OCEAN DATA AND INFORMATION SYSTEM (ODIS) AND WEB-BASED SERVICES

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ABSTRACT:

The Ocean Data and Information System (ODIS) is a one stop shop for providing data and information on physical, chemical and biological parameters of ocean and coasts on various spatial and temporal domains that is vital for both research and operational oceanography. It is an end-to-end ocean data management system, developed by exploiting the advances in the field of information and communication technology that brought revolutionary changes in data acquisition, processing, analysis and data availability at a click away. ODIS is fed by voluminous (~5 Tb per year) and highly heterogeneous oceanographic data in real time, acquired from the Ocean Observing Systems (both in-situ and remote sensing) established in the Indian Ocean. The challenges involved in developing ODIS are integration of heterogeneous data received from a wide variety of ocean observing systems, generation of metadata, quality control, generation of database and implementation of data warehousing and mining concepts for providing web-based data services. ODIS forms as a vital component for providing web-based services. The web-site has been matured as a prime vehicle for providing ocean data, information and advisory services such as potential fishing zone, ocean state forecast, Indian Argo, Indian Ocean Global Ocean Observing System, etc. The web-based online delivery system facilitates the user with multi-lingual and Web-GIS capabilities to query, analyze, visualize and download the ocean data, information and advisory services on different spatial and temporal resolutions. In this paper, we describe the development of ocean data and information system, data flow from various ocean observing system, formats, metadata base, quality control procedures and web-based data services that facilitates online data discovery, visualization and delivery. We also give an account on the web-based ocean information and advisory services and the challenges involved in ocean data management and web-based services. Further, we briefly discuss on the efforts with regard to open standards and interoperability issues pertaining to marine data management for seamless exchange of data.

1. INTRODUCTION

The Indian National Centre for Ocean Information (INCOIS) has been playing a key role in the Indian Ocean by providing ocean data, information and advisory services to society, industry, government and scientific community through sustained ocean observations and constant improvements through systematic and focused research in ocean data, information management and ocean modelling.

The observations from the oceans are the backbone for any kind of operational services (potential fishing zone advisory services, ocean state forecast, storm surges, cyclones, monsoon variability, tsunami etc.), research and development including validation of satellite sensors and parameterizing key processes for models and verifying model simulations. In order to provide a variety of operational services, a network of in-situ ocean observing systems particularly the cutting edge technology such as Argo floats and other observational platforms, viz. drifting buoys, XBT surveys, current meter mooring array, moored buoys, tide gauges, bottom pressure recorders, coastal radars were established in the Indian Ocean. The data received from these observing systems is vital for developing robust ocean and coastal forecasting system.

INCOIS, being the central repository for marine data in the country, receives voluminous oceanographic data in real time, from the network of in-situ and remote sensing observing systems. In addition, a large amount of historical data has been obtained from the web and other sources for various in-house studies and modelling activities. Availability of ocean data in real-time is essential for spatial analysis and decision support system to provide ocean information and advisory services and forcing models that lead to climate predictability, both short-term and long-term. Further, with the vast amount of data available, Ocean models could be fruitfully utilized to undertake need based user projects for coastal and offshore applications**.**

Apart from serving as a national repository of marine data, the INCOIS has been designated as the National Oceanographic Data Centre (NODC) by the International Oceanographic Data and Information Exchange (IODE) Programme of Intergovernmental Oceanographic Commission (IOC). Further, as part of the International Argo Programme, INCOIS serves as the National and Regional Argo Data Centre for India and the Indian Ocean, respectively.

The objectives of the data centre at national and regional levels are acquisition, processing, quality control, inventory, archival and dissemination of data and data products in accordance with national responsibilities and also responsible for international data exchange. Finally, exploitation of the advancements in the web and geospatial technology for providing data and information services in real-time forms crucial part in the ocean data and information system.

2. OCEAN DATA AND INFORMATION SYSTEM

The Ocean Data and Information System (ODIS) provide ocean data and data products required for both research and operational oceanography. The ODIS is supported by the data received from both the in-situ platforms and satellites, Global Telecommunication System (GTS), projects/experiments, data from other sources and the data exclusively retrieved for the Indian Ocean from historical data sets.

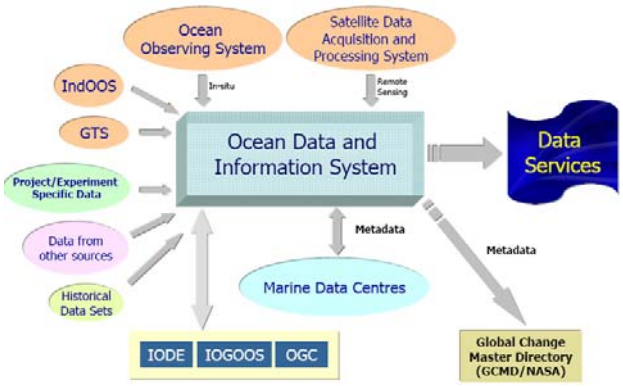

Figure 1. Elements of the Ocean Data and Information System

Strong organizational arrangements are in place with all the agencies involved in ocean observational programmes to ensure the real-time data flow to ODIS. We plan to strengthen the system with the data generated from a chain of designated Marine Data Centres, academia, etc. by networking and enabling them on the INCOIS web-site with appropriate access privileges. Further, we have active collaboration with IODE, Indian Ocean Global Ocean Observation System (IOGOOS) and Open Geospatial Consortium (OGC) programmes on data and information management related activities. The total estimated data flow from both the in-situ and remote sensing satellites is estimated about 5 Tb per year.

Platform/Instrument	Parameters
Argo Floats	Temperature and Salinity Profiles up to 2000 m
Moored Buoys	Air Pressure, Air Temperature, Wind Speed and Direction, Water Temperature, Significant Wave Height, Wave Direction, Current Speed and Direction
Drifting Buoy	Sea Surface Temperature, Air Temperature, Barometric Pressure, Sea Surface Currents
Tide Gauges	Sea Level
Bottom Pressure Recorders	Water Column Height
XBT Observations	Temperature Profiles up to 760 m
Current Meter Data from the Equatorial Current Meter Mooring Arrays	Current vector

Table 1. In-situ Ocean Observing System and the parameters measured

A sophisticated communication system was deployed to receive data from the in-situ platforms in real-time. The in-situ platforms and the parameters measured are listed in the Table 1.

The Satellite Data Acquisition and Processing System (SDAPS) was setup to receive remote sensing data in real time from NOAA (17 and 18), Terra and Aqua Satellites to meet the operational data requirements of Potential Fishing Zone advisory services and Indian Argo Project.

Sensor/Satellite	Parameters
AVHRR- NOAA (17 and 18)	Sea Surface Temperature
MODIS - Terra and Aqua	SST and Chlorophyll (Other atmospheric and ocean parameters are generated on request)

Table 2. Remote sensing data received from the satellites in real-time at SDAPS

The data received from various observing systems in real-time at different communication systems are assembled and standardized. The metadata was generated using the Marine Environmental Data Inventory Software developed by the IOC (MEDI, 2002) for the Moored Buoy, Drifting Buoy, Current Meter Mooring and XBT data sets. The metadata for the Argo floats are generated as per the guidelines of the Argo Programme.

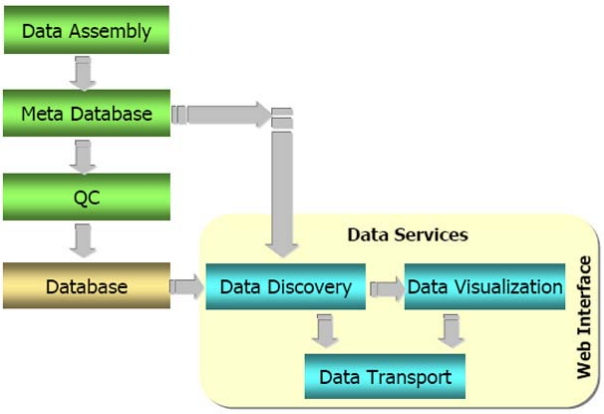

Figure 2. Data management flow chart

The data go through the quality control procedures for each of the observing system separately as per the internationally adopted quality control procedures and standards (Uday et al., 2007; NDBC, 2003; Hansen and Poulain, 1996). The quality controlled data then loaded to the data base for providing web-based data services.

The data received from the Moored Buoys, Drifting Buoys are published on the web after the real-time quality control checks. The data from the Tide Gauges, Bottom Pressure Recorders and Seismic Stations are being used internally at Tsunami Early Warning Centre for its operational activities. The data sets from the XBT surveys and Current Meter Mooring Array are received in delayed mode and go through the same process before publishing on the web. The entire process of reception, data processing, quality control, loading in to the database, web publishing and also dissemination to the users for their operational activities was fully automated. The Argo data after

the QC are made available to the scientific community on the web-site with in 24 hours of the acquisition. The interactive web-interface for accessing and downloading the Argo float data is discussed in the next chapter. Web-interfaces were developed for data discovery, visualisation and transport of other data sets.

In addition to the data sets discussed above, large amount of data generated from various national and international experiments, model outputs, reanalysis data sets and historical data sets extracted exclusively for the Indian Ocean region as listed in the Table 3 are available with us. These data sets are also being organised in to the database to build a comprehensive India Ocean Database.

Data sets	Parameters	Period
Simple Oceanographic Data Assimilation	Currents, Temperature, Salinity	1955-2001
Joint Environmental Data Analysis Centre	Temperature Profiles	1955-2004
National Centre for Environmental Prediction	Surface meteorology, Surface fluxes	1950-2005
CMAP	Rainfall	1979-2006
Altimeter	Sea Surface Height Anomaly	1996-2007
TMI	Sea Surface Temperature, Rainfall, Wind Speed	1997-2007
Quickscat	Wind Vector	1998-2007
SeaWifs	Chlorophyll	1997-2005

Table 3. Other data holdings

The main challenge in developing ODIS is managing highly heterogeneous and voluminous data from a suite of in-situ platforms and remote sensing satellites, developing open standards and addressing the interoperability issues for exchange of data. To meet these objectives and data demands from wide spectrum of users, it is necessary to harmonize the data in standard formats, apply quality control procedures, generate meta data and database, while adopting international standards for seamless exchange of data.

3. WEB-BASED SERVICES

3.1 Web-GIS

The advent of internet technology facilitates the user with easy and faster access to the availability of information at a mouse-click and the Geographical Information System (GIS) provides the capability for storing and managing large amounts of spatial data. A Web-GIS system combines the potential of both internet and GIS technologies enabling the users to access the geospatial information and data via web-browsers without purchasing expensive, proprietary GIS software. Data and map services are being implemented using Web-GIS. The growing number of research publications and implementation of many common GIS software have proven the potential and increased utility of Web-GIS (Dragicevic, 2004; Markstorm et al, 2002; Tsou 2004).

The web-based ocean data, information and advisory services viz. Potential Fishing Zone Mission, Ocean State Forecast, Indian Argo Project were developed with Web-GIS technology. The web-based multilingual on-line data and information delivery system with Web-GIS capability enables the users to query, analyze, visualize and download ocean data, information and advisories for their regions of interest. The system allows integration of large amount of data from different sources and management. The whole system consists of about 320 data tables both in vector, raster formats with the relative attributes, all of them gathered in six main databases viz. ITOPS (18 Tables), OSF (8 Tables), ARGO (14 Tables), PFZ (92 Tables), IOGOOS (11 Tables), SDE (175 Tables) which are updated daily.

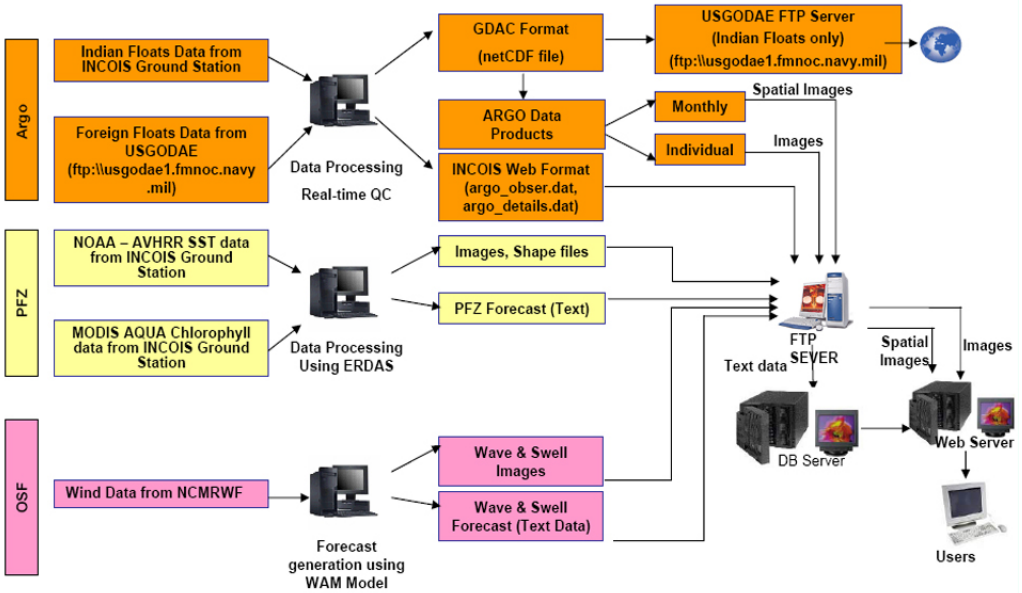

Figure 3. Flowchart describing the data reception, processing and web-services

Web-Environment: The Web Server is installed with IBM Websphere, IBM HTTP Server, TOMCAT, ArcIMS (Map Services), MSWEFT and other Web Tools. Application Server is installed with Web Code that is responsible for handling the business logic. Database Server is installed with Oracle 9i RDBMS with Oracle partitioning and ArcSDE. Mirror Servers (both Web Server & Database Server) are synchronized with respective servers.

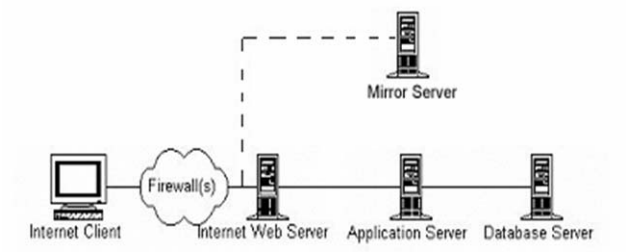

Figure 4. Web environment

Web development Tools: Web development tools include Microsoft Visual Source Safe, Dream Weaver , Adobe Photo Shop, Adobe Image Maker, Gif Animator, Microsoft WEFT, iLEAP, Visual Age for Java, Jcreator, Java, JSP, Servlets, SnagIT, Robohelp, ArcIMS 3.0,Tomcat 3.2.1, Microsoft Internet Information Server (IIS), Websphere 4.0.3, ArcSDE 8.2 and Oracle 9i.

3.2 Potential Fishing Zone (PFZ) Advisory Services

The PFZ advisories provide information on the likely availability of fishes based on the Sea Surface Temperature derived from NOAA-AVHRR and Chlorophyll from OCM-Oceansat1. The SST and Chlorophyll data received at INCOIS are analysed for identification of Potential Fishing Zones (Nayak et. al., 2007). The identified features are delineated as PFZ lines and overlaid on the base maps. The PFZ maps are translated in to PFZ text, which gives information about the latitude, longitude and depth of shelf at specific locations as well as angle, direction and distance from the landing centres/light houses. ERDAS Imagine software is used for generation of PFZ data, maps, shape files, SST and Chlorophyll images in GeoTIFF and generic binary formats. These file are loaded in to Database Server and Web Server for providing web-based services. PFZ advisories are generated thrice a week and published on the website with interactive Web-GIS interface.

The multi-lingual advisories are available in 10 languages (English, Hindi, Gujarati, Marathi, Kannada, Malayalam, Tamil, Telugu, Oriya and Bengali) for approximately 400 nodes distributed in 12 Sectors along the Indian coastline including Islands. The GIS layers include Bathymetry, Light Houses, Landing Centers, Sectors, PFZ Lines. The vector coverage of the PFZ advisories, images of Sea Surface Temperature and Chlorophyll are also available on web.

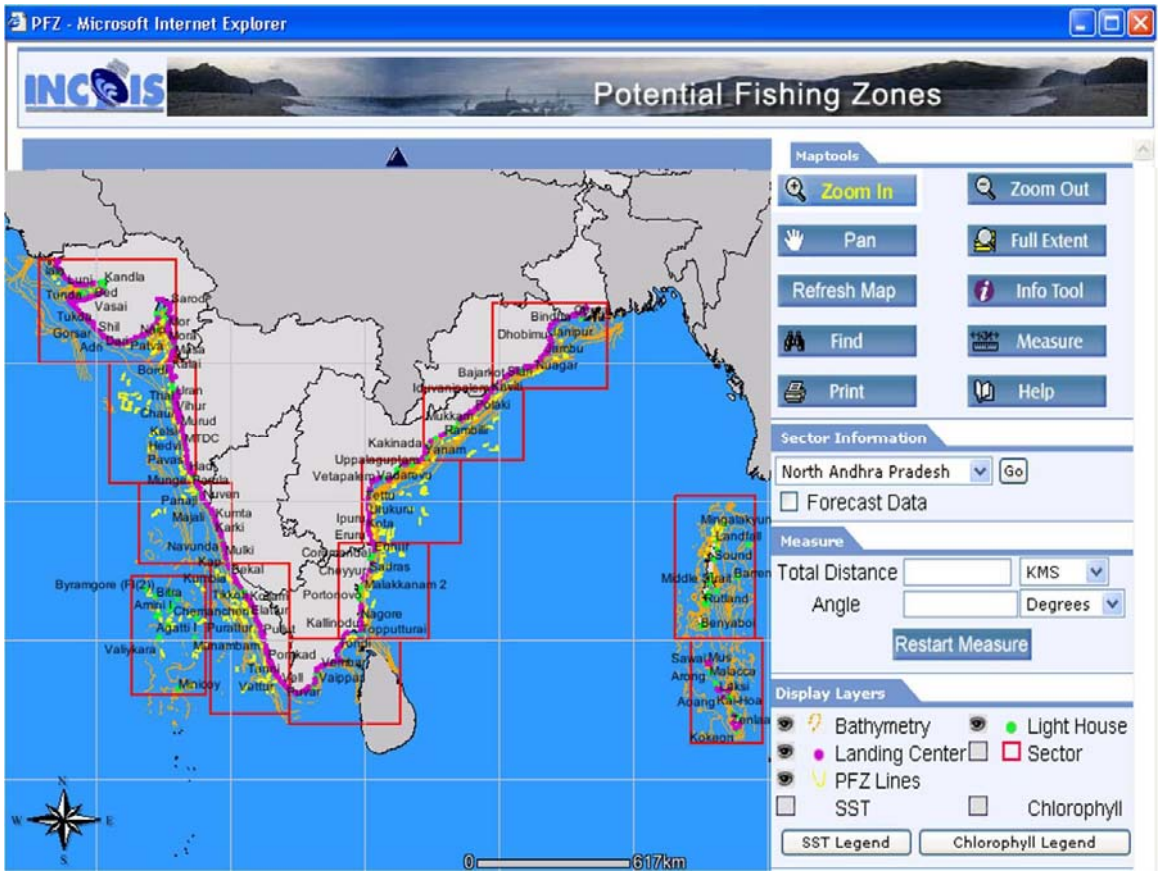

Figure 5. Interactive Web-GIS page providing Potential Fishing Zone information

3.3 Ocean State Forecast

Reliable forecast of the ocean state is vital to the shipping, fishery, offshore industries, ports and harbours as well as to navy and coast guards for the safe travel and operation in the sea. The sea surface wind fields forecast by National Centre for Medium Range Weather Forecast (NCMRWF) provide input for driving the Wave Model (WAM 3 GC) to forecast wave parameters.

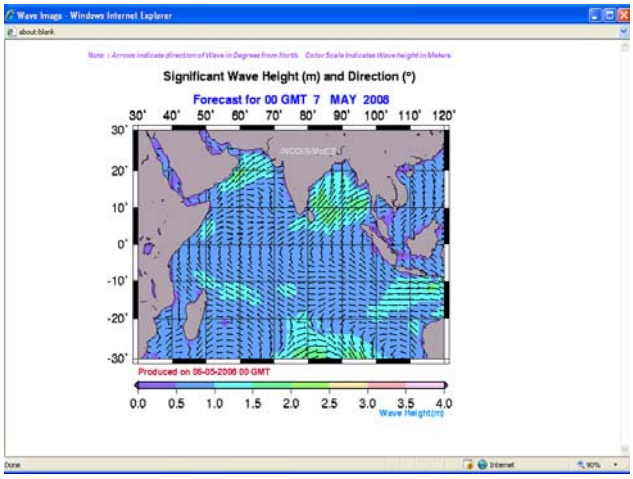

Figure 6. Ocean State Forecast product of Significant Wave Height

The Ocean State Forecast products (wave and swell parameters) are being generated using WAM Model for the next five days at six hourly intervals at 150 km spatial resolution for the tropical Indian Ocean. The forecast is disseminated through INCOIS web-site and also by e-mail to the users. The products are available in text and image formats and uses Web-GIS facility to the user for interactive selection of the forecast products.

3.4 Argo

Argo is a global array of free-drifting profiling floats that enable continuous monitoring of the temperature, salinity, and velocity of the upper ocean up to 2000 m depth, with all data being relayed and made publicly available within hours after collection. As part of the International Argo Programme in the Indian Ocean, 160 floats were deployed by India and 817 floats were deployed by various other countries.

The web-interface with Web-GIS features display the distribution and status of Argo floats deployed by different countries in the Indian Ocean. The Web-GIS features also allow the users to see the float information, selection of float by id and country, query with desired time, depth and parameters, and download required data in ASCII format. It also provides tools for measuring distance among the floats, selection of floats in group. The GIS layers include active floats, inactive floats, total floats and trajectory of the floats. Regional Coordination of Argo float deployment in the Indian Ocean is done through web-interface.

The Argo value added data products available on INCOIS Website are listed below.

Float-wise data products: Water Plot of Temperature, Water Plot of Salinity, Temperature vs. Salinity Plot, Time Series Surface Temperature, Time Series Surface Salinity, Time Series Surface Pressure, Time Series Bottom Pressure, Float Trajectory.

Monthly data products: Temperature, Salinity and Geostrophic Currents data products are available at 0, 75, 100, 200, 500, 1000m depths, Mixed Layer Depth, Isothermal Layer Depth, Depth of 20° Isotherm, Depth of 26° Isotherm, Heat Content, Dynamic Height, Sea Surface Height Anomaly.

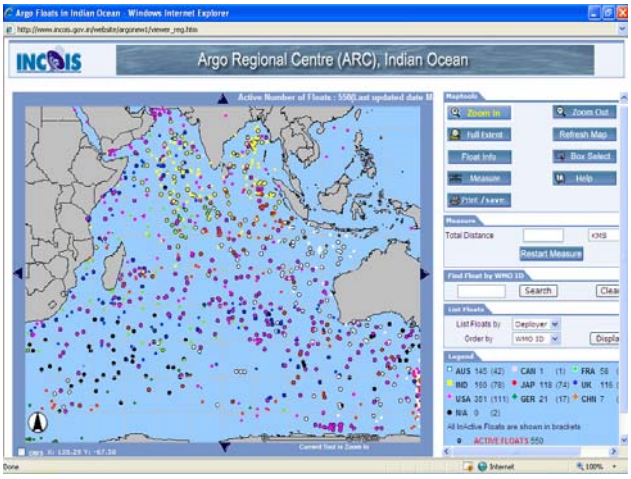

Figure 7. Interactive Web-GIS page displaying distribution and status of Argo floats

3.5 Web Statistics

INCOIS website (www.incois.gov.in) has been widely used website among wide spectrum of users and scientific community. The web Statistics for the period Jan-Dec 2007 are given in the Table 4.

Web Page	Visitors	Page Views
INCOIS Home Page	1,940	9,839
PFZ Home Page	2,637	7,903
PFZ Forecast	2,859	20,033
PFZ Web GIS	543	18,673
OSF Home Page	1,553	4,183
OSF Forecast	1,503	6,015
OSF Web GIS	1,187	4892
Argo Home Page	1,832	6,165
Argo Data Products	593	2,105
Argo Web GIS	1,315	3,987
IOGOOS Home Page	1,170	2,649

Table 4. Webpage statistics

4. OPEN STANDARDS AND INTEROPERABILITY

Open standards and interoperability are being widely used for the land based GIS applications and now gaining wider acceptance in marine community. The recent international projects in ocean sciences deals with compliance with open standards and interoperability for exchange of the data.
INCOIS joined the Ocean Science Interoperability (Ocean IE) Project evolved by the Open Geospatial Consortium (OGC)

(http://www.opengeospatial.org/projects/initiatives/oceansie), in its early stages to play a major role in developing open standards and addressing the interoperability issues. These developments certainly facilitate enormous potential for sharing oceanographic and meteorological data with common standards for providing web-based and location based services.

Live Access Server: The Live Access Server (LAS), a highly configurable web server designed to provide flexible access to geo-referenced scientific data (http://ferret.pmel.noaa.gov/Ferret/LAS/). LAS use the Open-source Project for a Network Data Access Protocol (OpenDAP) and Distributed Ocean Data System (DODS) technology. The LAS allows the user to download and visualize data using a simple graphical user interface.

LAS enable the data provider to (i) unify access to multiple types of data in a single interface, (ii) create thematic data servers from distributed data sources, (iii) offer derived products on the fly (iv) remedy metadata inadequacies (poorly self-describing data), (v) offer unique products (e.g. visualization styles specialized for the data).

LAS enable the Web user to visualize data with on-the-fly graphics, request custom subsets of variables in a choice of file formats, access background reference material about the data (metadata) and compare variables from distributed locations.

The LAS was implemented at INCOIS to serve the gridded data products in net common data format (netCDF) that is widely used by the oceanographic community. The LAS at INCOIS serves the ocean scientific community with the data following data sets:

- ARGO Data Products: Temperature and Salinity at 20 levels – 10 Days and Monthly.
- Quickscat Daily Data Products: Meridional wind stress component, Wind stress curl, Wind stress magnitude, Zonal wind stress component.
- Quickscat Monthly Data Products: Meridional wind speed component, Wind speed module, Zonal wind speed component.
- Sea Surface Height Anomaly: 10 Day Composite.
- TMI 3 Day Composite Data Product: Sea Surface Temperature
- TMI Monthly Data Products: Atmospheric Water Vapour, Cloud Liquid Water, Rain Rate, Sea Surface Temperature, Surface Wind Speed using 11 Ghz channel, Surface Wind Speed using 37 Ghz channel.
- Levitus Climatology: Temperature and Salinity at 18 levels.

The LAS is emerging as a promising web application for providing oceanographic data and addressing open standards and interoperability issues.

5. CONCLUSIONS

The Ocean Data and Information System, an end-to-end system was designed for data acquisition, processing, quality control, and database generation for providing web-based ocean data, information and advisory services.
A state-of-the-art database driven user friendly dynamic website with multilingual capability, Web-GIS facilities for providing ocean information and advisory services such as PFZ, OSF, Argo data and products, etc. was developed. INCOIS Website (www.incois.gov.in) has been matured as a prime vehicle for delivery of ocean data, information and advisory services. Location based services are the need of the hour.

We have initiated the development of data warehousing and data mining concepts to improve the functionality of the website and maintain a centralized repository of enterprise data.

REFERENCES

Dragicevic, S., 2004. The potential of Web-based GIS. *Journal of Geographical Systems*, 6 (2), pp. 79–81.

Hansen, D.V., and Marie Poulain, P., 1996. Quality control and interpolation of WOCE/TOGA drifter data. *Journal of Atmospheric and Oceanic Technology*, 13, pp. 900-909.

Live Access Server, http://ferret.pmel.noaa.gov/Ferret/LAS/.

Markstrom, S.L., McCabe, G., and David, O., 2002. Web-based distribution of geo-scientific models. Computers and Geosciences, 28, pp. 577–581.

MEDI: The IOC Metadata System. Software User Manual, *IOC User Manual, UNESCO 2002.*

Nayak, S., Kumar, T. S., and Kumar, M.N., 2007. Satellite-based fishery service in India. *The Full Picture*. Group on Earth Observations, Geneva, Switzerland, pp. 256-257.

NDBC Technical Document 03-02, 2003. Handbook of Automated Data Quality Control Checks and Procedures of the National Data Buoy Center.

OGC Ocean Science Interoperability Experiment, http://www.opengeospatial.org/projects/initiatives/oceansie.

Tsou, M. H., 2004. Integrative Web-based GIS and image processing tools for environmental monitoring and natural resource management. *Journal of Geographical Systems*, 6(2), pp. 155–174.

Udaya Bhaskar, T.V.S., Devender, R., and Ravichandran, M. 2007. Technical Report on Argo Data Processing.

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