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AN ERROR ANALYSIS BETWEEN SATELLITE IMAGES DERIVED SURFACE TEMPERATURE AND METEOROLOGICAL SURFACE TEMPERATURE MEASUREMENT OF YOLA TOWN

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ABSTRACT

The research focuses an error analysis between satellite images derived surface temperature and meteorological surface temperature measurement. The two set of data were used in this research, satellite image derived surface temperature and meteorological data measured for both the raining and dry seasons of the same period of years (i.e. 2007, 2010, and 2013) was analysed the error between the two measured. Surface temperature from a satellite image thermal band 6 of Landsat 7 ETM+ was calculated using equations (1) to (3), while meteorological data surface temperature of Yola town was obtained from Modibo Adama University of technology Yola, the error analysis that is Average Relative Error (ARE) and Root Mean-Square Error (RMSE) for both the measured temperature was carried out using equation (4) to (6). Base on the research ARE and RMSEs are found to be high in dry seasons than the raining seasons, for dry season AREs are 2.286, 0.910 and 2.341, while RMSEs are 5.225, 0.828 and 5.481 for the years 2007, 2010 and 2013 respectively. For raining season AREs are 0.472, 2,388 and 1.303 while, RMSEs are 0.222, 5.703 and 1.698 for the years 2007, 2010 and 2013 respectively.

KEYWORDS: *Surface Temperature, Meteorological, Satellite Images, Root Mean Square Error and Average Relative Error.*

1. INTRODUCTION

Several recent studies have been conducted to improve the accuracy of satellite temperature measurements by comparing satellite image surface temperature data with meteorological measurement. (Mihalcea *et-al.* 2008) attempted to investigate and the accuracy of Landsat ETM+ image surface temperature data by measuring surface temperatures all of these studies found that satellite temperature data were useful as alternative measures for meteorological temperature data.

Nonetheless, most relevant studies to date that compare meteorological temperature data to satellite-based measurements are limited to homogeneous areas or rural areas. Therefore, this study aimed to validate the accuracy of satellite image surface temperature data in an urban area through comparisons of satellite images Landsat EMT+ with meteorological temperature measurements. Additionally, we evaluated and compared temperature measurements collected during the dry and the raining season because thermal characteristics can vary periodically.

Land surface temperature is sensitive to vegetation and soil moisture, hence it can be used to detect land use/land cover changes, e.g. tendencies towards urbanization, desertification etc.

Various studies have been carried out to investigate surface temperature using the vegetation abundance (Weng & Schubring 2004). The major effects of the atmosphere are absorption, upward atmospheric emission, and the downward atmospheric irradiance reflected from the surface (Pierangelo et al., 2004).

Satellite image surface temperature data were extracted using Landsat ETM+ thermal band 6. The Landsat ETM+ instrument, is composed of four sensors: SWIR (short wave infrared), VNIR (visible near infrared), TIR (thermal infrared) and panchromatic. It also has 8 spectrum channels to analyse radiance. The spatial resolution of the Landsat thermal Band 6 is 60 m, and it is used to generate data for the Temperature Emissivity Separation used for finding the emissivity of land coverage values Surface temperatures were extracted after geometric and radiometric corrections using ENVI 4.5 software, an image processing program. Surface temperature data extracted from the satellite image represents radiant temperature, which is the temperature conversion of radiant energy released from the surface, and it is closely related to the emissivity for surface. (Caselles et al 2005)

The main aim of this research is to analyse an error between satellite images derived surface temperature and meteorological surface temperature measurement.

2. MATERIAL AND METHOD

Two set of data were used in this research, satellite image derived surface temperature and meteorological data measured for both the raining and dry seasons of the same period of years (i.e. 2007, 2010, and 2013) was analysed the error between the two measured.

2.1 Study Area:-

Yola is the capital city of and administrative centre of Adamawa state, Nigeria. Its geographical located between latitude $9^0$11'59"N and longitude12^{0}28'59"E. it also occupies an area of 662.47km^2 and has a population of 336,648 according to (national population commission census 2006)

2.2 Data Acquisition and Source:-

2.2.1 Satellite Image Data:-

A landsat satellite image of yola was downloaded from Global Land cover Facility homepage (http://glcf.umaics.umd.edu/index.shtml). The spatial resolution is 60m for the thermal infrared (band6 (10.4 – 11.5)) the approximate scene size is 200x200 km the data is in GeoTIFF format with geographic lat/log coordinates, it is referenced to the WGS84

2.2.2 Meteorological Data:-

The seasonal mean temperature was obtained from Department of Geography meteorological unit situated in Modibo Adama University of Technology Yola, Nigeria. The data obtained covered a period of four years (2003, 2007, 2010, and 2013) for Yola Town, located on latitude $9^0$11'59"N and longitude 12^{0}28'59"E

2.3.1 METHOD OF COMPUTATION

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:

$$L = Gain \ x \ DN + Bias \qquad 1$$

Where:
L = spectral radiance measured
DN = digital number value recorded
Gain = $(L_{max} - L_{min}) / 255$
Bias = L_{min}
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)*:

$$T_s = \frac{T(a)}{\left(1+\frac{T(a)}{b}\right) In.e} \quad 3$$

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})

2.3.2 ***Relationship*** Correlation between satellite derived surface temperature and metrological measured surface temperature was studied by computing Pearson's product moment correlation coefficient, *r*:

$$r = \frac{\sum_{i=1}^{n}(t_s-\bar{t}_s)(t_m-\bar{t}_m)}{\sqrt{\sum_{i=1}^{n}(t_s-\bar{t}_s)^2\sum(t_m-\bar{t}_m)^2}} \quad 4$$

Where r is the correlation coefficient, t_s and $\bar{t}_s$ are the satellite measured temperature and its average value, and t_m and $\bar{t}_m$ are the metrological measured temperature and its mean average value.

2.3.3 Error analysis. Average relative error (ARE) and root mean-squared error (RMSE) were used to evaluate differences between satellite measured temperature and a metrological measured temperature, and were computed as follows:

$$r_e = \frac{1}{n}\sum_{i=1}^{n}\frac{|t_s-t_m|}{t_m} \, x\, 100 \quad 5$$

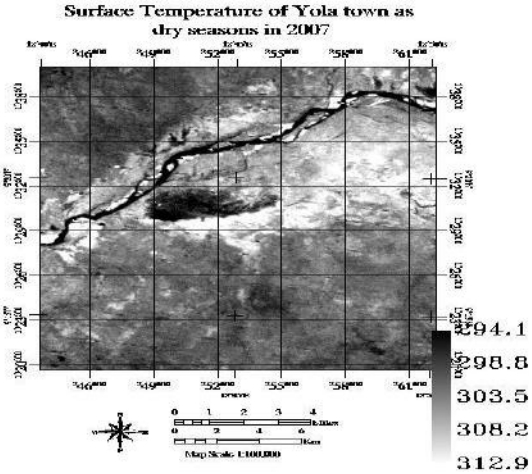
$$S = \sqrt{\frac{(t_{s1-}\,t_{m1})^2+(t_{s2}-t_{m2})+\cdots+(t_{sn}-t_{mm})}{n}} \quad 6$$

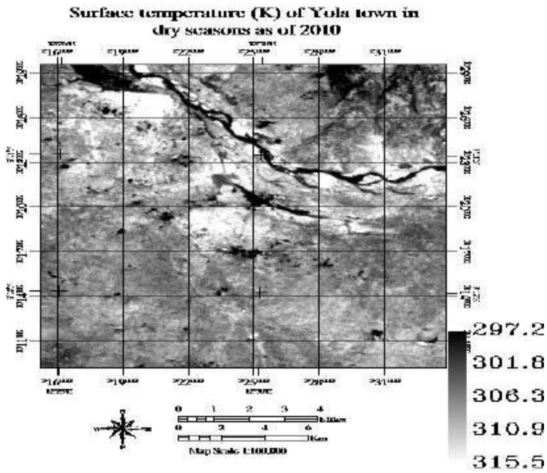
Which r_e and S stand for ARE and RMSE respectively, t_s is satellite measured temperature and t_m is metrological measured temperature. n is the number samples and equals to the number of years of the study.

3.RESULT

The resulted surface temperature from a satellite image thermal band 6 of Landsat 7 ETM+ was calculated using equations (1) to (3) as shown in [Figures] below, while the measured temperature from meteorological data was given in the table2 below. The error analysis that is Average Relative Error (ARE) and Root Mean-Square Error (RMSE) for both the measured temperature was carried out using equation (4) to (6).

Surface Temperature Measured by satellite images as of Dry season





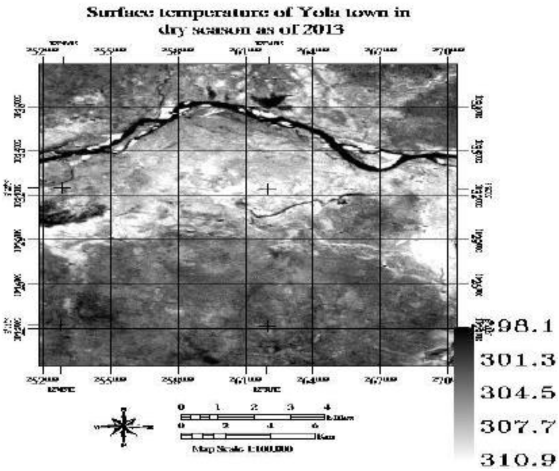
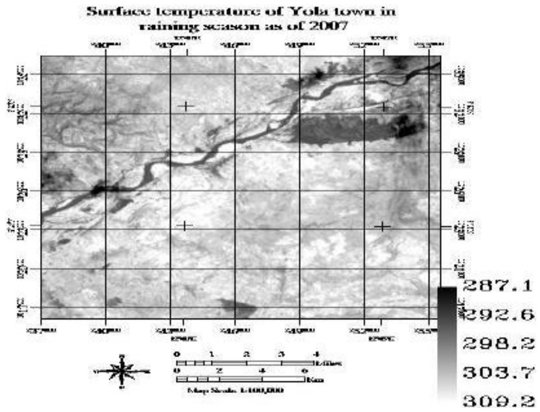
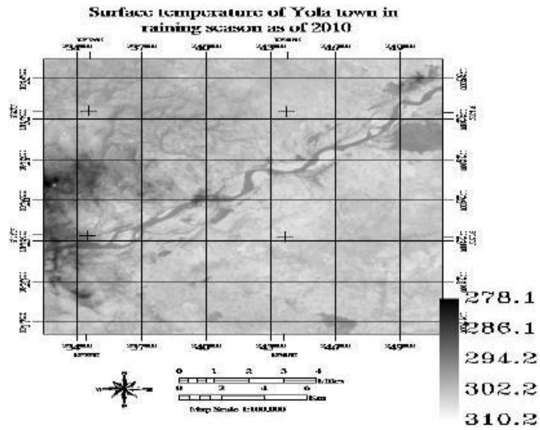


Table2; showing both the mean satellite measured temperature and meteorological measured with their r, ARE (r_e), and RMSE (s) as of dry season

Yrs. of study	T_s (K)	T_m (K)	ARE (r_e)	RMSE (s)
2007	303.5	310.6	2.286	5.225
2010	306.3	309.8	0.910	0.828
2013	304.5	311.8	2.341	5.481

Surface Temperature Measured by satellite images as of raining season





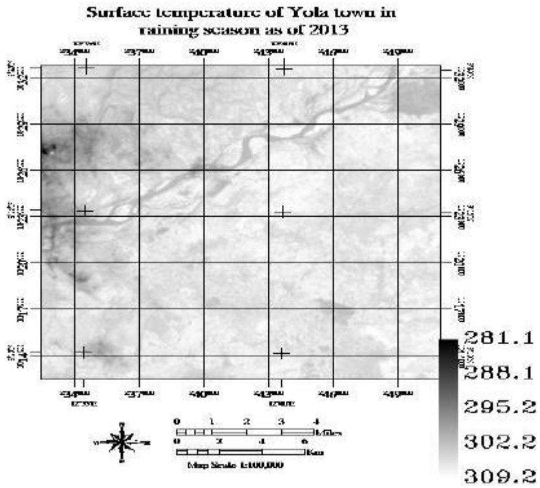


Table3; showing both the mean satellite measured temperature and meteorological measured with their r, ARE (r_e), and RMSE (s) as of raining season.

Yrs. of study	T_s (K)	T_m (K)	ARE (r_e)	RMSE (s)
2007	298.2	296.8	0.472	0.222
2010	294.3	301.5	2.388	5.703
2013	295.2	299.1	1.303	1.698

ARE and RMSE of satellite image measured Surface Temperature and meteorological measured were calculated for 2007, 2010, and 2013 for both dry and raining seasons. The results for dry seasons show that ARE is quite large in 2007 and 2013 with a values of 2.286 and 2.341 respectively, although relatively low values are observed in 2010 (0.910). The RMSE values are relatively high and greatest in 2007 and 2013 with values of 5.225 and 5.481 respectively when a RMSE of 0.8281 is observed for 2010.

While for raining season ARE is relatively high for the year 2010 with value of 2.388 and for 2007 and 2013 are 0.472 and 1.303 respectively. And RMSE for 2010 is high which 5.702 are and for 2007 and 2013 are 0.222 and 1.698 respectively.

4. CONCLUSIONS

The correlation between satellite image measured temperature and meteorological measured temperature was computed (Equation 4) and differences were quantified by average relative error (ARE) and root mean-squared error (RMSE) (Equations 5 and 6). An investigation of the relationship between satellite image measured temperature and metrological data measured temperature demonstrates that differences are relatively very small. This conclusion is confirmed by an analysis of the relationship between satellite temperature data and meteorological measured temperature for each year, which indicates moderate to high correlations of 1, were observed between satellite measured temperature and meteorological measured temperature of Yola Town.

Base on the research ARE and RMSEs are found to be high in dry seasons than the raining seasons, for dry season AREs are 2.286, 0.910 and 2.341, while RMSEs are 5.225, 0.828 and 5.481 for the years 2007, 2010 and 2013 respectively. For raining season AREs are 0.472, 2,388 and 1.303 while, RMSEs are 0.222, 5.703 and 1.698 for the years 2007, 2010 and 2013 respectively.

REFERENCES

1. *C. Mihalcea, B. W. Brock, G. Diolaiuti .(2008), "Using ASTER satellite and ground-based surface temperature measurements to derive supraglacial debris cover and thickness patterns on Miage Glacier (Mont Blanc Massif, Italy)," Cold Regions Science and Technology, 52:3 (341–354). View at Publisher · View at Google Scholar · View at Scopus*
2. *Caselles, V. C. Coll, E. Valor, and E. Rubio, 1995 "Mapping land surface emissivity using AVHRR data application to La Mancha, Spain," Remote Sensing Reviews, 12: (3-4), 311–333,. View at Google Scholar · View at Scopus*
3. *NASA, (2016). Landsat 7 Science Data Users Handbook. National Aeronautics and Space Administration. Retrieved January 2016 from: http://landsathandbook.gsfc.nasa.gov*
4. *Pierangelo, C., Ch'edin, C., Jacquinet-Husson, N. & Armante, R., 2004. Dust altitude and infrared optical depth from ARIS, Atmospheric Chemistry and Physics Discussions, 4, 333-3358.*
5. *Qin Z, Karniel A, Berliner P (2001): A mono-window algorithm for retrieving land surface temperature from Landsat TM data and its application to the Israel-Egypt border region. Int J Remote Sensing, 22:3719-3746*
6. *Weng, Q., Lu, D. & Schubring, J., 2004. Estimation of land surface temperature-vegetation abundance relationship for urban heat island studies, Remote Sensing of Environment, 89:4, 467-483.*