NOAA Technical Memorandum ERL WPL-24

SPECTRAL TRANSMISSION OF WATER VAPOR FROM 1 to 12000 cm^{-1} AT LOW CONCENTRATION AND LOW TEMPERATURE

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The transmittance of water vapor in the spectral range 0-12000 cm^{-1} is presented for T = 245 K, a pressure of 0.66 atmospheres, and for five values of total precipitable water content between 2.1 and 1070 μm.

As is well known, the absorption of electromagnetic radiation by water vapor, in the spectral range from 16 to 1000 μm, exceeds (with a few exceptions) 10 dB/km. As shown in Fig. 1 and in Derr[1] the attenuation exceeds 1000 dB/km in some regions. The attenuation shown in Fig. 1 is appropriate for a midsummer day in midwest America. Relative humidity was assumed to be 50% at 300 K and 1 atmosphere pressure. This amounts to 1.3 precipitable centimeters of water in a 1-km path. The data were smoothed by a sliding average extending over 30 cm^{-1}.

Such large attenuation effectively prevents spectroscopic observations of atmospheric constituents, and of astronomical sources from the Earth. However, from special locations on the Earth[2], mountain tops, the South Pole, and from balloon and aircraft observatories, the amount of precipitable water vapor is considerably less. In order to estimate the improvement in observation possible under such conditions we have calculated the transmittance of water vapor as shown in Figs. 2A and 2B.

The spectra were computed by using the line parameter data for water vapor from the AFCRL compilation[3]. In addition to the absorption lines the effect of the infrared continuum, as discussed by Roberts, Selby and Biberman[4], was included in the 400-1200 cm^{-1} spectral region. The instrumental bandwidth is assumed to be 25 cm^{-1}. Thus, in effect, the data have been smoothed with a sliding average extending over 25 cm^{-1}. Temperature is assumed to be 235 K, pressure = 0.66 atmospheres, equivalent to approximately 11000 feet. Graphs are given for a water vapor content, over a 10-km homogeneous path, as follows:

Graph	Relative humidity (%)	Total Precipitable water vapor (μm)
1	0.1	2.1
2	1.0	21.0
3	10.0	214.0
4	25.0	536.0
5	50.0	1070.0

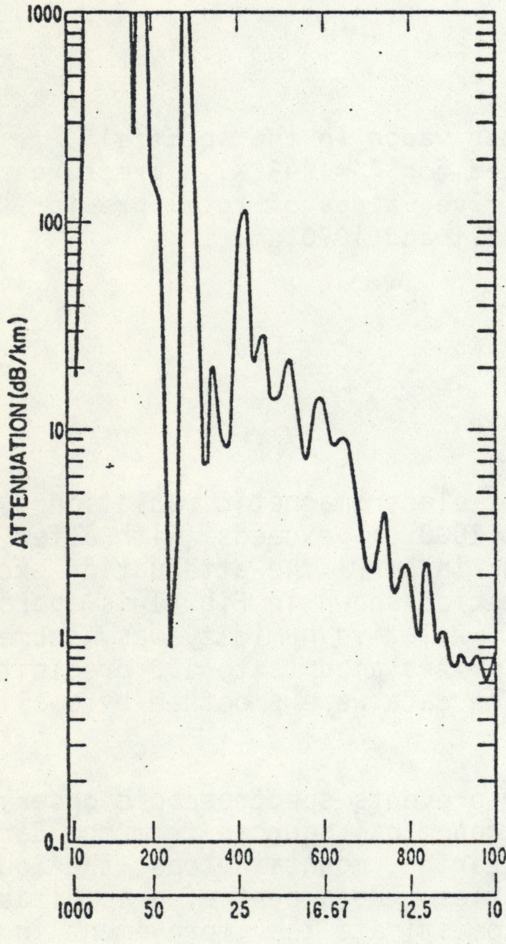

Figure 1. Attenuation by 1.3 pr cm water vapor at 300 K and 1 atmosphere pressure, smoothed by a sliding average over 30 cm^{-1}.

Conclusions

The transmittance spectra of Figs. 2A and 2B show that the attenuation due to water vapor is sufficiently low to permit some astronomical and atmospheric observations over the spectral range from 0-12000 cm^{-1}, when the total precipitable water vapor is below 214 μm (Graph 3). For larger amounts of water vapor, up to 1070.0 (Graph 5), the rotational band, the 6.3-μm band, and the 2.7-μm band produce strong attenuation in limited spectral regions. Beyond these concentrations the attenuation grows rapidly up to and beyond the levels shown in Fig. 1.

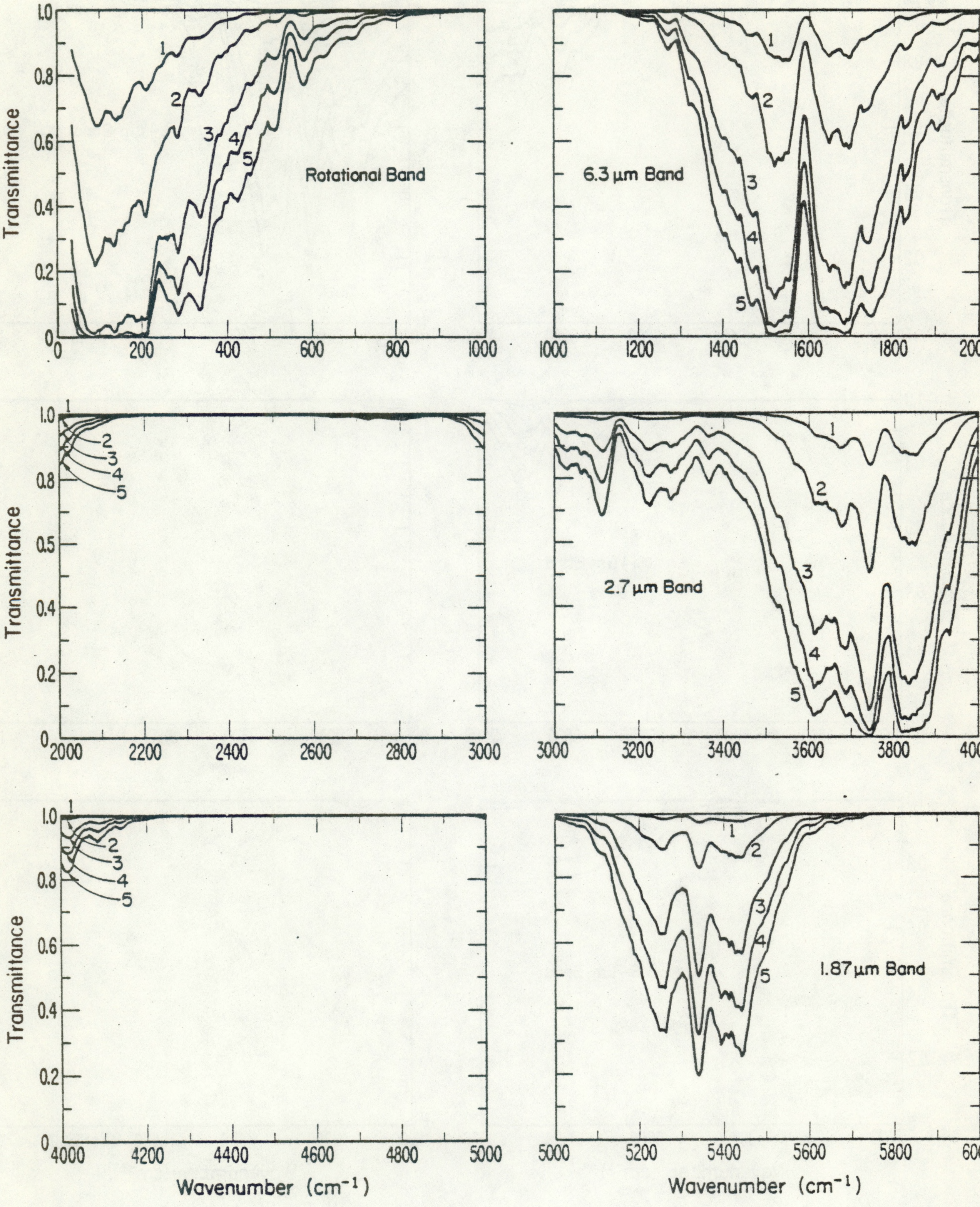

Figure 2A. Low resolution water vapor spectra computed for the spectral regions 0 to 12000 cm^{-1} for the South Pole region. T = 235 K, P = 0.66 atmospheres.

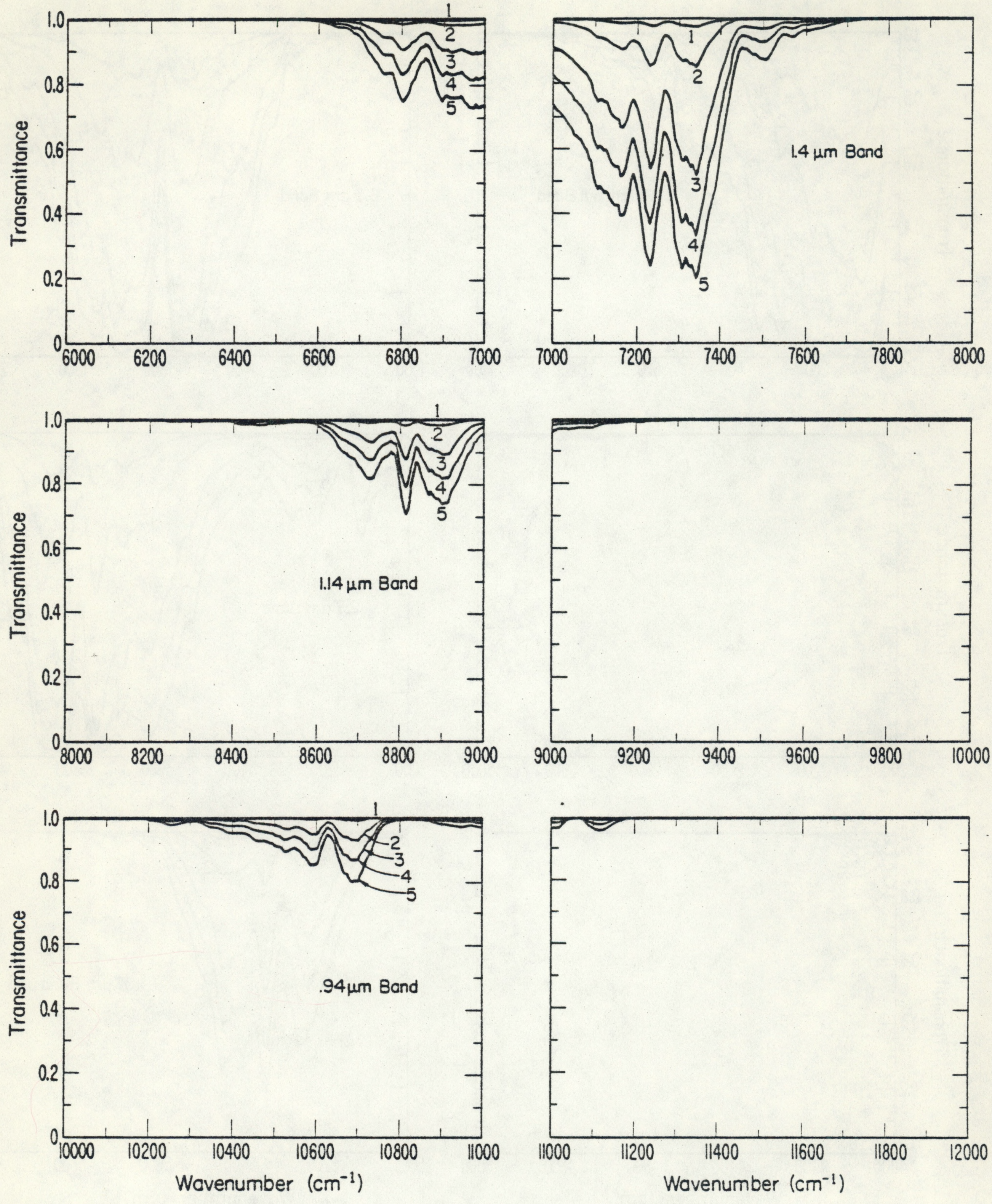

Figure 2B. Low resolution water vapor spectra computed for the spectral regions 0 to 12000 cm^{-1} for the South Pole region. $T = 235$ K, $P = 0.66$ atmospheres.

REFERENCES

1. V. E. Derr, NASA CR-863, 114 pp (1967).
2. G. P. Kuiper, Communications of the Lunar and Planetary Laboratory, Vol. 8, Part 5, No. 156 (1970).
3. R. A. McClatchey, W. S. Benedict, S. A. Clough, D. E. Burch, R. F. Calfee, K. Fox, L. S. Rothman, and J. S. Garing, AFCRL TR-730096, Environmental Research Paper No. 434 (1973).
4. R. E. Roberts, J. E. A. Selby, and L. M. Biberman, Appl. Opt., Vol. 15, 2085 (1976).