National Report on Ocean Remote Sensing in China

Contents

1. Status of Remote Sensing Utilization in Marine Environment Monitoring

1.1 Marine remote sensing researches and applications in early period

Remote sensing researches and applications for marine environment monitoring started from the early 1980s in P R China. During this period, NOAA/AVHRR data were used to calculate the sea surface temperature, monitor the winter ice in Bohai Sea, and trace the movement of hurricanes (Pan, et al.,1989). The first NOAA receiving station was constructed in 1987 by National Marine Environment Forecasting Center with the financial support from central government. The system was applied to monitor the formation, development and withering of the ice in Bohai Sea by integration with marine dynamic model. And the products derived were delivered to such users as oil development base, ship firms in Bohai Sea area.

Landsat images were intensively used in the monitoring of coastal environment. For example, Landsat MSS images were firstly applied to detect the shoreline change in the Yellow River Delta in 1982 by the administration bureaus of the Yellow River basin. Since then, Landsat TM and ETM images have become the main data sources for monitoring of coastal ocean environment in China. The scientists in East China Normal University conducted many studies in the application of remote sensing images to investigate the environmental change in the Yangtze River delta. For example, sediment transportation in the Yangtze River delta was been successfully monitored through multi-temporal TM images, and the fresh water belt along the coast bank was precisely detected.

1.2 Progresses and achievements in 1990s

(1) Marine optical remote sensing

The technique of the marine optical remote sensing has been well developed in China in the last ten years(Pan, et al., 2004). The scientists in the second Institute of Marine Science of State Ocean Administration conducted the pilot studies of optical remote sensing in China with the support from the Ministry of Sciences and technology of China. First, the technique of validation of the satellite data was developed by means of in-situ measuring vertical spectra profile such as down irradiant and up radiance to derive the water leaving radiance in order to keep the satisfactory accuracy of the water radiance by the optical remote sensing(Pan et al., 2000; Tang, et al., 2004). Second, the series of the AVHRR and SeaWiFS data were collected and used to develop the models of measuring suspended sediment for the marine engineering application and detecting other marine environment such as red tide and oil spilling (Pan, et al, 2001a; Pan, et al., 2001b). Finally, prototype software packages and local operational systems were developed and constructed.

SeaWiFS data were intensively used to monitor the red tides since 1995, and some models with local parameters were developed(Mao, et al., 2001a, b; Pan et al, 1997; Pan et al, 1998a; Pan et al., 1998b; Wei, et al., 2003) .

(2) Satellite altimeter researches and applications

As an active microwave sensor, satellite altimeter can acquire instantaneous range between satellite and sea surface, sea surface radar backscattering cross section and waveform information. The sea surface wind speed, significant wave height, ocean tide, geoid, gravitational field and so on can be derived. Satellite altimeter can work all weather and all time. Now there are more than seven-years time series global measurement by Topex/Poseidon satellite.

The method, model and software of retrieving the marine environment parameters from altimeter data were deeply studied. The tides in East-china Sea and South-China Sea were estimated by using T/P altimeter data. To estimate the East-China Sea tides, a least squares fit was developed to determine the 21 tidal constituents, including 8 principle tidal constituents. A high space resolution numerical tidal model and an adjoint model are presented in order to obtain the coast tide and remedy the low space resolution of T/P altimeter data. A semi-theoretic sea surface backscattering model for high wind speed has been set up and used to extract wind speed from T/P data. Meanwhile, a seasonal empirical model has also been made for high wind speed. The wind speed precision is better than 10% or 2m/s for wind speed less than 20m/s and 10% for high sea state. Global wind speed variability has been derived from six years TOPEX data using this model. An ocean wave model is assimilated using the Topex data. A new method and its modification were developed to extract the ocean gravitational field and its anomaly with high resolution and precision from the fusion data of GEOSAT, ERS-1, ERS-2 and Topex satellites. The sea bottom topography where depth is more than 2000 meters is retrieved using the respond function technology for anomalous gravitational field and in situ data. An atlas of ocean wave, wind speed, tide, gravitational field and large-scale sea bottom topography in China Sea and Northwest Pacific Ocean will be published by electronic edition.

(3) Satellite SAR researches and applications

By developing image processing of the SAR image and information separation technique, establishing ocean small and meso-scale process (including underwater topography) SAR imaging model and applying the method of the mathematics and physics inverse problem, high technique have be developed about measuring the ocean wave direction spectra and detecting water depth of ocean and meso-scale process to serve ocean environment monitor, astronautics SAR serving as the main technique support. Ocean wave direction spectra data and assimilation system of the ocean wave numerical models were also established for improving prediction ability of ocean environment parameters.

1.3 China ocean satellite program

The HY- 1 satellite, launched on May 15, 2002, is the first ocean satellite of China for detecting ocean color and sea surface temperature. The main sensors on board include 10-band Chinese Ocean Color and Temperature Scanner (COCTS) and 4-band CCD imager. The main technical systems of optical remote sensing were developed by Second Institute of Oceanography (SIO), State Oceanic Administration (SOA), in 1997 and by National Satellite Ocean Application Service (NSOAS) in 2002. Those systems include the functions of data receiving, processing, distribution, calibration, validation and application for different kinds of satellite, such as FY21 , HY21 , SeaWiFS , AVHRR and MODIS (Jiang, et al.,2002; Li, et al, 2002; Pan, et al 2003; Wang, et al., 2003))

Table One Optical sensors for marine environment monitoring

Sensor	Satellite	Variables	Observing cycle	Intended use of data
AVHRR	NOAA	SST	0.5D	Locating Fishing spots; retrieve thermal front information et al
VISSR	GMS	SST	0.5h	Locating Fishing spots; retrieve thermal front information et al
MVIRS	FY-1C	SST, CHLA	0.5D	Retrieve water color, locating fishing spots, tracing the ocean current
SeaWiFS	SeaStar	CHLA	1 D	Understanding Ocean dynamics, locating fishing spots et al
MODIS	Terra	SST, CHLA	1 D	Monitoring water quality, detecting the change of current fronts, understanding ocean dynamics.
COCTS	HY-1	SST, CHLA	1D	Understanding ocean dynamics, monitoring water quality, detect the current fronts
CCD	HY-1	CHLA	10D	Understanding environmental change in coastal zone area
TM/ETM	Landsat	Water color	16D	Coastal change
CCD	CBERS	Water color	26D	Coastal change
IMRSS	CBERS	Water color	26D	Coastal change
WFI	CBERS	Water color	26D	Coastal change

In order to promote the application of HY-1 data, a number of set s of marine bio-optical in situ data which are water AOPs and IOPs , such as water leaving radiance , attenuation and up and down water radiance , are measured by investigation boats , and those in-situ data have been applied for HY-1A satellite orbit calibration and the atmospheric correction. The neural network technique is used to inverse the chlorophyll a, and the slope of two optical channels reflectance is developed for more accuracy suspended material mapping and the optical data are tested to extract the marine chemical constituents, such as dissolved organic carbon. The optical remote sensing products are applied for red tide detection, coastal water quality classification, oil spilling monitoring and fishery. Some beneficial suggestions about continuous development of science and technology of the marine optical remote sensing application are discussed in the paper.

2. Case Examples of Remote Sensing Applications in Marine Environmental Monitoring

2.1 Ocean ice monitoring in Bohai Sea

In order to monitor the ice in Bohai Sea, a variety of satellite data were used and many different methods were developed. And an operational system has been put into work. The scientists from China Ocean University and the First Institute of Marine Sciences of SOA in Qingdao, and National Ocean Environment Prediction Center of SOA conducted many studies in the application of remote sensing technologies to sea ice studies, with support from National five-year plan Science and technology Program which is listed into national budget in term of five-year period since 1985, and National High-tech Research Program which was issued since 1986. The main achievements and progresses can be summaried as following.

(1) The operational System for Sea Ice Monitoring based on Optical Satellites

For NOAA satellite, the HRPT data with its original accuracy of 10 bits/word is stored on a computer disk. The pre-processing software package executes the separation of AVHRR five channel data from HRPT, performs radiance calibration and geographic location and forms 1B data sets. We select the Bohai Sea and form the image file of five channels. The image file is projected into a Mercator map and rectified with landmarks, and geometric accuracy is less than one pixel. Image processing software has two functions. One is to make real color composition with channel 1,2 and 4 of AVHRR. A histogram technique is used to enhance the images, so the sea ice is easy to identify at real color images. The other is used to differentiate the ice, water, cloud and land, and to classify the ice according to the optical model of ice and other measurements. The outputs from this module are a real color image of sea ice, ice classification by color-coded images and graphs of ice classification and ice edge. The numerical analysis software includes calculation of ice thickness and concentration, and calculation of ice apparent displacement by the use of template match method. The grid used in numerical calculations is in accordance with that in numerical prediction modes.

For GMS satellite, the S-VISSR data was real-timely ingested and processed on microcomputer. The products were used to monitor tropical cyclones in summer and sea ice in winter (use VIS 1.25km) and transferred to the department of forecast via network, shared in our local net.

In 1998 and 1999, Level 1B and 1A product of SeaWiFS of SeaStar were used to monitor the sea ice. The image of sea ice is much clearer than NOAA satellite because the SeaWiFS instrument have a good ratio of signal and noise.

(2) Sea Ice Monitoring with Satellite SAR

The satellite-borne SAR data provides high resolution images independent of light and cloud conditions, and is more helpful for monitoring the sea ice. A series of researches have been conducted during last ten years. For example a Sino-Canada cooperative project on monitoring the sea ice was issued in 1995. The SAR data from ERS (ESA) and JERS (NASDA) satellites was used. In 1998, RADARSAT International (RSI) sponsored the project, The Evaluation and Demonstration of Radarsat Data and their Applications on China's Bohai Sea Ice Research. Four ScanSAR scenes of Bohai sea were collected, two ScanSAR Wide B with 500 km swath, 100m resolution and two ScanSAR Narrow modes with 300 km swath,50m resolution. The results from SAR image shows clearly the texture of sea ice field, the size of floating ice and the openings in the ice attributable to its high resolution, which are hardly visible on AVHRR and GMS images (Figure one). All the information is useful to estimate the ice concentration in the field of views (one important input parameter for the numerical model of ice) and to find the fractures and leads for ship routing.

2.2 Coastal erosion and shoreline migration

Since its advent, satellite remote sensing technology has been widely and intensively applied into the coastal monitoring, including coastal bank erosion and shoreline changes. Institute of Geography of Chinese Academy of Sciences (CAS) and Institute of Oceanography of CAS has conducted many researches in the Yellow River Delta with the supports from national five-year plan program and High-tech program (Lin, 1991).

20 scenes images from Landsat satellite were used to analyze the shoreline change in the Yellow river delta since 1976 as shown in Table Three and Figure two. During the period of from 1976 to 1985, the river mouth grew into Sea very quickly. And the old river mouth area was slightly eroded and shoreline was receded. During the ten years from 1985 to 1995, there was no big change over

whole river delta, being the balance sediment and erosion. In July 1996, the Yellow River artificially shifted its course. A new river mouth began to form just beside the north of the old river mouth as shown in Figure One. During the last 30 years the Yellow river delta grew for about 330km^2, being 13.8km^2 per year. In this research the China and Brazil Resources and Environment data were intensively used.

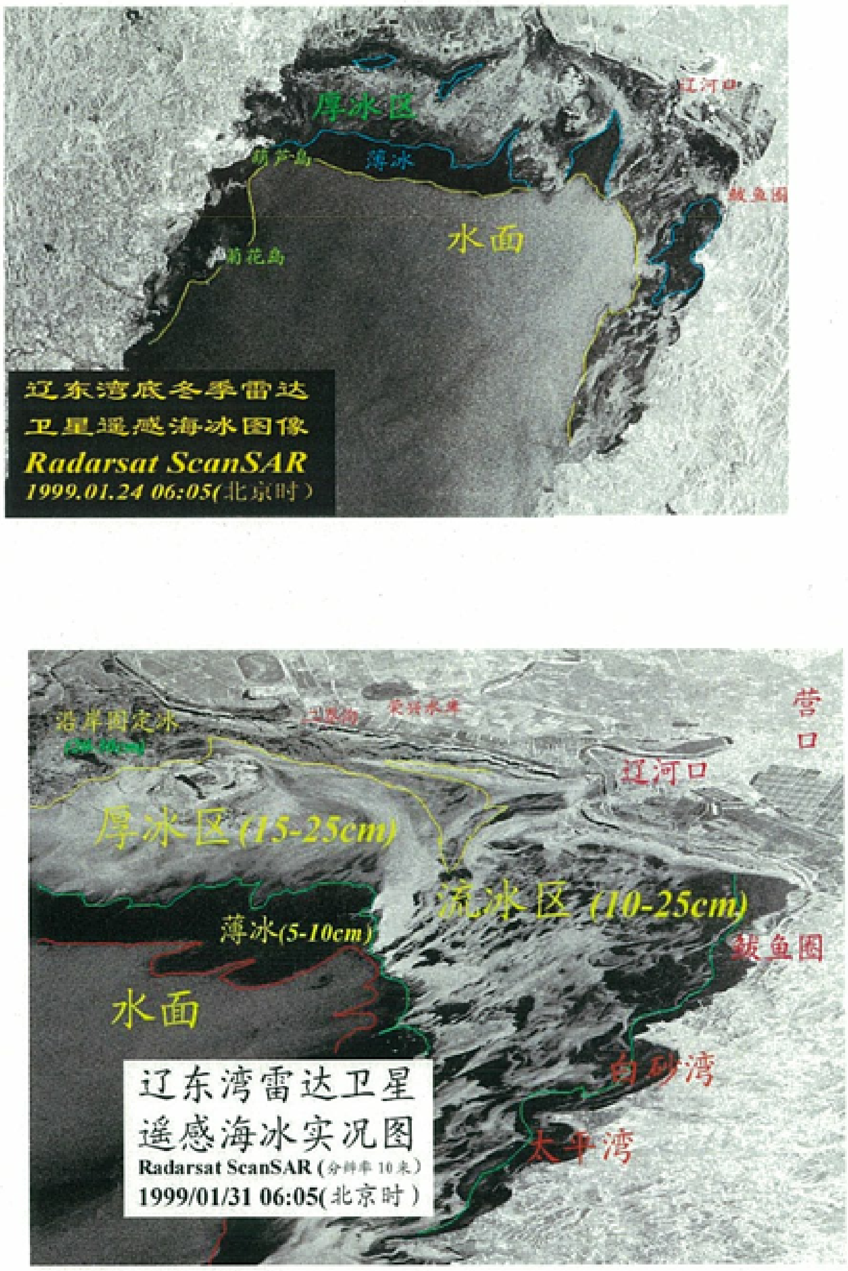


Figure 1 Bohai Ice monitoring by using ScanSAR in January 1999

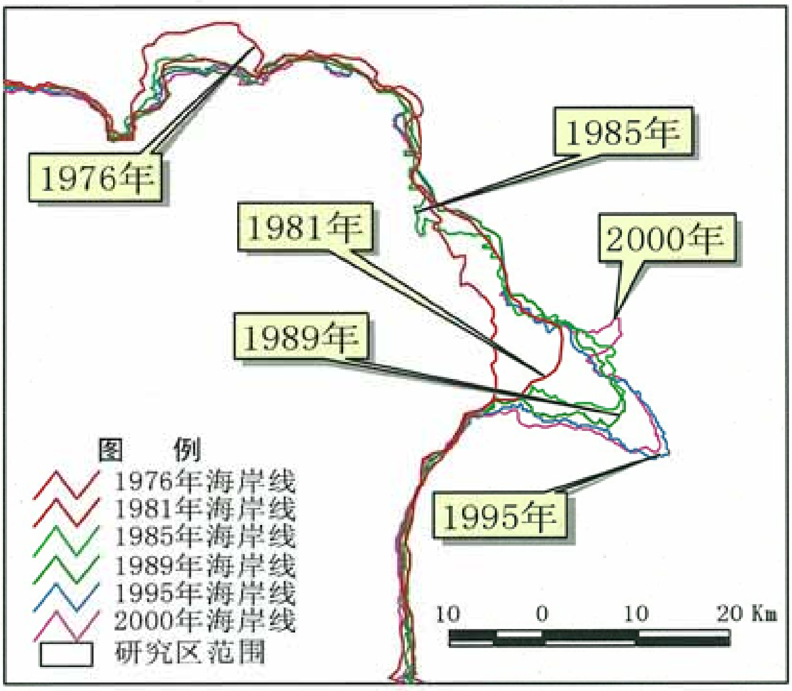


Figure 2 Coastal line migration over the Yellow River Delta during 1976-2000

Table Two Shoreline change and delta growth in the Yellow River

Image date	Length of shoreline (km)	Land area in existing river mouth(km^2)	Land area in old river mouth(km^2)
1976-12-01	180.9	195.0	862.2
1977-05-10	175.6	194.7	790.5
1981-11-21	174.2	339.6	761.1
1984-10-05	211.2	385.1	776.5
1985-03-04	216.2	408.0	784.4
1986-06-05	210.3	397.2	762.8
1987-05-07	207.9	363.2	757.6
1989-02-13	205.4	453.8	744.2
1991-01-26	216.0	446.7	737.7
1992-04-02	217.0	482.2	746.7
1993-10-30	220.6	495.6	749.7
1994-02-19	215.2	487.5	744.6
1995-03-10	221.2	498.3	742.4
1996-05-31	223.2	500.1	736.1
1997-10-09	223.1	526.7	728.6
1998-05-05	2218.2	514.7	732.0
1999-06-25	225.7	530.0	738.5
2000-05-02	223.2	524.5	725.6

2.3 Red tide monitoring

(1) Relationship of fluorescence line height with Chlorophyll a concentration

Many studies reveal the close relationship between red tide and chlorophyll a concentration. So it is very important to understand how chlorophyll a and their changes affect the water color and water leaving reflectance of sea water. In order to investigate the relation of sun-induced fluorescence peak near 700nm with chlorophyll a concéntration, a series of experiences and measures were conducted by using red tide species such as *Gymnodinium* sp., *Heterosigma akashiwo* , *Ceratium furca* and other algae such as *Nitzschia* closterium , *Dicrateria zhanjiangensis Hu.* , *Platymonas* sp. , *Chlorococcum* sp. ,*Platymonas helgolandica var tsingtaoensis* , *Chlorella* sp. , which were sampled in situ or artificially cultured. The figure three showed showed that all of the algae have a positive correlation relationship with results except *Heterosigma akashiwo* , *Chlorococcum* sp. And *Gymnodinium* sp. . The lowest *R* of 014692 among the positive correlation results is measured in the analysis of *Chlorella* sp. . The difference of results lies in two facts, one is the shift of fluorescence peak position, the other is high reflectance of phytoplankton at red and infrared light.

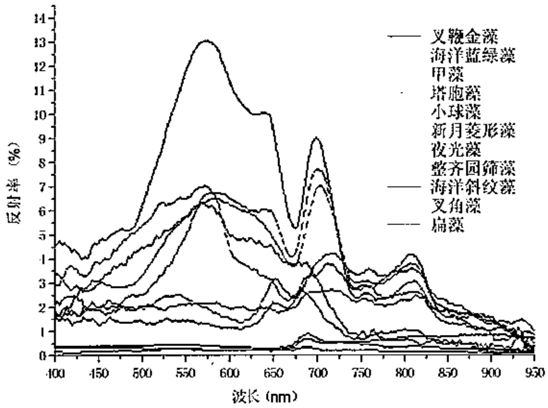


Figure 3 Reflectance of different kinds of algae and wavelengths

(2) Detecting Red Tide from AVHRR Images

Many cases studies have approved that AVHRR images are very helpful to detect the red tides. The algorithms used may be classified into ratio one and minus one between band one and band two. Here we used ratio model to monitor the red tide in Liaodong estuary. C_{21} is used to represent the ratio between near infrared band and red band of AVHRR images. Regression of in situ chlorophyll concentration in the Liaodong estuary and C_{21} presents the close relations with regression coefficient 0. 75, as shown in Figure Four.

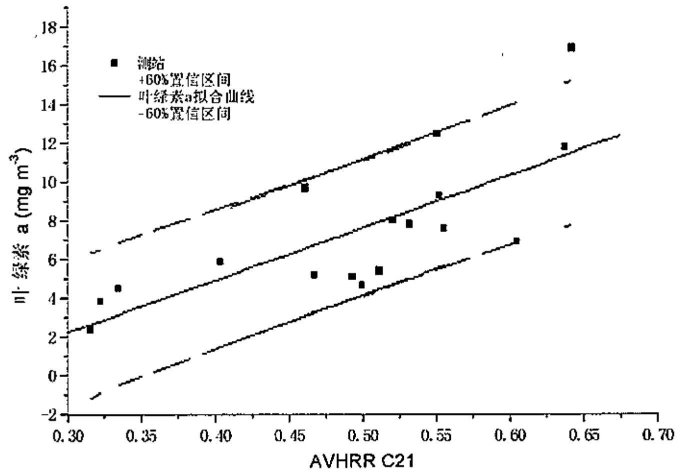


Figure 4 Linear relationship between Chlorophyll a concentration & bands ratio

(3) Detecting Red Tide from SeaWiFS Images

Many researches have been devoted to the monitoring of red tides in China coastal oceans. Early work was focused on application of NOAA and SeaWiFS data by the researchers in the Second Institute of Marine Science of SOA, financed by national five-year plan program. Prof Delu Pan has developed several models to extract red tides information from the satellite images, and successfully applied these methods in monitoring of Bohai red tide happening in 1998 as shown in Table Four & Figure five.

Table Three Bohai Red Tide monitoring by using SeaWiFS data

Image date	Area affected by Red tide (km^2)
98.8.25	1400
98.8.27	4000
98.9.2	4080
98.9.11	3700
98.9.15	2200
98.9.18	3400
98.9.21	3500
98.9.22	3020
98.9.27	2800
98.10.3	1020

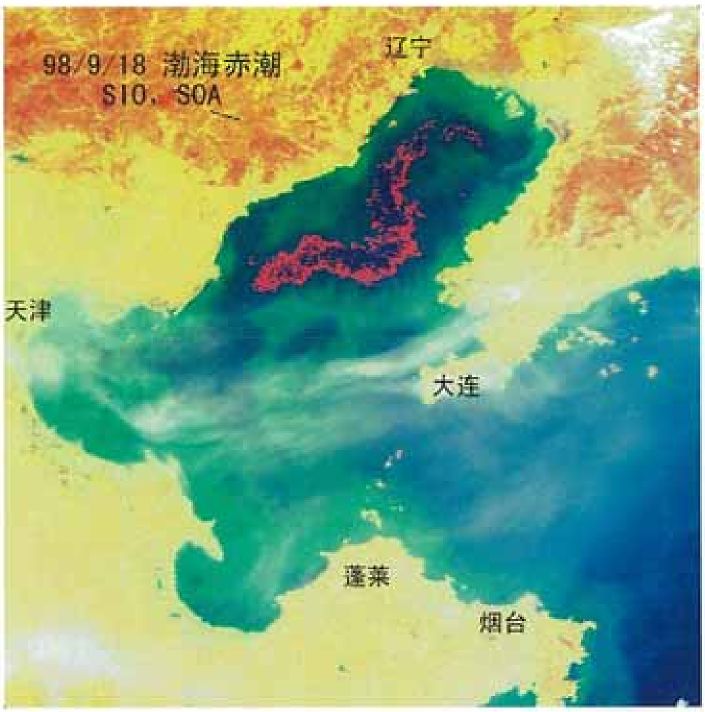


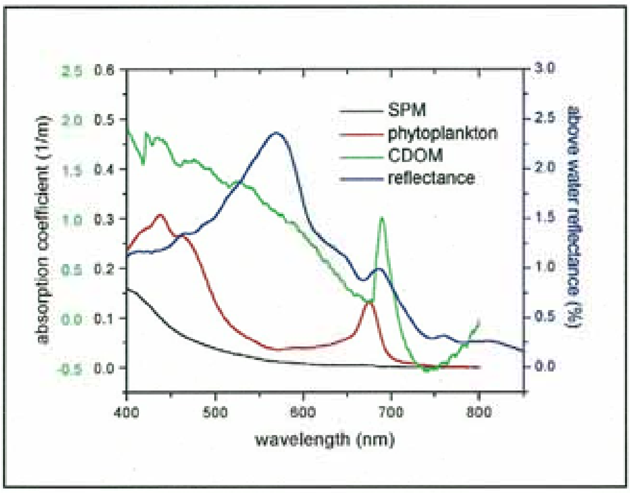
Figure 5 Red Tide monitoring by Using SeaWiFS in 1998

(4) Detecting Red Tide from MODIS Images

Since MODIS images are available, they find a particular use in red tide monitoring, and some of successful case studies further confirm to this. In last two years, we conducted many field measures over the sea in Bohai Bay area. Figure Six showed one of our spectral measures when a red tide happened in Dalian Bay. Based on this series of measures, we proposed a ratio model of band 1 and band 2 to calculate the relationship between the ratio and chlorophyll a concentration as shown in Figure Six. And we used this relation to quick identify the water area affected by red tide in the experiment region.

Prof Dongzhi Zhao, a professor in Center for Marine Environmental Monitoring of SOA, has being conducted a research on application of MODIS data to monitoring of red tide with the support by National High-tech Research Program since 1999. He has proposed a semi-analytical method to detect the red tide on the MODIS images on the basis of the many spectral measures and analysis. This method has been tested in 2003 red tide happening in Liaodong Bay in Bohai Sea as shown in Figure Seven.

Prof Fenzheng Su from Institute of Geography of CAS applied the MODIS images to monitor the red tide in the coastal ocean along the coastal zone as shown in Figure Eight. In his study he developed a new algorithm to detect the density of chlorophyll a with the in-situ data.



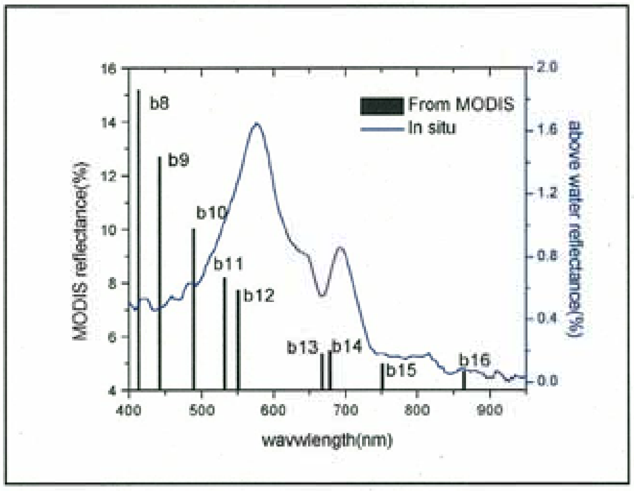


Figure 6 Water color spectrum and MODIS reflectance

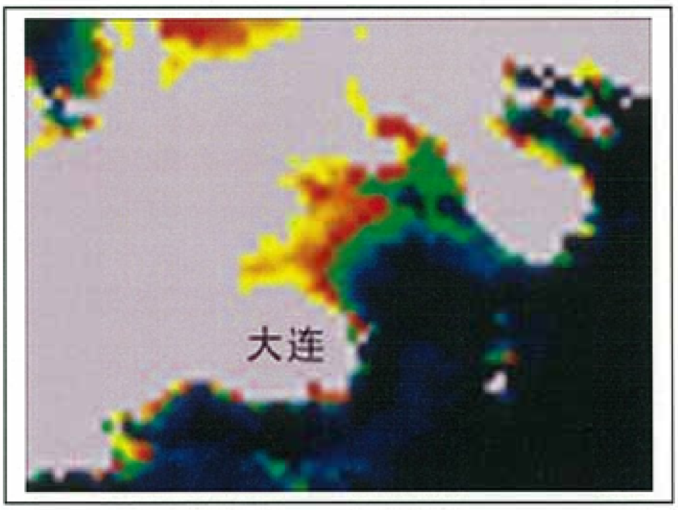


Figure 7 Red Tide in Dalian Bay in July 2003.

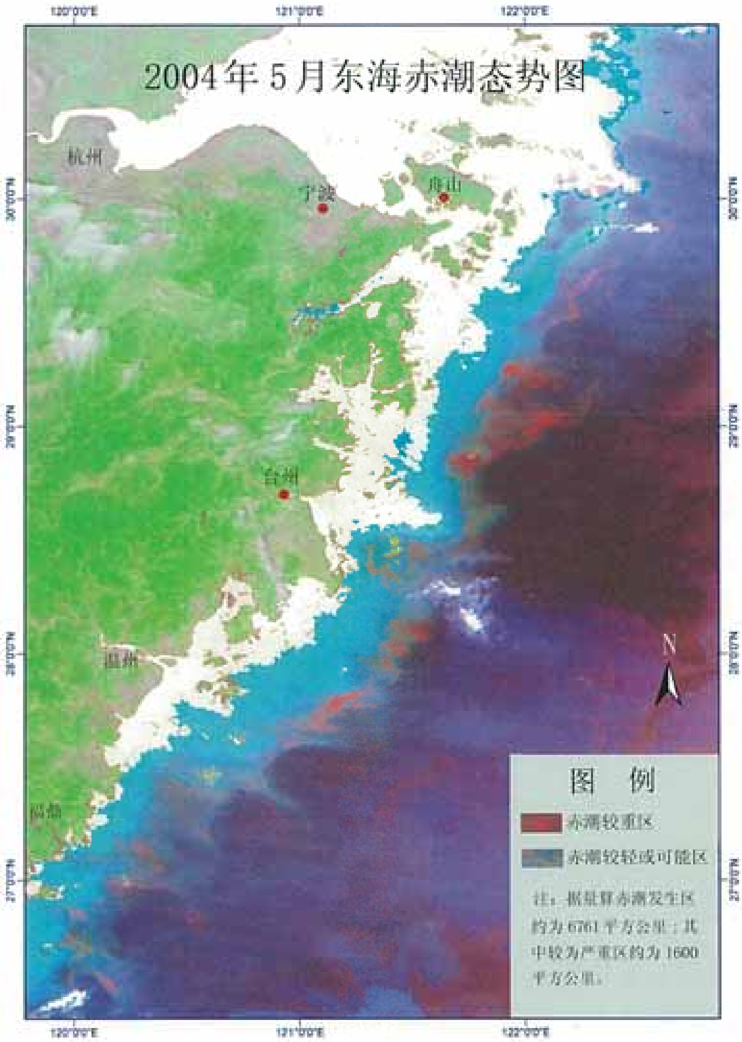


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Figure 8 Red tide monitoring by MODIS in May 2004

2.4 The other related studies

In the early 1990's, Chinese scientists conducted a comprehensive survey of land use and land cover along the coastal zone by using Landsat TM/ETM data on the scale of 1:100 000 with the support by national five-year plan program. A database was also developed based on this survey. This database is being used by central and provincial governments in the regional planning and management.

Dr Xinqiang He(2004) developed a semi-analytical inversing model of water transparency by using the theory of radioative transfer in water. The accuracy of this semi-analytical inversing model was validated by using the larger scale *in-situ* data , and the result shows that the correlation is 0. 84 with the relative error of 22. 6 % and absolute error of 4. 7 m.

In the late 1990s, some researches on marine fishery were conducted. Dr. Su and Du developed some model to set up relationship between fish spots and its environmental parameters such as SST(Du, et al., 2003; Du, et al., 2004; Fan, et al 2002;Su, et al., 2002). The data mining methods were also introduced to analyze huge amount of data(Su, et al, 2004)

3. Status of R&D on Remote Sensing Technology for Marine Environment

3.1 Sensors and satellites

Airborne high spatial resolution SAR sensor was developed in China. This sensor is very useful to measure the shorelines and their change under all-weather conditions. More researches will be devoted to the algorithms development.

Operational Modular Imaging Spectrometer(OMIS) is a high spectral sensor developed by China scientists in the early 1990's. It consists of 128 bands covering the spetrum of 460~1250 nm. Based on OMIS, a new hyperspectral imager, called as Ocean Hyperspectral Imager(OHI), was designed and developed for the monitoring of ocean environment. OHI has 246 bands covering 400~870 nm.

As HY-1A was out of work, the HY-1B will be launched in late 2005. The technical indicators are same as HY-1A. HY-2 satellite is under plan. It will carry more microwave sensors such as altimeters, micro-radiometer and microwave scatters.

3.2 Algorithm for geo-physical parameters

A number of sets of marine bio-optical in-situ data which are water AOPs and IOPs , such as water leaving radiance , attenuation and up and down water radiance , are measured by investigation boats by SIO and National Marine Satellite Application Center, and those in-situ data have been applied for HY-1A satellite orbit calibration and the atmospheric correction. Neural network technique is used to inverse the chlorophyll a, and the slope of the optical channel reflectance in the two channels is developed for more accuracy suspended material mapping and the optical data are tested to extract the marine chemical constituent s, such as dissolved organic carbon. Most of such researches were funded by national ocean satellite program.

Some researches oriented to microwave sensors application were also implemented. The Institute of Oceanography of Chinese Academy of Sciences developed the database of huge waves along the China seas by using Topex satellite data.

4. Introduction of latest findings

(1) A Genetic Algorithm for Retrieval of Water Constituents from Ocean Color Remote Sensed Data in Case 2 Waters

The optimization approach is one of the most promising methods for retrieval of water constituents in case 2 waters, but almost previous applications of this approach suffer from their local search techniques. In Prof. Delu Pan's study, a genetic algorithm is developed as a global optimization scheme to simultaneously retrieve concentrations of chlorophyll, suspended sediment and yellow low substance. To separate the contributions to the radiance spectra by co-exiting constituents, two reflectance ratios were embodied to the objective function, and a real valued genetic algorithm was used to optimize it. The performance of the algorithm is demonstrated with a simulated data set. Under noise free conditions, three water constituents are estimated accurately. Tests with noisy data show that the algorithm is robust against errors in the reflectance data.

(2) The study on the inversing model of water transparency using the SeaWiFS data

Water transparency (Secchi disc depth) is a basic parameter that describes the optical property of water. Prof. Yan Li from the Second Institute of Marine of SOA, and Prof. Junwu Tang from the Center for Ocean Satellite Application of SOA conducted many field measurements with the support by the national ocean satellite program and national high-tech research program. A semi-analytical inversing model of water transparency was provided using the theory of radiative transfer in water. The accuracy of this semi-analytical inversing model was validated by using the larger-scale *in-situ* data , and the result shows that the correlation is 0. 84 with the relative error 22. 6 % and absolute error 4. 7 m. Using this inversing model of water transparency and SeaWiFS data , serial images of water transparency distribution were generated with monthly average in China'seas in 1999.

(3) The atmospheric correction algorithm of SeaWiFS data

A practical atmospheric correction algorithm for the Sea-viewing Wide Field-of- view Sensor (SeaWiFS) is presented, which is based on the radiative transfer models and *in situ* data. The radiance received by the satellite was decomposed in four parts which are rayleigh scattering, aerosol scattering, sun glint radiance and water leaving radiance.

The four components values obtained by the model were compared with models in SeaDAS software developed by NASA and *in-situ* data. The difference of rayleigh scattering radiance between the model and the NASA's model is about 5 percent. The distribution patterns of aerosol scattering are similar to that of NASA's. The water leaving radiances of SeaWiFS six bands are near to the *in-situ* data. As the atmospheric conditions above case 1 water are used for case 2 water, the model can be used in processing SeaWiFS data of coastal areas where the NASA's model often fails in atmospheric correction. This model also solved the problem of the negative of the water leaving radiance of SeaWiFS 412nm and 443nm bands. The atmospheric correction model is more suitable in processing SeaWiFS data under the specific atmospheric and oceanic situations in China Seas than models in SeaDAS software. This is very useful in extracting ocean color information from SeaWiFS data and in studying the atmospheric correction models of FY21C and HY21 satellite data of China.

(4) A temperature error control technology for an operational satellite application system

The accuracy of satellite measured sea surface temperature (SST) is the key for both SST algorithms and applications, which is reported to reach 0. 5 degree C. In fact, the accuracy of satellite measured SST is affected by many factors, it is very difficult to obtain root mean square (RMS) error within 1 degree C in an operational satellite SST application system. Many values of

SST are found to be much lower than temperature measured by the ships in evaluating the accuracy of SST derived from NOAA satellite data. The error distribution shows that larger negative values of temperature bias take up a high proportion with the maximum up to - 17. 2 degree C. Many patches of low temperature abnormality , distributing in the SST images , are caused by thin clouds or fogs , which may be mistakenly taken as eddy or front . The temperature abnormality is very difficult to be detected by SST inversion algorithm and cloud detection technology. A temperature error control technology is developed employing standard reference temperature images to detect the temperature abnormality. This method can efficiently detect the temperature abnormality to remove the abnormal low values of SST and improve the accuracy of satellite measured SST. The RMS error is improved from 5. 71 to 1. 75 degree C in an operational SST system. It has been applied to drawing the fishery chart products of the North Pacific.

5. Strategies / Plans for RS related activities

5.1 Satellite data webservice and data sharing

In order to promote the application of remote sensing technologies into marine environment monitoring, a satallite data website is being under construction, sponsored by China central governments through National Platform for scientific Data Sharing program. First, a comprehensive metadata base was included, which provides a good guide into the possible avail dataset regarding marine environment in P R China.

This website real-timely provides MODIS images and related higher-level products including the sea surface temperature, chlorophyll-a concentration, suspended sediment concentration in China coastal oceans. Besides international satellite images, some of the China HY-1 images were also included in the database.

High resolution satellite images such as Landsat ETM, CBRES-1/2 were also build in the database. At present, the dataset only covers the coastal zone areas, and more images will be built-in. In order to meet the needs of researches, some of SAR images were put into the database.

5.2 Comprehensive marine environmental harnessing

(1) Bohai environment monitoring and harnessing

Since 1999, China central government and provincial governments jointly promote the construction of comprehensive monitoring network in Bohai Sea. More than 100 gauges stations have being constructed and networked. Now we can collect the real-time data about the Bohai Sea environment, including the sea surface temperature, salt concentration, ocean current, sea surface wind and wave.

Remote sensing technology plays an important role in this local system. One ground radar station, located in Qindao, was constructed by North Sea Sub-bureau of SOA to monitor the Bohai ice and sea surface wind. And one MODIS ground receiving station, located in Daling and run by the Environmental Monitoring Center of SOA, receives and processes the optical images covering the Bohai Sea and provides real-time service to local users.

(2) China East sea environment monitoring

A satellite based hazard monitoring system was built in China East Sea by East Sea Sub-bureau of SOA. The system was designed to monitor the typhoon movement, detect the huge wave and movement. Besides the NOAA, FY-1 and MODIS data were received, two high-frequency ground wave radar systems were used to monitoring the sea surface wave and ocean current.

A ship-based monitoring system was equipped with advanced equipment such as real-time water sample collecting system, automated temperature and salt measurement system.

(3) China coastal zone investigation

In order to have a full understanding about the development along the coastal zone, Second-time China coastal zone investigation was started in 2004. Remote sensing technology is listed as one of the key technologies in this activity. High resolution images data will be used to investigate the land use and land cover, monitor the pollutant discharge of point sources and non-point sources. Coastal zone erosion will be intensively surveyed.

5.3 Coastal hazard monitoring warning system

(1) Oil-spill monitoring and detection system

An airborne remote sensing system was developed n 1998 by State oceanic Administration (SOA) of P R China to monitor and detect the possible oil-spill over the China seas. This system was equipped with high spectral imager, X-band SAR and video system. The ground data processing system was built by North Sea Branch of SOA located in Qindao. This system successfully monitored several heavy oil spill over Bohai Sea and East Sea.

(2) Storm-surge monitoring system

In the Yellow River delta the storm surge is a most danger natural disaster. In order to defense the invasion of storm surge, a hazard warning system was developed in 1988 by Dongying city government, located in the Lower Yellow River Delta. The Dongying city government is also responsible for the operation of the system. Now remote sensing technology becomes one of the major methods used to monitor the surge and evaluate the damage of the hazards.

6. Challenges and Prospects

6.1 Real-time watch of red tide

Red tide has been a most threatening to acqua-agriculture in China. It is needed to develop an efficient method to retrieve red tide information from satellite images, and detect the harmful species. A prediction and warning system needs to be established by joint efforts from governments, farmers and the scientific society.

6.2 Ocean color data usability in case II water area

Due to the effect of sediment and many other kinds of yellow matters, ocean color remote sensing technology does not work well in the coastal oceans. More and more research should be devoted to the on-site measurement of the sea water radiance and a new model should be developed to calculate the physical and non-physical parameters of the ocean environment.

7. Suggested activities for the NOWPAP Region

7.1 Remote sensing data and method sharing among NOWPAP region

It is suggested to develop common remote sensing dataset covering the NOWPAP region and promote the data sharing. Through the data sharing all the member countries can jointly deal with the large scale issues and problems. So it needs to enhance the website development.

Besides the data sharing, technology exchange will also be needed. It would be very beneficial to all the member countries to have a common method and algorithms to calculate the various kinds of the ocean environmental parameters. It is suggested to develop a shared remote sensing software package by the joint efforts by WG4.

7.2 Enhancement of the technical training program

In order to make full use of modern remote sensing technologies to monitor the NOWAPA regional environment, it is suggested that WG4 should set up long-term training program for all the member countries. The training course delivers not only remote sensing knowledge, but also special techniques training.

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NRSCC http://www.nrsc.gov.cn

National Marine Data and Information Center http://www.nmdis.gov.cn

SOA http://www.soa.gov.cn

List of Acronyms

AOP	Aspect Optical Property
AVHRR	Advanced Very High Resolution Radiometers
COCTS	Chinese Ocean Colour and Temperature Scanners
CZCS	Coastal Zone Colour Scanner
ETM	Enhanced Thematic Mapper
ERS	European Remote Sensing Satellite
ESA	European Space Agency
FY-2	Fengyun No.2 Meteorological Satellite
GMS	Glostationary Meteorological Satellite
HY-1	China Hai Yang Satellite No 1
IOP	Internal Optical Property
JERS	Japan Earth Resource Satellite
MODIS	Moderate Resolution Imaging Spectrometer
NASA	National Aeronautic and Space Administration
NASDA	National Space Development Agency of Japan
NOAA	National Oceanic and Atmospheric Administration
OCTS	Ocean Colour and Temperature Scanner
SAR	Side-looking Aperture Radar
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SIO	Second Institute of Oceanography
SOA	State Oceanic Administration of China
SST	Sea Surface Temperture
S-VISSR	Stretched-Vissible Infrared Spin Scan Radiometer
TM	Thematic Mapper
T/P Altimeter	Topex Altimeter
VISSR	Visible infrared spin-scan radiometer