A STUDY ON THE RELATIONSHIP BETWEEN INCOMING SOLAR UV RADIATION AND CLOUD COVER

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ABSTRACT

In this study an empirical relationship between the incoming solar UV radiation and concurrently measured cloud cover at Bombay (19°01'N, 72°55'E), based on data pertaining to two year (1986-1987) period is established. It is compared with a similar relationship used elsewhere and found to differ in its form as well as in the regression coefficients. Possible reasons for this discrepancy are discussed. Conditions underwhich the two relationships agree are also examined.

INTRODUCTION

Observed data on solar UV radiation reaching the earths surface are sparse and particularly so in tropics. In tropical region, recent studies by Chacko et al. (1983), Ilyas (1987) and Daoo et al. (1991) deal with such observations. In the absence of direct measurements, the solar UV radiation is generally estimated from its extra-terrestrial value and assuming certain average atmospheric conditions. It has been established that the UV radiation is significantly attenuated by cloud cover and the atmospheric ozone content before reaching the surface. Among these, variation in ozone content is known to be somewhat regular but not so the cloud cover variation. Hence estimates are generally made for clear sky conditions and effect of cloud cover is accounted for by using an empirical relationship between clear sky UV radiation and cloud cover observations. In this study one such attempt is described. Based on measured data on UV radiation during 1986-87 and concurrently observed cloud data at Bombay (19°01'N, 72°55'E) an empirical relationship is established. This can be used to predict UV radiation if cloud data is available and clear sky radiation is known. Such relationship is particularly useful because cloud cover data are routinely available at National Weather Service stations in the country and can be conveniently used to predict incoming UV radiation under actual conditions.

MEASUREMENT AND SITE DETAILS

The measuring instrument was an Eppley UV radiometer (model TUVR) having a spectral response over the region 295-390 nm wavelengths. Measurement accuracy is within 5 %. Data on cloud cover were obtained from weather reports routinely published by India Meteorological Department. The measurement site was within the campus of Bhabha Atomic Reaserch Centre at

Bombay. The site is located in a region subject to industrial air pollution. Further the site experiences regular monsoon rains during June to September. During this period the sky is generally overcast with cumulus types of clouds. Even during non-monsoon periods the sky is rarely clear except for few occasions during winter months.

RESULTS AND DISCUSSION

Plot of ratio of monthly mean daily total of UV radiation (UV) to mean daily total under clear sky conditions (UV_o) and concurrent daytime average cloud observations in fractions of cloud cover (n) is shown in Fig 1. Average daytime cloud cover is obtained from the visual observations made after every three hours. Clear sky UV radiation is obtained from the computed clear sky global solar radiation for Bombay (Mani and Rangarajan, 1982) and using observed ratio of the UV radiation to the global solar radiation, during clear weather (Daoo et al., 1991). Thus UV_o represents the radiation received at the earth surface under cloudfree atmosphere for average atmospheric conditions with respect to other relevent constituents like ozone and dust content.

Visual inspection of the scatter plot suggests a non-linear relationship. Regression analysis of the data set gives following relationship :

$$UV/UV_o = 0.80 + 0.45\,n - 0.84\,n^2 \qquad (1)$$

with correlation coefficient (r) = 0.785

The only other equivalent relationship widely quoted in literature (Johnson et al., 1976; Ilyas, 1987), after converting it as per our notations is -

$$UV/UV_o = (1 - 0.56\,n) \qquad (2)$$

Comparison of Eq (1) and (2) reveals that -

(1) Eq (1) is quadratic while Eq (2) is linear. For higher cloud cover amount ($n > 0.3$), Eq (1) also tends to show a monotonic decrease as expected from Eq (2). The quadratic relationship shows a major departure from the linear form for low cloud cover amounts. Low cloud cover amounts are generally associated with broken or passing clouds (usually of cirrus type in the present case). These type of clouds lead to significantly increased diffuse radiation compared to that under higher cloud cover conditions. As a result the incoming UV radiation initially (when the cloud cover is less) does not decrease as expected but shows a slight increase and afterwards (for higher cloud cover) it decreases monotonically. Higher cloud cover conditions are usually associated with uniform and continuous sheet type of cloud (generally of cumulus type in the present case) obstructing the sun directly and hence the monotonic decrease. Thus the quadratic expression given here could give more realistic estimates under low cloud cover conditions.

(2) Intercept of Eq (1) is 0.80 and not unity like Eq (2). Relatively larger atmospheric dust content in the region can be one of the responsible factors in determining this.

(3) In low cloud cover range ($n < 0.3$), Eq (1) when compared with Eq (2), underestimates the ratio UV/UV_0 (upto a maximum of about 25 %) while in the higher cloud cover range it generally overestimates the ratio (upto a maximum of about 12 %). Hence while using any such relationship for estimating the incoming solar UV radiation levels, consideration must be given to the higher and lower ranges of cloud cover amounts. Otherwise the results can be misleading. This is particularly true for tropical regions where low cloud cover conditions occur with significant frequency.

CONCLUSIONS

The relationship established in this study is quadratic in form in contrast to linear relationship used in earlier studies. The difference has been attributed to the type and nature of cloud cover and dust content prevailing in the atmosphere. The relationship used in the earlier studies is generally suited for high cloud cover conditions (cloud cover > 0.3) whereas the present relationship is applicable to whole range of cloud cover.

REFERENCES

1. Chacko, O., Rahalkar, C.G. and Desikan, V., 1983, Ultraviolet radiation at Pune, Mausam, 34, 4, pp. 425-430.

2. Ilyas, M.,1987, Effect of cloudiness on solar ultraviolet radiation reaching the surface, Atmos. Environ., 21, pp. 1483-1484.

3. Daoo, V.J., Faby Sunny and Shirvaikar, V.V., 1991, Solar UV radiation measurements at Bombay, Ind. J. Pure & Appl. Phys., 29, pp. 71-72.

4. Mani, A. and Rangarajan, S., 1982, Solar radiation over India, Allied Pub. Pvt. Ltd., New Delhi, India.

5. Johnson, F.S., Mo, T. and Green E.S., 1976, Average latitudinal variation in ultraviolet radiation at the earth's surface, Photochem. Photobiol., 23, pp. 179-188.

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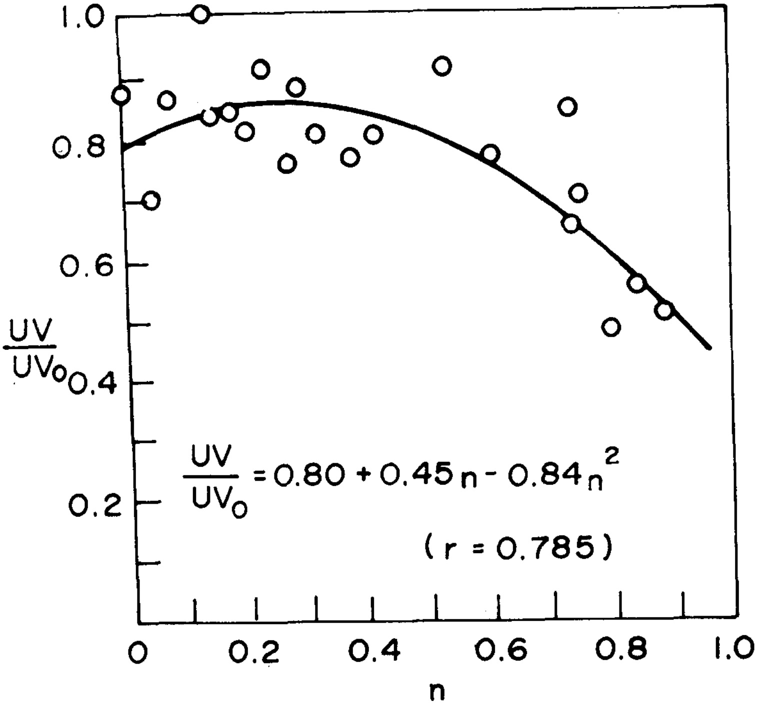

FIG. 1. RELATIONSHIP BETWEEN RATIO OF ACTUAL TO CLEAR SKY SOLAR UV RADIATION (UV/UV_0) AND CLOUD COVER IN FRACTION (n) (BOMBAY 1986-87)