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Time Series Analysis of Land Cover and Land Surface Temperature Change using Remote Sensing Method in Seoul

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Abstract

Seoul has been made constantly changing environment due to rapid urban development and industrialization which is the capital of the Republic of Korea. The change of land cover and land surface temperature are required to monitor and manage continuously. Thus, Landsat satellite images were used in order to efficiently manage the changing environment of the metropolis in this study. We calculated quantitatively change amount of urban area, forest, water, bare soil, and farm by performing the classification using the acquired Landsat images. Also, we calculated the land surface temperature using thermal band and NASA equation to analyze the change of thermal environment according to urbanization. And we performed correlation analysis in tandem with the results of classification. As a result, we could recognize that the land surface temperature increases due to urban expansion.

Keywords: Landsat Satellite image, Land Cover Change, Surface Temperature, Remote Sensing

Background and Purpose

Korea has been rapidly changing urban environment by rapid urban development and industrialization [1]. In particular, Seoul has invested a lot of budget to ensure the conservation of ecological resources in the inner city green spaces [2][3]. But nevertheless, 17, 289people/km^2 of the highest among major cities in the OECD countries with high population density [4][5]. And urban space is covered with asphalt and concrete impermeable layer has a structurally weak spatial distribution for the thermal environment of the city. In particular, the density of buildings and apartments in the city has a very weak and vulnerable to heat waves and tropical nights phenomenon according to climate change and contribute to the temperature increase in the inner city to the microclimate characteristics [6]. Therefore, it is necessary to manage not only change of land cover but also temperature of land surface consistently from the past until now [7][8].

Urban change detection is analyzed by time series approaching of changing information according to time about the large area [9][10]. Remote sensing technique using satellite images which is broad based and easy to obtain the data and can be quickly analyzed in accordance with the development of image analysis software, so this technique is used to detect the urban changes in many studies [11][12].

This study obtained a wide range of Landsat satellite images of targets when the entire Seoul area, which used to be land cover changes as well as monitor the surface temperature changes [13][14]. Also, the relationship between change of land cover and change of land surface temperature was analyzedusing these results to investigate the effect on thermal environment of the city.

Acquisition of Satellite Images

In this study, we acquired 5Landsat satellite images on same time when is on September 1993, September 1996, September 2000, September 2006, and September 2013 to detect and analyze the environmental change of Seoul. Table 1 shows the information of satellite images used in this study. And Figure 1 shows the study area including the latitude and longitude.

Table 1: Satellite images used in this study

Date	Kind of satellite images	Resolution (m)	Cloud cover(%)
Sep. 25, 1993	Landsat 5 TM	30	5
Sep. 01, 1996	Landsat 5 TM	30	0
Sep. 04, 2000	Landsat 7 ETM+	30	1
Sep. 13, 2006	Landsat 5 TM	30	0
Sep. 16, 2013	Landsat 8 OLI TIRS	30	0

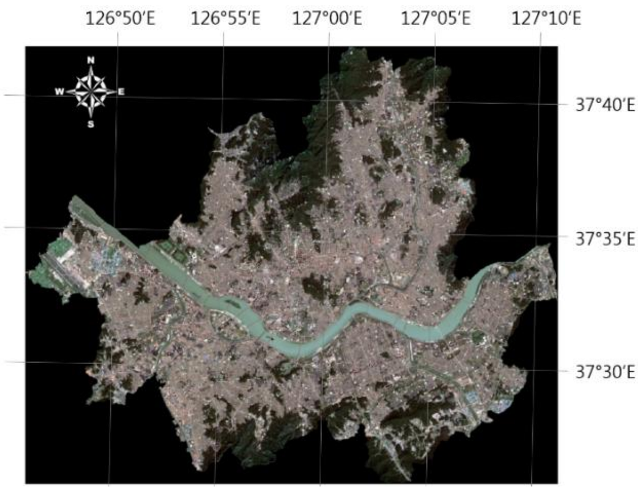


Figure 1: Study area

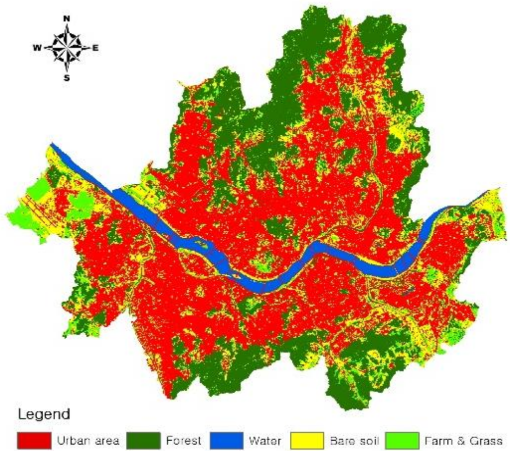
Change of Land Coverage

We set ROI(Region of Interest)s by selecting the representative region to calculate the result of land cover using acquired images. Classification item was set 5 sorts according to big class level criteria of land cover classification map as shown in Table 2.

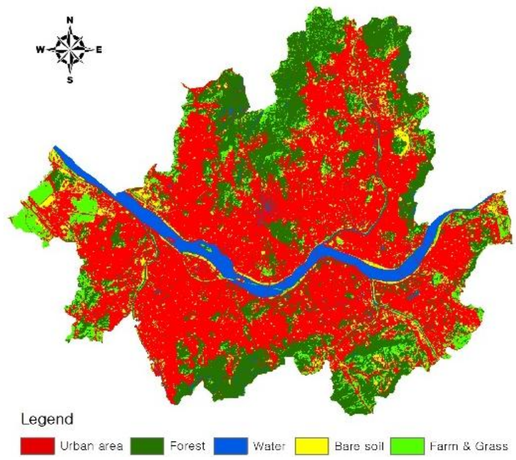
Table 2: Classification item

Classification Item	Color	
Urban area	Red	
Forest	Sea green	
Water	Blue	
Bare soil	Yellow	
Farm &Grass	Green	

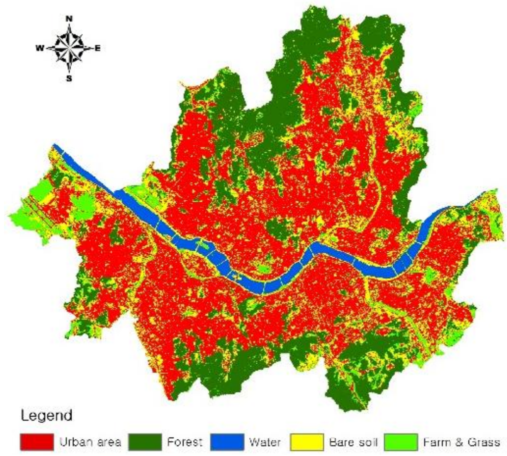
We classified the 5 images using three classification methods (Minimum Distance, Maximum Likelihood, Support Vector Machine)based on the selectedROIs because these methods are the most used recently. Minimum Distance is the methodto allocate Euclid distance to the classification item of minimum distance. Euclid distance is from selected pixel in the training region to the average vector. Maximum Likelihood is the method to perform the classification depending on the statistical distribution assuming that the selected pixel according to classification item follows the normal distribution basically [15]. SVM is the method to classify based on the notion of fitting an optimal separating hyperplane between classes by focusing on the training samples that lie at the edge of the class distributions, the support vectors [16]. Figure 2 shows the results of classification according to each method.



Result of ML



Result of MD
(1) 1993. 09. 25



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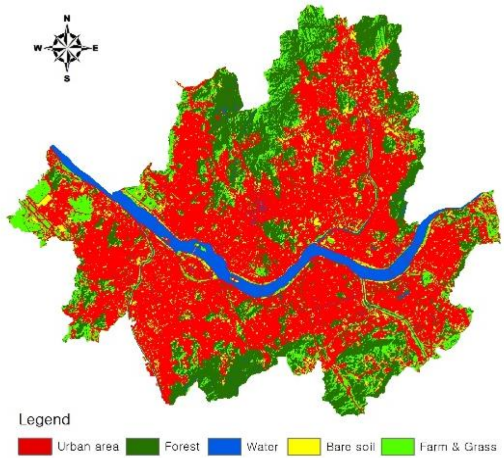
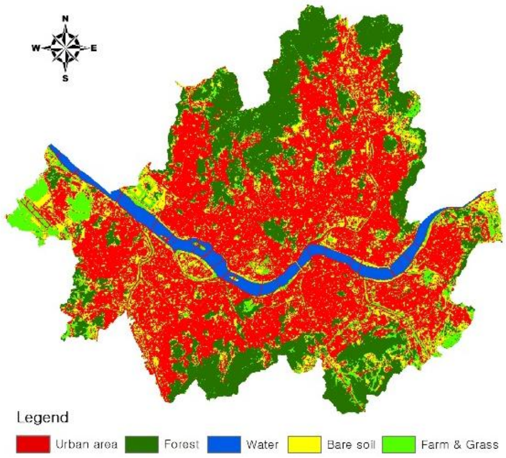
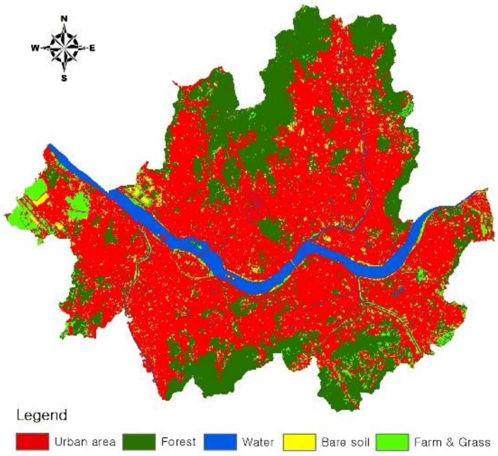


Result of MD
(2) 1996. 09. 01

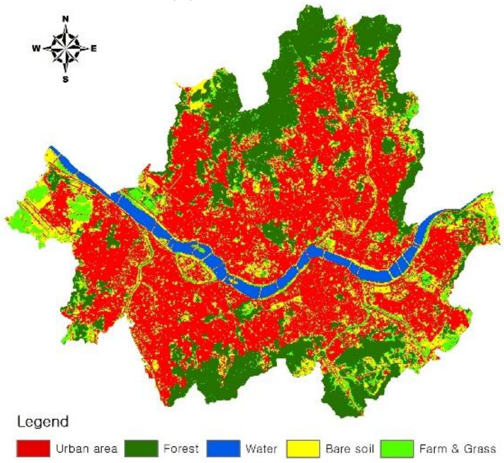


Result of ML

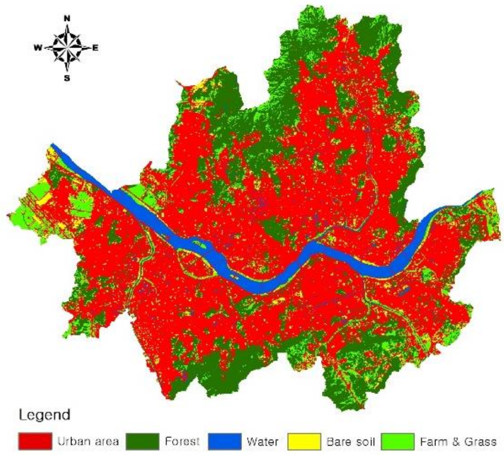


Result of MD

(3) 2000. 09. 04

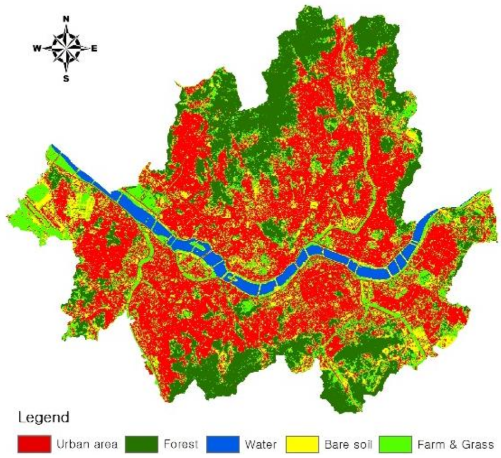


Result of ML

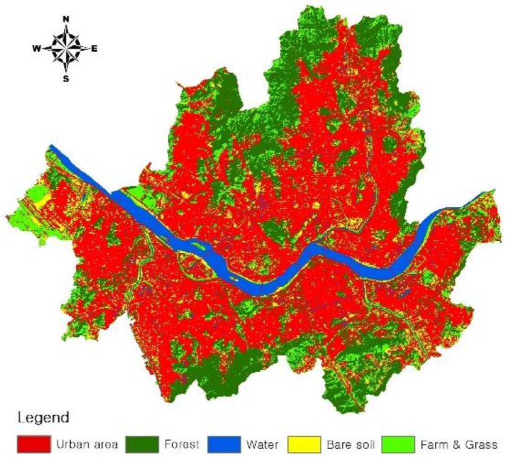


Result of MD

(4) 2006. 09. 13



Result of ML



Result of MD

(5) 2013. 09. 16

Figure2: Results of ML and MD classification

As shown in Figure 2, in case of minimum distance method, classification result was missed in the outside forest area. Also, in case of maximum likelihood method, the result was missed in the bridges on the Han River and outside forest area. On the other hand, brides on the Han River and outside forest area were classified to urban and forest correctly as shown in

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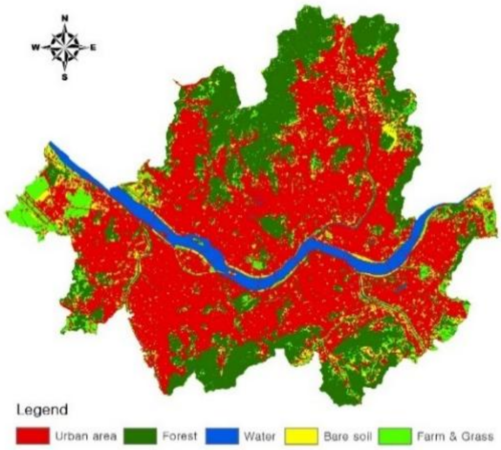
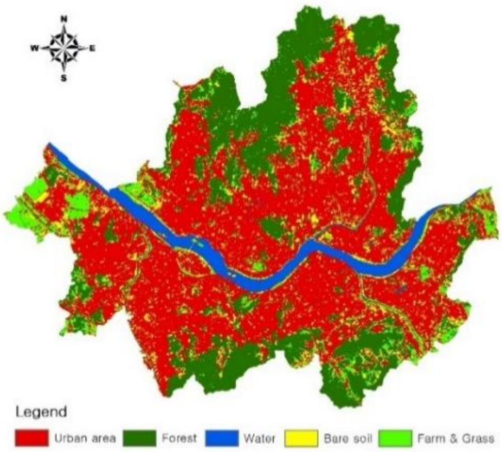
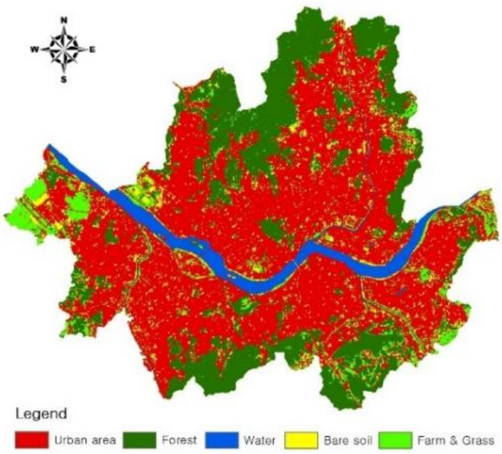
Figure 3. The maximum likelihood classification is a method of assuming the groups that form a normal distribution of each target area and classifying with calculating the possibility for each of the target areas groups of the pixel to be classified and have the maximum possibility group [10].



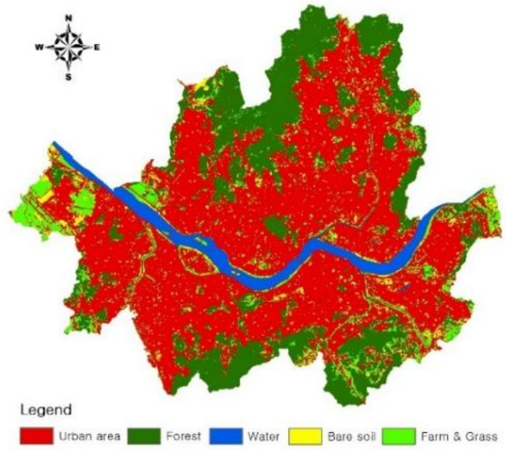
(1) 1993. 09. 25



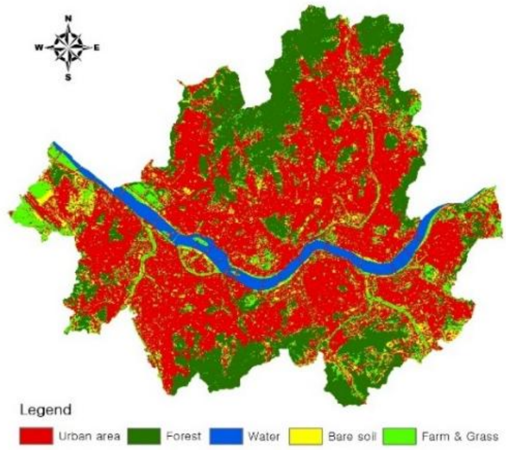
(2) 1996. 09. 01



(3) 2000. 09. 04



(4) 2006. 09. 13



(5) 2013. 09. 16

Figure3: Results of SVMclassification

Table 3 indicates the area change of land coverages. In this table, we could know that area of city increased from 1993 to 2006 consistently, on the other hand, area of forest decreased at the same period of time.

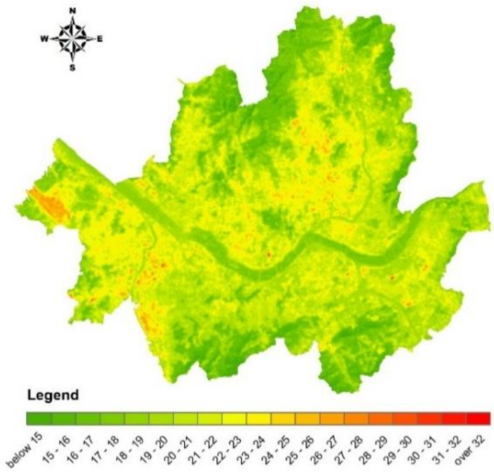
Table 3. Area changeof land coverage (Unit: km^2)

Classification	1993	1996	2000	2006	2013
Urban area	327. 99	329. 45	346. 63	355. 98	325. 49
Forest	161. 40	149. 14	147. 29	141. 68	147. 07
Water	28. 04	29. 26	29. 51	28. 29	25. 26
Bare soil	35. 24	43. 67	34. 13	28. 42	36. 74
Farm & Grass	53. 60	54. 75	48. 70	51. 90	71. 72

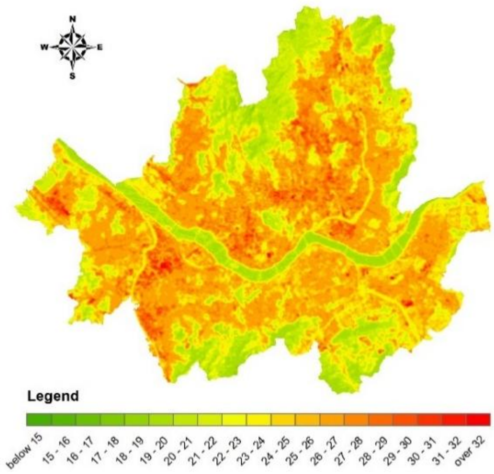
Also, the most characteristic point between 2006 and 2013 is the area change of urban and farm. Urban area decreased about 30km^2 and farm area increased about 20km^2 in this period. This phenomenon can be seen as a result of “Seoul Hopes Planting Trees” which is started from 2012.

Change of Land Surface Temperature

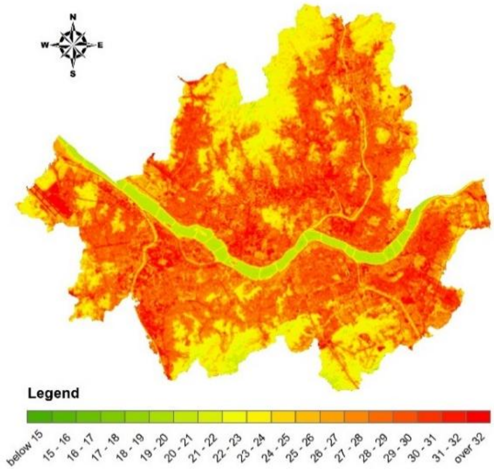
There are several models to calculate the land surface temperature using satellite images for example, RESTEC(Remote Sensing Technology Center of JAPAN) method, Quadratic method, and NASA model. NASA model mostly used among these methods was used [9]. Thus, the land surface temperature of satellite images was calculated using NASA model in this study. The spectral radiance of thermal band on Landsat 5 TM, 7 ETM+, and 8 OLI TIRS was converted to Celsiustemperature. These results are shown in the Figure 4. The average temperature about overall areawas19. 87℃ in 1993, 24. 26℃ in 1996, 27. 01℃ in 2000, 24. 96℃ in 2006, 25. 18℃ in 2013.



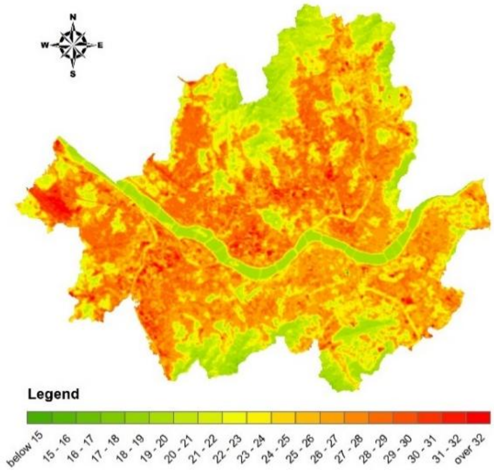
(1) 1993. 09. 25



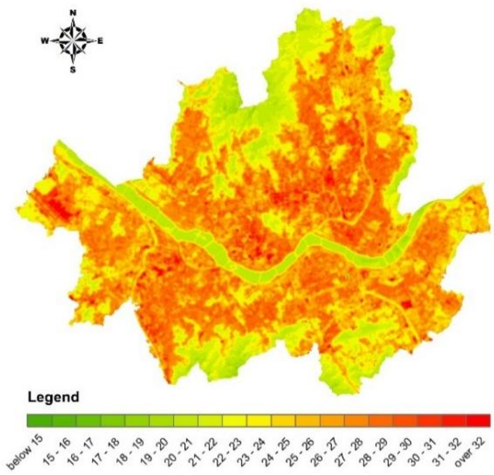
(2) 1996. 09. 01



(3) 2000. 09. 04



(4) 2006. 09. 13



(5) 2013. 09. 16

Figure4: Results ofland surface temperature

Table 4. Changeof land surface temperature (℃)

Classification	1993	1996	2000	2006	2013
Urban area	21. 33	26. 05	28. 91	26. 81	27. 25
Forest	17. 54	21. 32	23. 88	21. 42	22. 24
Water	18. 27	20. 61	21. 18	20. 40	20. 74
Bare soil	21. 08	25. 56	28. 57	26. 54	26. 89
Farm & Grass	19. 79	23. 50	26. 27	24. 75	24. 98
Average	19. 87	24. 26	27. 01	24. 96	25. 18

As shown in Figure 4, the center of city is higher than the outskirts of a city. Also, difference of temperature between center area and outskirts of a city was increased from 1993 to 2006. For the detail analysis, change of land surface temperature according to the classification results is shown in Table 4. In this table, temperaturedifference between urban area and forest are 3. 79℃in 1993, 4. 73℃in 1996, 5. 03℃in 2000, 5. 39℃in 2006, and 5. 01℃in 2013. We could know that temperature of urban area is increased constantly due to the continuous urbanization. And the average temperature of forest shows the lowest classification item except for the water.

Conclusions

In this study, we classified the time serialLandsat satellite images to analyze the change of land cover. Also, we calculated the land surface temperature using Landsat thermal band based on NASA equation to analyze thermal environment. As these results, we could recognize the followings.

First, we could know that the urban area increased consistently from 1993 to 2006, on the other hand, area of forest decreased on same period by analyzing the classification results. Also, urban area was decreased about 30km^2 and farm area was increased about 20km^2 from 2006 to 2013. These phenomenon can be seen as results of “industrialization” between 1993 and 2006 and “Seoul Hopes Planting Trees” between 2006 and 2013.

Second, we could recognize that the temperature of urban center is higher than the outskirts of a city. Also, difference of temperature between urban center and outskirts was increased from 1993 to 2006. And temperature of urban area is increased constantly because of continuous urbanization.

These results of analysis will be able to use basic data on the sphere of urban management. Also, it is expected to analyze the land use and land surface temperature through the continuous study in Seoul.

Acknowledgments

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