

MONITORING AND ANALYSIS ON CHANGE OF LAND SURFACE TEMPERATURE BASED ON SATELLITE DATA

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Abstract- Current climate has been changed continuously, especially average global temperature rising. Although temperature is slightly risen, it may cause disasters. This research aims to analyze on Land Surface Temperature (*LST*) by applying Terra/MODIS data in 4 periods of time (2007, 2012, 2017, and 2021) and the case study of this research was Sakon Nakhon Province. Research methodology consisted of: 1) the use of Terra/Modis data that were monthly data from 4 periods of time with the total number of 48 data for analyzing and inspecting *LST* of Sakon Nakhon Province; and 2) Analyze obtained data to find statistic relation with temperature data obtained from Surface Station of Thai Meteorological Department (TMD). The results revealed that analyzed *LST* data were similar to temperature data obtained from Surface Station TMD. When finding relation through correlation analysis, it was found that correlation coefficient was $R=0.946$ with high relation level. Moreover, when analyzing such data by using simple regression analysis, it was found that Coefficient of Determination was $R^2=0.935$. The results of this research represented that using Terra/MODIS data to analyze *LST* was reliable and interested persons could implement such method to examine and analyze *LST* in other areas of Thailand further.

Keywords: Remote Sensing, Land Surface Temperature Digital Image Processing, Terra/MODIS Data.

1. INTRODUCTION

Current climate has been changed continuously, especially average global temperature rising or global warming. Although temperature is slightly risen, it may increase severity of disasters including drought, wildfire, flood, and storm [1]. Change of temperature throughout the world that was higher each year was caused by the problem on global warming. Such changing was reflected from occurred El Nino and La Nina [2]. Thailand is a developing country on economy and industry with rapid change of land use from agricultural areas to industrial areas within a few decades. Normally, temperature of agricultural areas is higher than that of forest area but it is still lower than that of urban areas [3]. Such development causes increase of urban areas for building residences,

commercial buildings, and industrial factories. On the other hand, green areas that help to absorb solar radiation like trees, forests, and agricultural plants, helping to transform energy from solar radiation to be energy for photosynthesis, seem to be reduced. Consequently, temperature was higher significantly [4, 5].

Land Surface Temperature (*LST*) is the study on land surface heat that can be perceived when contacting such place whereas the perspective on land observing satellite must can be seen through atmosphere to the area that may be building's roof, tree top, ice, or snow. As a result, *LST* was different from air temperature. Mostly, *LST* was utilized for studying on global climate change due to higher temperature, studying on climate formats by examining increase of greenhouse gas in atmosphere affecting to *LST*, increase of *LST* affecting to glacier, ice sheets, and plants in global ecosystem, etc. [6-10].

Remote sensing technology has been accepted as modern and efficient technology that can be applied to monitor and detect phenomena occurred on earth rapidly and timely [11-18]. From studying on related researches and documents on *LST* analysis, it was found that researchers analyzed on *LST* by applying remote sensing technology with satellite data like change of *LST* of urban areas [19, 20], the study on Urban heat Island [21-25], measurement and specification of wildfire areas from *LST*, etc. [26, 27]. With importance of climate change and temperature rising as mentioned above, this research aims to inspect and analyze *LST* by using data obtained from Terra/MODIS satellite in 4 periods of time (2007, 2012, 2017, and 2021) in the research areas in Sakon Nakhon Province, Thailand.

2. MATERIAL AND METHOD

2.1. Study Area

Sakon Nakhon Province (Figure 1) is one of 19 northeastern provinces. It is located from Latitude $16^{\circ}45'$ to Latitude $18^{\circ}15'$ North and from Longitude $103^{\circ}15'$ to $104^{\circ}30'$ East with the total area of 9,605.76 km². For general landscape, the southern part is high mountain ranges with slopes to the northern part and the eastern part. It is located on the area that is higher than sea level around 172 m.

Its climate is classified as seasonal tropical rain or tropical grassland climate. In southwestern monsoon season, climate is humid with abundant rainfall. In northeastern monsoon season or winter, climate is dry and drought throughout the season.



Figure 1. Sakon Nakhon Province, Thailand

2.2. Satellite Data

This research used data from Terra/MODIS satellite that was MOD11A2 product recoding data from January to December in 2007, 2012, 2017, and 2021. MOD 11A2 product was data in the form of Land Surface Temperature consisted of 12 science datasets with resolution of pixels of 1000 m plus with sinusoidal projection.

2.3. Land Surface Temperature Data

This study collected data on land surface temperature obtained from Surface Station of Thai Meteorological Department (TMD) located in Sakon Nakhon Province, Thailand. The researcher collected temperature data from January to December in 2007, 2012, 2017, and 2021.

2.4. Methodology

In this research, methodology would be mentioned in the following procedures briefly:

1. This procedure was data preparation before analysis therefore it was necessary to delete all abnormal pixels of satellite data by using quality control file (QA band)
2. Transformed value of sinusoidal projection of Terra/MODIS data that was MOD11A2 product from sinusoidal projection to be Geographical Latitude/Longitude projection then set geographic coordinates to make Terra/MODIS data that was MOD11A2 product to have correct geographic coordinates. Since obtained Terra/MODIS data that was MOD11A2 product covered wide areas for facilitating data analysis process, it was necessary to screen satellite data to be in the research area, i.e., Sakon Nakhon Province, only.

3. Re-scaled Digital Number (DN) of Terra/MODIS Data that was MOD11A2 product with value ranged from 7500 to 65535 to be brightness temperature data with Kelvin (K) unit by using Equation 1 [28]. Subsequently, Kelvin (K) unit was adjusted to be degrees Celsius (°C) by using Equation 2.

$$LST = DN \times 0.02 \tag{1}$$

where,

LST = Land Surface Temperature

DN = Digital number

$$\text{Centigrade} = \text{Kelvin} - 273.15 \tag{2}$$

where,

Centigrade = Land Surface Temperature in °C

4. Processed monthly Terra/MODIS data that was MOD11A2 product from 12 months (January to December) obtained from the 4th procedure as average monthly data.

5. Analyzed statistical relation by using the analysis results of *LST* to find statistical relation with temperature data obtained from Surface Station.

3. RESULT

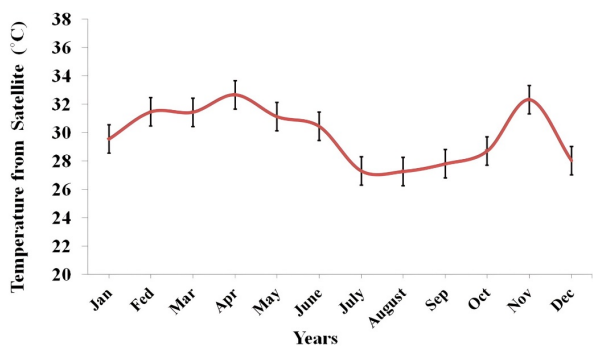
3.1. Results of Monthly and Yearly LST Analysis

Results of *LST* analysis by using monthly Terra/MODIS data that was MOD11A2 product in 4 periods of time (2007, 2012, 2017, 2021) could be represented as shown from Figure 2.

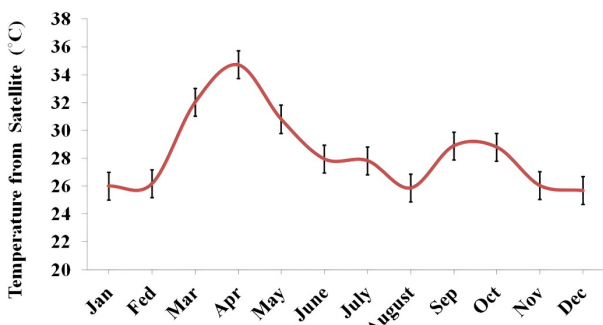
From Figure 2a, average results of monthly *LST* analysis in this research revealed that the area of Sakon Nakhon Province in 2007 had the highest temperature at 38 °C and the lowest temperature at 13 °C with average temperature at 30 °C. From analyzing *LST*, it was found that average temperature was ranged from 24-31 °C and 31-38 °C that was in moderate level. In January, land surface would be covered by a large number of plants then *LST* would be higher in April with the lowest level of *LST* in August.

From Figure 2b, average results of monthly *LST* analysis in this research revealed that the area of Sakon Nakhon Province in 2012 had the highest temperature at 35 °C and the lowest temperature at 16 °C with average temperature at 28 °C. From analyzing *LST*, it was found that average temperature was ranged from 17-24 °C and 24-31 °C that was in good level. In January, land surface would be covered by a large number of plants then *LST* would be higher in April with the lowest level of *LST* in December.

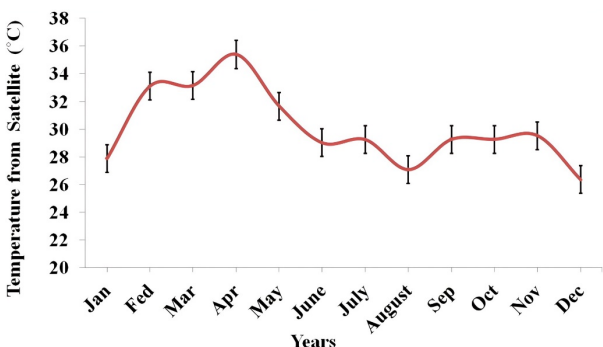
From Figure 2c, average results of monthly *LST* analysis in this research revealed that the area of Sakon Nakhon Province in 2017 had the highest temperature at 39 °C and the lowest temperature at 15 °C with average temperature at 30 °C. From analyzing *LST*, it was found that average temperature was ranged from 24-31 °C and 31-38 °C that was in moderate level. In January, land surface would be covered by a large number of plants then *LST* would be higher in April with the lowest level of *LST* in December.



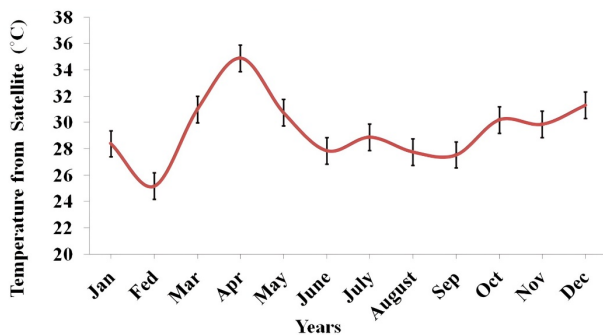
(a)



(b)



(c)



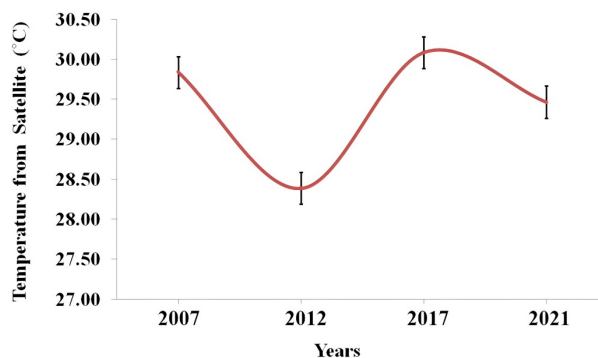
(d)

Figure 2. Results of LST analysis by using monthly Terra/MODIS data (a) 2007, (b) 2012, (c) 2017, (d) 2021

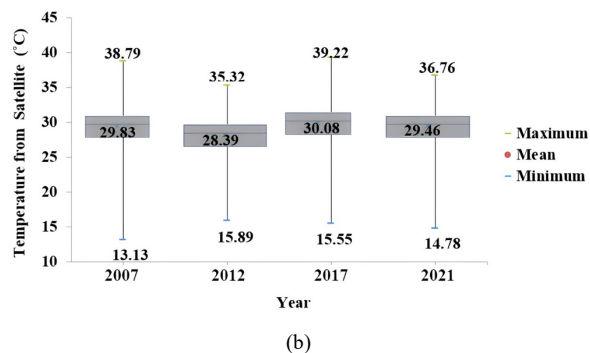
From Figure 2d, average results of monthly ST analysis in this research revealed that the area of Sakon Nakhon Province in 2021 had the highest temperature at 36 °C and the lowest temperature at 14 °C with average

temperature at 30 °C. From analyzing LST, it was found that average temperature was ranged from 24-31 °C and 31-38 °C requiring improvement due to high temperature. Subsequently, LST would be lowest from February to March. LST would start to be higher in April and henceforth reflecting spatial temperature clearly.

Moreover, when analyzing results of monthly LST analysis by using data from Terra/MODIS satellite that was MOD11A2 production in 4 periods of time as yearly LST analysis, temperature result could be shown in the form of spatial LST data that were classified into 5 levels as shown in Figure 3.



(a)



(b)

Figure 3. (a) and (b) MOD11A2 production in 4 periods of time as yearly LST analysis

From Figures 3a and 3b, it was found that in 2007 (with the highest temperature at 38.79 °C and the lowest temperature at 1313 °C with average temperature at 29.83 °C), 2012 (with the highest temperature at 35.32 °C and the lowest temperature at 15.89 °C with average temperature at 28.39 °C), 2017 (with the highest temperature at 39.22 °C and the lowest temperature at 15.55 °C with average temperature at 30.08 °C), and 2021 (with the highest temperature at 36.76 °C and the lowest temperature at 14.78 °C with average temperature at 29.46 °C), analysis on land surface temperature would depend on condition of plants and rainfall. These factors were comparable. If land surface temperature was lower than mean and close to 17-24 °C, it referred that land surface temperature was quite low. If land surface temperature was close to 24-31 °C, it referred that land surface temperature was moderate and it was considered as good condition.

3.2 Results of Comparison of Average LST

Results of comparison of average *LST* obtained from analysis on data obtained from Terra/MODIS that was MOD11A2 product with mean from Thai Meteorological Department (TMD) in 4 periods of time could be shown in Figure 4 whereas graph represented variation of *LST* in each year. Moreover, when using *LST* data obtained from analyzing data obtained from Terra/MODIS that was MOD11A2 product and mean from Surface Station of Thai Meteorological Department (TMD) in 4 periods of time to find relation in the form of simple correlation analysis and simple linear regression, the result of such analysis was shown in Figure 5.

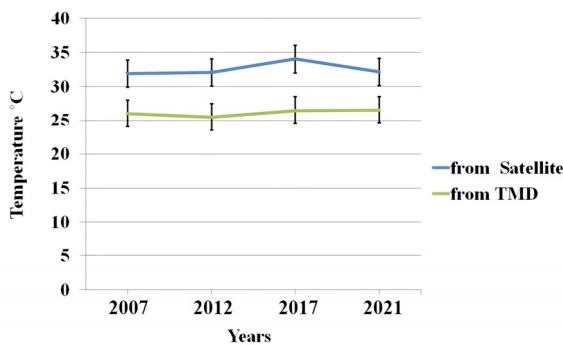


Figure 4. Comparison of average *LST*

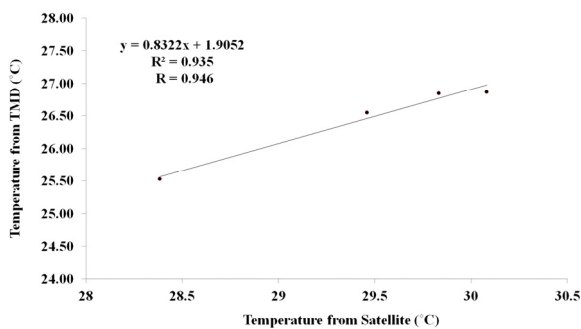


Figure 5. Relation analysis

From Figure 5, it could explain relationship between *LST* analyzed from satellite data and *LST* obtained from Surface Station of Thai Meteorological Department (TMD) when using both data sets to analyze with simple correlation analysis that was the study on relationship between x and y and direction of relationship. Whereas, x was independent variable and y was dependent variable. In this research, the researcher set dependent variable (x) as *LST* analyzed from satellite data whereas dependent variable (y) was temperature obtained from Surface Station of Thai Meteorological Department (TMD). Results of analysis on such relationship revealed that simple correlation analysis obtained from satellite data had relationship with *LST* obtained from Surface Station of Thai Meteorological Department (TMD) in the same direction with value of $R=0.946$. When analyzing both datasets by using simple regression analysis that was analysis on predictor (x) and response (y), it was found that change of *LST* analyzed from Surface Station of Thai Meteorological Department (TMD) was $R^2=0.935$.

3.3 Results of Time Series Analysis

Results of time series analysis between average *LST* data obtained from satellite and average temperature data obtained from Surface Station of Thai Meteorological Department (TMD) in Sakon Nakhon Province were shown in Figure 6.

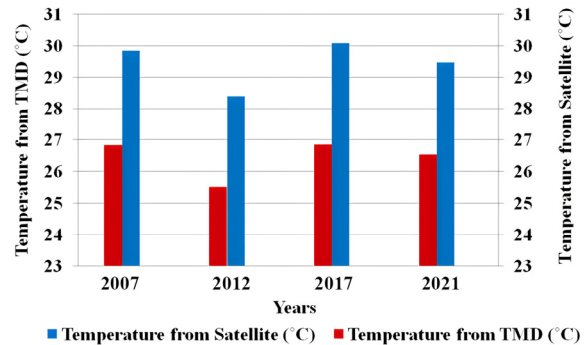


Figure 6. Time series analysis

From Figure 6, it represented time series change between average *LST* data obtained from satellite and average temperature data obtained from Surface Station of Thai Meteorological Department (TMD). It was found that time series change of average *LST* of both datasets in 4 periods of time had similar average *LST*. Time series change of average *LST* of both datasets in 2017 had the highest level of average *LST* whereas 2012 had the lowest level of average *LST*. For most of average *LST* based on analysis, average *LST* obtained from satellite data was lower than that of Thai Meteorological Department (TMD) around 1-3 °C.

4. CONCLUSIONS

The results of the study on examination and analysis on change of land surface temperature based on Terra/MODIS data in 4 periods of time (2007, 2012, 2017, and 2021), in both spatial and time series formats, revealed that spatial change and time series change of *LST* obtained from Terra/MODIS satellite that was MOD11A2 product was consistent with and had similar value with temperature obtained from Surface Station of Thai Meteorological Department (TMD). It could be seen that *LST* obtained from Terra/MODIS satellite that was MOD11A2 product was higher than average temperature obtained from Surface Station 1 of Thai Meteorological Department (TMD) by 3 °C. It could be seen that when *LST* obtained from Terra/MODIS satellite was higher, temperature obtained from Surface Station of Thai Meteorological Department (TMD) would be higher, too. On the other hand, if *LST* obtained from Terra/MODIS satellite was lower, average temperature obtained from Surface Station of Thai Meteorological Department (TMD) would be lower as well. As a result, relationship on time series change between average *LST* obtained from satellite had the same variation with that of average *LST* obtained from Thai Meteorological Department (TMD).

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