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VARIABILITY STUDY OF TEMPERATURE FOR A TROPICAL STATION

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ABSTRACT

The monthly deviation of maximum temperature from the median value has been used to carry out a variability study of temperature for a tropical station, Ibadan (lat. 7.4^0 N, long. 3.4^0 E) Nigeria. The study was undertaken for different seasons during periods of high and low solar activity. Results from the assumed linear correlation between solar activity and maximum temperature suggest that a non-linear form of equation might be appropriate for the variables. Generally, the range of variation of the deviations is independent of solar activity. Negative deviations were greater than positive deviations for both periods of solar activity. Variations occurred in the dry season months of February, March and April during the period of low solar activity, whereas for the wet season, the range of variation occurred in the months of July and September for both periods of high and low solar activity. Temperature variations from the median value do not give thermal gradients that could portend threats to the environment.

Key words: Variability, maximum temperature, tropical station, solar activity, thermal gradients.

INTRODUCTION

The state of activity of the sun varies tremendously in the upper atmosphere where the atmospheric regions are strongly heated by solar ultraviolet radiation and subsequently become heated and ionized. The response of the upper atmosphere (about 60 – 1500 km) to solar disturbances is complex but several studies have affirmed for instance, the dependence of total column electron content with corresponding variations of solar activity (Rastogi and Alex 1987 and Radicella, et al., 1993).

The relationship between solar activity as measured by Zurich sunspot number and tropospheric weather has been controversial and intriguing because of the possibility that the consequences of solar activity might extend below the upper atmosphere (where its influence is unquestionably a major one) to affect meteorological variables in the troposphere, such as temperature.

To date, no conclusive evidences have been reported in the literature, over the sun-weather relationships. It is possible that some efforts may have been made in this direction and probably the results obtained may have either lacked concrete statistical significance or the correlations have appeared questionable for lack of any conceivable scientific mechanism.

The purpose of this study, is to assess the variability of temperature and its dependence on seasonal solar activity, with a view to determining if there are some aspects of solar activity that affects temperature in the present era where global climatic change, ozone depletion and the future of planet earth is receiving a pride of place in world scientific discourse, even if only slightly.

The study was carried out using data from Ibadan (latitude 7.43^0 N, longitude 3.90^0 E, altitude 227.23 km) central station of the International Institute of Tropical Agriculture (IITA-Ibadan, Nigeria). The data was obtained from HMP 35 C Temp / RH probe with an accuracy of $\pm$ 0.2 ^{0}C (Jagtap and Alabi, 1997). Monthly values of temperature for 8 years of low solar activity and 8 years of high solar activity, were used for the analysis.

PROCEDURES OF DATA ANALYSIS

For clarity and effective analysis of data, solar activity has been grouped into two, namely periods of low solar activity (mean sunspot number, $\bar{R}_z \leq 30$) and periods of high solar activity ($\bar{R}_z \geq 90$). This is shown in Table 1.

The number and dimensions of the mean annual Zurich sunspot number R_z change continuously with time and hence with its activities.

If we assume that a linear relationship between the variables exists, then the degree of correlation between maximum temperature and sunspot number may be measured by the product moment correlation coefficient, r, defined as:

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$$r = \frac{\sum x_i y_i - \frac{\sum x_i \sum y_i}{N}}{\left[\left(\sum x_i^2 - \frac{(\sum x_i)^2}{N}\right)\left(\sum y_i^2 - \frac{(\sum y_i)^2}{N}\right)\right]^{1/2}} \quad (1)$$

where x_i = the value of sunspot number for a particular month.

y_i = the corresponding value of maximum temperature for that particular month.

and N is the number of years of database.

A method of establishing the level of availability of solar radiation on horizontal or inclined surfaces or changes in atmospheric conditions may be determined by defining the 'clearness index' or 'cloudiness index' for any location. The clearness index is a measure of the transparency of the atmosphere to solar radiation, while the cloudiness index defines the cloudiness and turbidity of the atmosphere. The two radiation parameters thus describe different conditions in relation to radiation transfer in the atmosphere.

In Nigeria, Ideriah and Suleman (1989) characterized the sky conditions in Ibadan in terms of the monthly clearness index for the period 1975 to 1980. The two broad seasonal trends, namely dry season and wet season were subsequently subdivided into six periods as follows:

Dry season

- (a) November, December, January
- (b) February, March, April

Wet season

- (a) August
- (b) July, September
- (c) June, October
- (d) May

Physically, temperatures are lowered by increased clouds as clouds reduce solar irradiance of the ground. Since temperature is a surrogate for measurements of irradiance, the study would be carried out along the lines of the seasonal patterns used by Ideriah and Suleman (1989) for Ibadan.

Seasonal characterization of some locations in the West African sub-region may be found in the literature (Awachie and Okeke, 1982; Kuye and Jagtap, 1992; Akuffo and Brew-Hammond, 1993 and Udo, 2000).

The deviations of monthly values of maximum temperature from the median values were determined for both periods of high and low solar activity. Median values of temperature are used in the analysis because in practice, they give indication of a more suitable measure of central tendency than mean values. Mean values are affected by the extreme values of a data distribution while median values are not.

RESULTS AND DISCUSSION

The coefficient of correlation between maximum temperature and sunspot number was calculated using equation (1). The kind of analysis that suggests a possible correlation between temperature and solar activity is illustrated in Fig. 1. It was found that positive correlations between maximum temperature at Ibadan and sunspot number exist with the highest correlation coefficient of 0.70 being recorded in May and the least with magnitude 0.10 in June (typical rainy season months) during the period of low solar activity. Such a wide variation can hardly be explained from any scientific point of view.

The fluctuations of the variations in correlation coefficient climaxes during the period of high solar activity with a high positive correlation coefficient of 0.8 in the month of August and a rapid reversal of a negative correlation coefficient of –0.8 in the month of September. Negative values of correlation coefficient may be interpreted as physical contradiction of solar-terrestrial relationships in terms of activities around the sun and meteorological variables at the surface of the earth.

It seems clear then that variations of correlation coefficients of these nature cannot explain satisfactorily any linear relationships between solar activity and maximum temperature at the ground level, that could be of use to any scientific application. It is however possible that there may be high non-linear correlation between the variables that might require further investigation.

It has become imperative at this juncture to appraise the statistical significance or otherwise of the monthly, seasonal deviations of temperature from the median values for both periods of low and high solar activity. Deviations of maximum temperature from the median for the periods under investigation were calculated.

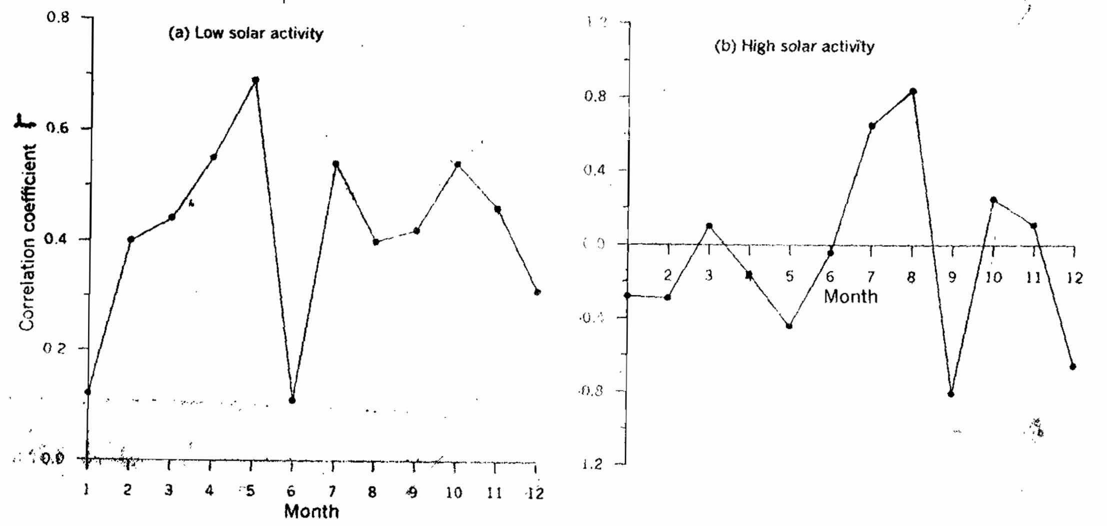

Fig. 1: Correlation coefficients of sunspot numbers and monthly average deviations of maximum temperature from the median.

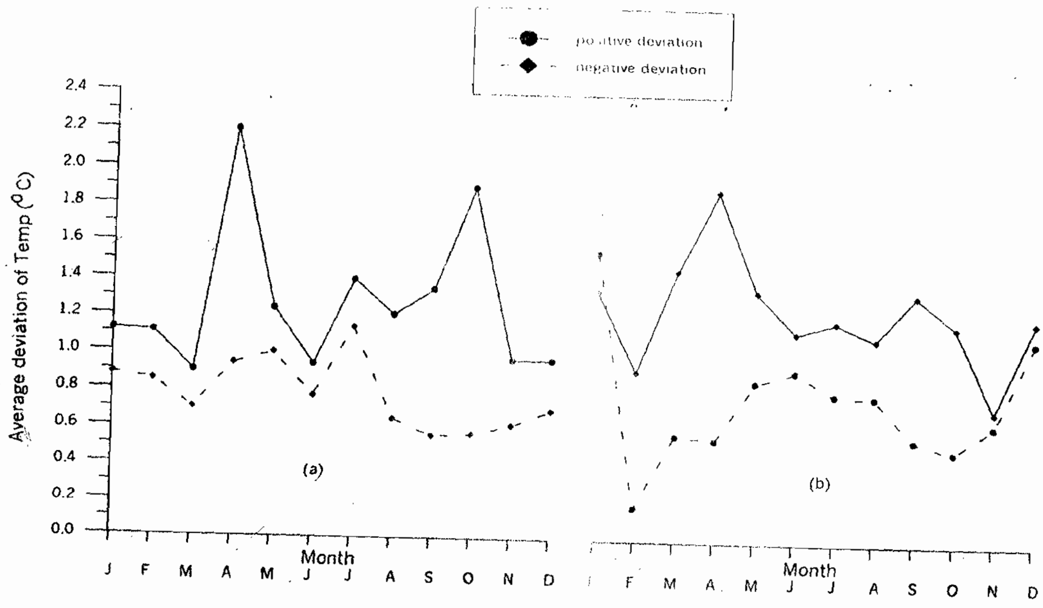

Fig. 2: Monthly average positive and negative deviations of temperature from the median.

Figure 2 shows the results obtained. Generally, the range of variations for both periods of solar activity are not significantly different.

Table 2 shows the average seasonal values and the range of variations of each period of solar activity. For the dry season the highest range of variations occurred in the months of February, March and April during the period of low solar activity, while the reverse was the case at the period of high solar activity. On the average however, the magnitudes of the range of variations are comparable for both periods of solar activity.

The situation is different during the wet season. The highest range of variation occurred in July and September for both periods of solar activity. The lowest range of variation occurred during the month of August at both periods of solar activity. The absolute magnitudes of the negative deviations are of consistently higher values than those of the positive deviations at all seasons during both periods of low and high solar activity. Table 3 shows the average positive (Ud+) and average negative (Ud-) deviations for each period of solar activity. The deviations, on the average, are of the same order of magnitudes for both

Table 1: Characterization of mean Zurich sunspot number, R_Z

Low solar activity		High solar activity	
Year	R_Z	Year	R_Z
1980	154.6	1985	17.9
1981	140.4	1986	13.4
1982	115.9	1987	29.4
1989	157.6	1995	17.5
1990	142.6	1996	8.6
1991	145.7	1997	21.5

periods of solar activity. The negative deviations are greater than the positive deviations for the periods under investigation.

Results from the above analysis on the variability of temperature deviations from the median values at Ibadan have indicated from the near two solar cycle data (1980-1998) that no abnormally high value of temperature deviation from the median were established, despite the high values of sunspot numbers observed during the period under study.

High values of sunspot numbers are normally associated with solar flares at the earth's upper atmosphere. Excessive eruptions of sunspots eject charged particles into space, often described as 'plasma dumping' along latitudes close to 66.5^{0}N and 66.5^{0}S as shown from a theory by Stormer (1907), cited by Olatunji (1989), which could interfere with shortwave radio communication, satellite communication, power supply systems and also cause large variations in the earth's magnetic field.

Results from the present study however indicate that the variations of maximum temperature from the median values during both periods of solar activity do not represent drastic temperature gradients that could threaten thermal comfort in the tropical environment. Further investigation

Table 2: Seasonal average positive (Ud+) and negative (Ud-) deviations of temperature and range.

	Low solar activity			High solar activity		
	Ud(+)	Ud(-)	Range	Ud(+)	Ud(-)	Range
Dry season						
(a) Nov., Dec., Jan.	2.20	-3.06	5.26	3.31	-3.29	6.60
(b) Feb., March, April	2.49	-4.21	6.70	1.33	-4.30	5.63
Wet season						
(a) August	0.65	-1.21	1.86	0.80	-1.11	1.91
(b) July. Sept.	1.70	-2.75	4.45	1.38	-2.55	3.93
(c) June, October	1.34	-2.84	4.18	1.44	-2.32	3.76
(d) May	1.00	-1.24	2.24	0.87	-1.36	2.23

Table 3: Average deviation of temperature for the entire periods of high and low solar activity

	Ud+ (^{0}C)	Ud-(^{0}C)
Low solar activity	0.81	-1.27
High solar activity	0.76	-1.24

may be necessary to validate the results of this work using hourly or daily data as input for the study.

CONCLUSION

The study looked into the variability of maximum temperature for a tropical station, Ibadan, Nigeria and its dependence on monthly seasonal solar activity.

From the study, it has been shown that a relationship between maximum temperature and sunspot number for periods of low and high solar activity does not suggest a possible linear correlation between the two variables, but there could be high non-linear correlations as indicated by some of the results in the study. Linear coefficients of correlation measure the goodness of fit of the equation assumed for the data.

Deviations of temperature from the median show that, on the average, negative deviation is greater than positive deviation for both periods of low and high solar activity.

The highest range of variations occurred in the dry season months of February, March and April during the periods of low solar activity, while the situation is reversed during the period of high solar activity.

For the wet season, however, the highest range of variation occurred in the months of July and September for both periods of solar activity, while the month of August also recorded the lowest range of variation for both periods of solar activity.

Deviations of temperature from the median values and the range of variation observed in the present study suggests that abnormalities in terms of temperature gradients which could portend potential threats to thermal comfort in the tropical environment does not seem feasible from the point of view of contemporary sunspot eruptions.

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