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Study of the variability of atmospheric parameters for Yola

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ABSTRACT

Solar radiation which is the electromagnetic energy from the Sun(both total and in various wavelengths) varies at different time scales from seconds to decades or centuries— as a consequence of solar activity. The energy received from the Sun is one of the natural driving forces of the Earth's atmosphere and since this energy is not constant because of the changing of day and night times, it has been argued that there must be some non-zero climate responsible for it. This response must be fully specified in order to improve our understanding of the climate system and the impact of anthropogenic activities on it. However, despite all the efforts, if and how subtle variations of solar radiation affect climate and weather still remains an unsolved puzzle. One key element that is very often taken as evidence of a response is the similarity of periodicities between several solar activity indices and different meteorological parameters. The coefficients 'a' and 'b' were calculated from equations (6) and (7) to 0.33 and 0.46 respectively. Equation (8) was used in calculating the clearness index for Yola (9.14^{0}N of latitude) which appeared to show the clearness of the sky of Yola from February to July and October to December.

Keywords: Global solar radiation, ambient temperature, Relative humidity, Rain fall.

INTRODUCTION

Yola which is the capital city of Adamawa State appears tobe very hot almost throughout the months of the year. The temperature there seems to be very high even not on a sunny day. This tells us that the city is also having a high humidity. Hence, we were able to check the variation of the global solar radiation with some atmospheric parameters like the relative humidity, ambient temperature, the rain fall pattern and the cloud cover.

The number of Sunspots visible on the Sun is not constant, but varies over 11- year cycle known as the Solar cycle. The Solar cycle has a great influence on space weather and a significant influence on the Earth's climate since the Sun's luminosity has a direct relationship with magnetic activity [1]. Solar activity minima tend to be correlated with colder temperatures and longer than average Solar cycles tend to be correlated with hotter temperatures. In the 17th century, Solar cycle appeared to have stopped entirely for several decades; few sunspots were observed during this period. During this era, known as the Maunder minimum or little ice age, Europe experienced unusually cold temperatures [2]. Earlier extended minima have been discovered through analysis of tree rings and appeared to coincide with lower-than-average global temperatures [3].

It was then established that our Sun is a fairly typical star, nothing more than one of the variable stars of the Universe. The Sun undergoes changes characterized by variations in its output of electromagnetic and particle radiation over a wide range of temporal scales due to the degrees of activity. Whether these changes have anything to do with the Earth's atmosphere and, especially with weather and climate, has been debated for more than 150 years. In 1982 a National Academy of Sciences (NAS) Panel on Solar Variability, Weather and Climate studied the issue in detail and concluded that "it is conceivable that solar variability plays a role in altering weather and climate at some yet unspecified level of significance"[4]. Since 1982 explosive growth in our knowledge on the Sun's variability and the responses of the different layers of the Earth's atmosphere to it has been made due mainly to Earth satellite observations. The most important discovery is that the total solar irradiance (TSI from now on) varies by about 0.1% over the 11-year solar activity cycle being higher during the maximum of the cycle. Not just the TSI, but also the entire solar spectrum exhibits variations which are strongly wavelength dependent. Larger changes occur at shorter UV wavelengths. Radiation at these wavelengths, which is responsible for stratospheric ozone production, is now known to vary as much as 10% with the 11-year solar cycle and causes changes in the total column ozone at a level which is comparable to the decadal depletion by increasing chlorofluorocarbons. Variations also occur at the solar energetic particle outputs which impact primarily the high latitude terrestrial upper and middle atmosphere. These variations provide evidence of a solar-forced climate change and have been acknowledged by a subsequent NAS study [5]. But like its 1982 predecessor this report too was unable to give a definitive answer to the age-old question of the Sun–climate connection. Apart from the above two referred NAS studies special conferences were devoted to this subject, like "The Solar Engine and its Influence on Terrestrial Atmosphere and Climate" [6] or "The Solar Cycle and Climate" [7]. A recent excellent book which considers the possible meteorological effects of solar activity is that of [8], while several reviews and papers of interest can be found dispersed in nearly every kind of scientific journal due to the truly multidisciplinary character of this subject. Despite the more than 150 years scientific work supporting the view that meteorological phenomena must respond to variations of solar activity, this subject is far from being settled. On the other hand it is, nowadays, widely assumed that increase of the aerosols and greenhouse gases (especially the carbon dioxide), which result from human activities, will have as a result significant warming of the Earth during the next years. This warming should be accompanied by dramatic changes affecting life on it and having several ecological, social and economic consequences. In this context, the improvement of our understanding of the climate system is not only a challenging endeavour of the current scientific research, but also a subject of paramount concern. It is obvious, that in order to isolate a greenhouse footprint of climate change, and we must be able to make distinctions between the contributions that arise from anthropogenic impacts and those that are due to natural influences and particularly the one due to the solar variability. Lack of knowledge of solar influences will limit our ability to clearly gauge the possible impacts of our own activities on the present and future climate.

Nomenclatures

H_0 = extraterrestrial insulation on horizontal surface in the absence of atmosphere measured in (MJ/m^2-day)

H_g = the monthly average daily global solar radiation falling on a horizontal surface at a particular location measured in (MJ/m^2-day)

a, b = Coefficients defined in equations (6) and (7) respectively
I_{sc} = solar constants having the recommended value of $1367Wm^{-2}$(Klein, 1977)
d = day number in the month of the year
Φ = the latitude of the location (degree)
δ = the solar declination (degree)
w_s = is the sunset hour angle, at solar noon being zero and in the morning is positive (degree)
S_{max} = the day-length in (hour)
S = the monthly mean daily number of observed sunshine hours (hour)
K_T = clearness index

MATERIALS AND METHODS

Data Collection

The following parameters were collected from the Archives of the Adamawa State air-port Yola for the period of five years, from two thousand and three to two thousand and seven (2003-2007).

✓Sunshine hour
✓Ambient temperature
✓Relative humidity
✓Averaged amount of rain fall

Data Analysis

The solar radiation outside the atmosphere incident on a horizontal surface (Extraterrestrial Radiation on a horizontal Surface) is given by the following expression.

$$H_o = \frac{24x3600}{\pi} I_{sc}\left[1 + 0.033\cos\left(\frac{360d}{365}\right)\right]\left[\cos\Phi\cos\delta\sin w_s + \sin\Phi\sin\delta\left(\frac{2\pi w_s}{360}\right)\right] \quad (1)$$

H_0 is the extraterrestrial insolation on horizontal surface where I_{sc} is the solar constants having the recommended value of 1367Wm^{-2}[9], Φ the latitude, δ the solar declination, w_s is the sunset hour angle [10].

$$S_{max} = \frac{2}{15} w_s \quad (2)$$

With S_{max} being the day-length.

The declination angle is calculated as [11]:

$$\delta = 23.45\sin\left\{\frac{360(284 + d)}{365}\right\} \quad (3)$$

and

$$\cos w_s = -\tan\Phi\tan\delta \quad (4)$$

The Global Radiation At Horizontal Surface:

[12] was the first scientist known to suggest a simple linear relationship to estimate global solar radiation. Later on [13] put the correlation in a convenient form.

The monthly global solar radiation H/H_0 falling on a horizontal surface at particular location is given as below

$$\frac{H_g}{H_o} = a + b\left(\frac{S}{S_{max}}\right) \quad (5)$$

where H_g is the monthly average daily global solar radiation falling on a horizontal surface at a particular location, H_0 the monthly mean daily radiation on a horizontal surface in the absence of atmosphere, S the monthly mean daily number of observed sunshine hours, S_{max} the monthly mean value of day length at a particular location and "a", "b" the climatologically determined regression constants to be determined as follows, [14]

$$a = -0.110 + 0.235\cos\Phi + 0.323\left(\frac{S}{Smax}\right) \quad (6)$$

$$b = 1.449 - 0.553\cos\Phi - 0.694\left(\frac{S}{Smax}\right) \quad (7)$$

In equation (5) S/S_{max} is often called the percentage of possible sunshine hour [15].

$$K_T = \frac{H_g}{H_o} \quad (8)$$

Where K_T represents clearness index [10].

RESULTS AND DISCUSSION

The equation (5) above was used in estimating the global solar radiation when the extraterrestrial radiation Ho was obtained from equation (1) and the day-length from equation (2) since the sunshine hour has been measured and obtained from the Yola, Adamawa State air port. The coefficients 'a' and 'b' were calculated from equations (6) and

(7) to 0.33 and 0.46 respectively. Equation (8) was used in calculating the clearness index for Yola (9.14^{0}N of latitude) which appeared to show the clearness of the sky of Yola from February to July and October to December.

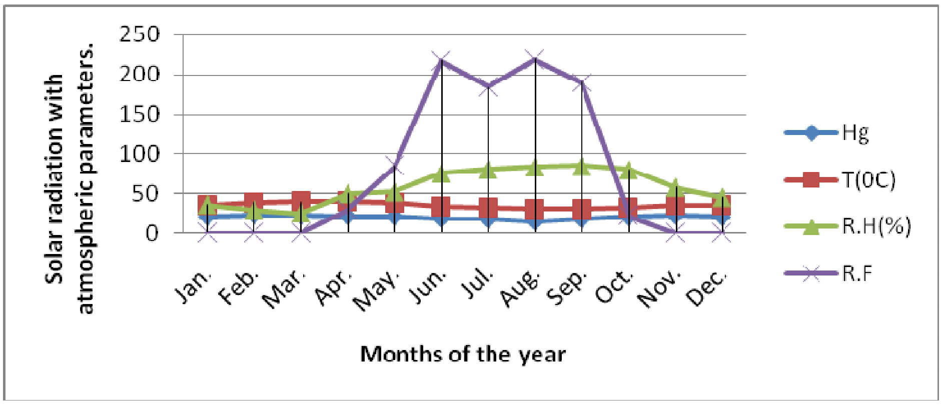

Figure 1. Variability of the Solar radiation with Temperature, (^{o}C), Relative humidity, (%) and the Rain fall (mm) in the year (2003)

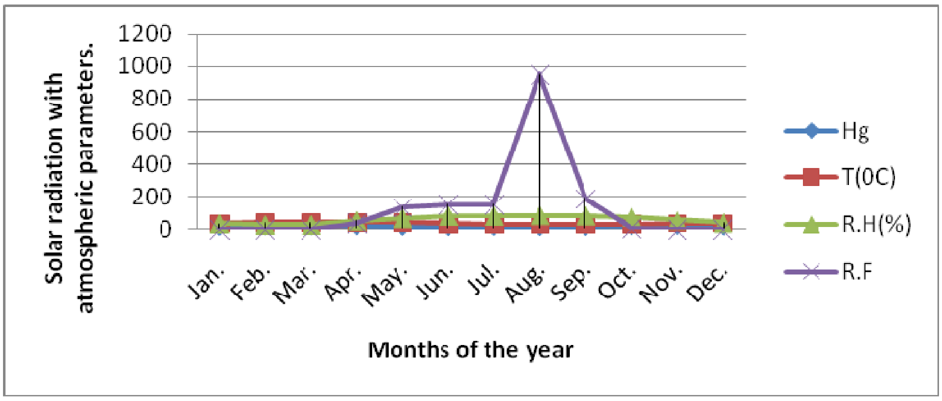

Figure 2. Variability of the Solar radiation with Temperature, (^{o}C), Relative humidity, (%) and the Rain fall (mm) in the year (2004)

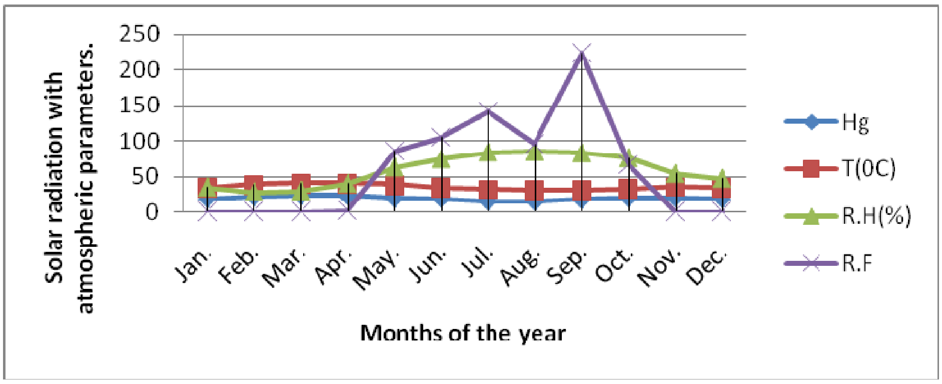

Figure 3. Variability of the Solar radiation with Temperature, (^{o}C), Relative humidity, (%) and the Rain fall (mm) in the year (2005)

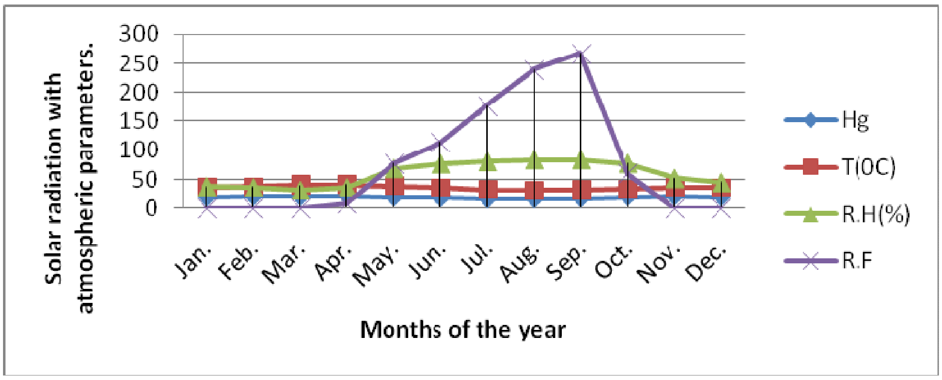

Figure 4. Variability of the Solar radiation with Temperature, (°C), Relative humidity, (%) and the Rain fall (mm) in the year (2006)

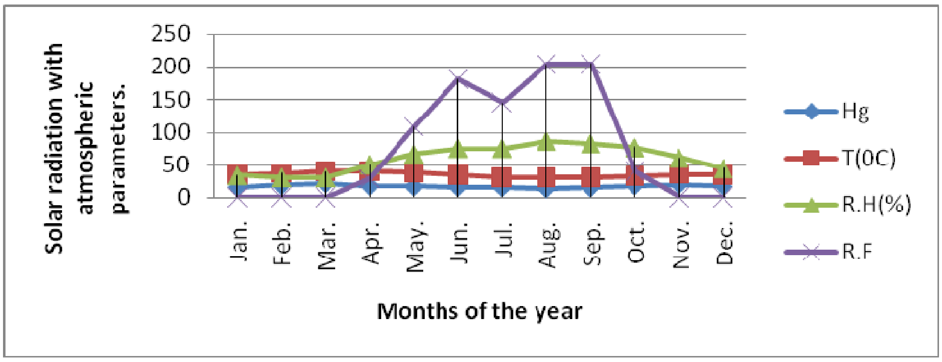

Figure 5. Variability of the Solar radiation with Temperature, (°C), Relative humidity, (%) and the Rain fall (mm) in year (2007)

Shown above are plots of the variability of the global solar radiation against the ambient temperatures, the relative humidity and the amount of rain fall. Figure 1, is the plot for year 2003, in which we have the maximum rainfall of 219.2mm, in the month of August at the temperature of 31.1°C, relative humidity of 84% and the solar radiation of 14.8MJ/m^2-day. Figure 2, is the plot for year 2004, in which we have the maximum rainfall of 189.6mm, in the month of September at the temperature of 31.3°C, relative humidity of 84% and the solar radiation of 18.1MJ/m^2-day. Figure 3, is the plot for year 2005, in which we have the maximum rainfall of 223.7mm, in the month of September at the temperature of 31.5°C, relative humidity of 83% and the solar radiation of 17.5MJ/m^2-day. Figure 4, is the plot for year 2006, in which we have the maximum rainfall of 267.0mm, in the month of September at the temperature of 31.3°C, relative humidity of 84% and the solar radiation of 17.0MJ/m^2-day. Figure 5, is the plot for year 2007, in which we have the maximum rainfall of 205.0mm, in the month of September at the temperature of 31.4°C, relative humidity of 83% and the solar radiation of 15.2MJ/m^2-day.

CONCLUSION

From this study, the clearness index of Yola is encouraging which is a favorable condition for solar energy utilization. The degree of hotness of Yola appeared to be because how humid the city is which even appeared to be high during rainy season. It has also been seen that the rainfall time for Yola has always been from April to October, with the peak of it been in September with the exception of the year 2004 which appeared to have the peak in August.

And of course, part of the recent upsurge of interest in the evaluation of Sun-climate relationships is due to the fact that man-produced substances are believed to be altering our environment and this subject has raised the public and scientific concerns. In that spirit the detection of cycles in both solar and climatic variables is important because it may provide an impetus to develop physical theories to better quantify the terrestrial relevance of the Sun's variability. Thus research in this area is important not only because it will lead to the improvement of our understanding of the climate system, but also for protecting life and environmental quality and predicting the time of rainfall in the location so as to know when to plant and what to plant earlier than the others. It is noteworthy, that the influence of solar variable inputs on climate is only a side branch of the general field of climate modeling and should not be understood to suggest that anthropogenic changes are not important.

The significance of any correlation is difficult to assess as long as the physical mechanism has not been established and formulated. A serious basis for a linking mechanism is the one proposed by Tinsley and his colleagues [16]; [17], where it is assumed that electrically induced changes in the microphysics of clouds (electro freezing) enhance ice nucleation and formation of clouds, and can lead to large scale changes in tropospheric circulation. An answer to the problem of the connection between cosmic ray flux and cloud radiative forcing may be provided by a team of atmospheric, solar– terrestrial and particle physicists, which has joined together to construct the cosmic leaving outdoor droplets (CLOUD) experiment [18]. It is noteworthy, that a successful mechanism will improve our basic understanding of fundamental physical processes that influence our climate system.

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