

DAS 4.2: New and noteworthy

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DAS (Data Assimilation System – <http://data.ecology.su.se/Models/das>) is a program to query and analyze hydrographic and chemical data from the Baltic Sea. These data are collected by a large scientific community from all countries around the Baltic and stored in the database BED (Baltic Environmental Database) at the Department of Systems Ecology, Stockholm University (<http://data.ecology.su.se/Models/bed.htm>). DAS itself acts as a client in this client/server system. The primary objective of DAS is to construct a 3D grid of parameters for the whole Baltic (or large parts like Baltic Proper, Gulf of Finland etc.) using data from the database and analyze these 3D data in different ways. Recently the need to work with data for coastal areas has arisen. Many of these coastal areas have to be described with a high spatial resolution (horizontal step is about 100m or even less). Thus, the main objective for the new version of DAS is to make it possible to work with both large scale areas using coarse grids (a few km) and small scale coastal areas with high resolution (dozens of meters).

Architecture and information flow

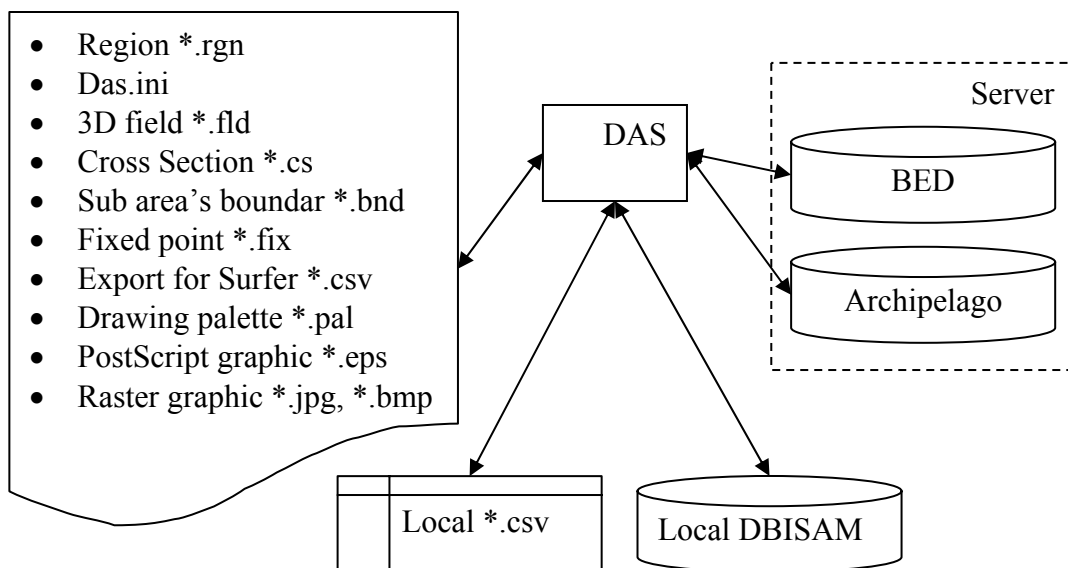


Figure 1 Scheme of data flows

Figure 1 presents the data sources of DAS and a list of files (actually, their default extensions) which can be generated by the program. DAS can request hydrographic data from remote local databases. The remote database are managed by the Firebird (<http://firebird.sourceforge.net>) relational database management system (DBMS) based on the source code of the InterBase DBMS released by Borland Software Corp. The DBISAM database management system developed by Elevate Software (<http://www.elevatesoft.com>) is used to manage a local database. DAS can also import data, prepared as a text file in .csv (comma separated values) format and save these data as a local database for later use.

The local files used by DAS are:

- das.ini contains all initial configuration of the DAS (names of the files, user name, password, default database and so on);
- *.rgn – file(s) with *.rgn extension describes a grid and contains the grid parameters like horizontal step, vertical resolution and bathymetry of the area;
- *.fld – file, contained 3D gridded data of two parameters (temperature and salinity for example) and the bathymetry for this grid. This file contained all necessary information about gridded data and can be used as initial condition in a 3D model. DAS can save interpolated data in this format or can read a file in this format to analyze the data which had been prepared by a 3D model.
- *.cs – file describes coordinates of a cross section.
- *.bnd – file can be used to store (and restore) boundary of a sub area of the grid for detailed analysis.
- *.fix – file can used to store coordinates of points in the area, which have a “true” values of the parameters and this file can be used in the 3D hydrodynamic model for the procedure of hydrodynamic interpolation.
- *.csv – this file is used to store the data in comma separated values format for later visualization using the Surfer program developed by GoldenSoftware (<http://www.goldensoftware.com>).
- Files *.eps, *.jpg and *.bmp are used to save a graphic output for later use.

Grid description

Parameters of a grid used by DAS are provided by a file with *.rgn extension. This file describes dimension of the grid, vertical resolution, geographical projection,

coordinates of the reference point and depth in each grid cell. Distribution of DAS contains the following “ready to use” grids:

- bs9260.rgn – Baltic Sea with 5’ x 10’ resolution in northward and eastward directions respectively;
- bs5000.rgn – Baltic Sea with 5000x5000 meters resolution
- stockholm50.rgn – Stockholm Archipelago with 50x50 meters resolution
- archipelago100.rgn – Sweden archipelago between Gavle and Bråviken with 100x100 meters resolution.

There are also two grids with only one layer (zero – bottom): bs1852.rgn – a grid for the Baltic Sea with 1’ x 2’ resolution in northward and eastward directions respectively, and archipelago50.rgn – a grid of Sweden archipelago between Gavle and Bråviken with 50x50 meters resolution. These grids are provided as a template to create grids for the sub areas. Figure 2 – Figure 7 shows how a sub grid can be generated. Firstly the “template” grid should be read as a current area. It can be done by using the “Change area” item of the “File” menu (Figure 2).

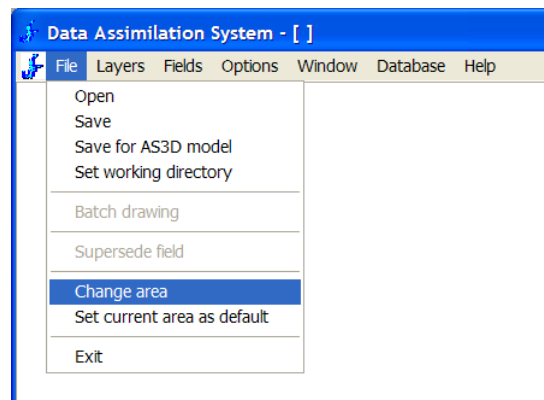


Figure 2 File menu "Change area"

Select a grid file (it is archipelago50.rgn in this example) and click “OK”. Note, the grid archipelago50.rgn is very big and work with it consumes lot of computer’s memory (more then 1.5G) and CPU time. It takes several minutes on a computer with 768M of RAM and Pentium-4 2GHz CPU.

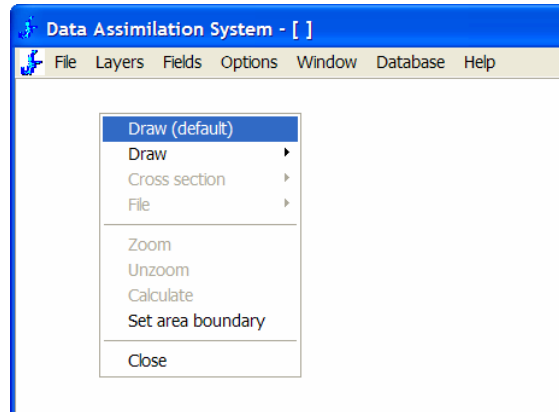


Figure 3 Popup menu to work with gridded data

Then depth distribution can be shown using the item “Draw (default)” in the popup menu (Figure 3). This depth distribution is presented on the Figure 4.

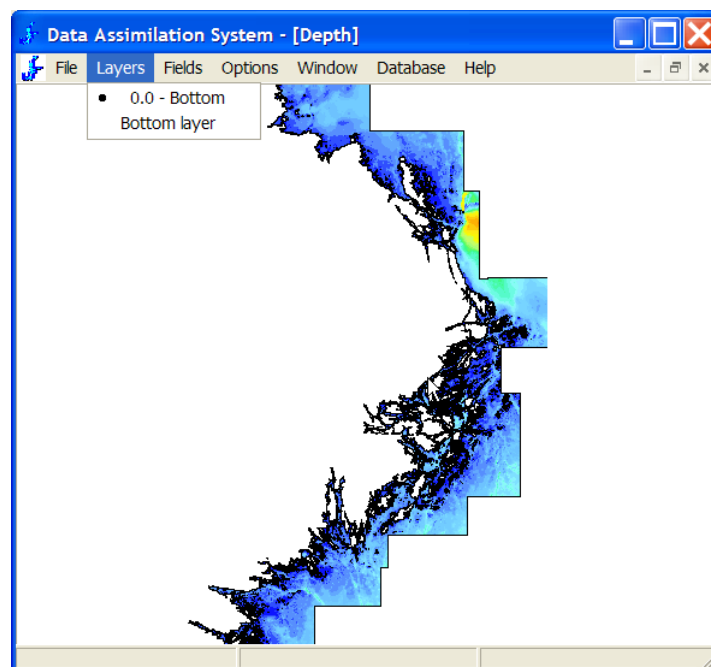


Figure 4 Menu "Layers"

The figure also shows that there is only one layer. Now, using “Zoom” (Figure 3) the sub area of interest can be selected. To create a grid file for this selected sub area the “Save grid for current area” item (Figure 5) has to be employed.

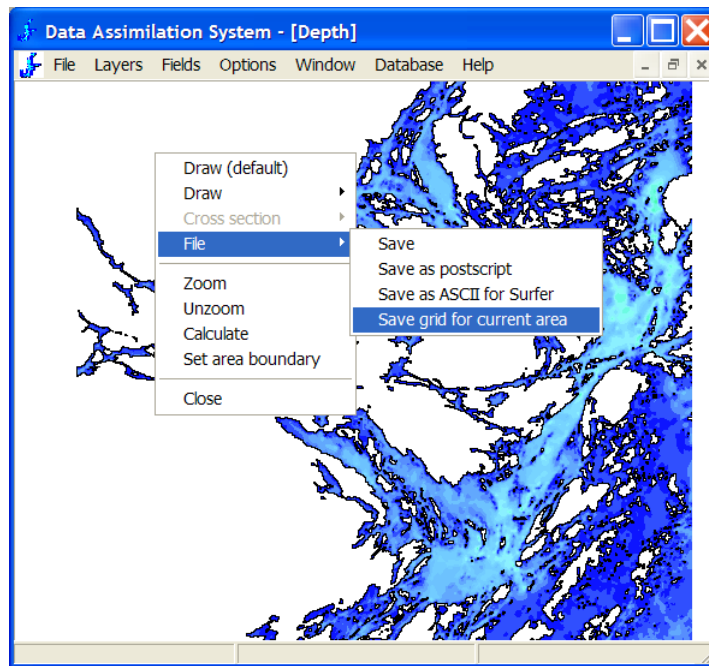


Figure 5 Saving the grid for current area

The dialog window “Save bathymetry for current region” (Figure 6) allows the user to set vertical and horizontal resolution for the new grid.

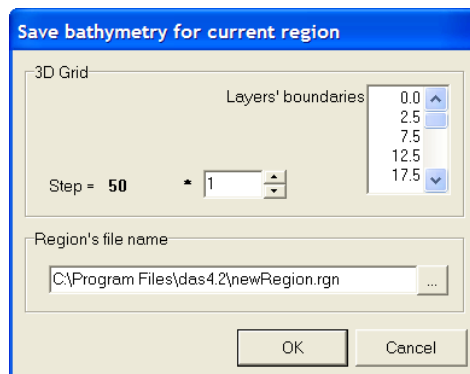


Figure 6 Setting of parameters of the grid

That’s it. To check what has been done, the generated file should be read (Figure 2) and displayed (Figure 3).

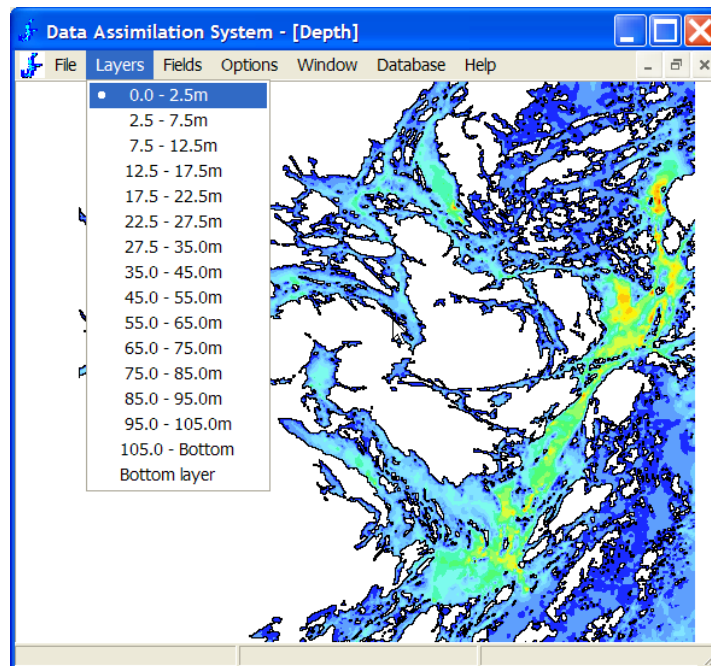


Figure 7 New grid with vertical resolution

Figure 7 presents a “proof” that everything has been done correctly. The item “Set current area as default” of the “File” menu makes DAS load this grid automatically each time.

Request data from databases

DAS can query the data from different sources:

- Baltic Environmental Database which contained hydrographic sampling data for the Baltic Sea and cover period of time starting 1900.
- Archipelago database contains hydrographic data collected in the Sweden archipelago between Gavle and Bråviken (password required).
- Local database – to manage the data locally the DAS is using the DBISAM database management system developed by Elevate Software (<http://www.elevatesoft.com>). Local database can be generated by either using DAS (saving requested data) or by freely available a client program for the DBISAM database (<http://www.elevatesoft.com/util212.htm>)
- Local table in *.csv (Comma Separated Values) format, which also can be constructed by DAS and then modified using a text editor or Microsoft Excel.

Addresses of two databases at the Department of System Ecology, Stockholm University: the Baltic Environmental Database (BED) and the database that contains

sampling data from the Stockholm archipelago (Archipelago) are built-in into the DAS (see Figure 8).

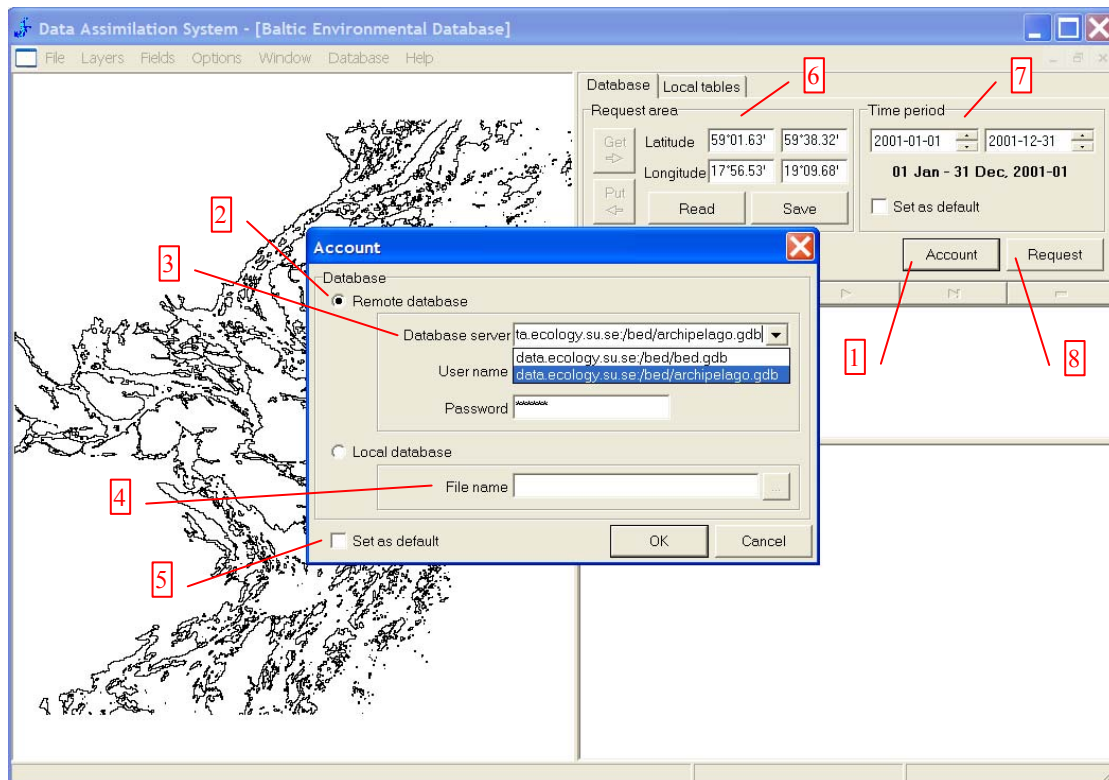


Figure 8 Setting of the database

The button “Account” (1) shows a dialog window “Account” where the user can specify the type of database (remote or local) to work with using the radio buttons (2). In case of “Remote database” the edit combo box (3) allows to choose one of the default databases or type in an address of another database. The text fields “User name” and “Password” are used to set an account for user access to the database. When working with the local database in DBISAM format, the file name of the database should be specified in the “File name” text edit box (4). The check box “Set as default” (5) saves these parameters as default values that will be used next time.

The “Request area” panel (6) is used to specify boundary coordinates for the area of interest. One can set these coordinates either by typing their values in the text boxes or by using the popup menu option “Zoom” for graphic selection in the map area. The “Zoom” changes the displayed region only and one must press button “Get” to use these boundary coordinates for the request. The “Put” button does the opposite – it adjusts the display area according to the coordinates in the request panel. The buttons “Read” and “Save” allows store/restore of these coordinates.

The “Time period” panel (7) defines a period within a year when the requested measurements were made for different years. The specified period of time can subsequently be used as default by employing the checked box “Set as default”.

The “Request” button sends a request to the database. Received data can then be saved as a local database in the DBISAM format or as a text file in CSV format. This can be done from the tabbed pane “Local tables” in the right – top corner.

Constructing 3D gridded data

Constructing of 3D gridded data is based on an iterative procedure of linear interpolation/extrapolation scheme. The procedure of interpolation/extrapolation uses two parameters: “Distance of interpolation” d_{Int} is a maximal allowed distance that can be filled using linear interpolation and the parameter “Distance of extrapolation” d_{Ext} defines a distance to be filled using extrapolation.

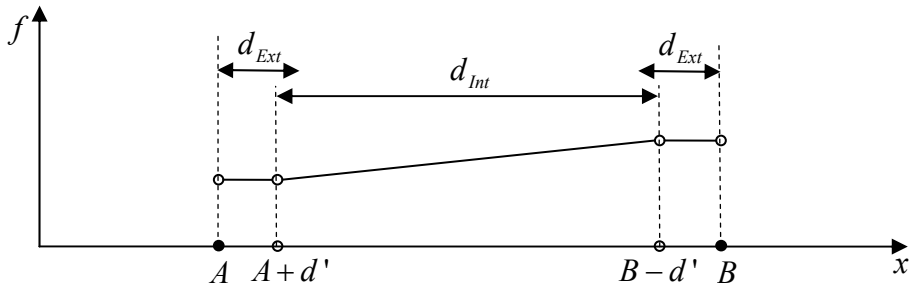


Figure 9 Linear interpolation / extrapolation scheme

Where A and B are the coordinates of two points with the data, d_{Int} and d_{Ext} are distances of interpolation and extrapolation respectively and

$$d' = \begin{cases} 0 & B - A \leq d_{Int} \\ \frac{(B - A) - d_{Int}}{2} & B - A \leq d_{Int} + 2d_{Ext} \\ d_{Ext} & B - A > d_{Int} + 2d_{Ext} \end{cases} \quad (1)$$

In case the distance between points with data $B - A \leq d_{Ext} + d_{Int} + d_{Ext}$ the function is calculated as a combination of extrapolation and interpolation:

$$f = \begin{cases} f_A & A < x \leq A + d' \\ f_{A+d'} + \frac{(f_{B-d'} - f_{A+d'})[x - (A + d')]}{(B - d') - (A + d')} & A + d' < x < B - d' \\ f_B & B - d' \leq x < B \end{cases} \quad (2)$$

Otherwise extrapolation is only used (see Figure 10)

$$f = \begin{cases} f_A & A < x \leq A + d' \\ f_B & B - d' \leq x < B \end{cases} \quad (3)$$

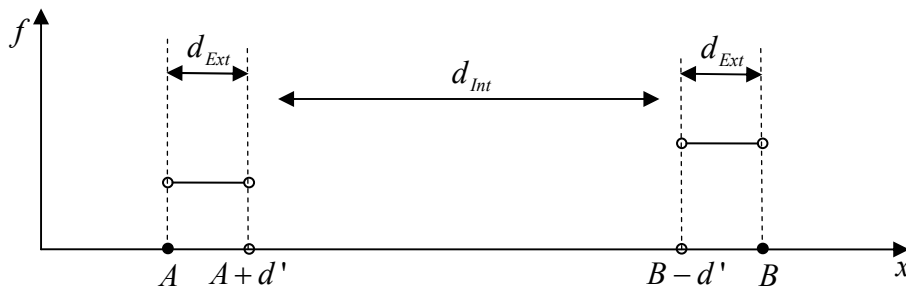


Figure 10 Extrapolation scheme

This procedure is used for one-dimensional interpolation first along the x axis, then along the y and z axes (see Figure 11). These calculations are performed iteratively while all grid points obtain values. Strictly speaking it is not true; iterations are performed until the number of “empty” points are equal on two contiguous iterations. This particular case will be discussed later (see Figure 14, Figure 15).

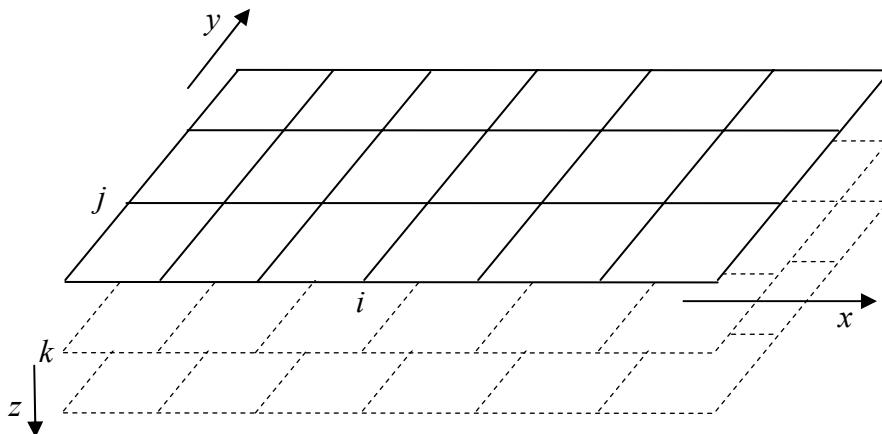


Figure 11 Coordinates and indices of the grid

Since the result of linear interpolation depends on the order of elementary one-dimensional interpolations (along x, y, z - axes), the average of six possible permutations of these elementary procedures is used. At a final stage a Tukey's cosine-filter (Tukey, 1977) is used to smooth the interpolation result.

To start the interpolation procedure the "Interpolation" sub menu is used (Figure 12).

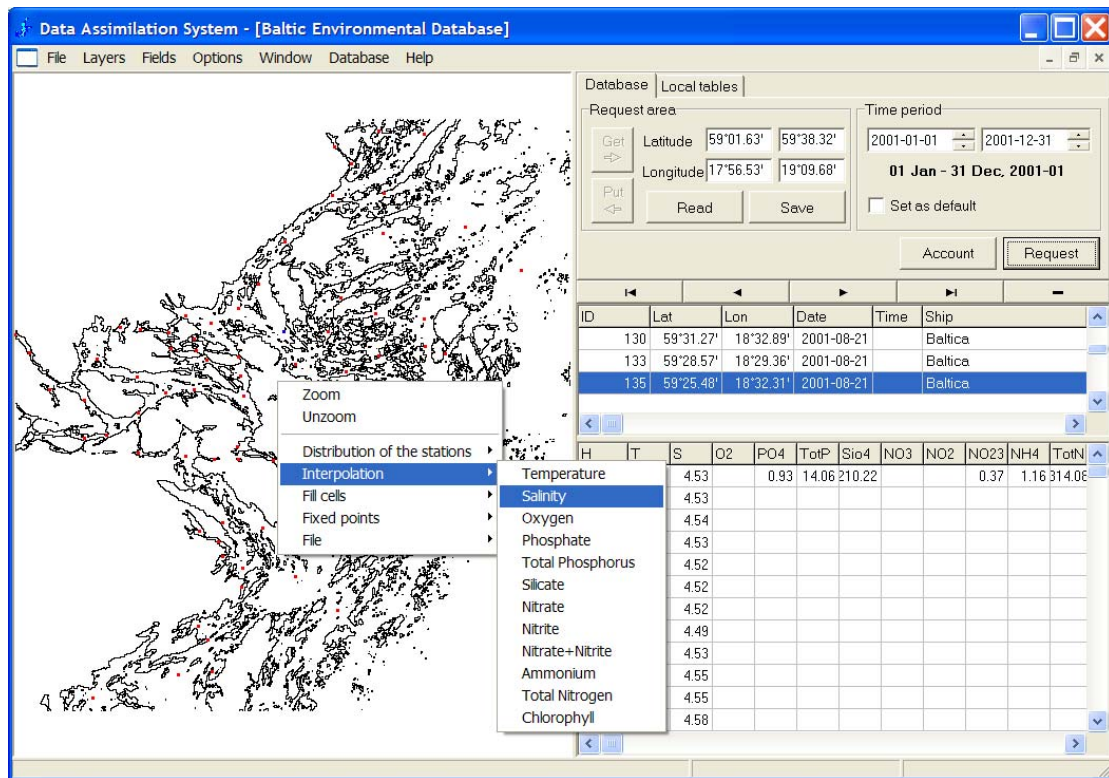


Figure 12 Start of interpolation procedure

When a variable for interpolation is selected (salinity in the example, presented on Figure 12) the dialog window "Gridded data" is activated (Figure 13).

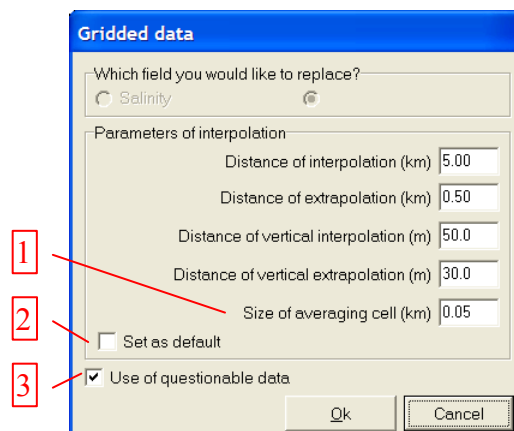


Figure 13 Setting of the interpolation parameters

This window contains besides already the discussed parameters of interpolation / extrapolation procedure the text field “Size of averaging cell” (1). This text field allows the user to change the size of the cell, within which all observations are averaged, before interpolation takes place. The checked box “Set as default” (2) sets the specified parameters of interpolation as default. The checked box “Use of questionable data” (3) makes it possible to exclude data marked in the database as ‘questionable’ from further calculations.

As has been mentioned early the interpolation is performed iteratively until the number of “empty” points is equal on two contiguous iterations. Ideally this number should be zero but in some cases it is not. The program checks the result of interpolation and shows a warning if “empty” points do exist in the area (Figure 14).

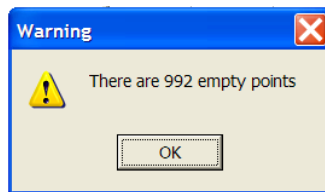


Figure 14 Empty points warning

In some cases there are such “wet” points in the area, which have no connection to the area with data and therefore these grid points remain “empty” despite of many iterations. An example of such situation is presented on the Figure 15.

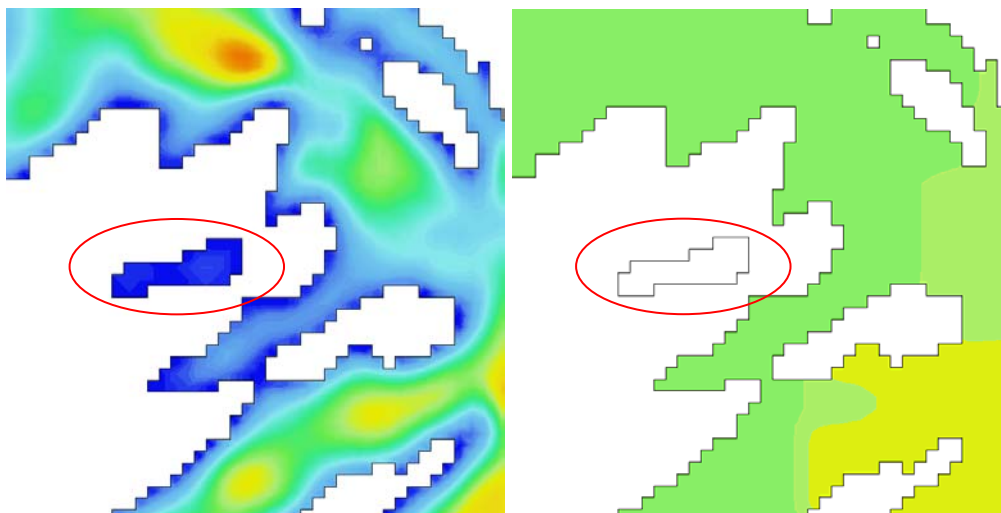


Figure 15 "Empty points": depth distribution (left) and salinity field (right)

The circled area has neither measurements nor connection to another area with data. Thus there is no way to interpolate data into these “wet” cells. Similar isolated areas are also presented on the Figure 17.

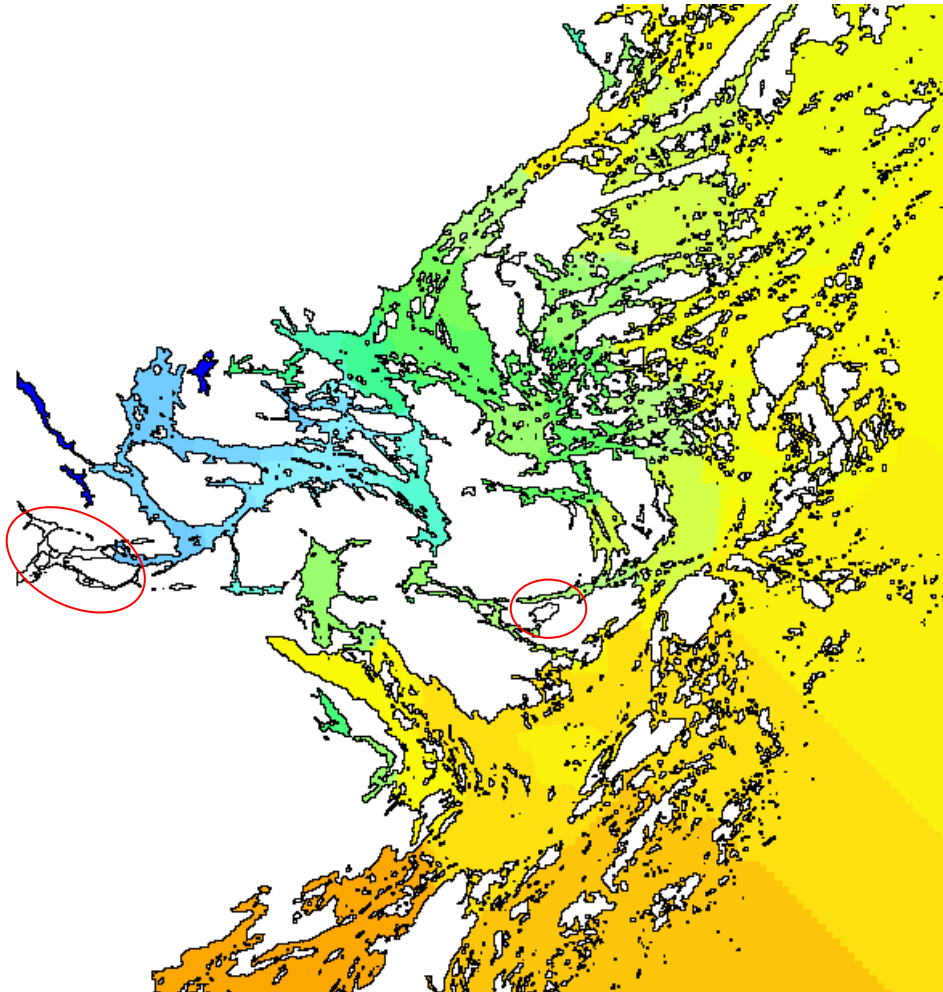


Figure 16 Distribution of salinity in Stockholm archipelago

As an example the salinity distribution in Stockholm archipelago is presented in Figure 16. The grid's step is 50 meters, the distance of interpolation is 5 km, distance of extrapolation is 500 meters, distance of vertical interpolation is 50 m, and distance of vertical extrapolation is 30 m (as was presented on Figure 13). The right lower corner of the grid has no measured data and grid cells in this area can obtain their values only by using extrapolation.

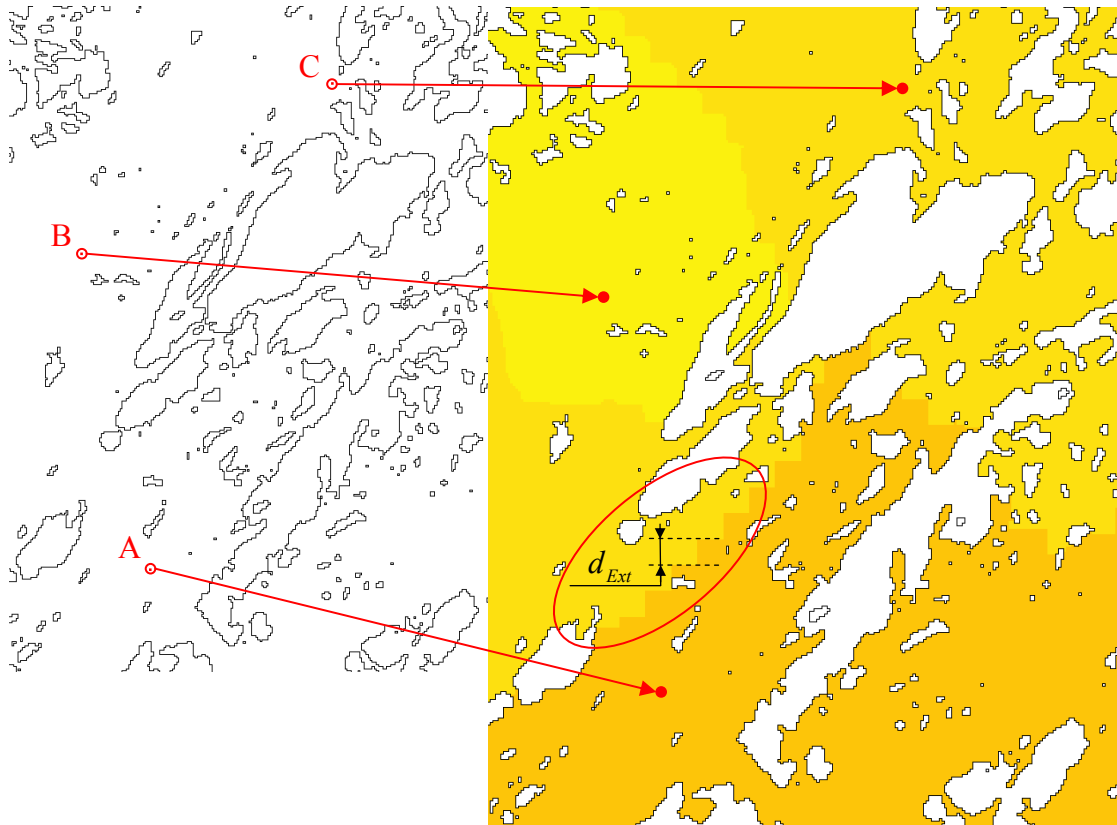


Figure 17 Example of interpolation

Figure 17 shows zoomed area with the last measured data in the south – eastern corner of the grid (stations A, B, and C). Circled stairs are the result of extrapolation procedure.

Main menu

File

Open – read gridded data prepared by DAS or other program in DAS format (AS3D model, for example).

Save – saves interpolated gridded data for later use by DAS.

Save for AS3D model – saves gridded data as initial condition for AS3D model (this data can be read by DAS as well).

Set working directory – sets working directory for current session.

Batch drawing – allows specifying several *.fld files which will be loaded consequently to create series of images according to current drawing parameters (name of field, layer, and parameters of the drawing palette). It mainly can be used for preparation of images to make an animation.

Supersede field – allows constructing a field as a linear combination of the others (Figure 18). These calculations could be performed repeatedly, using the result as an operand for the next calculation.

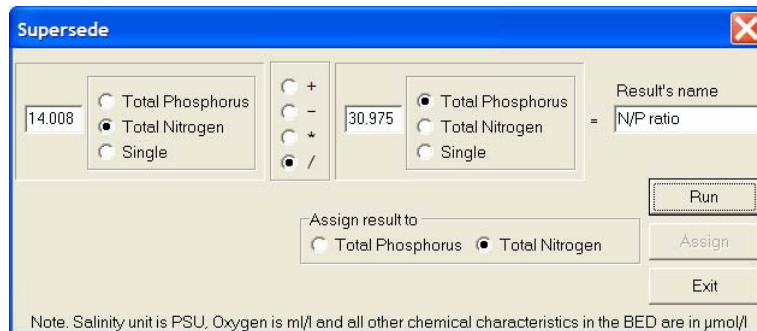


Figure 18 Constructing field as a linear combination of others

Change area – allows changing of an area (grid, bathymetry).

Set current area as default – sets current area as default area. This area will be loaded next time you start DAS.

Exit – terminates the program.

Layers

The “Layers” menu contains a list of layers in vertical direction and it is used to specify the layer for drawing (Figure 19).

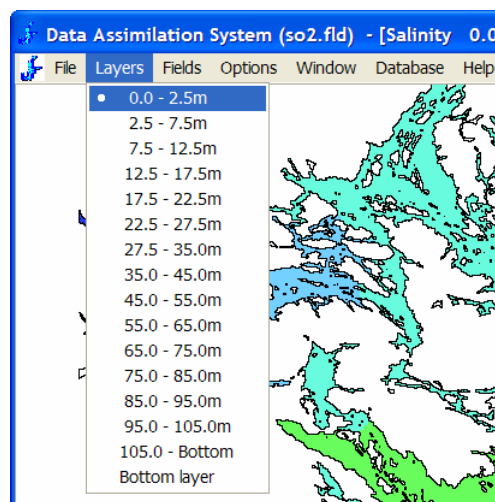


Figure 19 Menu "Layers"

The virtual “Bottom layer” means the nearest layer to the bottom in each grid cell.

Fields

The “Fields” menu contains a list of available fields. Generally, DAS can construct and work with two 3D fields that have been constructed using data from the database (salinity and oxygen, for example). Also the 2D “depth” field is always available (see Figure 20).

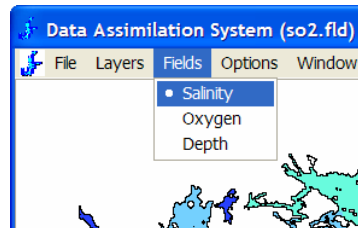


Figure 20 Menu "Fields"

An additional 2D field “Thickness” is appeared in the “Fields” menu (Figure 21) as a result of calculation of integral parameters and this layer represents a thickness” of water with parameters according to the criteria of calculation.

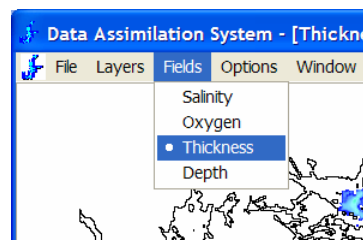


Figure 21 Additional field "thickness"

When DAS is used for analysis of the modeling results the menu “Fields” holds several additional fields (see Figure 22).

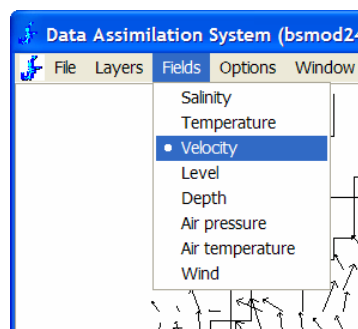


Figure 22 Menu "Fields" for modeling result

Options

All parameters of the graphical output are controlled by the dialog window **Options** which has several pages with control information.

The **Palette** page (Figure 23) allows manipulating of the color palette and will set **Min**, **Max** values and a color **Step** (a range of the function values within the same color) for each available oceanographic parameter. A left button mouse double click over any palette's color calls a palette editor to change this color. The button **Save** writes the current palette, the button **Read** reads a palette from the hard disk and the **Reverse** button reverses the order of the colors in the palette.

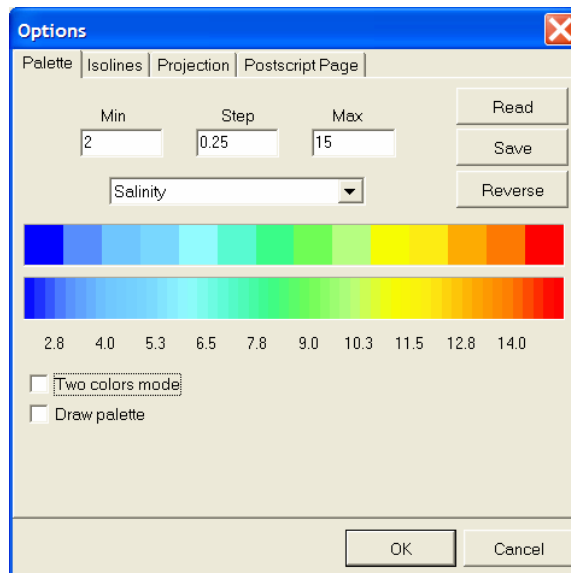


Figure 23 "Palette" page

There is also the possibility to investigate position of a certain boundary between water with different values of the state parameters. To do it one can check the **Two colors mode** check box and set the **Bound** value (Figure 24).

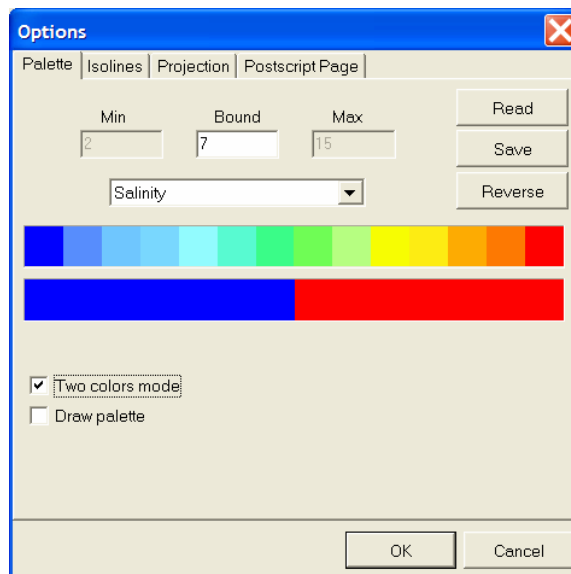


Figure 24 Setting of "Two color mode"

In this case all area with values of the function less than **Bound** value will be painted with the 'left' color and higher – with the 'right' color. The checked box “**Draw palette**” adds the palette on the screen together with the graphic output.

The second page in the “**Options**” window can be “**Isolines**” or “**Vectors**” and this depends on the currently selected field in the “**Fields**” menu. If the field selected in the “**Fields**” menu is a scalar field (salinity, temperature, depth, etc) the “**Isolines**” page will be shown (Figure 25).

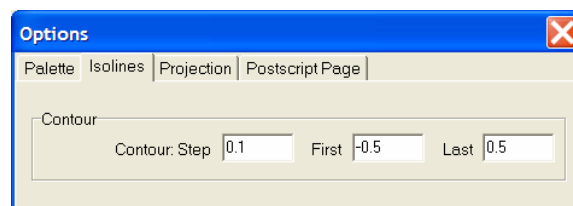


Figure 25 Parameters for contour plot

This panel allows to change **Step** between contour lines and a range of values between first and last contour lines (**First** and **Last** values). To turn this drawing off the **First** and the **Last** values should get the same an unrealistic value.

If the field selected in the “**Fields**” menu is a vector field (velocity, wind) the “**Vectors**” page will appear (Figure 26).

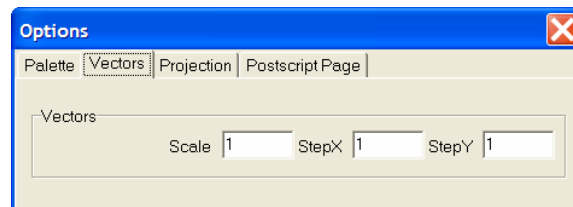


Figure 26 Parameters for drawing of vector field

The “**Scale**” parameter determines size of vectors on the graphic output. Default scale (equal to one) means that velocity of 10 cm/s is equal to size of a grid cell. The parameters “**StepX**” and “**StepY**” are steps of drawing the vectors.

The “**Projection**” page (Figure 27) defines all parameters for the 3D projection.

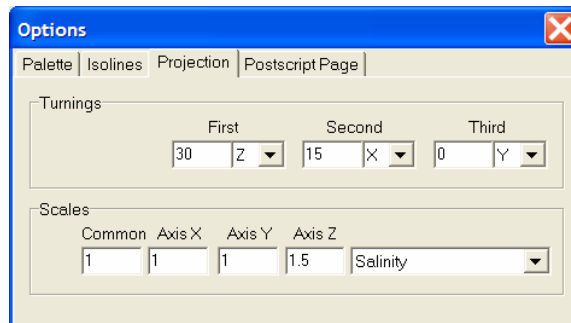


Figure 27 Setting parameters of projection for 3D drawing

Turning angles are in degrees, counter-clockwise looking to zero respective to the selected axis. After turnings, each drawing element is scaled along all axes by **Common** scale and then scaled again along each axis by an appropriate scale. These projection parameters are the same for all fields, except the scale along axis Z, which is different for different fields. The latter is needed to draw fields with very distinct values (e.g. salinity and atmospheric pressure) in compatible form.

The “**PostScript Page**” (Figure 28) defines parameters of a page for postscript output.

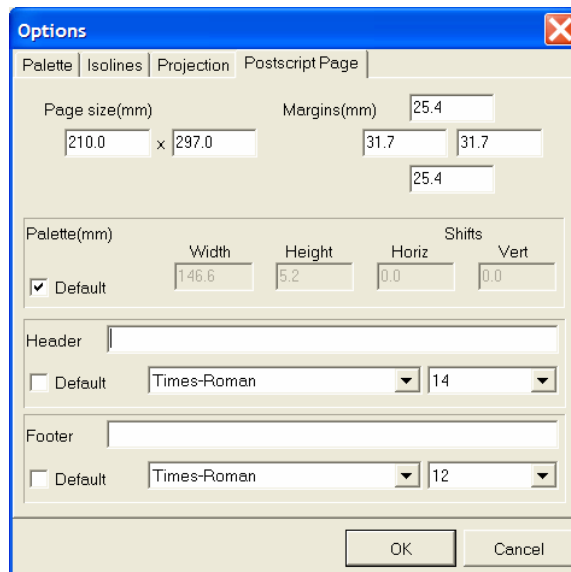


Figure 28 Parameters of postscript page

Default **Header** value is a name of the file with the fields and default **Footer** contains name of the field (salinity, for example) and boundaries of the layer.

Miscellaneous

Calculation of integral characteristics

As soon as DAS works with gridded data it can use tools to calculate some integral characteristics. Such means are provided by **Calculate** item that is available on the drawing window's popup menu. It starts a dialogue box, which calculates volume of the water, amounts of substances and their mean values in the current area according to set of criteria.

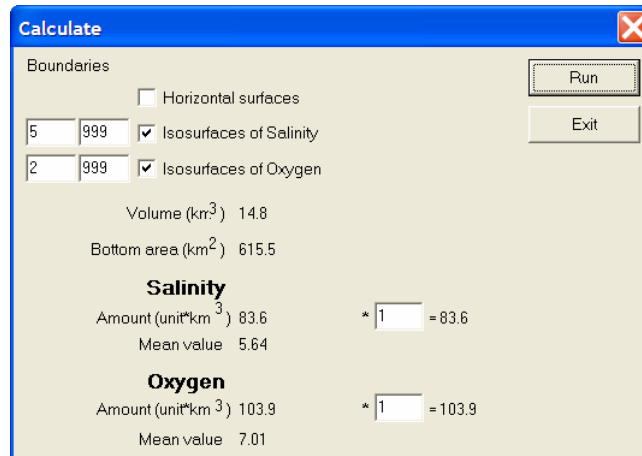


Figure 29 "Calculate" dialog box

These criteria are combinations of the interval for the vertical coordinate (horizontal surfaces) and intervals for both substances. If an appropriate box is checked boundaries edit boxes are used to set values of the boundary surfaces. Unchecked box means that this part of the criteria is not applied. For horizontal surfaces boundary values are in meters from free surface to the bottom. In case of the *Isosurfaces* type of boundaries, these edit boxes present values of the isosurface for “upper” and “down” boundaries. During the calculation DAS automatically creates a 2D field with spatial distribution of the thickness of the water that matches the criteria. One can investigate this field in graphical form later (the item **Thickness** in the **Fields** menu).

References

- Seifert, T. and B. Kayser. 1995. A high resolution spherical grid topography of the Baltic Sea. Meereswissenschaftliche Berichte / Marine Science Reports, Institut für Ostseeforschung, Warnemünde.
- Tukey, J. W. (1977). Exploratory data analysis. Addison – Wesley, Reading, Mass. xvi + 688pp.
- Sokolov, A., O.Andrejev, F.Wulff and M.Rodriguez Medina: The Data Assimilation System for Data Analysis in the Baltic Sea. Systems Ecology Contributions, 3, Stockholm University, 1997, 66pp.