SHORTER CONTRIBUTION

A note on the measurement of atmospheric turbidity

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In a recent letter to the Editor, *Tellus*, Dr Ångström (1972) has raised some doubts about the accuracy of the values of the wavelength exponent 'α' obtained by me using photoelectric Sun photometers that operate at the wavelengths 0.40 and 0.60 micron. He has observed that because of the day-to-day variations in the total ozone, the computed extinction coefficients at 0.60 micron (which is affected by ozone absorption) could be considerably in error and thereby the accuracy of the 'α' values could also be affected. In reply to this, I would like to make the following remarks.

The total ozone over the tropical regions has a behaviour very much different from that in the middle and high latitudes. The day-to-day, month-to-month and year-to-year changes of total ozone in the tropics are extremely small. For the location of Poona, a standard amount of 0.25 cm of ozone at S.T.P. was assumed by me in the computations. The standard deviation of the daily values with respect to this annual mean works out to about 0.010 cm only. The highest ozone values during one year reach 0.270 cm and the lowest, around 0.235. The decadic ozone absorption coefficient in the Chappuis band at 0.60 micron is 0.067 per cm of ozone and the mean correction for the total atmospheric extinction on account of ozone absorption works out to 0.017 for Poona. The errors in B (0.60 μ) caused by day-to-day fluctuations in ozone amount would not be greater than 0.002 in terms of absolute value. The errors in the evaluation of α would amount to 5% for a moderately turbid atmosphere and 10% for a clear atmosphere. It would thus be seen that non-inclusion of the daily values of total ozone in the computations can lead to very small errors.

Dr Ångström has raised another point as to whether proper corrections for Rayleigh scattering have been applied by me. I have made use of the Rayleigh extinction coefficients as worked out by Penndorf (1957) using a depolarisation term $=(6+3\varrho)/(6-7\varrho)$ where ϱ is taken as 0.035 for air. These coefficients are sufficiently accurate for use in atmospheric optics.

Dr Ångström has referred to the relative advantages of the pyrheliometer and the sun photometer. He suggests that the pyrheliometric technique is well suited for use at network stations for providing climatologically useful information on the total dust content of the atmosphere and its role in the energy exchange between the earth and space. This technique has also been recommended by him for background pollution measurements. As already pointed out by me in my paper (1972), the routine sun photometer measurements have yielded more realiable and mutually consistent values than those with the pyrheliometer. By the use of dual wave length photometers operating at 0.4 and 0.6 or 0.7 microns not only do we obtain B(λ) accurately but also α. With these two parameters, the solar energy reaching the earth's surface in any wavelength band, large or small, can be easily computed on a climatological basis. For studies on background pollution for which the accuracy of measurements has to be of a high order the sun photometer technique appears to be more suitable for the following reasons.

In the technique using the sun photometer, measurement of the relative intensities of solar radiation in narrow spectral bands are made using photoelectric sensors. Since the release of electrons from the sensor is governed by quantum process, the response is very fast and thereby an accurate sighting of the sun on the instrument is possible. The aperture of the photometer can be made as small as 2° and thus the vitiating effects of circumsolar radiation from the aureole are reduced to a minimum. The linearity of response can be achieved by the use of narrow band filters and operational amplifiers. The calibration of each instrument can be done independently using the sun as a source under conditions of constant atmospheric transparency. The extra-terrestrial constant of each instrument will have to be determined periodically and a careful watch kept on its trend. As the cost of the equipment is very small, a set of 2 or 3 photometers can be maintained at each observing station to ensure mutual consistency of the turbidity values.

On the other hand, the pyrheliometric technique of measuring atmospheric turbidity over large spectral intervals involves several standard assumptions which may not be valid in individual atmospheric situations. With this technique, the absolute intensity of solar radiation, in a wide spectral band usually 0.3 to 0.63 μ, is measured and compared with that which should have been recorded under various assumed conditions of turbidity. In practice, a standard table or a nomogram is used for picking out the β-value corresponding to each combination of solar intensity and the prevailing air mass. This technique suffers from one serious drawback, viz. the pyrheliometer measures not only the radiation emanating from the sun's disk, but also that from the aureole. Under conditions of high turbidity and low values of prevailing α, the amount of circumsolar radiation entering the instrument within a cone of about 10° (the effective aperture of the ordinary pyrheliometers) could be several percent of the 'true' solar radiation. The standard table for evaluating β does not include circumsolar radiation and thus the β values deduced from actual pyrheliometer readings are bound to be *too low*.

Because of the high variability of the distribution of intensity in the solar aureole as determined by both β and α, no simple correction can be applied for the elimination of circumsolar radiation. In fact, the climatological mean β-values for Delhi for the hot summer months April and May as determined by pyrheliometers (Mani et al., 1963) and Chacko et al. (1965) range from 0.040 to 0.065 only. These appear to be too low, considering the fact that the dust content of the air over these areas in summer is extraordinarily high and the visibility very low. An account of the investigation on this aspect by the author, now in progress, will be published in due course.

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