STUDY ON THE SEASONAL CHANGE OF URBAN HEAT ISLAND PHENOMENON USING AIRBORNE THEMAL IMAGE

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1. INTRODUCTION

It is well known and documented that urbanization can have significant effects on local weather and climate. One of these effects is the urban heat island, for which the air temperatures of the central urban locations are several degrees higher than those of nearby rural areas of similar elevation. The urban heat island effect has been the subject of numerous studies in recent decades and is exhibited by many major cities around the world. In order to establish a countermeasure against the urban heat island, it is necessary to understand the feature of the thermal environment, especially, the distribution of air temperature. It is, however, difficult to know the distribution of air temperature for large area through the field measurements. The method to provide the information on the distribution of air temperature for a large area or region would need to be developed for the establishment of sound environmental planning to improve the thermal condition in cities.

The studies using remote sensing data dealt with urban heat island phenomena, although they mainly analyzed not air temperature but surface temperature. The reasons why they didn't deal with air temperature were that TIR data reflected the surface temperature of each object and air temperature varied depending on many elements. On the other hand, it is well stated and reported that the surface temperature of greenery is strongly correlated with the ambient air temperature. Using this feature, there is a possibility to retrieve the distribution of air temperature for large area from surface temperature map. In this study, it was aimed to examine the method to create air temperature map using remote sensing data, to acquire the air temperature map, and to discuss the thermal environment using the map.

In order to understand the thermal environment of the region, however, it is also necessary to understand the land cover distribution because land cover is one of the primary factors determining the thermal condition. Besides, there is frequent change of land cover annually in nearby rural areas owing to the variety of cultivating crops according to a season. The land cover of croplands in the study site, which was water in springtime due to the irrigation, becomes green due to the rice plants grown up. In addition, it was covered with snow in wintertime. Therefore, the distribution of land cover and the annual land cover change were examined to obtain information of a characteristic thermal environment formed in the region, and to discuss the seasonal change of urban heat island phenomenon.

2. REMOTE SENSING DATA

Observation by air-borne multi-spectral scanner (MSS) was performed in order to generate land cover maps and surface temperature maps of the Tonami district, Japan for April and July of 2002, winter of 2006 both in daytime and in nighttime. The two observation altitudes were set at 6,000 m (high), which allowed observation of the entire Tonami plane, and 1,500 m (low), which allowed observation of detailed ground surface information. Spatial resolutions were 8.0m and 0.5m respectively.

Prior to understanding of the land cover distribution, rectification and the land cover classification were done using the airborne MSS and GIS data. First of all, rectification was done by a second-order polynomial transformation using the airborne MSS data, and GIS data drawn on a scale of 1 to 5000. Extracting a small area from rectified MSS data, 6 items of polygon were created for signature, supervised classification was implemented. Considering the land cover change, the land cover maps were generated.

3. SURFACE TEMPERATURE DISTRIBUTION AND AIR TEMPERATURE DISTRIBUTION

Then, land cover maps and surface temperature maps for three seasons were compared and examined. The maps indicated that the surface temperatures of paddy fields scored much lower than air temperature both in daytime and nighttime in summertime. It means that paddy field can be utilized to countermeasure against urban heat island phenomenon. Regarding to the buildings, although the surface temperatures of traditional houses with tiled roofs scored higher than air temperature in daytime in summertime, it scored much lower than air temperature in nighttime. The surface temperatures of RC buildings and road scored much higher than air temperature in both time. This means RC buildings and roads commit to make worse the thermal condition. Next, the surface temperatures of trees were examined. There were little buildings higher than 10 meters in Tonami. If the trees were not surrounded by other objectives, the surface temperatures of treetop during the nighttime would be determined by diffuse sky radiation and Sensible heat flux. Therefore, the surface temperatures of treetop can't score higher than air temperature. Diffuse sky radiation could be considered to be constant in and around the Tonami urbanized area during the observation time. The surface temperature of treetop, therefore, would vary depending on sensible heat flux. Sensible heat flux would be determined by land cover type and wind velocity, and surface temperature and ambient air temperature. As stated, there were little buildings higher than 10m. That means the height of urban canopy would be around 10m. The wind velocity right above urban canopy could be considered to be constant. So, the surface temperatures of treetop in Tonami Plain would reflect the air temperature around each tree. Besides, heat capacity of leaves is quite small. The surface temperature on the trees can be considered to increase close to the ambient air temperature even with low wind velocity. The distribution map of surface temperatures on treetops, therefore, could be considered as a air temperature map. The highest temperatures at the top of trees higher than 15m were extracted and plotted in the map for three seasons, and then compared to each other. The results indicated that the temperatures of treetop in urban district were two to three degrees higher than them of surrounding areas, and the influences of urban heat island phenomenon were observed in the range of 500m from the boundary in leeward in all seasons, although no distinguish difference in surface temperatures between central area and nearby rural area in spring time. This indicated that the urban heat island phenomenon in spring time was generated mainly by other factor such as exhausted anthropogenic heat.

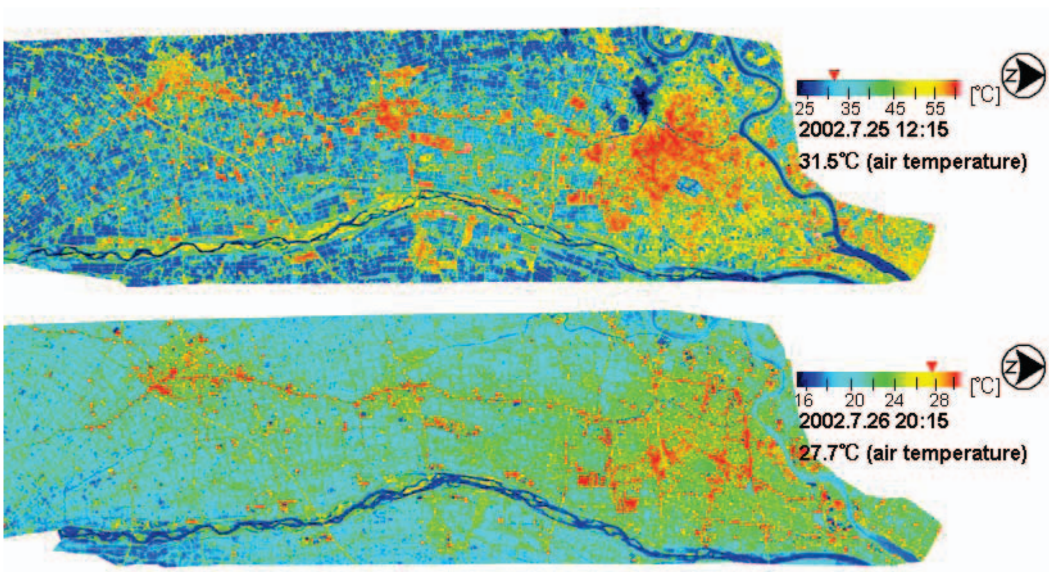

FIG. 1 Examples of surface temperature maps (daytime and nighttime, spatial resolution: 8.0m)

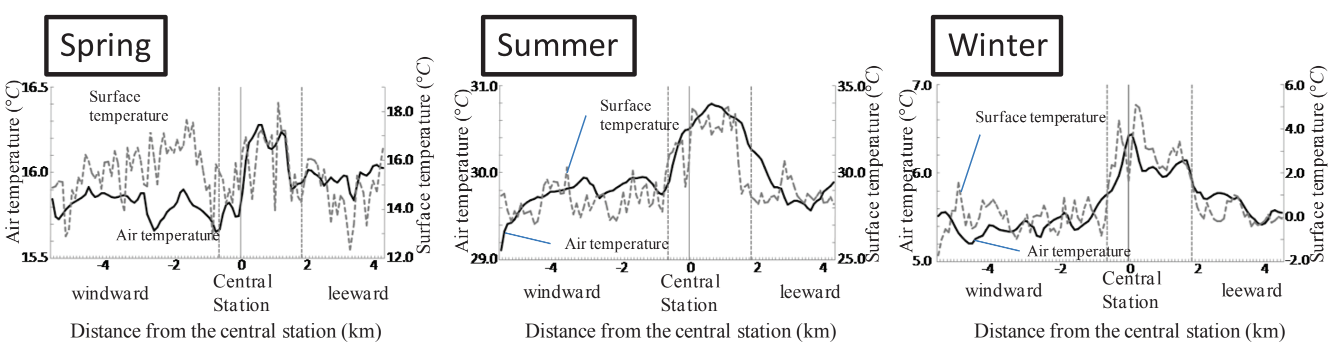

FIG. 2 Change of surface temperature and air temperature, and the distance form the central station