Remote sensing retrieval of chlorophyll-a concentration in the coastal waters of Hong Kong based on Landsat-8 OLI and Sentinel-2 MSI sensors

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Abstract. Using Landsat-8 OLI remote sensing data and Sentinel-2 MSI remote sensing data as data sources, selecting the coastal waters of Hong Kong as the study area, using semi-analytical model as the method, selecting the same time as the measured chlorophyll-a concentration at the monitoring point and the cloud coverage rate of remote sensing images two types of remote sensing images with clear images less than 10%. For the two types of remote sensing images, two thirds of the remote sensing image data are selected after preprocessing, and the remote sensing reflectance of the monitoring point location corresponding to the actual date is extracted for correlation analysis, and the most relevant inversion factor is obtained for modeling. Meanwhile the remaining 1/3 of the data is used to test the accuracy of its inversional regression model. The best inversional regression model based on Landsat-8 remote sensing data is $Y=6.8x^2-20.77x+17.02$, $R^2=0.906$ which is slightly higher than the best inversional regression model based on Sentinel-2 remote sensing data $Y=-3.345e+05x^2+3826x-3.44$, $R^2=0.801$, which proves the feasibility of inverting the two types of remote sensing data for the chlorophyll-a concentration in the Hong Kong offshore waters, and the inversional results of the two types of data show that the chlorophyll-a concentration in the internal waters of the Hong Kong offshore waters is higher than the phenomenon of external chlorophyll-a concentration.

1. Introduction
With the substantial increase in the number of coastal populations, marine environmental protection in offshore waters is also facing great challenges. Under the dual pressure of man-made destruction and natural factors, the water quality of offshore waters has seriously declined. It is urgent to monitor and repair the ecological environment of offshore waters to protect the marine environment. Chlorophyll-a is an important part of the water body, and its concentration can accurately and effectively reflect the biological content of phytoplankton in the water body. It is the main evaluation parameter of marine primary productivity, and it is also one of the important indicators for monitoring the water quality and the degree of nutrition of the water body.

The coastal waters of Hong Kong belong to the typical coastal waters, which are obviously affected by the comprehensive pollution of terrestrial resources and marine environment. The water quality is a second-class water body, and its main uses are fish farm aquaculture, industrial manufacturing cooling water source, waste water discharge location and offshore Transportation etc. As the economic development along the Pearl River Estuary in the western part of Hong Kong is increasing, the water pollution of the industrial area and the domestic sewage of residents accompanying the development have greatly affected the water quality of Hong Kong seas. In order to improve the above-menioned...
phenomenon, reasonably and effectively repair the sea environment of Hong Kong, monitoring the sea water color and water quality of the sea has become one of the main methods and means.

Due to the strong regional quality of the second-class water body and the complex composition of the water body, it is costly to monitor the seawater quality by artificially deploying seawater sampling and monitoring methods, and the workload is heavy. At the same time, with the increasing improvement of remote sensing technology, the use of satellite remote sensing data to monitor the spatial distribution of chlorophyll in offshore waters has become the main way to monitor sea water color and water quality. Using satellite remote sensing data to retrieve chlorophyll-a concentration mainly includes empirical analysis method, semi-analytical model method, and theoretical analysis method [1]. In the study of using the semi-analytical model method to estimate the concentration of chlorophyll-a, OC3 (ocean chlorophyll 3), OC4 (ocean chlorophyll 4), and a series of algorithms established by O'Reilly et al. are used as NASA official business algorithms for processing global chlorophyll-a concentration data [2]. However, because the MODIS data is applied to ocean water color with a spatial resolution of 1km, it is suitable for large-scale ocean water color changes research, and is not applicable to Hong Kong offshore waters. N. Wagle et al. obtained the chlorophyll-a concentration of Lake Phewa in Kaski District by linking the measured data and the band emissivity extracted from Landsat-8 remote sensing images [5]. Luan Hong et al. used Landsat-8 OLI multispectral data to perform quantitative remote sensing inversion of suspended sediment and chlorophyll-a in the Pearl River Estuary, and realized the quantitative inversion and monitoring of suspended sediment and chlorophyll-a by the OLI sensor [3]. Yang Guangpu et al. used Landsat TM/ETM+ images from 1986 to 2015 to construct a quantitative inversion model based on measured data, combined with the measured chlorophyll-a concentration data in Jiaozhou Bay, and obtained the distribution of chlorophyll-a concentration in the sea area of Jiaozhou Bay in the past 30 years [4]. Each parameter inversion for water bodies has strict directivity. Different types of water bodies, different water body parameters of the same type of water body, and the obtained inversion models are completely different. Therefore, the above-mentioned inversion models for water bodies in different regions are completely different. The parameter sensitivity is different, and the coastal waters of Hong Kong have their own sensitive parameters to optical images. Hongyan Xi and others used the method of profile data extrapolation and water spectrum simulation to complete the extrapolation of the remote sensing reflectance spectrum of the underwater surface, and established a semi-analytical algorithm for the inversion of chlorophyll-a in the low-concentration area [6], but only performed on part of the sea near Hong Kong. The results of the study did not cover the entire Hong Kong waters. However, most of the existing inversions based on Landsat-8 OLI and Sentinel-2 MSI remote sensing data are concentrated in inland lakes, lakes and The water structure of the ocean is different, and the water quality characteristics are different, which proves the feasibility of the above two types of data for establishing the chlorophyll-a concentration inversion model suitable for the offshore waters belonging to the typical second type of water. The inversion of remote sensing image data has strict requirements on the cloud coverage of the image, and the re-return period of the above two types of data is relatively long. It is particularly important to study the two types of data for comprehensive monitoring of water color and water quality changes of this type of water.

In view of the above phenomena, this paper uses Landsat-8 and Sentinel-2 remote sensing image data, taking Hong Kong offshore waters as the research object, combining the two remote sensing image multispectral data and the measured chlorophyll-a concentration data, using the semi-analytical model method, establish their corresponding chlorophyll-a concentration inversion models, determine the best inversion models of the two remote sensing image data through accuracy evaluation. The obtained model was used to invert the chlorophyll-a concentration in the offshore waters of Hong Kong Port during the effective operation period of the two data satellites during the three years 2017-2019, and the inversion results were analyzed.

2. Data acquisition and preprocessing

2.1. Measured data acquisition
The coastal waters of Hong Kong are located on the southern coast of China, the northern part is close to Guangdong Province, the south bank faces the South China Sea, the west bank faces the Pearl River mouth, and the eastern part is a semi-enclosed area. The measured data of chlorophyll-a in the coastal waters of Hong Kong Port used in this study were downloaded from the official website of the Hong Kong Environmental Protection Agency (https://cd.epic.epd.gov.hk/), a total of 10 water quality control areas, 76 monitoring stations, and monitoring points It is distributed around the coast of Hong Kong in a circle. The sampling period of each station varies from two to three times a month depending on the degree of water pollution. The measured chlorophyll-a concentration data downloaded in this article correspond to the cloudless and clear data dates of Landsat-8 and Sentinel-2 remote sensing images, and the unit is μg/L.

Figure 1. The geographical location of the study area and the distribution of the monitoring points of the measured chlorophyll-a concentration

2.2. Remote sensing image data acquisition and processing

2.2.1. Landsat-8 OLI remote sensing data acquisition and processing

Landsat-8 satellite was successfully launched by NASA on February 11, 2013. Landsat-8 remote sensing data can be obtained through the official website of the United States Geological Survey USGS (https://earthexplorer.usgs.gov/), this article the remote sensing image data used is the multispectral data taken by the OLI (Operational Land Imager) sensor of the satellite. This article downloads 11 remote sensing images with cloud coverage below 10% over the study area from 2013 to 2018, good atmospheric transparency, and corresponding chlorophyll-a measured data collection dates.

The preprocessing of Landsat-8 remote sensing images includes radiometric calibration, atmospheric correction, water and land separation, and band reflectivity extraction. Radiation calibration is a process of converting the DN value of the image into physical quantities such as radiation intensity or reflectance through corresponding calculations. For Landsat-8 data, the radiation intensity value is calculated by the following formula:

\[ L_\lambda = \text{gain} \times DN + \text{offset} \]  

In the formula, \( L_\lambda \) is the corresponding thermal radiation intensity value (W•m\(^{-2}\)•sr\(^{-1}\)•μm\(^{-1}\)) when the wavelength of the multi-spectral and thermal infrared data is \( \lambda \), obtained by using the Radiometric Calibration module in the ENVI 5.3 software; DN is Pixel value; gain is the band gain coefficient (W•m\(^{-2}\)•sr\(^{-1}\)•μm\(^{-1}\)•DN)), offset is the offset coefficient (W•m\(^{-2}\)•sr\(^{-1}\)•μm\(^{-1}\)), above These parameters can be obtained from the header file (MTL.txt) of the original Landsat-8 image [7]. Atmospheric correction is due to the fact that most of the various radiant energy received by satellite remote sensing (mainly the solar short-wave radiation energy) is the energy that is attenuated after a series of processes such as atmospheric scattering and absorption. During the energy absorption process, it is affected by these factors. The spectrum finally received by the sensor will also change. In order to remove the interference from the atmosphere and obtain the true surface emissivity, the image needs to be
atmospherically corrected so that it can accurately reflect the surface information. This paper uses the FLAASH model in the ENVI5.3 software to perform atmospheric correction on Landsat-8 multispectral data. This module is based on pixel-level corrections based on the MODTRAN atmospheric radiation transmission model. Finally, according to the normalized water body difference coefficient (NDWI), determine the suitable water threshold value in the coastal waters of Hong Kong, carry out water and land separation to accurately extract the water body information of the study area, and use the ARCGIS software to extract the remote sensing reflectance of each band from the monitoring point [8].

2.2.2. Sentinel-2 MSI remote sensing data acquisition and processing
This article is through the official website of the United States Geological Survey USGS (https://earthexplorer.usgs.gov/) Download a total of 11 scenes of Sentinel-2 image data with cloud coverage below 10% over the study area from 2017 to 2018, including 5 scenes of Sentinel-2A image data and 6 scenes of Sentinel-2B image data view.

The preprocessing of Sentinel-2 remote sensing image data includes atmospheric correction, resampling, geometric correction, water and land separation, and band reflectance extraction. This article downloads Sentinel-2L1C-level remote sensing image data. The data covers an area of 100 square kilometers. It is composed of UTM/WGS84 projection orthographic images. The digital elevation model (DEM) is used for orthographic correction and projected to the cartographic coordinates. Atmospheric correction uses the open source atmospheric correction plug-in Sen2Cor provided by ESA itself, which is the Sentinel-2 L2A product generation and formatting processor. The B10 band will be deleted after atmospheric correction. This band is mainly used for atmospheric correction. Cumulus information [11]. Resampling is based on the S2 Resampling Processor of SNAP software, using the nearest neighbor method, with a resolution of 10m. Use the Landsat-8 image after geometric precision correction as the reference image, use the image Registration Workflow plug-in in ENVI5.3 software, select the points with the same name and use the cubic convolution method for geometric correction. Use the geometry extraction tool in ARCGIS to obtain the remote sensing reflectivity of each band of the monitoring point.

### Table 1. Landsat-8 OLI and Sentinel-2 MSI imaging parameters

| Date of measured data | Sensor          | Date of measured data | Sensor          |
|-----------------------|-----------------|-----------------------|-----------------|
| 2013-10-28            | Landsat-8 OLI   | 2014-01-16            | Landsat-8 OLI   |
| 2014-10-15            | Landsat-8 OLI   | 2015-01-19            | Landsat-8 OLI   |
| 2016-01-06            | Landsat-8 OLI   | 2016-07-25            | Landsat-8 OLI   |
| 2017-10-12            | Sentinel-2A     | 2017-10-27            | Sentinel-2B     |
| 2017-11-01            | Landsat-8 OLI   | 2017-11-01            | Sentinel-2A     |
| 2017-11-17            | Landsat-8 OLI   | 2017-12-11            | Sentinel-2A     |
| 2018-01-11            | Landsat-8 OLI   | 2018-01-12            | Sentinel-2B     |
| 2018-01-15            | Sentinel-2B     | 2018-01-17            | Sentinel-2A     |
| 2018-03-09            | Landsat-8 OLI   | 2018-06-11            | Sentinel-2B     |
| 2018-09-19            | Sentinel-2B     | 2018-10-03            | Landsat-8 OLI   |
| 2018-11-21            | Sentinel-2B     | 2018-11-23            | Sentinel-2A     |

3. Chlorophyll-a concentration inversion
The semi-analytical model inversion mainly uses the reflectance of the band or the reflectance of the band combination to establish a formula algorithm for the concentration of chlorophyll-a. After the Landsat-8 and Sentinel-2 remote sensing image data are preprocessed, the measured chlorophyll-a concentration and the reflectance of each band of the two multispectral data at the Hong Kong offshore waters monitoring site are analyzed by Pearson correlation, and the correlation with the measured data is obtained. And perform various types of band mathematical combinations. Finally, the band or combination of bands with the greatest correlation with the measured data is obtained. With this factor
as the independent variable and the measured chlorophyll-a concentration as the dependent variable, the chlorophyll-a concentration inversion model is established.

3.1. Determination of chlorophyll-a concentration inversion band

Randomly select 2/3 of the measured data and its corresponding Landsat-8 band reflectivity, and conduct Pearson correlation analysis. The correlation results show that in the B2 (450-510nm) band, the remote sensing reflectance has the highest correlation with the measured value of chlorophyll-a. Combined with the reflection spectrum characteristics of chlorophyll, it has a strong absorption effect on blue and red light with chlorophyll. The reflection effect near the band (green light) is at a peak state. At the same time, the correlation between the two bands of B1 (430-450nm) and B3 (530-590nm) and the measured chlorophyll-a concentration is also very significant, indicating that the chlorophyll-a concentration will be relatively compared for the band where the reflectivity is not very high. Sensitive.

Table 2. Landsat-8 remote sensing data band and band combination reflectivity and measured chlorophyll-a concentration correlation coefficient

| Band combination | Correlation coefficient | Band combination | Correlation coefficient |
|------------------|-------------------------|------------------|-------------------------|
| B1               | -0.692                  | B2               | -0.707                  |
| B3               | -0.653                  | B4               | -0.565                  |
| B5               | -0.445                  | B6               | -0.396                  |
| B7               | -0.429                  | B6/B3            | 0.761                   |
| B7/B3            | 0.736                   | B3/B1            | -0.72                   |
| (B2+B4)/(B3+B1)  | 0.775                   | (B2+B3)/(B1+B4)  | **0.816**               |
| (B1+B4)/(B3+B2)  | 0.715                   | (B3-B4)/(B3+B4)  | -0.622                  |

Combining the experience of research on the inversion of marine chlorophyll-a concentration, the currently commonly used water color remote sensing inversion band types mainly include: single band factor, dual band ratio, multi-band combination, normalized vegetation index, etc. [9-10]. In this paper, using 2/3 of the measured chlorophyll-a concentration data and the remote sensing reflectance extracted from the corresponding Landsat-8 remote sensing image data, combined with the above single-band correlation value (r), the above-mentioned inversion factors are performed on the 7 bands of Landsat-8 Combine, and perform Pearson correlation analysis again for the results of the combination and the actual measured chlorophyll-a concentration. From the analysis results, it is concluded that (B2+B3)/(B1+B4) has the highest correlation with the measured data, r=0.816, and this band is used as the input variable for the semi-analytical model of Landsat-2 OLI remote sensing data.

Using randomly selected 2/3 of the measured data and its corresponding Sentinel-2 band reflectivity, the Pearson correlation analysis was performed. The correlation analysis results are shown in Table 3. The correlation coefficient between the reflectance of the B2 band and the measured chlorophyll-a concentration is -0.817, showing an obvious negative correlation. The B1 band is second only to it, and also showing a significant trend of correlation. The remaining bands also show a correlation with the measured chlorophyll-a concentration unevenness. Because Sentinel-2 remote sensing data has more bands, the bands with a correlation coefficient greater than 0.5 are selected for dual-band ratio, multi-band combination, and normalization. The vegetation index and other combinations are used as the inversion factor and the corresponding measured chlorophyll-a concentration to perform Pearson correlation analysis again. The correlation results show that 1/B2 This band has the best correlation with the measured data r=0.857, which is determined to be the input independent variable to determine the semi-analytical model of Sentinel-2 MSI remote sensing data.
Table 3. Sentinel-2 remote sensing data band and band combination reflectivity and measured chlorophyll-a concentration correlation coefficient

| Band combination | Correlation coefficient | Band combination | Correlation coefficient |
|-------------------|-------------------------|-------------------|-------------------------|
| B1                | -0.815                  | B2                | -0.817                  |
| B3                | -0.743                  | B4                | -0.735                  |
| B5                | -0.67                   | B6                | -0.629                  |
| B7                | -0.593                  | B8                | -0.631                  |
| B8A               | -0.601                  | B9                | -0.272                  |
| B11               | -0.404                  | B12               | -0.388                  |
| B3/B4             | 0.703                   | (B1+B2)/(B4+B8)   | 0.666                   |
| 1/B2              | **0.857**               | (B3+B5)/(B4+B6)   | 0.674                   |

3.2. Based on Landsat-8 OLI and Sentinel-2 MSI chlorophyll-a concentration inversion model

The above results indicate that for Landsat-8 remote sensing data, the (B2+B3)/(B1+B4) combination as the inversion factor and the measured chlorophyll-a concentration correlation analysis shows that the significance P is less than 0.001, indicating that it is 99% The two are significantly correlated within the confidence interval of, so they are used as the characteristic variable of the inversion model of chlorophyll-a concentration in the coastal waters of Hong Kong Port based on Landsat-8 remote sensing data. In the same way, 1/B2 is combined as the inversion band, which is the characteristic variable for constructing the inversion model of chlorophyll-a concentration in the coastal waters of Hong Kong based on Sentinel-2 remote sensing data. Using the principle of least squares curve fitting, the inversion factors of the above two kinds of remote sensing data are used as independent variables, and the corresponding measured chlorophyll-a concentration is used as the dependent variable. Matlab software is used to perform regression analysis on them, and the unary linear and e Exponential, quadratic, logarithmic, and power exponential models.

Using the coefficient of determination and the root mean square error to evaluate the accuracy of the established inversion model, for Landsat-8 OLI remote sensing data, the univariate quadratic model \( Y=6.8x^2-20.77x+17.02 \) \( R^2=0.728 \), which proves its high accuracy For the remaining four models, RMSE=1.189, and the deviation between the inverted value of the one-variable quadratic model and the measured value is smaller than that of the other four models, so \( Y=6.8x^2-20.77x+17.02 \) is selected as Landsat-8 remote sensing data for Hong Kong offshore waters The semi-analytical model for the inversion of chlorophyll-a concentration; in the same way, for the Sentinel-2 MSI remote sensing data, the univariate quadratic model \( Y=-3.345e+05x^2+3826x-3.44 \), \( R^2=0.7579 \), RMSE=1.047, which proves that the inversion result is better than that The remaining four regression models are used as Sentinel-2 remote sensing data to retrieve the chlorophyll-a concentration in the coastal waters of Hong Kong.

Table 4. Based on Landsat-8 OLI and Sentinel-2 MSI chlorophyll-a concentration remote sensing inversion model and accuracy comparison

| Data       | Inversion band | name    | Model method | R²      | RMSE |
|------------|----------------|---------|--------------|---------|------|
| Landsat-8  | (B2+B3)/(B1+B4)| Quadratic| \( Y=6.8x^2-20.77x+17.02 \) | 0.7280  | 1.189|
|            |                | e index | \( Y=18.74e^{-1.928x} \) | 0.7000  | 1.230|
|            |                | Linear  | \( Y=-8.65x+13.50 \) | 0.6825  | 1.265|
|            |                | Logarithmic | \( Y=6.045\ln(x)+3.149 \) | 0.6779  | 1.275|
|            |                | Power exponent | \( Y=2.71x^{-0.8635} \) | 0.5298  | 1.540|
Quadratic: $Y = -3.345 \times 10^5 x^2 + 3826x - 3.44$

Exponential: $Y = 0.9198e^{45.3x}$

Linear: $Y = 1903x - 1.284$

Logarithmic: $Y = 10.89 \ln(x) + 32.36$

Power exponent: $Y = 9128x^{1.324}$

4. Results and analysis

4.1. Inversion model accuracy check

In order to verify the accuracy of the above inversion model, the remaining 1/3 remote sensing reflectivity of Landsat-8 and Sentinel-2 remote sensing images were used to substitute the respective inversion models to calculate the chlorophyll-a concentration verification value, and the corresponding chlorophyll-a concentration measured value. The results are shown in the table. The average relative error of the verification results based on the Landsat-8 remote sensing data inversion model is 42.474, $R^2=0.906$, RMSE=1.395. The average relative error of the verification result obtained based on the Sentinel-2 data inversion model is 29.914, $R^2=0.801$, RMSE=0.868. The $R^2$ result shows that the inversion model based on the Landsat-8 remote sensing data is better than the Sentinel-2 remote sensing data inversion model. The result of linear fitting between the verified value and the measured value is better; and the RMSE result shows that the former has a greater degree of deviation from the measured value than the latter, and the result obtained based on the Sentinel-2 remote sensing data inversion model is more detailed.

| Y = | 0.7579 | 1.047 |
|-----|---------|-------|
| e index | 0.6350 | 1.268 |
| Linear | 0.7344 | 1.082 |
| Logarithmic | 0.7404 | 1.069 |
| Power exponent | 0.7151 | 1.120 |

Table 5. Landsat-8 and Sentinel-2 remote sensing data inversion model verification

| Measured value (g/L) | Verification value (g/L) | Relative error (%) | Measured value (g/L) | Verification value (g/L) | Relative error (%) |
|----------------------|--------------------------|--------------------|----------------------|--------------------------|--------------------|
| 1.2                  | 2.12                     | 76.67              | 0.8                  | 0.35                     | 56.25              |
| 2.7                  | 1.20                     | 55.56              | 0.7                  | 0.62                     | 11.43              |
| 2.8                  | 1.77                     | 36.79              | 1.8                  | 1.22                     | 32.22              |
| 12.0                 | 15.36                    | 28.00              | 5.7                  | 3.18                     | 44.21              |
| 1.8                  | 1.19                     | 33.89              | 2.4                  | 2.01                     | 16.25              |
| 1.8                  | 1.59                     | 11.67              | 1.9                  | 1.72                     | 9.47               |
| 1.9                  | 1.27                     | 33.16              | 1.6                  | 2.00                     | 25.00              |
| 3.1                  | 1.61                     | 48.06              | 3.3                  | 3.02                     | 8.48               |
| 1.9                  | 1.30                     | 31.58              | 4.4                  | 2.64                     | 40.00              |
| 3.1                  | 1.35                     | 56.45              | 0.7                  | 0.72                     | 2.86               |
| 1.5                  | 2.06                     | 37.33              | 1.0                  | 1.24                     | 24.00              |
| 2.3                  | 1.59                     | 30.87              | 0.9                  | 1.09                     | 21.11              |
| 3.1                  | 1.17                     | 62.26              | 0.6                  | 1.20                     | 100.00             |
| 1.7                  | 2.59                     | 52.35              | 1.9                  | 1.31                     | 31.05              |
|                     |                          |                    | 1.1                  | 1.39                     | 26.36              |
| Average relative error | 42.474                  |                    |                      | 29.914                   |                    |
| $R^2$                | 0.906                    |                    |                      | 0.801                    |                    |
| RMSE                 | 1.395                    |                    |                      | 0.868                    |                    |
4.2. Chlorophyll-a concentration inversion

In order to further intuitively compare and analyze the models used to retrieve the chlorophyll-a concentration in the coastal waters of Hong Kong from Landsat-8 OLI remote sensing data and Sentinel-2 MSI remote sensing data, the two sensors were selected for high visibility and low cloud cover over Hong Kong. Same date (2017-October 2019) remote sensing images, using semi-analytical model to perform chlorophyll-a concentration regression processing on the images respectively.

The chlorophyll-a concentration distribution obtained by the inversion of the two types of data is obviously inconsistent. The area is located in the eastern Tolo port and the strait and the haven area of the coastal waters of Hong Kong. It can be clearly seen that the chlorophyll-a concentration retrieved based on Sentinel-2 remote sensing data is higher than that of Landsat-8. The concentration of chlorophyll-a retrieved from remote sensing data has changed significantly. Chlorophyll-a concentration distribution results in October 2018 can be seen in Figure 2(e), the highest chlorophyll-a concentration in the Tolo Harbor, Strait and Haven areas in Figure 2(e) reached 18.48 μg/L, and in this small area offshore in the sea area, the concentration of chlorophyll-a shows very obvious concentration changes, and the changes are abundant, and the results obtained based on Sentinel-2 remote sensing data are more refined.

Figure 2. An inversion map of the chlorophyll-a concentration distribution in the coastal waters of Hong Kong based on a semi-analytical model from 2017 to October 2019 (Figures a, b, and c are based on Landsat-8 OLI remote sensing data, and Figures d, e, and f are Sentinel-2 MSI remote sensing data).

Regarding the overall distribution of chlorophyll-a concentration in the coastal waters of Hong Kong, the inversion results of the two types of data both show that the chlorophyll-a concentration in the coastal waters is higher than that in the outside. The chlorophyll-a concentration in the Tolo Harbour, the strait and the shelter bay area located in the eastern sea area of Hong Kong are both higher. The chlorophyll-a concentration in the western buffer zone, southern buffer zone, northern buffer zone, and western buffer zone located in the western waters of Hong Kong is generally higher than that in the Victoria Bay area located in the southwest of Hong Kong.

5. conclusion

Based on Landsat-8 OLI and Sentinel-2 MSI remote sensing data, this paper uses a semi-analytical model algorithm to establish an inversion regression model for the chlorophyll-a concentration in the coastal waters of Hong Kong, and compares and analyzes the effects of the two types of data sources on the chlorophyll in the coastal waters of Hong Kong. a Concentration distribution results. Get the following conclusions:

a) Based on the semi-analytical model inversion, the best inversion factor calculated from the corresponding remote sensing reflectance extracted from the Landsat-8 remote sensing image data based on the measured chlorophyll-a concentration at the monitoring points in Hong Kong offshore waters is \( \frac{B2+B3}{B1+B4} \), \( R = 0.816 \). The best inversion factor calculated from the corresponding remote sensing reflectivity extracted from Sentinel-2 remote sensing image data is \( \frac{1}{B2} \), and \( r = 0.857 \). The best inversion regression model based on Landsat-8 remote sensing data is \( Y = 6.8x2 - 20.77x + 17.02 \),
R²=0.906. The best inversion regression model based on Sentinel-2 remote sensing data is Y=-3.345e+05x²+3826x-3.44, R²=0.801.

b) On the whole, Hong Kong's offshore waters also show a phenomenon that the chlorophyll-a concentration in the inner sea is higher than the outer chlorophyll-a concentration. However, the image data of the two types of sensors are limited by the inconsistency of transit time and cloud cover, which can be compared and there are too few images at the same time, these factors all affect the inversion accuracy and the comprehensiveness of the comparison of the two data inversion results to a certain extent.

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