



CommonGIS[®]

Reference Manual

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©

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1. Introduction

CommonGIS is not an ordinary Geographical Information System (GIS). It rather supports many different user groups in their task to analyze and interpret geographical data.

The main purpose of CommonGIS is to enable the user to analyze spatial data interactively. The user can select from a set of spatially related statistical values and CommonGIS automatically creates a set of maps or diagrams using cartographic knowledge. Additionally the user has visual and computational methods at his disposal in order to prepare spatial-oriented decisions. He can evaluate alternative options by selecting criteria, giving them weights, ranking the resulting options, showing similarities between options, etc..

This manual mainly intends to help the user to get familiar with CommonGIS. Furthermore it shall also serve as a reference book. Hence it is subdivided in a task-focussed way so that the user can access the required information for executing and continuing his tasks directly.

Supported by the index and the glossary the user can acquire the manual's contents by looking up general keywords or technical terms from CommonGIS.

In the last part some Frequently Asked Questions (FAQs) and deepening answers about the use of CommonGIS are described. They shall contribute to a growing understanding of the possibilities and the use of CommonGIS.

CommonGIS is developed and distributed at the Fraunhofer Institut Autonomie Intelligente Systeme (AIS), department SPADE. Further information about SPADE or AIS can be found in the WWW under the following URLs:

[< http://www.ais.fraunhofer.de >](http://www.ais.fraunhofer.de)

[< http://www.ais.fraunhofer.de/SPADE >](http://www.ais.fraunhofer.de/SPADE)

Updated information concerning CommonGIS is offered within the CommonGIS forum where users of CommonGIS can exchange ideas and are invited to give feedback, suggestions, and utter criticism.

The forum is accessible under:

[< http://www.commongis.de >](http://www.commongis.de)

The development of CommonGIS was partly supported by EU-funded projects (ESPRIT project 28983).

The system contains software from different partners:

1. file management utilities by IITP RAS
(<http://www.iitp.ru/>)
2. Implementation of the Open GIS simple feature specification by the University of Bonn
(<http://www.guib.uni-bonn.de/exse/results/welcom.html>)
3. Map printing by Dialogis GmbH
(<http://www.dialogis.de>)

1.1. Overview

CommonGIS is a Java-based GIS (Geographical Information System) usable within the Web which follows the approach to link statistical data to spatial entities. It comfortably supports the preparation and interactive analysis of thematic maps.

To analyze the data the user can choose between different kinds of interactive choropleth maps: unclassified, classified and qualitative, with additional charts with bars, cakes or pies. Within the chosen map the user is given the possibility to focus on special geographical objects so that he might discover similar spatial structures hidden so far. In order to reduce the complexity of the data the user can interactively hide statistical outliers and have only objects displayed which fulfill certain conditions (dynamic query).

The user selects a subset from a set of spatial statistical data and let CommonGIS display them in maps which are suitable for the visual evaluation of the data and their interrelations. Therefore a variety of methods is available - ideal point analysis, weighted linear combination, ordered weighted averaging, multiple criteria comparison or Pareto set.

In order to prepare the data for further analyses, new attributes can be calculated (calculation of statistic indices, arithmetic computation, combination of attribute data, dynamic classification and cross classification) or geographical transformations can be performed (transformation of points and lines in raster data, combination and derivative of raster data, transformation of raster in vector data).

CommonGIS can work with the following data formats:

- Geo formats: *shp*, *adf*, *bil* (ArcGIS); *MIF/.MID* (map info.); *gml*, *wbk* (OpenGIS); *flt* (GeoProcessor), *ovl* (Descartes).
- tables: *dbf* (Dbase); ASCII; clipboard (ASCII).
- images: gif; jpeg.
- DBMS: ODBC data bases; Oracle.

1.2. Use concept

CommonGIS supports the user with the analysis of spatial data (arranging, separating, preparing and processing of data) and with the presentation of the results. The burden of performing routine activities, e.g. drawing or updating maps, is taken from the user. In order to find interrelations between data objects and to explore their roots CommonGIS displays alternative presentations of the data simultaneously and enables the user to interpret data efficiently.

First the user must provide appropriate data and organize it in CommonGIS (see section 4.1 *Preparing data*). For this purpose he loads geographical layers and tables with attribute data referring to spatial objects. The initial state for further analysis is a thematic basemap which shows the data of the different layers (see section 3.2 *How to use CommonGIS?*).

Now the user

- produces different maps, tables and diagrams within CommonGIS (see section 4.2 *Presenting data*),

- lets the system compute new data from the existing data set (see section 4,3 *Computing data*) or
- (cor)relates data according to decision criteria (see section 4,4 *Supporting decision making*).

The maps and diagrams are linked together, so that the user can regard the same data from different perspectives, i.e. in different kinds of analytical visualisations. Additionally the user can interrelate selected attributes and weight them, so that the influencing factors for some characteristics can be estimated (e.g. optimal resort for family X, suitable location for a branch office, classification of roads according to traffic volume...).

If the user has achieved an interesting result by interpreting the data with CommonGIS, he needs to be able to save it in an appropriate manner (see section 4,5 *Saving results*). Furthermore GIS-appliers are frequently asked to present and justify their analytical results. If the user is asked to report his results in written form he can export maps, charts or diagrams into regular office tools easily. In future versions CommonGIS will provide a special commenting tool to support the handling of (intermediate) results.

The succeeding table lists the general tasks of handling (geo) data together with the handling-methods available in CommonGIS. At the same time, it shows how this manual is structured.¹



Chapter	Task	CommonGIS functions
Preparing data	Define layers	<i>Project: Open</i> <i>Project: Data import</i> <i>Edit: Add layer</i>
	Define attributes	<i>Edit: Add attribute</i>
Presenting data	Visualize data in maps	<i>Display: Display wizard...</i>
	Visualize data in diagrams	<i>Display: Display wizard...</i>
	Visualize data in tables	<i>Display: View table</i>
	Represent raster data	<i>Subwindow "Manipulate": Drawing properties</i>
Calculating data	Transform attributes	<i>Calculate: Calculate in a table</i>
	- arithmetic operations - statistic operations geographic transformations (operations on raster and vector data)	<i>... Arithmetics</i> <i>... Statistics</i> <i>Calculate: Geographic computations</i>
Relating data	Multi-criteria decision support	<i>Calculate: Calculate in a table</i>
	Multivariate analysis Dynamic query	<i>... Decision support</i> <i>... Multidimensional analysis</i> <i>Calculate: Dynamic query</i>
Saving results	Save current state of work	<i>Project: Save Snapshot</i>
	Save project	<i>Project: Save</i>
	Save created map	 : <i>Save map</i>
	Print created map	 : <i>Print map</i>
	Export data	<i>Project: Data export</i>

Table 1.2.1 Analyze data with CommonGIS.

¹ If you read the manual sequentially, you will notice that specific usage information is repeated in different contexts. This is to support readers who directly delve into some special section to inform them of particular important system characteristics.

1.3. System concept

CommonGIS can be applied to any spatially related data independent of the faculty as long as it matches the intended formats. So it's methods and tools can be used within a wide range of different applications (cartography, demography, land register, geo marketing...).

Different data sets which shall be analyzed with CommonGIS are combined into a project, called "application" (file suffix ".app"). From a technical point of view a project is composed of a set of files containing application data and several handling files, telling the system, how the geo data has to be visualized and analysed.

Thus the project file (.app) contains the metadata specifying first which layers shall be displayed in the map view and refers secondly to the external files required for each layer.

Consequently a project is made up of two kinds of files:

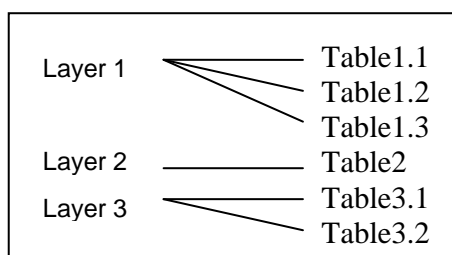
- table-files containing attribute data, usually referring to spatial objects (districts, cities, regions,...).

The objects or data records are addressed by their unique identifiers. Each table should have a column for the object identifiers.

- geographical layers, made up of vector data or raster data, which specify the graphical visualisation.

There is no limit for the number of layers or tables which can be integrated into a project but one table can only refer to one single layer (see pattern below). When defining the project the user is asked to assign a table to specific layer and consequently each table should be assigned to the geographical layer, which contains the spatial objects from the table. These objects must have the same identifiers in the table and the geographical layer. Layers, which do not contain objects of any table, can serve as geographical background. The layers of a project are listed in the legend of the map (see left border in fig. 1.3.1).

Application scheme:



Wallis.app:

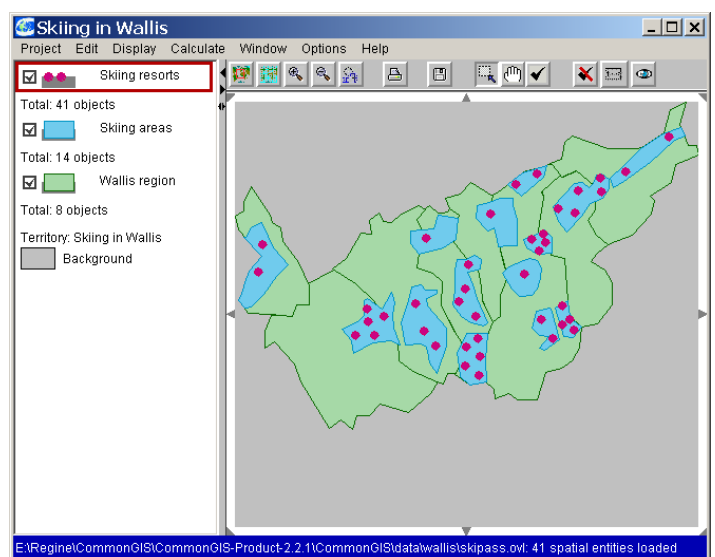
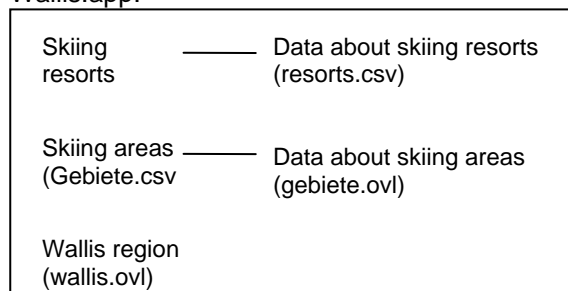


Figure 1.3.1 Elements of a CommonGIS project

The project "Skiing in Wallis" in fig. 1.3.1 consists of three vector layers (Skiing resorts, Skiing areas, Wallis region) and two tables (Data about Skiing areas, Data about Skiing resorts), which are assigned to the layers of the same name. The layer "Wallis region" does not have data assigned to it. In table 1.3.1 the file "wallis.app" is listed in the left column. It describes which files are loaded and how they are represented within CommonGIS. The window in the right column lists the files belonging to the project.

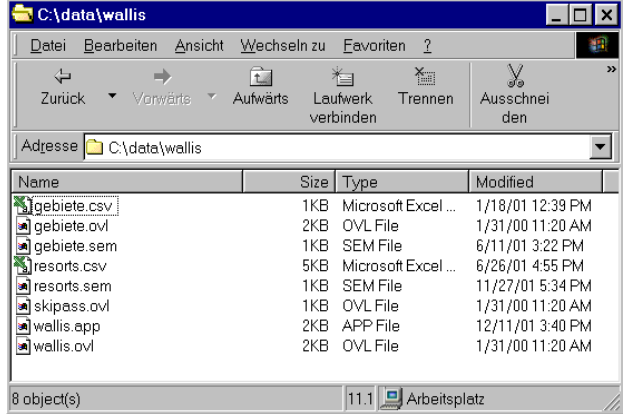
<pre> APPL_NAME "Skiing in Wallis" USER_UNIT "m" LAYER "wallis.ovl" "Wallis region" FORMAT "OVL" TYPE AREA DRAWING + TRANSPARENCY - BORDERS + BORDERW 1 BORDERCOLOR (11,105,1) BACKGROUND (166,217,167) HATCH_STYLE 1 LAYER "gebiete.ovl" "Skiing areas" FORMAT "OVL" TYPE AREA ... LAYER "skipass.ovl" "Skiing resorts" FORMAT "OVL" TYPE POINT DRAWING + ... TABLEDATA "gebiete.csv" "Data about skiing areas" FORMAT "CSV" DELIMITER "," FIELD_NAMES_IN_ROW 1 ID_FIELD 1 NAME_FIELD 2 LAYER_REF "gebiete.ovl" TABLEDATA "resorts.csv" "Data about skiing resorts" DELIMITER "," FIELD_NAMES_IN_ROW 1 ID_FIELD 1 NAME_FIELD 2 LAYER_REF "skipass.ovl" DECISION_RESULT_DIR "analysis_results/" DECISION_RESULT_FILE "vote.csv" *DECISION_RESULT_SCRIPT "http://borneo.gmd.de/cgi- bin/descartes/fss/fss" DECISION_TYPE "classification" n" </pre>	
--	--

Table 1.3.1 Components of project „Wallis“

In CommonGIS different representation modes of the same information can be visible on the screen at the same time (different maps, diagrams and graphs). These representations are dynamically linked. If the user points to an object with the mouse in one representation, this object is highlighted in the other visible representations as well. Results, which are obtained in a window, are simultaneously supplemented in the other representations.

1.4. Hardware and Software Requirements

CommonGIS runs on a PC with at least 16 MB RAM.

CommonGIS is implemented in **Java**. It runs as a Java application locally or as applet in a web browser. Therefore it will run, if the Internet browser supports Java applets. Recent versions of **Netscape** (4.x or higher) or **InterNet Explorer** (4.0 or higher) must be installed and **Java** must be enabled in the options.

The Java run time environment (JRE) (minimum requirement: Version1.1) is attached to the CommonGIS software package.

1.5. Profile of Fraunhofer Institut Autonome Intelligente Systeme

Fraunhofer AIS develops solutions that - by way of their intelligence – help to improve human decision-making and - by way of their autonomy – relieve humans of onerous tasks and, in particular, widen the scope of human action. Knowledge computing and autonomous robots are the core activities of the institute founded in 1998.

AIS develops *business intelligence* solutions that enable improved decision-making through integrated analysis of databases as well as of data from multimedia-, text-, web- and geo - sources (visualization, extraction of information, data mining). The systems designed by AIS are used by commercial and logistics companies – among them one of the leading retail groups in Europe – to support their production site analysis and marketing campaigns interactively. The fact that ideation processes are facilitated by AIS software applies to both in small and large teams – in contexts as diverse as business environments or citizen involvement committees on a municipal level, for instance. The schemes used by AIS to model complex systems are derived from multi-agent systems developed in telematics applications.

In the field of *autonomous robots*, AIS develops sensor-based, robust wheel-driven and walking mobile robots. The institute is a leading player in terms of sensor fusion of 3D laser scanner data for the purpose of unknown environment exploration. The development of robots, however, does not only serve to perform explorative tasks but also fosters improvement in the field of education, considering that robots contain elements featuring mechatronics, computer science, and electronics, all of these disciplines forming part of engineer education and training. For these purposes AIS provides its own specific robotic systems. Last but not least, the institute's range of expertise also includes real-time simulation and control of non-linear systems, intelligent control systems as well as hardware and software integration.

In addition to membership in the IuK Group, AIS is linked to other Fraunhofer Institutes via five different expert networks: Fraunhofer Vision Alliance, Fraunhofer Traffic and Transportation Alliance, E-Government Centre, Fraunhofer Regional Initiative North-Rhine Westphalia, Fraunhofer Adaptronics Alliance.

The AIS entered into a strategic cooperation with the Department of Applied Computing Science of the Bonn-Rhein-Sieg Technical College. The two partners jointly offer a Master course entitled "Autonomous Systems". Successful completion of this international, three-semester course of study will lead to the award of a degree named „Master of Science in Autonomous Systems”.

2. Installing CommonGIS

2.1. *Installing the software*

You received the CommonGIS software either on CD or you downloaded it from our server.

On the CommonGIS installation CD you will find the file "CommonGIS.exe" (Self extractor). You only need to doubleclick on it and indicate in the following dialogue, at what position in your file system you want to install CommonGIS.

If you downloaded the file "CommonGIS.zip" from our server you have to unpack the program first of all. Select the folder in which you want to install the program and unpack the file to this directory ("Unzip").

Please get further details for installation from the files "How_to_install.pdf" and "Readme" in appendix 1.

2.2. *Starting CommonGIS*

Now open the recently "CommonGIS" folder containing the "CommonGIS" files. You can work with CommonGIS in two different ways:

- as local application

Start the program by double-clicking file "CommonGIS-J2-en". CommonGIS will be running with its own Java Virtual Machine (under jre122).

You can create a shortcut to this starting file at the desktop (right mouse button), so that you can call CommonGIS directly from the desktop, when you start your system the next time.

- as applet in your browser

Launch the program by opening the file "applet.html" (double-clicking). CommonGIS will be running in your browser now. If there are problems occurring when executing the applet in your browser please follow the installation instructions in appendix 1, section *installing the Web variant*.

In addition to the pdf-file automatically provided in the installation folder during installation, the CommonGIS user manual is also available online (menu option *Help:Index*).

Language Configuration: If you would like to change the language of the CommonGIS user interface, open file "system" with the help of a text editor (e.g. Notepad under "accessories") and change the variable LANGUAGE to "german" or "english", respectively.

Enter

LANGUAGE=german

to change the user interface to german language,
enter

LANGUAGE=english

to set the user interface to english.

2.3. *If you want to use your own Java Virtual Machine*

Open the starting file ("CommonGIS-J2-en") within the CommonGIS folder in a text editor (e.g. Notepad in "accessories").

Enter the path name denoting your Java Virtual Machine (containing folder bin and lib), e.g.:

set JAVA_HOME=C:\Program Files\JavaSoft\JRE\1.3.1_06

If you use Java 1 (i.e. 1.1.x), you have to uncomment the call to Java by deleting „rem“ and comment the call to Java 2 by inserting „rem“:

rem for Java Runtime 2 and higher:

rem "%JAVA_HOME%\bin\java" -Xms50000000 -Xmx500000000 -classpath %CLASSPATH% esda_main.RunDescartes %1

rem for Java Runtime 1.1.x

"%JAVA_HOME%\bin\jre" -ms50000000 -mx500000000 -classpath %CLASSPATH% esda_main.RunDescartes %1

Save the file and start CommonGIS as described earlier.

3. First Steps with CommonGIS

3.1. *Tasks supported by CommonGIS*

Visualising data

The exploratory analysis of data serves as a mean to uncover important characteristics and relations of data by making them visible from different perspectives. In order to support the investigation of the data, the maps and diagrams produced in CommonGIS are interactive and dynamically linked so that changes of attribute sets, data filters, data classifications or calculated data are immediately reflected in all active displays.

CommonGIS provides the user with means

- to recognize spatial patterns or relations,
- to recover information to explain the observed findings
- to detect connections between spatial and/or temporal phenomena.

CommonGIS offers thematic maps which can be enriched with statistic diagrams to support these tasks.

On selecting menu option *Display: Display wizard...*, the user is asked to specify thematic data and select attributes he wants to investigate. First of all, CommonGIS checks which display methods could be suggestive and provides the user only with this subset.

Singular attributes:

If the user selects exactly one attribute with numeric values, he gets the maps and diagrams listed in fig. 3.1.1 (in bold).

Selected attributes:	Maps	Charts
elevation min	<input checked="" type="radio"/> Do not build a map <input type="radio"/> Unclassified choropleth map <input type="radio"/> Classified choropleth map <input type="radio"/> Cross-classification <input type="radio"/> Standalone bars <input type="radio"/> Graduated circles <input type="radio"/> Parallel bars <input type="radio"/> Pies <input type="radio"/> Triangles <input type="radio"/> Class mosaics <input type="radio"/> Dominance classification <input type="radio"/> Multiple choropleth maps <input type="radio"/> Multiple maps with classes <input type="radio"/> Multiple maps with standalone bars <input type="radio"/> Multiple maps with graduated circles <input type="radio"/> Qualitative colouring <input type="radio"/> Icons <input type="radio"/> Qualitative Cross-Classification <input type="radio"/> Stacks <input type="radio"/> Utility bars <input type="radio"/> Utility wheels Map location: Automatic	<input checked="" type="radio"/> Do not build a chart <input type="radio"/> Attribute statistics <input type="radio"/> Frequency histogram <input type="radio"/> Dot plot (horizontal) <input type="radio"/> Dot plot (vertical) <input type="radio"/> Dispersion graph <input type="radio"/> Ranged distribution histogram <input type="radio"/> Classification <input type="radio"/> Scatter plot <input type="radio"/> Scatter plot matrix <input type="radio"/> Parallel coordinates plot <input type="radio"/> 1:n Correlation Graph <input type="radio"/> n:n Correlation Graph <input type="radio"/> District Overview

OK Back Cancel

Figure 3.1.1 Context-dependant range of display methods for a single numeric attribute.

If the user wants to have a closer look on an attribute with logical values (yes, no), he can choose between the alternatives in fig. 3.1.2 printed in bold.

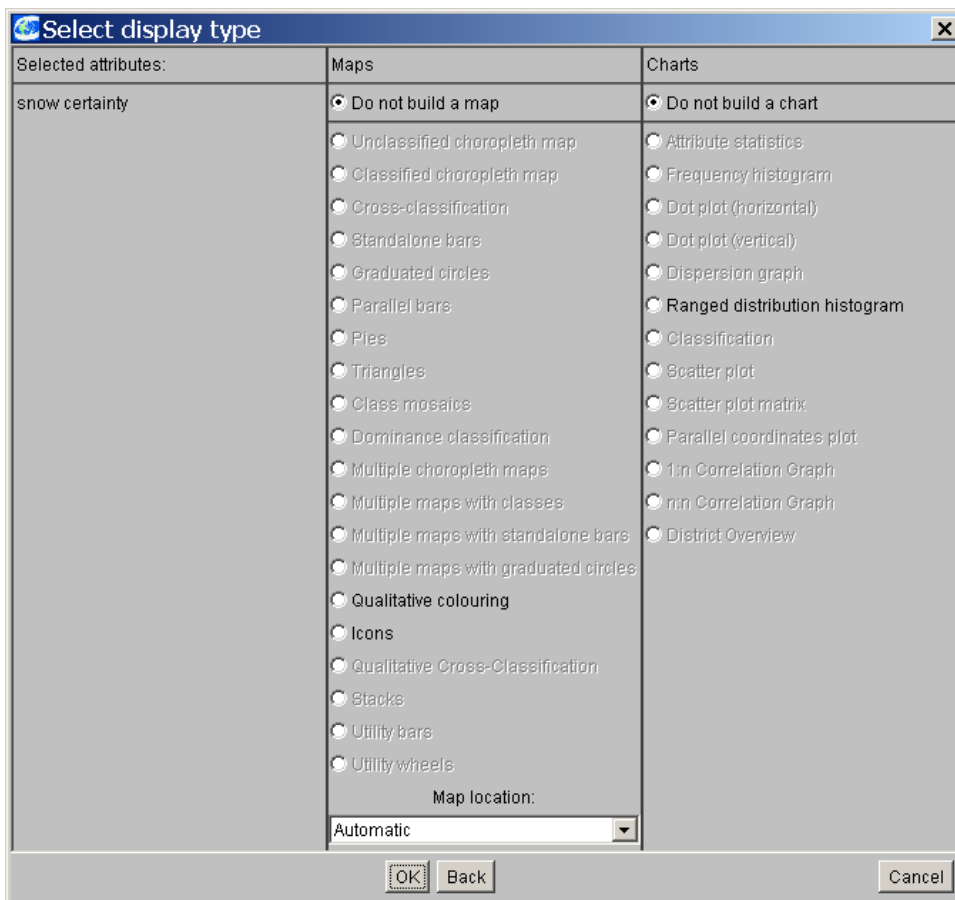


Fig. 3.1.2 Context-dependant range of display methods for a single Boolean attribute.

Several attributes:

Having several related attributes selected CommonGIS offers the user again a different range of display methods:

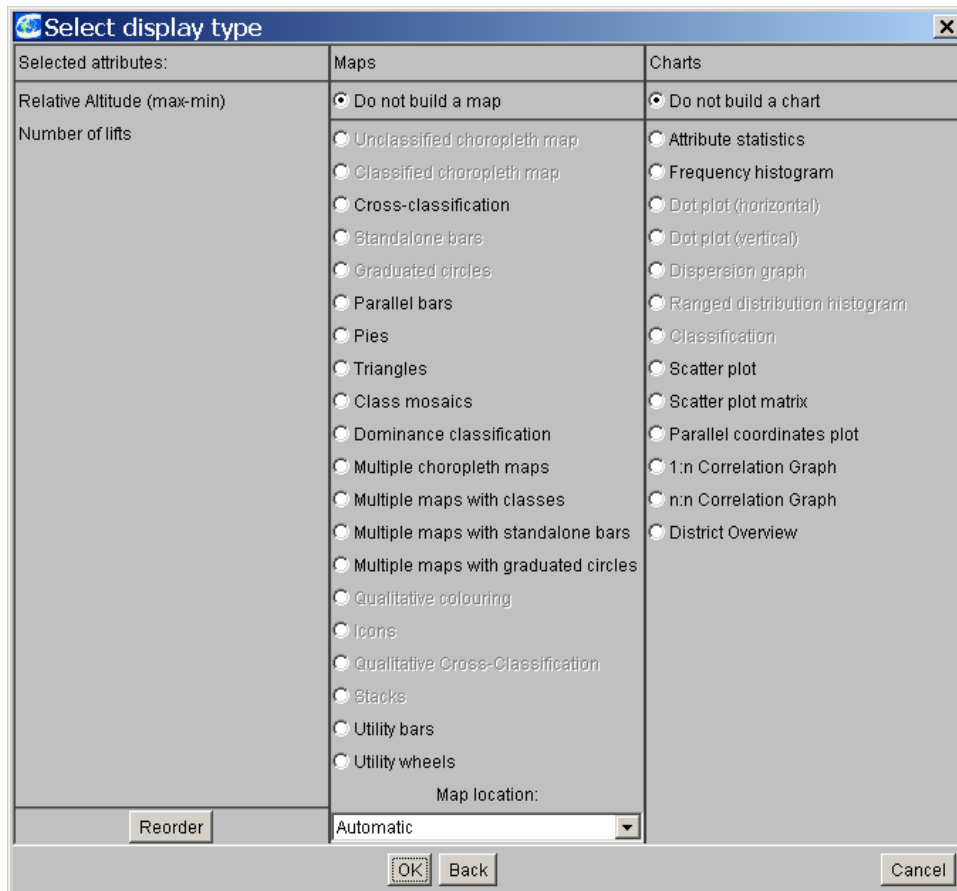


Fig. 3.1.3 Context-dependant range of display methods for several attributes.

Attributes with temporal information:

If the user analyses time series, i.e. data changing over time, he can select special visualization methods.

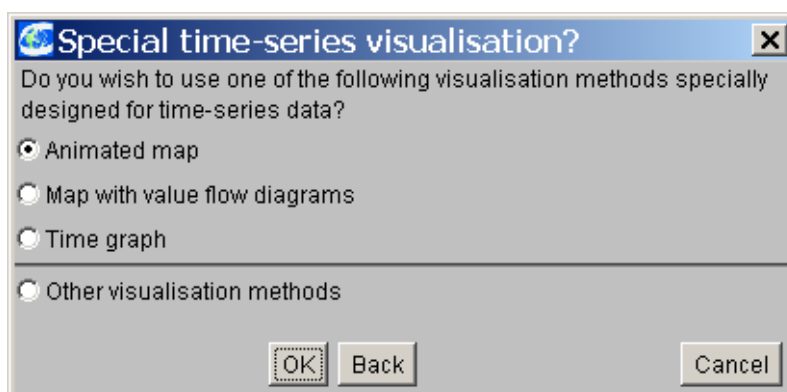


Fig. 3.1.4 Context-dependant range of display methods for time-series data.

Within CommonGIS it is possible to create multiple displays representing different attributes of the same data set or the same attributes in different ways. Thus, the user can open one or more maps and various kinds of non-cartographic displays: dot plots, scatter plots, parallel coordinate plots. All these representations are dynamically linked. When the

user points with the mouse to an object in some representation, all graphic items referring to this object in other representations (contour in a map, dot in a dot plot or a scatter plot, line in a parallel coordinate plot) are simultaneously highlighted.

Calculating data

Besides the visual representation of spatial data additional statistical calculations and multivariate analyses can help to explain the amount of data which shall be analyzed and to prepare informed decisions.

CommonGIS supports the user to

- collect and/or produce the data needed for decision-making,
- discover and represent alternative options,
- evaluate and select alternative options.

CommonGIS offers arithmetic and statistic calculation methods and methods which assist the user particularly in the spatial decision making process.

On selecting the menu option *Calculate:Calculate in a table*, the following computational methods are available:

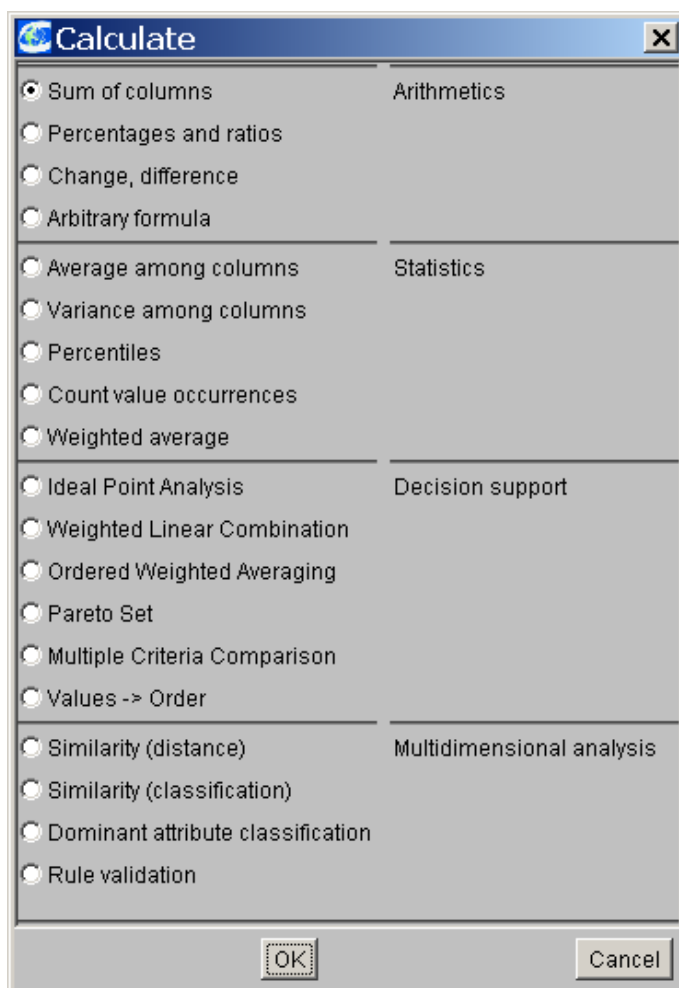


Fig. 3.1.5 Calculation methods of CommonGIS

Another useful tool for decision making is “dynamic query” (menu option *Calculate:Dynamic Query*). With this tool you can interactively set and dynamically alter constraints on attribute values. In this way the user can successively narrow the set of options to those fulfilling the criteria he considers as the most important.

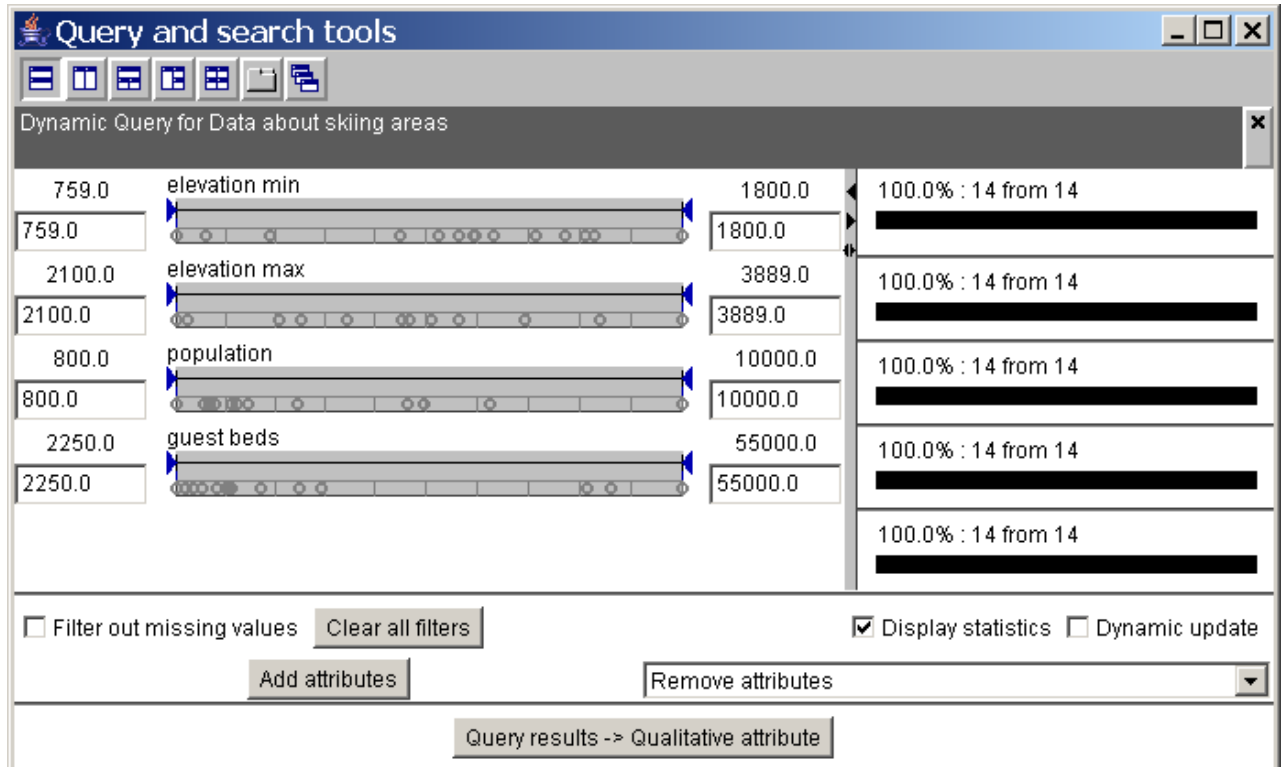


Fig. 3.1.6 Dynamic query on data about skiing resorts (project „Wallis.app“).

Working with raster- (grid-) data

Besides vector and thematic data CommonGIS can also work on raster data. Raster data is suitable for showing a realistic impression of surfaces and to model continuous phenomena. Meanwhile many topographic maps are available as scanned digital raster files and can be implemented for the analysis of spatial phenomena in CommonGIS.

The user can

- produce a new map layer from the existing raster data which fulfills certain conditions,
- compute attributes and vector objects from raster data,
- combine raster maps,
- examine raster data more closely.

To this end CommonGIS offers the menu option *Calculate: Geographic computations* (see Fig. 3.1.7).

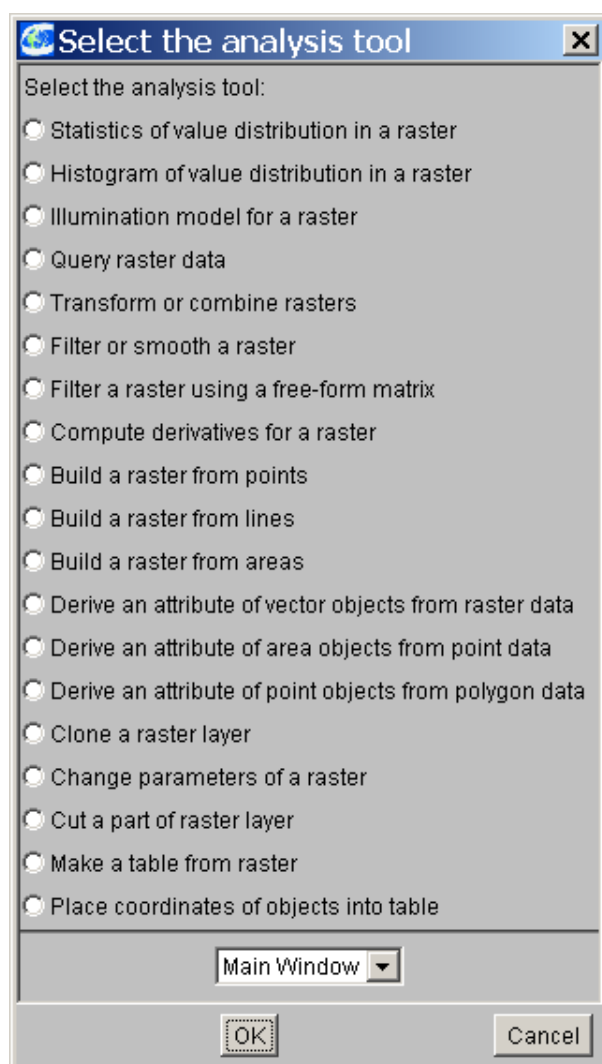


Fig. 3.1.7 Analysis of raster data.

3.2. How to use CommonGIS?

Please call **CommonGIS** ("CommonGIS-J2-en" or "applet") on your Windows computer.

Now you see

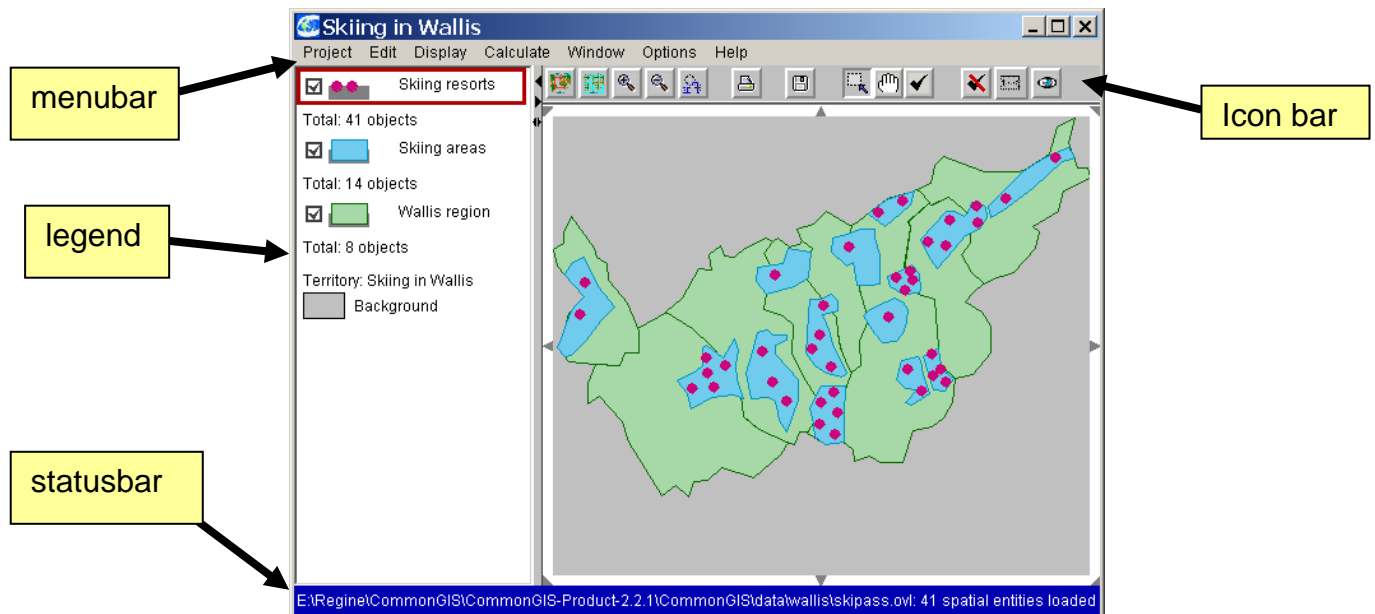
- a Java system window: in this window status messages are listed which serve to recognize and track bugs during development. You can minimize this window so that it appears only in the taskbar at the bottom of the screen. If you close it completely, CommonGIS is also terminated. (You can ignore the contents of this window. Messages like "NOT available" or "ERROR" appear occasionally, which need not mean, however, that CommonGIS is affected in its function.)

- and the CommonGIS start up window with the menu bar:



To load thematic data and geo data use the menu option *Project:Open* and select the sample project "wallis.app" (file "\data\wallis" in your installation folder).

Now you see the main window of CommonGIS – the map window with the basemap:










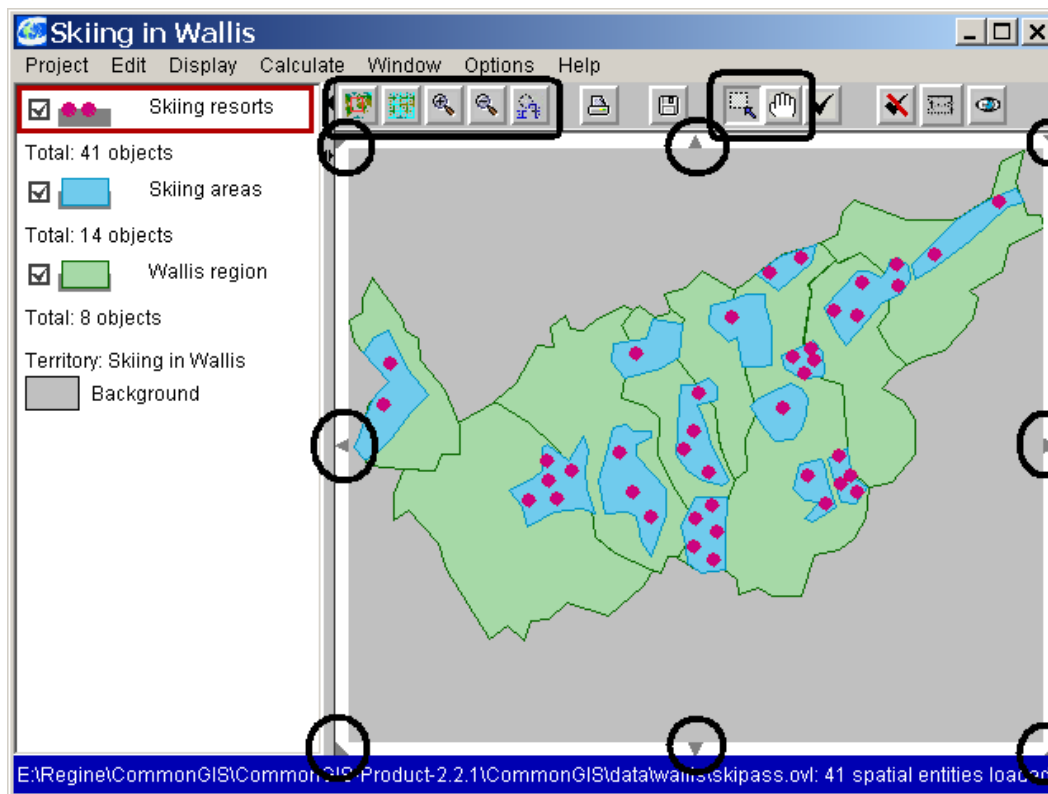
The map shows three geographical layers: the layer “Wallis region” overlaid by layer “Skiing areas” and as uppermost layer the layer “Skiing resorts”.

Note: Usually layers with point objects should be arranged on top of line objects and area objects so that they are not covered up. The layers are overlaid in the order they were added to the project, i.e. the layers shown at the bottom of the legend were added first and are now drawn first too, and the layers at the top are drawn last.

Changing the map view

There are several ways to zoom in or zoom out the map view or to adjust the visible pane:

- Zoom in by mouse-click on symbol  (see marking frame) or by dragging a box within the map window, i.e. click on symbol  (set as default at the beginning) and mark the rectangular on the map to be scaled up leaving the left mouse button pressed.
- Zoom out by mouse-click on symbol  (see marking frame).
- Move map beyond display borders: Select one of the little grey triangles surrounding the map (see markers) which points to the direction in which you want to view more of the map and click on it or click on symbol  and drag the cursor to draw a line holding the left mouse button pressed, which indicates the direction and the size of the shift.
- The map zooms to its original extent (again) by mouse-click on symbol .
- Show the size and position of the displayed map section compared to the complete map. Clicking on symbol  opens a separate navigation window outlining the displayed portion of the map relative to the whole map.
- Undo the last navigation action by mouse-click on symbol  (see marking frame).



Changing size of window parts:



Every CommonGIS window consists of several subwindows – legend window and map window for example - each having small black triangles at the inner borders. With them the size of the subwindows within the containing window can be individually changed by dragging the mouse to indicate the desired size or mouse clicking to enlarge the subwindow.

Thus the user has the opportunity to reduce the amount of information displayed in the subwindows by constraining visibility only to those subwindows which display relevant information and hide the others by clicking on the triangle on the window border. So you can fade out the layers legend subwindow for example in order to see only the map window and the map manipulation window in the right column if you intend to analyse specific visualisations (see chapter 4).

Legend

The bar left to the map lists the loaded layers and offers the particular parameters used to draw the layer (legend). There is always exactly one active layer, which is marked by a red box. You can only start editing or working on the objects of this active layer. The default active layer is the first layer on the list.

When you move the mouse cursor over the map and stop on any object, the name of the object appears in a popup window next to the cursor. If you click on the object it is highlighted (thick borders) and selected in the related attribute tables or diagrams, graphs etc. This way you can search and select all objects on the active layer relevant for a task in order to prepare working with them.

The two symbols   in the iconbar on top of the map support the selection of objects. The first symbol allows selection of several objects at once by pulling a rectangle

around the desired objects with the mouse. With the second symbol you can deselect the objects again, so that you need not click on all the objects separately. In order to deselect all highlighted objects you can also doubleclick with the mouse on an area within the map which does not contain any objects.

In order to mark another layer active click with the mouse on the name of the desired layer in the legend window. Now this layer obtains the red box and the following mouse actions refer to the objects of this layer.

The appearance (color or line strength), visibility and the interrelations of the particular layers can also be specified in the legend window.


Interactive layer operations	Action to perform in the legend
Switch on/off drawing of a layer	Click on the icon (not) containing a checkmark.
Change the active layer	Click on the name of the layer that should become active.
Change the order of layer drawing	Drag the legend item of the layer to be moved (by keeping the left mouse button pressed on the layer name) to the desired position in the list. (The layer shown at the bottom of the legend is drawn first, and the layer at the top is drawn last.)
Change the visual properties of a layer	Double-click on the legend symbol of the layer to change. A dialog for editing the visual properties will appear on the screen (colors, labels, scale).
Remove layer	Menu option <i>Edit: Remove layer</i>

Table 3.2.1 Operations on layers.


For every layer in the map the following information is displayed:


- name of the layer,
- icon to symbolize the type of the objects in the layer (point, line, area)

 - point objects

 - line objects

 - polygons

 - areal objects

 - raster data,

- small box with checkmark indicating whether the layer is drawn or not. Upon a mouse click in the ckeck box the layer gets invisible and the checkmark is deleted from the box. To draw the layer again, click on the box and both the layer and the checkmark reappear.
- the number of objects within the layer.

In order to change layer characteristics, click on the layer type symbol beneath the layer's name and a parameter window opens:

- Click on the symbol for point objects beneath layer "Skiing resorts" in the legend. The following window appears:

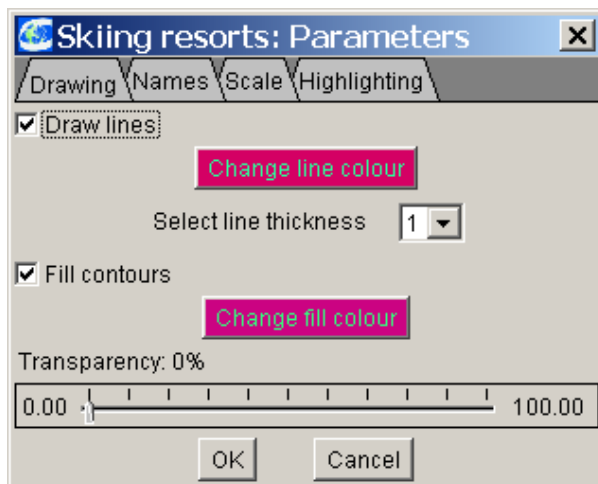
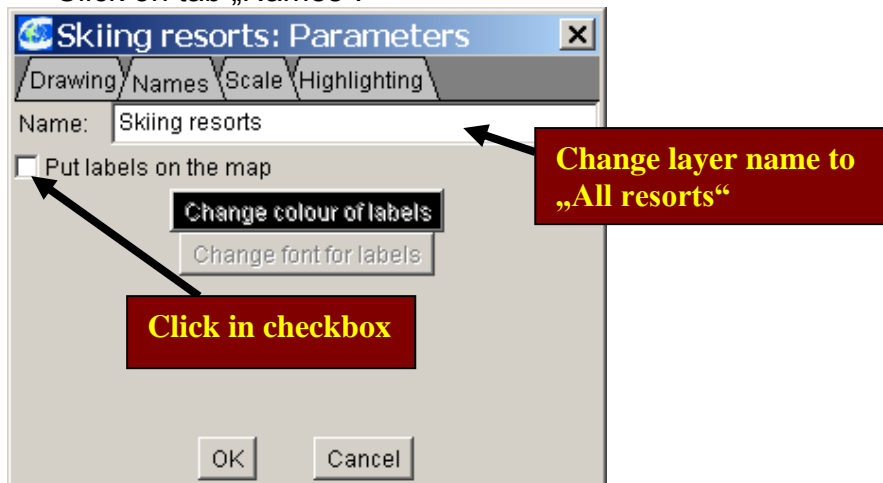


Fig. 3.2.1 Parameters for presenting a layer on the map.

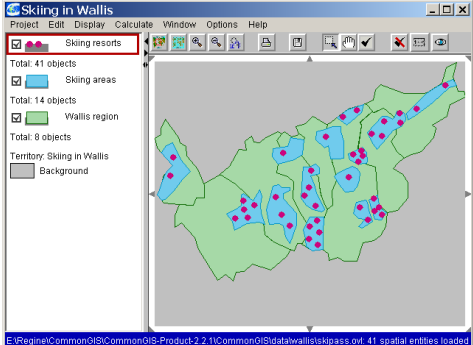
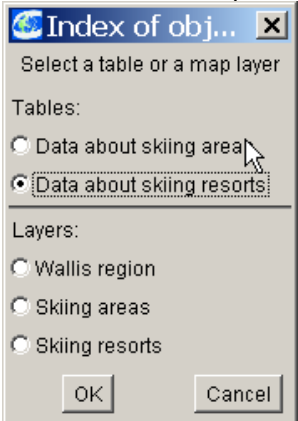
- Click on tab „Names“:



- Result (see Fig. 3.2.2):
 - The name of the layer has changed.
 - The user can adjust whether the objects names shall be permanently displayed on the map or not by activating the check box “Put labels on the map” in the “Names” tab of the layer parameters check box
- The permanent labelling is indicated in the legend by adding icon "L" (label) to the symbols of this layer.

A map of Wallis showing the skiing-regions and –resorts appears on the screen and further information concerning size, height and level of the ski-slopes, prices for skiing passes and references to further online-ressources is yet implemented to the project.

Exemple dialogue with CommonGIS:

Subtasks	Input of user	Output of system
1. Loading prepared data about skiing-regions in wallis	<p>Choose <i>Project: Open</i></p> <p>User clicks on button "<i>Browse</i>" and interactively chooses the folder which contains the file „wallis.app“ with the project description (.../data/wallis/wallis.app).</p>	<p>A selection window for the wanted application (Extension "*.app") is displayed</p>  <p>A thematic map of Wallis is displayed containing the skiing areas and skiing resorts.</p>
<p>2. Removing yet visited skiing-resorts.</p> <ul style="list-style-type: none"> - Locate yet visited skiing-resorts by their position on the map. <p>- Locate yet visited skiing-resorts by their name.</p>	<p>User mouse clicks on the concerned resorts on the map.</p> <p>Choose <i>Display: View objects</i></p> <p>Click on table "Data about skiing resorts" in window „Index of objects“.</p>	<p>The resort to which the mouse pointer points becomes permanently marked and its name is displayed (as long as the layer „skiing resorts“ is marked as active layer).</p> <p>The available tables and layers are offered for selection in a separate window.</p>  <p>The table "Data about skiing resorts" is displayed as list of objects provided with identifiers in a separate window. The choosen location is marked as inverted.</p>

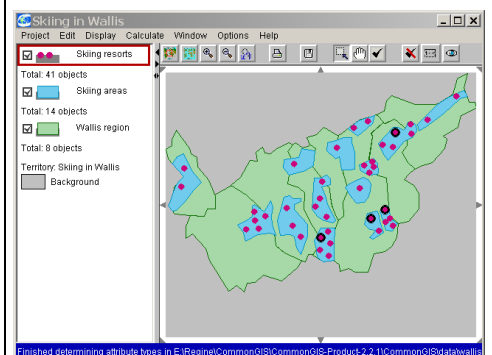
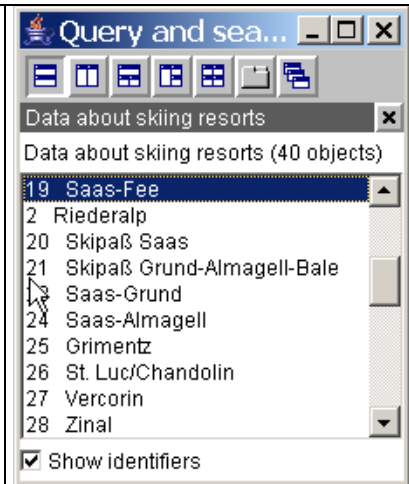
- Fading out selected skiing-resorts.

The list of objects helps the user to identify the locations. From this list he picks out the names „Bettmeralp“, „Zermatt“ and „Saas Grund“.

The user selects *Edit: Add/edit layer* for fading out or even removing the locations.

He selects the layer "Skiing resorts".

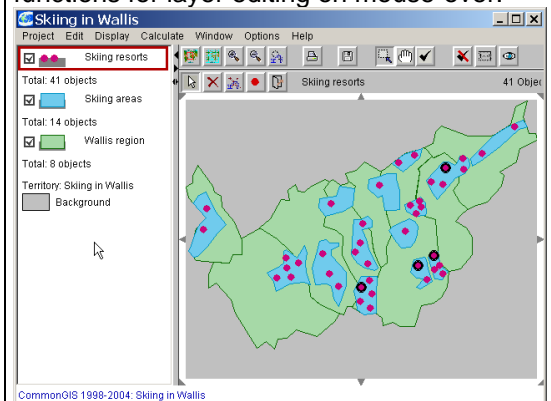
He clicks on the remove symbol and selects one of the tagged names on the map.



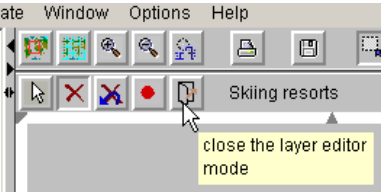
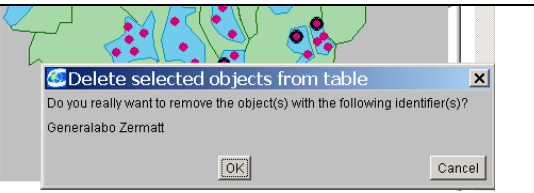
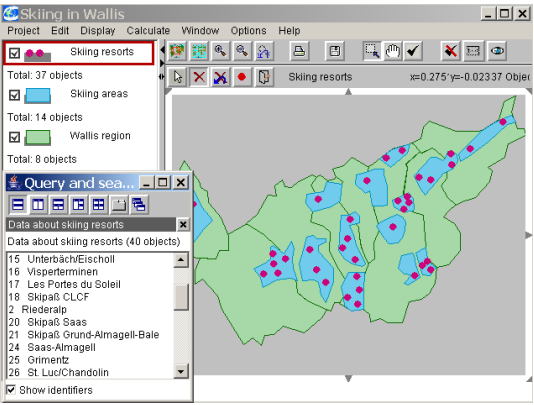
Both the list of objects and the map display the chosen objects as selected.

Display of a selection window for the target layer.

The second iconbar explains the possible functions for layer editing on mouse-over.



A dialogue window appears which asks the user for confirmation of erasing operation.

	<p>Selection of "OK"...</p> <p>Deletion of any pre-selected names as described above.</p> <p>Completion of the layer-operation by clicking on the finishing symbol on the lower icon bar:</p>  <p>Closing of the object list by closing the separate window.</p> <p>The user intends to take a look at the underlying data. Therefore he chooses: "Display: View table"</p> <p>He selects "Skiing resorts".</p> <p>He chooses option „Select all“ below the attribute list.</p>	 <p>...leads to a direct deletion of the object's name from the list and it's entry on the map.</p> <p>The four selected objects have been removed both from the map and the object list.</p>  <p>Display of a selection window for the layers is displayed.</p> <p>A selection window for the attributes of this layer becomes displayed.</p> <p>A table with all the locations and attributes and their values appears.</p>
--	--	--

4. Facing the still available amount of data the user tries to fade out additional data sets by redefining the attribute demands. For the price of the ski pass and the size of the skiing-region vary considerably he decides to diminish the amount of solution

To sort the attributes according to their height the user selects „maximum elevation“ from the drop down list in the „sort by“ field at the lower edge of the window.

He changes the order to “Descending” to see highest resorts first in the list.

He recognizes that far more skiing -regions match the height criterion than are useful for decision making.

For constraining the assortment he calls „*Calculate:Dynamic query*“, selects the table “Data about skiing resorts” and includes all attributes (button „Select all“).

The user enlarges the window so that he can define the limits interactively by dragging the blue arrow to the desired position at the scale

Maximum elevation: min 2500
Length ski runs: min 50 km
Beginner runs: min 30 %

The user points to one of the dots at the attribute scale.

He observes the filtered data set at the table view (Window of option: *Display: View Table*).

He reactivates the window

Table view: Data about skiing resorts

Identifiers	Maximum elevation	Relative Altitude (max-min)	Duration of skiing season	Number of lifts	Price for ski pass (6 days)	Price discount for kids %
Aletsch-Abbi	2870	1820	128	19	253	37.94
Arolla	2900	897	128	5	145	37.93
Bellwald-Richinen	2433	783	128	4	188	28.19
Bürchen-Töbel	2550	1090	121	8	163	33.13
Crans Montana	3000	1500	142	26	212	39.62
Emerald	2282	1047	114	3	160	33.75
Evirens	2700	1330	128	7	155	39.1
Ferrières	2700	1500	121	10	211	32.7
Fischeralp	2870	1820	128	6	213	37.56
Grimmelt	2900	1330	121	9	181	39.78
Osprey	2200	320	110	2	163	33.13
Hannigalp-Seetalhorn	2890	1270	135	8	206	38.81
Klein Matterhorn-Schwarzsee	3820	2200	169	13	146	15.75
La Forclaz	2200	500	128	4	115	34.78
Lauchernalp	2700	730	121	3	187	35.83
Les Portes du Soleil	2466	1566	116	139	224	33.93
Riederalp	2340	461	135	4	164	39.63
Riffelberg-Stockhorn	3413	1793	155	3	222	50
Saas-Almagell	2400	728	121	4	161	35.4

Sort by: No selection Ascending TableLens just selected items Attribute info Attribute

The table becomes sorted ascending.

The table is resorted.

Query and search tools

Dynamic Query for Data about skiing resorts

Maximum elevation

2200.0

3820.0

100.0% : 36 from 36

Relative Altitude (max-min)

320.0

2509.0

100.0% : 36 from 36

Duration of skiing season

110.0

169.0

100.0% : 36 from 36

Number of lifts

2.0

139.0

100.0% : 36 from 36

Price for ski pass (6 days)

115.0

354.0

100.0% : 36 from 36

Price discount for kids %

15.75

50.0

100.0% : 36 from 36

Total length of ski runs

5.0

650.0

100.0% : 36 from 36

Beginner level runs %

5.0

60.0

100.0% : 36 from 36

Intermediate level runs %

10.0

95.0

100.0% : 36 from 36

Expert level runs %

0.0

39.02

100.0% : 36 from 36

Filter out missing values Clear all filters

Display statistics Dynamic update

Add attributes Remove attributes

Query results -> Qualitative attribute

Restriction of table reduces resorts to 10 locations.

After the adjustment of the values the matching counts are displayed in percentage and absolute values at the right section of the window.

All the values for this location (and any

alternatives by taking only smaller skiing-regions with lower ski pass prices into account .

Query and search tools by clicking on it and redefines the limit values for ski pass price and lift number:
Price for ski pass: max 270
Number of lifts: max 25

He takes another look at the table ...

... and the map:

5. Saving the results for further utilization:

- Definitive exclusion of deleted objects from the examination

- Separate saving of location assortment for subsequent constrictions or the generation of another selected set

- Export of data,

- Visualization in CommonGIS

The user selects menu option *Project: Save as*, for saving the altered layer „Skiing resorts“.

He activates the check box in front of the layer name and enters a project name and a file name for the new project description.

The user selects *Project: Export data* for saving the acquired selection as a proper layer.

Selection of "ovl"-format and

location with the same value) become marked and the absolute attribute values are listed in a pop-up window.
The location even gets highlighted at the thematic map.

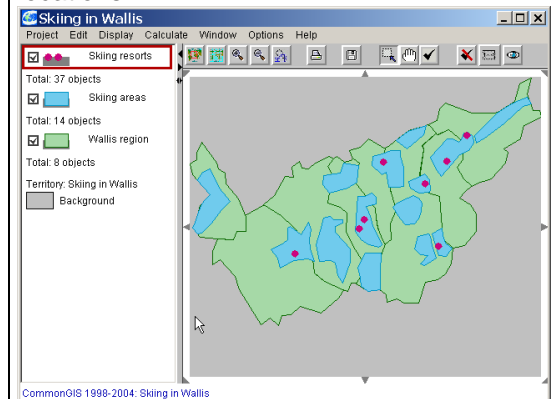
Now there are only 7 data sets left which match the predefined criteria:

Table view: Data about skiing resorts

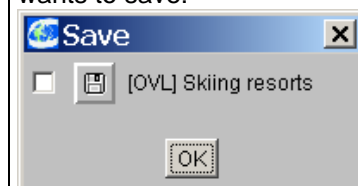
Identifiers	Maximum elevation	Relative Altitude (max-min)	Duration of skiing season	Number of lifts	Price for ski pass (6 days)	Price discount for kids %
Belalp	3100	1770	135	9	199	49.75
St. Luc/Chandolin	3025	1370	121	13	181	39.78
Skopell Verbier	3023	2202	121	14	251	39.84
Grimmeltz	2900	1330	121	8	181	39.78
Aletsch-Abo	2870	1820	128	19	253	37.84
Tignes	2700	1288	128	7	208	50
Unterbach/Eischoll	2600	1380	121	7	163	33.13

Sort by: Maximum elevation Descending TableLens Just selected items Attribute info Attribute

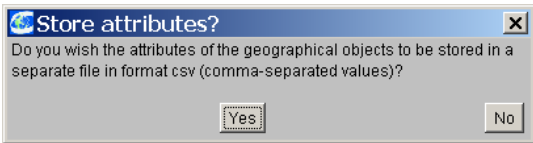
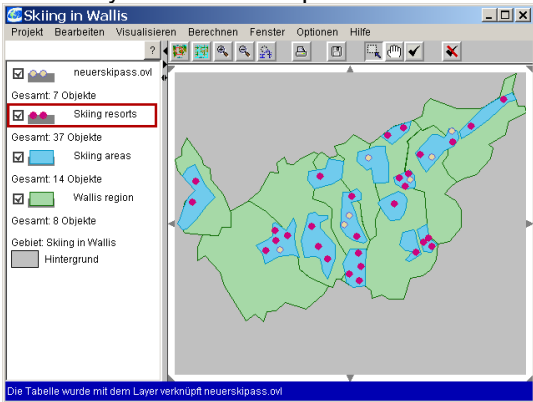
The map now only shows the 7 remaining locations:



Now he is asked which of the altered data he wants to save:



Additionally to the project description the layer gets saved under the original file name (The former data is stored in a homonymous file with the extension .bak)

	<p>layer „Skiing resorts“ Confirmation with „Yes“, Selection of every attribute and the input of the new filename „newselection“.</p> <p>The user selects menu option <i>Project: Import data</i> and format „ovl-file“.</p> <p>He chooses by button „Browse“ the generated file and marks the table belonging to this layer.</p> <p>Restore the original layer „Skiing resorts“ by closing the dynamic query window.</p> <p>The user recognizes that he would like to gain further information to the skiing-resorts. He specifically retrieves them from the WWW</p>	<p>The window „Data export“ offers the available data formats.</p>  <p>Creation of a new layer (viz a file becomes created).</p> <p>Request to enter the filename of the import data.</p> <p>The new layer is loaded.</p> <p>The newly generated layer with the selection of skiing-resorts now superimposes the former layer with the complete set of resorts.</p>  <p>The URLs are also saved in the table so that they are directly available to the user.</p>
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3.3. Where do I find answers to my questions? – Menu **Help**

At the end of this task-oriented manual you find an index to facilitate search for specific information on some topic in this manual.

In addition there is a glossary listing technical terms used. In the glossary you can also find web-links related to basic information on geoinformatics and cartography in the Internet.

For further information on CommonGIS look on our website www.commongis.de. This site is updated sequentially and tells you about new versions, examples and meetings. Additionally, there is a forum offered for registered users of CommonGIS. The CommonGIS forum is intended for discussion related to the CommonGIS software: ask

questions and get answers, share useful data sources, discuss tasks and solutions, submit suggestions for improvement or report bugs. The essence of textual continuous discussions is summarized as „Frequently Asked Questions“ and is accessible via web and attached to newer manual versions.

Don't hesitate to mail us your questions, problems or suggestions to support@commongis.com.

Help – online

You can also get on-line help within CommonGIS via menu *Help*.

The help text is offered in the language selected for the CommonGIS user interface (German or English so far).

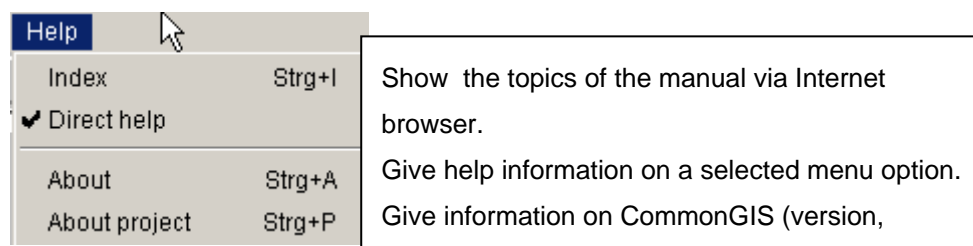


Fig. 3.3.1 Menu *Help*



Fig. 3.3.2 Information on the current version after calling menu option *Help:Info*

4. Analysing geodata with CommonGIS

4.1. Preparing data – Menu **Project**

In the following manual section the options of the menu *Project* will be described in the required order for performing typical tasks with CommonGIS.

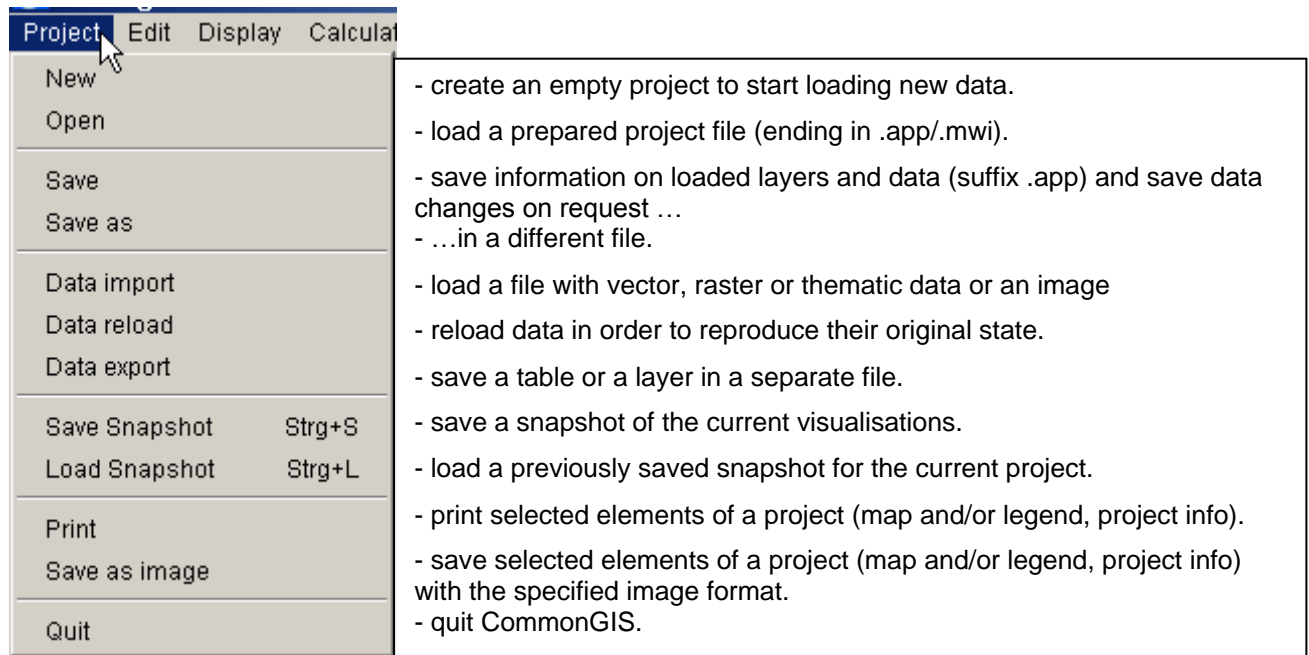


Fig. 4.1.1 Menu *Project*.

Creating a project

Within CommonGIS a project can be interactively created.

Start CommonGIS in its stand-alone version by

1. calling „CommonGIS-en“,
and successively load the required layers and tables using
2. *Project: Data import*.

Furthermore, you can specify how the layers shall be represented on the map, which layers should be loaded directly and which become "switched off" when starting the project again, i.e. these layers are only loaded if the user "restarts" them (click on small box left to layer name).

In order to save a project constructed this way, call

3. *Project: Save*

and assign a name to the project and the project file (ending in suffix .app). CommonGIS produces a project description and saves it. At the next CommonGIS session the user only needs to open this project description (*Project: Open*) and the layers and tables are automatically loaded and arranged as stated in the *.app file.

That implies that there are two ways to load data into CommonGIS:

Project: Open opens a prepared project, which usually consists of geographical layers and thematic data assigned to geographical objects.

Project files (ending in „*.app“) specify how layers and thematic data are linked and how they are presented and ordered on the map. (Old „.mwi“-files of earlier CommonGIS–versions can still be read.)

Project: Data import load a file with vector, raster or thematic data or an image (see Fig. 4.1.2).

Note: CommonGIS applies, whenever possible, a so-called delayed data loading to speed up the handling of large data sets at runtime. This means that geographic data for a layer that is initially switched off will not be loaded until the user explicitly switches the layer on. Similarly, thematic data are not loaded until the user first addresses a table in order to view this table or visualize attributes from it.

CommonGIS can work with different formats of data:

- files:
 - thematic data: DBF (dBase), ASCII with delimiters, in particular CSV - comma-separated values (Excel)
 - vector geographic data: Shape (ArcGIS), MIF/MID (MapInfo), GML (OpenGIS), WKB (OpenGIS)
 - raster data: ADF, BIL, ESR (ArcGIS), FLT (GeoProcessor)
 - images: GIF, JPEG
- clipboard: Excel, WinWord (thematische Daten)
- database: ODBC (thematische Daten), Oracle (thematic data and vector data)

Besides, CommonGIS works with its own OVL format for vector data that is optimized for smaller file sizes and hence faster transmission over the Internet.

Note: In this version of CommonGIS you can only load MIF/MID-data but you cannot yet save them back in the same format. In order to save changes of the data, two files are created: data are saved as ASCII into one file, layer information is saved into an .ovl-file.

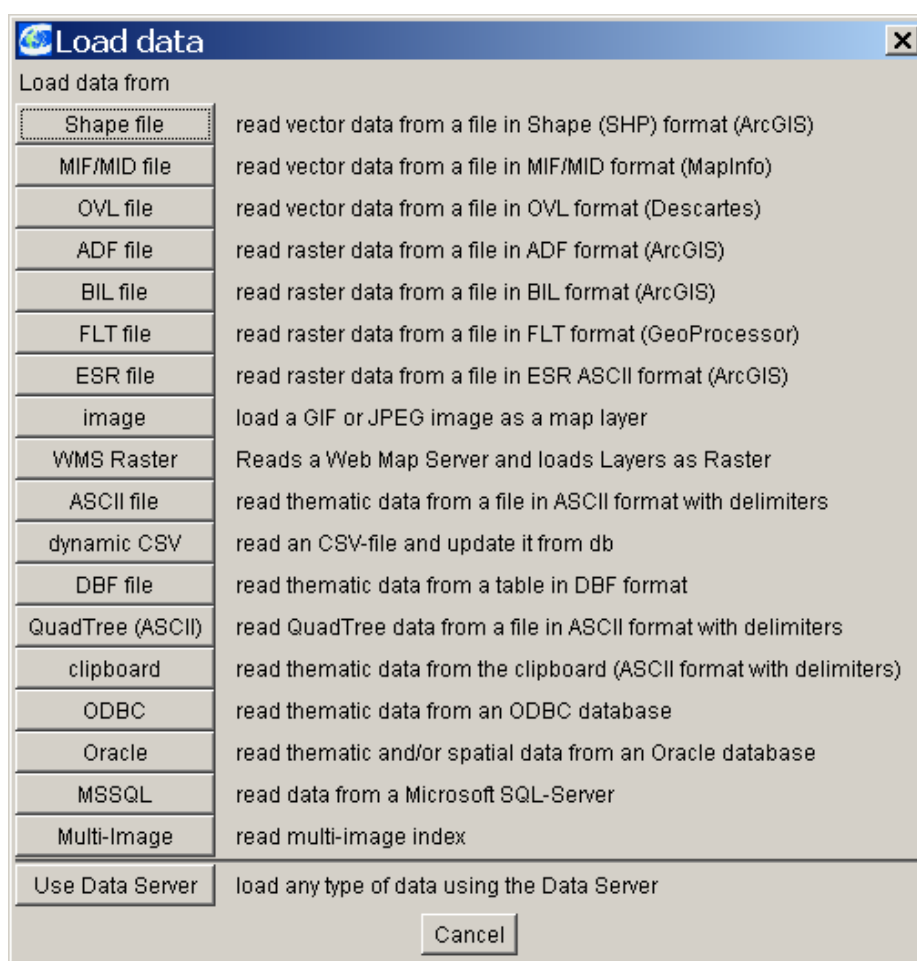


Fig. 4.1.2 Load data in different formats.

Geographic data can be loaded layer by layer to the system. Each new layer overlays the already loaded ones. Thematic data can be added stepwise as well.

When loading certain data formats (vector data, DBF-files) you can specify a projection for the coordinate system.

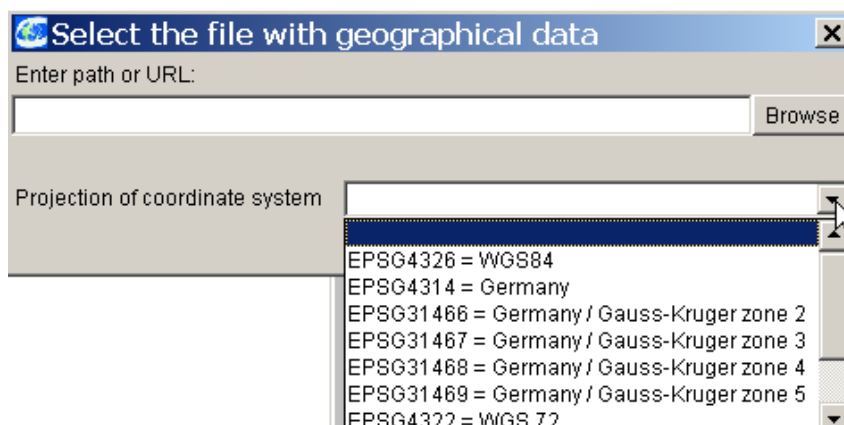


Fig. 4.1.3 Loading of data with projection specification

Depending on the file format the system needs some additional information about the structure of the data to be loaded.

- Shape-files (.shp) and DBF-files (.dbf):

Shape files (shp) and DBF files (dbf) provide the user with a data preview that supports him to specify which line holds the identifiers of the attributes and which column holds the number or the name of a data record.

The 'Data preview' dialog box displays a table of data with 7 columns. The first three columns are highlighted in green and have black boxes around their headers. Arrows point from these boxes to input fields below the table.

1	2	3	4	5	6	7
OBJECTID	NUMMER	NAME	ST_ID	NR_STADTBE	STADTBEZIR	NR_STADT
integer	string	string	integer	string	string	string
1	61201	Alt-Worringen	78	6	Chorweiler	612
2	61203	Am Worringer Bruch	78	6	Chorweiler	612
3	61103	Thenhoven	67	6	Chorweiler	611
4	60101	Rheinkassel	75	6	Chorweiler	601
5	61001	Blumenberg	77	6	Chorweiler	610

Identifiers are in field (enter the name or the number of the field)

If there is no field with identifiers, the system will produce default identifiers from record numbers

Names of entities are in field (set name or number or leave empty)

☐ Coordinates of entities are in fields

X: Y: (enter names or numbers)

OK Cancel

Fig. 4.1.4 Loading Shape- or DBF-data.

- Textfiles (.csv, .txt):

In order to load data from a text formatted file the system needs to know how the values are separated from each other (default for value separator is a comma), where the names of entities are and how the data records can be identified.

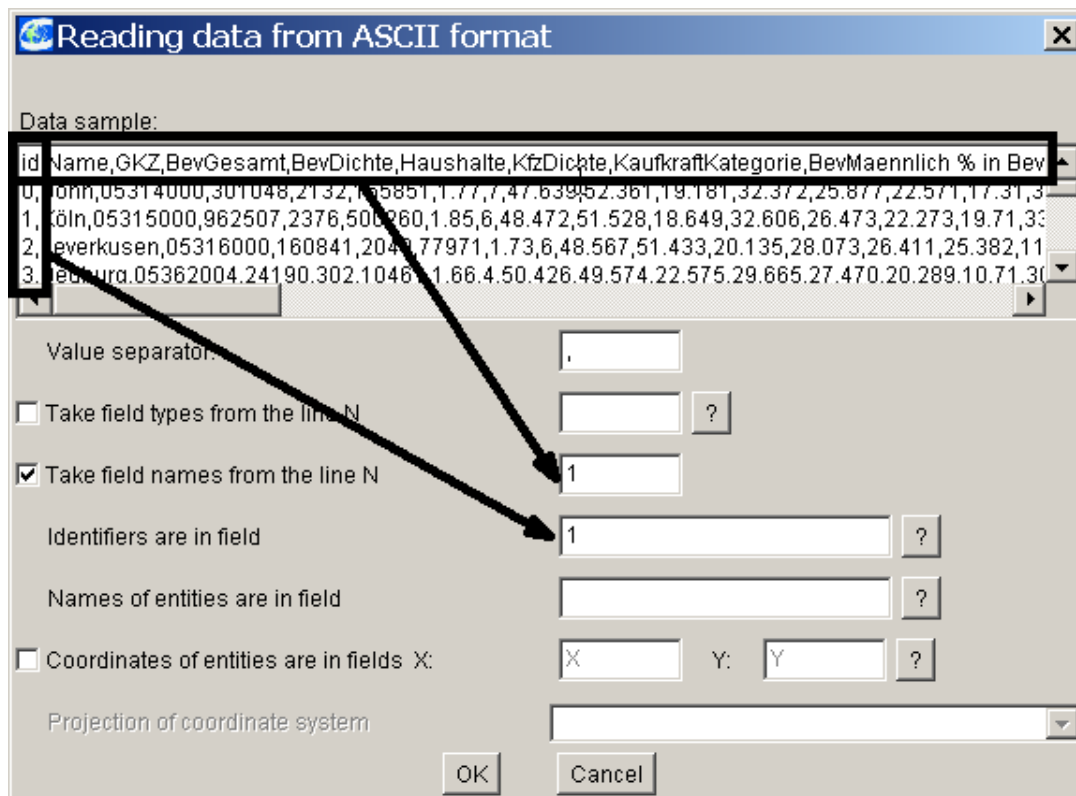
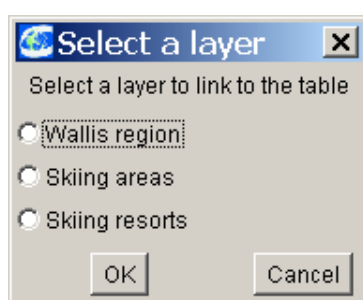


Fig. 4.1.5 Load data from text file.

In this example the field names are given in line 1, the identifiers are in field 1 and the values are separated by “,”.

- Linking of thematic data and visual representation:

On loading thematic data the user is asked which geographical layer the data should be linked to. A table should be assigned to that geographical layer which contains the spatial objects from the table. Objects in the table and objects of the layer must have the same identifiers then.



If the linking was successful (message about success is given in the status line), objects being displayed in different representations (map, diagram, graph) can be simultaneously highlighted and manipulated, i.e. changes in one view are broadcasted to any other view.

After the user has arranged the data he wants to examine satisfyingly, he can save this configuration within a project file. Supported by this project file the specified data arrangement can be directly loaded at the next CommonGIS session (*Project: Open*), without having to add the files individually again.

Project: Save save information on loaded layers and linked thematic data to the yet established specification file.

A project file with suffix „.app“ is created, which contains the specification of how layers and thematic data are linked and in what order they are loaded.

Project: Save as save information on loaded layers and linked thematic data to a new specification file with a different name.

That means that the user can save data changed during a CommonGIS session either in the original file or in a new file. However, this does not happen automatically. The user calls menu option *Project: Save (as)*, then he can select, which of the data changed he would like to save in addition to the project definition data (see also ch. 4.5). When terminating CommonGIS without having saved the changed project status (*Project: Quit*) CommonGIS indicates the user to the data which was changed and the user now can save the modification or quit the program without saving.

Changing a project – Menu **Edit**

In order to set up a project in such a manner that it supports the analysis of the data at the best, the user usually generates the most adequate arrangement of layers and data for the task at hand by trial and error. So it happens e.g. that data is loaded which turns out to be not actually needed in the project and hence can easily be removed by the menu *Edit*.

To meet the specific requirements of a project and its elements the user can use the following options from menu *Edit*:

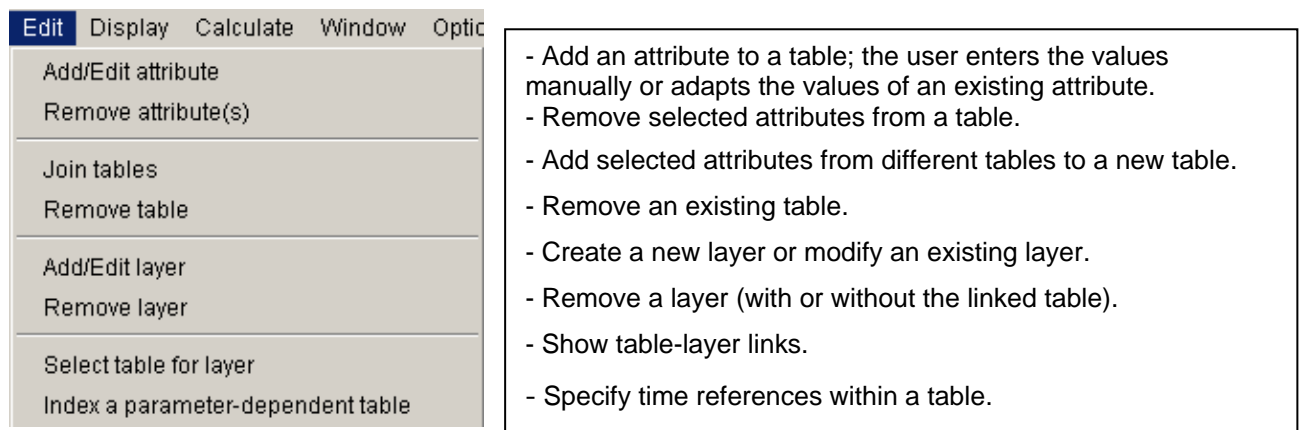


Fig. 4.1.6 Menu *Edit*.

Edit: Add/Edit attribute Add an attribute to a table; the user enters the values manually or adapts the values of an existing attribute.

In the example "Wallis.app" Mrs. Flink could produce an attribute "visited" with the string values "old" and "new". For each ski resort where Mrs. Flink already spent her holidays, she can enter the value "old". On the map the classification in "old" and "new" ski resorts immediately becomes visible.

Edit: Remove attribute(s) Remove selected attributes from a table.

If the table becomes edited, the changes are preliminary as long as the project is not saved (*Project: Save*). On saving a project the data-saving dialogue appears and asks for confirmation.

Edit: Join tables

Merge selected attributes from different tables to a new table.

The joined table is also created only preliminary. To save the table physically select menu option *Project: Save* and click in the box near the table name, see section 4.5.

Edit: Remove table

Remove an existing table.

Again, the table is only preliminary removed from the current working state. Only when the project is saved (*Project: Save*) the table becomes permanently removed from the project description (but not physically deleted in the file directory).

Edit: Add/Edit layer

Create a new layer interactively or modify an existing layer.

The user can create a completely new layer or supplement or change an existing layer.

While editing a layer a new icon bar appears above the map, which offers the editing operations delete, insert and quit for layer adjustment (Fig. 4.1.7, right).

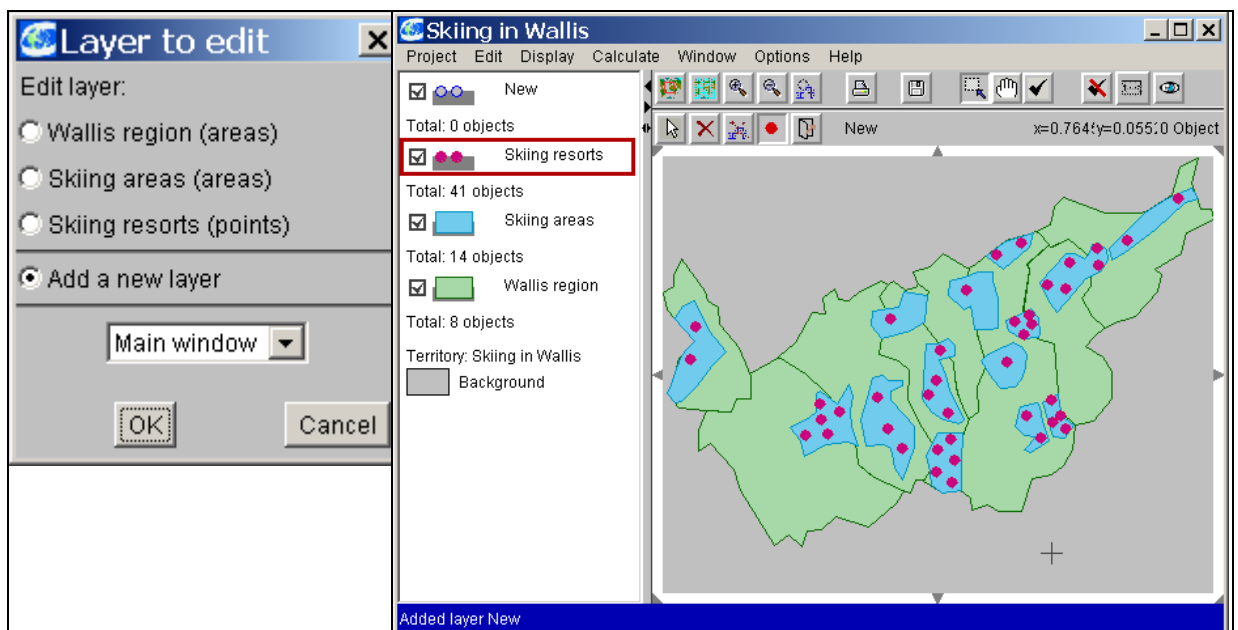



Fig. 4.1.7 Create layer „New“

The user creates a new object by clicking on symbol . With the mouse pointer he selects the location for the new object in the map and creates the new feature by clicking on the left mouse button. Then, CommonGIS asks for the object's values (see Fig. 4.1.8).

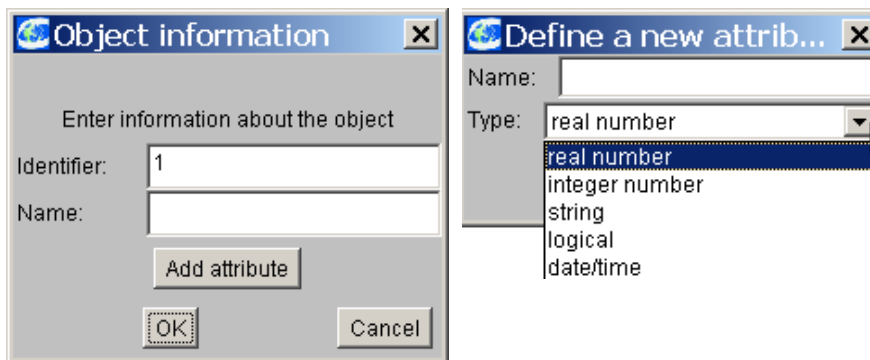



Fig. 4.1.8 Create layer object interactively

If the user wants to edit an existing object of the active layer, he clicks on it and gets an editable list of values for this attribute (see Fig 4.6.6., right). To delete an object the icon  is used. Click on the icon and on the object in the map which shall be deleted from the layer and confirm.

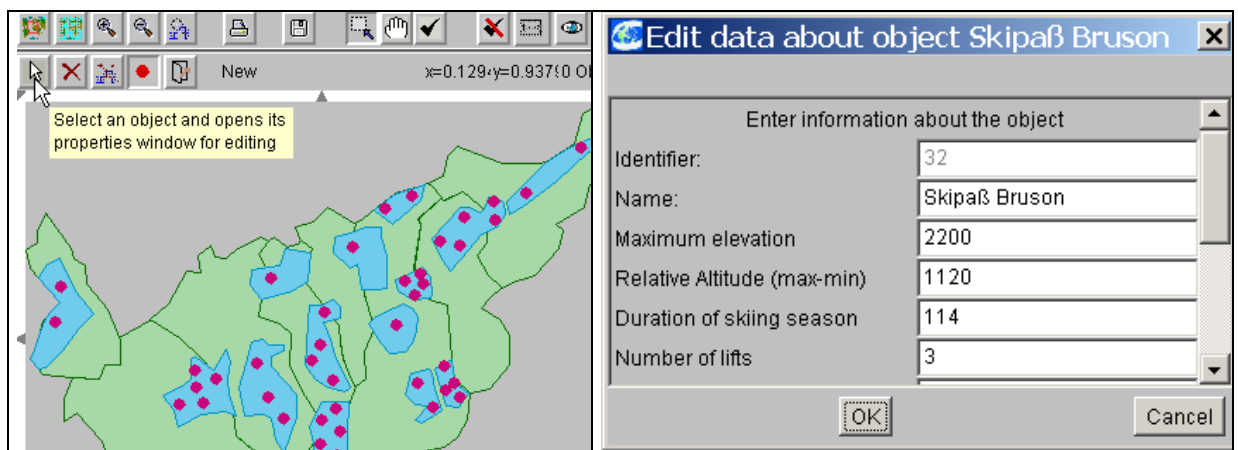


Abb. 4.1.9 Change layer object.

Edit: Remove layer Remove a layer (with or without the linked table).

The layer is only preliminary removed from the current working state. Only when the project is saved in the end (*Project: Save*) the layer is removed permanently from the project description (but not physically deleted).

Edit: Select table for layer Show table-layer links to get a survey of all layers and corresponding tables.

Edit: Index a parameter-dependent table Specify time references of attributes within a table.

For being able to analyse data with time references in CommonGIS the user must specify which attributes contain the time references, what the time reference means and how the time parameter should be represented in the table. In addition he must select the attributes, which depend on the time parameter (see section *Presenting Temporal Data*).

4.2. Presenting Data – Menu **Display**

Interpreting data is easier if the data is displayed in an appropriate way. Alternative visual perspectives on the same data allow the user to regard the data from different points of view in order to discover regular patterns, striking (dis)similarities and interdependencies. Also the temporal development of the data can be instructive.

CommonGIS supports the user with the analysis of the available data, as the data can be visualised and arranged in various ways.

Geographical data (vector data, raster data or images) are directly assigned to a map (geographical layer) after loading. Thematic data are formatted as a table on the screen. In addition the user can select between supplementing diagrams in order to visualise and explore spatial data. Data referring to some time period (time series) can be animated to show changes of data over time.

Option *Display wizard* in menu *Display* offers the available types of maps and charts. First the user selects the attributes to visualize from some table. Then CommonGIS offers the matching visualization methods depending on the number and values of the attributes.

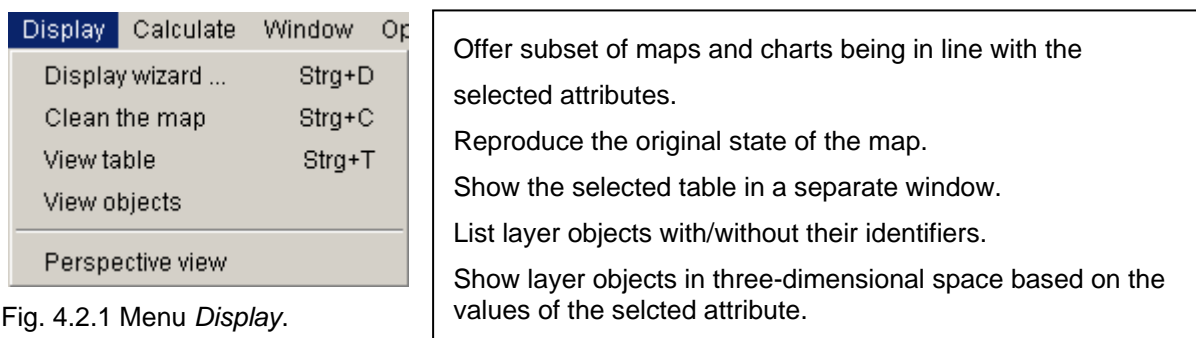


Fig. 4.2.1 Menu *Display*.

Presenting spatial data in maps

In the following section we use project "pt.app" as example which is stored in folder data/pt and contains data and maps on demographic, seismographic, hydrographic and geographical conditions of Portugal.

Open the project (*Project: Open – Browse: data/pt/pt.app*) and take a look on the basic map of the project (fig. 4.2.2): you see the regional map of Portugal (layer "Scanned map") overlaid by a representation of the administrative districts (layer "Administrative division"); on top there are the provinces with their borders (layer "Provinces"). The other available layers (Nature reserve areas, Seismic and hydrographic zones) are not displayed in this view.

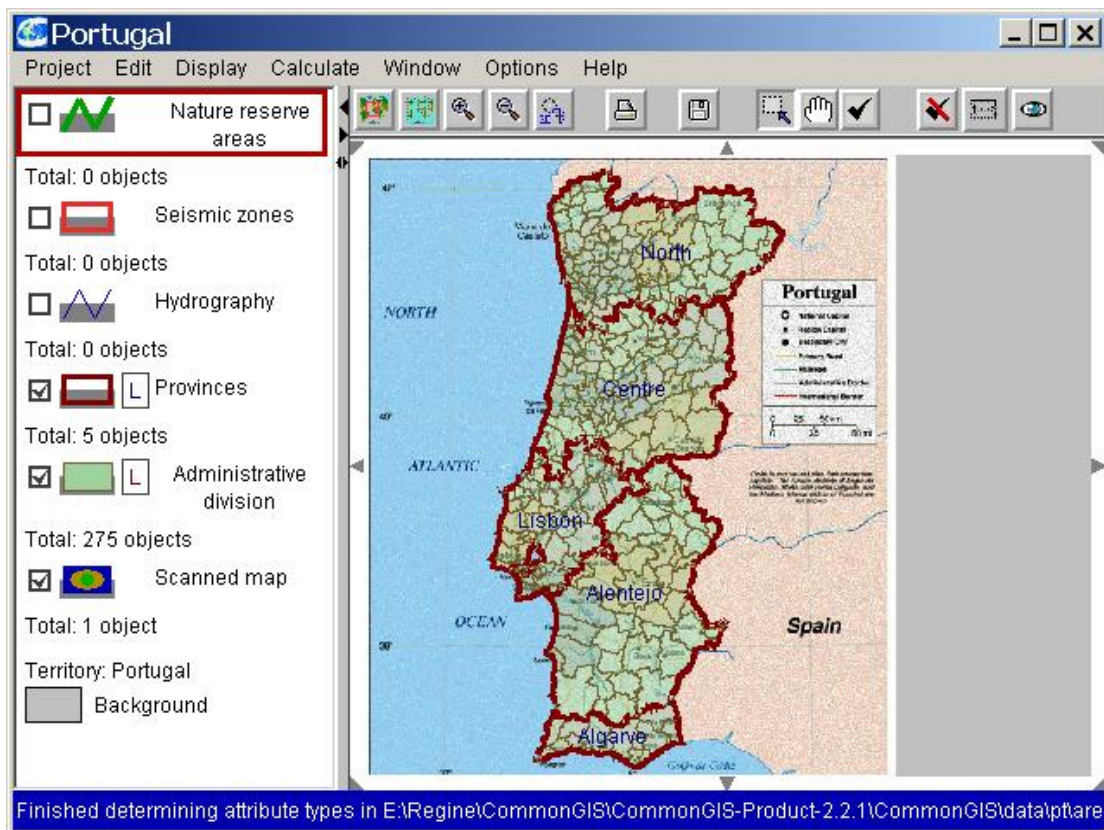


Fig. 4.2.2 The basic map of project „data/pt/pt.app“

In [chapter 3.2 How to use CommonGIS](#) we already described the handling of the basic map, the icon bar and the legend.

Note: In this map the transparency of layer "Administrative division" is set to a value of 50 what means that layer "Administrative division" will be 50 percent transparent. Therefore the scanned map shows through the layers drawn above. In order to represent diagrams more clearly, set the transparency to 0% resulting in the presentation shown in fig. 4.2.3 on the right.

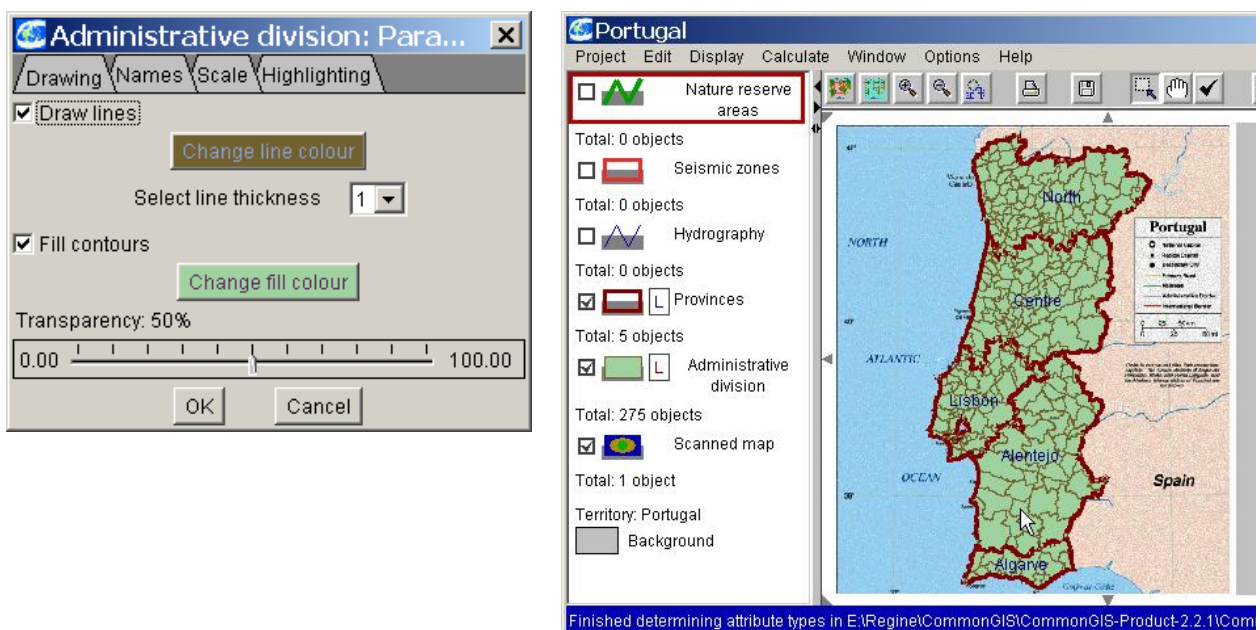


Fig. 4.2.3 Changing transparency of layer „Administrative division“

Now select option *Display wizard* from menu *Display*.

You will be asked to select a table from the list of available tables for the visualization will be based on the data from this table. The name of the table is followed by the name of the layer to which the table refers (name in parentheses).



Next the attributes for visualization must be selected ("Select attributes" dialogue).

Whenever you have to select attributes for visualization and calculation methods this happens in a separate window (see fig 4.2.3). You mark the required attributes in the list on the left side and click on the arrow between the two partial windows directed to the right (or doubleclick on the last selected attribute). The selected attributes are transferred to the right side. If one or more attributes shall be removed from the list on the right side again, mark these by clicking and select the arrow between the two partial windows showing to the left (or again doubleclick).

You can use the two arrows below the right list of choosen attributes to change the order of the attributes. This can be necessary if the displayed sequence is not appropriate for creating diagrams and performing calculations. Clicking on button "Clear list" will transfer all attributes from the right side to the left side again which means that no attributes are selected anymore.

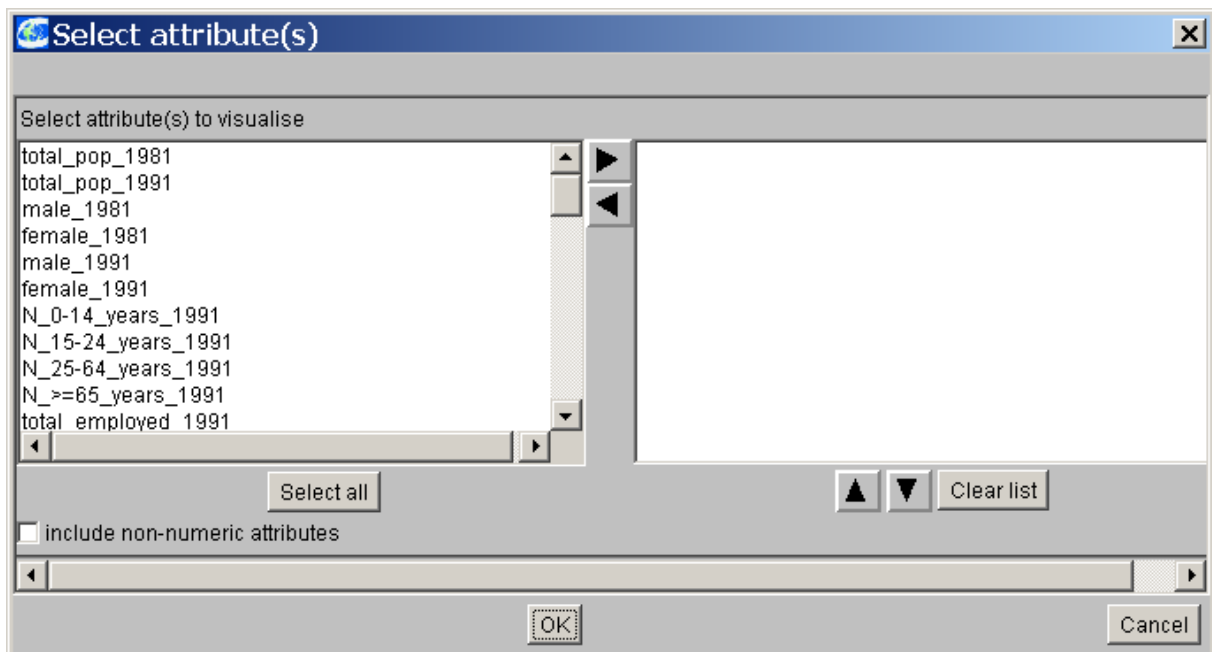


Fig. 4.2.3 „Select attributes“ dialogue

As a result of attribute selection different types of maps and diagrams for representation are offered to the user dependening on the number of attributes selected and their type - numeric or string values.

It is a substantial advantage of CommonGIS that it enables the user to explore the relevant data in various ways. You can easily produce different visualizations and diagrams in order to select the most significant among them.

By selecting a display method you can also choose if the new presentation of the data shall overlay the current view in the main window or if it is displayed in a new window on the screen. However, the menu bar is available only in the main window (see section 4.5 – menu *Window*).

Note: Since there is no way of undoing actions in the present version of CommonGIS, option *Display: Clean the map* helps to go back to the starting version of the map without losing data already calculated.

Choropleth maps

Depending on the type of attribute(s) selected a different set of choropleth map types is offered for selection by the *Display wizard* (bold items in middle column).

Maps

☒ Do not build a map

☐ Unclassified choropleth map

☐ Classified choropleth map

☐ Cross-classification

☐ Standalone bars

☐ Graduated circles

☐ Parallel bars

☐ Pies

☐ Triangles

☐ Class mosaics

☐ Dominance classification

☐ Multiple choropleth maps

☐ Multiple maps with classes

☐ Multiple maps with standalone bars

☐ Multiple maps with graduated circles

☐ Qualitative colouring

☐ Icons

☐ Qualitative Cross-Classification

☐ Stacks

☐ Utility bars

☐ Utility wheels

Map location:

Automatic

Within a **choropleth map** the values of some attribute referring to units of territory division are encoded by different colors or shades. Varying degrees of darkness symbolize different attribute values.

In **unclassified** choropleth maps values of a numeric attribute are converted into degrees of darkness directly, without previous classification: the degrees of darkness are (roughly) proportional to the values they represent.

Multiple choropleth maps are used to contrast the distribution of several attributes in different subwindows without classification.

Classified means that the value range of the attribute is divided into intervals (classes) that are assigned different colors.

Cross-classification creates a classified choropleth map arranging the values of the two attributes selected within the four classes high/high, high/low, low/high and low/low.

Qualitative colouring converts non-numeric values to different colors.

In our example the attribute `%_of_Pop_by_age>=65` is visualized for getting an impression of the distribution of high age inhabitants over the country.

After selecting the attribute all the maps and diagrams, which can be produced for this attribute, are marked in bold (see fig. 4.2.4).

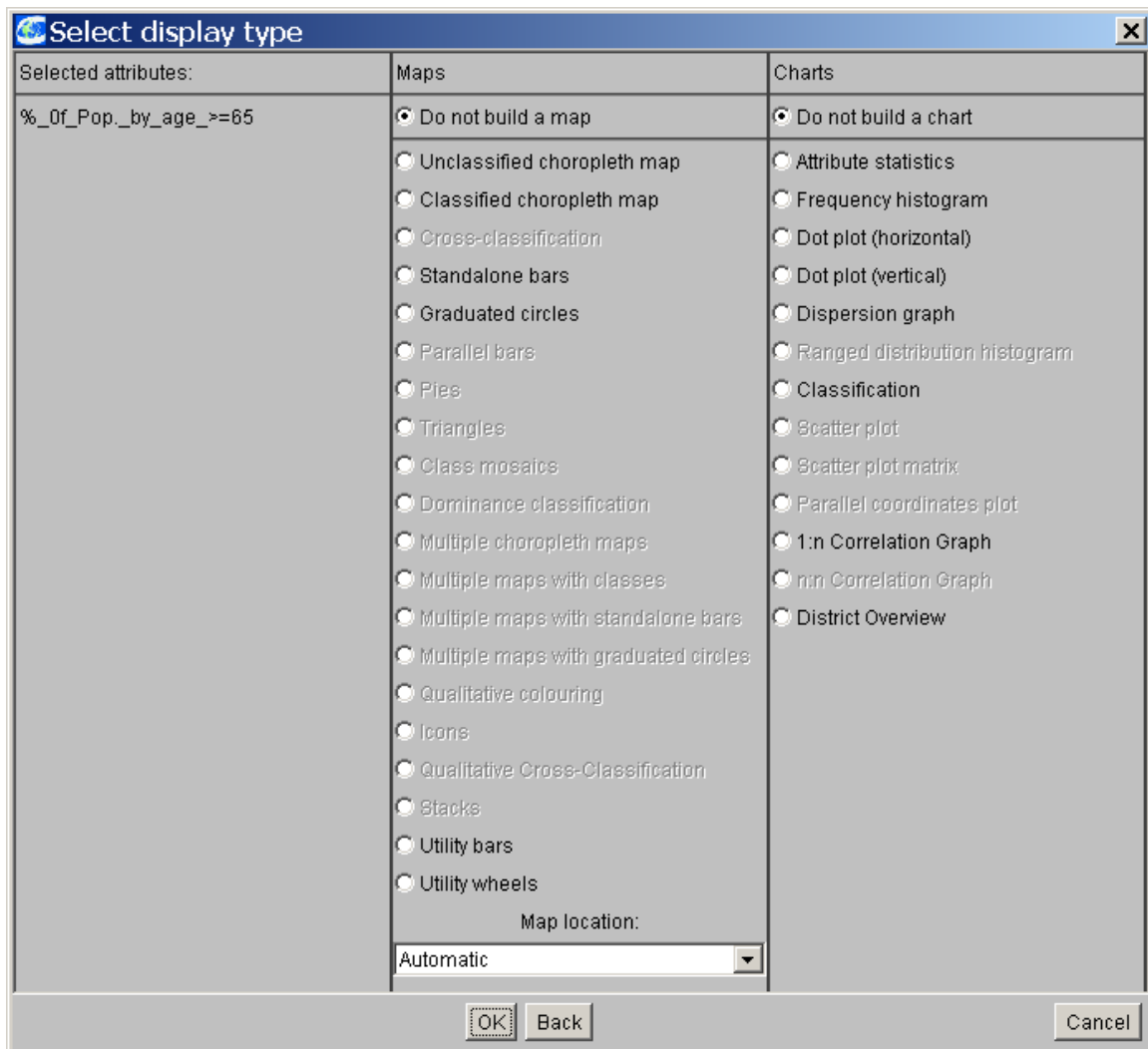


Fig. 4.2.4 „Select display“ dialogue

Unclassified choropleth map

In the unclassified choropleth map shown in fig. 4.2.5 you can see the spatial distribution of the inhabitants older than 65 years. The darker the fields the higher are the underlying attribute values.

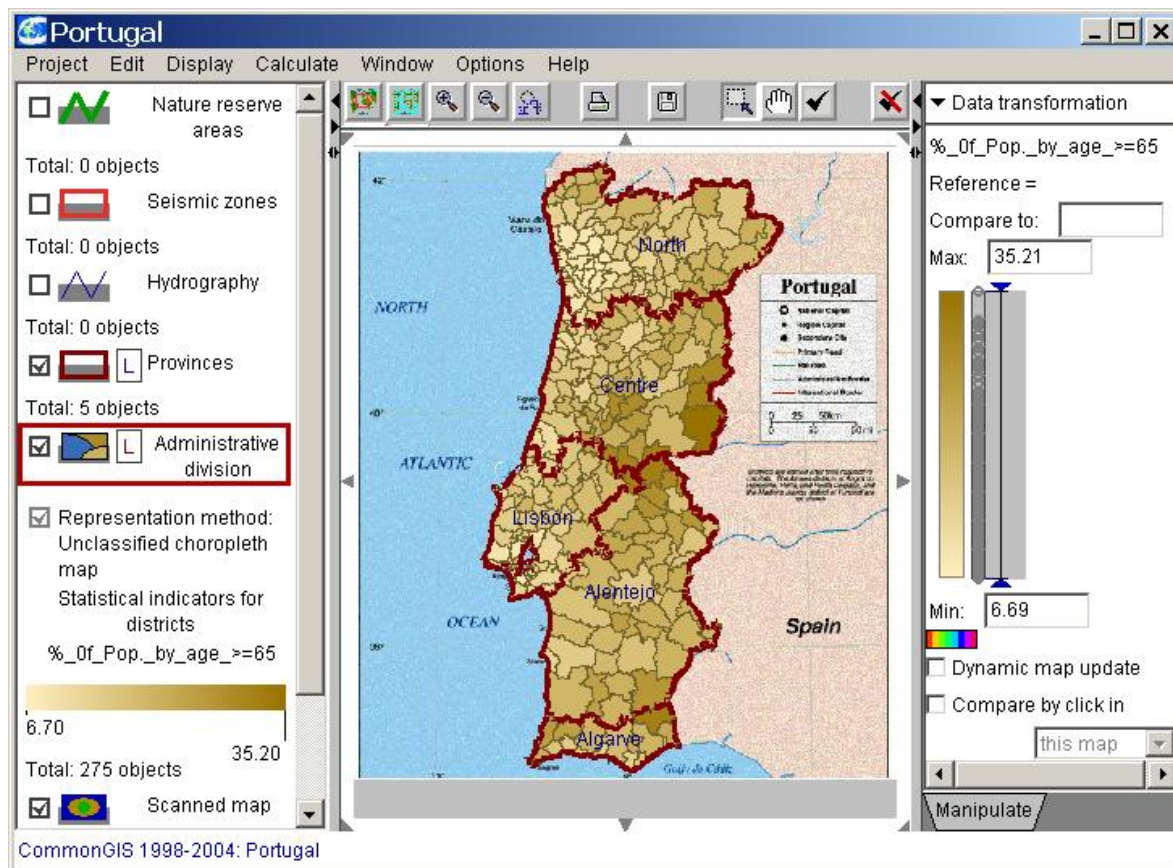


Fig. 4.2.5 Unclassed choropleth map

Applying the visualization method did not only change the map appearance. In addition to the legend on the left side there is another column to the right of the map called "Manipulation" window. It offers further tools for manipulating the choropleth maps.

The color scale in the right column shows which color corresponds to which attribute values. In the parallel grey bar all attribute values (percentage of inhabitants older than 65 years per administrative district) are sorted ascending, symbolized by a dot in the bar. Here the minimum value is 6.69 % (brightest area) and the maximum value is 35.21 % (darkest area). This representation as *dot plot* is interactive. In order to see where the two areas with the extreme values are located on the map, click on the lowest and highest dots in the bar. The corresponding areas on the map are highlighted in response (see figure).

Visual comparison

"Visual comparison" can help the user to recognize spatial patterns, to compare entities and to locate particular values on the map.

In order to recognize spatial structures and tendencies the user can accomplish a "visual comparison". Imagine you want to see all areas having a proportion of 20 % or more of people aged 65 or higher, you either enter value "20" to the field "compare to: _____" and press the "Enter" key (see fig 4.2.6) or you directly select the desired position in the color scale. A double ended arrow appears dividing the color scale into different segments. Now the areas in the map corresponding to proportions lower than 20 are recolored in blue, meaning that they are somehow "faded out". The areas with values exactly equal to the reference value (20 %) are given a special color (e.g. white). For analyzing the

distribution of the attribute values more closely you can move the double ended arrow across the scale with the mouse pointer.

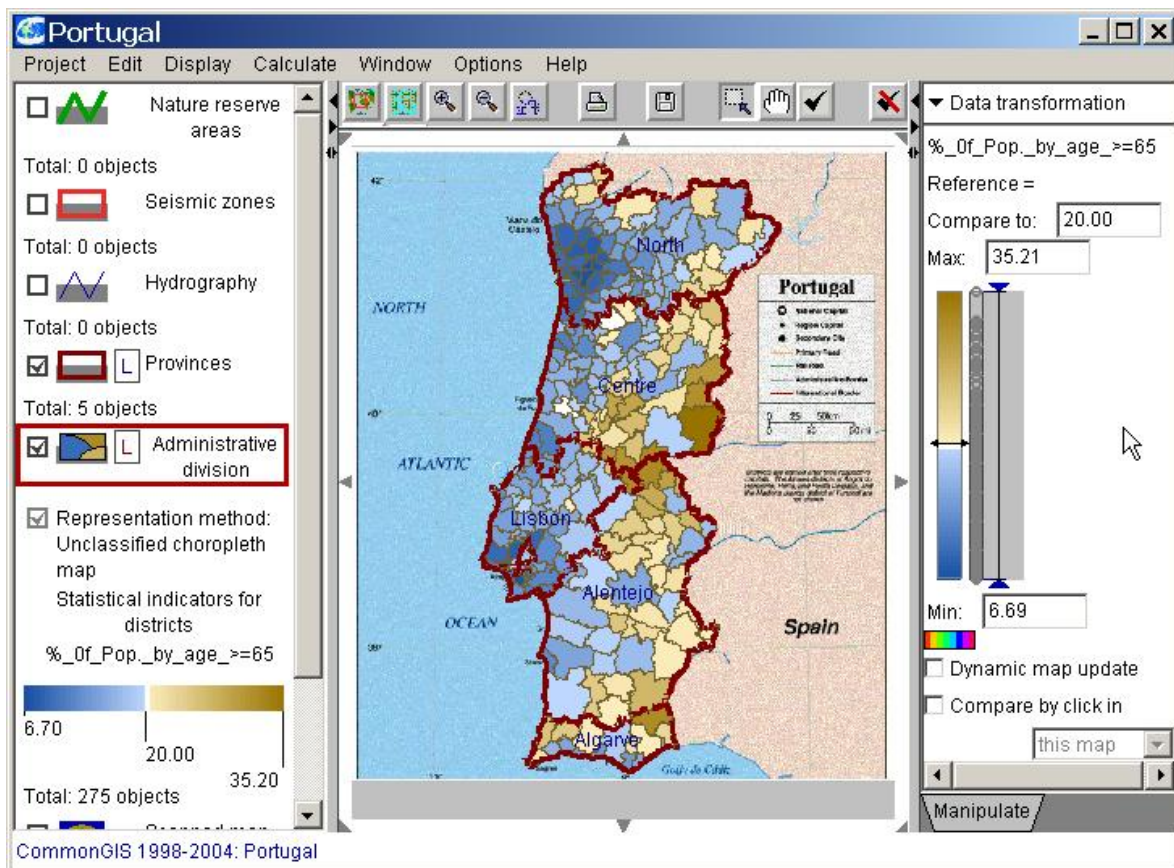


Fig. 4.2.6 Visual comparison

If you want to assess a certain administrative district according to the considered attribute with regard to all other districts, a map supporting this special view can be produced. Click on the small box "compare by click in" at the bottom of the manipulation window. Now select the district in question with the mouse in the map and click on it. This district is taken as reference value now and the map is updated accordingly (e.g. brown color for all districts having higher values, blue color for all districts with values lower than the reference value).

Multiple choropleth maps

If you want to discover more about the spatial distribution of the young population in Portugal (attribute `%_of_Pop_by_age_0-14`), select

- *Display: Display wizard...*,
- Choose the new attribute in addition to the former one,
- mark list entry "Multiple choropleth maps" in column "Maps"

and look at the resulting maps in Fig. 4.2.7.

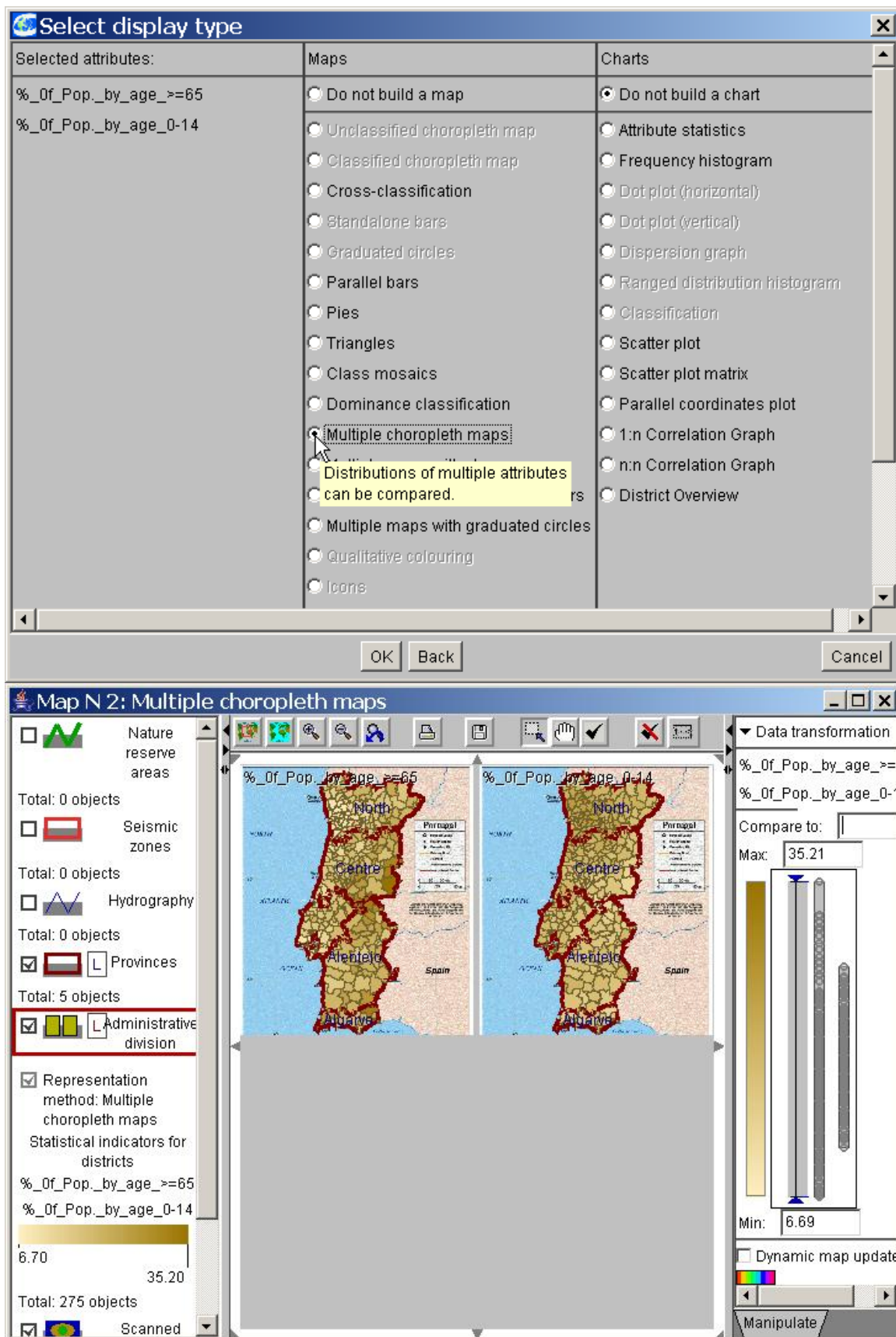


Fig. 4.2.7 Multiple choropleth maps

You can see both from the color and from the position in the dot plots, that the district with the highest proportion of people older than 65 years has only few inhabitants at the age of 0 - 14 (black dot on the right scale). Vice versa the district "Povoia de Lanhoso" with the

highest proportion of young people shows a low value for attribute `%_of_Pop_by_age>=65`. A correlation like this can be vividly demonstrated by this kind of representation.

Hiding outliers

The dot plot shows the distribution of the attribute values. Each dot represents the attribute value of one object. When you touch a dot with the mouse, the dot and all the views of this object in other representations (map, plots, etc.) are highlighted. Attached to the dot plot there is another interactive bar which contains two blue triangular delimiters. The delimiters are used to define a subset of objects to be shown.

Data samples under study frequently contain a couple of very high or very low values (concerning numeric attributes) while the remaining values are statistically relatively close to each other. Such very high or low values are called *outliers*. For example, the birth rates in all but one countries of Europe lie between 10.56 and 14.51 births per 10000 population while the outlying country has 21.70.

Maps as well as other graphical displays built to represent such data sets can be less expressive with regard to the mainstream values, for differences between these values can be hardly perceivable from the presentation. Hiding outliers from view gives an opportunity to map the mainstream values to a shorter value interval and allow to figure out the differences among those values.

In order to hide outliers in CommonGIS the user drags the triangular delimiters of the grey bar right to the dot plot up and/or down until the values which shall be excluded from the map view are situated outside of the bar. The changes are directly transferred to the map and the new extreme values are indicated in the manipulation window.

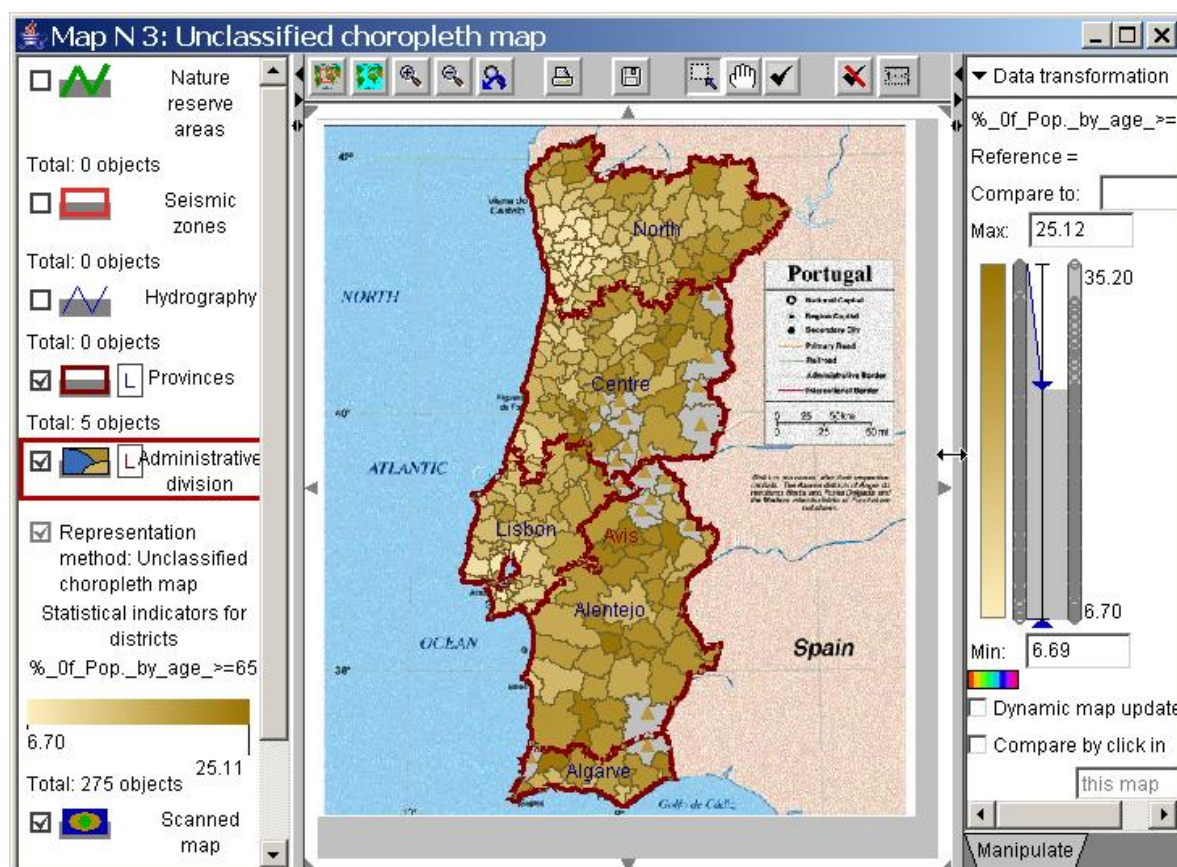


Fig. 4.2.8 Hiding outliers

If you hide the maximum values of attribute `%_of_Pop_by_age>=65`, being more widely distributed on the bar than the other values, you get the map in fig. 4.2.8. Now there are far more dark-brown colored fields. Such a map is more suitable to support assumptions on a national trend than the first map in fig. 4.2.5.

The new maximum value is 25.12 % now. The new value is numerically displayed in the manipulation window and graphically related to the former range of values. Now there are two dot plots: the right one contains the entire (former) range of values, whereas the left one represents the specified subset. In the map only those values are encoded by color which lie between the two delimiters.

Hiding of outliers is also possible in other visualization methods.

Classified choropleth map

In a classified choropleth map the values of an attribute are represented in such a way that it may become obvious that they belong to different classes. The range of values of the attribute is divided into sections that are assigned different colors. Geographical objects are drawn on the map in the color which is assigned to the corresponding interval.

In order to get a classified choropleth map showing the distribution of the high-aged population, select

- *Display: Display wizard...*,
 - choose attribute `%_of_Pop_by_age>=65` from the list,
 - mark list entry „classified choropleth map“ in column „Map“
- and look at the resulting map in Fig. 4.2.9.

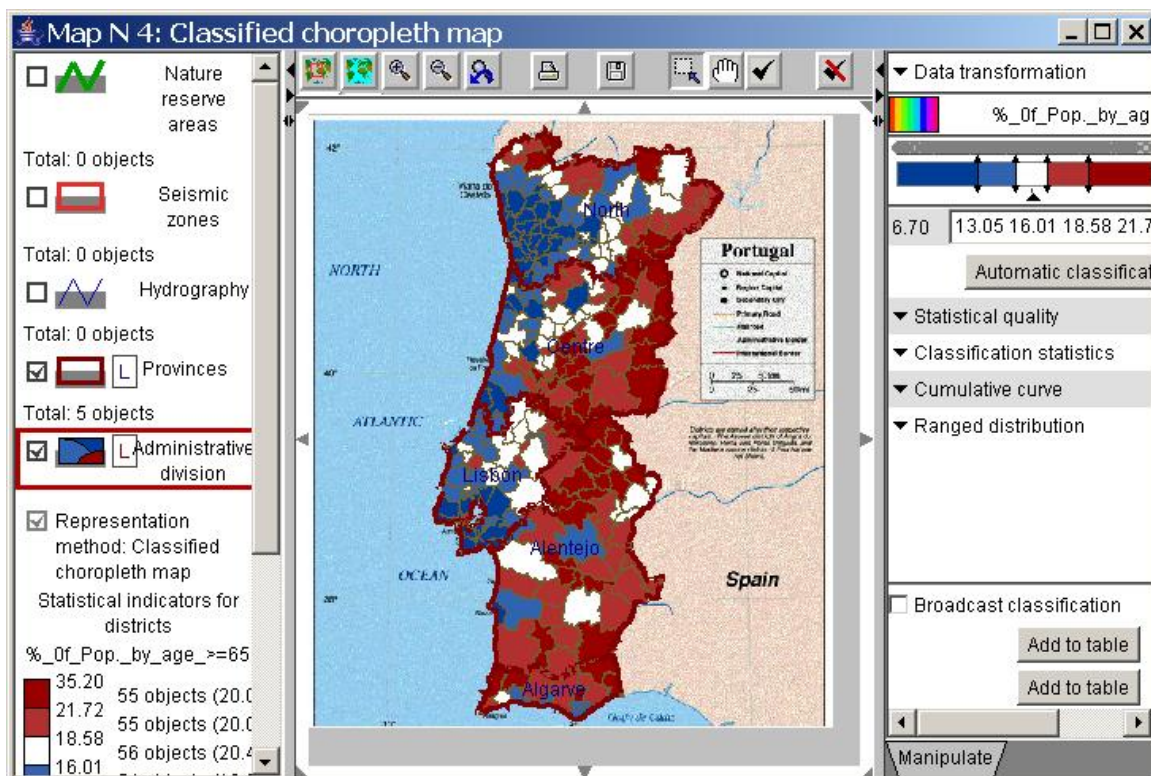


Fig. 4.2.9 Classified choropleth map of distribution of high-aged population.

In fig. 4.2.10 the left column was decreased in width while the right one was increased in order to be able to work more comfortably with the tools for handling classifications.

The attribute values were divided in 5 classes with each class containing approximately the same number of values. Usually this results in highly unequal intervals (see fig. 4.2.10, right window) since the values are not regularly distributed over the range of values.

The size of classes, the type of classification and the number of classes can either be changed directly within the classification scale or with assistance of the "Automatic classification" dialogue, see fig. 4.2.10 (to start click on the corresponding button in the manipulation window).

The classification scale in the manipulation window shows the classes within the attribute value range and the assigned colors. The small black arrow pointing into the classification scale marks the reference class. Members of this class are drawn in white. Lower value objects are represented by blue shades in our example, the objects with higher values are drawn in red shades. The reference class can be changed by moving the pointer. The horizontal dot plot above the scale shows the distribution of the attribute values within the classes.

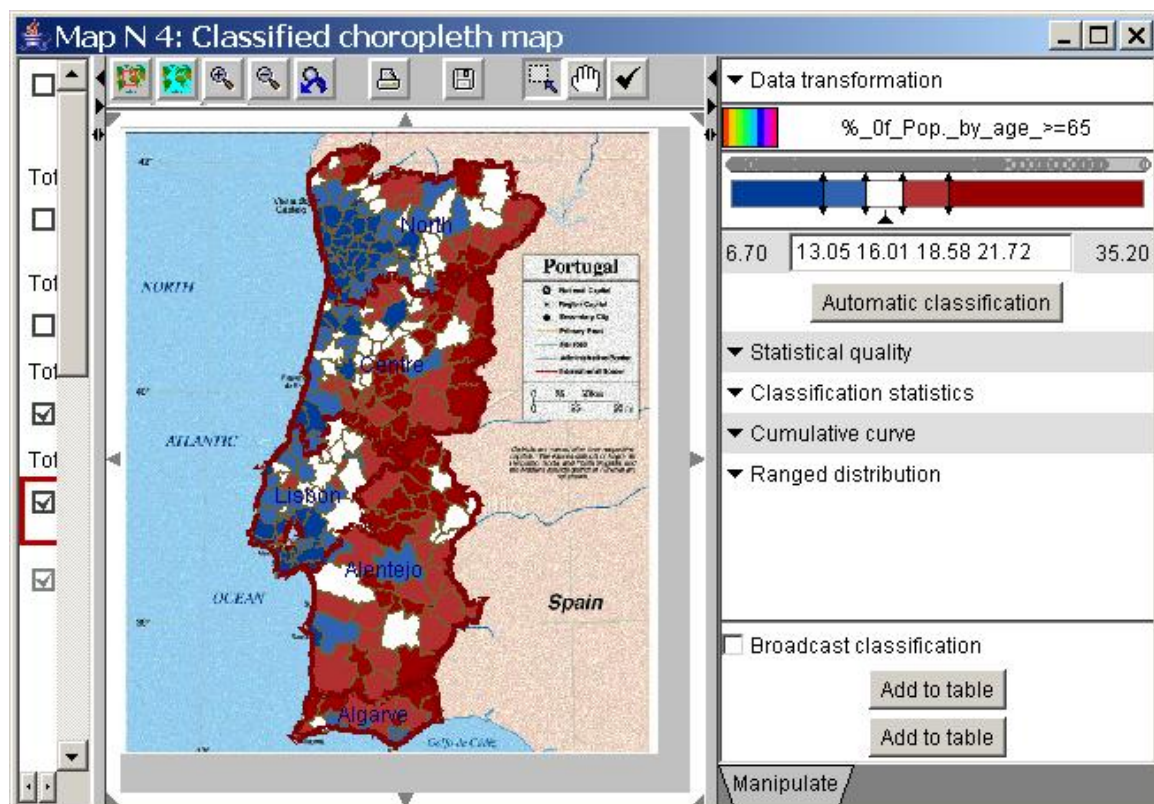


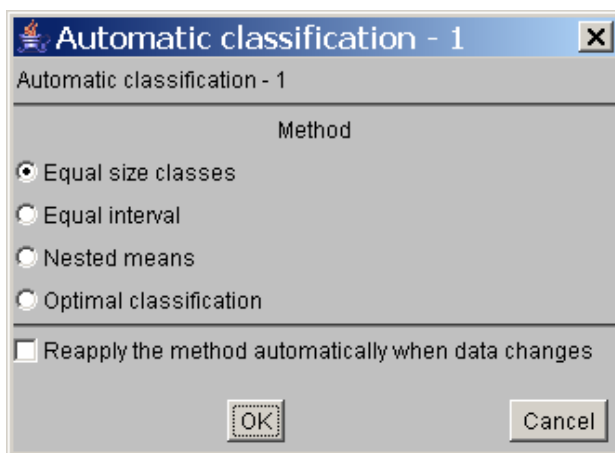
Abb. 4.2.10 Classified choropleth map with modified intervals.

You can change the class borders in the classification scale by dragging the arrows with the mouse. If an arrow is pulled up to the next arrow, the two neighbouring classes are combined into one class. In order to further divide a class click on the desired position within the target class. The class becomes divided at this position and is replaced by two classes. The classes can also be defined by entering values directly underneath the scale. The map (and all other visualizations of this attribute) are updated immediately when changing class sizes. While the arrow is moved only the objects belonging to the

two classes affected by the boundary change are updated in colors while the remaining objects are drawn in neutral grey color. So you can solely concentrate on the changes of the spatial patterns resulting from the movement of the boundary.

Classification methods

On selecting "Classified choropleth map" you get as a default a classification with 5 equal large classes. Adapt the classification to your requirements by clicking on button "Automatic classification" in the map manipulation window. After having selected a method for classification you become asked for further information, e.g. number of classes or error computation mode.



- Classification into equal intervals
- Classification with equal frequencies of objects in the classes
- Nested means
- Statistically optimal classification

When activated the classification method is reapplied when data change.

Fig. 4.2.11 Classification methods

As a result the new classification is represented in the map and in the classification scale. Additionally statistical computations and information about the quality of the classification are available. By clicking on the arrows below the "Automatic classification" button information on "statistic quality", "classification statistics", "cumulative curve" and "Ranged distribution" can be made visible, see fig. 4.2.10. To hide this information click on the arrow at the right lower edge of the respective information area. In fig. 4.2.12 the four available information areas are shown.

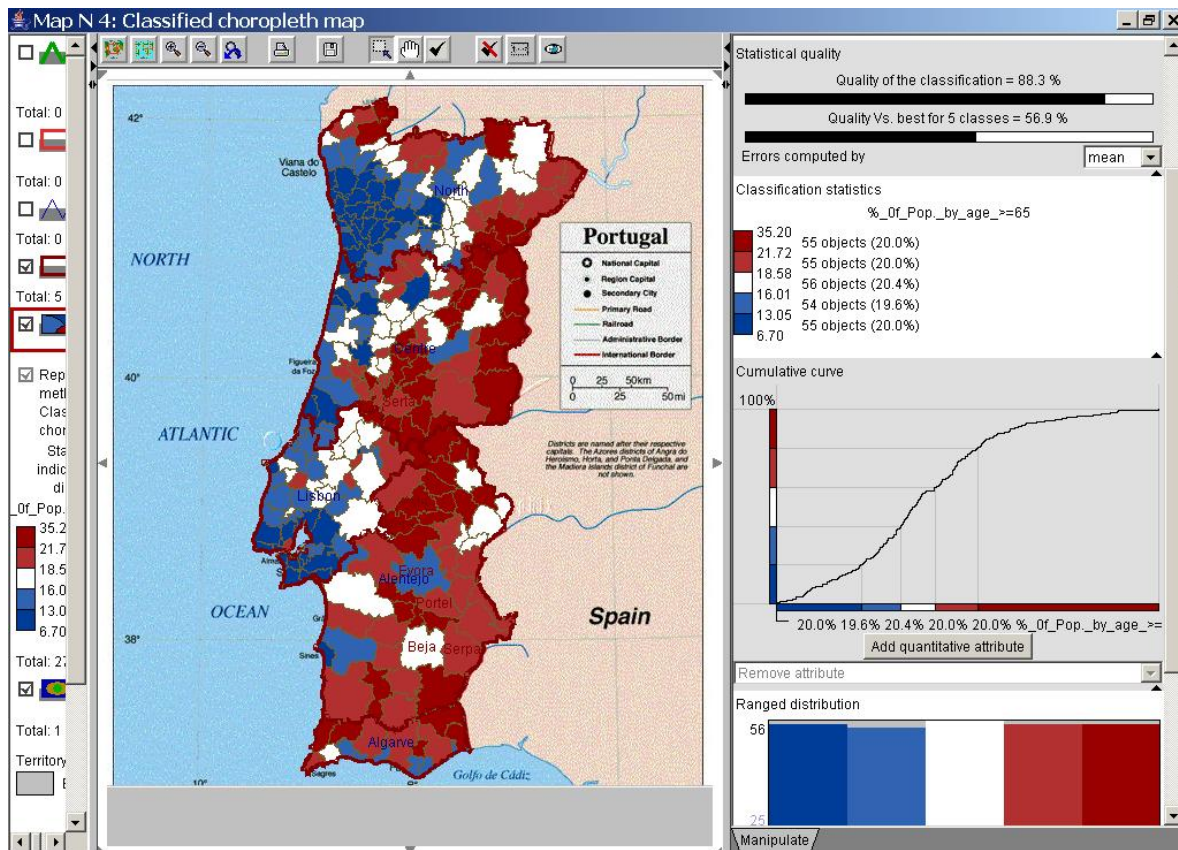


Fig. 4.2.12 Statistical data on data classification

Statistical quality

With any classification the data processed loses some of its accuracy. This loss of accuracy (i.e. the statistical error introduced by the classification) can be measured in CommonGIS. The user can choose whether the error is computed by "average value" (default), "median" or "entropy".

For each classification produced by the system or modified by the user two indicators of the quality are computed:

1. loss of precision in the result of the classification.
2. ratio of the first value to the value for the statistically optimal classification with the same number of classes.

Hence, the first indicator expresses how far the classification is from the original data set and the second one how far it is from the optimal classification. Both quality indicators are presented as numbers measured in the scale 0% to 100% as well as graphically. The indicators are automatically updated after each change of the classes.

Classification statistics

The classification statistics is a kind of legend to the current classification. For each class the color, the boundary values, the number of objects contained and their proportion to the whole set of objects are listed.

Cumulative curve

A visual representation of the statistical value distribution can help the analyst to meet the statistical criteria in the course of interactive classification also. The dot plot above the classification scale can be a useful way, but overlapping of point symbols may obscure understanding of the distribution.

An additional method for graphical representation of statistical distribution is the cumulative frequency curve or ogive. The cumulative frequency curve maps the frequency of the attribute values to a graph. The horizontal axis represents the value range of an attribute, the vertical axis shows the proportional frequency of objects. The vertical position of each point of the curve corresponds to the number of objects with values of the attribute being less than or equal to the value represented by the horizontal position of this point. Peculiarities of value distribution can be perceived from the shape of the ogive. Steep segments correspond to clusters of close values.

Ranged distribution

The diagram "Ranged distribution" offers yet another view to the classification statistics. Here the class sizes are represented as bars. Since "equal size classes" was adjusted as classification parameter in the example, the bars are approximately of equal height. If the class sizes are different, you can display them sorted by size (enable option "Ranged").

If the user has found a suitable classification, he can transfer the categorization as new attribute into the table. Each object is assigned a designator corresponding to the respective class (e.g. few older people, middle number of older people, many older people). The table can be arranged according to class membership. Other methods can be applied to this new attribute again.

Cross-classification

If you want to analyse the relationship between two attributes, you can do a cross classification.

In order to obtain cross-classes for the two attributes `%_of_Pop_by_age>=65` and `%_of_Pop_by_age_0-14`, select

- *Display: Display wizard...*,
- Choose the attributes `%_of_Pop_by_age>=65` and `%_of_Pop_by_age_0-14`,
- Mark list entry „Cross-classification“ in column „Maps“

and look at the resulting map in fig. 4.2.13.

The classified choropleth map shows the distribution of the attribute values concerning the four classes which are displayed within the two-dimensional point graph in the manipulation window to the right:

- high values for attribute1 and high values for attribute2
- high values for attribute1 and low values for attribute2
- low values for attribute1 and high values for attribute2
- low values for attribute1 and low values for attribute2

Partitioning of the classes is done according to the classification parameters, which can be adjusted in the column "Manipulate". Here, the attribute values are divided into 4 classes in such a way that each class contains approximately the same number of values.

The dot plot reveals that areas with a high percentage of inhabitants under 14 years have few old people, while areas showing many inhabitants over 65 years have only a small portion of young population. From the choropleth map you can infer a general tendency: the more the administrative districts are located towards the inland and toward the south of the country, the more older inhabitants are registered while there is a younger population at the coast and in the north.

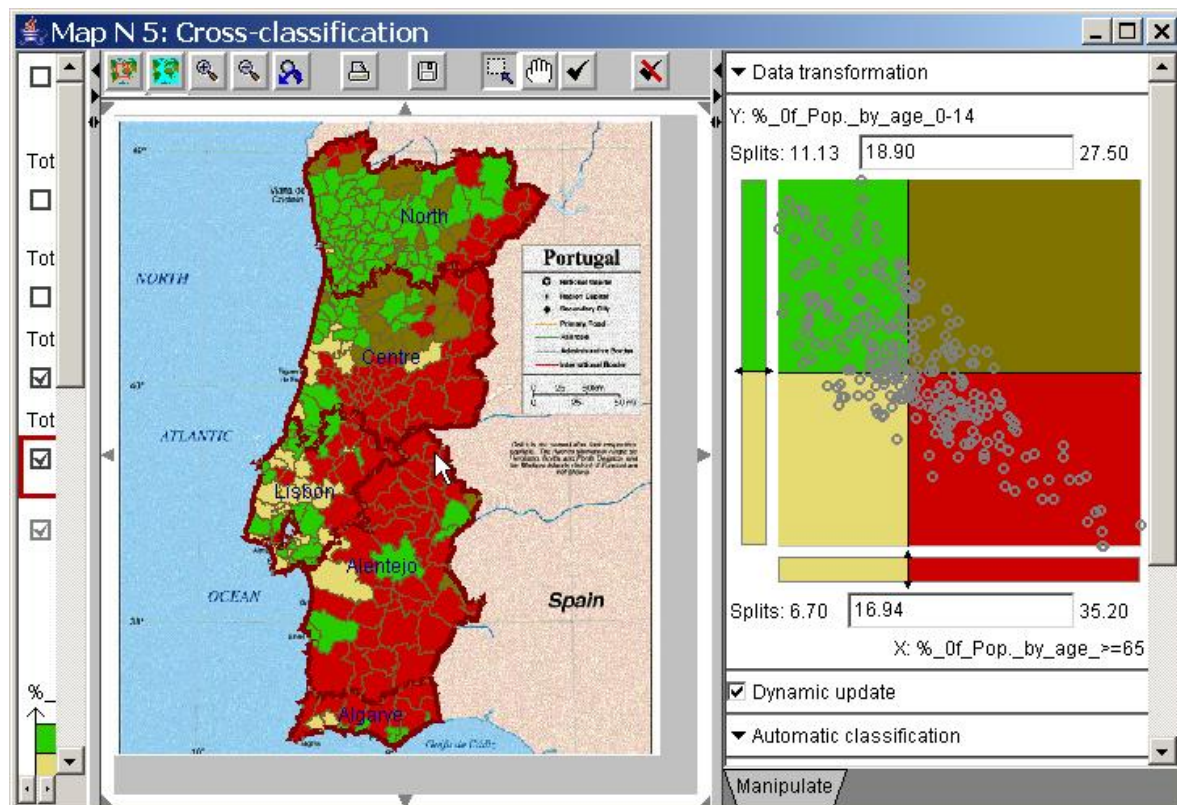


Fig. 4.2.13 Cross-classification of young and old population.

Qualitative colouring

When attributes do not consist of numeric values so that no ordering is possible (e.g. boolean or string values), the distribution of the attribute values can be displayed by assigning different colors to each value. In the example project "wallis.app" there is an attribute "snow certainty" in layer "Skiing areas" (click on "include non-numeric attributes" when selecting attributes). This value indicates whether a skiing area has snow certainty or not. A visualization with qualitative colouring can be seen in fig. 4.2.14.

In the legend left to the map the presentation method selected and the classification statistics are mentioned below the layer name "Skiing areas". This information can as well be represented in the manipulation window to the right (by clicking on the arrow left to the entry "classification statistics").

Within a qualitative choropleth map you can also show, e.g., Internet addresses of ski places (see also "Stacks" in section "Maps with special diagrams") or if an area has a certain characteristic or not. In fig. 4.2.15 you see a qualitative colouring representing the

predominating religions in European countries (attribute "religion" in project "eu.app"). The colors can be changed by clicking on the small colored box left to the class names (being the attribute values).

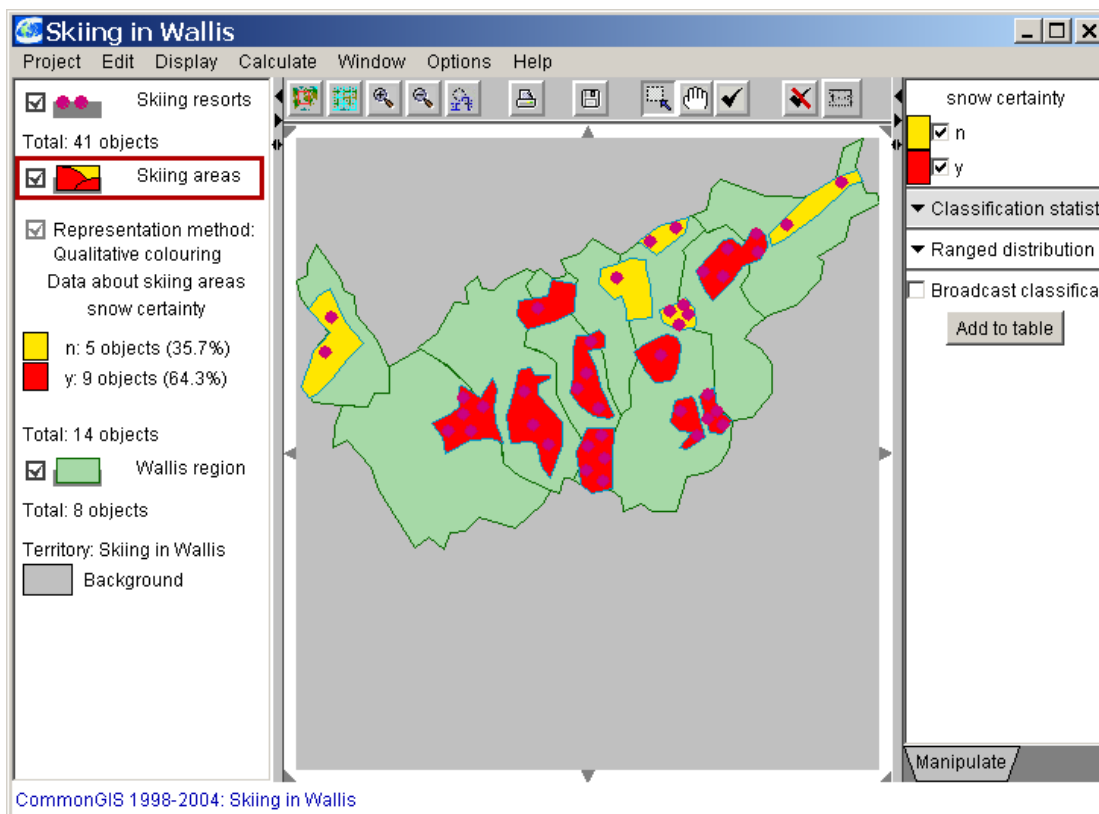


Fig. 4.2.14 Qualitative colouring for snow certainty.

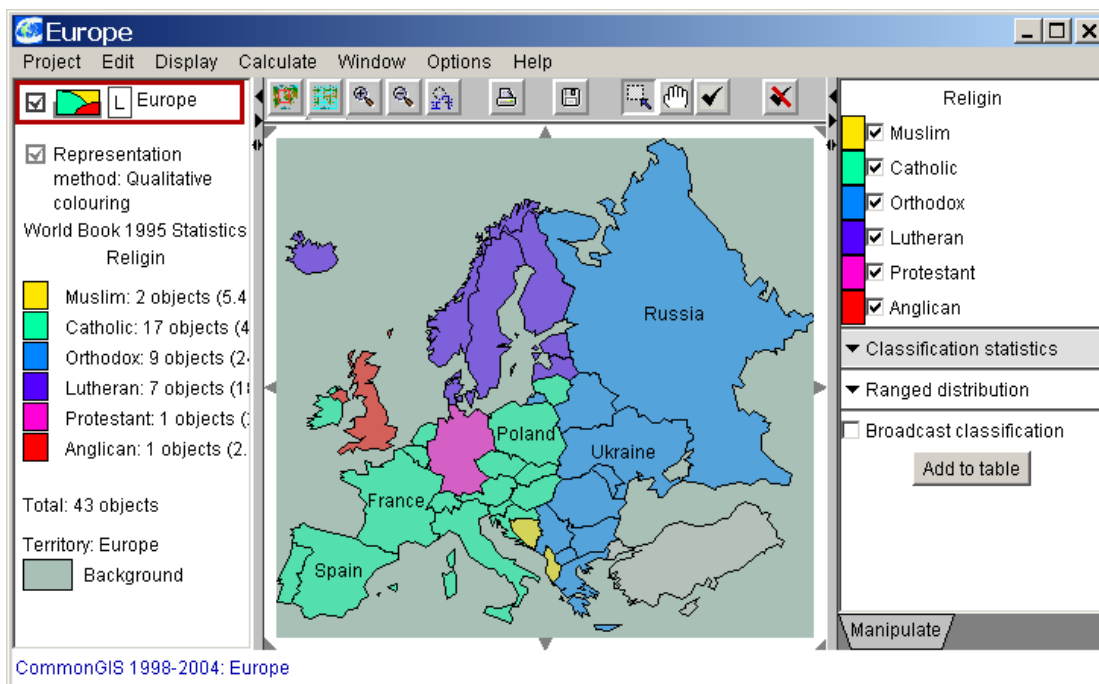
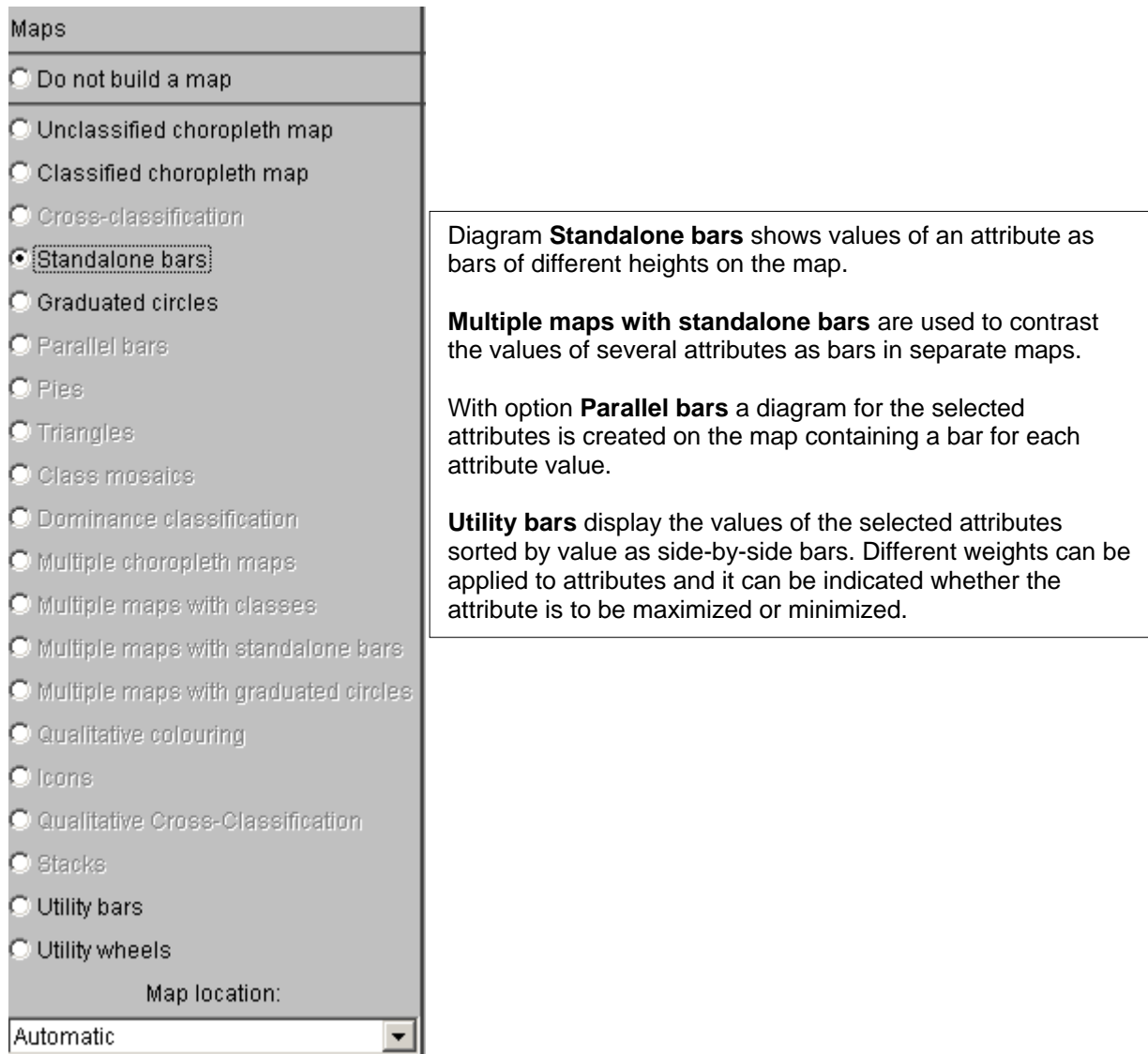


Fig. 4.2.15 Qualitative colouring for religion

Maps and diagrams (bar charts)

The maps in CommonGIS can be supplied by a broad variety of diagrams. The integration of diagrams into maps allows to relate attribute values directly to the spatial information of the map.



The screenshot shows a dialog box titled 'Maps' with a list of options. The 'Standalone bars' option is selected. To the right of the list, a text box provides information about the 'Standalone bars' diagram type.

Maps

- ☐ Do not build a map
- ☐ Unclassified choropleth map
- ☐ Classified choropleth map
- ☐ Cross-classification
- ☒ **Standalone bars**
- ☐ Graduated circles
- ☐ Parallel bars
- ☐ Pies
- ☐ Triangles
- ☐ Class mosaics
- ☐ Dominance classification
- ☐ Multiple choropleth maps
- ☐ Multiple maps with classes
- ☐ Multiple maps with standalone bars
- ☐ Multiple maps with graduated circles
- ☐ Qualitative colouring
- ☐ Icons
- ☐ Qualitative Cross-Classification
- ☐ Stacks
- ☐ Utility bars
- ☐ Utility wheels

Map location:

Automatic

Diagram **Standalone bars** shows values of an attribute as bars of different heights on the map.

Multiple maps with standalone bars are used to contrast the values of several attributes as bars in separate maps.

With option **Parallel bars** a diagram for the selected attributes is created on the map containing a bar for each attribute value.

Utility bars display the values of the selected attributes sorted by value as side-by-side bars. Different weights can be applied to attributes and it can be indicated whether the attribute is to be maximized or minimized.


Standalone bars

If you want to get a visual impression of the height of attribute values in the basic map of a project, the attribute values can be displayed as single bars with a height proportional to the value. The higher the attribute value, the higher is the bar.

In order to get standalone bars for attribute `%_of_Pop_by_age>=65` in the basic map of the project "pt.app" select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65`,
- Mark list entry "Standalone bars" in column "Maps"

and look at the resulting map which is supplemented by a bar for each attribute value.

Since the net of the administrative districts on this map is represented very narrow, the bars which are drawn upon the map, cover the map nearly completely, so that the user needs to implement another level of abstraction to continue with his analysis. The user clicks e.g. on the icon  in the icon bar, draws with the mouse a rectangular area in the middle right part of the map (where he assumes a high portion of older inhabitants) and receives as result the map section in fig. 4.2.16.a.

If the user wants to include only those areas into the analysis with more than 20 % of the inhabitants being older than 65 years, he performs a "visual comparison" (see also section, p. 43):

- Enter value "20" in the "compare to: _____" field and press the "Enter" key or
- select the reference value directly on the color scale by clicking on it and dragging the arrow to the desired place.

As a result the user can see the second map in fig. 4.2.16.b in which all the bars representing a value less than 20 are drawn in a different color. In order to mark the negative deviation from the reference value, those bars are arranged downwards, while the bars showing values higher than the reference value are drawn upwards.

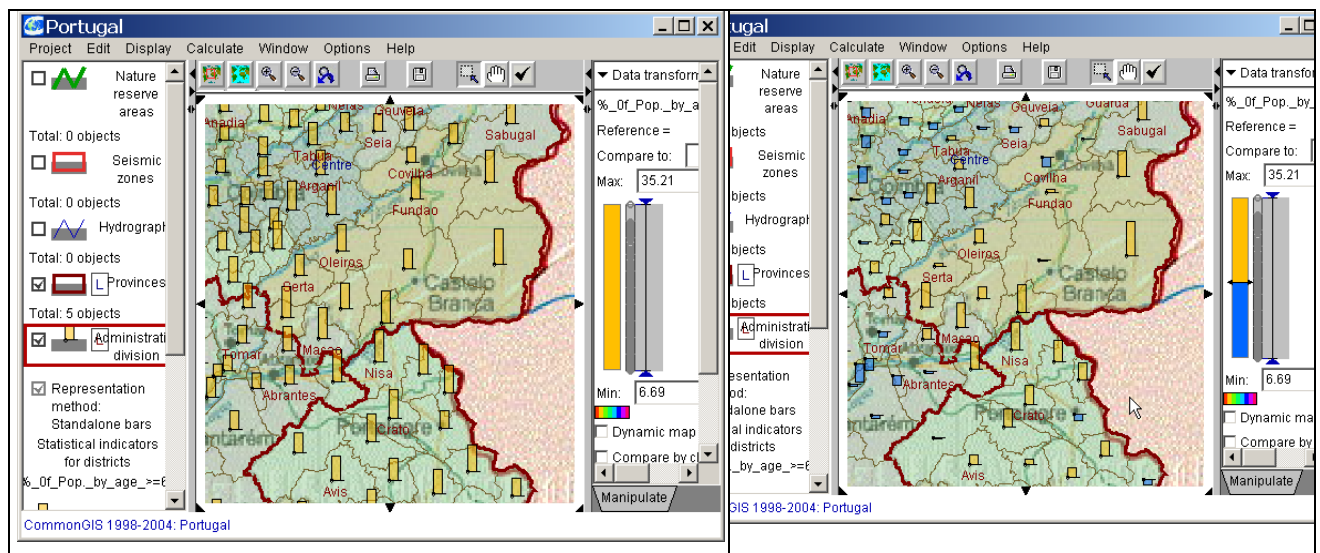


Fig. 4.2.16 a: Standalone bars, b: Standalone bars with visual comparison

Multiple maps with standalone bars

If you intend to compare two (or more) attributes (e.g. $\%_{\text{of_Pop_by_age}} \geq 65$ and $\%_{\text{of_Pop_by_age_0-14}}$) in bar representation select

- *Display: Display wizard...*,
- Choose attributes $\%_{\text{of_Pop_by_age}} \geq 65$ and $\%_{\text{of_Pop_by_age_0-14}}$,
- Mark list entry „Multiple maps with standalone bars“ in column „Maps“.

The resulting maps are each showing the values of one attribute as bars with different heights (see fig. 4.2.17). Again the user has to change the abstraction level to simplify the general survey.

Clicking on the Zoom-in icon equally scales up all maps within this window.

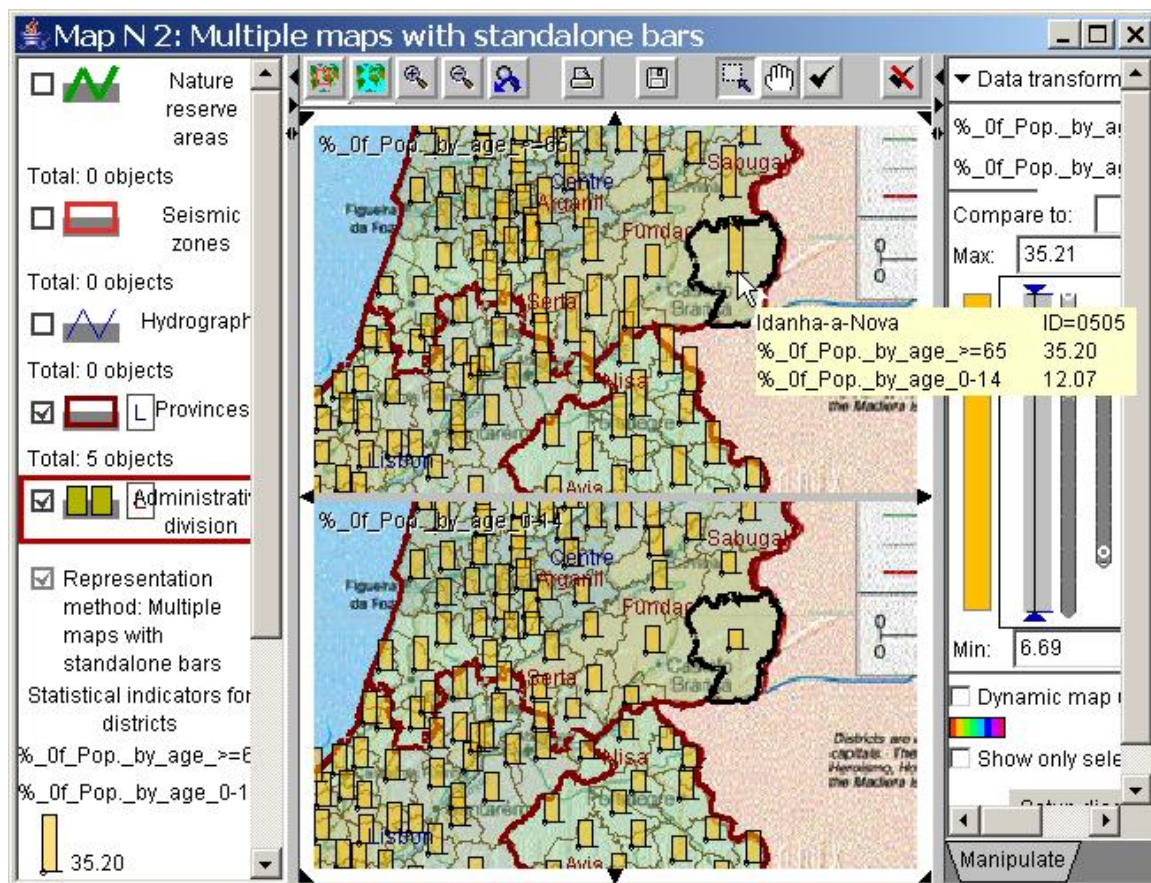


Fig. 4.2.17 Multiple maps with standalone bars

When you move the mouse cursor on any object in one of the maps, the values of the selected attributes for this object are listed for simplifying the comparison between the absolute values. With this kind of diagram, you can again perform "visual comparison" including all associated maps.

Parallel bars

If you want to see the bars for the selected attributes in a single diagram, select „Parallel bars“ as display method.

The display of the two attributes `%_of_Pop_by_age_>=65` and `%_of_Pop_by_age_0-14` in a single bar diagram results in the map from fig. 4.2.18. If you select all of the four attributes describing the proportion of the population based on age, the map in fig. 4.2.19 is created. Here it becomes also clearly visible that you should pay attention to the order of the attributes when selecting them. In this example it would make sense to arrange the groups ascending or descending on the basis of age.

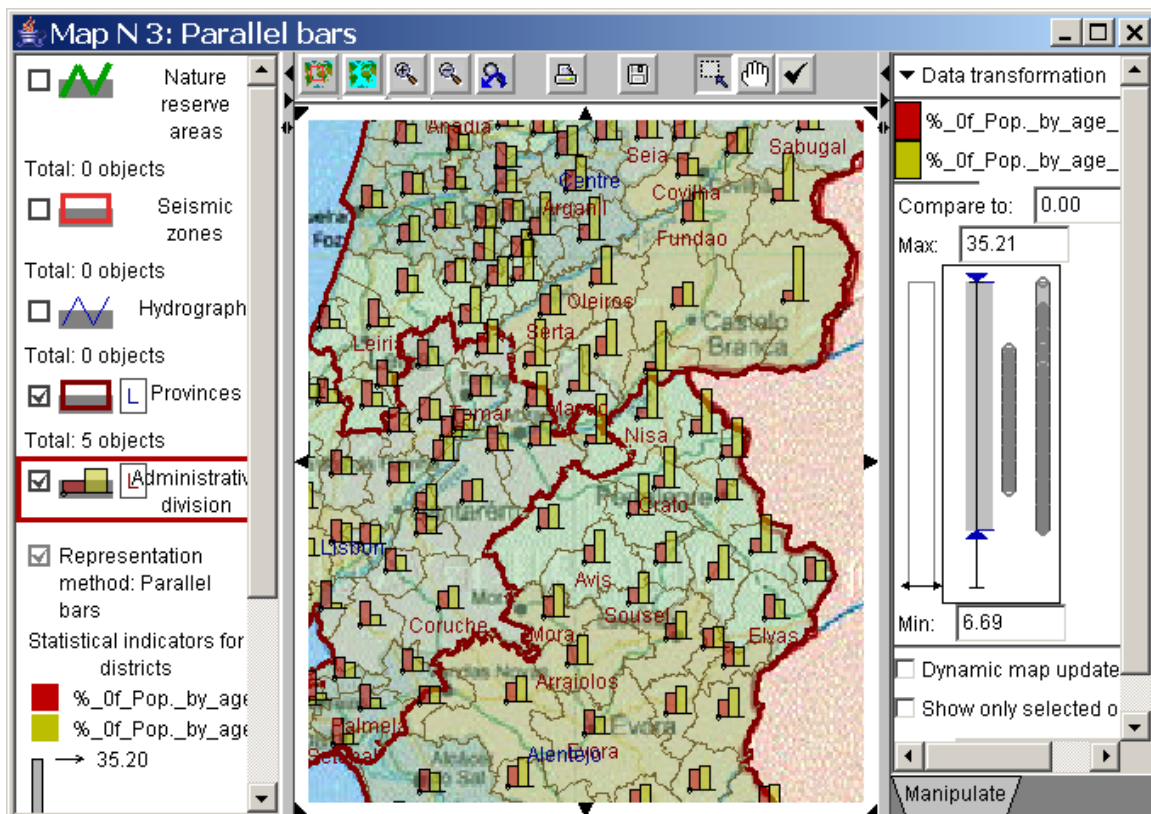


Fig. 4.2.18 Parallel bars for two attributes.

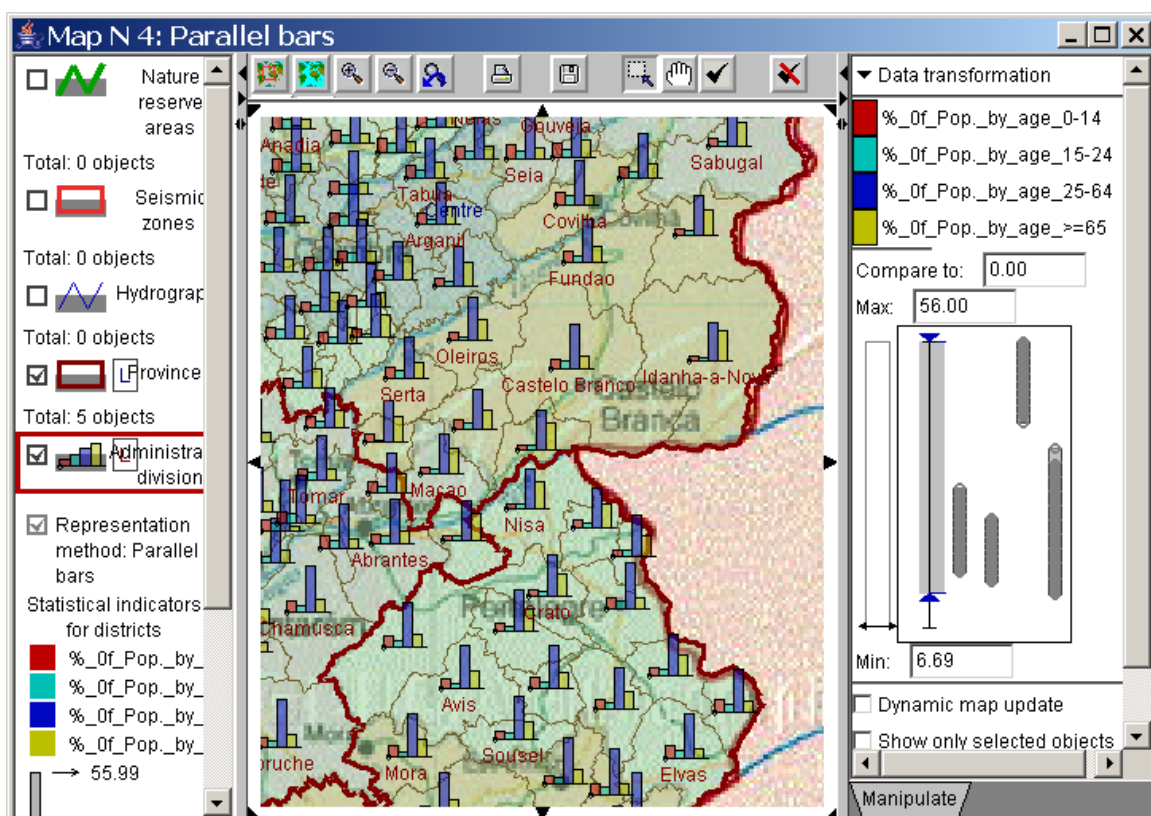


Fig. 4.2.19 Parallel bars for four attributes (all ages).

At the right side of the map you can use the interactive dot plots again (within the subwindow "Manipulate"), you can perform "visual comparison" and "hiding outlier values" in order to analyse the indicated data.

Utility bars

Utility bars are similar to standalone bars, but they offer additional analysis methods (see subwindow "Manipulate").

Fig. 4.2.20 shows „Utility bars“ with attributes *%_of_Pop_by_age_0-14*, *%_of_Pop_by_age_15-24*, *%_of_Pop_by_age_25-65* and *%_of_Pop_by_age>=65*. Contrary to the parallel bars diagram the bars are ordered by size in this case.

Bar width:

In the subwindow "Manipulate" you see that each attribute is assigned a scale from 0 to 1 specifying the relative importance of the attribute. Changing the weight accordingly effects the width of the bar on the map. The current weight is indicated right of the scale. The option "Set equal weights" below the list of scales assigns the same weight to all selected attributes.

Bar height:

Beyond that it can be indicated whether an attribute affects the analysis positively or negatively. The arrow before the attribute name symbolizes whether the attribute is to be maximized or minimized. An arrow pointing north-east means for the analysis that higher values of this attribute lead to better results (benefit criterion). If the arrow points south-east, then this attribute should be minimized, i.e. the smaller the attribute values, the better (cost criterion). If the optimization direction of an attribute is changed, the height of the corresponding bar is adjusted in each diagram. This in turn often leads to a reordering of the bars which are arranged by their size from left to the right (default setting).

Further attributes can be added or removed dynamically to the presentation by clicking on the "Add criterion" and/or "Remove criterion" buttons in the lower part of subwindow "Manipulate" and selecting the desired attributes from the list of the available attributes.

If it is interesting to compare the values of an object to the other objects, you can select this object as reference object of a visual comparison. When clicking on the button "Select object for comparison:" at top right, a list of the available objects is offered for selection. If the option "Compare by click in" is denoted with a checkmark, you can select the desired object directly in the map.

The selected reference object is represented in the map by a horizontal line. The objects to which it is compared are represented as follows: The attribute value of an object is indicated by a bar directed upwards, if this attribute has a value better than the attribute value of the reference object. Values which are lower than the reference value are represented by a bar directed downwards.

To support visual search for the best option on the map, there is an interactive scale titled "Show signs" (in subwindow "Manipulate"), which allows the user to specify the proportion from/to which area diagrams are to be drawn at all (indicated as proportion of the maximum area). This value is changed by dragging the left triangle with the mouse.

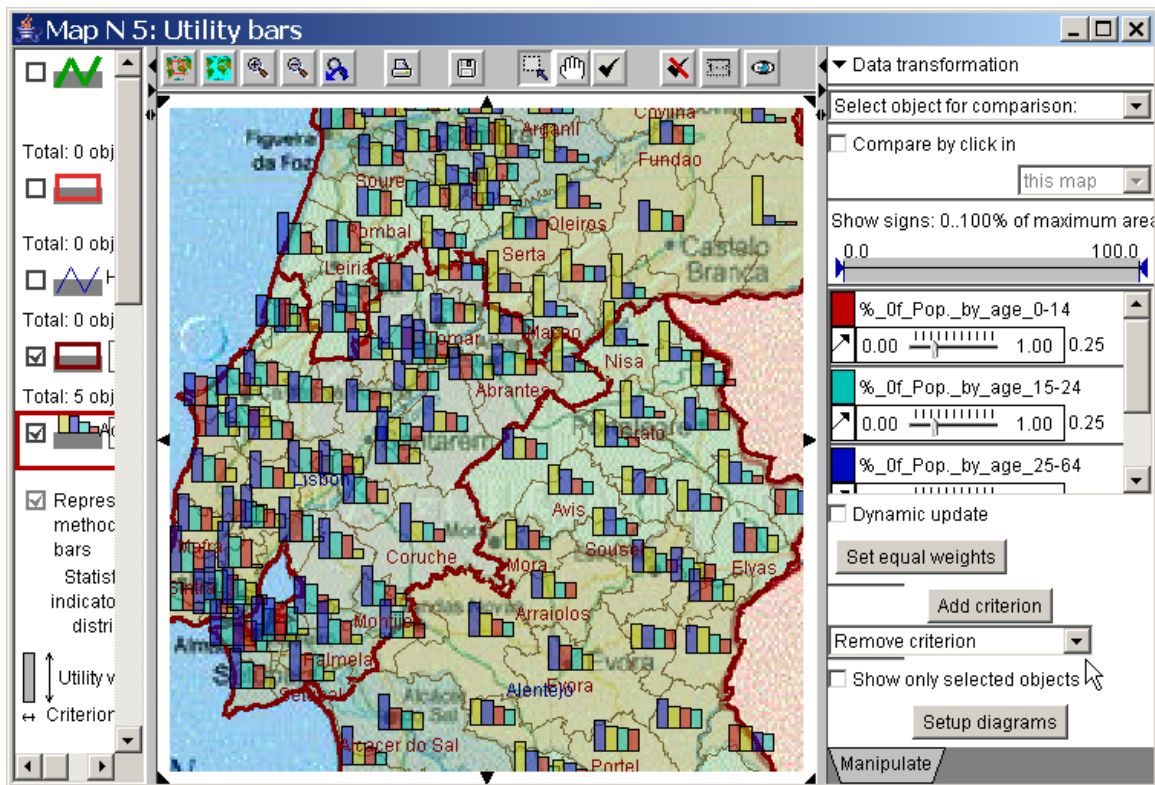


Fig. 4.2.20: Utility bars for age distribution of population.

Using the "Setup diagrams" button down to the right in subwindow „Manipulate“, you can adjust the maximum width and height and the order of segments (see fig. 4.2.21).

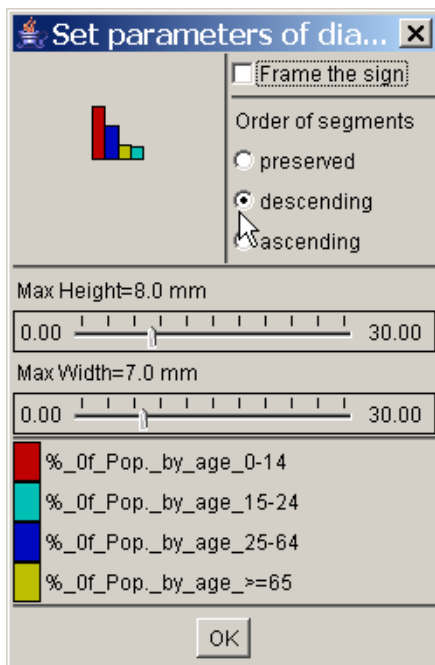


Fig. 4.2.21 Parameter of utility bars.

The total area which is covered by the elements of a utility bar chart is an indication for the "quality" or "utility" of the appropriate object. In order to be able to compare the options visually, the diagrams can be surrounded by a frame, a thin line around the maximal values (see fig 4.2.21, top right). The framed area corresponds to the optimum value of all attributes.

Note: If you change the weights of the criteria, the area of the diagrams changes also, i.e. previously visible diagrams do not appear any more, while diagrams faded out before become visible now.

Maps and diagrams (pie charts)

Diagram **Graduated circles** shows values of an attribute as pie charts with different radii on the map.

Multiple maps with graduated circles are used to contrast the values of several attributes as circles in separate maps.

With option **Pies** a diagram is created for the selected attributes on the map containing a slice for each attribute value.


Utility wheels display the values of the selected attributes sorted by value as pie charts. Different weights can be applied to attributes and it can be indicated whether the attribute it to be maximized or minimized.

Graduated circles

If you want to get a visual impression of the height of attribute values in the basic map of a project, the attribute values can be displayed as single circles with a radius proportional to the value. Thereby it is valid that the higher the attribute value, the bigger is the circle.

In order to get graduated circles for attribute `%_of_Pop_by_age>=65` in the basic map of the project "pt.app", select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65`,
- Mark list entry "Graduated circles" in column "Maps"

and look at the resulting map which is supplemented by a coloured circle for each attribute value. Since the net of the administrative districts on this map is represented very narrow, the circles cover the map nearly completely, so that the user needs to implement another level of abstraction to continue with his analysis. The user clicks e.g. on the icon  in the icon bar, draws with the mouse a rectangular area in the middle right part of the

map (where he assumes a high portion of older inhabitants) and receives as result the map section in fig. 4.2.22.a.

If the user wants to include only those areas into the analysis with more than 20 % of the inhabitants being older than 65 years, he performs a "visual comparison" (see also section 4.2, p. 43):

- Enter value "20" in the "compare to: _____" field and press the "Enter" key or
- select the reference value directly on the color scale by clicking on it and dragging the arrow to the desired place.

As a result the user can see the second map in fig. 4.2.22.b, in which all circles representing a value smaller than 20 are drawn in a different color. (Transparency of layer "Administrative division" was set to 0 % in order to stress the difference in color.)

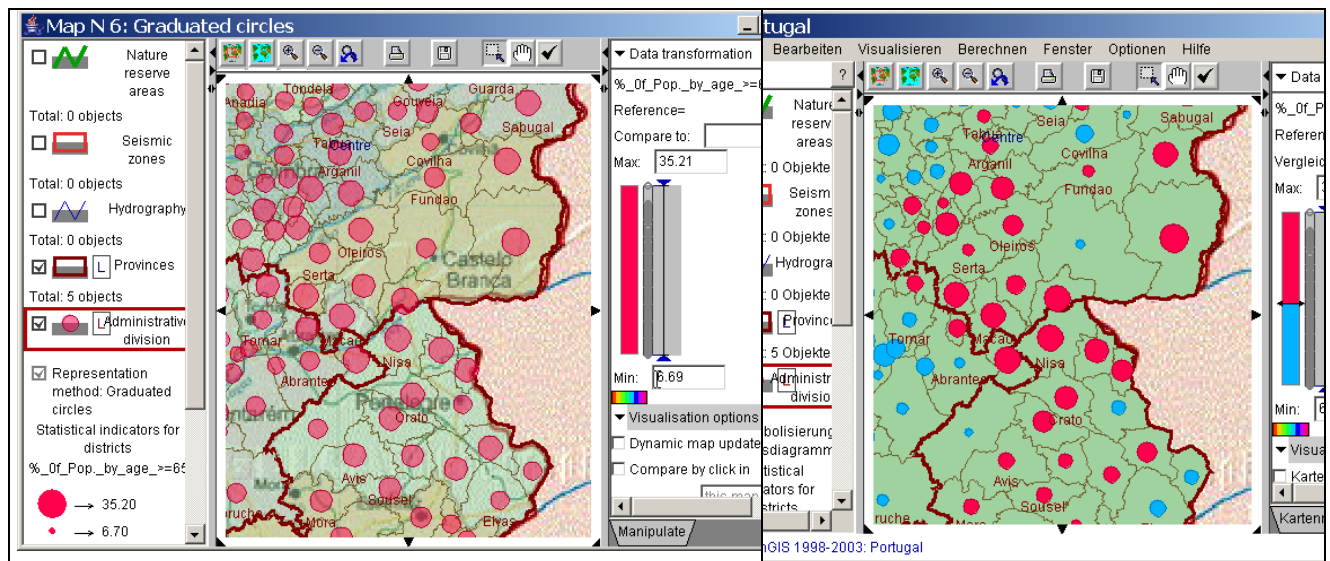


Fig. 4.2.22 a: Graduated circles, b: Graduated circles with visual comparison

Multiple maps with graduated circles

If you want to compare two (or more) attributes (e.g. $\%_{\text{of_Pop_by_age}} \geq 65$ and $\%_{\text{of_Pop_by_age_0-14}}$) as graduated circles, select

- *Display: Display wizard...*,
- Choose attributes $\%_{\text{of_Pop_by_age}} \geq 65$ and $\%_{\text{of_Pop_by_age_0-14}}$,
- Mark list entry „Multiple maps with graduated circles“ in column „Maps“.

The resulting maps are each showing the values of one attribute as circles of different size. Again the user has to change the abstraction level to simplify the general survey. Clicking on the Zoom-in icon equally scales up all maps within this window (see fig. 4.2.23).

When you move the mouse cursor on any object in one of the maps, the values of the selected attributes for this object are listed, so that you can compare the absolute values, too. With this kind of diagram, again you can perform "visual comparison" including all associated maps.

The sequence of the attributes within the pie chart can be changed by mouse-clicking in the legend of the window “Manipulate” and dragging the attribute in question to the desired location in the attribute list. A small green arrow indicates where the attribute is placed if the mouse button is released. The drawing color of attributes can be changed by clicking on the colored boxes in the attribute list.

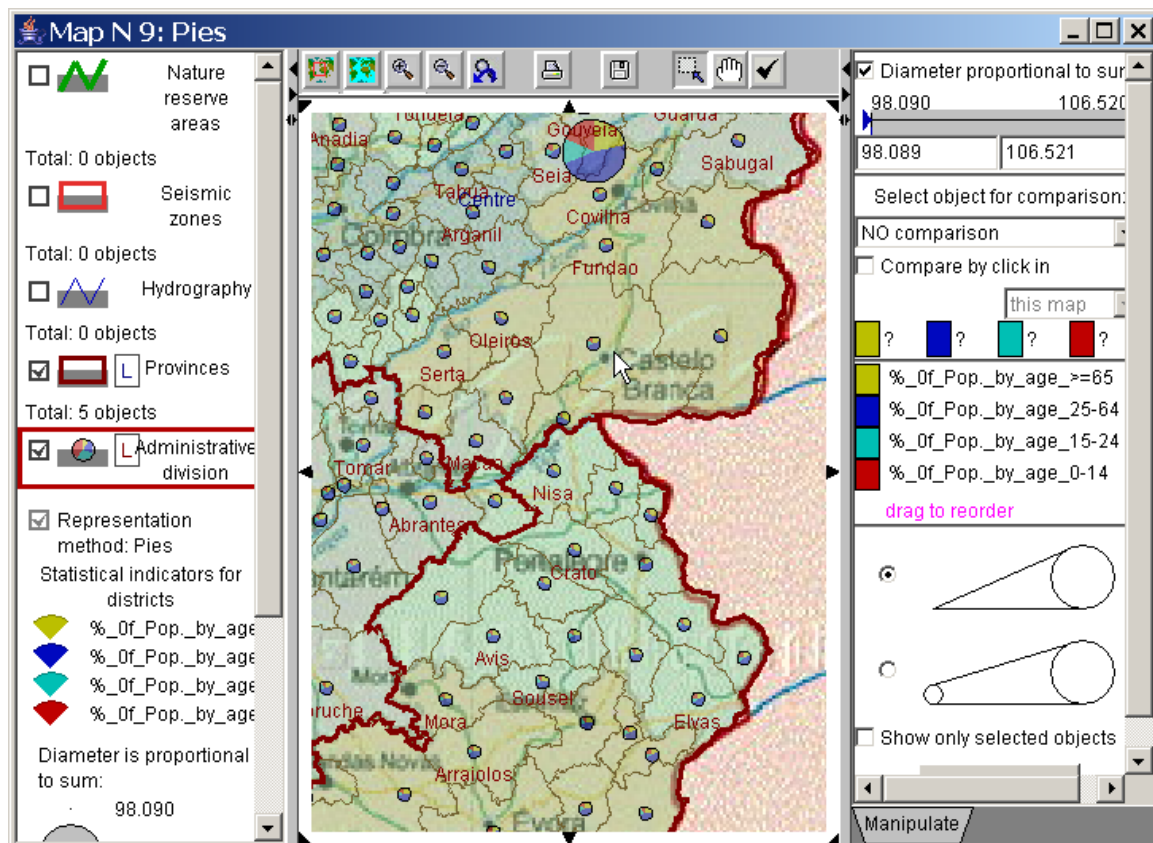


Fig. 4.2.24: Pie charts showing the relations of age groups.

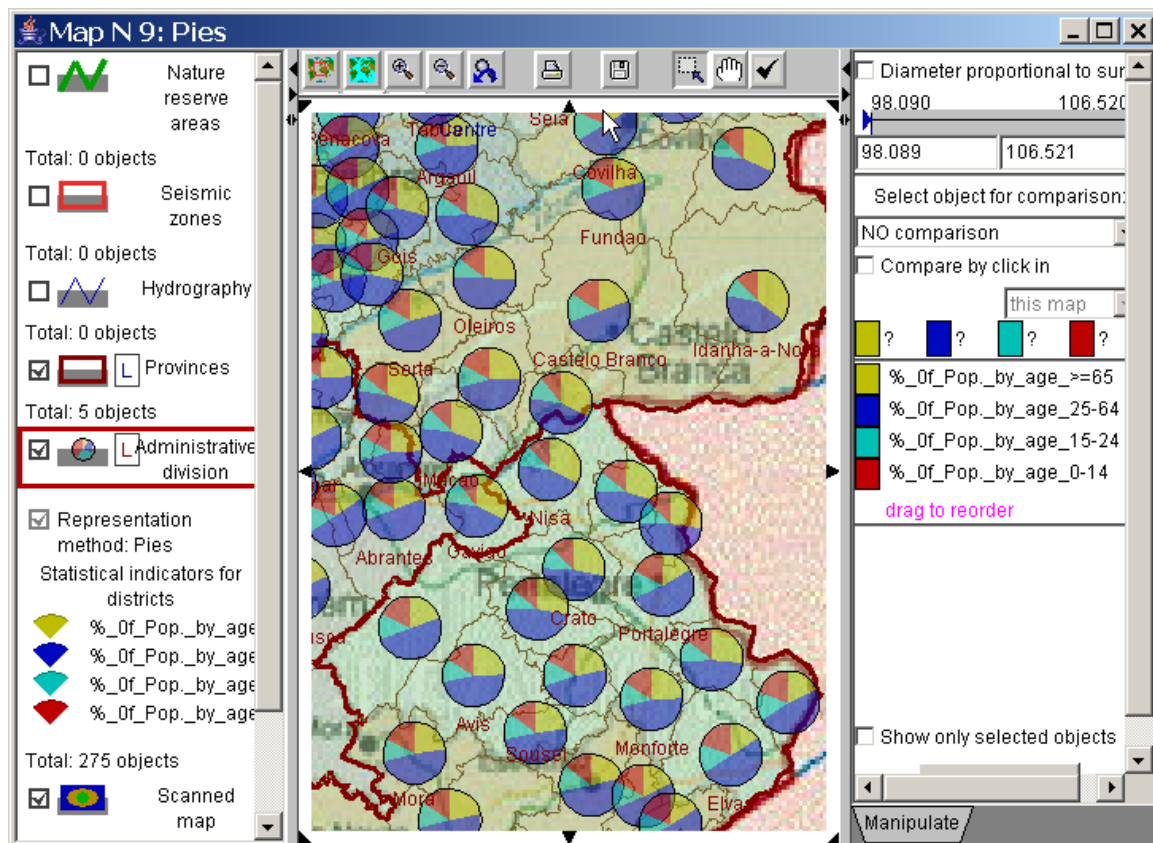


Abb. 4.2.25: Pie charts showing all age groups - enlarged.

Utility wheels

Utility wheels are similar to pie charts, but they offer additional analysis methods (see subwindow "Manipulate"). With this kind of diagram, however, the portions of an individual pie chart are visualized relative to all existing portions. The district Idanha-a-Nova e.g. has a very large blue slice which shows that the corresponding attribute value is near to the maximum value and higher than in many other districts.

Fig. 4.2.26 shows „Utility wheels“ with attributes `%_of_Pop_by_age_0-14`, `%_of_Pop_by_age_15-24`, `%_of_Pop_by_age_25-65` and `%_of_Pop_by_age>=65`. The pie slices within a diagram are ordered by size.

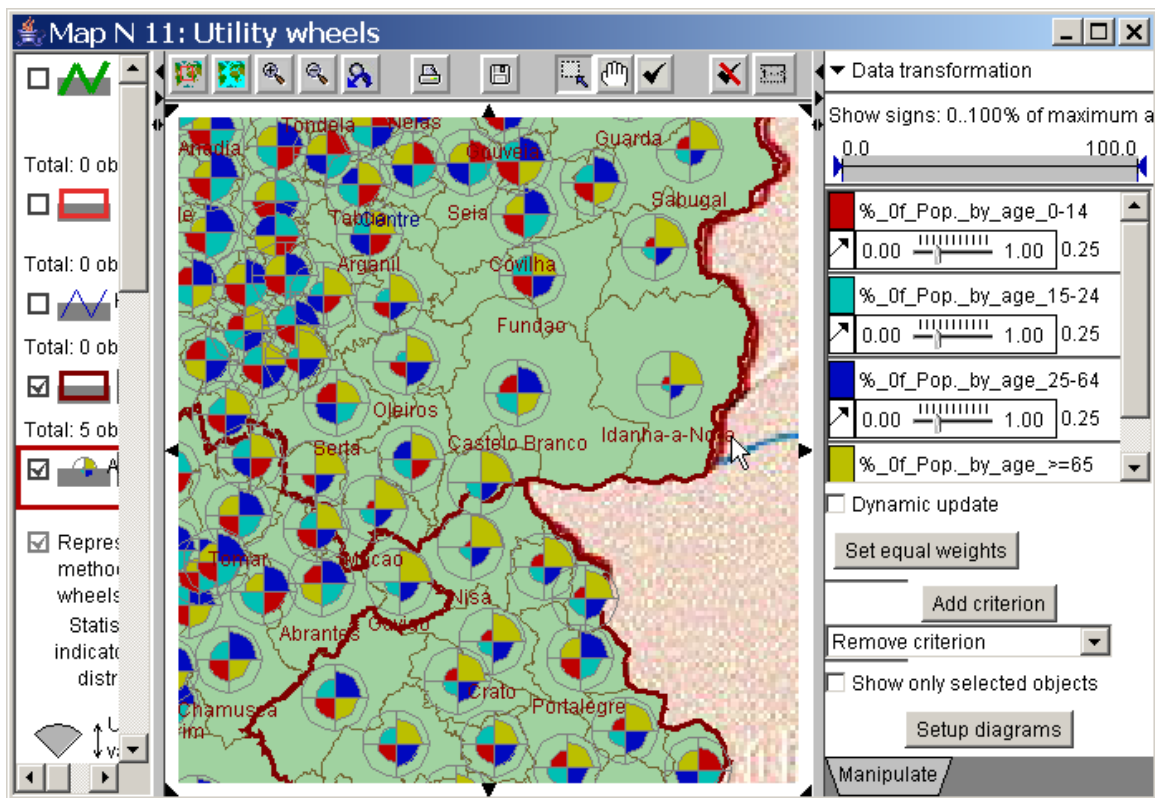


Fig. 4.2.26: Utility wheels for the age structure within Portugal.

Slice angle:

In subwindow "Manipulate" you see that each attribute is assigned a scale from 0 to 1 specifying the relative importance of the attribute. Changing the weight accordingly effects the angle of the slices. The current weight is indicated right of the scale. The option "Set equal weights" below the list of scales assigns the same weight to all selected attributes.

Pie diameter:

Beyond that it can be indicated whether an attribute affects the analysis positively or negatively. The arrow before the attribute name symbolizes whether the attribute is to be maximized or minimized. An arrow pointing north-east means for the analysis that higher values of this attribute lead to better results (benefit criterion). If the arrow points south-east, then this attribute should be minimized, i.e. the smaller the attribute values, the better (cost criterion). If the optimization direction of an attribute is changed, the radius of the corresponding pie slice is adjusted in each diagram. This in turn often leads to a reordering of the slices, which are arranged by their size from top in clockwise direction (default setting).

Further attributes can be added or removed dynamically to the presentation by clicking on the "Add criterion" and/or "Remove criterion" buttons in the lower part of subwindow "Manipulate" and selecting the desired attributes from the list of the available attributes.

Using the "Setup diagrams" button down to the right in subwindow „Manipulate“ you can adjust the diameter and the order of segments (see fig. 4.2.27).

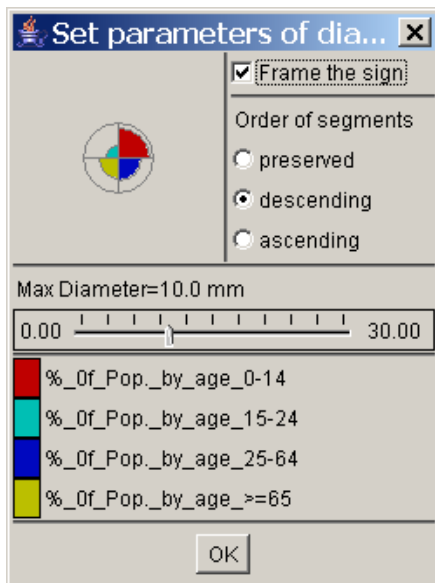


Abb. 4.2.27: Parameter of utility wheels.

Maps with special diagrams

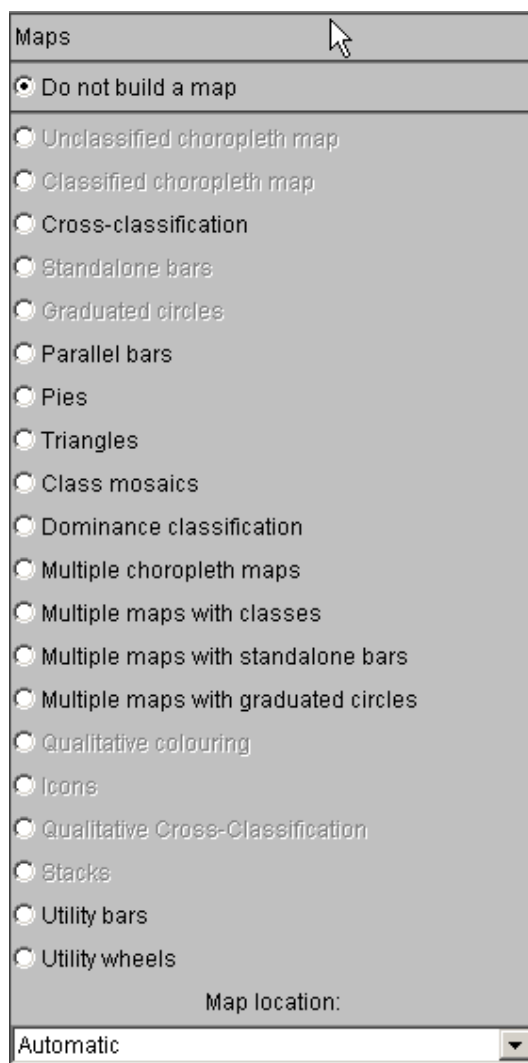


Diagram **Triangles** shows the values of two attributes as triangles with variable width and height on the map.

Icons symbolize a non-numeric attribute by different icons on the map, e.g. boolean values for the absence/ existence of a characteristic, belonging to a group, strings as attribute values.


Stacks are used to mark a string attribute on the map and list the text value in a separate list.

Triangle diagrams

Triangle diagrams express the relationship of two attributes and support the evaluation of both attributes at once. The triangle diagram is created by entering the values of the two attributes into a coordinate system. This value represents the top of the triangle; the height is determined by one of the attributes and its width is set according to the other attribute.

In order to compare two attributes by triangles (e.g. *%_of_Pop_by_age>=65* and *%_of_Pop_by_age_0-14*), select

- *Display: Display wizard...*,
- Choose the attributes *%_of_Pop_by_age>=65* and *%_of_Pop_by_age_0-14* ,
- mark list entry "triangles" in column "Maps"

and look at the resulting map with a triangle diagram for each administrative district. Since the net of the administrative districts on this map is represented very narrow, the triangles cover the map nearly completely, so that the user needs to implement another level of abstraction to continue with his analysis. The user clicks e.g. on icon  in the icon bar, draws with the mouse a rectangular area in the middle right part of the map and receives as result the map section in fig. 4.2.28.

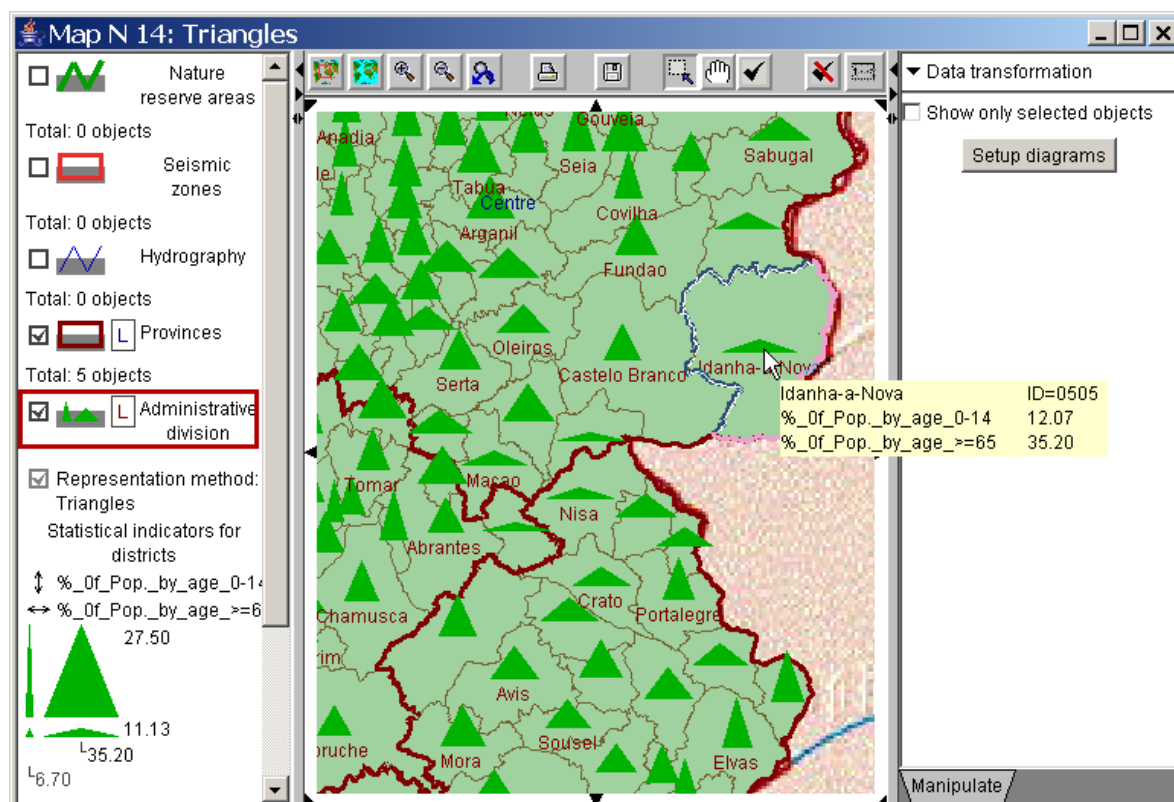


Fig. 4.2.28: Triangles to represent the ratio of young population to old population.

The meaning of the dimensions of the triangles is explained in the legend in the left column. The small double-sided arrows indicate the axis to which an attribute is assigned. In fig. 4.2.28 you can see that the value for the young inhabitants are represented horizontally while the proportion of the population older than 65 years is displayed vertically. The maximum values of each attribute are written right to the triangles (upper right – horizontal attribute, lower right – vertical attribute). In order to clarify how different values within the dimensions affect the triangle, the four triangles indicate the possible minima and maxima:

- lower left: minima of both attributes;
- upper left: maximum of age 0-14 and minimum of age beyond 65;
- upper right: maximum of both attributes;
- lower right: minimum of age 0-14 and maximum of age beyond 65.

In district Idanha-a-Nova the form of the diagram is very similar to the lower right diagram in the legend meaning that there are living many old and few young inhabitants.

Change the color and minimum and maximum height and width of the triangles by editing the parameters in fig. 4.2.29. This dialogue appears when you click on the “Setup diagrams” button in subwindow “Manipulate” or in the legend of the triangles within the left window column.

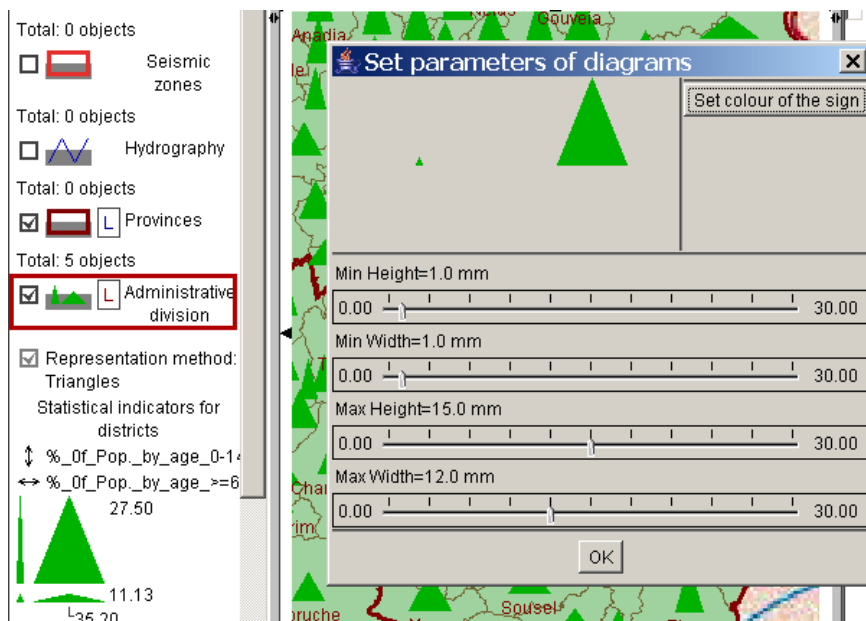


Fig. 4.2.29: Change characteristics of triangles.

Icons

You can indicate an attribute with non-numerical values (e.g. logical values such as yes/no, true/false, text) by different pictograms on the map. (Different colors can be produced by using the option "Qualitative choropleth map", see section "Choropleth maps").

In our project "wallis.app" the attribute "snow certainty" of layer "Skiing areas" can be represented by icons, see fig. 4.2.30. (In order to select this attribute from the “Select attribute” dialogue you must click on option “include non-numeric attributes” below the attribute list to the left.) Skiing areas designated as being snow-safe are marked by a circle, the other areas are assigned a square as symbol.

The form of the icons can be changed by clicking on the explanation of the icons in the legend and selecting a pictogram for editing in the following dialogue. In addition to the default geometrical symbols you can also load a picture in GIF or JPEG format as symbol.

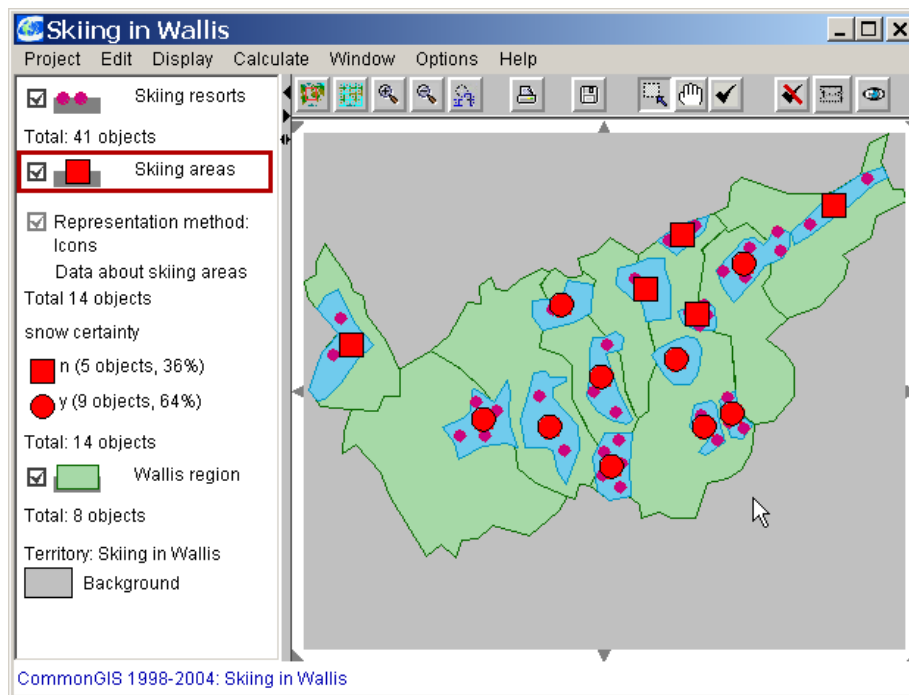


Fig. 4.2.30: Icons for a boolean attribute.

Stacks

If an attribute consists of text strings (e.g. URLs), the “Stacks” diagram allows to attach multi-colour squares to objects in the map to visualize the allocation of text to spatial objects. The attribute value, namely a text string, is listed in the legend and in the subwindow “Manipulate”. (Different colors can be produced by using the option “Qualitative choropleth map”, pictograms by way of the option “Icons”).

In our project “wallis.app” the attribute “URL” of layer “Skiing resorts” can be represented by stacks, see fig. 4.2.31. (In order to select this attribute from the “Select attribute” dialogue you must click on option “include non-numeric attributes” below the attribute list to the left.)

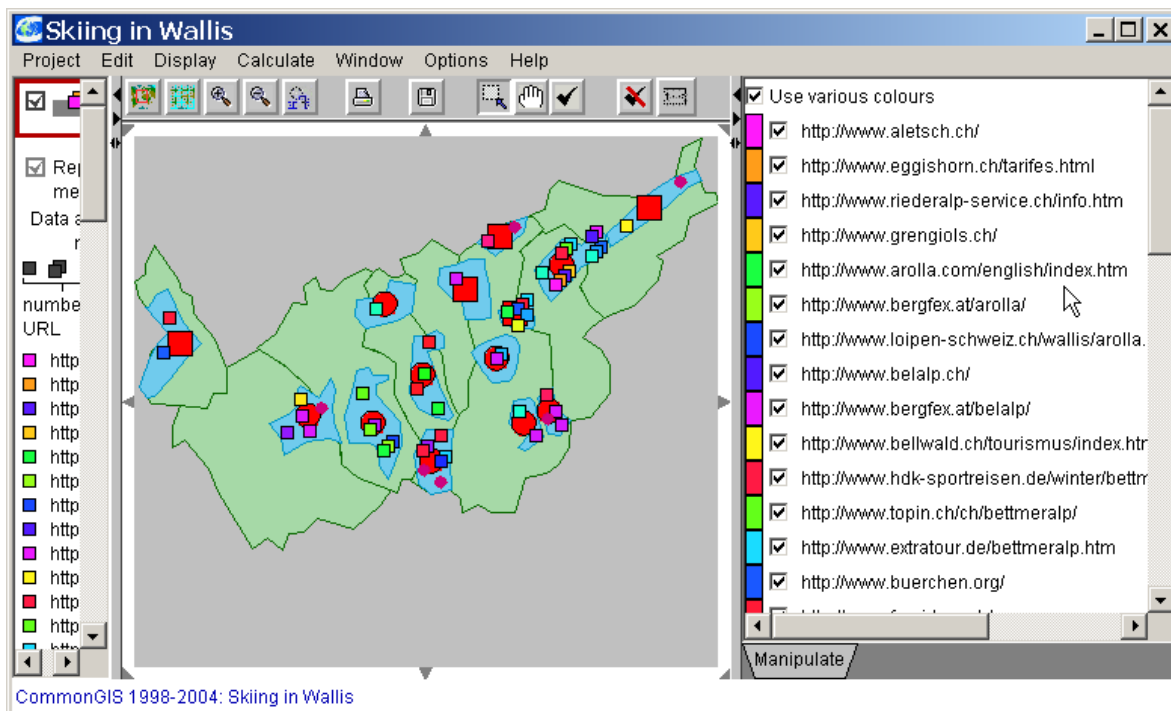


Fig. 4.2.31: Stacks to show URLs of Skiing resorts.

You can change the minimum height and width of the squares by clicking on the explanation of the squares in the legend. The color of the individual squares can be adjusted by clicking on the small colored boxes in the "Manipulate" window and selecting the desired color in the appearing color slide. By clicking on the option "use various colors" the color can be completely switched off and only small black boxes remain on the map.

Perspective View

Display: Perspective view

show layer objects in three-dimensional space based on values of the selected attribute.

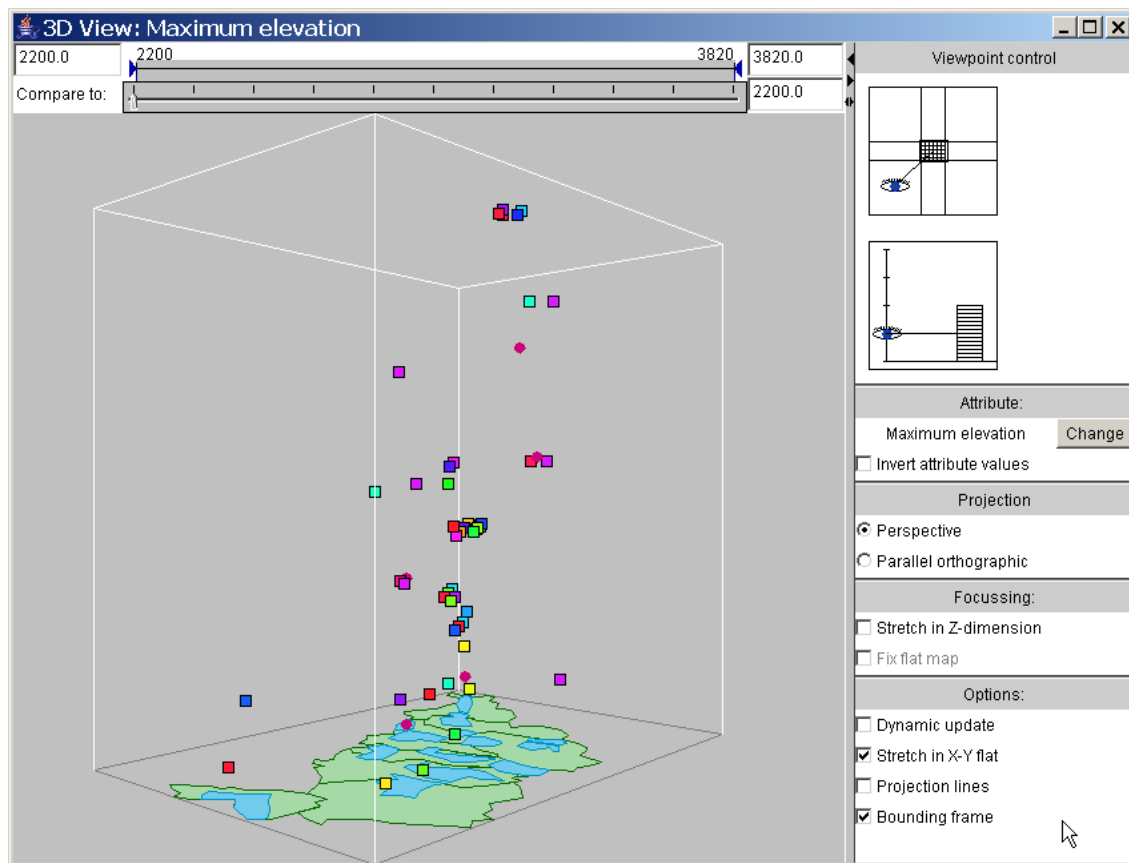


Fig. 4.2.32 Three-dimensional view of attribute *Maximum elevation* (Wallis:Skiing resorts)

Searching for objects on maps

The menu option *Display: View objects* first asks for selecting a layer or table and then produces a separate window named "Query and search tools" which contains the objects of a layer with their names and identifiers. This option supports the user with searching for an object on the map whose name or identifier is known to him. The user can select the wanted object in the list via name, and its location on the map is highlighted (see fig. 4.2.33).

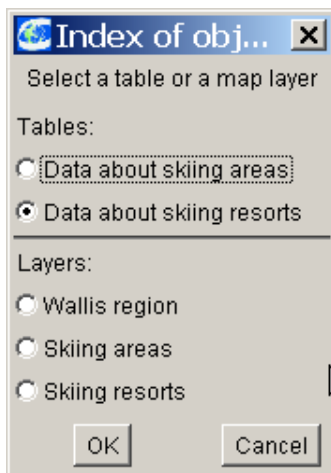


Fig. 4.2.33 Dialogue to select object list

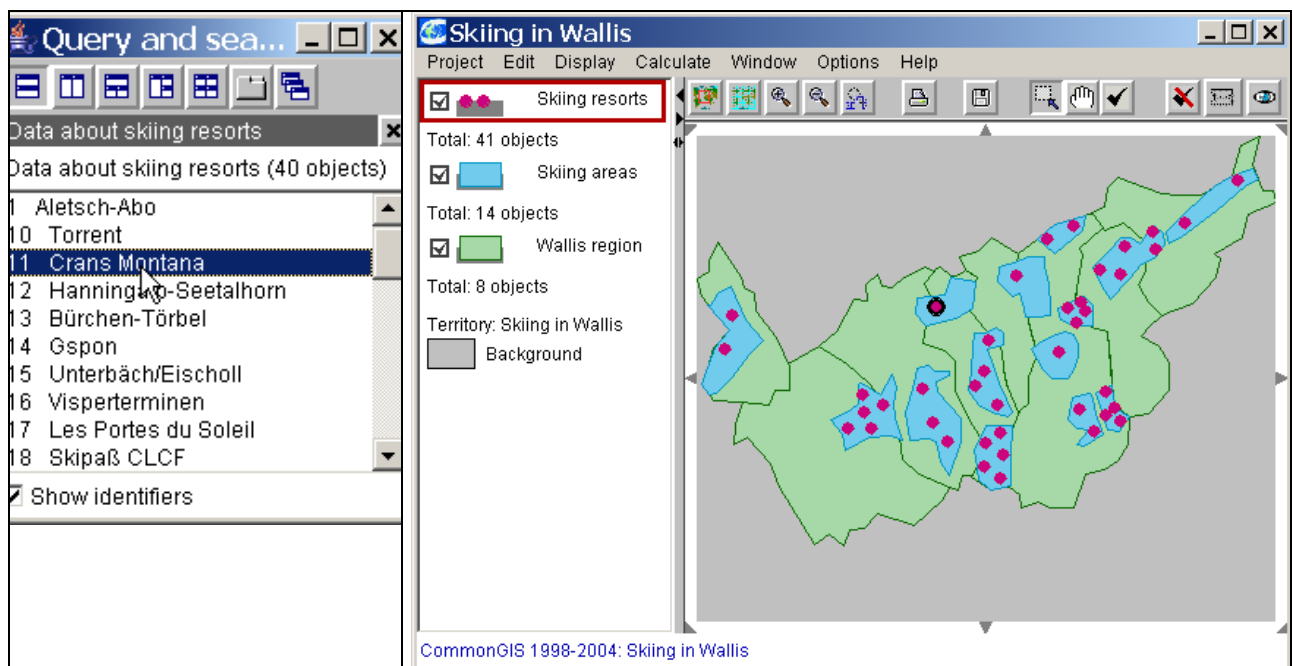


Fig. 4.2.34 Query and search tools

Presenting temporal data in maps

Time series contain attributes whose values were assigned to different points in time. We use project "wetter.app" in folder "data/wetter" as an example of the analysis of a time sequence. This project consists of data and maps about temperature changes in Germany. Within CommonGIS you can get a visual impression of those changes over years.

If you open the project (*Project: Open* – Browse: data/wetter/wetter.app), you see the basic project map (fig. 4.2.35): the outlines of Germany (layer "Germany") are supplemented by representations of the meteorological stations (layer "Freie Stationen").

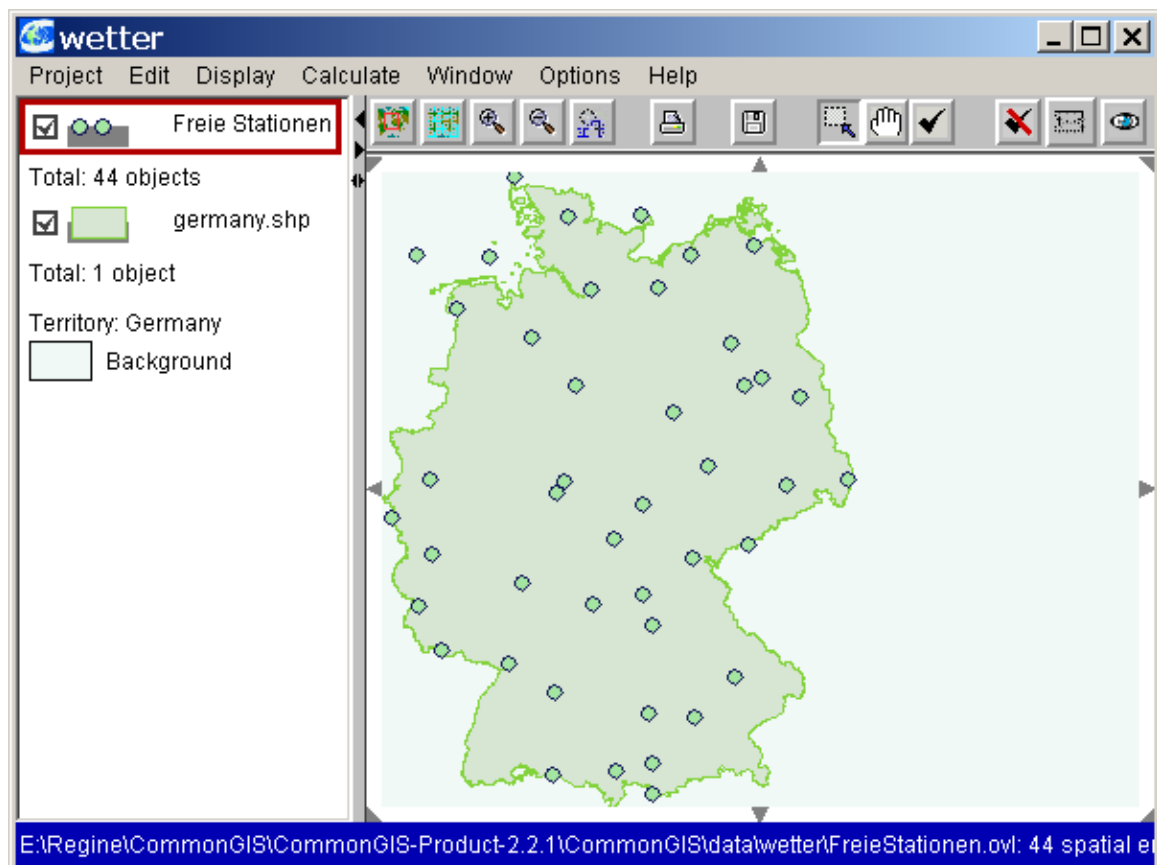


Fig. 4.2.35: Basic project map for „data/wetter/wetter.app“

In order to analyse lowest nocturnal temperatures in Germany from 1-1991 to 5-2003 select

- *Display: Display wizard...*,
- Choose table 3) *Wetter (Freie Stationen)*,
- Select attribute *TNN*,
- Mark option *Animated Map* from the list of special time-series visualisation methods
- And list entry „Classified choropleth map“ as display method.

The resulting map in fig. 4.2.36 is now classified. It also appears an additional window „Time controls“ to control time animation (see. fig. 4.2.37).

On the main map you see the 44 meteorological stations which are classified according to the attribute values in month 1-1991. The legend shows the classification statistics - as usual, and in subwindow „Manipulate“ you can adjust further parameters.

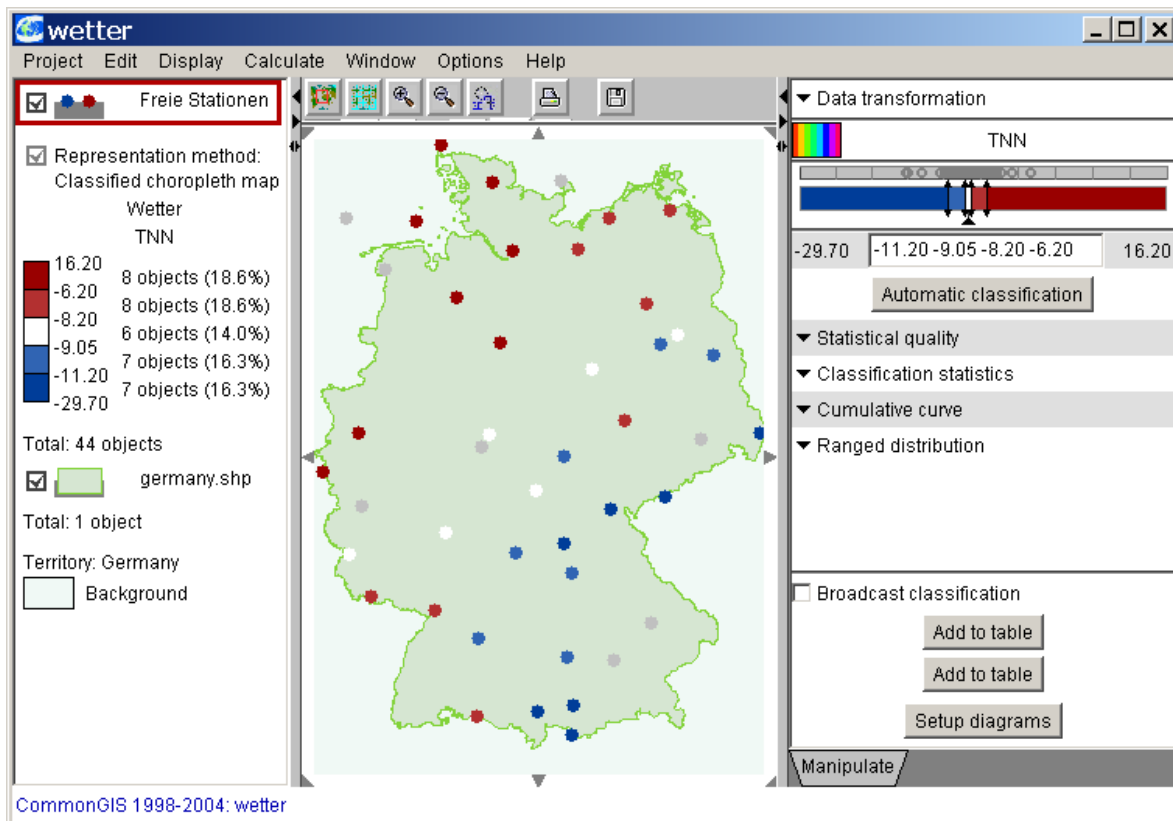


Fig. 4.2.36 Classification of lowest temperatures.

The window "Time controls" supports you to reveal interesting time changes from your data. You can look up the point in time currently displayed on the map and set a specific time to be displayed. This is done by shifting the bar in the time scale with the mouse or directly typing a value into the input window below the bar. You can also animate the time series, so that the map continuously displays the data of the next point in time. The icons below the time scale serve to control the animation process.

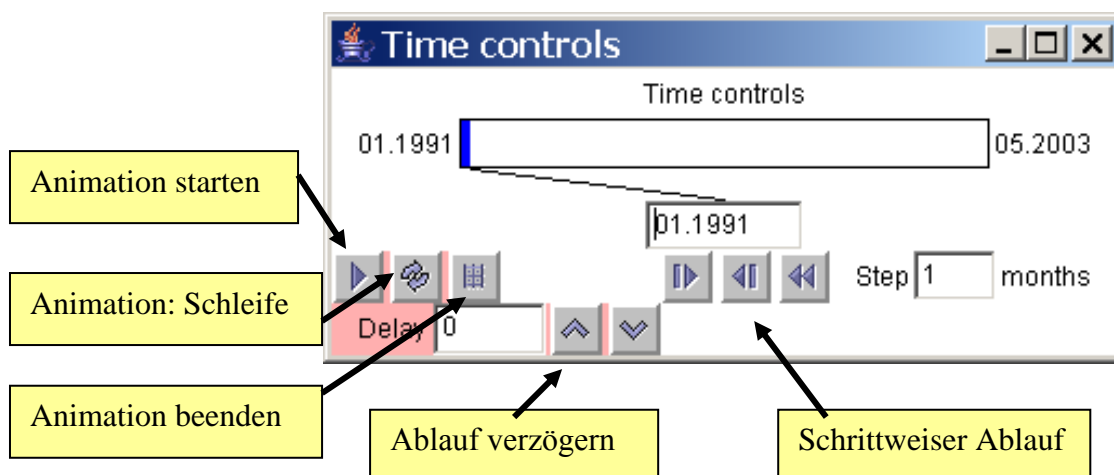


Fig. 4.2.37 Window „Time controls“ to support animation.

Since the five automatically computed classes of attribute values are not suitable for the intended analysis, the classification is adapted by dragging the pointers in the classification scale in the manipulation window. The color blue is to stand for lowest temperatures below 0° Celsius, white should be used for temperatures around 0° Celsius and red should symbolize temperatures above 0° Celsius (see fig. 4.2.38).

In order to examine the nocturnal lowest temperatures of May 2002 until May 2003 for striking outliers, the user adjusts 5-2002 as starting point in the time control window and activates the animation. If animation runs too fast, you can slow it down by increasing the value in field "Delay". Outstanding months are illustrated in fig. 4. 2.39.

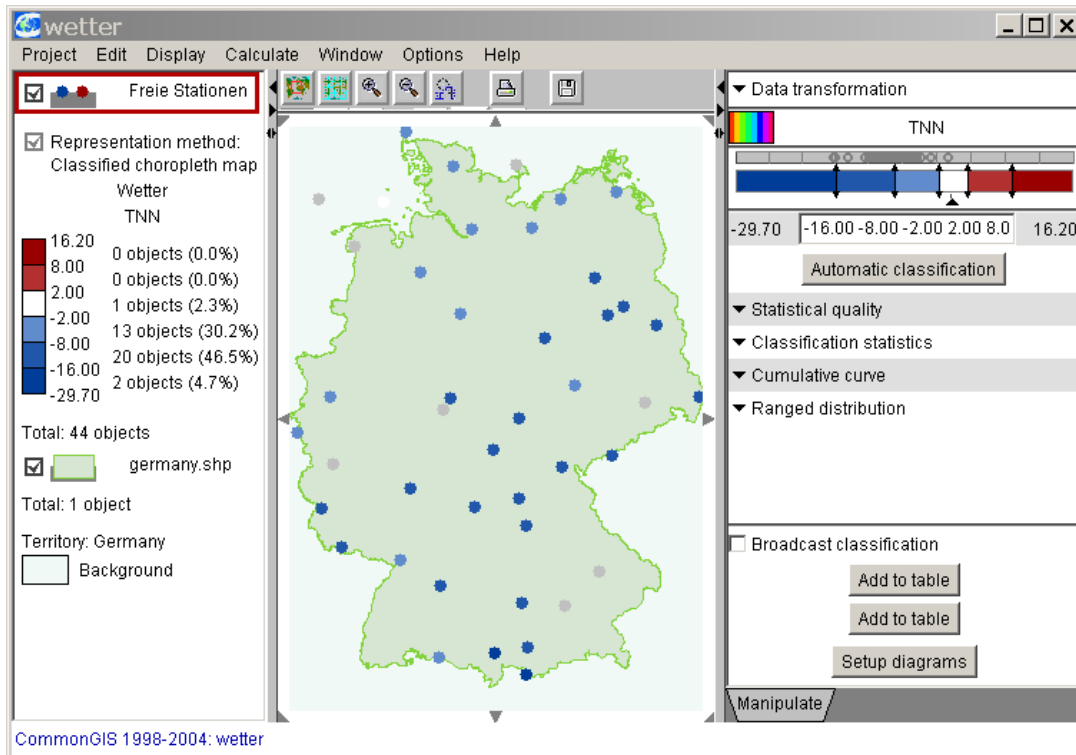
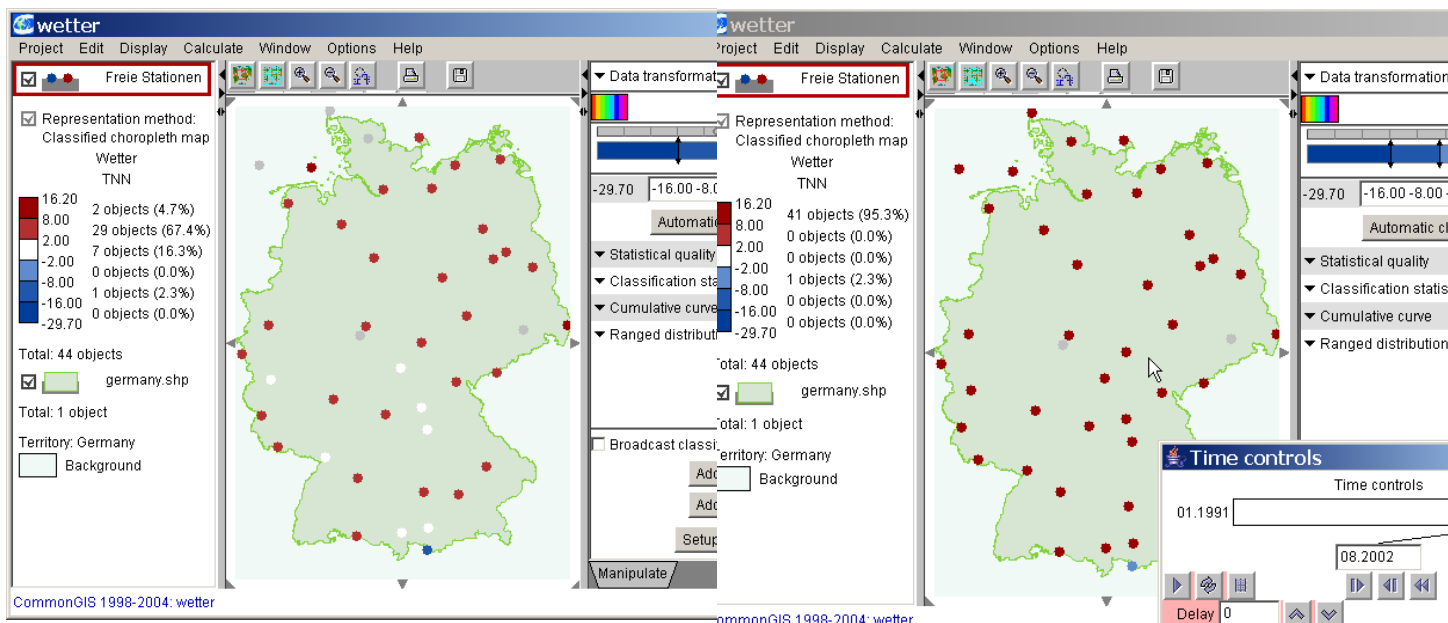
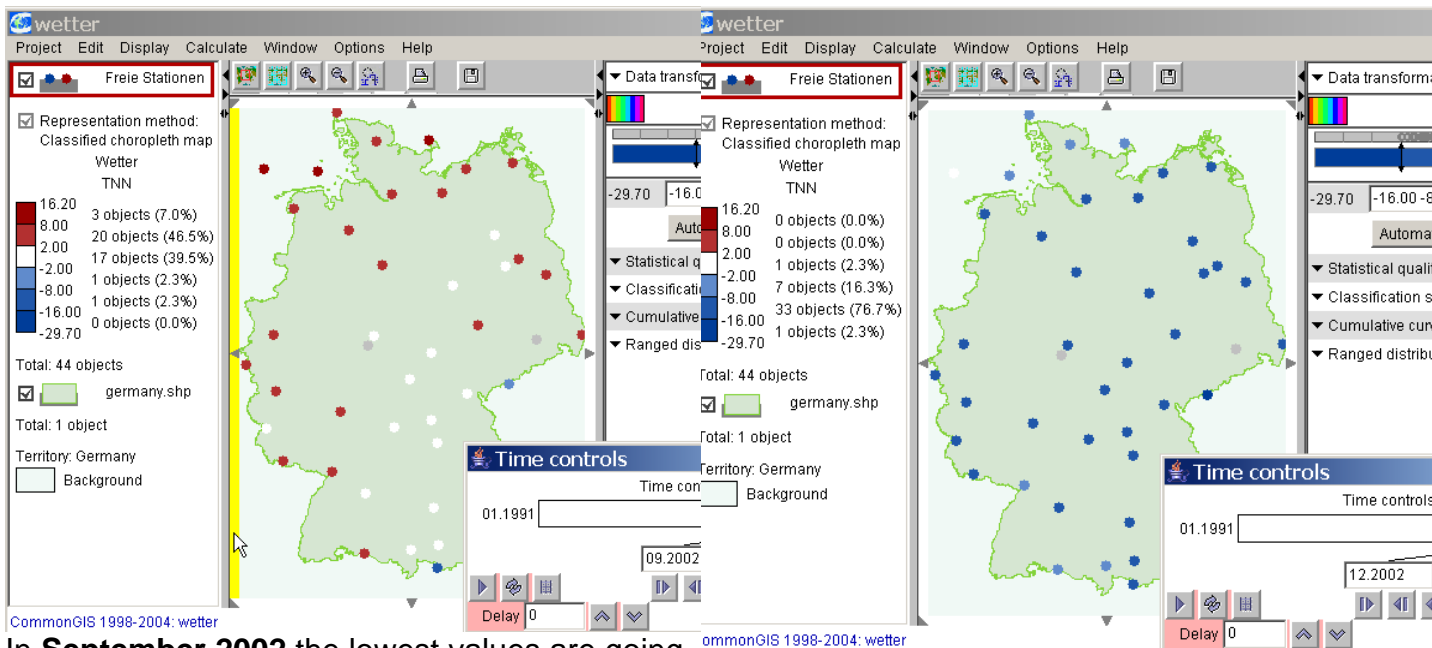


Fig. 4.2.38 Classification of attribute TNN adjusted to 0° Celsius as reference value.



Starting point of the analysis:
Mai 2002 – Germany shows nocturnal temperatures around and above the freezing point with one exception.

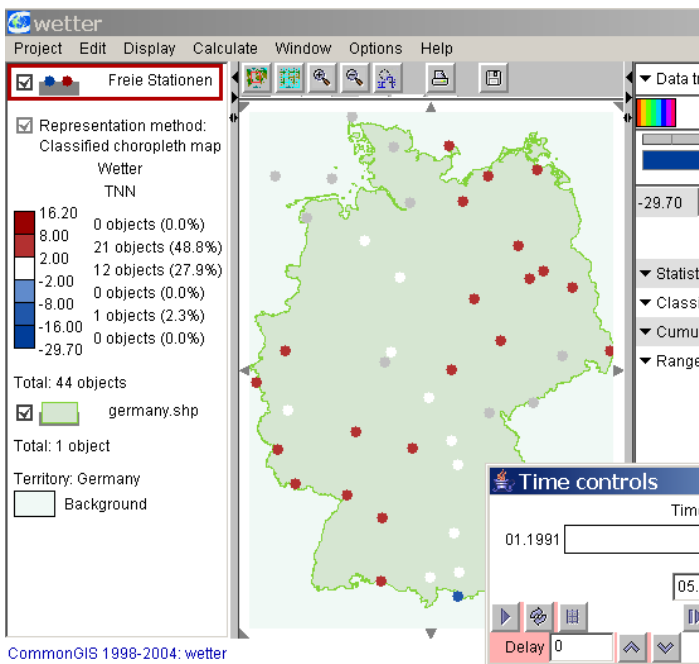
In **August 2002** Germany is covered by a heat wave: there are no temperatures below 8° degrees Celsius at night.



In **September 2002** the lowest values are going down to the freezing point.

From **November 2002 until January 2003** a cold wave from the east spreads over Germany

...



May 2003 brings warm air masses with cloud coverage. The lowest temperatures rise above the freezing point, but still remain below the values of the previous year.

Fig. 4.2.39 Time series with interesting months.

Defining of temporal attributes from source data (see also section 5, FAQ):

In order to evaluate the meteorological data with its time references in CommonGIS, you must either insert special instructions into the "app." file (see below) or perform the definitions within CommonGIS.

In order to specify time references first import the meteorological data as "ASCII file" in CommonGIS.

- Select *Project:Data import*,
- Choose format *ASCII file* and
- Enter further information as in fig. 4.2.40.

The table produced for "Wetterdaten.csv" in fig. 4.2.41 lists the attributes for each measuring point per month (e.g. TNN – nocturnal lowest temperatures, TNM –nocturnal Maximum).

Reading data from ASCII format

Data sample:

```
STAT;JJJMMM;QN;TNN;TNM;TMM;TXM;TX;SOS;NMM;RSS;RSX;FMM;FX;Jahr;Monat
10004;200304;1;;;7.2;;13.6;;;;;21.5;2003;04
10004;200303;1;;;5.6;;9.4;;;;;18.9;2003;03
10004;200302;1;;;2.6;;6.6;77.2;;;;;19.6;2003;02
10004;200301;1;;;4.2;;8.6;;;;;23.8;2003;01
```

Value separator: ;

☐ Take field types from the line N

☒ Take field names from the line N

Identifiers are in field 1

Names of entities are in field

☐ Coordinates of entities are in fields X: X Y: Y

Projection of coordinate system

OK Cancel

Fig. 4.2.40 Loading of meteorological data from ASCII-file „Wetterdaten.csv“.

Table view: Wetterdaten.csv

	JJJJMM	QN	TNN	TNM	TMM	TXM	TXX	SOS	NMM	RSS	RSX	FMM	FXX	Jahr	Monat
10004	200304	1			7.2		13.6						21.5	2003	04
10004	200303	1			5.6		9.4						18.9	2003	03
10004	200302	1			2.6		6.6	77.2					19.6	2003	02
10004	200301	1			4.2		8.6						23.8	2003	01
10004	200212	1	-1.7	2.9	4.5	5.7	9	36.6					22.4	2002	12
10004	200211	1			9.4		12.9						25.9	2002	11
10004	200210	1			11.5		17.5						34.1	2002	10
10004	200209	1	12.7	15.7	17	18	21.3	166.2					24.1	2002	09
10004	200208	1	16.2	18.3	19.3	20.4	22.4	223.2				3.4	18.1	2002	08
10004	200207	1					24.9						12.9	2002	07
10004	200206	1					20.3						21.2	2002	06
10004	200205	1			11.2		15.3	225.4					16.7	2002	05
10004	200204	1			7.8		11.4	150.4					20.6	2002	04
10004	200203	1	2.5	5.2	6.4	7.5	10.1	152.3					25.6	2002	03
10004	200202	1	1.6	5.4	7	8.3	10.5	96.9					38.2	2002	02
10004	200201	1			5.9		9.4						24.2	2002	01
10004	200112	1			6.5		11.7	56.9					29.3	2001	12
10004	200111	1	3.6	8.2	10.1	11.3	13.9	42.5					28.3	2001	11
10004	200110	1			14.8		17.1						26.3	2001	10
10004	200109	1			14.8		18.1	85.5					25.5	2001	09
10004	200108	1	14.1	16.5	17.9	19.3	23.1	212.5				4.3	32.3	2001	08
10004	200107	1	12.8	15.9	17.1	18.3	22.1	269.7					25.2	2001	07

Sort by: No selection Ascending ☐ TableLens ☐ just selected items ☐ Attribute info Attribute...

Fig. 4.2.41 Table with meteorological data.

Finally call

- *Edit: Index a parameter-dependent table*

and perform the following three dialogue steps represented in figures 4.1.42 and 4.1.43.

Step1: Select attribute JJJJMM indicating year and month and click on button “Select”.

Step1, continue: Specify the time moments and their meaning.

Time references in columns

Table indexing; stage 1 of 3

Finding and extracting time references specified in one or more columns

Task Explanations Examples

Does the table contain one or more columns that specify the time moments the data in rows are based on?

Columns	Values
JJJJMM	
QN	
TNN	
TNM	
TMM	
TXM	
TXX	
SOS	

Select Show values ☐ Sort alphabetically

Time references are in columns:

Column name: Format: Meaning or template:

No columns have been selected yet

Resulting column or parameter name:

☒ This is a parameter ☐ Keep old

OK

Time references in columns

Table indexing; stage 1 of 3

Finding and extracting time references specified in one or more columns

Task Explanations Examples

Does the table contain one or more columns that specify the time moments the data in rows are based on?

Columns	Values
JJJJMM	
QN	
TNN	
TNM	
TMM	
TXM	
TXX	
SOS	
NMM	
RSS	
RSX	
FMM	
FXX	

Select Show values ☐ Sort alphabetically

Time references are in columns:

Column name: Format: Meaning or template:

JJJJMM Compound value YYYYMM

Resulting column or parameter name: monthly temp

☒ This is a parameter ☐ Keep old

Template for displaying resulting dates/times: MM.YYYY

OK

Fig. 4.2.42 Indexing of a table with time references, step 1.

Step 2: Since there are no non-temporal references, step2 is closed by clicking the "Cancel" button.

Step 3: The attributes including the same time references as before separately can be excluded from indexing.

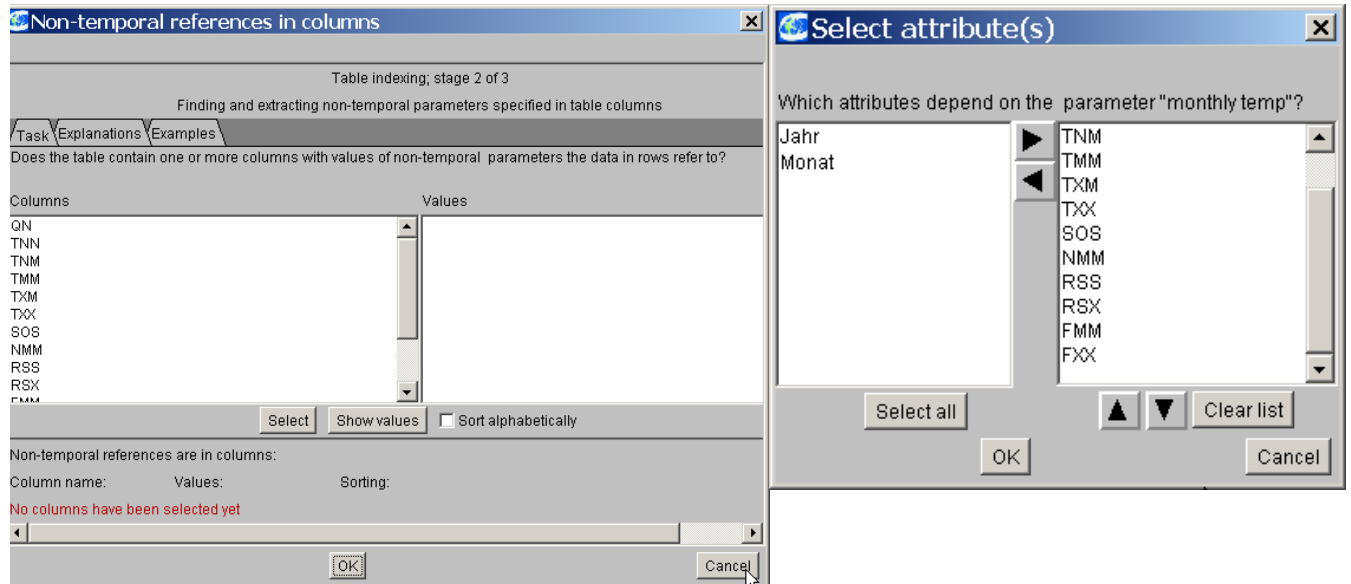


Fig. 4.2.43 Indexing of a table with time references, Step 2 and 3.

You can check the result of indexing by listing the new attributes in table "Wetterdaten.csv" with menu option *Display: View table*. Notice the symbol "(T)" in front of attribute names when selecting attributes, it shows that CommonGIS recognizes the attributes as time-dependent attributes. Now pick out the interesting monthly values for the selected parameters and look at the list with attributes for the selected months (see fig. 4.2.44).

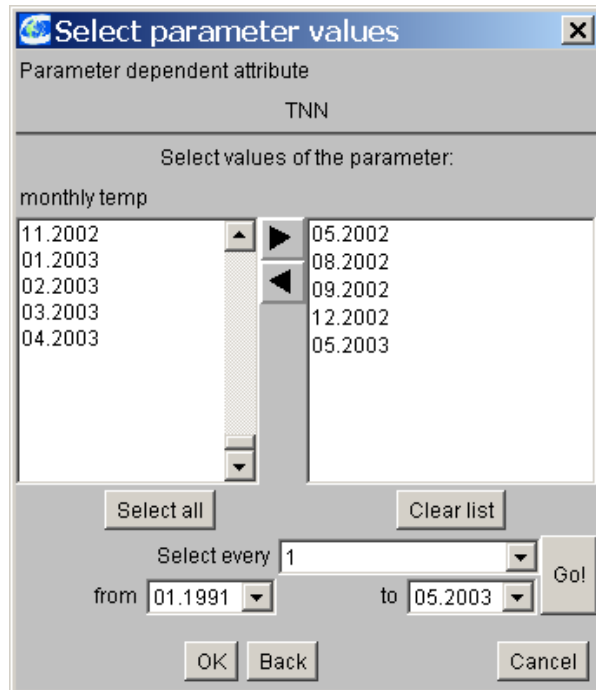
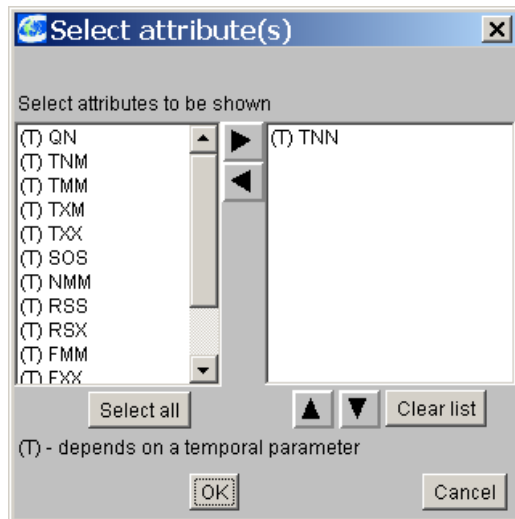


Table view: Wetterdaten.csv

	TNN; monthly temp=05.2002	TNN; monthly temp=08.2002	TNN; monthly temp=09.2002	TNN; monthly temp=12.2002	TNN; monthly temp=05.2003
10004		16.2	12.7	-1.7	
10015	8	16.2	10.5	-4.5	
10020		15.7	7	-6.9	
10035		11.8	4.7	-7.3	
10055	7.5	15.6	8.8	-6.2	4.5
10147	4.7	11.6	3.3	-10.8	
10162	6	13	4.4	-10.4	2.4
10170	6.8	16.1	6.7	-9.8	4.6
10184	6.3	14.1	3.7	-12	3
10200	3.1	11.2	4.7	-9.8	
10224	3.2	12.2	5.4	-10.4	0.4
10270	5.4	11.9	1.5	-10.8	2.2
10338	5.3	12.4	3.4	-11.1	1.1
10361	7.2	12.5	1.3	-14.4	3.3
10379	6.8	14.1	1.6	-12.1	4.4
10384	6.3	13.8	2.3	-12.3	3.7
10393	7.8	14.3	3	-12.7	3.8
10400	4.6	10.9	3.4	-10.7	2.7
10438	3.1	11.5	0.9	-11.3	1.9
10685	3.7	9.4	1	-12.3	
10708	3.8	10.6	3.5	-8.3	2.6

Sort by: No Ascending ☐ TableLens ☐ just selected items ☐ Attribute info

Fig. 4.2.44 Indexed table showing data for interesting months.

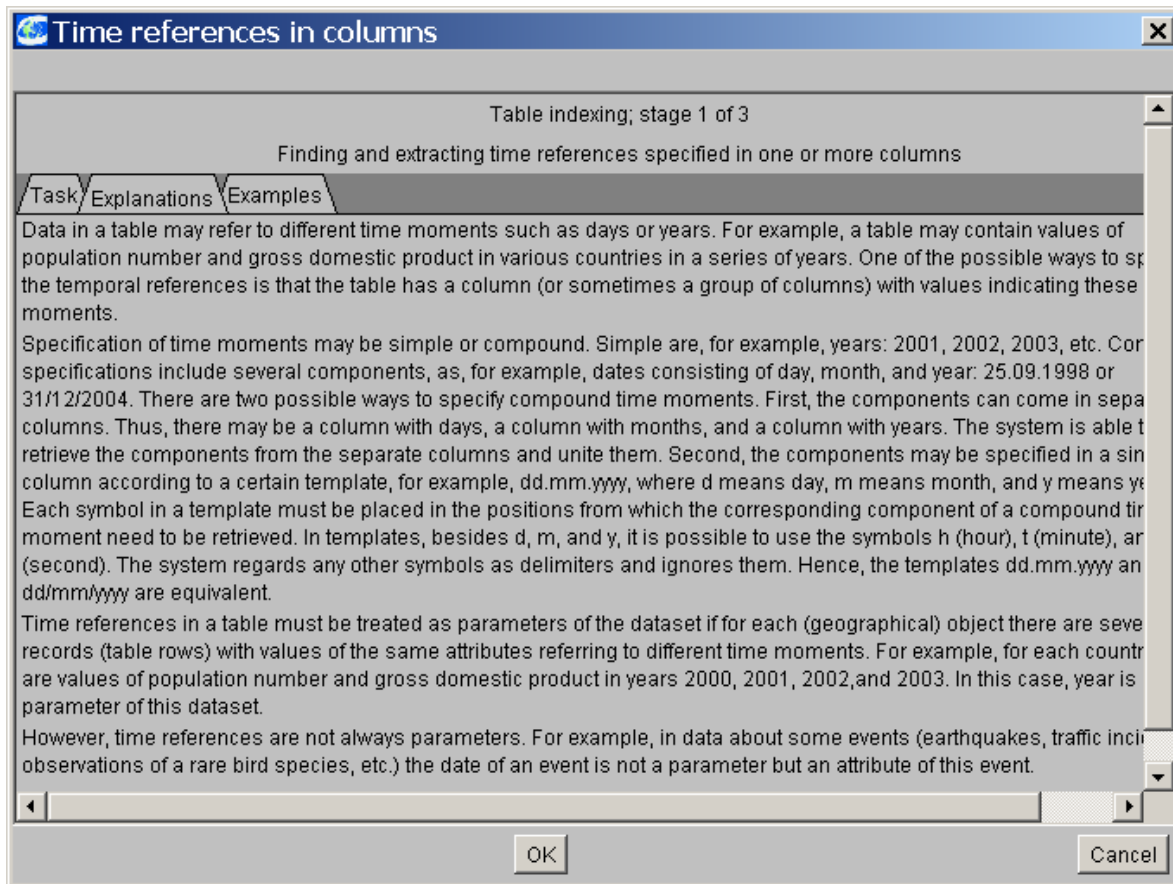


Fig. 4.2.45 Table indexing.

The definitions made are transformed in the following instructions into the "app." file:

```
TABLEDATA "Wetterdaten.csv" "Wetterdaten.csv"
IDENTIFIER "Wetterdaten.csv"
FORMAT "CSV"
DELIMITER ";"
FIELD_NAMES_IN_ROW 1
ID_FIELD 1
<TimeReference>
meaning="OCCURRED_AT"
"JJJJMM"="yyyymm"
attr_name="monthly temp"
attr_scheme="mm.yyyy"
is_parameter=yes
dependent_columns="QN";"TNN";"TNM";"TMM";"TXM";"TXX";"SOS";"NMM";"RSS";"RSX";"FMM";"FXX"
</TimeReference>
LAYER_REF "FreieStationen.ovl"
```

Presenting spatial data in charts

In order to explore data, it is often necessary to compare attribute values of selected objects or to relate several attributes with its entire range of values to each other. Such tasks occur if the regarded attributes are comparable, i.e. if they are measured within the same units and are related in contents. CommonGIS offers a broad variety of graphical analysis tools to support the user in visualising and relating attributes.

In the following we use again project "pt.app" as example which is stored in file "data/pt" and contains data and maps on demographic, seismographic, hydrographic and geographical conditions of Portugal.

- Open the project „pt.app“ (*Project: Open – Browse: data/pt.app*):
Take a look at the basic map of the project (fig. 4.2.2): you see the regional map of Portugal (layer „Scanned map“) overlaid by a representation of the administrative districts (layer „Administrative division“); on top there are the provinces with their borders (layer „Provinces“). The other available layers (Nature reserve areas, seismic and hydrographic zones) are not displayed in this view.
- Now select menu *Display* with option *Display wizard...*:
You will be asked to select a table from the list of available tables. Visualization will be based on the data from this table. The name of the table is followed by the layer to which the table refers (name in parentheses).
- Click on table „1)“ and then on the „OK“ button.
Now the attributes for visualisation must be selected („Select attributes“ dialogue).


Whenever you have to select attributes for visualisation and calculation methods this happens in a separate window (see fig. 4.2.3).

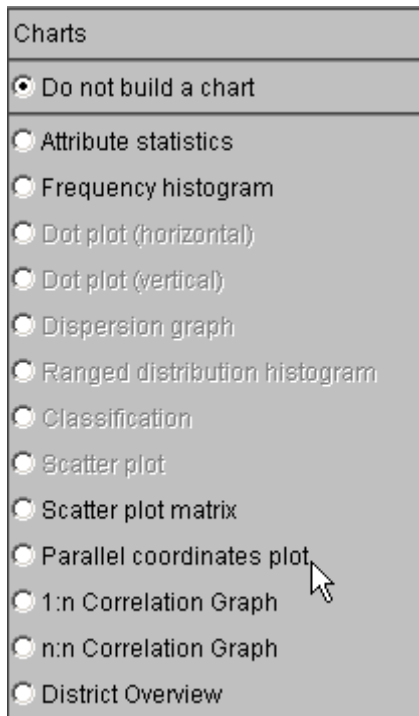
- Select the attributes *total_pop_1981*, *total_pop_1991*, *%_of_Pop_by_age_0-14*, *%_of_Pop_by_age>=65*

Depending on the number and type of attribute(s) selected a different set of chart types is offered by the Display wizard for selection in the right column.

If you select objects in a diagram (by clicking), these objects are simultaneously highlighted in all displayed maps and charts. This only works for maps if the layer which is assigned to the table containing the object is marked as active. In our example the layer "Administrative division" should be selected as active in order to be able to use this advantage during the analysis.

All charts are displayed in window "Graphical analysis tools", what means if you intend to analyze different diagrams of the same attribute or the same diagram for different attributes, these diagrams are added to this window. Since the diagrams are dynamically linked as well, the selection of an object simultaneously highlights this object in all other representations, so that interesting objects can be examined from different perspectives.

Each subwindow can be separately closed (with icon  belonging to the subwindow) or changed in size within the container window (with the help of the small black triangles at the edge of the subwindow). If you close the window "Graphical analysis tools", all diagrams are closed. If you create another diagram, the container window will only contain this newly produced representation.



Attribut statistics give statistical characteristics for the selected attributes.

The **Frequency histogram** is a bar chart, showing how often similar attribute values occur.

A **Dot plot** displays how the attribute values are distributed on the range of values. A dot plot can be aligned **horizontally** or **vertically**.

A **Dispersion graph** is a vertical dot plot showing attribute values which are very close to each other which seem to be „stacked“.

A **Ranged distribution histogram** is a bar chart showing how qualitative objects are distributed.

Classification can be used to divide the range of values of an attribute into classes.

Within a **Scatter plot** the value distribution of two attributes is presented in a two-dimensional grid.

A **Scatter plot matrix** contains a scatter plot for each combination of any two of the selected attributes.

A **Parallel coordinates plot** shows objects as lines connecting the axes of the selected attributes within two-dimensional space.

Correlation Graphs display the correlation of quantitative attributes with their correlation coefficients (correlation of one attribute to others – 1:n; several attributes to each other – n:n).

The **District Overview** can be used to display attribute values, mean and median for a certain spatial object.

Attribute statistics

In addition to the presentation of spatial data in maps or tables (see sections with corresponding titles) the "Attribute statistics" tool provides a general survey of all values of an attribute by computing characteristic statistical variables.

- Mark list entry "Attribute statistics" in column "Charts".

As a result, fig. 4.2.46 shows the four attributes selected above with their characteristic quantities. The explanations of the characteristic values are given in the figure.

Below the statistical values you see another option enabling a comparison between different attributes by equalizing the range of values. If you click on the option

☐ **Common Min and Max**, the graphic scales left to the statistical variables are standardized, so that you can relate the range of values of the attributes to one another.

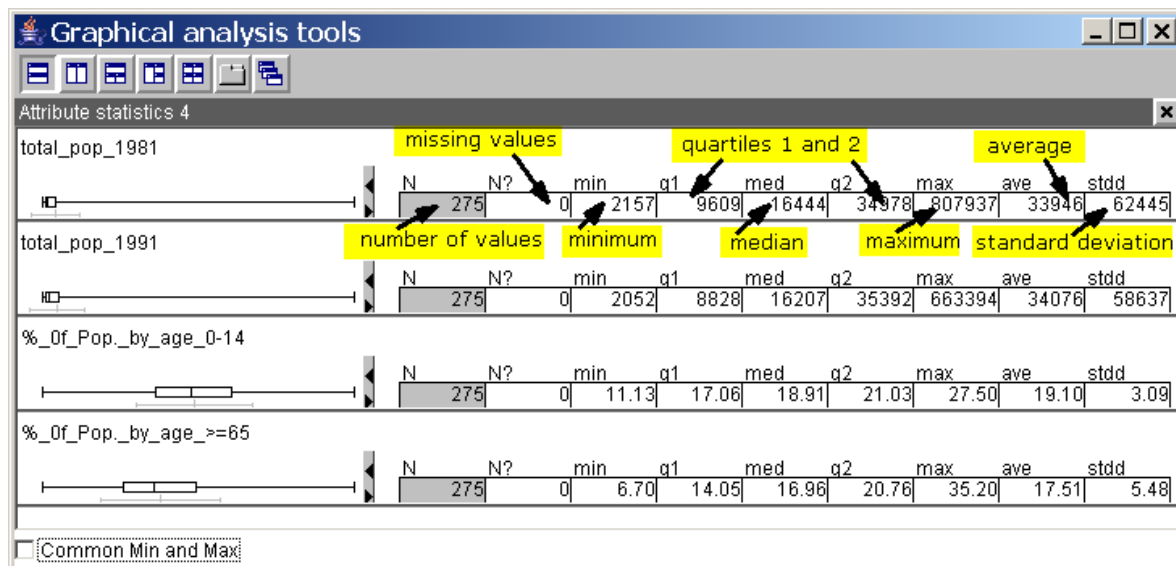


Fig. 4.2.46: Attribute statistics with statistical variables.

Frequency histogram

The **Frequency histogram** is a bar chart showing how often similar attribute values occur.

In order to create the frequency histogram for an attribute (e.g. `%_of_Pop_by_age>=65`), select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65`,
- mark list entry "Frequency histogram" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.47).

If you move the mouse on a bar in the histogram, the exact interval borders and the objects contained in it are listed. If you click on the bar, all objects included in the bar are highlighted on the map and the user can detect the location of the objects on the map. You have to make sure that the appropriate layer (here "Administrative division") is active (by clicking on its name in the legend). Again with this kind of diagram the user can hide interactively "outlier values" (see ch. 4,2).

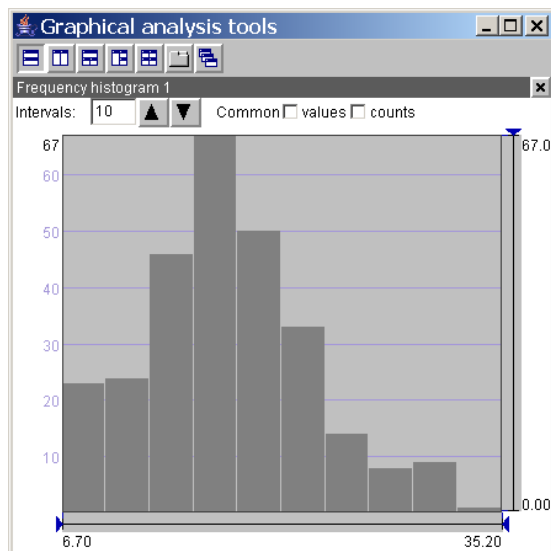


Fig. 4.2.47: Frequency histogram.

Dot plots

A **Dot plot** displays the attribute values within the range of values on a linear scale. A dot plot can be aligned horizontally or vertically.

In our example the attribute `%_of_Pop_by_age>=65` is visualized as a dot plot in order to get an impression of how the proportions of older inhabitants are distributed within the country.

Dot plot (horizontal)

If you want to see a horizontal dot plot for some attribute (e.g. `%_of_Pop_by_age>=65`), select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65`,
- mark list entry "Dot plot (horizontal)" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.48).

If you move the mouse to one of the dots in the diagram, the attribute values for this object/these objects are listed, so that you can also look at the absolute values. If you click on any dot in the dot plot, the object is highlighted on the map simultaneously giving feedback about the location of the associated object. You have to make sure that the appropriate layer (here "Administrative division") is active (by clicking on its name in the legend). Again with this kind of diagram the user can interactively hide "outlier values" (see ch. 4,2).

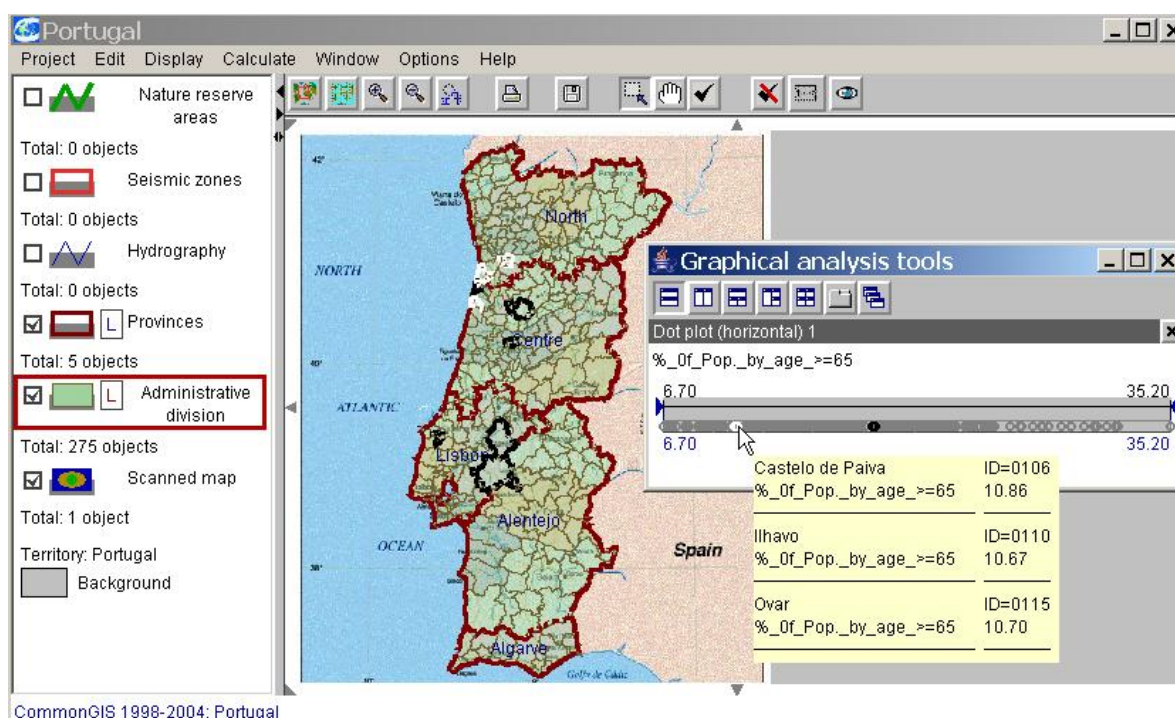


Fig. 4.2.48 Horizontal dot plot

Now if you want to discover all areas with a very high proportion of older population, you can increase the lower value interactively for examining the interesting range more closely. On selecting the remaining dots (by dragging) these are shown on the map, so you can check whether the older inhabitants live within certain areas of the country or whether there are districts everywhere in the country having a high portion of inhabitants older than 65 years.

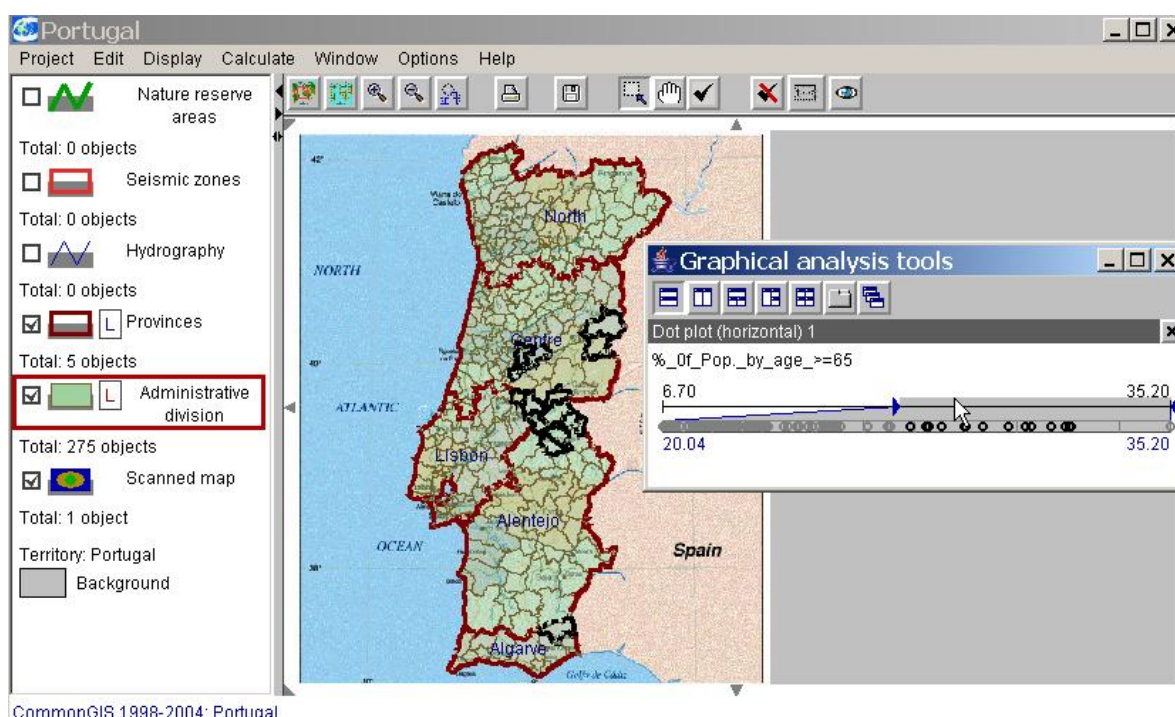


Fig. 4.2.49: Horizontal dot plot with a restricted range of values.

Dot plot (vertical)

You see the vertical dot plot for attribute `%_of_Pop_without-primary_school` in fig. 4.2.50. It is created similarly to the horizontal dot plot by selecting *Display: Display wizard... – Dot plot (vertical)*.

If you move the mouse to one of the dots in the diagram, the attribute values for this object/these objects are listed, so that you can also look at the absolute values. If you click on any dot in the dot plot, the object is highlighted on the map simultaneously giving feedback about the location of the associated object. The object is highlighted in other displayed diagrams as well. Again with this kind of diagram the user can interactively hide "outlier values" (see ch. 4,2).

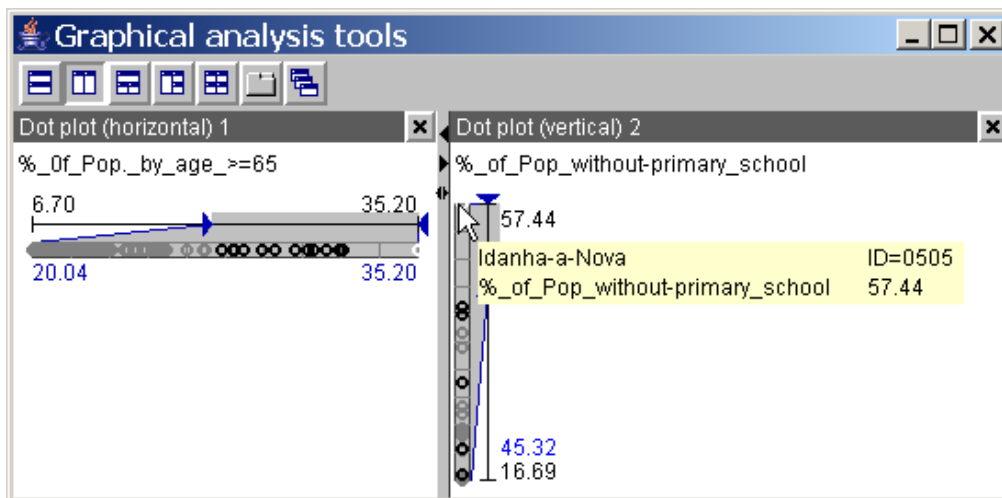


Fig. 4.2.50: Vertical dot plot

Now if you want to discover all areas with a very high proportion of older population, you can increase the lower value interactively in order to examine the interesting range more closely. By selecting the remaining dots on the map, the user can check whether the older inhabitants live within certain areas of the country or whether there are districts everywhere in the country having a high portion of inhabitants older than 65 years.

Dispersion graph

The dispersion graph is produced by selecting menu option *Display: Display wizard... – Dispersion graph*. This diagram type is a kind of extended vertical dot plot. The dispersion graph for attribute `%_of_Pop_by_age_>=65` is shown in fig. 4.2.51. Dots representing attribute values with only small deviations are drawn on top of each other in "stacks". This kind of diagram offers advantages to a linear representation if the attribute values are very close together. The stacked representation allows the user to differentiate between objects with equal attribute values and get an impression of the dispersion of values.

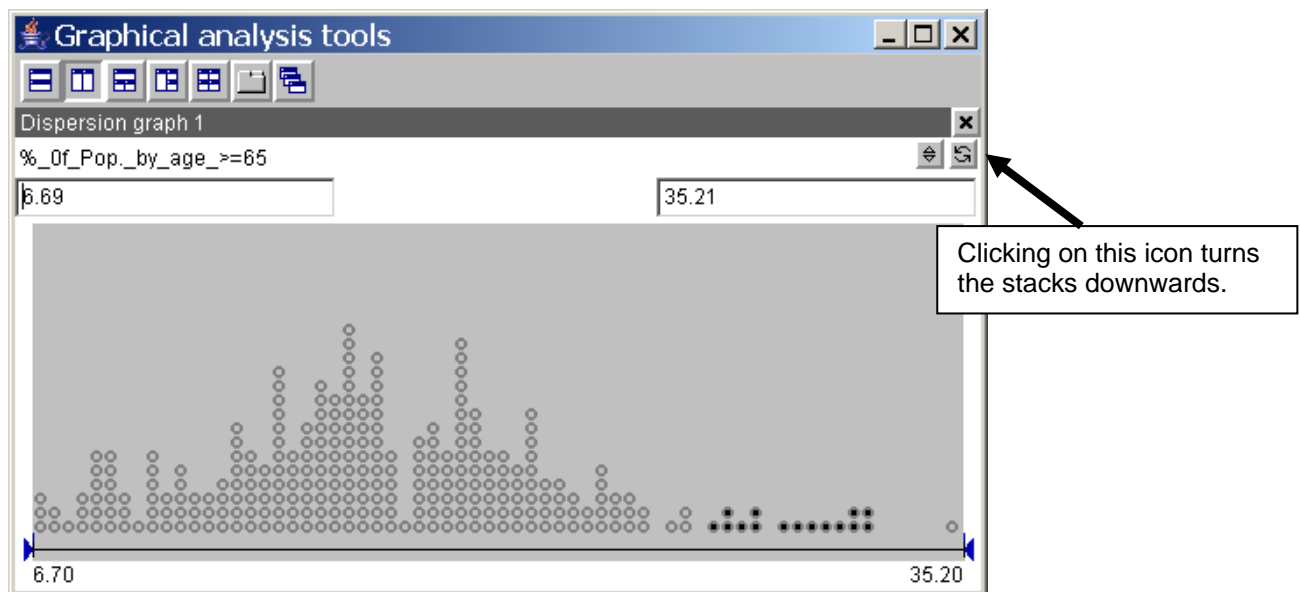


Fig. 4.2.51: Dispersion graph

If you move the mouse to one of the dots in the diagram, the attribute values for this object/these objects are listed, so that you can also look at the absolute values. If you click on any dot in the dispersion graph, the object is highlighted on the map simultaneously giving feedback about the location of the associated object. The object is highlighted in other displayed diagrams as well. Again with this kind of diagram the user can interactively hide "outlier values" (see ch. 4,2).

Ranged distribution histogram

A **Ranged distribution histogram** is a bar chart showing how qualitative objects are distributed.

If you want to see a ranged distribution histogram for attribute *Religion* in project "eu.app" (Project: Open – browse: data/eu.app), select

- Display: Display wizard...,
- Choose attribute *Religion* (only possible when the checkbox „include non-numeric attributes“ is marked while selecting attributes),
- mark list entry "Ranged distribution histogram" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.52).

If you move the mouse to one of the bars in the diagram, the value assigned to this bar and the objects contained in it are listed on the screen. If you click on the bar, all objects included in it are highlighted on the map simultaneously giving feedback about the location of the associated objects. You have to make sure that the appropriate layer is active. If you select objects on the map, they are highlighted in the displayed diagrams as well.

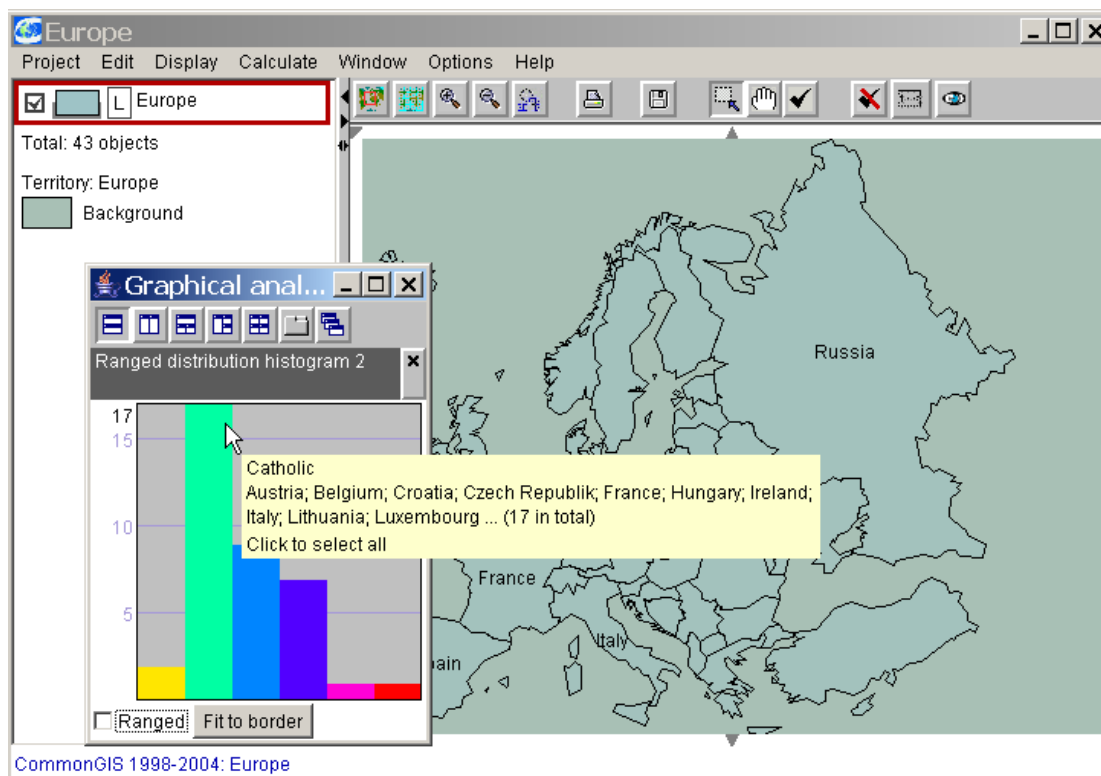


Fig. 4.2.52: Distribution of religion within Europe

Classification

You can classify the range of values of an attribute without indicating the classes in the map. All possibilities which are described with Classified choropleth maps (p. 47) are available then.

If you want to classify an attribute (e.g. `%_of_Pop_by_age>=65`), select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65`,
- mark list entry "Classification" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.53). There you see all the tools for analysing and changing of classifications known from subwindow "Manipulate" within the main CommonGIS window showing a "Classified choropleth map".

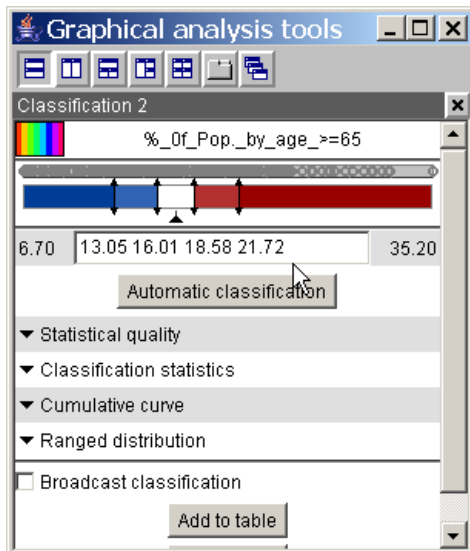


Fig. 4.2.53 Classification of an attribute.

Scatter plots

Scatter plots allow to evaluate dependencies between two attributes of a tables attribute set. They display the values of the two associated statistical series as points in a two-dimensional diagram.

Scatter plot

If you want to compare the distribution of the values of two attributes (e.g. `%_of_Pop_by_age>=65` and `%_of_Pop_without-primary_school`), select

- *Display: Display wizard...*,
- Choose the attribute `%_of_Pop_by_age>=65` and `%_of_Pop_without-primary_school`,
- mark list entry "Scatter plot" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.53).

In the produced scatter plot the values of both attributes are drawn as coordinates into a two-dimensional coordinate system. The regression graph is also computed and added to the diagram (red line). On the top right (likewise in red) the correlation coefficient is indicated (**C(X, Y)**).

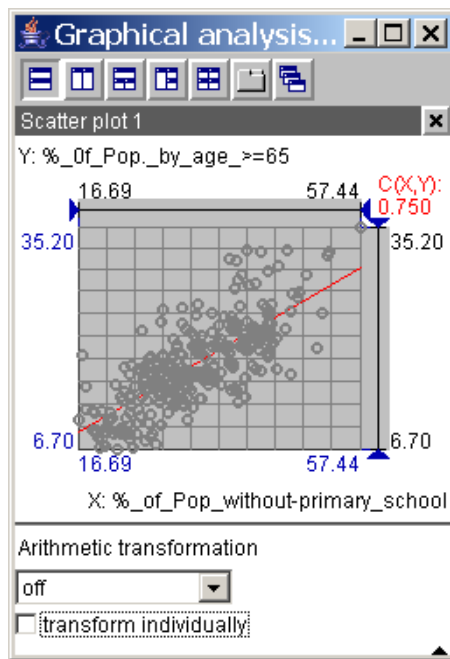


Fig. 4.2.54 Scatter plot

If you move the mouse to one of the dots in the diagram, the attribute values for this object/these objects are listed, so that you can also look at the absolute values. If you click on any dot in the scatter plot, the object is highlighted on the map simultaneously giving feedback about the location of the associated object. Again with this kind of diagram the user can interactively hide "outlier values" (see ch. 4,2); this can be done for each of the two dimensions.

Scatter plot matrix

If you want to correlate some attributes (e.g. the attributes concerning the age structure in relation to the attribute about education), select

- *Display: Display wizard...*,
- Choose the attributes *%_of_Pop_by_age_15-24*, *%_of_Pop_by_age_25-64*, *%_of_Pop_by_age_>=65* and *%_of_Pop_without-primary_school*,
- mark list entry "Scatter plot matrix" in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.54).

For each possible combination of attributes scatter plots are drawn (namely "young – middle-aged", "young – old", "middle-aged – old", "young – education", "middle-aged – education", "old – education"). The diagrams are all represented twice: the scatter plots on the lower left are similar in content to those on the upper right beside that the x- and y-axes are swapped. All diagrams can be manipulated individually (see scatter plot).

The three scatter plots in the right and lower part of the matrix show the correlation between the population without primary school and age.

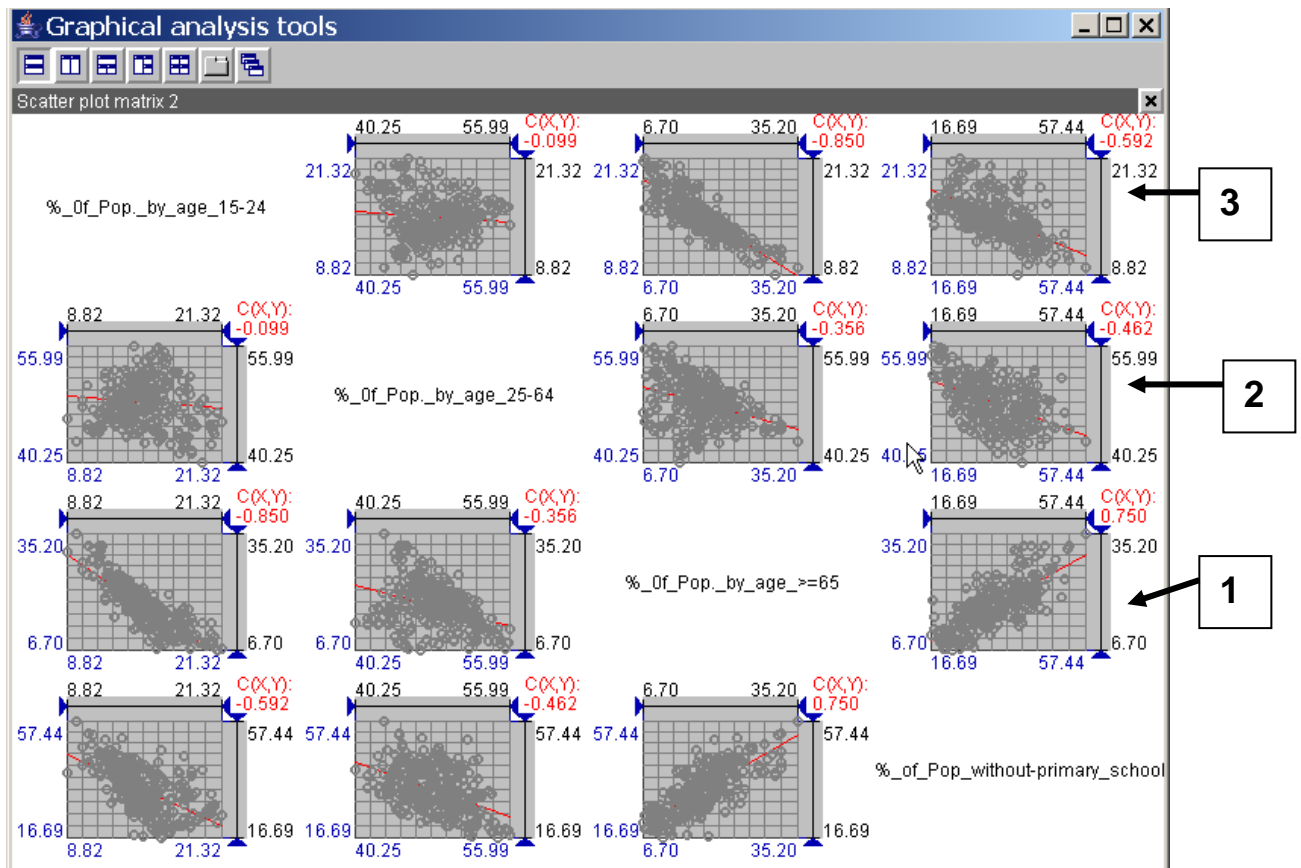


Fig. 4.2.54 Scatter plot matrix for age classes (15-24, 25-64 und >=65 years) and population without primary school.

A hypothesis could be that in there exists a high and positive correlation between a high proportion of people older than 65 and a high proportion of people without primary school. That means in turn that you can assume that most of the young population has a primary school education nowadays (data conditions 1991). The scatter plots from fig. 4.2.54 can help to support this hypothesis.

In diagram 1 the proportion of the population without primary school is small in those districts which have only few population older than 65 years; whereas in areas with a high percentage of older people there is also a high percentage of people without primary school education. The distribution runs near to the regression line, the correlation coefficient is positive and quite high. With the two other diagrams (2 and 3) showing the population younger than 65 years, the correlation coefficient is negative, what means that in areas with a high proportion of younger population the proportion of people without primary school education is small.

Parallel coordinates plot

An important activity in exploratory analysis is the investigation of relationships among attributes. It involves the comparison of value variation of different attributes and the seeking for correlation between attributes. A parallel coordinates plot can effectively support these tasks.

In a parallel coordinates plot the attribute values of all data records are registered on parallel axes which are assigned to the attributes selected. The lengths of the axes reflect the range of values of the appropriate attribute. The attribute values belonging to a data

record are connected by a horizontal line, so that each data record is characterized by a polygon. Thus you get a representation of multidimensional data in two-dimensional space.

If you want to create a parallel coordinates plot for selected attributes, select

- *Display: Display wizard...*,
- Choose the attributes *%_of_Pop_by_age_15-24*, *%_of_Pop_by_age_25-64*, *%_of_Pop_by_age_>=65* and *%_of_Pop_without-primary_school* from *Table 1*,
- mark list entry "Parallel coordinates plot " in column "Charts"

and look at the resulting diagram which is attached to the window "Graphical analysis tools" (see fig. 4.2.55).

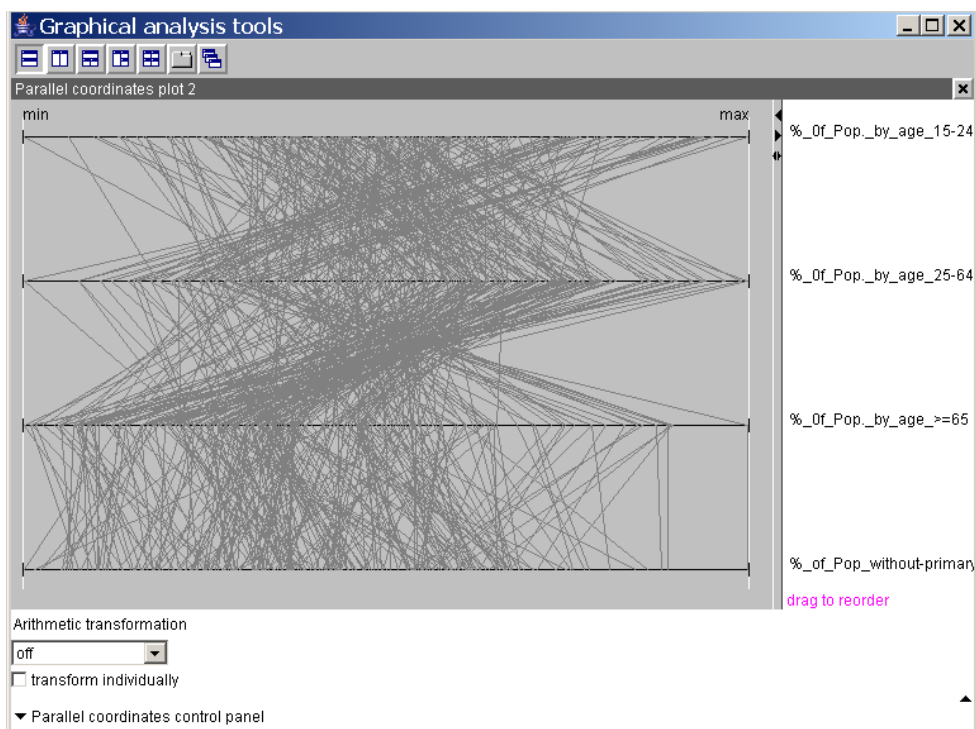


Fig. 4.2.55: Parallel coordinates plot for attributes with age and educational data.

If the lines between two or more neighboring axes are nearly parallel to each other, the corresponding attributes are positively correlated. If lines have either north-east to south-west or north-west to south-east orientation, the attributes are negatively correlated. In order to detect such pairs of correlated attributes the order of the attribute axes can be changed by dragging an attribute name to the desired location with the mouse.

By clicking on the small arrowhead in the bottom line the "parallel coordinates control panel" is opened, allowing the adjustment of the representation of parallel coordinates. The alignment of the graph – adjustable by selecting from the list in the control panel – affects the scale of the axes for the individual attributes (see Abb. 4.2.56).

In the standard form of parallel coordinates plot ("Individual Min and Max", as in fig. 4.2.55) the leftmost position of each axis (min) corresponds to the minimum value of the respective attribute and the rightmost (max) to the maximum value. Thus each axis is assigned an individual range of values.

In order to compare attributes with an equal range of values more easily (here all selected attributes are indicated in %), the axes can be aligned with respect to the common

minimum and maximum, so that equal positions on the axes represent also equal values (see Abb. 4.2.56). Now you recognize more clearly that the proportion of the people aged 15-64 forms the largest part of the population.

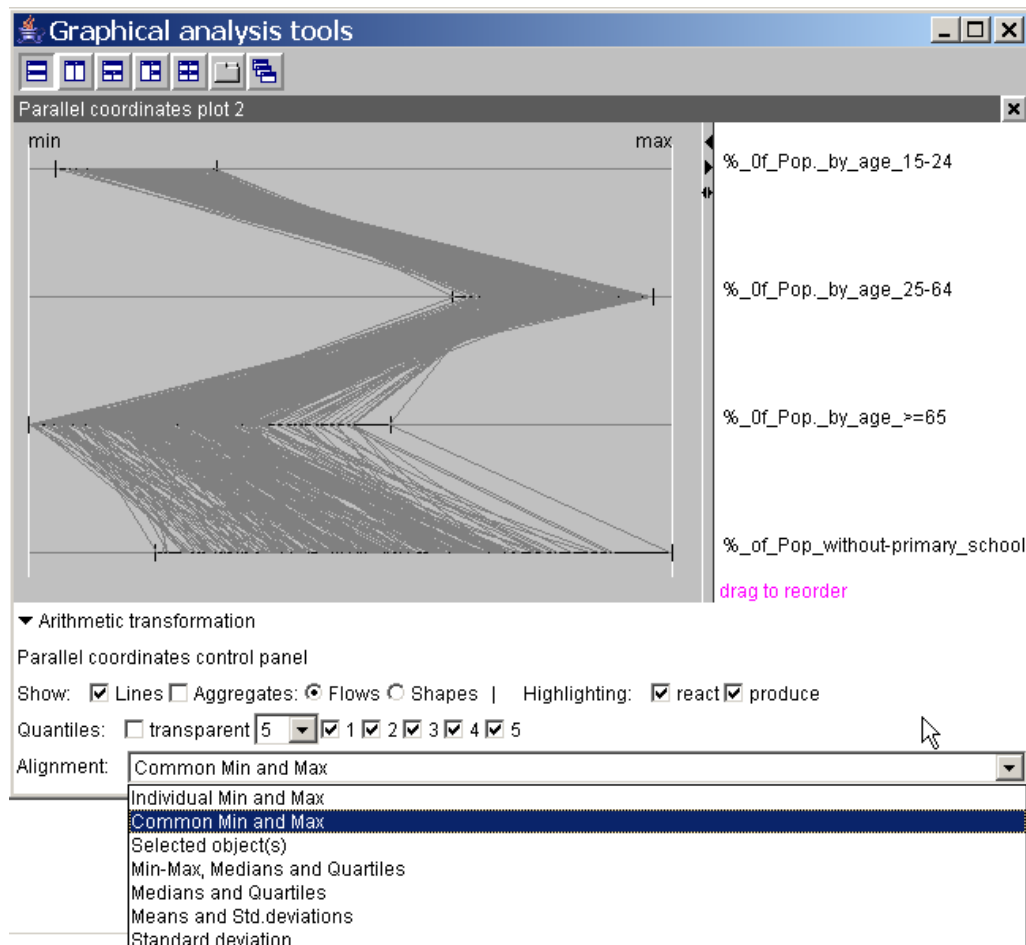


Fig. 4.2.56: Parallel coordinates plots with various alignment functions.

If you want to have a closer look at certain objects, select them by clicking in any diagram or map and then choose „selected object(s)“ as alignment.

Note: When the containing window of the diagram is too small and you try to select an object at a point where many lines meet, the attribute popup-list may hide the line in such a way that you are not able to select it anymore. In this case you should increase the window size to the entire screen, perform the selection and decrease it again.

Scaling the axes to alignment „Selected object(s)“ means that the lines representing the selected objects are centered and the axes are adjusted accordingly (fig. 4.2.57, upper right diagram). When more than two objects are selected CommonGIS calculates the average and uses that.

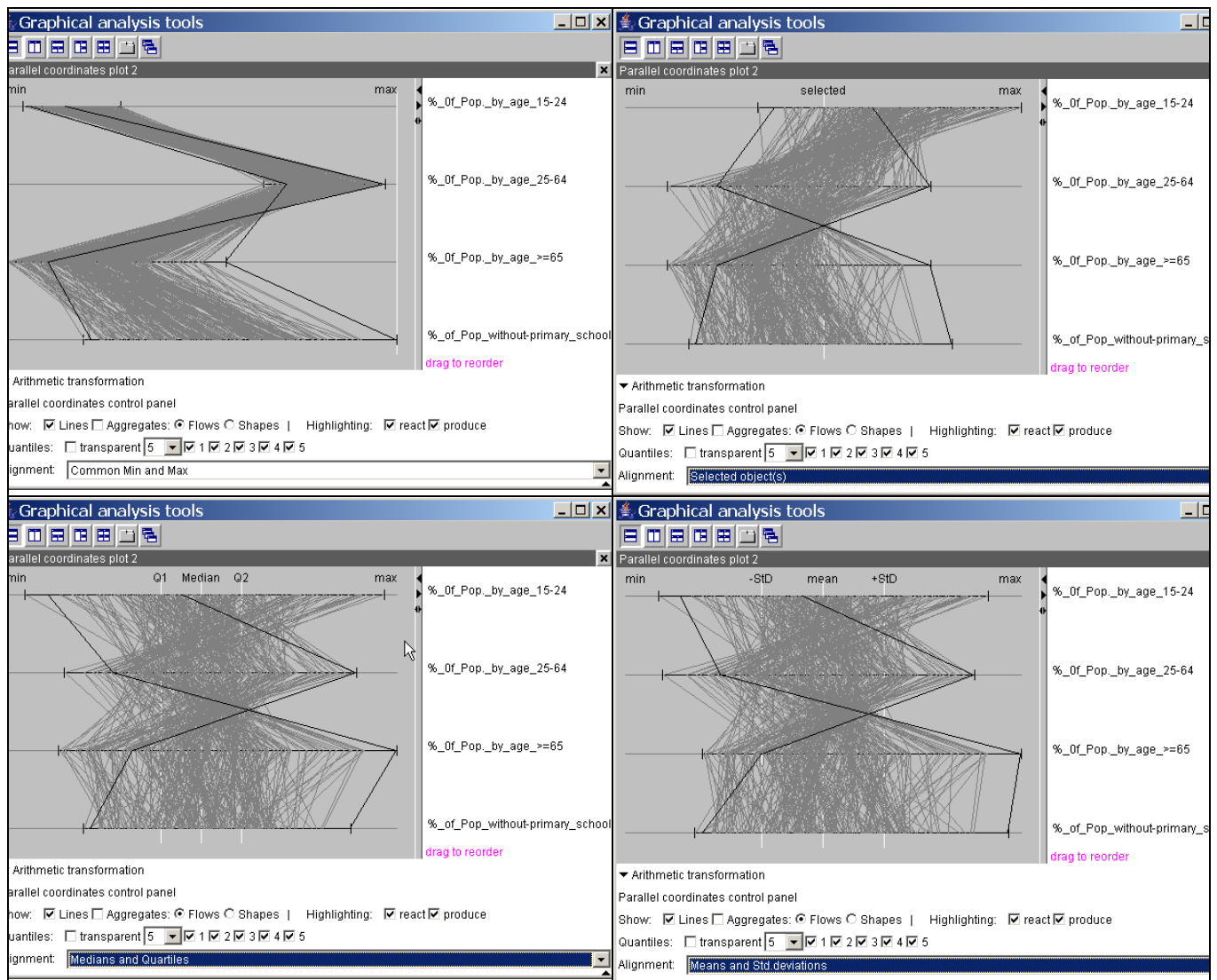


Fig. 4.2.57: Parallel coordinates plots with various alignment and selected objects *Idanha-a-Nova* and *Entroncamento*.

If there are outliers in the data, i.e. values which deviate a lot from the rest, it will be difficult to discover correlations between attributes or compare data records in the default diagram. In this case it is recommended to change the alignment to "Medians and Quartiles" and/or "Means and Std deviations" as done in the two lower diagrams in fig. 4.2.57. These scaling methods normalize the axes according to the median or the mean values. Thus a more compressed representation is achieved in the graph, and outliers emerge more clearly.

Correlation-Graph

You can choose between two methods in order to calculate the correlation of numeric attributes in CommonGIS:

- in order to correlate the attribute selected first to the other selected attributes use chart type „1:n Correlation Graph“
- in order to correlate all selected attributes which each other use chart type „n:n Correlation Graph“.

1:n Correlation Graph

If you want to know in how far the selected attribute correlates with other interesting attributes, select

- *Display: Display wizard...*,
- Choose attributes *%_of_Pop_without-primary_school*, *%_of_Pop_by_age_15-24*, *%_of_Pop_by_age_25-66* and *%_of_Pop_by_age>=65* from *Table 1*,
- Mark list entry „1:n Correlation-Graph“ in column „Charts“

and look at the resulting diagram in fig. 4.2.58.

The diagram reveals the dependency of the attributes age structure and education even more clearly than the scatter plot matrix from Abb. 4.2.54.

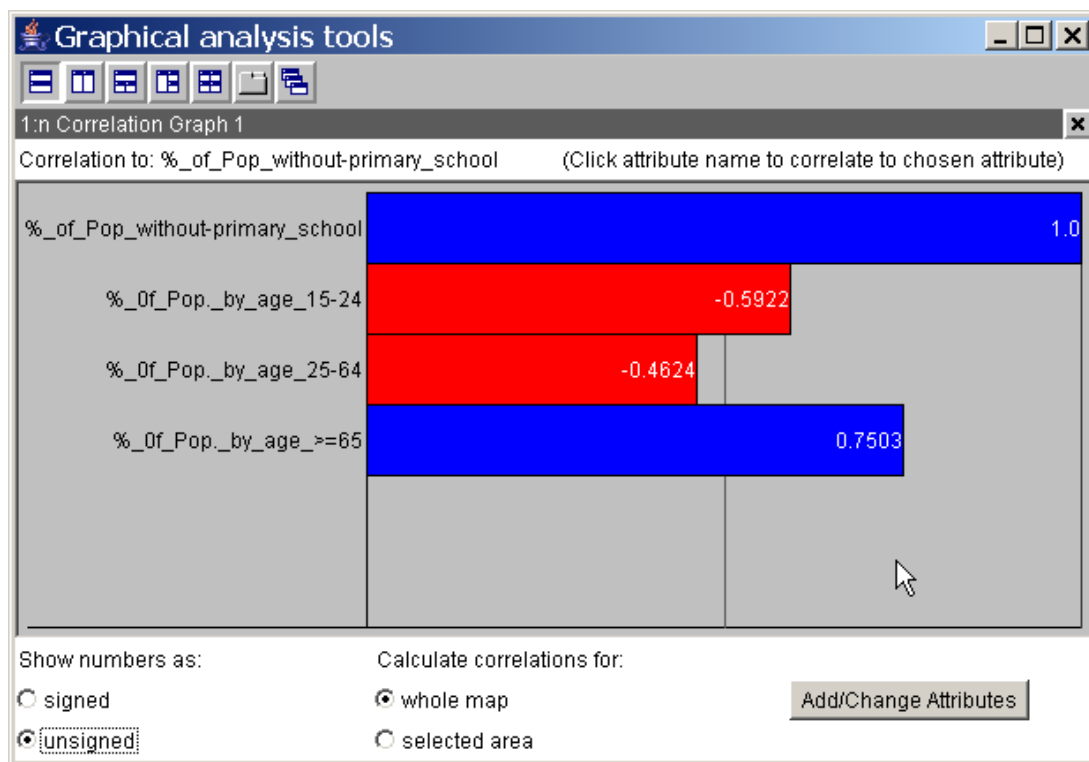


Fig. 4.2.58 1:n Correlation

If you are interested in attribute dependencies of a subset of objects, select these by clicking in the map – similar to every other representation – and mark the entry "selected area" as parameter to calculate correlation at the bottom of the Correlation diagram.

Fig 4.2.59 shows clearly the correlation between high age structure and low proportion of primary school education and vice versa for the two selected administrative districts *Idanha-a-Nova* and *Entroncamento*.

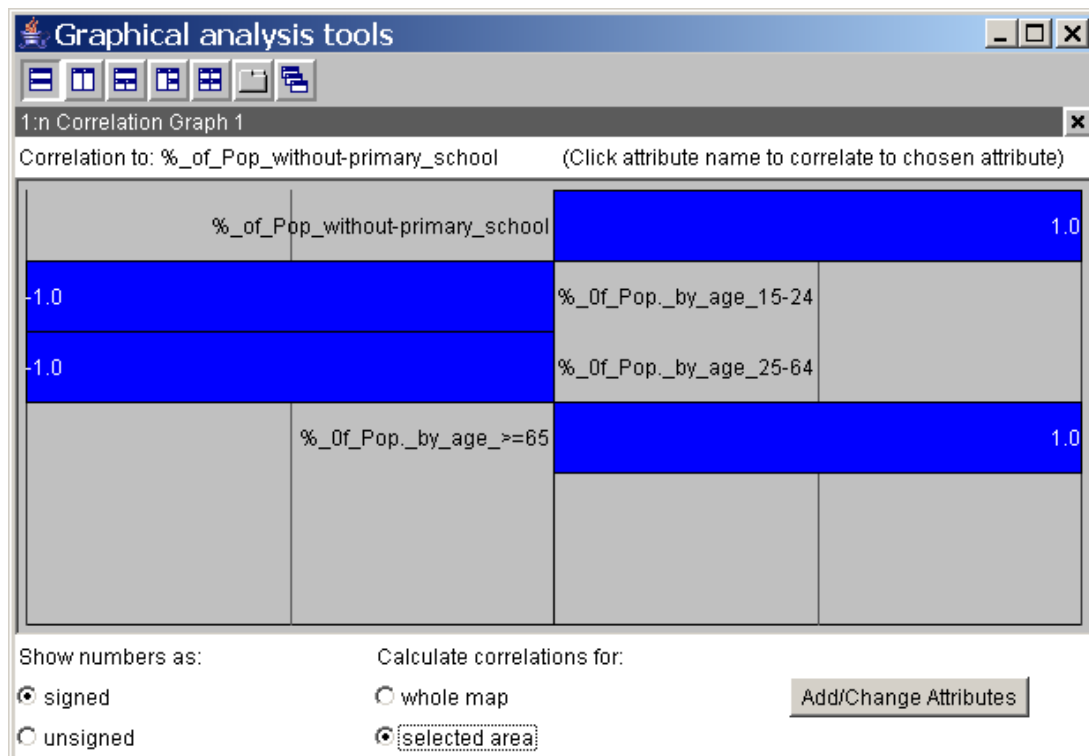


Abb. 4.2.59 1:n correlation for „signed“ numbers and „selected area“ *Idanha-a-Nova* and *Entroncamento*.

n:n Correlation Graph

If you want to know if there are correlations between any of the selected attributes, select

- *Display: Display wizard...*,
- Choose attributes %_of_Pop_without-primary_school, %_of_Pop_by_age_15-24, %_of_Pop_by_age_25-66 and %_of_Pop_by_age>=65 from *Table 1*,
- Mark list entry „n:n Correlation-Graph“ in column „Charts“

and look at the resulting diagram in fig. 4.2.60.

Positive correlations are represented by blue bars, negative correlations are marked red. If you move the mouse on any bar, the value of the correlation coefficient is shown in a small popup window. Again you can adapt the diagram to your needs by using the options at the bottom of the diagram window.

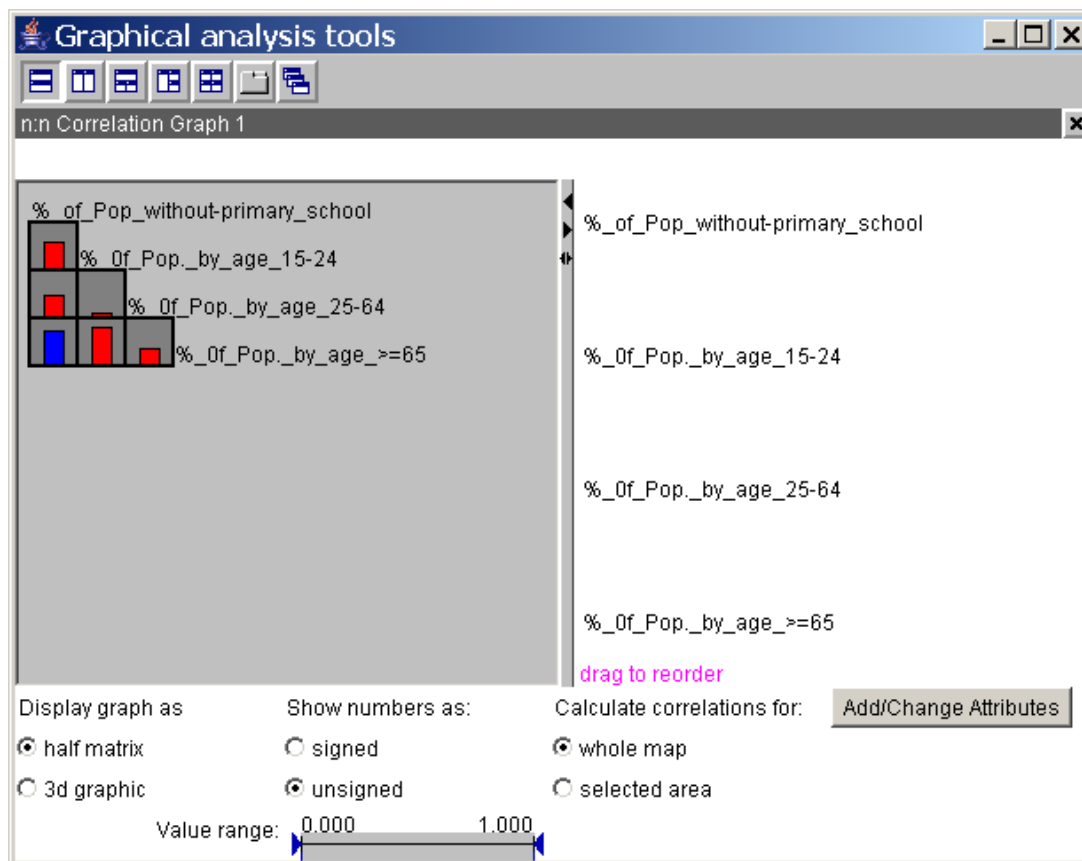


Fig. 4.2.60 n:n correlations of age structure and education.

District overview

The District Overview displays the values of selected attributes for one or more districts (objects) represented on the map.

Only numeric attributes can be selected. If this is not the case, this diagram is not active for selecting, i.e. you cannot mark this type of representation.

If you want to examine the selected attributes for certain objects more closely, select

- *Display: Display wizard...*,
- Choose attributes *% of Pop_without-primary_school*, *% of Pop_by_age_15-24*, *% of Pop_by_age_25-65* and *% of Pop_by_age>=65* from *Table 1*,
- Mark list entry „District Overview“ in column „Charts“

and look at the resulting diagram in fig. 4.2.61.

Note: By default the statistical variables of the district with the lowest identifier in the table (*ID*) are shown in the diagram - independent of the currently selected districts on the map.

You can change to the desired district by selecting it from the list at the bottom of the window or by clicking on the map object. If more than one district is selected, the average of the attribute values in the graph is indicated, provided that option "Selection change" is activated.

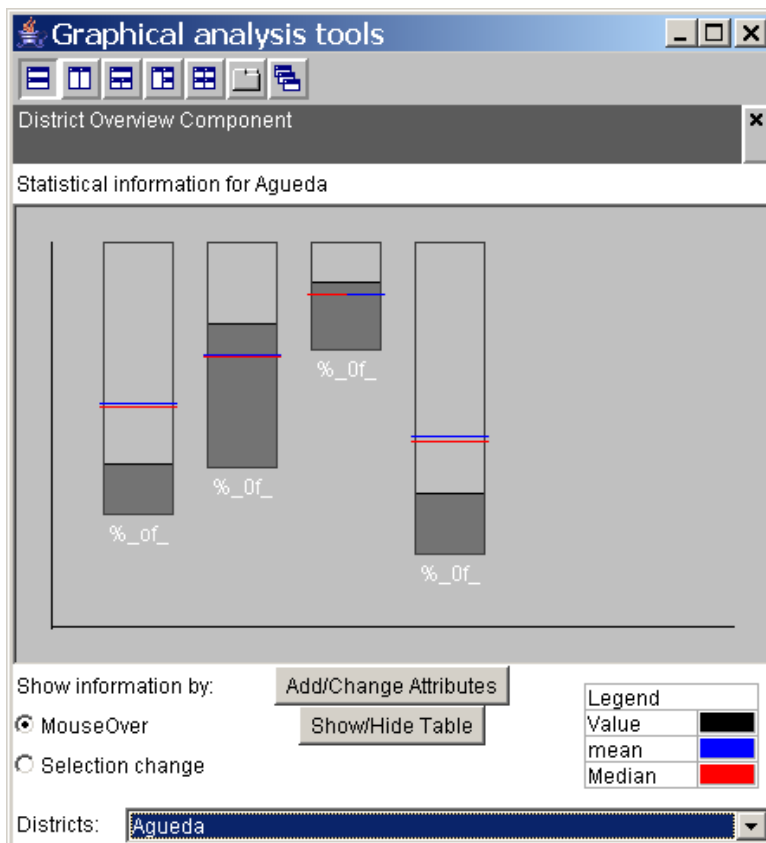


Fig. 4.2.61 District Overview including statistical variables for district *Agueda*.

The overall height of a bar in the representation corresponds to the map-wide maximum value of that attribute. The filled part represents the attribute value of the currently selected district. From this bar representation the user can get an idea of the ratio of the current value and the maximum attribute value.

Additionally for each attribute the mean and the median values are indicated in the bar. The blue line stands for the mean value and the red line represents the median.

In order to see the numerical values either point with the mouse to the bar of the attribute in question (a popup window appears listing the exact values) or add a table with the values of all selected attributes beneath the bar chart by marking "Show/Hide table" (see fig. 4.2.62).

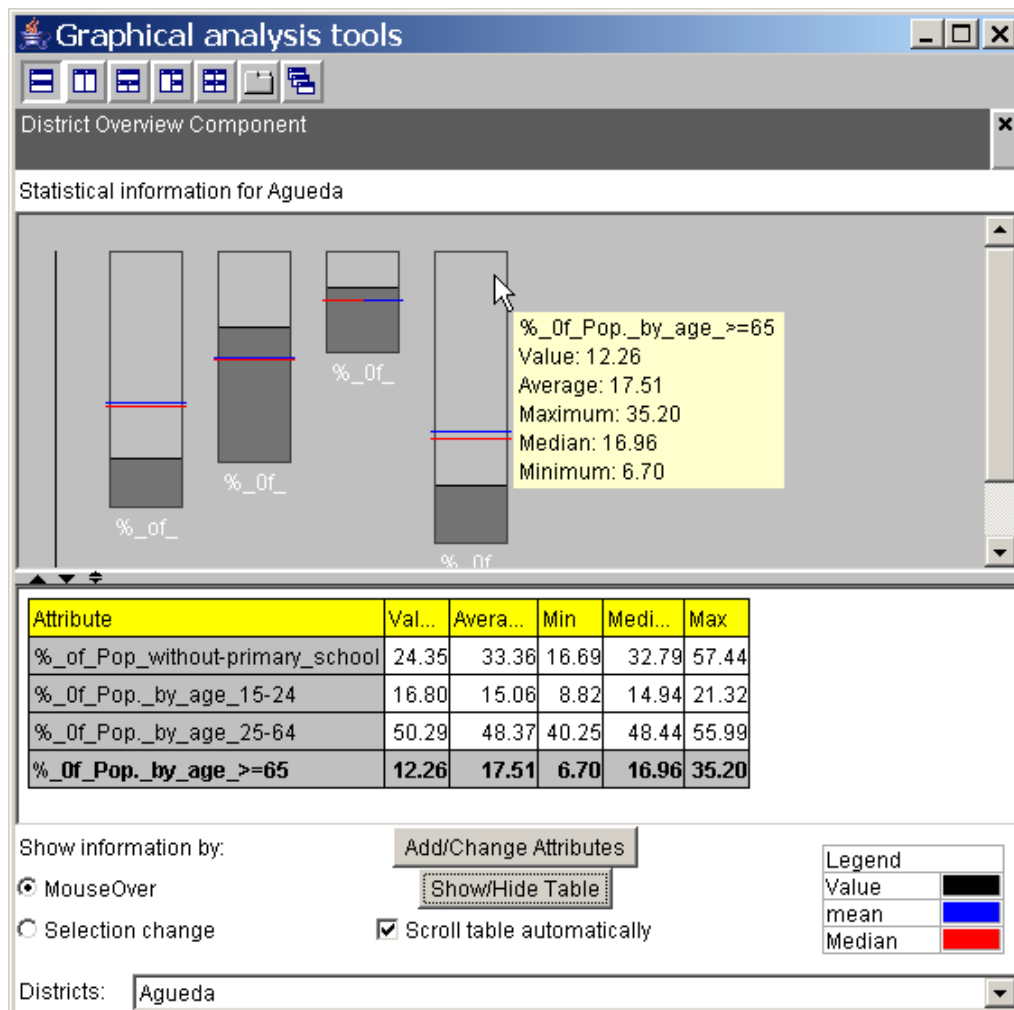


Fig. 4.2.62 District view showing statistical variables of attributes within additional table and popup window near to mouse position for district *Agueda*.

Presenting spatial data in tables

The data presented on the map can be listed within a table, thus providing an overview on the data values and a different perspective with respect to the meaning and relationship of the data.

By dynamic linking of the table representation to the map display (and other visualizations) the user can evaluate objects selected in the table in their spatial context on the map. For a potentially interesting object from any visualization he can study the complete data record in the table as well.

To create a table representation of layer data the user selects option *View table* from menu *Display*:

Display: View table

display the selected table in a separate window.

Figure 4.2.63 shows the table selecting dialogue. For each table the name and the corresponding layer (in parentheses) is given.



Fig. 4.2.63: Selecting of a table for viewing.

After selection of the desired attributes, a separate table window on the screen is opened. In figure 4.2.64 you see table 1) *Statistical of indicator is represented to for districts (administrative division)*. You also could open more windows for further tables.

identifiers	total_pop_1981	total_pop_1991	male_1981	female_1981
Agueda	43216	44045	21164	22052
Albergaria-a-Velha	21326	21995	10365	10961
Anadia	29820	28899	14400	15420
Arouca	23896	23894	11482	12414
Aveiro	60284	66444	29089	31195
Castelo de Paiva	17026	16515	8390	8636
Espinho	32409	34956	15502	16907
Estarreja	26261	26742	12699	13562
Santa Maria da Feira	109531	118641	52929	56602
Ilhavo	31383	33235	15146	16237
Mealhada	19305	18272	9302	10003
Murtosa	9816	9579	4573	5243
Oliveira de Azemeis	62821	66846	30737	32084
Oliveira do Bairro	17517	18660	8288	9229
Ovar	45378	49659	21718	23660
Sao Joao da Madeira	16444	18452	7957	8487
Sever do Vouga	13783	13826	6604	7179
Vagos	18548	19068	8637	9911
Vale de Cambra	24224	24537	11825	12399
Aljustrel	12870	11990	6324	6546
Almodovar	10637	8999	5467	5170
Alvito	2968	2650	1472	1496

Fig. 4.2.64: Data for administrative division in table form.

Within the table each data record is represented within a row (in this case all data belonging to one district). Each value is entered to the column, which corresponds to the assigned attribute. Since the tables are often very large, you mostly see only a part of the table in the window. With the help of the scrollbars (lower and right side of window), usual options to change the window size and special options to fade out attributes and re-sort the objects you can adjust the section of the table you want to see.

The sequence of the data records is determined by the identifiers which are usually hidden. You can make them visible by clicking on the small box above the column containing the name of the objects (see fig. 4.2.64). The headings of the columns (attribute names) are arranged according to the sequence in the attribute selection window, i.e. sequentially as the attributes were read in (see fig. 4.2.2).

You can re-sort both the lines and the columns:

- Changing sequence of objects (lines)

If you want to rearrange the objects in decreasing order according to high age structure,

- Scroll the table to the right, until you see attribute `%_of_Pop_by_age>=65`,

- Click on the attribute name *%_of_Pop_by_age>=65* two times, and look at the result in fig. 4.2.65, which contains the re-sorted table. The object list is re-sorted whenever the user clicks on any attribute name. This attribute serves as sorting criterion, i.e. the objects are listed in such a way that the values of this attribute are arranged ascendingly. If you click on the attribute name again, the values are now represented in a descending order.

You also can identify the attribute to be sorted in the attribute list accessible via field "Sort by:" (at the bottom of the table window). Next to this field you can indicate whether values should be arranged in ascending or descending order.

- Changing sequence/number of attributes (columns)

In order to look only at those attributes which refer to age structure,

- Click on check box "Attribute..." (lower right edge of window)
 - Choose attributes *%_of_Pop_by_age_15-24*, *%_of_Pop_by_age_25-65*, *%_of_Pop_by_age>=65* and *%_of_Pop_without-primary_school* as usual,
 - Define the desired ordering (by using the arrow heads below the right list)
- and look at the resulting table containing only the selected attributes.

If you simply want to change the order of the attributes within the table, select all attributes in the attribute selection window just as described above and create the desired sequence with the arrow keys.

Let's assume that the user is interested in finding the districts with the highest proportion of older population on the map. He successively selects the first seven objects by clicking on the corresponding lines in the table. The seven districts are highlighted on the map simultaneously (see Fig. 4.2.65), provided that the layer assigned to the table is active (here: *Administrative division*).

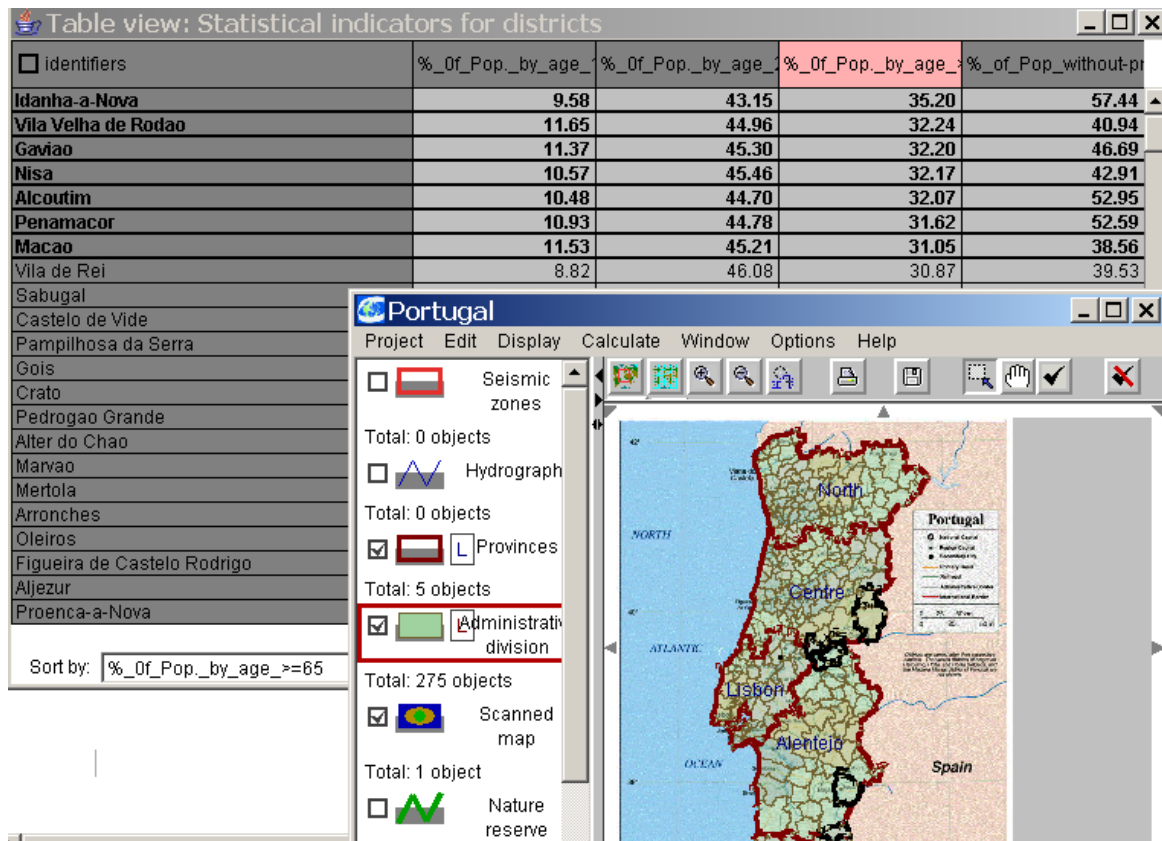


Fig. 4.2.65: Data about administrative division descendingly ordered by proportion of old population.

- Selecting several objects arranged successively

In order to select several objects at one time click on the first name/value of the desired list, leave the mouse button pressed, move to the last name/value of the partial list and release the mouse button.


In order to deselect a selection of objects proceed in exactly the same way. In order to waive the selection of all selected objects in the table and the map you also can use the icon  from the icon bar of the map.

Table lens

If the user wants to search a table for remarkable values (e.g. outliers), this can be quite laborious with large data sets. The table lens graphically supports the user with the recognition of remarkable values by adding a bar representation to the table.

In order to show the table lens

- Click on the checkbox next to „Table lens“ (at the bottom of the table window), and look at the result in fig. 4.2.66.

identifiers	%_Of_Pop_by_age_>=65	%_Of_Pop_by_age_18-64	%_Of_Pop_by_age_15-64	%_of_Pop_without-pr
Ponte de Sor	19.54	50.03	12.86	41.35
Ferreira do Alentejo	19.45	49.01	13.26	42.68
Reguengos de Monsaraz	19.44	49.64	13.36	40.66
Castelo Branco	19.35	50.16	14.03	33.57
Golega	19.27	49.75	13.55	34.03
Boticas	19.10	46.85	14.38	44.19
Ansiao	19.10	48.22	15.33	34.45
Abrantes	19.07	49.97	14.76	31.26
Aljustrel	19.01	49.10	14.00	38.48
Grandola	18.95	52.31	11.88	43.8
Oliveira do Hospital	18.89	47.27	14.82	30.45
Vila Nova de Cerveira	18.87	47.10	15.08	28.82
Loule	18.86	50.50	13.37	31.5
Lisboa	18.78	52.07	14.94	17.27
Vila Nova de Poiares	18.63	46.60	15.48	27.1
Coruche	18.54	52.78	13.46	44.01
Tondela	18.49	47.55	15.02	28.91
Chamusca	18.49	51.34	12.85	34.91
Murtosa	18.48	44.48	15.86	26.89
Bombarral	18.44	49.49	14.12	30.23
Santa Marta de Penaguião	18.05	45.29	15.65	38.47
Santarem	17.83	50.48	14.16	27.94

Sort by: %_Of_Pop_by_age_>=65 Descending ☒ TableLens ☐ condensed ☐ just selected items ☐ Attribute info Attribute...

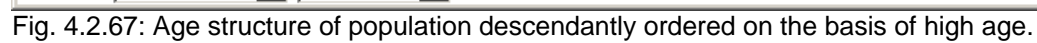
Fig. 4.2.66: Age structure of population descendantly ordered on the basis of high age.

Alternatively, the values can be faded out so that a more compressed representation results.

In order to compress the table lens representation

- Click on the checkbox next to „condensed“ (at the bottom of the table window), and look at the resulting table view in fig. 4.2.67.

In order to find outlier values first regard e.g. the condensed representation and select the interesting data records by clicking. If you click on the checkbox "condensed" again, the bar representation with the data values is redrawn. Now one can go through the table and analyze the marked objects more closely. In our example this proceeding reveals that the correlation between older population and missing primary school education does not apply to Lisbon.



Presenting raster data

In addition to thematic data the user can use raster data in CommonGIS. "Raster data of the topographic cartography is particularly suitable as spatial reference and background information. Raster maps can be overlaid with thematic data and can serve as a basis for the computer-aided treatment of thematic maps (e.g. geology, hydrology, land use, nature protection, etc..)" (see [Bundesamt für Kartographie und Geodäsie](#)). With raster data continuous information can be shown very well, e.g. land elevations.

Geographical raster (grid) data consist of numeric values which are assigned to the cells of a regular grid. Raster data are characterized by

- number of columns,
- number of rows,
- cell sizes in X- and Y-dimensions,
- geographical reference (often specified as coordinates of the upper-left corner of the grid).

For the following examples we draw on the project "Vegetationsindex.app" in folder data/NDVI_82und93, which contains world maps representing the vegetation index of the years 82 and 93 at different seasons.

When opening the project (*Project: Open – Browse: data/NDVI_82und93/Vegetationsindex.app*), you see the basic map of the project (fig. 4.2.2): a world map showing the vegetation index NDVI of october 1993. The NDVI (Normalized Difference Vegetation Index) indicates the state of vitality of green vegetation: the higher the NDVI-value, the more vital the green vegetation.

The other available layers (NDVI for additional months) are not activated in this view.

To learn about the handling of the basemap, the symbol bar and the legend see *chapter 3,2 How to use CommonGIS?*. With raster layers you can show the associated graticule by clicking with the mouse on the map; the graticule is faded out by clicking again.

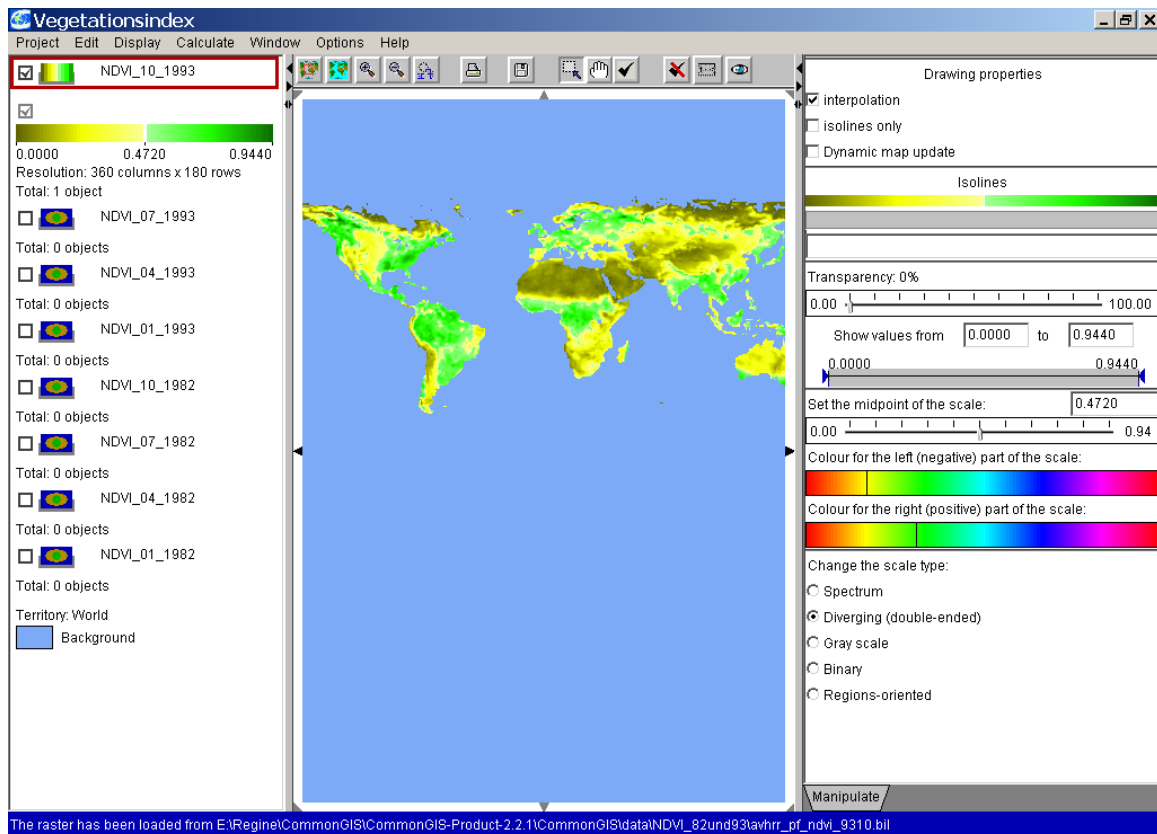


Fig. 4.2.65: The basemap of project „data/NDVI_82und93/ Vegetationsindex.app“

In order to analyse raster data visually you can adjust the presentation of raster maps in CommonGIS according to your tasks. You can change the color scale and parameter such as transparency and boundary values for raster data, overlay raster layers with vector layers or change the sequence of layers and their visibility.

CommonGIS creates a map from raster data by assigning a color to each cell value of the raster data set. The visualisation of values and according colors is defined by a "colour scale". In figure 4.2.65 the values for vegetation density (in layer "NDVI_10_1993") are represented by shades of the colors yellow and green. For values from 0 to 0,4720 (the midpoint of the scale) - indication of a low vegetation vitality - yellow was used, all values larger than the midpoint are green; a value of exactly 0,4720 is painted in white. The allocation of values to the colour scale is shown in the legend below the layer name.

Note: Note that in the legend the inactive raster layers "NDVI_7_1993" to "NDVI_1_1982" have a different symbol assigned to their names than the active raster layer "NDVI_10_1993". These layers are predefined as not being visible when opening the project (see section "Creating a project"). By reason of efficiency they are not loaded into CommonGIS until the user actually needs and activates them. Only then they are assigned a colour scale.

Within the manipulation window the user can adapt the visualisation of the map (see fig. 4.2.65, right window) according to the relevant questions. In order to fade out certain values from the representation, the user can limit the range of values both from bottom-up and top down. For this purpose he can either shift the arrow heads on the scale or type the values directly into the input fields. After changing the values in the input fields, you must confirm the input with the "Enter" key in order to take effect!

If you want to focus the analysis e.g. only on areas in Africa with sparse or no vegetation which hence are represented by a vegetation index smaller than the center of the scale,

- enter the value 0.4720 into the right input field for showing the value range within the middle of the manipulation window and press the "Enter" key
 - zoom the map in order to focus on Africa
- and look at the resulting map in fig. 4.2.66.

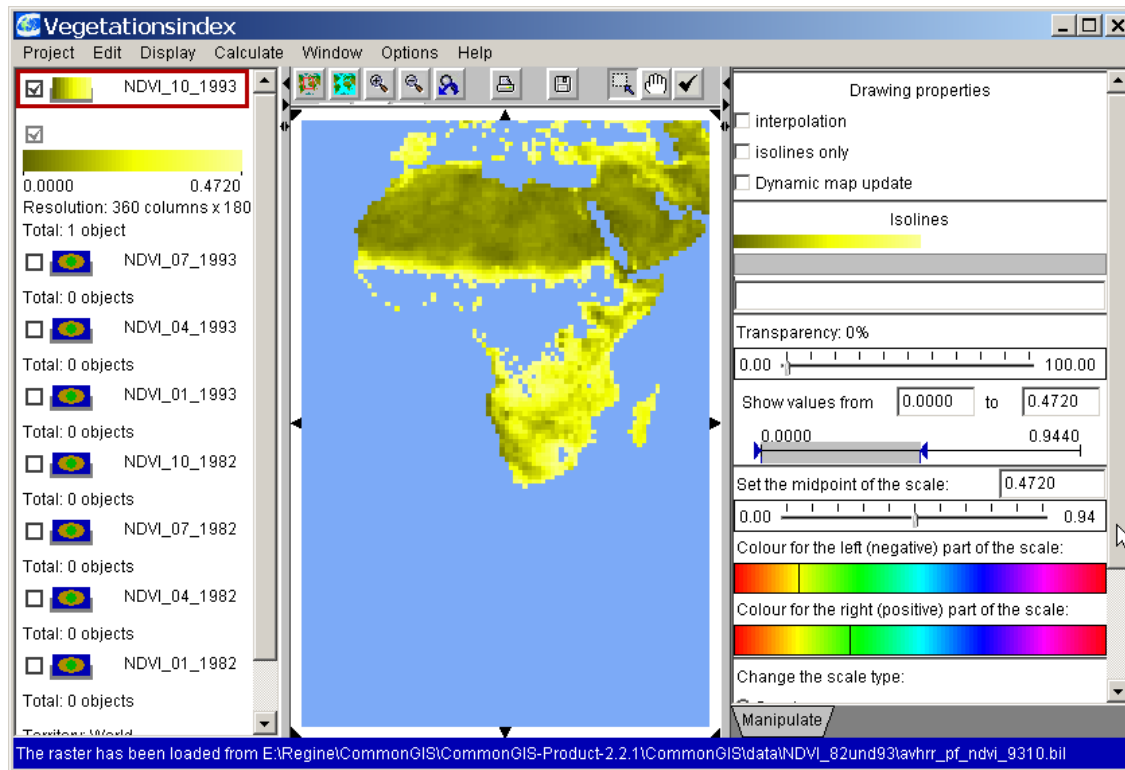


Fig. 4.2.66 Narrowing range of values for „NDVI_10_1993“

The user can choose between the following types of color scales:






Spectrum	Colors from the entire chromatic spectrum are assigned to values.	
Diverging (double-ended)	Separated by the selected midpoint the values below are shaded using the first selected colour, the values above are represented by shades of the second colour.	
Grey scale	Only shades of grey are used.	
Binary	Binary raster: value 1 is represented by some selected colour while zero values are not shown. Non-binary raster: positive values are shown in one and the same colour while zero and negative values are not shown.	
Regions-oriented	Default colour scheme: RGB - classical colour scheme with red, green and blue. The system interpolates each of them independently. Default interpolation function: logarithmic. You can choose between Linear, Logarithmic and Exponent functions for colour interpolation. This option could be helpful for some maps to get more pleasant colour transitions to recognize value changes easily.	

Fig. 4.2.67 Different colour scales for layer „NDVI_10_1993“

In addition to the tools for visual analysis in CommonGIS you can also perform computations on raster data, which are described in the next section (*calculations on raster data*).

4.3. Calculating data – Menu **Calculate**

CommonGIS also supports the user with the calculation of new data on the basis of the available data.

Calculation methods can be applied either to tables (Calculate in a table) or to raster data (geographic computations). The menu *calculation* offers the following options:

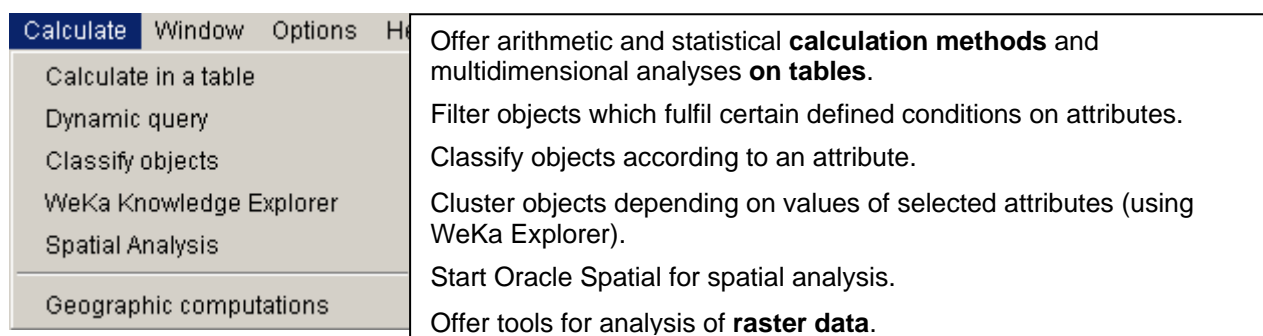


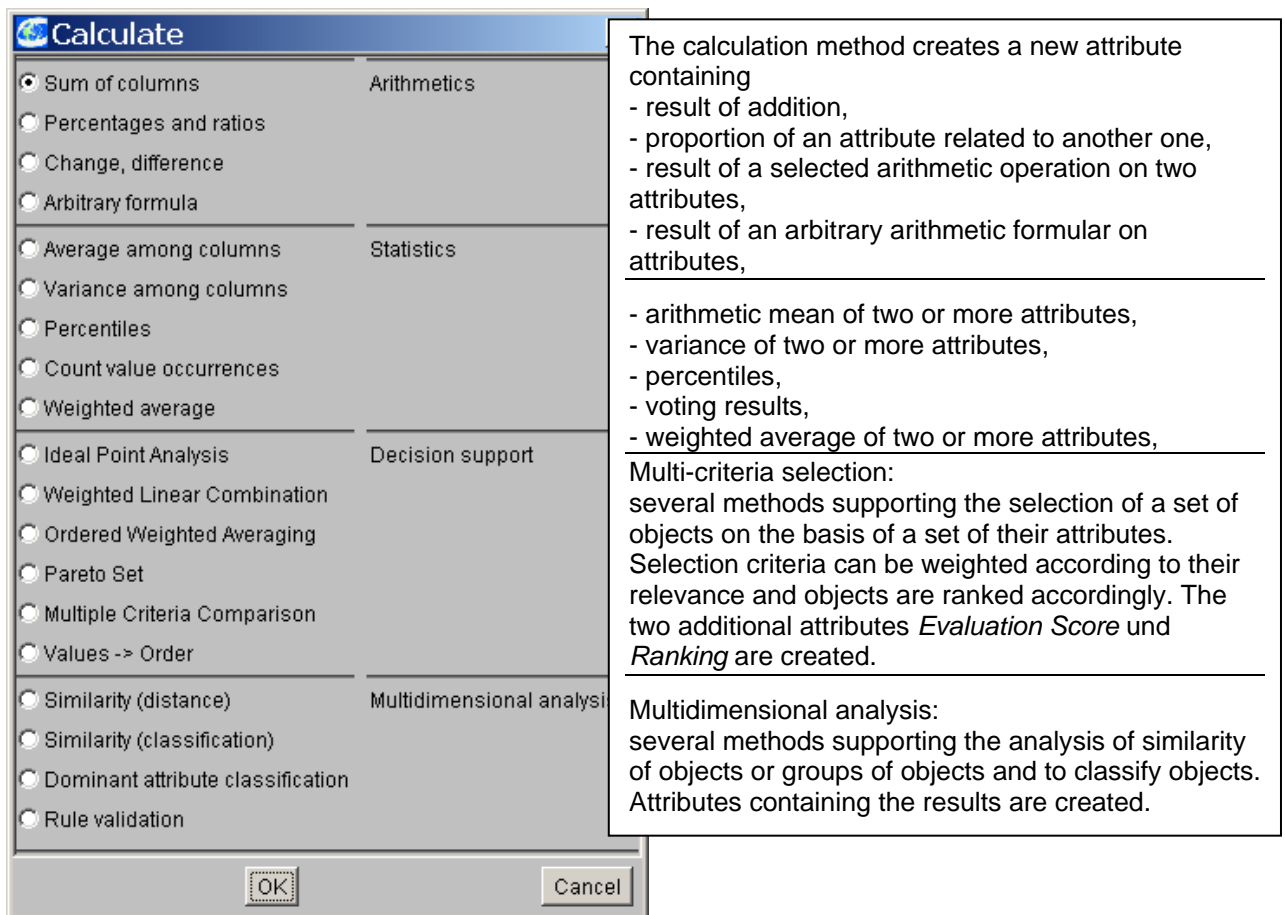
Fig. 4.3.1: Menu *Calculate*.

In addition to relatively simple computations on tables there are also some complex methods. They are offered as *table computations* supporting multi-criteria selection and multidimensional analysis. Just as the *Dynamic query*-method these methods help the user to relate data and evaluate them. These methods are described separately in *chapter 4.4 Relating data*.

Calculating on tables

Calculations on tables are performed on attributes of a selected table. The result of the computation is added to the original table as a new attribute. For the new attribute a name is produced automatically. It is composed of the operation used and the attributes involved. Additionally, the user has the possibility of assigning another suitable name.

The following section describes the table operations sequentially as they are listed in the calculation submenu. As example some computations are demonstrated on the data about the population structure of Portugal.



Submenu *Calculate* for tables.

Arithmetic calculation methods

Sum of columns

The selected attributes are summed up and a new attribute containing the sums is added to the table. The suggested name for the new attribute can be changed using the common editing functions (see fig. 4.3.2). The attribute is represented as an unclassified choropleth map.

If you want to get an overview of the spatial distribution of the young population within Portugal, first summarize the population below 14 years and the population between 14 and 24 years.

Select

- *Calculate: Calculate in a table*,
- Choose Table 1): Statistical indicators for districts,
- Mark list entry "Sum of columns" in window "Calculate",
- Choose the attributes *%_of_Pop_by_age_0-14* and *%_of_Pop_by_age_15-24*,
- Change or accept the name of the new attribute (see. fig. 4.3.2)

and look at the resulting choropleth map in fig. 4.3.3 on the left, showing the distribution of the new attribute. The new attribute *sum of %_of_Pop_by_age_0-24* is also represented in the right subwindow „Manipulate“ and in the table (right in fig. 4.3.3).

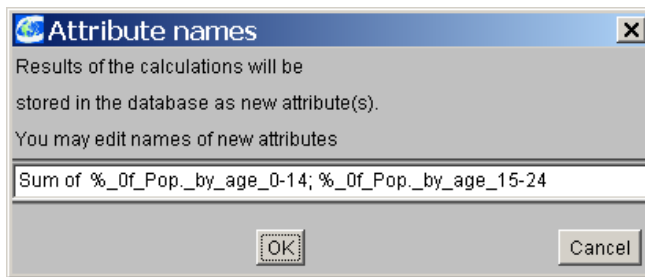


Fig. 4.3.2 Sum of young population

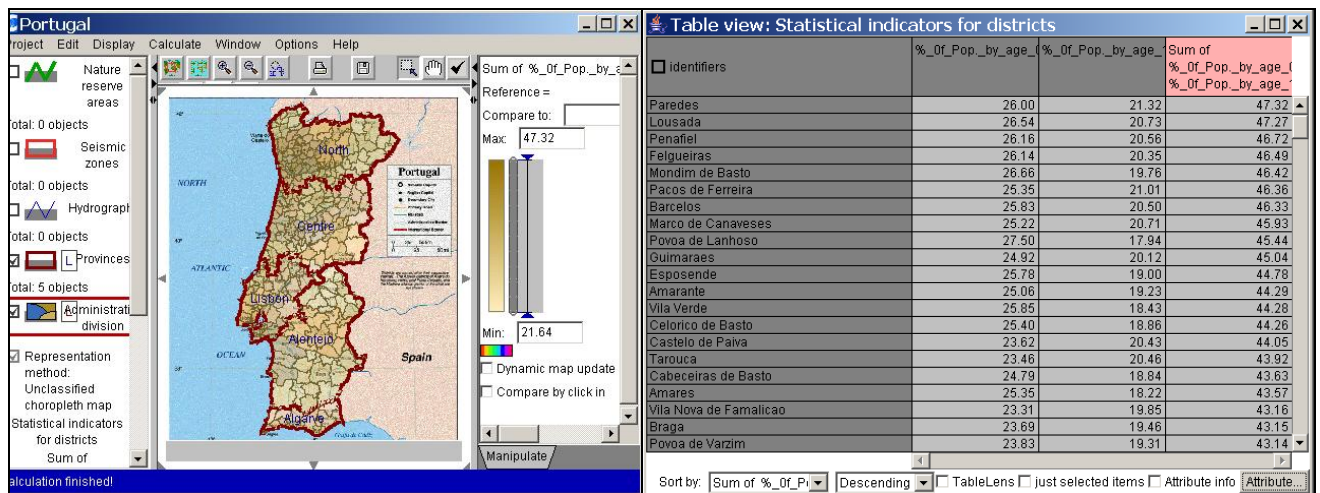


Fig. 4.3.3 Sum of young population

Percentages and ratios

These computational methods allow it to calculate proportions of attributes to another one or to relate attributes by dividing them. One can indicate whether the reference value should be an attribute, the sum of the attributes in question or a numerical value.

If you want to calculate the rate of employment for Portugal in 1991, select

- Calculate: Calculate in a table,
- Choose Table 1): Statistical indicators for districts,
- Mark list entry "Percentages and ratios" in window "Calculate",
- Choose the attribute *total_employed_1991*.

Now you are asked to specify the operation in window „Compute percentages or ratios“ (see fig. 4.3.4):

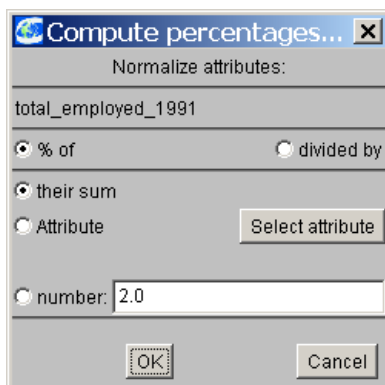


Fig. 4.3.4 Ratio of employed persons to total population in 1991

- Click on button „Select attribute“ and choose attribute *total_pop_1991* from the list in window “select attribute(s)”, complete operation by clicking „OK“ button,
- Enter „Rate of employment“ as name for the new attribute in window „Attribute names“.

The resulting choropleth map in fig. 4.3.5 shows the spatial distribution of the new attribute. In the subwindow „Manipulate“ and in the attributes table (fig. 4.3.5, to the right) you see the new attribute *rate of employment* in different views.

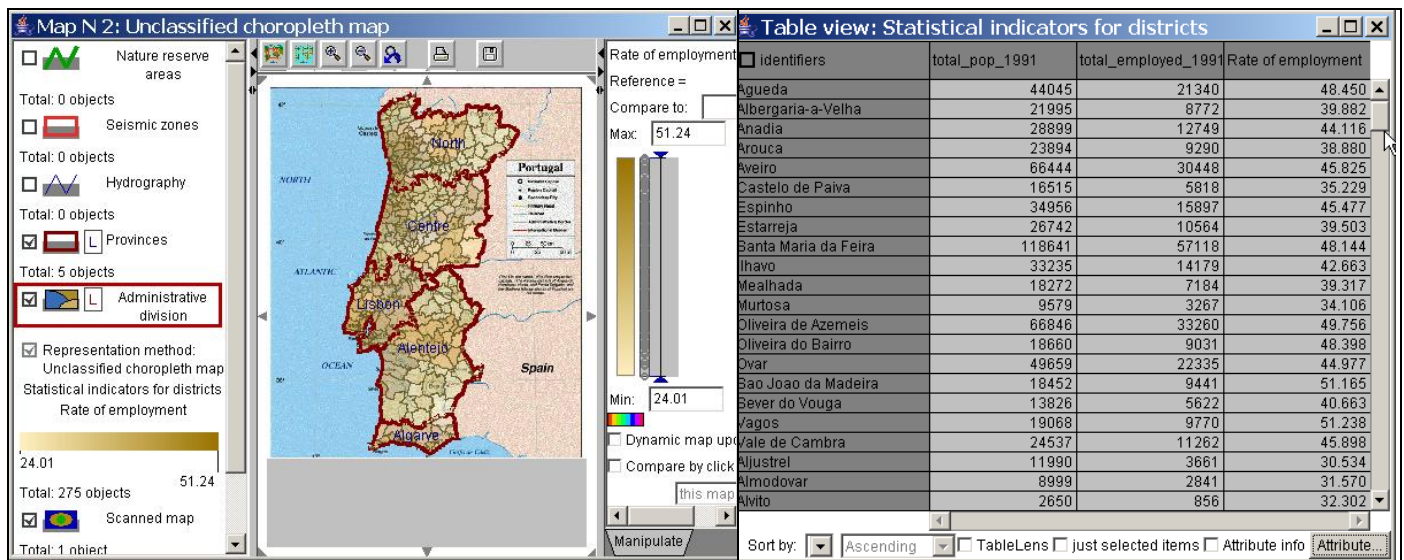


Fig. 4.3.5 Rate of employment 1991

Change and difference

Operations for change and difference calculate the arithmetic difference for two or more attributes (e.g. for regarding change or deviation), ratio or both.

Looking at the difference of employed persons (*total_employed_1991*) and unemployed persons (*total_unemployed_1991*) offers yet another view on the data. Since again absolute population numbers are used for calculation, the highest difference (between persons employed and persons unemployed) results for Lisbon, although the employment rate amounts "only" 42,37 %.

Within this view the high number of inhabitants affects the distribution of the attribute (see fig. 4.3.7).

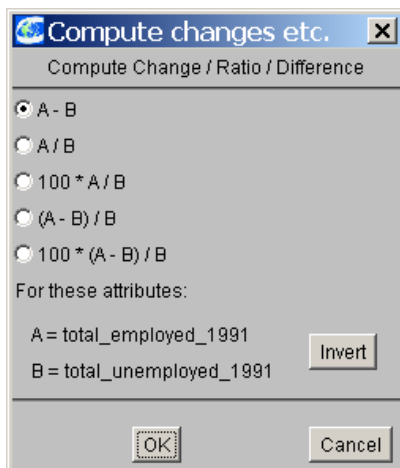


Fig. 4.3.6 Difference between employed and unemployed persons

Within window “Compute changes” the sequence of attributes A and B can still be transposed by pressing button "Invert". (Usually you can only change the sequence of attributes while selecting attributes in the attribute selection window.)

Table view: Statistical indicators for districts			
<input type="checkbox"/> identifiers	total_employed_1991	total_unemployed_1991	Difference_employed - unemployed_1991
Lisboa	281078	22043	259035
Loures	153319	10124	143195
Porto	133666	9943	123723
Sintra	124590	8844	115746
Vila Nova de Gaia	115949	6849	109100
Amadora	84172	6084	78088
Guimaraes	79164	2904	76260
Matosinhos	70763	5423	65340
Cascais	69890	5161	64729
Oeiras	69868	5166	64702
Gondomar	65579	3746	61833
Braga	64058	3300	60758
Almada	65204	6428	58776
Coimbra	61264	4068	57196
Santa Maria da Feira	57118	1589	55529
Vila Nova de Famalicao	57367	1908	55459
Barcelos	51467	1361	50106
Santo Tirso	51889	2397	49492
Seixal	52037	5399	46638
Maia	45153	2213	42940
Leiria	43837	1617	42220

Sort by: Difference_emplo Descending ☐ TableLens ☐ just selected items ☐ Attribute info Attribute...

Fig. 4.3.7 Difference of employed and unemployed persons.

Arbitrary formulas

In addition to the prepared computational methods already described the user can construct a broad variety of other formulas on selected attributes.

Select

- *Calculate: Calculate in a table,*
- Choose Table 1): Statistical indicators for districts,
- Mark list entry “Arbitrary formula” in window “Calculate”,
- Choose the attributes *total_employed_1991*, *total_unemployed_1991* und *female_employed_1991*.

Now you are asked to specify the formula (see fig. 4.3.8). The available functions and operators are listed in fig. 4.3.9.

Fig. 4.3.8 Constructing a formula on attributes

The user types the formula either directly into the input line in the lower part of the window or he composes it by selecting the parts from the lists within the upper range of the window. An attribute from the attribute list is transferred to the formula line by doubleclicking, while a function or an operator is inserted when the button "Insert" is clicked after having selected the desired option.

Name of function	Definition of function	Operator (and definition)
ABS()	Absolute value	+ - arithmetic addition - - arithmetic subtraction * - arithmetic multiplication / - arithmetic division < - comparison less <= - comparison less or equal > - comparison greater >= - comparison greater or equal = - comparison equal <> - comparison not equal ! - logical not & - logical and - logical or
ATAN()	Arctangent	
BLK()	BLK(x)=1 if x is defined, else BLK(x)=0	
COS()	Cosine	
DAY(.,.)	Day(year,month,day) counts the number of days from 1970.1.01	
EXP()	Exponent	
IF(.,.)	If logical expression a is true then result is b	
INTR(.,.)	else c	
LN()	INTR(x,x1,y1,x2,y2...) gives value in point x of piece-linear function defined by knots (xi, yi).	
LG()	Natural logarithm	
MAX()	Logarithm	
MIN()	Maximum value	
RAND()	Minimum value	
ROUND()	Random value	
SIGN()	Round value	
SIN()	Algebraic sign	
SQRT()	Sine	
	Square root	

Fig. 4.3.9 Functions and operators in formulas

Statistical computations

Average among columns

This option computes the arithmetic mean of two or more attribute values and stores the result as a new attribute. The mean value shows a central tendency. The computation is carried out according to the formula:

$$X = \text{Sum}(X_i) / n \quad X_i - \text{value of attribute } 1 \dots n.$$

If you want to compare the mean value of births in 1996 with 1997 throughout the provinces, select

- *Calculate: Calculate in a table*,
- Choose Table 2): Data about provinces,
- Mark list entry "Average among columns" in window "Calculate",
- Choose the attributes *Number of birth (1996, both sexes)* and *Number of birth (1997, both sexes)*,
- Accept the name „Average from Number of“,

and look at the resulting choropleth map in fig. 4.3.10 showing the spatial distribution of the new attribute relative to the provinces.

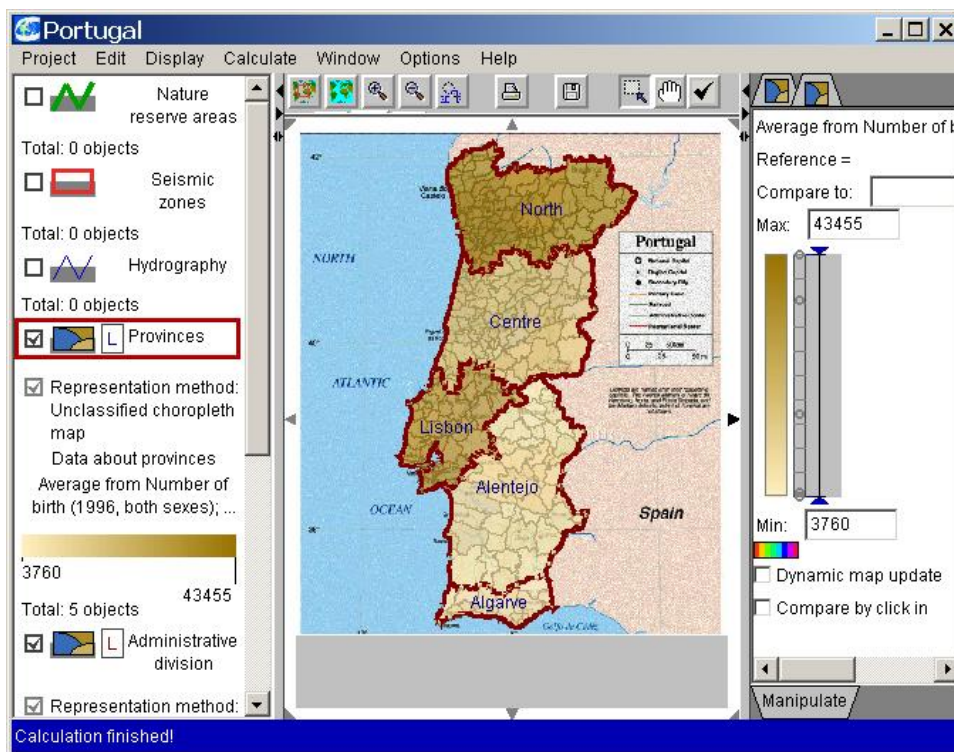


Fig. 4.3.10 Mean birth rate for provinces in 1996 and 1997

Variance among columns

In order to examine deviations and differences between objects the statistical measure of variance is usually used. The computation is carried out according to the formula:

$$V = \text{Sum}(X_i - X)^2 / n, \quad X - \text{mean value and} \\ X_i - \text{value of attribute } 1 \dots n.$$

If you want to compare the variance of births in 1996 with 1997 throughout the provinces, select

- *Calculate: Calculate in a table*,
- Choose Table 2): Data about provinces,
- Mark list entry "Variance among columns" in window "Calculate",
- Choose the attributes *Number of birth (1996, both sexes)* and *Number of birth (1997, both sexes)*,
- Accept the name „*Variance: Number of*“ ,

and look at the resulting choropleth map in fig. 4.3.11 showing the spatial distribution of the new attribute relative to the provinces.

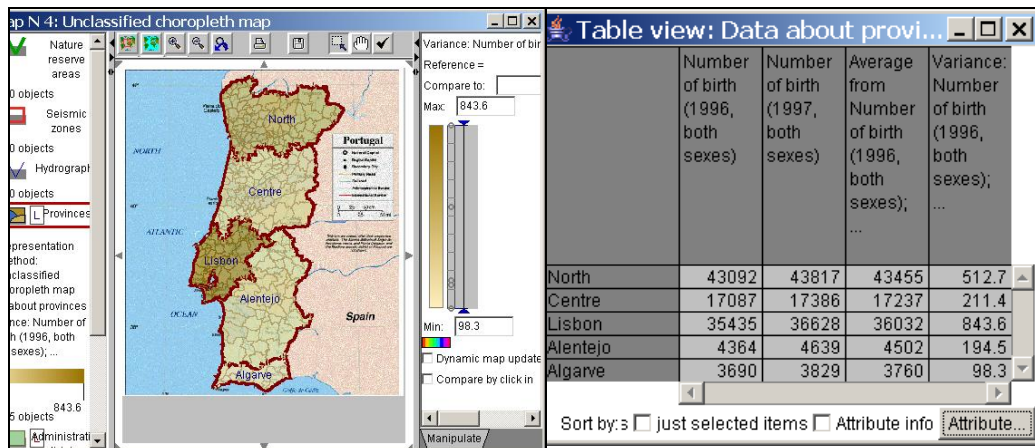


Fig. 4.3.11 Variance of births in 1996 and 1997

Percentiles

If the user needs to compute user-defined percentiles of the distribution between the sexes in 1991, select

- *Calculate: Calculate in a table*,
- Choose Table 1): Statistical indicators for districts,
- Mark list entry "Percentiles" in window "Calculate",
- Choose the attributes *female_1991* and *male_1991*,
- Type in the percentile values (separated by blanks),
- Change or accept the suggested names and confirm that the selected attributes are comparable,

and look at the resulting map in fig. 4.3.13 visualizing the new attributes containing the percentiles.

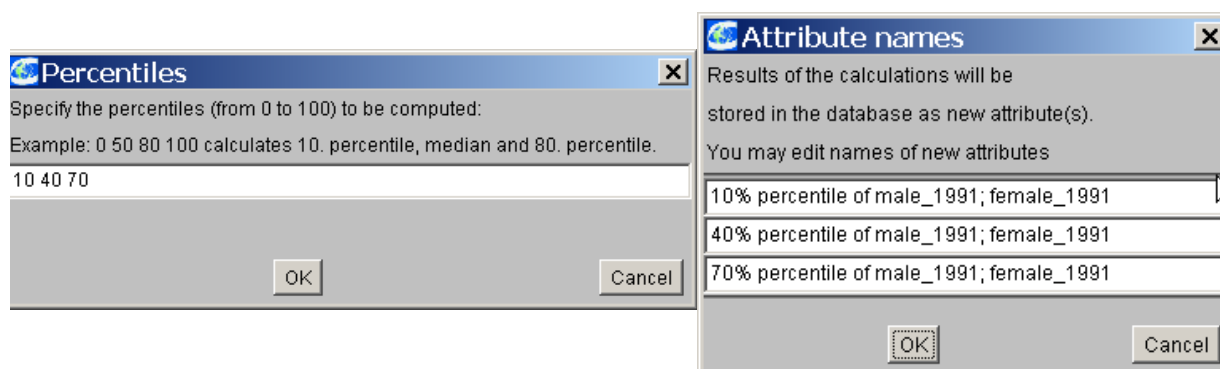


Fig. 4.3.12 Specification of percentile values

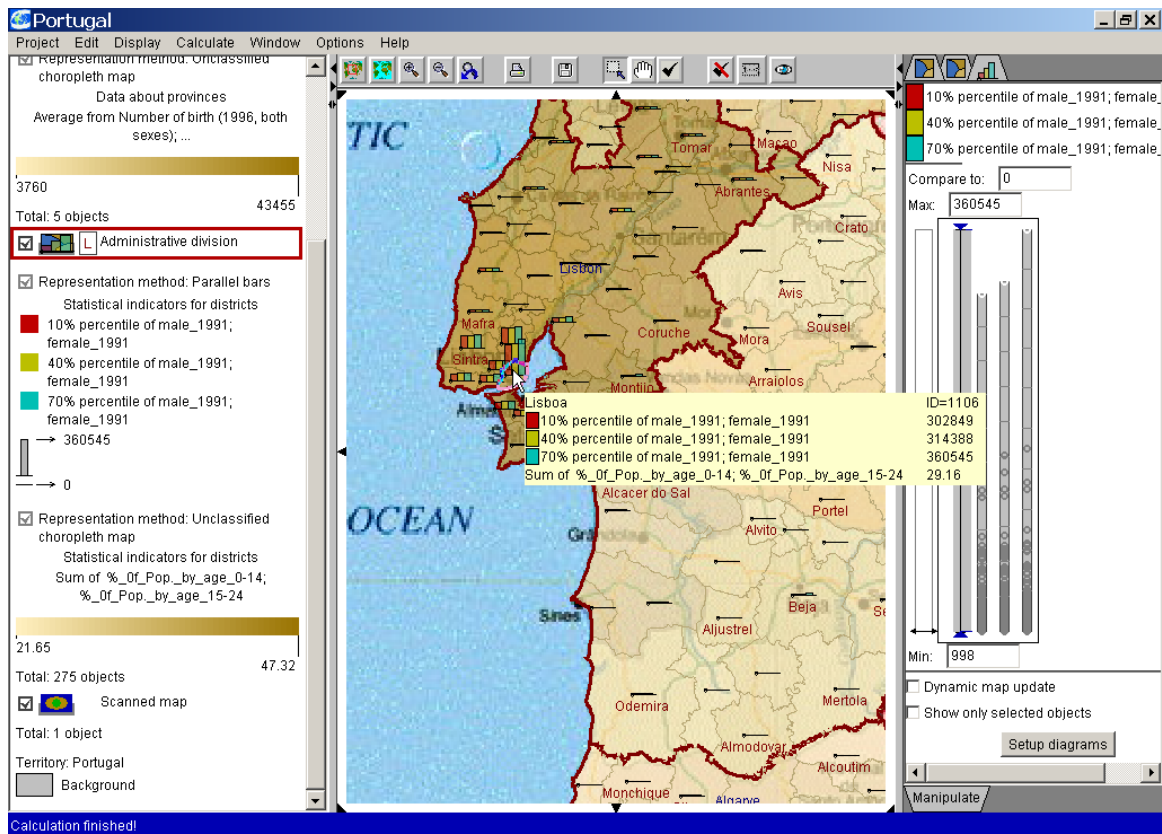


Fig. 4.3.13 Percentiles as bar charts.

Table view: Statistical indicators for districts

identifiers	male_1991	female_1991	10% percentile of male_1991; female_1991	40% percentile of male_1991; female_1991	70% percentile of male_1991; female_1991
Agueda	21469	22576	21469	21690	22576
Albergaria-a-Velha	10739	11256	10739	10842	11256
Anadia	13943	14956	13943	14146	14956
Arouca	11609	12285	11609	11744	12285
Aveiro	32004	34440	32004	32491	34440
Castelo de Paiva	8153	8362	8153	8195	8362
Espinho	16825	18131	16825	17086	18131
Estarreja	12918	13824	12918	13099	13824
Santa Maria da Feira	57573	61068	57573	58272	61068
Ilhavo	16055	17180	16055	16280	17180
Mealhada	8807	9465	8807	8939	9465
Murtosa	4620	4959	4620	4688	4959
Oliveira de Azemeis	32739	34107	32739	33013	34107
Oliveira do Bairro	8803	9857	8803	9014	9857
Ovar	24181	25478	24181	24440	25478
Sao Joao da Madeira	8910	9542	8910	9036	9542
Sever do Vouga	6608	7218	6608	6730	7218
Vagos	9120	9948	9120	9286	9948
Vale de Cambra	12022	12515	12022	12121	12515

Sort by: No selectio Ascending TableLens just selected items Attribute info Attribute..

Fig. 4.3.14 Attributes containing percentiles in table view.

Counting value frequencies – voting results

CommonGIS also offers support for group decision making. One possible scenario of group decision making supposes that the group members individually analyse the range of options and then vote about the options. The person leading the process of group decision making has to evaluate the results of voting. The evaluation can be supported by the “Counting value occurrences” calculation method.

First the vote of each person is stored in a column of a table with rows corresponding to the options. CommonGIS now offers the facilitator the possibility to automatically count the votes.

In the part of the table where the votes are stored, the frequency of each value is counted for each row. For each distinguishable value in the vote attributes a new attribute is created. (The voting may not offer more than 10 different characteristics to be assigned to a voting option.)

The obtained counts can be visualized using all kinds of display methods offered in CommonGIS.

Weighted average

If you want to compute the weighted average of the population density in 1981 and 1991, select

- *Calculate: Calculate in a table*,
- Choose Table 1): Statistical indicators for districts,
- Mark list entry “Weighted average” in window “Calculate”,
- Choose the attributes *Population_density_1981* and *Population_density_1991*,
- Change the attribute name to „*Weighted average: population density*“,

and look at the resulting choropleth map and the diagram in fig. 4.3.15 showing both attributes together with their weighted average as a parallel coordinates plot (see section parallel coordinates plot).

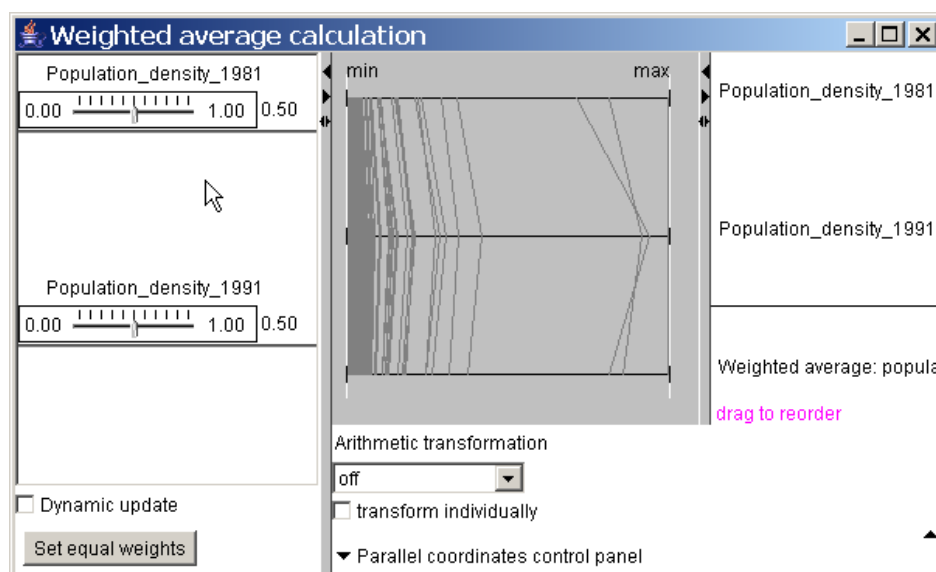


Fig. 4.3.15 Weighted average of population density

Classification and grouping of objects

Grouping or classifying objects can assist to structure the data and to reduce the complexity of the analysis. Menu *Calculate* contains two options for this purpose:

Calculate: Classify objects

Classify objects relative to an attribute.

Calculate: WeKa Knowledge Explorer

Group objects depending on the values of the selected attributes.

Classify objects

For demonstrating this method we return to the example project “Skiing in wallis alps”. In order to exclude the skiing resorts already visited in earlier vacations from the set of alternatives for the next vacation you can group these skiing resorts in a separate class of objects and later easily exclude them from further analysis.

Select

- *Calculate: Classify objects*,
- Choose Table 2): Data about skiing resorts,
- Mark option “create new” in window „Classification attribute“ (see fig. 4.3.16, left)
- Change the attribute name to „Skiing resorts visited“

and look at the window „Classify objects“ (fig. 4.3.16, right) which you can use to create and adjust the classification.

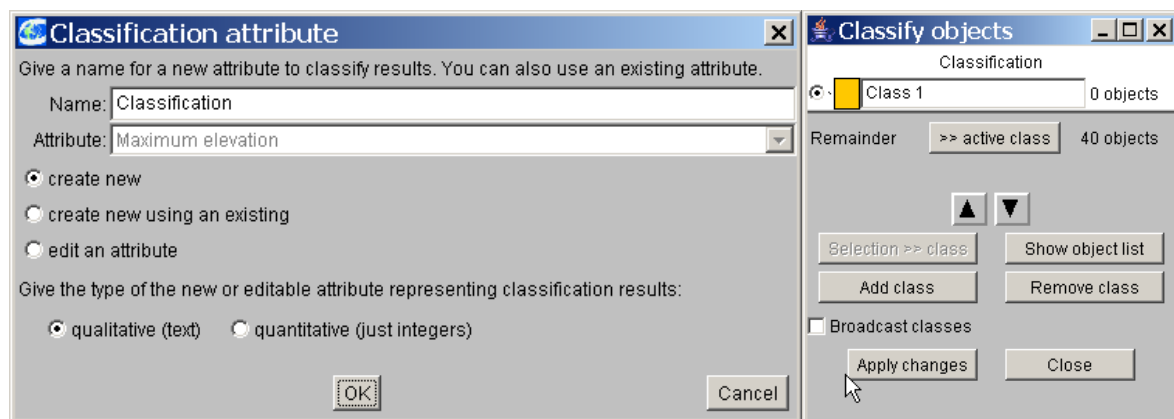


Fig. 4.3.16 Specify classification attribute and adjust classification

Now the user selects by mouse click all the places on the map which he already visited and intends to classify. Then he clicks on the button "selection >> class" in order to assign this selection to a new class. The result is shown in the map in fig. 4.3.17, left. Information about the classification can also be found in the class definition window to the right. The user can adapt the class name, add or delete classes and change the allocation of objects to classes.

In order to add objects to a class select the appropriate class and click on the desired objects on the map. By clicking on "selection >> class" these are added to the selected class.

In order to delete objects from a class select a class, click on button "Show object list " and choose the objects you want to remove from the class.

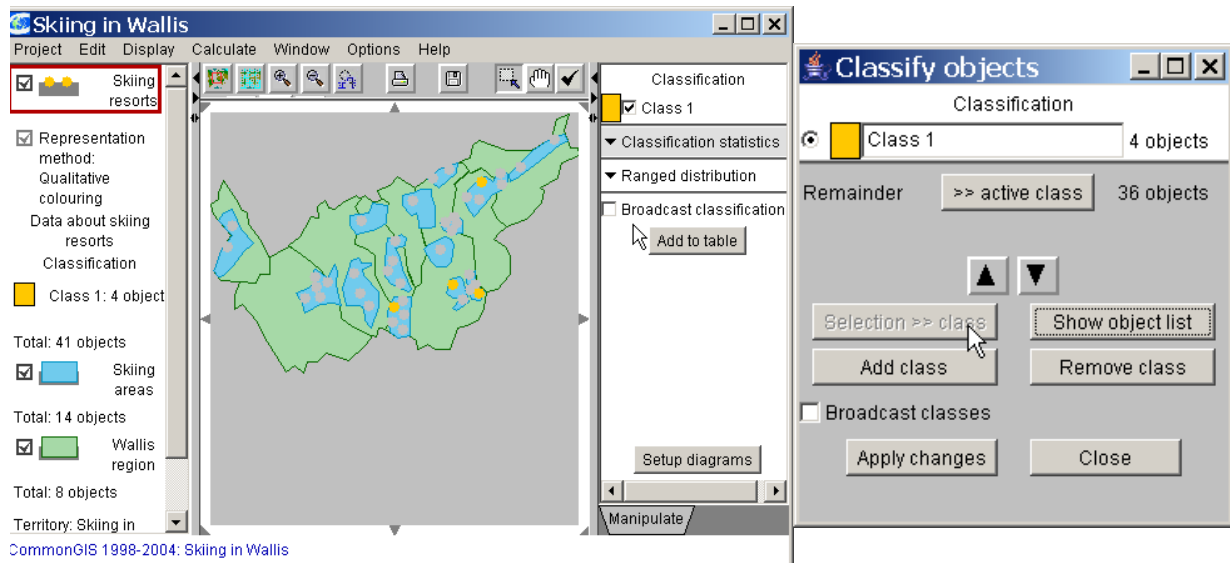


Fig. 4.3.17 Special class with skiing resorts visited.

Analysis of clusters with the WeKa Knowledge Explorer

Clustering can give hints to outliers or striking characteristics which can be examined further within the table view.

Clustering of the attributes *Maximum elevation*, *Number of lifts*, *Price for ski pass*, *Price discount for kids (%)* and *Beginner level runs (%)* from the example „Skiing in the Wallis alps“, section 3.2, produces the groups of skiing resorts in fig. 4.3.19. The user can define the number of classes to create and the set of attributes to use in the special window “Weka Clusterer Control Panel”. The analysis is started if the user clicks on the button “Run clusterer” in this window.

In order to cluster the skiing resorts select

- *Calculate: WeKa Knowledge Explorer*,
 - Choose Table 2: Data about skiing resorts aus,
 - Choose the attributes *Maximum elevation*, *Number of lifts*, *Price for ski pass*, *Price discount for kids (%)* and *Beginner level runs (%)*,
 - Click on button „Run clusterer“ in window „Weka Clusterer Control Panel“
- and look at the resulting map in fig. 4.3.18, right.

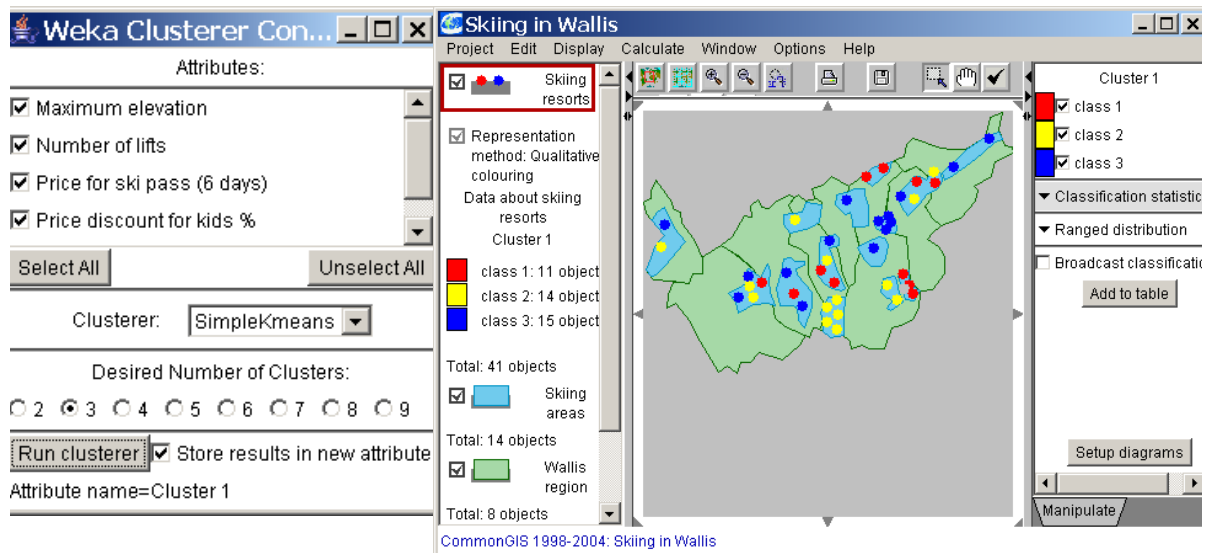


Fig. 4.3.18 Clustering of skiing resorts.

In order to examine the classes more closely broadcast the classification by clicking on the broadcast option in the “Manipulate” window and take a look at the table containing the cluster attribute. Now you can list the data objects e.g. belonging to class 2.

Note: All Weka-based methods are applied to the current state of data and don't react to further data changes. All data records with missing values are ignored.

Calculating on raster data

Sometimes, raster data sets may have some features that make them inappropriate for analysis.

For example, the original raster data set (in BIL-format) on which project „Vegetationsindex“ is based, contains negative values being far below -1.0 while the positive values don't exceed 1.0.

Let us suppose that the user is interested in the vitality – indicating growth or reduction - of green vegetation over time.

For negative values only appear for water and land covered with snow and ice, the user can either filter out all negative values completely (as done in the example project layers) or he can normalize the negative values to lie within a range of -0.1 to 0.

CommonGIS supports the user in adjusting the available raster data to his analysis task. To this purpose menu *calculation* offers a broad variety of *geographic computations*.

Note: When combining raster layers with different spatial resolutions the cell size of the resulting raster will be set to the maximum cell size of the source rasters. If there is not enough memory for the resulting raster, the system will decrease its spatial resolution until it fits to the available free memory.

The following section describes the available raster operations in the order as they appear in the geographic computation menu. As example some transformations on the raster data giving the vegetation index of 1982 and 1993 are performed (data/NDVI_82und93/Vegetationsindex.app).

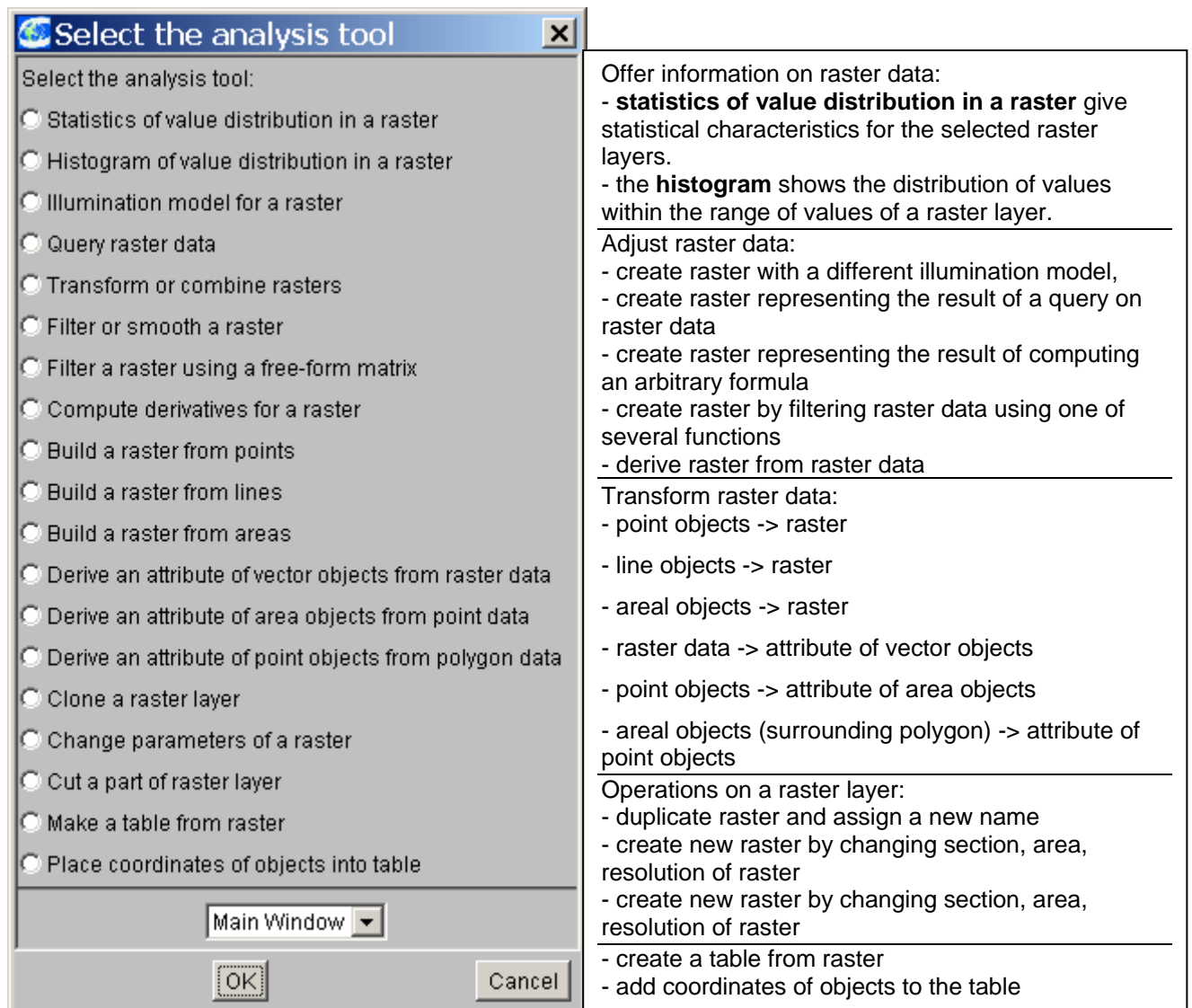


Fig. 4.3.19 Submenu *Geographic Computations*

Information on raster data

The following operations present information on raster data in the form of diagrams on the screen. These diagrams are assembled within the window "Graphic analysis tools" (see also section 4.2: *Presenting spatial data in charts*).

As the computational basis the raster data are taken like they were read in into CommonGIS.

That means, if the range of values is changed in the visual presentation, no storing in the underlying data set is performed and consequently the changes in the data view are not reflected in the data diagrams.

Statistics of value distribution

In order to take a look at the relevant statistical variables of one or more raster layers, select

- *Calculate: Geographic computations,*
- Mark list entry „Statistics of value distribution in a raster“ in window “Select the analysis tool”,

- Choose all raster layers in the selection window, and look at the resulting diagram in fig. 4.3.20 showing the statistical values for the raster layers.

Note: Sometimes some fields seem to contain no value. Only "." appear instead of a number. In order to be able to see all values, you must expand the window in this case.

The statistics of value distribution is formatted in the same way as the attribute statistics described in section 4.2.

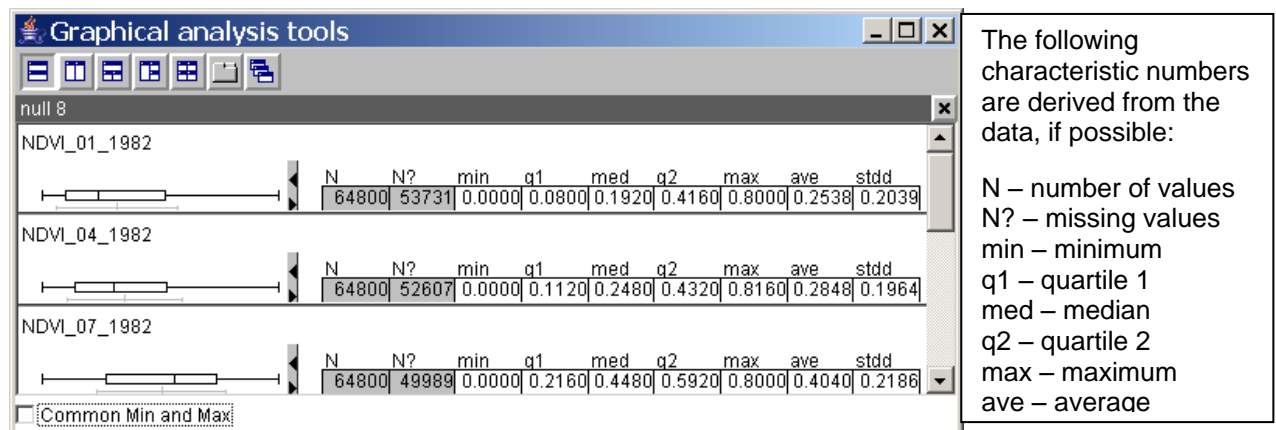


Fig. 4.3.20 Statistics of value distribution for the raster layers „NDVI_01_1982.tif“, etc..

The graphic scales in the left of the statistical variables show the range of values relative to the union of all ranges of the selected layers. Below the values you see another option enabling a comparison between different rasters by equalizing the range of values by adapting common minimal and maximal values.

If you click on the option ☐ Common Min and Max, the graphic scales are standardised so that you can relate the range of values of the rasters to one another.

The number of missing values is very large in this example. This comes from the fact, that only raster values greater than or equal to 0 are loaded by the application.

Histogram of raster value distribution

If you are interested in the distribution of the raster values within a layer, select

- *Calculate: Geographic computations,*
- Mark list entry „Histogram of value distribution in a raster“ in window “Select the analysis tool”,
- Choose a raster layer in the following dialog (e.g. „NDVI_10_1993“),

and look at the resulting diagram in fig. 4.3.21 showing the different values and their frequencies for the raster layer.

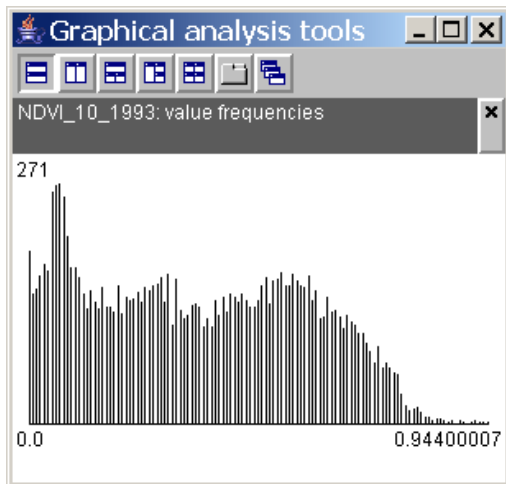


Fig. 4.3.21 Histogram for „NDVI_10_1993“

Adjusting raster data

Raster illumination model

Sometimes raster data can be analysed easier if they can be examined from a different perspective by means of an illumination model.

If you want to enrich some raster layer with an illumination model, select

- *Calculate: Geographic computations,*
- Mark list entry „Illumination model for a raster“ in window “Select the analysis tool”,
- Choose a raster layer in the following dialog (e.g. „NDVI_10_1993“),
- Adapt parameters „Azimuth“ und „Angle“ to your purposes (see fig. 4.3.22),
- Accept or change the suggested name „Illumination of NDVI_10_1993“ for the new layer

And look at the resulting map in fig. 4.3.23.

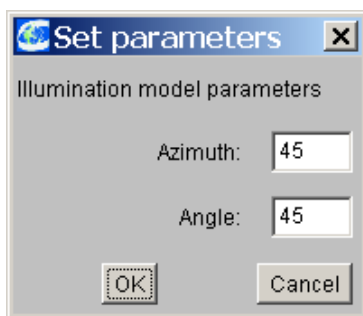


Fig. 4.3.22 Parameters dialog for adjusting the illumination model.

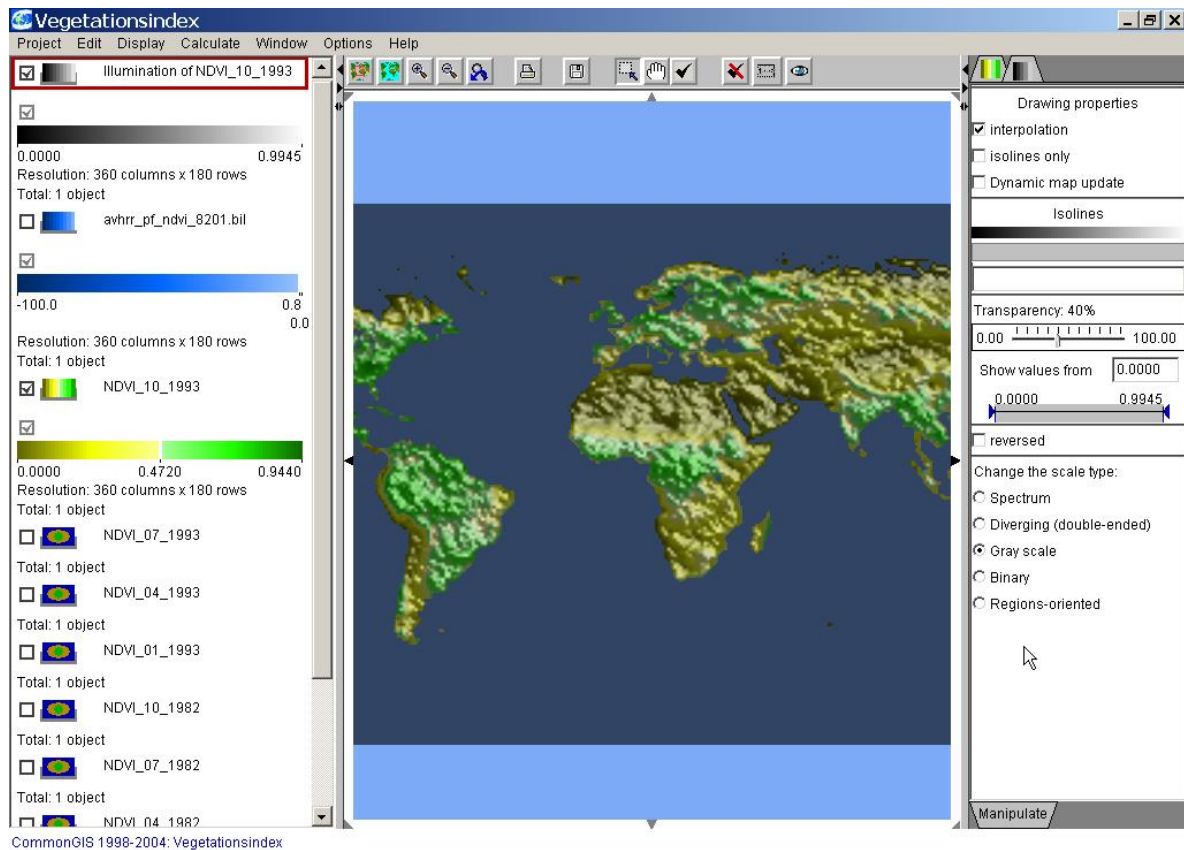


Fig. 4.3.23 Illumination model for layer „NDVI_10_1993“

Query raster data

With this option the user can compare the displayed data or narrow the data to a specific view. Another application would be to identify areas or objects with special characteristics on the map by displaying them exclusively and fading out the other areas, which do not have the desired characteristics.

For this purpose a formula can be defined using arithmetic and comparative as well as logical operators.

In order to create a raster map highlighting the zones with a very high vegetation index for layer „NDVI_10_1993“, select

- *Calculate: Geographic computations,*
- Mark list entry „Query raster data“ in window “Select the analysis tool”,
- Specify the formula for extracting the values exceeding a limit of 0.75 in the following dialog (see fig. 4.3.24),
- Accept or change the suggested name „NDVI_10_1993>0.75“ for the new layer and look at the resulting map in fig. 4.3.25.

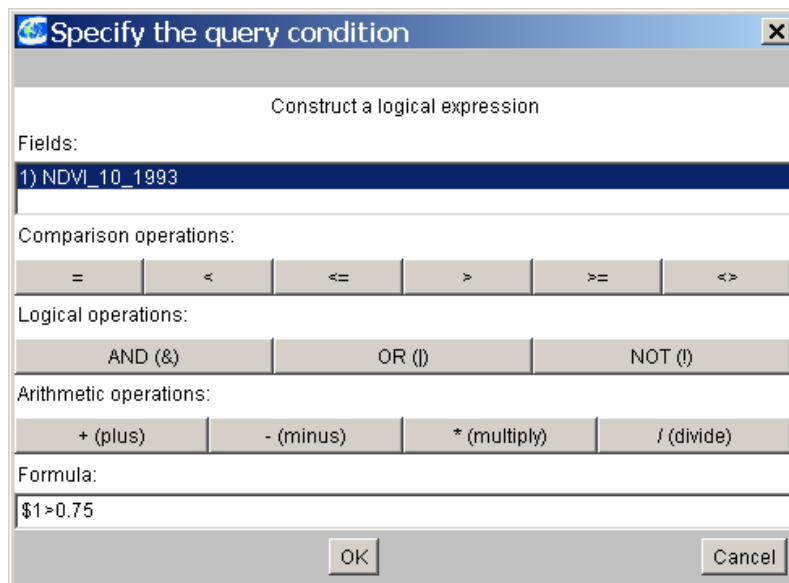


Fig. 4.3.24 Constructing a query on raster data

The formula is set up in the input line in the lower part of the window, as the user either directly types it into the input field or transfers the parts from the upper part of the window by clicking on the appropriate operator button. The variable for a raster level is inserted by doubleclick; to input an operator from the bars only one click is necessary. In order to structure a formula, partial expressions can be put in parentheses.

As a result a new layer with a binary raster is produced: cells meeting the query are assigned value 1, the others get a value of 0. On the map only the cells with value 1 are drawn; the default colour scale is binary and as drawing colour red is preset. You can change both in the lower right part of the "Manipulate" column.

If layers with different expansion are addressed by a formula, the user can choose whether the expansion of the new layer is determined by union or intersection of the selected rasters. By intersection the largest rectangle present in all rasters is constructed while union creates the smallest rectangle, which contains all rasters.

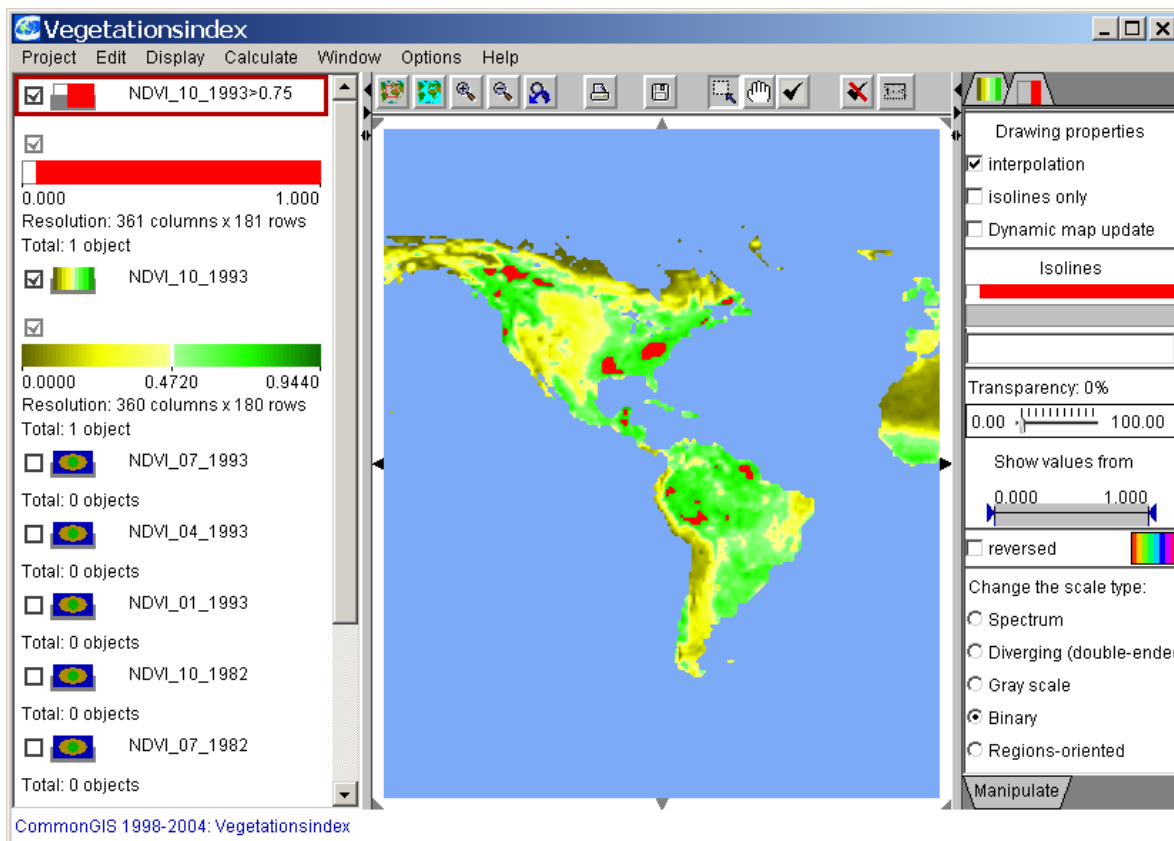


Fig. 4.3.25 New layer with binary scale as query result

Transform or combine raster data

Even more options for computations on raster data are given by menu *Calculate*:

Geographic computations:

Transform or combine rasters.

The available functions and operators are listed in fig. 4.3.27 (see also section 4.3 *Calculating on tables: Arbitrary formulas*).

In order to create a raster map showing the vegetation index for layer „NDVI_10_1993“ normalised from - 0.1 to 0.1, load the original raster data (in BIL-format) from file “data/NDVI_82und93/avhrr_pf_ndvi_9310” using menu *Project: Data import – BIL file*. You see the complete map of the world including the areas with a vegetation index smaller than 0. The values cover a range from -100 to 1.0.

Now select

- *Calculate: Geographic computations,*
- Mark list entry „Transform or combine rasters“ in window “Select the analysis tool”,
- Specify the formula for standardising the negative values in the following dialog (see fig. 4.3.26),
- Accept or change the suggested name „ NDVI_10_1993_normalised“ for the new layer

And look at the resulting map in fig. 4.3.28.

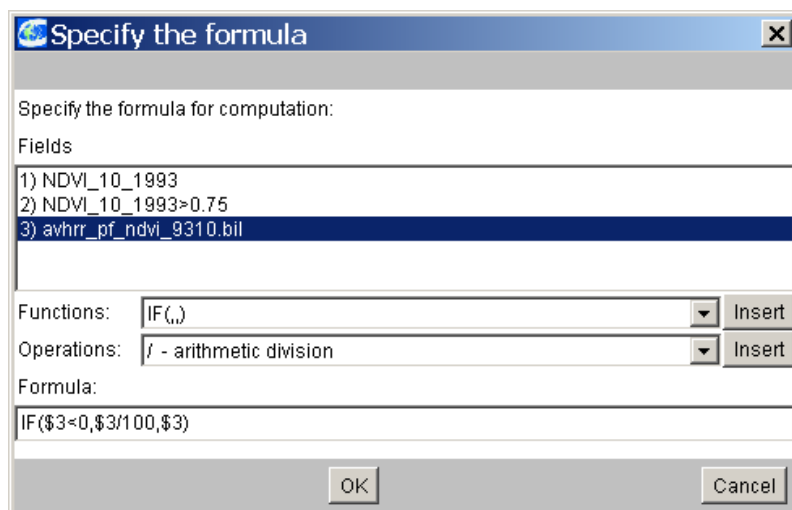


Fig. 4.3.26 Constructing a formula on raster data

The formula is set up in the input line in the lower part of the window, as the user either types it in directly or transfers the formula parts from the upper part of the window by clicking on the appropriate buttons. The variable for a raster level is inserted by doubleclick; to input an operator from the lists select it and click on the “Insert”-button.

Name of function	Definition of function	Operator (and definition)
ABS()	Absolute value	+ - arithmetic addition - - arithmetic subtraction * - arithmetic multiplication / - arithmetic division < - comparison less <= - comparison less or equal > - comparison greater >= - comparison greater or equal = - comparison equal <> - comparison not equal ! - logical not & - logical and - logical or
ATAN()	Arctangent	
BLK()	BLK(x)=1 if x is defined, else BLK(x)=0	
COS()	Cosine	
DAY(,)	Day(year,month,day) counts the number of days from 1970.1.01	
EXP()	Exponent	
IF(,)	If logical expression a is true then result is b else c	
INTR(,)	INTR(x,x1,y1,x2,y2...) gives value in point x of piece-linear function defined by knots (xi, yi).	
LN()	Natural logarithm	
LG()	Logarithm	
MAX()	Maximum value	
MIN()	Minimum value	
RAND()	Random value	
ROUND()	Round value	
SIGN()	Algebraic sign	
SIN()	Sine	
SQRT()	Square root	

Fig. 4.3.27 Functions and operators in formulas

After the user has confirmed the formula by clicking the “OK”-button the new layer is computed. Before the layer is drawn the user is requested to name the layer. As shown in fig. 4.3.28, CommonGIS has assigned a diverging colour scale to the layer. The user can adapt the map to his needs by e.g. changing the colour of both scale parts.

The original layer „avhrr_pf_ndvi_9310“ is not used anymore and can either be switched off (click on the checkbox left to the layer name in the legend) or even removed from CommonGIS (to save memory). The layer can be removed from the project by menu option *Edit: Remove layer* (see section 4.1).

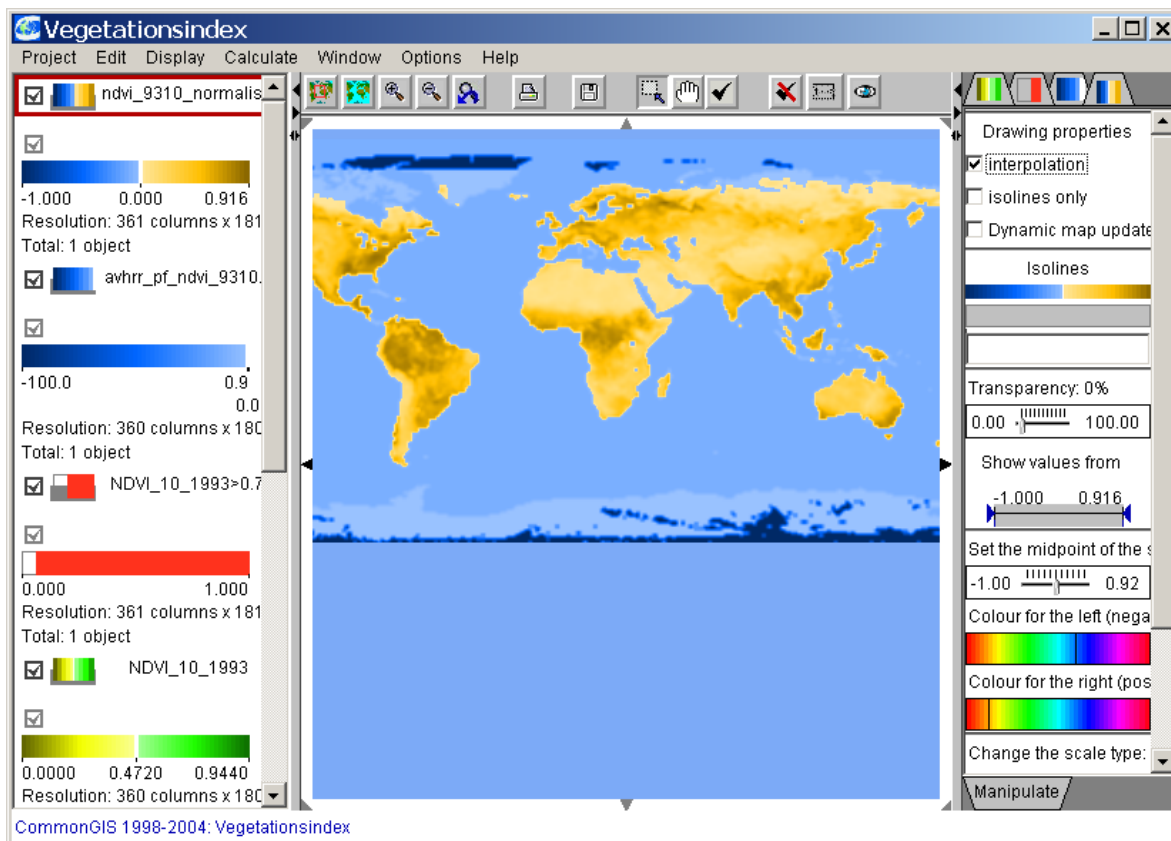


Fig. 4.3.28 Result of raster transformation

Filter or smooth raster data sets

In order to be able to recognize general patterns or spatial tendencies you can smooth a raster layer, thus making individual values step back. This operation can be based on different criteria. The parameters offered by CommonGIS are listed in fig. 4.3.29.

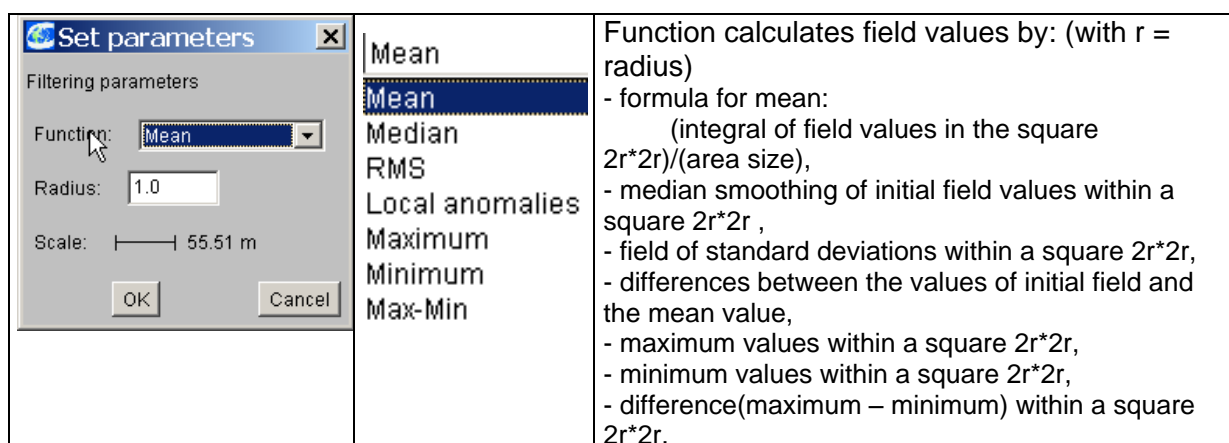


Fig. 4.3.29 Functions to filter or smooth a raster layer.

In the two pictures in fig. 4.3.30 you can see the effect of smoothing the layer "NDVI_10_1993" with function "mean". (Smoothing is initiated by calling menu option *Calculate: Geographic computations* and selecting list entry „Filter or smooth a raster“.)

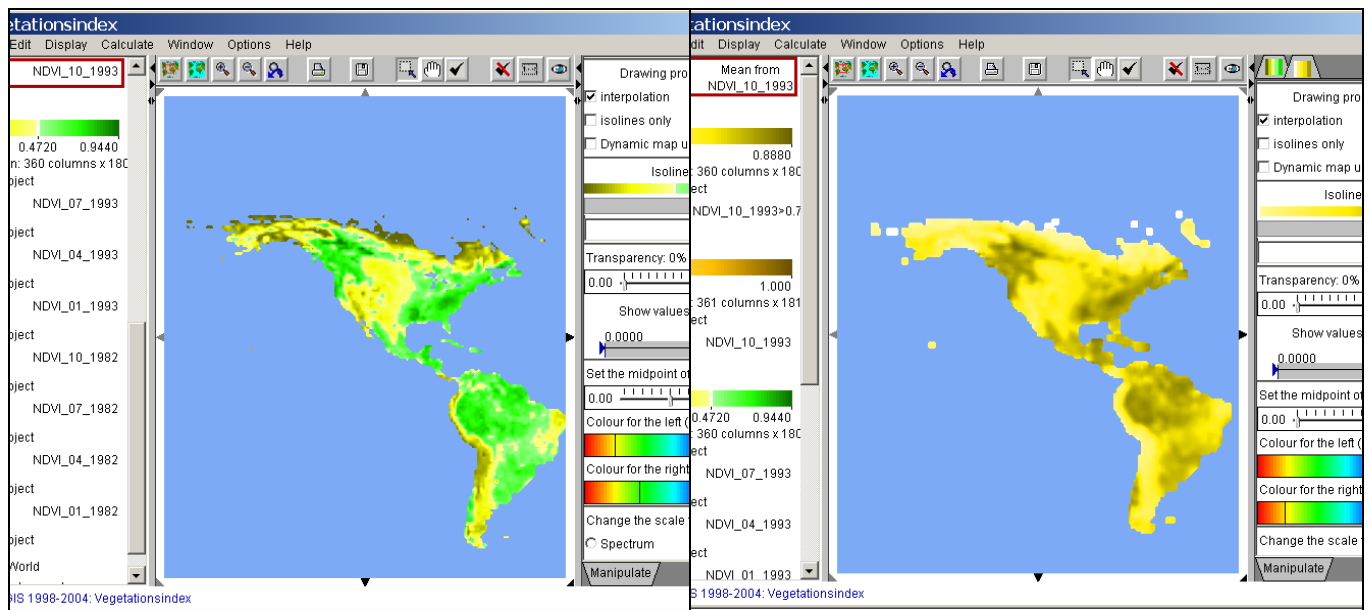


Fig. 4.3.30 Smoothing of layer „NDVI_10_1993“ with function „mean“

Filter a raster using a „free-form matrix“

Another way of filtering is the application of a matrix of values, by which the raster cells are multiplied and then normalised.

After the user has selected the size of the free-form matrix he enters the values to be multiplied with. The entries in the matrix thus represent weightings. The value in the field "scale" determines by which number the result should be divided after weighting and summing up. Usually this value should correspond to the sum of the weights in the matrix (see example in fig. 3.4.31, right).

Depending on the task it may be meaningful to smooth a raster layer, thus making individual values step back and stress trends. On the other side you can point out differences by applying negative values in the matrix.

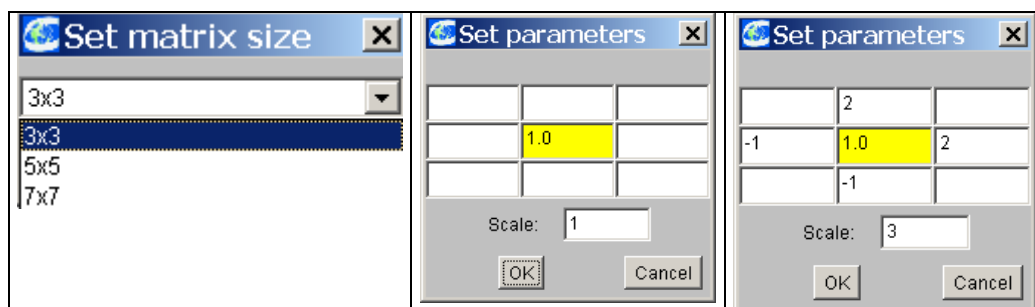


Fig. 4.3.31 Parameter of matrix

Compute derivatives for a raster

Select menu *Calculate:*

Geographic computations:

Compute derivatives for a raster.

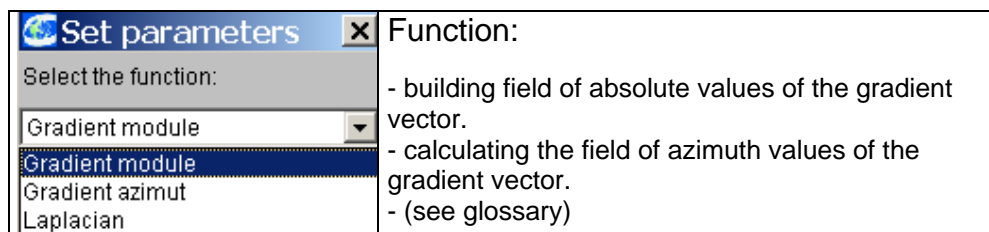


Fig. 4.3.32 Functions for deriving raster data

Transforming raster data

Data transformations of vector to raster format and reverse allow to generate missing data in both formats. Thus the data set can be completed and applied for a broader spectrum of geographical visualisations and operations.

Transform point objects to raster data

If you want to find out in which region most of the skiing resorts in the Wallis alps are located, you can create a raster from layer „Skiing resorts“ of the „Wallis“ project.

Select

- *Calculate: Geographic computations,*
- Mark list entry „Build a raster from points“ in window “Select the analysis tool”,
- Choose point layer Skiing resorts,
- Select parameter „Density“ as function and type in „0.1“ as radius of buffer (see fig. 4.3.33, left),
- Accept all further parameters (see fig. 4.3.34, right),
- Accept or change the suggested name „Density of Skiing resorts“

And look at the resulting map in fig. 4.3.35.

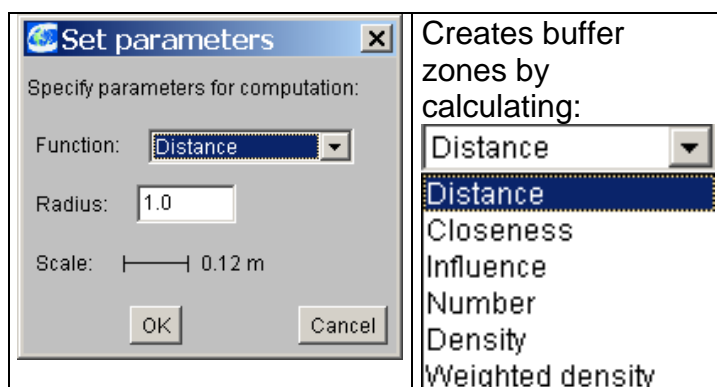


Fig. 4.3.33 Functions to transform vectors to rasters.

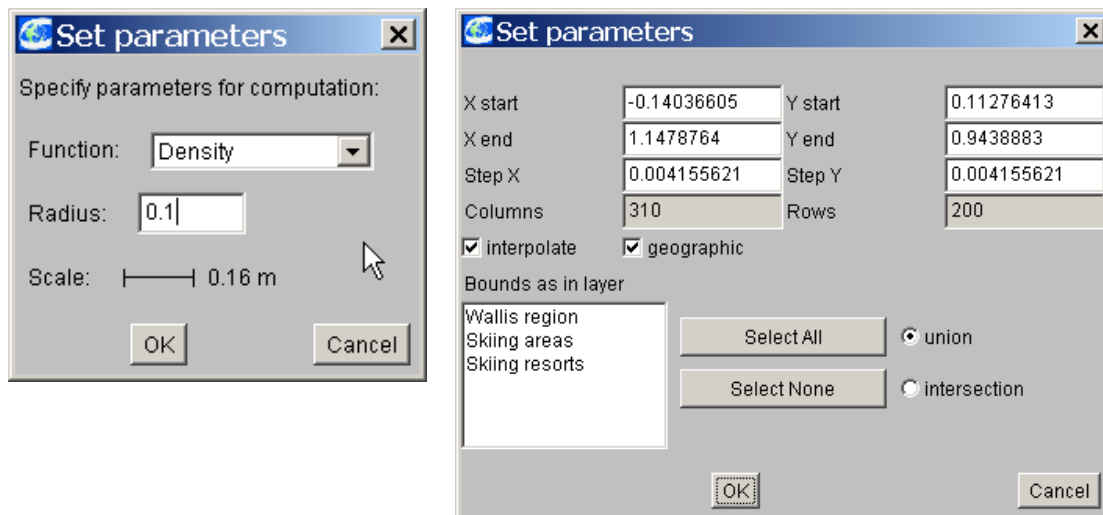


Fig. 4.3.34 Parameters for creating raster.

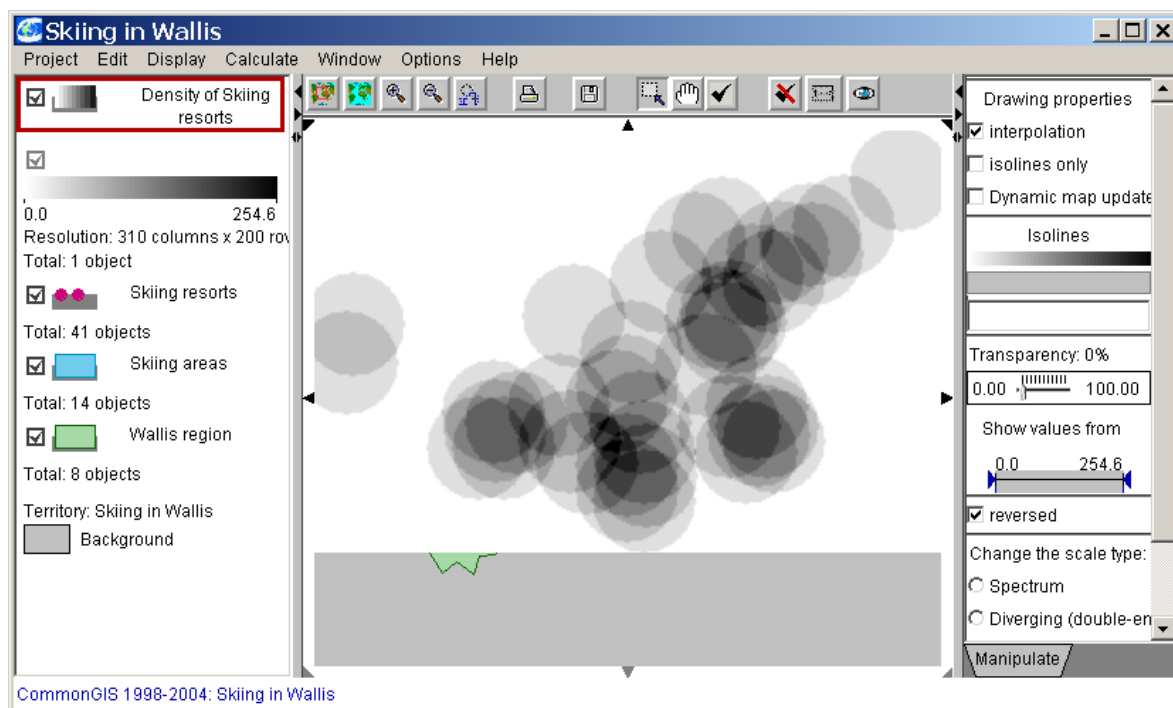


Fig. 4.3.35 Raster from points showing high density of resorts in the south.

Transform line objects to raster data

The geographic analysis function "*Build a raster from lines*" creates a raster relative to line data depending on the computational function selected. The user proceeds in exactly the same way as in the case of point data.

Transform area objects to raster data

Function „*Build a raster from areas*“ of menu option *Calculate: Geographic computations* creates a raster for every attribute of an area object depending on the selected parameters. First, the user selects the layer and the desired attributes of this layer and finally he sets the parameters suitable for the production of the rasters. As result a raster layer is provided for each attribute selected and you can give a suitable name for each new raster layer.

Transform raster data to attributes of vector objects

The following example shows how a new attribute for a vector object can be produced from raster data.

We use the raster layer "Density of skiing resorts" just created and the vector layer "Skiing resorts" from the "Wallis" project.

Note: The layers affected by transformations must be loaded into CommonGIS, either implicitly by project definition or explicitly by activating the small box before the layer name (see delayed data loading). Otherwise the message "No appropriate layers available!" appears.

A new attribute shall be created indicating the average density of skiing resorts within skiing areas.

Select

- *Calculate: Geographic computations,*
- Mark list entry „Derive an attribute of vector objects from raster data“ in window „Select the analysis tool“,
- Choose vector layer Skiing areas,
- Choose raster layer Density of skiing resorts,
- Select parameter „mean“ as function, type in „mean density“ as attribute name und checkmark option „include partial zones“ (see fig. 4.3.38).

For every area of layer Skiing areas the new attribute „mean density“ is calculated now (in case of a large amount of data progress is displayed in the status line below).

As a result the table Data about skiing areas is extended with the new attribute (menu *Display: View table*). The new attribute is also visualised within a choropleth map. If necessary you have to rearrange the sequence of the layers within the legend to see the target layer on the map. In our example you can hide raster layer „Density of skiing resorts“ to see the resulting map (fig. 4.3.39).

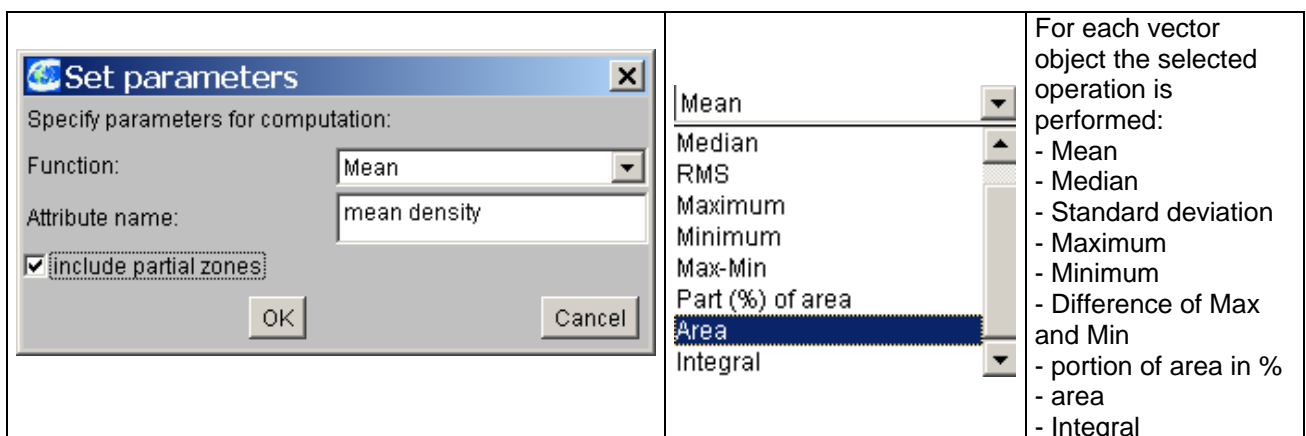


Fig. 4.3.38 Parameter for raster transformation

Note: Activating option „include partial zones“ guarantees that all objects are considered within the calculation. Otherwise objects which are not completely covered by the raster layer would be excluded from calculation.

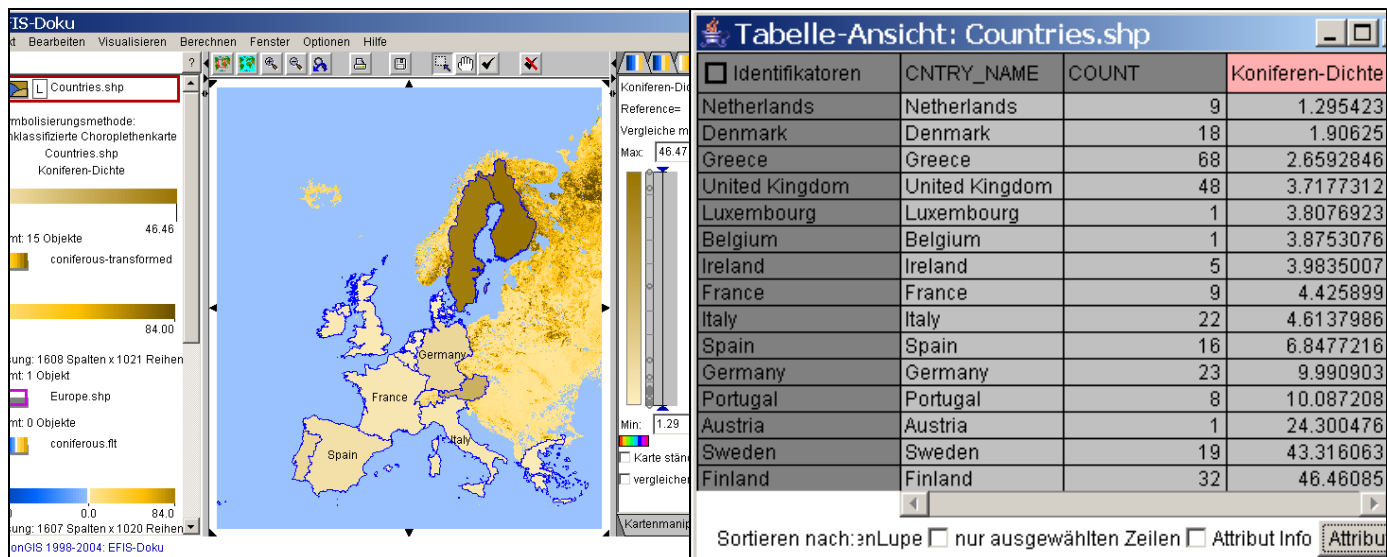


Fig. 4.3.39 Result of calculating an attribute from raster.

Derive an attribute of area objects from point data

Derive an attribute of point objects from polygon data

Operations on a raster layer

Copy a raster layer

If the user needs the same raster several times in order to perform different operations on the same basis or produce different visualisations he can duplicate a raster layer.

Select

- *Calculate: Geographic computations*,
- Mark list entry „Clone a raster layer“ in window “Select the analysis tool”,
- Choose the layer to be duplicated,
- Enter a name for the new layer

And look at the new layer within the CommonGIS window.

Change parameters of a raster or cut a part of a raster layer

Both options allow it to change and store a raster layer as a new layer with certain characteristics different from the original raster layer. The available parameters are represented in fig. 4.3.40.

- By changing the values of *X start*, *Y start*, *X end* and *Y end* you can restrict a raster data set to the desired spatial dimension.
- The values for *Step X* and *Step Y* specify the height and width of a raster cell. If you change these values (use *Enter* to confirm) the number of *rows* and *columns* is adapted as well as the values for *X end* and *Y end*.

You can use other layers as reference in order to define the expansion of a layer or to build intersection or union:

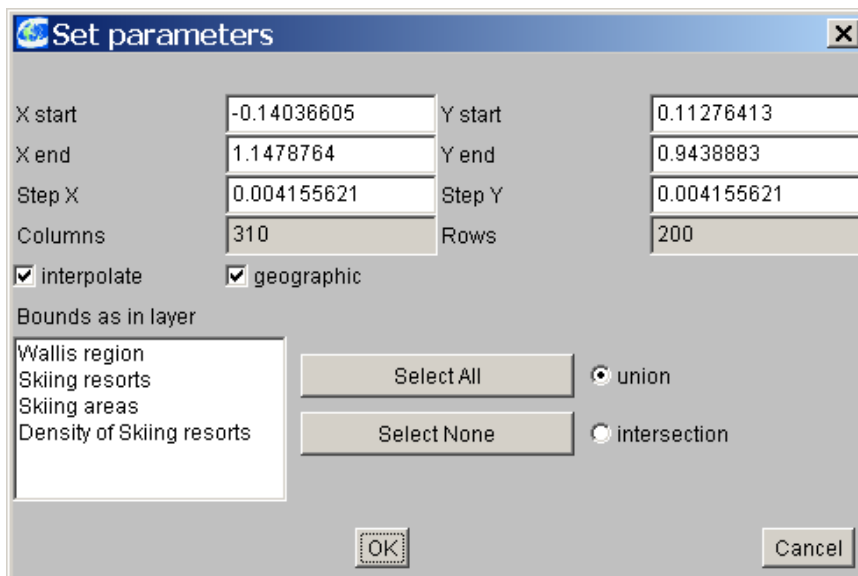


Fig. 4.3.40 Adjusting a raster by changing parameters.

Note: By changing *Step X* and *Step Y* a raster resolution can be refined or reduced. Refinement is limited to the available memory. The smaller the raster cells the more memory is needed. There is a tradeoff between a sufficiently precise raster presentation and the demand for memory.

Make a table from raster

If the user wants to apply the parameters of a raster layer as raw data he can generate a table from the raster including the attributes *x*, *y*, *x1*, *y1*, *x2*, *y2*, *Mean*, *Median*, *Mode*, *Standard deviation*, *Maximum*, *Minimum*, *Difference of Maximum and Minimum* and *Sum*.

In order to compare the raster layers „NDVI_10_1993“ and „NDVI_10_1982“ based on statistical characteristics produce a set of attributes from these raster layers.

Select

- *Calculate: Geographic computations,*
- Mark list entry „Make a table from raster“ in window “Select the analysis tool”,
- Choose the layers „NDVI_10_1993“ and „NDVI_10_1982“ to be used for calculation,
- Change the name of the new layer to „Grid for 10-93 and 10-83“

And look at the new layer in the CommonGIS window (fig. 4.3.42) and window „Grid“ offering tools to change the granularity of the grid.

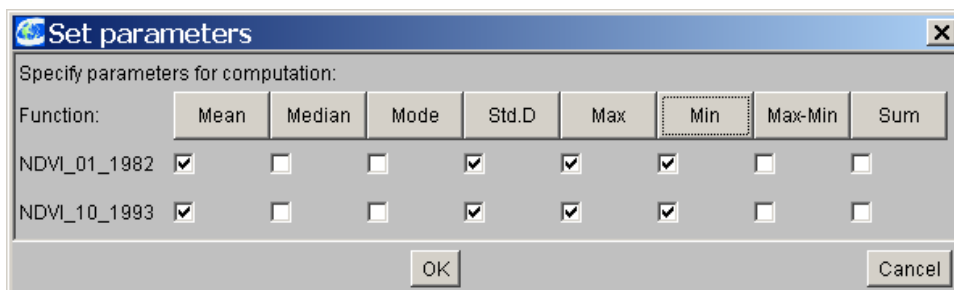
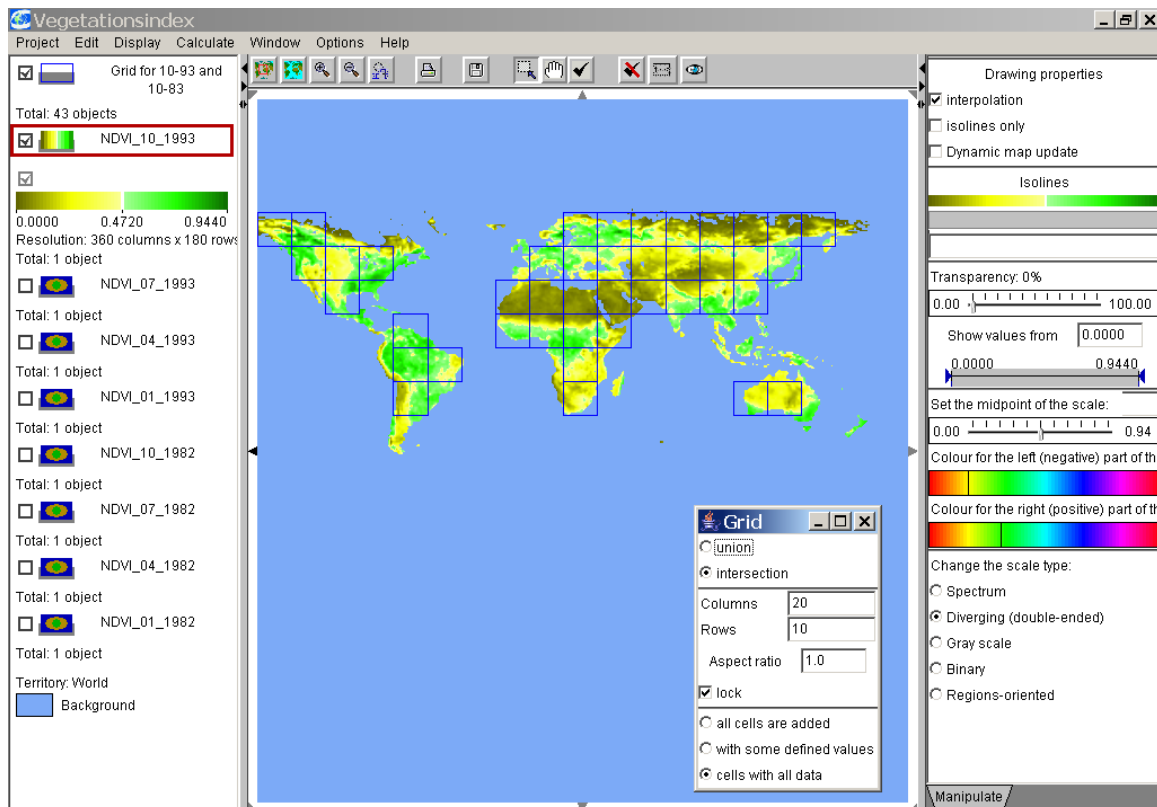


Fig. 4.3.41 Possible attributes in table.



CommonGIS 1998-2004: Vegetationsindex

Fig. 4.3.42

The attribute values are calculated for each cell; the cell sizes are larger than the original ones. In order to change the cell size adapt the number of columns and rows (confirm with *Enter* key). The attribute values are computed again and the table is adapted accordingly.

If you want to look at the data produced use menu option *Display: View table* and select interesting attributes.

Table view: Grid for 10-93 and 10-83

	NDVI_10_1982 - Mean	NDVI_10_1982 - Std.D	NDVI_10_1982 - Max	NDVI_10_1982 - Min	NDVI_10_1993 - Mean	NDVI_10_1993 - Std.D	NDVI_10_1993 - Max	NDVI_10_1993 - Min
6_3	0.4254865	0.20984879	0.76000005	0.0080	0.4194631	0.20299026	0.744	0.016
11_3	0.23341936	0.09885131	0.536	0.064	0.2667097	0.11020135	0.512	0.080000006
16_3	0.24297006	0.1221352	0.66400003	0.104	0.3333653	0.15364097	0.744	0.17600001
17_3	0.18634146	0.06466337	0.44000003	0.016	0.25619513	0.10072391	0.648	0.048
6_4	0.53627163	0.10999049	0.72	0.016	0.60938275	0.14231023	0.808	0.0080
7_4	0.42308825	0.116070956	0.64000005	0.136	0.48250002	0.12699461	0.712	0.17600001
11_4	0.3899185	0.12623103	0.688	0.120000005	0.37015676	0.1514195	0.8	0.08800001
6_5	0.4955583	0.09342325	0.66400003	0.216	0.6217914	0.11334393	0.79200006	0.264
9_5	0.33413473	0.17317863	0.58400005	0.032	0.407171	0.1968637	0.73600006	0.040000003
10_5	0.3081612	0.18491852	0.57600003	0.0080	0.3882491	0.23198378	0.776	0.016
11_5	0.36002472	0.20325671	0.69600004	0.0080	0.41792595	0.23907655	0.776	0.024
12_5	0.23759261	0.16934869	0.6	0.0	0.23030415	0.17956842	0.688	0.0
4_6	0.36501697	0.13834493	0.64000005	0.104	0.51396614	0.15680882	0.84800005	0.2
9_6	0.061714288	0.049292136	0.30400002	0.0080	0.08095853	0.055363808	0.35200003	0.024
10_6	0.05385235	0.026006054	0.16000001	0.0	0.07079195	0.027455818	0.224	0.016
11_6	0.040442556	0.025515035	0.256	0.0	0.061063293	0.030988522	0.312	0.0
12_6	0.048546765	0.034979362	0.256	0.0	0.07630556	0.04766335	0.256	0.0
13_6	0.0723077	0.059826713	0.36	0.0	0.11633614	0.079231896	0.47200003	0.0080
14_6	0.28357005	0.16696343	0.624	0.0080	0.37284145	0.1880491	0.688	0.032
15_6	0.42703897	0.17742541	0.712	0.032	0.4467273	0.18684123	0.776	0.024
16_6	0.41408697	0.08682873	0.6	0.24800001	0.4854348	0.1303689	0.79200006	0.15200001
3_7	0.3909388	0.17546044	0.76000005	0.032	0.47836736	0.19710603	0.84800005	0.048
4_7	0.3598762	0.1174139	0.64000005	0.14400001	0.4111703	0.11297647	0.75200003	0.14400001
5_7	0.5034126	0.08768103	0.67200005	0.224	0.5224336	0.18818702	0.85600007	0.048
10_7	0.46728304	0.100921705	0.712	0.16000001	0.5081887	0.13556427	0.768	0.112

Sort by: No selection Ascending ☐ TableLens ☐ just selected items ☐ Attribute info Attribute...

Fig. 4.3.43 Table created from raster layers.

Place coordinates of objects into table

If you need the positional values of some object add the coordinates x and y to the table by selecting

Menu *Calculate:*

Geographic computations:

Place coordinates of objects into table.

4.4. Relating data

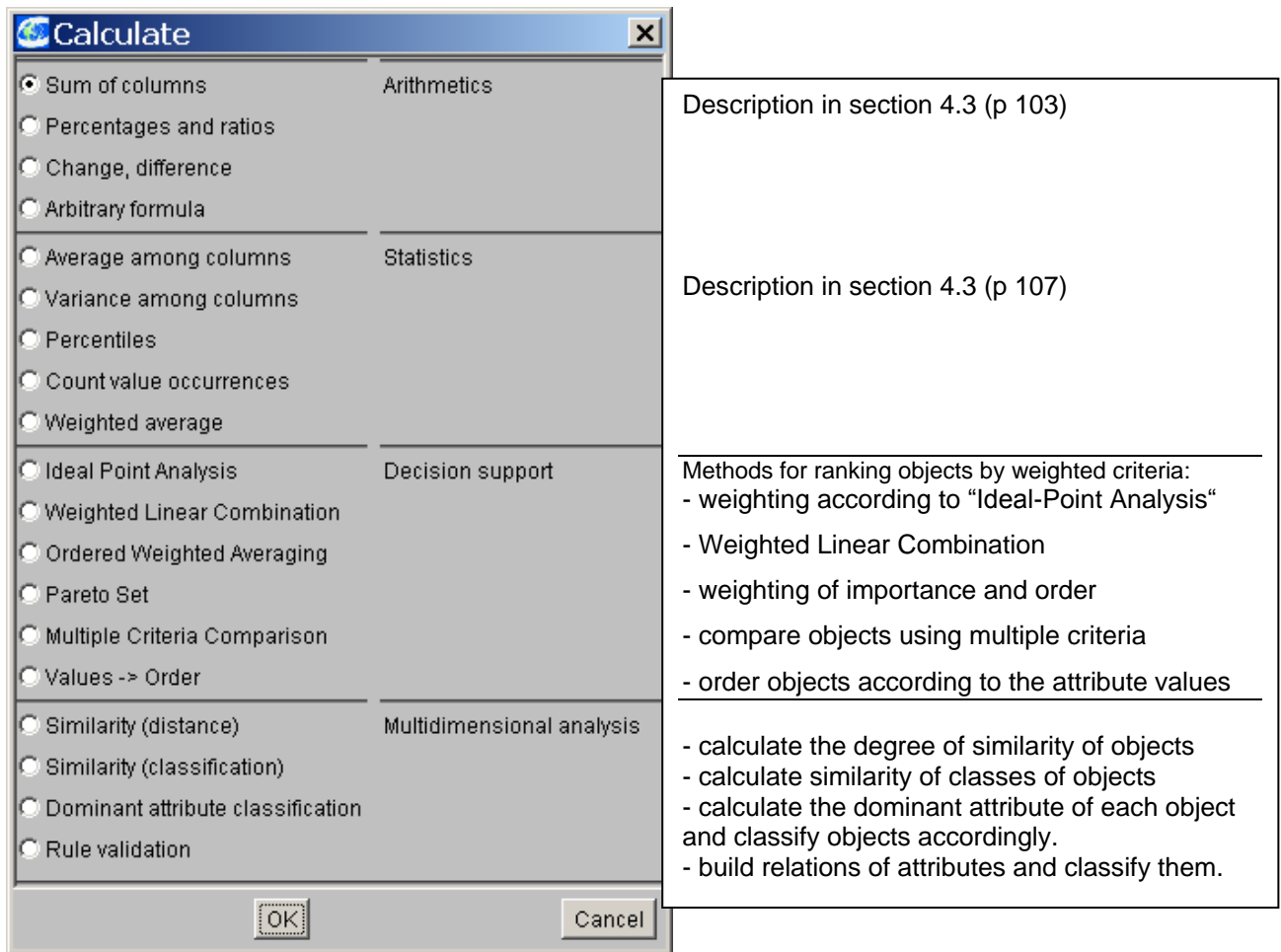
Often decisions must be made based upon the available data. In many cases there is no “one best decision” - options which show optimal value occurrences concerning some attributes hold perhaps poor values in other attributes. So when assessing options for data analysis, several selection criteria with regard to the data sets must be applied.

CommonGIS offers a number of computational methods to evaluate objects on the basis of multiple criteria and rank them according to the relative importance of the criteria.

These methods rely on the following conditions:

- Criteria are numeric or ordinal attributes.
- Types of criteria:
A benefit criterion should have attribute values as high as possible to be appropriate, a cost criterion should have values as small as possible.
- Importance of criteria:
Direct weighting or ranking,
indirect specification via tolerance intervals.
- Types of result:
Evaluation score or ranking,

subset of options approximating the specified objective best.



Multi-criteria decision making

Analysis of data for sound decision making often involves the task to recognize and evaluate the required data. CommonGIS supports the user with the search of options – it enables the user to select a suitable object set and to evaluate the object characteristics. Evaluating objects is done by summarizing the decision-relevant attributes according to their relative meaning (weighting) (see also Utility Bars and Utility Wheels in section 4.2).

We use again the project „wallis.app“ to demonstrate how CommonGIS supports the user in sound decision making when searching for a suitable skiing resort (see also section 3.2, example „Skiing in the Wallis alps“).

Ideal-Point Analysis

If you want to compare skiing resorts especially suitable for families with children, select

- *Calculate: Calculate in a table*,
- Choose *Tabelle 2: Data about Skiing resorts*,
- Mark list entry „Ideal Point Analysis“ in window „Calculate“,
- Choose the attributes *Price discount for kids %*, *Beginner level runs %*, *Maximum elevation* and *Price for ski pass (6 days)*,
- Accept the names „*Evaluation score*“ and „*Ranking*“ suggested by the system,

and look at the resulting choropleth map in fig. 4.4.1 on the left and the new dialog window for the „Ideal Point “ decision support method (right in fig. 4.4.1).

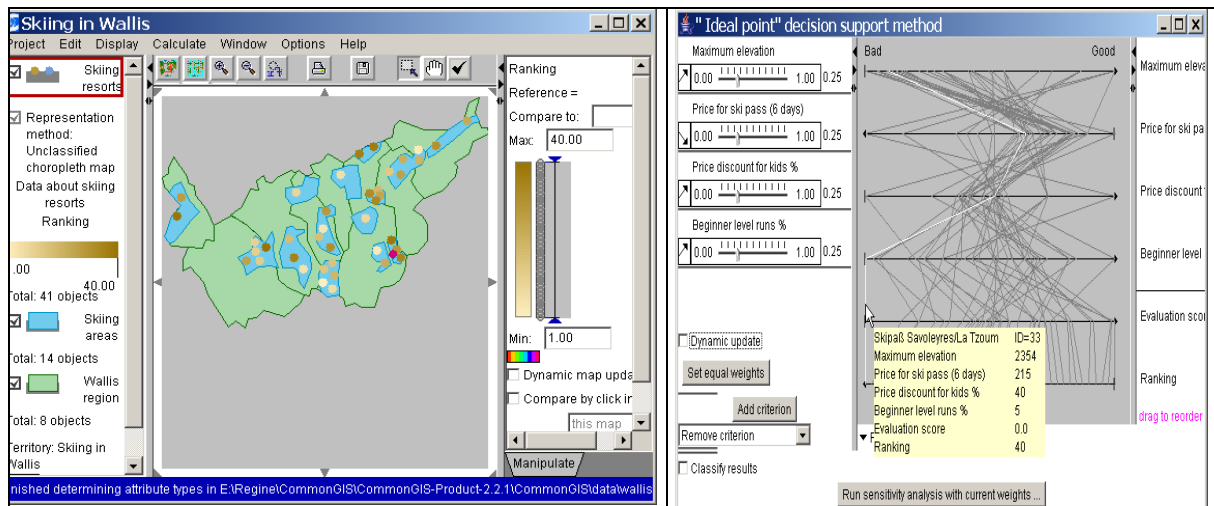


Fig. 4.4.1 Ideal Point Analysis of Wallis skiing resorts

Within the choropleth map the evaluation of the point objects after execution of the ideal point method is shown colour coded: The 40 existing skiing areas are arranged in order on a scale from 1 (light brown) to 40 (dark brown).

In the additional analysis window the attributes selected for evaluation (selection criteria) and their weightings are listed. A scale from 0 to 1 is assigned to each attribute allowing the user to specify the relative importance of the attribute. The currently assigned weight is indicated in a number right of the scale. The option "set equal weights" below the list of scales attaches the same weight to all attributes.

Note: CommonGIS assumes all criteria to be numeric attributes. If you want to use a qualitative attribute you have to specify an order of preference among its values and encode the values by numbers like 1, 2, 3, ... or -1, 0, 1.

Moreover for each attribute you can specify whether it should affect the analysis positively or negatively. The arrow before the attribute name indicates whether the influence of the attribute is to be maximized or minimized. If the arrow shows upward right higher values of this attribute will lead to better results (benefit criterion). If it points downward right, then the attribute is to be minimized, i.e. the smaller the attribute values, the better (cost criterion).

The characteristics of the selection criteria are also presented in a graph with parallel coordinates. The lengths of the axes reflect the relative weighting of the criteria: the more important a criterion, the longer is the associated axis. In this graph the two attributes *Evaluation Score* und *Ranking* produced by the analysis method are inserted as well. The *Evaluation Score* is calculated from the values of the selection criteria and their weights and determines the *Ranking* of the options. A ranking of 1 marks the best option while the highest ranking value (40 in this case) denotes the worst option. Vice versa the best option gets an evaluation score of 100 and the worst option has an evaluation score of 0 (see table right in fig. 4.4.2).²

² More details on this method are described in <http://www.ais.fraunhofer.de/and/2003-12-Prague/lection5.ppt>.

In order to analyse the result in more detail you can classify the options according to their ranking. Click on the option "classify results" at the bottom of the window "Ideal point decision support method". Three groups are formed dividing the options with high, medium and low ranking values. The affiliation to a group is visualised by different colours in the choropleth map. The classification can be transferred into the table (or any other presentation) by clicking on the small box "Broadcast classification" in the manipulation window.

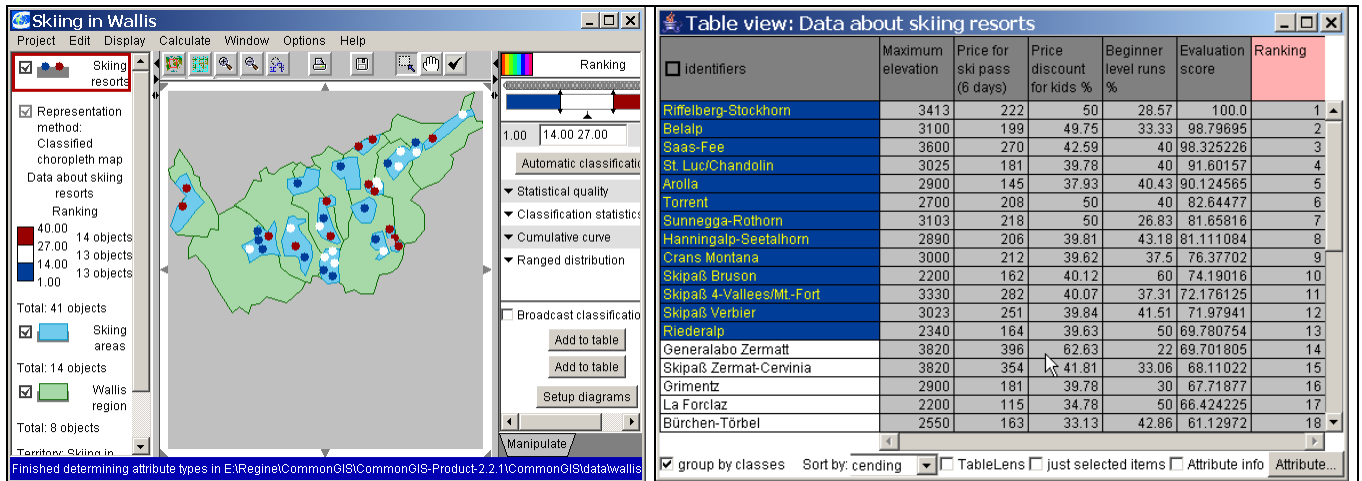


Fig. 4.4.2 Classification of results

Weighted Linear Combination

You can start this method by selecting menu option *Calculate: Calculate in a table* and list entry *Weighted Linear Combination*. Choose the same table and attributes as above and look at the resulting choropleth map and the graph with parallel coordinates.

If you compare the graphs in fig. 4.4.1 and 4.4.3 you see some differences in evaluation. These are caused by the calculation formulas assigned to the methods.

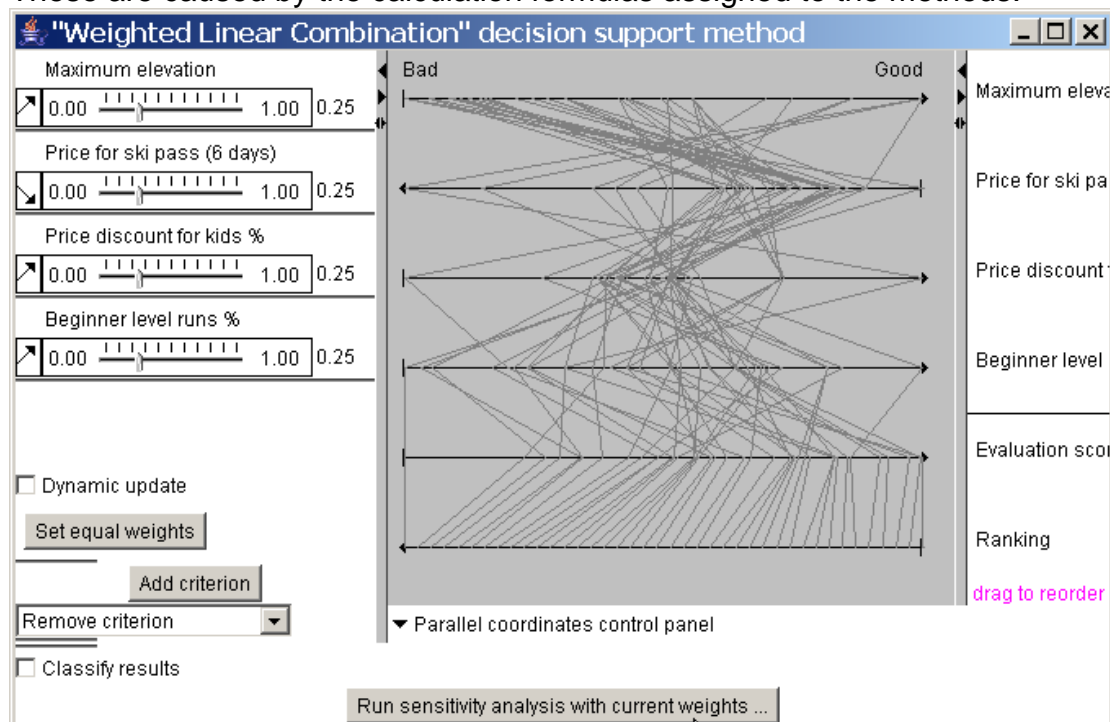


Fig. 4.4.3 Weighted Linear Combination

The computation of method „Weighted Linear Combination“ is carried out according to the formula:

$$X_w = \text{Sum}(w_i X_i)$$

w_i – non-negative weights, adding up to value 1,
 X_i – values of attributes 1 .. n.

Ordered Weighted Averaging – OWA

Method „*Ordered Weighted Averaging*“ in menu *Calculate: Calculate in a table* uses two vectors for weighting when evaluating the available options

- Criterion importance weights (w_j)
- Order weights (v_j)

according to the following formula

$$\text{OWA} = \text{Sum}(v_j b_{ij})$$

$b_{i1} \geq b_{i2} \geq \dots \geq b_{in}$; sequence evolves from ordering of weighted attribute values $w_1 a_{i1}, w_2 a_{i2}, \dots, w_n a_{in}$, with a_j – values of attributes 1 .. n.

The computation can be divided into three steps³:

- define weights for the ordering,
- sort the weighted attribute values of each alternative in descending order,
- multiply the values by the appropriate weighting for the ordering and sum up the results.

When calling the method in CommonGIS the user is offered the following dialogue window (fig. 4.4.4, same input values as above):

Fig. 4.4.4 Dialogue window OWA

³More details on this method are described in: Claus Rinner, Jacek Malczewski (2002): **Web-Enabled Spatial Decision Analysis Using Ordered Weighted Averaging (OWA)**. *Journal of Geographical Systems* 4(4): 385-403 (<http://link.springer.de/link/service/journals/10109/bibs/2004004/20040385.htm>), see also <http://individual.utoronto.ca/rinner/> for more publications and talks on this topic.

The following effects can be obtained by changing the default values:

Parameters in left window part:

Scale 1

- Assign a weight for the order to the attribute value with the highest criterion weight of each option

Scale 2

- Assign a weight for the order to the attribute value with a good medium criterion weight of each option

Scale 3

- Assign a weight for the order to the attribute value with a lower medium criterion weight of each option

Scale 4

- Assign a weight for the order to the attribute value with the lowest criterion weight of each option

Button „Set to WLC“

- Set equal order weights in order to compensate between good and bad values

Button „Set to AND“

- Set order weight of 1 to the worst value of each alternative (pessimistic approach)

Button „Random“

- Set order weights randomly

Button „Set to OR“

- Set order weight of 1 to the best value of each alternative (optimistic approach)

Parameters in right window part:

Field „Risk“

- + - Increase risk by increasing weight of best value
- - Reduce risk by increasing weight of worst value

Field „Tradeoff“

- + - Increase tradeoff by reducing maximal weight
- - Reduce tradeoff by increasing maximal weight

Field „Dispersion“

- + - Increase dispersion by reducing maximal weight
- - Reduce dispersion by increasing maximal weight

Pareto Set

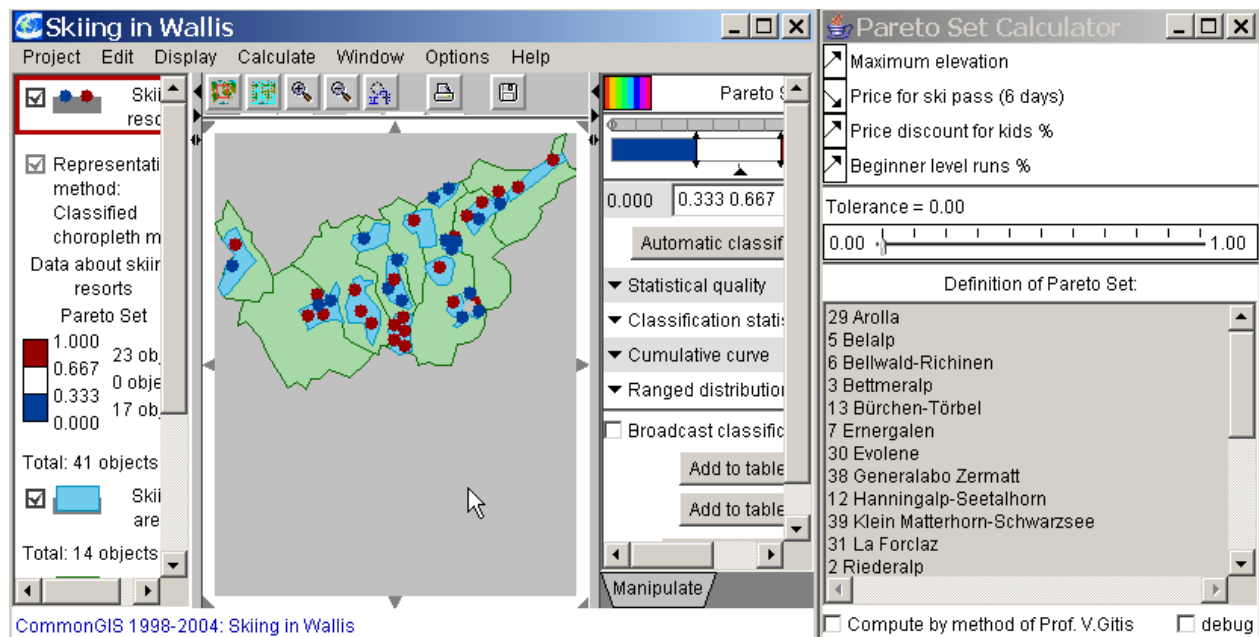


Fig. 4.4.5 Pareto Set

Multiple Criteria Comparison

With this method objects are compared on the basis of several selected attributes. Four new attributes are produced which classify the objects as equivalent, better, worse or incomparable.

If you want to compare several skiing resorts with respect to the attributes *Maximum elevation*, *Price discount for kids %* und *Beginner level runs %*, select

- **Calculate:** Calculate in a table,
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Multiple Criteria“ in window „Calculate“,
- Choose the three attributes from above,
- Accept the suggested class names (see fig. 4.4.6)

And look at the choropleth map left in fig. 4.4.7. To the right in fig. 4.4.7 you see window „Multiple criteria comparison“, which allows the user to specify further parameters for performing the comparison.

Attribute names

Results of the calculations will be stored in the database as new attribute(s). You may edit names of new attributes and their values:

Multiple Criteria Comparison	
1 ->	equivalent
2 ->	better
3 ->	worse
4 ->	incomparable

OK Cancel

Fig. 4.4.6 Evaluation categories

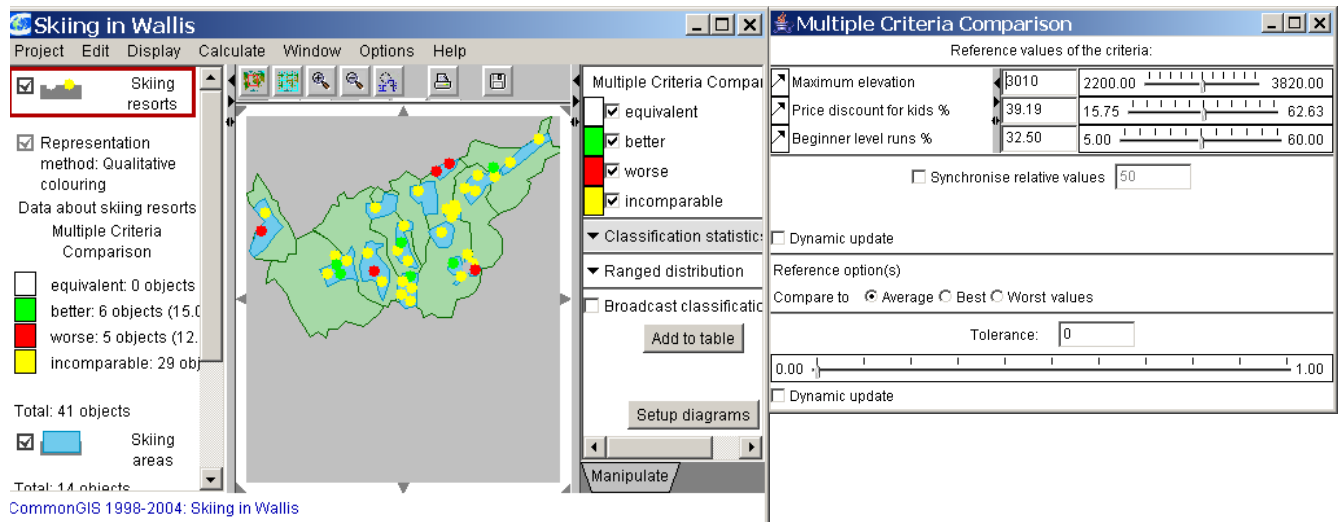


Fig. 4.4.7 Comparison with multiple criteria.

Values -> Order

With this option the user can produce a ranking order for the available objects on the basis of the values of a specific attribute. The ranking order is visualised on the map by colour shading. Rank 1 is drawn brightly, the last rank is coloured with the darkest shade.

In order to rank the skiing resorts according to maximum elevation, select

- *Calculate: Calculate in a table*,
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Values -> Order“ in window „Calculate“,
- Choose the attribute *Maximum elevation*,
- Select “Decrease” as ordering direction,
- Accept the suggested name „*Decrease order: Maximum elevation*“

And look at the resulting choropleth map in fig. 4.4.8 on the left. In fig. 4.4.8 to the right you see a table showing the attribute in question and the new attribute produced for ranking.

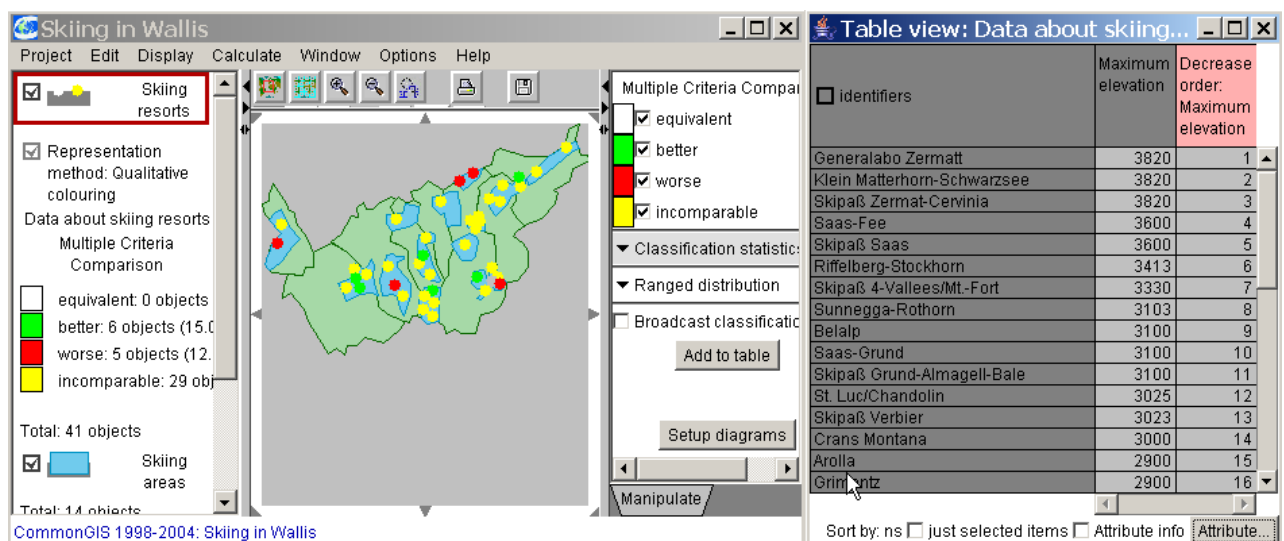


Fig. 4.4.8 Ranking of objects with respect to some attribute.

Multidimensional Analysis

In CommonGIS there are several methods supporting the analysis of similarity of objects or groups of objects and to classify objects. Attributes containing the results are created.

Similarity (distance)

An especially interesting kind of data analysis can be accomplished by calculating the degree of similarity or distance between objects in the multidimensional attribute space.

The user can e.g. select all objects being equivalent to an object with characteristics already known to him. Based on the selected reference object the distance or difference of the other objects relative to this reference object is determined. In general you can say, the lower the distance between the object and the reference object, the higher the degree of similarity between these two objects. The number of dimensions depends on the number of attributes which describe an object.

Now if family Flink wants to get a first picture of large skiing resorts which guarantee an adequate amount of snow like Zermatt, which they have visited during one of the last vacations, they would select

- *Calculate: Calculate in a table,*
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Similarity (distance)“ in window „Calculate“,
- Choose the attributes *Relative Altitude (max-min)*, *Duration of skiing season* and *Number of lifts*,
- Select “Generalabo Zermatt” as reference object (see fig. 4.4.9, left),
- Accept the suggested name „Distance to Generalabo Zermatt“

and take a look at the resulting choropleth map in fig. 4.4.9 on the right. Another view on the computational results (graph with parallel coordinates) is offered within the new window "Similarity in attribute space" (fig. 4.4.10), which also permits to make further adjustments.

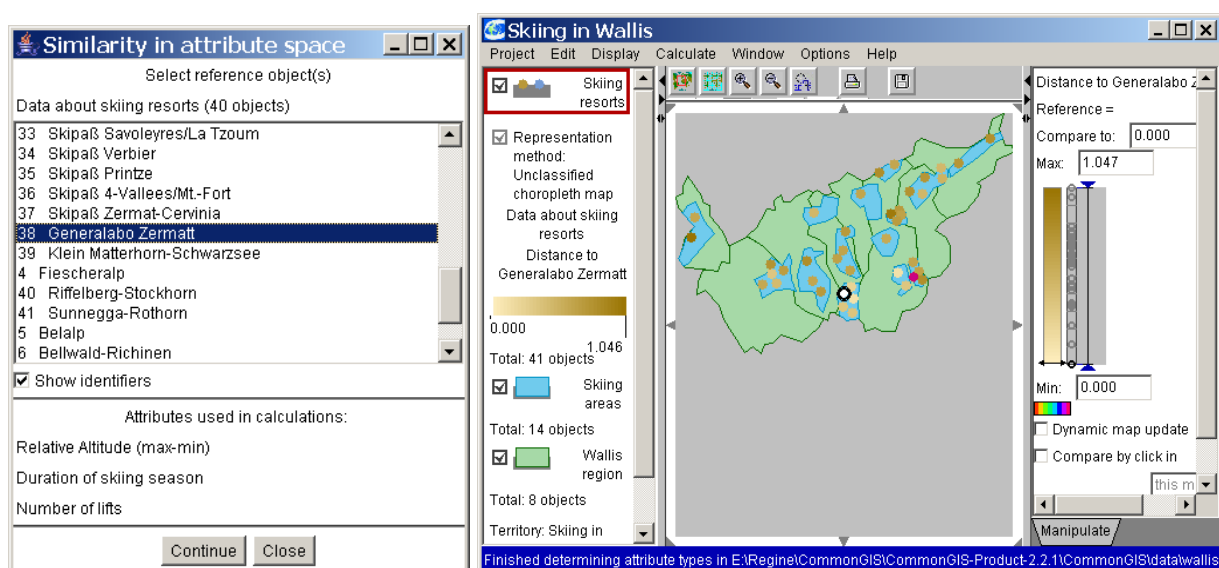


Fig. 4.4.9 Select reference object and resulting choropleth map with distances calculated.

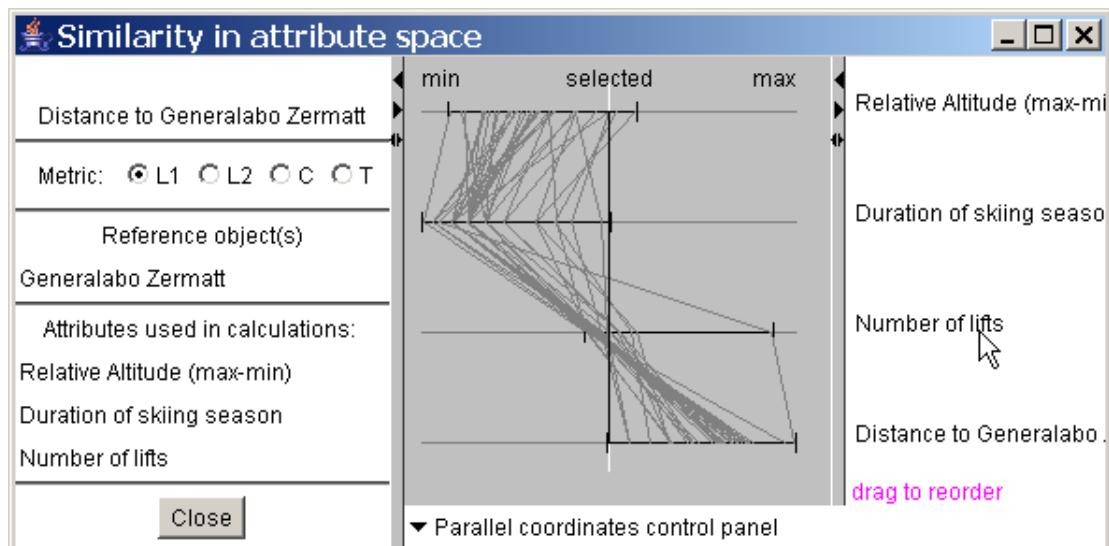


Fig. 4.4.10 Presentation of results as graph with parallel coordinates; more parameters to adjust the computation.

The calculation results can be displayed in a graph with parallel coordinates. The graph contains axes for the attributes selected by the user and an additional axis for the computed distance as the new attribute. The lines representing the objects are aligned relative to the reference object to ease comparison. The closer a line is located at the straight-lined reference graph, the more similar the associated object is to the reference object.

Again, the user can change the parameters of the computation. Adjustments immediately become visible in the diagram and all associated visualisations.

In CommonGIS several metrics can be applied to calculate the distance of objects:

L1:	$\text{Dist}(A, B) = \text{Sum}(\text{Abs}(A_i - B_i))$, A_i – values of selected attributes 1 .. n of object A B_i – values of selected attributes 1 .. n of object B.
L2:	$\text{Dist}(A, B) = \text{Sqrt}(\text{Sum}(A_i - B_i)^2)$, A_i – values of selected attributes 1 .. n of object A B_i – values of selected attributes 1 .. n of object B.
C:	$\text{Dist}(A, B) = \text{Max}(\text{Abs}(A_i - B_i))$, A_i – values of selected attributes 1 .. n of object A B_i – values of selected attributes 1 .. n of object B.
T:	Special metric for time series data – reflects number of time moments with similar change of values.

The “T” - metric should be exclusively applied to time series!

Similarity (classification)

You can also use the similarity of objects in the multidimensional attribute space to classify the data set. For this purpose you select two reference objects from the basic data set whose attribute values represent the target classes. Each remaining object is then assigned to the reference object being most similar.

Let's assume you want to find the skiing resorts being most similar to the „best“ skiing resort which was assigned rank 1 in the Ideal Point analysis (see fig. 4.4.1) (in terms of relative altitude and price discount for kids). At the same time you want to exclude those resorts being near to the one with rank 40. Now select

- *Calculate: Calculate in a table*,
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Similarity (classification)“ in window „Calculate“ ,
- Choose the attributes *Relative Altitude (max-min)* and *Price discount for kids %*,
- Select „Riffelberg-Stockhorn“ and „Skipass Savoleyres/La Tzoum“ as reference objects (see fig. 4.4.11),
- Accept the suggested names for the three attributes to be created

And look at the resulting choropleth map left in fig. 4.4.12. The figure on the right shows the table view with the distance values computed. Another view on the computational results (graph with parallel coordinates) is offered within the new window „Classification by similarity“ (fig. 4.4.13), which also permits to make further adjustments.

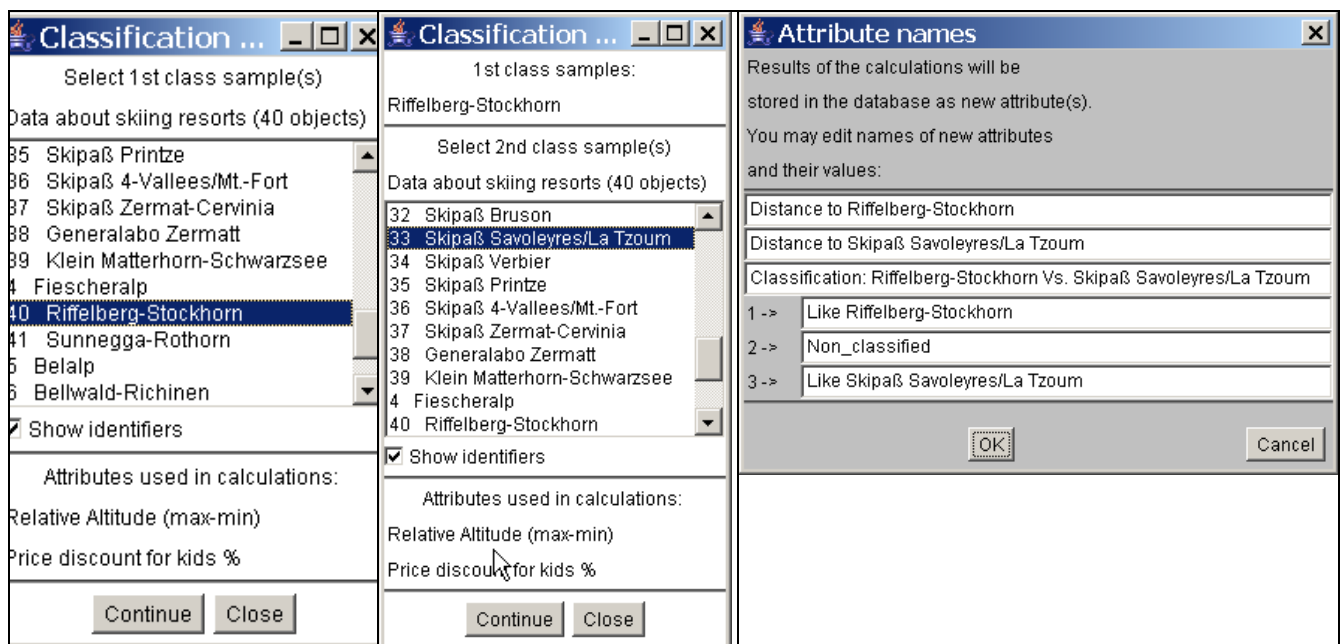


Fig. 4.4.11 Dialog to classify attributes according to their similarity

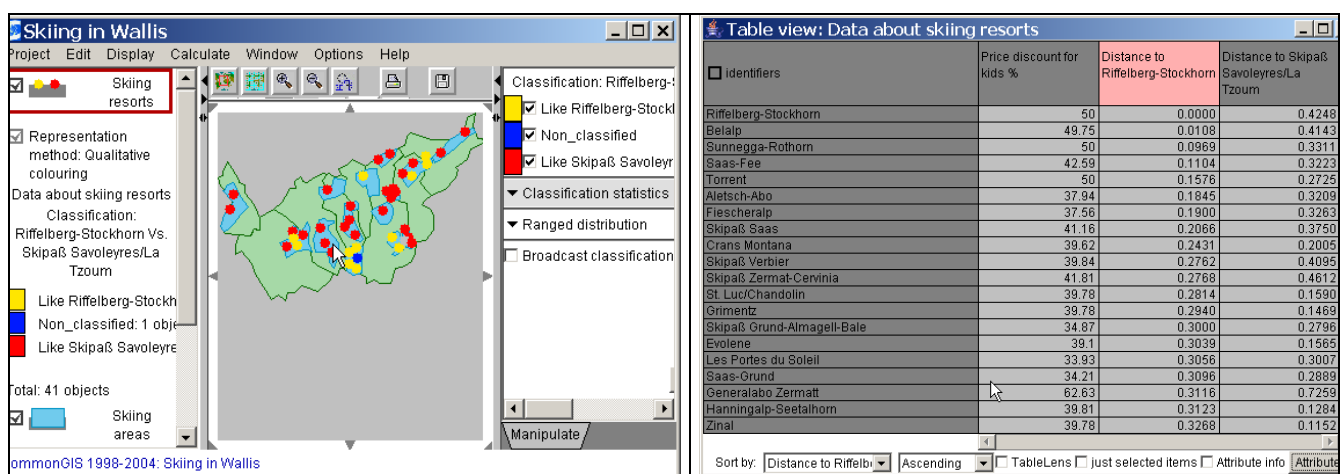


Fig. 4.4.12 Classification of skiing resorts in terms of similarity to reference objects.

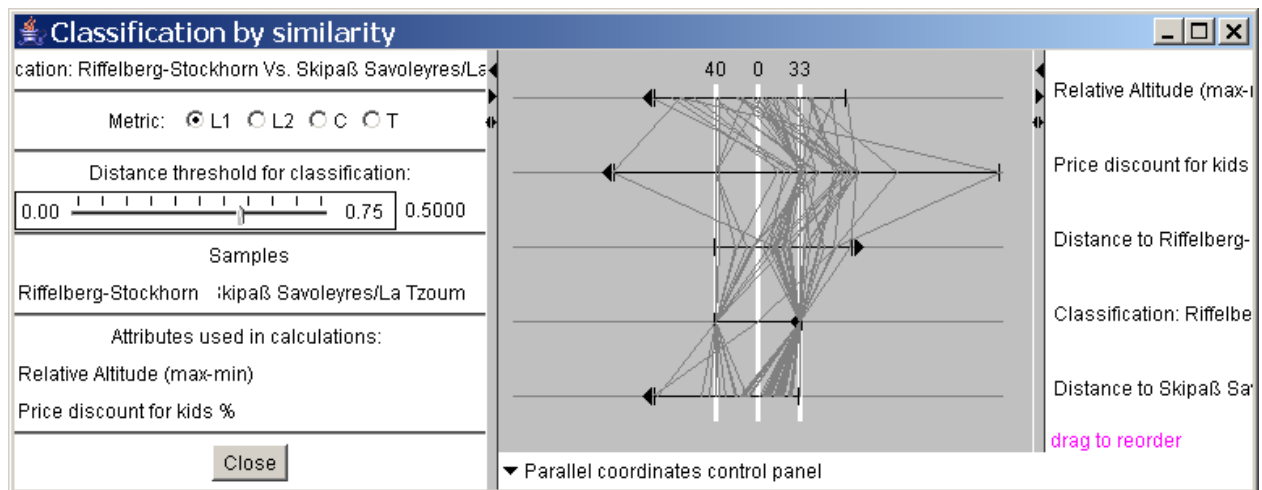


Fig. 4.4.13 Dialog window „Classification by similarity“

For each remaining object the system computes distances d_1 and d_2 in the attribute space to the given reference objects of the classes 1 and 2. An object is included in class 1 if $d_1 < d_2$ and it is included in class 2 if $d_1 > d_2$.

If for some object both distances exceed a specified threshold d_0 ($\min(d_1, d_2) > d_0$), this object is not assigned to any of the classes (it is too different from both samples). To change d_0 move the slider in „Distance threshold for classification“ (fig. 4.4.13) to the desired position.

The task of similarity-based classification is also supported with a parallel coordinates plot. The plot contains axes for all source attributes, the distances to the classes 1 and 2, and the results of classification. The axes are transformed so that the lines for the two samples are straight (this is only possible if the values of all attributes for these two objects are different). If some line lies close to the line of one of the samples, the corresponding object belongs to the class the sample represents.

The scale of each axis is determined by the difference between the values of the attribute for sample 1 and sample 2. The orientation of an axis may change to right-to-left in order to make the value for sample 1 be located on the left of that for sample 2.

Dominant attribute classification

This method gives the dominant selected criteria (minimum or maximum) of every object with respect to the selected attributes.

Two attributes are created:

- a qualitative attribute indicating if the attribute is dominant or not,
- the level of dominance as a numeric attribute.

In order to see which skiing resorts are convenient to experts, intermediates or beginners, select

- *Calculate: Calculate in a table*,
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Dominant attribute classification“ in window „Calculate“,
- Choose the attributes *Beginner level runs %*, *Intermediate level runs %* and *Expert level runs %*,

- Change the suggested name for the last of the new attributes by deleting the attribute names (result: Dominant degree) and look at the resulting choropleth map in fig. 4.4.15. Another view on the computational results (graph with parallel coordinates) is offered within the new window "Dominant attribute calculation" (fig. 4.4.14), which also permits to make further adjustments.

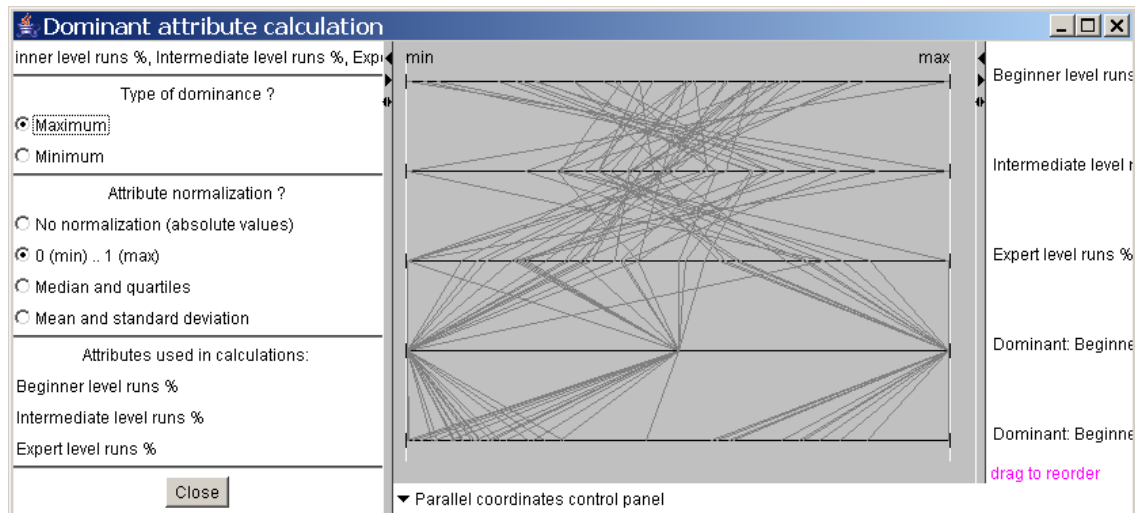


Fig. 4.4.14 View on classification results and additional parameters.

The look of the plot can be changed by normalisation (see fig. 4.4.14 left column):

No normalisation (absolute values)	Attributes are presented on a single scale of their absolute values without any normalisation.
0 (min) ... 1 (max)	Attributes are normalised onto a scale from 0.0 to 1.0 such that 0.0 corresponds to the minimum value and 1.0 corresponds to the maximum of each attribute.
Median and quartiles	Attributes are presented on a scale with the medial values of each attribute aligned in the centre and the quartiles are also aligned.
Mean and standard deviation	Attributes are presented on a scale with the mean values of each attribute aligned in the centre and the means ± 1 standard deviation are also aligned.

Table 4.4.1 Normalization

For each object the dominant attribute is displayed in a certain colour. The colours can be changed by clicking on the coloured box in the manipulation window. With the check boxes next to these attributes the colour can be switched on and off.

When the check box „Broadcast classification“ is checked all dots and lines in other displayed charts have the same colour as in this map.

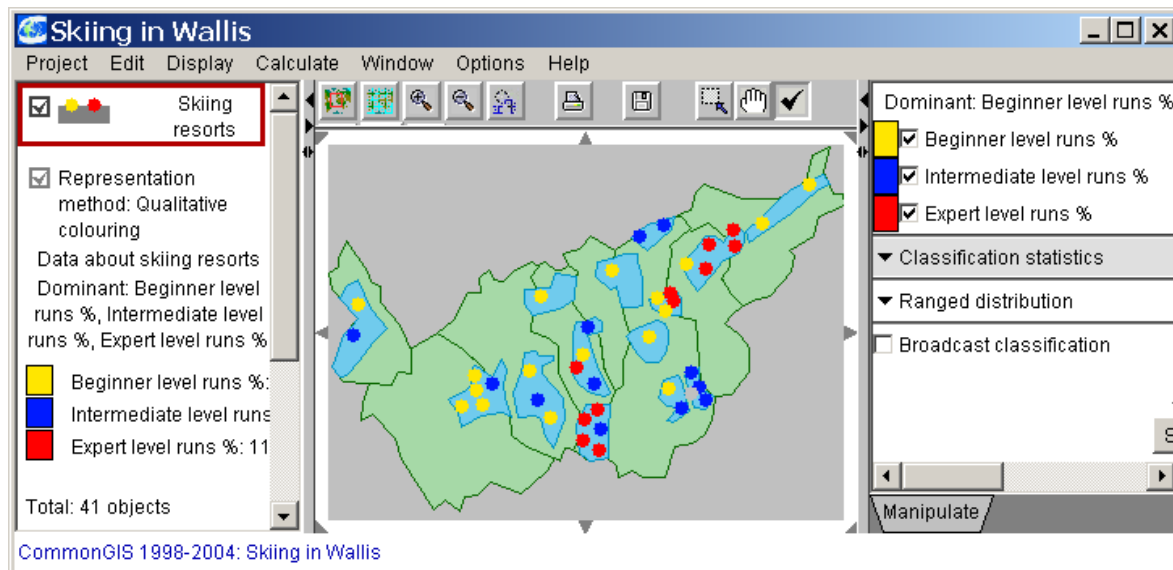


Fig. 4.4.15 Visualisation of dominant attribute classification

Rule Validation

This method creates a classification of the desired relations between attributes.

A new attribute is derived, which reflects the classification of the object into one of the four produced classes.

An example: if you want to evaluate which skiing resorts offer a well-priced ski pass and a high discount for kids at the same time, select

- *Calculate: Calculate in a table,*
- Choose Table 2: Data about Skiing resorts,
- Mark list entry „Rule validation“ in window „Calculate“,
- Choose the attributes *Price for ski pass (6 days)* and *Price discount for kids %*,
- Accept the suggested class names

And look at the resulting choropleth map left in fig. 4.4.17. The new window "IF-THEN Rule Validation" (right in fig. 4.4.16) permits to set further conditions concerning the selected attributes.

If the user sets the price limit for the ski pass to 270 and increases the desired discount to 35 he can see in map 4.4.17 at the right side, which places are suitable under these conditions.

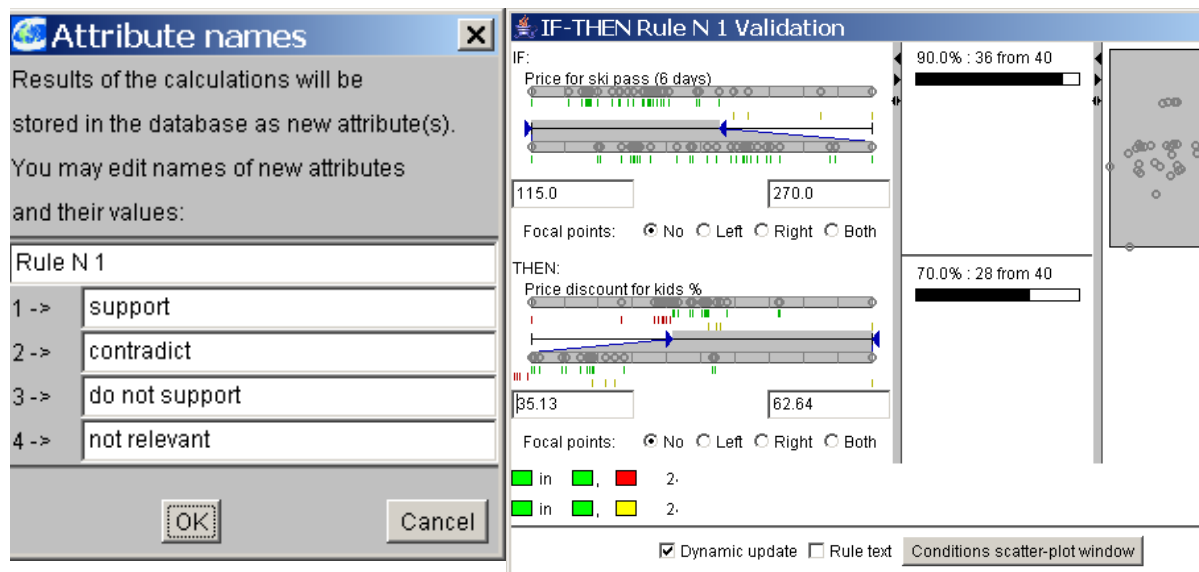


Fig. 4.4.16 Classification and specification of rules

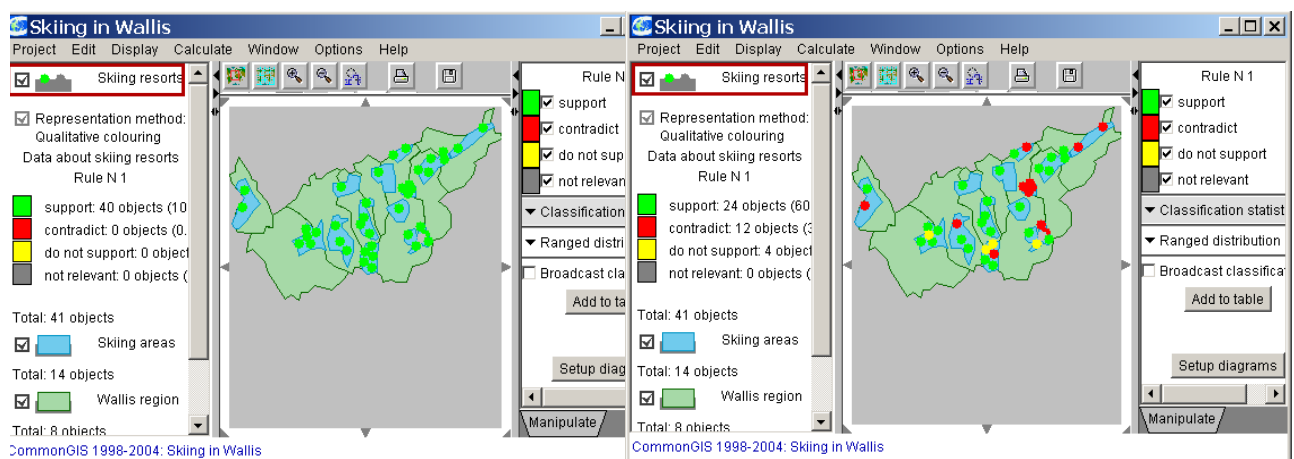


Fig. 4.4.17 Object classes before and after rule specification

Dynamic query

By means of the "dynamic query" calculation method the user can reduce the set of objects to those objects whose values lie within a specified range of values regarding attributes relevant for a decision.

With this tool you can interactively set and dynamically alter constraints on attribute values. In response to manipulations all visualisations and diagrams of CommonGIS are immediately redrawn to show only objects satisfying the specified constraints. A decision maker can impose constraints not only on source attributes but also on derived attributes which have resulted from former computations.

If you want to take a closer look at skiing resorts satisfying the following conditions

- Skiing resort should have a maximum elevation of at least 2700 m,
- Not less than 12 lifts,
- A maximum price of 230 Franken for 6 days,
- at least 30% price discount for kids, and
- at least 25% beginner level runs,

select

- *Calculate: Dynamic query,*
- Choose Table 2: Data about Skiing resorts,
- Choose the attributes *Maximum Elevation, Number of lifts, Price for ski pass (6 days), Price discount for kids %* and *Beginner level runs %*,

and look at the window „Dynamic Query ...“ within the „Query and search tools“ window in fig. 4.4.18. (The map has not been altered up to now.)

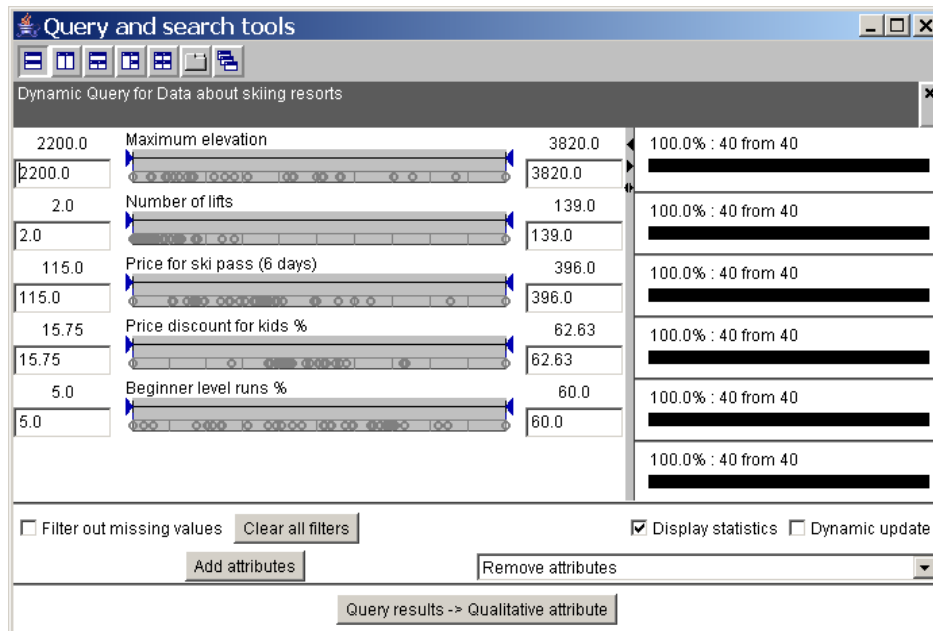


Fig. 4.4.18

In the window "Dynamic Query" the selected attributes are listed with their minima and maxima.

The right column shows how many objects lie within the range of values. Now you can change the range of values by modifying the value in the respective input field to the desired minimum and/or maximum value and by pressing the "Enter" key on each input. There is an immediate feedback in the right column showing how many objects are contained within the new range of values. The objects excluded from the range of values are faded out from the map window as well.

You can also define the new limits by using the mouse button. By clicking on an arrow head and shifting it to the desired point within the horizontal dot plot you can trace, how many objects are faded out on selecting a threshold value.

After having specified the conditions listed above the window looks like fig. 4.4.19, left. The associated map is displayed in fig. 4.4.19 to the right. There you can see that only 3 skiing resorts satisfy all the specified conditions.

In the lower part of the „Dynamic Query“ window there are some more parameters:

„Filter out missing values“ – When some objects have no value assigned they can be excluded from the resulting object set by activating (clicking) the check box.

„Clear all filters“ – re-establish the original situation with the complete ranges of values.

„Display statistics“ – turned on by default; give an overview on how many objects fulfil the respective constraints in the right part of the window. The last bar shows how many objects fulfil all constraints.

„Add attributes” or „Remove attributes” – change attribute set to be included into the query.

„Query results -> Qualitative attribute” – create a new attribute which indicates for each object if it is contained in the sample object set.

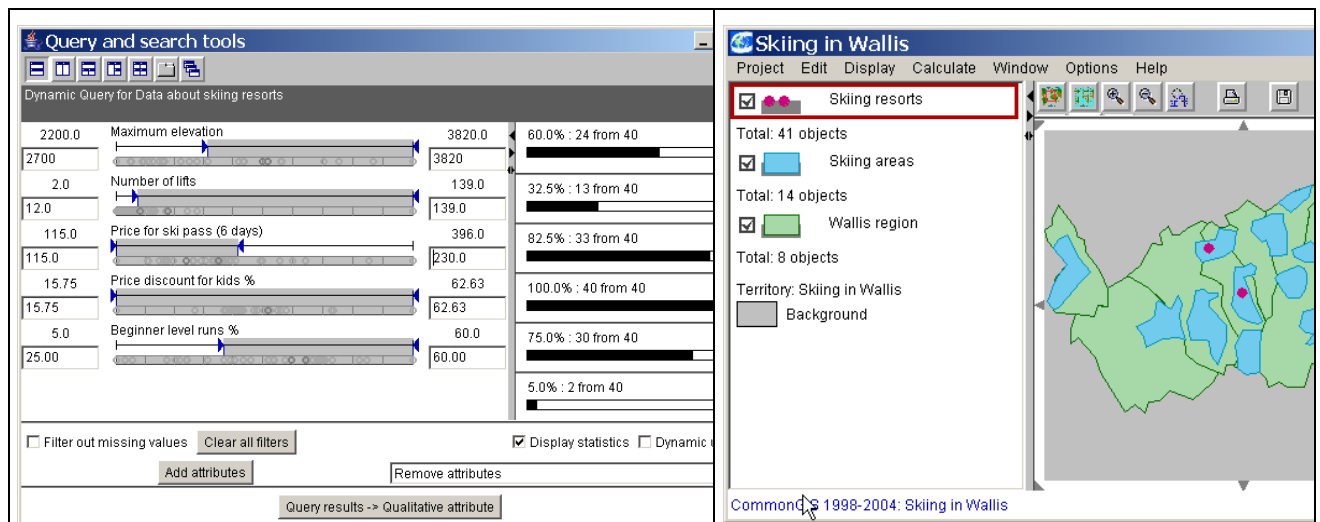


Fig. 4.4.19 Dynamic query restricts the set of objects according to certain conditions.

4.5. Saving results

An essential advantage of the data analysis with CommonGIS is the broad variety of possibilities for data exploration. You can easily produce many different visualisations and diagrams, in order to select the most meaningful among them finally.

To support this task the user can reuse intermediate results by

- arranging them in different windows on the screen,
- saving them as snapshots,
- saving them in files and/or printing them.

Keeping (intermediate) results – Menu **Window**

The options of menu *window* allow the user to arrange the produced maps and other visualisations on the screen in such a way that he has a suitable environment for continuing with his task.

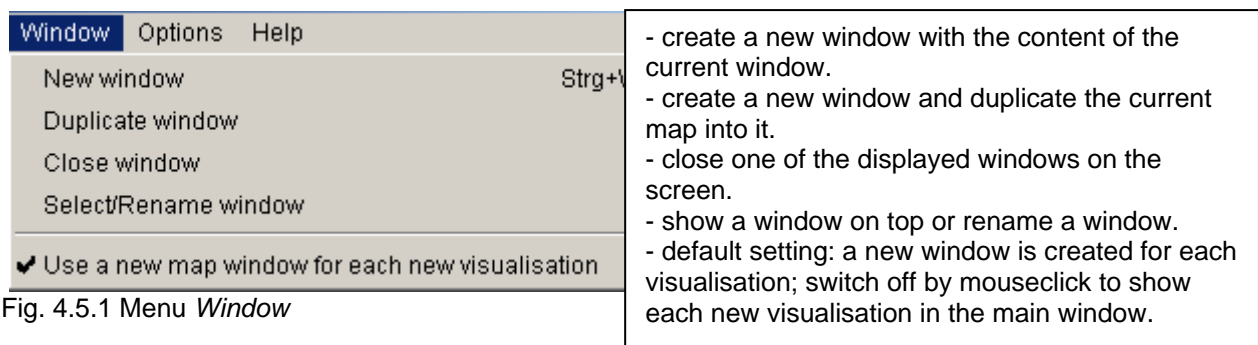


Fig. 4.5.1 Menu *Window*

Window: New window

create a new window with the content of the current window.

Window: Duplicate window

create a new window and duplicate the current map into it.

If you want to compare several visualisations or if you have produced a visualisation, which could be needed again later, this option allows the user to keep a produced map in a separate window. This "neighbour window" is titled with a sequential number (map N1...). This kind of window differs from the "main window" by the lack of the menu bar. For a neighbour window the set of possible actions is limited to the change of the representation, i.e. operations via the symbol bar and operations on layers via the legend (see ch. 3.2).

Window: Close window

close one or more of the displayed windows (see fig. 4.5.2, to the left).

Window: Select/Rename window

Show a window in front or rename a window (see fig. 4.5.2, middle and right).

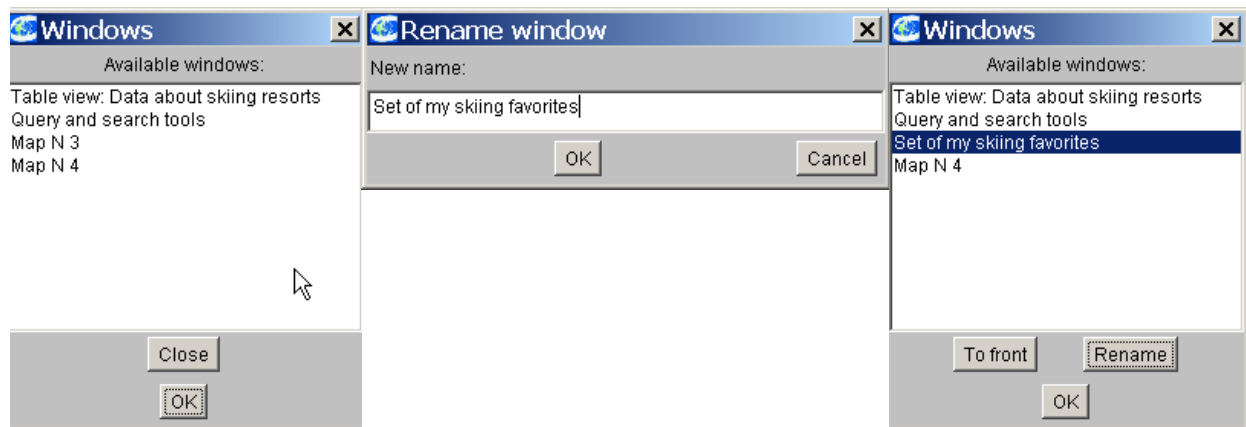


Fig. 4.5.2 Handling of windows

*Back up, save and print – Menu **Project***

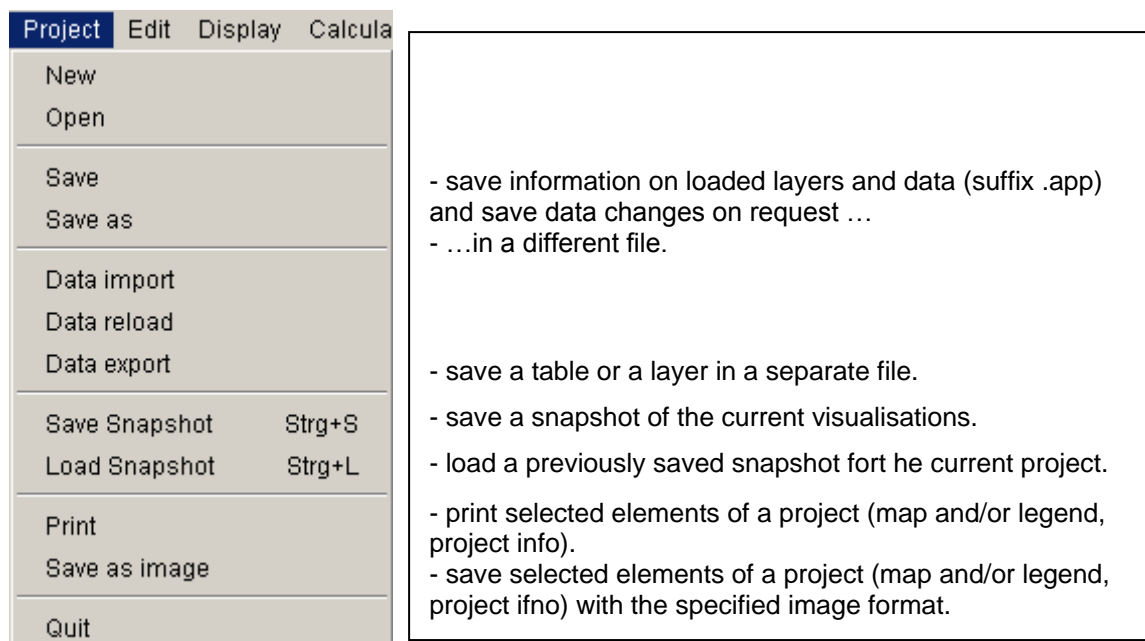


Fig. 4.5.2 Back up, save and print in menu *Project*

Saving snapshots

If you must interrupt your current task and you want to make sure that you can resume it at the point where you stopped, select

- *Project: Save Snapshot*,
 - Enter an appropriate name and a description for the task status,
- and a file with a system-chosen name is created containing all information to recover the state of work.

On selecting menu option *Project: Load Snapshot* you get a list of all available snapshots to select the desired one. A prerequisite for loading is that the underlying project must be opened.

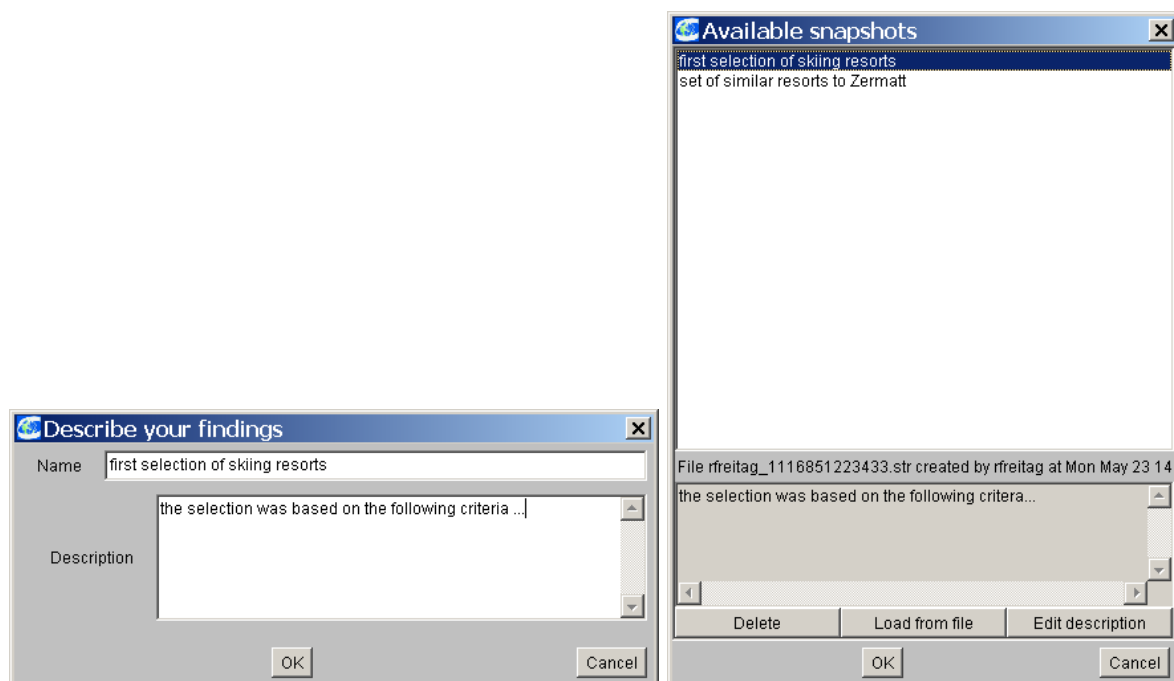


Fig. 4.5.3 Save snapshot

Saving and printing results

CommonGIS supports in particular the exploration of spatial data and the dynamic change of perspectives on the data. If the user has finally produced maps or has arranged or computed data, as the basis for decision making, he can store all information to keep track of the decision making process. He can save the project structure, tables, layers or maps as files or print maps directly.

Project: Save save information on loaded layers and linked thematic data to the yet established specification file.

A project file with suffix “.app” is created, which contains the specification of how layers and thematic data are linked and in what order they are loaded.

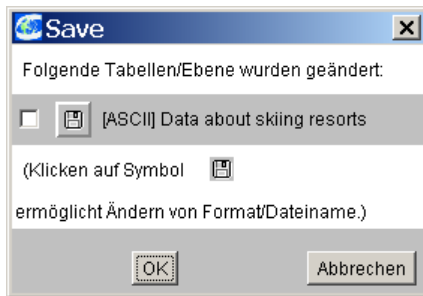


Fig. 4.5.4 Save a project and the related files.

Note: In contrast to earlier versions of CommonGIS you can as well store analysis data with menu option *Save*. An additional file with ending *.bak* is produced, in which the old file is kept. You can reproduce the old file by simply deleting the file ending.

Note: Filtering with dynamic query is not taken as data change by the system and is therefore not saved. In order to preserve the result of a dynamic query you must use menu option *project: Data export*.

Project: Save as save information on loaded layers and linked thematic data to a new specification file with a different name.

A project file with the supplied name and suffix *“.app”* is created, which contains the specification of how layers and thematic data are linked and in which sequence they are loaded.

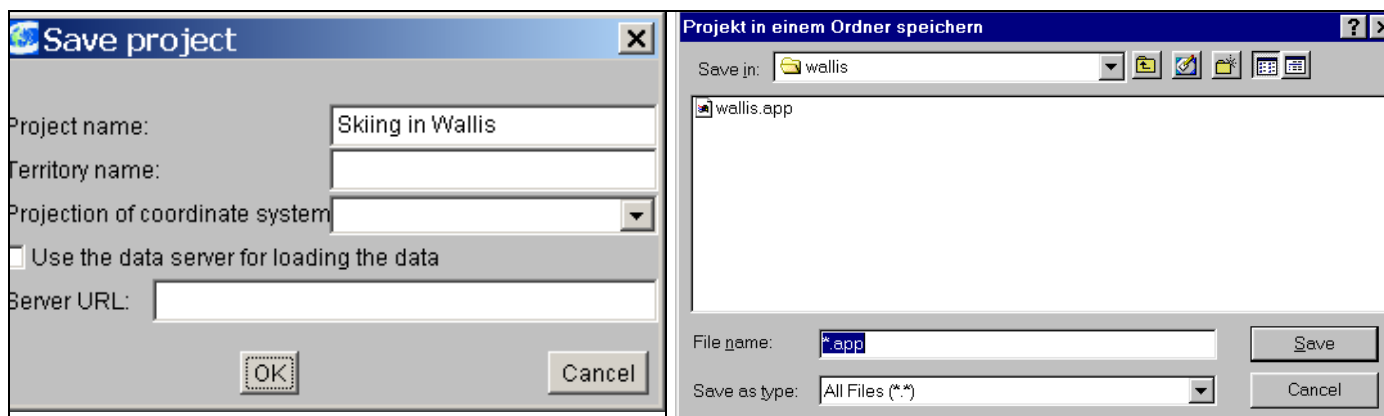


Fig. 4.5.5 Save project with a new name in a new file.

First the user is asked for a project name (fig. 4.5.5, left part) which is the title of the main window after loading the project. Then the user types in or selects the name of the file, in which he would like to store the project information (fig. 4.5.5, right part).

Additionally he can define the projection of the coordinate system of the data set (fig. 4.5.6).

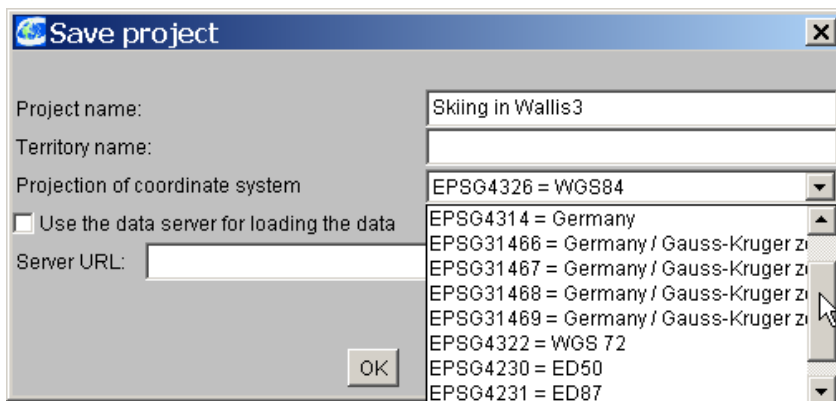


Fig. 4.5.6 Specify coordinate system.

Project: Data export

save attributes or tables resulting from the analysis in the desired external data format.

If you want to save a table which was extended by new attributes computed by some calculation method of CommonGIS, select

- *Project: Data export*,
- Mark first list entry „csv (comma-separated values)“ in window „Export data“ (see fig. 4.5.7),
- Choose e.g. Table2: Data about Skiing resorts,
- Select the attributes to be saved (old and new ones) and
- Enter a name for the new file (ending in „.csv“).

The file is produced now and can also be reused in CommonGIS again by using the menu option *Project: Data import*.

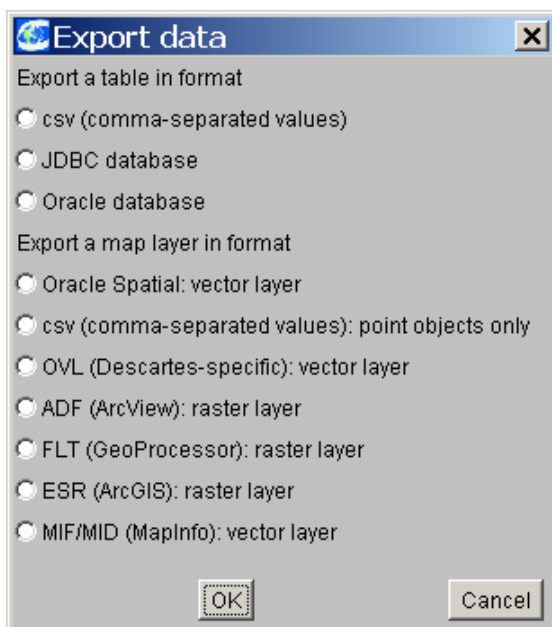


Fig. 4.5.7 Export formats in CommonGIS



Save map oder
Project: Save as image

save the map from the main window; the user can choose if either the map or the legend or both should be saved (see fig. 4.5.8, to the left).

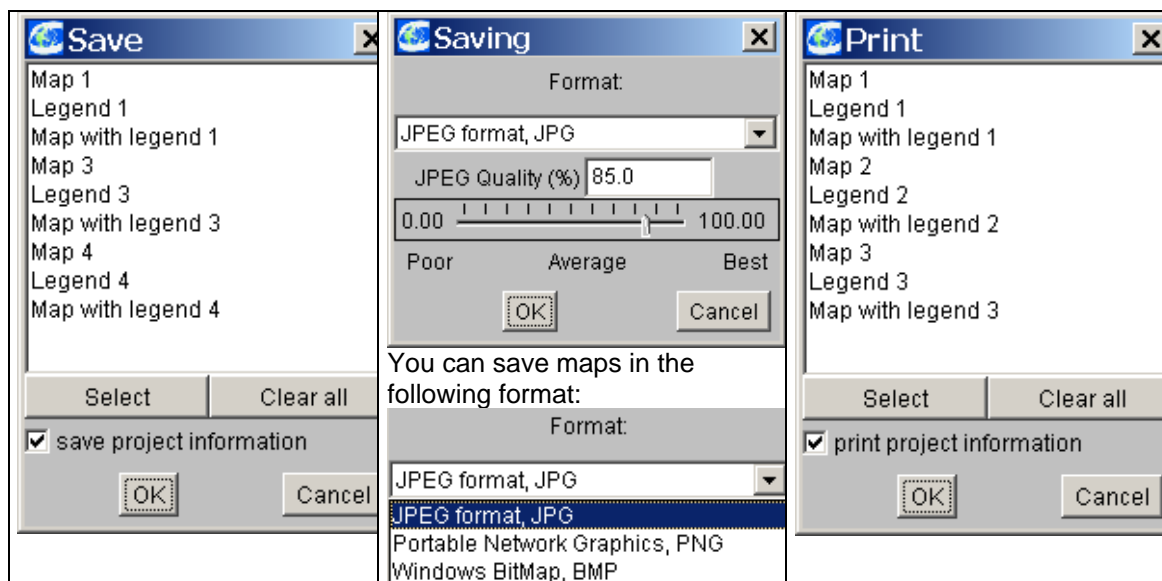


Fig. 4.5.8 Karten speichern



Print map
Project: Print

oder

print the map from the main window; the user can choose if either the map or the legend or both should be printed (see fig. 4.5.8, to the right).

4.6. Auxiliary Options – Menu **Options**

Options	Help
Show records options... Strg+R	Parameters of permanent view of attributes.
Popup records options...	Parameters of popup attribute list.
set scale and coordinate fields visible	Switch on/off scale and coordinate fields at the bottom of the main map window.

Fig. 4.6.1 Menu *Options* parameters of CommonGIS

Show attribute values

CommonGIS offers different ways of looking at attribute values when working with maps. A complete tabular view on the data is presented on selecting menu option *Display: View table* (see chapter 4.2: Presenting spatial data in tables). In order to focus on special objects and/or on special attributes you can adapt the table to your needs. In addition you can have a selection of especially important objects in dependence on their attributes presented permanently within the “Object View” in the right part of the main window. Use menu option *Options: Show records options* to display the “Object View”.

Options: Show records options

Switch on/off permanent view of attributes.

In order to see the attribute values of the objects you are just working on, i.e. the values of the selected objects, you provide for the permanent data record window by marking option “Use persistent object view” in dialog window “Record viewing options” (see fig. 4.6.2, left). Now you can choose whether the attributes on all displays or only manually selected attributes shall be listed. (By default the attributes currently represented on the map or other graphical displays are taken.)

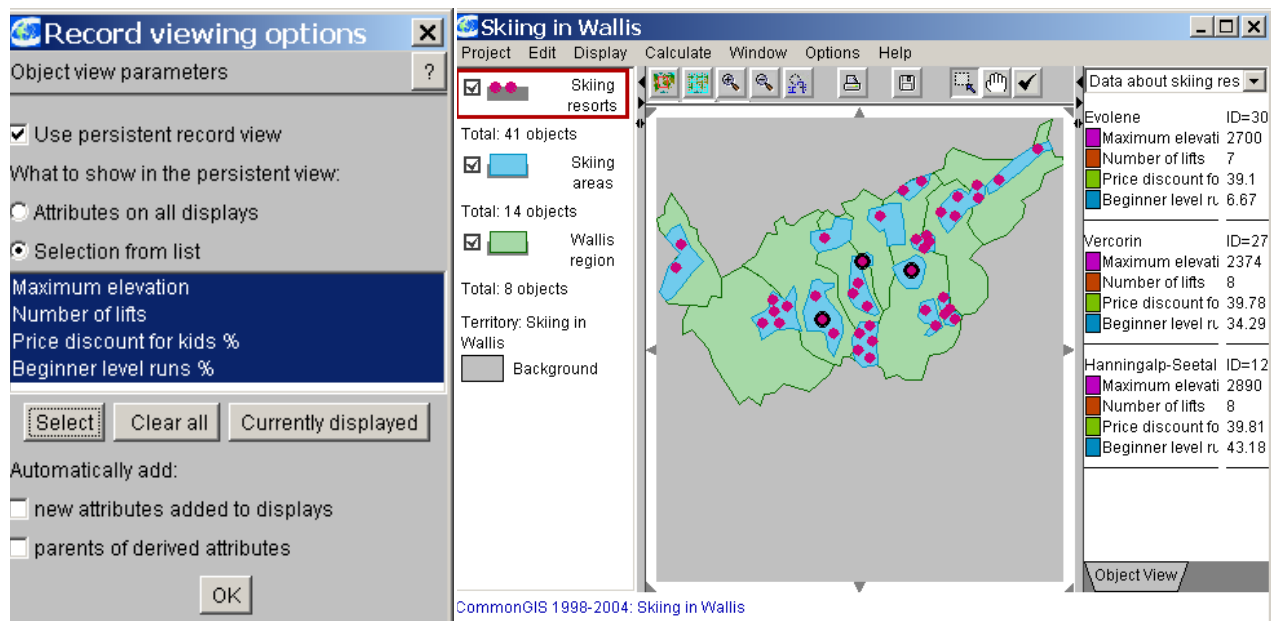


Fig. 4.6.2 Show attribute values

Another setting concerns the popup list which appears when the mouse pointer comes across an object in some visualisation. Next to this object information, such as name and designator, is presented in a small window as long as the mouse pointer remains on the object. The window disappears again if the pointer is moved on and leaves the object area.

Options: Popup records options

Select attributes to be displayed in popup list for each object to which you point with the mouse.

You can switch this behavior off by clicking on the small box left to "Enable record display in popup window". Selection and deselection of attributes take place within a separate selection window as usual. If you want to remove an attribute from the popup list, select it and click on the "Remove attribute" button (fig. 4.6.3).

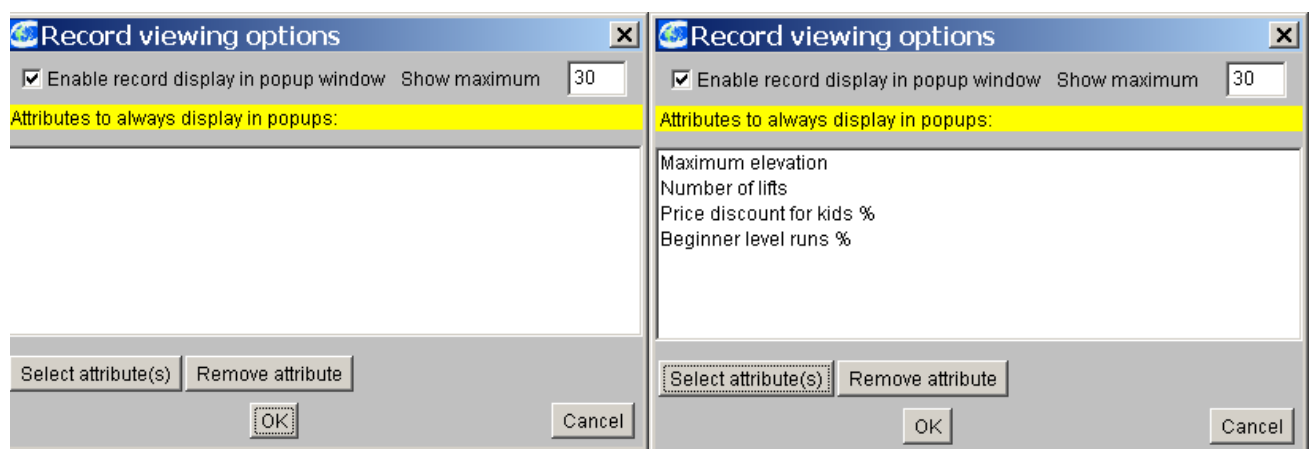


Fig. 4.6.3 Change popup list.

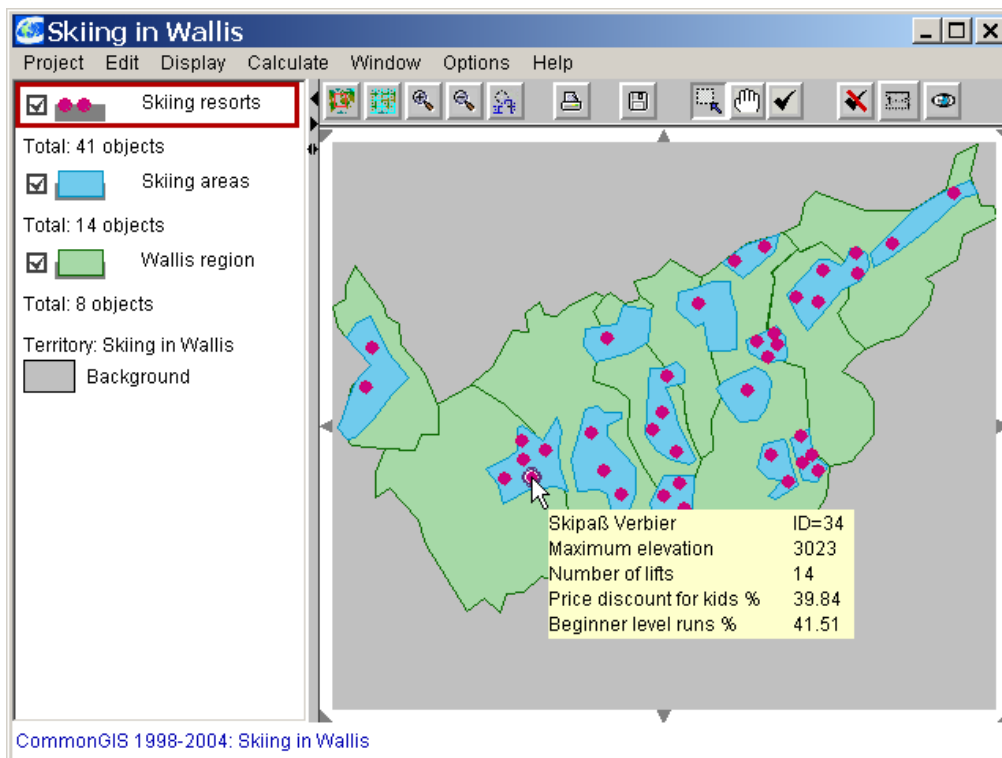


Fig. 4.6.4 Popup list showing attribute values for selected attributes.

Additionally, the user can adjust CommonGIS to show fields for scale and coordinates at the bottom of the main window. That means, that coordinates and – when necessary scale - are dynamically adapted to keep track of the current pointer position and zoom status (fig. 4.6.5).

Options: set scale and coordinate fields visible

By default the fields are not visible. On selecting this menu option it is check-marked and the fields are shown. If you perform it again the fields disappear and the check mark is removed from the option.

In fig. 4.6.5 to the right you also see the parameter window for specifying the scale which is activated by clicking on the symbol left to the respective layer name in the legend (see chapter 3.2).

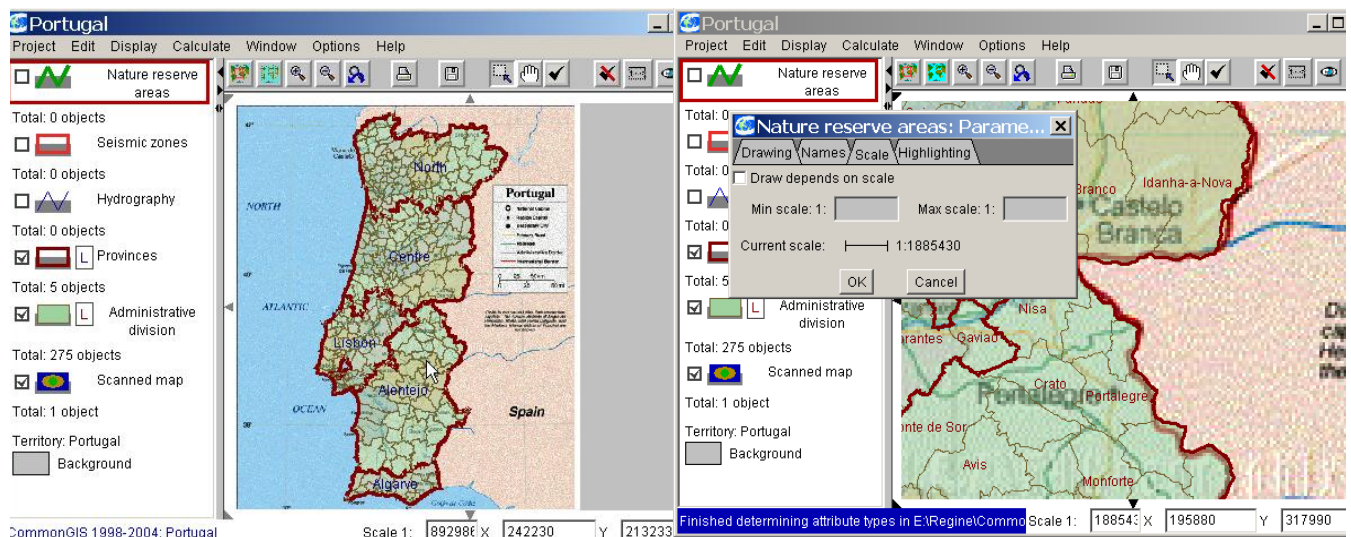


Fig. 4.6.5 Scale and coordinates are permanently visible at the bottom of the main window.

Map projections

If a project has a specified coordinate system, CommonGIS can make use of this information when presenting the data and in handling the map.

The scale is indicated in the legend, the scale and coordinate fields are automatically visible and there is a new symbol in the symbol border, which permits to measure distances between arbitrary points on the map (see fig. 4.6.6).

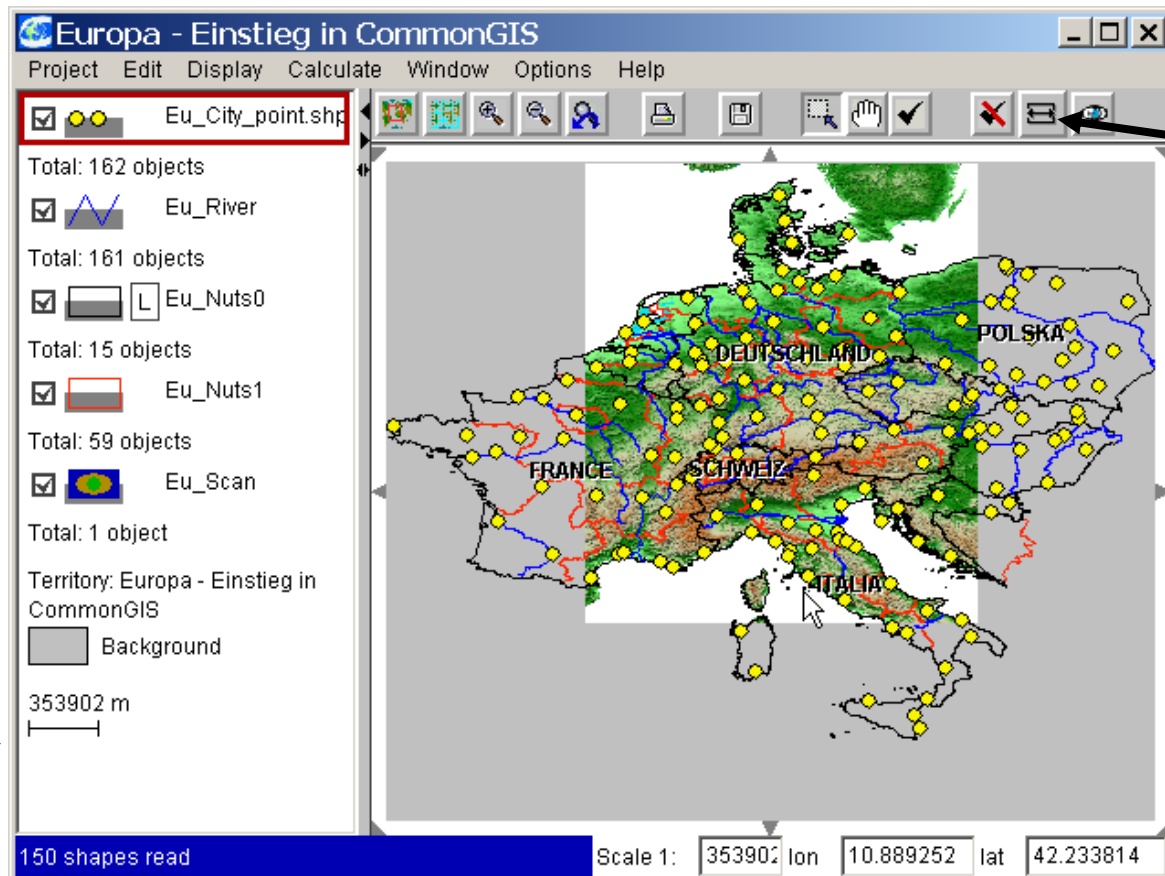



Fig. 4.6.6 Additional information for maps with defined projection.

After clicking on symbol  in the icon bar you can specify the first point of the distance to be measured in the map by mouse clicking. If you drag the mouse pointer to the second position on the map, the distance between position 1 and the current mouse position is calculated and displayed in the yellow text field at the head of the map. Clicking again completes the first measurement (see fig. 4.6.7). The last position is taken as the starting point of a new measurement. In this way you can calculate the distance between two points by dividing the way into subsections.

The measurement is stopped by clicking on the symbol for measuring in the icon bar again.

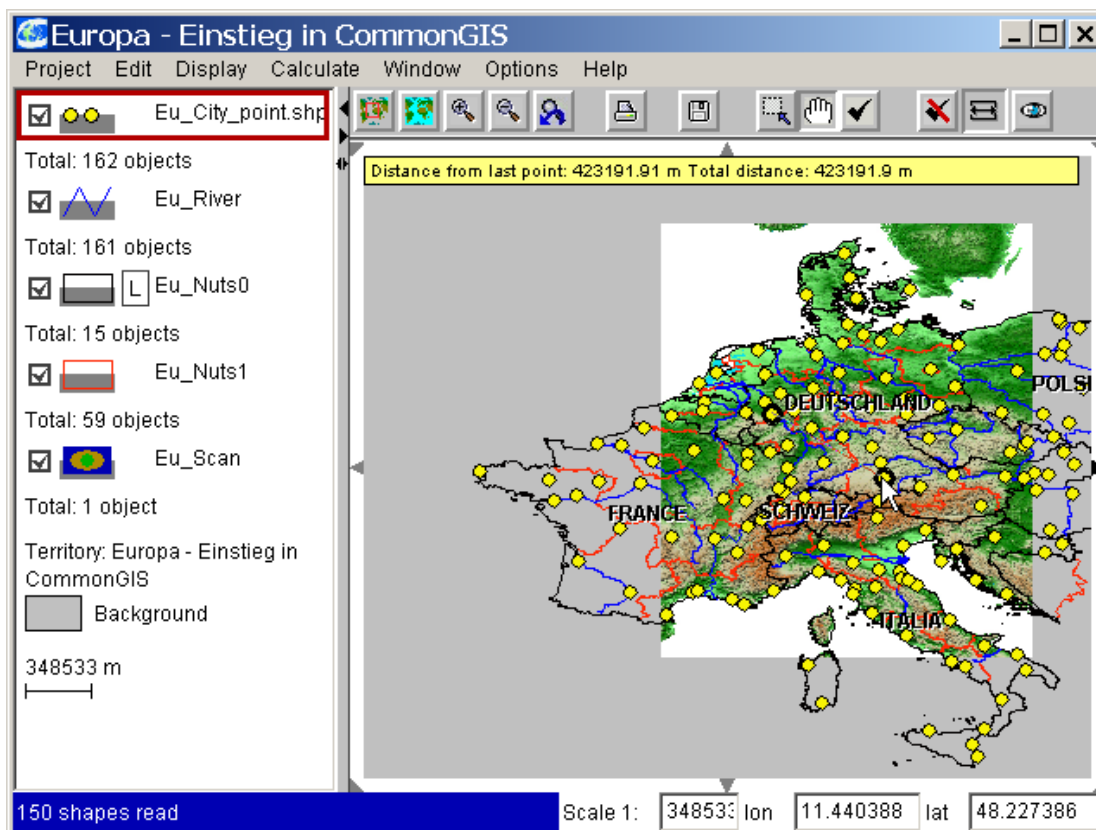


Fig. 4.6.7 Determine distances on a map.

Appendix 1

How_to_install.pdf: CommonGIS installation instruction

If you **download CommonGIS**, please get:

- CommonGIS-product-2.2.0.zip:
A zip file that contains software, demodata (folder "data"), and the user manual in german as pdf-file (Handbuch-2_2_0.pdf).
- how_to_install.pdf:
this file with special installation guide for user-specific configurations.
- Folder "Developers_instructions.zip" for system administrator and developer:
customisation information (customizing.doc), how to create an application in CommonGIS (applfile.doc) and development information for programmers (api.doc, for_programmers.zip).

Installation of the local variant of the system

Unpack the (self-extracting) zip file into a folder of your choice. There you can find batch files called

"CommonGIS-de" and "CommonGIS-en" for running the product version with Java1 in German or English.

To start CommonGIS with the attached JRE, open one of these files.

and

"CommonGIS-J2-de" and "CommonGIS-J2-en" for running the product version with Java2 in German or English.

To start CommonGIS with Java2, open one of these files. Java2 has to be installed on your computer.

File README.doc contained in the created folder helps you with your first steps in CommonGIS.

CommonGIS-product-2.2.0

If you unpacked the archive correctly, your directory will have the following content:

- 1) **CommonGIS.jar** (packed Java class), the configuration of the system;
- 2) file **system.cnf** specifying the path to a Web browser (the system uses it for displaying the help topics) and the path to the help files.
- 3) subdirectory **help** with the files used for online help. These files having HTML format can also be read off-line using any browser. The content of the help is contained in /help/german/Inhalt.htm;
- 4) subdirectory **data** containing data for a few example CommonGIS applications (in further subdirectories);
- 5) subdirectory **lib** used by CommonGIS to access the Java classes needed to run the system.

Start one of the provided batch files **CommonGIS-*** in order to run the system on your computer. The **.bat** file contains command lines and parameters.

The meaning of some parameters which can be changed by the user is explained in the table below.

-Xms50000000 -Xmx500000000	Optional parameters defining how much virtual memory will be available for the Java application. If you are not going to work with large volumes of data, you may remove these items.
-------------------------------	---

You should also edit the path to the browser in the file **system.cnf**, i.e. replace it by the actual path to the browser on your machine.

Before running the system, we recommend you to read **README.doc** (in German) or help **Handbuch-2_2_0.pdf** (in German).

Installation of the Web variant of the system (applet)

CommonGIS may run both locally and on a Web page as an applet. For running in the Web you can use the same archives with the classes as for running locally. However, the full configuration of the system may occur to be too large for the use in the Web. Therefore we recommend you to use one of the smaller configurations.

For running the system in the Web you will need to install it on a Web server. There you must have access to some subdirectory of the directory **WWW** or **htdocs** (the exact name depends on the specific server). This is the directory where all Web pages available on this server are stored. Best of all, create a separate subdirectory where CommonGIS will be installed. Ensure that reading and executing of files in this directory is allowed to anybody. This directory will be further referred to as CommonGIS-directory.

Ensure that reading of the file with the archive is permitted to anybody. Make a subdirectory of the CommonGIS-directory for storing help files and put the help files in it. The subdirectory and the files should be open for reading. Put the file **system.cnf** in the CommonGIS-directory. The file must allow reading by anybody. It must contain a single line:

```
PATH_TO_HELP="help/",
```

where “doc” is the name of the subdirectory with the help files (if you have named this subdirectory differently, replace “doc/” with the actual name).

Make a subdirectory of the CommonGIS-directory where the data will be located. The subdirectory should be open for reading to anybody. Put the data and the application specification file (*.app) in this subdirectory and ensure that reading of all the files is allowed to anybody. You can create an application specification file for your own application interactively, using the local variant of the system. You can also create this file manually by following the instruction contained in the file **apppfile.doc**.

Create an HTML page from which the system will start. You may use as example file start.html provided. The page must contain the so-called **applet tag** that looks like follows:

```
<APPLET archive=CommonGIS.jar code=esda_main.CommonGISApplet.class width=200
height=30>
<PARAM name=Application value="data/eu/eu.app">
</APPLET>
```

Below some of the items are explained:

```
archive=CommonGIS.jar
```

- specifies for the browser the name of the archive with the Java classes of the system. If you use an archive with a different name, replace CommonGIS.jar by this name.

```
code=esda_main.CommonGISApplet.class
```

- the main class that starts the work of the whole system. Note that the main class for the Web version is different from the main class for the local version.

- specify the size of the applet area in the browser. Not important since this area is not actually used: the applet creates a frame where all the work is done.

```
<PARAM name=Application value="data/eu/eu.app">
```

- this applet parameter tells the system where to take the specification of the data to be loaded. You must replace the text "data/eu/eu.app" with the actual path to your application specification file.

Besides the applet tag, the HTML file may contain any text, images, etc. Ensure that the file is open for reading to everybody.

Suppose, for example, that you installed the system on the server **www.myserver.com** in the subdirectory **CommonGIS** of the server's directory with Web documents. Suppose that your

HTML file with the applet tag is called **MyPage.html**. In order to run the system, you start a browser and open in it the following URL:

<http://www.myserver.com/CommonGIS/MyPage.html>

After this the page will be loaded in the browser, then the archive with the CommonGIS classes will be loaded, and then the system will start its work.

Appendix 2

All menu options and default settings at a glance:

The CommonGIS menu system

Within the menus the following operations can be performed:

Project (section 4.1)	New	Create an empty project to start loading new data.
	Open	Load a prepared project file (ending in .app/.mwi).
	Save	Save information on loaded layers and data (suffix .app) and save data changes on request.
	Save as	Save information on loaded layers and data (suffix .app) and save data changes on request as a new project.
	Data import	Load a file with vector, raster or thematic data or an image.
	Data reload	Reload data in order to reproduce their original state.
	Data export	Save a table or a layer in a separate file.
	Save Snapshot	Save a snapshot of the current visualisations.
	Load Snapshot	Load a previously saved snapshot for the current project.
	Print	Print selected elements of a project (map and/or legend, project info).
	Save as image	Save selected elements of a project (map and/or legend, project info) with the specified image format.
	Quit	Quit CommonGIS.
Edit (section 4.1)	Add/Edit attribute	Add an attribute to a table; the user enters the values manually or adapts the values of an existing attribute.
	Remove attribute(s)	Remove selected attributes from a table.
	Join tables	Add selected attributes from different tables to a new table.
	Remove table	Remove an existing table.
	Add/Edit layer	Create a new layer or modify an existing layer.
	Remove layer	Remove a layer (with or without the linked table).
	Select table for layer	Show table-layer links.
	Index a parameter-dependent table	Specify time references within a table
Display (section 4.2)	Display wizard	Offer subset of maps and charts being in line with the selected attributes.

	Clean the map	Reproduce the original state of the map.
	View table	Show the selected table in a separate window.
	View objects	List layer objects with/without their identifiers.
	Perspective view	Show layer objects in three-dimensional space based on the values of the selected attribute.
Calculate (section 4.3)	Calculate in a table	Offer arithmetic and statistical calculation methods and multidimensional analyses on tables.
	Dynamic query	Filter objects which satisfy conditions on attributes.
	Classify objects	Classify objects relative to an attribute.
	WeKa Knowledge Explorer	Cluster objects depending on values of selected attributes (using WeKa Explorer).
	Spatial Analysis	Start Oracle Spatial for spatial analysis.
	Geographic computations	Offer tools for analysis of raster data.
Window (section 4.5)	New window	Create a new window with the content of the current window.
	Duplicate window	Create a new window and duplicate the current map to it.
	Close window	Close one of the displayed windows on the screen.
	Select/Rename window	Show a window on top or rename a window.
	Use a new map window for each new visualisation	Default setting: a new window is created for each visualisation; switch off to show each new visualisation in the main window.
Options (section 4.6)	Show records options	Parameters of permanent view of attributes.
	Popup records options	Parameters of popup attribute list.
	Set scale and coordinate fields visible	Switch on/off scale and coordinate fields at the bottom of the main map window.
Help (section 3.3)	Index	Show the topics of the manual via Internet browser.
	Task support guide	Show special topics for decision support in the browser.
	Direct help	Give help information on a selected menu option.
	About	Give information on CommonGIS (version, copyright...)
	About project	Show project description of the current project.

Default settings in CommonGIS

- **Selection of objects** by mouse dragging is automatically enabled in all noncartographic displays. In a map window mouse dragging can be used as well for zooming and shifting map segments. The user can switch between different interpretations of mouse dragging by using the three dragging symbols in the icon bar (see section 3.2).
- In a map with several layers the user can only select **objects of the active layer**. In order to activate a layer you must click on its name in the legend. If the active layer changes the object selection of the previous layer is no longer visible. It reappears on activating this layer again.
- When new attributes are created by CommonGIS a **default attribute name** is suggested to the user, usually consisting of the operation name and the attribute names involved. The name for the new attribute can be changed using the common editing functions

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