNCH(JMAX) = '# '
          RQL(JMAX) = JMAX + DIML*LCNT
      END IF
      IF(JMAX.LT.DIML)GO TO 300
  999 RETURN
C
C     ***********************************************************************
C
      END
```

```
      SUBROUTINE ATMPR(MOL,AI,VIBE,VIBL,VIBQ,GL,GU,DEGV,PROT,TEXP,TANI,
     1TANF,HMAX)
C
C     *******************************************************************
C
C     SUBROUTINE FOR READING, ORGANIZING, AND PRINTING THE ATMOSPHERIC PRO-
C     FILE FOUND ON TAPE2,  AND FOR SETTING UP COMMON/A/. OF THE TOTAL CON-
C     TENTS OF /A/,  ONLY THE FIRST 7 (OUT OF 13) ARRAYS, PLUS THE ORDINARY
C     VARIABLES  ARE NEEDED BY THE MAIN PROGRAM.  C2 AND BST ARE SET IN THE
C     MAIN PROGRAM.
C
C     *******************************************************************
C
C
C     THE DATA WHICH MAY BE READ ARE:
C
C     * ALT     ALTITUDE (KM)
C     * TRTMP   TRANSLATIONAL TEMPERATURE (KELVIN)
C     * RHO     TOTAL NUMBER DENSITY OF RADIATING MOLECULE (CM-3)
C       NL      NUMBER DENSITY OF LOWER VIBRATIONAL LEVEL  (CM-3) (REAL)
C       NU      NUMBER DENSITY OF UPPER VIBRATIONAL LEVEL  (CM-3) (REAL)
C     **TVL     VIBRATIONAL TEMPERATURE DESCRIBING LOWER LEVEL (KELVIN)
C     * TVU     VIBRATIONAL TEMPERATURE DESCRIBING UPPER LEVEL (KELVIN)
C
C     * TVQ     VIBRATIONAL TEMPERATURE DESCRIBING LOWEST EXCITED LEVEL (K)
C       N0      NUMB DENS, GROUND VIBRATIONAL LEVEL (CM-3) (FOR P FN; REAL)
C       N1      NUMB DENS, FIRST  EXCITED VIB LEVEL (CM-3) (FOR P FN; REAL)
C
C     THESE QUANTITIES ARE NOT ALL REQUIRED.  THE ATMOSPHERIC PROFILES  MAY
C     BE DEFINED IN TERMS OF NUMBER DENSITIES  OR VIBRATIONAL TEMPERATURES,
C     AND THE PROGRAM AUTOMATICALLY  RECOGNIZES CERTAIN COMBINATIONS  WHICH
C     ARE LISTED BELOW. (SEE THE LATER COMMENTS.)  THE QUANTITIES WITH SIN-
C     GLE ASTERISKS ARE DIRECTLY USED BY NLTE (FOR HOT BANDS, TVL IS ALSO).
C     THEY MUST THEREFORE BE READ DIRECTLY OR CALCULATED BY ATMPR.
C
C     FOR REGULAR BANDS, POSSIBLE PROPER COMBINATIONS OF INPUT DATA ARE:
C
C   INDEX                                       NVP NPF
C     1.  ALT,TRTMP,RHO,TVU,TVQ                  1   1
C     2.  ALT,TRTMP,RHO,TVU,N0,N1                1   2
C     3.  ALT,TRTMP,NL,NU,TVQ                    2   1
C     4.  ALT,TRTMP,NL,NU,N0,N1                  2   2
C
C     IN ADDITION, FOR REGULAR BANDS THE PROGRAM WILL ACCEPT:
C
C     5.  ALT,TRTMP,RHO,TVU                      1   0
C     6.  ALT,TRTMP,NL,NU                        2   0
C
C     FOR HOT BANDS, POSSIBLE COMBINATIONS ARE:
C
C     7.  ALT,TRTMP,RHO,TVL,TVU,TVQ              1   1
C     8.  ALT,TRTMP,RHO,TVL,TVU,N0,N1            1   2
C     9.  ALT,TRTMP,RHO,NL,NU,TVQ                2   1
C     10. ALT,TRTMP,RHO,NL,NU,N0,N1              2   2
C
C     FOR EITHER REGULAR OR HOT BANDS, LTE CONDITIONS ARE IMPLIED BY
C
C     11. ALT,TRTMP,RHO                          3   3
C
```

```
C      THE FORMAT FOR ALL THESE POSSIBILITIES IS (F5.1,F10.3,5E12.5). THE
C      PROGRAM IDENTIFIES THE OPTION SELECTED AND CALCULATES THE REQUIRED
C      QUANTITIES WHICH ARE NOT DIRECTLY READ IN.  IN THE CASE OF OPTIONS
C      5 AND 6,  APPROXIMATIONS ARE NECESSARILY MADE UNLESS THE RADIATING
C      LEVELS ARE  THE GROUND AND FIRST EXCITED VIBRATIONAL STATES.  THAT
C      IS, THE VIBRATIONAL  PARTITION FUNCTION  WILL BE CALCULATED  USING
C      THE TWO RADIATING STATES  INSTEAD OF THE GROUND  AND FIRST EXCITED
C      STATES, AND IT WILL BE SLIGHTLY IN ERROR AS A RESULT. SEE THE COM-
C      MENTS IN THE OUTPUT.
C
C      FOR HOT BANDS IN WHICH THE VIBRATIONAL TEMPERATURES,  TVL AND TVU,
C      CAN BE ASSUMED IDENTICAL, ZEROES IN THE TVU DATA FIELD WILL RESULT
C      IN DATA FOR TVL BEING USED FOR TVU AS WELL (OPTIONS 7 AND 8 ONLY).
C
C      IMPORTANT NOTE:
C                    THE NUMBER DENSITIES NL AND NU REFLECT THE ABUNDANCE
C      OF THE ISOTOPE UNDER CONSIDERATION. RHO, ON THE OTHER HAND, IS THE
C      TOTAL NUMBER DENSITY OF THE SPECIE, INCLUDING ALL ISOTOPES.
C
C      ANOTHER IMPORTANT NOTE:
C
C      THE PROGRAM AUTOMATICALLY DISTINGUISHES AMONG THE ELEVEN CASES CI-
C      TED ABOVE.  IT DOES SO BY READING THE FIRST DATA CARD-IMAGE  (COR-
C      RESPONDING  TO THE LOWEST ALTITUDE ON THE ATMOSPHERIC-PROFILE DATA
C      FILE)  AND LOOKING AT NUMERICAL  VALUES OF SOME OF THE  QUANTITIES
C      READ.  THE CRITERIA USED TO DISTINGUISH  BETWEEN THE VARIOUS CASES
C      ARE GIVEN BELOW, FOLLOWED BY THE RULES FOR INTERPRETING THE FIELDS
C      AND FIXING THE CORRESPONDING VALUES OF NVP AND NPF.  THE INTERPRE-
C      TATIONS  ARE MADE IN  SUBROUTINE OPTION  AND PRINTED AS DIAGNOSTIC
C      OUTPUT ON UNIT 6.
C
C      THE NUMERICAL VALUE, X, FOUND IN THE 5TH DATA FIELD  (6TH, FOR HOT
C      BANDS) IS USED TO DETERMINE NPF:
C
C      (A) IF X.LE.0,  DATA FOR THE  PARTITION FUNCTION  ARE ABSENT,  SET
C                                                                NPF = 0.
C
C      (B) IF 0<X<10000, FIELD 5 (6 FOR HOT BANDS) IS ASSUMED TO BE A VI-
C                                BRATIONAL TEMPERATURE, TVQ. SET NPF = 1.
C
C      (C) IF X.GE.10000, FIELDS 5 AND 6  (6 AND 7 FOR HOT BANDS) ARE AS-
C                                SUMED TO BE NUMBER DENSITIES, N0 AND N1.
C                                                            SET NPF = 2.
C
C      THE NUMERICAL VALUE, Y, FOUND IN THE 4TH DATA FIELD IS USED TO DE-
C      TERMINE NVP:
C
C      (D) IF Y.LE.0, DATA FOR THE RADIATING  LEVELS ARE ABSENT,  AND LTE
C                     CONDITIONS ARE ASSUMED (ALSO FOR THE PARTITION FUN-
C                     CTION, REGARDLESS OF CRITERIA (A)-(C).) COLUMN 3 IS
C                     INTERPRETED AS THE TOTAL NUMBER DENSITY, RHO.   SET
C                                                                NVP = 3.
C
C      (E) IF 0<Y<1000,  FIELD 4  IS ASSUMED TO BE A VIBRATIONAL TEMPERA-
C                      TURE, TVU  (FIELDS 4 AND 5 FOR HOT BANDS,  TVL AND
C                      TVU). FIELD 3 IS THE TOTAL NUMBER DENSITY, RHO, IN
C                                                 EITHER CASE. SET NVP = 1.
C
C      (F) IF Y.GE.1000,  FIELDS 3 AND 4  (4 AND 5 FOR HOT BANDS) ARE AS-
C                                SUMED TO BE NUMBER DENSITIES, NL AND NU.
```

```
C                                                  SET NVP = 2.
C
C     OVERRIDES:
C             IT IS POSSIBLE TO OVERRIDE ANY OF THE RULES LISTED ABOVE
C     WITH THE CRITERIA (A) THRU (F)  BY ENTERING CERTAIN CHARACTER DATA
C     ANYWHERE WITHIN A FIELD COMPRISING COLUMNS  76 THROUGH 90  (ON THE
C     LOWEST-ALTITUDE CARD ONLY). THERE ARE TWO COMMON REASONS FOR DOING
C     THIS. FIRST, ONE MAY WISH TO CALCULATE  RESULTS FOR LTE CONDITIONS
C     REGARDLESS  OF THE VIBRATIONAL TEMPERATURES OR NUMBER DENSITIES ON
C     THE FILE.  SECOND, FOR HIGH-LYING STATES  THE NUMBER DENSITIES MAY
C     ACTUALLY HAVE VALUES BELOW 1000 SO THAT CRITERIA (E) AND (F) COULD
C     BE CONFUSED.
C
C     ACCEPTABLE VALUES FOR THE OVERRIDE CHARACTER DATA ARE:
C
C       SYMBOL    MEANING
C
C        LTE    LTE CONDITIONS PREVAIL
C        T,T    RULES (B) AND (E) APPLY, REGARDLESS OF VALUES OF X AND Y
C        T,N    RULES (B) AND (F) APPLY, REGARDLESS OF VALUES OF X AND Y
C        N,T    RULES (C) AND (E) APPLY, REGARDLESS OF VALUES OF X AND Y
C        N,N    RULES (C) AND (F) APPLY, REGARDLESS OF VALUES OF X AND Y
C
C     ******************************************************************
C
      INTEGER A,GL,GU,DEGV
      REAL N0,N1,NL,NU
      CHARACTER*1  AST(5)
      CHARACTER*3  MOL
      CHARACTER*15 CODE
C
      DIMENSION DUM(250),TRTMP(250),PRESS(250),RHO(250),TVL(250)
      DIMENSION TVU(250),QV(250),NL(250),NU(250),TVQ(250),N0(250)
      DIMENSION N1(250),ALT(250),PR(192)
C
      COMMON/A/ALT,TRTMP,PRESS,RHO,TVL,TVU,QV,NL,NU,TVQ,N0,N1,DUM,
     1         KMAX,C2,BST,TMIN
      COMMON/P/PR
C
C     ******************************************************************
C
  100 FORMAT(BZ,F5.0,F10.3,5E12.5,A15)
  101 FORMAT(//,' $$$$$ ATMOSPHERIC PROFILE STARTS ABOVE TANI, ADJUST',
     1' TANI TO',F7.2,' KM  $$$$$',//)
  102 FORMAT(//,' $$$$$ HMAX GREATER THAN ALTITUDE OF UPPERMOST ',
     1'POINT OF ATMOSPHERIC PROFILE, RESET HMAX TO',F7.2,' KM $$$$$',
     2//)
  103 FORMAT(/,' INPUT OPTION #',I3,'; NVP =',I2,', NPF =',I2,
     1', VIBL ',A1,' 0; (SEE COMMENTS IN ATMPR)',/)
  104 FORMAT(//,2X,' $$$$$ SUBSTITUTE TVU FOR TVQ,  THE VIBRATIONAL ',
     1'TEMPERATURE USED IN FINDING THE PARTITION FUNCTION')
  105 FORMAT(9X,'SMALL ERRORS WILL OCCUR IN ALL ABSORPTION CALCULAT',
     1'IONS (ALSO STARRED QUANTITIES IN PROFILE)  $$$$$',//)
  106 FORMAT(9X,'SMALL ERRORS WILL OCCUR IN PRINTED OUTPUT (STARRED',
     1' IN PROFILE) BUT NOT IN RADIANCE CALCULATIONS  $$$$$',//)
  107 FORMAT(10X,'ALT',5X,'TR TEMP   VB TEMP',7X,'TOT PRESS',3X,A3,2X,
     1'DENSITY    LOWER STATE   UPPER STATE    VB TEMP    PART',/,
     29X,'(KM)',2(7X,'(K)'),10X,'(ATMOS)',7X,'(CM-3)',2X,
     32(8X,'(CM-3)'),10X,'(1)',7X,'FN')
  108 FORMAT(I4,F9.2,2X,2F10.3,2X,1P,2E14.4,2X,2E14.4,0P,F13.3,F9.5)
```

```
  109 FORMAT(I4,F9.2,2X,3F10.3,2X,1P,2E14.4,2X,2E14.4,0P,F13.3,F9.5)
  110 FORMAT(10X,'ALT',5X,'TR TEMP',5X,'TVL',7X,'TVU',9X,'TOT PRESS',
     13X,A3,2X,'DENSITY      LOWER STATE    UPPER STATE      VB TEMP      ',
     2'PART',/,9X,'(KM)',3(7X,'(K)'),10X,'(ATMOS)',7X,'(CM-3)',3X,
     32(8X,'(CM-3)'),9X,'(1)',7X,'FN')
  111 FORMAT(53X,A1,17X,A1,13X,A1,12X,A1,9X,A1)
  112 FORMAT(63X,A1,17X,A1,13X,A1,12X,A1,9X,A1)
  113 FORMAT(//,' $$$$$ HMAX INCOMPATIBLE WITH TANF, ADJUST HMAX TO',
     1F5.0,' KM $$$$$',//)
  114 FORMAT(' THE LOWER- AND UPPER-STATE POPULATIONS REFLECT AN ',
     1'ABUNDANCE OF',F7.5,' W.R.T. TOTAL ',A3,/)
  115 FORMAT(//,' $$$$$ CAUTION---FOR HOT BANDS THE PARTITION FUNCTION',
     1' PARAMETERS MUST BE READ IN $$$$$',//)
  116 FORMAT(//,' $$$$$  CAUTION---ATMOSPHERIC PROFILE CONTAINS MORE',
     1' THAN 250 ENTRIES, UPPER REGIONS NOT READ  $$$$$',//)
C
C     *********************************************************************
C
      WRITE(4,111)
C
C     READ AND WRITE THE HEADER FROM TAPE2. THEN READ THE FIRST CARD-IMAGE
C     (FORMAT(F5.1,F10.3,5E12.5,A15)). CALL SUBROUTINE OPTION TO INTERPRET
C     THE QUANTITIES FOUND THERE. THE INTERPRETATION IS WRITTEN TO UNIT 6.
C
C**** 2A
C*****
      CALL HEADER(2)
C
C**** 2B
C*****
      READ(2,100)(DUM(I),I=1,7),CODE
      CALL OPTION(DUM,CODE,VIBL,NVP,NPF,INDEX)
      CALL REWND(2)
C
C     *********************************************************************
C
      AST(1) = '='
      IF(VIBL.GT.0.0)AST(1) = '>'
      WRITE(4,103)INDEX,NVP,NPF,AST(1)
      WRITE(4,114)AI,MOL
      DO 175 I = 1,5
  175 AST(I) = ' '
      IX = 0
      E = AINT(TANI)
      IF(VIBL.GT.0.0)THEN
          IF(DUM(5).EQ.0.0.AND.NVP.EQ.1)IX = 99
          IF(DUM(6).EQ.0.0)THEN
              WRITE(4,115)
              WRITE(6,115)
          END IF
      END IF
C
C     ********************************************************************
C
C     READ THE ATMOSPHERIC DATA---FORMAT(F5.1,F10.3,5E12.5)
C
C**** 2B
C*****
  180 K = 1
      IF(VIBL.GT.0.0)GO TO 190
```

```
  185 IF(K.GE.251)GO TO 199
      READ(2,100,END=200)ALT(K),TRTMP(K),RHO(K),TVU(K),N0(K),
     1N1(K)
      TVL(K) = 1.0E+90
      IF(ALT(K).GE.E)K = K + 1
      GO TO 185
  190 IF(K.GE.251)GO TO 199
      READ(2,100,END=200)ALT(K),TRTMP(K),RHO(K),TVL(K),TVU(K),
     1N0(K),N1(K)
      IF(ALT(K).GE.E)K = K + 1
      GO TO 190
C
C     ******************************************************************
C
C     CHECK TO SEE IF TANI FALLS ABOVE ALT(1). IF SO, CONTINUE.  IF NOT,
C     CHECK TO SEE IF THE  LOWER BOUNDARY  OF THE USEFUL  ATMOSPHERE WAS
C     CORRECTLY DETERMINED. (FOR ALTITUDE SPACINGS OF GREATER THAN 1 KM,
C     IT MIGHT NOT BE.) IF CORRECTLY DETERMINED, RESET TANI. IF NOT, RE-
C     WIND AND REREAD TAPE2 TO GET THE CORRECT PROFILE RANGE.  ALSO, FIX
C     THE INDEX, KMAX,  CORRESPONDING TO THE ALTITUDE USED FOR THE "TOP"
C     OF THE ATMOSPHERE,  ADJUSTING THE  "TOP"  DOWNWARD  IF THE PROFILE
C     READ IN DOES NOT EXTEND AS FAR AS ANTICIPATED.
C
  199 WRITE(4,116)
      WRITE(6,116)
  200 KMAX = K - 1
      IF(ALT(1).LE.TANI)GO TO 205
      IF(DUM(1).LE.TANI)THEN
          CALL REWND(2)
          DUM(1) = ALT(1)
          E = AINT(TANI - (ALT(2)-ALT(1)) + 1)
          GO TO 180
      ELSE
          TANI = ALT(1)
          WRITE(4,101)TANI
          WRITE(6,101)TANI
      END IF
  205 IF(HMAX.GE.TANF)GO TO 210
      HMAX = AINT(TANF+50)
      WRITE(4,113)HMAX
      WRITE(6,113)HMAX
  210 IF(HMAX.GT.ALT(KMAX))THEN
C                                         RESET HMAX
          I = HMAX
          HMAX = ALT(KMAX)
          IF(I.NE.1001)THEN
              WRITE(4,102)HMAX
              WRITE(6,102)HMAX
          END IF
          IF(TANF.GE.HMAX)STOP    'TANF TOO HIGH'
      ELSE IF(HMAX.LT.ALT(KMAX))THEN
C                                         RESET KMAX
          I = KMAX
          DO 215 A = KMAX,1,-1
          IF(ALT(A).LT.HMAX)GO TO 220
  215     I = A
  220     KMAX = I
      END IF
C
C     ******************************************************************
```

```
C
C     DETERMINE THE PRESSURE, IN ATMOSPHERES, AT EACH ALTITUDE
C
      DO 280 A = 1,KMAX
      IP = INT(ALT(A))
      E = IP
      IF(IP.GT.300)THEN
          PRESS(A) = 0.0
      ELSE IF(IP.GT.191)THEN
          PRESS(A) = PR(192)*EXP((191.-ALT(A))/4.4)
      ELSE IF(E.EQ.ALT(A))THEN
          PRESS(A) = PR(IP+1)
      ELSE
          E = ALOG(PR(IP+1))
          QVIB = ALOG(PR(IP+2))
          Z1 = IP
          Z2 = Z1 + 1.0
          CALL LINT(ALT(A),F,E,QVIB,Z1,Z2)
          PRESS(A) = EXP(F)
      END IF
  280 CONTINUE
C
C     ******************************************************************
C
C     FIND THE VIBRATIONAL TEMPERATURE  FOR THE PARTITION FUNCTION,  TVQ
C
      IF(NPF.EQ.3)THEN
          DO 305 A = 1,KMAX
  305     TVQ(A) = TRTMP(A)
      ELSE IF(NPF.EQ.2)THEN
          CALL VIBTMP(C2,1,KMAX,VIBQ,DEGV,N0,N1,TVQ)
      ELSE IF(NPF.EQ.1)THEN
          DO 310 A = 1,KMAX
  310     TVQ(A) = N0(A)
      ELSE IF(INDEX.EQ.6)THEN
          CALL VIBTMP(C2,1,KMAX,VIBE,GU,RHO,TVU,TVQ)
          IF(VIBE.NE.VIBQ)THEN
              WRITE(4,104)
              WRITE(4,106)
              WRITE(6,104)
              WRITE(6,106)
              WRITE(4,108)
              AST(1) = AST(4) = AST(5) = '*'
          END IF
      ELSE
          DO 315 A = 1,KMAX
  315     TVQ(A) = TVU(A)
          IF(VIBE.NE.VIBQ)THEN
              WRITE(4,104)
              WRITE(4,105)
              WRITE(6,104)
              WRITE(6,105)
              WRITE(4,108)
              AST(2) = AST(3) = AST(4) = AST(5) = '*'
          END IF
      END IF
C
C     CALCULATE THE VIBRATIONAL PARTITION FUNCTION
C
      DO 320 A = 1,KMAX
```

```
  320 QV(A) = 1.0/(1.0 - EXP(-C2*VIBQ/TVQ(A)))**DEGV
C
C     ******************************************************************
C
C     CALCULATE AND PRINT THE ATMOSPHERIC PROFILE FOR REGULAR BANDS
C
      IF(VIBL.GT.0.0)GO TO 400
      WRITE(4,107)MOL
      WRITE(4,111)(AST(I),I=1,5)
C
      IF(NVP.EQ.4)THEN
          DO 340 A = 1,KMAX
          TVU(A) = TRTMP(A)
  340     RHO(A) = RHO(A)*QV(A)/AI
      ELSE IF(NVP.EQ.3)THEN
          DO 345 A = 1,KMAX
  345     TVU(A) = TRTMP(A)
      ELSE IF(NVP.EQ.2)THEN
          DO 350 A = 1,KMAX
          NL(A) = RHO(A)
          NU(A) = TVU(A)
  350     RHO(A) = RHO(A)*QV(A)/AI
      END IF
C
      IF(NVP.EQ.2)THEN
          CALL VIBTMP(C2,1,KMAX,VIBE,GU,NL,NU,TVU)
      ELSE
          CALL VIBPOP(C2,1,KMAX,AI,VIBL,GL,RHO,QV,TVL,NL)
          CALL VIBPOP(C2,1,KMAX,AI,VIBE,GU,RHO,QV,TVU,NU)
      END IF
C
      DO 360 A = 1,KMAX
  360 WRITE(4,108)A,ALT(A),TRTMP(A),TVU(A),PRESS(A),RHO(A),NL(A),NU(A),
     1TVQ(A),QV(A)
      GO TO 490
C
C     ********************************************************************
C
C     CALCULATE AND PRINT THE ATMOSPHERIC PROFILE FOR HOT BANDS
C
  400 WRITE(4,110)MOL
      WRITE(4,112)(AST(I),I=1,5)
C
      IF(NVP.EQ.3)THEN
          DO 445 A = 1,KMAX
          TVL(A) = TRTMP(A)
  445     TVU(A) = TRTMP(A)
      ELSE IF(NVP.EQ.2)THEN
          DO 450 A = 1,KMAX
          NL(A) = TVL(A)
          NU(A) = TVU(A)
  450     DUM(A) = AI*RHO(A)/QV(A)
C
      ELSE IF(IX.EQ.99)THEN
          DO 455 A = 1,KMAX
  455     TVU(A) = TVL(A)
      END IF
C
      E = VIBL + VIBE
      IF(NVP.EQ.1.OR.NVP.EQ.3)THEN
```

```
            CALL VIBPOP(C2,1,KMAX,AI,VIBL,GL,RHO,QV,TVL,NL)
            CALL VIBPOP(C2,1,KMAX,AI,E,GU,RHO,QV,TVU,NU)
        ELSE
            CALL VIBTMP(C2,1,KMAX,VIBL,GL,DUM,NL,TVL)
            CALL VIBTMP(C2,1,KMAX,E,GU,DUM,NU,TVU)
        END IF
C
        DO 460 A = 1,KMAX
  460   WRITE(4,109)A,ALT(A),TRTMP(A),TVL(A),TVU(A),PRESS(A),RHO(A),NL(A),
     1NU(A),TVQ(A),QV(A)
C
  490 CONTINUE
C
C     ********************************************************************
C
C     THE ARRAYS  RHO AND PRESS ARE CONVERTED TO THE GEOMETRIC MEAN DENSITY
C     IN THE LAYER WHOSE BOUNDARIES ARE A AND A+1, AND STORED WITH INDEX A.
C
C     THE ARRAYS TRTMP, TVL, AND TVU  ARE CONVERTED TO AVERAGE TEMPERATURES
C     IN THE LAYER WHOSE BOUNDARIES ARE A AND A + 1. THESE AVERAGE TEMPERA-
C     TURES ARE ALSO MULTIPLIED BY  1/C2  (SEE COMMENT IN THE MAIN PROGRAM;
C     THIS FACTOR APPEARS WHENEVER THE TEMPERATURES ARE USED) AND ARE STOR-
C     ED IN THE SAME ARRAYS. AS WITH RHO AND PRESS, THE INDEX FOR THE LAYER
C     WHOSE BOUNDARIES ARE ALT(A) AND ALT(A+1) KM ABOVE THE EARTH'S SURFACE
C     IS A.
C
C     QV BECOMES AN ARRAY STORING THE PRODUCT OF TWO  RATIOS:
C                   THE VIBRATIONAL PARTITION FUNCTION AT TS  (QVIB) TO
C                   THE VIBRATIONAL PARTITION FUNCTION AT TVQ (QV(A))
C     AND           THE ROTATIONAL  PARTITION FUNCTION AT TS TO
C                   THE ROTATIONAL  PARTITION FUNCTION AT TRTMP
C     THE LATTER RATIO IS  A POWER OF THE RATIO OF TEMPERATURES,  TS/TRTMP,
C     WHERE  TRTMP  IS THE ACTUAL TRANSLATIONAL TEMPERATURE (NOT MULTIPLIED
C     BY 1/C2) AND TS = 296 K. THE EXPONENT IS PROT.
C
C     PRESS(A) IS INITIALLY THE TOTAL PRESSURE,  IN ATMOSPHERES.  AT STATE-
C     MENT 500, IT BECOMES AN ARRAY STORING THE FACTOR BY WHICH THE LORENTZ
C     LINEWIDTH PARAMETER  (GIVEN ON THE LINE FILE AT TS  AND 1 ATMOSPHERE)
C     IS MULTIPLIED TO CORRECT FOR PRESSURE AND  TEMPERATURE AT VARIOUS AL-
C     TITUDES.
C
      QVIB = 1.0/(1.0 - EXP(-VIBQ/BST))**DEGV
      KMAX = KMAX - 1
      E = 1.0 - TEXP
      TMIN = 1.0E+10
      DO 500 A = 1,KMAX
      RHO(A)   = SQRT(RHO(A)*RHO(A+1))
      PRESS(A) = SQRT(PRESS(A)*PRESS(A+1))
      TRTMP(A) = 0.5*(TRTMP(A) + TRTMP(A+1))/C2
      IF(TRTMP(A).LT.TMIN)TMIN = TRTMP(A)
      TVL(A) = 0.5*(TVL(A) + TVL(A+1))/C2
      TVU(A) = 0.5*(TVU(A) + TVU(A+1))/C2
      TVQ(A) = 0.5*(TVQ(A) + TVQ(A+1))/C2
      QV(A) = 1.0/(1.0 - EXP(-VIBQ/TVQ(A)))**DEGV
      QV(A)  = (QVIB/QV(A))*(BST/TRTMP(A))**PROT
  500 PRESS(A) = PRESS(A)*(BST/TRTMP(A))**E
      TMIN = ANINT(TMIN*C2)
C
      RETURN
      END
```

```
      SUBROUTINE OPTION(DUM,CODE,VIBL,NVP,NPF,INDEX)
C
C     SUBROUTINE OPTION  DETERMINES THE  INPUT OPTIONS  FOR THE ATMOSPHERIC
C     PROFILE. IT READS THE FIRST DATA CARD-IMAGE---THAT IS, THE CARD-IMAGE
C     CONTAINING THE  ATMOSPHERIC PROPERTIES AT THE LOWEST ALTITUDE  ON THE
C     FILE---AND DECIDES,  ON THE BASIS OF THE NUMERCAL VALUES READ AND THE
C     TYPE OF BAND  UNDER CONSIDERATION,  WHAT THE UNDETERMINED  QUANTITIES
C     MUST BE. THEN THE OVERRIDE   CODE  IS CHECKED TO SEE IF THESE DEFAULT
C     INTERPRETATIONS NEED TO BE CHANGED.
C
      CHARACTER*1 B1,B2
      CHARACTER*3 COD
      CHARACTER*12 MSG(9),MSH(5)
      CHARACTER*15 CODE
      DIMENSION DUM(250)
      DATA (MSG(I),I=1,9)/'  TOT # DENS','  LST V TEMP','  UST V TEMP',
     1                    '  LST # DENS','  UST # DENS','  1ST V TEMP',
     2                    '  GST # DENS','  1ST # DENS','   NOT USED '/
C
  100 FORMAT(1X,' ALT     TR TEMP',5A12,A15,33X,'(INTERP)')
C
C     DISSECT THE OVERRIDE CODE
C
      CALL SHFT(CODE,CODE)
      B1  = CODE(15:15)
      IF(B1.EQ.'''')THEN
          CODE(15:15) = ' '
          CALL SHFT(CODE,CODE)
      END IF
      COD = CODE(13:15)
      B1  = CODE(13:13)
      B2  = CODE(15:15)
C
C     CHECK THE FIRST ATMOSPHERIC DATA RECORD TO ESTABLISH THE INPUT OPTION
C     USED. IGNORE OVERRIDES FOR NOW.
C
      E = DUM(5)
      IF(VIBL.GT.0.0)E = DUM(6)
C
      IF(E.LE.0.0)THEN
          NPF = 0
      ELSE IF(E.LT.10000.)THEN
          NPF = 1
      ELSE
          NPF = 2
      END IF
C
      E = DUM(4)
      IF(E.LE.0.0)THEN
          NVP = 3
          NPF = 3
      ELSE IF(E.LT.1000.)THEN
          NVP = 1
      ELSE
          NVP = 2
      END IF
C
C     INITIALIZE MESSAGE ARRAYS
C
```

```
      IF(COD.EQ.'LTE')THEN
          MSG(2) = MSG(3) = MSG(5) = MSG(6) = MSG(7) = MSG(8) = MSG(9)
      END IF
      DO 190 I = 1,5
  190 MSH(I) = '
C
C     SET THE INTERPRETIVE MESSAGES FOR REGULAR BANDS
C
      IF(VIBL.EQ.0.0)THEN
C
          IF(NVP.EQ.1)THEN
              MSH(1) = MSG(1)
              MSH(2) = MSG(3)
          ELSE IF(NVP.EQ.2)THEN
              MSH(1) = MSG(4)
              MSH(2) = MSG(5)
          ELSE
              MSH(1) = MSG(1)
          END IF
C
          IF(NPF.EQ.1)THEN
              MSH(3) = MSG(6)
          ELSE IF(NPF.EQ.2)THEN
              MSH(3) = MSG(7)
              MSH(4) = MSG(8)
          END IF
C
C     SET THE INTERPRETIVE MESSAGES FOR HOT BANDS
C
      ELSE
          MSH(1) = MSG(1)
          IF(NVP.EQ.1)THEN
              MSH(2) = MSG(2)
              MSH(3) = MSG(3)
          ELSE IF(NVP.EQ.2)THEN
              MSH(2) = MSG(4)
              MSH(3) = MSG(5)
          END IF
C
          IF(NPF.EQ.1)THEN
              MSH(4) = MSG(6)
          ELSE IF(NPF.EQ.2)THEN
              MSH(4) = MSG(7)
              MSH(5) = MSG(8)
          END IF
      END IF
C
C     CHECK TO SEE IF NPF SHOULD BE OVERRIDDEN; IF SO, REWRITE MESSAGES
C
      I = 0
      IF(VIBL.GT.0.0)I = 1
C
      IF(B2.EQ.'N'.AND.NPF.EQ.1)THEN
          NPF = 2
          MSH(3+I) = MSG(7)
          MSH(4+I) = MSG(8)
      ELSE IF(B2.EQ.'T'.AND.NPF.EQ.2)THEN
          NPF = 1
          MSH(3+I) = MSG(6)
          MSH(4+I) = '
```

```
      END IF
C
C     CHECK TO SEE IF NVP SHOULD BE OVERRIDDEN; IF SO, REWRITE MESSAGES
C
      IF(B1.EQ.'N'.AND.NVP.EQ.1)THEN
          NVP = 2
          MSH(1+I) = MSG(4)
          MSH(2+I) = MSG(5)
      ELSE IF(B1.EQ.'T'.AND.NVP.EQ.2)THEN
          NVP = 1
          MSH(1+I) = MSG(1+I)
          MSH(2+I) = MSG(3)
      END IF
C
C     CHECK THE LTE FLAG
C
      IF(COD.EQ.'LTE'.AND.NVP.NE.3)THEN
          NPF = 3
          NVP = NVP + 2
          IF(VIBL.GT.0.0)NVP = 3
      END IF
C
C     SET INDEX
C
      INDEX = 1
      IF(VIBL.GT.0.0)INDEX = 7
      IF(NPF.EQ.2)INDEX = INDEX + 1
      IF(NVP.EQ.2)INDEX = INDEX + 2
      IF(NPF.EQ.0)INDEX = NVP + 4
      IF(NPF.EQ.3)INDEX = NVP + 8
C
C     WRITE OUT THE DIAGNOSTIC MESSAGES TO UNIT 6
C
      WRITE(6,100)(MSH(I),I=1,5),CODE
      RETURN
      END
```

```
      SUBROUTINE ZVGTC(DV,K1,K2)
C
C     VOIGT PROFILE ALGORITHM DESIGNED FOR FAST EXECUTION IN PROGRAM NLTE.
C     DOPPLER PROFILE IS SUBSTITUTED IN SOME REGIONS.  THE METHOD EMPLOYED
C     IN REGIONS 1, 2 AND 3  WAS ORIGINALLY OUTLINED BY  PIERLUISSI ET AL,
C     JQSRT 18, 555(1977). THE ROUTINE HAS BEEN TESTED FOR 0<X<25 AND Y=0,
C     .000001<Y<10. IT GIVES AN ACCURACY OF BETTER THAN .1% FOR X<1.25 AND
C     BETTER THAN .5% EVERYWHERE ELSE IN THIS AREA.  THAT IS, THE ABSOLUTE
C     ERROR  IS LESS THAN  .001 OR .005  TIMES THE CORRECT FUNCTION VALUE.
C     FOR Y<.000001,  WHERE THE DOPPLER PROFILE IS SUBSTITUTED,  THE FRAC-
C     TIONAL ERROR MAY BE GREATER FOR X>3.3 BUT THE ABSOLUTE ERROR IS VERY
C     SMALL.
C
C     THE SUBROUTINE FORM OF ZVGTC IS SET UP TO EVALUATE AN ARRAY OF VOIGT
C     FUNCTIONS, VGT, CORRESPONDING TO A SINGLE FREQUENCY DV AND DIFFERENT
C     ALTITUDES. THE INPUT COMING THROUGH COMMON /C/ INCLUDES ARRAYS SPEC-
C     IFYING THE LINEWIDTH RATIO  AND THE DOPPLER WIDTH FOR EACH ALTITUDE.
C     K1 AND K2 ARE THE BOTTOM AND TOP LAYER-INDICES.
C
C
C     Y  = A = SQRT(LN2)*ALFL/ALFD
C     X  = SQRT(LN2)*DV/ALFD
C     DV = NU - NU0
C
C     RAT  = ARRAY OF VALUES OF Y
C     DWID = ARRAY OF VALUES OF ALFD (DOPPLER WIDTHS)
C     VGT  = ARRAY OF FUNCTION VALUES
C
C     AN     = 1/(N|*(2N+1)),  N = 0,...,56  (COEFFS, REGION 1 SERIES)
C     W6     = WEIGHT  FOR 2-PT  GAUSS-HERMITE QUADRATURE TIMES 2/PI
C     W1-W3 = WEIGHTS FOR 6-PT  GAUSS-HERMITE QUADRATURE TIMES 2/PI
C     U6     = SQUARE  OF ZERO   FIXED BY 2-PT GAUSS-HERMITE QUADRATURE
C     U1-U3 = SQUARES OF ZEROES FIXED BY 6-PT GAUSS-HERMITE QUADRATURE
C     PISQ  = 2/SQRT(PI);    SL = SQRT(LN2);    SLP = SQRT(LN2/PI)
C
      DIMENSION AN(57),TST1(9),TST2(6),RAT(250),DWID(250),VGT(250)
      COMMON/C/RAT,DWID,VGT
C
      DATA (TST1(N),N=1,9)/4*.90E-03,.17E-03,.32E-04,.62E-05,2*.10E-05/
      DATA (TST2(N),N=1,6)/.10E+00,.10E-01,.10E-02,.10E-03,2*.10E-04/
C
      DATA (AN(N),N=1,57)/1.,.3333333333333,       .10,
     1 .2380952380952E-01,  .4629629629630E-02,  .7575757575758E-03,
     2 .1068376068376E-03,  .1322751322751E-04,  .1458916900093E-05,
     3 .1450385222315E-06,  .1312253296380E-07,  .1089222103715E-08,
     4 .8350702795147E-10,  .5947794013638E-11,  .3955429516459E-12,
     5 .2466827010264E-13,  .1448326464360E-14,  .8032735012416E-16,
     6 .4221407288807E-17,  .2107855191442E-18,  .1002516493491E-19,
     7 .4551846758928E-21,  .1977064753878E-22,  .8230149299214E-24,
     8 .3289260349176E-25,  .1264107898899E-26,  .4678483515519E-28,
     9 .1669761793417E-29,  .5754191643982E-31,  .1916942862110E-32,
     A .6180307588223E-34,  .1930357208815E-35,  .5846755007469E-37,
     B .1718856062802E-38,  .4908923964523E-40,  .1363041261779E-41,
     C .3682493515461E-43,  .9687280238871E-45,  .2483069097455E-46,
     D .6205657919638E-48,  .1513107949541E-49,  .3601579309810E-51,
     E .8373419683872E-53,  .1902541227290E-54,  .4226789754194E-56,
     F .9186429502399E-58,  .1954102582324E-59,  .4070135277853E-61,
     G .8304614505929E-63,  .1660580513451E-64,  .3255395462013E-66,
     H .6259184116949E-68,  .1180761838912E-69,  .2186210422954E-71,
```

```
     I  .3974252722665E-73,  .7095717391818E-75,  .1244665977389E-76/
C
      DATA SLP     /.4697186393498/
      DATA PISQ,SL /1.128379167096,  .8325546111577/
      DATA W1,W2,W3/.4613135279626,  .09999216171035,.2883893874868E-02/
      DATA U1,U2,U3/.1901635091935,  1.784492748543,  5.525343742263/
      DATA W6,U6   /.5642150484, .5/
C
C     ***********************************************************************
C
      DO 500 K = K1,K2
      X = DV*SL/DWID(K)
      Y = RAT(K)
C
C     DETERMINE WHICH REGION TO ENTER
C
      IF(X.GT.4.9)THEN
          INDEX = 3
      ELSE IF(Y.LT.1.0E-06)THEN
          INDEX = 4
      ELSE IF(Y.GT.1.5)THEN
          INDEX = 2
      ELSE
          INDEX = 1
          N = 1 + INT(3.333333333333*(X-3.3))
          IF(X.LT.3.3)THEN
              N = 1 + INT(2.5*(X-.1))
              IF(Y.LT.TST1(N))INDEX = 4
          ELSE IF(Y.GT.TST2(N))THEN
              INDEX = 2
          END IF
      END IF
C
C     ***********
C     REGION ONE:  PIERLUISSI'S SERIES, EXTENDED
C     ***********
C
      IF(INDEX.EQ.1)THEN
          S = X*X - Y*Y
          T = 2.0*X*Y
          SER = Y
          SEI = -X
          FPR = Y
          FPI = -X
C
          NMAX = INT(10.45*X) - 4 + 6*INT(Y)
          N = 8 + 4*INT(Y)
          IF(NMAX.LT.N)NMAX = N
C
          DO 100 N = 1,NMAX
          FNR = FPR*S - FPI*T
          FNI = FPI*S + FPR*T
          SER = SER + FNR*AN(N+1)
          SEI = SEI + FNI*AN(N+1)
          FPR = FNR
  100     FPI = FNI
          VGT(K) = SLP*EXP(-S)*(COS(T)*(1.0-PISQ*SER) - SIN(T)*PISQ*SEI)
C
C     ***********
C     REGION TWO: 6-PT GAUSS-HERMITE QUADRATURE
```

```
C     ***********
C
      ELSE IF(INDEX.EQ.2)THEN
          S = X*X - Y*Y
          T = 2.0*X*Y
          T2 = T*T
          T = T*X
          F1 = S - U1
          F2 = S - U2
          F3 = S - U3
          VGT(K) = SLP*(W1*(T - Y*F1)/(F1*F1 + T2) +
     1                  W2*(T - Y*F2)/(F2*F2 + T2) +
     2                  W3*(T - Y*F3)/(F3*F3 + T2))
C
C     *************
C     REGION THREE: 2-PT GAUSS-HERMITE QUADRATURE (FASTER THAN DOPP)
C     *************
C
      ELSE IF(INDEX.EQ.3)THEN
          T = 2.0*X*Y
          SEI = T*T
          T = T*X
          FPR = X*X - Y*Y - U6
          VGT(K) = SLP*W6*(T - Y*FPR)/(FPR*FPR + SEI)
C
C     ************
C     REGION FOUR: SUBSTITUTE DOPPLER PROFILE
C     ************
C
      ELSE
          VGT(K) = SLP*EXP(-X*X)
      END IF
C
  500 VGT(K) = VGT(K)/DWID(K)
C
C     **********************************************************************
C
      RETURN
      END
```

```
      SUBROUTINE SPECTRM(VMIN,VMAX,DEL,FWHM,UNIT,MOL,ISO,UST,LST,
     1BR,HGTS,IMXX,LOOK,MSG)
C
      CHARACTER*1 BL
      CHARACTER*2 BR
      CHARACTER*3 MOL
      CHARACTER*4 UN,UNIT
      CHARACTER*7 FN,LL
      CHARACTER*8 UST,LST
      CHARACTER*10 MSG(2)
      LOGICAL EX,OD,CMPL
      REAL EPS
      PARAMETER(CMPL=.FALSE.,EPS=1.0E-06)
      DIMENSION HGTS(50),R(500,12),GL(500),RAW(5),RAI(12)
      SAVE R,GL,RAI,LMAX,IMAX,NOB
C
  100 FORMAT('CXXXXXXX BAND RADIANCE     ---NLTE OUTPUT')
  101 FORMAT('C',A3,I4,2A8,1X,A2,'---',2A10)
  102 FORMAT(F8.3,F7.3,1X,A4,A7,' LOOK; HTS (KM) =',12F7.2)
  103 FORMAT(F8.3,F7.3,1X,A4,A7,17X,12F7.2)
  104 FORMAT(F10.3,1X,1P,12E10.3)
  105 FORMAT(20X,I5,E10.3)
  106 FORMAT(//,' UNIT 7 HEADER:',/)
  107 FORMAT(1H1,'SUBROUTINE SPECTRM:',//,
     1' CUMULATIVE RADIANCE FOR',I3,' VIEWING PATHS AND',I3,1X,A3,
     2' BANDS',//,' INTEGRATED RADIANCE (WATT/CM2*STER)',/,
     3' SYNTHETIC  SPECTRUM (WATT/CM2*STER*',A4,')',//,
     4' FWHM FOR TRIANGULAR  SCANNING FUNCTION =',F7.3,1X,A4,'  DEL =',
     5F6.3,1X,A4)
  108 FORMAT(/,3X,A7,1X,12(F7.2,' KM'))
  109 FORMAT(/,' CREATE NEW DATABASE FOR BAND RADIANCES ON UNIT 7,',
     1' FILE SPECF')
  110 FORMAT(/,' SUBROUTINE SPECTRM RECOGNIZES FILE WITH PREVIOU',
     1'SLY-CALCULATED BAND RADIANCES; WILL ADD TO THIS DATA-BASE',/)
  111 FORMAT(/,' SUBROUTINE SPECTRM  DETECTS INCONSISTENCIES BETWEEN',
     1' CURRENT AND PREVIOUS VALUES OF SIGNIFICANT',/,' PARAMETERS,',
     2' WILL NOT ADD BAND RADIANCES; IGNORE PREVIOUS UNIT 7, OPEN',
     3' NEW UNIT 7 AS FILE SPECG')
  112 FORMAT(/,' PARAMETER VALUES ARE:   PRESENT  PREVIOUS',/,
     1/,17X,'FWHM',2F10.3,
     2/,17X,'DEL ',2F10.3,
     3/,17X,'GEOM',2(3X,A7),
     4/,17X,'UNITS',5X,A4,6X,A4,
     512(/,16X,A1,'ALT ',2F10.2))
  113 FORMAT(///,' $$$$$ PROBLEM IN ACCESSING UNIT',I2,
     1'  (INQUIRE), FWHM WILL BE RESET TO ZERO $$$$$',A1,/,
     2', $$$$$ SEE UNIT 6 OUTPUT $$$$$',//)
  114 FORMAT(' IOSTAT =',I6,A1,
     1/,' EX =',L2,
     2/,' OD =',L2,
     3/,' NM =',I2,
     4/,' FN =',A7,
     5//,' FWHM RESET TO ZERO, CONTINUE WITH NLTE',//)
  115 FORMAT(//,' $$$$$ CAUTION: SPECTRAL RADIANCE ARRAY IS TOO SMALL,',
     1' SOME POINTS ARE NOT CALCULATED $$$$$',/,
     2' $$$$$',10X,'GMIN, GMAX, DEL =',3F10.3,1X,A4,17X,'$$$$$',//)
  116 FORMAT(F10.3,10E10.3)
  117 FORMAT(' LMAX =',I4,',  RANGE =',F9.3,' TO',F9.3,2X,A4)
  118 FORMAT(//,' $$$$$ PROBLEM OPENING ',A4,'FILE',A7,'ON UNIT',I2,
```

```
     1'    IOS =',I4,/,6X,' RESET FWHM TO ZERO AND CONTINUE WITH NLTE',
     2' $$$$$',//)
  119 FORMAT(' NOTE THAT IMAX =',I3,' BUT ONLY 12 SPECTRA ARE WRITTEN',
     1' TO UNIT 7')
  120 FORMAT(I3,8X,1P,12E10.3)
  121 FORMAT(' (INTEG''TD)',1P,12E10.3)
C
C
C     **********************************************************************
C
C     SUBROUTINE SPECTRM---PURPOSE  IS TO GENERATE A SYNTHETIC SPECTRUM FOR
C     THE VIBRATIONAL BAND UNDER CONSIDERATION AND ADD THE RESULTS TO SPEC-
C     TRA FROM OTHER BANDS PREVIOUSLY GENERATED. ONLY 12 L-O-S PATHS CAN BE
C     CONSIDERED AT ONCE---OTHERS ARE IGNORED BY THIS ROUTINE.
C
C     MAIN ENTRY:  CHECK TO SEE IF PREVIOUSLY-GENERATED SPECTRA ARE AVAILA-
C                  BLE. PERFORM INITIALIZATION STEPS, OPEN UNIT 7, AND READ
C                  PREVIOUS RESULTS (IF ANY).
C
C     ENTRY SPEC1: ADD THE CONTRIBUTIONS FOR EACH LINE-OF-SIGHT PATH (I) AT
C                  EACH DESIGNATED WAVELENGTH (L)
C
C     ENTRY SPEC2: ADD THE CONTRIBUTIONS  FROM THE CURRENT BAND  TO THE RE-
C                  SULTS  FROM BANDS  COMPILED EARLIER (IF ANY).  WRITE THE
C                  RESULTS TO UNIT 7.
C
C     **********************************************************************
C
C     MAIN ENTRY:
C
C     INITIALIZATION
C
      BL = ' '
      IMAX = IMXX
      IF(IMAX.GT.12)IMAX = 12
C
C     UNITS CHOSEN ARE EITHER CM-1 OR UM (MICRONS)
C     VMIN, VMAX ARE IN CM-1, HOWEVER.
C
      IF(UNIT.EQ.'CM-1')THEN
          GMIN = INT((VMIN-FWHM)/DEL)*DEL + DEL
          GMAX = INT((VMAX+FWHM)/DEL)*DEL
      ELSE
          GMAX = 10000./VMIN + FWHM
          GMIN = 10000./VMAX - FWHM
          GMIN = INT(GMIN/DEL)*DEL + DEL
          GMAX = INT(GMAX/DEL)*DEL
      END IF
C
C     **********************************************************************
C
C     QUERY BY FILENAME TO ESTABLISH THE CURRENT STATUS OF SPECF
C
      L1 = 7
      LL = ' SPECF '
      UN = 'OLD '
      INQUIRE(FILE='SPECF',IOSTAT=IOS,ERR=900,EXIST=EX,OPENED=OD,
     1NUMBER=NM,NAME=FN)
      FN = '   LIMB'
      IF(LOOK.EQ.1)FN = ' ZENITH'
```

```
      IF(.NOT.EX)GO TO 300
C
C     ************************************************************************
C
C     FILE SPECF EXISTS AS A LOCAL FILE; READ IT
C
      OPEN(7,IOSTAT=IOS,ERR=901,FILE='SPECF',STATUS='OLD')
      REWIND(7)
      WRITE(4,106)
C$    IF(CMPL)
      WRITE(9,106)
C$    ENDIF
      CALL HEADER(7)
      READ(7,103)FW,DL,UN,LL,(GL(I),I=1,IMAX)
      READ(7,120)NOB,(RAI(I),I=1,IMAX)
C
C     PARAMETER CHECK (VALUES ON THE FIRST DATA CARD-IMAGE)
C
      TEST = ABS(FWHM-FW)
      V = ABS(DEL-DL)
      IF(TEST.GT.EPS.OR.V.GT.EPS)GO TO 290
      IF(FN.NE.LL.OR.UNIT.NE.UN)GO TO 290
      DO 210 I = 1,IMAX
      V = ABS(GL(I)-HGTS(I))
  210 IF(V.GT.EPS)GO TO 290
      WRITE(4,110)
      IF(IMXX.GT.IMAX)WRITE(4,119)IMXX
C$    IF(CMPL)
      WRITE(9,110)
C$    ENDIF
C
C     ************************************************************************
C
C     PARAMETERS CHECK OUT: READ THE PREVIOUSLY-COMPILED BAND-RADIANCE DATA
C
      DO 220 L = 1,500
      READ(7,104,END=225)GL(L),(R(L,I),I=1,IMAX)
  220 LMAX = L
  225 CONTINUE
      WRITE(4,117)LMAX,GL(1),GL(LMAX),UNIT
C
C     IF NECESSARY, ADJUST THE INDEX RANGE (1-LMAX) TO COVER THE FULL WAVE-
C     LENGTH OR ENERGY RANGE (GL(1)-GL(LMAX))  REQUIRED BY THE CURRENT BAND
C     AND THE ONES PREVIOUSLY COMPILED. IF MORE THAN 500 POINTS ARE REQUES-
C     TED,  ELIMINATE SOME NEW POINTS RATHER THAN THOSE FROM EARLIER BANDS.
C
      K = INT((GL(1)-GMIN)/DEL + EPS)
      IF(K.GT.0.AND.LMAX.LT.500)THEN
          IF((K+LMAX).GT.500)THEN
              K = 500 - LMAX
              WRITE(4,115)GMIN,GMAX,DEL,UNIT
              WRITE(6,115)GMIN,GMAX,DEL,UNIT
          END IF
          DO 230 L = LMAX,1,-1
          GL(L+K)  = GL(L)
          DO 230 I = 1,IMAX
  230     R(L+K,I) = R(L,I)
          DO 235 L = 1,K
          GL(L) = GL(K+1) - (K-L+1)*DEL
          DO 235 I = 1,IMAX
```

```
  235       R(L,I) = 0.0
            LMAX = LMAX + K
        END IF
C
        K = INT((GMAX-GL(LMAX))/DEL + EPS)
        IF(K.GT.0.AND.LMAX.LT.500)THEN
            IF((K+LMAX).GT.500)THEN
                K = 500 - LMAX
                WRITE(4,115)GMIN,GMAX,DEL,UNIT
                WRITE(6,115)GMIN,GMAX,DEL,UNIT
            END IF
            DO 245 L = LMAX+1,LMAX+K
            GL(L) = GL(LMAX) + (L-LMAX)*DEL
            DO 245 I = 1,IMAX
  245       R(L,I) = 0.0
            LMAX = LMAX + K
        END IF
        WRITE(4,117)LMAX,GL(1),GL(LMAX),UNIT
C
C       REPOSITION UNIT 7, RETURN TO LINES
C
        CALL REWND(7)
        WRITE(7,101)MOL,ISO,UST,LST,BR,MSG(1),MSG(2)
        WRITE(7,102)FWHM,DEL,UNIT,FN,(HGTS(I),I=1,IMAX)
        RETURN
C
C       **********************************************************************
C
C       PARAMETERS DON'T CHECK OUT: FILE SPECF CONTAINS THE WRONG INFORMATION
C       OPEN SPECG AS AN ALTERNATE FILE FOR OUTPUT FROM THE CURRENT BAND.
C
  290 WRITE(4,111)
      WRITE(6,111)
C$    IF(CMPL)
      WRITE(9,111)
C$    ENDIF
      WRITE(4,112)FWHM,FW,DEL,DL,FN,LL,UNIT,UN,(BL,HGTS(I),GL(I),
     1I=1,IMAX)
      WRITE(6,112)FWHM,FW,DEL,DL,FN,LL,UNIT,UN,(BL,HGTS(I),GL(I),
     1I=1,IMAX)
      CLOSE(7)
      LL = ' SPECG '
      UN = 'NEW '
      OPEN(7,IOSTAT=IOS,ERR=901,FILE='SPECG',STATUS='NEW')
      GO TO 301
C
C     **********************************************************************
C
C     FILE SPECF DOES NOT EXIST OR IS EMPTY; OPEN IT AS UNIT 7. WRITE HEAD-
C     ERS AND THE INITIAL DATA RECORD.
C
  300 LL = ' SPECF '
      UN = 'NEW '
      OPEN(7,IOSTAT=IOS,ERR=901,FILE='SPECF',STATUS='NEW')
      WRITE(4,109)
C$    IF(CMPL)
      WRITE(9,109)
C$    ENDIF
  301 IF(IMXX.GT.IMAX)WRITE(4,119)IMXX
      WRITE(7,100)
```

```
      WRITE(7,101)MOL,ISO,UST,LST,BR,MSG(1),MSG(2)
      WRITE(7,102)FWHM,DEL,UNIT,FN,(HGTS(I),I=1,IMAX)
C
C     DEFINE THE ARRAY OF WAVENUMBERS OR WAVELENGTHS TO BE USED. INITIALIZE
C     THE ARRAY OF SPECTRAL  INTENSITIES AND THE TOTAL  INTEGRATED RADIANCE
C     ARRAY FOR EACH LINE-OF-SIGHT PATH. RETURN TO LINES.
C
      NOB = 0
      DO 355 I = 1,IMAX
  355 RAI(I) = 0.0
      DO 360 L = 1,500
      GL(L) = GMIN + DEL*(L-1)
      IF(GL(L).GT.(GMAX+EPS))GO TO 370
      LMAX = L
      DO 360 I = 1,IMAX
  360 R(L,I) = 0.0
      IF((GL(500)+DEL).LT.GMAX)THEN
          WRITE(4,115)GMIN,GMAX,DEL,UNIT
          WRITE(6,115)GMIN,GMAX,DEL,UNIT
      END IF
  370 WRITE(4,117)LMAX,GL(1),GL(LMAX),UNIT
      RETURN
C
C     ********************************************************************
C     ********************************************************************
C     ********************************************************************
C
C     ENTRY SPEC1:  ADD THE CONTRIBUTION FROM THE CURRENT LINE TO THE CUMU-
C     LATIVE RESULTS OBTAINED SO FAR.
C
      ENTRY SPEC1(FWHM,VINIT,NR,IMXXX,RAW)
C
      FW = FWHM*FWHM
      V = VINIT
      IF(UNIT.NE.'CM-1')V = 10000./VINIT
      NM = IMXXX
      K = 5*(NR-1) + IMXXX
      IF(K.GT.12)NM = 2
C
      DO 400 L = 1,LMAX
      TEST = ABS(GL(L)-V)
      IF(TEST.GT.FWHM)GO TO 400
      DO 395 I = 1,NM
      K = 5*(NR-1) + I
  395 R(L,K) = R(L,K) + RAW(I)*(FWHM-TEST)/FW
  400 CONTINUE
      DO 410 I = 1,NM
      K = 5*(NR-1) + I
  410 RAI(K) = RAI(K) + RAW(I)
      RETURN
C
C     ********************************************************************
C     ********************************************************************
C     ********************************************************************
C
C     ENTRY SPEC2:  WRITE THE COMPLETED SYNTHETIC SPECTRUM TO UNITS 4 AND 7
C
      ENTRY SPEC2(FWHM)
      NOB = NOB + 1
      FN = '(CM-1) '
```

```
      IF(UNIT.NE.'CM-1')FN = ' WL(UM)'
      WRITE(4,107)IMAX,NOB,MOL,UNIT,FWHM,UNIT,DEL,UNIT
      WRITE(4,108)FN,(HGTS(I),I=1,IMAX)
      WRITE(4,102)
      WRITE(7,120)NOB,(RAI(I),I=1,IMAX)
      WRITE(4,121)(RAI(I),I=1,IMAX)
      WRITE(4,102)
      DO 500 L = 1,LMAX
      WRITE(7,104)GL(L),(R(L,I),I=1,IMAX)
  500 WRITE(4,104)GL(L),(R(L,I),I=1,IMAX)
      REWIND(7)
      CLOSE(7)
      RETURN
C
C     *********************************************************************
C     *********************************************************************
C     *********************************************************************
C
C
C     ERROR RETURNS: THERE IS A PROBLEM WITH AN INQUIRE OR OPEN
C
  900 WRITE(4,113)L1,BL
      WRITE(6,113)L1
      WRITE(6,114)IOS,BL,EX,OD,NM,FN
      FWHM = 0.0
      RETURN
C
  901 WRITE(4,118)UN,LL,L1,IOS
      WRITE(6,118)UN,LL,L1,IOS
      FWHM = 0.0
      RETURN
      END
```

```
      SUBROUTINE PATH(ALT,HGTS,IMXX,HTS,IMAX,NR,KMAX,LOOK,K1)
C
C     SUBROUTINE TO SET THE LOWER-ALTITUDE INDEX, K1, FOR EACH L-O-S PATH
C     AND TO PRINT THE PARAMETERS DESCRIBING THE PATHS.
C
      CHARACTER*9 MSG(2)
      DIMENSION ALT(250),HGTS(50),HTS(5),K1(5)
      DATA MSG(1),MSG(2)/', TANGENT',', OBSERV.'/
C
C     DETERMINE IMAX AND STACK THE VALUES OF HGTS INTO HTS
C
      K = IMXX - 5*(NR-1)
      IMAX = MIN(K,5)
      DO 170 I = 1,IMAX
      K = 5*(NR-1) + I
  170 HTS(I) = HGTS(K)
      WRITE(4,101)NR,IMAX
C
C     SET K1 FOR EACH PATH
C
      DO 200 I = 1,IMAX
      DO 180 K = 1,KMAX-1
      IF(ALT(K+1).GT.HTS(I))THEN
          K1(I) = K
          GO TO 190
      END IF
  180 CONTINUE
      IF(ALT(KMAX).LE.HTS(I))K1(I) = KMAX
C
C     WRITE THE PATH PARAMETERS
C
  190 J = KMAX - K1(I) + 1
      K = 5*(NR-1) + I
  200 WRITE(4,100)K,MSG(LOOK+1),HTS(I),K1(I),KMAX,ALT(K1(I)),ALT(KMAX),J
C
  100 FORMAT(' PATH #',I2,A9,' HT =',F7.2,' KM,  USE LAYERS',I3,
     1' THRU',I4,' (ALTITUDES',F7.2,' THRU',F7.2,' KM)',I4,' LAYERS')
  101 FORMAT(1H1,'GROUP #',I2,' WITH',I2,' VIEWING PATHS',//)
C
      RETURN
      END
```

```
      SUBROUTINE HEADER(IU)
C
C     SUBROUTINE TO READ THE HEADERS ON THE INPUT FILES USED, AND TO COPY
C     THEM, FOR REFERENCE, TO UNIT 6.  IU IS THE UNIT NUMBER.
C
      CHARACTER*1 CH,BL
      CHARACTER*130 MSG
      DIMENSION NU(7)
      SAVE NU
C
  100 FORMAT(A1,A120)
  101 FORMAT(1X,A1,A120,'  (HEADER)')
  102 FORMAT(//,' UNIT',I2,':')
  103 FORMAT(' AAAAABBBBBBBBBBCCCCCCCCCCDDDDDDDDDDEEEEEEEEEEE',
     1'FFFFFFFFFFFFGGGGGGGGGGGG---------------',33X,'(FORMAT)')
  104 FORMAT(' 11111111112222222222333333333344444444445555555555',
     1'666666666677777777778888888888',43X,'(FORMAT)')
  105 FORMAT(1X,A1,A120,'  (DATA)')
C
      BL = ' '
      J = 0
      WRITE(6,102)IU
  200 READ(IU,100)CH,MSG
      IF(CH.EQ.'C')THEN
          WRITE(4,100)BL,MSG
          WRITE(9,100)BL,MSG
          WRITE(6,101)CH,MSG
          J = J + 1
          GO TO 200
      ELSE
          BACKSPACE IU
          IF(IU.EQ.2)WRITE(6,103)
          IF(IU.NE.2)WRITE(6,104)
          WRITE(6,105)CH,MSG
          NU(IU) = J
      END IF
      RETURN
C
      ENTRY REWND(IU)
C
C     PROCEDURE TO REPOSITION THE INPUT FILES AT THE FIRST DATA CARD-IMAGE
C     (E.G., SKIP THE HEADER)
C
      REWIND(IU)
      IF(NU(IU).EQ.0)RETURN
      DO 300 J = 1,NU(IU)
  300 READ(IU,100)CH
      RETURN
      END
```

```
      FUNCTION VWERF (XX,A)
C
C     THE METHOD IS DUE TO RYBICKI. THE FORTRAN LISTING WAS
C     PUBLISHED AS AN APPENDIX TO E. H. AVRETT AND R. LOESER,
C     "FORMATION OF LINE AND CONTINUOUS SPECTRA," SPECIAL REPORT 303,
C     SMITHSONIAN ASTROPHYSICAL OBSERVATORY, CAMBRIDGE, MASS. (1970)
C
C     THE METHOD OF  CALCULATION IS DESCRIBED BY B. H. ARMSTRONG
C     AND R. W. NICHOLLS, "EMISSION, ABSORPTION AND TRANSFER OF
C     RADIATION IN HEATED ATMOSPHERES," PERGAMON PRESS,NEW YORK,
C     (1972) - PP. 235-237.
C
C     "ORIGINAL" VERSION FROM DEGGES CHANGED BY ADDITION OF SAVE STATEMENT
C
      COMPLEX Z
      DIMENSION C(131)
     SAVE NTRY,NP1,NPNP1,RHSQ,Q1,RTLN2,C
      DATA NTRY,NMAX,RH,PI,Q2,Q3 /1,15,3.0,3.1415926535898,
     1 5.6418958354776E-01,8.9793561062583E-02/
C
      IF (NTRY .EQ. 1)  GO TO 170
  110 CONTINUE
      X = RTLN2*XX
      IF (A .EQ. 0.0)  GO TO 160
      IF ((X + A) .GT. 25.0)  GO TO 190
C     DO COMPUTATION FOR GENERAL CASE
      A1 = RH*A
      A2 = A*A
      IF (A .LT. 0.1)  GO TO 120
      Z = CEXP(CMPLX(-Q1*A,Q1*X))
      VWERF = 0.0
      GO TO 130
  120 CONTINUE
      Z = CCOS(CMPLX(Q1*X,Q1*A))
      VWERF = Q2*EXP(A2 - X*X)*COS(2.0*A*X)
  130 CONTINUE
      B1 = (1.0 - REAL(Z))*A*0.5*RH
      B2 = -AIMAG(Z)
      S = -0.5*(FLOAT(NP1) + RH*X)
      T = S*S + 0.25*RHSQ*A2
     DO 150 N = 1, NPNP1
      T = T + S + 0.25
      S = S + 0.5
      B1 = A1 - B1
      B2 = -B2
      IF (T .GT. 2.5E-12)  GO TO 140
      VWERF = VWERF - C(N)*A/RH
      GO TO 150
  140 CONTINUE
      VWERF = VWERF + C(N)*(B2*S + B1)/T
  150 CONTINUE
  155 CONTINUE
      VWERF = VWERF*RTLN2
      RETURN
  160 CONTINUE
      VWERF = RTLN2*Q2*EXP(-X*X)
      RETURN
  170 CONTINUE
      NTRY = 0
```

```
      NP1 = NMAX + 1
      NPNP1 = NMAX + NP1
      RHSQ = RH*RH
      K = -NP1
      DO 180 N = 1, NPNP1
      K = K + 1
      C(N) = Q3*EXP(-FLOAT(K*K)/RHSQ)
  180 CONTINUE
      Q1 = RH*PI
      RTLN2 = SQRT(ALOG(2.0))
      GO TO 110
  190 CONTINUE
C
C     USE ASYMPTOTIC EXPANSION FOR COMPLEX ERROR FUNCTION
C     FOR LARGE X AND A.
C
      AN = 2.5
      DENR = A
      DENI = -X
      DO 200 I = 1, 5
      DEN = AN/(DENR*DENR + DENI*DENI)
      DENR = DEN*DENR + A
      DENI = -DENI*DEN - X
      AN = AN - 0.5
  200 CONTINUE
      DEN = Q2/(DENR*DENR + DENI*DENI)
      VWERF = RTLN2*Q2*DEN*DENR
      RETURN
      END
```

```
      SUBROUTINE MOLEC(MOL,ISO,UST,LST,MOLWT,DEGV,PROT,TEXP,VIBE,VIBL,
     1                 VIBQ,GL,GU,AI,FMT,FLAG)
C
C     ******************************************************************
C
C     SUBROUTINE MOLEC, GIVEN THE MOLECULE CODE (MOL)  AND THE ISOTOPE CODE
C     (ISO), RETURNS PARAMETERS WHICH ARE UNIQUELY ASSOCIATED WITH THE MOL-
C     ECULE IN QUESTION:
C                             MOLWT, THE MOLECULAR WEIGHT
C                             DEGV,  THE DEGENERACY OF THE VIBRATIONAL MANIFOLD
C                             PROT,  THE EXPONENT OF TEMPERATURE IN THE ROTAT'L
C                                    PARTITION FUNCTION
C                             TEXP,  THE EXPONENT OF TEMPERATURE IN THE LORENTZ
C                                    LINEWIDTH CORRECTION
C                             VIBQ,  THE VIBRATIONAL QUANTUM IN THE PARTIT'N FN
C                             AI,    THE ISOTOPIC ABUNDANCE
C
C     ALSO, MOLEC RETURNS A CHARACTER VARIABLE, FMT,  SPECIFYING THE FORMAT
C     NEEDED FOR READING THE LINEFILES.  SINCE  BR AND NRL  (SEE LINES) ARE
C     NOT APPROPRIATE DESCRIPTIONS FOR H2O, O3, AND CH4 (THE NONLINEAR MOL-
C     ECULES), THE LINES ARE SIMPLY NUMBERED IN THE ORDER IN WHICH THEY ARE
C     READ.
C
C     FOR CH4, THE CORRECT PARTITION FUNCTION RESULTS TO WITHIN ONE PERCENT
C     IF A SINGLE LEVEL AT 1370 CM-1  (VIBQ)  WITH A DEGENERACY OF 5 (DEGV)
C     IS CHOSEN.
C
C     DEGV IS 2  FOR LINEAR TRIATOMIC MOLECULES, 5 FOR CH4, 1 OTHERWISE
C     PROT IS 1  FOR ALL LINEAR MOLECULES, 1.5 OTHERWISE
C     TEXP IS .25 FOR CO2, .5 OTHERWISE
C
C     GIVEN THE UPPER AND LOWER VIBRATIONAL LEVEL CODES (UST AND LST), THIS
C     SUBROUTINE  ALSO RETURNS  CERTAIN VALUES  WHICH ARE  ASSOCIATED  WITH
C     INDIVIDUAL VIBRATIONAL TRANSITIONS,  PROVIDED THE LATTER CAN BE FOUND
C     IN THE DATABASE MOLPAR. MOLPAR CONTAINS DATA PERTAINING ONLY TO TRAN-
C     SITIONS OF CO2 AND NO,  AND NOT ALL TRANSITIONS AT THAT.  THE INTEGER
C     VARIABLE FLAG IS SET TO ZERO IF THESE QUANTITIES ARE NOT FOUND.
C
C     THIS SUBROUTINE,  AND HENCE  PROGRAM NLTE,  RECOGNIZES ONLY THE FIRST
C     EIGHT MOLECULES IN THE A.F.G.L. DATABASE---THAT IS,  ONLY THOSE WHOSE
C     CODES APPEAR IN THE FIRST DATA STATEMENT BELOW.
C
C     ******************************************************************
C
      INTEGER DEGV,DEG(8),STW2(29),STW8(13),GL,GU
      LOGICAL FLAG
      CHARACTER*3 MOLCOD(8),MOL
      CHARACTER*8 NAM2(29),NAM8(13),UST,LST
      CHARACTER*31 F1
      CHARACTER*9  F2
      CHARACTER*7  F3
      CHARACTER*47 FMT
      DIMENSION ENL2(29,7),ENL8(13,3)
      DIMENSION MLWT(8,7),MISO(8,7),ABUN(8,7),VIB(8,7),PRT(8),TXP(8)
      COMMON/M/MISO,MLWT,ABUN,VIB,DEG,PRT,TXP,ENL2,STW2,ENL8,STW8
      COMMON/N/NAM2,NAM8
      DATA (MOLCOD(I),I=1,8)/'H2O','CO2','O3 ','N2O'.'CO ','CH4','O2 ',
     1                       'NO '/
      DATA F1/'(BZ,F10.4,E10.3,F5.4,F10.3,2A8,'/
```

```
      DATA F3/',4X,I4)'/
C
   90 FORMAT(//,' $$$$$  ERROR: MOLECULE OR ISOTOPE CODE NOT RECOG',
     1'NIZED  $$$$$',/)
C
C     CHECK THE MOLECULE AND ISOTOPE CODES
C
      IC = 0
      DO 100 I = 1,8
  100 IF(MOLCOD(I).EQ.MOL)IC = I
      IF(IC.EQ.0)THEN
          WRITE(4,90)
          WRITE(6,90)
          RETURN
      END IF
      ID = 0
      DO 110 I = 1,7
  110 IF(MISO(IC,I).EQ.ISO)ID = I
      IF(ID.EQ.0)THEN
          WRITE(4,90)
          WRITE(6,90)
          RETURN
      END IF
C
C     SET THE SIX MOLECULAR PARAMETERS
C
      MOLWT = MLWT(IC,ID)
      AI    = ABUN(IC,ID)
      VIBQ = VIB(IC,ID)
      DEGV = DEG(IC)
      PROT = PRT(IC)
      TEXP = TXP(IC)
C
C     SET THE FORMAT FOR READING THE AFGL LINEFILE.
C
      F2 = '14X,A1,I3'
      IF(IC.EQ.7)F2 = '12X,A2,I4'
      IF(IC.EQ.1.OR.IC.EQ.3)F2 = 'A1,I17
      IF(IC.EQ.6)F2 = 'A1,16X,I1'
      IF(IC.EQ.8.OR.IC.EQ.5)THEN
          F2 = '12X,A1,I3'
          F3 = ',6X,I4)'
      END IF
      FMT = F1//F2//F3
C
C     CHECK TO SEE IF THE PROPERTIES OF THE VIBRATIONAL LEVELS ARE STORED
C     IN THE DATABASE, MOLPAR. SET THE INTEGER VARIABLE, FLAG.
C
      FLAG = .TRUE.
      IF(IC.EQ.2.OR.IC.EQ.8)THEN
          IMAX = 29
          IF(IC.EQ.8)THEN
              IMAX = 13
              DO 200 I = 1,IMAX
              NAM2(I) = NAM8(I)
              STW2(I) = STW8(I)
  200         ENL2(I,ID) = ENL8(I,ID)
          END IF
C
          IL = 0
```

```
          IU = 0
          DO 210 I = 1,IMAX
          IF(LST.EQ.NAM2(I))IL = I
  210     IF(UST.EQ.NAM2(I))IU = I
          IF(IL.EQ.0.OR.IU.EQ.0)GO TO 300
          GU = STW2(IU)
          GL = STW2(IL)
          VIBL = ENL2(IL,ID)
          VIBE = ENL2(IU,ID)
          IF(VIBE.EQ.0.0)GO TO 300
          IF(VIBL.EQ.0.0.AND.IL.GT.1)GO TO 300
          VIBE = VIBE - VIBL
          FLAG = .FALSE.
      END IF
C
  300 RETURN
      END
```

```
      SUBROUTINE SHFT(VAR,DUM)
C
C     SUBROUTINE TO CONVERT A LEFT-JUSTIFIED CHARACTER VARIABLE, VAR, TO A
C     RIGHT-JUSTIFIED VARIABLE.
C
      CHARACTER VAR*(*),DUM*(*),B*1,BL*1
      DATA BL/' '/
      L = LEN(VAR)
      DO 10 I = 1,L
      B = VAR(L:L)
      IF(B.NE.BL)RETURN
      DUM = BL//VAR
   10 VAR = DUM
      RETURN
      END

      SUBROUTINE LINT(Z,F,F1,F2,Z1,Z2)
C
C     SUBROUTINE TO PERFORM LINEAR INTERPOLATION OF F(Z)---TO OBTAIN
C     F AT A POINT Z.
C
      D = Z2 - Z1
      F = F2*(Z - Z1)/D - F1*(Z - Z2)/D
      RETURN
      END

      SUBROUTINE VIBTMP(C2,HMIN,HMAX,E,G,POP0,POP1,VT)
C
C     SUBROUTINE TO CALCULATE A VIBRATIONAL TEMPERATURE PROFILE FROM TWO
C     VIBRATIONAL POPULATION PROFILES. THE LOWER STATE (OF THE TWO WHOSE
C     POPULATIONS ARE GIVEN) IS ASSUMED TO BE THE GROUND STATE.
C
      INTEGER A,HMIN,HMAX,G
      DIMENSION VT(250),POP0(250),POP1(250)
C
      DO 100 A = HMIN,HMAX
  100 VT(A) = -C2*E/ALOG(POP1(A)/(G*POP0(A)))
      RETURN
      END

      SUBROUTINE VIBPOP(C2,HMIN,HMAX,AI,E,G,RHO,QV,VT,POP)
C
C     SUBROUTINE TO CALCULATE A VIBRATIONAL POPULATION PROFILE FROM
C     THE CORRESPONDING VIBRATIONAL TEMPERATURE PROFILE.
C
      INTEGER A,HMIN,HMAX,G
C
      DIMENSION VT(250),RHO(250),POP(250),QV(250)
C
      DO 100 A = HMIN,HMAX
  100 POP(A) = AI*G*RHO(A)*EXP(-C2*E/VT(A))/QV(A)
      RETURN
      END
```

```
      BLOCK DATA MOLPAR
C
      INTEGER DEGV(8),STW2(29),STW8(13)
      CHARACTER*8 NAM2(29),NAM8(13)
      DIMENSION ENL2(29,7),ENL8(13,3)
      DIMENSION MISO(8,7),MLWT(8,7),ABUN(8,7),VIBQ(8,7),PROT(8),TEXP(8)
      COMMON/M/MISO,MLWT,ABUN,VIBQ,DEGV,PROT,TEXP,ENL2,STW2,ENL8,STW8
      COMMON/N/NAM2,NAM8
C
C     SET MOLECULAR PARAMETERS FOR H2O
C
      DATA (MISO(1,I),I=1,7)/161,162,181,171,3*-1/
      DATA (MLWT(1,I),I=1,4)/ 18, 19, 20, 19/
      DATA (ABUN(1,I),I=1,4)/.99729,.00030,.00204,.00037/
      DATA (VIBQ(1,I),I=1,4)/1594.7498,1403.489,1588.279,1591.325/
C
C     SET MOLECULAR PARAMETERS FOR CO2 (MOLECULE # 2)
C
      DATA (MISO(2,I),I=1,7)/626,636,628,627,638,637,828/
      DATA (MLWT(2,I),I=1,7)/ 44, 45, 46, 45, 47, 46, 48/
      DATA (ABUN(2,I),I=1,7)/.98414,.01105,.00402,.00073,.0000452,
     1                       .0000082,.00000412/
      DATA (VIBQ(2,I),I=1,7)/667.379,648.479,662.374,664.730,643.23,
     1                       645.72, 657.33/
C
C     SET MOLECULAR PARAMETERS FOR O3
C
      DATA (MISO(3,I),I=1,7)/666,668,686,4*-1/
      DATA (MLWT(3,I),I=1,3)/ 48, 50, 50/
      DATA (ABUN(3,I),I=1,3)/.99279,.00406,.00203/
      DATA (VIBQ(3,I),I=1,3)/3*700.9316/
C
C     SET MOLECULAR PARAMETERS FOR N2O
C
      DATA (MISO(4,I),I=1,7)/446,456,546,448,447,2*-1/
      DATA (MLWT(4,I),I=1,5)/ 44, 45, 45, 46, 45/
      DATA (ABUN(4,I),I=1,5)/.99022,.00368,.00368,.00202,.00037/
      DATA (VIBQ(4,I),I=1,5)/588.768,575.5,585.32,584.1,586.3/
C
C     SET MOLECULAR PARAMETERS FOR CO
C
      DATA (MISO(5,I),I=1,7)/26,36,28,27,3*-1/
      DATA (MLWT(5,I),I=1,4)/28,29,30,29/
      DATA (ABUN(5,I),I=1,4)/.98652,.01107,.00202,.000369/
      DATA (VIBQ(5,I),I=1,4)/2143.2716,2096.0674,2092.1231,2116.2957/
C
C     SET MOLECULAR PARAMETERS FOR CH4 (211 AND 311) AND CH3D (212)
C
      DATA (MISO(6,I),I=1,7)/211,311,212,4*-1/
      DATA (MLWT(6,I),I=1,3)/ 16, 17, 17/
      DATA (ABUN(6,I),I=1,3)/.98515,.01110,.00060/
      DATA (VIBQ(6,I),I=1,3)/3*1370./
C
C     SET MOLECULAR PARAMETERS FOR O2
C
      DATA (MISO(7,I),I=1,7)/66,68,67,4*-1/
      DATA (MLWT(7,I),I=1,3)/32,34,33/
      DATA (ABUN(7,I),I=1,3)/.99519,.00407,.00074/
      DATA (VIBQ(7,I),I=1,3)/3*1556.3791/
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C
C     SET MOLECULAR PARAMETERS FOR NO  (MOLECULE # 8)
C
      DATA (MISO(8,I),I=1,7)/46,56,48,4*-1/
      DATA (MLWT(8,I),I=1,3)/30,31,32/
      DATA (ABUN(8,I),I=1,3)/.99390,.00369,.00203/
      DATA (VIBQ(8,I),I=1,3)/1875.9711,1842.9177,1827.2844/
C
C     SET DEGV, PROT, AND TEXP FOR ALL EIGHT MOLECULES
C
      DATA (DEGV(I),I=1,8)/1,2,1,2,1,5,1,1/
      DATA (PROT(I),I=1,8)/1.5,1.0,1.5,1.0,1.0,1.5,1.0,1.0/
      DATA (TEXP(I),I=1,8)/.5,.25,6*.5/
C
C     ***********************************************************************
C                           CO2 VIBRATIONAL LEVEL PARAMETERS
C
C
C     IDENTIFY CO2 ENERGY LEVELS USING AFGL NOTATION
C
      DATA (NAM2(I),I=1,29)/'00001','01101','10002','02201','10001',
     1                      '11102','03301','11101','00011','20003',
     2                      '12202','20002','04401','12201','20001',
     3                      '01111',
     4                      '10012','02211','10011',
     5                      '11112','03311','11111','00021',
     6                      '20013','12212',
     7                      '04411','20012','12211','20011'/
C
C     SET ENERGY LEVELS FOR THE 626 ISOTOPE
C
      DATA (ENL2(I,1),I=1,29)/0.,667.379, 1285.4087,1335.129, 1388.1847,
     1                1932.472, 2003.244, 2076.855, 2349.1433,2548.373,
     2                2585.032, 2671.146, 2671.716, 2760.735, 2797.140,
     3                3004.012,
     4                3612.842, 3659.271, 3714.783,
     5                4247.707, 4314.912, 4390.627, 4673.327,
     6                4853.629, 4887.982,
     7                4970.930, 4977.839, 5061.788, 5099.663/
C
C     SET ENERGY LEVELS FOR THE 636 ISOTOPE
C
      DATA (ENL2(I,2),I=1,29)/0.,648.479, 1265.8282,1297.268, 1370.0625,
     1                1896.547, 1946.343, 2037.093, 2283.4875,2507.50,
     2                2531.63,  2595.614, 2645.086, 2700.25,  2750.48,
     3                2920.239,
     4                3527.7376,3557.316, 3632.9096,
     5                4147.239, 4194.704, 4287.70,  4543.549,
     6                4748.062, 4770.987,
     7                4831.99,  4887.387, 4938.802, 4991.346/
C
C     SET ENERGY LEVELS FOR THE 628 ISOTOPE
C
      DATA (ENL2(I,3),I=1,29)/0.,662.3743,1259.426, 1325.15,  1365.844,
     1                1901.748, 1988.328, 2049.346, 2332.1127,2500.776,
     2                2549.425, 2614.235, 2651.875, 2728.264, 2757.229,
     3                2982.106,
     4                3571.143, 3632.52,  2675.13,
     5                4201.19,  4283.35,  4346.13,  4639.502,
     6                4791.26,  4836.63,
```

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     7                 4904.846, 4934.565, 5012.55,  5042.584/
C
C     SET ENERGY LEVELS FOR THE 627 ISOTOPE
C
      DATA (ENL2(I,4),I=1,29)/0.,664.73,  1271.875, 1329.87,  1376.03,
     1                 1916.31,  1995.36,  2062.41,  2340.0136,2523.58,
     2                 2566.33,  2641.26,     0.0,   2743.68,  2776.00,
     3                 2992.31,
     4                 3590.86,  3645.02,  3693.64,
     5                 4223.33,     0.0,   4367.08,  4655.205,
     6                 4821.515,    0.0,
     7                    0.0,   4939.35,     0.0,   5075.344/
C
C     SET ENERGY LEVELS FOR THE 638, 637, AND 828 ISOTOPES
C
      DATA (ENL2(I,5),I=1,29)/0.,643.23,  1244.93,  1286.86,  1342.37,
     1                   3*0.0,  2265.973, 20*0.0/
      DATA (ENL2(I,6),I=1,29)/0.,645.744, 1254.83, 1291.80,  1355.52,
     1                   3*0.0,  2274.33,  20*0.0/
      DATA (ENL2(I,7),I=1,29)/0.,657.33, 1230.33, 1315.08, 1347.097,
     1                   3*0.0,  2314.052, 20*0.0/
C
C     SET THE STATISTICAL WEIGHTS OF THE 29 CO2 LEVELS
C
      DATA (STW2(I),I=1,29)/ 1, 2, 1, 2, 1,
     1                       2, 2, 2, 1, 1,
     2                       2, 1, 2, 2, 1,
     3                       2,
     4                       1, 2, 1,
     5                       2, 2, 2, 1,
     6                       1, 2,
     7                       2, 1, 2, 1/
C
C     *********************************************************************
C                           NO VIBRATIONAL LEVEL PARAMETERS
C
C
C     IDENTIFY THE NO VIBRATIONAL LEVELS
C
      DATA (NAM8(I),I=1,13)/'0','1','2','3','4','5','6','7','8','9',
     1                      '10','11','12'/
C
C     SET ENERGY LEVELS FOR THE 46,56, AND 48 ISOTOPES
C
      DATA (ENL8(I,1),I=1,13)/0.0,1875.9711,3723.8526, 5543.6909,
     1                        7335.5312,9099.4078,10835.3427,6*0.0/
      DATA (ENL8(I,2),I=1,13)/0.0,1842.9177,11*0.0/
      DATA (ENL8(I,3),I=1,13)/0.0,1827.2844,11*0.0/
C
C     SET THE STATISTICAL WEIGHTS OF THE NO LEVELS
C
      DATA (STW8(I),I=1,13)/13*1/
C
C     *********************************************************************
C
C
      END
```

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      BLOCK DATA PRESS
C
C     ATMOSPHERIC PRESSURE, IN ATMOSPHERES, AT ALTITUDES BETWEEN 0 AND 191
C     IN 1-KM INTERVALS. DATA ARE FROM US STANDARD ATMOSPHERE, 1976.
C
      DIMENSION PR(192)
      COMMON/P/PR
C
C     ALTITUDES 0-95 KM IN THE FIRST HALF OF THE ARRAY
C
      DATA (PR(I),I=1,96)/
     1.10000E+01,.88700E+00,.78461E+00,.69204E+00,.60854E+00,.53341E+00,
     2.46600E+00,.40567E+00,.35185E+00,.30397E+00,.26153E+00,.22403E+00,
     3.19145E+00,.16362E+00,.13985E+00,.11953E+00,.10217E+00,.87340E-01,
     4.74663E-01,.63829E-01,.54570E-01,.46671E-01,.39945E-01,.34215E-01,
     5.29328E-01,.25158E-01,.21597E-01,.18553E-01,.15950E-01,.13727E-01,
     6.11813E-01,.10177E-01,.87743E-02,.75727E-02,.65473E-02,.56708E-02,
     7.49200E-02,.42758E-02,.37220E-02,.32452E-02,.28338E-02,.24803E-02,
     8.21709E-02,.19056E-02,.16728E-02,.14725E-02,.12962E-02,.11439E-02,
     9.10095E-02,.89153E-03,.78735E-03,.69530E-03,.61401E-03,.54121E-03,
     A.47705E-03,.41941E-03,.36873E-03,.32331E-03,.28348E-03,.24786E-03,
     B.21671E-03,.18892E-03,.16470E-03,.14314E-03,.12441E-03,.10778E-03,
     C.93372E-04,.80619E-04,.69607E-04,.59888E-04,.51526E-04,.44168E-04,
     D.37861E-04,.32350E-04,.27642E-04,.23552E-04,.20067E-04,.17762E-04,
     E.15721E-04,.12779E-04,.10387E-04,.87689E-05,.74028E-05,.62288E-05,
     F.52410E-05,.43947E-05,.36850E-05,.30852E-05,.25831E-05,.21634E-05,
     G.18119E-05,.15181E-05,.12719E-05,.10662E-05,.89375E-06,.74997E-06/
C
C     ALTITUDES 96-190 KM IN THE SECOND HALF OF THE ARRAY
C
      DATA (PR(I),I=97,192)/
     H.62932E-06,.52900E-06,.44468E-06,.37482E-06,.31593E-06,.26863E-06,
     I.22841E-06,.19508E-06,.16661E-06,.14310E-06,.12291E-06,.10632E-06,
     J.91970E-07,.80301E-07,.70113E-07,.61997E-07,.54821E-07,.49053E-07,
     K.43892E-07,.39661E-07,.35837E-07,.32652E-07,.29750E-07,.27299E-07,
     L.25050E-07,.23127E-07,.21352E-07,.19816E-07,.18391E-07,.17145E-07,
     M.15983E-07,.14957E-07,.13997E-07,.13143E-07,.12341E-07,.11623E-07,
     N.10947E-07,.10337E-07,.97614E-08,.92397E-08,.87459E-08,.82962E-08,
     O.78696E-08,.74795E-08,.71087E-08,.67682E-08,.64440E-08,.61453E-08,
     P.58604E-08,.55970E-08,.53454E-08,.51121E-08,.48890E-08,.46815E-08,
     R.44828E-08,.43063E-08,.41367E-08,.39738E-08,.38173E-08,.36670E-08,
     S.35[illegible]26E-08,.33839E-08,.32507E-08,.31227E-08,.29997E-08,.28937E-08,
     T.27914E-08,.26928E-08,.25976E-08,.25058E-08,.24173E-08,.23319E-08,
     U.22495E-08,.21700E-08,.20933E-08,.20257E-08,.19602E-08,.18969E-08,
     V.18356E-08,.17762E-08,.17188E-08,.16633E-08,.16095E-08,.15575E-08,
     X.15072E-08,.14620E-08,.14182E-08,.13757E-08,.13345E-08,.12945E-08,
     Y.12557E-08,.12181E-08,.11816E-08,.11451E-08,.11118E-08,.10797E-08/
C
      END
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