# Multidisciplinary marine environmental database for the Aral Sea

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## Abstract

Special unique database management and processing system (*Oceanbase*) have been developed to work with the large sets of multivariable interdisciplinary oceanographic and environmental data. *AralBase* system developed to work with the Aral Sea interdisciplinary data is a variety of the *OceanBase*. *AralBase* is a special database application with the expanded functionality designed to explore large multidisciplinary oceanographic and environmental data sets. It provides many possibilities for data loading, selection, access, processing, analysis, preview and export. The *AralBase* has a customizing user-friendly multi-windows interface. A user can create his/her own desktops and open and arrange as many windows as he/she needs.

The most valuable feature of *AralBase* is the integration of many service tools that allow the user to carry out almost all data processing without any additional software. At the moment, the database is loaded with the oceanographic and meteorological data provided by the participants of the Inco-Copernicus Aral-Kum Project.

The *OceanBase* system and the *AralBase*, in particular, are the very flexible systems, and they can be used in any environmental and oceanographic project or institution dealing with the water environment (ocean, lakes, rivers) data. The preloaded data bases with the Data Explorer system module can be distributed among the interested scientists and experts to simplify drastically their work with data.
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## 1. Introduction

The recent oceanographic and environmental projects operate usually with large interdisciplinary multivariable data sets. These data sets have to be quality checked, reliably stored, and analysed. It is necessary to manage large sets of interdisciplinary data of the marine and coastal environment that can contain a lot of variables from different sources and with different structure (oceanographic, meteorological, biological, etc.). Moreover, the most interesting scientific results can be obtained at the boundaries between different disciplines.

However, it is a very complicated task to combine these multidiscipline data sets, to verify them, and to provide the possibility to analyze them jointly. The industry standard database management

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systems (DBMS) are not enough suitable to process such combined data sets and to perform this task efficiently.

The work to address this task has been conducted at the Database Laboratory of the Marine Hydrophysical Institute (MHI) since 1989. As a result of this work, several special marine database management systems were developed at MHI to fulfill the multipurpose multidiscipline management of such data using the Windows platform (Vladimirov, 1992; Vladimirov and Miroshnichenko, 1997; Miroshnichenko et al., 1998). The main objective of these systems is to provide for easy, quick and effective work with marine environmental data in oceanography, ecology and environmental management for different scientists and experts: oceanographers, biologists, chemists, ecologists.

These systems are also used for the calibration and interpretation of the remote sensing data and images.

## 2. *AralBase* system

Special unique database management and processing system (*OceanBase*) have been developed to work with the large sets of multivariable interdisciplinary oceanographic and environmental data (Vladimirov et al., 1998; Mishonov et al., 1998).

It works under Windows 95/98/NT/2000/XP as a Local Area Network (LAN) application has effective Administrator and Data Manager modules, and can be used simultaneously by several users.

*AralBase* system developed to work with the Aral Sea interdisciplinary data is a variety of the
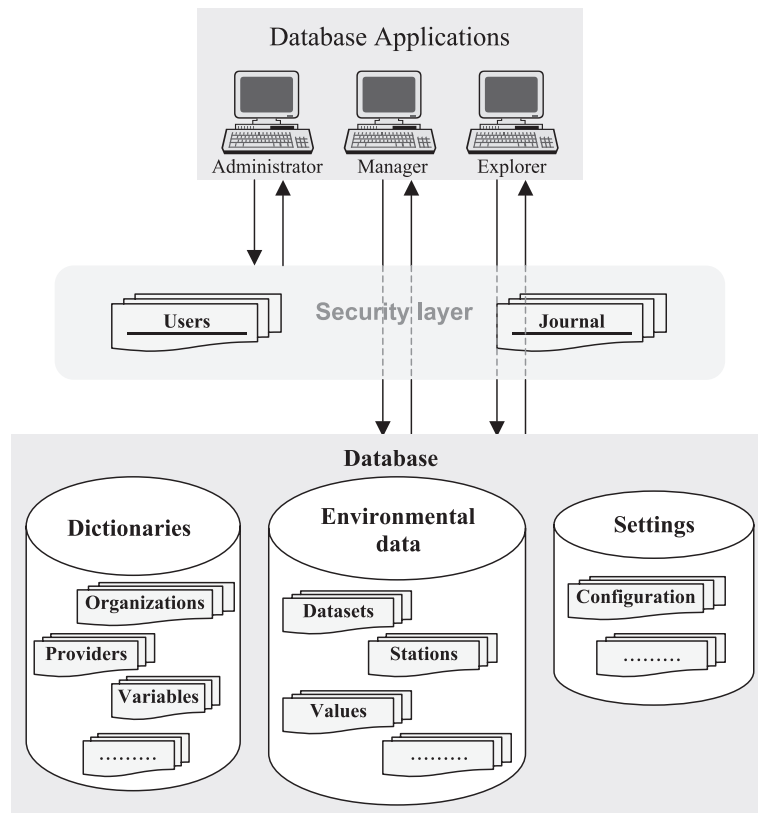


Fig. 1. Database management structure of the *AralBase*.

*OceanBase*. The structure of the database management within the *AralBase* system is presented on Fig. 1.

## 2.1. Brief description of the database structure

*AralBase* works with its own database. It is relational database in Borland® Paradox™ format. To avoid unauthorised access, database files are protected with the passwords and they are not accessible through the Paradox or any other software except the *AralBase* system.

All collected data are grouped into the *data sets*. A data set is usually a set of *stations*. It is described by its *start* and *end* date, has a *name*, and belongs to an *organisation*. Usually, data set contains data of a research vessel cruise. Division of data to *data sets* and *stations* is arbitrary and is determined by *data providers*. Generally speaking, *data set* may not belong to only one *organisation*; for example, it can be a joint *cruise. Data provider* can differ from the *organisation*. For example, it can be a department or a scientist, or a data centre.

*Station* is a point located in space and time where some oceanographic or environmental measurements were carried out. It is characterised by its *name*, *date* and *time*, geographic *co-ordinates*, and *water depth*, and contains at least one *data profile* containing at least one value. Name is a text string containing not more than 20 characters. Hour, minutes and water depth may be unknown. A station can belong to only one data set.

The initial list of *variables* (*names*, *full names*, *formats*, and *units*) was created by the *AralBase* developers and can be extended by the Database Administrator and Data Managers.

Each data value is supplied with the quality flag. We had chosen the scheme employed for data reported in real-time by GTSPP (UNESCO, 1993). The main advantage of this scheme is its universality and possibility to be applied to any type of data loaded into the database. It uses one character field with the following interpretation:

0 = data are not checked.
1 = data are checked and appear correct.
2 = data are checked and appear inconsistent but correct.

3 = data are checked and appear doubtful.
4 = data are checked and appear to be wrong.
5 = data are checked and the value has been altered.
6 to 9 = reserved for future use.

Quality flag are assigned by the responsible data managers during the data loadings or after it.

## 2.2. Brief description of the software

*AralBase* is a special database application with the expanded functionality designed to explore large multidisciplinary oceanographic and environmental data sets. It provides many possibilities for data loading, selection, access, processing, analysis, preview and export.

The main task of the *AralBase* is oceanographic and environmental data access. There are some similar commercial applications to accomplish this task, but this system makes it better due to its specialisation, rich functionality and high efficiency. The most valuable feature of *AralBase*, is the integration of many service tools that allow to the user to carry out almost all data processing without any additional software.

The *AralBase* consists of three main applications:

- AralBase Administrator
- AralBase Data Manager
- AralBase Data Explorer

The AralBase Administrator is the main application of the *AralBase* and it permits to run all main modules and tasks of the system, except the *AralBase* Explorer. It is the main instrument of the database Administrator. The *AralBase* Data Manager permits to organise work of the Administrator and the Data Managers on the data entry, editing and quality control. The AralBase Data Explorer is the main module for the end-user of the system. It provides the possibilities for data selection, access, preview, export and processing, but it does not give the possibility to change any data loaded into the database.

Borland Delphi was used to develop database application. This is one of the most comprehensive development platforms for creation of the PC-based database applications with high performance.

### 2.3. Database users

To provide more efficient and secure access to the database, the *AralBase* has five types of Database users:

- Master (system developer) with full access to all system possibilities. After the system installation, nobody has this status permanently.
- Administrator with full access except the possibility to change the internal system features. Usually, only one person has the Administrator rights for a particular database.
- Data Manager(s) with possibility to add new data and information and to change the data and information previously entered by this data manager. In principle, the number of the data managers is unlimited. However, it is recommended to limit it, taking into account that they are responsible for the quality of data loaded into the database.
- End-user(s) with options to work with all loaded into the database data and information but without possibility to change something in data or system information. The number of the end users is unlimited.
- Disconnected. This status can be set up for all types of users (except the master) to keep their references on the entered data and information but to prevent the access with their passwords to the *AralBase*.

### 2.4. Database security levels

The *AralBase* has been designed to work in the Local Area Network. That is why, it has the security features to prevent unauthorised access to the system and to data, and to track any activity related to the system.
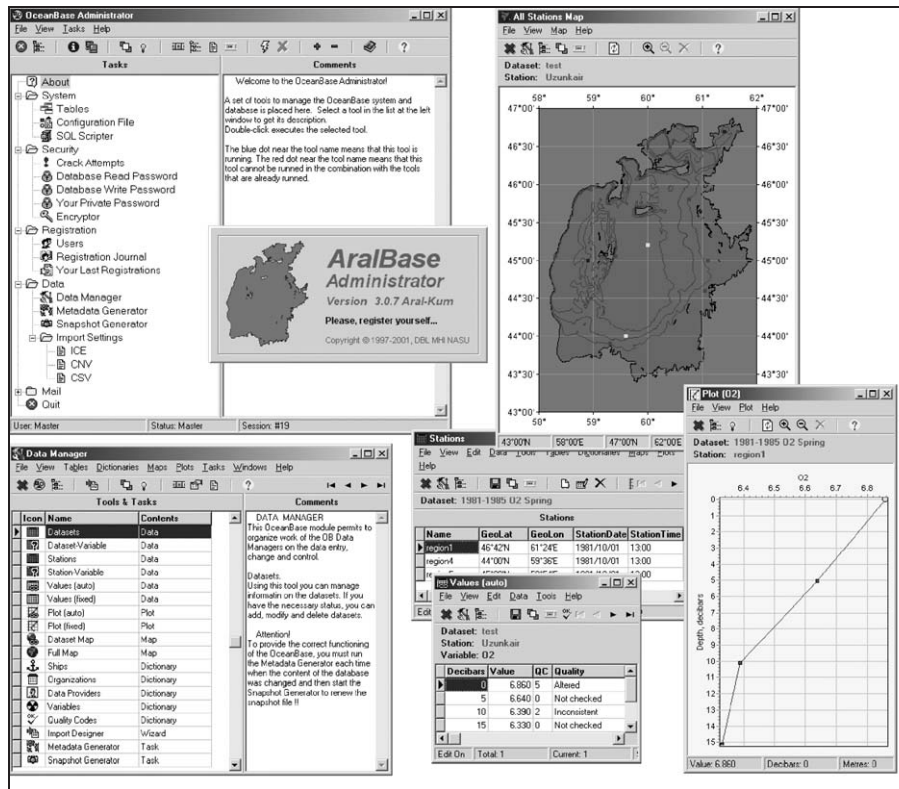


Fig. 2. Example of the Data Manager desktop.

All files (tables) of the database are encrypted. There are two passwords, the same for each table: master and secondary passwords. The master passwords allows to all types of operations on the tables (read, write, restructures, etc.). The secondary password provides read operation on all tables and write operations on tables related to the user registration. These two passwords are encrypted also and stored in the *AralBase* configuration file. So, it is impossible to read any information from the database without *AralBase* software and passwords. Two passwords are used to provide additional protection of the database and to give a flexibility to Administrator in the database security management. Common user opens the database with an auxiliary password and he/she can change only registration tables, not the tables containing real data.

All users have their own private passwords. This password is necessary to register and run the *AralBase* software. Moreover, it is used to track their activity, so all serious actions are tracked and authorised.

The Data Managers can create, edit and delete records in the database tables. Almost all records keep information on their creation and modification. The only Data Manager, who entered the data, is permitted to modify or delete them. Only the Administrator can change this reference. By default, the Data Manager who created the record is responsible for its content.

Administrator maintains the list of all users. Data Managers and Users cannot change any registration information.

## 3. *AralBase user interface*

The *AralBase* has a customizing user-friendly multi-windows interface (Figs. 2 and 3). An user can create his own desktops, open and arrange as many windows as he/she needs. All settings can be stored in the configuration files to create task-oriented desktops for the routine tasks. Data, information and
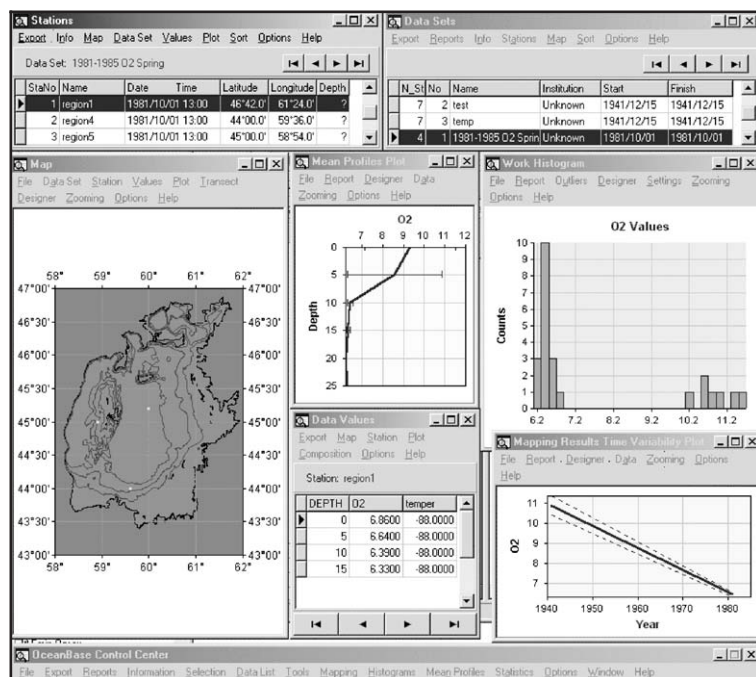


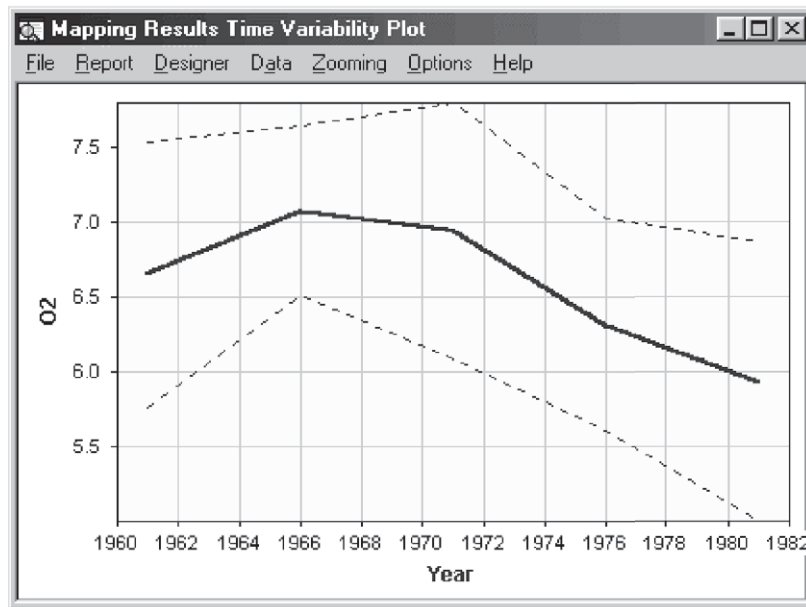Fig. 3. Example of the Data Explorer desktop.

Fig. 4. Variability of the dissolved oxygen at one of the stations in the Aral Sea.

graphics in different windows are cross-linked and synchronized. Main features of the system user interface are as follows:

- Multi-windows approach allows a user to display only necessary tools and arrange them on the screen in a convenient manner.
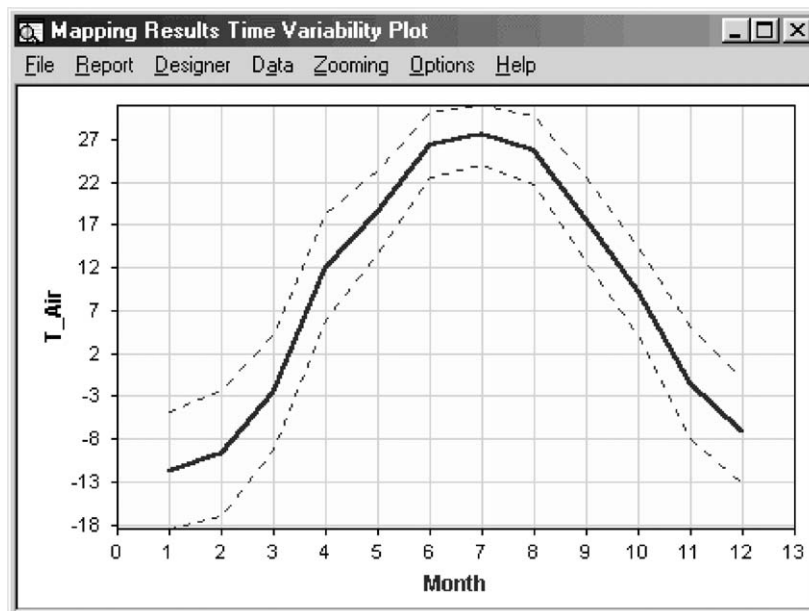


Fig. 5. Variability of the monthly averaged air temperature at the northern coast of the Aral Sea.

- Ability to save/load the most important settings to the configuration file. Auto save/load option is available.
- Easy navigation through the data sets, stations, data values.
- Cross-links between windows synchronize its tool operations and provide convenient access to referenced information.
- A rich set of tools to display original data and results of data processing (various kinds of maps, plots and histograms).
- Auto scaling, auto stepping, auto formatting save user's time and efforts.
- Many controls allowing customization of windows, tools, algorithms, etc.
- Long operations are accompanied by a progress bar indicating a completion percent; there is also the ability to cancel these operations and preview their preliminary results.
- Context-sensitive help and a comprehensive manual provide users with all necessary information.

Although the *AralBase* was not designed to manage time series data, it permits to store this type of data as well. It provides also the simple tools to analyze and present them (Figs. 4 and 5).

The "background" Aral Sea shore line and isobathes presented at the maps were taken from "GEBCO Digital Atlas CD-ROM" (IOC et al., 1994) to provide the possibility to present the historical data. However, any other recent shore line and isobathes information can be easily used for the data mapping.

At the moment, the database is loaded with the oceanographic and meteorological data provided by the participants of the Inco-Copernicus Aral-Kum Project. More variables and data can be loaded in case they will be provided from any source. Taking into account the volume of existing regional data archives, the capacity of the *AralBase* system is unlimited.

## 4. Conclusions

The *OceanBase* system and the *AralBase*, in particular, are the very flexible systems and they can be used in any environmental and oceanographic project or institution dealing with the water environment (ocean, lakes, rivers) data. The preloaded data bases with the Data Explorer system module can be distributed among the interested scientists and experts to simplify drastically their work with data.

## Acknowledgements

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