Jurnal Teknologi, 42(F) Jun. 2005: 1–10

A STUDY OF GLOBAL WARMING IN MALAYSIA

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Abstract. The aim of this investigation is to study the global warming trend in Malaysia. This investigation uses approximately 50 years of temperature data set. Least square regression line, coupled with null hypothesis tests were carried out to detect any significant trend. The most significant results of this investigation are: (a) a significant increase of the mean annual temperature, ranging from 0.99 to 3.44°C per 100 years is forecasted, and (b) the mean annual temperature regression lines (for all the analyzed stations) exhibit that the global warming trend has increased in the past 30 years. This last result shows a perfect agreement with the latest report of the Intergovernmental Panel of Climatic Change (IPCC).

Keywords: Global warming, Malaysia, temperature, significant trend, regression

Abstrak. Tujuan penyelidikan ini adalah untuk mengkaji tren pemanasan global di Malaysia. Data suhu sebanyak 50 tahun telah digunakan. Garis regresi kuasa dua terkecil dan ujian hipotesis nol telah digunakan untuk mengesan sebarang corak yang bererti. Keputusan yang paling nyata bagi penyelidikan ini ialah: (a) peningkatan yang nyata dalam suhu purata tahunan terletak antara 0.99°C ke 3.44°C bagi 100 tahun telah diramalkan, dan (b) garis regresi suhu purata tahunan (bagi kesemua stesen dikaji) menunjukkan tren pemanasan suhu telah meningkat dalam tempoh 30 tahun lalu. Keputusan ini menunjukkan persetujuan dengan laporan terbaru *Intergovernmental Panel of Climatic Change*.

Kata kunci: Pemanasan global, Malaysia, suhu, corak bererti, regresi

1.0 INTRODUCTION

The temperature distribution of Jakarta has been analyzed [1]. In that particular study, using a data ranging from 1866 to 1993, the global warming increase of Jakarta was 1.64°C.

Jakarta is located at approximately 6 degrees south. Therefore, a wet season followed by a dry season pattern is perfectly defined. This is not the case of Malaysia where February and June represent the "driest" months of Peninsular Malaysia. In spite of this, few stations in Malaysia register an average monthly rainfall lower than 100 mm (which is not the case of Jakarta).

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A previous study analyzed the distribution of temperature, sea level pressure, evaporation, and insolation in East Malaysia [2]. Given the fact that Malaysia gained its independence in not more than 60 years, the collected temperature data set of East Malaysia is quite recent. Thus, in that particular study, only thirty years of data has been available. Nevertheless, the results of [2] show a perfect agreement with the temperature forecast for the next 100 years according with the IPCC latest report [3]. This is due to the fact that the global warming rate has greatly increased in the last 30 years [3].

This study represents both an extension of [1] and a continuation of [2].

2.0 DATA

The results of our study are expected to be different from [2] if we adopt data for a longer time period. For the sake of completeness, the present investigation will use approximately 50 years of temperature data, provided mainly by the Global Historical Climate Network [4]. A second source of data is provided by the Malaysian Meteorological Service [5]. Efforts were made to find stations representing all the geographical area of Malaysia. In Peninsular Malaysia, Penang and Kuala Lumpur were selected to be the representation of the West Coast, Kota Bahru of the East Coast, and Cameron Highland of highlands area. In East Malaysia, Kuching and Kota Kinabalu were selected to represent Sarawak and Sabah, respectively. The locations of the stations as well as the geographical coordinates are shown in Figure 1 and Table 1, respectively.

Table 1 Geographic coordinates of the stations

No.	Station	Latitude (°N)	Longitude (°N)	Height (m)
1	Penang	05° 18’	100°16’	2.8
2	Kota Bahru	06° 10’	102° 17’	4.6
3	Kuala Lumpur	03° 07’	101° 33’	16.5
4	Cameron Highland	04° 28’	101° 22’	1545.0
5	Kuching	01° 29’	110° 20’	21.7
6	Kota Kinabalu	05° 56’	116° 03’	2.3

3.0 METHODOLOGY

3.1 Secular Trend Analysis

The analysis of:

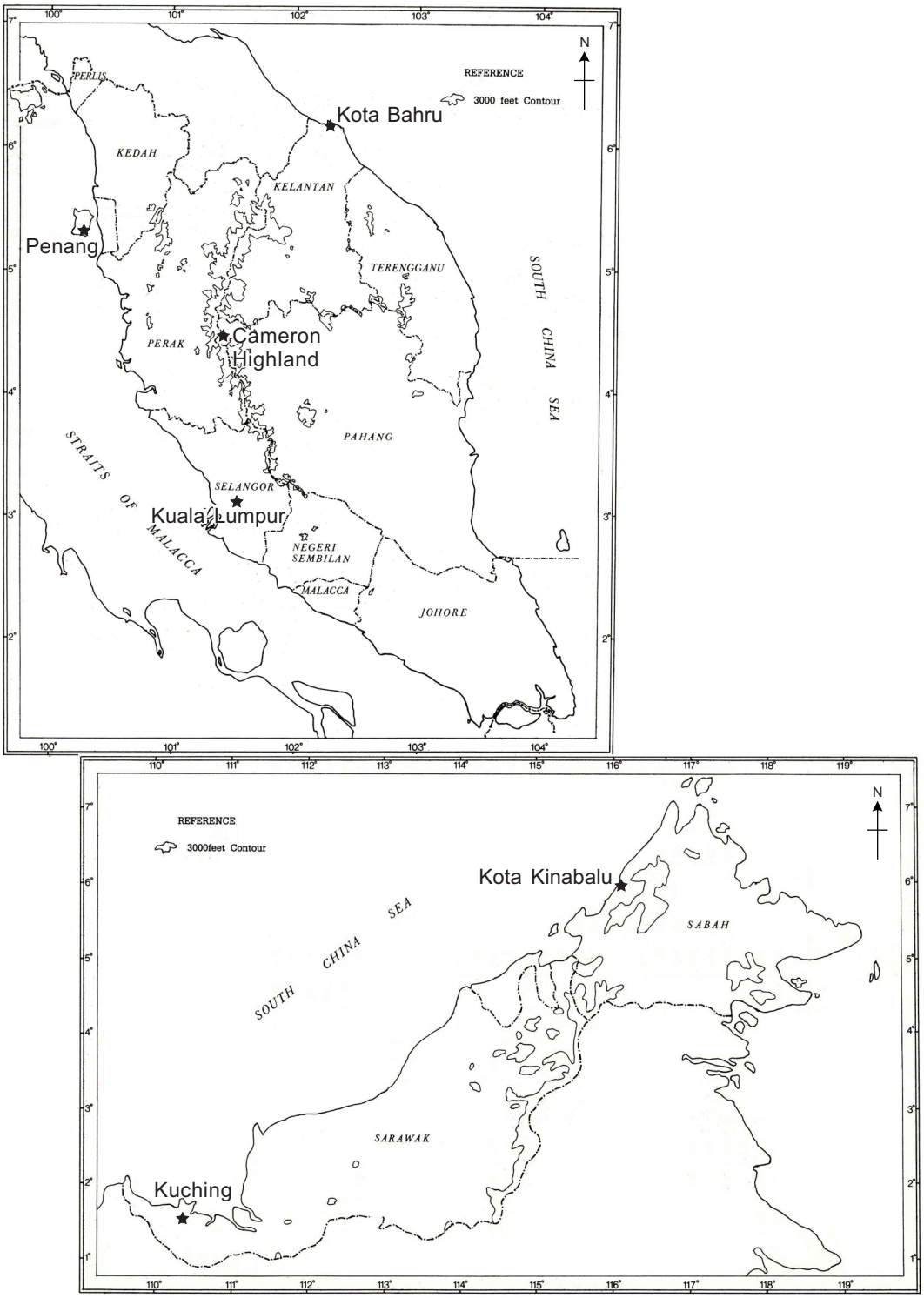

Figure 1 Location of the stations

(i) the regression lines of the mean annual value for the longest available year span,
(ii) the regression lines of the mean annual value for the past 30 years, of temperature has been made.

The regression lines of the mean annual value are plotted to determine whether there is any (increasing/decreasing) trend. The increasing/decreasing rate is then obtained from the slope of the linear regression equation. Due to the fact that the regression lines are plotted by using mean annual value, the seasonal (or monthly) effect is absent. Figure 2 shows the regression line of the mean annual temperature of Kuala Lumpur for the period of 1951-2001.

The correlation coefficients that are obtained from the regression line are tested for their statistical significance before any reasonable conclusion may be drawn. This is primarily due to the fact that such correlations are calculated from the sample data and therefore, subject to sampling error. It is essential to check whether the computed correlation is meaningful or it is merely a false value due to sampling error. Therefore, the Null Hypotheses Testing for the correlation coefficient of Kuala Lumpur mean annual temperature regression line is done.

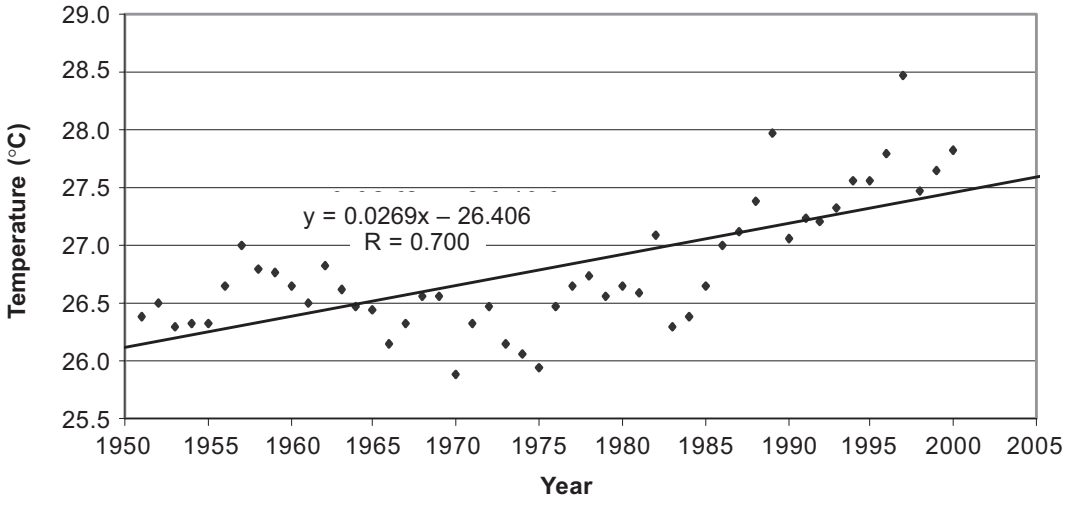

Figure 2 The regression line of the mean annual temperature of Kuala Lumpur from 1951-2001

It is convenient to define the null hypotheses and alternative hypothesis as follows:

Null hypothesis, H_0:	$\rho = 0$ (no significant relationship between the two variables)
Alternative hypotheses, H_1:	$\rho \neq 0$ (The relationship between the two variables is significant)

where ρ represents the population correlation coefficient; r, (= 0.696 in our case) the sample correlation coefficient; and n (=51), the extent of the sample.

For a sample larger than 30, the distribution of the sample correlation coefficient estimate, r, is normal with a mean of ρ and a standard error $\sqrt{\frac{1-r^2}{n-2}}$ [6].

Therefore, a z-test is conducted to test the hypotheses with respect to significance of such statistics. The test statistics is given by:

$$z = r / \{\sqrt{\frac{1-r^2}{n-2}}\}$$

that may be compared against normal distribution table values (or z distribution) at a desired level of significance.

This analysis is made to determine as to whether the sample correlation coefficient, r, is significantly different from zero, that is to say, are the variables truly related [6].

Furthermore, by taking a 5 % level of significance (95 % confidence level) that is perfectly adequate for our purpose. Therefore, the

Standard error of r, S.E. $r = \sqrt{\frac{1-r^2}{n-2}} = \sqrt{\frac{1-0.696^2}{51-2}} = 0.103$

Thus, the test statistics

$$z = 0.696 / 0.103 = 6.79$$

The table values of the standard normal z distribution at a 5 % level of significance (95% confidence level) are approximately –1.96 and 1.96. Given the fact that the calculated value, 6.79, is numerically larger than 1.96, the null hypothesis is rejected. In summary, the alternative hypothesis is accepted. This, in turn implies that there is a significant relationship between the two variables.

Following Figure 2, if a similar analysis is done for the period of 1971-2001, i.e. 30 years, the warming rate for Kuala Lumpur is 6.3°C/100 years as compared to the warming rate of 2.7°C/100 years obtained previously. The Pearson correlation coefficient of 0.886 shows that the warming rate for the past 30 years is very significant. This point to the fact that "the global warming rate has greatly increased for the past 30 years", as suggested by [3], is significant in Malaysia.

4.0 DISCUSSION OF RESULTS

4.1 Mean Annual Temperature Regression Line

Global warming has been studied using the linear analysis. While Figure 2 represents Kuala Lumpur, Figures 3-7 show the regression line of the mean annual temperature for the other five selected stations.

The regression lines of the mean annual temperature of the selected meteorological stations are plotted and the Pearson correlation coefficients are tested for its statistical significance with the null hypothesis test (Table 2).

Table 2 shows that all Pearson correlation coefficients are statistical significant at a 95% confidence level. Therefore, the results are statistically significant.

It is observed that in Peninsular Malaysia, the global warming ranges from 0.99 to 2.69°C/100 year. Kuala Lumpur has the highest warming trend with 2.69°C/100 year. This may be due to the fact that Kuala Lumpur, as a developed urban area, was experiencing a double effect: the urban heat-island effect and global warming. The

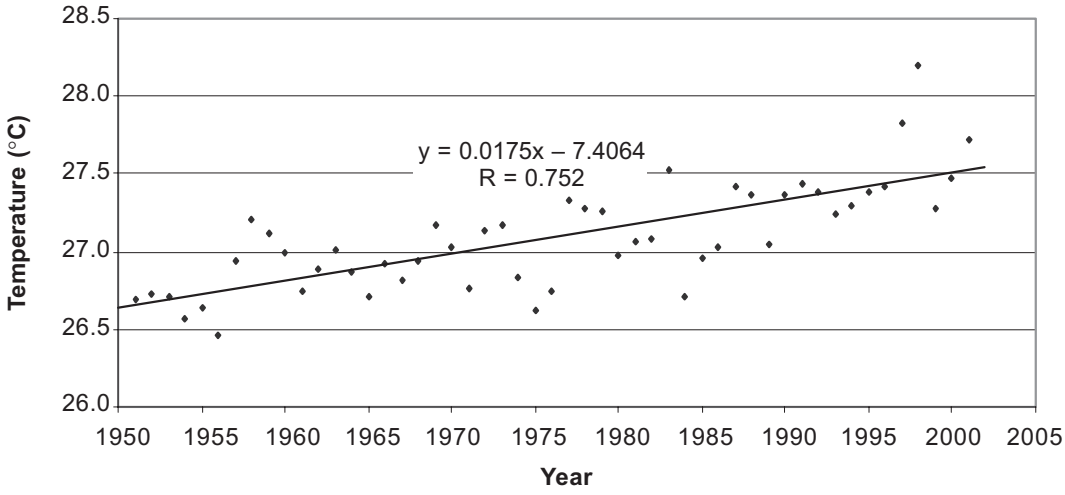

Figure 3 The regression line of the mean annual temperature of Penang from 1951-2001

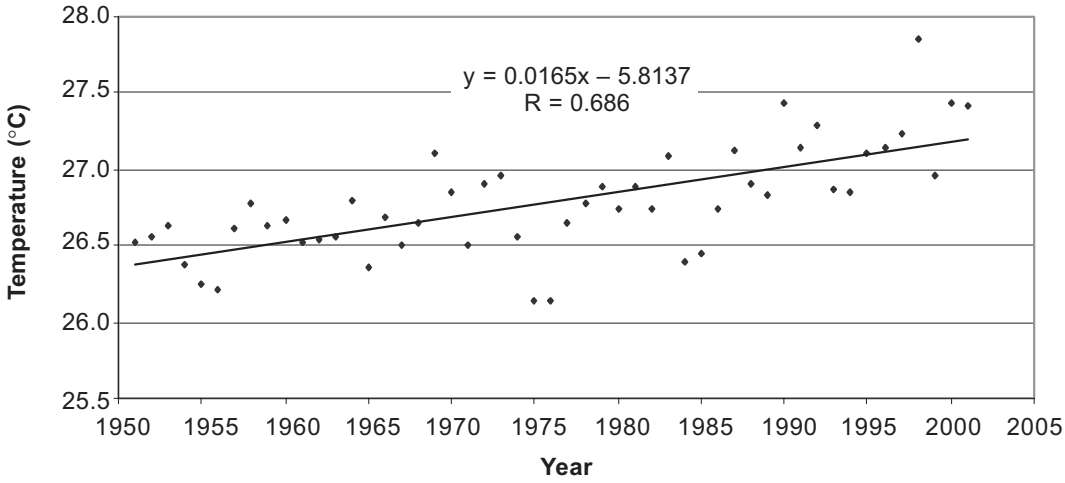

Figure 4 The regression line of the mean annual temperature of Kota Bahru from 1951-2001

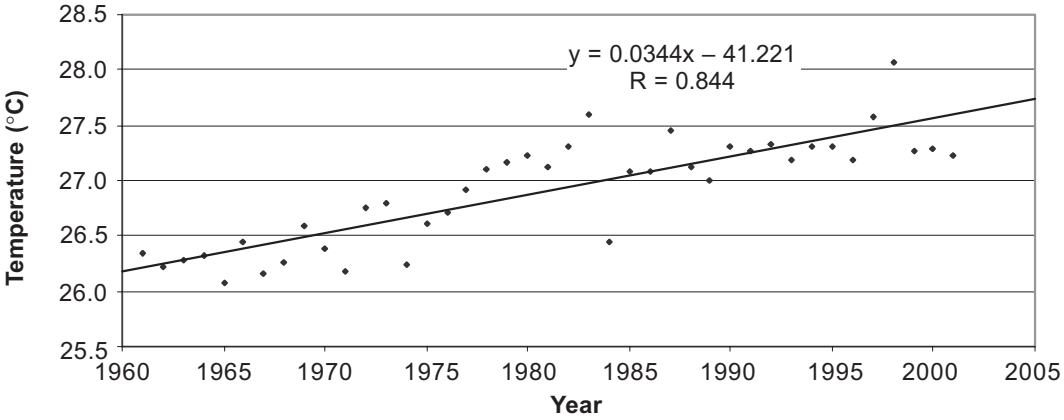

Figure 5 The regression line of the mean annual temperature of Kota Kinabalu from 1951-2001

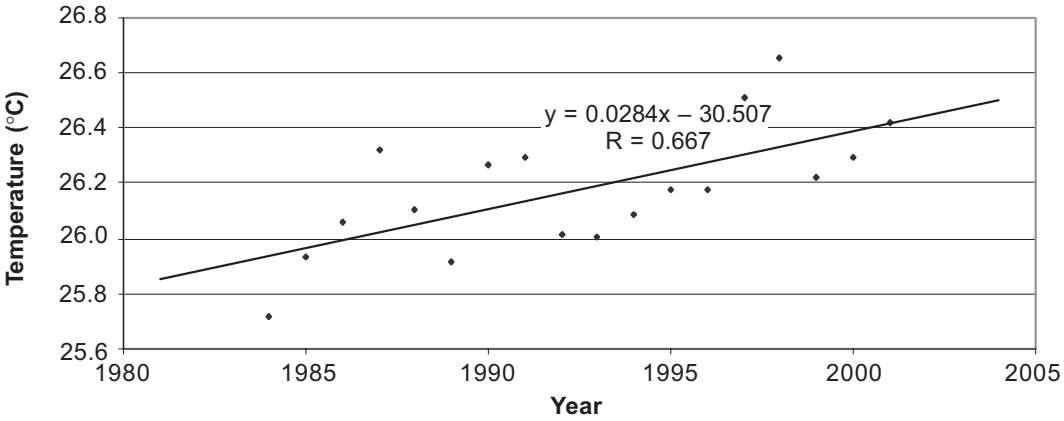

Figure 6 The regression line of the mean annual temperature of Kuching from 1951-2001

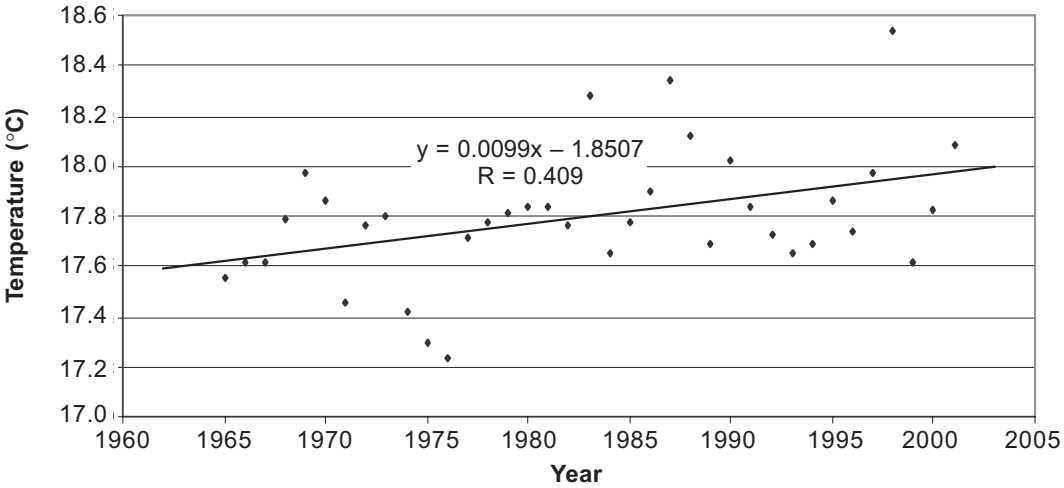

Figure 7 The regression line of the mean annual temperature of Cameron Highland from 1951-2001

Table 2 The results of null hypothesis test on Pearson correlation coefficient of mean annual temperature regression line for selected station

Station	Year	Trend (°C)/ 100 year	Pearson correlation coefficient, *r*	Test-statistics *z*	Statistical significant? (Test-statistics $z > 1.96$?)
Penang	1951-2001	1.75	0.752	7.986	Yes
Kota Bharu	1951-2001	1.65	0.686	6.598	Yes
Kuala Lumpur	1951-2001	2.69	0.700	6.786	Yes
Cameron Highland	1965-2001	0.99	0.409	2.670	Yes
Kota Kinabalu	1961-2001	3.44	0.844	9.836	Yes
Kuching	1984-2001	2.84	0.667	2.245	Yes

causes of urban heat island effect may be related to (a) the increasing population, (b) energy use densities, (c) densely built-up building, (d) high rate of emission, etc [7].

It is interesting to know that Penang and Kota Bahru experienced a very similar warming. However, Cameron Highland experienced a slightly lower warming rate (of 0.99°C/100 year). This may due to the fact that Cameron Highland was overcast from 10 a.m. onwards attributable to anabatic winds. This effect prevents the solar radiation to penetrate as compared to other lowland stations [8].

Compared to Peninsular Malaysia, the warming rate for East Malaysia was relatively higher. Kota Kinabalu was 3.44°C/100 years and Kuching was 2.84°C/100 years.

4.2 Mean Annual Temperature Regression Line for the Past 30 Years

If a similar analysis is done for the period of 1971-2001, i.e. 30 years, the warming rates is higher (Table 3). This is due to the fact that the global warming rate has greatly increased for the past 30 years as stated in [3].

Once the regression lines of the mean annual temperature for the period of 1971-2001 were plotted, the Pearson correlation coefficients are tested for its statistical significance with the null hypothesis test (Table 3). For Penang, the warming rate for the past 30 years was 2.55°C/100 year, that is 0.8°C/100 year higher than the one for 50 years (1.75°C/100 year). The warming rate of Kota Bahru and Cameron Highland also exhibited differences of 1.25°C/100 year and 0.36°C/100 year respectively. Kuala Lumpur showed the largest difference (3.69°C/100 years) in the warming trend.

Table 3 Summary of mean annual temperature regression line for the past 30 years (1971-2001)

Station	Statistical significant at 95% confidence level?	Trend (°C/100 year)
Penang	Yes	2.55
Kota Bharu	Yes	2.90
Kuala Lumpur	Yes	6.33
Cameron Highland	Yes	1.35
Kota Kinabalu	Yes	2.93

5.0 CONCLUSION

The temperature trend in Malaysia, due to global warming is addressed in this particular paper. The most significant results of this study are:

(1) A significant increase of the mean annual temperature ranging from 0.99 to 3.44°C per 100 years is observed.
(2) The mean annual temperature regression lines for all stations exhibit that the warming trend has greatly increased significantly in the past 30 years, with values ranging from 1.35 to 6.33°C per 100 years. This show perfect agreement with the latest report of the IPCC [3].

ACKNOWLEDGEMENTS

This research has been supported by the no.74086 IRPA grant. The authors gracefully acknowledge this support. Our thanks are also extended to the Malaysian Meteorological Service for providing us the necessary data to carry out this investigation.

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