Measurement of Atmospheric Total Ozone by the Filter Photometric Method

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Abstract. The total ozone content in the atmosphere was determined from the multichannel photometer observations of direct solar radiation made in the urban environment at Pune (18° 32'N, 73° 51'E, 559 m ASL) and Sinhagad hill station (18° 22'N, 73° 45'E, 1305 m ASL) during March 1980–February 1982. The total ozone content of the atmosphere was computed making use of the differential absorption of solar radiation due to ozone at 0.4 and 0.6 µm wavelengths in the Chappuis band. The values of the ozone data obtained from the photometer observations at Pune and Sinhagad were compared with the corresponding ozone data obtained from the Dobson spectrophotometer located at Pune. Values of ozone obtained by the photometric method were found to be smaller by 8–18% than the Dobson values when Vigroux’s absorption coefficients were used. Similarly, when the absorption coefficients of Inn and Tanaka (1953) were used, the ozone values obtained by the photometric method were smaller by 4–14% than the Dobson values. The ozone values at the hill station obtained from the photometric method were in better agreement (5%) with the Dobson values.

Key words. Chappuis band absorption, ozone optical thickness, Dobson spectrophotometer, Vigroux’s absorption coefficient, multichannel photometer.

1. Introduction

Dobson spectrophotometers are generally used for routine observations of atmospheric ozone at a few stations in India. One of the Dobson spectrophotometers is located at Pune (18° 32'N, 73° 51'E, 559 m ASL) and values of atmospheric total ozone data are available for a long period. Special photometric observations of direct solar radiation in the visible region were made on clear days (free from dust and haze) at Pune, very near to the location of the Dobson spectrophotometer, during March 1980–February 1982. Similar photometric observations were also made at a nearby hill station, Sinhagad (18° 22'N, 73° 45'E, 1305 m ASL) during January 1982. The environment at Pune may be classified as urban and at Sinhagad as clear or nonurban. Atmospheric total ozone values were computed from the photometric observations of solar radiation in the Chappuis band (Johnson, 1974; Shaw, 1979). The ozone values obtained from the photometer observations at Pune and Sinhagad were compared with the Dobson values for the corresponding days of observations at Pune. There was good agreement between the ozone data obtained from the Dobson spectrophotometer and the photometric method. The details of the photometer used for the observations, the method of computation of atmospheric ozone and the results obtained are discussed below.
2. Observations

Observations of direct solar radiation at 0.4 and 0.6 \( \mu \text{m} \) wavelengths were made using Volz-type sunphotometers with narrow bandwidth interference filters and a selenium barrier photocell. The filter for the blue light has a peak transmission at 0.4010 \( \mu \text{m} \) with a half width of 30 AU and that for the red light at 0.6005 \( \mu \text{m} \) with a half width of 20 AU. The red light is influenced by ozone absorption, whereas the blue light is not absorbed.

The instrument was calibrated using the Langley method for 15 days’ continuous observations. The extra-terrestrial values for the blue and red wavelengths \( (E_{02} \text{ and } E_{01}) \) were computed by extrapolating the curves to zero airmass. For calibration purposes, the photometric observations were taken every 5 min from sunrise to 0800 h and from 1600 h to sunset, and during the remaining period the observations were taken at 10 min intervals. Drift in the extra-terrestrial constants \( (E_{02} \text{ and } E_{01}) \) is about 1% per year. The calibration was repeated once in every two months.

3. Computation of Atmospheric Ozone

The total ozone content of the atmosphere was computed making use of the differential absorption of solar radiation due to ozone at 0.4 and 0.6 \( \mu \text{m} \) wavelengths in the Chappuis band (Shaw, 1979). Absorption coefficients of Vigroux, 1953 were used in the computations. The following equations were used for the computation of the total ozone.

\[
\ln \frac{E_2}{E_1} = (K_1 - K_2) u_0 \sec \rho \left[ 1 + \frac{(\lambda_1^2 - \lambda_2^2)}{3Z_0} \sec \theta + \frac{E_{02}}{E_{01}} + (d_2 - d_1) e \right]
\]

where
- \( \frac{E_2}{E_1} \) Ratio of the solar flux density at the wavelength \( \lambda_2 \) and \( \lambda_1 \) on the surface of the Earth.
- \( K_1, K_2 \) Absorption coefficient per unit length of optical path through the ozone for wavelengths \( \lambda_1 \) and \( \lambda_2 \), respectively.
- \( u_0 \) Thickness of ozone layer.
- \( \rho \) Zenith angle of the Sun when the Sun is viewed from the height at which the ozone layer exists.
- \( \lambda_1, \lambda_2 \) Wavelengths of the solar flux which is strongly/weakly absorbed by ozone \( -0.6 \mu \text{m}/0.4 \mu \text{m} \).
- \( \beta \lambda_1^{-4}, \beta \lambda_2^{-4} \) Rayleigh scattering coefficient for the wavelengths \( \lambda_1 \) and \( \lambda_2 \), respectively.
- \( Z_0 \) Mean height of the ozone layer.
- \( \frac{E_{02}}{E_{01}} \) Ratio of the flux density at the above two wavelengths at the top of the atmosphere.
- \( d_1, d_2 \) Decadic turbidity coefficients at \( \lambda_1 \) and \( \lambda_2 \).
- \( e \) Constant for converting common log to natural log.