Some Statistical Characteristics of Solar Radiation and Sunshine Variations in Tropical Area. A Case Study of the Klang Valley Region, Malaysia

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ABSTRACT

The purpose of this study is to investigate the variations and trends in monthly, seasonal and annual solar radiation in the Klang Valley Region for the period 1975-2002. The least square method was used for the trend analysis. The linear trend is used mainly to test the change in solar radiation and sunshine to set limits on the rate of change. Trend line and values and significance levels of the slopes have been found. The seasonal and the annual average values were computed from the monthly average radiation data. The seasonal and annual average solar radiation and sunshine values were designated as dependent variables, and thus, were fitted linearly for season and annual means for each station. The results showed that the mean of maximum incoming global radiation in September with a value of 21.1 MJ m^{-2} at Petaling Jaya, while the mean minimum in November and December with values of 10.7 and 10.9 MJ m^{-2} at Petaling Jaya. The low amounts of solar radiation received in November and December are due to greater cloudiness during the period coinciding with the northeast monsoon season. On rainy days, very little global solar radiation is received. The overall average rate of change in global solar radiation during 1975-2002 and 1977-2000 is represented by the slope of the linear regression was small (-0.126 and -0.314 MJ m-2 per year for Subang Airport and Petaling Jaya respectively). The sunshine results revealed that there is a maximum in May of 7.0 hours at Subang Airport and a minimum in November with a value of 4.5 hours at Universiti Kebangsaan Malaysia. The coefficient of variation (C.V.) ranged from 4.7% in April to 22.3% in December. The coefficient of variation has a wide range during April and December, suggesting large variations from month to month. The statistically fitted linear trend at Subang Airport and Petaling Jaya over the period 1970-1999 were -4.30 and 0.22 hour per year and statistically not significant. At Universiti Kebangsaan Malaysia the linear trend over the shorter period of measurement available, 1979-2000 was -13.57 hour per year, and was significant at 0.05 level.

KEYWORDS: solar radiation trends, sunshine trends, linear regression.

INTRODUCTION

The knowledge of solar radiation climate of an area is important for assessing the potential use of solar energy to be converted to either thermal or electrical energy, as a power source. Such information is a prerequisite for the design of solar energy conversation systems (Omran, 2000). WMO (1981) stated that solar radiation data are useful to the solar system designer and developer only if provision is made to reconstruct time series of these data at sufficiently short intervals. The recent energy crisis in the world has prompted many countries to look for alternative energy resources. Since one of the most abundant energy sources is solar energy, there is, therefore, an urgent need to study the solar radiation for the purpose of exploiting its use as a supplementary energy resource (Hu and Lim 1983).

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Sunshine is a climate parameter which, compared to temperature and precipitation, has not received adequate attention (Weber, 1990). Changes in sunshine can often be directly related to changes in atmospheric circulation patterns and other climate parameters. Accordingly, the aim of this study is to examine variations and trends in solar radiation and sunshine throughout the Klang Valley Region for the period 1970-2000.

DATA AND MATERIALS

The monthly data used in this study obtained from the Malaysian Meteorological Service (MMS). The solar radiation and sunshine data on which this study is based are being monitored at only three meteorological stations at Subang Airport, Petaling Jaya and Universiti Kebangsaan Malaysia. The databases utilized in this study are from 1975-2002 and 1977-2000 for Subang Airport and Petaling Jaya respectively. The Klang Valley Region, the most populous, urbanized and industrialized region in Malaysia. In order to test variation in solar radiation over the Klang Valley Region, it is necessary to examine the historical records of monthly means. Annual means were calculated for the period 1975-2002. Trend analysis of data is undertaken to provide a long-term perspective on 1975-2002 data. The linear trend is used mainly to test the change in solar radiation and to set limits on the rate of change. Statistical significance of trends has been estimated by the use of the Student's T test. The following regression equation is fitted by least squares to the observed solar radiation:

$$T = a + b\,(s- / s) \qquad (1.1)$$

where a is the overall mean, b is the slope, s is the year and s- is the mean of the years. The annual time series of solar radiation for 1975-2000 from MMS are used for depicting an annual trend. The basic statistical model is

$$Ys = a + b + Vs \qquad (1.2)$$

Where

Ys is the response solar radiation (in year), s, a are the constant term, b is a trend variable, either linear or model-based, incorporating a trend parameter and Vs is the error term in year s. This model used by Bloomfield (1992), who explained that estimation of the trend parameter (is simple when the trend model is parametrically linear).

RESULTS

Monthly variations and trends in solar radiation:

Tables 1-2 show the monthly average daily global solar radiation for the stations Subang Airport and Petaling Jaya, respectively. The tables show that large monthly values of global solar radiation are available in both stations from May to August. This large value reaches a maximum of 17.5 MJ m^{-2} and 17.2 MJ m^{-2} in all the stations, while the minimum is 14.2 MJ m^{-2} in December. The medium values are higher, but quite similar to the arithmetic mean. The differences between them are very small. The maximum is obtained in September with a value of 21.1 MJ m^{-2} and the minimum in November with a value of 16.80 MJ m^{-2}. The coefficient of variation ranged from 4.6% to 13.6%. The coefficient of variation reaches quite low values during inter-monsoon months particularly in April, May and October. This shows a high stability during such months. This stability is also confirmed by the low values of the standard deviation (S.D.) in the same period. The standard deviation does not reach 2 in any month, even though the mean values are higher than 16 MJ m^{-2} in many months. Simple linear regression and slope of solar radiation were calculated for each month of the two stations and the parameters of these equations are presented in Tables 3 and 4. They were found to vary considerably in both magnitude and statistical significant. High insignificant increases in slope were found at Subang Airport for many months of the year. Whereas there

were insignificant increases for four of the 12 months, from April to May and October to November. At Petaling Jaya station, there were small and statistically insignificant increases in solar radiation from April to May and November to December. The coefficient of determination of the linear regression, r^2 ranged between zero and 0.09 was not significant at 0.05 level of significant.

Table 1. Monthly mean of global solar radiation (MJ m^{-2}) for Subang Airport, 1975-2002

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Mean	15.4	16.8	17.5	16.8	16.3	15.9	15.7	15.6	15.7	15.8	14.4	14.2	15.8
Median	15.6	17.0	18.1	16.8	16.4	15.9	15.9	15.8	16.1	15.8	14.2	14.3	16.0
Mode	15.2	13.6	13.8	16.8	13.6	13.5	13.7	15.7	12.5	12.6	14.1	11.0	14.1
SD	1.7	1.4	1.6	1.2	1.3	0.70	1.0	1.1	1.3	1.4	1.1	1.6	0.80
CV	11.0	8.3	9.4	7.1	8.1	4.6	6.3	7.4	8.4	8.8	7.5	11.1	5.1
Var.	2.8	1.9	2.7	1.4	1.8	0.50	1.0	1.3	1.8	2.0	1.1	2.5	0.6
Min	12.2	13.6	13.8	14.5	13.6	13.5	13.7	12.8	12.5	12.6	12.1	11.0	14.1
Max	18.3	19.5	19.8	18.7	18.2	17.3	17.2	18.8	18.0	19.2	16.8	17.8	17.5

Table 2. Monthly mean of global solar radiation (MJ m^{-2}) for Petaling Jaya, 1977-2000

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Mean	15.4	16.7	17.2	16.8	15.9	15.5	15.7	15.6	15.8	16.0	14.6	14.3	15.8
Median	15.3	16.7	17.1	16.9	16.1	15.4	15.7	15.7	15.6	16.1	14.6	14.3	15.8
Mode	15.2	14.4	12.9	17.1	12.5	15.0	16.1	12.9	15.5	16.1	14.6	15.6	15.3
SD	1.6	1.2	1.7	0.9	1.0	1.0	1.1	1.3	1.6	0.9	1.4	1.9	0.6
CV	10.3	7.2	9.7	5.2	6.2	6.4	6.7	8.4	10.4	5.9	9.5	13.6	3.6
Var.	2.5	1.4	2.7	0.7	1.0	0.9	1.1	1.7	2.7	0.9	1.9	3.8	0.3
Min	11.7	14.4	12.9	15.1	12.5	13.4	13.6	12.9	12.2	14.1	10.7	10.9	14.8
Max	18.1	19.4	20.0	18.6	17.4	17.9	18.0	17.8	21.1	18.1	17.9	20.2	17.0

Table 3. Value of mean solar radiation regression coefficient and slope for Subang Airport, 1975-2002

	J	F	M	A	M	J	J	A	S	O	N	D	Y
a	16.0	17.1	16.2	16.7	15.9	15.9	15.9	16.2	16.2	15.7	14.0	14.5	16.0
b	-0.4	-0.2	-0.9	0.7	0.3	-0.3	-0.9	-0.4	-0.3	0.6	0.2	-0.1	-0.1
r^2	0.04	0.01	0.00	0.00	0.03	0.00	0.00	0.08	0.04	0.00	0.03	0.00	0.01
Sig.	0.28	0.53	0.92	0.82	0.37	0.88	0.71	0.13	0.29	0.85	0.38	0.81	0.59

Table 4. Value of monthly mean solar radiation regression coefficient and slope for Petaling Jaya, 1977-2000

	J	F	M	A	M	J	J	A	S	O	N	D	Y
a	15.4	17.2	18.0	16.6	15.6	16.3	15.9	16.5	20.8	16.2	14.5	14.8	16.1
b	-0.3	-0.4	-0.6	0.1	0.2	-0.6	-0.1	-0.7	-0.5	-0.1	0.3	-0.4	-0.3
r^2	0.04	0.01	0.00	0.00	0.03	0.00	0.00	0.09	0.04	0.00	0.03	0.00	0.01
Sig.	0.28	0.53	0.92	0.82	0.37	0.88	0.71	0.13	0.29	0.85	0.38	0.81	0.59

SEASONAL VARIATIONS AND TRENDS IN SOLAR RADIATION

Table 5 depicts seasonal variation in solar radiation in the Klang Valley Region. In southwest monsoon a gradually variation takes place. The northeast monsoon months a similar behaviour to the inter-monsoon months. Tables 6-7 show the value of seasonal mean solar radiation regression coefficient and slope for Subang Airport and Petaling Jaya respectively. Significant decreases in slope were found at Subang Airport and Petaling Jaya in inter-monsoon season (April-May), southwest monsoon season and inter-monsoon (Oct-Nov) respectively. On the other hand, there were significant increases in northeast monsoon season. The parameters of the seasonal linear regression of b and r differed somewhat at the two stations. Small interannual trends of opposite sign were found in the above parameters, but these were not significant at either of the two stations.

Table 5. Seasonal variations in solar radiation at the Klang Valley Region

	Northeast monsoon			**Transitional monsoon (April-May)**			**Southwest monsoon**			**Transitional monsoon (October-November)**		
	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min
Subang	19.8	16.0	11.0	18.7	16.6	13.6	18.8	15.7	12.5	19.2	15.1	12.1
P.Jaya	20.2	15.9	10.9	18.6	16.3	12.5	21.1	15.7	12.2	18.1	15.3	10.7

Table 6. Value of seasonal mean solar radiation regression coefficient and slope for Subang Airport, 1975-2002

	Northeast monsoon	**Transitional monsoon (April-May)**	**Southwest monsoon**	**Transitional monsoon (October-November)**
a	14.20	16.70	15.90	16.09
b	0.30	-0.79	-0.35	-0.35
r^2	0.26	0.01	0.01	0.16
Sig.	0.00	0.45	0.26	0.00

Table 7. Value of seasonal mean solar radiation regression coefficient and slope for Petaling Jaya, 1977-2000

	Northeast monsoon	**Transitional monsoon (April-May)**	**Southwest monsoon**	**Transitional monsoon (October-November)**
a	14.10	16.90	15.67	16.47
b	0.36	-0.24	-0.29	-,47
r^2	0.27	0.11	0.00	,22
Sig.	0.00	0.002	0.95	0.001

ANNUAL VARIATIONS AND TRENDS IN SOLAR RADIATION

Fig. 1-2 show the annual mean of global radiation, three moving average, long-term mean and linear trend for the period 1975-2002 and 1977-2000 for Subang Airport and Petaling Jaya, respectively. The lowest and highest mean annual solar radiation values are 168.8 MJ m-2 in 1994 at Subang Airport and 210 MJ m^{-2} in 1975 also at Subang Airport. It is observed that during 1981-1986 at Subang Airport and 1991-1994 at Subang Airport and Petaling Jaya, the annual amounts have been consistently lower than the long-term mean, whereas the other years recorded higher or within long-term mean values of solar radiation. The complete 27-year long record of solar radiation measured at Subang Airport showed a very low insignificant decrease between 1975 and 2002 averaging -0.126 MJ m^{-2} per year. While solar radiation at Petaling Jaya showed relatively greater decrease between 1977 and 2000, -0.314 MJ m^{-2} per year, which was not significant at p = 0.05. The smoothed trend in annual solar radiation shown in Fig. 2 was obtained by applying a 3-year moving average.

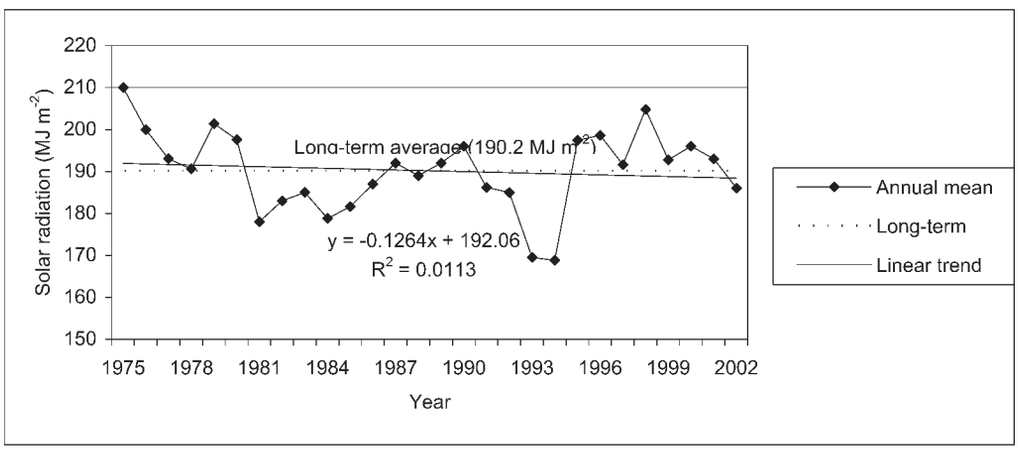

Figure 1. Mean Annual solar radiation at Subang Airport, 1975-2002

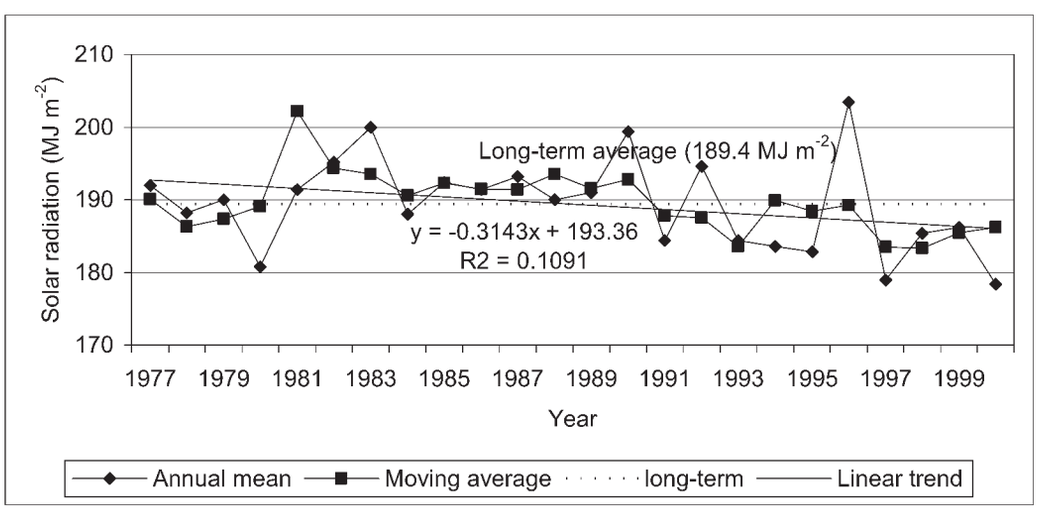

Figure 2. Annual mean, 3-year moving average, long-term mean and linear trend of solar radiation (MJ m^{-2}) at Petaling Jaya, 1977-2000

MONTHLY VARIATIONS AND TRENDS IN SUNSHINE

Table 8, Table 9 and Table 10 give the mean daily sunshine values for every month for three meteorological stations, Subang Airport, Petaling Jaya and Universiti Kebangsaan Malaysia, respectively. There is a maximum in August of 8.5 hours at Universiti Kebangsaan Malaysia and a minimum in November with a value of 2.3 hours in September and December at Subang Airport and Universiti Kebangsaan Malaysia. From Table 8, Table 9 and Table 10 become evident a general low trend on the sunshine duration values during the months October, November and December. The coefficient of variation (C.V.) ranged from 4.7 % in April to 22.3% in December. The coefficient of variation has a wide range during April and December, suggesting large variations from month to month.

Table 8. Monthly mean of sunshine (hours) for Subang Airport, 1970-1999

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Mean	6.0	6.70	6.60	6.50	6.60	6.40	6.40	6.0	5.20	5.40	4.90	5.0	6.0
Median	6.30	6.80	6.70	6.40	6.60	6.30	6.40	5.90	5.30	5.50	4.90	4.90	6.0
Mode	6.30	6.70	7.10	7.0	7.10	5.90	6.60	4.80	5.80	5.90	4.60	3.10	6.10
SD	1.01	1.06	0.94	0.57	0.54	0.54	0.66	0.84	0.76	0.63	0.50	1.06	0.27
CV	16.8	16.4	14.2	8.8	8.2	8.4	10.3	14.0	14.6	11.7	10.2	21.3	4.5
Var.	1.02	1.12	0.88	0.33	0.29	0.29	0.44	0.70	0.58	0.40	0.25	1.12	7.2
Min	3.90	4.10	4.70	5.40	5.50	5.70	5.10	4.80	2.30	3.50	3.80	3.0	5.50
Max	7.60	8.40	8.20	7.80	7.50	7.70	8.10	7.90	6.10	6.80	5.90	7.0	6.40

Table 9. Monthly mean of sunshine (hours) for Petaling Jaya, 1970-1999

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Mean	5.80	6.50	6.30	6.20	6.20	5.80	6.10	5.70	5.10	5.20	4.60	4.70	5.70
Median	6.0	6.50	6.30	6.10	6.20	6.0	6.10	5.60	5.20	5.20	4.60	4.60	5.70
Mode	6.30	6.50	6.30	5.90	5.60	5.70	5.80	4.90	5.20	5.60	4.30	3.0	5.90
SD	0.99	1.03	0.89	0.54	0.58	1.05	0.72	0.79	0.83	0.60	0.51	1.03	0.29
CV	16.9	16.1	12.5	4.7	5.3	19.0	8.4	10.9	13.3	6.9	5.6	22.3	1.46
Var.	0.98	1.05	0.79	0.29	0.33	1.10	0.51	0.62	0.63	0.36	0.26	1.05	8.30
Min	3.5	3.8	4.30	5.10	5.20	2.70	4.10	4.80	2.20	3.50	3.40	2.50	5.10
Max	7.0	8.30	7.60	7.10	7.30	7.40	8.0	7.70	6.10	6.80	5.8	6.70	6.30

Table 10. Monthly mean of sunshine (hours) for Universiti Kebangsaan Malaysia, 1979-2000

	J	F	M	A	M	J	J	A	S	O	N	D	Y
Mean	5.40	6.20	6.20	6.30	6.40	6.30	6.30	5.70	5.10	5.0	4.50	4.80	5.70
Median	5.40	6.20	6.20	6.30	6.30	6.30	6.40	5.50	5.20	5.0	4.50	4.70	5.70
Mode	5.40	6.20	6.20	6.40	5.90	6.30	6.40	5.40	4.70	5.0	4.50	4.60	5.30
SD	1.07	1.02	1.05	0.50	0.67	0.78	0.78	0.95	0.81	0.67	0.59	1.06	0.43
CV	19.8	16.4	16.9	7.9	10.5	12.4	12.4	16.7	15.9	13.4	13.1	22.1	7.5
Var.	1.14	1.05	1.12	0.25	0.45	0.60	0.62	0.90	0.66	0.45	0.34	1.12	0.19
Min	3.60	4.10	4.20	5.40	5.30	4.80	4.70	4.20	3.70	2.90	3.10	2.30	4.90
Max	7.40	7.90	7.50	7.40	8.40	7.90	7.60	8.50	6.60	5.90	5.40	7.0	6.50

ANNUAL VARIATIONS AND TRENDS

Fig. 3-5 show the mean annual hours of sunshine for Subang Airport, Petaling Jaya and Universiti Kebangsaan Malaysia respectively. At both sites, a decrease in the annual totals of sunshine hours was found. The statistically fitted linear trend at Subang Airport and Petaling Jaya over the period 1970-1999 were -4.30 and 0.22 hour per year and statistically not significant. While at Universiti Kebangsaan Malaysia the linear trend over the shorter period of measurement available, 1979-2000 was -13.57 hour per year, and was only significant at p = 0.007. Long-term decreases in sunshine were found at two stations, with trends of different magnitudes and statistically non-significance; the considerable year-to-year variations in the long-term trends at the two sites. The figures demonstrate a discernible decrease in the time-series starting in 1978, 1982 and 1987 for Subang Airport, Petaling Jaya and Universiti Kebangsaan Malaysia, respectively.

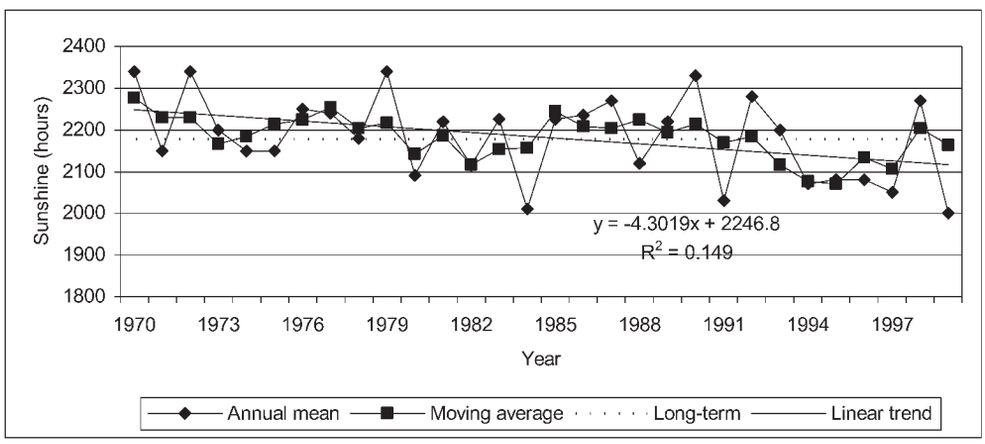

Figure 3. Annual mean, 3-year moving average, long-term mean and linear trend of sunshine (hours) at Subang Airport, 1970-1999.

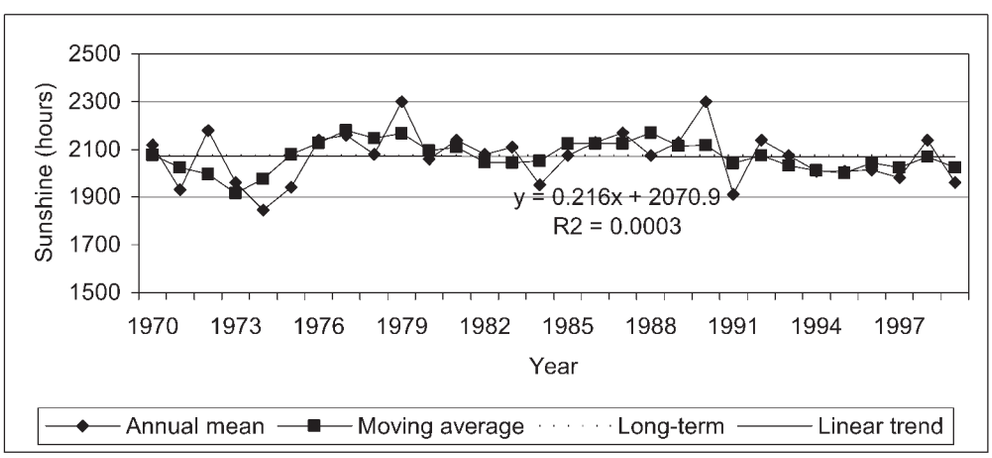

Figure 4. Annual mean, 3-year moving average, long-term mean and linear trend of sunshine (hours) at Petaling Jaya, 1970-1999.

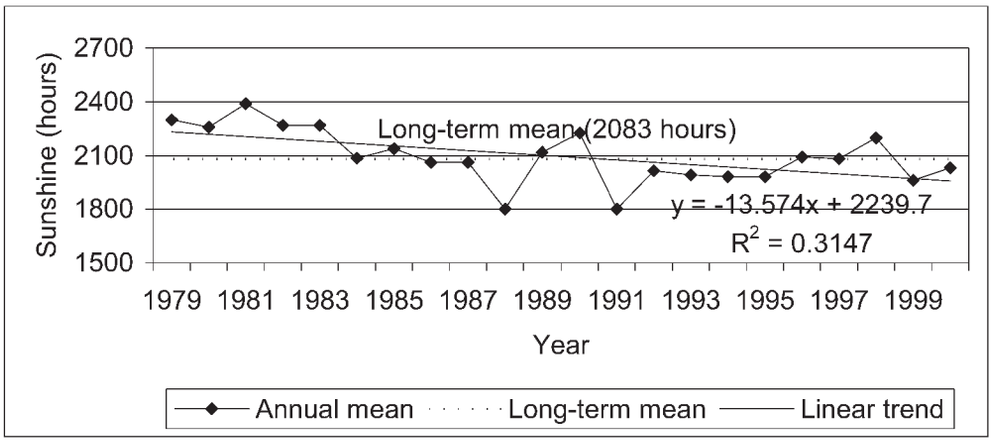

Figure 5. Annual mean, long-term mean and linear trend of sunshine (hours) at University Kebangsaan Malaysia, 1979-2000.

DISCUSSION

The study has focused on monthly, seasonal and annual values of solar radiation and sunshine in the Klang Valley Region. The statistical analysis shows that a large value of daily global solar radiation has a maximum of 17.5 MJ m^{-2} in March and a minimum of 14.2 MJ m-2 in December. Because with arrival of the northeast monsoon (November and December) the solar radiation continues to diminish over the east coast region, particularly over the northeast region, in agreement with the fact that of the northeast monsoon is greatest over the exposed part of the Peninsula (Hu and Lim 1983). Over the west coast and southern regions, the solar radiation is expected higher (mainly greater than 14 MJ m^{-2} per day).

It also shows that daily global radiation is high in Petaling Jaya all over the year, while it is high in Subang Airport during the period May to August. The increasing solar radiation at Petaling Jaya throughout the year may be due to the increase of atmospheric aerosol due to air pollution. The aerosol effect is to decrease direct and global irradiation due to increase in both absorption and scattering (Omran, 2000). Linear regression calculated for mean monthly values during the period of the study showed small differences in the parameters. The slopes for monthly ranged from a minimum of -0.1 to a maximum of 0.7 and statistically non-significant trend for the slope.

The distribution of the seasonal mean values of solar radiation exhibits a high symmetry. Inter-monsoon seasons April-May and October-November show a similar behaviour, just like the northeast monsoon months. This fact may be easily explained from the seasonal symmetry in relation to the northeast monsoon season and inter-monsoon seasons. In any event, the increasing cloudiness and precipitation during these seasons. During southwest monsoon the distribution is relatively uniform with values ranging between 15.5 MJ m^{-2} and 15.9 MJ m^{-2} per month. The highest variability occurred in November-December and March-April is possibly in function of being the changing months between wet and dry season. December is a month with a relatively high variability mainly due to cloud effects associated with northeast monsoon rains. Moreover, in November and December which are considered to be early northeast monsoon months coinciding with the presence of a marked rainfall maximum. Hu and Lim (1983) investigated solar radiation and sunshine duration for a total of 14 stations in Peninsular Malaysia. They found that the distribution pattern of global solar radiation follows somewhat with that of rainfall pattern. Whereas Barradas (1991) analyzed

radiation regime in a tropical dry deciduous forest in western Mexico. The results showed a drastic change between rainy and dry season. Furthermore, Hu and Lim (1983) pointed out that in the northern autumn transition (October) there is a general increase in rainfall throughout the Peninsula, especially over the west coast region whose two-rainfall maximum coincide with the two transitional periods. It follows that there is corresponding decrease in the global solar radiation over the Peninsula.

It is also observed that during 1983, 1990, 1991, 1994 and 1997, the annual amount has been lower than the period mean value while the rest of the period recorded within or higher than averages values of global radiation. This might be due to the haze episode in 1983, 1990, 1991,1994 and 1997, that had changed pollution concentrations and hence its effects on incoming solar radiation, by more irregular fluctuations owing to molecular reflection from and absorption by clouds (Yassen, 2000). Solar radiation at Petaling Jay station showed relatively a greater decrease between 1977 and 2000, -0.314 MJ m^{-2} per year, which was not significant at $p = 0.05$. However, analysis of the complete series of measurement at Subang Airport between 1975-2002 shows a much smaller annual decline, -0.126 per year and also not statistically significant. Long-term decreases in solar radiation were found at both stations, with trends of different magnitudes and statistically not significance; the considerable year-to-year variations in the long-term trends at two sites. Interpretation of the major results of this study, namely the insignificant reductions in solar radiation measured at Subang Airport and Petaling Jaya stations. This might be due to the long-term decrease in sunshine hour duration measured at the same site. Measurement of sunshine duration at the Subang Airport and Petaling Jaya suggest that the negative trend.

CONCLUSIONS

The study has focused on long-term of monthly, seasonal and annual values of solar radiation and sunshine over the Klang Valley Region. The statistical analysis shows that a large value of daily global solar radiation has a maximum of 17.5 MJ m^{-2} in March and a minimum of 10.7 MJ m^{-2} in December. The distribution of the seasonal mean values of solar radiation exhibits a high symmetry. Inter-monsoon seasons April-May and October-November show a similar behaviour, just like the northeast monsoon months.

The results revealed that during 1983, 1990, 1991, 1994 and 1997, the annual amount has been lower than the period mean value while the rest of the period recorded within or higher than averages values of global radiation. This might be due to the haze episode in 1983, 1990, 1991, 1994 and 1997. The overall average rate of change in global solar radiation during 1975-2002 and 1977-2000 is represented by the slope of the linear regression was small with value of -0.126 and -0.314 MJ m^{-2} per year for Subang Airport and Petaling Jaya, respectively.

Long-term decreases in sunshine were found at two stations, with trends of different magnitudes and statistically non-significance; the considerable year-to-year variations in the long-term trends at the two sites.

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بعض الخصائص الإحصائية لتغير الإشعاع الشمسي والإشراق في المنطقة المدارية: دراسة حالة إقليم وادي كلانق، ماليزيا

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الملخص

تهدف هذه الدراسة للبحث عن أسباب التباينات الشهرية والموسمية والسنوية للإشعاع الشمسي واتجاهاته في إقليم وادي كلافق خلال الفترة 1975-2002. يعتبر إقليم وادي كلانق الأكثر كثافة سكانية وتطوراً عمرانياً وصناعياً . فالبيانات الشهرية التي استخدمت لهذه الدراسة قد تم الحصول عليها من مصلحة الأرصاد الجوي لمحطتي Subang و Petalin و Jaya . ولقد استخدم الاتجاه الخطي لاختبار التغير للإشعاع الشمسي والإشراق وتحديد معدل التغير. أوضحت النتائج أن الحد الأعلى للإشعاع الشمسي في شهر نوفمبر ($21.1\ MJ\ m^{-2}$) في محطة Petaling Jaya، بينما الحد الأدنى للإشعاع في شهري نوفمبر ($10.7MJ\ m^{-2}$) وديسمبر ($15.9\ MJ\ m^{-2}$) في محطة Petaling Jaya أيضاً. فالحد الأدنى للإشعاع الشمسي خلال شهري نوفمبر وديسمبر يرجع إلي كثرة السحب خلال موسم المونسون الشمالي الشرقي . فخلال موسم الأمطار تصل إلي الأرض نسبة ضئيلة من الإشعاع الشمسي . بشكل عام متوسط معدل التغير للإشعاع الشمسي خلال الفترة 1975- 2002 و 1977- 2000 المتمثل بالانحدار الخطي ضئيل، يقدر بـ -0.126 و -0.314 $MJ\ m^{-2}$ / سنة لمحطتي Subang وPetaling Jaya علي التوالي. أوضحت النتائج أن أقصي ساعات للإشراق في شهر نوفمبر حوالي 4/ ساعة في الجامعة الوطنية الماليزية. يتراوح معدل التغير بين 4.7% في إبريل و 22.3 في ديسمبر. اتجاه الانحدار خلال الفترة 1970- 1999 لمحطتي Subang وPetaling Jaya حوالي – 4.3 و0.22/ساعة /سنة وليس له دلالة إحصائية، بينما اتجاه الانحدار في الجامعة الوطنية الماليزية خلال الفترة القصيرة 1979– 2000 يقدر بـ -13.57 ساعة / سنة وذو دلالة إحصائية مستوي 95%.