

Based on Landsat8 Analysis of Urban Heat Island Effect in Mianyang City District

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Abstract: The accelerated urbanization process has formed heat islands in urban areas, resulting in the heat island effect, which brings about increased pollution, reduced visibility and other adverse effects, seriously affecting people's production and life. In this paper, we use Landsat8 remote sensing image data from 2013 to 2018 to analyze the heat island situation in the urbanization process, taking Mianyang city as an example. The results show that: the very strong heat island area in Mianyang city area is concentrated in the city center, and the weak heat island area changes to the strong heat island area; the non-heat island area is concentrated in the places with high vegetation cover or water bodies, and the very strong heat island is concentrated in the densely populated places and around the Fuling River; the overall heat island effect in Mianyang city area shows an increasing trend, and the intensity of heat island has a decreasing trend until 2018.

Keywords: Heat island effect; temperature inversion; Mianyang Municipal District.

1. Introduction

The heat island effect refers to an area that Temperature higher than the surrounding areas [1]. In recent years, the rapid development of urbanization and the gradual implementation of urban-rural integration have accelerated the process of urbanization, and the population has gradually gathered in the urban areas, which, along with the increase of impervious surfaces and the rapid growth of the population, has led to the formation of "heat islands" in the urban areas. Mianyang city in Sichuan province is the only science and technology city in China, along with the slogan of "Chengde homogenization and DeMian integrated development", Mianyang city has accelerated the urbanization process, the population concentration, the heat exhaust of urban vehicles, heavy industry and chemical plants industrial energy release have far-reaching impacts on the entire development of Mianyang city and its ecological environment, so that the heat island effect is increasingly prominent. The problem of heat island effect is becoming more and more prominent. In order to analyze the heat island effect caused by urbanization in Mianyang City, we investigate the heat island situation in Mianyang City in recent years, which will contribute to the improvement of the heat island situation in Mianyang City.

The heat island effect was firstly proposed by foreign scholars, and its development was earlier than that in China [2]. Domestic research on the heat island effect began in the late 20th century, and at first it was mainly focused on the observation and analysis of the heat island effect in large cities [3]. The distribution and change characteristics of urban heat islands were obtained by analyzing and simulating the temperature data of ground observation points in time and space [4]. With the wide application of remote sensing images, many scholars have made use of remote sensing images to study them. The thermal infrared remote sensing data are used to study the formation of heat island effect and the impact of heat island effect on the atmospheric environment, etc. [5]. landsat8 satellite contains OLI land imager, TIRS thermal infrared sensor [6], and at the same time, thermal infrared wavelength band has been increased to two, and the

temperature accuracy of surface temperature inversion can reach to be similar to that of standard surface temperature in MODIS with the root-mean-square error of the temperature being less than 2K [7]. The temperature accuracy of the surface temperature inversion can be similar to that of the MODIS standard surface temperature [7] within 2K of the root mean square error of the temperature.

Therefore, this paper takes Mianyang City as an example and uses landsat8 satellite data to carry out temperature inversion and then analyzes the heat island situation of the city, and the results obtained will have a positive effect on the improvement of the heat island situation of the city and other areas.

2. Overview of the Study Area

Mianyang City is located between latitude 30°42'~33°03' north and longitude 103°45'~105°43' east, enjoying the name of "China's only science and technology city", and is the second largest economic city in Sichuan. Mianyang City is located in The Fulcrum River Upper middle class, located in Sichuan Bas in Northwest. It belongs to the northern subtropical mountainous and humid monsoon climate zone, with pleasant temperature and climate, suitable for living, and rapid economic development. The city district is located at the central part of Mianyang, with dozens of universities and science and technology cities, densely populated, and is the main urban area for Mianyang's economic, educational, transportation, and industrial development.

3. Data and Methods

3.1. Data sources and processing

In this paper, the Landsat 8 OLI_TIRS data from 2013 to 2018 are mainly used, and the data source and adoption are from the geospatial data cloud. According to the need, it is pre-processed accordingly, including radiometric calibration, atmospheric correction, fusion, cropping and so on.

3.2. Research methodology

In this paper, the surface temperature inversion calculation

was performed using Landsat8 satellite data with the atmospheric correction method, and the heat island effect [8] was quantitatively analyzed using the thermal field variability index (TFVI).

(1) Temperature inversion

Basic principle: Based on the influence of the atmosphere on surface thermal radiation, the intensity of surface thermal radiation is obtained by subtracting the total amount of atmospherically influenced thermal radiation from the satellite sensors and converting it into the corresponding surface temperature [9].

① NDVI calculation

$$NDVI = (NIR - R) / (NIR + R) \quad (\text{Equation 1})$$

Where NIR stands for near-infrared band and R stands for

Radiative Transfer Equation.

$$L\lambda = [\varepsilon B(TS) + (1 - \varepsilon) L\tau + L\uparrow] \quad (\text{Equation 4})$$

Radiant Brightness Equation.

$$B(TS) = [L\lambda - L\uparrow - \tau(1 - \varepsilon) L\downarrow] / \tau\varepsilon \quad (\text{Equation 5})$$

ε represents the surface specific emissivity, TS is the true surface temperature (K), B(TS) is the blackbody thermal radiance brightness, and τ refers to the atmospheric transmittance in the thermal infrared band [11].

(2) Heat island effect monitoring

TFVI is defined as the ratio of the difference between the LST at a point and the average LST in the study area to the average LST in the study area [8], calculated as follows:

$$TFVI = (T - TMEAN) / TMEAN \quad (\text{Equation 6})$$

where TFVI is the urban thermal field variability index; T is the LST at a point in the city, and TMEAN is the average LST in the urban study area.

4. Results and Analysis

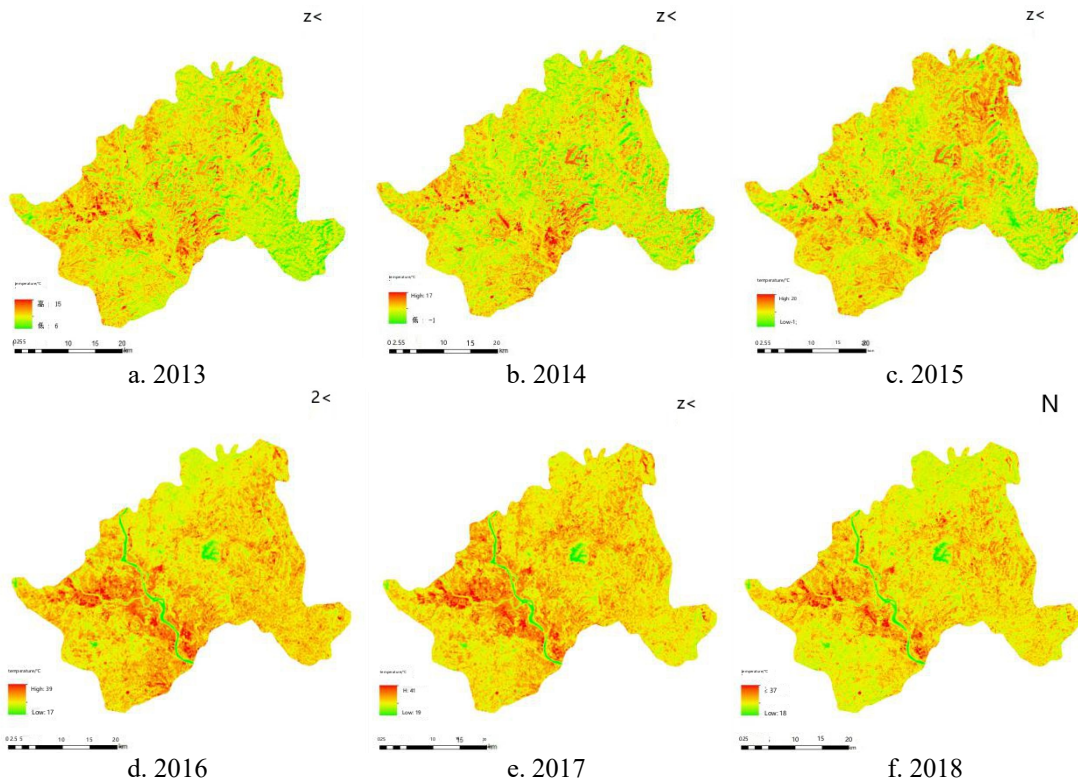


Figure 1. Temperature inversion for Mianyang city district

The temperature inversion of the six-year image of Mianyang city area is shown in Fig. 1. The high-temperature areas are mainly concentrated in the northwest and southeast directions and distributed along the Fuling River, which is roughly the same as the distribution of the urban area of the city district. This shows that heat islands were formed during

the development of the city.

According to the calculation of TFVI (urban thermal field variability index), the larger the heat island proportion index, the more occupied area and the greatest degree of heat island effect. In the article, the calculated TFVI heat island classification is divided into five levels [9], non-heat island

(TFVI<0), very weak heat island (0<TFVI<0.3), weak heat island (0.3<TFVI<0.6), strong heat island (0.6<TFVI<1), and

very strong heat island (TFVI>1).

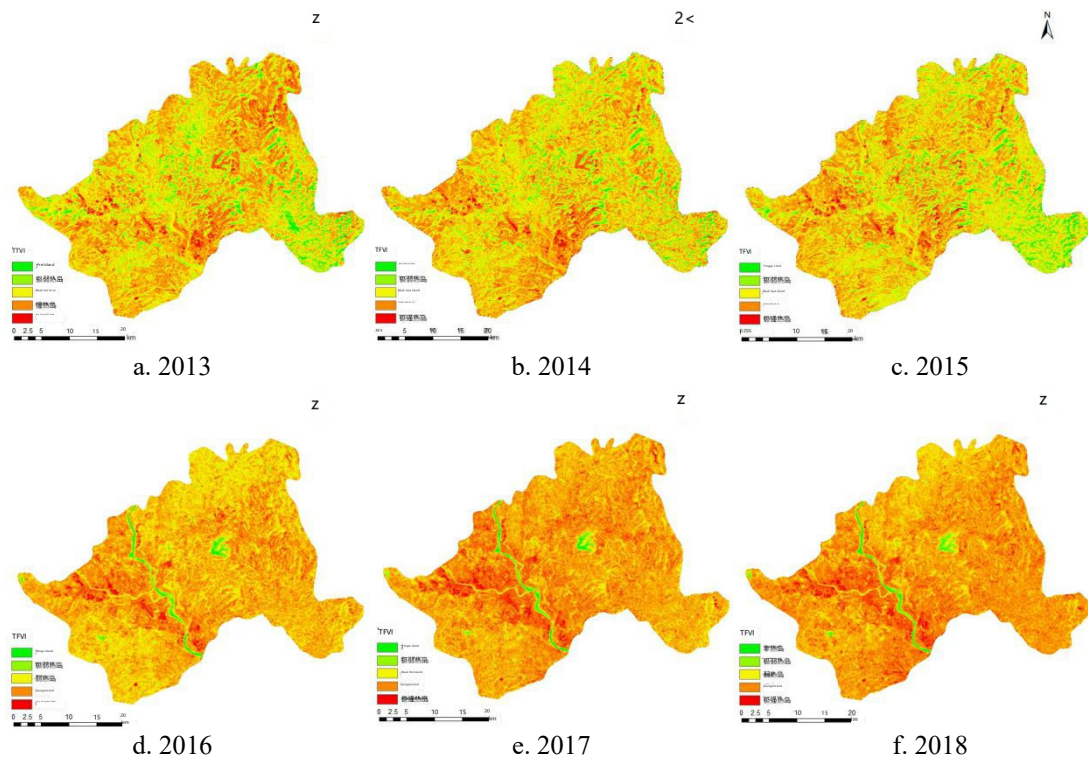


Figure 2. TFVI index map of Mianyang Municipal Jurisdiction

As shown in Figure 2, in 2013, the non-heat islands are mainly distributed in the east, and the very strong heat islands are less, mainly distributed in the center of the municipal district; in 2014, the non-heat island area decreases, and the weak heat island area begins to appear in the east; in 2015, the very strong heat islands appear in the northeast, and the other areas are the same as in the previous two years; in 2016, the very strong heat islands are mainly distributed in the two sides of the river, and the strong heat islands are mainly located in the south and the north and in the northeast, and the weak heat islands rarely appear in the north; in 2017, the strong heat island area remains the same, and the weak heat islands in the north disappear, and the strong heat islands predominate in the whole city district; in 2018, the strong heat islands and weak heat islands predominate. The strong heat island area remained in 2017, the weak heat island disappeared in the northern part of the city district, and the strong heat island dominated the whole city district; in 2018, the strong heat island and weak heat island dominated the city district, with the weak heat island in the north and southwest, the strong heat island in the east, and the very strong heat island dispersed in the city center; the extremely weak heat island decreased, the strong heat island and the proportion increased, and the extremely strong heat island had the upward trend of the response from 2013 to 2015. From 2016 to 2018, strong heat islands and very strong heat islands dominate, and the trend is obvious, very strong heat islands are mainly concentrated in the center of the city and near commercial, residential and other built-up areas, and there is a tendency of spreading around, and very strong heat islands and strong heat islands decrease in 2018.

5. Conclusion

This paper analyzes the heat island effect in the Mianyang Municipal District based on landsat8 satellite data, through temperature inversion, and by applying the urban heat field variability index, and the following conclusions are obtained.

(1) Non-heat island areas are concentrated in areas with high vegetation cover, or where there are bodies of water, and are mainly dispersed in the eastern part of the municipal districts, and the extent of the distribution of non-heat island areas has decreased from 2013 to 2018.

(2) Extremely strong heat island is concentrated in densely populated places and around the Fuling River, the heat island effect to a large extent with the urban population or industrialization began to increase dramatically, the heat island effect began to strengthen.

(3) The dispersion of strong and very strong heat islands in the western part of the Municipal District is significantly higher than in the eastern part, indicating that the population is mainly concentrated in the western part of the Municipal District and that the western part of the Municipal District is developing at a faster rate than the eastern part of the Municipal District.

(4) The heat island effect of Mianyang city area as a whole showed an increasing trend, and the heat island intensity had a decreasing trend until 2018. This may be related to the environmental protection policies in recent years.

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