UNIVERSITY OF MAURITIUS RESEARCH JOURNAL – Volume 16 – 2010
University of Mauritius, Réduit, Mauritius

Research Week 2009/2010

Global Warming and Changing Temperature Patterns over Mauritius

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Paper Accepted on 24 August 2010

Abstract

This paper discusses the changing temperature pattern over Mauritius. We observe an increase of the annual mean temperature at Pamplemousses since 1876 with an average rate of 0.009°C per year with a significant correlation coefficient of 0.67. Compared to the mean temperature for the period of 1951 to 1960, we find that there is a shift in time (decadal) in the warming from northwest to other regions over the island. The temperature deviations are more marked in winter than in summer. Moreover, the number of hot days per year is increasing and the number of cold days is decreasing.

Keywords: Temperature spatial variation, trend, hot and cold days, krigging

**For correspondences and reprints*

1. INTRODUCTION

The earth's climate has been evolving since millions of years. Greenhouse gases, occurring in the atmosphere both naturally and mainly due to anthropogenic human activities trap much heat from the sun and heat the planet. The temperature of the air around the earth has been changing since thousands of years (Trenberth et al. 2007, Rosenzweig et al. 2007).

In Mauritius, although systematic and continuous temperature measurements were started in 1874 by Mr Cere, the Director of the Botanical Gardens of Pamplemousses, it was not until 1876 that reliable recordings were made at the Royal Alfred Observatory (RAO) at Pamplemousses which could be used for computation of trends. The records at RAO have been meticulously kept including details of the instruments used and their exposure. The RAO records therefore constitute a very important set of data of appreciable length for Mauritius from 1876 to 1952. Herchenroder was the first to analyse air temperature and humidity of the RAO from 1876 to 1935. His analysis revealed that the temperature at Pamplemousses decreased by a fraction of a degree between 1900 and 1935. By 1950, this temperature decrease appears to have been recovered. In this paper, long term data for Mauritius have been analysed in the context of global warming.

The warming of the global climate systems has changed the temperature patterns over the globe (IPCC 2007e). D. Wilkins and Wright (2004) from the Department for Environment Food and Rural Affairs (DEFRA) of UK have defined two parameters which are the hot day and the cold day. A hot day occurs when the daily mean temperature is at or above 20^{o}C while a cold day occurs when the daily mean temperature is at or below 0^{o}C. In the case of Mauritius, we define a hot day to be a mean daily temperature of 3^{o}C or more above the long term annual temperature of 1971-2000.

Annual temperature distribution over Mauritius is characterized by a mean maximum of 31°C along the northern and western coastal areas in December and January and a mean minimum temperature of about 14°C over the plateau in July and August. Absolute maximum and minimum temperatures recorded have been 37.5°C and 6.5°C respectively (NCC 1999). Although the average seasonal variation of temperature is relatively small, being of the order of 4^{o}C, it is nevertheless sufficient to cause a well-marked difference in the season. Temperatures are generally higher in the coastal areas decreasing towards the central plateau (CP). Also, the northern (N) and western (W) regions of Mauritius, located on the leeward of the trade winds, are warmer than the southern and eastern regions. Diurnal air temperature variations varies from 6 ^{o}C to 7.5 ^{o}C in the CP, from 8.4 ^{o}C to 10 ^{o}C in the W, 6.5 ^{o}C to 8.5 ^{o}C in the N. Departures in daily temperature of more than 2^{o}C from the normal is not uncommon and is usually caused by the passage of low-pressure systems in summer and high-pressure systems in winter.

2. SOURCES OF DATA AND METHODOLOGY

To study the changes in the temperature patterns over Mauritius, long term monthly air temperature data which have been quality controlled and updated accurately by the Mauritius Meteorological Services have been studied from some targeted stations as shown in figure 1.

We have used the regression techniques to analyse the trends of the monthly mean data for the 1950 to 2008 period of the temperature recorded at the five reliable stations that satisfy the requirement. Pamplemousses represents the north, Fuel the east, Medine the west, Plaisance represents the south and Vacoas the centre. Our main objective here is to find any temporal fluctuations in the temperature patterns over Mauritius as far as climate change is concerned.

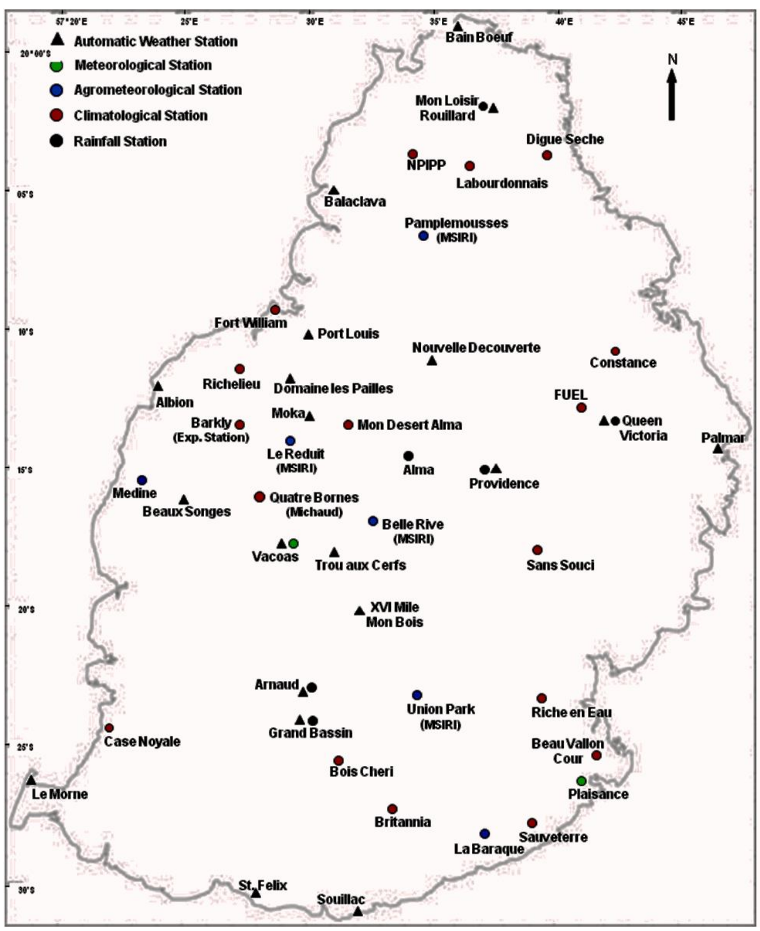


Figure 1: Stations over Mauritius (Source: Mauritius Meteorological Services)

3. RESULTS AND DISCUSSIONS

3.1 Time Series and Trends

Figure 2 shows the time series of the annual mean temperature at Pamplemousses since 1876 and corresponding thirty years running mean curve and the linear trend line indicating the increase in annual average temperature at a rate of 0.009°C per year with a significant correlation coefficient of 0.67.

Figure 3 displays the mean maximum temperature variation with the seasons over Mauritius for the period 1950 to 2008 where January, February, March and December are the hottest while July and August are the coolest months. It also clearly indicates that irrespective of the month, there is always an increasing trend in the mean maximum temperature.

Figure 4 shows the trend in the mean temperature recorded at different regions all over the island, north-east, south-west, north-west and south-east. An average of all these, that is, the mean monthly temperature over the whole island has also been considered. All of them are indicating an increase in the trend. The polynomial trend line indicates that the temperature was more or less stable before 1975. It is as from 1975 onwards that the temperature is showing the increasing side. An increase of about 0.8°C on the average has been noted from 1975 up to 2008 with a higher rate as from the 1990's.

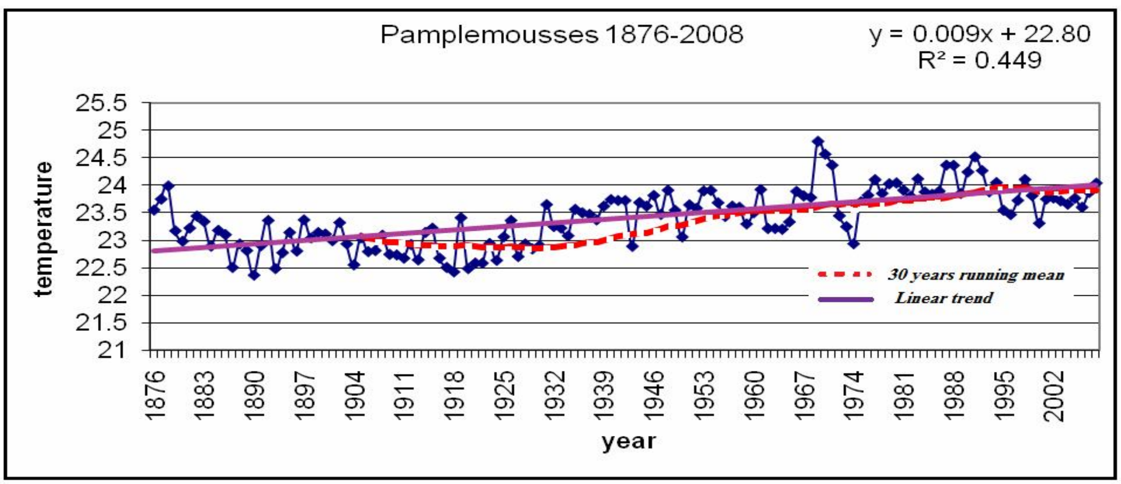


Figure 2: Annual mean temperature recorded at Pamplemousses Station from 1876 to 2008 [Sources Herchen and Borgne, Central Statistics Office and Mauritius Meteorological Services]

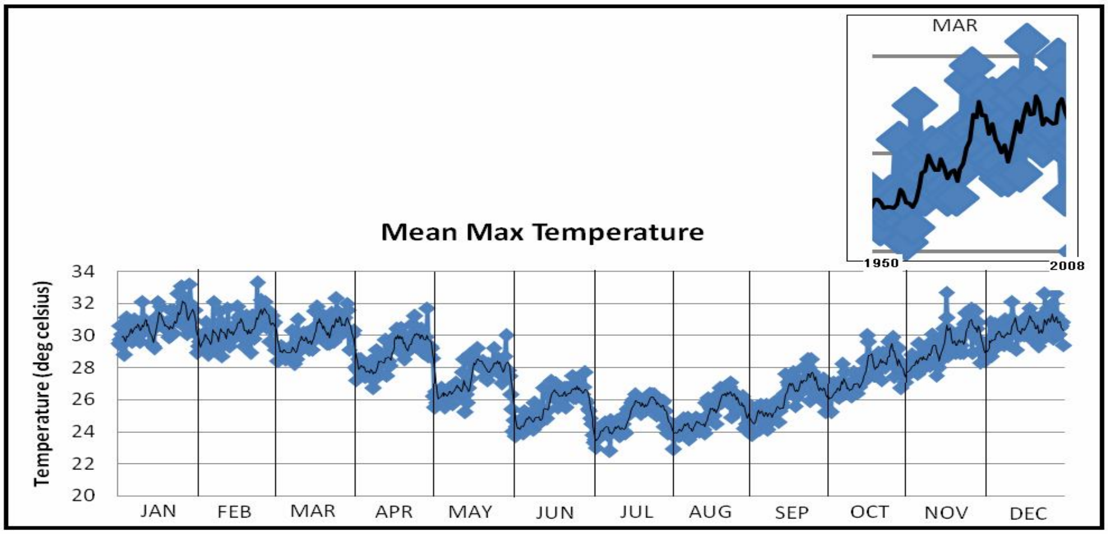


Figure 3: Monthly variation of mean maximum temperature 1950 to 2008. The inset shows the trend for March.

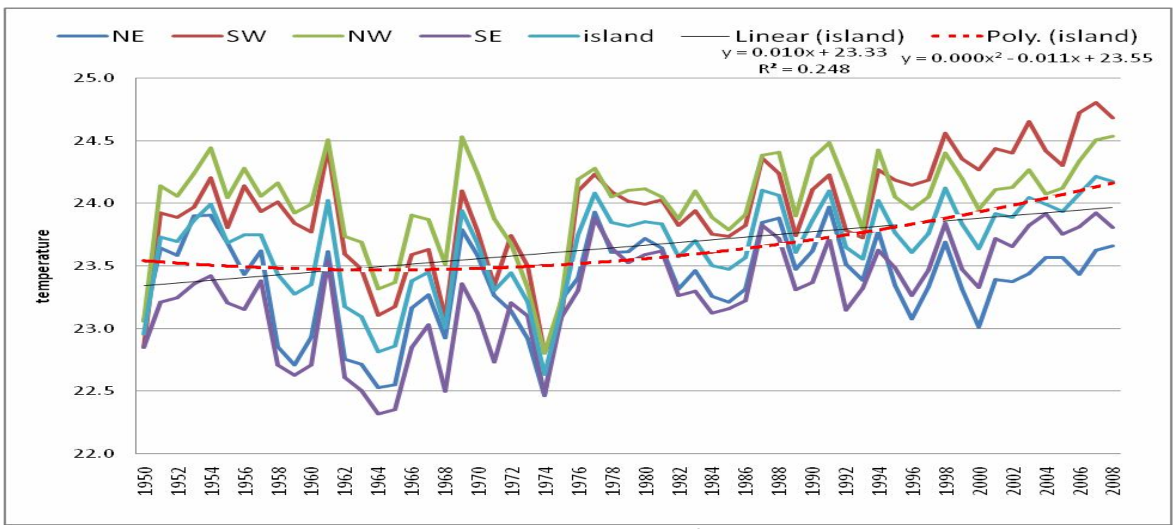


Figure 4: Regional temperature recorded from 1950 to 2008

3.2 Number of Hot and Cold Days

For Mauritius, we have chosen to define a hot day to be a mean daily temperature of 3°C or more above the long term annual temperature of 1971-2000. For this purpose, we have chosen only two stations namely, Vacoas to represent the centre and Plaisance to represent the coastal region. Figures 5(a) and 5(b) show the variation in the number of hot days occurring at Plaisance and Vacoas respectively. A quadratic model is a better fit to the data for Pamplemousses since we obtains a larger correlation coefficient $r = 0.5$ instead of $r = 0.4$ when a simple linear model is used. Furthermore, we observe that as from 1976 onwards, the number of hot days increase quadratically for Plaisance. As far as Vacoas is concerned, we find that the simple linear model is a better model than the quadratic one since both leads to nearly the same correlation coefficient value of r = 0.3, showing a low temporal correlation for the increasing number of hot days.

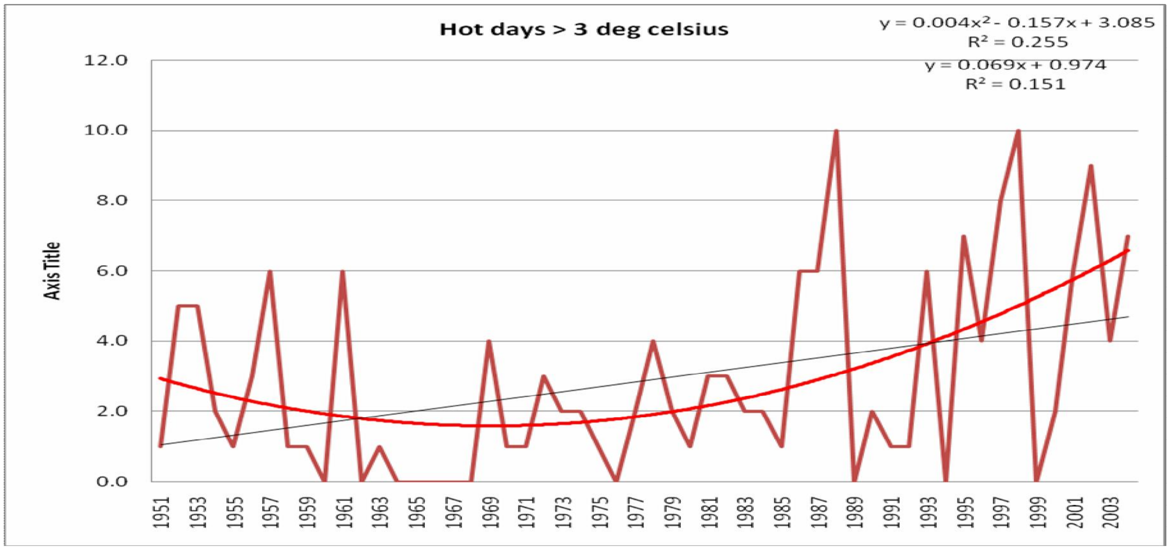


Figure 5(a): Number of hot days at Plaisance

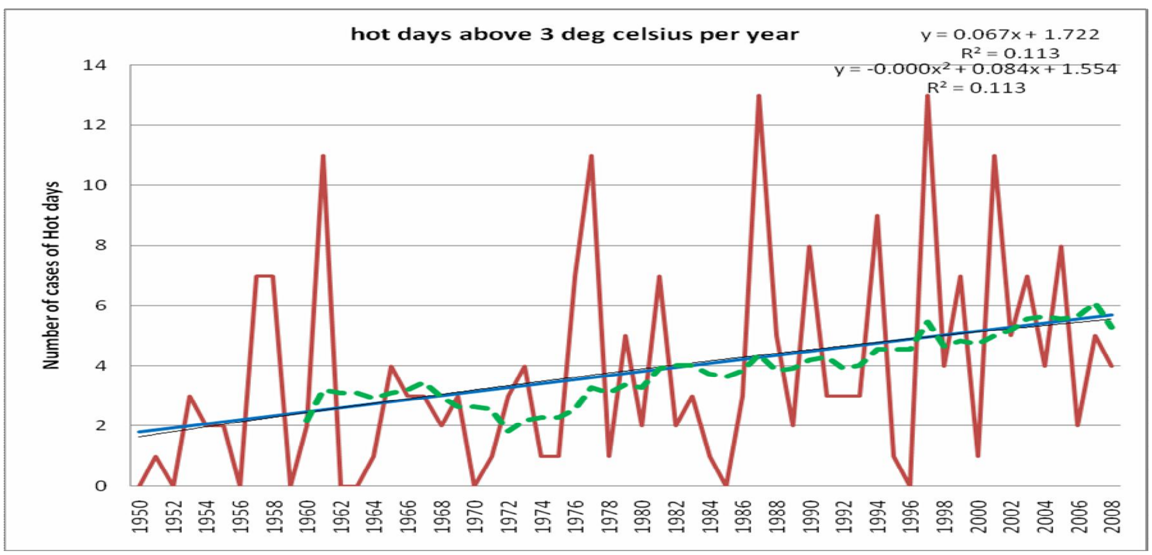


Figure 5(b): Number of hot days at Vacoas

When the number of cold days is considered as shown in figure 6(a)-6(b) we obtain a quadratic model with r = -0.48 and r = -0.78 for Palisance and Vacoas respectively which clearly indicates that we have a decreasing number of cold days with time.

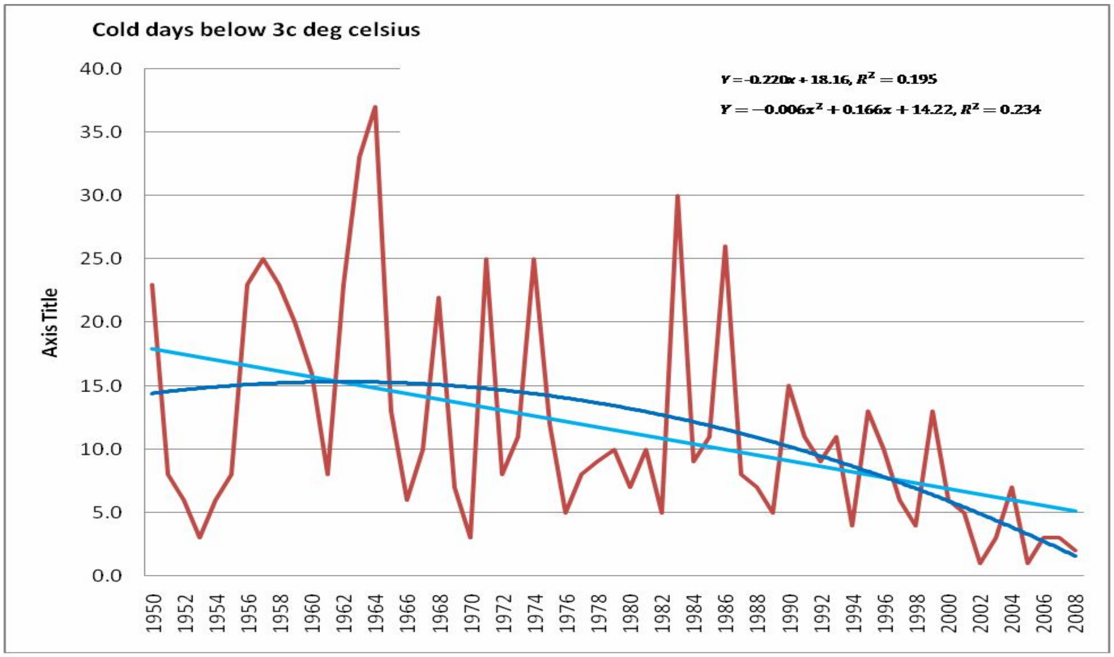


Figure 6(a): Number of cold days at Plaisance

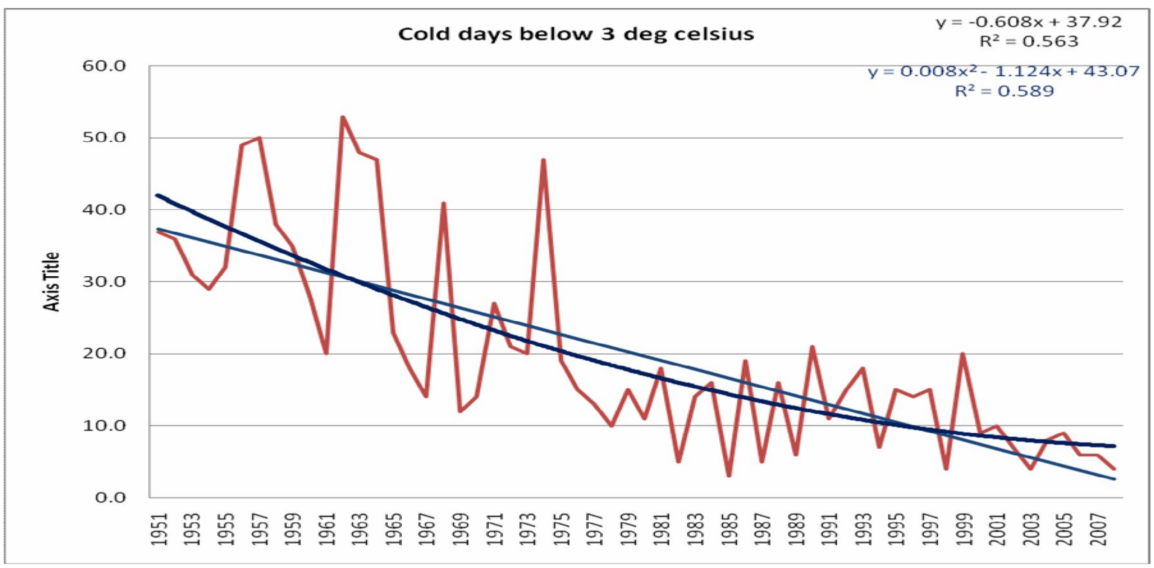


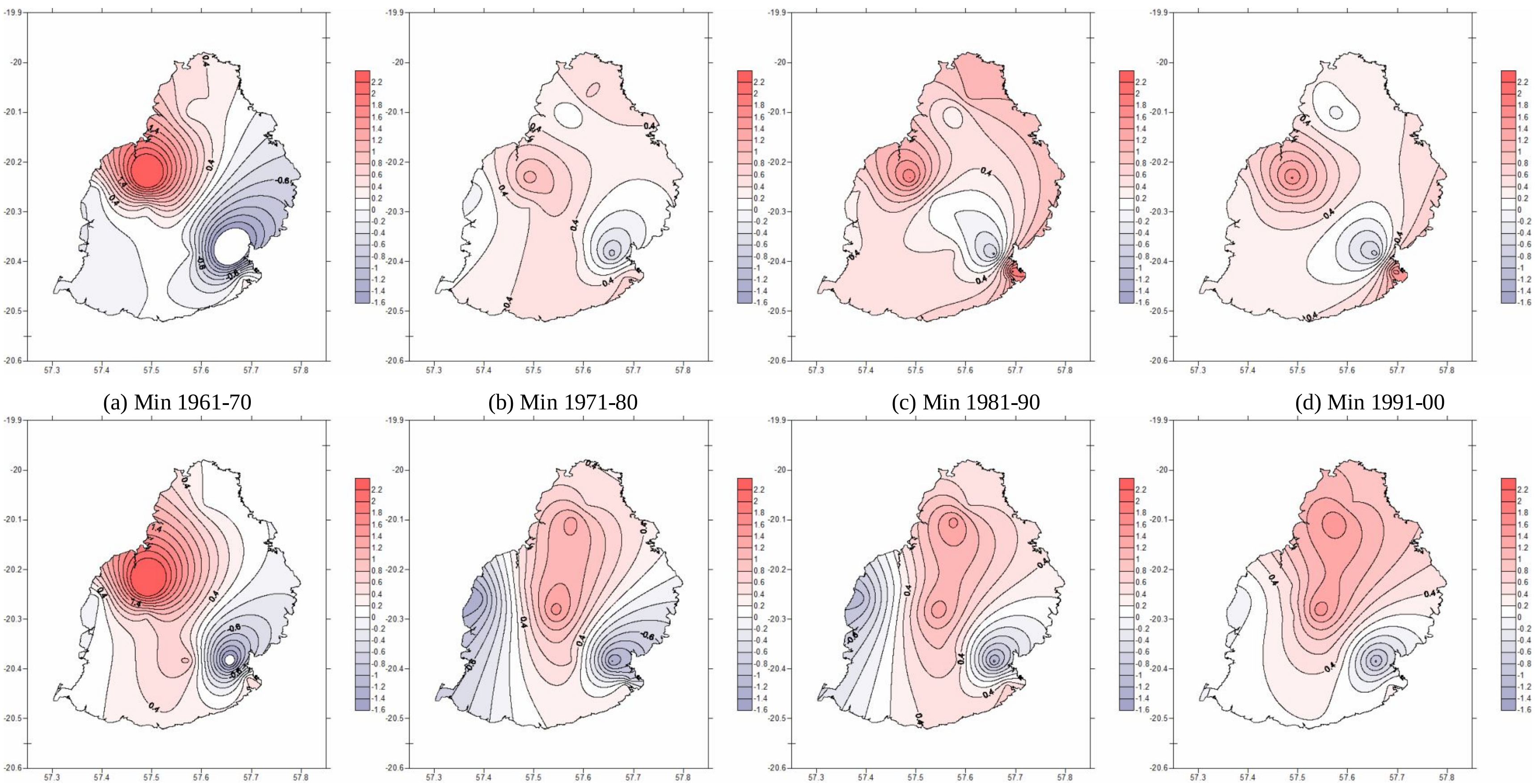
Figure 6(b): Number of cold days at Vacoas

3.3 Decadal Evolution of Minimum and Maximum Temperatures

Figure 7 shows krigged maps generated using SURFER® software of the decadal (1961-1970, 1971-1980, 1981-1990, 1990-2000) evolutions of minimum and maximum temperature for the month of April when compared to the 1951-1960 decade. The plots have been generated using 10 stations around the island which include Vacoas, Plaisance, Medine, Pamplemousses, Belle Rive, Beau Valon

Cour, Labourdonais, Riche Lieu, Reduit and Union Park. Table 1 summarises the findings in the decadal monthly anomalies. We note that there is a warming of 1.0 to 2.2^{o}C in the minimum throughout the year for the decade to the NW of the island. The area widens during the months April, June and July. The warming spreads to the northern and the southern areas with time 1960 to 1990. The coastal zones are also becoming warmer.

Figure 8 shows the deviation for April for each of the decades 1961-1970, 1971-1980, 1981-1990, 1990-2000 relative to the previous decade, that is 1961-1970 relative to 1950-1961, 1971-1980 relative to 1961-1970 and so on. Table 2 summaries the findings. We observe a variation in the warming and cooling in for the whole year as we go from the 1960's to the 1990's. Only the maximum temperature for January shows a continuous warming and a shift from the northwest to the other regions. The minimum temperature for September to December in the 1990's indicates a cooling compared to the previous decade.



(a) Min 1961-70 (b) Min 1971-80 (c) Min 1981-90 (d) Min 1991-00

(e) Max 1961-70 (f) Max 1971-80 (g) Max 1981-90 (h) Max 1991-00

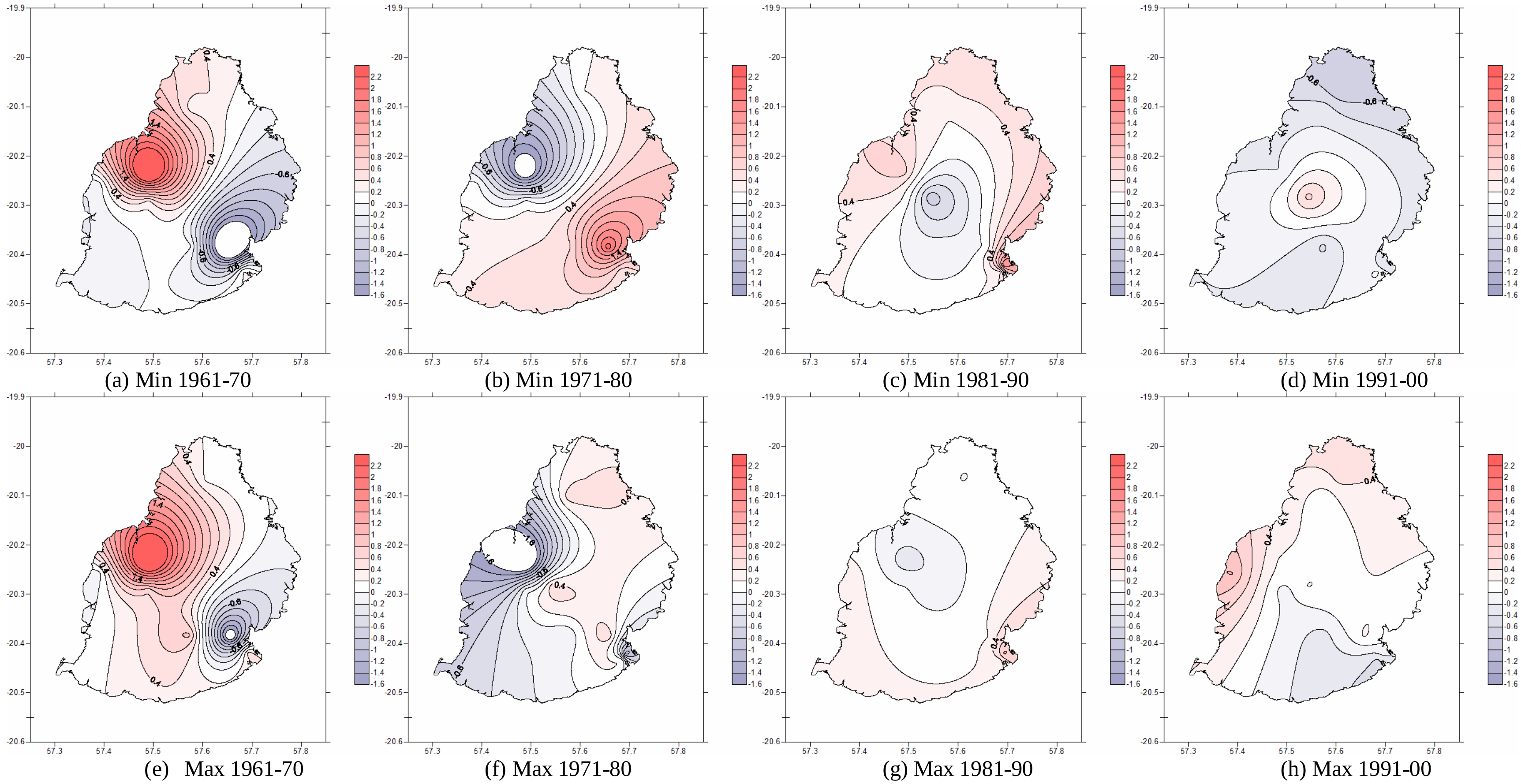
Figure 7: Evolution of minimum (top) and maximum (bottom) April temperature deviations relative to 1951-60

Table 1: Summary of decadal temperature variation (compared to 1951-1960)

Decades	Minimum temperature	Maximum temperature
1961 To 1970	Warming of +1 to +2.2^{o}C in the minimum throughout the year for the decade to the NW of the island. The area widens during the months April, June and July. The warming is spreading to N as we move from 1960's to 1990's. A significant warming in June and July	Warming of +1 to +2.2^{o}C in the maximum throughout the year for the decade to the NW of the island. The area widens during the months April, to September. Significant warming in June and July. Warming shifts towards the Centre and the N as we move from 1960's to 1990's.
1971 to 1980	Relatively cool decade, we note practically no warming in January, February, March and September. For the rest of the year, we note warming occurring in the centre, to the S and the N.	Relatively cool decade, little warming in Centre for January, extending towards N and S from February& March, decreasing towards December
1981 to 1990	Warming of up to +1.5^{o}C in the month of April, July, October and November. For the rest of the year, we note no significant warming except to the NW.	Little warming in Centre for January, picking up as from April, highest occurring in May to September to +2.0^{o}C and extending towards N and S.
1991 to 2000	Warming up to 1.5^{o}C to the NW, SE and N in February, more significant in April, gradually decreasing up to December. But NW remains warm.	Warming in the Centre and the N for the whole year, less significant in January and December, peaking to +2.0^{o}C April, May and June.

Table 2: Summary of decadal temperature variation with previous decades

Decades	Minimum temperature	Maximum temperature
1961 to 1970	NW is again warmer by +1 to +2.2°C throughout the year. The area widens during the months April, May, June and July; including September, October and November. The warming confines itself to the NW and the N. A significant warming in April, June and July.	NW warmer by +1 to +2.2°C in the maximum Wide areas during the months April, June July and August. Significant warming in June. The warming is shifting towards the Centre and the other sectors as we move from 1960's.
1971 to 1980	SE warming by +2.2°C in April, May, July, August and October. Relatively less warming in January and December.	Warming in the S and the SE, gradually extending to the N. Highest of the order of +1.5°C in May. No noticeable warming in February is observed.
1981 to 1990	Warming noted all sectors, except the centre. Highest +1.2°C to the NW and SE in October. No noticeable warming is observed in July.	Warming SE throughout year, extending to other sectors except in May and December. Highest +1.0°C in February.
1991 to 2000	NW and SE +1°C. Centre warming in February, March, April, May, June and July. Again from September to December no noticeable warming is observed.	Warming all sectors in January to June except April, August, November and December no warming in SE. September warming of +2.0°C in NW



(a) Min 1961-70 (b) Min 1971-80 (c) Min 1981-90 (d) Min 1991-00

(e) Max 1961-70 (f) Max 1971-80 (g) Max 1981-90 (h) Max 1991-00

Figure 8: Evolution of minimum (top) and maximum (bottom) April temperature deviations relative to previous decade

4. CONCLUSIONS

We note a gradual increase in the mean temperature from 23.5°C in 1976 to 24.3°C in 2008, that is, an increase of about 0.8°C. Linear and quadratic increasing trends in the mean minimum/maximum temperature for summer/winter with time over the island occur for almost all the stations. The observations of the hot/cold days further support the notion of global warming with the increasing trend in the number of hot-days and the decreasing trend in the number of cold-days. In addition, we find that the number of hot and cold days along the coastal regions respectively increase and decrease quadratically. Furthermore, almost a linear increase and decrease in the number of hot and cold days have been observed at the centre. Decadal trends reveal a warming towards the south and the upland areas as we move from the 1950's to the 1990's.

5. ACKNOWLEDGEMENTS

We would like to acknowledge the Mauritius Meteorological Services for providing the necessary data in order to pursue this research work.

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