Annex VI-1

Draft National Report on Ocean Remote Sensing in China

(Reviewed by the Second Meeting of NOWPAP WG4)

1. Status of RS utilization in marine environment monitoring

1.1 Marine remote sensing researches and applications in the 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. The first NOAA receiving station was constructed in 1987 by National Marine Environment Forecasting Center. The system was applied to monitor the formation, development and withering 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.

Landsat images were intensively used in monitoring of coastal environment. For example, Landsat MSS images were firstly applied to detect the shoreline change in the Yellow River Delta in 1982. Since then, Landsat TM and ETM images have become the main data sources for monitoring of coastal ocean environment in China. 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 ten years. 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 the satisfactory accuracy of the water radiance by the optical remote sensing. 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. Finally, prototype software packages and local operational systems were developed and constructed.

(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. Anocean 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 system of optical remote sensing were developed both by Second Institute of Oceanography (SIO) , State Oceanic Administ ration (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.

Table One Optical sensors for marine environment monitoring

Sensor	Satellite	Variables	Observing cycle	Intended use of data
AVHRR	NOAA	5	0.5D	SST,
	GMS			
MVIRS	FY-1C	8	0.5D	SST, water color
SeaWiFS	SeaStar	8	1 D	SST, water color
MODIS	Terra	36	1 D	Water color, Phaeopigmenta
COCTS	HY-1	10		Water color, SST
CCD	HY-1	4		LOCIZ
TM/ETM	Landsat	7/8	16D	Coastal change
CCD	CBERS	5	26D	Coastal change
IMRSS	CBERS	4	26D	Coastal change
WFI	CBERS	2	26D	Coastal change

Table Two Microwave sensors for marine environment monitoring

Sensor	Satellite	Variables	Observing cycle	Intended use of data
SAR	ERS-1/2	C		
ScanSAR	Radarsat	C	24D	
Altimeter	Topex/Poseidon			
Altimeter	GeoSAT			
Scatter	ERS-1/2			
SeaWinds	QUICKSCAT			
ASAR	ENVISAT	C	35D	

2. Case examples of RS application 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.

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 more 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 use. 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. All 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.

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. 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.

Table Three 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

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. 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.

Prof Dongzhi Zhao has being conducted a research on application of MODIS data to monitoring of red tide. 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 One.

Table Four 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

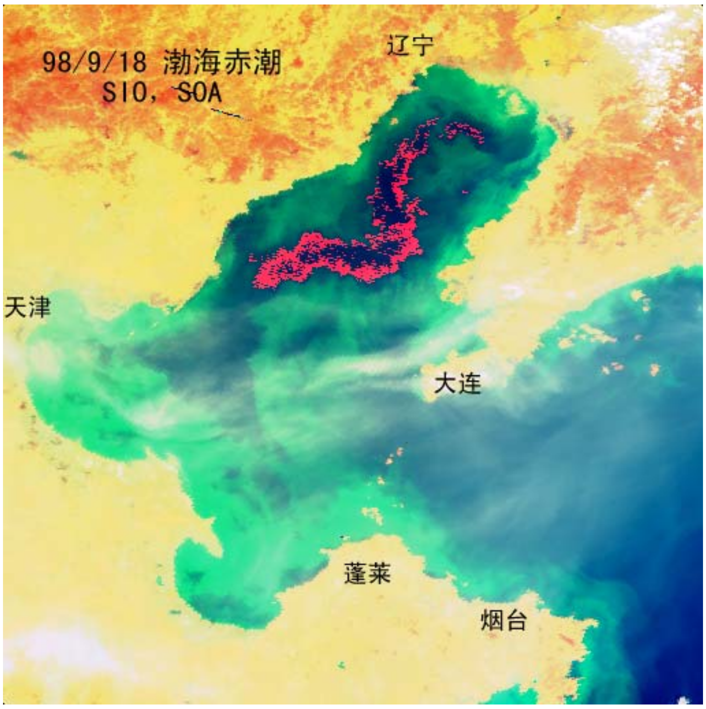

Figure One Red Tide monitoring by Using SeaWiFS in 1998

3. Status of R&D on remote sensing technology for marine environment

3.1 Sensor

High spatial resolution airborne SAR sensor was developed in China. This sensor is very useful to measure the shoreline under all-weather conditions. More researches will be devoted to the algorithms development.

3.2 Algorithm for geo-physical parameters

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 HY21A satellite orbit calibration and the atmospheric correction. Neural network technique is used to inverse the chlorophyll a , and the slope of two optical channel reflectance 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.

3.3 Validation of geo-physical parameters

(to be added)

4. Introduction of latest findings

(to be added)

5. Strategies / Plans for RS related activities

(to be added)

6. Challenges and Prospects

(to be added)

7. Suggested activities for the NOWPAP Region

(to be added)