SUNSHINE HOURS VARIABILITY AND ITS RESPONSE TO AEROSOLS IN LAGOS STATE NIGERIA†

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Abstract
This paper analyses the variability of sunshine hours for an equatorial region of Lagos (06°35' N, 03°19' E) Nigeria. It is found that the total sunshine hours has seasonal variability which maximizes in April and minimizes in July. Unlike a decreasing trend in sunshine hours found in some countries the sunshine hours in Lagos the busiest city in Nigeria is found to be increasing at a rate of 0.0449hrs/yr for a period of nine years. The paper investigates the possibly effects of Aerosols on the variability of the sunshine hours using Aerosol Index from Earth Probe TOMS (Total Ozone Mapping Spectrometer) Version.8.

Key Words: Sunshine hours, Aerosols, clouds, Lagos, solar radiation,

1. INTRODUCTION

The energy transferred from the sun in the form of radiant energy to the earth’s surface is called solar radiation, Donald (1982). Solar radiation is an important source of energy which plays a pivotal role in technological and social development. In recent times, the cost of conventional fuel has been on the increase and its availability is shrinking day by day. Realizing this, man has been attempting for some time to make use of the sun’s radiant energy as an alternative source of energy. However, his success has been limited as the economic utilization of solar energy requires a level of technological development that has not yet been attained. Presently the world is witnessing very rapid technological


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advances, as such it is expected that within a few years the cost of solar energy tapped directly will become competitive with that of the conventional sources of energy. Solar radiation knowledge is essential in the study and design of systems which use solar radiation data applications and should be thoroughly measured on a continuous basis over long periods of time.

It has been observed that the network of stations measuring solar radiation data is sparse in many countries of the world. In Nigeria, only few stations have been measuring the daily solar radiation on a consistent basis (Chineke, 2007). It therefore becomes necessary that solar irradiance has to be estimated from other meteorological data (Zhou et al. 2005; Sabziparvar 2007; Wu et al. 2007; Bulut and Buyukalaca 2007). Stanhill and Cohen 2005 recommended that Sunshine duration is an equally reliable proxy for exploring changes in solar radiation.

Solar irradiance measurements from various regions around the globe have documented a steady decline in solar radiation across the globe from the mid-1950s to the 1980s, a phenomenon that is generally termed as global dimming (Stanhill and Cohen 2001; Liepert 2002; Alpert et al. 2005, Ohmura, 2006, Roderick and Farquhar, 2002). From the mid 1980s an increasing trend in solar irradiance has been observed around the globe which is termed solar brightening (Wild et al., 2005).

A number of authors have discussed in detail the potential reasons for global decrease in solar radiation and sunshine hours. This includes; Satheesh and Moorthy (2005) who showed that wind speed quite significantly contributes to global irradian forces by influencing natural aerosol concentration. Liu et al (2002) illustrated that increase in regional scale clouds as a result of increasing anthropogenic emissions of aerosols could lead to reduction in sunshine hours, while Cutforth and Judiesch (2007) suggested that increased cloudiness could reduce the sunshine hours. Pinker et al. (2005) attributed the possible causes of global dimming to changing cloud cover, increasing manmade aerosols and the lowering of atmospheric transparency following explosive volcanic eruption.

Foukai et al., (2006) noted that both the solar dimming and brightening cannot be explained by variations of the Sun’s radiative output while Norris and Wild (2007) suggested that it could be as a result of changing in atmospheric transmittance caused by variations in aerosol concentrations.

Aerosols are known to affect climate in two ways, they influence the planetary albedo by scattering and absorbing radiation (direct effect) and they modify the physical and radiative properties of clouds by acting as cloud condensation nuclei (indirect effect).
Although the exact magnitude of aerosol-induced radiative forcing is uncertain, aerosols are thought to have a net cooling effect. Thus, they may mask the warming effects of anthropogenic increases in greenhouse gases (Wigley, 1989; Kaufman et al., 1991; Charlson et al., 1992; Obiekezie and Okeke 2005; Penner et al., 1992; Christopher et al., 1996; Kiehl, 1999, etc).

Following the recommendation of Stanhill and Cohen (2005), this work is set out to estimate the variations in sunshine hours for Lagos the busiest city in Nigeria and to investigate the possibly effects of Aerosols on the variability of this sunshine hours.

2. SOURCES OF DATA

Mean monthly sunshine hours, defined as the number of hours of bright sunlight per day as measured by a sunshine recorder were collected for an equatorial region of Lagos (06°35' N, 03°19' E) Nigeria from the archives of the Nigerian Meteorological Agency, Federal Ministry of Aviation, Oshodi, Lagos, and were available for nine consecutive years starting from 1997 to 2005. The Aerosol index for Lagos was obtained from the Earth Probe TOMS (Total Ozone Mapping Spectrometer) Version.8.

3. RESULTS AND DISCUSSION

Fig.1. depicts the yearly variation in sunshine hours for the duration of nine years from 1997- 2005. A positive linear trend of 0.0449hrs/yr is found which is an indication that sunshine hours has not been decreasing but shows a minimal growth or a steady rise (Solar brightening) over the years. This result is in disagreement with the results obtained by (Tan 1999) in Southwest China, (Li 2000) in central China, (Yao and Wu 2002; Tang and Li 2003) Qinghai-Tibet plateau, (Yang et al. 2004) North and Northeast China, (Zhang et al. 2004) Eastern China, (Xu and Zhao2005) in the Yellow River basin, (Liu et al 2002) in Taiwan and (Palle and Butler 2001) in Ireland all of which portrays a decreasing trend in sunshine hours (Solar dimming).

From fig.1, 2004 is found to have the highest sunshine hours with a mean value of about 5.6hrs/day while the minimum is found in 1998 with a mean value of about 4.8 hrs/day. The general picture of how the sunshine hours varied over the years shows that Lagos city has at least 5 hours of bright sunshine hours on the average per day.

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To thoroughly understand and isolate the driving forces behind the variations in sunshine hours, average monthly sunshine hours for the nine year period is plotted in Fig. 2. Average monthly sunshine hours is highest in April with a mean value of 6.3 hrs/day and the lowest is found in July. The mean sunshine-hours in April is found to be 1.67 times higher than the mean value in July. Based on the prevailing seasons in the study area, i.e., The Long Rainy Season (April –July), the Short Dry Season (August-September), the Short Rainy Season (October-November), the Long Dry Season (December- March) the average seasonal trends of sunshine hours are –0.84, 0.167, 0.48 and 0.15 hr, respectively. These values suggest a decline in sunshine hours during the long rainy season as compared to the other three seasons (short rainy season, short dry season, and long dry season).

This result is consonance with the results of Ezekwe, (1988), Akpabio, and Etuk, (2003).
Fig. 2. Variation of sunshine hours with months of the year

Fig. 3 displays the monthly variation of TOMS aerosol index for Lagos during the nine year period (TOMS aerosol index of less than 0.1 indicates a crystal clear sky with maximum visibility, whereas a value of 4 indicates the presence of aerosols so dense you would have difficulty seeing the mid-day sun). From fig.3, the minimum index was found in August with a mean value of about 0.73 which indicates a clear sky free from aerosols while the highest value was found in January with a mean value of about 3.18 indicating the presence of moderate aerosols in the sky.
From fig. 3, the month of August is seen with a small value of aerosol index indicating a very clear sky; in effect a high value in bright sunshine hours is expected but when compared with fig. 2, the month of August has less than 5hrs of sunshine. Also, the month of January has high value of aerosol index implying that aerosol is indicated in the sky; the hours of sunshine from fig. 2 was found to be more than 5hrs. The linear regression analysis does not show a significant positive correlation between sunshine hours and aerosol index both at monthly level ($r = 0.538214$, $r^2 = 0.289674$) and annual level ($r = 0.3225$, $r^2 = 0.1040$). It could be deduced from here that the direct effect of aerosols (absorption and scattering of direct sunlight) does not influence sunshine hours in Lagos. The result is in consonance with the results of Palle and Butler (2001) and in variance with the results of Luo et al. (2000) and Guo and Ren (2006) who analyzed the change of sunshine hours and effect of aerosol and concluded that a decrease in visibility resulting from an increase of aerosol is the main reason of sunshine duration decrease.
4. CONCLUSION

The results obtained here reveal that sunshine hours vary regularly; in years, in months and in seasons. The yearly variation displays an increasing trend which suggests solar brightening; the monthly variation is seen with a maximum occurring in April which is about 1.67 times larger than the minimum which occurred in July. The seasonal trend is seen to have a negative value for the long rainy season implying that sunshine hours decreases in the long rainy seasons as compared to the other three seasons (short rainy season, short dry season, and long dry season).

The linear regression analysis result does not show a significant positive correlation between sunshine hours and aerosol index. It is generally expected that as the aerosols in the sky increases, the duration of sunshine hours should decrease but this is not so for the city of Lagos, it is therefore concluded that aerosols in the sky do not directly influence the duration of sunshine hours in Lagos, Nigeria.

Consequently, it is suggested that a comprehensive statistical analysis of other meteorological data could be very helpful in investigating the cause of this observed variability in sunshine hours.

Acknowledgment

The Nigerian Meteorological Agency, Federal Ministry of Aviation, Oshodi, Lagos and NASA/GSFC TOMS Processing Team are gratefully acknowledged for providing the sunshine hours data and the Aerosol Index data.

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