On the Water Vapor Continuum Absorption in the Spectral Range 400 cm^{-1} to 600 cm^{-1} from Near the Ground Measurements

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Introduction

In spite of studying for years, the nature of water vapor continuum absorption in the "atmospheric microwindows of relative transparency" remains open to question. The water vapor pressure dependence of continuum absorption and its temperature dependence were established using laboratory and atmospheric measurements. Continuum absorption in the Earth's atmosphere is known to cover a wide spectral range, but it is revealed most greatly in far infrared. Therefore, we have tried to show up its features in the spectral range from 400 cm^{-1} to 600 cm^{-1}, which is less investigated in natural atmospheric observations.

Experimental Procedure and Data Reduction

Near the ground observations were performed at Zvenigorod Scientific Station of Oboukhov Institute of Atmospheric Physics in 1999 using a measurements technique (Georgievski et al. 1972), which includes a spectrophotometer UR-20 with instrumental resolution from 5 cm^{-1} to 7 cm^{-1}. The spectra of relative radiation intensity I_ν transmitted by the air with an optical path length L = 162 m were recorded for 10 min. The values of I_ν, obtained at the same atmospheric condition, were reproduced within an accuracy of ±2%. The spectral recording were accompanied by observing temperature at dry and wet thermometers of aspiration psychrometer within the limits of ±0.1°C. In addition to temperature t by these observations, the values of water vapor partial pressure e, mbar, and the thickness of precipitated water vapor layer w, cm, were determined. Meteorological parameters varied within the following limits: t – from -30°C to +34°C; e – from 0.4 mb to 22 mb; w – from 0.005 cm to 0.25 cm. To interpret the experimental data, the absorption of atmospheric gases by individual ro-vibrational spectral lines were calculated. The data base HITRAN-96 was used. In this way, selective atmospheric transmittance P_s has been determined. After that, the figures illustrating the dependence of relation $I_\nu(w)/P_s(w)$ were used to define the radiation intensity I_o at w = 0, and so the continuum-like optical thickness τ_c has been estimated at different values of w. The atmospheric "windows" at 410 cm^{-1}, 500 cm^{-1}, 560 cm^{-1}, and 610 cm^{-1} were selected for analysis. The influence of aerosol scattering was neglected because of small optical path length.

Results

The results of our observations are shown in Figure 1 as the dependence of τ_c versus w. To reveal the temperature dependence of τ_c, all data were separated into two groups: • are data obtained within the temperature interval from -30°C to +19.9°C; circles are data obtained from +20°C to +34°C. The results of observations permit us to reveal the following features of values of τ_c:

1. The continuum optical thickness has a noticeable dispersion at given w; it is larger than experimental errors.

2. Nonlinear dependence $\tau_c(w)$ gives the evidence concerning e-type's effect, of partial water pressure effect.

3. The values of τ_c obtained at low temperatures are greater than ones obtained at elevated temperatures.

Because of the large dispersion of τ_c, we find difficulty in quantitative analysis. Rough estimates show that the values of continuum absorption optical thickness decrease by 2% to 3% with increasing of temperature per 1 K. It should be mentioned that in the similar natural atmospheric observations (Bignell et al. 1963) the continuum absorption temperature dependence could not be detected.

Let us consider the mean values of continuum absorption coefficient $K(\nu) = \tau_c / L$ obtained in this work in comparison with Bignell et al. (see Table 1). It is obvious that they are in satisfactory agreement with each other.

Table 1. Continuum absorption coefficient.

ν, cm^{-1}	410	500	560	610
K, cm^{-1}; this work	4,5 ± 0,2	2,7 ± 0,2	1,5 ± 0,1	0,7 ± 0,1
K, cm^{-1}; Bignell et al. (1963)	--	2,2 ± 0,1	1,47 ± 0,1	0,67 ± 0,1

Conclusions

Our results confirm as a whole the results of laboratory experiments concerning the positive water vapor pressure dependence and negative temperature dependence of τ_c. Because our data have a large dispersion, one can suppose that τ_c depends to some extent on relative humidity. For examination of this assumption, we pay special attention to the variation of τ_c when meteorological parameters t, e, and w are close to each other but relative humidity changes considerably; these situations can be realized in winter.

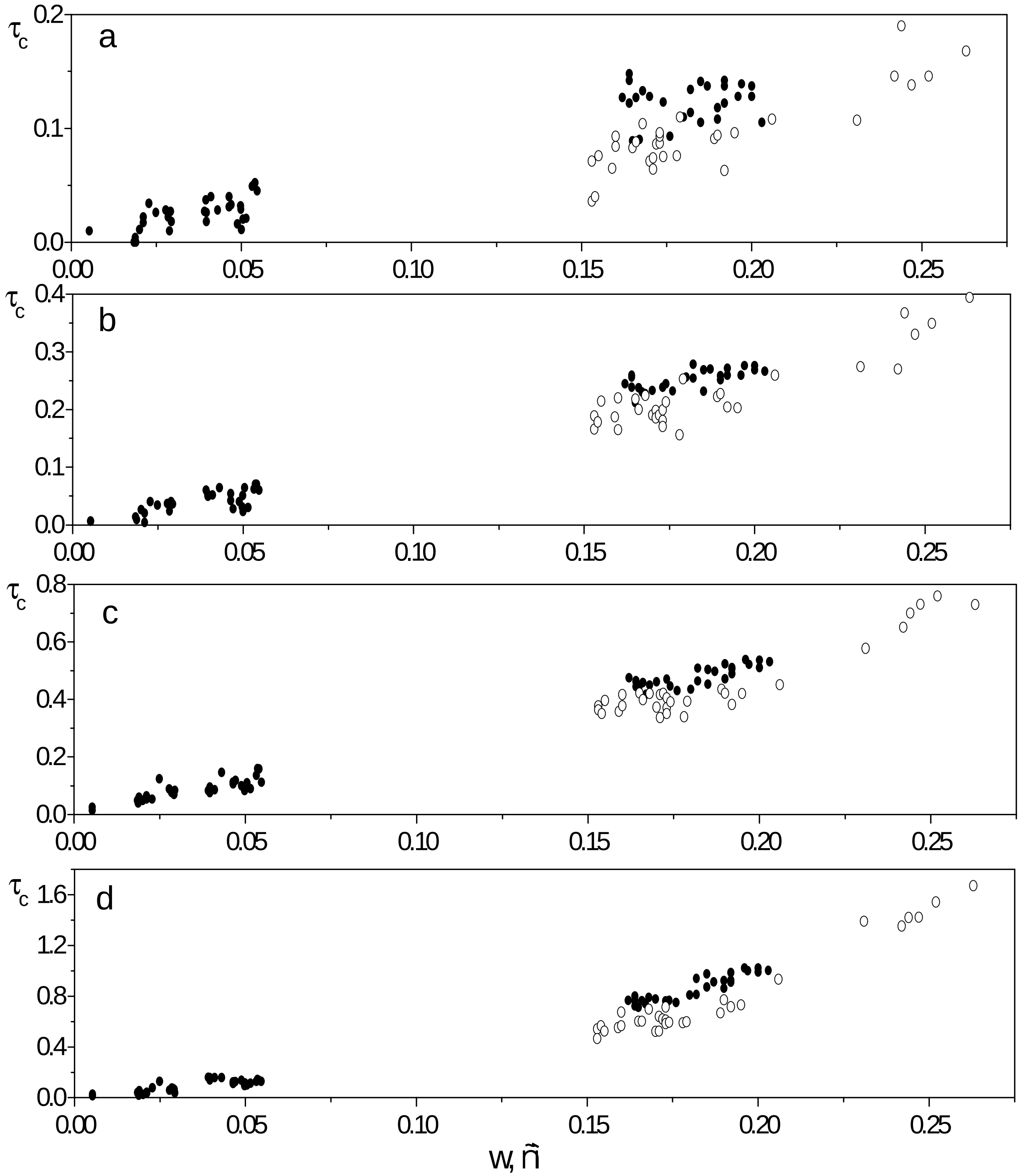

Figure 1. Continuum optical thickness versus the thickness τ_c of precipitated water vapor layer w: (a) ν = 610 cm^{-1}, (b) ν = 560 cm^{-1}, (c) ν = 500 cm^{-1}, and (d) ν = 410 cm-1.

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References

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