Annex V-3 Draft Integrated Report 2003

(Prepared and Submitted by CEARAC Secretariat)

Chapter 1 Situation of remote sensing monitoring in NOWPAP region

The present situation of remote sensing monitoring in the region was reviewed based mainly on National Reports submitted to the first FPM in February 2003.

1.1 Sensors used for Marine Environmental Monitoring

Sensors currently used for marine environmental monitoring in NOWPAP Members are shown in Table 1. Japan, China, Korea, and Russia use 4, 2, 5, and 9 types of sensors, respectively, mainly for marine environmental monitoring.

Table 1 Sensors used for Marine Environmental Monitoring in NOWPAP Members

Sensor	Satellites	NOWPAP Members			
		Japan	China	Korea	Russia
AVHRR (Advanced very High Resolution Radiometer)	NOAA	○	○	○	○
SeaWiFS (Sea-Viewing Wide Field-of-View Sensor)	OrbView-2	○		○	
MODIS (Moderate Resolution Imaging Spectroradiometer)	Terra Aqua	○		○	○
GLI (Global Imager)	ADEOS-II	○			○
MVISR (Multi-Channel Visible and IR Scan Radiometer)	FY-1	○	○		
S-VISSR (Stretched-Visible and infrared spin Scan Radiometer)	GMS-5			○	
OCM (Ocean Color Monitor)	IRS-P4			○	
VISSR (Visible and infrared spin Scan Radiometer)	METEOSAT				○
HRVIR (High-Resolution Visible Infrared)	SPOT				○
RLS-BO (Side-looking radar)	Okean-01 Okean-O				○
MSU-SK, MSU-E (multispectral scanner)	Resurs–01				○
SAR (Synthetic Aperture Radar)	ERS-1				○
AMI-SAR (Active Microwave Instrument - Synthetic Aperture Radar)	ERS-2				○
ASAR (Advanced Synthetic Aperture Radar) MERIS (Medium Resolution Imaging Spectrometer Instrument)	ENVISAT				○
TMI (TRMM Microwave Imager)	TRMM				○

1.2 Utilization of Remote Sensing in NOWPAP region

1.2.1 Japan

1.2.1.1 Sea surface temperature

AVHRR (Advanced Very High Resolution Radiometer) on POES (Polar orbital Environmental satellites) NOAA has been observing sea surface temperature for a long time. Receiving systems for AVHRR are widely distributed in Japan, among which about 30 receiving stations from Hokkaido to Ishigaki Island are in operation.

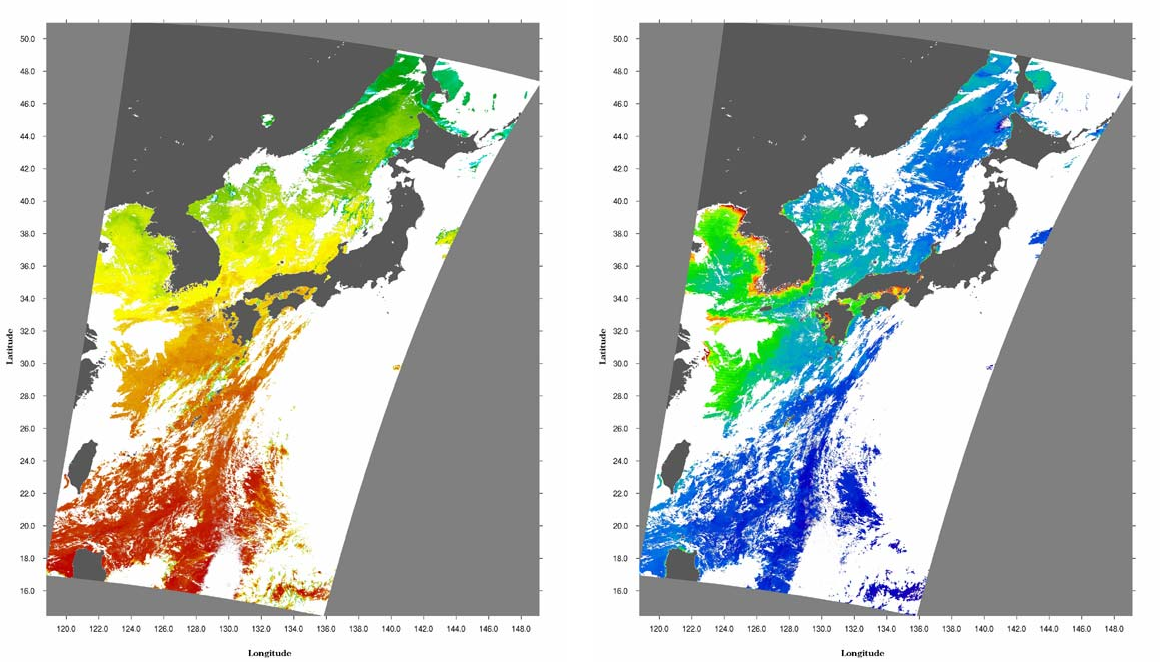
NASA (National Aeronautics and Space Administration) and NOAA (National Oceanic and Atmospheric Administration) provide sea surface temperature data (MCSST: Multi-Channel Sea Surface Temperature) observed by AVHRR on the POES NOAA satellite as the products of the AVHRR Pathfinder Project. In Japan national research institutes, educational institutions, and fishery related institutes such as fisheries experiment stations provide SST data observed by AVHRR on the POES NOAA satellite.

1.2.1.2 *Chlorophyll-a* and ocean color related data

SeaWiFS (Sea-Viewing Wide Field-of-View Sensor) contributed to observation of *chlorophyll-a* concentration and research of ocean color science.

NASDA (National Space Development Agency of Japan) received SeaWiFS data at Tokai University, produces *chlorophyll-a* distribution maps in waters around Japan, and provides them for SeaWiFS authorized users.

Utilization of the MODIS (Moderate Resolution Imaging Spectroradiometer) data has no restrictions on use. Therefore, a variety of institutes, mainly educational institutions such as universities, receive and process the data. Tokai University receives MODIS data at Kumamoto, Japan, and NASDA processes and provides *chlorophyll-a* distribution map, sea surface temperature map, and false color image. Program for GLI (Global Imager) is modified and applied to produce high-level processed datasets for the MODIS data as NASA policy not to open programs for MODIS because of copyright issues. Figure 1 shows *chlorophyll-a* distribution and SST observed by MODIS and provided by NASDA.



SST
http://kuroshio.eorc.nasda.go.jp/ADEOS/mod_nrt/data/nrt/day/200209/3002/A2GL10209300201OD1_OSTFR_03036_03654_sst.jpg

Chlorophyll-a
http://kuroshio.eorc.nasda.go.jp/ADEOS/mod_nrt/data/nrt/day/200209/3002/A2GL10209300201OD1_OCSFR_03036_03654_chla.jpg

Figure 1 SST and *chlorophyll-a* by MODIS (September 30, 2002)

1.2.2 China

The main current satellites now operated in China for marine monitoring are NOAA and FY-1. The NOAA is mainly used in weather monitoring, such information as cloud, heat and coastal water temperature can be acquired from it. The FY-1 with resolution of 1.1km is mainly used in weather and marine monitoring. In part of Chinese coastal area (Bohai Sea and East Sea), the information of HAB and *chlorophyll-a* in provided by FY-1.

But the effect of the both satellites is not very good in marine monitoring. In the near future China plans to start MODIS with resolution of 250m in marine monitoring.

At present, China use satellite data to measure coastal water quality, to forecast the influence of social economic factors such as land-use, urbanization etc. to the coastal line, to monitor the dynamic change of the coastal line wet-land and according to the responding relationship of contamination and the spectrum wave band, China can use hyperspectral remote sensing to monitor some items such as chroma, turbidity, *chlorophyll-a* and CDOM (colored dissolved organic matter). The last but not the least is that we use the satellite data in HAB fast spot monitoring.

1.2.3 Korea

Korea is operating five kinds of earth observing satellites (Marine remote sensing system (NFRDI, KOREA) is shown in Figure 2). The real-time information on sea surface temperature around the Korean Waters was acquired from the NOAA satellite series and that around the entire western Pacific Ocean from the GMS-5. The ocean color such as phytoplankton distributions around the Korean Waters is provided from the SeaWiFS, MODIS and OCM satellites.

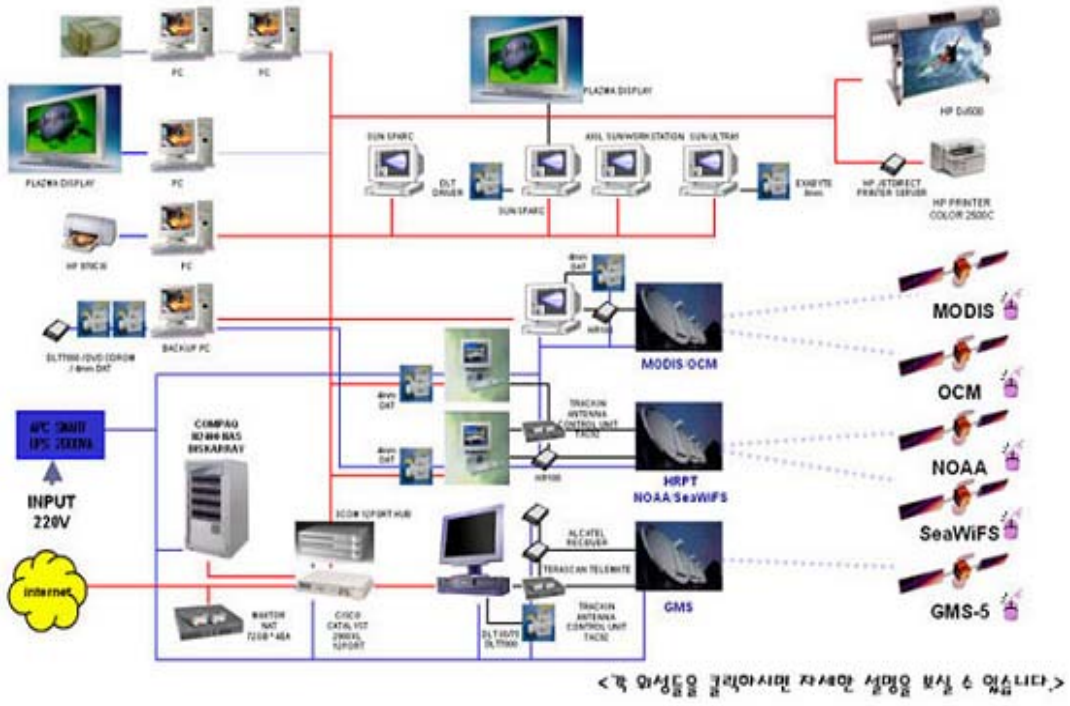


Figure 2 Marine remote sensing system (NFRDI, KOREA)

NOAA satellites with AVHRR provide real-time information for water temperature in the Korean waters 6 times per day, while GMS-5 with S-VISSR provide that in the northwestern Pacific 8 times per day. The spatial solutions are 1km with accuracy of 0.5℃ for NOAA and 5km with accuracy of 1℃ for GMS-5. NOAA data is very useful to understand the thermal front and optimal temperature for sustainable fishing in Korean waters and GMS-5 data can be used for negotiation of the issue on the fishing ground of saury between neighboring countries such as Russia and Japan.

The satellite data on water temperature and ocean color can be available in web site (http://www.nfrdi.re.kr/kodc) for free. These data are updated and provided to fisherman very promptly every day.

1.2.4 Russia

1.2.4.1 Apkon 2 system

Apkon 2 system can be used for land, sea ice and ocean monitoring and surveillance.

1.2.4.2 NOAA

The NOAA Coastal Services Center serves as the nation's coastal resource managers.

1.2.4.3 Passive microwave Aqua AMSR-E, ADEOS-II AMSR

The important feature of microwave data is that SST and near surface wind can be measured through clouds. This is a distinct advantage over the traditional infrared SST observations that require a cloud-free field of view. Ocean areas with persistent cloud coverage can now be viewed on a daily basis. Furthermore, microwave SST and wind speed data are not affected by aerosols and are almost insensitive to atmospheric water vapor. Additionally, the fields of the total atmospheric water vapor, cloud liquid water

content, precipitation, sea ice compactness, etc. can be also retrieved.

1.2.4.4 Active microwave ERS-2 SAR, ENVISAT ASAR, QuikSCAT9

A high spatial resolution of SAR data makes it possible to study sea surface water circulation in a range from hundreds meters to several tens kilometers. The eddies, fronts, currents, upwellings, internal wave, island wakes, sea ice, oil pollution, ship wakes as well as the imprints of the various atmospheric phenomena are revealed on SAR images due to their brightness contrasts and distinctive spatial characteristics.

1.2.5 Summary of Utilization of Remote Sensing in NOWPAP Region

Most countries in NOWPAP region use NOAA for SST observation due to its established methodology and observation frequency. The remote sensing data are utilized for fisheries. NOAA will be used for SST observation continuously in the future.

Regarding *chlorophyll-a* and ocean color related data, sensors used in NOWPAP Members vary from each other. Japan uses SeaWiFS, MODIS, GLI, and FY-1 (MVISR), China uses FY-1 (MVISR), Korea uses SeaWiFS, MODIS, and OCM. Russia uses MODIS, GLI etc., even though ocean color observation is not clearly stated. Methods of remote sensing data utilization should be integrated to make the best use of ocean color sensors used in NOWPAP region.

For Oil spill application, Synthetic Aperture Radar (SAR) could be used and its utilization needs to be considered in the future.

1.3 Major Research Activities

1.3.1 Japan

1.3.1.1 Sea Surface Temperature

SST observed by AVHRR helps to understand time and spatial fluctuations of water mass, ocean front, and eddy. These data are utilized for researches of physical processes. Moreover, recent provisions of sea surface temperature for fishery and the research of the formation mechanism of fishing ground are considered as examples.

1.3.1.2 Ocean color sensor

Observation of *chlorophyll-a* concentration by ocean color sensor such as SeaWiFS helps to catch and predict fluctuation of time and spatial distribution of primary productivity. The examples of application to fishery are the tentative provision of data to fishermen, and the research of the formation mechanism of fishing ground with SST data. Also, there is a possibility of ocean color application to the research of algae blooms.

NASA and NASDA jointly worked on algorithms between OCTS (Ocean Color and Temperature Scanner: ADEOS-I) and SeaWiFS so that both sensors keep a consistency in measuring *chlorophyll-a* distribution. At present, OCTS is processed with the adjusted algorithm, and the datasets are open to the public. NASDA also statistically adjust the parameters between SeaWiFS and MODIS to keep a consistency in *chlorophyll-a* distribution. The consistent *chlorophyll-a* distribution data from November 1996 derived from different sensor is available. As for *chlorophyll-a* distribution data derived from GLI, adjustments between different sensors are planned as same way to keep the consistency.

1.3.1.3 Watch system of the ocean environment in the northwest pacific region

In order to promote sea observation by satellite remote sensing, the Ministry of the

Environment of Japan entrusts examinations of the project called "Watch system of the ocean environment in the northwest pacific region" to NPEC (Northwest Pacific Region Environmental Cooperation Center) from 2000, and the receiving station has been in operation since March 2002 (http://www.nowpap3.go.jp/jsw/).

This project has two objectives, which are to examine a possibility of ocean observation by polar orbital meteorological satellite, and to examine a suitable system for ocean pollution monitoring by meteorological satellite. With regard to the former, ocean observation by AVHRR on the NOAA satellite and MVISR (Multi-Channel Visible and IR Scan Radiometer) on the FY-1 satellite is subject to study. These satellites observe with relatively high frequency in time, and it is meaningful to increase an observation opportunities, while clouds frequently cover the ocean. MVISR has similar abilities such as resolution and bands to AVHRR, and is able to observe in blue and green bands. With regard to the latter, meteorological satellite has a limitation in their abilities to observe ocean environment, especially in a sense of pollution, because these are not originally designed to observe ocean environment. This project examine the best suitable satellite observation system for monitoring ocean pollution from the points of software and hardware.

In this project all received data is archived so as to be used in the future researches. Catalog/database system manages the observation data in the archives. The data is accessible on the web, and distribution maps such as cloud and SST and 10 days composite image of SST of day and night are available. In order to encourage the data use, data is processed corresponding to the requirements of users as an experimental service.

1.3.2 China

1.3.2.1 Application for HAB monitoring

The main research activities on remote sensing for marine monitoring are focusing on the remote sensing multi-sensor integrated system research, HAB feature spectrum measurement and satellite remote sensing monitoring feasibility research, the quick transmission of the remote sensing image data through internet for real-time monitoring, remote sensing application technology and method research, By all efforts, China find three methods of HAB disaster satellite remote sensing monitoring:

- the first one is image synthesization. The direct character of most HAB phenomena is the abnormity of the coastal water color. Using this characteristic, and choosing three bands image to synthesize false-color image, China will find the exceptional coastal water area, which is the HAB area.
- the second one is to use the difference of the temperature of the coastal water. The change mechanism of the temperature of the coastal water is distinctively different before and after HAB happens.
- the third one is the information retraction of the coastal water surface cell biology quantity, calculate using the satellite image band, build relationship of image radiation brightness and HAB phytoplankton cell quantity, then inverse coastal water surface phytoplankton cell quantity, according to the threshold of the HAB biology cell quantity, the HAB areas are confirmed and measured.

1.3.2.2 Needs of *in situ* data

Despite a better tool of remote sensing in marine monitoring, China still cannot abandon the manual sampling and lab analysis, for when red tides occurs, the RS image can only tell us the move direction and developing trend. The algae species that cause red tides

should rely on manual sampling and lab analysis.

1.3.3 Korea

The calibration and validation of satellite data was done through the comparison with the *in situ* data. To actively use the IR band data of MODIS satellite, Korea is trying to find the relationship on SST between NOAA IR band data and MODIS radiance data at the same time and space.
The information of ocean color was obtained from SeaWiFS with resolution of 1km. *chlorophyll-a* information is estimated using 2 ocean color algorithms with the band ratio between 490nm and 550nm. Korea receives Indian ocean color satellite (OCM) data one time every other day. The resolution of OCM (360 m) is three times higher than that of SeaWiFS. Therefore it is possible to monitor ocean color in the bay and coastal water. For calibration and validation, OCM data is compared with SeaWiFS data. After calibration and validation of OCM data, *Chlorophyll-a* concentration in the coastal water of the Korean peninsular is measured.

Korea is also monitoring the turbid water using the band of red, green and blue on MODIS. The quantification of turbid water with digital data from MODIS is in progress.

1.3.4 Russia

1.3.4.1 The Inter-Institute Center for the Satellite Monitoring of Environment

The main mission of the Center is to conduct the Regional Satellite Monitoring of various nature objects and processes in the frames of scientific programs and applications conducted in institutes.

- Monitoring objects-at present:
  SST, frontal zones, eddies, currents, sea ice, typhoons etc.
- Monitoring objects-in sight:
  forest fires, floods, oil pollutions at sea
- Monitoring applications-at present:
  - scientific investigations (physical oceanography and meteorology);
  - information support of maritime cruises;
  - fishing areas productivity evaluation and forecast (with TINRO-Center)

1.3.4.2 Marine monitoring projects using satellite data

The main goal is to investigate dynamic phenomena and processes in Far Eastern seas and in the Northwestern Pacific on the basis of development and application of remote acoustic, optical and passive and active microwave techniques.

- Comprehensive investigation of oceanic processes, characteristics and resources of Far Eastern Russian seas.
- Investigation of the state and operation of marine ecosystems of the Far Eastern seas and their productive possibilities.
- Comprehensive study of the state and variability of the coastal zone of the Far Eastern seas.

1.3.4.3 Research activities on remote sensing for marine applications

-Passive and active microwave remote sensing-

- Coastal zone oceanography

- Coastal zone metrology
- Air-sea interaction in the coastal zone
- Relation of the coastal zone and the open sea

1.3.5 Summary of Major Research Activities in NOWPAP region

Japan, China, and Korea have been researching ocean color. Especially in China and Korea, researches on ocean color (related to HAB in China) comparing *in situ* data with remote sensing data have been conducted due to serious damage to fishery caused by red tide. In Japan, chemical and biological processes in the ocean have been studied such as estimation of primary productivity including its variation in time and space through the observation of *chlorophyll-a* concentration by ocean color sensor. Also in Japan, variation of water body, ocean front, eddies in time, space, and mechanism has been studied by the observation of SST as well as studies of ocean color.

In Russia, regional satellite monitoring has been conducted/studied targeting SST, frontal zones, eddies, currents, sea ice, typhoons etc presently; and forest fires, floods, oil pollutions at sea in sight. Also, investigation of physical processes in Far Eastern seas is conducted based on the development and application of remote acoustic, optical and passive and active microwave techniques.

Chapter 2 Challenges and Future Prospects in NOWPAP region

2.1.1 Japan

2.1.1.1 Ocean color

GLI/ADEOS-II was launched on December 2002 to improve observation program of OCTS/ADEOS-I from the view of observation range and precision. It has 23 bands in visible and near infrared, 6 bands in infrared, and 7 bands in intermediate and thermal infrared wavelength. It succeeded in transmitting the first image on January 2003, and NASDA planed to open its data to the public from December 2003.

2.1.1.2 Proposed plan of work for remote sensing on ocean environment

It is important to monitor fluctuation of ocean environment for the process studies in physical, biological and chemical oceanography, and fisheries. In the NOWPAP region, ocean environmental study will be expanded to a basin scale phenomena like the Tsushima current and to a region scale phenomena like algae blooms in the coastal waters. Compared with current ocean observation methods using research vessels or observation buoys, remote sensing will provide opportunities to monitor a basin scale phenomena instantly. The objective for the studies is to establish a capability to analyze and predict basin and regional scale phenomena.

Analysis and examination for prediction methods of basin scale fluctuation

The objective of the work plan is to analyze basin scale variation of ocean phenomena and to predict basin scale phenomena of the Sea of Japan and the Yellow Sea. SST and *chlorophyll-a* since 1980s are major targets to be analyzed in time and spatial domain related to a climate change. Based on the response functions of these parameters to the climate change, related environmental parameters will be studied so as to develop methods to predict a change of the ocean.

- Analysis of temporal change of basic parameters
  Satellite estimates SST, *chlorophyll-a* concentration and attenuation coefficient in 4km grid. A basin scale phenomena could be classified into multiple regions based on the response functions to the climate change, and its details in time and space will be given to represent each region. Also, sea surface wind and sea surface height observed by microwave sensors will be studied to analyze and predict a volume transport from the Kuroshio and to predict its temporal change.
- Validation of temporal change of basic parameters
  Sea surface temperature data set in coarse resolution and in time series will be validated with the high resolution sea surface temperature data.
- Examination of Related Parameters
  Time series data set of SST and *chlorophyll-a* will be examined with highly correlated parameters. Precipitation, snowfall, sea level height, fluctuation and regime shift of fishery resources, and Southern Oscillation Index (SOI) are candidates of correlated parameters.
- Prediction of ocean fluctuation
  Based on analysis in time series, prediction methods of related parameters' fluctuations in the Sea of Japan or the Yellow Sea will be developed.

2.1.2 China

Four priorities in State 863 Program of China are established in the field of marine resource and environmental technology, one of which is concerned with the marine monitoring. The main purpose of this priority is to develop advanced technologies in ocean dynamic environment monitoring, marine remote sensing and oceanic fishery information gathering, protecting marine environment and forecasting marine disasters. The priority also aims to build up the capability of fast spot monitoring of the marine environment, real-time and multi-dimensional monitoring of the ocean dynamic environment.

2.1.3 Korea

The other studies in progress are the oceanographic features of the upwelling cold water, recurring eddy, red tide, optical properties, quantification of transparency and so on around the Korean peninsular from multi-spectral satellite remote sensing.

2.1.4 Russia

2.1.4.1 Current and future national satellite programs applicable for marine monitoring

The main task of "SPUTNIK" Server (this server is joint project of SRC "Planeta" Russian Committee for Hydrometeorology (Rosgidromet) and Space Research Institute (IKI RAS)) is to provide information about Russian weather satellites.

2.1.4.2 Marine monitoring projects using satellite data

The project will allow to study the structure, composition and spatial distribution of meso- and submesoscale inhomogeneities, their temporal variability using remote techniques in the Japan and Okhotsk seas including a shelf zone and transition zone between shallow and deep sea. Systems of operational detection and forecast of transfer and degradation of oil pollution adapted to Primorye and Sakhalin shelf will be created. These investigations are currently central and have an additional support in connection of development of international projects in the Northwestern Pacific such as NEAR-GOOS, COOP, NOWPAP/UNEP and ICZM.

2.1.4.3 Projects with the European and Japan Space Agencies

- Investigation of mesoscale phenomena in the coastal zone of the Japan and Okhotsk seas with ERS-1 and ERS-2 SAR data. (Project AO-401 with ESA (1998-2003))
- Study of interaction of oceanic and atmospheric processes in the Japan Sea and the Southern Okhotsk Sea using ENVISAT ASAR and MERIS measurements. (Project AO-ID-391 with ESA (2002-2004))
- Agreement on Research Algorithm for the Advanced Earth Observing Satellite II between the National Space Development. (NASDA and V.I. П'ichev Pacific Oceanological Institute, Far Eastern Branch, Russian Academy of Sciences (POI FEB RAS)(2001-2004))

2.1.4.4 National priorities for the future activities in remote sensing of environment

- Rosaviakosmos. Federal Space Program (2001-2005)
  Manufacturing and launching of space apparatus:
  "Arkon", "Sich-1M", "Resurs-DK", "Resurs-01", "Meteor-3M"N2, "Electro", "Vulkan" and "Arkon-2"

- Khrunichev State Space Center
  Manufacturing and launching of space apparatus:
  "Monitor-E, -N, -C, -O, -P3, -P23

- NPO Mashinostroenia
  - Satellite with S-band SAR, VV and HH polarizations
  - Spatial resolution from several meters to 100-150 m (scan SAR)
  - Launching at the end of 2004 or in 2005

2.1.4.5 Suggested activities on the regional level

- Joint Monitoring programs based on remote sensing data
  Analysis of the ERS-1/2 and ENVISAT Synthetic Aperture Radar, ENVISAT MERIS, NOAA AVHRR and scatterometer data collected over the Japan and Yellow Seas to study the surface manifestations of oceanic phenomena (currents, eddies, fronts, internal waves, upwellings), river/sea mixing zones, oil pollution, sea ice, and mesoscale regulated structures in the surface wind field important for coastal zone management and monitoring.
- Training and education courses

2.1.5 Summary of Challenges and Future Prospects in NOWPAP region

Challenges and future prospects in NOWPAP region are summarized as below.
A bad news is the environmental observation satellite of GLI/ADEOS II terminated its communication on Oct. 25, 2003 which was launched in Dec. 2002 as a successor of OCTS/ADEOS I. The other satellite that takes over the role of this satellite is expected to be launched after this.

2.1.5.1 Analysis and examination for prediction methods of basin scale fluctuation

- Analysis of temporal change of basic parameters
- Validation of temporal change of basic parameters
- Examination of related parameters
- Prediction of ocean fluctuation

2.1.5.2 Suggested activities on the regional level

Plan of Work for remote sensing monitoring in NOWPAP region

(To be completed based on the discussion of the WG Meeting. Newly proposed activities, if any, will be amended.)

Chapter 3 Activities of NOWPAP WG 4 in 2003

(Accomplishment of meeting and its Record of Discussion will be compiled)