Study on the Influence of Urban Heat Island Effect on Four Seasons Based on Remote Sensing Images

Ting Xu, Huaidong Ma, Wenrui Yao

School of Resources and Civil Engineering, Liaoning Institute of Science and Technology, Benxi 117004, China.

Abstract: Due to the intensification of anthropogenic heat sources such as traffic, industry, commerce and residential areas in the central area of the city, the near-surface temperature in the area rises, making the urban heat island effect more obvious in the city. Using Landsat remote sensing data as the data source and Beijing as the research area, this paper inverts land surface temperature in spring, summer, autumn and winter of Beijing through radiative transfer equation, and compares four seasons temperature data, four seasons temperature distribution and four seasons heat island effect distribution. The results show that the heat island effect is more obvious in summer than in other four seasons, and the heat island effect is mainly concentrated in the second ring road of Beijing. It can be seen from the distribution map of heat island effect in winter that the heat island effect is mainly distributed in the surrounding area of Beijing city. Burning coal for heating in winter causes the temperature in the surrounding area to rise, and the temperature difference between the area and the suburbs is obvious, and the heat island effect is significant.

Keywords: Landsat Remote Sensing Image; Land Use Classification; Heat Island Effect

Introduction

With the acceleration of the urbanization process and the development of urban and rural integration, China's urban population is increasing sharply, and the structural types of urban underlying surfaces have also undergone great changes. So that the atmosphere and the environment between the formation of a new contradiction- urban heat problem. The intensification of urban heat island effect is due to the replacement of natural surface such as vegetation and water by impervious surface, which leads to the increase of surface temperature. As human activities change the temperature of the atmosphere, the ventilation conditions of the city become poor, resulting in the gradual accumulation of heat. The emission of pollutants makes the air quality deteriorate, which poses a serious threat to human health, forms an obvious heat island effect climate, and has a profound impact on the living standards of urban residents. In view of this, the study of urban heat island effect has attracted the attention of most researchers[1]. As one of the key factors to study the urban heat island effect, the research technology and method of surface temperature have been developed from the traditional weather station research method to the remote sensing image research method. Based on the land surface temperature information retrieved from remote sensing images, the distribution characteristics of urban heat island effect and other relevant information can be intuitively seen, which can provide important data support for urban spatial planning.

1. Study area and data source

1.1 Study area

As the capital of China, Beijing is not only the national political and cultural center, but also a world-renowned ancient capital and a modern international city. Beijing is located in the northern part of the North China Great Plain, its geographical coordinates are between 115.7° -117.4 ° E, 39.4° -41.6 ° N, and its center is located at 39°54 '20 "N, 116°25' 29" E. The terrain is high in the northwest and low in the southeast, surrounded by mountains on three sides in the west, north and northeast, while the southeast shows a gradually sloping plain toward the Bohai Sea. This region is a typical warm zone semi-humid continental monsoon climate, with hot and rainy summer and cold and dry winter, while spring and autumn are short and rapid, with four distinct seasons and the same season of rain and heat[2].

1.2 Data source

The data in this paper are derived from Landsat-8 satellite images in the Geospatial Data cloud (http:// www.gscloud.cn). Landsat-8 carries sensors such as the Land Imager OLI and the thermal infrared sensor TIRS.

2. Experimental results and analysis

2.1 Image preprocessing

Remote sensing data preprocessing mainly includes two aspects, namely remote sensing image geometry processing and remote sensing image radiation processing. The geometric processing of remote sensing image is mainly to deal with the geometric deformation of remote sensing image caused by the sensor imaging mode, the sensor external azimuth element change, atmospheric refraction and other related factors. The data downloaded in this paper are processed by remote sensing image geometry, so there is no need to do remote sensing geometry processing. Image preprocessing includes radiometric calibration, atmospheric correction, image Mosaic, image clipping and so on.

Figure 1 Study area

2.2 land surface temperature retrieval

2.2.1 Calculation of normalized vegetation index

Normalized Vegetation Index (NDVI) is used to detect vegetation growth state, vegetation coverage and eliminate some radiation errors. NDVI can reflect the background effects of plant canopy, such as soil, wet ground, snow, dead leaves, roughness, etc., and is related to vegetation cover. The calculation formula is as follows[3] :

$$NDVI = \frac{NIR - R}{NIR + R} \quad (1)$$

In the formula, NIR represents the reflection value of the near infrared band, and R represents the reflection value of the infrared band. The value range of NDVI is (-1-1). The larger the NDVI value, the denser the vegetation cover.

2.2.2 Vegetation coverage

Vegetation coverage is the ratio of the vertical projected area of vegetation on the ground to the total area of the study area. It reflects the photosynthetic vegetation area and vegetation density. When calculating the vegetation coverage, the land types of the whole image should be roughly divided into water bodies, vegetation and buildings according to the calculated NDVI value in advance. The formula is as follows:

$$FV=(NDVI-NDVIS)/(NDVIV-NDVIS) \quad (2)$$

NDVI- normalized differential vegetation index;NDVIV-0.474510；NDVIS-0

2.2.3 Specific surface emissivity

Surface specific emissivity, also known as emissivity, refers to the ratio of the radiation emitted by the surface to the radiation emitted by the blackbody at the same temperature, and is related to the composition of the surface, surface roughness, wavelength and other factors.

In this paper, the specific emissivity of water pixels is specified as 0.995, and the estimated specific emissivity of natural surface and urban pixels is calculated according to the following formula:

$$\varepsilon building = 0.9625 + 0.0614FV - 0.0461FV2 \quad (3)$$

$$\varepsilon building = 0.9589 + 0.086FV - 0.0671FV2 \quad (4)$$

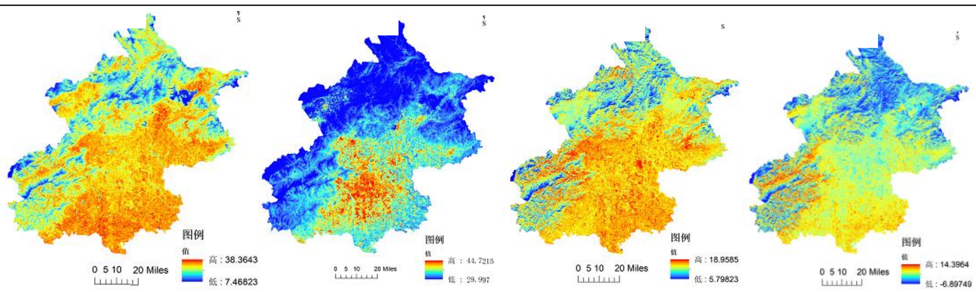
εsurface- specific emissivity of natural pixel, εbuilding- specific emissivity of urban pixel.

2.2.4 Land surface temperature retrieval

Radiative Transfer Equation (RTE), also known as atmospheric correction method, is a method used in this paper to invert surface temperature. This method is simple to operate and easy to implement, and has no excessive requirements on the thermal infrared band. It is only necessary to obtain the atmospheric upgoing radiation value, atmospheric downgoing radiation value, atmospheric transmittance, and surface specific emissivity to invert the surface temperature. Surface temperature is a necessary factor for the study of heat island effect, and it can be clearly seen from the spatial distribution of surface temperature inversion results in Beijing that there is an obvious urban heat island effect in Beijing. The data in this paper take the distribution of the heat island effect in four seasons, which are divided into spring, summer, demand, winter and four seasons, and the inversion temperature is shown in the table below.

Table 1 Summary of temperature inversion results for the four seasons (unit: ℃)

Imaging time	Max	Min	Mean	Standard deviatio
2018、4、8	38.36	7.47	22.04	4.64
2017、7、10	44.72	29.99	34.00	3.80
2017、10、30	18.96	5.80	14.24	2.79
2017、12、17	14.40	-6.97	2.64	2.96



a. spring b. summer c. autumn d. winter

Figure 2. Surface temperature in four seasons

3. Conclusion

This article takes Beijing as the research area and extracts surface temperature information through radiation transfer equations to obtain remote sensing image data of the four adjacent seasons of spring, summer, autumn, and winter in Beijing. It can be concluded that summer has the highest temperature, and the heat island effect in summer is more pronounced than the other four seasons. The heat island effect is mainly concentrated in the urban area of Beijing; From the distribution map of the heat island effect in winter, it can be seen that the heat island effect is mainly distributed in the surrounding areas of Beijing city. Burning coal for heating in winter leads to an increase in temperature in the surrounding areas of the city, with a significant temperature difference from the suburbs. The heat island effect is significant, indicating that human daily life and production are the key causes of the heat island effect.

References

[1] Mu S. Analysis of Urumqi heat island effect based on Landsat8 remote sensing image [J]. Computer Knowledge and Technology, 2020,(34):230-232.

[2] Zhang Y. Spatial and temporal distribution of NO_2 in the Beijing-Tianjin-Hebei region from 2009 to 2016 [D]. Taiyuan: Shanxi University, 2018.

[3] Long X, Li J, Liu QH. Remote Sensing Technology and Application[J]. 2013,(6) : 969-977.

Fund Project: Basic Scientific Research Project (Youth Project) of the Department of Education of Liaoning Province, "Key Technology Research on the characteristics of Temporal and Spatial changes of Urban Heat Island Effect" (LJKQZ20222333).

About author: Xu Ting (1988 -), female, master, lecturer. Research direction: Engaged in digital mapping, remote sensing monitoring teaching and research work.