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SPATIAL-TEMPORAL CHANGE OF LAND SURFACE TEMPERATURE USING SATELLITE REMOTE SENSING DATA

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Abstract: Currently, the global weather condition has been changing continuously, especially the increased global temperature which could pose more and more risks of extreme weather such as intense heat wave, drought, and flood. The primary objective of this study was to analyze the spatial-temporal change of land surface temperature using data from Terra/Modis Satellite, together with the mathematical calculation method during 4 periods of time in the study area of Buriram Province. It was found from the study into land surface temperature as analyzed from the satellite's date in 2004, 2008, 2013, and 2018 that the annual average land surface temperature was at 32.90 Degree Celsius, 30.33 Degree Celsius, 31.26 Degree Celsius and 33.20 Degree Celsius, respectively. When such land surface temperature result was brought to find statistical relationship with the average annual temperature as measured from the ground-based station by Thai Meteorological Department, it was found that each of 4 periods of time as mentioned was highly related. This study result revealed that the analysis of land surface temperature change using data from Terra/Modis Satellite can be applied to analyze, monitoring, and follow up the spatial-temporal change of land surface temperature.

Keywords: Land surface temperature, remote sensing, Terra/Modis data

INTRODUCTION

The fourth assessment report by the Intergovernmental Panel on Climate Change states that the global warming has become more obvious at present in that the global average land surface temperature increased for about 0.8 Degree Celsius; and as from 1980-1999, the temperature had been increasing more and more. Also, it was estimated that within 2100, the average global land surface temperature would increase between 1.1- 6.4 Degree Celsius as well (Lemke et al., 2007). For Thailand which is the developing country in terms of economy and industry, the use of land had been changed from using land for doing agriculture to be using land as industrial areas continuously (Charoentrakulpeeti, 2012; Dechaphongthana et al., 2017). Normally, the temperature of agricultural field would be higher than the forest field, but it still is lower than the temperature of the field in urban community and with constructions (Zhou et al., 2011; Rotjanakusol et al., 2017). From such development, there are more and more communities, commercial buildings, and industrial plants; whereas the green areas that functions in absorbing sun ray and changing it to be energy in the photo synthesis process have become less and less in numbers thus increasing the urban district temperature to the extent that leads to the phenomenon called Urban Head Island finally (Quan et al., 2016; Ermida et al., 2017).

On part of land surface temperature, it would be the study into one form of land global surface heat that is by monitoring the temperature. Mostly, land surface temperature would be used to study the change of global weather change due to the increased heat (Rotjanakusol and Laosuwan, 2018), the study into the weather condition forms by examining the increase of greenhouse gas in the climate that affects the surface temperature, the increase of surface temperature that affects the ices including plants in the global ecological system (Eliasson, 1996; Earth Observatory, 2016). According to the study and analysis of land surface temperature, it was found that there are researches done to study the surface temperature by using thermal infrared such as the change of urban land temperature (Lagouarde et al.,2013; Blackett, 2014; Wang et al., 2015; Chen et al., 2017), the phenomenon of urban heat island (Mallick et al., 2008; Mirzaei and Haghighat, 2010; Ningrum, 2018),the monitoring and specification of areas where there is wild fire by different methods to calculate land surface temperature (Roy et al.,2010; Ambrosia et al.,2011; Suksabai and Nakhapakorn, 2014).

Currently, there are many researches that focus on the importance of land surface temperature, and also that it has become more interesting in developing the land surface temperature monitoring method by applying Remote Sensing Technology together with the development of mathematical equation to find land surface temperature such as radiative transfer equation-based method, split window algorithm, and single channel algorithm (Latif, 2013; Yu et al., 2014; Rajeshwari and Mani, 2014; Laosuwan et al., 2017; Peebkhunthod et al.,2018). Due to the importance of temperature increase as mentioned, the objective is this study was to analyze the change of spatial land surface temperature by using data from Terra/Modis in Buriram Province during 4 periods of time including 2004, 2008, 2013 and 2018.

STUDY AREA AND DATA

Study area

Buriram Province (Fig. 1) administration is divided into 23 districts, 189 sub-districts, with the total area of 10,322.885 km^2, with its boundary connected with

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nearby provinces and country as follows: to the north it borders Khon Kaen Province, Mahasarakham Province, and Surin Province, to the east it borders Surin Province, to the south it borders Sakaew Province and Cambodia, and to the west it borders Nakhon Ratchasima Province.

Data

Data used in the study: Data from Terra/Modis Satellite, MOD11A2 product that recorded data during January to December in 2004, 2008, 2013 and 2018, were applied in this study; MOD11A2 is the data in form of land surface temperature consisting of 12 science dataset (SDS), with spatial resolution of 1000 m and with map projection in sinusoidal form. The researcher downloaded the data from LAADS DAAC at https://ladsweb.modaps.eosdis.nasa.gov/.

Data on ground temperature: In this study, the data on average annual temperatures were collected from 20 ground monitoring stations located in Buriram Province (Thai Meteorological Department, 2018).

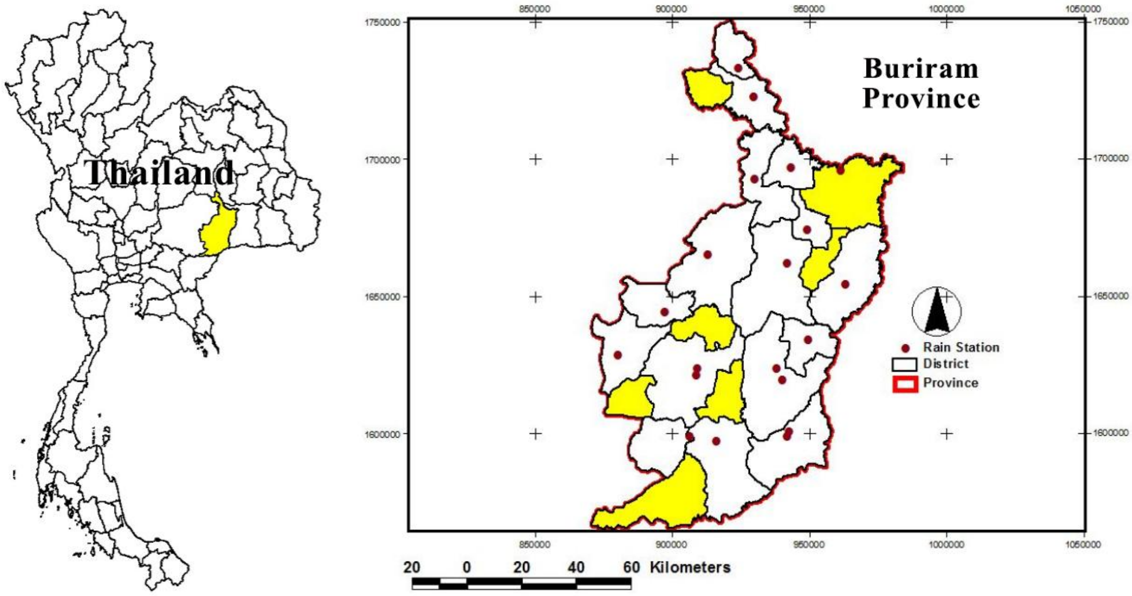

Fig. 1. Buriram province

METHODOLOGY

For the convenience in this presentation, the methodology would be stated in brief as follows:

1) In this initial stage, the data were prepared before analysis, so it was necessary to remove all abnormal pixel of data from satellite from the QA band.

2) Convert projection value of data from satellite from sinusoidal projection to be geographical latitude/longitude projection as well as adjusting the geo-reference so that the data from satellite could have accurate geographical coordinate.

3) Since the acquired data from satellite cover the wide area, therefore, for the convenience in data analysis process, only the data in the study area which was Buriram Province were left.

4) Rescale the digital number (DN) of data from satellite which is 7500 – 65535 to be changed to be brightness-temperature in degree Kelvin by equation 1 and after that, change Kelvin into Celsius by using equation 2.

5) Bring the data from satellite on monthly basis from 12 months (January to December) acquired from Step 4 to be processed into average annual data.

6) An analyze the statistical relationship by taking the land surface temperature result that was analyzed to find the statistical relationship with the data on temperature from the ground monitoring stations.

$$LST = DN * 0.02 \quad (1)$$

$$°C = Kelvin - 273.15 \quad (2)$$

RESULTS AND DISCUSSION

The result of spatial land surface temperature analysis

According to the land surface temperature analysis by using data from Terra/Modis Satellite in Buriram Province during 4 periods of time, it was found that in 2004 the analysis result was that the average annual temperature was 32.90 Degree Celsius; in 2008 the analysis result was that the average annual temperature was 30.33Degree Celsius; in 2013 the analysis result was that the average annual temperature was 31.26 Degree Celsius; in 2018 the analysis result was that the average annual temperature was 33.20 Degree Celsius.

In order to show more detailed land surface temperature, the land surface temperature was divided into 4 parts (Fig. 2) that were Part 1 land surface temperature was between 20.90-24.90 Degree Celsius, Part 2 land surface temperature was between 24.90-28.90 Degree Celsius, Part 3 land surface temperature was between 28.90-32.90 Degree Celsius, and Part 4 land surface temperature was between 32.90-36.90 Degree Celsius; each part of land surface temperature from each year can be expressed in terms of size of the area and percentage of the study area as follows:

In 2004, land surface temperature in the first part, the analysis result can be calculated into the area of 0.283 km^2 or equal to 0.003 % of the study area; land surface temperature in the second part, the analysis result can be calculated into the area of 649.843 km^2 or equal to 6.301% of the study area; land surface temperature in the third part, the analysis result can be calculated into the area of 7,131.251 km^2 or equal to 69.149 % of the study area; land surface temperature in the fourth part, the analysis result can be calculated into the area of 2,276.246 km^2 or equal to 22.071% of the study area.

In 2008, land surface temperature in the first part, the analysis result can be calculated into the area of 411.740 km^2 or equal to 3.992% of the study area; land surface temperature in the second part, the analysis result can be calculated into the area of 1,378.039 km^2 or equal to 13.362% of the study area; land surface temperature in the third part, the analysis result can be calculated into the area of 8,260.602 km^2 or equal to 80.100% of the study area; land surface temperature in the fourth part, the analysis result can be calculated into the area of 7.242 km^2 or equal to 0.070% of the study area.

In 2013, land surface temperature in the first part, the analysis result can be calculated into the area of 78.303 km^2 or equal to 0.759% of the study area; land surface temperature in the second part, the analysis result can be calculated into the area of 831.137 km^2 or equal to 8.059% of the study area; land surface temperature in the third part, the analysis result can be calculated into the area of 8,748.865 km^2 or equal to 84.834% of the study area; land surface temperature in the fourth part, the analysis result can be calculated into the area of 417.989 km^2 or equal to 4.053 % of the study area.

In 2018, land surface temperature in the first part, the analysis result can be calculated into the area of 16.502 km^2 or equal to 0.160 % of the study area; land surface temperature in the second part, the analysis result can be calculated into the area of 764.280 km^2 or equal to 7.411% of the study area; land surface temperature in the third part, the analysis result can be calculated into the area of 3,263.850 km^2 or equal to 31.648% of the study area; land surface temperature in the fourth part, the analysis result can be calculated into the area of 5,937.839 km^2 or equal to 57.577% of the study area.

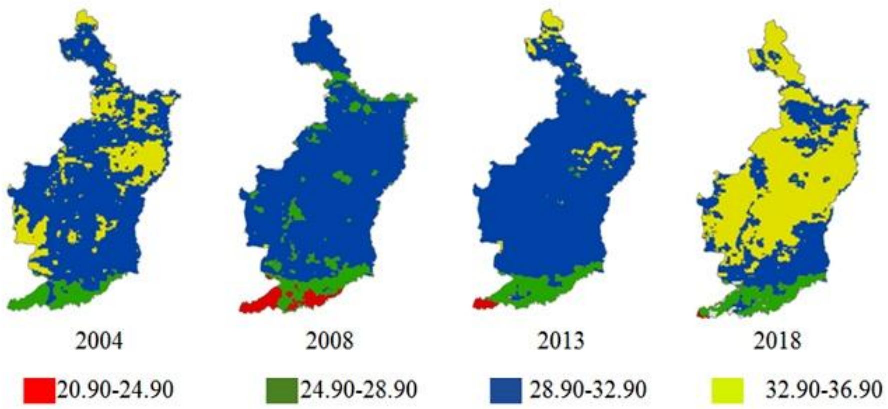

Fig. 2. Land surface temperature in 4 periods of Buriram province

The analysis result of change of multi-temporal

The spatial land surface temperature changes were analyzed during 4 periods of time including 2004, 2008, 2013, and 2018 by using land surface temperature as analyzed from Terra/Modis Satellite and data of average annual temperature from the ground monitoring stations to be expressed in graph for the analysis of change of land surface temperature in such 4 periods of time; the analysis result of temporal land surface temperature change can be expressed in Fig 3.

According to Fig 3, it was found that the temporal change of land surface temperature as analyzed from Terra/Modis Satellite was consistent with the average annual temperature from ground monitoring stations. When land surface temperature as analyzed from satellite increased, the average annual temperature from ground monitoring station increased accordingly. Also, when land surface temperature as analyzed from satellite decreased, the average annual temperature from ground monitoring station decreased accordingly. From these 4 periods of time, it was found that in 2008, it was the year when the temperature was the lowest; and in 2018, it was found that the temperature was the highest.

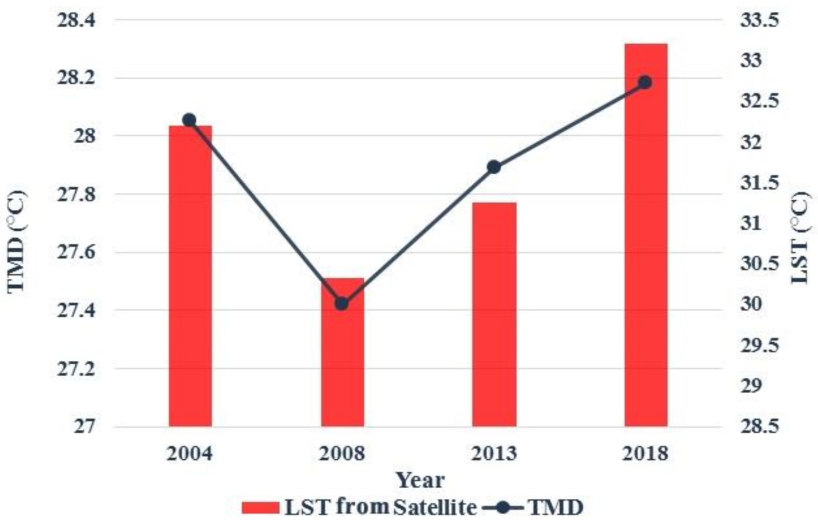

Fig. 3. Multi-temporal of land surface temperature changes

The analysis result of statistical relationship

In order to make the analysis result of land surface temperature from Terra/Modis Satellite become reliable, therefore, in this study, such land surface temperature analysis result was brought to find the statistical relationship with the data of average annual temperature from 20 ground monitoring stations located in Buriram Province in form of simple correlation analysis, which was to find the relationship between X and Y to see what the extent of their relationship was and how they were related, where X was independent variable and y was dependent variable. In this study, the independent variable (X) was land surface temperature as analyzed from satellite, and the dependent variable (y) was average annual temperature from ground monitoring stations. From such analysis into the relationship, it was found that both sets of data were highly related and were in the same direction, with Correlation Coefficient R = 0.9442.

CONCLUSIONS

In this research, the method for analyzing the land surface temperature change was presented by using data from Terra/Modis Satellite together with the mathematical calculation method during 4 periods of time in study area of Buriram Province. It was found from the research result that land surface temperature analyzed from satellite in 2004, 2008, 2013 and 2018 was that average annual land surface temperature were 32.19 Degree Celsius, 30.33 Degree Celsius, 31.26 Degree Celsius and 33.20 Degree Celsius, respectively. On part of data on temperature from ground monitoring stations from TMD, the average annual temperatures were 28.05 Degree Celsius, 27.42 Degree Celsius, 27.89 Degree Celsius, and 28.18 Degree Celsius, respectively. Both datasets had difference of temperature of 4.14 Degree Celsius, 2.91Degree Celsius, 3.37 Degree Celsius, and 5.02 Degree Celsius, respectively. So, both datasets were examined again to check for the cause that the abnormality was not found in land surface temperature analyzed from satellite. On part of the data from ground monitoring stations, it was noted that Buriram Province has 20 monitoring stations scattered in various districts, at least 1 station per district; however, there are 7 districts (see in Fig. 1), which have no monitoring stations at all; so it is possible that temperatures obtained from ground monitoring stations did not cover the whole province, there was some slight error when finding average annual value. Besides, in this study, the statistical analysis was done by taking land surface temperature from satellite to be analyzed to find the statistical relationship with the average annual temperatures in form of simple correlation analysis and it was found that both datasets were highly related and were in the same directions, with correlation coefficient R = 0.9442. This study result revealed that the analysis of land surface temperature change using data from Terra/Modis Satellite can be applied to analyze, monitoring, and follow up the spatial-temporal change of land surface temperature.

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