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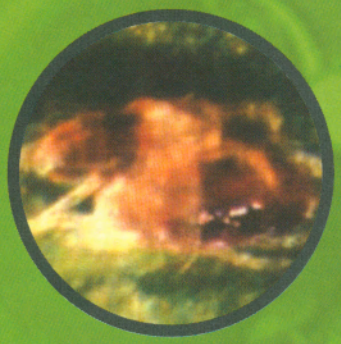

Volume 12 | 2007

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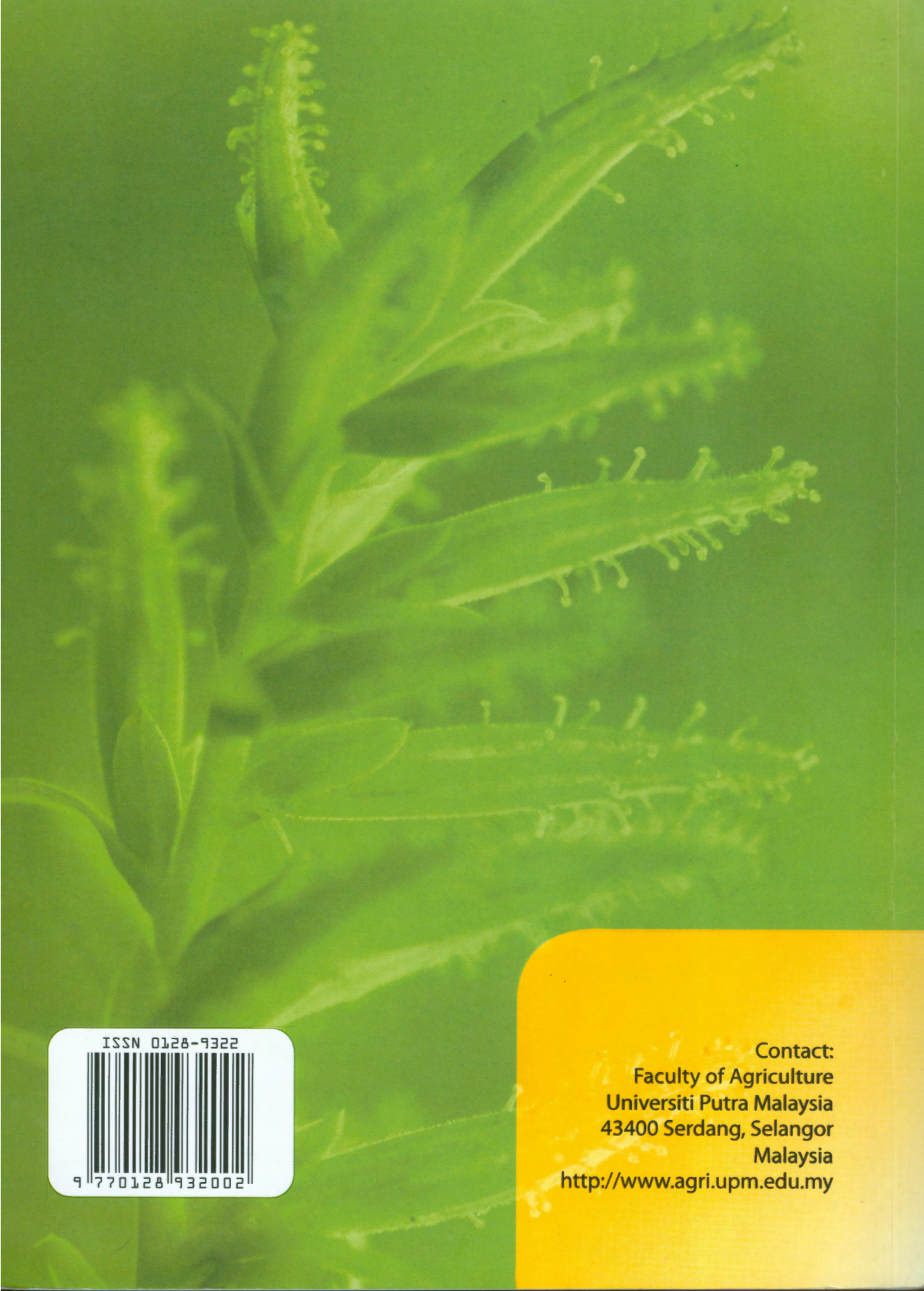

ISSN 0128-9322

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AgroSearch Research Bulletin 12: 33-44 (2007)

An Update of the Analysis of Serdang's Weather 1985-2007

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ABSTRACT

This paper is an update of the analysis of Serdang's weather from 1985 to 2007. Weather properties analysed were the same as before which were the minimum and maximum air temperatures, total rainfall, wind speed, sunshine hours, evaporation and solar irradiance. From the analyses, Serdang area has become warmer and wetter within the 23 years period. For every ten years, the mean annual maximum and minimum temperatures have increased by 0.4°C and 0.6°C, respectively. The total annual rainfall has also increased by nearly 215 mm every ten years and the sunshine hours also increased by 18 minutes for every ten years. Solar irradiancealso showed a similar increase by 0.55MJ m^{-2} for every ten years. Only the wind speed showed a decrease by 0.13 ms^{-1} for every ten years. No clear changes were observed for evaporation, however, monthly mean of evaporation could be estimated fairly accurately using measured data of solar irradiance, sunshine hour, rainfall, maximum and minimum air temperature.

INTRODUCTION

Serdang (3° 2' N; 101° 42' E) is a town located in the state of Selangor, Malaysia. For more than 20 years, the Faculty of Agriculture, Universiti Putra Malaysia has measured continuously the daily weather properties of Serdang. Teh (2006) analysed the weather for Serdang from 1985-2004. Consequently, the purpose of this paper was to present the continuity of the statistics and changes of several weather properties in Serdang for the period 2005-2007.

MATERIALS and METHODS

Daily weather properties analysed in this paper were the minimum and maximum air temperatures, total rainfall, wind speed, evaporation, sunshine hours, and solar irradiance. The minimum and maximum air temperatures were measured using the minimum and maximum thermometers, respectively. Both of these thermometers were kept inside the Stevenson screen protected from immediate exposure to weather elements. It consists of a white wooden box that is fitted onto a steel frame, set, 1.5m above the ground.

Rainfall was measured using a simple rain gauge 0.5m tall, placed on the ground just high enough to avoid splashes. It consists of aspecial drum that is used to record the depth of the water collected. The rain water that is caught in a funnel on the top will run down into a measuring cylinder below. The water level in the measuring cylinder is then recorded manually.

Wind speed was measured using an instrument called an anemometer. It consists of four small cups that catch the wind and spin on an axis at different speeds according to the strength of the wind. A recording device is used to count how many times they spin in a given time.

Evaporation of free water was determined by measuring the water level in an evaporation pan. The evaporation pan is made to the standard specifications with an internal diameter of 1207 mm and height of 254 mm using 20 gauge galvanized iron (Teh, 2006).

Sunshine hour is defined as the sum of hours in a day during which the direct solar irradiance exceeds 120Wm $^{-2}$ (Campbell and Norman, 1998). The sunshine hours were recorded using a Campbell-Stokes sunshine recorder. The instrument works by focusing the sun's rays and burning a mark on a card which was then measured.

Solar irradiance was determined by using the following formula;

Solar irradiance, $I = I_{et,d}$ [0.29+ (0.42 sunshine hour/DL)]

where $I_{et,d}$ is the extra terrestrial solar irradiance (Wm $^{-2}$); S is the sunshine hour (hours);

DL is daylength (hours). $I_{et,d}$ is calculated as:

ET solar irradiance,

$I_{et,d} = 3600 \times I_c \times A$

where I_c and A was determine by using the following formula:

$I_c = 1370\ [1+0.333 \cos(2\pi(\text{doy}-10)/365)]$

$A = 24/\pi\ [a \times \cos^{-1}(-a/b + b\sqrt{(1+(a/b)^2)}]\ A = \frac{24}{\pi}$

$a = \sin\delta \sin\lambda$; and $b = \cos\delta \cos\lambda$

where doy is day of year (Jan 1=1, Jan 2=2…Feb 1=32, and so on); λ the site latitute (radians); and δ the solar declination (radians), calculated as:

Solar declination, $\delta = -0.4093 \cos[2\pi(\text{doy}+10)/365]$

Day length is calculated as:

Daylength, DL $= t_{ss} - t_{sr}$

where t_{ss} is the sunset and t_{sr} the hour of sunrise. The value of sunset and sunrise hours were calculated as:

Sunset, $t_{ss} = 12 + [(12/\pi)\ \text{acos}(-a/b)]$

Sunrise, $t_{sr} = 24 - t_{ss}$

All of these weather data properties were measured at 08:00 hours every day. Data analysed were done by plotting several contour charts to determine how the monthly means of maximumand minimum air temperatures, wind speed, sunshine hours, and solar irradiance would vary with month and year. For rainfall and evaporation, their monthly totals were plotted against the month and year to determine the monthly and annual distribution of rainfall and evaporation.

Stepwise linear regression was used to determine if monthly mean evaporation could be estimated using several other measured data. Analysis was done using the statistical software SPSS version 16.0 (SPSS Inc., Chicago).

RESULTS and DISCUSSION

Maximum and minimum air temperature

Mean annual maximum and minimum air temperature for the period of 1985-2007 were 32.8 ° C and 22.7°C, respectively. In a year, the mean annual maximum air temperatures (TMAX) usually peaked up during March (up to 36°C). In the later years (1998-2007), however, TMAX peaked for larger periods from January to May, in particular in 1998, 2002 and 2005 (Fig. 1). In 2005, the highest temperature of up to 37°C was recorded in April. Standard deviation of TMAX for 1985-1996 and 1996-2007 were 0.71 and 0.84, respectively.

The mean monthly minimum air temperatures (TMIN) generally peaked twice a year up to 24°C in May and October (Fig. 2). In spite of that, as the year progressed (2000 onwards) TMIN pattern became progressively less variable throughout the year. Standard deviation of TMIN for 1985-1992 is 0.54 while for 2000-2007 is 0.33. From 1998 onwards, TMIN is generally 24°C every year.

The difference between TMAX and TMIN ranges from about 8 to 14°C. Generally January-June each year experienced the largest difference (11°C or more), whereas June-July

experienced a lesser difference between TMAX and TMIN (8-11°C) (Fig.3). However, Fig. 4 shows no clear trend of any change in the temperature difference between TMAX and TMIN. There was a general increasing trends for both maximum and minimum air temperatures (Fig. 5 and 6). For every ten years, the mean annual maximum and minimum air temperatures generally increased by 0.4°C and 0.6°C, respectively. This shows that Serdang experienced a general increase in warm weather for the past 23 years.

Ranfall

The mean total rainfall for the period 1985-2007 was 24449.87 mm year $^{-1}$. Generally, there were two period of heavy rainfall (about 300-500 mm month $^{-1}$) in a year,i.e. March-April and October-December (Fig. 7). Both 1990 and 1998 were dry years whereby both years experienced a mean total rainfall of about 2176 mm year $^{-1}$. In contrast, both 2003 and 2007 were wet years, whereby both years experienced a mean total rainfallof 3018 mm year $^{-1}$. There was a general increase in the total annual rainfall in Serdang for the period 1985-2007 (Fig. 8). Total annual rainfall increased by nearly 22mm every year, indicating that Serdang experienced a general increase in precipitation in the past 23 years.

Wind speed.

The mean annual wind speed for Serdang for the period 1985-2007 was 0.76ms $^{-1}$. As the year progressed, there was a decline in wind speed; 1985-1987 experienced a mean annual wind speed of 0.96ms $^{-1}$ as compared to 0.70ms $^{-1}$ in 2005-2007. Fig 9 also showed that the number of months experiencing peak mean monthly wind speeds of up to 1.2ms^{-1} progressively declined from 1985 to 1996. Generally, wind speed experienced a decline in the mean annual wind speed of about 0.32ms $^{-1}$ (Fig. 10) in the past 23 years. After 1996, the mean monthly wind speed seldom achieved 1.2ms $^{-1}$ in contrast to the years before 1996. Moreover, after 1996, there was generally little variation in mean monthly wind speeds. However, half year ended 2003, the wind speed again experienced mean monthly wind speeds of up to 1.2 ms $^{-1}$ until the month of August. Figure 10 showed the mean annual wind speed generally declined by 0.13 ms for every ten years.

Sunshine Hours

The mean annual sunshine hours for Serdang for the period 1985-2007 were 6 h day $^{-1}$. Malaysia typically has a day length of 12h (period from time of sun rise to sun set), which means that on the average, 50% of each day period experiences direct solar irradiance that exceeds 120Wm $^{-2}$ (i.e. bright sunshine). Typically, January to August each year received 6-8h of sunshine day $^{-1}$, in while February to April recorded the highest peak period, receiving up to 8h sunshine day $^{-1}$ (Fig.11). This meant that Serdang experienced greater sunshine in the early months of the years as compared to the latter months. Figure 12 shows that every ten years, the mean annual sunshine hours for Serdang increased by about 18 minutes.

Solar Irradiance

The mean annual solar irradiance for the period of 1985-2007 was 17.97 MJ m $^{-2}$ day $^{-1}$. Generally, the solar irradiance received is between 14-22 MJ m $^{-2}$ day $^{-1}$ each year. The month between February to May, gave the highest peak period, receiving up to 22 MJ m $^{-2}$ day $^{-1}$. Figure 13 showed that in the early months of the years, Serdang received monthly mean data of 121.47 MJ m $^{-2}$ day $^{-1}$ for the period 1985-2007 compared to the latter months which is 112.45 MJ m $^{-2}$ day $^{-1}$. In the early months, when Serdang received more sunshine hours, the amount of solar irradiance was also higher. Figure 14 shows that every ten years, the solar irradiance increased about 0.55 MJ m $^{-2}$ day $^{-1}$.

Evaporation

The mean annual evaporation for Serdang for the period 1985-2007 was 4.3 mm day $^{-1}$. No clear trend could be identified for any change in the mean monthly or annual evaporation (Fig 15). However in April of 2003, Serdang area experienced a peak mean monthly evaporation of 8 mm day $^{-1}$ (Fig. 16). Mean monthly pan evaporation could be estimated using stepwise regression method with the following regression equations:

$$E = -6.963 + 0.4I - 0.002RAIN + 0.256\,TMAX + 0.172S - 0.131TMIN \quad [1]$$

where E is the mean monthly pan evaporation (mm day $^{-1}$); I is the mean monthly solar irradiance (MJ m $^{-2}$); RAIN is the total monthly rainfall (mm month $^{-1}$); TMAX is the mean monthly maximum daily air temperature (°C); TMIN is the mean monthly minimum daily air temperature (°C); and S is the mean monthly sunshine hour (h day $^{-1}$). As expected, Eq. [1] shows that evaporation increases with increasing solar irradiance, maximum air temperature and sunshine hours, but evaporation would reduce with increasing rainfall and minimum air temperature. The value of R^2 is 0.769.

CONCLUSION

The weather data for Serdang for the periods 1985-2007 has changed in particular the mean annual maximum and minimum air temperatures (increased by 0.4 and 0.6°C for every ten years respectively), the total annual rainfall (increased by 215mm for every ten years), mean annual wind speed (decreased by 0.13ms $^{-1}$ for every ten years), the mean annual sunshine hour (increasing 18 minutes for every ten years) and the mean annual solar irradiance (increased by 0.55 MJ m $^{-2}$ for every ten years). However, no change in pan evaporation could be observed although mean monthly evaporation could be estimated fairly accurately using measured data of solar irradiance, rainfall, maximum air temperature, sunshine hour and minimum air temperature.

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Campbell, G.S. and Norman, J.M. 1998. *An Introduction to Environmental Biophysics.* (2nd ed.). Springer-Verlag, New York.

Teh, C.B.S. 2006. A Warmer and Wetter Serdang; Analysis of Its Weather 1985-2004. *Agro Search Research Bulletin* 11(1): 5-17.

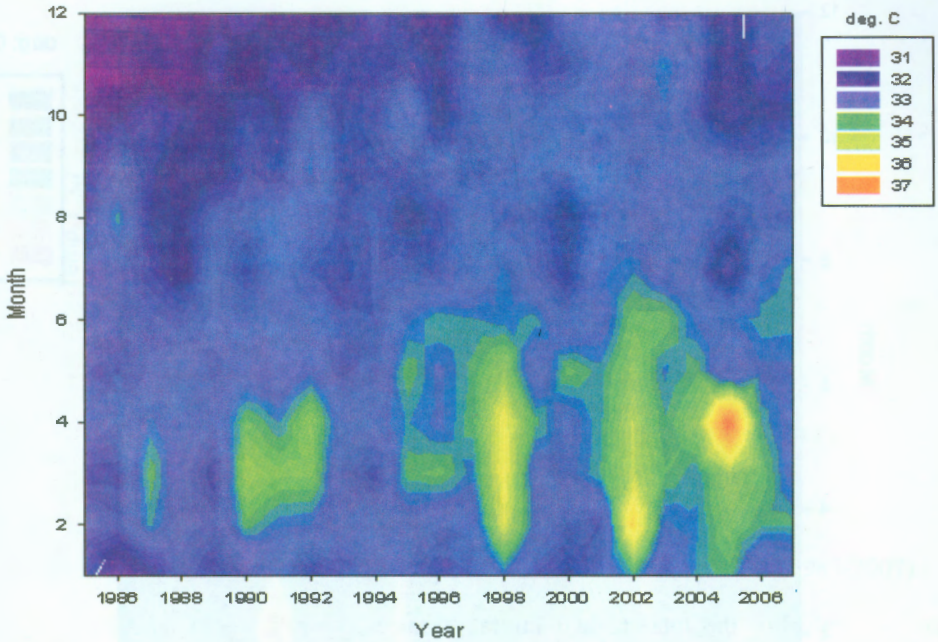
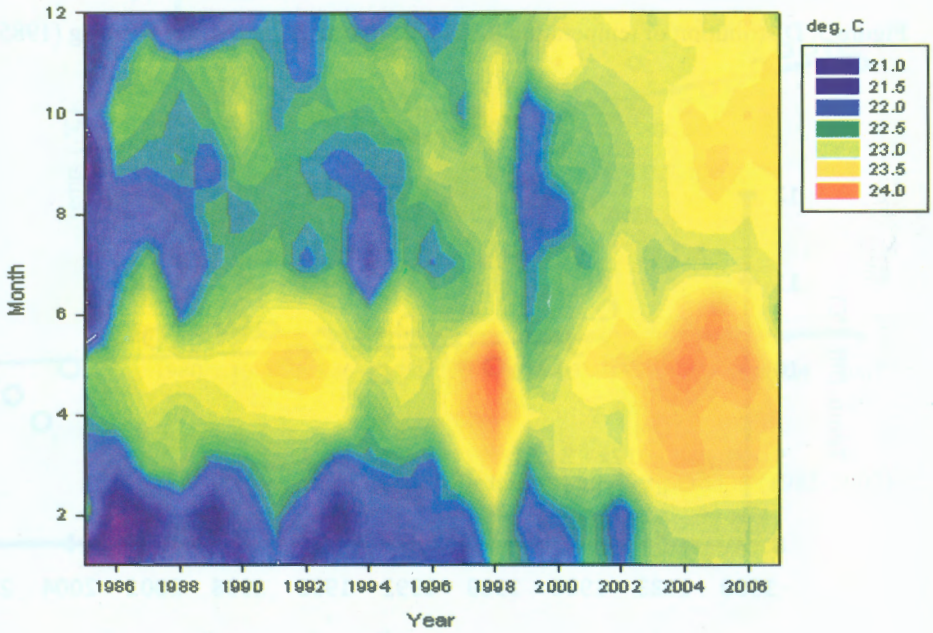


Figure 1. Distribution of maximum air temperature (monthly means) for Serdang (1985-2007)



(minimum)

Figure 2 . Distribution of maximum air temperature (monthly means) for Serdang (1985- 2007)

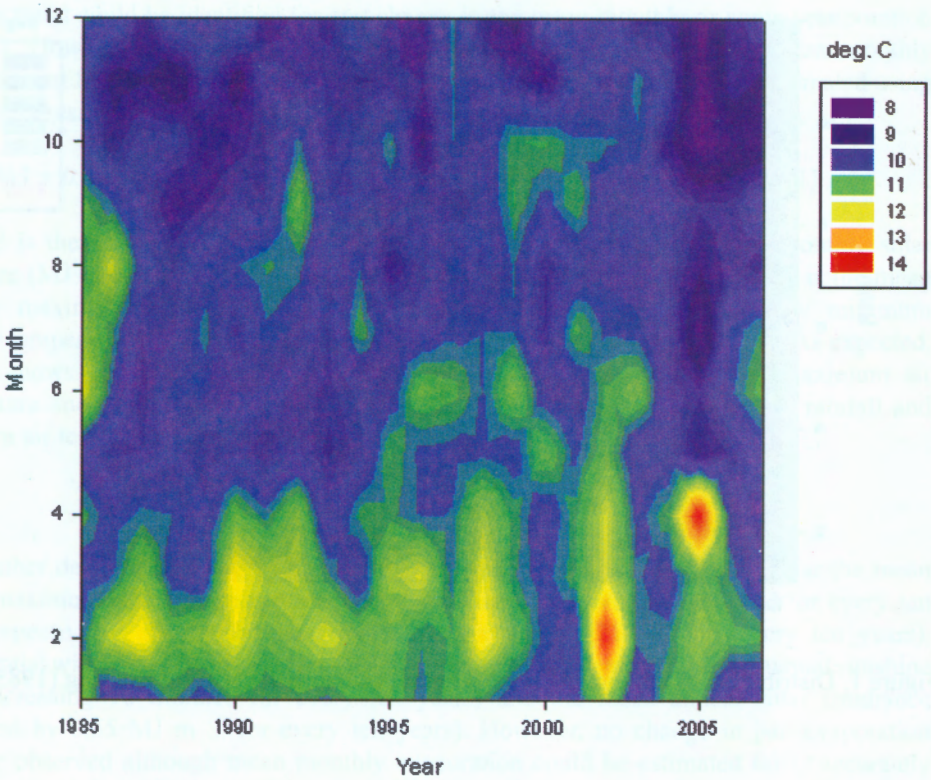


Figure 3. Distribution of temperature difference (monthly means) for Serdang (1985-2007)

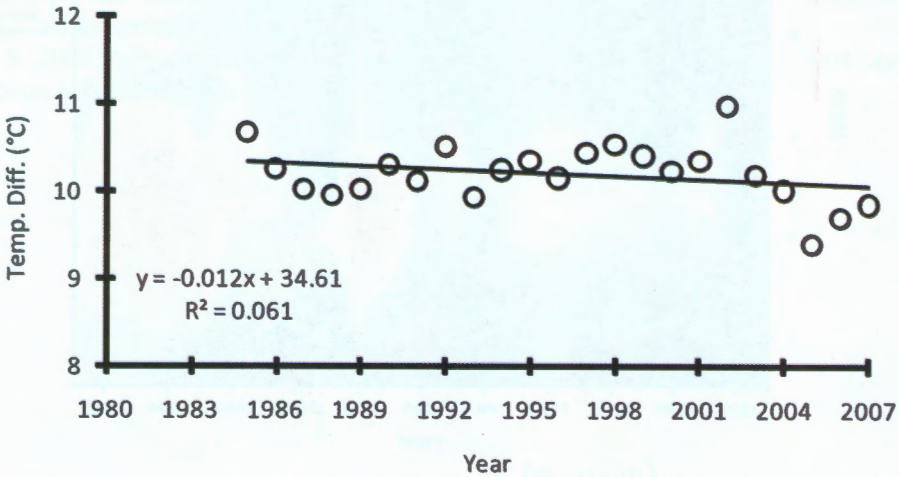


Figure 4. Mean annual temperature difference for Serdang (1985-2007)

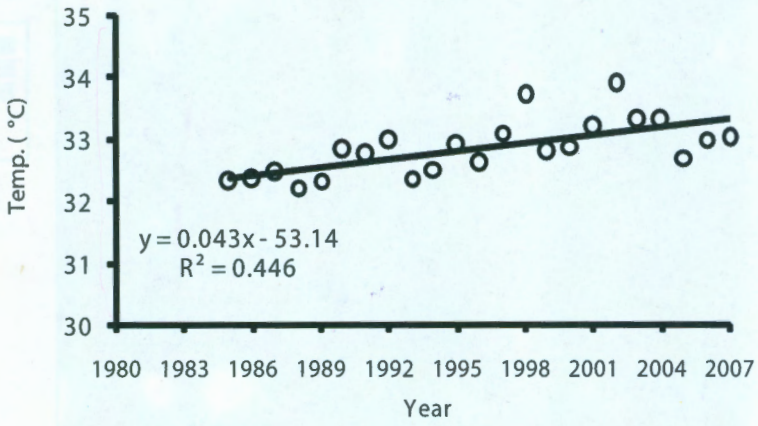


Figure 5. Mean annual maximum air temperature for Serdang (1985-2007)

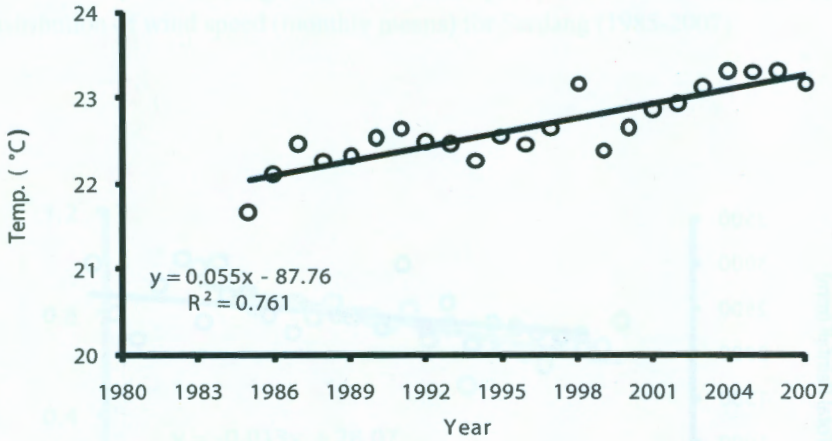


Figure 6. Mean annual minimum air temperature for Serdang (1985-2007)

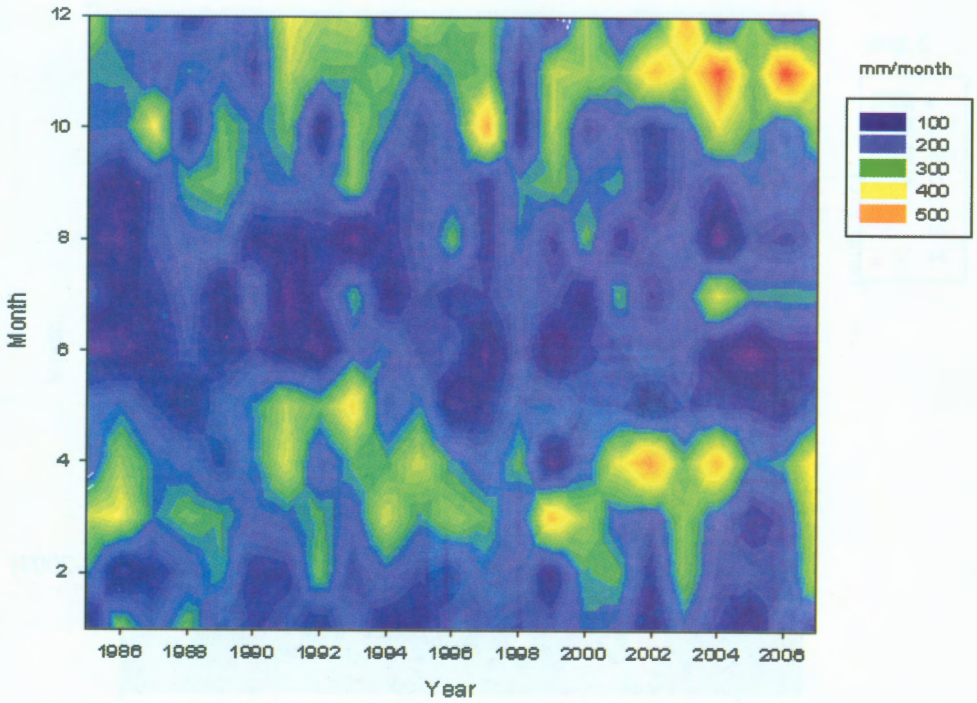


Figure 7. Distribution of total monthly rainfall for Serdang (1985-2007)

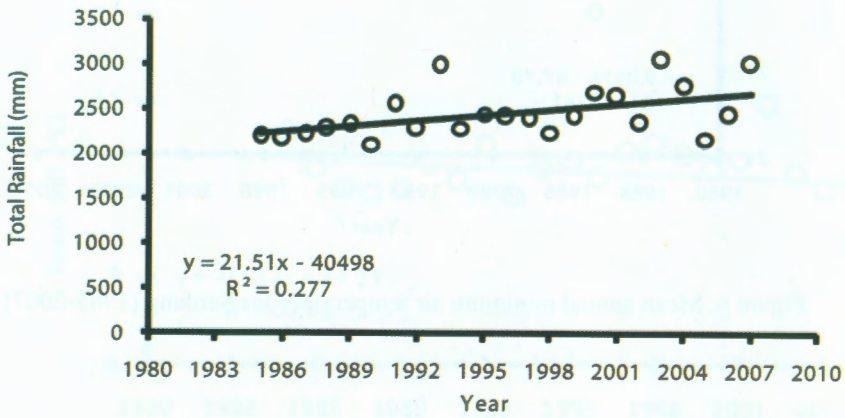


Figure 8. Total annual rainfall for Serdang (1985-2007)

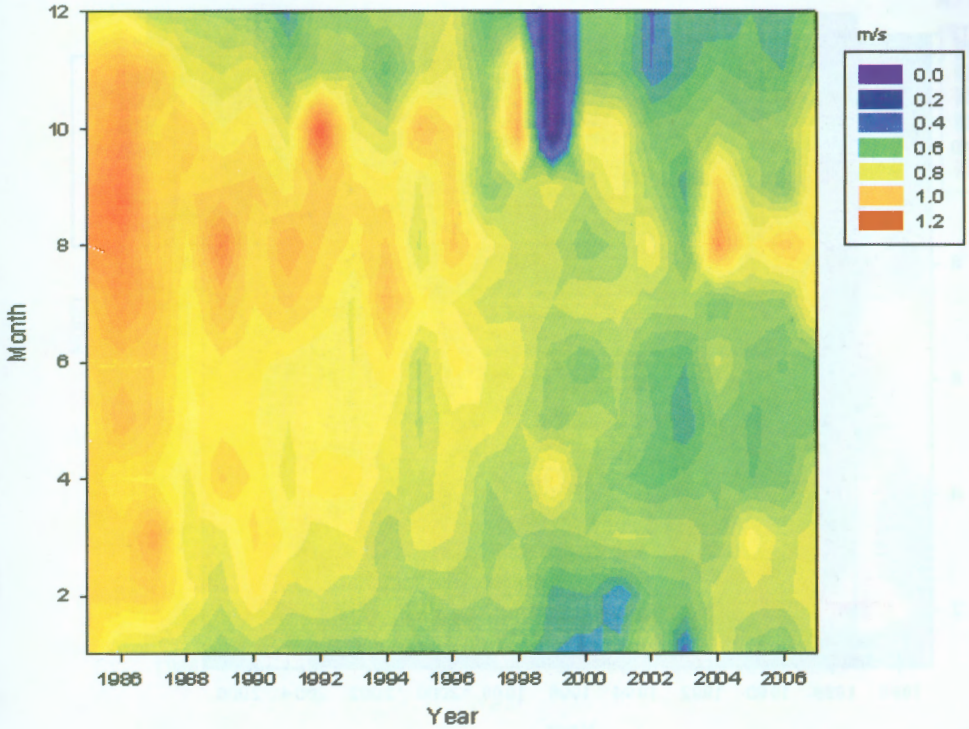


Figure 9. Distribution of wind speed (monthly means) for Serdang (1985-2007)

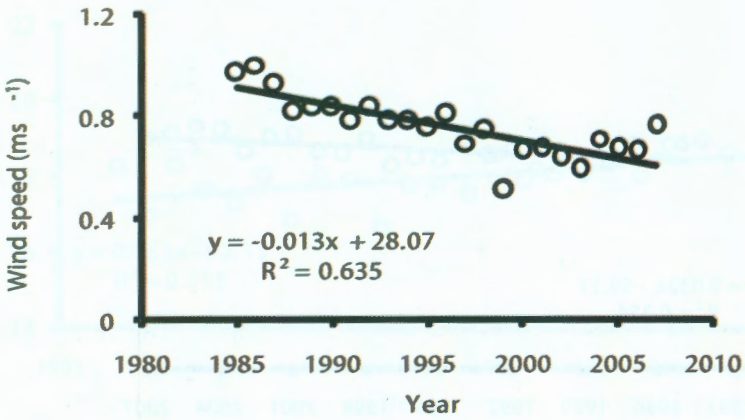


Figure 10. Mean annual wind speed for Serdang (1985-2007)

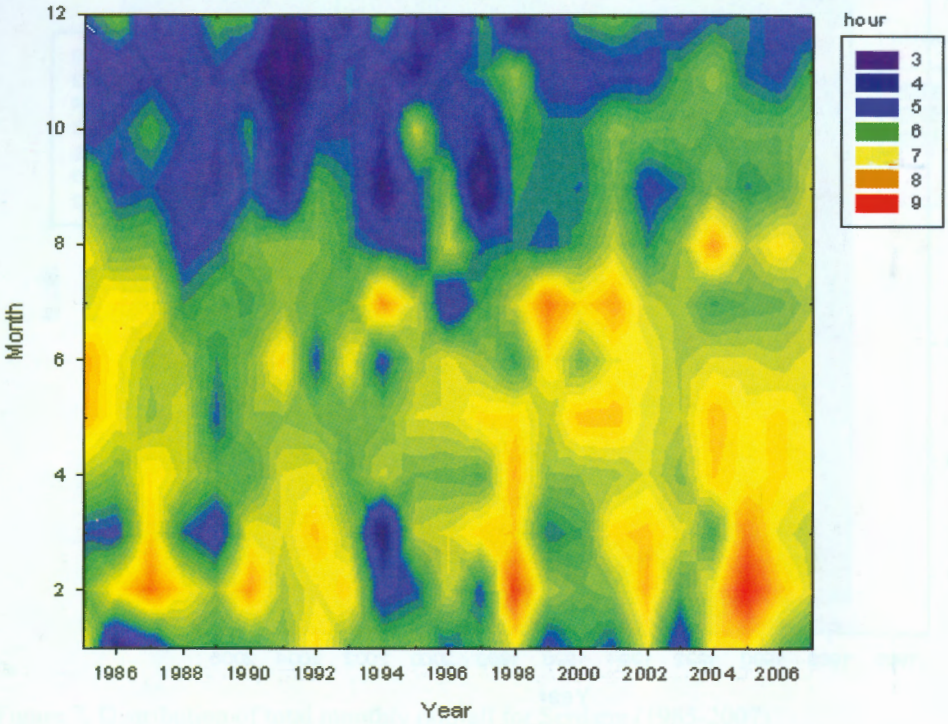


Figure 11. Distribution of sunshine hour (monthly means) for Serdang (1985-2007)

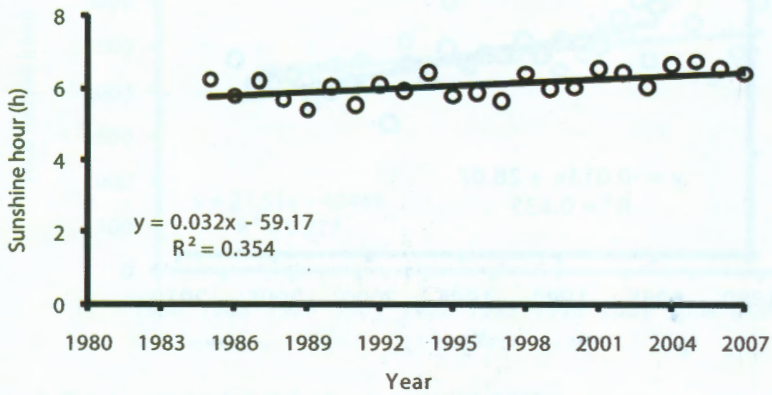


Figure 12. Mean annual sunshine hour for Serdang (1985-2007)

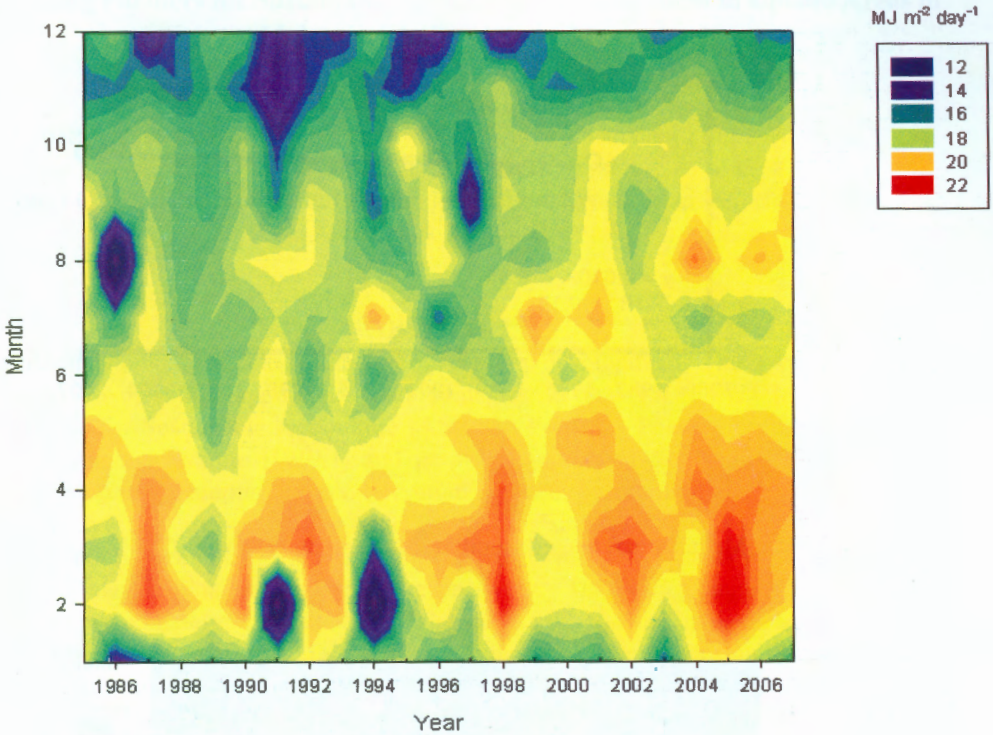
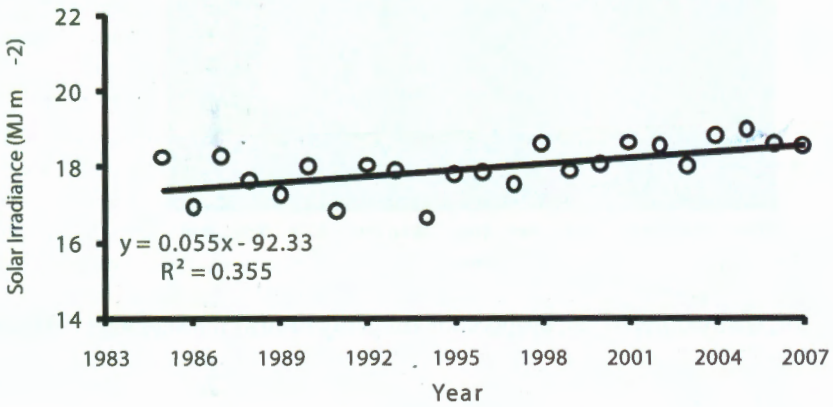


Figure 13. Distribution of solar irradiance (monthly means) for Serdang (1985-2007)



CFigure 14. Mean annual solar irradiance hour for Serdang (1985-2007)

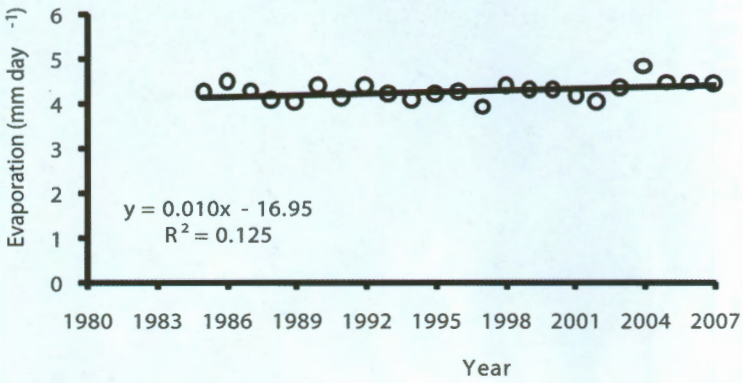


Figure 15. Mean annual pan evaporation for Serdang (1985-2007)

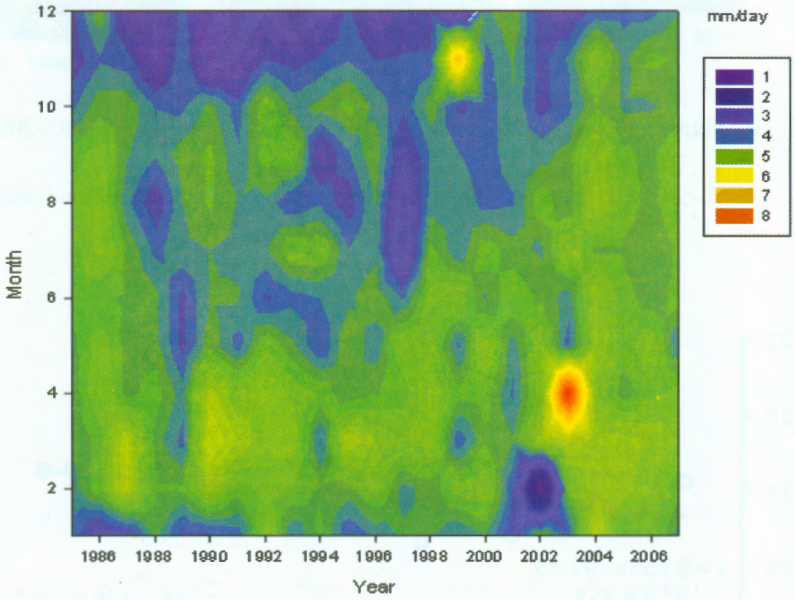


Figure 16. Distribution of pan evaporation (monthly means) for Serdang (1985-2007)