Chlorophyll retrieval of typical lakes in southeast Hubei Province based on landsat-8

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ABSTRACT

Body chlorophyll a is an important index to reflect the quality of water quality, and it is also the primary consideration for water quality monitoring based on satellite remote sensing images. Taking five typical lakes in southeastern Hubei as an example, this paper studied the chlorophyll inversion model applicable to five lakes in southeastern Hubei on November 11, 2021 under the combination mode of various bands of Landsat-8 images. Based on the measured chlorophyll a data on the ground, the accuracy of different chlorophyll inversion methods was evaluated, and the chlorophyll content and spatial distribution were obtained by the final inversion. The experimental results show that the accuracy of the multi-band combination is high, and the correlation between the B5/B4 band combination and the chlorophyll a content is the highest. The fitting coefficient of the model is higher than 60%, and the inversion accuracy is good. The distribution of chlorophyll was different in different degrees. The chlorophyll concentration in most lakes was higher on the shore and lower in the center of the lake.

Keywords: Remote sensing, chlorophyll a, spatial distribution

1. INTRODUCTION

Lakes and rivers play an irreplaceable role in the earth's ecosystem and are also an important part of the hydrosphere[1]. However, with the rapid development of human industrialization, human beings are faced with various environmental problems[2]. Lakes and rivers are suffering from serious pollution problems. The water quality of lakes is deteriorating, and the continuous occurrence of eutrophication also has an impact on human activities, so the change of water quality has gradually attracted attention. Suspended matter and colored soluble organic matter, etc. Comprehensive monitoring of these indicators is conducive to reflecting the quality of water[3].

There are many methods for monitoring and early warning water quality. For example, the traditional water monitoring method mainly involves manual sampling and chemical analysis[4]. However, due to the large area of water bodies such as lakes, the high cost of human and material resources, and the small measurement range, the overall water quality of lakes cannot be fully reflected. At the same time, manual sampling cannot meet the real-time dynamic water monitoring, the timeliness is poor, cannot play a timely warning role. With the progress of science and technology, more and more means of water quality detection have been developed, such as drones, remote sensing satellites and other methods are gradually emerging[5].

Compared with traditional monitoring methods, remote sensing has incomparable advantages, such as wide monitoring range and strong timeliness, long-term and dynamic monitoring of lake water quality[6], timely warning of eutrophication such as bloom, which improves the limitations of traditional water quality monitoring methods[7], and the cost of obtaining remote sensing data is also more convenient than traditional methods. This also greatly improves the efficiency of monitoring water quality changes.

2. METHODOLOGY

Water quality remote sensing inversion methods mainly include analytical method, empirical method and semi-empirical method. In addition, with the continuous development of remote sensing technology, new methods such as machine

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learning have also appeared.

The analysis method is based on the biological-optical model as the core. According to the optical mechanism of water body and the radiation transfer equation, the ratio of the actual absorption coefficient and the backscattering coefficient is calculated by using the reflectivity of remote sensing, and the inversion model between the reflection spectrum and water quality parameters is constructed[8]. This model has strong physical properties, so it is also known as the physical analysis method. This method needs to obtain a large number of water quality parameters and optical properties to establish a regional parameter model, but because the optical properties of water bodies are difficult to obtain, this method has certain spatial and temporal limitations.

The empirical method is to establish a regression model by selecting different wavebands or combinations of wavebands, and then select remote sensing data at the same time and use water quality data monitored on the ground for water quality inversion[9]. This method is a relatively simple and easy to implement method, so it is widely used in different water bodies. However, due to the different optical properties of different water bodies, And the absorption bands are not the same, so the lack of certain generality, commonly used empirical models include two-band ratio, three-band ratio, multi-band linear model and nonlinear model.

Semi-empirical method emerged in the 1990s. It combines the spectral information of water quality parameters with statistical model, and establishes the optimal band combination to establish a mathematical statistical model[10]. It not only has certain physical significance, but also has the advantages of both analytical method and empirical method. Semi-empirical method can calibrate the field measured water spectral data independent of remote sensing image[11] to reduce the dependence on ground measured data. However, this method requires highly synchronized measured data and remote sensing data, so it also has certain time limitations.

From the above model, it can be seen that the traditional methods are basically to select a specific band and combine the measured data and remote sensing satellite images to build a linear model. In recent years, with the continuous development of artificial intelligence, the construction of non-linear models through machine learning has also been widely used, such as BP neural network, support vector machine and hybrid algorithm[12]. With the continuous development of artificial intelligence technology, the traditional machine learning method represented by artificial neural net ANN has strong adaptability, self-organization and fault tolerance. Because this method can simulate extremely complex relationships, it has become an efficient remote sensing retrieval strategy for water quality. For example, Zhang et al.[13], taking Taihu Lake as an example, built two machine learning method models for retrieving chlorophyll a concentration in Taihu Lake based on MODIS remote sensing images, and evaluated the generalization ability of the two models from three aspects: model validation, stability and robustness analysis, and comparison of the inversion results of the whole lake. Zhu[14] proposed a hyperspectral inversion model of inland water quality parameters (VIP-BP) based on multivariate optimization modeling strategy. Based on the optimization results of water spectral information and combined with BP neural network algorithm, the influence of spatial and temporal resolution of satellite remote sensing data on the inversion results of river water quality parameters was discussed.

3. RESEARCH PROGRESS OF LAKE WATER QUALITY PARAMETERS

Chlorophyll is one of the important indicators for detecting changes in water quality and an index to measure the degree of eutrophication of water body. Therefore, many scholars at home and abroad use remote sensing satellites to invert the chlorophyll concentration of lake body to monitor changes in water quality. Wang et al.[15] used Sentinel-2 satellite images. Quantitative inversion of chlorophyll a and comprehensive nutrient status index of major rivers entering the sea in Lianyungang was carried out. The optimal model was applied to Sentinel-2 image on June 25, 2022, and the spatial distribution results of chlorophyll a concentration and comprehensive nutrient status index of major rivers entering the sea in Lianyungang were obtained. Sun et al.[16], taking Chaohu Lake and the lower reaches of Nanfeihe River tributary as research areas, used Sentinel-2 satellite remote sensing data sources to construct a chlorophyll a concentration inversion model, explored the spatial-temporal variation of chlorophyll A concentration, and built a deep neural network (DNN) model. Nie et al.[17] selected the latest sun-induced chlorophyll fluorescence data to characterize vegetation productivity in the Yangtze River Basin. Based on the Global Terrestrial Data Assimilation System (GLDAS v.5) dataset, adopted the partial least squares regression method to systematically identify the spatial-temporal evolution of SIF in the Yangtze River Basin, and analyzed the response of SIF to changes in precipitation, temperature and net radiation. Leng[18] constructed a new algal bloom monitoring index, Denoising algal bloom index (DABI), based on the long time series Landsat satellites. Based on multi-period satellite remote sensing data, the spatio-temporal variation of chlorophyll concentration during the non-ice period in 2016-2022 and the spatio-temporal characteristics of algal bloom outbreak during 1986-2022 in Daihai were analyzed.

4. RESULTS AND DISCUSSION

4.1 Research area

The southeastern Hubei region (113.53 °-116.13 °E, 29.03 °-table30.89 °N) is densely covered with river networks, and the number of lakes and reservoirs is close to 2/3 of the total in Hubei Province, which plays an important role in the Yangtze River protection strategy. This study selected 5 typical lakes in southeast Hubei, namely, Xiandao Lake, Baoan Lake, Daye Lake, Wanghu Lake and Cihu Lake, as Figure 1. The ecological system of Xiandao Lake is relatively sound, and the network lake is seriously polluted by agriculture, but the former is an aquaculture lake and the latter is an urban lake, which are representative.

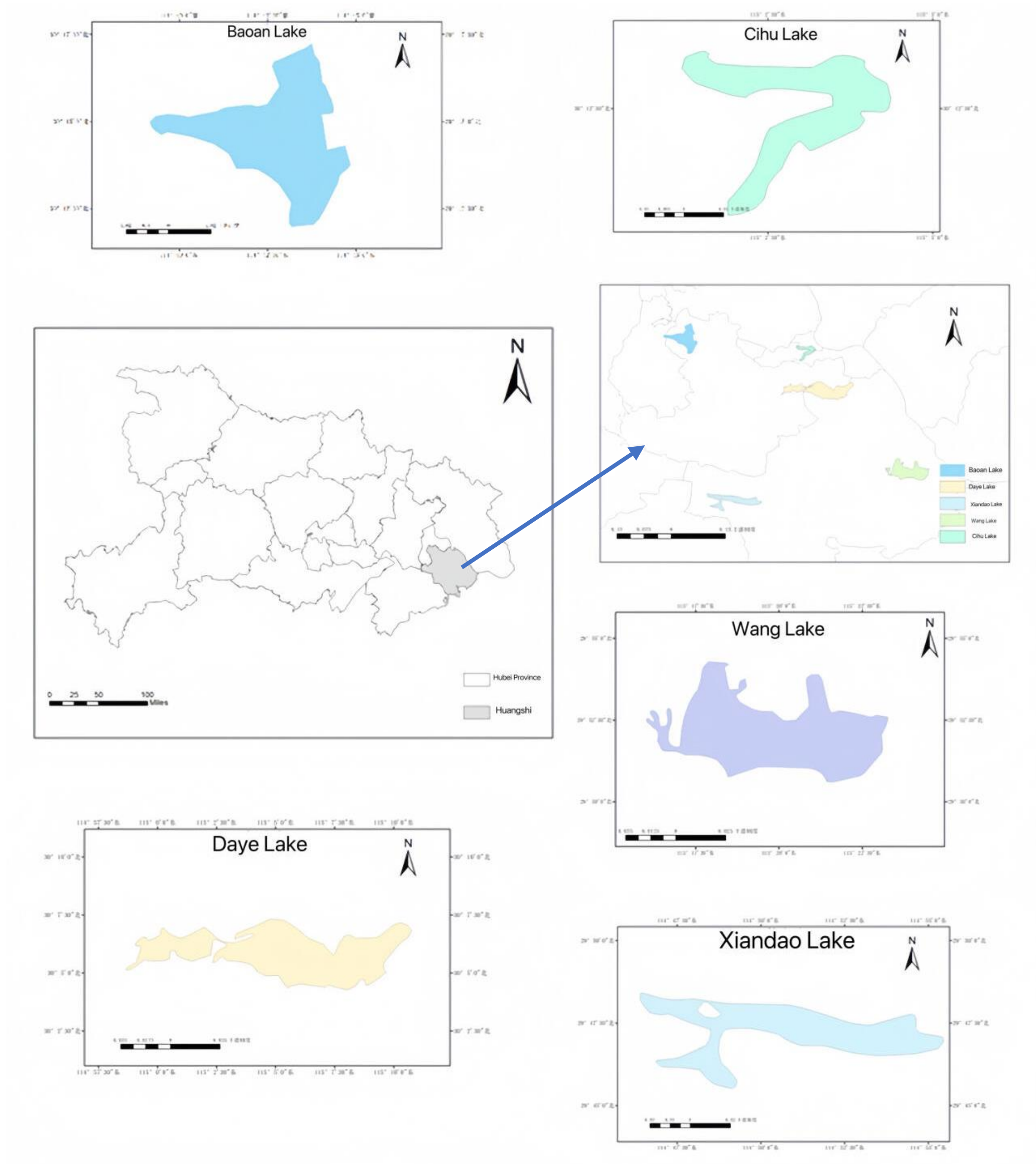

Figure 1. Distribution map of five lakes in southeastern Hubei.

4.2 Data collection

Landsat-8, launched on February 11, 2013, is part of the U.S. Land Survey series, which includes the Thermal Land Imager (OLI) and Thermal Infrared Sensor (TIRS). The OLI sensor consists of a total of nine bands, covering all bands from infrared to visible light[19].

4.3 Application of water quality inversion

In this paper, five typical lakes in southeastern Hubei were selected as the research area to analyze the correlation between chlorophyll a content in water on November 11, 2021 and each band and band combination of Landsat8 images, and the correlation analysis of different bands and different band combinations was carried out. The results show that the correlation between chlorophyll a and spectral data can be significantly improved by using band combination. The accuracy of this model can be used for the inversion of chlorophyll a content in selected lakes. The distribution maps of chlorophyll a in five lakes are shown as Figure 2 follows:

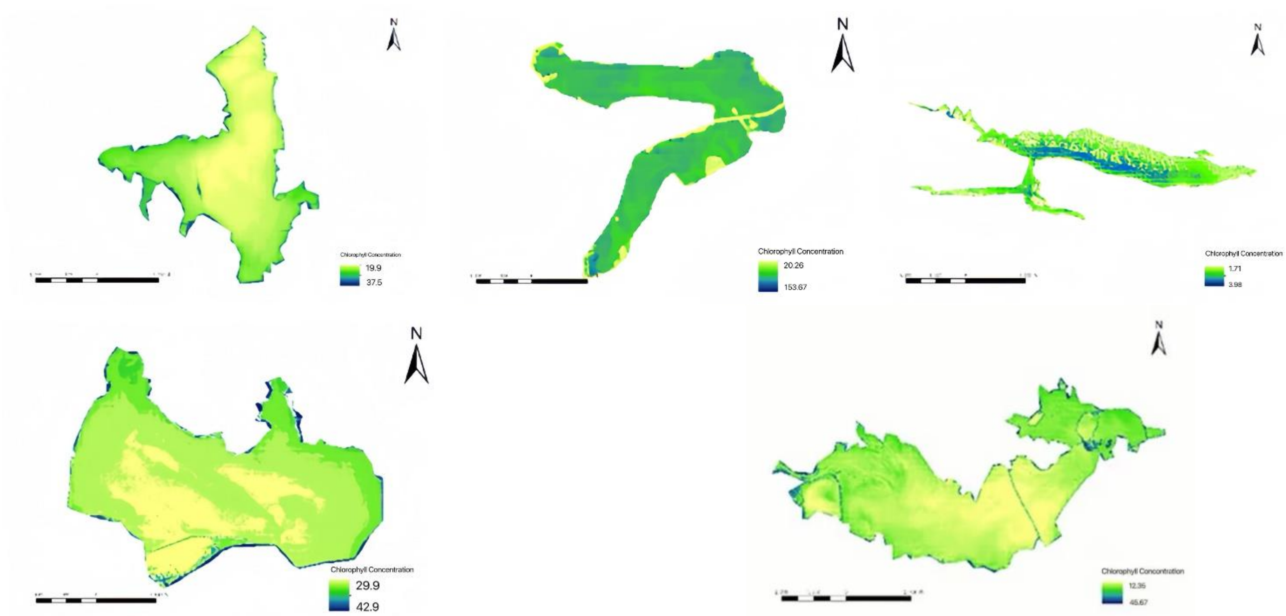

Figure 2. Distribution map of five lakes in southeastern Hubei.

5. CONCLUSIONS

According to the inversion results and images, the method of band combination has achieved a good effect in chlorophyll inversion of five lakes in southeast Hubei Province, which is helpful to the development of water quality inversion. However, there are some problems:

(1) The data source of the water quality prediction model is remote sensing data and field measurements, and there are some human factors, so it is necessary to improve the spatial resolution and radiation resolution, as well as the uncertainty in the process of data transmission and interaction.

(2) Water quality characteristics are affected by many factors, so it is necessary to further explore how to add additional variables to improve the prediction accuracy of the model.

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