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Developing a Model for Predicting the Visibility for Sokoto Using Fraction of Sunshine Hours Data

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Abstract: A model which correlate visibility with fraction of sunshine hours was formulated for estimating the monthly mean visibility at Sokoto (13°3'N, 8°'E), Nigeria, West Africa are presented. Visibility covering a period of 5 years (2002-2006), obtained from the Meteorological Department Sultan Abubakar (III) International Airport Sokoto. The prediction of the model and the measured visibility was tested using the correlation coefficient and percentage absolute error method. The model was found to be V = 34.55-31.10 (n/N). This could be used to obtain an on the spot estimate of the visibility when required.

Key words: Visibility, fraction of sunshine hour, fog, correlation, dense, Nigeria

INTRODUCTION

Visibility could be defined in many ways depending on the field of interest. In meteorology, visibility is a measure of the distance at which an object or light can be clearly discerned (en.wikipedia.org). It is reported within surface weather observations and METAR code either in meters or sature miles, depending upon the country. Visibility affects all forms of traffic; roads, sailing and aviation. Meteorological visibility refers to transparency of air in dark, meteorological visibility is still the same as in daylight for the same air.

In aviation, visibility is defined as the greater of the greatest distance at a black object of suitable dimensions, situated near the ground can be seen and recognized when observed against a bright background. However, visibility is often reduced some what by air pollution and high humidity. Various weather stations report this as haze (Dry) or mist (Moist). Fog and smoke can reduce visibility to near zero making driving extremely dangerous. Visibility of <100 m or 1/16th of a mile usually reported as zero (Michael, 2010). In these conditions, roads may be closed or automatic warning lights and signs may be activated to warn drivers. These have been put in place in certain areas that are prone to repeatedly low visibility particularly after massive pile-up accidents involving collision or several (or even dozens) of automobiles have occurred there. In addition an advisory is often issued by a government weather agency for low visibility such as a dense for advisory from the US National weather service. Those generally advise motorists to avoid travel until the fog burns off or other conditions improve (Seinfeld and Pandis, 2006). Airport travel is also often delayed by low visibility, sometimes causing long wait due to instrument flight rules and wider spacing of aircraft.

Fraction of sunshine hours is defined as the ratio of the total number of hours of sunshine to the maximum total possible during the day, denoted by n/N where n is the total number of hours of sunshine and N is the maximum total possible during a day (Stanhill, 1966). It can be measured by using pyranometer or pyrheliometer depending on the solar radiation you want to measure i.e., total radiation and beam radiation, etc. (Drummond, 1956).

It is intended in this research to present some results of measurements and analysis of visibility at Sokoto and to develop model for estimating the visibility in terms of the meteorological parameters having significant influence on it. The meteorological parameter is fraction of sunshine hours. The recent related research works include that of Usman.

MATERIALS AND METHODS

A 5 years record (2002-2006) of the monthly mean visibility was obtained from the meteorological department Sultan Abubakar (III). International Airport Sokoto and sunshine duration hours is collected from the Energy Research Centre, Sokoto. Also, obtained were the latitude and longitude of Sokoto, respectively.

The model between the average monthly mean visibility and the meteorological parameter is formulated for this research is as follow:

$$V = a+b\,(n/N) \quad (1)$$

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Where:

V = Visibility
n/N = Fraction of sunshine hours
a, b = Coefficient of regression to be determined

N can be obtained by the relation given by Duffie and Beckman (1991) as:

$$N = 2/15 \cos^{-1}(-\tan\theta \tan\delta) \quad (2)$$

Where:

N = Maximum total possible during a day
θ = Latitude
δ = Solar declination angle

$$\delta = 23.47 \sin[0.9864(284+j)] \quad (3)$$

where, n is the number of days i.e., for Jan 1, j = 1 and Dec 31, j = 365 (Duffie and Beckman, 1991).

RESULTS AND DISCUSSION

For the station under consideration, the measured value of the average monthly mean visibility and the associated parameter is calculated from the data obtained from the meteorological department Sultan Abubakar (III) International Airport Sokoto and Energy Research Centre, Sokoto.

Also, the measured, predicted and percentage absolute error values are determined. These were shown in Table 1 and 2.

The results obtained from Table 2 shows that variations exist between the measured and predicted values of the average monthly mean visibility.

That at March to May visibility is high, minimum at January, November and December while very low at February, August and September with August having the lowest visibility due to heavy rainfall. The results obtained by this analysis also confirm some results of relative humidity measurements earlier reported by Usman where August has the highest rainfall.

In Table 3, statistical analyses of the visibility with the meteorological parameters were shown. From the results, there is reasonable correlation between V_m and $V_{n/N}$ as indicated in the values of the correlation coefficients of 0.63. Hence the linear regression model in terms of fraction of sunshine hours (n/N) for estimating visibility is:

$$V = 34.55 - 31.10\,(n/N) \quad (4)$$

It was shown in Fig. 1 that the predicted values and the measured values ware closely related in the months of January and April which is confirmed from Table 2 because the 2 months have the lowest error. The months of February, August and November have wide gap which is also confirmed from Table 2 because the months recorded high error values with August having the highest value of 6.17%. Table 3 shows the mean of absolute error in percentage.

Table 1: Measured values of the average monthly mean visibility and fraction of sunshine hours, respectively

Months	V (km)	n/N
January	11.62	0.75
February	10.23	0.68
March	18.54	0.66
April	18.54	0.62
May	18.54	0.63
June	18.46	0.60
July	16.15	0.55
August	7.85	0.54
September	9.85	0.62
October	14.85	0.70
November	11.23	0.75
December	13.31	0.79

Meteorological Department Sultan Abubakar (III) International Airport, Sokoto and Energy Research Centre, Sokoto, Sokoto State in 2008

Table 2: Measured, predicted and percentage absolute error value (%) for model

Months	V_m (km)	$V_{n/N}$ (km)	$V_{n/N}$
January	11.62	11.23	0.39
February	10.23	13.40	3.17
March	18.54	15.89	2.65
April	18.54	17.76	0.78
May	18.54	17.45	1.09
June	18.46	15.27	3.19
July	16.15	14.96	1.19
August	7.85	14.02	6.17
September	9.85	11.23	1.38
October	14.85	12.78	2.07
November	11.23	15.27	4.04
December	13.31	9.98	3.33

Researchers computation, 2011

Table 3: Regression of visibility with fraction of sunshine hours and mean of percentage absolute error

	Coefficient of regression		Correl. coefficient (r)	Mean of absolute error
	a	B		
V_m vs. $V_{n/N}$	34.55	-31.10	0.63	2.45

Researcher's computation, 2011

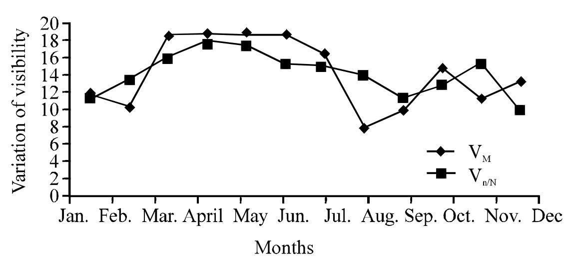

Fig. 1: Variation of the measured and the predicted values of visibility with the months of the year

CONCLUSION

A model for predicting the average monthly mean visibility in Sokoto was studied. The model was based on the fraction of sunshine hours collected over a period of 5 years (2002-2006). The results obtained shows that based on the correlation coefficient of the average monthly mean visibility it may be wisely estimated by the correlation:

$$V = 34.55 - 31.10\ (n/N)$$

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