The Urban Heat Island Analysis of Changsha-zhuzhou-xiangtan Urban Agglomeration Aased on Modis Data

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Abstract: Using a spatial resolution of MODIS land 1000m standard products ,we can get the Land Surface Temperature.Researching for the Land Surface Temperature including spatial and temporal distribution characteristics influence factors.The results show that Spring,Summer and Autumn temperatures mainly concentrated in the central region,Winter temperature mainly concentrated in the South region.From 2001 to 2015,the maximum temperature difference is summer daytime and the difference is 17.58℃,the minimum temperature difference is autumn daytime and the difference is 11.3℃.According to the thermal field intensity distribution,compared 2005 with 2015,Urban Heat Island intensity gradually increased in 2015,the high temperature area increased and distributed more concentrated,and diffusion weakened from the city to the surrounding,the urban heat field is higher than the thermal field.That index by calculating the thermal landscape,account for a dominant position in the middle of heat distribution,and all types index in 2015 are higher than in 2005.

1 Introduction

With the intensification of urbanization and industrialization, the area and scope of urban construction land is expanding, which makes the city have a phenomenon that the urban temperature is higher than the suburban temperature，called the “heat island effect”, it is affected by the urban landscape type and the impact of urban spatial patterns[1-4].

2 Research methods

2.1 Data collection

The MODIS data used was downloaded from the LAADS Web [5].The data of the four seasons of 2001, 2005, 2010 and 2015 were selected to analyze the seasonal and interannual variations of urban surface temperature in the Changsha, Zhuzhou and Xiangtan areas in the past 15 years, and the distribution of urban island heat island characteristics was obtained.

2.2 Data preprocessing

After obtaining the remote sensing image, it is first subjected to radiation calibration, atmospheric correction and other pretreatment;Then, the monthly maximum, seasonal average, and annual average data are synthesized for the surface temperature data, and the composite results are shown in Fig.1.

MODIS’s conversion formula is [6]:

$$MPVC = [(MPVK * 0.02) - 273] \quad (1)$$

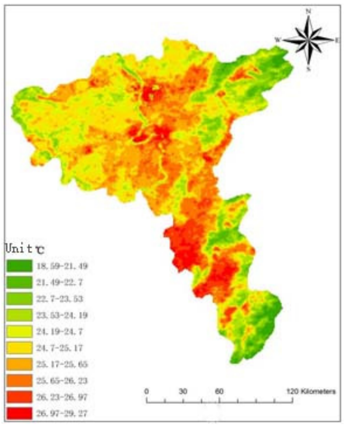

Fig. 1. Four-year average temperature in 2001, 2005, 2010, and 2015.

3 Results and analysis

3.1 Analysis of temporal and spatial variation of surface temperature

3.1.1 Seasonal variation analysis of surface temperature

Based on the average of daytime temperature calculations for each season in 2001, 2005, 2010, and 2015, the seasonal average of the corresponding four years, and the seasonal average and range of values for the four seasons are obtained, as shown in Table 1.

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Table 1. Seasonal mean and range of values.

season	Daytime average(℃)	Temperature range(℃)
Spring	25.29	19.37-31.68
Summer	28.45	21.06-38.64
Autumn	24.62	18.72-30.02
Winter	12.66	6.26-20.1

Fig. 2 calculates the anomalies for each season based on the daytime average of each season, and the difference results can reflect the difference in surface temperature in the same season in different years.

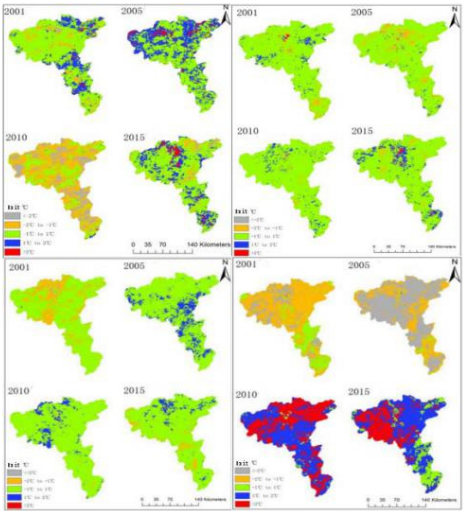

Fig. 2. Four-year spring, summer, autumn, winter difference.

3.1.2 Analysis of interannual variation of surface temperature

Table 2 shows the statistically obtained four-year interannual average temperature data and four-day average surface temperature information.

Table 2.Four-year average temperature.

Year (℃)	Daytime average	Maximum	Minimum	Standard deviation
2001	24.429	28.843	18.078	1.243
2005	24.609	29.452	18.243	1.211
2010	25.078	29.478	15.737	1.214
2015	25.365	30.388	18.38	1.368
AVG	24.870	29.2692	18.5904	1.199

In order to obtain the variation of the surface temperature between years, the difference calculation is compared, and the result is shown in Fig. 3.

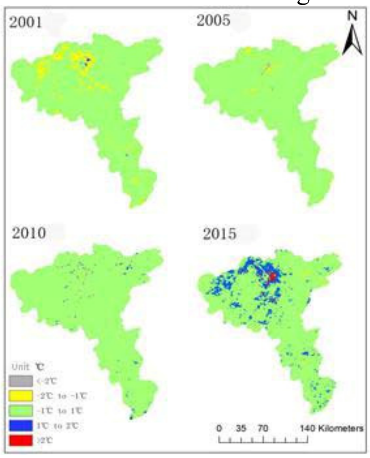

Fig. 3. Four-year average annual difference.

Table 3. Four-year average annual difference.

Year	Decrease<-2℃	Decrease-2℃ to -1℃	Change -1℃ to 1℃	Increase 1℃ to 2℃	Increase>2℃
2001	27(0.09)	2214(6.83)	30130(92.94)	34(0.1)	14(0.04)
2005	55(0.17)	365(1.13)	31989(98.67)	10(0.03)	0
2010	43(0.13)	60(0.19)	32059(98.89)	256(0.79)	1
2015	5(0.01)	223(0.69)	28522(87.98)	3449(10.64)	220(0.68)

3.1.3 Thermal field strength analysis

Heat island intensity is one of the important indicators for heat island effect assessment[7].In order to improve the comparability of remote sensing images,the temperature image maps of 2001, 2005, 2010, and 2015 were normalized, and the normalized formula was[8]:

$$Ni = \frac{Ti - T\min}{T\max - T\min} \qquad (2)$$

Density segmentation of normalized results.The classification results are shown in Fig. 4.

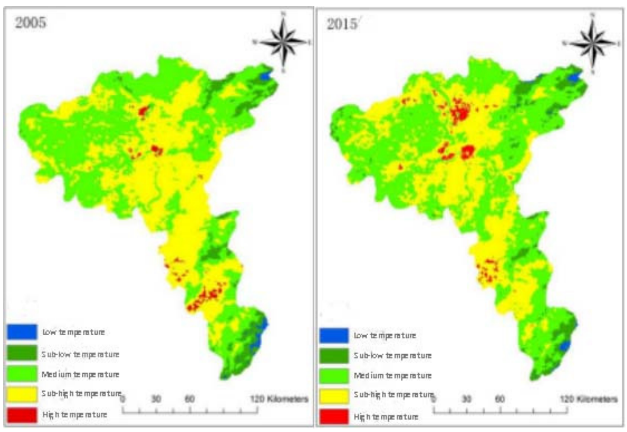

Fig. 4.2005 and 2015 thermal field classification map.

3.1.4 Thermal landscape pattern analysis

Common characterization methods for landscape pattern characteristics include landscape pattern index and spatial statistical methods [9-10]. Select the following landscape index to quantify the characteristics.

$$CA = \sum_{j=1}^{n} a_{ij} \times \frac{1}{10000} \quad (3)$$

$$PD = \frac{n_i}{A} \times 10000 \times 100 \quad (4)$$

$$PLAND = \sum_{j=1}^{n} a_{ij} / A \ (100) \quad (5)$$

$$AI = \left[\frac{g_{ii}}{\max g_{ii}} \right] \times 100 \quad (6)$$

$$LPI = \frac{\max_{j=1}^{n}(a_{ij})}{A} \times 100 \quad (7)$$

$$SHDI = -\sum_{i=1}^{m} p_i * In(p_i) \quad (8)$$

$$SHEI = \frac{-\sum_{i=1}^{m} p_i * In(p_i)}{Inm} \quad (9)$$

Table 4. Dynamic change of plaque type level index

TYPE	Year	CA	PD	PLAND	AI	LPI
Low temperature zone	2005	19147.5358	0.0005	0.6879	73.5577	0.4226
	2015	16571.6341	0.0006	0.5953	71.7877	0.2190
Sub-low temperature zone	2005	175075.4503	0.0022	6.2895	78.7810	2.3690
	2015	167862.9256	0.0030	6.0299	75.4253	0.2190
Medium temperature zone	2005	1308042.8690	0.0038	46.9910	87.9488	25.8398
	2015	1442161.4827	0.0051	51.8043	87.5855	17.0625
Sub-high temperature zone	2005	1247423.3163	0.0042	44.8132	89.0262	38.1196
	2015	1102485.9156	0.0052	39.6027	85.8366	24.8473
High temperature zone	2005	33916.0387	0.0013	1.2184	62.8000	0.2622
	2015	54780.8422	0.0018	1.9678	66.3673	0.5768

Table 5. Dynamic change of landscape level index.

Year	LPI	SHDI	SHEI
2005	38.1196	0.9765	0.6067
2015	24.8473	0.9847	0.6118

4 Conclusion and discussion

Through the research in this paper, we can draw the following conclusions:

According to the four-year average temperature map of the study area, the thermal field intensity in spring, summer and autumn is weakened from the center of the city to the periphery, and the trend from the north to the south is weakened and then weakened. The winter high temperature area is mainly concentrated in the central and southern regions. The thermal field strength is the strongest.

Foundation items

1.Development and Application of Intelligent Security Early Warning System for Visitors in Smart Scenic Areas and Time-Space Virtual Reconstruction Technology.Item Number: 20170220

2. Research on Intelligent Indoor Positioning Method Based on WIFI and Its Application.Item Number: 2018-B-02

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