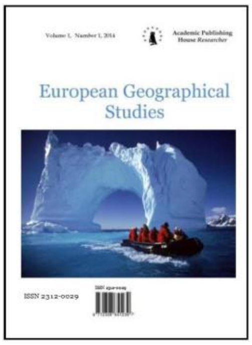
Published in the Russian Federation
European Geographical Studies
Has been issued since 2014.
ISSN: 2312-0029
Vol. 5, Is. 1, pp. 34-41, 2015

DOI: 10.13187/egs.2015.5.34
www.ejournal9.com



UDC 528.854.4

Application of Thermal Remote Sensing in Mapping Land Surface Temperature Distribution Map in Bac Binh District (Binh Thuan Province)

[1] Nguyen Thanh Son
[2] Le Duc Loc

[1] Hanoi University of Mining and Geology, Hanoi, Vietnam
[2] Le Quy Don Technical University, Hanoi, Vietnam

Abstract

Land surface temperature is one of the most important factors in climatology studies and human – environment interactions. Besides, land surface temperature is also an important factor when monitoring soil moisture. Ground-based observations reflect only thermal condition of local area around the station and in fact cannot establish the number of meteorological stations with expected density due to the high cost. Remote sensing technology with advantages such as wide area coverage and short revisit interval has been used effectively in the study of land surface temperature distribution. This article provides a synthetic analysis method of the actual problems monitoring the land surface temperature using LANDSAT thermal infrared image for monitor drought.

Keywords: Vietnam; multispectral image; thermal infrared image; land surface temperature.

Introduction

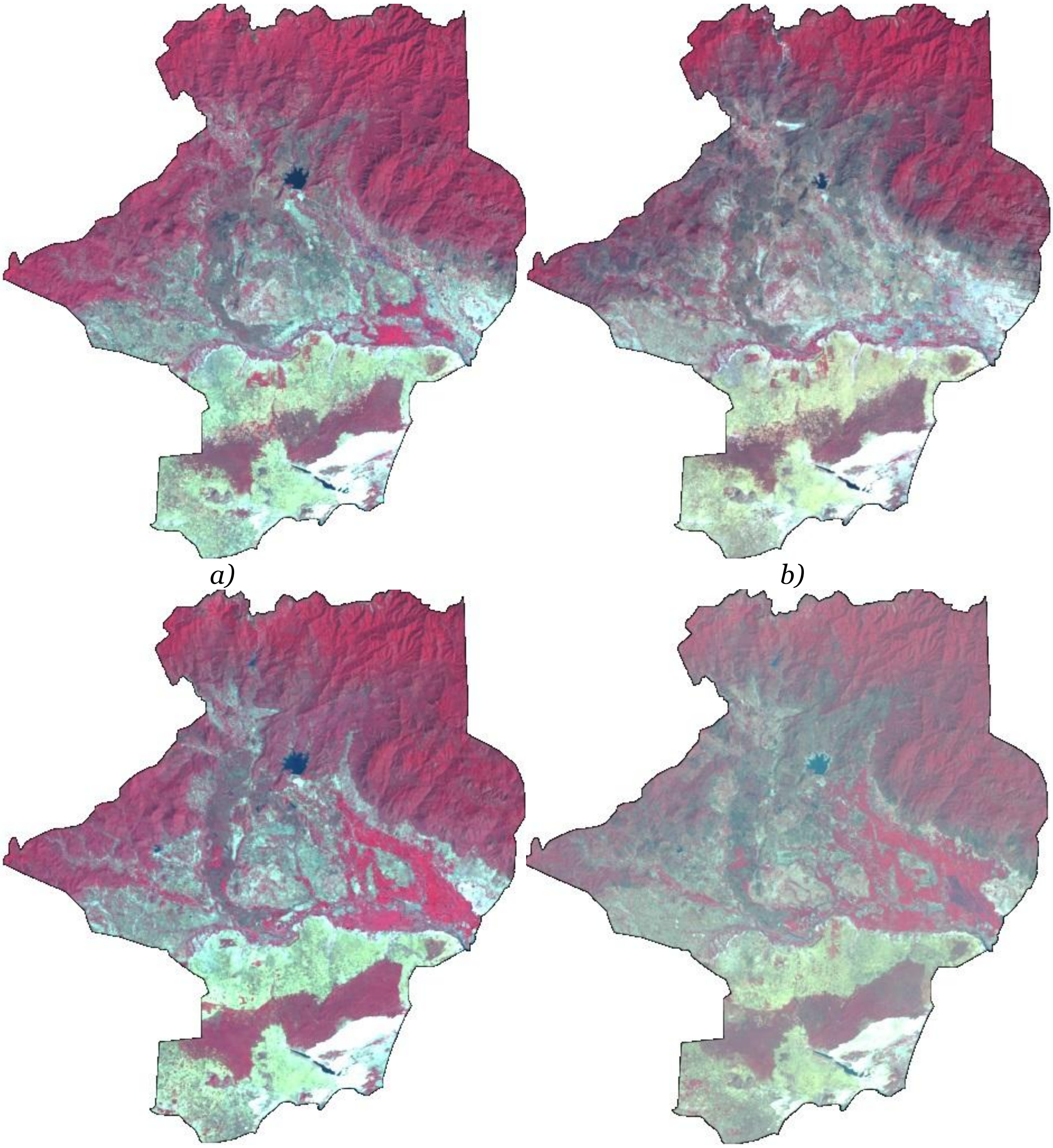
Drought is a natural phenomenon, which occurs in most regions in the world, caused immense damage in agricultural production and seriously affected on the environment. Application of remote sensing data in studying, monitoring and dealing with drought phenomenon has achieved positive results [1-7]. Compared to traditional methods, remote sensing technology with advantages such as wide area coverage and short revisit interval has been used effectively in the study of soil moisture and monitoring drought. This article presents results of land surface temperature monitoring from LANDSAT multispectral images in Bac Binh district, Binh Thuan province. Land surface temperature is one of the most important physical factors for water exchange processes and energy exchanges between land surfaces and the overlying atmosphere. Temperature can rise very quickly in the situation of drought on surface and vegetation. The results obtained in this study can be used to create the land surface temperature distribution map, to monitor drought phenomenon and vegetation health.

Materials and methodology

The study area is located at the Bac Binh district, Binh Thuan province (Vietnam), which is located on coast of South Central Vietnam. The province lies in the monsoon tropical area with two distinct seasons. The rainy season: from May to October and the dry season: from November to

April following year. The annual average temperature varies between 27°C and the yearly rainfall is 800 mm – 1500 mm.

To calculating land surface temperature we used LANDSAT ETM+ satellite image on 05 January 2002, 13 January 2005 and 12 February 2010 and LANDSAT 8 OLI image on 15 February 2014 (fig. 1). The Enhanced Thematic Mapper (ETM+) on board LANDSAT – 7 and Operational Land Imager (OLI) on board LANDSAT – 8 are multispectral radiometric sensors with varying spectral and spatial resolutions (30m spatial resolution for red, green, blue, near infrared and two bands of medium infrared; 60m for thermal infrared; and a 15m panchromatic band).



a) *b)*

c) *d)*

Fig. 1. The Landsat images in Bac Binh district (Binh Thuan province) 05 – 01 – 2002 (a), 13 – 01 – 2005 (b), 12 – 02 – 2010 (c) và 15 – 02 – 2014 (d)

1. Conversion of the digital number to spectral radiance

Image processing started with geometric and radiometric correction. Radiometric correction done by converted the digital number value in LANDSAT thermal band (band 6, band 6.1 and band 6.2) to radiance value. Method to convert digital number to radiance value is shown in equation 1 [8]:

$$L_{\lambda} = \frac{L\max - L\min}{DN\max - DN\min}(DN - DN\min) + L\min \quad (1)$$

where, L_{λ} - spectral radiance watts/(m*m * ster * μm);
DN – digital number;
Lmin – spectral radiance which is correlate with DNmin watts/(m*m * ster * μm);
Lmax – spectral radiance which is correlate with DNmax watts/(m*m * ster * μm);
DNmin = 1, minimum value of DN;
DNmax = 255, maximum value of DN.

Table 1: Value of Lmax, Lmin for image LANDSAT ETM, ETM+

Band	Satellite/Sensor	Lmax	Lmin
6.1	LANDSAT7 /ETM+ High gain	12.65	3.2
6.2	LANDSAT7 /ETM +Low gain	17.04	0.0
6	LANDSAT ETM, ETM+	15.503	1.238

Conversion LANDSAT 8 to Radiance

OLI and TIRS band data can be converted to TOA spectral radiance using the radiance rescaling factors provided in the metadata file [8]:

$$L_{\lambda} = M_L Q_{cal} + A_L \quad (2)$$

where:
L_{λ} - TOA spectral radiance (Watts/(m2 * srad * μm))
M_L - Band-specific multiplicative rescaling factor from the metadata (RADIANCE_MULT_BAND_x, where x is the band number)
A_L - Band-specific additive rescaling factor from the metadata (RADIANCE_ADD_BAND_x, where x is the band number)
Q_{cal} - Quantized and calibrated standard product pixel values (DN)

Table 2: The values of M_L, A_L of LANDSAT 8 thermal infrared image

Kênh	Satellite/Sensor	M_L	A_L
10	LANDSAT 8	$3.3420.10^{-4}$	$3.3420.10^{-4}$
11	LANDSAT 8	0.10000	0.10000

2. Conversion of the spectral radiance to brightness temperature

Method to convert radiance value to effective temperature value is shown in equation 3 [8]:

$$T_B = \frac{K_2}{\ln(1 + \frac{K_1}{L_{\lambda}})} \quad (3)$$

where, T_B - brightness temperature;
L_{λ} - spectral radiance watts/(m*m * ster * μm);
K1 = 666.09 W/(m*m*ster*μm), calibration const;
K2 = 1282.71 W/(m*m*ster*μm), calibration const.

3. Estimation of land surface emissivity

An alternative, operative procedure is to obtain the land surface emissivity image from the NDVI. The method proposed obtains the emissivity values from the NDVI considering different cases [6, 7]:

a) NDVI < 0.2. In this case, the pixel is considered as bare soil and then a constant value for the emissivity is assumed, typically of 0.95.

b) NDVI > 0.5. Pixels with NDVI values higher than 0.5 are considered as fully vegetated and then a constant value for the emissivity is assumed, typically of 0.99.

c) 0.2 < NDVI < 0.5. In this case, the pixels is composed by a mixture of bare soil and vegetation, and the emissivity is calculated according to the following equation:

$$\varepsilon = \varepsilon_V P_V + \varepsilon_S (1 - P_V) = 0.04 P_V + 0.95 \quad (4)$$

Where εv is the vegetation of the emissivity and εs is the soil emissivity. Pv is the vegetation proportion obtained according to the following equation [7]:

$$P_V = \left[\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}} \right]^2 \quad (5)$$

NDVI is normalized difference vegetation index, which is calculated according to the following equation:

$$NDVI = \frac{NIR - RED}{NIR + RED} \quad (6)$$

Where RED and NIR stand for the spectral reflectance measurements acquired in the red and near-infrared bands, respectively.

4. Calculation land surface temperature

Method to calculate land surface temperature is show in equation 7 [8]:

$$LST = \frac{T_B}{1 + (\frac{\lambda . T_B}{\rho}) * \ln \varepsilon} \quad (7)$$

Where T_B - brightness temperature (K°), λ – wavelength (11.5 μm), ε – land surface emissivity, $\rho = \frac{hc}{\sigma}$, h – Plank's constant ($6{,}626.10^{-34}$ J.sec), c – velocity of light ($2{,}998.10^{8}$ m/sec), σ – Stefan Boltzmann's constant, which is equal to $5{,}67.10^{-8}$ $Wm^{-2} K^{-4}$.

Results and discussions

Basing on the NDVI values of different land use classes, emissivity image was prepared by assigning emissivity values as 0.95 for building areas and 0.99 for vegetation areas. The emissivity image is shown in Fig. 2 below.

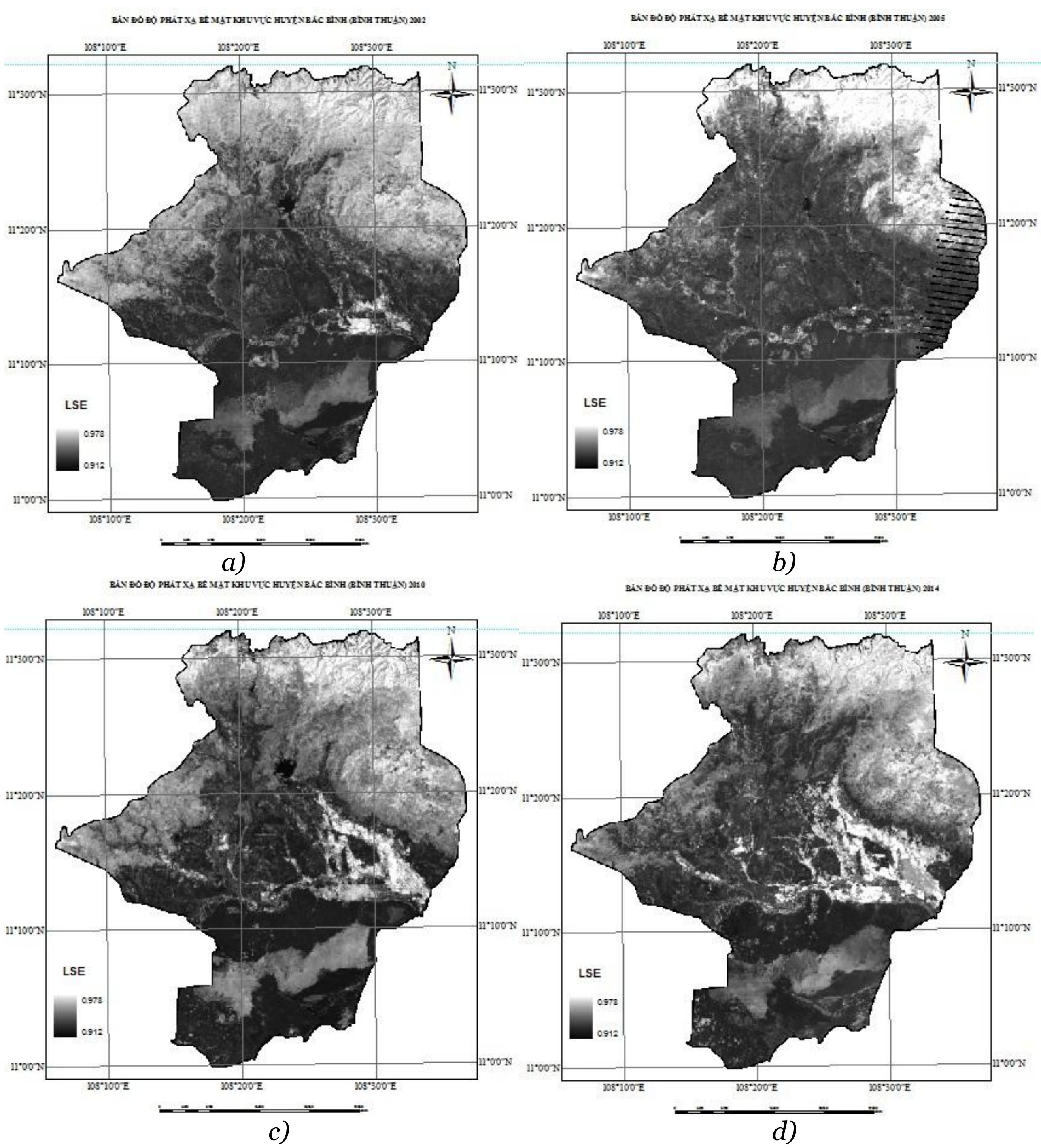
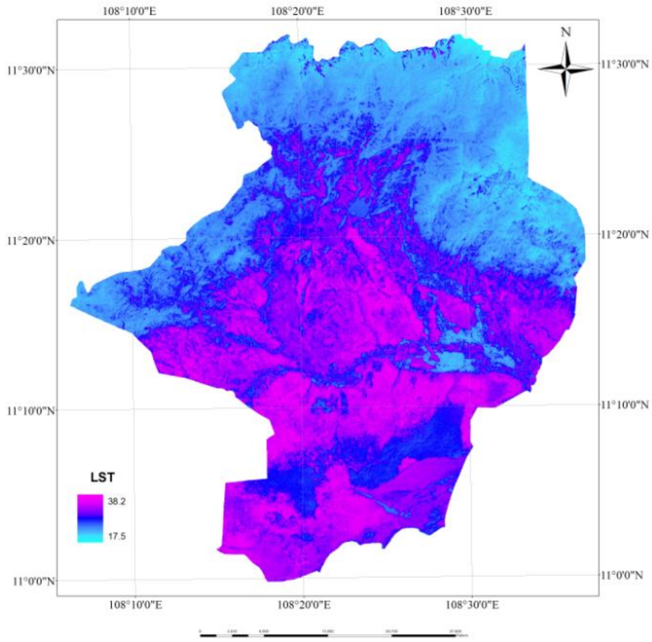


Fig. 2. Land surface emissivity in Bac Binh district (Binh Thuan province) 05 – 01 – 2002 (a), 13 – 01 – 2005 (b), 12 – 02 – 2010 (c) and 15 – 02 – 2014 (d)

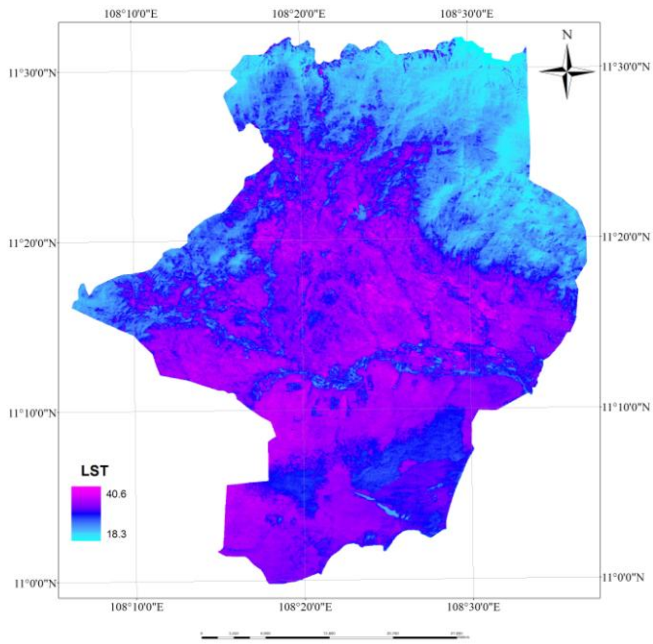
From brightness temperature and land surface emissivity images, the final land surface temperature image was obtained by using ERDAS Imagine 2014 program. The final land surface temperature image is shown in the Fig.3 below.

Analyze the results of estimation land surface temperature in Bac Binh district, Binh Thuan province showed that from the land surface temperature image 05 – 01 – 2002, it was observed that highest temperature of about 38.2°C exist at impervious area and lowest temperature of about 17.5°C are existing at vegetative areas. With land surface temperature image 13 – 01 – 2005, the highest temperatures was 40.6°C and the lowest temperatures about 18.3°C. From the land surface temperature image 12 – 02 – 2010, the highest temperature of about 41.7°C and lowest temperature of about 22.5^{o}C. With land surface temperature image 15 – 02 – 2014, the highest temperatures was 46.1^{o}C and the lowest temperatures about 20.0^{o}C

LAND SURFACE TEMPERATURE MAP IN BAC BINH DISTRICT (BINH THUAN PROVINCE) 05-01-2002



LAND SURFACE TEMPERATURE MAP IN BAC BINH DISTRICT (BINH THUAN PROVINCE) 13-01-2005



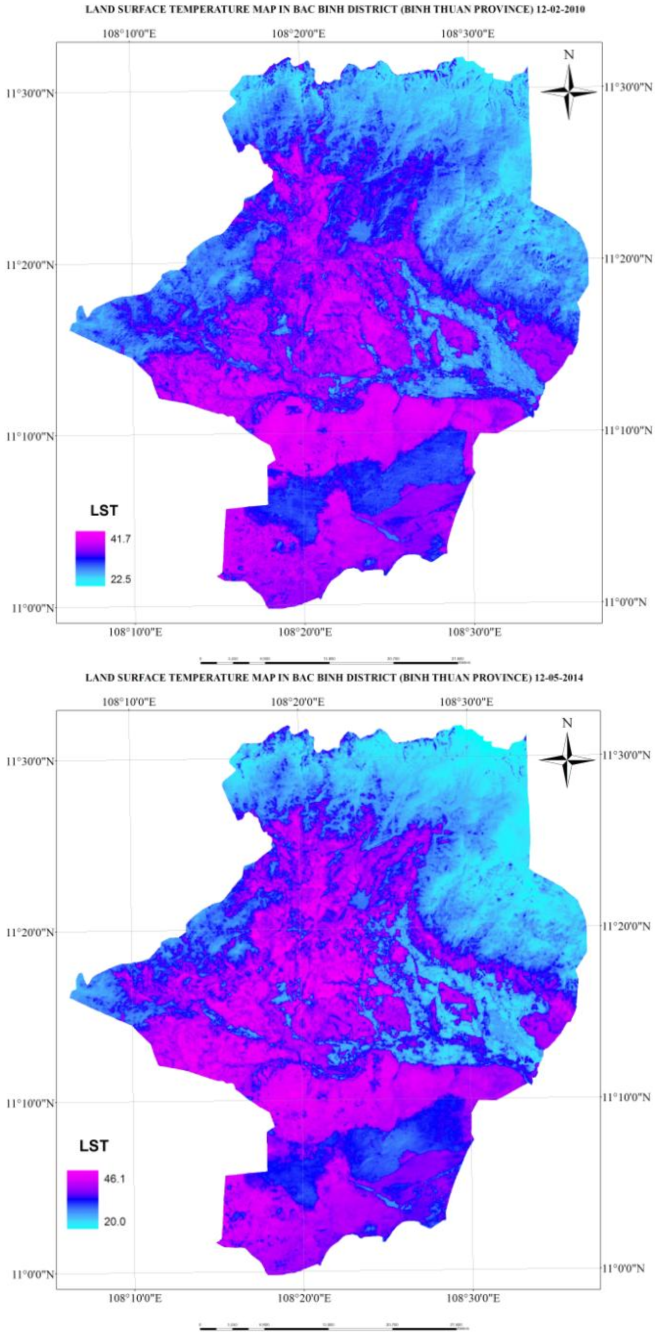


Fig. 3. Land Surface Temperature image of the study area for the year2007 and 2009

Conclusions

Drought disasters in Bac Binh district, Binh Thuan province have been occurring with increasing frequency in recent years. Evaluation of drought is one of the important items for the mitigation of its effects, but this evaluation difficult to obtain over large and remote areas. The use of remote sensing technique is useful for drought monitoring to obtain up to date information that difficult to collect by traditional methods such as field survey and sampling questionnaires.

References:

1. Trinh Le Hung (2014). *Studies of land surface temperature distribution using Landsat multispectral image, Vietnam journal of Earth sciences,* Vol. 36(01), 82–89.

2. Trinh Le Hung (2014). *Application of Landsat thermal infrared data to study soil moisture using temperature vegetation dryness index*, Vietnam journal of Earth sciences, Vol. 36(03), 262–270.

3. Tran Thi Van, Hoang Thai Lan, Le Van Trung (2009). *Thermal remote sensing method*

in study on urban surface temperature distribution, Vietnam journal of Earth sciences, Vo. 31(02), 168–177.

4. K. Sundara Kumar, P. Udaya Bhaskar, K. Padmakumari (2012), "Estimation of land surface temperature to study urban heat island effect using LANDSAT ETM+ image", International journal of Engineering Science and technology, Vol. 4, No. 2, pp. 771–778.

5. O.R. Garcia Cueto, E. Jauregui Ostos, D. Toudert, A. Tejeda Martinez (2007), "Detection of the urban heat island in Mexicali and its relationship with land use", Atmosfera 20(2), pp. 111–131.

6. Van de Griend A.A., Owen M. (1993). On the relationship between thermal emissivity and the normalized difference vegetation index for natural surface // International journal of remote sensing 14, pp. 1119–1131.

7. Valor E., Caselles V. (1996). Mapping land surface emissivity from NDVI. Application to European African and South American areas // Remote sensing of Environment, 57, pp. 167–184.

8. LANDSAT 7 Science data users Handbook, National aeronautics and space administration (NASA), 186 pp.