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Urban Nighttime Heat Island Effect Monitoring Based on DMSP/OLS and MODIS Data

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ABSTRACT

The urban heat island effect has become a hot issue of current scientific research, Anhui Province is in the eastern zone of China, since the reform and opening up, in the city of the building area of the non-stop expansion at the same time, the heat island effect of the city of Anhui Province is becoming more and more obvious, so quantitative research on the response relationship between nighttime lighting intensity and the city's nighttime temperature, to rationally plan the construction of the city to further alleviate and control the urban heat island to provide a scientific basis. In this paper, we use MOD11A1 data from MODIS data covering Anhui Province in 2013 to calculate the nighttime surface temperature, and since the value of NDBI is larger as it goes to the city center, we use this characteristic to construct the nighttime lighting index (NLI) based on NDBI, and then we extract the built-up areas of 16 cities in Anhui Province, and the accuracy of the extractions are all above 90%. The nighttime lighting index and the nighttime surface temperature of the built-up areas of each city were analyzed to establish a regression equation, and the nighttime surface temperature of the built-up areas of each city was obtained by inversion through the regression equation, and finally the nighttime heat island index NHII was calculated. The results show that the nighttime heat island level of the cities in the north of Anhui Province is generally higher than that in the south of Anhui Province, and that of the cities in the middle of Anhui Province is higher than that of the surrounding cities.

KEYWORDS

DMSP/OLS; Modis; Nighttime heat island effect; NHII

1. INTRODUCTION

High-temperature urban areas surrounded by low-temperature suburbs, like islands in the ocean, people call this phenomenon Urban Heat Island Effect (Urban Heat Island Effect) [1, 2], even at night there will be the phenomenon of heat island effect exists, and some scholars have found that the heat island effect is more pronounced at night than in the daytime, and the harm is even greater [3], the heat island effect at night will cause sulfur oxides, NOx and other atmospheric pollutants in the center of the heat island area aggregation, has a great harm to human health, greatly affecting the life and production of human society, so to deal with the urban heat island effect at night should not be delayed. Through the study of urban thermal environment and its influencing factors, through the study of urban thermal environment and its influencing factors, it is conducive to the sustainable development of the city and the improvement of the quality of human living environment.

This paper is based on DMSP/OLS nighttime light data and MOD11A1 data to quantitatively study the response relationship between nighttime light intensity and urban nighttime temperature, to monitor the urban nighttime heat island effect by means of remote sensing, to sound the alarm for the

heat island cities, to change their irrational urbanization and development methods, and to find the ways to mitigate and solve the urban nighttime heat island response. We will also find ways to mitigate and solve the urban nighttime heat island response, in order to further explore the causes and distribution patterns of the nighttime heat island effect, and to serve the urban management and macro decision-making.

2. STUDY AREA AND DATA SOURCES

2.1. Overview of the Study Area

Anhui, abbreviated as "Anhui", with Hefei as its capital, is located in the eastern part of China, belonging to the East China region, between longitude 114°54′-119°37′, latitude 29°41′-34°38′, in the hinterland of the Yangtze River delta, centered in the east, It is located in the hinterland of the Yangtze River Delta, with a central location in the east, along the river and through the sea, bordered by Jiangsu and Zhejiang in the east, Hubei and Henan in the west, Jiangxi in the south, and Shandong in the north, with an east-west width of 450 kilometers, and a north-south length of 570 kilometers, and contains a total of 16 prefectural-level cities, such as Hefei, Huaibei, Bengbu, Huainan, Lu'an, Ma'anshan, Anqing, Chizhou, and Huangshan, and so on.

2.2. Data Sources and Pre-Processing

The research data in this paper include (i) 2013 DMSP/OLS stable nighttime light data from the National Geographic Data Center (NGDC) under the U.S. National Oceanic and Atmospheric Administration (NOAA) (http://ngdc.noaa.gov/eog/dmsp/download.html), with a spatial resolution of 1km and a DN between 0 and 63; (ii) MOD11A1 data dated July 23, 2013, containing the LST_Night product, from the MODIS Advanced Land Product download at https://lpdaac.usgs.gov/data_access/data_pool; (iii) MOD09A1 data dated July 20, 2013, containing the eight-day reflectance synthesis product, from the download address of MODIS Advanced Terrestrial Product: https://lpdaac.usgs.gov/data_access/data_pool; (iv) 2013 vector data of administrative divisions of cities in Anhui Province, from the Geospatial Data Cloud website http://www.gscloud.cn; (v) Statistical data of built-up area of each city in Anhui Province in 2013, from the 2014 Statistical Yearbook of Anhui Province.

3. RESEARCH METHODS

3.1. Construction of the NDBI-based Nighttime Lighting Index

DMSP/OLS nighttime lighting data light saturation problem has a significant inhibitory effect on the DN value of the city center area [4], some scholars [5] proposed the desaturation method based on NDVI to get the desired effect, which uses the more to the city center of the NDVI value of the characteristics of the smaller put forward an operationally simple and effective desaturation method, and this paper uses the NDBI the more to the center of the city of the value of its greater This paper utilizes the characteristics of NDBI that the value of NDBI increases as it moves towards the city center, and constructs a night light index (NLI) based on NDBI so as to achieve the desaturation effect, which is calculated by the formula:

$$NDBI = \frac{\rho_{SWIR} - \rho_{NIR}}{\rho_{SWIR} + \rho_{NIR}} \tag{1}$$

$$NLI = (1 + NDBI) \times DN \tag{2}$$

where NDBI is the normalized building land index [6], ρ_{SWIR}, ρ_{NIR} Short-wave infrared and near-infrared reflectance, corresponding to the spectral reflectance of the 6th and 2nd bands of MOD09A1, respectively, representing the DN value of the original night light.

The results of the nighttime lighting index NLI are obtained as shown in Fig. 1, which not only achieves the effect of light desaturation, but also effectively suppresses the lighting values of water bodies, vegetation and other areas, increases the difference between urban and non-urban areas, and brings about an increase in the accuracy of the built-up area extraction afterwards.

Figure 1. Anhui NLI

3.2. Calculation of Nighttime Heat Island Index

Through the regression equation of night lighting and night temperature, the night surface temperature of built-up areas in each city is obtained inversely, and the average night surface temperature of each city is used as a measure to calculate the urban night heat island index (Night Heat Island Index) (Table 3), which is based on the following: (i) When the average night surface temperature is greater than or equal to 35℃, the NHII is 1; (ii) When the average night surface temperature is less than or equal to 15℃, the NHII is 0; (iii) When the average night surface temperature is between 15~35℃, the NHII is between 0 and 1, and the formula is as follows When the average night surface temperature is less than or equal to 15℃, the NHII is 0; (iv) When the average night surface temperature is between 15~35℃, the NHII is between 0 and 1, and the calculation formula is as follows:

$$NHII = \frac{LST_{Night} - 15}{35 - 15} \tag{3}$$

Where LST_{Night} indicates the average nighttime surface temperature in the city.

In order to further reflect the disparity between cities, the nighttime heat island index was normalized with the following normalization equation.

$$NHII' = \frac{NHII - NHII_{\max}}{NHII_{\max} - NHII_{\min}} \tag{4}$$

Where $NHII_{\max}$, $NHII_{\min}$ denote the maximum and minimum values of the heat island index, respectively.

After normalizing the nighttime heat island index for each city, it was divided into five classes according to its magnitude (Fig. 2): the first class (0.8~1), the second class (0.6~0.8), the third class (0.4~0.6), the fourth class (0.2~0.4), and the fifth class (0~0.2).

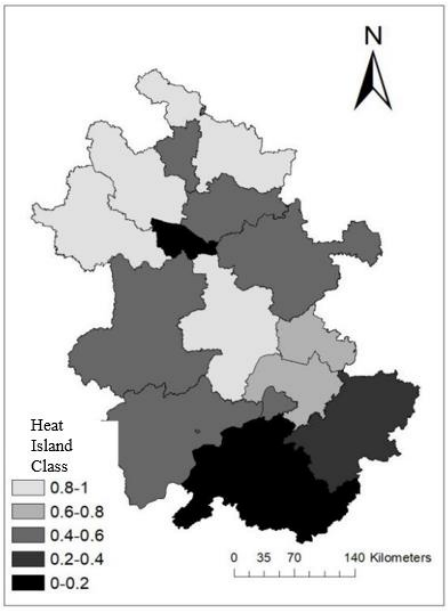

Figure 2. Distribution of nighttime heat island classes in Anhui Province

4. CONCLUSION

In this paper, the nighttime lighting index was constructed based on NDBI data, and the nighttime heat island effect rating of cities was evaluated by constructing the relationship between the nighttime lighting index and the nighttime surface temperature. It was found that the nighttime heat island grades of the cities in the north of Anhui Province were generally higher than those in the south, and the nighttime heat island grades of the cities in the center of Anhui Province were higher than those in the surrounding cities. Through the analysis, this is related to the geographical and geomorphological environment of Anhui Province as well as the urbanization development of Anhui Province.

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