

Analysis on urban heat island and spatial characteristics using GIS and MODIS Imagery

**Kyeong-Ho SEO, Kyung-Hun PARK, Gyeong-Ah KIM, Bong-Geun SONG,
Chul-Hyun CHOI, Kwang-Woo NAM and Yong-Cheol SUH**

Abstract: In this study, the urban heat island phenomenon according to spatial and topographical factors per regions in Korea was analyzed by utilizing MODIS satellite images and climate data. The correlation analysis of spatial and topographical characteristics, tropical night days and heat wave days showed that forest areas showed a negative correlation with surface temperature, tropical nights and heat wave while the urbanized areas and flatlands had a positive correlation. We think that the results of this study can be used as material for forecasting urban thermal island phenomenon according to spatial and topographical characteristics as well as climate change and providing alternatives for alleviating the related situation

Keywords: GIS, MODIS satellite imagery, urban heat island, land surface temperature

1. Introduction

Today, the urbanization of many cities around the world is increasing at a rapid pace due to rapid industrialization and reckless development. Population increase due to urbanization, increase of artificial structures and terrain change act as factors changing urban climate and this is pointed out as the major cause of urban heat island where the temperature difference between urban and suburban areas exceeds 2°C (Song and Park, 2012). The recent increase of summer heat waves and tropical nights resulting from recent climate change is causing negative effects on health such as daily heat stress and nightly insomnia. In addition, with increase in excessive use of air conditioning devices, energy problems according to increase in power consumption occur; as this increases the artificial heat in

urban areas during summer, the urban thermal island phenomenon can be adversely affected. This is not just a problem of one specific area but the climatic and physical environmental factors of urban areas have to be taken into account.

Therefore, in this study, we will identify the status and cause of urban heat island phenomenon in Korea by using MODIS satellite imaging data and climate data to provide alternatives for improvement..

2. Methods

2.1. Study Site

There are a special city, six metropolitan cities, 77 cities and 77 counties in Korea; the terrain is high at the east and low at the west with mountainous terrain formed at the east. In this study, the spatial characteristics and urban heat island were analyzed from a wide area perspective instead of local perspective and research performed over all of to analyze the cause of urban thermal island phenomenon and provide alternatives for improvement.

Kyung-Hun Park

Changwon National University 20 Changwondaehak-ro

Uichang-gu Changwon-si, Gyeongsangnam-do, Korea

E-mail address : landpkh@changwon.ac.kr

2.2. Study process

The study was performed as shown on Figure 1. To analyze the urban thermal island, the MOD11A2 image data summed up at 8-day interval at a 1km spatial resolution was utilized from MODIS LST(Land Surface Temperature) observed by the terra satellite; the land surface temperature was calculated after coordinate correction. The days of tropical nights were calculated by accumulating the detailed climate data of South Korea at a spatial resolution of 1km provided by National Institute of Meteorological Research then taking the days with a daily minimum temperature of at least 25°C; the heat wave days were calculated from the days with daily average over 33°C. By using the land coverage data of the MODIS satellite images, the spatial data was reclassified into urbanized areas, agricultural areas, forest areas, water areas, grass/bare land;. The surface temperature, heat wave days, and tropical night days were standardized and averaged for identical assessment per area for data accumulation; by utilizing the reclassified land coverage, the correlation between urban heat island and spatial characteristics was derived and an alternative for improving urban heat island was discussed.

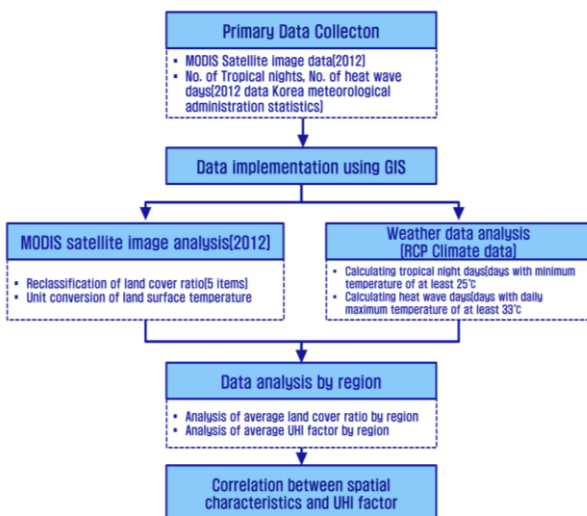


Figure 1. Study process

2.3. Research Method

2.3.1 MODIS satellite data

To establish the land surface temperature data per region, we utilized the LST data from the MODIS satellite images. MODIS is a sensor installed in the NASA's earth observation satellites of Terra and Aqua following sun synchronous orbits at an altitude of 705km (Ahn and Kim, 2007). The spatial resolution of a MODIS satellite image is 250m for band 1 and 2, 500m for band 3~7 and 1km for band 8~36. The data used for analysis is MODIS LST(MOD11A2) output the bands used for this data were 31 and 32, the spatial resolution is 1km and includes the surface temperature data synthesized on a 8-day basis. 46 surface temperature data are generated during 1 year; from these, the average temperature of summer(July ~ September) which is the hottest period in a year was used.

To analyze the difference in land surface temperature due to land coverage, MOD12Q1, the land coverage data of MODIS satellite images, was utilized. The land coverage data was categorized into 13 type categories such as urbanized areas, paddy fields, farmlands and forest areas then categorized again into the five categories of urban areas, agricultural areas, forest areas, water areas, grass land and bare land.

2.3.2 Data of heat wave and tropical night days

To establish data for the days of tropical nights and heat waves, we utilized the detailed (1km) climate change scenario for South Korea based on RCP (Representative Concentration Pathway) from the climate change scenario of the Korean peninsula provided by the climate information portal. The detailed(1km) South Korean climate change scenario on generated through a statistic detailing process based on the Korean peninsula(12.5km) climate change scenario generated through the local climate model. By applying the observation data(200~2010)

to the PRIDE model, the observation gap data with a resolution of 1km was generated to use as climate values. Then, the anomaly data was extracted by removing the seasonal cycle per each grid point from the 12.5km Korean peninsula scenario data. By adding the anomaly of the regional climate model to the observed climate values, a new 1km grid type scenario data with the model's systematic error removed was created (Climate Information Portal, www.climate.go.kr).

In this study, the daily temperature data of 2012 was obtained from the detailed South Korean climate data established in this way then the heat wave days data accumulated by calculating the tropical night days from the no. of days with minimum temperature of 25°C and the heat wave days from the no. of days with a daily maximum temperature of at least 33°C.

3. Results

3.1 Analysis of urban heat island characteristics per region

By reclassifying the land coverage, the areas with the highest urbanized area ratio were Bucheon(85.0%), Seoul(81.6%), Guri(60.5%), and Anyang(60.0%) in that order; we can see that concentration occurred in large city areas. The average summer surface temperature was shown to be the highest in Suwon at 29.7°C; the areas with the most heat wave days were Busan (15.9 days), Changnyeong (12.6days), and Haman (11.5 days), in that order. The number of tropical nights was largest in Gwangmyeong with 68.9 days, followed by Mokpo, Muan and Yeosu.

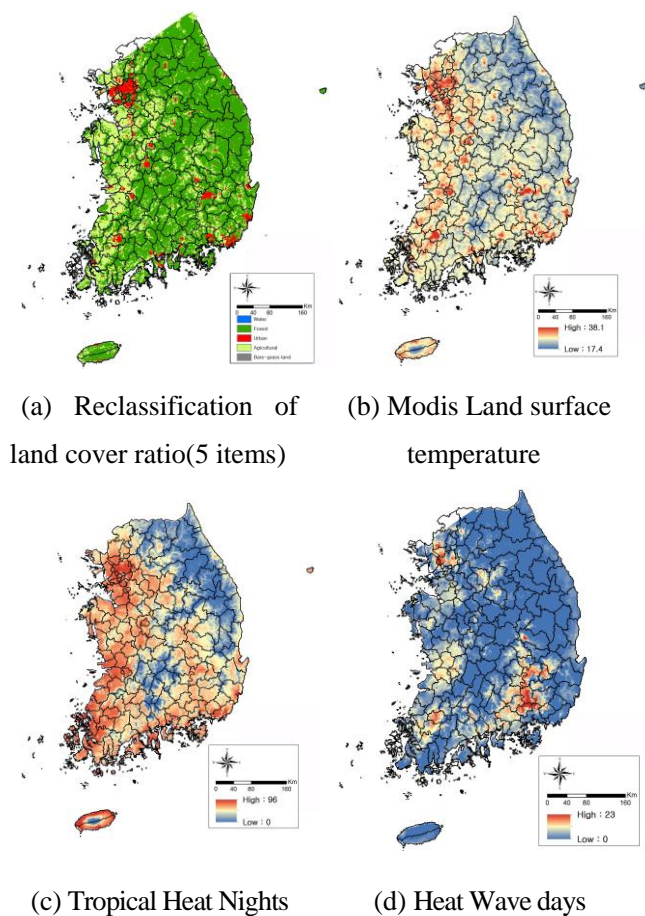


Figure 2. Analysis of Urban Heat Island factor according to Administrative Boundary

3.2 Correlation analysis of spatial characteristics and urban heat island factors

The results of correlation analysis on spatial and topographical characteristics, surface temperature, tropical night days and heat wave days of year 2012 showed that, forest areas showed -0.83 for tropical night days, -0.56 for heat wave days and -0.87 for surface temperature; therefore, the R value was analyzed to show a negative correlation. This can lead to the conclusion that a large forest area reduces tropical nights, heat wave and land surface temperature. From the terrain characteristics factors, the urbanized areas were shown to have the largest correlation with tropical nights, Urbanized areas showed a correlation of 0.46 for no. of tropical nights, 0.41 for heat wave days and 0.69 for

surface temperature therefore having a positive correlation; the land surface temperature was affected most by the urbanized areas. The correlation analysis on land surface temperature, no. of tropical nights and no. of heat wave days showed that the correlation between land surface temperature and no of tropical nights was 0.88 while the correlation between surface temperature and no. of heat wave days was 0.95, thereby having a high correlation. Summarizing these results, the land surface temperature increased with higher ratio of urbanization per each region in the whole country which in turn affected the occurrence of tropical nights and heat waves.

Table 1. Correlation analysis of spatial characteristics and urban heat island factors

Classify	U	A	F	B	W
Modis LST	0.69	0.53	-0.87	0.09	0.11
Heat wave days	0.41	0.38	-0.56	0.06	-0.04
Tropical night days	0.49	0.60	-0.84	0.24	0.36

*U: urbanized areas, A: agricultural areas, F: forest areas, B: bare land-grass land, W: water

4. Discussion and Conclusion

In this study, an analysis was performed on the urban heat island by utilizing the MODIS satellite images and climate data on Korea. The study results showed that the more urbanized areas are distributed, the higher the land surface temperature; it can be predicted that this results in tropical nights and heat wave phenomena. In the future, it is necessary to

analyze urban thermal island phenomena through analysis on time series data and a variety of factors such as terrain related factors.

Acknowledgement

This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (No. NRF-2016R1A2B4015460).

References

- Ahn, J.S. and H.D. Kim. 2007. A Comparative Study of Algorithms for Estimating Land Surface Temperature from MODIS. Journal of Nakdonggang environmental research institute 12:49-61.
- Song, B.G. and K.H. Park. 2012. Analysis of heat island characteristics considering urban space at nighttime. Journal of the Korean Association of Geographic Information Studies 16(2): 16-29.