Remote Estimation of Land Surface Temperature for Different LULC Features of a Moist Deciduous Tropical Forest Region

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Abstract Potential of Landsat TM thermal sensor is investigated to retrieve land surface temperature (LST) using spectral index (NDVI), spectral radiance and surface emissivity for a moist deciduous tropical forest area of Munger forests (Bihar, India). Surface emissivity values derived from NDVI are directly used for LST estimation. LST varies spatially due to the complexity of land surface cover features and helps in land-use/land-cover profiling. Areas covered with vegetation show minimum temperatures; while barren and exposed land shows high values. Built-up land generally has higher LST, but when dispersed in small pockets in the forests, the LST value decreases as revealed in the results.

Keywords Landsat · Forest surface temperature (FST) · Normalized difference vegetation index (NDVI) · Land-use/land-cover (LULC) · Emissivity

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1 Introduction

Land surface temperature (LST) is controlled by several physical and chemical thermodynamics, surface and atmospheric parameters and on the other hand, LST controls several physical, chemical and biological processes of the Earth (Becker and Li 1990). It can provide important information about the surface physical properties and climate which plays a role in many environmental and meteorological processes (Dousset and Gourmelon 2003; Weng et al. 2004). Moreover, changes in land-use/land-cover (LU/LC) and anthropogenic activities affect the climate. Conventional methods like measuring air temperature with land observing stations and temperature sensors mounted on vehicles for estimating temperatures are expensive and time taking and can even lead to problems of spatial interpolation. Remote sensing becomes a better alternative in this context. Possibly the best way to retrieve this parameter regionally and globally is the use of satellite remote sensing due to the availability of high resolution, consistent and repetitive coverage and capability of measurements of earth surface conditions (Owen et al. 1998). Dash et al. (2001, 2002) gave a detailed conceptualization of the physics and theory behind deriving LST. Quantitative estimation of surface temperature along different LULC features can be made by using thermal infrared (TIR) sensors mounted on remote sensing satellites. LST is sensitive to vegetation and soil moisture; and hence can detect changes in LULC features (Mallick et al. 2008).

Valuable studies related to Urban Heat Island effect are carried out using integrated geospatial techniques (Sarkar 2004; Weng et al. 2004; Fan et al. 2007; Stathopoulou and Cartalis 2007; Jenerette et al. 2007; Li and Yu 2008; Hais and Kučera 2008; Cheval and Dumitrescu 2009). MODIS is used widely for estimation of LST for small-scale global scenario (Galve et al. 2007; Pinheiro et al. 2007; Akhoondzadeh and Saradjian 2008; Hanes and Schwartz 2011; van Leeuwen et al. 2011; Mildrexler et al. 2011; Hachem et al. 2012). The use of Landsat Thematic Mapper (TM) and ETM+ thermal data is better for large-scale regional and local set-up. Thermal infrared band (10.44–12.42 µm) present in TM/ETM+ with high spatial resolution (120 m for TM and 60 m for ETM+) are much useful for local and regional thermal infrared study. Several researches targeted in the retrieval of LST from Landsat 4 and 5 thermal infrared data (Schott and Volchok 1985; Wukelic et al. 1989; Goetz et al. 1995). Innovative robust however easy techniques are required to attain high accuracy in prediction of LST from TM/ETM+ TIR data with fewer parameters. Earth's surface encompasses various complicated land-use and land-cover feature types. It is difficult to accurately determine the surface emissivities of these features. An error of approximately 6 °C could occur for an assumed emissivity of 1; while, maximum error of only 0.8 °C can be attained with adjustments made on emissivity values (Sutherland and Bartholic 1979). The incoming solar radiation at the Earth's surface results due to the complex interaction of energy between the Earth's surface and atmosphere is also an important parameter (Dubayah and Rich 1995). Moreover, spectral vegetation indices have