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# The influence of vegetation cover change on the land surface temperature in the central Guizhou urban agglomeration from 2000 to 2019

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**Abstract:** We used land surface temperature (LST) and normalized difference vegetation index (NDVI) data from 2000 to 2019, using change trend analysis, correlation analysis, and other methods to explore the impact of vegetation cover changes on ground surface temperature. From 2000 to 2019, in the central Guizhou urban agglomeration, the LST showed a fluctuating downward trend, with an average trend rate of  $-5.1\%a^{-1}$ . NDVI showed a fluctuating upward trend, with an average trend rate of  $0.56\%a^{-1}$ . The area with increasing LST ( $P < 0.5$ ) accounted for about 9.8%, and the area with a decreasing trend accounted for about 90.2%. The region of NDVI showing an increasing trend ( $P < 0.5$ ) accounted for approximately 97.34%, and the area of decreasing trend accounts for about 2.67%. About 96.8% of the regional area NDVI is negatively correlated with LST, and about 3.2% of the regional area is positively correlated.

## 1. Introduction

With the expansion of cities, the natural surface composed of vegetation and water bodies is transformed into buildings and impervious surface area (ISA)[1]. It leads to an increase in land surface temperature (LST) and many heat-related deaths[2], seriously affect the environment and the quality of life of residents[3], and reduce the urban ecosystem service value. Changes in the types of land cover caused by natural or human activities are important factors leading to changes in the urban thermal environment[4]. As an important part of the terrestrial ecosystem, vegetation is a natural link that connects elements such as soil, atmosphere, and moisture, and is of great significance to regional sustainable development[5]. As a type of land cover, vegetation plays an essential role in improving the urban thermal environment[6].

Studies have shown that normalized difference vegetation index (NDVI) is negatively correlated with LST at the regional scale, and vegetation has a cooling effect on LST[7]. A large number of studies have shown that there is a negative correlation between LST and NDVI, especially in urban areas[8]. Existing research mainly focuses on provinces, urban areas, or large-scale urban agglomerations. There is little literature on the central Guizhou urban agglomeration.

Therefore, based on the Moderate Resolution Imaging Spectroradiometer (MODIS) NDVI and LST data, we use the change trend method and related analysis methods to reveal the changes of NDVI and LST and the impact of vegetation NDVI on LST, to provide a reference for the development of the central Guizhou urban agglomeration.



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## 2. Materials and methods

### 2.1. Study areas

The central Guizhou urban agglomeration (CGZ) is located in the central part of Guizhou Province, and its scope includes six cities (prefectures) of Guiyang City, Zunyi City, Anshun City, Bijie City, Qiandongnan Prefecture, Qiannan Prefecture and 33 counties (cities, districts) (Figure 1).

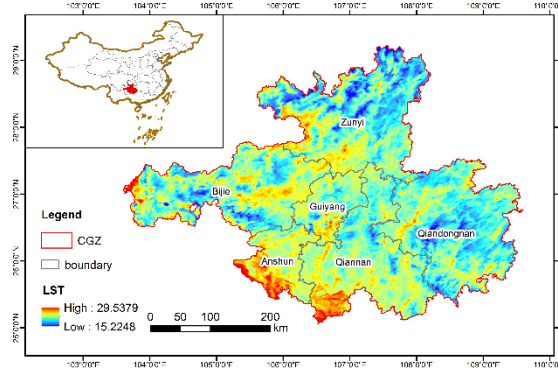


Figure.1 The location of the CGZ and the average surface temperature from 2000 to 2019

### 2.2. Data

The NDVI data we choose is MOD13A2 data with a time resolution of 16d; the LST data is daytime data of MOD11A2 with a time resolution of 8d. The time span of the two is 2000-2019, and the spatial resolution is 1km. The data sets are from the National Aeronautics and Space Administration (NASA). The maximum value synthesis method (MVC) was used to obtain the monthly value of NDVI, and the average value of each month was used as the NDVI value of the year. The average value synthesis method was used to obtain the LST value of the year.

### 2.3. Methods

**2.3.1. Change trend analysis.** One-variable linear regression was used to calculate the inter-annual change trend of NDVI or LST, and the slope of the linear regression equation was defined as the inter-annual change trend rate of NDVI or LST (slope). The calculation formula of the slope was as follows:

$$\text{slope} = \frac{n \times \sum_{i=1}^n (i \times V_i) - \sum_{i=1}^n i \sum_{i=1}^n V_i}{n \times \sum_{i=1}^n i^2 - \sum_{i=1}^n i} \quad (1)$$

Where: the slope is the slope of the unary linear regression equation fitted by NDVI or LST and the time variable;  $i$  is the time variable, equal to an integer from 1 to  $n$ ;  $n$  is the number of years in the study period, equal to 20;  $V_i$  is the growth of the  $i$ -th year quarterly average NDVI or LST.

### 2.3.2. Correlation analysis between LST and NDVI.

The correlation coefficient between NDVI and LST was calculated pixel by pixel to characterize the degree of correlation between NDVI and LST. The calculation formula is:

$$R_{xy} = \frac{\sum_{i=1}^n [(x_i - \bar{x})(y_i - \bar{y})]}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2 \sum_{i=1}^n (y_i - \bar{y})^2}} \quad (2)$$

Where: is the correlation coefficient of the two variables; and respectively represent the value of the  $i$ -th year; and respectively represent the average value.

### 3. Results and discussion

#### 3.1. Temporal and Spatial Changes of LST and NDVI in the CGZ

From 2000 to 2019, the LST of the CGZ showed a fluctuating downward trend, with an average trend rate of  $-0.051\text{a}^{-1}$ . NDVI showed a fluctuating upward trend, with an average trend rate of  $0.0056\text{a}^{-1}$ .

Figures 2 showed that the changing trends of LST and NDVI from 2000 to 2019 had great spatial heterogeneity. The area of LST increasing trend accounted for about 9.8%, and the area of decreasing trend accounted for about 90.2%. In terms of the significance of the change ( $P < 0.5$ ), the area of the significantly reduced area accounts for about 0.26%, and the area of the area significantly reduced accounts for about 34.4%.

The area of NDVI showing an increasing trend accounted for about 97.34%, and the area of decreasing trend accounted for about 2.67%. The proportion of areas with increasing NDVI is the largest in Bijie City and the smallest in Guiyang City. In terms of the significance of the change ( $P < 0.5$ ), the area of the significantly reduced area accounts for about 0.54%, and the area of the area significantly reduced accounts for about 79.8%. NDVI showed a significant increasing trend, most of which were distributed in the southern and western parts of the Guizhou urban agglomeration.

The distribution of NDVI in the CGZ was related to urbanization and land coverage. The NDVI in the CGZ showed an overall increasing trend, especially in Bijie City, where the desertification was severe, which showed that forest engineering and desertification control have achieved results. In the CGZ, the distribution and changes of LST are related to human activities and land cover. In urban areas, due to the expansion of urban land, the impervious surface increases, which in turn causes the surface temperature to rise. The surface temperature in the south is the highest, and the surface temperature in the north is the lowest, showing a certain cross-distribution on the whole, and it is relatively consistent with the mountain trend.

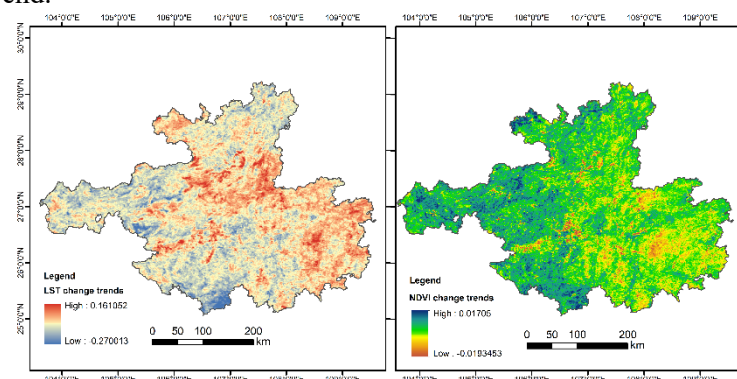


Figure.2 The spatial distribution of LST and NDVI change trends in the CGZ from 2000 to 2019

#### 3.2. The change and correlation of LST with NDVI

Using linear fitting to analyze the average annual NDVI and LST from 2000 to 2019, it shows that as the NDVI increases, the LST shows a decreasing trend. It can be seen from the change curve of NDVI and LST that the changing trend of NDVI and LST is opposite on the whole. Years with high NDVI have low LST. At the same time, the impact of NDVI on LST is lagging.

In CGZ, about 96.8% of the regional area NDVI is negatively correlated with LST, and about 3.2% of the regional area is positively correlated; the positively correlated areas are mostly distributed in the central and eastern regions, and most of the positively correlated areas are less significant (Figure 3).

Most areas with positive correlation are more significant. From the spatial distribution point of view, the distribution of positively correlated areas is related to urban distribution, which indicates that human activities will cause normal phenomena to deviate. While urbanization will cause the surface temperature to rise, NDVI will also increase, and NDVI may increase. It is related to the increase in temperature caused by urbanization and urban greening. And some mountainous regions are also positively correlated distribution areas, which may be related to the increase in regional temperature,

increased vegetation activity, and greenness of vegetation caused by global warming; at the same time, the increase in temperature will also affect the surface temperature, making the surface temperature positively correlated.

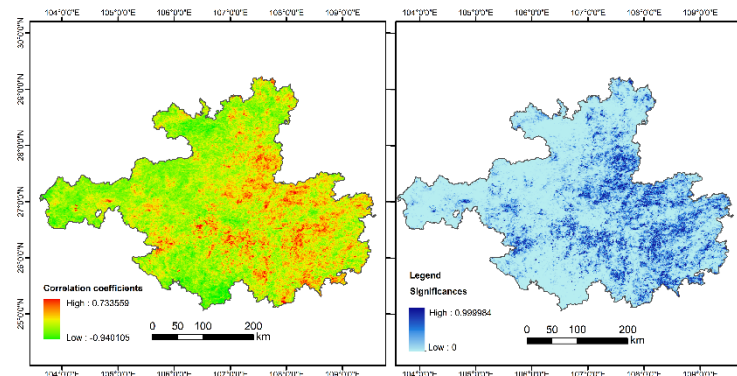


Figure.3 The correlation coefficient and significance level of LST and NDVI in the CGZ

#### 4. Conclusion

(1) From 2000 to 2019, the LST of the urban agglomeration in CGZ showed a fluctuating downward trend, with an average trend rate of  $-0.051 \text{ a}^{-1}$ . NDVI showed a fluctuating upward trend, with an average trend rate of  $0.0056 \text{ a}^{-1}$ .

(2) The area of LST increasing trend ( $P < 0.5$ ) accounted for about 9.8%, and the area of decreasing trend accounted for about 90.2%. The area of NDVI showing an increasing trend ( $P < 0.5$ ) accounted for about 97.34%, and the area of decreasing trend accounts for about 2.67%.

(3) The changing trends of NDVI and LST were generally opposite. About 96.8% of the area was negatively correlated, and approximately 3.2% of the area was positively correlated.

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