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RESEARCH ARTICLE

LITERATURE SURVEY OF UV-B AND OZONE OVER A PERIOD OF 1966-2015.

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Abstract

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The aim of this paper is to briefly review some of the contributions made in the analysis of UV-B irradiance during the period 1966-2015. The study of incoming UV-B irradiance is mainly classified into analysis based on ground measuring instruments, analyzing the incoming radiation with certain regression models and the impact of incoming UV-B irradiance as a function of different atmospheric variables. Much of the work has been reported regarding UV-B irradiance for the past two decades.

Everett et al., (1966) studied the effect of UV-B irradiance like Erythema and its dependence on various wavelengths. They explained the penetration of the incoming ultraviolet rays in the biological band on human skin and its sensitivity at a given wavelength. They pointed out the wavelength dependence of various biological effects due to incoming UV-B irradiance. They analyzed that ozone absorption was more at 310 nm wavelength. Bais et al., (1994) studied the change in solar UV-B irradiance at high and middle latitudes and reported that the incoming UV-B irradiance depends on wavelength, season and solar zenith angle. Measurements made at Mouna Loa by Bodhaine et al., (1997) indicate that effective wavelength for erythemal irradiance is about 308 nm. Scotto, J (1986) has extensively studied the epidemiologic surveys of nonmelanoma skin cancer since early 1970's. It is reported that under experimental conditions UV-B leads to skin erythema and alters DNA. In addition to these effects UV-B exposure may partially lead to aging process of skin in human beings. Madronich et al., (1998) has given an exclusive analysis incoming UV-B irradiance that reach the surface of earth surface for a long period for all latitudes over the globe. In addition to these effects other biological effects on plants, animals are also discussed by using TOMS data. Longstreth et al., (1998) has given an approximation of excess skin cancers up to year 2100 and various health risks involved in exposing to UV-B radiation. Bernhard Meyer and Markus Degunther (2000) estimated erythemal irradiance from the weighting function of McKinlay and Diffey 1987. A model was developed with atmospheric parameters and the graphs plotted with visibility on x-axis and corresponding erythemal irradiance on y-axis are presented. Udelhofen et al., (2000) analyzed the difference between the satellite measured erythemal UV and ground measured erythemal UV irradiances. They explained that TOMS UV irradiance is very useful for any conditions of the sky.

Bener, P (1972) has given the quantitative aspects of UV-B irradiance and their biological effects due to anthropogenic modifications. He studied the variation in atmospheric ozone and its impact on the incmoming UV-B irradiance and their biological effects on mankind. Similar studies based on sea level solar radiation in the biological band and their quantitative aspects due to anthropogenic modifications has been reported (Halpern et al., (1974) ,Dave, J.V and Halpern, P (1976)).

Cutchis, P (1974) had studied extensively the relation between decrease in stratospheric ozone and the impact on corresponding incoming solar UV-B irradiance Brasseur, G and Simon, P.C (1981) studied the incoming UV-B irradiance on long term basis and indicated that the variability in UV-B irradiance causes change in atmospheric temperature, dynamics and composition.

Green, A.E.S et al., (1974) discussed the effect of incoming UV-B irradiance in terms of various atmospheric parameters and quantized a formula known as GSS (Green, Shettle and Sawada) formula which is of prime importance even till date. They reported that the ultra-violet radiation is strongly dependent on wavelength.

Srivastava et al., (1984) made ground based measurements on Indian subcontinent and reported that the incoming UV-B irradiance is inversely proportional to solar zenith angle.

Farman, J et al., (1985) studied the ozone variations in Antarctica region and reported large losses. They assessed the seasonal interactions and their impact on the total ozone in this region and indicated that the losses in ozone continue for the next decade also.S.Diaz et al., (2001) studied the long term variability in UV-B irradiances at places influenced by ozone hole and places that are not being influenced by similar effect. Ushuaia (54.49 deg S) and San Diego (32.45 deg N) were the two stations where UV measurements were made at which irradiances were at peak level during the time of overpass of the ozone hole. Teramura et al., (1991) has given an extensive analysis with respect to the impact of UV-B irradiance on plant growth. Caldwell et al., (1998) reported thet influence of UV-B irradiance on animals, agriculture, forest, plants and crops.

J.F.Gleason et al., (1993) studied the measurements made by Total Ozone Mapping Spectrometer (TOMS) aboard on Nimbus-7 satellite for a period of 1979-1991 andreported that ozone amounts were low in a wide range of latitudes in both the hemispheres and larger decreases were found in the regions lying between 10^0 South to 20^0 South and 10^0 North to 60^0 North. Vorotsos, C (1994) reported that ozone reduction of 2.5% during summer and 7% during winter per decade cause an increase of UV-B irradiance by 5% and 14% by comparing TOMS ozone data with incoming UV-B irradiance at Athens, Greece(38^0 N,24^0 E) during 1989-1991. A statistical model was developed with various atmospheric parameters and indicated that the interannual variability in TOMS ozone (Herman et.al, 2000.]

Seckmeyer et al., (1994) reported spectral UV measurements made between 1992 and 1993 in Germany at a latitude of 48.20^0 North. They found that the UV-B irradiance levels increased in 1993 when compared to 1992 which implies a decrease in ozone during 1993 when compared to 1992. This decrease was explained as due to the impact of clouds and aerosols which should be taken into consideration in addition to stratospheric ozone if any attempt is to made for studying UV-B and ozone relationship. Degunther and Meerkotter (2000) insisted on the effect of surface albedo besides solar elevation, cloudiness, total ozone and aerosol loading. They reported an enhancement of UV irradiance by 50 % under clear sky conditions.

Helmut Tug and Marcus E.M. Bauman (1994) discussed the problems concerning solar UV-B measurements for biological research and reported that the current instrumentation and the observing techniques need to be improved. They stressed the need for a spectrophotometric device with multi channel detector system counting single photon events for reliable measurements. Slaper et al., (1995) insisted on the comparison of various spectral instruments that are used to measure the incoming UV irradiance worldwide. It is felt that various instruments differ with respect to their calibration factors and when the measurements made by these instruments are compared, it may lead to inaccurate result. Hence a method that corrects this discrepancy is reviewed.

Michal Janouch and Jiri Smitka (1997) developed a statistical model for estimation of erythemal UV irradiance at Czech Republic with respect to changes in ozone. The estimated irradiance was compared with measured irradiance and found to be highly correlated. In this model the erythemally weighted UV-B irradiance (EUV) is taken as dependent variable and Earth-Sun distance correction (D), solar zenith angle(ZA), relative air mass (MU) and total ozone in Dobson Units/1000 (X) were taken as independent variables. The model is based on the formula given by

$$EUV = D * \cos ZA * \exp (7.091- 0.855 * MU - 3.569 * MU * X + 0.153 MU^2 + 1.338 * MU^{2} * X^{2})$$

This relation holds good for this station with error percentage of 0.9 for solar zenith angle greater than 30^0 to 1.5% for 60^0-70^0. This model is reported to be a modification of the Canadian statistical model given by Burrows et al., 1994 and suits good for this station.

Kirchoff and Echer (2000) have studied the UV-B and Ozone relations at two South American Brazilian stations one located at low latitude[Cuiaba(15 ^{0} S) and other located at high latitude [Punta Arenas(53.2 ^{0} S)] and reported anti-correlations between them. In similar fashion intercomparison between two stations was taken by Echer and Kirchoff (2000) at a high latitude South American station Punta Arenas (53.2^0 S) at fixed zenith angle which was compared with GUV data from another station Ferraz (62 ^{0} S). Dubrovsky, M (2000) have taken up the comparison of UV-B irradiances corresponding to two high latitude stations Hradec Kralove(50.17^0 N, 278 mt. asl) and Milesovka (50.55 ^{0} N,827 mt. asl) which differ in altitude that belong to Czech Republic. A bilinear regression model was developed with ozone, solar zenith angle, sun-earth distance correction and air-mass as independent variables and the incoming UV-B irradiance as the dependent variable. He derived RAF values for both stations using this model and reported the values as 1.06 and 1.11 for both stations. He made inter comparison between both the stations by taking altitude effect and his analysis revealed that the altitude effect was in between 4 and 8 % per 1000mts. Sahai et al., (2000) used measurements made with Dobson spectrophotometers to study the ozone trend at Cachoeira Paulista (22.7^0 S) and Natal (5.8^0 S) in Brazil. They used a model that accounts for QBO, seasonal variation and solar cycle and indicated the trend at both stations in tropical region. They reported that at one station the trend in ozone decreased by 4.6% and there was no significant change in the other station. Krzyscin et al., (2001) calculated the monthly means of total ozone from ground based measurements taken at 18 stations in North America and Europe and studied the correlation between summer and midwinter for a period of 14 years from 1963-1997.The correlation coefficients between summer and winter is found to be 0.86 for North America where as it is only 0.62 for Europe. In addition the changes in the ozone may be influenced by the long 11 year solar cycle and other factors.

UNEP ASSESSMENT (2002) in its executive summary reported that the depletion of ozone is still continuing. The quality and quantity of ground based UV measurements is continually improving but a global scale assessment from these measurements is not yet found. It is due to clouds, airborne fine particles etc. which affect the incoming UV radiation. It is also reported that the comparison between satellite and ground measured data have large variation especially in polluted regions. This is due to anthropogenic aerosols that play major role in polluted areas. Affects of UV-B on terrestrial eco-systems, materials, air quality etc. continue to progress throughout the globe.

Krishna Prasad and Niranjan (2005) studied the relation between UV-B irradiance and TOMS Ozone by developing a regression model exclusively for Visakhapatnam. They reported the dependence of UV-B on ozone by calculating RAF values for some biological effects.

Narasipuram V K Prasad, Niranjan and Madhavi (2010) estimated different biologically effective irradiances at Visakhapatnam for the year 2010.

N.V. Krishna Prasad, Sarma, Ramesh, Prasad and Madhavi (2015) estimated solar UV-B irradiation and its variability with columnar ozone at Visakhapatnam for the period 2005-2013. Long term variation of incoming UV-B irradiance was estimated.