"Detecting Trend on Urban Warming Temperature in Mandalay City"

Dr. Kyaw Zaya Htun[1], Dr. Myint Myint Khaing[2], Dr. Swe Swe Aye[3]

[1] *Remote Sensing Department, Mandalay Technological University, Myanmar*
[2] *Associate Professor, Remote Sensing Department, Mandalay Technological University*
[3] *Pro-Rector, Yangon Technological University, Myanmar*
kyawzaya.htun@gmail.com

Abstract--This study developed a method for detecting urban land surface temperature in Mandalay City using Multi-temporal Landsat image data for the period 2000 to 2005. Land surface temperatures are important in studying of global warming in estimating radiation budgets in heat balance studies and as a control for climate model. The ability of the surface for emit radiation (surface emissivity) is a main parameter for detecting land surface temperature (LST). Therefore, knowledge of the surface emissivity is crucial for estimating the radiation balance at the earth surface. This study also indicated that LST data can aid in modeling urban planning and monitor environment. In this paper, evaluation the usefulness of multi-temporal Landsat image data for determining LST in Mandalay City was determined based on association surface emissivity value with land cover information.

Keywords-- LST, surface emissivity, radiation,

I.INTRODUCTION

Land surface temperature (LST) is maintained by the incoming solar and long wave irradiation, the outgoing terrestrial infrared radiation, the sensible and latent heat flux, and the ground heat flux. Therefore, LST is a good indicator of the energy balance at the Earth's surface. LST is also strongly influenced by the ability of the surface to emit radiation (i.e. surface emissivity). Surface emissivity (ε) is the ratio of energy emitted from a natural material from an ideal blackbody at the same temperature and emissivity from thermal infrared remote sensing data which is important for the study of urban planning, water and energy balances, climate models, lithological mapping and resource exploration, and etc.

Emissivity classification was conducted in this study, based on the conventional land cover classification. The objectives of this study is to retrieve the LST in Mandalay City, from Landsat ETM + thermal infrared data using surface emissivity which was based on the conventional land cover classification during a five year period (2000 to 2005).

II. STUDY AREA AND DATA

The study area, Mandalay City, is located at the centre of Myanmar which is a mega city with the biggest industrial and commercial center in Central Region of Myanmar. The study composes of major part of Mandalay city and parts of surrounding Sagaing division and Shan state.

Mandalay city can be classified into two regions based on urbanization: Urban region where the region is fully urbanized, suburban region where their region is mainly agriculture land. Two scenes of Landsat ETM+ images acquired an Feb 16,2000 (path 133/ Row 045) and March 17,2005 (Path 133/ Row045) are applied in this study (figure 1&2).

III. RETRIEVAL OF LST FROM LANDSAT ETM + IMAGES

Surface emissivity is known to be important factor in radiance balances and transfer. However, the Earth's surface is compared of complex land use and land cover patterns and surface emissivities are difficult to measure accurately. The effect of surface emissivity on satellite measurements can be generalized into three categories[3] ;

(i) Emissivity causes a reduction of surface emitted radiance.

(ii)Non-black surface reflect radiance

(iii)The isotropy of reflectivity and emissivity may reduce or increase the total radiance from surface.

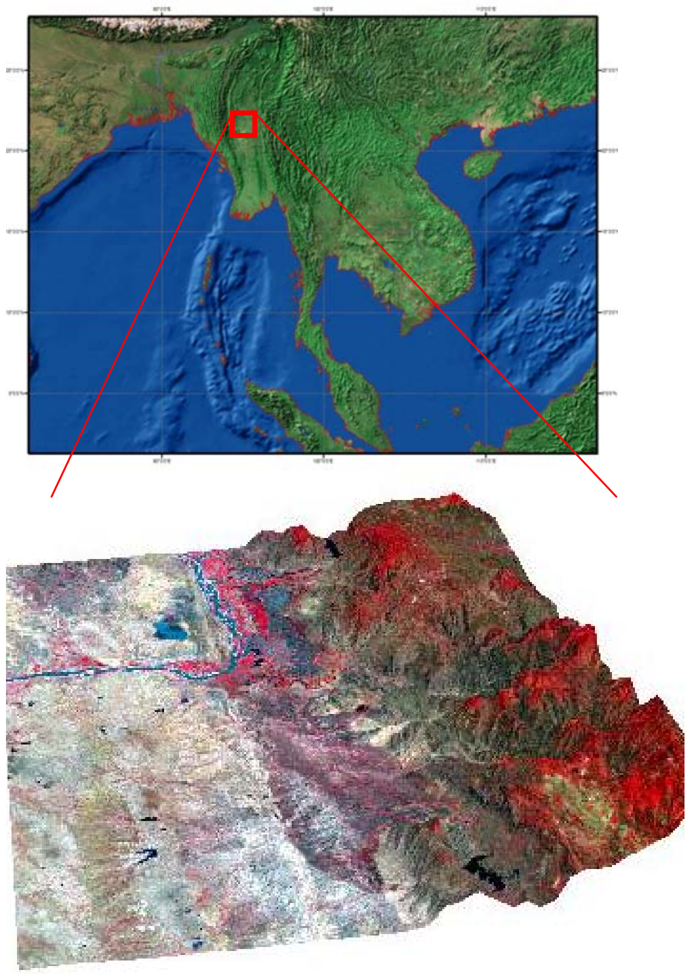
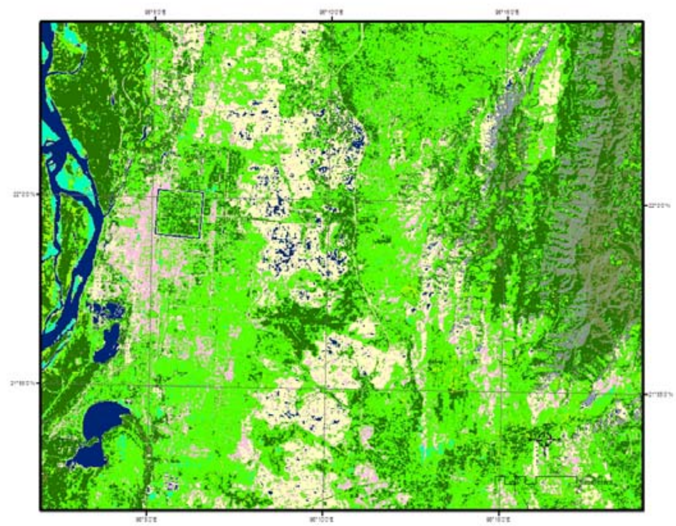
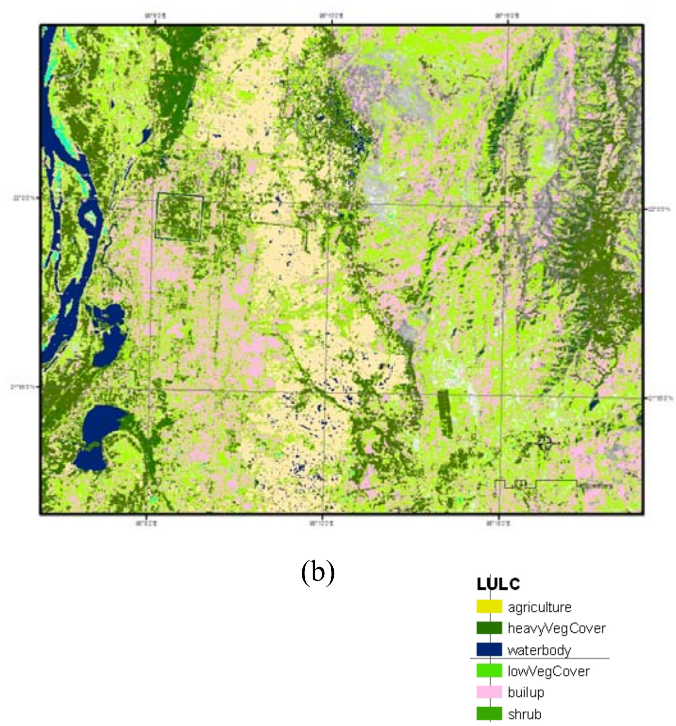


Fig 1. Study Area, Mandalay City, Myanmar

Therefore, retrieval of LST from multispectral data requires an accurate measurement of emissivity value of the surface. The emissivity of the surface is controlled by such factors as water content, chemical composition, structure and roughness. For vegetated surfaces, emissivity can vary significantly with plant species, areal density and growth stage. At the same time, emissivity is a function of wavelength, commonly referred to or spectral emissivity. Among different methods for estimation of emissivity for ground objects, surface emissivity based on the conventional land cover classification method was used in this study [1].



(a)



(b)

Fig 2. Land Cover Map of Study Area
(a) 2000 (b) 2005

In this study, both unsupervised and supervised classification methods were applied to classify the Landsat ETM+ multispectral image to land cover map and to derived associated surface emissivity. In unsupervised classification, 15 clusters were applied to assist the selection of training sites. The land cover classification was then done as supervised classification using the Maximum Likelihood algorithm. After the classification, a post-classification recording was applied to group the land cover types into six broad emissivity classes, such as forest (ε=0.990), grass (ε=0.991), water (ε=0.986), bare soil (ε=0.982), and urban region (ε=0.972). each of land cover categories was assigned an emissivity value by reference to the emissivity classification scheme [2].

The LST were derived from the Lansat ETM + thermal infrared band (10.44-12.42 mm), which has a spatial resolution of 60m. The following equation was used to convert the digital number (DN) of Landsat ETM + thermal infrared band into spectral radiance.

$$L_\lambda = 0.0370588 \times D_N + 3.2 \text{ ----------- } 1$$

The next step is to covert the spectral radiance to at satellite bright near temperature (i.e. blackbody temperature, T_B, under the assumption of uniform emissivity [3]. The conversion formula

$$T_B = \frac{K_2}{L_n\left(\frac{K_1}{L_\lambda} + 1\right)} \quad \text{----------- } 2$$

Where T_B is effective at satellite temperature in K, L_λ is spectral radiance in W / (m^2 ster μm); and K_2 and k1 are pre-launch validation contour. For Lansat ETM+ , K_1=666.09 m Wcm^{-2} sr^{-1} $km^{-1}$and k_2=1282.71K. The temperature values obtained above are referenced to blackbody. Therefore, correction for spectral emissivity (ε) are necessary according to the nature of land cover. The job retrieving spectral emissivity is mentioned in the section "surface emissivity". The emissivity corrected landsurface temperature (S_t) were computed as followed:

$$S_t = \frac{T_B}{1 + (\lambda x\ T_B / S) \ln \varepsilon} \quad \text{----------- } 3$$

IV. RESULTS

Digital numbers (DN) derived from ETM+ thermal data, converted brightness temperature (ε) and corrected emissivity to get land surface temperatures data. The surface emissivity was derived from Classification-based emissivity method. Analysis from imagery indicates that the residential areas are placed with highest surface temperature relative to vegetation and water exhibiting lower temperature. The land surface temperature maps for year 2000 and 2005 of the study area were generated based on seven classed (figure 3 & 4).

The mean temperature value is distributed suitably to each region in Mandalay City, of which the highest is in urban region and the lowest is in suburban area. This indicates that the LST data can be used to model urban planning by means of guiding the best land areas for effective usage. The result shows that the maximum temperature difference of urban region between the year 2000 and 2005 is five degree Celsius. In order to test the LST obtained with method, values measured in situ are needed. According to ground data, the maximum temperature of Mandalay City in 2000 is 26.9 degree Celsius and in 2005 is 29.5 degree Celsius. Comparison was also conducted through the actual ground data from station. It can be seen that real temperature and LST derived from image are not too much different.

V. CONCLUSION

Many factors affect the retrieval of LST from satellite thermal infrared data but some of them, such as transmittance, air moisture, down welling and upwelling radiance, are usually difficult to obtain, especially from satellite observations. In this study, we chose as variables surface emissivity because it has been provided an important factor in affecting the retrieval of LST from satellite thermal data The Landsat-7 ETM+ thermal infrared data can be retrieved the LST in Mandalay City from using surface emissivity based on the conventional land cover classification.

In future, more ground truth temperatures in different emissivity classes will be collected and ancillary data will be applied to get the best result. We believe that with more ground truth temperature measured in different 'emissivity classes', the accuracy of the LST data will be further improved. This study also indicated that LST data can aid in modeling urban planning and monitor environment. It gives a perspective for the application of satellite thermal data in improving environment quality and the planning strategies for heat island reduction.

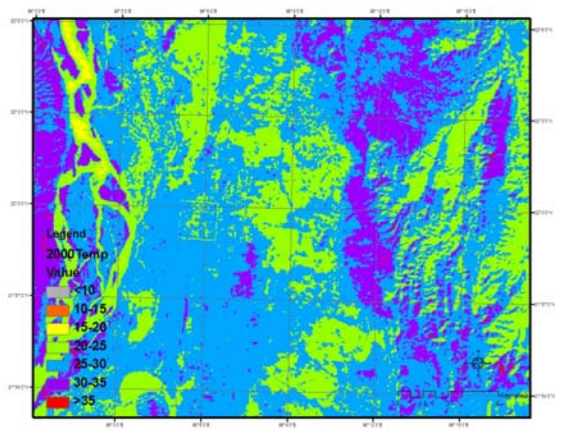


Fig 3. Land surface temperature map of Mandalay City (2000)

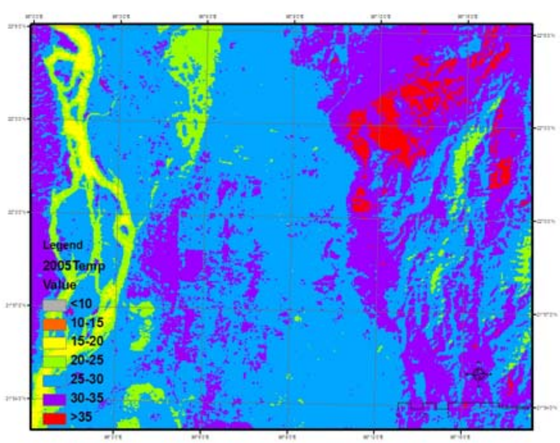


Fig 4. Land surface temperature map of Mandalay City (2005)

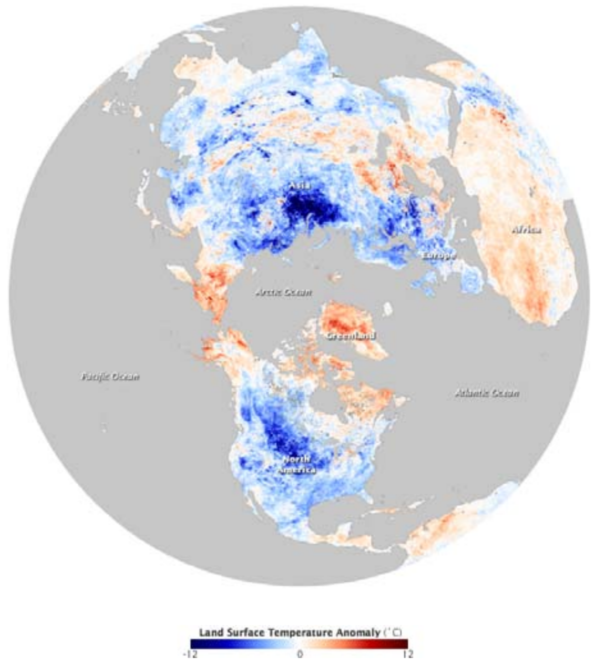


Fig 5. Earth Observatory for 2010 source: NASA

REFERENCES

[1] Sobrino. (2002). "Surface emissivity retrieval from Digital Airborne Imaging Spectrometer data". Journal Geophysical Research,1998.

[2] Snyder, W.C.(1998). "Classification based emissivity for land surface temperature measurement from space". International Journal of Remote Sensing.

[3] Prata, A.J.(1993). "Land surface temperatures derived from the advanced very high resolution radiometer and the along-track scanning radiometer". Journal of Geophysical Research, 1998.