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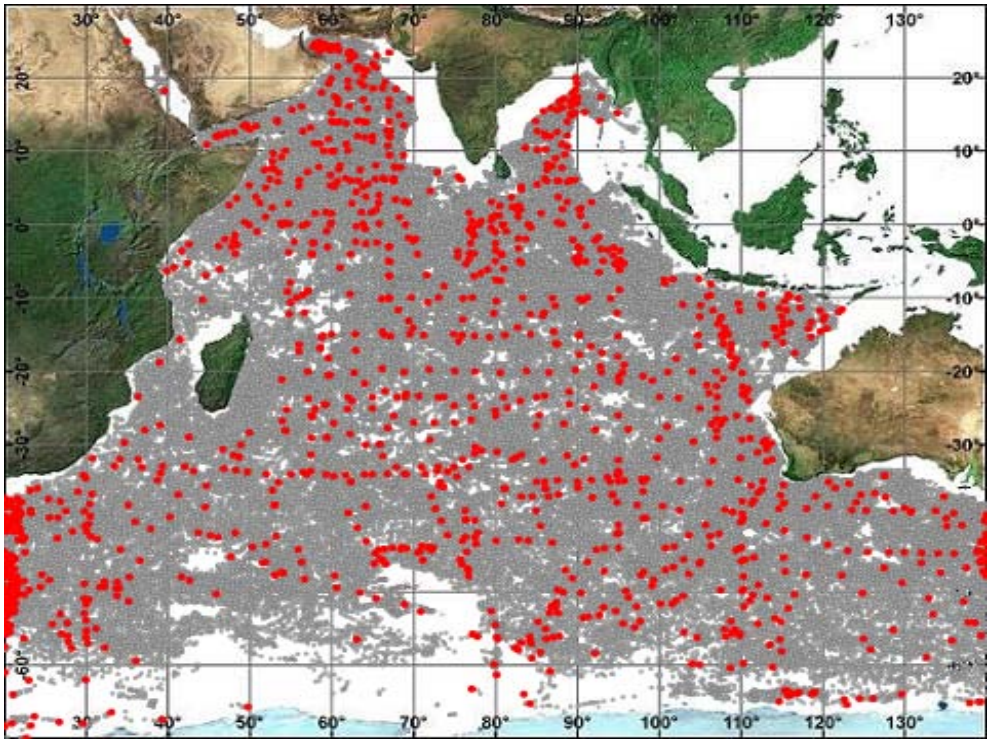

ARGO DATA AND PRODUCTS FOR THE INDIAN OCEAN

By

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11. **Abstract**

Argo is an internationally coordinated activity aimed at characterizing both the temperature and salinity structure of the mid- and upper-ocean through deployment of autonomous profiling floats and making the data available to users with in 24 hrs of reception. To cater to wide users of oceanographic data, mainly from the universities, who lack high bandwidth internet connections, an Argo Data Explorer (ADE) on Argo data and products for the Indian Ocean is prepared. ADE is a Java-based application that provides the interface for the selecting Argo temperature and salinity profiles from region of interest. In addition to the Argo data, value added products obtained from temperature and salinity profiles are also included. 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. Users lacking high-speed network for downloading the Argo data, can order for a copy of the DVD.

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Abstract

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1. INTRODUCTION

Many researchers at universities and organizations in India, involved in oceanographic research are facing problems with inadequate technical facilities to accumulate diverse in situ data sets. The ability of the researchers to work productively with large data and diversified datasets has been limited by difficulties related to network transfer or significant subsets of the data for specific observations or data characteristics of interest. This report describes in detail a product released by Data and Information Group (DMG) at Indian National Centre for Ocean Information Services ((INCOIS). To cater to wide variety of users with out high-speed network access, a DVD on "Argo and Product for Indian Ocean" that contain temperature and salinity (T/S) profiles obtained from Argo profiling floats in the Indian Ocean is compiled. Also all the required software for accessing and analyzing the data is also provided. This product is released mainly keeping the interest of remote users with low band width internet connections in mind.

Argo is an internationally coordinated activity directed at characterizing both the T/S structure of the mid- and upper-ocean and the advective field at mid-depth through deployment of autonomous profiling floats (Argo Science Team, 2001; Ravichandran et al., 2004). It is envisioned that the resulting T/S profiles will be used to:

- Initialize climate forecast models,
- Detect and attribute climate change effects on the ocean,
- Calibrate/validate satellite altimetric data, and
- Increase understanding of the ocean and its role in global climate.

These objectives demonstrate that Argo data are to be utilized by both operational and research communities.

Argo collects T/S profiles from a sparse (average 3° x 3° spacing) array of robotic floats that populate the ice-free oceans that are deeper than about 2000m. These floats also give information on the surface and subsurface currents. Each profile is made up of about 45 – 75 data points. The first Argo floats were deployed in 2000 and it reached its target of 3000 floats in Global ocean by mid 2007. Argo data are made available to users quickly and free of restriction with in 24 hrs of data reception.

2. About the Product

To cater to wide users of oceanographic data, mainly from the universities, who lack high bandwidth internet connections, an Argo Data Explorer (ADE) on Argo data and products for the Indian Ocean is prepared. ADE is a Java-based application that provides the interface for the selecting Argo temperature and salinity profiles from region of interest. In addition to the Argo data, value added products obtained from temperature and salinity profiles are also included. 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. Users lacking high-speed network for downloading the Argo data, can order for a copy of the DVD.

The DVD on "**Argo Data and Products for Indian Ocean**", is developed by the Data Management and Information Group (DMG) of the Indian National Centre for Ocean

Information Services (INCOIS), Hyderabad, India. The DVD contains 116593 temperature and salinity profiles, obtained from 1275 Argo floats deployed by India and other countries in the Indian Ocean (20°E – 140°E and 70°S – 30°N) during January, 2001 – December, 2009 excluding profiles in the Exclusive Economic Zone (EEZ). The interface provides the selection of the region to extract the data and graphical representation of the temperature and salinity of the selected profiles, statistics of the data and various value added products.

In addition this DVD contains:

- Objectively analyzed Value Added Products (gif images) as listed below:
    - Temperature, Salinity and Geostrophic Currents (0, 75, 100, 200, 500, 1000 M depths).
    - Heat Content up to 300 M.
    - Mixed Layer Depth, Isothermal Layer Depth.
    - Depth of 20° and 26° Isotherms.
    - Dynamic Height.
- MLD Climatology
    - Mixed Layer Depth
    - Median Deviation
    - Anomaly
    - Data Density
- Argo statistics

- Floats deployed against survived
- Year wise floats
- Year wise profiles
- Age of floats
- Floats position
- Density maps

❖ Temperature Salinity plots

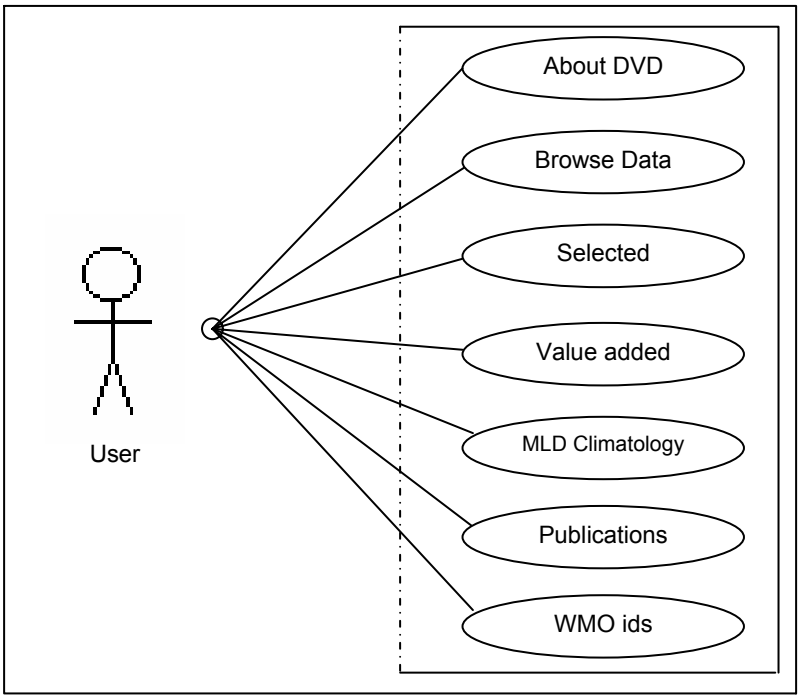


Fig 1: "Use Case" modeling for Argo DVD.

3. METHODOLOGY

This ADE application is developed using Java, Swings with NetBeans IDE, JFreeCharts, SVG, HTML and MS Access database. Fig 1 shows the contents of the DVD as viewed by the user. DVD opens up giving the information pertaining to the DVD. Various frames like Browse Data, Selected data, Value Added Products, MLD Climatology, Publications and WMOIDs list are all provided as multiple tabs for the user. The user can switch to the tab of his choice. The detailed activity diagram is shown in Fig 2.

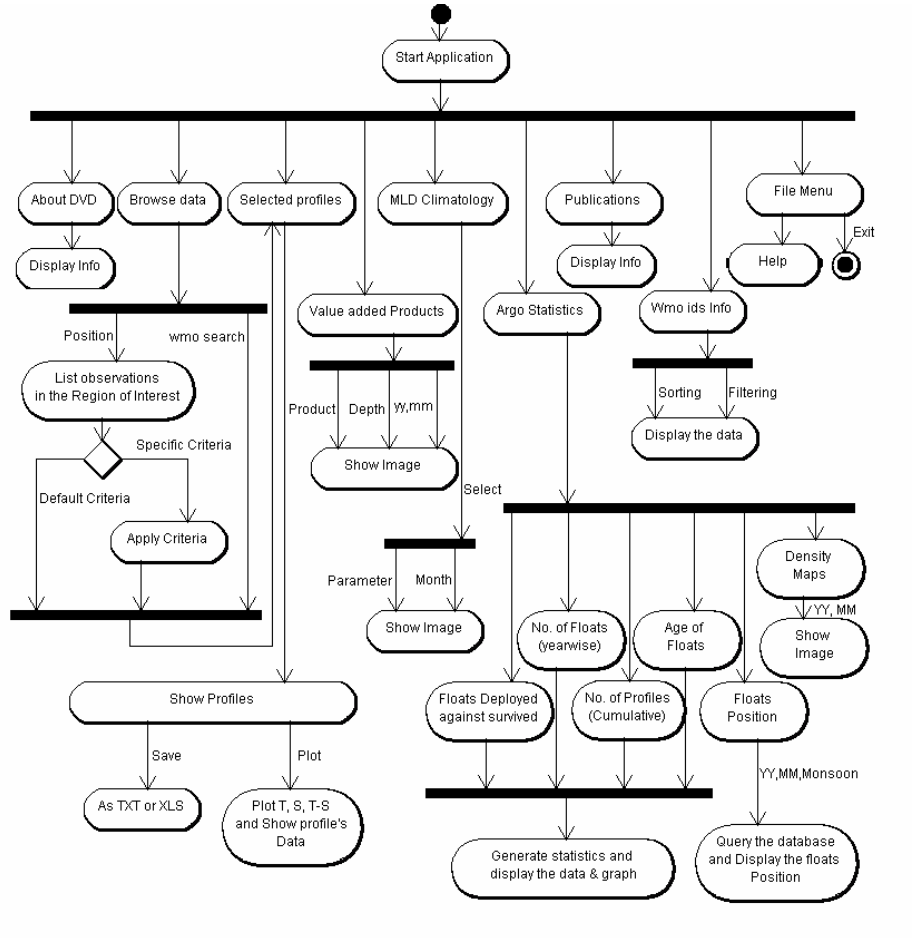


Fig 2: "Activity Diagram" for Argo DVD.

4. DVD Components

The DVD is designed keeping the "end users" in mind. The DVD can be easily traversed with unified search, discovery for accessing Argo profiles data. The disc is structured using the following directory hierarchy:

The top-level key files are as follows:

a. README.txt - This file contains a description of this disc.

c. argo.bat - This file is used to open the main menu of the ARGO project in Windows environment or in DOS.

In addition there are five directories:

a. \DBASE - This directory contains database of Argo profiles, Objectively analyzed grided products (NetCDF format) and MLD_climatology (NetCDF format).

b. \DOCUMENTS - This directory contains Quality Control processing manuals and the manual describing the objective analysis methodology used for generating values added products.

c. \HTMLPAGES - This directory contains supporting html pages of the application.

d. \SOFTWARES - This directory contains ncbrowse software to view the objectively analyzed NetCDF files.

e. \LIB - This directory contains supporting library files to run the application.

f. \JRE - This directory contains Java Virtual Machine to run the application.

4.1 Database structure

All the temperature and salinity profiles obtained from the Argo floats are organized in to table for each access. The table structures are defined as :

Table #1 : Argo_details_yyyy

Column Name	Data Type
ad_observation_id	Text
depth	Number
depth_flag	Number
temperature	Number
temperature_flag	Number
salinity	Number
salinity_flag	Number
density	Number
density_flag	Number

Table #2 : Argo_observations

Column Name	Data Type
ao_observation_id	Text
ao_wmo_number	Number
latitude	Number
longitude	Number
date_of_datasent	Date/Time
argo_indicator	Number

Table #3 : Argo_gen_info_table

Column Name	Data Type
agi_wmo_number	Number
agi_start_lat	Number
agi_start_long	Number
agi_dep_nation	Text

Table #4 : ids_info_table

Column Name	Data Type
wmo_id	Number
first_obs_date	Date/Time
latitude	Number
longitude	Number
no_of_profiles	Number
status	Text
deployed_country	Text

To access the data by using ADE, we need the following data tables.

1. Argo_details_yyyy : which contains the observation's data, where 'yyyy' represents the year (2001 to 2009). This year wise separation of the observation's data is useful in managing the data easily.
2. Argo_observations : which consists of the observation details.
3. Argo_gen_info_table : consists of metadata of the argo floats.
4. ids_info_table : is derived from the Argo_observations table and Argo_gen_info table. Which consists of the float's first observation's date and its lat, lon position, number of profiles it executed and the status of the float whether it is active or inactive.

4.2 ARGO DATA EXPLORER

The ADE consists of several modules each represented in a tab (Fig 1). The following section describe in brief about each module represented by a separate tab as shown in use case diagram.

4.2.1. About DVD Tab

This shows information contined in the DVD and also the contact information. Any modifications required to this panel can be achieved by modifying an html file named about_dvd.html in the hlmlpages directory without recompilation of the entire application. Snapshot of the "About the DVD" tab is shown in Fig 3.

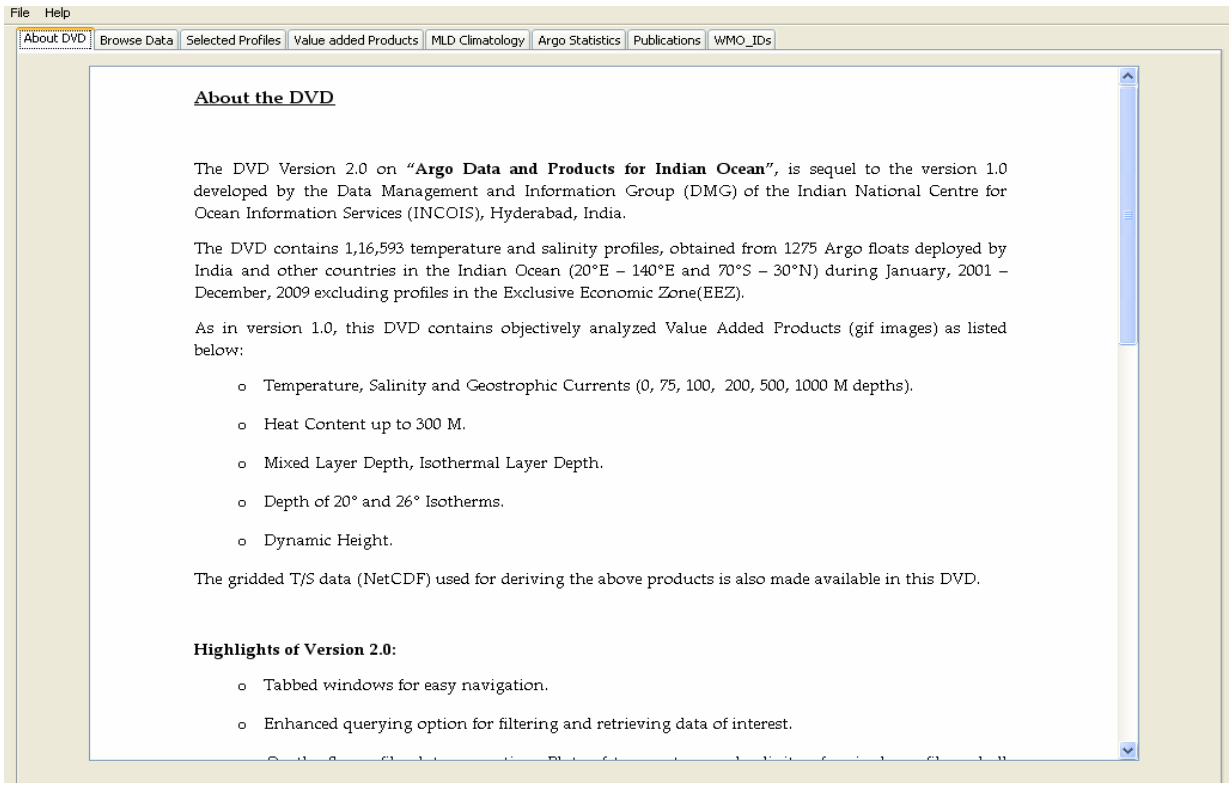


Fig 3 Snapshot of the "About the DVD" tab.

4.2.2. Browse Data Tab

At the start, (Fig 4, region 1) a panel showing all the Argo profile locations (in grey color) along with the first observation location (in red) is provided. This gives the user an idea about the Argo data density in the entire Indian Ocean. The Argo data distribution panel contains the image which is created by using image of Indian ocean region of 20E – 140E and 30N – 70S with the size 479 X 399. These points are imposed on the Indian ocean image by mapping the latitude, longitude positions to image coordinates using Scalable Vector Graphics (SVG). User can select data from this by specifying the region of his choice by drawing a box on the data density image or by entering the longitude and latitude information in the text boxes provided (Fig 4, region 2).

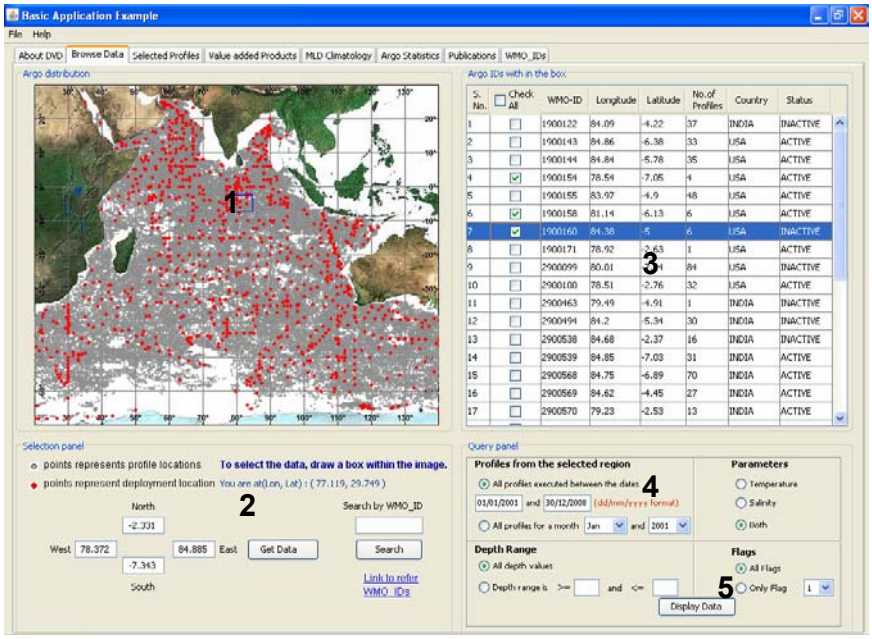


Fig 4. Panel showing the Argo profile locations, profile information falling in the region of interest, query panel.

The information about the profiles falling with in the region of interest will then be displayed in table with fields like WMOID, Longitude, Latitude, No of Profiles, Country, Status (region 3, Fig 4). Then the user can check against the checkboxes provided in conjunction with a variety of queries provided in the query panel (region 4, Fig 4) like Date range search, Depth range search, Parameter wise search, Flag wise search to display the data of interest from the selected floats.

4.2.3. Selected Profiles Tab

After, the "Display data" button is pressed in (Fig 4, region 5), the queries filter unwanted data and display the data of interest in detail in the "selected profiles" panel shown

in Fig 5. All the profiles pertaining to each Argo floats falling in the region of interest is shown in region 1, Fig 5. The temperature and salinity profile plot corresponding to a

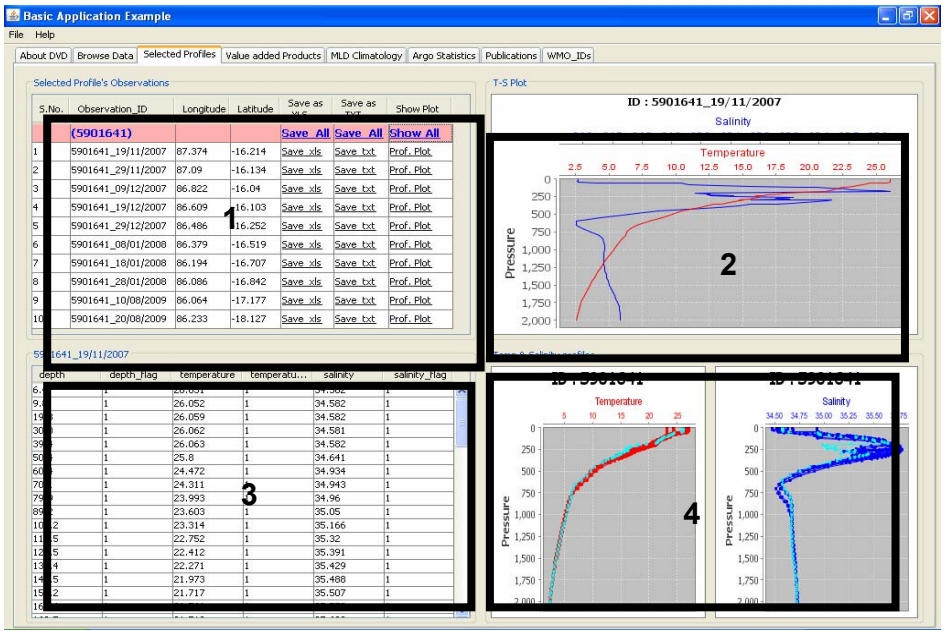


Fig 5. Panel displaying the information pertaining to the profiles falling with in the region of interest.

particular profile is shown in region 2, Fig 5. Data in ASCII format pertaining to a single profile selected is shown in region 3, Fig 5 along with the quality flags. All the temperature and salinity profiles for the Argo float in focus is shown in region 4, Fig 5. Profile with Cyan color represents the profile in focus. Zoom facility for having a closer look at the profiles is also provided.

Once the region of interest is selected and profiles are visually checked and one is satisfied about its quality one can save single or set of profiles in two format viz., text and

Microsoft XLS format (Fig 6). The later is provided such that user can recreate the profile plots for use with out much of a processing.

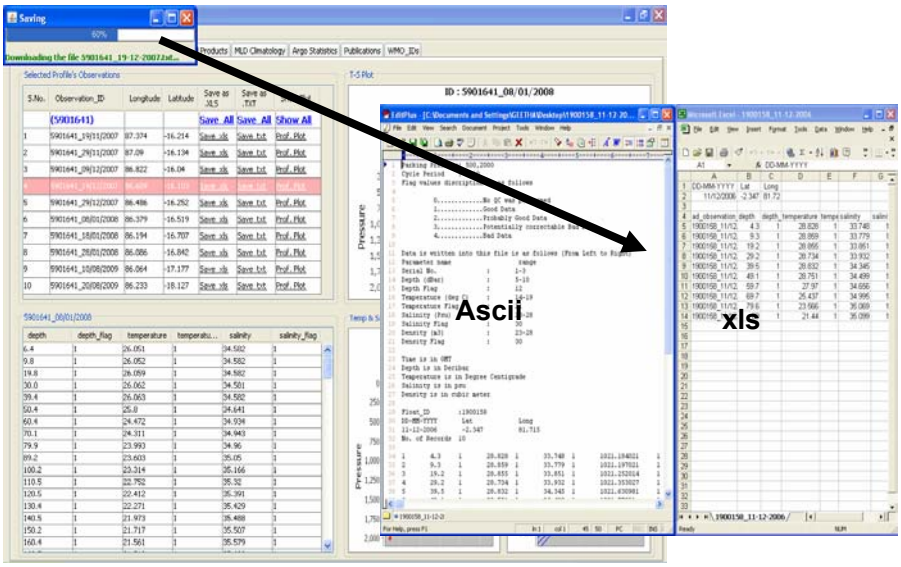


Fig 6. File save menu showing files being saved in the format based on users choice.

4.2.4. Value added Products Tab

Apart from the individual T/S profiles the DVD also contains objectively analysed products. The irregularly spaced Argo data is objectively analyzed on to 1° X 1° degree using Kessler and McCreary 1993 methodology. Two gridded products, on 10 day and monthly basis are available in NetCDF format. In addition various derived products based on the gridded products are also made available in GIF format. The full set of value added products available in the DVD are:

- Objectively analyzed Value Added Products (gif images) as listed below:
- Temperature, Salinity and Geostrophic Currents (0, 75, 100, 200, 500, 1000M depths).

- Heat Content up to 300 M.
- Mixed Layer Depth, Isothermal Layer Depth.
- Depth of 20° and 26° Isotherms.
- Dynamic Height.
- Gridded T/S product in NetCDF format for 10 days and monthly periods.
- MLD Climatology obtained from all the T/S profiles.
- Various Argo statistics
- Temperature Salinity plots.

GUI is provided for viewing the derived products of interest. Users can choose the parameters, depth, months and years of choice to view the desired products and save them on to their respective systems for use in research work.

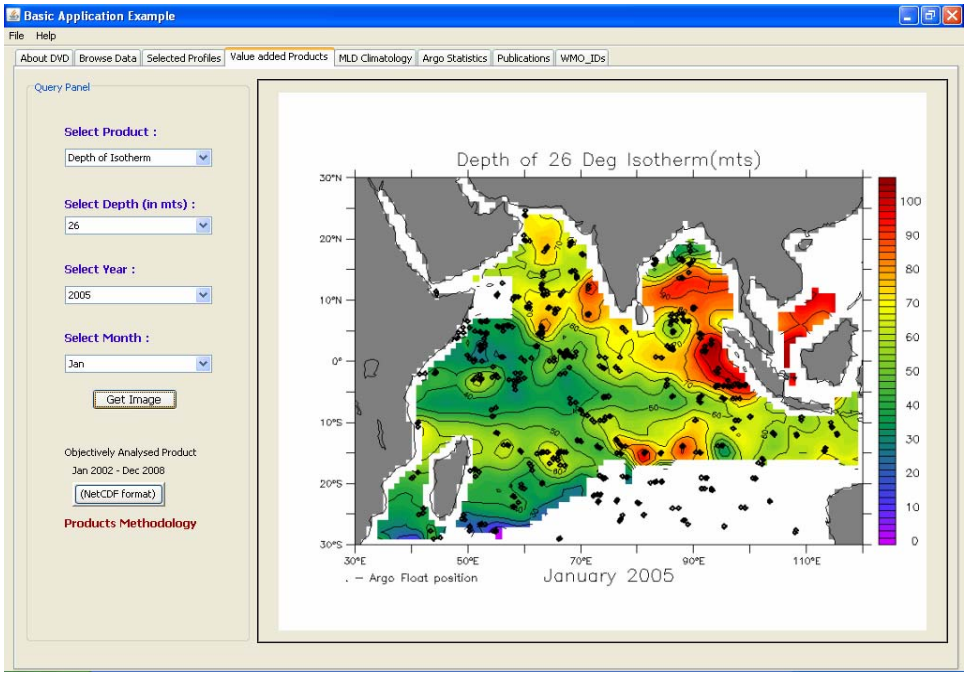


Fig 7. Sample valued added product (Depth of 26 Deg Isotherm)

The methodology to generate products can be viewed by clicking "Products Methodology" link in the query panel. Fig 8 shows snapshot of the "Products Methodology" page.

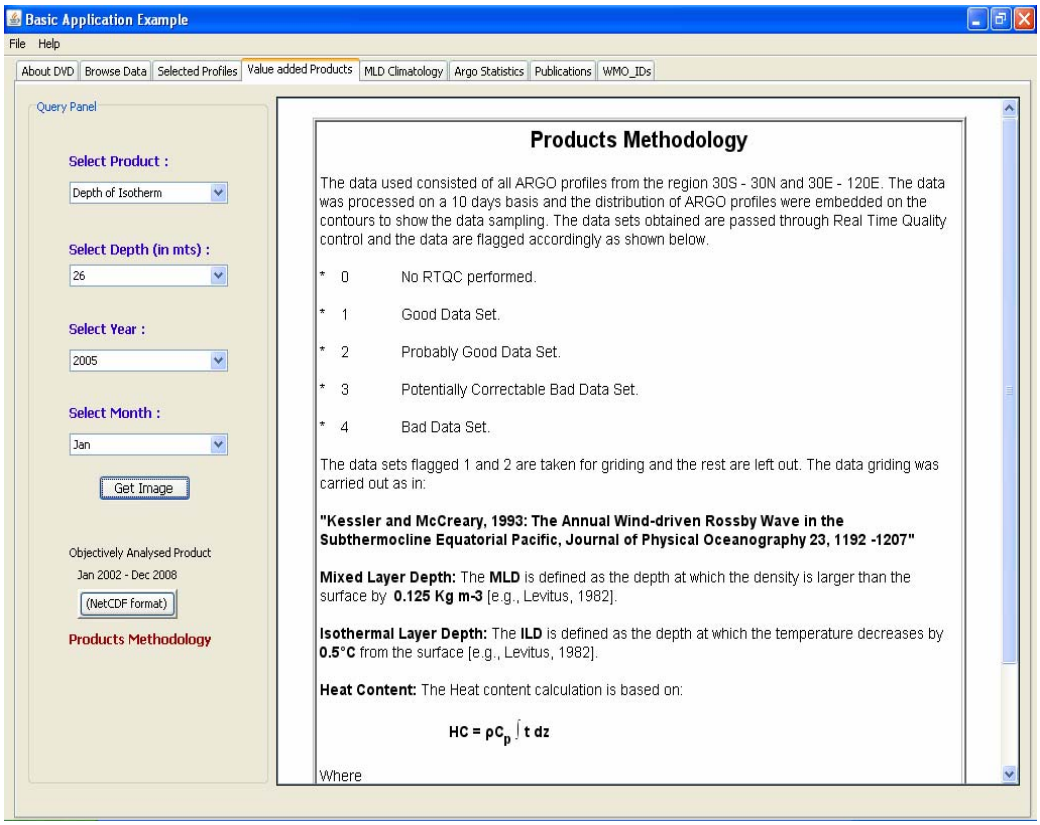


Fig 8. Snapshot of "Products Methodology" page.

4.2.5. MLD Climatology Tab

Mixed layer depth is obtained utilizing all the temperature and salinity profiles from January 2001 – December 2008. This product is also made available in the DVD for the users in their respective research. To view the Mixed Layer Depth Climatology products MLD Query Panel is used.

Various parameters in MLD Climatology are:

- Mixed Layer Depth

- Median Deviation
- Anomaly
- Data Density

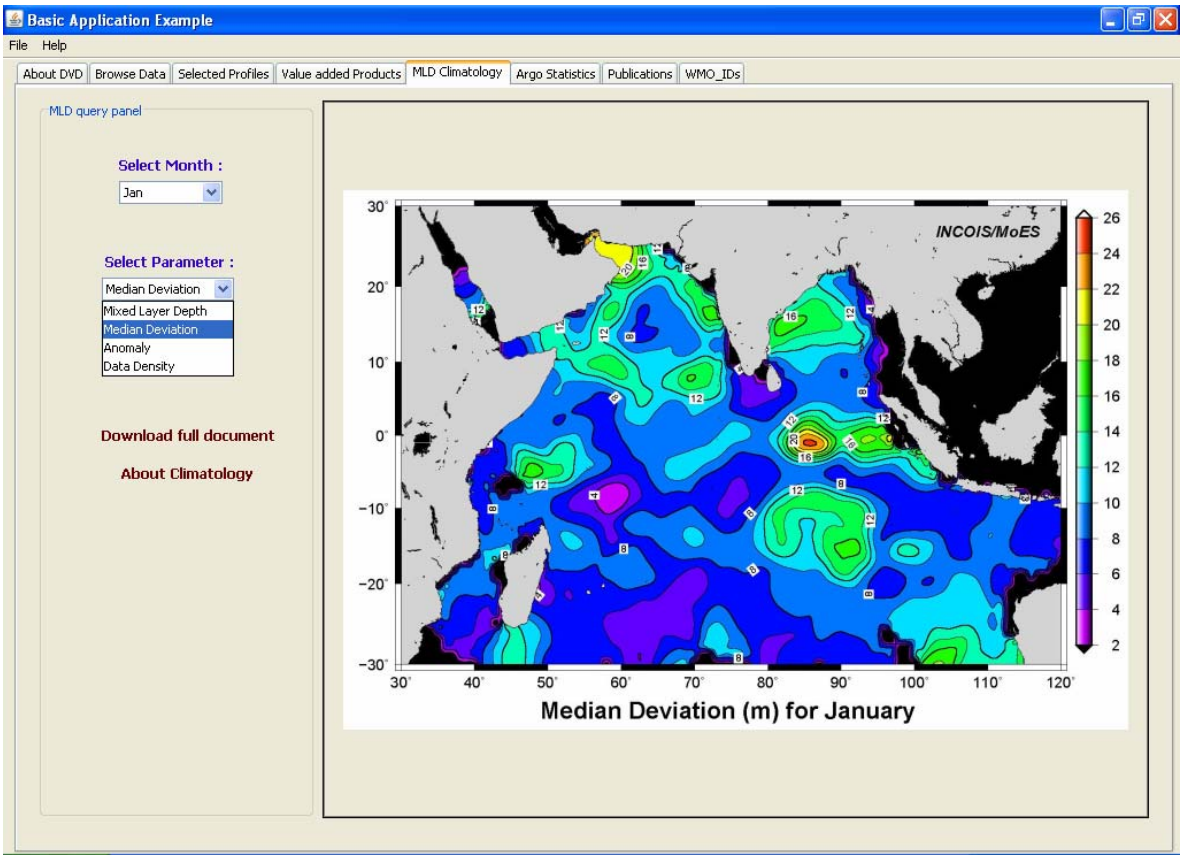


Fig 9. Snapshot of the Mixed Layer Depth climatology obtained from Argo profiles.

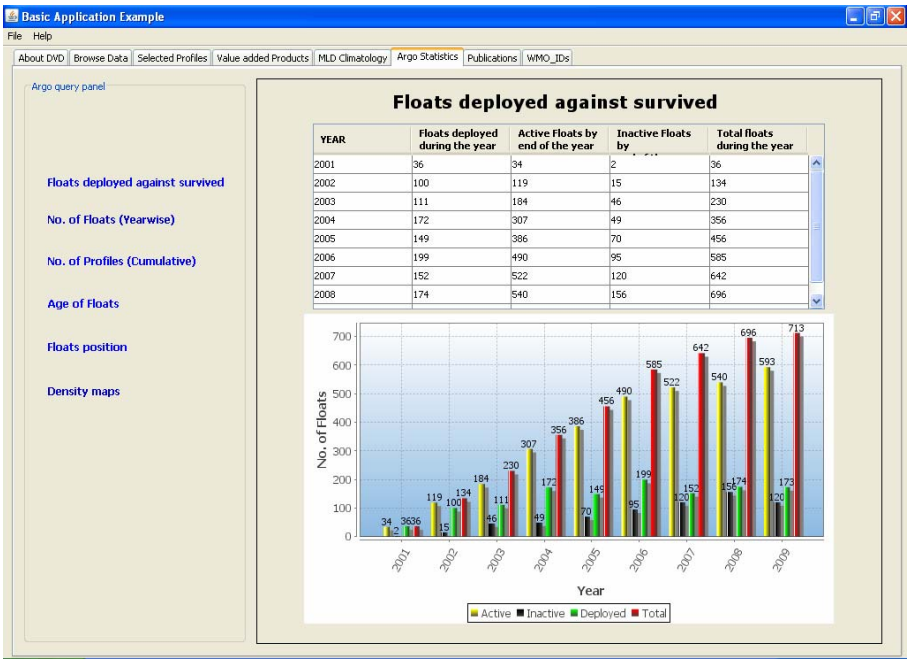
Detailed information about the climatology preparation is provided in a PDF document which can be obtained by using the "About Climatology" link in MLD Query Panel. To download the full document, use the link "Download full document" in MLD Query Panel.

4.2.6. Argo Statistics Tab

This tab provides various statistical information about the floats. These dynamic graphs are displayed using JFreeCharts. The Argo Query Panel consists of different types querying links as:

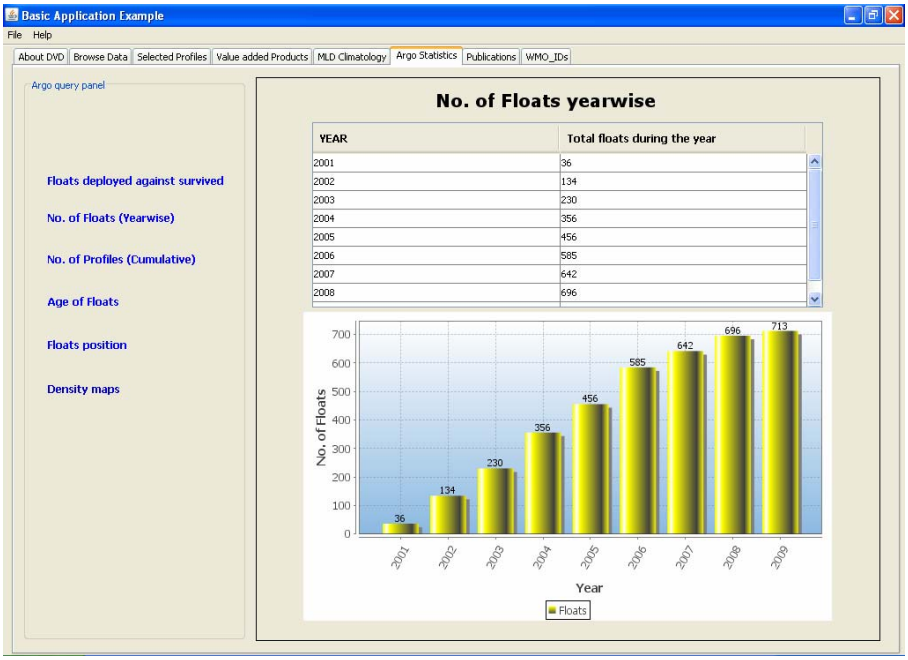
4.2.6.1. Floats deployed against survived:

This shows the floats deployed during the year, Active and Inactive floats by the end of the year, and the total number of floats during the year.



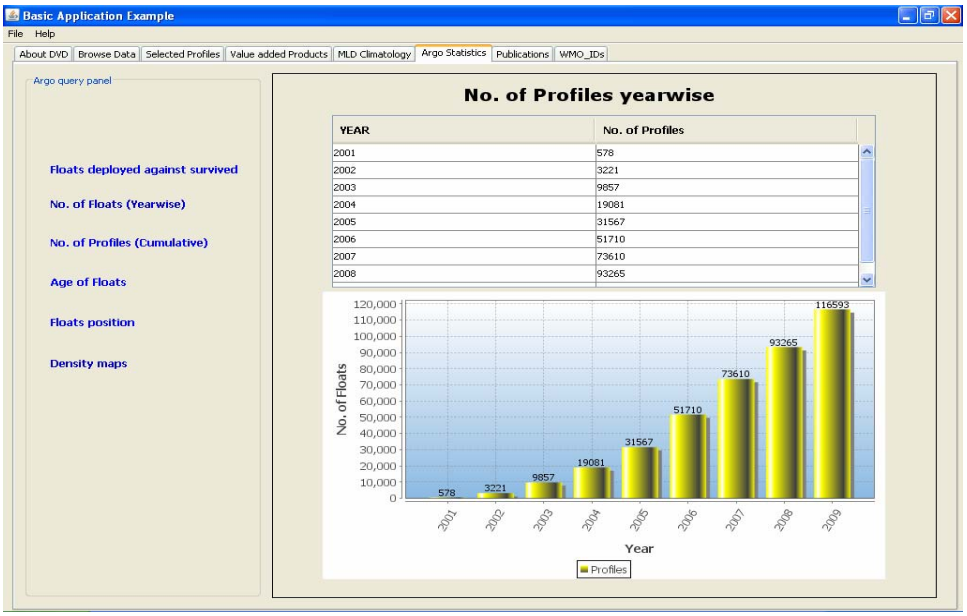
4.2.6.2. No. of Floats (year wise):

This gives the cumulative number of floats deployed during each year.



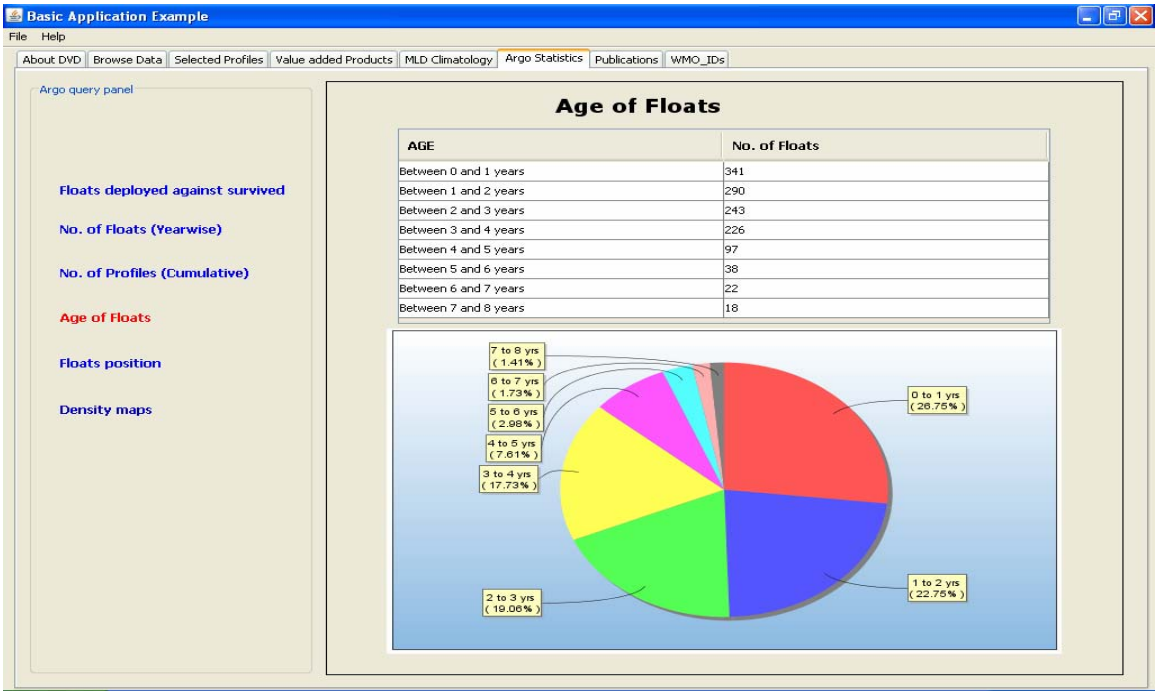
4.2.6.3. No. of Profiles (year wise)

This gives the cumulative number of profiles year wise obtained from various Argo floats per each year. This is indication of amount of data available to the user for his research.



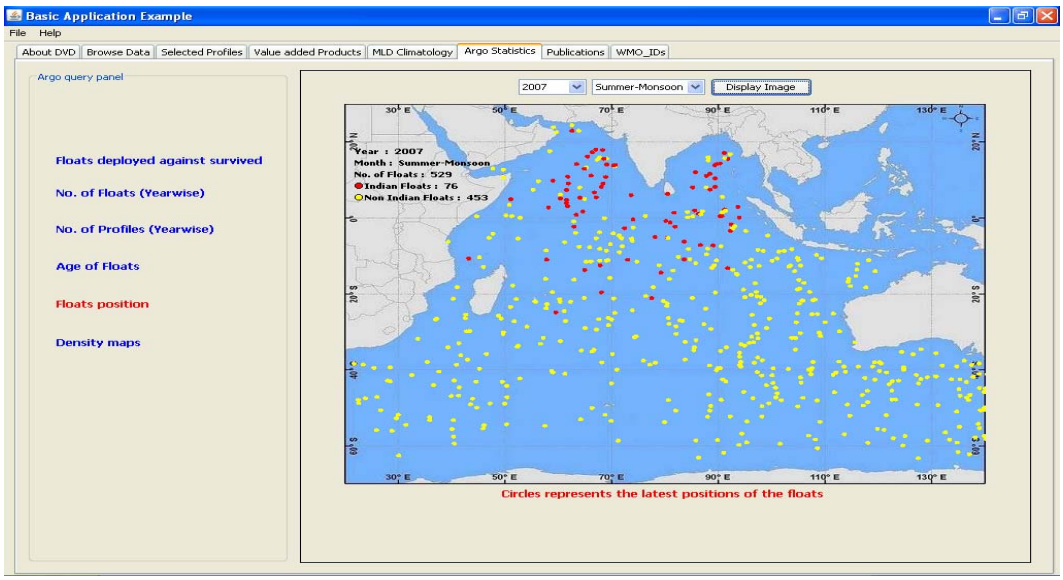
4.2.6.4. Age of Floats:

This gives an indication as to the age of the floats. This also acts as a indicator for acquiring the statistics for new deployment. Higher the number of old aged floats higher the requirement for new acquisition as the floats tend to die sooner or later.



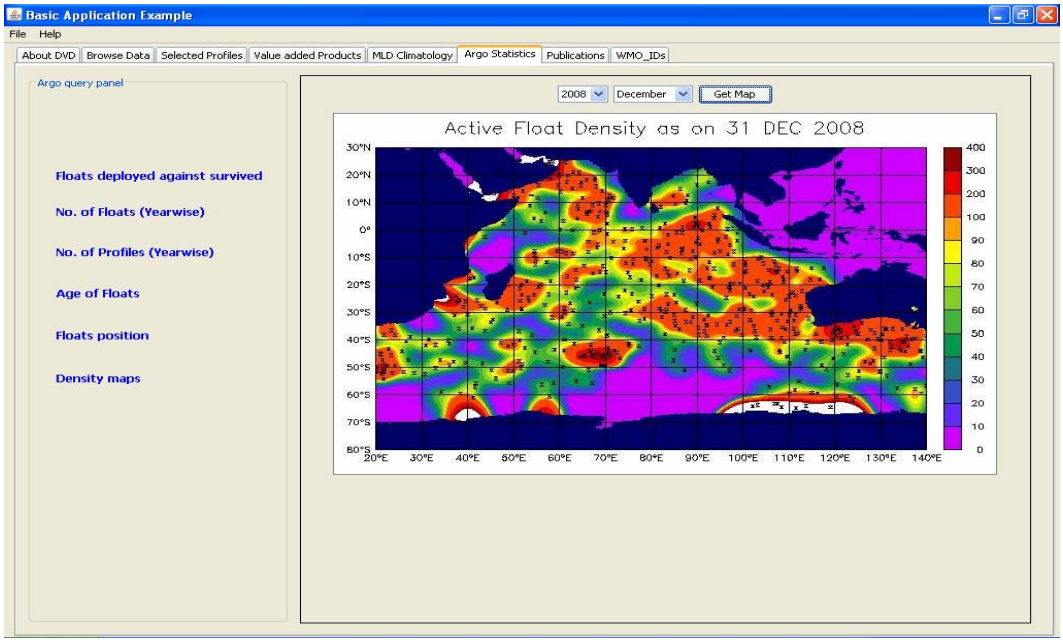
4.2.6.5. Floats Position

This panel shows the recent floats positions for the selected year and month. This is vital for checking the float density for a specific region of interest. Similarly another panel for profile position is also provided. These two can be used to know if any new deployment is required in specific region and if adequate number of profiles are present in region of interest.



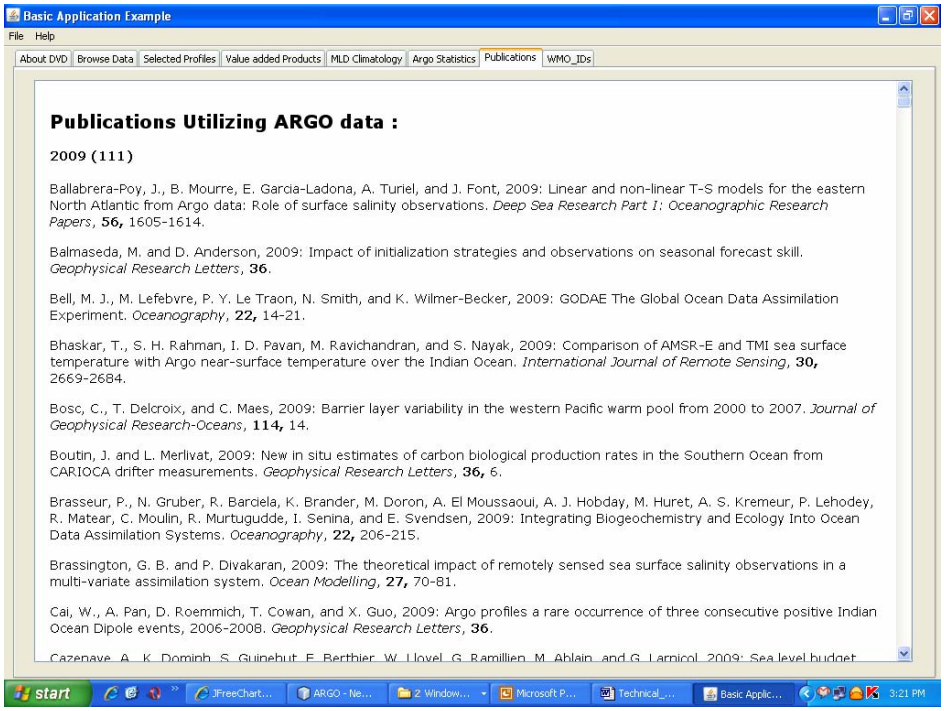
4.2.6.6. Density Maps

This panel shows the float density maps for the selected year and month. The density maps are vital in future deployment plans. It is considered that the presence of a single float in 3 x 3 box is 100%. Hence for all future deployment a region where the density is less than 50% is chosen for new deployment.



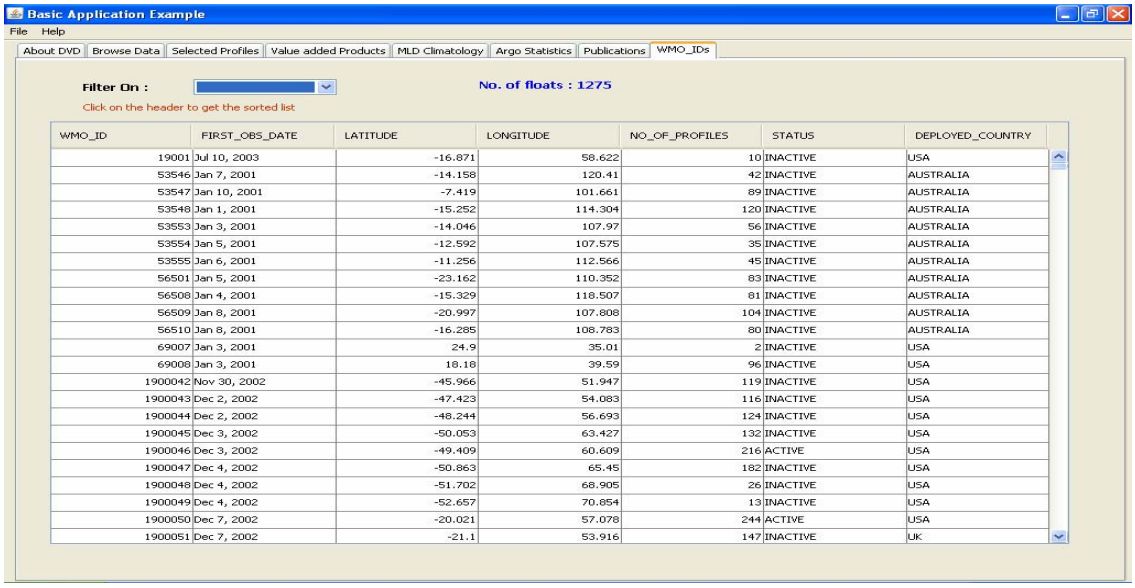
4.2.7. Publications Tab:

This tab provides literature information regarding the paper published utilizing the Argo profile data. Users can get a fair idea about broad region in which the Argo is put to use. This will also act a ready reconer for citing the publication.



4.2.8. WMO_IDs Tab:

In the first panel the user can choose region of his choice for extracting data. What if the user is interested in obtaining data from a single float. To cater to such a requirement, a tab showing unique wmo_id's details is provided. The user can get the information about the float ID of his choice and obtain data by entering the WMOID in the query panel.



WMO_ID	FIRST_OBS_DATE	LATITUDE	LONGITUDE	NO_OF_PROFILES	STATUS	DEPLOYED_COUNTRY
19001	Jul 10, 2003	-16.871	58.622	10	INACTIVE	USA
53546	Jan 7, 2001	-14.158	120.41	42	INACTIVE	AUSTRALIA
53547	Jan 10, 2001	-7.419	101.661	89	INACTIVE	AUSTRALIA
53548	Jan 1, 2001	-15.252	114.304	120	INACTIVE	AUSTRALIA
53553	Jan 3, 2001	-14.046	107.97	56	INACTIVE	AUSTRALIA
53554	Jan 5, 2001	-12.592	107.575	35	INACTIVE	AUSTRALIA
53555	Jan 6, 2001	-11.256	112.566	45	INACTIVE	AUSTRALIA
56501	Jan 5, 2001	-23.162	110.352	83	INACTIVE	AUSTRALIA
56508	Jan 4, 2001	-15.329	118.507	81	INACTIVE	AUSTRALIA
56509	Jan 8, 2001	-20.997	107.808	104	INACTIVE	AUSTRALIA
56510	Jan 8, 2001	-16.285	108.783	80	INACTIVE	AUSTRALIA
69007	Jan 3, 2001	24.9	35.01	2	INACTIVE	USA
69008	Jan 3, 2001	18.18	39.59	96	INACTIVE	USA
1900042	Nov 30, 2002	-45.966	51.947	119	INACTIVE	USA
1900043	Dec 2, 2002	-47.423	54.083	116	INACTIVE	USA
1900044	Dec 2, 2002	-48.244	56.693	124	INACTIVE	USA
1900045	Dec 3, 2002	-50.053	63.427	132	INACTIVE	USA
1900046	Dec 3, 2002	-49.409	60.609	216	ACTIVE	USA
1900047	Dec 4, 2002	-50.863	65.45	182	INACTIVE	USA
1900048	Dec 4, 2002	-51.702	68.905	26	INACTIVE	USA
1900049	Dec 4, 2002	-52.657	70.854	13	INACTIVE	USA
1900050	Dec 7, 2002	-20.021	57.078	244	ACTIVE	USA
1900051	Dec 7, 2002	-21.1	53.916	147	INACTIVE	UK

The data is retrieved as unique wmo_ids and the first observation date is obtained as the floats's first observation date , the latitude and longitudes are taken at the first observation date, the STATUS, represents the present status of the float which is evaluated as "INACTIVE" if the data is not received from the past 60days , otherwise set as "ACTIVE". The Deployed country is the country which deployed the float.

5. SYSTEM REQUIREMENTS

The ADE application was developed using Java an object oriented programming language, Swings with NetBeans IDE, JFreeCharts, SVG, HTML and MS Access database. The ADE can be run any Windows platform that has java Virtual Machine (JRE xcxcc) and SVG graphics installed. The platforms supported currently by ADE must posses the following hardware and software components:

5.1 Hardware Requirements

WINDOWS™ Intel Pentium processor

128 MB RAM minimum, 256 MB recommended

100 MB available hard-drive space minimum

256-color video display adapter and monitor

DVD-COMBO Drive

5.2 Software Requirements

WINDOWS™: Microsoft Windows 9X/2000/NT/ME/XP

World Wide Web browser for viewing .HTML files

Acrobat Reader® for viewing .PDF files

6. Conclusions and Future plans

Argo is an international program aimed at seeding the ocean with floats that measure the ocean temperature and salinity at regular intervals from surface up to 2000 m. To cater to wide users of the oceanographic data suffering with low bandwidth connections, DMG, INCOIS has come up with a Argo Data Explorer DVD on "Argo data and product for the Indian Ocean". The ADE provides efficient data sharing and integration, easy to access to and long-term archiving of Argo data sets. It demonstrates that DMG, INCOIS products and services are responsive to needs of the Indian Ocean region communities, universities and research organizations. In future, taking inputs from users of ADE, we plan to come up with newer version incorporating all suggestions and feed backs.

Acknowledgements

The DMG team, thank Director, INCOIS for encouragement and facilities to carry out the work. Special thanks are due to Secretary, MoES for his special interest in the data products. All the colleagues at INCOIS who gave values suggestion for improvement of the product are highly acknowledged. Argo data were collected and made freely available by the International Argo Project and the National programmes that contribute to it (**http://www.argo.ucsd.edu**, **http://argo.jcommops.org**).

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