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Gridded GDP Dataset of Yunnan Border Area (1992–2013)

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Abstract: The Yunnan border area is located on the southwestern border of Yunnan Province. It is located in the economic corridors of Myanmar, India, China, and Bangladesh and has an important geographical position. Therefore, it is critical to implement the spatial fitting of the Gross Domestic Product (GDP) data in the Yunnan border area with high precision. In this study, the Yunnan border area was used as the research area, and DMSP/OLS nighttime light data, land use data, and Yunnan provincial statistical data were used as data sources to implement the spatial fitting of the GDP data for the research area from 1992 to 2013. Saturation correction, mutual correction, annual fusion, interannual correction, reprojection, resampling, and clipping were performed on nighttime light data. Spatialization of the primary industry based on land use data was implemented. Based on nighttime light data, a "classification regression" method was used to implement the spatialization of the secondary and tertiary industries to obtain the spatialization of the GDP and verify the fitting results. The results show that the error of the primary industry fitting value of all periods is 1.12% at the maximum, and the fitting error is small. The relative error of the fitting of the secondary and tertiary industries after classification regression is less than 6.40% in each period, and the relative fitting error of the final GDP of each period is less than 4.24%, with high accuracy. The dataset is stored in the .tif file format. The spatial resolution of a single file is 1-km, and there were a total of 22 groups of files; the amount of the data volume was 68.6 MB (when compressed to 1 file, it was 3.43 MB).

Keywords: GDP spatialization; Yunnan border area; nighttime light data; land use data

Dataset Available Statement:

The dataset supporting this paper was published at: Lu, X., Li, J., Duan P., *et al*. 1-km grid GDP dataset in Yunnan surrounding area (1992–2013) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. DOI: 10.3974/geodb.2020.03.11.V1.

1 Introduction

The border areas of Yunnan are located in the economic corridors of China, India, Myanmar, and Bangladesh. They serve as a bridge and link between China, South Asia and the South-east Asian countries for material, cultural, economic and trade exchanges. Therefore,

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[2] Lu, X., Li, J., Duan P., *et al*. 1-km grid GDP dataset in Yunnan surrounding area (1992–2013) [J/DB/OL]. *Digital Journal of Global Change Data Repository*, 2020. DOI:10.3974/geodb.2020.03.11.V1.

this geographical location is very important for China's development. The Gross Domestic Product (GDP) is an evaluation indicator that measures a region's economic development, gauges urban development and reflects regional planning[1]. The traditional GDP statistical data is limited by separations in administrative units, so it is difficult to obtain very precise economic data that show the differences within the administrative units, and it is impossible to conduct a comprehensive analysis in combination with raster data such as ecological environment[2] data. Through the spatial fitting of the GDP data, the above problems can be solved. With the continuous progress and development of remote sensing technology, remote sensing data such as nighttime light data and land use data are widely used in the spatial fitting of GDP data. The DMSP/OLS nighttime light data acquired by the US Defense Military Meteorological Satellite has been applied since the 1970s[3]. The data has strong photoelectric amplification capabilities, can intuitively reflect human activities, and has the advantages of extended time spans and wide spatial coverages. After continuous improvement and updating, it has been applied to many aspects of development planning such as urbanization monitoring, population analysis, energy consumption and GDP estimation. Therefore, based on the DMSP/OLS nighttime light data, combined with land use data and statistical data, this study constructed a spatial dataset of the GDP in the Yunnan border area from 1992 to 2013. This dataset reflects the economic differences within the administrative divisions of the Yunnan border area and can be comprehensively analyzed with raster image data such as natural ecological environment data.

2 Metadata of the Dataset

The metadata of the dataset[4] is summarized in Table 1. It includes the dataset full name, short name, authors, geographical region, years, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Metadata summary of the dataset

Items	Description
Dataset full name	1-km grid GDP dataset in Yunnan surrounding area (1992–2013)
Dataset short name	YunnanBorderGDP1992-2013
Authors	Lu, X. AAS-6714-2020, College of Tourism and Geographical Sciences, Yunnan Normal University, lx_rsgis@163.com Li, J. AAS-6000-2020, College of Tourism and Geographical Sciences, Yunnan Normal University, keguigiser@163.com Duan, P. College of Tourism and Geographical Sciences, Yunnan Normal University, duanpingshai@163.com Li, C. College of Tourism and Geographical Sciences, Yunnan Normal University, lichen924541412@163.com Cheng, F. College of Tourism and Geographical Sciences, Yunnan Normal University, chengfeng_rs@163.com Wang, J. L. College of Tourism and Geographical Sciences, Yunnan Normal University, jlwang@ynnu.edu.cn
Geographical region	Yunnan border area, including eight prefectures including Baoshan city, Honghe Hanizuyizu autonomous prefecture, Lincang city, Dehong Daizu-Jingpozu autonomous prefecture, Nujiang Lisuzu autonomous prefecture, Xishuangbanna Daizu autonomous prefecture, Pu'er city and Wenshan city
Year	1992–2013
Temporal resolution	1 Year
Spatial resolution	1 km
Data format	.tif

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Items	Description
Data size	68.6 MB (before compression), 3.43 MB (after compression)
Data files	GDP spatialization product data
Foundation(s)	Ministry of Science and Technology of P. R. China (SQ2018YFE011725); National Natural Science Foundation of China (41561048)
Computing environment	ArcGIS
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (in the *Digital Journal of Global Change Data Repository*), and publications (in the *Journal of Global Change Data & Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use ***Data*** subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[5]
Communication and searchable system	DOI, DCI, CSCD, WDS/ISC, GEOSS, China GEOSS, Crossref

3 Methods

3.1 Introduction and Data Preprocessing

The DMSP/OLS nighttime light data includes three kinds of image data products, which are average visible, stable lights, & cloud free coverage data, average lights X Pct data, and global radiance calibrated nighttime lights data. Average visible, stable lights, & cloud free coverage data includes three data types, namely, average visible light image, stable light image, and cloud free coverages data. The data used in this study is the stable light image. The phase is from 1992–2013, the DN value range is 0–63, and the pixel size is 0.008,333°.

Because the sensor of these data product has not been calibrated on the satellite, the different light images obtained by each sensor lacks continuity and comparability, and a saturation of the pixel DN value exists in the central area of the city[6–7]. Therefore, this study combines the methods of Elvidge, Wu, Liu, etc.[8–10] to perform saturation correction, mutual correction, annual fusion, interannual correction, reprojection for the Albers projection, resampling for 1,000 m, and clipping of the nighttime light data. Calibration steps: (1) Do a mutual calibration and saturation calibration. Perform mutual correction and saturation correction on the image to be corrected, from 1992 to 2013, and the data of the 2006 F16 sensor in the data from the radiation calibration product. The reference area is Jixi city, Heilongjiang province. The calibration model is:

$$DN_{correct} = a \times DN^2 + b \times DN + c \quad (1)$$

where DN is the brightness value before the correction, a, b, c are regression coefficients, and $DN_{correct}$ is the corrected DN value.

(2) Annual fusion. The data obtained by different sensors in the same year is inconsistent, and some of the images corrected after step (1) are fused within the year according to the following equation (2).

$$DN_{(n,i)} = \begin{cases} 0 & DN^a_{(n,i)} = 0 \mid DN^b_{(n,i)} = 0 \\ (DN^a_{(n,i)} + DN^b_{(n,i)})/2 & \text{others} \end{cases} \quad (2)$$

$$(n = 1994, 1997, 1998, \ldots, 2007)$$

where $DN^a_{(n,i)}$ and $DN^b_{(n,i)}$ represent the DN value of the i-pixel acquired by two different sensors in the n year after the mutual calibration and the saturation correction, respectively, and $DN_{(n,i)}$ represents the DN of the i-pixel after the n-year fusion and correction of the image within the year.

(3) Interannual correction. After the fusion within the year, there is still the phenomenon of incomparable images between different years. The correction equation is given in equation (3).

$$DN_{(n,i)} = \begin{cases} 0 & DN_{(n+1,i)} = 0 \\ DN_{(n-1,i)} & DN_{(n+1,i)} > 0 \,\&\, DN_{(n-1,i)} > DN_{(n,i)} \\ DN_{(n,i)} & \text{others} \end{cases} \quad (3)$$

$$(n = 1992, 1993, 1994, \ldots, 2013)$$

In the equation, $DN_{(n-1,i)}$, $DN_{(n,i)}$, $DN_{(n+1,i)}$, respectively represent the DN values of the image pixel i in n-1 year, n year, n+1 year.

3.2 Algorithm

The correlation between the primary industry and the land use data for the fields of cultivated land, forest, grass and water is high[11]. Therefore, the agricultural, forestry, animal husbandry, and fishery output value data in the primary industry are modeled respectively with the corresponding land types in the land use data. The modeling equation is as follows:

$$\mathrm{GDP}_{1ij} = \sum_{k=1}^{4} Gk_{ij} \quad (4)$$

In equation (4), GDP_{1ij} represents the output value of the first industry in the j grid of the i administrative region; Gk_{ij} represents the four kinds of output values for k = 1–4, respectively corresponding to the serial numbers of agricultural, forestry, animal husbandry and fishery output values in the primary industry.

The brightness of the DMSP/OLS nighttime light data has a certain correlation with the secondary and tertiary industries, and the distribution of different light brightness values of night lights can be used to fit the secondary and tertiary industries. The fitting model is as follows:

$$\mathrm{GDP}_{23} = a \cdot \mathrm{SOL} \quad (5)$$

GDP_{23} represents the fitting value of the secondary and tertiary industries, and a is the fitting coefficient. Where SOL stands for:

$$\mathrm{SOL} = \sum_{m=1}^{\max} N_m \cdot B_m \quad (6)$$

where N_m represents the number of pixels whose brightness value is m, and B_m represents the brightness value of the pixel itself.

Based on the nighttime light index, the error between the fitting results of the global modeling of the secondary and tertiary industries and the statistical data is large. Therefore, in order to reduce the deficiency of the global modeling the study uses the concept of “classification regression”, that is, adding the relative error to the fitting model for the global modeling; the equation is as follows:

$$\delta = \frac{\mathrm{GDP}_{23} - \mathrm{GDP}_S}{\mathrm{GDP}_S} \times 100\% \tag{7}$$

GDP_S is the statistical value of the secondary and tertiary industries in the study area. The specific process of “classification regression” modeling is:

(1) According to the initial fitting equation, filter out the counties with $|\delta|<25\%$ to form the first equation. These counties are fitted with the first equation.

(2) Divide the counties where $|\delta|>25\%$ into two parts, where $\delta>25\%$, rebuild the fitting model’s overestimated section, and in counties where $\delta<-25\%$ rebuild the fitting model’s underestimated section;

(3) After building the model through the above two steps, if there still exist counties with $|\delta|>25\%$, and if the number is greater than 10% of the total fitting model number, then continue to partition the model until the fitting equation is $|\delta|<25\%$ or the number of the remaining fitting model is less than 10%; then the modeling is terminated.

The primary industry model fitting results obtained above, and the secondary and tertiary industries model fitting results are overlaid to obtain the GDP fitting results. The obtained fitting results still will have large fitting errors in some counties. Therefore, a linear correction within the county area is performed on the obtained GDP fitting results. The correction model is as follows:

$$\mathrm{GDP}_{correct} = \mathrm{GDP}_{estimated} \cdot (\mathrm{GDP}^* / \mathrm{GDP}_{all}) \tag{8}$$

In the equation, $\mathrm{GDP}_{correct}$ represents the corrected GDP raster data, $\mathrm{GDP}_{estimated}$ is the estimated GDP data of each grid, GDP^* represents the statistical GDP data of the county, and GDP_{all} is the estimated GDP data of the corresponding county.

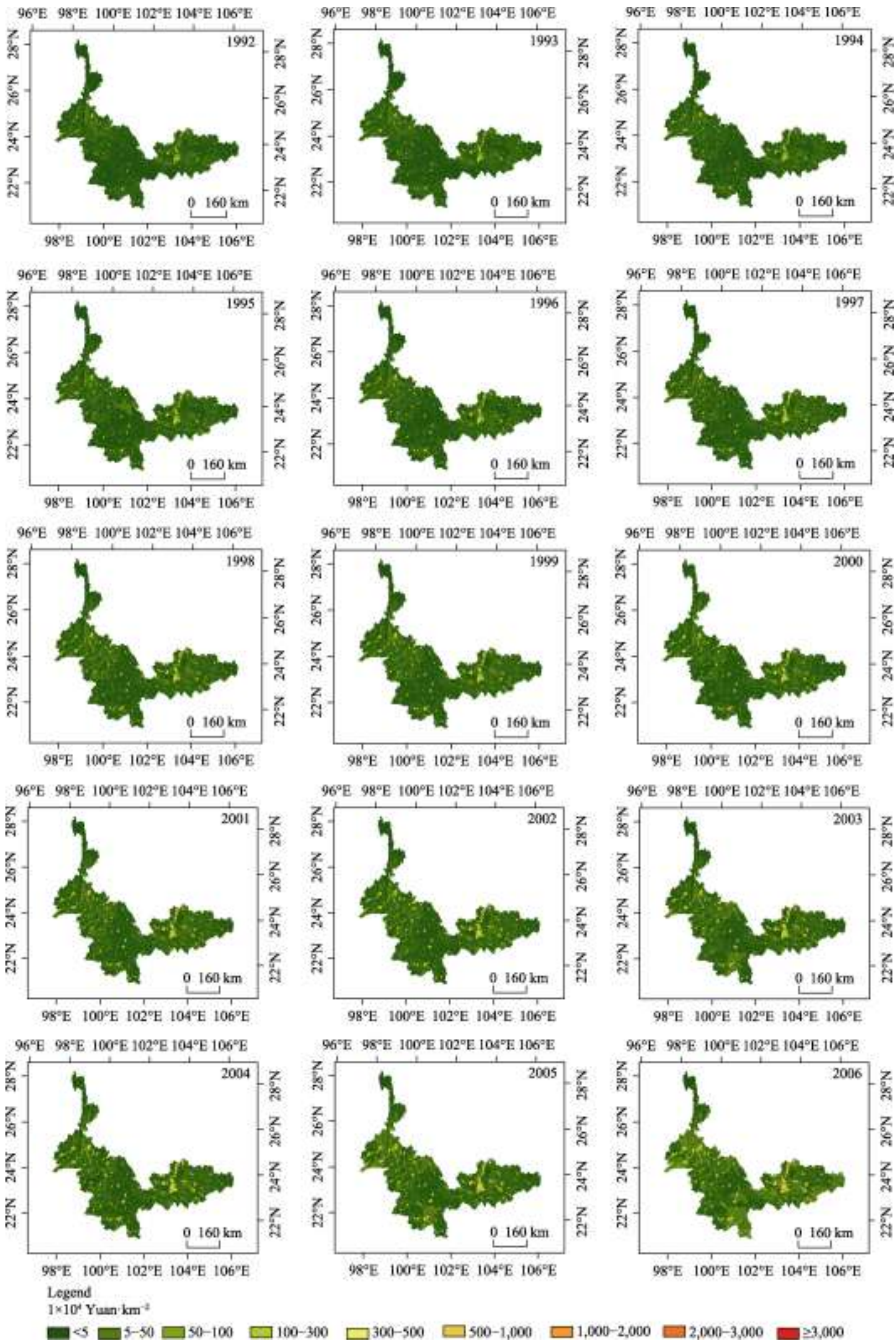
4 Data Results and Validation

4.1 Data Products

The Grided GDP dataset of Yunnan border area includes spatial distribution of 8 prefectures from 1992 to 2013 and spatial distribution is shown in Figure 1[12–13].

4.2 Data Results

From 1992 to 2004, the regions with a higher GDP and better economic development were mainly distributed in the eastern region of the border area of the Yunnan-Honghe Hanizuyizu autonomous prefecture with scattered distributions in the western part area. Since 2005, the economic development of Baoshan city, Dehong Daizu-Jingpozu autonomous prefecture and Xishuangbanna Daizu autonomous prefecture has gradually improved, while the economic development of Lincang city and Pu’er city in the central region has lagged behind other regions. After 2010, the high-value pixel area of the GDP gradually spread throughout the border areas, and the economic development level of each prefecture gradually increased.



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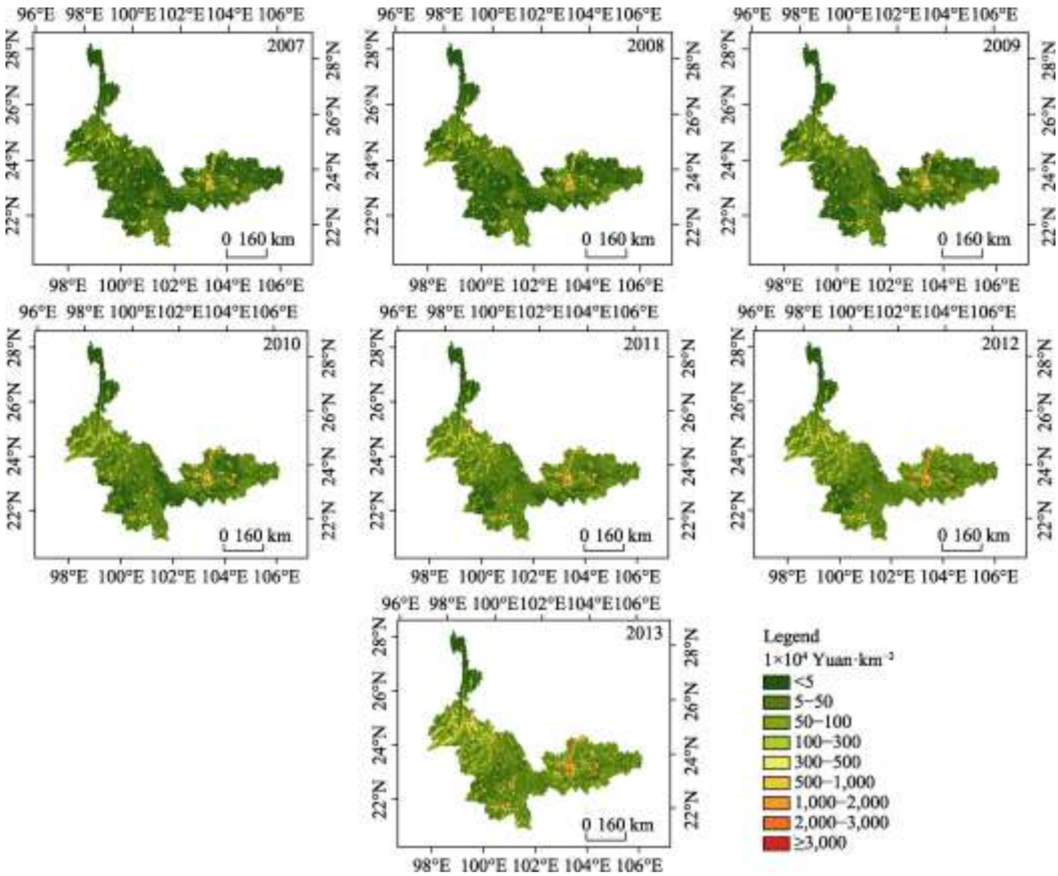

Figure 1 Spatial distribution of GDP in Yunnan border area from 1992 to 2013

In terms of counties, counties with high GDP values such as Gejiu city, Kaiyuan city, and Mile county have always been at the forefront of economic development in the border regions. In particular, Mile county has been ranked first in GDP in the border areas since 2001. After 2001, Baoshan, Jinghong, Tengchong, Mengzi, and Jianshui developed gradually. The GDP pixel value increased year by year, and the high-value pixel area gradually spread out from the center of the city. The low value GDP pixel areas are mainly concentrated in counties such as Gongshan, Fugong, Ximeng and Lianghe, and the economic development is slow for these areas.

4.3 Data Validation

The error between the fitting value of the primary industry, the fitting value of the secondary and tertiary industries, the fitting value of the GDP and the corresponding GDP statistics can be compared and analyzed. The error analysis results show that: the relative error of the primary industry fitting value of the fitting data in each period can reach 0.09%, at minimum, and the maximum does not exceed 1.12%. The error is small and the fitting accuracy is high. It shows that the primary industry is feasible according to the land use data and the precision is high. The maximum error of the unclassified regression fitting of the secondary and tertiary industries is –29.09%, and the relative error of the fitting after classification regression is only −6.40%, and the minimum can reach −0.40%. It shows that the classification regression fitting method greatly improves the fitting accuracy of the secondary and tertiary industries. The relative error of the final GDP fitting is only −4.24% at the maximum, with a higher precision and better fitting accuracy. The fitting results can be used for subsequent data calculations, analysis and other applications.

5 Discussion and Conclusion

This research is based on the use of land use data to fit the GDP of the primary industry by using the DMSP/OLS nighttime light data and a classification regression fitting method to fit the secondary and tertiary industries. The fitting period is from 1992 to 2013. By verifying the accuracy of the fitting results, the results show that the fitting accuracy of each industry is high. The relative error of the fittings in the primary industry is not higher than 1.12%, the relative error of the fittings in the secondary and tertiary industries are not more than 6.40%, and the relative error of the final GDP fitting is only −4.24%, and the fitting effect is good. Additionally, the inversion accuracy is high. These data can be further used for the analysis of economic differences within administrative divisions and may be combined with other raster image data for spatial calculations and analysis.

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