International Journal on
"Technical and Physical Problems of Engineering"
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

March 2022 | Issue 50 | Volume 14 | Number 1 | Pages 24-28

ESTIMATION OF DYNAMICS OF LAND SURFACE TEMPERATURE USING TERRA/MODIS LAND SURFACE TEMPERATURE DATA

J. Piamdee T. Laosuwan

Department of Physics, Faculty of Science, Mahasarakham University, Kantarawichai District, Mahasarakham, Thailand, jenjira@msu.ac.th, teerawong@msu.ac.th

Abstract- The current global climate has changed continually due to human activities that change the composition of the earth's atmosphere. The noticeable climate change is an increase in the average global temperature, which increases the risk of severe weather to extreme weather conditions. The objective of the study is to present the estimation of dynamics of Land Surface Temperature (LST) using Terra/MODIS Land Surface Temperature and Emissivity (LST&E) product data in Songkhla Province over a period of 10 years. The research methodology are as follows: 1) To analyze MOD11A2 data mutually with mathematical methods using a software package, 2) To analyze the statistical relationship between the data analyzed from MOD11A2 and LST obtained from ground stations. The study results showed that the average LST from MOD11A2 and average LST from ground stations were consistent. In addition, statistical relationship analysis represented that both sets of data were in the same direction and had a high level of statistical relationship which appeared $r = 0.960$. The study results indicated that the analysis of LST from MOD11A2 is reliable and can be used to estimate dynamics of LST effectively.

Keywords: Remote Sensing, Land Surface Temperature (LST), Terra/Modis Data.

1. INTRODUCTION

At present, the global climate has changed more severely and frequently, reflecting from more occurrences of El Nino (drought) and La Niña (flood), including the constant rise in LST of the earth [1-2]. Thailand is a developing country both economically and industrially. The land uses were changed utilities from the purposes of agriculture to industries continuously in the past few decades [3]. Normally, the temperatures of agricultural lands will be higher than the temperatures of forest areas, but still lower than the temperatures of urban areas with building [4]. Such the growing has resulted in an increase in residential communities as well as commercial and industrial buildings. Conversely, green areas that absorb the sun's rays and transform into energy for the photosynthesis process are decreasing. This causes the rise in urban temperatures and finally leads to the urban heat island phenomenon [5].

The study of LST is another method of monitoring the heat of the earth's surface which is popularly used to track global temperatures [6]. Mostly, the LST will be used beneficially, such as climate change due to an increase of global heat, the study of climate forms by examining the upsurge in greenhouse gases in the atmosphere that affects LST, the upsurge in LST that affects the polar ice sheet including the study of LST that affects plants in ecosystems in different regions of the world [7-9]. According to the study from researches and documents related to the analysis of LST, there are many researches that analyzed LST using satellite data, such as changes of LST in urban areas [10, 11], the study of urban heat island phenomena [12, 13], detection and monitoring forest fires from LST [14, 15], etc. In addition, there are currently many researchers focusing on development of techniques for measuring LST with remote sensing technology.

Remote sensing has been recognized as modern and effective technology that can be applied to track and check various phenomena on the earth in real time [16-19]. Meanwhile, there are many researches developed mathematical equations to be used to analyze LST mutually with remote sensing data such as Radiative Transfer Equation-Based Method, Mono-Window/Single Channel Algorithms, Split-Window Algorithms [20-22], etc. From the importance of climate change and the increase in temperature mentioned previously, this study aims to focus on estimating the dynamics of LST using Terra/MODIS LST&E data in Songkhla Province during the 10 years of 2009 - 2018.

2. MATERIAL AND METHOD

2.1. Study Area and Data

Study Area: Songkhla Province (Figure 1) is located on the eastern side of the Southern region of Thailand between the latitude of 6.3°-7.9° North and the longitude of 100.1°-101.1° East, with a height of 4 meters above mean sea level.

Satellite Data: Terra/MODIS LST&E data (MOD11A2 V.6 product) provides an average 8 day per pixel with a 1 kilometer and spatial resolution in a 1200×1200-kilometer grid. For collecting the data of LST from Terra/MODIS LST&E (MOD11A2) satellite in this research, the data was

collected during the 10 years period (2009-2018). In this study, downloaded the data from MODIS/VIIRS Land Product Subsets (https://modis.ornl.gov/).

LST Data: This study compiled the average monthly LST from Thai Meteorological Department's ground stations located in Songkhla Province.

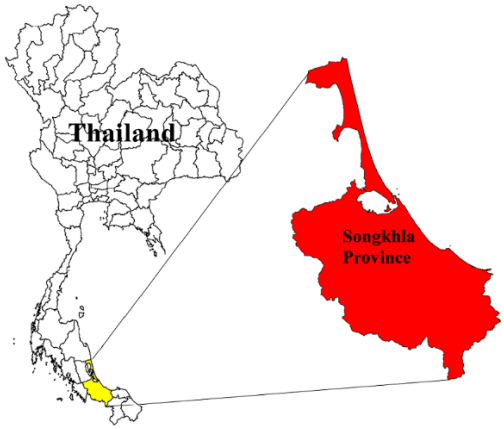

Figure 1. Songkhla province

2.2. Methodology

For brevity of presenting methodology, in this study, we would like to mention the operation procedures in brief as follows;

2.2.1. Satellite Data Analysis

For brevity of presenting methodology, in this study, we would like to mention the operation procedures in brief as follows;

(1) To prepare satellite data for this study, MOD11A2 data from MODIS/VIIRS Land Product Subsets was used.

(2) To bring MOD11A2 obtained for checking faults and accuracy before analyzing. Also, it was necessary to delete all the abnormal pixels of MOD11A2 data with a quality control file called QA band.

(3) To change the projection of MOD11A2 data from sinusoidal to geographical latitude/longitude projection and prepare geo-reference in order to make MOD11A2 data to have the correct geographic coordinates.

(4) Since MOD11A2 data obtained covered a wide area, to facilitate data analysis process, data were shortened to cover only study area, which is Songkhla province.

(5) In addition, to use MOD11A2, it was necessary to adjust the Digital Number (DN). The DN values for this study will be transformed to LST with centigrade unit values under the following equation: LST (°C) = DN×0.02-273.15 [23, 24].

(6) To bring the MOD11A2 data obtained to process to the average monthly data of each year (January to December of all 10 years). Then, the average monthly data for each year was calculated to be the average annual data.

2.2.2. Statistical Relationship Analysis

To ensure the reliability of MOD11A2 data analyzed, this study therefore analyzed the statistical relationship with correlation coefficient from two sets of data (two variables) including the LST analyzed from MOD11A2 and monthly average LST from Thai Meteorological Department (TMD) ground stations.

3. RESULT AND DISCUSSION

3.1. Analysis Result of LST

The analysis results of LST of Songkhla Province from MOD11A2 data can be displayed in the form of annual average LST data in the spatial form as presented in Figure 2. From Figure 2, it showed the analysis results of annual LST of Songkhla Province area. The results showed that the average LST was mainly distributed in green and yellow areas, which had the average LST in the ranges of 24-30 °C and 31-37 °C. At any rate, the researcher exemplified the year 2016 (The year with the highest average temperature) which can be found the area with high average LST mostly and distributed more than the area with low average LST.

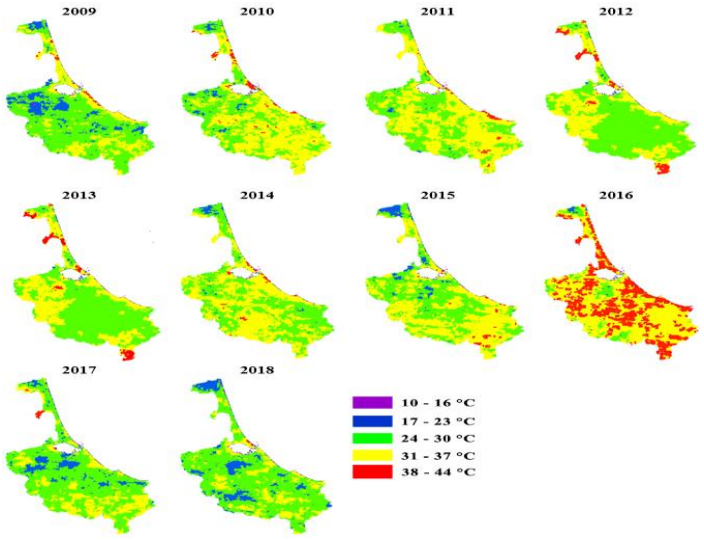

Figure 2. Spatial analysis of LST in Songkhla province, Thailand

The most average LST were in yellow and red areas, with had the average LST in the range of 31-37 °C and 38-44 °C. In 2018 (the year with the lowest average temperature), it can be found the area with low average LST mostly and distributed more than the area with high average LST. The most average LST were in blue areas, with had the average LST in the range of 17-23 °C. For easy understanding, the researcher brought the MOD11A2 data analyzed previously to display in the form of graph as shown in Figure 3.

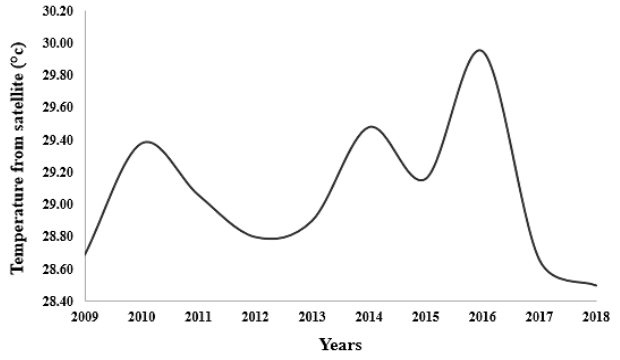

Figure 3. Display data analyzed of LST

The graph shows the change of the average annual LST each year in the period of 10 year studied. In Figure 4, it also shows the maximum, minimum, and average of LST in 10-year period of Songkhla Province.

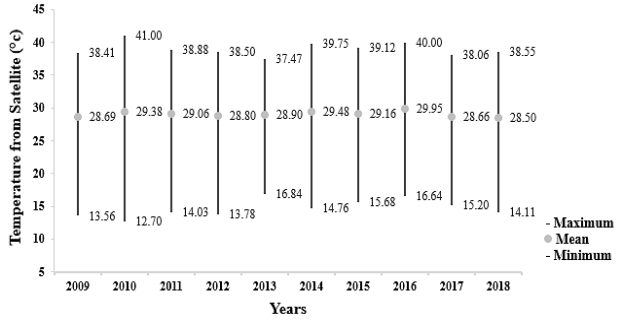

Figure 4. Average annual LST each year in the period of 10 years

In addition, when the analysis results from MOD11A2 were divided into 5 data ranges, the percentage and square kilometers are shown as follows: 1st period - LST was between 10-16 °C, 2nd period - LST was between 17-23 °C, 3rd period - LST was between 24-30 °C, 4th period - LST was between 31-37 °C, 5th period - LST was between 38-44 °C. The classification results can be shown in Figure 5. An example was given to explain the results in 2016 and in 2018. In the classification of LST in 2016, it was found that the 1st period was equal to 0.63% or equivalent to the area of 45.427 Km^2, period 2 was equal to 5.52% or equivalent to the area of 397.498 Km^2, period 3 was equal to 47.28% or equivalent to the area of 3,402.376 Km^2, period 4 was equal to 45.73% or equivalent to the area of 3,290.931 Km^2, period 5 was equal to 0.84% or equivalent to the area of 60.692 Km^2.

In the classification of LST in 2018, it was found that the 1st period was equal to 0.66% or equivalent to the area of 47.315 Km^2, period 2 was equal to 14.53% or equivalent to the area of 1,045.643 Km^2, period 3 was equal to 64.57% or equivalent to the area of 4,645.642 Km^2, period 4 was equal to 19.80% or equivalent to the area of 1,424.460 Km^2, period 5 was equal to 0.44% or equivalent to the area of 31.457 Km^2.

In the classification of LST in 2018, it was found that the 1st period was equal to 0.66% or equivalent to the area of 47.315 Km^2, period 2 was equal to 14.53% or equivalent to the area of 1,045.643 Km^2, period 3 was equal to 64.57% or equivalent to the area of 4,645.642 Km^2, period 4 was equal to 19.80% or equivalent to the area of 1,424.460 Km^2, period 5 was equal to 0.44% or equivalent to the area of 31.457 Km^2.

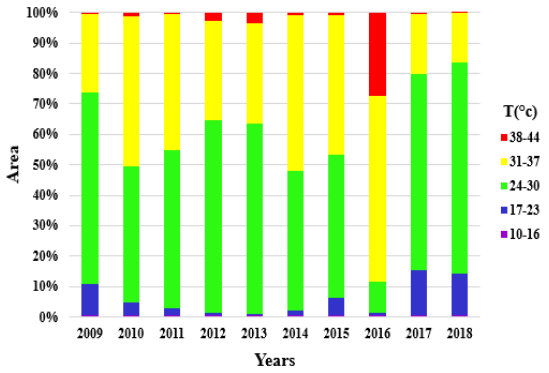

Figure 5. Analysis results in 5 data ranges

3.2. Analysis Result Statistical Relationship

The analysis results of statistical relationship using correlation coefficient methods between the LST data analyzed from MOD11A2 and the temperature data from TMD's ground stations were found to be in the same direction with a high level of statistical relationship which appeared r = 0.960 as shown in Figure 6.

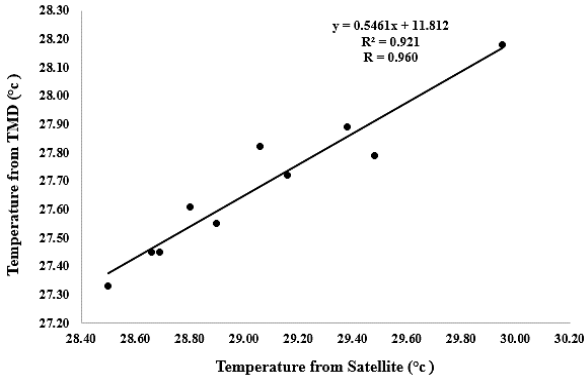

Figure 6. Analysis results of statistical relationship

Although the two sets of data were analyzed to find out simple liner regression in order to analyze independent variables x (LST data analyzed from MOD11A2 and dependent variable y (temperature data from ground stations), it was found that the change of LST analyzed from MOD11A2 was in line with the LST from the ground stations approximately 92.10% (r^2 = 0.921) and the remaining 9.20% was the results of other causes.

4. CONCLUSIONS

This research presents the methods for estimating the dynamics of LST using Terra/MODIS LST&E data (MOD11A2) during the period of 10 years in Songkhla Province (2009-2018). For the study results of the year 2009-2018, the average LST were 28.69 ºC, 29.38 ºC, 29.06 ºC, 28.80 ºC, 28.90 ºC, 29.48 ºC, 29.16 ºC, 29.95 ºC, 28.66 ºC, 28.50 ºC, respectively. The LST from TMD's ground stations during 2009-2018 represented 27.45 ºC, 27.89 ºC, 27.82 ºC, 27.61 ºC, 27.55 ºC, 27.79 ºC, 27.72 ºC, 28.18 ºC, 27.45 ºC, 27.33 ºC. At any rate, the LST analyzed from MOD11A2 will be higher than the LST from the ground stations approximately 1-2 ºC. Moreover, the study results showed that, from the 10 years' period studied, 2016 was the year with the maximum average temperature (29.95 ºC) and 2018 was the year with the lowest average temperature (28.50 ºC).

For the statistical relationship between the LST analyzed from MOD11A2 and the LST from the ground stations were in the same direction and had a high level of statistical relationship which appeared r = 0.960. In addition, when comparing the results of this study with related researches such as the research of [22] with the topic "An enhanced single-channel algorithm for retrieving LST from Landsat series data", the research of [4] with the topic "Application of Remote Sensing for Temperature Monitoring: the Technique for LST Analysis", and the research of [18] with the topic "Spatial-temporal Change of LST using Satellite Remote Sensing Data", all these three researches have the analysis results in the same direction with this study. Therefore, this study suggests that the analysis of LST from MOD11A2 is reliable and can be applied to estimate the dynamics of LST effectively. This research approach can assess land use areas, such as farmland, which are used to assess the energy potential of biomass for local use. It is also a guideline for temperature assessment to design heating and cooling systems in various systems.

REFERENCES

[1] W. Cai, G. Wang, A. Santoso, M.J. McPhaden, L. Wu, F.F. Jin, A. Timmermann, M. Collins, G. Vecchi, M. Lengaigne, M. England, D. Dommenget, K. Takahashi, E. Guilyardi, "Increased Frequency of Extreme La Nina Events under Greenhouse Warming", Nature Climate Change, Vol. 5, No. 2, pp. 132-137, 2015.

[2] FAO, The World Bank, "Understanding the Drought Impact of El Nino/La Nina in the Grain Production Areas in Eastern Europe and Central Asia: Russia, Ukraine and Kazakhstan", Rome, Italy, 2019.

[3] W. Charoentrakulpeeti, "Impact of Land Cover on Atmospheric Temperature in Bangkok", NIDA Journal of Environmental Management, Vol. 8, No. 1, pp. 1-18, 2012.

[4] T. Laosuwan, T. Gomasathit, T. Rotjanakusol, "Application of Remote Sensing for Temperature Monitoring: The Technique for Land Surface Temperature Analysis", Journal of Ecological Engineering, Vol. 18, No. 3, pp. 53-60, 2017.

[5] K. Suksabai, K. Nakhapakorn, "Fire Detection Using LANDSAT Thermal Data: In Sai Yok District, Kanchanaburi Province, Thailand", Thai Science and Technology Journal, Vol. 22, No. 4, pp.462-473, 2014.

[6] S. Khandelwal, R. Goyal, N. Kau, A. Mathew, "Assessment of land surface temperature variation due to change in elevation of area surrounding Jaipur, India", The Egyptian Journal of Remote Sensing and Space Science, Vol. 21, No. 1, pp. 87-94, 2018.

[7] N.H. Wong, C. Yu, "Study of Green Areas and Urban Heat Island in a Tropical City", Habitat International, Vol. 29, No. 3, pp. 547-558, 2005.

[8] J. Zhou, Y.H. Chen, J.F. Wang, W.F. Zhan, "Maximum Nighttime Urban Heat Island (UHI) Intensity Simulation by Integrating Remotely Sensed Data and Meteorological Observations", IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Vol. 4, No. 1, pp. 138-146, 2011.

[9] A. Mathew, S. Sreekumar, S. Khandelwal, N. Kaul, R. Kumar, "Prediction of Surface Temperatures for the Assessment of Urban Heat Island Effect over Ahmedabad City Using Linear Time Series Model", Energy and Buildings, Vol. 128, pp. 605-616, 2016.

[10] S. Youneszadeh, N. Amiri, P. Pilesjo, "The Effect of Land Use Change on Land Surface Temperature in the Netherlands - International Archives of the Photogrammetry", Remote Sensing and Spatial Information Sciences - ISPRS Archives, Vol. 40, No. 1W5, pp. 745-748, 2015.

[11] T. Rotjanakusol, T. Laosuwan, "Inundation Area Investigation Approach using Remote Sensing Technology on 2017 Flooding in Sakon Nakhon Province Thailand", Studia Universitatis "Vasile Goldis" Seria Stiintele Vietii (Life Sciences Series), Vol. 28, No. 4, pp. 159-166, 2018.

[12] J. Yang, M. Santamouris, "Urban Heat Island and Mitigation Technologies in Asian and Australian Cities - Impact and Mitigation", Urban Science, Vol. 2, No. 3, p. 74, 2018.

[13] M. Santamouris, S. Haddad, M. Saliari, K. Vasilakopoulou, A. Synnefa, R. Paolini, G. Ulpiani, S. Garshasbi, F. Fiorito, "On the Energy Impact of Urban Heat Island in Sydney: Climate and Energy Potential of Mitigation Technologies", Energy Build, Vol. 166, pp. 154-164, 2018.

[14] M. Amraoui, C.C. Dacamara, J.M.C. Pereira, "Detection and Monitoring of African Vegetation Fires using MSG-SEVIRI Imagery", Remote Sensing of Environment, Vol. 114, No. 5, pp. 1038-1052, 2010.

[15] B. Hally, L. Wallace, K. Reinke, S. Jones, A. Skidmore, "Advances in Active Fire Detection using a Multi-Temporal Method for Next-Generation Geostationary Satellite Data", International Journal of Digital Earth, Vol. 12, No. 9, pp. 1030-1045, 2018.

[16] S.R. Rustamova, K.T. Mammadov, A. Kurnaz, S.N. Hasanova, R.B. Rustamov, "Cost Estimation for Space Technology Application in Project Budget Development", International Journal on Technical and Physical Problems of Engineering (IJTPE), Iss. 21, Vol. 6, No. 4, December 2014.

[17] N.A. Babayeva, R.B. Rustamov, "Remote Sensing and GIS Applications in Architectural Design", International Journal on Technical and Physical Problems of Engineering (IJTPE), Iss. 18, Vol. 6, No. 1, March 2014.
[18] N. Jomsrekrayom, P. Meena, T. Laosuwan, "Spatiotemporal Analysis of Vegetation Drought Variability in the Middle of the Northeast Region of Thailand using Terra/Modis Satellite Data", Geographia Technica, Vol. 16, Special Issue, pp. 70-81, 2021.
[19] P. Meena, T. Laosuwan, "Spatiotemporal Variation Analysis of Atmospheric Carbon Dioxide Concentration using Remote Sensing Technology", International Journal on Technical and Physical Problems of Engineering (IJTPE), Iss. 48, Vol. 13, No. 3, September 2021.
[20] C. Auntarin, P Chunpang, W. Chokkuea, T. Laosuwan, "Using a Split-Window Algorithm for the Retrieval of the Land Surface Temperature via Landsat-8 OLI/TIRS", Geographia Technica, Vol. 16, Special Issue, pp. 30-42, 2021.
[21] C. Du, H. Ren, Q. Qin, J. Meng, S. Zhao, "A Practical Split-Window Algorithm for Estimating Land Surface Temperature from Landsat 8 Data", Remote Sensing, Vol. 7, No. 1, pp. 647-665, 2015.
[22] M. Wang, Z. Zhang, G. He, G. Wang, T. Long, Y. Peng, "An Enhanced Single-channel Algorithm for Retrieving Land Surface Temperature from Landsat Series Data", J. Geophys. Res. Atmos., Vol. 121, No. 19, pp. 712-722, 2016.
[23] G. Zhang, X. Xiao, J. Dong, W. Kou, C. Jin, Y. Qin, Y. Zhou, J. Wang, M.A. Menarguez, C. Biradar, "Mapping Paddy Rice Planting Areas through Time Series Analysis of MODIS Land Surface Temperature and Vegetation Index Data", ISPRS Journal of Photogrammetry and Remote Sensing, Vol. 106, pp. 157-171, 2015.
[24] S. Sruthi, M.A. Mohammed Aslam, "Agricultural Drought Analysis Using the NDVI and Land Surface Temperature Data; A Case Study of Raichur District", Aquatic Procedia, Vol. 4, pp. 1258-1264, 2015.

BIOGRAPHIES

Jenjira Piamdee was born in Nongkhai, Thailand in 1977. She received the D.Eng. degree in Energy Engineering from Chiang Mai University, Thailand in 2013. Currently, she is a Lecturer at Department of Physics, Mahasarakham University, Mahasarakham, Thailand. Her research interests are in the renewable energy, energy conservation, energy modeling and economics, environmental impact etc.

Teerawong Laosuwan was born in Hat Yai, Songkhla, Thailand on October 2, 1971. He received the Ph.D. degree in Electrical and Computer Engineering from Mahasarakham University Mahasarakham, Thailand in 2012. Currently, he is an Associate Professor at Department of Physics, Mahasarakham University. His research interests are in the remote sensing, geo-informatics, GIS modeling, mobile application development, drone surveying and mapping, etc.