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Parametric Analysis of Ground Temperature Profile in Bwari-North Central Nigeria

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Abstract
Predicting future climatic changes is a vital key towards positioning both private and governmental budgeting. This study was on the validity of predicting natural disasters using data from ground temperature. The Bwari region of Abuja-Nigeria was the research site and the research duration was five years. The net earth radiation was discovered to have increased and has been unable to be abated by natural forces. 2013 might experience an increased solar radiation upon the earth, though, there may be a reduced flooding and a heavier flooding in 2014 or 2015.
Keywords: mean monthly ground temperature, flooding, solar radiation, net earth's radiation

INTRODUCTION

The ground temperature which has been synonymously used as soil temperature determines many activities on the land surface. For example agricultural activities rely on the ground temperature for meaningful crop production; the estimation of the ground heat flux and sensible heat flux (Uno et al.,2011a&b); the fractional estimation of the net radiation (Uno et al., 2012); calculation of the evapotranspiration for agricultural purposes; for perceiving the variation of soil compaction in an area(Uno et al.,2011a); detect shallow ground water flow system and to estimate ground water flow velocity (Cartwright 1968, 1974); to detect leakages zone beneath earthen dams(Birman, 1969);to detect areas of increased ground-water flow (O'Brien, 1970).
Many research have done various mathematical modeling to explain ground temperature with respect to time and soil depth. For example, Ingersoll et al.,(1954), formulated an equation from the diffusion of heat equation for a semi-infinite solid which relates temperature below the surface of the earth at a given depth to time as shown below

$$T(z,t) = \frac{1}{2}T(0)exp - z(\frac{\pi}{\alpha P})^2 \sin\left[\frac{2\pi t}{p} + \emptyset(z)\right] + T_m \qquad [1]$$

Where, T(z,t) is the temperature (^{o}c) z centimeters below the surface at a time t. T(0) is the peak-to-peak temperature variation at the surface (^{o}c),z is the depth below the surface, t is the time, α is the thermal diffusivity of the material, P is the period of the wave, $\emptyset(z)$ is the phase of the wave at a depth z below the surface and T_m is the mean annual temperature.
Hilel (1982) gave the annual variation of daily average soil temperature at different depths with a sinusoidal function.

$$T(z,t) = T_a + A_0 e^{-z/d} \sin\left(\frac{2\pi(t-t_o)}{365} - \frac{z}{d} - \frac{\pi}{2}\right) \qquad [2]$$

where T(z,t) is the soil temperature at time (t), **z** is the soil depth, T_a is the average soil temperature (^{o}C), A_0 is the annual amplitude of the surface soil temperature (^{o}C), d is the damping depth (m) of annual fluctuation and t_0 is the time lag .

We derived our own soil model which we called the temperature deviation curve model. Basically, it is represented as

$$\Delta T = A_0 e^{-\rho_s/\rho_b} \sin\left(-\frac{\rho_s}{\rho_b} - \frac{\pi}{2}\right) \quad [3]$$

where ρ_s = soil particle density which is a approximately 2.66gcm^{-3} by Gupta et al. (2011), ρ_b = soil bulk density.It was used to determine the susceptibility of Abuja metropolis to soil compaction (Uno et al., 2012a); determine the annual amplitude of the surface soil temperatures of the same region (Uno et al., 2012a); estimate soil heat flux from both short and long-term remotely sensed surface temperature (Uno et al., 2012b);

The first task we undertook was to formulate our kind of solution from equation [1&2]

$$\Delta T = T(0) e^{-z(\frac{\pi}{\alpha})^2} \sin\left[\frac{2\pi(t - t_o)}{365} + \emptyset(z)\right] \quad [4]$$

where $\Delta T = T(z,t) - T_m$.

This paper is fundamentally targeted at monitoring the ground temperatures for five years to predict what may likely be in the coming years. Most importantly, the recent climatic change which was responsible for massive flooding in Nigeria would be monitored from the set of data's provided by the metrological agency.

MATERIAL AND METHOD

The study area is Abuja, Federal Capital Territory (FCT), central part of Nigeria . The soil samples were collected from the sampling sites in Bwari area council. The region of study is located between latitude 8^o 24'N - 9^o 20'N of the equator and between longitudes 7^o 30'E - 8^o 48'E of the Greenwich Meridian**.** The study was carried at 30cm soil depth. The subsoil for the soil samples were identified within the particles range 68±3% sand,26±5% clay,5±2% silt, 0.6±3% organic carbon,1±2% organic matter. Bwari area council and its environs are known for agricultural produce as majority of its population are farmers. Drenches were made and thermometers were inserted at exactly 30cm below the soil surface as shown in figure[1]. Precisely, four thermometers were spaced four(4) metres along the drench. The drench was properly covered. The thermometers were read and recorded at every two hours from 11am to 5pm. The average readings were recorded against each. The experiment duration was forty-eight (60) months i.e. from 2008 to 2012.

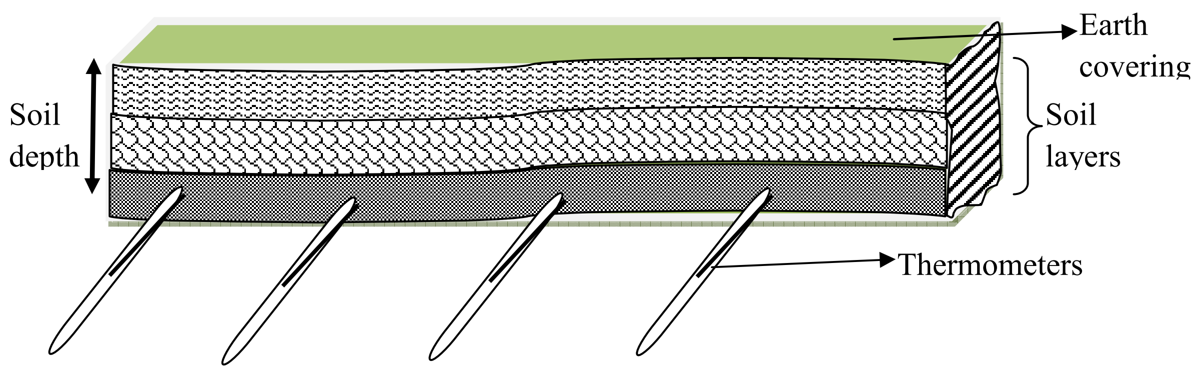


Figure1: Practical measuring method of determining ground temperature

RESULTS AND DISCUSSION

The mean temperatures for the months for the five years are recorded as shown below (table[1]-[5]). May 2008, had the highest mean temperature for five years. The temperature builds –up from January to April affirms that the solar radiation for 2008 had an arithmetic progression over the Bwari region. Thereafter, (viewing figure[1]) drops low from the month of June to august. This period had the lowest drop in five years. It could be explained that the period had the highest rainfall in five years. The temperature build-up form from september,2008 to march 2009 is striking. First, the solar radiation dose over this region was fluctuating, though it observed the usual temperature increase due to the dry season.

March and august, 2009 had the highest monthly mean temperatures in five years. Between these periods, though there had been the usual decrease in temperature due to the wet season, the minute drop in temperature might as well mean that the rainfall that year was low compared to the previous year (2008). The peak of the rain for 2009 might as well be in September due to the sharp drop between august and September.

October, 2009 to April, 2010 had an unusual increase in temperature which was as a result of the low rainfall previously explained. This fact, can be supported by the monthly mean temperatures i.e. in five years, January, February and April had the highest temperature. May to December, 2010 had a very undulating ground temperature which suggests that the net radiation over the Bwari region was unusual

May to November, 2011 had the highest monthly ground temperatures for 5years (except for the month of August). This shows that solar radiation over the region from undulating features attained in the previous year's increased, though still undulating.

Flooding was an issue in Nigeria in 2012. Most communities close to the river were flooded and many were left homeless. Even though it had been established that climate change brings about heavy rains (Bariweni et al.(2012)), the analysis of the ground temperatures at this period is important to predict likely occurrences in the future. We had earlier proved mathematically, that the popular net radiation equation given by Sellers et al., (1996) was imperfect for calculating earth's net radiation. The mathematical findings (Uno et al., 2012c) predicted the unsual climatic change due to the increase in global warming.

The results shown for 2012 generated questions which we would try answer. The first question is: Was there an unusual ground temperature feature to predict the natural disaster in the year? Recall that 2011 was characterized with the highest monthly mean ground temperatures. Usually, when there is a high ground temperature, there had been a high solar radiation coupled with a high evaporation at the shallow ground surfaces. The results ought to be heavy rain down pour experienced in 2012. The second question is: Did the heavy down pour balance the increased net earth radiation? Recall from tables [1-4], the ground temperatures for 2012 (table [5]) did not decrease as it ought to - meaning that the heavy down pour did not balance the increased solar radiation. December 2012, recorded the highest monthly mean temperatures to support the answer given to question two. The ultimate (and the last) question is: Would there be any natural disaster in the immediate future? Recall from tables [1-4], that there is always a build up from October to March of the preceding year. This means that 2013 might experience an increase solar radiation upon the earth. Though from the ground temperature data for 2012 (judging by the features in the previous years (see figures[1&2])) there may be a reduced flooding and a heavier flooding in 2014.

Table(1): Monthly mean temperature for 2008

	Mean monthly temperature (°C)
January	26.64
February	28.97
March	32.42
April	32.50
May	**31.06**
June	28.25
July	27.13
August	26.28
September	27.02
October	27.56
November	28.09
December	28.28

Table(2): Monthly mean temperature for 2009

	Mean monthly temperature (°C)
January	27.78
February	30.86
March	**33.13**
April	31.59
May	30.62
June	29.09
July	27.43
August	**27.15**
September	26.94
October	27.27
November	28.04
December	27.91

Table(3): Monthly mean temperature for 2010

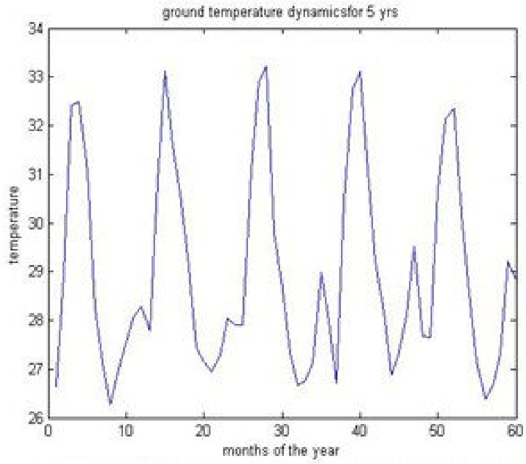
	Mean monthly temperature (°C)
January	**27.90**
February	**31.09**
March	32.91
April	**33.22**
May	29.82
June	28.65
July	27.35
August	26.67
September	26.77
October	27.14
November	28.98
December	27.98

Table(4): Monthly mean temperature for 2011

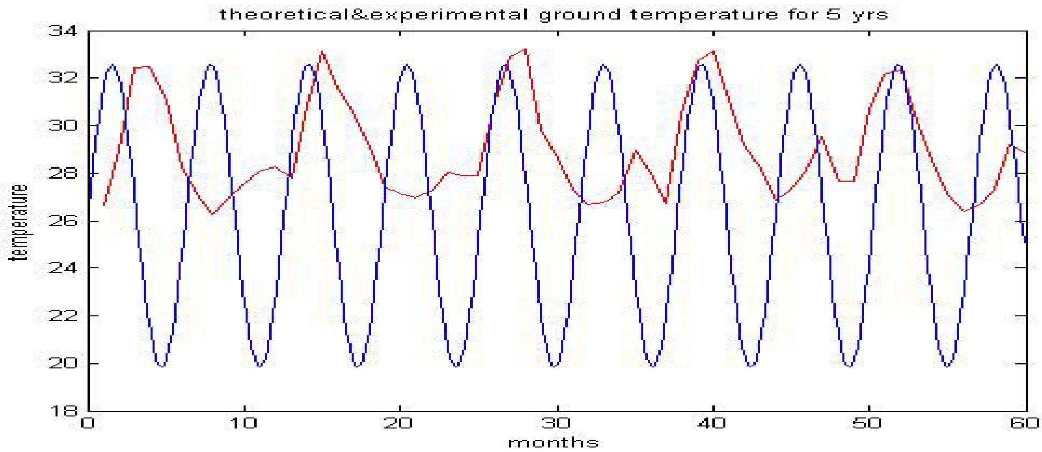
	Mean monthly temperature (°C)
January	26.72
February	30.45
March	32.76
April	33.12
May	**31.06**
June	**29.21**
July	**28.16**
August	26.87
September	**27.34**
October	**28.12**
November	**29.53**
December	27.67

Table(5): Monthly mean temperature for 2012

	Mean monthly temperature (°C)
January	27.64
February	30.67
March	32.15
April	32.34
May	30.20
June	28.56
July	27.15
August	26.39
September	26.66
October	27.33
November	29.21
December	**28.82**



Figure[1]:Temperature dynamics for 5 years



Figure[2]: theoretical & experimental comparism of ground temperatures for 5 years

CONCLUSION

There had been striking features of the ground temperatures over five years which shows that even when natural forces (rainfall e.t.c) tried balancing the net earth radiation, the reality of climatic change steps in. Since there is an unabated solar radiation increase in the region, what might likely happen in the future is a function of the subsequent data's and the precautionary measures put in place by the government to facilitate the ozone UV healing. Nevertheless, we still encourage further research into the global effects of the unbalanced earth's net radiation. 2013 might experience an increase solar radiation upon the earth and as a result, there may be a reduced flooding. The effects of the increased solar over the area may lead to heavier flooding in either 2014 or 2015.

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