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Moffett Field, California 94035-1000

SUMMARY

This report describes a new software tool, ATRAN, which computes the transmittance of Earth's atmosphere at near- and far-infrared wavelengths. We compare the capabilities of this program with others currently available and demonstrate its utility for observational data calibration and reduction. The program employs current water-vapor and ozone models to produce fast and accurate transmittance spectra for wavelengths ranging from 0.8 μm to 10 mm.

1. INTRODUCTION

During the last year, through the acquisition of an augmented data base and the improvement of existing software algorithms, we have developed a software tool, "ATRAN," which accurately and efficiently models Earth's atmospheric transmission of radiation ranging from 0.8 to 10,000 μm in wavelength, which includes the near-infrared (NIR), far-infrared (FIR), and microwave windows. This report describes the main features of this new software product, and gives instructions for its use.

The virtues of the new software over existing packages include its high accuracy and ability to model both high- and low-resolution ($\Delta\lambda/\lambda = 0.0001$ to 0.1) spectral profiles. The program achieves high accuracy by modeling Earth's atmosphere in detail, using ozone and water-vapor models derived from detailed observations. The program performs its calculation efficiently, making it especially useful for real-time applications.

Since the software identifies spectral lines present in high-resolution NIR, FIR, and microwave spectral-line observations, it is useful in the routine wavelength calibration of the spectrometers used to make such observations. The software is also particularly useful for determining the extinction toward astronomical sources as a function of wavelength, observational altitude, and zenith angle, and for correcting the observed flux. The program output consists of numerical data files, and screen and hardcopy graphical displays.

Our work relies largely on previous NIR and FIR studies of Earth's atmospheric absorption properties, including studies of the atmospheric absorption of the emission lines from astronomical objects. In the following section we trace the development of this software from such studies.

We would like to acknowledge the help of Richard Freedman in supplying us with the HITRAN data base, as well as invaluable advice regarding its use. We thank David Goorvitch for encouraging us to expand the scope of the software and the domain of its use, and for providing the necessary support to make this project possible. We also thank Jason Craig for his help with the broad line search, and in preparing this document using TeX.

2. COMPARING THIS PRODUCT WITH OTHERS

Currently, there are several computer programs available for modeling atmospheric transmittance. Here we describe some of those programs, and trace their evolution as software tools used within the Space Science Division at Ames Research Center. Attributes of the various programs are listed and compared with those of ATRAN. Another product, available from the Jet Propulsion Laboratory, is also mentioned.

The program DEGRADE (ref. 1) provided the basis for the programs ATMOS and CDG21 (refs. 2 and 3), which were implemented on a CDC 7600 and an HP 2100 computer at Ames. The authors of references 2 and 3 also utilized some of first spectral-line lists compiled by the Air Force Geophysical Laboratories (AFGL, now Phillips Research Laboratories, PL). These programs are now obsolete, but they formed the basis of further work, and references 1–3 contain very concise and useful descriptions of the process of modeling atmospheric absorption lines.

As an improvement to this software, the program NWATR was modified from DEGRADE in 1976, by J. Simpson at Ames, for use on an HP 1000 computer. NWATR was moved to the Ames CRAY YMP computer and was extended to handle shorter wavelengths (to 3 μm) in 1988. This CRAY NWATR version is also called DEGRADE.

In 1989 a new program, ATRAN, (the product described herein) was written at Ames to run on a VAX 8600. In 1991 a second version of ATRAN was produced to run on UNIX machines (Sun workstations, and a DEC Ultrix system). The spectral-line list for all versions of ATRAN, as well as for the CRAY version of NWATR, is the newest 1991 HITRAN data base (ref. 4) provided by PL.

Independent of these efforts, PL, in an ongoing large-scale project of the USAF Systems Command, has produced a series of atmospheric modeling programs. The most recent versions are called LOWTRAN7 (ref. 5) and FASCOD3 (refs. 6 and 7). This same group has continually refined and expanded their data base of atmospheric lines, which was formerly called the AFGL data base; it is now called the HITRAN data base. HITRAN is the data base that all of the programs—FASCOD3, NWATR (the CRAY version), and ATRAN—currently use.

The source code for FASCOD3 and the object code for LOWTRAN7 (a PC version) are available in the Space Science Division (from R. Freedman and the author, respectively), although owing to their size, neither program has ever been compiled and run. Portions of FASCOD2 have been extracted and used in programs written by R. Freedman on the CRAY YMP to model planetary atmospheres such as those of Venus and Mars. FASCOD2 for the PC (in a version called PCLnTRAN) is available from the ONTAR Corporation of Brookline, Massachusetts.

The programs NWATR, ATRAN, and FASCOD are described and compared below.

NWATR

The acronym NWATR begins with N as a tag for spectroscopy software, and WATR stands for water vapor absorption, etc. The great virtue of this program is its simplicity. Although other programs may give results that are more accurate than those of HP 1000 NWATR (by several percent in some cases), NWATR is relatively short and simple. The program ATRAN is about an order of magnitude longer and more complex than NWATR, and FASCOD is yet another order of magnitude more complex than ATRAN. NWATR is primarily set up to model the atmosphere above 41,000 ft. Its model divides the atmosphere into 1, 10, or 20 layers, assigning to the layers characteristic pressures above 41,000 ft; the pressures may be linearly scaled. The atmosphere is described by a single temperature, which also may be reset. The program searches for lines residing a fixed number of wave numbers outside the range of interest for deep lines, looking for line wings which may cause absorption in the range. This procedure is sufficient at high altitudes for most FIR wavelengths with $\lambda > 9$ μm.

The CRAY version of NWATR has recently been augmented to access the latest PL data base, HITRAN. The program has also been equipped with a 10-layer atmospheric ozone model, pressures to sea level pressure, and a temperature function with altitude, and has been extended to calculate emission lines in addition to absorption lines. Access is only possible through the CRAY, or to the older version residing on an HP 1000 (soon to be discarded). Detailed comparisons of the CRAY NWATR and the ATRAN have not been conducted; each program has undergone recent improvements.

ATRAN

ATRAN (Atmospheric TRANsmission) was written to accomplish several goals. These goals, in general, involve an increase in accuracy over existing software without a loss in execution speed.

One goal is to model the atmosphere in more detail so as to accurately calculate atmospheric transmittance from altitudes ranging from 0 to 30 km. For this purpose, we use several detailed atmospheric models from the literature. These include models for the mixed gases, water vapor, and ozone (all these input models are described in sec. 4). The program is versatile in using the models, dividing the gas distributions into an arbitrary number of layers of equal mass, and raising or lowering the water and ozone distribution with altitude to match conditions observed. A useful approximation, the "Curtis-Godson" approximation, is also used to model the uppermost layer in the calculations.

The program covers a wide range of wavelengths, from 0.8 to 10,000 μm (8000 Å to 10 mm), thereby including the near-infrared, the far-infrared, and the microwave windows. To handle this wide range, the program performs its calculations specially for the particular wavelength range selected. For example, to compute the integration step in wave number, the program considers the pressure at the highest atmospheric layer (which determines the width of the narrowest lines), the typical line width at the given wavelength, and the resolution degradation caused by the user-selected smoothing function. Likewise, the program knows the location of very deep lines within these windows, lines that have wings extending several hundred wave numbers. When attempting to compute transmittance spectra near these lines, the program will extend its integration range to take into effect the wings from these lines. The cutoff criterion for weak lines (lines with wings that are sufficiently shallow to constitute a negligible opacity) is determined in part by a knowledge of the number of contributing lines at a particular wavelength. The program keeps track of the number of absorption lines present per wave number as a function of wave number. The program can also handle a large wavelength range, computing transmittance spectra spanning up to 800 wave numbers. The user is given a choice of smoothing functions, or an additional "no-smoothing" option, which will produce a quick look at the true transmittance, independent of measuring instruments. The Lorentz line shape is used at wavelengths below 100 μm, whereas the more precise kinetic (Van Vleck) line shape is used at longer wavelengths.

To assist in laboratory settings, the program has a "tank" mode, in which a single gas, such as water vapor, or D_2O, is modeled on the basis of the pressure, gas column density, and temperature within the tank, that is, one layer.

An important feature of the program is the production of presentable, self-documented plots, which contain a legend describing all the input information that went into the production of the particular transmittance profile. This is accomplished by means of a MONGO interactive plot command file produced by the program. The plot axes may be configured variously for wave number, wavelength, or velocity. Additionally, in plots showing significant atmospheric absorption, the deepest 40 lines in the profile are marked, and the absorbing species are identified at the bottom of the plot. The plotting capability extends to various graphic screens, X and SunView windows, and laser printers. Also, the user is given a file containing the plot commands, and another file containing the sampled function.

A final important attribute of the program is its portability. Currently, versions of the code are running identically under UNIX and VMS environments. Along with the program, the HITRAN data base (in a condensed form) is supplied, as well as programs that will read and write the data base in ASCII and binary.

NWATR and ATRAN are found to run comparably fast on the same machine, producing a transmittance profile typically in less than a minute.

Appendixes A–C list ATRAN and give instructions for its installation and operation.

FASCOD

Most of the attributes of ATRAN described above are also present in the Fast Atmospheric Signature Code (FASCOD). Earth's atmosphere is modeled here in many *spherical* layers and emphasis is placed on the program's ability to efficiently sample (sort through) the spectral-line list in preparing a transmittance profile. The program will compute radiance (emission) in addition to atmospheric absorption. FASCOD models the same large range of wavelengths spanned by ATRAN, since both programs use the same Phillips Research Laboratories (PL) HITRAN data base.

FASCOD contains many refinements for computing transmittance and radiance profiles. These include computing the effect of line coupling (below two wave numbers), continuum emission, and continuum absorption of line emission. Continuum functions within the program are also used to correct line shapes for impact broadening. The program will treat Earth atmospheres that are out of local thermodynamic equilibrium, and will also accept a foreign atmosphere of the user's construction. Upper atmosphere gases at altitudes up to 120 km are included in the models, which contain a variety of aerosols. FASCOD has also been equipped with routines from the associated PL product LOWTRAN (which computes transmission at low resolution). These routines take into account Earth atmospheric changes with climate, latitude, season, and weather. FASCOD is a much larger and more general product than NWATR or ATRAN. We do not have specific information about its total size and speed. It clearly has attributes that are beyond the needs of many of the current users of ATRAN and NWATR, and it presumably runs significantly more slowly. We note that the information we report here on FASCOD is gathered from reference 7, and not from experience with the program.

JPL Data Base

There exists another atmospheric data base (ref. 8), concentrated at wavelengths longward of 30 μm, extending into the millimeter range. This effort is conducted at the California Institute of Technology and at the Jet Propulsion Laboratory. The authors have collected a large catalog of line transitions for 130 atomic and molecular species. (The products above model fewer species. FASCOD models about 28 species, and ATRAN and NWATR select the most abundant 7 of these. The CRAY NWATR program, in one version, now also models the additional "trace species.")

We have recently learned of two other codes. The first, GENLN, is very similar to FASCOD, and was developed at Oxford University, transported to NCAR by David Edwards, and developed further there. The second, IRTRAN, is used at Goddard Space Flight Center. We have no further information on these codes.

3. BASIC MATHEMATICS

We now discuss the fundamental calculations performed by ATRAN. Our discussion follows the treatment of Augason and Burnes (ref. 2). The transmittance, t, is defined as the fraction of radiative intensity that passes through the atmosphere unabsorbed, $t = I/I_0$. Transmittance within a wavelength band (or wave-number band, where wave number σ cm^{-1} is given by $\sigma = 10000/\lambda$), with λ in microns, is calculated at finely spaced wave-number intervals. At each wave number σ, the absorption due to the relevant molecular transition is computed. The absorption depends on the ambient temperature, pressure, and gas density, and in order to correctly characterize these atmospheric parameters with altitude, we divide the atmosphere into multiple layers. At a specific wave number σ, for each molecular transition and each atmospheric layer, a column density ω and an absorption coefficient κ are determined. At a particular wave number σ, the $\kappa\omega$ values are summed for all the contributing transitions (indexed i), and layers (indexed l). The exponentiation of $-\kappa\omega$ gives the transmittance:

$$t(\sigma) = exp\left(- \sum_{i,l} \kappa_{i,l}(\sigma)\omega_{i,l} \right)$$

The number of significantly contributing transitions I, where $i = 1$ to I, depends on the wave number, and may range from zero to thousands. In the above expression, the absorption coefficient κ for the ith transition is given by

$$\kappa_i(\sigma) = S_i L(\gamma_i, \sigma)$$

where S_i is the line strength for the ith transition, and L is the line-shape function centered at wave number σ_i with a half width at half maximum (HWHM) given by γ_i. For wavelengths less than 100 μm, a Lorentzian line shape accurately describes the (pressure-broadened) lines:

$$L(\gamma_i, \sigma) = \frac{1}{\pi} \frac{\gamma_i}{(\sigma - \sigma_i)^2 + {\gamma_i}^2}$$

At longer wavelengths, an approximation to the classical line shape (refs. 9–11), sometimes called the "kinetic" line shape, is appropriate:

$$L(\gamma_i, \sigma) = \frac{1}{\pi} \frac{\sigma\sigma_i 4\gamma_i}{(\sigma^2 - \sigma_i^2)^2 + 4{\gamma_i}^2\sigma^2}$$

In each case, the function L is normalized to have unity area over the interval $-\infty \leq \sigma \leq \infty$. The half width at half maximum γ_i scales with pressure P(atm) and temperature T as

$$\gamma_i = {\gamma_i}^0 P \left(\frac{296}{T}\right)^{n_i}$$

where n$_i$ varies for each transition (indexed by i, the transition index), and averages between 0.5 and 0.62. We note that the extreme wings of some lines, (e.g., H_2O lines in the microwave window), may not be well represented by these functions, as is discussed in reference 12. Also, reference 13 discusses in some detail the temperature dependence of absorption coefficients.

The line strength is corrected for stimulated emission at temperature T by

$$S_i = S_i^0 \left(\frac{T_0}{T}\right)^{m_j} exp\left(-\frac{E(T_0 - T)}{0.695\ T_0\ T}\right) \times \left[\frac{1 - exp\left(\frac{-\sigma_i}{0.695\ T}\right)}{1 - exp\left(\frac{-\sigma}{0.695\ T_0}\right)}\right]$$

where $T_0 = 296$ K is the reference temperature for the transition parameters. The value m_j for species j describes the temperature dependence of the partition function, and depends on the species. Table 1 gives m_j, a typical value for n_i, the abundance in parts per million (ppm), and species index j for the seven most important atmospheric species. These are the seven species followed by the program.

Note that the exact value for n_i is available for each transition from the HITRAN data base, and ATRAN uses the data base value for each transition. (For some species, n$_i$ is dependent on the rotation quantum number J.)

The HITRAN data base (expanded from the former 1986 data base to include parameter corrections, additional weaker lines, a broader wavelength coverage, and more species, gives the following data for each transition: σ_i, ${S_i}^0$, ${\gamma_i}^0, E, j$, and n_i. Note that for isotopic transitions, the line-strength parameter in

Table 1. Specie parameters

Molecule	m_j	n_i	Abundance, ppm	Index = j
H_2O	1.5	0.62	-	1
CO_2	1.0	0.5	330	2
O_3	1.5	0.5	-	3
N_2O	1.0	0.5	0.28	4
CO	1.0	0.5	0.75	5
CH_4	1.5	0.5	1.6	6
O_2	1.0	0.5	2.1	7

the data base has been weighted downward by the isotopic ratio, so that the column density ω of the most common isotope may still be used to compute the line strength.

The atmospheric line data from HITRAN, in combination with model atmospheric physical parameters ω, T, and P, provide the information necessary to compute a transmittance spectrum.

4. DETAILS OF THE CODE

A sequential flowchart of the program is given below. The flow is controlled by a main program, which calls a succession of subroutines. The subroutines perform the functions necessary to compute one transmittance function. If additional functions are required, control returns to the beginning of the main program. The subroutines are as follows:

GETPRT Sets up the parts per million of atmospheric gases

GETLEV Reads in the standard atmospheric model table giving temperature, pressure, etc., at 0.1-km intervals

GETATM Shifts water vapor and ozone content of atmosphere in altitude if necessary

SCALGS Sets up the scaling coefficients for the line parameters S_i and γ_i

LEVELS Divides atmospheric model into layers

GETLAM Establishes wavelength range and resolution

GETPLO Sets up instrumental smoothing function for plot

GETSET Reads through spectral line data base to records of relevance

INTEG Integrates absorption line profiles at each layer

EXPO Exponentiates $-\kappa\omega$ to determine transmittance

PLOT Writes out the data array and a MONGO control file for plotting

Below we discuss key portions of the code which establish the atmospheric model, carry out the integration, and simulate the instrumental smoothing functions.

Earth Atmosphere Model

The atmospheric model is set up in three stages. In the first stage, the user chooses fundamental parameters for the atmosphere: observational altitude, zenith angle, overhead water-vapor content (if available), and total ozone content (if available). The program also reads in a standard atmosphere parameter table (appendix D) which gives the temperature, pressure, and overhead column density for the mixed gases and the water vapor and ozone separately (figs. 1–4). The ozone data include a selection of four distributions in altitude that are typical for the latitudes 9°, 30°, 43°, and 59° north or south. These have been taken from figure 5.7 of reference 14.

At an arbitrary latitude, it is observed that when the total ozone column density changes, the shape of the density profile also changes, and the profile is likely to resemble one of the four profiles we have tabulated. The total column densities (in molecules cm^{-2}) of the profiles are 6.86×10^{18} (lat. 9°), 8.41×10^{18} (lat. 30°), 1.03×10^{19} (lat. 43°), 1.21×10^{19} (lat. 59°). The program selects the profile most closely matching the observed total column of ozone (a value that may come from satellite observations). If no ozone value is supplied, the program assumes a value of 9.13×10^{18}, which is typical for the latitude of 39° north or south (ref. 14). After selecting the best profile, the density

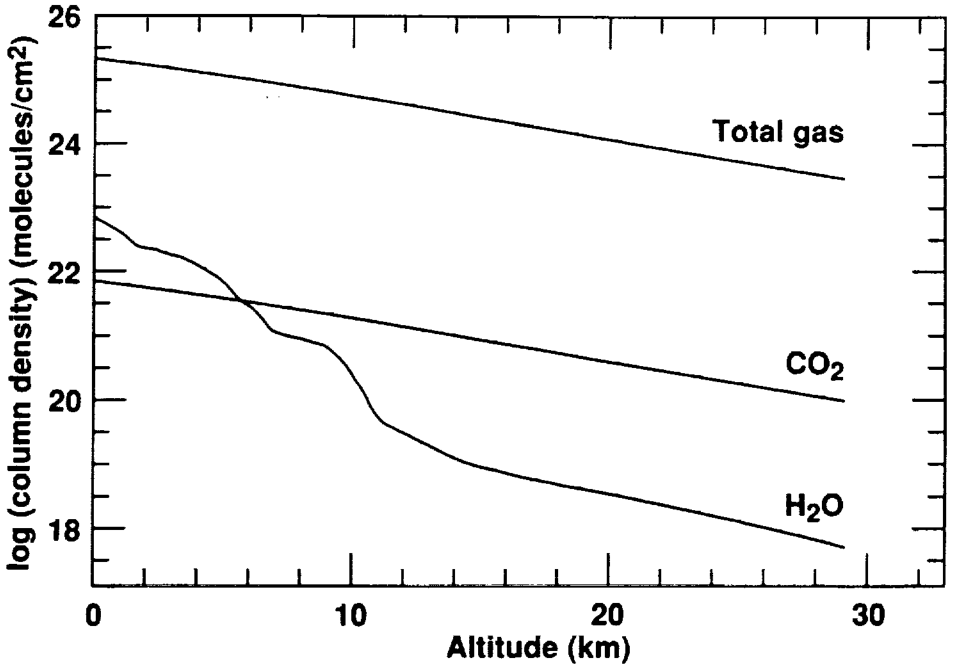

Figure 1. Atmospheric gas overhead column density falls exponentially with altitude (ref. 16); water vapor column density falls off more rapidly, as traced by balloon soundings (ref. 15).

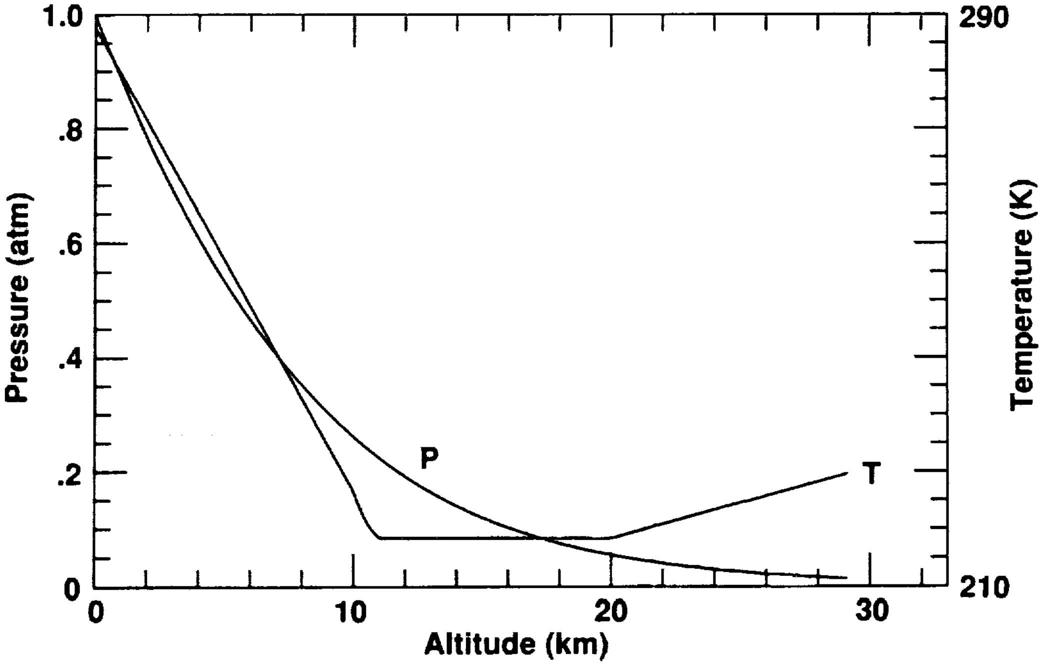

Figure 2. Temperature and pressure of atmosphere (from ref. 16).

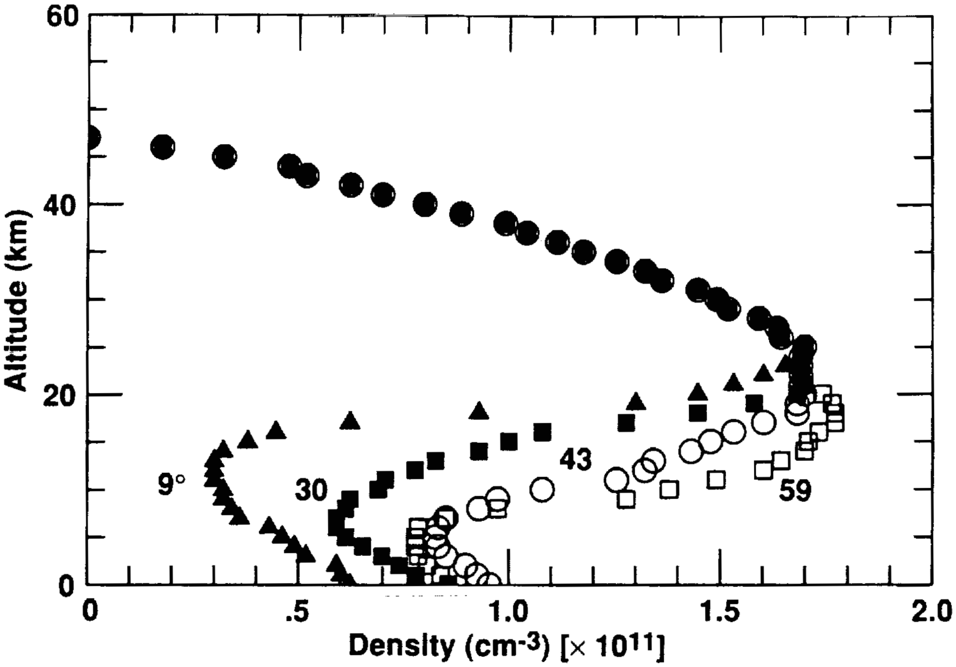

Figure 3. Ozone density profile at four latitudes (from ref. 14).

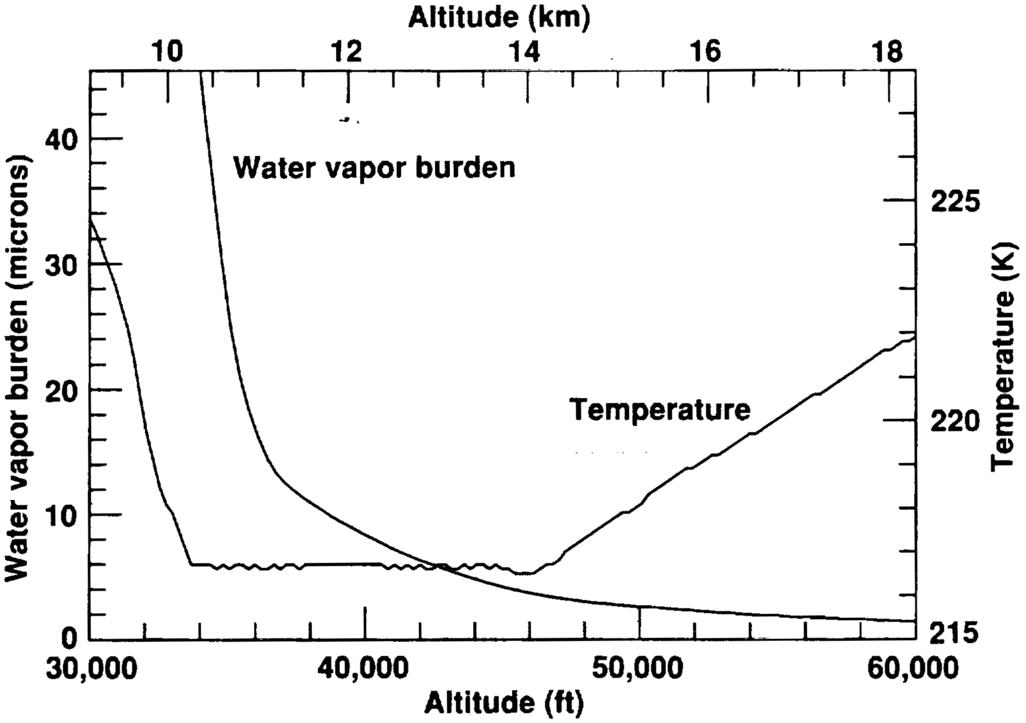

Figure 4. A detailed look at the water-vapor burden through the tropopause, where the overhead burden may drop to half, from altitude 41,000 ft to altitude 45,000 ft, for example.

values at each layer are linearly scaled to match the observed total column density.

The density values for the atmospheric water-vapor content are taken from reference 15. Especially important to airborne astronomy is the altitude gradient in the water-vapor burden through the tropopause. (By burden, we mean the overhead column density, toward the zenith. This quantity is sometime expressed as the height of an equivalent column of liquid water.) A typical water-vapor profile is shown in figure 1, representing balloon flights at a latitude of 39°. As the altitude of the tropopause rises and falls, the ambient pressure and density profile of the water-vapor component will do likewise. So, when the observed overhead water-vapor column density differs from the average profile tabulated in the model, the program moves the atmospheric profile (including the temperature and pressure profile) up or down in altitude (within reasonable limits) to best match the reported water-vapor column density. After an integer number of 0.1-km steps, to achieve the closest match, the profile is then linearly scaled in density to exactly match the observed value. If the user supplies no information of the overhead water content, the standard model is used, which gives, for example, a overhead burden of 7 μm of (precipitable) water at 41,000 ft (12.5 km) (fig. 4).

The mixed gases (indexed 2, 4–7 in table 1) are also modeled at 0.1-km steps, using a constant term for their concentration in parts per million as given in table 1 (from ref. 5). The gas densities, pressures, and temperatures are from the U.S. Standard Atmosphere (ref. 16), tabulated up to 30 km, as given in appendix D.

The second stage of setting up the atmosphere is to divide the atmosphere into several equal mass layers (excluding the gases above 30 km, which are treated separately). We find the altitudes that divide the mixed gases, water vapor, and ozone into equal mass layers separately, through the use of interpolation routines operating on the tabulated column densities with altitude. We then find the altitude that divides each layer into two equal masses, and save the temperature and pressure at this altitude to characterize the layer. A typical number of such layers might be five, that is, L = 5. The three atmospheric components, ozone, water vapor, and the mixed gases, have very different distributions with altitude. By establishing a model with equal mass layers for each component separately, the temperature and pressure variations within each of these components are accurately tracked.

An additional feature of the program is the use of the Curtis-Godson approximation (e.g., ref. 2). This is considered the best way to model the overhead parameters if only a single layer is used, and also, for multiple-layer models, to parameterize the topmost layer (here comprising the gases above 30 km). In this method, the average conditions above a ceiling altitude are set to the temperature and pressure of a specific (higher) altitude. For the mixed gases and ozone, this specific altitude is given by the altitude where the pressure is half that at the ceiling altitude. For water vapor, the approximation follows a different rule. For water vapor, the temperature and pressure are used from the specific altitude at which the water vapor is at a density that is half that at the ceiling altitude. For each ceiling altitude, the temperature and pressure values at half-pressure and half-density altitudes are tabulated.

In this way, the atmosphere is completely characterized by three sets of layers, where one set is for the mixed gases, one is for water vapor, and one is for ozone. Each set contains the temperature and pressure at the center of the layer, and the total column density of each layer. In each set, the layer column densities are equal except for the topmost layer.

The final stage of the atmospheric model setup is to predetermine the temperature-dependent coefficient $(296/T)^m$ (sec. 3). This term affects the line strength for each species. We tabulate these terms once for each of the possible exponents m listed in table 1, so as to integrate lines more efficiently.

Integrating Absorption Lines

Computing a transmittance spectrum requires the integration of a few to thousands of absorption lines over many layers. An efficient integration algorithm depends on integrating only the relevant lines and only the relevant portions of those lines. By relevant, we mean *significant*, such that all excluded lines, or line portions, if included, would produce an additional loss of less then 0.001 in the reported transmittance. This value, $\epsilon = 0.001$, is our error specification.

There are four steps in making the selections of relevant line portions:

1. Determine how far beyond the specified wavelength range to search for broad contributing lines.
2. Determine, for each line within the search range, what, if any, is the relevant extent of the line wings.
3. Integrate accurately narrow lines.

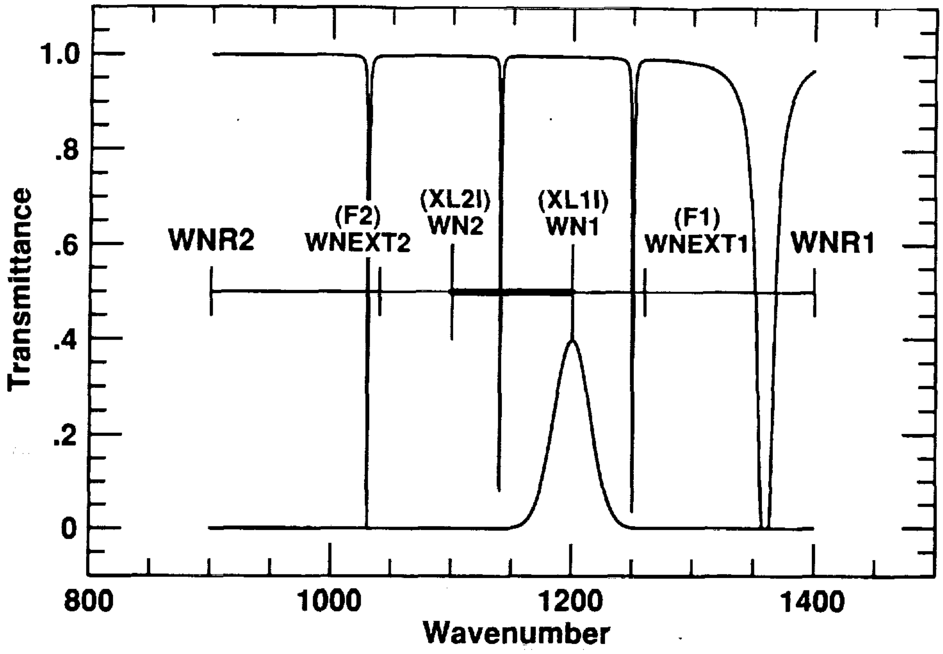

Figure 5. Hypothetical example showing three wave-number ranges used by the program. All absorption lines, such as the four shown, centered within the outermost range, WNR, are considered, but only the portions of the these lines within the WNEXT range are added into the fine array. The fine array runs from WNEXT1 to WNEXT2. The fine array is smoothed (a Gaussian smoothing function is shown at the bottom of the plot) to produce the transmittance spectrum between WN2 and WN1. In this hypothetical spectrum, a deep line at 1360 wave numbers has significant absorption in its wings at 1260. The smoothing function, centered at WN1, will include the absorption at 1260 to produce the smoothed absorption at WN1.

4. Determine the best sampling interval ($\Delta\sigma$) for the integration.

Steps (1) and (2) are very much related, and present some difficulties. One difficulty is that the absorption contribution of an extended line wing may be small, but may be significant if many such wings overlap at a single wavelength. The absorption at some wavelengths is dominated by the summation of thousands of faint overlapping absorption line wings. Determining where this occurs is difficult, and can lead to a bit of a vicious circle. The circle goes like this: the extent of a line that we should consider is determined by what we consider to be a significant level of absorption. A significant absorption level is fixed by our maximum tolerance (ϵ = 0.001) and by how many such line wings could possibly overlap at a point. But the number of such line wings depends on the width of the relevant portion of each line, thus completing the circle.

We have completed step (1) empirically for two altitude ranges: a ground-based, mountain-based, and low-altitude airborne range ($0 \leq$ altitude $\leq$ 39,000 ft); and, an airborne observation range (altitude $\geq$ 39,000 ft). The method of finding the maximum wave-number range in which to search for deep lines was to frame the search in the most extreme situations. We chose an extreme zenith angle of 80° and a single-layer atmosphere (thus maximizing pressure and temperature broadening effects).

We considered all deep absorption line features and determined how far away, in wave number, from the line center the absorption becomes insignificant. This was computed for the ground-based and airborne cases, from 0.8 to 10,000 μm We encoded the results into tables within the program (see subroutine SEARCH), and used these tables to conduct efficient line integrations. The variable IWINGS holds the distance expressed in wave numbers.

As shown in figure 5, the range of wavelengths for which the user would like transmittance information is given by the variables (WL1I, WL2I), which stand for wavelength 1 (input), wavelength 2 (input). These are equated to the wave numbers (WN1, WN2). The instrumental resolution is given by DWNI which stands for the delta-wave-number inputted. The program prepares a spectrum beyond the (WN1, WN2) range. The extended range, given by (WNEXT1, WNEXT2), is an integer number of instrumental FWHM widths, so that the effects of lines beyond the edge of the spectrum are included. The integer is called ISLITS in the program, and ISLITS = 2. Thus, WNEXT2 = WN2 + ISLITS × DWLI. In the program, this range is also called (F1, F2), which stands for the first and last wave numbers of the "fine" array, where fine refers to the high-resolution integration array. However, lines that contribute to the range (WNEXT1, WNEXT2) may have centers outside this range. The search range for (WNEXT1, WNEXT2) is (WNR1, WNR2) where WNR2 = WNEXT2 + IWINGS, as explained above. Figure 5 show the three ranges. (WN1, WN2) is requested of the user. The program prepares a spectrum for the range (WNEXT1, WNEXT2) drawing on lines that originate within (WNR1, WNR2). In this hypothetical example, the smoothing function is shown at the bottom of the plot, at the far edge of the requested range. Its wings are considered out to WNEXT1, where a deep line, centered within WNR1 affects the transmittance.

The second step, regarding how far out to integrate a line's wings for lines within (WNR1, WNR2) is accomplished as follows:

Suppose there are N absorption lines which have an absorption coefficient κ in each of L layers at a particular wave number. Then the transmittance is

$$t = e^{-NL\omega'\kappa}$$

where $\omega' = \omega/\mu$, with μ being the cosine of the zenith angle, so as to account for the number of air masses along a line of sight.

To calculate an absorption cutoff, we assume there are N lines exactly at the cutoff absorption level at a particular wavelength. (Assuming all excluded absorptions are at a level equal to the cutoff is a worst-case scenario which allows us to calculate the cutoff.) We have

$$(1-\epsilon) = e^{-NL\omega'\kappa}$$

With $\epsilon = 0.001$, all the excluded absorption lines together could contribute at worst a 0.1% loss in transmission. Solving for κ and then S,

$$\ln\,(1-\epsilon) < -NL\omega'\kappa$$

with

$$\kappa = \frac{S\gamma}{\pi(\Delta\sigma^2+\gamma^2)}$$

$$\frac{-\pi\ \ln(1-\epsilon)}{LN} = \omega'\frac{S\gamma}{\Delta\sigma^2+\gamma^2}$$

$$\text{CONST} = \frac{-\pi\ \ln\,(1-\epsilon)}{L}$$

At this point we wish to know N, the maximum number of lines that could have a contribution at the wave number in question. To do so, we have made a table of the number of line centers per wave number extending from 0.8 to 10,000 μm (in the file SKIPA.DAT). (This table is also used to efficiently advance the HITRAN data base to the relevant records.) We use the table and an extreme line width of 6 wave numbers (set by the variable JWINGS), and find the total number of lines centered within ±3 wave numbers of each σ within the range. The maximum value so obtained is called MAXLPN (maximum overlaps per wave number), and is tabulated in subroutine GETSET. We then have:

MAXLPN (Maximum number of overlapping lines per wave number) = N

So now,

$$\frac{\text{CONST}}{\text{MAXLPN}} = \frac{\omega' S\gamma}{\Delta\sigma^2+\gamma^2}$$

and

$$\Delta\sigma_{max} = \left(\omega' S\gamma\frac{\text{MAXPLN}}{\text{CONST}} - \gamma^2\right)^{\frac{1}{2}}$$

This last expression tells us how far to integrate a line. Various cases are handled in subroutine INTEG. For a line centered at σ_i, the significant range is $\sigma_i \pm \Delta\sigma_{max}$. If the term within the square root is negative, the line is everywhere too weak, and it is rejected. If the entire range $\sigma_i - \Delta\sigma_{max}$ to $\sigma_i + \Delta\sigma_{max}$ lies outside of (WNEXT1, WNEXT2), again, we reject the line. If part or all of a line is within the range, the entire line is integrated or at least the part of the line extending to the fine array edge. Finally, if $2 \times \Delta\sigma_{max}$ is less than the resolution of the fine array, a special integration technique is used. We model such narrow lines with a triangle function to determine the mean absorption within the interval and integrate this value into the fine array. A comparison of a triangle function and a Lorentzian is shown in figure 6. It may be seen here that for the region within $|\sigma| < 0.5$ FWHM, the triangle function provides a good approximation to the Lorentzian. The occurrence of such under-resolved lines is counted by the variable IDELIN (delta functions inside the range), and is rather infrequent. (This therefore accomplishes step (3) above.)

Finally, we discuss the resolution (step (4)). The fine array, dimensioned F(1000000), is used to sum the absorption from each line and each layer. This is done by INTEG. The wave-number resolution of this array, FD, is determined by FD = RESRB × P(L-1), where RESRB is the resolution "rock-bottom," the resolution required to handle sea-level line widths, (i.e., lines at 1 atm). We are scaling this value by the pressure to correctly model the line shapes of narrow lines from regions of low pressure. From examining a histogram of line widths (γ_i) over the entire wave-number range (fig. 7), we have determined that RESRB be set to 0.01 wave numbers. P(L-1) is the pressure characterizing the top of the atmosphere model, just below the L*th* layer, whereas the L*th* layer includes only the gas above 30 km. In a multiple-layer atmosphere, each layer will typically hold much more mass than the L*th*. In a one–layer atmosphere, we use the Curtis-Godson pressure for P(L-1). For one layer and an altitude of 41,000 ft, the resolution of the fine array is typically a little less than 0.001 wave numbers. When we divide the atmosphere into L layers, then the larger the value of L, the closer the center of the L-1*th* layer will be to the 30 km, and therefore the smaller the pressure of the L-1*th* layer will be. For a given observing altitude, as L goes up, P(L-1) will go down, and DF will go down.

It is important to note that since the number of resolution elements, NF, given by NF = (NWEXT2-WNEXT1)/DF, goes as L, and the number of layers goes as L, the length of time required to compute a transmittance spectrum goes as L^2. When high accuracy is not required, for example, if ~3% errors are acceptable at the centers of lines, then a single layer, L = 1, will usually suffice, depending on the instrumental resolution.

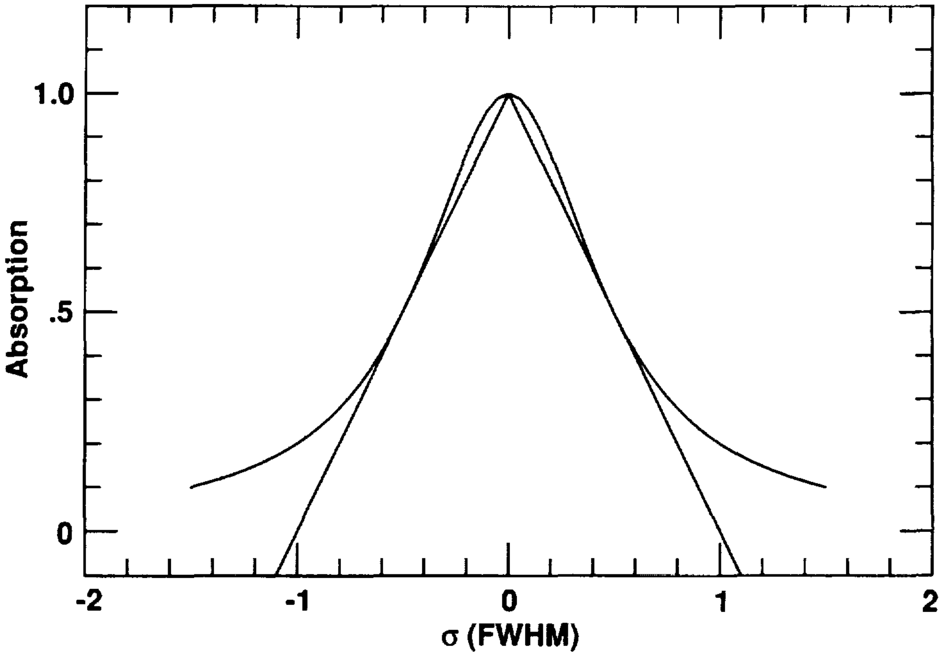

Figure 6. Lines significantly narrower than the fine array step are estimated with a triangle function, which provides a good estimate of the Lorentzian line shape within the central 0.5 FWHM (full width at half maximum) as seen here.

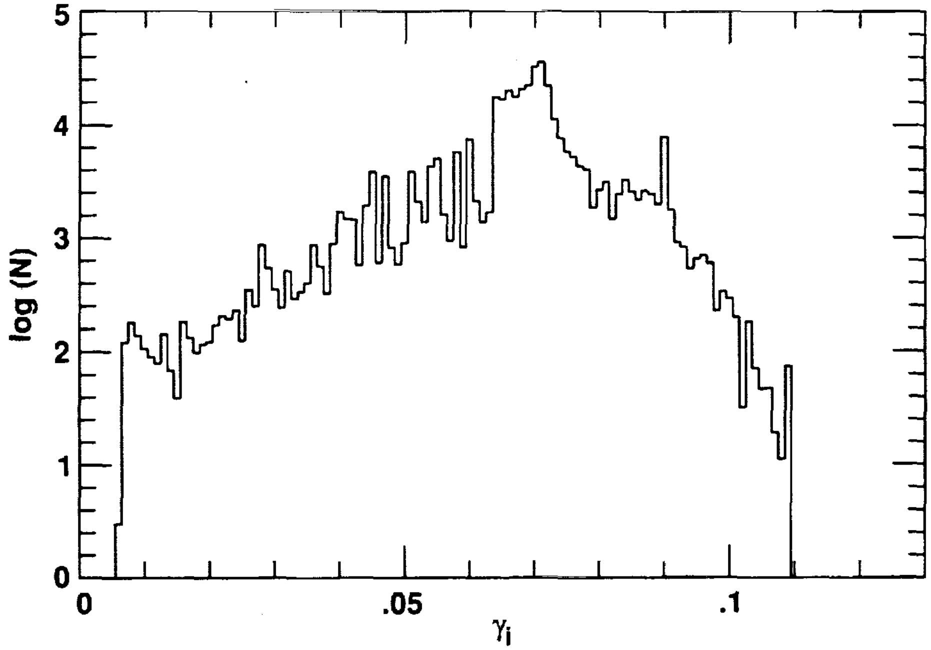

Figure 7. A histogram of γ_i is shown for the wavelength range between 0.8 and 10,000 μm; a very small fraction of the lines have widths narrower than 0.01 wave numbers, the largest resolution that the program will use for the fine array.

Instrumental Profiles

The ATRAN program will compute any one of four instrumental profiles, a triangle, a Gaussian, a sinc function, and a rectangle. These are shown in figure 8, all on the same axes, with the x-axis in FWHM units and the y-axis with normalized maxima. The rectangular function, with its sharp falloff, will tend to retain the high frequencies present in an unsmoothed profile, unlike the other functions. Smoothing occurs in a very straightforward manner. To compute a smoothed value at a particular wave number, the smoothing function is aligned with that point, and the fine array is averaged over a 2 × FWHM span of the smoothing function.

A "no-smoothing" option is also available. Here the fine array will be written out just as it appears, if space allows (the limit is currently set to 20,000 elements, the data-point limitation of a MONGO (x,y) plot). This represents the atmospheric transmittance as seen without any instrumental degradation in resolution. If the fine array contains more than 20,000 elements, the program will select the lowest integral sampling interval for the data points (e.g., each second, each third) and output these as the output data file. The no-smoothing option is the fastest, because the data are simply copied-out.

Plots of transmittance from flight and sea-level altitude are displayed for the entire wavelength range in appendixes E–G.

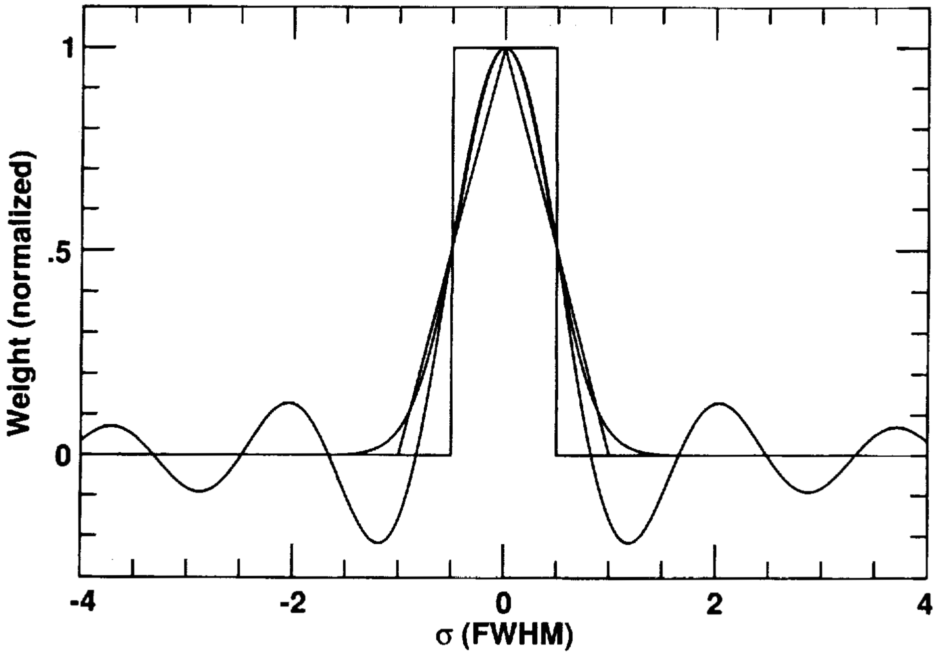

Figure 8. The four instrumental profiles, triangle, Gaussian, rectangle, and sinc, are plotted as a function of the FWHM (full width at half maximum).

REFERENCES

1. Deutschman, E. M.; and Calfee, R.: Two Computer Programs to Produce Theoretical Absorption Spectra of Water Vapor and Carbon Dioxide. Report IER 31-ITSA 31, Institute for Environmental Research, Boulder, Colo., 1967.
2. Augason, Gordon C.; and Burnes, Nancy S.: CDG21: A Computer Program for Computing Atmospheric Transmission Using the C-141, HP-2100 Computer. NASA TM-73194, 1977.
3. Augason, G. C.; Mord, A. J.; et al.: Water Vapor Absorption Spectra of the Upper Atmosphere (45-185 cm^{-1}). Applied Optics, vol. 14, 1975, p. 2146.
4. Rothman, L. S.; et al.: The HITRAN Database: 1986 Edition. Appl. Opt., vol. 26, 1987, p. 4058. (See also, J. Quant. Spectros. Radiat. Transfer, vol. xx, 1992, in press.)
5. Kneizys, F. X.; et al.: Atmospheric Transmittance/ Radiance: Computer Code LOWTRAN 6. Technical Report AFGL-TR-83-0187 (Phillips Research Laboratories) PL, Hanscom AFB, Mass., 1983.
6. Clough, S. A.; Kneizys, F. X.; Rothman, L. S.; and Gallery, W. O.: Atmospheric Spectral Transmission and Radiance: FASCOD1B. SPIE, vol. 277, 1981, p. 152.
7. Clough, S. A.; Kneizys, F. X.; Shettle, E. P.; and Anderson, G. P.: Atmospheric Radiance and Transmittance: FASCOD2. 6th Conference on Atmospheric Radiation, Williamsburg, Md., 1986.
8. Poynter R. L.; and Pickett, H. M.: Submillimeter, Millimeter, and Microwave Spectral Line Catalog. Appl. Opt., vol. 24, 1985, p. 2235.
9. Townes, C. H.; and Schawlow, A. L.: Microwave Spectroscopy. Dover Press, New York, 1975, p. 341, equations 13.13–13.16.
10. Van Vleck, J. H.; and Weisskopf, V. P.: Absorption, Emission and Linebreaths. Rev. Mod. Phys., vol. 17, 1975, p. 227.
11. Gross, E. P.: Shape of Collision-Broadened Spectral Lines. Phys. Rev., vol. 97, p. 395.
12. Burch, D. L.: Absorption of Infrared Radiant Energy by CO_2 and H_2O. III. Absorption by H_2O between 0.5 and 36 cm^{-1}. J. Opt. Soc. Am., vol. 58, 1968, p. 1383.
13. Heaton, H. I.: Temperature Scaling of Absorption Coefficients. J. Quant. Spectros. Radiat. Transfer, vol. 16, 1976, p. 801.
14. Brasseur, G.; and Solomon, S.: Aeronomy of the Middle Atmosphere. Reidel, Boston, 1986.
15. Mastenbrook, H. J.: Water Vapor Distribution in the Stratosphere and High Troposphere. J. Atmos. Sci., vol. 25, 1968, p. 299.
16. U.S. Standard Atmosphere. NASA, USAF, and National Weather Bureau, Washington, D.C., 1962.

APPENDICES

APPENDIX A

SOFTWARE LISTING OF ATRAN

We list the UNIX implementation of the program. The VMS implementation differs only slightly.

```
        PROGRAM ATRAN
C ******************************************************************
C Calculates IR atmospheric absorption
C S. Lord - May 1988, Rev. July 1991
C ******************************************************************
C
        CHARACTER*1 A
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
        COMMON /LIMIT/NFMAX,NRES,BOTL,TOPL,ISLITS,IWINGS,IPLOTN
     1   ,RESRB,AC,JWINGS
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        COMMON /FARRA/F(1000000)
        COMMON /FVECT/F1,F2,FD,NF
        COMMON /PVECT/P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /SKIPS/ISKIPWN(12500),ISKIPSUM(12500),ISKIPMAX(12500)
        COMMON /PARRA/P(20000),IPTYPE
        COMMON /TERM/ITERM
        COMMON /STRONG/SLINES(80),ISPEC(80),SEW(80),ISTRONG
      1  ,IPOINT,STRENGTH
C
C (THE DIMENSION 12500 MAY CHANGE WITH THE SIZE OF THE AFGL FILE...)
C
C Define Global limits
C
C Dimension of the "Fine" array (too big for an HP1000)
        NFMAX=1000000
C  Fractional accuracy spec. on final trans. spectrum
        AC=0.01
C  resolution Rock Bottom
        RESRB=0.01
C  Fine array resolution is at max RESRB wave numbers
C  times the top layer atmospheric pressure, in atm.s,
C  which is typically less than 0.1 atm, and so
C  the resolution of the fine array is typically a
C  little less than 0.001 wave numbers.
C  The fine array resolution can be set as small as the
        NRES=10
C  user requires. It is always set to less than
C  1/NRES times the instrumental resolution to obtain
C  accurate results.
C  Lowest wavelength currently available (micrometers).
        BOTL=0.8
C  Highest wavelength currently available (micrometers).
        TOPL= 10000
C  Look for wings from lines ISLITS instrumental
C  slit widths beyond plot range.
        ISLITS=2
C  lines may overlap from the surrounding JWINGS WN's
        JWINGS=3
C  Maximum number of points allowed in plot.
```

```
        IPLOTN=20000
C  Counts the number of diff. functions on 1 plot (1-9).
        IPLTCNT=0
C  Number of strong lines that will appear at the bottom
        ISTRONG=80
C  of the plot, STRENGTH is the minimum values of
        STRENGTH=-ALOG(1-.05)
C  - ln(equivalent width) required to get on the list
C*****************************************************************
C** Main Entry Point
C*****************************************************************
        PRINT*
        PRINT*
C
        PRINT*,' Welcome to atmospheric modeling program!'
        PRINT*
        PRINT*,' If you don''t know what to answer to a question'
     1   ,', try' the answer given in parentheses.'
        PRINT*
1007    WRITE(*,'('' Input Terminal type. '')')
        WRITE(*,'('' 1 for Tektronics, 2 for X window, 3 for Sunview'
     1   ,' window',/,' 4 for GraphOn (1): '',$)')
        READ(*,*,ERR=1007)ITERM
        PRINT*,'{',ITERM,'}'
        IF(ITERM.LT.1.OR.ITERM.GT.4)GO TO 1007
1008    WRITE(*,'('' Plot x-axis units in wavelength (um) [1], ''
     1   ,''or wavenumbers (cm^-1) [2] (1): '',$)')
        READ(*,*,ERR=1008)IPTYPE
        PRINT*,'{',IPTYPE,'}'
        IF(IPTYPE.NE.1.AND.IPTYPE.NE.2)GO TO 1008
1       CONTINUE
c       WRITE(*,'('' Input nominal max line width in wavenumbers '',
c     1   /,'' and deep line search in wavenumbers (temporary'',
c     1   '' parameters)(3,20): '',$)')
c
c       READ*,JJWINGS,IIWINGS
C       PRINT*,'{',JJWINGS,IIWINGS,'}'
c
c         IF(JJWINGS.LT.1.OR.JJWINGS.GT.20
c     1   .OR.IIWINGS.LT.1.OR.IIWINGS.GE.100)THEN
c           PRINT*,' Range is 1 to 20 and 1 to 100. Try again'
c           GOTO 1
c         ENDIF
c       IWINGS=IIWINGS
c       JWINGS=JJWINGS
        JWINGS=3
C
C  Establish the parts per million of atm gases
        CALL GETPRT
C  Read in model atmosphere parameters
        IF(ITANK.NE.1)CALL GETLEV
C  Set-up the atmospheric or slab model
        CALL GETATM
```

```
C  Establish the wavelength range
2       CALL GETLAM
C  Set-up the plot x-axis
        CALL GETPLO
C  Find section of atm. line data file of relevance
        CALL GETSET(IER)
        IF(IER.EQ.1)GO TO 2
C  Integrate all lines & levels into the fine array
        CALL INTEG
C  Convert opacity to transmission by exponentiating
        CALL EXPO
C  Smooth the fine array into the plot array
        CALL SMEAR
C  Output the plot
        CALL PLOT
3       PRINT 4
4       FORMAT(' Another function on this plot (Y or N) (N): ',$)
        READ 5,A
        PRINT*,'{',A,'}'
5       FORMAT(A1)
                IF(A.EQ.'Y'.OR.A.EQ.'y')THEN
                        IF(IPLTCNT.EQ.10)THEN
                        PRINT*,' Maximum (9) exceeded'
                        STOP
                        ENDIF
                GO TO 1
                ELSE IF (A.NE.'N'.AND.A.NE.'n')THEN
                GO TO 3
                ENDIF
        PRINT*,' p.plo, a MONGO control file has been made.'
        PRINT*,' parray.dat1, the output data has been written.'
        CLOSE(20)
        END


        SUBROUTINE GETPRT
C ***********************************
C Finds the atmospheric constituents
C ***********************************
        REAL PPM(2:7)
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        COMMON /PART/PARTS(2:7),CDOZ,IDISTO3
        COMMON /ATMJNK/AWV,AZ,AWVL,IATYPE,IALAY,IALT,TORR
        DATA PARTS/330E-6,0.,.28E-6,.075E-6,1.6E-6,2.1E-1/,
C  Gordon's Value   Ozone Ozone Ozone Ozone
C     1   CDOZ/1.31E19/
C     Jan's Value   Ozone Ozone Ozone Ozone [Pick one!]
C     1   CDOZ/6.68E18/
C     Steve's value for lat 39 (TOMS data average) also
     1   CDOZ/9.13E18/
C     Brasseur & Solomon, Fig .7 give the following
```

```
C     totals for various latitudes....
C  lat   9    30      43      59
C   6.86E18 8.41E18 1.03E19 1.21E19
C
        ITANK=0
        IDISTO3=3
2221    PRINT*,' Enter:'
        PRINT*,' 0 for a standard atmosphere of mixed gases,'
        PRINT*,' 1 for a single H2O layer (a tank),'
        PRINT 22
22      FORMAT(' 2 for a special atmosphere, or -1 to exit (0): ',$)
        READ(*,*,ERR=2221)I
        PRINT*,'{',I,'}'
        IATYPE=I
           IF(I.EQ.-1)STOP
           IF(I.EQ.0)THEN
           RETURN
           ELSEIF (I.EQ.1)THEN
           ITANK=1
           RETURN
           ENDIF
        IF(I.NE.2)GO TO 2221
          DO L=2,7
            PPM(L)=PARTS(L)*1E6
          ENDDO
15      WRITE(*,10)PPM(2),CDOZ,(PPM(J),J=4,7)
10      FORMAT(' Molecule:  CO2    O3(tot/cm2)  N2O   ',
     1  ' CO    CH4     O2   ',/,
     1       ' Index:     2      3            4      ',
     1   ' 5      6      7    ',/
     2            ,' PPM:     ',F5.0,'      ',1PE8.2,'    ',
     3           0PF6.2,1X,0PF6.3,1X,0PF4.1,3X,1PE7.1)
        PRINT*,' Enter 0 to continue or the gas index number '
     1          ,'to change the ppm of that gas:'
        READ(*,*,ERR=15)I
        PRINT*,'{',I,'}'
                IF(I.EQ.3)THEN
1033    PRINT*,' Ozone layer has total column density of ',CDOZ
        PRINT*,' (this is looking through the entire atmosphere)'
        PRINT*,' (in molecules per cm^2). New value (use a negative'
        PRINT*,' number to input in Dobson units):'
        READ(*,*,ERR=1033)CDOZ
        PRINT*,'{',CDOZ,'}'
                IF(CDOZ.LT.0)CDOZ=ABS(CDOZ)*2.69E16
C
C use the appropriate atmospheric ozone curve
C we have a selection of 4 distribution for the
C latitudes: 9, 30, 43, and 59,
C taken from Fig 5.7 B&S, op cit.
C We choose the closest, based on the total
C column density. If the
C default O3 value is used (no adjustment), then
C the distribution defaults to the 59 lat. (IDISTO3=1).
```

```
C
C at the various lat.s we have:  6.86E18 8.41E18 1.03E19 1.21E19
C
                IF(CDOZ.LT.3E18)THEN
                TYP=6.86E18/2.6E16
        PRINT*,' That''s VERY little O3! Typical min is 6.86E18/cm^2'
                PRINT*,' which is ',TYP,' Dobson units'
                ENDIF
                IF(CDOZ.LT.7.635E18)IDISTO3=1
                IF(CDOZ.GT.7.635E18.AND.CDOZ.LT.9.355E18)IDISTO3=2
                IF(CDOZ.GT.9.355E18.AND.CDOZ.LT.1.12E19)IDISTO3=3
                IF(CDOZ.GE.1.12E19)IDISTO3=4
                IF(CDOZ.GT.2.4E19)THEN
                TYP=1.12E19/2.6E16
        PRINT*,' That''s a LOT of O3! Typical max is 1.12E19/cm^3'
                PRINT*,' which is ',TYP,' Dobson units'
                ENDIF
                ELSEIF(I.GE.2.AND.I.LE.7)THEN
6861            PRINT*,' Old value = ',PPM(I)
                PRINT*, ' Enter new value: '
                READ(*,*,ERR=6861)PPM(I)
        PRINT*,'{',PPM,'}'
                PARTS(I)=PPM(I)/1E6
                ELSEIF (I.EQ.0)THEN
                RETURN
                ENDIF
        GO TO 15
        END

        SUBROUTINE GETLEV
C *********************************************************************
C Reads in the atmospheric model
C compiled by Gordon Augason NASA/Ames, and
C Described in the Documentation
C for program "CDG21" by Augason and Burnes
C *********************************************************************
        COMMON /MODEL/ ALT(292),ST(292),SP(292),CH2O(292),SC(292)
     1   ,TH2O(292),TMIX(292),PH2O(292),PMIX(292),CO3(4,292),IH2OTOP
        CHARACTER*1 A1
C
        OPEN(1,FILE='/work/cgs/atran/model.dat',STATUS='OLD',ERR=123)
C      1   READONLY)
C
C Advance past the header, ("/" in a FORMAT statement here is unsafe)
C
        READ(1,100,ERR=30)A1,A1,A1,A1
100     FORMAT(A1)
        DO 1 I=1,292
1       READ(1,*,END=30,ERR=30)ALT(I),ST(I),SP(I),CH2O(I),SC(I),
     1   TH2O(I),TMIX(I),PH2O(I),PMIX(I),(CO3(J,I),J=1,4)
        CLOSE (1)
        RETURN
30      PRINT*,' Error reading model.dat'
```

```
        STOP
123     PRINT*,' Can''t find model.dat'
        STOP
        END
        SUBROUTINE GETATM
C ************************************************************
C Establishes the T, P, and Column Densities of water vapor,
C ozone, and mixed gases in a n-layer model atmosphere
C ************************************************************
        COMMON/D2O/D2OG
        COMMON /PART/PARTS(2:7),CDOZ,IDISTO3
        COMMON /ATMJNK/AWV,AZ,AWVL,IATYPE,IALAY,IALT,TORR
        CHARACTER*11 MILMIC
        COMMON /MODEL/ ALT(292),ST(292),SP(292),CH2O(292),SC(292)
     1   ,TH2O(292),TMIX(292),PH2O(292),PMIX(292),CO3(4,292),IH2OTOP
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
          IF(ITANK.EQ.1)THEN
5010        PRINT 501
501         FORMAT(' Enter pressure in Torr (millimeters of Hg,'
     1     '  1/760 Atm) (15): ',$)
            READ(*,*,ERR=5010)TORR
            PRINT*,'{',TORR,'}'
            PALL(1,1)=TORR/760.
C
C     Let's assume a room temperature. Labs are typically about 68 F.
C
            TALL(1,1)=293.15
5020        PRINT 502
502         FORMAT(' Enter water column density in micron (10): ',$)
            READ(*,*,ERR=5020)WVMIC
            PRINT*,'{',WVMIC,'}'
            AWV=WVMIC
            AWVL=WVMIC
            WGASES(1,1)=(WVMIC/2.994E-19)*1.E-20
5030        PRINT 503
503         FORMAT(' Enter D2O column density in microns (0): ',$)
            READ(*,*,ERR=5030)D2OC
            D2OG=(D2OC/2.994E-19)*1.E-20

            LAYER=1
            IALAY=1
            CALL SCALGS
            RETURN
          ENDIF
C
C Start here for non-tank case, ie - an atmosphere
C
C We've read in the model already.
C (This will happen for each function plotted
C which is useful,
C because we rescale standard atmospheric density, P and T
C distributions.
```

```
C
C
C the overhead H2O column density in the atmosphere can be shifted,
C by which we mean we reset
C the distribution to reside at at higher or lower
C altitudes. The distribution can also
C be scaled (multiplied by a constant).
C Nominally, our lookup table of
C density, etc, stops at array elt 292.(29.1 km)
C This may be lowered
C for situations with less water than the standard model.
C
        IH2OTOP=292
1       PRINT 11
11      FORMAT(' Enter altitude (feet) (41000): ',$)
        READ(*,*,ERR=1)ALTFT
        PRINT*,'{',ALTFT,'}'
        IALT=ALTFT
2       ALTKM=ALTFT*.0003048
C
C Get overhead burden in molecules cm^-2 of H2O at this altitude
C WVMOD is the wv in precipitable microns
C WCOL  is the WV in molecules / cm^3
C
        WCOL=A1ATB1(CH2O,ALT,292,ALTKM,IERR)
        IF(IERR.NE.0)THEN
        PRINT*,' Altitude out of range 0 to 95,470 ft. try again.'
        GO TO 1
        ENDIF
        WVMOD=WCOL*2.9940E-19
        WVMOD1=WVMOD
        AWV=WVMOD
        MILMIC='Microns'
C
C Speak in the optimal units
C
          IF(WVMOD.LT.1.OR.WVMOD.GT.1E6)THEN
            WRITE(*,15)WVMOD
15          FORMAT('The atmospheric model gives ',1PE9.3,
     1      ' microns of water toward the zenith.')
          ELSE
              IF(WVMOD.GE.1E3.AND.WVMOD.LT.1E6)THEN
                MILMIC='Millimeters'
                WVMOD1=WVMOD*1E-3
              ENDIF
            WRITE(*,20)WVMOD1,MILMIC
20          FORMAT('  The atmospheric model gives
     1     ',F5.1,' ',A11,' of water,'
     1     ,' toward the zenith.')
          ENDIF
C
C Scale water vapor column density array if so desired
C
```

```
2510      PRINT 25
25        FORMAT(' Enter preferred value at this altitude in MICRONS,',
     1     /,'  or 0 for no adjustment of the model (0): ',$)
          READ(*,*,ERR=2510)WV
          PRINT*,'{',WV,'}'
C
C Now, if the overhead H2O is different than the standard model, we
C move the atmospheric H2O,
C along with its Temp and Pressure up or down
C in Altitude. We do this at most 10 km, 35,000 ft.
C We then mult the density at each layer by a scale factor to get the
C overhead burden to exactly the value desired.
C
            IF(WV.GT.0)THEN
C
C find the altitude at which this burden occurs
C
              TARGET=WV/2.994E-19
              ALTNEW=A1ATB1(ALT,CH2O,292,TARGET,IERR)
                IF(IERR.EQ.1)THEN
          PRINT*,' The overhead burden of the model does not include'
          PRINT*,' this value in its range, we''ll scale std. profile.'
                  GO TO 1010
                ENDIF
              ALTINFT=ALTNEW/.0003048
C     PRINT*,' This burden is found above ',ALTINFT,' ft in the model'
              ALTDIF=ALTNEW-ALTKM
                IF(ABS(ALTDIF).GT.35)THEN
          PRINT*,' This is too far to shift the water vapor,
     1 we''ll just scale it...'
                  GOTO 1010
                ENDIF
C
C Shift atmospheric H2O distribution up or down.
C
              ITENTHS=NINT(10*ALTDIF)
C
C If the appropriate altitude is within
C 0.1 km of the altitude being used
C (ALTKM) no shifting is necessary, just scaling
C
              IF(ITENTHS.EQ.0)GO TO 1010
C
C If ITENTHS<0 then the user wants
C more overhead H2O. We shift the overhead
C column density found at each layer
C to a higher layer.
C Since CH2O(292) holds
C the total H2O above 29.1 km,
C we deposit into this array element those layers
C shifted to altitudes above 29.1 km.
C The Curtis-Godson approx. will be slightly
C less accurate when N=1, since
```

```
C we are not rederiving the alt.
C at 1/2 density for T and P.
C This will not be very different, nor important - if high accuracy
C is desired, then N should be greater than 1 anyway.
C
            ITEN=IABS(ITENTHS)
              IF(ITENTHS.LT.0)THEN
                  DO I=1,ITEN
                    CH2O(292)=CH2O(292)+CH2O(292-I)
                  ENDDO
C
C shift atm H2O up
C
                  DO I=291,2,-1
                      IF(I.LE.ITEN)THEN
                        CH2O(I)=CH2O(1)
                      ELSE
                        CH2O(I)=CH2O(I-ITEN)
                      ENDIF
                  ENDDO
              ELSEIF(ITENTHS.GT.0)THEN
C
C If ITENTHS<0 then the user wants less overhead H2O.
C We shift the overhead
C column density found at each layer down
C to a lower layer. CH2O(292) formerly
C held the total H2O above 29.1 km.
C Now we lower the altitude of the top layer
C by moving this element to a lower
C array location. I.e. the model for H2O
C now terminates lower than 29.1 km. Again,
C the Curtis Godson approx. will
C be slightly less accurate. (see above)
C
                  DO I=1,292-ITEN
                    CH2O(I)=CH2O(I+ITEN)
                  ENDDO
                IH2OTOP=292-ITEN
              ENDIF
C
C see how we did ... recompute overhead H2O
C
            WCOL=A1ATB1(CH2O,ALT,IH2OTOP,ALTKM,IERR)
            WVMOD1=WCOL*2.9940E-19
C           PRINT*,' New Atm model gives ',WVMOD1,' microns'
              IF(ABS(WV-WVMOD1)/WVMOD1.gt..2)then
                PRINT*,' Atm. shift failed!'
                STOP
              ENDIF
C
1010        CONTINUE
C           PRINT*,' SCALING H2O model'
            SCALE=WV/WVMOD1
```

```
C           PRINT*,' scale factor = ',scale
            AWV=WV
            IF(IATYPE.EQ.0)IATYPE=3
              DO I=1,IH2OTOP
                CH2O(I)=SCALE*CH2O(I)
              ENDDO
          ENDIF
C
C Now that we have out input model atmosphere, we break it into
C N levels, (N can be 1)
C
31      PRINT 311
311     FORMAT(' Number of atmospheric layers (2 recommended)(2): ',$)
        READ(*,*,ERR=31)LAYERS
        PRINT*,'{',LAYERS,'}'
          IF(LAYERS.LT.1.OR.LAYERS.GT.300)THEN
            PRINT*,' Number of layers must be between 1 and 300'
            GO TO 31
          ENDIF
        LAYER=LAYERS
        IALAY=LAYERS
331     PRINT 3311
3311    FORMAT(' Zenith angle through atmosphere (0=UP)(0): ',$)
        READ(*,*,ERR=331)Z
        PRINT*,'{',Z,'}'
           IF(MOD(Z,180.).EQ.90)THEN
            PRINT*,' Not allowed for this slab atmosphere.'
            GO TO 331
          ENDIF
        AZ=Z
        XMU=COSD(Z)
        AWVL=AWV/XMU
        CALL LEVELS(LAYERS,ALTKM,XMU)
        CALL SCALGS
C       PRINT*,'Got through'
        RETURN
        END


        SUBROUTINE LEVELS(N,ALTKM,ZMU)
C ****************************************************
C Divides up the atmosphere into layers of equal mass
C ****************************************************
        COMMON /PART/PARTS(2:7),CDOZ,IDISTO3
        COMMON /MODEL/ ALT(292),ST(292),SP(292),CH2O(292),SC(292)
     1   ,TH2O(292),TMIX(292),PH2O(292),PMIX(292),CO3(4,292),IH2OTOP
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        REAL CDO3(292),CO3CONS(4)
        DATA CO3CONS/6.86E18,8.41E18,1.03E19,1.21E19/
        ITP=IH2OTOP
        IALT=ALTKM*10+1
C
```

```
C
C In the model atmosphere there are 5 mixed gas components,
C and then there is water vapor and ozone.  Ozone occupies its own
C special distribution as does H2O. We treat these components
C separately in the multi-layer integration.
C
C O3 and Water vapor share the T and P of the 5
C mixed components, w/a separate
C column density fn. with alt.. If more
C than one layer is requested ( N > 1 ),
C we divide the mixed gas and water
C vapor each into N-1 layers between the
C observer's altitude and 29.1 km, such that
C each layer contains equal mass.
C We find the T and P at
C the midpoint of each layer, and record these
C data in WGASES, TALL, PALL for use
C in the integration. For the Nth layer
C (also, when N is 1), we use
C the Curtis-Godson approximation.
C When N>1 the Nth layer is the
C gas above 29.1 km. When N=1, the
C approximation is used to the gas above
C the altitude of observation.
C The C.G. approximation approximates the average conditions
C above a
C given altitude by using C the atmospheric
C parameters T and P for the mixed
C gases which reside at a higher altitude,
C namely where the pressure is half
C the pressure at the given altitude. For
C water vapor the approximation uses
C a different rule. For water vapor, the
C T and P are used from an altitude
C at which the water vapor is at
C half the density as that at the altitude of
C observation.
C
C We load the best O3 distribution
C (determined in GETPRTS) into a local array,
C scaling to get the total to match the requested value.
C
          DO I=1,292
            CDO3(I)=CO3(IDISTO3,I)*CDOZ/CO3CONS(IDISTO3)
          ENDDO
C
C The routine loads up three
C arrays... WGASES( 7 species , 2 index)
C where index=1 is for the column density
C for N-1 layers of equal column density
C and index = 2 is for the
C Nth layer, it is the column density of all the
C gas above the N-1th layer (to infinity)
```

```
C When N=1, the index=1 term is used only,
C and it is the column density above
C the observation altitude.
C the other 2 arrays that
C are loaded are the pressure and
C temperature arrays, PALL( 3 = H2O, mixed,
C and O3, 300 = max num of levels)
C and TALL likewise.
C The routine checks first to see if
C it is loading up a multi-layer atm
C and fills the arrays if this is
C so, else it loads a single layer atm (N=1)
C
          IF(N.NE.1)THEN
C
C This is a multi-layered atm.
C Do mixed gases, O3, and water vapor in tandem
C
          CDBOT= A1ATB1(SC  ,ALT,292,ALTKM,IERR )
          CDBOTW=A1ATB1(CH2O,ALT,ITP,ALTKM,IERRW)
          CDBOTO=A1ATB1(CDO3,ALT,292,ALTKM,IERRO)
                IF(IERR.NE.0.OR.IERRW.NE.0.OR.IERRO.NE.0)THEN
                PRINT*,'Alt. = ',ALTKM,' out of range in sub. LEVELS'
                STOP
                ENDIF
C
C Get total column density between input alt and 29.1 km
C H2O may have been scaled. Use new value.
C
          TOTLC= CDBOT  - 2.930E23
          TOTLCW=CDBOTW - CH2O(ITP)
          TOTLCO=CDBOTO - CDO3(292)
C
C We are interested in
C the layer centers. Find the column density at each
C
          IDIVS=(N-1)*2
          DELC =TOTLC /IDIVS
          DELCW=TOTLCW/IDIVS
          DELCO=TOTLCO/IDIVS
          LEVEL=0
          DO 300 I=1,IDIVS-1,2
C
                LEVEL=LEVEL+1
                XLAYC =CDBOT -I*DELC
                XLAYCW=CDBOTW-I*DELCW
                XLAYCO=CDBOTO-I*DELCO
C
C To find the T's and P's, we interpolate from the column density
C We only look at the arrays over the range between the altitude of
C Observation and the top of the array
C
        NUM=292-IALT+1
        NWV=ITP-IALT+1
        PALL (1,LEVEL)=A1ATB1(SP(IALT),CH2O(IALT),NWV,XLAYCW,IE1)
        PALL (2,LEVEL)=A1ATB1(SP(IALT),SC(IALT)   ,NUM,XLAYC, IE2)
        PALL (3,LEVEL)=A1ATB1(SP(IALT),CDO3(IALT),NUM,XLAYCO,IE3)
        TALL (1,LEVEL)=A1ATB1(ST(IALT),CH2O(IALT),NWV,XLAYCW,IE4)
        TALL (2,LEVEL)=A1ATB1(ST(IALT),SC(IALT)   ,NUM,XLAYC, IE5)
        TALL (3,LEVEL)=A1ATB1(ST(IALT),CDO3(IALT),NUM,XLAYCO,IE6)
C
                IF(IE1.NE.0.OR.IE2.NE.0.OR.IE3.NE.0
     1          .OR.IE4.NE.0.OR.IE5.NE.0.OR.IE6.NE.0)THEN
                PRINT*,' Column density(s) out of range in '
     1          ,'Sub. LEVEL, error flags are: '
     1          ,IE1,IE2,IE3,IE4,IE5,IE6
                STOP
                ENDIF
300       CONTINUE
C
C Finally load up the WGASES-array that holds in W(IS,1) the  column
C density at each level
C -  and treating ozone (IS=3) and H2O (IS=1) with
C their own function. We remove a factor
C of 1.0E20, which we will add into the
C line strengths, in order to easily prevent under and over-flow.
C Recall that all N-1 levels of the atmosphere
C have the same column density
C WGASES(1, ...), and the top of the
C atm has column density WGASES(2, ...)
C
          DO 250 IS=1,7
                IF (IS.EQ.1)THEN
C
C Water
C
                WGASES(IS,1)=(2.*DELCW /ZMU)*1.E-20
                WGASES(IS,2)=(CH2O(ITP)/ZMU)*1.E-20
C
                ELSEIF (IS.EQ.3) THEN
C
C Ozone
C
                WGASES(IS,1)=(2.*DELCO /ZMU)*1.E-20
                WGASES(IS,2)=(CDO3(292)/ZMU)*1.E-20
                ELSE
C
C Mixed gases
C
                WGASES(IS,1)=(2.*DELC/ZMU)*PARTS(IS)*1.E-20
                WGASES(IS,2)=(SC(292)/ZMU)*PARTS(IS)*1.E-20
                ENDIF
250       CONTINUE
C
C Now we treat the top
C Nth level of the atmosphere using 29.1 km values
```

```
C
          TALL(1,N)= TH2O(ITP)
          TALL(2,N)= TMIX(292)
          TALL(3,N)= TMIX(292)
          PALL(1,N)= PH2O(ITP)
          PALL(2,N)= PMIX(292)
          PALL(3,N)= PMIX(292)
C
C If the user has requested a
C 1 layer atmosphere (N=1) then load this up instead
C----------------------------------------------------------------
C
          ELSE
C
C H2O Layer, use T and P at 1/2 density
C
          TALL (1,N)=A1ATB1(TH2O,ALT,ITP,ALTKM,IE1)
          PALL (1,N)=A1ATB1(PH2O,ALT,ITP,ALTKM,IE2)
C
C Mixed gases, use T and P at 1/2 pressure
C
          TALL (2,N)=A1ATB1(TMIX,ALT,292,ALTKM,IE3)
          PALL (2,N)=A1ATB1(PMIX,ALT,292,ALTKM,IE4)
C
C Ozone if we are under 22 km (ie, we are not in a balloon or rocket)
C then we are under the
C bulk of the Ozone Layer - use T P parameters of
C 22 km, else, use the T and P at altitude
C
                IF(ALTKM.LT.22)THEN
                  TALL (3,N)=A1ATB1(ST,ALT,292,22.,IE5)
                  PALL (3,N)=A1ATB1(SP,ALT,292,22.,IE6)
                ELSE
                  TALL (3,N)=A1ATB1(ST,ALT,292,ALTKM,IE7)
                  PALL (3,N)=A1ATB1(SP,ALT,292,ALTKM,IE8)
                ENDIF
          DO 600 IS=1,7
C
C H2O
C
                IF(IS.EQ.1)THEN
                WGASES(IS,N)=A1ATB1(CH2O,ALT,ITP,ALTKM,IE9)
     1          /ZMU*1E-20
C
C Ozone
C
                ELSEIF (IS.EQ.3)THEN
                WGASES(IS,N)=A1ATB1(CDO3,ALT,292,ALTKM,IE10)
     1          /ZMU*1E-20
C
C Mixed gases
C
```

```
                ELSE
                WGASES(IS,N)=A1ATB1(SC  ,ALT,292,ALTKM,IE11)
     1          /ZMU*PARTS(IS)*1E-20
C
                ENDIF
                IF(IE1.NE.0.OR.IE2.NE.0.OR.IE3.NE.0.OR.IE4.NE.0
     1          .OR.IE5.NE.0.OR.IE6.NE.0.OR.IE7.NE.0.OR.IE8.NE.0
     2          .OR.IE9.NE.0.OR.IE0.NE.0.OR.IE10.NE.0.OR.IE11.NE.0)
     3          THEN
                PRINT*,' Column density(s) out of range in '
     1          ,'sub. LEVEL, error FLAG 1,2,...  are: ',
     2          IE1,IE2,IE3,IE4,IE5,IE6,IE7,IE8,IE9,IE10,IE11
                STOP
                ENDIF

600       CONTINUE
          ENDIF
Cd      IF(N.NE.1)PRINT*,' T P TW,PW ',TALL(2,N),PALL(2,N),TALL(1,N)
Cd     1   ,PALL(1,N)
c       OPEN(7,FILE='le.',STATUS='NEW')
c       DO I=1,2
c       WRITE(7,777)I,(WGASES(II,I),II=1,7)
c777    FORMAT(1X,I1,1X,7(E8.3,1X),/)
c       ENDDO
c       DO J=1,N
c       WRITE(7,888)J,(PALL(K,J),K=1,3),(TALL(KK,J),KK=1,3)
c888    FORMAT(1X,I2,1X,6(E8.3,1X))
c       ENDDO
c       CLOSE(7)
        RETURN
        END

        SUBROUTINE SCALGS
C *******************************************************************
C Provides Gamma and S scale factors for line shapes
C for all N species T(1,) is H2O, T(2,) is mixed gas, T(3,) is O3,
C & likewise for P, and the S and Gamma scale factors, SSCALE, GSCALE
C (As usual, hundreds of memory locations (eg, T(3,2:300) )
C are unused, because
C O3 is treated currently as a monolayer. Perhaps this will change.
C ********************************************************************
        REAL EXPM(3),EXPN(3)
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        COMMON /SCALE/SSCALE(3,300),GSCALE(3,300)
        DATA EXPM/1.5,1.0,1.5/,EXPN/0.62,0.5,0.5/
        ITYPES=3
        IF(ITANK.EQ.1)ITYPES=1
          DO  K=1,ITYPES
            NLEV=LAYER
                DO I=1,NLEV
                  SSCALE(K,I)=             (296./TALL(K,I))**EXPM(K)
                  GSCALE(K,I)= PALL(K,I) * (296./TALL(K,I))**EXPN(K)
```

```
c                 PRINT*,' IN SUB SS,GS, K LEV ',SSCALE(K,I),
c     1           GSCALE(K,I),K,I
                ENDDO
          ENDDO
        RETURN
        END

        SUBROUTINE GETLAM
C *****************************************
C  Get the wavelength range and resolution
C *****************************************
        REAL ASPN(19)
        CHARACTER*3 MOLE(7),ASP(19)*5,ASPECIES*5
        COMMON /ATMJNK/AWV,AZ,AWVL,IATYPE,IALAY,IALT,TORR
        COMMON /LIMIT/NFMAX,NRES,BOTL,TOPL,ISLITS,IWINGS,IPLOTN
     1   ,RESRB,AC,JWINGS
        COMMON /FVECT/F1,F2,FD,NF
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        DATA ASP/'SIII','SIII2','OIII','OIII2','OI',
     1    'OI2','CII','NIII','SiII','NeIII','NII',
     2    'SI','FeII','OIV','NeV','FeIII','NII2','SII','SII2'/
        DATA ASPN/ 18.713, 33.480, 51.815, 88.356, 63.18372,
     1    145.52548, 157.741, 57.330, 34.814, 36.010,121.897,
     2    25.249,25.9882,25.87,24.28,22.93,205.25,68.49,129.7/
        DATA MOLE/'H2O','CO2',' O3',' N2O',' CO','CH4',' O2'/
2010    PRINT 2011
2011    FORMAT(' Enter wavelength of spectral line of interest',/,
     1    '  (this is used to make the velocity scale), or...',/,
     2    ' -1 for species specification, ',/,
     2     ' or else 0 for don''t care (0): ',$)
        READ(*,*,ERR=2010)WLLINE
        PRINT*,'{',WLLINE,'}'
        IF (WLLINE.EQ.-1) THEN
20121           PRINT 2012
2012    FORMAT(' Enter species (with no trailing tabs), eg. OI',
     1    /,' (enter ''NO'' to get out,'
     1    ' enter ''LI'' to print the list) (NO): ',$)
                READ(*,2013,ERR=20121)ASPECIES
                WRITE(*,20132)ASPECIES
2013            FORMAT(A5)
20132           FORMAT('{',A5,'}')
                        IF(ASPECIES.EQ.'LI'.OR.ASPECIES.EQ.'LI')THEN
                          DO II=1,19
                          WRITE(*,4013)ASP(II),ASPN(II)
4013            FORMAT(1X,A5,' at wavelength ',F9.5)
                          ENDDO
                        GO TO 20121
                        ENDIF
                IF(ASPECIES.EQ.'NO')GO TO 2010
                DO II=1,16
                IF(ASPECIES.EQ.ASP(II))THEN
                        WLLINE=ASPN(II)
                        PRINT 20131,ASPECIES,WLLINE
20131                   FORMAT(1X,A5,' Wavelength = ',F8.4)
                        GOTO 100
                        ENDIF
                ENDDO
                PRINT2014,ASPECIES
2014    FORMAT(1X,A5,' Not found, try again. (Get out with ''NO'') ')
                GO TO 20121
        ENDIF
100     PRINT 1011
1011    FORMAT(' You may enter the limits of the x-axis in either',/,
     1   ' wavelength or velocity; each unit will be printed.',/,
     2   ' Enter wavelength range of interest; Lambda 1 and Lambda 2'
     3  , ' in microns.',/,
     4   ' (''0 0'' for velocities instead) (10 10.1): ',$)
        READ(*,*,ERR=100)WL1I,WL2I
        PRINT*,'{',WL1I,WL2I,'}'
          IF(WL1I.LT.0)THEN
                DUM=WL2I
                WL2I=-10000/WL1I
                WL1I=-10000/DUM
                PRINT*, ' Wavelengths ',WL1I,' to ', WL2I
          ENDIF
        IF(WL1I.EQ.0)THEN
                IF(WLLINE.EQ.0)GO TO 2010
10110           PRINT 10111
10111           FORMAT(' Enter beginning and ending velocity (km/s) ',
     1          'for plot (-1000 1000): ',$)
                READ(*,*,ERR=10110)V1,V2
                PRINT*,'{',V1,V2,'}'
                WL1I=(1+V1/2.9979E5)*WLLINE
                WL2I=(1+V2/2.9979E5)*WLLINE
                PRINT 10112,WL1I,WL2I
10112           FORMAT(' The wavelength range is then ',F9.5,1X,F9.5)
        ENDIF
        WL1=WL1I
        WL2=WL2I
        IF(WLLINE.EQ.0)WLLINE=0.5*(WL1I+WL2I)
        IF(WL1.LT.BOTL.OR.WL2.GT.TOPL.OR.WL1.GT.WL2)THEN
                PRINT*,' Invalid
     1   range. Min, Max are: ',BOTL,TOPL,' microns'
                PRINT*,' Try again...'
                GO TO 100
                ENDIF
C
C We set the variable IWINGS which tells how far out of the requested
C wavelength range deep lines could reside which might influence the
C spectrum. We consider
C two cases, at or above flight altitude (Alt=41000 ft)
C IDEEP=1, and below flight altitude, or a tank IDEEP=2
C
```

```
        IDEEP=1
        IF(IALT.LT.41000.OR.ITANK.EQ.1)IDEEP=2
        CALL SEARCH(WL1I,WL2I,IDEEP,IWINGS)
111     PRINT 1111
1111    FORMAT(' Enter instrumental resolution in microns ',/,
        1 ' (0 for the CGS high resolution system',
        1 ' resolution = 60 km/s),'/,
        1 ' or -1 for no smoothing. (0): ',$)
        READ(*,*,ERR=111)DWLI
        PRINT*,'{',DWLI,'}'
        IF (DWLI.EQ.0)DWLI=RES(WLLINE)
        IF (DWLI.EQ.-1)DWLI=0
        IF(DWLI.LT.0)GO TO 111
        WLCENTER=.5*(WL1I+WL2I)
        WNCENTER=WLORWN(WLCENTER)
        DWNI=DLORDN(DWLI,WLCENTER)
        DWNIN=DWNI/NRES
        WN1=WLORWN(WL1)
        WN2=WLORWN(WL2)
          IF(ITANK.NE.1)THEN
              IF(LAYER.EQ.1)THEN
                DWN=PALL(2,1)*RESRB
C               PRINT*,' RESRB, PALL(2,1) ,DWN ',RESRB,PALL(2,1),DWN
              ELSE
                DWN=PALL(2,LAYER-1)*RESRB
              ENDIF
          ELSE
            DWN=PALL(1,1)*RESRB
          ENDIF
C       PRINT*,'DWN, DWNIN ',DWN, DWNIN
        IF(DWLI.NE.0.AND.DWNIN.LT.DWN)DWN=DWNIN

C
C Check that the range & resolution
C requested will fit into the fine array, characterized by FVECT
C

        WNEXT2=WN2-ISLITS*DWNI
        WLEXT2=WLORWN(WNEXT2)
          IF(WLEXT2.GT.TOPL)THEN
            PRINT*,' Warning, the instrumental slit',
        1 ' will encompass no lines ',
        1    'longward of ',TOPL,' um - these are not in the database.'
          WLEXT2=TOPL
          WNEXT2=WLORWN(TOPL)
          ENDIF
        WNEXT1=WN1+ISLITS*DWNI
        WLEXT1=WLORWN(WNEXT1)
          IF(WLEXT1.LT.BOTL)THEN
            PRINT*,' Warning, the instrumental slit'
        1 ,' will encompass no lines ',
        1    'shortward of ',BOTL,
        1 ' um - these are not in the database.'
```

```
          WLEXT1=BOTL
          WNEXT1=WLORWN(BOTL)
          ENDIF

        XNTEST=(WNEXT1-WNEXT2)/DWN
        COMPARE=NFMAX
          IF(XNTEST+1.LT.COMPARE)THEN
          NF=XNTEST+1
          F2=WNEXT2
          FD=DWN
          F1=WNEXT2+FD*NF
          WNR1=WNEXT1+IWINGS
          WLR1=WLORWN(WNR1)
            IF(WLR1.LT.BOTL)THEN
              WLR1=BOTL
              WNR1=WLORWN(BOTL)
            ENDIF
          WNR2=WNEXT2-IWINGS
          IF(WNR2.LE.0)WNR2=1E-3
          WLR2=WLORWN(WNR2)
            IF(WLR2.GT.TOPL.OR.WLR2.LT.0)THEN
              WLR2=TOPL
              WNR2=WLORWN(TOPL)
            ENDIF
C
C COMMON /FVECT/ is now set up for the fine array,
C
          ELSE
                DO IDECEXP=4,-5,-1
                        DO ICOEF=9,0,-1
                        DELWL=ICOEF*10.**(IDECEXP-1)+10.**IDECEXP
                        WLTEST1=WLCENTER-DELWL-ISLITS*DWLI
                        IF(WLTEST1.LT.BOTL)GOTO 8500
                        WNTEST1=WLORWN(WLTEST1)
                        WLTEST2=WLCENTER+DELWL+ISLITS*DWLI
                        IF(WLTEST2.GT.TOPL)GOTO 8500
                        WNTEST2=WLORWN(WLTEST2)
                        XNTEST=(WNTEST1-WNTEST2)/DWN
c               PRINT*,' DEL WL1,WL2,XN ',DELWL,WLTEST1,WLTEST2,XNTEST
                        IF(XNTEST+1.LT.COMPARE)GO TO 9000
8500                    CONTINUE
                        ENDDO
                ENDDO
                PRINT*,' Wavelength range too large, '
                PRINT*, 'Trouble finding acceptable range...'
                GO TO 100

9000            WL1=AMAX1(BOTL,WLTEST1)
                WL2=AMIN1(TOPL,WLTEST2)
                PRINT 1001,WL1,WL2
1001            FORMAT(' Range too large. Try something like ',/,
        1 F13.7,' - ',F13.7)
                        PRINT*,'  Enter new Lambda 1, Lambda 2'
        1               ,', and/or resolution.'
        PRINT*,' Wavelength range too large. Try a smaller range.'
                GO TO 100
          ENDIF
        RETURN
        END

        SUBROUTINE SEARCH(WWL1,WWL2,IDEEP,IWINGS)
C *************************************************
C Determines how far to search for deep lines
C *************************************************

        REAL WNLST(8),SEARCHLST(8,2)
        DATA WNLST/1,280,600,740,1600,3200,3800,12500/
        DATA SEARCHLST/30, 10, 80, 10,800, 30, 10,0,
        1            200,200,200,200,800,200,200,0/
        WN1=10000./WWL2
        WN2=10000./WWL1
           DO I=1,7
                IF(WN1.GE.WNLST(I).AND.WN1.LE.WNLST(I+1))THEN
                INDEX1=I
                ENDIF
                IF(WN2.GE.WNLST(I).AND.WN2.LE.WNLST(I+1))THEN
                INDEX2=I
                ENDIF
           ENDDO
        IWINGS=0
                DO I=INDEX1,INDEX2
        IF(SEARCHLST(I,IDEEP).GT.IWINGS)IWINGS=SEARCHLST(I,IDEEP)
                ENDDO

                IF(IWINGS.EQ.0)THEN
                PRINT*,' ERROR SETING IWINGS'
                STOP
                ENDIF
        RETURN
        END

        FUNCTION RES(WL)
C
C Give the resolution of the CGS "High Resolution System" for a
C specified wavelength
C
c for now...
        res=wl*60./3e5
        RETURN
        END

        SUBROUTINE GETPLO
C ***********************
C Get the plot parameters
C ***********************
```

```
        COMMON /LIMIT/NFMAX,NRES,BOTL,TOPL,ISLITS,IWINGS,IPLOTN
     1   ,RESRB,AC,JWINGS
        COMMON /FVECT/ F1,F2,FD,NF
        COMMON /PVECT/P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /RANGE/ WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
C
C now for /PVECT/ which controls the plotting array
C
C Take care of case where there is now smoothing, instrumental res=0
C
                IF(DWLI.EQ.0)THEN
                IHOP=NF/IPLOTN+1
C               PRINT*,' NF,IPLOTN,IHOP ',NF,IPLOTN,IHOP
499             PRINT 500,IHOP
500     FORMAT(' The ''fine array'' will be plotted, by sampling ',
        1' each ',I3,' elements. Input 0 if',/,
        2' this is OK, or else a larger integer element interval: ',$)
                READ(*,*,ERR=499)IHOP1
                PRINT*,'{',IHOP1,'}'
                IF(IHOP1.EQ.0)IHOP1=IHOP
                IF(IHOP.GT.IHOP1)GO TO 499
                IZSKIP=IHOP1
                P1=WL1I
                P2=WL2I
                NP=(1.*NF)/IZSKIP
                PD=(P2-P1)/NP
                GOTO 100
                ENDIF
C
         PRINT*,' Setting the data point spacing ',
        1'(sampling) to 1/5 instrument resolution...'
         RESI=0.2*DWLI
        NIND=(WL2I-WL1I)/RESI
501     WRITE(*,5011)NIND
5011    FORMAT('  There will be',I7,' points plotted.')
        IF(NIND.LT.3.OR.NIND.GT.IPLOTN)THEN
                PRINT*,' Number of points must be greater than 2'
     1          ,' and less than ',IPLOTN
        GOTO 599
        ENDIF
        IF(RESI.GE..0001.AND.RESI.LT.10.)THEN
        WRITE(*,502)RESI
502     FORMAT('  Their spacing will be ',F7.4,' microns.')
        ELSE
        WRITE(*,503)RESI
503     FORMAT('  Their spacing will be ',1PE9.3,' microns.')
        ENDIF
599     PRINT 999
999     FORMAT(' Enter a new number of points, or 0 to keep these '
     1   ,'values, or ',/,' -1 to change the spacing (0): ',$)
        READ(*,*,ERR=599)L
        PRINT*,'{',L,'}'
```

```
                IF(L.GT.0)THEN
C
C                  New # of points
C
                        IF(L.GE.2.AND.L.LE.IPLOTN)THEN
                        P1=WL1I
                        P2=WL2I
                        PD=(WL2I-WL1I)/L
                        NP=L
                        ELSE
                PRINT*,' Number of points must be greater than 2'
     1                  ,' and less than ',IPLOTN
                        GO TO 501
                        ENDIF
                ELSEIF (L.EQ.-1)THEN
C
C           New # of points for new spacing
C
8880            PRINT 888
888             FORMAT(' Enter new spacing in microns (.005): ',$)
                READ(*,*,ERR=8880)RESNEW
                PRINT*,'{',RESNEW,'}'
                L=(WL2I-WL1I)/RESNEW
                        IF(L.GE.2.AND.L.LE.IPLOTN)THEN
                        P1=WL1I
                        P2=WL2I
                        PD=RESNEW
                        NP=L
                        PRINT*,' ',NP,' points will be plotted.'
                        ELSE
                        PRINT*,' ',L,' points result....'
                PRINT*,' Number of points must be greater than 2'
     1          ,' and less than ',IPLOTN,', (Mongo can''t handle'
                        PRINT*,' many more). Try again...'
                        GO TO 501
                        ENDIF
                ELSE
C
C                   Use existing number of points
C
                        IF(NIND.GE.2.AND.NIND.LE.IPLOTN)THEN
                        P1=WL1I
                        P2=WL2I
                        PD=RESI
                        NP=NIND
                        ELSE
                PRINT*,' Number of points must be greater than 2'
     1          ,' and less than ',IPLOTN,', (Mongo can''t handle'
                        PRINT*,' many more). Try again...'
                        GO TO 501
                        ENDIF
                ENDIF
100       NINST=5
```

```
          IF(DWLI.GT.0)THEN
2           PRINT*,' Select instrument profile function: '
            PRINT 3
3           FORMAT(' [1] Triangle, [2] Gaussian, [3] Sinc,',
        1   ' [4] Rectangle (2): ',$)
            READ(*,*,ERR=2)NINST
            PRINT*,'{',NINST,'}'
            IF(NINST.LT.1.OR.NINST.GT.4)GO TO 2
            IF(NINST.EQ.3)CALL SINC0(DWLI)
          ENDIF
        RETURN
        END

        FUNCTION A1ATB1(A,B,N,B1,IERR)
C
C       A general interpolation function - S.Lord 12 MAY 88
C       Interpolates to find
C       A1(B1), given absissa B and ordinate values B-array
C       B array (the absissa) must be
C       monotonically increasing or decreasing
C
C Error Flag:      IERR=0   No error
C                      =-1  B1 less than entire B-array range
C                       +1     greater
C                       +2  B array contains adjacent equal elements
C                       +3  B array is not monotonic
        REAL A(N),B(N)
        IERR=0
C
        IF(B(1).LE.B(N))THEN
C
C Treat ascending B-array case first:
C
                IF(B1.LT.B(1))THEN
                IERR=-1
                RETURN
                ENDIF
                IF(B1.GT.B(N))THEN
                IERR=1
                RETURN
                ENDIF
C
                DO 10 J=2,N
                        I=J-1
                                IF(B(I).EQ.B(J))THEN
                                  IERR=2
                                  RETURN
                                ENDIF
                                IF(B(I).GT.B(J))THEN
                                  IERR=3
                                  RETURN
                                ENDIF
                        IF(B(J).GE.B1)THEN
```

```
                      A1ATB1=A(I)+(A(J)-A(I))*(B1-B(I))/(B(J)-B(I))
                      RETURN
                      ENDIF
10              CONTINUE
                PRINT*,' A1TOB1 1'
                STOP
C
C Treat decending B-array case second:
C
        ELSE
                IF(B1.LT.B(N))THEN
                IERR=-1
                RETURN
                ENDIF
                IF(B1.GT.B(1))THEN
                IERR=1
                RETURN
                ENDIF
C
                DO 20 J=2,N
                        I=J-1
                                IF(B(I).EQ.B(J))THEN
                                  IERR=2
                                  RETURN
                                ENDIF
                                IF(B(I).LT.B(J))THEN
                                  IERR=3
                                  RETURN
                                ENDIF
                        IF(B(J).LE.B1)THEN
                        A1ATB1=A(I)+(A(J)-A(I))*(B1-B(I))/(B(J)-B(I))
                        RETURN
                        ENDIF
20              CONTINUE
                PRINT*,' A1TOB1 2'
                STOP
        ENDIF
        END

        FUNCTION WLORWN(ARG)
C ****************************************************************
C WL - wavelength, WN - wave number. Converts one to the other.
C ****************************************************************
C This calculates wavelength (lambda
C in microns) at a wave number (cm^-1).
C Conversely it calculates a wave number (cm^-1)
C at a wave length (microns)
C It's a little silly to do in
C a function, but it trades speed for clarity.
C
        WLORWN=1E4/ARG
        RETURN
```

```
      END

      FUNCTION DLORDN(DELARG,ARG)
C *******************************************************************
C  DL - delta lambda, DN - C delta wave number.
C Converts one to the other.
C  Note: DELARG and ARG are the input
C and are the same type unit.
C *******************************************************************
C This calculates delta lambda (microns) at delta sigma (cm^-1).
C Conversely it calculates delta sigma
C (cm^-1) at delta lambda (microns)
C Formally, the sign should be reversed, but
C this is not usually desired.
C
      DLORDN=1E4*DELARG/(ARG*ARG)
      RETURN
      END

      FUNCTION IFATWN(WN,IE)
C ********************************************************************
C Finds the index in the F = Fine array
C that represents the largest wave number
C that is less than WN.
C If WN is less than the first wave number F1, IE=-1
C ********************************************************************
C If WN is greater than the last WN, IE = 1. Else, IE=0. N.B. we have
C set up the fine array in decreasing wave number, FD is negative.
C
      COMMON /FVECT/ F1,F2,FD,NF
      IFATWN=NINT((WN-F1)/FD)+1
      IE=0
      IF(IFATWN.LT.1)IE=-1
      IF(IFATWN.GT.NF)IE=1
      RETURN
      END

      SUBROUTINE GETSET(IER)
C *******************************************************************
C Uses a file listing the number of lines per integer wavenumber,
C *******************************************************************
C The AFCRL database provides the input.
C Also SKIPA records the number of lines
C( = records) of the AFCRL database
C that must be read to arrive at a wavenumber's first line, all listed
C in two columns from the shortest to longest wavenumber.
C
      COMMON /LIMIT/NFMAX,NRES,BOTL,TOPL,ISLITS,IWINGS,IPLOTN
     1  ,RESRB,AC,JWINGS
      COMMON /FVECT/ F1,F2,FD,NF
      COMMON /RANGE/ WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1 , WLEXT2,WLLINE,IZSKIP
      COMMON /WREAD/ IRECA,IRECZ
```

```
        COMMON /SKIPS/ISKIPWN(12500),ISKIPSUM(12500),ISKIPMAX(12500)
C
Cd      print*,'ext21 read21 ',wnext2,wnext1,wnr2,wnr1
        IER=0
        OPEN(1,FILE='/work/cgs/atran/skipa.dat',STATUS='OLD',ERR=1232)
C,READONLY)
        IBEG=10000./TOPL+.0001
        IEND=10000./BOTL+.0001
c       PRINT*,' WNR1 WNR2 ',WNR1,WNR2
C       PRINT*,' TOPL,BOTL,IBEG,IEND ',TOPL,BOTL,IBEG,IEND

                IF(IBEG.GT.WNR2.OR.IEND.LT.WNR1)THEN
                WLR1=WLORWN(WNR1)
                WLR2=WLORWN(WNR2)
                PRINT*,' AFCRL file''s available wavelength range:'
                PRINT10,BOTL,TOPL,WLR1,WLR2
10              FORMAT(' ',F7.2,' - ',F7.2,/
     1          , ' does not include desired span:'
     2          , F7.2,' - ',F7.2,' which is the span,',/,
     3         ' extended to include nearby line wings')
                CLOSE(1)
                IER=1
                RETURN
                ENDIF
        IFLAG=0
C       PRINT*,' BEFORE LOOP WNR2,1 ',WNR2,WNR1
        DO 1 I=IBEG,IEND
        READ(1,*,END=21,ERR=20)LPN,NTOT
C       PRINT*,' IN LOOP, WN, LPN,NTOT= ',I,LPN,NTOT
        ISKIPWN(I)=LPN
        IF(IFLAG.EQ.0)THEN
                IF(I+1.GT.WNR2)THEN
                IFLAG=1
C               PRINT*,' Flags up, we''re rolling! '
                IRECA=NTOT
                ENDIF
        ELSEIF (IFLAG.EQ.1)THEN
                IF(I.GT.WNR1)THEN
                IRECZ=NTOT
                IFLAG=2
                ENDIF
        ELSEIF (IFLAG.EQ.2)THEN
                IF(I.GT.WNR1+IWINGS)GO TO 15
        ENDIF
1       CONTINUE
        PRINT*,' Warning, '
        1 ,'lacking information for line wings shortward of ',
        1 IBOTL,' micrometers'
        GOTO15
20      CONTINUE
        PRINT*,' Error in skipa.dat, WN, LPN,NTOT= ',I,LPN,NTOT
        IER=1
        RETURN
```

```
21      PRINT*,' Premature end of file in SKIPA File.'
        IER=1
        RETURN
15      CONTINUE
        IF(IRECZ.EQ.IRECA)GOTO21
C       PRINT*,' IRECA,IRECZ ',IRECA,IRECZ
        CLOSE (1)
C
C The arrays ISKIPSUM and ISKIPMAX count
C the max possible line with wings
C IWINGS wave numbers out from the center
C that may overlap at a wavenumber
C
        IWNBEG=WNR2
        IWNEND=WNR1
c       PRINT*,' start and stop wn on getset... ',IWNBEG,IWNEND
          DO I=IWNBEG,IWNEND
            J=MAX(I-JWINGS,1)
            K=MIN(I+JWINGS,12500)
            ISKIPSUM(I)=0
              DO L=J,K
                ISKIPSUM(I)=ISKIPSUM(I)+ISKIPWN(L)
              ENDDO
          ENDDO
          DO I=IWNBEG,IWNEND
            J=MAX(I-JWINGS,1)
            K=MIN(I+JWINGS,12500)
            ISKIPMAX(I)=1
              DO L=J,K
                IF(ISKIPSUM(L).GT.ISKIPMAX(I))ISKIPMAX(I)=ISKIPSUM(L)
              ENDDO
          ENDDO
            JBEG=MAX(IWNBEG-IWINGS,1)
            KEND=MIN(IWNEND+IWINGS,12500)
c         PRINT*,' WN WAVELENGTH ISKIPWN  ISKIPSUM  SKIPMAK '
c       PRINT*,'--------------------------------------------'
c         DO I=JBEG,KEND
c         WAVELEN=10000./I
c           WRITE(*,4444)I,WAVELEN,ISKIPWN(I),ISKIPSUM(I),ISKIPMAX(I)
c4444   FORMAT(1X,I7,1X,F10.3,1X,3(I6,2X))
c         ENDDO
        OPEN(1,FILE='/work/cgs/atran/afgl.bin',STATUS='OLD',
     1  FORM='UNFORMATTED',
     2   iostat=ierrs)
        if(ierrs.ne.0)goto1234
        WRITE(*,'(''Reading through database'
        1 ,' to this wavelength......'')')
        DO I=1,IRECA
        READ(1)
        ENDDO
        PRINT*,' '
C       PRINT*,' Data file advanced'
C       READ(1)wn,st,wd,ep,n
```

```
C       WL=10000./WN
C       PRINT*,' WL WN ',WL,WN
        RETURN
1232    PRINT*,' Can''t fine skipa.dat'
        STOP
1234    PRINT*,' Can''t find afgl.bin'
        print*,'ierrs= ',ierrs
        STOP
        END

        SUBROUTINE INTEG
C *****************************************************
C Integrates Lorentz line shapes into the fine array
C *****************************************************
C Reads the lines from the AFCRL database one by one, and, for each
C level of the atmosphere, add the  lines into the Fine array.  The
C lines are all Lorentzian.
C
C statistical counters.... IWEAK
C
C IWEAK          The line at line cntr
C       (for gamma etc. in this layer) is too weak
C IDELIN         delta fn. in range
C       (fn. has FWHP less than .5 FD; is integrated)
C IDELOUT        delta fn. out of range (rejected)
C IWIDEIN        broad line, in range, (integrated)
C IWIDEOUT       broad line, out of range, (rejected)
C
        CHARACTER*3 MOLE(7)
        INTEGER IN(7),INN(7),IWEAK(7,300),IDELIN(7,300),
        1 IDELOUT(7,300),IWIDEOUT(7,300),IWIDEIN(7,300)
        REAL*8 E
        COMMON/D2O/D2OG
        COMMON /LIMIT/NFMAX,NRES,BOTL,TOPL,ISLITS,IWINGS,IPLOTN
     1   ,RESRB,AC,JWINGS
        COMMON /FARRA/F(1000000)
        COMMON /PVECT/P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /FVECT/F1,F2,FD,NF
        COMMON /WREAD/ IRECA,IRECZ
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
        COMMON /WGAS/ WGASES(7,2),PALL(3,300),TALL(3,300)
     1   ,ITANK,LAYER
        COMMON /SCALE/SSCALE(3,300),GSCALE(3,300)
        COMMON /SKIPS/ISKIPWN(12500),ISKIPSUM(12500),ISKIPMAX(12500)
        COMMON /STRONG/SLINES(80),ISPEC(80),SEW(80),ISTRONG
     1   ,IPOINT,STRENGTH
        DATA MOLE/'H2O','CO2',' O3',' N2O',' CO','CH4',' O2'/
        DATA IN/1,2,3,4*2/,
     1   INN/1,2,3,2,2,3,2/,PI/3.14159265/,PII/0.318309886/
c       open(81,file='deb.',status='new')
C
C Clear statistics counters
```

```
C
C       IZIP=0
C       IZAP=0
        WN1I=10000./WL1I
        WN2I=10000./WL2I
        IF(DWLI.GT.0)WNINST=DLORDN(DWLI,WLEXT1)
        IF(DWLI.EQ.0)WNINST=NRES*FD
        IF(IPLTCNT.NE.0)THEN
C       PRINT*,' CLEARING STAT COUNTERS...'
          DO I=1,300
              DO J=1,7
                IWEAK(J,I)=0
                IDELIN(J,I)=0
                IWIDEOUT(J,I)=0
                IWIDEIN(J,I)=0
                IDELOUT(J,I)=0
              ENDDO
          ENDDO
C       PRINT*,' STAT COUNTERS CLEAR'
C
        PRINT*,' Reinitializing Arrays...'
          DO I=1,NF
            F(I)=0
          ENDDO
C       PRINT*,' FINE ARRAY CLEAR'
        ENDIF
C
        IATMOK=0
        IACCEPT=0
        IREJECT=0
        HALFF=FD/2.
        CONST=-LOG(1-AC)*PI/LAYER
C
C Outermost loop for the lines
C
Cd      PRINT*,' Beginning read-in loop...'
C
                ITOTL=IRECZ-IRECA+1
           DO 1 I=IRECA,IRECZ
                ITELL=I-IRECA+1
             IF(MOD(ITELL,500).EQ.0)THEN
               WRITE(*,5555)ITELL,ITOTL
5555           FORMAT(1X,I8,' out of ',I8,' lines processed.')
             ENDIF
           READ(1)WN0,S0,GAMMA0,E,ISP,XN
c               if (iii.eq.141685)then
c               print*,' got it '
c               go to 1
c               endif
C       IF(WN0.GT.1003.6)PRINT*, ' IN INTEG WN0= ', WN0
           S0=S0*1E+20
C
C Check to see if we are
```

```
C starting or stopping our read within the range
C
             IF(I.EQ.IRECA.AND.WNO.GT.WNEXT2)THEN
               PRINT*,' WARNING '
        1 ,'- Starting read inside range, WNO, WNEXT2 ',
        1        WNO,WNEXT2
             ENDIF
             IF(I.EQ.IRECZ.AND.WNO.LT.WNEXT1)THEN
       PRINT*,' WARNING - Ending read inside range, WNO, WNEXT1 ',
     1        WNO,WNEXT1
             ENDIF
C
C Lines not in the
C F array interval are easily dismissed if they are too
C narrow, set a flag.  Remember WNEXT1 > WNEXT2
C
                IF(WNO.LE.WNEXT1.AND.WNO.GE.WNEXT2)THEN
                INTERV=1
                ELSE
                INTERV=0
                ENDIF
Cd              WRITE(*,1111)INTERV
1111    FORMAT(' INTERV#############',2X,I1)
C
C Check to see if we are out of the range
C of WNR1 WNR2 necessary for the integ.
C
        IF(WNO.LT.WNR2)THEN
                IREJECT=IREJECT+1
                GOTO1
        ENDIF
C
C Check to see if we have passed the necessary range
C
        IF(WNO.GT.WNR1)GOTO 9999
C
C Check if it is not H2O and we
C are modeling the "tank." (if so, reject)
C
        IF (ITANK.EQ.1)THEN
                IF(ISP.NE.1) THEN
                IREJECT=IREJECT+1
                GO TO 1
                ENDIF
        ENDIF
C
                IACCEPT=IACCEPT+1
Cd              PRINT*,' '
Cd              PRINT*,' '
Cd      PRINT*,' Accepting No. ',IACCEPT
           LEVS=LAYER
           K=IN(ISP)
           KK=INN(ISP)
```

```
C
C MAXLPN is the maximum
C number of lines that can overlap at this wave number
C XLIM is a constant to use in
C comparison with line center strengths, to
C determine if a line is significant.
C
           IND=WN0
           MAXLPN=ISKIPMAX(IND)
           IF(MAXLPN.EQ.0)THEN
           PRINT*,' ???? IND, ISKIPMAX(IND) ',IND,ISKIPMAX(IND)
           MAXLPN=1
           ENDIF
                   XLIM=CONST/MAXLPN
C
C Middle loop for the atmospheric levels
C
                DO 100 LEV=1,LEVS
                IF(LEV.EQ.LEVS)INDEX=2
                IF(LEV.LT.LEVS.OR.LEVS.EQ.1)INDEX=1
                W=WGASES(ISP,INDEX)
                S=SSCALE(K,LEV)*SSCAL1(WN0,E,TALL(K,LEV))*S0
                  IF(ITANK.EQ.1)THEN
                     IF(D2OG.GT.0.AND.ABS(WN0-48.75267).LT..0003)THEN
                                W=D2OG
                                S=S*1E7
                                PRINT*,' (Picked up the D2O line!)'
                        ENDIF
                  ENDIF

C
C               X=SSCAL1(WN0,E,TALL(K,LEV))
c WRITE(81,*)' K LEV TALL(K,LEV) P',K,LEV,TALL(K,LEV),PALL(K,LEV)
c WRITE(81,*)' X,SS,SG,S0,S',X,SSCALE(K,LEV),GSCALE(K,LEV),S0,S
c WRITE(81,*)' ISP,LEV,WG,LEVS ',ISP,LEV,WGASES(ISP,INDEX),LEVS
C

                GAMMA=GAMMA0 * PALL(K,LEV) * (296./TALL(K,LEV))**XN
                TERM=S*W*GAMMA/XLIM-GAMMA*GAMMA
                TERM1=S*W*GAMMA-GAMMA*GAMMA
C
C IF TERM < 0 it means the line
C center is below the threshold for significance
C
                  IF(TERM.LT.0)THEN
                    IWEAK(ISP,LEV)=IWEAK(ISP,LEV)+1
                    GOTO 100
                  ENDIF
C
C Determine if the equivalent width is sufficient to include the line
C in the list to mark.
C
                IF(LEV.EQ.1.AND.WN0.GE.WN2I.AND.WN0.LE.
        1 WN1I)THEN
                EW=S*W*LAYER/WNINST
                  IF(EW.GT.STRENGTH)THEN
                      IF(IPOINT.GE.ISTRONG)THEN
C
C List is full... we see if we can bump one of lesser lines
C
                          DO IS=1,ISTRONG
                            IF(SEW(IS).LT.EW)THEN
                                SLINES(IS)=WN0
                                SEW(IS)=EW
                                ISPEC(IS)=ISP
                                GO TO 1777
                            ENDIF
                          ENDDO
                    ELSE
                          IPOINT=IPOINT+1
                          SLINES(IPOINT)=WN0
                          SEW(IPOINT)=EW
                          ISPEC(IPOINT)=ISP
                    ENDIF
                ENDIF
              ENDIF
C
C DELSIG is the number
C of wavenumbers beyond which the line becomes weak
C enough to ignore.
C

1777            DELSIG=SQRT(TERM)
C               IF(TERM1.LE.0)GO TO 1778
C               DELSIG1=SQRT(TERM1)

C
C Reality check #1... If this bell rings,
C we need to increase the value of
C IWINGS

C               IF(DELSIG1.GT.1)WRITE(55,1755)WN0,MOLE(ISP),DELSIG1
1755            FORMAT(1X,F11.5,3x,A3,3x,F8.2)
Cd              WL0=WLORWN(WN0)
Cd              if(iaccept.eq.15)then
Cd              print*,' s0,gamma0 e s gamma w ',s0,gamma0,e,s,gamma,w
Cd              endif
Cd              write(*,156)WLEXT1,WLEXT2,WL0,WN0,F1,FD,TERM,NF
156     format(' WLEXT1   WLEXT2      WL0       WN0        F1'
     1  ,'       FD '
     1  ,'      TERM        NF',/,7(F9.4,1X)I6)
C
C See if it's a delta fn. within the WN range...
C
1778                IF(2*DELSIG.LT.FD.AND.INTERV.EQ.1)THEN
                      INF=NINT((F1-WN0)/FD)+1
```

```
                        IF(INF.GE.1.AND.INF.LE.NF)THEN
c                           IF(2*GAMMA.GT.FD)THEN
c                     PRINT*,' RATHER BROAD DEL FN, 2*G, 2*DEL, FD ',
c     1                        2*GAMMA,2*DELSIG,FD
c                           ENDIF
                          CEN=S*W/GAMMA
                            IF(CEN.LT.XLIM)THEN
       PRINT*,' Reality check 2 failed... center is less than limit',
     1      ' Center, limit ',cen,xlim
                            ENDIF
                          YMEAN=.5/PI*(CEN+XLIM)
                          YAVE=YMEAN*2*DELSIG/FD
Cd                        PRINT*,' MIN DEL INT INTO ',INF
                          F(INF)=F(INF)+YAVE
                        ELSE
Cd                        WRITE(*,157)INF
157                       FORMAT(1X,'IDELIN TROUBLE, INF',/,1X,I6)
                        ENDIF
Cd                    PRINT*,' TAKEN IDELIN'
                      IDELIN(ISP,LEV)=IDELIN(ISP,LEV)+1
                      GO TO 100
                    ELSEIF(2*DELSIG.LT.FD.AND.INTERV.EQ.0)THEN
Cd                    PRINT*,' TOO FAR MINIDEL'
                      IDELOUT(ISP,LEV)=IDELOUT(ISP,LEV)+1
                      GO TO 100
                    ENDIF
Cd                PRINT*,' IDELOUT NOT THE CASE'
Cd                WRITE(*,1599)FD,ZD,AWAY1,FDTOT
1599              FORMAT('    FD     ZD       AWAY1   FDTOT   ',/,
     1            4(F9.4,1X))
C
C We set up our F array integration
C range, and make sure the ends don't
C exceed the F array extent.
C
        Z1=WN0+DELSIG
        Z2=WN0-DELSIG
C
C I1 and I2 are the indices of the F array between which the line has
C significant extinction.
C
        I1=NINT((F1-Z1)/FD)+1
        I2=NINT((F1-Z2)/FD)+1
C
                IF (I1.GT.NF.OR.I2.LT.1)THEN
                  IWIDEOUT(ISP,LEV)=IWIDEOUT(ISP,LEV)+1
                  GO TO 100
                ENDIF
        IWIDEIN(ISP,LEV)=IWIDEIN(ISP,LEV)+1
        IF(I1.LT.1)I1=1
        IF(I2.GT.NF)I2=NF
Cd      PRINT*,' GAMMA ',GAMMA
```

```
                  IF(WLEXT2.LT.100)THEN
C                       IF(IZAP.EQ.0)PRINT*,' LORENTZ'
C                       IZAP=1
                    CON=S*W*GAMMA/PI
                    GAMMA2=GAMMA**2
                    WN0F1FD=WN0-F1-FD
                    DO INOW=I1,I2
                      DEL=WN0F1FD+INOW*FD
                      F(INOW)=F(INOW)+CON/(GAMMA2+DEL*DEL)
                    ENDDO
                  ELSE
C                       IF(IZIP.EQ.0)PRINT*,' KINETIC'
C                       IZIP=1
                    CON=S*W*4*WN0*GAMMA/PI
                    GAMMA42=4*GAMMA**2
                    WN02=WN0*WN0
                    F1FD=F1+FD
                    DO INOW=I1,I2
                      SIG=F1FD-INOW*FD
                      SIG2=SIG*SIG
                      DIF=WN02-SIG2
                      F(INOW)=F(INOW)+SIG*CON/(DIF*DIF+GAMMA42*SIG2)
                    ENDDO
                  ENDIF

Cd      DO 109 II= IFBEG-1,IFEND+1
Cd109   PRINT*,II,F(II)
100             CONTINUE
1          CONTINUE
9999    PRINT*,IACCEPT,' CONSIDERED, ',IREJECT,' REJECTED'
        PRINT*,' OF THOSE CONSIDERED..... '
        PRINT*,' '
        PRINT*,' IWEAK    '
        1 ,'1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)   '
        PRINT*,' Weak line, reject'
        PRINT 994
994     FORMAT(1X,70('-'))
        DO 1042 J=1,LAYER
1042    PRINT 77, J,(IWEAK(ISP,J),ISP=1,7)
        PRINT*,' '
        PRINT*,' IDELIN  1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2) '
        PRINT*,' Narrow line in range, accept'
        PRINT 99
99      FORMAT(1X,70('-'))
        DO 1002 J=1,LAYER
1002    PRINT 77, J,(IDELIN(ISP,J),ISP=1,7)
        PRINT*,' '
        PRINT*,
        1 ' IDELOUT  1(H2O)2(CO2)3(O3) 4(N20) 5(CO) 6(CH4)7(O2)   '
        PRINT*,' Narrow line out range, reject'
        PRINT 99
        DO 1003 J=1,LAYER
1003    PRINT 77, J,(IDELOUT(ISP,J),ISP=1,7)
```

```
        PRINT*,' '
        PRINT*,
        1 ' IWIDEOUT 1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)   '
        PRINT*,' Broad line out range, reject'
        PRINT 99
        DO 1004 J=1,LAYER
1004    PRINT 77, J,(IWIDEOUT(ISP,J),ISP=1,7)
        PRINT*,' '
        PRINT*,
        1 ' IWIDEIN  1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)   '
        PRINT*,' Broad line in range, accept'
        PRINT 99
        DO 1005 J=1,LAYER
1005    PRINT 77, J,(IWIDEIN(ISP,J),ISP=1,7)
77      FORMAT(' LYR.',I2,7(I6))
        CLOSE (1)
        RETURN
        END


        FUNCTION SSCAL1(WN0,E,T)
C *****************************************************
C Finds the S (line strength) scaling parameter that is
C wave number, energy, and Temperature dependent
C ******************************************************
        REAL*8 E
        WN695=WN0/0.695
        TERM1=EXP(-E*(296-T)/(0.694927*296*T))
        TERM2=(1-EXP(-WN695/T  ))
        TERM3=(1-EXP(-WN695/296))
        SSCAL1=TERM1*TERM2/TERM3
        RETURN
        END


        SUBROUTINE EXPO
C
C**************************************************************
C Converts Opacities to Transmissions en situ by exponentiating
C**************************************************************
        COMMON /FARRA/F(1000000)
        COMMON /FVECT/F1,F2,FD,NF
        PRINT*,' Converting opacity to transmittance...'
        DO I=1,NF
                IF(F(I).LT.0)THEN
                PRINT*,' NEGATIVE OPACITY! F(I), I ',F(I),I
                STOP
                ELSEIF (F(I).LT.10)THEN
                F(I)=EXP(-F(I))
                ELSE
                F(I)=0
                ENDIF
        ENDDO
        RETURN
        END

        SUBROUTINE SMEAR
C***********************************************
C Smooths the "fine" array by the selected instrument
C function, and puts it into the plot array
C***********************************************

        REAL HWHMS(4)
        COMMON /PARRA/P(20000),IPTYPE,
        1  /PVECT/P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /FARRA/F(1000000), /FVECT/F1,F2,FD,NF
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
        1, WLEXT2,WLLINE,IZSKIP
C
C HWHMS are the number of half
C widths at half powers from the center of a
C particular weighting function which need computing. The
C functions are indexed
C 1=Triangle, 2=Gaussian, 3=Sinc, 4=Box. The Sinc function
C is the broadest.
C
        DATA HWHMS/2.1,3.,8.1,1.1/
C
C We determine the range of indices in
C the fine array over which to apply
C the smoothing function. Variables are defined:
C
C DWLI            the instrumental resolution
C FWHM              "    "           "
C                 (full width at half maximum)
C HWHM            half width at half maximum
C DLAM1           the spacing of the F array IN WVLGTH (micr)
C                 at the low wl end
C N               the number of indices in the F
C                 array needed to contain half
C                 of the extent of the selected weighting function
C I               indexes the element of the P array being computed
C PL              the wavelength of this element (microns)
C ICENTF          the index of
C                 the nearest F array element corresponding to PL
C IF1 to IF2      the index range to smooth the F array to get P(I)
C IFS             the index of an F array value
C WL              the wavelength of this F array element
C DWL             how far in wavelength this
C                 element is from the P(I)'s wl
C PINT            the integrated weighted P array value
C
          IF(DWLI.EQ.0)RETURN
        FWHM=DWLI
        HWHM=0.5*DWLI
        DLAM1=DLORDN(FD,F1)
        N=HWHMS(NINST)*HWHM/DLAM1+.5
           IF(N.LT.2)THEN
        PRINT*,' Only one fine array point for each plotted point!'
           ENDIF
C
        PRINT*,' Smoothing the Fine array.....'
        ITASK=2*N*NP/1000
        ITCNT=0
          DO I=1,NP
            PL=P1+(I-1)*PD
            ICENTF=(F1-WLORWN(PL))/FD+1.5
            IF1=ICENTF-N
            IF2=ICENTF+N
            IF(IF1.LT.1 )IF1=1
            IF(IF2.GT.NF)IF2=NF
              IF(IF2.GT.NF.OR.IF1.LT.1)THEN
                PRINT*,' CAN''T SMOOTH TO OBTAIN PLOT INDEX ',I,
        1       ' AT WAVELENGTH ',PL
                STOP
              ENDIF
            PINT=0
            WT=0
              DO IFS=IF1,IF2
                ITCNT=ITCNT+1
                  IF(ITASK.GT.50..AND.MOD(ITCNT,50000).EQ.0)THEN
                    ITA=ITCNT/1000
                    WRITE(*,3535)ITA,ITASK
3535                FORMAT(1X,I7,' K out of ',I7,' K smoothing',
        1           ' operations done.')
                  ENDIF
                WL=WLORWN(F1-(IFS-1)*FD)
                DWL=PL-WL
                WTI=DINST(DWL,FWHM,NINST)
                WT=WT+WTI
                PINT=PINT+WTI*F(IFS)
              ENDDO
              IF(WT.NE.0)THEN
                P(I)=PINT/WT
              ELSE
                P(I)=0
              ENDIF
900         CONTINUE
          ENDDO
C
C Compute the total transmission through the band for both arrays
C
        SUMP=0
                DO IP=1,NP
                SUMP=SUMP+P(IP)
                ENDDO
        SUMP=SUMP/NP
        SUMF=0
                DO IF=1,NF
                SUMF=SUMF+F(IF)
                ENDDO
        SUMF=SUMF/NF
        PRINT*, 'F TRANS, P TRANS: ',SUMF,SUMP
        RETURN
        END


        SUBROUTINE SINC0(FWHM)
C****************************
C This determines
C a constant C so that we may smooth the data with a SINC
C function possessing the correct full width at half maximum (FWHM)
C I.E., SIN( C * HWHM ) / ( C * HWHM ) = 0.5, where HWHM = 0.5 FWHM.
C To find C we use the method of Successive Approximations.
C****************************
        COMMON /SINCC/C

        HWHM=0.5*FWHM
        C=HWHM

        DO I=1,200
        C=2./HWHM * SIN (C*HWHM)
        ENDDO

        HALF=SIN(C*HWHM)/(C*HWHM)
        IF(ABS(0.5-HALF).GT..01)THEN
                PRINT*,' SINC INITIALIZATION FAILED, HALF= ',HALF
                STOP
        ENDIF
        RETURN
        END

        FUNCTION DINST(DELWL,FWHM,NINST)
C**********************************************
C Evaluates one of four (NINST=1 to 4) instrumental functions at
C a wavelength displacement DELWL from the function center, with the
C instrument function completely defined by NINST and FWHM
C If a SINC function is used (NINST=3) then SINC0 must be call prior
C to using this function.
C NINST=1 Triangle, 2 Gaussian, 3 Sinc, 4 Rectangle
C**********************************************
        COMMON /SINCC/C
        GO TO (10,20,30,40)NINST
        PRINT*,' INSTRUMENT FUNCTION UNDEFINED', NINST
        STOP
C
C TRIANGLE (NINST=1)
C
10      DINST=-ABS(DELWL)/FWHM+1
        IF(DINST.LT.0)DINST=0
        RETURN
C
```

```
C GAUSSIAN (NINST=2)
C
20      EXPON=0.693*(DELWL*2/FWHM)**2
        IF(EXPON.LT.10)THEN
        DINST=EXP(-EXPON)
        ELSE
        DINST=0
        ENDIF
        RETURN
C
C SINC (NINST=3)
C
30      IF(DELWL.NE.0)THEN
        DINST=SIN(C*DELWL)/(C*DELWL)
        ELSE
        DINST=1
        ENDIF
        RETURN
C
C RECTANGLE (NINST=4)
C
40      IF(ABS(DELWL).LT.FWHM/2.)THEN
        DINST=1
        ELSE
        DINST=0
        ENDIF
        RETURN
        END

        SUBROUTINE PLOT
C
C*******************************************
C Sends P array to Mongo
C*******************************************
C
        CHARACTER*35 UNIT(2),AUNIT,PNAME(9)*11,TEN(3)*10
        INTEGER MTERM(4),MPLOC(4,4),IDOTS(3,7)
        REAL DOTLOC(3)
        COMMON /TERM/ITERM
        COMMON /PARRA/P(20000),IPTYPE
        COMMON /PVECT/P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /FARRA/F(1000000)
        COMMON /FVECT/F1,F2,FD,NF
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
        COMMON /STRONG/SLINES(80),ISPEC(80),SEW(80),ISTRONG
     1  ,IPOINT,STRENGTH
        LOGICAL EX
        DATA MTERM/3,11,7,14/,MPLOC/100,750,100,700,  40,375,60,350,
     1   48,453,78,379, 40,375,40,350/
        DATA PNAME/'parray.dat1',
        1 'parray.dat2','parray.dat3','parray.dat4',
     1  'parray.dat5','parray.dat6','parray.dat7','parray.dat8',
     2  'parray.dat9'/
        DATA UNIT/'\\\\rWavelength ( \\gmm )',
        1 '\\\\rWavenumber ( cm\\u-\\u1 )'/
        DATA DOTLOC/-.08,-.06, -.04/
        DATA IDOTS/0,0,1, 0,1,0, 0,1,1, 1,0,0, 1,0,1, 1,1,0, 1,1,1/
        IPLTCNT=IPLTCNT+1
        IF(IPLTCNT.EQ.1)THEN
                DO II=1,9
                  INQUIRE(FILE=PNAME(II),EXIST=EX)
                  IF(EX.EQ..TRUE.)THEN
                    OPEN(11,FILE=PNAME(II),STATUS='OLD')
                    CLOSE(11,STATUS='DELETE')
                  ENDIF
                ENDDO
        ENDIF
        OPEN(10,FILE=PNAME(IPLTCNT),STATUS='NEW')
                IF(DWLI.EQ.0)THEN
                        DO JJ=1,NF,IZSKIP
                        WL=F1-(JJ-1)*FD
                                IF(IPTYPE.EQ.1)WL=10000./WL
                        WRITE(10,*)II,WL,F(JJ)
                        ENDDO
                ELSE
                        DO II=1,NP
                        WL=P1+(II-1)*PD
                          IF(IPTYPE.EQ.2)WL=10000./WL
                        WRITE(10,*)II,WL,P(II)
                        ENDDO
                ENDIF
        CLOSE (10)
        IF(IPLTCNT.EQ.1)THEN
                INQUIRE(FILE='p.plo',EXIST=EX)
                IF(EX.EQ..TRUE.)THEN
                        OPEN(11,FILE='p.plo',STATUS='OLD')
                        CLOSE(11,STATUS='DELETE')
                ENDIF
                OPEN(20,FILE='p.plo',STATUS='NEW')
                AUNIT=UNIT(IPTYPE)
                YUP=1.2
                  IF(IPTYPE.EQ.2)THEN
                   P1=10000/WL2I
                   P2=10000/WL1I
                   P11=P1-.1*(P2-P1)
                   P22=P2+.1*(P2-P1)
                    STARTWL=WL2I
                    WRITE(TEN(1),1011)STARTWL
1011                FORMAT(F10.4)
                    STOPWL=WL1I
                    WRITE(TEN(3),1011)STOPWL
                    CENTERWN=.5*(P11+P22)
                    CENTERWL=10000/CENTERWN
                    WRITE(TEN(2),1011)CENTERWL
                    WRITE(20,131)MTERM(ITERM),(MPLOC(I,ITERM),I=1,4),
        1            P11,P22,CENTERWN,P11,P22,
        1            P1,P1,CENTERWN,CENTERWN,P2,P2,
        1            P1,TEN(1),CENTERWN,TEN(2),P2,TEN(3)
131                  FORMAT(     'TERM ',I2                ,/,
        1            'ERA'                                 ,/,
        1            'EXP 1.'                              ,/,
        1            'LOC ',4(I4,1X)                       ,/,
        2            'LIM ',F13.7,1X,F13.7,' -.1 1.1'      ,/,
        1            'RELOC ',F13.7,' 1.2'                 ,/,
        9            'PUTL 8 \\\\rWavelength ( \\gmm )'    ,/,
        8            'RELOC ',F13.7,' 1.1'                 ,/,
C  Top y line
        8            'DRAW ',F13.7,' 1.1'                  ,/,
        8            'RELOC ',F13.7,' 1.1'                 ,/,
C  left top tick
        8            'DRAW ',F13.7,' 1.05'                 ,/,
        8            'RELOC ',F13.7,' 1.1'                 ,/,
C  middle top tick
        8            'DRAW ',F13.7,' 1.05'                 ,/,
        8            'RELOC ',F13.7,' 1.1'                 ,/,
C  right top tick
        8            'DRAW ',F13.7,' 1.05'                 ,/,
        8            'RELOC ',F13.7,' 1.15'                ,/,
C Left top Number
        8            'PUTL 6 \\\\r',A10                    ,/,
        8            'RELOC ',F13.7,'  1.15'               ,/,
C  Middle top Number
        8            'PUTL 5 \\\\r',A10                    ,/,
        8            'RELOC ',F13.7,' 1.15'                ,/,
C  Right top Number
        8            'PUTL 4 \\\\r',A10                    )
                   ELSE
                    P11=P1-.1*(P2-P1)
                    P22=P2+.1*(P2-P1)
                    XMID=0.5*(P22+P11)
                   VMID=2.9979E5*(XMID-WLLINE)/WLLINE
                     V1=2.9979E5*(P11-WLLINE)/WLLINE
                     V2=2.9979E5*(P22-WLLINE)/WLLINE
                     WRITE(20,132)MTERM(ITERM),(MPLOC(I,ITERM),I=1,4),
        1            V1,V2,VMID,YUP
132                  FORMAT(     'TERM ',I2                ,/,
        1            'ERA'                                 ,/,
        1            'EXP 1.'                              ,/,
        1            'LOC ',4(I4,1X)                       ,/,
        2            'LIM ',2(F15.5,1X),' -.1 1.1'         ,/,
        8            'RELOC ',F15.5,1X,F4.2                ,/,
        9            'PUTL 8 \\\\rVelocity (km s\\u-\\u1 )'         ,/,
        2            'BOX -1 -1 +1 -1')
                   ENDIF
                 WRITE(20,133)P11,P22,AUNIT
133              FORMAT(
        4        'LIM ',2(F13.7,1X),' -.1 1.1'    ,/,
        5        'BOX  1  2  -1  0'               ,/,
     6          'YLAB \\\\rTransmittance'                         ,/,
     7          'XLAB ',A35                              ,/,
     8          'DATA parray.dat1'                       ,/,
     9          'YCOL 3'                                 ,/,
     1          'XCOL 2'                                 ,/,
     2          'CONN')
C
C mark strong lines
C
        IF(IPOINT.GE.1)WRITE(20,155)
155     FORMAT('EXP 0.3',/,'PTY 10 3 ')
        DO I=1,IPOINT
        IF(IPTYPE.EQ.1)SLINES(I)=10000./SLINES(I)
        WRITE(20,156)SLINES(I),SLINES(I)
156     FORMAT('RELOC ',F13.7,' -0.02'/,'DRAW ',F13.7,' -.1')
                DO J=1,3
                  IF (IDOTS(J,ISPEC(I)).EQ.1)THEN
                    WRITE(20,157)SLINES(I),DOTLOC(J)
157                 FORMAT('RELOC ',F13.7,' ',F6.3,/,'DOT')
                  ENDIF
                ENDDO
        ENDDO
                CALL KEY(P11,P22)
                ELSE
c       PRINT*,
C       1' IPTYPE, IPLTCNT, P11, P22 ',IPTYPE,PNAME(IPLTCNT),P11,P22
        WRITE(20,134)(MPLOC(I,ITERM),I=1,4),P11,P22,PNAME(IPLTCNT)
134     FORMAT(
     1          'LOC ',4(I4,1X)                         ,/,
     2          'LIM ',2(F13.7,1X),' -.1 1.1'           ,/,
     8          'DATA ',A11                             ,/,
     9          'YCOL 3'                                ,/,
     1          'XCOL 2'                                ,/,
     2          'CONN')
        ENDIF
        RETURN
C
        END
        SUBROUTINE KEY(P11,P22)
C**************************************************
C Writes a key on the right side of the plot
C**************************************************
        INTEGER MTERM(4),MKLOC(4,4),MPLOC(4,4),IDOTS(3,7)
        REAL POSY(20),DOTLOC(3),KEYLOC(7)
        CHARACTER COMMT*20, LAB(17)*20,TYPES(4)*15,TYPEI*15,
     1   FNS(5)*10,FNI*15,DATER*24,LINENAM(7)*5,DATERI(24)*1,DATERF*30
        COMMON /PART/PARTS(2:7),CDOZ,IDISTO3
        COMMON /TERM/ITERM
        COMMON /STRONG/SLINES(80),ISPEC(80),SEW(80),ISTRONG
     1    ,IPOINT,STRENGTH
        COMMON /ATMJNK/AWV,AZ,AWVL,IATYPE,IALAY,IALT,TORR
        COMMON /PVECT/ P1,P2,PD,NP,NINST,IPLTCNT
        COMMON /RANGE/WL1I,WL2I,DWLI,WNEXT1,WNEXT2,WNR1,WNR2,WLEXT1
     1  , WLEXT2,WLLINE,IZSKIP
        DATA MTERM/3,11,7,14/,MPLOC/100,750,100,700,  40,375,60,350,
     1   48,453,78,379, 40,375,40,350/
        DATA DOTLOC/11.7,12,12.3/,UP/12.5/,DOWN/11.5/,YLET/10.9/
        DATA IDOTS/0,0,1, 0,1,0, 0,1,1, 1,0,0, 1,0,1, 1,1,0, 1,1,1/
        DATA LINENAM
        1 /'H\\d2O','CO\\d2','O\\d3','N\\d2O','CO','CH\\d4',' O\\d2'/
        DATA KEYLOC/.1,.4,.7,1.0,1.3,1.6,1.9/
        DATA MKLOC/760,1000,100,760,   380,600,50,375,
     1   459,604,99,452, 380,500,10,375/

        DATA TYPES/'Standard','Tank','Special','Std.&H\\d2O Adj.'/
        DATA FNS/'Triangle','Gaussian','Sinc','Rectangle','None'/
        DATA POSY/20,18,17,16,15,14,13,10,9,8,7,6,5,4,3,5*0/
        DATA LAB/' ','Zenith WV','Zenith Ang','L.O.S. WV',
     1   'Atm. Type','Layers','Altitude','Lambda 1','Lambda 2',
     2   'Sampling','Res(FWHM)  ','Instr. Fn.','Line Ctr','Num. Pts.',
     3   'Ozone','Time','P(mm Hg)'/
        PRINT 11
11      FORMAT(' Comment for plot (A20)',
     1   ' (you may use mongo ''\\u'', etc.)(Test): ')
        READ 12,COMMT
12      FORMAT(A20)
        PRINT 121,COMMT
121     FORMAT('{',A20,'}')
        CALL FDATE(DATER)
        WRITE(DATERF,1212)DATER
1212    FORMAT(A24)
        READ(DATERF,1213)DATERI
1213    FORMAT(24A1)
C               IF((DATERI(5).eq.'A'.or.DATERI(5).eq.'M').and.
C       1          (DATERI(6).eq.'p'.or.DATERI(6).eq.'a').and.
C       2          (DATERI(7).eq.'r'.or.DATERI(7).eq.'y').and.
C       3       DATERI(24).eq.'2')then
C               PRINT*,' '
C               ELSE
C               PRINT*,' Sorry, software has expired.'
C               STOP
C               ENDIF

        CALL TIME(TIMER)
        TYPEI=TYPES(IATYPE+1)
        FNI=FNS(NINST)

        WRITE (20,20)(MKLOC(I,ITERM),I=1,4)

20      FORMAT( 'LOC ',4(I4,1X)                    ,/,
     1          'LIMIT 0 2 0 22'                   ,/,
     2          'EXP .8'        )
        DO I=1,15
                  WRITE(20,30)POSY(I),LAB(I)
30                FORMAT('RELOC 0 ',F4.1,/,'PUTL 6 \\\\r',A15)
        ENDDO
        WRITE(20,40)
     1   POSY(1),COMMT,    POSY(2),AWV,   POSY(3),AZ,      POSY(4),AWVL,
     2   POSY(5),TYPEI,   POSY(6),IALAY,POSY(7),IALT,    POSY(8),P1,
     3   POSY(9),P2,      POSY(10),PD,   POSY(11),DWLI,   POSY(12),FNI,
     4   POSY(13),WLLINE,POSY(14),NP,POSY(15),CDOZ

 40     FORMAT(
C  COMMT
     1   'RELOC 0 ',F4.1,/,'PUTL 6 \\\\r',A20    ,/,
C  AWV
     2   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F8.1   ,/,
C  AZ
     3   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F5.1   ,/,
C  AWVL
     4   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F8.1   ,/,
C  TYPEI
     5   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',A15    ,/,
C  IALAY
     6   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',I3     ,/,
C  IALT
     7   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',I5     ,/,
C  P1
     8   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F9.3   ,/,
C  P2
     9   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F9.3   ,/,
C  PD
     9   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F9.6   ,/,
C  NP
     1   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F9.6   ,/,
C  FNI
     2   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',A9     ,/,
C  WLLINE
     3   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F9.3   ,/,
C  NP
     4   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',I7     ,/,
C  OZONE
     5   'RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',1PE8.2)


C TIME and date
        WRITE(20,898)DATER
898     FORMAT('RELOC -1 -3',/,'PUTL 6 \\\\r ',A24)
C
C Write Line Key, after determining if line was seen.
C
          IF(IATYPE.NE.1.AND.IPOINT.GT.0)THEN
            WRITE(20,*)'PTYPE 10 3'
            ILI=0
              DO 2000 I=1,7
                  DO J=1,IPOINT
                    IF(ISPEC(J).EQ.I)GO TO 1000
                  ENDDO
```

```
                GO TO 2000
1000            ILI=ILI+1
                WRITE(20,100)KEYLOC(ILI),UP,KEYLOC(ILI),DOWN
100             FORMAT('RELOC ',F7.3,' ',F7.3,/,'DRAW ',F7.3,' ',F7.3)
                  WRITE(20,*)'EXP .3'
                  DO K=1,3
                      IF(IDOTS(K,I).EQ.1)THEN
                        WRITE(20,200)KEYLOC(ILI),DOTLOC(K)
200                     FORMAT('RELOC ',F7.3,' ',F7.3,/,'DOT')
                      ENDIF
                  ENDDO
                WRITE(20,300)KEYLOC(ILI),YLET,LINENAM(I)
300     FORMAT('EXP .8',/,'RELOC ',F7.3,' ',F7.3,/,'PUTL 5 \\\\r',A5)
2000          CONTINUE
          ELSEIF(IATYPE.EQ.1)THEN
            WRITE(20,50)POSY(17),LAB(17)
50          FORMAT('RELOC 0 ',F4.1,/,'PUTL 6 \\\\r',A15)
            WRITE(20,60)POSY(17),TORR
C  PRESSURE
60          FORMAT('RELOC 1 ',F4.1,/,'PUTL 6 \\\\r',F7.3 )
          ENDIF
        WRITE(20,134)(MPLOC(I,ITERM),I=1,4),P11,P22
134     FORMAT(
     1  'LOC ',4(I4,1X),/,
     2  'LIM ',2(F13.7,1X),' -.1 1.1')
        RETURN
        END
```

APPENDIX B

INSTALLING THE PROGRAMS

Instructions for installing the ATRAN software on UNIX and VMS machines are given. Additionally, three supporting programs are listed. WR.F reads the ASCII HITRAN data base. SKIPA.F determines the number of absorption lines per wave number. GTOLA.F converts MONGO screen display code to hardcopy printing code.

APPENDIX B INSTALLING THE PROGRAMS

Note, this software is already installed on some of the NASA/Ames SS Division computers. If you are using GAL, see STARCAT$DISK:[catalog]HELP_ATMOSPHERE for instructions. If you are using CYGNUS, use /work/doc/atran.doc. The software is also already installed on PAN and CMA.

Installing this software on other UNIX and VMS systems is quite straight forward. It involves 3 steps:

First the user must acquire 6 files: afgl.dat, wr.f, skipa.dat, model.dat, atran.f and laseatran.f. The three programs with the .f extension are UNIX versions. For a VMS system, instead acquire WR.FOR, ATRAN.FOR and LASEATRAN.FOR. Contact the author to acquire these files.

Of these files, only AFGL.DAT is very large. Below is a directory listing. (AFGL.BIN is discussed below.)

```
 BYTES   DATE          FILE      Listed
 ---------------------------------------
 12569616 Aug  5 23:01 afgl.bin
 23044296 Aug  5 21:59 afgl.dat
    29744 Aug  5 21:55 model.dat   App. D
   575000 Aug  5 21:55 skipa.dat
   152660 Aug  5 22:44 wr
     1035 Dec 16 14:58 wr.f
    64127 Dec 16 14:58 atran.f     App. A
     2556 Dec 16 14:59 laseatran.f
```

The second step is to make the database, afgl.bin. To do this, edit the file wr.f. The directory areas in the two OPEN statements must be modified to reflect where afgl.dat is, and where you would like afgl.bin to reside. Select the appropriate directories in wr.f, compile and run it. This routine will generate afgl.bin in a few minutes. (afgl.dat is not used by the software after afgl.bin has been created. The .bin file is about half the size of the .dat file.)

The last step is different for VMS systems and UNIX systems.

For VMS systems:

Before program atran.for may be compiled, one change must be made. Locate the OPEN statement, which opens the AFGL.DAT file (this is the HITRAN database). Modify the directory to correspond to where AFGL.BIN resides on your system. ATRAN.FOR may then be compiled and linked. The other directory areas used by the program are defined as logical symbols. Some of these must be defined by each user. The following gives commands that may be entered into the users login.com file:

```
$!
$! Where ATRAN.EXE, MODEL.DAT, and  SKIPA.DAT reside:
$!
$       DEFINE/NOLOG    ATRANDIR        USER$DISK7:[LORD.WV]
$!      (for example)
$!
$! Next is the user's directory.
$! This is where the newly created MONGO
$! plotting control files are put.
$!
$       DEFINE/NOLOG    ATRANUSERDIR    USER$DISKyours:[yourdir]
$!
$! Next is user's area for the array of up to
$! 20000 ASCII X,Y data points.
$! The program will delete all old versions,
$! so these files normally do not
$! pile-up.
$!
$       DEFINE/NOLOG    ATRANSCRATCHDIR SCRATCH$DISK:[yourdir]
$! (for example)
$!
$! To run ATRAN type "RUN ATRANDIR:Z"
$!
$! ATRAN will make two files: ATRANUSERDIR:P.PLO and
$! ATRANSCRATCH$DISK:PARRAY.DAT
$! P.PLO in turn, will use PARRAY.DAT to make a plot.
$!
```

For UNIX Systems:

Check all occurrences within OPEN statements within atran.f for the files afgl.bin, model.dat, and skipa.dat. Edit these to refer to the particular directory where you wish these files to reside. Then compile atran.f. Users may run the program with their pwd (present working directory) set arbitrarily. The data files parray.dat* and the plot file p.plo will be written into that directory. (All previous versions of p.plo and parray.dat* will first be removed by the program.

This completes the installation notes for UNIX and VMS systems.

Another useful program is laseatran.f (or laseatran.for). It will quickly edit a p.plo file to change the MONGO LOCATION commands and MONGO TERM commands to values appropriate for make a hard copy of the plot.

Finally, if the user ever wishes to go to the source, to the unabridged HITRAN database, we show how this is done at the SS Division at NASA/Ames. HITRAN resides on a tape which may be read off the CRAY-YMP computer. The following procedure is used to select a subset of that tape, and output it in ASCII, to provide a database, as we have done. The database we selected is all occurrences of the 7 species indicated in Table~1. The user is able to select a customized database with the following procedure. One must have a CRAY account to accomplish this.

```
#
# Procedure to read out a portion of the HITRAN database. Written
# By R. Freedman, 1991.
# The procedure accesses accounts on the computer
# columbia, for which passwords are required.
#
# This procedure assumes that you have already created a
# temporary [scratch]
# directory $TMP on your CRAY account. Such a directory holds database
# changes temporarily.
#
cd $TMP
#
# The following version makes line files for FASCODE2.
# It uses the new partition
# functions, the IDs for line lists, and a new binary format.
#
# To transfer the output of the procedure to another computer,
# use ftp.
#
# We assume that user has a .netrc file active on their account.
#
ftp columbia << END
cd /csf/ss/sst/freedman/hitran_91
get ../exe/select_newf2 select.e
get ../binary/hitran_91_new_format h91
#
# We are getting a table of block-line IDs.
#
quit
END
cp /u2/sst/freedman/hitran_91/notes/header_102 102
#
# Finally, the user must run "select.e"
# and answer questions that appear on the screen.
# These questions will pertain to the subset of the HITRAN lines to be
# written into the output file.
#
# REMEMBER that the file name for the database is h91
# - use this name when
# answering the questions.
#
```

```
        PROGRAM WR
C
C This program will read the afgl.dat file and produce the
C afgl.bin file.
C commented lines may be uncommented to check for IEEE violations
C

c       integer oldstatus,fpstatus
        REAL*8 E
        OPEN(1,FILE='afgl.bin',STATUS='NEW',
     1  FORM='UNFORMATTED',IOSTAT=IERRS)
        IF(IERRS.NE.0)GOTO10
        OPEN(2,FILE='afgl.dat',STATUS='OLD')
        I=1
1       READ(2,22,END=20,ERR=11),I,WN0,S0,GAMMA0,E,ISP,XN
22      FORMAT
        1(1X,I7,F13.5,2X,1PE12.6,2X,0PF5.3,2X,0PF10.4,2X,I2,2X,0PF5.3)
        WRITE(1)WN0,S0,GAMMA0,E,ISP,XN
c       oldstatus = fpstatus(0)
c       IF(and(oldstatus,8).ne.0)THEN
c       print*, ' inexact occured'
c       PRINT*,I,WN0,S0,GAMMA0,E,ISP,XN
c       endif
c       IF(and(oldstatus,32).ne.0)then
c       print*, 'underflow occured'
c       PRINT*,I,WN0,S0,GAMMA0,E,ISP,XN
c       endif
        I=I+1
        IF((I/1000)*1000.EQ.I)THEN
          J=I/1000
          PRINT*,J,' K out of 349 K'
C
C Actually, total number of lines from .8 to 100000 microns is 349156
C
          ENDIF
        IF(1.EQ.1)GO TO 1
10      PRINT*,' OPEN ERROR'
        STOP
11      PRINT*,' READ ERROR'
        STOP
20      PRINT*,' Normal end... afgl.bin written'
        end
        PROGRAM SKIPA
C
C This program reads the hitran database (afgl.bin) file, and
C counts how many lines there are per wavenumber. It Outputs this
C information in a file called LISTA.DAT
C
C The current version assumes that the span of wavenumbers in afgl.bin
C runs from 1 to 125000
C
        INTEGER A(12500),B(12500)
        DATA A/12500*0/,B/12500*0/
        REAL*8 E
        OPEN(1,FILE='AFGL.BIN',STATUS='OLD',
        1 RECORDTYPE='FIXED',RECL=7,FORM='UNFORMATTED',
        2 IOSTAT=IERRS)
        OPEN(2,FILE='SKIPA.DAT',STATUS='NEW')
        I=0
1       READ(1,ERR=10,END=20)WN0,S0,GAMMA0,E,ISP,XN
        J=WN0
        A(J)=A(J)+1
        I=I+1
        IF((I/1000)*1000.EQ.I)PRINT*,I
        IF(1.EQ.1)GO TO 1
10      PRINT*,' ERROR'
20      PRINT*,' ENDING, LINE ',I
        B(1)=0
        DO I=2,12500
        B(I)=A(I-1)+B(I-1)
        ENDDO
        DO I=1,12500
        WL=10000./I
        WRITE(2,23)A(I),B(I),I,I+1,WL
23      FORMAT(2X,I7,2X,I7,4X,I5,'-',I5,2X,F10.4)
        ENDDO
        END
        PROGRAM GOTOLA
c
c The purpose of this program is to quickly translate Mongo
c plot files intended for a graphics terminal to a Mongo plot
c file for the laser printer (device imp). THUS: GO to LA(ser).
c
C We do only 5 things to the file :
c
c 1) DEL all occurances of "TER" commands
c 2) DEL all occurances of "ERA" commands (ERASE)
c 3) Start the new .IMP file with "psland
c 4) End   the new .IMP file with "hard"
c 5) Change 1st "LOC ..." to "LOC 80 570 100 500"
c 6) Change 2nd "loc ..." to "loc 585 750 100 560"
c - S. Lord 1-May-1988.
c
        LOGICAL EX
        CHARACTER*3 TROI
        CHARACTER*77 REST
C
C Delete any old p.imp files
C
        INQUIRE(FILE='p.imp',EXIST=EX)
                IF(EX.EQ..TRUE.)THEN
                OPEN(11,FILE='p.imp',STATUS='OLD')
                CLOSE(11,STATUS='DELETE')
                ENDIF
        LOCFLG=0
C
10      CONTINUE
        OPEN(1,FILE='p.plo',STATUS='OLD')
        OPEN(2,FILE='p.imp',STATUS='NEW')
        WRITE(2,111)
111     FORMAT(' psland')
        DO 1100 I=1,3000
        READ(1,33,END=44)TROI,REST
33      FORMAT(A3,A77)
        IF(TROI.EQ.'TER'.OR.TROI.EQ.'ERA'.OR.
        1  TROI.EQ.'ter'.OR.TROI.EQ.'era')GO TO 1100
        IF  (TROI.EQ.'LOC'.OR.TROI.EQ.'loc')THEN
                IF(LOCFLG.NE.1)THEN
                        REST=' 80 570 100 500'
                        ELSE
                        REST=' 585 750 100 560'
                ENDIF
                LOCFLG=LOCFLG+1
        ENDIF
        WRITE(2,33)TROI,REST
1100    CONTINUE
        PRINT*,' A length problem??'
        STOP
44      WRITE(2,45)
```

```
45      FORMAT(’hard’,/,’end’)
        print 46,’P’
46      FORMAT(’... Success! "’,A1,’.IMP"    Created’)
        STOP
20      PRINT*,’ Try again....’
        GO TO 10
        END
```

APPENDIX C

OPERATING INSTRUCTIONS AND SAMPLE RUNS

Example ATRAN runs on UNIX and VMS systems are shown.

Instructions to run the program atran.f and ATRAN.FOR

UNIX instructions: atran.f

We compile atran.f with:

```
f77 -o atran atran.f
```

To run atran, type " /dir/atran "
where dir is the directory path to atran.

The program will ask you your terminal type for plotting. If you are on a HDS, GraphOn, or other Tektronics Emulating Terminal, select Tektronics; menu item 1. If you are on an X terminal, select 2.

After running the program, you may wish to see the plot on the screen. type:

```
mongo
*term 11  (if your are on an X Terminal,
"term 3" if you are on a Tektronix emulator)
*inp p.plo
 (Where mongo has typed the "*" .) Type
*end
to exit MONGO.
```

compile the program laseatran.f:

```
f77 -o laseatran laseatran.f
```

To get a laser hardcopy, type:

```
laseatran
 mongo
* inp p.imp
 (Where mongo has typed the "*" .)  Type
*end
to exit MONGO.
```

VMS instructions (ATRAN.FOR)

ATRAN has been compiled with

```
fortran atran.for
link atran
```

then run atran.exe from any area with

```
r atrandir:atran
```

the program will ask a series of questions, shown in the example below.

To get a plot on a graphics screen type:

```
MONGO
```

```
* inp p.plo
* end
```

Also, compile the program LASEATRAN.FOR:

```
FOR LASEATRAN
LIN LASEATRAN
```

To get a laser hardcopy, type:

```
LASEATRAN
MONGO
* INP P.IMP
```

(Where MONGO has typed the "*" .) Type ^Z to exit MONGO.

The following is a sample run of the program atran on a UNIX machine.
(A run on a VMS system would proceed identically,
except that the initial command would be "r atrandir:atran"
rather than "atran")
Our helpful comments below begin with ">". User input appears after
queries ending with a colon.

```
-------------------------------------------------------------

cygnus/work/lord>atran

> user selects program atran


 Welcome to atmospheric modeling program!

 If you don't know what to answer to a question, try
 the answer given in parentheses.

 Input Terminal type.
 1 for Tektronics, 2 for X window, 3 for Sunview window
 4 for GraphOn (1): 1
{  1}

> user selects a Tek screen for graphics. Note: GraphOn 230's
> support either  Tek or GraphOn graphics type MONGO output
> (term 3 and 11 in 1989  VMS MONGO), HDS terminals support at least
> Tek (term 3) output. So if you have a GraphOn, an HDS, or a
> Tek 4010 etc. emulating terminal, option 1 above may
> be best.

Plot x-axis units in wavelength (um) [1],
or wavenumbers (cm^-1) [2] (1): 1 { 1}

> With option 1, a wavelength scale (in micrometers)
> will appear on the bottom  of the plot, and a velocity
> scale will appear on the top.
> With option 2, a wave number (10000/wavelength)
> scale will appear at the
> bottom and a wavelength scale will appear at the top.
```

```
 Enter:
 0 for a standard atmosphere of mixed gases,
 1 for a single H2O layer (a tank),
 2 for a special atmosphere, or -1 to exit (0): 0
{ 0}

> user selects standard earth atmosphere model,
> the "U.S. Standard Atmosphere"  (Ref. 16)

Enter altitude (feet) (41000): 41000
{    41000.0}

> user selects typical flight altitude of the
> Kuiper Airborne Observatory.

 The atmospheric model gives   7.3 Microns     of water,
toward the zenith.
Enter preferred value at this altitude in MICRONS,
 or 0 for no adjustment of the model (0): 0
{ 0.}

> The program has integrated all the
> water vapor in its model (Ref. 15) above
> the airplane to be 7.3 precipitable microns.
> The user accepts this value.

Number of atmospheric layers (2 recommended)(2): 5
{ 5}

> A 5 layer atmosphere
> (modeling mixing ratio, density, pressure and temperature
> at 5 overhead points), is selected.

Zenith angle through atmosphere (0=UP)(0): 0
{ 0.}

> the user has selected absorption along
> a line of sight directly overhead.

Enter wavelength of spectral line of interest
 (this is used to make the velocity scale), or...,
-1 for species specification,
or else 0 for don't care (0): 0
{ 0.}

> the user does not care
> if the doppler velocity scale for
> the top abscissa
> is centered on a specific rest (v=0) wavelength.
> So, v=0 will be centered at
> the midpoint of the wavelength range, selected next.
```

```
You may enter the limits of the x-axis in either
wavelength or velocity; each unit will be printed.
Enter wavelength range of interest; Lambda 1 and Lambda 2 in microns.
('0 0' for velocities instead) (10 10.1): 13.9 14.1
{    13.9000    14.1000}

> The program will determine the transmission between 13.9 and 14.1
> micrometers. This will be the functions range on the x-axis.
> The plot box boundaries will frame a region slightly (10%) larger.

Enter instrumental resolution in microns
(0 for the CGS high resolution system resolution = 60 km/s),
or -1 for no smoothing. (0): .001
{    1.00000E-03}

> the transmission spectrum will be smoothed by an
> "instrument" point spread function with full width
> at half power = 0.001 micrometers.

 Setting the data point spacing (sampling)
 to 1/5 instrument resolution...
 There will be   1000 points plotted.
 Their spacing will be  0.0002 microns.
Enter a new number of points, or 0 to keep these values, or
-1 to change the spacing (0): 0
{ 0}

> the output file and the plot will record data
> at 1/5 * 0.001 micrometer
> spacing, and over the range, this will
> amount to 1000 points. User accepts this.

 Select instrument profile function:
[1] Triangle, [2] Gaussian, [3] Sinc, [4] Rectangle (2): 2
{ 2}

> the instrument function will be a
> Gaussian. We note that the FWHM of a
> rectangle function equals the FWZP
> of a rectangle - a rectangle function
> has vertical fall-off which preserves
> high frequencies present in the
> unsmoothed transmission spectra.
> The choice of this function can yield
> a more rapidly varying spectrum
> than will the others.

Reading through database to this wavelength regime................

  34125 CONSIDERED,   24 REJECTED
 OF THOSE CONSIDERED.....

      500 out of    34173 lines processed.
 1000 out of    34173 lines processed.
 1500 out of    34173 lines processed.
 2000 out of    34173 lines processed.
 2500 out of    34173 lines processed.
 3000 out of    34173 lines processed.
 3500 out of    34173 lines processed.
 4000 out of    34173 lines processed.
 4500 out of    34173 lines processed.
 5000 out of    34173 lines processed.
 5500 out of    34173 lines processed.
 6000 out of    34173 lines processed.
 6500 out of    34173 lines processed.
 7000 out of    34173 lines processed.
 7500 out of    34173 lines processed.
 8000 out of    34173 lines processed.
 8500 out of    34173 lines processed.
 9000 out of    34173 lines processed.
 9500 out of    34173 lines processed.
10000 out of    34173 lines processed.
10500 out of    34173 lines processed.
11000 out of    34173 lines processed.
11500 out of    34173 lines processed.
12000 out of    34173 lines processed.
12500 out of    34173 lines processed.
13000 out of    34173 lines processed.
13500 out of    34173 lines processed.
14000 out of    34173 lines processed.
14500 out of    34173 lines processed.
15000 out of    34173 lines processed.
15500 out of    34173 lines processed.
16000 out of    34173 lines processed.
16500 out of    34173 lines processed.
17000 out of    34173 lines processed.
17500 out of    34173 lines processed.
18000 out of    34173 lines processed.
18500 out of    34173 lines processed.
19000 out of    34173 lines processed.
19500 out of    34173 lines processed.
20000 out of    34173 lines processed.
20500 out of    34173 lines processed.
21000 out of    34173 lines processed.
21500 out of    34173 lines processed.
22000 out of    34173 lines processed.
22500 out of    34173 lines processed.
23000 out of    34173 lines processed.
23500 out of    34173 lines processed.
24000 out of    34173 lines processed.
24500 out of    34173 lines processed.
25000 out of    34173 lines processed.
25500 out of    34173 lines processed.
26000 out of    34173 lines processed.
26500 out of    34173 lines processed.
27000 out of    34173 lines processed.
```

```
      27500 out of    34173 lines processed.
      28000 out of    34173 lines processed.
      28500 out of    34173 lines processed.
      29000 out of    34173 lines processed.
      29500 out of    34173 lines processed.
      30000 out of    34173 lines processed.
      30500 out of    34173 lines processed.
      31000 out of    34173 lines processed.
      31500 out of    34173 lines processed.
      32000 out of    34173 lines processed.
      32500 out of    34173 lines processed.
      33000 out of    34173 lines processed.
      33500 out of    34173 lines processed.
      34000 out of    34173 lines processed.

> This takes a few minutes.
> The seven species are indexed in the table
> below. The number of line accepted
> and rejected in each layer (abreviated
> LYR is given, along with an explanation
> as to why the line was accepted or
> rejected.
>
> The lines are broken up into 5 categories...
> IWEAK          The line, even at line center is too weak to consider
> IDELIN         delta fn. in range
>               (fn. has FWHP less than .5 FD; is integrated)
> IDELOUT        delta fn. out of range (rejected)
> IWIDEOUT       broad line, out of range, (rejected)
> IWIDEIN        broad line, in range, (integrated)

 OF THOSE CONSIDERED.....
  IWEAK    1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
 Weak line, reject
---------------------------------------------------------------------
 LYR. 1    158  3078  3782    50     0     0     0
 LYR. 2    155  2645  2457    46     0     0     0
 LYR. 3    150  2124   998    41     0     0     0
 LYR. 4    127  1142   196    20     0     0     0
 LYR. 5    131    57     0     4     0     0     0

 IDELIN    1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
Very narrow lines, within range, integrate with triangular approx.
---------------------------------------------------------------------
 LYR. 1      0     0     1     0     0     0     0
 LYR. 2      0     0     4     0     0     0     0
 LYR. 3      0     2     4     0     0     0     0
 LYR. 4      0     2     5     0     0     0     0
 LYR. 5      3    28     0     0     0     0     0

 IDELOUT   1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
 Narrow line out range, reject
--------------------------------------------------------------------
```

```
 LYR. 1      0      0     1     0      0      0      0
 LYR. 2      0      0     4     0      0      0      0
 LYR. 3      0      2     4     0      0      0      0
 LYR. 4      0      2     5     0      0      0      0
 LYR. 5      3     28     0     0      0      0      0

 IWIDEOUT 1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
 Broad line out range, reject
--------------------------------------------------------------------
 LYR. 1    171   9571 14981   152      0      0      0
 LYR. 2    173   9991 16224   156      0      0      0
 LYR. 3    178 10506 17545    162      0      0      0
 LYR. 4    199 11502 18286    183      0      0      0
 LYR. 5    194 12574 18484    199      0      0      0

 IWIDEIN  1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
 Broad line in range, accept
--------------------------------------------------------------------
 LYR. 1      9    842  1315    15      0      0      0
 LYR. 2     10    855  1394    15      0      0      0
 LYR. 3     10    859  1532    14      0      0      0
 LYR. 4     12    845  1592    14      0      0      0
 LYR. 5     10    832  1595    14      0      0      0
 Converting opacity to transmittance...
 Smoothing the Fine array.....
      50 K out of     458 K smoothing operations done.
     100 K out of     458 K smoothing operations done.
     150 K out of     458 K smoothing operations done.
     200 K out of     458 K smoothing operations done.
     250 K out of     458 K smoothing operations done.
     300 K out of     458 K smoothing operations done.
     350 K out of     458 K smoothing operations done.
     400 K out of     458 K smoothing operations done.
     450 K out of     458 K smoothing operations done.
F TRANS, P TRANS:    0.689112   0.691854
 Comment for plot (A20) (you may use mongo '\u', etc.)(Test):
demo
{demo                }

> The transmission of the atmosphere
> is first calculated at very high
> resolution, typically at 0.001
> delta-wavenumber resolution. (recall that
> delta-wavelength=delta-wavenumber
> x wavelength^2/10000, with units of
> microns and cm^-1.) The number of
> operations (mults and adds) necessary for
> smoothing equals the number of resolution
> elements (each .001 cm-1)
> across the smoothing function times
> the number of points in the final plot
> (1000 here). There are about 450 resolution
> elements across a .001 micrometer
> FWHM Gaussian instrumental function
> here, so about 1/2 million multiplies
> must be  done. Decreasing the number
> of points to plot, or the resolution,
> each decreases the number of smoothing
> operations linearly.


F TRANS, P TRANS:   0.6967122      0.7027934

> these quantities are the average atmospheric transition
> before and after smoothing

Comment for plot (A20) (you may use mongo '\u', etc.)(Test): demo

> There is a comment line in the plot. The comment here is "demo"

Another function on this plot (Y or N) (N): n
 p.plo, a MONGO control file has been made.
 parray.dat1, the output data has been written.

> the x,y data pairs (wavelength, transmission)
> have been written to a
> parray.dat1. A mongo style plotting file has been written to
> the users area, and is called p.plo

mongo              ! (This is LICKMONGO)
* input p.plo

> this will produce a plot on the screen shown in figure C1

> to get a hard copy, follow this example...

cygnus/work/lord> laseatran
... Success! "P.IMP"    Created
cygnus/work/lord> mongo
 * inp p.imp
using paper size letter
  -17 vectors plotted.
 * end
```

For users wishing to automate the running of this program, we list below the input.

```
*********************************************************************
************              Input Alone             ******************
*********************************************************************

1               ! Tektronics terminal
1               ! wavelength is on the x-axis
0               ! a standard atmosphere
41000           ! altitude in feet
0               ! use model overhead water vapor
1               ! number of layers
```

```
0                 ! zenith angle
0                 ! wavelength of velocity=0
13.9 14.1         ! the range of the x-axis
.001              ! resolution in microns
0                 ! use default plot spacing
2                 ! select Gaussian function
demo\\e           ! plot label, \\e is end of string
no                ! no more plots on this axis
-------------------------------------------------------------------
```

Next we list a run that uses some of the other features of the program...

```
cygnus/work/lord> atran

 Welcome to EXPERIMENTAL atmospheric modeling program!

 If you don't know what to answer to a question, try
 the answer given in parentheses.

 Input Terminal type.
 1 for Tektronics, 2 for X window, 3 for Sunview window
 4 for GraphOn (1): 1
{ 1}

Plot x-axis units in wavelength (um) [1],
or wavenumbers (cm^-1) [2] (1): 2
{ 2}

> user selects wavenumbers for bottom x-axis,
top x-axis will be wavelength

 Enter:
 0 for a standard atmosphere of mixed gases,
 1 for a single H2O layer (a tank),
 2 for a special atmosphere, or -1 to exit (0): 2
{ 2}

> by answering with option 2 here, the user may adjust the quantity of
> gases (other than H2O) in the atmosphere

Molecule:  CO2    O3(tot/cm2)  N2O   CO     CH4    O2
Index:      2      3            4     5      6      7
PPM:      330.    9.13E+18     0.28  0.075  1.6   2.1E+05
 Enter 0 to continue or the gas index number to
change the ppm of that gas: 3
{ 3.}

> user will modify ozone content

 Ozone layer has total column density of   9.1299999E+18
 (this is looking through the entire atmosphere)
 (in molecules per cm^2). New value (use a negative
 number to input in Dobson units):
```

```
1.3e19
{     1.30000E+19}

> there will be a little more ozone than the standard model

Molecule:  CO2    O3(tot/cm2)  N2O   CO     CH4     O2
Index:       2      3            4      5      6       7
PPM:      330.    1.30E+19     0.28  0.075  1.6   2.1E+05
 Enter 0 to continue or the gas index number
to change the ppm of that gas: 0
{ 0}

> user is happy with other gas parts per million (ppm).

Enter altitude (feet) (41000): 13500
{   13500.0}

> user has selected an altitude characteristic of
> a mountain top observatory.

 The atmospheric model gives   3.5 Millimeters of water,
toward the zenith.
Enter preferred value at this altitude in MICRONS,
 or 0 for no adjustment of the model (0): 2000
{   2000.00}

> user has forced the overhead water vapor to be 2 mm.

Number of atmospheric layers (2 recommended)(2): 1
{ 1}

> a single layer atmosphere will
> provide the model. The calculations will
> be rapid, although the line shapes may
> be slightly broader than in the
> more accurate multi-layer runs.

Zenith angle through atmosphere (0=UP)(0): 45
{    45.0000}

> The source will be at an angle 45 deg. from
> the zenith, so we will
> look through root 2 airmasses, increasing
> the column density of all gases
> by this amount.

Enter wavelength of spectral line of interest
 (this is used to make the velocity scale), or...,
-1 for species specification,
or else 0 for don't care (0): -1
{   -1.00000}

> user has chosen to select a spectral line from the internal list
```

```
Enter species, eg. OI,
(enter 'NO' to get out, enter 'LI' to print the list) (NO): LI
{LI  }

> user has asked to see the list

SIII  at wavelength  18.71300
SIII2 at wavelength  33.48000
OIII  at wavelength  51.81500
OIII2 at wavelength  88.35600
OI    at wavelength  63.18372
OI2   at wavelength 145.52548
CII   at wavelength 157.74100
NIII  at wavelength  57.33000
SiII  at wavelength  34.81400
NeIII at wavelength  36.01000
NII   at wavelength 121.89700
SI    at wavelength  25.24900
FeII  at wavelength  25.98820
OIV   at wavelength  25.87000
NeV   at wavelength  24.28000
FeIII at wavelength  22.93000
Enter species, eg. OI,
(enter 'NO' to get out, enter 'LI' to print the list) (NO): SIII
{SIII }

> user picks Sulfur++

SIII  Wavelength =  18.7130
You may enter the limits of the x-axis in either
wavelength or velocity; each unit will be printed.
Enter wavelength range of interest; Lambda 1 and Lambda 2 in microns.
('0 0' for velocities instead) (10 10.1): 0 0
{0 0 }

> user chooses to specify wavelength
> range using velocities from line center.
> Note, wavenumbers could have been
> entered, by using negative numbers here.
> if the user had answered -530,-540, the
> plot range would be from
> 530 cm-1 to 540 cm-1.

Enter beginning and ending velocity (km/s)
for plot (-1000 1000): -3000 3000
{  -3000.00    3000.00}
> the velocity range will run
> from -3000 km/s to +3000 km/s around the rest
> wavelength.
{  0.}

The wavelength range is then  18.52574  18.90026
```

```
Enter instrumental resolution in microns
(0 for the CGS high resolution system resolution = 60 km/s),
or -1 for no smoothing. (0): 0
{ 0.}

> the resolution is set to 60 km/s  (about .0035 microns)

 Setting the data point spacing
> (sampling) to 1/5 instrument resolution...
 There will be    500 points plotted.
 Their spacing will be  0.0007 microns.
Enter a new number of points, or 0 to keep these values, or
-1 to change the spacing (0): 300
{ 300}

> user has chosen to have fewer points plotted.
> There will be 3 points per
> FWHP of the instrument function plotted.

 Select instrument profile function:
[1] Triangle, [2] Gaussian, [3] Sinc, [4] Rectangle (2): 4
{ 4}

> the instrument function is rectangular

Reading through database to this wavelength regime.............

       500 out of    40581 lines processed.
      1000 out of    40581 lines processed.
      1500 out of    40581 lines processed.
      2000 out of    40581 lines processed.
      2500 out of    40581 lines processed.
      3000 out of    40581 lines processed.
      3500 out of    40581 lines processed.
      4000 out of    40581 lines processed.
      4500 out of    40581 lines processed.
      5000 out of    40581 lines processed.
      5500 out of    40581 lines processed.
      6000 out of    40581 lines processed.
      6500 out of    40581 lines processed.
      7000 out of    40581 lines processed.
      7500 out of    40581 lines processed.
      8000 out of    40581 lines processed.
      8500 out of    40581 lines processed.
      9000 out of    40581 lines processed.
      9500 out of    40581 lines processed.
     10000 out of    40581 lines processed.
     10500 out of    40581 lines processed.
     11000 out of    40581 lines processed.
     11500 out of    40581 lines processed.
     12000 out of    40581 lines processed.
     12500 out of    40581 lines processed.
     13000 out of    40581 lines processed.
```

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37500 out of    40581 lines processed.
38000 out of    40581 lines processed.
38500 out of    40581 lines processed.
39000 out of    40581 lines processed.
39500 out of    40581 lines processed.
```

```
    40000 out of    40581 lines processed.
   40354 CONSIDERED,    32 REJECTED
  OF THOSE CONSIDERED.....

  IWEAK    1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
  Weak line, reject
 --------------------------------------------------------------------
  LYR. 1    94  1584   367   204      0   572     0

  IDELOUT 1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
  Narrow line in range, accept
 --------------------------------------------------------------------
  LYR. 1     1     2   182     0      0     0     0

  IDELOUT  1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
  Narrow line out range, reject
 --------------------------------------------------------------------
  LYR. 1     1     2   182     0      0     0     0

  IWIDEOUT 1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
  Broad line out range, reject
 --------------------------------------------------------------------
  LYR. 1  1201 14971 18773  1990      0     0     0

  IWIDEIN  1(H2O)2(CO2)3(O3) 4(N2O) 5(CO) 6(CH4)7(O2)
  Broad line in range, accept
 --------------------------------------------------------------------
  LYR. 1    99   302     0    12      0     0     0
  Converting opacity to transmittance...
  Smoothing the Fine array.....
 F TRANS, P TRANS:    0.792826   0.790070
  Comment for plot (A20) (you may use mongo '\u', etc.)(Test):
 demo2
 {demo2                 }
  Another function on this plot (Y or N) (N): y
 {y}

 > the user has selected to display
 > another transmission function on this plot.
 > we skip the identical dialog that
 > transpires, and show just the places
 > where the users response differed.

  Ozone layer has total column density of   1.3000000E+19
  (this is looking through the entire atmosphere)
  (in molecules per cm^2). New value (use a negative
  number to input in Dobson units):
 .5e18
 { .5000E18 }

  That's VERY little O3! Typical min is 6.86E18/cm^3
  which is    263.8462     Dobson units
 Molecule:  CO2    O3(tot/cm2)  N2O   CO    CH4    O2
```

```
Index:      2      3            4      5      6      7
PPM:     330.     5.00E+17     0.28  0.075  1.6   2.1E+05
 Enter 0 to continue or the gas
index number to change the ppm of that gas: 0
{0 }

Enter altitude (feet) (41000): 13500
{ 13500}

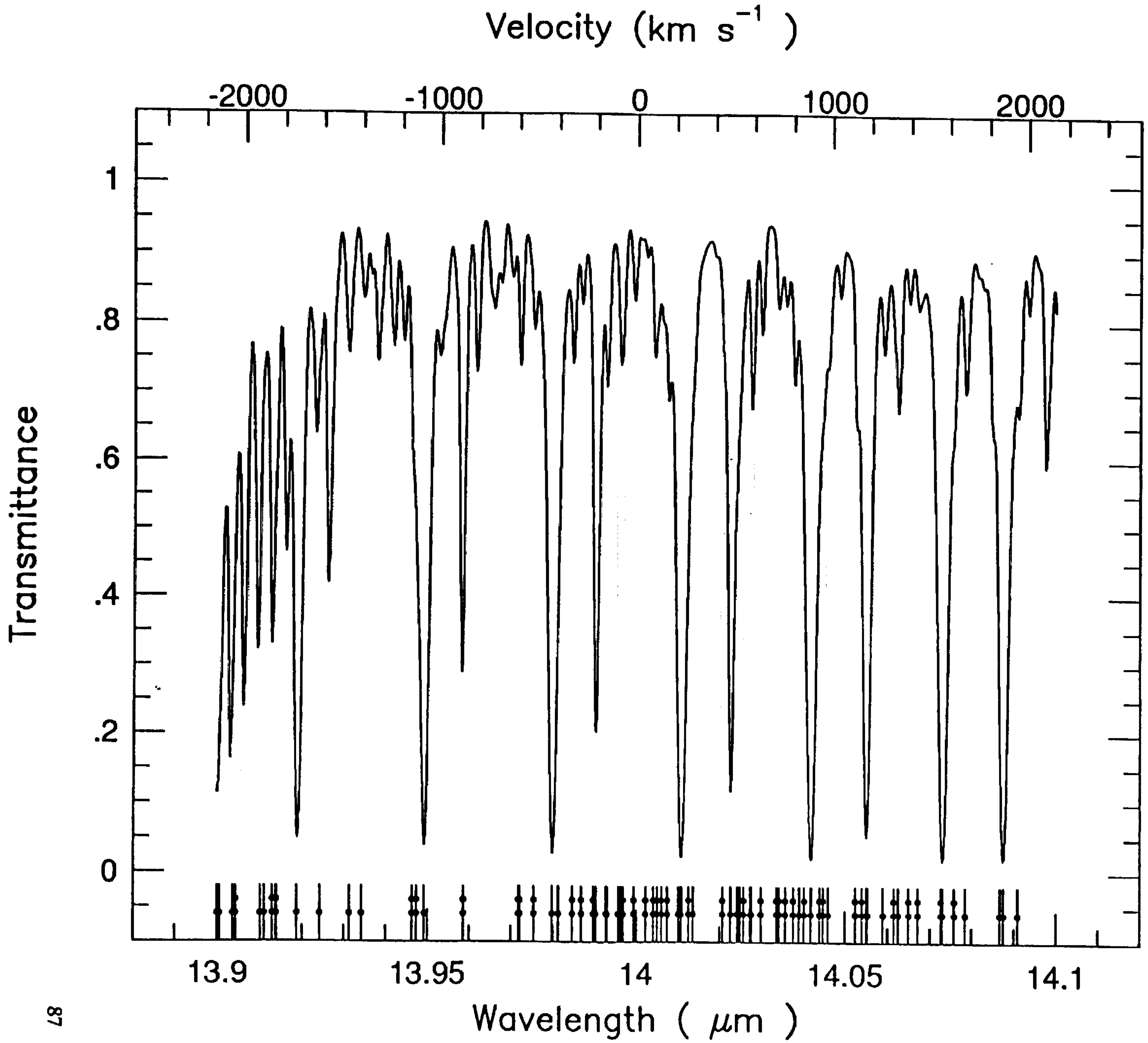
 The atmospheric model gives   3.5 Millimeters of water,
toward the zenith.
Enter preferred value at this altitude in MICRONS,
 or 0 for no adjustment of the model (0): 1000

> this second function will have only 1mm H2O and also less ozone
..... (some dialog skipped)

F TRANS, P TRANS:    0.854487   0.852218
Another function on this plot (Y or N) (N): N
 P.PLO, a MONGO control file has been made.
 PARRAY.DAT, the output data has been written.
mongo
* term 3
* input p.plo
```

This will yield a plot like the one shown in Figure C2.

```
--------------------------------------------------
to make a hard copy
/work/lord/laseatran
then start mongo again....
mongo
* input p.imp
* end
and you will get a hardcopy.
```



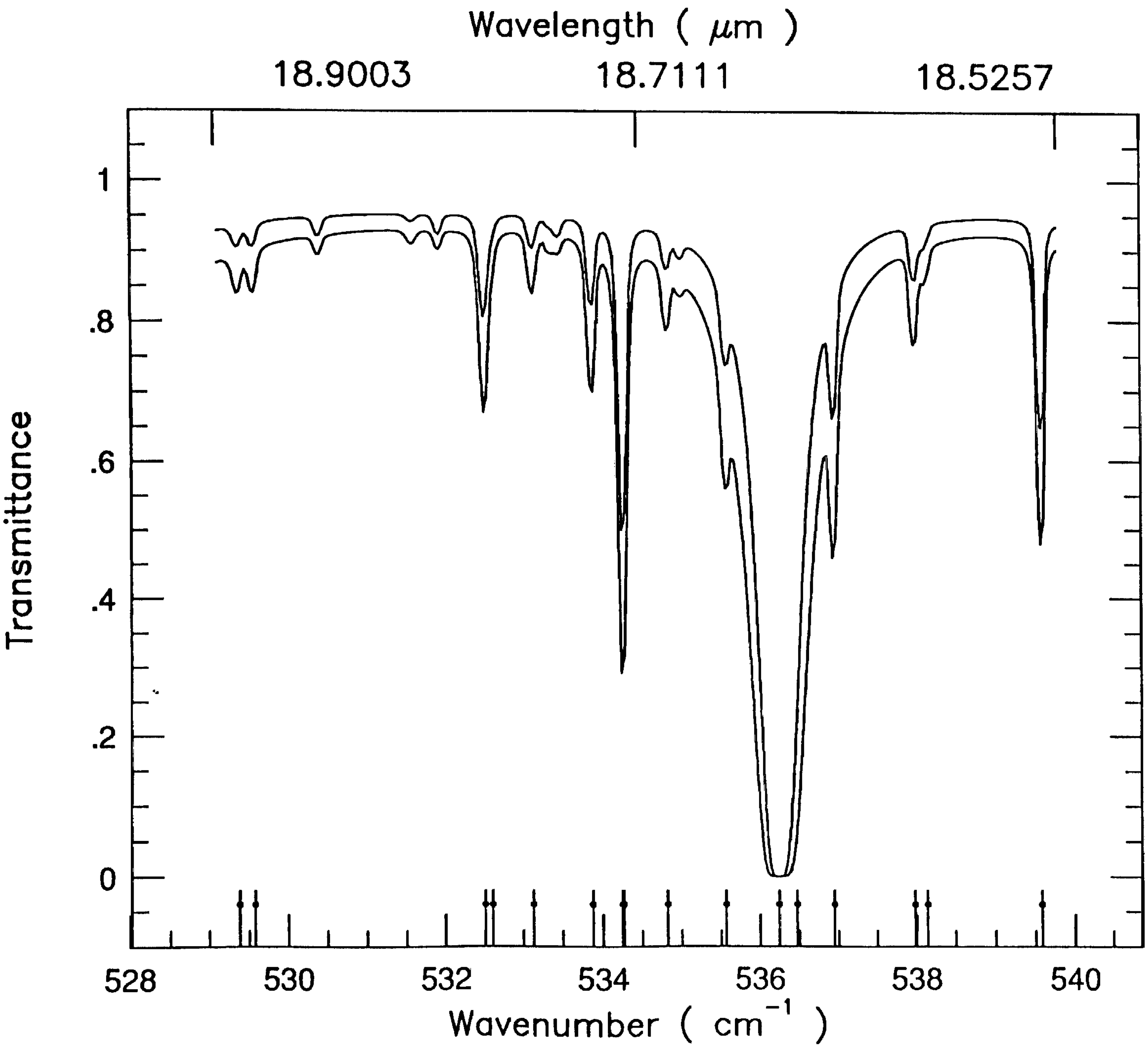
demo figure C1

Zenith WV	7.3
Zenith Ang	0.0
L.O.S. WV	7.3
Atm. Type	Standard
Layers	5
Altitude	41000

CO_2 O_3

Lambda 1	13.900
Lambda 2	14.100
Sampling	0.000200
Res(FWHM)	0.001000
Instr. Fn.	Gaussian
Line Ctr	14.000
Num. Pts.	1000
Ozone	9.13E+18

Thu Dec 19 13:54:05 1991



demo figure C2

Zenith WV	2000.0
Zenith Ang	45.0
L.O.S. WV	2828.4
Atm. Type	Special
Layers	1
Altitude	13500

H_2O

Lambda 1	529.093
Lambda 2	539.790
Sampling	0.001248
Res(FWHM)	0.003743
Instr. Fn.	Rectangle
Line Ctr	18.713
Num. Pts.	300
Ozone	1.30E+19

Thu Dec 19 14:08:52 1991

APPENDIX D

MODEL ATMOSPHERE TABLE

The standard atmosphere model is given showing pressure, temperature, and column density as a function of altitude. The median pressure and temperature overhead is also given, and four ozone profiles for different latitudes.

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H2O	MIX GAS	H2O	MIX	H2O	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)		03	(MOL/CM^2)	
0.0	288.2	1.0000	7.410E22	2.148E25	280.6	252.6	.8692	.5000	6.8581E18	8.4126E18	1.0325E19	1.2119E19
0.1	287.5	0.9881	6.705E22	2.123E25	279.8	252.0	.8561	.4941	6.8539E18	8.4054E18	1.0316E19	1.2111E19
0.2	286.9	0.9764	6.341E22	2.098E25	279.3	251.4	.8489	.4882	6.8497E18	8.3983E18	1.0308E19	1.2104E19
0.3	286.2	0.9645	6.055E22	2.072E25	278.9	250.8	.8430	.4822	6.8456E18	8.3914E18	1.0299E19	1.2097E19
0.4	285.6	0.9535	5.777E22	2.049E25	278.6	250.3	.8372	.4767	6.8414E18	8.3845E18	1.0290E19	1.2090E19
0.5	284.9	0.9415	5.473E22	2.023E25	278.2	249.7	.8307	.4708	6.8373E18	8.3778E18	1.0281E19	1.2083E19
0.6	284.3	0.9308	5.201E22	2.000E25	277.7	249.1	.8240	.4654	6.8332E18	8.3712E18	1.0272E19	1.2076E19
0.7	283.6	0.9194	4.926E22	1.975E25	277.0	248.5	.8133	.4597	6.8291E18	8.3647E18	1.0264E19	1.2069E19
0.8	282.9	0.9084	4.666E22	1.952E25	275.6	248.0	.7906	.4542	6.8251E18	8.3584E18	1.0255E19	1.2062E19
0.9	282.3	0.8978	4.400E22	1.929E25	272.8	247.4	.7497	.4489	6.8210E18	8.3521E18	1.0247E19	1.2055E19
1.0	281.7	0.8872	4.152E22	1.906E25	271.7	246.9	.7342	.4436	6.8170E18	8.3460E18	1.0238E19	1.2048E19
1.1	281.0	0.8765	3.898E22	1.884E25	270.5	246.3	.7176	.4383	6.8130E18	8.3400E18	1.0230E19	1.2041E19
1.2	280.4	0.8660	3.617E22	1.861E25	268.7	245.7	.6928	.4330	6.8090E18	8.3340E18	1.0221E19	1.2034E19
1.3	279.7	0.8553	3.332E22	1.838E25	266.5	245.2	.6634	.4277	6.8050E18	8.3281E18	1.0213E19	1.2027E19
1.4	279.0	0.8443	3.059E22	1.815E25	265.1	244.5	.6454	.4222	6.8011E18	8.3223E18	1.0205E19	1.2021E19
1.5	278.4	0.8344	2.824E22	1.793E25	263.9	244.0	.6299	.4172	6.7971E18	8.3165E18	1.0197E19	1.2014E19
1.6	277.8	0.8242	2.605E22	1.771E25	262.6	243.4	.6157	.4121	6.7932E18	8.3107E18	1.0189E19	1.2007E19
1.7	277.1	0.8138	2.468E22	1.749E25	262.1	242.8	.6074	.4069	6.7892E18	8.3050E18	1.0180E19	1.2001E19
1.8	276.5	0.8043	2.402E22	1.729E25	261.7	242.3	.6032	.4021	6.7853E18	8.2994E18	1.0172E19	1.1994E19
1.9	275.8	0.7945	2.352E22	1.708E25	261.4	241.7	.5998	.3972	6.7814E18	8.2938E18	1.0164E19	1.1988E19
2.0	275.2	0.7846	2.307E22	1.687E25	261.2	241.2	.5967	.3923	6.7775E18	8.2882E18	1.0156E19	1.1981E19
2.1	274.5	0.7747	2.271E22	1.665E25	261.0	240.6	.5943	.3874	6.7736E18	8.2827E18	1.0149E19	1.1975E19
2.2	273.8	0.7649	2.236E22	1.644E25	260.8	240.0	.5919	.3824	6.7697E18	8.2773E18	1.0141E19	1.1968E19
2.3	273.2	0.7556	2.212E22	1.624E25	260.7	239.4	.5903	.3778	6.7659E18	8.2719E18	1.0133E19	1.1962E19
2.4	272.6	0.7464	2.188E22	1.605E25	260.5	238.9	.5887	.3732	6.7622E18	8.2665E18	1.0125E19	1.1956E19
2.5	271.9	0.7372	2.110E22	1.585E25	260.1	238.3	.5836	.3686	6.7586E18	8.2612E18	1.0118E19	1.1949E19
2.6	271.3	0.7280	2.012E22	1.565E25	259.6	237.7	.5774	.3640	6.7550E18	8.2560E18	1.0110E19	1.1943E19
2.7	270.6	0.7187	1.954E22	1.545E25	259.2	237.2	.5736	.3594	6.7514E18	8.2508E18	1.0103E19	1.1937E19
2.8	269.9	0.7095	1.907E22	1.526E25	258.9	236.6	.5703	.3548	6.7479E18	8.2456E18	1.0095E19	1.1931E19
2.9	269.3	0.7008	1.854E22	1.507E25	258.6	236.0	.5664	.3504	6.7445E18	8.2405E18	1.0088E19	1.1925E19
3.0	268.7	0.6922	1.806E22	1.488E25	258.3	235.5	.5627	.3461	6.7412E18	8.2355E18	1.0081E19	1.1919E19
3.1	268.0	0.6836	1.762E22	1.470E25	258.0	234.9	.5594	.3418	6.7379E18	8.2305E18	1.0074E19	1.1912E19
3.2	267.4	0.6749	1.723E22	1.451E25	257.7	234.4	.5564	.3375	6.7346E18	8.2255E18	1.0067E19	1.1906E19
3.3	266.7	0.6663	1.682E22	1.433E25	257.5	233.8	.5535	.3331	6.7313E18	8.2206E18	1.0060E19	1.1900E19
3.4	266.1	0.6577	1.628E22	1.414E25	257.2	233.2	.5498	.3288	6.7281E18	8.2158E18	1.0053E19	1.1894E19
3.5	265.4	0.6491	1.560E22	1.396E25	256.8	232.6	.5454	.3245	6.7249E18	8.2110E18	1.0046E19	1.1888E19
3.6	264.7	0.6405	1.491E22	1.378E25	256.4	232.0	.5412	.3203	6.7217E18	8.2062E18	1.0039E19	1.1882E19
3.7	264.1	0.6325	1.431E22	1.360E25	256.0	231.5	.5376	.3162	6.7185E18	8.2015E18	1.0032E19	1.1876E19
3.8	263.5	0.6244	1.372E22	1.343E25	255.7	230.9	.5340	.3122	6.7153E18	8.1969E18	1.0025E19	1.1870E19
3.9	262.8	0.6163	1.307E22	1.326E25	255.4	230.3	.5301	.3082	6.7122E18	8.1923E18	1.0018E19	1.1864E19
4.0	262.1	0.6083	1.241E22	1.308E25	255.0	229.8	.5260	.3041	6.7091E18	8.1877E18	1.0011E19	1.1858E19
4.1	261.5	0.6003	1.180E22	1.291E25	254.7	229.2	.5223	.3001	6.7060E18	8.1832E18	1.0005E19	1.1852E19
4.2	260.9	0.5929	1.125E22	1.275E25	254.3	228.6	.5190	.2964	6.7029E18	8.1788E18	9.9978E18	1.1846E19
4.3	260.2	0.5852	1.067E22	1.259E25	254.0	228.1	.5154	.2926	6.6998E18	8.1744E18	9.9910E18	1.1840E19
4.4	259.6	0.5774	1.006E22	1.242E25	253.7	227.5	.5116	.2887	6.6968E18	8.1700E18	9.9843E18	1.1834E19

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H2O	MIX GAS	H2O	MIX	H2O	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)	03 (MOL/CM^2)			
4.5	258.9	0.5696	9.489E21	1.225E25	253.3	226.9	.5083	.2848	6.6938E18	8.1656E18	9.9775E18	1.1828E19
4.6	258.3	0.5622	8.997E21	1.209E25	253.0	226.4	.5048	.2811	6.6908E18	8.1613E18	9.9707E18	1.1822E19
4.7	257.6	0.5552	8.529E21	1.194E25	252.7	225.8	.5016	.2776	6.6878E18	8.1571E18	9.9640E18	1.1816E19
4.8	257.0	0.5480	7.999E21	1.179E25	252.3	225.3	.4973	.2740	6.6848E18	8.1529E18	9.9573E18	1.1810E19
4.9	256.3	0.5406	7.406E21	1.163E25	251.7	224.7	.4910	.2703	6.6819E18	8.1487E18	9.9506E18	1.1804E19
5.0	255.7	0.5336	6.824E21	1.148E25	250.9	224.1	.4832	.2668	6.6790E18	8.1445E18	9.9438E18	1.1798E19
5.1	255.1	0.5266	6.248E21	1.133E25	250.1	223.6	.4747	.2633	6.6761E18	8.1404E18	9.9371E18	1.1792E19
5.2	254.4	0.5195	5.667E21	1.118E25	249.1	222.8	.4649	.2597	6.6732E18	8.1364E18	9.9304E18	1.1786E19
5.3	253.7	0.5124	5.093E21	1.103E25	248.1	221.9	.4549	.2562	6.6703E18	8.1323E18	9.9237E18	1.1780E19
5.4	253.1	0.5054	4.542E21	1.088E25	247.2	221.1	.4471	.2527	6.6675E18	8.1283E18	9.9170E18	1.1774E19
5.5	252.4	0.4986	4.076E21	1.073E25	246.6	220.4	.4407	.2493	6.6647E18	8.1242E18	9.9102E18	1.1768E19
5.6	251.8	0.4918	3.738E21	1.058E25	246.0	219.7	.4355	.2459	6.6619E18	8.1202E18	9.9035E18	1.1762E19
5.7	251.2	0.4855	3.497E21	1.045E25	245.6	219.2	.4318	.2428	6.6591E18	8.1163E18	9.8967E18	1.1756E19
5.8	250.5	0.4791	3.270E21	1.031E25	245.2	218.6	.4284	.2396	6.6563E18	8.1123E18	9.8900E18	1.1750E19
5.9	249.8	0.4724	3.052E21	1.017E25	244.9	218.1	.4252	.2362	6.6536E18	8.1084E18	9.8832E18	1.1744E19
6.0	249.2	0.4661	2.866E21	1.003E25	244.6	217.7	.4222	.2330	6.6509E18	8.1044E18	9.8764E18	1.1738E19
6.1	248.6	0.4599	2.695E21	9.898E24	244.2	217.3	.4191	.2299	6.6482E18	8.1005E18	9.8696E18	1.1731E19
6.2	247.9	0.4534	2.498E21	9.759E24	243.7	217.0	.4144	.2267	6.6455E18	8.0966E18	9.8628E18	1.1725E19
6.3	247.2	0.4470	2.265E21	9.621E24	242.8	216.8	.4024	.2235	6.6429E18	8.0927E18	9.8559E18	1.1719E19
6.4	246.6	0.4411	2.052E21	9.495E24	240.2	216.7	.3842	.2206	6.6403E18	8.0888E18	9.8490E18	1.1713E19
6.5	246.0	0.4352	1.860E21	9.368E24	237.3	216.7	.3601	.2176	6.6378E18	8.0849E18	9.8421E18	1.1706E19
6.6	245.3	0.4292	1.662E21	9.239E24	234.2	216.7	.3364	.2146	6.6353E18	8.0810E18	9.8351E18	1.1699E19
6.7	244.7	0.4231	1.460E21	9.109E24	231.1	216.7	.3133	.2116	6.6328E18	8.0771E18	9.8282E18	1.1693E19
6.8	244.0	0.4171	1.300E21	8.979E24	229.4	216.7	.3014	.2085	6.6304E18	8.0732E18	9.8212E18	1.1686E19
6.9	243.3	0.4114	1.205E21	8.857E24	228.7	216.7	.2969	.2057	6.6280E18	8.0693E18	9.8141E18	1.1679E19
7.0	242.7	0.4057	1.153E21	8.735E24	228.4	216.7	.2945	.2029	6.6257E18	8.0654E18	9.8070E18	1.1672E19
7.1	242.0	0.3999	1.118E21	8.609E24	228.1	216.7	.2928	.1999	6.6234E18	8.0615E18	9.7999E18	1.1665E19
7.2	241.4	0.3941	1.085E21	8.486E24	227.9	216.7	.2912	.1971	6.6211E18	8.0576E18	9.7927E18	1.1658E19
7.3	240.7	0.3886	1.051E21	8.367E24	227.6	216.7	.2895	.1943	6.6188E18	8.0537E18	9.7853E18	1.1650E19
7.4	240.1	0.3833	1.021E21	8.254E24	227.4	216.7	.2880	.1917	6.6165E18	8.0497E18	9.7778E18	1.1642E19
7.5	239.4	0.3778	9.901E20	8.134E24	227.2	216.6	.2864	.1889	6.6143E18	8.0457E18	9.7701E18	1.1634E19
7.6	238.8	0.3727	9.671E20	8.025E24	227.0	216.6	.2852	.1863	6.6120E18	8.0417E18	9.7623E18	1.1626E19
7.7	238.2	0.3674	9.508E20	7.912E24	226.8	216.7	.2843	.1837	6.6098E18	8.0377E18	9.7544E18	1.1618E19
7.8	237.5	0.3618	9.350E20	7.791E24	226.7	216.6	.2835	.1809	6.6075E18	8.0337E18	9.7463E18	1.1609E19
7.9	236.8	0.3568	9.188E20	7.683E24	226.6	216.6	.2827	.1784	6.6053E18	8.0296E18	9.7381E18	1.1600E19
8.0	236.2	0.3520	9.013E20	7.580E24	226.5	216.7	.2818	.1760	6.6031E18	8.0255E18	9.7297E18	1.1591E19
8.1	235.6	0.3468	8.802E20	7.469E24	226.3	216.6	.2808	.1734	6.6009E18	8.0214E18	9.7212E18	1.1581E19
8.2	234.9	0.3417	8.566E20	7.360E24	226.1	216.6	.2796	.1709	6.5987E18	8.0173E18	9.7127E18	1.1571E19
8.3	234.3	0.3368	8.327E20	7.254E24	225.9	216.7	.2784	.1684	6.5965E18	8.0132E18	9.7040E18	1.1560E19
8.4	233.6	0.3319	8.081E20	7.148E24	225.7	216.6	.2772	.1659	6.5944E18	8.0091E18	9.6952E18	1.1547E19
8.5	233.0	0.3270	7.831E20	7.043E24	225.6	216.6	.2759	.1635	6.5922E18	8.0049E18	9.6863E18	1.1534E19
8.6	232.2	0.3223	7.638E20	6.943E24	225.4	216.7	.2749	.1611	6.5901E18	8.0008E18	9.6774E18	1.1520E19
8.7	231.7	0.3176	7.470E20	6.842E24	225.2	216.6	.2741	.1588	6.5879E18	7.9966E18	9.6684E18	1.1505E19
8.8	231.0	0.3131	7.291E20	6.745E24	225.1	216.6	.2731	.1566	6.5858E18	7.9925E18	9.6592E18	1.1489E19
8.9	230.4	0.3085	7.064E20	6.646E24	224.9	216.7	.2720	.1542	6.5837E18	7.9883E18	9.6500E18	1.1472E19

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H20	MIX GAS	H20	MIX	H20	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)		03 (MOL/CM^2)		
9.0	229.7	0.3040	6.744E20	6.549E24	224.6	216.6	.2704	.1520	6.5816E18	7.9841E18	9.6407E18	1.1453E19
9.1	229.1	0.2994	6.292E20	6.450E24	224.3	216.7	.2681	.1497	6.5795E18	7.9799E18	9.6313E18	1.1434E19
9.2	228.4	0.2950	5.818E20	6.355E24	223.9	216.7	.2657	.1475	6.5774E18	7.9756E18	9.6216E18	1.1415E19
9.3	227.8	0.2907	5.374E20	6.263E24	223.5	216.6	.2636	.1453	6.5753E18	7.9713E18	9.6117E18	1.1395E19
9.4	227.1	0.2861	4.922E20	6.164E24	223.1	216.7	.2613	.1431	6.5732E18	7.9669E18	9.6015E18	1.1374E19
9.5	226.5	0.2819	4.511E20	6.074E24	222.6	216.7	.2591	.1409	6.5711E18	7.9624E18	9.5911E18	1.1353E19
9.6	225.8	0.2778	4.105E20	5.987E24	222.1	216.7	.2568	.1389	6.5690E18	7.9578E18	9.5804E18	1.1332E19
9.7	225.2	0.2738	3.710E20	5.900E24	221.4	216.7	.2537	.1369	6.5669E18	7.9532E18	9.5694E18	1.1310E19
9.8	224.5	0.2696	3.298E20	5.810E24	220.5	216.7	.2495	.1348	6.5648E18	7.9485E18	9.5582E18	1.1287E19
9.9	223.9	0.2655	2.886E20	5.722E24	219.7	216.7	.2460	.1328	6.5627E18	7.9438E18	9.5467E18	1.1264E19
10.0	223.2	0.2617	2.498E20	5.639E24	219.1	216.7	.2425	.1309	6.5606E18	7.9389E18	9.5350E18	1.1241E19
10.1	222.2	0.2574	2.091E20	5.547E24	218.5	216.7	.2388	.1287	6.5585E18	7.9340E18	9.5230E18	1.1217E19
10.2	221.3	0.2534	1.839E20	5.462E24	218.1	216.7	.2363	.1267	6.5564E18	7.9291E18	9.5104E18	1.1192E19
10.3	220.5	0.2497	1.659E20	5.382E24	217.9	216.7	.2345	.1248	6.5543E18	7.9242E18	9.4972E18	1.1167E19
10.4	219.7	0.2458	1.431E20	5.298E24	217.5	216.7	.2313	.1229	6.5522E18	7.9192E18	9.4834E18	1.1141E19
10.5	219.0	0.2420	1.224E20	5.217E24	217.1	216.7	.2274	.1210	6.5502E18	7.9142E18	9.4690E18	1.1114E19
10.6	218.4	0.2383	1.018E20	5.136E24	216.7	216.7	.2218	.1191	6.5481E18	7.9092E18	9.4540E18	1.1086E19
10.7	217.9	0.2346	8.345E19	5.056E24	216.7	216.7	.2131	.1173	6.5461E18	7.9042E18	9.4384E18	1.1058E19
10.8	217.5	0.2311	7.074E19	4.981E24	216.7	216.7	.2016	.1155	6.5440E18	7.8992E18	9.4222E18	1.1029E19
10.9	217.1	0.2276	6.168E19	4.905E24	216.7	216.7	.1922	.1138	6.5420E18	7.8941E18	9.4054E18	1.1000E19
11.0	216.8	0.2241	5.464E19	4.830E24	216.6	216.7	.1841	.1120	6.5400E18	7.8890E18	9.3880E18	1.0969E19
11.1	216.7	0.2206	4.892E19	4.755E24	216.7	216.7	.1773	.1103	6.5380E18	7.8839E18	9.3700E18	1.0938E19
11.2	216.7	0.2171	4.472E19	4.680E24	216.6	216.7	.1720	.1085	6.5360E18	7.8788E18	9.3517E18	1.0907E19
11.3	216.7	0.2136	4.202E19	4.605E24	216.7	216.7	.1683	.1068	6.5340E18	7.8735E18	9.3331E18	1.0874E19
11.4	216.7	0.2103	3.997E19	4.533E24	216.7	216.7	.1653	.1051	6.5320E18	7.8681E18	9.3142E18	1.0840E19
11.5	216.7	0.2070	3.810E19	4.462E24	216.6	216.7	.1625	.1035	6.5300E18	7.8626E18	9.2950E18	1.0805E19
11.6	216.7	0.2038	3.648E19	4.394E24	216.7	216.7	.1601	.1019	6.5280E18	7.8571E18	9.2755E18	1.0770E19
11.7	216.7	0.2007	3.492E19	4.327E24	216.6	216.7	.1577	.1003	6.5260E18	7.8515E18	9.2557E18	1.0734E19
11.8	216.7	0.1974	3.328E19	4.257E24	216.6	216.6	.1552	.0987	6.5240E18	7.8457E18	9.2356E18	1.0696E19
11.9	216.7	0.1945	3.186E19	4.194E24	216.7	216.7	.1530	.0972	6.5220E18	7.8399E18	9.2152E18	1.0658E19
12.0	216.7	0.1915	3.053E19	4.130E24	216.6	216.7	.1507	.0957	6.5200E18	7.8340E18	9.1945E18	1.0619E19
12.1	216.6	0.1885	2.922E19	4.065E24	216.7	216.6	.1485	.0943	6.5180E18	7.8280E18	9.1735E18	1.0579E19
12.2	216.6	0.1855	2.792E19	3.999E24	216.7	216.7	.1463	.0927	6.5160E18	7.8219E18	9.1524E18	1.0539E19
12.3	216.7	0.1826	2.672E19	3.938E24	216.6	216.7	.1440	.0913	6.5140E18	7.8158E18	9.1312E18	1.0498E19
12.4	216.6	0.1797	2.549E19	3.876E24	216.7	216.6	.1414	.0899	6.5120E18	7.8096E18	9.1099E18	1.0457E19
12.5	216.7	0.1768	2.427E19	3.813E24	216.7	216.6	.1386	.0884	6.5100E18	7.8033E18	9.0885E18	1.0415E19
12.6	216.7	0.1741	2.317E19	3.754E24	216.7	216.7	.1359	.0870	6.5080E18	7.7969E18	9.0670E18	1.0373E19
12.7	216.6	0.1714	2.214E19	3.696E24	216.7	216.7	.1331	.0857	6.5060E18	7.7905E18	9.0454E18	1.0331E19
12.8	216.7	0.1688	2.118E19	3.640E24	216.7	216.6	.1303	.0844	6.5040E18	7.7840E18	9.0237E18	1.0288E19
12.9	216.7	0.1663	2.031E19	3.586E24	216.7	216.6	.1277	.0831	6.5020E18	7.7775E18	9.0019E18	1.0245E19
13.0	216.6	0.1637	1.944E19	3.530E24	216.7	216.7	.1248	.0818	6.5000E18	7.7708E18	8.9800E18	1.0201E19
13.1	216.7	0.1611	1.858E19	3.475E24	216.7	216.6	.1214	.0806	6.4980E18	7.7641E18	8.9580E18	1.0157E19
13.2	216.6	0.1586	1.775E19	3.421E24	216.7	216.6	.1177	.0793	6.4960E18	7.7573E18	8.9355E18	1.0112E19
13.3	216.6	0.1561	1.693E19	3.368E24	216.7	216.7	.1136	.0781	6.4940E18	7.7502E18	8.9125E18	1.0067E19
13.4	216.7	0.1537	1.614E19	3.315E24	216.7	216.7	.1092	.0768	6.4919E18	7.7430E18	8.8890E18	1.0021E19

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H2O	MIX GAS	H2O	MIX	H2O	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)	O3 (MOL/CM^2)			
13.5	216.6	0.1512	1.542E19	3.262E24	216.7	216.6	.1059	.0756	6.4899E18	7.7355E18	8.8650E18	9.9750E18
13.6	216.7	0.1488	1.470E19	3.211E24	216.7	216.6	.1027	.0744	6.4879E18	7.7279E18	8.8405E18	9.9280E18
13.7	216.7	0.1466	1.405E19	3.163E24	216.6	216.6	.0997	.0733	6.4858E18	7.7202E18	8.8155E18	9.8804E18
13.8	216.6	0.1444	1.345E19	3.114E24	216.7	216.7	.0970	.0722	6.4837E18	7.7122E18	8.7900E18	9.8322E18
13.9	216.7	0.1421	1.289E19	3.065E24	216.6	216.6	.0941	.0711	6.4816E18	7.7041E18	8.7640E18	9.7834E18
14.0	216.7	0.1399	1.241E19	3.018E24	216.7	216.6	.0915	.0699	6.4796E18	7.6957E18	8.7375E18	9.7340E18
14.1	216.7	0.1377	1.195E19	2.972E24	216.6	216.7	.0888	.0689	6.4775E18	7.6872E18	8.7105E18	9.6840E18
14.2	216.7	0.1355	1.150E19	2.923E24	216.7	216.7	.0862	.0677	6.4753E18	7.6786E18	8.6832E18	9.6339E18
14.3	216.7	0.1333	1.110E19	2.877E24	216.6	216.6	.0833	.0667	6.4732E18	7.6698E18	8.6556E18	9.5837E18
14.4	216.7	0.1312	1.074E19	2.832E24	216.6	216.6	.0808	.0656	6.4710E18	7.6608E18	8.6277E18	9.5334E18
14.5	216.7	0.1292	1.040E19	2.788E24	216.7	216.7	.0786	.0646	6.4688E18	7.6517E18	8.5995E18	9.4830E18
14.6	216.7	0.1272	1.007E19	2.744E24	216.7	216.6	.0766	.0636	6.4665E18	7.6425E18	8.5710E18	9.4325E18
14.7	216.7	0.1252	9.775E18	2.702E24	216.6	216.6	.0749	.0626	6.4642E18	7.6331E18	8.5422E18	9.3819E18
14.8	216.7	0.1233	9.520E18	2.662E24	216.6	216.6	.0734	.0617	6.4619E18	7.6235E18	8.5131E18	9.3312E18
14.9	216.7	0.1214	9.287E18	2.621E24	216.7	216.5	.0720	.0607	6.4596E18	7.6138E18	8.4837E18	9.2804E18
15.0	216.7	0.1195	9.077E18	2.580E24	216.6	216.5	.0706	.0597	6.4572E18	7.6040E18	8.4540E18	9.2295E18
15.1	216.7	0.1176	8.866E18	2.539E24	216.7	216.5	.0690	.0588	6.4548E18	7.5940E18	8.4240E18	9.1785E18
15.2	216.7	0.1158	8.670E18	2.500E24	216.7	216.5	.0675	.0579	6.4524E18	7.5838E18	8.3936E18	9.1272E18
15.3	216.7	0.1140	8.500E18	2.461E24	216.6	216.5	.0660	.0570	6.4499E18	7.5734E18	8.3628E18	9.0756E18
15.4	216.7	0.1122	8.343E18	2.422E24	216.7	216.6	.0646	.0561	6.4474E18	7.5628E18	8.3316E18	9.0237E18
15.5	216.7	0.1104	8.188E18	2.383E24	216.6	216.6	.0634	.0552	6.4448E18	7.5520E18	8.3000E18	8.9715E18
15.6	216.7	0.1087	8.021E18	2.346E24	216.6	216.7	.0622	.0543	6.4422E18	7.5410E18	8.2680E18	8.9190E18
15.7	216.7	0.1070	7.837E18	2.309E24	216.5	216.7	.0609	.0535	6.4396E18	7.5298E18	8.2356E18	8.8662E18
15.8	216.7	0.1054	7.654E18	2.275E24	216.5	216.8	.0596	.0527	6.4369E18	7.5184E18	8.2028E18	8.8131E18
15.9	216.7	0.1038	7.472E18	2.240E24	216.5	216.9	.0583	.0519	6.4342E18	7.5068E18	8.1696E18	8.7597E18
16.0	216.7	0.1021	7.290E18	2.205E24	216.5	217.0	.0571	.0510	6.4314E18	7.4950E18	8.1360E18	8.7060E18
16.1	216.7	0.1005	7.111E18	2.170E24	216.6	217.1	.0560	.0503	6.4286E18	7.4830E18	8.1020E18	8.6520E18
16.2	216.6	0.0990	6.943E18	2.138E24	216.7	217.2	.0549	.0495	6.4257E18	7.4703E18	8.0674E18	8.5975E18
16.3	216.7	0.0975	6.773E18	2.104E24	216.7	217.3	.0537	.0487	6.4226E18	7.4569E18	8.0322E18	8.5425E18
16.4	216.7	0.0959	6.611E18	2.070E24	216.8	217.4	.0526	.0479	6.4194E18	7.4428E18	7.9964E18	8.4870E18
16.5	216.6	0.0944	6.473E18	2.038E24	217.0	217.5	.0517	.0472	6.4160E18	7.4280E18	7.9600E18	8.4310E18
16.6	216.7	0.0929	6.337E18	2.007E24	217.1	217.6	.0507	.0465	6.4125E18	7.4125E18	7.9230E18	8.3745E18
16.7	216.7	0.0915	6.207E18	1.975E24	217.2	217.7	.0498	.0457	6.4089E18	7.3963E18	7.8854E18	8.3175E18
16.8	216.6	0.0900	6.084E18	1.945E24	217.3	217.8	.0490	.0450	6.4051E18	7.3794E18	7.8472E18	8.2600E18
16.9	216.6	0.0886	5.958E18	1.915E24	217.4	217.9	.0481	.0443	6.4012E18	7.3618E18	7.8084E18	8.2020E18
17.0	216.7	0.0873	5.834E18	1.885E24	217.5	218.0	.0473	.0437	6.3971E18	7.3435E18	7.7690E18	8.1435E18
17.1	216.7	0.0859	5.730E18	1.856E24	217.6	218.1	.0466	.0430	6.3929E18	7.3245E18	7.7290E18	8.0845E18
17.2	216.6	0.0846	5.640E18	1.827E24	217.7	218.3	.0459	.0423	6.3883E18	7.3046E18	7.6882E18	8.0255E18
17.3	216.6	0.0832	5.545E18	1.798E24	217.8	218.4	.0453	.0416	6.3832E18	7.2838E18	7.6466E18	7.9665E18
17.4	216.7	0.0819	5.450E18	1.770E24	217.9	218.4	.0447	.0410	6.3777E18	7.2621E18	7.6042E18	7.9075E18
17.5	216.6	0.0807	5.359E18	1.743E24	217.9	218.5	.0442	.0404	6.3718E18	7.2395E18	7.5610E18	7.8485E18
17.6	216.6	0.0795	5.273E18	1.717E24	218.0	218.6	.0436	.0397	6.3655E18	7.2160E18	7.5170E18	7.7895E18
17.7	216.7	0.0783	5.180E18	1.691E24	218.1	218.7	.0430	.0391	6.3587E18	7.1916E18	7.4722E18	7.7305E18
17.8	216.7	0.0770	5.074E18	1.663E24	218.3	218.8	.0422	.0385	6.3515E18	7.1663E18	7.4266E18	7.6715E18
17.9	216.6	0.0758	4.967E18	1.637E24	218.4	218.9	.0414	.0379	6.3438E18	7.1401E18	7.3802E18	7.6125E18

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H20	MIX GAS	H20	MIX	H20	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)		O3	(MOL/CM^2)	
18.0	216.6	0.0746	4.862E18	1.612E24	218.5	219.0	.0408	.0373	6.3358E18	7.1130E18	7.3330E18	7.5535E18
18.1	216.6	0.0734	4.762E18	1.587E24	218.6	219.1	.0401	.0367	6.3273E18	7.0850E18	7.2850E18	7.4945E18
18.2	216.7	0.0723	4.668E18	1.562E24	218.7	219.2	.0394	.0362	6.3176E18	7.0560E18	7.2370E18	7.4356E18
18.3	216.6	0.0712	4.584E18	1.538E24	218.8	219.3	.0388	.0356	6.3068E18	7.0260E18	7.1890E18	7.3768E18
18.4	216.6	0.0701	4.506E18	1.515E24	218.9	219.4	.0383	.0351	6.2949E18	6.9950E18	7.1410E18	7.3181E18
18.5	216.7	0.0690	4.432E18	1.491E24	218.9	219.5	.0379	.0345	6.2818E18	6.9630E18	7.0930E18	7.2595E18
18.6	216.7	0.0679	4.362E18	1.468E24	219.0	219.7	.0374	.0340	6.2675E18	6.9300E18	7.0450E18	7.2010E18
18.7	216.6	0.0669	4.297E18	1.445E24	219.1	219.8	.0370	.0334	6.2521E18	6.8960E18	6.9970E18	7.1426E18
18.8	216.6	0.0658	4.238E18	1.423E24	219.2	219.9	.0366	.0329	6.2356E18	6.8610E18	6.9490E18	7.0843E18
18.9	216.7	0.0648	4.182E18	1.401E24	219.2	220.0	.0363	.0324	6.2179E18	6.8250E18	6.9010E18	7.0261E18
19.0	216.6	0.0639	4.123E18	1.380E24	219.3	220.1	.0358	.0320	6.1990E18	6.7880E18	6.8530E18	6.9680E18
19.1	216.6	0.0628	4.055E18	1.358E24	219.4	220.2	.0354	.0314	6.1790E18	6.7500E18	6.8050E18	6.9100E18
19.2	216.6	0.0618	3.983E18	1.335E24	219.5	220.3	.0348	.0309	6.1582E18	6.7110E18	6.7568E18	6.8523E18
19.3	216.5	0.0608	3.915E18	1.315E24	219.6	220.4	.0343	.0304	6.1366E18	6.6710E18	6.7084E18	6.7949E18
19.4	216.5	0.0599	3.850E18	1.295E24	219.7	220.5	.0339	.0300	6.1142E18	6.6300E18	6.6598E18	6.7378E18
19.5	216.5	0.0590	3.788E18	1.275E24	219.7	220.6	.0335	.0295	6.0910E18	6.5880E18	6.6110E18	6.6810E18
19.6	216.5	0.0581	3.724E18	1.256E24	219.8	220.7	.0330	.0291	6.0670E18	6.5450E18	6.5620E18	6.6245E18
19.7	216.5	0.0572	3.655E18	1.236E24	219.9	220.8	.0325	.0286	6.0422E18	6.5010E18	6.5128E18	6.5683E18
19.8	216.6	0.0563	3.584E18	1.217E24	220.0	220.9	.0320	.0281	6.0166E18	6.4560E18	6.4634E18	6.5124E18
19.9	216.6	0.0555	3.515E18	1.198E24	220.1	221.0	.0316	.0278	5.9902E18	6.4100E18	6.4138E18	6.4568E18
20.0	216.7	0.0546	3.450E18	1.180E24	220.2	221.1	.0311	.0273	5.9630E18	6.3630E18	6.3640E18	6.4015E18
20.1	216.7	0.0537	3.387E18	1.162E24	220.3	221.2	.0307	.0269	5.9350E18	6.3150E18	6.3140E18	6.3465E18
20.2	216.8	0.0529	3.326E18	1.144E24	220.4	221.3	.0303	.0265	5.9064E18	6.2668E18	6.2641E18	6.2920E18
20.3	216.9	0.0521	3.267E18	1.126E24	220.5	221.4	.0299	.0260	5.8772E18	6.2184E18	6.2143E18	6.2380E18
20.4	217.0	0.0513	3.210E18	1.108E24	220.6	221.5	.0295	.0257	5.8474E18	6.1698E18	6.1646E18	6.1845E18
20.5	217.1	0.0505	3.154E18	1.091E24	220.6	221.6	.0291	.0253	5.8170E18	6.1210E18	6.1150E18	6.1315E18
20.6	217.2	0.0497	3.096E18	1.074E24	220.7	221.7	.0287	.0248	5.7860E18	6.0720E18	6.0655E18	6.0790E18
20.7	217.3	0.0489	3.035E18	1.057E24	220.8	221.8	.0282	.0245	5.7544E18	6.0228E18	6.0161E18	6.0270E18
20.8	217.4	0.0481	2.978E18	1.041E24	220.9	221.8	.0279	.0240	5.7222E18	5.9734E18	5.9668E18	5.9755E18
20.9	217.5	0.0474	2.924E18	1.024E24	221.0	221.9	.0275	.0237	5.6894E18	5.9238E18	5.9176E18	5.9245E18
21.0	217.6	0.0467	2.875E18	1.009E24	221.1	222.0	.0270	.0234	5.6560E18	5.8740E18	5.8685E18	5.8740E18
21.1	217.7	0.0460	2.825E18	9.939E23	221.2	222.1	.0267	.0230	5.6220E18	5.8240E18	5.8195E18	5.8240E18
21.2	217.8	0.0452	2.767E18	9.780E23	221.3	222.2	.0263	.0226	5.5874E18	5.7741E18	5.7705E18	5.7741E18
21.3	217.9	0.0445	2.704E18	9.621E23	221.4	222.3	.0259	.0223	5.5522E18	5.7243E18	5.7215E18	5.7243E18
21.4	218.0	0.0438	2.648E18	9.473E23	221.5	222.4	.0255	.0219	5.5164E18	5.6746E18	5.6725E18	5.6746E18
21.5	218.1	0.0431	2.600E18	9.328E23	221.6	222.5	.0252	.0215	5.4800E18	5.6250E18	5.6235E18	5.6250E18
21.6	218.2	0.0425	2.557E18	9.189E23	221.6	222.6	.0250	.0213	5.4430E18	5.5755E18	5.5745E18	5.5755E18
21.7	218.4	0.0418	2.514E18	9.050E23	221.7	222.7	.0247	.0209	5.4054E18	5.5261E18	5.5255E18	5.5261E18
21.8	218.4	0.0412	2.466E18	8.909E23	221.8	222.8	.0244	.0206	5.3672E18	5.4768E18	5.4765E18	5.4768E18
21.9	218.5	0.0406	2.419E18	8.775E23	221.8	222.9	.0241	.0203	5.3284E18	5.4276E18	5.4275E18	5.4276E18
22.0	218.6	0.0400	2.373E18	8.643E23	221.9	223.0	.0238	.0200	5.2890E18	5.3785E18	5.3785E18	5.3785E18
22.1	218.7	0.0393	2.327E18	8.511E23	222.0	223.1	.0234	.0196	5.2490E18	5.3295E18	5.3295E18	5.3295E18
22.2	218.8	0.0387	2.281E18	8.379E23	222.1	223.2	.0231	.0193	5.2085E18	5.2805E18	5.2805E18	5.2805E18
22.3	218.9	0.0381	2.234E18	8.247E23	222.2	223.3	.0227	.0191	5.1675E18	5.2315E18	5.2315E18	5.2315E18
22.4	219.0	0.0375	2.186E18	8.115E23	222.3	223.4	.0223	.0188	5.1260E18	5.1825E18	5.1825E18	5.1825E18

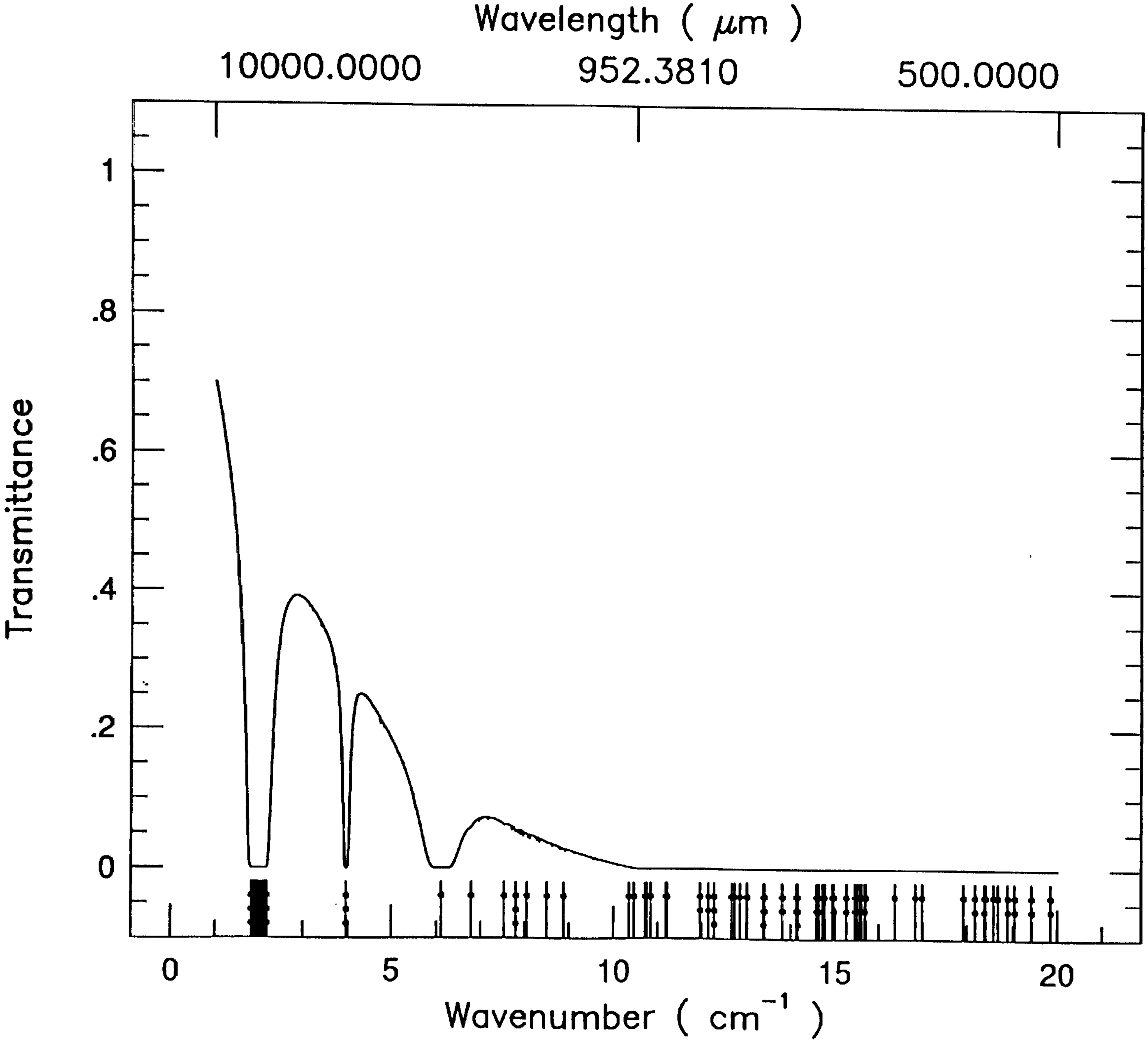
ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H20	MIX GAS	H20	MIX	H20	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)	03 (MOL/CM^2)			
22.5	219.1	0.0369	2.141E18	7.989E23	222.4	223.6	.0219	.0184	5.0840E18	5.1335E18	5.1335E18	5.1335E18
22.6	219.2	0.0364	2.100E18	7.869E23	222.5	223.6	.0216	.0182	5.0415E18	5.0845E18	5.0845E18	5.0845E18
22.7	219.3	0.0358	2.060E18	7.749E23	222.6	223.7	.0213	.0179	4.9985E18	5.0355E18	5.0355E18	5.0355E18
22.8	219.4	0.0353	2.022E18	7.634E23	222.7	223.8	.0210	.0177	4.9550E18	4.9865E18	4.9865E18	4.9865E18
22.9	219.5	0.0347	1.984E18	7.518E23	222.8	223.9	.0207	.0173	4.9110E18	4.9375E18	4.9375E18	4.9375E18
23.0	219.6	0.0342	1.947E18	7.402E23	222.8	224.0	.0205	.0171	4.8665E18	4.8885E18	4.8885E18	4.8885E18
23.1	219.7	0.0337	1.910E18	7.286E23	222.9	224.1	.0202	.0169	4.8215E18	4.8395E18	4.8395E18	4.8395E18
23.2	219.8	0.0332	1.875E18	7.176E23	223.0	224.2	.0200	.0166	4.7761E18	4.7905E18	4.7905E18	4.7905E18
23.3	219.9	0.0327	1.840E18	7.069E23	223.1	224.3	.0197	.0163	4.7303E18	4.7415E18	4.7415E18	4.7415E18
23.4	220.0	0.0322	1.804E18	6.962E23	223.2	224.4	.0195	.0161	4.6841E18	4.6925E18	4.6925E18	4.6925E18
23.5	220.1	0.0317	1.767E18	6.856E23	223.3	224.5	.0192	.0159	4.6375E18	4.6435E18	4.6435E18	4.6435E18
23.6	220.2	0.0312	1.729E18	6.749E23	223.4	224.7	.0189	.0156	4.5905E18	4.5945E18	4.5945E18	4.5945E18
23.7	220.3	0.0307	1.693E18	6.645E23	223.5	224.8	.0186	.0154	4.5431E18	4.5455E18	4.5455E18	4.5455E18
23.8	220.4	0.0302	1.658E18	6.543E23	223.6	224.8	.0184	.0151	4.4953E18	4.4965E18	4.4965E18	4.4965E18
23.9	220.5	0.0298	1.624E18	6.441E23	223.7	224.9	.0181	.0149	4.4471E18	4.4475E18	4.4475E18	4.4475E18
24.0	220.6	0.0293	1.592E18	6.346E23	223.7	225.1	.0179	.0147	4.3985E18	4.3985E18	4.3985E18	4.3985E18
24.1	220.7	0.0289	1.560E18	6.250E23	223.8	225.2	.0176	.0144	4.3495E18	4.3495E18	4.3495E18	4.3495E18
24.2	220.8	0.0284	1.529E18	6.155E23	223.9	225.3	.0174	.0142	4.3004E18	4.3004E18	4.3004E18	4.3004E18
24.3	220.9	0.0280	1.499E18	6.060E23	224.0	225.3	.0172	.0140	4.2512E18	4.2512E18	4.2512E18	4.2512E18
24.4	221.0	0.0276	1.470E18	5.965E23	224.1	225.4	.0169	.0138	4.2019E18	4.2019E18	4.2019E18	4.2019E18
24.5	221.1	0.0271	1.441E18	5.878E23	224.2	225.6	.0167	.0136	4.1525E18	4.1525E18	4.1525E18	4.1525E18
24.6	221.2	0.0267	1.413E18	5.788E23	224.3	225.7	.0165	.0133	4.1030E18	4.1030E18	4.1030E18	4.1030E18
24.7	221.3	0.0263	1.384E18	5.701E23	224.3	225.8	.0163	.0132	4.0534E18	4.0534E18	4.0534E18	4.0534E18
24.8	221.4	0.0259	1.354E18	5.615E23	224.4	225.9	.0161	.0130	4.0037E18	4.0037E18	4.0037E18	4.0037E18
24.9	221.5	0.0255	1.323E18	5.530E23	224.5	226.0	.0158	.0127	3.9539E18	3.9539E18	3.9539E18	3.9539E18
25.0	221.6	0.0251	1.292E18	5.445E23	224.6	226.1	.0156	.0126	3.9040E18	3.9040E18	3.9040E18	3.9040E18
25.1	221.7	0.0248	1.261E18	5.361E23	224.7	226.2	.0154	.0124	3.8540E18	3.8540E18	3.8540E18	3.8540E18
25.2	221.8	0.0244	1.232E18	5.282E23	224.8	226.3	.0151	.0122	3.8046E18	3.8046E18	3.8046E18	3.8046E18
25.3	221.8	0.0240	1.204E18	5.203E23	224.9	226.4	.0149	.0120	3.7558E18	3.7558E18	3.7558E18	3.7558E18
25.4	221.9	0.0237	1.178E18	5.124E23	225.0	226.5	.0147	.0119	3.7076E18	3.7076E18	3.7076E18	3.7076E18
25.5	222.0	0.0233	1.155E18	5.048E23	225.1	226.6	.0146	.0116	3.6600E18	3.6600E18	3.6600E18	3.6600E18
25.6	222.1	0.0230	1.133E18	4.973E23	225.2	226.7	.0143	.0115	3.6130E18	3.6130E18	3.6130E18	3.6130E18
25.7	222.2	0.0226	1.113E18	4.898E23	225.3	226.8	.0142	.0113	3.5666E18	3.5666E18	3.5666E18	3.5666E18
25.8	222.3	0.0223	1.093E18	4.823E23	225.3	226.9	.0141	.0111	3.5208E18	3.5208E18	3.5208E18	3.5208E18
25.9	222.4	0.0219	1.073E18	4.748E23	225.4	227.0	.0139	.0110	3.4756E18	3.4756E18	3.4756E18	3.4756E18
26.0	222.5	0.0216	1.050E18	4.674E23	225.5	227.1	.0137	.0108	3.4310E18	3.4310E18	3.4310E18	3.4310E18
26.1	222.6	0.0213	1.028E18	4.606E23	225.6	227.2	.0136	.0106	3.3870E18	3.3870E18	3.3870E18	3.3870E18
26.2	222.7	0.0209	1.005E18	4.537E23	225.7	227.3	.0134	.0104	3.3431E18	3.3431E18	3.3431E18	3.3431E18
26.3	222.8	0.0206	9.824E17	4.469E23	225.7	227.4	.0132	.0103	3.2993E18	3.2993E18	3.2993E18	3.2993E18
26.4	222.9	0.0203	9.596E17	4.401E23	225.8	227.5	.0131	.0102	3.2556E18	3.2556E18	3.2556E18	3.2556E18
26.5	223.0	0.0200	9.372E17	4.332E23	225.9	227.5	.0129	.0100	3.2120E18	3.2120E18	3.2120E18	3.2120E18
26.6	223.1	0.0197	9.169E17	4.268E23	226.0	227.5	.0127	.0099	3.1685E18	3.1685E18	3.1685E18	3.1685E18
26.7	223.2	0.0194	8.975E17	4.205E23	226.1	227.6	.0126	.0097	3.1251E18	3.1251E18	3.1251E18	3.1251E18
26.8	223.3	0.0191	8.787E17	4.143E23	226.2	227.7	.0124	.0095	3.0818E18	3.0818E18	3.0818E18	3.0818E18
26.9	223.4	0.0188	8.603E17	4.081E23	226.3	227.8	.0122	.0094	3.0386E18	3.0386E18	3.0386E18	3.0386E18

ALT	T	P	COL. DEN.	COL. DEN.	T(.5)	T(.5)	P(.5)	P(.5)	COL. DEN. (4 Profiles)			
			H20	MIX GAS	H20	MIX	H20	MIX	9 LAT	36 LAT	43 LAT	56 LAT
(KM)	(K)	(ATM)	(MOL/CM^2)	(MOL/CM^2)	(K)	(K)	(ATM)	(ATM)	O3 (MOL/CM^2)			
27.0	223.5	0.0186	8.420E17	4.020E23	226.4	227.9	.0121	.0093	2.9955E18	2.9955E18	2.9955E18	2.9955E18
27.1	223.6	0.0183	8.235E17	3.959E23	226.4	228.0	.0119	.0092	2.9525E18	2.9525E18	2.9525E18	2.9525E18
27.2	223.7	0.0180	8.046E17	3.898E23	226.5	228.2	.0118	.0090	2.9099E18	2.9099E18	2.9099E18	2.9099E18
27.3	223.8	0.0177	7.868E17	3.841E23	226.6	228.4	.0117	.0088	2.8677E18	2.8677E18	2.8677E18	2.8677E18
27.4	223.9	0.0175	7.691E17	3.784E23	226.7	228.6	.0115	.0088	2.8259E18	2.8259E18	2.8259E18	2.8259E18
27.5	224.0	0.0172	7.514E17	3.728E23	226.7	228.8	.0114	.0086	2.7845E18	2.7845E18	2.7845E18	2.7845E18
27.6	224.1	0.0169	7.341E17	3.672E23	226.8	229.0	.0113	.0084	2.7435E18	2.7435E18	2.7435E18	2.7435E18
27.7	224.2	0.0167	7.170E17	3.617E23	226.9	229.3	.0112	.0083	2.7029E18	2.7029E18	2.7029E18	2.7029E18
27.8	224.3	0.0164	6.998E17	3.562E23	227.0	229.5	.0110	.0082	2.6627E18	2.6627E18	2.6627E18	2.6627E18
27.9	224.4	0.0162	6.826E17	3.508E23	227.0	229.8	.0109	.0081	2.6229E18	2.6229E18	2.6229E18	2.6229E18
28.0	224.5	0.0159	6.668E17	3.456E23	227.1	230.1	.0108	.0080	2.5835E18	2.5835E18	2.5835E18	2.5835E18
28.1	224.6	0.0157	6.513E17	3.405E23	227.2	230.3	.0106	.0078	2.5445E18	2.5445E18	2.5445E18	2.5445E18
28.2	224.7	0.0155	6.363E17	3.353E23	227.4	230.6	.0104	.0077	2.5061E18	2.5061E18	2.5061E18	2.5061E18
28.3	224.8	0.0152	6.219E17	3.303E23	227.5	230.9	.0102	.0076	2.4683E18	2.4683E18	2.4683E18	2.4683E18
28.4	224.9	0.0150	6.076E17	3.254E23	227.5	231.2	.0100	.0075	2.4311E18	2.4311E18	2.4311E18	2.4311E18
28.5	225.0	0.0148	5.931E17	3.204E23	227.5	231.5	.0099	.0074	2.3945E18	2.3945E18	2.3945E18	2.3945E18
28.6	225.1	0.0146	5.788E17	3.157E23	227.5	231.8	.0099	.0073	2.3585E18	2.3585E18	2.3585E18	2.3585E18
28.7	225.2	0.0143	5.642E17	3.109E23	227.5	232.1	.0099	.0071	2.3231E18	2.3231E18	2.3231E18	2.3231E18
28.8	225.3	0.0141	5.496E17	3.063E23	227.5	232.3	.0099	.0071	2.2883E18	2.2883E18	2.2883E18	2.2883E18
28.9	225.4	0.0139	5.357E17	3.019E23	227.5	232.6	.0099	.0069	2.2541E18	2.2541E18	2.2541E18	2.2541E18
29.0	225.5	0.0137	5.221E17	2.975E23	227.5	232.9	.0099	.0069	2.2205E18	2.2205E18	2.2205E18	2.2205E18
29.1	225.6	0.0135	5.086E17	2.930E23	227.5	233.2	.0099	.0068	2.1875E18	2.1875E18	2.1875E18	2.1875E18

APPENDIX E

TRANSMITTANCE AT SEA LEVEL

We show the transmittance at sea-level. The plots are numbered from 1 to 45 covering 10,000 μm to 0.8 μm.

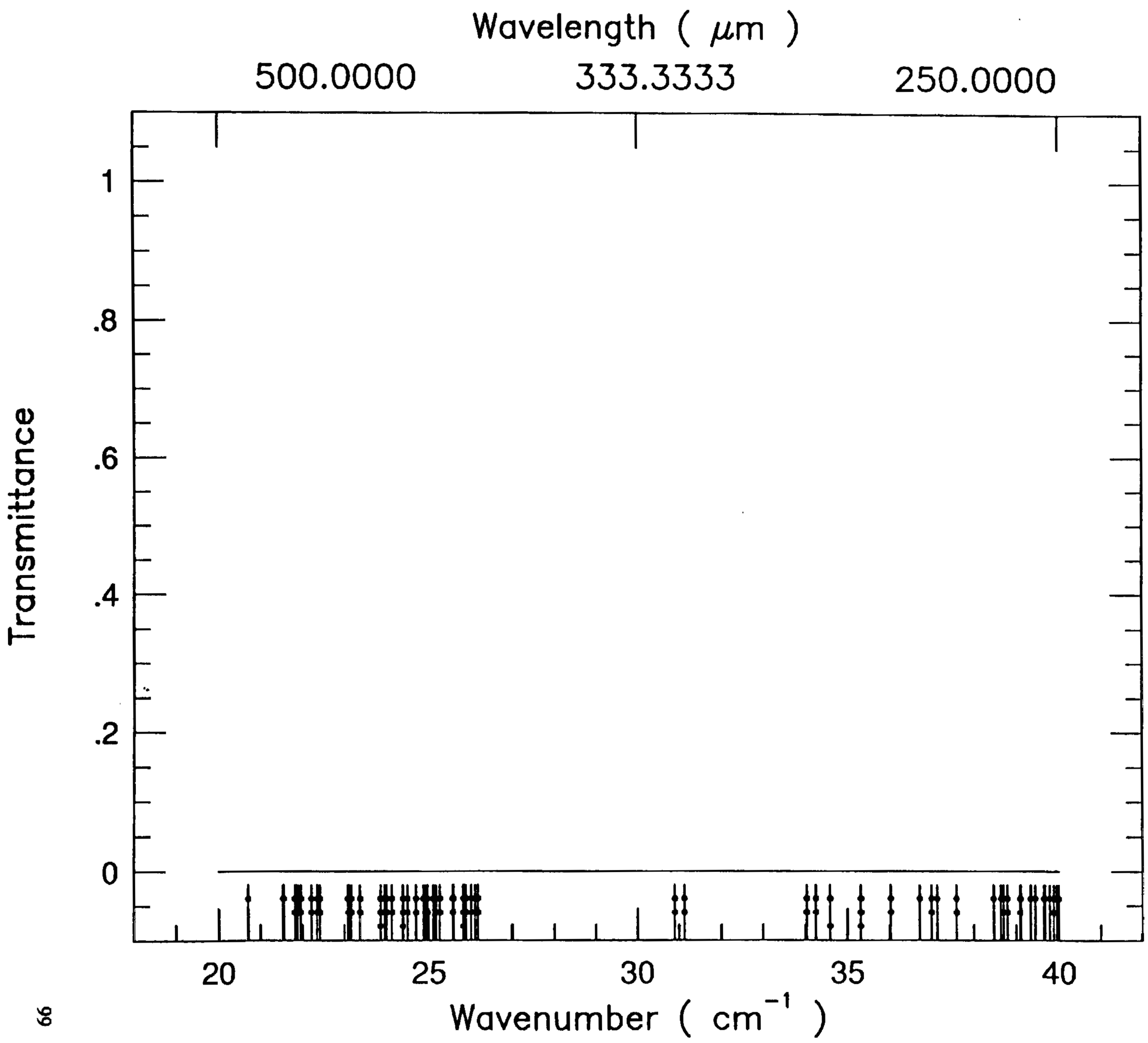


1

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

Lambda 1	1.000
Lambda 2	20.000
Sampling	2.499342
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	5250.000
Num. Pts.	3801
Ozone	9.13E+18

Wed Oct 23 15:44:36 1991



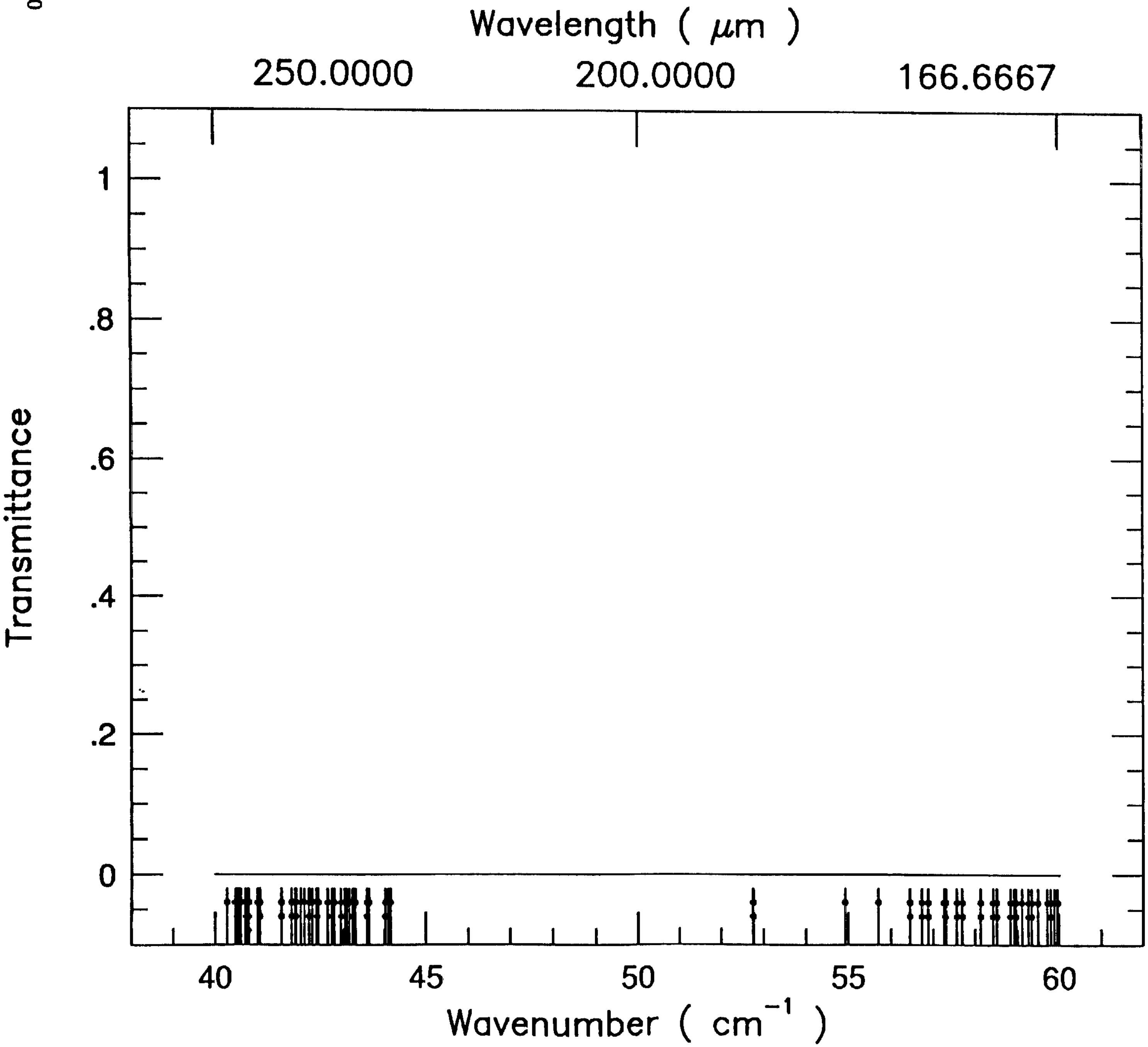
2

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O O_3 CO O_2

Lambda 1	20.000
Lambda 2	40.000
Sampling	0.062484
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	375.000
Num. Pts.	4001
Ozone	9.13E+18

Wed Oct 23 15:52:20 1991



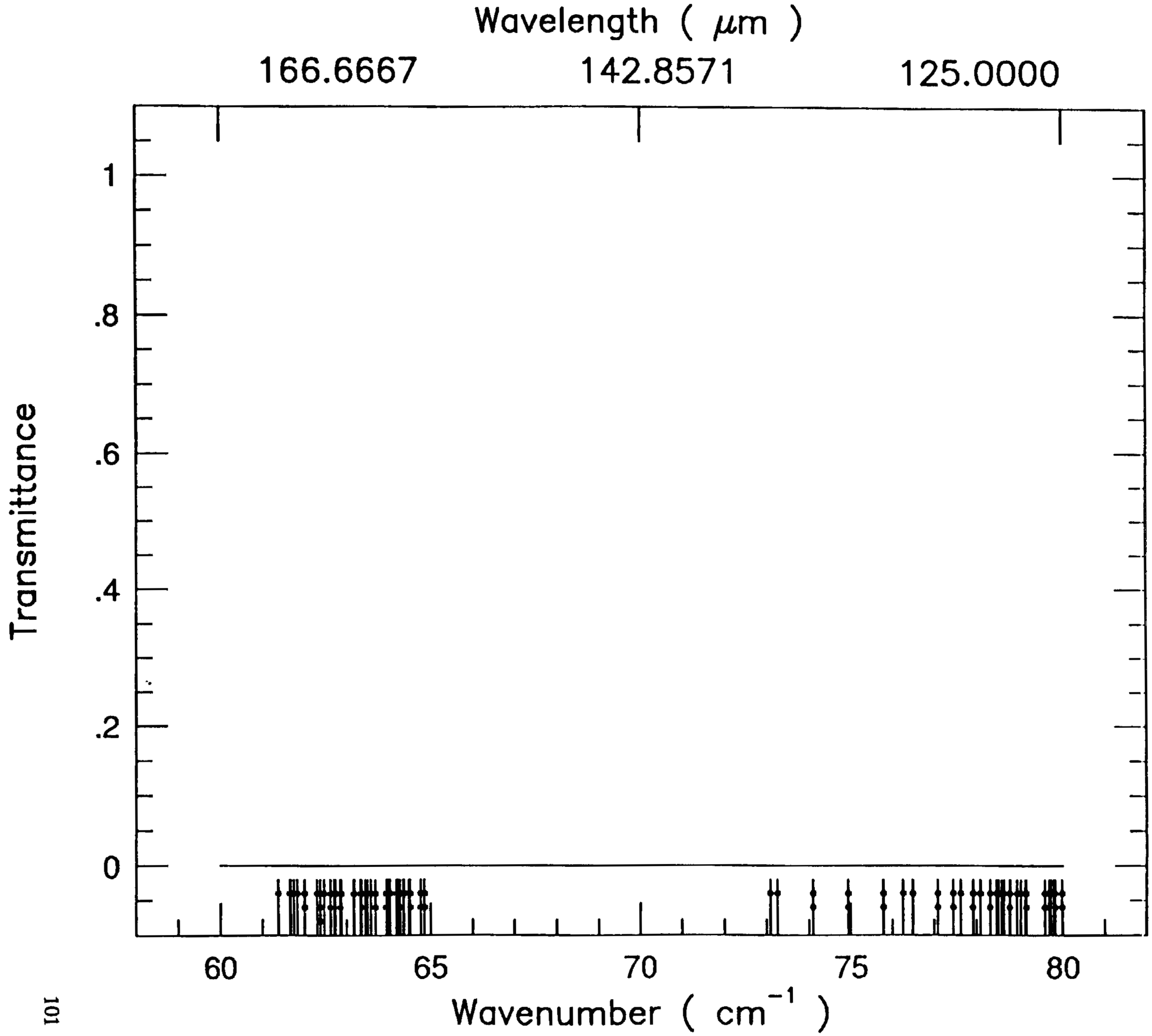
3

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O O_3 O_2

Lambda 1	40.000
Lambda 2	60.000
Sampling	0.020828
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	208.333
Num. Pts.	4001
Ozone	9.13E+18

Wed Oct 23 15:53:50 1991



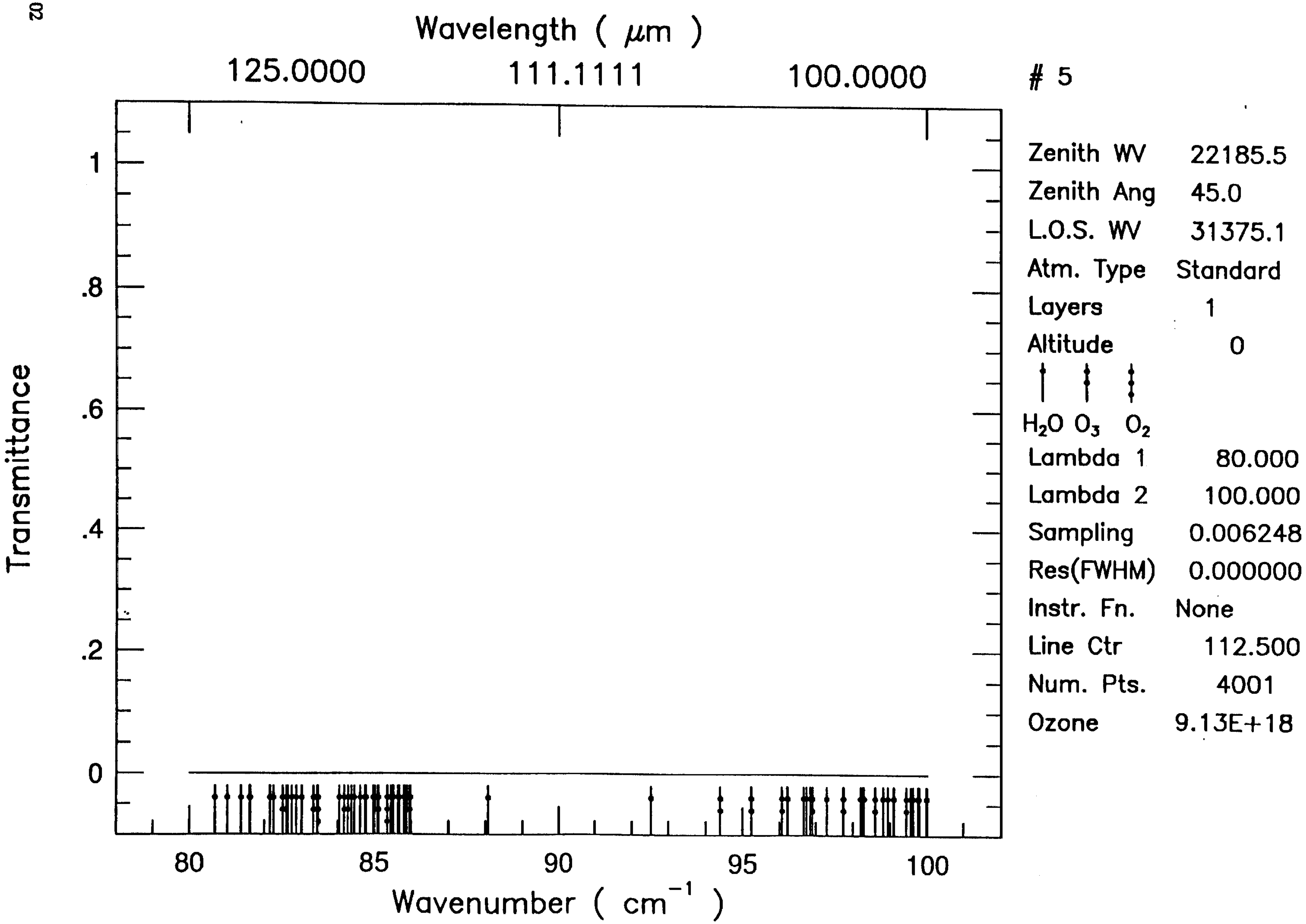
4

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O O_3 O_2

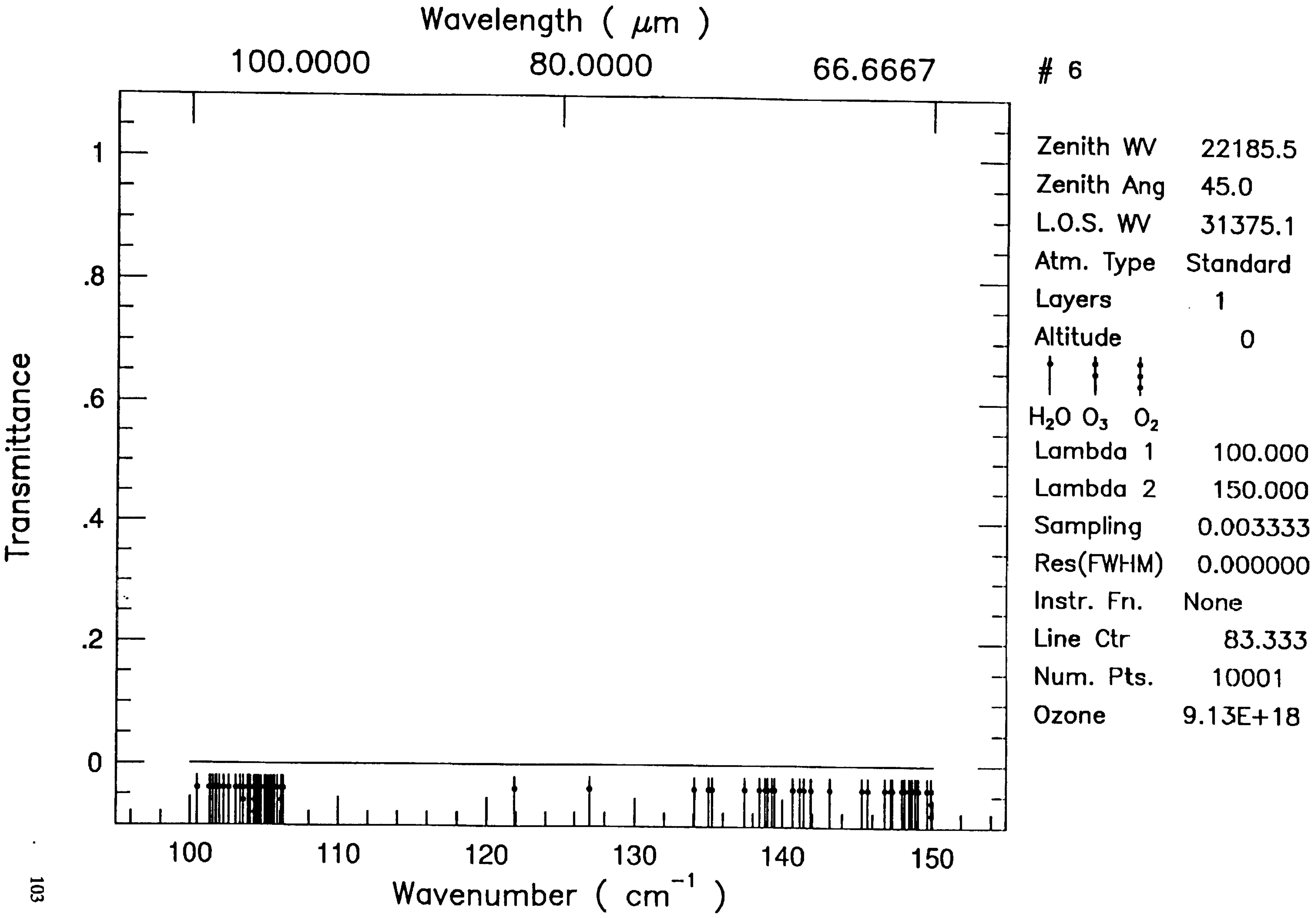
Lambda 1	60.000
Lambda 2	80.000
Sampling	0.010414
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	145.833
Num. Pts.	4001
Ozone	9.13E+18

Wed Oct 23 15:55:26 1991



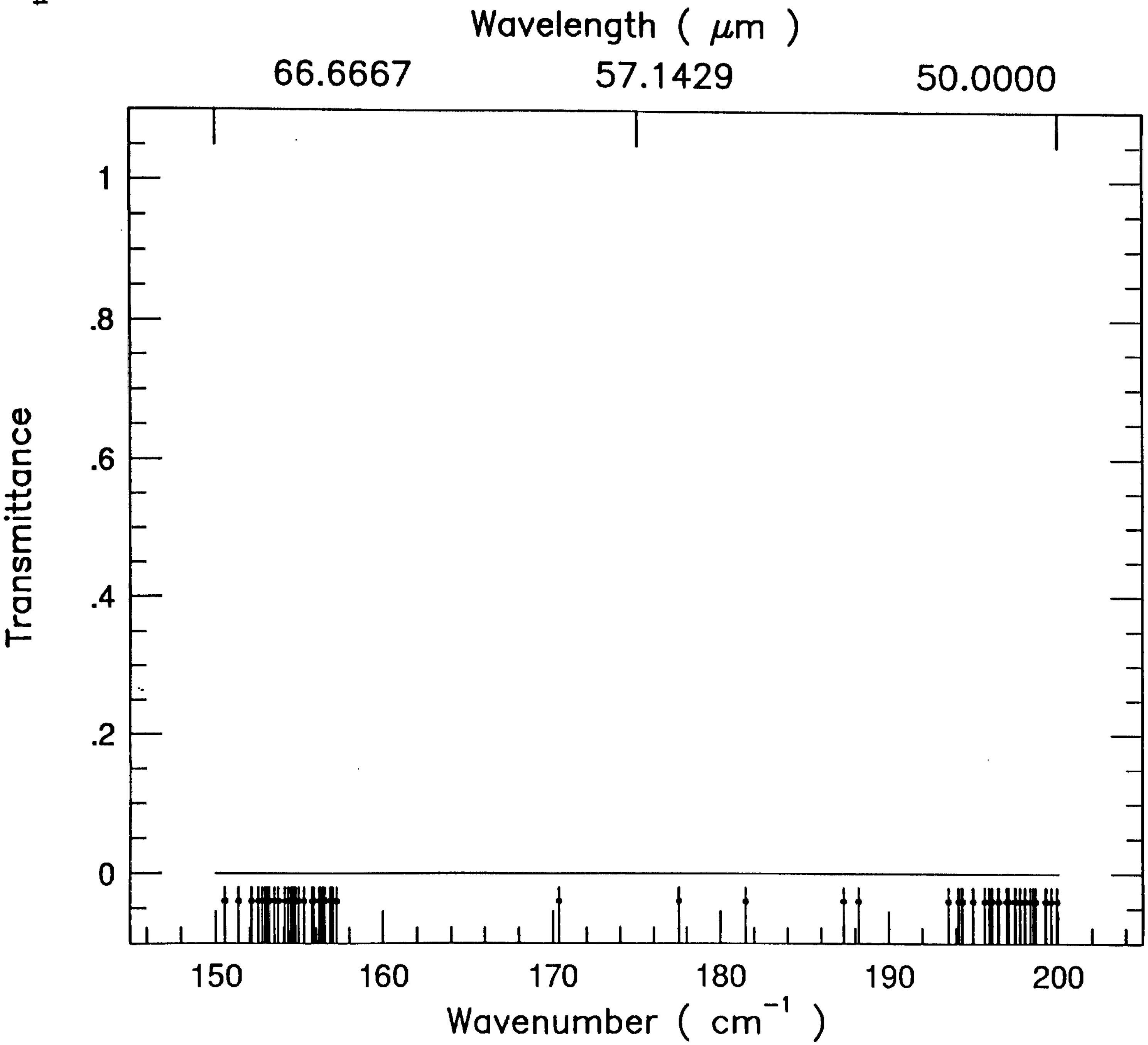
Zenith WV 22185.5
Zenith Ang 45.0
L.O.S. WV 31375.1
Atm. Type Standard
Layers 1
Altitude 0
Lambda 1 80.000
Lambda 2 100.000
Sampling 0.006248
Res(FWHM) 0.000000
Instr. Fn. None
Line Ctr 112.500
Num. Pts. 4001
Ozone 9.13E+18

Wed Oct 23 15:57:17 1991



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	100.000
Lambda 2	150.000
Sampling	0.003333
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	83.333
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 15:58:51 1991



7

Zenith WV 22185.5

Zenith Ang 45.0

L.O.S. WV 31375.1

Atm. Type Standard

Layers 1

Altitude 0

H_2O

Lambda 1 150.000

Lambda 2 200.000

Sampling 0.001666

Res(FWHM) 0.000000

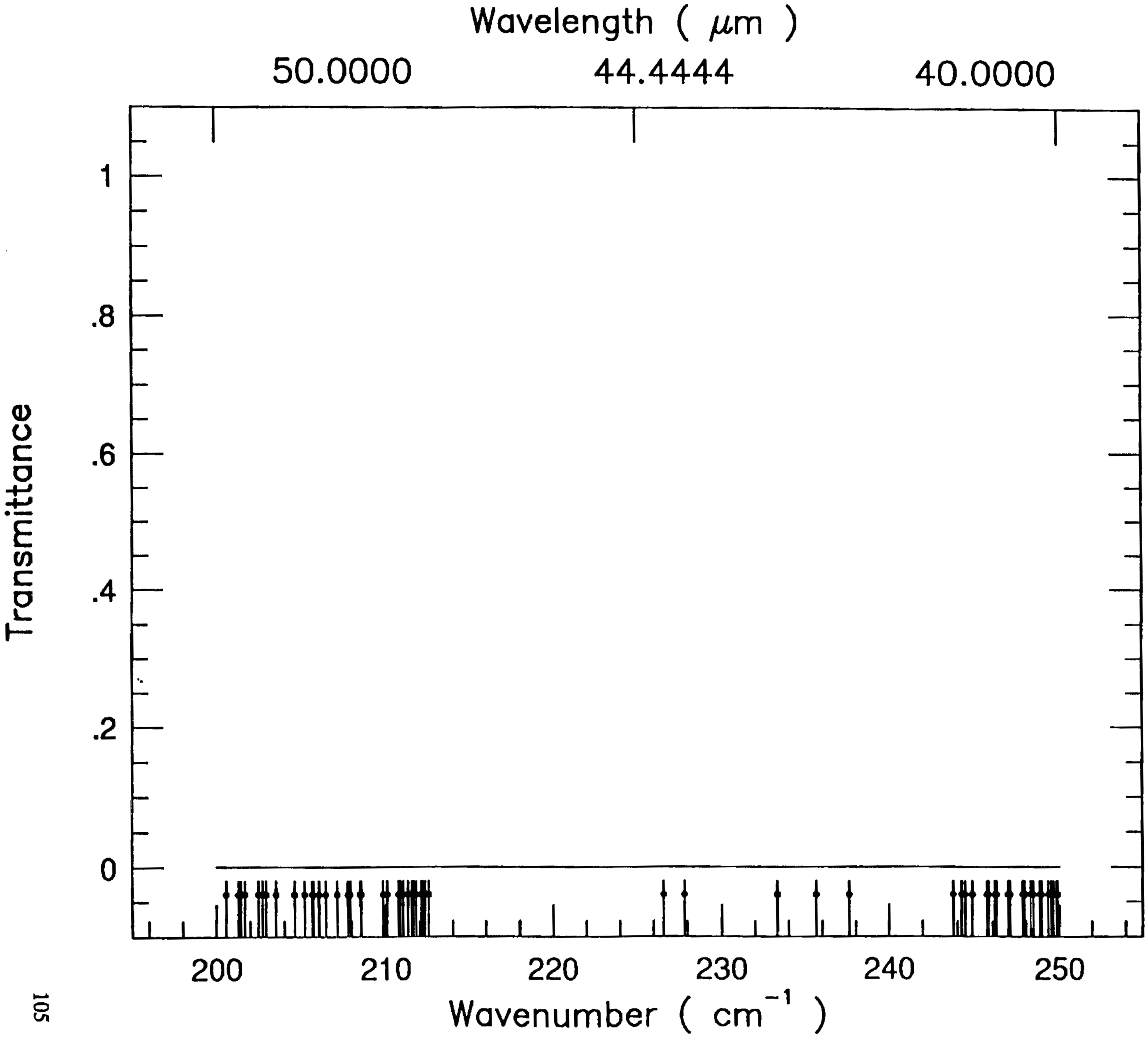
Instr. Fn. None

Line Ctr 58.333

Num. Pts. 10001

Ozone 9.13E+18

Wed Oct 23 16:01:47 1991



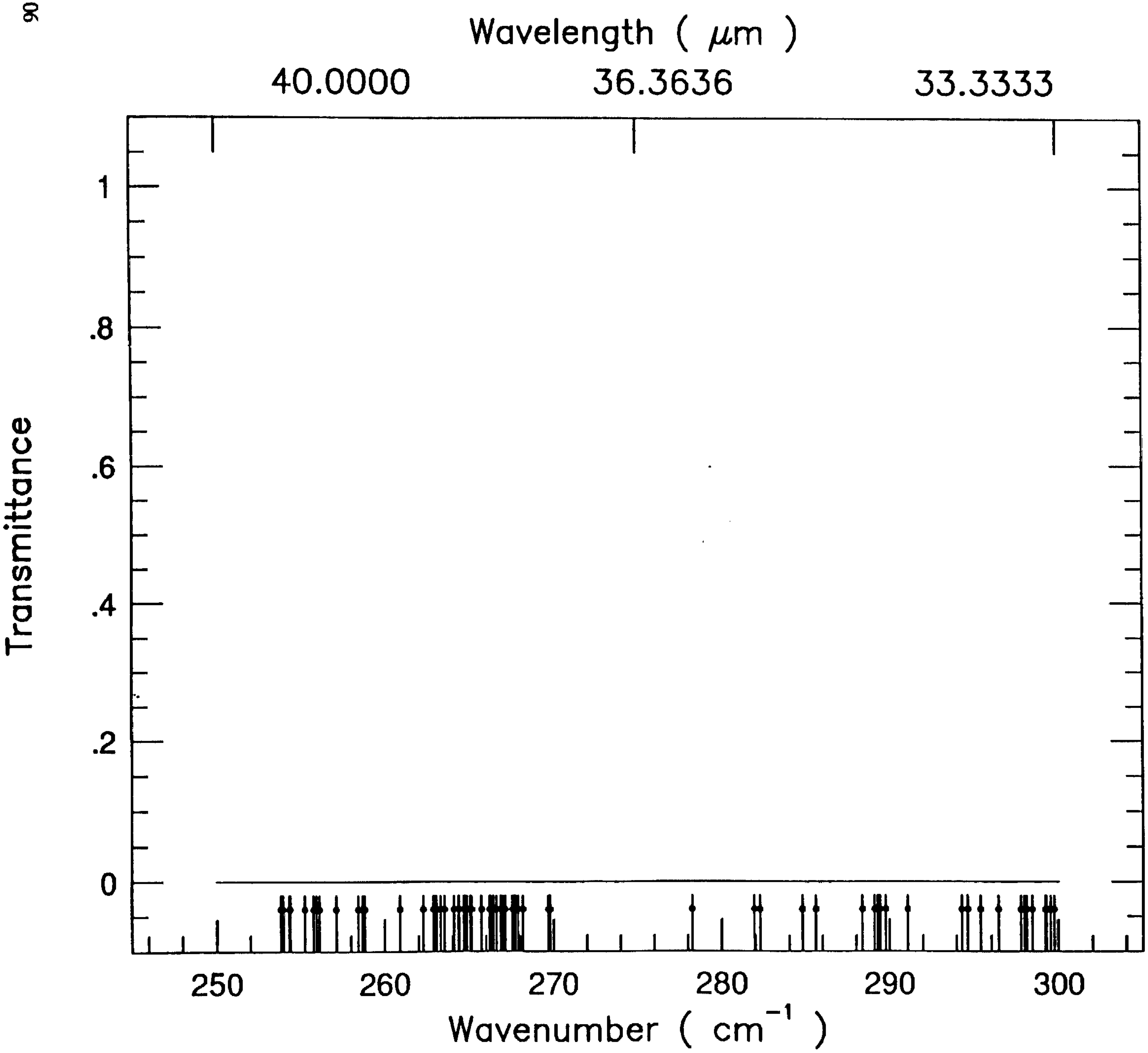
8

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	200.000
Lambda 2	250.000
Sampling	0.001000
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	45.000
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:05:10 1991



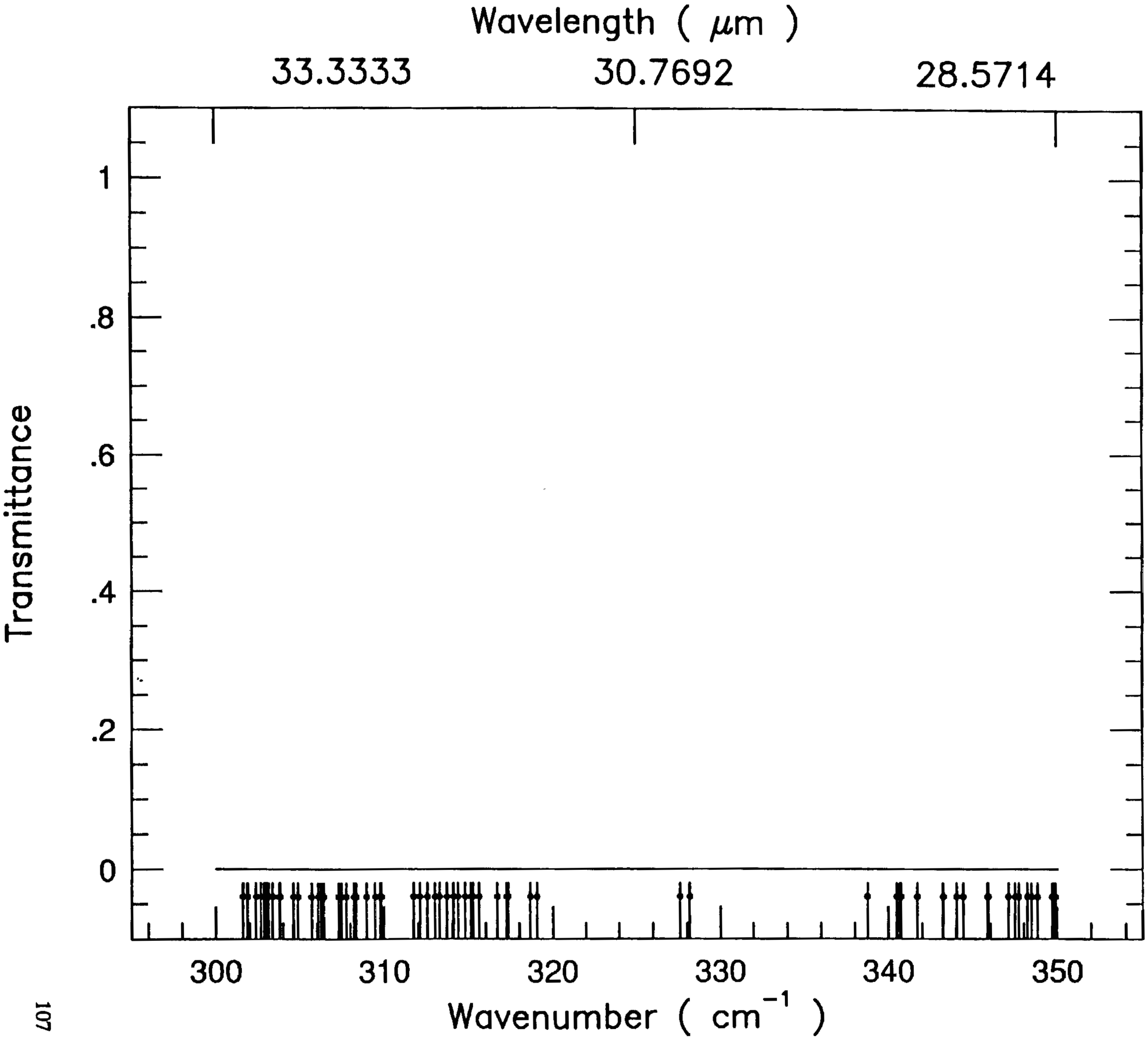
9

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	250.000
Lambda 2	300.000
Sampling	0.000667
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	36.667
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:08:04 1991



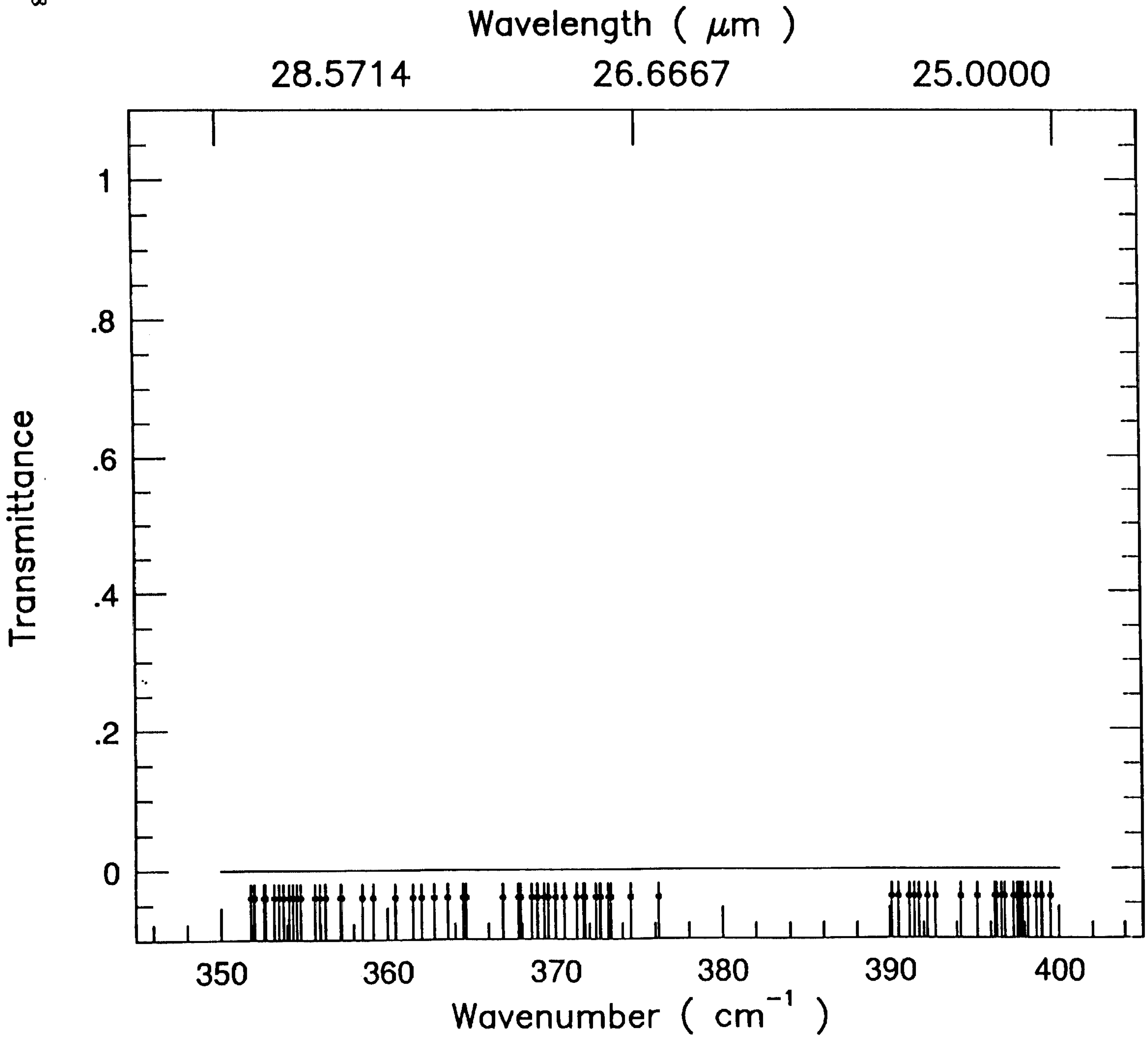
#10

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	300.000
Lambda 2	350.000
Sampling	0.000476
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	30.952
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:09:44 1991



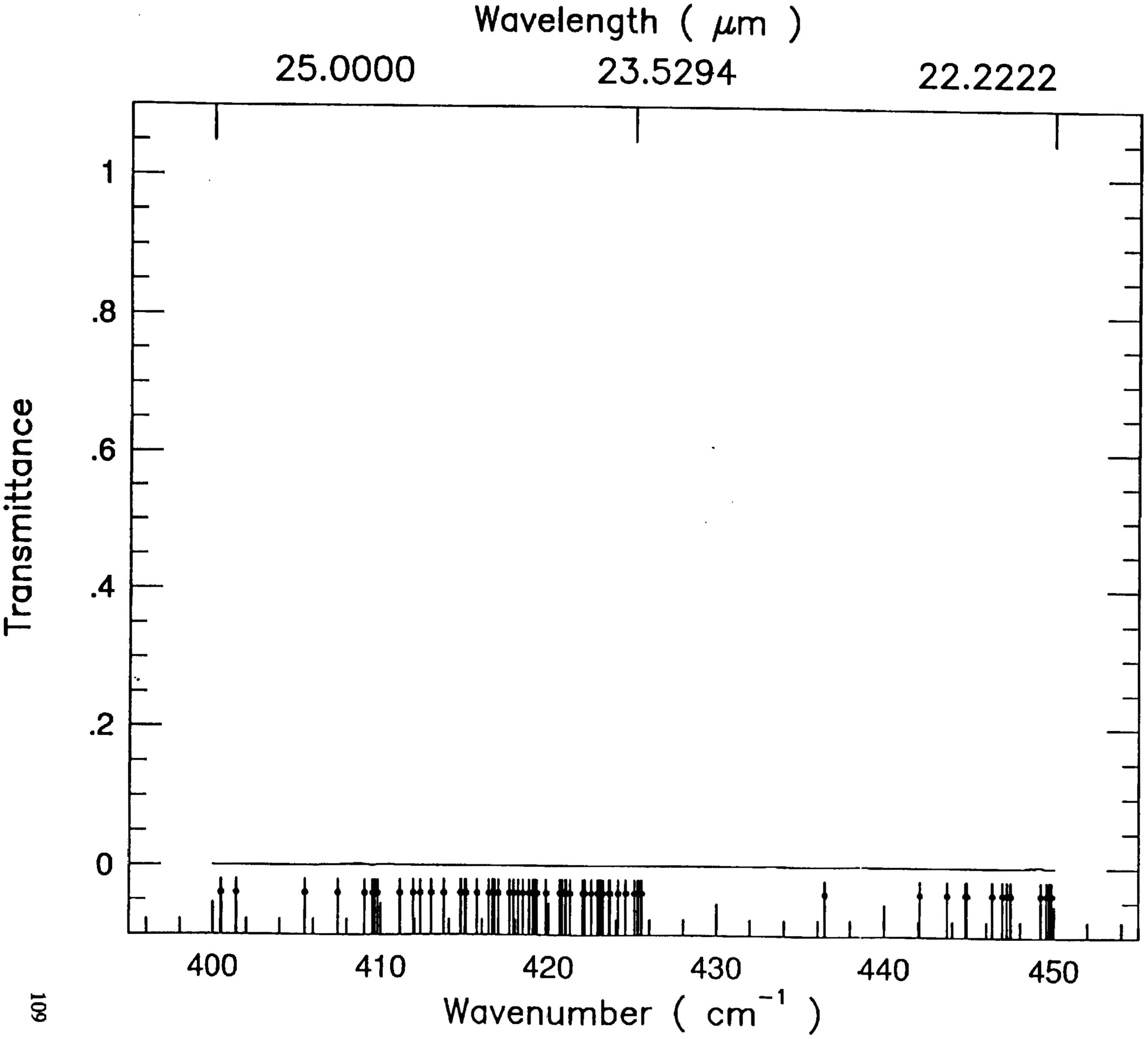
#11

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	350.000
Lambda 2	400.000
Sampling	0.000357
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	26.786
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:11:19 1991



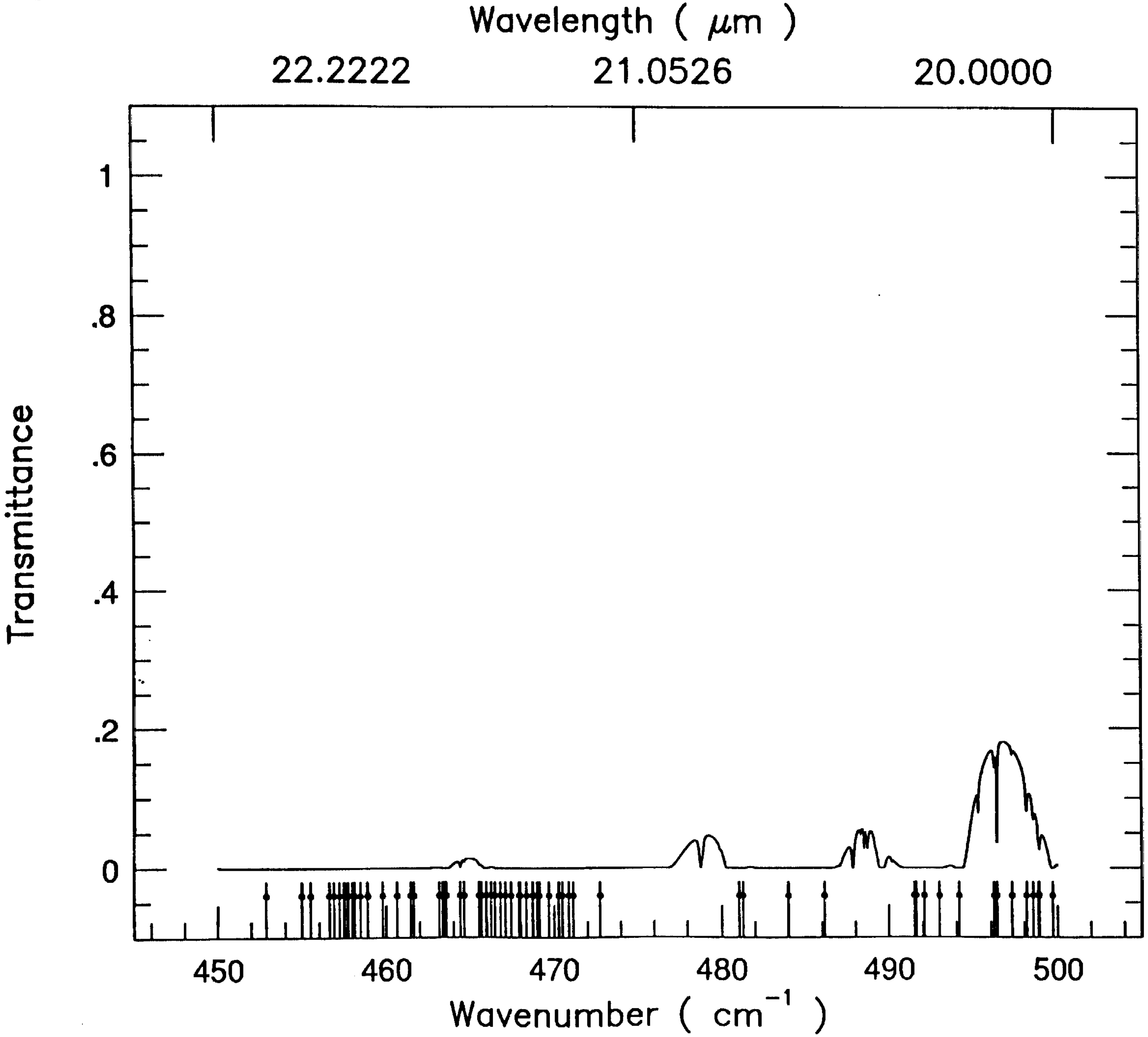
#12

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	400.000
Lambda 2	450.000
Sampling	0.000278
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	23.611
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:13:08 1991



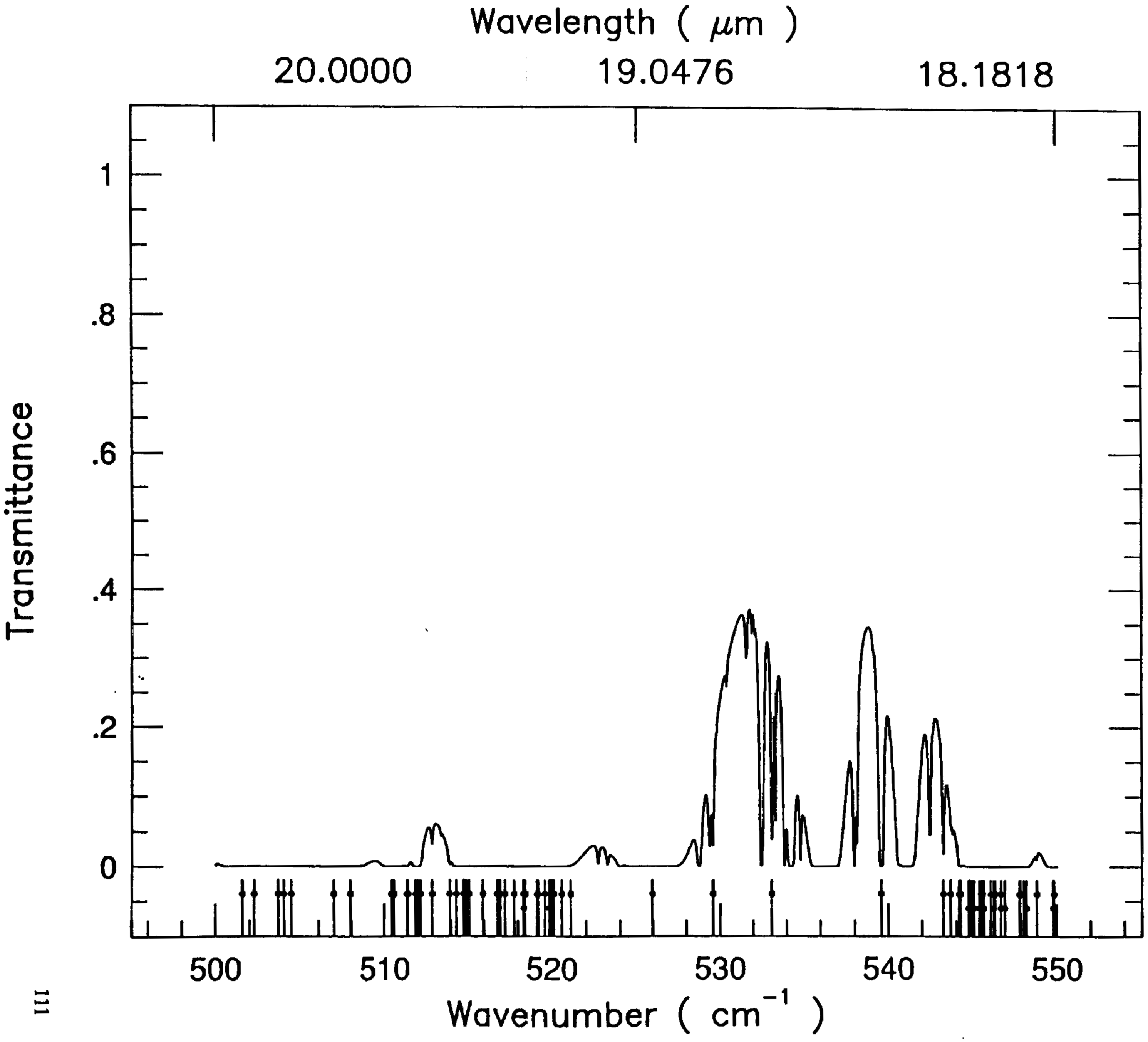
#13

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	450.000
Lambda 2	500.000
Sampling	0.000222
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	21.111
Num. Pts.	10000
Ozone	9.13E+18

Wed Oct 23 16:15:30 1991



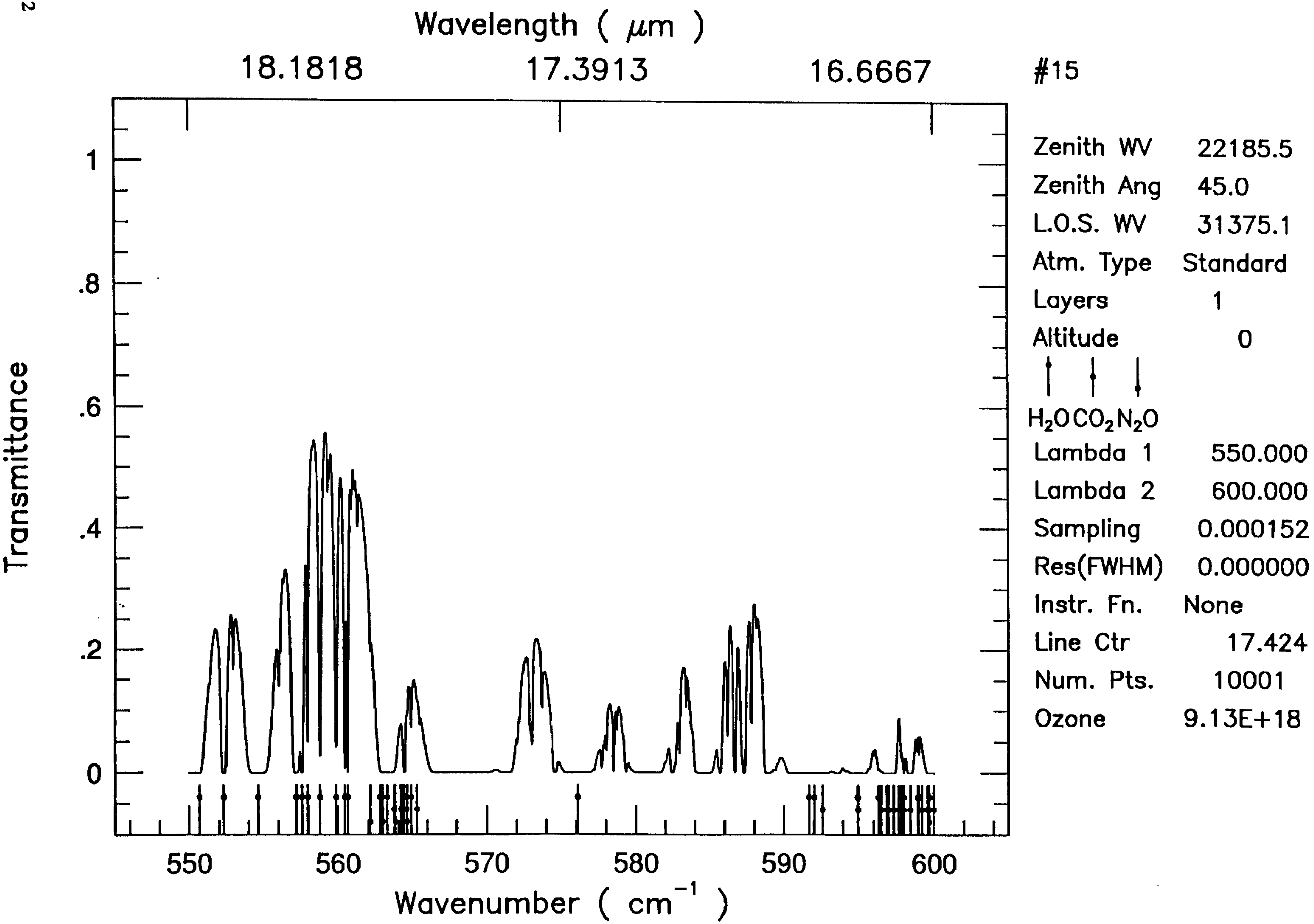
#14

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2

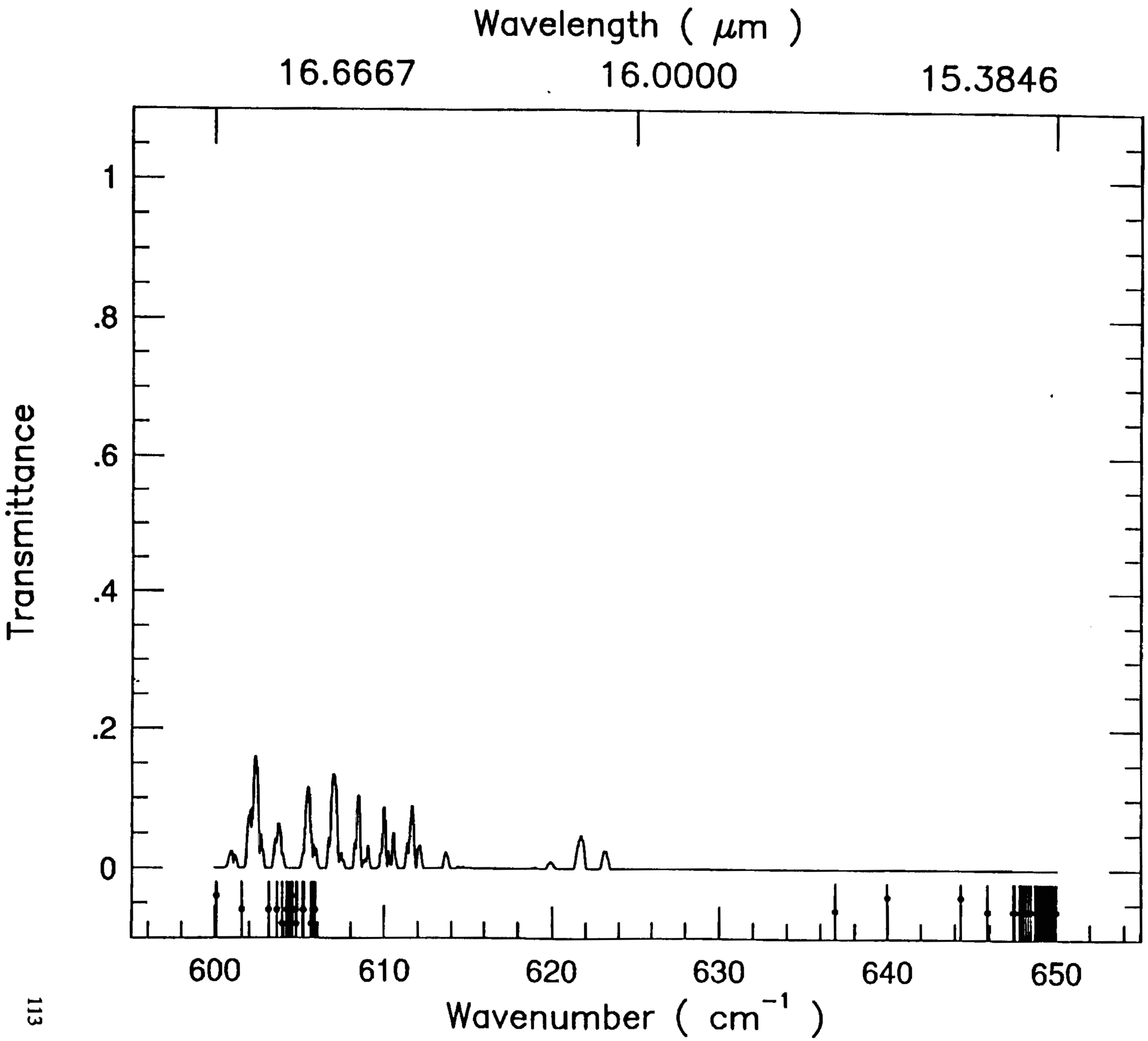
Lambda 1	500.000
Lambda 2	550.000
Sampling	0.000182
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	19.091
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:17:20 1991



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	550.000
Lambda 2	600.000
Sampling	0.000152
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	17.424
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:20:04 1991



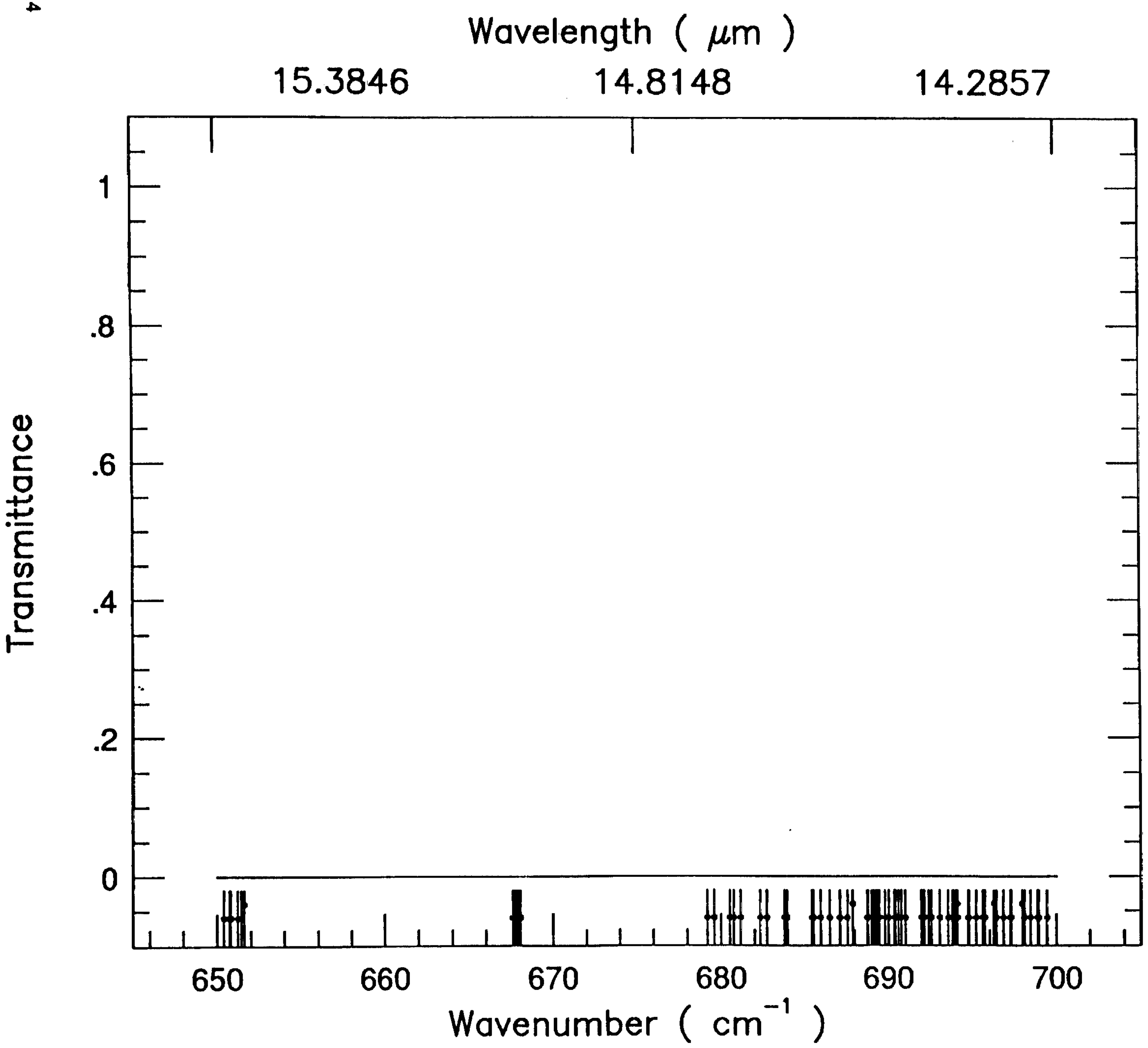
#16

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2 N_2O

Lambda 1	600.000
Lambda 2	650.000
Sampling	0.000128
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	16.026
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:24:26 1991



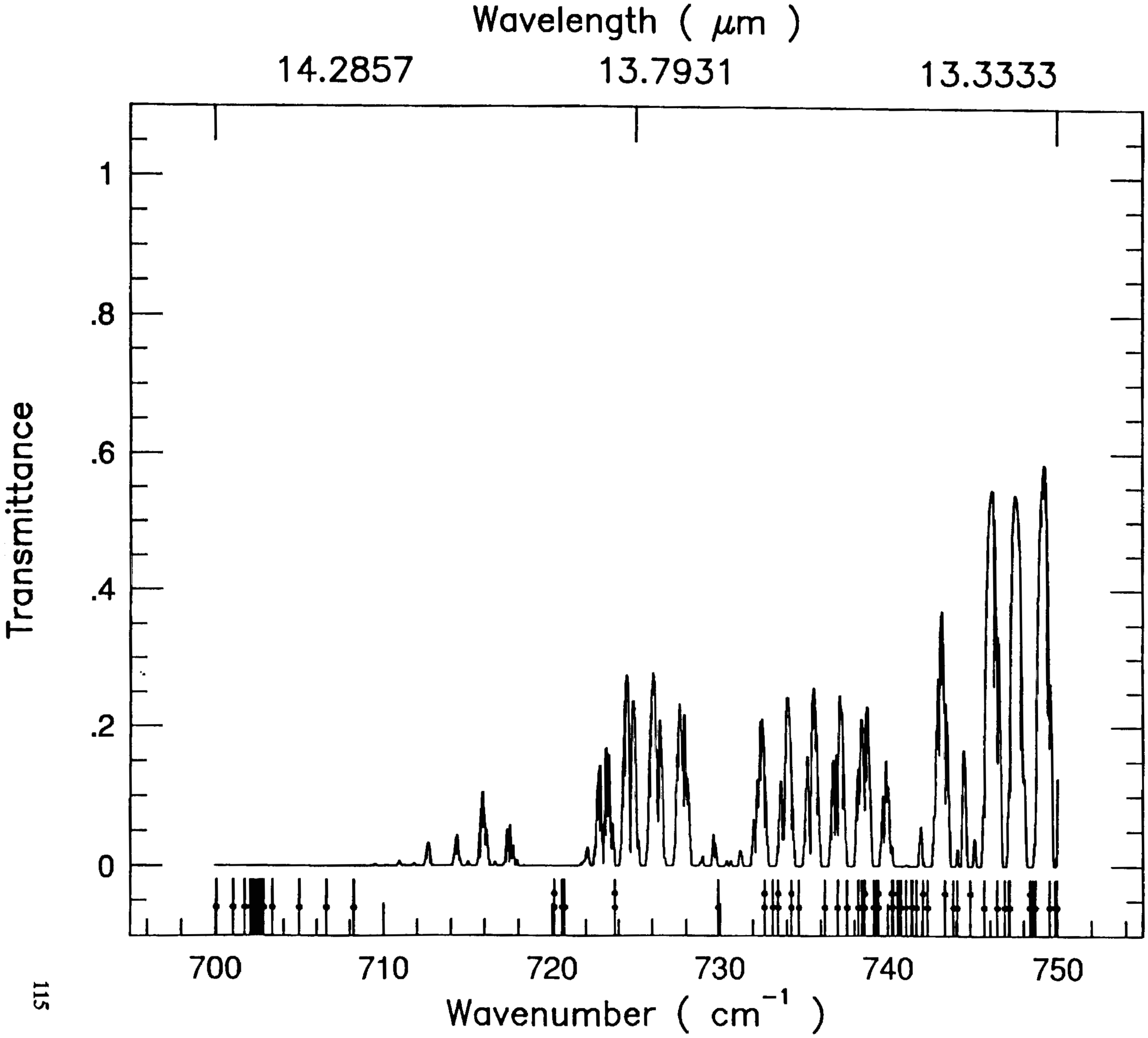
#17

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2

Lambda 1	650.000
Lambda 2	700.000
Sampling	0.000110
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	14.835
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:29:37 1991



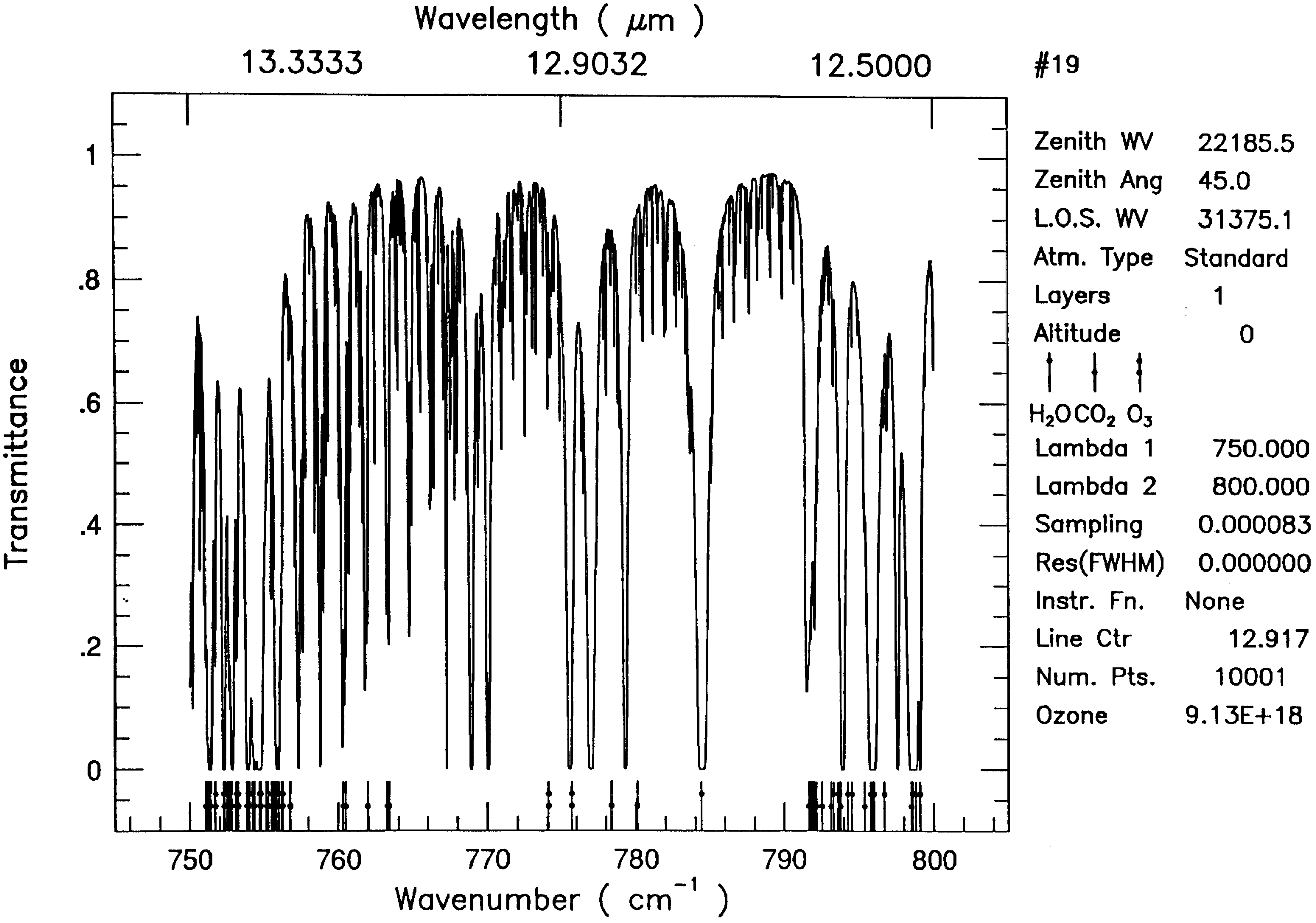
#18

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2 O_3

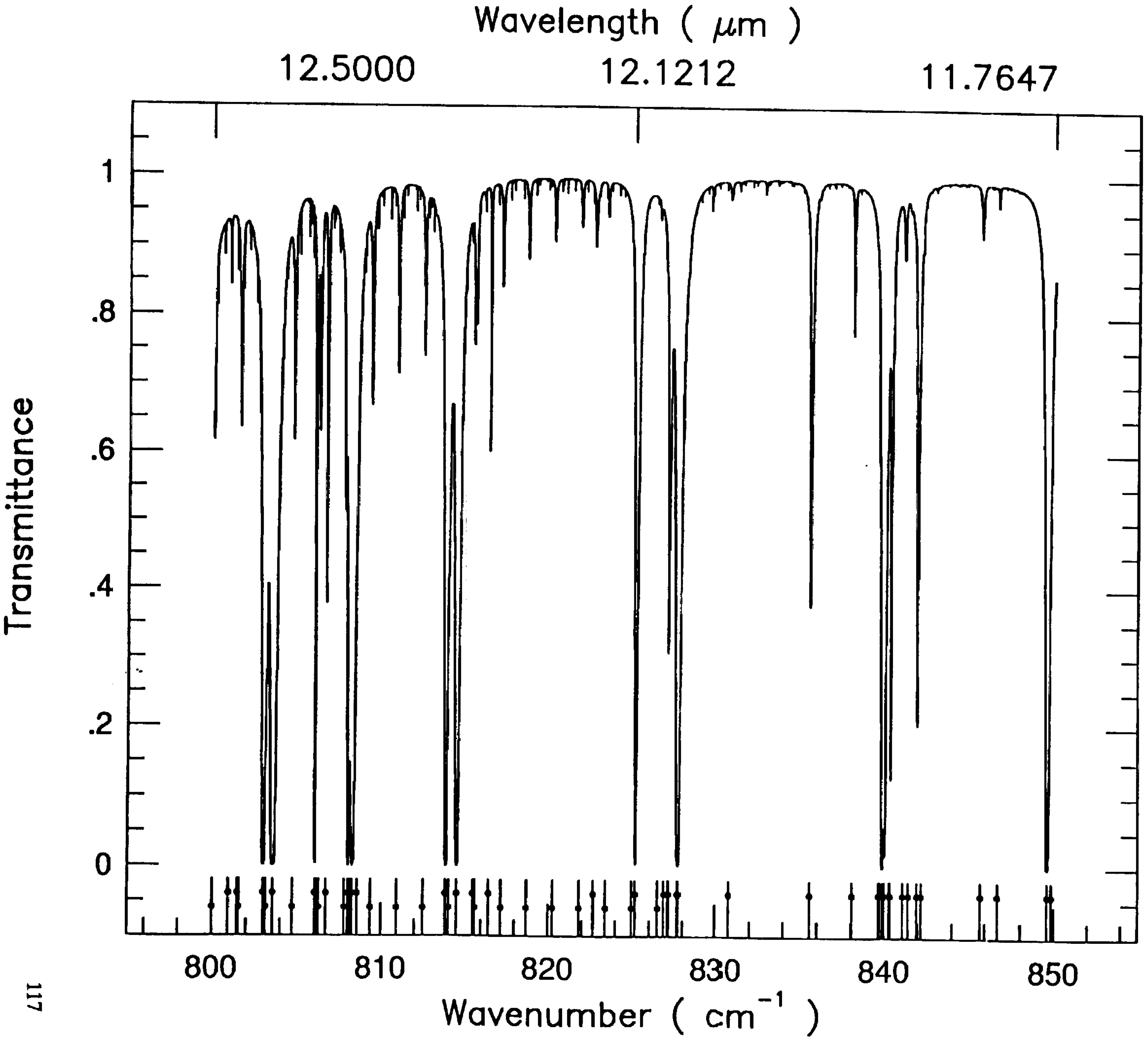
Lambda 1	700.000
Lambda 2	750.000
Sampling	0.000095
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	13.810
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:32:42 1991



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	750.000
Lambda 2	800.000
Sampling	0.000083
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	12.917
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:34:32 1991



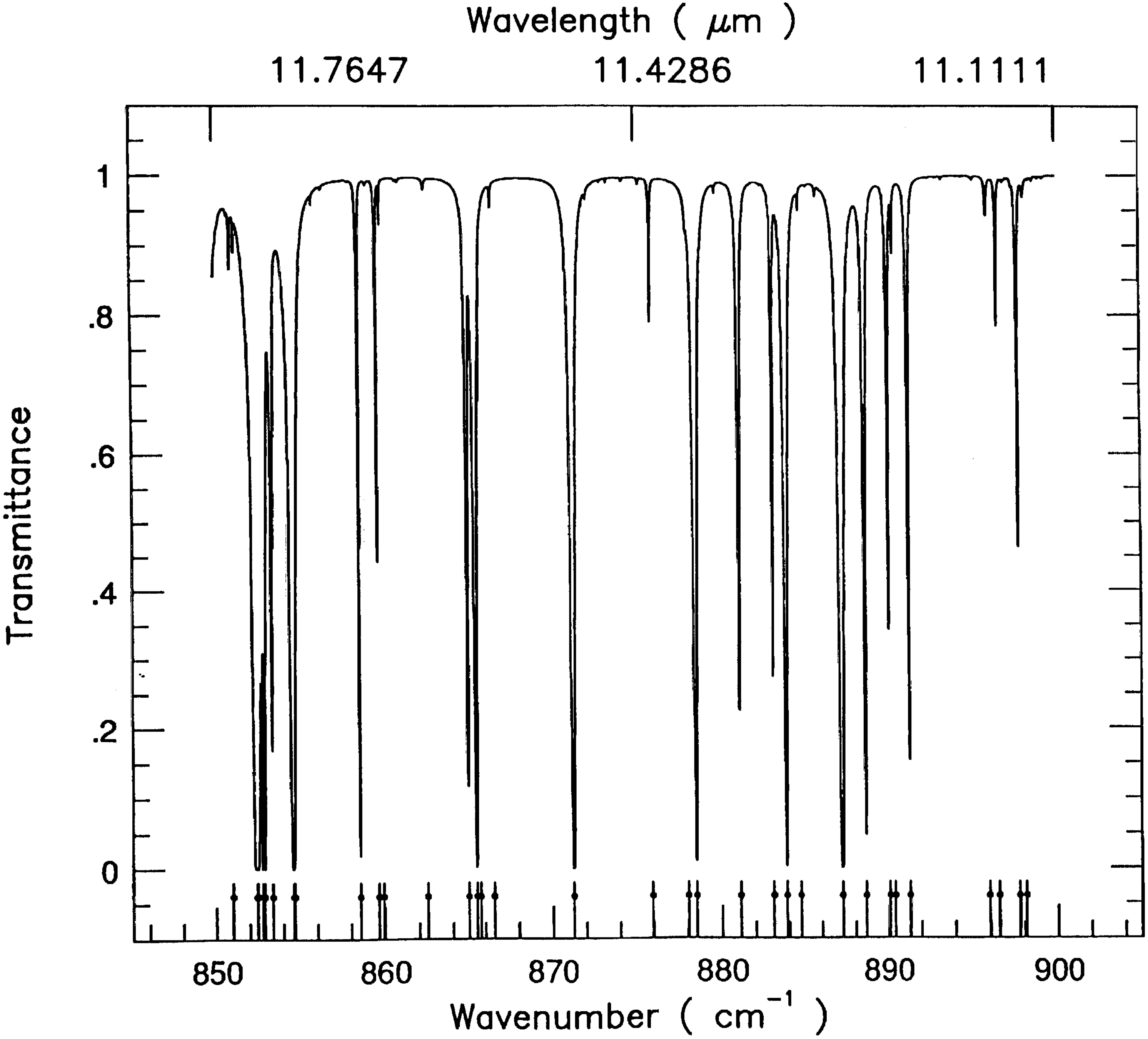
#20

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2

Lambda 1	800.000
Lambda 2	850.000
Sampling	0.000074
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	12.132
Num. Pts.	10001
Ozone	9.13E+18

Wed Oct 23 16:37:03 1991



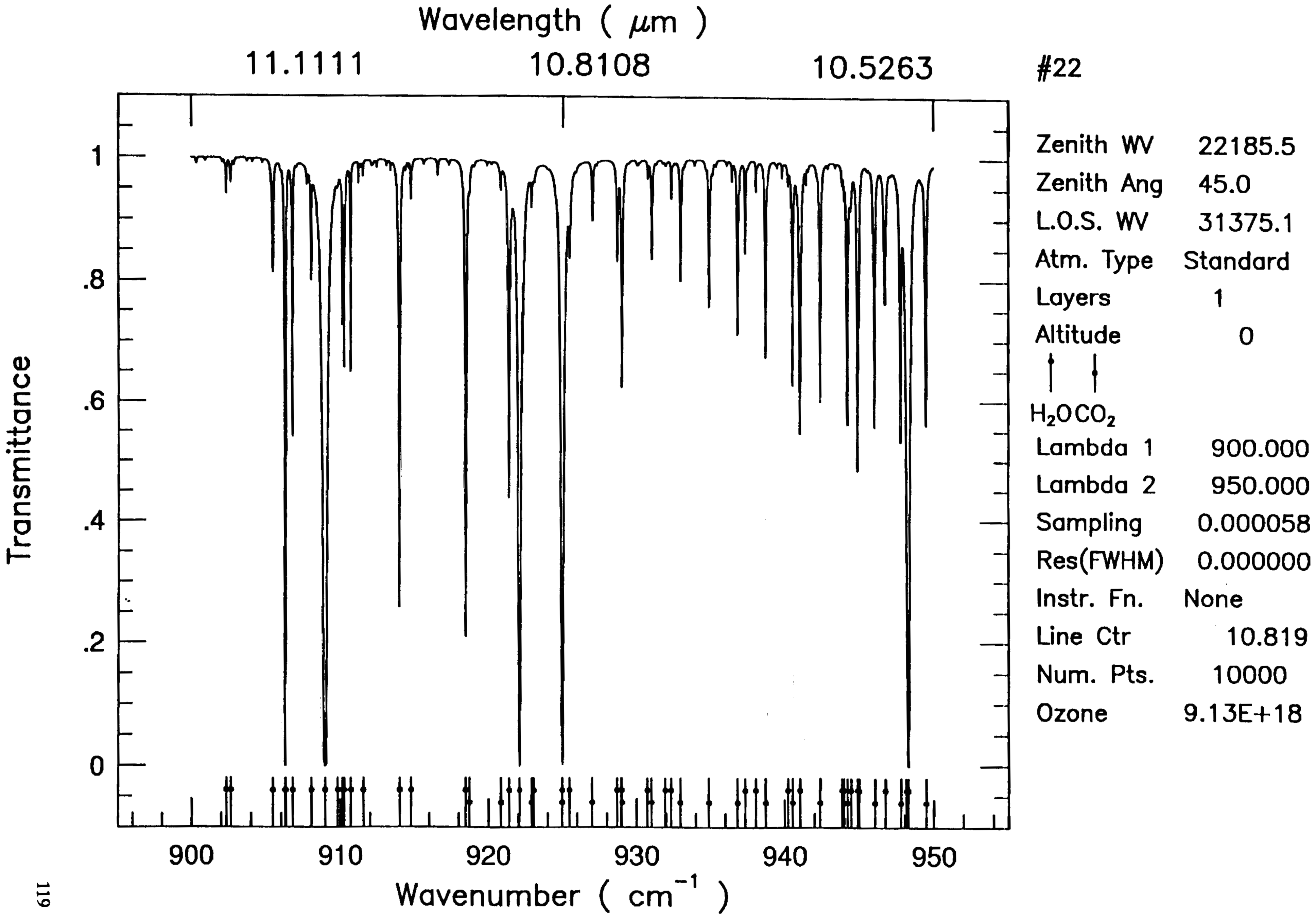
#21

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	850.000
Lambda 2	900.000
Sampling	0.000065
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	11.438
Num. Pts.	10001
Ozone	9.13E+18

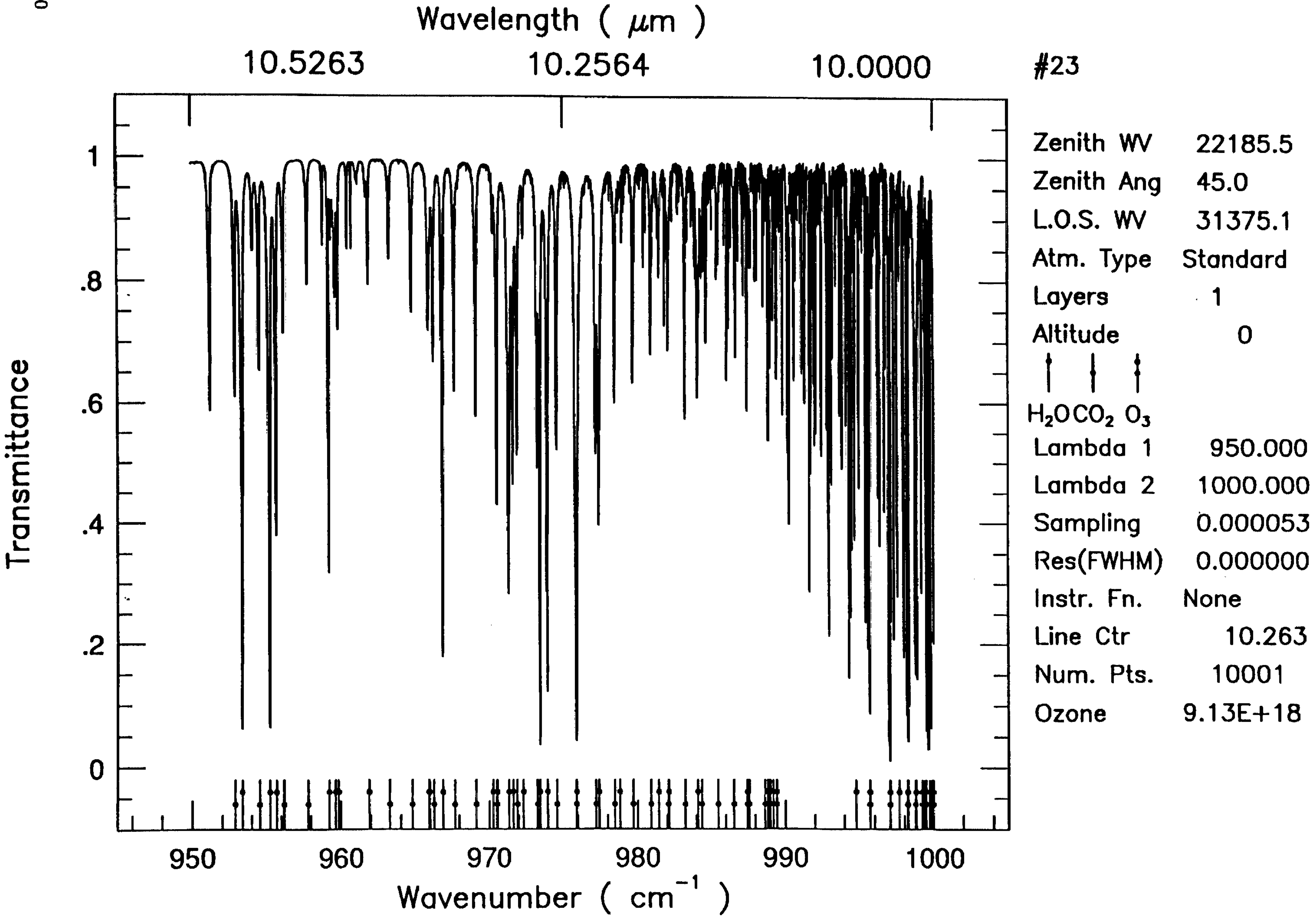
Wed Oct 23 16:39:17 1991



#22

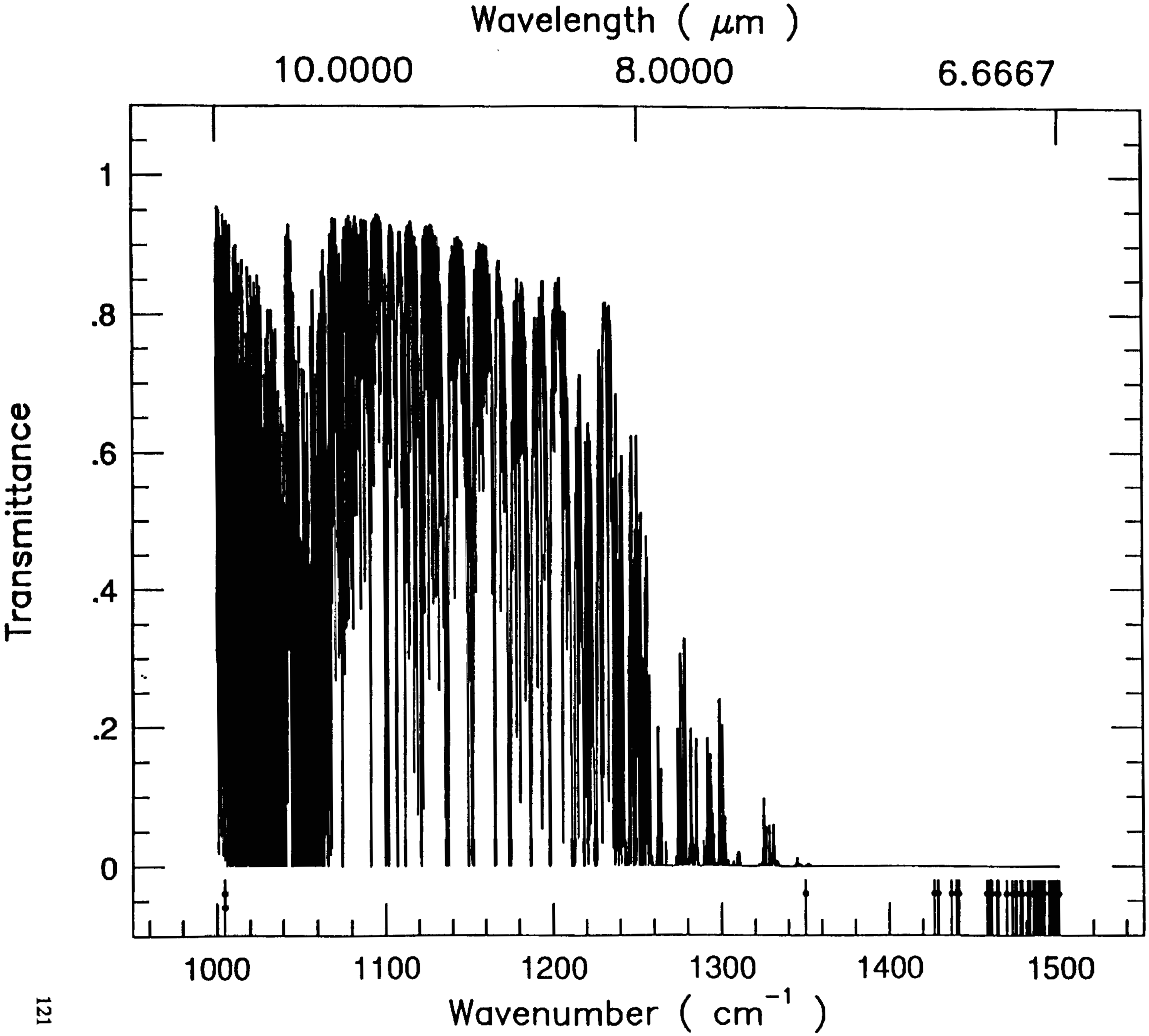
Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	900.000
Lambda 2	950.000
Sampling	0.000058
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	10.819
Num. Pts.	10000
Ozone	9.13E+18

Wed Oct 23 16:40:57 1991



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	950.000
Lambda 2	1000.000
Sampling	0.000053
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	10.263
Num. Pts.	10001
Ozone	9.13E+18

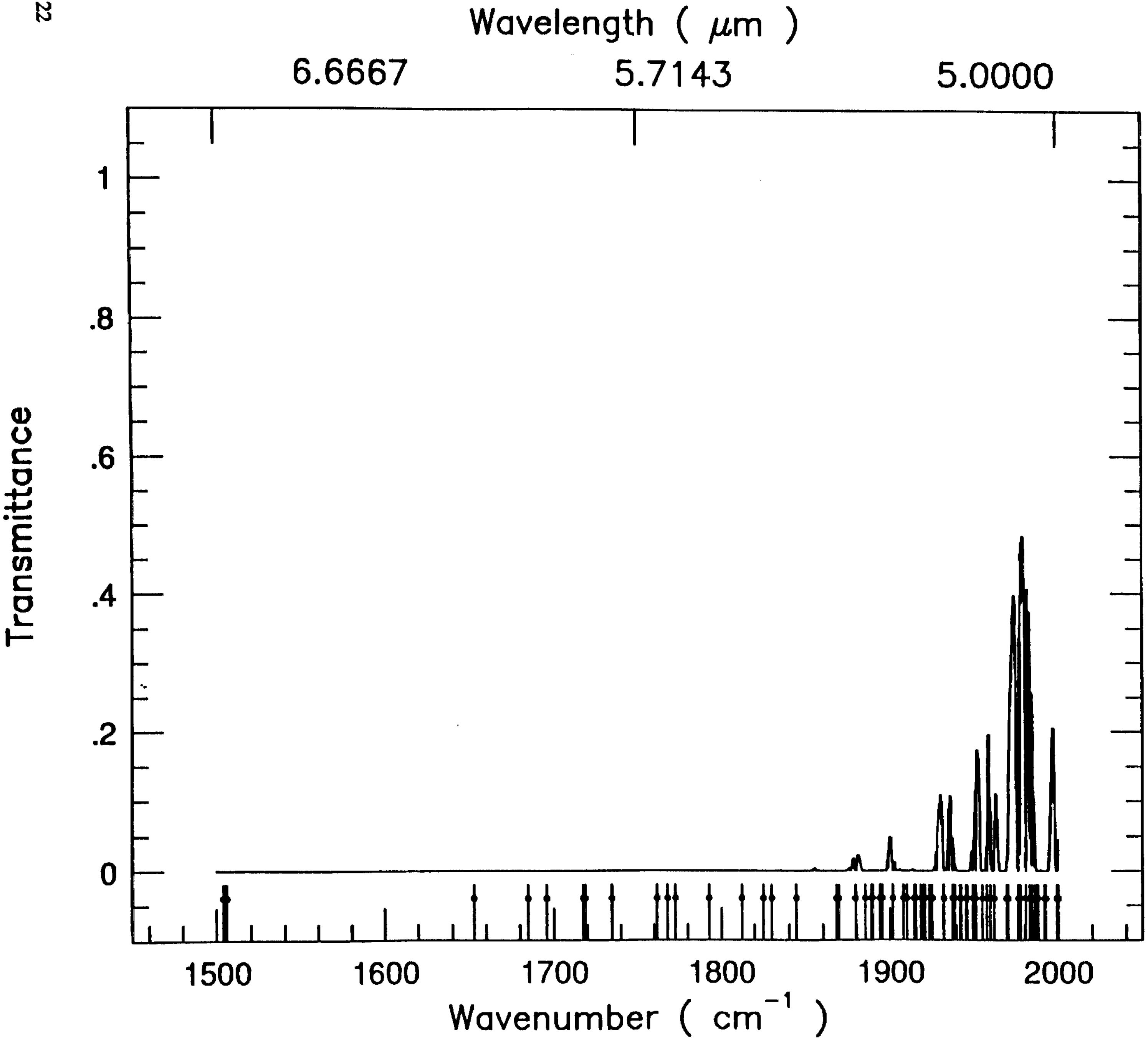
Wed Oct 23 16:43:34 1991



#24

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	1000.000
Lambda 2	1500.000
Sampling	0.000200
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	8.333
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:02:30 1991



#25

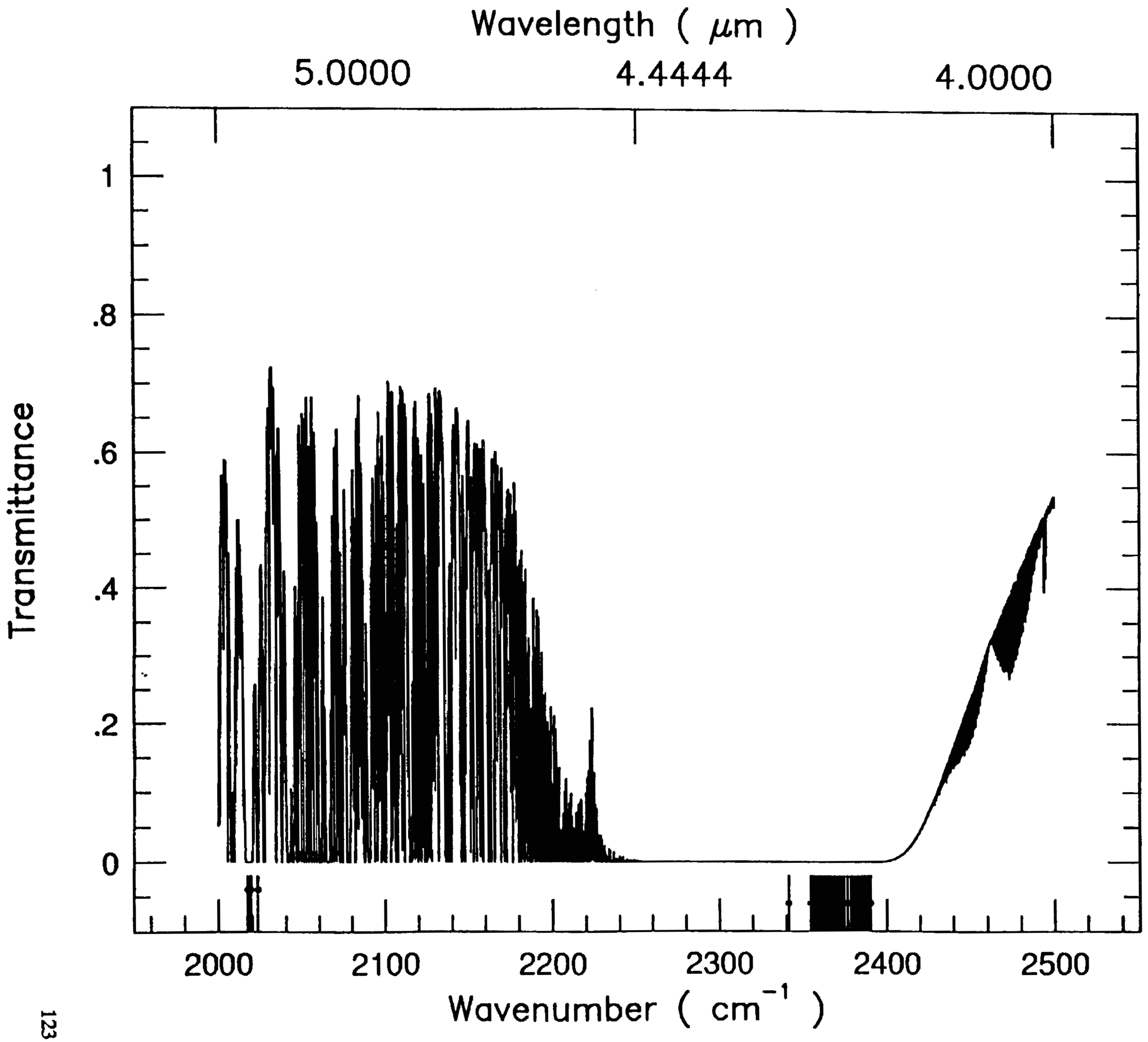
Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	1500.000
Lambda 2	2000.000
Sampling	0.000100
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	5.833
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:12:45 1991

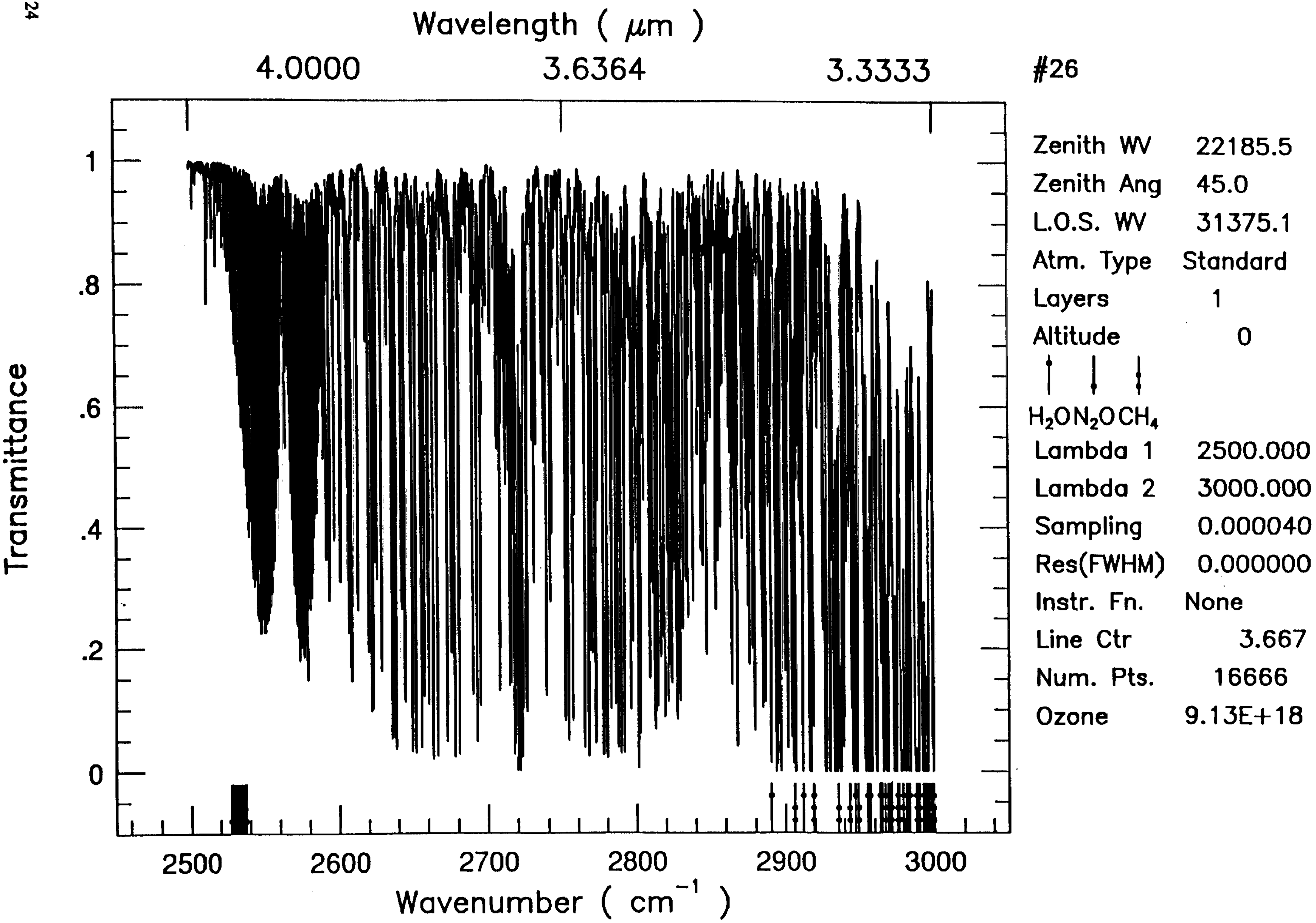
#25a



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

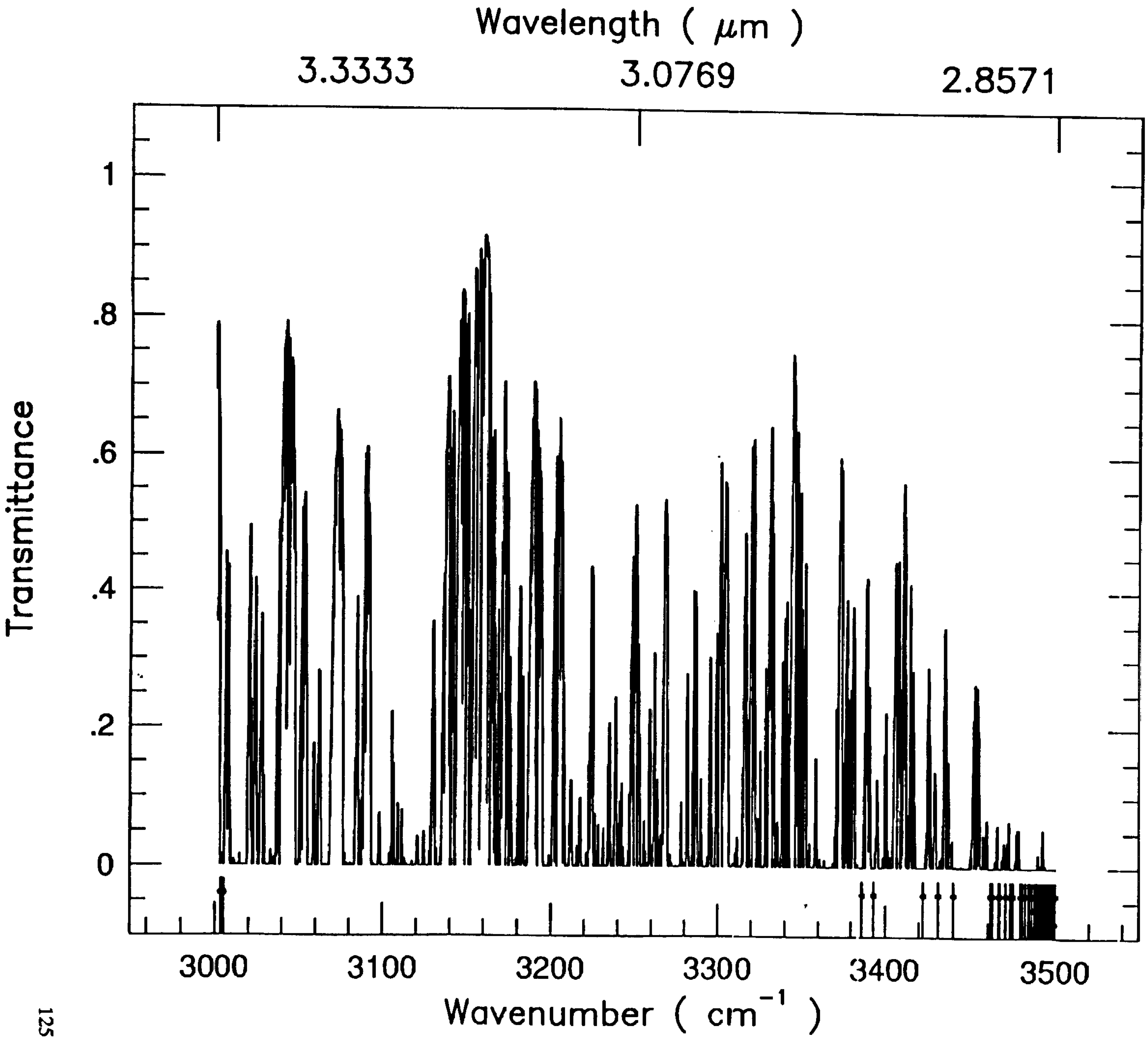
Lambda 1	2000.000
Lambda 2	2500.000
Sampling	0.000060
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	4.500
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 16:53:17 1991



Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	2500.000
Lambda 2	3000.000
Sampling	0.000040
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	3.667
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:16:34 1991



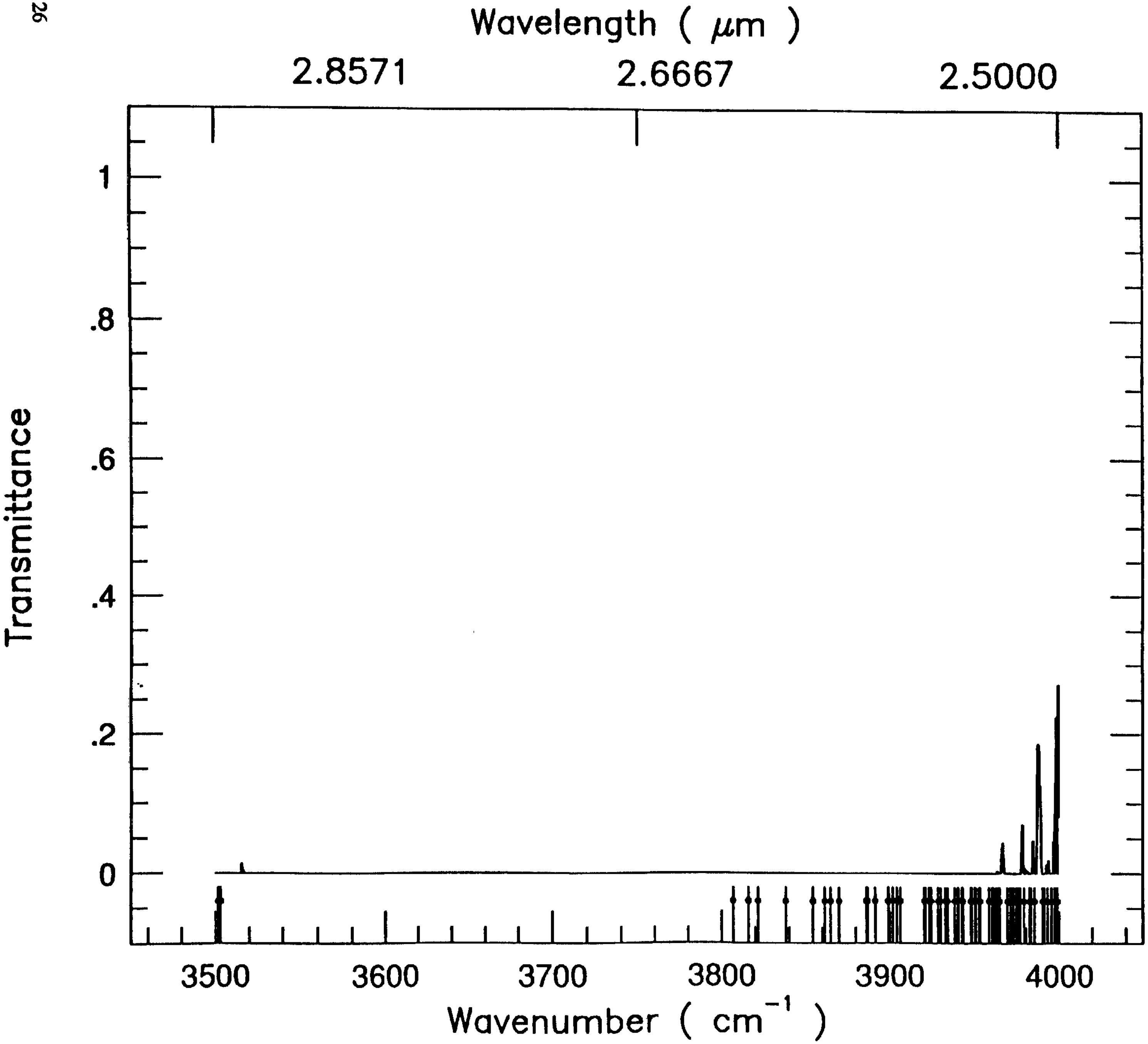
#27

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2 N_2O

Lambda 1	3000.000
Lambda 2	3500.000
Sampling	0.000029
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	3.095
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:21:35 1991



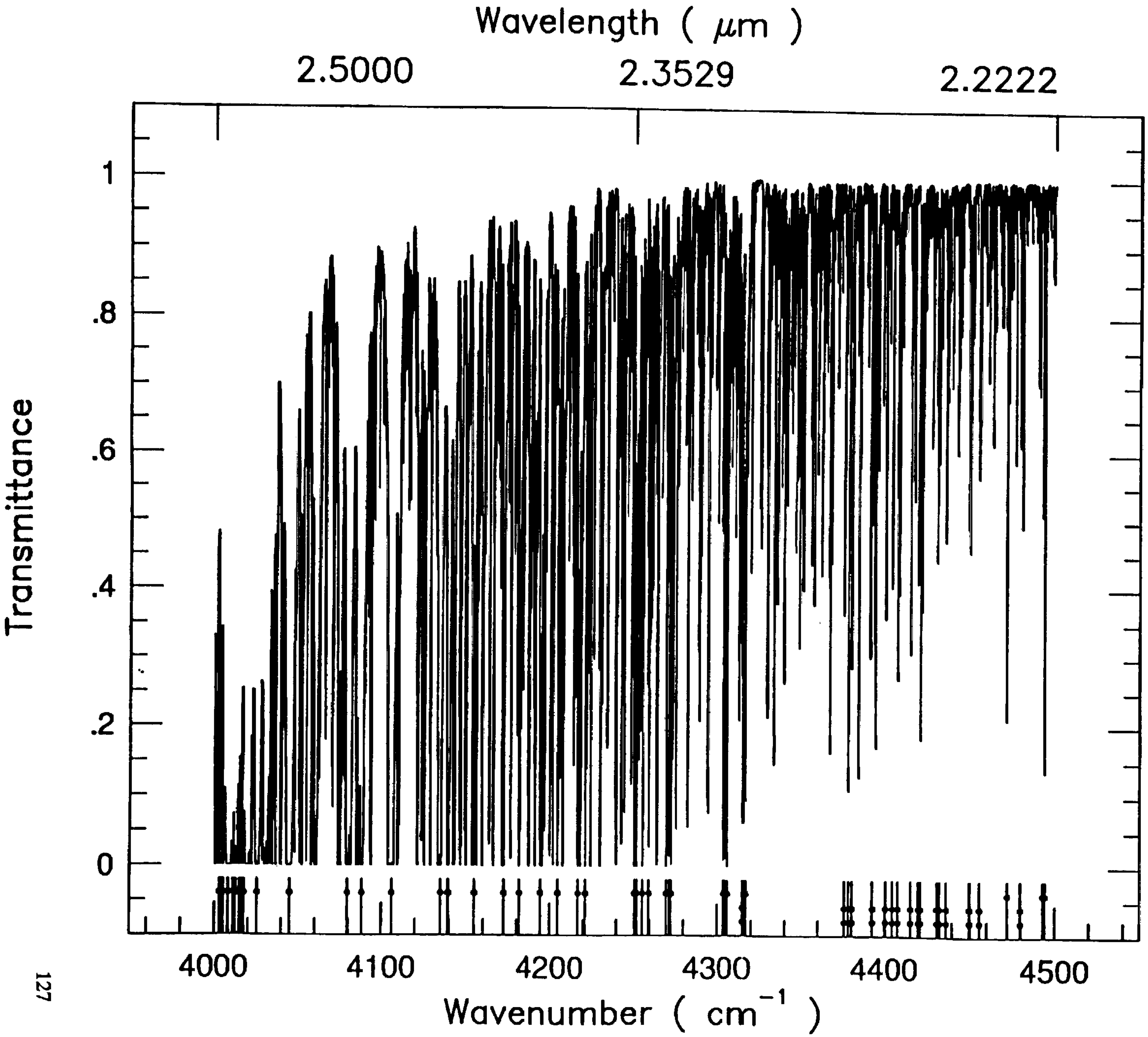
#28

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	3500.000
Lambda 2	4000.000
Sampling	0.000021
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.679
Num. Pts.	16666
Ozone	9.13E+18

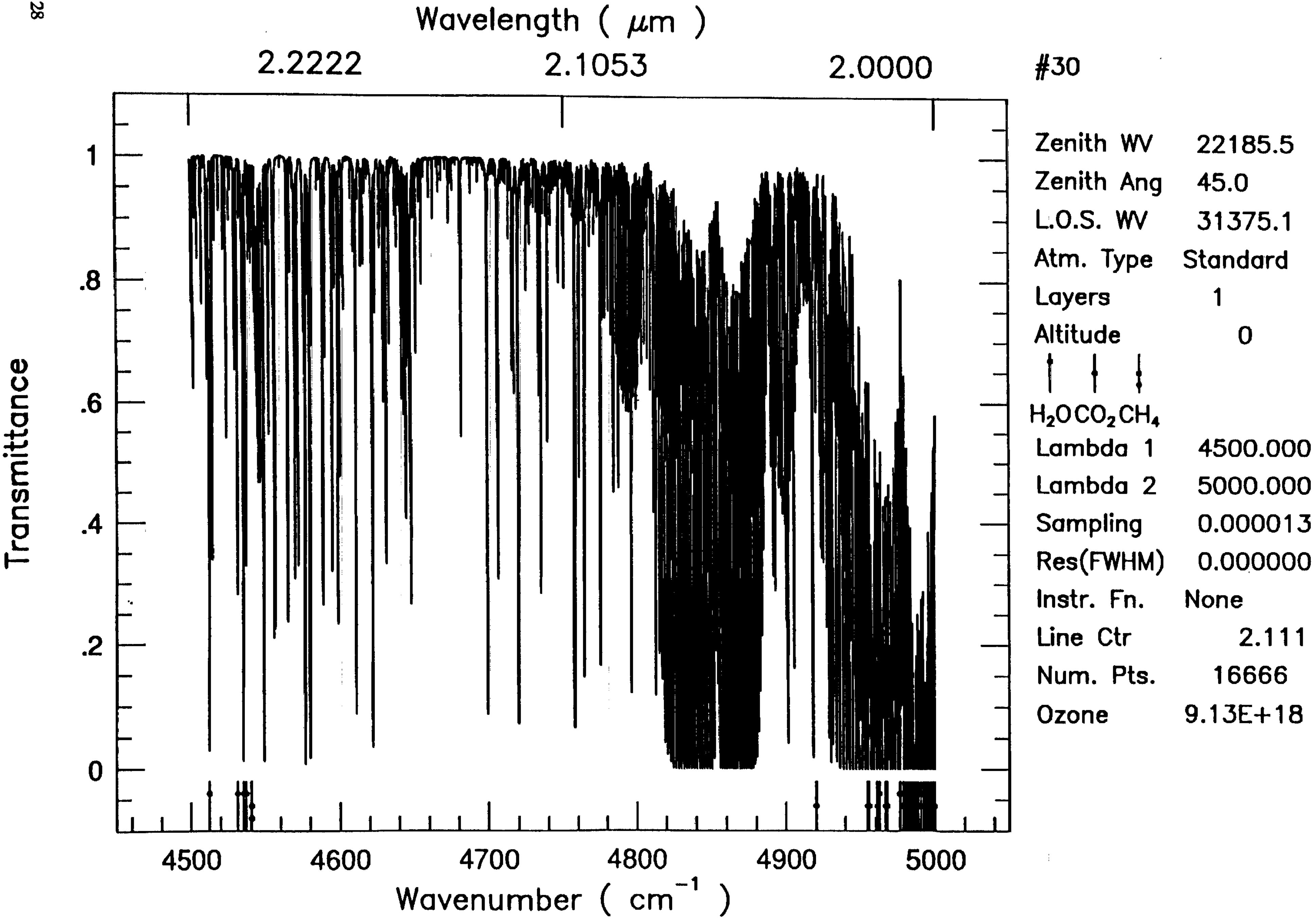
Wed Oct 23 17:33:14 1991



#29

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	4000.000
Lambda 2	4500.000
Sampling	0.000017
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.361
Num. Pts.	16666
Ozone	9.13E+18

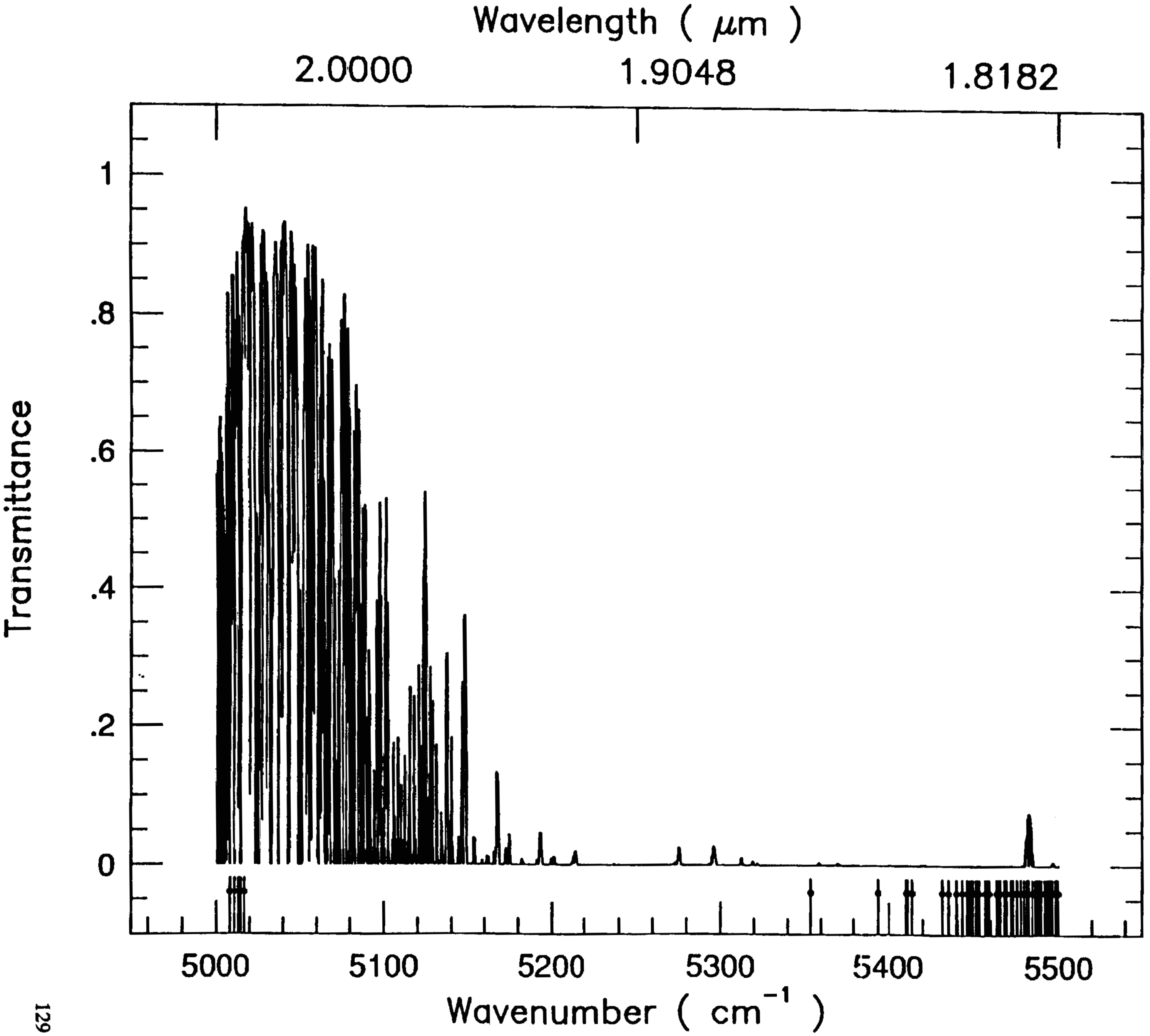
Wed Oct 23 17:36:18 1991



#30

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
Lambda 1	4500.000
Lambda 2	5000.000
Sampling	0.000013
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.111
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:39:08 1991



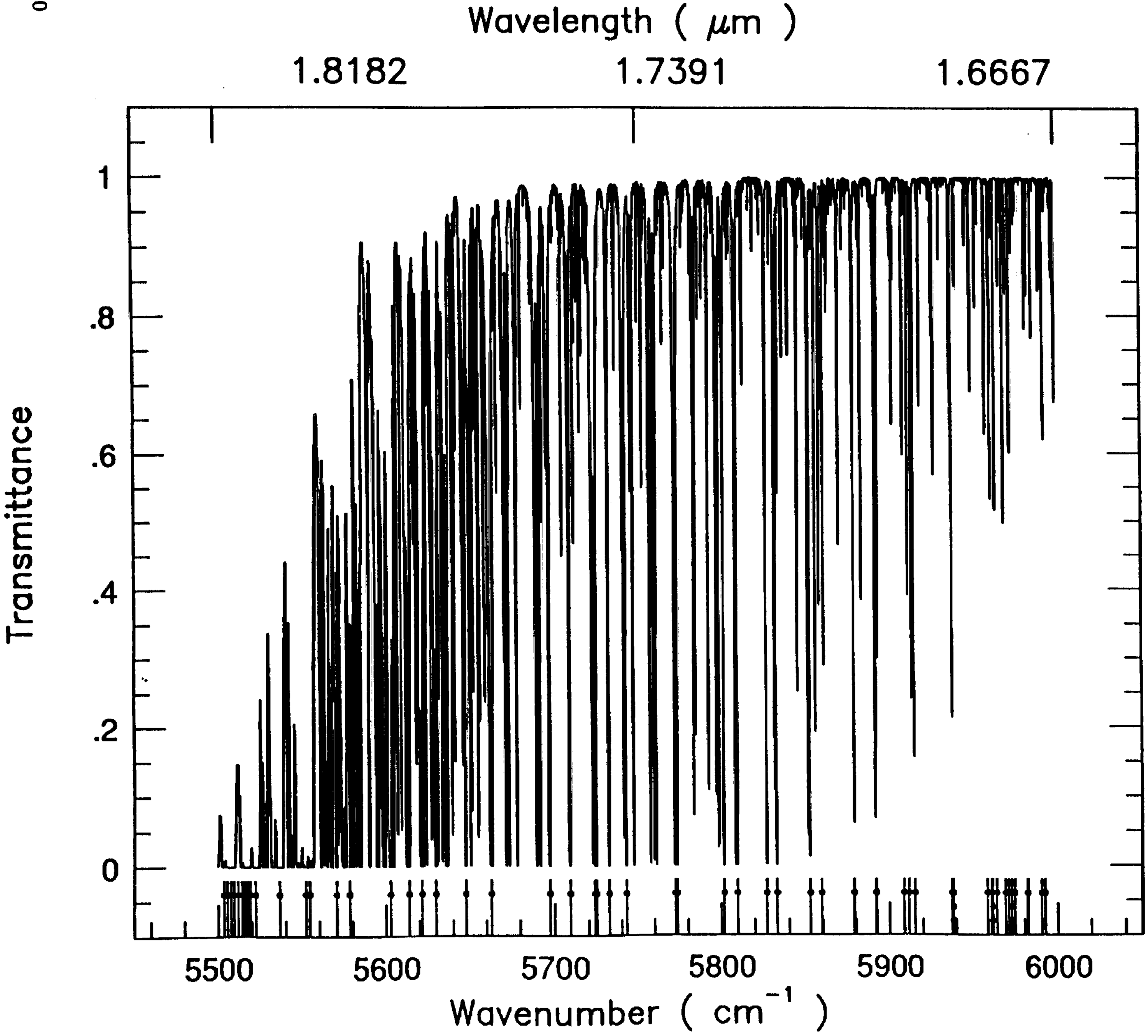
#31

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

↑
H_2O

Lambda 1	5000.000
Lambda 2	5500.000
Sampling	0.000011
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.909
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:43:42 1991



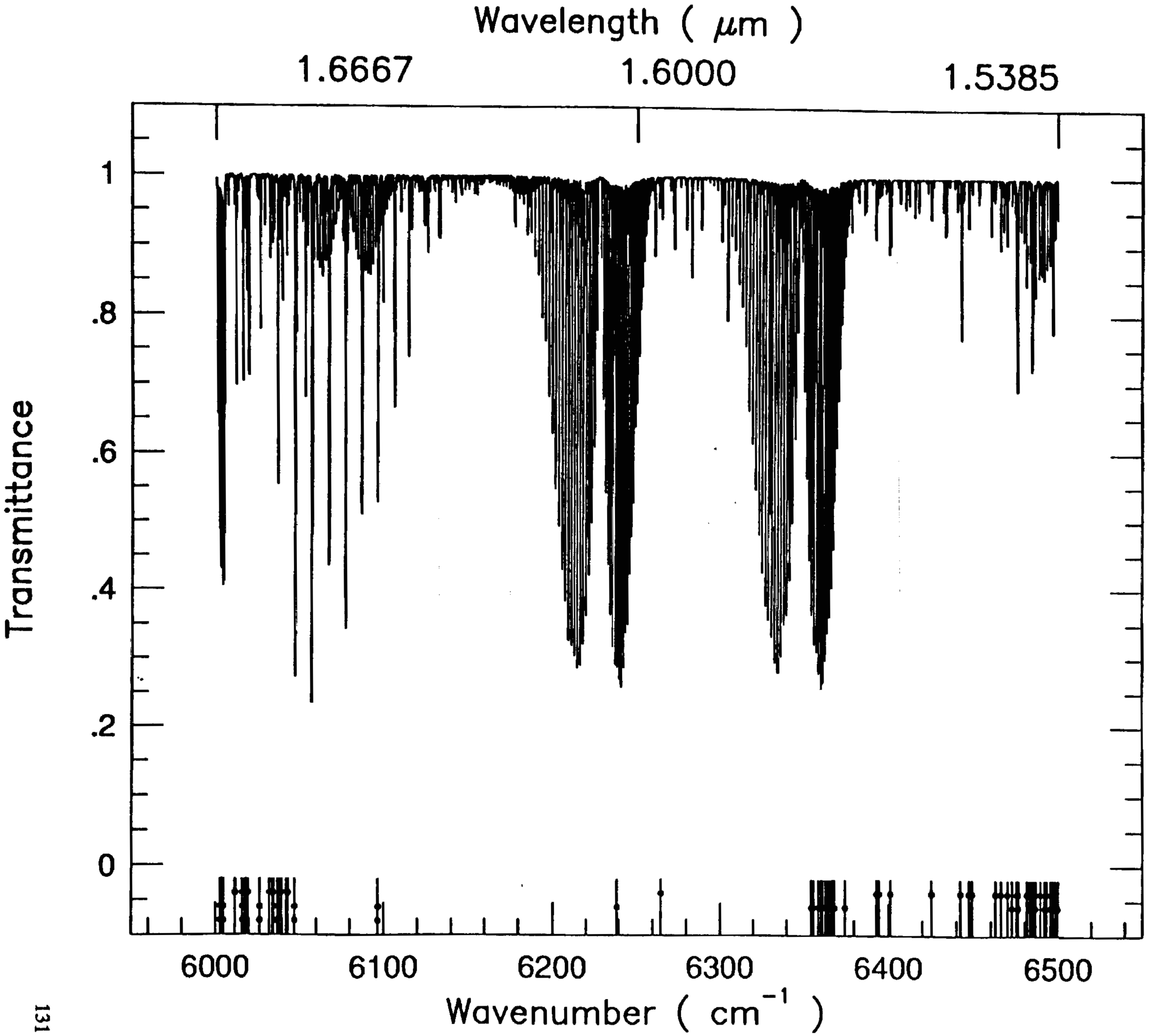
#32

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CH_4

Lambda 1	5500.000
Lambda 2	6000.000
Sampling	0.000009
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.742
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:46:31 1991



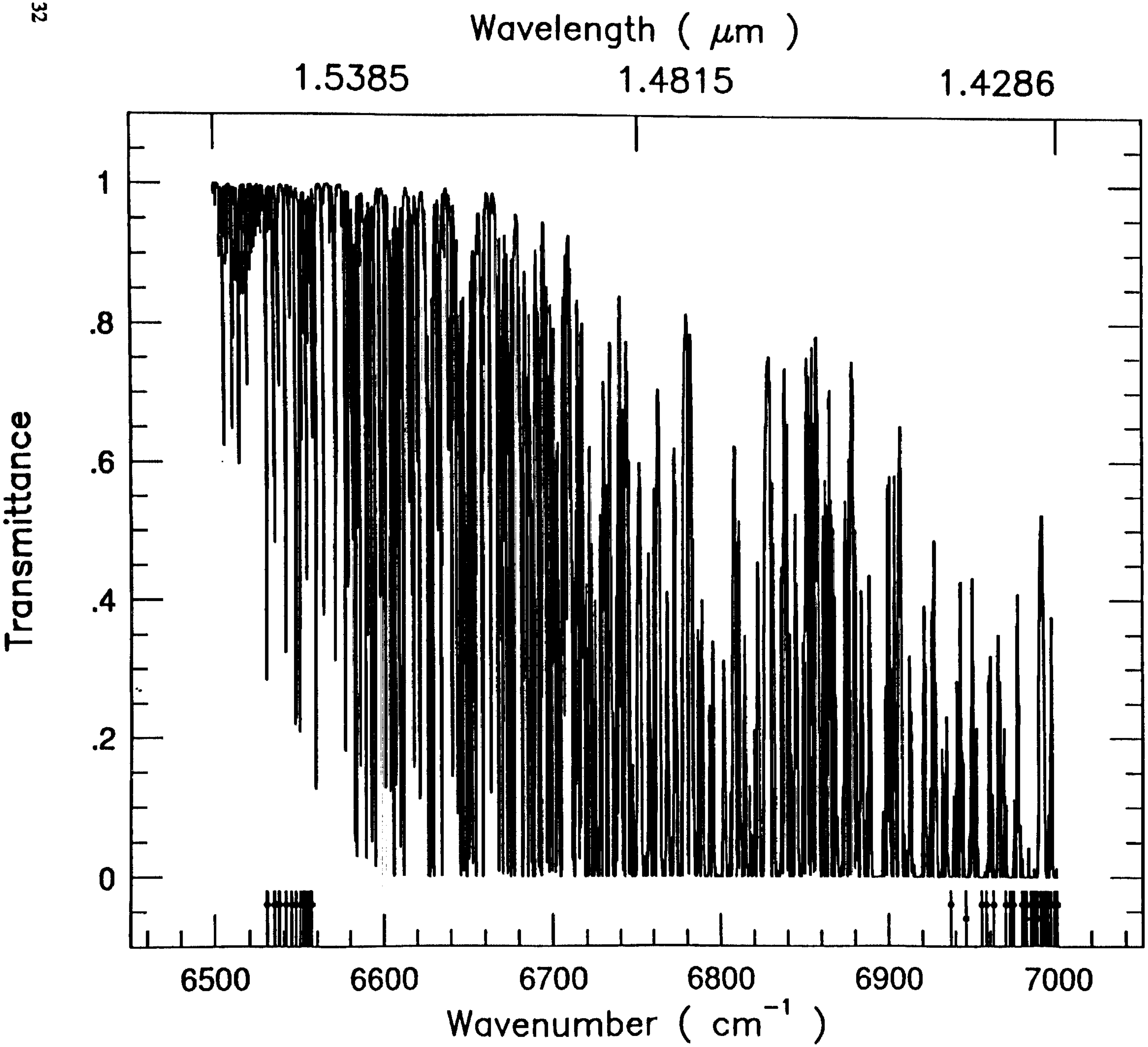
#33

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2 CH_4

Lambda 1	6000.000
Lambda 2	6500.000
Sampling	0.000008
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.603
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:49:07 1991



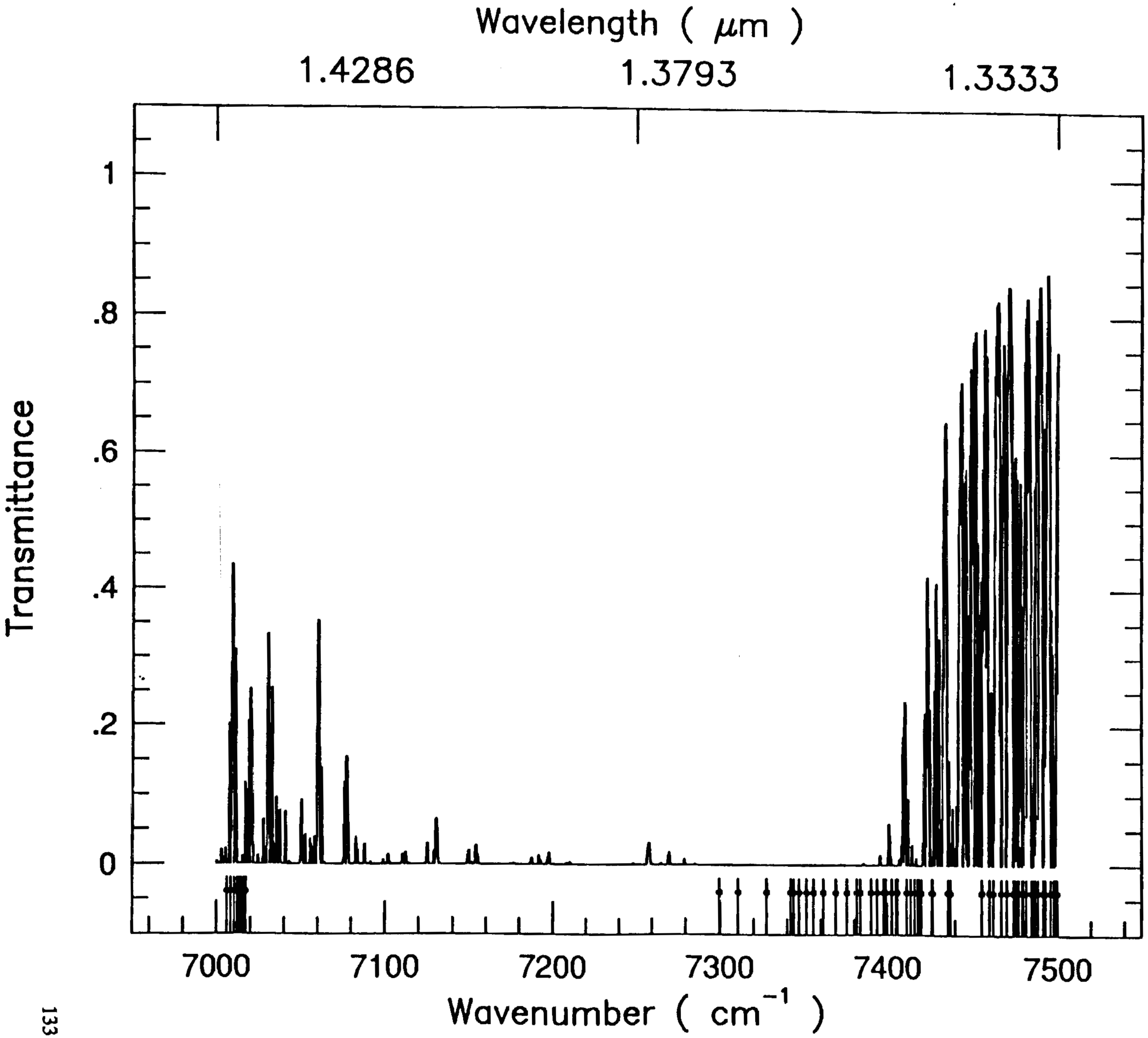
#34

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O CO_2

Lambda 1	6500.000
Lambda 2	7000.000
Sampling	0.000007
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.484
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:52:13 1991



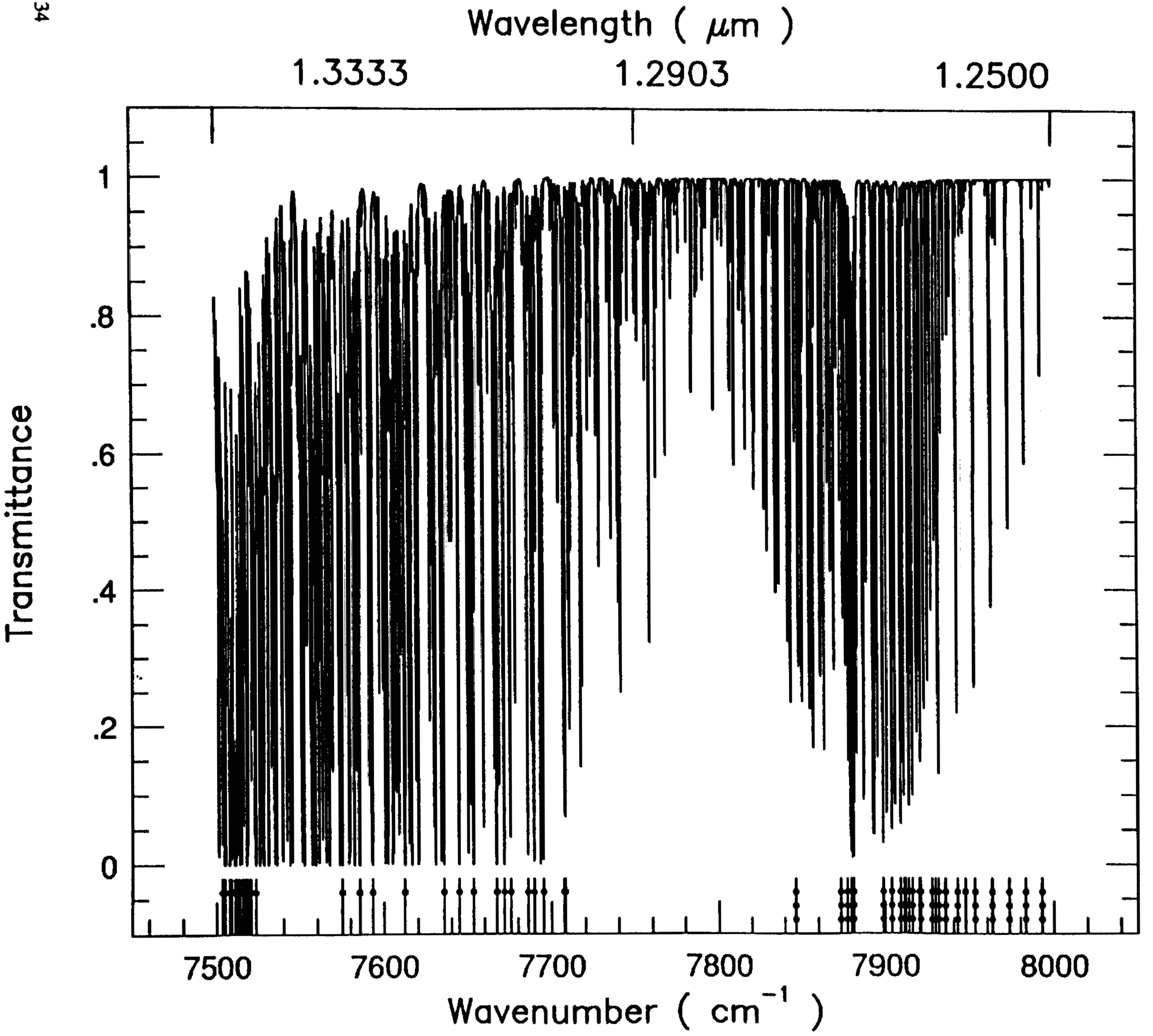
#35

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	7000.000
Lambda 2	7500.000
Sampling	0.000006
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.381
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 17:56:30 1991



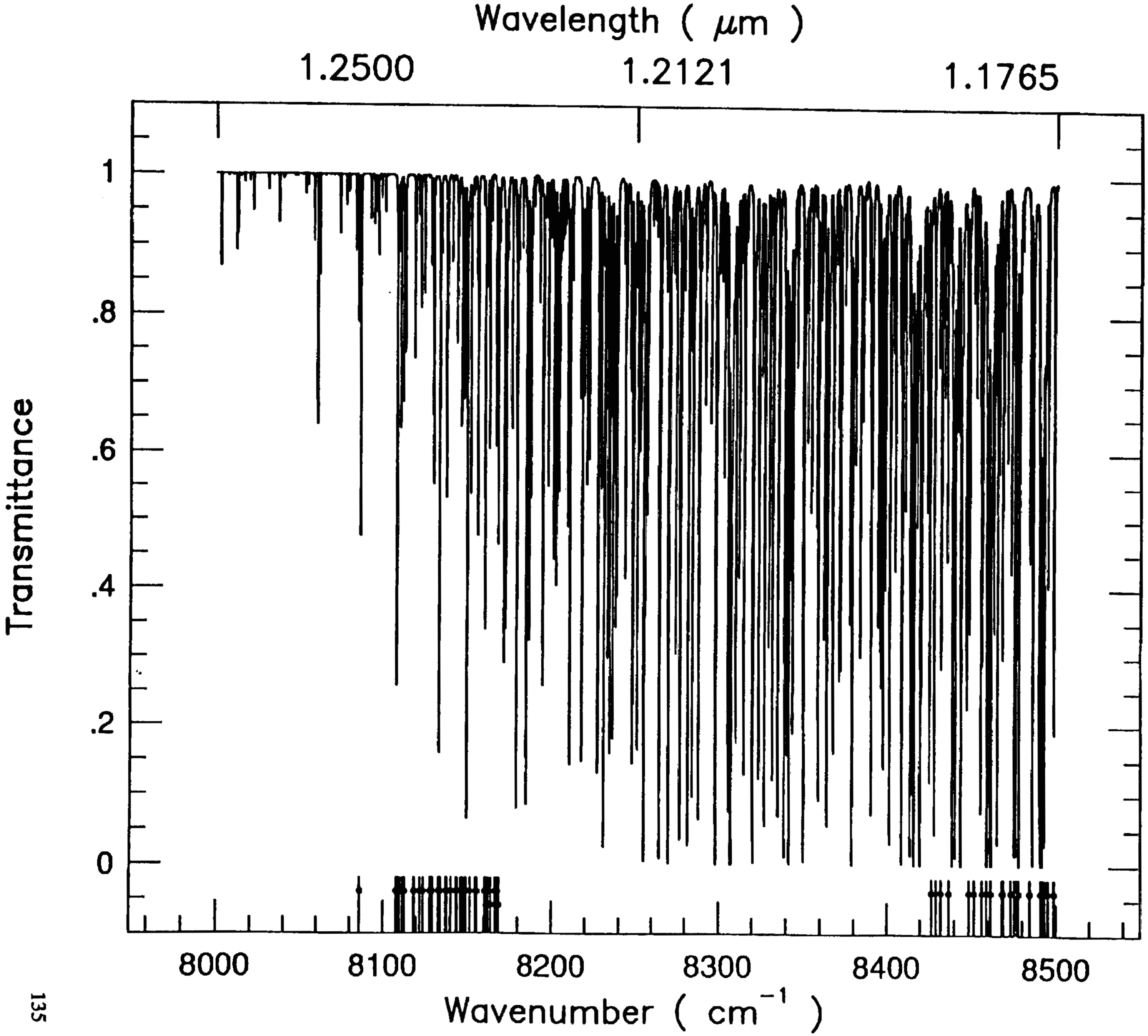
#36

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O O_2

Lambda 1	7500.000
Lambda 2	8000.000
Sampling	0.000005
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.292
Num. Pts.	16666
Ozone	9.13E+18

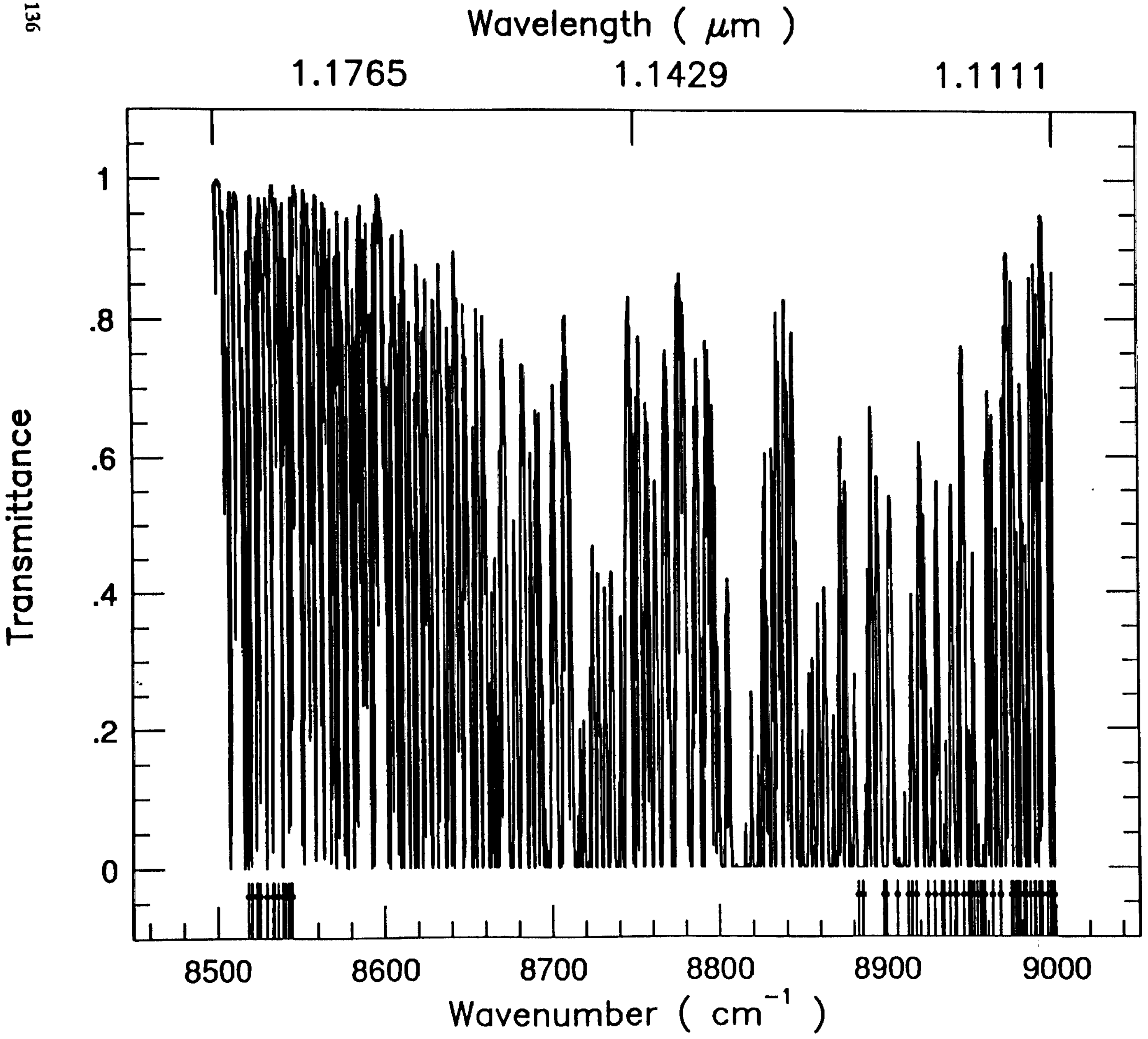
Wed Oct 23 17:59:13 1991



#37

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0
H_2O CO_2	
Lambda 1	8000.000
Lambda 2	8500.000
Sampling	0.000004
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.213
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:01:55 1991



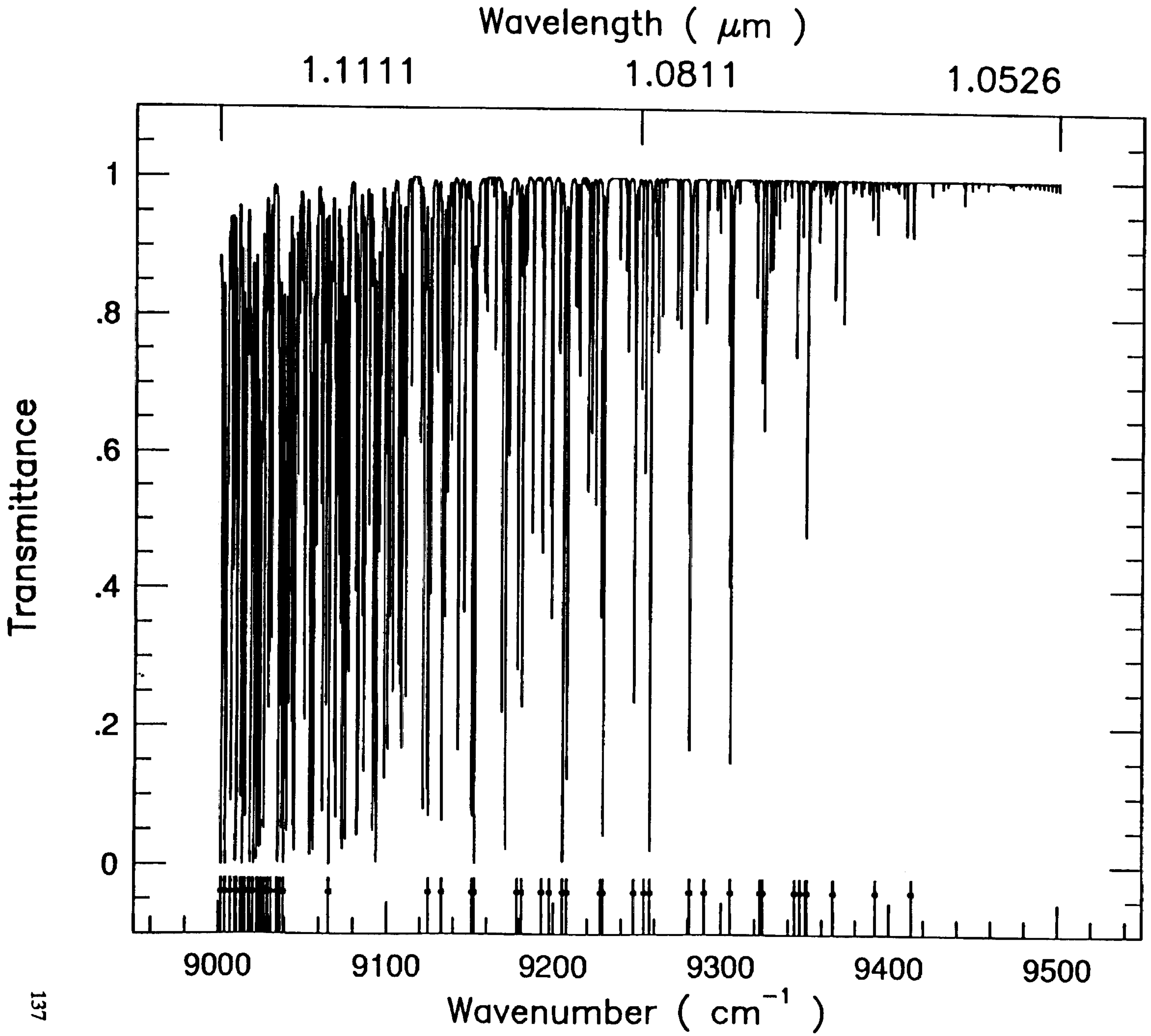
#38

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

↑
H_2O

Lambda 1	8500.000
Lambda 2	9000.000
Sampling	0.000004
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.144
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:05:02 1991



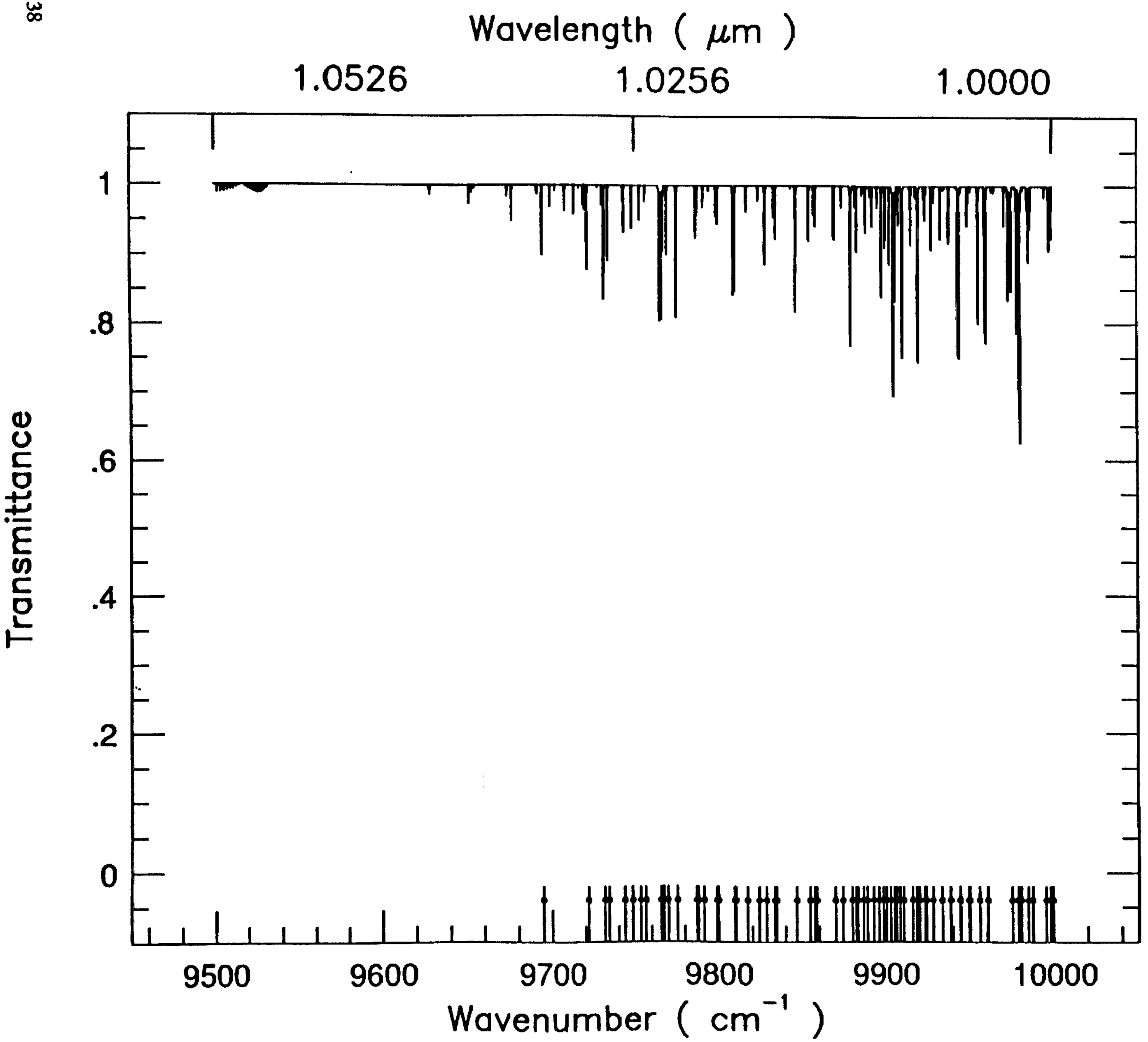
#39

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

↑
H_2O

Lambda 1	9000.000
Lambda 2	9500.000
Sampling	0.000004
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.082
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:07:44 1991



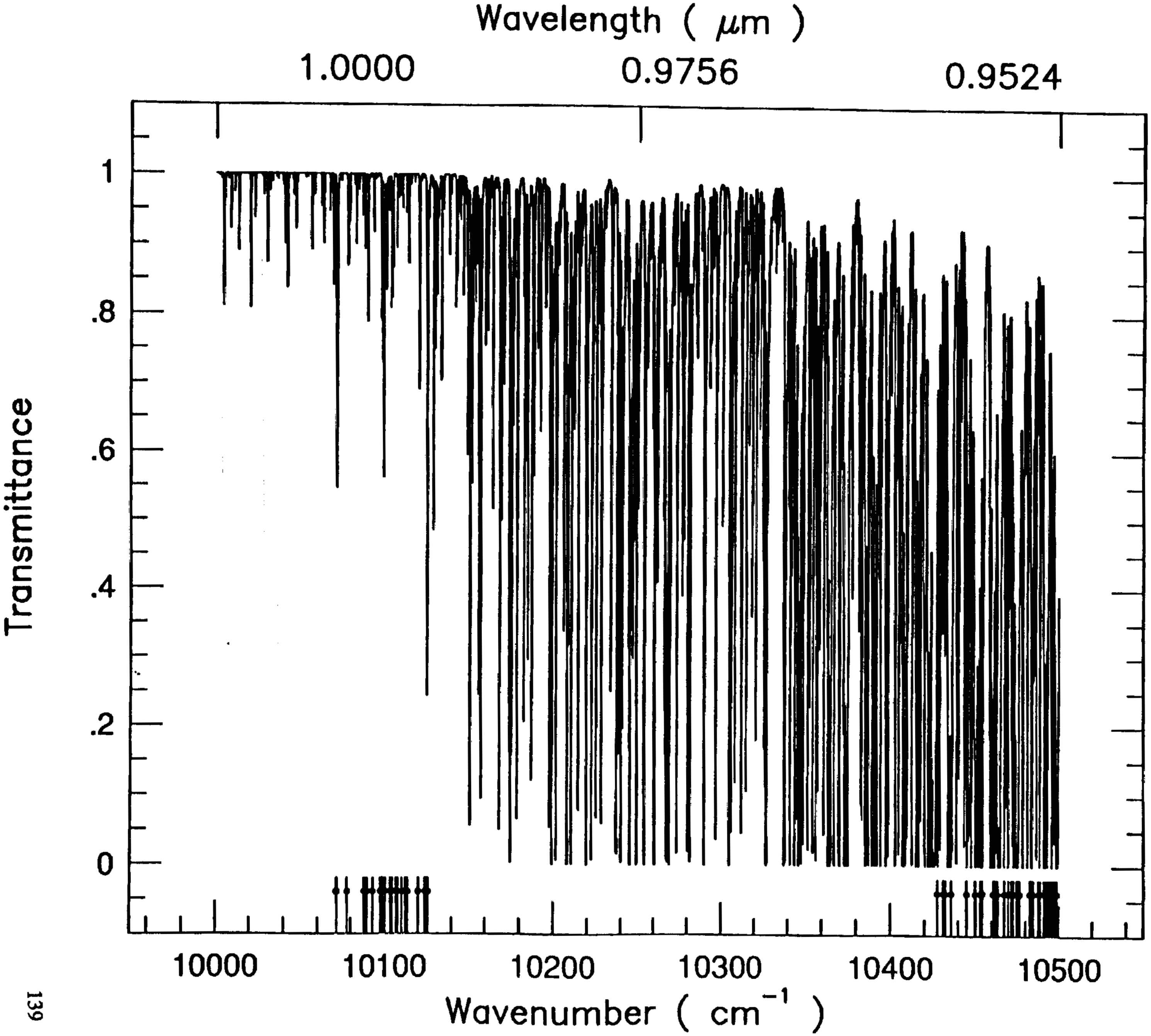
#40

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	9500.000
Lambda 2	10000.000
Sampling	0.000003
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.026
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:10:23 1991



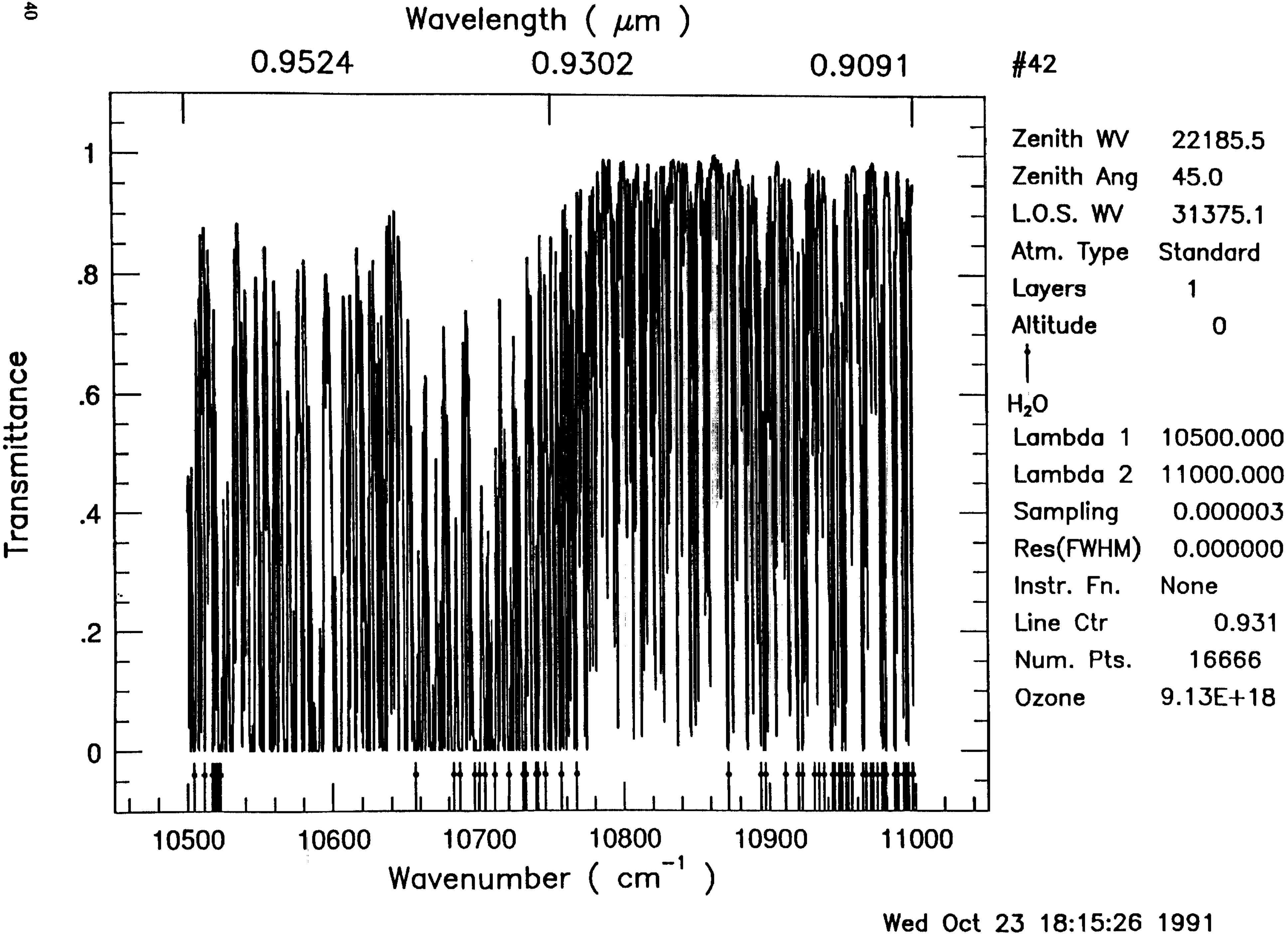
#41

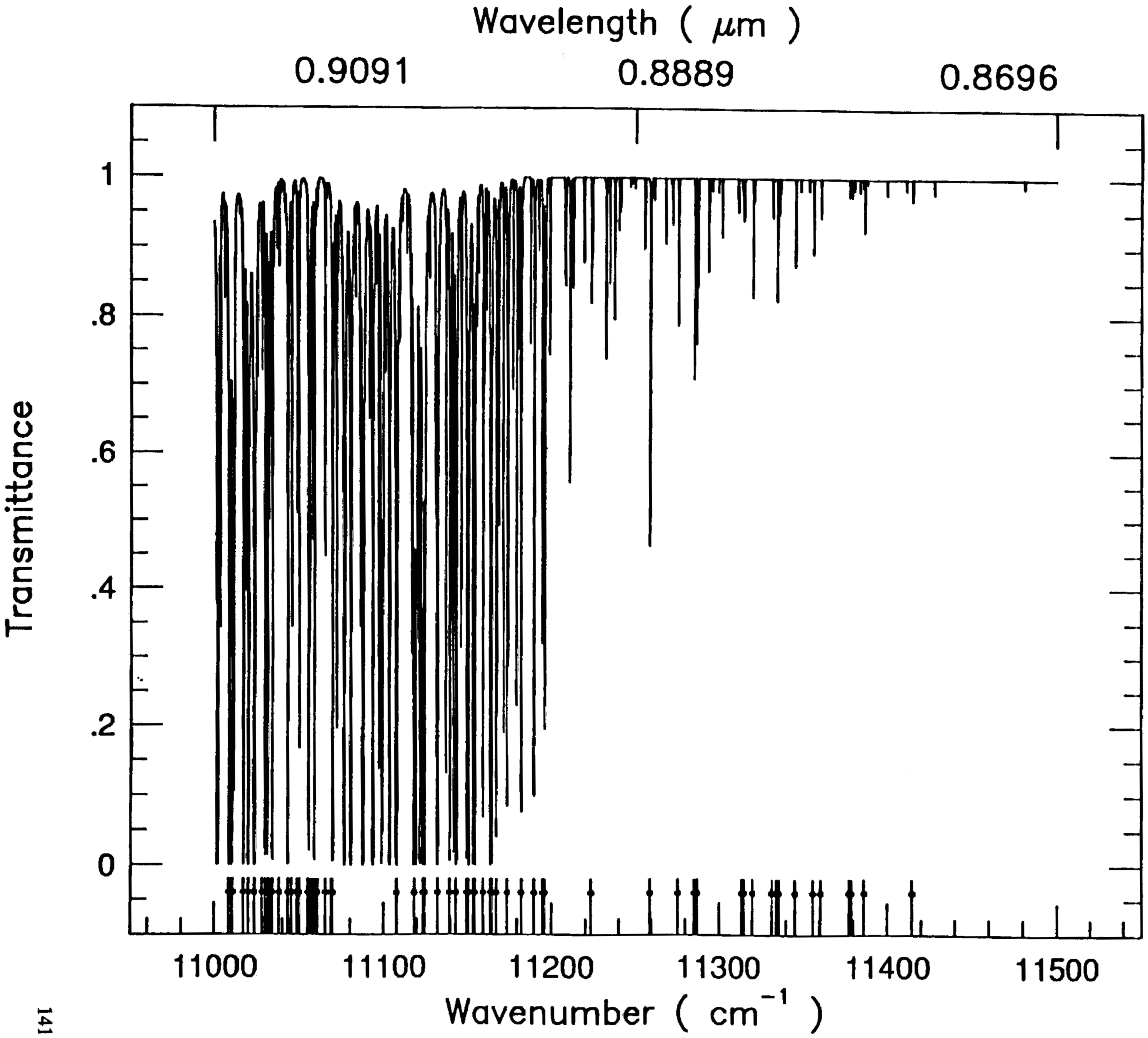
Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	10000.000
Lambda 2	10500.000
Sampling	0.000003
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.976
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:12:49 1991


Wavelength (μm)
0.9524
0.9302
0.9091
#42
Transmittance
1
.8
.6
.4
.2
0
10500
10600
10700
10800
10900
11000
Wavenumber (cm^-1)
Zenith WV 22185.5
Zenith Ang 45.0
L.O.S. WV 31375.1
Atm. Type Standard
Layers 1
Altitude 0
H2O
Lambda 1 10500.000
Lambda 2 11000.000
Sampling 0.000003
Res(FWHM) 0.000000
Instr. Fn. None
Line Ctr 0.931
Num. Pts. 16666
Ozone 9.13E+18
Wed Oct 23 18:15:26 1991



#43

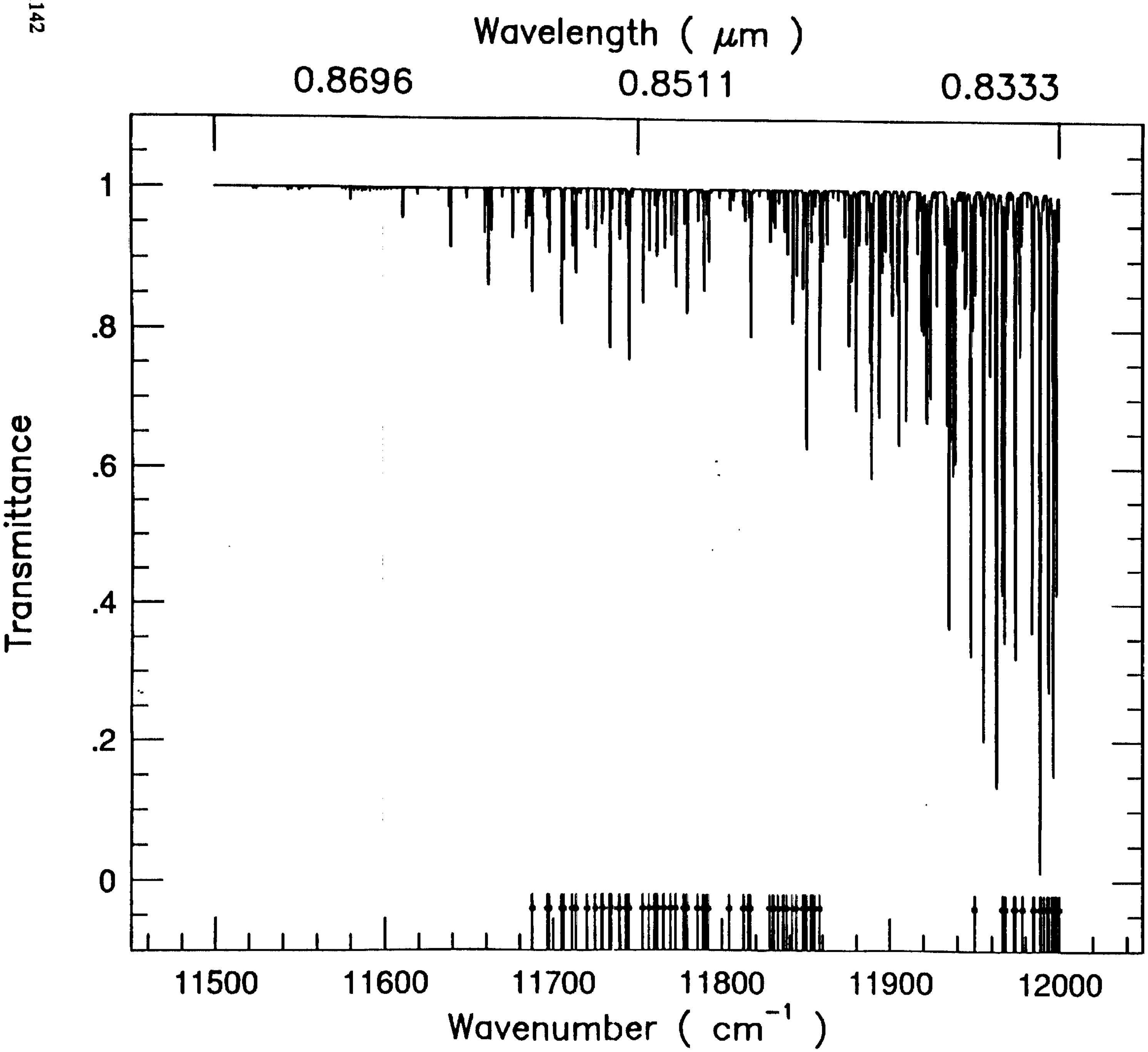
Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

↑

H_2O

Lambda 1	11000.000
Lambda 2	11500.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.889
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:17:49 1991



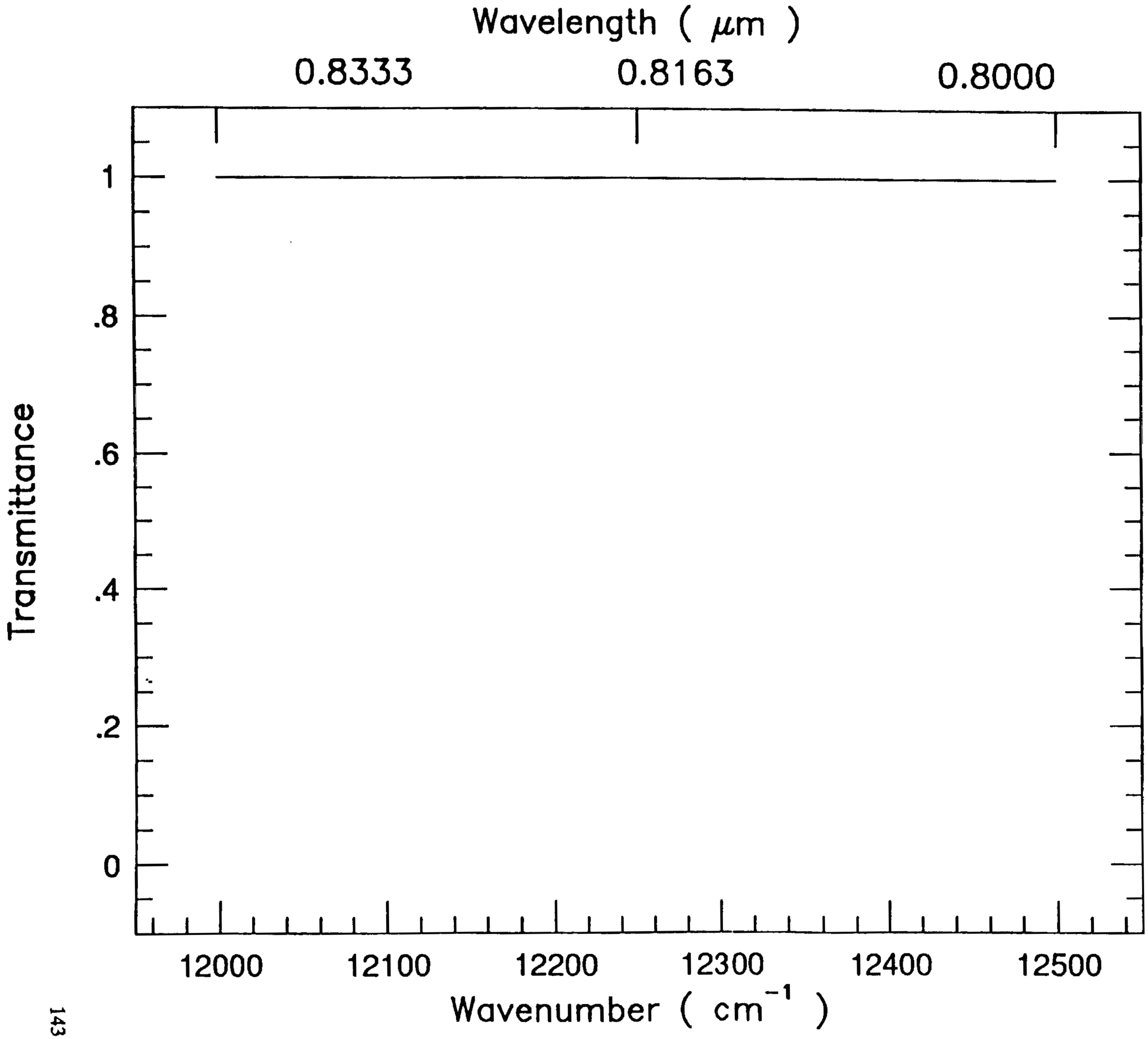
#44

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

H_2O

Lambda 1	11500.000
Lambda 2	12000.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.851
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:20:08 1991



#45

Zenith WV	22185.5
Zenith Ang	45.0
L.O.S. WV	31375.1
Atm. Type	Standard
Layers	1
Altitude	0

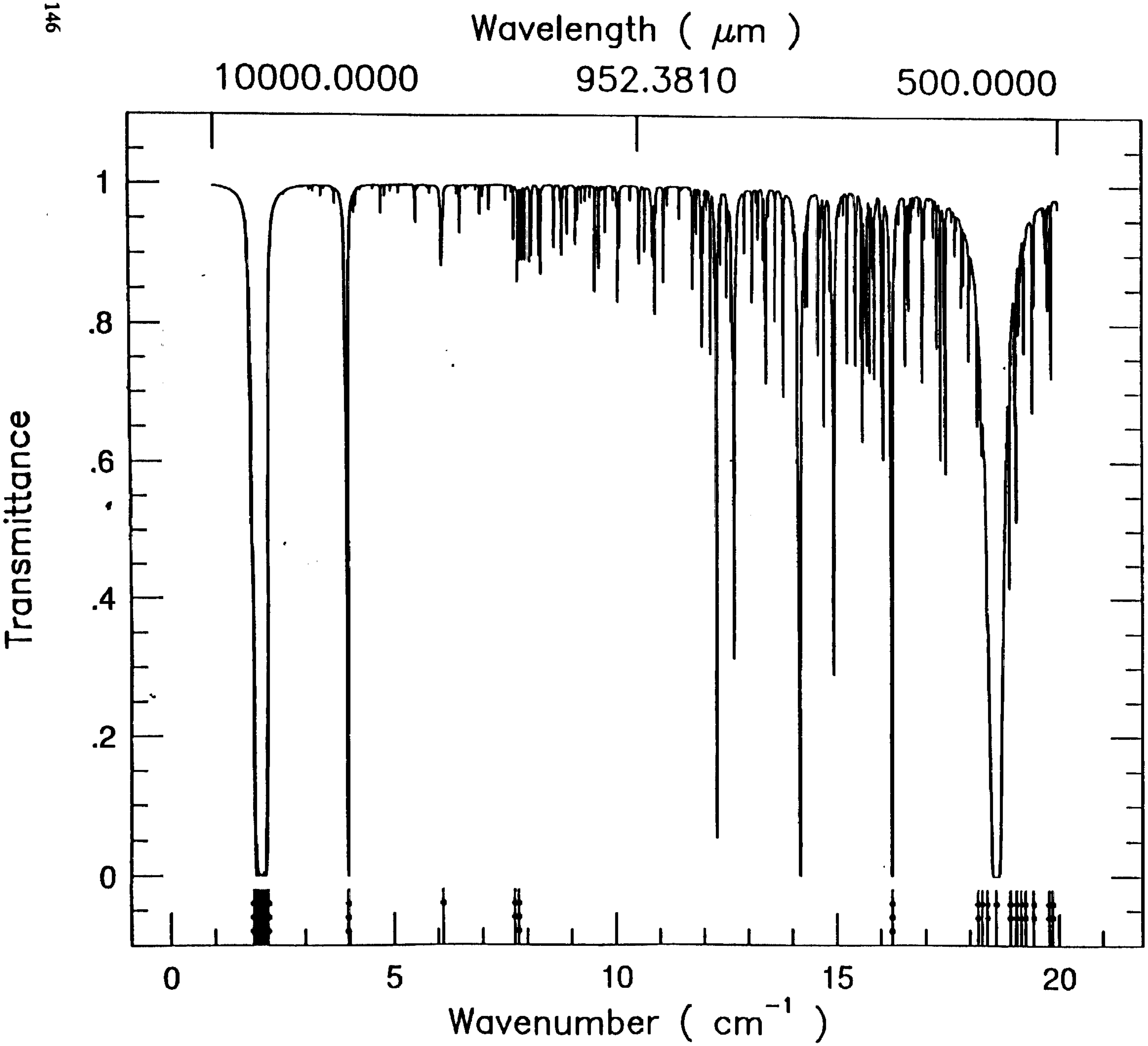
Lambda 1	12000.000
Lambda 2	12500.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.817
Num. Pts.	16666
Ozone	9.13E+18

Wed Oct 23 18:22:26 1991

APPENDIX F

TRANSMITTANCE AT FLIGHT ALTITUDE

We show the transmittance at 41,000 ft. The plots are numbered from 1 to 45 covering 10,000 μm to 0.8 μm.



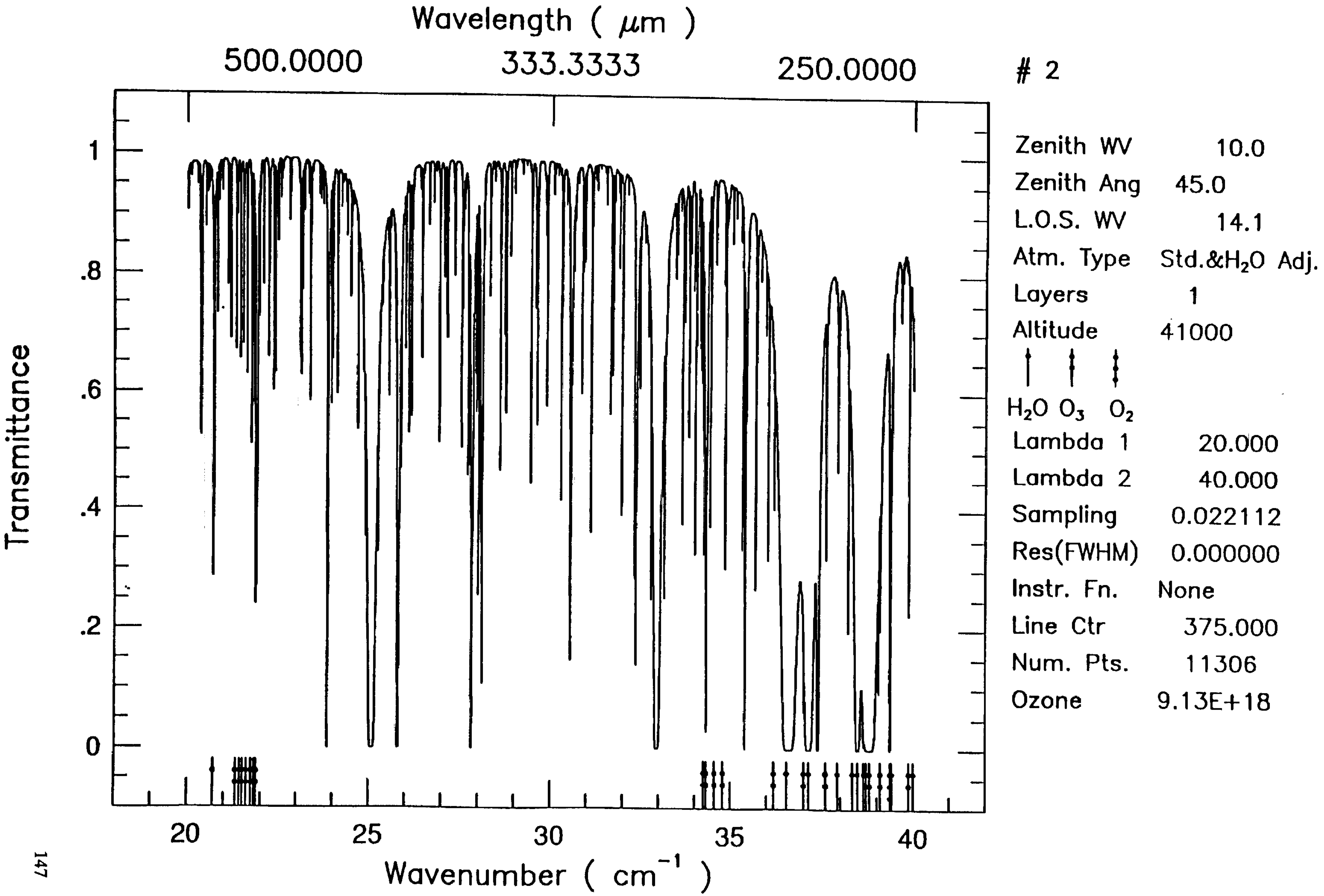
```
# 1

Zenith WV         10.0
Zenith Ang      45.0
L.O.S. WV         14.1
Atm. Type     Std.&H2O Adj.
Layers              1
Altitude      41000

H2O O3  O2
Lambda 1          1.000
Lambda 2         20.000
Sampling        0.884461
Res(FWHM)       0.000000
Instr. Fn.    None
Line Ctr        5250.000
Num. Pts.        10741
Ozone         9.13E+18
```

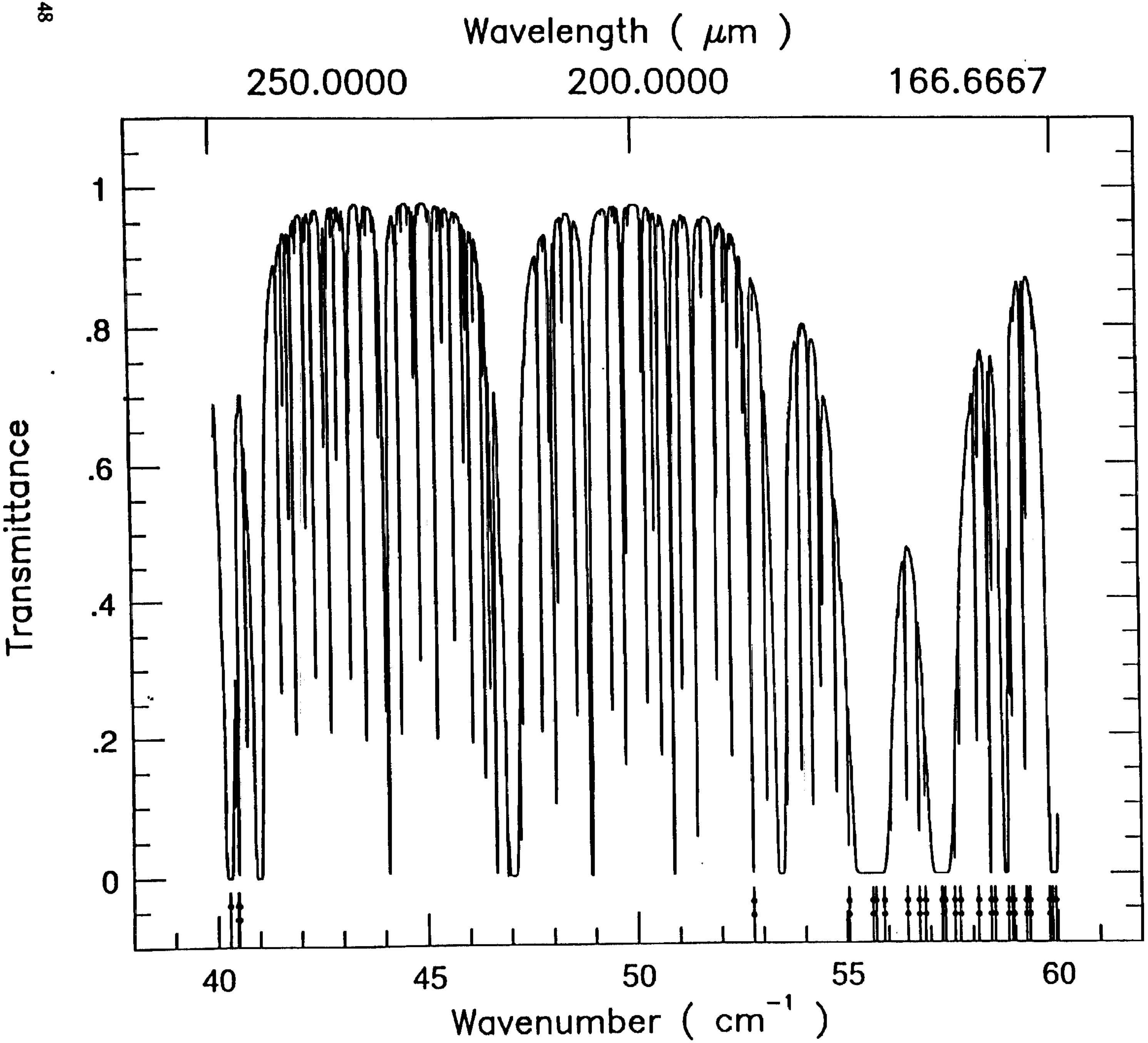
Tue Oct 8 19:42:52 1991

2



Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	20.000
Lambda 2	40.000
Sampling	0.022112
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	375.000
Num. Pts.	11306
Ozone	9.13E+18

Tue Oct 8 19:44:25 1991



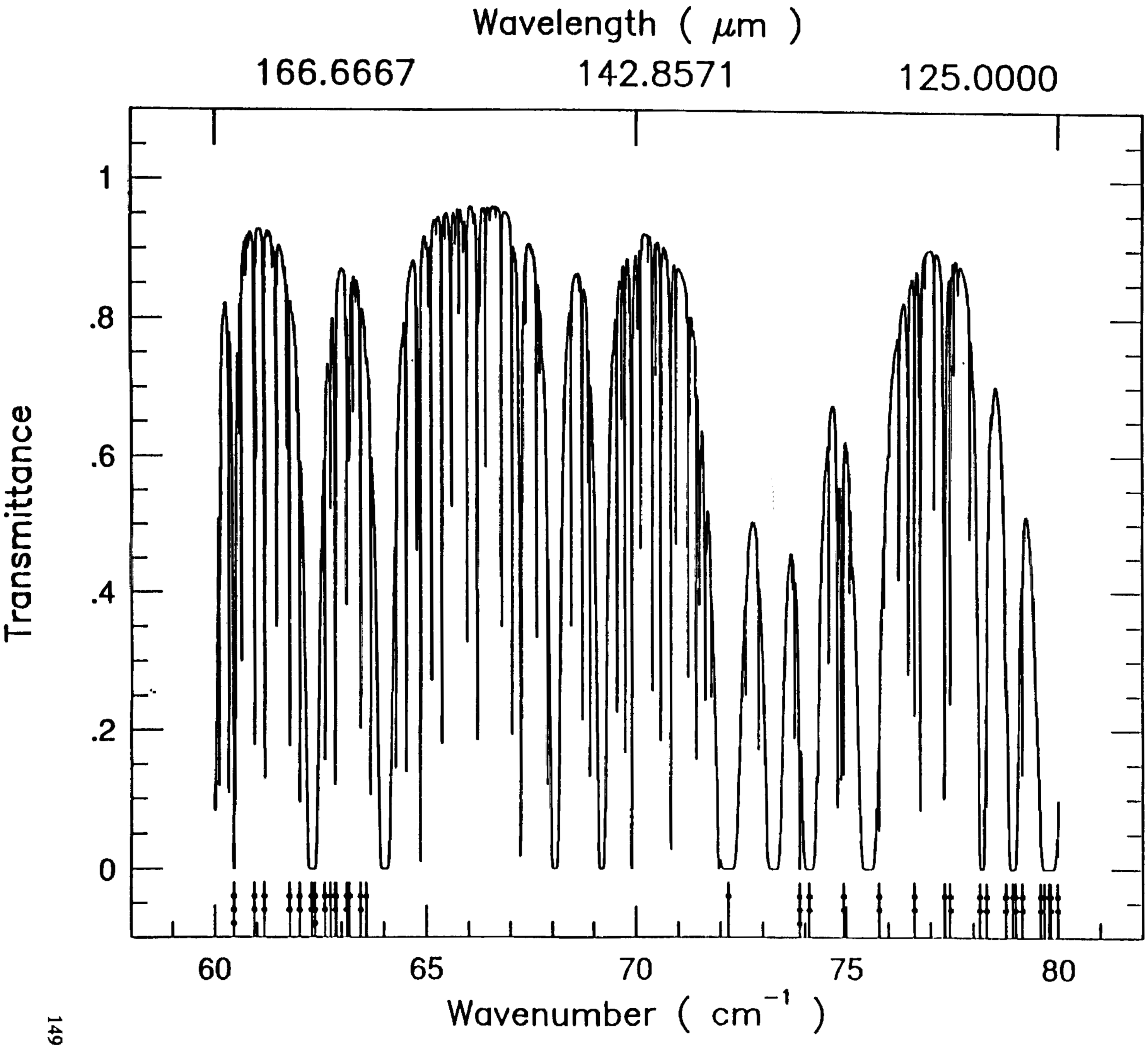
3

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O O_3

Lambda 1	40.000
Lambda 2	60.000
Sampling	0.007371
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	208.333
Num. Pts.	11306
Ozone	9.13E+18

Tue Oct 8 19:46:07 1991



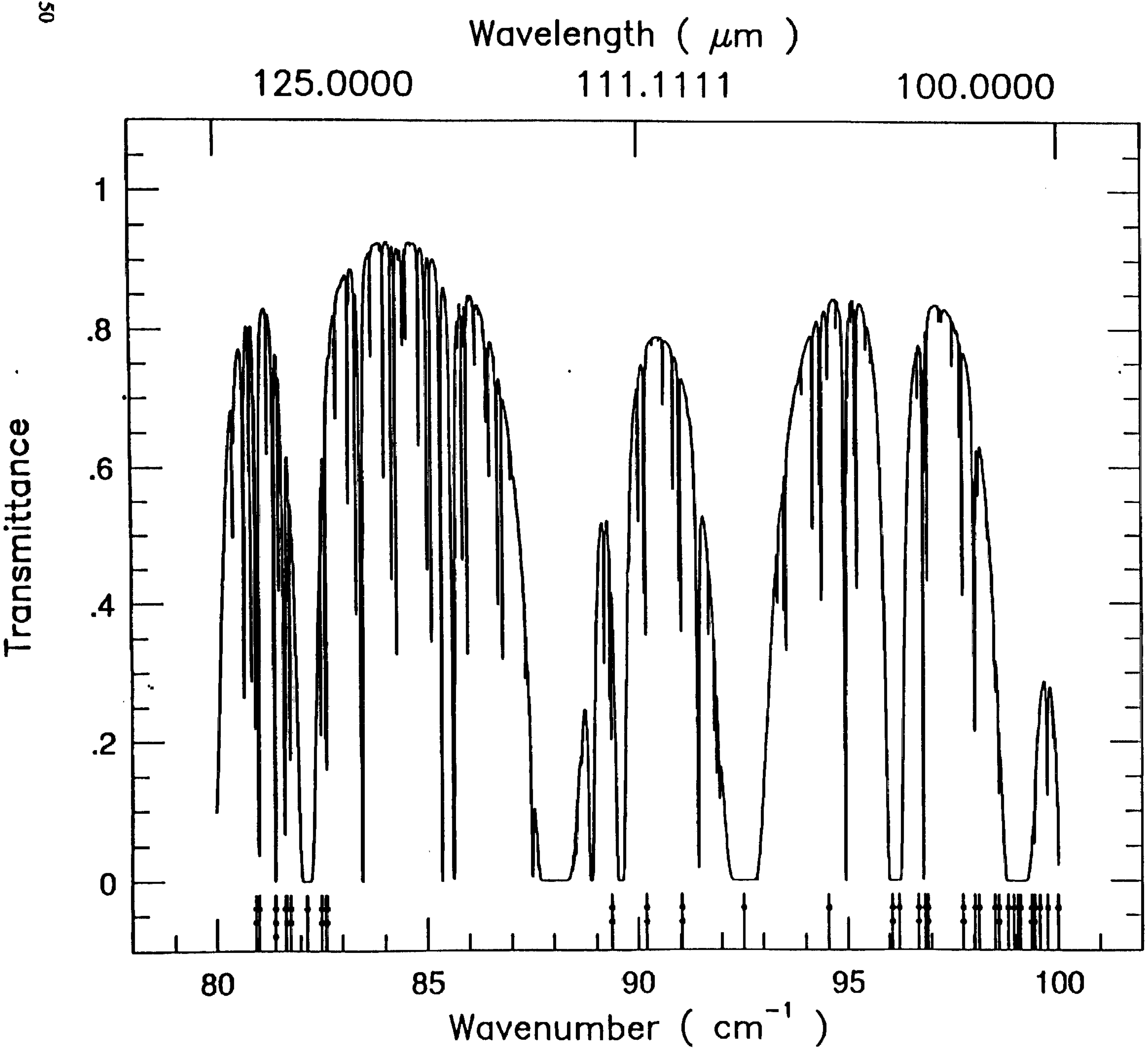
4

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

┃ ┃ ┃
H_2O O_3 O_2

Lambda 1	60.000
Lambda 2	80.000
Sampling	0.003685
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	145.833
Num. Pts.	11306
Ozone	9.13E+18

Tue Oct 8 19:47:48 1991



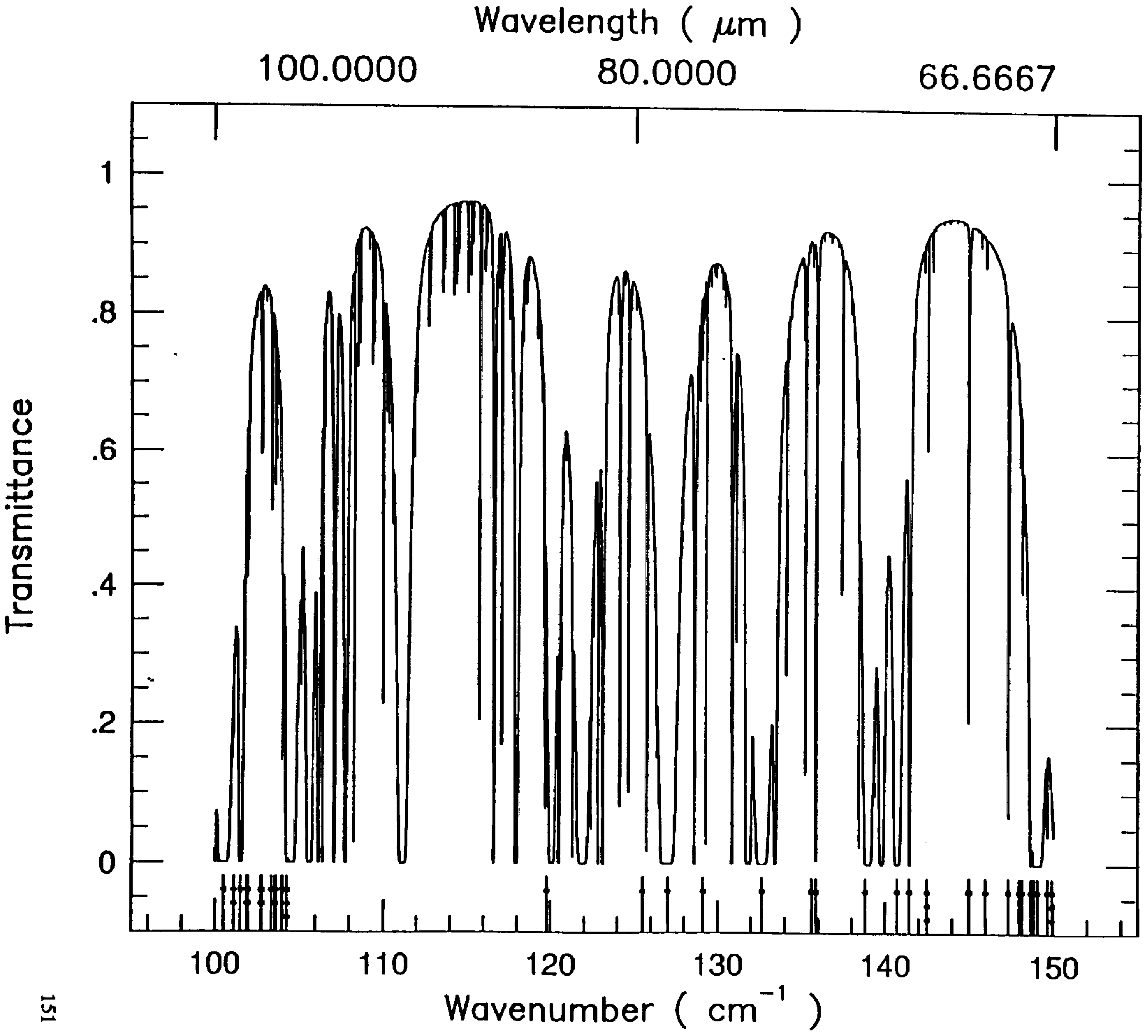
5

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O O_3 O_2

Lambda 1	80.000
Lambda 2	100.000
Sampling	0.002211
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	112.500
Num. Pts.	11306
Ozone	9.13E+18

Tue Oct 8 19:49:25 1991



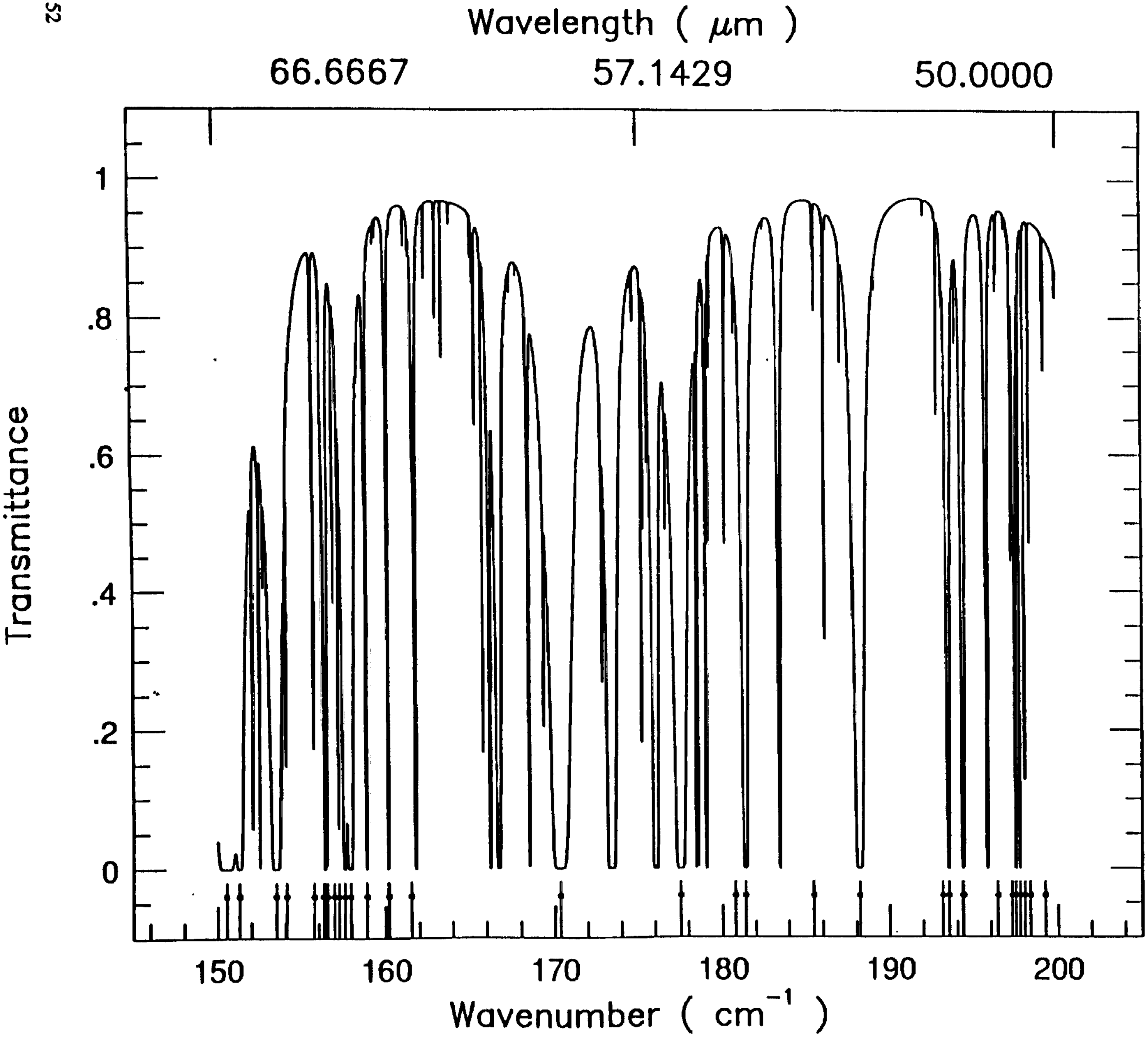
6

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O O_3 O_2

Lambda 1	100.000
Lambda 2	150.000
Sampling	0.001769
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	83.333
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 19:51:19 1991



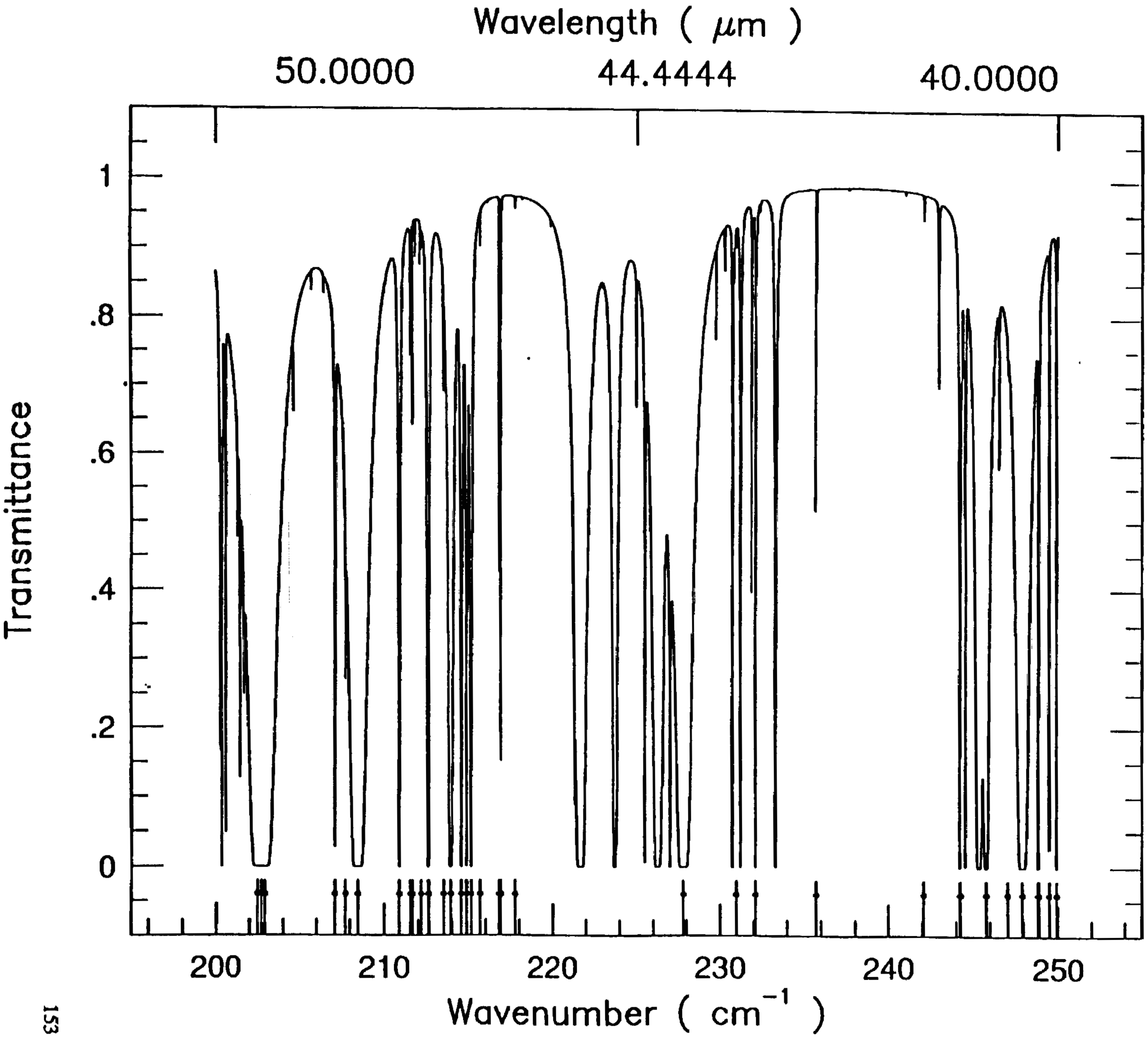
7

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O

Lambda 1	150.000
Lambda 2	200.000
Sampling	0.000885
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	58.333
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 19:53:45 1991



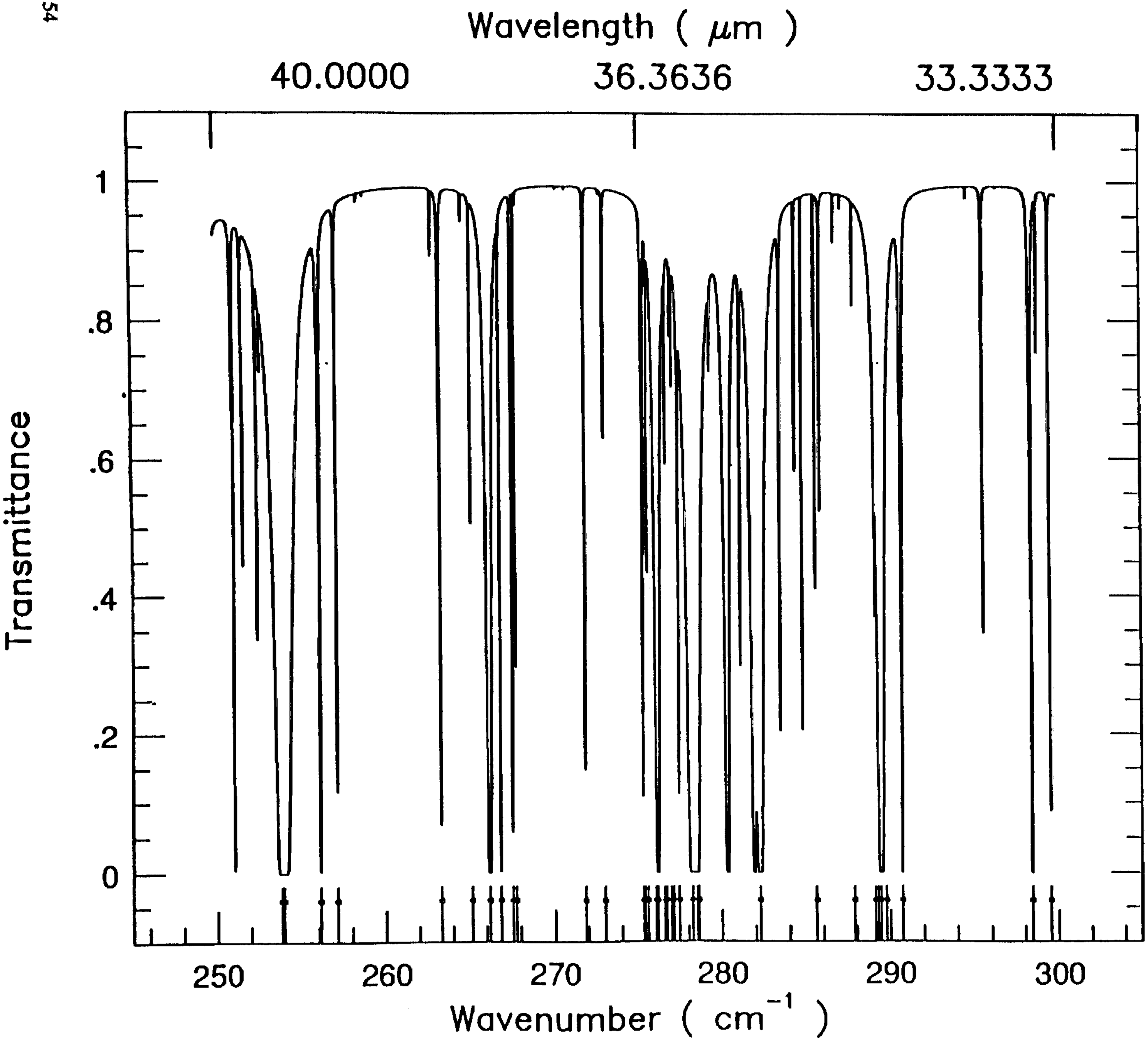
8

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑
H_2O

Lambda 1	200.000
Lambda 2	250.000
Sampling	0.000531
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	45.000
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 19:56:08 1991



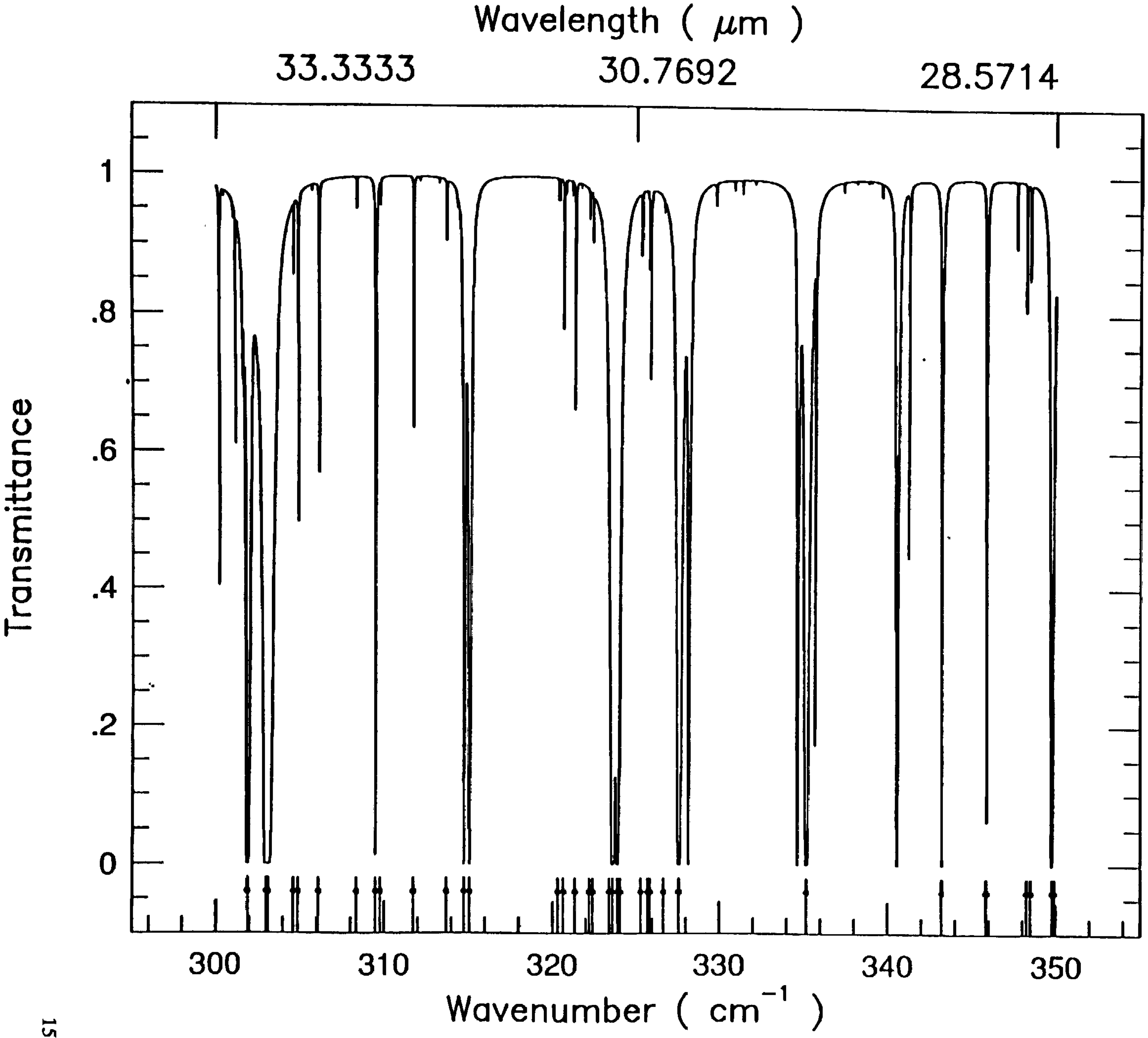
9

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑
H_2O

Lambda 1	250.000
Lambda 2	300.000
Sampling	0.000354
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	36.667
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 19:58:31 1991



#10

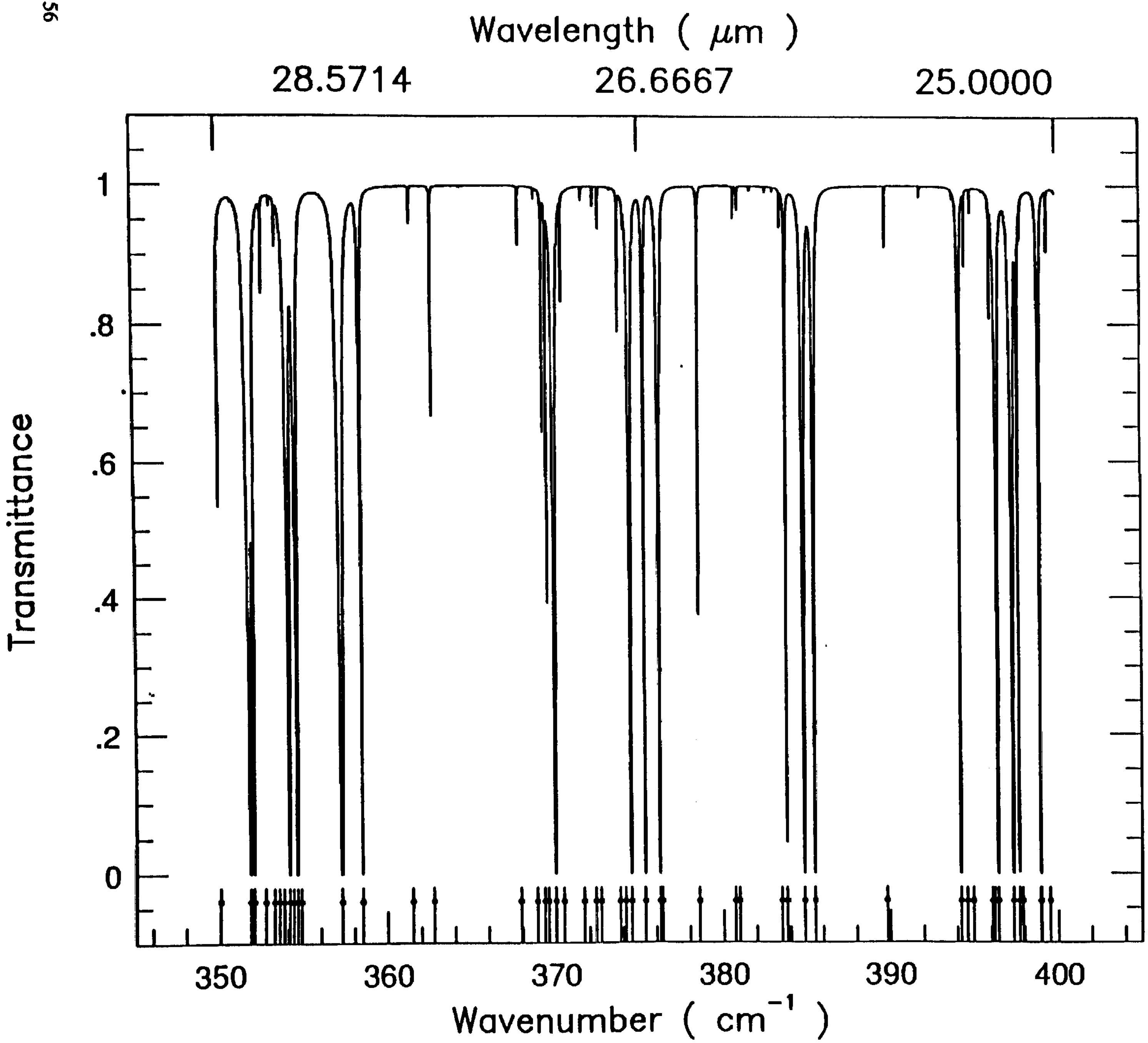
Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑

H_2O

Lambda 1	300.000
Lambda 2	350.000
Sampling	0.000253
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	30.952
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:00:53 1991



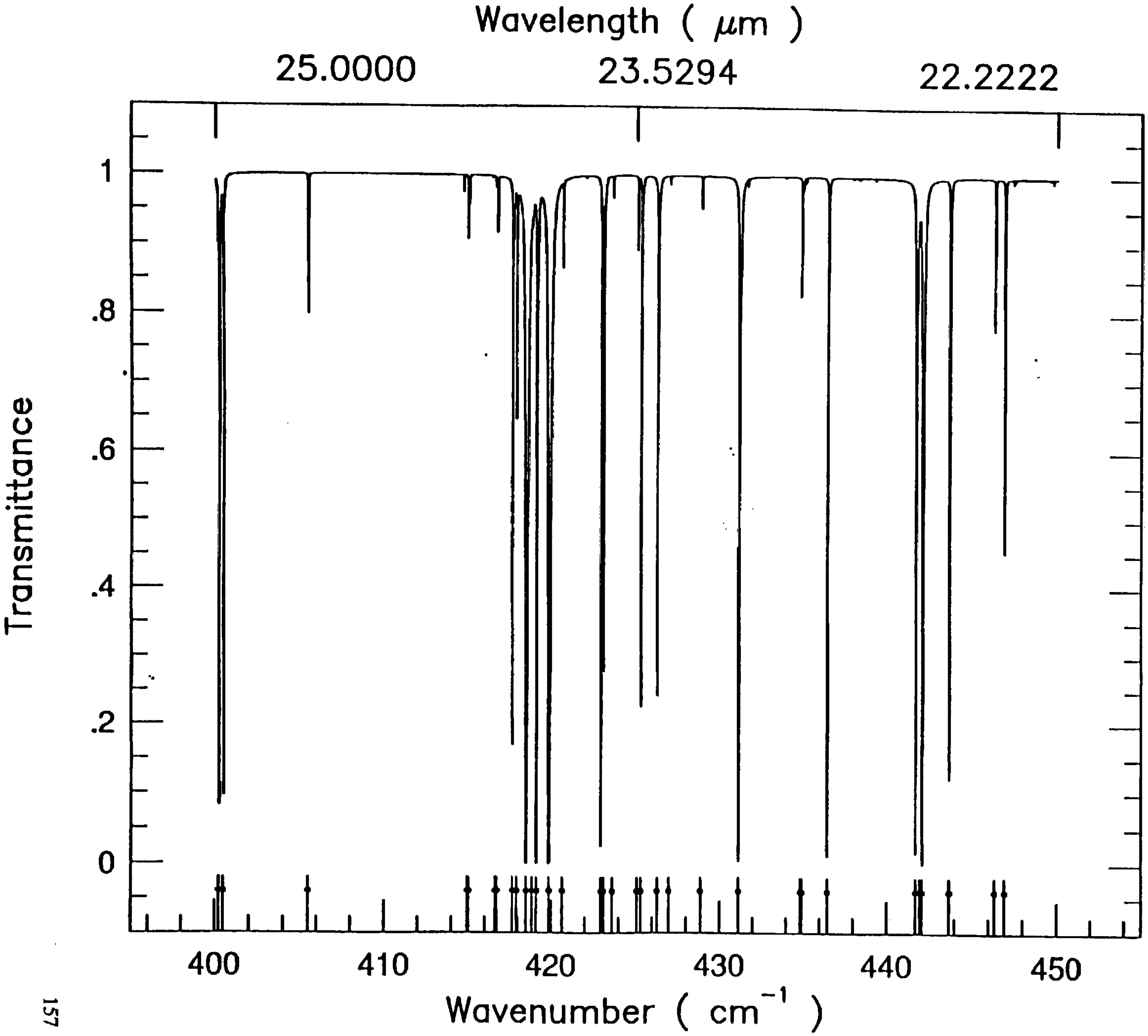
#11

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑
H_2O

Lambda 1	350.000
Lambda 2	400.000
Sampling	0.000190
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	26.786
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:03:37 1991



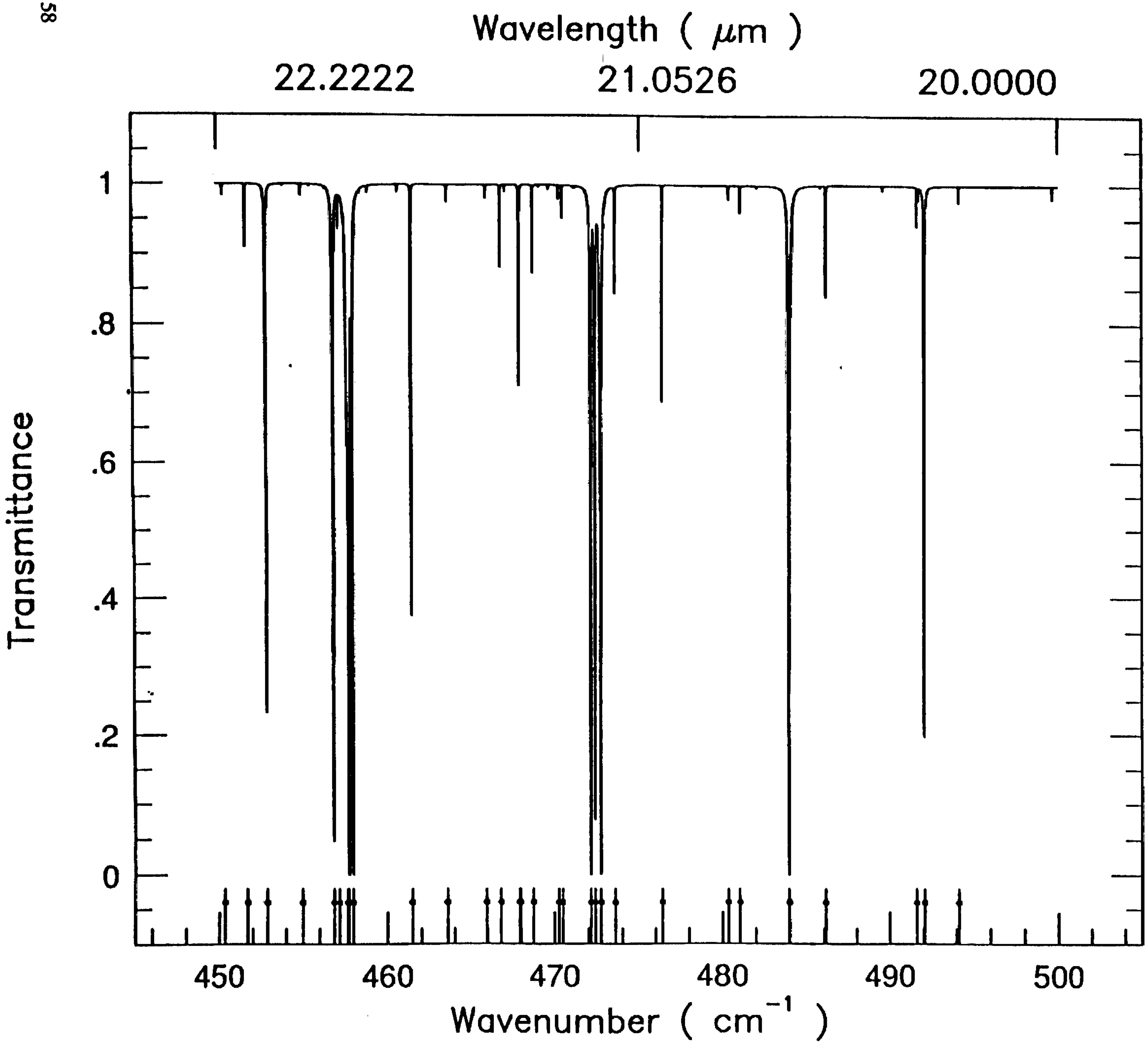
#12

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑
H_2O

Lambda 1	400.000
Lambda 2	450.000
Sampling	0.000147
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	23.611
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:05:59 1991



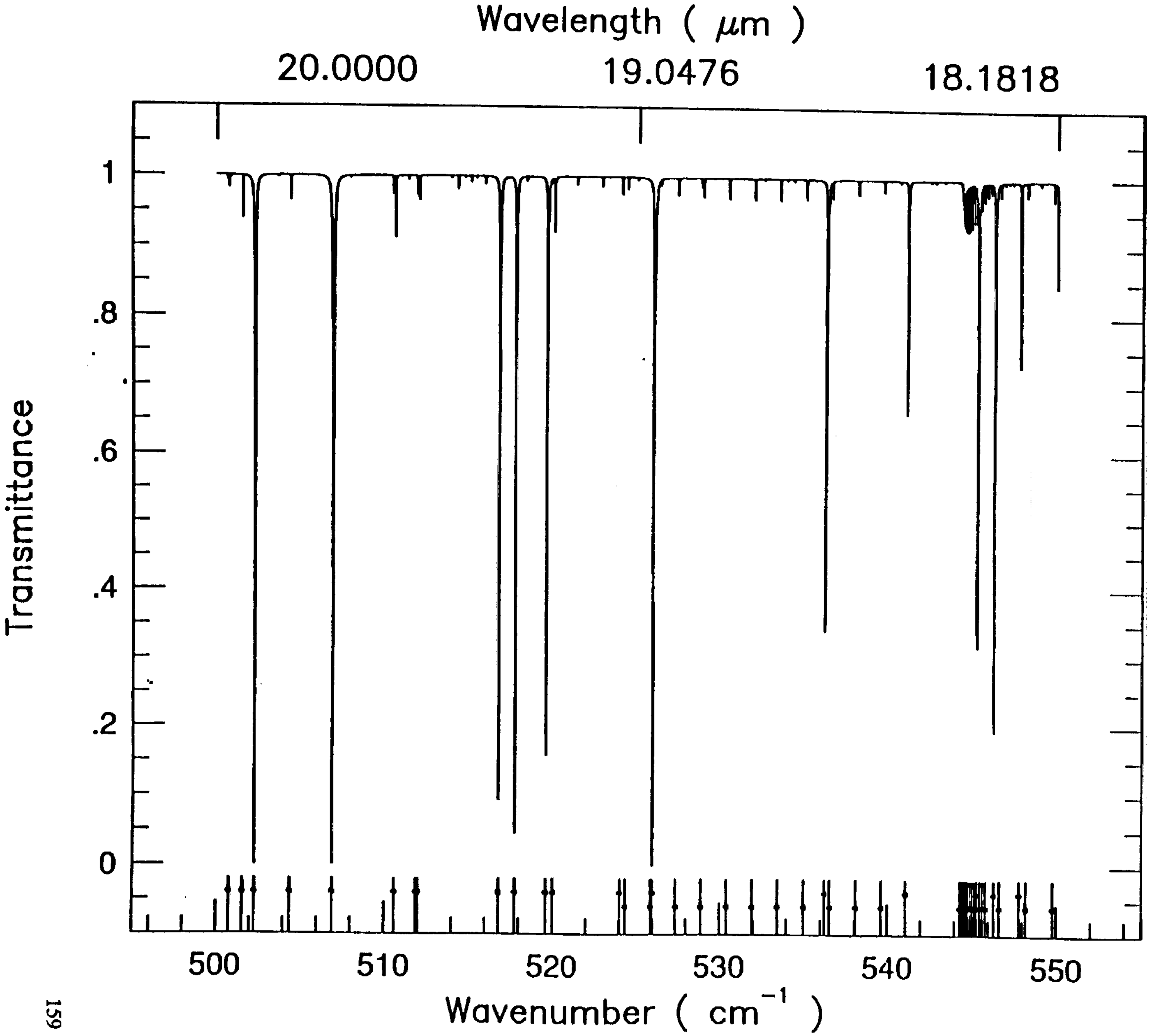
#13

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O

Lambda 1	450.000
Lambda 2	500.000
Sampling	0.000118
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	21.111
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:08:22 1991



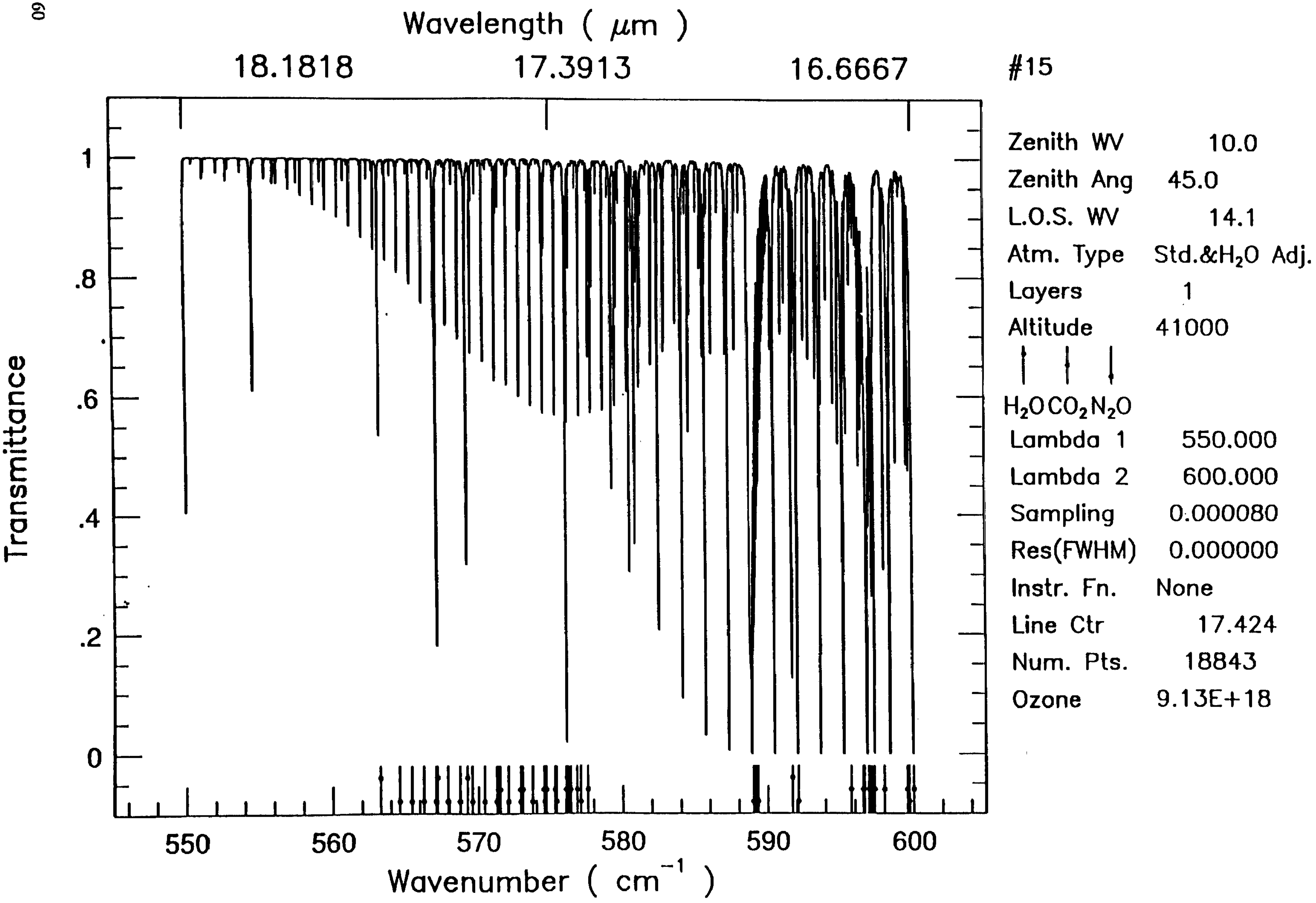
#14

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2

Lambda 1	500.000
Lambda 2	550.000
Sampling	0.000096
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	19.091
Num. Pts.	18843
Ozone	9.13E+18

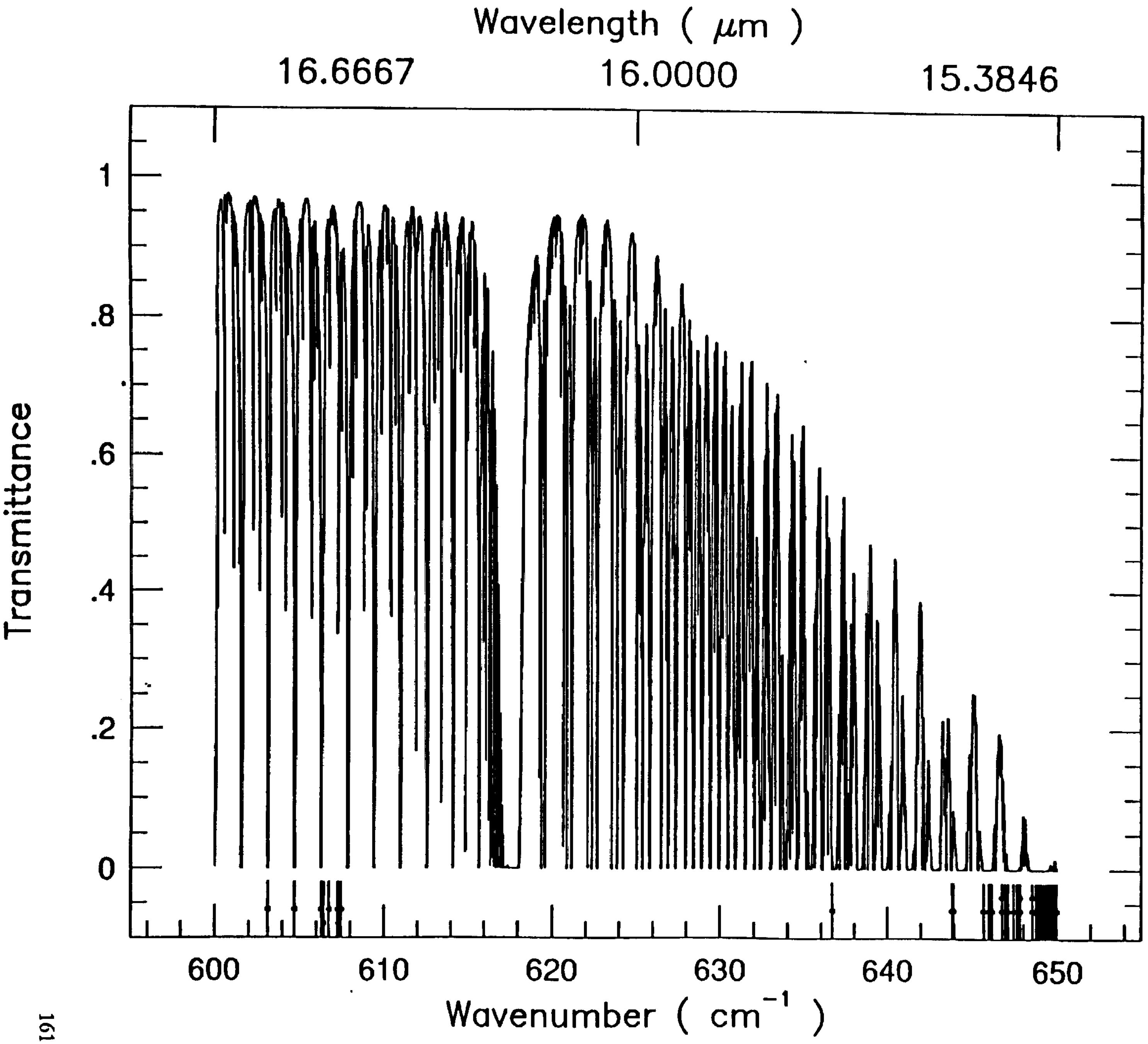
Tue Oct 8 20:10:29 1991



#15

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	550.000
Lambda 2	600.000
Sampling	0.000080
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	17.424
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:12:49 1991



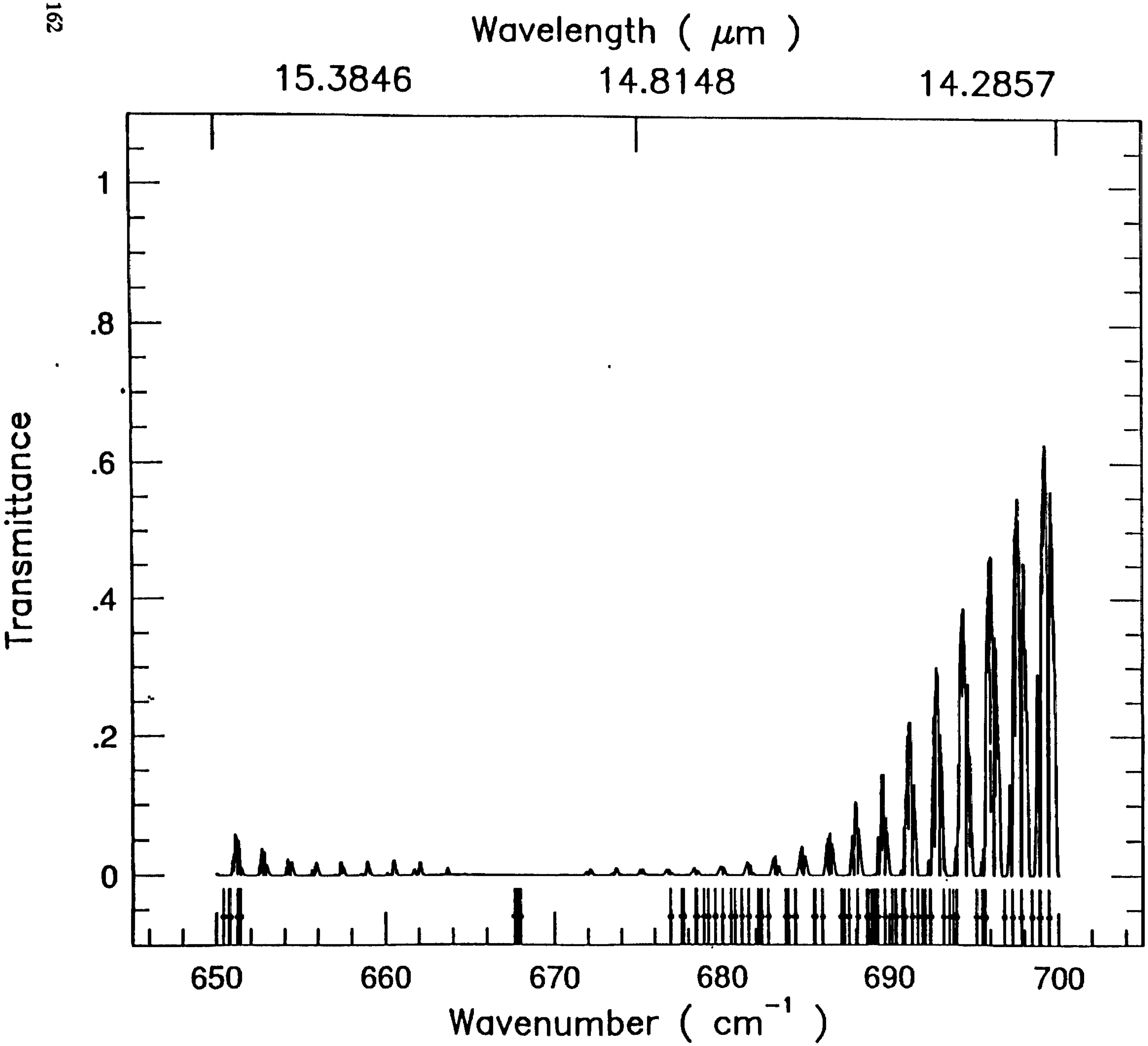
#16

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2 O_3 N_2O

Lambda 1	600.000
Lambda 2	650.000
Sampling	0.000068
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	16.026
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:16:41 1991



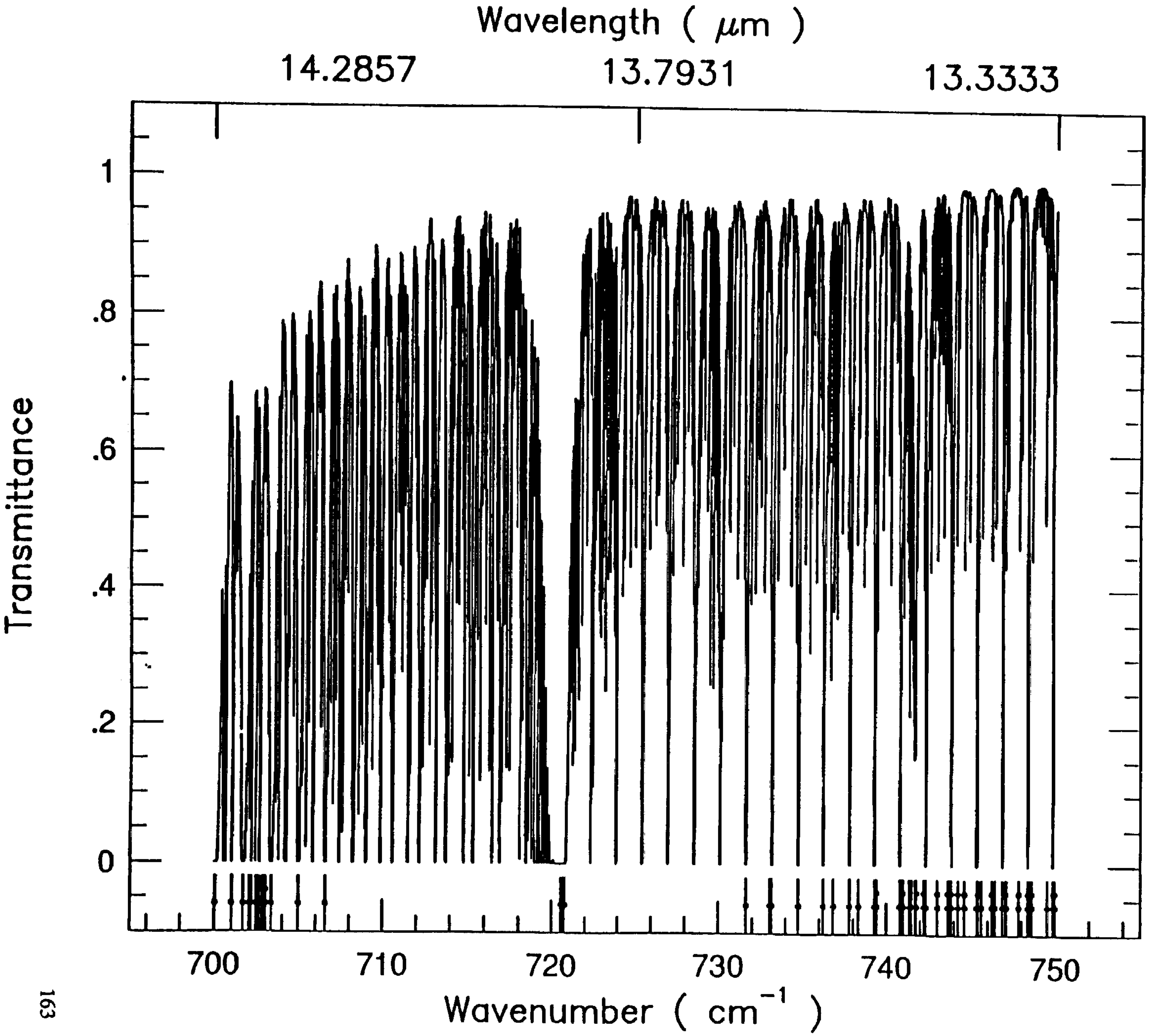
#17

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2

Lambda 1	650.000
Lambda 2	700.000
Sampling	0.000058
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	14.835
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:21:38 1991



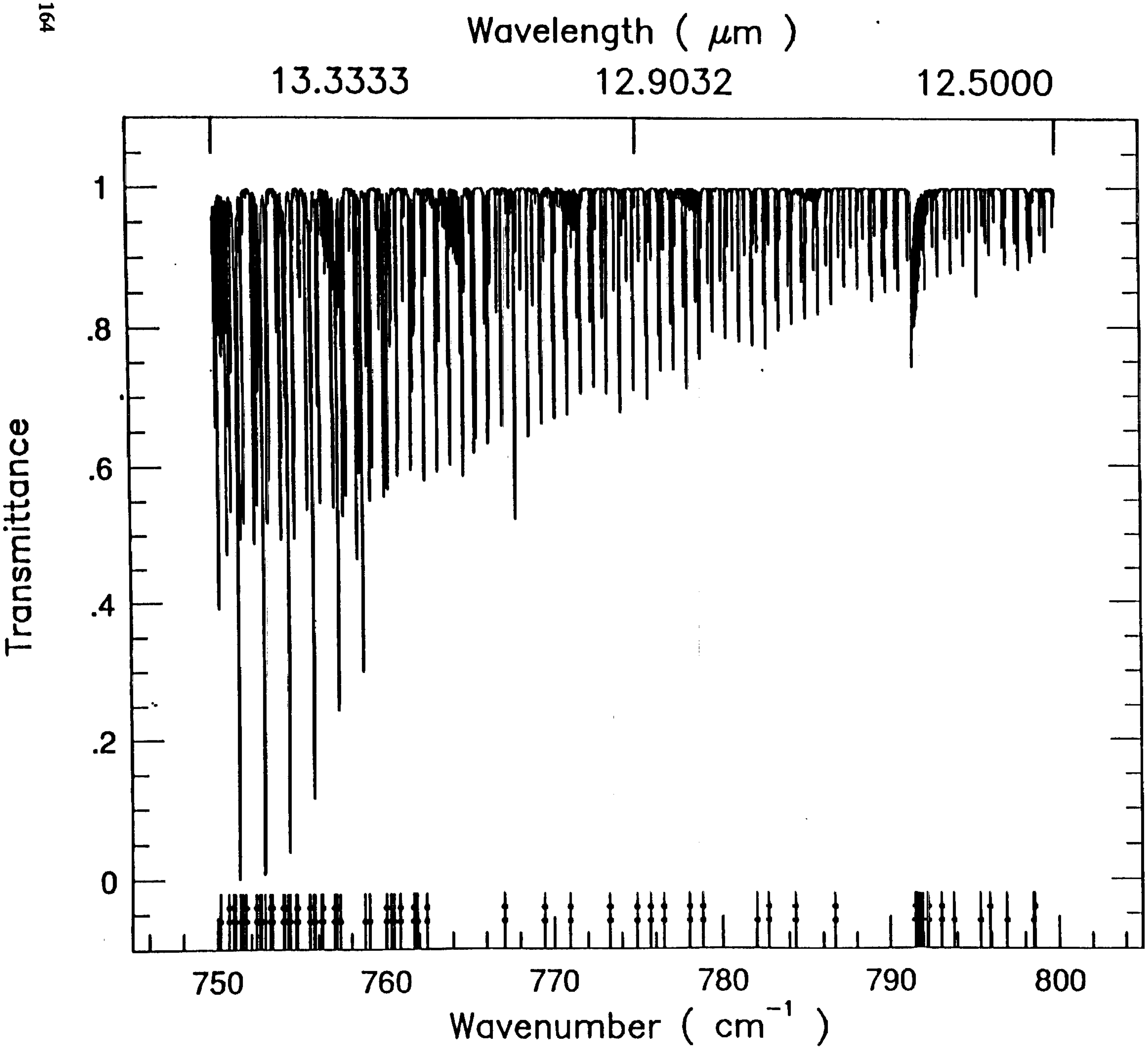
#18

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2 O_3

Lambda 1	700.000
Lambda 2	750.000
Sampling	0.000051
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	13.810
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:25:31 1991



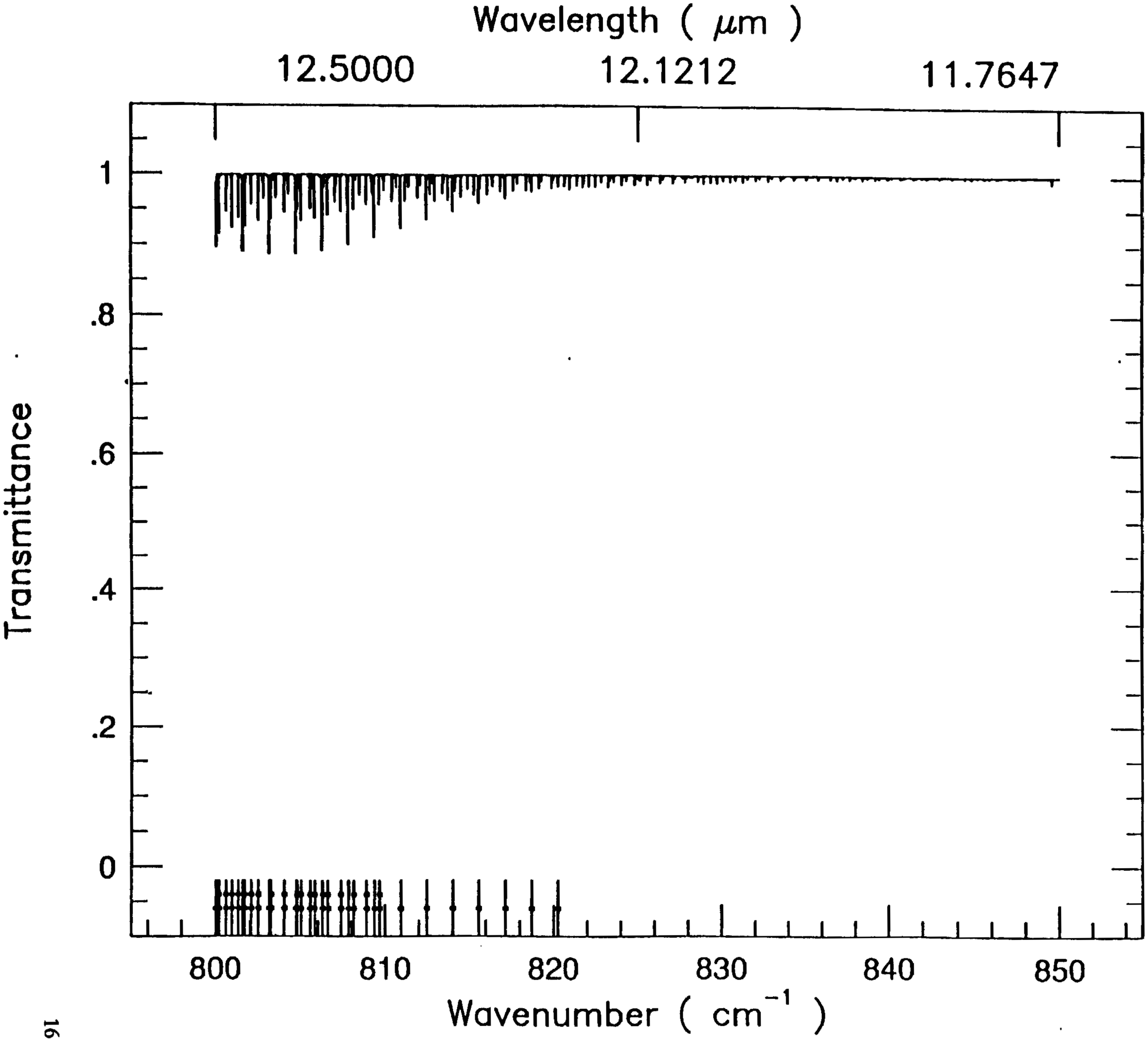
#19

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2 O_3

Lambda 1	750.000
Lambda 2	800.000
Sampling	0.000044
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	12.917
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:27:51 1991



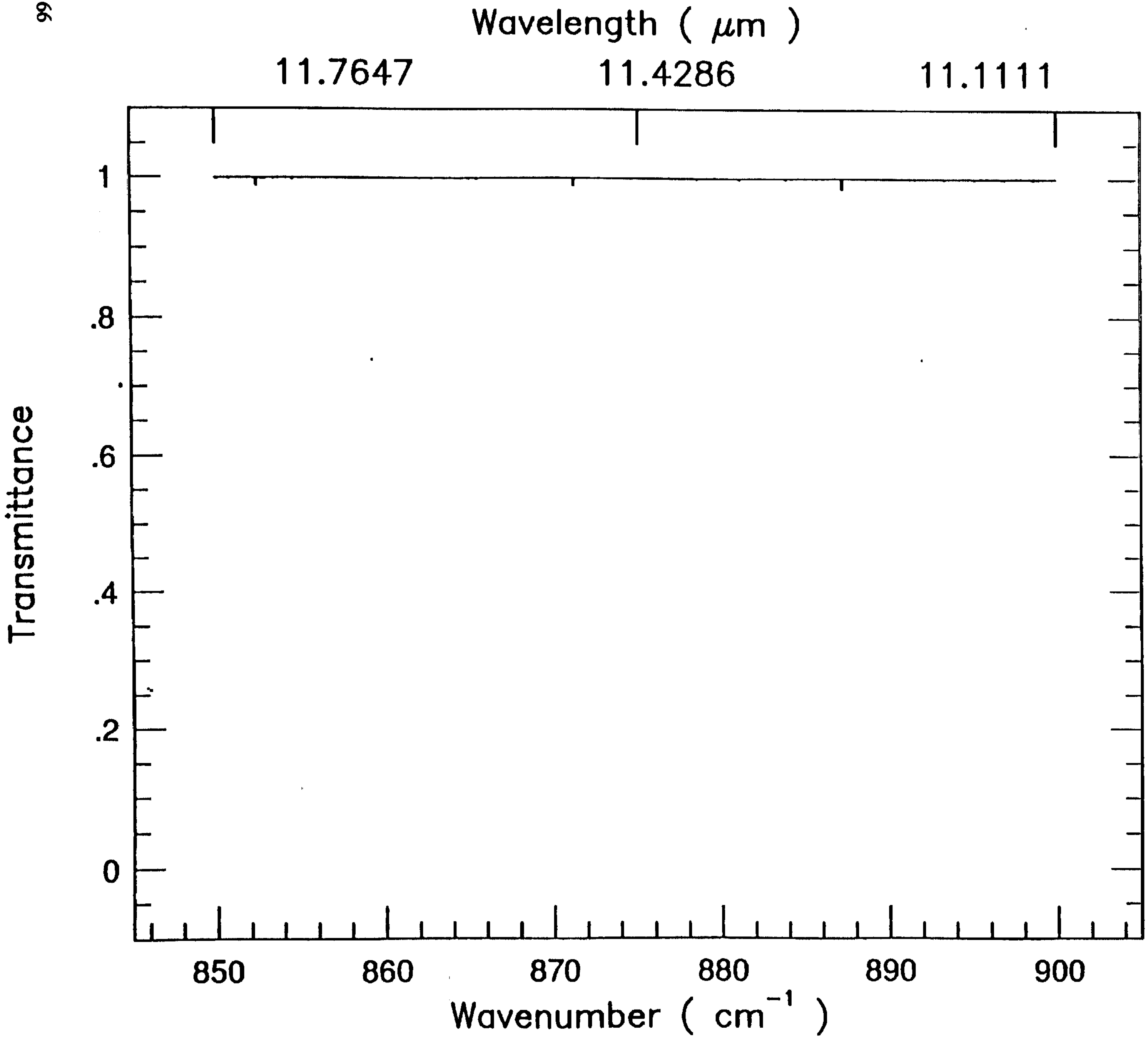
#20

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2 O_3

Lambda 1	800.000
Lambda 2	850.000
Sampling	0.000039
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	12.132
Num. Pts.	18843
Ozone	9.13E+18

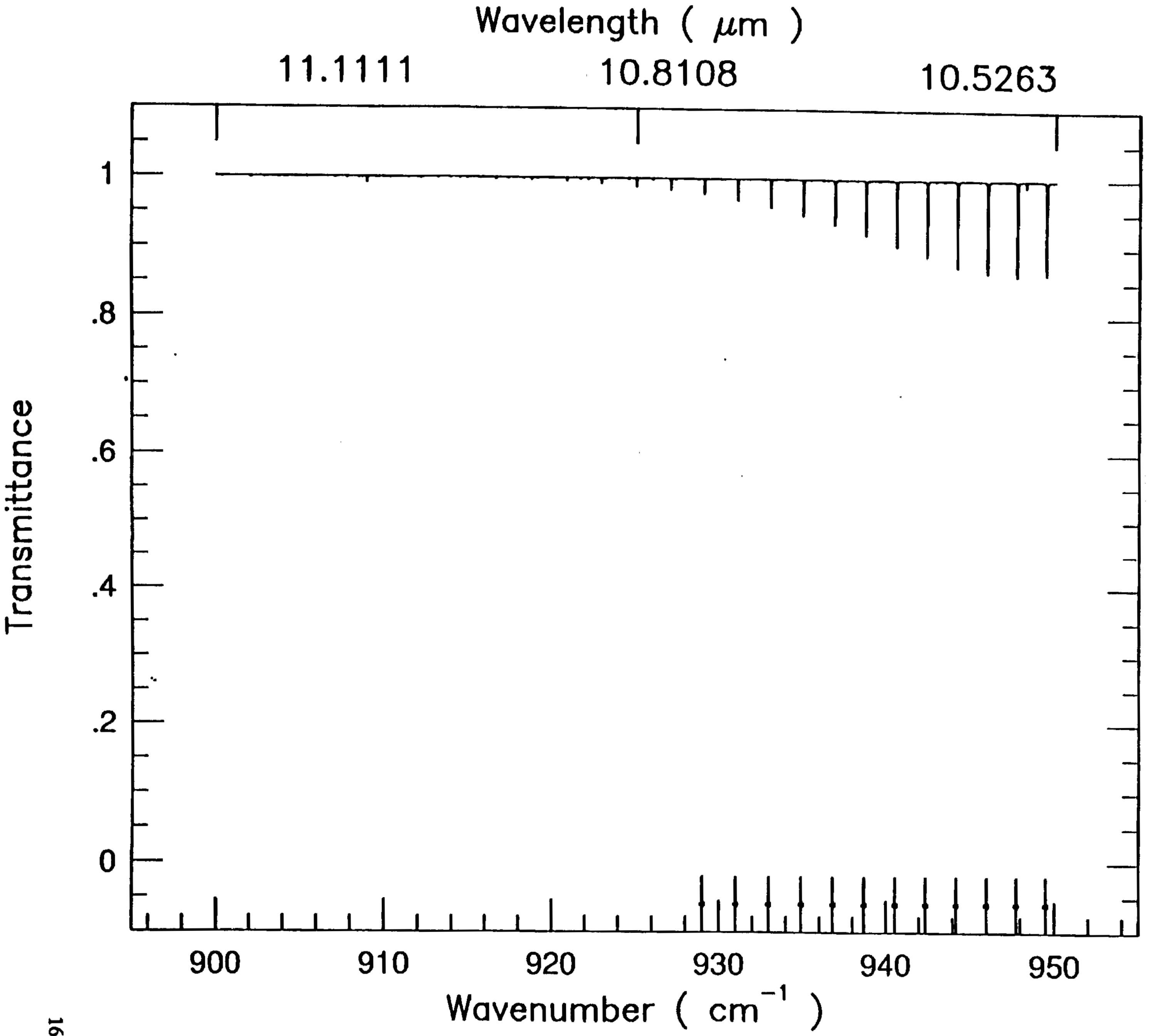
Tue Oct 8 20:30:04 1991



#21

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	850.000
Lambda 2	900.000
Sampling	0.000035
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	11.438
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:32:17 1991



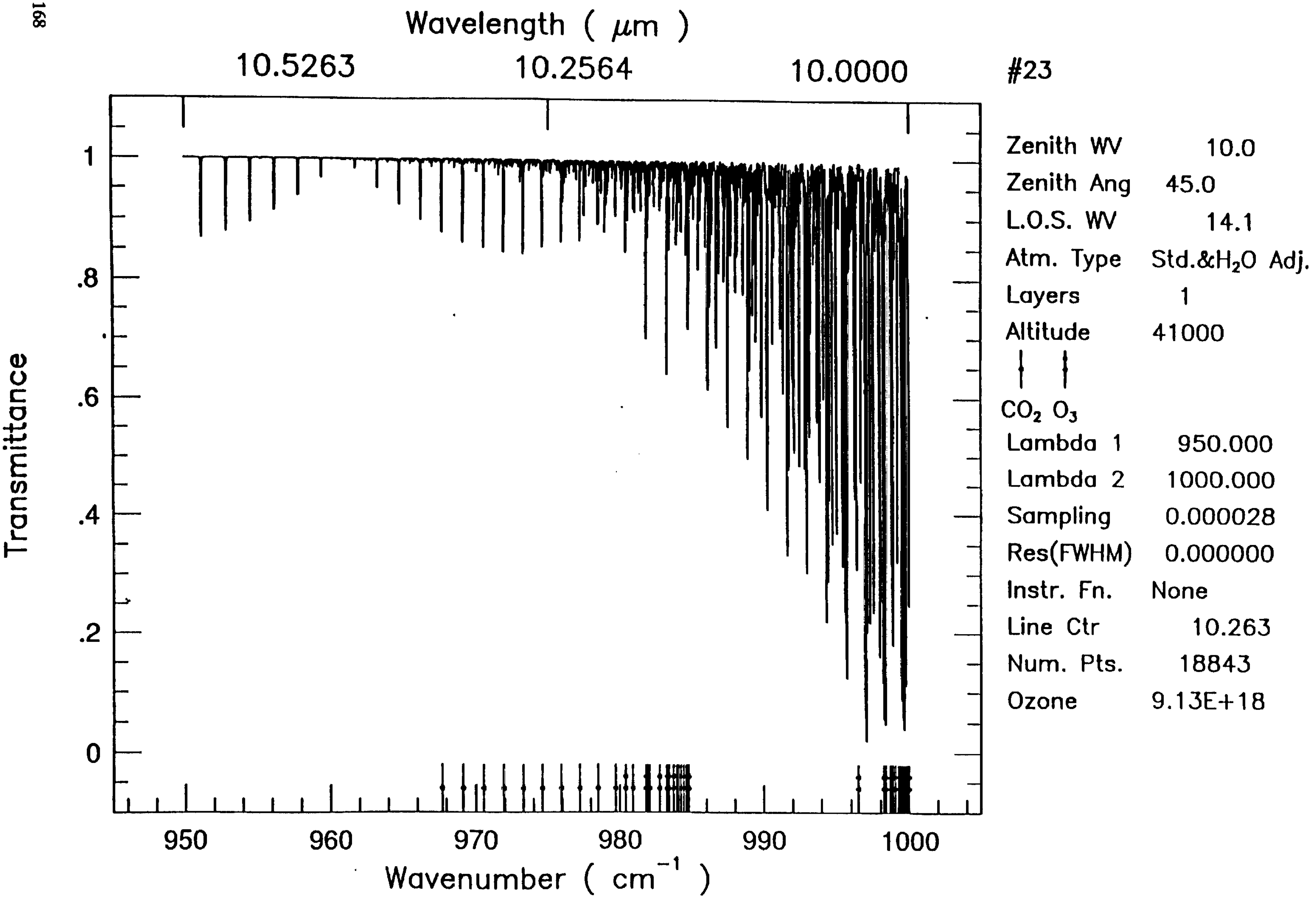
#22

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2

Lambda 1	900.000
Lambda 2	950.000
Sampling	0.000031
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	10.819
Num. Pts.	18843
Ozone	9.13E+18

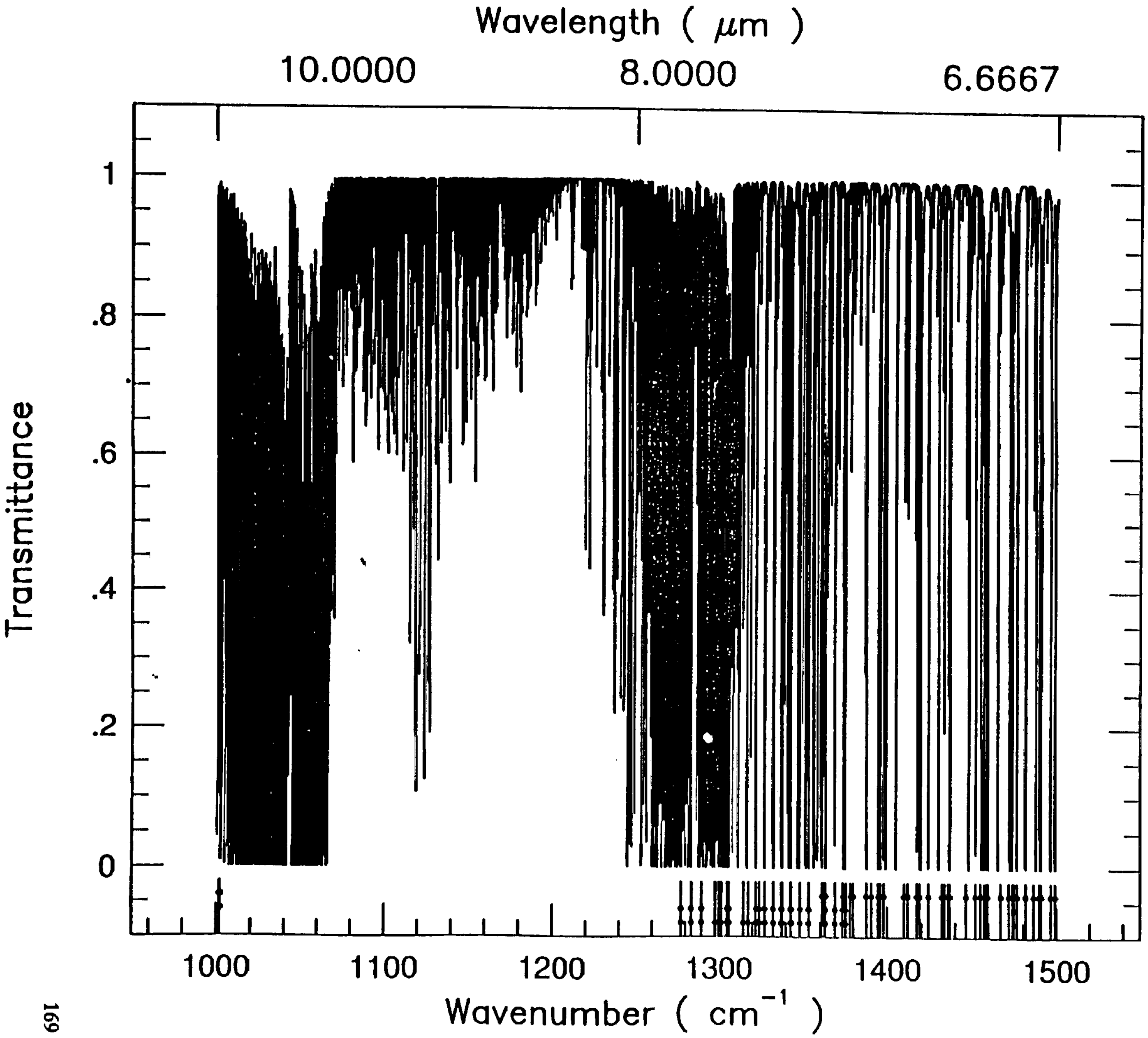
Tue Oct 8 20:34:31 1991



Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	950.000
Lambda 2	1000.000
Sampling	0.000028
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	10.263
Num. Pts.	18843
Ozone	9.13E+18

Tue Oct 8 20:37:38 1991

#24

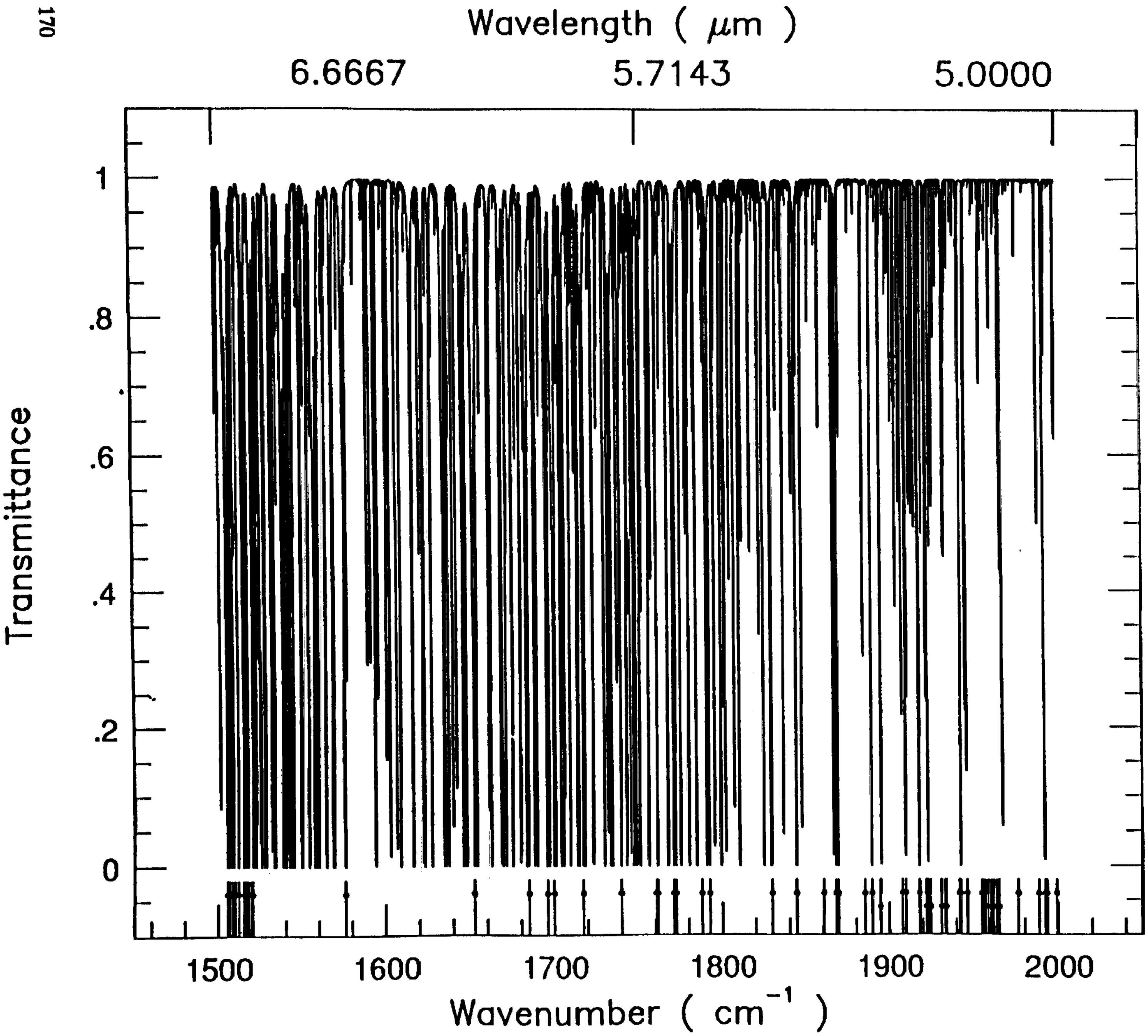


Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O O_3 N_2O CH_4

Lambda 1	1000.000
Lambda 2	1500.000
Sampling	0.000171
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	8.333
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 20:45:15 1991



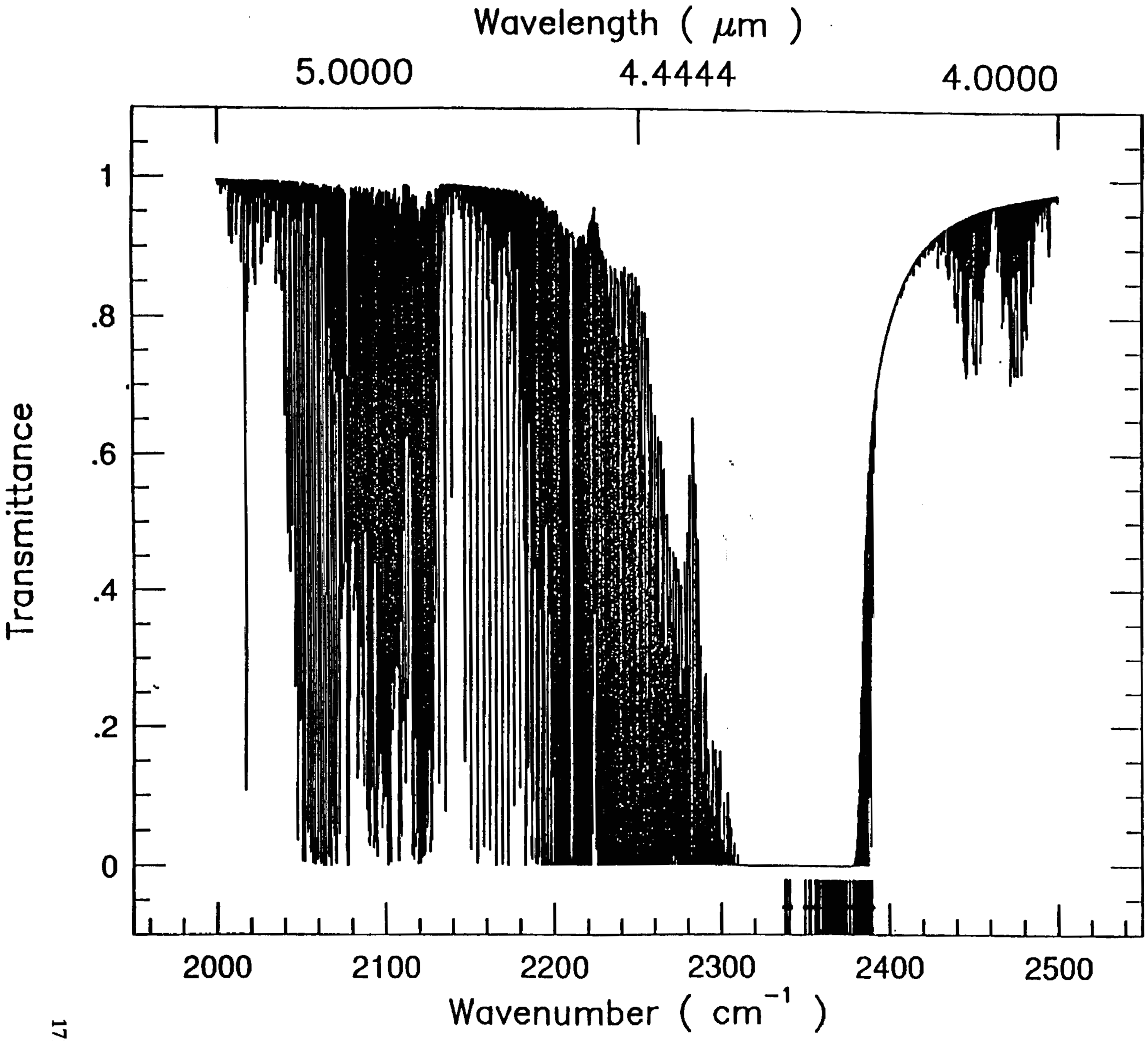
#25

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2

Lambda 1	1500.000
Lambda 2	2000.000
Sampling	0.000086
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	5.833
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 20:49:43 1991



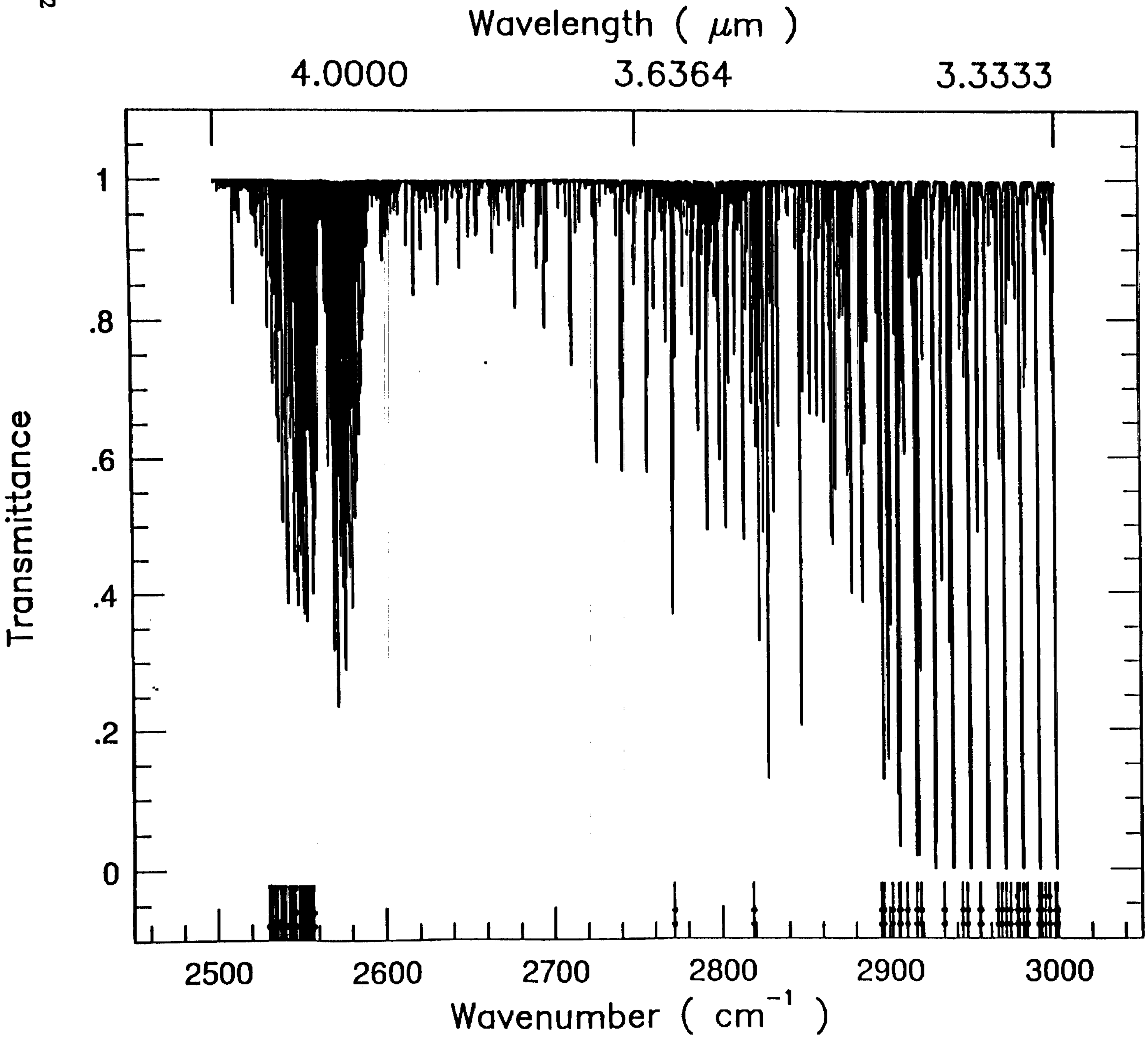
#25a

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2

Lambda 1	2000.000
Lambda 2	2500.000
Sampling	0.000051
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	4.500
Num. Pts.	19493
Ozone	9.13E+18

Mon Oct 14 17:29:26 1991



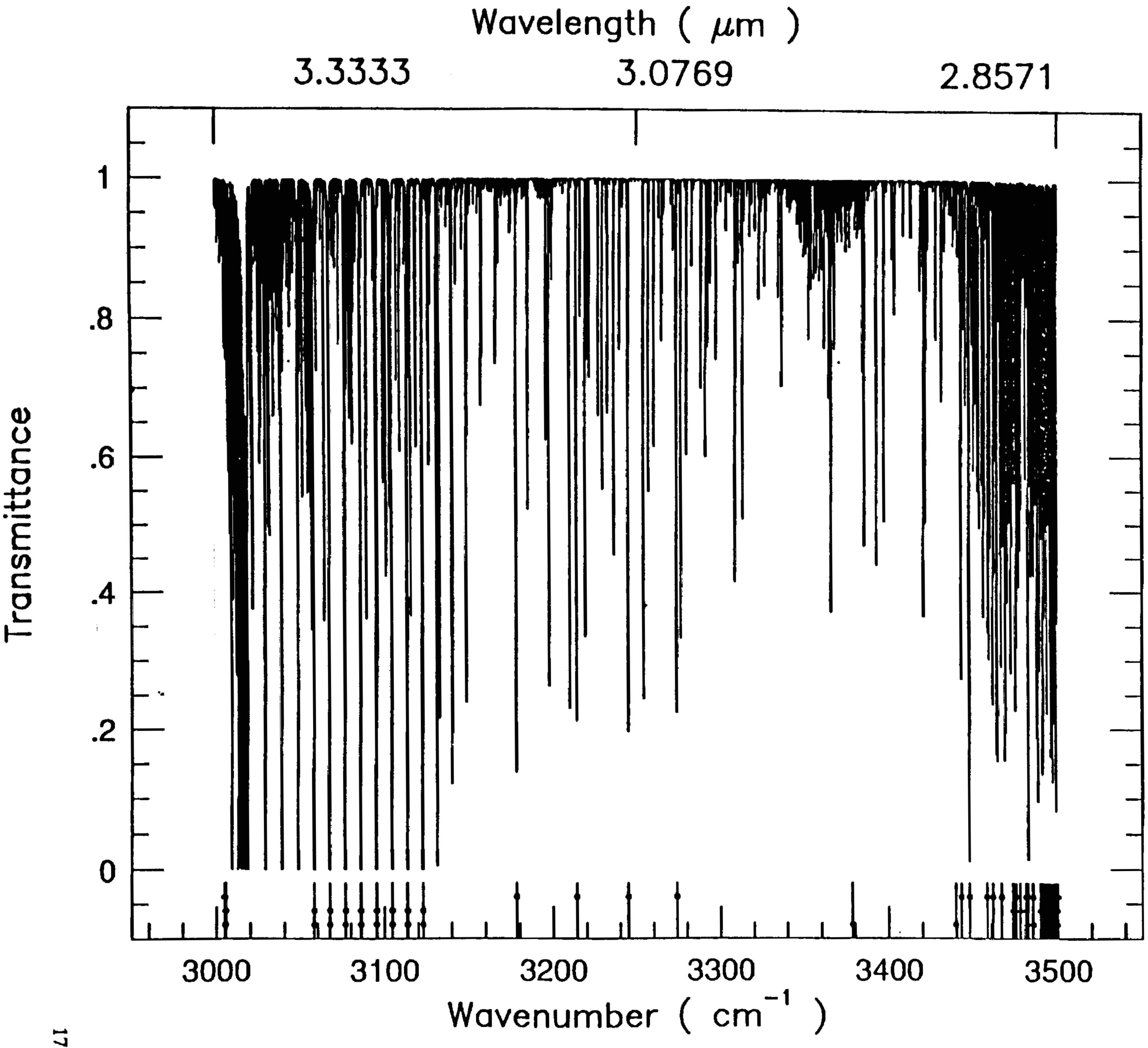
#26

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O N_2O CH_4

Lambda 1	2500.000
Lambda 2	3000.000
Sampling	0.000034
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	3.667
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 20:53:36 1991

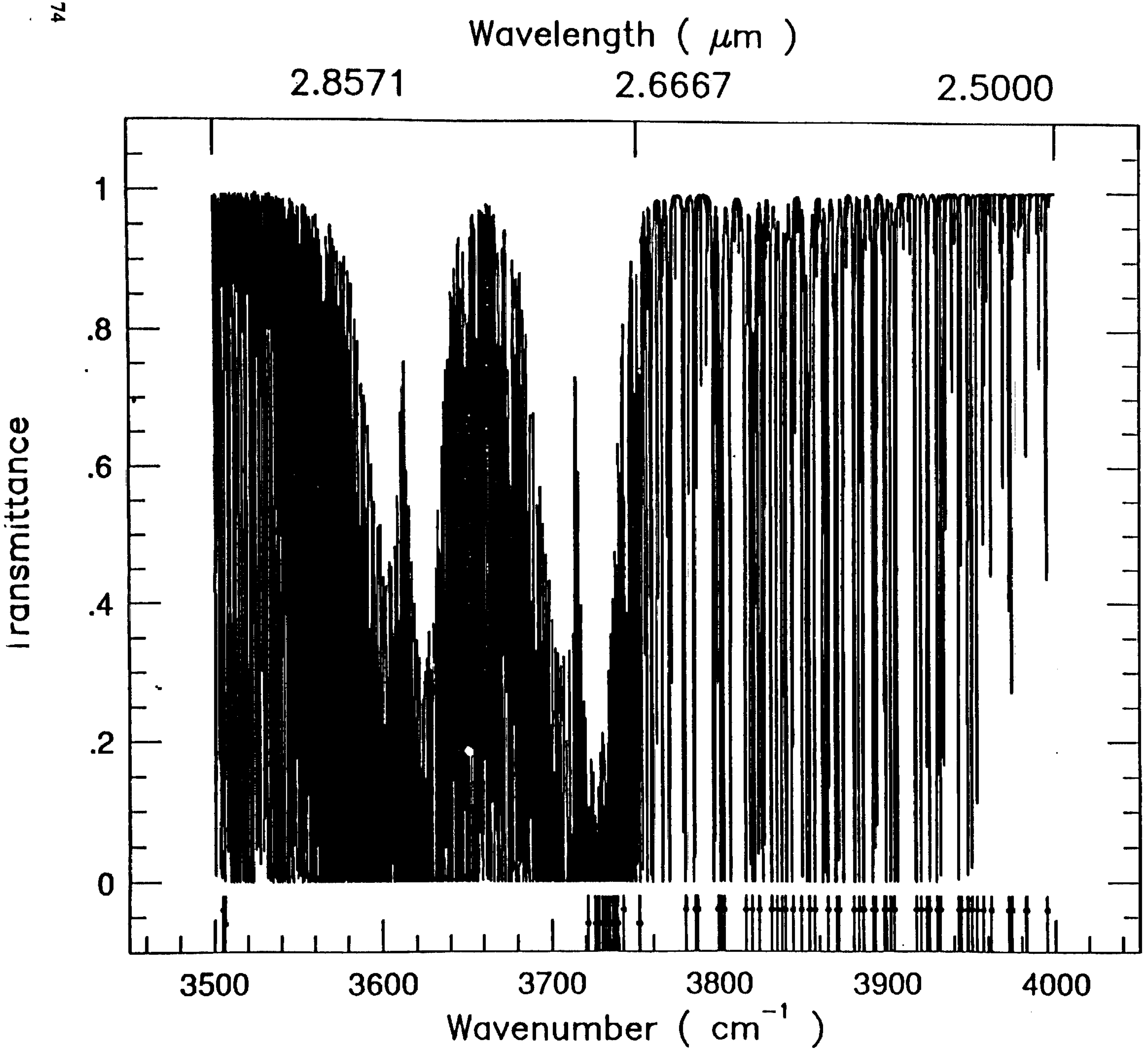


#27

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

Lambda 1	3000.000
Lambda 2	3500.000
Sampling	0.000024
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	3.095
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 20:57:20 1991



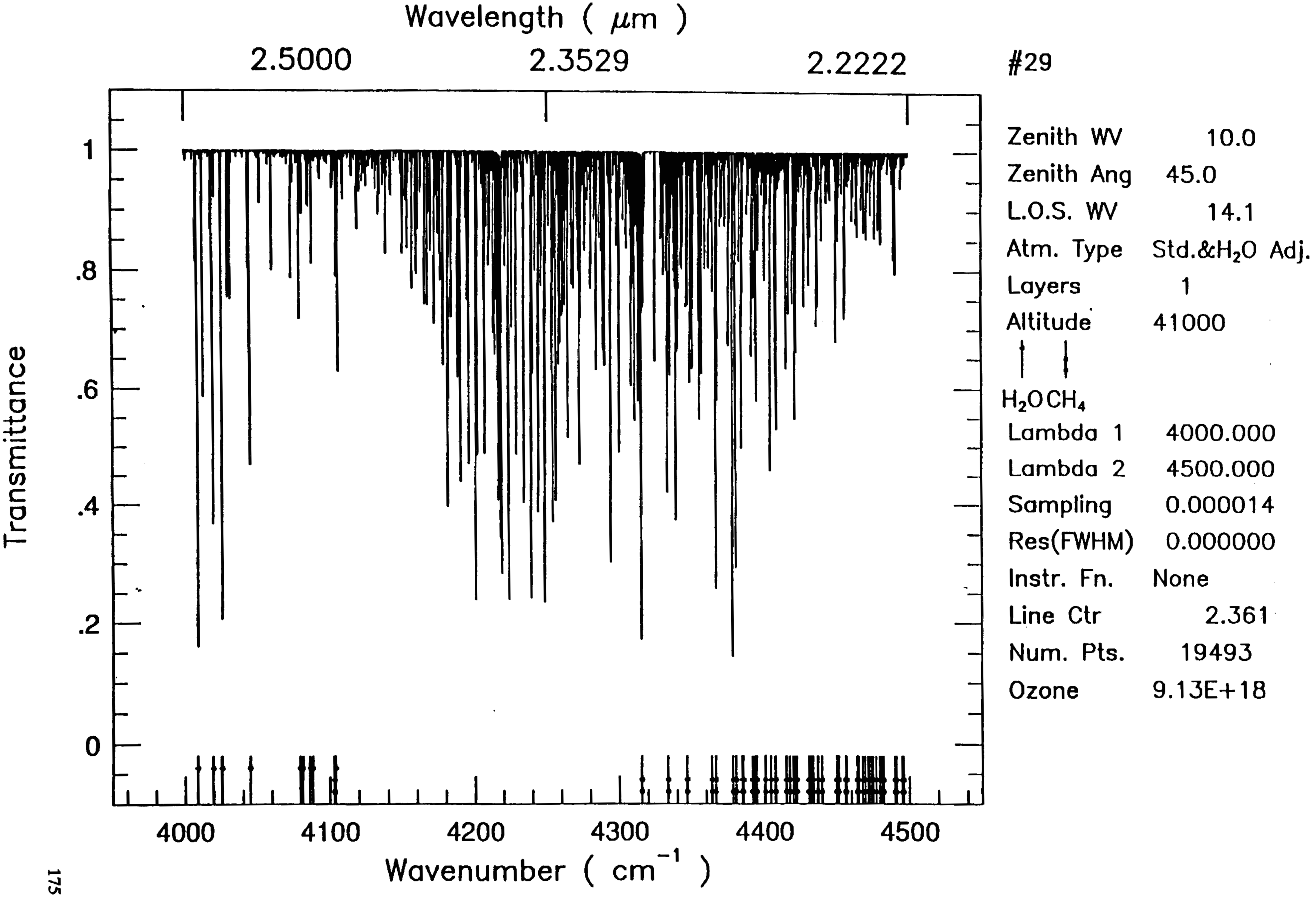
#28

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2

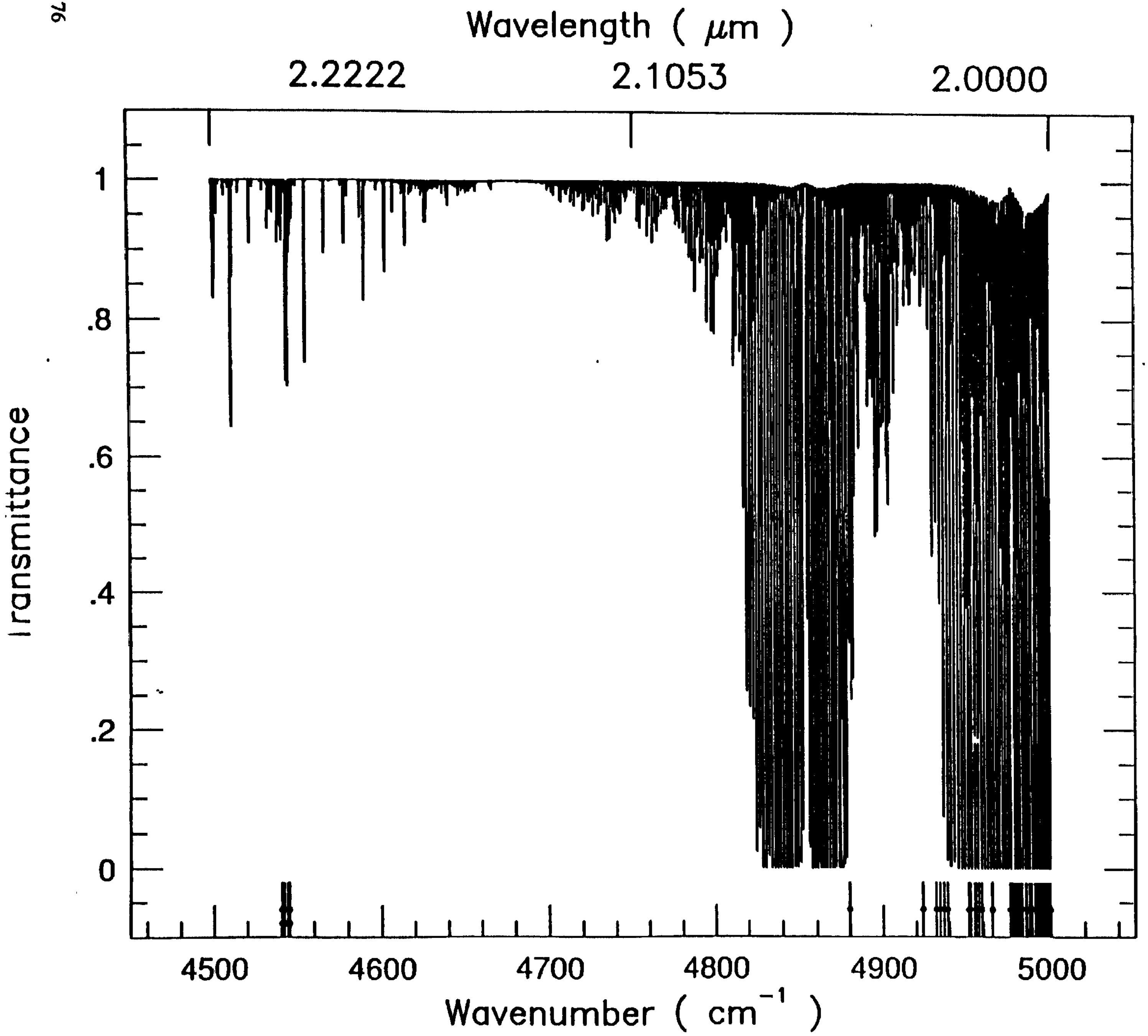
Lambda 1	3500.000
Lambda 2	4000.000
Sampling	0.000018
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.679
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:03:24 1991



Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	4000.000
Lambda 2	4500.000
Sampling	0.000014
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.361
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:06:09 1991



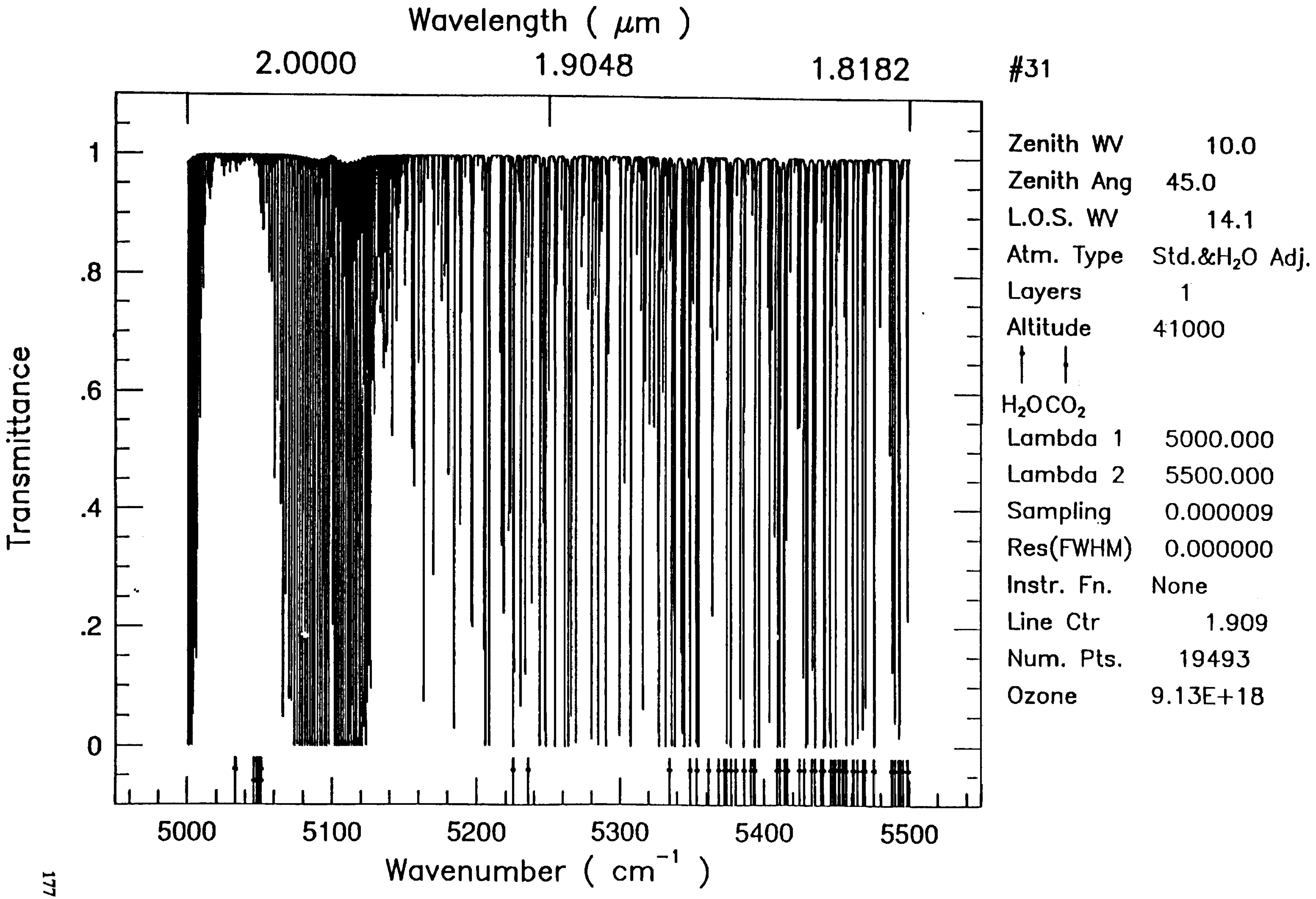
#30

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2 CH_4

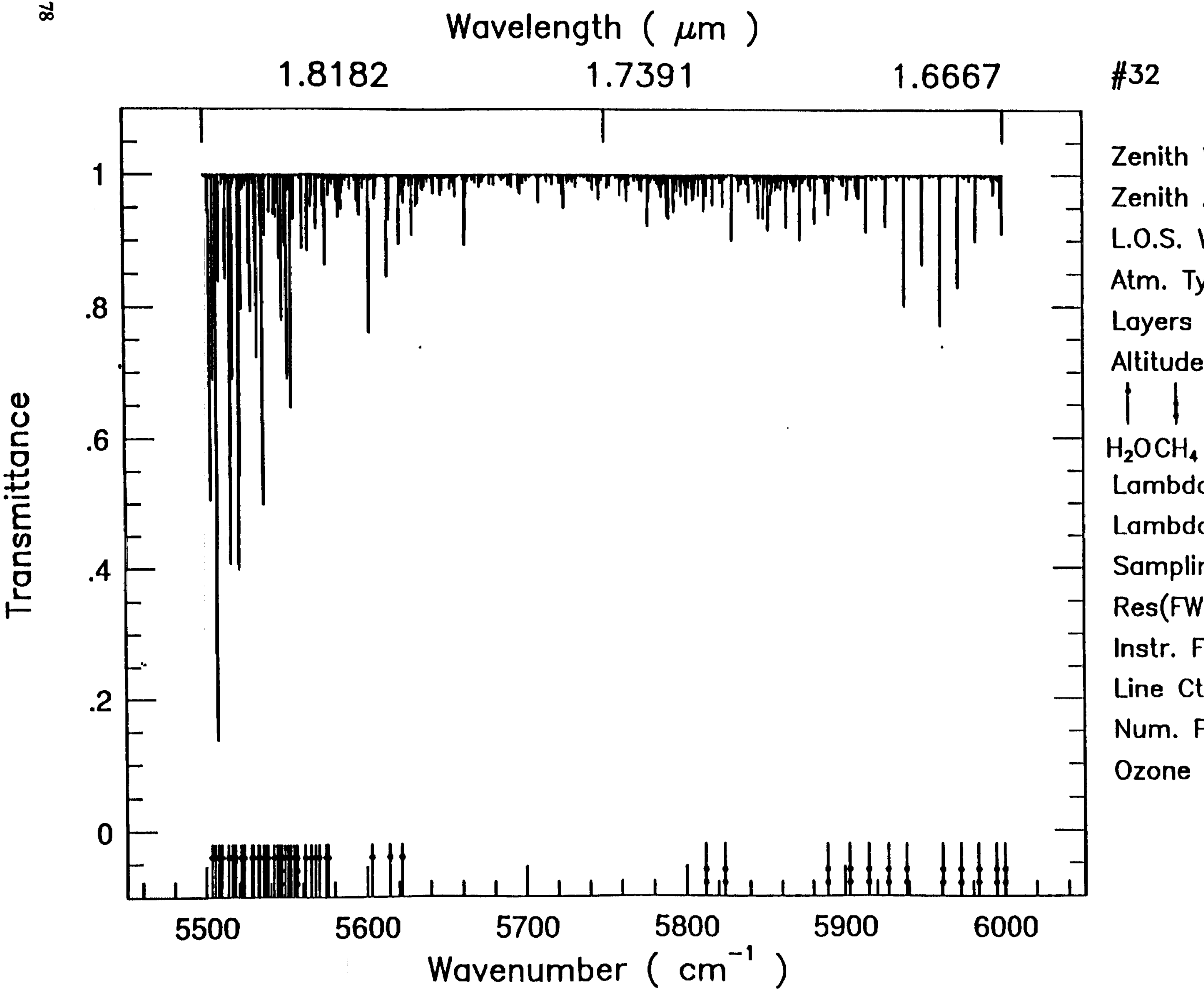
Lambda 1	4500.000
Lambda 2	5000.000
Sampling	0.000011
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	2.111
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:08:59 1991



Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	5000.000
Lambda 2	5500.000
Sampling	0.000009
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.909
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:11:50 1991

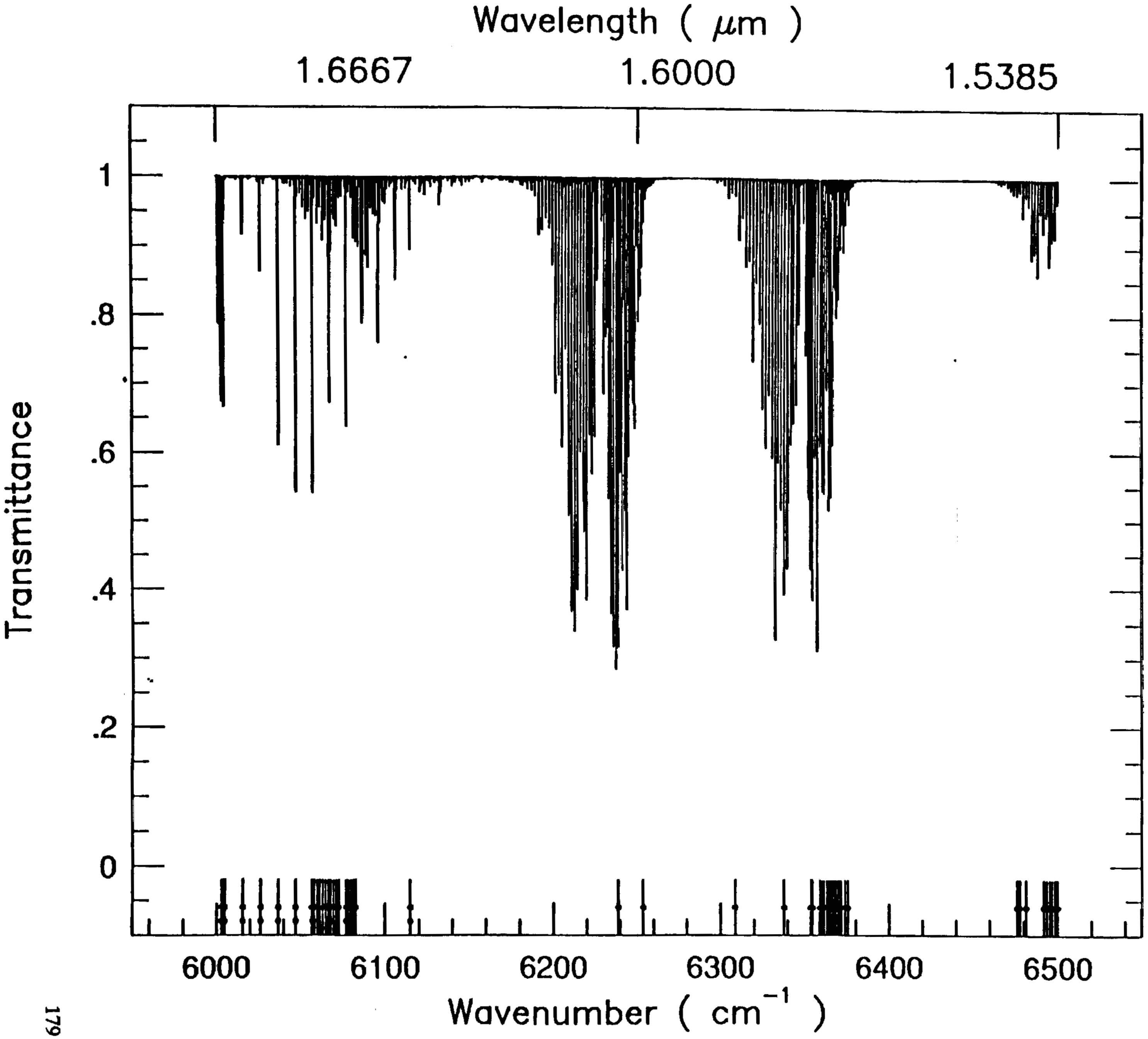


#32

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	5500.000
Lambda 2	6000.000
Sampling	0.000008
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.742
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:14:31 1991

#33

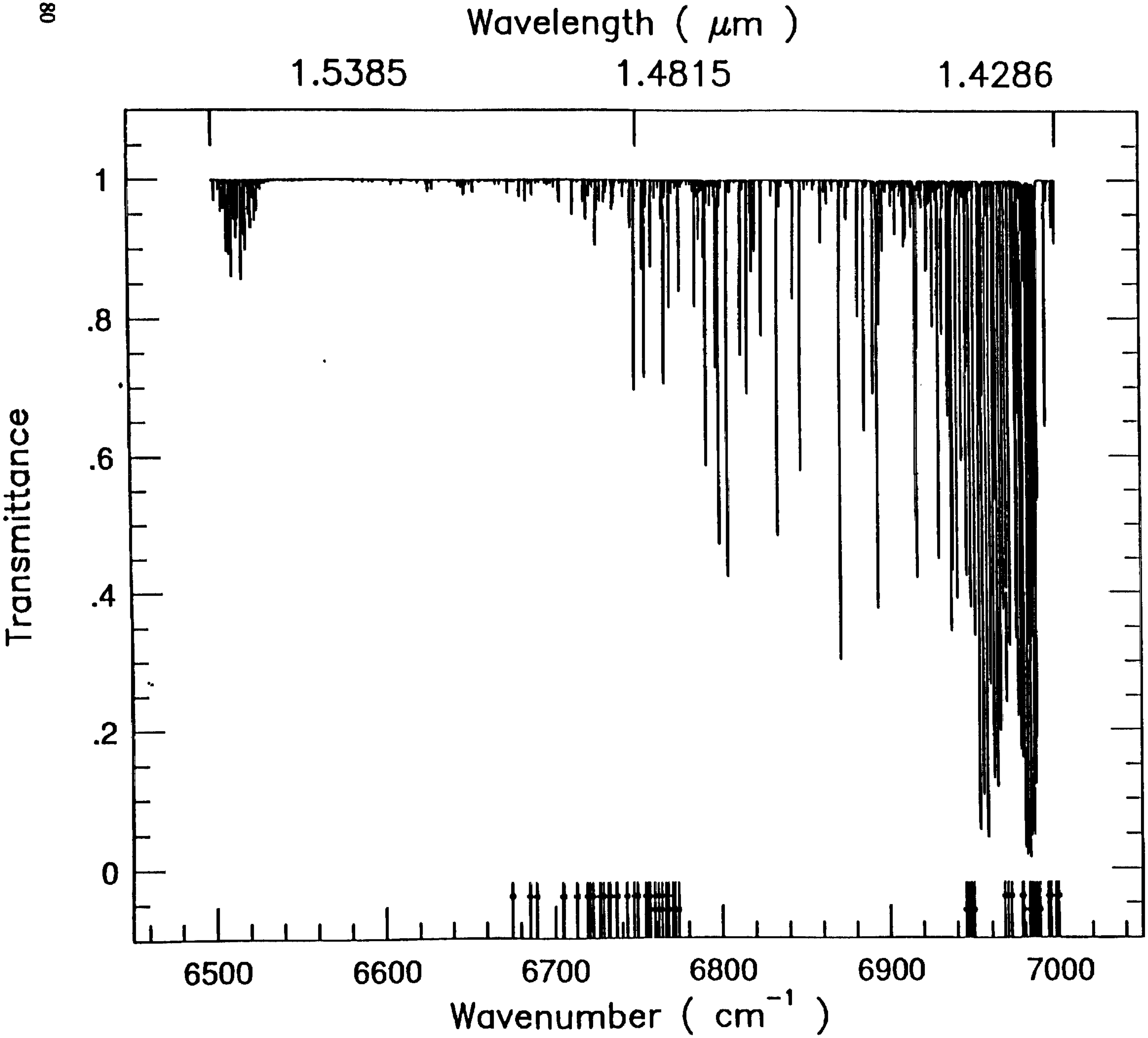


Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

CO_2 CH_4

Lambda 1	6000.000
Lambda 2	6500.000
Sampling	0.000007
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.603
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:17:13 1991



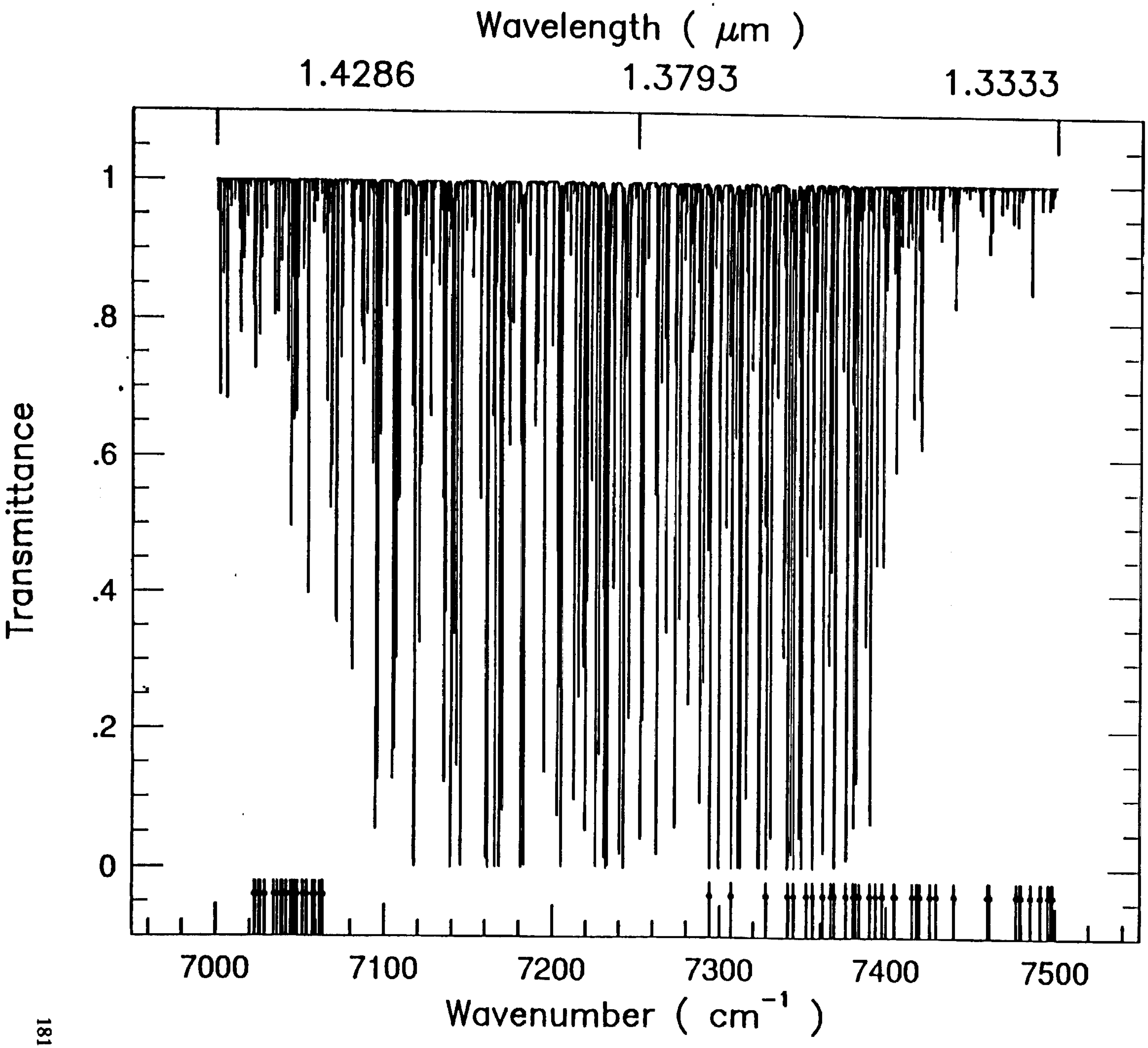
#34

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2

Lambda 1	6500.000
Lambda 2	7000.000
Sampling	0.000006
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.484
Num. Pts.	19493
Ozone	9.13E+18

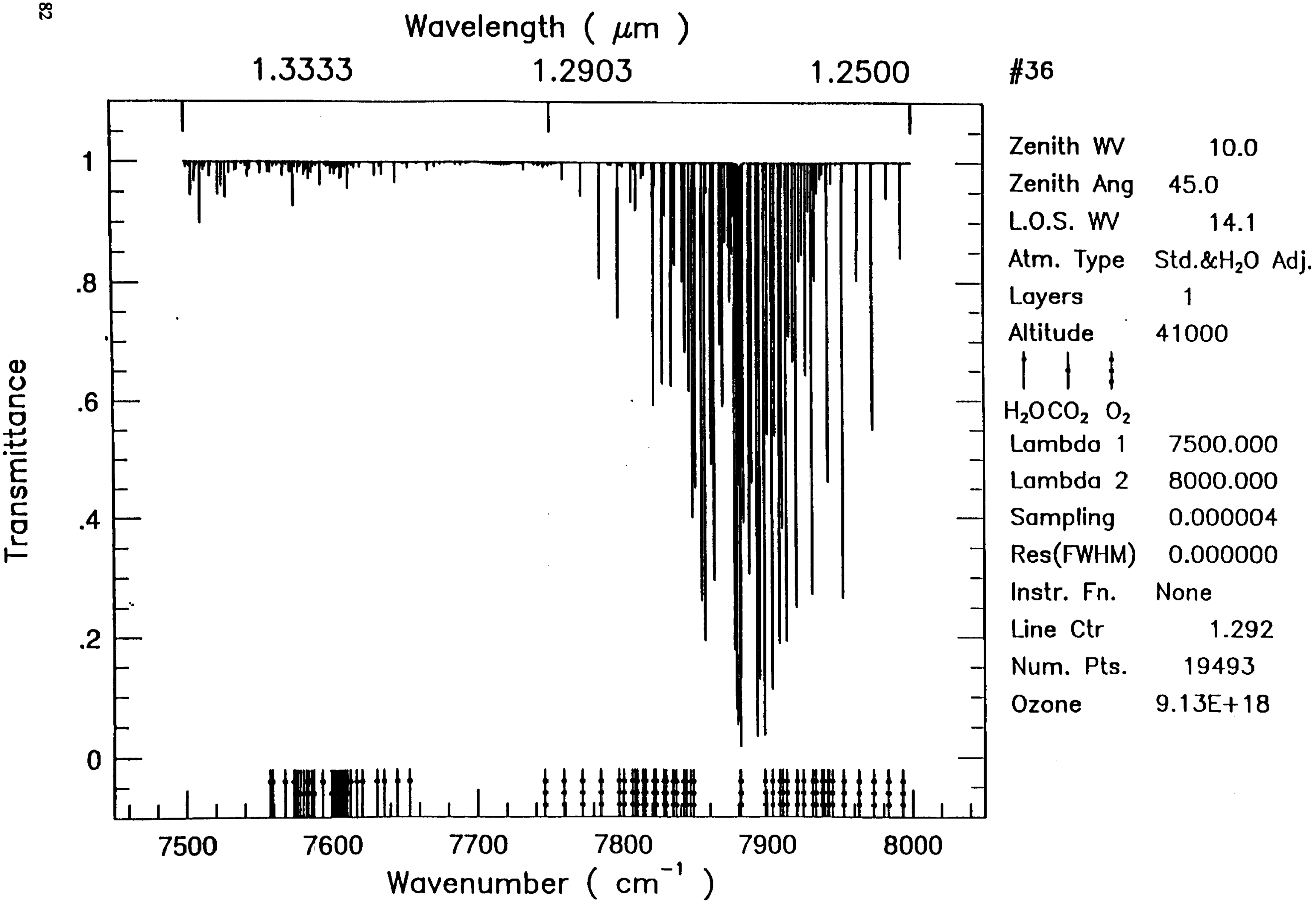
Tue Oct 8 21:19:56 1991



#35

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	7000.000
Lambda 2	7500.000
Sampling	0.000005
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.381
Num. Pts.	19493
Ozone	9.13E+18

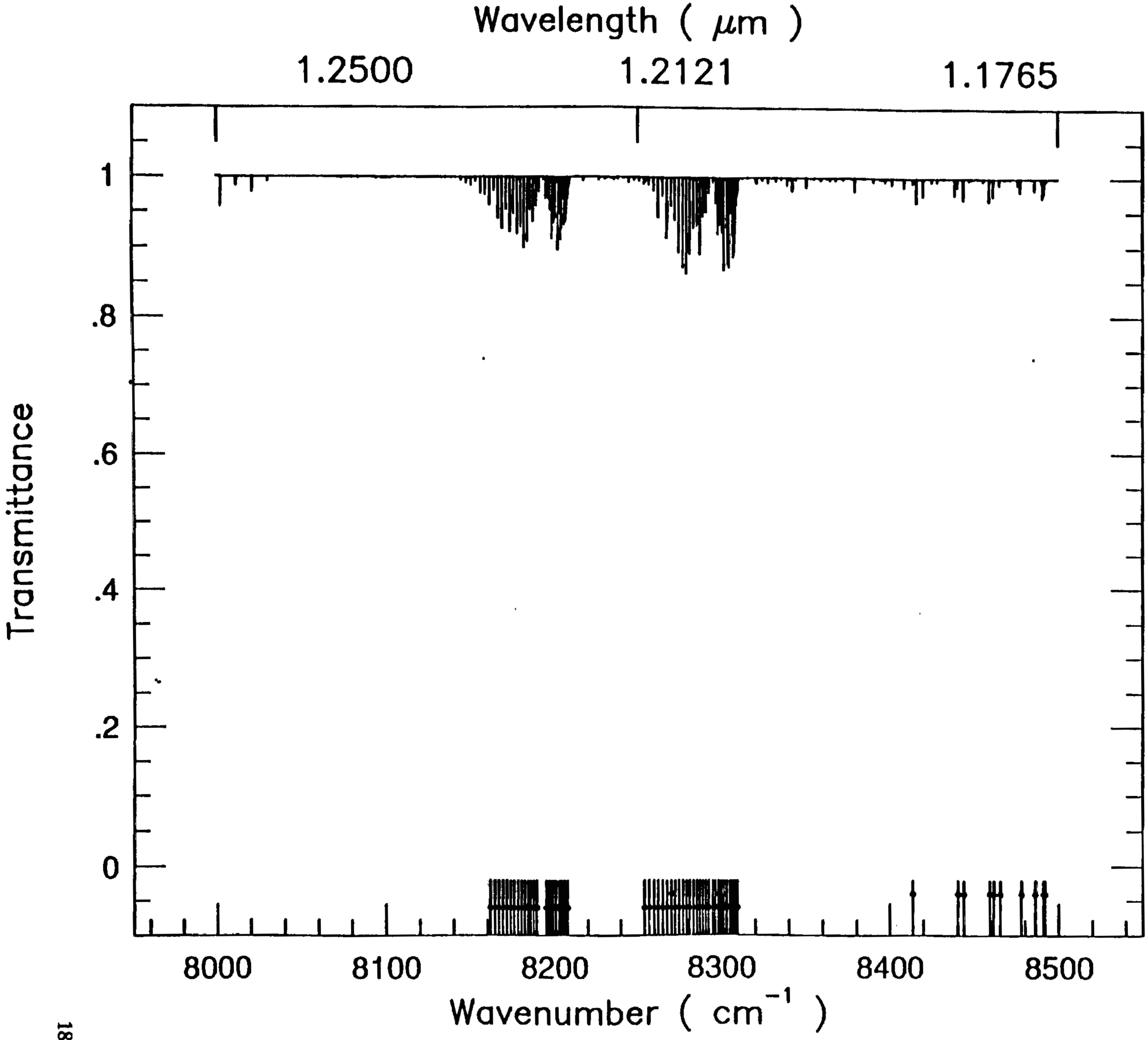
Tue Oct 8 21:22:42 1991



#36

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	7500.000
Lambda 2	8000.000
Sampling	0.000004
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.292
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:25:22 1991



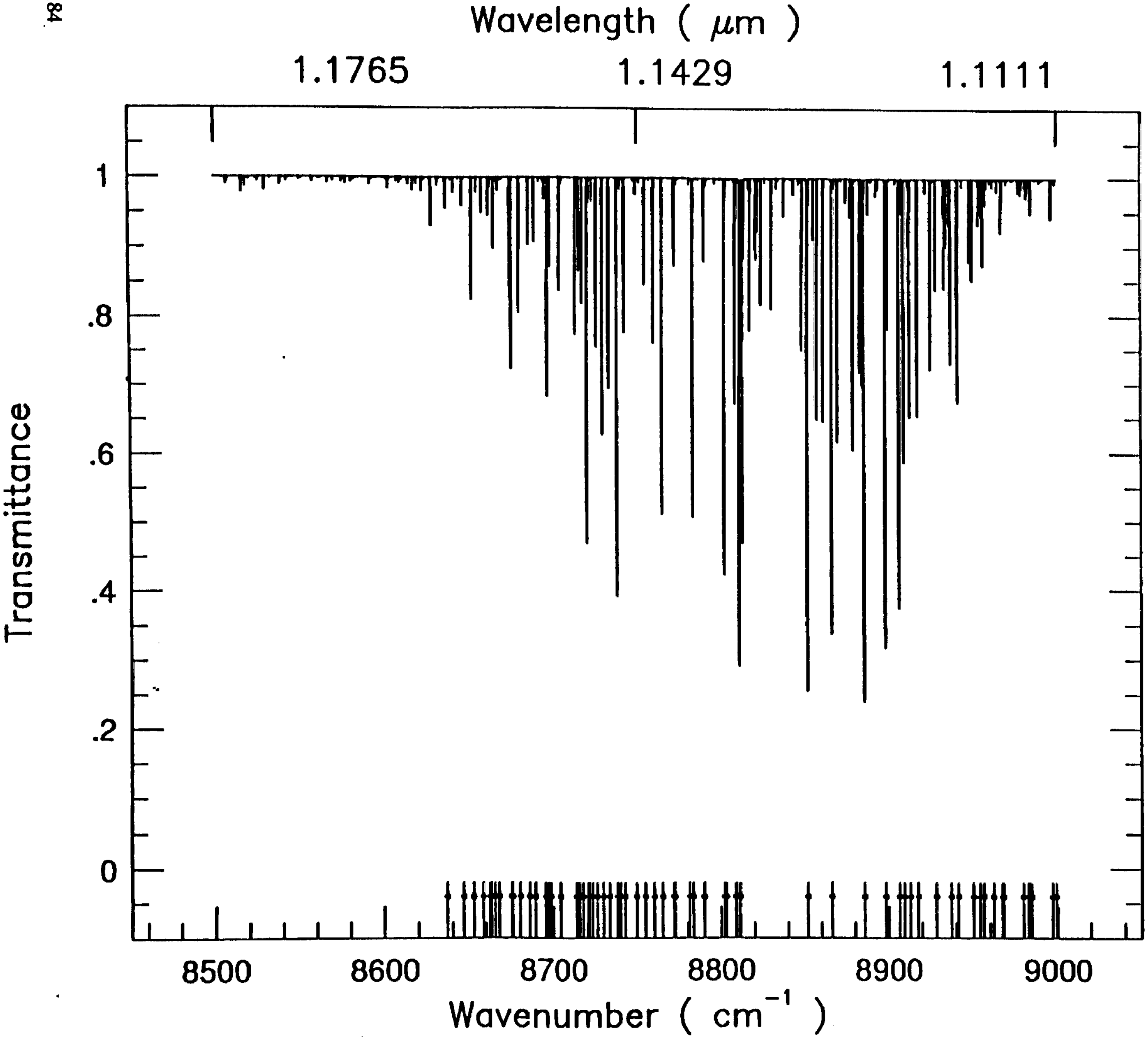
#37

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O CO_2

Lambda 1	8000.000
Lambda 2	8500.000
Sampling	0.000004
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.213
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:28:04 1991



#38

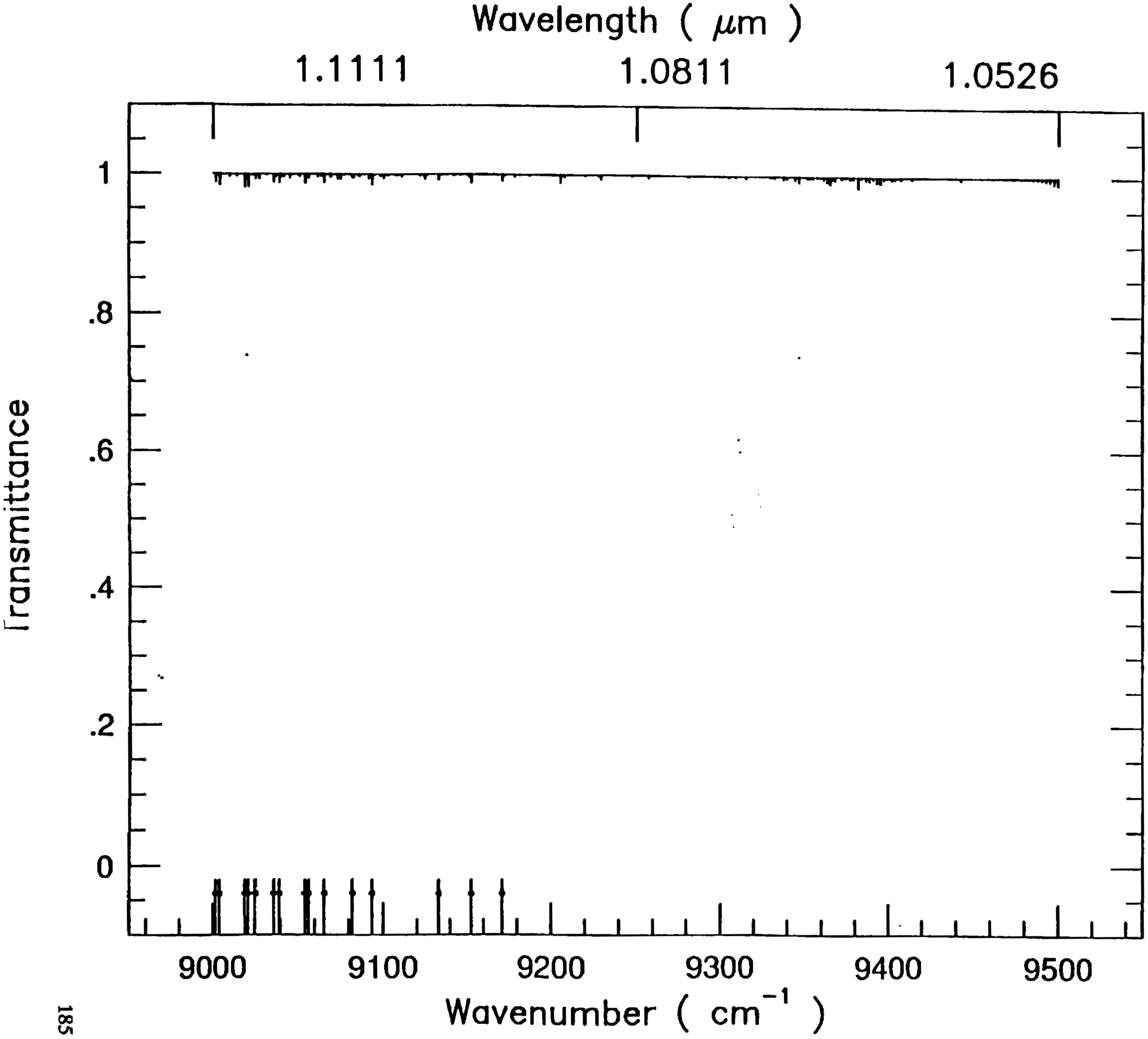
Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑

H_2O

Lambda 1	8500.000
Lambda 2	9000.000
Sampling	0.000003
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.144
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:30:46 1991



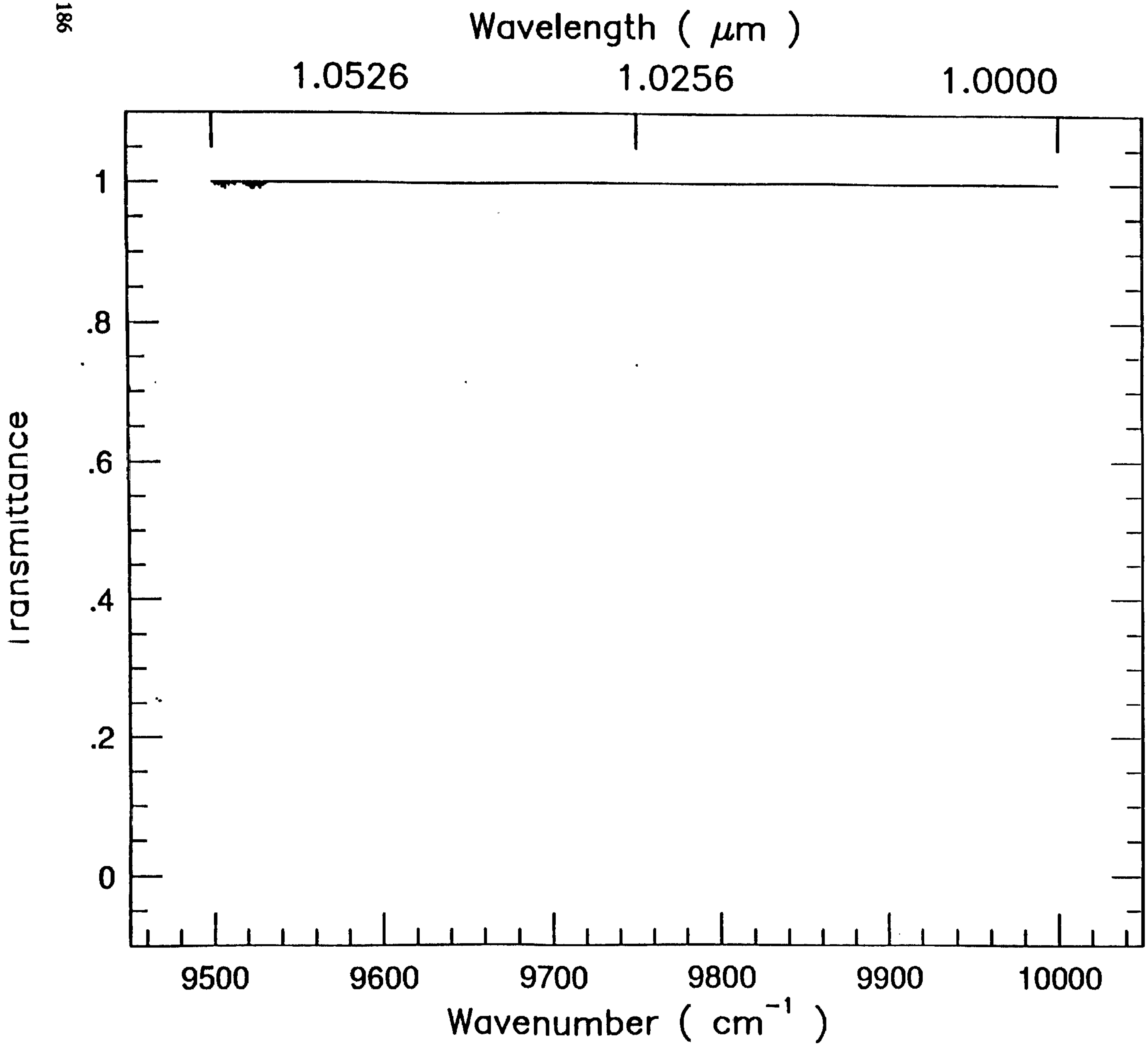
#39

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O

Lambda 1	9000.000
Lambda 2	9500.000
Sampling	0.000003
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.082
Num. Pts.	19493
Ozone	9.13E+18

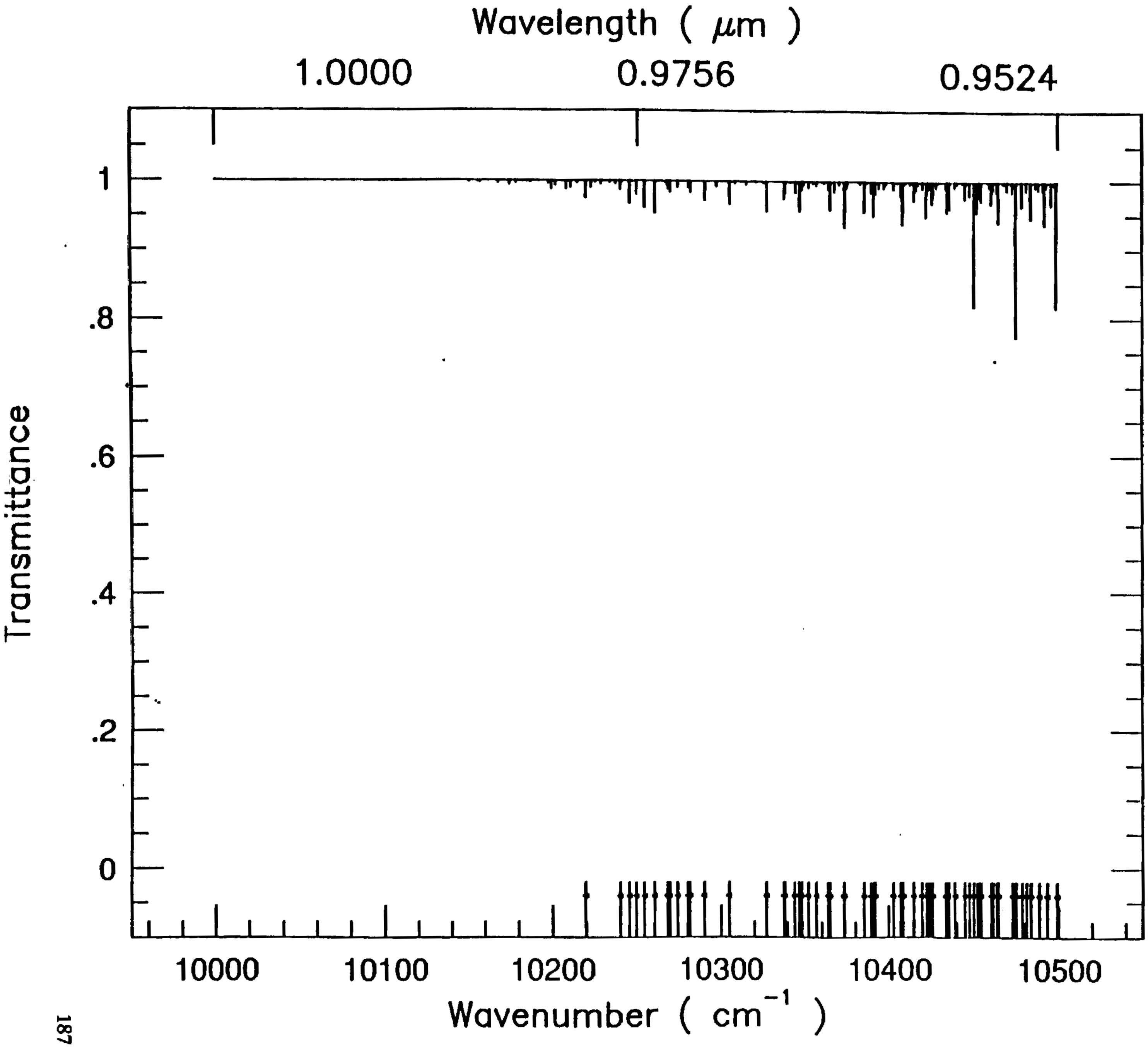
Tue Oct 8 21:33:26 1991



#40

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	9500.000
Lambda 2	10000.000
Sampling	0.000003
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	1.026
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:36:05 1991



#41

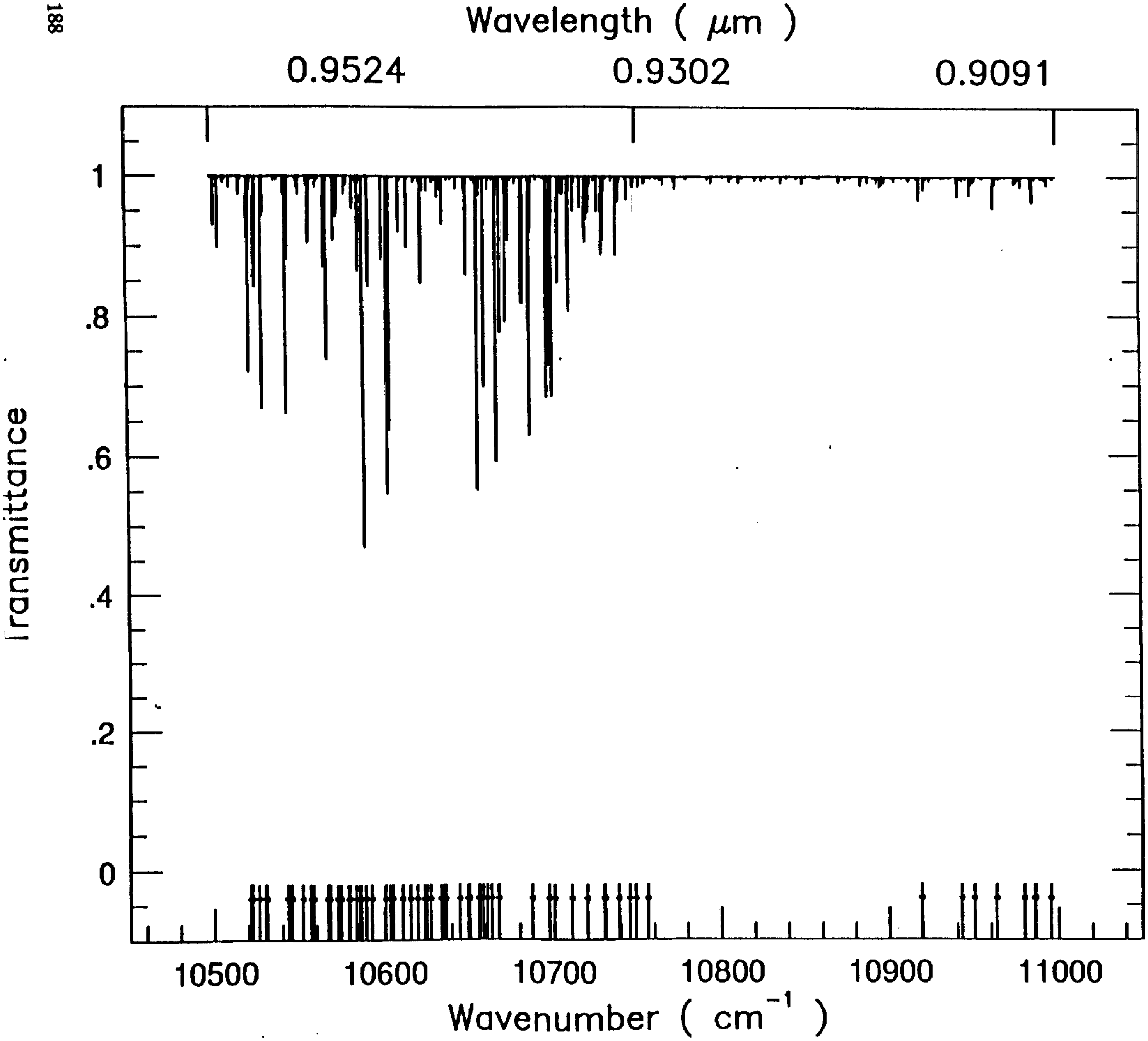
Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

↑

H_2O

Lambda 1	10000.000
Lambda 2	10500.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.976
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:38:44 1991



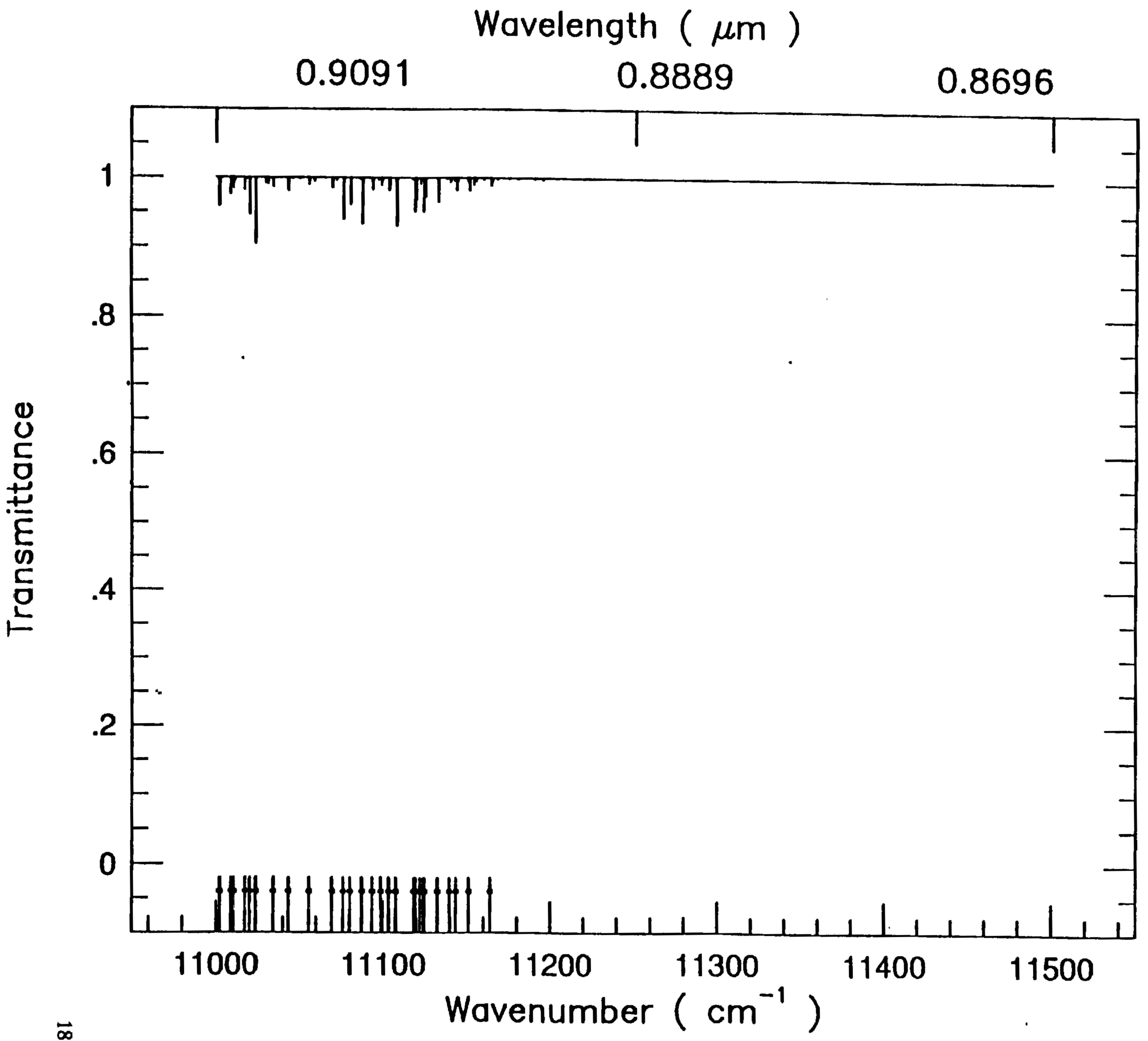
#42

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O

Lambda 1	10500.000
Lambda 2	11000.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.931
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:41:27 1991



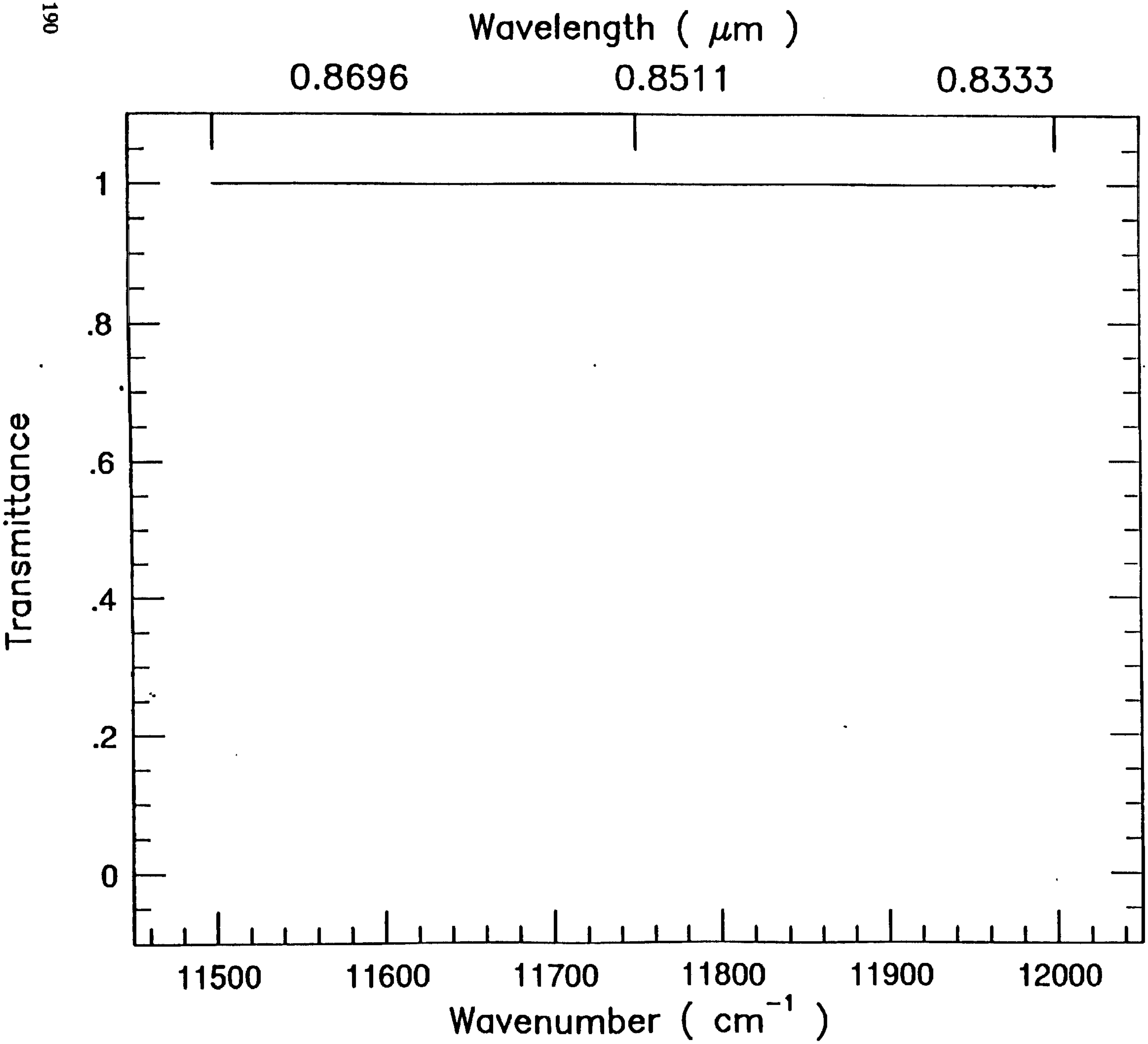
#43

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000

H_2O

Lambda 1	11000.000
Lambda 2	11500.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.889
Num. Pts.	19493
Ozone	9.13E+18

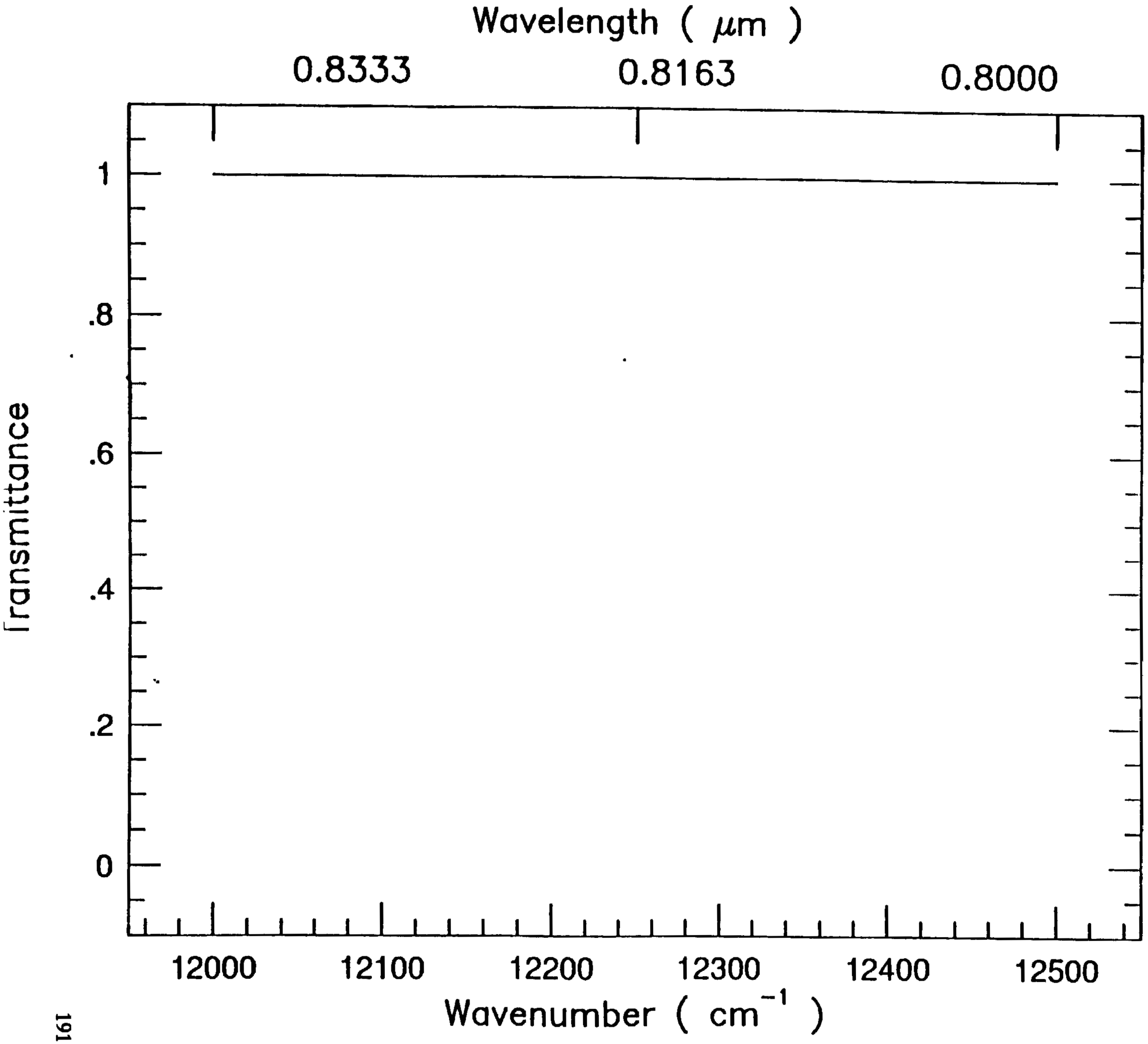
Tue Oct 8 21:44:08 1991



#44

Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	11500.000
Lambda 2	12000.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.851
Num. Pts.	19493
Ozone	9.13E+18

Tue Oct 8 21:46:49 1991



#45

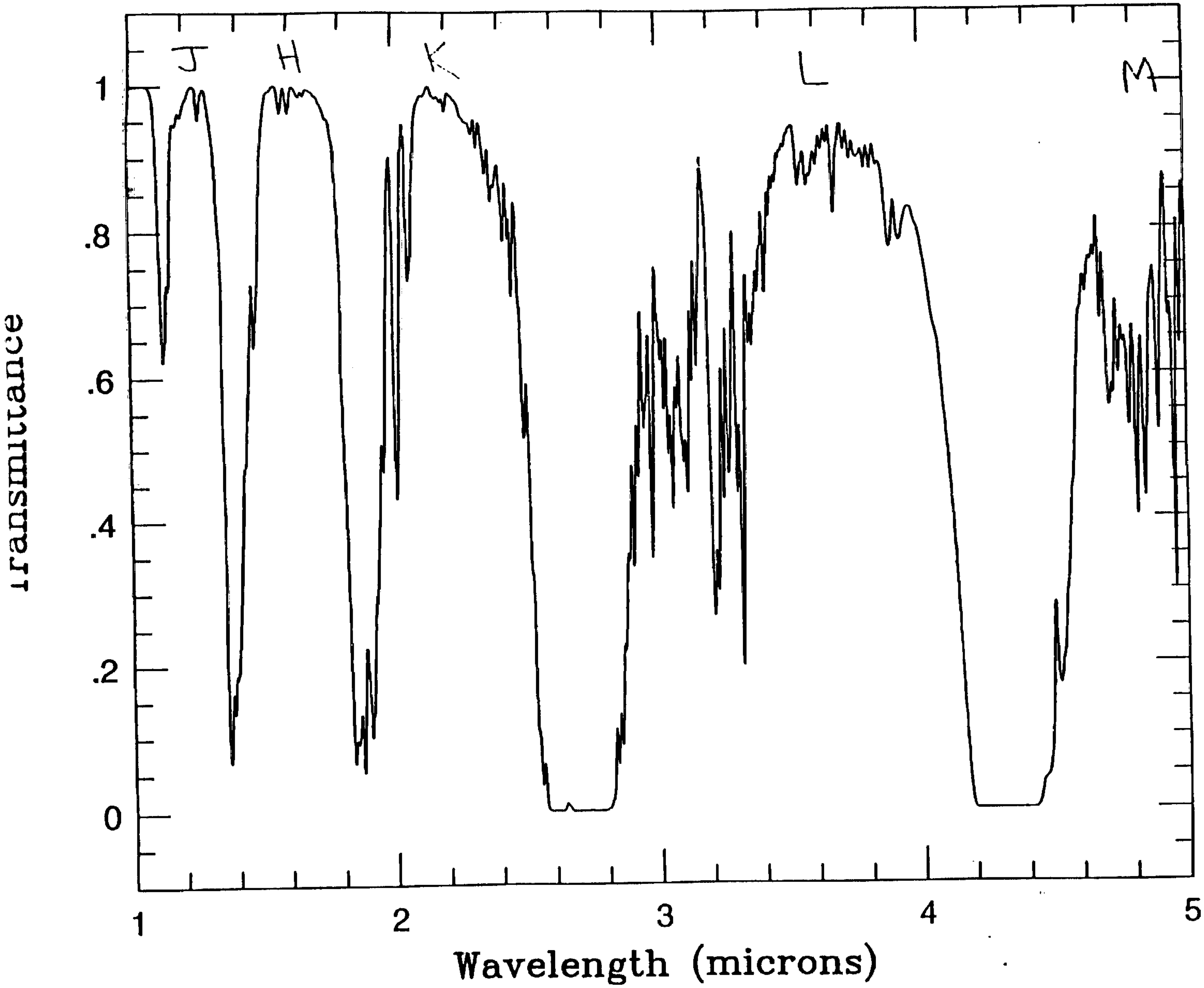
Zenith WV	10.0
Zenith Ang	45.0
L.O.S. WV	14.1
Atm. Type	Std.&H_2O Adj.
Layers	1
Altitude	41000
Lambda 1	12000.000
Lambda 2	12500.000
Sampling	0.000002
Res(FWHM)	0.000000
Instr. Fn.	None
Line Ctr	0.817
Num. Pts.	19493
Ozone	9.13E+18

Wed Oct 9 12:10:24 1991

APPENDIX G

NEAR-IR BANDS AT MOUNTAINTOP ALTITUDE

The following spectrum was produced by running ATRAN 15 times, producing data files that encompass the near-IR band from 1 to 5 μm. These files were appended to one file, and plotted as shown. The bands J, H, K. L, M are shown.



Zenith WV	3508.5
Zenith Ang	45.0
L.O.S. WV	4961.8
Atm. Type	Standard
Layers	1
Altitude	13500
Lambda 1	1.000
Lambda 2	5.000
Sampling	0.002000
Res(FWHM)	0.010000
Instr. Fn.	Gaussian
Line Ctr	2.5
Num. Pts.	1990
Ozone	9.13E+18

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(415) 604-5502

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13. ABSTRACT *(Maximum 200 words)*

This report describes a new software tool ATRAN which computes the transmittance of Earth's atmosphere at near- and far-infrared wavelengths. We compare the capabilities of this program with others currently available and demonstrate its utility for observational data calibration and reduction. The program employs current water-vapor and ozone models to produce fast and accurate transmittance spectra for wavelengths ranging from 0.8 µm to 10 mm.

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