NIGERIAN JOURNAL OF SPACE RESEARCH 10: 61 - 71, 2011 MAY 31

Solar Irradiance Variation with Humidity, Temperature and Wind Speed in Minna, Nigeria

Ezenwora, J.A., Oyedum, O.D., Igwe, K.C., Eichie, J. O. and Moses, A.S.

Department of Physics, Federal University of Technology, Minna

Abstract

Over some years now climatic change has become a serious global issue affecting lives of humans, species and our environment negatively. Scientific research efforts are geared toward possible solution to this. Meteorological data collation and analysis play a pivotal role in these research efforts. Solar irradiance variation with humidity, temperature and wind speed have been analyzed using data from Nigeria Environmental and Climatic Observation Programme (NECOP) station deployed at the grounds of Federal University of Technology Minna (latitude 09°37'N, longitude 06°32'E and 249 metres above sea level). The data which was recorded at five minutes intervals was averaged monthly for sunshine hours between 07.00 and 18.00 hours local time. Yearly variation of solar irradiance with relative humidity, temperature and wind speed for two year period are obtained. The variations follow seasonal variations and the results which reveal decreasing trend of solar irradiance within the period also show, on average, decrease in relative humidity, ambient temperature and wind speed.

Key Words: Solar irradiance, Variation, Humidity, Wind speed

1. Introduction

The Sun is the source of most of the energy on Earth-the power source for plants, the cause of flow of atmosphere and of water, and the source of the warmth which makes life possible. None would exist without it. At the Earth's orbit, neglecting absorption by the atmosphere, each square meter of area facing the Sun receives about 1380 joules per second (nearly 2 horsepower). That quantity is known as the solar constant and sensors aboard NASA's satellites over the 1979-99 interval suggests it varied by only about 0.2%

The process of energy change has been going on for billions of years and will continue for billions more until the sun becomes a 'red giant'- exhausted of most of its energy potential. Meanwhile some four million tons of the sun's matter will continue to be changed into energy every second. Conventional heat energy derives from the sun, photosynthesis converts the incident solar energy into plant growth; the vegetation rots away and the ever greater

pressures and temperatures exerted upon this composted, recycled material during the passage of thousands upon thousands of years processes this gradually into the solid, liquid and gaseous fuels which warm our homes, heat our food, propel our transport and progress the march of industrial sophistication (David and Gerald, 1994).

Solar energy is the energy force that sustains life on earth for all plants, animals and people. The earth receives this radiant energy from the sun in the form of electromagnetic waves, which the sun continually emits into space. The earth is essentially a huge solar energy collector receiving large quantities of this energy which manifests itself in various forms other than those mentioned earlier, like heated air masses causing wind, and evaporation of the oceans resulting as rain which can form rivers. This solar energy are tapped directly as solar energy (thermal and photovoltaic), and indirectly as wind, biomass, and hydroelectric energy. It is clean energy, a renewable resource that allows for local energy independence (Foster, 1998).

Over some years now, changes in the statistical distribution of weather over period of time that range from decades to millions of years, have been reported. These changes manifest in different forms like Global Warming, which is defined as the increase of the average temperature on Earth. As the Earth is getting hotter, disasters like hurricanes, droughts and floods are getting more frequent. Over the last 100 years, the average air temperature near the Earth's surface has risen by a little less than 1 degree Celsius or 1.3 degrees Fahrenheit. It doesn't seem that much, yet it is responsible for the conspicuous increase in storms, floods and raging forest fires we have seen in recent years (Allianz.com). In 2009/2010 winter, Britain experienced the longest cold spell in more than three decades, North America was hit by blizzards that brought frost to Florida, and two dozen patients in a psychiatric hospital froze to death on the Caribbean island of Cuba. Also, in Florida, January 2010 icicles was seen hanging from an orange tree in Plant City, water was sprayed onto the tree to protect it from cold weather. 'Surely, global warming has got to be a joke'! Global Cooling or Warming: What to Believe? (Allianz.com).

That is how the argument goes and the number of comments and articles that promote it around the world is growing. The UK's Daily Mail newspaper, among the most avid proponents of 'global cooling', even proclaimed the beginning of a 'mini ice age'. But the fact is that these observed changes are real and so for better understanding of these changes, data analyses from synoptic stations covering all zones and locati

Minna is located in latitude 09°37'N and longitude 06°32'E, at altitude 249 metres above sea level and is one of the Northern states of Nigeria that lies partially, within the semi-arid Sahelian belt of West Africa. The climate of this zone is characterized by two distinct and well-defined seasons, namely wet (or rainy) and dry seasons (also known as Hammattan). These seasons correspond to northern hemisphere summer and winter respectively. The annual onset and cessation of the dry and wet seasons follow the quasi-periodic north-south to-and fro movement of the inter-tropical convergence zone (ITCZ). The ITCZ demarcates the dry dust-laden north-east trade wind from the moisture-laden south-west trade wind. The dry season in the Sahel zone of Nigeria sets in about October each year and persist till about May of the next year. This is the period when the ITCZ is displaced to the south and the prevailing north-east trade wind transports large quantities of dust and smoke from biomass burning into the atmosphere over the entire region (Anuforom, *et al*, 2007).

Dust and smoke aerosols affect the climate system at local, regional and global scales in a number of ways. Due to its direct radiative impact, dust aerosol affects atmospheric temperature, thereby modifying the vertical temperature distribution in the troposphere as a result of the changes in heating and cooling rates at different altitudes (Carlson and Benjamin, 1980; Quijano *et al.*, 2000). The stability of the atmosphere is thus affected. Some studies have suggested that dust and smoke aerosol in the atmosphere affects also the photosynthetically active radiation (PAR) from the sun. The combined effect of dust on PAR and surface temperature affects the physiology and productivity of plants as reported in China (Chameides *et al.*, 1999). Similarly, Isezuo (2003) found that in Sokoto (North West Nigeria), the peaks of hospital admissions for hypertension-related morbidities correspond with peaks of low solar radiation and low temperature in the locality.

So far this discussion demonstrates quite clearly that changes in solar radiation, be it increase or decrease in man-made or natural causes, have a ripple effect on almost, if not all other meteorological parameters with attendant disastrous consequences on life on planet Earth. Intensified research effort from all parts of the globe must be on board for better understanding and mitigation of this monster, if life must continue on this planet; data collation and analyses from every nook and cranny should play a leading role in this regard.

In this study solar irradiance variation with humidity, temperature and wind speed have been analyzed using data from NECOP station deployed at the grounds of Federal University of Technology Minna. The data cover from 2008 to 2009.

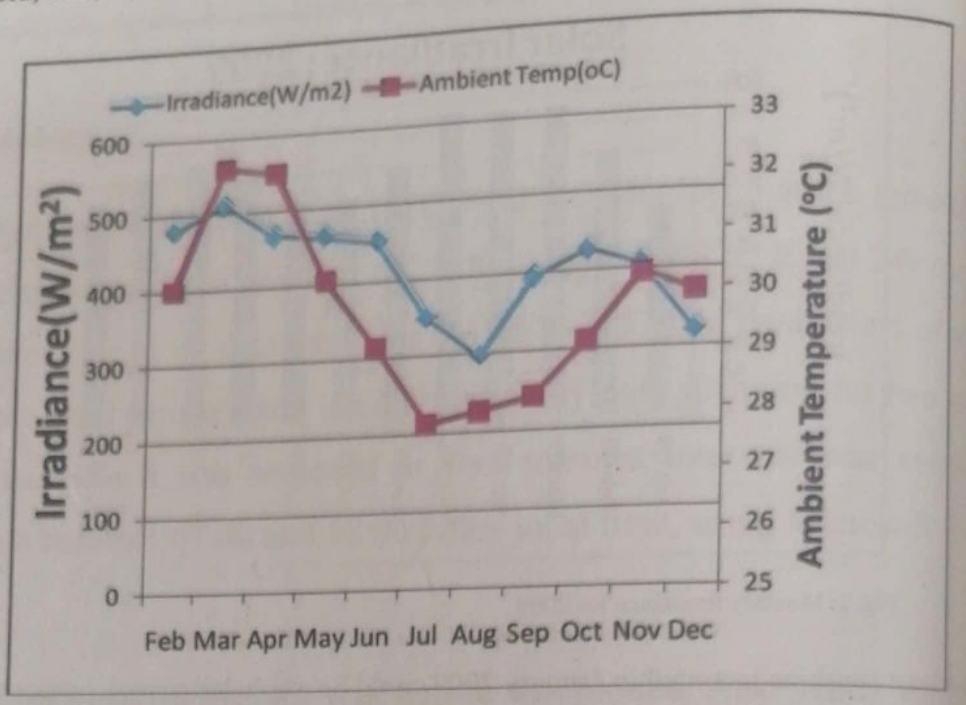

Fig. 3(b)

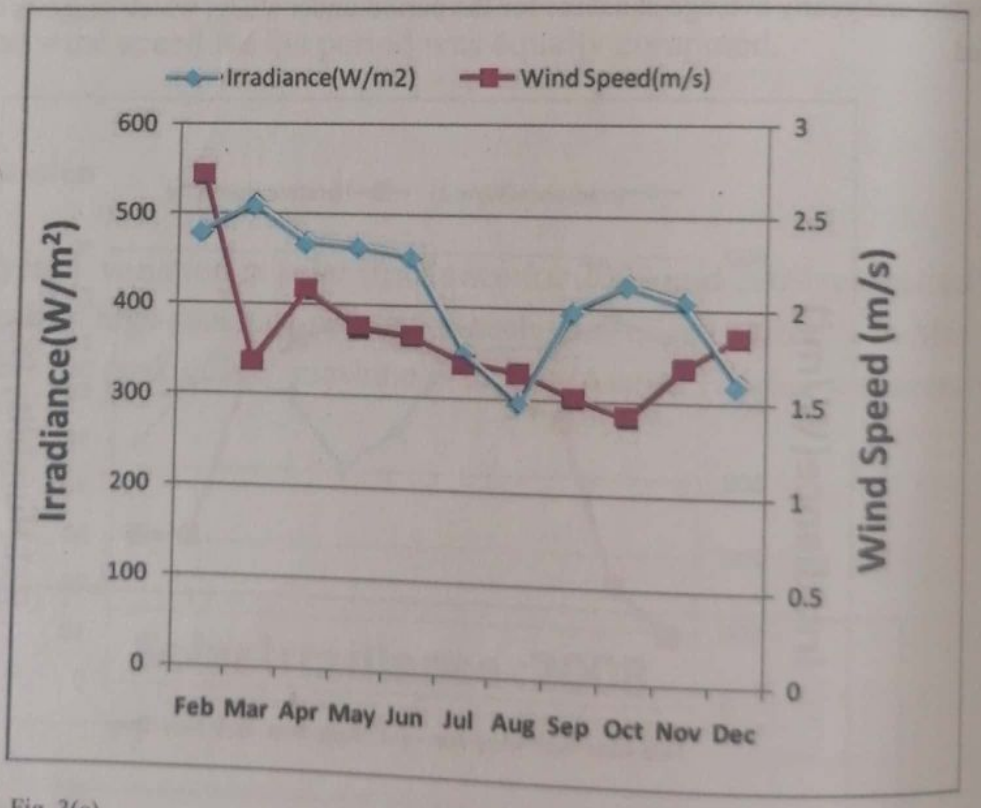

Fig. 3(c)

Fig. 3: Annual (2008) variability in solar irradiance with (a) relative humidity (b) ambient temperature and (c) wind speed.

Figs. 3(a - c) show yearly variation in 2008 of solar irradiance with humidity, temperature and wind speed respectively, while Figs. 4(a - c) show same for 2009.

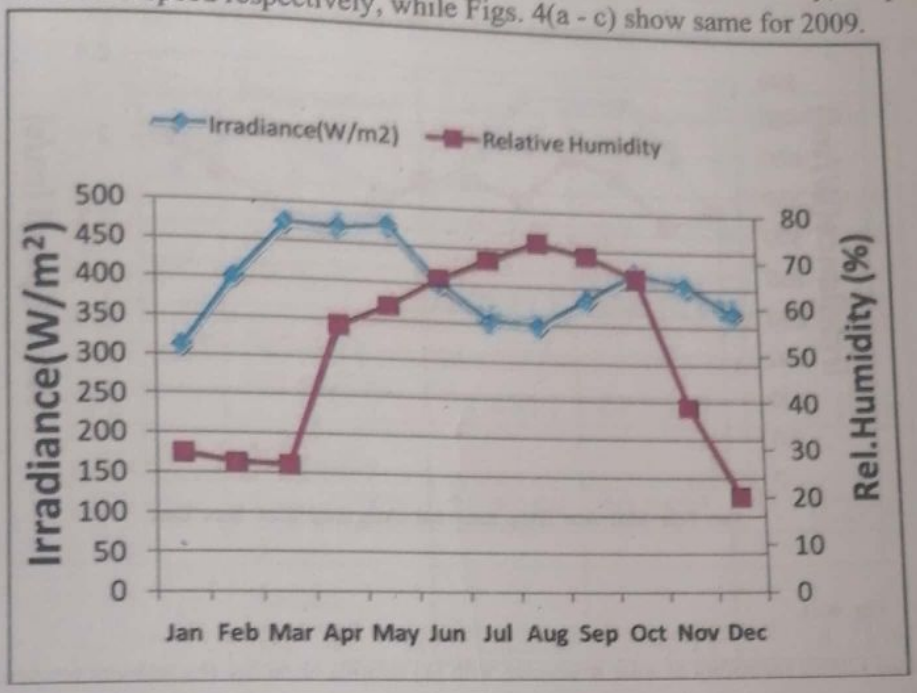

Fig. 4(a)

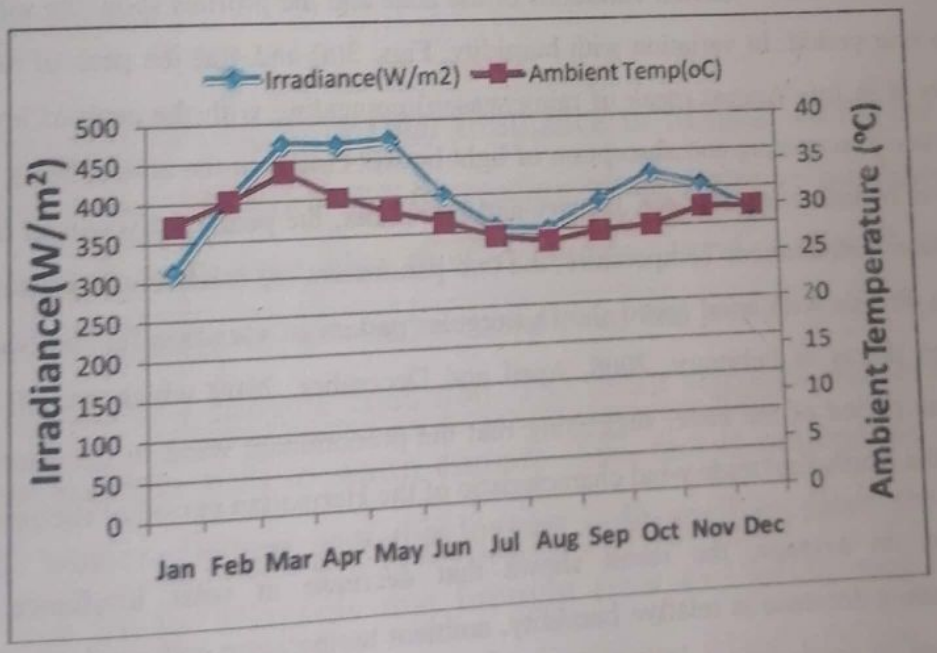

Fig. 4(b)

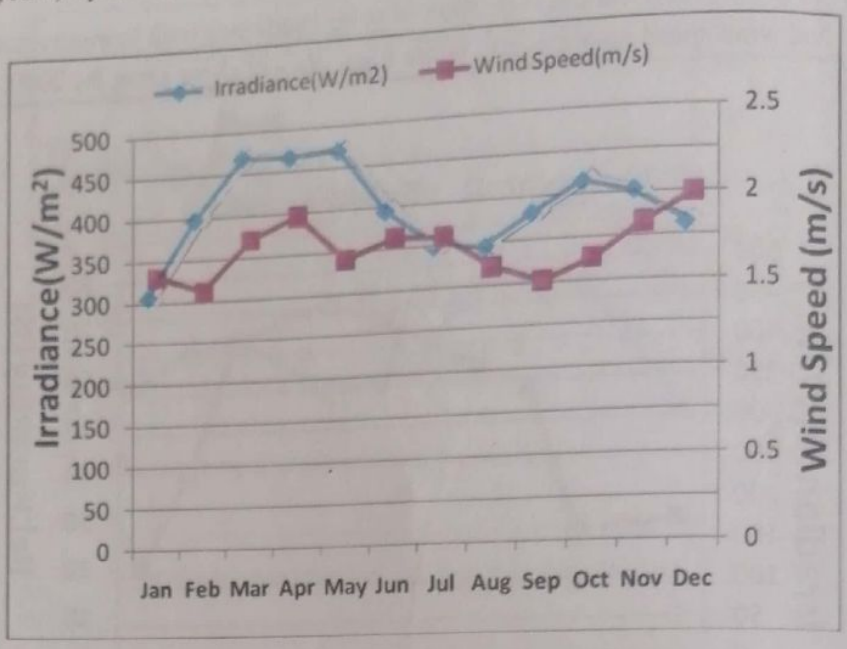

Fig. 4(c)

Fig. 4: Annual (2009) variability in solar irradiance with (a) relative humidity (b) ambient temperature and (c) wind speed.

The variations follow seasonal variations of the zone and the profiles show the same trend in the two year period. In variation with humidity, Figs. 3(a) and 4(a) the peak of high relative humidity is in July/August (peak of rainy season) coinciding with the peak of low sunshine period (due to scattering and absorption of light by wet clouds in the atmosphere), low points of relative humidity are between January and December, the peak of dry season of the zone. In variation with ambient Temperature, the two parameters are relatively in phase, Figs. 3(b) and 4(b). Profile with wind speed shows irregular pattern of variation for the two years but with high points in February, 2008, April and December, 2009 which are all within the Harmattan period of the zone, suggesting that the predominant wind in the zone at surface level, is the North-East trade wind characteristic of the Harmattan period of the zone.

Generally, on average, the result shows that decrease in solar irradiance results in corresponding decrease in relative humidity, ambient temperature and wind speed. Table I summarises in percentage, yearly variation of these meteorological parameters within the study period.

Table 1: Percentage variation in the four meteorological parameters

Parameters	Year 2008	Year 2009	Variation in percentage
Irradiance (W/m^2)	417.412	398.143	4.62%
Relative Humidity	51.4811	49.8529	3.16%
Ambient Temp (^oC)	29.8269	29.7591	0.22%
Wind Speed (m/s)	1.8218	1.74511	4.21%

4. Conclusion

In this study the variability in solar irradiance in Minna, within the period from February 2008 to December 2009 shows a decreasing trend. Relative humidity, ambient temperature and wind speed on average, also show decreasing trend. Although the study period is short and hence the change is a weather condition, the result is in opposing trend to global warming, which is a climatic condition. The result suggests that there may not be a smooth transformation from cold to warm climate. This fact is pointed out by Allianz.com, that in 2009/2010 winter, Britain saw the longest cold spell in more than three decades, North America was hit by blizzards that brought frost to Florida, and two dozen patients in a psychiatric hospital froze to death on the Caribbean island of Cuba. Also in Florida, January 2010 icicles was seen hanging from an orange tree in Plant City, water was sprayed onto the tree to protect it from cold weather.

Also environmental research work carried out on the Sahel zone of Nigeria by Nicholson *et al.* (1998) argue that there has been no progressive change of the Saharan boundary or vegetation cover in the Sahel during the last 16 years preceding their study, as against the trend of encroachment of the Sahara desert.

The result implies clearly that within global climatic change, there are existences of localized weather conditions that may not necessarily conform to the trend of global climatic change. conditions can persist as long as about two decades or more and can

equally have adverse effect on life on planet Earth, it is recommended that weather monitoring equipments for short and long term analyses be provided in all zones and localities of the globe to provide high density data collation and analyses needed for better understanding and possible mitigation of these phenomena.

Acknowledgement

The data used in this paper are obtained from NECOP station in Minna provided by the Centre for Basic Space Science, University of Nigeria, Nsukka. We are grateful to the Director, Professor P.N. Okeke, the management and entire staff of the centre.

References

Allianz.com, (2009). What is global warming? In www.knowledge.Allianz.com

Allianz.com, (2009). Global cooling or warming: what to believe? In www.knowledge.Allianz.com

Anuforom, A.C. *et al.*, (2007). Inter-annual variability and long-term trend of UV-absorbing aerosols during Harmattan season in sub-Saharan West Africa. *Atmospheric Environment* 41, 1550-1559.

Carlson, T.N. and Benjamin, S.G., (1980). Radiative heating rates for Saharan Dust. *Journal of Atmospheric Science* 37, 193-213.

Chameides, W.L., *et al.*, (1999). Case study of the effects of atmospheric aerosols and regional haze on agriculture: An opportunity to enhance crop yields in China through emission controls? *Proceedings of the National Academy of Science*, USA 96 (24). 13,626-13,633.

David, K. and Gerald, H., (1994). Applied Solar Energy (2nd edition). Cambridge: Cambridge University press.

Foster, R., Photovoltaic Market Development and Barriers in Mexico, MBA Thesis, Graduate School of Business, New Mexico State University, Las Cruces, New Mexico, December, 1998, 206 pp.

Isezuo, S.A., (2003). Seasonal variation in hospitalization for hypertension-related morbidities in Sokoto, north western Nigeria. *International Journal of Circumpolar Health* 62 (4), 397-409.

Quijano, A.L. *et al.*, 2000. Radiative heating and direct radiative forcing by mineral dust in cloudy atmospheric conditions. *Journal of Geophysical Research* 105 (D10), 12,207-12,219.