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LAND SURFACE TEMPRATURE ESTIMATION FOR CHITRAKOOT DISTRICT FROM LANDSAT 8 IMAGES

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Abstract

The Land Surface Temperature (LST) can be states as radiative skin temperature of ground. The Land Surface Temperature (LST) depends on the albedo, soil moisture; the vegetation cover and. LST is very much important for the several types of studies as climate change, global warming, site suitability and urban land change detection studies. LST is widely uses as mixture of vegetation and bare soil temperatures. Because both the vegetation and bear soil respond rapidly to changes in incoming solar radiation due to cloud cover and aerosol load modifications, and the results are LST displays quick variations too. In this study the LST has been estimated with respect to top of atmospheric radiance, brightness temperature and the Land Surface Emissivity (LSE) is retrieved band 10 thermal bands. Normalized Difference Vegetation Index (NDVI) values determined from the Red and Near Infrared bands.

Keywords: LST (Land Surface Temperature), NDVI (Normalised differenced vegetation index), Brightness temperature, Land Surface Emissivity (LSE), Top of Atmosphere (TOA) Radiance.

Introduction

Land surface temperature of a location is how hot the surface of the Earth would feel to the physical touch in a particular location. From a satellite's view the surface is whatever it sees when it looks through the atmosphere to the ground. Snow and ice, the roof of a building, the grass on a lawn, or the leaves in the canopy of a forest can be the features seen from the satellites. LST plays an important role in the process of detection of land surface as it is involved in the Processes of energy and water exchange with the atmosphere. LST is very much useful for the scientific community, and for those who are dealing with climate and meteorological models and site selection studies affected by the surface heat. Accurate values of LST are also of special interest in a broad range of areas linked to land surface processes, as well meteorology, hydrology, agro meteorology, climatology and environmental studies.

In this study Land surface temperature is estimated by the top of atmospheric radiance and the brightness temperature. LANDSAT 8 have two sensors, these are the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). OLI accumulate data on 30m spatial resolution with eight bands which are located in regions of the electromagnetic spectrum in visible and near-infrared and the shortwave infrared range, and with 15m spatial resolution panchromatic band. TIR radiance at a spatial resolution of 100m senses by the TIRS using two bands located in the atmospheric window between 10 and 12 μm.

The Land Surface Temperature has been estimated by the Landsat band 10 thermal bands. Using raster image calculator LST is calculated applying a set of equations through. Which go through a process of creating Top of Atmosphere (TOA) Radiance, then creation of Top of Atmosphere (TOA) Brightness Temperature, and Normalized Differential Vegetation Index (NDVI) to Land Surface Emissivity (LSE) then Land Surface Temperature (LST). The LST of chitrakoot lies between the 24.54 degree Celsius to 37.52 degree Celsius.

Study area

Chitrakoot means the 'Hill of many wonders'. Chitrakoot is situated in the northern part of the Vindhyan range of the mountains in Uttar Pradesh. Chitrakoot district was created 4 September 1998. District Chitrakoot lies in global location between Lat. 24° 48′ to 25° 12′ N and Lang. 80° 58′ to 81° 34′ E. district Covered the distance by from East to West is 62 Km. and North to South is 57.5 Km. A major part of chitrakoot has covered with land Forest and vegetation. The climate of the district is sub-tropical. May with average mean temperature 35.3oC is the hottest month. The coldest month is January with average mean temperature 16.55oC. Temperature in Chitrakoot during monsoon season stays roughly around 28 degrees (c) and 35 degrees (c)

Material and methodology

Landsat 8 is one of the Landsat series of NASA (National Aeronautics and Space Administration). The data of Landsat 8 is available in USGS (United States Geological Survey) Earth Explorer website at free of cost. Landsat 8 satellite images have the 16 days revisits time. In the present study, the TIR bands 10 and 11 were used to estimate brightness temperature and bands 4 and 5 were used to generate NDVI of the study area.

Satellite data over chitrakoot region of October of 2016 have been used in this study. Landsat 8 provides metadata of the bands such as thermal constant, rescaling factor value etc., which can be used for Calculation like LST.

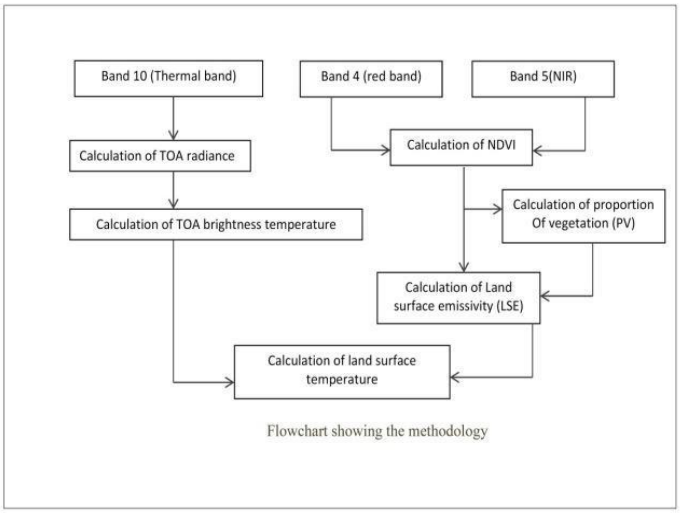


Figure no.1 showing the methodology of estimation of LST

Table no.1 showing Wavelength and Resolution of Landsat8

Spectral band	Centre of band (nm)	Bandwidth (nm)	Spatial Resolution (m)
Coastal/Aerosol	443	433-453	30
Blue	4826	450-515	30
Green	5613	525-600	30
Red	6546	630-680	30
Near infrared	864.6	845-885	30
Short-wavelength infrared	1609	1560-1660	30
Short-wavelength infrared	2201	2100-2300	30
Panchromatic	0590	500-680	15
Cirrus	1375	1360-1390	30

List of equations for the Process of calculation of LST

1. Top of Atmosphere (TOA) Radiance

Using the radiance rescaling factor, Thermal Infra-Red Digital Numbers has been converted to TOA spectral radiance.

$L\lambda = ML * Qcal + AL$

Where;

$L\lambda$ = TOA spectral radiance

ML = represents the specific multiplicative rescaling factor AL = is the band specific additive rescaling factors that is 0.1

Qcal = Quantized and calibrated standard product pixel values (band10 image)

2. Top of Atmosphere (TOA) Brightness Temperature

Spectral radiance data can be converted to top of atmosphere brightness temperature using the thermal constant Values in Meta data file.

$BT = K2 / \ln (k1 / L\lambda + 1) - 272.15$

Where;

BT = Top of atmosphere brightness temperature (°C)

$L\lambda$ = TOA spectral radiance

K1 = K1 Constant Band 10, value has been used 774.88

K2 = K2 Constant Band 10, value has been used 1321.07

3. Normalized Differential Vegetation Index (NDVI):

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which Calculated using Near Infra-red (Bnad 5) and Red (Band 4) bands.

NDVI = (NIR – RED) / (NIR + RED)

Where: RED= DN values from the RED band

NIR= DN values from Near-Infrared band

4. Proportion of Vegetation

Proportion of vegetation is the proportion of the differences of DN values of NDVI and DN value of minimum NDVI by the addition of NDVI max and NDVI minimum.

PV = [(NDVI – NDVI min) / (NDVI max + NDVI min)]

Where:

PV = Proportion of Vegetation

NDVI = DN values from NDVI Image

NDVI min = Minimum DN values from NDVI Image

NDVI max = Maximum DN values from NDVI Image

5. Land Surface Emissivity (LSE)

Land surface emissivity (LSE) is the average emissivity of an element of the surface of the Earth calculated from NDVI values.

E = 0.004 * PV + 0.986

Where:

E = Land Surface Emissivity

PV = Proportion of Vegetation

6. Land Surface Temperature (LST)

The Land Surface Temperature (LST) is the radiative temperature which calculated using Top of atmosphere brightness temperature, Wavelength of emitted radiance, Land Surface Emissivity.

LST = (BT / 1) + W * (BT / 14380) * ln(E)

Where:

BT = Top of atmosphere brightness temperature (°C)

W = Wavelength of emitted radiance
E = Land Surface Emissivity

Results and discussions

Land surface temperature is extracted by applying all these equations and results are as showing the figures. Land surface emissivity is calculated by the NDVI (Normalized difference vegetation index), LSE is generated by the equation as E = 0.004 * PV + 0.986 and ranges from 0.98 to 0.99. Applying the techniques for use with the Landsat-8 requires the use of OLI bands that are band 4and 5 to processed estimate the LSE in the TIRS bands that is band 10 by the use of NDVI., the LSE determined from a land-cover classification, in which the emissivity values for each class are assumed.

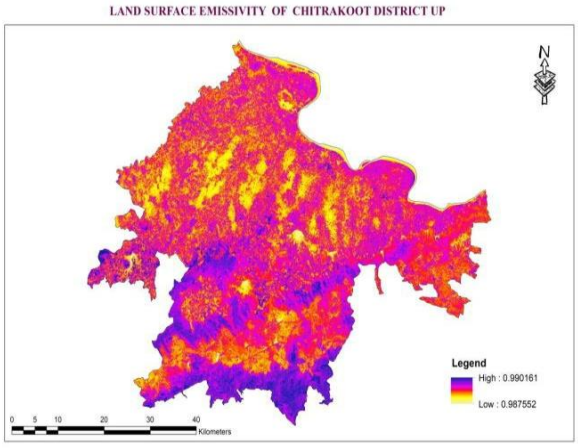


Figure no.2 showing land surface emissivity

Generally at sensor radiances measurements at a wavelength region are stored in Digital Numbers (DNs) and that are converted using a quantification system for the ease of data storage. DN values don't have unit and any physical connotation; so they need to be converted to radiance, after that at-sensor (top-of-atmosphere) brightness temperature and, then it can be converted to land surface temperature.

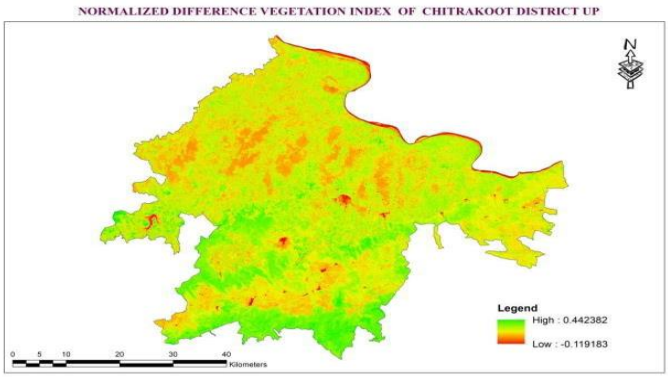


Figure no. 3 showing brightness temperature

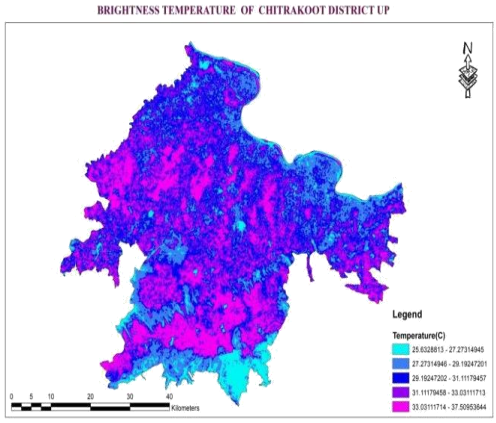


Figure no. 4 showing normalized difference vegetation index

NDVI can be shown as the ratio NIR / (NIR+VIS), which ranges from 0 to 1 and is thus never negative nor limitless in range. But important thing about the concept in the understanding of the NDVI algebraic formula is that, despite its name, it is a transformation of a spectral ratio (NIR/VIS), and functionally it has no relationship with the spectral difference (NIR-VIS).

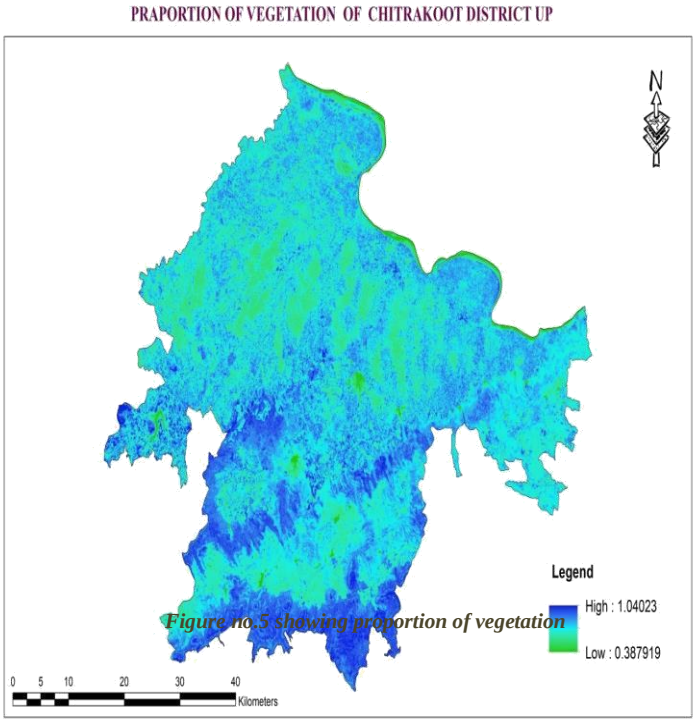
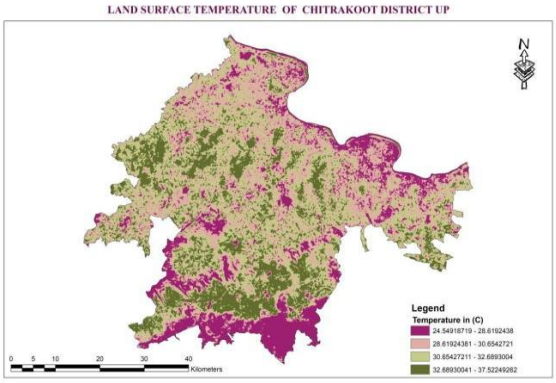


Figure no.5 showing proportion of vegetation



Figureno.6 showing land surface temperature

Conclusion

NDVI (normalized difference vegetation index), brightness temperature, LSE (land surface emissivity), and LST (Land surface temperature) of an area were determined using Arc GIS. NDVI Maps shows that vegetation is high as the value 0.44. Estimated LST values revels that, forest and vegetation and water bodies have low surface temperature comparing to the bear soil and surface temperature lies in the range 24 – 37°C. Thus, LST can be estimated using Landsat 8 with multiband OLI and TIR images.

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