e-ISSN: 2582-5208
International Research Journal of Modernization in Engineering Technology and Science
Volume:03/Issue:01/January-2021 Impact Factor- 5.354 www.irjmets.com

THE RELATIONSHIP BETWEEN SUNSPOTS NUMBER AND SOME LOWER ATMOSPHERIC PARAMETERS AT SOLAR MINIMUM OF SOLAR CYCLE 24.

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ABSTRACT

This study investigates the relationship between Sunspots Number (SSN) and some meteorological parameters (rainfall, solar radiation, maximum temperature and relative humidity) over Sokoto (which lies in the Rima Basin area between latitude 12º 15' 29" North of the equator and longitude 13º 58' 22" East of the Greenwich meridian). The datasets used for both SSN and meteorological parameters are from January 2008 to December 2008, which correspond to the year of solar minimum. The findings of this research work show a tendency of SSN driving the commencement of rainfall. The solar radiation depicted a very significant relationship with SSN. The maximum temperature shows the likelihood of been influenced by the SSN at the solar minimum while the relative humidity was found to establish a relatively significant correlation at solar minimum. Evidently, at the solar minimum of the solar cycle, the rainfall and the maximum temperature were found to have a moderate coefficient of –0.42 and 0.41 respectively, the relative humidity has a moderate coefficient of -0.5 while the solar radiation has a high moderate coefficient of 0.69. Thus, a relationship is seen to be established between SSN and the lower atmospheric parameters at solar minimum of solar cycle 24.

Keywords: Sunspots number (SSN), Meteorological Parameters, Solar minimum.

I. INTRODUCTION

Solar minimum is a regular period of low solar activity during the 11 years solar cycle. It occurs during the last phase of the previous cycle and temporally overlapping onset and rise of the next cycle (Karen and Oran 1999). Climate is most affected by several natural (such as atmospheric composition, solar energy flux, albedo), and anthropogenic factors. However, there are also subtle natural phenomena which can have a significant impact on the climate. One of such phenomena is solar activity. It is quite evident that, the Earth's atmospheric composition has been changing continuously since the beginning of the industrial evolution, especially after the 1970's. This change is generally attributed to two main factors: greenhouse gases (GHGs) and solar activity changes (El-Borie et al., 2012). The solar-climate relationship is currently a matter of a fierce debate. Despite the increasing evidence of its importance, solar-climate variability is likely to remain controversial until a physical mechanism is established. Nevertheless, it is important to identify the primary forcing agents since they provide the fundamental reason why the climate changed. A key issue of climate change is to identify the forcing and their relative contributions (Badruddin, 2014). Some scientist asserted that the sun has an influence in our climate but the extent of this influence compare to other contribution is really not known. The recent change in our climate is a matter of great concern. Many researchers have justified that the carbon emission in our atmosphere is majorly responsible in weather variation the world is experiencing. The question is, if the world tends to reduce the carbon emission and yet the global temperature tends to be increasing, then, it invariably indicates that there seems to be a correlation between the solar activity and atmospheric temperature. In this regard, climate change has become a prominent item on the agenda of world concerns. It is a growing crisis with economic, health and safety, food production security, and other dimensions (Hady, 2013).

The sunspots is one of the most notable phenomena in the sun's surface. It is a dark area on the sun's surface and the next most obvious feature that appears on the photosphere after the dazzling brightness of the sun. The life of a sunspot is highly variable; some spots last only a few days, whereas a few may survive four or five solar rotations (of about 27 days each). Their exact nature is not known, but they appear to be vortices in the matter comprising the photosphere. Sunspots appear dark because the surface temperature is only about 3000 °K, compared with the 6000 °K of the quiet photosphere. Sunspots tend to group together. A group may contain a few isolated spots or dozens of spots. One of the most interesting features of sunspots is their unusually strong magnetic fields. These may approach 0.4 Wb/m^2 (Weber per square meter) (4000 G) for the larger spots (Davies, 1965).

The sunspot number (SSN) time series is the only direct record at our disposal to retrace the Long-term evolution of the solar cycle and the probable long-term influence of the Sun on the Earth environment. Therefore, it was and is still used as key information in many fields of research, quite obviously in solar physics, but also in climate studies (Hathaway, 2002). The troposphere and lower part of the stratosphere have been of considerable interest both in understanding the dynamics of lower atmosphere as all of our normal day-to-day activities occur here. All atmospheric weather is confined in this lower region (Joshua and Shola, 2012). Obviously, most weather occurs in the troposphere, the lower part of the atmosphere. Weather is made up of multiple parameters, including air temperature, atmospheric pressure, humidity, precipitation, solar radiation and wind. Each of these factors can be measured to define typical weather patterns and to determine the quality of local atmospheric conditions. Although, a significant number of studies have been performed in this field reporting correlations between parameters characterizing solar activity and numerous meteorological parameters such as temperature, pressure, wind velocity and global circulation, precipitation etc, these correlations have been studied on long-time scales (e.g. millennial time scales, centennial time scales and decadal time scales), as well as on short-time scales when the solar activity variations last some days, but our focus in this research is mainly to determine the existence of a relationship between the sunspots number and meteorological parameters at solar minimum of solar cycle 24. The objective of this research work is therefore to illustrate and analyze the variability of sunspots number and some meteorological parameters from January 2008-December 2008.

II. MATERIALS AND METHODS

The data involved in this research work are: the sunspot index and the Meteorological data. The daily mean sunspot number is freely obtained from the United States National Geophysics Data Center. The data was interpolated to produce an average as monthly mean sunspot number. However, observed meteorological data recorded in the Sokoto Airport Meteorological station were also used in this study. The data were provided by National Meteorological Agency of Nigeria (NIMET). Daily meteorological data including maximum temperature, relative humidity, solar radiation and amount of rainfall for 2008 (a period of 1year) were collected. The daily Meteorological data were also interpolated to produce averages for monthly mean. The data spans January, 2008 to December 2008.

An integration of MATLAB and a Statistical Correlation was adopted in this study in order to visualise the trends of correlation between the different parameters in relation to Sunspot number and the strength of their correlation as well. The visual curve observation techniques using, MATLAB was employed for graphical representations to illustrate the nature and variation of each parameter to ascertain how the sunspots number has connection with each of the other parameters. And a Pearson correlation coefficient was employed to measure the strength of the coefficient association between the two separate variable. Where the r = 1 means, a perfect positive correlation and the value r = -1 means, a perfect negative correlation. To study the amount or degree of correlation between two variables say X and Y, Spearman rank correlation is computed as follows.

$$r(x,y)=\frac{\sum\left(x-\bar{x}\right)\left(y-\bar{y}\right)}{\sqrt{\left[\sum(x-\bar{x})^2\sum\left(y-\bar{y}\right)^2\right]}}$$

The categorization of coefficient with their respective strength by (Laurenz et.,al 2019) is adopted in this research work with a modification to accommodate certain values beyond their specification. The categorization is of the range:

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0.25-0.34 coefficient to represent a low correlation

0.35-0.49 coefficient to represent a moderate low correlation

0.50-0.65 coefficient to represent a moderate correlation.

0.66-0.75 coefficient to represent a moderate high correlation

III. RESULT AND DISCUSSION

Monthly variation of Plot of SSN and Associated Parameters for 2008

Figure 1.0 and 2.0 shows the plot of monthly variation of SSN, rainfall, solar radiation, maximum temperature and relative humidity for 2008. The SSN in 2008 marked the commencement of solar cycle 24. It is characterized with the lowest solar activity and hence regarded as a year of solar minimum. The result of the comparison between the variation of SSN and rainfall in 2008 revealed that, the commencement of the rainfall in the month of April is also seen to correspond to a slight increase in SSN as shown in Figure 2.0. This line of connection is as well in correspondence with the peak of maximum temperature. It is however observed that the peak of SSN in the month of March corresponds to the peak of solar radiation. Further observation from the plot shows a strong connection between the SSN in relation to solar radiation, maximum temperature and relative humidity in the month of August. It is seen that the minimum declination of SSN corresponds to the minimum declination of solar radiation and maximum temperature. It is however seen to coincide with the peak of relative humidity with a one month lag at the peak of rainfall as shown in Figure 2.0.

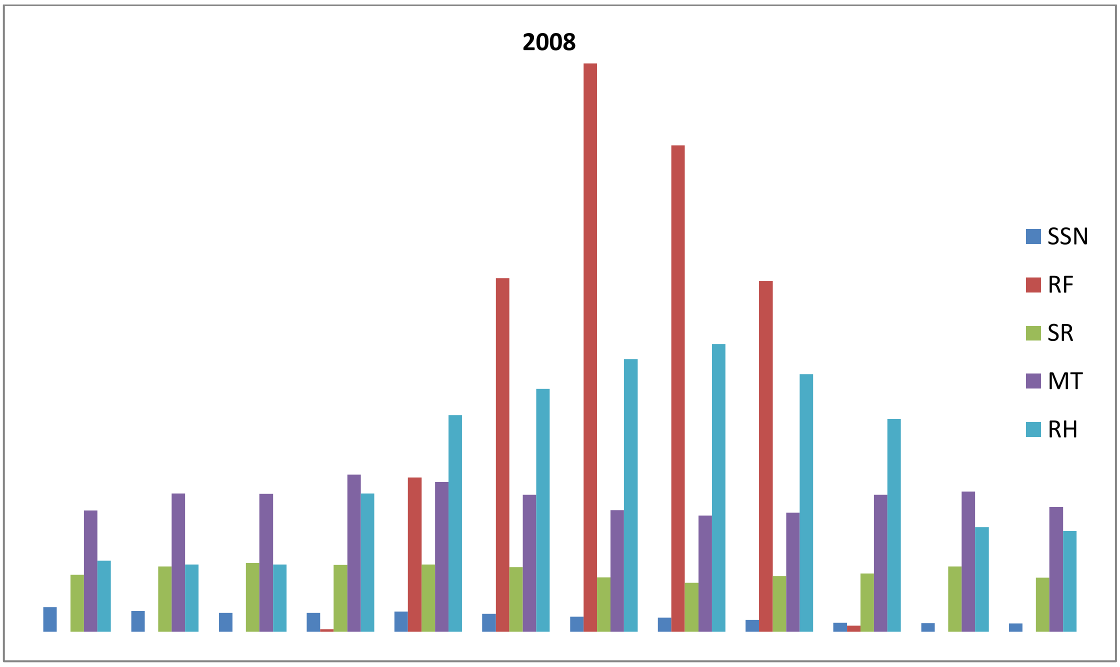

Fig.-1: Monthly variation of SSN, rainfall, solar radiation, maximum temperature and relative humidity.

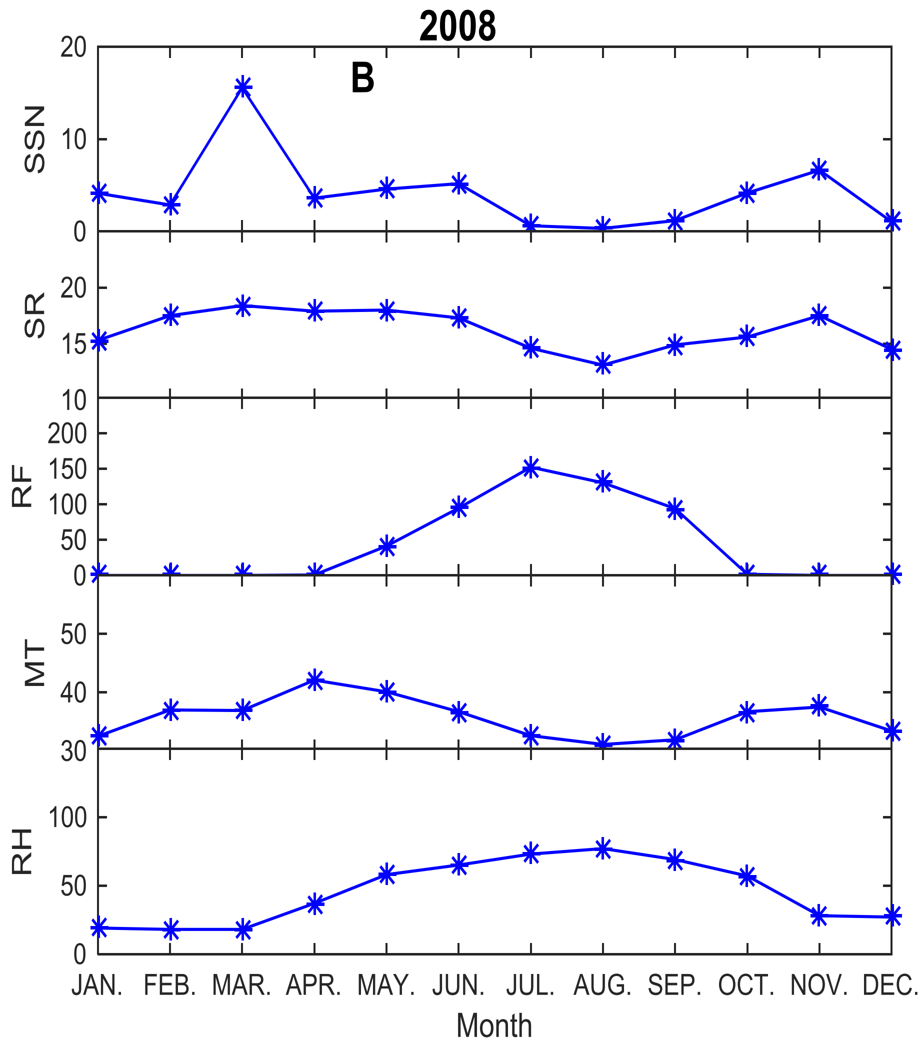

Fig.-2: 2008 plot of SSN and sub plots lower atmospheric parameters

IV. STATISTICAL ANALYSIS

In order to investigate whether a more direct association between solar activity and other parameters can be established, a statistical configuration is employed on the computed correlation analysis. The correlation between sunspots number and meteorological parameters in 2008, shows significant years shaded in the table 1.1 The Pearson coefficients vary within year ranging from moderate high to moderate low correlation, comprising of both positive and negative coefficient. The shaded potion on the table is an indication of the strength of the coefficient. The blue color represents a moderate high coefficient, the red color represents a moderate coefficient, and the green color represents a moderate low coefficient.

From table 1.1 it is shown that, the solar radiation has moderate high coefficient of 0.69. It can also be deduced that, the rainfall distribution over the years has a moderate negative correlation of -0.46 in 2008, The maximum temperature has a moderate low coefficient of 0.41, while the relative humidity has a negative moderate coefficient of -0.50.

Table-1: showing the strength of correlation between the SSN lower atmospheric parameters

SSN	2008
RF	-0.46
SR	0.69

MT	0.410
RH	-0.50

The variation of the SSN and the amount of rainfall shows likelihood of the SSN driving the commencement of rainfall at solar minimum. This is in agreement with the finding of Calbet et al. (2001) who established a possible relationship between sunspot number and total annual precipitation from the Izana Observatory. Engel and Geel (2012) also affirm the influence of solar activity on a centennial to millennial timescale. Laurenz et al. (2019) had shown a correlation between precipitation and solar activity in central Europe during some months in a visual curve comparison. The results were similar to that of (Li et al. 2017). However, Tripathi, and Bhattacharya(2014) in their research on Sunspot Activity Over the Indian Rainfall Pattern, a critical analysis of the result indicates a positive correlation between rainfall and average number of sunspot on long term time scale whereas on 11-year cycle the correlation coefficient is negative or very low.

The monthly variation of SSN and solar radiation shows a decline in SSN corresponding to an increase in solar radiation in the early months. It is then followed by a decline in SSN and a corresponding decline in solar radiation in the later months around the year of solar minimum. From a statistical point of view, a powerful positive relationship in 2008 is established. These evidently indicate a possible influence of SSN on solar radiation which is in conformity with the finding of Sumathi and Selvaraj (2011), in their work on Solar Constant, Sunspots and Solar Activity studying 23 solar cycles. It was found that solar energy value varies with sunspot numbers.

The comparison of the variation of SSN and maximum temperature depicted an existence of a significant correspondence between them. The peak of solar radiation is seen to correspond with minimum declination of the SSN around the solar minimum (2007-2010).

The monthly variation of SSN and relative humidity relates a declining SSN at solar minimum corresponding well with the relative humidity. Georgieva et al. (2005) confirms that solar activity influence on climate is mediated by its influence on atmospheric circulation.

V. CONCLUSION

From the study, it can be concluded that, the findings of this research work shows a tendency of SSN driving the commencement of rainfall at solar minimum. The solar radiation depicted a very significant relationship with SSN. The maximum temperature shows the likelihood of been influenced by the SSN at solar minimum and finally, the relative humidity was found to establish a relatively significant correlation at solar minimum. However, the findings of this study will therefore be of great importance for weather production by meteorological agencies.

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