Analysis of Economic Indicators in Zhanjiang City during Epidemic Period Based on Remote Sensing Light Index

Yuyan Gao*

School of Surveying, Mapping and Geoinformation, Shandong Jianzhu University, Jinan, 250101, China

* Corresponding Author Email: 631402050117@mails.cqjtu.edu.cn

Abstract. GDP (Gross Domestic Product) reflects the economic power and market scale of a city, offering an important reference for political decision-making and national development. The luminous remote sensing plays an important role in exploring the city economic development, analyzing and forecasting urban GDP. The luminous remote sensing is a new method to evaluate and display macro issues of economic and social development. This article analyzes the correlation between the lighting index and the economic index GDP, and constructs the best linear regression model of the economic index of Zhanjiang, considering the impact of the Covid-19. Based on the regression slope of night light intensity before and after the Covid-19, this article analyzes the economic trend of Zhanjiang during the epidemic period. The results show that there is a significant linear correlation between the night light index and the socio-economic index, and the regression slope of the light can reflect the short-term economic trend and evaluate the city-level economic indicators well.

Keywords: NPP-VIIRS; GDP analysis; Zhanjiang economy; epidemic period.

1. Introduction

GDP (Gross Domestic Product) reflects the economic power and market scale of a city. Hence, GDP is an important reference for political decision-making and national development[1]. However, traditional GDP statistics can only reflect the macro-economic situation of a certain region in numerical form, while the spatialization of GDP can reflect the basic economic situation of the studied area more completely[2]. As there is a significant linear correlation between the night light index and the socio-economic index, the night light index can represent the temporal and spatial distribution characteristics of regional economic development, providing certain theoretical guidance for regional development and governmental decision[3].

The luminous remote sensing refers to the process in which satellite sensors obtain visible light such as town light, ship light and oil well burning under cloudless conditions at night. Since the visible light at night is closely connected with human activities, the luminous remote sensing can effectively obtain the dynamics of economic and social development, making a new way to evaluate and display macro issues of economic and social development[4]. The luminous remote sensing plays an important role in analyzing and predicting urban economic development. Compared with traditional social and economic census methods, the method based on the luminous remote sensing data can provide intuitive images and make up for the limitations of traditional methods.

This article chooses Zhanjiang as the research area to calculate the light index and analyze the correlation between the light index and the corresponding regional economic data. Based on the analysis of the correlation between the light index and the corresponding regional economic data, this article mainly studies the change trend of the night light index of Zhanjiang during the epidemic period and explore the dynamic change law between the light index and the GDP of Zhanjiang.

The results show that there is a significant linear correlation between the night light index and the socio-economic index, and the regression slope of the light can reflect the short-term economic trend and evaluate the city-level economic indicators well. In addition, the emergence of COVID-19 leads to an obvious breakpoint of the regression slope.

2. GDP spatial modeling based on luminous remote sensing light index

The input data of GDP spatial modeling mainly includes the annual lighting data of NPP-VIIRS (Visible Infrared Imaging Radiometer) and the annual GDP statistical data of the city provided by the National Bureau of Statistics. The research area is divided into a 1km×1km spatial grid. Through the regression analysis, the regression analysis model of the remote sensing lighting index and GDP is established, and the spatial modeling of GDP is finally realized. The technical roadmap of GDP spatial modeling is shown in Fig.1.

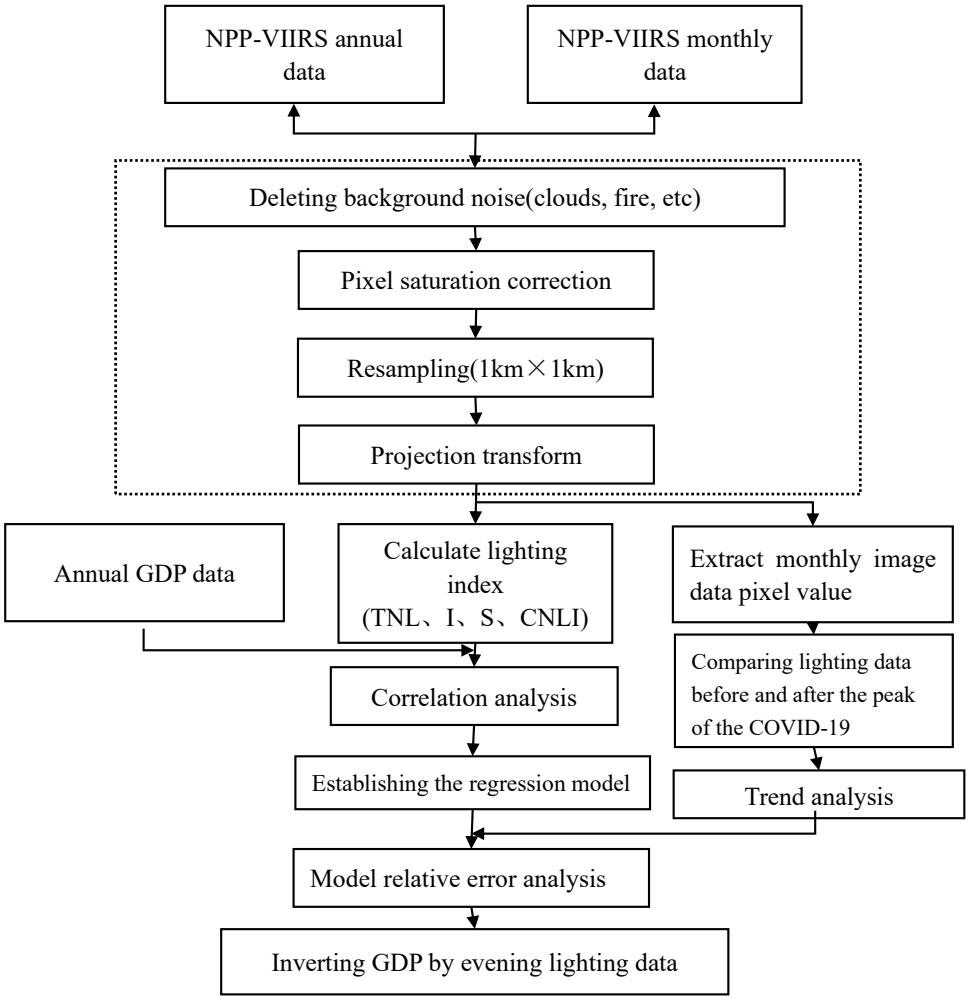

Fig. 1 Technical roadmap of GDP spatial modeling

2.1. Calculation of lighting index

This article mainly uses the Total Nighttime Light intensity (TNL), the average relative Light intensity (I), the light area ratio (S) and the Compounded Night Light Index (CNLI) to establish the relationship with the city economic level.

TNL is the sum of the product of the light attribute value and the number of corresponding attribute values; the average relative light intensity refers to the ratio of total night light intensity to maximum light intensity; The light area ratio refers to the number of pixels whose pixel radiation brightness is not 0 and the ratio of the total number of pixels; The comprehensive light index CNLI refers to the product of the average relative light intensity and the light area ratio. The formulas for the calculation of lighting index are shown as follows:

$$TNL = \sum_{i=1}^{n} DN_i \times n_i; \quad (1)$$

$$I = TNL/DN_{max} \times N; \quad (2)$$

$$S=N\times n; \tag{3}$$

$$CNLI=I\times S; \tag{4}$$

In the formulas, DN_i is the radiation brightness value of the i-th pixel; n_i is the number of corresponding i-th attribute value; n is the total number of pixels; DN_{max} is the maximum pixel radiation brightness; N is the sum of the number of pixels whose radiation brightness is not 0[5,6].

2.2. Correlation analysis between lighting index and GDP

Since the night lighting data has little correlation with the output value of the primary industry and has a greater correlation with the gross production value GDP, this article mainly analyzes the correlation between the lighting parameters (*TNL*, *I*, *S*, *CNLI)* and the gross production value GDP. The lighting index with the largest correlation coefficient is selected for research, and the regression model between the lighting index and GDP is established.

$$GDP= A+b\times C_i; \tag{5}$$

In the formula, GDP is the dependent variable, it representing the gross product; A and b are regression model coefficient variable, C_i is the independent variable, representing lighting index[7].

3. Studied object

3.1. Overview of studied area

Zhanjiang City is located on Leizhou Peninsula at the intersection of Guangdong, Guangxi and Qiongzhou Strait, facing the South China Sea across Qiongzhou Strait and Hainan Province in the south, facing Beibu Gulf in the west, and backed by the Great Southwest and connected to Maoming City in the east. It covers an area of 11693 square kilometers and lies between 20°-21°35' North latitude and 109°31'-110°55' east longitude. With the population of 7.92 million and GDP of 301.2 billion yuan in 2019, Zhanjiang City is dominated by the tertiary industry.

3.2. Night lighting data

2014-2019 NPP-VIIRS data is from the National Environmental Information Center. Based on the Visible Infrared Imaging Radiometer Suite (VIIRS) day/night band (DNB) night data, a set of average radiation composite image visible light channel of 0.4~0.9μm is produced. With a spatial resolution of 500 m, the night light data includes monthly data and annual average data. Since the establishment of GDP model needs to exclude other lighting interference, data preprocessing operations are required: the original data of NPP-VIIRS adopts the longitude and latitude coordinate system of WGS-1984, and the spatial resolution is 15", which will cause the problem that the image area decreases with the increase of latitude. In order to avoid the influence of image area deformation and facilitate image area calculation, NPP-VIIRS image data are transformed by Alberts equal-area projection. At the same time, the background noise removal, negative value removal, cloud removal, fire point removal, pixel saturation correction and other operations are carried out, so as to minimize the adverse effects of climate, haze and geographical location on the luminous remote sensing data. The region can be divided into 1km×1km size grid to find the change and distribution of light brightness, and realize the spatial expression of night light data. Fig.2 shows the night light index of Zhanjiang City in 2020, and the DN value is divided into 5 intervals. The DN value is the ratio of the night light data divided by the morning light data.

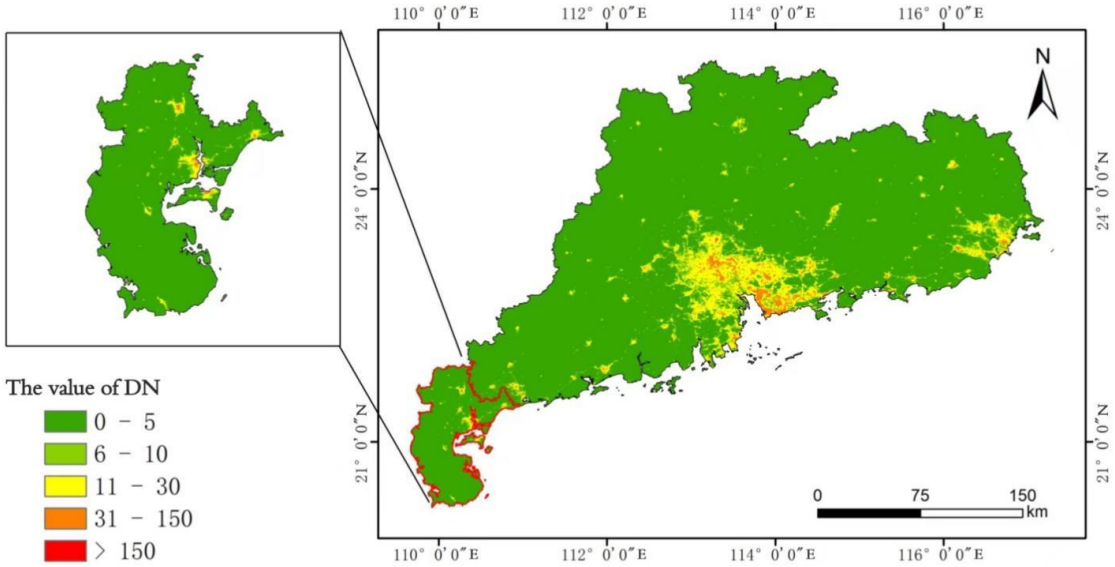

Fig. 2 Light data of studied area

3.3. GDP data

GDP data is sourced from Guangdong Provincial Government[8] and the website of National Bureau of Statistics of China[9]. The data are collected at city level, county level and zone level. In this article, the statistical data includes the GDP statistics of each zone and county-level city of Zhanjiang in recent years[10].

4. Economic analysis of Zhanjiang City based on luminous remote sensing lighting index

4.1. Correlation analysis between lighting index and GDP

In order to make the analysis more reliable, the correlation between each lighting index and GDP has been analyzed. The obtained correlation coefficients are shown in Table 1. The results show that the correlation between total lighting intensity *TNL* and GDP is the strongest correlation, and the correlation coefficient between them is 0.945. *TNL* of total lighting intensity at night can play a better role in fitting GDP, so *TNL* of total lighting intensity can be selected for subsequent research.

Table 1. Results of correlation analysis between lighting index and GDP

TNL	S	I	CNLI
0.945	0.726	0.725	0.882

4.2. Impact of COVID-19

In early 2020, the COVID-19 outbreaks in Zhanjiang. Due to the severe impact of COVID-19 on local economic activities, there are large differences in lighting data before and after the outbreak. The regression slope trend analysis results for each month in 2020 are shown in Table 2.

Table 2. Regression slope trend analysis of night light in 2020

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

0.87	0.84	1.33	1.11	0.87	0.70	0.73	0.74	0.71	0.85	0.89	1.12

By analyzing the data in Table 2, it can be found that the night light return slope will be affected by the COVID-19, as the COVID-19 prevention policy of Zhanjiang becomes stricter from January to February, the regression slope of lighting decreases slightly in February 2020; With the continuous relaxation of COVID-19 prevention policies in Zhanjiang from February to March, the slope of light return reaches its peak in March 2020; As the COVID-19 prevention policy of Zhanjiang from March to June becomes stricter, the slope of light regression decreases and reaches the lowest level in June 2020; With the relaxation of the city's COVID-19 prevention policy in July and August 2020, the light level gradually recovers, and the regression slope increases from 0.71 to 0.85 and 0.89 in October and November 2020, and finally rises to 1.12 in December, which exceeds the pre-COVID-19 level. It can be found that the luminous remote sensing lighting index can very sensitively capture the impact of COVID-19 on the economic activities of Zhanjiang City.

5. Conclusion

Based on long-term NPP-VIIRS luminous remote sensing data, this article analyzes the economic activities in Zhanjiang City during the period of COVID-19 by using four light indices: total intensity of night light, average relative intensity of light, light area ratio and comprehensive light index. The following conclusions can be made: 1) There is a significant linear correlation between the night light index and the socio-economic index, among which the TNL correlation is the strongest. TNL is a good assessment of city-level economic indicators; 2) The emergence of the COVID-19 brings a breakpoint phenomenon in the night light data, and the regression models before and after the COVID-19 are significantly different; 3) The regression slope of light can reflect the short-term economic trend well. The regression slope of light reaches the lowest level during the peak period of COVID-19, and gradually increases after the relaxation of COVID-19 prevention policies. The regression slope of light can sensitively capture the change of urban economic trend.

References

[1] Lan Yan-Qian, Wu Yingdan, Zhao Xin-Yue, Guo Yibei, Shao Y L.Analysis of economic indicators in Hubei Province during the epidemic period based on luminous remote sensing light index. Journal of Hubei University of Technology, 2023, 02:111-115.

[2] Hu Xin. Based on the night light data of GDP spatialization research. Liaoning engineering technology university, 2022.

[3] Yin Zhuo. Based on remote sensing data of luminous GDP forecast analysis of time and space. Liaoning engineering technology university, 2021.

[4] Application of glow-in-the-dark remote sensing technology in assessing Economic and social development and its guarantee for the construction quality of the "Belt and Road". Macro quality research, 2015, 3 (4) : 8.

[5] Wu Zhenyu. Research on economic development monitoring of urban industrial parks based on long time series data. Jiangsu ocean university, 2023.

[6] Wei Xiaopeng. Spatiotemporal Analysis of high-quality urban construction effect based on luminous Remote sensing. Dalian Ocean University,2023.

[7] Zhou Minqiang. Study on the coordination of spatial and temporal characteristics of economic development and traffic superiority degree in China's coastal economic belt. Zhejiang University,2021.

[8] Zhanjiang Municipal People's Government. GDP of Zhanjiang City by year. 2020.04.04, 2023.08.02 www.gd.gov.cn.

[9] State Statistics Bureau. Monthly data. 2020.12.04, 2023.08.02 www.stats.gov.cn.

[10] Zhang Chengwei. Research on development of Beijing-Tianjin-Hebei City cluster from 1993 to 2018 based on multi-source luminous remote sensing data. Hebei Normal University,2021.