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3 authors:

Cat Tuong Truong Thi
Mientrung Institute for Scientific Research

Nguyễn Hoàng Sơn
Hue University

Nguyễn Ngọc Đàn
Trường Đại học Sư phạm Huế

STUDY ON LAND SURFACE TEMPERATURE AND ITS INTERACTION WITH LANDUSE TYPES BY USING THERMAL INFRARED CHANNELS. A CASE IN HUE CITY, VIETNAM

Trương Thị Cát Tường[1], Nguyễn Hoàng Sơn[2], Nguyễn Ngọc Đàn[1]

[1] *Hue Institute of Natural Resources, Environment and Sustainable development*

[2] *Geography Department, Hue University's College Education*

Email: [1] *tuong.tuong@gmail.com*

[1] *ngocdan859@gmail.com*

[2] *sonkdia06@yahoo.com*

ABSTRACT

Land surface temperature (LST) is a key parameter in the physics of land surface processes. It has a close relationship with sun energy as well as the heat radiation to the atmosphere, therefore, it affect urban environment system greatly.

The aim of this study is to estimate LST from remotely sensed data as well as the interaction between LST and landuse types, based on thermal infrared channels from Landsat 8 OLI. The results show that LST is retrieved from satellite images and is related with surface emissivity and vegetation proportion. Furthermore, there is a LST difference between landuse types in study areas, such as water, vegetable, baresoil and impervious surface. This difference has a importance significance for planners and managers to work out the sustainable urban development.

Keywords. Land surface temperature, landuse, thermal data.

1. INTRODUCTION

Land surface temperature (LST) is a key climated parameter, is created by the balance between sun energy to land surface and radiant energy of the earth to the space among planets.

It is clear that different landuse types have significantly different effects on LST due to different radiation by sun energy. Especially, in the analysis of different landuse types, impervious surface has a close relationship with urban environment. High level of urbanization make the building and transportation areas larger. So it lead to change the thermal properties of soil, make heat radiation to atmosphere increase and influence whole urban ecosystem. Hence, the study on the change of LST on difference landuse plays a important role in environment management, particularly planner and manager for sustainable landuse strategies.

2. STUDY AREA

The study area in Hue city, Thua Thien Hue province, located between latitude of 16^0 and $16,8^0$ N and between longitude of 107,8-$108,2^0$ E (Figure 1). It has severe weather conditions and differ with others in the province. It has two distinct seasons: the dry season falls between March and August with hot and muggy weather; but the rainy season which often happen storms and floods is from August to January.

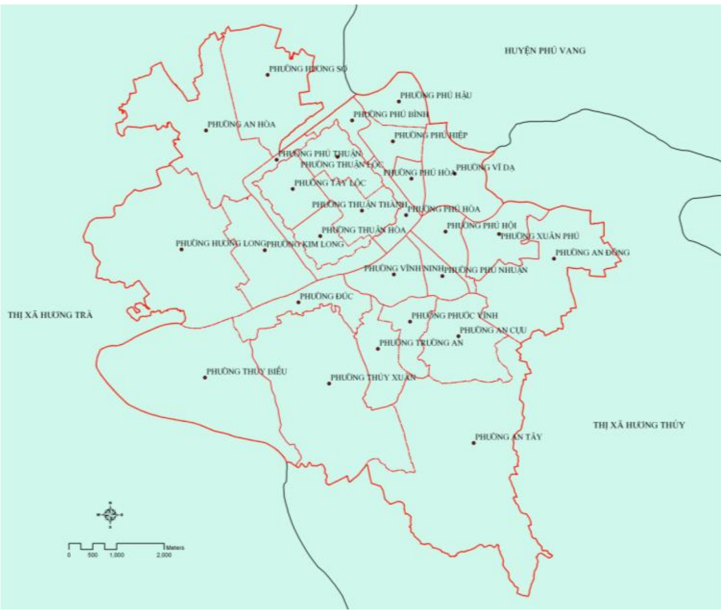

Figure 1. The study area in the central of Thua Thien Hue province

3. MATERIALS AND METHODS

3.1. Materials

Satellite Landsat 8 OLI image on 27-6-2013 with resolution 100 m was used for retrieval LST over Hue city. Besides, some vector files were added to support image process, including topography, hydrology, transportation, administrative boundaries.

3.2. Methods

3.2.1. Radiance calibration

The radiance values from Landsat 8 can be computed from DN values using equation:

$$L_\lambda = M_L Q_{cal} + A_L \quad (1)$$

In which:

L_λ: TOA spectral radiance (W/m^2×srad×µm)

M_L: Band-specific multiplicative rescaling factor

A_L: Band-specific additive rescaling factor

Q_{cal}: Quantized and calibrated standard product pixel values (DN)

3.2.2. Classification

The Maximum Likelihood method was used to combined with NDVI threshold to classify for eliminating confusion pixels and deriving final classified samples.

3.2.3. TOA brightness temperature (T_B)

The thermal TIRS bands 10 and 11 can be used to compute brightness temperature from radiance by inverting the Planck function.

$$T_B = K_2/\ln(K_1/L_\lambda + 1) \quad (2)$$

Trong đó:

T: TOA brightness temperature (K)

L_λ: TOA spectral radiance (W/m^2.Ster.µm)

K_1: Band-specific thermal conversion constant (W/m^2.Ster.µm)

K_2: Band-specific thermal conversion constant (W/m^2.Ster.µm)

Then, TB convert from Kelvin to Celcius unit following the under fomular:

$$T_B\ (^0C) = T_B\ (Kelvin) - 273{,}16 \quad (3)$$

3.2.4. Emissivity *(ε)*

The emissivity is calculated according to the following equation:

$$\varepsilon = \varepsilon_v P_v + \varepsilon_s(1 - P_v) + d\varepsilon \quad (4)$$

where ε_v is the vegetation of the emissivity and ε_s is the soil emissivity, P_v is the vegetation proportion obtained according to:

$$P_v = \left(\frac{NDVI - NDVI_S}{NDVI_v - NDVI_S}\right)^2 \quad (5)$$

The term in Equation (4) includes the effect of the geometrical distribution of the natural surfaces and also the internal reflections. For plain surfaces, this term is negligible, but for heterogeneous and rough surfaces, as forest, this term can reach a value of 2%. A good approximation for this term can be given by:

$$d\varepsilon = (1 - \varepsilon_s)(1 - P_v)F\varepsilon_v \quad (6)$$

where F is a shape factor whose mean value, assuming different geometrical distributions, is 0.55.

3.2.5. Land surface temperature *(T_S)*

Land surface temperature is calculated by Stefan-Bolzman law according to:

$$T_S = \frac{1}{\varepsilon^{1/4}} T_B \quad (7)$$

4. RESULTS AND DICUSSION

4.1. Landuse in the study area

According to natural and cultural characteristics of this study area, it were classified into 7 categories: water, imperious surface, fields, full vegetable areas, baresoil, baresoil mixed impervious surface, and plant mixed residential. The results of analysis were showed in Figure 2 and Table 1.

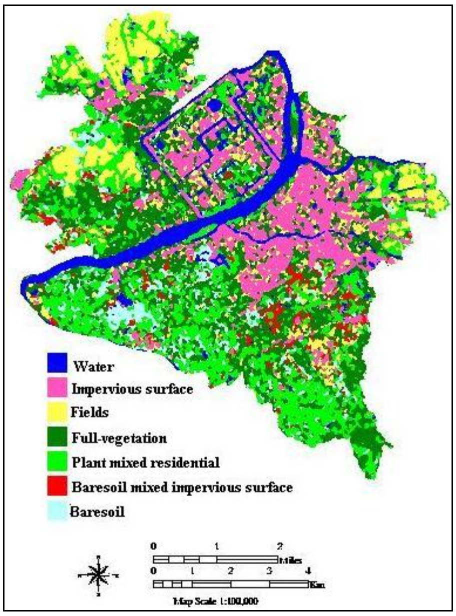

Figure 2. Result of landuse classification in the study area

Table 1. Result of landuse statistics in the study area

Landuse	Area (ha)	Rate (%)
Water	704.98	9.84
Impervious surface	1,216.89	16.98
Field areas	941.40	13.13
Full-vegetable	1,988.55	27.74
Plant mixed residential	1,659.87	23.16
Baresoil mixed impervious surface	212.13	2.96
Baresoil	443.43	6.19
Total	7,167.25	100.00

4.2. Land surface temperature in the study area

Temperature (LST) was derived from two thermal infrared channel (band 10 and 11) in Landsat 8 imagery related with emissivity (ε) and vegetation proportion (P_v). The surface emissivity was derived from the NDVI values. NDVI of only baresoil ($NDVI_s$) and NDVI of only vegetable ($NDVI_v$) were determined for retrieving land surface emissivity. In this case, $NDVI_s$ was -0.085 and $NDVI_v$ was 0.623. The mean emissivity values ε_s, ε_v used in this study was 0.856 and 0,993 respectively. Then, these were used to estimated the land surface emissivity and LST according to equations (5), (6), và (4).

The results showed that LST was various in different landuse types over the study area. Particularly, there was a high temperature concentrated in impervious surface and baresoil, with above 32 °C, while it was under 27°C in full-vegetable areas and water bodies.

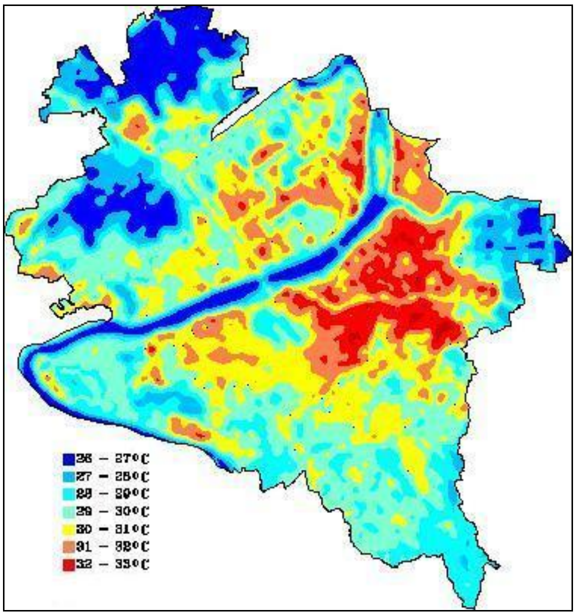

Figure 3. Result of LST estimation

4.3. Interaction between LST and landuse types

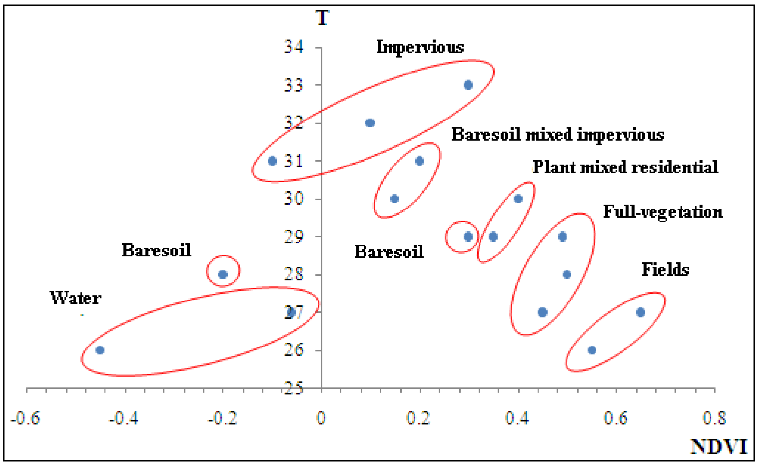

Figure 4. Interaction between LST and NDVI

The impact of landuse to LST difference is able to considered through interaction between LST and NDVI. Figure 4 showed that this interaction is negative. It is clear that higher temperature is associated with impervious surface and baresoil where have low NDVI. In contrast, the temperature of water bodies, fields, full-vegetable areas with high NDVI is lower.

5. CONCLUSION

Hue city was classified into 7 categories, including water, imperious surface, fields, full vegetable areas, baresoil, baresoil mixed impervious surface, and plant mixed residential. In the analysis of different landuse types, the results indicate that different landuse types have significantly different effects on LST and NDVI as estimated by the Landsat 8 OLI sensor. The results also reveal that the interaction between LST and NDVI is negative.

We looked closely at the difference between the brightness temperatures from thermal bands 10 and 11 for evidence of atmospheric absorption or emission of TIR radiation. They don't have their own split window method using line-by-line solutions to the radiative transfer equations. So, we expect to continue this study for accuracy assessment by field test and other thermal images.

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