A Model Simulation of Temperature in Ilorin, Nigeria

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Abstract

Long time series of daily metrological data that are needed in various applications are not always available or appropriate for use at many locations. The temperature simulation model generated for the period of year 2000, 2001 and 2002 was evaluated. Its validity was tested on the monthly mean temperature for the year 2007 and 2008. Observed values and predicted values for the monthly mean temperature were tested graphically for the three years. Various statistical techniques such as descriptive statistics and correlation coefficient were employed to analyze the data. The mean and standard deviation for the observed and predicted values for the years under consideration were calculated and compared. The different in standard error between the observed value and predicted values for the monthly mean temperature is ± 0.01 and the correlation coefficient of 0.98 was obtained. This shows that the model can predict future monthly mean temperature in Ilorin with high accuracy.

Keywords: Temperature, simulation model, correlation coefficient, statistical techniques

INTRODUCTION

Climate and weather have much in common, yet they are not identical. The weather of any place is the sum total of the atmospheric variables for a brief period of time. Thus, climate represents a composite of the day-to-day weather conditions and of the atmospheric elements for a long period of time. Daily weather data are needed in many applications to aid in design of hydraulic structures to evaluate the effects of watershed changes on hydrology within of runoff areas, water quality or erosion (Richardson and Wright, 1984). Information concerning hourly and daily air temperature values is needed for most practical applications of solar energy systems. Thermal solar systems, building design, and thermal simulation performance analysis all require atmospheric temperature values. However, in different geographical areas these data are not available and must be estimated through models that use daily maximum, daily minimum, or monthly average air temperature values obtained from published data. Temperature is one of the main meteorological variables measured by meteorological service networks. Nevertheless, daily and hourly time series, required for most complicated studies and simulations, are expensive. Moreover, they often contain missing data, and, worst of all, these networks are only available in few sites world wide. In Nigeria, the situation is worse because the few ones in the country are hundreds of kilometers apart. It is estimated that Nigeria has over

97,000 rural communities (Oti, 1995), whose population is characterized with deprivation from conventional energy, arising from poor supply infrastructure. Only 18% of the rural population had access to electricity by 1991/1992 (FOS, 1996). Solar radiation data may be considered as an essential requirement to conduct feasibility studies for solar energy systems. There are several models that predict daily minimum, maximum and mean air temperature values. Amato et al (1989) discussed dynamic models for both air temperature and solar irradiance daily time series for Italian climate. Hernandez et al. (1991) developed models for the prediction of daily minimum air temperatures. However Cuomo et al. (1986) studied and analyzed air temperature on a daily basis in the Italian climate. Macchiato et al. (1993) consider 50 stations in southern Italy to analyzed cold and hot air temperature. Heinemann et al. (1996) developed an algorithm for the synthesis of hourly ambient temperature time series that takes into account a monthly average daily temperature pattern. This paper is a continuation of the effort to develop a model which can be used to predict monthly temperature in Ilorin North central Nigeria as the current power supply in the country is inadequate and unreliable.

MATERIALS AND MEASUREMANT PROCEDURE

Measurements of relative humidity at a minute interval and those of temperature and atmospheric pressure was carried out at University of Ilorin in the Department of Physics, North central Nigeria daily for the year, 2004, 2005 and 2006.These data were obtained by a combined temperature, relative humidity and pressure sensor. The sensor contains a beta therm 100KA61 thermistor and a vaisala capacitive relative humidity sensor. The output signals from the sensor are converted from millivolts to their respective units. The instruments are connected to a data logger that record data for eleven days after which the data is downloaded to the computer for analysis. The instrument produces 1440 records daily. The measured data are subjected to quality control check for incorrect measurements.

RESULTS AND DISCUSSION

Three years (2004, 2005 and 2006) sets of data were collected and analyze using Microsoft Excel. These set of data were recorded at a minute interval summing up to 1440 readings daily. The daily mean temperatures were determined by taking an average of the maximum temperature (12 noon) and minimum temperature (12 mid- night). The hourly temperature and the monthly mean temperature were also determined. The model developed for the monthly mean temperature is as shown in equation 1.

$$T_{P=} \frac{T_A}{i+t} + T_m \; Sin\, X \qquad (1)$$

Where T_P is the predicted monthly mean value, T_m is the observed value for the month to be predicted, t is the months (t = 1 for January and 12 for December), X is the mean, i is the year and T_A is the temperature amplitude. The model generated was used to predict the mean daily temperature for year 2004, 2005 and 2006 as shown in figure 1 and table 1. The mean, standard error, standard deviation, variance and correlation coefficient of the observed data were also compared with its predicted value are as shown in table 2 and 3 for year 2004, table 4 and5 for 2005 and table 6 and 7 for 2006. Figure 1 and table 1 show that majority of the predicted values coincided with the observed values while others were very close to the measured values. This shows that the generated model for the monthly mean temperature in Ilorin fits the data. Table 3, 5 and 7 show the correlation coefficient for year 2004, 2005 and 2006 between the measured and predicted values to be 0.93, 0.98 and 0.99 respectively. These values are good for the model as the correlation coefficients are close to unity it indicates high closeness between the measured an d the predicted values. The coefficient of determination R^2 between the measured and the predicted values were also very close to unity which shows the high accuracy of the model. Other calculated parameters like the mean, standard deviation, and variance show a very close relationship between the measured and predicted values.

CONCLUSION

Based on the values of the coefficient and correlation coefficient the equations:

$$T_{P=} \frac{T_A}{i+t} + T_m \ Sin\, X$$

have been found suitable for predicting the monthly mean temperature in Ilorin. The derived data and correlation will provide a useful source of information to designers of renewable energy and air-conditioning systems for these areas. It would also enrich the National Energy data bank. Consequently,
the work should be extended to other zones of the country. The technique used in the model for generating the monthly mean temperature has been discussed. The analysis of the model generated revealed that the predicted values for the monthly mean temperature for the three years (2004, 2005 and 2005) were very close to the measured values. Hence the model generated can be used to predict temperature in Ilorin when long series of historic data are required for research.

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Table 1: Observed values and predicted values for monthly mean temperature (^{o}C) for year 2004, 2005 and 2006.

Months	Observed Values	Predicted Values
1	26.29	26.75
2	28.02	28.98
3	29.03	29.46
4	27.92	28.18
5	27.19	27.34
6	24.94	25.12
7	23.96	24.12
8	23.75	23.87
9	23.90	23.97
10	26.76	26.65
11	27.40	27.23
12	26.89	26.73
13	26.37	26.22
14	28.15	27.89
15	29.19	28.86
16	27.86	27.59
17	26.69	26.47
18	25.34	25.18

19	24.42	24.30
20	23.84	23.74
21	24.12	24.00
22	25.94	25.72
23	27.22	26.93
24	26.84	26.56
25	26.26	26.01
26	28.27	27.91
27	29.30	28.88
28	27.98	27.63
29	27.08	26.77
30	25.13	24.92
31	24.91	24.71
32	23.67	23.53
33	24.31	24.13
34	26.81	26.50
35	27.06	26.74
36	26.93	26.61

Table 2: The mean, standard error, standard deviation and variance of the observed data and the predicted data for year 2004.

	Observed value	Predicted value
Mean	26.34	25.70
Standard error	0.52	0.58
Standard deviation	1.79	2.01
Variance	3.20	4.05

Table 3: Correlation coefficient R for the year 2004

Correlation coefficient R	0.93
Coefficient of determination R^2	0.87

Table 4: The mean, standard error, standard deviation and variance of the observed data and the predicted data for year 2005

	Observed value	Predicted value
Mean	26.33	25.12
Standard error	0.48	0.46
Standard deviation	1.68	1.61
Variance	2.81	2.57

Table 5: Correlation coefficient R for the year 2005

Correlation coefficient R	0.98
Coefficient of determination R^2	0.96

Table 6: The mean, standard error, standard deviation and variance of the observed data and the predicted data for year 2006.

	Observed value	Predicted value
Mean	26.48	25.20
Standard error	0.49	0.46
Standard deviation	1.69	1.61
Variance	2.85	2.58

Table 7: Correlation coefficient R for the year 2006

Correlation coefficient R	0.99
Coefficient of determination R^2	0.98

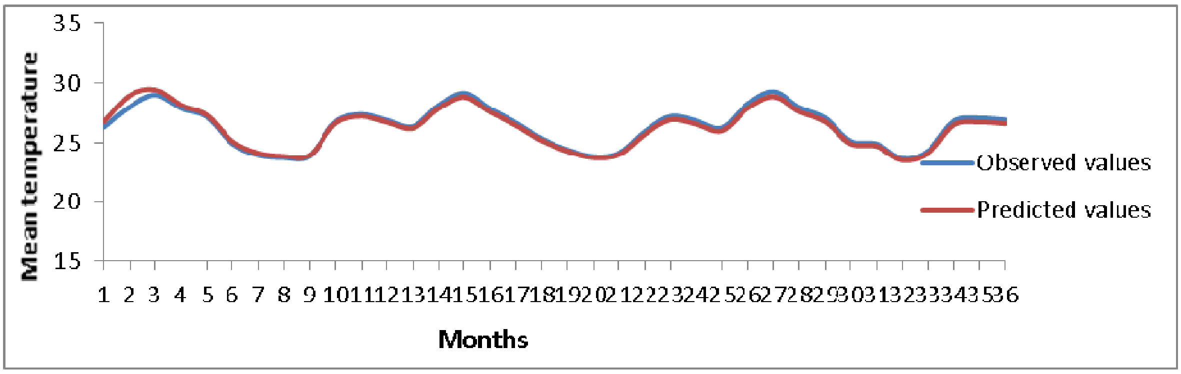

Figure 1: The trend of monthly mean temperature of the predicted and the observed values for three years