

MAPPING LAND SURFACE TEMPERATURE (LST) FROM SATELLITE IMAGERIES. CASE STUDY IN HOCHIMINH CITY

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ABSTRACT

In recent years, remote sensing technology is used popularly in many fields and it is considered as an efficient method in creating and updating GIS data in Viet Nam. However, studies to extract land surface temperature (LST) from infrared channels of satellite imageries are limited and still at an initial step, especially in Ho Chi Minh city. This paper introduces the experimental results in applying two methods: Reference Channel Method (REF) and Emissivity Normalization Method (NOR) from Landsat7 ETM⁺ imageries to create the LST map for Ho Chi Minh city. The results are compared to monitored data of the meteorological stations to evaluate accuracy as well as reliability for each method. The results show that the outcome can be used with other data for finding solutions to urban heat island problems.

Key words: Land Surface Temperature (LST), satellite imageries, Reference channel method (REF), Emissivity normalization method (NOR), Ho Chi Minh City (HCMC), urban heat island

1 INTRODUCTION

Population quickly increases in mega-cities made some problems for stable development. Along with environmental pollution and declination of vegetation cover, raising temperature, especially land surface, is an important problem needed to solve

Nowadays, in Viet Nam, remote sensing technology becomes an useful tool for various fields. It has been applied in creating and updating GIS data. However, studying to extract land surface

temperature (LST) from infrared channels of satellite imageries is still limited and at initial steps, especially in Ho Chi Minh city.

There were studies about LST, such as Tran Hung and Yoshifumi Yashuoka (2002) and Pham Van Cu and Hiroshi Watanabe (2004) carried out studies in Ho Chi Minh City and Ha Noi respectively on LST in various covered area. Their result accuracy was not evaluated because collecting data from meteorological stations is limited and there were not LST specialized devices.

There have been different methods of extracting LST developed and applied for infrared channels of different imageries as NOAA, MODIS, LANDSAT, ASTER. In this paper, two methods Reference channel method (REF) and Emissivity Normalization Method (NOR) were used for Landsat7 ETM⁺ imageries to create the LST map.

2 METHODS

2.1 Study area

Ho Chi Minh city (figure 1) locates in the south of Viet Nam with a relatively flat topography. According to the Statistical Office in Ho Chi Minh city, in 2004 the average temperature is 28⁰C, maximum 30.1⁰C on April and minimum 26.6⁰C on December.



Figure 1: Study area

Ho Chi Minh city is the biggest city in Viet Nam, with total area of 2 095.01km². The population on 2004 is 6.062.993 habitants, which grows about 17% compared to 2000 (*website <http://www.pso.hochiminhcity.gov.vn>*). The urbanization has been strongly occurring in recent years. According to Urban Space Development Towards 2010 Project, the speed of urbanization is still stronger in the West and the East direction of the city (*website <http://www.hochiminhcity.gov.vn>*).

2.2 Data collections

Imagery data used for creating LST map in Ho Chi Minh area is from infrared bands of Landsat 7 ETM⁺, acquired on Jan. 18, 2004, listed as Table 1.

Table 1: The imageries data collection

ID	Type	Level of product	Infrared bands	Resolution	Time	Date
1	Landsat7 ETM ⁺ (path/row:125/052)	L1G	band 6	60m	10:02:27	Jan. 18, 2004
2	Landsat7 ETM ⁺ (path/row:125/053)	L1G	band 6	60m	10:03:01	Jan. 18, 2004

The measured temperature at Tan Son Hoa station at 10:00:00 AM on Jan. 18, 2004 (supplied by the Southern Regional Hydrometeorological Centre) is collected to evaluate the accuracy the derived results.

2.3 Extraction of LST from Landsat7 ETM⁺ data

Landsat7 ETM⁺ imagery was processed at level 1G (L1G). Thus, to extract LST, DN values of data had to be converted to spectral radiance values using published post-launch gains, which were calculated following the equation:

$$\text{Radiance} = L = (\text{LMAX} - \text{LMIN})/255 * \text{DN} + \text{LMIN} \quad (1)$$

where:

DN : digital number

LMAX, LMIN : are derived depend on gain status

Table 3: LMAX, LMIN values (unit: W/m²*str*μm)

Band	Low gain		High gain	
	LMIN	LMAX	LMIN	LMAX
6	0.00	17.04	3.20	12.65

In next step, the spectral radiance is converted to brightness temperature at satellite sensor (the temperature is referenced to a black body, TB) using the following equation:

$$T_B = \frac{K2}{\ln\left(\frac{K1}{L} + 1\right)}, \text{ (unit: Kelvin)} \quad (2)$$

where:

K1, K2 : are constants applied for Landsat7 ETM⁺

Table 4: K1, K2 coefficients

	K1 (W/m ² *str*μm)	K2 (Kelvin)
Landsat 7 ETM ⁺	666.09	1282.71

Because the temperature values above are referenced to a black body with an invariable emissivity and the specified emissivity values belong to REF or NOR method, the derived temperature values above is required make a correction to types of land cover as the below equation.

$$T_{LST} = \frac{T_B}{1 + (\lambda + T_B/\rho) * \ln \varepsilon} \quad , (unit: Kelvin) \quad (3)$$

where:

λ : wavelength (μm)

$\rho = h*c/\sigma = 1.438*10^{-2}$ (m K)

σ : Boltzmann constant ($1.38*10^{-23}$ J/K)

h : Planck's constant ($6.626*10^{-34}$ Js)

c : velocity of light ($2.998*10^8$ m/s)

ε : emissivity constant

Reference Channel Method (REF): The reference channel method assumes that all pixels in a channel of the thermal infrared band have the same emissivity constant, from which temperature image is calculated.

Emissivity Normalization Method (NOR): The emissivity normalization method assumes that the pixels at a located position in two thermal infrared channels, data have the same emissivity constant. LST values are computed in turn for every pixel and band in the thermal infrared data.

Finally, the derived LST in Kelvin degree is converted to Celsius degree using the following equation:

$$T_{LST} (^{\circ}\text{C}) = T_{LST} (\text{K}) - 273.16 \quad (4)$$

In addition land use/ land cover extracted from the imageries is also used for finding urban heat island as well as estimating reliability of results.

(1), (2) are extracted from http://ltpwww.gsfc.nasa.gov/ISA/handbook/handbook_toc.html

(3) is extracted from Qihao Weng, Dengsheng Lu, Jacquelyn Schubring (2004)

(4) is extracted from *Thermodynamics Textbook, Natural Science of University, Viet Nam, 2002.*

3 RESULTS

3.1 LST map with REF

LST values derived from Landsat7 ETM⁺ imageries on Jan. 18, 2004 by REF ranging from 23^oC to 34^oC. Ho Chi Minh city LST map is showed in Figure 2.

3.2 LST map with NOR

LST values are extracted from Landsat7 ETM⁺ imageries on Jan. 18, 2004 based on NOR method ranging from 23⁰C to 34⁰C for the whole city, showing in Figure 3.

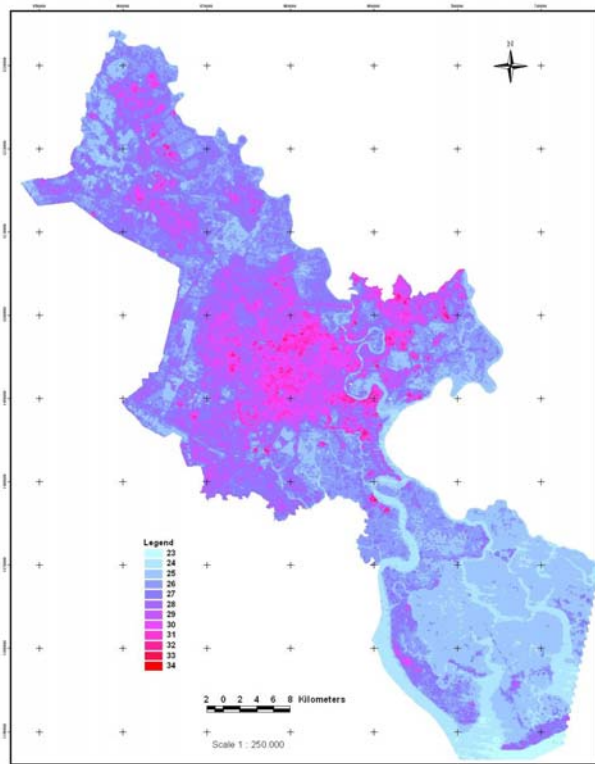


Figure 2: The HoChiMinh city LST map on Jan. 18, 2004 (Using REF)

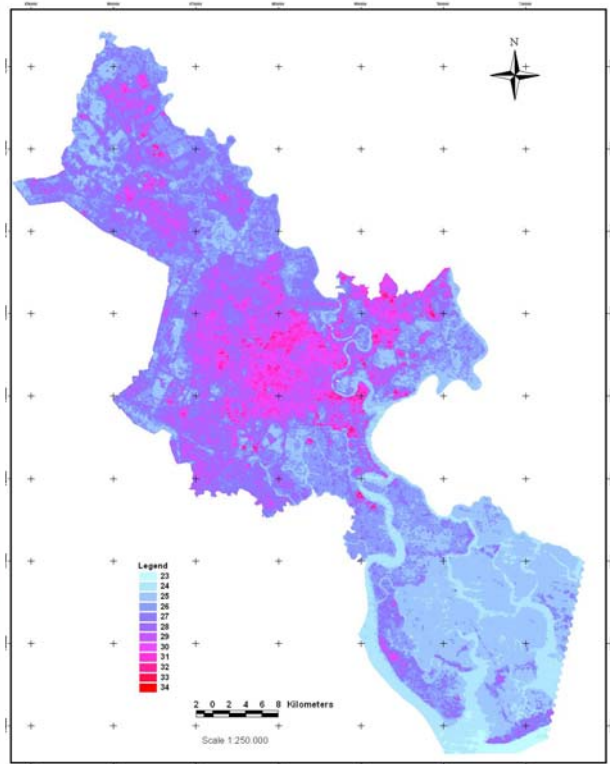


Figure 3: The HoChiMinh city LST map on Jan. 18, 2004 (Using NOR)

Derived LST values in both methods are not much different. In the city centre, LST values are high ranging from 29⁰C to 34⁰C. In the suburban, the LST values are lower, from 23⁰C to 28⁰C. At those places of low vegetated or without vegetation, LST values are higher than other places.

Both results are compared to data at Tan Son Hoa station to estimate the accuracy, which indicates that there is a small deviation of temperature about 0.3⁰C between the derived LST and field value (30⁰C at 10:02:27 AM and 30.3⁰C at 10:00:00 AM for derived LST and station respectively).

To compare relation between land cover types and LST, land use map (Figure 4) created from Landsat imagery is overlaid on LST map. This comparison shows that LST values are low at the perennials, annual plants, forest land, agricultural land and aquacultural areas. They range from 23⁰C to 28⁰C. LST values are higher, from 29⁰C to 34⁰C, at settlement areas, urban land and other land areas.

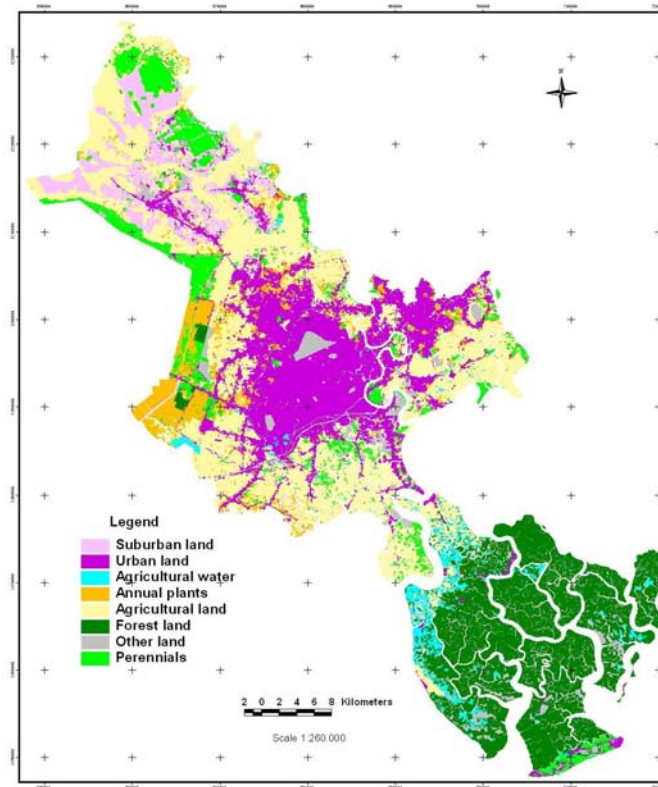


Figure 4: The HoChiMinh city land-use map

4 CONCLUSIONS

LST maps derived from both methods REF and NOR are not much different. LST values at the city centre are higher than that in the surrounding areas. These are also similar at low vegetated cover areas or without vegetation areas comparing to high vegetated cover ones.

In Ho Chi Minh city, the minimum LST values is 23⁰C and maximum is 34⁰C. The deviation is about 0.3⁰C between derived LST values and field temperature at Tan Son Hoa station.

Derived LST values are useful for studying changes of regional climate, particularly in the urbanizing areas. However, to evaluate the accuracy more exactly, field data have to collected more from other places around Ho Chi Minh city.

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