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CHENNAI'S REGIONAL TEMPERATURE VARIATION AND ITS CORRELATION WITH SUNSPOT NUMBERS AND CO_2 EMISSION

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ABSTRACT

Earth's climate is determined by complex interactions between the Sun, oceans, atmosphere, land, and living things. The composition of the atmosphere is particularly important because certain gases (including water vapour, carbon dioxide, methane, ozone, and nitrous oxide) absorb heat radiated from the Earth's surface. As the atmosphere warms, it in turn radiates heat back to the surface, to create what is commonly called the "greenhouse effect." Changes in the composition of the atmosphere alter the intensity of the greenhouse effect.Variations of Chennai's average mean temperature and diurnal temperature range for a period of ten years are investigated and is compared with past hundred years data. There is an observed variability of average mean temperature and diurnal temperature range. The variation in the temperature can be influenced by various climate forcing. In this paper we have correlated the sunspot numbers and Carbon dioxide emission with DTR and have estimated which influences the DTR more. Global warming over land can be characterized by faster warming at nights. This observed recent trend should lead to considerable decrease in the diurnal temperature range (DTR). The decrease of the diurnal temperature range is approximately equal to the increase of mean temperature[1].

INTRODUCTION

The work of the farmers, power company engineers, weather analysts and many others would be great deal more difficult without accurate information of careful recording of temperature data. The difference between the daily maximum and minimum temperature is called the diurnal temperature or range of temperature. The greatest variation in daily temperature occurs at the earth's surface and becomes progressively smaller as we move away from the surface. This daily variation in temperature is larger on clear days than on cloudy days. The diurnal temperature range can be analyzed in four different categories like the deserts, plateau regions, cities and humid regions.

The largest diurnal range of temperature occurs on high desserts, where the air is often cloud free, and there is less carbon dioxide and water vapour above to radiate much infrared radiation back to the space.

An elevated plateau region like Reno which is located at 1350m above sea level will have 35degree Celsius in the day and will cool down to 15 degrees at night time.

Thus, showing a temperature range of 25 degrees.

The city region can be split into two categories coastal and inland. Coastal cities usually have a smaller diurnal temperature range than the inlands as the water vapour will heat and cool more slowly than land. The city inlands which also have a decreased DTR are caused due to urban heat islands.

The urban heat islands are due to industrial and urban development. In rural areas a large part of the incoming solar energy is used to evaporate water from vegetation and soil. In the cities where less vegetation and exposed soil exits, the majority of the solar energy is absorbed by urban structures and asphalt. Hence during warm daylight hours, less evaporative cooling in cities allows the surface temperature to rise higher than in rural areas. And during night time the temperature does not reduce much due to radiation emitted from the urban structures.

Chennai is located on the thermal equator on the southeast coast (Coromandel Coast) of India at an average altitude of 6 metres from the sea level. The latitude and longitude of this city is 13°04 N 80°17 E respectively. It covers a total area of 174 sq km that is spread irregularly in the northeast corner of Tamil Nadu. Its proximity to the Bay of Bengal ensures a hot & humid climate for most of the year.

The highest temperature is attained in late May and early June which is usually about 38 °C (100.4 °F) it exceeds 40 °C (104° °F) for a few days. Average daily temperature in Chennai during January is around 24 °C (75.2 °F), though the temperature rarely falls below 18 °C (64.4 °F). The lowest temperature recorded is 15.8 °C (60.44 °F) and highest 44.1 °C (111.38 °F) [2].

Thus Chennai falls under the fourth category of the diurnal temperature range.

In this paper we study the relationship between the solar activity, carbon dioxide emission and their influence on the daily temperature which may prove to be the evidence for the climate change over Chennai.

DATA AND METHODOLOGY

The maximum and minimum temperature data of Chennai for the month of March, April, May and June are taken in two parts. First, for a period of hundred years (1901-2000). Next, for a period of ten years (2001-2010). The data for maximum and minimum temperature are obtained from the Indian Meteorological department**.** The sunspot number data for the corresponding months are obtained from National Geophysical Data Centre, Boulder, Colorado, USA[3]. Similarly the carbon dioxide data are obtained for a period of 1980 to 2009. From the NOAA web site[4]. Solar activity, green house gases and climate change are much of much interest these days.

The statistical analysis of the examined data series involves a non parametric rank correlation technique (Spearman Rank Correlation)[5]. The statistical reliability of the obtained correlations is evaluated by a significance test. The Diurnal Temperature Range(DTR) between the hundred years data and ten years temperature maximum and minimum data are determined. Followed by this a statistical correlation is worked out between diurnal temperature range and sun spot numbers. And the same is carried out for the carbon dioxide emission data.

The anomaly in diurnal temperature is shown in Table 1. And the correlation values are shown in Table 3. A graph is plotted between the temperature range and sun spot numbers and between the temperature range and carbon dioxide for

the months of March, April, May and June. It is shown in Figure 1 and Figure 2 respectively.

RESULTS

Comparing the value of maximum and minimum temperatures for March, April, May and June in column two and three of Table 1: we observe a slight rise in the maximum and minimum temperature individually. The diurnal temperature range shows a slight anomaly. The anomaly was expected to be more prominent as per the concept of global warming. As the global warming increases the night time temperature increases leading to decrease in the diurnal temperature range. Column 2 of Table 1 shows a decreased diurnal temperature range. But column 3 shows slightly higher values of diurnal temperature range.

This result is contrary to several observed trends in the other regions of the world. A city is characterized by a decrease in the DTR.

Thus the anomaly is investigated further. For this we have considered the DTR in six other coastal cities of Tamil Nadu and compared it with the DTR of six Inland cities in the state. The results are tabulated in Table 2. From the data it is inferred that all the coastal cities exhibit an increased DTR. The Inland cities exhibit a decreased DTR effect. Thus the anomaly in Chennai City can be attributed to the effect of its coast line.

The change in DTR can be forced by natural and anthropogenic factors. Table 3 shows the correlation between the diurnal temperature range, sunspot numbers and the carbon dioxide emission. We can infer from table 3 the sunspot numbers shows a good correlation with the DTR than the carbon dioxide emission.

The Figure 1 shows a prominent relevance between the sunspot numbers and the DTR than the carbon dioxide emission as in Figure 2.

DISCUSSION

The coastal parts of India often come under the warm and humid zones. The city of Chennai falls under this zone. The contradictory result obtained from the Table 1 can be due the increased aerosol concentration in the atmosphere in the city during the last ten years[6], apart for this the ocean currents, direction of prevailing winds, the El Nino effect, water vapour concentration all these factors affect the DTR in the Chennai region and thus we observe an increase in DTR.

The city inland are affected by the Urban Heat Island Effect (UHIE)[7] which increase the night time temperature thus increasing the minimum Temperature at a faster rate than the increase in the maximum temperature. This leads to a decreased DTR in these regions.

In Table 3 the significance of correlation depends on the sample size. For large sample as in our case even the small relations between variables will be significant. Here we have $r = 0.2$ at a significant level $p<0.005$. Thus the sunspot numbers correlate well with the DTR than the Carbon dioxide emission. From Figure 1 we can infer that the sunspot numbers varies promptly with the temperature range except for the month of May. May is the peak summer month in Chennai so the temperature is not affected by sunspot numbers alone. The anomaly during this time is caused by various other anthropogenic agents. Figure 2 represents the graph between the carbon dioxide emission and the temperature range. We can infer that the trend of variation in

temperature range is moving well ahead than that of the carbon dioxide emission[8].

CONCLUSION

The solar forcing is more prominent on the diurnal temperature range. The contradictory result of Table 1 is due to the topographic status of Chennai city which poses a dynamic climate. The maximum and minimum temperature increases for all the twelve cities that were considered. For the coastal regions the increase in the maximum temperature is more than the increase in the minimum temperature leading to increased DTR. For the inland cities the increase in the minimum temperature is more than the increase in the maximum temperature leading to decreased DTR. The relationship between the regional surface air temperature and the sunspots shows a statistically significant value yet quite low. In conclusion at regional level the temperature changes are correlated with corresponding solar activity. Signatures of human activity are not yet distinguishable in the observations. Even though solar activity may not be the dominant factor in global warming, it is important enough that understanding how the climate responds to small changes in solar irradiance will help us to predict the climate changes caused by human activity.

Table1: Anomaly In Temperature Range For 100 Years And Last Ten Years Maximum and minimum temperature

Table 2: DTR for Coastal cities and Inland Cities

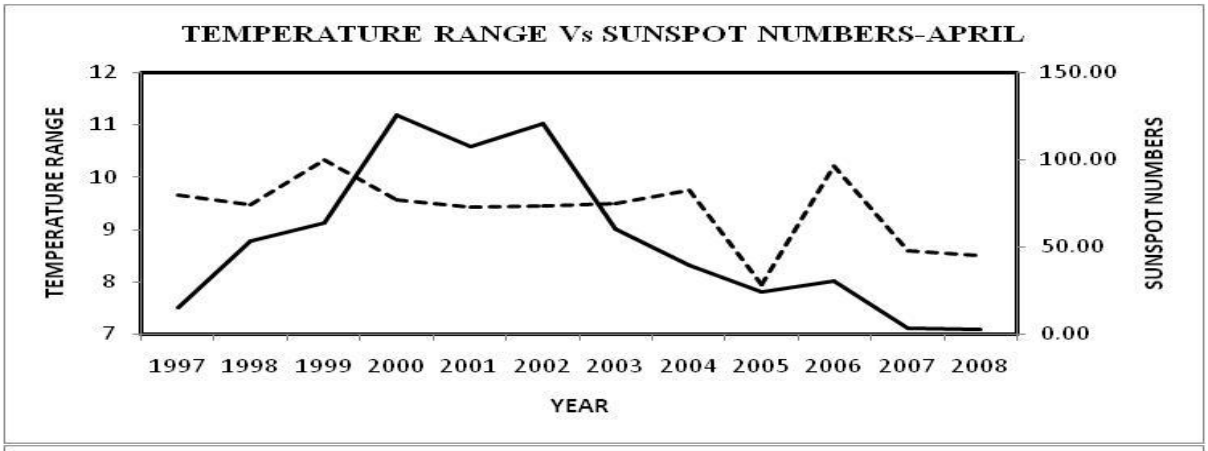
Coastal Cities	March		April		May		June	
	1990 - 1999	2000-2009	1990-1999	2000-2009	1990-1999	2000-2009	1990-1999	2000-2009
Karaikal	7.4	8.5	6.8	8.5	8.4	10.3	9.4	10.1
Nagapattinam	7.4	7.8	6.8	7.5	8.4	9.8	9.8	10.1
Chennai	8.9	8.9	7.9	8.2	8.7	9.9	9.1	9.6
Pnodichery	8.4	8.8	7.5	8.4	8.3	10.5	9.6	10.4

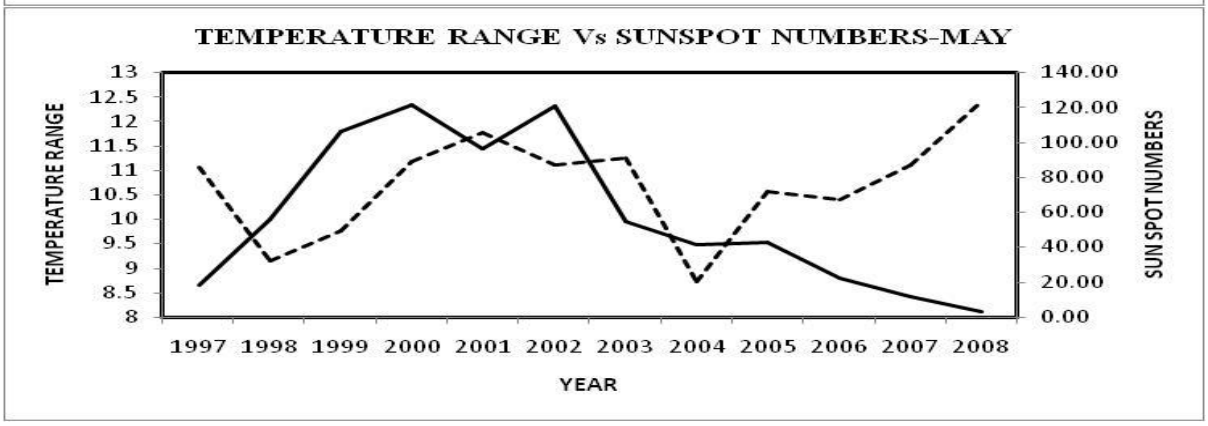
Pamban	7.8	7.5	7.3	7.1	6.3	5.7	6.0	5.6
Cadalore	9.5	9.1	8.3	8.7	9.6	10.8	10.5	10.7

Inland Cities	March		April		May		June	
	1990-1999	2000-2009	1990-1999	2000-2009	1990-1999	2000-2009	1990-1999	2000-2009
Kodaikanal	11.2	10.2	9.6	9.1	9.0	8.1	8.0	6.6
Trichy	12.8	11.9	12.0	11.0	11.2	11.3	10.5	10.4
Vellure	14.8	14.8	13.5	13.8	13.0	14.0	11.2	12.0
Dharmapuri	15.2	13.9	13.4	12.2	12.0	11.4	11.0	9.8
Coimbatore	14.6	13.1	12.9	11.6	11.3	10.9	9.8	9.7
Salem	15.8	13.6	13.6	11.8	12.8	11.2	11.8	10.0

MONTH	SSN	CO_2
MARCH	0.29371	0.1002
APRIL	0.27972	-0.0917
MAY	0.22028	0.3200
JUNE	-0.13287	-0.0409

Table 3: Spearman rank correlation between sunspot numbers , carbon dioxide and diurnal temperature range


TEMPERATURE RANGE Vs SUNSPOT NUMBERS-APRIL
TEMPERATURE RANGE
SUNSPOT NUMBERS
YEAR
12
11
10
9
8
7
150.00
100.00
50.00
0.00
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008


TEMPERATURE RANGE Vs SUNSPOT NUMBERS-MAY
TEMPERATURE RANGE
SUN SPOT NUMBERS
YEAR
13
12.5
12
11.5
11
10.5
10
9.5
9
8.5
8
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008

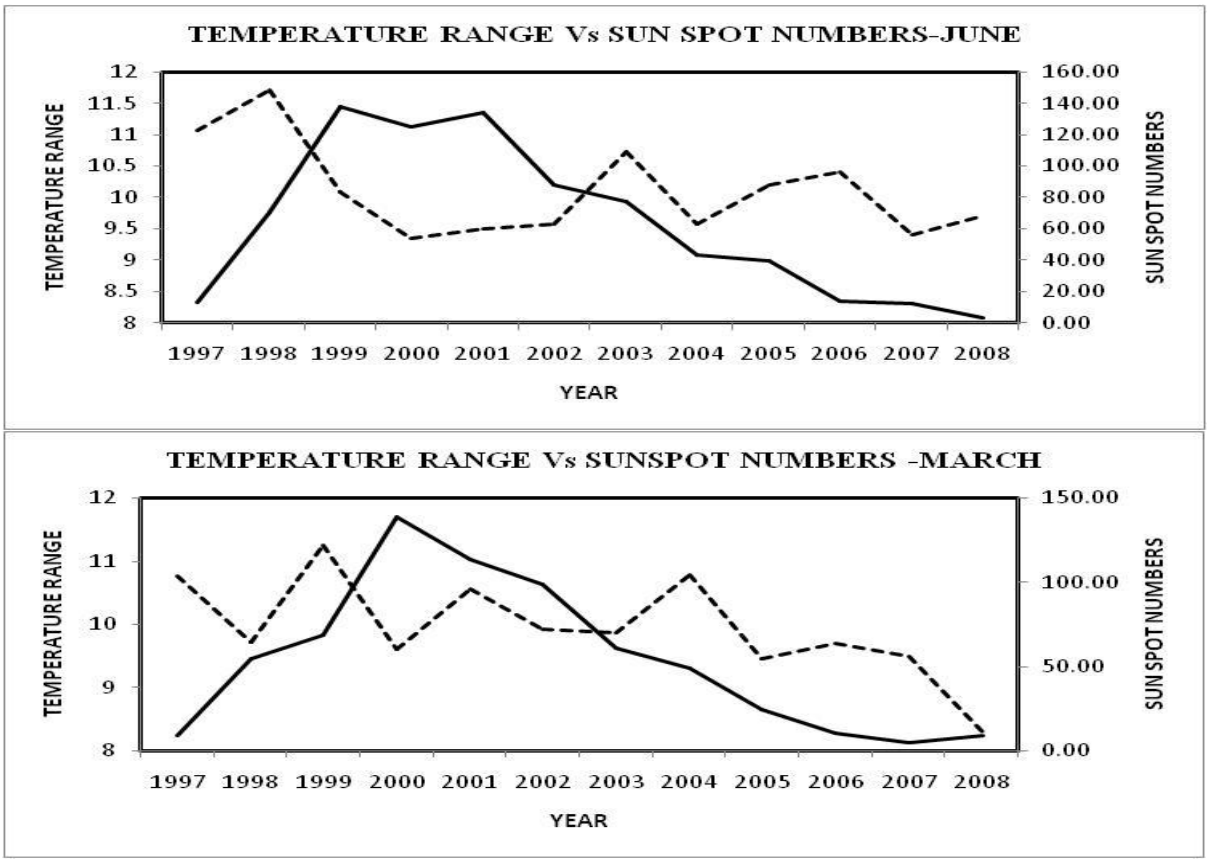


Figure 1: variation of sunspot number with temperature range for March,April ,May and June

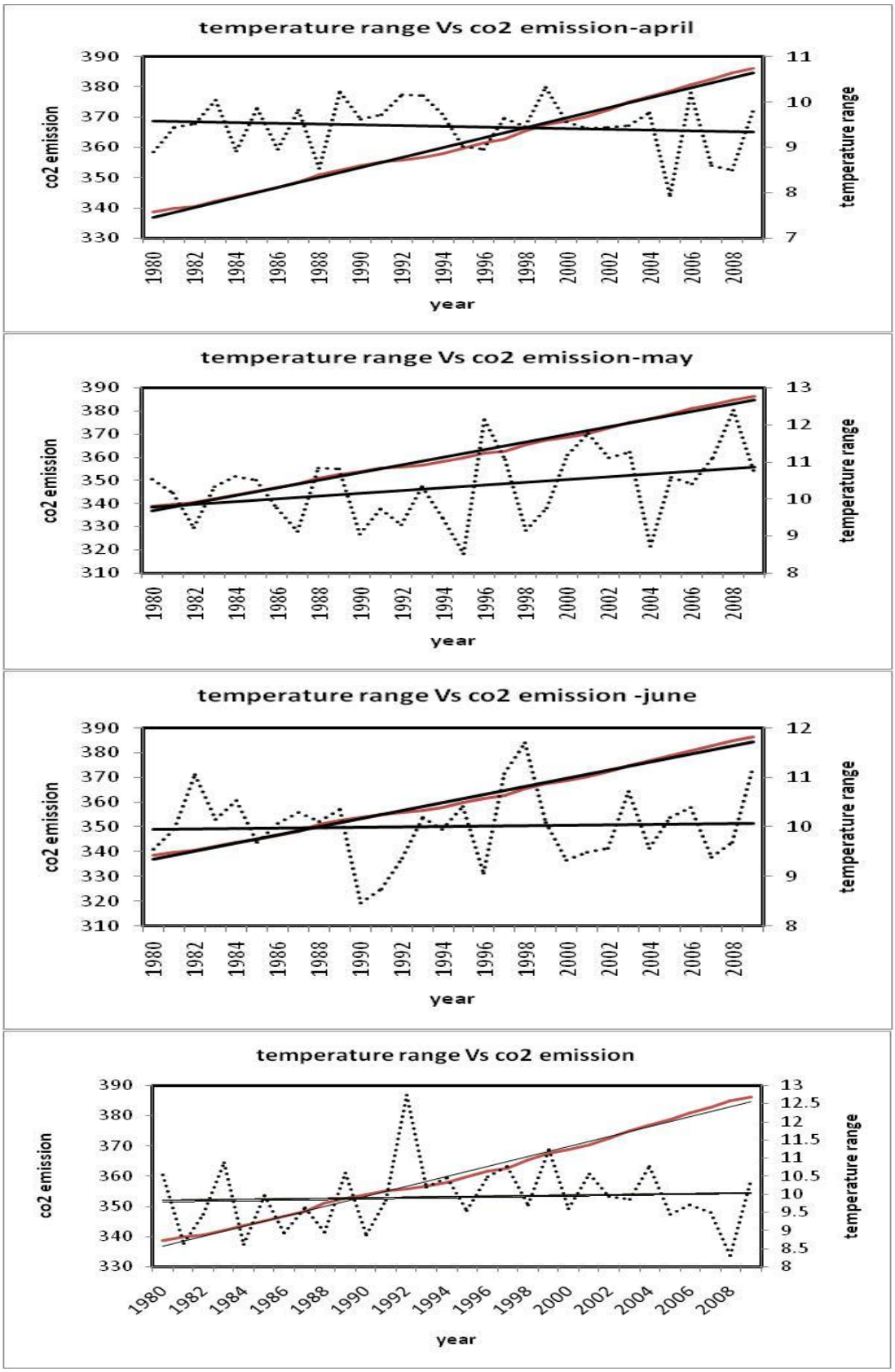


Figure 2: Variation of Temperature range with carbon dioxide concentration

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