NRIAG Journal of Astronomy and Geophysics (2012) 1, 159–164

National Research Institute of Astronomy and Geophysics

NRIAG Journal of Astronomy and Geophysics

www.elsevier.com/locate/nrjag

Ground-based measurements of UV Index (UVI) at Helwan

H. Farouk [a], R.H. Hamid [b], Hamdy K. Elminir [c], A. Abulwfa [b,*]

[a] Al-Azhar University, Faculty of Science, Nasr City, Cairo, Egypt
[b] National Research Institute of Astronomy and Geophysics, 11421 Helwan, Cairo, Egypt
[c] Misr Engineering & Technology Academy of Engineering, Mansora, Egypt

Received 15 October 2012; accepted 9 December 2012

Abstract On October 2010 UV Index (UVI) ground-based measurements were carried out by weather station at solar laboratory in NRIAG. The daily variation has maximum values in spring and summer days, while minimum values in autumn and winter days. The low level of UVI between 2.55 and 2.825 was found in December, January and February. The moderate level of UVI between 3.075 and 5.6 was found in March, October and November. The high level of UVI between 6.7 and 7.65 was found in April, May and September. The very high level of UVI between 8 and 8.6 was found in June, July and August. High level of radiation over 6 months per year including 3 months with a very high level UVI. According to the equation $\{UVI = a[SZA]^b\}$ the UVI increases with decreasing SZA by 82% on a daily scale and 88% on a monthly scale. Helwan exposure to a high level of radiation over 6 months per year including 3 months with a very high level UVI, so it is advisable not to direct exposure to the sun from 11 am to 2:00 pm.

1. Introduction

The UV Index is defined as the next day forecast of the amount of skin damage by UV radiation that is expected to reach the earth's surface at the time when the sun is highest in the sky (solar noon). The amount of UV radiation reaching the surface is primarily related to the elevation of the sun in the sky, the amount of ozone in the stratosphere, and the amount of clouds present. The UV Index takes the range from 0 at the night time, up to 15 or 16 at the tropic's area at high elevations with clear skies. At the high and mid latitudes the UV Index is greatest when the sun is highest in the sky and rapidly decreases when the sun approaches the horizon. The higher the UV Index, the greater the dose rate of skin damaging (and eye damaging) by UV radiation. Consequently, the higher the UV Index, the smaller the time it takes before skin damage occurs. The National Weather Service "NOAA" was developing Table 1 to represent the UV index. Additionally, all UV radiations are not created equally.

There are some factors which affect their levels such as:

1.1. Latitude

The closer you get to the equator, the higher the UV radiation levels will be.

* Corresponding author. Tel.: +20 02 25560645.
E-mail address: ahmed_abulwfa@yahoo.com (A. Abulwfa).

☆ Peer review under responsibility of National Research Institute of Astronomy and Geophysics.

Production and hosting by Elsevier

2090-9977 © 2013 Production and hosting by Elsevier B.V. on behalf of National Research Institute of Astronomy and Geophysics.
http://dx.doi.org/10.1016/j.nrjag.2012.12.012

Table 1 The UV Index on a 0–10+ scale.

UV index	Exposure level	Minutes to Burn
1–2	Low	60
3–5	Moderate	45
6–7	High	30
8–10	Very high	15
10+	Extreme	10

1.2. Sun elevation

As the sun climbs higher into the sky, UV radiation also intensifies. That means UV radiation levels are highest around noontime and in the summer.

1.3. Time of the day

According to research, 10 am to 4 pm is the most dangerous period for UV radiation and it is purported that as much as 60% of the day's radiation comes between those times.

1.4. Time of the year

In most countries, UV radiation levels are usually many times higher in summer than in winter. When summer is at its peak, you can burn in 15 min or less. The months from May to September seem to pose the greatest risk for UV rays. The UV Index Program, Environment Canada http://www.msc-smc.ec.gc.ca/topics/uv/index_e.html had developed a guide as shown in Table 1.

Increase in solar ultraviolet radiation UV at the surface level is shown by (Blumthaler and Ambach, 1990; Kerr, 1993; Feister and Grewe, 1995). During the passage of the Antarctic ozone hole over Punta Arenas (Chile) in October 1992, the solar ultraviolet erythemal radiation UV-B increased from about 70 to 180 mW/m^2 (Kirchhoff et al., 1997). Daily and yearly field measurements of ultraviolet radiation have shown that, depending on location, 39–80% of the half-hourly readings of sufficient intensity to produce minimum erythema occur between 10:00 am and 2:00 pm during the late spring and early summer months of May through August (Scotto and Fears, 1977). The solar erythema dose, UV-A radiation flux and the global radiation had been measured by (Blumthaler and Ambach, 1990) since 1980 in high mountains. Measurements of global and UV radiation initiated in 1994 were carried out by (Ilyas et al., 1999). They showed that, the maximum daily total UV-B and global radiation values are highest in March and September. On seasonal scale, the total global radiation shows a larger variation than UV-B radiation due to its stronger attenuation by clouds. The surface level of solar erythemal radiation is high or extreme from 10:30 to 15:30 as per Malaysian Standard Time. A good linear relationship exists between the UV-B and global irradiance which enables estimation of UV-B flux in tropical equatorial areas (Ilyas et al., 1999). The Egyptian atmospheric dust sources become active in March and cease about October. The most active area is roughly oriented NWSE with southeastern most extension at 24–25°N, 33°E, a little north of Aswan and the northwestern extension at 27°N, 29°E. The Mediterranean is frequently impacted by dust storms in the late spring and summer (Prospero Joseph et al., 2002). The number of days with high UV dose increased strongly from the early 1990s onwards. Especially during the period of 1994–2003 a large fraction of the total number of days with high UV dose was found. The interplay of low total ozone with a clear-sky or partial cloudy conditions led to the largest fraction of days showing high UV doses (Rieder et al., 2010). The coefficient of variation for EUV experienced a strong increase (from 1.5% to 95%) as a function of SZA under completely cloud-free conditions, while coefficient of variation for total solar irradiance was lower than 1.3% for the entire range of SZA (Antón et al., 2011b). The EUV is dependent on solar zenith angle and cloud cover, for the lowest SZAs, there is 10% decrease in the R_{EUV} from cloudless to overcast conditions. For the highest SZAs, a growing trend appears at 68% from 0 to 8 octas. The Rayleigh scattering is the most influential factor for high cloud optical thickness producing EUV. However, molecular and particulate absorbers (tropospheric ozone and aerosols) can attenuate more UV-B wavelengths than UV-A in a cloudy scenario. i.e., the ozone and aerosol absorption/scattering of UV radiation play important roles in the values of R_{EUV} (de Miguel et al., 2011b). Estimation of the UVI can be significantly improved by including measurements of ozone layer thickness; that will additionally contribute to better calculation of the UV radiation (Malinovic-Milicevic and Mihailovic, 2011).

2. Instrumentation

The UV Sensor Figs. 1 and 2 included with DAVIS weather station (Vantage Pro2) measures the sun-burning portion of the UV spectrum. Its spectral response matches very closely the Erythema Action Spectrum (EAS), defined by McKinlay and Diffey (1987) and adopted by the Commission Internationale de l'Eclairage (C.I.E.) as the standard representation of the human skin's sensitivity to UV radiation. The sensor measures global solar UV irradiance, the sum of the components of solar UV transmitted directly and those scattered in the atmosphere. Scattered UV is a major portion of global irradiance. The transducer is a semiconductor photodiode that responds only to radiation in the region of interest.

The diffuser provides an excellent cosine response. With multiple hard-oxide coatings, the interference filter provides the Erythema Action spectral response. It is stable in the presence of heat and humidity. The outer shell shields the sensor from thermal radiation and provides a path for convection cooling of the body, minimizing heating of the sensor interior. It provides a cutoff ring for cosine response, a level indicator, and finds to aid in aligning the sensor with the sun's rays. The sensor is calibrated against a Yankee Environmental Systems'

Fig. 1 Solar UV Radiation Sensor DS6490.

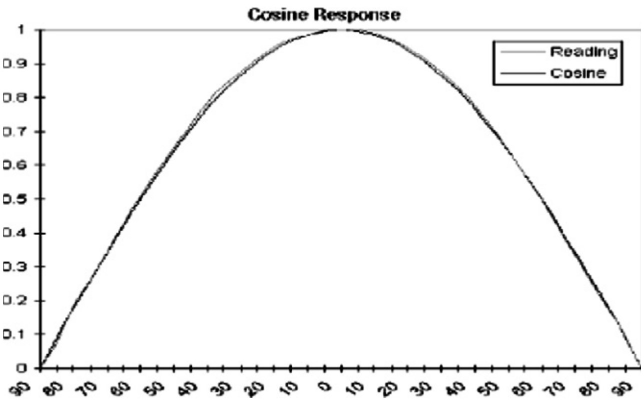

Fig. 2 Cosine response of solar UV radiation sensor DS6490.

Ultraviolet Pyranometer, model UVB-1, in natural summer daylight.

3. Observation and results

3.1. UV Index time series

Data used in this work were observed at noon time. The UVI time series over Helwan showed that, the daily variation of UVI has maximum values in spring and summer days, while minimum values achieved in autumn and winter days as shown in Fig. 3. Generally, the absolute maximum value of 10.5 was found on August, 3rd 2011, this value refers to a high level of harmful radiation, so it must warn against exposure to the sun at the afternoons during the summer days, especially in the month of August. The absolute minimum value was 0.9 on February, 7th 2012; this value does not represent any danger and it is not necessary to take any precaution. The average value of our data was 5.17, this value represents a moderate level, but some precautions should be taken to avoid darkening of the skin and should be stayed in shade at midday.

3.2. Daily UV Index

Over the daily scale, there were important notes representing in the range of daily variation as follows: The range of daily variation in March and April reaches to 4.4 and 7 respectively on UVI scale as shown in Fig. 4. March and April are months of the spring season that is characterized by fluctuations of weather, therefore necessary precautions must be taken to avoid excessive exposure to radiation. The average daily series of recorded UVI was represented in Fig. 5.

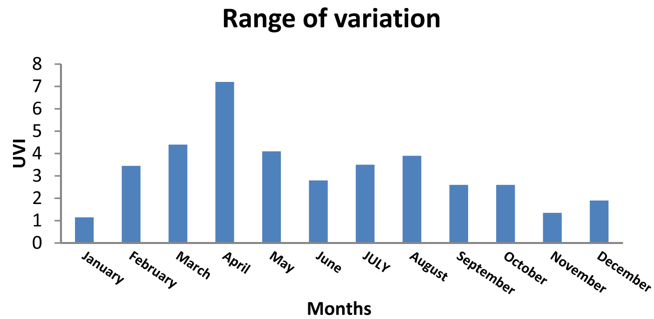

Fig. 4 Range of daily variation of UVI over Helwan.

3.3. Monthly UV Index

Over the monthly scale, the rate of variation illustrates how often the UVI values tend to increase or decrease. Generally, the maximum rate of variation was 12.3% found in March and minimum was 0.1% found in December. The increasing rates were found in February, March, April, June and July, where the maximum increasing rate was 12.3% in March, the minimum increasing rate was 1.9% in February. Months of January, May, August, September, October, November and December tend to decrease. 10.1% is the maximum rate found in August, while the minimum was 0.1% found in December. These results were reported in Table 2 the negative sign refers to a decrease in rate. July and August have the highest average values of 8.55. The absolute maximum of 10.5 was found in August and the absolute minimum of 1.1 was found in February.

On the other side, the classification of exposure Category of UVI shows that, the low level of UVI between 2.55 and 2.825 was found in December, January and February (i.e. Winter season). The moderate level of UVI between 3.075 and 5.6 was founded in March, October and November. The high level of UVI between 6.7 and 7.65 was found in April, May and September. The very high level of UVI between 8 and 8.6 was found in June, July and August (i.e. Summer season) as shown in Table 2 and Fig. 6.

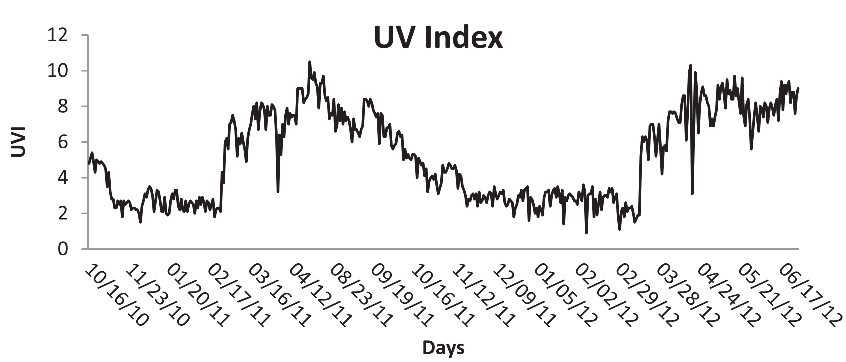

Fig. 3 Daily UVI over Helwan in period (10/16/2010 – 6/20/2102) with missed data during intervals from 4/15/2011 to 7/8/2011.

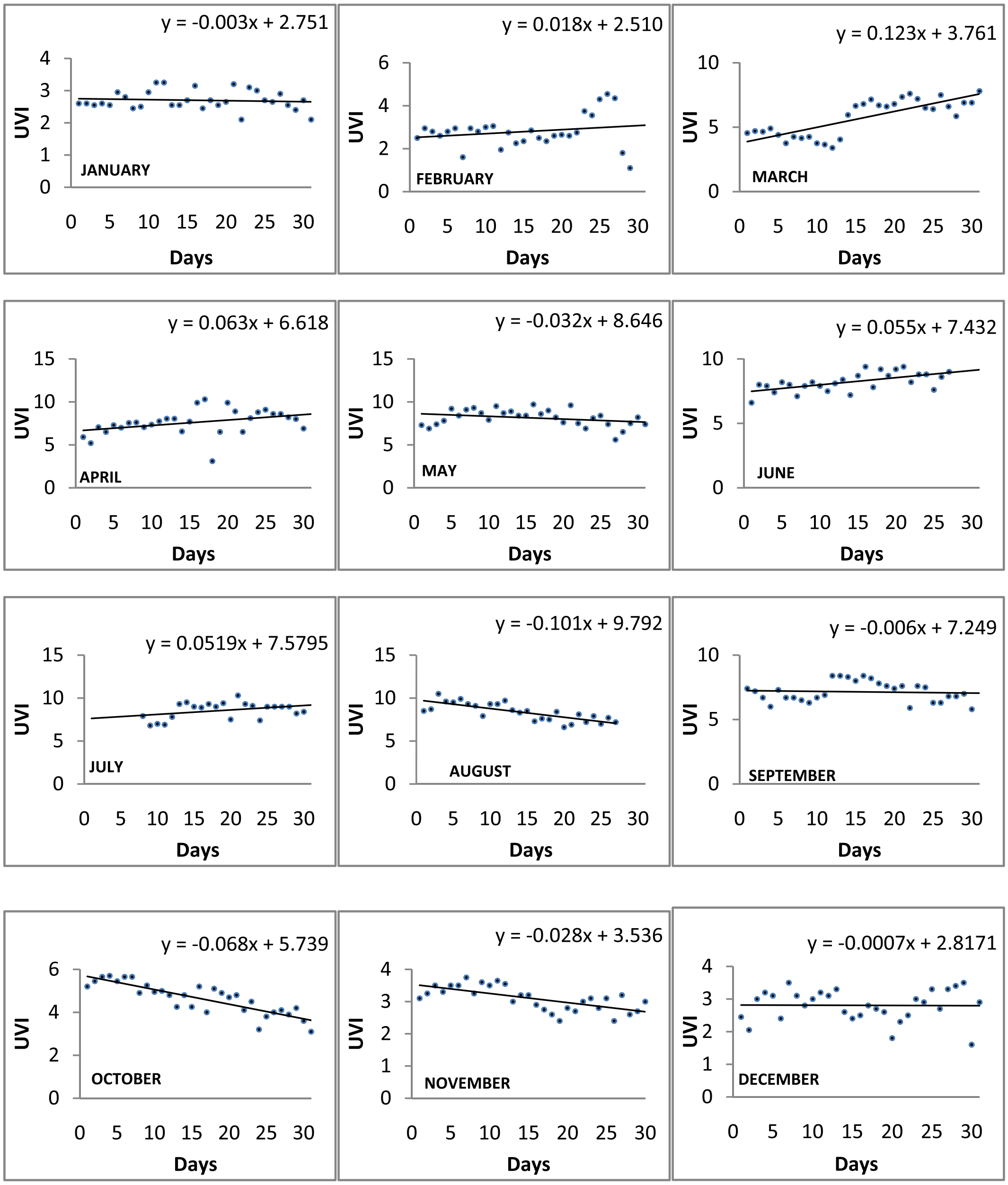

Fig. 5 Daily UVI over Helwan in period of study.

Table 2 Monthly variation of UVI over Helwan.

	Max	Min	Average	Rate of variation%	Exposure category
January	3.25	2.1	2.675	−0.3	Low
February	4.55	1.1	2.825	1.9	Low
March	7.8	3.4	5.6	12.3	Moderate
April	10.3	3.1	6.7	6.3	High
May	9.7	5.6	7.65	−3.2	High
June	9.4	6.6	8	5.6	Very high
July	10.3	6.8	8.55	5.19	Very high
August	10.5	6.6	8.55	−10.1	Very high
September	8.4	5.8	7.1	−0.6	High
October	5.7	3.1	4.4	−6.8	Moderate
November	3.75	2.4	3.075	−2.8	Moderate
December	3.5	1.6	2.55	−0.1	Low

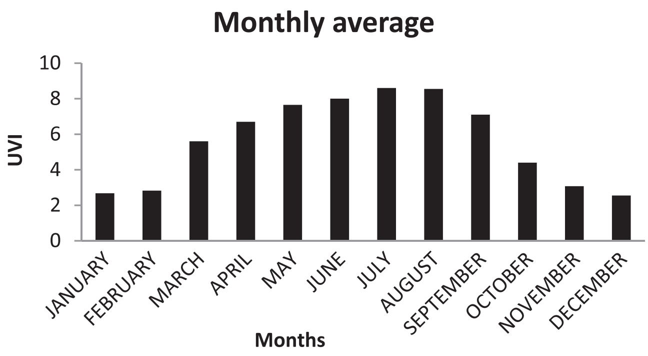

Fig. 6 Monthly variation of UVI over Helwan.

The exposure category in Table 2 refers to that, Helwan exposure to a high level of radiation over 6 months per year including 3 months with a very high level UVI, so it is advisable not to direct exposure to the sun from 11 am to 2:00 pm.

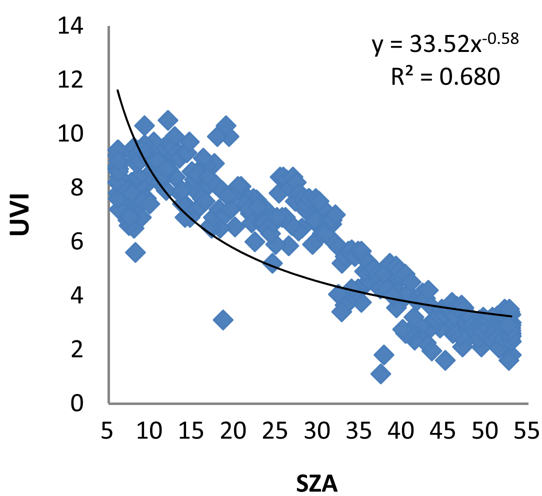

Fig. 7 Relationship between UVI and SZA on daily average scale at Helwan.

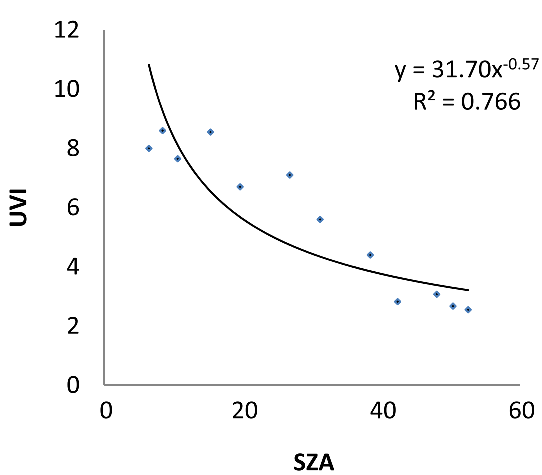

Fig. 8 Relationship between UVI and SZA on monthly average scale at Helwan.

4. Relationship between UV Index and SZA

Many studies were conducted on the dependence of UV Index on solar zenith angle around noon (SZA) in all sky conditions (Adam, 2011; El-Nobi, 2012). It was found that the data are going towards the following formula:

$$UVI = a[SZA]^b \quad (1)$$

where a and b were determined from a least squares fitting. The data were chosen around noon because the path of the solar radiation through the atmosphere is the shortest to avoid the effect of the atmospheric components.

Fig. 7 shows the inverse relation between UVI and SZA on the daily scale. The correlation coefficient of Eq. (1) equals 82%. This means that the SZA is responsible for changes of UVI by 82% on the daily values. On the other hand, the monthly average has a correlation coefficient equal to 88%, so the SZA is responsible for changes of UVI by 88% on the monthly values as shown in Fig. 8.

5. Conclusion

UVI is an indicator of the effect of UV-B on the human skin. The daily variation of UVI has maximum values in spring and summer days, while minimum values in autumn and winter days. The maximum value found in August, 3rd 2011 was 10.5. This value refers to a high level of harmful radiation, so it must warn against exposure to the sun at the afternoons during the summer days. The low levels of UVI were found in December, January and February. The moderate level of UVI was found in March, October and November. The high level of UVI was found in April, May and September. The very high level of UVI was found in June, July and August. It is advisable not to have a direct exposure to the sun from 11 am to 2:00 pm. The UVI increases with decreasing SZA by 82% on the daily scale and 88% on the monthly scale.

6. Recommendation

Be careful in the hot days and do not have a direct exposure to sun, especially in the afternoon. Be careful during the days of the month of April, where weather fluctuations lead to a rapid change in the value of UVI. Publish the stations of UVI on the nationwide level to create a national network. Knowing the impacts of UVI through meteorological bulletins is advised. Awareness among people of the dangers of UVI must be increased.

References

Adam, M.E.-N., 2011. Effect of the atmosphere on UVB radiation reaching the earth's surface: dependence on solar zenith angle. Atmos. Oceanic Sci. Lett. 4.

Antón, M., Gil, J.E., Cazorla, A., Fernández-Gálvez, J., Foyo-Moreno, I., Olmo, F.J., Alados-Arboledas, L., 2011. Short-term variability of experimental ultraviolet and total solar irradiance in Southeastern Spain. Atmos. Environ. 45, 4815–4821.

Argimiro de Miguel, 2011. David Mateos, Julia Bilbao, Roberto Román, 2011b, Sensitivity analysis of ratio between ultraviolet and total shortwave solar radiation to cloudiness, ozone, aerosols and precipitable water. Atmos. Res. 102 (2011), 136–144.

Blumthaler, M., Ambach, W., 1990. Indication of increasing solar ultraviolet-B radiation flux in alpine regions. Science 248, 206–208.

El-Nobi Eman F., 2012. "Distribution of UV-index in some upper Egypt regions", PhD, South Valley University.

Rieder, H.E., Staehelin, J., Weihs, P., Vuilleumier, L., Maeder, J.A., Holawe, F., et al, 2010. Relationship between high daily erythemal UV doses, total ozone, surface albedo and cloudiness: an analysis of 30 years of data from Switzerland and Austria. Atmos. Res. 98 (1), 9–20.

Ilyas, M., Pandy, A., Hassan, S.I.S., 1999. UV-B radiation at Penang. Atmos. Res. 51, 141–152.

Scotto, Joseph, Fears, Thomas R., 1977. Intensity patterns of solar ultraviolet radiation. Environ. Res. 14 (1), 113–127.

Kerr, R.A., 1993. The ozone hole reaches a new low. Science 262, 501.

Kirchhoff, V.W.J.H., Zamorano, F., Casiccia, C., 1997. UV-B enhancements at Punta Arenas. Chile J. Photochem. Photobiol. B 38, 174–177.

McKinlay, A.F., Diffey, B.L., 1987. A reference spectrum for ultraviolet induced erythema in human skin. CIE J. 6 (1), 17–22.

Prospero Joseph, M., Ginoux Paul, Torres Omar, Nicholson Sharon, E., Gill Thomas E., 2002. Environmental characterization of global sources of atmospheric soil dust identified with the Nimbus7 Total Ozone Mapping Spectrometer (TOMS) absorbing aerosol product, Reviews of Geophysics, 40.

Malinovic-Milicevic, Slavica, Mihailovic, Dragutin T., 2011. The use of NEOPLANTA model for evaluating the UV index in the Vojvodina region (Serbia). Atmos. Res. 101 (3), 621–630.

Feister, U., Grewe, R., 1995. Higher UV radiation inferred from low ozone levels at northern mid-latitudes in 1992 and 1993. Global. Planet. Change 11 (1995), 25–34.