Estimation of land surface Temperature of Maiduguri Metropolitan Area: A Case Study of Jere & some part of Mafa using Landsat 8 Operational Land Image (OLI)

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Abstract
Estimation of land surface Temperature of Maiduguri Metropolitan Area: A Case Study of Jere & some part of Mafa using Landsat 8 Operational Land Image (OLI) the research revealed mean solar radiance as 10.54 W/m²/str/μm the calculated minimum and maximum NDVI values are respectively -0.01674 and 0.5489, used to obtain proportion to vegetation which is then used to determine the emissivity of the area having minimum emissivity of 0.986 and maximum of 0.99, the minimum and maximum land surface temperature of Maiduguri Metropolitan areas are respectively 41.16 °C and 26.11 °C.

KEY WORDS: Landsat 8 satellite images, Temperature, Solar Radiance and Emissivity
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1. INTRODUCTION
Temperature is simply the average translational kinetic energy of a particular body of day to day basis. The weather aspect of temperature can be varied throughout the day. Cold and hot waves are factors that affect the temperatures of particular climates. Satellite Thermal Infrared sensors measure top atmosphere irradiances, from which temperatures can be determined using Plank’s law (Ifatimehin, 2007).

Land surface temperature would provide vital information about climate changes which plays a role in many environmental processes (Dousset and Gourmelon, 2003). Temperature, controlled by atmospheric, thermal properties of the surface and subsurface media, is an important factor controlling most physical, chemical, and biological aspect of the Earth (Becker et al, 1990).

Surface temperature could be emphasized as the temperature of any object recorded and is determined by the varying patterns of spectral responses of each object. Considering the resolution of satellite data, the surface temperature can be defined as the average surface temperature of the ground under the pixel scale mixed with different fractions of surface types.

Numerous factors need to be measured in order to estimate the surface temperature from satellite thermal data. Digital number from Landsat 8 Operational Land Image (OLI) with wavelength range of 10·4–12·5 μm was applied in order to calculate surface temperatures using equation 6, which state the radiance emitted from an object at a certain wavelength and its temperature (Shindell et al 2001). In the estimation of surface temperature from
satellite thermal data, the Digital Number (DN) of image pixels first needs to be converted into spectral radiance using the sensor calibration data (Markham and Barker, 1986).

However, 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, upwelling radiance from the atmosphere, as well as the downwelling radiance from the sky integrated over the hemisphere above the surface. Therefore, the effects of both surfaces emissivity and atmosphere must be corrected in the accurate estimation of Surface Temperature (Qin et al., 2001).

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). Land 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).

The aim of this research is to estimate the land surface temperature of Maiduguri Metropolitan area: a case study of Jere & some part of Mafa using Landsat 8 Operational Land Image.

2. METHODS

2.1 Data Used

Landsat 8 satellite images data of Borno state, primarily downloaded from United States Geological Survey (USGS) was used for this research. The Thermal Infrared (TIR) band 10 was used to estimate brightness temperature of the study area. Landsat 8 provides metadata of the band such as thermal constant, rescaling factor value etc., which can be used to calculate the LST. Band Wavelength of (10.60 $\mu$m -11.20 $\mu$m) and Resolution of 30 m of Landsat8 are given in Metadata (MTD) file and the following values were used.

- Radiance Add Band 10=$R_{\text{add,B}}=0.10000$
- Radiance Mult Band 10=$R_{\text{mult,B}}=0.0003342$
- $K_1$ Constant band 10 = 774.8853
- $K_2$ Constant Band 10 = 1321.0789

2.2 Data processing

2.2.1 Solar Radiance

Using the rescaling factor from MTD file, (TIR) Digital Numbers can be converted to solar radiance.

\[
L_\lambda = R_{\text{ML}}(Q_{\text{cal}}) + R_{\text{AL}}
\]

Where:
- $L_\lambda$ = Solar radiance (W/m²/ster/μm);
- $R_{\text{ML}}$ = Band Specific multiplicative rescaling factor from the MTD file
- $R_{\text{AL}}$ = Band specific additive rescaling factor from the MTD file
- $Q_{\text{cal}}$ = Quantized and calibrated standard product digital numbers (DN);
2.2.2 Brightness Temperature:

Solar radiance would be converted to brightness temperature using the thermal constant Values in MTD file (Qin, et-al (2001)):
3 Results:

3.1 Solar Radiance

![Solar Radiance Map of Maiduguri Metropolitan Area](image1)

The calculated solar radiance of Maiduguri metropolitan shows a maximum values of about 11.76 W/(m² str μm), minimum values of 0.932 W/(m² str μm) and mean values of 10.54 W/(m² str μm)

3.2 Normalized Differential Vegetation Index (NDVI)

![Normalized Differential Vegetation Index (NDVI) Map of Maiduguri Metropolitan Area](image2)

Normalised difference visualised index of maiduguri metropolitan council have been determined given the lowest value of -0.167434 indicating water body or highly moisture area, highest values of 0.574898 are revealed in
housing and residential areas while vegetation regions have an intermediate values ranging between 0.0801 to 0.327454.

3.3 Land Surface Emmissivity

![Land Surface Emmissivity Map](image)

Fig. 3: Land Surface Emmissivity Maps of Maiduguri Metropolitan Area

The emmissivity were determined in order to calculate the accurate land surface temperature from the solar radiant and brightness temperature, while we have the minimum value of 0.986 and maximum value of 0.99.

3.4 Land Surface Temperature

![Land Surface Temperature Map](image)

Fig. 4: Land Surface Temperature of Maiduguri Metropolitan Area

The land surface temperature of maiduguri metropolitan council was determined and the result show maximum temperature of 41.16°C and minimum land surface temperature of 26.11°C.
4. Conclusion

This research successfully determined Land Surface Temperature of Maiduguri Metropolitan having Minimum and Maximum values of 26.11 °C and 41.16 °C respectively. This was accompanied by values obtained from the following tools; solar radiance value of 10.54 W/m²/str/μm, minimum and maximum values of NDVI as -0.01674 and 0.5489 respectively why land surface emissivity minimum value of 0.986 and maximum value of 0.99. It is obvious that water and vegetation are very good shielding factors for radiation and temperature.

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