

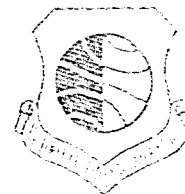
AD A058643

WUG FILE 0011

LEVEL

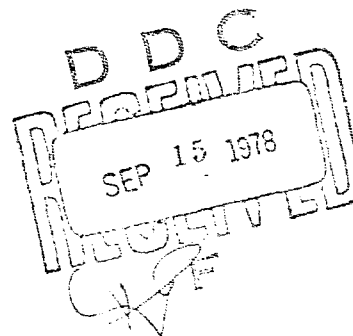
12

AFGL-TR-78-0053
ENVIRONMENTAL RESEARCH PAPERS, NO. 626



Atmospheric Transmittance/Radiance: Computer Code LOWTRAN 4

J. E. A. SELBY
F. X. KNEIZYS
J. H. CHETWYND, JR.
R. A. McCLATCHEY

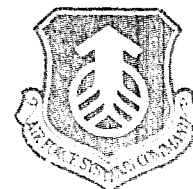


28 February 1978

Approved for public release; distribution unlimited.

OPTICAL PHYSICS DIVISION PROJECT 7670
AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS 01731

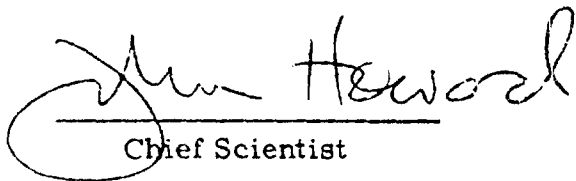
AIR FORCE SYSTEMS COMMAND, USAF



This report has been reviewed by the ESD Information Office (OI) and is releasable to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER


Chief Scientist

Qualified requestors may obtain additional copies from the Defense Documentation Center. All others should apply to the National Technical Information Service.

9
Environmental
Research papers

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER	2. SECURITY CLASSIFICATION	3. REPORT TYPE	4. REPORT'S CATALOG NUMBER
AFGL-TR-78-0053, AFGL-ERP-626			
5. TITLE (and Subtitle)	6. TYPE OF REPORT & PERIOD COVERED		
ATMOSPHERIC TRANSMITTANCE/RADIANCE: COMPUTER CODE LOWTRAN 4.	Scientific, Interim.		
7. AUTHOR	8. PERFORMING ORG. REPORT NUMBER		
J. E. A. Selby, R. A. McClatchey F. N. Kneizys J. H. Chetwynd, Jr.	ERP No. 626		
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AND WORK UNIT NUMBERS		
Air Force Geophysics Laboratory (OPD) Hanscom AFB, Massachusetts 01731	62101F 76700905		
11. CONTROLLING OFFICE NAME AND ADDRESS	12. DATE OF REPORT		
Air Force Geophysics Laboratory (OPD) Hanscom AFB, Massachusetts 01731	28 Feb 1978		
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	13. NUMBER OF PAGES		
	100		
15. SECURITY CLASS. (of this report)		16. DECLASSIFICATION DOWNGRADING SCHEDULE	
Unclassified			
17. DISTRIBUTION STATEMENT (of this Report)			
Approved for public release; distribution unlimited.			
18. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)			
19. SUPPLEMENTARY NOTES			
* Present address Grumman Aerospace Corporation			
20. KEY WORDS (Continue on reverse side if necessary and identify by block number)			
Atmospheric transmittance Atmospheric optics Atmospheric radiance Radiative transfer Infrared Attenuation Visible micrometers			
21. ABSTRACT (Continue on reverse side if necessary and identify by block number)			
This report describes a computer code for predicting atmospheric transmittance and the thermal radiation emitted by the atmosphere and earth in the wavelength range from 0.25 to 28.5 μm at a spectral resolution of 20 cm^{-1} . The program is based on the LOWTRAN 3B (1976) computer code and includes the same data package. The effect of aerosol radiance and nitric acid (HNO_3) transmittance and radiance is included. The computer code also contains six standard (geographical and seasonal) atmospheric models and four standard aerosol models with an option to replace either with non-standard or			

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 63 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

438 578

400

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

20. (Cont)

measured values. The program can be run in one of two modes, namely, to compute only atmospheric transmittance (as LOWTRAN 3B) or radiance and atmospheric transmittance for any given path geometry.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

ADDITIONAL FOR
 Write Section ☒
 Edit Section ☐
 DISCONTINUITY CODES
 SPECIAL
 A

Contents

1. INTRODUCTION	7
2. ATMOSPHERIC RADIANCE	9
3. MODIFICATION OF TRANSMITTANCE FUNCTION	11
4. NITRIC ACID	12
5. PROGRAM MODIFICATION	13
6. INSTRUCTIONS FOR USING LOWTRAN 4	14
6.1 Input Data and Formats	14
6.2 Basic Instructions	14
6.3 Non-Standard Conditions	19
7. EXAMPLE OF PROGRAM USE	21
7.1 Problem	21
7.2 Output from LOWTRAN 4	22
8. EXAMPLES OF RADIANCE SPECTRA	27
9. COMPARISONS WITH MEASUREMENTS	32
10. COMMENTS	39
REFERENCES	41
APPENDIX A: Listing of Program and Data	43
APPENDIX B: Basic Flow Chart of LOWTRAN 4	87
APPENDIX C: Symbols and Definitions	93
APPENDIX D: LOWTRAN 3B (1976), ERRATA SHEET No. 2 (September 1977)	99

Illustrations

1. Upward and Downward Atmospheric Radiance through a Three-Layered Atmosphere	10
2. Volume Mixing Ratio of Atmospheric Nitric Acid as a Function of Altitude	13
3. Atmospheric Radiance for a Vertical Path to Space from Ground Level for Six Model Atmospheres (400 to 2000 cm^{-1})	28
4. Atmospheric Radiance for a Vertical Path to Space from Ground Level for Six Model Atmospheres (2000 to 3600 cm^{-1})	29
5. Atmospheric Radiance for a Vertical Path to Ground from Space for Six Model Atmospheres (400 to 2000 cm^{-1})	29
6. Atmospheric Radiance for a Vertical Path to Ground from Space for Six Model Atmospheres (2000 to 3600 cm^{-1})	30
7. Variation of Atmospheric Radiance With Altitude for Vertical Paths to Space and the 1962 U.S. Standard Atmosphere	30
8. Variation of Atmospheric Radiance With Altitude for Slant Paths to Space (Zenith Angle = 45°) and the 1962 U.S. Standard Atmosphere	31
9. Variation of Atmospheric Limb Radiance With Tangent Height for the 1962 U.S. Standard Atmosphere	31
10. Comparison Between LOWTRAN Prediction and University of Michigan Balloon Measurement of Atmospheric Radiance over Northern Nebraska	33
11. Comparison Between LOWTRAN Prediction and NIMBUS 3 Satellite Measurement of Atmospheric Radiance over the Gulf of Mexico	34
12. Comparison Between LOWTRAN Predictions and NIMBUS 4 Satellite Measurements of Atmospheric Radiance over the Sahara Desert, the Mediterranean, and the Antarctic	35
13. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 9.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	36
14. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 13.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	36
15. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 18.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	36
16. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 24.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	36
17. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 93° on 19 February 1975, and LOWTRAN Comparison	37
18. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 81° on 19 February 1975, and LOWTRAN Comparison	37
19. Sample Spectrum of Long Wavelength Region Observed at an Altitude of 9.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	37

Illustrations

20.	Sample Spectrum of Long Wavelength Region Observed at an Altitude of 20.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison	37
21.	Sample Spectrum of Long Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 93° on 19 February 1975, and LOWTRAN Comparison	38
22.	Sample Spectrum of Long Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 81° on 19 February 1975, and LOWTRAN Comparison	38
B1.	General Flow Chart for LOWTRAN 4	88
B2.	Flow Chart for Calculation of Equivalent Path Quantities	89
B3.	Flow Chart for Transmittance/Radiance Loop	90
B4.	Flow Chart for Transmittance Calculations	91

Tables

1.	Typical Output of LOWTRAN 4	23
A1.	Listing of Fortran Code LOWTRAN 4	45
A2.	Listing of Data for LOWTRAN 4	75

Atmospheric Transmittance/Radiance: Computer Code LOWTRAN 4

1. INTRODUCTION

This report describes the development of a Fortran computer code LOWTRAN 4 designed to calculate atmospheric radiance and/or transmittance for a given atmospheric path at moderate spectral resolution. The present code is based on the current LOWTRAN atmospheric transmittance code, LOWTRAN 3B¹ (and its predecessors LOWTRAN 3,² LOWTRAN 2,³ LOWTRAN 1⁴). All the capabilities of the LOWTRAN transmittance codes have been preserved in the conversion of the computer code to atmospheric radiance calculations. The LOWTRAN 4 program will perform either atmospheric transmittance or radiance calculations. The mode of the calculation is determined by a single input control parameter.

(Received for publication 27 February 1978)

1. Selby J. E. A., Shettle, E. P., and McClatchey, R. A. (1976) Atmospheric Transmittance from 0.25 to 28.5 μ m: Supplement LOWTRAN 3B AFGL-TR-76-0258.
2. Selby, J. E. A., and McClatchey, R. A. (1975) Atmospheric Transmittance from 0.25 to 28.5 μ m: Computer Code LOWTRAN 3, AFCRL-TR-75-0255.
3. Selby, J. E. A., and McClatchey, R. A. (1972) Atmospheric Transmittance from 0.25 to 28.5 μ m: Computer Code LOWTRAN 2, AFCRL-TR-72-0745.
4. Manley, O. P., Smith, H. J. P., Treve, Y. M., Carpenter, J. W., Degges, T. C., and Doan, L. R. (1971) OPTIR II, AFCRL-71-0528 (Vol. 2 & 3); (1973) OPTIR III, AFCRL-TR-73-0217 and 0491; and (1974) OPTIR IIIB, AFCRL-TR-74-0319.

Continuity with the LOWTRAN 3B transmittance code has been retained. Changes in the program required for radiance calculations have been minimized. Only two new subroutines have been added to the program. Although a new card sequencing has been established in the LOWTRAN 4 program, a comparison with the previous LOWTRAN 3B code has been provided (see Appendix A) to facilitate user conversion of this program to the radiance mode.

In this report, we will describe the changes made in the transmittance code. These include a discussion of the method used in the calculation of atmospheric radiance, the addition of HNO_3 as an atmospheric absorber, and the modification of the empirical transmittance functions for small absorber amounts. In addition, instructions for using LOWTRAN 4 are given in Section 6. A listing of the computer code and data is given in Appendix A (note data is the same as LOWTRAN 3B). A flow chart of the program is provided in Appendix B, and a definition of symbols in Appendix C. Sample output from the program is provided in Section 7. Examples of atmospheric radiance calculations from LOWTRAN 4 are presented in Section 8. Comparison with measurements are given in Section 9. Some comments on the program use are discussed in Section 10.

The latest errata sheet (September 1977) to the LOWTRAN 3B (1976) code has been reprinted in Appendix D. Users of the LOWTRAN 3B program should verify that the corrections listed in Appendix D have been made in their present codes and in the conversion of their codes to the radiance mode, as described in this report.

Users of the current LOWTRAN 3B transmittance code will find this report sufficient in itself for performing atmospheric radiance/transmittance calculations. For those unfamiliar with the LOWTRAN band model type calculations, more complete information is provided in the previous LOWTRAN¹⁻⁴ reports, as well as the Optical Properties of the Atmosphere Report.⁵

The computer code has been tested for atmospheric radiance calculations for various atmospheric paths. However, no attempt has been made at this time to optimize either the computer code or the execution time. If any discrepancies are encountered or problems occur in the use of the code, please notify F. X. Kneizys, AFGL/OPI, Hanscom AFB, MA 01731.

The LOWTRAN 4 card deck will be made available from the National Climatic Center, Federal Building, Asheville, NC 28801 for a charge of \$20.00. (Please address requests to Mr. R. Davis.)

5. McClatchey, R. A., Fenn, R. W., Selby, J. E. A., Volz, F. E., and Garing, J. S. (1972) Optical Properties of the Atmosphere (Third Edition) AFCRL-72-0497.

2. ATMOSPHERIC RADIANCE

The LOWTRAN 3B transmittance program has been modified to calculate atmospheric and earth radiance. A numerical evaluation of the integral form of the equation of radiative transfer has been added to the program. The emission from aerosols and the treatment of aerosol and molecular scattering were considered only in the zeroth order. Additional contributions to atmospheric emission from radiation scattered one or more times has been neglected. Local thermodynamic equilibrium was assumed in the atmosphere.

The average atmospheric radiance (over a 20-cm^{-1} interval) at the frequency, $\bar{\nu}$, along a given line-of-sight in terms of the LOWTRAN transmittance parameters is given by

$$I(\bar{\nu}) = \int_{\bar{\tau}_a^b}^1 d\bar{\tau}_a B(\bar{\nu}, T) \bar{\tau}_s + B(\bar{\nu}, T_b) \bar{\tau}_t^b \quad (1)$$

where the integral represents the atmospheric contribution and the second term is the contribution of the boundary, (for example, the surface of the earth or a cloud top) and

$\bar{\tau}_a$ = average transmittance due to absorption,

$\bar{\tau}_s$ = average transmittance due to scattering,

$\bar{\tau}_t = \bar{\tau}_a \bar{\tau}_s$ = average total transmittance,

$\bar{\tau}_a^b, \bar{\tau}_t^b$ = average total transmittances from the observer to boundary,

$B(\bar{\nu}, T)$ = average Planck (blackbody) function corresponding to the frequency $\bar{\nu}$ and the temperature T of an atmospheric layer,

T_b = temperature of the boundary.

The emissivity of the boundary is assumed to be unity.

The LOWTRAN band model approach used here assumes that since the blackbody function is a slowly varying function of frequency we can represent the average value of the radiance in terms of the average values of the transmittance and the blackbody function. $\bar{\tau}_a$, $\bar{\tau}_s$, and $\bar{\tau}_t$ vary from 1 to $\bar{\tau}_a^b$, $\bar{\tau}_s^b$, and $\bar{\tau}_t^b$ along the observers line-of-sight. For lines of sight which do not intersect the earth or a cloud layer, the second term in Eq. (1) is omitted.

The numerical analogue to Eq. (1) has been incorporated into the LOWTRAN 4 computer program. The numerical integration of the radiance along a line-of-sight for a given model atmosphere defined at N levels is given by

$$I(\bar{\nu}) = \sum_{i=1}^{N-1} (\bar{\tau}_a(i) - \bar{\tau}_a(i+1)) B\left(\bar{\nu}, \frac{T(i)+T(i+1)}{2}\right) \left(\frac{\bar{\tau}_s(i) + \bar{\tau}_s(i+1)}{2} \right) + B(\bar{\nu}, T_b) \bar{\tau}_t^b \quad (2)$$

Thus, the spectral radiance from a given atmospheric slant path (line-of-sight) can be calculated by dividing the atmosphere into a series of isothermal layers and summing the radiance contributions from each of the layers along the line-of-sight, that is, numerically evaluating Eq. (1). This can be clearly seen from the following simple example.

Neglecting scattering, consider a three-layered atmosphere characterized by temperatures T_1 , T_2 , and T_3 as shown in Figure 1. Let $\bar{\tau}_1$, $\bar{\tau}_2$, and $\bar{\tau}_3$ be the transmittances from the ground to the boundaries of each of the layers respectively (see Figure 1a). Figure 1b shows the corresponding case for an observer in space (distinguished by primed $\bar{\tau}$ values).

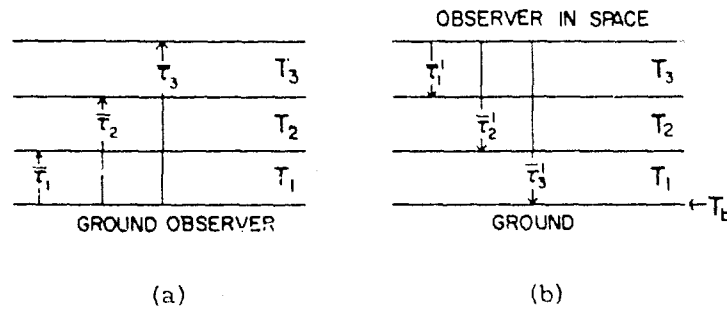


Figure 1. Upward and Downward Atmospheric Radiance Through a Three-Layered Atmosphere

Then from Eq. (2) the total downward spectral radiance for an observer on the ground (looking upwards) is given by

$$I(\bar{\nu}) \downarrow = (1 - \bar{\tau}_1) B(\bar{\nu}, T_1) + (\bar{\tau}_1 - \bar{\tau}_2) B(\bar{\nu}, T_2) + (\bar{\tau}_2 - \bar{\tau}_3) B(\bar{\nu}, T_3) . \quad (3)$$

Similarly for an observer looking down from the top of the atmosphere (see Figure 1b), the total upward spectral radiance is given by

$$I(\bar{\nu}) \uparrow = (1 - \bar{\tau}'_1) B(\bar{\nu}, T_3) + (\bar{\tau}'_1 - \bar{\tau}'_2) B(\bar{\nu}, T_2) + (\bar{\tau}'_2 - \bar{\tau}'_3) B(\bar{\nu}, T_1) + \bar{\tau}'_3 B(\bar{\nu}, T_b) . \quad (4)$$

A comparison of Eqs. (3) and (4) shows that in addition to the boundary contributions to the total upward spectral radiance, the total downward and the total

upward spectral radiances from the same atmospheric layers are not the same but depend on the position of the observer relative to a given atmospheric slant path. In the LOWTRAN 4 radiance program, the position of the observer is always defined by the input parameter, H1 (see Section 6).

3. MODIFICATION OF TRANSMITTANCE FUNCTION

In the LOWTRAN 3/3B transmittance model,^{1,2} the average transmittance $\bar{\tau}$ over a 20-cm^{-1} interval (due to molecular absorption) is represented by a single parameter model of the form

$$\bar{\tau} = f(C_\nu \omega^*) \quad (5)$$

where C_ν is a wavelength (or wavenumber) dependent absorption coefficient and ω^* is an "equivalent absorber amount" for the atmospheric path, which is defined in terms of the pressure $P(z)$, temperature $T(z)$, concentration of absorber ΔL , and an empirical constant n as follows

$$\omega^* = \Delta L \left\{ \frac{P(z)}{P_0} \sqrt{\frac{T_0}{T(z)}} \right\}^n \quad (6)$$

If Eq. (6) is substituted in Eq. (5) and n is set to zero and unity, respectively, Eq. (5) reverts to the well known weak line and strong line approximations common to most band models.

The form of the function f and parameter n was determined empirically using both laboratory transmittance data and available molecular line constants. In both cases, the transmittance was degraded in resolution to 20 cm^{-1} throughout the entire spectral range covered here. It was found that the functions f for H_2O and the combined contributions of the uniformly mixed gases were essentially identical, although the parameter n differed in the two cases. Mean values of n were determined to be 0.9 for H_2O , 0.75 for the uniformly mixed gases, and 0.4 for ozone. For sufficiently small values of the argument $C_\nu \omega^*$, the transmittance in LOWTRAN 3B and earlier models was set to unity.

Since the LOWTRAN 4 program now calculates radiance as well as transmittance, the transmittance functions, f , were modified for radiance calculations from atmospheric layers of small optical thickness. For cases where $(0.999 \leq \bar{\tau} \leq 1)$ the transmittance functions now have the analytic form

$$\bar{\tau} = 1 - a(C_\nu \omega^*)^b \quad (7)$$

with $a = 0.088$ and $b = 0.81$ for H_2O and the uniformly mixed gases and $a = 0.055$ and $b = 1.03$ for ozone. This pseudo-linear approximation in Eq. (7) is used in the computer program for transmittances between 0.999 and 1.

The parameters a and b were determined from a least squares fit of the empirically derived transmittance function in Eq. (5).

4. NITRIC ACID

Measurements made from balloon flights⁶ have shown the existence of nitric acid in the earth's atmosphere. Although nitric acid is of only minor importance in atmospheric transmittance calculations, it has been shown to be a significant source of stratospheric emission, particularly in the atmospheric window region from 10 to 12 μm . Therefore, nitric acid has been added to the LOWTRAN program as a separate atmospheric absorber.

The transmittance due to HNO_3 has been assumed to lie in the weak line or linear region. Absorption coefficients digitized at 5 cm^{-1} intervals for the 5.9 μm , 7.5 μm , and 11.3 μm bands of HNO_3 have been incorporated into the LOWTRAN program as a subroutine (SUBROUTINE HNO3). These coefficients were obtained by Goldman, Kyle, and Bonomo⁷ by fitting their experimental results with the statistical band model approximation.

The concentration of atmospheric nitric acid varies with altitude and also appears to depend on latitude and season. Figure 2 shows the volume mixing ratio profile of atmospheric nitric acid as a function of altitude from the measurements of Evans, Kerr, and Wardle.⁸ For the purpose of this report, we have chosen this profile to represent a mean nitric acid profile in the LOWTRAN program. This profile appears in a data statement in the main program. If a more definitive nitric acid profile for a given latitude and season is available, the user can change the nitric acid concentration by simply replacing the data statement given in the main program.

The inclusion of nitric acid as an additional absorber will modify somewhat transmittances from those calculated with the LOWTRAN 3B (1976) code in the spectral regions described above. Differences in transmittance values will only be significant for long atmospheric limb paths passing through the peak of the nitric acid profile.

6. Murray, D.G., Kyle, T.G., Murray, F.H., and Williams, W.G. (1968) Nitric acid and nitric oxide in the lower stratosphere. Nature 218:79.

7. Goldman, A., Kyle, T.G., and Bonomo, F.W. (1974) Statistical band model parameters and integrated intensities for the 5.9- μ , 7.5- μ , and 11.3- μ bands of HNO_3 vapor. Appl. Opt. 13:65.

8. Evans, W.F., Kerr, J.B., and Wardle, D.L. (1975) The AES Stratospheric Balloon Measurements Project: Preliminary Results. Atmospheric Environment Service, Downsview, Ontario, Canada, Report No. APRB 30 X 4.

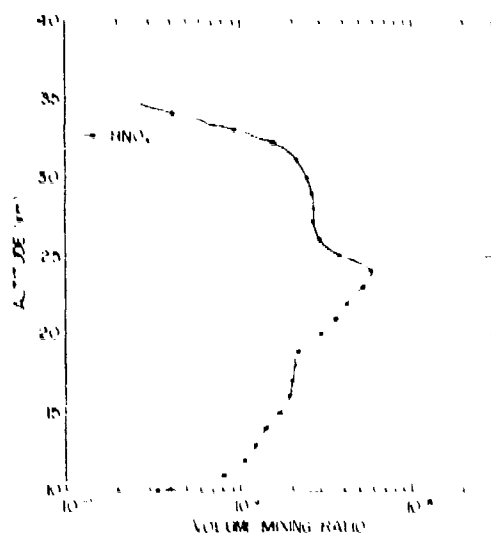


Figure 2. Volume Mixing Ratio of Atmospheric Nitric Acid as a Function of Altitude. See Reference 8

5. PROGRAM MODIFICATION

Program changes to the LOWTRAN 3/3B transmittance codes necessary for the conversion to a transmittance/radiance code were made in such a way as to preserve the logical flow in the original programs. Appendix A contains a listing of the FORTRAN computer code, LOWTRAN 4 together with the four subroutines, POINT, ANGLE, HNO3, and PATH. Although a new sequencing has been made in the code, the last column in the listing of Appendix A indicates the correspondence with the LOWTRAN 3B code. Changes in the code are indicated by the word, NEW, in the last column.

Two new subroutines have been added in the LOWTRAN 4 code. Subroutine PATH determines the cumulative absorber amounts through each of the layers intersected by the required atmospheric slant path. The amounts are stored in the matrix, WPATH, for each of the absorbing species. Subroutine HNO3 is called to find the nitric acid absorption coefficients as a function of frequency.

In the present program, a sample profile for the HNO_3 volume mixing ratio is provided in the data statement in the main program (DATA HMIN(1, . . . , 1)). The altitudes of the mixing ratios correspond to those for the model atmosphere altitudes.

Only two new control parameters (HEAUX, TBOUND) have been added to the program. These parameters, included on the first control card, will be fully explained in the instructions given in Section 6.

6. INSTRUCTIONS FOR USING LOWTRAN 4

The instructions for using LOWTRAN 4, with the exception of a change in a single control card, are essentially the same as those for the LOWTRAN 3, 3B transmittance codes. In an attempt to make the instructions as clear as possible and to provide sufficient information for utilization of the computer code in this report, Section 5 of the LOWTRAN 3² report has been repeated here in its entirety. Changes in the instructions required for radiance calculations are indicated by bars in the margins.

The input data for LOWTRAN 4 are given in Appendix A. In general, it is only necessary to change the last four cards (referred to here as No's. 1-4) in order to run the program for a given problem. The formats for the last four cards and their application will be discussed.

6.1 Input Data and Formats

The data necessary to specify a given problem are given on the last four cards as follows:

CARD 1	MODEL, HHAZE, ITYPE, LEN, JP, IM, M1, M2, M3, ML, EMISS, RO, TBOUND	FORMAT (11I3, 2F10.3)
CARD 2	H1, H2, ANGLE, RANGE, BETA, VIS	FORMAT (6F10.3)
CARD 3	V1, V2, DV	FORMAT (3F10.3)
CARD 4	IXY	FORMAT (I3)

Definitions of the above quantities will be discussed in Section 6.2.

If the quantity MODEL given in CARD 1 is set equal to 0 or 7 (which is the case if meteorological data are used input to the program), then the above card sequence (and format for CARD 2) is changed. These cases will be described in Section 6.3.

6.2 Basic Instructions

The various quantities to be specified on each of the four control cards (summarized in Section 6.1) will be discussed in this section.

CARD 1 MODEL, HAZE, ITYPE, LEN, JP, IM, M1, M2, M3, MI, IFMISS, RO, TROUND
--

The parameter MODEL selects one of the six geographical model atmospheres or specifies that meteorological data are to be used in place of the standard models. HAZE specifies whether aerosol attenuation is to be included in the calculation or not. For any problem the atmospheric path must be specified as one of three types according to ITYPE and LEN. IFMISS and TROUND are new control parameters for radiance calculations. The rest of the quantities given on CARD 1 (which can be left blank if not required) provide the user with options to suppress printing (JP), to intermix the six standard model atmospheres (M1, M2, M3) and to input a new model atmosphere (IM, MI). The options for the above parameters and their uses are stated and described in detail below:

MODEL = 0 if meteorological data are specified (for horizontal paths only).

= 1 selects TROPICAL MODEL ATMOSPHERE,

= 2 selects MIDLATITUDE SUMMER,

= 3 selects MIDLATITUDE WINTER,

= 4 selects SUBARCTIC SUMMER,

= 5 selects SUBARCTIC WINTER,

= 6 selects 1962 U.S. STANDARD

= 7 if a new model atmosphere (or radiosonde data) is to be inserted,

HAZE = 0 means no aerosol attenuation included in the calculations,

HAZE = 1 or 2 if aerosol attenuation is required (see also CARD 2),

If HAZE is set equal to 1 or 2 and visual range (VR) is not specified on CARD 2, then the program will automatically select visual ranges of 23 km or 5 km respectively,

HAZE = 7 Read other aerosol model into the program,

ITYPE = 1 for a horizontal (constant pressure) path,

= 2 for a vertical or slant path between two altitudes,

= 3 for a vertical or slant path to space,

† In these cases the format for Card 2 changes (see nonstandard conditions) Section 6.3,

The TYPE 1 path should not be confused with a long 90° path where the local height of the end of the trajectory is at a significantly different height. In such a case, specify the path according to ITYPE = 2.

LEN = 0 for normal operation of program.

LEN = 1 selects the downward TYPE 2 LONG path.

The parameter LEN can be ignored (that is, left blank) for the majority of cases. It need only be used for a downward looking path ($H_2 < H_1$) when two paths are possible for the same input parameters. In such a case, a computer printout statement will be given indicating that the user has two choices for the problem and that the shorter path has been executed. Set LEN = 1 for the longer case.

JP = 0 for normal operation of program

JP = 1 to suppress printing of transmittance table/or radiance table

IM = 1 when radiosonde data are to be read in initially

IM = 0 for normal operation of program or when subsequent calculations are to be run with MODEL = 7

ML = Number of levels to be read in for MODEL = 7

Note that IM and ML are only used when MODEL = 7 and then only on the first calculations when the data are read in.

M1 = M2 = M3 = 0 for normal operation of program.

The parameters M1, M2, and M3 can each take integral values between 0 and 6 and are used to modify or supplement the altitude profiles of temperature, water vapor, and ozone respectively, for any given atmospheric model specified by MODEL.

For example:

M1 = 1 selects the TROPICAL temperature altitude profile

M1 = 2 selects the MIDLATITUDE SUMMER temperature altitude profile

M1 = 6 selects the 1962 U.S. STANDARD temperature altitude profile

M2 = 1 selects the TROPICAL water vapor altitude profile

M2 = 2 selects the MIDLATITUDE SUMMER water vapor altitude profile

M2 = 6 selects the 1962 U.S. STANDARD water vapor altitude profile

M3 = 1 selects the TROPICAL ozone altitude profile

M3 = 2 selects the MIDLATITUDE SUMMER ozone altitude profile

M3 = 6 selects the 1962 U.S. STANDARD ozone altitude profile.

The control parameter, IEMISS, determines the mode of execution of the program.

IEMISS = 0 for program execution in transmittance mode

IEMISS = 1 for program execution in radiance mode.

A message is printed to the user on the output file indicating the mode of program execution.

RO = radius of the earth (km) at the particular geographical location at which the calculation is to be performed.

If RO is left blank, the program will use the midlatitude value of 6371.23 km if MODEL is set equal to 0 or 7. Otherwise the earth radius for the appropriate standard model atmosphere (specified by MODEL) will be used.

TBOUND = temperature of the earth ($^{\circ}$ K) at the location at which the calculation is to be performed.

TBOUND is only used in the radiance mode of the program for slant paths which intersect the earth. If TBOUND is left blank, the program will use the temperature of the first atmospheric layer as the boundary temperature.

In the case where MODEL = 7, the new atmosphere (model or radiosonde data) is inserted between CARDS 1 and 2 (see Section 6.3).

CARD 2: H1, H2, ANGLE, RANGE, BETA, VIS

CARD 2 is used to define the geometrical path parameters for a given problem.

H1 = initial altitude (km)

H2 = final altitude (km)

It is important to emphasize here that in the radiance mode of program execution (FEMISS = 1), H1, the initial altitude, always defines the position of the observer (or sensor). H1 and H2 cannot be used interchangeably as in the transmittance mode.

ANGLE = initial zenith angle (degrees) as measured from H1

RANGE = path length (km)

BETA = earth center angle subtended by H1 and H2 (degrees)

VIS = sea level visual range (km).

It is not necessary to specify every quantity given above; only those that adequately describe the problem according to the parameter ITYPE (as described below):

(1) Horizontal Paths (ITYPE = 1)

(a) specify H1, RANGE and VIS only

(b) If nonstandard meteorological data are to be used, that is, if

MODEL = 0 on CARD 1, then the following parameters must be specified on CARD 2: H1, P, T, DP, RH, WH, WO, VIS, RANGE according to FORMAT (3F10.3, 2F5.1, 2F10.3, 2F10.3), where P, T, DP, RH, WH, and WO are the pressure (mb), temperature ($^{\circ}$ C), dew point temperature ($^{\circ}$ C), relative humidity (%), H_2O density ($gm\ m^{-3}$) and ozone density ($gm\ m^{-3}$) respectively.

Note that it is necessary to specify all of the quantities underlined with a full line and one of the quantities underlined with a dashed line. If the ozone density (WO) is not known, a value can be chosen from one of the standard atmospheric models by using the parameter M3 on CARD 1.

(2) Slant Paths to Space (ITYPE = 3)
 (a) specify H1, ANGLE and VIS
 (b) specify H1, HMIN and VIS (for limb viewing problem where HMIN is the required tangent height or minimum altitude of the path trajectory.

(3) Slant Paths Between Two Altitudes (ITYPE = 2)

- (a) specify H1, H2, ANGLE and VIS
- (b) specify H1, ANGLE, RANGE and VIS
- (c) specify H1, H2, RANGE and VIS

For cases (b) and (c), the program will calculate H2 and ANGLE respectively, assuming no refraction; then proceed as for case (a). This method of defining the problem should be used when refraction effects are not important; for example, for ranges of a few tens of km at zenith angles less than 80°. It can also be used for larger angles (including 90°) provided that the path lies within one atmospheric layer.

(d) Specify H1, H2, BETA and VIS. Leave ANGLE and RANGE blank in this case. This method can be used when the geometrical configuration of the source and receiver is known accurately, but the initial zenith angle is not known precisely due to atmospheric refraction effects. Beta is most frequently determined by the user from ground range information.

In the cases of 2(b) and 3(d) above, the subroutine ANGLE is called in the program to determine the appropriate input zenith angle by an iterative technique taking into account atmospheric refraction.

In the case where MODEL = 7, the new model atmosphere (or radiosonde data) is inserted between CARDS 1 and 2.

CARD 3 V1, V2, DV

The spectral range over which transmittance data are required and the spectral increments at which the data are to be printed out is determined by CARD 3.

V1 = initial frequency in wavenumbers (cm^{-1})

V2 = final frequency in wavenumbers (cm^{-1}) where $V2 \geq V1$

DV = frequency increment (or step size) (cm^{-1})

(Note that $\nu = 10^4/\lambda$ where ν is the frequency in cm^{-1} and λ is the wavelength in microns, and that DV can only take values which are a multiple of 5.)

CARD 4 IXY

The control parameter IXY can cause the program to recycle, so that a series of problems can be run with one submission of LOWTRAN. Five values of IXY can be used to provide the options given on the following pages.

- IXY = 0 or blank card to end of program
- = 1 to select a new CARD 3 and CARD 4 only (assuming other parameters are unchanged)
- = 2 to select a new data sequence (CARDS 1, 2, 3, and 4)
- = 3 to select a new CARD 2 and CARD 4 only (assuming other parameters are unchanged)
- = 4 to select a new CARD 1 and CARD 4 only (assuming other parameters are unchanged)

Thus, if for the same model atmosphere and type of atmospheric path the reader wishes to make further transmittance calculations in different spectral intervals λ_1' to λ_2' etc. and for a different step size ($\Delta\lambda'$ etc.), then IXY is set equal to 1. In this case, the card sequence is as follows and can be repeated as many times as required,

```
CARD 4  IXY = 1
CARD 5   $\lambda_1'$   $\lambda_2'$   $\Delta\lambda'$ 
CARD 6  IXY = 1
CARD 7   $\lambda_1''$   $\lambda_2''$   $\Delta\lambda''$ 
CARD 8  IXY = 0
```

The final IXY card should always be a blank or zero. When using the IXY = 1 option, the wavelength dependence of the refractive index is not changed (use IXY = 2 option if this is required).

To make successive transmittance computations where just the geographical model atmosphere is changed and/or with or without aerosol attenuation, set IXY = 4 and construct a data card sequence along the same lines as given above. This sequence of recycling can be repeated successively.

When a series of problems is to be executed (with one submission of LOWTRAN) involving the standard atmospheric models (MODEL = 1 to 6) as well as cases involving MODEL = 0 and MODEL = 7, then the order in which the data are set up becomes very important. Note the following sequence.

1. Run all problems using MODEL = 1 through 6 first.
2. Secondly, run all problems involving the use of MODEL = 0.
3. Run all problems involving the use of MODEL = 7 last. The reason for running MODEL = 7 cases last is that when a new atmospheric model is read in, the altitudes may not correspond with those given in the standard models and the program will erase them. Similarly, if a MODEL = 0 case is run following a MODEL = 7 case, the first level of MODEL 7 is erased.

6.3 Non-Standard Conditions

Three options are available if atmospheric transmittance calculations are required for non-standard conditions. Here non-standard refers to conditions other

than those specified by the six model atmospheres provided by LOWTRAN, which are selected by the parameter MODEL on CARD 1. The three options enable the reader to insert:

(1) His own model atmosphere(s) in place of any (or all) of the six standard models, provided that the data are in exactly the same format and are specified at the same altitudes as the latter. In this case the appropriate print statements in LOWTRAN (that identify the atmospheric model used) must be changed correspondingly.

(2) An additional atmospheric model (MODEL = 7), which can be in the form of radiosonde data. The data need not be specified at the same altitudes as in the standard models.

(3) Meteorological conditions for a given horizontal path calculation (MODEL = 0 case).

The first of these options requires the most effort and needs no farther discussion here, other than a reference to Appendix A for a summary of the standard model atmosphere parameters, units, and formats.

ADDITIONAL ATMOSPHERIC MODEL (MODEL = 7)

New model atmospheres can be inserted between CARDS 1 and 2 provided the parameters MODEL and M1 are set equal to 7 and 1 respectively on CARD 1. The number of atmospheric levels to be inserted (M1) must also be specified on CARD 1. The appropriate meteorological parameters and format for the atmospheric data are given below.

Z, P, T, DP, RH, WH, WO, AHAZE [FORMAT (3F10,3, 2F5,1, 2F10,3, 2F10,3)] where

Z = altitude (km)

P = pressure (mb)

T = ambient temperature (°C)

DP = dew point temperature (°C)

RH = relative humidity (%)

WH = water vapor density (gm m^{-3})

WO = ozone density (gm m^{-3})

AHAZE = aerosol number density (cm^{-3})

Note that it is only necessary to specify those quantities underlined with a full line and either of the quantities underlined with the dashed line.

If the ozone density (WO) is not known then a value can be obtained from one of the standard atmospheric models (for the appropriate latitude and season) by using the parameter M3 on CARD 1.

If the aerosol number density was not measured as a function of altitude and the reader wishes to include aerosol attenuation in the calculation, set $HIACT = 1$ on CARD 1. In this case (as with the M1, M2, and M3 options) LOWTRAN will use the aerosol models already contained in the program and interpolate to give aerosol number density values at the same altitudes as the radiosonde (or new model atmosphere) data. The program will then look for a sea level visual range (VIS) to be specified on CARD 2. If VIS is not specified, a 23 km sea level visual range will be assumed. If aerosol attenuation is not required, set $HIACT = 0$ on CARD 1 as before.

HORIZONTAL PATHS (MODEL = 0)

If meteorological data are to be used for horizontal path atmospheric transmittance calculations, then set MODEL = 0 on CARD 1. The following parameters can then be specified on CARD 2:

CARD 2 H1, P, T, DP, RH, WH, WO, VIS, RANGE [FORMAT (3, F10, 3, 2F5, 1, 2F10, 3, 2F10, 3)] where the above parameters refer to altitude (km), pressure (mb), ambient temperature ($^{\circ}\text{C}$), dew point temperature ($^{\circ}\text{C}$), relative humidity (%), water vapor density (gm m^{-3}), ozone density (gm m^{-3}), visual range (km) and path length (km) respectively.

The format for the above card is similar to that for inputting radiosonde data (MODEL = 7). Again, it is only necessary to specify the quantities underlined with the solid line and one of the quantities underlined with the dashed line. The ozone density WO can be specified using the parameter M3 on CARD 1 if measurements are not available. In the latter case, a value will be calculated at altitude H1 based on the appropriate model atmosphere selected by M3.

7. EXAMPLE OF PROGRAM USE

7.1 Problem

Calculate the transmittance from 2350 to 2450 cm^{-1} in steps of 5 cm^{-1} for a slant path from 2.5 km to 8.5 km at a zenith angle of 65° , for a subarctic winter model atmosphere, and a 23 km visual range. Repeat the calculation for the same conditions executing the program in the radiance mode.

CARD 1 **5**1**2

CARD 2 *****2.50*****8.50*****65.0

CARD 3 *****2350.0*****2450.0*****5.0

CARD 4 **4

CARD 5 **5**1**2*****1(COLUMN 33)

CARD 6 BLANK

(* represents a space on the card)

7.2 Output from LOWTRAN 4

The output for this problem is given in Table 1. A message indicating the mode of execution of the program is printed as the first line of the output. For this problem, the first case will be executed in the transmittance mode.

The parameters defining the atmospheric path, model atmospheres and frequency range are next printed out. Following the heading HORIZONTAL PROFILES there are 13 columns. The first column gives a running integer associated with each level (level indicator). The second column gives the level altitude in km. The next 8 columns give the equivalent absorber amounts per km for the following absorbing species: water vapor, uniformly mixed gases, ozone, nitrogen, continuum, water vapor continuum (10 μm), molecular scattering, aerosol extinction¹ and UV ozone, respectively. The next three columns give the mean refractive index modulus from that level to the level above, the equivalent absorber amounts per km for the water vapor continuum (4 μm) and for nitric acid.

A heading VERTICAL PROFILES is then printed followed by 15 columns. The first and second columns give the integer associated with the levels traversed by the path and the height of the level. Then follow 8 columns which give the integrated equivalent absorber amounts from the initial altitude to the level above (in the same order as indicated above). The next 4 columns are labelled PSI, PHI, BETA, and THETA, and correspond to the angles similar to ψ , ϕ , β , and θ described in LOWTRAN 3.² Columns PSI and BETA give the accumulated values of ψ and β to the level above. Columns THETA and PHI give the local zenith angle θ_j corresponding to that level and the angle of arrival at the level above, respectively. The accumulated slant range is printed out in the last column under RANGE.

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

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

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

¹For all radiance calculations in this report, the average continental aerosol model was used.

Table 1. Typical Output of LOWTRAN 4

PROGRAM WILL BE EXECUTED IN THE TRANSMISSION MODE

S 1 2 0 0 2 0 0 0 1 0.000 0.000 0.000 0.000 0.000
 2.500 2.500 6.500 6.500 6.500 6.500 6.500 6.500 6.500 6.500
 H1= 2.500KM, H2= 6.500KM, ANGLE= 65.000GEOM, RANGE = 10.17KM, BETA= .11557, VIS= 6.0
 2350.030 2450.000 5.000

SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1 = 2.500 KM H2 = 6.500 KM, ZENITH ANGLE = 65.000 DEGREES

MODEL ATMOSPHERE S = SUB-APOTIC WINTER

HAZE MODEL 1 = 23 KM VISUAL RANGE

FREQUENCY RANGE V1= 2350.0 CM-1 TO V2= 2450.0 CM-1 FOR DV = 5.0 CM-1 (4.00 - 4.126 MICRONS)

HORIZONTAL PROFILES

1	0.0	1236.00	1095.01	1045.02	9745.00	6375.03	1035.01	1005.01	1915.12	2055.13	2915.11	0.
2	1.0	1095.00	9545.00	1835.02	6655.00	6345.03	9255.00	4835.00	1915.12	2055.13	2915.11	0.
3	2.0	7655.01	5685.00	1145.02	5205.00	4115.13	4195.00	1985.00	1915.12	2055.13	2915.11	0.
4	3.0	4925.01	5545.00	1745.02	4035.00	2425.03	4725.00	7985.01	2015.12	1975.03	1215.11	0.
5	4.0	2955.01	4485.00	1735.02	3145.00	1405.03	6465.00	4225.01	2115.12	1755.03	7055.12	0.
6	5.0	1155.01	3655.00	1725.02	2595.00	3805.04	5795.00	3335.01	2115.12	1575.03	3455.12	0.
7	6.0	5035.02	2995.00	1705.12	1955.00	1385.04	5155.00	2245.01	2245.02	1445.03	1725.12	0.
8	7.0	2465.02	2375.01	2345.02	1595.01	6015.05	4575.00	2485.01	2245.02	1245.03	1975.12	0.
9	8.0	4425.03	1895.00	2045.02	1145.00	1145.06	4465.00	2155.01	4215.12	1095.03	4445.15	0.
10	9.0	2995.03	1475.00	6495.02	8955.01	5335.06	3515.00	2065.01	7475.12	9355.04	1475.15	0.
11	10.0	1685.03	1125.00	6415.02	6435.01	2905.16	3015.00	2015.01	1145.12	8355.04	6255.15	0.
12	11.0	1015.03	8495.01	6285.02	4705.01	1585.06	2995.00	1345.01	1145.12	6645.04	2555.14	0.
13	12.0	5985.04	6455.01	1175.01	3455.01	9675.07	2175.00	1975.01	2015.12	2845.04	2845.14	0.
14	13.0	3805.04	6505.01	1175.01	2515.01	8545.07	1875.00	1475.01	2115.12	1505.04	1625.14	0.
15	14.0	1745.04	7735.01	1155.01	1145.01	7945.07	1695.00	1175.01	2215.12	1005.04	1625.14	0.
16	15.0	1155.04	2635.01	1135.01	1145.01	7145.07	1375.00	1175.01	2215.12	1005.04	1625.14	0.
17	16.0	8595.05	2165.01	1175.01	9945.02	2335.07	1175.00	1165.01	2215.12	1005.04	1625.14	0.
18	17.0	6585.05	1695.01	1105.01	7205.02	9205.08	1045.00	1985.01	2045.12	2045.04	2045.14	0.
19	18.0	4955.05	1255.01	1035.01	5215.02	7335.08	8645.01	1575.01	2045.12	2045.04	2045.14	0.
20	19.0	4215.05	9545.02	9415.02	3345.02	6345.08	7345.01	1245.01	2045.12	2045.04	2045.14	0.
21	20.0	3365.05	7265.02	8245.02	2345.02	4655.08	6345.01	9435.02	2045.12	2045.04	2045.14	0.
22	21.0	2305.05	5515.02	7055.02	2345.02	4655.08	5445.01	6445.02	2045.12	2045.04	2045.14	0.
23	22.0	2865.05	4195.02	6105.02	1515.02	3945.08	4645.01	5345.02	2045.12	2045.04	2045.14	0.
24	23.0	2635.05	3145.02	5245.02	1105.02	3525.08	3345.01	3345.02	2045.12	2045.04	2045.14	0.
25	24.0	2575.05	2415.02	4325.02	8915.03	3515.08	3175.01	3125.02	1645.12	1645.04	1645.14	0.
26	25.0	2455.05	1815.02	3435.02	5345.03	3485.08	2045.01	2045.02	1445.12	1445.04	1445.14	0.
27	26.0	2345.05	1345.02	2435.02	4445.03	3485.08	1275.01	7915.03	7045.12	7045.04	7045.14	0.
28	27.0	2245.05	1105.02	1525.02	3235.04	3485.08	5715.02	2045.03	4245.12	4245.04	4245.14	0.
29	28.0	2185.05	8785.04	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
30	29.0	2125.05	7615.05	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
31	30.0	2065.05	6465.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
32	31.0	2005.05	5315.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
33	32.0	1945.05	4165.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
34	33.0	1885.05	3015.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
35	34.0	1825.05	1865.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
36	35.0	1765.05	715.06	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
37	36.0	1705.05	6005.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
38	37.0	1645.05	4855.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
39	38.0	1585.05	3705.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
40	39.0	1525.05	2555.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
41	40.0	1465.05	1405.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
42	41.0	1405.05	225.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
43	42.0	1345.05	115.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
44	43.0	1285.05	5.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
45	44.0	1225.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
46	45.0	1165.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
47	46.0	1105.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
48	47.0	1045.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
49	48.0	985.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
50	49.0	925.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
51	50.0	865.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
52	51.0	805.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
53	52.0	745.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
54	53.0	685.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
55	54.0	625.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
56	55.0	565.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
57	56.0	505.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
58	57.0	445.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
59	58.0	385.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
60	59.0	325.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
61	60.0	265.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
62	61.0	205.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
63	62.0	145.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
64	63.0	85.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
65	64.0	25.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.
66	65.0	0.05	0.07	1115.03	4495.05	2305.10	2595.12	5485.04	1345.12	1345.04	1345.14	0.

FROM POINT1 HEIGHT= 2.5000 KM, H= 3.400, INDEX ABOVE & BELOW Y= .2150E-03, .2284E-07, I.D= 1
 EQUIV. ABSORBED AMOUNTS PER KM AT Y= .643E-01, .647E+03, .174E-02, .459E+02, .316E-03, .771E+00, .132E+03, .236E-12

FROM POINT1 HEIGHT= 6.5000 KM, H= 9.400, INDEX ABOVE & BELOW Y= .1046E-13, .1122E-03, I.D= 1
 EQUIV. ABSORBED AMOUNTS PER KM AT Y= .361E-03, .167E+00, .363E-02, .102E+00, .659E-06, .377E+00, .556E-12

THIS PAGE IS BEST QUALITY PRACTICABLE
 FROM COPY FURNISHED TO DDO

Table 1. Typical Output of OUTPUTAN 4 (Cont.)

EQUIVALENT SEA LEVEL ABSORBER AMOUNTS															
OPTICAL PROFILES		WATER VAPOR		CO2 ETC.		OZONE		NITROGEN (CONT)		MOL SCAT		AEROSOL		TOTAL	
	CM CM-2	PM	CM CM-2	PM	CM CM-2	PM	ATM CM	PM	CM CM-2	PM	CM CM-2	PM	CM CM-2	PM	
WATER	22.36E+00	4.94E+00			2.80E+00				7.85E+00	5.04E+00			2.87E+00	1.76E+00	
CO2															
O3															
N2															
PM															
WATER	4.5E+00	1.5E+00													
CO2	6.0E+00	2.0E+00													
O3	1.0E+00	0.3E+00													
N2	1.0E+00	0.3E+00													
PM	1.0E+00	0.3E+00													
WATER	1.0E+00	0.3E+00													
CO2	1.0E+00	0.3E+00													
O3	1.0E+00	0.3E+00													
N2	1.0E+00	0.3E+00													
PM	1.0E+00	0.3E+00													

1948-49 =

24

THIS PAGE IS BEST QUALITY PRACTICALLY
FROM COPY FURNISHED TO DDC

[illegible]

25

PROGRAM WILL BE EXECUTED IN THE EMISSION MODE

PROGRAM WILL BE EXECUTED IN THE EMISSION MODE

CLINT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1 = 2.500 KM H2 = 1.500 KM, ZENITH ANGLE = 65.600 DEGREES

031NIM 01204-BFS.- 5 393M450M1W 1300M

MAZP MODEL 1 = 27 KM VISUAL RANGE

FREQUENCY RANGE = 11.5 MHz TO 2150.0 MHz V2 = 255.0 CM-1 V3 = 5.0 CM-1 (4.0% - 4.2% MASS)

DATE FILED: 7/1/2002

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80																				

25000 MM Y = 2.500E+03
 INDEF A90/E 1 981.06 Y = .215E+03
 0284E-03 J3 ID = 1
 3 NP = 3 DEF
 EQUIV APPROX AMOUNT PER MM AT Y = 5135-03
 017F+03
 074E-03
 035E+03
 036E+03
 077E+03
 013E+03
 030E+03

[illegible]

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table 1. Typical Output of LOWTRAN 4 (Cont)

[illegible]
$$= 3.26 \text{ AVERAGE TRANSMITTANCE} = .3674$$

RAJPAK 2350.000 ,25963E-07
INTEGRATED ABSORPTION FROM 2350 TO 2450 CM-1 =
INTEGRATED RADIANCE = .12272E-05WATT CM -2 SP.

The second case is now executed for the same conditions in the radiance mode. The output of the program is identical to the transmittance mode up to and including the printing of the equivalent sea level absorber amounts.

Two parameters, J1 and J2, are then printed out. These parameters control the loading of the cumulative absorber amounts into the matrix, WPATH.

A heading CUMULATIVE ABSORBER AMOUNTS FOR THE ATMOSPHERIC PATH is then printed followed by 12 columns. The first column gives an integer associated with the layer traversal by the atmospheric slant path. The following 10 columns which give the cumulative absorber amounts for the following species: water vapor, uniformly mixed gases, ozone, nitrogen continuum, water vapor continuum (10 μm), molecular scattering, aerosol extinction, UV ozone, water vapor continuum (4 μm) and nitric acid. The last column is the average temperature of the layer.

A radiance table, containing six columns, now follows. The first two columns give the frequency (cm^{-1}) and the wavelength (μm). The next two columns give the radiance in units of $\text{W}/\text{cm}^2\text{-ster-cm}^{-1}$ and $\text{W}/\text{cm}^2\text{-ster-}\mu\text{m}$. The next column gives the cumulative integrated radiance ($\text{W}/\text{cm}^2\text{-ster}$). The last column is the total transmittance.

Finally the maximum and minimum radiances and their frequencies, the integrated absorption, the average transmittance, and the total integrated radiance are printed.

8. EXAMPLES OF RADIANCE SPECTRA

Some examples of radiance spectra obtained from LOWTRAN 4 are presented in Figures 3 through 9. Figures 3 and 4 show the atmospheric radiance as seen by an observer at the ground looking straight up to space (H1=0 km, zenith ANGLE=0°) for the six model atmospheres with a 23 km visual range. Figure 3 is for the spectral region from 400 to 2000 cm^{-1} and Figure 4 for the spectral region from 2000 to 3600 cm^{-1} .

Figures 5 and 6 show the atmospheric radiance as seen by an observer in space looking straight down to the ground (H1= 100 km, zenith ANGLE=180°) for the six model atmospheres with a 23 km visual range. The temperature of the ground for these plots is the appropriate boundary temperature of the first layer in the model atmosphere. Figure 5 is for the spectral region from 400 to 2000 cm^{-1} and Figure 6 for the spectral region from 2000 to 3600 cm^{-1} .

Figures 7 through 9 show atmospheric radiance spectra from 400 to 4000 cm^{-1} calculated using the U.S. Standard Atmosphere, 1962, with a 23 km visual range for three different types of atmospheric paths. Figure 7 shows the zenith radiance for an observer at altitudes of 0, 20, and 40 km. Figure 8 shows the atmospheric

radiance at a zenith angle of 45° as seen by an observer at altitudes of 0, 20, and 40 km. Figure 3 shows the comparisons of the limb radiance as seen from space for tangent heights of 0, 20, and 40 km.

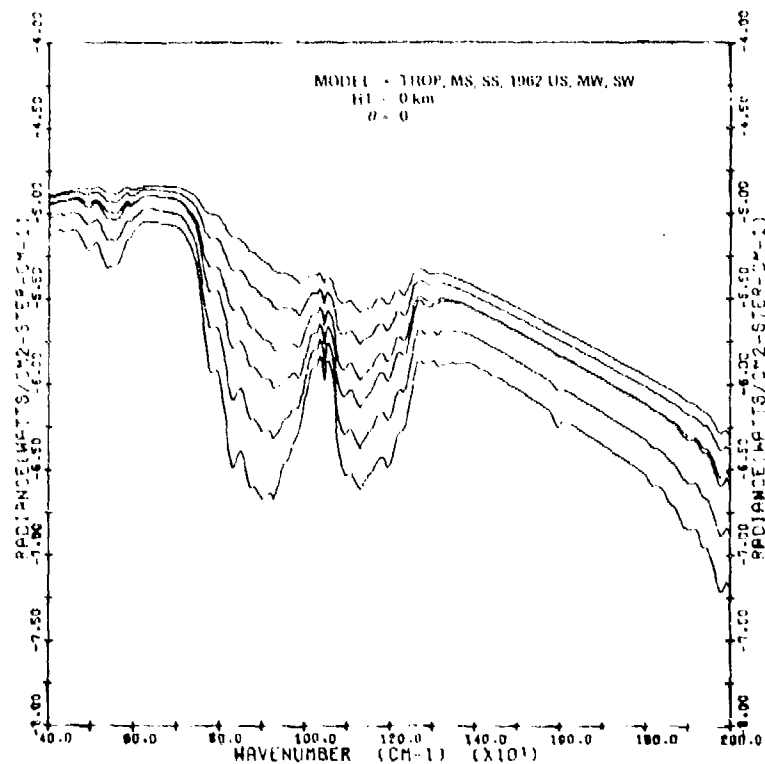


Figure 3. Atmospheric Radiance for a Vertical Path to Space from Ground Level for Six Model Atmospheres (400 to 2000 cm^{-1})

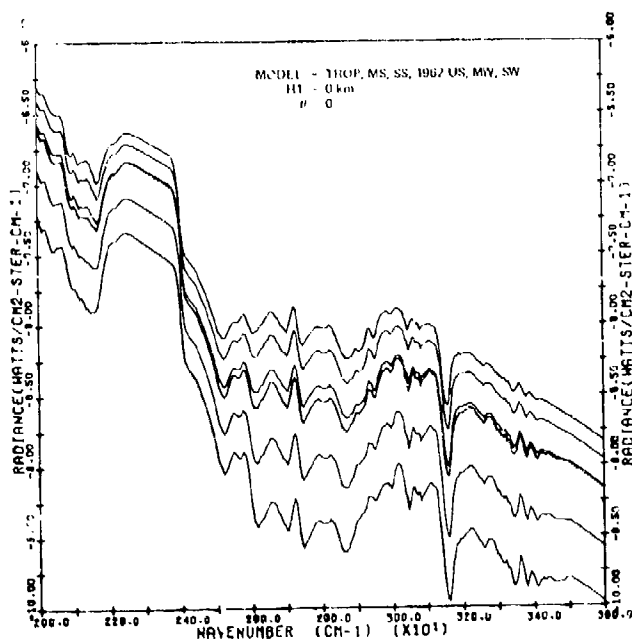


Figure 4. Atmospheric Radiance for a Vertical Path to Space from Ground Level for Six Model Atmospheres (2000 to 3600 cm^{-1})

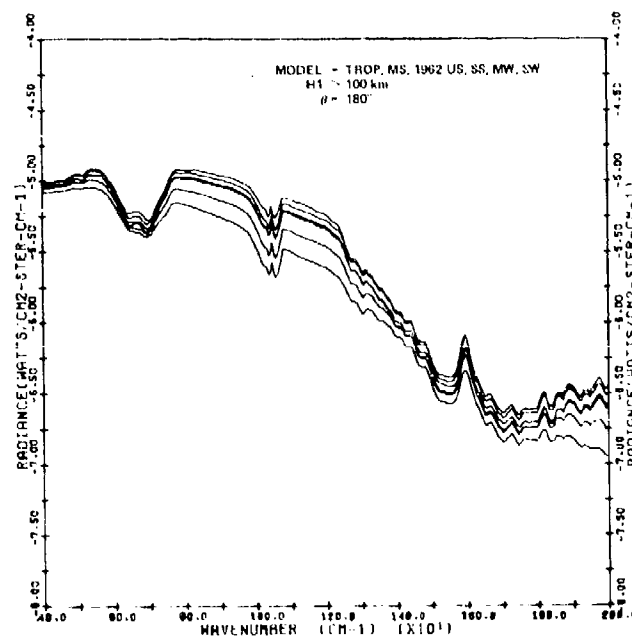


Figure 5. Atmospheric Radiance for a Vertical Path to Ground from Space for Six Model Atmospheres (400 to 2000 cm^{-1})

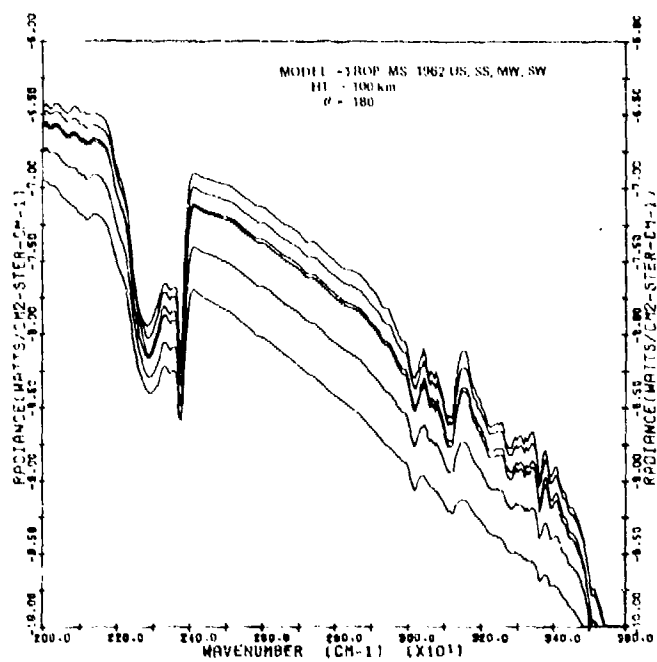


Figure 6. Atmospheric Radiance for a Vertical Path to Ground from Space for Six Model Atmospheres (2000 to 3600 cm^{-1})

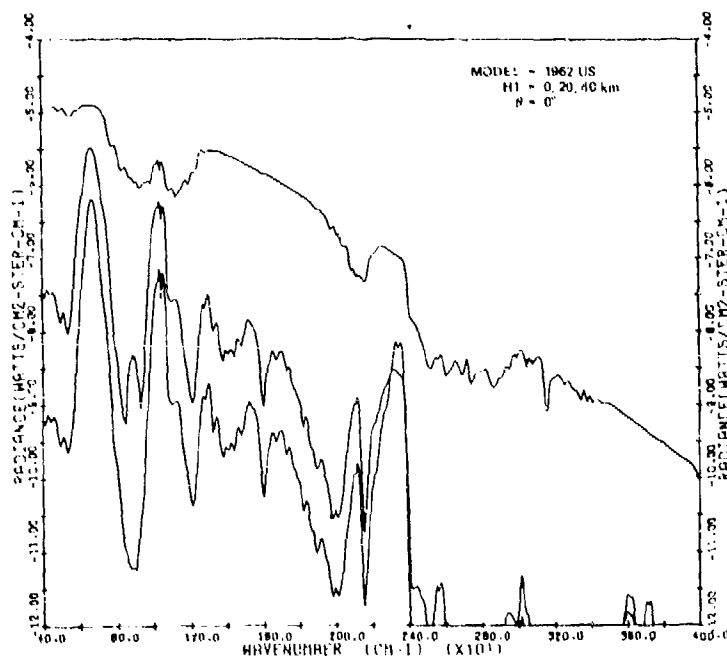


Figure 7. Variation of Atmospheric Radiance With Altitude for Vertical Paths to Space and the 1962 U.S. Standard Atmosphere

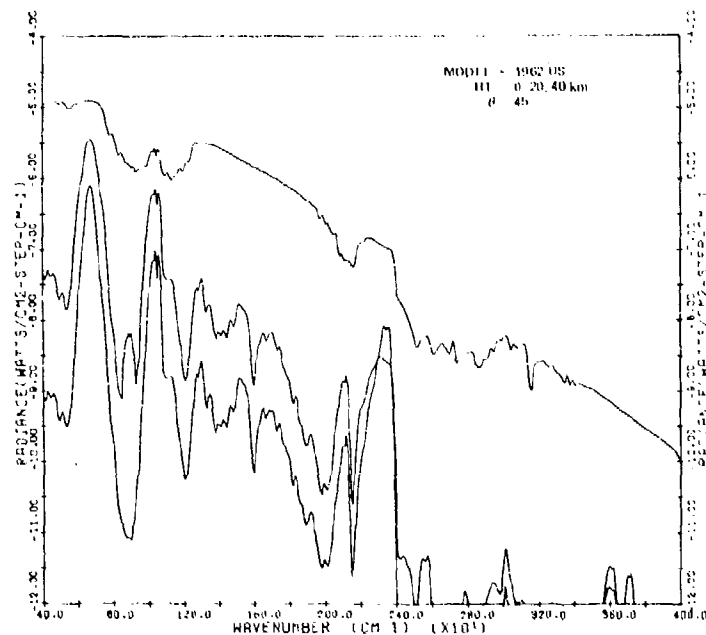


Figure 8. Variation of Atmospheric Radiance With Altitude for Slant Paths to Space (Zenith Angle = 45°) and the 1962 U.S. Standard Atmosphere

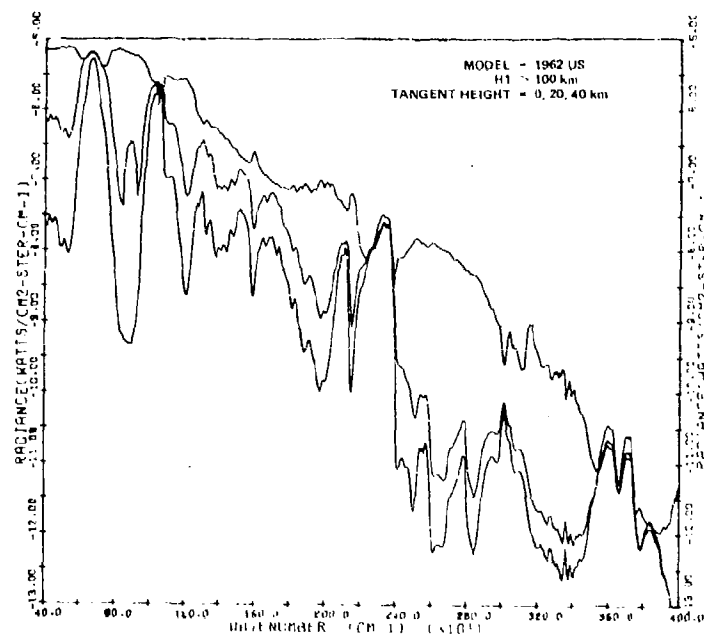


Figure 9. Variation of Atmospheric Limb Radiance With Tangent Height for the 1962 U.S. Standard Atmosphere

9. COMPARISONS WITH MEASUREMENTS

Figures 10 through 22 show some comparisons of LOWTRAN 4 calculations with measurements of atmospheric spectral radiance from both balloon and satellite platforms.

Figure 10 shows a comparison of the calculated upward atmospheric radiance with an interferometer measurement from a balloon flight over northern Nebraska by Chaney at the University of Michigan.⁹ The measurement was taken at a float altitude of 111,700 ft. The calculated radiance used the midlatitude winter model, with a 23 km visual range, and a ground temperature of 280°K.

Figure 11 shows a comparison of an interferometer measurement made from the Nimbus 3 satellite¹⁰ looking down over the Gulf of Mexico with the calculated atmospheric radiance. The resolution of the interferometer was 5 cm^{-1} as compared to the 20 cm^{-1} resolution of LOWTRAN. Two theoretical models, the tropical and midlatitude summer, were used for comparison, as shown in Figure 11, and are displaced two divisions above and below the measured radiance for clarity. Both models assumed a 23 km visual range and used the temperature at OKM in the model atmosphere as the boundary temperature.

Figure 12 shows the comparison of atmospheric radiance as seen from space between the LOWTRAN calculation and measurements from the Nimbus 4 satellite¹¹ for three different geographic locations. The spectra, obtained with a Michelson interferometer of resolution 2.8 cm^{-1} , were measured over the Sahara Desert, the Mediterranean, and the Antarctic. The calculated LOWTRAN radiances used the midlatitude winter model and a ground temperature of 320°K for the Sahara; the midlatitude winter model and a ground temperature of 285°K for the Mediterranean; and an arctic winter cold model taken from the AFURL Handbook of Geophysics and Space Environments¹² and a ground temperature of 190°K for the Antarctic comparison. All three calculations assumed a 23 km visual range for aerosols.

Figures 13 through 22 show a detailed comparison of calculated and observed atmospheric spectral radiance vs wavelength in both the 8 to 14 μm and the 18 to 27 μm spectral regions. The measurements were made on a balloon flight launched

9. Chaney, L. W. (1969) An Experimental Fourier Transform Asymmetrical Interferometer for Atmospheric Radiation Measurements, University of Michigan Technical Report 65863-18-T.
10. Conrath, B. J., Hanel, R. A., Kunde, V. G., and Prabhakara, C. (1970) The Infrared Interferometer Experiment on Nimbus 3, Goddard Space Flight Center Greenbelt, Maryland, Report X-620-70-213.
11. Hanel, R. A., and Conrath, B. J. (1970) Thermal Emission Spectra of the Earth and Atmosphere Obtained from the Nimbus 4 Michelson Interferometer Experiment, Goddard Space Flight Center, Greenbelt, Maryland, Report X-620-70-244.
12. Valley, S. D., Ed. (1965) Handbook of Geophysics and Space Environments, AFURL.

from Holloman AFB, New Mexico by Murrer et al,¹³ University of Denver. The instrument used for these observations was a LiHe grating spectrometer, operated in the first and second order of the grating. The resolution was 0.03 μm in the 8 to 14 μm region, and 0.06 μm in the 18 to 27 μm region. The data in these figures are presented as a function of altitude and as a function of zenith angle. Figures 13 through 18 cover the 8 to 14 μm region and Figures 19 through 22, the 18 to 27 μm region. The LOWTRAN radiance calculation used the pressure, temperature, ozone, and nitric acid profiles from the Murrer report,¹³ and the midlatitude winter water vapor profile contained in LOWTRAN.

The dominant spectral features in Figures 13 to 18 are the 9.0 and 9.6 μm ozone bands, the 11.3 μm band of nitric acid, and the carbon dioxide bands between 12 and 14 μm . In the long wavelength region, the spectral radiance is due primarily to water vapor rotational transitions. Because the resolution of the LOWTRAN radiance calculation is inferior to the measurements in this region, the comparisons here can only serve to verify the level of the calculated radiance.

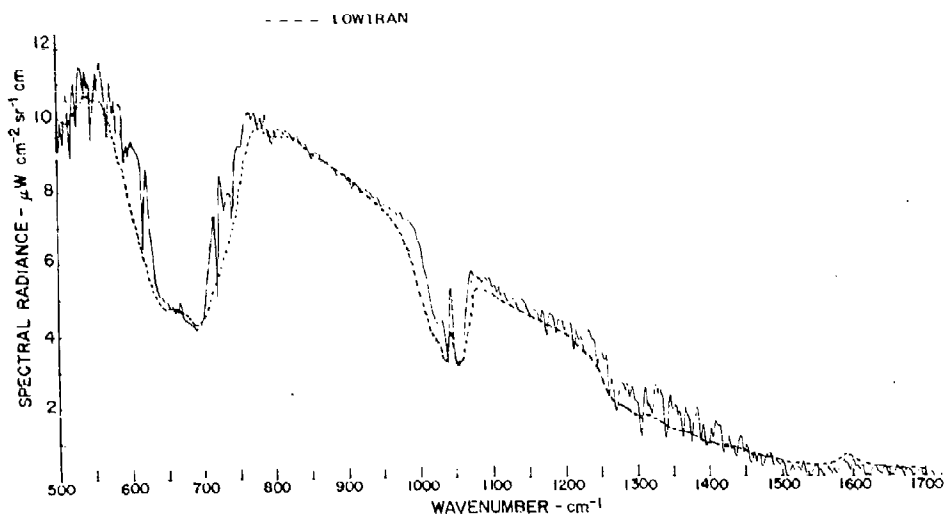


Figure 10. Comparison Between LOWTRAN Prediction and University of Michigan Balloon Measurement of Atmospheric Radiance Over Northern Nebraska

13. Murrer, D.G., Brooks, J.N., Goldman, A., Kesters, J.J., and Williams, W.J. (1977) Water Vapor Nitric Acid and Ozone Mixing Ratio Height Profiles Derived From Spectral Radiometric Measurements. University of Denver, Denver, Colorado 80208, Contract Report No. 332.

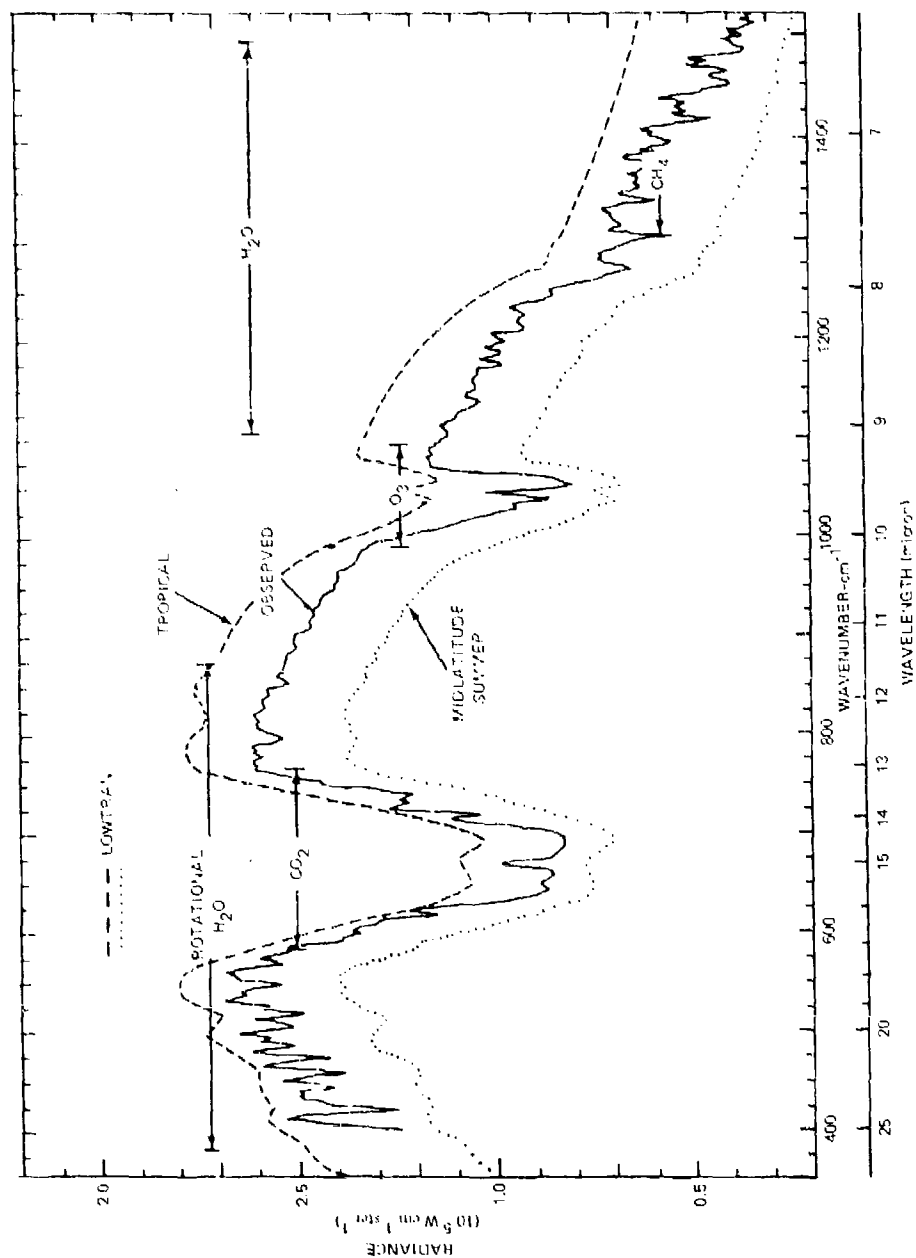


Figure 11. Comparison Between LOWTRAN Prediction and NIMBUS 3 Satellite Measurement of Atmospheric Radiance Over the Gulf of Mexico

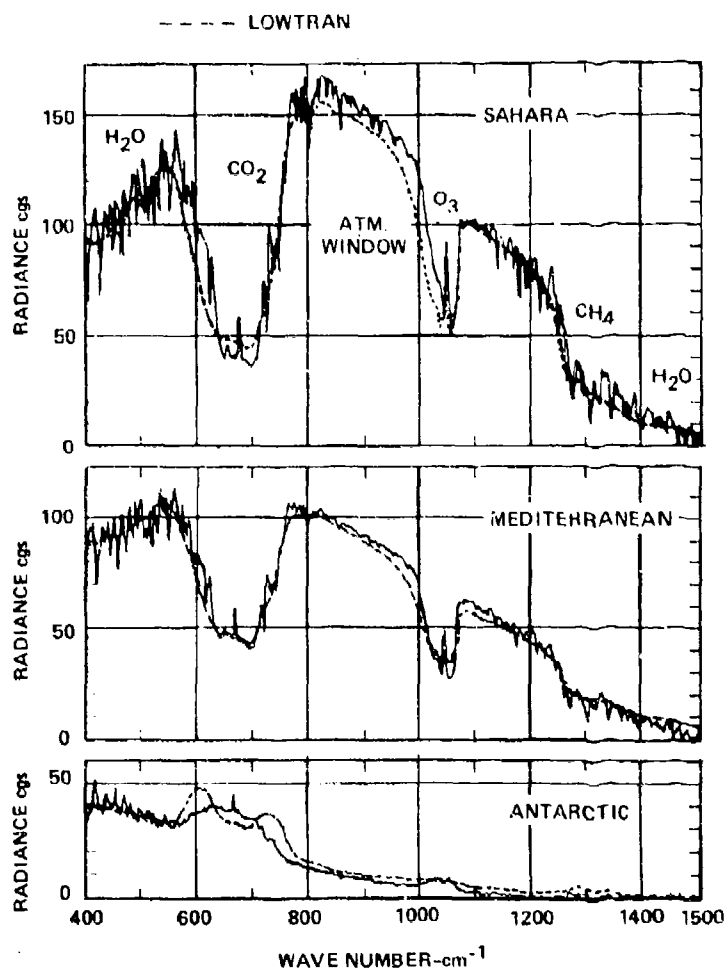


Figure 12. Comparison Between LOWTRAN Prediction and NIMBUS 4 Satellite Measurements of Atmospheric Radiance over the Sahara Desert, the Mediterranean, and the Antarctic

— MURCRAE ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

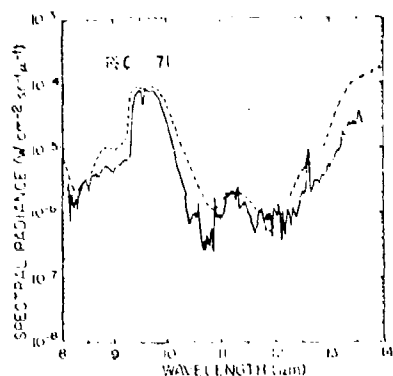


Figure 13. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 9.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCRAE ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

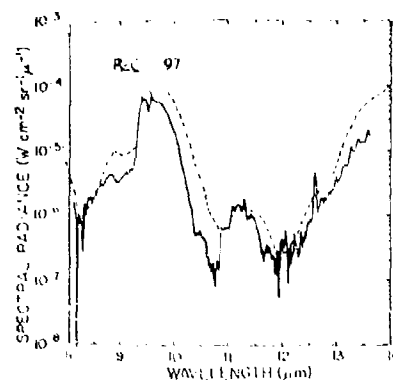


Figure 14. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 13.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCRAE ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

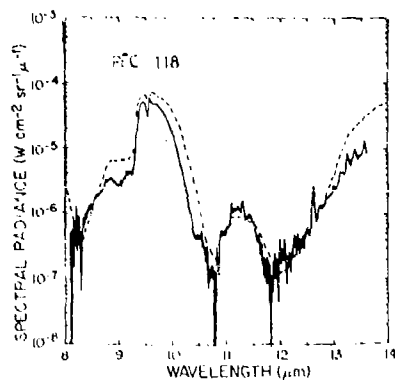


Figure 15. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 18.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCRAE ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

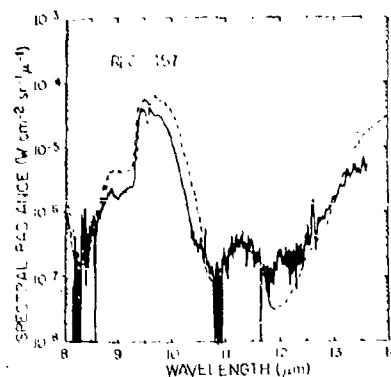


Figure 16. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 24.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCRAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

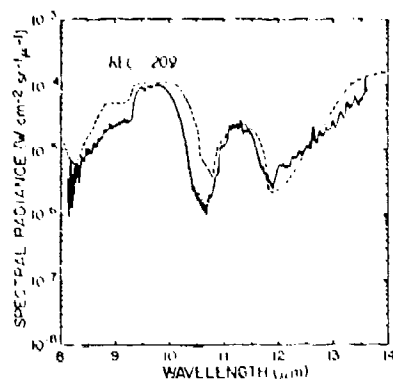


Figure 17. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 93° on 19 February 1975, and LOWTRAN Comparison

— MURCRAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

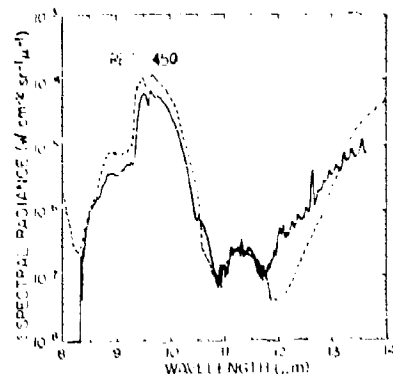


Figure 18. Sample Spectrum of Short Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 81° on 19 February 1975, and LOWTRAN Comparison

— MURCRAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

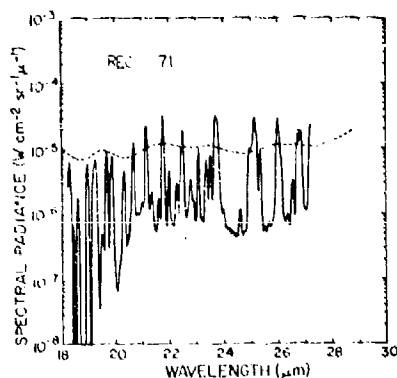


Figure 19. Sample Spectrum of Long Wavelength Region Observed at an Altitude of 9.5 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCRAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

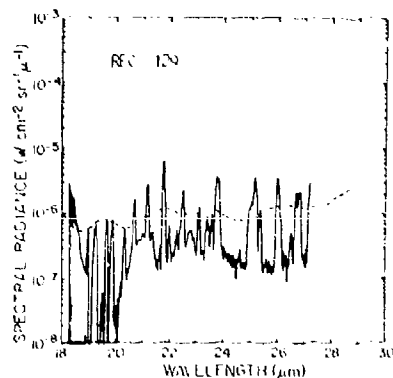


Figure 20. Sample Spectrum of Long Wavelength Region Observed at an Altitude of 20.0 km and a Zenith Angle of 63° on 19 February 1975, and LOWTRAN Comparison

— MURCHAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

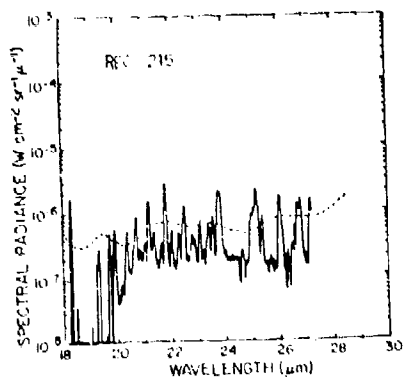


Figure 22. Sample Spectrum of Long Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 81° on 19 February 1975, and LOWTRAN Comparison

— MURCHAY ET AL. HOLLOMAN AFB, NEW MEXICO,
19 FEBRUARY 1975
--- LOWTRAN

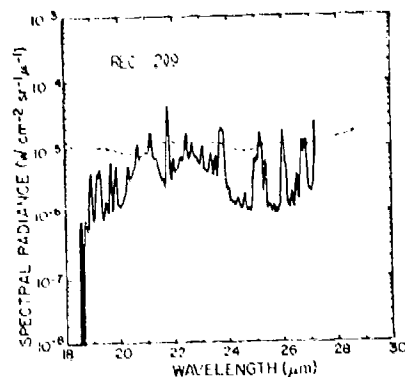


Figure 21. Sample Spectrum of Long Wavelength Region Observed at an Altitude of 29.1 km and a Zenith Angle of 93° on 19 February 1975, and LOWTRAN Comparison

10. COMMENTS

The LOWTRAN model was originally conceived as an atmospheric transmittance model. In the conversion to a radiance model, additional constraints on both the validity of the model as well as the range of applicability are introduced for atmospheric radiance calculations. It should be remembered that the digitized molecular absorption coefficients in LOWTRAN were obtained for conditions representative of moderate atmospheric paths and will tend to underestimate the transmittance for very long paths and overestimate the transmittance for very short paths. The modification of the transmittance function described in Section 3 was made to give some improvements to the radiance calculations for the short path cases. In addition, the radiance calculations assume local thermodynamic equilibrium exists in each layer of the model atmospheres. This assumption will break down for radiance calculations in the upper atmosphere. Therefore, because of the limitations in the LOWTRAN model for short paths (or small absorber amounts) and deviations from thermal equilibrium, both conditions which occur in the upper atmosphere it is recommended that the LOWTRAN radiance calculations be restricted to altitudes below 40 km.

For the shorter wavelengths ($\leq 5 \mu\text{m}$), scattered solar radiation becomes an important source of background radiation. Since this has not been included in the LOWTRAN model, radiance calculations at the shorter wavelengths with a sunlit atmosphere should be made with caution.

With the obvious limitations in the LOWTRAN radiance code described above, the agreement between measurements and radiance calculations shown in Figures 10 through 22 is remarkably good for the cases considered. Further comparisons with measurements are planned for other spectral regions and other geometries to verify the radiance model.

An additional note should be made here on the calculation of transmittance. Although the code will calculate total transmittance for a given atmospheric path in either mode of program execution, the time is increased by a factor of N in the radiance mode, where N is the number of atmospheric layers along a given path.

References

1. Selby, J. E. A., Shettle, E. P., and McClatchey, R. A. (1976) Atmospheric Transmittance from 0.25 to 28.5 μ m; Supplement LOWTRAN 3B, AFRL-TR-76-0253.
2. Selby, J. E. A., and McClatchey, R. A. (1975) Atmospheric Transmittance from 0.25 to 28.5 μ m; Computer Code LOWTRAN 3, AFRL-TR-75-0255.
3. Selby, J. E. A., and McClatchey, R. A. (1972) Atmospheric Transmittance from 0.25 to 28.5 μ m; Computer Code LOWTRAN 3, AFRL-TR-72-0745.
4. Manley, O. P., Smith, H. J. P., Treve, Y. M., Carpenter, J. W., Degges, T. C., and Doan, L. R. (1971) OPTIR II, AFRL-74-0523 (Vol. 2 & 3); (1973) OPTIR III, AFRL-TR-73-0217 and 0491; and (1974) OPTIR HIR, AFRL-TR-74-0319.
5. McClatchey, R. A., Fenn, R. W., Selby, J. E. A., Volz, F. P., and Garing, J. S. (1972) Optical Properties of the Atmosphere (Third Edition) AFRL-72-0497.
6. Murcray, D. G., Kyle, T. G., Murcray, F. H., and Williams, W. G. (1968) Nitric acid and nitric oxide in the lower stratosphere. Nature 218:78.
7. Goldman, A., Kyle, T. G., and Bonomo, F. W. (1971) Statistical band model parameters and integrated intensities for the 5.9- μ , 7.5- μ , and 11.3- μ bands of HNO_3 vapor, Appl. Opt. 10:65.
8. Evans, W. F., Kerr, J. B., and Wardle, D. I. (1975) The AES Stratospheric Balloon Measurements Project: Preliminary Results, Atmospheric Environment Service, Downsview, Ontario, Canada, Report No. APRB 30 X 4.
9. Chaney, L. W. (1969) An Experimental Fourier Transform Asymmetrical Interferometer for Atmospheric Radiation Measurements, University of Michigan Technical Report 05863-18-T.
10. Conrath, B. J., Hanel, R. A., Kunde, V. G., and Prabhakara, C. (1970) The Infrared Interferometer Experiment on Nimbus 3, Goddard Space Flight Center Greenbelt, Maryland, Report X-620-70-213.
11. Hanel, R. A., and Conrath, B. J. (1970) Thermal Emission Spectra of the Earth and Atmosphere Obtained from the Nimbus 3 Michelson Interferometer Experiment, Goddard Space Flight Center, Greenbelt, Maryland, Report X-620-70-244.

References

12. Valley, S.L., Ed. (1965) Handbook of Geophysics and Space Environments, AFCL.
13. Mureray, D.G., Brooks, J.N., Goldman, A., Kusters, J.J., and Williams, W.J. (1977) Water Vapor, Nitric Acid and Ozone Mixing Ratio Height Profiles Derived from Spectral Radiometric Measurements, University of Denver, Denver, Colorado 80208, Contract Report No. 332.

Appendix A

Listing of Program and Data

A listing of the Fortran program LOWTRAN 4 (PROGRAM LOWE4M) is given in Table A1 together with the four subroutines PATH, HNO3, POINT, and ANGL. The input data for the program is given in Table A2. A general flow chart for the main program is presented in Appendix B, and definitions of the symbols used in the computer codes are summarized in Appendix C.

The subroutine POINT has a twofold purpose. When the subroutine is called for a given altitude X , it is used to determine the mean refractive index (1) and in the layer between X and the level above, $TX(9)$, and (2) in the layer between X and the level below, YN . In addition, an interpolation scheme is used to determine the effective absorber amounts per km at altitude X for each absorber. When the parameter IP is set equal to zero, only the mean refractive index above and below altitude X is determined from POINT.

The subroutine ANGL is used solely for the purpose of calculating the initial zenith angle (θ_0 or ANGL) by an iterative scheme taking into account refraction, given (1) the initial and final altitudes of the path ($H1$ and $H2$ respectively) and the angle subtended at the earth's center (ϕ or BETAD) by the trajectory, or (2) the initial altitude and tangent height ($H1$ and $HAIN$ respectively). A more detailed explanation of subroutine ANGL is given in Appendix C of the LOWTRAN 3 report.²

PATH and HNO3 are new subroutines which have been added to the program. Subroutine PATH is used to determine and store the cumulative absorber amounts through the layers of the atmospheric slant path. Subroutine HNO3 is called to find the nitric acid absorption coefficients as a function of frequency.

The last column in the listing of the program in Table A1 is the corresponding listing of the LOWTRAN 3B computer code. Changes in the previous code are indicated by the word, NEW.

It should be noted that in the main program, card LOWE 7390, the temporary fog correction has been commented. The fog model should only be used for transmittance calculations as discussed in Appendix D. It should not be used for radiance calculations.

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4

```

PROGRAM LOWTRAN4(INPUT,OUTPUT,TAPES,TAPES=OUTPUT,TAPE 7)
COMMON /34/ P(7,34),I(7,34),FH(11,34),WH(7,34),M,NL,R1,CW,CO,PI
DIMENSION MO(7,34),H2(34),H2(6),AH2F(34),AH2P(70)
DIMENSION TR(67),FW(67),F2(67),H2(7),TX(11),VH(11)
DIMENSION HSTOP(34)
COMMON C1(2540),C2(1675),C3(540),C4(133),C5(15),C6(107)
COMMON VY(45),C7(45),C7A(45)
DIMENSION HMIX(54),HMAX(34,11)
DIMENSION MPATH(68,11),TPOY(68)
COMMON ZEM1Z, IEMISS,KMAX,ANGLE,LEN,HMIN,IJ,J1,J2,JMIN,JEXTRA,IITYP
COMMON ZEM2Z, IEMAX,LENSTOR,NUL,H(11),E(11)
COMMON ZEM3Z, H1,H2,H3,MODEL
C HMIX(1)=HMAX VOLUME MIXING RATIOS TIMES 100 FROM EVANS PROFILE
DATA H1Z/9*0.1,0.1,0.33,0.8,1.0,1.4,1.6,1.8,1.9,2.0,2.1,2.3,3.0,4,
17,4.0,5.0,6.0,8,0.6,0.22,0.07/
C I(1,V)=1.170996E-16*(V**5)/(EXP(1.43879*V/T)-1.)
C MATTS: CM=2.54 MICRON-1
C(A)=.50(18.0766-14.9999*A-2.4388*A*A)*A
DATA H2(1)/50.0 KM,H2(2)/50.0 KM/
C *****
C LOWTRAN 4 DEC 77
C
C AUTHOR S
C J. A. SUDY,
C F. X. KNEIFYN,
C J. M. CHILWIND JR.
C R. A. MCDONALD
C
C PROGRAM LOWTRAN 4 CALCULATES THE TRANSMITTANCE AND/OR RADIANCE
C OF THE ATMOSPHERE
C FROM 750 CM-1 TO 40000 CM-1 (12.25 TO 2.5 MICRONS) AT 25 CM-1
C SPECTRAL RESOLUTION ON A LINEAR WAVELENGTH SCALE.
C REFRACTION AND EARTH CURVATURE EFFECTS ARE INCLUDED. ATMOSPHERE
C IS LAYERED IN ONE KM. INTERVALS BETWEEN 0 AND 75 KM., 5 KM. INTER-
C VALS TO 50 KM., A TWENTY KM. INTERVAL TO 70 KM., AND A THIRTY KM.
C INTERVAL TO 100 KM.
C *****
C PROGRAM ACTIVATED BY SUBMISSION OF FOUR CARD SEQUENCE AS FOLLOWS
C
C CARD 1 MODEL,IMAX,IITYP,LEN,JP,IM,H1,H2,H3,H4,IEMISS,PO,TROUND
C FORMAT(11I3,2F10,3)
C CARD 2 H1,H2,ANGLE,RANGE,DELTA,VIS FORMAT(7F10,3)
C CARD 3 V1, V2, DV FORMAT(7F10,3)
C CARD 4 IXY FORMAT(13)
C
C MODEL=1,2,3,4,5 OR 6 SELECTS ONE OF THE FOLLOWING MODEL ATMOSPHERES:
C TROPICAL,MIDLATITUDE SUMMER,MIDLATITUDE WINTER,SUBARCTIC SUMMER,
C SUBARCTIC WINTER,OR THE 1962 U.S. STANDARD RESPECTIVELY
C MODEL=0 FOR MOD17. PATH WHEN METEOROL. DATA USED INSTEAD OF CARD 2,3,4
C READ H1,P(CM),I(DEC C),DOW PT,TEMP(DEC C),%REL HUMIDITY,H2O CONSLTLOW

```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

C	(CM,M-3),O3 DENSITY(CM-M-1), VIS(KM),RANGE(KM) WITH FORMAT 429.	LOWE 510	A 28*
C	MODEL=7 WHEN NEW MODEL ATMOSPHERE (E.G. RADIOSONOL DATA) USED.	LOWE 520	A 29A
C	DATA CARDS ARE READ IN BETWEEN CARDS 1 AND 2, AND SHOULD CONTAIN:	LOWE 530	A 29B
C	ALTITUDE(KM.),PRESSURE,TEMP,DEW PT,TEMP,REL. HUMIDITY,H2O DENSITY,	LOWE 540	A 29C
C	O3 DENSITY,AEROSOL NO. DENSITY(CM-3) ACCORDING TO FORMAT 429.	LOWE 550	A 29D
C	NOTE THAT EITHER DEW PT, TEMP,OR REL. HUMIDITY CAN BE USED.	LOWE 560	A 29E
C		LOWE 570	A 29F
C	M1,M2,M3, ARE USED TO CHANGE TEMP,H2O, AND O3 ALTITUDE PROFILES.	LOWE 580	A 29G
C	IFMISS=0=TRANSMISSION MODE / IFMISS=1=MISSION MODE	LOWE 590	NEW
C	TBOUND=TEMPERATURE OF EARTH IN DEGREES KELVIN	LOWE 600	NEW
C	IF TBOUND = ZERO, ASSUMES AIR TEMPERATURE OF MODEL ATMOS.	LOWE 610	NEW
C		LOWE 620	A 30
C	IF IHAZE=0 NO AEROSOL SCATTERING IS COMPUTED	LOWE 630	A 31
C	IHAZE = 1 IF AEROSOL ATTENUATION REQUIRED (THIS IS USED IN	LOWE 640	A 32
C	CONJUNCTION WITH VISUAL RANGE(SEE CARD 2))	LOWE 650	A 33
C	IHAZE = 1 OR 2 ALSO GIVE AEROSOL ATTENUATION FOR 23KM AND 5KM VIS.	LOWE 660	A 34
C	HAZE MODELS RESPECTIVELY IF VIS = 0 ON CARD 2	LOWE 670	A 35
C	IHAZE = 7 FOR OTHER AEROSOL MODELS (E.G. MARITIME ECT) WHICH	LOWE 680	A 35*
C	ARE READ INTO PROGRAM	LOWE 690	A 35*
C		LOWE 700	A 36
C	ITYPE=1,2 OR 3 INDICATES THE TYPE OF ATMOSPHERIC PATH	LOWE 710	A 37
C	ITYPE=3,VERTICAL OR SLANT PATH TO SPACE	LOWE 720	A 38
C	ITYPE=2,VERTICAL OR SLANT PATH BETWEEN TWO ALTITUDES	LOWE 730	A 39
C	ITYPE=1, CORRESPONDS TO A HORIZONTAL (CONSTANT PRESSURE) PATH	LOWE 740	A 40
C		LOWE 750	A 41
C	H1=OBSERVED ALTITUDE (KM)	LOWE 760	A 42
C	H2=SOURCE ALTITUDE (KM)	LOWE 770	A 43
C	ANGLE=ZENITH ANGLE AT H1 (DEGREES)	LOWE 780	A 44
C	RANGE=PATH LENGTH (KM)	LOWE 790	A 45
C	BETA=EARTH CENTRE ANGLE	LOWE 800	A 46
C	VIS = VISUAL RANGE AT SEA LEVEL (KM)	LOWE 810	A 47
C	(IF IITYPE=1 READ H1 AND RANGE;IF IITYPE=3 READ H1 AND ANGLE,	LOWE 820	A 48
C	IF IITYPE=2 READ H1 AND TWO OTHER PARAMETERS E.G. H2 AND ANGLE)	LOWE 830	A 49
C		LOWE 840	A 50
C	V1=INITIAL FREQUENCY (WAVENUMBER CM-1) INTEGER VALUE	LOWE 850	A 51
C	V2=FINAL FREQUENCY(WAVENUMBER CM-1) INTEGER VALUE	LOWE 860	A 52
C	DV= FREQUENCY INTERVALS AT WHICH TRANSMITTANCE IS PRINTED	LOWE 870	A 53
C	NOTE: DV MUST BE A MULTIPLE OF 5 CM-1	LOWE 880	A 54
C		LOWE 890	A 55
C	IXY=0 TO END DATA ,=1 FOR NEW V1,V2,DV ONLY , =2 TO CONTINUE DATA	LOWE 900	A 56
C	IXY=3 FOR NEW CARD 2 ONLY, =4 FOR NEW CARD 1 ONLY.	LOWE 910	A 57A
C	*****	LOWE 920	A 57B
C	HNIX(9)=HNIX(29)=1.0 E-50	LOWE 930	NEW
C	IXY=0	LOWE 940	A 57C
C	KMAX=11	LOWE 950	NEW
C	READ (5,400) IATM,NL	LOWE 960	A 58
C	READ (5,401) (H21(I),I=1,NL)	LOWE 970	A 59
C	READ (5,401) (H22(I),I=1,5)	LOWE 980	A 60
C	H22(6)=H21(5)	LOWE 990	A 60*
C	DO 1 J=1,3	LOWE1000	A 61

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	K2=2*J	LOWE1010	A 62
	K1=K2-1	LOWE1020	A 63
	DO 1 I=1,NL	LOWE1030	A 64
1	READ (5,402) Z(I), (P(K,I),T(K,I),WH(K,I),W0(K,I),K=K1,K2)	LOWE1040	A 65
	READ (5,431) (VX(I),C7(I),C7A(I),I=1,44)	LOWE1050	A 66*
	READ (5,403) (IP(I),FW(I),FO(I),I=1,67)	LOWE1060	A 67
	READ (5,404) (C1(I),I=1,2500)	LOWE1070	A 68
	READ (5,404) (C2(I),I=1,1575)	LOWE1080	A 69
	READ (5,404) (C3(I),I=1,540)	LOWE1090	A 70
	READ (5,405) (C4(I),I=1,133)	LOWE1100	A 71
	READ (5,404) (C5(I),I=1,15)	LOWE1110	A 72
	READ (5,405) (C8(I),I=1,102)	LOWE1120	A 73
	JSTOR=0	LOWE1140	NEW
	PI=2.0*ASIN(1.0)	LOWE1150	A 74*
	CA=PI/180.	LOWE1160	A 75
	IP=0	LOWE1170	A 76
2	CONTINUE	LOWE1180	A 77
	RE=6371.23	LOWE1190	A 78
	IFIND=0	LOWE1200	A 79
C	JP NF (SUPPRESS PRINT	LOWE1210	A 79*
	READ 400,MODEL,THA7E,I1YPE,LEN,JP,IM,H1,H2,H3,ML,IEMISS,RO,IBOUND	LOWE1220	NEW
C	IF MISS=0=TRANSMISSION MODE / IF MISS=1=EMISSION MODE	LOWE1230	NEW
	IF(IEMISS,EQ.1) PRINT 1177	LOWE1240	NEW
	IF(IEMISS,EQ.0) PRINT 1171	LOWE1250	NEW
	LENSIOF=LEN	LOWE1260	NEW
	PRINT400,MODEL,THA7E,I1YPE,LEN,JP,IM,H1,H2,H3,ML,IEMISS,RO,IBOUND	LOWE1270	NEW
200	M=MODEL	LOWE1280	A 80
	IF (M,EQ.1) RE=6378.79	LOWE1290	A 83
	IF (M,EQ.4) RE=6356.91	LOWE1300	A 84
	IF (M,EQ.5) RE=6356.91	LOWE1310	A 84A
	IF (THA7E,NE.7) GO TO 250	LOWE1320	A 85A
	READ 431, (VX(I),C7(I),C7A(I),I=1,44)	LOWE1330	A 85C
	PRINT 431, (VX(I),C7(I),C7A(I),I=1,44)	LOWE1340	A 85D
	THA7E=1	LOWE1350	A 86
250	IF(RO,GT.0)RE=RO	LOWE1360	A 86
	IF(M,EQ.7.AND.IM,NE.0) GO TO 4	LOWE1370	A 86A
	IF(IM,GT.3) GO TO 8	LOWE1380	A 86A
	IF (MODEL,EQ.0) GO TO 4	LOWE1390	A 86
300	READ 406, H1,H2,ANGLE,RANGE,BETA,VIS	LOWE1400	A 87*
	PRINT 425, H1,H2,ANGLE,RANGE,BETA,VIS	LOWE1410	A 88
	X1=RE+H1	LOWE1420	A 89
	IF (I1YPE,EQ.3) GO TO 560	LOWE1430	A 90*
	IF (I1YPE,EQ.1) GO TO 8	LOWE1440	A 91
	X2=RE+H2	LOWE1450	A 92
	IF (RANGE,EQ.0.) GO TO 5	LOWE1460	A 93
	PRINT 428, H1,H2,ANGLE,RANGE,BETA,VIS	LOWE1470	A 94
	IF (H2,EQ.0.AND.ANGLE,NE.0) GO TO 3	LOWE1480	A 95
	ANGLE=ACOS(0.5*(H2-H1)*(1.+X2/X1)/RANGE-RANGE/X1)/CA	LOWE1490	A 96
	GO TO 7	LOWE1500	A 97

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

3	X2=SQRT((X1/RANGE+RANGE/X1+2.0*COS(ANGLE*GA))*X1*RANGE)	LOWE1510	A 98
	H2=X2-PE	LOWE1520	A 99
	GO TO 7	LOWE1530	A 100
4	CONTINUE	LOWE1540	A 101*
	IF(PL,LF,0)HL=1	LOWE1550	A 102*
	DO 540 K=1,HL	LOWE1560	A 103A
	AMAZE(K)=0.0	LOWE1570	A 103B
	IF(M,EO,0)READ 429,H1,P(7,1),TMP,DP,RH,WH(7,K),WO(7,K),VIS,RANGE	LOWE1580	A 103C
	IF(M,EO,0)PRINT 430,H1,P(7,1),TMP,DP,RH,WH(7,K),WO(7,K),VIS,RANGE	LOWE1590	A 103D
	IF(M,GT,0)READ 429,Z(K),P(7,K),TMP,DP,RH,WH(7,K),WO(7,K),AMAZE(K)	LOWE1600	A 103E
	IF(M,EO,0)Z(K)=H1	LOWE1610	A 103F
	J=FIX(Z(K)+1.0E-6)+1.	LOWE1620	A 103G
	IF(Z(K).GE.25.0) J=(Z(K)-25.0)/5.0+26.	LOWE1630	A 103H
	IF(Z(K).GE.50.0) J=(Z(K)-50.0)/20.0+31.	LOWE1640	A 103I
	IF(Z(K).GE.70.0) J=(Z(K)-70.0)/30.0+32.	LOWE1650	A 103J
	IF(J,GT,33)J=33	LOWE1660	A 103K
	FAC=Z(K)-FLOAT(J-1)	LOWE1670	A 103L
	IF(J,LT,26) GO TO 500	LOWE1680	A 103M
	FAC=Z(K)-5.0*FLOAT(J-26)-25.0/5.	LOWE1690	A 103N
	IF(J,GE,31) FAC=(Z(K)-50.0)/20.	LOWE1700	A 103O
	IF(J,GE,32) FAC=(Z(K)-70.0)/30.	LOWE1710	A 103P
	IF(FAC,GT,1.0) FAC=1.0	LOWE1720	A 103Q
500	L=J+1	LOWE1730	A 103R
	T(7,K)=TMP+273.15	LOWE1740	A 103S
	IF(M1,GT,0)T(7,K)=T(M1,J)*(T(M1,L)/T(M1,J))*FAC	LOWE1750	A 103T
	TT=273.15/T(7,K)	LOWE1760	A 103U
	IF(PH,LE,0.9) TT=273.15/(273.15+DP)	LOWE1770	A 103V
	IF(WH(7,K),LE,0.9) WH(7,K)=F(TT)	LOWE1780	A 103W
	TH(7,CT,J)WH(7,K)=WH(M2,J)*(WH(M2,L)/WH(M2,J))*FAC	LOWE1790	A 103X
	IF(M,GT,0.3) WH(7,K)=0.31*WH(M2,J)	LOWE1800	A 103Y
	IF(M3,GT,0)WO(7,K)=WO(M3,J)*(WO(M3,L)/WO(M3,J))*FAC	LOWE1810	A 103Z
	HSTOR(K)=0.	LOWE1820	N W
	IF(HMIX(J),LE,0.1) GO TO 572	LOWE1830	N W
	HSTOR(K)=HMIX(J)*(HMIX(L)/HMIX(J))*FAC	LOWE1840	N W
520	CONTINUE	LOWE1850	N W
	IF(Z(K).GE.5.0)GO TO 520	LOWE1860	A 104A
	IF(AMAZE(K),LE,0.0)AMZ2(K)=H22(J)*(H22(L)/H22(J))*FAC	LOWE1870	A 104B
520	IF(AMAZE(K),LE,0.0)AMAZE(K)=H21(J)*(H21(L)/H21(J))*FAC	LOWE1880	A 104C
	IF(MODEL,EO,0)GO TO 8	LOWE1890	A 104D
	IF(K,EO,1)PRINT 441	LOWE1900	A 104E
	PRINT 420,Z(K),P(7,K),TMP,DP,RH,WH(7,K),WO(7,K),AMAZE(K)	LOWE1910	A 104F
540	CONTINUE	LOWE1920	A 104G
	IM=0	LOWE1930	A 104H
	NL=HL	LOWE1940	A 104I
	M1=0	LOWE1950	A 104J
	M2=0	LOWE1960	A 104K
	M3=0	LOWE1970	A 104L
C	NOTE THAT Z(I) MAY NOT CORRESPOND TO THE VALUES GIVEN FOR STANDARD	LOWE1980	A 104M
C	MODEL ATMOSPHERES	LOWE1990	A 104N
	IF(IXY,GT,3) GO TO 8	LOWE2000	N W

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	GO TO 300	LOWE 2010	A 1040
560	IF (RANGE.GT.0.0) GO TO 580	LOWE 2020	A 1040
	IF (H2.GT.0.0.AND.H2.LT.H1) IFIND=1	LOWE 2030	A 1040
	GO TO 2	LOWE 2040	A 1040
580	ITYPE=2	LOWE 2050	A 1045
	BETA=ACOS(0.5*(RANGE*RANGE/(X1*X2)-X2/X1-X1/X2))/CA	LOWE 2060	A 1047
5	IF (BETA.EQ.0.) GO TO 6	LOWE 2070	A 105
	IFIND=1	LOWE 2080	A 106
	BET=CA*BETA	LOWE 2090	A 107
	X2=XE+H2	LOWE 2100	A 108
	ANGLE=ATAN(X2*SIN(BET))/(X2*COS(BET)-X1)/CA	LOWE 2110	A 109
	RANGE=X2*SIN(BET)/SIN(ANGLE*CA)	LOWE 2120	A 110
	BET=BETA	LOWE 2130	A 111
	GO TO 2	LOWE 2140	A 112
6	RANGE=(X2/X1)**2-(SIN(ANGLE*CA))**2	LOWE 2150	A 113
	IF (RANGE.GT.0.) RANGE=X1*(SIN(RANGE-1-ASIN(COS(ANGLE*CA))))	LOWE 2160	A 114
7	IF (ANGLE.LT.0.0.AND.ANGLE.GT.-180.) BET=ASIN(RANGE*SIN(ANGLE*CA)/X2)	LOWE 2170	A 115
	IF (ANGLE.LT.0.) ANGLE=ANGLE+PI	LOWE 2180	A 116
	IF (RANGE.LT.0.) RANGE=-RANGE	LOWE 2190	A 117
	BET=BET/CA	LOWE 2200	A 118
	PRINT 428, H1,H2,ANGLE,RANGE,BET,VIS	LOWE 2210	A 119
8	CONTINUE	LOWE 2220	A 120A
	DO 1002 I=1,34	LOWE 2230	NEW
	DO 1002 J=1,KMAX	LOWE 2240	NEW
1002	WLAY(I,J)=0.	LOWE 2250	NEW
	SUM=0.	LOWE 2260	A 120B
	IF (IXY.LE.0) READ 406,V1,V2,DV	LOWE 2270	A 121
	IF (IXY.LE.0) PRINT 406,V1,V2,DV	LOWE 2280	A 122
	IF (ITYPE.EQ.1) PRINT 407, H1,RANGE	LOWE 2290	A 123
	IF (ITYPE.EQ.2) PRINT 408, H1,H2,ANGLE	LOWE 2300	A 124
	IF (ITYPE.EQ.3) PRINT 409, H1,ANGLE	LOWE 2310	A 125
	IF (MODEL.EQ.0) M=7	LOWE 2320	A 126A
	IF (VIS.GT.0.0) PRINT 417,VIS	LOWE 2330	A 126B
	IF (VIS.LT.0.0.AND.VIS.GT.0.0) PRINT 440	LOWE 2340	A 127
	IF (M.EQ.1) PRINT 410, M	LOWE 2350	A 128
	IF (M.EQ.2) PRINT 411, M	LOWE 2360	A 129
	IF (M.EQ.3) PRINT 412, M	LOWE 2370	A 130
	IF (M.EQ.4) PRINT 413, M	LOWE 2380	A 131
	IF (M.EQ.5) PRINT 415, M	LOWE 2390	A 132
	IF (M.EQ.6) PRINT 414, M	LOWE 2400	A 133
	IF (IHAZE.EQ.0.) PRINT 425	LOWE 2410	A 134
	IF (VIS.LE.0.0.AND.IHAZE.GT.0) PRINT 416,IHAZE,HZ(IHAZE)	LOWE 2420	A 135
	AVH=10000./V1	LOWE 2430	A 136
	ALAM=10000./V2	LOWE 2440	NEW
	RADMIN=1.0E+300 \$RADMAX=0. \$ VMIN=0. \$ VMAX=0.	LOWE 2450	A 137
	PRINT 418, V1,V2,DV,ALAM,AVH	LOWE 2460	A 138
	AVH=0.5E-4*(V1+V2)	LOWE 2470	A 139
	AVH=AVH*AVH	LOWE 2480	A 140
	CO=77.46+.459*AVH	LOWE 2490	A 141
	CM=63.487-0.3473*AVH	LOWE 2500	

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

9	IF (IFIND.EQ.1) GO TO 15	LOWE2510	A 147
	IF (IFIND.EQ.1) CALL ANGL (H1,H2,ANGLE,BETA,LEN,ML)	LOWE2520	A 148
	IFIND=0	LOWE2530	A 149
	IF (JPF.EQ.0) PRINT 427	LOWE2540	A 149*
	IF (ITYPE.EQ.1) GO TO 15	LOWE2550	A 147
	DO 11 K=1,KMAX	LOWE2560	NEW
	WH(K)=0.0	LOWE2570	A 149
11	CONTINUE	LOWE2580	A 150
	BETA=0.0	LOWE2590	A 151-
	SR=0.0	LOWE2600	A 153
	IP=0	LOWE2610	A 154-
C****	NOW DEFINE CONSTANT PRESSURE PATH QUANTITIES EH(1-8)	LOWE2620	A 156
	Y=CA*ANGLE	LOWE2630	A 157
	SPHI=SIN(Y)	LOWE2640	A 158
	R1=(RF+H1)*SPHI	LOWE2650	A 159
	IF (H1.GT.7(NL)) GO TO 13	LOWE2660	A 160
	GO TO 15	LOWE2670	A 161
13	X=(RE+Z(NL))/(RE+H1)	LOWE2680	A 162
	IF (SPHI.GT.X) GO TO 14	LOWE2690	A 163
	H1=Z(NL)	LOWE2700	A 164
	J1=NL	LOWE2710	A 165
	SPHI=SPHI/X	LOWE2720	A 166
	ANGLE=180.0-ASIN(SPHI)/CA	LOWE2730	A 167
	R1=(RF+H1)*SPHI	LOWE2740	A 168
	GO TO 15	LOWE2750	A 170
14	HMIN=R1-RF	LOWE2760	A 171
	PRINT 433, HMIN	LOWE2770	A 172
	GO TO 95	LOWE2780	A 173
15	DO 17 J=1,NL	LOWE2790	A 174
	PS=P(M,I)/1013.0	LOWE2800	A 175
	TS=273.15/T(M,I)	LOWE2810	A 176A
	IF (H1.GT.0.AND.H.LT.7) TS=273.15/T(M,I)	LOWE2820	A 176B
	X=PS*TS	LOWE2830	A 177
	PT=PS*SQR(TS)	LOWE2840	A 178
	D=0.1*WH(M,I)	LOWE2850	A 179
	IF (H2.GT.0.AND.H.LT.7) D=0.1*WH(M2,I)	LOWE2860	A 180*
	EH(1,I)=D*PT**0.9	LOWE2870	A 181*
	EH(2,I)=X*PT**0.75	LOWE2880	A 182*
	EH(4,I)=0.8*PT**X	LOWE2890	A 183
	PPW=4.56E-5*D*273.15/TS	LOWE2900	A 184*
	TS1=(296.0/273.15)*TS	LOWE2910	*A 185A
	EH(5,I)=D*PPW*EXP(6.0A*(TS1-1.0))+0.002*D*(PS-PPW)	LOWE2920	*A 185B
	EH(10,I)=D*(PPW+0.12*(PS-PPW))*EXP(4.56*(TS1-1.0))	LOWE2930	*A 186C
	EH(6,I)=X	LOWE2940	A 186
	HAZF=H21(I)	LOWE2950	A 187
	IF (M.EQ.7) HAZE=HAZF(I)	LOWE2960	A 188*
	IF (Z(I).GE.5.0) GO TO 155	LOWE2970	A 189*
	IF (M.NE.7.AND.HAZF.EQ.2) HAZE=H22(I)	LOWE2980	A 190A
	IF (HAZF.EQ.2.AND.M.EQ.7) HAZF=H22(I)	LOWE2990	A 190B
	IF (VIS.LE.0.0) GO TO 150	LOWE3000	A 190C

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	IF (M,NE,7) HAZE=6.389*(AHZ(1)-AHZ(11))/VIS*H2(1)/5.-H2(1)/23.)	LOWE5010	A 1900
	IF (M,NE,7) GO TO 150	LOWE5020	A 1901
	HAZE=6.389*(AHZ(11)-AHZ(11))/VIS*HAZE(1)/5.-AHZ(11)/23.)	LOWE5030	A 1902
150	IF (HAZE,LT,0.0) HAZE=9.0	LOWE5040	A 1903
	PH(7,1)=HAZE/PH(1,1)	LOWE5050	A 1904
	IF (MODEL,EQ,7) PH(7,1)=HAZE/AHAZE(1)	LOWE5060	A 1905
	PH(8,1)=46.6667*W0(M,1)	LOWE5070	A 1906
	IF (M,GT,0.AND,M,LT,7) PH(8,1)=46.6667*W0(M,1)	LOWE5080	A 1907
	PH(3,1)=PH(1,1)*PT**0.5	LOWE5090	A 1908
C	PH(11,1)=HNO3 ABSORBER AMOUNT (ATM-CM)/KM	LOWE5100	NEW
	PH(11,1)=PS*IS*HMIX(1)*1.0E-06	LOWE5110	NEW
	IF (MODEL,EQ,0.0.AND,MODEL,EQ,7) PH(11,1)=PS*IS*HSTOR(1)*1.0E-06	LOWE5120	NEW
	PH(9,1)=1.0	LOWE5130	A 1909
	REF=1.0E-6*(CO*X*1013.0/273.15-PPW*CH)	LOWE5140	*A 1910
	IF (I,EQ,NL) GO TO 16	LOWE5150	A 1911
	IF (MODEL,EQ,0.0.AND,I,GT,1) GO TO 26	LOWE5160	A 1912
	IC=ICM,I+1	LOWE5170	A 1913
	W2=WH(M,I+1)	LOWE5180	A 1914
	IF (M,GT,0) IC=ICM,I+1	LOWE5190	A 1915
	IF (M,GT,0) W2=WH(M2,I+1)	LOWE5200	A 1916
	PPW=PPW-6.6667*W2*12	LOWE5210	A 1917
	IF (I,1)=0.5*(PH(1,1)+0.5*(CO*P(M,I+1)/IC-PPW*CH))	LOWE5220	*A 1918
16	IF (I,EQ,NL) PH(3,1)=0.	LOWE5230	A 1919
	IS=PH(1,GT,7(I)) J1=1	LOWE5240	A 1920
	IF (I,IN,7.0.0.0.0.0.0.0) PRINT 434, I,7(I),PH(1,1),K=1,KMAX	LOWE5250	NEW
	PH(9,1)=PH(9,1)+1.0	LOWE5260	A 1921
17	CONTINUE	LOWE5270	A 1922
170	IF (I,FIND,EQ,1) GO TO 9	LOWE5280	A 1923
	IF=1	LOWE5290	A 1924
	IK=0	LOWE5300	A 1925
	XI=H1	LOWE5310	A 1926
	CALL POINT (H1,YN,N,NP1,IX,IP)	LOWE5320	A 1927
	J1=N	LOWE5330	A 1928
	IX1=IX(9)	LOWE5340	A 1929
	DO 18 K=1,KMAX	LOWE5350	NEW
18	F(K)=TX(K)	LOWE5360	A 1930
	IF (I,TYPE,EQ,1) GO TO 26	LOWE5370	A 1931
	IF (I,TYPE,EQ,3) H2=7(NL)	LOWE5380	A 1932
	IF (ANGLE,GT,90.0) GO TO 28	LOWE5390	A 1933
19	IF (ANGLE,GT,90.0.AND,NP1,GT,0) J1=J1+1	LOWE5400	A 1934
	J2=NL	LOWE5410	A 1935
	IF (I,TYPE,EQ,3) GO TO 20	LOWE5420	A 1936
	CALL POINT (H2,YN,N,NP1,IX,IP)	LOWE5430	A 1937
	J2=N	LOWE5440	A 1938
	IF (NP,GT,0) J2=J2-1	LOWE5450	A 1939
20	DO 21 K=1,KMAX	LOWE5460	NEW
	IF (K,EQ,9) GO TO 21	LOWE5470	*A 1940
	PH(K,J1)=F(K)	LOWE5480	A 1941
	IF (I,TYPE,EQ,3) GO TO 21	LOWE5490	A 1942
	PH(K,J2)=TX(K)	LOWE5500	A 1943

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

21	CONTINUE	LOWE3510	A 225
	IF (J1,EQ,J2) TX1=TX1+YN-FH(I,J1)	LOWE3520	A 226
G****	NOW DEFINE VERTICAL PATH QUANTITIES VHI(1-N)	LOWE3530	A 227
	IF (JP,EQ,0) PRINT 420	LOWE3540	A 228*
	DO 1020 K=1,KMAX	LOWE3550	NEW
1020	W(K)=0.	LOWE3560	NEW
	DO 25 I=J1,J2	LOWE3570	A 229
	X1=Z(I)	LOWE3580	A 230
	X2=Z(I+1)	LOWE3590	A 231
	IF (I,EQ,J1) X1=M1	LOWE3600	A 232
	IF (I,EQ,J2) X2=M2	LOWE3610	A 233
	DZ=X2-X1	LOWE3620	A 234
	IF (I,EQ,NL) DZ=Z(I)-Z(I-1)	LOWE3630	A 234
	DZ=DZ	LOWE3640	A 236
G****	UPWARD TRAJECTORY	LOWE3650	A 237
	RX=(RE+X1)/(RE+X2)	LOWE3660	A 238
	THETA=ASIN(SPHI)/CA	LOWE3670	A 239
	PHI=ASIN(SPHI*RX)/CA	LOWE3680	A 240
	BETA=THETA-PHI	LOWE3690	A 241
	SALP=RX*SPHI	LOWE3700	A 242
	IF (SPHI,GT,1.E-10) DS=(RE+X2)*SIN(BETA*CA)/SPHI	LOWE3710	A 243
	BETA=BETA+RET	LOWE3720	A 244
	PSI=BETA+PHI-ANGLE	LOWE3730	A 245
	PHI=180.-PHI	LOWE3740	A 246
	SR=SR+DS	LOWE3750	A 247
	JEXTRA=0	LOWE3760	NEW
	DO 1024 K=1,KMAX	LOWE3770	NEW
	EV=DS*FH(K,I)	LOWE3780	A 249
	IF (I,EQ,NL) GO TO 22	LOWE3790	A 250
	IF (EH(K,I),EQ,0.0,CR,EH(K,I+1),EQ,0.0) GO TO 23	LOWE3800	A 251
	IF (EH(K,I),EQ,EH(K,I+1)) GO TO 24	LOWE3810	A 252
	EV=DS*(FH(K,I)-FH(K,I+1))/ALOG(EH(K,I)/EH(K,I+1))	LOWE3820	A 253
	GO TO 24	LOWE3830	A 254
22	IF (EH(K,I),EQ,0.0) GO TO 23	LOWE3840	A 255
	IF (EH(K,I-1),EQ,0.0) GO TO 23	LOWE3850	A 256
	IF (EH(K,I),EQ,EH(K,I-1)) GO TO 24	LOWE3860	A 257
	EV=EV/ALOG(EH(K,I-1)/EH(K,I))	LOWE3870	A 258
	GO TO 24	LOWE3880	A 259
23	EV=0.	LOWE3890	A 260
24	W(K)=W(K)+EV	LOWE3900	A 261
	IF (I,EQ,J2) GO TO 1023	LOWE3910	NEW
1022	W(K)=W(K)+EV	LOWE3920	NEW
	W(K)=0.	LOWE3930	NEW
	GO TO 1024	LOWE3940	NEW
1023	W(K)=EV	LOWE3950	NEW
	IF (J1,NE,J2) GO TO 1024	LOWE3960	NEW
	W(K)=W(K)+EV	LOWE3970	NEW
	W(K)=0.	LOWE3980	NEW
	JEXTRA=1	LOWE3990	NEW
1024	CONTINUE	LOWE4000	NEW

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	IF (JP.EQ.0) PRINT 435, I,X1,(VH(L),L=1,6),PS1,PHI,BETA,THETA,SR	LOWE4010	A 262*
	IF (I.GE.NL) GO TO 25	LOWE4020	A 263
	IF (I+1.EQ.J2) EH(9,I+1)=YN	LOWE4030	A 264
	IF (I.EQ.J1) EH(9,I)=TX1	LOWE4040	A 265
	RN=EH(9,I+1)/EH(9,I)	LOWE4050	A 266
	SPH1=SPH1*RX/RN	LOWE4060	A 267
	IF (SALF.GE.RN) SPH1=SALF	LOWE4070	A 268
25	CONTINUE	LOWE4080	A 269
	GO TO 47	LOWE4090	A 270
C****	HORIZONTAL PATH	LOWE4100	A 271
26	DO 27 K=1,KMAX	LOWE4110	NEW
	W(K)=RANGE*EH(K,1)	LOWE4120	A 273*
	IF (MODEL.GT.0) W(K)=RANGE*TX(K)	LOWE4130	A 274*
	VH(K)=W(K)	LOWE4140	NEW
27	CONTINUE	LOWE4150	A 275
	GO TO 49	LOWE4160	A 276
28	CONTINUE	LOWE4170	A 277
C****	DOWNWARD TRAJECTORY	LOWE4180	A 278
	K2=0	LOWE4190	A 279
	IF (NP1.EQ.1) J1=J1-1	LOWE4200	A 280
	J2=J1+1	LOWE4210	A 281
	J=J1+1	LOWE4220	A 283
	YN1=YN	LOWE4230	A 282
	IF (H2.GT.Z(J1+1).OR.H1.EQ.H2) GO TO 30	LOWE4240	A 284
	IF (NP1.EQ.1.AND.H2.GE.Z(J1+1)) GO TO 30	LOWE4250	A 285
	CALL POINT (HC,YN,N,NP,IX,IP)	LOWE4260	A 286
	DO 29 K=1,KMAX	LOWE4270	NEW
29	W(K)=TX(K)	LOWE4280	A 288
	TX2=TX(9)	LOWE4290	A 289
	YX2=YN	LOWE4300	A 290
	IF (H2.LT.H1) H=H2	LOWE4310	A 291
	J2=N	LOWE4320	A 292
	IF (J1.EQ.J2) TX2=TX1+YN2-EH(9,N)	LOWE4330	A 293
	IF (H2.GT.H1) TX1=TX2	LOWE4340	A 294
	IF (J1.EQ.J2.AND.H2.LT.H1) YN1=TX2	LOWE4350	A 295
30	A0=(RF+H1)*SPH1*YN1	LOWE4360	A 296
	IF (H2.GE.H1) YN2=YN1	LOWE4370	A 297
	DO 31 I=1,J1	LOWE4380	A 298
	HMIN=A0/EH(9,I)-RE	LOWE4390	A 299
	IF (I.EQ.J1) HMIN=A0/YN1-RF	LOWE4400	A 300
	JMIN=I	LOWE4410	A 301
	IF (HMIN.LE.Z(I+1)) GO TO 32	LOWE4420	A 302
31	CONTINUE	LOWE4430	A 303
32	X=HMIN	LOWE4440	A 304
	IF (HMIN.LE.0) GO TO 34	LOWE4450	A 305
	CALL POINT (IX,YN,N,NP,IX,IP)	LOWE4460	A 306
	JM1A=N	LOWE4470	A 307
	TX3=TX(9)	LOWE4480	A 308
	IF (J2.EQ.N.OR.J1.EQ.N) TX3=YN2+TX(9)-EH(9,N)	LOWE4490	A 309
	IF (TX3.LT.0.0) TX3=TX(9)	LOWE4500	A 309*

**THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC**

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	IF (J1.EQ.N.AND.H2.GT.H1) GO TO 33	LOWE4510	A 310
	HMIN=AD/TX3-RE	LOWE4520	A 311
33	IF (ABS(X-HMIN).GT.0.0001) GO TO 32	LOWE4530	A 312
	IF (J1.EQ.N.AND.H2.GE.H1) YN1=TX3	LOWE4540	A 313
	IF (J2.EQ.N.AND.J1.NE.J2) YN2=TX3	LOWE4550	A 314
	IF (H2.GE.H1) TX2=TX3	LOWE4560	A 315
	IF (H2.GE.H1) J2=N	LOWE4570	A 316
	IF (H2.GE.H1.OR.H2.LT.HMIN) H=HMIN	LOWE4580	A 317
	PRINT 436, HMIN	LOWE4590	A 318
	IF (H2.LT.HMIN) J2=N	LOWE4600	A 318*
	IF (H2.LT.HMIN) PRINT 440, HMIN	LOWE4610	A 319
	GO TO 34	LOWE4620	A 320
34	PRINT 436, HMIN	LOWE4630	A 321
	IF (H2.LT.H1) GO TO 35	LOWE4640	A 322
	IF (ITYPF.EQ.3.OR.H2.GE.H1) PRINT 437	LOWE4650	A 323
	ITYPE=2	LOWE4660	A 324
	TX2=EH(9,1)	LOWE4670	A 325
	JMIN=0	LOWE4680	A 326
	J2=1	LOWE4690	A 327
	H2=0.0	LOWE4700	A 328
	H=0.0	LOWE4710	A 329
C****	NOW DEFINE VERTICAL PATH QUANTITIES VR(1-8)	LOWE4720	A 330
35	IF (JF.EQ.C) PRINT 420	LOWE4730	A 331*
	JSTOR=J-1	LOWE4740	NEW
	DO 40 I=1,NL	LOWE4750	A 332
	J=J-1	LOWE4760	A 333
	REF=EH(C,J)	LOWE4770	A 334
	IF (I.EQ.1) REF=YN1	LOWE4780	A 335
	IF (I.EQ.1.AND.K2.EQ.1) REF=YN2	LOWE4790	A 336
	IF (J.EQ.J2.AND.K2.EQ.0) REF=TX2	LOWE4800	A 337
	IF (I.NE.1) X1=Z(J+1)	LOWE4810	A 338
	X2=Z(J)	LOWE4820	A 339
	IF (J.EQ.J2.AND.K2.EQ.0) X2=H	LOWE4830	A 340
	IF (J.EQ.JMIN.AND.K2.EQ.1) X2=HMIN	LOWE4840	A 341
	HM=(RE+X1)*SPHI-RE	LOWE4850	A 342
	IF (HM.GT.Z(J).AND.HM.GT.X2) X2=HM	LOWE4860	A 343
	RX=(RE+X1)/(RE+X2)	LOWE4870	A 344
	DS=X1-X2	LOWE4880	A 345
	ALP=90.0	LOWE4890	A 346
	THET=ASIN(SPHI)/CA	LOWE4900	A 347
	SALP=RY*SPHI	LOWE4910	A 348
	IF (ABS(X2-HM).GT.1.0E-5) ALP=ASIN(SALP)/CA	LOWE4920	A 349
	RET=ALP-THET	LOWE4930	A 350
	IF (SPHI.GT.1.0E-10) DS=(RE+X2)*SIN(BET*CA)/SPHI	LOWE4940	A 351
	THETA=180.0-THET	LOWE4950	A 352
	BETA=BETA+RET	LOWE4960	A 353
	PSI=BETA-ALP-ANGLE+180.0	LOWE4970	A 354
	SR=SR+DS	LOWE4980	A 355
	DO 1039 K=1,KMAX	LOWE4990	NEW
	AJ=EH(K,J)	LOWE5000	A 357

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	RJ=EH(K,J+1)	LOWE5010	A 358
	IF (J.EQ.J1) RJ=E(K)	LOWE5020	A 359
	IF (J.EQ.J2.AND.H2.LT.H1.AND.H2.GT.0.0) AJ=W(K)	LOWE5030	A 360
	IF (J.EQ.JMIN.AND.H2.GF.H1) AJ=TX(K)	LOWE5040	A 361
	IF (J.EQ.JMIN.AND.ARS(H2-HM).LT.1.0E-5) AJ=TX(K)	LOWE5050	A 362
	IF (K2.EQ.0) GO TO 36	LOWE5060	A 363
	IF (J.EQ.J2) RJ=W(K)	LOWE5070	A 364
	IF (J.EQ.JMIN) AJ=TX(K)	LOWE5080	A 365
36	IF (AJ.EQ.0.0.OR.BJ.EQ.0.0) GO TO 38	LOWE5090	A 366
	IF (AJ.EQ.0.0) GO TO 37	LOWE5100	A 367
	EV=DS*(AJ-BJ)/ALOG(AJ/RJ)	LOWE5110	A 368
	GO TO 39	LOWE5120	A 369
37	EV=DS*AJ	LOWE5130	A 370
	GO TO 39	LOWE5140	A 371
38	EV=0.0	LOWE5150	A 372
39	VH(K)=VH(K)+EV	LOWE5160	A 373
1039	WLAY(J,K)=EV	LOWE5170	NEW
	IF (JP.EQ.0) PRINT 435, J,X1,(VH(L),L=1,8),PSI,ALP,BETA,THETA,SR	LOWE5180	A 374
	IF (J.EQ.J2.AND.H2.GF.H1) GO TO 45	LOWE5190	A 375
	IF (J.EQ.JMIN.AND.K2.LO.1) GO TO 43	LOWE5200	A 376
	IF (J.NE.1) RN=REF/EH(S,J-1)	LOWE5210	A 377
	IF (J.EQ.J2+1) RN=REF/TX2	LOWE5220	A 378
	IF (J.EQ.J2.AND.K2.EQ.0) RN=REF/YN2	LOWE5230	A 379
	IF (J.EQ.(JMIN+1).AND.K2.EQ.1) RN=REF/TX3	LOWE5240	A 380
	IF (SALP.GF.RN) RN=1.0	LOWE5250	A 381
	SPHI=SALP*RN	LOWE5260	A 382
	IF (J.EQ.J2.AND.K2.EQ.0) GO TO 41	LOWE5270	A 383
40	CONTINUE	LOWE5280	A 384
41	IF (HMIN.LE.0) GO TO 47	LOWE5290	A 385
	IF (LFN.EQ.0) PRINT 438	LOWE5300	A 386
	IF (LEN.EQ.0) GO TO 47	LOWE5310	A 387
	IF (LFN.EQ.1) PRINT 439	LOWE5320	A 388
	K2=1	LOWE5330	A 389
	X1=X2	LOWE5340	A 390
	IF (ARS(X1-HMIN).LE.0.001) GO TO 47	LOWE5350	A 391
	H=HMIN	LOWE5360	A 392
	J=J2+1	LOWE5370	A 393
	IF (NP2.EQ.1) J=J-1	LOWE5380	A 394
	B=BETA	LOWE5390	A 395
	PH=180.0-ASIN(SPHI)/CA	LOWE5400	A 396
	TS=SR	LOWE5410	A 397
	PS=PSI	LOWE5420	A 398
	DO 42 K=1,KMAX	LOWE5430	NEW
42	F(K)=VH(K)	LOWE5440	A 400
	GO TO 35	LOWE5450	A 401
43	BETA=2.*BETA-B	LOWE5460	A 402
	PSI=2.*PSI-PS	LOWE5470	A 403
	SR=2.*SR-TS	LOWE5480	A 404
C	LONG PATH TAKEN	LOWE5490	A 405
	PHI=PH	LOWE5500	A 406

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	DO 44 K=1,KMAX	LOWE 5510	NLW
44	VH(K)=2.*VH(K)-1.(K)	LOWE 5520	A 408
	GO TO 47	LOWE 5530	A 409
45	DO 46 K=1,KMAX	LOWE 5540	NLW
46	VH(K)=2.0*VH(K)	LOWE 5550	A 411
	RETA=2.0*RETA	LOWE 5560	A 412
	SR=2.0*SR	LOWE 5570	A 413
	IF (H2.EQ.H1) GO TO 47	LOWE 5580	A 414
	RN=TX1/YN1	LOWE 5590	A 415
	SPH1=SIN(ANGLE*CA)	LOWE 5600	A 416
	IF (SPH1.LT.RN) SPH1=SPH1/RN	LOWE 5610	A 417
	GO TO 19	LOWE 5620	A 418
47	CONTINUE	LOWE 5630	A 419
	IF (ANGLE.GT.90.0) PRINT 406,HN	LOWE 5640	A 419
	DO 48 K=1,KMAX	LOWE 5650	NLW
	W(K)=VH(K)	LOWE 5660	A 421
48	CONTINUE	LOWE 5670	A 422
49	WRITE (6,419)	LOWE 5680	A 423
	WRITE (6,1155)	LOWE 5690	NLW
	WRITE (6,421) (W(I),I=1,8),W(11),W(11)	LOWE 5700	NLW
	WRITE (7,3000) N,IMAZE,ITYPE,M1,ANGLE,HHIN,V1,V2,DV	LOWE 5710	NLW
3000	FORMAT(113,6F11.4)	LOWE 5720	NLW
	I=1	LOWE 5730	A 425
	L=1	LOWE 5740	A 426
	IV1=V1/5.0	LOWE 5750	A 427
	IV2=V2/5.+.99	LOWE 5760	A 428
	IV1=5*IV1	LOWE 5770	A 429
	IV2=5*IV2	LOWE 5780	A 430
	IF (IV1.LT.350) IV1=350	LOWE 5790	A 431
	IF (IV2.GT.50000) IV2=50000	LOWE 5800	A 432
	IF (DV.LT.5.) DV=5.	LOWE 5810	A 433
	IV=DV	LOWE 5820	A 434
	IV=IV1-IV	LOWE 5830	A 435
	ICOUNT=0	LOWE 5840	A 436
	IF (IFMISS.EQ.0) GO TO 50	LOWE 5850	NLW
	RADSUM=0.0	LOWE 5860	NLW
	FACTOR=0.5	LOWE 5870	NLW
	CALL PATH(WLAY,WPATH,IBBY)	LOWE 5880	NLW
	PRINT 1156	LOWE 5890	NLW
	PRINT 1157	LOWE 5900	NLW
	IF (IFMISS.EQ.0) IKMAX=IKLO	LOWE 5910	NLW
0****	BEGINNING OF TRANSMITTANCE CALCULATIONS	LOWE 5920	A 437
50	IV=IV*IV	LOWE 5930	A 438A
	SUMV=0.	LOWE 5940	NLW
	TLOLD=1. \$ TSOLD=1.	LOWE 5950	NLW
	IKLO=1	LOWE 5960	NLW
	IF (IFMISS.EQ.0) IKLO=IKMAX	LOWE 5970	NLW
	DO 1050 IK=IKLO,IKMAX	LOWE 5980	NLW
	IF (IFMISS.EQ.0) GO TO 1056	LOWE 5990	NLW
	DO 1052 K=1,KMAX	LOWE 6000	NLW

THIS PAGE IS BEST QUALITY PRACTICALLY
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

W(K)=WPATH(IK,K)	LOWE6010	NEW
1052 CONTINUE	LOWE6020	NEW
1055 IJ=IK	LOWE6030	NEW
IF(JP.NE.0) GO TO 52	LOWE6040	A 438
IF (ICOUNT,EO.0) GO TO 51	LOWE6050	A 439
IF (ICOUNT,EQ,50) GO TO 51	LOWE6060	A 440
GO TO 52	LOWE6070	A 441
51 ICOUNT=0	LOWE6080	A 442
IF(IFMISS.EQ.0) PRINT 422	LOWE6090	NEW
52 DO 53 K=1,KMAX	LOWE6100	NEW
TX(K)=0.0	LOWE6110	A 445
IF (K.LT.4) TX(K)=1.0	LOWE6120	A 446
53 CONTINUE	LOWE6130	A 447
ICOUNT=ICOUNT+1	LOWE6140	A 448
SUM=0.0	LOWE6150	A 449
V=IV	LOWE6160	A 450
I=(IV-350)/5+1	LOWE6170	A 451
C ***** HNO3	LOWE6180	NEW
C HNO3 ABSORPTION CALCULATION	LOWE6190	NEW
CALL HNO3 (V,HARS)	LOWE6200	NEW
TX(11)=HARS*W(11)	LOWE6210	NEW
SUM=SUM+TX(11)	LOWE6220	NEW
IF (IV.LT.670) GO TO 72	LOWE6230	*A 452*
IF (IV.LE.3000) GO TO 61	LOWE6240	*A 453*
C ***** MOLECULAR SCATTERING	LOWE6250	A 454
C6=9.807E-2*(V**4.0117)	LOWE6260	A 455
TX(6)=C6*W(6)	LOWE6270	A 456
SUM=SUM+TX(6)	LOWE6280	A 457
IF (IV.LT.9200) GO TO 72	LOWE6290	A 458
IF (IV.LT.13000) GO TO 69	LOWE6300	A 459
C ***** UV OZONE	LOWE6310	A 460
IF (IV.LE.23400) GO TO 54	LOWE6320	A 461
IF (IV.GE.27500) GO TO 55	LOWE6330	A 462
GO TO 67	LOWE6340	A 463
54 XX=200.0	LOWE6350	A 464
XI=(V-13000.0)/XX+1.0	LOWE6360	A 465
L1=1	LOWE6370	A 466
L2=53	LOWE6380	A 467
GO TO 56	LOWE6390	A 468
55 XX=500.0	LOWE6400	A 469
XI=(V-27500.0)/XX+57.0	LOWE6410	A 470
L1=57	LOWE6420	A 471
L2=102	LOWE6430	A 472
56 DO 57 N=L1,L2	LOWE6440	A 473
X0=XI-FLOAT(N)	LOWE6450	A 474
IF (X0) 59,50,57	LOWE6460	A 475
57 CONTINUE	LOWE6470	A 476
58 TX(8)=W(8)*C8(N)	LOWE6480	A 477
GO TO 60	LOWE6490	A 478
59 TX(8)=C8(N)+X0*(C8(N)-C8(N-1))	LOWE6500	A 479

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

TX(8)=W(8)*TX(8)	LOWE6510	A 480
60 SUM=SUM+TX(8)	LOWE6520	A 481
IF(IV.GT.14500)GO TO 87	LOWE6530	A 482
GO TO 59	LOWE6540	A 483
C***** WATER VAPOR CONTINUUM 10 MICRON REGION	LOWE6550	A 484
61 IF(IV.GT.1350) GO TO 67	LOWE6560	A 485
TX(5)=(4.18+5578.0*EXP(-7.87E-3*V))*W(5)	LOWE6570	A 486
GO TO 66	LOWE6580	A 487
62 IF(IV.LT.2350) GO TO 68	LOWE6590	A 488
C***** WATER VAPOR CONTINUUM 4 MICRON REGION	LOWE6600	A 489
XI=(V-2350.0)/50.0+1.0	LOWE6610	A 490
NH=XI+1.001	LOWE6620	A 491
XH=XI-FLOAT(NH)	LOWE6630	A 492
TX(5)=C5(NH)	LOWE6640	A 493
64 TX(5)=TX(5)+XH*(C5(NH)-C5(NH-1))	LOWE6650	A 494
65 TX(5)=TX(5)*W(10)	LOWE6660	A 495
66 SUM=SUM+TX(5)	LOWE6670	A 496
IF(IV.LE.1350.OR.IV.GT.2740) GO TO 72	LOWE6680	A 497
C***** NITROGEN CONTINUUM	LOWE6690	A 500
68 IF(IV.LT.2080) GO TO 72	LOWE6700	A 501
K4=I-346	LOWE6710	A 502
TX(4)=C4(K4)*W(4)	LOWE6720	A 503
SUM=SUM+TX(4)	LOWE6730	A 504
GO TO 72	LOWE6740	A 505
C***** WATER VAPOUR	LOWE6750	A 506
69 IF(IV.LT.12800.AND.IV.GE.9875) GO TO 70	LOWE6760	A 507
IF(IV.LE.14520.AND.IV.GE.13400) GO TO 71	LOWE6770	A 508
GO TO 76	LOWE6780	A 509
70 I=I-135	LOWE6790	A 510
GO TO 72	LOWE6800	A 511
71 I=I-255	LOWE6810	A 512
72 K1=1	LOWE6820	A 513
IF(W(1).LT.1.0E-20) GO TO 76	LOWE6830	A 514
WS1=ALOG10(W(1))+C1(I)	LOWE6840	A 515
IF(WS1.LT.-2.3468) TX(1)=1.-.087787*EXP(1.855595*WS1)	LOWE6850	NEW
IF(WS1.LT.-2.3468) GO TO 76	LOWE6860	A 516
IF(WS1.GT.3.5682) GO TO 75	LOWE6870	A 517
IF(WS1.GT.2.0) K1=40	LOWE6880	A 518
DO 73 K=K1,67	LOWE6890	A 519
IF(WS1.LE.FW(K)) GO TO 74	LOWE6900	A 520
73 CONTINUE	LOWE6910	A 521
74 TX(1)=TR(K)+(TR(K-1)-TR(K))*(FW(K)-WS1)/(FW(K)-FW(K-1))	LOWE6920	A 522
GO TO 76	LOWE6930	A 523
75 TX(1)=6.0	LOWE6940	A 524
76 CONTINUE	LOWE6950	A 525
C***** UNIFORMLY MIXED GASES	LOWE6960	A 526
IF(IV.LT.8060.AND.IV.GE.500) GO TO 77	LOWE6970	A 527
IF(IV.LT.13190.AND.IV.GT.12970) GO TO 78	LOWE6980	A 528
GO TO 83	LOWE6990	A 529
77 J=I-30	LOWE7000	A 530

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO LDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

78	GO TO 74	LOWE 7010	A 531
	J=(IV-12950)/5+1516	LOWE 7020	A 532
79	IF(W(2).LT.1.0E-20) GO TO 83	LOWE 7030	A 533*
	K1=1	LOWE 7040	A 534
	WS2=ALOG10(W(2))*C2(J)	LOWE 7050	A 535
	IF (WS2.LT.-2.3468) TX(2)=1.-.087747*EXP(1.855595*WS2)	LOWE 7060	NEH
	IF (WS2.LT.-2.3468) GO TO 83	LOWE 7070	A 536
	IF (WS2.GT.3.5682) GO TO 87	LOWE 7080	A 537
	IF (WS2.GT.2.0) K1=40	LOWE 7090	A 538
	DO 80 K=K1,67	LOWE 7100	A 539
	IF (WS2.LE.FW(K)) GO TO 81	LOWE 7110	A 540
80	CONTINUE	LOWE 7120	A 541
81	TX(2)=TR(K)+(TR(K-1)-TR(K))*(FW(K)-WS2)/(FW(K)-FW(K-1))	LOWE 7130	A 542
	GO TO 83	LOWE 7140	A 543
82	TX(2)=0.0	LOWE 7150	A 544
83	CONTINUE	LOWE 7160	A 545
C*****	OZONE	LOWE 7170	A 546
	IF (IV.LT.575.0R, IV.GT.3270) GO TO 87	LOWE 7180	A 546*
	L=1-45	LOWE 7190	A 547
	K1=1	LOWE 7200	A 548
	IF (W(3).LT.1.0E-20) GO TO 87	LOWE 7210	A 549
	WS3=ALOG10(W(3))+C3(L)	LOWE 7220	A 550
	IF (WS3.LT.-1.6778) TX(3)=1.-.055194*EXP(2.367853*WS3)	LOWE 7230	NEH
	IF (WS3.LT.-1.6778) GO TO 87	LOWE 7240	A 551
	IF (WS3.GT.3.9345) GO TO 86	LOWE 7250	A 552
	IF (WS3.GT.1.5) K1=36	LOWE 7260	A 553
	DO 84 K=K1,67	LOWE 7270	A 554
	IF (WS3.LE.FO(K)) GO TO 85	LOWE 7280	A 555
84	CONTINUE	LOWE 7290	A 556-
85	TX(3)=TR(K)-(TR(K)-TR(K-1))*(FO(K)-WS3)/(FO(K)-FO(K-1))	LOWE 7300	A 558
	GO TO 87	LOWE 7310	A 559
86	TX(3)=0.0	LOWE 7320	A 560
87	CONTINUE	LOWE 7330	A 561
C*****	AEROSOL EXTINCTION	LOWE 7340	A 562
	ALAM=1.0E+4/V	LOWE 7350	A 563A
	XX=0.0	LOWE 7360	A 563B
	YY=0.0	LOWE 7370	A 563C
C*****	TEMPORARY FOG CORRECTION FOR VIS BELOW 2 KM.	LOWE 7380	A 563U
C	IF(VIS.GT.0.0.AND.VIS.LT.2.0) XX=0.158	LOWE 7390	NEH
C	TEMPORARY FOG SUPPRESSED	LOWE 7400	NEH
	IF (IHATE.FO.0.0R, XX.GT.0.0) GO TO 90	LOWE 7410	A 564*
	DO 88 N=1,44	LOWE 7420	A 565*
	XD=ALAM-VX(N)	LOWE 7430	A 566*
	IF(XD)89,88,88	LOWE 7440	A 567*
88	CONTINUE	LOWE 7450	A 568A
89	XX=(C7(N)-C7(N-1))*XD/(VX(N)-VX(N-1))+C7(N)	LOWE 7460	A 568B
	YY=(C7A(N)-C7A(N-1))*XD/(VX(N)-VX(N-1))+C7A(N)	LOWE 7470	A 568C
90	TX(10)=YY*M(7)	LOWE 7480	A 568D
	TX(7)=XX*M(7)	LOWE 7490	A 569*
	SUM=SUM+TX(7)	LOWE 7500	A 570

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	TX(9)=SUM	LOWE7510	A 571
	DO 94 K=4,KMAX	LOWE7520	NEW
	IF (TX(K).EQ.0.0) GO TO 92	LOWE7530	A 573
	IF (TX(K).LE.0.1) GO TO 91	LOWE7540	A 574
	IF (TX(K).GT.20.) GO TO 93	LOWE7550	A 575
	TX(K)=EXP(-TX(K))	LOWE7560	A 576
	GO TO 94	LOWE7570	A 577
91	TX(K)=1.0-TX(K)+0.5*TX(K)*TX(K)	LOWE7580	A 578
	GO TO 94	LOWE7590	A 579
92	TX(K)=1.0	LOWE7600	A 580
	GO TO 94	LOWE7610	A 581
93	TX(K)=0.	LOWE7620	A 582
94	CONTINUE	LOWE7630	A 583
	TX(9)=TX(1)*TX(2)*TX(3)*TX(4)	LOWE7640	A 584
	IF (IV.GE.13000) TX(3)=TX(8)	LOWE7650	A 585
	IF (IEMISS.EQ.0) GO TO 1210	LOWE7660	NEW
	ALAM=1.0E+04/V	LOWE7670	NEW
	ARRK=FF(TBBY(IK),V)	LOWE7680	NEW
	TLNEW=(TX(9)*TX(10))/(TX(7)*TX(6))	LOWE7690	NEW
	TSNEW=(TX(7)*TX(6))/TX(10)	LOWE7700	NEW
	DTAU=TLOLD-TLNEW	LOWE7710	NEW
	IF (DTAU.LT.1.0E-5.AND.TLNEW.LT.1.0E-5) GO TO 1104	LOWE7720	NEW
	SUMV=SUMV+0.5*ARRK*DTAU*(TSOLD+TSNEW)	LOWE7730	NEW
	TLOLD=TLNEW \$ TSOLD=TSNEW	LOWE7740	NEW
1050	CONTINUE	LOWE7750	NEW
1104	CONTINUE	LOWE7760	NEW
	TAUG=0	LOWE7770	NEW
	IF (HMIN.LE.0.0.AND.IL.EQ.1) TAUG=TX(9)	LOWE7780	NEW
	T1=T(M,1)	LOWE7790	NEW
	IF (TROUND.GT.0.0) T1=TROUND	LOWE7800	NEW
	ARR=FF(T1,V)*TAUG	LOWE7810	NEW
	IF (HMIN.LE.0) SUMV=SUMV+ARR	LOWE7820	NEW
	SUMVV=SUMV	LOWE7830	NEW
	IF (IV.GT.1V1) FACTOR=1.0	LOWE7840	NEW
	IF (IV.GE.1V2) FACTOR=0.5	LOWE7850	NEW
	SUMV=(1.0E+04/V**2)*SUMV	LOWE7860	NEW
	RADSUM=RADSUM+DV*FACTOR*SUMV	LOWE7870	NEW
	IF (JP.EQ.0) PRINT 1160, V,ALAM,SUMV,SUMVV,RADSUM,TX(9)	LOWE7880	NEW
	IF (SUMV.GE.RADMAX) VRMAX=V	LOWE7890	NEW
	IF (SUMV.GE.RADMAX) RADMAX=SUMV	LOWE7900	NEW
	IF (SUMV.LE.RADMIN) VRMIN=V	LOWE7910	NEW
	IF (SUMV.LE.RADMIN) RADMIN=SUMV	LOWE7920	NEW
	WRITE(7,3010) V,SUMV,SUMVV,RADSUM,TX(9),TX(1)	LOWE7930	NEW
3010	FORMAT(F10.1,11F10.3)	LOWE7940	NEW
1210	TX(10)=1.-TX(10)	LOWE7950	NEW
	AR=1.-TX(9)	LOWE7960	A 586B
	IF (IV.EQ.1V1.OR.1V.EQ.1V2) AR=0.5*AR	LOWE7970	A 586C
	SUMA=SUMA+AR*DV	LOWE7980	A 586D
	IF (IEMISS.EQ.1) GO TO 1220	LOWE7990	NEW
	IF (JP.EQ.0) WRITE(6,423) IV,ALAM,TX(9),(TX(K),K=1,7),TX(10),SUMA	LOWE8000	A 587*

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

1720	CONTINUE	LOWE8010	NEW
	IF (IV,GE,IV2) GO TO 95	LOWE8020	A 588
	GO TO 50	LOWE8030	A 589
95	READ 400, IXV	LOWE8040	A 590
	IF (IEMISS,EQ,1) PRINT 1175,VRMIN,RADMIN,VRMAX,RADMAX	LOWE8050	NEW
1175	FORMAT(* RADMIN *,F12.3,E12.5,/,* RADMAX *,F12.3,F12.5)	LOWE8060	NEW
	ENDFILE 7	LOWE8070	NEW
	JSTOR=0 \$ IFIND=0	LOWE8080	NEW
	AB=1.0-SUMA/FLOAT(IV2-IV1)	LOWE8090	NEW
	PRINT 424, IV1,IV2,SUMA,AB	LOWE8100	A 591B
	IF (IEMISS,EQ,1) PRINT 443,RADSUM	LOWE8110	NEW
443	FORMAT(* INTEGRATED RADIANCE =*,F12.5,* WATT CM -2 SR*)	LOWE8120	NEW
	PRINT 400,IXV	LOWE8130	A 591C
	IF (IXV,EQ,0) GO TO 100	LOWE8140	A 591D
	GO TO 196,2,97,9A,1001,IXV	LOWE8150	A 591E
96	READ 406, V1,V2,OV	LOWE8160	A 592
	AVH=10000./V1	LOWE8170	A 593
	ALAM=10000./V2	LOWE8180	A 594
	PRINT 418, V1,V2,OV,ALAM,AVH	LOWE8190	A 595
	SUMA=0.0	LOWE8200	A 596*
	GO TO 47	LOWE8210	NEW
97	IF (MODEL,EQ,0) GO TO 200	LOWE8220	A 598A
	GO TO 300	LOWE8230	A 598B
98	READ 400,MODEL,HAZF,ITYPE,LEN,JP,IM,M1,M2,M3,ML,IEMISS,RO,TBOUND	LOWE8240	NEW
	IF (IEMISS,EQ,1) PRINT 1170	LOWE8250	NEW
	IF (IEMISS,EQ,0) PRINT 1171	LOWE8260	NEW
	LENSTOP=LEN	LOWE8270	NEW
	PRINT 400,MODEL,HAZF,ITYPE,LEN,JP,IM,M1,M2,M3,ML,IEMISS,RO,TBOUND	LOWE8280	NEW
	GO TO 200	LOWE8290	A 598E
100	STOP	LOWE8300	A 599*
400	FORMAT(1113,2F10.3)	LOWE8310	NEW
1170	FORMAT(*1 PROGRAM WILL BE EXECUTED IN THE EMISSION MODE*)	LOWE8320	NEW
1171	FORMAT(*1 PROGRAM WILL BE EXECUTED IN THE TRANSMISSION MODE*)	LOWE8330	NEW
401	FORMAT (8F10.3)	LOWE8340	A 601
402	FORMAT (F6.1,2(F10.3,F6.1,2F10.3))	LOWE8350	A 602
403	FORMAT (4(F6.3,2F7.4))	LOWE8360	A 603
404	FORMAT (15F5.2)	LOWE8370	A 604
405	FORMAT (8E9.2)	LOWE8380	A 605
406	FORMAT (7F10.3)	LOWE8390	A 606
407	FORMAT (//10X,28H HORIZONTAL PATH, ALTITUDE =,F7.3,11H KM,RANGE =,LOWE8400	LOWE8400	A 607
	1F7.3,3H KM)	LOWE8410	A 608
408	FORMAT (//10X,50H SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1	LOWE8420	A 609
	1=,F7.3,8H KM H2 =,F7.3,18H KM,ZENITH ANGLE =,F7.3,8H DEGREES)	LOWE8430	A 610
409	FORMAT (//10X,39H SLANT PATH TO SPACE FROM ALTITUDE H1 =,F7.3,19H	LOWE8440	A 611
	1KM, ZENITH ANGLE =,F7.3,8H DEGREES)	LOWE8450	A 612
410	FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,11H = TROPICAL)	LOWE8460	A 613
411	FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,21H = MIDLATITUDE SUMMER)	LOWE8470	A 614
412	FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,21H = MIDLATITUDE WINTER)	LOWE8480	A 615
413	FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,21H = SUB-ARCTIC SUMMER)	LOWE8490	A 616
414	FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,21H = 1962 US STANDARD)	LOWE8500	A 617

**THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC**

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

```

415 FORMAT (/20X,18H MODEL ATMOSPHERE ,I1,21H = SUB-ARCTIC WINTER ) LOWE8510 A 618
416 FORMAT (/20X,18H HAZE MODEL ,I1,3H = ,A5,13H VISUAL RANGE) LOWE8520 A 619
417 FORMAT (/25X*HAZE MODEL =*,F5.1,* KM VISUAL RANGE AT SEA LEVEL*) LOWE8530 A 620
418 FORMAT (/10X,21H FREQUENCY RANGE V1= ,F7.1,13H CM-1 TO V2= ,F7.1,1LOWE8540 A 621
14H CM-1 FOR DV = ,F6.1,04 CM-1 (,F6.2,* - *,F6.2,* MICRONS *) LOWE8550 A 622
419 FORMAT (/10X,36H EQUIVALENT SEA LEVEL ABSORBER AMOUNTS//21X110HHAZELOWE8560 A 623
1ER VAPOUR CO2 ETC. OZONE NITROGEN (CONT) H2O (CONT) LOWE8570 A 624
2 MOL SCAT AEROSOL OZONE (U-V)/24X,7HGM CM-2,1X,2HGM,1LOWE8580 A 625
30X,6HATM CM,10X,2HGM,9X,7HGM CM-2,10X,2HGM,13X,2HGM,10X,1HATM CM) LOWE8590 A 626
420 FORMAT (1H1,///10X,* VERTICAL PROFILES *,64X,*PSI*,6X,*PHI*,6X,*LOWE8600 A 627
1RFTA*,4X,*THETA RANGE*) LOWE8610 A 628
421 FORMAT (/10X,8H W(1-8)=8(E14.3)/ 74X,E14.3,28X,E14.3/) LOWE8620 NEW
422 FORMAT (1H1,///10X,32H REF0 WAVELENGTH TOTAL H2O,5X4HCO2+,5X,6LOWE8630 A 630*
14H OZONE N2 CONT H2O CONT MOL SCAT AEROSOL AEROSOL INTEGRATEDLOWE8640 A 631*
2 /11X,14H CM-1 MICRONS,9(4XGHTRANS),4X,20H ABS ABSORPTION ) LOWE8650 A 632*
423 FORMAT(13X,16,11F9.4) LOWE8660 NEW
424 FORMAT (* INTEGRATED ABSORPTION FROM*,I5,* Y0*,I5,* CM-1 =*,F10.2,LOWE8670 A 634A
1*,AVERAGE TRANSMITTANCE =*,F6.4) LOWE8680 A 634B
425 FORMAT (10X,7F10.3) LOWE8690 A 635
426 FORMAT (/20X,*AEROSOL SCATTERING NOT COMPUTED,1HAZE=0*) LOWE8700 A 636
427 FORMAT (1H1,///10X,20H HORIZONTAL PROFILES/) LOWE8710 A 637
428 FORMAT (10X,* H1=*,F7.3,*KM,H2=*,F7.3,*KM,ANGLE=*,F6.4,*GEOM. RANGELOWE8720 A 638
1E =*,F7.2,*KM,BETA=*,F8.5,*VIS=*,F6.1) LOWE8730 A 639
429 FORMAT(3F10.3,7F5.1,2E10.1,2F10.3) LOWE8740 A 640*
430 FORMAT(10X,*INPUT METEOROLOGICAL DATA*/10X,*Z=*,F7.2,* KM, P=*,F7LOWE8750 A 641*
1.2,* MB,T=*,F5.1,* C, DEW PT.TEMP*,F5.1,* C, REL HUMIDITY=*,F5.1, LOWE8760 A 642*
2* %, H2O DENSITY=*,1PE9.2,* GM M-3*/10*,* OZONE DENSITY=*,14.2,* GLOWE8770 A 643*
3M-3, VISUAL RANGE=*,0PF6.1,* KM,RANGE=*,F10.3,* KM *) LOWE8780 A 644*
431 FORMAT(6F6.2,2F7.5) LOWE8790 A 645*
432 FORMAT (* STARTING PARAMETERS H1 AND ANGLE HAVE BEEN REDEFINEDH1=LOWE8800 A 646
1 *,F10.3,ANGLE =*,F10.6) LOWE8810 A 647
433 FORMAT (* TRAJECTORY MISSES EARTH'S ATMOSPHERE. CLOSEST DISTANCE OFLOWE8820 A 648
1 APPROACH IS*,F10.2,1X,/,1X,*END OF CALCULATION*) LOWE8830 A 649
434 FORMAT (10X,I4,F6.1,11(E10.3)) LOWE8840 A 650
435 FORMAT (15,F7.1,8F10.3,4F9.4,F7.1) LOWE8850 A 651
436 FORMAT (* HMIN = *,F10.3) LOWE8860 A 652
437 FORMAT (* PATH INTERSECTS EARTH - PATH CHANGED TO TYPE 2 WITH H2 =LOWE8870 A 653
1 0.0 KM*) LOWE8880 A 654
438 FORMAT (* CHOICE OF TWO PATHS FOR THIS CASE -SHORTEST PATH TAKEN. LOWE8890 A 655
1 FOR LONGER PATH SET LEN=1.0*) LOWE8900 A 656
439 FORMAT (* CHOICE OF TWO PATHS FOR THIS CASE -LONGEST PATH TAKEN. LOWE8910 A 657
1 FOR SHORT PATH SET LEN = 0 *) LOWE8920 A 658
440 FORMAT (* H2 WAS SET LESS THAN HMIN AND HAS BEEN RESET EQUAL TO LOWE8930 A 659
1 HMIN I.E. H2 = *,F10.3) LOWE8940 A 660
441 FORMAT(* MODEL ATMOSPHERE NO. 7*/ 4X,*7 (KM)*,3X,*P (M3)*,4X, LOWE8950 A 661*
1 *T (C) DEW PT 1/2RH H2O(GM.M-3) O3(GM.M-3) NO. DEN.*) LOWE8960 A 662*
442 FORMAT(* FOG CONDITIONS MAY EXIST AT SEA LEVEL FOR THIS VISUAL RALOWE8970 A 663*
1NGE*,/,* IF SO THEN ASSUME THE TRANSMITTANCE DUE TO FOG IS GIVEN LOWE8980 A 664*
2BY THE TRANSMITTANCE AT 0.55 MICRONS*) LOWE8990 A 665*
1109 FORMAT (9I3) LOWE9000 NEW

```

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

1155	FORMAT (11X,*NITRIC ACID*)	LOWE9010	NEW
1156	FORMAT (1H1,50X,*RADIANCE(WATTS/CM2-STER-XXX)*)	LOWE9020	NEW
1157	FORMAT (30X,*FR(CM-1) WVL(MICRON) PER CM-1 PER MICRON*,*	LOWE9030	NEW
1	INTEGRAL TRANS*)	LOWE9040	NEW
1160	FORMAT(30X,F8.1,F13.6,3E11.5,F13.6)	LOWE9050	NEW
	END	LOWE9060	A 666*

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

SUBROUTINE PATH(WLAY, WPATH, TBBY)	PATH 10	NEW
COMMON Z(34), P(7,34), T(7,34), EH(11,34), MH(7,34), M, NL, RE, CW, CO, PI	PATH 20	NEW
DIMENSION WLAY(34,11), TBBY(68), WPATH(68,11)	PATH 30	NEW
COMMON /EM1/ IEMISS, KMAX, ANGLE, LEN, HMIN, IJ, J1, J2, JMIN, JEXTRA, ITYPE	PATH 40	NEW
COMMON /EM2/ IL, IKMAX, LENSTOR, NLL, W(11), E(11)	PATH 50	NEW
COMMON /EM3/ H1, H2, NP1, MODEL	PATH 60	NEW
IF (ITYPE.EQ.1) GO TO 2000	PATH 70	NEW
IF (ITYPE.EQ.2.AND.H1.EQ.H2) J2=J1	PATH 80	NEW
IF (H2.GT.H1.AND.ANGLE.GT.90..AND.NP1.EQ.1) J1=J1-1	PATH 90	NEW
IF (JEXTRA.EQ.1) J2=J2+1	PATH 100	NEW
IF ((ITYPE.EQ.2).AND.(H1.GT.H2).AND.(LENSTOR.EQ.1)) J2=J2-1	PATH 110	NEW
IF (ITYPE.EQ.3) J2=NLL	PATH 120	NEW
PRINT 1109, J1, J2	PATH 130	NEW
1109 FORMAT(9I4)	PATH 140	NEW
PRINT 910	PATH 150	NEW
910 FORMAT (///,23X,* CUMULATIVE ABSORBER AMOUNTS FOR THE ATMOSPHERE	PATH 160	NEW
11C PATH*,//	PATH 170	NEW
210X,*H2O*,6X,*CO2*,8X,*O3*,9X,*N2*,8X,*H2O C*,6X,*MOL S*,7X,	PATH 180	NEW
3 *AFRC*,5X,*O3 UV*,7X,*H2O C*,7X,*HNO3*,5X,*TAVE*)	PATH 190	NEW
DO 1052 IK=1,68	PATH 200	NEW
TBBY(IK)=0.	PATH 210	NEW
DO 1052 K=1,KMAX	PATH 220	NEW
WPATH(IK,K)=0.	PATH 230	NEW
1052 CONTINUE	PATH 240	NEW
LEN=0	PATH 250	NEW
NLL=NLL-1	PATH 260	NEW
IL=J1+1	PATH 270	NEW
IJ=IL+NLL	PATH 280	NEW
DO 1060 K=1,KMAX	PATH 290	NEW
E(K)=0.	PATH 300	NEW
1060 CONTINUE	PATH 310	NEW
IF (ANGLE.GT.90.0) GO TO 1061	PATH 320	NEW
LEN=1.	PATH 330	NEW
IL=J1-1	PATH 340	NEW
HMIN=1.0E-6	PATH 350	NEW
IJ=NLL	PATH 360	NEW
1061 CONTINUE	PATH 370	NEW
DO 1050 IK=1,68	PATH 380	NEW
IF (LEN.EQ.0) IL=IL-1	PATH 390	NEW
IF (LEN.EQ.1) IL=IL+1	PATH 400	NEW
IJ=IJ-1	PATH 410	NEW
IF (IL.EQ.0) GO TO 1050	PATH 420	NEW
DO 1064 K=1,KMAX	PATH 430	NEW
W(K)=E(K)+WLAY(IL,K)	PATH 440	NEW
WPATH(IK,K)=W(K)	PATH 450	NEW
1064 CONTINUE	PATH 460	NEW
IF (IL.LE.0.OR.IL.GE.NL) GO TO 1053	PATH 470	NEW
TBAR=(T(M,IL)+T(M,IL+1))*0.5	PATH 480	NEW
C JEXTRA IS 1 ONLY WHEN PROGRAM NEVER LEAVES ONE LAYER	PATH 490	NEW
IF (JEXTRA.EQ.1) TBAR=(T(M,J1)+T(M,J1+1))*0.5	PATH 500	NEW

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

1053	CONTINUE	PATH 510	NEW
	TBBY(IK)=TBR	PATH 520	NEW
	DO 1103 K=1,KMAX	PATH 530	NEW
	F(K)=W(K)	PATH 540	NEW
1103	CONTINUE	PATH 550	NEW
	IF (ANGLE.LE.90.0.AND.IL.EQ.NULL) GO TO 1104	PATH 560	NEW
	IF (ITYPE.EQ.1.AND.ANGLE.LE.90.0) GO TO 1062	PATH 570	NEW
	IF (ITYPE.EQ.2.AND.LEN.EQ.1.AND.IL.EQ.J2) GO TO 1104	PATH 580	NEW
	IF (ITYPE.EQ.2.AND.LENSTOR.EQ.0.AND.IL.EQ.J2) GO TO 1104	PATH 590	NEW
	IF (IL.EQ.JMIN.AND.HMIN.GT.0) LEN=1	PATH 600	NEW
	IF (IL.EQ.1.AND.HMIN.LE.0.0) GO TO 1104	PATH 610	NEW
	IF (LEN.EQ.3) GO TO 1062	PATH 620	NEW
	IF (IL.EQ.JMIN.AND.IJ.EQ.IL+NULL) IL=IL-1	PATH 630	NEW
	IF (ITYPE.EQ.2.AND.IL.EQ.J2) GO TO 1104	PATH 640	NEW
1062	CONTINUE	PATH 650	NEW
	PRINT900,IK,(WPATH(IK,K),K=1,8),WPATH(IK,10),WPATH(IK,11),TBBY(IK)	PATH 660	NEW
1050	CONTINUE	PATH 670	NEW
	IKMAX=F8	PATH 680	NEW
	LEN=LENSTOR	PATH 690	NEW
	RETURN	PATH 700	NEW
1104	CONTINUE	PATH 710	NEW
	PRINT900,IK,(WPATH(IK,K),K=1,8),WPATH(IK,10),WPATH(IK,11),TBBY(IK)	PATH 720	NEW
	IKMAX=IK	PATH 730	NEW
	LEN=LENSTOR	PATH 740	NEW
	RETURN	PATH 750	NEW
2000	DO 2052 K=1,KMAX	PATH 760	NEW
	WPATH(1,K)=W(K)	PATH 770	NEW
2052	CONTINUE	PATH 780	NEW
	IF (MODEL.EQ.0) J1=1	PATH 790	NEW
	J2=J1	PATH 800	NEW
	TBBY(1)=1(N,J1)	PATH 810	NEW
	IKMAX=1	PATH 820	NEW
	PRINT 1109, J1,J2	PATH 830	NEW
	PRINT 910	PATH 840	NEW
	IK=1	PATH 850	NEW
	PRINT900,IK,(WPATH(IK,K),K=1,8),WPATH(IK,10),WPATH(IK,11),TBBY(IK)	PATH 860	NEW
	HMIN=1.0E-6	PATH 870	NEW
	RETURN	PATH 880	NEW
900	FORMAT(I5,10F11.3,F10.3)	PATH 890	NEW
	END	PATH 900	NEW

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDG

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

SUBROUTINE HNO3 (V,HARS)	HNO3 10	NEW
DIMENSION H1(15), H2(16), H3(13)	HNO3 20	NEW
C ARRAY H1 CONTAINS HNO3 ABS, COEF (CM-1ATM-1) FROM 850 TO 920 CM-1	HNO3 30	NEW
DATA H1/2.197,3.911,6.154,8.150,9.217,9.461,11.56,11.10,11.17,12.4	HNO3 40	NEW
10,10.49,7.509,6.136,4.899,2.866/	HNO3 50	NEW
C ARRAY H2 CONTAINS HNO3 ABS, COEF (CM-1ATM-1) FROM 1275 TO 1350 CM-1	HNO3 60	NEW
DATA H2/2.824,4.611,6.755,8.759,10.51,13.74,18.00,21.51,23.09,21.6	HNO3 70	NEW
18,21.32,16.62,16.42,17.87,14.86,8.716/	HNO3 80	NEW
C ARRAY H3 CONTAINS HNO3 ABS, COEF (CM-1ATM-1) FROM 1675 TO 1735 CM-1	HNO3 90	NEW
DATA H3/5.003,8.803,14.12,19.83,21.31,23.58,23.22,21.09,26.99,25.8	HNO3 100	NEW
14,24.79,17.68,9.420/	HNO3 110	NEW
HARS=0.	HNO3 120	NEW
IF (V.GE.850.0.AND.V.LE.920.0) GO TO 1000	HNO3 130	NEW
IF (V.GE.1275.0.AND.V.LE.1350.0) GO TO 1001	HNO3 140	NEW
IF (V.GE.1675.0.AND.V.LE.1735.0) GO TO 1002	HNO3 150	NEW
GO TO 1003	HNO3 160	NEW
1000 I=(V-845.)/5.	HNO3 170	NEW
HARS=H1(I)	HNO3 180	NEW
GO TO 1003	HNO3 190	NEW
1001 I=(V-1270.)/5.	HNO3 200	NEW
HARS=H2(I)	HNO3 210	NEW
GO TO 1003	HNO3 220	NEW
1002 I=(V-1670.)/5.	HNO3 230	NEW
HARS=H3(I)	HNO3 240	NEW
1003 RETURN	HNO3 250	NEW
END	HNO3 260	NEW

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

SUBROUTINE POINT (X,YN,N,NP,TX,IP)	POIN	10	B	1
COMMON Z(34),P(7,34),T(7,34),EH(11,34),WH(7,34),N,NL,RE,CW,CO,PI	POIN	20		NEW
COMMON /EM1/ IEMISS,KMAX	POIN	30		NEW
DIMENSION TX(11)	POIN	40		NEW
C*****	POIN	50	B	4
C SUBROUTINE POINT COMPUTES THE MEAN REFRACTIVE INDEX ABOVE AND BELOW	PCIN	60	B	5
C A GIVEN ALTITUDE AND INTERPOLATES EXPONENTIALLY TO DETERMINE THE	POIN	70	B	6
C EQUIVALENT ABSORBER AMOUNTS AT THAT ALTITUDE.	POIN	80	B	7
C	POIN	90	B	8
C*****	PCIN	100	B	9
C	POIN	110	B	10
C X IS THE HEIGHT IN QUESTION	POIN	120	B	11
C TX(9) AND YN ARE THE MEAN REFRACTIVE INDICES ABOVE AND BELOW X	POIN	130	B	12
C N IS THE LEVEL INTEGER CORRESPONDING TO X OR THE LEVEL BELOW X	POIN	140	B	13
C NP = 1 IF X COINCIDES WITH MODEL ATMOSPHERE LEVEL, IF NOT NP = 0	POIN	150	B	14
C TX(1-8) ARE ABSORBER AMOUNTS PER KM AT HEIGHT X	POIN	160	B	15
C*****	POIN	170	B	16
N=NL	POIN	180	P	17*
NP=0	POIN	190	B	18
IF(X,LT,0.0) X=Z(1)	POIN	200	B	19A
IF (X,GT,7(NL)) GO TO 4	POIN	210	B	19B
DO 1 I=1,NL	POIN	220	B	20
N=I	POIN	230	B	21
IF (X-Z(I)) 2,4,1	POIN	240	B	22
1 CONTINUE	POIN	250	B	23-
2 J2=N	POIN	260	B	25
N=N-1	POIN	270	B	26
FAC=(X-Z(N))/(Z(J2)-Z(N))	POIN	280	B	27
PX1=P(M,N)*(P(M,J2)/P(M,N))*FAC	POIN	290	B	28
TX1=T(M,N)*(T(M,J2)/T(M,N))*FAC	POIN	300	B	29
WX1=WH(M,N)*(WH(M,J2)/WH(M,N))*FAC	POIN	310	B	30
TX(3)=CO*PX1/TX1-4.56E-6*WX1*TX1*CW	POIN	320	B	31
TX(2)=CO*P(M,J2)/T(M,J2)-4.56E-6*WH(M,J2)*T(M,J2)*CW	POIN	330	B	32
TX(1)=CO*P(M,N)/T(M,N)-4.56E-6*WH(M,N)*T(M,N)*CW	POIN	340	B	33
TX(9)=0.5E-6*(TX(2)+TX(3))	POIN	350	B	34
YN=0.5E-6*(TX(1)+TX(3))	POIN	360	B	35
IF (IP,EQ,0) GO TO 9	POIN	370	B	36
DO 3 K=1,KMAX	POIN	380		NEW
IF(K,EO,9) GO TO 3	POIN	390	*B	37B
TX(K)=0.0	POIN	400	*B	37C
IF (EH(K,N),EQ,0.0) GO TO 3	POIN	410	B	38
IF (EH(K,N),GT,1000.0) GO TO 3	POIN	420	B	39
TX(K)=EH(K,N)*(EH(K,J2)/EH(K,N))*FAC	POIN	430	B	40
3 CONTINUE	POIN	440	B	41
GO TO 9	POIN	450	B	42
4 NP=1	POIN	460	B	43
IF (IP,EO,0) GO TO 6	POIN	470	B	44
DO 5 K=1,KMAX	POIN	480		NEW
5 TX(K)=EH(K,N)	POIN	490	B	46
6 TX(9)=EH(9,N)-1.	POIN	500	B	47

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

YN=0.0	POIN 510	R	48
C**** CARDS B 24 AND 50 THROUGH 59 ARE NO LONGER REQUIRED	POIN 520	R	48+
IF (N.GT.1) YN=EH(9,N-1)-1.0	POIN 530	R	49
9 CONTINUE	POIN 540	R	60
IF (IP.EQ.1) PRINT 400, X,N,NP,TX(9),YN,IP,(TX(K),K=1,8)	POIN 550	R	61
TX(9)=TX(9)+1.	POIN 560	R	62
YN=YN+1.	POIN 570	R	63
RETURN	POIN 580	R	64
C	POIN 590	R	65
400 FORMAT (/,* FROM POINT: HEIGHT=*,F10.4,* KM,N=*,I3,*,NF=*,I2,*,REFPOIN 600	POIN 600	R	66
1. INDEX ABOVE & BELOW X=*,2F11.4,*,IP=*,I3,/,12X,*EQUIN. ABSORBER POIN 610	POIN 610	R	67
AMOUNTS PER KM AT X=*,8F10.3)	POIN 620	R	68
END	POIN 630	R	69

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1 Listing of Fortran Code LOWTRAN 4 (Cont)

SUBROUTINE ANGL (H1,H2,ANGLE,B1,LEN,ML)	ANGL 10	C 1*
COMMON Z(34),P(7,34),T(7,34),EH(11,34),MH(7,34),M,NL,RE,CW,CO,PI	ANGL 20	NEW
COMMON /EM1/ IEMISS,KMAX	ANGL 30	NEW
DIMENSION TX(11)	ANGL 40	NEW
*****	ANGL 50	C 4
C THIS SUBROUTINE CALCULATES THE INITIAL ZENITH ANGLE (ANGLE)	ANGL 60	C 5
C TAKING INTO ACCOUNT REFRACTION EFFECTS GIVEN H1,H2, AND BETA	ANGL 70	C 6
C (WHERE BETA IS THE EARTH CENTRE ANGLE SUBTENDED BY H1 AND H2),	ANGL 80	C 7
C ASSUMING THE REFRACTIVE INDEX TO BE CONSTANT IN A GIVEN LAYER.	ANGL 90	C 8
C FOR GREATER ACCURACY INCREASE THE NUMBER OF LEVELS IN THE MODEL	ANGL 100	C 9
C ATMOSPHERE.	ANGL 110	C 10
C	ANGL 120	C 11
C	ANGL 130	C 12
C THIS SUBROUTINE CAN BE REMOVED FROM THE PROGRAM IF NOT REQUIRED.	ANGL 140	C 13
*****	ANGL 150	C 14
TP=99	ANGL 160	C 15
CA=PI/180.	ANGL 170	C 16
X1=PI*H1	ANGL 180	C 17
X2=PI*H2	ANGL 190	C 18
LEN=0.	ANGL 200	C 19
IT=0	ANGL 210	C 20
B1=01*CA	ANGL 220	C 21
TANG=X2*SIN(B1)/(X2*COS(B1)-X1)	ANGL 240	C 22
THET=ATAN(TANG)	ANGL 250	C 23
IF (THE T.LT.0.0) THET=THET+PI	ANGL 260	C 24
SEHI=SIN(THET)	ANGL 270	C 25
ANG=THE T/CA	ANGL 280	C 26
C PRINT 404, B1,ANG,TANG	ANGL 290	C 27
IN=THET	ANGL 300	C 28
TM=IN-PI*CA	ANGL 310	C 29
1 ANGLE=THET	ANGL 320	C 30
FRT=0.	ANGL 330	C 31
BETA=0.	ANGL 340	C 32
BET1=0	ANGL 350	C 33
BET2=0	ANGL 360	C 34
BET1=0	ANGL 370	C 35
BET2=0	ANGL 380	C 36
FRT3=0.0	ANGL 390	C 37
IF (B1.LT.0.0) GO TO 2	ANGL 400	C 37*
C PRINT 400, IT	ANGL 410	C 38
Y=2.*THET	ANGL 420	C 39
IF (Y-PI.GT.1.0E-8) GO TO 9	ANGL 430	C 40
IF (YP,EQ.100) GO TO 6	ANGL 440	C 41
XMIN=X2*COS(B1)-RF	ANGL 450	C 42
IF (XMIN-H1) 8,4,4	ANGL 460	C 43
2 HMIN=H2	ANGL 470	C 44A
H2=H1	ANGL 480	C 44B
H1=HMIN	ANGL 490	C 44C
3 ANGLE=C.5*PI	ANGL 500	C 44D

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	THET=ANGLE	ANGLE 510	C 45
	SPHI=1.0	ANGLE 520	C 46
	ANG=ANGLE/CA	ANGLE 530	C 47
6	PRINT 404, B1, ANG, SPHI	ANGLE 540	C 48
4	IF=100	ANGLE 550	C 49
	CALL POINT (H1,YN,N,NP,IX,IP)	ANGLE 560	C 50
	J1=N	ANGLE 570	C 51
	TX1=TX(9)	ANGLE 580	C 52
5	CALL POINT (H2,YN,N,NP,IX,IP)	ANGLE 590	C 53
	IF (NP.EQ.1) N=N-1	ANGLE 600	C 54
	J2=N	ANGLE 610	C 55
	10 (J1.EQ.J2) TX1=TX1+YN-FH(9,J1)	ANGLE 620	C 56
6	DO 7 J=J1,J2	ANGLE 630	C 57
	X1=RE+Z(J)	ANGLE 640	C 58
	X2=RE+Z(J+1)	ANGLE 650	C 59
	IF (J.EQ.J1) X1=RE+H1	ANGLE 660	C 60
	IF (J.EQ.J2) X2=RE+H2	ANGLE 670	C 61
	SALP=X1*SPHI/X2	ANGLE 680	C 62
	ALP=ASIN(SALP)	ANGLE 690	C 63
	RN=TH(9,J+1)/EH(9,J)	ANGLE 700	C 64
	IF ((J+1).EQ.J2) RN=YN/EH(9,J)	ANGLE 710	C 65
	IF (J.EQ.J1) RN=TH(9,J+1)/TX1	ANGLE 720	C 66
	IF ((J+1).EQ.J2.AND.J.EQ.J1) RN=YN/TX1	ANGLE 730	C 67
	DEL=THET-ALP	ANGLE 740	C 68
	FB=-TAN(ALP)	ANGLE 750	C 69
	IF (J.NE.J1) FB=FB+TAN(THET)	ANGLE 760	C 70
	FBI=FB+FB	ANGLE 770	C 71
	DETA=DETA+DEI	ANGLE 780	C 72
	TH1=THET/CA	ANGLE 790	C 73
	DE=DEI/CA	ANGLE 800	C 74
	C=ALP/CA	ANGLE 810	C 75
6	PRINT 405, J,Z(J),THET,ALP,DEI,DETA,FBI,FB,TH1,DE,C	ANGLE 820	C 76
	IF (X2.EQ.NE+H2) C=FI-ALP	ANGLE 830	C 77
	IF (SALP.GE.RN) RN=1.	ANGLE 840	C 78
	SPHI=SALP/RN	ANGLE 850	C 79
	THET=ASIN(SPHI)	ANGLE 860	C 80
7	CONTINUE	ANGLE 870	C 81
	IF (H1.LE.0.0) GO TO 29	ANGLE 880	C 82
	GO TO 26	ANGLE 890	C 83
8	CONTINUE	ANGLE 900	C 84
	TANG=-TANG	ANGLE 910	C 85
	ANGLE=PI-ANGLE	ANGLE 920	C 86
	YN=ANGLE	ANGLE 930	C 87
	ANG=ANG/CA	ANGLE 940	C 88
6	PRINT 404, B1, ANG, TANG	ANGLE 950	C 89
	IF (H1.LE.0.0) GO TO 3	ANGLE 960	C 90
9	CONTINUE	ANGLE 970	C 91
	IP=101	ANGLE 980	C 92
	CALL POINT (H1,YN,N,NP1,IX,IP)	ANGLE 990	C 93
	TX1=TX(9)	ANGLE 1000	C 93

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	YN1=YN	ANGL 1010	C 94
	IF (NP1.EQ.1) N=N-1	ANGL 1020	C 95
	J2=NL	ANGL 1030	C 96A
	IF (M.EQ.7) J2=ML	ANGL 1040	C 96B
	J1=N	ANGL 1050	C 97
	J=J1+1	ANGL 1060	C 98
	IF (H2.GE.H1) GO TO 13	ANGL 1070	C 99
	CALL POINT (H2,YN,N,NF,IX,IP)	ANGL 1080	C 100
	TX2=TX(9)	ANGL 1090	C 101
	YN2=YN	ANGL 1100	C 102
	J2=N	ANGL 1110	C 103
	IF (J1.EQ.J2) TX2=YN1+TX(9)-FH(9,J1)	ANGL 1120	C 104
10	J=J-1	ANGL 1130	C 105
	X1=RE+Z(J+1)	ANGL 1140	C 106
	X2=RE+Z(J)	ANGL 1150	C 107
	IF (J.EQ.J1) X1=RE+H1	ANGL 1160	C 108
	IF (J.EQ.J2) X2=RE+H2	ANGL 1170	C 109
	SALP=X1*SPHI/X2	ANGL 1180	C 110
	HMIN=X1*SPHI-RE	ANGL 1190	C 111
C	PRINT 402, J,X1,Z(J),SPHI,SALP,HMIN,RE	ANGL 1200	C 112
	IF (SALP.LE.1.0) GO TO 11	ANGL 1210	C 113
	SALP=SPHI	ANGL 1220	C 114
	IF (HMIN.GT.H2) GO TO 18	ANGL 1230	C 115
11	ALP=ASIN(SALP)	ANGL 1240	C 116
	THET=ASIN(SPHI)	ANGL 1250	C 117
	DET=ALP-THET	ANGL 1260	C 118
	DET1=DET+DET	ANGL 1270	C 119
	FR=TAN(ALP)	ANGL 1280	C 120
	IF (J.NE.J1) FR=FR-TAN(THET)	ANGL 1290	C 121
	FBI1=FBI1+FR	ANGL 1300	C 122
	TH1=THET/CA	ANGL 1310	C 123
	BE=DET/CA	ANGL 1320	C 124
	AL=ALP/CA	ANGL 1330	C 125
C	PRINT 402, J,X2,THET,ALP,DET1,DET,HMIN,HMIN,FBI1,TH1,BE,AL	ANGL 1340	C 126
	IF (X2.EQ.RE+H2) C=FI-ALP	ANGL 1350	C 127
	REF=FR(9,J)	ANGL 1360	C 128
	IF (J.EQ.J1) REF=YN1	ANGL 1370	C 129
	IF (J.EQ.J2) REF=TX2	ANGL 1380	C 130
	IF (J.EQ.1) GO TO 12	ANGL 1390	C 131
	RN=FR(9,J)/FR(9,J-1)	ANGL 1400	C 132
	IF (J.EQ.J1) RN=YN1/FR(9,J-1)	ANGL 1410	C 133A
	IF (J.EQ.J2+1) RN=REF/TX2	ANGL 1420	C 133B
	IF (J.EQ.J2) RN=REF/YN2	ANGL 1430	C 133C
	IF (SALP.GE. RN) RN=1.	ANGL 1440	C 134
	SPHI=SALP*RN	ANGL 1450	C 135
	IF (7(J),1E,H2) GO TO 12	ANGL 1460	C 136
	GO TO 10	ANGL 1470	C 137
12	X1=X2	ANGL 1480	C 138
	IF (ABS(7(J)-H2).LT.1.0E-10.AND.J.NE.1) GO TO 13	ANGL 1490	C 139
	GO TO 14	ANGL 1500	C 140

THIS PAGE IS BEST QUALITY PRACTICAL
FROM COPY FURNISHED TO DDG

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

13	J=J-1	ANGL1510	C 141
	X1=RE+Z(J+1)	ANGL1520	C 142
	IF (J.EQ.J1) X1=RE+H1	ANGL1530	C 143
	IF (J.EQ.J2.AND.J.NE.J1) X1=RE+H2	ANGL1540	C 144
14	X2=RE+Z(J)	ANGL1550	C 145
	HMIN=X1*SPHI-RE	ANGL1560	C 146
	IF (HMIN.LE.0.0) GO TO 25	ANGL1570	C 147
	IF (Z(J).LT.HMIN) GO TO 18	ANGL1580	C 148
	REF=EH(9,J)	ANGL1590	C 149
	IF (J.EQ.J2) REF=YN	ANGL1600	C 150
	SALF=X1*SPHI/X2	ANGL1610	C 151
	ALP=ASIN(SALP)	ANGL1620	C 152
	THET=ASIN(SPHI)	ANGL1630	C 153
	BET=ALP-THET	ANGL1640	C 154
	FB=TAN(ALP)-TAN(THET)	ANGL1650	C 155
	FRT2=FBT2+FB	ANGL1660	C 156
	BET2=BET2+FBT	ANGL1670	C 157
	BMIN=BET1+BET2	ANGL1680	C 158
	AL=ALP/CA	ANGL1690	C 159
	TH1=THET/CA	ANGL1700	C 160
C	PRINT 402, J, X2, THE T, ALP, BET2, BET, BMIN, HMIN, FRT2, TH1, BF, AL	ANGL1710	C 161
	RN=REF/FH(9,J-1)	ANGL1720	C 162
	IF (SALP.GE.RN) RN=1.0	ANGL1730	C 163
	SPHI=SALP*RN	ANGL1740	C 164
	GO TO 13	ANGL1750	C 165
17	TX3=YN1+TX(9)-EH(9,J1)	ANGL1760	C 166
	YN1=TX3	ANGL1770	C 167
	IF (ABS(H2-Z(J+1)).LE.1.0E-5) YN1=TX(9)	ANGL1780	C 168
	IF (ABS(H1-Z(J+1)).LE.1.0E-5) YN1=TX(9)	ANGL1790	C 169
	PA=1.0	ANGL1800	C 170
	GO TO 19	ANGL1810	C 171
18	CALL POINT (HMIN,YN,N,NP, TX, IP)	ANGL1820	C 172
	IP=102	ANGL1830	C 173
	TX3=TX(9)	ANGL1840	C 174
	IF (J.EQ.J1.AND.H2.GE.H1) GO TO 17	ANGL1850	C 175
	IF (J.EQ.J1.OR.J.EQ.J2) TX3=YN2+TX(9)-EH(9,J)	ANGL1860	C 176
	IF (HMIN.GT.H2) TX3=TX(9)	ANGL1870	C 177
	IF (J.EQ.J1.AND.HMIN.GT.H2) GO TO 17	ANGL1880	C 178
	RN=REF/TX3	ANGL1890	C 179
	IF (SALF.GE.RN) RN=1.	ANGL1900	C 180
	SPHI=SALP*RN	ANGL1910	C 181
	X=X1*SPHI-RE	ANGL1920	C 182
	DIF=ABS(HMIN-X)	ANGL1930	C 183
	HMIN=X	ANGL1940	C 184
	IF (DIF-1.0E-5) 19,19,18	ANGL1950	C 185
19	X2=RE+HMIN	ANGL1960	C 186
C	PRINT 403, HMIN,DIF,RN	ANGL1970	C 187
	THET=ASIN(SPHI)	ANGL1980	C 188
	IF (RN.EQ.1.0) FRT3=-TAN(THET)	ANGL1990	C 189
	IF (RN.EQ.1) GO TO 20	ANGL2000	C 189

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

	DNX=(TX3-1.0)*ALOG((TX3-1.0)/(REF-1.0))/(X2-X1)	ANGL2010	C 190
	FRT3=-TAN(THET)*(1.0-1.0/(1.0+TX3/(X2*DNX)))	ANGL2020	C 191
20	BFT=C.*PI-THET	ANGL2030	C 192
	BET2=BET1+BET	ANGL2040	C 193
	BMIN=BFT1+BET2	ANGL2050	C 194
	IF (M2,GE,M1) GO TO 23	ANGL2060	C 195
	BET=BET1+2.*BET2	ANGL2070	C 196
	B1=B1-BET1	ANGL2080	C 197
	B2=BET-R1	ANGL2090	C 198
21	C03=ABS(BMIN-R1)	ANGL2100	C 199A
	IF (D03,GT,001,AND,D02,GT,D01) GO TO 25	ANGL2110	C 199B
	IF (D02,GT,D03) GO TO 22	ANGL2120	C 199C
	IF (D02,GT,D01) GO TO 25	ANGL2130	C 200
	BETA=BET	ANGL2140	C 201
	FRT=FRT1+2.0*(FRT2+FRT3)	ANGL2150	C 202
	LEN=1.	ANGL2160	C 203
	GO TO 26	ANGL2170	C 204
22	BETA=BFT1+BET2	ANGL2180	C 205
	FRT=FRT1+FRT2+FRT3	ANGL2190	C 206
C	PRINT 401, J,BE1 ,FRT,FRT1,FRT2,FRT3,IX1,YN1	ANGL2200	C 207
	GO TO 26	ANGL2210	C 208
23	BETA=2.0*(BET1+BET2)	ANGL2220	C 209
	LEN=1.	ANGL2230	C 210
	FRT=2.0*(FRT1+FRT2+FRT3)	ANGL2240	C 211
	PRINT 401, J,BETA,FRT,FRT1,FRT2,FRT3,IX1,YN1	ANGL2250	C 212
	IF (M2,LE,M1) GO TO 26	ANGL2260	C 213
	IF=103	ANGL2270	C 214
	IF (NP1,LE,1) J1=J1+1	ANGL2280	C 215
	SPHI=SIN(ANGLF)	ANGL2290	C 216
	IF (7(J1+1),LE,M2) GO TO 24	ANGL2300	C 217
	PN=TX1/YN1	ANGL2310	C 218
	IF (SPHI,GE,RN) RN=1.	ANGL2320	C 219
	SPHI=SPHI/RN	ANGL2330	C 220
	THET=ASIN(SPHI)	ANGL2340	C 221
	GO TO 6	ANGL2350	C 222
24	CALL FPOINT (M2,YN,N,NP,IX,IF)	ANGL2360	C 223
	TX1=TX1+YN-EN(Q,J1)	ANGL2370	C 224
	RN=TX1/YN1	ANGL2380	C 225
	J2=J1	ANGL2390	C 226
	IF (SPHI,GE,RN) RN=1.	ANGL2400	C 227
	SPHI=SPHI/RN	ANGL2410	C 228
	THET=ASIN(SPHI)	ANGL2420	C 229
	GO TO 5	ANGL2430	C 230
25	BETA=BET1	ANGL2440	C 231
	LEN=0.	ANGL2450	C 232
	FRT=FRT1	ANGL2460	C 233
26	THET=ANGLE*(R1-BETA)/(1.+FRT/TANG)	ANGL2470	C 234
	D0FTA=BETA/CA	ANGL2480	C 235
	B=D0FT1/CA	ANGL2490	C 236
	TH1=THET/CA	ANGL2500	C 237

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A1. Listing of Fortran Code LOWTRAN 4 (Cont)

PRINT 404, BETA, OBETA, FBT, TH1, TANG	ANGL 2510	C 238
IF (THET.GT.IN.OR.THET.LY.TH) THET=(TN+TH)/2.	ANGL 2520	C 239
TH1=THET/CA	ANGL 2530	C 240*
PRINT 404, BET1,B,FBT,TH1	ANGL 2540	C 241*
TN1=TN/CA	ANGL 2550	C 242
TH1=TH/CA	ANGL 2560	C 243
PRINT 405, TN,TH,TN1,TH1	ANGL 2570	C 244
SPHI=SIN(THET)	ANGL 2580	C 245
TANG=TAN(THET)	ANGL 2590	C 246
IT=IT+1	ANGL 2600	C 247
DRE=ABS(B1-BETA)	ANGL 2610	C 248
OTH=A9S(ANGLE-THET)	ANGL 2620	C 249
IF (IT.EQ.10) THET=0.5*(ANGLE+THET)	ANGL 2630	C 250*
IF (IT.EQ.10) GO TO 2A	ANGL 2640	C 251
IF (DRE.GT.1.0E-7.AND.OTH.GT.1.0E-7) GO TO 1	ANGL 2650	C 252
28 ANGLE=THET/CA	ANGL 2660	C 253
PRINT 406, ANGLE, IT	ANGL 2670	C 254
RETURN	ANGL 2680	C 255A
29 H1=H2	ANGL 2690	C 255B
ANGLE=0/CA	ANGL 2700	C 255C
PRINT 406, ANGLE, IT	ANGL 2710	C 255D
RETURN	ANGL 2720	C 255E
0	ANGL 2730	C 256
400 FORMAT (/// ITERATION NUMBER *,I3,///)	ANGL 2740	C 257
401 FORMAT (I6,E16.7,8F13.8)	ANGL 2750	C 258
402 FORMAT (I4,F10.4,6F13.4,4F10.4/)	ANGL 2760	C 259
403 FORMAT (* HMIN=*,F14.6,* DIF=*,F14.6,* PR=*,E16.8)	ANGL 2770	C 260
404 FORMAT (* TOTAL BETA = *,E14.6,F15.6,*,FBT = *,E14.6,* THET = *,F10.4,*,TANG=*,F10.6)	ANGL 2780	C 261
405 FORMAT (5F12.6)	ANGL 2790	C 262
406 FORMAT (AX,/1H*,*ZENITH ANGLE =*,F7.3,* DEGREES & RECOMPUTED	ANGL 2800	C 263
1 FROM SUBROUTINE ANGL (ITERATION*,I3,*)*)	ANGL 2810	C 264
END	ANGL 2820	C 265
	ANGL 2830	C 266

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN 4 (Cont)

9.0	2.992E+01	225.7	1.6E-02	1.2E-04	3.107E+02	232.0	4.2E-02	1.1E-04
10.0	2.568E+02	219.7	7.5E-03	1.6E-04	2.677E+02	225.0	1.5E-02	1.3E-04
11.0	2.199E+02	219.2	6.9E-03	2.1E-04	2.300E+02	225.0	9.4E-03	1.8E-04
12.0	1.882E+02	218.7	6.0E-03	2.6E-04	1.977E+02	225.0	6.0E-03	2.1E-04
13.0	1.610E+02	218.2	1.8E-03	3.0E-04	1.700E+02	225.0	1.8E-03	2.6E-04
14.0	1.378E+02	217.7	1.0E-03	3.2E-04	1.460E+02	225.0	1.0E-03	2.8E-04
15.0	1.178E+02	217.2	7.6E-04	3.4E-04	1.250E+02	225.0	7.6E-04	3.2E-04
16.0	1.007E+02	216.7	6.4E-04	3.6E-04	1.080E+02	225.0	6.4E-04	3.4E-04
17.0	8.610E+01	216.2	5.6E-04	3.9E-04	9.280E+01	225.0	5.6E-04	3.9E-04
18.0	7.350E+01	215.7	5.0E-04	4.1E-04	7.980E+01	225.0	5.0E-04	4.1E-04
19.0	6.280E+01	215.2	4.9E-04	4.3E-04	6.860E+01	225.0	4.9E-04	4.1E-04
20.0	5.370E+01	215.2	4.5E-04	4.5E-04	5.890E+01	225.0	4.5E-04	3.9E-04
21.0	4.580E+01	215.2	5.1E-04	4.3E-04	5.070E+01	225.0	5.1E-04	3.6E-04
22.0	3.910E+01	215.2	5.1E-04	4.3E-04	4.360E+01	225.0	5.1E-04	3.2E-04
23.0	3.340E+01	215.2	5.4E-04	3.9E-04	3.750E+01	225.0	5.4E-04	3.0E-04
24.0	2.860E+01	215.2	6.0E-04	3.6E-04	3.227E+01	226.0	6.0E-04	2.8E-04
25.0	2.430E+01	215.2	6.7E-04	3.4E-04	2.780E+01	228.0	6.7E-04	2.6E-04
30.0	1.110E+01	217.4	3.6E-04	1.9E-04	1.340E+01	235.0	3.6E-04	1.4E-04
35.0	5.180E+00	227.8	1.1E-04	9.2E-05	6.610E+00	247.0	1.1E-04	9.2E-05
40.0	2.530E+00	243.2	4.3E-05	4.1E-05	3.400E+00	262.0	4.3E-05	4.1E-05
45.0	1.290E+00	258.5	1.9E-05	1.3E-05	1.810E+00	274.0	1.9E-05	1.3E-05
50.0	6.820E-01	265.7	6.3E-06	4.3E-06	9.870E-01	277.0	6.3E-06	4.3E-06
70.0	4.670E-02	233.7	1.4E-07	8.6E-08	7.070E-02	216.0	1.4E-07	8.6E-08
100.0	3.000E-04	210.2	1.0E-09	4.3E-11	3.000E-04	210.0	1.0E-09	4.3E-11
99999.	0.000E+00	210.	0.0E-00	0.0E-00	0.000E+00	210.0	0.0E-00	0.0E-00
0.0	1.013E+03	257.1	1.2E+00	4.1E-05	1.013E+03	238.1	5.9E+00	5.4E-05
1.0	8.878E+02	259.1	1.2E+00	4.1E-05	8.986E+02	281.0	4.2E+00	5.4E-05
2.0	7.775E+02	255.9	9.4E-01	4.1E-05	7.950E+02	275.1	2.9E+00	5.4E-05
3.0	6.798E+02	252.7	6.8E-01	4.3E-05	7.012E+02	268.7	1.8E+00	5.0E-05
4.0	5.932E+02	247.7	4.1E-01	4.5E-05	6.166E+02	262.2	1.1E+00	4.6E-05
5.0	5.158E+02	240.9	2.0E-01	4.7E-05	5.405E+02	255.7	6.4E-01	4.6E-05
6.0	4.467E+02	234.1	9.8E-02	4.9E-05	4.722E+02	249.2	3.8E-01	4.5E-05
7.0	3.853E+02	227.3	5.4E-02	7.1E-05	4.111E+02	242.7	2.1E-01	4.9E-05
8.0	3.308E+02	220.6	1.1E-02	9.0E-05	3.565E+02	236.2	1.2E-01	5.2E-05
9.0	2.829E+02	217.2	8.4E-03	1.6E-04	3.080E+02	229.7	4.6E-02	7.1E-05
10.0	2.418E+02	217.2	5.5E-03	2.4E-04	2.650E+02	223.2	1.8E-02	9.0E-05
11.0	2.067E+02	217.2	3.8E-03	3.2E-04	2.270E+02	216.8	8.2E-03	1.3E-04
12.0	1.766E+02	217.2	2.6E-03	4.3E-04	1.940E+02	216.6	3.7E-03	1.6E-04
13.0	1.510E+02	217.2	1.8E-03	4.7E-04	1.658E+02	216.6	1.8E-03	1.7E-04
14.0	1.291E+02	217.2	1.0E-03	4.9E-04	1.417E+02	216.6	8.4E-04	1.9E-04
15.0	1.103E+02	217.2	7.6E-04	5.6E-04	1.211E+02	216.6	7.2E-04	2.1E-04
16.0	9.431E+01	216.6	6.4E-04	6.7E-04	1.035E+02	216.6	6.1E-04	2.4E-04
17.0	8.058E+01	216.0	5.6E-04	6.2E-04	8.850E+01	216.6	5.2E-04	2.8E-04
18.0	6.882E+01	215.4	5.0E-04	6.2E-04	7.565E+01	216.6	4.4E-04	3.2E-04
19.0	5.875E+01	214.8	4.9E-04	6.0E-04	6.467E+01	216.6	4.4E-04	3.5E-04
20.0	5.014E+01	214.1	4.5E-04	5.6E-04	5.529E+01	216.6	4.4E-04	3.8E-04
21.0	4.277E+01	213.6	5.1E-04	5.1E-04	4.729E+01	217.6	4.8E-04	3.8E-04
22.0	3.647E+01	213.0	5.1E-04	4.7E-04	4.047E+01	218.6	5.2E-04	3.9E-04
23.0	3.109E+01	212.4	5.4E-04	4.3E-04	3.467E+01	219.6	5.7E-04	3.8E-04
24.0	2.649E+01	211.8	6.0E-04	3.6E-04	2.972E+01	220.6	6.1E-04	3.6E-04

MODEL ATMOSPHERES 3 & 4 CONTINUED

MODEL ATMOSPHERES 3 & 5

THIS PAGE IS BEST QUALITY PRACTICALLY
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN 4 (Cont)

25.0	2.26E+01	211.2	6.7E-04	3.2E-04	2.549E+01	221.6	6.6E-04	3.4E-04
30.0	1.0.0E+01	216.0	3.6E-04	1.5E-04	1.197E+01	226.5	3.8E-04	2.0E-04
35.0	4.701E+00	220.2	1.1E-04	9.2E-05	5.746E+00	236.5	1.0E-04	1.1E-04
40.0	2.243E+00	234.7	4.3E-05	4.1E-05	2.871E+00	253.4	6.7E-05	4.9E-05
45.0	1.113E+00	247.0	1.9E-05	1.3E-05	1.491E+00	264.2	3.2E-05	1.7E-05
50.0	5.719E-01	259.3	6.3E-06	4.3E-06	7.978E-01	270.6	1.2E-05	4.0E-06
70.0	4.016E-02	245.7	1.4E-07	8.6E-08	5.520E-02	219.7	1.5E-07	8.6E-08
100.0	3.000E-04	210.0	1.0E-09	4.3E-11	3.008E-04	210.0	1.0E-09	4.3E-11
99999.	0.000E+00	210.	0.0E-00	0.0E-00	0.000E+00	210.0	0.0E-00	0.0E-00
.200	.38223	.07945	.290	.327	.03661	.300	.28540	.02110
.488	.17989	.01114	.550	.15800	.01095	.694	.12064	.00968
1.060	.07078	.01070	1.536	.04184	.00933	1.800	.03126	.00700
2.500	.02068	.00463	3.030	.01900	.00584	3.900	.01767	.00250
4.000	.01654	.00232	5.000	.01533	.00321	5.500	.01479	.00388
7.200	.01569	.00745	7.900	.01102	.00617	8.200	.01019	.00807
8.700	.01994	.01126	9.000	.02112	.01209	9.200	.02213	.01378
9.30	.01744	.00332	10.00	.01714	.00810	10.50	.01588	.00680
11.50	.01455	.00335	12.50	.01365	.00516	13.00	.01339	.00523
15.00	.01368	.00834	16.40	.01384	.00696	17.20	.01430	.00767
20.30	.01427	.00767	22.50	.01381	.00767	25.00	.01302	.00749
0.999	2.3468	1.6778	0.998	2.0362	1.3980	0.996	1.6990	1.1192
0.992	1.3274	0.8239	0.990	1.2007	0.7258	0.980	0.7875	0.4318
0.986	0.3468	0.1074	0.950	0.1938	0.0	0.940	0.0655	0.0969
0.920	0.1553	0.2304	0.910	0.2430	0.3010	0.900	0.3324	0.3522
0.860	0.6128	0.5563	0.840	0.7243	0.6435	0.820	0.8261	0.7243
0.780	1.0000	0.8573	0.760	1.0792	0.9191	0.740	1.1461	0.9731
0.700	1.2672	1.0719	0.680	1.3284	1.1173	0.660	1.3397	1.1614
0.620	1.4955	1.2480	0.600	1.5441	1.2900	0.580	1.5966	1.3253
0.540	1.6857	1.3979	0.520	1.7340	1.4393	0.500	1.7782	1.4698
0.460	1.8692	1.5314	0.440	1.9191	1.5682	0.420	1.9538	1.6021
0.380	2.0607	1.6721	0.360	2.1038	1.7076	0.340	2.1461	1.7482
0.300	2.2304	1.8325	0.280	2.2788	1.8865	0.260	2.3263	1.9395
0.220	2.4183	2.0607	0.200	2.4698	2.1206	0.180	2.5159	2.1903
0.140	2.6284	2.3385	0.120	2.6907	2.4313	0.100	2.7559	2.5195
0.060	2.9031	2.7853	0.040	3.0003	2.9777	0.020	3.0637	3.1072
0.015	3.2041	3.3617	0.010	3.2718	3.4771	0.008	3.3054	3.5563
0.004	3.3979	3.7076	0.002	3.4914	3.8325	0.001	3.5682	3.9345
3.93	3.72	3.54	3.42	3.77	3.37	3.36	3.33	3.25
3.12	3.08	3.03	3.00	3.01	3.03	3.07	3.05	3.01
2.62	2.67	2.72	2.71	2.60	2.46	2.35	2.26	2.22
2.34	2.42	2.39	2.21	2.01	1.90	1.83	1.78	1.73
1.39	1.30	1.25	1.18	1.19	1.18	1.21	1.33	1.47
0.49	0.60	0.71	0.79	0.99	0.86	0.73	0.53	0.43
0.80	0.63	0.47	0.32	0.08	0.21	0.29	0.21	0.01
-0.35	0.30	0.31	0.37	0.42	0.48	0.42	0.40	0.39
-0.50	0.42	0.39	0.38	0.37	0.40	0.51	0.67	0.82
-0.16	0.19	0.28	0.33	0.35	0.28	0.22	0.10	0.05
0.11	0.23	0.26	0.19	0.11	0.00	0.09	0.02	0.03
0.75	0.79	0.79	0.71	0.69	0.76	0.88	1.01	1.16
1.41	1.75	1.83	1.99	2.05	2.03	2.00	1.96	1.90

4.444
SPECTRAL DATA

TRANSMITTANCE COEFFICIENT

SPECTRAL DATA

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN-4 (Cont)

2.68	2.67	2.73	2.79	2.81	2.91	2.93	3.02	3.16	3.23	3.30	3.34	3.43	3.57	3.69	1325
3.59	3.58	3.57	3.61	3.71	3.71	3.69	3.64	3.60	3.68	3.80	3.95	4.05	4.05	4.07	1400
3.99	3.96	4.01	4.13	4.22	4.35	4.49	4.58	4.62	4.63	4.61	4.57	4.56	4.56	4.53	1475
4.49	4.46	4.40	4.28	4.14	3.92	3.63	3.35	3.15	3.10	3.24	3.47	3.66	3.80	3.93	1550
4.00	4.04	4.15	4.23	4.31	4.35	4.31	4.23	4.20	4.24	4.28	4.35	4.42	4.42	4.44	1625
4.46	4.40	4.30	4.22	4.13	4.07	4.12	4.19	4.22	4.23	4.16	4.04	3.99	3.94	3.93	1700
3.91	3.86	3.83	3.80	3.78	3.70	3.54	3.40	3.30	3.31	3.42	3.52	3.52	3.49	3.41	1775
3.21	3.14	3.10	3.06	3.11	2.98	2.88	2.78	2.74	2.76	2.72	2.76	2.82	2.85	2.86	1850
2.75	2.64	2.60	2.61	2.64	2.56	2.49	2.37	2.25	2.14	2.08	2.11	2.20	2.31	2.38	1925
2.15	2.06	1.98	2.03	2.05	1.96	1.84	1.72	1.64	1.59	1.57	1.57	1.60	1.63	1.51	2000
1.38	1.07	0.91	0.87	0.92	1.04	1.01	0.92	0.84	0.92	0.97	1.01	1.06	1.10	1.06	2075
1.01	0.91	0.79	0.55	0.47	0.41	0.39	0.38	0.34	0.33	0.36	0.43	0.48	0.45	0.38	2150
0.27	0.21	0.22	0.29	0.37	0.38	0.37	0.29	0.19	0.13	0.11	0.03	-0.05	-0.12	-0.24	2225
-0.31	-0.39	-0.43	-0.50	-0.59	-0.68	-0.73	-0.80	-0.92	-1.06	-1.14	-1.22	-1.27	-1.28	-1.33	2300
-1.32	-1.43	-1.51	-1.63	-1.74	-1.82	-1.96	-2.09	-2.21	-2.21	-2.24	-2.27	-2.36	-2.51	-2.65	2375
-2.70	-2.63	-2.57	-2.56	-2.59	-2.67	-2.69	-2.67	-2.68	-2.62	-2.52	-2.42	-2.29	-2.14	-2.00	2450
-1.87	-1.71	-1.51	-1.39	-1.27	-1.12	-1.01	-0.89	-0.75	-0.68	-0.57	-0.47	-0.42	-0.32	-0.27	2525
-0.26	-0.19	-0.13	-0.11	-0.01	0.05	0.08	0.17	0.25	0.31	0.41	0.43	0.44	0.43	0.36	2600
0.35	0.31	0.25	0.25	0.22	0.21	0.33	0.49	0.65	0.76	0.71	0.51	0.30	0.13	0.10	2675
0.17	0.24	0.31	0.38	0.45	0.51	0.56	0.60	0.63	0.62	0.63	0.64	0.66	0.69	0.76	2750
0.75	0.74	0.70	0.62	0.53	0.46	0.39	0.38	0.37	0.38	0.42	0.47	0.50	0.53	0.69	2825
0.67	0.62	0.64	0.66	0.76	0.90	1.11	1.13	1.11	0.97	0.98	1.17	1.38	1.52	1.70	2900
1.76	1.84	1.92	1.90	1.87	1.91	2.02	2.13	2.13	2.18	2.22	2.25	2.03	2.01	1.77	2975
1.93	2.19	2.28	2.14	2.15	2.22	2.31	2.14	2.26	2.36	2.51	2.66	2.73	2.68	2.64	3050
2.64	2.22	1.95	1.61	1.11	0.88	0.83	0.89	1.20	1.62	1.82	1.99	2.01	2.14	2.16	3125
2.21	2.30	2.33	2.42	2.50	2.51	2.49	2.46	2.42	2.37	2.37	2.33	2.31	2.43	2.56	3200
2.61	2.63	2.60	2.50	2.38	2.41	2.34	2.31	2.32	2.40	2.27	2.32	2.27	2.09	2.08	3275
2.17	2.41	2.77	2.66	2.49	2.29	2.23	2.42	2.61	2.59	2.49	2.40	2.39	2.51	2.66	3350
2.68	2.68	2.70	2.82	2.83	2.82	2.81	2.84	2.86	2.91	2.96	3.03	3.08	3.21	3.30	3425
3.40	3.52	3.49	3.46	3.51	3.54	3.56	3.55	3.57	3.61	3.71	3.80	3.92	3.99	4.06	3500
4.02	4.06	4.12	4.26	4.30	4.22	4.32	4.42	4.53	4.64	4.55	4.46	4.28	4.32	4.38	3575
4.37	4.24	4.13	4.14	4.20	4.25	4.32	4.35	4.31	4.27	4.25	4.27	4.31	4.36	4.41	3650
4.52	4.59	4.71	4.79	4.81	4.73	4.61	4.42	4.28	4.08	4.00	3.88	3.86	3.92	3.98	3725
4.12	4.18	4.31	4.37	4.42	4.50	4.53	4.58	4.59	4.61	4.61	4.59	4.53	4.49	4.44	3800
4.41	4.40	4.34	4.30	4.26	4.09	3.96	3.87	3.73	3.77	3.79	3.75	3.72	3.62	3.56	3875
3.51	3.48	3.32	3.18	3.07	2.96	2.87	2.80	2.68	2.58	2.59	2.51	2.59	2.67	2.60	3950
2.42	2.32	2.20	2.12	2.00	1.92	1.79	1.63	1.60	1.69	1.78	2.04	2.00	1.81	1.70	4025
1.63	1.61	1.60	1.49	1.14	1.35	1.64	1.69	1.70	1.59	1.45	1.29	1.19	1.08	1.02	4100
1.04	1.10	1.16	1.20	1.23	1.22	1.08	1.08	1.06	0.89	0.93	0.73	0.58	0.54	0.77	4175
0.81	0.74	0.71	0.57	0.49	0.43	0.38	0.12	0.10	0.20	0.41	0.37	0.31	0.11	-0.13	4250
-0.21	-0.32	-0.36	-0.39	-0.33	-0.39	-0.45	-0.50	-0.55	-0.62	-0.68	-0.77	-0.84	-0.91	-1.00	4325
-1.11	-1.19	-1.28	-1.31	-1.39	-1.43	-1.48	-1.52	-1.57	-1.60	-1.61	-1.60	-1.58	-1.51	-1.42	4400
-1.32	-1.26	-1.16	-1.06	-0.83	-0.71	-0.61	-0.52	-0.43	-0.36	-0.30	-0.21	-0.19	-0.17	-0.15	4475
-0.13	-0.17	-0.19	-0.12	-0.06	0.01	0.00	0.11	0.23	0.32	0.44	0.51	0.48	0.47	0.42	4550
-0.40	-0.40	-0.39	-0.37	-0.35	-0.48	-0.75	-1.13	-1.58	-1.80	-1.66	-1.52	-1.35	-1.19	-1.02	4625
-0.88	-0.66	-0.65	-0.63	-0.62	-0.66	-0.73	-0.79	-0.88	-0.84	-0.70	-0.59	-0.43	-0.39	-0.50	4700
-0.61	-0.74	-0.79	-0.76	-0.69	-0.62	-0.59	-0.52	-0.48	-0.48	-0.42	-0.39	-0.38	-0.33	-0.29	4775
-0.26	-0.23	-0.22	-0.22	-0.37	-0.50	-0.60	-0.60	-0.51	-0.46	-0.42	-0.43	-0.45	-0.35	-0.24	4850
-0.14	-0.08	-0.08	0.00	0.11	0.32	0.43	0.42	0.32	0.23	0.22	0.28	0.45	0.55	0.62	4925
0.65	0.71	0.75	0.80	0.83	0.85	0.87	0.90	0.93	1.00	1.04	1.15	1.22	1.32	1.31	5000

Table A2. Listing of Data for LOWTRAN 4 (Cont)

1.32	1.33	1.48	1.78	1.87	2.01	1.92	1.86	1.89	1.92	1.98	2.03	2.39	2.31	2.48	5075
2.70	2.71	2.76	2.78	2.70	2.77	3.08	2.94	3.05	2.94	3.23	3.20	3.19	3.32	3.11	5150
3.41	3.31	3.36	3.46	3.36	3.39	3.50	3.41	3.22	3.19	2.98	2.78	2.98	3.02	2.82	5225
2.98	2.86	2.92	2.92	3.05	3.22	3.60	3.78	3.81	3.96	3.76	3.62	3.34	3.08	3.31	5300
3.16	3.37	3.41	3.30	3.33	3.33	3.51	3.48	3.43	3.52	3.31	3.40	3.58	3.61	3.49	5375
3.46	3.42	3.19	3.18	3.30	3.00	2.99	3.21	3.11	3.14	3.10	2.72	2.81	2.95	2.69	5450
2.73	2.72	2.47	2.51	2.60	2.42	2.37	2.73	1.91	1.87	1.81	1.78	1.53	1.51	1.62	5525
1.59	1.50	1.42	1.32	1.22	1.12	1.08	1.02	0.97	0.92	0.90	0.87	0.84	0.82	0.79	5600
0.78	0.76	0.75	0.72	0.71	0.71	0.70	0.69	0.67	0.61	0.59	0.52	0.48	0.41	0.39	5675
0.38	0.33	0.32	0.30	0.30	0.30	0.29	0.28	0.27	0.26	0.25	0.23	0.22	0.21	0.20	5750
0.18	0.14	0.13	0.06	0.01	0.03	0.07	0.11	0.16	0.21	0.24	0.29	0.32	0.38	0.41	5825
-0.45	-0.50	-0.54	-0.61	-0.69	-0.76	-0.84	-0.90	-0.97	-1.01	-1.10	-1.13	-1.19	-1.22	-1.28	5900
-1.30	-1.33	-1.36	-1.39	-1.43	-1.48	-1.50	-1.52	-1.57	-1.61	-1.66	-1.70	-1.72	-1.78	-1.81	5975
-1.89	-1.92	-2.00	-2.08	-2.16	-2.24	-2.31	-2.40	-2.48	-2.54	-2.61	-2.71	-2.83	-2.95	-3.10	6050
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6125
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6200
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6275
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6350
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6425
-3.78	-3.33	-3.01	-2.82	-2.68	-2.49	-2.30	-2.13	-2.00	-1.81	-1.60	-1.41	-1.13	-0.90	-0.79	6500
-0.63	-0.48	-0.36	-0.28	-0.16	-0.06	0.08	0.20	0.29	0.41	0.54	0.69	0.80	0.92	1.04	6575
1.19	1.19	1.01	0.98	1.02	1.19	1.29	1.30	1.29	1.33	1.19	1.39	1.42	1.43	1.70	6650
1.62	1.54	1.41	1.53	1.86	1.96	1.97	2.02	2.01	1.94	1.94	1.83	2.03	2.21	2.42	6725
2.30	2.16	2.02	2.02	2.02	2.13	1.90	1.71	2.01	1.56	1.56	1.51	1.30	1.63	1.64	6800
1.67	1.70	2.22	2.32	2.38	2.30	1.93	2.39	2.49	2.52	2.57	2.21	2.18	2.40	2.41	6875
2.45	2.51	2.23	2.49	2.30	2.61	2.72	2.52	2.63	2.56	2.51	2.70	2.62	2.62	2.80	6950
2.74	2.79	2.74	2.70	2.88	2.81	2.72	2.76	2.84	2.92	2.98	2.88	2.88	3.02	3.08	7025
3.26	3.03	3.14	3.28	3.03	3.11	3.15	3.30	3.31	3.22	3.00	3.06	3.34	3.40	3.37	7100
3.32	3.08	3.09	3.09	3.01	3.07	3.07	3.31	3.21	3.31	3.67	3.58	3.79	3.70	3.49	7175
3.39	3.11	3.13	3.01	3.10	3.01	3.18	3.32	3.43	3.35	3.40	3.39	3.39	3.51	3.54	7250
3.42	3.50	3.67	3.59	3.63	3.66	3.48	3.39	3.29	3.31	3.41	3.23	3.32	3.12	2.91	7325
2.91	2.75	2.78	2.72	2.62	2.58	2.32	2.22	2.00	1.97	1.68	1.62	1.64	1.53	1.56	7400
1.51	1.52	1.48	1.42	1.42	1.40	1.41	1.43	1.56	1.52	1.51	1.52	1.39	1.34	1.30	7475
1.09	1.16	1.21	1.20	1.22	1.20	1.18	1.20	1.19	1.17	1.10	1.10	1.09	1.10	1.11	7550
1.04	0.98	0.90	0.86	0.90	0.90	0.90	0.81	0.71	0.79	0.70	0.71	0.67	0.62	0.53	7625
0.42	0.31	0.20	0.01	-0.08	-0.17	-0.26	-0.35	-0.44	-0.53	-0.63	-0.73	-0.83	-0.93	-1.04	7700
-1.14	-1.24	-1.34	-1.44	-1.54	-1.64	-1.74	-1.84	-1.94	-2.04	-2.14	-2.24	-2.34	-2.44	-2.54	7775
-2.64	-2.74	-2.84	-2.94	-3.04	-3.14	-3.24	-3.34	-3.44	-3.54	-3.64	-3.74	-3.84	-3.94	-4.04	7850
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	7925
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	8000
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	8075
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	8150
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	8225
-4.15	-4.06	-3.97	-3.88	-3.79	-3.70	-3.61	-3.52	-3.43	-3.34	-3.25	-3.16	-3.07	-2.98	-2.89	8300
-2.80	-2.71	-2.62	-2.53	-2.44	-2.35	-2.26	-2.18	-2.09	-2.00	-1.91	-1.82	-1.73	-1.64	-1.55	8375
-1.46	-1.37	-1.28	-1.19	-1.10	-1.01	-0.92	-0.83	-0.74	-0.65	-0.56	-0.47	-0.38	-0.29	-0.20	8450
-0.14	-0.09	-0.02	0.03	0.10	0.17	0.22	0.30	0.35	0.41	0.45	0.42	0.40	0.43	0.46	8525
0.50	0.59	0.71	0.84	0.93	1.01	1.06	1.07	1.02	1.01	1.12	1.23	1.24	1.28	1.34	8600
1.43	1.52	1.56	1.59	1.56	1.51	1.61	1.50	1.70	1.82	1.92	1.94	1.89	1.81	1.45	8675
1.30	1.28	1.43	1.50	1.49	1.55	1.48	1.32	1.39	1.53	1.82	2.23	2.61	2.51	2.20	8750

SPECTRAL DATA 4.0

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDG

Table A2. Listing of Data for LOWTRAN 4 (Cont)

1.86 1.61 1.19 1.32 1.52 1.70 1.90 2.01 1.92 1.91 2.12 2.10 2.01 2.18 1.99 8825
2.11 2.28 2.21 2.13 2.00 1.91 1.92 1.97 1.88 1.91 1.91 1.92 1.93 1.74 1.61 8900
1.58 1.27 1.20 1.18 1.11 0.99 0.86 0.71 0.60 0.44 0.31 0.19 0.03-0.07-0.21 8975
-0.35-0.49-0.64-0.79-0.94-1.11-1.24-1.41-1.57-1.73-1.91-2.09-2.27-2.45-2.63 9050
-2.81-2.99-3.16-3.37-3.56-3.75-3.94-4.13-4.31-4.49-4.66-4.83-4.99-5.14-5.28 9125
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 9150
-2.89-2.79-2.74-2.63-2.47-2.29-2.20-2.17-2.23-2.27-2.32-2.12-2.08-2.07-2.07 9250
-2.07-1.98-1.77-1.70-1.63-1.60-1.59-1.43-1.21-1.15-1.09-1.13-1.29-1.19-0.98 10025
-0.93-0.87-0.91-0.88-0.71-0.62-0.59-0.58-0.63-0.58-0.39-0.22-0.14-0.06-0.01 10100
-0.01-0.08-0.20-0.16-0.02 0.18 0.32 0.42 0.37 0.23 0.12 0.15 0.28 0.43 0.59 10175
0.58 0.53 0.44 0.39 0.38 0.35 0.23 0.26 0.19 0.08 0.10 0.18 0.27 0.38 0.43 10250
0.32 0.37 0.58 0.64 0.87 0.98 1.00 1.02 1.13 1.08 1.08 1.16 1.16 1.30 1.41 10325
1.40 1.32 1.32 1.37 1.42 1.50 1.42 1.38 1.36 1.38 1.49 1.63 1.62 1.62 1.70 10400
1.68 1.60 1.56 1.56 1.63 1.64 1.56 1.49 1.49 1.52 1.58 1.62 1.62 1.61 1.61 10475
1.62 1.63 1.71 1.72 1.70 1.70 1.67 1.62 1.66 1.70 1.67 1.56 1.49 1.42 1.38 10550
1.26 1.20 1.13 1.14 1.19 1.29 1.50 1.72 1.85 1.78 1.82 1.88 1.82 1.89 1.99 10625
2.00 2.14 2.24 2.02 2.02 1.98 1.90 1.83 1.71 1.72 1.69 1.59 1.50 1.36 1.20 10700
0.98 0.63 0.43 0.29 0.16 0.05 0.02 0.03 0.03 0.01-0.08-0.18-0.20-0.11-0.06 10775
-0.03-0.14-0.21-0.08-0.06 0.10 0.18 0.11 0.32 0.42 0.44 0.38 0.20 0.42 0.43 10850
0.41 0.33 0.32 0.41 0.50 0.46 0.31 0.18 0.03 0.20 0.21 0.34 0.36 0.20 0.35 10925
0.39 0.42 0.38 0.32 0.30 0.16-0.01-0.23-0.41-0.52-0.48-0.58-0.61-0.48-0.31 11000
-0.03 0.21 0.36 0.39 0.47 0.44 0.40 0.51 0.59 0.53 0.69 0.57 0.48 0.52 0.62 11075
0.59 0.55 0.50 0.32 0.26 0.11-0.08-0.10-0.16-0.43-0.62-0.88-1.09-1.16-1.31 11150
-1.45-1.49-1.78-1.91-2.11-1.97-1.97-1.97-1.97-2.20-2.20-2.01-1.99-2.00-2.04 11225
-2.37-2.49-2.44-2.36-2.32-2.19-2.10-2.25-2.16-2.36-2.44-2.40-2.49-2.48-2.43 11300
-2.40-2.36-2.40-2.49-2.59-2.68-2.89-3.28-3.51-3.74-3.97-4.20-4.43-4.66-4.89 11375
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 11450
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 11525
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 11600
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 11675
-3.71-3.56-3.40-3.21-3.06-2.90-2.74-2.60-2.46-2.32-2.17-2.03-1.87-1.79-1.74 11750
-1.83-1.82-1.71-1.59-1.49-1.46-1.46-1.49-1.49-1.25-1.24-1.08-0.90-1.06-0.91 11825
-0.91-1.01-0.99-0.87-0.92-0.79-0.42-0.54-0.38-0.42-0.48-0.34-0.27-0.17-0.28 11900
-0.38-0.22-0.30-0.08-0.01-0.20 0.06 0.10 0.06 0.14-0.12-0.02-0.62-0.13-0.11 11975
-0.10-0.06-0.05-0.04-0.10-0.04-0.06-0.21-0.38-0.61-0.40-0.31-0.42-0.58-0.57 12050
-0.54-0.24 0.11 0.51 0.81 0.79 0.62 0.26-0.31-0.67-0.60-0.88-0.50-0.39-0.10 12125
0.09 0.06 0.08 0.16 0.21 0.13 0.32 0.35 0.51 0.60 0.51 0.51 0.40 0.40 0.43 12200
0.42 0.33 0.43 0.34 0.22 0.13-0.11-0.31-0.31-0.41-0.41-0.39-0.53-0.69-0.84 12275
-0.88-1.01-1.10-1.19-1.29-1.45-1.49-1.67-1.67-1.51-1.66-1.60-1.69-1.83-1.51 12350
-1.42-1.40-1.24-1.38-1.31-1.30-1.30-1.28-1.39-1.33-1.40-1.35-1.37-1.39-1.41 12425
-1.49-1.48-1.56-1.47-1.46-1.41-1.42-1.48-1.41-1.31-1.15-1.13-1.20-1.41-1.88 12500
-2.08-2.08-2.22-2.35-2.35-1.98-1.92-1.78-1.57-1.69-1.70-1.70-1.66-1.84-1.50 12575
-1.56-1.42-1.29-1.38-1.28-1.48-1.58-1.44-1.53-1.48-1.48-1.58-1.58-1.69-1.79 12650
-2.00-2.16-1.99-2.23-2.04-2.04-2.39-2.74-3.09-3.44-3.79-4.14-4.49-4.84-5.19 12725
-2.46-2.26-1.99-2.01-2.14-2.31-2.15-2.01-1.99-2.14-2.41-2.12-1.99-1.84-1.79 12800
-1.71-1.78-1.72-1.68-1.78-1.52-1.38-1.29-1.22-0.91-0.90-1.01-0.76-0.90-0.90 12875
-0.90-1.19-1.00-0.79-0.68-0.68-0.73-0.85-0.85-0.61-0.61-0.48-0.51-0.92-0.83 12950
-0.61-0.41-0.29-0.29-0.61-0.74-0.19-0.18 0.19 0.19 0.20 0.20 0.20 0.02 0.01 13025
-0.01 0.18 0.28 0.11 0. -0.37-0.10 0.02 0.16 0.20 0. 0.09 0.09 0.09 0.07 13100
0.22 0.11 0.11 0.21 0.09 0.21 0.20 0.37 0.28 0.07 0.09-0.29-0.69-0.69-0.74 13175

SPECIAL DATA 720

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN 4 (Cont)

-0.88-1.01-0.86-0.54-0.19 0.19 0.23 0.21 0.29 0.28 0.29 0.52 0.54 0.51 .6013850
0.40 0.49 0.48 0.46 0.49 0.27 0.06-0.33-0.81-1.17-1.11-1.37-1.52-1.54-1.9413925
-2.06-2.06-2.14-1.96-2.00-2.00-2.08-2.23-2.31-2.31-2.53-2.31-2.31-2.2814000
-2.34-2.34-1.91-1.82-1.69-1.56-1.84-1.91-1.75-1.83-1.76-1.54-1.98-1.80-1.6814075
-1.69-1.56-1.60-1.71-1.36-1.36-1.44-1.48-1.40-1.48-1.36-1.45-1.49-1.85-1.3914150
-1.23-1.18-1.18-1.34-1.36-1.23-1.23-1.37-1.30-1.40-1.28-1.27-1.37-1.32-1.3214225
-1.22-1.28-1.38-1.69-2.07-2.42-2.58-2.58-2.80-2.58-2.43-1.88-1.60-1.26-1.1614300
-1.23-1.10-1.23-1.10-0.83-0.80-0.80-0.98-0.97-0.97-0.91-0.92-1.13-1.2414375
-1.50-1.89-2.18-2.32-2.63-3.91-4.20-4.49-4.78-5.07-5.07-5.07-5.07-5.0714450
-4.25-3.70-3.20-2.75-1.90-1.73-1.51-1.29-1.11-0.91-0.71-0.51-0.30-0.22 530
0.49 0.76 1.08 1.29 1.56 1.76 1.91 2.08 2.23 2.36 2.51 2.72 2.90 3.12 3.37 575
3.56 3.69 3.79 3.86 3.88 3.86 3.73 3.58 3.39 3.17 2.86 2.73 2.52 2.31 2.17 650
2.01 1.84 1.77 1.63 1.47 1.21 0.92 0.53 0.23-0.17-0.53-0.74-0.81-0.84-0.86 725
-1.00-1.16-1.42-1.61-1.86-2.10-2.29-2.51-2.72-2.91-3.14-5.00-5.00-5.00 800
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-2.68-2.47-2.14-1.97-1.71-1.50-1.32-1.21-1.13 875
-1.09-1.11-1.10-1.09-1.01-1.01-1.11-1.33-1.66-2.13-2.51-2.83-2.71-2.39-2.09 950
-1.78-1.59-1.33-1.18-1.01-0.96-0.91-0.90-1.87-0.60-0.79-0.86-1.37-1.26-1.69 1375
-2.11-2.74-3.09-3.50-3.03-2.58-2.23-1.89-1.54-1.28-1.13-1.11-1.16-1.20-1.23 1100
-1.21-1.17-1.12-1.15-1.19-1.20-1.17-1.02-0.89-0.69-0.42-0.24-0.01 0.18 0.40 1175
0.57 0.77 0.96 1.07 1.13 1.11 1.08 1.15 1.27 1.33 1.44 1.40 1.13 0.89 0.63 1250
0.54 0.65 0.78 0.81 0.86 0.82 0.68 0.47 0.14-0.12-0.48-0.92-1.43-1.89 2.32 1325
-2.81-5.00-5.00-5.00-5.00-3.14-2.47-2.00-1.71-1.53-1.61-1.69-1.82-1.37-1.90-1.94 1400
-2.04-2.10-2.23-2.32-2.48-2.71-2.88-3.09-3.29-3.43-3.00-1.69-1.42-1.38-1.49 1475
-1.70-2.01-2.41-2.64-2.63-2.49-2.38-2.27-2.16-2.05-1.94-1.83-1.76-1.71-1.70 1550
-1.72-1.81-1.92-2.03-2.27-2.61-3.21-4.01-5.00-5.00-5.00-5.00-5.00-5.00-5.00 1625
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 1700
-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-4.30-3.42-3.17-2.98 1775
-2.83-2.71-2.67-2.67-2.68-2.58-2.33-2.01-1.64-1.32-0.97-0.76-0.63-0.59-0.60 1850
-0.63-0.69-0.87-1.08-1.26-1.53-1.87-1.91-1.93-2.02-2.21-2.48-2.86-3.08-3.11 1925
-3.09-2.93-2.76-2.39-2.01-1.69-1.36-0.99-0.63-0.28 0.00 0.08 0.11 0.12 0.12 2000
0.07 0.01-0.08-0.23-0.40-0.51-0.53-0.57-0.60-0.61-0.73-0.81-0.95-1.05-1.02 2075
-0.91-0.68-0.41-0.09 0.16 0.41 0.76 1.00 1.18 1.39 1.51 1.58 1.68 1.71 1.80 2150
1.91 2.02 2.18 2.32 2.50 2.61 2.69 2.81 2.89 2.96 3.04 3.14 3.27 3.41 3.55 2225
3.72 3.90 4.03 4.22 4.42 4.61 4.71 4.73 4.65 4.63 4.72 4.78 4.79 4.50 3.62 2300
3.23 2.79 2.30 1.86 1.35 0.92-0.24-1.69-2.18-2.01-1.79-1.53-1.32-1.20-1.15 2375
-1.12-1.18-1.25-1.26-1.20-1.17-1.20-1.32-1.54-1.84-2.16-2.30-2.26-2.01-1.71 2450
-1.36-1.06-0.81-0.61-0.49-0.45-0.47-0.49-0.46-0.37-0.31-0.34-0.49-0.75-1.11 2525
-1.43-2.01-2.60-2.89-2.87-2.74-2.51-2.42-2.38-2.39-2.42-2.46-2.48-2.49-2.43 2600
-2.43-2.46-2.53-2.68-2.74-2.82-2.87-2.83-2.82-2.79-2.71-2.66-2.49-2.40-2.32 2675
-2.26-2.23-2.20-2.09-2.02-1.96-1.88-1.84-1.85-1.86-1.87-1.83-1.79-1.73-1.68 2750
-1.64-1.69-1.74-1.79-1.87-1.78-1.63-1.50-1.37-1.21-1.00-0.83-0.69-0.53-0.41 2825
-0.30-0.19-0.09-0.04 0.02 0.10 0.16 0.18 0.23 0.26 0.27 0.26 0.24 0.22 0.17 2900
0.12 0.07-0.01-0.07-0.09 0.32 0.72 0.91 1.12 1.03 0.67 0.18-0.11-0.38-0.24 2975
-0.17-0.08-0.00 0.09 0.13 0.18 0.24 0.27 0.29 0.31 0.29 0.26 0.23 0.21 0.13 3050
0.09 0.02-0.04-0.18-0.32-0.51-0.72-0.93-1.18-1.50-1.62-1.81-2.04-2.29-2.49 3125
-2.62-2.87-3.03-3.21-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00-5.00 3200
-5.00-4.01-3.38-3.01-2.63-2.32-2.09-1.98-1.94-2.00-2.14-2.26-2.20-2.02-1.82 3275
-1.59-1.43-1.38-1.46-1.64-1.90-2.09-2.54-2.91-3.28-3.61-3.72-3.64-3.56-3.41 3350
-3.37-3.30-3.16-3.01-2.76-2.51-2.20-1.80-1.49-1.22-0.97-0.72-0.49-0.20 0.03 3425
0.20 0.36 0.51 0.51 0.67 0.83 1.00 1.22 1.39 1.56 1.70 1.86 2.01 2.26 2.31 3500

SPECTRAL DATA - UNIFORM MIXED CASES

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN 4 (Cont)

2.47	2.61	2.76	2.92	3.01	3.05	3.02	2.98	2.93	3.01	3.03	2.97	2.78	2.44	2.13	3575
1.83	1.79	1.49	1.50	1.67	1.94	2.22	2.50	2.71	2.93	3.12	3.18	3.17	3.15	3.21	3650
3.26	3.19	2.98	2.59	2.14	1.70	1.22	0.65	-0.27	-1.09	-2.54	-3.06	-2.94	-2.78	-2.68	3725
-2.61	-2.60	-2.63	-2.60	-2.57	-2.53	-2.57	-2.64	-2.77	-3.04	-3.38	-3.98	-5.00	-5.00	-5.00	3800
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.10	-5.00	-5.00	-5.00	3875
-5.00	-4.00	-3.73	-3.62	-3.59	-3.53	-3.56	-3.57	-3.51	-3.51	-3.45	-3.37	-3.26	-3.21	-3.18	3950
-3.27	-3.36	-3.60	-3.96	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	4025
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	4100
-4.07	-3.89	-3.76	-3.67	-3.56	-3.42	-3.35	-3.26	-3.18	-3.14	-3.11	-3.09	-3.10	-3.12	-3.23	4175
-3.30	-3.38	-3.37	-3.29	-3.14	-3.08	-3.00	-2.93	-2.83	-2.91	-3.00	-3.08	-3.16	-3.31	-3.48	4250
-3.71	-3.98	-5.00	-5.00	-5.00	-4.62	-3.98	-3.69	-3.42	-3.18	-2.95	-2.77	-2.61	-2.48	-2.35	4325
-2.41	-2.41	-2.40	-2.38	-2.34	-2.27	-2.21	-2.31	-2.49	-2.73	-3.71	-4.13	-5.00	-5.00	-5.00	4400
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	4475
-5.00	-5.00	-4.13	-4.02	-3.99	-3.96	-3.87	-3.73	-3.51	-3.29	-3.13	-2.99	-2.84	-2.73	-2.69	4550
-2.63	-2.69	-2.65	-2.62	-2.59	-2.57	-2.62	-2.61	-3.04	-3.21	-3.39	-3.42	-3.36	-3.21	-3.03	4625
-2.93	-2.80	-2.64	-2.52	-2.37	-2.28	-2.20	-2.13	-2.07	-2.02	-1.96	-1.46	-1.78	-1.63	-1.44	4700
-1.31	-1.20	-1.00	-0.98	-0.94	-0.86	-0.76	-0.62	-0.31	-0.03	0.13	0.36	0.37	0.36	0.36	4775
0.35	0.35	0.39	0.46	0.48	0.41	0.23	-0.08	-0.33	-0.67	-0.88	-0.96	-0.98	-0.87	-0.67	4850
-0.36	-0.12	0.14	0.44	0.68	0.90	1.11	1.19	1.24	1.25	1.26	1.27	1.51	1.59	1.50	4925
1.28	0.71	0.11	-0.26	-0.67	-1.32	-1.61	-1.68	-1.42	-1.18	-0.91	-0.59	-0.27	-0.06	0.29	5000
0.57	0.73	0.92	0.91	0.73	0.79	0.91	1.01	1.03	0.88	0.72	0.63	0.38	0.12	-0.21	5075
-0.47	-0.67	-1.23	-1.67	-2.31	-2.76	-3.24	-3.49	-3.51	-3.47	-3.39	-3.37	-3.43	-3.53	-3.56	5150
-3.36	-3.18	-3.07	-2.96	-3.08	-3.14	-3.12	-3.23	-3.07	-2.83	-2.47	-2.23	-2.27	-1.91	-1.78	5225
-1.63	-1.46	-1.27	-1.23	-1.26	-1.40	-1.57	-1.98	-2.28	-2.87	-3.74	-5.00	-5.00	-5.00	-5.00	5300
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5375
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5450
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5525
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5600
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5675
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5750
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5825
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	5900
-4.48	-4.40	-4.29	-4.17	-3.90	-3.73	-3.54	-3.62	-3.72	-3.73	-3.69	-3.31	-3.12	-2.91	-2.63	5975
-2.41	-2.27	-2.16	-2.11	-2.28	-2.29	-2.21	-2.06	-1.91	-1.99	-2.27	-2.59	-2.90	-3.35	-3.69	6050
-3.79	-3.68	-3.53	-3.40	-3.39	-3.31	-3.18	-2.97	-2.63	-2.39	-2.11	-1.83	-1.58	-1.49	-1.22	6125
-1.08	-0.89	-0.68	-0.54	-0.71	-0.79	-0.78	-0.66	-0.40	-0.54	-0.80	-1.37	-2.08	-2.44	-3.46	6200
-3.72	-3.74	-3.59	-3.22	-2.98	-2.52	-2.21	-1.64	-1.34	-1.03	-0.86	-0.72	-0.61	-0.70	-0.72	6275
-0.67	-0.57	-0.38	-0.51	-0.97	-1.36	-1.89	-2.74	-3.13	-4.21	-4.57	-4.62	-4.78	-4.87	-5.00	6350
-5.00	-5.00	-5.00	-5.00	-5.00	-4.93	-4.46	-3.99	-3.45	-2.99	-2.63	-2.30	-2.09	-2.02	-2.12	6425
-2.18	-2.13	-2.04	-1.78	-1.83	-2.08	-2.28	-2.61	-3.01	-3.15	-3.22	-3.29	-3.58	-3.89	-4.46	6500
-4.88	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	6575
-4.81	-4.52	-4.11	-3.69	-3.09	-2.99	-2.91	-2.89	-3.19	-3.20	-3.36	-3.62	-3.89	-3.92	-3.73	6650
-3.53	-3.37	-3.19	-3.02	-2.79	-2.52	-2.36	-2.24	-2.19	-2.32	-2.41	-2.29	-2.00	-2.00	-2.18	6725
-2.47	-2.91	-3.57	-4.89	-5.00	-5.00	-5.00	-5.00	-5.00	-4.61	-4.18	-3.89	-3.57	-3.30	-3.02	6800
-2.74	-2.51	-2.20	-1.96	-1.73	-1.57	-1.38	-1.21	-1.11	-0.98	-0.87	-0.78	-0.60	-0.37	-0.18	6875
-0.04	-0.04	-0.06	-0.16	-0.18	-0.19	-0.23	-0.45	-1.02	-1.97	-2.70	-3.71	-4.01	-4.20	-4.35	6950
-4.53	-4.73	-4.81	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	7025
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	7100
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	7175
-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	-5.00	7250

SECURITY DATA - UNCLASSIFIED

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for COWTRAN 4 (cont)

[illegible]

31-70-1000-1345

Table A2. Listing of Data for LOWTRAN 4 (Cont)

DATE	DESCRIPTION	AMOUNT	BALANCE
1/1/20	OPENING BALANCE		100.00
1/15/20	PAYROLL	50.00	50.00
1/20/20	RECEIVED	25.00	75.00
1/25/20	PAYROLL	50.00	25.00
1/30/20	RECEIVED	25.00	50.00
2/5/20	PAYROLL	50.00	0.00
2/10/20	RECEIVED	25.00	25.00
2/15/20	PAYROLL	50.00	0.00
2/20/20	RECEIVED	25.00	25.00
2/25/20	PAYROLL	50.00	0.00
2/28/20	RECEIVED	25.00	25.00
3/5/20	PAYROLL	50.00	0.00
3/10/20	RECEIVED	25.00	25.00
3/15/20	PAYROLL	50.00	0.00
3/20/20	RECEIVED	25.00	25.00
3/25/20	PAYROLL	50.00	0.00
3/30/20	RECEIVED	25.00	25.00
4/5/20	PAYROLL	50.00	0.00
4/10/20	RECEIVED	25.00	25.00
4/15/20	PAYROLL	50.00	0.00
4/20/20	RECEIVED	25.00	25.00
4/25/20	PAYROLL	50.00	0.00
4/30/20	RECEIVED	25.00	25.00
5/5/20	PAYROLL	50.00	0.00
5/10/20	RECEIVED	25.00	25.00
5/15/20	PAYROLL	50.00	0.00
5/20/20	RECEIVED	25.00	25.00
5/25/20	PAYROLL	50.00	0.00
5/30/20	RECEIVED	25.00	25.00
6/5/20	PAYROLL	50.00	0.00
6/10/20	RECEIVED	25.00	25.00
6/15/20	PAYROLL	50.00	0.00
6/20/20	RECEIVED	25.00	25.00
6/25/20	PAYROLL	50.00	0.00
6/30/20	RECEIVED	25.00	25.00
7/5/20	PAYROLL	50.00	0.00
7/10/20	RECEIVED	25.00	25.00
7/15/20	PAYROLL	50.00	0.00
7/20/20	RECEIVED	25.00	25.00
7/25/20	PAYROLL	50.00	0.00
7/30/20	RECEIVED	25.00	25.00
8/5/20	PAYROLL	50.00	0.00
8/10/20	RECEIVED	25.00	25.00
8/15/20	PAYROLL	50.00	0.00
8/20/20	RECEIVED	25.00	25.00
8/25/20	PAYROLL	50.00	0.00
8/30/20	RECEIVED	25.00	25.00
9/5/20	PAYROLL	50.00	0.00
9/10/20	RECEIVED	25.00	25.00
9/15/20	PAYROLL	50.00	0.00
9/20/20	RECEIVED	25.00	25.00
9/25/20	PAYROLL	50.00	0.00
9/30/20	RECEIVED	25.00	25.00
10/5/20	PAYROLL	50.00	0.00
10/10/20	RECEIVED	25.00	25.00
10/15/20	PAYROLL	50.00	0.00
10/20/20	RECEIVED	25.00	25.00
10/25/20	PAYROLL	50.00	0.00
10/30/20	RECEIVED	25.00	25.00
11/5/20	PAYROLL	50.00	0.00
11/10/20	RECEIVED	25.00	25.00
11/15/20	PAYROLL	50.00	0.00
11/20/20	RECEIVED	25.00	25.00
11/25/20	PAYROLL	50.00	0.00
11/30/20	RECEIVED	25.00	25.00
12/5/20	PAYROLL	50.00	0.00
12/10/20	RECEIVED	25.00	25.00
12/15/20	PAYROLL	50.00	0.00
12/20/20	RECEIVED	25.00	25.00
12/25/20	PAYROLL	50.00	0.00
12/30/20	RECEIVED	25.00	25.00
1/1/21	OPENING BALANCE		100.00

Table A2. Listing of Data for LOWTRAN-4 (Cont)

(
T
U
Y
-
Z
(
(
IT

2000

— 22 —

1990

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

Table A2. Listing of Data for LOWTRAN 4 (Cont)

7.20	.01330	.00629	7.90	.00784	.00564	8.20	.00809	.00702	8.50	.01530	.01160
8.70	.02190	.01180	9.00	.02380	.01310	9.20	.02350	.01430	9.50	.01650	.00937
10.00	.01570	.00698	10.50	.01350	.00549	11.00	.01220	.00439	13.00	.00939	.00386
14.00	.00827	.00464	16.00	.01010	.00651	17.20	.01100	.00607	18.50	.00923	.00506
20.00	.01010	.00587	25.00	.00878	.00565	27.90	.00821	.00562	30.00	.00808	.00581
0.	0.	0.	10.								
1020.	20200.	5.									

UNCLASSIFIED

Appendix B

Basic Flow Chart for LOWTRAN 4

A general flow chart for LOWTRAN 4 is given in Figure B1 which shows the overall mode of operation of the program. More detailed flow charts are also given for the main blocks in the program, that is, where the equivalent absorber amounts and refraction calculations are made (Figure B2), the transmittance/radiance loop (Figure B3), and the transmittance calculations (Figure B4).

The notation used in the flow charts is as follows:

(1) If a condition stated within a given block is fulfilled, then the direction of flow is sideways as indicated by the direction in which the block points (for example $\rightarrow$ for the following block $\square \rightarrow$).

(2) If the condition stated within a block is not fulfilled, the flow is downwards.

The numbers appearing on the flow charts correspond to the statement numbers given in the main program (see Table A1).

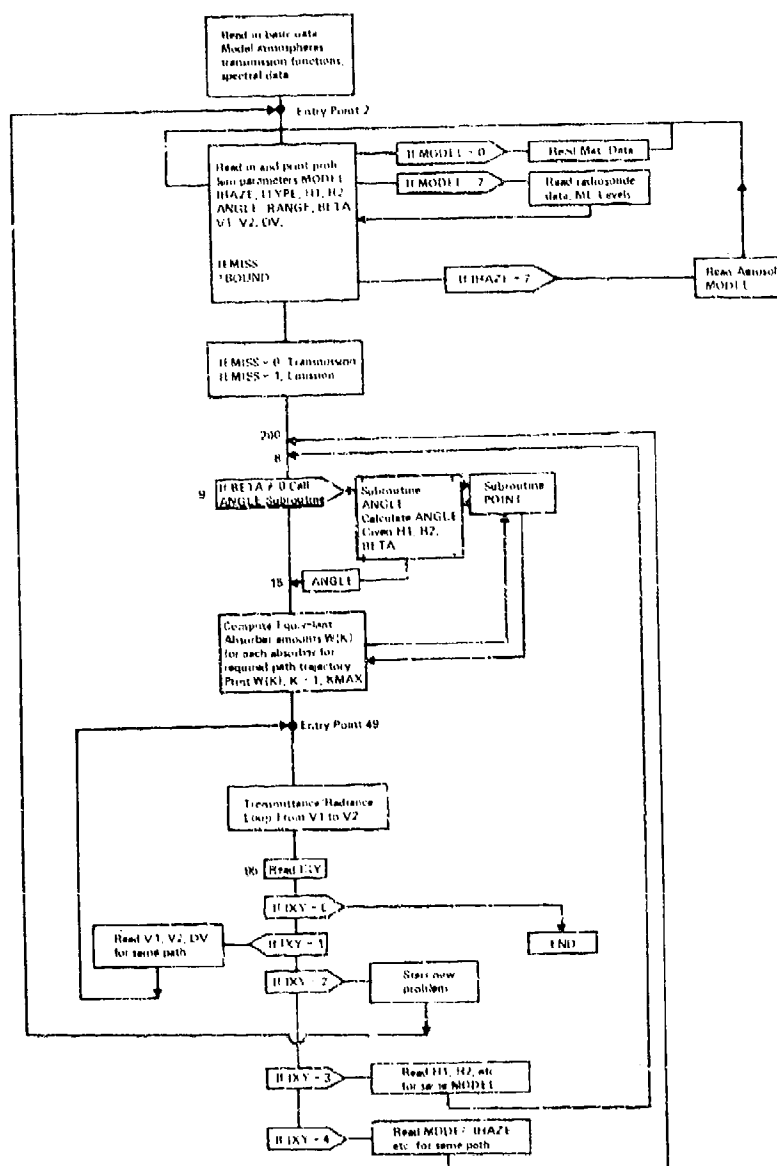


Figure B1. General Flow Chart for LOWTRAN 4

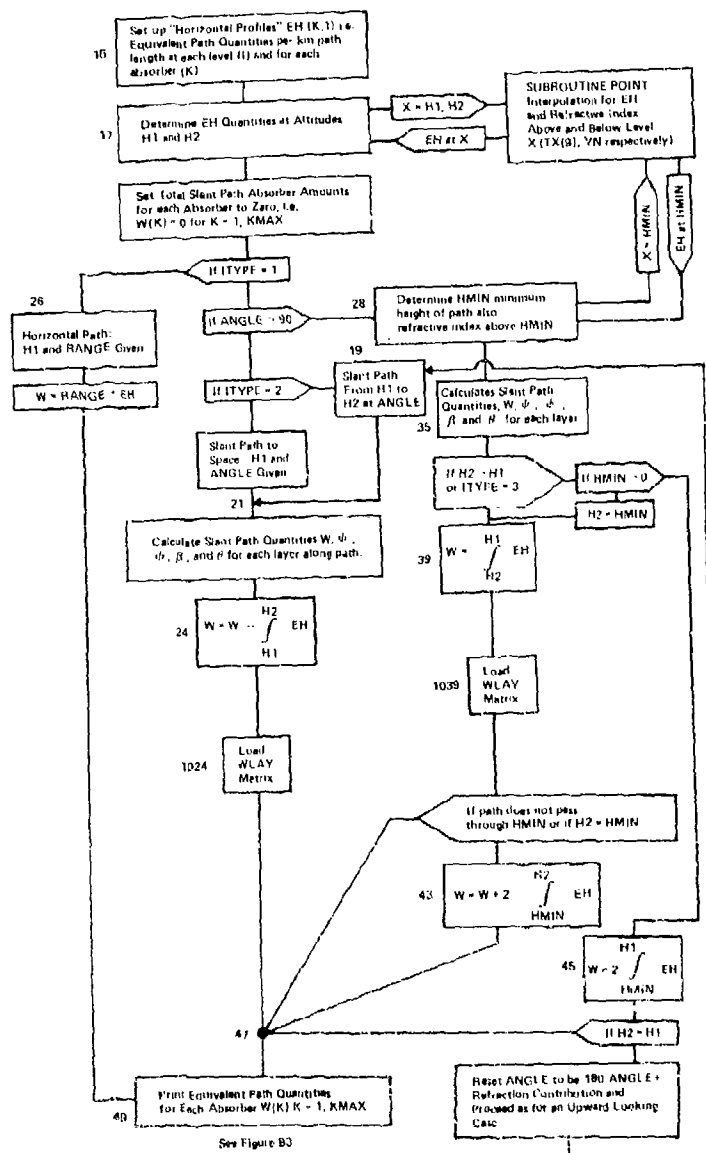


Figure B2. Flow Chart for Calculation of Equivalent Path Quantities

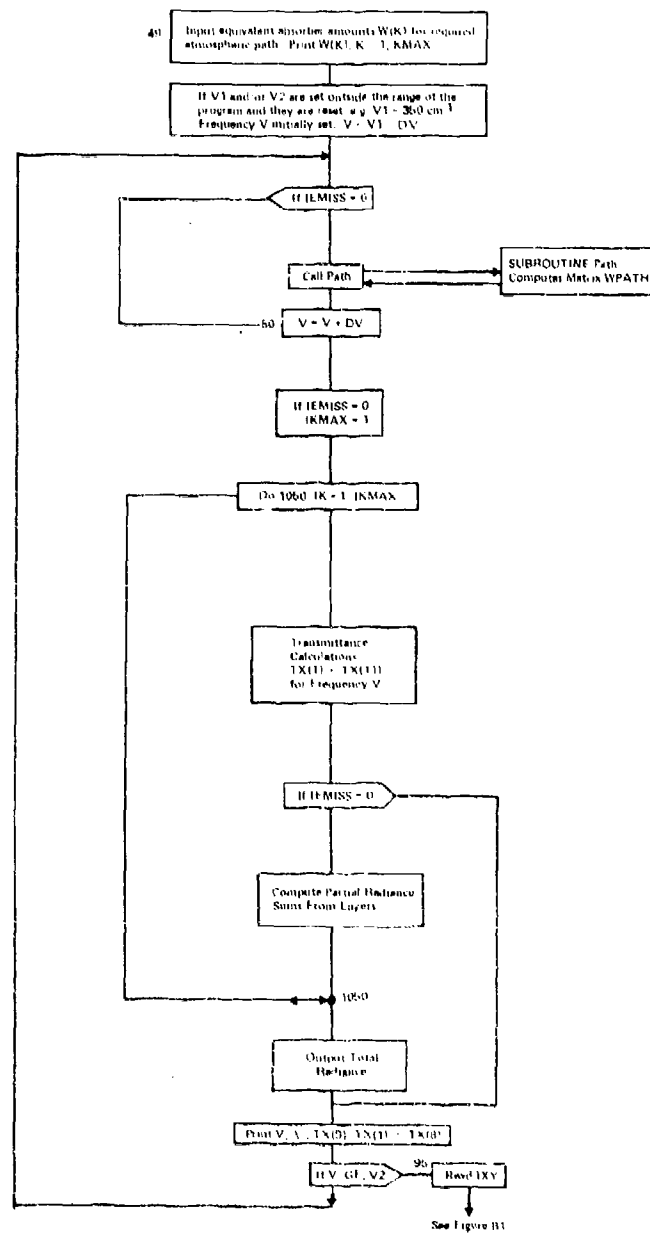


Figure B3. Flow Chart for Transmittance/Radiance Loop

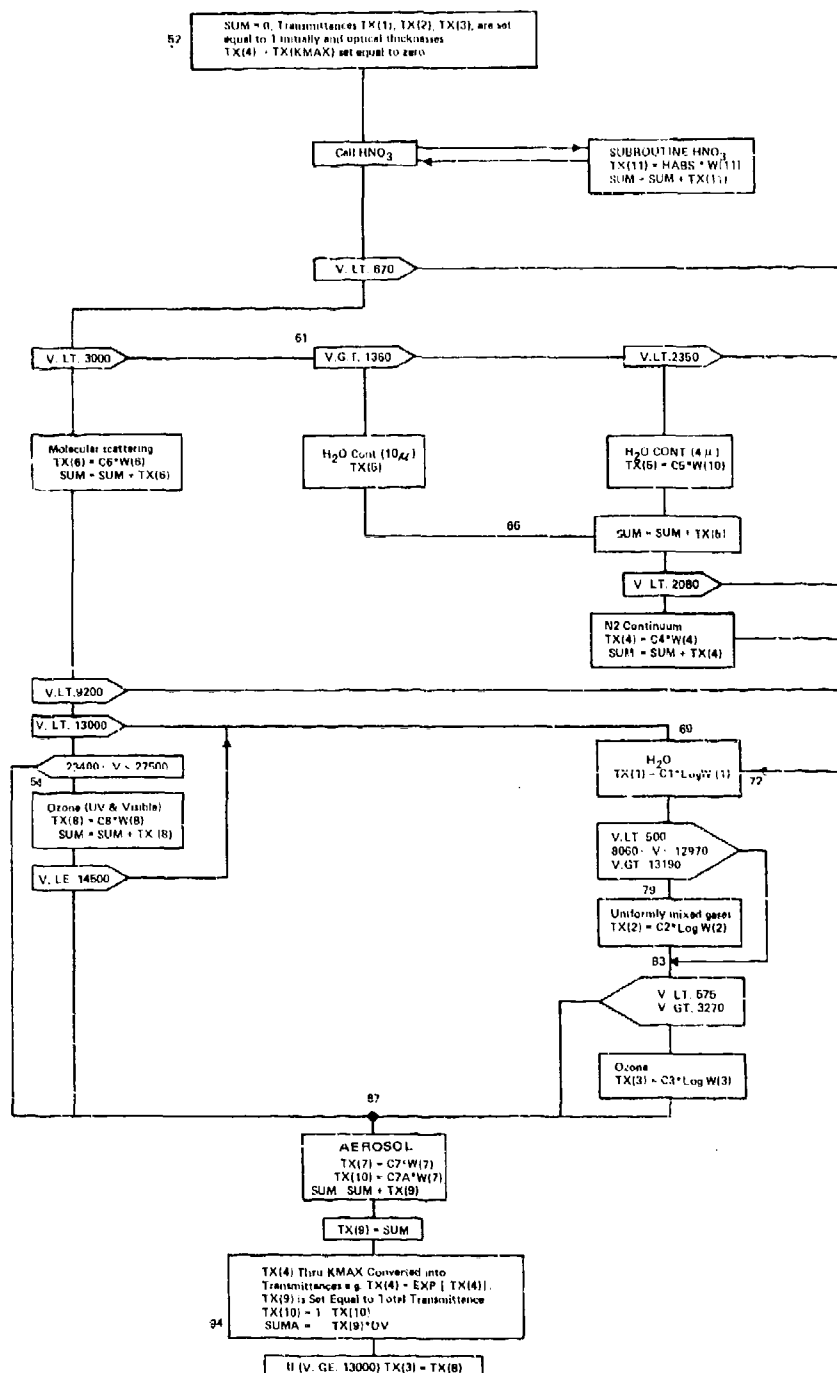


Figure B4. Flow Chart for Transmittance Calculations

Appendix C

Symbols and Definitions

AB	Absorption at frequency V ; also average transmittance
AHAZE	Aerosol number density for MODEL = 7
AHZ2	Aerosol number density for MODEL = 7
AJ	Equivalent absorber amount per km at level J
ALAM	Wavelength (μm)
ALP	Angle of arrival at adjacent level
ANGLE	Input zenith angle (degrees)
AO	Constant $A = (R_o + H_1)n_o \sin \theta_o$
AVW	Average wavelength used in refractive index expression
B	Storage parameter for BETA
BBG	Black body function of boundary times the total transmittance along the path
BBIK	Black body function of the IK layer and the frequency V
BET	Angle subtended at the earth's center as path traverses adjacent levels
BETA	Total angle subtended by path at earth's center
BJ	Equivalent absorber amount per km at level J + 1
CA	Conversion factor from degrees to radians
CO	Wavelength dependent coefficient used in refractive index expression
CW	Wavelength dependent coefficient used in refractive index expression
C1	Log absorption coefficient for water vapor
C2	Log absorption coefficient for uniformly mixed gases
C3	Log absorption coefficient for ozone

C4	Absorption coefficient for nitrogen ($\sim 4 \mu\text{m}$)
C5	Absorption coefficient for water vapor continuum ($\sim 10 \mu\text{m}$)
C6	Extinction coefficient for molecular scattering
C7	Extinction coefficient for aerosol models
C7A	Aerosol absorption coefficient
C8	Absorption coefficient for ozone (UV and visible regions)
D	Water vapor amount (pr. cm/km) at level 1
DTAU	Differential transmittance (due to absorption) across the IK layer
DP	Dew point temperature ($^{\circ}\text{C}$)
DS	Path length from level 1 to level 1 + 1
DV	Wavenumber increment at which transmittance is calculated
DZ	Height increment from level 1 to level 1 + 1
E(K)	Equivalent absorber amounts per km at height H1
EH(1,1)	Equivalent absorber amount per km for H_2O at level Z(1)
EH(2,1)	Equivalent absorber amount per km for $\text{CO}_2 + \text{N}_2\text{O}$ etc at level Z(1)
EH(3,1)	Equivalent absorber amount per km for O_3 at level Z(1)
EH(4,1)	Equivalent absorber amount per km for N_2 at level Z(1)
EH(5,1)	Equivalent absorber amount per km for H_2O continuum at level Z(1), ($10 \mu\text{m}$)
EH(6,1)	Equivalent absorber amount per km for molecular scattering at level Z(1)
EH(7,1)	Equivalent absorber amount per km for aerosol extinction at level Z(1)
EH(8,1)	Equivalent absorber amount per km for ozone (UV and visible) at level Z(1)
EH(9,1)	Mean refractive index of layer above level Z(1)
EH(10,1)	Equivalent absorber amount per km for H_2O continuum at level Z(1), ($4 \mu\text{m}$)
EH(11,1)	Equivalent absorber amount per km for nitric acid at level Z(1)
EV	Integrated absorber amount from level 1 to level 1 + 1
F	Function for determining saturation vapor density of water (gm m^{-3})
FF	Black body function ($\text{W/cm}^2\text{-ster-}\mu\text{m}$)
FAC	Interpolation parameter
FACTOR	Integration weighting parameter
FO	Transmission function logarithmic absorber amount scale for O_3
FW	Transmission function logarithmic absorber amount scale for H_2O and the uniformly mixed gases
H	Altitude dependent control parameter
H1	Initial altitude (km)
H2	Final altitude (km)
HARS	Nitric acid absorption coefficient

HAZF	Aerosol number density (no. cm^{-3})
HM	Estimated tangent height (km)
HMIN	Minimum altitude of path trajectory (km)
HMX(I)	Nitric acid volume mixing ratio (times 1.0×10^9) at the level Z(I)
HSTOR(I)	Interpolated nitric acid volume mixing ratios
HZ(I)	Hollerith titles for visibility
HZ1	Aerosol number density (no. cm^{-3}) for 23 km visual range
HZ2	Aerosol number density (no. cm^{-3}) for 5 km visual range
I	Running integer used as altitude (level) indicator and frequency indicator
IATM	Number of model atmospheres
ICOUNT	Output page counter
IDV	Frequency increment (cm^{-1})
IEMISS	Input control parameter determining mode of program execution (=0 for transmittance, =1 for radiance mode)
IFIND	Indicator for using subroutine ANGL
IHAZE	Aerosol model indicator
IJ	Equals IK
IK	Running integer used as layer indicator along the atmospheric path
IKLO	Lower limit of layer loop (=1)
IKMAX	Upper limit of layer loop
IL	Integer indicator used to determine if the atmospheric path intersects the earth
IM	Parameter used when reading in a new atmospheric model
IP	Indicator for using subroutine POINT to calculate refractive index only (IP = 0) or equivalent absorber amounts also (IP $\neq$ 0)
ITYPE	Indicator for type of atmospheric path
IV	Frequency at which transmittance is calculated
IV1	Starting frequency (equivalent to V1)
IV2	Last frequency (equivalent to V2)
IXY	Parameter for terminating program and cycling indicator
J	Running integer for altitude identification
JEXTRA	Integer indicator used when H1, H2, and HMIN are in the same layer (ITYPE=2)
JMIN	Altitude indicator for minimum height of path
JP	Print option parameter
JSTOR	Integer indicator used when vertical profile changes from downward to upward path
J1	Level indicator for altitude H1
J2	Level indicator for altitude H2
K	Absorber indicator, K = 1, 2, 3, etc., corresponds to H_2O uniformly mixed gases, O_3 etc, respectively

KMAX	Upper limit of absorber amount loops (≈ 11)
K1	Integer used in reading two model atmospheres on one card
K2	Integer used in reading two model atmospheres on one card and cycling parameter for downward looking paths
K4	Frequency indicator for nitrogen continuum transmittance calculation
L	Frequency indicator for ozone transmittance calculation
LEN	Parameter used for defining longest of two paths
LENSTOR	Integer storage for parameter LEN, needed for cases run in succession
L1	Frequency identifier for UV and visible ozone transmittance calculation
L2	Frequency identifier for UV and visible ozone transmittance calculation
M	Integer used to identify required model atmosphere
ML	Number of levels in radiosonde data input (MODEL = 7)
MODEL	Integer used to identify required model atmosphere
M1	Integer for selecting H ₂ O altitude profile for (M=M1)
M2	Integer for selecting temperature altitude profile for (M=M2)
M3	Integer for selecting O ₃ altitude profile for (M=M3)
N	Indicator for level below given input altitude used in POINT subroutine; also as frequency indicator in UV and visible ozone transmittance calculation
NH	Frequency indicator for water vapor continuum transmittance calculation
NL	Number of levels in model atmosphere data
NLL	Equals NL-1
NP	Indicator for determining whether H1 or H2 coincide with levels in the model atmosphere
NP1	Value of NP for altitude H1
NP2	Value of NP for altitude H2
P(M, I)	Pressure (mb) at level I for model atmosphere M
PH	$180^\circ - \text{PHI}$
PHI	Angle of arrival at H2
PI	3.141592654 that is (π)
PPW	Partial pressure of water vapor (in atmospheres)
PS	Total pressure in atmospheres
PSI	Angular deviation of path from initial direction
PT	Product of total pressure (atm) and the square root of $273/T(M, I)$
RADMAX	Maximum value of radiance
RADMIN	Minimum value of radiance
RADSUM	Integrated radiance ($\text{W}/\text{cm}^2\text{-ster}$)
RANGE	Path length (km)
RE	Earth radius (km)

REF	Refractive index of air at level I
RH	Relative humidity (%)
RN	Ratio of refractive indices of air above and below a given level
RO	Earth radius (km) read in as input (=RE)
RX	Ratio of earth center distances between adjacent levels
R1	The product of the sine of the initial zenith angle and the earth center distance to starting altitude
SALP	Sine of angle of arrival at adjacent level (cf $\sin \alpha$)
SPHI	Sine of the local zenith angle at a given level (cf $\sin \theta$)
SR	Slant range (km)
SUM	Sum of the optical thicknesses of absorbers 4 through 11
SUMA	Accumulated integrated absorption
SUMV	Radiance ($\text{W}/\text{cm}^2\text{-ster-cm}^{-1}$)
SUMVV	Radiance ($\text{W}/\text{cm}^2\text{-ster-}\mu\text{m}$)
T(M, I)	Temperature ($^{\circ}\text{K}$) for model atmosphere M at level I
TAUG	Total transmittance to the boundary
TBBY(IK)	Average temperature of the IK layer
TBOUND	Input temperature of the boundary in $^{\circ}\text{K}$
THET	Zenith angle at a given level (in radians)
THETA	Zenith angle at a given level (in degrees)
TMP	Ambient temperature ($^{\circ}\text{C}$)
TR	Transmittance scales for transmission functions
TS	Ratio of standard temperature (273. 0 $^{\circ}\text{K}$) to temperature at Level I
TSNEW	Transmittance (due to scattering) to the far boundary of the IK layer
TSOLD	Transmittance (due to scattering) to the near boundary of the IK layer
TS1	Ratio of 296 $^{\circ}\text{K}$ to ambient temperature ($^{\circ}\text{K}$)
TT	Ratio 273. 15/(TMP+ 273. 15)
TX(K)	Equivalent absorber amounts per km at a given altitude obtained from POINT; also transmittance values at a given wavelength for each absorber type (K = 1, KMAX)
TX(9)	Total transmittance at frequency V
TX(10)	Absorption due to aerosol only at frequency V
TX1	Refractive index of layer above initial altitude H1
TX2	Refractive index of layer above final altitude H2
TX3	Refractive index of layer above minimum altitude HMIN
T1	Temperature of the boundary ($^{\circ}\text{K}$)
T2	Temperature of the I+1 boundary used in index of refraction calculation
V	Running frequency (cm^{-1})
VH(K)	Integral of the equivalent absorber amounts from H1 to level I
VIS	Visual range (km) at sea level

VRMAX	Frequency of the maximum radiance (cm^{-1})
VRMIN	Frequency of the minimum radiance (cm^{-1})
VX	Wavelength at which aerosol coefficients are read in (μm)
V1	Initial frequency for transmittance calculation, cm^{-1}
V2	Final frequency for transmittance calculation, cm^{-1}
W(K)	Total equivalent absorber amount for entire path
WH(M, I)	Water vapor density for atmospheric model M at level I (gm m^{-3})
WLAY(I, K)	The absorber amount for the species, K, and the atmospheric layer, I
WO(M, I)	Ozone density for atmospheric model M at level I (gm m^{-3})
WPATH(IK, K)	The cumulative absorber amount of the species, K, for the IK layer along the atmospheric slant path
WS1	Transmission function scaling factor for H_2O at given wavelength
WS2	Transmission function scaling factor for CO_2 , etc., at given wavelength
WS3	Transmission function scaling factor for O_3 at given wavelength
W2	Water vapor density for atmospheric model M at level I + 1 (gm m^{-3})
X	Input height to POINT subroutine
XD	Wavenumber interpolation parameter in UV ozone transmittance calculation
XH	Wavenumber interpolation parameters in H_2O continuum calculation
XI	Wavenumber interpolation parameter
XX	Wavenumber identification parameter for UV ozone transmittance calculation
X1	Earth center distance of level I
X2	Earth center distance of level I + 1
Y	Input zenith angle in radians
YN	Refractive index of layer <u>below</u> input height from POINT subroutine
YN1	Refractive index of layer below initial altitude H1
YN2	Refractive index of layer below final altitude H2
YY	Aerosol absorption coefficient at frequency V
Z(I)	Altitude at level I in km

Appendix D

Errata Sheet No. 2 (September 1977), Atmospheric Transmittance
From 0.25 to 28.5 μm : Supplement LOWTRAN 3B(1976),
AFGL-TR-0158, 1 November 1976,
Environmental Research Papers, No. 587

1. Page 52 - Line A 3M should read A 3*
2. Page 53 - The second line A 81 should be removed
3. Page 54 - Reverse the order of statements A 103F and A 103G and relabel them:
i. e., IF (M.EQ.0) Z(K) = H1 A* 103F
 J = IFIX (Z(K) + 1.0E-6) + 1 A* 103G
4. Page 56 - Line *A 185B should read:
$$EH(5,1) = D*PPW*EXP(6.08*(TS1-1.0)) + 0.002*D(PS-PPW) *A 185B$$
5. Page 56 - Line A 204 is correct, i. e. IP=-1
6. Page 63 - Line A 586A should be removed.
7. Page 64 - Replace UALENTVENT by EQUIVALENT in line A 623
8. Page 78 - The 9th and 10th cards from the bottom of page 78 should be interchanged. The wavenumber identifications for these cards are 17800 and 19400 (see extreme right hand side of card).
9. Cautionary Note: When standard radiosonde data are used (MODEL-7 option), insert a card for sea level even though the required transmittance path does not extend to sea level. The reason for inserting the sea level altitude card is to correctly interpolate the aerosol number densities at the required altitudes for a given sea level visual range. However the above does not apply if the user is inserting his own aerosol extinction data for a given starting altitude.

10. Example: On page 79 a set of input data for LOWTRAN 3B is given. The first example (represented by the first three cards) is to calculate the transmittance for a 65° zenith angle slant path from altitudes 2.5 km to 8.5 km for a 23 km visual range (rural aerosol) subarctic winter atmosphere covering the wavenumber range from 2350 to 2450 cm^{-1} (i. e. 4.08 - 4.27 μm).

The four examples which follow are to calculate the average transmittance from 1820 to 20,000 cm^{-1} (i. e. from 0.5 to 5.5 μm) for a 10 km horizontal path at sea level (using the 1962 U. S. Standard Atmosphere) for four different aerosol models, namely, Maritime, Urban, Rural, and Tropospheric respectively.

It is recommended that the various aerosol model data sets be labelled and stored for further use.

The extinction coefficients for the Average Continental aerosol model originally contained in LOWTRAN 3 are included as an additional data set at the end of LOWTRAN 3B (1976) card deck available from the National Climatic Center, Federal Building, Asheville, No. Carolina 28801 for a charge of \$20.00. (Please address requests to Mr. R. Davis.)

11. Page 25 - delete the last three lines on this page.

12. Page 26 - Delete lines *A 494 and *A 495, and change line *A 491 to read:

$$\text{NH} = \text{XI} + 1.001$$

13. Page 33 - Lines A 85G and A 85H should be interchanged to be consistent with page 53.

14. Page 54 - Insert - IF(IXY.GT.3) GO TO 8 after A 104N.

15. Page 62 - A 563 should be

$$\text{IF}(\text{VIS.GT.0.0.AND.VIS.LT.2.0}) \text{XX}=0.158$$

Cautionary Note: The temporary fog correction will scale aerosol extinction regardless of atmospheric path. As presently coded, it probably should be restricted to horizontal paths (ITYPE=1) under 1 km in altitude.

16. Page 66 - Delete card C 21B in ANGL.[†]

[†]NEW ERRATUM