Empirical Relationship for Ultraviolet Solar Radiation Over Egypt

A.A . Trabea, and I. Salem*

Department of physics Faculty of Education, Al- Arish Branch, Suez Canal University, Egypt .
**Department of physics Faculty of Science, Zagazig University,Egypt.*

The ultraviolet component of solar radiation was measured in Egypt for the last years by the Meteorological Authority of Egypt, in Cairo and Aswan stations. Cairo represents the typical weather conditions for Lower Egypt and Aswan represents the typical weather conditions for Upper Egypt. Measured data of global and ultraviolet solar radiation in Cairo and Aswan for the period (1990-1992) have been processed, arranged, discussed and used to investigate an empirical relationship with correlation coefficient 96%. This empirical relationship was used in calculating the ultraviolet component of solar radiation in Cairo, Aswan and other selected locations(Matrough, Al-Arish, Bahtim and Al-Kharga) during other two years (1993 and 1994). The calculated values of ultraviolet radiation were compared with the measured data at both Cairo and Aswan sites and were in a good agreement. This encourages the use of the empirical formula in calculating the components of ultraviolet solar radiation at any other location over Egypt .

Introduction

Energy from the sun is the basis for life on earth, and the solar spectrum is a mixture of radiation, visible, ultraviolet and infrared radiation. The ultraviolet solar radiation is extending from 290 nm to about 400 nm.[1].

The solar ultraviolet radiation is a very important component of our environment. The ultraviolet part of the spectrum has been divided by the astronomers and astrophysicists into four parts namely (a) near ultraviolet which covers a spectral range 380-300 nm. (b) Middle ultraviolet of spectrum range 300-200 nm. (c) Far ultraviolet of spectrum range 200-100 nm. And, (d) extreme ultraviolet of spectrum rang 100-4 nm. High doses of ultraviolet radiation, especially band b (230-290 nm.) cause skin diseases, eye cataracts, pigmentation, photo decomposition , degradation of materials and may also harm crops [2,3]. Inverse relation is already known between the ozone density in the atmosphere and the amount of UV radiation reaching the earth surface. From this point of view, the amount of UV radiation is highly affected by the ozone destroy pollutants such as freo refrigerants, spry, and atomic bomb test [4.5].

In Egypt measurements of global solar radiation began in 1956 in Cairo and 1980 in Aswan. The ultraviolet solar radiation measurements in Cairo and Aswan were combined in 1990 using Epply radiometer, since it is sensitive to the solar radiation in the band 295 – 385 nm[6] .

In the present paper a correlation between the ultraviolet (UV) and the global solar radiation (G) over Egypt were carried out. The data material is collected over three years in Cairo (30^o 05^-N, 31^o 17^-E) and Aswan (23^o 58^- N, 32^o 47^- E). The choice of Cairo and Aswan locations was due to two reasons. First, Cairo represents the typical weather conditions of Lower Egypt while Aswan represents the typical weather conditions of Upper Egypt. Second, the ultraviolet radiation source of data are available and measured only in these stations. The investigated empirical relationship was used to calculate the values of UV solar radiation for both Matrough(25^o 27^- N, 30^o 35^- E), Al-Arish (31^o 07^-N, 33^o 45^- E), Bahtim (30^o 09^- N, 31^o 15^- E) and Al-kharaga (25^o 27^-N, 30^o 35^-E) stations .

Results and discussion

1. Global and UV solar radiation measurements in Cairo.

The monthly average daily and the annual mean data of global and ultraviolet solar radiation at Cairo for the period (1990-1992) are illustrated by Fig. (la,b). From the Figure, the higher values of global solar radiation are in June and the lower values are in January and December. The ultraviolet solar radiation has a maximum values also in June for 1990 and 1992. While the maximum value in 1991 was in July. The annual mean values for G and UV are 18.10 and 0.60 (MJ/m^2 /day) respectively.

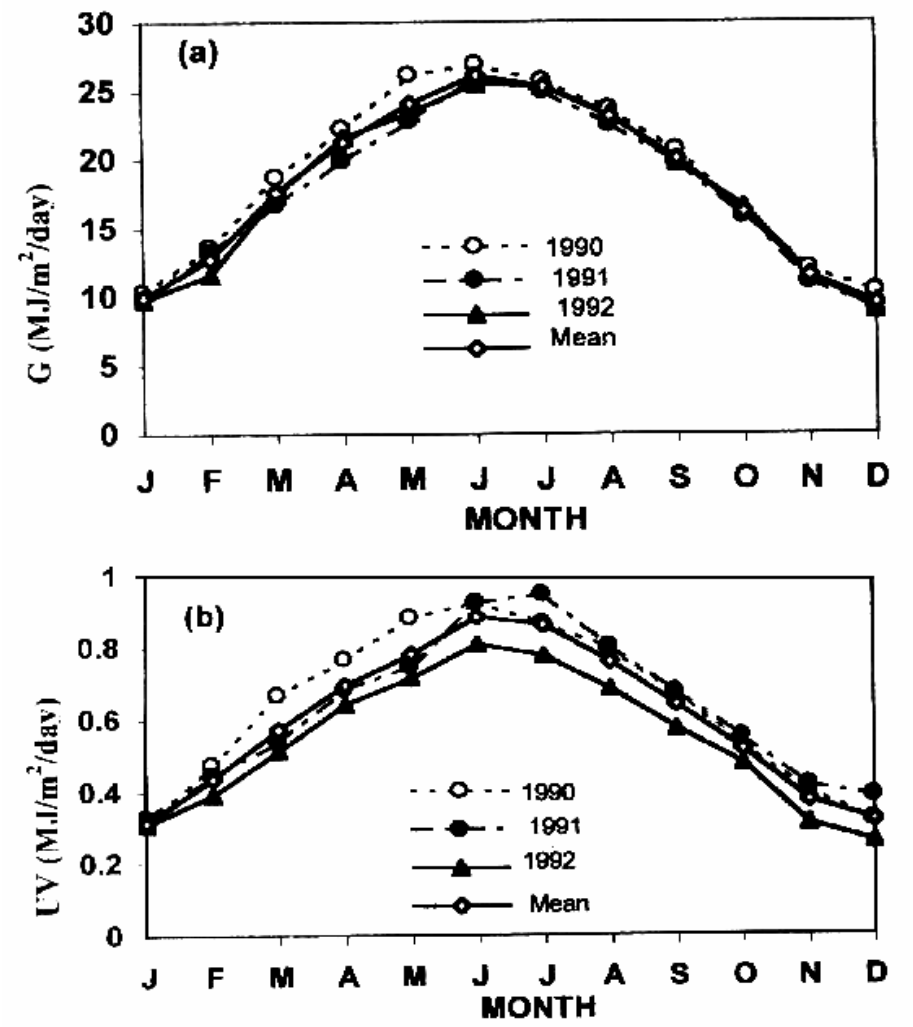

Fig. (1): Measurements date during the period (1990-1992) at Cairo station for (a) Global solar radiation (G) and (b) Ultraviolet solar radiation (UV).

2. Global and UV solar radiation measurements in Aswan

We have also analyzed both global and ultraviolet solar radiation at Aswan site. Figure (2a, b) contains the same parameters like Fig. (1a, b) but at Aswan station. From the Figure, one may notice that, the values of global and ultraviolet solar radiation for the three years were confirmed and shows the same behavior as the average values. The global and ultraviolet solar radiation has the maximum values in July, while the minimum values were in December. On the other hand, the maximum values for global and ultraviolet solar radiation were 27.87 and 0.95 (MJ/m^2/day) in December, respectively. The annual mean values of G and UV were 22.09 and 0.75 (MJ/m^2 /day) respectively.

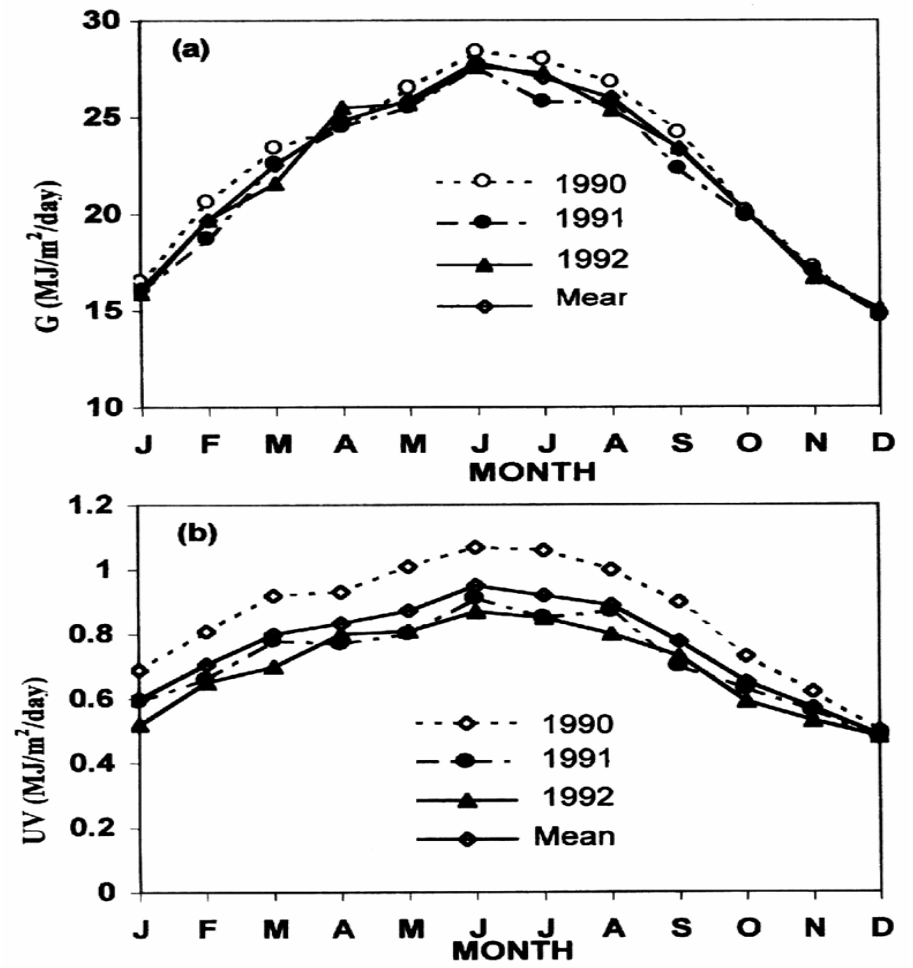

Fig. (2): Measurements date during the period (1990-1992) at Aswan station for (a) Global solar radiation (G) and (b) Ultraviolet solar radiation (UV).

From the above measured data for G and UV solar radiation during the mentioned period in Cairo and Aswan, it was found that UV solar radiation values at Aswan are higher than the corresponding values at Cairo. This is due to the fact that the mean sea level at Aswan is higher than that of Cairo, also the amount of insulation at Aswan is greater than that of Cairo. The data are in a good agreement, where G and UV increase in Summer and decrease in Winter. This enabled us to investigate an empirical relationship to calculate the ultraviolet component from the values of global solar radiation over Egypt as follows:

3. Empirical formula of ultraviolet solar radiation investigated over Egypt

Many types of correlations were tried to find out the best fit between G and UV data. It was found that the data is going towards the best linear fit in the form:

$$UV = a\,G \pm b \quad \ldots\ldots\ldots\ldots(1)$$

where a and b are regression coefficients which depend on the weather parameters of the location. The data have been processed by a computer program and the obtained values for a and b were found to be 0.035 and –0.021 respectively. The obtained values for the correlation coefficient was CC= 0.96 and the standard error of estimation was 0.061.

4. Verification of the empirical equation

a. At Cairo

Accordingly; the empirical relationship investigated Eq.(1) becomes:

$$UV = 0.035\,G - 0.021 \quad \ldots\ldots\ldots\ldots(2)$$

The measured data of global solar radiation during new period (1993 and 1994) are introduced in Eq. (2) to calculate the corresponding values of UV radiation. The estimated data of ultraviolet solar radiation were compared with the corresponding measured data during the mentioned period. The results were illustrated by Fig. (3a, b and c) From the Figure, it can be seen that the estimated values of UV solar radiation are in a good agreement with the measured values for all months. The assurance factor which represent the ratio between the estimated and the measured values of ultraviolet solar radiation (UVes/UVm) was in the range form 0.94 to 1.07 for the year 1993, 0.78 to 1.04 for the year 1994, and 0.88 to 1.03 for the average data. The annual mean values of the assurance factor are 1.01, 0.92 and 0.96 for the studied period. On the other hand the deviation between

measured and estimated values is small, where the deviation between the annual measured values and the estimated values does not exceed about ± 8 % error.

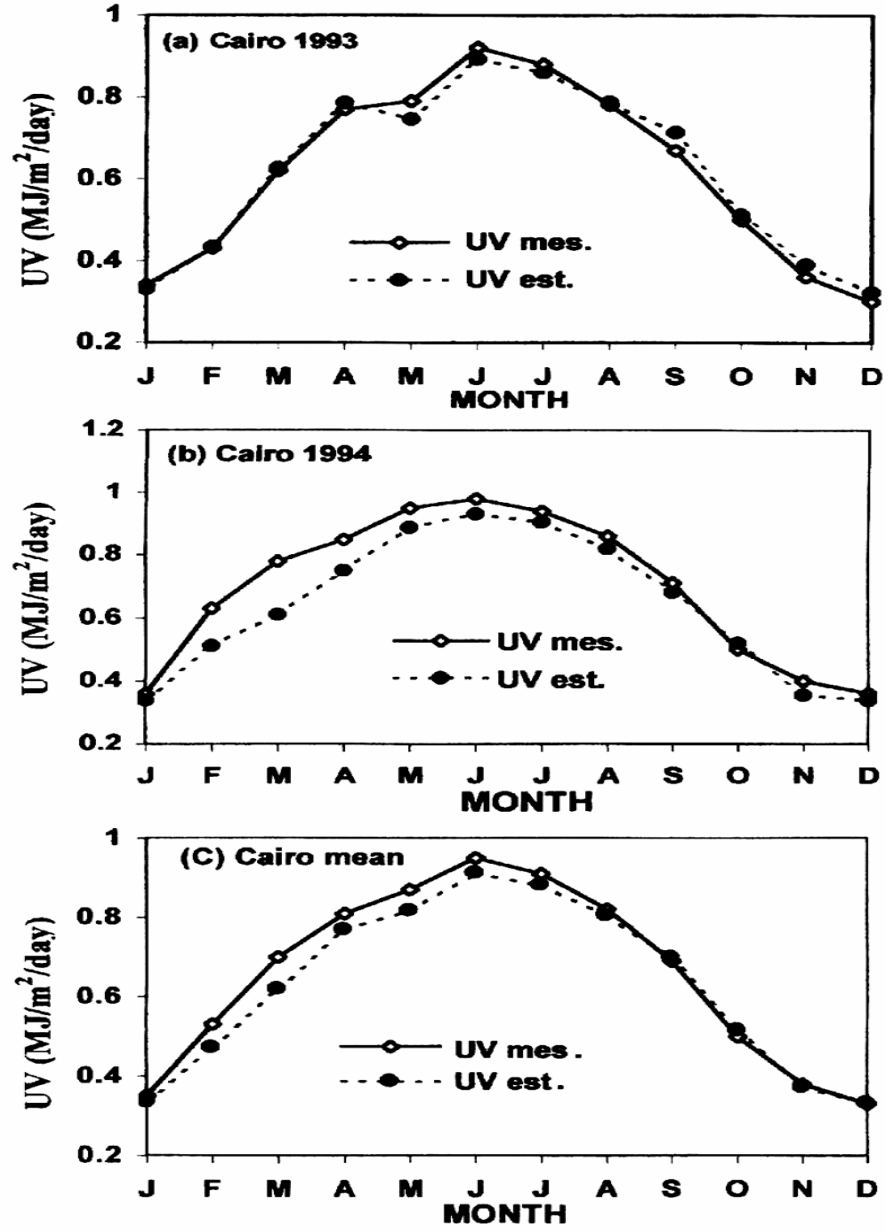

Fig. (3): Comparison between measured and estimated values of ultraviolet solar radiation at Cairo site for (a) 1993, (b) 1994 and (c) the mean.

b. At Aswan

The estimated values of UV solar radiation using Eq.(2) were compared with the corresponding measured values for the same period at Aswan site. The results are illustrated by Fig. (4a, b and c). The curves shows that the estimated values were confirm the measured values and also has the same trend from January to December during the years 1993 and 1994, also the average has the same trend. The error between measured and estimated values does not exceed ± 8 %.

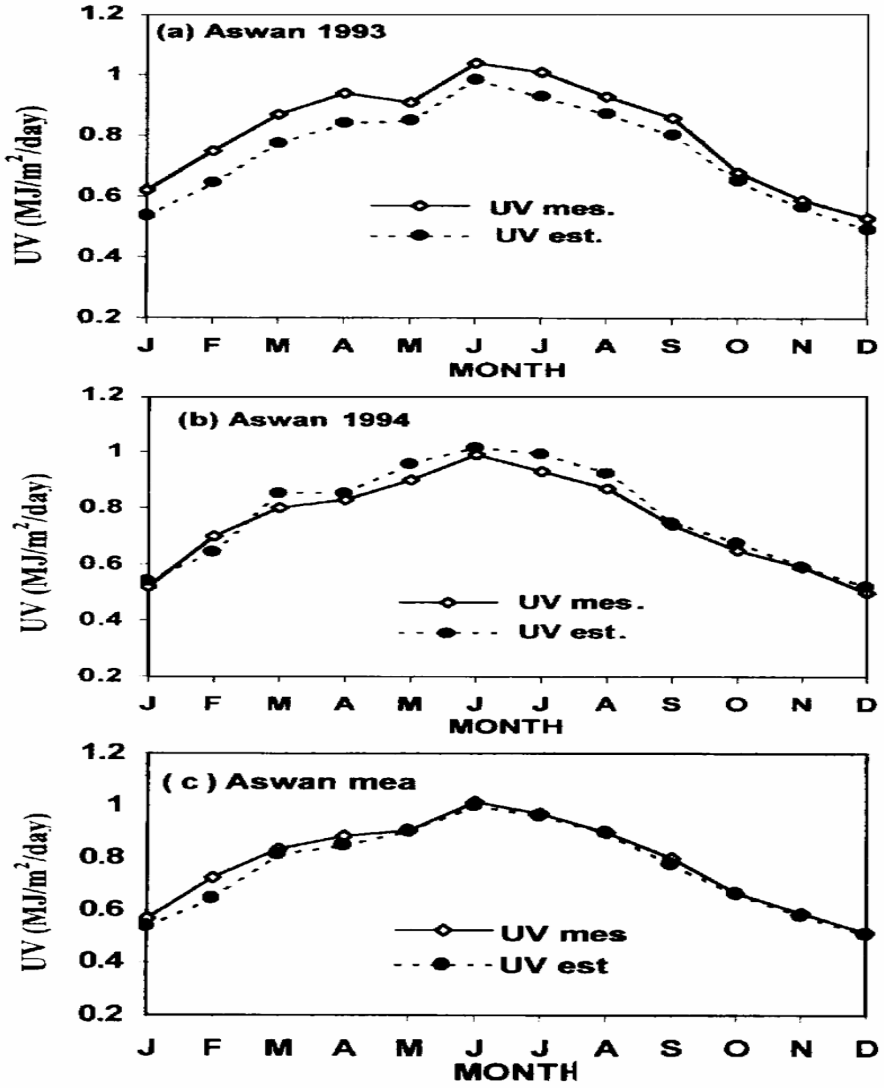

Fig. (4): Comparison between measured and estimated values of ultraviolet solar radiation at Aswan site for (a) 1993, (b) 1994 and (c) the mean.

5. Ultraviolet solar radiation over Egypt

After testing the empirical formula Eq.(2) at Cairo and Aswan sites the formula has been used to estimate the ultraviolet solar radiation level at other locations in Egypt. Since Cairo represents the weather conditions of lower Egypt and Aswan represents the typical weather conditions of Upper Egypt, and the measured values of UV are only available at these stations, it can be use Eq.(2) to estimate the values of UV at different sites in Egypt as follows.

a. At Upper Egypt

The measured values of global solar radiation during the period (1993-1994) at Matrough and Arish stations were substituted in Eq.(2) to estimate the values of ultraviolet solar radiation. The results compared with the corresponding measured values at Cairo where Cairo is the nearest sit in which the measured data are available. Matrough and Arish sits represent the weather conditions of north Egypt. Fig. (5a, b) compare the estimated values of ultraviolet solar radiation and the measured values at Cairo. The Figure shows that, the estimated values of ultraviolet solar radiation are in the same order as the corresponding measured values. The deviation is small during the full year except some months such as February and October at Matrough and March at Arish .On the other hand, the annual mean values of the assurance factor were1.02 and 1.03 at Matrough and Arish respectively (i.e. the average error does not exceed about 3%). On the other hand the measured and the estimated values lie in the same range and have the same trend during all months.

Bahtim station is the nearest to Cairo and they represent together the weather conditions of middle Egypt. Fig. (5c) illustrates the same data for Bahtim station as an example for middle Egypt. The agreement and deviation between the estimated and the measured values appear in the Figure, where the annual mean values for estimated, measured and the assurance factors are 0.65, 0.64 and 0.98, respectively (error of about 2 %).

b. At Lower Egypt

With respect to Lower Egypt, the measured values of global solar radiation at Kharga station were used to estimate the ultraviolet solar radiation using the investigated empirical formula Eq.(2) The results were compared with the measured values at Aswan and plotted in Fig. (6). The Figure clears that the estimated values are confirmed with the measured values and the deviation is small during all months. The higher value of the assurance factor was 0.99 in August and the lower value were 0.87 in

January and February. The annual mean value of the assurance factor is 0.95 (i.e the error is approximately 5%). Because the investigated sites cover different locations allover Egypt where the compression was made , we may conclude that the empirical formula Eq.(2) may be applied to estimate UV solar radiation component at any location in Egypt.

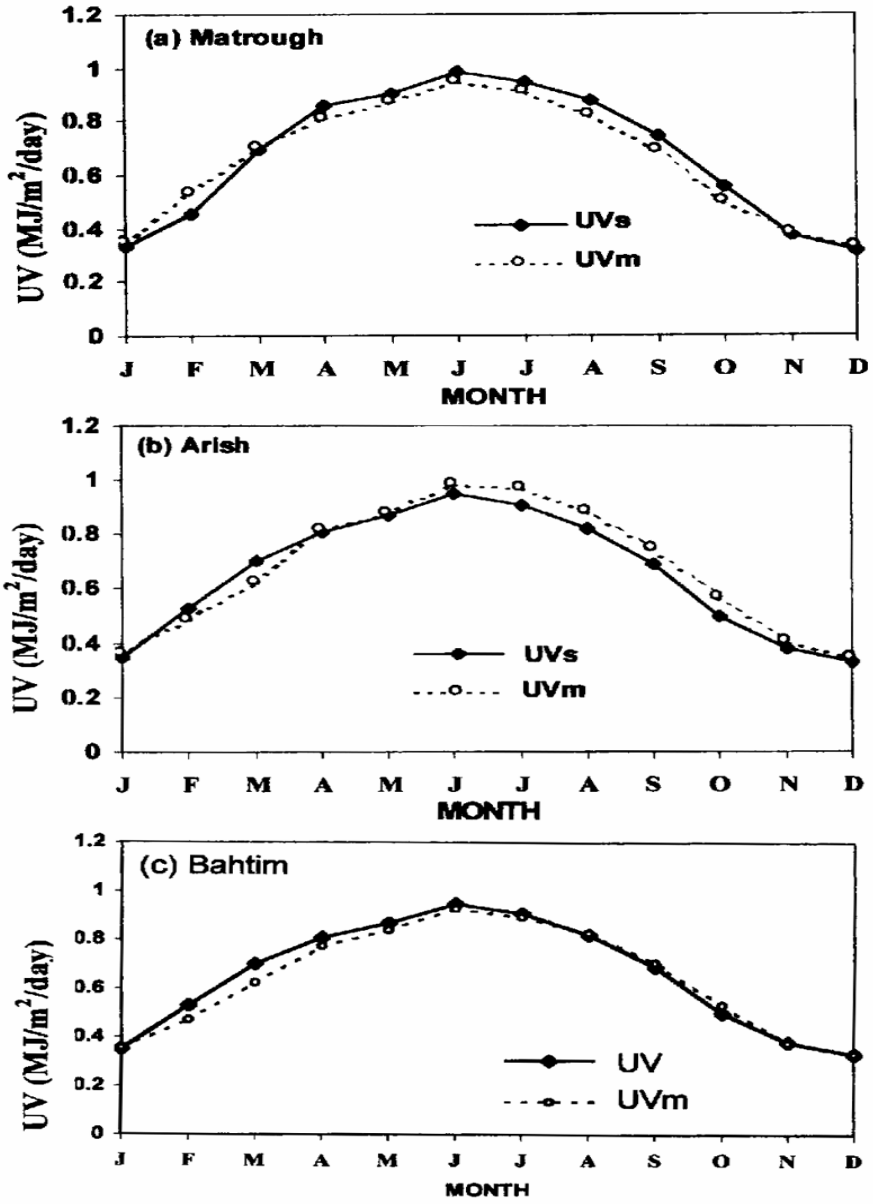

Fig. (5): Comparison between estimated values of ultraviolet solar radiation at (a) Matrough, (b) Arish and (c) Bahtim sites and the measured values Cairo site.

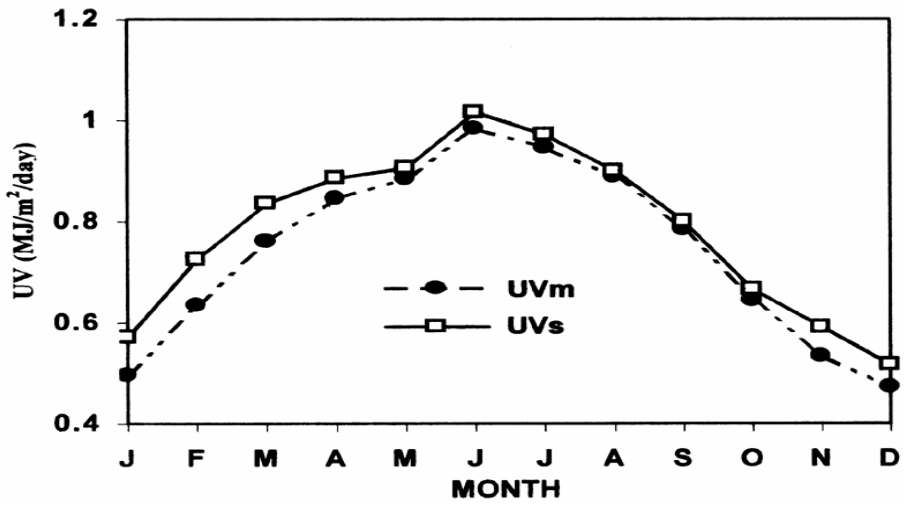

Fig. (6): Comparison between estimated values of ultraviolet solar radiation at Kharga site and the corresponding measured values at Aswan site.

Conclusions

An integral view of the present paper shows that the values of Ultraviolet solar radiation in Aswan (Upper Egypt) are higher than the corresponding values in Cairo (Lower Egypt). Global and ultraviolet solar radiation data has the same trend during the full year and are in a good correlation. The investigated empirical relationship (UV = 0.035G- 0.021) has correlation coefficient of 0.96 and standard error of 0.061. From the results obtained and discussions, it was found that there is a good agreement between measured and estimated values of UV component of solar radiation. The annual mean values of error does not exceed about ± 3% in the north and the diddle of Egypt and ±5% in the south, which favor the use of the investigated empirical formula with confidence to calculate the ultraviolet component of solar radiation at different sites in Egypt.

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