
PRACTICE PAPER

Marine Data Services at National Oceanographic Data Centre-India

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In this paper we introduce about the marine data archived at Indian National Centre for Ocean Information Services (INCOIS), Ministry of Earth Sciences, India. Heterogeneous data from in situ, remote sensing and ocean models are archived. In-situ ocean observations includes data from Lagrangian as well Eulerian platforms like Argo floats, moored buoys etc, while remote sensing include data from NOAA satellite series, OceanScat etc. The data generated is translated into ocean information services through analysis and modelling. Data is disseminated to users using variety of means like web with GIS features, ERDDAP, Live Access server with facilities to search, visualize and download.

Keywords: Ocean data services; in situ; remote sensing; Web-GIS; Live Access Server; INCOIS

1 Introduction

The Indian National Centre for Ocean Information (INCOIS) was established as an autonomous body in 1999 under the Ministry of Earth Sciences (MoES), Govt. of India. Ever since its inception, INCOIS has been playing a key role in providing ocean data, information and advisory services to society, industry, government and scientific communities through sustained ocean observations. Part of this service includes constant improvements through systematic and focused research.

A network of ocean observing systems covering both open and coastal oceans and including both in-situ and remote sensing instruments, has been established in the Indian Ocean by various agencies under MoES. These observing network provides data on various oceanographic and surface meteorological parameters in real-time. INCOIS, being the central repository for marine data in the country, receives data from these ocean observation systems in real/near real time as well as in delayed mode. In addition to these, large amount of historical data are also obtained from all possible sources (for example, web, individual scientists, programme offices, etc.) and archived at INCOIS. Strong organizational links established with various agencies involved in ocean observational programs, ensure constant flow of marine data to INCOIS. Communication network set up at INCOIS ensures real time data reception from in-situ platforms like Argo floats, moored buoys, drifting buoys, tide gauges, tsunami buoys, wave rider buoys and ship mounted automated weather stations (AWS) etc. The communication network mainly makes use of the Indian geosynchronous satellites, INSAT, and for special cases, the Argos satellite system.

The data centre at INCOIS is bestowed with the authority by MoES, to acquire all data pertaining to the marine environment collected through various national or regional programmes. INCOIS receives the data from a suite of sensors and in situ platforms from heterogeneous sources. Such data received from different sources and platforms are processed and quality controlled following international standards (for example, Argo profiling data using Argo Data Management Team directives, drifting buoy program data using Hansen and Poulain, 1996; XBT data using CSIRO cookbook, Bailey et al., 1994). The quality flagged data are then archived for dissemination and also used in generation of value added data products. The Data Centre also maintains the inventory of metadata and publishes it on the web site for the benefit of users. These processed data sets and derived products are made accessible to various users following National Data Policy

(NDSAP, 2012). The data holding at INCOIS are classified as open and restricted and any data within the Exclusive Economic Zone (EEZ) is generally restricted for users. However this data is shared with researchers of Indian origin with an undertaking that the data will be specifically used for research purpose only and will not be shared with any others. All commercial users are charged based on the parameter of interest and duration of data sought. Request from foreign nationals are put up for approval by committee of members formed by Director, INCOIS. Further the data centre at INCOIS is also responsible for international data exchange. Data from platforms like Argo floats, drifting buoys, Moored buoys are all shared with international community in terms of sharing the data on GTS and Global Data Archival Centres (GDAC) with the involvement in programs like International Argo program, Oceansites etc. INCOIS has been identified by the IODE/IOC to host the mirror site of OBIS which publishes primary data on marine species locations. The quality control procedures, standards and format specified by the international community for all these data sets are duly followed and the data is exchanged with the community.

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

2 Data holding and dissemination mechanisms

Figure 1 shows the types of data sets archived and served to the end users as a part of marine data services from INCOIS. The data sets are classified into three categories viz., in situ, Remote Sensing and Models outputs. Some historical data sets and maps which are obtained as a legacy from parent organization at the time establishment of INCOIS are also archived. These historical data sets are clubbed along with other in situ measurements and used in re-analysis products. The maps are digitized and are used for applications related to fisheries. **Table 1** lists the data archived at INCOIS that includes the data collected during specific programmes, permanent observation platforms, moving platforms like satellite tracked drifters, ships etc, remote sensing and model reanalysis data. While the in situ data is available in the form of individual observations scattered around the ocean, Remote Sensing and Model outputs are available on regular grids. The variety of data received at multi dimensions and time scales presents a challenge in their archival and retrieval. Often, the same parameter obtained from different platforms/sensors needs to be archived together for easy retrieval and analysis. Based on the type of data, different dissemination mechanism is chosen to serve the end user. The dissemination mechanism along with the type of data is provided in **Table 2**.

2.1 Ocean Data and Information System (ODIS)

To deal with heterogeneous type of in situ data sets and to allow easy retrieval and analysis facilities, the Ocean Data and Information System (ODIS) has been set up to act as a one stop shop for in situ data and information with varying parameters from open oceans and coastal regions being displayed and delivered as per the data policies. Elements of the ODIS set up at INCOIS is shown in **Figure 2**. ODIS was designed and developed using open access data management and web access tools like MySQL, UMN MapServer and

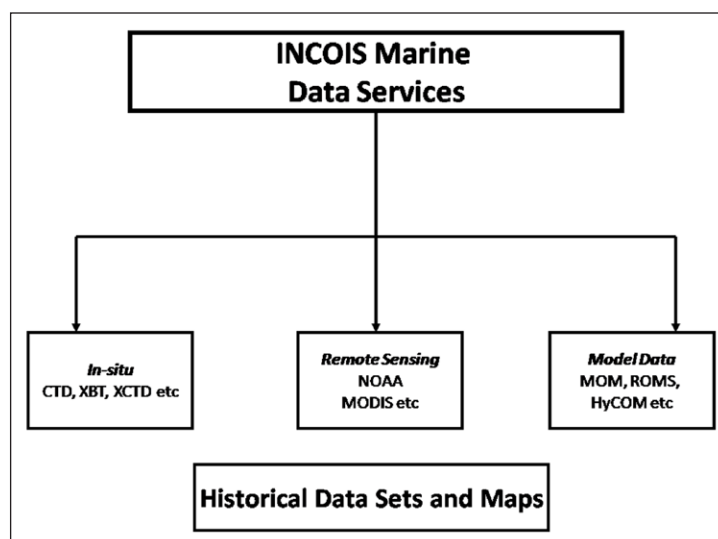


Figure 1: Types of data sets archived and served at INCOIS.

Table 1: List of various data holdings archived at INCOIS for dissemination to end users.

Type of Data	Parameters
In situ <ul style="list-style-type: none"> • Argo (http://www.incois.gov.in/argo/argo.jsp) • Moored buoys (www.odis.incois.gov.in) • Drifting buoys (www.odis.incois.gov.in) • Tide gauges (www.odis.incois.gov.in) • Bottom pressure recorders (www.odis.incois.gov.in) • XBT observations (www.odis.incois.gov.in) • Current meters (www.odis.incois.gov.in) • HF Radars (www.odis.incois.gov.in) • Automatic Weather Stations (www.odis.incois.gov.in) • Wave Rider Buoys (www.odis.incois.gov.in) • Wave Height Meter (www.odis.incois.gov.in) • CTD (www.odis.incois.gov.in) • Coastal Ocean Monitoring and Prediction System (http://www.incois.gov.in/portal/comaps/home.jsp) 	<ul style="list-style-type: none"> • Temperature and salinity • Air pressure • air temperature • wind speed and direction • water temperature • wave height and direction • current speed and direction • Wave parameters • SST and Air Temperature • Atmospheric Pressure • Sea Surface Currents • Sea Level • Pollution monitoring along the coast.
Remote Sensing <ul style="list-style-type: none"> • MODIS/Terra and Aqua (las.incois.gov.in) • OCM-1&2/Oceansat-2 (las.incois.gov.in) • Altimeter/TOPEX • TMI/TRMM-TMI (las.incois.gov.in) • Quicksat & ASCAT (las.incois.gov.in) • SeaWifs 	<ul style="list-style-type: none"> • Sea surface temperature • Chlorophyll • Wave height • Sea level • Rainfall • Wind speed and Wind vector
Ocean Models <ul style="list-style-type: none"> • Simple Oceanographic Data Assimilation (SODA) • Joint Environmental Data Analysis Centre (JEDA) • National Centre for Environmental Prediction (NCEP) • CPC Merged Analysis of Precipitation (CMAP). • WW3 analysis products. • various parameters from MOM and ROMS models. 	<ul style="list-style-type: none"> • Ocean currents • Temperature and salinity • Depth of 20 deg Isotherm • Mixed Layer Depth • Isothermal Layer Depth • Rainfall • Wave parameters

Table 2: Methods employed for dissemination of data and value added products by INCOIS.

Type of data	Dissemination method	URL for access
In situ	Ocean data and information system and ERDDAP	http://odis.incois.gov.in and http://erddap.incois.gov.in/erddap/tabledap/Indian_ARGO_Floats.graph?longitude%2Clatitude%2CCYCLE_NUMBER&time%3E=2017-08-21T00%3A00%3A00Z&time%3C=2017-08-28T00%3A00%3A00Z&longitude%3E=20&longitude%3C=150&latitude%3E=-70&latitude%3C=30&.draw=markers&.marker=5%7C5&.color=0x000000&.colorBar=%7C%7C%7C%7C%7C&.bgColor=0xffccccff
Remote Sensing data	Web services and Live Accesses Server and ERDDAP	http://www.incois.gov.in/portal/remotesensing/TERA_display.html and http://las.incois.gov.in/las/UI.vm#panelHeaderHidden=false;differences=false;autoContour=false;xCATID=AVHRR-AMSR-ID;xDSID=id-5bcbfeb022;varid=sst-id-5bcbfeb022;imageSize=auto;over=xy;compute=Nonetoken;zlo=0;zhi=0;tlo=01-Jun-2002%2000:00;thi=01-Jun-2002%2000:00;catid=AVHRR-AMSR-ID;dsid=id-5bcbfeb022;varid=sst-id-5bcbfeb022;avarcount=0;xlo=20.125;xhi=139.88;ylo=-29.875;yhi=29.88;operation_id=Plot_2D_XY_zoom;view=xy http://erddap.incois.gov.in/erddap/griddap/AMSR2_3Day_Global.graph
Model outputs	Live Access Server	http://las.incois.gov.in

OpenLayers (Mapserver Team, 2013). It thus serves as an end-to-end ocean data management system (Shesu et al., 2013).

2.2 Data services through Live Access Server (LAS)

While ODIS is used to disseminate unstructured in situ observations, Remote Sensing and Model data which are in regular grids are served using Live Access Server (LAS). Also value added products derived from the in situ observations using objective analysis (eg: gridded product of Argo profile data; Udaya Bhaskar et al., 2007) is made available via the LAS. The data sets are quality controlled using a three way quality control process, (Udaya Bhaskar et al., 2012) before they are used in generation of value added products. The resulting value added products, model generated data sets, remote sensing data are updated regularly as and when the data are available. **Table 3** provides the data made available through the INCOIS LAS. A snapshot of products available on Live Access Server is given in **Figure 3**. Live Access Server is designed to provide flexible access to geo-referenced scientific data (Devender et al., 2013). A LAS that uses the Open-source Project for a Network Data Access Protocol (OpenDAP) and Distributed Ocean Data System (DODS) technology allows the user to visualize, download, and even perform the preliminary analysis of data in a graphical user interface. The preliminary analysis include generation of area averages, time series plots pertaining to any desired location, generation of hovmoller plots, scatter plots of different parameters, anomaly plots, multi-parameter view etc.

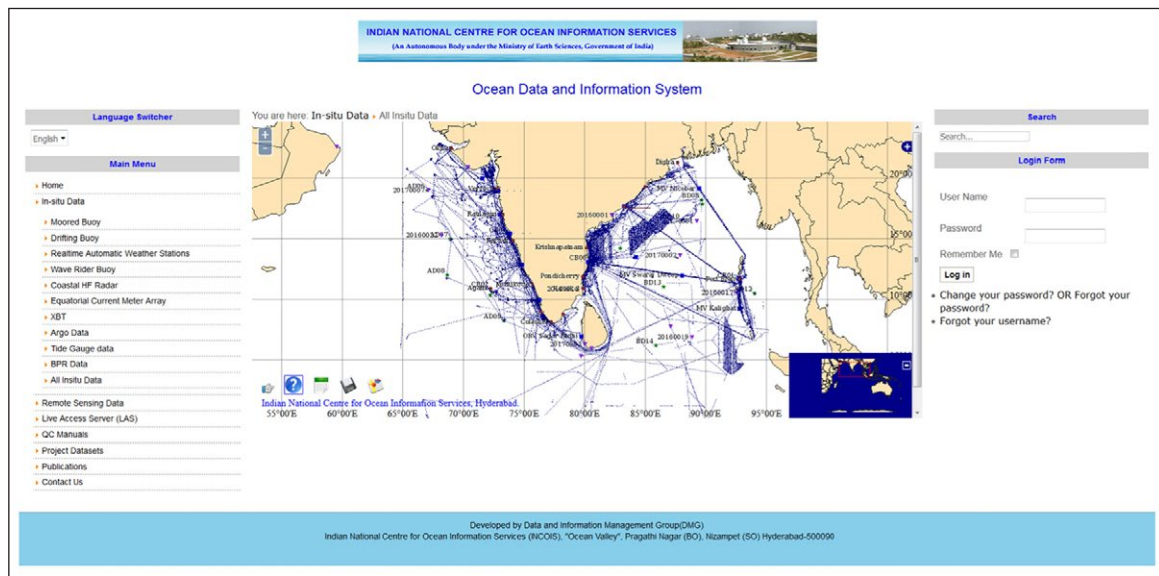


Figure 2: Ocean Data and Information System at INCOIS for dissemination of in situ data (Shesu et al., 2013).

Table 3: Products available on INCOIS Live Access Server (las.incois.gov.in).

Product	Availability Period
Objectively Analyzed Argo (10 days & Monthly)	Jan 2002–Till date
AMSRE (3 day & monthly)	June 2002–Till date
NOAA High resolution SST	Sep 1981–Till date
NOAA SST (INCOIS ground station)	2008–Till date
WHOI Air – Sea Fluxes	Jan 1985–Jul 2010
OCEAN Analysis (MOM –GODAS)	Jan 2003–Jun 2011
Ocean Color Monitor (OCM1)	Jan 2003–Apr 2006
QuikScat Wind products	Aug 1999–Nov 2009
TMI (3 day and monthly)	Jan 1998–Till date
ASCAT wind products	November 2008–Till date

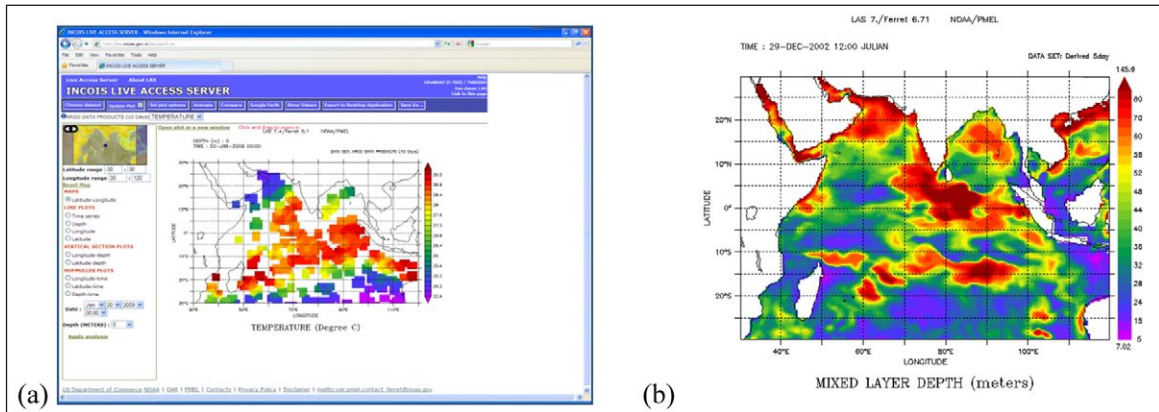


Figure 3: Data products on INCOIS Live Access Server **(a)** Temperature (gridded) and **(b)** Ocean Analysis (MOM-GODAS) derived MLD.

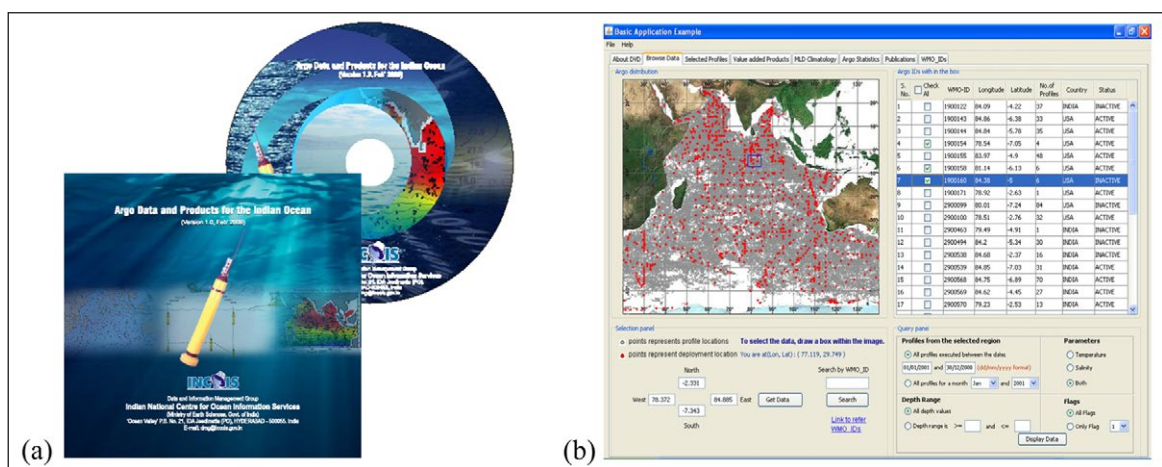


Figure 4: In situ data and data products as off line products from INCOIS.

2.3 Web-based data services

The advent of internet technology provided the user with easy and faster access to the available information with a mouse-click and the Geographical Information System (GIS) provided the capability for storing and managing large amounts of spatial data. A Web-GIS system combines the advantages of both internet and GIS technologies, allowing users to access the geospatial information and data via web-browsers without purchasing expensive, proprietary GIS software.

These web-based data services developed at INCOIS are now providing ocean data, information and advisory services using the Web-GIS technologies like Java, Java script, HTML, Arc-View and Arc-Info, UMN maps-erver (Rama Rao et al., 2009; Markstorm et al., 2002; Tsou, 2004), enabling the users to query, analyze, visualize and download ocean data, information and advisories for their regions of interest. The system also allows the integration of data from different sources and management.

2.4 Off line products via DVDs

Keeping in mind the users with lower bandwidth, INCOIS also serves data and data products in the form of DVDs (**Figure 4a**). Users are encouraged to register for the products and the product is supplied upon receipt of the registration form. Apart from the data, the DVD contains software with Graph User Interface which has similar feature to that of traditional Web GIS where in the user can search, query, visualize and download the data of his choice (**Figure 4b**).

The software is a Java-based application that provides the interface for the selecting in situ data from region of interest. The interface provided in DVD gives the users power to select data from any region of interest, view the profile plots, zoom and filter based on multitude of queries (Geetha et al., 2010). In addition to all these sometime the data sets which are huge in size are served through dedicated FTP. Users are given limited period access (generally 15 days) with in which they are required to download the intended data lest it will be automatically deleted from the FTP archives.

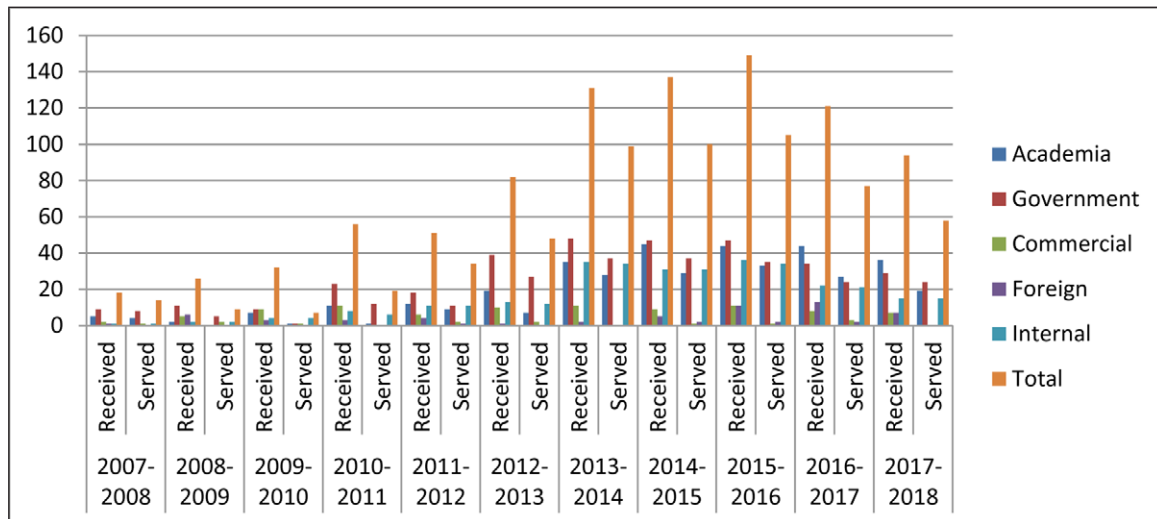


Figure 5: Distribution of the different types of requests processed since 2007.

2.5 Users of data

As mentioned in the introduction the users are classified as per the data type that is whether it is open or restricted data. For providing the data a user request form is provided to each user irrespective of whether is data open or restricted. All these request are archived for data auditing purpose. **Figure 5** gives the distribution of users viz., academia, government, commercial, foreign etc. From our experience it is known that these data requests are pertaining to very specific data sets like currents, wave parameters, coastal observation data which are of high value both commercially and from a research point of view. In addition to these hits, view and downloads from other sites like LAS, web sites, ERDDAP are also continuously monitored. This number is quite high and often runs into millions of hits.

There are many operational centers in the world providing valuable data pertaining to marine environment like Coriolis in France, BODC in UK, ICSWSE of Kyushu University Japan and many others. One thing unique with the NODC of India that is INCOIS is that it is providing wide range of heterogeneous data spanning in situ, model output, remote sensing, value added products derived from in situ etc in various data format and various dissemination mechanisms. All possible methods right from web dissemination to FTP to off line DVDs are employed with a single aim that the end users should be benefited with the use of this data.

3. Summary and conclusions

INCOIS, being the central repository for marine data in India, receives oceanographic data in real time as well as in delayed mode from various networks. INCOIS with strong organizational links with all the agencies involved in ocean observational programmes ensure constant flow of data to its centre. Once all the data pertaining to the marine environment are archived, INCOIS is bestowed with the authority to process it uniformly, perform quality check, archive and disseminate it in the form of data and data products in accordance with India's national data policy. The data archived at the centre are divided into three categories viz., in situ, Remote sensing and model outputs. Different modes of dissemination based on the type of data is chosen. ODIS and LAS/ERDDAP are chosen to disseminate in situ and data in regular grid format respectively. INCOIS, through its data management activities, plays a vital role in many areas critical to the study of climate change, marine resources. Its links to international programs ensures that the Indian data is available for global models, thereby strengthening these models and also allows Indian researchers to access these global datasets, in turn strengthening their research outcomes.

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Competing Interests

The authors have no competing interests to declare.


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