CGMS XXXIV CNSA-WP-02
Prepared by CNSA
Agenda Item: B.3
Discussed in Plenary

HY-1 satellite program and its application in China

The Chinese first Haiyang satellite (HY-1A) is an experimental and operational satellite for detecting ocean color and sea surface temperature. It was successfully launched on 15 May. 2002. The main sensors on board include the 10-band Chinese Ocean Color and Temperature Scanner (COCTS) as well as a 4-band CCD imager.

HY-1A satellite has run about two years and has monitored large sea areas of China. The first orbit images were received and processed by ground stations in Beijing and Sanya, on 29 May 2002. Two ground stations have got about 1830 orbit passes (3 passes each day) data from HY-1A satellite. The National Satellite Ocean Application Service carried out a great number of application work according to the properties of the two sensors on the satellite. Data from the Satellite have found wide applications in marine resource management, marine environment monitoring and protection, marine disaster monitoring and forecasting, oceanographic research and international cooperation.

HY-1B satellite, the successor of HY-1A satellite，is approved and will be launch in 2006. Its specifications will adjusted for the requirement of ocean observation according to the experiences of HY-1A satellite.

1. Introduction

The HY-1A satellite was successfully launched to altitude of 870 km together with FY-1D satellite by a CZ-4B rocket at the Taiyuan Satellite Launching Center in north China's Shanxi Province, on 15 May 2002[1]. The satellite was placed in a near sun-synchronous polar orbit at an altitude of 798 km after 7 times orbit adjusted and transferred. Ground stations in Beijing and Sanya, on 29 May, received the first orbit images. After in-orbit testing and process, we obtain ocean-color data for primary production, coastal zone changes and environmental monitoring of the China Seas, and HY-1A satellite and ground station runs operational and it was delivered to user (SOA) on Sept. 18, 2002. The thematic data products were provided by NSOAS.

2. HY-1A satellite characteristics and ground system

2. 1 satellite characteristics

The main use of HY-1A is to detect the marine environmental parameters of the China Seas, including chlorophyll concentration, suspended sediment concentration, and dissolved organic matter, pollutants, as well as sea surface temperature. The satellite will play an important role in developing and utilizing the marine bio-resources, constructing and managing the harbor, detecting the ocean pollution, investigating and developing coastal resources and studying the global environmental changes.

HY-1A satellite is a small satellite with a mass of approx. 367kg and a power generation capability of more than 350W, three-axis stabilized. The working life is about 2 years. The spacecraft was launched to altitude of 870km together with FY-1D satellite. In order to get a short repeat period and good time for observing ocean color , orbit transfer was made 7 times and finally the satellite move and operate in a near sun-synchronous and near-polar orbit at altitude of 798 km. The satellite is composed of the communication and data transmission subsystem, the electrical power subsystem and the attitude and orbital control subsystem. On the satellite there are two sensors, one is the Ocean Color and Temperature Scanner (COCTS), the other is CCD imager. Their main characteristics are listed in table 1:

Table 1: Satellite and Orbit Characteristics

Orbit type	Near Circular and near sun-synchronous
Equator crossing time	8:53-10:10am (descending node)
Altitude	798km
Inclination	98.8 deg
Period	100.8 minute
Repeat observation period	3days for COCTS, 7days for CCD
Mass	367kg
Payload	COCTS and CCD
Attitude control	3 axis stabilized
Downlink frequency	X-band
Design life	2 years
Memory recorder on board	80Mbyte (can record 18 minute COCTS data)

The COCTS is an optical radiometer to detect ocean color and surface temperature. COCTS has a function to detect the amount of chlorophyll and dissolved substances in the water, and temperature distribution. The data of COCTS will be used to get the information of ocean conditions for fishery and environment monitoring. Its repeat period is 3 days. There are 8-channel visible and near-infrared band and 2-channel thermal infrared band with the spatial resolution of 1.1km.

The CCD is a medium spatial resolution optical sensor for observing ocean color, land and coastal zones. CCD has 4

spectral bands from 0.42-0.89μm with spatial resolution of 250m. The CCD data will be used for regional mapping of different water constituents and vegetation, monitoring pollution of coastal zones for resource exploration etc. Its repeat period is 7 days. The main characteristics are summarized in table 2. 3. 4

Table 2 Major parameters of COCTS and CCD

Parameter	COCTS	CCD
Spatial resolution	1.1km	0.25km
Scan coverage	1400km	500km
Digitization	10bit/pixel	12bit/pixel
Radiometer accuracy	10%	10%

Table 3 COCTS bands and detecting object

Band (micro m)	Main detecting object
0.402-0.422	Yellow substance、water pollution
0.433-0.453	Chlorophyll absorption
0.480-0.500	Chlorophyll、sea ice、pollutant
0.510-0.530	Chlorophyll、water depth、pollutant、suspended sediment
0.555-0.575	Chlorophyll、vegetation、sand
0.660-0.680	Fluorescence、suspended sediment、atmospheric correction、aerosol
0.730-0.770	Suspended sediment、atmospheric correction、vegetation
0.845-0.885	Atmospheric correction、water vapor
10.30-11.40	Surface temperature
11.40-12.50	Surface temperature

Table 4 CCD bands and detecting object

Band (micro m)	Main detecting object
0.42-0.50	Suspended sediment、pollutant、vegetation、sea ice
0.52-0.60	Pollutant、vegetation、ocean color 、sea ice
0.61-0.69	Soil、Atmospheric correction、water vapor
0.76-0.89	Soil、Atmospheric correction、water vapor

2.2 The ground system

The HY-1A satellite ground system consists of components for data receiving and preprocessing, data processing, data archiving and distribution, calibration and validation, communication, operation control and application and demonstration subsystem. The ground segment is very important to demonstrate satellite application. NSOAS is responsible for marking the satellite observation schedule, real-time receiving and processing archiving and distribution

of HY-1A satellite information products for marine environmental parameters forecast operational. The structure of HY-1 ground system shows as Fig.1.

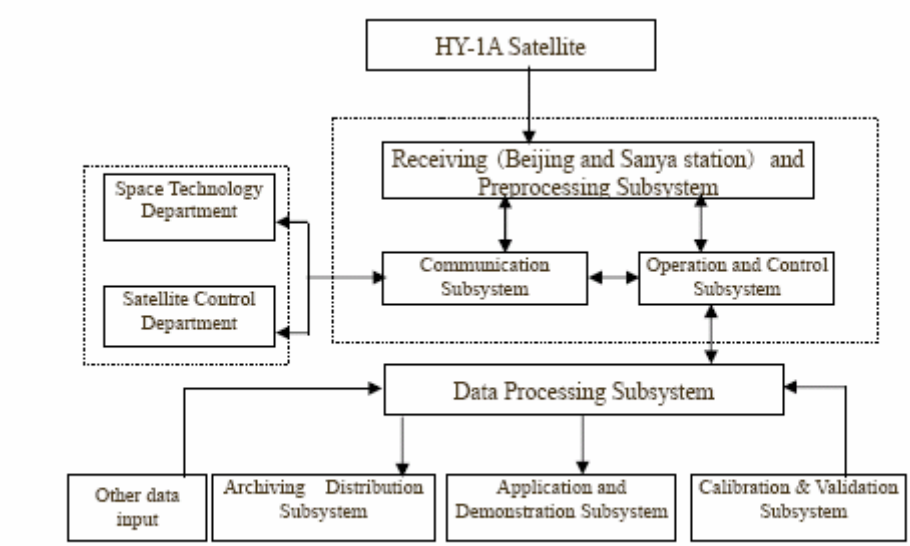

Fig. 1. The Structure of HY-1 ground system

There are four Level data product types after processed for HY-1satellite as table 5

Table 5 HY-1 satellite data product types

Level	Sensor	Data product type
Level-0	COCTS	COCTS raw data after unpacked (L0)
	CCD	CCD raw data after unpacked (L0)
Level-1	COCTS	After geographic location (L1A), and radiance calibration (L1B)
	CCD	After geographic location (L1A), and radiance calibration (L1B)
Level-2	COCTS	6 Normalized water-leaving radiance (412、443、490、510、555 and 670 nm) 3 aerosol radiance (670、750 &865nm) Chlorophyll-a concentration SST Pigment concentration Aerosol optical thickness at 865 nm Suspended matter concentration Diffuse attenuation coefficient
	CCD	Vegetation index NDVI and suspended sediment
Level-3	COCTS	Monthly and week statistical report for level-2
	CCD	Thematic data product

3. Applications and product show

Since May 2002 HY-1A satellite has monitored large sea areas of China, the Pacific, Indian, Atlantic and Arctic oceans, as well as the North and South poles. Two ground stations have got 2 or 3 passes each day. The coverage of the Beijing and Sanya ground stations as Fig. 2. These remote sensing imageries cover different sea areas and inland surface present so abundant coastal features, morphology and marine information, bright and gorgeous rivers, lakes and seas as well as various land vegetations. More than 40 quantitative satellite remote sensing products including chlorophyll, suspended

sand, sea surface temperature, vegetation index were developed [2]. Application service projects such as studies of ocean fisheries, marine primary productivity, monitoring of red tide, sea surface temperature, and sea ice and coastline variation were fulfilled.

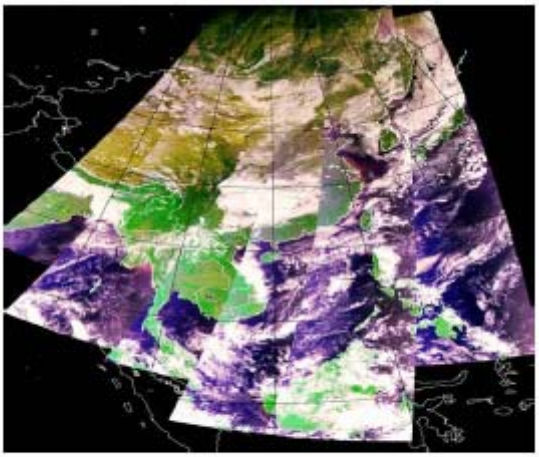

Fig. 2. HY-1A COCTS three-day mosaic image of the Beijing and Sanya ground stations of Jan.14-16,2003, (R/ch6,G/ch8, B/ch2

(1) Monitoring of ocean color

Ocean color is one of the basic elements of the marine environment and an important index of reference for activities such as offshore production and oceanographic research. Large scale and periodical acquisition of ocean color information was realized in the offshore and the adjacent sea areas by using HY-1A Satellite. Meanwhile we have got Chlorophyll-a average distribution and four seasons change from COCTS level-2 product. Fig. 3 shows Chlorophyll-a average distribution in China's sea area.

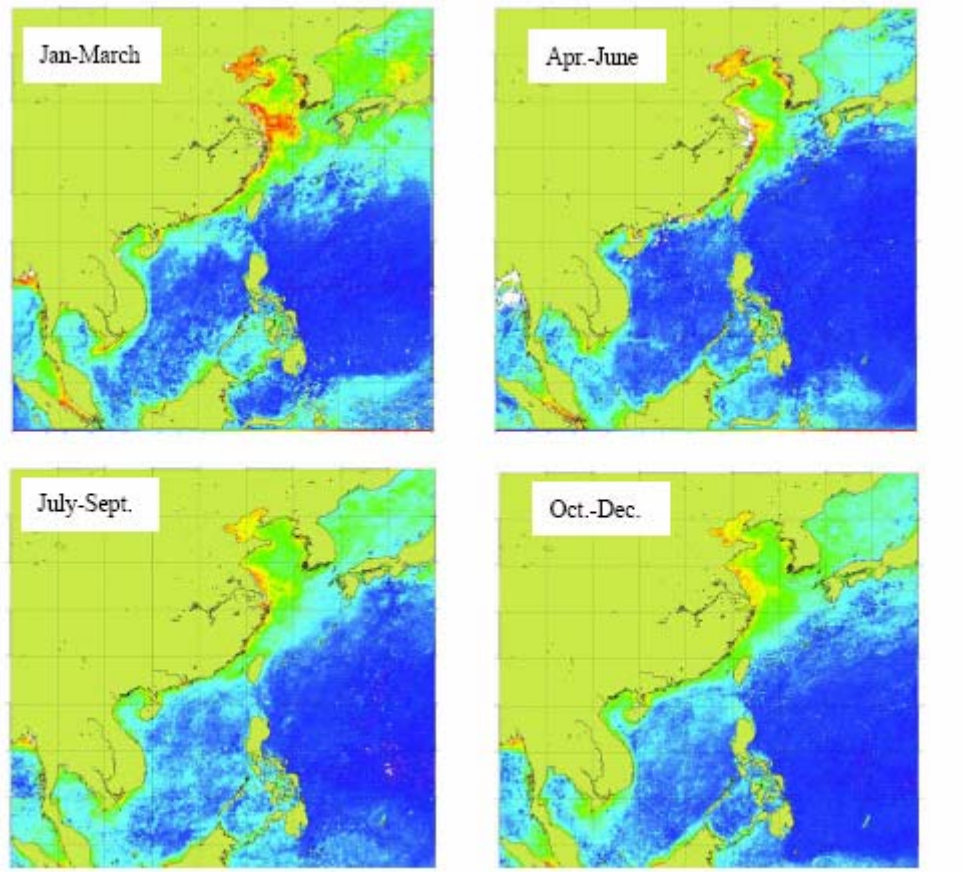

Fig.3. Chlorophyll-a average distribution in China's sea area in four seasons 2003

(2) Monitoring of sea surface temperature

Sea surface temperature (SST) is also an important variable about the dynamics of the marine environment. We can get SST from channel 9 and Channel 10 of COCTS on HY-1A Satellite, and we can also get the SST distribution and 4 seasons change. Fig. 4 shows SST average distribution in China's sea area.

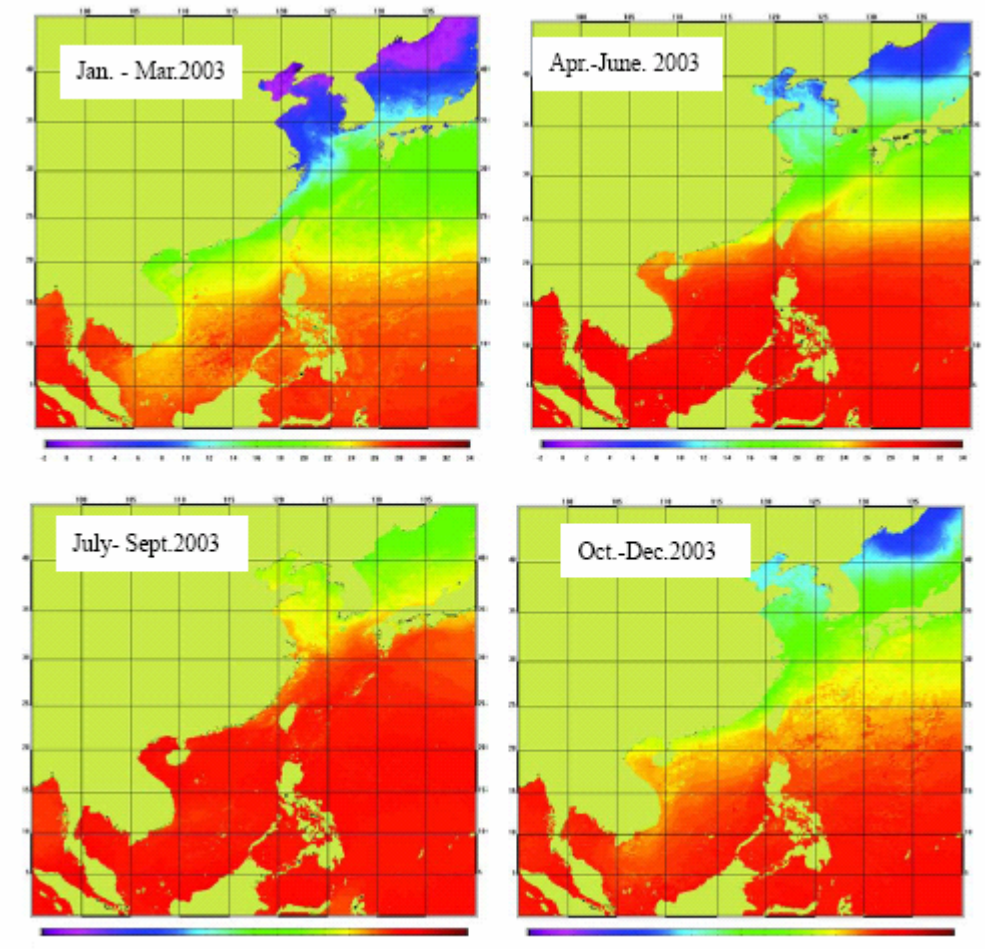

Fig.4. SST average distributions in China's sea area in four seasons 2003

(3) Sea ice monitoring

The Bohai Sea covered with ice from December to March every year. The maximum extent of sea ice generally occurs in January and the typical thickness is less than 50cm. Sea ice threatens oil platform operation and the ship transportation. A variety of sea ice parameters, such as ice extent, thickness, concentration and image was extracted from visible and infrared channel of NOAA and GMS operational satellite in the past. During the winter of 2002~2003, the data of the HY-1A were applied to the sea ice monitoring and forecasting for the Bohai Sea of China for the first time [3]. The sea ice retrieve system of the HY-1A has been constructed. It receives 1B data from the satellite, outputs sea ice images and provides digital products of ice concentration, ice thickness and ice edge, which can be used as important information for sea ice monitoring and the initial fields of the numeric sea ice forecast and as one of the reference data for the sea ice forecasting verification.

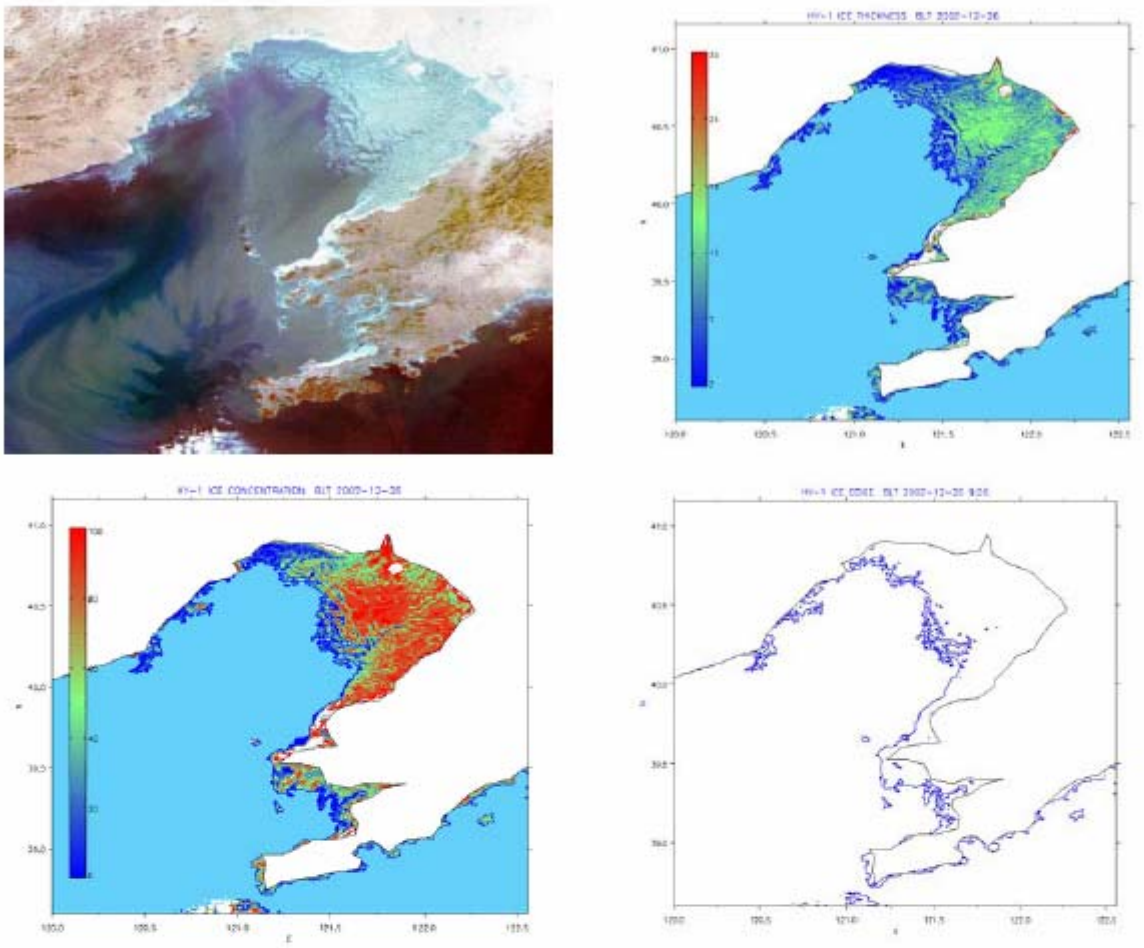

Fig. 5. The sea ice image and ice thickness, concentration, edge distribution from CCD

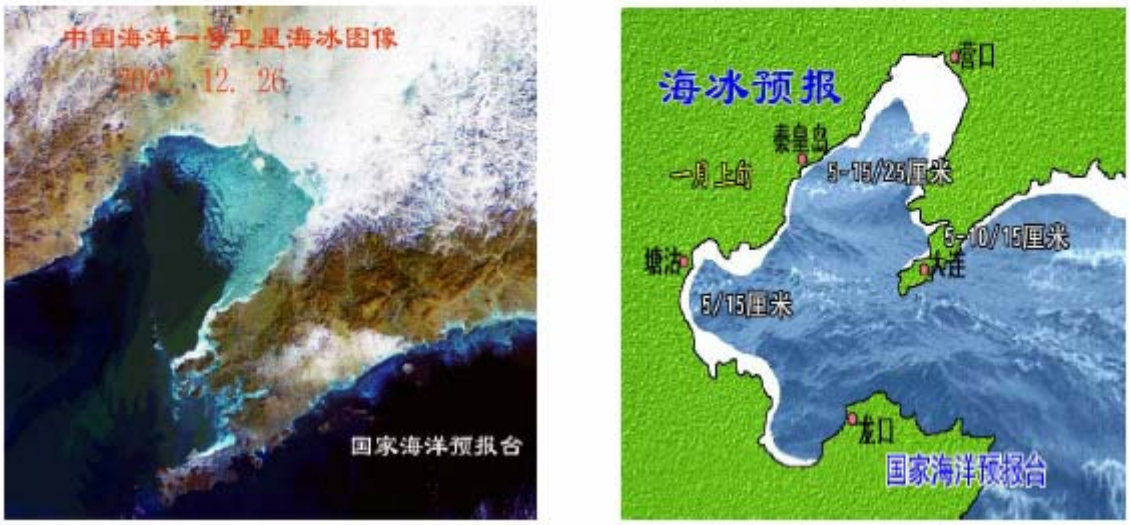

Fig. 6. The Bohai Sea ice image of HY-1A (left) on Dec.26, 2002 and the Bohai Sea ice forecasting graph of the first ten days of January, 2003 (left) broadcasted by CCTV on December 29, 2002

(4)Detection of red tide and pollution events

Several red tide events were detected using data products of ocean color and sea surface temperature extracted from

HY-1A Satellite data, including the red tide event occurred on 15 June, 2002 in Liao Dong bay, on 25 April 2003 in the waters off Qinghuangdao, the red tide event on 1 July 2003 in the adjacent waters around the Dagu mooring area off Tianjin, the red tide event on 11 August 2003 in the waters around the Caofeidian Port in the Bohai Sea, and the red tide event on 18 September 2003 in the sea area to the north east of the Yangtze River estuary. Information about these red tide events was distributed timely to the local ocean administrative agencies in the form of "Bulletin on Satellite-observed Red Tide". Fig. 7 shows the red tide in Liao Dong Bay on 15 June. 2002.

(5)Monitoring coastal zone

In 2002-2003, many charts of the environment in the Yellow River estuary, the Yangtze River estuary and the Pearl River estuary were prepared by the National Satellite Ocean Application Service and the First Institute of Oceanography of the State Oceanic Administration, using the high resolution remote sensing data provided by the CCD imager on HY-1A Satellite, which included Charts of resource investigation and vegetation classification, charts of dynamic variation of the coastline, and charts of suspended sediment grading in the estuaries. All of the charts are highly useful in the resource investigation in the coastal areas, the monitoring of the dynamic variation of the coastline, the research on the distribution characteristics of suspended sediments in the estuaries, and the study on the classification and utilization of lands in the estuaries. They played important role in the functional zoning of the coastal areas, in the coastal zone management and in the utilization of resources in the estuaries in China. Fig.8 shows sediment distribution of the Liao He Estuary and Liao Dong Bay from HY-1A CCD imager.

Fig. 7. Red tide on the Liao Dong Bay from HY-1A CCD on June 15, 2002, Green color area is the position of the red tide.

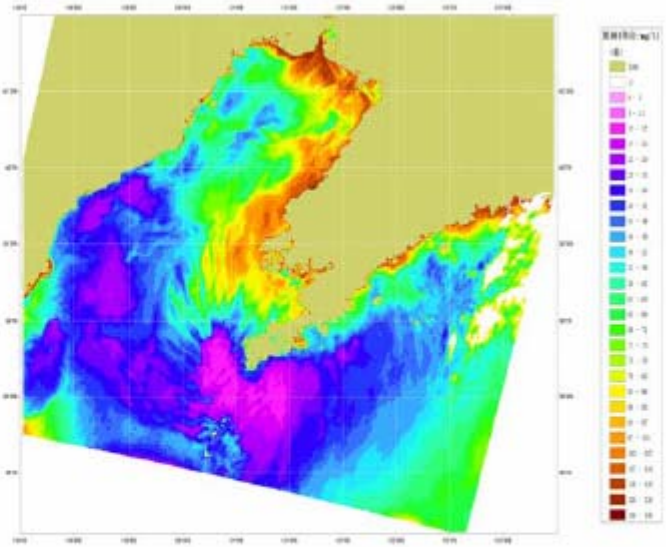

Fig.8. Estuary monitoring: Sediment distribution of the Liao He Estuary and Liao Dong Bay from HY-1A CCD imager on Apr.4, 2003.

4 The status of the on-orbit HY-1A

HY-1A satellite was launched on May 15th, 2002. The earth observation data was transmitted from 29 May. It made observations on 1830 orbit tracks over earth. Fig.9. shows Schematic diagram of observing area.

The K mirror of COCTS works unstable since June 15 2002. The data from COCTS was generally usable after the adjustment of the rotation of the K mirror through process software. The CZI sensor stopped working on Dec. 1, 2003, after 17 months of operation, because of electrical circuit failure. The solar power arrays can not provide enough power for HY-1A satellite on 30 March 2004.

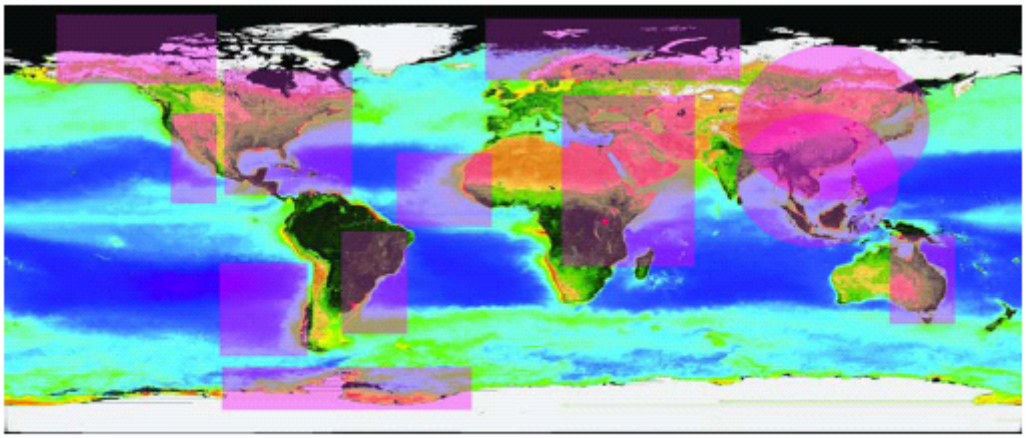

Fig.9. Schematic diagram of observing area

5. Development of HY-1B Satellite

The development of HY-1B, as the successor of HY-1A Satellite, was initiated in 2003. is planned to launch in 2006.According to the design plan and requirements, the general technical specifications of HY-1B will be similar to that of HY-1A, the satellite platform will be of the same type as used by HY-1A, the significant payload will still be the 10-band ocean color and temperature scanner (COCTS) and the 4-band CCD imager. Some functions of HY-1B, in comparison with HY-1A, will be improved. Modifications of the techniques and equipment will be made to eliminate problems that jeopardized HY-1A and meet the requirement of ocean observation. The lifetime of HY-1B will be designed to be 3 years. The angle of view of the COCTS will be increased and the coverage period of COCTS will be one day. The capability of remote sensing over seawaters beyond China's jurisdiction will be greatly enhanced. The local time of descending node will be adjusted to 10:30AM; the amount of the on-orbit memory will be increased for the ability of the globe observation.

6. Data policy

All data can be available and free for domestic users in accordance with agreement. And the Level 1b data of COCTS on HY-1A/B satellite can be provided for scientific research community outside China, in accordance with the memorandum of understanding (MOU) between the related entity and NSOAS. The data was processed after cloud detection geographic location, and radiance calibration. The data format is standard HDF. The coverage area will be included the west pacific ocean and the arranged area as user requirement. The data can be distributed by internet or CD-ROM media.

7. Conclusion

HY-1A satellite is the beginning of a new era of china’s ocean remote sensing and also ended the history of no ocean-satellite in china, it has run about two years and used widely for marine environmental monitoring. We will continue to develop Chinese own ocean satellite and utilize other satellites as much as possible; we will also promote international cooperation in remote sensing for globe environment problem.