A WARMER AND WETTER SERDANG: ANALYSIS OF ITS WEATHER 1985-2003

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INTRODUCTION

Serdang (3° 2' N; 101° 42' E) is a town located in the state of Selangor, Malaysia. For nearly twenty years, the Faculty of Agriculture, Universiti Putra Malaysia has measured continuously several daily weather properties for Serdang. Although these data were recorded dutifully and at times requested by interested individuals, they have not yet been analysed rigorously in particular how the weather has changed during this near twenty-year period. Consequently, the purpose of this paper was to present the statistics and changes of several climatological properties in Serdang for the period 1985-2003.

MAXIMUM AND MINIMUM AIR TEMPERATURE

The average daily maximum and minimum air temperature for the period 1985-2003 were 32.8 °C and 22.5°C, respectively. Maximum air temperature (TMAX) usually peaked (up to 36 °C) during March; however, at later years, TMAX would peak for longer periods from January to May in particular for 1998 and 2002 (Fig. 1). Moreover, from 2000 onwards, TMAX would also peak (up to 34 °C) for second time later in the year, albeit about 2 °C less than the first peak, around September and October.

Minimum air temperature (TMIN) would generally peak (up to 24 °C) twice in a year at May and October (Fig. 2). Nonetheless, as the years progressed (1998 onwards), TMIN would progressively be less variable throughout the year. For example, the standard deviation of TMIN for 1985-1987 and 2001-2003 were 0.64 and 0.35, respectively, which showed a more constant TMIN throughout the year for the later years.

There was a general increasing trend for both TMAX and TMIN (Fig. 3 and 4). For every ten years TMAX and TMIN would generally increase 0.6 °C and 0.5 °C, respectively. This showed that Serdang was experiencing a general increase in warm weather for the past 19 years.

The annual variation of both TMAX and TMIN could be fitted by the following sine equation:

$$TMAX \text{ or } TMIN = a + b\sin\left(c + \frac{2\pi}{d}M\right) \quad [1]$$

where *TMAX* and *TMIN* are the monthly average of maximum and minimum air temperature, respectively (°C): *M* is the month number (1 for January, 2 for February and so on); and *a*, *b*, *c* and *d* are empirical coefficients which would differ from year to year (Table 1 and 2).

RAINFALL

The average total annual rainfall for Serdang for the period 1985-2003 was 2426.4 mm. Generally, there would be two periods of heavy rainfall (about 300-500 mm month^{-1}) in a year at March-April and October-December (Fig. 5). Both 1990 and 1998 were dry years, both years experiencing a mean total rainfall of about 2176 mm year^{-1}. In contrast, both 2002 and 2003 were wet years, experiencing a mean total rainfall of about 2692 mm year^{-1}. There was a general increase in total annual rainfall in Serdang for the period 1985-2003 (Fig. 6). Generally, total annual rainfall

would increase by 26 mm every year; this indicated that Serdang was experiencing a general increase in wet weather for the past 19 years.

The generic sine equation as Eq. [1] was used to fit the annual variation of rainfall:

$$R = a + b\sin\left(c + \frac{2\pi}{d}M\right) \quad [2]$$

where R is the monthly total rainfall (mm). The other variables are the same as described for Eq. [1]. Table 3 shows that the empirical coefficients of rainfall would differ from year to year.

WIND SPEED

The average daily wind speed for Serdang for the period 1985-2003 was 0.8 ms^{-1}. As the years progressed, there was a general decline in wind speed, where 1985-1987 experienced mean wind speed of about 0.9 ms^{-1} as compared to 0.6 ms^{-1} for 2001-2003 (Fig. 7). Moreover, periods of peak wind speeds (up to 1.2 ms^{-1}) would progressively decline from 1985 to 1996, where after 1997 there was generally little annual variation in wind speeds. Fig. 8 shows that the mean annual wind speed would generally decline 0.19 ms^{-1} for every ten years.

SUNSHINE HOURS

Sunshine hours is the sum of hours in a day during which the direct solar irradiance exceeds 120 Wm^{-2} (Campbell and Norman, 1998). The average daily sunshine hours for Serdang for the period 1985-2003 was 5.9 hours. Typically, January to August each year would receive 6-8 hours of sunshine, in which February to April were the highest peak period, receiving up to 8 hours of sunshine (Fig. 9). Fig. 10 shows no trend of change in the annual mean sunshine hours for Serdang.

PAN EVAPORATION

Evaporation of free water was measured from the pan evaporation. The average pan evaporation for Serdang for the period 1985-2003 was 4.2 mm day^{-1}. No clear trend could be identified for any change in the mean annual or monthly pan evaporation (Fig. 11 and 12). Monthly mean pan evaporation could be estimated using the following regression equation:

$$E = -4.542 + 0.284TMAX - 0.087TMIN + 0.125S + 0.862W \quad [3]$$

where E is the monthly mean pan evaporation (mm day^{-1}); W is the monthly mean wind speed (ms^{-1}); S is the monthly mean sunshine hours (hour); and $TMAX$ and $TMIN$ are the variables as described previously. All coefficients in Eq. [3] were significantly different from zero at the 5% level, and Eq. [3] explained about 57% of the observed variance. As expected, Eq. [3] shows that evaporation would increase with increasing sunshine hours, wind speed and air temperature. Fig. 13 shows the degree of fit of Eq. [3] to the measured pan evaporation.

CONCLUSION

The weather for Serdang for the period 1985-2003 has changed in particular the mean daily maximum and minimum air temperature (increasing by 0.6 °C and 0.5 °C for every ten years, respectively), total annual rainfall (increasing by 26 mm every year), and mean daily wind speed (decreasing by 0.19 ms^{-1} every year). Nonetheless, no changes in mean daily sunshine hours and pan evaporation could be observed, although pan evaporation could be estimated fairly accurately using measured data of sunshine hours, maximum and minimum air temperatures, and wind speed.

Daily weather data for Serdang is available upon request from the Soil Physics Laboratory, Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia.

REFERENCES

Campbell, G.S., Norman, J.M., 1998. An introduction to environmental biophysics. 2nd. edn. Springer-Verlag, New York.

Table 1. Equation coefficients for the monthly mean maximum air temperature

	Coefficients			
Year	**a**	**b**	**c**	**d**
1985	32.17	0.82	5.94	15.21
1986	32.09	0.97	5.24	15.53
1987	32.43	0.87	6.08	13.69
1988	32.20	0.88	6.49	14.52
1989	32.37	0.57	4.91	10.92
1990	32.82	0.99	6.12	12.75
1991	32.58	0.96	6.49	17.76
1992	33.06	0.97	3.76	5.43
1993	32.37	0.44	6.54	14.72
1994	32.52	0.32	6.90	16.06
1995	32.89	0.75	5.86	12.40
1996	32.50	1.01	5.83	14.04
1997	33.15	0.66	4.77	9.67
1998	33.67	1.32	6.31	13.92
1999	17.67	15.61	7.52	94.52
2000	32.67	0.72	3.73	6.45
2001	33.21	0.38	4.36	8.56
2002	33.91	1.18	6.40	13.17
2003	14.47	19.21	7.51	109.49

Table 2. Equation coefficients for the monthly mean minimum air temperature

	Coefficients			
Year	**a**	**b**	**c**	**d**
1985	21.66	-0.57	8.90	12.07
1986	4.26	-18.31	10.51	99.47
1987	5.67	-17.18	10.57	101.42
1988	7.63	-14.95	10.68	112.71
1989	7.39	-15.34	10.54	93.72
1990	9.28	-13.63	10.51	92.22
1991	22.68	-0.53	7.44	9.42
1992	22.56	-0.64	7.53	9.56
1993	-2.36	-25.16	10.65	134.91
1994	12.52	-9.90	10.65	131.10
1995	-4.26	-27.14	10.68	142.63
1996	0.28	-22.51	10.65	131.40
1997	22.72	-0.56	7.62	9.63
1998	23.20	-0.52	8.06	10.10
1999	22.40	0.37	4.32	8.01
2000	21.31	-1.55	10.10	99.39
2001	22.86	0.31	4.02	7.66
2002	13.27	-9.93	10.48	96.03
2003	23.11	0.33	4.99	9.39

Table 3. Equation coefficients for the monthly total rainfall

	Coefficients			
Year	**a**	**b**	**c**	**d**
1985	162.12	113.48	5.28	8.06
1986	162.12	116.18	5.64	8.93
1987	173.70	75.36	4.80	6.91
1988	187.32	58.67	6.06	6.69
1989	178.85	92.76	5.55	7.14
1990	178.70	43.70	2.83	5.45
1991	208.12	149.04	4.27	7.01
1992	176.77	89.95	5.50	8.80
1993	248.71	101.24	2.64	5.92
1994	178.74	95.70	4.63	6.98
1995	200.03	90.39	4.52	8.00
1996	190.79	52.08	5.43	7.61
1997	171.87	127.73	5.72	7.91
1998	189.07	42.99	4.90	11.35
1999	186.07	111.40	5.05	6.90
2000	211.19	74.70	6.59	9.56
2001	214.55	44.69	4.87	6.71
2002	187.58	110.21	4.12	7.09
2003	237.26	94.30	5.96	9.17

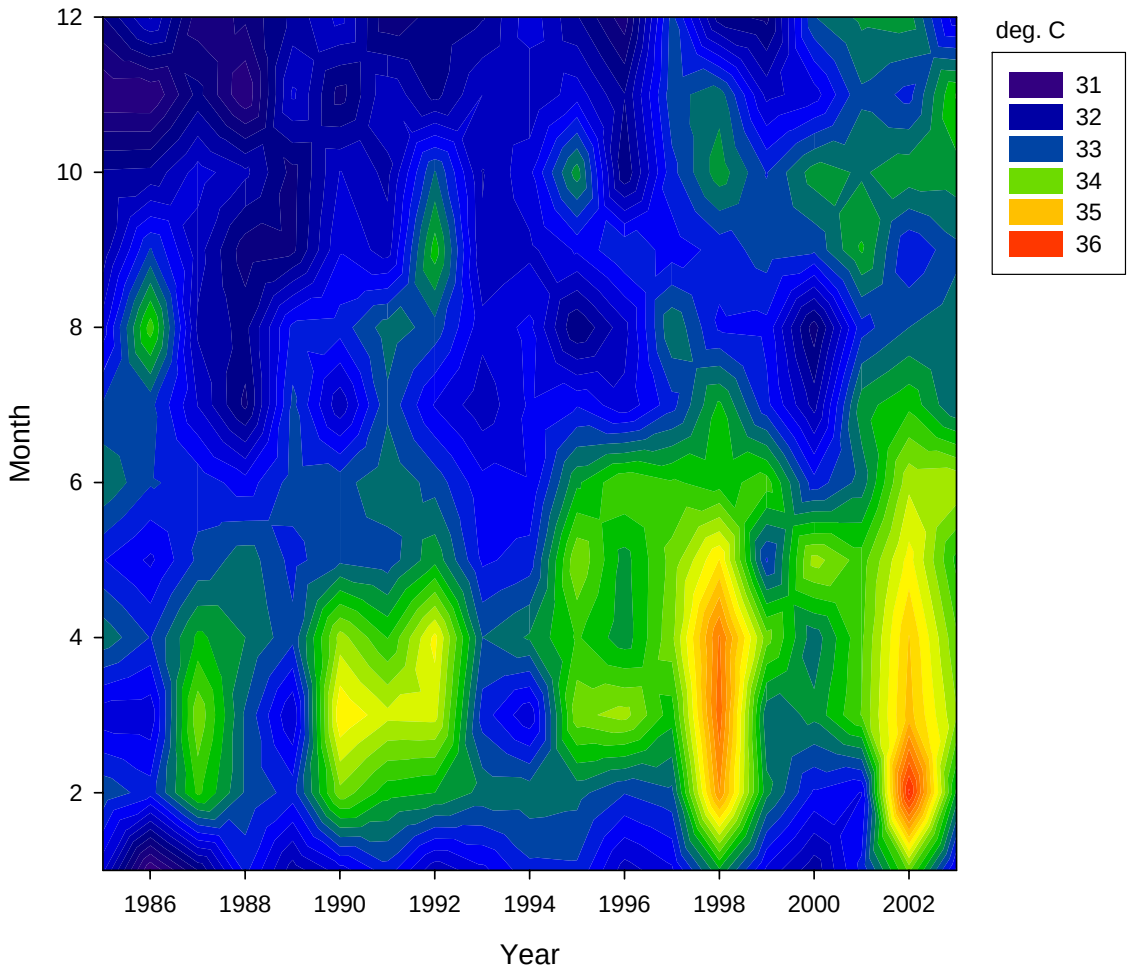

Fig. 1. Distribution of maximum air temperature for Serdang (1985-2003)

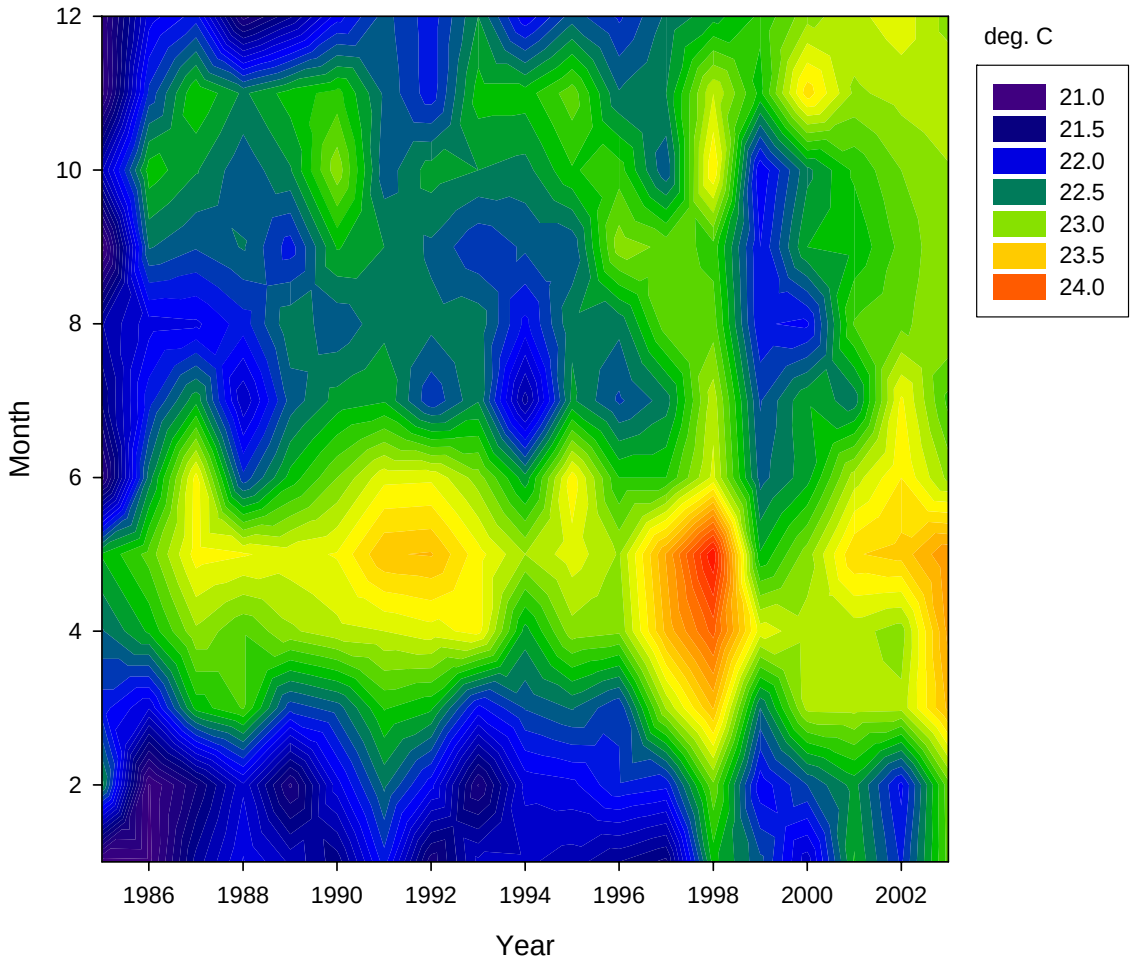

Fig. 2. Distribution of minimum air temperature for Serdang (1985-2003)

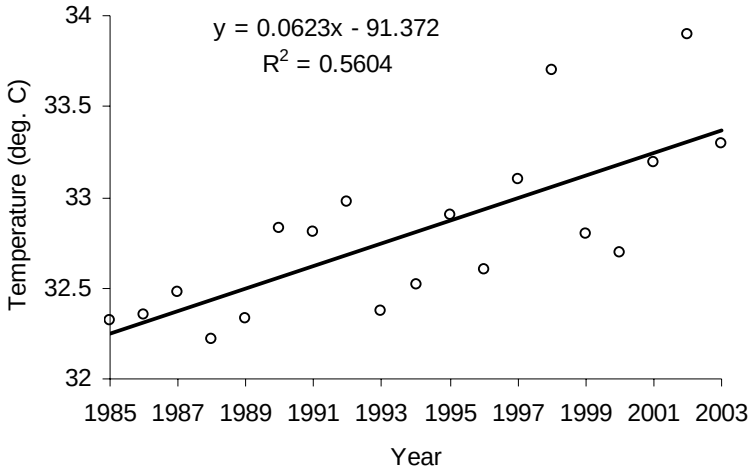

Fig. 3. Mean annual maximum air temperature for Serdang (1985-2003)

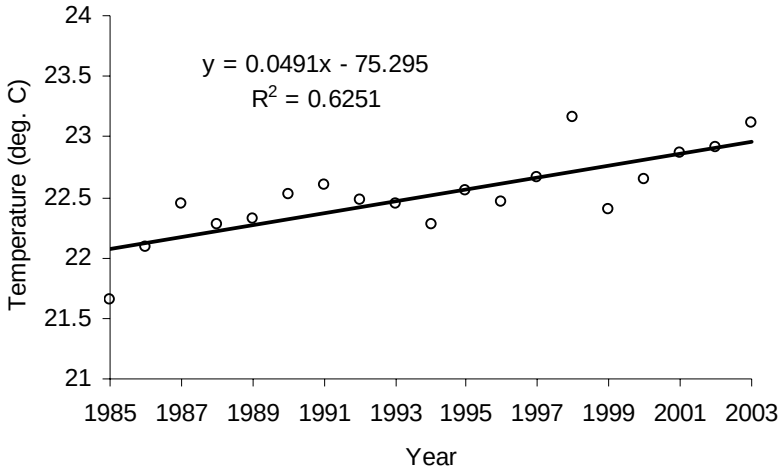

Fig. 4. Mean annual minimum air temperature for Serdang (1985-2003)

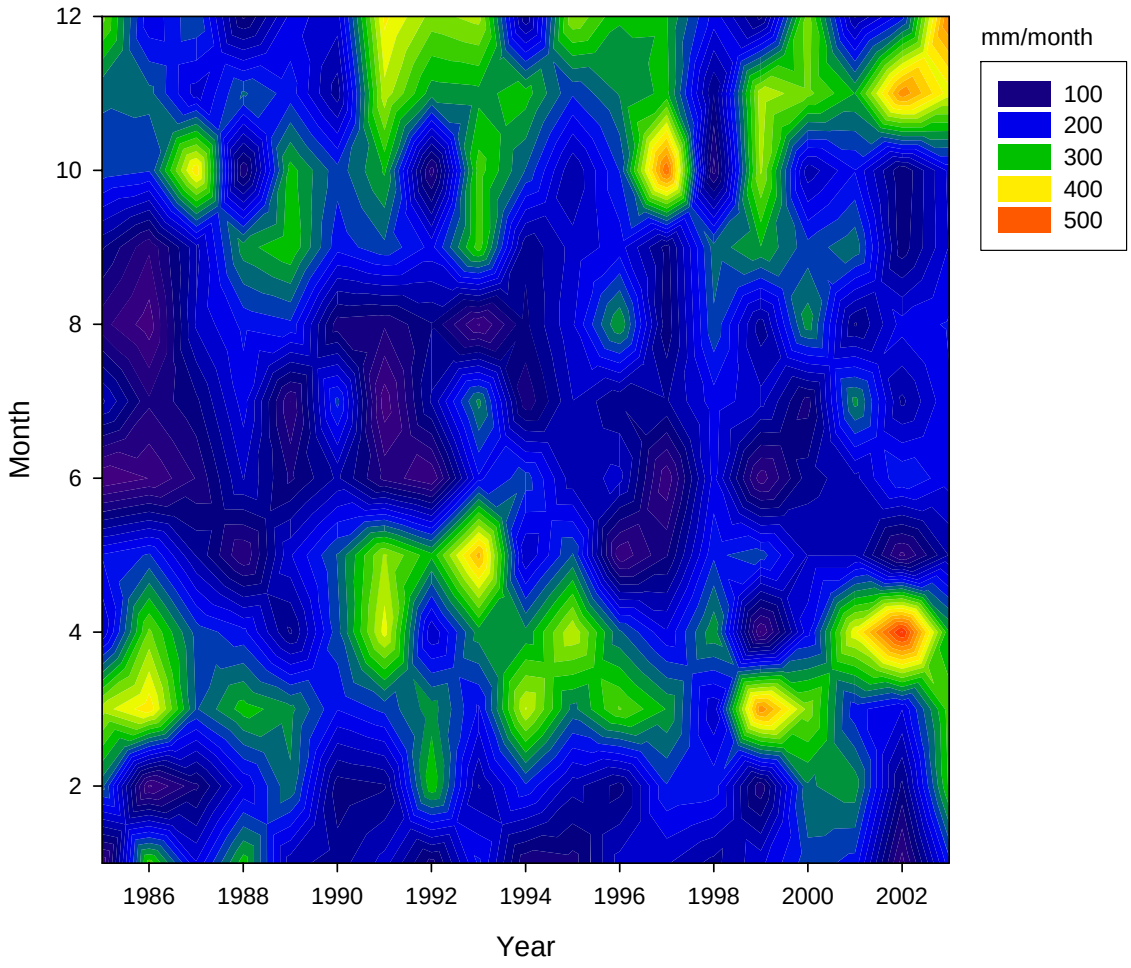

Fig. 5. Distribution of total rainfall for Serdang (1985-2003)

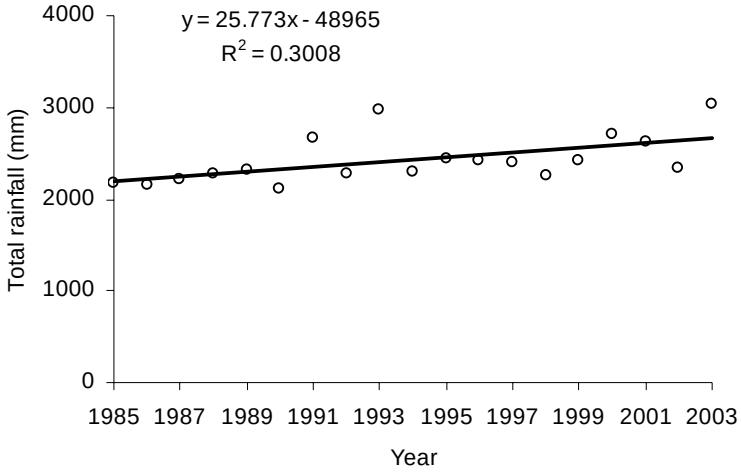

Fig. 6. Total annual rainfall for Serdang (1985-2003)

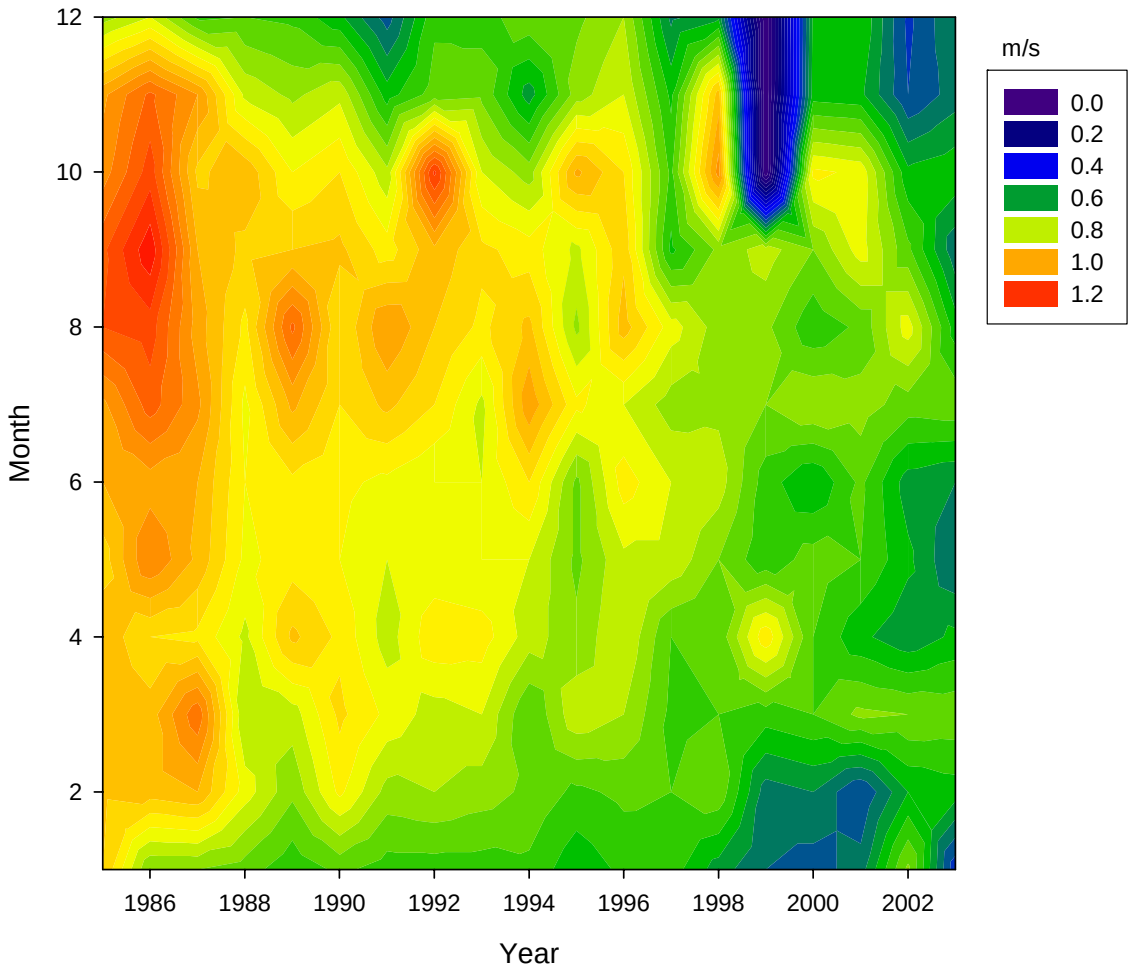

Fig. 7. Distribution of wind speed for Serdang (1985-2003)

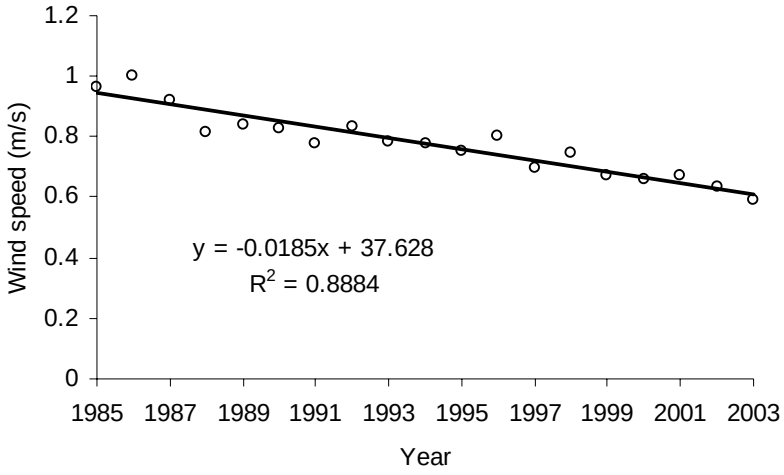

Fig. 8. Mean annual wind speed for Serdang (1985-2003)

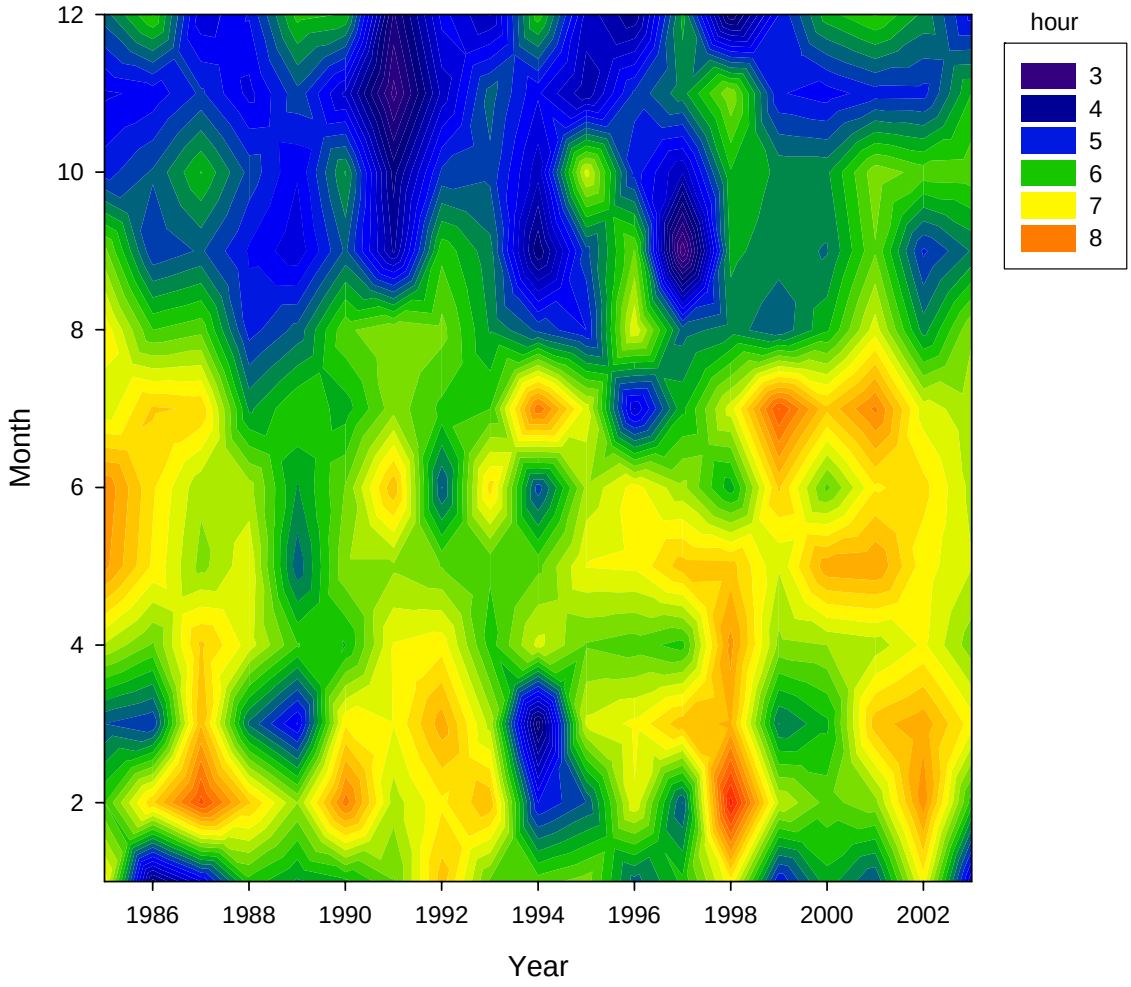

Fig. 9. Distribution of sunshine hours for Serdang (1985-2003)

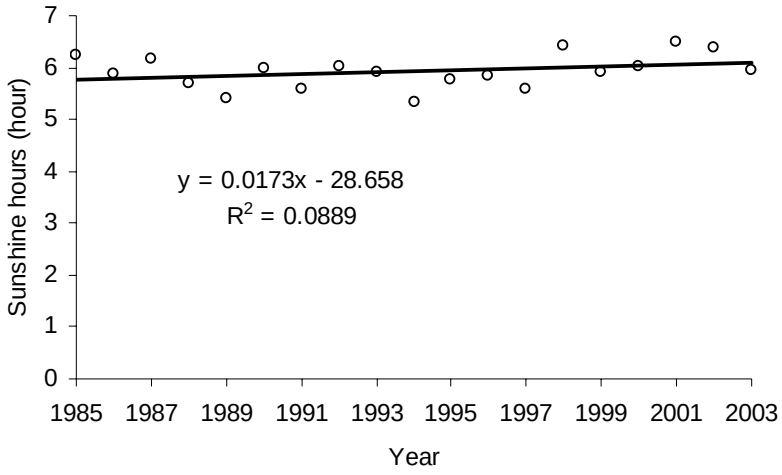

Fig. 10. Mean annual sunshine hours for Serdang (1985-2003)

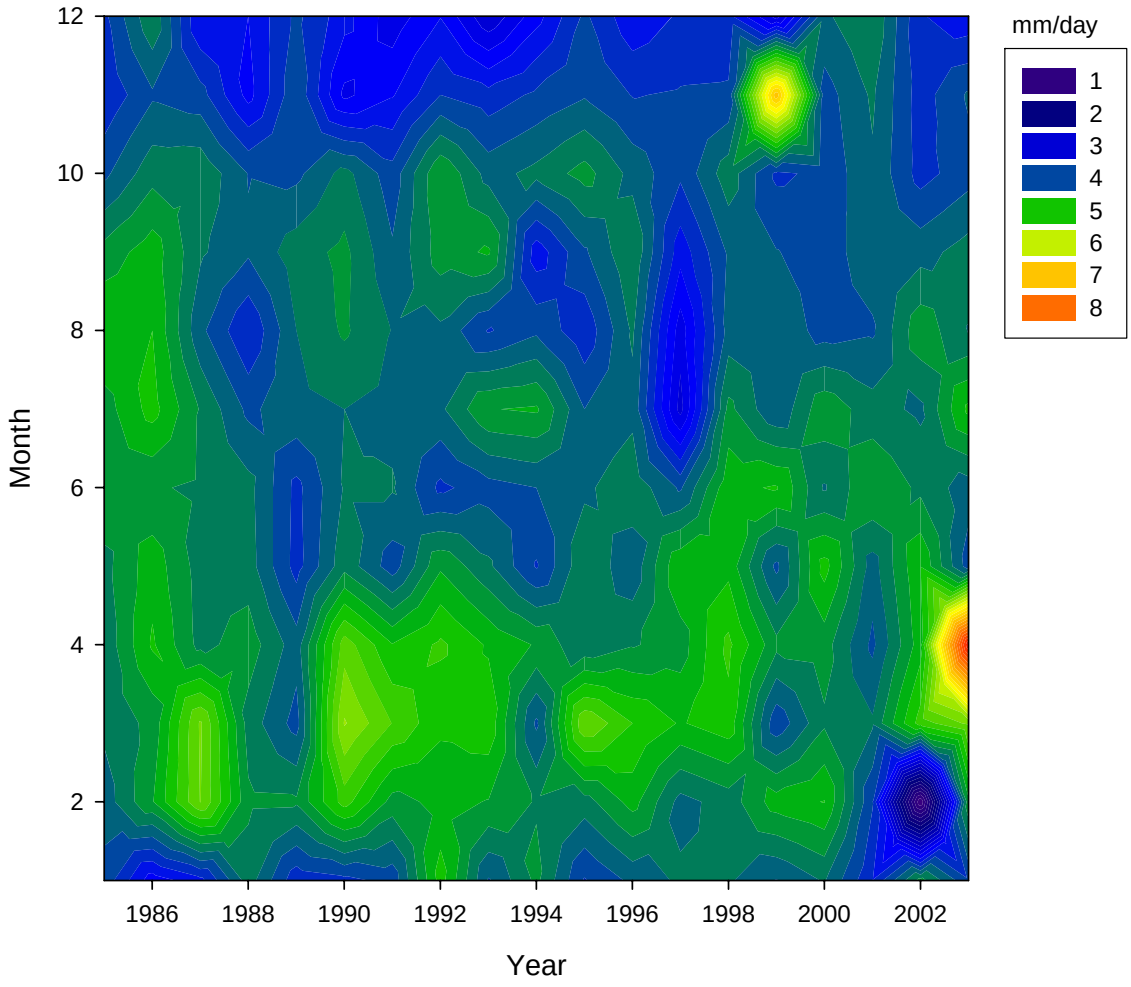

Fig. 11. Distribution of pan evaporation for Serdang (1985-2003)

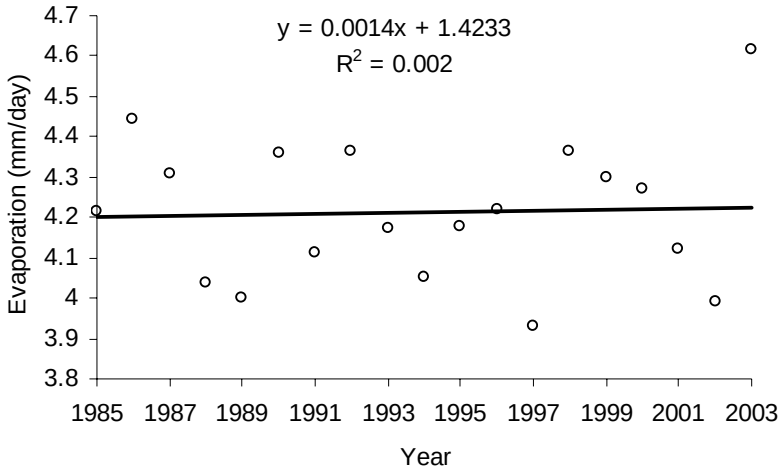

Fig. 12. Mean annual pan evaporation for Serdang (1985-2003)

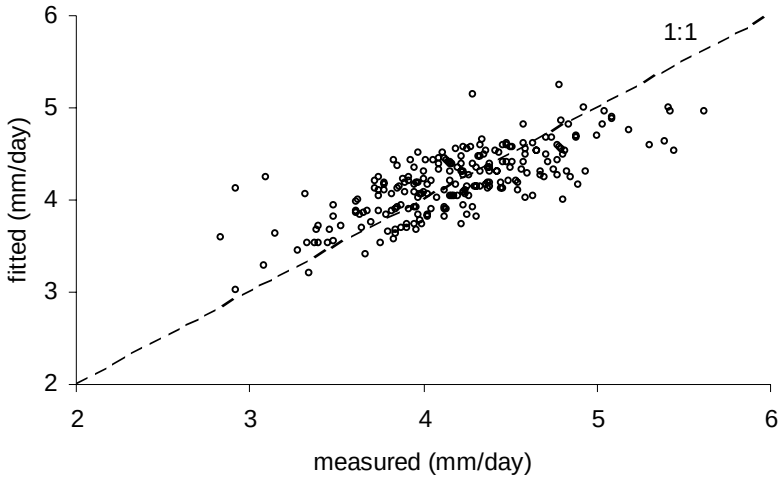

Fig. 13. Comparison between fitted (estimated) and measured pan evaporation