A MODEL OF RETRIEVAL CDOM BASED ON THE HJ-1 SATELLITE

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KEY WORDS: CDOM, Absorption coefficient; Spectral slope; $a_g(440)$; Retrieval model.

ABSTRACT: Yellow Substances (also chromophoric dissolved organic matter, CDOM) is the pool of absorbing substance in water and it comes mainly from chlorophyll decomposer and terrestrially organic contamination. In the fields of water color remote sensing, its optical absorption properties are mainly described with absorption coefficient and spectral slope. In this study the satellite HJ-1/CCD was taken that has a relatively high spatial resolution as the sensor of non-water-color band to establish models of the CDOM concentration retrieval of offshore water body case II. The experimental data in-situ including the absorption coefficient of CDOM and apparent optical properties are obtained at the regions of Panjin, Liaoning province in May 2008, August 2009 and June 2010. With the measurement data, first, the exponential spectral slope (S) was determined; Secondly, the model of retrieval $a_g(440)$ based on the HJ-1 satellite four CCD sensors was created respectively, which can be as the concentration of yellow substances; Finally, the model for water CDOM retrieval from HJ-1 satellite was applied in the region of Liaodong bay.

1. INTRODUCTION

The satellites environment A & B (HJ-1A/1B) was successfully launched on September 6, 2008, each HJ-1A and HJ-1B were loaded with two CCD cameras of exactly the same designed principle, which are 4-band wide-cover multi-spectral visible light camera CCD, HJ-1A and HJ-1B are not color satellite, but the CCD cameras still has some information of water, which may serve as a water color remote sensing device of environment [1].

In the water color remote sensing, a_g (440) (the absorption coefficient at 440nm) is usually used to represent the concentration of CDOM in water, spectral slope S to represent the degree of attenuation of CDOM absorption coefficient. The current researches show that spectral slope S has no relation with CDOM concentration, but is related to its component, the simulation band range by establishing a model and reference wave length [2].

Currently, the CDOM concentration retrieval models established for water color sensors are mostly used the band ratio method[3-5] .Taking into account that HJ-1/CCD band set includes 670nm (B3) and 490nm (B1), the study area is located in estuaries, so based on the Bowers model[6], by using the experiment data obtained in Liaohe oil field of Panjin city, Liaoning province of CHINA in May 2008, August 2009 and June 2010, the remote sensing modes of retrieving CDOM optical characteristics are established, which can provide technical support for detecting organic contamination by remote sensing data.

2. EXPERIMENT AND DATA ACQUISITION

2.1 Experimental Description

The experimental field work was conducted in Panjin city, Liaoning province of China. In the region there are Liaohe oil field which is the third largest oil field in China and reed wetland which is largest in Asia. In November each year reed is processed in the paper mills after harvested. The activity of field's producing and paper-making is inevitably to bring about organic contamination.

The experimental time is in May 2008, August 2009 and June 2010. The experimental data in-situ included the absorption coefficient of CDOM, apparent optical properties, COD and petroleum pollutants concentration. The measuring method is showed in table 1 and seventy samples were obtained.

Table 1 the measuring data and methods

Items	Contents	Method	Reference standard
apparent optical properties	remote sensing reflectance	spectrometry (ASD)	NASA standard
inherent optical properties	absorption coefficient of CDOM	UV-3900, 350-900nm (HITACHI)	

2.2 Measurements of CDOM absorption coefficients

The measurement of CDOM absorption coefficients is using GF / F membrane to filter water samples and then measuring their absorbance by spectrophotometer. Firstly, soaked the polycarbonate membrane of 0.22μm aperture with 10% hydrochloric acid, and then filtered water samples with vacuum pump to obtain CDOM samples, used sample pools of 10cm length and made reference by Milli-Q water (pure water), the spectrophotometer is U-3010 of Hitachi, put the 10cm cuvette filled with water and sample cuvette into the two optical paths of spectrophotometer, measuring the optical density $OD_{bs}(\lambda)$ of the reference water (dimensionless) ; removed the sample cuvette, discarded the water, filled with samples, measuring the optical density of CDOM related to water $OD_s(\lambda)$ (dimensionless).In accordance with the specification of marine optical measurements given by NASA[7], CDOM absorption coefficient is calculated as,

$$a_g(\lambda)=2.303/L*[[OD_s(\lambda)- OD_{bs}(\lambda)]- OD_{null}] \qquad (1)$$

Where, L is the optical path of cuvette (typically 0.1m), $OD_s(\lambda)$is the optical density related to the reference water samples (dimensionless), $OD_{bs}(\lambda)$ is the optical density of blank pure water processed by the sample handling procedure related to the reference pure water (dimensionless), OD_{null} is the apparent residual optical density at the long wavelength band of visible light or at the bands of near-infrared where the absorption of dissolved substances can be assumed to be zero (dimensionless), which is the residual absorption of long wavelength visible light or near infrared band. In the specification of marine optical measurements given by NASA it is recommended that OD_{null} takes the average of 590-600nm, due to the turbid water body case II, taking the recommended 590 ~ 600nm band as a residual correction band will result in a "too low "estimate of CDOM absorption coefficients, mainly because the absorption of the dissolved substances of high turbidity in water case II at 590 ~ 600nm band is strong and small particles in filtered clear liquid may cause scattering, so in this paper, the residual correction method using 750nm wavelength band made for turbid water bodies by Bricaud et al. (1981) is applied[8], which is calculating the absorption coefficients of each wavelength λ(nm) by formula (2), and then correcting scattering by formula (3).

$$a_g(\lambda')=2.303/L*[OD_s(\lambda)- OD_{bs}(\lambda)] \qquad (2)$$

$$a_g(\lambda)= a_g(\lambda')- a_g(750)\cdot\lambda/750 \qquad (3)$$

Where, $a_g(\lambda)$ is the absorption coefficient of CDOM (m^{-1}) at wavelength λ; $a_g(\lambda')$ is the uncorrected absorption coefficient of CDOM (m^{-1}) at wavelength λ; $a_g(750)$ is the absorption coefficient of CDOM (m^{-1}) at wavelength 750nm; the meaning of λ, $OD_s(\lambda)$, $OD_{bs}(\lambda)$ and L is the same as formula (1).

2.3 Water spectrometry measurement

The aim of water spectrometry measurement is to reverse CDOM by using remote sensing reflectance. For water spectrometry measurement we applied visible near infrared spectroradiometer (ASD FieldSpec3 350-2500nm) produced by ASD company of the USA, the reference board is the 30% reflectance standard board. The measurement method was above the water surface, using (40°, 135°) relative observation geometry, where observation nadir angle was 40 °, the angle between equipment observation azimuth and solar was 135 °. At each observation point, measured in the order of the gray board, water, sky, gray board, gray shading board, each group measured 15 spectra, each spectral interval was 1 second.

3. INVERSION MODEL OF CDOM

3.1 Analysis of CDOM optical absorption characteristics

The optical properties of CDOM are expressed by absorption coefficient and its spectral slope and defined on the optics as some wavelength beam attenuation, in units of m-1. Figure 1 is a test to get a group of CDOM absorption coefficient distribution trends, Table 1 showed the COD value for the corresponding sample. Seen from Figure 1, the water absorption coefficient of CDOM was e exponential trend, and with the COD concentration increases, the spectral slope of the significant changes in the absorption coefficient at 440nm also increased significantly.

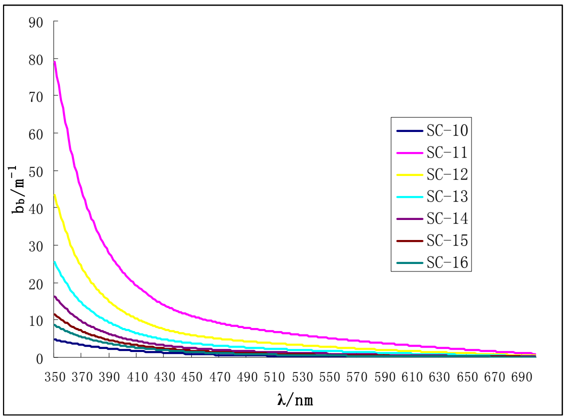

Fig. 1 Yellow substance absorption coefficient of water distribution

Table 1 Fig. 1 corresponds to the COD value of the sample

Sample No.	SC-10	SC-11	SC-12	SC-13	SC-14	SC-15	SC-16
COD(mg/L)	15.62	343.73	203.11	122.91	41.66	46.87	35.15

Previous studies showed that CDOM absorption spectrum decreased exponentially with wavelength from UV to visible light [8], under normal circumstances, using the formula (4) to describe the CDOM absorption coefficient changes with wavelength,

$$a_g(\lambda)= a_g(\lambda_0) \exp[-S(\lambda-\lambda_0)] \quad (4)$$

Where $a_g(\lambda)$ is the CDOM absorption coefficient(m-1)at wavelength λ, λ_0 is the reference wavelength (nm), S is the spectrum slope coefficient(nm^{-1}). In the study of CDOM optical coefficient properties, the absorption coefficient at 440nm ($a_g(440)$) and spectral slope S are two important parameters. About 28 samples was used of mix proportion text in August 2009 and June 2010, took 440nm as reference band λ_0, substituting into formula (4) fitting out spectral slope S in water with organic contamination. It is showed that in this experiment the spectral slope S are between 0.0086 (nm^{-1}) and 0.014 (nm^{-1}), the average is 0.010892 nm^{-1}.

3.2 The retrieval model of CDOM concentration

According to the formula (3) to extract water COD value, the key is how to get from the remote sensing data sources a_g (440).Currently, the CDOM concentration retrieval models established for water color sensors are mostly used the band ratio method [9]. Bowers et al (2004) proposed the remote sensing model for the estuary region to use the reflectance ratio at 670nm and 490nm estimating CDOM absorption coefficient at 440nm [6], that is,

$$a_g(440)=1.45*(R(670)/R(490))-0.488 \quad (5)$$

Where $a_g(440)$ is CDOM absorption coefficient at wavelength 440nm(m^{-1}); R(670) and R(490) are remote sensing reflectance at wavelength 670nm and 490nm respectively.
Taking into account that HJ-1/CCD band set includes 670nm (B3) and 490nm (B1), the study area is located in estuaries, so based on the Bower's model, we used the test data in August 2009, combining with HJ-1/CCD band response function to simulate the remote sensing model of retrieving CDOM water by using the two wide-bands (B1: 430~490nm and B3: 630~690nm) of non-water-color satellite HJ-1/CCD, that is

$$a_g(440)=2.47*(R3/R1)-0.27 \quad (6)$$

Where $a_g(440)$is the same as in Formula (5); R1 and R3 are the remote sensing reflectance corresponding to band B1 and B3 of HJ-1/CCD (dimensionless).
HJ-1 A and B satellites were equipped with a four-band star set to complete the same CCD sensor. Analysis showed that four CCD corresponding to the band 1 (B1: 430 ~ 490nm) and band 3 (B3: 630 ~ 690nm) of remote sensing reflectance difference is very small, so the formula (6) for four HJ-1/CCD sensors.

Because of the difficulty to get HJ-1 satellite transit synchronized water CDOM observations, it is used in May 2008 and August 2009 trial set aside out of 11 samples to simulate HJ-1 corresponding band of the remote sensing reflectance, substituted into equation (6) to obtain estimates of CDOM concentration ag (440), and water samples with the corresponding values of CDOM analysis to verify the results in table 2. According to table 2 , the estimates of the relative error of 18%were calculated, this indicated that according to (6) the results of the calculation has a certain accuracy. .

Table 2 estimation error of CDOM

Measured	3.5833	3.1578	2.1673	2.8422	1.0213	1.3612	1.8757	2.6515	2.779	0.2271	4.0159
Estimated	3.7399	3.4732	2.2907	3.4214	2.2261	1.5361	1.9346	2.0006	2.0914	0.1955	4.7331
Difference	-0.1566	-0.3154	-0.1234	-0.5792	-1.2048	-0.1749	-0.0589	0.6509	0.6876	0.0316	-0.7172

3. CONCLUSION

COD reflects the degree of organic contamination on water and its influence on water absorption coefficient mainly reflect on that of CDOM. Petroleum contamination belongs to the one of organic contamination. Thus it is feasible that using optical absorption properties of CDOM retrieve organic contamination in water. Through the mix proportion test in field, the remote sensing models of retrieving organic contamination in water based on the CDOM absorption spectral will be proposed. The models are not only simple and easy to operate, but also suitable as a business running. As long as the CDOM concentration $a_g(440)$ is calculated with remote sensing reflectance to determine a regional exponential slope S, the value of organic contamination in water can be figured out. The establishment of and provide a way to monitor water organic contamination with remote sensing technology. The models can promote the application of water color remote sensing in monitoring components of environmental pollution.

ACKNOWLEDGMENTS

This work was funded by National Natural Science Foundation of China (Grant No. 40771196), National Oceanic Public Good Project (Grant No. 201005025-04) and Key Projects in the National Science & Technology Pillar Program during the Eleventh Five-Year Plan Period (Grant No. 2008BAC34B05-5).

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