USE OF THERMAL INFRARED CHANNELS OF ASTER TO EVALUATE THE LAND SURFACE TEMPERATURE CHANGES OF AN URBAN AREA IN HANOI, VIETNAM

Pham Van Cu[1] and Hiroshi Watanabe[2]

[1]Centre for Remote Sensing and Geomatics, Institute of Geology,

Vietnamese Academy of Science and Technology, 340 Bach Dang Hanoi Vietnam

Email: phamvancu@hn.vnn.vn

[2]Earth Remote Sensing Data Analysis Center,

Forefront Tower 14F, 3-12-1 Kachidoki, Chuo-ku, Tokyo, Japan**,**

Email: watanabe@ersdac.or.jp

ABSTRACT

One of the advantages of ASTER data is the TIR channels in spite of their spatial resolution of 90m, i.e., 6 times courser than that of VNIR bands. In our investigation, TIR bands are used to compare the temperature at the surface of different land cover types and to evaluate their Land surface Temperature (LST). Our study is aiming to compare the LST of different land cover types in a zone where agriculture land is situated under the invasion of urbanization.

Two data set of 29 September 2001 and 13 January 2003 we received from ERSDAC have already been calibrated and geo-referenced and TIR channels are used to extract the Land Surface Temperature (LST) by Plank equation.

The LST computed in Celsius Degree (C^o) of each date is than crossed with Land Cover Classes extracted from VNIR channels of the same date to obtain the LST of each land cover type. The results we have obtained show that the difference in LST of agriculture land cover types and that of urbanized land may be used to evaluate the extension of the urban areas in using multi-date ASTER TIR channels. Inside the urban classes, different LST correspond to different types of construction.

Spatial resolution of 90m of TIR channels of ASTER is useful when we have a series of VNIR and SWIR data acquired in the same moment for the same territory. For such kind of application the relative calibration of two dates is needed.

1. INTRODUCTION

The raise of land surface temperature due the urban growth with high and higher rhythm in a developing city like Hanoi in Vietnam is to be controlled for many reasons including the needs of the land cover pattern harmonization for the best spatial arrangement of built areas and others non-built objects. This rationale can affect different aspect of the Hanoi Municipality such as its environment health and life quality of its habitants. The spatial pattern of land cover repartition associated to the Land Surface Temperature can be assessed by different ways among which the analysis Thermo-Infrared bands of remote sensing data seems to be efficient with their capacities of identification of land cover types by their spectral specification in these wave lengths. The data collected by the ASTER sensor on board of satellite Terra provide images of the earth at visible, shortwave and thermal infrared wavelengths and will produce important new data products including a global emissivity map. These data will be of particular value to the earth science community but will also greatly assist with surface radiation and hydrological modeling (Donoghue, 2000). This allows to assess the surface temperature of different land cover types for the acquisition moments and therefore, to help the spatial repartition pattern control of the land use practice, especially in the urban areas for a harmonized urbanization.

In this study we use two ASTER data sets provided by ERSDAC in the framework of a collaboration between the Centre for Remote Sensing VTGEO and ERSDAC. Objective of this mini-project is to test the capacities of ASTER data in urban mapping and the possibilities to create the value added for ASTER data application (Pham Van Cu et al., 2004).

2. DATA USED AND DATA ANALYSIS

2.1. Data Specifications

One of the advantages of ASTER data is the TIR channel in spice of their spatial resolution of 90m, i.e., 6 times courser than that of VNIR bands. In our investigation, TIR bands are used to compare the temperature at the surface of different land cover types and to evaluate the LST. The use of thermal infrared data measured by remote sensors is complicated since at-sensor radiances must be corrected for atmospheric absorption and emission, mainly due to water vapor. Additionally, thermal radiances vary with both land surface temperature (LST) and emissivity, which are coupled in the measurements (Coll et al., 2001). For this reason the data we received from ERSDAC have already been calibrated appropriately to the radiometric specifications and calibration parameters of the sensor (Watanabe, 2003).

2.2 TIR Data Analysis

TIR data are used to extract the Land Surface Temperature (LST) by Plank equation as folowing:

$$T = \frac{C_2 / \lambda_n}{\ln\left(\frac{C_1}{\pi \lambda^5{}_n L} + 1\right)}$$

Where :

$$C_1 = 2\pi hc^2 = 3{,}7418 * 10^{-16}(\mathrm{Wm}^2)$$

$$C_2 = hc / k = 1{,}4338 * 10^{-2}(\mathrm{mK})$$

$$L = (DN_n - 1)R_n$$

where :

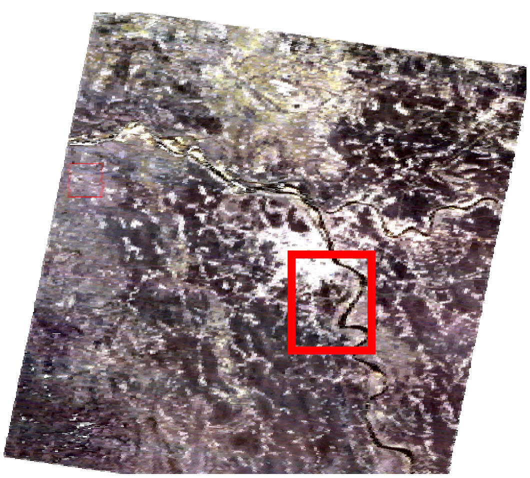
h is Plank's constant (6,626176*10-34)
k is Boltzmann's constant (1,380662*10-34)
c is light velocity (2.997925*108)
DN pixel value at 1B
L is radiance W/(m^2 *sr*m)

The parameters used for TIR bands of ASTER (Watanabe, 2003) are listed as bellow:

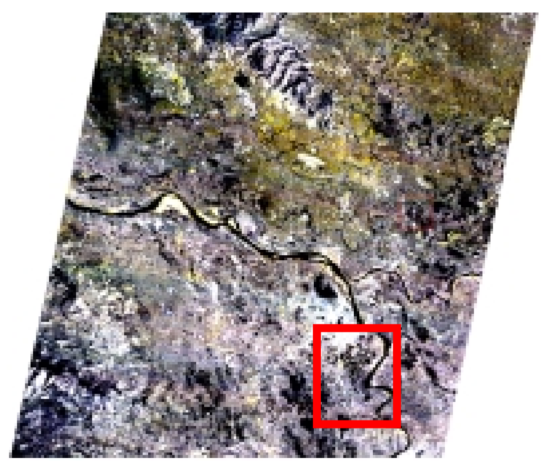
Table 1: Parameters used to transform DN into Land Surface Temperature

Band(n)	Wave Length n (m)	R(n)
10	8,30E-06	6,882E+03
11	8,65E-06	6,780E+03
12	9,10E-06	6,590E+03
13	1,06E-05	5,693E+03
14	1,13E-05	5,225E+03

The LST extracted form TIR bands in C^o are shown in figure1.



Color Composite of LST (in C^o) derived from TIR Bands 14 (R), 13 (G) and 10 (B) 26 Sep. 2001

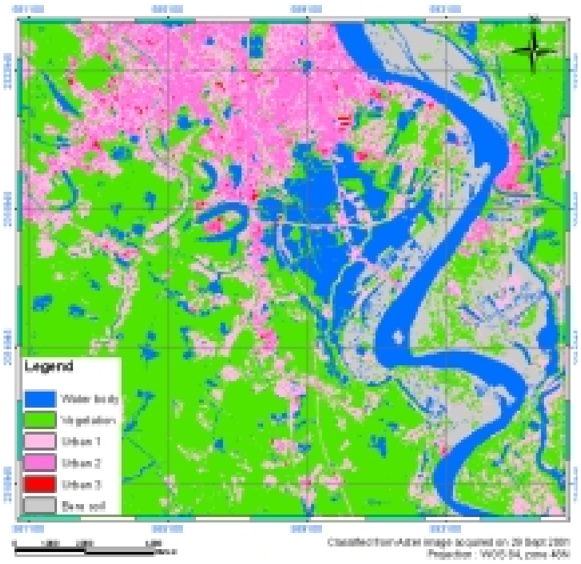


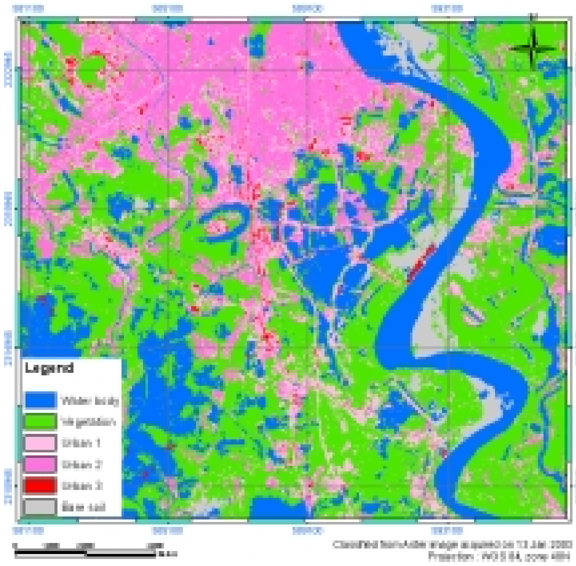
Color Composite of LST (in C^o) derived from TIR Bands 14 (R), 13 (G) and 10 (B) 13 Jan. 2003

Figure 1: Color Composite of LST (in C^o) of two date, Square in Red is pilot site corresponding to classified subset

2.3. Overlay of Land Surface Temperature and Land Cover Types:

The two image subset of pilot site in Hanoi is classified in using Urban Index (fig.2) and then crossed with the temperature image subsets of the same site to evaluate their surface temperature.





Classification of 2001 Image Classification of 2003 Image

Figure 2: Classification of image subset of two dates

The results are shown in tables 2, 3 and figures 3, 4 bellow:

Table 2: Crossing of Land Cover Types and Surface Temperature of 26 Sep. 2001 in Thanh Tri

T (C^o)	bare soil	urban1	urban2	urban3	vegetation	water
21	13	28	8		29	8948
22	874	805	131	36	98023	64623
23	3230	9504	828	63	201651	46260
24	9491	30172	2524	417	83979	24863
25	21776	50619	6329	587	56208	12825
26	17517	45749	14373	1123	20028	4692
27	9807	27274	28517	1384	5546	1433
28	5027	14762	30042	1075	1407	600
29	3100	3444	11519	505	176	100
30	1693	542	1624	62	22	13

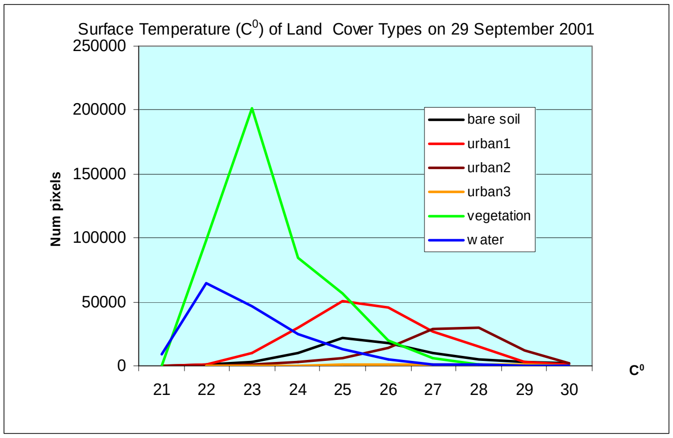


Figure 3: Surface Temperature of Land Cover Types on 26 September 2001 in Thanh Tri Hanoi

Table 3: Crossing of Land Cover Types and Surface Temperature of 13 Jan. 2003 in Thanh Tri Hanoi

T (C^o)	water	vegetation	Urban3	Urban2	Urban1	Bare Soil
10		12	6		18	
11						
12			22	5	9	
13	87	18	70	15	26	
14	5359	67	32	374	137	14
15	59225	4030	134	3415	1007	233
16	103919	42218	769	9160	5583	1575
17	48135	177454	1910	27271	26234	7862
18	16443	165284	3647	70153	56023	15296
19	4193	13267	3397	51447	23840	8784
20	1141	1104	1442	9776	5641	1514
21	243	308	718	2823	1621	427
22	27	107	183	966	466	160
23	11	70	29	328	186	170
24	4	3	26	84	31	140
25				35	1	36

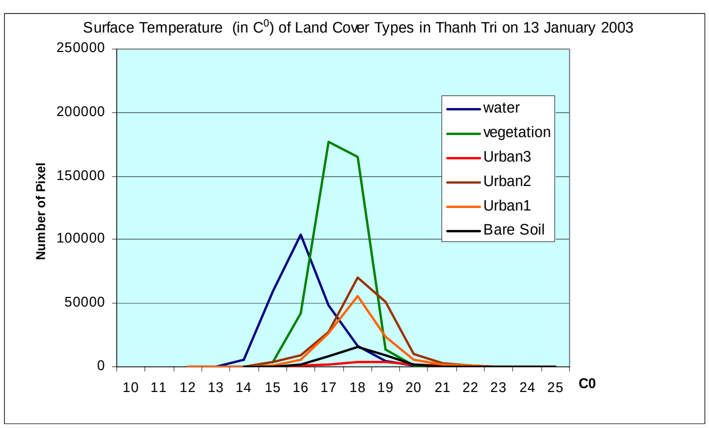


Figure 4: Surface Temperature of Land Cover Types on 13 January 2003 in Thanh Tri Hanoi Area

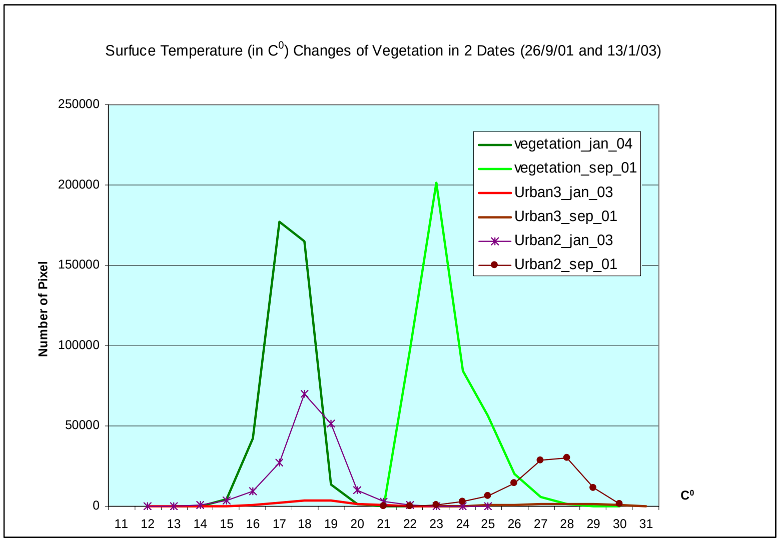


Figure 5: Difference of Surface Temperature of Vegetation and Urbanized areas in Thanh Tri between 2 dates 26 Sep. 2001 and 13 Jan. 2003

CONCLUSION

In both dates, urban objects always have a higher surface temperature in comparison to vegetation. The Class Urban 3 occupying less space than 2 others urban classes but has more concentrated temperature spectra due to their higher homogeneous morphologic pattern. The Classes Urban 1 and Urban 2 are more heterogeneous due to the presence of vegetation and other mixed objects inside the classes.

In the same time, we compare the surface temperature of land cover types of 2 dates to indicate the difference between these to dates in terms of Surface Temperature of the vegetation and urbanized areas of the studied zone (see figure 5)

This figure 5 demonstrates the large different between surface temperature of land cover on these to dates and this difference fits well the average seasonal temperature difference of Hanoi (about 10 C^o).

REFERENCE

Coll C., Caslles V., Rubio E., Sospedra F. and Valor E., 2001. Analysis of thermal infrared data from the Digital Airborne Imaging Spectrometer. *International Journal of Remote Sensing*, 2001, vol. 22, no. 18, 3703–3718

Donoghue Daniel N.M. . 2000. Remote sensing: sensors and applications. *Progress in Physical Geography* 24,3 (2000) pp. 407–414

Pham Van Cu, Chu Xuan Huy, Hoang Kim Huong, Ha Xuan Thu, Le Minh Vinh, Le Thanh Hoa, Lam Dao Nguyen, Pham Bach Viet. 2004. *PERIODIC REPORT OF WORK PACKAGE FOR 2003. Implementation of ASTER application in Vietnam*. ERDAC Tokyo and VTGEO Hanoi. 31 pages.

Watanabe, H. 2003. *ASTER GDS Current Status.* ERSDAC, Japan. Power point presentation, 90 pages.