Coastal Environment Remote Sensing in Bohai and Yellow Sea in China

Ling Sun

Institute of Satellite Meteorology, National Satellite Meteorological Center,
China Meteorological Administration
No.46 South Avenue of Zhong-guan-cun, Beijing 100081, China
Tel : 86-10-68406763, Fax : 86-10-62183844
E-mail : sunling@nsmc.cma.gov.cn

1. Introduction

Bohai Sea, the inland water of China, and Yellow Sea as a part of the northwest Pacific region are affluent in natural resources and play an important role in human life and economy exploitation at Chinese eastern littoral. To achieve sustainable development, the environment of this region should be monitored and assessed routinely, especially along the coast.

In this paper, the current marine environment status derived from routine in-situ data in this region is described. Some representative progresses in marine environment monitoring with optical remote sensing are presented. The current status of red tide monitoring with remote sensing is introduced. Some remaining problems and suggestions in marine environment assessment with remote sensing are put forward.

2. Marine Environment Status in Bohai and Yellow Sea along China

According to the "2007 Marine Environment Quality Communique in China", pollution in Bohai Sea was still serious. The area that did not reach the quality standard of clean waters amounted to ~2.4×10^4 km^2, amounting to 31% of the total area. The areas of heavily, medium, slightly polluted and comparatively clean waters were about 0.6, 0.5, 0.6 and 0.7×10^4 km^2, respectively. Heavily polluted areas were mainly centered at the seashore of Liaodong Bay, Bohai Bay, Yellow River estuary and Laizhou Bay. As for the Yellow Sea, the area that did not reach the quality standard of clean waters amounted to ~2.8×10^4 km^2, about 1.5×10^4 km^2 less than 2006.The areas of heavily, medium, slightly polluted and comparatively clean waters were about 0.3, 0.4, 1.2 and 0.9×10^4 km^2, respectively. The areas of heavily polluted waters were significantly reduced in comparison with 2006. Heavily polluted areas were mainly centered at Yalujiang River estuary, Dalian Bay and the seashore of Suibei. Main pollutants in this region were inorganic nitrogen, active phosphate and oil kind.

3. Coastal Water Quality Monitoring and Assessment

Water quality assessment with remote sensing is the combination of environmental parameters retrieval indicative of water quality and the specific assessment criteria. With remote sensing, the spatio-temporal distribution and variation of marine environment can be obtained more rapidly, frequently and simultaneously.

In China, the coastal environment is seriously polluted with complex composition and obvious regional features. Operational global algorithms are mostly invalid or can't get reasonable results. Relative to the expanse marine abutted and various problems to be solved, researches in ocean color remote sensing are much dispersed. Investigations in the Bohai and Yellow sea are not very systemic and integrated. Remote sensing models applied with good validation results have not been constructed yet.

Atmospheric correction is the premise of effective acquisition of water environmental parameters with remote sensing, and algorithms suitable for the very turbid waters is a hotspot. Simplified procedures with an assumption of fixed property of aerosol scattering and water-leaving reflectance in the NIR bands were experimented in certain regional waters. An optimization method over highly turbid waters based on the Rrs relations among visible bands derived from in-situ data and the simple c exponent model for aerosol scattering was tried in East China Sea using SeaWiFS. Adopting SWIR bands instead of NIR bands, an algorithm based on look-up tables including 9 aerosol models was presented for MODIS and applied to China coastal regions with a primary validation in the Yellow and East China Sea.

Concentration retrieval models for the three major components (Chl, TSM and gelbstoff) were studied extensively. Statistical model was still most widely used while ANN and semi-analytical models were also tried. These models were derived from different in-situ dataset among which data collected in Yellow Sea and East China Sea in spring and autumn 2003 were intensively investigated. Limited data amount restricted the comprehensive understanding of water optical properties and the model construction with more universal suitability among regions and seasons.

Other biochemical parameters not optically-active but important for water quality assessment such as DOC, COD, TN and TP were tried to be retrieved. These parameters were either related to Chl or TSM, or directly modeled as functions of Rrs. But most researches were done with limited data in a small region. Because of the nature of indirect and unclear relationships between these non-optically-active parameters and water optical property, models were more localized.

According to the national standard of sea water quality in China, 4 grades are defined. But chlorophyll concentration is not included in the standard. With limited remote sensed parameters, proper water quality assessment method should be built up, including the parameters used, assessment model and classification thresholds. Besides the simple factor method, integrative index method such as TSI or TSI_M commonly used in inland waters for eutrophication evaluation may be adopted.

Some remote sensing results are presented, among which the monthly mean distributions of water-leaving reflectance and chlorophyll for Apr. and Sep. 2003 are shown in Fig 1and Fig 2, separately.

4. Red Tide Monitoring

Red tide has become the second serious marine disaster along the China coast with increasing occurring frequency, area and lasting time. Red tide happens more frequently in Bohai Sea, while relatively less along the coast of Yellow Sea. Red tide remote sensing can provide the information of occurring position, area and trend.

The basis for red tide remote sensing is the knowledge of the biological, environmental conditions and optical properties. Some red tide remote sensing techniques have been developed, mainly based on the variation features of chlorophyll concentration, phytoplankton sell amount, ocean color and SST and using threshold or ANN techniques. The threshold method based on spectral features of red tide water was most widely used, and the interpretation based on image composition was also very important in practice.

Because of the limited precision of red tide related parameters in coastal regions, spectral feature differences among red tide waters and the mixing pixel effect caused by the irregular shape of red tide water, red tide remote sensing was still on the stage of experiment, and no method with sufficient veracity and suitability was presented.

Some red tide detection cases are introduced.

5. Remaining Issues

To promote the development of coastal environmental assessment, some insufficiencies of remote sensing should be overcome, such as precision, valid data frequency and fusion of different data. Besides the consistent assessment standard, more self-contained in-situ dataset covering the variation in space and time should be collected to get more reliable retrieval model and carry out effective satellite product validation, which needs long time efforts.

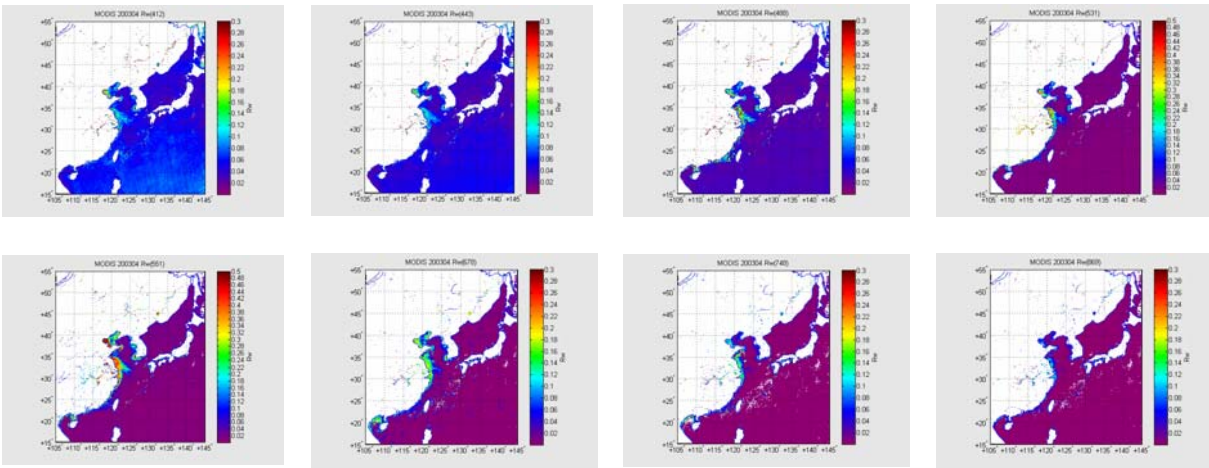

Figure 1. Monthly Mean Water-leaving Reflectance Distribution (Apr. 2003)

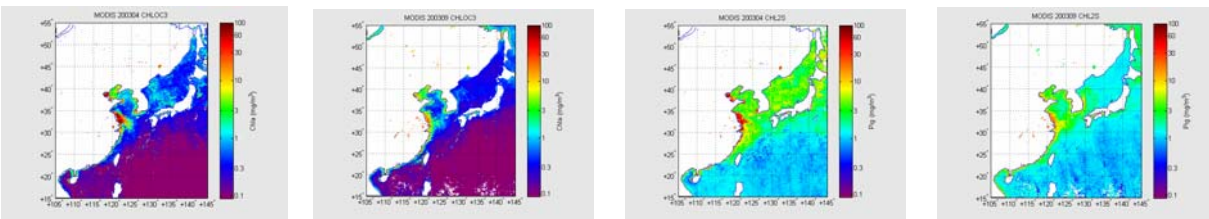

Figure 2. Monthly Mean Chl a Concentration Distribution (Apr. and Sep. 2003)

Reference:

[1] Ding Jing, Tang Jun-wu, Song Qing-jun, Wang Xiao-mei. 2006. Atmospheric Correction for Chinese Coastal Turbid Waters Using Iteration and Optimization Method. Journal of

Remote Sensing, 10(5): 732-741.
[2] Li Hua. 2006. The Study on Atmospheric Correction Algorithm of Case-2 Turbid Water and the Infection in the Extraction of Ocean Color Information. Guangzhou: Master dissertation of Sun Yat-sen University.
[3] Li Xiao-bin, Chen Chun-qun, Shi Ping, Li Xing. 2007. Retrieval of Total Inorganic Nitrogen Concentration in Pearl River Estuary by Remote Sensing. Acta Scientiae Circumstantiae, 27(2): 313-318.
[4] Liu Liang-ming, Zhang Hong-mei, Zhang Feng. 2007. Atmospheric Correction of MODIS Imagery for Turbid Coastal Waters. Geomatics and Information Science of Wuhan University, 32(2): 104-107.
[5] Lou Xiu-lin, Huang Wei-gen. 2003. An Artificial Neural Network Method for Detecting Red Tides with NOAA AVHRR Imagery. Journal of Remote Sensing, 7(2):125-130.
[6] Mao Xian-mou, Huang Wei-gen. 2003. Algorithms of Multiband Remote Sensing for Coastal Red Tide Waters. Chinese Journal of Applied Ecology, 14(7): 1200-1202.
[7] Qiu Zhong-feng. 2006. Ocean Color Remote Sensing Algorithms and Red Tides Detection in the High Frequency Red Tides Areas of the East China Sea. Qingdao: PhD dissertation of Institute of Oceanology, CAS.
[8] State Oceanic Administration. 2007. Marine Environment Quality Communique of China in 2007.
[9] Sun Ling, Zhang Jie, Guo Mao-hua. 2007. Atmospheric Correction over Case 2 Waters Using Neutral Network. Journal of Remote Sensing, 11(3): 398-405.
[10] Sun Ling. 2005. Atmospheric Correction and Water Components Retrieval for HY-1A CCD. Qingdao: PhD dissertation of Institute of Oceanology, CAS.
[11] Tang Jun-wu, Wang Xiao-mei, Song Qing-jun, et al. 2004. The Statistic Inversion Algorithms of Water Constituents for Yellow Sea & East China Sea. Acta Oceanologica Sinica, 23(4): 617-626.
[12] Zhang Xiao-yu, Lin Yi-an, Tang Ren-you, Pan De-lu, Wang Di-feng, Gong Fang. 2005. Preliminary Study of Concentration Distribution of Total Particulate Phosphorus in Estuary by Remote Sensing Technology. Acta Oceanologica Sinica, 27(1): 51-56.
[13] Zhao Dong-zhi, Zhang Feng-shou, Zhao Ling, Cong Pi-fu. 2003. Detect of Chlorophyll a and Red Tide in Coastal Water Using Band Ration of AVHRR. Marine Environmental Science, 22(4): 9-12.
[14] Zhao Dong-zhi. 2004. The Distribution Rule of Red Tide in China and Red Tide Remote Sensing Detection Model. Shanghai: PhD dissertation of East China Normal University.