ESTIMATION OF HEAT ISLAND POTENTIAL BASED ON LAND-USE TYPE IN DAEGU

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ABSTRACT:

This study aims to estimate a heat island potential distribution based on the land-use types using LANDSAT/TM(1100LST April 2000) and AWS data in Daegu. The heat island potential is defined as a difference between surface temperature and air-temperature at each place. The study area was selected as about 900k㎢ square including Daegu metropolitan area. Land-use data obtained by dividing all of Daegu metropolitan area into 1-km-square three types of maps were prepared, in the 1960s, 1970s and 2000s respectively. The types of land-use were divided into 5. Forest and farm lands have been reduced at a wide range during 40 years, most of which changed to urban area.
The heat island potential distribution presented a striking contrasts according to land-use types. For example, the heat island potential of urban area was higher than 14℃ in comparison to those of water or paddy rice areas.
Keywords: heat island potential, LANDSAT/TM, land-use

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1. INSTRUCTIONS

The significantly contrasting heat dispersion can be verified, by estimating the surface temperature of urban area, where artificial structures are covering the region, and rural area, where woods and water abundant, by using the heat image data observed by satellites or airplanes in fine summer weeks. The surface temperature of farmland, including water, forest, and fields, is similar to the air temperature or rather somewhat low; however, it can be verified that surfaces of the towns concentrated with population and suburb complexes under development usually mark 20℃ above the air temperature. Through such heat image data, it can be conjectured that asphalt and artificial concrete structures covering the city are closely related.

The urban development, until now, preferred functionality and efficiency, and the worldwide urban developments established in industrialization era did not consider the city climate. Instead, it was rather turned away, for pleasant indoor atmosphere (excessive discharge of artificial heat from air conditioning).

In this study, change in land use of Daegu for las 40 years is examined, and with remote satellite investigation, the contrasting dispersion of surface temperature according to the land use is quantitatively visualized. With this basis, the transition in Heat Island Potential : HIP from land use change is estimated.

Heat Island Potential is defined as the difference of air and surface temperatures in a given time; it is used as an index to evaluate the effect of surface change to surrounding temperature of the developed land.

2. REACH DATA AND METHODOLOGY

2.1 Reach Data

In order to investigate the long-term land use change of Daegu region, the yearly topographical map was used. The surface temperatures following land use was estimated from LANDSAT/TM data, and the temperature data for estimation of Heat Island Potential caused by sensible heat conveyed from surface to air during daytime was obtained from AWS of Daegu.

2.2 Reach Methodology

For calculating the temperature distribution of Daegu using thermal band 6, the following equstions were used

$$T = \frac{K2}{\ln(\frac{K1}{L_K} + 1)} \qquad (1)$$

Where

T : Effective-satellite temperature in kelvin
K2 : Calibration constant 2 in Kelvin

K1 : Calibration constant 1 in

$$mW \cdot cm^{-2} \cdot ster^{-1} \cdot \mu m^{-1}$$

L_λ : Spectral radiance at the sensor's aperture

$$mW \cdot cm^{-2} \cdot ster^{-1} \cdot \mu m^{-1}$$

And

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{cal\ max}}\right) Q_{cal\ max} + LMIN_\lambda \quad (2)$$

L_λ : spectral radiance at the sensor's aperture in $W/(m^2 \cdot sr \cdot \mu m)$

Q_{cal} : quantized calibrated pixel value in DNs

$Q_{cal\ min}$: minimum quantized calibrated pixel value (DN) cooresponding to $LMIN_\lambda$

$Q_{cal\ max}$: maximum quantized calibrated pixel value (DN) cooresponding to $LMAX_\lambda$

$LMIN_\lambda$: spectral radiance that is scaled to $Q_{cal\ min}$ in $W/(m^2 \cdot sr \cdot \mu m)$

$LMAX_\lambda$: spectral radiance that is scaled to $Q_{cal\ max}$ in $W/(m^2 \cdot sr \cdot \mu m)$

And,

The temperature data for estimation of Heat Island Potential caused by sensible heat conveyed from surface to air during daytime was following equstions were used

$$HPI = \frac{\int_{all\ area}(T_s - T_a)}{Sd} \quad (3)$$

Where,

HPI : Heat island potential

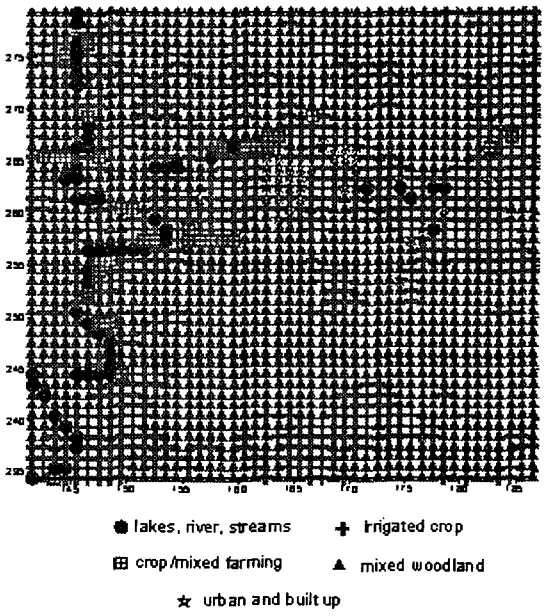
T_s : Surface temperature of micro-area (K)

T_a : Urban canopy layer of mean temperature (K)

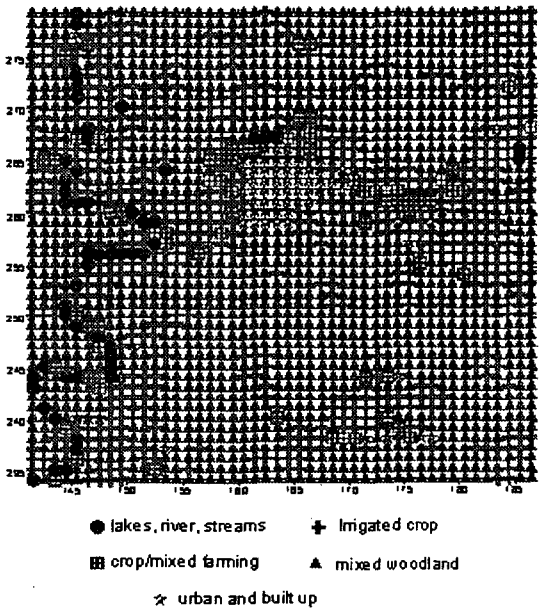
Sd : horizontal projected area

3. RESULT AND DISCCUSSION

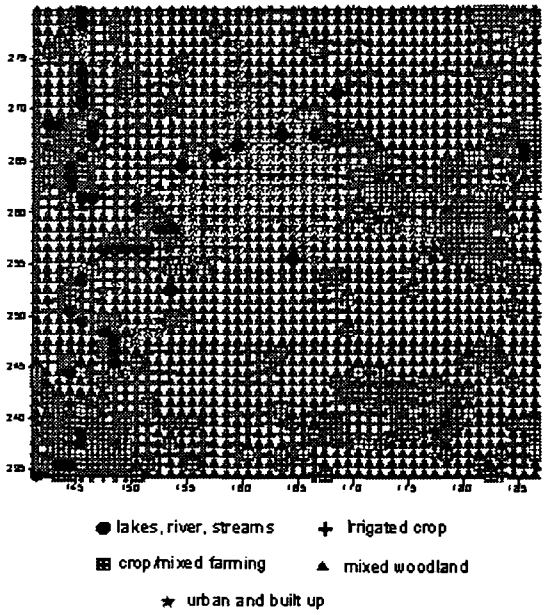
Figure. 2 shows Land-use change between in circa 1963(a), 1975(b) and in circa 2002(c). The figure tells us that confirm remarkable expansion of city scope of an artificial structure.



(a) 1963



(b)1975



(c) 2002

Figure 1. Land-use change between in circa 1963(a), 1975(b) and in circa 2002(c).

In the results of this study, it could be confirmed that Dalseo-Gu, with full-sized apartment complex, consisting of asphalt and concrete, and Seongseo Industrial Complex, where large-scale industrial complex is located, are forming surface temperature 9 ~ 14 ℃ higher than forests and farmlands. The surface temperature of MT.AP and MT. PALGONG ,with forest area, showed distribution 23~26℃. DALSEOGU, with Agricultural area, showed Distribution of 26 ℃.

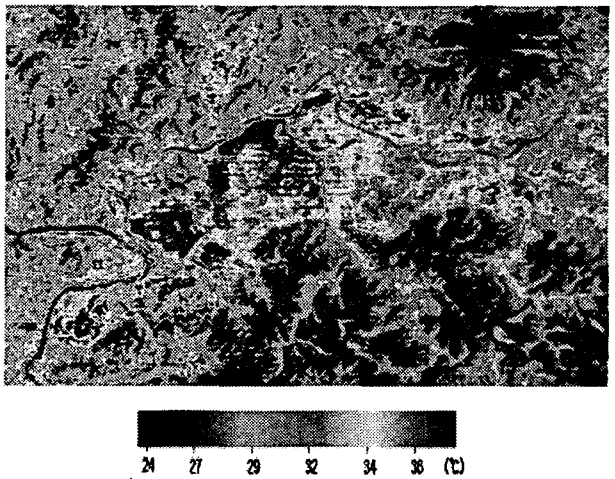


Figure 2. Distribution of surface temperature estimated by using LANDSAT/TM data at 1100LST on May 25, 2000.

Moreover, the air temperature observed by auto weather observation network close to this region was verified to be 9 ~ 10 ℃. Therefore, in calculating the HIP by land use, the air temperature of 32℃, which is the average value of 6 observation locations, was used.

Table 1 shows HIP calculated by using the surface temperature estimated by LANDSAT/TM data and the surface air temperatures observed from the automatic urban weather observation system established by Keimyung University. Although the evaluation period was daytime of late spring, it was verified that the HIP of urbanized areas were 10 ℃ higher than green belt, and 5 ℃ higher than water area.

From these results, necessity of securing green belt and watersides in urban development were proposed. Relating to a measurement test and observation study relevant to this research, the urban areas comprising 30% or more green and waterside do not show significantly higher temperatures, compared to suburban areas.

Table 1. HIP calculated by using the surface temperature estimated by LANDSAT/TM data and the surface air temperatures observed from the automatic urban weather observation system established by Keimyung University.

classification	Surface temperature(℃)	HIP(℃)
Water	31	0
Forest area	26	-5
Industrial area	40	9
Commercial Store area	36	5
Residential area	34	3
Agricultural area	26	-5

4. CONCLUSION

The urban development, until now, preferred functionality and efficiency, and the worldwide urban developments established in industrialization era did not consider the city climate. Instead, it was rather turned away, for pleasant indoor atmosphere (excessive discharge of artificial heat from air conditioning).

In this study, change in land use of Daegu for las 40 years is examined, and with remote satellite investigation, the contrasting dispersion of surface temperature according to the land use is quantitatively visualized. With this basis, the transition in Heat Island Potential : HIP from land use change is estimated.

Heat Island Potential is defined as the difference of air and surface temperatures in a given time; it is used as an index to evaluate the effect of surface change to surrounding temperature of the developed land.

1) For the last 40 years, the city (roads and a buildings) increased by 5.5 times. It is the phenomenon that our country where an urbanization speed is the fastest in the whole world is particular to that area of a city increased by an explosion enemy in this way during a short period.

2) Characteristics of land use along HPI distribution appear conspicuously. Characteristic of land availability appears remarkably in HIP's distribution, this depends greatly on difference of conversion ratio by absorption coefficient of sun radiant energy and sensible energy by land availability.

Although the evaluation period was daytime of late spring, it was verified that the HIP of urbanized areas were 11 ℃ higher than green belt, and 8 ℃ higher than farm land.

From these results, necessity of securing green belt and watersides in urban development were proposed. Relating to a measurement test and observation study relevant to this research, the urban areas comprising 30% or more green and waterside do not show significantly higher temperatures, compared to suburban areas.

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