

Transmission function of the red atmospheric oxygen bands

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Abstract: Transmission functions of the oxygen A, B and γ bands have been calculated by a line-by-line integration over a wide range of temperatures, pressures and path lengths. All significant lines of isotopic species O_2^{16} , $O^{16}O^{17}$ and $O^{16}O^{18}$ whose relative line strengths are greater than 10^{-7} times that of the strongest line in each band of O_2^{16} are taken into account in the calculation and mixed Doppler-Lorentz profile is employed as the line shape factor. Transmission functions for the whole bands and for each 5 cm^{-1} interval within the bands are tabulated in detail.

1. Introduction

An accurate evaluation of the absorption of solar radiation by the oxygen band is very important for the estimation of radiation balance of the terrestrial atmosphere (Yamamoto, 1962), for satellite measurements of the cloud-top height (Yamamoto and Wark, 1961; Chapman, 1962; Saiedy et al., 1967; Gorodetskiy et al., 1971) and for the discovery of the oxygen on other planets.

The oxygen bands emerged in the near infrared region are the red atmospheric system in the region 6200\AA – 7600\AA and the infrared atmospheric system in the region 10600\AA – 12700\AA . It is well known that the former, which is treated in this study, is about 20 times as intense as the latter (Herzberg and Herzberg, 1947).

Earlier determinations of the line parameters for the red atmospheric bands (Allen, 1937; Van de Hulst, 1945; Wark and Mercer, 1965; Adiks and Dianov-Klokov, 1968; Burch and Gryvank, 1969; Miller et al., 1969, 1976; Galkin et al., 1972; Giver et al., 1974) are in conflict with each other. It is also the case for the transmission functions calculated by several workers (Wark and Mercer; Adiks et al., 1972). Recently, by comparing the absorption of the A band measured in our laboratory with those calculated from the sets of line parameters determined by several workers, we have found (Tanaka et al., 1978) that the line strengths proposed by Miller et al. and the line half-widths by Giver et al. provide the most plausible set of line parameters. Then we take this opportunity of calculating accurately the atmospheric transmission functions for the red atmospheric bands on the basis of the above line parameters.

In this paper, a method is described by which the transmission functions were calculated over a wide range of temperatures, pressures and path lengths. The results of calculation are presented in detail in the tables.

2. Band structure

As shown by Mulliken (1928), the red atmospheric oxygen bands are the intercombination band arising from the magnetic dipole electronic transition between $^1\Sigma_g^+$ and $^3\Sigma_g^-$. The vibrational bands corresponding to the transition (0-0) centered at 7620Å, (1-0) at 6880Å and (2-0) at 6280Å in this band system are designated as A band, B band and γ band, respectively. Since the transition $^1\Sigma_g^+ \rightarrow ^3\Sigma_g^-$ is strictly forbidden by electric dipole selection rules, these oxygen bands are very weak in the normal sense. But as is known from the fact that this band system is clearly observed in the solar spectra obtained at sea level, the absorption due to these bands, especially due to the A band, is comparatively strong in the terrestrial atmosphere which involves a large amount of oxygen. The red atmospheric bands consist of two P-form branches (PQ and PP , $\Delta K = -1$) and two R-form branches (RQ and RR , $\Delta K = +1$) which can be accounted for by the magnetic dipole selection rules $\Delta J = 0, \pm 1$ with the restriction $J = 0 \leftrightarrow \frac{1}{2}$, $J = 0, + \leftrightarrow +, - \leftrightarrow -, - \leftrightarrow +$. The corresponding transitions for the oxygen O_2^{16} are indicated in Fig. 1 by solid line. The broken-line circles refer to antisymmetric levels which are absent for the homonuclear molecule O_2^{16} because of zero nuclear spin of O_2^{16} , but present in the minor isotopic molecules such as $O^{16}O^{17}$ and $O^{16}O^{18}$. Although several expressions on rotational energy of triplet-splitting levels of the $^3\Sigma_g^-$ ground state have been derived by Schlapp (1937), Tinkham and Strandberg (1955) and Watson (1968), the predictions of energy from these formulae are nearly identical. According to the theory developed by Schlapp, the rotational energies of the $^3\Sigma_g^-$ ground state associated with a given value of K are expressed by the following formulae:

$$E_{J=K-1} = W + (2K+3)B - \lambda - [(2K+3)^2B^2 + \lambda^2 - 2\lambda B]^{1/2} + \mu(K+1) \quad (1)$$

$$E_{J=K} = W$$

$$E_{J=K+1} = W - (2K-1)B - \lambda + [(2K+3)^2B^2 + \lambda^2 - 2\lambda B]^{1/2} - \mu K \quad (3)$$

where W is the rotational energy for the usual nonrigid rotator given by

$$W = BK(K+1) - DK^2(K+1)^2 + \dots, \quad (4)$$

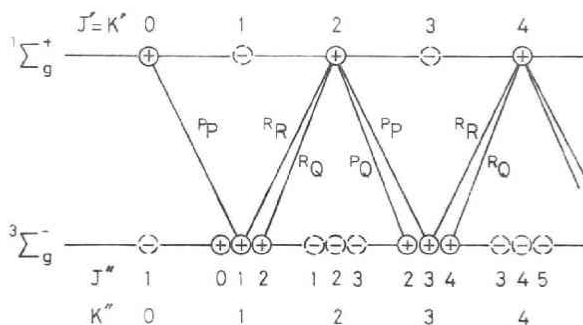


Fig. 1: Transitions in the red system of atmospheric oxygen bands of O_2^{16} . The broken-line circles refer to antisymmetric rotational levels which are absent for zero nuclear spin. Spectra of $O^{16}O^{17}$ and $O^{16}O^{18}$ contain additional transitions among these levels.

B and D are the rotational constants and λ and μ are the splitting constants which represent a coupling of the spin to the internuclear axis and a magnetic coupling between the electron spin and the axis of rotation, respectively.

The molecular constants of three isotopic molecules, O_2^{16} , $\text{O}^{16}\text{O}^{17}$ and $\text{O}^{16}\text{O}^{18}$ in the states $^3\Sigma_g^-$ and $^1\Sigma_g^+$ have been determined accurately by Babcock and Herzberg (1948). The constants used in this calculation are summarized in Table 1. The values of ν_{i0} represent the center of each band. The molecular constants for O_2^{16} contained in the table are taken from Babcock and Herzberg, and those for the minor isotopic molecules, $\text{O}^{16}\text{O}^{17}$ and $\text{O}^{16}\text{O}^{18}$, are obtained from the values of molecular constants for O_2^{16} and the theoretical relations (Herzberg, 1950).

Table 1: Molecular constants of the three oxygen molecules.

| | O_2^{16} | | $\text{O}^{16}\text{O}^{17}$ | | $\text{O}^{16}\text{O}^{18}$ | |
|----------------------------|------------------------|------------------------|------------------------------|------------------------|------------------------------|------------------------|
| | $^3\Sigma_g^-$ | $^1\Sigma_g^+$ | $^3\Sigma_g^-$ | $^1\Sigma_g^+$ | $^3\Sigma_g^-$ | $^1\Sigma_g^+$ |
| $B_0(\text{cm}^{-1})$ | 1.43777 | 1.39133 | 1.39542 | 1.35037 | 1.35793 | 1.31411 |
| $D_0(\text{cm}^{-1})$ | 4.913×10^{-6} | 5.395×10^{-6} | 4.628×10^{-6} | 5.081×10^{-6} | 4.382×10^{-6} | 4.811×10^{-6} |
| $\nu_{00}(\text{cm}^{-1})$ | | 13120.908 | | 13122.021 | | 13123.019 |
| $B_1(\text{cm}^{-1})$ | | 1.37306 | | 1.33290 | | 1.29735 |
| $D_1(\text{cm}^{-1})$ | | 5.472×10^{-6} | | 5.153×10^{-6} | | 4.879×10^{-6} |
| $\nu_{10}(\text{cm}^{-1})$ | | 14525.660 | | 14506.281 | | 14488.873 |
| $B_2(\text{cm}^{-1})$ | | 1.35472 | | 1.31537 | | 1.28052 |
| $D_2(\text{cm}^{-1})$ | | 5.549×10^{-6} | | 5.262×10^{-6} | | 4.948×10^{-6} |
| $\nu_{20}(\text{cm}^{-1})$ | | 15902.416 | | 15863.372 | | 15828.291 |
| $\lambda(\text{cm}^{-1})$ | 1.984 | | 1.984 | | 1.984 | |
| $\mu(\text{cm}^{-1})$ | -0.00837 | | -0.00790 | | -0.00740 | |

3. Line parameters and details of calculation.

The mean transmission in the spectral interval $\nu_1 \sim \nu_2$, τ , is given by

$$\tau = \frac{1}{\nu_2 - \nu_1} \int_{\nu_1}^{\nu_2} \exp(-\sum_i k_{\nu_i} u) d\nu. \quad (5)$$

Here k_{ν_i} is the absorption coefficient of the i th line at wavenumber ν and u is the absorber thickness defined by

$$u = 0.21pl \frac{273.15}{T} \quad (6)$$

where $0.21p$ is the partial pressure of the oxygen, l is the geometrical pathlength and T is the absolute temperature. The band limits adopted in this calculation are 13240 cm^{-1} – 12905 cm^{-1} , 14625 cm^{-1} – 14300 cm^{-1} and 15980 cm^{-1} – 15685 cm^{-1} for the A, B and γ bands, respectively. These band intervals are divided into subintervals with 5 cm^{-1} width, and each subinterval into a lot of smaller intervals. Four-point Gaussian quadrature is applied over these smaller intervals and the resulting transmissions are averaged over each 5 cm^{-1} subinterval and over the whole band interval. In order to set the transmission at each point, contributions from all lines of isotopic species,

O_2^{16} , $O^{16}O^{17}$ and $O^{16}O^{18}$, are taken into account, if their line strengths are greater than 10^{-7} times that of the strongest line of O_2^{16} in each band. The details of the line parameters governing directly the calculated results will be discussed below.

The Lorentz and Doppler half-widths of the red atmospheric bands become comparable at the comparatively high pressure of about 0.35 atm, so that, over a wide range of pressures, the absorption coefficient k_ν is given by the mixed Doppler-Lorentz profile, i.e. Voigt profile, in the form

$$k_\nu = \frac{k_0 y}{\pi} \int_{-\infty}^{+\infty} \frac{\exp(-t^2)}{y^2 + (x-t)^2} dt, \quad (7)$$

where $k_0 = \frac{S}{\gamma_D} \left(\frac{\ln 2}{\pi} \right)^{1/2}$, $y = \frac{\gamma_L}{\gamma_D} (\ln 2)^{1/2}$, $x = \frac{(\nu - \nu_0)}{\gamma_D} (\ln 2)^{1/2}$
and

$$\gamma_D = \frac{\nu_0}{c} \left(\frac{2kT \ln 2}{m} \right)^{1/2}.$$

It is well known that this profile reduces to the Lorentz profile given by

$$k_\nu = \frac{1}{\pi} \frac{S \gamma_L}{(\nu - \nu_0)^2 + \gamma_L^2} \quad (8)$$

in the high pressure range where collision broadening predominates and to the Doppler profile given by

$$k_\nu = k_0 \exp(-x^2) \quad (9)$$

in the low pressure range where Doppler broadening surpasses collision broadening. Although the Voigt profile (i.e. Lorentz profile for stationary molecules) is subject to doubt as the shape factor of the oxygen line in the works of Adiks and Dianov-Klovov and Burch and Gryvank, our absorption measurement for the A band has provided a good confirmation on this profile. Thus the employment of the Voigt profile in calculating the transmission functions of the red atmospheric bands is expected to give satisfactory results. The integral (7) can not be evaluated analytically, so that the efficient numerical method developed by Drayson (1976) is adopted except for the far wing of each line; the wings of all lines whose line centers are more distant than 10 cm^{-1} from each quadrature point are simply replaced by the Lorentz wing. This procedure reduces remarkably the computer time, while still retaining accurate wing effects.

The Lorentz half-width γ_L is normally represented by

$$\gamma_L = \gamma_L^\circ P \left(\frac{273.15}{T} \right)^n, \quad (10)$$

γ_L° being the value of γ_L at STP. For the atmosphere composed of 21% oxygen and 79% nitrogen, γ_L is given by

$$\gamma_L = \left[0.21 \gamma_{O_2-O_2}^\circ \left(\frac{273.15}{T} \right)^{n'} + 0.79 \gamma_{O_2-N_2}^\circ \left(\frac{273.15}{T} \right)^{n''} \right] P_{tot} \quad (11)$$

where P_{tot} is the total pressure and $\gamma_{0_2-0_2}^0$ and $\gamma_{0_2-N_2}^0$ are, respectively, the half-widths of the self-broadened and nitrogen-broadened oxygen line at STP. Since the temperature dependence of the half-widths of oxygen lines is not clarified yet, the same value of 0.5 is straightforwardly given to n , n' and n'' according to the classical pressure-broadening theory. Miller, Giver and Boese (Miller et al., 1969; Giver et al.,

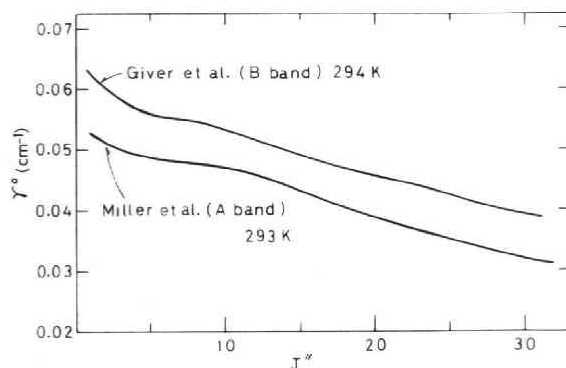


Fig. 2: Half-widths of self-broadened oxygen lines at 1 atm pressure. Giver et al.'s results for the B band are given by upper curve. The results of Miller et al. for the A band are given by lower curve.

1974), who belong to the same study group, have measured the self-broadened half-widths of the oxygen A and B bands and found considerably different results for both bands as shown in Fig. 2. They have also found that there are no systematic differences between self-broadened and nitrogen-broadened half-widths. Since it is quite believable that the half-width is not so much different from band to band, the disagreement in their results is unlikely to be physically significant. In this connection, they have mentioned in the paper for the B band (Giver et al., 1974) that this difference is probably attributable to the greater uncertainties included in their analysis of the half-widths for the A band, and that the half-widths for the B band are more precise than those for the A band. We have also made sure that their half-widths for the B band are most plausible as the selfbroadened as well as nitrogen-broadened widths of the oxygen lines. Therefore, we have adopted the self-broadened half-widths by Giver et al. as the half-widths of all oxygen bands. Unfortunately, their measurements of the half-width is limited up to $J''=25$ line. Accordingly, the half-widths of lines with $J''=25\sim40$ are obtained by the extrapolation from observed values, and the constant value of 0.033 cm^{-1} (at 294 K) is assumed for lines with $J''\geq40$.

The strength of an individual line defined by

$$S_{J''} = \int_{-\infty}^{+\infty} k_{\nu} d\nu, \quad (12)$$

can be calculated from the band strength S_v by the following relation:

$$S_{J''} = S_v \frac{F_{J''}}{Q_T} \exp(-hc E_{J''}/kT) \quad (13)$$

where $F_{J''}$ is the weighting function, Q_T is the rotational partition function given by

$$Q_T = \sum_{J''} F_{J''} \exp(-hcE_{J''}/kT), \quad (14)$$

$E_{J''}$ is the rotational energy presented by Eqs (1), (2) and (3) and double primes denotes the lower energy state. The weighting function $F_{J''}$ have been obtained experimentally by Childs and Mecke (1931) and theoretically by Schlapp, Tinkham and Strandberg and Watson. The distribution of line strengths determined from the recent laboratory measurements (Adiks and Dianov-klovov; Burch and Gryvnak; Miller et al.; Galkin et al.; Giver et al.) indicates a good consistence with that derived from theoretical function rather than that from experimental function. Moreover, Miller et al., Glakin et al. and Giver et al. have shown that the differences of the line strengths predicted by each theoretical function are so small that the selection of correct weighting function for the oxygen band would be permitted to only exceptionally accurate measurement. Thus the Schlapp's weighting function presented in Table 2 is employed in this calculation.

Table 2: Types of lines and Schlapp's weighting function.

| | J'' | ΔK | ΔJ | Weighting function |
|------|---------|------------|------------|-------------------------|
| PP | K'' | -1 | -1 | $\frac{1}{2}(J''+1)$ |
| PQ | $K''-1$ | -1 | 0 | $\frac{1}{2}(J''+0.75)$ |
| RQ | $K''+1$ | +1 | 0 | $\frac{1}{2}(J''+0.25)$ |
| RR | K'' | +1 | +1 | $\frac{1}{2}J''$ |

In employing Eq. (13), the band strength is the most important factor. Since the strength of the A band of $532 \pm 21 \text{ cm}^{-1} \text{ km}^{-1} \text{ atm}^{-1}$ STP determined by Miller et al. have been confirmed by us, this value is applied straightforwardly to Eq. (13). For the B and γ bands, only a few measurements have been done so far, and the band strengths are not yet established firmly. In this study, we adopt the $40.8 \pm 0.6 \text{ cm}^{-1} \text{ km}^{-1} \text{ atm}^{-1}$ STP and $1.52 \pm 0.07 \text{ cm}^{-1} \text{ km}^{-1} \text{ atm}^{-1}$ STP for the B and γ bands, which were determined by Giver et al. and Miller et al. (1976), respectively, under laboratory conditions. These authors have used the same experimental procedure in a series of investigations on the red atmospheric bands, and more accurate method of data analysis has been employed for these two bands than for the A bands.

The disagreement of the experimental line strengths and those calculated on the bases of Eq. (13) and theoretical weighting function, whose possible cause may be attributed to the effect of vibration-rotation interaction excluded from Eq. (13), has been recognized by Miller et al., but completely denied by Galkin et al. Since no significant differences have been found in earlier comparisons of spectra for the A

band (Tanaka et al.), this disagreement if it exists would affect little the calculated transmission functions of the A band. However, if Miller et al.'s suggestion of an increasing vibration-rotation interaction for the higher vibrational levels in the ${}^1\Sigma_g^+$ upper state is true, the transmission functions for the γ band, especially those for 5 cm^{-1} interval, would include some systematic errors.

4. Calculated results

The condition of the absorption path under which transmissions have been performed by the method described in the previous section is shown in Table 3. The temperature T , total air pressure P and path length L are given in units of K, atm and km, respectively. The absorber thicknesses can be easily obtained by Eq. (6) in unit of atm km.

Table 3: Temperatures, pressures and path lengths of tabulated transmission functions.

| $T(\text{K})$ | $P(\text{atm})$ | $L(\text{km})$ |
|---------------|-----------------|----------------|
| 300 | 1.0 | 50.0 |
| 250 | 0.75 | 20.0 |
| 200 | 0.5 | 10.0 |
| | 0.35 | 5.0 |
| | 0.2 | 2.0 |
| | 0.1 | 1.0 |
| | 0.05 | 0.5 |
| | 0.02 | 0.2 |
| | 0.01 | |

The calculated transmission functions are made an entry in Tables 4, 5 and 6 which correspond to the A, B and γ bands, respectively. The wavenumbers CWN listed in the tables refer to the center of the 5 cm^{-1} interval. For economy, some results of the 5 cm^{-1} interval near the band wings and all results of γ band for the pressure less than 0.02 atm, which are nearly equal to 1.0, are not shown in the tables. The transmission functions for the whole bands are represented in the lowest part of each table.

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| CWN (nm) | | | | | | | | | | | | | | PATH LENGTH (km) | | | | | | | | | | | | | |
|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--|--|
| 50.8 50.9 51.0 51.1 51.2 | | | | | | | | | | | | | | 50.8 50.9 51.0 51.1 51.2 | | | | | | | | | | | | | |
| Path 1 (km) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11917.5 | 0.9817 | 0.9926 | 0.9963 | 0.9982 | 0.9995 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 11977.5 | 0.9169 | 0.9517 | 0.9702 | 0.9783 | 0.9798 | 0.9244 | 0.8778 | 0.8288 | 0.7824 | 0.7384 | 0.6964 | | |
| 11918.5 | 0.9780 | 0.9901 | 0.9956 | 0.9978 | 0.9991 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 11978.5 | 0.9124 | 0.9464 | 0.9644 | 0.9724 | 0.9739 | 0.9184 | 0.8718 | 0.8242 | 0.7798 | 0.7358 | 0.6938 | | |
| 11919.5 | 0.9728 | 0.9890 | 0.9963 | 0.9972 | 0.9989 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 11979.5 | 0.9079 | 0.9419 | 0.9600 | 0.9680 | 0.9695 | 0.9134 | 0.8668 | 0.8192 | 0.7748 | 0.7308 | 0.6888 | | |
| 11920.5 | 0.9651 | 0.9860 | 0.9930 | 0.9965 | 0.9988 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 11980.5 | 0.9034 | 0.9374 | 0.9555 | 0.9635 | 0.9650 | 0.9094 | 0.8628 | 0.8152 | 0.7708 | 0.7268 | 0.6848 | | |
| 11921.5 | 0.9556 | 0.9811 | 0.9903 | 0.9932 | 0.9981 | 0.9990 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 11981.5 | 0.9000 | 0.9340 | 0.9521 | 0.9601 | 0.9616 | 0.9060 | 0.8594 | 0.8118 | 0.7674 | 0.7234 | 0.6814 | | |
| 11922.5 | 0.9321 | 0.9722 | 0.9860 | 0.9930 | 0.9972 | 0.9996 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 0.9993 | 11982.5 | 0.8965 | 0.9305 | 0.9486 | 0.9566 | 0.9581 | 0.9026 | 0.8560 | 0.8084 | 0.7640 | 0.7200 | 0.6780 | | |
| 11923.5 | 0.8845 | 0.9265 | 0.9556 | 0.9785 | 0.9910 | 0.9956 | 0.9972 | 0.9972 | 0.9972 | 0.9972 | 0.9972 | 0.9972 | 0.9972 | 11983.5 | 0.8930 | 0.9270 | 0.9451 | 0.9531 | 0.9546 | 0.8990 | 0.8524 | 0.8048 | 0.7604 | 0.7164 | 0.6744 | | |
| 11924.5 | 0.2442 | 0.4472 | 0.7092 | 0.7090 | 0.8256 | 0.8880 | 0.9120 | 0.9120 | 0.9120 | 0.9120 | 0.9120 | 0.9120 | 0.9120 | 11984.5 | 0.8895 | 0.9235 | 0.9416 | 0.9496 | 0.9511 | 0.8950 | 0.8484 | 0.8008 | 0.7564 | 0.7124 | 0.6704 | | |
| 11925.5 | 0.1562 | 0.2423 | 0.4068 | 0.4232 | 0.4664 | 0.5077 | 0.5478 | 0.5478 | 0.5478 | 0.5478 | 0.5478 | 0.5478 | 0.5478 | 11985.5 | 0.8860 | 0.9200 | 0.9381 | 0.9461 | 0.9476 | 0.8900 | 0.8434 | 0.7958 | 0.7514 | 0.7074 | 0.6654 | | |
| 11926.5 | 0.0234 | 0.1180 | 0.2408 | 0.2845 | 0.3455 | 0.4293 | 0.5269 | 0.5269 | 0.5269 | 0.5269 | 0.5269 | 0.5269 | 0.5269 | 11986.5 | 0.8825 | 0.9165 | 0.9346 | 0.9426 | 0.9441 | 0.8860 | 0.8394 | 0.7918 | 0.7474 | 0.7034 | 0.6614 | | |
| 11927.5 | 0.0094 | 0.0549 | 0.1292 | 0.1715 | 0.2253 | 0.2943 | 0.3818 | 0.3818 | 0.3818 | 0.3818 | 0.3818 | 0.3818 | 0.3818 | 11987.5 | 0.8790 | 0.9130 | 0.9311 | 0.9391 | 0.9406 | 0.8830 | 0.8364 | 0.7888 | 0.7444 | 0.7004 | 0.6584 | | |
| 11928.5 | 0.0027 | 0.0076 | 0.0244 | 0.0358 | 0.0512 | 0.0744 | 0.1044 | 0.1044 | 0.1044 | 0.1044 | 0.1044 | 0.1044 | 0.1044 | 11988.5 | 0.8755 | 0.9095 | 0.9276 | 0.9356 | 0.9371 | 0.8790 | 0.8324 | 0.7848 | 0.7404 | 0.6964 | 0.6544 | | |
| 11929.5 | 0.0106 | 0.0344 | 0.1240 | 0.2367 | 0.4220 | 0.7110 | 0.9177 | 0.9177 | 0.9177 | 0.9177 | 0.9177 | 0.9177 | 0.9177 | 11989.5 | 0.8720 | 0.9060 | 0.9241 | 0.9321 | 0.9336 | 0.8760 | 0.8294 | 0.7818 | 0.7374 | 0.6934 | 0.6514 | | |
| 11930.5 | 0.0430 | 0.1863 | 0.4436 | 0.6738 | 0.8700 | 0.9866 | 0.9866 | 0.9866 | 0.9866 | 0.9866 | 0.9866 | 0.9866 | 0.9866 | 11990.5 | 0.8685 | 0.9025 | 0.9206 | 0.9286 | 0.9301 | 0.8730 | 0.8264 | 0.7788 | 0.7344 | 0.6904 | 0.6484 | | |
| 11931.5 | 0.1425 | 0.3407 | 0.6866 | 0.8307 | 0.7635 | 0.6332 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 11991.5 | 0.8650 | 0.8990 | 0.9171 | 0.9251 | 0.9266 | 0.8680 | 0.8214 | 0.7738 | 0.7294 | 0.6854 | 0.6434 | | |
| 11932.5 | 0.7377 | 0.8641 | 0.9598 | 0.9856 | 0.9876 | 0.9888 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 11992.5 | 0.8615 | 0.8955 | 0.9136 | 0.9216 | 0.9231 | 0.8645 | 0.8179 | 0.7703 | 0.7259 | 0.6819 | 0.6399 | | |
| 11933.5 | 0.2404 | 0.5145 | 0.8537 | 0.7404 | 0.5831 | 0.4087 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 11993.5 | 0.8580 | 0.8920 | 0.9101 | 0.9181 | 0.9196 | 0.8610 | 0.8144 | 0.7668 | 0.7224 | 0.6784 | 0.6364 | | |
| 11934.5 | 0.0227 | 0.2031 | 0.6828 | 0.9262 | 0.8873 | 0.7768 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 11994.5 | 0.8545 | 0.8885 | 0.9066 | 0.9146 | 0.9161 | 0.8575 | 0.8109 | 0.7633 | 0.7189 | 0.6749 | 0.6329 | | |
| 11935.5 | 0.0269 | 0.2742 | 0.7687 | 0.7587 | 0.6827 | 0.7452 | 0.8291 | 0.8291 | 0.8291 | 0.8291 | 0.8291 | 0.8291 | 0.8291 | 11995.5 | 0.8510 | 0.8850 | 0.9031 | 0.9111 | 0.9126 | 0.8540 | 0.8074 | 0.7598 | 0.7154 | 0.6714 | 0.6294 | | |
| 11936.5 | 0.1719 | 0.3906 | 0.7501 | 0.8774 | 0.7881 | 0.6876 | 0.6041 | 0.6041 | 0.6041 | 0.6041 | 0.6041 | 0.6041 | 0.6041 | 11996.5 | 0.8475 | 0.8815 | 0.9000 | 0.9080 | 0.9095 | 0.8505 | 0.8039 | 0.7563 | 0.7119 | 0.6679 | 0.6259 | | |
| 11937.5 | 0.2030 | 0.4799 | 0.8590 | 0.7941 | 0.7064 | 0.6373 | 0.6094 | 0.6094 | 0.6094 | 0.6094 | 0.6094 | 0.6094 | 0.6094 | 11997.5 | 0.8440 | 0.8780 | 0.8965 | 0.9045 | 0.9060 | 0.8470 | 0.8004 | 0.7528 | 0.7084 | 0.6644 | 0.6224 | | |
| 11938.5 | 0.0676 | 0.2716 | 0.8420 | 0.9083 | 0.8703 | 0.7416 | 0.6264 | 0.6264 | 0.6264 | 0.6264 | 0.6264 | 0.6264 | 0.6264 | 11998.5 | 0.8405 | 0.8745 | 0.8930 | 0.9010 | 0.9025 | 0.8435 | 0.7969 | 0.7493 | 0.7049 | 0.6609 | 0.6189 | | |
| 11939.5 | 0.2388 | 0.5076 | 0.8372 | 0.7340 | 0.6280 | 0.6857 | 0.8194 | 0.8194 | 0.8194 | 0.8194 | 0.8194 | 0.8194 | 0.8194 | 11999.5 | 0.8370 | 0.8710 | 0.8895 | 0.8975 | 0.8990 | 0.8400 | 0.7934 | 0.7458 | 0.7014 | 0.6574 | 0.6154 | | |
| 11940.5 | 0.3749 | 0.5542 | 0.6804 | 0.7486 | 0.8354 | 0.8863 | 0.9181 | 0.9181 | 0.9181 | 0.9181 | 0.9181 | 0.9181 | 0.9181 | 12000.5 | 0.8335 | 0.8675 | 0.8860 | 0.8940 | 0.8955 | 0.8365 | 0.7899 | 0.7423 | 0.6979 | 0.6539 | 0.6119 | | |
| Path 2 (km) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11941.5 | 0.9887 | 0.9958 | 0.9978 | 0.9989 | 0.9996 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12001.5 | 0.8300 | 0.8640 | 0.8825 | 0.8905 | 0.8920 | 0.8330 | 0.7864 | 0.7388 | 0.6944 | 0.6504 | 0.6084 | | |
| 11942.5 | 0.9885 | 0.9946 | 0.9975 | 0.9986 | 0.9993 | 0.9997 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12002.5 | 0.8265 | 0.8605 | 0.8790 | 0.8870 | 0.8885 | 0.8300 | 0.7834 | 0.7358 | 0.6914 | 0.6474 | 0.6054 | | |
| 11943.5 | 0.9858 | 0.9931 | 0.9961 | 0.9973 | 0.9985 | 0.9997 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12003.5 | 0.8230 | 0.8570 | 0.8755 | 0.8835 | 0.8850 | 0.8265 | 0.7799 | 0.7323 | 0.6879 | 0.6439 | 0.6019 | | |
| 11944.5 | 0.9749 | 0.9907 | 0.9953 | 0.9977 | 0.9988 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12004.5 | 0.8195 | 0.8535 | 0.8720 | 0.8800 | 0.8815 | 0.8230 | 0.7764 | 0.7288 | 0.6844 | 0.6404 | 0.5984 | | |
| 11945.5 | 0.9684 | 0.9863 | 0.9931 | 0.9966 | 0.9986 | 0.9993 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12005.5 | 0.8160 | 0.8500 | 0.8685 | 0.8765 | 0.8780 | 0.8200 | 0.7734 | 0.7258 | 0.6814 | 0.6374 | 0.5954 | | |
| 11946.5 | 0.9596 | 0.9850 | 0.9937 | 0.9972 | 0.9992 | 0.9997 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12006.5 | 0.8125 | 0.8465 | 0.8650 | 0.8730 | 0.8745 | 0.8160 | 0.7694 | 0.7218 | 0.6774 | 0.6334 | 0.5914 | | |
| 11947.5 | 0.9393 | 0.9829 | 0.9916 | 0.9971 | 0.9994 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12007.5 | 0.8090 | 0.8430 | 0.8615 | 0.8695 | 0.8710 | 0.8125 | 0.7659 | 0.7183 | 0.6739 | 0.6299 | 0.5879 | | |
| 11948.5 | 0.8842 | 0.9787 | 0.9916 | 0.9971 | 0.9994 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 0.9998 | 12008.5 | 0.8055 | 0.8395 | 0.8580 | 0.8660 | 0.8675 | 0.8090 | 0.7624 | 0.7148 | 0.6704 | 0.6264 | 0.5844 | | |
| 11949.5 | 0.0887 | 0.2476 | 0.5848 | 0.5244 | 0.4772 | 0.7667 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 12009.5 | 0.8020 | 0.8360 | 0.8545 | 0.8625 | 0.8640 | 0.8055 | 0.7589 | 0.7113 | 0.6669 | 0.6229 | 0.5809 | | |
| 11950.5 | 0.0193 | 0.0595 | 0.1617 | 0.2457 | 0.3336 | 0.4358 | 0.5597 | 0.5597 | 0.5597 | 0.5597 | 0.5597 | 0.5597 | 0.5597 | 12010.5 | 0.7985 | 0.8325 | 0.8510 | 0.8590 | 0.8605 | 0.8020 | 0.7554 | 0.7078 | 0.6634 | 0.6194 | 0.5774 | | |
| 11951.5 | 0.0277 | 0.1552 | 0.3070 | 0.4449 | 0.5346 | 0.7384 | 0.8121 | 0.8121 | 0.8121 | 0.8121 | 0.8121 | 0.8121 | 0.8121 | 12011.5 | 0.7950 | 0.8290 | 0.8475 | 0.8555 | 0.8570 | 0.7985 | 0.7519 | 0.7043 | 0.6599 | 0.6159 | 0.5739 | | |
| 11952.5 | 0.0888 | 0.2476 | 0.5848 | 0.5244 | 0.4772 | 0.7667 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 0.8317 | 12012.5 | 0.7915 | 0.8255 | 0.8440 | 0.8520 | 0.8535 | 0.7950 | 0.7484 | 0.7008 | 0.6564 | 0.6124 | 0.5704 | | |
| 11953.5 | 0.1433 | 0.3407 | 0.6866 | 0.8307 | 0.7635 | 0.6332 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 0.4866 | 12013.5 | 0.7880 | 0.8220 | 0.8405 | 0.8485 | 0.8500 | 0.7915 | 0.7449 | 0.6973 | 0.6529 | 0.6089 | 0.5669 | | |
| 11954.5 | 0.7377 | 0.8641 | 0.9598 | 0.9856 | 0.9876 | 0.9888 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 0.9898 | 12014.5 | 0.7845 | 0.8185 | 0.8370 | 0.8450 | 0.8465 | 0.7880 | 0.7414 | 0.6938 | 0.6494 | 0.6054 | 0.5634 | | |
| 11955.5 | 0.2404 | 0.5145 | 0.8537 | 0.7404 | 0.5831 | 0.4087 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 0.2572 | 12015.5 | 0.7810 | 0.8150 | 0.8335 | 0.8415 | 0.8430 | 0.7845 | 0.7379 | 0.6903 | 0.6459 | 0.6019 | 0.5599 | | |
| 11956.5 | 0.0227 | 0.2031 | 0.6828 | 0.9262 | 0.8873 | 0.7768 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 0.6414 | 12016.5 | 0.7775 | 0.8115 | 0.8300 | 0.8380 | 0.8395 | 0.7810 | 0.7344 | 0.6868 | 0.6424 | 0.5984 | 0.5564 | | |
| 11957.5 | 0.0269 | 0.2742 | 0.76 | | | | | | | | | | | | | | | | | | | | | | | | |

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| CWN (cm) | | | | | | | | | | PATH LENGTH (km) | | | | | | | | | |
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Table 5-3: Transmission functions for the B band at 200 K, averaged over 5 cm⁻¹ intervals and over the whole band interval.

| CWN (cm) | | | | | | | | | | PATH LENGTH (mm) | | | | | | | | | | CWN (cm) | | | | | | | | | | PATH LENGTH (mm) | | | | | | | | | |
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[illegible]

TRANSMISSION FUNCTION OF THE RED ATMOSPHERIC OXYGEN BANDS 113

| CW/Nm | PATH LENGTH(km) | | | | | | | | CW/Nm | PATH LENGTH(km) | | | | | | | |
|------------|-----------------|----------|--------|--------|--------|--------|--------|--------|---------|-----------------|--------|--------|--------|--------|--------|--------|--------|
| | 0.0 | 20.0 | 40.0 | 60.0 | 80.0 | 1.0 | 2.0 | 3.0 | | 0.0 | 20.0 | 40.0 | 60.0 | 80.0 | 1.0 | 2.0 | 3.0 |
| Path = Sea | | | | | | | | | | | | | | | | | |
| 15842.5 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0002 | 1.0003 | 1.0004 | 15857.5 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 15837.5 | 0.9998 | 0.9998 | 0.9999 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15852.5 | 0.9997 | 0.9998 | 0.9998 | 0.9999 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 15832.5 | 0.9998 | 0.9999 | 0.9999 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15847.5 | 0.9995 | 0.9998 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0000 | 1.0000 |
| 15827.5 | 0.9997 | 0.9998 | 0.9999 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15842.5 | 0.9993 | 0.9997 | 0.9996 | 0.9997 | 0.9998 | 1.0000 | 1.0000 | 1.0000 |
| 15822.5 | 0.9995 | 0.9998 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15837.5 | 0.9992 | 0.9997 | 0.9996 | 0.9997 | 0.9998 | 1.0000 | 1.0000 | 1.0000 |
| 15817.5 | 0.9995 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15832.5 | 0.9991 | 0.9996 | 0.9995 | 0.9996 | 0.9997 | 1.0000 | 1.0000 | 1.0000 |
| 15812.5 | 0.9994 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15827.5 | 0.9990 | 0.9995 | 0.9994 | 0.9995 | 0.9996 | 1.0000 | 1.0000 | 1.0000 |
| 15807.5 | 0.9994 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 1.0001 | 15822.5 | 0.9989 | 0.9994 | 0.9993 | 0.9994 | 0.9995 | 1.0000 | 1.0000 | 1.0000 |
| 15802.5 | 0.9993 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 15817.5 | 0.9988 | 0.9993 | 0.9992 | 0.9993 | 0.9994 | 1.0000 | 1.0000 | 1.0000 |
| 15797.5 | 0.9993 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 1.0001 | 15812.5 | 0.9987 | 0.9992 | 0.9991 | 0.9992 | 0.9993 | 1.0000 | 1.0000 | 1.0000 |
| 15792.5 | 0.9992 | 0.9995 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 1.0001 | 15807.5 | 0.9986 | 0.9991 | 0.9990 | 0.9991 | 0.9992 | 1.0000 | 1.0000 | 1.0000 |
| 15787.5 | 0.9991 | 0.9994 | 0.9995 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 1.0000 | 15802.5 | 0.9985 | 0.9990 | 0.9989 | 0.9990 | 0.9991 | 1.0000 | 1.0000 | 1.0000 |
| 15782.5 | 0.9990 | 0.9993 | 0.9994 | 0.9995 | 0.9996 | 0.9997 | 0.9998 | 0.9999 | 15797.5 | 0.9984 | 0.9989 | 0.9988 | 0.9989 | 0.9990 | 1.0000 | 1.0000 | 1.0000 |
| 15777.5 | 0.9989 | 0.9992 | 0.9993 | 0.9994 | 0.9995 | 0.9996 | 0.9997 | 0.9998 | 15792.5 | 0.9983 | 0.9988 | 0.9987 | 0.9988 | 0.9989 | 1.0000 | 1.0000 | 1.0000 |
| 15772.5 | 0.9988 | 0.9991 | 0.9992 | 0.9993 | 0.9994 | 0.9995 | 0.9996 | 0.9997 | 15787.5 | 0.9982 | 0.9987 | 0.9986 | 0.9987 | 0.9988 | 1.0000 | 1.0000 | 1.0000 |
| 15767.5 | 0.9987 | 0.9990 | 0.9991 | 0.9992 | 0.9993 | 0.9994 | 0.9995 | 0.9996 | 15782.5 | 0.9981 | 0.9986 | 0.9985 | 0.9986 | 0.9987 | 1.0000 | 1.0000 | 1.0000 |
| 15762.5 | 0.9986 | 0.9989 | 0.9990 | 0.9991 | 0.9992 | 0.9993 | 0.9994 | 0.9995 | 15777.5 | 0.9980 | 0.9985 | 0.9984 | 0.9985 | 0.9986 | 1.0000 | 1.0000 | 1.0000 |
| 15757.5 | 0.9985 | 0.9988 | 0.9989 | 0.9990 | 0.9991 | 0.9992 | 0.9993 | 0.9994 | | | | | | | | | |
| 15752.5 | 0.9984 | 0.9987 | 0.9988 | 0.9989 | 0.9990 | 0.9991 | 0.9992 | 0.9993 | BAND | 0.9977 | 0.9981 | 0.9980 | 0.9981 | 0.9982 | 0.9983 | 0.9984 | 0.9985 |
| 15747.5 | 0.9983 | 0.9986 | 0.9987 | 0.9988 | 0.9989 | 0.9990 | 0.9991 | 0.9992 | | | | | | | | | |
| 15742.5 | 0.9982 | 0.9985 | 0.9986 | 0.9987 | 0.9988 | 0.9989 | 0.9990 | 0.9991 | | | | | | | | | |
| 15737.5 | 0.9981 | 0.9984 | 0.9985 | 0.9986 | 0.9987 | 0.9988 | 0.9989 | 0.9990 | | | | | | | | | |
| 15732.5 | 0.9980 | 0.9983 | 0.9984 | 0.9985 | 0.9986 | 0.9987 | 0.9988 | 0.9989 | | | | | | | | | |
| 15727.5 | 0.9979 | 0.9982 | 0.9983 | 0.9984 | 0.9985 | 0.9986 | 0.9987 | 0.9988 | | | | | | | | | |
| 15722.5 | 0.9978 | 0.9981 | 0.9982 | 0.9983 | 0.9984 | 0.9985 | 0.9986 | 0.9987 | | | | | | | | | |
| 15717.5 | 0.9977 | 0.9980 | 0.9981 | 0.9982 | 0.9983 | 0.9984 | 0.9985 | 0.9986 | | | | | | | | | |
| 15712.5 | 0.9976 | 0.9979 | 0.9980 | 0.9981 | 0.9982 | 0.9983 | 0.9984 | 0.9985 | | | | | | | | | |
| 15707.5 | 0.9975 | 0.9978 | 0.9979 | 0.9980 | 0.9981 | 0.9982 | 0.9983 | 0.9984 | | | | | | | | | |
| 15702.5 | 0.9974 | 0.9977 | 0.9978 | 0.9979 | 0.9980 | 0.9981 | 0.9982 | 0.9983 | | | | | | | | | |
| 15697.5 | 0.9973 | 0.9976 | 0.9977 | 0.9978 | 0.9979 | 0.9980 | 0.9981 | 0.9982 | | | | | | | | | |
| 15692.5 | 0.9972 | 0.9975 | 0.9976 | 0.9977 | 0.9978 | 0.9979 | 0.9980 | 0.9981 | | | | | | | | | |
| 15687.5 | 0.9971 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9978 | 0.9979 | 0.9980 | | | | | | | | | |
| 15682.5 | 0.9970 | 0.9973 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9978 | 0.9979 | | | | | | | | | |
| 15677.5 | 0.9969 | 0.9972 | 0.9973 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9978 | | | | | | | | | |
| 15672.5 | 0.9968 | 0.9971 | 0.9972 | 0.9973 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | | | | | | | | | |
| 15667.5 | 0.9967 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 | 0.9975 | 0.9976 | | | | | | | | | |
| 15662.5 | 0.9966 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 | 0.9975 | | | | | | | | | |
| 15657.5 | 0.9965 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 | | | | | | | | | |
| 15652.5 | 0.9964 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | | | | | | | | | |
| 15647.5 | 0.9963 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | | | | | | | | | |
| 15642.5 | 0.9962 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | | | | | | | | | |
| 15637.5 | 0.9961 | 0.9964 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | | | | | | | | | |
| 15632.5 | 0.9960 | 0.9963 | 0.9964 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | | | | | | | | | |
| 15627.5 | 0.9959 | 0.9962 | 0.9963 | 0.9964 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | | | | | | | | | |
| 15622.5 | 0.9958 | 0.9961 | 0.9962 | 0.9963 | 0.9964 | 0.9965 | 0.9966 | 0.9967 | | | | | | | | | |
| 15617.5 | 0.9957 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 | 0.9965 | 0.9966 | | | | | | | | | |
| 15612.5 | 0.9956 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 | 0.9965 | | | | | | | | | |
| 15607.5 | 0.9955 | 0.9958 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 | | | | | | | | | |
| 15602.5 | 0.9954 | 0.9957 | 0.9958 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | | | | | | | | | |
| 15597.5 | 0.9953 | 0.9956 | 0.9957 | 0.9958 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | | | | | | | | | |
| 15592.5 | 0.9952 | 0.9955 | 0.9956 | 0.9957 | 0.9958 | 0.9959 | 0.9960 | 0.9961 | | | | | | | | | |
| 15587.5 | 0.9951 | 0.9954 | 0.9955 | 0.9956 | 0.9957 | 0.9958 | 0.9959 | 0.9960 | | | | | | | | | |
| 15582.5 | 0.9950 | 0.9953 | 0.9954 | 0.9955 | 0.9956 | 0.9957 | 0.9958 | 0.9959 | | | | | | | | | |
| 15577.5 | 0.9949 | 0.9952 | 0.9953 | 0.9954 | 0.9955 | 0.9956 | 0.9957 | 0.9958 | | | | | | | | | |
| 15572.5 | 0.9948 | 0.9951 | 0.9952 | 0.9953 | 0.9954 | 0.9955 | 0.9956 | 0.9957 | | | | | | | | | |
| 15567.5 | 0.9947 | 0.9950 | 0.9951 | 0.9952 | 0.9953 | 0.9954 | 0.9955 | 0.9956 | | | | | | | | | |
| 15562.5 | 0.9946 | 0.9949 | 0.9950 | 0.9951 | 0.9952 | 0.9953 | 0.9954 | 0.9955 | | | | | | | | | |
| 15557.5 | 0.9945 | 0.9948 | 0.9949 | 0.9950 | 0.9951 | 0.9952 | 0.9953 | 0.9954 | | | | | | | | | |
| 15552.5 | 0.9944 | 0.9947 | 0.9948 | 0.9949 | 0.9950 | 0.9951 | 0.9952 | 0.9953 | | | | | | | | | |
| 15547.5 | 0.9943 | 0.9946 | 0.9947 | 0.9948 | 0.9949 | 0.9950 | 0.9951 | 0.9952 | | | | | | | | | |
| 15542.5 | 0.9942 | 0.9945 | 0.9946 | 0.9947 | 0.9948 | 0.9949 | 0.9950 | 0.9951 | | | | | | | | | |
| 15537.5 | 0.9941 | 0.9944 | 0.9945 | 0.9946 | 0.9947 | 0.9948 | 0.9949 | 0.9950 | | | | | | | | | |
| 15532.5 | 0.9940 | 0.9943 | 0.9944 | 0.9945 | 0.9946 | 0.9947 | 0.9948 | 0.9949 | | | | | | | | | |
| 15527.5 | 0.9939 | 0.9942 | 0.9943 | 0.9944 | 0.9945 | 0.9946 | 0.9947 | 0.9948 | | | | | | | | | |
| 15522.5 | 0.9938 | 0.9941 | 0.9942 | 0.9943 | 0.9944 | 0.9945 | 0.9946 | 0.9947 | | | | | | | | | |
| 15517.5 | 0.9937 | 0.9940 | 0.9941 | 0.9942 | 0.9943 | 0.9944 | 0.9945 | 0.9946 | | | | | | | | | |
| 15512.5 | 0.9936 | 0.9939 | 0.9940 | 0.9941 | 0.9942 | 0.9943 | 0.9944 | 0.9945 | | | | | | | | | |
| 15507.5 | 0.9935 | 0.9938 | 0.9939 | 0.9940 | 0.9941 | 0.9942 | 0.9943 | 0.9944 | | | | | | | | | |
| 15502.5 | 0.9934 | 0.9937 | 0.9938 | 0.9939 | 0.9940 | 0.9941 | 0.9942 | 0.9943 | | | | | | | | | |
| 15497.5 | 0.9933 | 0.9936 | 0.9937 | 0.9938 | 0.9939 | 0.9940 | 0.9941 | 0.9942 | | | | | | | | | |
| 15492.5 | 0.9932 | 0.9935 | 0.9936 | 0.9937 | 0.9938 | 0.9939 | 0.9940 | 0.9941 | | | | | | | | | |
| 15487.5 | 0.9931 | 0.9934 | 0.9935 | 0.9936 | 0.9937 | 0.9938 | 0.9939 | 0.9940 | | | | | | | | | |
| 15482.5 | 0.9930 | 0.9933 | 0.9934 | 0.9935 | 0.9936 | 0.9937 | 0.9938 | 0.9939 | | | | | | | | | |
| 15477.5 | 0.9929 | 0.9932 | 0.9933 | 0.9934 | 0.9935 | 0.9936 | 0.9937 | 0.9938 | | | | | | | | | |
| 15472.5 | 0.9928 | 0.9931</ | | | | | | | | | | | | | | | |