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ESTIMATION OF SURFACE TEMPERATURE OF MUBI TOWN USING SATELLITE IMAGES

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ABSTRACT

This research emphasizes the need to estimate surface temperature of Mubi town using satellite images, by ENVI 4.5 software, the Enhanced Thematic Mapper Plus (ETM+) sensors acquire as a digital number (DN) range from 0 - 255 in thermal band (band 6.2) was used, firstly the DNs was converted to radiance values (measured in $W/m^2/sr/\mu m$) using the bias and gain values specify to the individual pixel. Secondly the radiance values were converted to surface temperature (in Kelvin). The results indicate that there is a significant variation in temperatures among the different season in Mubi. The mean temperatures estimated for the whole seasons are 311k in Summer solstice, 314K in Vernal equinox, 303K in Winter solstice and 302K in Autumnal equinox seasons. The overall goal of the work is to find the most suitable site in Mubi metropolis for optimal performance of solar devices. We believe that the proposed method can be an ideal tool that will increase the performance of solar parameters estimation studies

KEYWORDS: *Temperature, Satellite Images, Radiance and Seasons within a year*

1. INTRODUCTION

Temperature is simply the measurement of how hot or cold a region is on a day-to day basis. The weather aspect of temperature can change throughout the day; however, it generally falls within a certain range of predictable highs and lows (as climate) (Ifatimehin, 2007).

Satellite Thermal Infrared sensors measure top of the atmosphere radiances, from which brightness temperatures (also known as blackbody temperatures) can be derived using Plank's law Surface temperature can provide important information about the physical properties and climate which plays a role in many environmental processes (Dousset and Gourmelon 2003). Many studies have estimated the relative warmth of cities by measuring the air temperature, using land based observation stations (Weng and Schubring 2004).

Two approaches have been developed to recover Surface Temperature from multispectral Thermal Infrared imagery; the first approach utilizes a radiative transfer equation to correct the at-sensor radiance to surface radiance, followed by an emissivity model to separate the surface radiance into temperature and emissivity (Artis and Carnahan 1982),

Surface Temperatures are then calculated as a linear combination of the two channels. A major disadvantage of this approach is that the coefficients are only valid for the data sets used to derive those (Dash *et-al*, 2002).

Surface Temperature, controlled by the surface energy balance, atmospheric state, thermal properties of the surface, and subsurface media, is an important factor controlling most physical, chemical, and biological processes of the Earth (Becker *et-al*, 1990).

Surface temperature could be explained as the temperature of the surfaces of any object recorded by the sensor and is determined by the varying patterns of spectral responses of each object. Numerous factors need to be quantified in order to estimate the Surface temperature accurately from satellite thermal data. Digital number from band six of the Landsat Thematic Mapper (wavelength 10·4–12·5 μm) were used to derive surface temperatures by applying a form of Plank's Black Body Equation, which defines the relationship between the radiance emitted from an object at a certain wavelength and its absolute temperature (Shindell *et-al* 2001).

In the estimation of Surface temperature from satellite thermal data, the digital number (ND) of image pixels first needs to be converted into spectral radiance using the sensor calibration data (Markham and Barker, 1986).

The radiance converted from digital number does not represent a true surface temperature but a mixed signal or the sum of different fractions of energy. These fractions include the energy emitted from the ground, up welling radiance from the atmosphere, as well as the down welling radiance from the sky integrated over the hemisphere above the surface. Therefore, the effects of both surface emissivity and atmosphere must be corrected in the accurate estimation of Surface temperature (Qin *et-al*, 1999).

At infrared wavelengths the concept of surface temperature is useful for remote temperature measurements. At terrestrial IR wavelengths most land and water surfaces as well as dense cloud layers have a nearly constant emissivity $\varepsilon > 0.95$. Therefore, in case of a transparent atmosphere, the brightness temperature of the surface is very close to its thermodynamic temperature (Petty, 2004).

Surface emissivity is a key parameter for determination of Surface Temperature as well as in the environmental studies. Most natural surfaces are able to emit only part of their potential radiant energy (Caselles *et-al*, 1997). Therefore, direct temperature measurements by infrared (IR) thermometers (on a remote sensing system) can only give the radiant (apparent) temperature, which is known as the surface temperature. In order to obtain the true temperature, the emissivity of the observed surface must be known with an acceptable level of accuracy.

Temperatures should be further corrected with spectral emissivity values prior to the computation of Surface Temperature to account for the roughness properties of the land surface, (Friedl, 2002)

The aims of this research is to estimate the surface temperature of Mubi town by using satellite images in other to achieved this aim the following objectives have to be formulated; To acquire the satellite images of study area, to determine the amount of radiation, and convert the radiation to surface temperature

2. METHODOLOGY

Study area:-

Mubi town is geographically located between at 10°27'N and Longitudes 13°27'E, North of the GMT. It lies on the bank of Yedzaram River due to west, which flows through north into Lake Chad basin, and it situated along the side of Mountains which mostly form its drainage and relief. The area is in boundary internationally with Cameroon due to North and within the state by Michika, Hong and Maiha to the east, west, and south respectively. Also, it occupies an area of 2,327km^2 and has a population of 265,109 according to (National Population Commission) Census 2006.

Data Source:-

Primarily the data was downloaded free from Global Land Cover Facility homepage (http://glcf.umiacs.umd.edu/index.shtml). Spatial resolution of thermal infrared (band6 (10.4 - 12.5 μm)) are 60m. The data is in GeoTIFF format with geographic lat/long coordinates and a (approximately 30 m) grid. It is referenced to the WGS84.

Data Processing:-

The first process is to convert the DNs to radiance values using the bias and gain values specific to the individual pixel. Second processes are to convert the solar radiance to temperature in Kelvin; the effective at-sensor brightness temperature is obtained from the spectral radiance using Plank's inverse function. The surface emissivity is used to retrieve the final ST. It was processed using ENVI 4.5 software in a computer system. Below are steps to be followed in other to measured three depended solar parameters, for the suitable site for solar station in Mubi Town using satellite images.

Step1. Conversion of Digital Number (DN) to Spectral Radiance

This process requires information on the gain and bias of the sensor in each band the calibration is given by the following expression for at satellite spectral radiance, L:

$$L\lambda = (L_{max} - L_{min}) /255 \times DN + L_{min} \quad 1$$

Where:

L = spectral radiance measured over spectral bandwidth of a channel

DN = digital number value recorded

L_{max} = radiance measured at detector saturation in $Wm^{-2}sr^{-1}\mu m$

L_{min} = lowest radiance measured by detector in $Wm^{-2}sr^{-1}\mu m$

Table 1. ***L_{max}* and *L_{min}* Values of Landsat data**

Band No	Satellite/ Sensor	L_{max} ($Wm^{-2}sr^{-1}\mu m$)	L_{min} ($Wm^{-2}sr^{-1}\mu m$)
6.1	Landsat7 / ETM+ Low	17.04	00.00
6.2	Landsat7 / ETM+ High	12.65	03.20

The spectral radiances of each band at digital numbers for the sensors in TM 7 are given in the following reference values are given (NASA Landsat7 Hand book)

Step2. Conversion of radiance to surface temperature

The spectral radiances (Lλ) will be converted into effective satellite temperatures T (a) by

$$T\,(a) = \frac{K2}{In(\frac{K1}{L\lambda}+1)} \qquad 2$$

For Landsat ETM+ the NASA handbook gives K_1 =666.09 $Wm^{-2}sr^{-1}\mu m^{-1}$ and K_2=1282.71 K respectively. For Landsat ETM+ the values were also given in the header information of the thermal bands. Then, corrections for emissivity (e) were applied to the radiant temperatures according to the nature of land cover. The emissivity corrected surface temperature can be computed as follows (Qin, *et al)*:

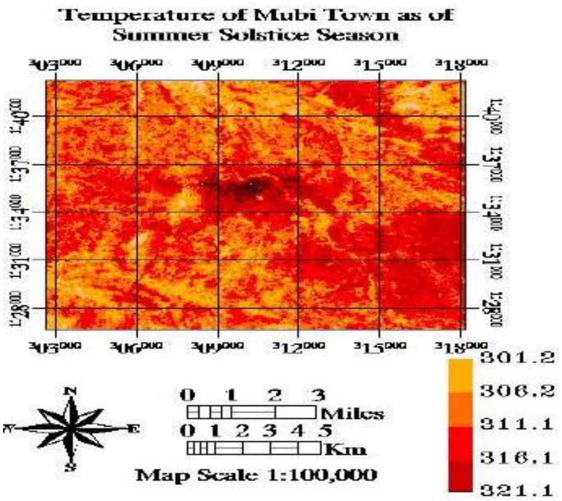
$$T_s = \frac{T(a)}{\left(1+\frac{T(a)}{b}\right) In.e}$$

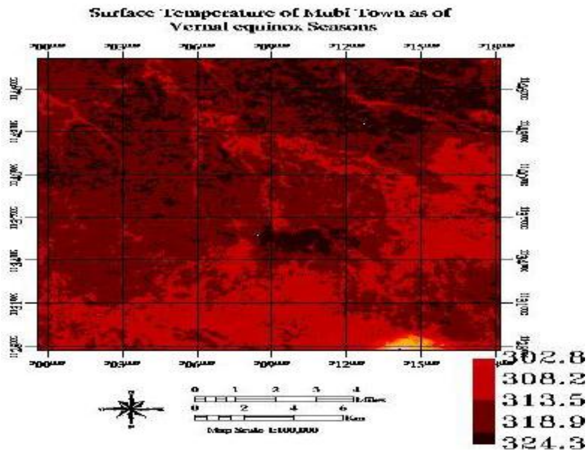
Where l = wavelength of emitted radiance (for which the peak response and the average of the limiting wavelengths (=11.5 mm) (Markham and Barker 1985) will be used, b = hc/K ($1.438'10^{-2}$ m K), K = Stefan Boltzmann's constant ($1.38'10^{-23}$J K^{-1}), h = Planck's constant ($6.26'10^{-34}$J s), and c = velocity of light ($2.998'10^{8}$ m s^{-1})

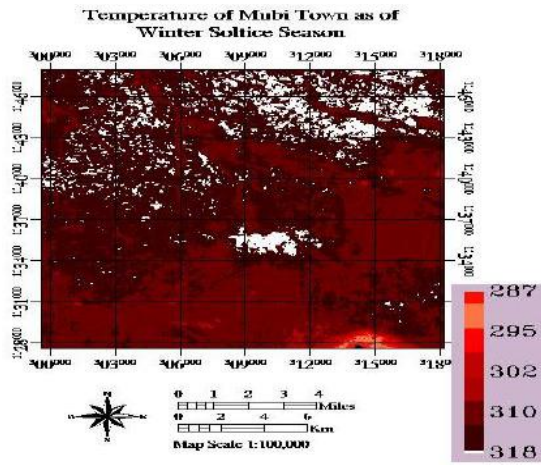
3. RESULT

The resulting surface temperatures for the four scenes seasons are presented in Figures below. The mean temperatures estimated for the whole study area are 311k in Summer solstice, 314K in Vernal equinox, 303K in Winter solstice and 302K in Autumnal equinox seasons. Table 3 shows the derived land surface temperature of complete seasons within a year.

The thermal energy responses of different season in the study area indicate the variation in surface temperature of different seasons within a year. Estimated surface temperature from a thermal band of Landsat 7 ETM+ is as shown in [Figures]. The analysis of imagery indicates summer solstice and Vernal equinox are the seasons with highest surface temperature, while winter solstices and autumnal equinox are the seasons with the lowest temperature respectively.







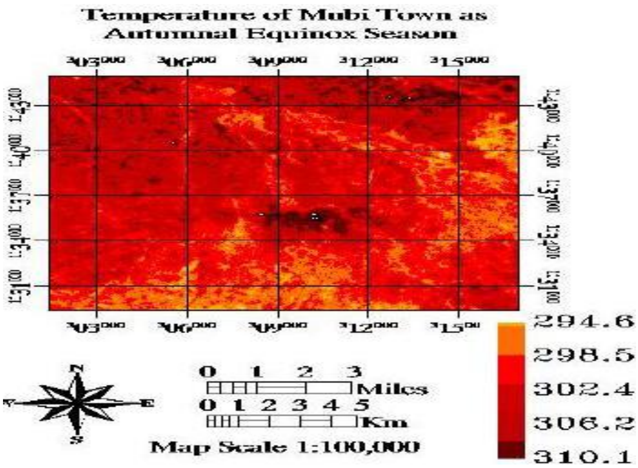


Table 2. Surface Temperature of the four seasons within a year

seasons	T_{max} (K)	T_{min} (K)	Mean T(K)
Summer solstice	321.1	301.2	311.2
Vernal Equinox	324.3	302.8	313.5
Winter Solstice	318.2	287.8	303.0
Autumnal Equinox	310.1	294.6	302.4

4. CONCLUSION

In this research, an attempt has been made to estimate surface temperatures of Mubi metropolitan. The Landsat-7 ETM+ thermal band data are the available data processing surface temperature of any topographic and climatic conditions of the area. The thermal energy responses of different seasons within a year in study area indicate the variation in surface temperature of different season. The mean temperatures estimated for the whole seasons of Mubi town are; 311K in Summer solstice, 314K in Vernal equinox, 303K in Winter solstice and 302K in Autumnal equinox seasons. Table 3 shows the land surface temperature of complete seasons within a year.

Surface temperature help us to find out the solutions for suitable locating of best sites for solar energy power station, urban environment quality improvement and the planning strategies for heat island reduction etc.

All these results correspond well with the local environmental conditions of the respective seasons. It can be concluded from the study that this method can be utilized for long-term determination of surface temperature of Mubi the results show that the satellite derived temperatures values are in the acceptable range. The present results show that satellite data can provide regionally representative values for surface temperatures, which is not possible from ground observations given the scarcity of data

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