Proceedings

The Ninth Workshop of OMISAR (WOM-9) on the Application and Networking of Satellite Data

November 1-3, 2002, Ho Chi Minh City, Vietnam

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(Ocean Models and Information System for the APEC Region)

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The Ninth Workshop of OMISAR (WOM-9) on the Application and Networking of Satellite Data

Contents

Status of Oceanographic Data for the Sea of Vietnam

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ABSTRACT

Through a period of nearly one century, by many surveys, investigations on the sea of Vietnam, an oceanographic database has been set up nearly 100 most fundamental oceanographic factors. This database has managed the data of 6.731 surveys on the East Sea and adjacent areas, including 679 surveys conducted by Vietnam. The number of serial observation stations is 149.844. The stations are distributed in areas of 1 degree longitude by 1 degree latitude. Over 1.000 long-term observation stations on current, wave and sea level, including many continuous observation stations on current for 7-28 days and nights on 8-10 layers from the surface to the depths of thousand meters with a time period for measuring one data is 10-30 minutes. The database consists of following types of data: (1) Marine hydrology and chemistry; (2) Marine dynamics; (3) Marine meteorology; (4) Marine geology and geophysics; (5) Marine biology; (6) Marine pollution.

The study, investigation, survey, monitoring to collect the marine information and data should meet the need of economic development, marine environmental and resource protection, natural calamity prevention, national security protection on the East Sea. To achieve these objectives, the management, exploitation and development of the oceanographic database have been oriented to focus on the following issues: (1) East Sea and the climate; (2) Scientific bases for protection of marine ecosystems and environment; (3) Scientific bases for serving integrated coastal zone management.

THE ESSENTIALITIES

The Vietnamese Exclusive Economic Zone (EEZ) is large about one million square kilometers, more than three times the territory. The coast is long about 3,260 km, with more than 3,000 islands, in which the most famous are Hoang Sa and Truong Sa archipelagos.

Historically, the sovereignty of a nation is combined by the politics, national defense, economics, science and technology. Almost the great nations and the nations around the East Sea have focused to establish national potential and research projects, monitoring for exploitation of East Sea. Therefore, the nations should develop the study, investigation, survey, monitoring to collect and to share the marine information and data

STATUS OF OCEANOGRAPHIC DATA ON THE SEA OF VIETNAM

The study, investigation, survey and monitoring on Vietnam seas have been carried out very early, in the beginning years of the last century. Nowadays, Vietnam has organized monitoring systems for tide, climate, meteorology, marine ecosystems and environment, along the north to the south coast of the country, and in islands (Fig. 1) and expanded some marking buoys, floating stations and vessels for monitoring and collecting marine data.

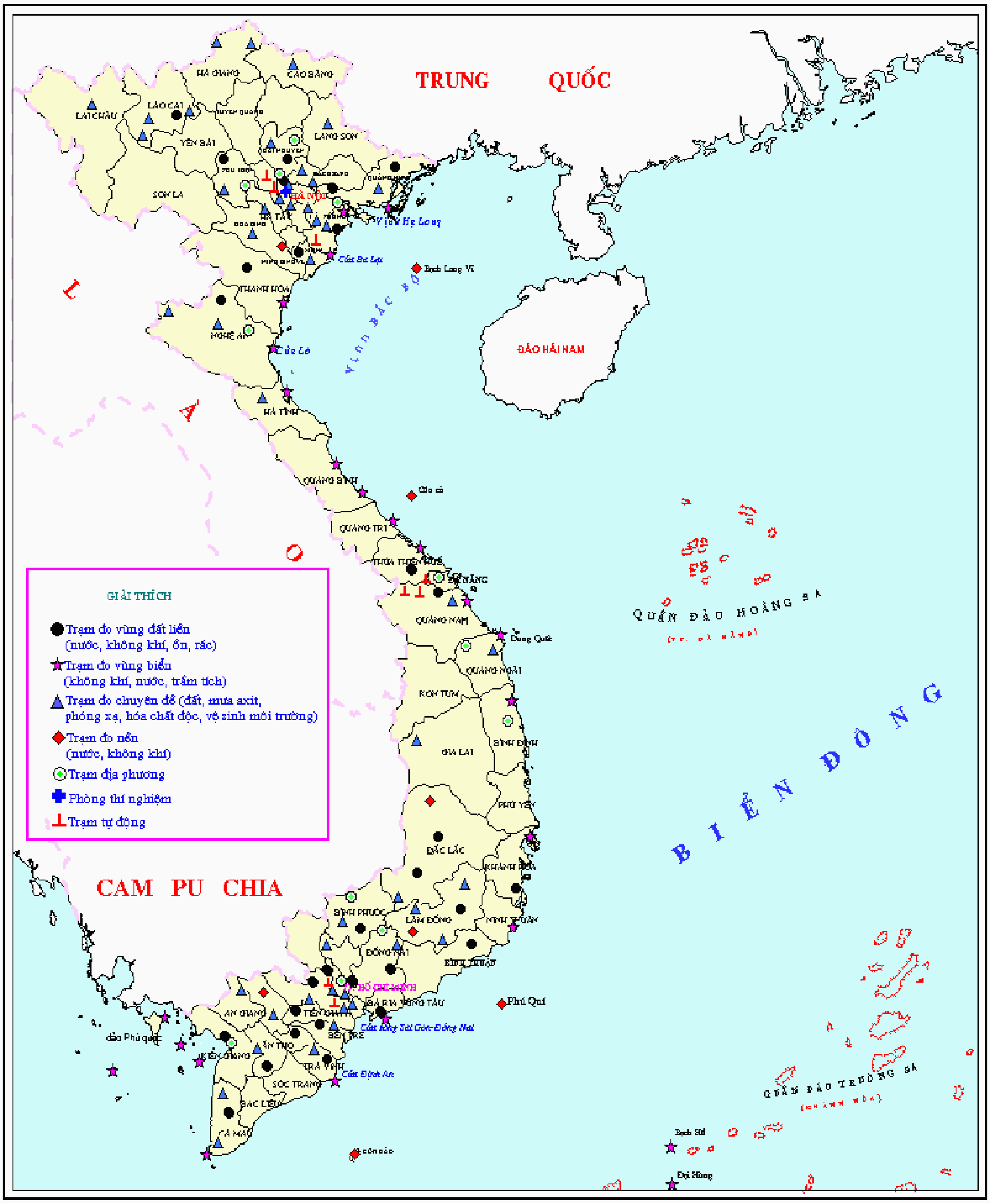

Figure 1. *The network of marine environmental monitoring stations of Vietnam*

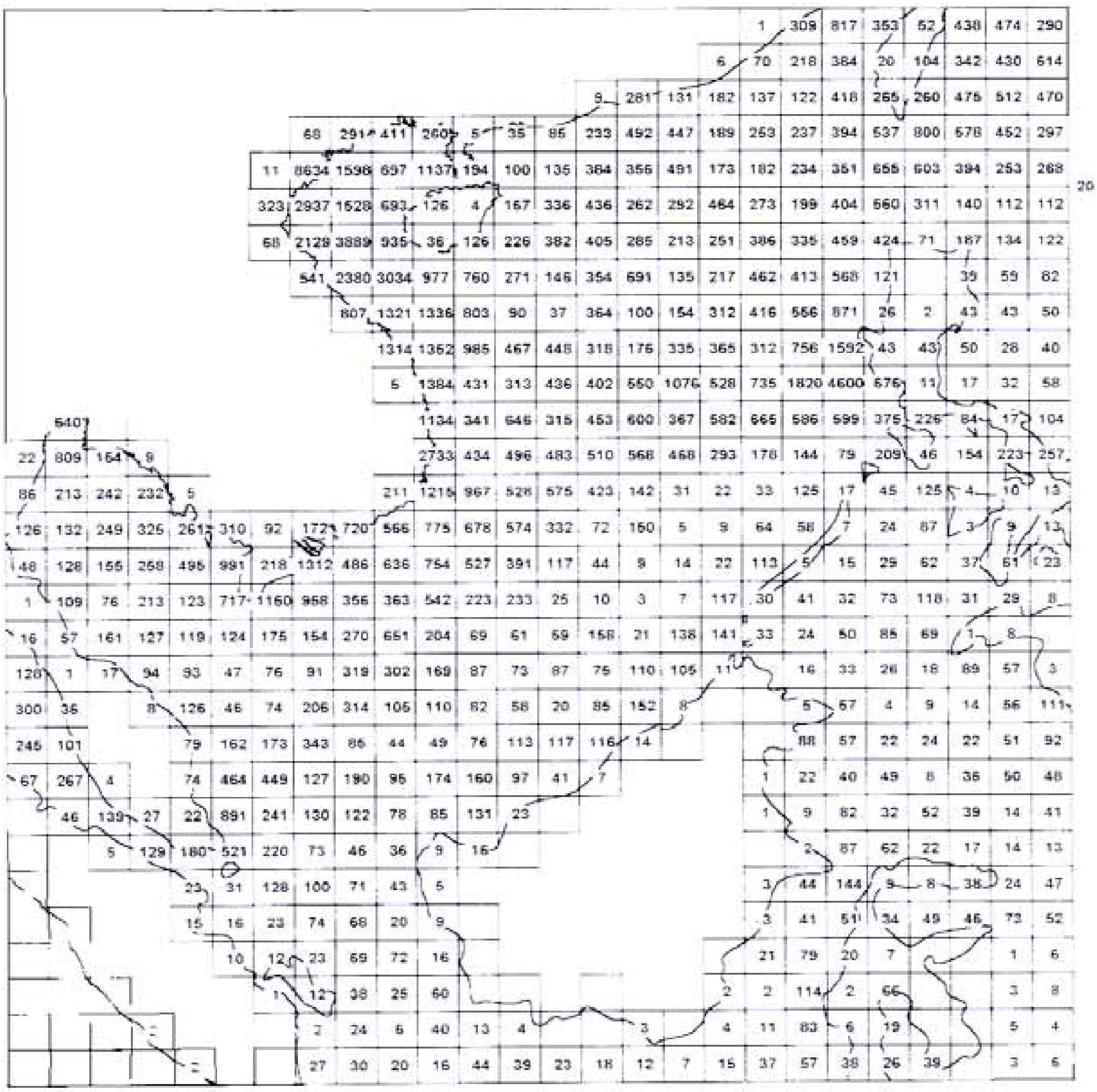

Figure 2. *Distribution of the number of existing observation stations in oceanographic database of East Sea and adjacent areas*

The marine database of the Institute of Oceanography has managed the data of 6.731 surveys on the East Sea and adjacent areas, including 679 surveys conducted by Vietnam. The number of serial observation stations is 149.844. The stations are distributed by 1 degree longitude × 1 degree latitude. Over 1.000 long-term observation stations on current, wave and sea level, including many continuous observation stations on current for 7-28 days and nights on 8-10 layers from the surface to the depths of thousand meters with a time period for measuring one data is 10-30 minutes. The numbers and types of data in this database are explained in Table 1 and Table 2. Some valuable products have been generated from those data (Table 3).

Table1. *The existing database (CSDL-VODC) of East Sea and adjacent areas from data sources of Vietnam and foreign country*

Articles	Number of surveys	Number of observation stations	Number of stations according to factors	Number of surveys according to time	Note
Total number of surveys	6,731				
By Vietnam	679				
By foreign countries (with or without cooperation)	6,052				USA: 3.977 surveys USSR (former): 191 - Japan: 624 - England : 169 - China: 115 - Australia: 316 - Thailand: 54 - Indonesia: 68 - The Philippines: 8 - Taiwan: 45 - Singapore: 41 - Canada: 27 - New Zealand: 24 - Holland: 16 - Denmark: 7 - France: 4 Malaysia: 3 - Germany: 3 - India : 2
Number of serial observation stations		149,844			
Number of continuous observation stations on current (1-7 days)		604			
Current on surface layer			94,514		
Meteorology			5,821		
Water temperature			125,955		
Salinity			35,699		
Dissolved oxygen			13,273		
Nutritious salt			20,502		
Pollution			2,758		
Marine biology			11,490		
Fish			2,928		
Bottom sediment			5,611 (14,200)		
Magnetic			10,098 (18,000)		
Gravity			4,046 (35,000)		
Seism			(25,000)		
Depth			2,006 (24,000)		
Before 1954				280	
Period 1954-1975				3,617	
Period 1976-1998				2.,34	

Note: Data in brackets are inventoried data, but not carried in CSDL-VODC completely.

Table 2. *Types and amount of oceanographic data of East Sea and adjacent areas in database of theInstitute of Oceanography*

Data types	Number of serial observation stations	Number of survey data sequence	Number of monitoring data	Monitoring time
Marine hydrography and chemistry				
Water temperature	125,995	242	3,380,954	1888-1999
Salinity	35,699	64	524,218	1907-1999
Oxygen	13,273		267,048	1929-1998
Phosphate	7,847		55,775	1929-1998
P_{total}	802		1,583	1991-1998
Nitrate	3,956		26,802	1929-1998
Nitrite	3,731		24,559	1929-1998
N_{total}	819		1,783	1991-1998
Silicate	4,968		35,781	1947-1998
Alkali	894		6,465	1961-1998
pH	7,503		49,109	1929-1998
Marine dynamics				
Current in surface layer	94,514		94,514	1900-1998
Continuous observation current		604	171,965	1980-1998
Marine water level		304	209,587	1990-1998
Marine wave	2,005	122	22,077	1976-1998
Marine meteorology				
Air pressure	497	190	23,045	1970-1998
Wind	2,370	241	33,253	1970-1998
Cloud thickness	529		1,053	1970-1998
Air temperature	556	241	34,009	1970-1998
Humidity	1,056	242	29,183	1970-1998
Rainfall	813	192	4,476	1970-1998
Water color	261		261	1970-1998
Water purity	2,028		2,028	1970-1998
Marine geology and geophysics				
Sediment	5.611 (colors)		118,520	1976-1998
Gravity	4,046		4,046	1990
Magnetic	10,098		10,098	1990
Depth	2,006		2,006	1990
Marine Biology				
Primary biology productivity	628		1,146	1983-1988
Chlorophyll-a	2.687		3,467	1961-1988
Phytoplankton	1,044		4,762	1960-1988
Zooplankton	2,450		26,545	1960-1988
Fish eggs & larvae	2,552		10,097	1960-1988
Phytobenthos	671		790	1990-1998
Zoobenthos	1,458		10,565	1960-1988
Marine pollution				

Suspended matters	1.471		3,162	1996-1998
Heavy metals	909		5,628	1996-1998
Medicament for plants	45		360	1996-1998
Petroleum	333		333	1996-1998
Other pollutants			2,959	1996-1998

Table 3. *Some main products*

No.	Products	Summary	Actual value	Destination
1	Oceanographic database	Including 4 data files for PC: 1. *WOD_98.vod* – provided by the USA center for marine data 2. *WOD_B.vod* – provided by the Russian center for marine data (Center B) 3. *OD_VN.vod* – provided by the national marine programmes of Vietnam 4. *JpCurrent.vod* – data of current on surface layer, provided by the Japanese center for marine data	Foundation for establishing the national marine database Providing a lot of oceanographic data types for marine researching, exploitation, national security protection…	- Centers for marine data - Centers for marine natural resources - Institutes of meteor and hydrography forecasting - National defense
2	Factual foundations for establishing marine data bank and regulations			- Strategists for marine policy -National center for marine data
3	VODC for PC 2.0	VODC for PC 2.0 is a software for marine data management, based on Microsoft Access 97.	It can be used for establishing marine database with 11 data types, easy conversion for traditional marine data format in the world	- Centers for marine data - Centers for marine data collection and management.
4	VODC for Network 1.0	VODC for Network 1.0 is a software for marine data management, designed for LAN and based on SQL Server, including 2 parts: *VODC Server*: contains all data and some inquiry procedures, operated by SQL server. *VODC Client*: contains utilities for accessing to VODC Server and for multi-user, installed for workstations using 32 bits OS.	VODC for Network 1.0 has been used for establishing marine database of all East Sea. It supports the model for concentrated marine data management and can be accessed on Internet.	- Centers for marine data - Centers for marine data collection and management.

5	VODC Home Page	VODC Home Page is a WEB page of the current project and the future Bank of Oceanographic Data built with the aim of providing oceanographic data and information to the users through the Internet by service of WWW and FPT. VODC Home Page is managed by Web Server	Total updated information and partial data in the database (VODC Server) could be searched through VODC Home Page	Agencies and persons who have requires of oceanographic data and information
6	MGDM	Special software for geophysical data management, developed for Window systems.	Managing and accessing geophysical data	- Centers for marine data - Centers for marine data collection and management.
7	CDS/ISIS for Windows	A software for information management of UNESCO, interface in Vietnamese, and database is designed convenient for marine data structures.	Managing marine data effectively for marine data structures in the world	- Centers for marine data - Centers for marine data collection and management.
8	Some other products	Maps of temperature and salty distribution for all East Sea, maps of dynamics, terrain and currents …	For research and exploitation of East Sea	- Centers for marine data - Centers for natural resources of marine - Institutes of meteor and hydrography forecasting - National defence
9	CD-ROM: East Sea data	Storing all results of the national project KHCN-06.01: software, information, marine database collected by Vietnam and foreigner countries	Providing tools and procedure for managing marine data, foundation to establishing the national oceanographic data bank. References for marine researchers Users can access to data of all East Sea	- Centers for marine data - Centers for natural resources of marine - Institutes of meteor and hydrography forecasting - National defence

CONCLUSION

The Institute of Oceanography is focused on setting up, developing and upgrading its Center of Oceanographic Data (with the headquarter at Nha Trang and two branches in Hanoi and Hai Phong). These are to meet the need of information to supply to all branches and to build a clue for oceanographic data exchange, updating in the region and in the world.

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Ocean Remote Sensing and its Application in China

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ABSTRACT

With the advancement of space technology and the development of ocean science, satellite remote sensing has become an important tool for marine research as well as for marine environment observation and prediction. Over the past decade, China has exerted great effort to apply satellite data for both ocean research and operational purposes. Furthermore, China has successfully launched her first ocean satellite this year, which is an ocean color satellite designed to detect some of the marine environmental parameters in the Chinese sea waters, including chlorophyll concentration, suspended sediment concentration, dissolved organic matter, and sea surface temperature. In this paper, a brief introduction of the ocean application of remote sensing data in China is presented, and a description of the new ocean satellite program is given.

INTRODUCTION

China is a coastal country with a lengthy coastline of around 18,000 kilometers along the mainland and a vast sea area under its jurisdiction. The coastal area of China is densely populated and economically developed. The coastal area only accounts for 13.4% of the nation’s land area, but supports 40.2% of the nation’s population and produces 62% of the GNP.

Observing and monitoring the ocean, protecting the marine environment, developing and exploiting ocean resources are of great importance to the social and economic development of China. Over the past decade, China has made great efforts to develop new technologies for the above-stated purposes, including the application of satellite remote sensing data to ocean research and ocean-related operational activities.

The research institutions under the State Oceanic Administration (SOA), a government agency in China responsible for coastal and ocean affairs, have been active in utilizing data from satellite and from aircraft in China’s coastal and ocean management, including sea area utilization, ocean functional zoning, marine environment protection, public ocean services and resource conservation. Fruitful results have been achieved. Some examples of successful remote sensing application ocean satellite data in the prediction of harmful algae bloom and in sea ice prediction in China’s coastal waters. Over the past few years, emphasis has been shifted to the development of ocean satellites for both research and operational purposes, and a program for the development of satellite for ocean observation has been launched.

With the increase of population and the gradual depletion of terrestrial resources, China, like many other coastal states, has to embark on new programs for harnessing ocean resources. The ocean will play an ever-increasing role in China's future development. Within this context, ocean satellite will be one of the focuses in China's future ocean technology development agenda.

APPLICATION OF SATELLITE REMOTE SENSING

In the late 1970's, measurements from satellites demonstrated that ocean color remote sensing is a powerful tool for understanding oceanic biological and physical process. In 1978, Nimbus-7 coastal zone color scanner CZCS started to operate, providing observations of ocean color from the space. This provides oceanographers with good opportunity to observe the variable patterns of global biological productivity. Following that, the Chinese satellites FY-1A and FY-1B were launched to orbits respectively in 1987 and 1989. In 1996, Japan's ADEOS Ocean Color and Temperature Sensor OCTS provided ocean color data for about ten months. And in August 1997, one special ocean color satellite – SeaStar -- was successfully launched. The sea-viewing wide field-of-view sensor, SeaWiFS, installed on SeaStar, brought to oceanographers a large volume of quality ocean color remote sensing data.

Since the late 1980's, a number of institutions in China have been studying the application of data from satellites to oceanographic research and operation. Since 1994, the Second Institute of Oceanography (SIO) of SOA, together with other institutes, has been implementing a project for the development of a Chinese scientific research system for SeaWiFS, which includes data receiving, processing, distribution, calibration /validation and application.

The ground station located in SIO is a SeaWiFS scientific research station authorized by NASA of USA to receive SeaWiFS data. Since September 1997, the station has been normally receiving and archiving SeaWiFS data. And the data has been used for various purposes, such as measuring the concentration of chlorophyll, suspended material, and for the study of red tide and the dynamics of the coastal water in China's waters.

The results of studies on the application of satellite data on red tide show that SeaWiFS data has great potential in determining environmental characteristics of the coastal water around China.

Sea ice is present in the coastal area in winter in the northern part of China, especially in the Bohai Sea and in the northern part of the Yellow Sea. There are even sea ice disasters in these areas. Therefore, special attention has been paid to sea ice monitoring and forecasting in China.

Since 1970s, research has been conducted on the application of remote sensing to sea ice monitoring and forecasting in China. At the beginning, study and experiment was carried out only in aerial remote sensing. In 1980s, research was directed to satellite remote sensing. Scientists in the National Marine Environment forecasting Center carried out sea ice remote sensing research, which promoted the application of satellite remote sensing data to sea ice monitoring and forecasting. In 1990s, a study was conducted on multi-source data fusion for use in sea ice monitoring and forecasting.

Numerical sea ice forecasting, using remote sensing data, have been in routine operation in China now.

CHINA'S OCEAN SATELLITE PROGRAM

The experiences of ocean satellite observations in a number of countries have exhibited the usefulness of satellite remote sensing. In order to effectively monitor the ocean and improve the accuracy and timeliness of marine environment forecasting, China has embarked on its ocean-oriented satellite program, and an operational satellite application system will be established. The first ocean satellite of the program, HY-1 (HY is the abbreviation of "Hai Yang", which means "Ocean"), is an ocean-color satellite designed to measure marine environmental parameters such as chlorophyll concentration, suspended sediment concentration, dissolved organic matter, pollutants and sea surface temperature. It was successfully launched in May 2002.

General description of the satellite

HY-1, a three-axis stabilized small satellite, is designed to operate in orbit for about 2 years. In order to obtain a short repeat period, orbit transfer is made, making the satellite move and operate in a near sun-synchronous and near-polar orbit at the altitude of 798 km.

Tasks of the satellite

The mission of the first ocean satellite is designed to monitor marine environmental variation in the coastal and ocean areas off China, including: marine primary productivity, dynamics of meso-scale eddies, etc. It is also aimed at monitoring the variations of the coastal zone, obtaining experiences for developing space observation of the ocean, and promoting the development of small satellite platform.

Sensors

China's first ocean satellite is equipped with two sensors: the 10-babd Ocean Color and Temperature Scanner (COCTS) and the 4-band CCD coastal zone imager (CZI), designed and manufactured by Shanghai Institute of Technical Physics of the Chinese Academy of Sciences and the Chinese Academy of Space Technology. The COCTS is an optical radiometer to detect ocean color and surface temperature.

The COCTS has a function to detect chlorophyll concentration and dissolved substances in the water, as well as temperature distribution. The data from OCTS will be used to get information on ocean conditions for fishery and environment monitoring purposes. It has a repeat period of 3 days, and 8-channel visible and near-infrared bands and 2-channel thermal infrared band with a spatial resolution of 1.1km.

Table 1 Main characteristics of the satellite

Orbit Type	Pseudo solar sync, near-circle polar orbit
Altitude	978km
Inclination	98.8 Degree
Node	Descending 8:45~10:40am
Period	100.8 minutes
Repeat coverage period	COCTS:3 days, CCD:7 days
Weight	367kg
Attitude control	3-axis stabilization
Designed duration	2 years

Ground stations

National Satellite Ocean Application Service affiliated to the State Oceanic Administration (SOA) is responsible for acquiring, processing, archiving and managing, distributing, applying and analyzing the HY-1 data. It operates the satellite ground application system. Fig.1 is the structure of the system. Two ground stations to receive raw data have been built in Beijing and Sanya, Hainan Province respectively.

Future Development

China's first ocean color satellite HY-1 was launched as a piggyback satellite on FY-1 satellite using Long March rocket. There are many restrictions, such as the equator-crossing time, the size and weight of the satellite, the power system, etc. and the efficiency of this satellite is not as ideal as expected, therefore much remains to be improved. However, the operation of HY-1 satellite is considered a new milestone in the history of satellite development in China. In order to further promote ocean remote sensing, China has planned to continue to augment its satellite program in the future and launch a series of ocean-oriented satellites.

The satellite observation will not only become one of the major components in China's coastal and ocean observation and monitoring network, it will also become an integrated part of the Global Ocean Observing System (GOOS) sponsored by the Inter-governmental Oceanographic Commission (IOC) of UNESCO, WMO and UNEP.

China, in addition to the development of its own ocean satellites, will make more efforts to enhance its research on the application of remote sensing data from both domestic and foreign satellites. The detections of harmful algae bloom, the monitoring of sea ice, sea wave, sea surface temperature, wind field, underwater topography will be some of the main areas in satellite data application research.

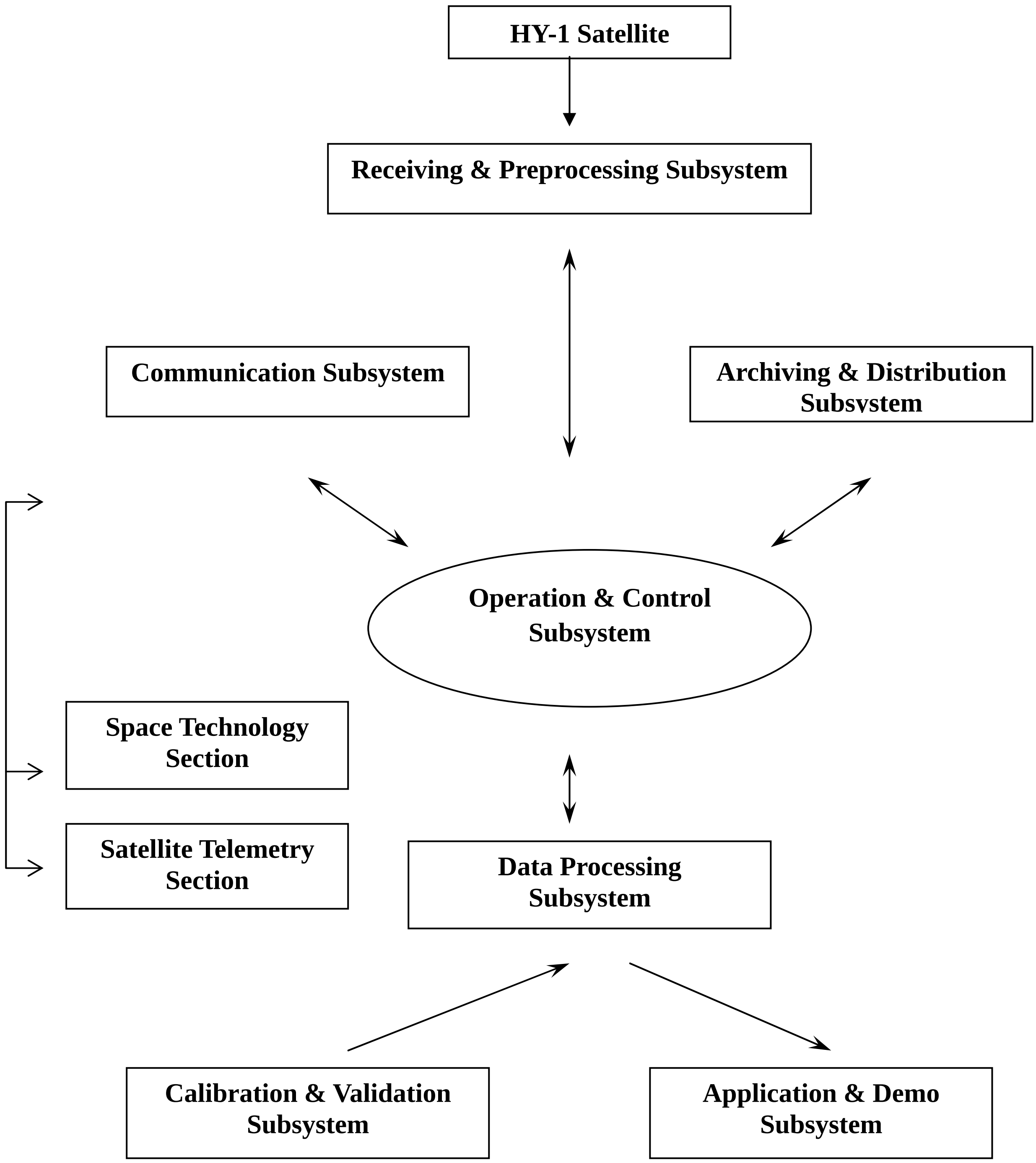

Fig.1 Structure of the satellite ground application system

On the Decision Support Framework (DSF) for the Mekong Basin Study

Dr Nguyen Tat Dac (Mekong River Commission Secretariat)

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ABSTRACT

The paper describes a Decision Support Framework (DSF) being developed in the Framework of the Mekong Water Utilisation Programme Start-up Project. The DSF will contain a Knowledge Base, a Basin Modelling Package and Impact Analysis Tools. Transboundary issues are an important aspect of basin planning in the Lower Mekong. The DSF will be used to assist in developing rules for water sharing amongst the four member states in the Mekong River Commission (MRC) and to support decision making for basin planning and management through assessment of the environmental and socio-economic impacts of development options.

The Basin Planning process is discussed together with the implications of the 1995 Mekong Agreement. The structure and each component part of the DSF are described together with the institutional arrangements for its deployment.

THE WATER UTILISATION PROGRAMME START-UP PROJECT

The Water Utilisation Programme (WUP) Start-Up Project is intended to help the Mekong River Commission (MRC) member states to implement key elements of the 1995 Mekong Agreement. It will provide the technical and institutional capacities required for longer-term co-operation for sustainable management of the basin's water and ecological resources. There are three components to the WUP Start-up Project:

- A Basin Modelling and Knowledge Base
- B "Rules" for Water Utilisation
- C Institutional Strengthening and Capacity Building

THE BASIN MODELLING AND KNOWLEDGE BASE DEVELOPMENT SUB-PROJECT

The Basin Modeling and Knowledge Base Development Sub-Project (WUP-A) is being undertaken by Hal crow Group Ltd for the MRC under Component A of the WUP. An important outcome of this project will be a Decision Support Framework (DSF), which will contain a Knowledge Base, a Basin Modelling Package and Impact Analysis Tools.

When completed the WUP DSF is to be used to assist in developing rules for water sharing amongst the four member States in the Mekong River Commission (MRC) and to support decision making for basin planning and management through assessment of the environmental and socio-economic impacts of development options.

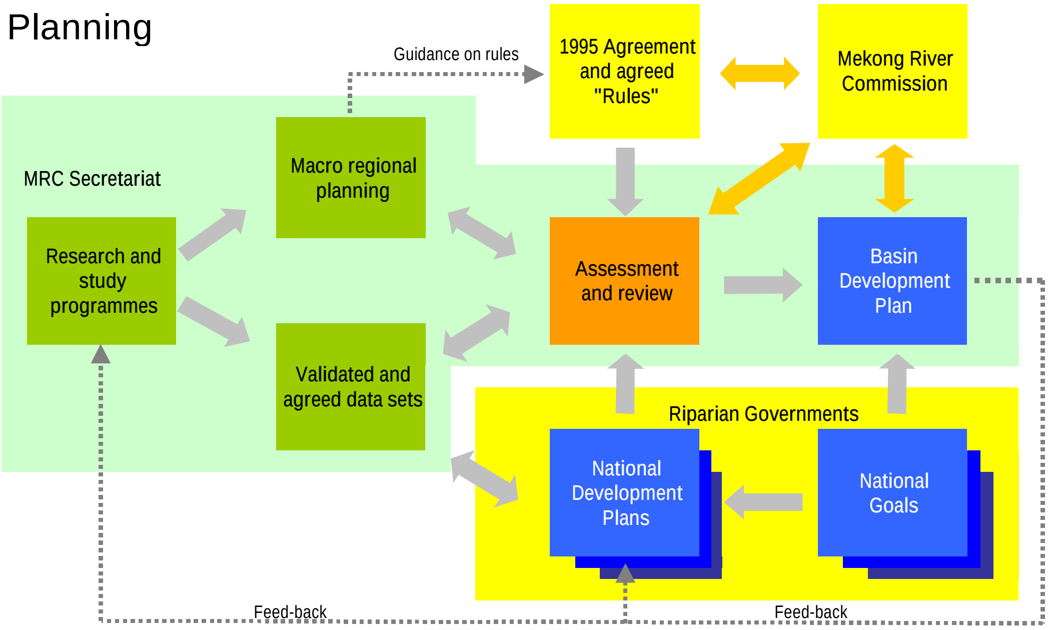
REQUIREMENTS OF THE 1995 MEKONG AGREEMENT

The process for Basin Development Planning draws its mandate from and must be guided by the 1995 Agreement signed by each of the four Governments[1]. The Agreement prescribes a number of conditions that need to be followed in planning and managing the water and related resources of the Mekong River Basin.

THE BASIN DEVELOPMENT PLAN (BDP)

A key element of the Decision Support Framework is to facilitate both the preparation of the *rules* (Article 26) governing utilization of the waters of the Mekong Basin as well as preparation of the *Basin Development Plan* (Article 24). The BDP is to be carried out in two phases, each of three years duration. The first phase, which started in October 2001, will formulate the BDP, and the second phase will revise and consolidate it.

THE BASIN PLANNING PROCESS



In general the Basin Planning Process can be outlined by the above diagram.

FUNCTIONAL REQUIREMENTS OF THE DSF

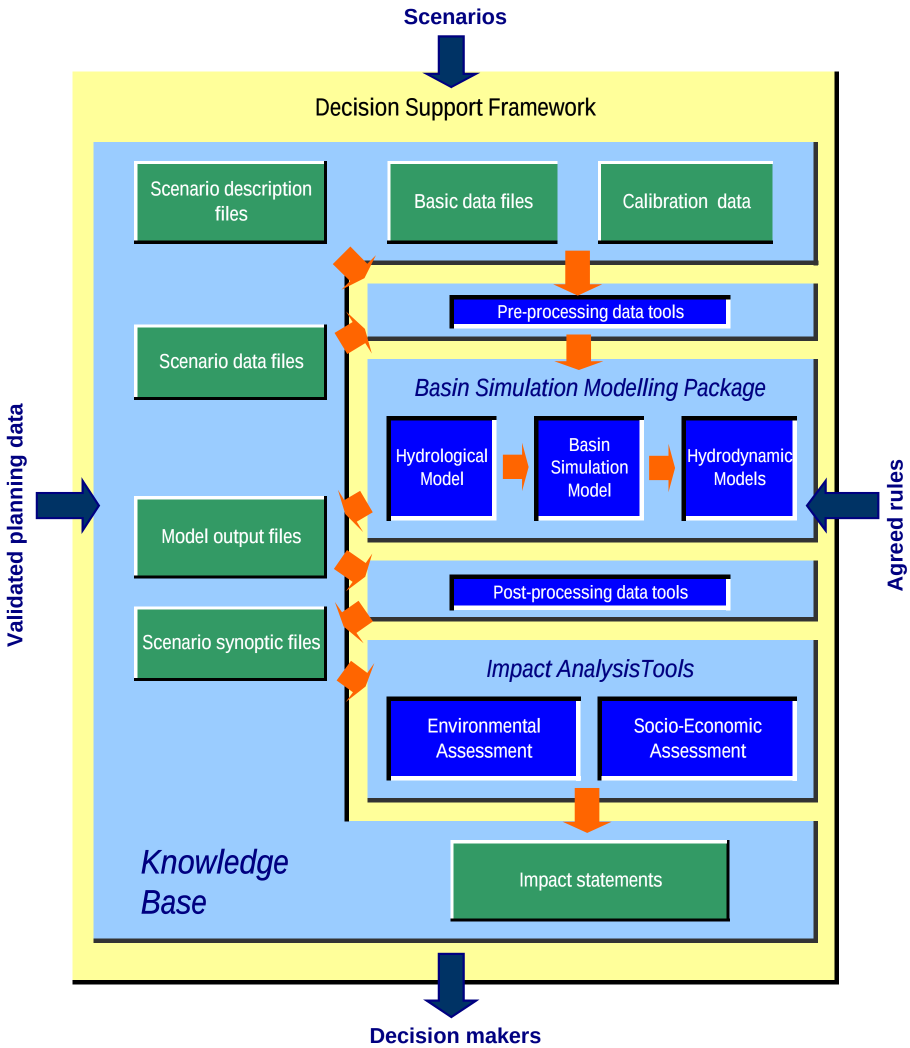
The role of the DSF is to provide a transparent analytical framework to support decision taking. As such, the DSF will form an integral part of the overall planning process. It will facilitate the testing of development scenarios (unique combinations of hydrological conditions, system demands and proposed interventions) proposed separately by the four National Mekong Committees (NMCs) or MRCS, leading to statements of the environmental and socio-economic impacts associated with the scenario.

OVERALL STRUCTURE OF THE DSF

Three main elements of the DSF have been specified, as illustrated below:

- ***Knowledge Base*** incorporating physical, hydraulic/hydrologic, spatial and specific planning data, as well as model calibration data, and able to store and enable access to the results of modelling runs and impact assessment, incorporating also user friendly applications to access and manage use of other components of the DSF
- ***Basin Simulation Modelling Package*** containing the primary simulation models (hydrology, basin simulation, hydraulic and Delta salinity models) and the secondary models (water quality, sediment and groundwater as required).
- ***Impact Analysis Tools*** enabling the results of the model runs to be translated into impacts on selected environmental and socio-economic parameters.

Four levels of user are envisaged. The **Manager or Planner** will be able to view the results of previously run scenarios, the **Operator** can make restricted changes to previous scenarios and then run these new scenarios and view results, **Modellers** who will have full access rights to the modelling software so that major edits can be made to model data files, and **Administrators** who will manage the DSF (add, change and delete users access rights and maintain the database).



Three main versions of the user interface will be provided to limit user access to an appropriate degree.
Modularity is an important concept, and although the DSF interface will provide the user with the impression that the tools are integrated, in fact the system will be highly modular using separate applications for specific functionality.

THE BASIN SIMULATION MODELLING PACKAGE

The Basin Simulation Modelling Package (BSMP) comprises the three river and catchment simulation models. In addition to supporting the overall planning process, application of these models will enable the impacts of alternative water utilisation rules to be investigated. This will mainly through use of the Basin Simulation Model, except where detailed hydraulics are required, such as flow reversals in the Tonle Sap River and salinity issues in the Delta, to be addressed by the hydrodynamic model. Modelling of "rules" may include irrigation access rules, hydropower generation rules, flow rules for navigation, minimum environmental flows and flood mitigation rules.

Hydrological Model

The **SWAT** (Soil and Water Assessment Tool) model is a continuous simulation model at a river basin scale model designed to predict the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use and management conditions over long periods of time. SWAT requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring in the watershed.

The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. are directly modelled by SWAT using this input data, permitting progressive changes in management practices, climate, and vegetation, for instance, to be assessed in terms of impact on river flows and water quality. The basin is sub-divided into sub-basins, themselves sub-divided into hydrologic response units; ponds/wetlands; groundwater; and the main channel draining the sub-basin. The climatic variables required by SWAT consist of daily precipitation, maximum/minimum air temperature, solar radiation, wind speed and relative humidity.

Basin Simulation Model

The Basin Simulation Model is the main analysis tool for investigating the effects of changes in rules, development scenarios, etc, on the behaviour of the basin. The basin model will be run for a long period of time (probably decades). It will incorporate all features of the water resources of the basin, including diversions, water use and reservoir operation. Outputs from the basin model would be time series of variables throughout the basin, river flows usually being the most important.

The proposed basin modelling system is **IQQM** (Integrated Quantity and Quality Model), which is a hydrologic modelling tool developed by the Department of Land & Water Conservation, NSW (DLWC) for use in planning and evaluating water resource management policies. It is a generalised hydrologic simulation package, which is capable of application to regulated and unregulated streams, and is designed to be capable of addressing water quality and environmental issues as well as water quantity issues. The model is structured for investigating and resolving water sharing issues:

- at the inter-state or international level, and
- between competing groups of users, including the environment.

The model operates on a continuous basis and can be used to simulate river system behaviour for periods of years ranging up to hundreds. It is designed to operate at a daily time step but some processes can be simulated at time steps down to one hour if required.

Hydrodynamic Model

The **ISIS Flow** hydrodynamic model would be used to both understand the hydrodynamic processes and to determine the "hydraulic" changes that the scenarios have on behaviour of the river system in the lower basin. Flows determined from the hydrological model and basin simulation models would be translated by the hydrodynamic model into water levels, velocities and inundated areas. These "hydraulic outputs" would then be used in the impact analysis tools to determine the effects of the scenarios and changes to the "rules".

The model represents flow of water in open channels and floodplains. ISIS Flow incorporates a wide range of hydraulic units, such as a variety of hydraulic structure types.

Data requirements include topographic data, including channel cross-sections, structure dimensions etc., as well as appropriate boundary conditions at the upstream and downstream extents of the model. ISIS Flow software may need to be developed further to meet the particular needs of the project and investigations are underway to identify specific requirements.

TOOLS FOR IMPACT ANALYSIS

There is a range of environmental and socio-economic impact analysis tools that can be used within the context of the DSF. The foundation of the needs for Impact Analysis Tools lies with the trans-boundary issues of concern identified by the NMCs under another component of the Water Utilisation Programme. In general the main categories of trans-boundary issues have been sub-divided into 36 sub-issues, in order to characterize the relevant concerns and potential trans-boundary impacts of different development scenarios. The analytical tools for **environmental impact assessment** required for the DSF need to be issue-specific and predictive in a manner that is replicable, objective, quantitative and sensitive to impacts.

Environmental Impact Analysis Tools
Main categories

Time-Series River Flow and Water Quality Impact Analysis Tools - *Software to be provided in the DSF*

- Generic Hydrologic Analysis Tools
- Flood Analysis Tools
- Low Flow Analysis
- Tonle Sap Flow – Reversal Analysis

Spatial Impact Analysis Tools - *Provided within the DSF through use of proprietary software*

- Planning Sub-Area Classification
- Habitat Classification
- Multi-Theme Habitat Analysis
- Analysis of Spatial Changes Over Time
- Network Analysis
- Combined Spatial – Time Series Analysis

Functional Relationship Impact Analysis Tools - *Capability provided in DSF for later definition of tools by users*

- Environmental Risk Analysis
- Decision Trees
- Statistical Analysis

USER INTERFACE

The tools and data contained in the DSF will be accessed via a Graphical User Interface (GUI) that will provide menus, data entry dialogs, GIS-type views, graphs and tables. The DSF GUI will be built from standard generic components and will be customised for the DSF. The software development language used will be Visual Basic and all user dialogs and menus will be in English.

> Key components of the Knowledge Base database
>
> - The definition of development scenario metadata
> - The management of datasets used by the Simulation Models and Impact Analysis Tools
> - Data specifying the internal structure of the models
> - Input data to the models / tools
> - Output data from the models / tools
> - Procedures supporting the Knowledge Base database administration including those relating to database access,

KNOWLEDGE BASE

The Knowledge Base will be the central digital store of data and knowledge for use with the DSF. The normal method of accessing the information in the Knowledge Base will be through the WUP DSF user interface, although the databases which make up the Knowledge Base will be 'open' so that authorised individuals can access the data directly.

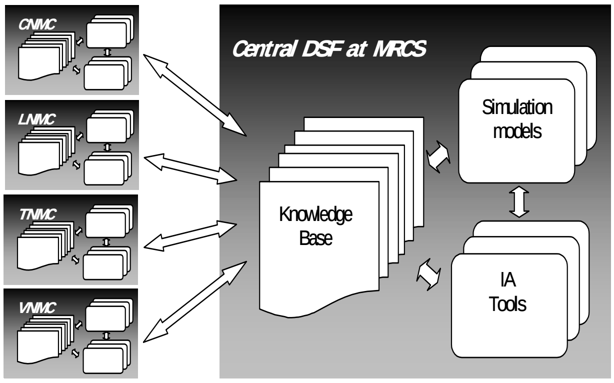
The key components of the Knowledge Base must be managed in a consistent and robust environment that provides a Decision Support Framework facilitating the decision making process. A further important requirement of the Knowledge Base is that it provides a mechanism for summarising the information obtained from the Simulation Models and the Impact Analysis Tools into a format whereby comparisons between development scenarios are readily made. The detailed procedures (and database structures) required for summarising the models and tools output data are being designed.

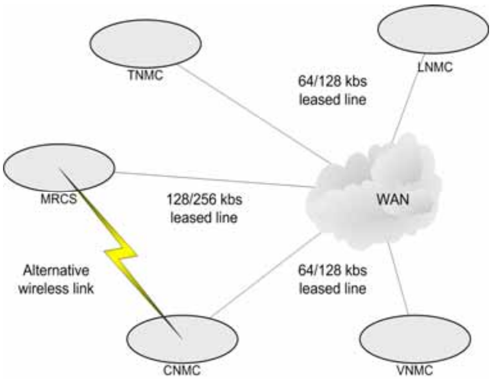
The top-level design of the database structure for the Knowledge Base is to provide flexibility in the definition of 'development scenarios'. A modular approach has been taken identifying scenario components that are defined through the use of look-up tables, not as discrete entities within the database design. This approach will contribute significantly to the sustainability of the Knowledge Base database by providing an in-built facility to meet changing user requirements and/or system infrastructure.

The overall structure will comprise both a 'core' database to manage the development scenario 'metadata', and associated datasets supporting the Simulation Models, Impact Analysis Tools and the DSF User Interface. The Knowledge Base will be able to differentiate between the Simulation Models input and output data (time-varying data) and the model 'systems' (time-invariant data). Input and output data will be edited by DSF 'operators' and as such will be explicitly referenced by the 'core' database. However, it is proposed that the model 'systems' should only be edited by DSF 'specialist modelers' through use of the proprietary model interfaces, and as such will only be referenced in the 'core' database as aggregated objects. Similarly, the Impact Analysis Tools input and output data will be explicitly referenced by the 'core' database.

COMPUTER AND COMMUNICATIONS NETWORKS, DATABASE ACCESS

Communications between all parties will play a vital role in realising the benefits of the 1995 Agreement, particularly with respect to arriving at an agreed Basin Development Plan. It is necessary to consider how the necessary inter-actions can be achieved within a secure communications environment, and at reasonable cost.





The function of the WUP Decision Support Framework (DSF) is to provide a rational basis for decision-taking within the planning process, aimed at derivation of Rules for water utilisation and preparation of a Basin Development Plan. To fulfill these requirements the DSF must be set up in a way that allows each NMC to prepare in private their own (national and regional) scenarios, prior to bringing their preferred choices to the regional debate. The set-up of the DSF must ensure that all parties are working with the same data and that a proposed scenario is replicable by another.

A number of principles have been considered in developing options for the system design. Firstly, there should be as little redundancy as possible in terms of stored information. Secondly, much of the basic data is imported only occasionally, and much of the data generated by a simulation run will be kept only temporarily whilst processing of summary results is completed. Thirdly, since the DSF is primarily a strategic planning tool, automatic updating is not required. Various arrangements involving local and distributed databases, and different capacity LANs and WANs were considered from the points of view of practicability and cost-effectiveness, as well as the ability to upgrade the systems in the future.

The communications capacity required to support modelling effectively over a Wide Area Network using real time connectivity to a central database will be too expensive to sustain at this point in time. The distributed nature of the planning system itself, and the privacy required at each location, predicates a system based on duplication of databases and files at each location with facilities to keep these up-to-date (but not necessarily on a very frequent basis) and for communicating lesser amounts of information between system users on a more frequent basis. However, maintaining the integrity of the information and of the system tools will be of paramount importance in maintaining mutual trust between the riparian planners.

Accordingly, the most appropriate solution is to develop the DSF in the expectation that it will operate on an enhanced LAN within MRCS and within each NMC, with high-speed Internet-based connections for communications and scenario meta-data, and the occasional large amounts of data more cost effectively transferred by couriered CDs. Such a system would suffer minimum disruption as and when MRCS is relocated.

CONCLUSIONS

In committing to the aims of their 1995 Agreement, the four member states of the Mekong River Commission have embarked on a challenging process of river basin management and development. Many trans-boundary issues arise that require careful assessment in a mutually acceptable manner. The Mekong River Commission's Secretariat is undertaking a wide range of complementary programmes to achieve these aims.

The Decision Support Framework being developed under MRC's Water Utilisation Project is specifically targeted at providing an analytical framework to support the preparation of Rules for Water Utilisation and a Basin Development Plan. Important functionalities of the DSF include effective representation of trans-boundary issues and the ability of each country to investigate and share alternative basin wide development scenarios on a common basis. Thus, much effort is being placed in the ensuring the transparency and integrity of the system so that, through mutual trust in the assessments made, a solid foundation will be laid to reaching consensus on how best to manage the water resources of the Lower Mekong Basin.

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Extraction of Spectra from Satellite Images for the Application in Coastal Zone

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ABSTRACT

As the population of the coastal zone grows, so does our need to invest in satellite remote sensing technology that allows us to increase our capacity to predict changes in the environment. Satellite remote sensing technique is widely used to monitor the sea-state in order to provide information for the coastal protection and management, and increase prediction capabilities for hazardous events. In this paper, we develop the multi-spectra analytic method to extract the wave field from satellite images. Owing the non-homogeneous property is identified in the near shore images; our method is established based on the Wavelet transform. The developed method is compared with the conventional Fourier spectrum analysis method and validated to have better resolution Finally, we illustrate some examples for the applications of wavelet transform in the last part of this paper. It is found that the average bias of analytic result by using wavelet transform is smaller than Fourier transform.

INTRODUCTION

After the first satellite launched by the former soviet republics in 1957, satellites were extensively used in many kinds of realms, such as surveying, communication, martial and so on. The satellite is an important tool of remote sensing technology nowadays. Many satellites that observe target by using microwave radar can monitor in all kinds of weather during day and night even in rainy or cloudy. The target of Satellite is the surface of the earth that mankind exist. However, 70% of the surface of the earth is occupied by water. To meet requirements of agriculture, residence and recreations, human tried to scramble for lands from the oceans to extend the spaces. The reclamations and developments of coastal zones are unavoidable alternatives, especially in the countries with rapidly increasing industrial and economic activities. In order to achieve the sustainable development of coastal zones, realization of the natural environments is essential. Nowadays, observation and understanding of the environment character is important in the effective use of the resources, especially for the ocean resource. Monitoring the oceanographic phenomena is the one of the approaches to obtain more understanding of natural surroundings.

The information of ocean wave is urgently required to solve many problems such as marine resource conservation, marine environment protection, and so on. Ocean waves feature extremely random. They cannot be fully understood only by theoretical approaches or laboratory experiments. Field measurements must be performed to increase the knowledge of waves. The field measurement involves In-Situ method and Remote Sensing technique. The main advantage of the remote sensing technique is that it provides space information of the wave field in regions, which cannot be covered by in-situ instruments. And the satellite is one of the most important remote sensing tool. Many oceanographic processes and phenomena can be observed by satellites, such as internal waves, wind signatures, oceanic fronts, current fields and mesoscale eddies. (Alpers et al, 1998, Hsu et al., 2000). In addition, it is possible to derive the wave character from satellite images, such as wave height, period and direction. They can be calculated from spectrum. The spectrum shows the energy distribution in frequency domain, and we can derive the spectrum from the satellite image. In this study, we focus on how to get image spectrum from the satellite image. There are some studies that used Fourier transform to get the image spectrum from image, but most of these studies are located in deep water area. However, near shore or shadow water area is the main region that mankind exist. We are interested in the wave measurements in the coastal ocean area. For this near shore area, the non-homogeneous property may be found. In order to establish a proper image spectrum analysis method to extract wave information from near shore satellite images, we adopt wavelet transform to analyze coastal images.

IMAGE SPECTRUM ANALYSIS THEORIES

Wavelet transform is an efficient and flexible tool in image analysis, that is, for the detection and measurement of certain characteristic features in images. The two-dimensional Wavelet transform is characterized by a rotation parameter, in addition to the usual translations and dilations. We consider 2-D images of finite energy, represented by a bounded non-negative function.

$$0 \le g(x,y) \le M, \quad M < \infty \tag{1}$$

where the discrete values of g(x,y) corresponding to the level of gray level of each pixel in an image. The Wavelet transform is the inner product of g(x,y) with a wavelet mother function, is defined as the following:

$$S\left(\vec{A},\vec{b}\right) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} g(x,y)\cdot \psi^{*}_{\vec{A},\vec{b}}(x,y)\,dxdy \tag{2}$$

where $\psi_{\vec{A},\vec{b}}(x,y)$ is the wavelet mother function, the asterisk denotes the complex conjugate quantity, $\vec{A} = (A_x, A_y)$ is the dilation of mother function in x direction and y direction respectively. $\vec{b} = (b_x, b_y)$ is the shift parameter, representing the displacement of mother function in x and y directions respectively.

$$\psi_{\vec{A},\vec{b}}(x,y) = \frac{1}{\left|\vec{A}\right|}\psi\left[\vec{A}^{-1}\left(x-b_x, y-b_y\right)\right] \tag{3}$$

The next step in the analysis is to choose an adequate analyzing wavelet mother function ψ. Because the wave pattern in an image is directional, we decide to use a directional wavelet mother function. The well-known Morlet wavelet function is adopted by this study. The 2-D Morlet wavelet function is:

$$\psi(\vec{x}) = e^{i\cdot\vec{n}\cdot\vec{x}} \cdot e^{-\frac{1}{2}|\vec{n}|^2} \tag{4}$$

where $\vec{n}$ is the oscillation parameter of wavelet function. Using the representation of Eq. (4), the Morlet wavelet becomes:

$$\psi_{\vec{A},\vec{b}}(\vec{x}) = \frac{1}{\sqrt{A_x^2 + A_y^2}}\exp\left[i\cdot\vec{n}\cdot\frac{\vec{x}-\vec{b}}{\vec{A}}\right]\exp\left[-\frac{1}{2}\left(\frac{\vec{x}-\vec{b}}{\vec{A}}\right)^2\right] \tag{5}$$

VALIDATION OF DERIVED IMAGE SPECTRUM ANALYSIS METHOD

This section aimed to verify the correctness for derivation of image spectrum by 2D Wavelet transform. The wave pattern images that include the local non-homogeneous image of multi-directional regular wave and the non-homogeneous images are simulated. The performance of 2D Wavelet transform analysis is assessed by comparing with the analysis results of Fourier transform.

The local non-homogeneous image with multi-directional regular wave pattern

(a) Image simulation

To verify the performance of wavelet transform in analyzing non-homogeneous image, we use Eq. (6) to simulate a non-homogeneous image with the wave patterns of four different directions that are arranged in four quadrants respectively.

$$f(x,y) = \sum_{i=1}^{4} a_i \cos\left(kx_i \cos\theta + ky_i \sin\theta\right) \qquad (6)$$

Where a_i is wave amplitude, k_{xi}, k_{yi} are wavenumber of component waves, θ is the wave direction of regular wave in the wave image. The simulation conditions are listed in Table 1, and the simulated image is shown in Figure 1 (Image I). The component waves in each quadrant are regular and homogeneous, while the margin of each quadrant and the whole image belong to non-homogeneity. We call such an image the local non-homogeneous image facilitated to differentiate the image spectrum estimation by wavelet transform and Fourier transform.

Table 1 Simulation conditions of local non-homogeneous image

No. of component waves	Wave height (m)	Wavelength (m)	Wave direction (degree)
(1)	0.20	10	45
(2)	0.15	8	-60
(3)	0.25	10	60
(4)	0.10	12	180

Image I

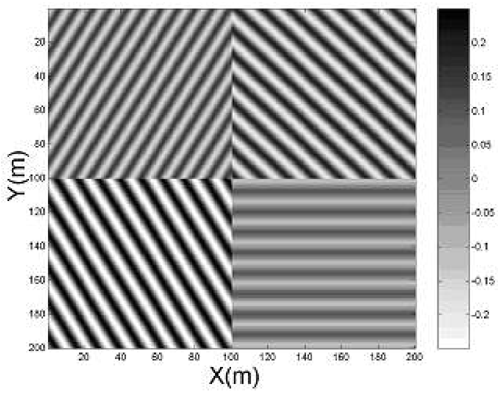

Figure1 *Simulation Image I with multi-directional regular wave pattern*

(b) Results

We get an average image spectrum by using Fourier transform as shown in Figure2.

Graphically, the wavelengths of the four component waves located at wavenumber (kx, ky) equal to (-0.68,0.39), (0.44,0.44), (0.54,0.31) and (0,-0.52) are 8m, 10m,10m and 12m respectively and the corresponding wave directions are –60 ,45 ,60 and 180 degree that are match with input conditions. Although Figure 2 presents the energy density of Image II, yet in fact, the component wave with wavelength of 10 m and wave direction of 45 degree only exits in first quadrant not second instead; the component wave with wavelength of 8 m and wave direction of -60 degree only exist in second quadrant, etc. They are all presented in the unique Fourier spectrum without localization. This is not a reasonable solution.

When we use wavelet transform to analyze the same image, we get the spectrum information in different position of the image due to the extractible localization for local image characteristics. The image spectrum located at A of Image I is shown in Figure 3. The result is just the input for A that its position is located at first quadrant of image I. This prove to the wavelet transform is a correct method for extraction of image features even for the local non-homogeneous image.

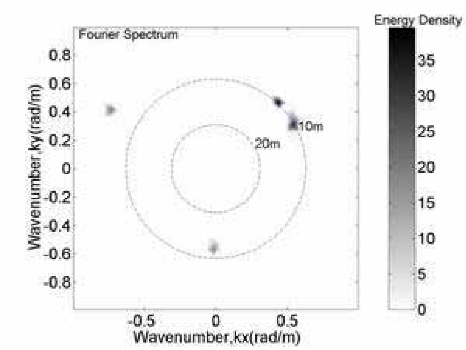

Figure 2. *Fourier spectrum of image I*

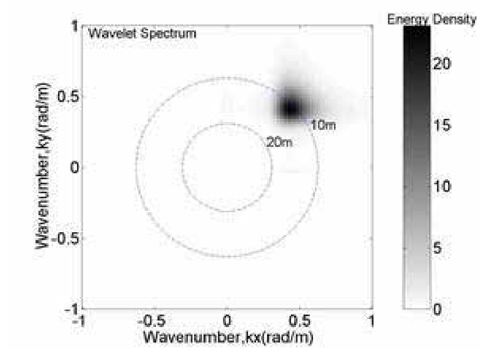

Figure 3. *Wavelet spectrum at A of Image I*

The non-homogeneous image with random wave pattern

(a) Image Simulation

The real sea-state is extremely random and irregular. This section uses a random sea-state simulation method that was presented by Goda & Mizusawa (1995) to simulate the near real sea-state image for testing the developed image spectrum analysis method.

$$f(x,y) = \sum_{m=1}^{M}\sum_{i=1}^{I} a_{mi}\cos[k_m x\sin(\theta_i) + k_m y\cos(\theta_i) + \varepsilon_{mi}] \tag{7}$$

where a_{mi} is the amplitude of random waves, k_m is the wavenumber, θ_i is the wave direction, ε_{mi} is the random phase. The simulated image is shown in Figure 4 (Image II).

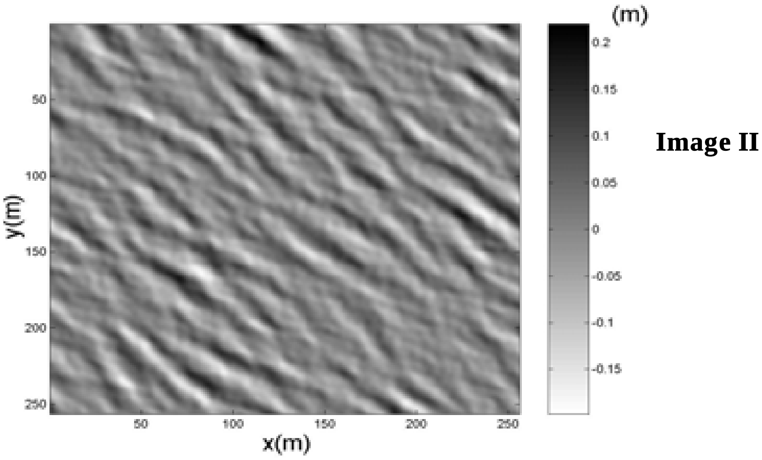

Figure4 *Simulation Image II with random wave*

(b) Results

Due to the outcome of Wavelet transform is a two-dimensional wavenumber spectrum, the spectral transform from wavenumber domain. to frequency domain. We used the direction-frequency spectrum of position B in Figure 5. The difference of wave direction between input spectrum and Wavelet spectrum is 2.7 degree and the differences of wavelength and peak frequency are 5.0m and 0.04Hz respectively. We analyze the Wavelet spectra at several positions. The comparative differences are always small than 6 degree for wave direction and 0.04 Hz for peak frequency. This test shows us that the Wavelet transform could be used to extract the spectrum features of the random sea-state.

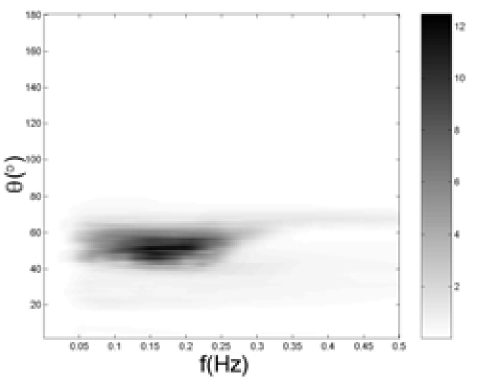

Figure 5 *Wavelet directional spectrum at B* of Image II

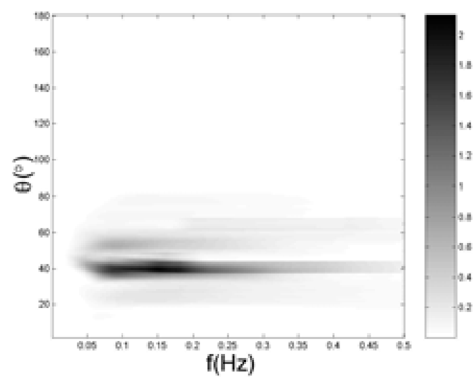

Figure 6 *Fourier directional spectrum of Image II*

ANALYSIS OF NEARSHORE SATELLITE IMAGES

In this section, SAR images (Fig. 7) from the spacecrafts that launched by first and second European Remote Sensing Satellites (ERS-1/2) are used. Each full SAR image spans an area of around 100 km×100 km, and all pixels are nearly square of 12.5 m by 12.5 m. The output of the SAR processor is an image that looks like a grainy photograph, with a dense irregular pattern of bright and dark spots. In this study, 5 SAR images are selected. They are from coastal areas in Taiwan.

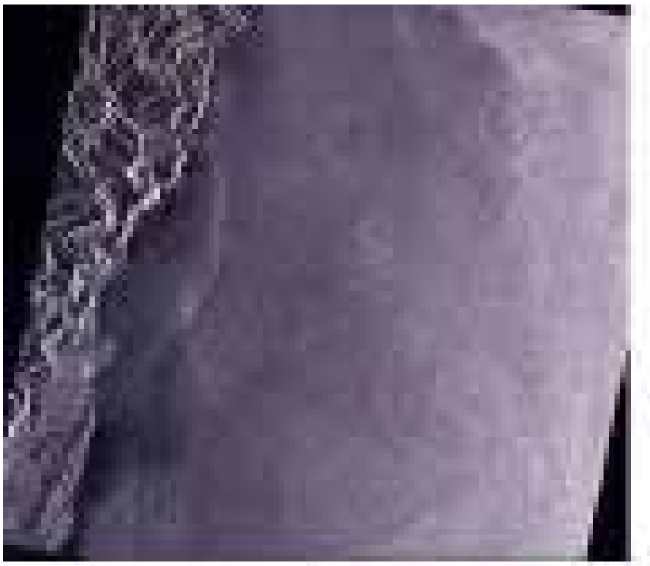

Figure 7 SAR image in eastern Taiwan water

In order to verify the results of SAR images analysis, In-situ data that observed by the data buoy around Taiwan sea area are collected. The data buoy is a powerful observation instrument whether used in deep or shallow water area (Kao et al., 1999). The data buoy provides oceanographic data such as wave height, period, and direction as well as meteorological data such as wind, barometric pressure and temperature.

We are interested in the quantitative differences between SAR images and in situ measurements. Biases of wavelength and direction derived from 5 sub-images and buoy data are estimated as listed in Table 2 and Table 3. It is found that the average bias of wavelength is 16.9m, and the average bias of wave direction is around 15.4 degree by using Fourier transform. The average bias of wavelength is 11.7m, and the average bias of wave direction is around 10.8 degree by using wavelet transform.

Table 2 *Biases of wavelength and direction derived by Fourier transform from sub-images and buoy data*

Image No.	Buoy data (A)		The result of Fourier transform (B)		|(A)-(B)|	
	Wave length (m)	Wave direction (◦)	Wave length (m)	Wave direction (◦)	Wave length (m)	Wave direction (◦)
1	132.0	96	159	106	27	10
2	129.3	79	122	96	7.3	17
3	134.0	68	146	86	12	18
4	118.0	101	140	132	22	31
5	127.7	112	144	111	16.3	1
The average bias					16.9	15.4

Table 3 *Biases of wavelength and direction derived by wavelet transform from sub-images and buoy data*

Image No.	Buoy data (A)		The result of wavelet transform (B)		|(A)-(B)|	
	Wave length (m)	Wave direction (∘)	Wave length (m)	Wave direction (∘)	Wave length (m)	Wave direction (∘)
1	132.0	96	135	96	3	0
2	129.3	79	166	72	36.7	7
3	134.0	68	139	81	5	13
4	118.0	101	107	110	11	9
5	127.7	112	125	87	2.7	25
The average bias					11.7	10.8

CONCLUSIONS

Remote sensing techniques have become quite popular for ocean wave measurement applications. The advantage of wave remote sensing technique is its capability of providing wave information in wide regions, which cannot be covered by in-situ instruments.

Through analysis the simulate image, the result of wavelet transform is similar to the result of traditional Fourier transform in analyzing homogeneous image. However, in analyzing non-homogeneous image, wavelet transform still get reasonable result, but Fourier transform will cause unreasonable result. In addition, in analyzing the satellite image (SAR), It is found that the average bias of wavelength and wave direction by using wavelet transform is smaller than Fourier transform.

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Sea Surface Observation in the Taiwan Strait Using Satellite Imager from HRPT Station

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ABSTRACT

A sequence of OrbView-2/SeaWiFS Chlorophyll-a (Chl-a) concentration and NOAA/AVHRR sea surface temperature (SST) images during the whole year of 1999 is used to understand the distribution of the upper ocean patterns in the Taiwan Strait (TS). All data were obtained from HRPT (High Resolution Picture Transmission) satellite receiving station at Department of Oceanography, National Taiwan Ocean University. It can be found that the higher Chl-a concentration with lower SST always happened along the western coast, while a wedge-like low Chl-a warmer water covered the whole southern TS and moved northward along the southeastern coast. During the summer the Chl-a shows a great contrast between central deeper water and coastal shallower water, but SST was nearly homogeneous around the whole TS. The empirical orthogonal function (EOF) analysis is also applied in this study. From gradient EOF mode 1 of Chl-a concentration, we can find that the bottom topography plays a very important role on its distribution; the higher Chl-a regions were located near the coastal area with the depth less than 50m. The gradient EOF mode1 from AVHRR SST images indicates that the water in the TS can be divided into two parts. One is the cold water in the west and extends to most of the northern TS, and the other one is the warmer water in the east covering most of the southern TS. The associated temporal amplitudes show that the horizontal variation of the SST is very small in the summer, which is opposite to the Chl-a field.

INTRODUCTION

Taiwan Strait (TS) is located between Chinese Taipei and Mainland China with the width varying from 160 km in the north to 200 km in the south (Figure 1). It is a shallow water channel, with an average depth of about 55 m, connecting the East China Sea (ECS) and the South China Sea (SCS) in the north and the south, respectively. The main currents in the TS are the China Coastal Current, the South China Sea Current, and the branch of the Kuroshio. The southwesterly monsoon drives the warm SCS water flowing all the way through TS during the summer, while the northeasterly monsoon drives the cold China Coast Current moves southward into the TS in winter. The warm water from the branch of the Kuroshio also moves northward into the strait during cold seasons (Fan, 1982). The topographic change may influence the movement of the currents in the strait. For example, Chern and Wang (2000) and Jan *et al*. (1998) noted that the southward flowing cold China Coastal Current always blocked by the Chang-Yuan Ridge and developed an oceanic front with the warm water of the northward moving Kuroshio branch current in the wintertime. Meanwhile, the interaction of the above two currents may induce upwelling around the Peng-Hu Islands (Fan, 1982).

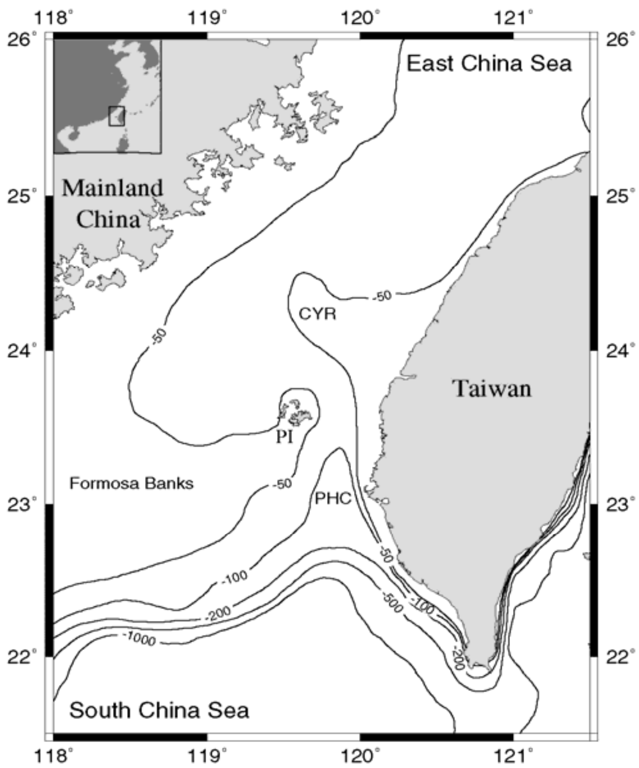

Figure 1: *Map of the Taiwan Strait with isobaths of 50, 100, 200, 500, and 1000m. PI, PHC, CYR represent the Peng-Hu Islands, Peng-Hu Channel, and Chang-Yuen Ridge, respectively.*

Satellite images can be used to detect surface patterns around the TS. Lin *et al.* (1992) found two groups of shear waves in the TS from one NOAA/AVHRR image on December 12, 1989. Kuo and Ho (1996) detected the angular velocity of an anticyclonic eddy in the northern TS through two consecutive NOAA/AVHRR images. Hu *et al.* (2001) combined the hydrographic and NOAA/AVHRR sea surface temperature data to detect the summer upwelling in the TS. These studies emphasized the SST properties of the TS mostly, but did not consider the long-term variation of the SST field in the whole TS. In this study, a sequence of NOAA/AVHRR images is considered to understand the spatial and temporal distributions of the thermal field in the TS during the whole year of 1999. Meanwhile, the associated nearly simultaneous OrbView-2/SeaWiFS images are also used to see the biological variability in the upper TS. Besides the specific patterns we can see from individual images, the EOF analysis is also be applied to decompose the time series of spatial SeaWiFS and AVHRR images into its dominant modes of variability.

SATELLITE OBSERVATION AND DATA ANALYSIS

All the AVHRR and SeaWiFS images in this study are received from the HRPT (High Resolution Picture Transmission) station at Department of Oceanography, National Taiwan Ocean University. Four of selected 3-day composite SeaWiFS-derived Chl-a concentration images and their corresponding AVHRR-derived SST images are shown in Figure 2 and 3, respectively.

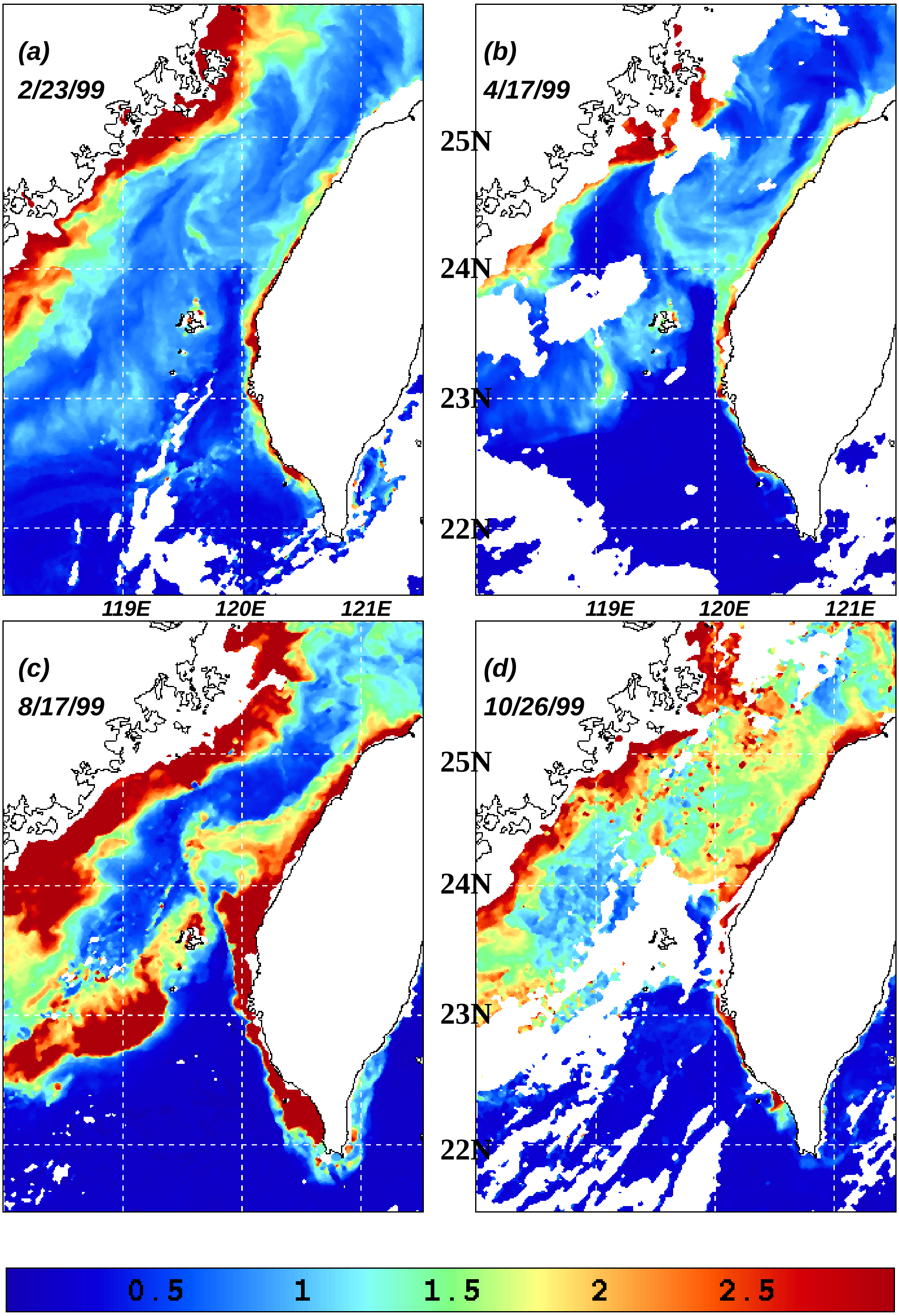

Figure 2: *SeaWiFS-derived Chl-a images in the Taiwan Strait. Color bar at the bottom indicates Chl-a concentration (mg m*$^{-3}$*) range and white pixels indicate no valid data.*

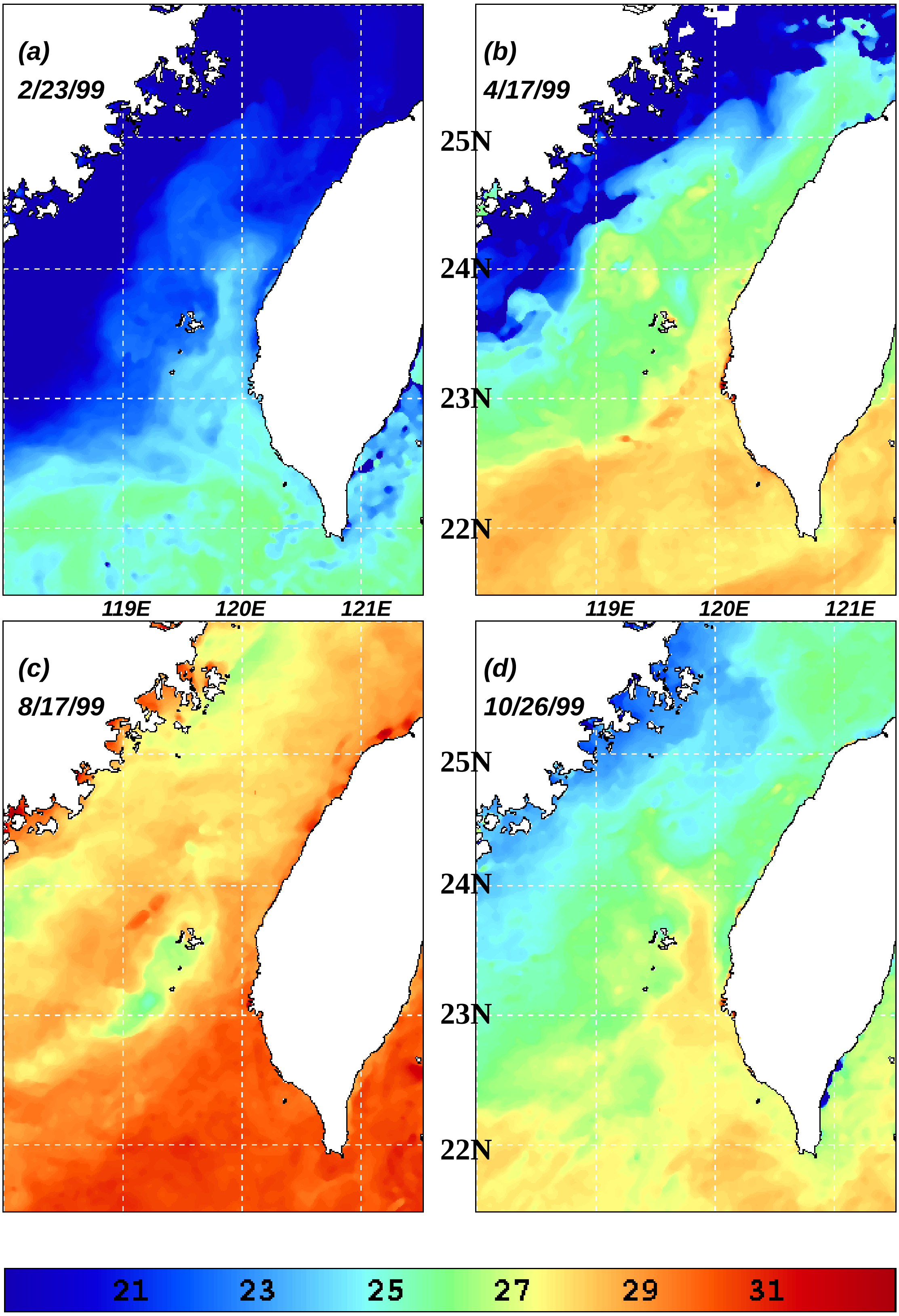

Figure 3: *Same as Figure 2 but for AVHRR-derived SST images. Color bar indicates SST (°C) range.*

We can see that the high Chl-a concentration is always around the coastal areas, especially in the western coast of the TS. A wedge-like low Chl-a area always covers the whole southern TS with depth greater than 100m and along the Peng-Hu Channel near the southeastern coast to the north of about 24°N. This low Chl-a water may stretch and makes a turn northwesterly along the channel between the Peng-Hu Islands and Chang-Yuen Ridge to cover more areas deeper than 50m. Meanwhile, the above low Chl-a water shows a much great contrast with the surrounding water during the summer. Figure 3 shows the corresponding SST field. We can see that the higher Chl-a water along the western TS contains lower SST, while the southeastern wedge-like low Chl-a water was always warmer. The SST field shows a different distribution as the Chl-a field during the summer, the whole TS covers nearly homogeneous warm water except some cold spots in the western coast and south of the Peng-Hu Islands.

Empirical orthogonal function (EOF) analysis is generally regarded as a very efficient method to extract information from a large data set; it can reduce the original information to a few time-varying spatial patterns that explain most of the variance in the data. The spatial distribution and its associated time-varying amplitudes of the first gradient EOF of SeaWiFS Chl-a images are shown in Figure 4a and 5a, respectively. This mode contains 65.8 % of the variance and is highly related to the bottom topography. Because the time-varying amplitudes in Figure 5a are all negative, the regions with depth greater than 50m are therefore low Chl-a water. They include the large wedge-like warm water and the area along the central TS. The western coastal water including Formosa Banks and the eastern coastal area containing Chang-Yuen Ridge are all relatively high Chl-a areas. The associated time-varying amplitudes of this mode also indicate that the great spatial Chl-a difference is in the summer, while the relative low Chl-a gradient during the wintertime.

The spatial patterns of the first covariance EOF for SeaWiFS Chl-a images are shown in Figure 4b. It shows a similar spatial distribution to the gradient EOF mode 1 in Figure 4a. This mode includes 43.5% of the variance. The corresponding time-varying amplitudes in Figure 5b show a large and negative value in August. This tremendous temporal change will enlarge the horizontal gradient of the Chl-a concentration during the summer. The spatial distribution of the first gradient EOF from NOAA/AVHRR SST images is shown in Figure 4c. It contains 90.6% of the variance. Because the corresponding temporal values in Figure 5c are all negative, the western region with positive spatial value would be the cold water while the eastern area with negative value would be the warm water region. Meanwhile, the coldest water is along the western coast and the warmest water covers most of the southern TS through the Peng-Hu Channel northward passing the water shallower than 100m in depth and stretching to the Chang-Yuan Ridge of about 24.3°N. Figure 5c also indicates the smallest spatial SST variation in summer while the largest spatial SST distribution in the wintertime.

The covariance EOF analysis from NOAA/AVHRR SST images is also considered in this study. The mode 1 contains 92.5% of the variance. Combining Figure 4d and 5d, we can see the lowest SST occurs in January and the highest SST in August or September. Meanwhile, the great seasonal SST variation occurs in the western coast of the TS while the lower temporal SST change in the eastern TS. These phenomena can be explained by the seasonal change of the flow patterns in these two distinct areas. The great seasonal SST change in the western coast area may be resulted from the steady southward cold water along the western coast of the TS from Mainland China in the winter and the warm water along the eastern strait from SCS during summer. The lower seasonal SST change in the eastern TS is because that warm water always exists in any season, it is from SCS in summer and from Kuroshio extension in winter.

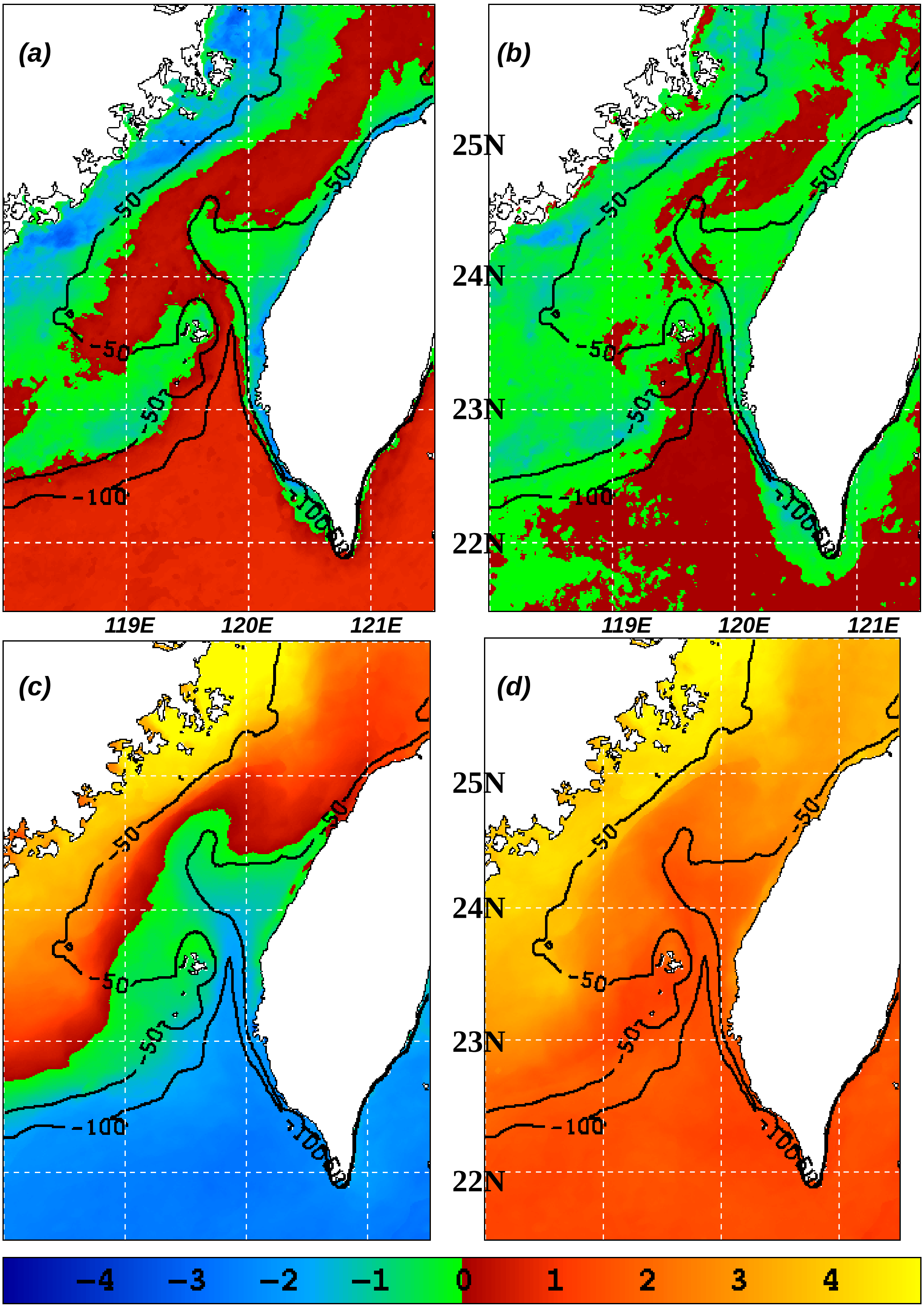

Figure 4: *The mode 1 spatial patterns of (a) gradient Chl-a, (b) covariance Chl-a, (c) gradient SST, and (d) covariance SST EOF. 50 and 100m isobaths are marked. The color bar indicates range of mg m^{-3} for Chl-a and ^{o}C for SST, respectively.*

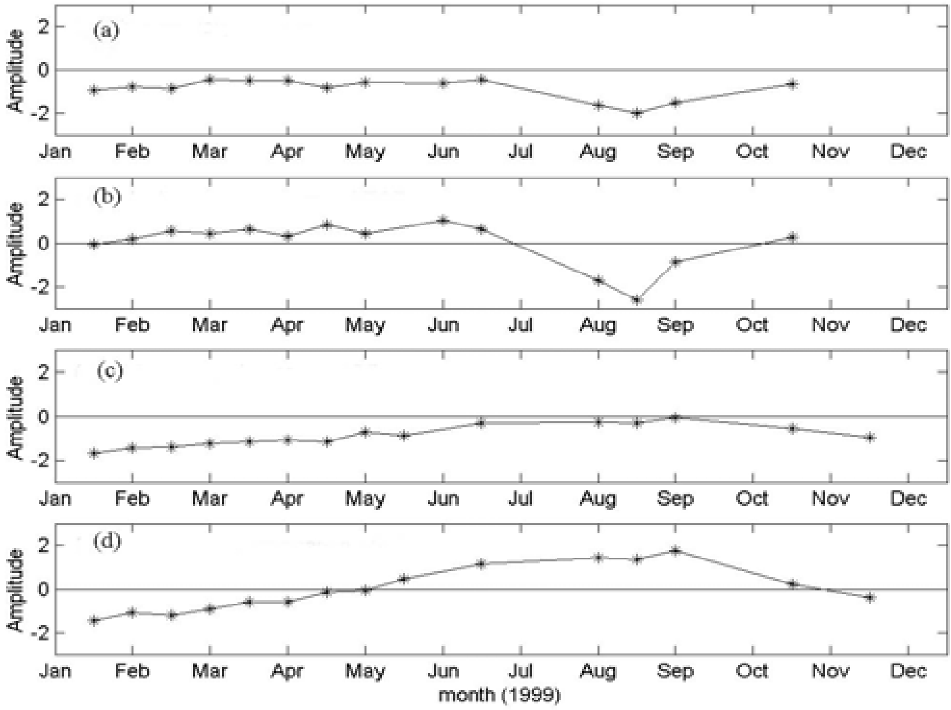

Figure 5: *Corresponding time-varying amplitudes of the spatial patterns in Figure 4.*

SUMMARY AND CONCLUSIONS

In this study, a sequence of OrbView-2/SeaWiFS and NOAA/AVHRR images offers a nearly simultaneous two-dimensional comparison of biological (Chl-a concentration) and physical (SST) variability in the upper ocean of the TS during 1999. The NOAA/AVHRR images shows that the SST distribution in the TS is mainly related to the seasonal monsoon wind prevailing. During the winter the strong northeasterly monsoon drives the coastal cold water southward along the western TS. Meanwhile, the branch of the warm Kuroshio also entered the south of TS and moved northward along the southeastern TS. The SST field therefore displays a distribution of that the western coast is colder than the eastern coast and southern part is warmer than the northern area. In the summertime the southwesterly monsoon push the warm SCS water northward to make nearly homogeneous water in TS. The SeaWiFS-derived Chl-a concentration in TS shows different variations as the SST distribution. The complex bottom topography plays a very important role on the Chl-a distribution in TS. The EOF analysis for Chl-a images shows that TS may compose two regions by depth. One is the higher Chl-a region including the western and eastern coasts and some areas in the middle TS with depth less than 50 m. The other one is the lower Chl-a region with the depth greater than 50 m, which includes the wedge-like water from the southern TS and part of deeper water along central TS. From EOF analysis for SST images, we can find that the variation of the SST field in TS is mainly affected by the interaction between monsoon and currents. The patterns of Chl-a concentration and SST field are not the same, especially in the summertime.

ACKNOWLEDGEMENTS

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Application of Satellite Remote Sensing on the Tuna Fishery of Eastern Tropical Pacific

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ABSTRACT

Tuna fishery is a major fishery in Chinese Taipei, as in many other countries. Blue Fin tuna festival is a tourist attraction in the southern Chinese Taipei. Swimming in the immense open ocean, tuna is studied mostly on its maximum sustainable yield (MSY), not much about its life history because their juvenile has little market value. In order to manage the tuna fishery or to maximize the catch per unit effort (CPUE), one must be able to predict where tuna-preferred oceanographic conditions are. For predicting the fishing ground, the climatological mean sea surface temperature (SST) or ocean color distribution do not offer more information than the no-prediction method: using the mean distribution of fish catch. Based on tuna catch data from a few experimental fishing vessels, the following conclusion may be drawn: CPUE is higher in regions of SST in 26^{o}C~28^{o}C, surface Chl. a concentration around 0.2 mg/m^3, surface current speed above 0.15 cm/s, higher sea surface height (SSH). Because all the marine environmental parameter may change quickly with time or in space, and only satellite remote sensing may provide near real time observation of the vast ocean, both fishing activities and fishery management may benefit from satellite oceanography.

Keywords: satellite, remote sensing, tuna, tropical Pacific

INTRODUCTION

The fast swimming tuna is one of the major resources in all world oceans. In the case of western North Pacific, the size of landed tuna increases along Kuroshio, but the landed tuna east of Mindanao has bi-modal structure, juvenile and matured tuna. To close its cycle of migration or life, we may assume the Indonesia water south of Mindanao being the breeding ground of tuna that swims along Kuroshio for thousands of kilometers. Long migration path may be a common character of tuna in all oceans. From the published statistics by the Food and Agriculture Organization of United Nations, the eastern tropical Pacific (ETP) is a region of high tuna catch since 1962. In this region, there are five major ocean currents, South Equatorial Current, Equatorial Counter Current, North Equatorial Current, Equatorial Under Current, and the weak South Equatorial Counter Current. The 5^{o}x5^o averaged, annual mean catch statistics is likely an average over three current system, and therefore can hardly provide any information on the correlation between the marine environment and the fish catch.

If fish schools has their preferred living environment, like all other animals, then the fish catch statistics should have some correlation with the marine environmental parameters, like surface temperature (SST), surface Chl. a concentration that is highly related to the primary productivity, ocean current, eddy, mixed layer depth, the thermocline depth, vertical temperature distribution, sea states, water clarity, etc.. For example, Chinese Taipei spear fishermen go out in high seas to catch tuna, not during sunny day with calm seas. For the far sea tuna fishermen, SST is still their primary factor in selecting fishing ground.

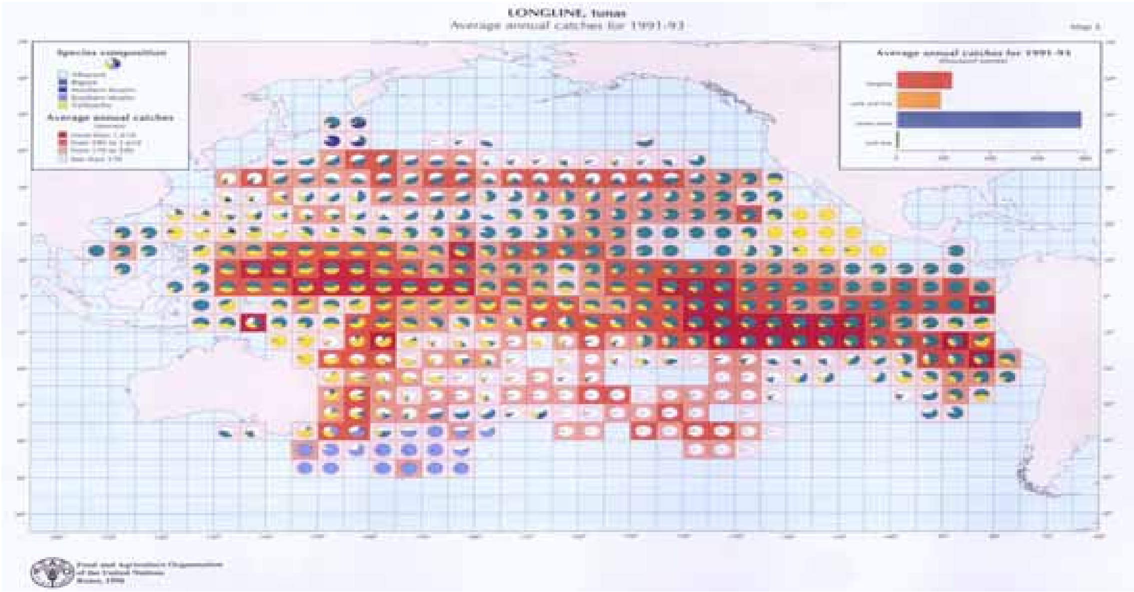

Fig. 1: *Averaged annual catch of tuna by longline fishery in 1991-1993 (UN/FAO)*

OCEANO GRAPHIC AND FISH CATCH DATA

The water temperature data used in this study are the weekly mean SST from IGOSS (Integrated Global Ocean Services System), the temperature profile data are from NODC (National Oceanographic Data Center) for estimating the mean temperature drop from surface to 100 m and to 200 m depth, the tuna catch data are from (1) IATTC (Inter-America Tropical Tuna Commission) for the $5^o x 5^o$ averaged, monthly mean catch statistics, and (2) experimental fishing vessels that was sponsored by the Fishery Administration of Chinese Taipei. The satellite-derived *Chl. a* concentrations are from SeaWiFS data bank.

ANALYSIS AND DISCUSSION

A direct proof of the fishermen's practice is to compare the CPUE of Big Eye tuna (BET) against the in situ SST. Figure 2 shows that the CPUE is higher when SST is in the range of 26^oC~28^oC. How about the CPUE against the mean SST, or the mean water temperature at 100 m and 200 m depth where water temperature changes less and slower than SST and where tuna spend more time during the day.

Figure 3 is a plot of CPUE against the monthly mean water temperature at surface, 100 m and 200 m depth. It is clear that the month mean water temperature does not show much correlation between the water temperature and CPUE. This is to say that the monthly mean water temperature has little practical value in predicting the fishing ground of BET in ETP.

The reason that Figure 2 matches fishermen's experience while Figure 3 does not, may be explained by the fast changing marine environmental parameters in ETP, especially near the region of equatorial upwelling, equatorial fronts between the currents. To make useful prediction of fishing ground, one will need near real-time oceanographic data that are only available through satellite remote sensing.

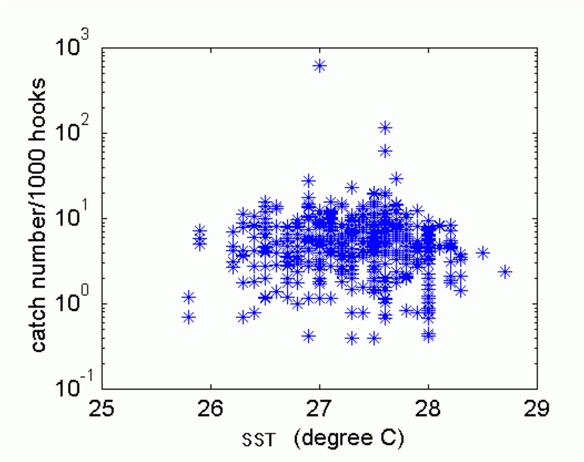

Fig. 2a *Scatter diagram of CPUE (log scale) vs. in situ SST from experimental fishing vessels. CPUE is number of tuna per 1000 hooks.*

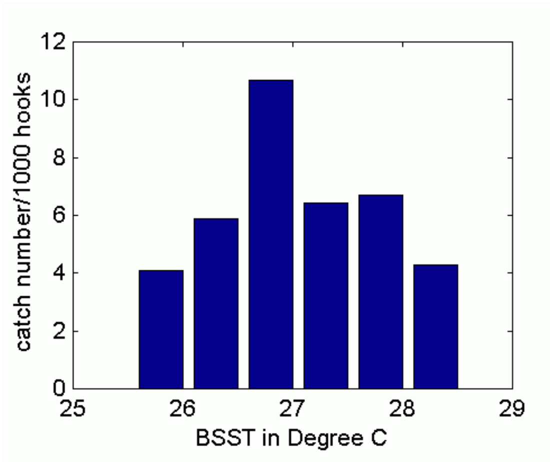

Fig. 2b *Bar chart of CPUE (linear scale) vs. in situ SST from experimental fishing vessels. CPUE is number of tuna per 1000 hooks.*

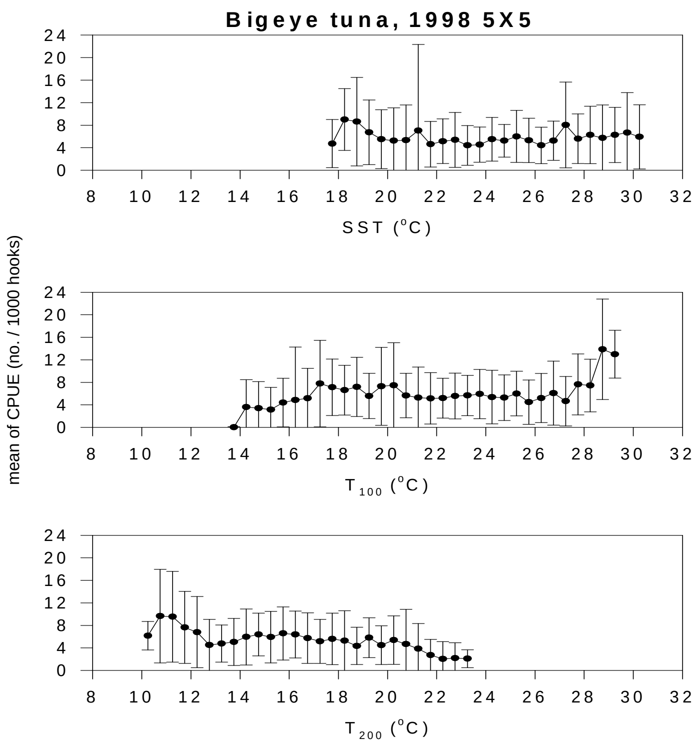

Fig. 3. *CPUE of Big Eye tuna vs. monthly mean temperature at surface, 100m and 200 m depth*

In most part of the world ocean, satellite-derived SSTs are readily available from internet for medium to coarse resolution SST images, or from local satellite ground station for high resolution SST images. Another useful satellite data is the image of ocean color or Chl. a concentration.

SATELLITE-DERIVED OCEAN COLOR

The application of SeaWiFS-derived ocean color on fishery is well accepted. But in EPT where cloud coverage is high, SeaWiFS sensors can hardly see the sea surface and therefore provide few useful ocean color data. Figure 4 shows the CPUE of BET vs. monthly mean Chl. a concentration. It is apparent that the correlation is low. But, if we compare the CPUE and satellite-derived Chl. a at the same time and at the location of fishing vessel, then we found that CPUE maximizes in regions of moderate productivity, or Chl. a of 0.2 mg/m^3.

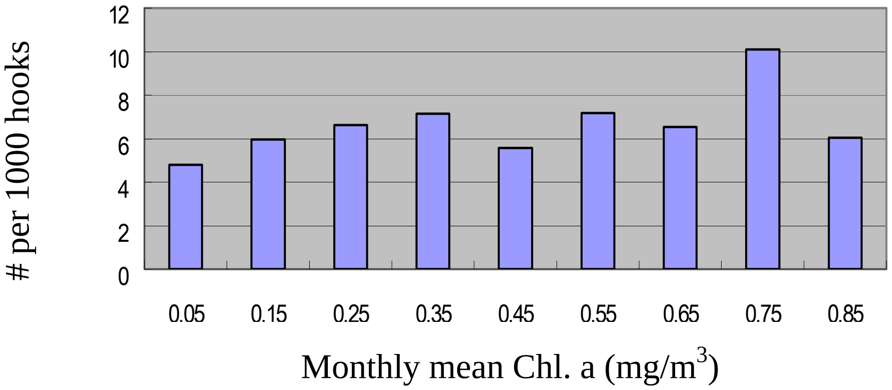

Fig. 4 *CPUE of Big Eye tuna vs. monthly mean of satellite-derived Chl. a concentration.*

SATELLITE-DERIVED OCEAN CURRENT

In most cases, fishing boats tend to stay away from regions of strong current while deploying their fishing gear. Figure 5 shows that the fishing boat white dots near (5^{o}N, 135W^o) tends to work near the edge of eddy and their CPUE of BET is higher for current speed larger than 0.15m/sec. Again, this kind of correlation does not exist between the CPUE and the mean current speed as in Fig. 6.

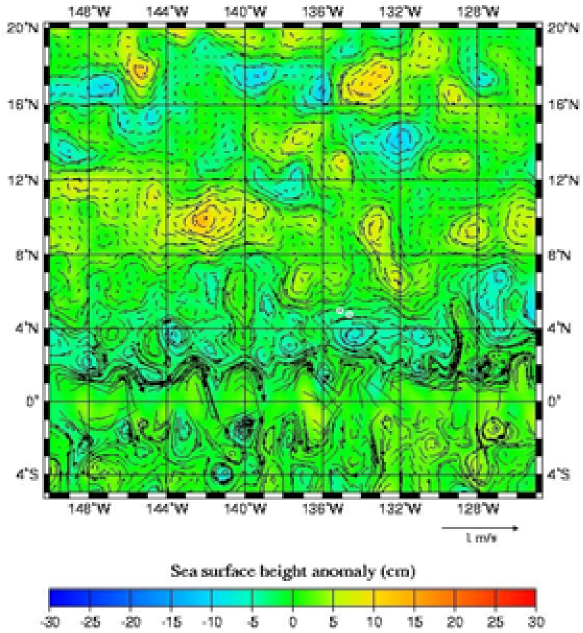

Fig. 5 *Eddies and fishing ground: in April of 1991, longline fishing boats (white dots) operated near an eddy centered at (5^{o}N, 135W^o)*

SATELLITE-DERIVED SEA SURFACE HEIGHT (SSH)

The life cycle and the feeding behavior of tuna is still a mystery to us. This mystery is soon to be resolved by the application of Archival Tag. Figure 7 shows the vertical migration of BET in one day. As the sun rises, BET dives (blue line in Fig. 7) from surface layer to the cold deep water (red line in Fig. 7). It will make a short trip to the upper layer to warm up after its body temperature (green line in Fig. 7) drops below its tolerance level. Therefore, the depth of warm surface mixed layer (about 80 m in Fig. 7) and thermocline influences the migration of BET, the chance that BET will see the hooks, and therefore the CPUE.

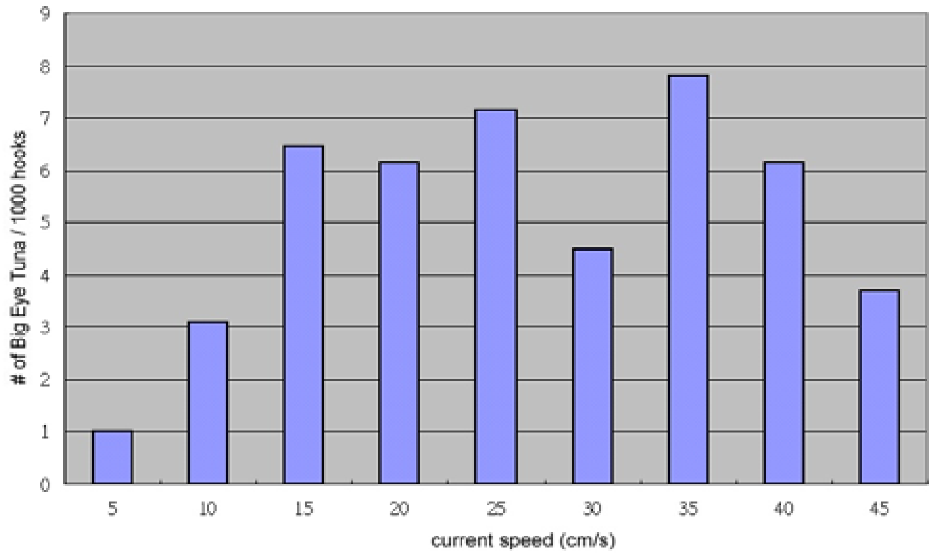

Fig. 6 *CPUE of Big Eye tuna vs. the speed of current (cm/s)*

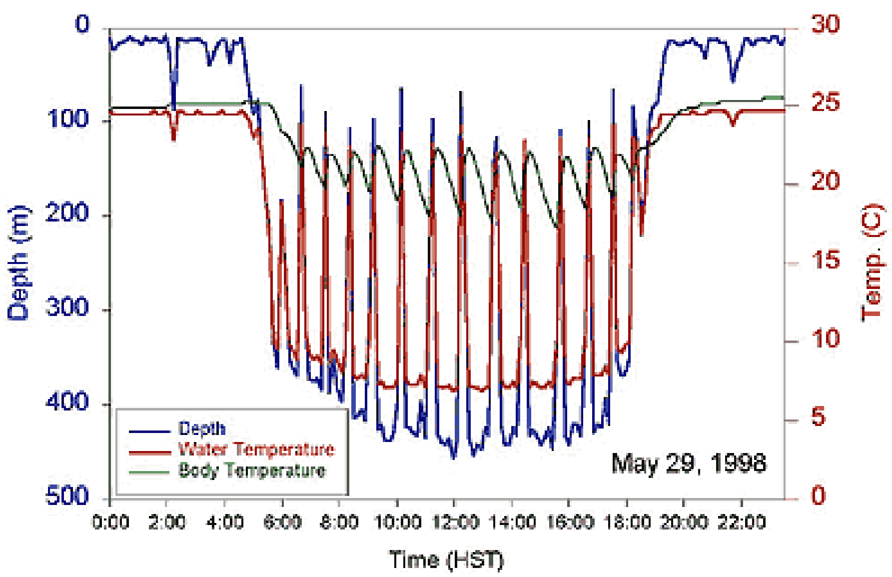

Fig. 7 *Vertical daily migration of a Big Eye tuna (source: Archive Tag of NMFS in Hawaii)*

In the plot of CPUE of BET vs. SSH, it is clear that CPUE of experimental fishing boats increases with SSH (Fig. 8a). Because the number of deployed hooks does not depend on SSH, the resulted CPUE (catch / 1000 hooks) should be a non-biased statistic from a non-biased sampling.

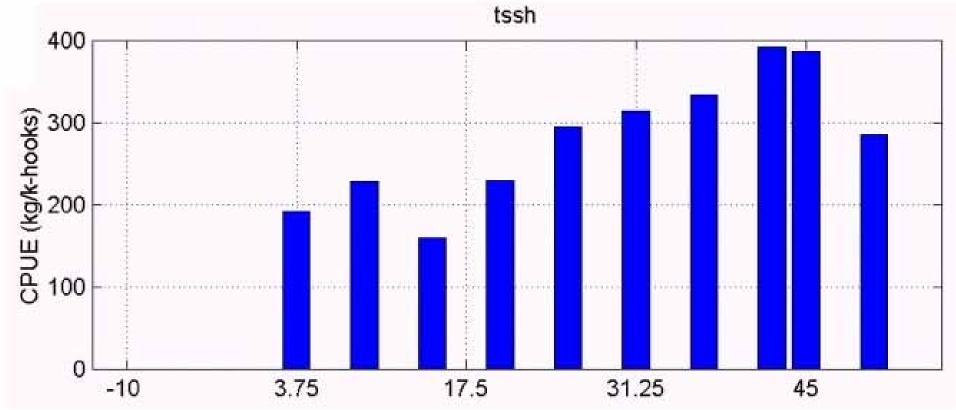

Fig. 8a *Mean CPUE vs. sea surface height (cm)*

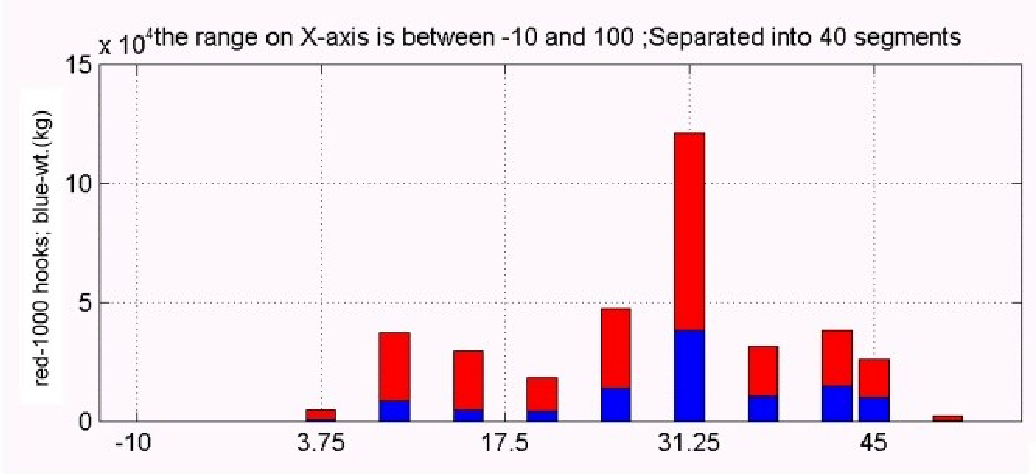

Fig. 8b *CPUE of Big Eye tuna (blue) and number of hooks deployed (red) vs. sea surface height (cm)*

CONCLUSION

From above analysis, it is clear that (1) sea surface temperature, ocean color, ocean current and sea surface height are all correlated to the CPUE of Big Eye tuna; (2) these marine environmental parameters are necessary conditions for the prediction of fishing ground, but none are sufficient condition; therefore, one has to weight their contributions in making prediction of fishing ground; (3) The CPUE has little correlation to the long-term mean or large-area averaged oceanographic data; (4) satellite remote sensing can provide the near real-time observation of world ocean. Since satellite data have been integrated into the fishing ground prediction by commercial companies, one should be able to do the same if sufficient manpower and time were invested.

ACKNOWLEDGEMENT

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Influence of Wave Motion in Mangrove Forest

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ABSTRACT

Mangrove forests are a buffer zone between the coast and the ocean. They have a special role in supporting fisheries and in the stabilizing the tropical coastal zones. Biochemical and trophodynamic processes in mangroves are strongly linked to wave movement, due to tides and waves.

In this paper, the theoretical attempt to predict the attenuation of wind-induced random surface waves in mangrove forests is presented. Wave motion is partly reflected from the forest, partly attenuated by interaction with trunks, and only partly transmitted through forest. The resulting rate of wave energy attenuation depends strongly on the density of the mangrove forest, diameter of mangrove roots and trunks and on the linearization coefficient relating to drag force.

INTRODUCTION

Mangroves are a special form of vegetation as they exit at the boundary of terrestrial and marine environment; in the tropic zones and subtropical zones, in the interior depressions. Biochemical and trophodynamic processes in mangroves are strongly linked to wave movement, due to tides and waves. Mangroves are very efficient in reducing wave energy and can be used as an environmentally friendly, soft – engineering option along muddy shores to protect the coast from erosion.

In recent years, it has been realized that mangroves may have a special role in supporting fisheries, stabilizing the coastal zone and protecting the lives and properties of the people living near the sea and offshore islands (Jackson and Winant, 1983; Jenkins and Skelly, 1987; Qureshi, 1990; Siddiqi and Khan, 1990; Mazda et al., 1997a; Massel, Furukawa and Brinkman, 1999). They also have an important role in transports and shore erosions (Furukawa and Wolanski, 1996). However, studies of physical processes in tropical mangrove swamps and mangrove – fringed estuaries are few, and far behind compared to those of temperate estuaries. Water circulation in riverine mangrove forests, which comprises tidal creeks and shallow mangrove swamps has been studied somewhat more than the other types of mangrove forests (Wolanski et al., 1992; Furukawa et al., 1997).

In this paper, a theoretical attempt to predict the attenuation of wind-induced random surface waves in mangrove forests is presented. The resulting rate of wave energy attenuation depends strongly on the density of the mangrove forest and linearization coefficient relating to drag force.

GOVERNING EQUATIONS AND BOUNDARY CONDITIONS

Governing equations

Let the origin of a rectangular coordinate system O(x,y,z) be taken at the mean free surface of the fluid, and the axes be chosen so that the x-coordinate is horizontal, directed perpendicularly to the mangrove, the y-coordinate extends along shore and the z-coordinate is vertical and increasing upwards (Fig. 2.). The water depth h(x) is assumed to be a slowly varying function of x-direction. Width of mangrove area is equal to L.

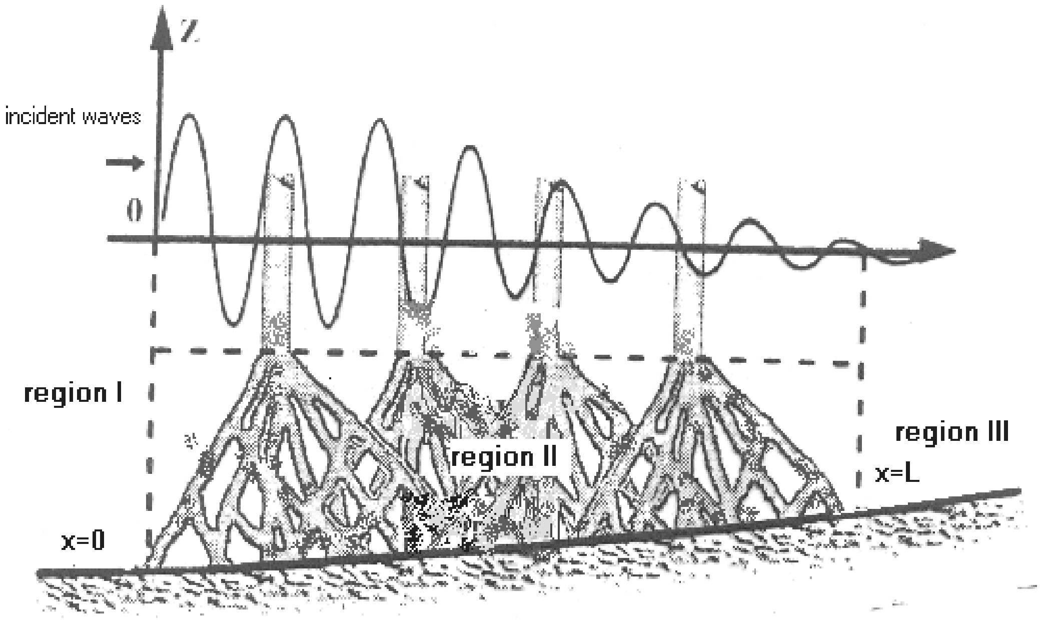

Fig. 1. *Coordinate system in mangrove forest*

The solution of the corresponding boundary value problem may be constructed from the particular in each region of the fluid domain.

In region I (in front of the mangroves: $-\infty < x < 0$; -h < z <0; $-\infty < y < \infty$), the wave field is composed from incident waves and waves reflected from mangrove forest. The water depth is assumed to be constant. Velocity potential takes the form:

$$\phi_1(x,y,t) = -\frac{igH_i}{2\omega} e^{-i\omega t}\left(e^{-ik_1(x\cos\theta_1 + y\sin\theta_1)} + K_r e^{ik_1(-x\cos\theta_1 + y\sin\theta_1)}\right) \quad (1)$$

where:

K_r : complex reflection coefficient

θ_1: incident angle

k_1 : wave number satisfying the dispersion relation.

H_I : incident wave height

ω : wave frequency

In region II (mangrove forest: 0< x <L ; -h<z<0), two wave systems are observed: waves propagated through mangrove, towards region 3 and waves reflected from the rear boundary of the mangrove area. Wave energy of both systems is strongly dissipated due to interaction with mangrove elements. The water depth h(x) is assumed to be a slowly varying function of x-direction. The governing velocity potential can be represented in the form:

$$\phi_2(x,y,t) = \frac{-igH_i}{2\omega} e^{-i\omega t} e^{-i\chi y} \varphi_{2x}(x) \quad (2)$$

where:

χ^2 : constant of separation and should satisfy the Snell's law (Berkhoff, 1973)

$\varphi_2(x)$: nondimensional wave height H(x)/ H_I

$$\nabla^2 \varphi + \frac{\nabla(gh)\nabla\varphi}{gh} + k^2(1 + if_e)\varphi = 0 \qquad (3)$$

in which:

g: gravitational acceleration

h: water depth

f_e : linearization coefficient and depends on the second and the third moments of the water velocity in the mangrove region. In order to get a practical solution, the linearization procedure, widely used in ocean engineering for determination of the forces on offshore structures, was applied (Gudmestad and Connel, 1983):

$$\frac{1}{\rho}\vec{F} \approx f_e \omega_p \vec{u} \qquad (4)$$

where:

$\vec{F}$: drag force vector

ω_p : peak frequency

$\vec{u}(x,z)$: wave-induced velocity at a given point in region II.

In region III (behind the mangroves: x > L ; -h < z < 0), only progressive waves are observed. The water depth is assumed to be constant. Velocity potential takes the form:

$$\phi_3(x,y,t) = -\frac{igH_i}{2\varpi} e^{-i\varpi t} K_T e^{ik_3(x\cos\theta_3 + y\sin\theta_3)} \qquad (5)$$

where K_T : transmission coefficient

Boundary Conditions

The potentials ϕ_1 , ϕ_2 and ϕ_3 must satisfy the matching conditions which provide continuity of pressure and horizontal velocity in particular points x = 0 and x = L.

<u>At x = 0</u> :

$$\begin{cases} \phi_1 = \phi_2 \\ \dfrac{\partial\phi_1}{\partial x} = n_p \dfrac{\partial\phi_2}{\partial x} \end{cases}$$

$$\Leftrightarrow n_p \varphi'_{2x}(0) + ik_1\cos\theta_1\varphi_{2x}(0) - 2ik_1\cos\theta_1 = 0 \qquad (6)$$

in which n_p: the 'surface porosity' of the mangroves at x=0. (Basically, it is a projection of the mangrove stand on the surface x=0). In this paper, mean values of porosities are assumed: (Massel, 1999)

$$n_p = 1 - \frac{V_t}{V_0}$$

where

V_t : the volume of trunks and roots and depends on their diameters,

V_0 : a total control volume.

* n_p=1 represents absence of mangrove forest
* n_p=0 is a fully reflective wall.

Therefore, the surface porosity is inversely proportional to trunk density.

At x=L:

$$\begin{cases} \phi_2 = \phi_3 \\ \dfrac{\partial\phi_3}{\partial x} = n_p \dfrac{\partial\phi_2}{\partial x} \end{cases}$$

=> $$n_p \varphi_{2x}'(L) = ik_3 \cos\theta_3 \varphi_{2x}(L) \quad (7)$$

In this paper, a finite difference method has been used and the resulting system of linear equations for $\varphi_2(x)$ was solved by the Cholesky'method.

EXAMPLE OF NUMERICAL CALCULATIONS

Input Data

Let us assume the following parameters of the mangrove forest: forest width L = 45m, water depth in region I h_1 = 1m and in region II h_3 = 0.2m. Water depth in region II varies slowly to x-direction. (Fig. 2.).

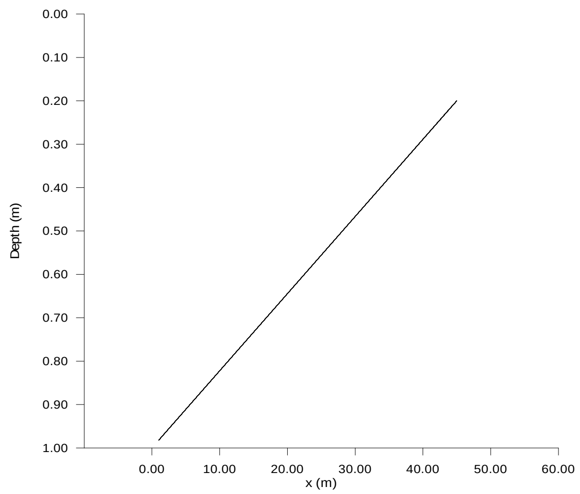

Fig. 2. *Suggested topography*

Some Results

The changes of wave height with different drag forces (f_e =0, f_e =0,1, f_e=0,5 and f_e=1) are shown in fig. 3. It is clearly that in case of no drag force (f_e=0), the equation (3.) becomes

Berkhoff equation without the dissipation of wave energy. Therefore, wave height is increasing as wave propagates into shallow water. Conversely, wave attenuation through the forest is proportional to the increase of drag force. This is the result of the wave-trunk interaction attenuating wave energy.

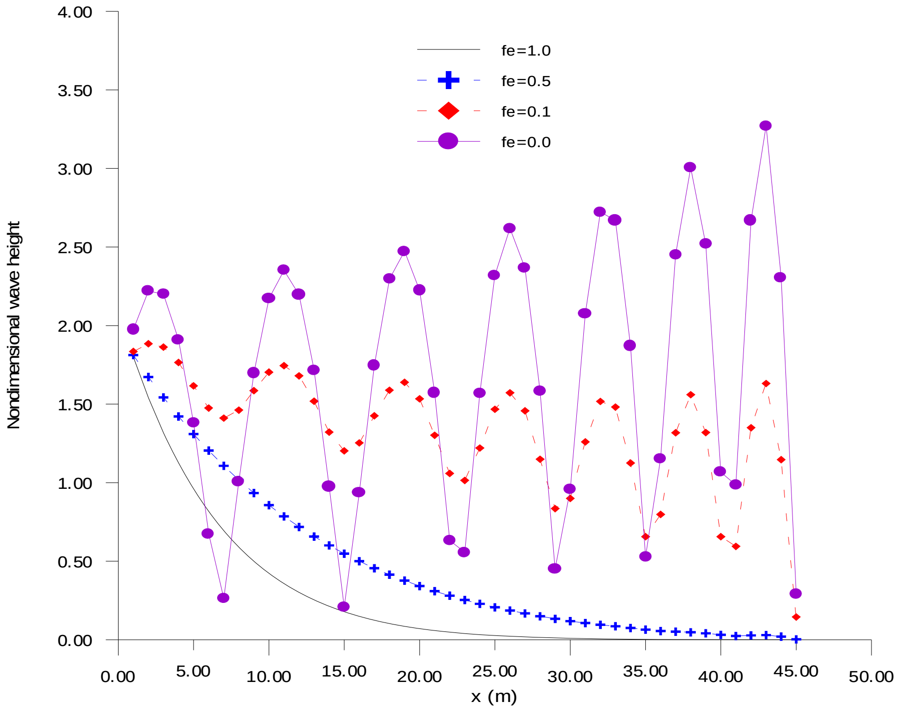

Fig. 3. *The changes of wave height with different drag forces*

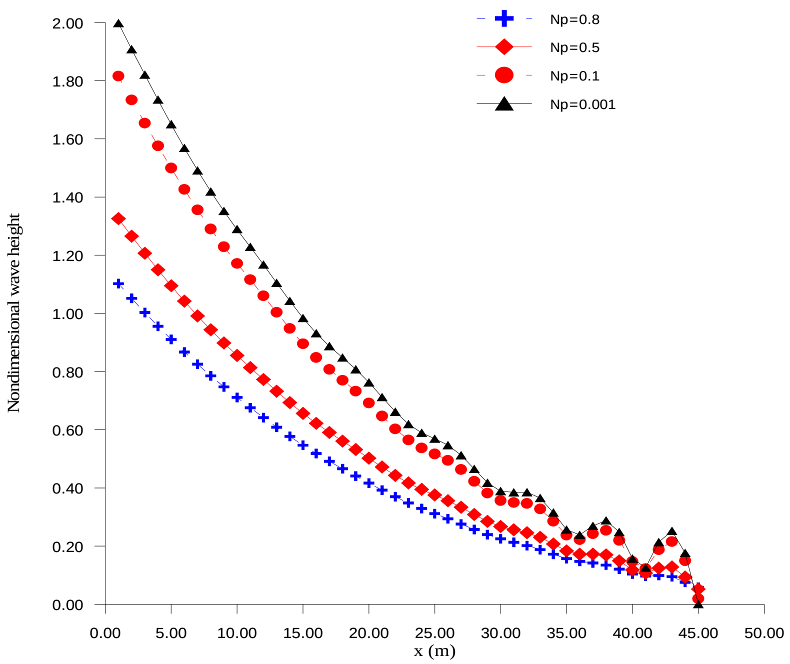

Fig. 4. *The changes of wave height with different surface porosities* n_p

The changes of wave height with different surface porosities n_p (n_p=0.001, n_p=0.1, n_p=0.5 and n_p=0.8) are shown in Fig.4. It is clearly that the resulting rate of wave energy attenuation depends strongly on surface porosity, i.e. on the density of the mangrove forest, diameter of mangrove roots and trunks.

CONCLUSIONS

1. Wave height decreases considerably through the mangrove forests due to the results of the wave-trunk interactions attenuating wave energy. The drag force can be known according to real conditions of problem.
2. The resulting rate of wave energy attenuation depends strongly on surface porosity, i.e. on the density of the mangrove forest, diameter of mangrove roots and trunks.
3. The model in which the influence of propagating of surface waves on the sediment transports and shore erosions is taking into account will be developed and will be applied on some any mangrove regions– locating at the estuary of Dong Tranh river in Can Thanh village, Can Gio district, Ho Chi Minh city.

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Observations of the Intrusion of Kuroshio into South China Sea from Satellite Infrared Images

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ABSTRACT

Characteristics of the Kuroshio intrusion into the South China Sea (SCS) through the Luzon Strait were analyzed using satellite infrared images. The Empirical Orthogonal Function (EOF) method was then applied to the infrared images from 1993 to 2000. The results show that the Kuroshio intrusion is not obvious during an El Niño year, but intensifies in a Niña year. During the onset of El Niño event, the water masses in the SCS occupied the whole SCS that it causes the Kuroshio loop can not be formed in the Luzon Strait. During a La Niña year, the Kuroshio intrusion can enter the SCS farther than that in normal years. The possible cause of these differences may be related to wind pattern changes in the western equatorial Pacific Ocean before and during the events.

Keywords: Satellite, Kuroshio Intrusion, Sea Surface Temperature, Luzon Strait, Empirical Orthogonal Function

INTRODUCTION

The Kuroshio flows northward as a western boundary current east of Luzon and Chinese Taipei. Between the two islands, there is a strait, called the Luzon Strait. The strait with its deepest sill at 2500 m forms a gap in the western boundary. It is about 350 km wide. The intrusion of waters from the Kuroshio into the South China Sea (SCS) through the Luzon Strait has been studied from more than 30 years. Chu (1972) suggested part of the Kuroshio always flows west through the Luzon Strait. Nitani (1972) presented the intrusion as far as 118°E in February 1967 and to 119°E in August-September 1942. Fan and Yu (1981) analyzed the T-S relationship obtained from hydrographic measurements in the Luzon Strait indicated intrusion in December 1980 and April 1981. Hydrographic observations also suggested partial intrusion in August 1980 (Fan and Yu, 1981) and August 1981 (Fan, 1982). Shaw (1989) and Shaw (1991) summarized previous studies and his investigation and concluded the hypothesis of a seasonal pattern of the intrusion process: intrusion of water from the Kuroshio begins in late summer, intensifies in winter, and ceases by late spring. The study of Kuroshio intrusion is not only from hydrographic measurements but also from satellite observations. Farris and Wimbush (1996) used satellite-derived sea surface temperature (SST) images together with wind data and found that the intrusion may be induced by the local wind stress. From previous studies, we found that the seasonal variation of the intrusion has been studied for a while, but the inter-annual variability does not understand well. Therefore, in this study we will concentrate on the relationship between the intrusion and the onset of El Niño event.

DATA AND DATA PROCESSING

The data we use in this study are the sea surface temperature (SST) data which were derived from Advanced Very High Resolution Radiometers (AVHRR) onboard the National Oceanic and Atmospheric Administration (NOAA) series satellites and were processed by the Jet Propulsion Laboratory (JPL) of National Aeronautics and Space Administration (NASA). The original resolution in space of an image is 4 km, however after Pathfinder processing, the spatial resolution is 9 km. A detail description of this data set and the data procession method can be found on the website of the Physical Oceanography Distributed Active Archive Center (PODAAC) of JPL/NASA.

The data we employed in this study are the Pathfinder Version 4.1 monthly data. The period is from 1993 to 2000. The area is covered from 17°N to 27°N and from 114°E to 124°E. Only the values of best pixels were used in this study. The missing values were interpolated by a weighted fill method.

In order to distinguish the event of normal, El Niño, or La Niña period, the Southern Oscillation Index (SOI) was employed as an indicator. According to SOI, the SST images were extracted from September 1997 to August 1998 as an El Niño period and from September 1998 to August 1999 as a La Niña period. Other periods are set to be normal periods. This definition has been applied to a previous study by Salamante and Villanoy (2000).

EOF ANALYSIS

To analyze the spatial and temporal variability of the intrusion, we performed a conventional Empirical Orthogonal Function (EOF) analysis. EOF method is a statistical technique used to resolve the variability of a multivariate data set to a number of mutually independent modes, each of which comprises a certain percentage of the total variance. The advantage of EOF analysis is that it provides a compact description of the spatial and temporal variability of data series in terms of orthogonal function (Emery and Thomson, 2001). Each EOF mode consists of a spatial pattern modulated by an associated time series. To realize the original data at a particular time, as expressed by an individual EOF, the EOF pattern must be multiplied by the corresponding value of its associated time series. For a given data set, EOF can be computed by using singular value decomposition (SVD) (Kelly, 1988).

KUROSHIO INTRUSION

Normal period

We applied the SVD method to the SST data. The data were removed the temporal mean before doing the EOF analysis. The normal period is suggested from September to August in the following years: 1993 to 1994, 1994 to 1995, 1995 to

1996, 1996 to 1997, and 1999 to 2000. The first mode of EOF decomposition of these data accounts for more than 90% of the total variance for each year. Therefore, only the spatial and temporal variability of the first mode of EOF will be discussed. Figures 1 and 2 show the first mode of EOF of years 1996 to 1997 and 1999 to 2000. The spatial and temporal variation patterns of normal years are similar. Therefore we only present 1996 to 1997 and 1999 to 2000 here as representatives. The top panel shows the amplitude of the variation as a time series, and the bottom panel shoes the spatial distribution. From the spatial distribution, one can see that the smaller variability (purple) represents the water mass of Kuroshio which occupied the area surrounding the northern Luzon. In this normal period, the Kuroshio intrusion through the Luzon Strait can be found as far as 119°E. From the time series of amplitude of variation, one can also found that the lowest SST of the study area is in February and the highest SST is in July or August. Ho et al. (2000) analyzed sea surface height (SSH) data derived from TOPEX/POSEIDON altimeter and found that SSH is high in the Luzon Strait from June to September. The concluded that the Kuroshio may intrude during that period.

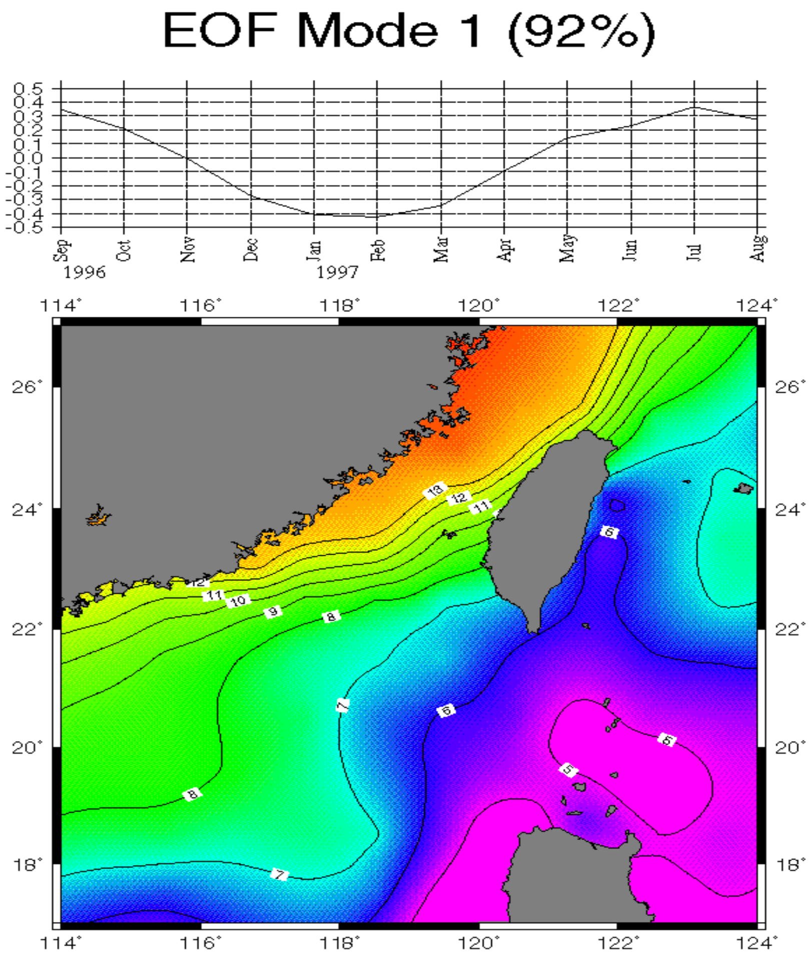

Figure 1. Amplitudes (top) and spatial structures (bottom) of the first EOF mode derived from SST for year 1996 to 1997.

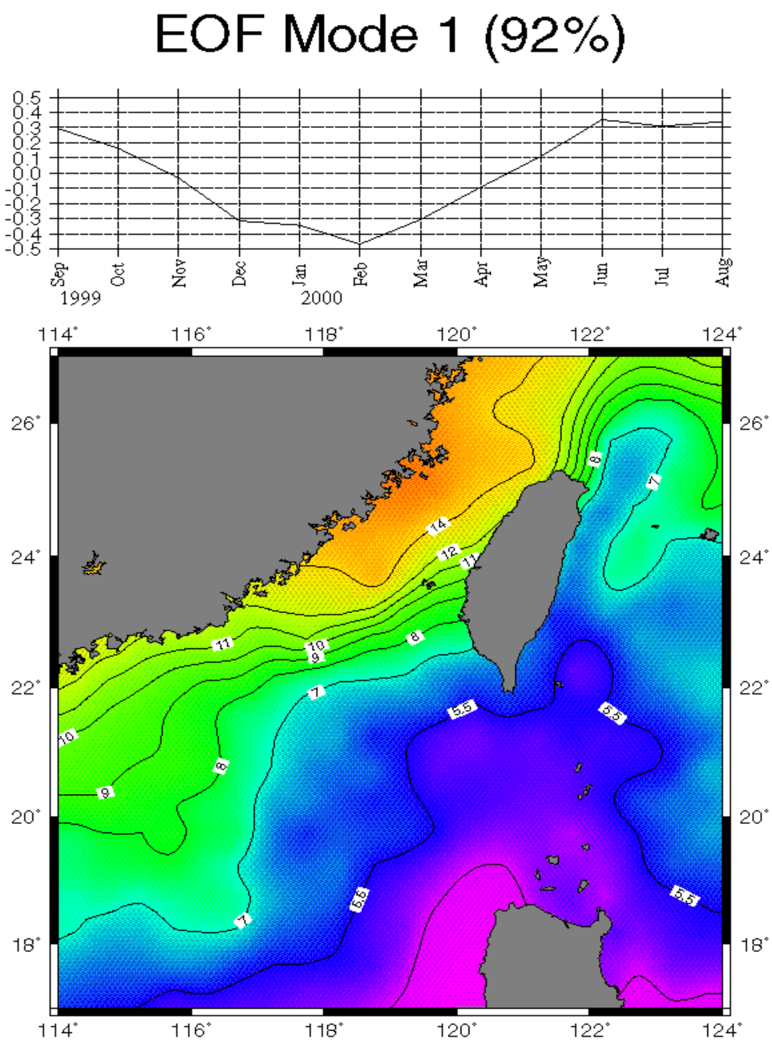

Figure 2. Same as Figure 1, but for year 1999 to 2000.

El Niño period

According to SOI, the El Niño period is defined from September 1997 to August 1998 in this study. Figure 3 shows the result of the first mode of EOF decomposition. It accounts for 90% of the total variance. From the spatial variation distribution, one can see that the Kuroshio intrusion is not obvious. It did not enter the Luzon Strait much because the water mass from the SCS occupied the whole SCS. The probable mechanism is that the southwesterly monsoon, which originates from the Indian Ocean and generates the westerly wind burst in the Western Pacific, is enhanced during the El Niño period. The time series of amplitude reveals a different phase to the normal year. In normal year, the lowest SST is in February and the highest SST is in July or August. However during the El Niño period, the lowest SST is in April and the highest SST is in September. It is about one to two months delay.

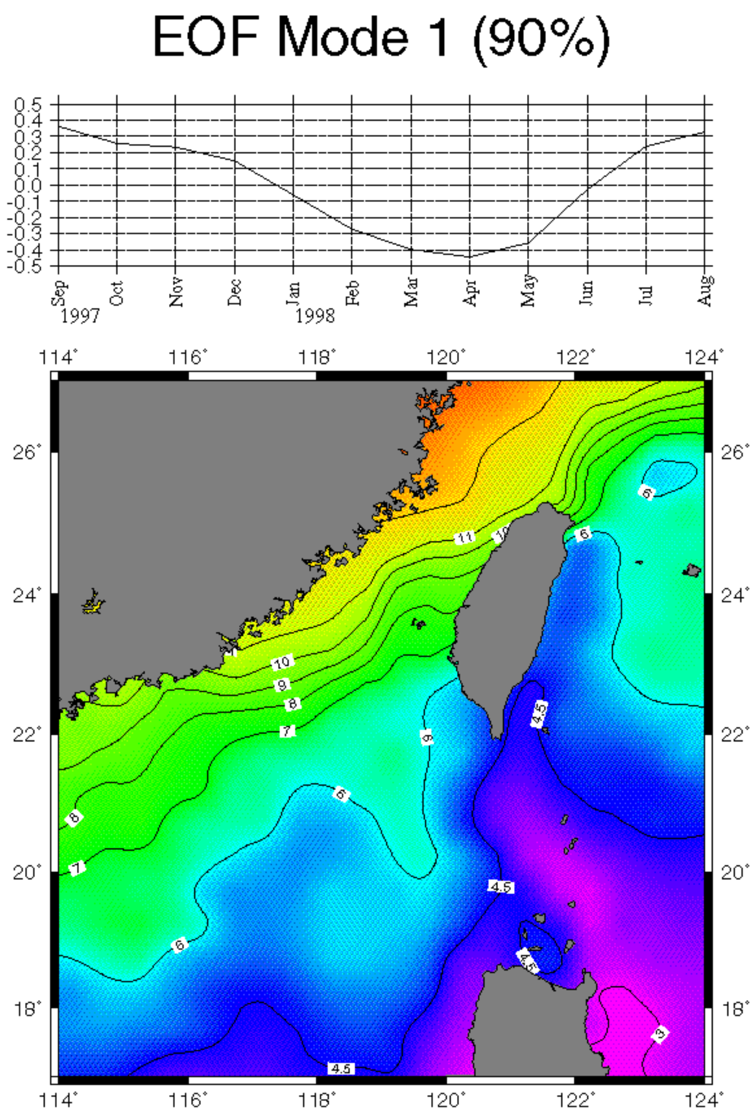

Figure 3. Same as Figure 1, but for year 1997 to 1998.

La Niña period

In this study, the La Niña period is from September 1998 to August 1999. The first mode of EOF accounts for 91% of the total variance. The spatial variation showed a different pattern to the El Niño period and a normal period. The Kuroshio intruded to the SCS through the Luzon Starit and reached as far as 118°E (Figure 4). As described by Farris and Wimbush (1996), the Kuroshio intrusion into the SCS is caused by the local wind stress directed to the south. The southeastern wind is enhanced during a La Niña period. Therefore, the intrusion into the SCS as seen in Figure 4 was probably caused by the southeastern wind. However, the amplitude revealed the lowest SST in March and April, and the highest SST in October. The month of lowest SST is similar to the El Niño period, but the highest SST is a month late comparison with the El Niño period and two months late with a normal year.

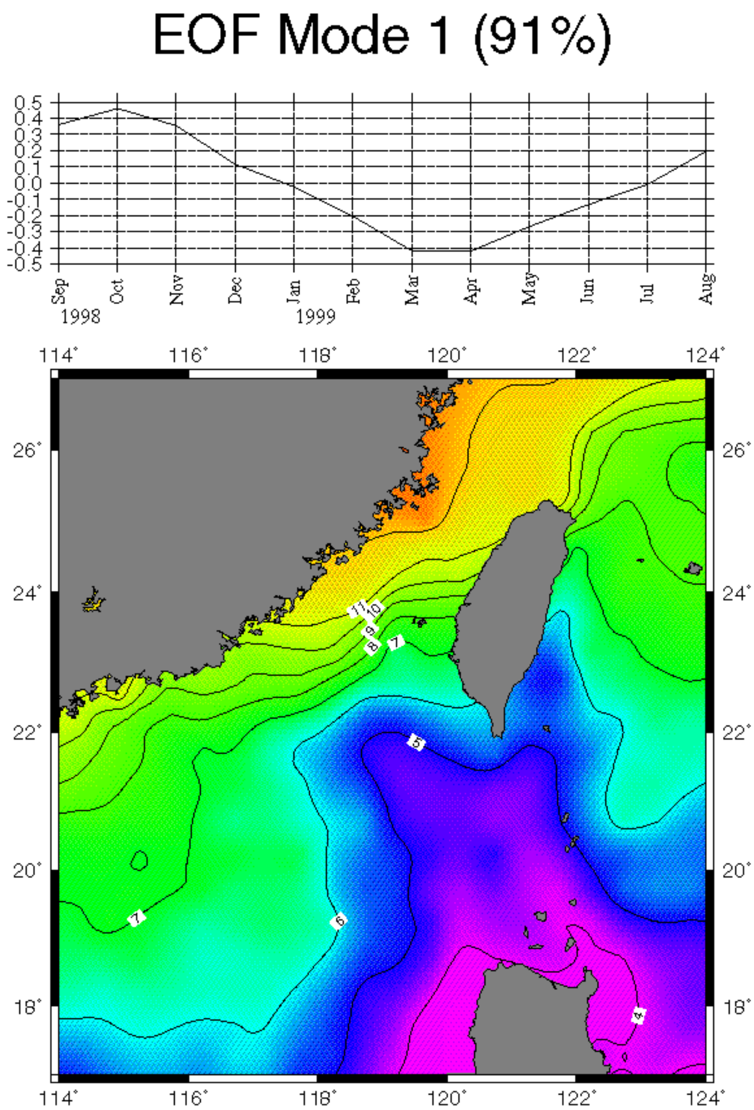

Figure 4. Same as Figure 1, but for year 1998 to 1999.

DISCUSSION AND CONCLUSIONS

In this paper, we have described the differences of the SST in normal, El Niño, and La Niña periods observed from satellite historical data from 1993 to 2000. EOF analysis revealed the Kuroshio partial intrusion into the SCS through the Luzon Strait in normal year. The intrusion could be reached as far as 119°E. During the El Niño period, the intrusion ceased because the water mass from the SCS entered the region. This may be caused by the westerly wind burst which occurs in El Niño period. In La Niña period, the intrusion was intensified. It could also be related to the wind stress. The southeasterly wind enhanced in La Niña period. The wind pushes the warm water in the western pacific warm pool to the west, and forces the Kuroshio intrusion into the SCS through the Luzon Strait.

The amplitudes of variation also show that the lowest and the highest months of SST are differences in normal, El Niño, and La Niña periods. In normal year, the lowest SST is in February and the highest SST is in July or August. In El Niño period, the lowest SST is in April and the highest SST is in September. In La Niña period, the lowest SST is in March and April and the highest SST is in October.

From this study, we may find that the Kuroshio intrusion into the SCS through the Luzon Strait is different among the normal, El Niño, and La Niña periods. This difference may be caused by the wind stress different during that period.

ACKNOWLEDGMENTS

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Networking Small Satellite Data for Marine Research

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ABSTRACT

This paper illustrates an application to network small satellite data and information for marine research using the Internet services and the world-wide-web technology. Database systems for small satellite data and ocean information have been designed and the client-server model has been used to communicate on the web pages between server and clients. This application has been developed and improved in sense of making its response more useful.

Keywords: Small satellite data, client-server model, World-wide-web, database management system.

INTRODUCTION

So far, compact disks have been the main way to transfer small satellite data and information on marine research. Such a way has some advantages when sending satellite images. But it takes time and does not response immediately, especially when a few of satellite data fields are needed.

In recent years, everybody can access Internet services cheaply and quickly, especially in transferring files. The Internet itself is no longer new, but it is one of the most important tools to communicate in the world. The Internet service works on the client-server model that enables to exchange information through web pages. These pages include text, picture and sound that can be linked to other pages. This achievement of the Internet can be applied to network ocean small satellite data and information or OSSDI.

Firstly, a database system must be designed to store data fields extracted from small satellite images. Then several web pages created to access and retrieve these fields through the client-server model and the Internet services. This is also a suggested way to share and to develop OSSDI.

SYSTEM ANALYSIS AND DESIGNS

OSSDI Client-Server Architecture

In general, the client program runs on a desktop of this computer and the server program on another machine, which could be on the other side of the world. Server programs must contain certain features that are laid out in Internet specifications. Sever program waits for client programs to ask for something. After receiving the client request and processing, sever program sends whatever was asked for or an error message. The world-wide-web uses the hypertext transfer protocol or HTTP to transfer information. HTTP enables clients, called browsers, to fetch pages from HTTP servers and to return data to the servers using Web browser.

Mainly, there are two architectures to develop the client-server model: client-side and server-side architecture. Each of them has some specific advantages in using. To design a model that is capable of developing and sharing OSSDI, a combination between the client-side and the server-side has been suggested and illustrated in Figure 1.

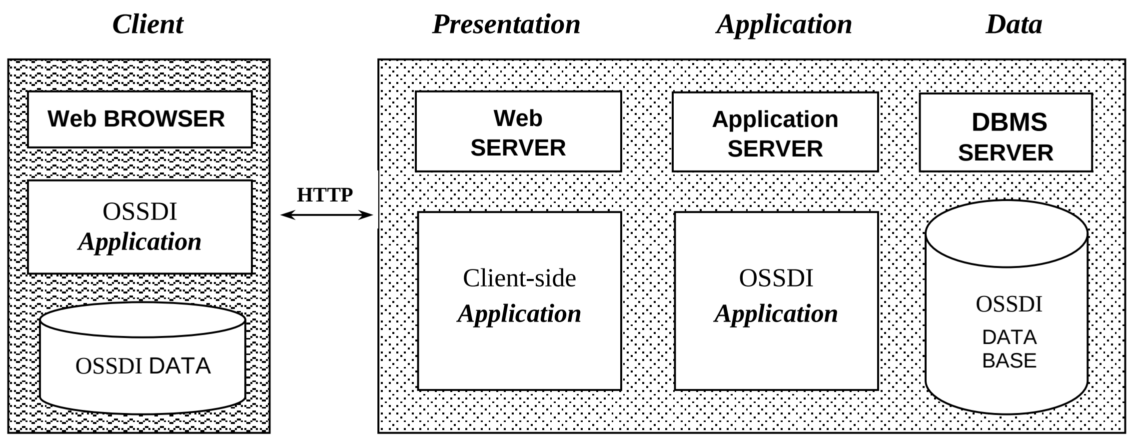

Figure 1. *Schema of OSSDI Architecture*

OSSDI Data Base Management System

OSSDI database firstly consists of data items that can be detected from small satellite images, relationships among data items, constrains and a schema describes the organization of data and relationship within the database.

Data items in an OSSDI database are extracted from satellite images using the technique of image processing, for example: temperature, sea surface temperature, vegetation, etc. They must verify the following features: independence, consistence, non-redundancy, security, persistence, validity and shared. These requirements firstly ensure the confidence of data in developing and sharing and then applications that access them are independent of how and where the data are stored.

This database provides a secure and survivable medium for the storage of shared persistent data. If data have a life beyond the boundaries of a program then database is appropriate place to maintain these persistent data. But the maintenance of persistent data alone does not imply the use or need for a database management system. Database management systems provide functions to query the database to find inter-related data items.

In networking small satellite data, OSSDI database can be represented in the relational model that is a strong environment for database design and database-user support. In such a database model, SQL – a structured query language that likes English language, can be used to access data in OSSDI database.

A great number of OSSDI databases from small satellite stations and Internet services combine to each other and establish an OSSDI distributed database system.

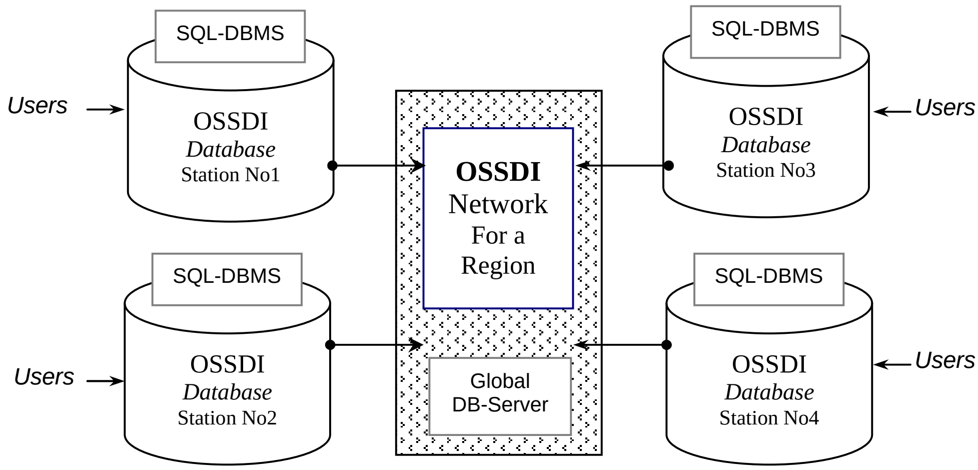

Figure 2. *OSSDI distributed database system.*

MS SQL Server manages OSSDI relational database on each small satellite station, as a local task. Through Internet services, all of these OSSDI databases can be networked. The databases that reside on the small satellite stations of the communications system are logically related by a unifying global database schema based on a unified singular OSSDI database model. The database distribution is transparent to the users of the OSSDI database at any station.

Networking OSSDI databases results an OSSDI distributed database system with several advantages:

- OSSDI can be stored at the location where it is most frequently used, hence reduce cost of communication by locating where it is most needed.
- Through distribution of the workload over several small satellite stations can improve data performance due to true parallelism be achieved. Such a system can also be upgraded easily when its current configuration exceeds its capacity or performance requirements.
- If the distributed system is networked appropriately, greater reliability and higher data availability are possible. Integration of OSSDI in marine research, and increased ability

to share OSSDI and processing enhance computing-applications support can be realized.

Evidently there some disadvantages when using such distributed databases for instance security may be even harder, system control be more complex, database management be more difficult, etc.

OSSDI Client-Server Interface

To communicate between clients or small satellite station and server, a schema has been suggested in figure 3, called OSSDI client-server interface or CSI. Some communication features of CSI have been designed, briefly as follows

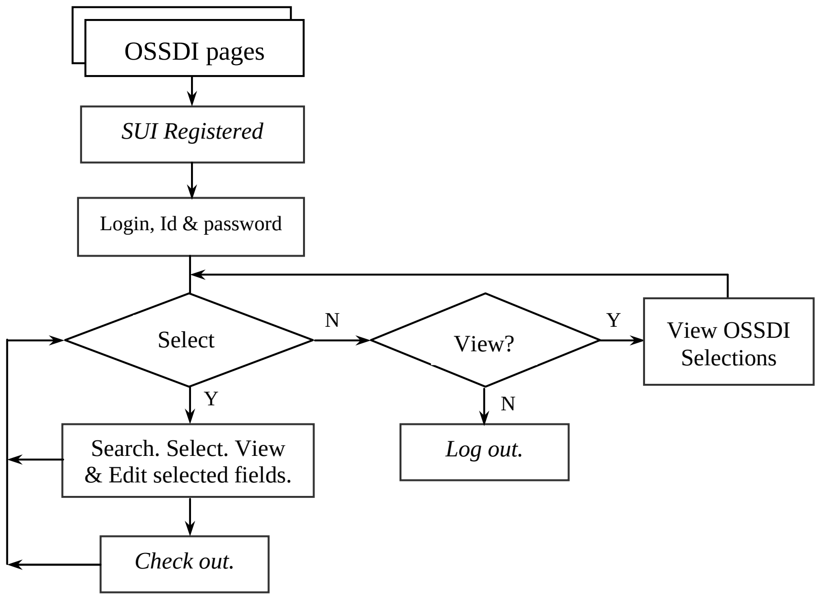

Figure 3. *OSSDI Client-Server Interface Flow Chart*

◆ Allow users to register and to logon into CSI to search and download OSSDI of some specific data fields, marine research document, update-path, etc. and use this application from any web browse supporting hypertext makeup language or HTML.

◆ Server can be able to view transactions of the users and can keep track all users' activities in CSI such as: information they query, download things, how many time they enter CSI, etc

◆ Notify server through e-mail when user needs a person to process such as: create new member, record of transactions carried out by users, questions, feedback, etc

◆ Notify users when their request is processed and downloaded.

CASE - STUDY

This case study develops an application for networking small satellite data for marine research. The user can view, search for, choose, and download data items available of the application. From the first page of the application (Figure 4.) users can login or new-register.

Figure 4. *Login page.*

To login, the user enters User ID and Password text boxes, and clicks on the Login button. If it is succeeds, then the user is taken to the main page of application. For the new user, click Register here link to be taken to next page (Figure 5). This page registers you with the application. You need to fill in the edit-boxes your name, user Id, agency, phone number, e-mail address, password and click on the Register here button

Figure 5. *Register page.*

If the registration is successful, then you are taken to main page of the application, else an error page is return. Figure 6 is the main page of the application, which allows user to view all the data items available in OSSDI. Also, they are able to search for data items using different search criteria. For example, data items date on any date or sea surface temperature images, etc.

Figure 6. *Main page*

When the user clicks on the SAT. IMAGES button, page list all available satellite images to be return (Figure 7). From the list, user can preview or add the image to their needed set of items by clicking on the View/Add button.

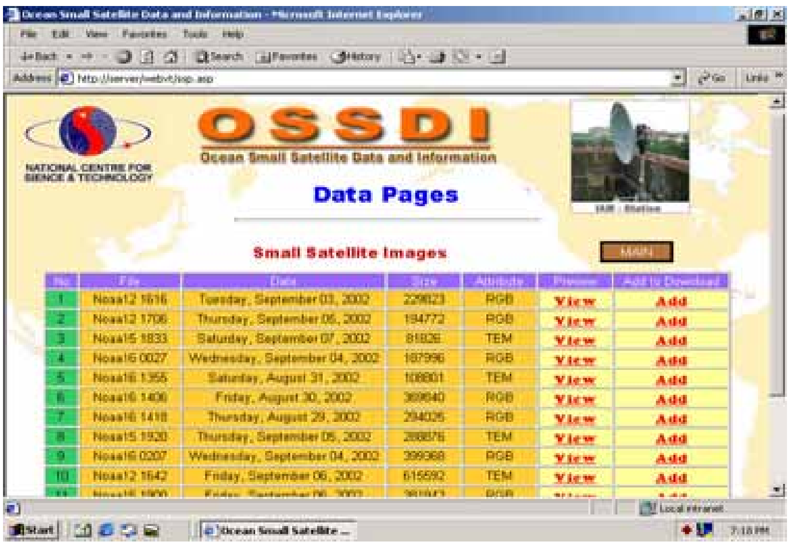

Figure 7. *List-view data page.*

User clicks on the MAIN button to download and return main page of the application.

Now, the selected data items are list on the sheet of the OSSDI-Selections of this page. From here the user can change their selection by click on the Delete check boxes. Clicking on the DELETE button results in the checked data items are deleted from the sheet. The user can confirm their selection to be ready for downloading by clicking on the CONFIRM button.

Figure 8. *The page displays selected items and allow users to change their selection*

Figure 9. *The selected data items can be downloaded*

Figure 9 is the page to be return when the user clicks on the VIEW STATUS button. User can download their selected data item if Status-field is “Download”, else their downloading is disabled. Clicking on the LOGOUT, the application returns to a page in Figure 10.

Figure 10. *The page is returned when logging-out.*

REMARKS

a. A model based on the client-server interface and distributed database system for setting up and networking small satellite image data has been implemented and suggested

b. A web-page application, named OSSDI, has been developed and improved for collecting and sharing data extracted from small satellite data between stations.

c. More case studies need to be done for testing suggested data model and OSSDI.

d. A computer program needs to be implemented and developed to extract ocean data fields from small satellite data.

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Track of Ocean Surface Currents from Satellite Ocean Color Images

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ABSTRACT

We performed a feature tracking method on computing velocities of ocean surface currents from satellite ocean color data. These data are from different sensors on different satellites - the Sea-viewing Wide Field-of-View Scanner (SeaWiFS) and the Ocean Color Imager (OCI). Two sets of ocean color data taken in 1999 from SeaWiFS and OCI were used for this propose. An objective feature tracking method, the Maximum Similarity in Shape-Matching (MSSM) is applied in this study. Two shape-specific points, the centroid and radius weighted mean, would be used to find the best correspondence of the feature between two sequential images. Because of the high percentage of cloudiness around Chinese Taipei especially during the wintertime, more consecutive images from these two types of satellite are helpful to get a longer variation of the sea surface pattern movement. The patterns we chose with high chlorophyll concentration include upwelling and sea surface front. The computation results show their velocities, which would be valuable to comparable with in situ investigation.

Keywords: OCI, SeaWiFS, Feature Tracking, Remote Sensing, Ocean Color

INTRODUCTION

After the launch of the first orbiting satellite in the early 1960s, it became clear that ocean color could be viewed from space in cloud free conditions. From the scientific perspective, acquisition of ocean color data from space in the 1990s is a high priority that has been recognized in reports of the National Research Council of the National Academy of Science (Hooker et al., 1992). It is known that satellite ocean color observations provide a crucial insight to the marine biosphere because of their capability to quantify certain fundamental properties on a global basis. The success of the Coastal Zone Color Scanner (CZCS, 1978-1986) in measuring the ocean color in the world's oceans has led to several proposals for follow-on systems. ROCSAT-1, the first experimental satellite of Chinese Taipei, was successful launch on the 27th January 1999. The satellite is designed to carry out three scientific experiments: ocean color imaging, ionospheric plasma and electrodynamics, and Ka-band communication. The payload instrument for ocean color imaging on ROCSAT-1 is called Ocean Color Imager (OCI). From the remote sensing point of view, we mean that ocean color is the relative amounts of water-leaving radiance in various portions of the visible spectrum. Measurements of water-leaving radiance allow concentrations of chlorophyll *a* to be derived. OCI is a nadir-viewing push-broom imager, which is designed to map reflected spectral radiances from ocean surfaces in six visible and near infrared bands. The six spectral bands are identical to the six of the eight spectral bands of Sea-viewing Wide Field-of-view Sensor (SeaWiFS). The band characteristic comparison of OCI and SeaWiFS is listed in Table 1.

Table 1. *A Comparison of characteristics between SeaWiFS and OCI.*

	SeaWiFS	OCI
Inclination	98.25°	35°
Altitude (km)	705	600
Period (min)	98.9	96.6
Orbital repeat time (days)	16	52
Spectral bands (nm)	B1 402-422 B2 433-453 B3 480-500 B4 500-520 B5 545-565 B6 660-680 B7 745-785 B8 845-885	B1 433-453 B2 480-500 B3 500-520 B4 545-565 B5 660-680 B6 845-885 B7 545-565
Nadir pixel (m^2)	1130 x 1130	800 x 800
Swath width (km)	2801	702
Redundancy	No	555 nm
Color sensing	Scanner	Push broom
Crossing equator time (local time)	12:00	9:00 ~ 15:00
Bits	10	12
Tilt	-20°, 0°, 20°	No
Launch date (year/month)	1997/8	1999/1

SeaWiFS was launched in August 1997. The similarity of two sensors provides a very good opportunity to perform multi-sensor studies. In this paper we will demonstrate how the data of OCI and SeaWiFS can be used together for estimating velocities of surface currents in the Luzon Strait.

DESCRIPTION OF OCI

The Orbit

Most of operational remote sensing satellites are placed on a sun-synchronous orbit to cover the entire earth, but the ROCSAT-1 is on a 35° inclination orbit. The selection of the orbit was based on the need of maximum contact time with the ground station in Chinese Taipei. Since the ROCSAT-1 does not broadcast data in L band, it transmits science data through its Telemetry, Tracking, and Command (TT&C) channel on S band. It means that only the selected sites can the data be downloaded, and that the data volume is severely limited. The situation is exasperated by the fact that only to one ground station in Chinese Taipei can the data be dumped. Therefore, in order to download the data as many as it can, the contact time with the ground station has to be as much as it can. Its orbital period is about 96.6 minutes. The constantly precession orbit is about -6 degrees/day and the satellite ground track repeat period is 52 days.

The OCI Instrument

OCI focal planes are of Thomson’s 1728-element linear Couple Charge Device (CCD) sensors. This kind of sensor is designed to have a distinctive anti-blooming feature. With a nominal telescope focal length of 19.5 mm and a photosite pitch of 13 μm square, an instantaneous field of view (IFOV) covers 2 CCD pixels. Therefore an 800 by 800 square meter footprint on the ground is formed by the push-broom action. The swath of OCI is about 700 km. A detail description of OCI characteristics can be found in Lin et al. (1999).

Comparison with SeaWiFS Data

A way to validate OCI data products is the intercomparison with other spaceborne ocean color sensors. The difficulties of this method, however, are spectral matching, ground spatial resolution, and sun-sensor geometry (Che, 1991). Unlike SeaWiFS on Obrview-2, it takes image near local noon. ROCSAT-1 is not on a sun-synchronous orbit. The 35° inclination orbit, however, enables us to find the certain areas that are simultaneously imaged by SeaWiFS. This work has been done by Ho et al. (2001). They concluded that OCI has the same quality as SeaWiFS. Therefore, we can combine these different sensors together to study ocean phenomena.

SURFACE CURRENT TRACKING

Methodology

In this study, an objective shape-matching method, the Maximum Similarity in Shape-Matching (MSSM) method, is used to compute the velocity for any clear feature in two consecutive images (Kuo and Yan, 1994). The basic idea of the MSSM method is described briefly as follows:

Given a certain shape *S* in the first image which includes a discrete set of point $\{(x_i, y_i), i=1,2,3,n\}$, then the coordinates the centroid $A(x_A, y_A)$ are defined as:

$$x_A = \sum_{i=1}^{n} \frac{x_i}{n}, \quad \text{and} \quad y_A = \sum_{ii=1}^{n} \frac{x_i}{n},$$

and the coordinates of the radius weighted mean B (x_B, y_B) are defined as:

$$x_B = \sum_{i=1}^{n} \frac{r_i x_i}{R}, \quad \text{and} \quad y_B = \sum_{i=1}^{n} \frac{r_i y_i}{R},$$

where r_i is the distance from point (x_i, y_i) on the shape S to the centroid A (x_A, y_A), and R is the summation of r_i, that is $R = \sum_{i=1}^{n} r_i$. Using the same idea, the coordinate values of the centroid $A'(x_{A,} y_A)$ and radius weighted mean $B'(x_{B,} y_B)$ for a certain pattern S' in the second image can also be determined. These two shape-specific points correspond to each other from the first image to the second image. That is, the centroid *A* corresponds to the centroid *A'* and the radius weighted mean *B* to *B'* with the same transformation functions of all the other point's corresponding from *S* to *S'*; for the case that *S'* in the second image is the right correspondence for *S* in the first image.

Considering the feature movement with scaling first (with parameter α), then rotation (about the coordinate origin with an angle θ), and finally translation (with the x, y displacements Δx and Δy). The relations *A* and *A'* are

$$x_A = (\alpha x_A)\cos\theta + (\alpha y_A)\sin\theta + \Delta x, \tag{1}$$

and

$$y_{A'} = -(\alpha x_A)\sin\theta + (\alpha y_A)\cos\theta + \Delta y. \tag{2}$$

Similarly between *B* and *B'* are

$$x_{B'} = (\alpha x_B)\cos\theta + (\alpha y_B)\sin\theta + \Delta x, \tag{3}$$

and

$$y_{B'} = -(\alpha x_B)\sin\theta + (\alpha y_B)\cos\theta + \Delta y. \tag{4}$$

Eqs. (1) to (4) form an equation set with four unknown variables: α, θ, Δx, and Δy. After solving that, the transformation relation for every point from the pattern *S* to *S"* in the second image can be obtained.

In order to get a good correspondence of *S*, a similarity comparison between *S'* and *S"* is necessary. A better choice of *S'*, called S'_{max}, in the search area of the second image would have the maximum similarity with the computed correspondence of *S"* to *S*. The similarity is defined as the ratio between N_C and *N*, where N_C is the count of the points in *S"* such that each pixel value is the same as at least one pixel value in the 3 by 3 neighborhood of the same coordinate point in *S'*, and *N* is the total number of the points in pattern *S'*. The angular velocity of the feature *S* can be determined by the orientation change from *S* to S'_{max}. The orientation of a given feature defined here is the unique line, which connects the centroid, and radius weighted mean of the feature (Figure 1).

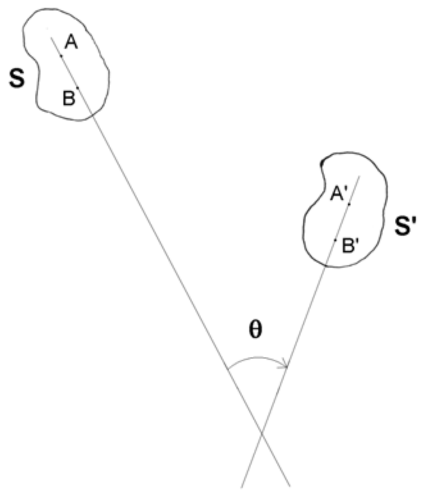

Figure 1: *The orientation of a given feature, S, defined by two shape-specific points, centroid, A, and radius-weighted mean, B. The angular velocity of the feature S can be determined by the orientation change from S to S'max.*

Surface Current measurements

Chlorophyll-a concentration images provided by ROCSAT-1/OCI and by OrbView-2/SeaWiFS are used to derive velocity of the sea surface pattern. The OCI data (Fig. 2) were processed by the OCI SDDC (Science Data Distribution Center). The SeaWiFS data were received and processed from the local HRPT receiving station. The above SDDC and HRPT station are all located at Department of Oceanography, National Taiwan Ocean University. Two sets of ocean color data taken in 1999 from SeaWiFS and OCI were used in this study. The details of the sequential images selected for the application of the MSSM method are summarized in Table 2.

Table 2. Sequential images and related attributed

	Sensor	Date	Time interval	velocity (cm/sec)
Set 1	SeaWiFS	3/25/99 04:23:55		
	OCI	3/26/99 02:05:00	21:41:05	37.7
	SeaWiFS	3/27/99 04:13:52	26:08:52	53.5
Set 2	OCI	4/16/99 00:23:59		
	SeaWiFS	4/16/99 04:14/52	03:50:53	upper one: 91.0
				lower one: 53.1

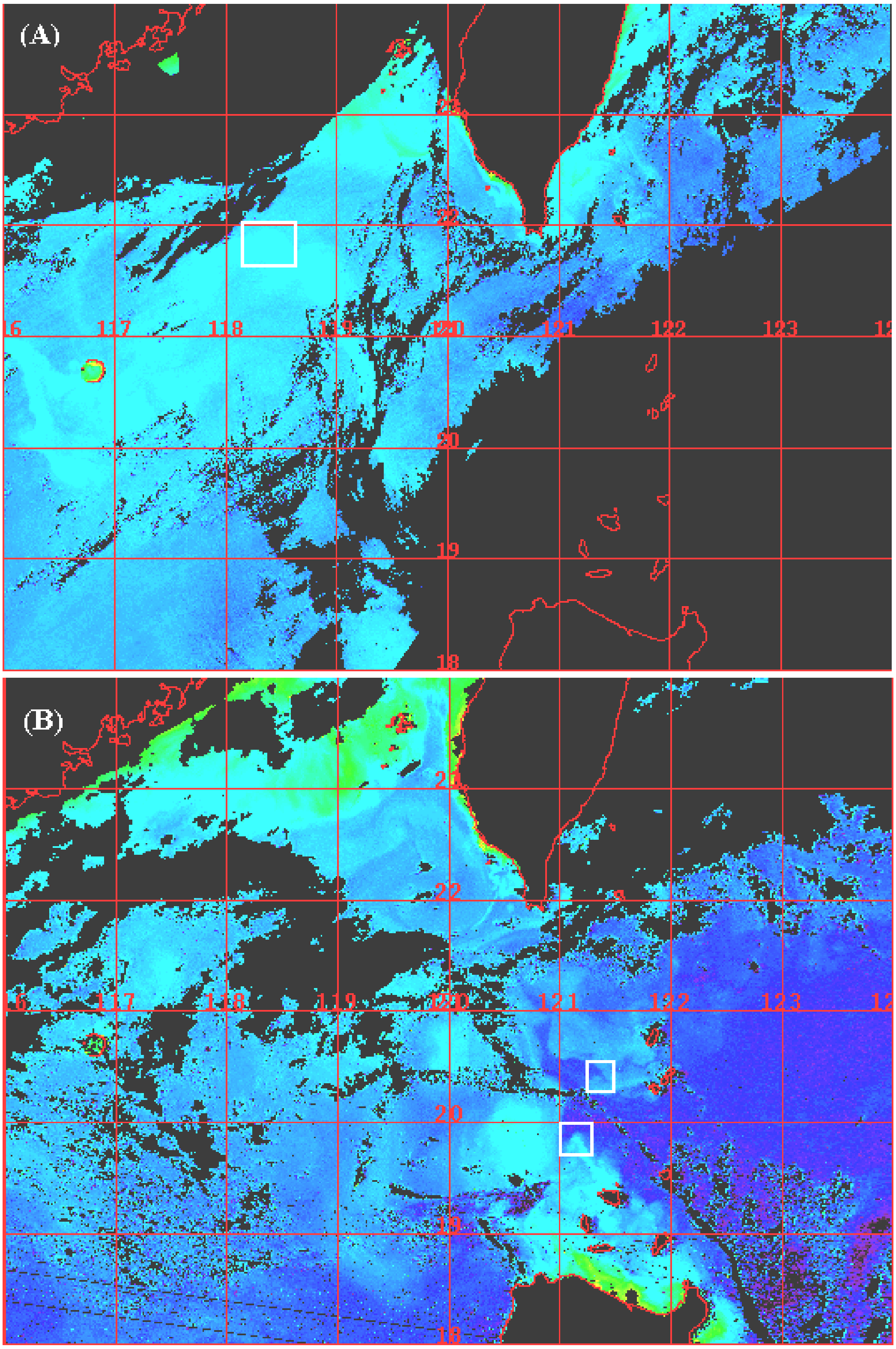

Figure 2: *(a) OCI-derived Chl-a image at March 26, 1999. (b) SeaWiFS-derived Chl-a image at*

April 16, 1999. The areas with white box are the patterns we considered.

There are three images in the first set, two SeaWiFS images taken on March 25 and 27 and one OCI image taken on March 26 (Fig. 2). All of them are located at the northern South China Sea (SCS). A clear feature near the Tong-Sa Island in the northern SCS was seen in these images. This feature represents high chlorophyll concentration, which is an upwelling caused by the interaction of ocean circulation and topography in the SCS. Using pattern recognition and feature tracking methods, one can identify the feature and calculate the movement of the feature. The movement of the feature has a northwestward direction with a speed of 38 cm/s from March 25 to 26 and a westward direction with a speed of 54 cm/s from March 26 to 27. These values are similar to that of previous studies by other investigators. There are one SeaWiFS and one OCI image in the second set. Both were taken on April 16, 1999 near the Luzon Strait. Two visible features were found in the Luzon Strait. One is in the upper area of Luzon Strait and the other is in the lower area of Luzon Strait. The movement of upper one has a northwestward speed of 91 cm/s and the lower one has a northward speed 54 cm/s. We believe that these features are somehow related to the Kuroshio branch, which enters the northern SCS through the Luzon Strait in spring.

SUMMARY

Historically, ocean surface feature tracking has been based on satellite data from a single orbital sensor collected over the revisit interval (e.g., Emery et al., 1986; Emery et al., 1992). In this study, the measurement of the sea surface patterns can be derived using data from more than one sensor on different satellites. The spectral band characteristics between the OCI and SeaWiFS are almost the same, more image pairs from these two sensors are therefore be used to detect the pattern movement during a shorter time interval. Furthermore, because of the high percentage of cloudiness around Chinese Taipei especially during the wintertime, it is difficult to get sufficient amount of clear visible and infrared images from single sensor. More than one type satellite image are necessary to get a longer variation of the sea surface pattern movement.

ACKNOWLEDGMENTS

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Study of Flood Extent with Remote Sensing

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ABSTRACT

Flooding happens mostly over the coastal region or low-lying land. It threatens the life of inhabitants, in addition to their property losses. Usually, the boundary of flooded region is determined with on site investigation, which is very difficult during flooding and even endangers the safety of field investigators. For a case of major flooding, on site investigation may take too many human and material resources before timely completion. Therefore, satellite remote sensing is a potential alternative for a fast and large-scale survey of flood region.

This study of delimiting the flood extent is through analyzing satellite images that were taken at different dates. For the case of flooding at Gangshan area after the typhoon Doug, we compared the satellite analysis against on site investigation and found that the extent of flooding matches each other. This result proves that satellite remote sensing is a viable method for quickly delimiting the extent of flooding.

Keywords: flood, remote sensing, typhoon Doug, multi-temporal image, image fusion

INTRODUCTION

Located in the subtropics, Chinese Taipei's climate is like many other tropical islands', humid and rainy, hit by typhoons several times annually. Although the rain of winter monsoon rain is mild through the winter, the rain from typhoon is heavy, comes in bursts, and often causes flooding that endangers the human life and their properties.

Preventive measure depends on accurate forecast of the location and rainfall rate, complete flood warning and monitoring system, and a functional flood simulation model. The timely information on the flood extent is essential for an effective operation on rescue and on the mitigation of flood damage. The same information is needed for claiming property loss to the insurance company and the government, especially for the loss of agricultural crops. The satellite or airborne images will greatly reduce the possibility of dispute on the amount of compensation.

The greater Gangshan region covers eight towns north of Kaohsiung. It is a flat plane with freeway passing the middle (Fig. 1 & 2). Typhoon Doug passed Chinese Taipei during 1994 August 7 & 8. Gangshan area was hard hit with continuous shower for 3 days. The worst flood is of 5 meters depth in Jiashing district. The freeway was closed during the flood. The cause of this flood includes the duration, location and the strength of the rainfall, the topography, geology, and structures on the ground.

To study this flood event, we have analyzed images from SPOT () and ERS (Earth Resource Satellite) SAR (Synthetic Aperture Radar) images. For the study of flood extent, we use mostly the SAR images, because the weather is usually very cloudy during flooding and satellite images of visible channels are mostly cloud images. Laura et al. (1995) used the airborne SIR-C SAR images of C & L bands, and of both polarizations to analyze and classify the flood in the Amazon region. Multi-Channel SAR images permit quantification of flood extent, the airborne SAR has the advantage of real time survey on request.

Pwivedi et al. (1999) used ERS-1 SAR images and Indian satellite IRS-1B visible images, and Landsat MSS & TM images, and Cowordin's method on wetland classification; Rao et al. (1999) successfully analyzed ERS-1 SAR and Landsat MSS data (i.e. merging microwave and visible images) to map coastal wetland; Wisetphanichkij et al. (1999) used JERS-1 SAR and OPS (optical sensor) images and data fusion technique to improve the reliability in determining the flood extent. Here, we select ERS-1 SAR and SPOT images and data fusion technique to define the extent of Gangshan flood. It is a feasibility study on such remote sensing technique.

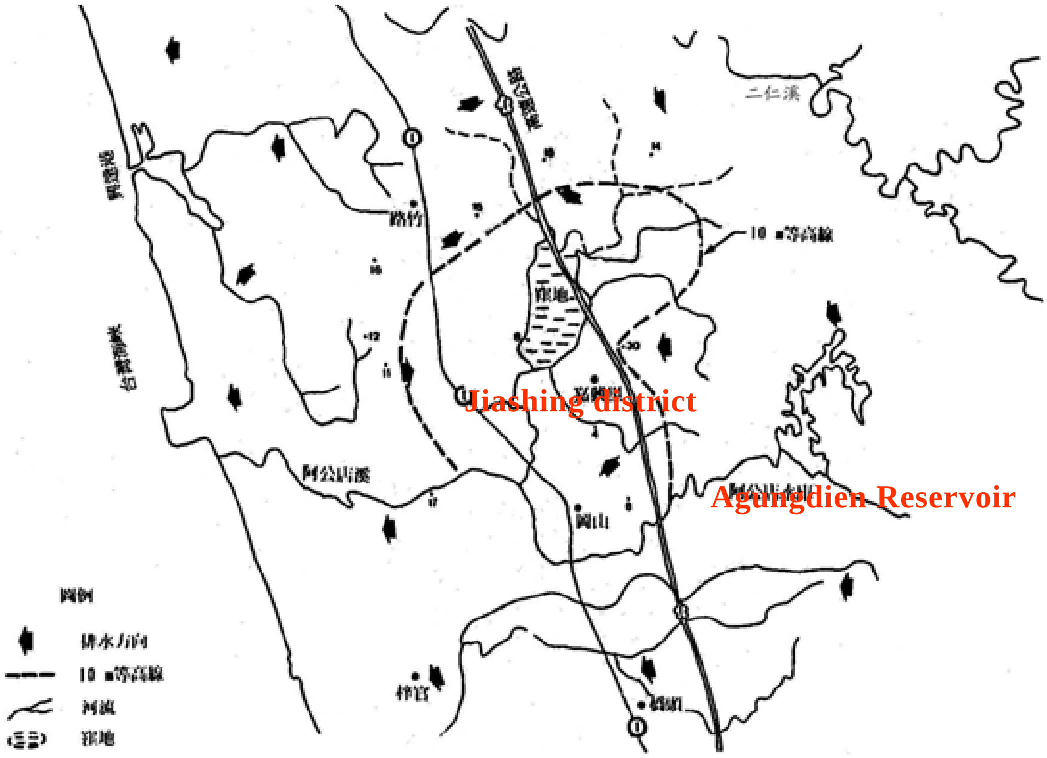

Figure 1. *The hydrology and drainage system of Gangshan region.*

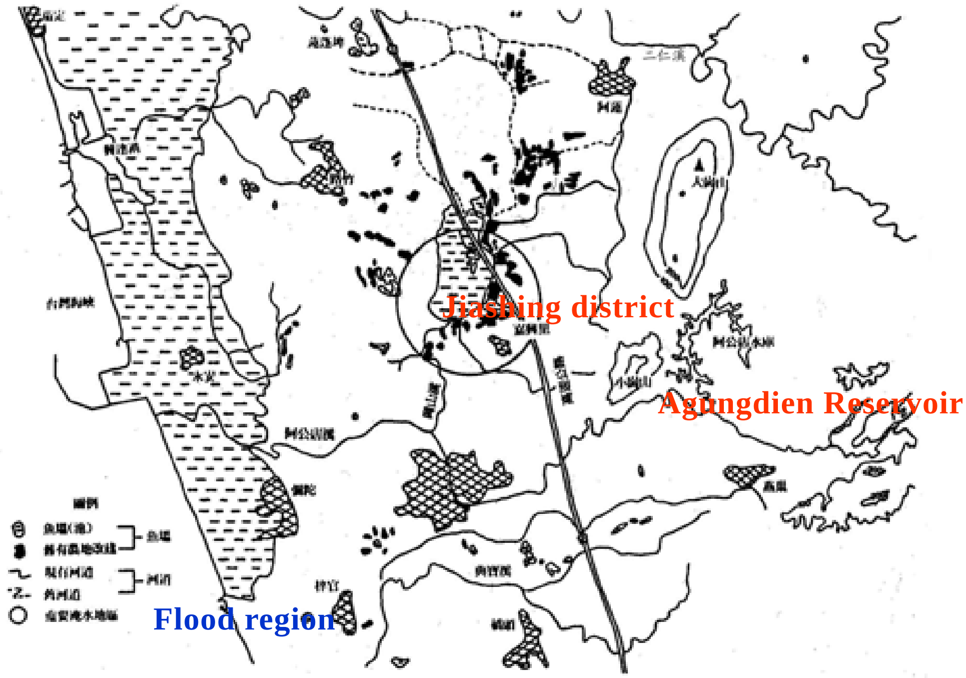

Figure 2: *The change of land use in Gangshan region.*

METHOD OF ANALYSIS

There are many methods to delimit the flood extent with remote sensing method. Because the weather is mostly cloudy during the flood, one can seldom obtain a cloud free satellite image for analysis. The microwave Synthetic Aperture Radar (SAR) images are often selected for its all-weather (non-interfered by cloud or rain), day-and-night property. Since SAR image has clear delimitation at the land-water boundary, it therefore is a good for mapping the flood extent.

In Chinese Taipei, flood is often associated with severe weather, like typhoon. Arial photograph of the flood is prohibited at this time, therefore the only available remote sensing data is from the satellite that is hundreds kilometer above the typhoon. The satellite SAR may provide near real time images of the earth surface for government officials to allocate the manpower and resources in mitigating the damages of typhoon flood, in re-build the community, and in future planning of the drainage system.

Profeti & Macintosh (1997) used ERS-1 SAR images, Landsat TM (Thematic Mapper) images, and archived land-use airborne photos to monitor the flood of Arno River in the central north Italy, from mid-October to early November of 1992. The mean difference of flood extent between the on site survey and remote sensing technique is about 32 m. Oberstadler & Huth (1997) used ERS-1 SAR images to estimate the flood height and flood lines of Rhine Valley from late December 1993 to early January 1994. Their results on flood lines matches well with ground data, and their estimate of water level has error of 46 cm ~ 109 cm. Paterson & Pultz used Radarsat-1 SAR images of 1996 March 23, April 25, and May 9 to monitor the Red River flood from late April to mid May. Saper & Nazarenko also used Radarsat-1 SAR images of 1997 Jan. 6 & 7to monitor California river flood on Jan. 4. Chinese Academy of Science used Radarsat-1 SAR images of 1998 July 26 & Aug. 1, and pre-flood Landsar-5 TM images to monitor the Yangtze River flood near Wuhan. National Central University also studied the flood near Wuhan using ERS SAR and SPOT images. There was no similar study of flood extent in Chinese Taipei.

There are two methods in analyzing SAR images for estimating flood extent. First, utilizes the characteristics of polarization of SAR images, e.g. HH polarization is effective in distinguishing flood or flooded vegetation (Hess et al., 1995). Second, compares the difference between pre-flood image and image of flood and enhance the differences to find flood extent (Rao et al., 1999; Dwivedi et al., 1999). The procedure for joint analysis of SAR and visible images of a flood is in Fig. 3.

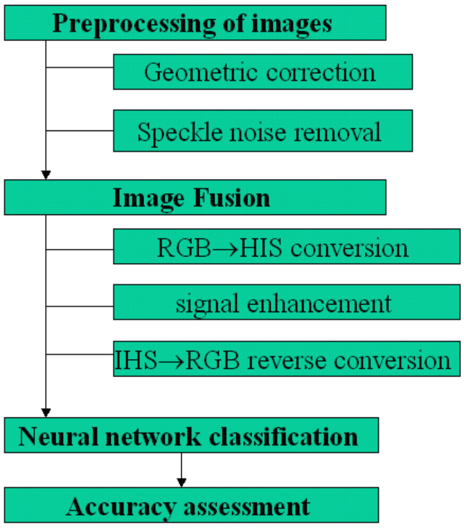

Figure 3. *Flow chart of fusion of radar and visible images in determining flood extent.*

Preprocessing of images

Geometric correction and speckle removal are helpful in locating the flood.

(a) Geometric correction

The motion plane of polar orbiting satellites is about 98.2^{o} counter clockwise from the equatorial plane. The rotation of the Earth, the change of satellite attitude, height, yaw, pitch and roll, all results distortion of satellite images. That is the scale, orientation and aspect ratio of satellite images do not match those of maps and aerial photos.

To match the satellite images with geographic maps, the satellite images must be corrected to the geographic coordinates. The popular methods are (1) analytic method that corrects the satellite images with its orbital parameters and attitude data (like pitch, roll, yaw, etc.); (2) rubber sheet stretching method that stretches the image to known ground control points (GCP).

The rubber sheet stretching method may adopt either local approach or the global approach that uses polynomial and least square fit to account for the translation , rotation, skew and scale errors. The pixel values of resulted image on a geographic coordinates are weighted average of neighboring pixels in the original image. The large change of topography further complicates the correction procedure. The GCPs are preferably easy to identify on the map and are evenly distributed.

(b) Speckle noise removal

Most SAR images contain lots of speckles. Speckles may be suppressed by averaging over images of multi-looks. The cost is the degradation of spatial resolution. More sophisticated methods like wavelet decomposition, mean, median, Lee & Lee-sigma methods have different advantage and disadvantage. They all trade the spatial resolution for less speckles.

Image Fusion

Image fusion is a method to represent different type of images with the same gray scale before merging. In this study, it contains three steps: conversion from RGB to HIS, signal enhancement, and reverse conversion from HIS to RGB.

(a)RGB→HIS conversion

this process converts visible image from RGB (Red、Green、Blue) color space into IHS (Intensity- Hue- Saturation) domain to assist analysis of flood. The conversion formula is:

$$I = \frac{R+G+B}{3}$$

$$S = 1 - \frac{3}{R+G+B}\left[\min(R,G,B)\right] \qquad (1)$$

$$H = \cos^{-1}\left\{\frac{\frac{1}{2}\left[(R-G)+(R-B)\right]}{(R-G)^2+(R-B)(G-B)^2}\right\}$$

where function min means minimal value.

(b) signal enhancement

take the difference of two SAR images before (g_1) and after (g_2) the flood to get the difference image and then merge the difference image into the optical image..

$$I' = I + |g_1 - g_2| \qquad (2)$$

I' is the enhanced optical image that contains the original optical image I and the difference of SAR images $|g_1 - g_2|$. The flood-induced change in SAR images will be enhanced in the optical image I'.

(c) IHS→RGB reverse conversion

Overlay I' , H , S images and reverse conversion to RGB color space for further analysis and accuracy assessment.

Neural network classification

The goal of classification is to differentiate the flood and dry region and compute the area of flood. The multi-layer perception (MLP) neural network basically uses Back Propagation (BP) method as classification tool. This model contains several layers and nodes, with neighboring layers connected with a weighting function. For a 3-layer case like Fig. 4 (Wisetphanichkij et al., 1999), the input vector is basic information, the center is a hidden black box, and the output vector is the optimized information. The output vector shows the classification for differentiating the flood and dry region

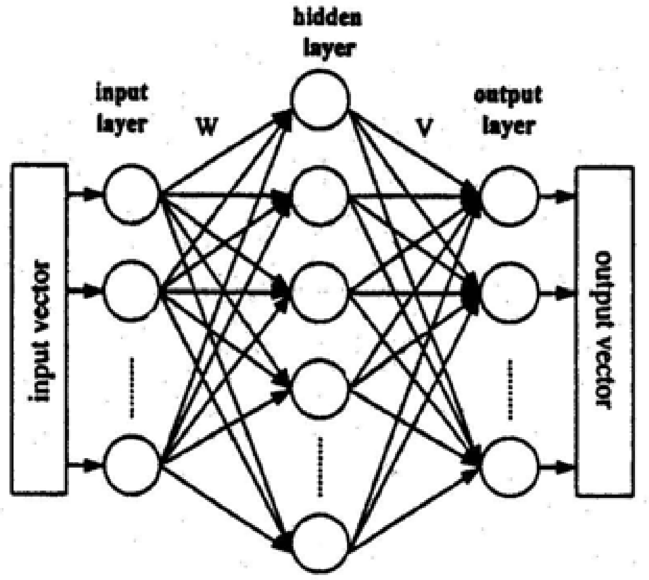

Fig. 4. *Three-layer structure of neural network classification*

The input and output vectors are

Input : $\chi_i = \Sigma_j (W_{ij} O_j + b_j)$ (3)

Output : $O_i = f(\chi_i)$ (4)

where W_{ij} are weighting function, W,V represent weighting functions for different layers O_j is input signal, and b_j is the bias, f is activation function which is a non-linear Sigmoid function

$$f(\chi_i) = \frac{1}{1 + e^{-\chi_i}} \quad (5)$$

In this multiple process, the summed squared error (SSE) from the true value is:

$$SSE = \frac{1}{2}\sum_P \sum_i \left(O_{pi} - t_{pi}\right)^2 \quad (6)$$

It means that any input vector Pj at any node I results an expected value O_{pi} that differs from true value t_{pi}, SSE is an indicator of the quality of the analysis.

Accuracy assessment

In addition to the SEE indicator on the quality of analysis, there are other assessment indicator on the satisfaction of the classification analysis (Congalton, 1991), like Producer's Accuracy (PA), User's Accuracy (UA), Overall Accuracy (OA), Average Accuracy (AA), Kappa hat ($\hat{k}$) and Tau coefficient (Tau), etc.。

REGION OF STUDY AND DATA

Typhoon Doug passed Chinese Taipei on 1994 August 7~8. It brought over 700 mm rainfall to the Gangshan region of Kaohsiung. It broke the 30-year record of that region and caused severe flood to more than 50,000 families in 8 districts of Gangshan. The worst flood happens in Jiashing district with over 5 m flood. Even the freeway was temporarily closed due to flood. The loss of life and property, the damages on public facilities, and the interrupt of major traffic route resulted huge economic loss.

The studied region covers 8 local districts for total about 170 km^2. This region is generally low-lying area, or a natural flood plain of surface elevation of 2.2 m. Many small creeks passing this region and flooding has always been a problem for this region because poor drainage system. The geographic location is in Fig. 1.

Due to the fast change of land use in the last 20 years, economic development often accompanies buildings on the flood plain and the passage for flood drainage. Another land use change is the proliferation of fishpond in this region. Many fish ponds have earth dykes surround it and these earth dykes reduces the draining speed of rain water and therefore resulted the severe flood over 8 district.

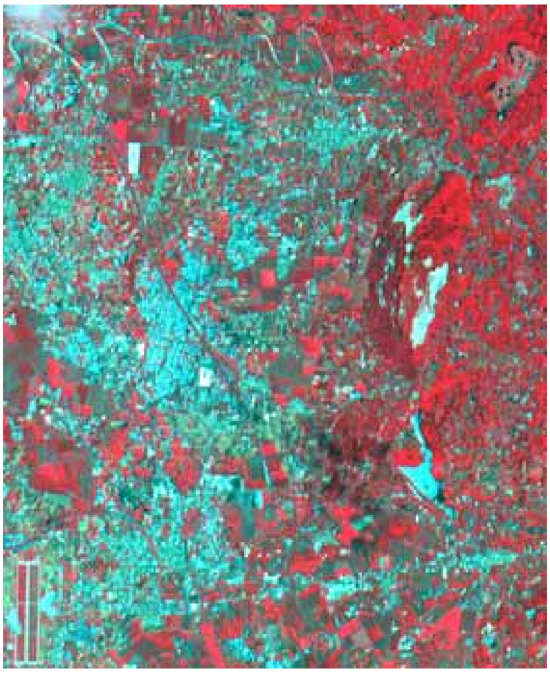

Fig. 5. *SPOT-2 image of Greater Gangshan region, 1994 June 8.*

The level-10 multi-spectral images of French SPOT-2 satellite were selected for remote sensing analysis. The date of the image is 1994 June 8, before the flood of 1994 Aug. 1~15. The pixel size is 12.5 m squared with RGB bands (Fig. 5). The selected ERS-1 SAR slant-range images are 1994 July 20 and Aug. 19 (Fig. 6 & 7) with pixel size of 12.5 m.

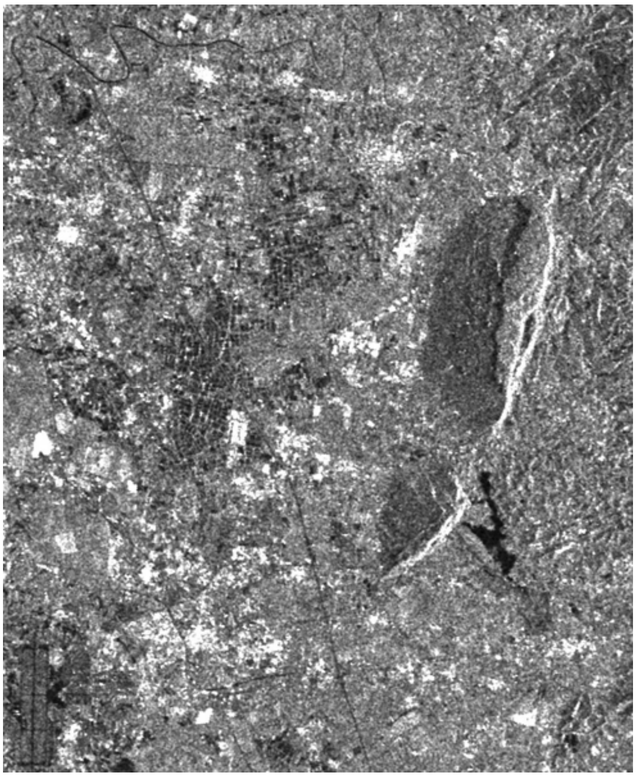

Fig. 6. *ERS-1 SAR image of Greater Gangshan region, 1994 July 20.*

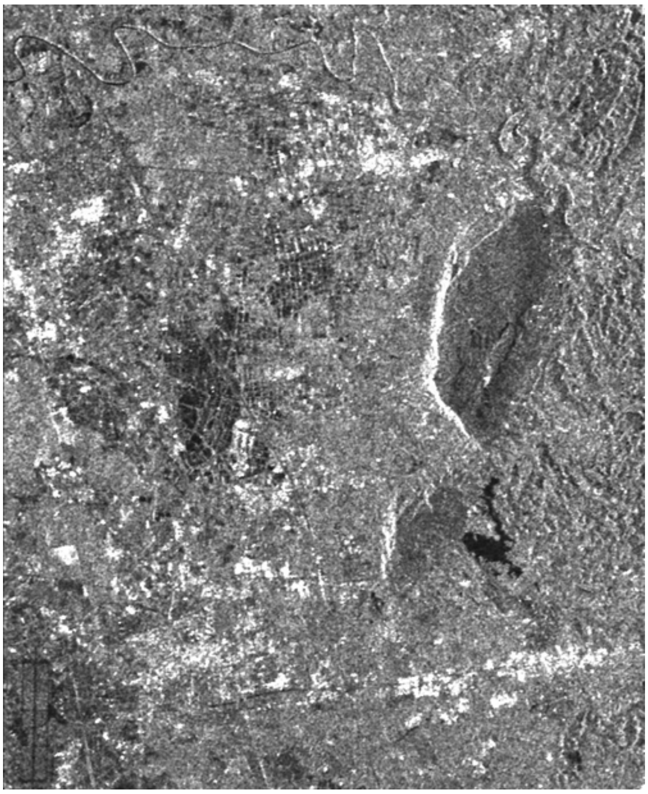

Fig. 7. *ERS-1 SAR image of Greater Gangshan region, 1994 Aug. 19.*

REMOTE SENSING ANALYSIS OF FLOOD EXTENT

During 1994 August 1~15, there were two typhoons Caitlin and Doug hit Chinese Taipei. They brought total 2018 mm of rain to the greater Gangshan region, and resulted the worst flood in this region. The following analysis is based on 3 satellite images as mentioned above.

The RGB bands of SPOT-2 image were fist converted HIS domain, Fig. 8. The spatial resolution of ERS-1 is insufficient for finding enough GCP, we therefore use the 2^{nd} order polynomial to correct the image to rms error of 2 pixels (25 m).

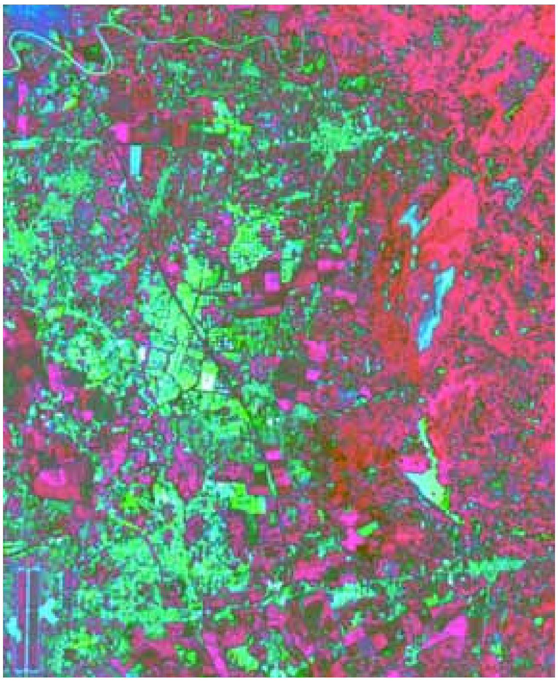

Fig. 8. *HIS image of SPOT-2 (1994/6/8) for the Greater Gangshan region.*

In removing the speckles, we adopted the Lee-sigma filter to remove speckles. Lee-sigma method assumes that the noise has Gaussian distribution with standard deviation (SD) about 0.26 for 4-look radar images. The SD of July 20 SAR image is 0.238, and 0.235 for Aug. 19 SAR image. With 3x3 window-size, any data outside of 2 sigma were removed. Only 5% of true data will fall outside of 2 sigma. The result is in Fig. 6 and 7.

Take the absolute value of difference between Fig. 6 & 7, add it to the optical image of SPOT HIS image, overlay all I, H, S images, then reverse conversion to RGB color space before classification analysis and color enhancement. This process did not result clear information on the flood extent. We therefore use the multi-temporal analysis to overlay the satellite images before and after the flood. Fig. 9 shows the result of overlaying SAR and SPOT images.

Fig. 4 shows that the flood over the freeway in Jiashing district, which is the same in Fig. 9 from remote sensing analysis. Light blue means light flood, and dark blue means severe flood. The result matches that of ground survey, the most severe flood is over Jiashing district (Fig. 10).

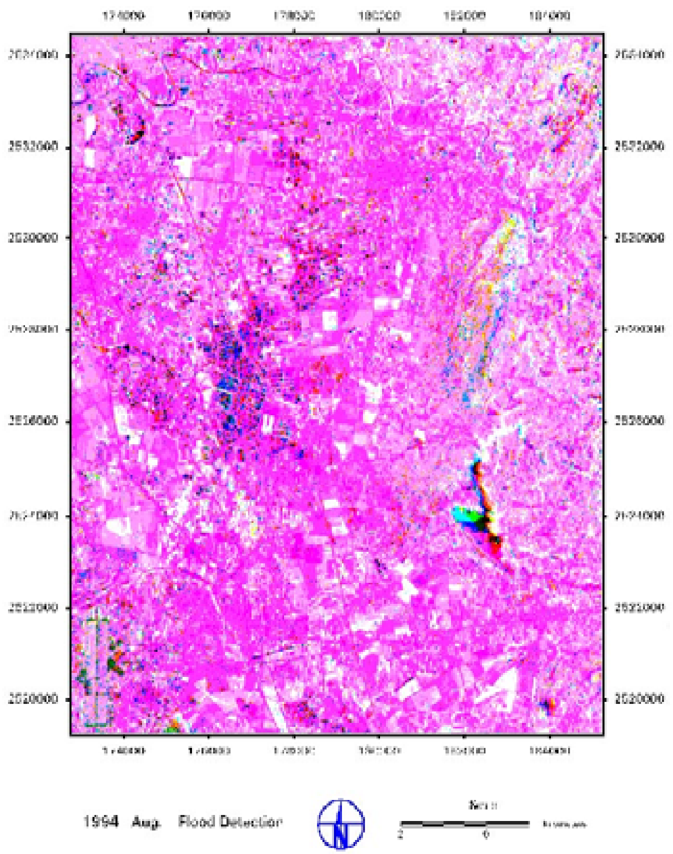

Fig. 9. *The analyzed image of flood classification for the Greater Gangshan area*

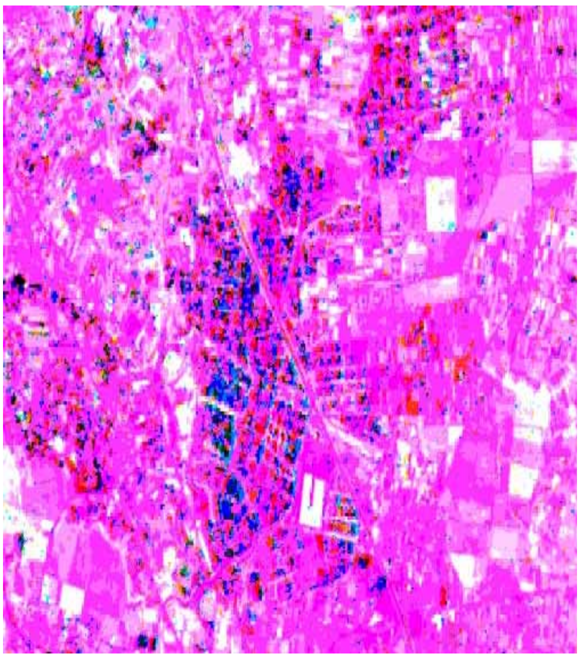

Fig. 10. *The flood analysis for Jiashing district of Gangshan.*

Fig. 10 can also be used to assess the flooding of fishpond (resulted fish loss) and farmland (resulted crop loss).

Although the image was taken 4 days after the flood, the high water content of earth surface still permits this study. Besides, the Agungdien Reservoir was slightly damaged during the flood. This water leakage phenomena is also visible in the analysis (the light and dark blue region in Fig. 11)

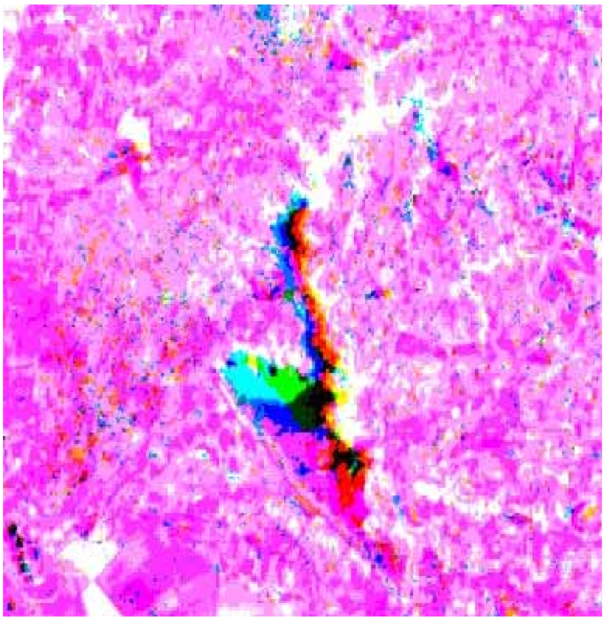

Fig. 11. *The flood analysis for Agungdien Reservoir.*

DISCUSSION AND CONCLUSION

Chinese Taipei is hit by typhoon several times a year. The typhoon rainstorm often cause severe flood in 2~3 days. This flood endangers the life and property of low-lying regions. In addition to preparing for the worst from the rainstorm, it will be better to have the near real time information on the flood, like the daily flood extent during the event. This will assist the government agencies to make the best use of their resources in mitigation the hazard from the flood. This information is also very useful as the basic information for the compensation to damages of crops and aquaculture. A few suggestions are worth taking notes for future study.

1. This study uses both ERS SAR images and SPOT visible images to analyze the flood in Gangshan in August 1994, due to typhoon Doug. The image fusion technique did not give expected result; it may due to the lapse from the time of full flood to the time when the satellite image was taken. The multi-temporal image overlay method gave acceptable result. It shows that the SAR images can be used for delimiting the flood extent for Jiashing farmland and fishponds, also the water leakage around the Dam of Agungdien Reservoir. Hence, remote sensing method is a good tool in assisting the survey of the flood.
2. The result from image analysis agrees well with the on site survey. Although there is 4 day lapse from the day of heavy rain and flood to the day of satellite image, SAR image still can reveal the flood extend because the high water content of earth surface. For further verification on the accuracy and reliability of the image analysis, one would need the satellite image on the day of flood.
3. If the water content of earth surface is available and included in the analysis, the

accuracy in delimiting flood extent shall be improved.

4. Radarsat SAR images are of HH polarization, which has larger reflection coefficient over the water surface than the VV polarization for ERS SAR. Radarsat SAR images should be considered in future study, including comparison to ERS SAR images. Besides, Radarsat SAR has multiple viewing angle and may revisit the site in 2~3 days with better ground resolution.
5. This study only used the signal strength of SAR images to delimit the flood extent. The difference between signal strength of different polarization may also reveal the flood extent. In this case, one would need only one SAR image at the time of flood is sufficient.

Flood happens almost every year in Chinese Taipei. The loss of life and properties is tremendous and is not decreasing at all. Besides, the losses in agriculture and aquaculture reached the level of national disaster and qualified for compensation. “A picture is more than a thousand words” means that an image of flood extent may be a legal tool for reducing disputes in the amount of compensation.

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Summary of Panel Discussion on Scientific Cooperation

1 **On the workshop WOM-9:**
All speakers of research papers of this workshop are on the frontline of satellite oceanographic research, and attendees fully participated the discussions. It is a fruitful experience for participants both from local and from abroad. The workshop was well organized and hosted by the Vietnamese scientists. Inviting local TV stations to interview the speakers is a new step in OMISAR workshops and is worth trying again in future workshops.

2 **On the networking of satellite data:**
It is greatly beneficial to everyone who participates OMISAR project,

2.1 in the capacity-building of operating small satellite ground station;

2.2 in exchanging of satellite data and in sharing experience of their application;

2.3 in working towards a network of sharing real-time satellite data.

3 **On the mitigation of flood along Mekong River:**
after long discussion, participants reached consensus on the followings:

3.1 Although the annual flood caused severe loss of life and property damages, it may also be an essential factor for the flourishing economy of Mekong Delta;

3.2 Eliminating the flood may result the loss of nourishment to the farmland and the supply of sediment to maintain the shoreline, and may worsen the impact of salt intrusion, etc.

3.3 Reducing the loss of life should be the top priority in disaster mitigation

3.4 Satellite radar (like Synthetic Aperture Radar, SAR) data may be the most useful tool among various satellite images, but SAR data are prohibitively expensive;

3.5 Models with mid-range flood-forecasting capability is a feasible method for early warning of flood damages;

3.6 Operational models require near-real time water level data along Mekong River for at least 300 km upstream;

3.7 This model requires full cooperation among all participating experts in deploying and maintaining telemetering equipment for measuring water levels, in providing digital elevation models, and in jointly developing operational flood-forecast models.

4 On the next OMISAR workshop on satellite data application:

4.1 Panel members unanimously recommend China to host the next workshop due to her advanced capability in developing hardware and software for satellite remote sensing; Chinese Taipei shall be the back-up in hosting the next workshop.

4.2 The recommended topic of workshop is
"Application of Remote Sensing on Marine Resources";
the date shall be determined by the hosting member economy.

All Panel members expressed their sincere thanks to the Local Organizing Committee, the National Centre for Natural Science and Technology, and especially to Mr. Khu who organized this workshop well and made it enjoyable for every participant.

WOM 9 - AGENDA

THE NINTH WORKSHOP OF OMISAR, Nov. 1-3, 2002

NCST Meeting Room. No.1, Mac Dinh Chi St. - Dist 1. Ho Chi Minh City – Vietnam

Nov. 1st

8:30 - 9:00 Registration

9:00 –9:45 Opening session

Introductory Address - Nguyen Phi Khu

a. Opening Remarks by NCST Vice Director General ***Nguyen Khoa Son***

b. Welcome by PC of HCM City

c. APEC-OMISAR Matters - Cho-Teng Liu

9:45-10:00 Coffee break

10:00-10:30 ***Data for Marine Research in Vietnam***

Nguyen Tac An. Institute of Oceanography
National Centre for Science and Technology. Vietnam.

10:30-11:00 ***Ocean Remote Sensing and its Application in China***

Jihui Yan. National Marine Environment Forecasting Center
State Oceanic Administration. Beijing, China

11:00-11:30 ***On the Decision Support Framework for the Mekong Basin Study***

N.T. Dac. Water Utilization Program (WUP)
Mekong River Commission Secretariat, PhnomPenh, Cambodia

11:30-12:00 Lunch

13:30-14:00 . ***Extraction of spectra from remote sensing images for the application in coastal protection***

Chia Chuen Kao, ***Lee Chung Wu***, Dong Jiing Doong. Department of Hydraulic and Ocean Engineering . National Cheng Kung University. Chinese Taipei.

14:00-14:30 ***Ocean Models for Marine Research in Vietnam***

Do Ngoc Quynh, *Pham Van Ninh*. Center for Marine Survey, Research and Consultation. Institute of Mechanics, NCST. Vietnam.

14:30-14:45 Coffee break

14:45-15:15 ***Sea surface observation in the Taiwan Strait using satellite imagery from HRPT station***

Nan Jung Kuo, *Chung-Ru Ho*. Department of Oceanography. National Taiwan Ocean University (NTOU), Keelung. Chinese Taipei

15:15-15:45 ***Application of satellite remote sensing on the tuna fishery of eastern tropical pacific***

***Cho Teng Liu**, Ching His Nan,* Institute Of Oceanography, National Taiwan University, Taipei; *Chung Ru Ho, Nan Jung Kuo, Ming Kuang Hsu*, Dept. of Oceanography, NTOU, Keelung; *Ruo Shan Tseng,* Dept. of Marine Resources, National Sun Yat-Sen Univ. Kaohsiung

18:30-20:30 *Banquet*

Nov. 2nd

8:30-9:00 ***Influence of wave motion in mangrove forest***

***La Thi Cang**, Vo Luong Hong Phuoc.*
Ho Chi Minh University of Natural Sciences.
Vietnam National University, Ho Chi Minh city, Vietnam.

9:00-9:30 ***Observations of the Intrusion of Kuroshio into the South China Sea from Satellite Infrared Images***

***Chung-Ru Ho**, Nan-Jung Kuo, Shih-Jen Huang and Wei-Peng Tsai.*
Department of Oceanography. NTOU, Keelung. Chinese Taipei

9:30-10:00 ***Networking Small Satellite Data for Marine Research***

***Nguyen Phi Khu**, Nguyen Minh Nam,* Institute of Applied Mechanics, *Vo Khac Tri, Tu Tuyet Hong.* SIWRR. Ho Chi Minh City of Vietnam

10:00-10:10 Coffee break

10:10-10:40 ***Track of Ocean Surface Currents from Satellite Ocean Color Images***

***Hsien-Wen Li**, Nan-Jung Kuo, Shih-Jen Huang, Wei-Peng Tsai*
Department of Oceanography. NTOU, Keelung. Chinese Taipei

10:40-11:10 ***Study of Flood Extent with Satellite Remote Sensing***

Li-Guang Leu, Ren-Ming Wu. Industrial and Technological Research Institute, Chinese, Taipei.

11:10-11:40 ***Strategic Orientation for Marine Research in Vietnam***

Pham Huy Tien Overseer of the KC09 Marine Research Project
National Centre for Science and Technology. Vietnam.

11:40-12:00 *Workshop closure* : APEC-OMISAR Address, NCST Address.

12:00-12:30 Lunch

14:30-16:30 *Technical tours*

Nov 3rd

8:30-9:30 Panel Discussion on Scientific Cooperation.

9:30-15:30 Cultural tours

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Proceedings

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Proceedings

The Sixth Steering Committee Meeting (SC-6) of Ocean Models and Information System for the APEC Region

Chinese Undersea Technology Association, Chinese Taipei
June 6-8, 2002, Taipei

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Remarks by the OMISAR Project Overseer
Dr. Gwo-Dong Roam

June 6, 2002

Distinguished Colleagues,

On behalf of Chinese Taipei, I would like to extend to all of you my warmest welcome to the Sixth Steering Committee of the APEC Ocean Models and Information System in the APEC Region. This project has been ongoing for about six years now. In those years, you have all showed your strong support of this project, for which I would like to thank you. Your valuable suggestions and expertise have indeed benefited this project greatly.

One of the mandates of the ministers in the Seoul Oceans Declaration is “to promote improved regional science collaboration and coordination to develop and facilitate ocean observing, assessment and forecasting systems, rapid response mechanisms for extreme weather and climate events.” This project is a direct response to such a mandate. An important aspect of this project is to share information and knowledge about our oceans, and the results of this project will contribute to ocean forecasting. As the overseer of this project, I would like to ask you to offer us your expert opinions to guide the direction of this project.

This project has become a common discussion topic for experts in many APEC economies, giving me a chance to get to know some of the best scientists in our region, and some of us have become close friends as a result of this project. This project will conclude one day, but I hope that our friendships will last well into the future. Thank you again for taking the time to be here. I hope you will have a pleasant stay in our city.

Meeting Summary of SC-6

The Sixth Steering Committee (SC-6) Meeting was held on June 6-7 in the conference room of the Chinese Undersea Technology Association in Taipei, and on June 8 in the conference room of Institute of Oceanography, National Taiwan University.

The meeting was co-chaired by Prof. Cho-Teng Liu and Prof. Chia Chuen Kao. It was participated by delegates from China; Hong Kong, China; Singapore and Vietnam.

Because of emergency condition of his family member, the Overseer of project OMISAR, Dr. Roam was not able to attend the meeting. He asked Prof. Liu to read his remarks at the beginning of the meeting.

The followings are summaries from the discussion among participants:

1. Prof. Liu presented the history of OMISAR project, the plan and the progress of the project since last meeting SC-5 that was held in the Department of Environmental Protection, Hong Kong, China.

2. Delegate from Hong Kong, China, Prof. LI Chi-Wei presented the preparation of WOM-8 (The Eighth Workshop on Ocean Models) that is to be held in Hong Kong late August. The central topic is comparing resultes of wave forecasting models that are based on the same data set. Prof. Kao also briefed the participants that most of the requested wind, wave and ancillary data for the comparison of wave-forecasting models, are available on internet and on CD. The venue of WOM-8 is the Kimberly Hotel in Hong Kong.

3. Delegates from Singapore, Prof. CHAN Eng-Soon and Dr. Pavlo Tkalich, presented the preparation of WOM-7. The central theme shall be the hydrodynamic models that aim at studying environmental problems. The venue of WOM-7 will be in the campus of National University of Singapore. The targeted dates are the beginning of October 2002.

4. Delegates from Vietnam, Mr. Khu and Mr. Tri presented their progress in preparing WOM-9 that is on the application and the networking of satellite data. Although Vietnamese are new in the OMISAR project, their approach in organizing international conference is well respectable. The venue of WOM-9 is in the conference room of National Centre of Science and Technology (NCST) of Vietnam. The targeted dates are Nov. 1-3, 2002.

5. Prof. Liu asked the participants to comments on the direction of OMISAR project. The suggestion of keeping the project name by members of SC-5 that was held in Hong Kong, China in May 2001 is sustained by members of SC-6.

6. On the central theme of future OMSIAR project, the following suggestions were raised among participants: study an event of natural marine disaster (like typhoon related disaster), red tides, shore erosion, salt intrusion, flooding, marine pollution, etc. The decision is left to the next Steering Committee Meeting.

Agenda of SC-6

Venue: Chinese Undersea Technology Association
6F-3, No. 160, Sec 1, Chien-Kuo S. Road, Taipei

June 6 (Thursday)

Time	Program
8:30	Depart from hotel for meeting
9:00 ~9:30	Registration and Welcoming Remarks
9:30~10:30	**Section I**：Review of the 2001 OMISAR activities: WOM-6 and WOM-5
10:30~11:00	Tea break
11:00~12:00	**Section II**：OMISAR 2003 proposal presentation; Group photos
12:00~13:30	Lunch break
13:30~15:30	**Section III**：Report of progress on WOM-7, WOM-8, and WOM-9
15:30~16:00	Tea break
16:00~17:30	**Section IV**：Discussion the planning of OMISAR 2003 and beyond
18:00	Dinner

June 7 (Friday)

8:30~17:00	1. am: Computex 2002 2. noon and pm: Field trip to the Dansui River Estuary

June 8 (Saturday):

there will be discussion sessions on NOAA data collected at the joint satellite ground station of OMISAR project in the Southern Institute of Water Resources Research (SIWRR), Ho Chi Minh City, Vietnam

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Appendix A: History and Progress of OMISAR-2002 Project

Drs. Cho-Teng LIU and Chia Chuen KAO

OMISAR 2002

Dr. Cho-Teng LIU / NTU
Dr. Chia Chuen KAO / NCKU

The Fifth Steering Committee SC5 of OMISAR

(hosted by the Environmental Protection Department of Hong Kong, China, May 10-11, 2001)

Recent Activity of OMISAR

- **WOM5 (2001 Nov. in Chinese Taipei)**
  on the small satellite station technology
- **WOM6 (2001 Sept. in Beijing, China)**
  Workshop on the validation and inter-comparison of marine wave forecasts
- **WOM7 (2002 April in Singapore)**
  The first workshop on selecting community models of ocean circulation and property transports
- Establish a **small satellite station** at a new site in APEC member economy

Spirit of OMISAR

OMISAR is a program of APEC MRC WG, participants jointly develop ocean models, and share information and technology

This is one of the goals of Osaka Action Agenda II

OMISAR follow-on

The Fifth Steering Committee Meeting SC5

- **Conclusion:** OMISAR is progressing well towards its goals of building the foundation of ocean models and information system
- **Recommendation:** we should **build on the existing sharing spirit and cooperative network** to **integrate models with observations and the newly available high resolution satellite data**

Preferred Ocean Monitoring System

- make observation at all time and all weather;
- The observation covers all regions;
- Least cost on the hardware, software and maintenance;
- Frequent observation
- deliver data at real time

There is no single system can do it all

OMISAR 2002 - components

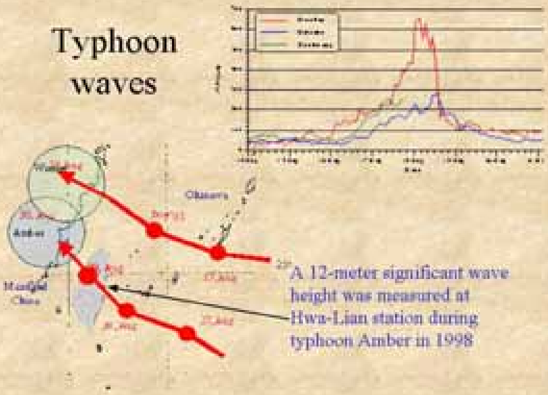
- Coastal ocean monitoring systems f(z,t)
- Along-way monitoring of water quality with commercial ships f(s,t)
- Satellite data f(x,y,t)
- Numerical models on the transport and dispersion of pollutants, and their impact on marine ecosystem and marine environment f(x,y,z,t)

Buoy – in-situ observation at sea

HKUST weather gauges

Dr. Kao's data buoy with weather, wave and water gauges

Typhoon waves



A 12-meter significant wave height was measured at Hwa-Lian station during typhoon Amber in 1998

Comparison of observation methods

	Data buoys	Numerical models	Satellite data	Intake water of commercial ships
type	Real data	simulation	Remote sensing data	Real data
All time and all weather	yes	yes	8 passes in cloud free day	Along shipping lane
Minimal unit cost, US$k	160		20	50
Spatial coverage	Point, water column	All region, all depths	Arial average	A line near surface
Data interval	min.	min	200 min.	week

Marine Environment RESEARCH IN SINGAPORE

Dr Eng-Soon Chan

Tropical Marine Science Institute
National University of Singapore

Singapore's Environment

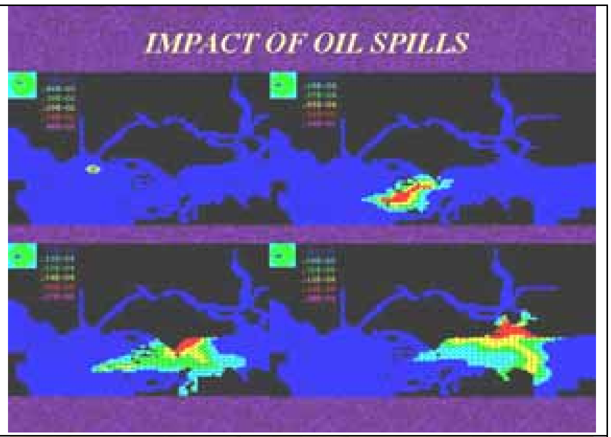
Environmental Perturbations

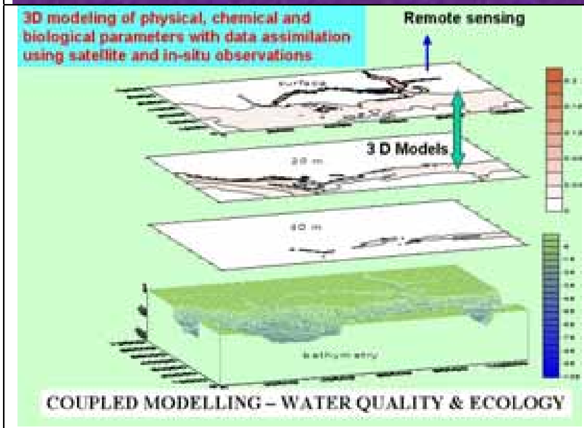
- Land based inputs
- Trans-boundary inputs
- Outfalls
- Vessel discharges
- Incidental spills
- Land reclamation

Implications

- Competing demands – water quality vs. economic development (thresholds, power plants, desalination, land reclamation, port developments,..)
- Establishing the baseline and tracking changes
- Need for continuous and integrated monitoring and forecasting
- Need for integrated effort


Monitoring & Modeling
Modeling of:
• Hydrodynamics
• Structure of the water column
• Transport –sediments, nutrients, pollutants
• Water quality
• Ecology
• Incidental spills


IMPACT OF OIL SPILLS

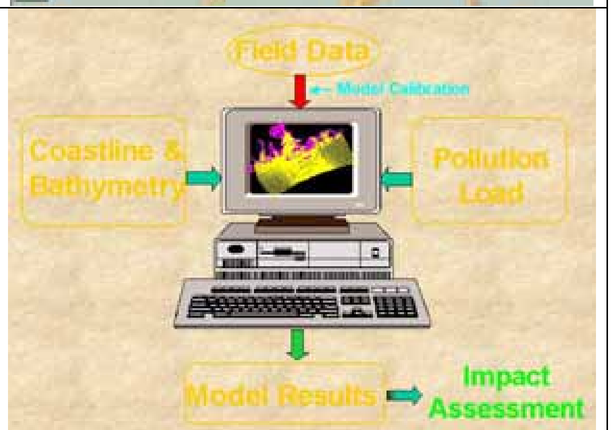

3D modeling of physical, chemical and biological parameters with data assimilation using satellite and in-situ observations
Remote sensing
3 D Models
COUPLED MODELLING – WATER QUALITY & ECOLOGY


Assessment of Cumulative Water Quality Impact of Coastal Developments in Hong Kong
Prepared by Alfred K.M. Ng
Presented by Alex Y. W. Chiu in OMISAR SC-5
Environmental Protection Dept.
Hong Kong SAR Government


Victoria Harbour


reclamation

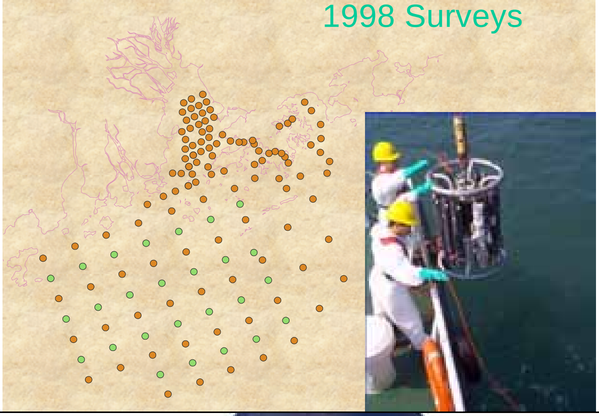

Anticipated Coastline at 2012

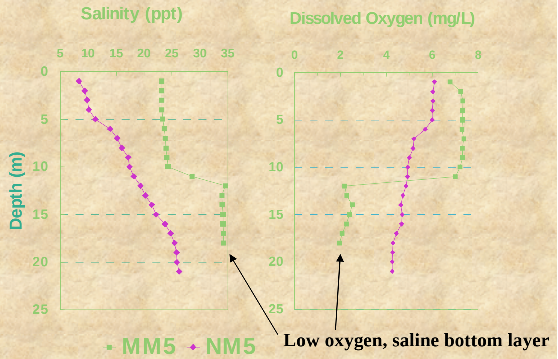

Field Data
Model Calibration
Coastline & Bathymetry
Pollution Load
Model Results
Impact Assessment

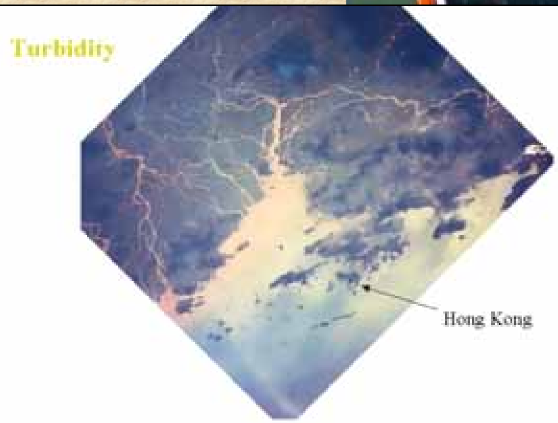
Field Surveys

- ✓ Mathematical models form the basis of this assessment
- ✓ Field surveys to provide data for calibration and verification of the models
- ✓ Intensive surveys conducted to provide spatial and temporal variations of water quality

1998 Surveys



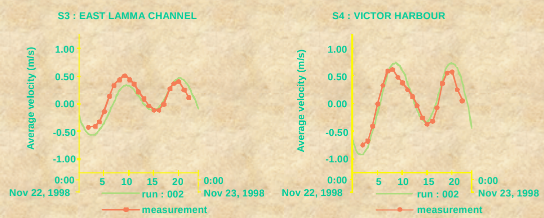


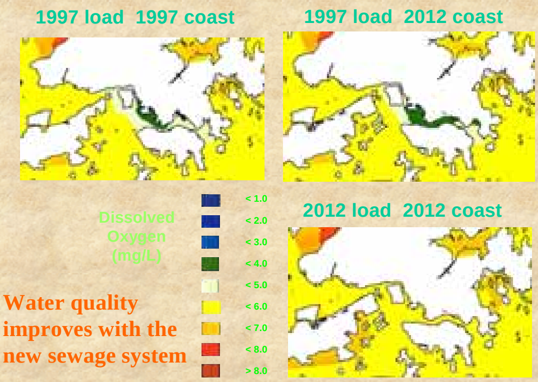


Model Grid Layout

- Curvilinear Grid
- 10 sigma layers
- 70m grid in Victoria Harbour; 7km at ocean boundary

Calibration of simulated tidal velocity





Water quality improves with the new sewage system

Ghost Fishing Near Hawaii

US NOAA/NMFS in Hawaii uses *in situ* data, satellite altimeter and temperature data and numerical models to predict

1. converging place of abandoned fishing nets => remove the nets
2. zone of turtle migration => no fishing zone

=> MRC tasks are more efficient with the help of ocean models that use *in situ* and satellite data

OMISAR 2002
(SWAT) project components

- **Coastal ocean monitoring systems** *f*(z,t) 1D
- **Along-way monitoring of water quality with commercial ships** *f*(s,t) 1D
- **Satellite data** *f*(x,y,t) 2D
- **Numerical models** *f*(x,y,z,t) 3D

New tasks in OMISAR 2002 :

(1) coastal ocean monitoring buoys
it is existing technology for Dr. Kao's Coastal Ocean Monitoring Center in Chinese Taipei

(2) water quality observation with commercial ships
Members of the International SeaKeepers Society monitor weather and water quality with yachts, and they transmit data to shore through Inmarsat-C;

Hochiminh City, Manila and Taipei form a triangle in the center of the marginal seas in the western Pacific.

We may form a network of satellite data that provides satellite data freely to the regional users.

The data from this network has the best coverage than any single satellite station (no matter how large is their dish)

Can we do it?

Yes, but how do we do it?

Time table?

Appendix B: Progress Report on Organizing WOM-9

MSc. Nguyen Phi Khu and MSc. Vo Khac Tri

ASIA-PACIFIC ECONOMIC COOPERATION
MARINE RESOURCE CONSERVATION WORKING GROUP

The Sixth Steering Committee of OMISAR
June, 6-7th 2002 - Chinese Undersea Technology Association Meeting Room
6F.3.No. 160, Sec 1, Chien-Kuo S.Rd. Taipei, Taiwan 106. Chinese Taipei

REPORT ON THE PROGRESS OF ORGANIZING THE NINTH-WOM

Nov 1-2nd 2002 - Ho Chi Minh City – Vietnam

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On behalf of NCST/IAM I would like to welcome all participants of the Sixth Steering Committee which is organized by the Ocean Models and Information System for APEC Region or OMISAR, and the APEC Marine Resource Conservation Working Group or MRC-WG.

Firstly, I wish to thank Professors Gwo-Dong Roam - OMISAR Project Overseer, Shiuan-Wu Chang EPA - Senior Research Fellow and Cho-Teng Liu - OMISAR Project Contractor who made many good chances for us to participate this meeting as well as some other OMISAR workshops.

I wish this sixth meeting a success and wishing that partnership among all participants will continue well beyond the end of this meeting.

Our working on the small satellite station technology will not be possible without strong technical support and funding from the Environment Protection Administration and the National Taiwan University, the Institute of Oceanography.

On April, 16th 02, the project of NCST/IAM small satellite station to study the coastal circulation was approved and funded by the EPA - such a station has also been setup at the Southern Institute of Water Resource Research of Vietnam since Nov, 01. These projects has really opened a new scientific research cooperation for us base on the small satellite station technology.

With these scientific truthful relationships, we wish an Agreement will be signed between NTU and IAM to start a science and training co-operation in the field of Marine Research.

Under the sponsorship of APEC MRC-WG ,EPA and my NCST the next small satellite workshop has been planed to open by the IAM and SIWRR. So, an urgent meeting of NCST's Scientific Council, IAM and SIWRR has been organized on June, 30th 02.

The attachment outline has been discussed and agreed to suggest as the main procedure and progress of organizing the ninth workshop of OMISAR or WOM-9. According to this meeting, our suggestions are as follows:

Scientific Committee:

N.D. Canh *(IAM,Ho Chi Minh City)* Leader and Secretary of IAM

S.W. Chang *(EPA,Taipei)* Senior Research Fellow

D.V. Khuong *(RIMF,Hai Phong City)* Deputy Director

C.T. Liu *(NTU,Chinese Taipei)* APEC Contractor

D.V. Luong *(HCMCity)* Director of Science, Technology & Environment Department of HCM city

D.V. Minh *(Co-chair,NCST,Hanoi)* General Director of National Centre for Natural Science and Technology of Vietnam

T.Q. Ngoc *(Ho Chi Minh City)* Director

N.A. Nien *(SIWRR, Ho Chi Minh City)* President of Scientific Council of Southern Institute of Water Resource Research

G.D. Roam *(Chair, OMISAR,Taipei)* Project Overseer of OMISAR

L. Sam *(SIWRR, Ho Chi Minh City)* Director

N.K. Son *(NCST,Hanoi)* Vice-General Director of NCST

P.H. Tien *(Hanoi)* Director of Marine Research Program

L.M. Triet *(Co-chair, NCST,HCM City)* President of Council of United ScientificBranches in Southern of Vietnam

Organizing Committee:

N. Dung *(IAM, HCM City)*
N.X. Hao *(IAM, HCM City)*
N.P. Khu *(IAM, HCM City)*
T.V. Lang *(sIIT, HCM City)*
C.T. Liu *(NTU, Taipei)*
V.T. Loan *(IAM, HCM City)*

T.D. Thang *(SIWRR, HCM City)*
V.K Tri *(SIWRR, HCM City)*
L.N. Xuyen *(NCST, HCM City)*

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Topics: Satellite Data and Applications

- Ocean Color Imager-Data Processing and Application
- Satellite Image Analysis and Remote Sensing
- Satellite Database Management System
- Small Satellite Data and Marine Conservation
- Small Satellite Data and Environment Protection

Place: NCST's Meeting Room.
at: No. 1, Mac Dinh Chi St., Dist. No.1, Ho Chi Minh City - Vietnam.

Date : November, 1-2nd 2002.

Deadlines: **Registration and Submission of Abstracts :** SEP.15th 2002
Notification of Acceptance : OCT.1st 2002

Anouncements:
The **1st** anouncement *About WOM9*: AUG. 1st 2002
The **2nd** *About registration and submission abstracst*: SEP.1st 2002
The **3rd** *About notification and the workshop last-Info*: OCT.5th 2002

Website : A website for the ninth-WOM and to communicate between the APEC/OMISAR small satellite stations and scientists in this field will be designed and issued in two-weeks before the ninth-WOM opened.

Tentative Agenda :

Day	**Time**	**Section**
FRI Nov. 1st	8:00 - 9:00	Registration
	9:00 -10:15	Opening. WOM Overview
	10:15-10:30	Coffee Break

	10:30-12:00	WOM9 reports
	12:00-13:00	Lunch
	13:30-15:00	WOM9 reports (cont.)
	15:00-15:30	Coffee Break
	13:30-15:00	WOM9 reports (cont.)
SAT Nov. 2nd	8:30 -10:30	Technical tours of local agencies
	10:30-15:30	Cultural tours
	17:00-19:00	WOM9 close and Banquet

The obligation of local host is providing: meeting room, transportation between airport and hotel, logistics, technical-tours of local agencies, cultural-sightseeing tour.

We would like to suggest that APEC will cover travel expenses of some speakers of the workshop. Every APEC-sponsored participants have to give a report with computer files to be recorded in the workshop proceeding.

Hopefully, more information from our EPA staff on details of APEC administration and on publishing the proceeding according to APEC requirement will be early issued to have enough time for our preparation.

Although, the local host fees for holding the workshop may not require to be paid, but we wish to get some special supports from the APEC and the other fund sources to be sure our first workshop in Vietnam will be quite successful.

We are very grateful for the sponsorship of APEC, OMISAR, EPA and NTU in organizing the ninth-workshop on small satellite station technology.

Lastly, I wish to thank our colleagues for all hardworks preparing for this meeting and our partnership will continue well beyond.

Thank you.