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# SCSODC: Integrating Ocean Data for Visualization Sharing and Application

**C Xu[1,3], S Li, D Wang, Q Xie[2]**

[1]South China Sea Institute of Oceanology, Chinese Academy of Sciences, 164 West Xingang Road, Guangzhou, 510301, China
[2]Sanya Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences, Sanya 572000, China

E-mail:xc@scsio.ac.cn

**Abstract.** The South China Sea Ocean Data Center (SCSODC) was founded in 2010 in order to improve collecting and managing of ocean data of the South China Sea Institute of Oceanology (SCSIO). The mission of SCSODC is to ensure the long term scientific stewardship of ocean data, information and products – collected through research groups, monitoring stations and observation cruises – and to facilitate the efficient use and distribution to possible users. However, data sharing and applications were limited due to the characteristics of distribution and heterogeneity that made it difficult to integrate the data. To surmount those difficulties, the Data Sharing System has been developed by the SCSODC using the most appropriate information management and information technology. The Data Sharing System uses open standards and tools to promote the capability to integrate ocean data and to interact with other data portals or users and includes a full range of processes such as data discovery, evaluation and access combining C/S and B/S mode. It provides a visualized management interface for the data managers and a transparent and seamless data access and application environment for users. Users are allowed to access data using the client software and to access interactive visualization application interface via a web browser. The architecture, key technologies and functionality of the system are discussed briefly in this paper. It is shown that the system of SCSODC is able to implement web visualization sharing and seamless access to ocean data in a distributed and heterogeneous environment.

## 1. Introduction

Marine science is essentially an observation-based science, the improve of its academic thoughts and research levels cannot be separated from the long-term observation and data accumulation [1]. With modern science developing in depth from the macro and micro levels, marine scientific research frontier and hotspot issues are becoming ever more complex and showing a trend of large-scope, long-range research and high-precision, large-scale computing. Information and netwotk technologies that are in used for ocean data management and sharing are necessary for marine science. However, ocean data were difficult to be integrated and shared due to the distribution and heterogeneity.

The data management of SCSIO was started in 2002 with the development of South China Sea Database (SCSODB). In 2007, a new system was built using OPeNDAP software framework and VisualDB platform for data management and sharing. It provides a visualized data management interface and various types of data services and applications. In 2010, the South China Sea Ocean Data Center (SCSODC) was founded in order to ensure the long term scientific stewardship of ocean data, information and products, – collected through research groups, monitoring stations and observation cruises of SCSIO – and to facilitate the efficient use and distribution to possible users.

[3]To whom any correspondence should be addressed

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The SCSODC Data Sharing System integrates multi-disciplinary, multi-type, and different formats data resources and provides a transparent and seamless data access and application environment for users. It allows scientists to access data seamlessly using a client program, which is easy to operate. It allows scientists to access interactive visualization application interface via a web browser. It supports the effective use of ocean data in a distributed and heterogeneous environment.

## 2. Architecture of SCSODC data sharing system

Over ten year construction and accumulation, the Data Sharing System has been basically formed the "scientific management – safe storage – service support" three-tire structure data management and sharing service system, by the data center, database, and data sharing infrastructure, to protect the long-term regular operation and data sharing services.

The OPeNDAP protocol and software framework are applied to build the SCSODC Data Sharing System foundation. It uses OPeNDAP data server, such as GDS, TDS, and Dapper to complete the core building of the system, takes advantage of DChart and LAS systems to extend OPeNDAP services, adopts VisualDB to provide a graphical user interface for data management and distribution, deploys Duckling in the cloud to build a virtual and collaborative scientific research environment, and finally forms the combination of C/S and B/S mode for data integration and sharing. The architecture of the SCSODC Data Sharing System is shown in Figure 1.

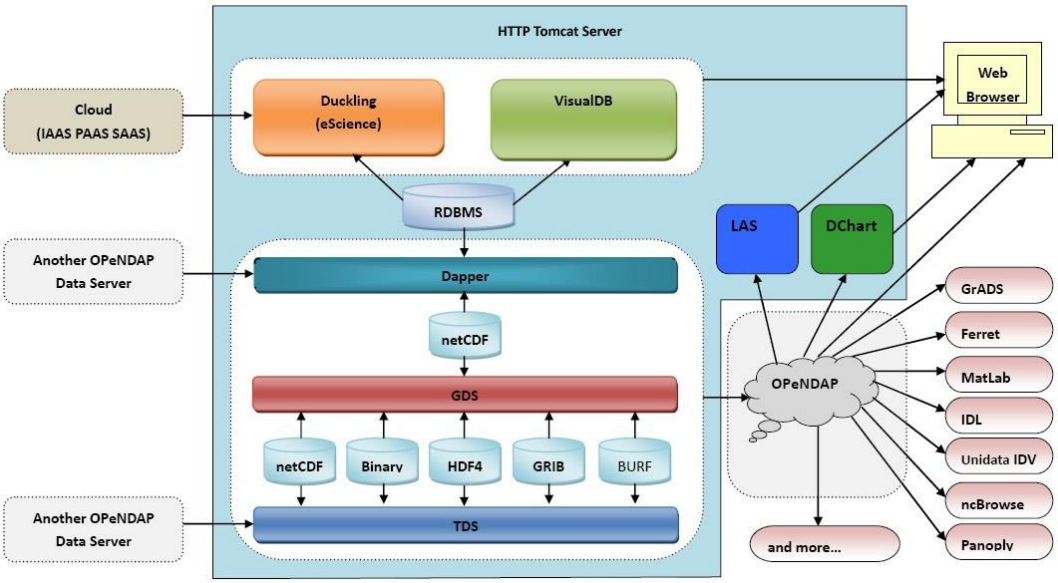



**Figure 1.** Architecture of SCSODC Data Sharing System.

## 3. Key SCSODC technologies

A variety of technologies are required to work together to meet the SCSODC Data Sharing System needs, from data models, file formats and metadata conventions through data transfer protocols to data management and end-user tools.

### *3.1. Data models, file formats and metadata conventions*

Ocean data could be stored in a large number of file formats, from free-form, plain-text files to structured binary formats. It is difficult to develop tools and applications that work with all formats of data models. To alleviate this difficulty, the oceanographic community is standardizing around the NetCDF file format, which provides an array-oriented, binary file format that can contain a wide variety of data types, from in situ measurements to large multidimensional grids of data from numerical models [2].

NetCDF provides a simple, discipline-neutral data model that encompasses multidimensional arrays and their attributes. NetCDF metadata conventions provide the additional semantics needed to encode ocean data in NetCDF format. The Climate and Forecast (CF) conventions focus on the description of gridded data from numerical models or analysed satellite products [3]. EPIC netCDF Conventions support the description of ocean observed or in-situ data, such as profile or time series

type data [4]. They both provide a means to describe the grid on which the data are expressed, together with a suite of "standard names" that are used to identify what the data represent.

The NetCDF file format and conventions have provided an effective means of encoding ocean data. A number of tools for oceanographic data analysis and visualization have been developed on top of these technologies, including Ferret, GrADS, LAS, and DChart. Using NetCDF, SCSODC Data Sharing System has achieved harmonization of previously-disparate data sets.

### *3.2. Accessing data online using OPeNDAP*

The simplest thing a scientist can do with an URL is to download the data it points to, but he or she may not require the entire dataset, which may be hundreds of gigabytes or even terabytes in size. The OPeNDAP provides a way for ocean researchers to access remote data over the internet. The users can very easily extract specific parameters from the remote dataset and can also extract subsets in space and time. This reduces internet traffic, as well as decreasing the load on the local machine [5].

OPeNDAP uses a client/server model, with a client that sends requests for data out onto the network to some server, that answers with the requested data.The combination of the OPeNDAP network communication model and the data translation facility make OPeNDAP a powerful tool for the retrieval, sampling, and display of large distributed datasets. Servers for a number of commonly-used data formats – NetCDF, HDF4, HDF5, GRIB-1, GRIB-2, BUFR, etc. – have been built. To serve data stored in one of these formats, SCSODC Data Sharing System simply needs to install the appropriate OPeNDAP server and a web server. The users need not learn about any of the archival formats, science OPeNDAP client programs import data transparently. Many end-user tools treat locally-held data in exactly the same way as remotely-held data on an OPeNDAP server, providing the scientist with the capability to analyse and visualize huge quantities of distributed data.

### *3.3. LAS and DChart*

The foundation of SCSODC Data Sharing System includes the use of OPeNDAP for access to distributed datasets, the use of LAS to generate products (maps and scientific graphics, tables and data subsets) and to perform intercomparison (regridding and differencing) between those datasets, and the use of DChart to visualize and download in-situ and gridded ocean data from files or OPeNDAP servers.

LAS is a work flow engine that creates useful products in response to requests from user interfaces. It can read data from various data sources and direct that data into various product-generating applications. It supports simple data analysis and visualization performed within a Web browser and advanced custom analysis using desktop applications such as Matlab or Ferret. The most basic of LAS output products are custom scientific visualization along all principal planes and axes: maps, time series, vertical sections and profiles, and space-time contour plots [6].

LAS is configured in SCSODC Data Sharing System to unify access to multiple types of data in a single interface and provide flexible access to ocean data. It enables scientists to visualize data with on-the-fly graphics in his or her precise specifications of region, contour levels, scaling, colour palettes and other graphical styling issues. It enables scientists to request custom subsets of variables in their choice of file formats and to compare (difference) variables from distributed locations.

DChart is a Web interface developed by PMEL for gridded and in-situ data collections. It is a Web application that takes advantage of Ajax technology to allow users to visualize and download in-situ oceanographic data from file or OPeNDAP server. Features include an interactive map that is draggable, an in-situ station layer that allows you to select data stations, and a plot window that allows you to plot data from one or more stations. Three plot types are supported (profile, property-property, and time series) and users can interact directly with the plot to pan or zoom in and out [7-8].

Millions of in-situ ocean observations of the South China Sea are now available to scientists through the OPeNDAP network protocol. With DChart, SCSODC Data Sharing System provides users interactive selection, browsing, plotting and downloading of in-situ observations from Dapper in a Web browser without having to download any plugins or applets.

### *3.4. VisualDB and Duckling*

VisualDB (aka VDB) is a data management and sharing platform that developed by Computer Network Information Center, CAS. It is a tool for data managers to manage and publish relational

databases and files system. It is a development framework to help developers to quickly develop data-oriented application. It is a set of solution to integrate heterogeneous data sources for applications in low cost [9].

VDB features include shielding data heterogeneity, providing a rich component library for data publish without writing code, providing a humane data editing platform with the field or record level access control, providing web services to facilitate other applications access to data and metadata, providing scalable secondary development interface. VDB function modules include directory configuration, data editing, atatistical analysis, website, security center, SQL query, and data service interface. Taking advantage of VDB, the SCSODC Data Sharing System realizes the visualized management and release of RDBMS data and varity information products.

Duckling is a collaborative work environment kit, designed to provide teamwork a comprehensive resource sharing and collaboration platform by Computer Network Information Center, CAS. Duckling is focuses on the needs of the new way of team activities, through collaborative work environment core tools kit and disciplines application plug-ins, integrates hardware, software, data, information and other resources over the network environment, to provide advanced information platform for the research team [10].

Duckling is a desktop collaborative tools kit, which makes UMT, DCT, CLB, UCT, AAT, LMT, DLM, CDT in one set to provide collaborative editing, information publishing, document management, instant messaging, VoIP, SMS notification, organizational structure, literature sharing, data calculating and other collaboration services. Using Duckling, SCSODC Data Sharing System realizes a unified login, business integration, communication integration and plugin integration, and develops more customization services to meet the applications needs of research teams in SCSIO.

## 4. Data integration and application

SCSODC Data Sharing System realizes the integration of multi-disciplinary, multi-type, heterogeneous and distribution ocean data resources, provides interactive visualization application services of the integrated data, and supports user access to data through the web browsers online simply and conveniently.

### *4.1. Types and formats of integrated data*

The integrated and shared ocean data resources of SCSODC Data Sharing System are complex and varied, including marine environmental observing data from comprehensive scientific survey of the South China Sea and its adjacent seas, experimental data obtained by means of experiments and analysis, reanalysis and forecast data product from numerical simulation and data assimilation, graphics products, landmark files and other types of information products. The distributed data include local NetCDF, ASCII and GrADS Binary files, remote OPeNDAP servers, SQL databases, and in-situ data streams. The integrated data types, formats and provided services are shown in Table 1.

**Table 1.** Types, formats and provided services of integrated data.

| Types | Sub-types | Formats | Provided services |
|---|---|---|---|
| **In-situ observation data** | Gridded data | Grads Binary/NetCDF | OPeNDAP/LAS/DChart |
| | Profiles | ASCII | VDB |
| | | NetCDF | OPeNDAP/LAS/DChart |
| | Time series | ASCII | VDB |
| | | NetCDF | OPeNDAP/LAS/DChart |
| **Data products** | Experimental data | EXCEL/ASCII | VDB |
| | | NetCDF | OPeNDAP/LAS/DChart |
| | Numerical modelling data | Grads Binary/NetCDF | OPeNDAP/LAS/DChart |
| | Reanalysis data | Grads Binary/NetCDF | OPeNDAP/LAS/DChart |
| **Graphics products** | Remote sensing image | EMF/TIFF/JPEG | VDB |
| | Image product | BMP/GIF/JPEG | VDB |
| **Animation data** | Landmark files | KML/KMZ | Google Earth/Maps |

*4.2. Data visualization and interactive application*

SCSODC Data Sharing System has realized the visualization management and interactive application of ocean data. The main functions include data discovery, seamless data access, interactive visualization applications, graphics and information products services, virtual collaborative environment applications, and user management services.

The OPeNDAP software is not only a data taransport mechamnism. A user can request, subsample, analyze, and visualize data use an OPeNDAP client program with which they are alredy familiar (for example, MatLab, GrADS, Ferret, …). A user can use web application (DChart or LAS) to interactive select, browse, plot and downdload data in a web browser without having to download any plugins or applets. A user also can animate data or information products (Latitude-longitude plots, vertical profiles, time series plots and KMZ/KML files) in Google Earth/Maps. And some of the interactive visualization applications are shown in figure 2.

## 5. Conclusions

The SCSODC Data Sharing System has distinct structure, targeted function, friendly user interface, and provides a good expandability. It has provided ocean researchers with the ability to access analyse and visualize data information and product, using a variety of approaches from web graphical interfaces to desktop application environments. The success of the system has depended on the agreement upon common standards and the development of technologies (e.g. NetCDF and OPeNDAP) and tools. Online seamless data sharing and interactive visualization applications demonstrate the high availability and reliable performance of the system. It now faces great challenges to continue to meet the changing needs of different types of user. We'll make a greater effort for extending the current technologies to encompass in-situ data and irregular numerical meshes, the development of general catalogues for discovering data, the adoption of GIS standards for sharing data, the establishment of a new ecosystem of e-Ocean Science for globally and interdisciplinary cooperation of scientists.

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[4] EPIC netCDF General Conventions homepage http://www.epic.noaa.gov/epic/document/convention.htm
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[6] Welcome to Live Access Server homepage http://ferret.pmel.noaa.gov/LAS
[7] DChart homepage http://www.epic.noaa.gov/epic/software/dchart/

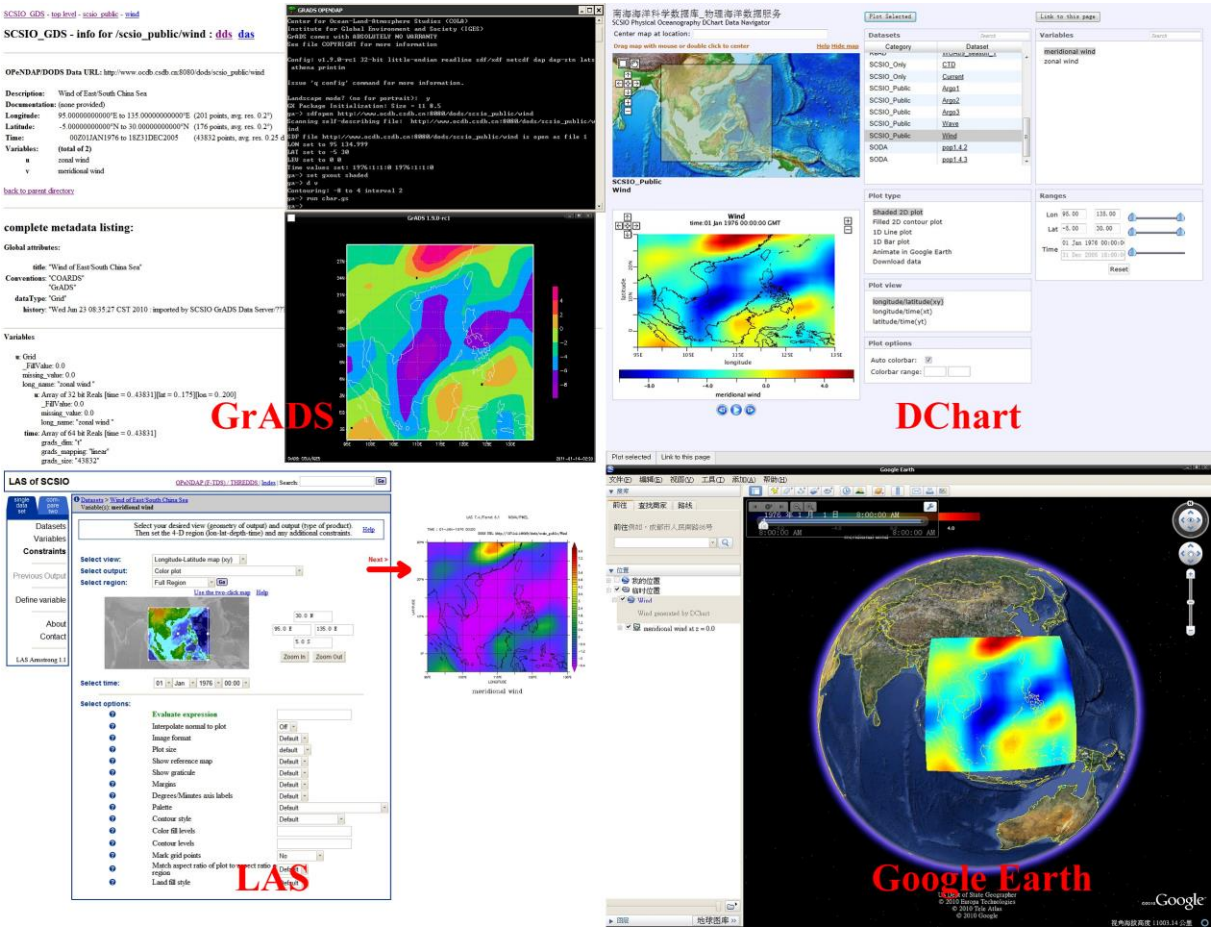



**Figure 2.** Different pictures plot of meridional wind by GrADS, DChart, LAS, and Google Earth. Data are from the SCSIO.

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