The gridding of China 's modernization level

Zhengliang Zhang

College of Geomatics, Xi'an University of Science and Technology, Xi'an 710054, Shaanxi, China

2312633950@qq.com

Abstract. Based on China 's social and economic statistics from 2006 to 2020, this paper constructs an evaluation index system of modernization level from three dimensions of economic development, social development and environmental development, and uses remote sensing data to grid it, and analyzes the spatial and temporal evolution characteristics of modernization level. The results show that: (1) From 2006 to 2020, the overall level of modernization in China is on the rise, and the absolute difference in the level of modernization shows a significant narrowing trend. The eastern coastal and inland provincial capital areas have a higher level of modernization, while the western and northeastern marginal areas have a lower level of modernization. (3) After gridding, the distribution of modernization levels at all levels has become more fragmented, breaking through the original administrative boundaries, but from a local point of view, it is still based on the urban center as the core of the local modernization level, and shows a trend of outward expansion.

Keywords: modernization; evaluation indicators; gridding

1   INTRODUCTION

Modernization refers to the process of continuous development of an area. To carry out modernization level evaluation is of great significance to scientifically understand the stage of modernization development of our country. The current research on modernization can be summarized into three research ideas: First, from the theoretical point of view, the connotation of modernization and related theories are combed and analyzed[1]; The second is to focus on the relevant studies on the construction of evaluation index system. The third type is based on the definition of modernization connotation and the construction of evaluation index system, using statistical methods to measure and evaluate the modernization level of individual provinces or developed cities, and on this basis, some problems in the modernization process are discussed[2]. However, the current research on modernization mostly stays in socio-economic statistical data, and there are few studies and analyses of modernization process combined with remote sensing data. The combination of remote sensing data and socio-economic statistics can transform traditional socio-economic data into spatial vector or grid data[3], and break

through the boundary of statistical units to reflect the internal heterogeneity of statistical units[4].

2   MATERIALS AND METHODS

2.1   Data Collection

This paper takes 336 cities in China as the research object, and the data comes from the ' China Urban Statistical Yearbook (2006-2021) '. High-income countries and world average data are collected from the World Bank World Development Indicators (WDI) database. (https://datatopics.worldbank.org/world-development-indicators/). Remote sensing data uses GDP grid data, population density grid data and PM2.5 data (Table 1)[5-8],.

Table 1. Remote sensing data source

Remote sensing data	Data source
GDP grid data	Resource and Environment Science and Data Center (https://www.resdc.cn/Default.aspx)
Population density grid data	WorldPop (https://hub.worldpop.org)
PM2.5 data	TPDC (https://data.tpdc.ac.cn/home)

2.2   Index System of Modernization Evaluation

Referring to the research results of existing scholars [9], this paper constructs the index system of modernization level from three dimensions, and uses remote sensing data to empower the dimensions (Table 2).

Table 2. Index System of Modernization Evaluation

First-level	Secondary	Ihird-level	Positive / Negative	Remote sensing data
Level of modern	Economic development (ECD)	GDP per capita (yuan / person)	Positive	GDP grid data
		GDP ratio of tertiary industry (%)	Positive	
		Proportion of tertiary industry employment (%)	Positive	
		Proportion of primary industry employment (%)	Negative	
	Social development (SOD)	Natural growth rate (%)	Positive	Population density grid data
		Urbanization rate (%)	Positive	
		Primary school teacher-student ratio (%)	Positive	
		Number of doctors per capita	Positive	
	Environmental development (ECE)	Electricity consumption / GDP (kwh / yuan)	Negative	PM2.5 data
		Average annual PM2.5 concentration (ug / m^3)	Negative	

2.3   Calculating Procedure

Empower the three-level indicators and calculate the modernization index value. The data are standardized using the x-dimensional values xxij, maximum xmax, minimum xmin, i-year, and j-index, as follows [10] :

$$\text{Positive indexes:}\quad y_{xij} = \frac{x_{xij} - x_{min}}{x_{max} - x_{min}} \tag{1}$$

$$\text{Negative indicators:}\quad y_{xij} = \frac{x_{max} - x_{xij}}{x_{max} - x_{min}} \tag{2}$$

Secondly, the information entropy E_{xj} of the index j is obtained by the number of cities z, and the calculation formula is as follows:

$$E_{xj} = -\left(\frac{1}{\ln z}\right)\sum_{i=1}^{z} \frac{y_{xij}}{\sum\limits_{i=1}^{z} y_{xij}} \ln\left(\frac{y_{xij}}{\sum\limits_{i=1}^{z} y_{xij}}\right) \tag{3}$$

Calculate the modernization level index G_i of each region in i year and x dimension, where m is the number of regions and n is the number of dimensions.

$$G_i = \sum_{x=1}^{n}\sum_{i=1}^{m} y_{xij} \frac{1 - E_{xj}}{\sum\limits_{i=1}^{z} y_{xij}} \tag{4}$$

By using the three-dimensional remote sensing data u and its weight w, the modernization level weight U is calculated, and U_{mean} is the mean value of U. Finally, the modernization level G_{MODI} after gridding is obtained, the formula is as follows:

$$U = u_{GDP} \times w_{ECD} + u_{POPD} \times w_{SOD} + u_{PM} \times w_{ECE} \tag{5}$$

$$G_{MODI} = \sqrt{\frac{U}{U_{mean}}} \times G_I \tag{6}$$

3   RESULT

3.1   Time variation characteristics of modernization in Yangtze River Delta

The distribution dynamic evolution diagram of modernization level index is drawn by kernel density estimation. The peak of China 's modernization level index generally

moves to the right, indicating that China 's modernization level index continues to increase. From the height and width of the peak, it shows a downward trend and the width is narrowed, indicating that the absolute difference of China 's modernization level index shows a significant narrowing trend. (Figure 1).
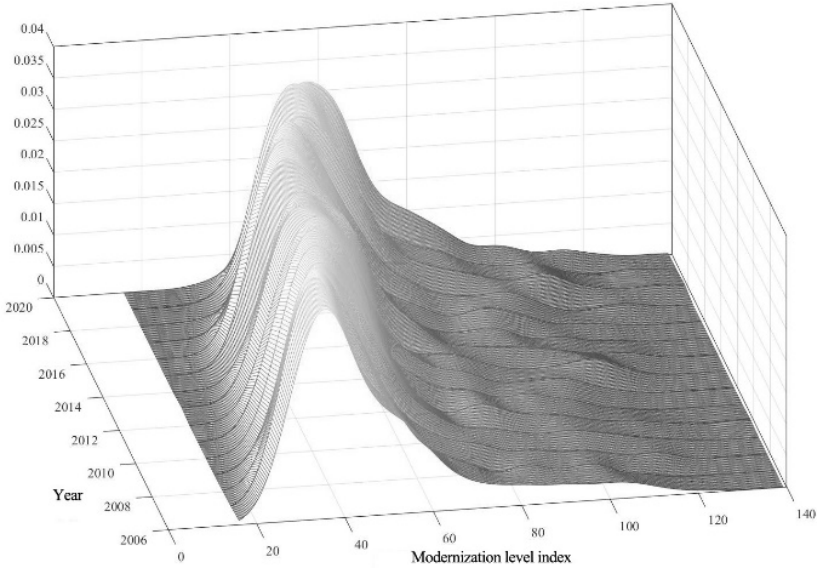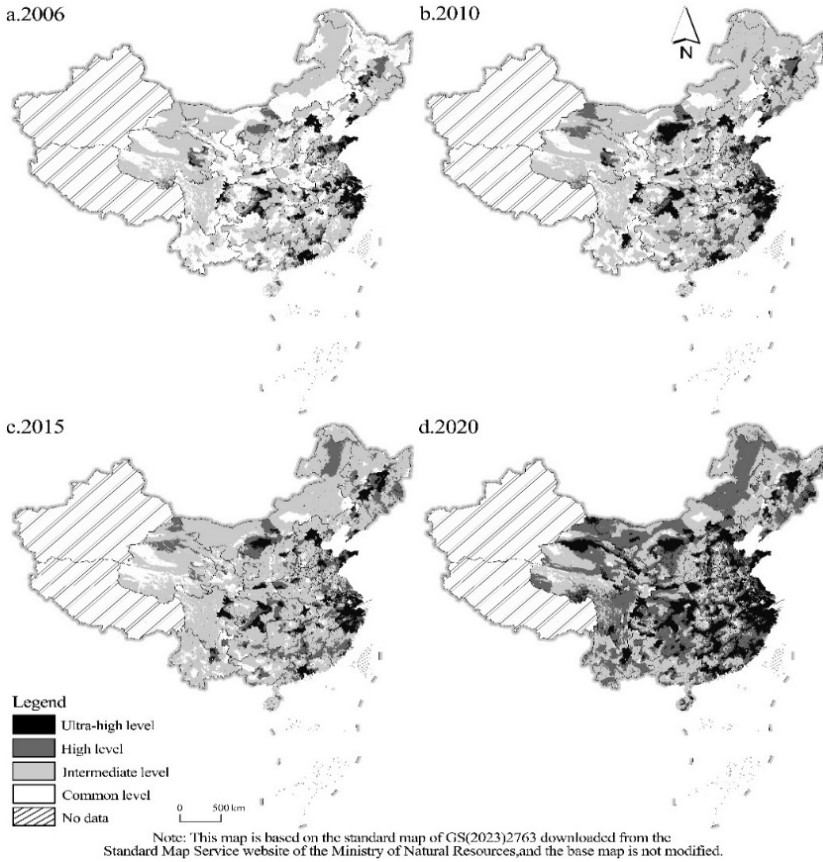

Fig. 1. Nuclear density estimation map of modernization level from 2006 to 2020

3.2   Spatial variation characteristics of modernization level

Based on the high-income countries and the world average level, the level of modernization is divided into four categories (Table 3).

Table 3. Modernization level classification standard

Classification	Score values
Ultra-high level	≥100 % of the average level of high-income countries
High level	≥70 % of the average level of high-income countries and the world average
Intermediate level	≥30 % of high-income countries and 60 % of the world average
Common level	<30 % of the average of high-income countries and 60 % of the world average

a.2006
b.2010
c.2015
d.2020

Legend
- Ultra-high level
- High level
- Intermediate level
- Common level
- No data

0 500 km

Note: This map is based on the standard map of GS(2023)2763 downloaded from the Standard Map Service website of the Ministry of Natural Resources,and the base map is not modified.

Fig. 2. Level of modernization after gridding, 2006-2020

(Figure 2). After the level of modernization is gridded, the level of modernization at all levels is fragmented, and the boundaries of administrative regions disappear, but the spatial location of important cities such as provincial capitals is still obvious. On the whole, the level of modernization in China is at the level of primary development, and it is characterized by high in the east and low in the west, showing an upward trend. However, from the local point of view, it is still based on the urban center as the core of the local modernization level, and shows a trend of outward expansion.

4   DISCUSSION

This paper selects the three dimensions of economy, society and environment to construct a modern evaluation index system and measure it, and uses remote sensing data for gridding. The economic development of the eastern coastal areas is earlier, the modernization level is higher, and the modernization process is faster[11].

In this paper, the modernization level grid is based on the municipal administrative unit. The next research can consider using county-level data and combining more relevant remote sensing data for gridding to improve accuracy.

5   CONCLUSIONS

From 2006 to 2020, the overall level of China 's modernization is on the rise, and the absolute gap in the level of modernization is obviously narrowing. The eastern coastal and inland provincial capital areas have a higher level of modernization, while the western and northeastern marginal areas have a lower level of modernization. After gridding, the distribution of modernization levels at all levels is more fragmented, breaking through the original administrative boundaries, but from a local perspective, the level of local modernization with the city center as the core still shows a trend of outward expansion.

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