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RAF of UV Index at Helwan, Egypt

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Abstract: *In this paper the Radiation Amplification Factor (RAF) was studied over Helwan (31°20'33.92"E, 29°51'46.55"N, 150m asl), it has a subtropical desert and hot climate. The ground observation of UVI which leading to this work was carried out in National Research Institute of Astronomy and Geophysics (NRIAG), Helwan, Cairo, Egypt through the period (2011 - 2015). The data of Ozone and Aerosol Index was obtained from Ozone Monitoring Instrument (OMI). This study covers the period from 2011 to 2015. Firstly, the parameters Ultraviolet index (UVI), total ozone content (TOC) and aerosol index (AI) are studied individually over all sky conditions. The radiation amplification factor (RAF) was studied over clear sky conditions, to clarification of the relativity ratio between TOC and UVI, also to estimate the dependence of UVI on AI changes.*

I. Introduction

The most significant health effects of UV exposure are erythema (reddening of the skin, sunburn) and different forms of skin cancer. The solar UV observation is very important for both research and public health purposes. The UV Index measures the intensity of UV. It was first defined by Environment Canada and since has been adopted by the World Meteorological Organization. UV Index uses a scale of 0 to 16 to rate the current intensity of UV. UVI was influenced by variations of ozone, aerosols, solar elevation, clouds, latitude, and time of year. The increasing amount of UV Index (UVI) (in percentage) when 1% decreases in the column of atmospheric ozone or 1% decreases in the Aerosol Index known as Radiation Amplification Factor (RAF). RAF is a very useful dimensionless quantity to estimate the climatic change (Don J. Durzan et al., 2005[14]). Unfortunately the relationship between ozone and UVI becomes non-linear for larger ozone changes, So RAF used only to estimate effects of small changes in ozone.

El-Nobi E. F., 2012[10] was reported RAF in Upper Egypt in period (1979-2000), she found that RAF varied from 0.96 to 1.06 and from 0.96 to 1.02 and from 1.03 to 1.09 at western desert, river Nile and red sea regions receptivity. H. Farouk et al., 2015[13] was reported RAF over Egypt in period (1979-2005) based on satellite data as following; RAF due to TOC varied from 0.83 % to 1.07%, while RAF due to AI varied from 0.007 % to 0.07%.

II. Instrument and Methodology

i. Calculate the RAF: According to many studies RAF may be calculated by the following equations:

$$UVI = k \times TOC^{-RAF} \quad \ldots\ldots\ldots\ldots(1)$$

$$UVI = b \times AI^{-(RAF(AI))} \quad \ldots\ldots\ldots(2)$$

Where k & b are related to other atmospheric parameters that also affected on UVI such as cloudiness, aerosols and pollution (McKenzie et al., 1991[1]; Madronich, 1993[2], [3]; Bodhaine et al.,1997[4]; Madronich et al., 1998[5]; Dubrovsky, 2000[6]; Zerefos, 2002[7], Serrano et al., 2008[8], Anton et al., 2009[9], Don J. Durzan et al., 2005[14]), Herman, J. R., 2010[15]).

To satisfy equation (1 or 2), some condition must be considered where:

1- The Clear sky cases (cloudy ≤10%).
2- Lowest solar zenith angle.
3- Lowest values of TOC (in case RAF due to AI).

ii. Calculate the solar zenith angle:

The solar zenith angle is found from

$\theta_o = \cos^{-1} (\sin \varphi \sin \delta + \cos \varphi \cos \delta \cos h)$ where φ is the latitude, δ is the solar declination, and h is the hour angle. The solar declination δ is found from

$\sin \delta = \sin \sin \lambda$ where λ is the longitude of the Earth from the vernal equinox. We can use the linear in time approximation:

$\lambda = 360^\circ\ t_v\ T$

where t_v is the time from the vernal equinox and T is the length of the year

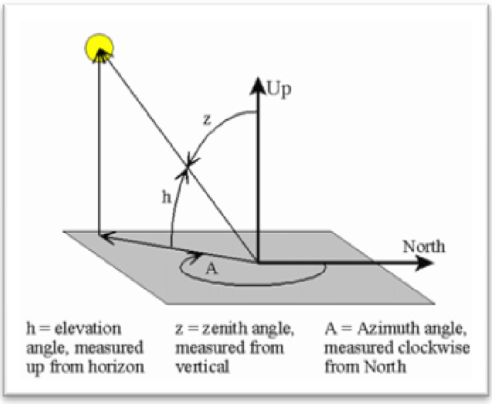

Fig. (2). Solar zenith angle

III. RAF due to TOC

To clarify the effect of TOC changes on UVI the other factors must be constant. Therefore, the Clear sky cases (cloudy ≤10%) and lowest solar zenith angle have been selected. Table (1) shows the correlation coefficients and RAF values for RAF equation.

Table (1). The parameters of RAF (due to TOC) equation.

Year	Equation	RAF	R²	r
2011	$y = 990.8x^{-0.85}$	0.85	0.105	0.324
2012	$y = 1840.x^{-0.95}$	0.95	0.032	0.178
2013	$y = 2465.x^{-1.00}$	1.00	0.050	0.223
2014	$y = 2574.x^{-1.03}$	1.03	0.035	0.187
2015	$y = 2692.x^{-1.04}$	1.04	0.109	0.33

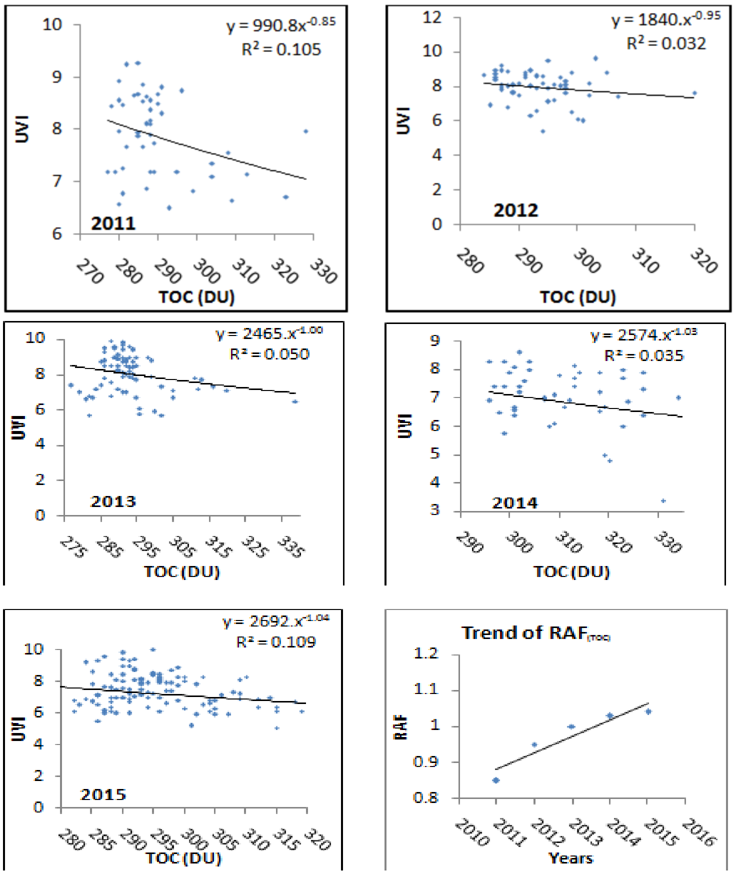

Fig. (2). The RAF of UVI due to TOC & RAF trend through (2011 - 2015)

Table (1) and Figure (1) illustrate the inverse relation between UVI and TOC. The correlation coefficient varied from 0.17 to 0.33. RAF varied from 0.85 to 1.04 the same result reported by Madronich et al., 1998 [5]. This means that the changes in TOC by 1% corresponding by variation in UVI by 0.85 % – 1.04%. According to Don J. Durzan et al., 2005[14] (0.85 >RAF< 1.04) that causes Immune suppression, human skin transformation, damage to cornea.

IV. RAF due to Aerosol Index

To clarify the effect of AI changes on UVI the other factors must be constant. Therefore, the Clear sky cases (REF ≤10%), lowest solar zenith angle and lowest values of TOC have been selected. (Krzyścin, 2011[11]; Kim et al, 2008[12]) give the RAF by the power form of RAF as in equation (2):

$$UVI = b \times AI^{-(RAFAI)} \quad \ldots\ldots\ldots\ldots(2)$$

Where b is related to other atmospheric constituents that also affected on UVI, such as TOC, SZA, albedo and cloudiness. Table (2) shows the correlation coefficients and RAF for Equations (2). It's clearly from Table (2) and Figure (3) the inverse relation between UVI and AI and The decreased trend of RAF. The correlation coefficient varied from 0.07 to 0.216. RAF varied from 0.03 to 0.07 the same result reported by Madronich et al., 1998[5]. This means that the changes in AI by 1% corresponding by variation in UVI by 0.03 % – 0.07%.

Table (2) The parameters of RAF (due to AI) equation (4)

Year	Equation	RAF	R^2	r
2011	$y = 9.228x^{-0.06}$	0.06	0.047	0.216
2012	$y = 8.657x^{-0.07}$	0.07	0.007	0.083
2013	$y = 8.201x^{-0.06}$	0.06	0.008	0.089
2014	$y = 6.555x^{-0.04}$	0.04	0.006	0.077
2015	$y = 8.754x^{-0.03}$	0.03	0.014	0.118

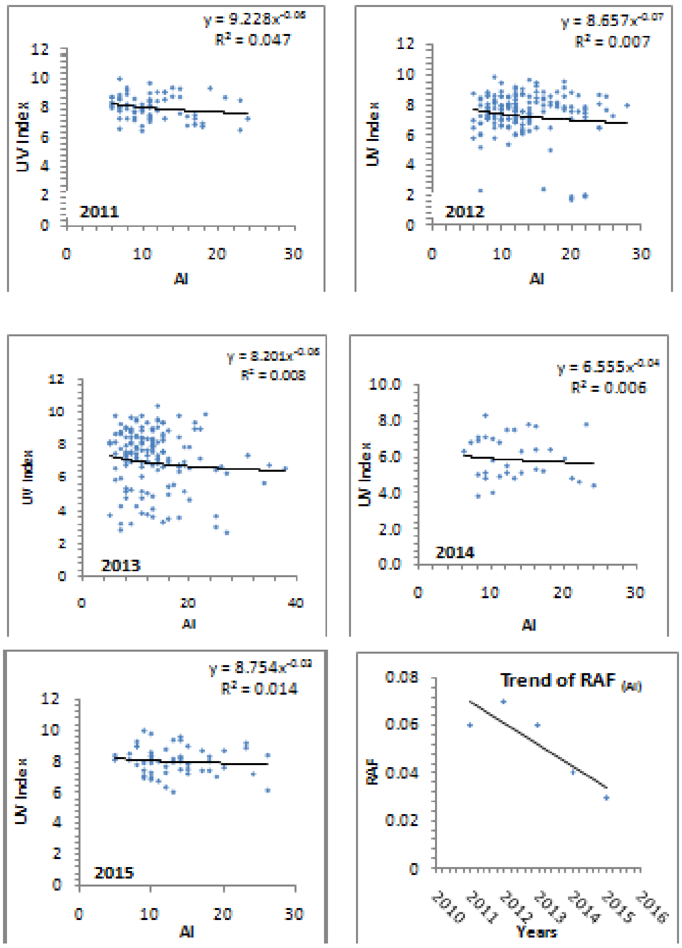

Fig. (3). The RAF of UVI due to AI & RAF trend through (2011 - 2015)

V. Conclusion

In this study:

1- The changes in RAF due to TOC are 0.85 >RAF< 1.04.

2- The changes in RAF due to AI are 0.03 >RAF< 0.07%.

The increased trend of RAF due to TOC through period of study may be a significant sign, so we need more interest to dipping study of ozone behavior.

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