International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-2 Issue-3, February 2013

Surface Temperature Estimation using Landsat Data for part of the Godavari and Tapi Basins, India: A Case Study

A. D. Prasad, Kamal Jain, Ajay Gairola

Abstract— ***This paper presents results of surface temperatures for a part of the Godavari and Tapi Basins, India. Thermal infrared remote sensing proved its capability in monitoring temperature field. Landsat data of the study area have been used for the surface temperature estimation and analysis. The method used to extract surface radiance from the digital number (DN) values is based on USGS, 2001. Landsat 7 Science Data User's Handbook. The surface temperature is then extracted from the surface radiance. Based on Landsat image, average temperature of the study area is 25°C, minimum temperature as 15ºC, maximum temperature as 35ºC respectively, are inferred. The results have been compared with data obtained by India Meteorological Department data. The comparison of observed temperatures has shown a good correlation, with a difference of 2-2.5°C.***

Index Terms—***GIS, Godavari, Landsat7, Temperature.***

I. INTRODUCTION

Satellite data are very useful in various applications like, astronomy, atmospheric studies, earth observation, communications, navigation, search and rescue. Land surface temperature is an important parameter in the field of atmospheric sciences as it combines the result of all surface-atmosphere interaction and energy fluxes between the ground and the atmosphere and is, therefore, a good indicator of the energy balance at the Earth's surface (Wan and Snyder, 1996). Surface temperature controls the surface heat and water exchange with the atmosphere which effecting climatic change in the region.

A traditional way of estimating surface temperature is by using weather-station based meteorological observations. This method is not a feasible solution for all types of topographic conditions. But remote sensing technique is useful in any topographic and climatic condition of the region. Thermal infrared remote sensing provided an opportunity to estimate land surface temperature from thermal band images. Satellites are equipped with sensors which can detect a range of infrared heat. Estimation of surface temperature from satellite infrared radiometers has been proven useful. Most studies have focused on the use of polar orbiting satellite systems because of their high spatial resolution (Sun et al., 2004).

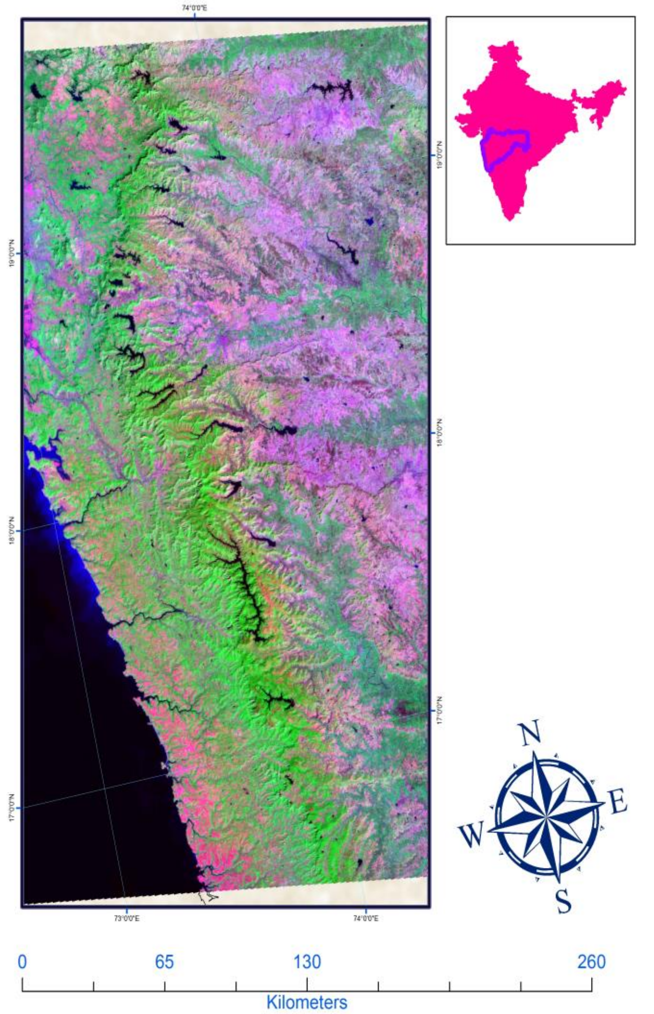

Figure 1. Study Area

The Landsat-7 satellite with ETM+ sensor has been used in sensing spectral resolution range of 10.40 – 12.5 (am) to capture the scene as band 6 images is best used in this field and the same is used in this study. Landsat-7 ETM+ has a high spatial resolution accuracy compared to other thermal sensors on other satellites, as well as the thermal imaging in this sensor is determined by two bands, one band is 6-1 where the acquisition the low gain, while the second band is 6-2, the acquisition will be high gain.

Manuscript published on 28 February 2013.
***** Correspondence Author (s)
A. D. Prasad, Department of Civil Engineering, Indian Institute of Technology Roorkee, INDIA.
Kamal Jain, Department of Civil Engineering, Indian Institute of Technology Roorkee, INDIA.
Ajay Gairola, Department of Civil Engineering, Indian Institute of Technology Roorkee, INDIA.

In this paper, an attempt has been made to estimate surface temperatures for part of the Godavari and Tapi basins, India by using Landsat data.

II. STUDY AREA

In this study, part of the Godavari and Tapi basins covering between 17°0'0" – 19°0'0" N and 73°0'0" - 74°0'0" E [Figure 1] is in Maharashtra, India has been considered. The Godavari is a perennial and the second largest river draining in India originates near Trayambak near Nasik, northeast of Mumbai in the state of Maharashtra at an elevation of 1067 m and flows for a length of about 1465 km before joining the Bay of Bengal. The Tapi River rises near Multai town in Betul district of Madhya Pradesh at an elevation of about 760 m and flows for a length of about 724 km before joining the Arabian Sea near Surat in Gujarat.

III. MATERIALS AND METHODS

Landsat-7 ETM+ thermal data have been used in this study. The data sets, "p147r047_7dt19991114" and p147r048_7dk19991114" downloaded from global land cover facility are used as input for estimation of surface temperature. USGS, 2001. Landsat 7 Science Data User's Handbook procedure has been followed to estimate the temperature and the methodology in this study has been divided into four phases: (1) Data Preparation, (2) Conversion from Digital Numbers to Spectral Radiance, (3) Conversion from Spectral Radiance to Temperature, (4) Surface Temperature Map preparation has been shown in the flow chart [Figure 2]. Thermal band scenes were processed and analyzed using the ArcGIS software.

A. Data Preparation

Making a good mosaic requires some planning as their order can help to decide which images should overlay others. ArcGIS's data management tools are used to make a mosaic data set to cover study area.

B. Conversion from Digital Numbers to Spectral Radiance

The data were converted to spectral radiance using an equation 1 as shown below:

$$L_\lambda = ((LMAX_\lambda - LMIN_\lambda)/(QCALMAX - QCALMIN)) * (QCAL - QCALMIN) + LMIN_\lambda \quad (1)$$

Where:

$L\lambda$ = Spectral Radiance at the sensor's aperture in watts/ (meter squared * ster * am)
QCAL = the quantized calibrated pixel value in DN
$LMIN\lambda$ = the spectral radiance that is scaled to QCALMIN in watts/ (meter squared * ster * am)
$LMAX\lambda$ = the spectral radiance that is scaled to QCALMAX in watts/ (meter squared * ster * am)
QCALMIN = the minimum quantized calibrated pixel value (corresponding to $LMIN\lambda$) in DN
QCALMAX = the maximum quantized calibrated pixel value (corresponding to $LMAX\lambda$) in DN

C. Conversion from Spectral Radiance to Temperature

By applying equation 2, thermal band radiance values are converted to brightness temperature values.

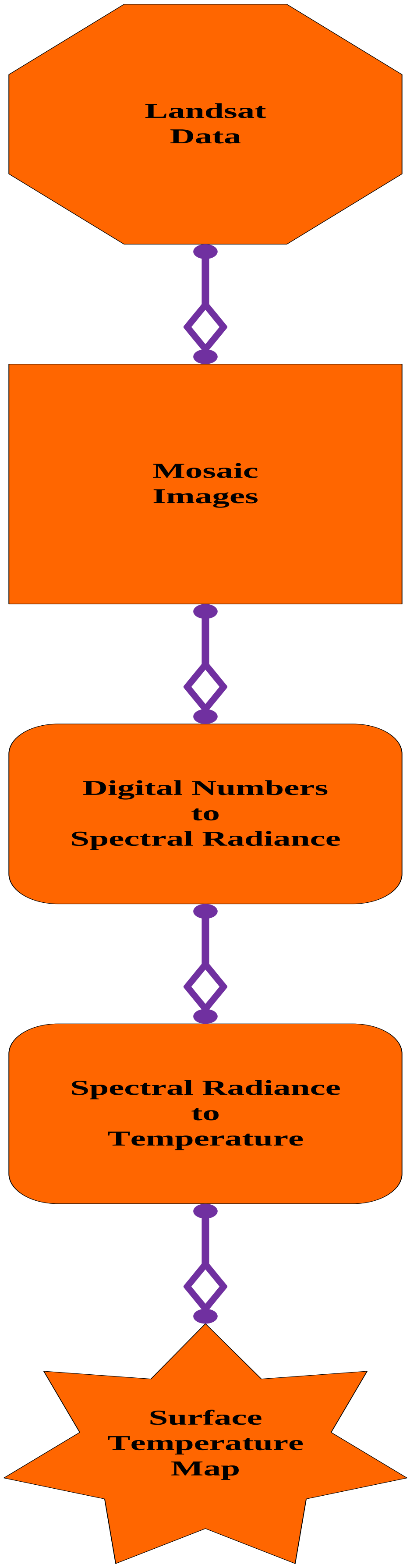

Figure 2. Flow Chart

$$T = \frac{K_2}{\ln\left(\frac{K_1}{L\lambda} + 1\right)} \qquad (2)$$

Where:

T = Effective at-satellite temperature in Kelvin
K1 = Calibration constant 1 (watts/meter squared*ster*µm)
K2 = Calibration constant 2 (Kelvin)
Lλ = Spectral radiance (watts/meter squared*ster*µm)

D. Surface Temperature Map preparation

Surface temperature map has been prepared by selecting an appropriate color ramp in symbology to distinguish the variation of estimated surface temperature.

IV. RESULTS

The thermal energy responses of different land use types and soil in the study area indicate the variation in surface temperature of different surface patterns. Estimated surface temperature from a thermal band of Landsat 7 ETM+ is as shown in [Figure 3]. The analysis of imagery indicates that residential areas, industrial areas and barren sandy area are the places with highest surface temperature. Forest areas, water logging areas are the places with the lowest temperature.

The results are compared with India Meteorological Department data and observed temperatures showed a good correlation, with differences of 2- 2.5ºC.

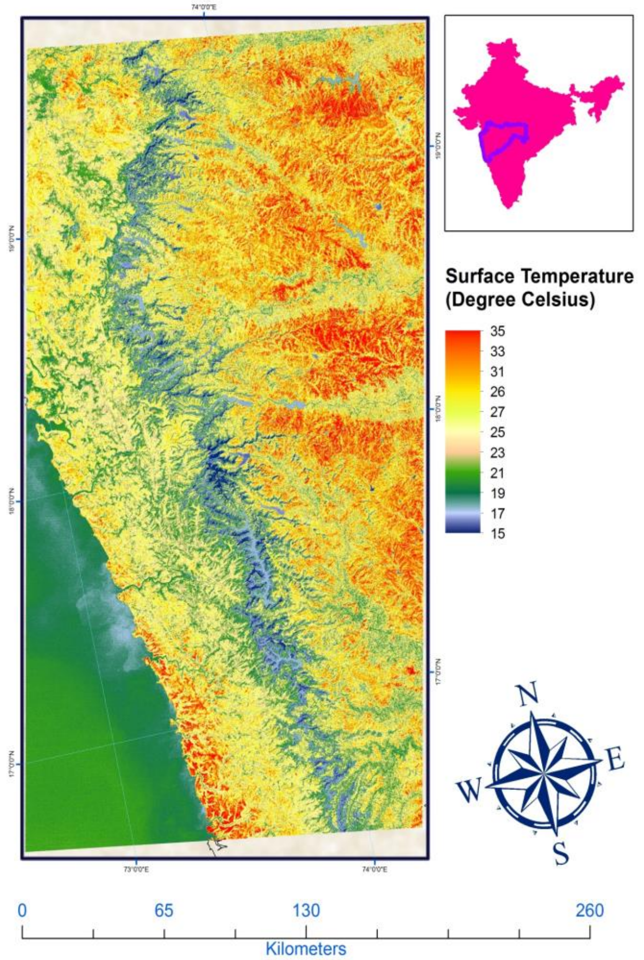

Figure 3. Surface Temperature Map

V. CONCLUSION

In this paper, an attempt has been made to estimate surface temperatures for part of the Godavari and Tapi Basins, India. The Landsat-7 ETM+ thermal band data are the freely available data processing surface temperature of any topographic and climatic conditions of the area. The thermal energy responses of different land use types and soil in study area indicate the variation in surface temperature of different surface patterns. The results are compared with India Meteorological Department data and observed temperatures showed a good correlation, with differences of 2- 2.5ºC. Surface temperature controls the surface heat and water exchange with the atmosphere which effecting climatic change in the region. Land surface temperature and land use land cover types help us to find out the best solutions for suitable reservoir site locations, locating best sites for solar energy power plants, urban environment quality improvement and the planning strategies for heat island reduction etc.

ACKNOWLEDGMENT

We would like to thank Prof. S.K.Govil (Retd. Head-PRS Division, Indian Institute of Remote Sensing, Dehradun) for supporting and suggestions for improvement of the paper.

REFERENCES

[1] El-Sayed Ewis Omran, Detection of Land-Use and Surface Temperature Change at Different Resolutions, Journal of Geographic Information System, 2012, 4, 189-203
[2] P K Srivastava, T J Majumdar and Amit K Bhattacharya, Study of land surface temperature and spectral emissivity using multi-sensor satellite data, J. Earth Syst. Sci. 119, No. 1, February 2010, pp. 67–74
[3] Sun, D. and Pinker, T. (2004). Case study of Soil Moisture effect on Land Surface Temperature Retrieval. IEEE Geoscience And Remote Sensing Letters. Vol. 1. No. 2 : 127 – 130.
[4] USGS, 2001. Landsat 7 Science Data User's Handbook

A. D. Prasad received B. Tech from Andhra University, M. Tech. from National Institute of Technology Karnataka. He worked as Asst. Environmental Engineer in the initial days of the career and afterwards shifted to IT sector, worked in the domain SAP – BI / SEM / IP and performed various roles as team member, technical leader, lead consultant, project manager and competency head. He worked at various capacities in India, USA, UAE, Saudi Arabia, Qatar, Malaysia, UK and South Africa before joining as a research scholar at Indian Institute of Technology Roorkee, India. He is also delivering lectures at various universities. His research interests include Energy, Renewable Energy, GIS, HAZOP, Hazards and Mitigation, Impact Analysis, SAP-GIS and Medical Image Processing. He is a life member of IGS (India).

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)