ON ACCURACY OF SEPARATING THE ATMOSPHERIC SPECTRAL TRANSPARENCY INTO COMPONENTS

G.A. Terez

Simferopol' State University
Received January 4, 1995

It is shown that the use of the Allen classic formula can lead to significant systematic error in calculating the Rayleigh component of the atmospheric transparency.

In the last ten years, the work on measuring the spectral transparency of the atmosphere and separating the total transparency into individual components has been extensively done. In this connection, the problem of accurate determination of the Rayleigh component becomes of special importance. Meanwhile, according to the data of different authors, the Rayleigh scattering coefficients differ by a few percents even in the visible wavelength range, and this difference may reach 10—12% in the near—UV range (300—400 nm).

To analyze the reliability of determination of the Rayleigh scattering intensity, let us use the data of observation at the Mauna Kea Observatory[1] (4170 m above sea level) familiar for very high transparency of the atmosphere. The aerosol component of the atmospheric transparency at the Mauna Kea Observatory is shown in Fig. 1. It was calculated for two cases: with the Rayleigh component determined from the well—known Allen formula[2] (curve *1*) and from our formula[3] (curve *2*).

It is seen from the figure that when the Allen formula was used for the wavelength longer than 385 nm, the aerosol component exceeded unity. This result cannot be explained by the error in measuring the transparency at the Mauna Kea Observatory, because the investigations were carried out with great care and the error did not exceed 1% at a wavelength of 385 nm. Thus, our formula is more accurate because it is based on the experimental data on the Rayleigh scattering.[3]

Let us consider now the 310—340 nm wavelength range, where the Huggins band of ozone absorption is situated. To this end, we use the data of Ref. 4 where the curve of aerosol transparency was drawn (curve *3* in Fig. 1) for the Terskol peak. The data were obtained by means of excluding the Rayleigh and ozone components from the total atmospheric transparency. The Rayleigh scattering was calculated by the Allen formula.[2] To calculate the ozone molecular absorption, Burlov—Vasil'ev and Vasil'eva used the ozone absorption coefficients proposed by Vigroux[5,6] for a temperature of 223 K and a reduced thickness of ozone layer of 0.28 cm. Burlov—Vasil'ev and Vasil'eva pointed out a sharp decrease in the aerosol component of the transparency at $\lambda < 325$ nm and its practically constant value in the 325—400 nm wavelength range.

Curve *4* in Fig. 1 shows the aerosol component at the Terskol peak, obtained from the observational data reported in Ref. 4 using our formula[3] for the Rayleigh scattering and the ozone absorption coefficients borrowed from Ref. 7. As is seen, the calculated aerosol transparency curve is much lower than the analogous curve from Ref. 4 and, what is most important, it decreases smoothly in the UV range. Thus, it seems to me that the conclusion[4] about a sharp decrease in the aerosol transparency at wavelengths longer than 325 nm, drawn in Ref. 4, is not right.
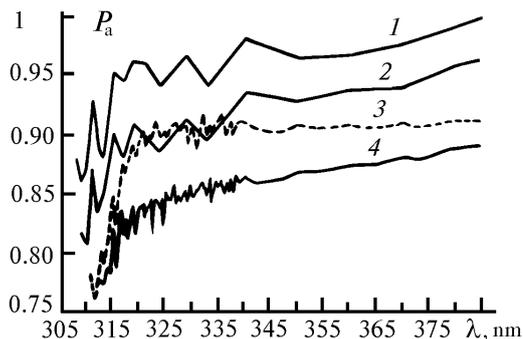

FIG. 1. Spectral behavior of the aerosol component of the atmospheric transparency: 1) Mauna Kea Observatory, Rayleigh and ozone components calculated from the data of Refs. 2, 5, and 6; 2) the same from the data of Refs. 3 and 7; 3) Terskol peak, Rayleigh and ozone components calculated from the data of Refs. 2, 5, and 6; 4) the same from the data of Refs. 3 and 7.

To determine the aerosol component in the UV spectral range, it is necessary to exclude the ozone component, in addition to the Rayleigh one, from the total atmospheric transparency. To calculate it, one usually uses the average monthly data on the total ozone content X for the observation site. That may lead to significant errors. For example, when analyzing the results of observations carried out in August 1989 at the Terskol peak,[4] the quantity X was taken to be equal to 0.28 cm. Actually, average daily values of the total ozone content in August 1989 varied from 0.27 to 0.30 cm. The calculations show

that such variations of the quantity X engender the variations of the ozone component of atmospheric transparency (atλ=310 nm) from 0.534 to 0.498, i.e., the possible systematic error is of ±3.5%. This error decreases to ±1.1% at λ=320 nm and becomes less than ±0.2% at λ = 330 nm.

It should be noted that the measured ozone absorption coefficients in the 300–350 nm wavelength range are in good agreement with the data of other researches.[6–8] So it is of little significance what literary sources are used for determining the value of the ozone molecular absorption. We note that the ozone band structure is well seen from curves *3* and *4* showing the aerosol component. It is natural, because the ozone absorption coefficients measured with very high resolution (better than 0.07 nm, see Ref. 7) were used for processing of the data of astronomical observations made by means of instrumentation with low spectral resolution.

In conclusion it should be noted that the Rayleigh optical thickness variations depend very weakly on the geographical latitude of the observation site (they do not exceed 0.3%, see Ref. 9). At the same time, the effect of the atmospheric pressure variations is more pronounced. For example, the atmospheric pressure in Simferopol' (240 m above sea level) may vary from 950 to 1000 hPa. The use of the mean value of atmospheric pressure for calculations leads to noticeable errors for the UV wavelength range: ±2.9, ±2.2, ±1.7, and ± 0.9% for λ = 300, 320, 340, and 400 nm, respectively.

REFERENCES

1. D. Alloin, O. Boulade, and L. Vigroux, in: Annual report, Société du telescope CFH (1986), p. 19.

2. C.W. Allen, *Astrophysical Quantities* (Athlone Press, London, 1973).

3. G.A. Terez, Izv. Akad. Nauk SSSR, Fiz. Atmos. Okeana **26**, No.5, 550–553 (1990).

4. K.A. Burlov–Vasil'ev and I.E. Vasil'eva, Izv. Akad. Nauk SSSR, Fiz. Atmos. Okeana **28**, No. 12, 1170–1175 (1992).

5. E. Vigroux, Ann. Phys. **8**, 759–762 (1953).

6. E. Vigroux, Ann. Phys. **2**, No.4, 209–215 (1967).

7. I.T. Molina and M.J. Molina, J. Geophys. Res. **D91**, No. 13, 14501–14508 (1986).

8. R.J. Paur and A.M. Bass, in: *Proc. Quadrennial Ozone Symposium*, Halkidiki, Greece (1985), pp. 611–616.

9. V.A. Gashko and K.S. Shifrin, in: *Atmospheric and Oceanic Optics. Proceedings of the VIth Workshop on Oceanic Optics*, Baku (1983), pp. 314–319.