IMPACT OF CORRIDOR STRUCTURE ON URBAN HEAT ISLAND IN BEIJING, CHINA

Mingyi DU , Weixian SUN, Yurong CHEN *

School of Geomatics and Urban Information, Beijing University of Civil Engineering and Architecture, 1# Zhanlanguan Road, Beijing 100044, China

KEY WORDS: Urban, Land Surface Temperature, Thermal Environment, Impact Analysis, Corridor Structure

ABSTRACT:

This paper focuses on examining the impact of corridor structure on urban heat island using the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data. To analyze the impact of the three corridor structures, i.e., road, greenbelt and water body, on surrounding temperatures, some of representative regions of road、greenbelt、water were chosen, and several surrounding regions were also chosen as comparative regions within second ring road. Generally speaking, these corridor structures have different effects on the urban heat island listed as follows. The cooling effect of water body to the urban heat island is the most obvious, greenbelt takes the second place, and then it is the road system whose direction is crucial to the alleviation of the urban heat island. Moreover the impacting range of the three corridor structures is limited, and usually not exceeding 300 meters.

1. NTRODUCTION

With rapid urbanization, urban heat island（UHI）becomes one of the urban environmental issues. UHI effect is due to the temperature difference between urban and its' surrounding suburban rural areas. The primary root of heat island in cities is due to the absorption of solar radiation by buildings, roads, and other subsurface materials during daytime. The absorbed heat is subsequently re-radiated to the surroundings and increases surrounding temperatures at night (Voogt, 2003). Corridor structure is defined as a long-narrow linear or belt patch in landscape ecology, such as road、water. The urban corridor structure is one of the impacting factors for researching urban heat island effect. So this paper focuses on examining the impact of corridor structure on urban heat island.

2. STUDY AREA AND METHODOLOGY

2.1 Study area and data description

Beijing is the capital of China, an international metropolis. It is necessary to preserving a higher demand of urban environment construction during the urbanization of Beijing. However, as the urban areas expanded rapidly, the city's population continues to be growing sharply, buildings becomes higher and dense, traffic accidents gets more frequent and more and more air-conditioning infrastructures are installed, all of which have brought severe influences on the urban environment and human beings. So it is significant for constructing suitable human settlement environment and maintaining capital continuable development to alleviate the UHI effect and improve the entire urban environment (Li et al., 2004). Our study area is the old city of Beijing which is enclosed by the second ring road. It is the center of Beijing which is controlled by severe heat island effect (Song, 2003).

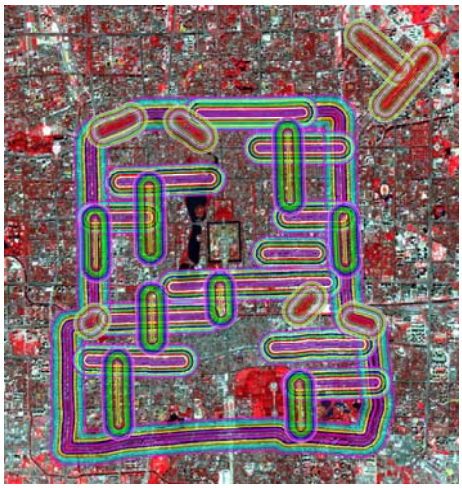
The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) data were collected as the main data source. ASTER data have five thermal infrared（TIR）bands at 90m spatial resolution. The spatial resolution is much higher than the forth、fifth channel of NOAA/AVHRR at 1.1 km and the sixth channel of TM data at 120m. In addition, the thermal infrared channels almost cover the whole thermal infrared bands. The image data acquired by ASTER can be used to estimate surface temperature and to estimate UHI effect (Zhu et al., 2003). The data on June 12, 2004 and June 23, 2005 were collected to do our research and analysis.

2.2 Methodology

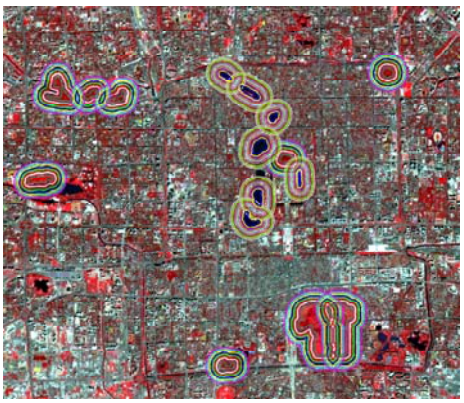
In order to examine the urban heat island, the land surface temperature must be retrived firstly. In this paper, the urban heat island effect was assessed by the land surface temperature difference between the urban area and the suburban rural area. The land surface temperature was obtained using an iterative self-consistent approach (Y. Xue et al., 2005) which is based on the split-window algorithm for all the ASTER thermal infrared bands.

Three urban corridor structures — road system、greenbelt system and water system were used to analyze the UHI effect. Figure 1 shows the location of the selected road system、greenbelt system and water system. To analyze the impact of the three corridor structures on surrounding temperatures, some of representative regions of road、greenbelt、water were chosen, and several surrounding regions were also selected as comparative regions within second ring road. The value of decreasing temperature is defined as the difference between the averaged temperature of every system and the averaged temperature of several comparative regions.

* Corresponding author: cyr6666@163.com.



(a) Location map of the chosen road system



(b) Location map of the chosen greenbelt、water system

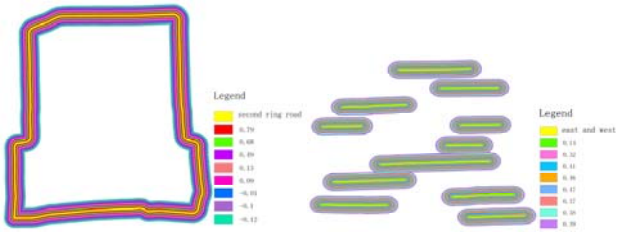
Figure 1 Location map of the selected road system、greenbelt system and water system

3. IMPACT ANALYSIS

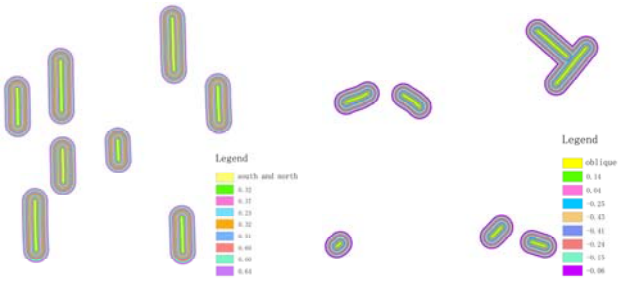
3.1 Road system

In order to study the impact of the road system on heat island, aiming at the characteristics of the roads in Beijing city. Three representative directions—east and west、south and north and oblique direction were selected, and the second ring road was selected separately. All of them were suffered from a buffer zone analysis. Buffer zones at an interval of 50 meters were established for these four different road systems, and there were eight buffer zones in all. All the buffer distances were extended from 50 meters to 400 meters. Figure 2 shows the buffer zone of the four road systems.

It is discovered that the effect of oblique direction road on alleviating UHI effect appeared to be slight, but the other road systems can alleviate the heat island effect to some extent. All of them have a certain obstructing function on the distribution of heat island (Figure 3). This might be caused by the road directions. The second ring road are composed by horizontal and vertical roads, when the direction of monsoon and roads are consistent, heat flow can be evacuated effectively as a result of the function of wind power which has a positive role on improving heat island effect. Moreover, some affiliated greenbelts nearby roads have transpiration and cooling effect (Li et al., 2004; Du et al., 2007). Only from the second ring road, however, we found that the highest decreasing temperature is 0.8℃ which indicates that the alleviate function is weak. And the value of decreasing temperature is less than 0 ℃ in the buffer zone of 250-300m, which means there is no cooling function. From our research, a conclusion can also be drawn that it is limited to hinder the heat island from road system.



(a) the second ring road (b) east and west direction



(c) south and north direction (d) oblique direction

Figure 2 Temperature decrease value of four road systems on surrounding environment on June 12, 2004

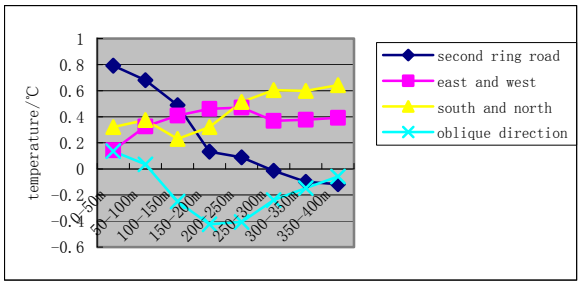


Figure 3 Statistic map of temperature decrease of road system impacting on surrounding environment

3.2 Greenbelt system

In order to study the impact of the greenbelt system on heat island effect, several larger regions covered greenbelt in the range of second ring road as well as nearby regions were chosen. They were also made a buffer zone analysis. The buffer distances are the same as mentioned above. Figure 4 shows the buffer zone of the greenbelt system.

Figure 5 shows that the value of the decreasing temperature is positive, and the highest value is nearly up to 5℃ that is more that five times the value of the road system. It is discovered that the improving effect of greenbelt is obvious on the surrounding distribution of heat island. But the decreasing degree of temperature showed a descending trend. It means that the cooling effect of greenbelt on heat island weakened gradually along with the further distance. The descending trend becomes gently in the buffer zone of 250-300m. From a statistical view, we can think that the improving effect of greenbelt on heat island is also limited which is the same as road system.

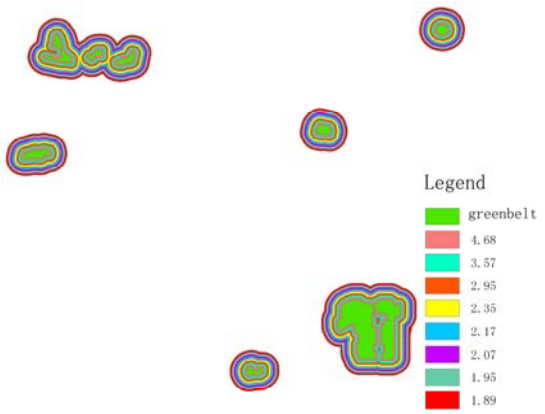


Figure 4 Temperature decrease value of greenbelt system on surrounding environment on June 12, 2004

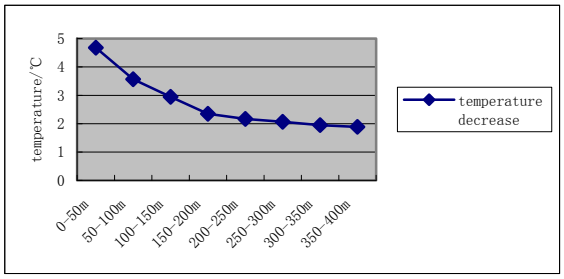


Figure 5 Statistic map of temperature decrease of greenbelt impacting on surrounding environment

3.3 Water system

In order to research the cooling effect of the water system on heat island, certain representative water bodies were chosen to a buffer zone analysis. The buffer distances are also the same as mentioned above (see Figure 6).

It is discovered that the cooling effect of water is extraordinary strong. In terms of the temperature decreasing value, the highest decreasing value of water is almost twice than the highest value of greenbelt, ten times more than the highest value of the road system. But the decreasing degree of temperature also shows a descending trend. It means that the cooling effect of water on heat island is weakened gradually, too. The descending trend becomes gently as well as after the buffer zone is 200-250m, the cooling effect of water is also limited (see Figure 7).

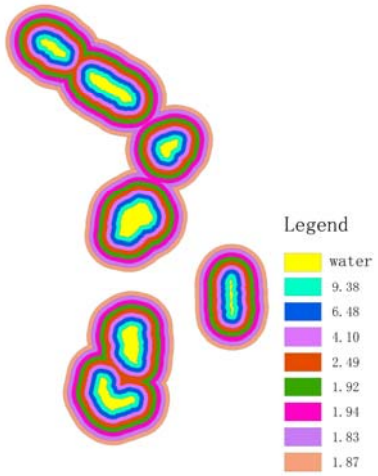


Figure 6 Temperature decrease value of water system on surrounding environment on June 12, 2004

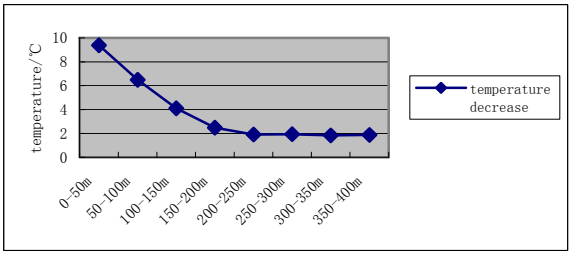


Figure 7 Statistic map of temperature decrease of water impacting on surrounding environment

3.4 Comparative analysis

Figure 8 shows the comparative of the three corridor structures on June 23, 2005. It is seen that the cooling effect of water is the most obvious, the lesser is greenbelt. But the impact effect of greenbelt is not to be neglected, because it is comparatively easy to add greenbelt at a certain range in the city. Greenbelt is not only has a lower costs, but also is accorded with the environmental policy of Beijing city (Li et al., 2004). It is hard to increase definite water surfaces because of limited water resources and higher preserving costs. So it is very important to make the best of the cooling effect of greenbelt on temperature. The least is the road system. This is because the road surface were mostly covered by the material of pitch、concrete and so on. All of which have great thermal capacity. But when the direction of monsoon and roads are consistent, heat flow can be evacuated effectively as a result of the function of wind power which has a positive role on improving heat island effect. Therefore the impact of city wind should be fully considered in road design and construction. The descending trend becomes also gently in the buffer zone of 250-300m. We can think that the impacting ranges of those three corridor structures are limited, and usually not exceeding 300 meters.

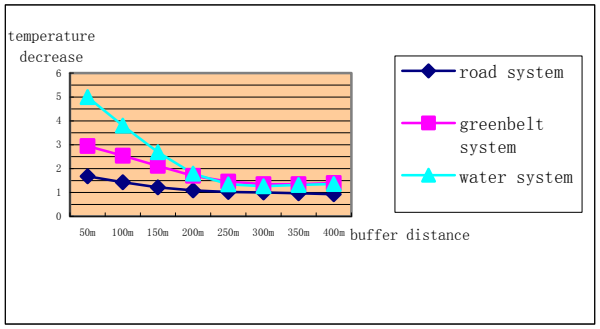


Figure 8 Comparative of the three corridor structures on June 23, 2005

4. CONCLUSIONS

In this study we have analyzed the impact of corridor structures on urban heat island using the ASTER data. Generally speaking, these corridor structures have different effects on the urban heat island as follows. The cooling effect of water is the most obvious, greenbelt takes the second place, and then it is road system whose direction is crucial to the alleviation of the urban heat island. Moreover the impacting range of the three corridor structures is limited, and usually not exceeding 300 meters. These results are benefit for the local government to make some measurements to alleviating thermal environmental problems in the old city of Beijing.

REFERENCES

DU Ming-yi, CHEN Yu-rong, et al., 2007. Influence allure structure on spatial heat environment in Beijing. *Journal of Liaoning Technical University*, 26(2), pp. 194-197.

J.A. Voogt, T.R. Oke, 2003. Thermal remote sensing of urban climates. *Remote Sensing of Environment*,86, pp. 370-384.

LI Yan-ming, ZHANG Ji-he, GU Run-ze, 2004. Research on the Relationship between Urban Greening and the Effect of Urban Heat Island. *China Garden*, 1, pp. 72-75.

Song Y L, Zhang S Y., 2003. The study on heat island effect in Beijing during last 40 years. *Chinese Journal of Eco-Agriculture*, 11(4), pp.126-129.

Y. Xue, Guoyin Cai, et al., 2005. Iterative self-consistent approach for Earth surface temperature determination, *International Journal of Remote Sensing*, 26(1), pp.185-192.

ZHU Li-jiang, QIN Qi-ming, CHEN Si-ji, 2003. The reading of ASTER data from file and the application of ASTER data. *Remote Sensing for Land & Resources*, 56(2), pp. 59-63.