Indian J.L.Sci. 6 (1) : 19-25, 2017
ISSN : 2277-1743 (Print)
ISSN : 2278-7879 (Online)

MONITORING OF OCCUPATIONAL AND SOLAR TERRESTRIAL ULTRAVIOLET RADIATION IN UTTARAKHAND

SUNIL KUMAR[1a], RIFHAT AARA[b] AND NAVEED CHOWDHARY[c]

[abc]Department of Zoology, D. A. V. (P. G.) College, Dehradun, Uttarakhand, India

ABSTRACT

The study regarding solar ultraviolet radiations has gained huge attention during recent years, because of its increasing effects at the Earth's surface due to ozone depletion. It affects many biological and photochemical processes, being quite harmful to individual organisms. Long- term exposure of humans to UV radiation is a big health hazard, inducing skin cancer, cataracts and immunosuppression. Scientists have thoroughly studied for many decades that the stratospheric ozone layer screens harmful ultraviolet radiation (UV-B) wave length 280-312 nm from the Earth's surface and protects against adverse effects on humans, the biosphere and physical degradation of materials. UV radiation is involved in different chemical, biological processes and affects human health, damages aquatic life, affects conservation and durability of materials, in addition to impacting global energy balance and climate change. Gases and particles due to absorption and scattering process affect UV transmittance across the Earth's atmosphere. Workers are occupationally exposed to UV-B and UV-A radiation during the welding process as UV rays are emitted which are harmful to workers. Monitoring of solar UV-B radiations was performed by measuring the intensities of solar UV radiations using Cole- Parmer radiometer having Vilber Laurmat France calibrated UV-B sensors with spectral sensitivity 312 nm. Four sites were selected for measurement of solar terrestrial UV-B radiation. Altitudinal, monthly and diurnal variations were observed and ASPUV and AWPUV were calculated. Natural solar UV-B level was minimum in December, January and February and maximum in months of June, July, August and September. Intensity of UV-B increases with increase in altitude. Results on monitoring of solar UV-B show diurnal, seasonal and altitudinal variations. Occupational exposure of UV-B was more in welders than annual average natural solar UV-B radiation. Solar UV radiation was found lower than Tibet. Cloud cover, air mass, dust, soot, pollution, climate, season, latitude, altitude and sun position affect the solar terrestrial UV radiations.

KEYWORDS : Ozone Depletion, Solar UV-B, UV Index, ASPUV, AWPUV, Occupational Workers

Solar ultraviolet (UV) radiation studies have received considerable attention because of its substantial increase at the Earth's surface due to ozone depletion. Solar radiation at Earth's surface can be classified in different ranges of wavelengths. It has been reported that long- term exposure of humans to UV radiation may be very detrimental, inducing skin cancer, cataracts and a dangerous weakening of immune functions. Interest in the role of UV-B radiation in aquatic and terrestrial ecosystems has grown due to evidence that levels of ambient UV-B radiation are increasing in response to stratospheric ozone depletion (Young, 1993). However, scientific research during the past three decades has shown that stratospheric ozone has been depleted. Although maximum depletion has been measured in the Antarctic region, generating the 'ozone hole', other mid-latitude regions report deficits (Zerefos and Bais, 1996). The ultraviolet interval (UV) ranges from 0.2 to 0.4 μm; the visible spectrum ranges within (0.390.770 μm) and the infrared (IR) portion of thermal radiation is generally divided into two parts: near IR (0.77-25 μm) and far IR (25-1000 μm) (Madronich and Flocke et al., 1997). UV radiations is usually divided into three bands: UV-C (200-280 nm), UV-B (280-315 nm) and UV-A (315-400 nm), but only UV-B and UV-A reach the surface (Vanicek et al., 2000), which is weakly absorbed by the ozone and therefore mostly arrives at the Earth's surface. The decline in stratospheric ozone has shifted the focus of the scientific community and the general public towards the variability of surface UV irradiance remain stable, reductions in stratospheric ozone would lead to an increase in UV irradiance at the ground, particularly at wavelengths below 320 nm (WHO, 2002; Garane et al., 2006). The interaction between the UV radiation, the atmospheric constituents and the characterictics of the surface is complicated and not yet fully understood (Fioletov et al, 2009; Hader et al., 2015; Lucas et al., 2015).

It notably affects many biological and photochemical processes, being quite harmful to individual organisms. Scientists have known for many decades that the stratospheric ozone layer screens harmful ultraviolet radiation (UV) from the Earth's surface. Therefore, it has also been known that the ozone layer protects against adverse effects on humans (skin cancer and cataracts), (Webb, 2011) the biosphere (e.g., inhibiting plant growth and damaging ecosystems), and physical infrastructure of the modern era (degradation of materials). UV radiation is

[1]Corresponding author

involved in different chemical and biological processes and UV radiation affects human health (both short-term deterministic effects, such as erythema or sunburn, and long-term deterministic/ stochastic effects such as photo aging/skin cancer), damages aquatic life, affects plants, affects conservation and durability of materials, in addition to impacting global energy balance and climate change (WMO, 2010; Williamson et al., 2014).

Gases and particles due to absorption and scattering processes affect UV radiation transmitted across the Earth's atmosphere. Not all effects are harmful, the synthesis of vitamin D is one of the beneficial effects of UV (Fioletov et al., 2009) and the corresponding action spectrum is used to quantify these effects (Webb et al., 2011). Stratospheric ozone is expected to recover in response to the ban on ozone depleting substances (ODSs) agreed upon in the Montreal Protocol in 1987 (Fitzka et al., 2012). However, it is difficult to predict future changes in ozone as the predictions suffer from uncertainties caused by the general climate change; numerical errors of simulation models; and by human behavior, which is not well controllable in several parts of the world. Decrease of stratospheric ozone and associated ultraviolet radiation reaching the earth surface has become a matter of growing concern (Pal, 2010; Prasad et al., 2011; Bhattacharya and Bhoumick, 2012). One of the other sources of UV emission is through welding process. Welding is a metal fabrication process in which metals are joined by the application of heat or pressure. UV, visible and IR radiation are by-products of the welding process, emitted by the arc formed between the electrode and the base metal. It causes severe damage to eyes and skin with prolonged exposure. Thus a study to between designed and monitor solar UV- B radiation in Uttarakhand and occupational workers of Dehradun and nearby areas.

MATERIALS AND METHODS

Instrumentation and Study Area

Solar UV-B monitoring was performed by measuring the intensities of solar UV radiations using Cole-Parmer radiometer having Vilber Laurmat France calibrated UV-B sensors with spectral sensitivity 312 nm. Uttarakhand Garhwal region situated between latitude from 28° 21' to 30° 21' north latitude and 78° 30' to 80° 30' east longitude is selected for the monitoring purpose. Few of the Sites selected for monitoring were Dehradun (500 msl), Mussourie (2005 msl), Nainital (2000 msl) and Chamoli (3000 msl).

METHODOLOGY

Measurement of natural solar UV-B radiation was measured every month for two to three consecutive days on clear sunny days depending on the weather conditions using radiometer with UV-B probe having spectral sensitivity 312 nm. Data of different locations in relation to weather, season, altitude, latitude, diurnal and monthly variation were collected. Maximum and minimum values of UV-B were recorded. Also average summer peak UV (ASPUV) and average winter peak UV (AWPUV) was calculated (McKenzie et al., 1991). Data in occupational workers of Dehradun, Saharanpur, Haridwar, Mussoorie like welding workers, motor, furniture, steel industry, gate grills were collected at least 10 locations in each district.

Table 1 : Altitudinal Variation of Solar Terrestrial UV-B Radiation in Garhwal Himalayan Region

Months	Dehradun (500 m)	Mussorie (2005 m)	Nainital (2000 m)	Chamoli (3000 m)	Site Average
Jan.- March	0.417	0.461	0.458	0.461	0.449
Aprl- June	0.650	0.768	0.765	0.768	0.737
July- Sept.	0.752	1.101	1.021	1.101	0.993
Oct.- Dec.	0.549	0.610	0.601	0.609	0.592

Results are Mean of 5 Observations in Each Group.

Table 2 : Monthly Variation of Solar UV-B radiation in Dehradun, Uttarakhand

Months	Dehradun	Mussourie	Nainital	Chamoli	Site Average
January	0.403	0.483	0.486	0.504	0.468
February	0.459	0.529	0.529	0.606	0.531
March	0.638	0.699	0.696	0.689	0.681
April	0.689	0.789	0.779	0.800	0.764
May	0.767	0.889	0.883	0.902	0.860
June	0.827	0.919	0.913	1.034	0.923
July	0.969	1.109	1.101	1.109	1.097
August	1.023	1.150	1.180	1.200	1.140
September	0.949	1.122	1.115	1.103	1.072
October	0.802	0.986	0.980	0.982	0.938
November	0.609	0.756	0.749	0.800	0.728
December	0.363	0.460	0.433	0.500	0.439
Annual mean value	0.708	0.884	0.820	0.852	0.800

Results are Mean of 5 Observations in Each Group.

Table 3 : Average Winter Peak UV (AWPUV) and Average Summer Peak UV (ASPUV) at Different Altitudes in Uttarakhand Region

S.No.	Place	MSL (Meter)	Average Winter Peak UV	Average Summer Peak UV
1.	Dehradun	500	0.480 ± 0.06	0.899 ± 0.012
2.	Mussourie	2000	0.540 ± 0.016	0.910 ± 0.028
3.	Nainital	2000	0.573 ± 0.012	1.022 ± 0.028
4.	Chamoli	3000	0.596 ± 0.016	1.039 ± 0.024

Results are mean ± S.E of 5 observations in each group.

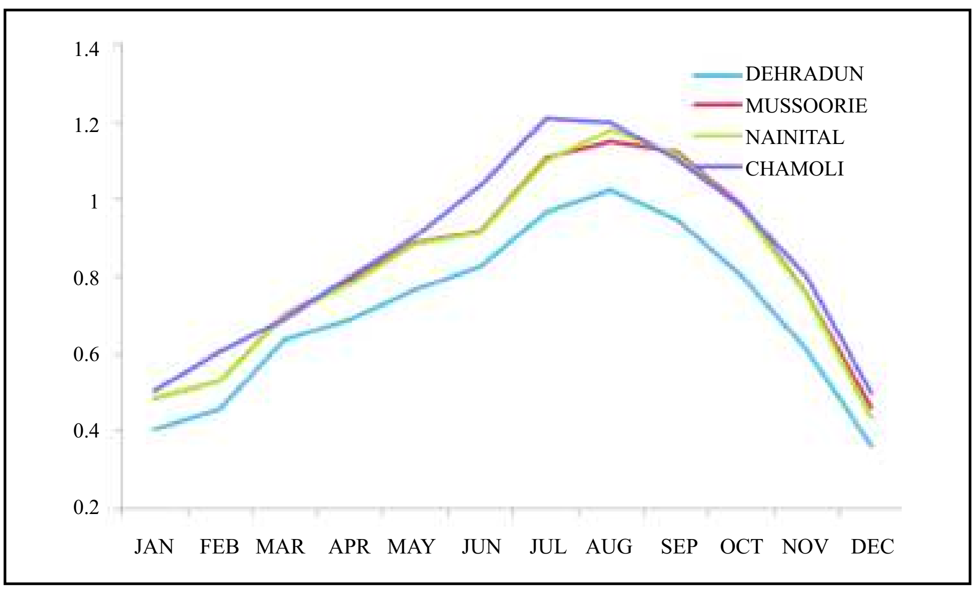

Figure 1 : Monthly Variation of UV-B In Uttarakhand

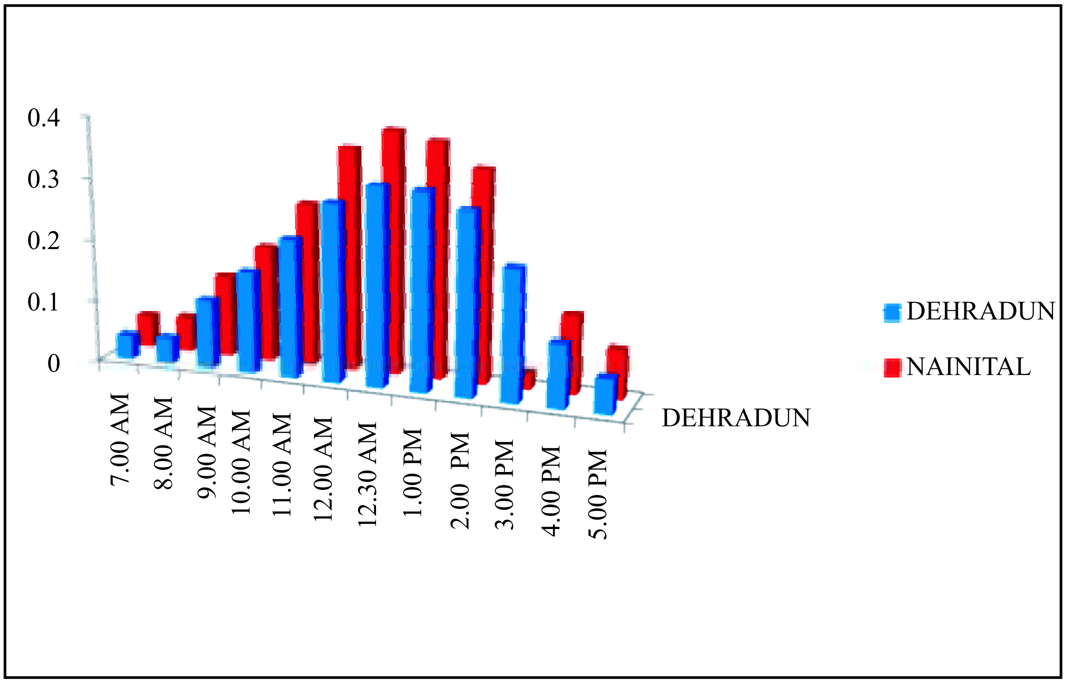

Figure 2 : Diurnal Variation In Uttarakhand In January

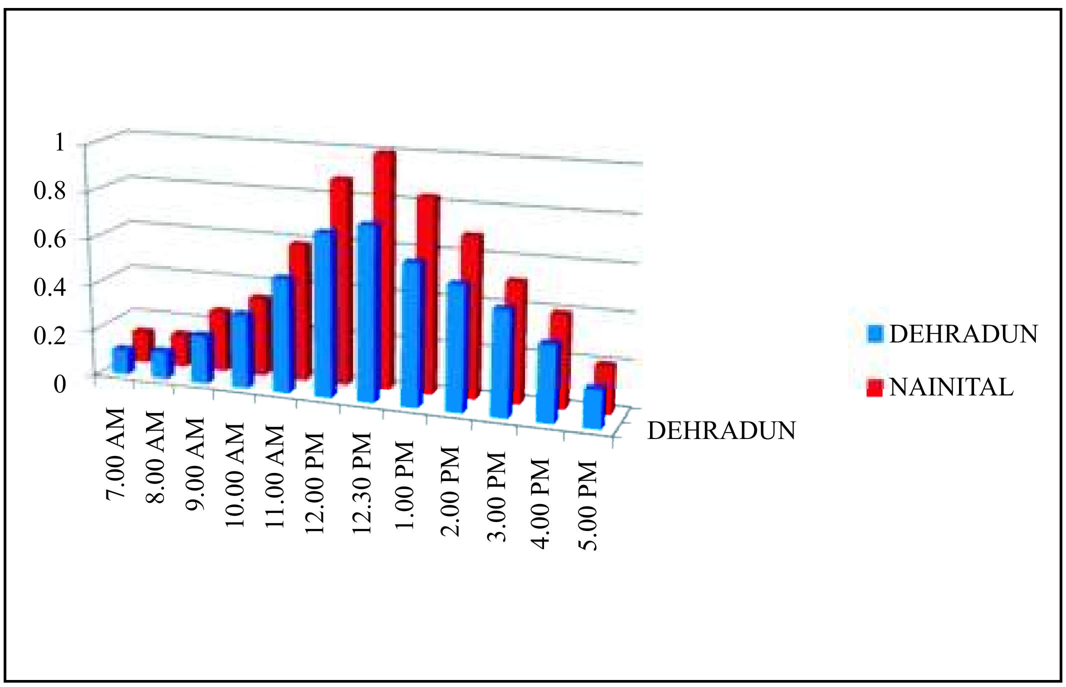

Figure 3 : Diurnal Variation in Uttrakhand in August

Table 4 : UV Radiation in Occupational Welders of Dehradun

S.No	Place	Average UV
1.	Mussoorie	0.490 ± 0.016
2.	Dehradun	0.510 ± 0.06
3.	Haridwar	0.715 ± 0.012
4.	Saharanpur	0.885 ± 0.016

Results are Mean ± S.E of 10 Observations in Each Group.

RESULTS AND DISCUSSION

All the results show in table 1 - 4 and figure 1 - 3. Natural solar UV-B radiation was measured every month for two to three consecutive days on clear sunny days depending on the weather conditions using radiometer with UV-B probe having spectral sensitivity 312 nm. Data of different locations in relation to weather, season, altitude, latitude, diurnal and monthly variation were collected. Maximum and minimum values of UV-B were recorded. Also average summer peak UV (ASPUV) and average winter peak UV (AWPUV) was calculated. Data collected contain fundamental/ baseline information on the solar terrestrial UV-B irradiance, climate change and detrimental effect of solar ultraviolet radiation coming on earth due to stratospheric ozone depletion on health and aquatic fauna. Natural solar UV-B radiations were minimum in December, January and February and maximum in July, August and September. Intensity of Solar UV-B radiation increases with increase in altitude. Result on monitoring of UV-B shows seasonal and altitudinal variations.

Diurnal variation in solar UV radiation was recorded from morning 8:00 am to 5:00 pm. In relation to diurnal variation solar UV-B level were highest between 12 noon to 1:30 pm, particularly at 12:30 pm. Data on monitoring of solar UV-B is showing altitudinal, seasonal and diurnal variation. The time interval between two consecutive measurements was one hour. In the month of January solar UV-B was found lowest in Dehradun and highest in Chamoli. Values are low at the time of sunrise and sunset. It increases gradually from morning with peak between 11:00 am to 1:00 pm and decreases after 12:30 pm till sunset. AWPUV included data of December, January, February and March. ASPUV included the data of May, June, July and August months. There was a gradual increase in value of ASPUV and AWPUV with increase in altitude. ASPUV was more than AWPUV and increased with increase in altitude. Highest Average winter peak UV was found in Chamoli i.e. 0.596 ± 0.016 and lowest average summer peak UV was found in Dehradun i.e. 0.899 ± 0.012. The amount of solar UV radiation reaching the atmosphere is changing periodically due to changes in the Earth-Sun distance and solar activity.

In solar energy terminology, the major portion of solar radiation is considered to be within the shortwave, the limit put variably from 3 to 4 nm. Anthropogenically caused stratospheric ozone depletion has increased the amount of UV-B on the earth and is predicted in future 25-30% increase in coming years (Taalas et al., 2004). The amount of UV-B reaching the surface of earth depends on the thickness of the ozone layer and atmosphere. This varies due to solar zenith. The angle of solar radiation changes with latitude, season, time of the day so that the highest effluence rate of UV-B radiation occurs in at the equatorial region in midsummer at mid day. However the relation ratio UVR to photosynthetically active radiation (PAR) is greatest during dawn and dusk. Solar UV- protection devices as sunscreen, sun glasses, solar caps, hats, clothes and umbrella should be used and direct sun exposure to eye and skin should be avoided during peak hours of UV- B radiation between 11:00 AM - 2:00 PM, particularly at high altitude, mountain region, especially during summer and after rain, when atmosphere is clear free from dust, haze, soot, cloud etc. Solar terrestrial UV monitoring data are useful for future government planning and policies regarding weather, climate human health and biodiversity conservation. A study on evolution of erythemal and total shortwave solar radiation in Valladolid, Spain was done to evaluate the effect of atmospheric factors (De Miguel et al., 2011). Erythemal UV observation was made at Belsk, Poland in the period 1976-2008 (Krzyscin, 2011). The increase is high in UV-B (280-315) nm and low in UV-A (315-400) nm. Moreover the changes of environmental ultraviolet index (UVI) vary from place to place depending on several factors such as incoming solar radiation, sun-earth distance, stratospheric temperature, sky condition, total column ozone, altitude, latitude and solar zenith angle. UV- C (< 280 nm) is mostly absorbed by ozone, oxygen and nitrogen molecules before penetrating the earth's atmosphere where as UV-B are absorbed strongly by the stratospheric ozone. UV-A is not affected by the atmospheric constituents. Ultraviolet photon has both beneficial and detrimental impact on living beings. Ultraviolet radiation also takes part in troposphere-stratosphere interaction.

ACKNOWLEDGEMENT

Authors are thankful to University Grants Commission (UGC), New Delhi for providing financial assistance 43-562/2014 (SR) and to Principal of the college for providing necessary facility.

REFERENCES

Asta J., Pal B., Arne D., Stefan A. E., Jorg R., Krsitin M., Michael, F. H., William, B. G., and Johan, M., 2011. Solar radiation and human health, Rep. Prog. Phys., 74, 066701, doi:10.1088/00344885/74/6/066710.

Bhattacharya R. and Bhoumick A., 2012. Trend analysis of total column ozone over India using TOMS data from 1979 to 2009. Int. J. Engg. Sci. Tech., **4** : 2159-2166.

De Miguel A., Roman R., Bilbao J., Mateos D., 2011. Evolution of erythemal and total shortwave solar radiation in Valladolid, Spain: effects of atmospheric factors. J. Atmos. Sol.-Terr. Phys. 73, 578586. doi:10.1088/00344885/74/6/066710.

Fioletov V.E., McArthur L.J.B., Mathews T.W., Marrett L., 2009. On the relationship between erythemal and vitamin D action spectrum weighted ultraviolet radiation. J. Photochem. Photobiol. B Biol. 95, 9e16, http://dx.doi.org/10.1016/j.jphotobiol. 2008.11.014.

Fitzka M., Simic S. and Hadzimustafic J., 2012. Trends in spectral UV radiation from long term measurements at Hoher Sonnblick, Austria, Theor. Appl. Climatol., 110, 585-593, doi:10.1007/s00704-012-0684-0.

Garane K., Bais A. F., Kazadzis S., Kazantzidis A. and Meleti C., 2006. Monitoring of UV spectral irradiance at Thessaloniki (1990-2005: data re-evaluation and quality control, Ann. Geophys., 24, 3215-3228, doi:10.5194/ angeo-24-3215-2006.

Hader D. P., Williamson C. E., Wangberg S. A:. Rautio M., Rose K. C., Gao K., Helbling E. W. Sinha R. P., and Worrest R., 2015. Effects of UV radiation on aquatic ecosystems and interactions with other environmental factors, Photochem. Photobio. S., 14, 108-126, doi: 10.1039/c4pp90035a.Johan M.,2011. Solar radiation and human health, Rep. Prog. Phys., 74, 066701.

Krzyscin J. W., Sobolweski P. S., Jaroslawski J., Podgorski J. and Rajewska-Wiech B., 2011. Erythemal UV observations at Belsk, Poland, in the period 1976-2008: data homogenization, climatology and trends, Acta Geophys., 59, 155-182, doi: 10.2478/s11600-010-0036-3.

Lucas R. M., Norval M., Neale R. E., Young A. R., de Gruijl, F. R., Takizawa Y., and van der Leun J. C., 2015. The consequences for human health of stratospheric ozone depletion in association with other environmental factors, Photochem. Photobio. S., 14, 53-87, doi:10.1039/c4pp90033b.

Madronich S. and Flocke S., 1997. Solar UV radiation. In: Zerefos, S., Bais, A.F. (Eds.). National Center for Atmospheric Research. Springer, Boulder, Colorado USA.

Madronich S., Shao M., Wilson S. R., Solomon K. R., Longstreth J. D., and Tang X. Y., 2015. Changes in air quality and tropospheric composition due to depletion of stratospheric ozone and interactions with changing climate: implications for human and environmental health, Photochem. Photobio.

S., 14, 149-169, doi:10.1039/c4pp90037e.

McKenzie R. L., Matthews W. A., Johnston P. V., 1991. The relationship between erythemal UV and ozone, derived from spectral irradiance measurements. Geophys. Res., 18 (12), 22692272.

Pal C., 2010. Variability of total ozone over India and its adjoining regions during 1997 to 2008, Atmos. Env., 44, pp. 1927-1936. Photobiology. Plenum.

Prasad N.V.K., Niranjan K., Sarma M. S. S. R. K. and Madhavi N., 2011. Regression analysis of biologically effective UV-B irradiance versus ozone at Visakhapatnam (17.7°N, 83.3°E), Int. J. Phys. Sci., 6, pp. 7838-7843.

Proceedings of ASI , Greece, NATO Series I-52. TEVINI, M. [ED.]. (1993). UV-B radiation and ozone depletion. Lewis.

Taalas P., Kaurola J. and Lindfors A., 2004. A Long- term ozone and UV estimates, In: Kayhko, J. Talve, L. editors. Understanding the global system, the Finnish perspective, Turku: Finnish Global Change Research Programme, 137.

UNEP (United Nations Environment Programme), 2010. Environmental Effects of Ozone Depletion and its Interaction with Climate Change: 2010 Assessment, ISBN 92-807-2312-X.

Vanicek K., Frei T., Litynska Z., Schmalwieser A., 2000. UV-Index for the public, COST-713 Action, Brussels.

Webb A. R., Slaper H., Koepke P., and Schmalwieser A. W., 2011. Know your standard: clarifying the CIE erythema ation spectrum, Photochem. Photobiol. 87, 483-486.

Williamson C. E., Zepp R R. G., Lucas R. M., Madronich S., Austin A. T., Ballare C. L., Noraval M., Sulzberger B., Bais A. F., McKenzie R. L., Robinson S. A., Hader D. P., Paul N. D., and Bornman J. F., 2014. Solar ultraviolet radiation in a changing climate, Nature Clim. Change, 4, 434-441.

WMO: WMO/UNEP Assessment, Scientific Assessment of Ozone Depletion, 2010. World Meteorological Organization Global Ozone Research and Monitoring Project Report No. 52. Geneva, Switzerland.

World Health Organization (WHO), 2002. Global Solar UV Index: A Practical Guide. 28 pp.

World Meteorological Organization: Scientific assessment of ozone depletion, 2003: 2002, Global ozone research and monitoring project, report no. 47, Geneva, Switzerland.

Young, A. R., L. 1993. Bjorn, J. Moan, and W. Nultsch [eds]., Environmental UV.

Zerefos C. S. and Bais A. F., 1996. Solar ultraviolet radiation: modelling, measurements and effects.