Coastal Ocean Data and Forecasts for Marine Applications

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Abstract

The U.S. coastal ocean observing data and numerical model forecasts are the basis for various marine operations and service. Observing data gives current information, while numerical model can lead the time and produce prediction or forecast results. In this note, we attempt to outline the Integrated Ocean Observing System (IOOS) and the existing models developed by the National Oceanic and Atmospheric Administration (NOAA) and the Navy for global and north America land surface and seas. To focus on marine service, we limit the contents to apply to weather, coastal ocean commerce and ecological process as well as marine transportation. The information here largely follows NOAA's missions – coordinating data and model forecasts to predict changes in the earth's environment and to meet nation's economic, social and environmental needs.

1. INTRODUCTION

The U.S. National Weather Service (NWS) has been using satellite, aircraft, ships and buoys for tracking storms, fronts, and daily weather patterns in a continuous manner over large ocean/coastal regions. To reduce vulnerability of coastal areas to natural hazards and to main essential ecological conservation, there is a need to integrate an ocean observing system to coordinate with Global Ocean Observing System (GOOS), which is the backbone of predicting change in global climate and earth environment health.

In past years, ocean conditions are inadequately captured, described, and making no positive impacts to coastal community. Ocean observations are performed for single purpose and owned by a variety of public agencies, academic institutions and private sector companies that cannot share data value and information. Beginning in 2000, the U.S. Congress directed the interagency NOPP to plan and to develop a sustained integrated ocean observing system (IOOS). The IOOS is also the U.S. contribution to the Global Ocean Observing System. Because IOOS cuts across and supports many NOAA office's missions and goals, NOAA is the lead Federal agency for implementing IOOS for U.S. coastal states and ocean communities.

Various research forecast systems, including global atmospheric forecast system and meso scale forecast system, global wave model as well as hurricane model forecasting are produced by NOAA research offices cooperated with NWS field offices with the National Center for Environmental Prediction (NCEP), Model products for different time horizon are combined with observed remote or ground data as provided for scientists and forecasters to adapt management decisions to coastal hazards or daily operation.

Among coastal ocean data and model forecast products, the NWS Coastal and Marine Office employs a number of marine parameters to fulfill its mission. In the order of priority (NAS, 1984), the important parameters are wind conditions, tropical storm track movement, wave heights and period, swell height and direction, water level (tide and storm surges), precipitation, sea surface temperature, surfs, ice and fog (visibility). Other parameters such as air humidity, barometer pressure and surface current flow are also referred for forecasts. The MWS's Meteorological Development Laboratory (MDL) has developed techniques for assessing these parameters in various platforms to generate guidance products. In the following, an outline of IOOS as well as model products is briefed.

2. Integrated Ocean Observing System

As with other special program, the IOOS is envisioned as an integrated ocean system which will link regional, national, and international networks of observations, data management and analysis systems to provide information needed to better understand and predict how changes will impact the nation's oceans, coasts, estuaries and lakes- and the people who live in or close to the coastal zone.

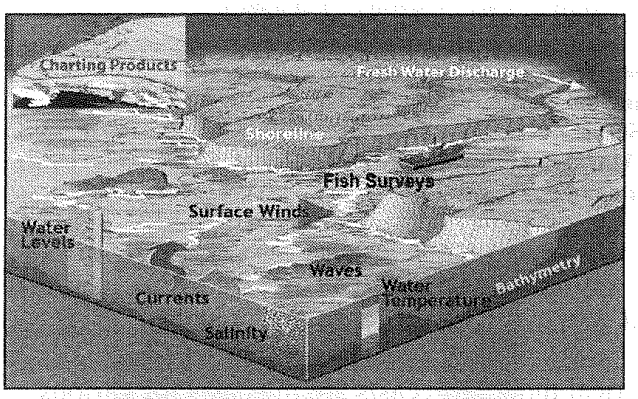

Figure 1: elements involved in coastal seas.

The primary components of IOOS include marine bathymetry and hydrodynamic parameters such as *tides and surface water waves, surface currents, local winds* and water temperature, heat flux, salinity, dissolved oxygen, fish stock abundance and zooplankton nutrients that measures marine life.

In 2002, at the Ocean.US Workshop the goals of IOOS are targeted by consensus as:

(1) improve predictions of climate change and its socio-economic effects; (2) improve the safety and efficiency of marine operations; (3) more effectively mitigate the disaster of natural hazards; (4) improve national and homeland security; (5) reduce public health risks; (6) more effectively protect and restore healthy marine eco-system ; and (7) enable an eco-system based management. An economic analysis was performed under contract to NOAA estimated $5 of return for industry and the public for every $1 invested in ocean observing and coastal predictions.

The IOOS is composed of three sub-systems: Observing system, Data Management and Communication (DMC), Modeling and analysis sub-system. IOOS data will be accessible through DMC data transport standards and protocols, subsequent to primary data assembly.

The implementation process will generate different products for different coastal ocean users to provide added value to national economy. The major challenge facing IOOS is one of coordination and cooperation among the partners and user community. A National Federation of Regional Associations is established to enhance cooperation among regions and provide a unified interface.

3. MODEL PRODUCTS and MISSIONS

In NOAA's FY2006 budget, accomplishments are highlighted in four mission goals:

Mission 1 – Protect, restore and manage the use of coastal/ocean resources through ecosystem-based management. To that end, environmental models (**HYCOM, NCOM**) are developed with high resolution of 6~10 kilometers that is driven by wind fields and heat fluxes. It can provide SST, salinity, surface currents and sea surface heights to continue the Harm Algal Bloom forecast system to identify algal coverage. NOAA also operates the Coral Reef Early Warning System (**CREWS**) to produce automated internet based warnings when conditions are conducive or predictive to coral bleaching.

Mission 2 -- Understand climate variability and change to enhance society's ability to plan and respond. NCEP has provided forecast (CFS, **GFS**) on seasonal to multi-decadal time scales to manage climate risk on global to regional scales.

Mission 3 -- Serve society's needs for weather and water information. Environmental models such as ETA, MM5, and GFS, RUC, RFS are used as drivers for NOAA's forecasting system for coastal storms and hurricane warning. The Navy also developed **NOGAPS** and **COAMPS** for global and regional air-ocean forecast.

Mission 4 -- Support the Nation's commerce information for safe, sound and efficient transportation. NOAA has cooperated with FAA to provide aerial chart, navigation atlas, and **PORT** model to port facilities. 2004 also unveil a Rescue Coordination Centers to respond emergency response.

It should be mentioned that most NWS model forecasts are disseminated in different platforms, such as MOS, AWIPS, NDFD, and FSL for cross checking the data output for issuing the forecasts.

In Table 1 model domain and forecast products of commonly used models are illustrated. These are by no means exclusive examples,

Table 1: Model products

Model	domain	Model Forecast
HYCOM	global	SST, SSH, currents
HAB	coast	Bio-optical, Hypoxia
NCOM	regional ocean	As HYCOM
GFS	global	Wind, pressure, etc.
WW3	global	Ocean waves

ETA	regional	Wind, pressure, etc.
WRF	meso	A local MM5 output
RFS	meso	Precipitations.

There are other products developed in NOAA's office for special coastal ocean mission. Herein, we highlight those projects which integrate ocean observations and model output applied in coastal marine area. The graphical results indicate the potential use of the modeling technique.

4. MARINE APPLICATIONS

After cold-war, research and development activities have been focused on continental shelf and coastal zone. Marine products have expanded to cover activities in marine resources and coastal recreation. The NWS's marine office (NWS, 2005) provides operational data and products for ocean and shallow water coastal marine zone:

In offshore high seas, 12 hour forecast of wind and waves for ship routing and mining and oil rig exploration; tropical cyclone tracking and tsunami warning are issued to protect marine fishery life and properties.

Near bay and coastal zone, 6~12 hours forecast of waves, sea surface temperature, icing condition and surface currents are issued for boating, dredging, waste disposal and fishing or recreational cruise.

Close to shore (0~10 mi), wind, wave and tide surges are recorded hourly for port and oil pipe operation as well as fishing, touring. Recently, we also watch breaking waves in the sun zone for beach touring and surfing activities. More efforts will be focused on rip current warning and public education in ocean related science and technology. NOAA continuously survey the sea bottom bathymetry and monitor datum changes, these information combined with shoreline model are used for estimating the cost of coastal protection and beach nourishment.

Applying ocean data and modeling techniques, NOAA provides severe storm warning, short and long-term weather forecasts, climate analysis, search and rescue and other specific services. The following listing highlights NOAA's achievements in various marine service and contribution to the nation's economy and environmental health and public safety.

Monitoring of Hurricane and issuing warning — NOAA's Satellite and Information Service and National Hurricane Center achieved a record of web "hits" before Hurricane Ivan making landfall.
http://www.ssd.noaa.gov/ps/trop/trop-atl.html
http://www.nhc.noaa.gov

20 years of Global Sea Surface Temperature — NASA collaborated with NODC produced a 20-year time series of data in 4-km resolution.
http://www.nodc.noaa.gov/sog/pathfinder4km

Argo data for Global Ocean Climate observing — Argo, an array of free-drifting floats, a component of global ocean observing.
http://www.nodc.noaa.gov/argo

Watch hypoxia dead zone in the Gulf of Mexico — NOAA provides near real-time data about dissolved oxygen in the Gulf of Mexico.
http://www.ncddc.noaa.gov/Habitat/coastwatch

Ocean waves forecast for global and region — Developed fine resolution of global wave model and regional wave model forecasts in America.
http://www.weatheroffice.ec.gc.ca/model_forecast/wave_e.htr.
http://polar.ncep.noaa.gov/waves/main_table.html

Rescue Coordination Centers for alert signals — NOAA and Russian satellites watch alerts from geostationary satellites to help the U.S. Coast Guard perform rescue service.
http://www.sarsat.noaa.gov

National Coastal Ocean time series data base — The product is for climate analysis, it has been developed for years to provide archived data of coastal water parameters.
http://www.nodc.noaa.gov/IDARS/tsdb/

5. SUMMARY and REMARKS

In the 21st century, due to economical growth slow down and more coastal populations, an adaptive government management is to apply the blue ocean strategy for opportunities. In science and technology program, an efficient management must work with agencies which operate data and have implemented model product that can maximize the use of information technology. This is a challenge for policy makers, scientists and engineers as well as industry suppliers, and the public.

The function of integrated ocean observing system can integrate collected data from the local to the international level to manage the environmental problem. Many geospatial and hyper spectral technologies can facilitate the use of data for decision making. In coastal ocean, observations include winds, wave, sea surface temperature and salinity, sea surface height and tide water level. With data assimilation or initial condition, model can predict most likely scenarios. This can support marine users most accurate and efficient information for decision process.

Taiwan is surrounded by coastal seas and ocean. Due to the size of land surface limitation, opportunities are restricted to clean and leisure industry. To balance the development in limited resources, out-to sea activities are mandated. In global commerce, ocean plays a significant role in

jobs, food supply, health, and national defense, recreation and energy resources. It is vital for global cooperation and networking with the partners in the entire spectrum of marine industry. A better use of coastal data and model forecasts is to the benefits of ocean scientists and planners to society.

6. REFERENCES

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