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Solar UVB radiation and aerosol pattern at Delhi

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Abstract : Measurements of UVB irradiance at 297 nm both Global (G) and Direct (D) have been taken at the local noon over Delhi (28.63 deg N, 77.22 deg E) with a variation of zenith angle from 5 degree to 50 degree over three years (1990–92). The ratio G/D has been utilized to estimate the aerosol conditions of the sky. Ozone variation over the period has been shown to be related to the Total Global UVB (G) and aerosol presence It is observed that the aerosol loading in 1990 was much less compared to 1991 and 1992. The high aerosol loading in 1991 and after, has been ascribed to a combined effect of large scale smoke emission from burnt oil-wells in Kuwait during Iraq war (January, 1991) and eruption of Pinatubo Volcano in June, 1991.

Keywords : Aerosols, UVB

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In recent years, estimation of Solar Ultraviolet radiations (200 nm to 400 nm) reaching the earth has gained significant importance primarily because of its adverse effects on the skin and the eye [1–5] and concern due to ozone depletion and fast Global Change. Depending upon its photobiological effect, ultraviolet spectrum is divided into three spectral regions :

UVC region (200 nm to 280 nm) from the Sun is almost completely absorbed by stratospheric ozone in the Hartley bands which extend from 200–320 nm. The Laboratory production of UVC, has however been shown to cause erythema very effeciently, cause inflammation of the cornea and is also germicidal in action.

UVB radiation (280 nm–320 nm) can cause skin cancer and expedites aging. It converts 7-dehydrocholestrol to vitamin D3 in skin. UVB radiations are partly absorbed by atmospheric ozone and only a fraction of the energy reaches the ground. Although UVA (320 nm–400 nm) is also melanogenic (producing tanning) and erythemogenic (producing redness of skin) like UVB, its magnitudes are relatively quite small. The amount of UVB reaching the ground is very much dependent upon total atmospheric ozone and aerosol

loading. The former reduce it by selective absorption of different wavelengths by the absorption bands and the latter by Mie scattering.

In view of the importance of solar UVB radiation on human health, the spectral measurements of these radiations are being regularly undertaken at NPL, New Delhi using a spectroradiometer. According to Hausser *et al* [6], erythema action spectrum for human skin indicate the peak of erythema effectiveness near 297 nm in solar UVB region. With this fact in view, spectral measurements of irradiance at 297 nm had been undertaken using an erythemal probe. The present study has also been undertaken to see the effect of aerosol loading on total Global/Direct UVB measurements and relation between ozone and UVB radiations in the presence of aerosols.

International light, U.S.A make IL 1700 research radiometer and erythema probe model SED 240 working at peak wavelength of 297 nm have been used for irradiance measurements. The instrument is mounted on a tripod stand and is further placed on a raised platform on terrace of the laboratory and kept away from any type of obstruction (tree line or concrete structure) to the 2 pi solid angle view of the instrument. It is set to face the zenith for total Global (G) measurements. Total global radiation (G) is defined as the total quantity of energy emitted by the Sun's disc at a particular wavelength as well as that scattered diffusively by the atmosphere and clouds passing through a unit area in the horizontal plane in a unit time.

Ambient outside temperatures during summer being generally higher than those prescribed for the instrument, the instrument is taken outside only at the time of measurements. The collimating tube for the purpose of direct measurements (D) essentially consists of a long cylindrical tube (30 cm) blackened from inside having a suitable diameter to fit well into the sensor element. The Direct solar radiations at normal incidence (D) is the quantity of Solar radiations at the particular wavelength emitted by the solid angle subtended by the visible disc of the sun and passing through a unit area held normal to the solar beam at the earth's surface in unit time.

The instument is calibrated periodically. The measurements were made at local apparent noon around 1220 hrs IST in clear sky conditions. Measurements were taken on cloudless days although hazy sky conditions prevailing over Delhi for most of the times could not be avoided. It would appear from the data that different sets of days were selected for taking measurements during 1990, 1991 and 1992. In fact the measurement days were selected on the basis of clarity of sky conditions and not arbitrarily. This diversity may affect the conclusions drawn from year to year comparison but nevertheless it presents an overview of the conditions prevailing. The output obtained from IL 1700 is directly obtained in watts/cm^2 after incorporating a calibration factor. Direct measurement (D) are made by orienting the detector fitted with a collimator towards the sun. Geographical location of Delhi (28.63 deg N, 77.22 deg E) being in monsoon belt and close to desert in the west has peculiar type of sky conditions over the year. From october to March the sky is relatively clear but from April to September, the sky is mostly covered by aerosols and haze before the onset of the Monson and by clouds during monsoon.

Real time data for three years (1990–92) of Total Global and direct radiation measurements at 297 nm have been recorded regularly at NPL at local noon (1220 hrs IST : 0650 UT). The zenith angle at local noon varies from 5 degree to 50 degrees. The intensity of UVB received at the ground depends upon a number of factors : (i) extraterrestrial intensity, (ii) pathlength through the atmosphere, which is a function of zenith angle, (iii) ozone, which has a strong variation in mid latitudes, aerosols, cloudiness, albedo of earth and atmosphere. Other factors being known at a place, the variation of UVB irradiance at ground wholly depends on ozone and aerosol content of the atmosphere. Tropospheric ozone has an exceptional behaviour in UVB absorption compared to stratospheric ozone [7]. This being possible because of longer pathway created for UVB through atmosphere due to Rayleigh scattering by air molecules and Mie scattering by aerosols present in the troposphere. Due to the low zenith angles of the Sun and relatively clear sky conditions during early summer, the irradiance received is higher compared to other times as has been observed by Sharma *et al* [8].

The ratio of Global to Direct irradiance (G/D) has been used for quantitative estimation of the sky conditions. Although both these parameters G and D are separately affected by the variation in zenith angle but the ratio G/D has been found to be independent of the zenith angle of the Sun. Figures 1–3 show the plots of G / D against day numbers for

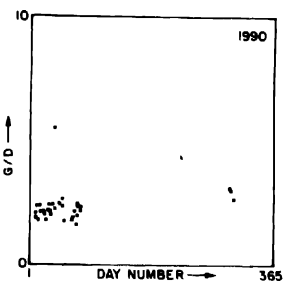

Figure 1. G/D *versus* day-number for the year 1990

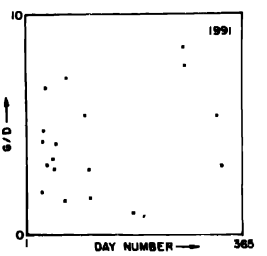

Figure 2. G/D *versus* day-number for the year 1991.

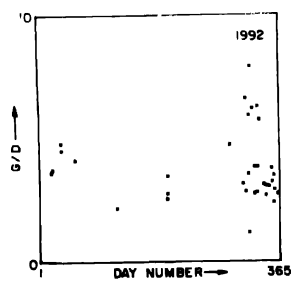

Figure 3. G/D *versus* day-number for the year 1992.

three years from 1990 to 1992. For apparently clear sky conditions, the ratio G/D has been found to fall between 2 and 3. The average value of G/D in 1990 has been found to be

2.34 indicating thereby that 66% of the irradiance was in the form of diffuse component. In the disturbed sky conditions like haze, cloud, smoke, dust *etc.* the value of G/D shoots up. The results show that in comparison to 1991 and 1992, the sky conditions over Delhi were relatively aerosol free in 1990. In 1991, the average value of G/D was found to be 5.06 indicating thereby that more than 80% of the irradiance was in the form of diffuse component and the sky had a much higher aerosol component. By the fall of 1992, the aerosol trend shows signs of settlement as indicated by G/D ratio in Figure 3. The average G/D value falls to 4.07 in 1992 and shows a clear trend of reduction of G/D values compared to 1991.

The higher values of aerosol in 1991 and 1992 compared to 1990 and finally showing a downward trend by the fall of 1992 has been viewed as the combined effect of large scale aerosol loading due to smoke from burnt out oil wells in war torn Kuwait (January '91) and eruption of Pinatubo volcano in Philipines in June 1991 [9–10]

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