



# user guide

version 1.0  
22<sup>nd</sup> September 2014

“Neue Dialektometrie mit Methoden der stochastischen Bildanalyse”  
DFG-financed project (2008-2014)

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## acknowledgements

*GeoLing* – along with this accompanying manual – was written as a part of the project *Neue Dialektometrie mit Methoden der stochastischen Bildanalyse* (“new dialectometry using methods of stochastic image analysis”), financed by the Deutsche Forschungsgemeinschaft (DFG) between 2008 and 2014. All work has been carried out by people associated with three institutions:

- *Institute of Stochastics* (Ulm University)
- *Lehrstuhl für Deutsche Sprachwissenschaft* (University of Augsburg)
- *Germanistische Sprachwissenschaft* (University of Salzburg)

## license and terms of usage

This software is licensed under the **GNU General Public License v 3.0** (published on 29 June 2007). The full text of GPL 3 is available at <https://www.gnu.org/licenses/gpl-3.0>.

Although we took reasonable precautions and conducted extensive testing, we would like to stress that the software comes without any warranty or guarantee.

## I. basics

### I.1 what is *GeoLing* and what does it do?

In short, *GeoLing* is a handy tool for performing statistical analyses on spatial data: You can use data from dialect surveys, transform them into smoothed maps (via density estimation), detect structures that run through the data and find groups of maps that share spatial features.

We developed this program with linguistic applications in mind, but that should not stop you from using it for any kind of spatially conditioned data.

### I.2 download and installation

The software is written in Java – as Java runs on multiple platforms, there is one version for all users. Please make sure that the Java version running on your machine is up to date; updates are obtainable on <http://www.java.com>. The latest version of *GeoLing* and this accompanying guide are available for download at <http://www.geoling.net/> as an archive file (*geoling.zip*). Note that *GeoLing* requires at least 2 GB RAM, furthermore we recommend a dual-core processor.

*GeoLing* is ready to use after unzipping the archive file (*geoling.zip*); no installation is required. It is important that *GeoLing* has full access to its own directory. This will be the case by default if you extract *GeoLing* somewhere in your own home directory. (In particular, write-access to the “properties” and “databases” subdirectories is required.)

Originally, the software was developed for and tested on the data of the *Sprachatlas von Bayerisch-Schwaben* (SBS).<sup>1</sup> The corresponding database (that served as basis for most examples in this documentation as well) is supplied for demonstration purposes.

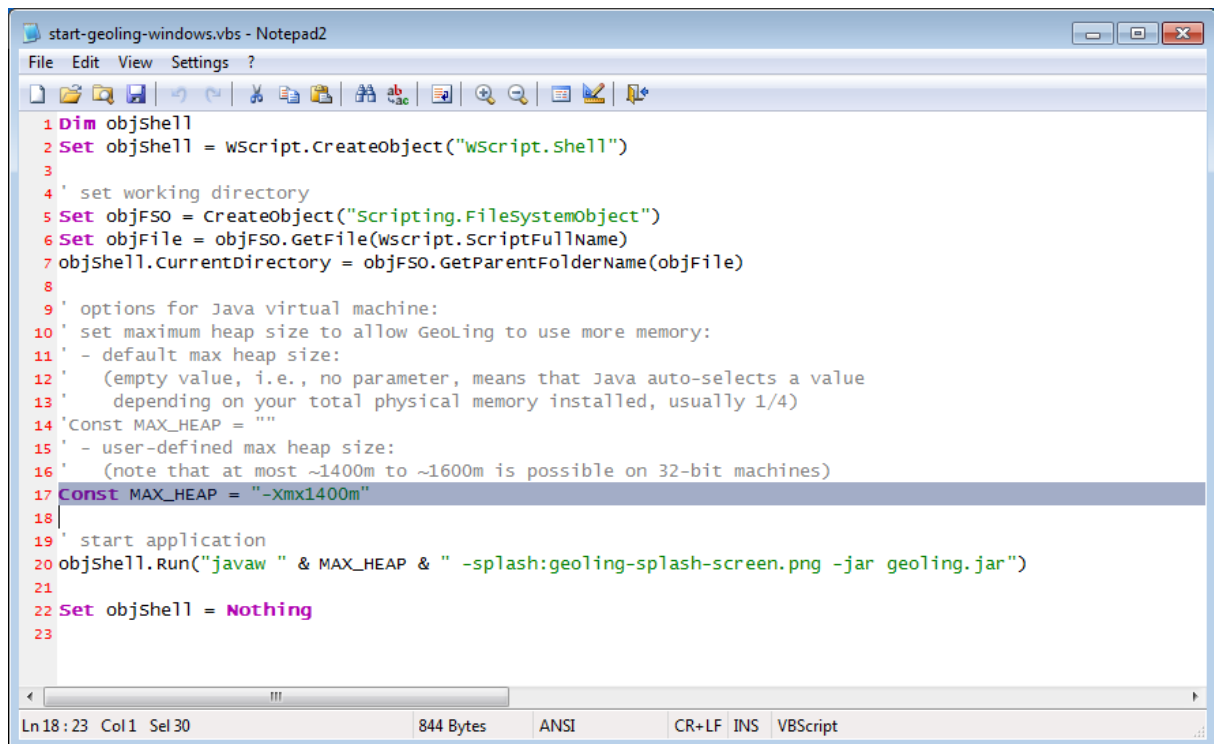
### I.3 starting *GeoLing*

The program starts by executing the file *geoling.jar*.

Included are batch scripts for both Windows (“start-geoling-windows.vbs”) and Linux/Mac (“start-geoling-linux.sh”) systems to provide more RAM for *GeoLing*. Since some operations (such as the clustering of maps, see II.6) require relative large amounts of memory, this is highly recommended. The batch scripts can be adapted to your own needs by using a simple text editor (Figure 1). The highlighted line can be modified to use more (or less) RAM. By default, 1400 MB are used as Java heap size, which is appropriate for 32-bit computers with 2 GB RAM. On 64-bit machines (with 64-bit Java installed) larger values may be used.

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<sup>1</sup> The *Sprachatlas von Bayerisch-Schwaben* is based on dialect data gathered in the 1980s in the transient area of the political regions of Swabia, Bavaria and Franconia in southern Germany (see SBS Volume 1 for further information).



```
1 Dim objShell
2 Set objShell = WScript.CreateObject("WScript.Shell")
3
4 ' set working directory
5 Set objFSO = CreateObject("Scripting.FileSystemObject")
6 Set objFile = objFSO.GetFile(WScript.ScriptFullName)
7 objShell.CurrentDirectory = objFSO.GetParentFolderName(objFile)
8
9 ' options for Java virtual machine:
10 ' set maximum heap size to allow GeolIng to use more memory:
11 ' - default max heap size:
12 '   (empty value, i.e., no parameter, means that Java auto-selects a value
13 '     depending on your total physical memory installed, usually 1/4)
14 'Const MAX_HEAP = ""
15 ' - user-defined max heap size:
16 '   (note that at most ~1400m to ~1600m is possible on 32-bit machines)
17 Const MAX_HEAP = "-Xmx1400m"
18
19 ' start application
20 objShell.Run("javaw " & MAX_HEAP & " -splash:geoling-splash-screen.png -jar geoling.jar")
21
22 Set objShell = Nothing
23
```

Figure 1: Batch script for running *GeoLing* with more RAM on a Windows platform.

## I.4 entering your data

*GeoLing* requires all data to be in the form of a SQL database. You can either set up a database running on a local server yourself or use the program's built-in options to let it set one up for you. Both options will be outlined in the following passages.

In either case, choose "Create new database" in the "Database" dialogue on startup (Figure 2).

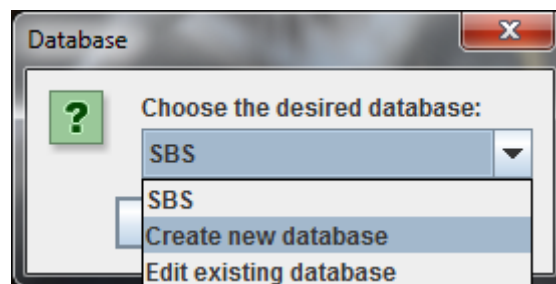


Figure 2: Creating a new database.

The following dialogue box (Figure 3) allows choosing between both options: Using a database that is running on a separate server or using a stripped-down built-in database management system. While the first option offers higher speed and usability in a network situation, it is only recommended for users with prior knowledge of database systems. The second one is easier to use for novices, but leads to slightly slower performance of *GeoLing* and is limited to local use.

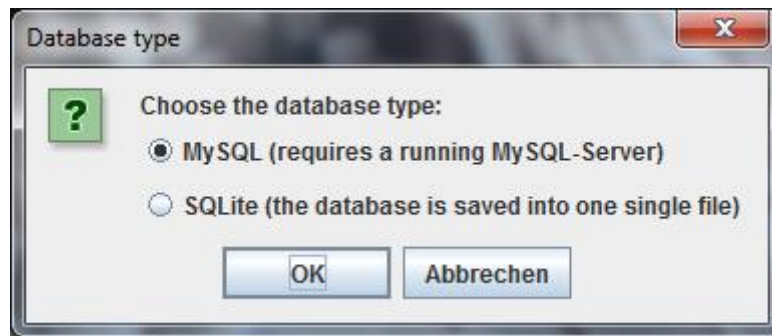


Figure 3: Choosing the database type.

### ⇒ First option: setting up a SQL database yourself

We start with the necessary steps for setting up a server. Should you prefer the second option, please skip this section. (If you are unsure, choose the second option. It is easy to switch to a MySQL database later on, if necessary.)

#### a) Installation of *MySQL Workbench*

For Windows users it is recommended to use the freely available application *MySQL Workbench* for the management of the SQL databases. The *MySQL Community Server* can be downloaded from <http://dev.mysql.com/downloads/mysql/>.

#### b) Setup New Connection

After installing the software, start the application *MySQL Workbench 6.0 CE*. Click on the plus button to the right of “MySQL Connections” to “Setup New Connection”. A window like in Figure 4 should appear; please fill in the blanks as in our example. (Of course, the “Connection Name” can be chosen freely. We decided on “IceCreamConnection” for our example.)

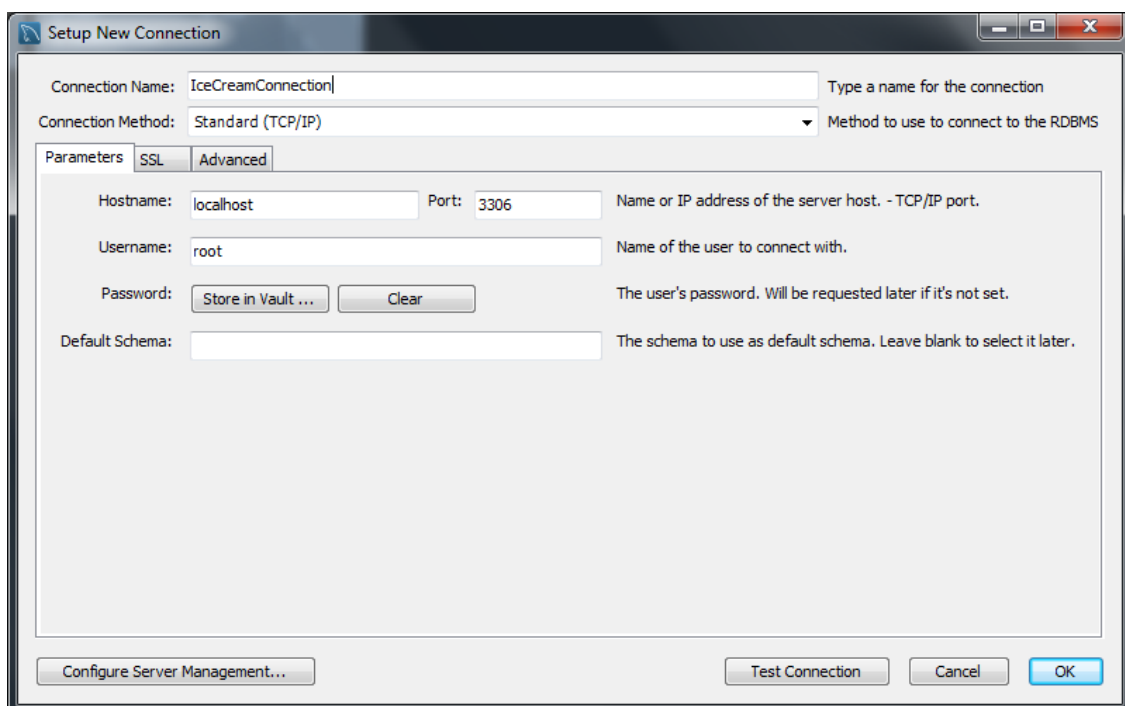


Figure 4: Setting up a new connection in *MySQL*.

If all values have been entered correctly, a click on the button “Test Connection” should yield the message “Connection parameters are correct”. Then, click on “OK” and you will see the new connection in *MySQL Workbench*.

### c) Create a new schema in the connected server

Click on the new connection and a new view appears. On the left, you can see a navigator bar containing some exemplary schemas. Click on the symbol “Create a schema in the connected server”, which shows two disks (marked yellow in Figure 5).

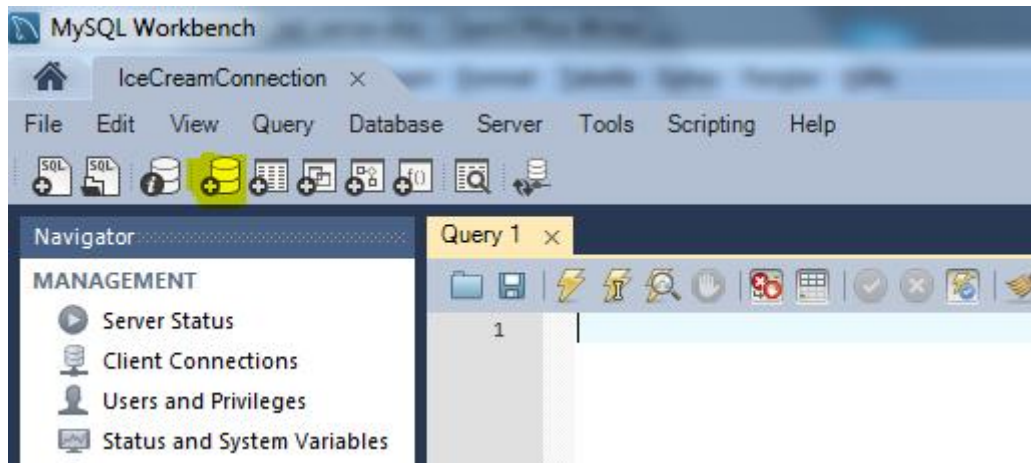


Figure 5: Creating a new schema in *MySQL*.

Enter a name (e.g. icecream) for the new schema and click “Apply”. Then, click on the symbol “Data Import/Restore”. In the window which opens next, choose the toggle button “Import from Self-Contained File” and choose the path to the file “dialectometry.sql”, which contains the create-statements for the tables. Then, select the “Default Schema to be Imported to” (e.g. icecream) and click on “Start Import”. After the import has been finished, a click on the new schema should reveal the following tables (in brackets: the names of the columns):

- bandwidths (id, map\_id, weights\_identification, kernel\_identification, distance\_identification, estimator\_identification, bandwidth)
- border\_coordinates (id, border\_id, order\_index, latitude, longitude)
- borders (id, name)
- categories (id, parent\_id, lft, rgt, name)
- categories\_maps (id, category\_id, map\_id)
- configuration\_options (id, name, value)
- distances (id, name, type, identification)
- groups (id, name)
- groups\_maps (id, group\_id, map\_id)
- informants (id, location\_id, name)
- interview\_answers (id, interviewer\_id, informant\_id, variant\_id)
- interviewers (id, name)
- levels (id, name)
- locations (id, name, code, latitude, longitude)
- location\_distances (id, distance\_id, location\_id1, location\_id2, distance)
- maps (id, name)
- tags (id, parent\_type, parent\_id, name, value)

- variants (id, map\_id, name)
- variants\_mappings (id, variant\_id, level\_id, to\_variant\_id)

If all 19 tables have been created, the installation of the local server and the creation of the required SQL database in the given format have been successful. Please make sure that your MySQL Server is running after every restart of your system. Otherwise, *GeoLing* cannot access the server.

⇒ **Second option: using *GeoLing*'s built-in database management system**

On startup, choose “Create new database” in the “Database” dialogue (Figure 2) and “SQLite” as database type (Figure 3). You are then prompted to set location and name for the database file (Figure 6). The filename should follow the pattern *databasename.db* (make sure you explicitly specify the file extension “.db”). A suitable location for the database file is the subdirectory “databases” located in the *GeoLing* directory. For example, the included SBS database is stored in “databases/SBS/SBS.db”.

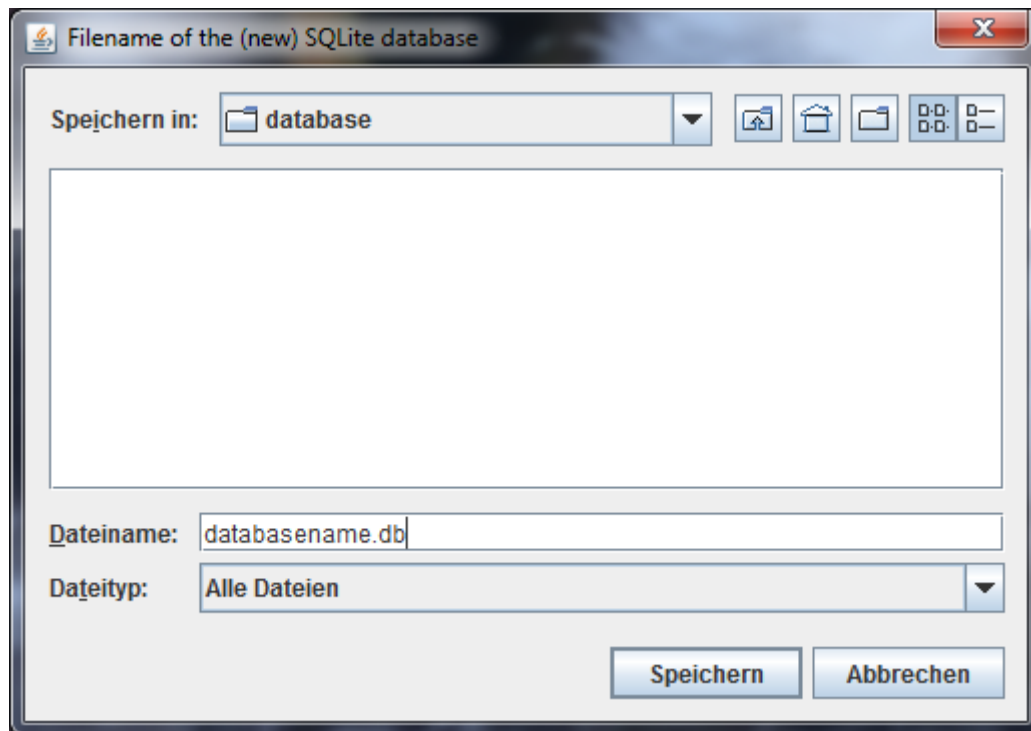


Figure 6: Specifying location and name of the database file.

⇒ **After setting up the database: import your own data**

The following passages outline each of the original files that are necessary for import. They should all be placed in one folder. Press the button “Choose input folder” to set its path (Figure 7).



Figure 7: Window for data import in *GeoLing*.

To the right there is a button for selecting the encoding of your data, UTF-8 or ISO-8859-1 (Figure 8).



Figure 8: Choosing the encoding of the data.

NB: *GeoLing* uses a decimal point (".") as a decimal mark, not a comma. There is no separator for thousands. All tables are csv-files with a semicolon (";") as delimiter – thus, **there should never be a semicolon in the data you wish to import**. We recommend avoiding special characters in your data if possible, because this eliminates the need to think about characters with special meanings or character encodings (like ISO-8859-1 or UTF-8) during data import/export.

Let's look at the specific files in detail:

`border_coordinates.csv`

This table determines the outer border of the basic map, delimiting the area of investigation. The first column features the order of the waypoints; the following ones latitude and longitude of these points (see Figure 9).



	A	B	C
1	order_index	latitude	longitude
2	1	50.218891	6.07321
3	2	46.85	7.32
4	3	46.33	7.76
5	4	46.3	7.99
6	5	46.592461	14.26993
7	6	46.687511	15.9872
8	7	47.72538	16.93586
9	8	48.14761	16.942051
10	9	48.724339	16.721939
11	10	51.266667	15.566667
12	11	53.944069	14.14374

Figure 9: border\_coordinates.csv.

NB: It is possible to define more than one outer border; thus, you will be asked to specify a name for each border.

## locations.csv

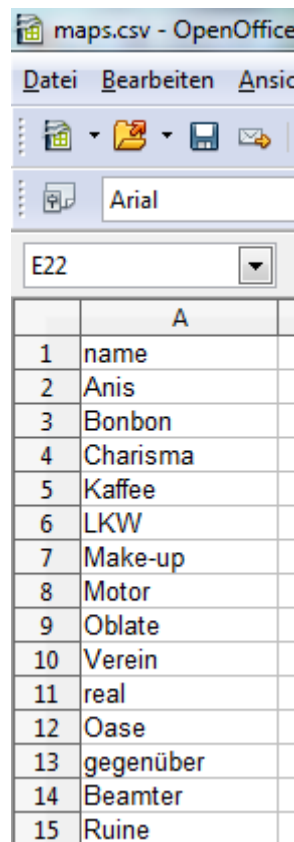
This table contains the names and coordinates of all locations, with the first column giving the name, the second an identifier (number/ID-tag/abbreviation) (that can be displayed directly in the maps), the third and fourth latitude and longitude (Figure 10). Note that the name must be unique, it is used in the other files as reference. All locations should have different geographical coordinates.

	A	B	C	D	E
1	name	code	latitude	longitude	
2	Aitrang	1	47.8196541	10.536059	
3	Altenmünster	2	48.4589825	10.5513457	
4	Altheim	3	48.5788648	10.0105589	
5	Asbach	4	48.6941038	10.81004	
6	Auchsheim	5	48.6908262	10.7806048	
7	Augsburg	6	48.3714407	10.8982552	
8	Biburg	7	48.374965	10.757741	
9	Bobingen	8	48.2746049	10.7738392	
10	Bühl	9	48.4185225	10.1894515	
11	Buxheim	10	47.9978929	10.1336661	

Figure 10: locations.csv.

maps.csv

Here, the names of all maps are recorded. Typically, this will be the same as the variable's name. Only one column is necessary (Figure 11). As for locations, the name has to be unique.



	A
1	name
2	Anis
3	Bonbon
4	Charisma
5	Kaffee
6	LKW
7	Make-up
8	Motor
9	Oblate
10	Verein
11	real
12	Oase
13	gegenüber
14	Beamter
15	Ruine

Figure 11: maps.csv.

informant\_answers.csv

This will probably be the largest of your source files: It bundles all the information (in case of dialectological uses all responses given by the informants) in a table following the pattern *informant* (rows) x *variables/maps* (columns) = *record* (fields). The first column contains the name of the informant, the second one the location (same spelling as in *locations.csv*), the third one the interviewer (or similar additional information on the record). Starting with the fourth column, each column's header bears the name of one of the maps listed in *maps.csv* (Figure 12). If a combination of informant and location features more than one record, they can be entered into the same field, separated by a “|” symbol.

	A	B	C	D	E	F	G
1	informant_name	location_name	interviewer_name	Anis	Bonbon	Charisma	Kaffee
2	BER0	Konstanz	I.B.	Anis	b"Onbon	char"Isma	kaff"EE
3	BER1	Augsburg	I.B.	A:nis	bonb"O	char"Isma	kaff"EE
4	BER2	München	I.B.	Anis	b"Ombom	ch"Arisma	k"Affee
5	BER3	Augsburg	I.B.	A:nis	b"Onbon	char"Isma	kaff"EE
6	BER4	Steppach	I.B.	A:nis	b"Onbon	ch"Arisma	kaff"EE
7	BER5	Steppach	I.B.	A:nis	b"Ombom	ch"Arisma	k"Affee
8	BER6	Augsburg	I.B.	A:nis	b"Onbon	char"Isma	kaff"EE
9	BER7	Gersthofen	I.B.	A:nis	b"Ombom	ch"Arisma	k"Affee
10	BER8	Diemantstein	I.B.	A:nis	b"Onbon	char"Isma	k"Affee
11	BER9	Gersthofen	I.B.	Anis	bonb"O	char"Isma	k"Affee
12	ENG0	Kraftisried	J.E.	A:nis	b"Onbon	ch"Arisma	kaff"EE
13	ENG1	Hochgreut	J.E.	A:nis	b"Onbon	char"Isma	kaff"EE
14	ENG2	Kraftisried	J.E.	A:nis	bonb"On	char"Isma	k"Affee
15	ENG3	Kraftisried	J.E.	A:nis	b"Onbon	char"Isma	kaff"EE
16	ENG4	Kraftisried	J.E.	A:nis	bonb"O	ch"Arisma	kaff"EE
17	ENG5	Kraftisried	J.E.	A:nis	b"Onbon	char"Isma	k"Affee
18	ENG6	Hochgreut	J.E.	A:nis	bonb"O	char"Isma	kaff"EE
19	ENG7	Aitrang	J.E.	A:nis	b"Onbon	char"Isma	kaff"EE
20	ENG8	Kraftisried	J.E.	A:nis	b"Onbon	ch"Arisma	k"Affee
21	ENG9	Görisried	J.E.	A:nis	bonb"O	char"Isma	k"Affee
22	FRA1	Wertingen	J.F.	A:nis	bonb"O	ch"Arisma	kaff"EE
23	FRA2	Biburg	J.F.	A:nis	bonb"O	char"Isma	kaff"EE
24	FRA3	Augsburg	J.F.	A:nis	b"Onbon	char"Isma	k"Affee
25	FRA4	Eppisburg	J.F.	A:nis	bonb"O	ch"Arisma	kaff"EE

Figure 12: informant\_answers.csv.

## categories.txt

This is a plain text file that is used to construct a hierarchy of maps that is later displayed in the map browser (see II.1). Possible hierarchies would for example be the traditional system of a dialect atlas: *volumes* > *topics* > *subtopics* > *single maps*. Each line contains the name of a category, followed by a colon, followed by all its direct children, each of them separated by a semicolon. The first line after the header contains the “top” category, e.g. the name of the atlas. The hierarchy is recursive, i.e. categories on a “lower” level can have subcategories themselves (Figure 13).

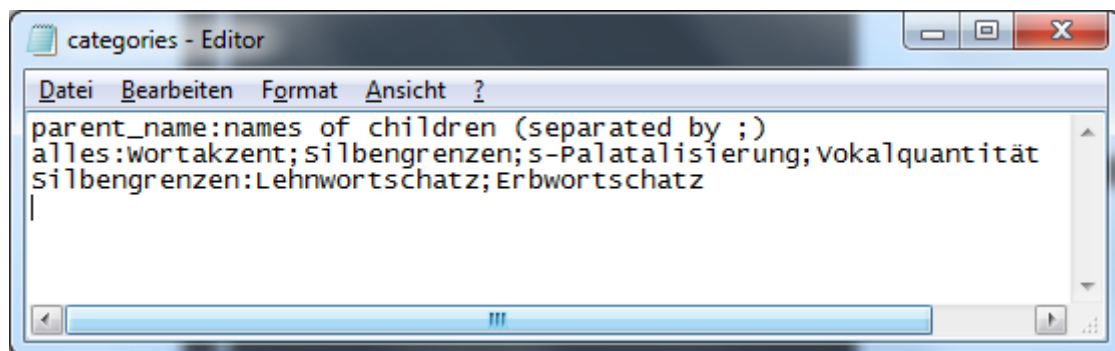


Figure 13: categories.txt.

### categories\_maps.txt

Each map has to be assigned to a category to be visible and accessible in the GUI. This allocation is taken care of through the entries in *categories\_maps.txt*. The basic principle follows the one above: Each line features a category, followed by a colon, and all maps that are to be assigned to the category. These maps are again separated from each other by a semicolon (Figure 14).

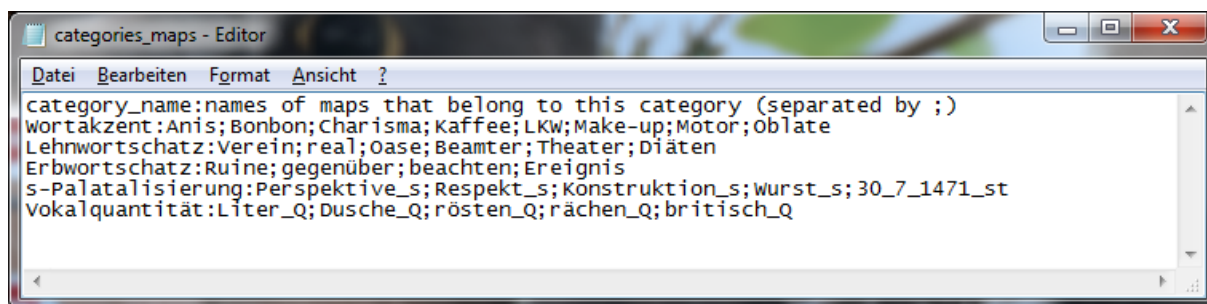


Figure 14: categories\_maps.txt.

### groups\_maps.txt

This third plain text file can be used to simplify analyses by providing ready-made groups of maps in the GUI (for example all maps containing fronted vowels). The difference of categories and groups is that categories are hierarchical and for selecting individual maps in the GUI, but groups are sets of maps which are used later on for analyses based on a sub-corpus. Principle and execution follow the other two text files above. This function is not mandatory for a successful import; groups can be generated from within the GUI as well (see II.3).

NB: It is essential to end all lines – also the last one – of these three plain text files with a line break; otherwise the import routine will ignore their content.

### distances.csv

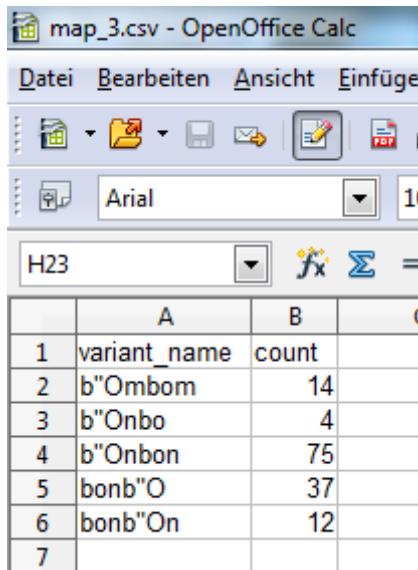
*GeoLing* is able to calculate the geographic distances between the locations based on the coordinates you provided in *locations.csv*. Nevertheless you are free to enter your own distance measures (e.g. travel time) using *distances.csv*. Figure 15 displays the way the distance values should be arranged.

	A	B	C	D
1	location_name1	location_name2	distance	
2	Berlin	München	783.6303710938	
3	Berlin	Frankfurt am Main	475.830078125	
4	Berlin	Hamburg	445.9838867188	
5	Berlin	Dortmund	779.6325683594	
6	Berlin	Ulm	393.4631347656	
7	Berlin	Augsburg	166.2902832031	
8	Berlin	Salzburg	129.2724609375	
9	Berlin	Wien	522.4609375	
10	München	Frankfurt am Main	617.0349121094	
11	München	Hamburg	648.9562988281	
12	München	Dortmund	691.7724609375	
13	München	Ulm	391.1437988281	
14	München	Augsburg	578.6437988281	
15	München	Salzburg	352.294921875	
16	München	Wien	806.5490722656	

Figure 15: distances.csv.

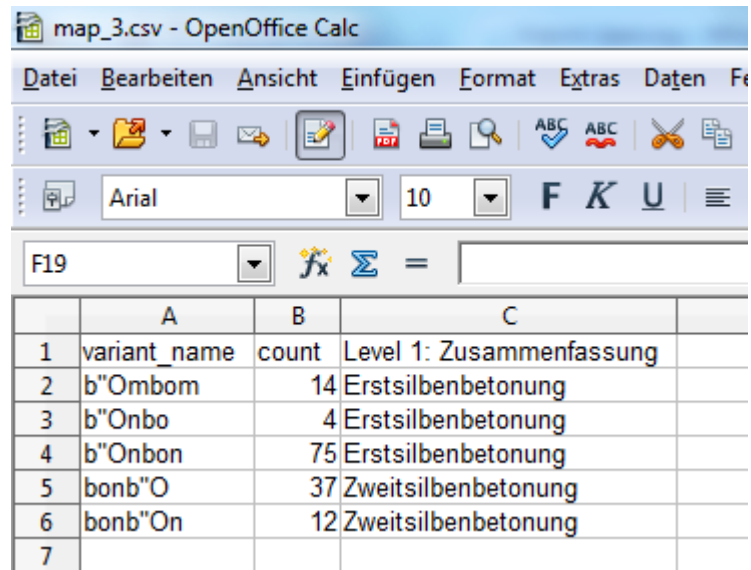
As last steps, the functions “Prepare variant mapping” and “Read variant mapping” are used to generate levels of abstraction or granularity over the base layer: For example, the data might contain complex phonetic transcriptions for every record, but you intend to use the data to draw a map on phonological or on purely lexical variation. You could then create a level of abstraction, where various raw phonetic values are mapped to a few phonological values – and another level where you disregard phonetic/phonological detail completely and focus on lexical differences instead.<sup>2</sup> “Prepare variant mapping” outputs a CSV table for every map that contains all variants (and their count) that are contained in the data (Figure 16). This file can be edited and then be imported again. Each additional column may contain one individual abstraction (see Figure 17 for a basic example with just one level). Should you not need any abstraction at all, it is sufficient to simply copy the first column and insert it as the third.

<sup>2</sup> Or, you might just use it to handle misspellings in the data.



	A	B	C
1	variant_name	count	
2	b"Ombom	14	
3	b"Onbo	4	
4	b"Onbon	75	
5	bonb"O	37	
6	bonb"On	12	
7			

Figure 16: Empty csv for mapping.



	A	B	C
1	variant_name	count	Level 1: Zusammenfassung
2	b"Ombom	14	Erstsilbenbetonung
3	b"Onbo	4	Erstsilbenbetonung
4	b"Onbon	75	Erstsilbenbetonung
5	bonb"O	37	Zweitsilbenbetonung
6	bonb"On	12	Zweitsilbenbetonung
7			

Figure 17: Mapping with one level of abstraction.

Finally, “Read variant mapping” reads and processes these edited tables.

Should you wish to revise or enlarge your database at a later time, you can access the editing process by choosing “Edit existing database” during the startup selections (Figure 18).

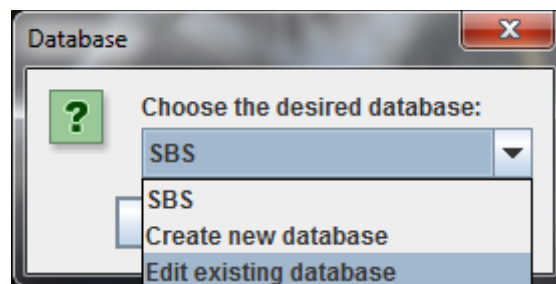


Figure 18: Editing an existing database.

## I.5 customizing and expanding the program

In compliance with the GPL 3 license, the entire source code for *GeoLing* is part of the package provided on the homepage. Thus, you can not only add your own program parts but tweak the existing ones to your exact needs.

## II. program functions

On startup, you are prompted for the database you want to work with (Figure 19).

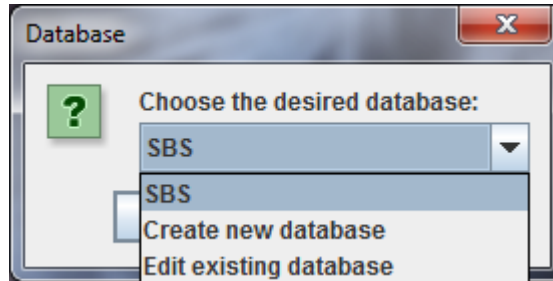


Figure 19: Database selection.

The database for the SBS (Sprachatlas von Bayerisch-Schwaben) is included for demonstration purposes. You may also create a new database or edit an existing one from this prompt (see I.4, *entering your data*).

When you've chosen a database, a screen as in Figure 20 opens. Three tabs – *Categories*, *Groups* and *Export* – are accessible in the top left of the window, three buttons on the right bottom – “Open selected map...”, “Open factor analysis...” and “Open cluster analysis...” – can be clicked to open further tabs. Each of those tabs contains one way of accessing, visualizing or analyzing the data. All of these tabs are explained in detail through the next paragraphs.

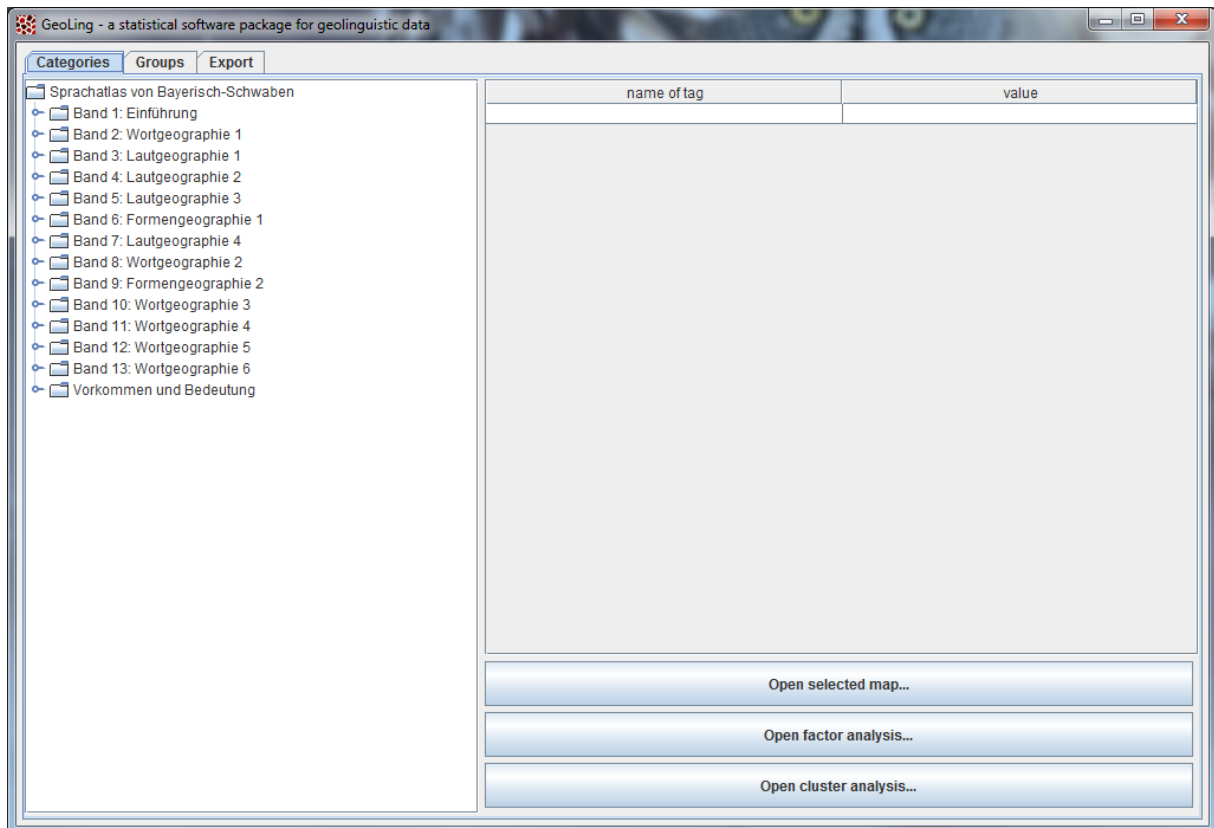


Figure 20: Startup screen.

The tab to the far left – which is active by default – is the map browser.



## II.1 map browser

The map browser displays the datasets contained in the database. For example, Figure 21 shows part of the SBS database structure: Just like in the printed form of the atlas, the data is subdivided into 13 volumes, and each of these volumes is subdivided into categories of maps. The map browser reflects this structure. Navigation through the tree enables the user to access each single dataset or “map”.

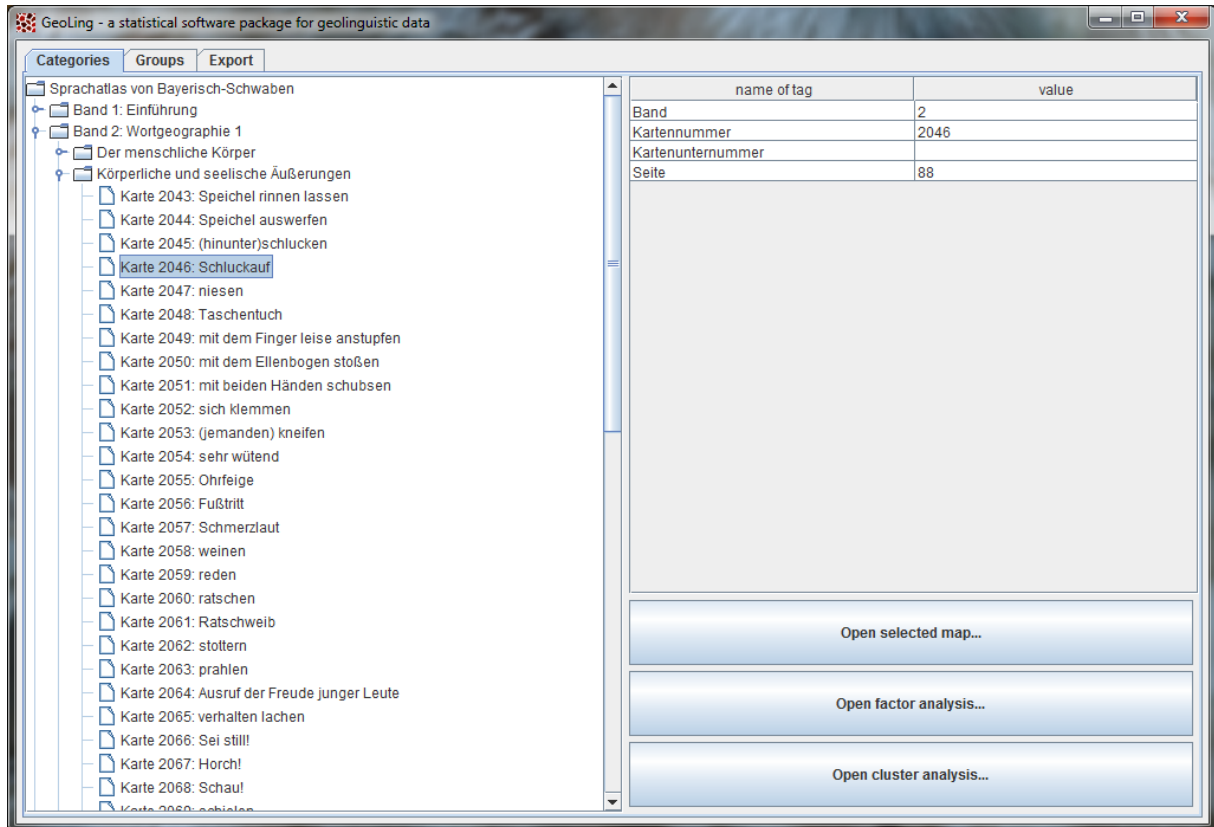


Figure 21: Map browser.

Highlighting an entry (as in Figure 21) reveals additional information about it in the right half of the window; a double click on it (or the button “Open selected map...”) opens a tab named “density estimation” for generating a density map.

## II.2 intensity estimation

This tab contains the means to transform the discrete point data of the map you clicked into graded area class maps. Before we get into the technical details, it might be wise to take a look at why doing so might be a good idea.

### Motivation

The motivation for intensity estimation of dialect data stems from the issues introduced in data collecting: All dialect data we survey are merely statistical samples. While dialectologists have always done their best in controlling for unwanted bias and putting great emphasis on the choice of subjects, there can be no doubt that there is no such thing as an “maximally representative” sample. But drawing conventional point-symbol maps from data sampled at isolated points suggests this nonetheless; graded area class maps do not.



If we acknowledge that our data are statistical samples, we must acknowledge that they contain a margin of error. Consider that we asked another person, consider that we asked more persons overall, consider that we asked the same persons on another day and in a different state of mind, etc. To compensate for this, we can assign a certain probability to every one of the data points – the intensity – and map that instead of the original samples. To estimate this individual probability, we take into account the surrounding data points since proximity often entails linguistic similarity. (We will have to define what exactly we talk about when we talk about “proximity”, however. As will be explained, we use *distance measures* for this.) Thus, maps generated employing intensity estimation are not only eye candy but offer a probabilistic view on the underlying data.<sup>3</sup> This is a reinterpretation of the data, not a modification: In intensity estimation, the “weight” of a data point is not altered, but is “smeared” across a certain ambit. Note that sometimes we say “density estimation” instead of “intensity estimation”. This is exactly the same – “density” comes from the statistical background, “intensity” is closer to the interpretation.

## Parameters

With this in mind, we can return to the program’s GUI. Figure 22 shows the tab for intensity estimation, where different parameters can be selected using check boxes and drop-down menus. These parameters are used to perform a so-called “kernel density estimation” to estimate the intensities.

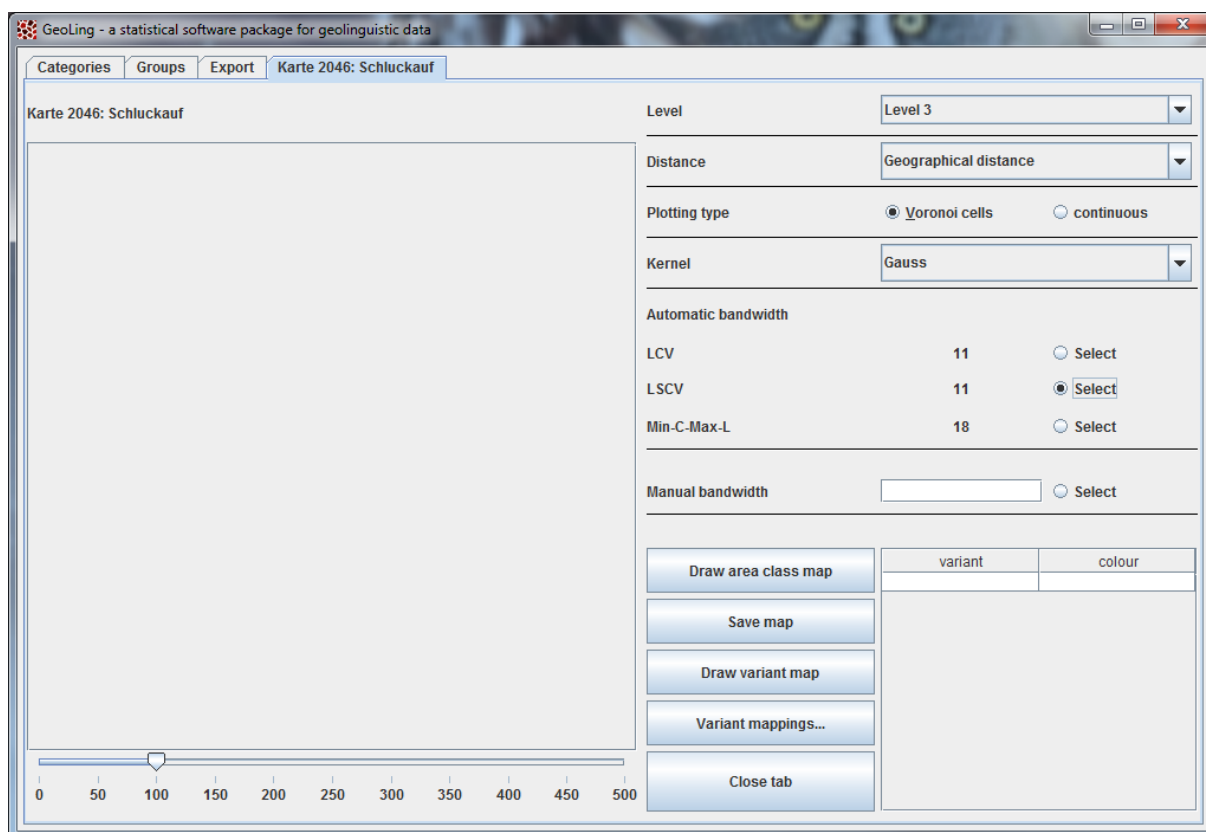


Figure 22: Tab for density estimation

<sup>3</sup> RUMPF / PICKL / ELSPAB / KÖNIG / SCHMIDT (2009) explain the whole process in full detail. Some applications are documented by RUMPF (2010), PICKL / RUMPF (2011, 2012), PICKL (2013a, b) and PRÖLL (2013a, b). SCHERRER (2011) and SCHERRER / RAMBOW (2010a, b) use this approach for automatic dialect translation systems.

Let's look at them from top to bottom:

parameter	description
<b>Level</b>	This drop-down menu sets the level of abstraction or “granularity”. For the SBS database, we used these levels to disregard phonetic or morphological details that would be over-informative for certain questions. PICKL (2013b: 75–78) covers this thoroughly.
<b>Distance</b>	Here, the type of distance measure between locations has to be selected. The SBS database features geographic and linguistic distances; <sup>4</sup> you can easily integrate your own distances (see I.4).
<b>Plotting type</b>	There are two types of maps that can be generated. One type subdivides the mapping space into Voronoi cells; every point of the area is assigned to the nearest point of measurement. The other one is continuous; it interpolates each value on a dense grid (only for geographic distances, see PRÖLL 2013b: 58–64 for more details).
<b>Kernel</b>	This is for choosing the kernel (Gauss, $K_3$ or Epanechnikov), which is used in kernel density estimation. In principle, the choice of kernel is not as relevant for the result as other parameters (see JANERT 2010: 20 in general or RUMPF 2010: 49–63 for our data). Still, it can have an effect.
<b>Automatic bandwidth</b>	These options select one of three methods for optimizing the bandwidth, which controls the range of the distance-dependent smoothing: <ul style="list-style-type: none"> <li>- LCV (likelihood cross-validation)</li> <li>- LSCV (least-squares cross-validation)</li> <li>- Min-C-Max-L, an algorithm that minimizes cost between two concurring statistical parameters of the map (see PICKL 2013a for details).</li> </ul>
<b>Manual bandwidth</b>	This lets you choose a bandwidth manually by entering a numeric value; it overrides the choices made in the field for automatic bandwidth above.

## Visualization

After choosing the parameters, a click on the button “Draw area class map” computes and visualizes the data. Figure 23 displays an example from the SBS data. The different colour hues represent different dominant variants. By “dominant” we mean that the variant has a higher intensity (density) than every one of the locally competing variants.

NB: Point the mouse to any location on the map to obtain more information in a tooltip (e.g. name of location, intensity values).

<sup>4</sup> PICKL / SPETTL / PRÖLL / ELSPAB / KÖNIG / SCHMIDT (2014) provide a comparison of the performance of geographic and linguistic distances in intensity estimation.

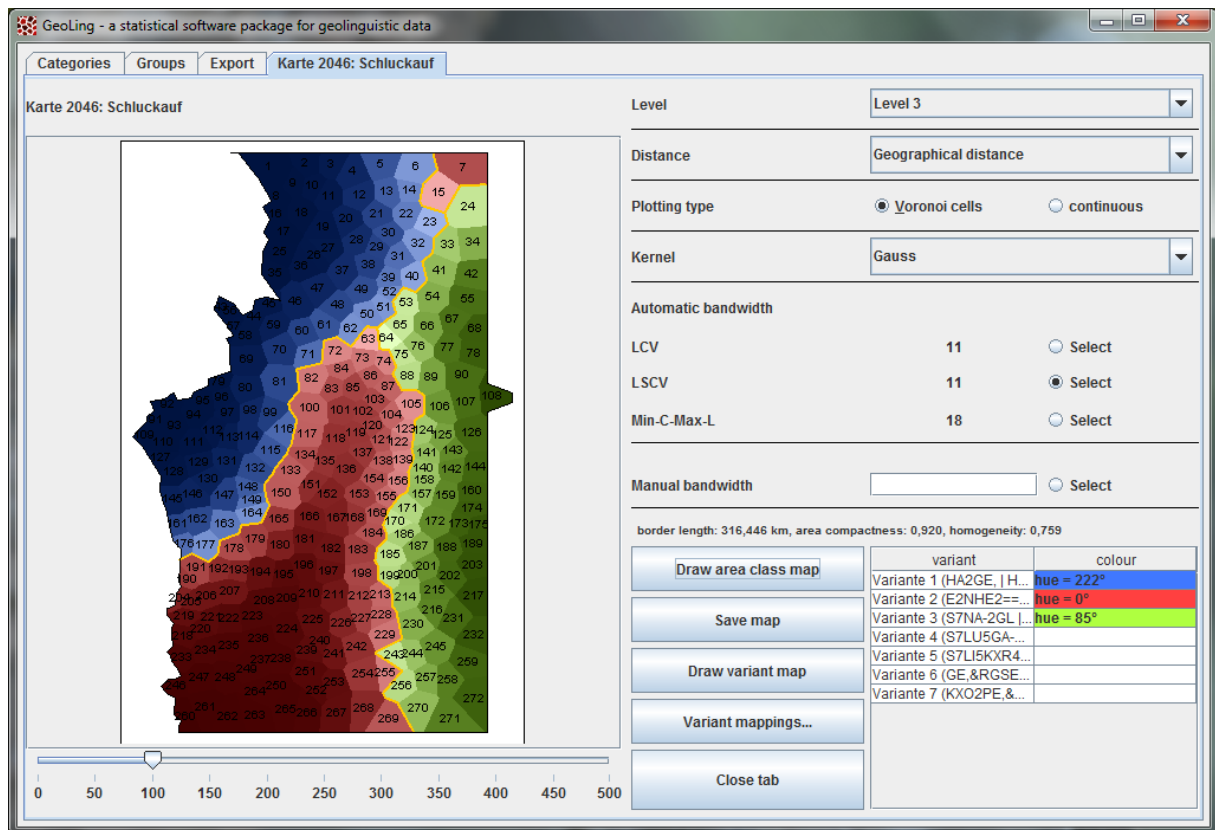


Figure 23: Display of an area class map.

## Spatial characteristics

The values displayed between the parameters and the buttons are three spatial characteristics established in RUMPF / PICKL / ELSPAB / KÖNIG / SCHMIDT (2009):

- total border length in kilometers, or *complexity*
- overall area *compactness* and
- overall *homogeneity*

The uses of these values are manifold: PICKL (2013a,b) and PRÖLL (2013b) show only some of the possible interpretations that arise from statistical tests performed on these values and their differences across maps.

## Export

Export options are available through a click on “Save map”. This opens a dialogue that allows to export the map itself to an Encapsulated PostScript (\*.eps) file or a Portable Network Graphics (\*.png) file, but also the intensity values in the form of an Extensive Markup Language (\*.xml) file.

## Dealing with single variants

The fields to the lower right side of the window show all the variants the currently viewed variable/map contains. Double-clicking on one of them allows for changing its colour in the area class map (see Figure 24).

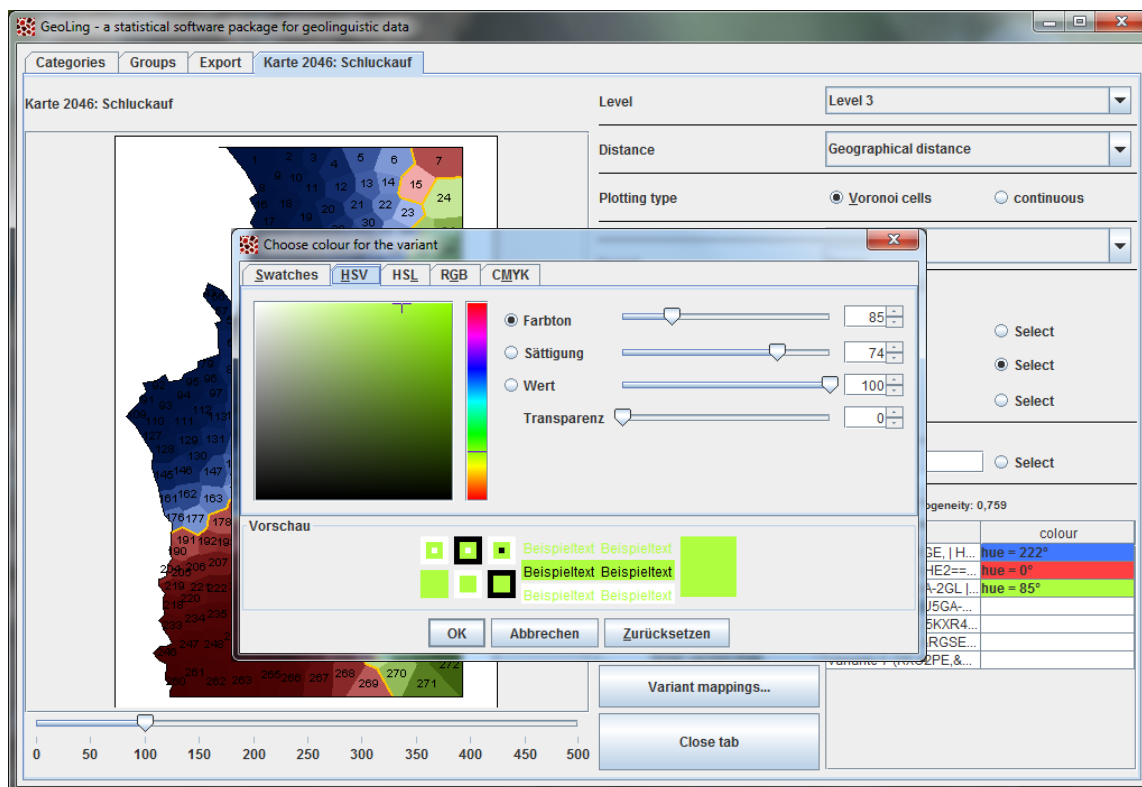


Figure 24: Changing the colour of a variant.

With just a single click on the variant and another one on “Draw variant map”, one can visualize a map of the density of just this single variant (be it dominant in the area class map or not). The colour of these maps is blue by default (see Figure 25).

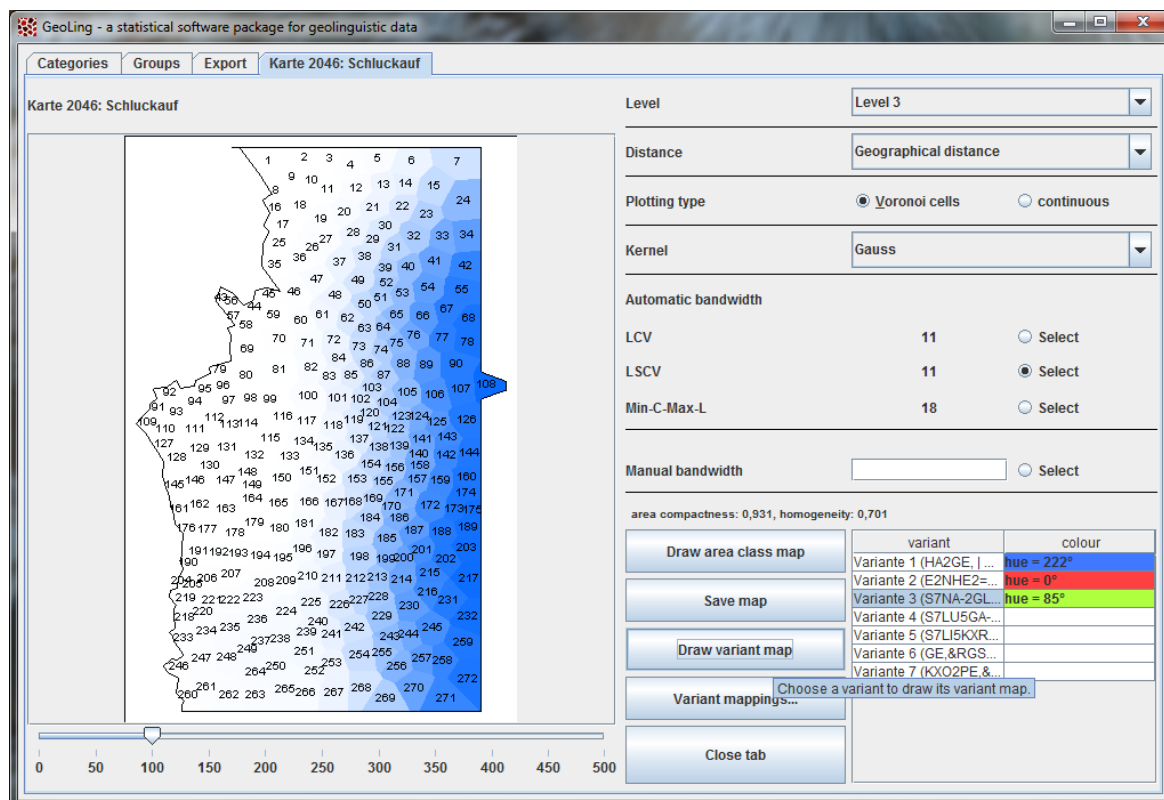


Figure 25: Display of a single variant.

NB: If you single click on the right-hand column (the one with colours) instead of the left column, then “Draw variant map” will use this colour instead of the default blue.

## II.3 group browser

The group browser tab is for combining single maps to groups; these groups can be chosen as the basis for further steps, for example doing a cluster analysis on all maps of vowels or a factor analysis of all maps that belong to the semantic field “crop”. In Figure 26, for example, a group containing all SBS maps on verbs is shown. The left part presents all the accessible groups by name (first column) and the number of maps (second column). A click on one of them reveals all maps contained therein in the right window.

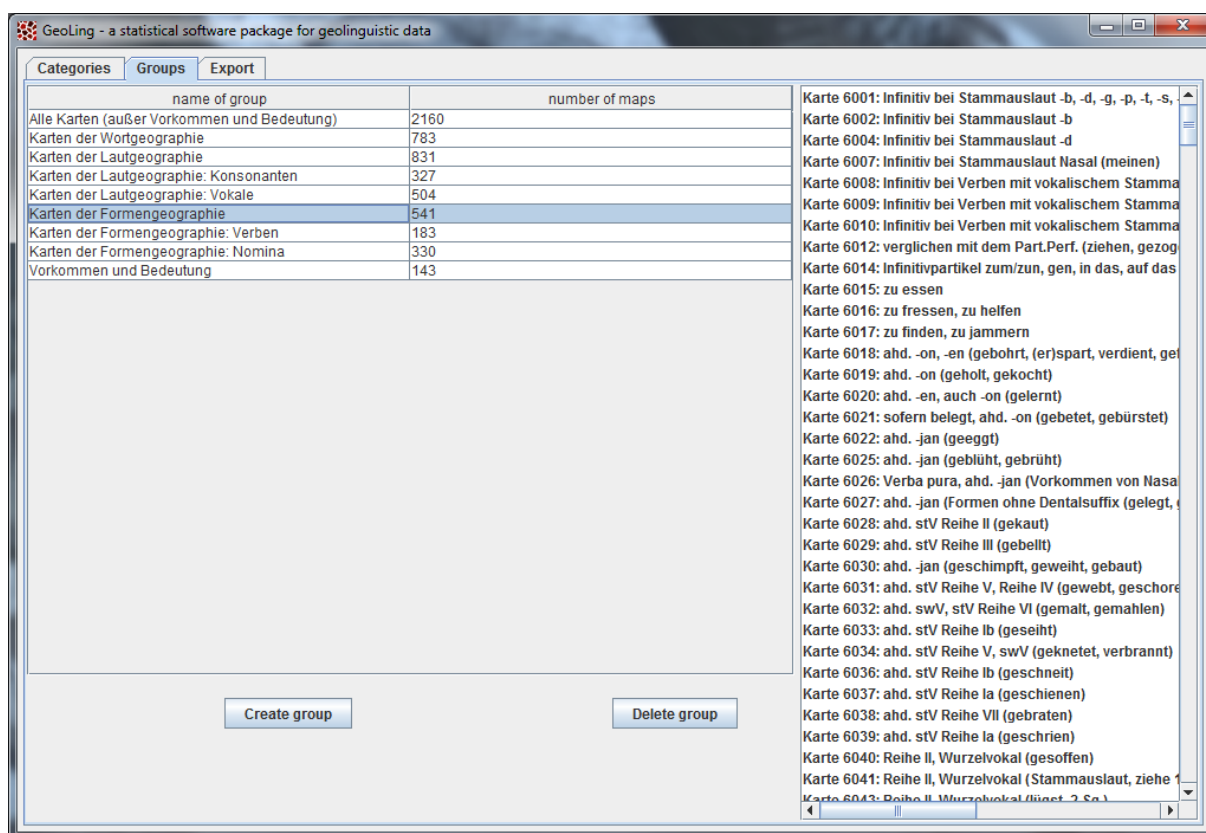


Figure 26: Group browser tab, featuring a selected group (left) and its content (right).

New groups can be assembled manually by clicking “Create group”. This opens a map browser where maps can be selected by ticking checkboxes.

## II.4 export

Often, you will want to generate or work with more than one map at once. But creating and exporting every single map separately would be tedious and uneconomical. For those cases the *export* tab allows for generating whole groups of maps (see II.3) via batch processing.

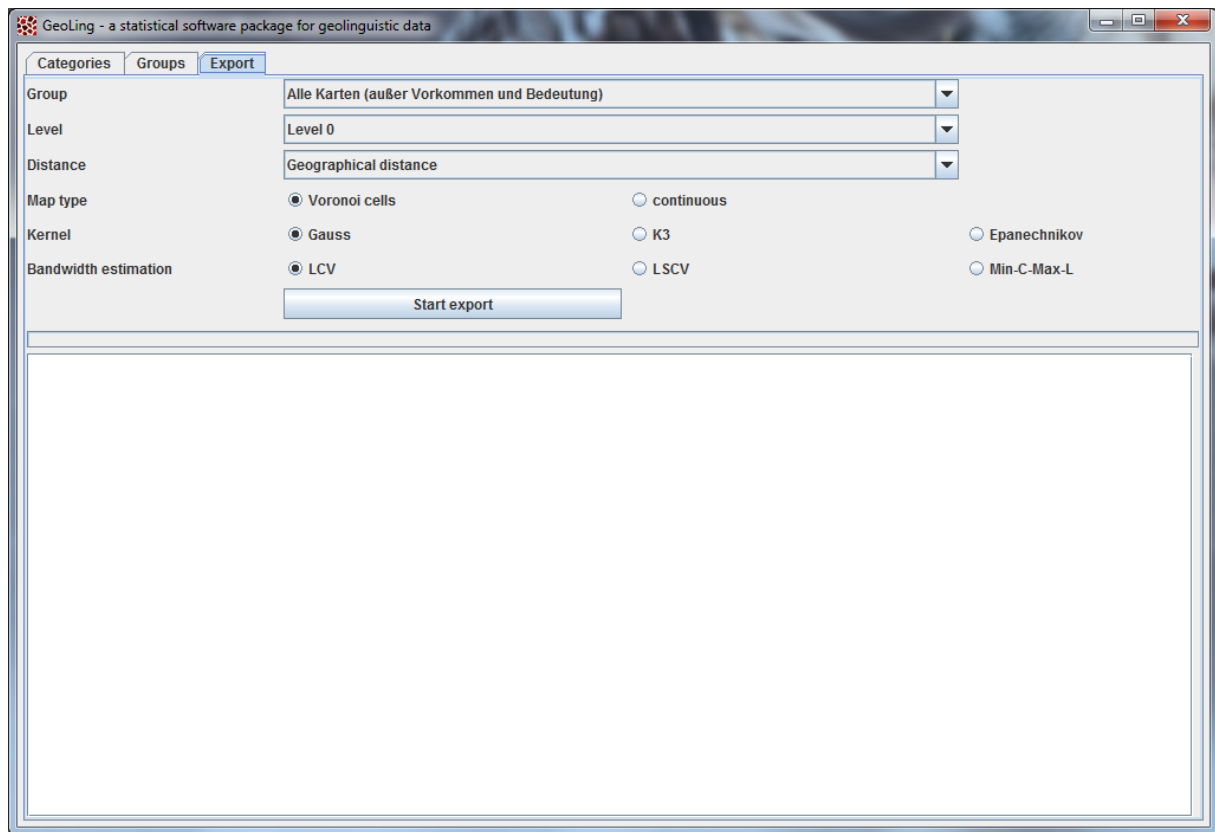


Figure 27: Export tab.

You can choose a pre-defined group of maps, select the parameters the same way as it's done in the calculation of single maps (see II.2) and set an output directory; the process then generates an EPS file and a PNG file containing the map as well as an XML file containing the resulting intensity values for each of the maps in the chosen group. In addition to that, it outputs a CSV (Comma Separated Value) file (easily interpretable by a broad selection of consumer software) that contains a list of all maps in the group, their respective *complexity*, overall *compactness* and overall *homogeneity*, as well as the number of dominant variants.

## II.5 factor analysis

The second of the tabs accessible via button on the startup screen (cf. the beginning of section II) opens a tab for performing a factor analysis.

### Background on factor analysis

Factor analysis is a technique for reducing the dimensions in data (originally developed for application in psychology, see e.g. WOTTAWA 1996: 813). It can be used for finding “traits” that run through the data, a small number of underlying patterns that can describe large parts of the overt variation in a compact way. To our knowledge, WERLEN (1984) was the first to use factor analysis in a variationist context; BIBER (1985, 1991) popularized its use by applying it in corpus linguistics.

## Parameters

Three parameters are directly accessible through the GUI (see Figure 28):

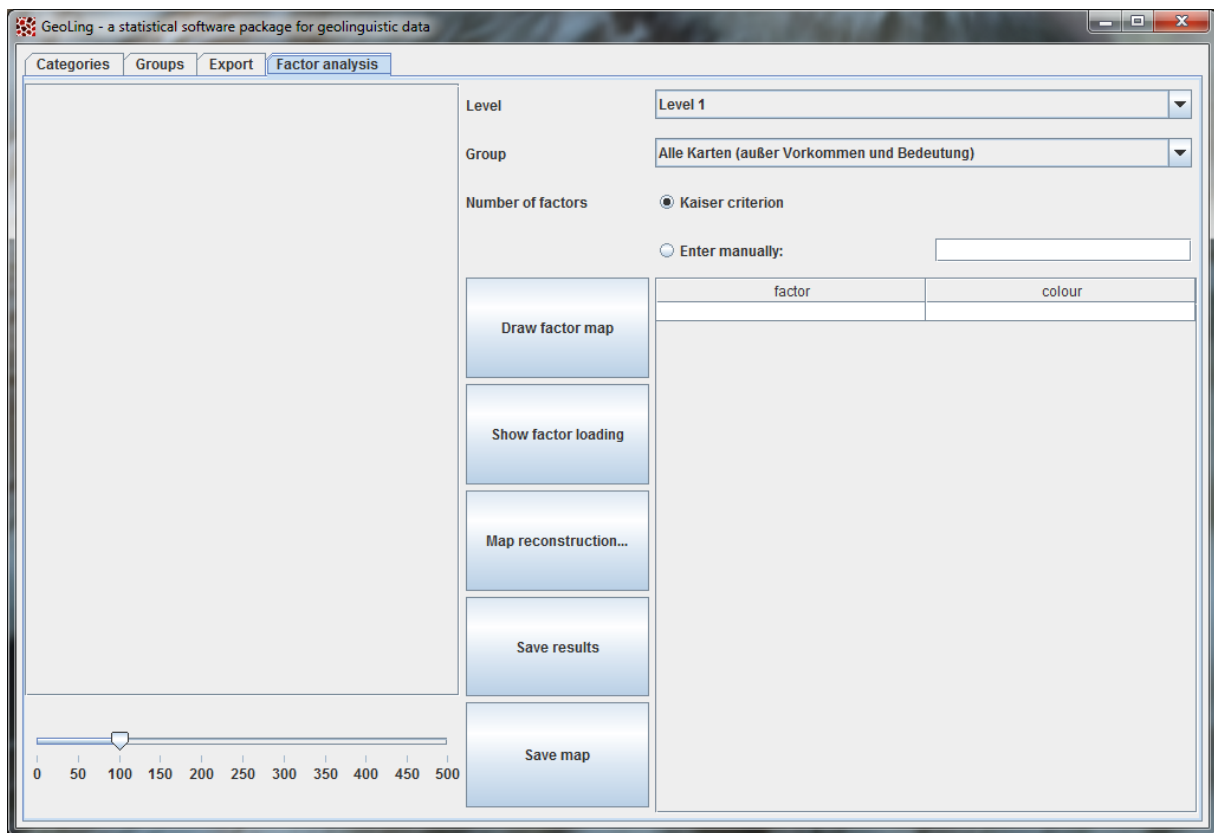


Figure 28: Factor analysis, basic mask.

The first one is – again – the abstraction level. For factor analysis, we recommend using an abstraction level as low as possible (e.g. level 1). The menu for “Group” lets you choose any of the groups of maps you specified in the group tab (II.3). The checkbox options deal with the number of factors that will be extracted from the data. There is a consensus that there is no right or wrong number of factors; nevertheless, methods for optimizing the number of factors have been developed and used for many years. We implemented the *Kaiser criterion*<sup>5</sup>, which is a widely used standard criterion. Still, it is possible to disregard the Kaiser criterion and set the number of factors manually by entering it in the text box.<sup>6</sup>

## Visualization

A click on the button “Draw factor map” starts the calculation of the factors. Figure 29 shows a typical result of an analysis like this, a factor map of all SBS maps dealing with nominal morphology. As always, the map has a mouse-over function: If you point the mouse to any location, a tooltip will reveal the local composition and interplay of factors.

<sup>5</sup> The Kaiser criterion disregards factors with an eigenvalue smaller than 1.

<sup>6</sup> In general, the Kaiser criterion is seen as a rather conservative approach that yields results with relatively high numbers of quite weak factors. However, our applications (PICKL 2013b, PRÖLL 2013, PRÖLL / PICKL / SPETTL to appear) could show that even those small factors are reasonably interpretable from a geolinguistic point of view.

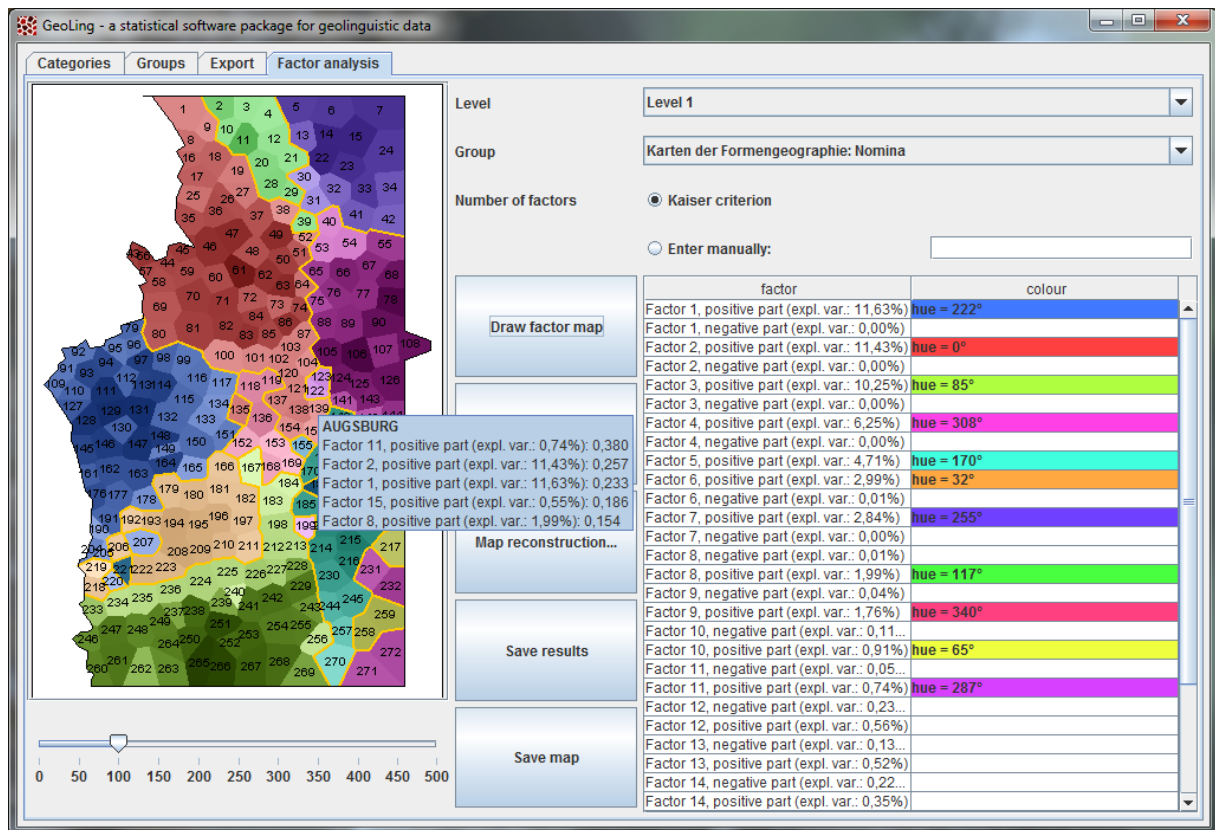


Figure 29: Example: Factor analysis of SBS maps featuring nominal morphology.

On the right side, a list with all the extracted factors appears, each giving the percentage of the overall variation it represents. The buttons “Save results” and “Save map” open save dialogues for exporting XML and EPS files of the analyses. As seen with the variants in density estimation (II.2), if you select one of the factors in this list and click “Show factor loading”, the drawing area visualizes this factor individually (Figure 30).



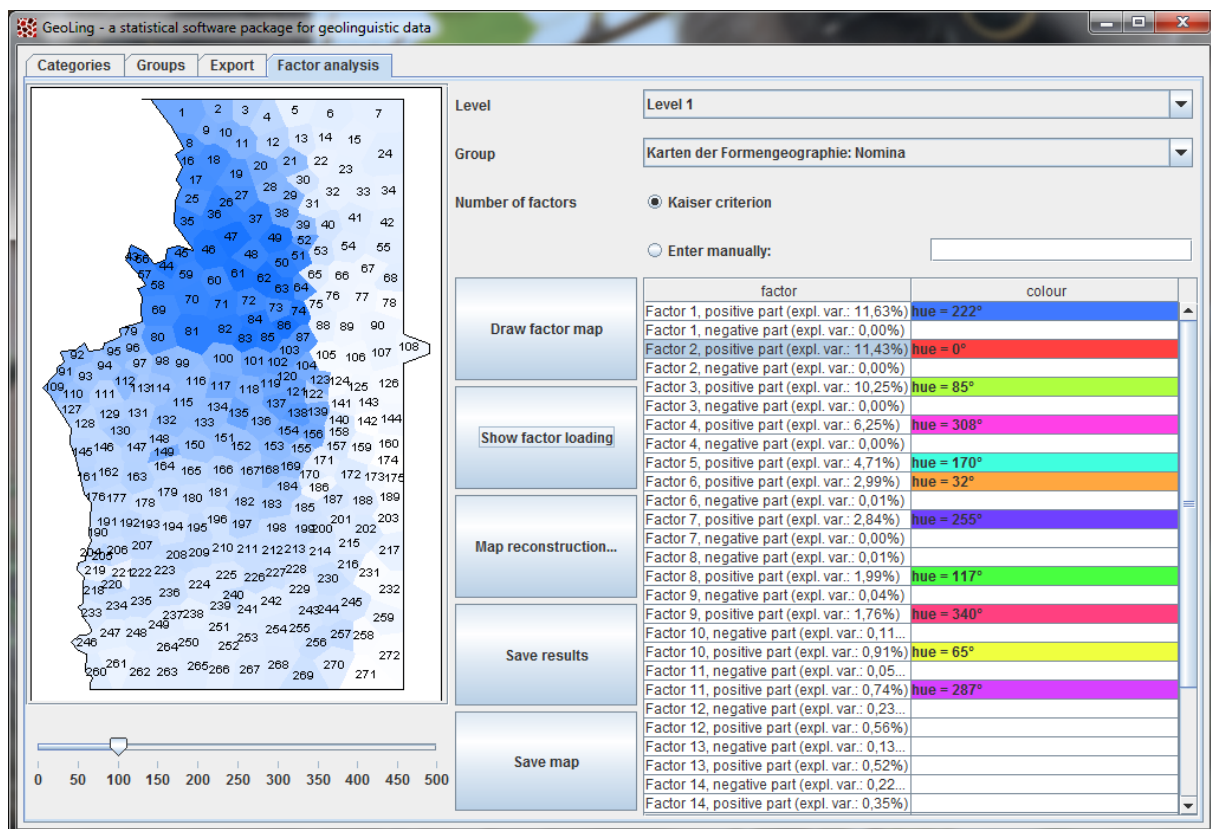


Figure 30: Example: Factor analysis of SBS maps featuring nominal morphology, display of single factor.

Clicking on “Reconstruct area class map” opens another tab named “Visualization of factor weights”. Here, you can draw single maps (or export groups of maps) based directly on the results of the factor analysis, using the factor loadings of all factors to reconstruct maps.

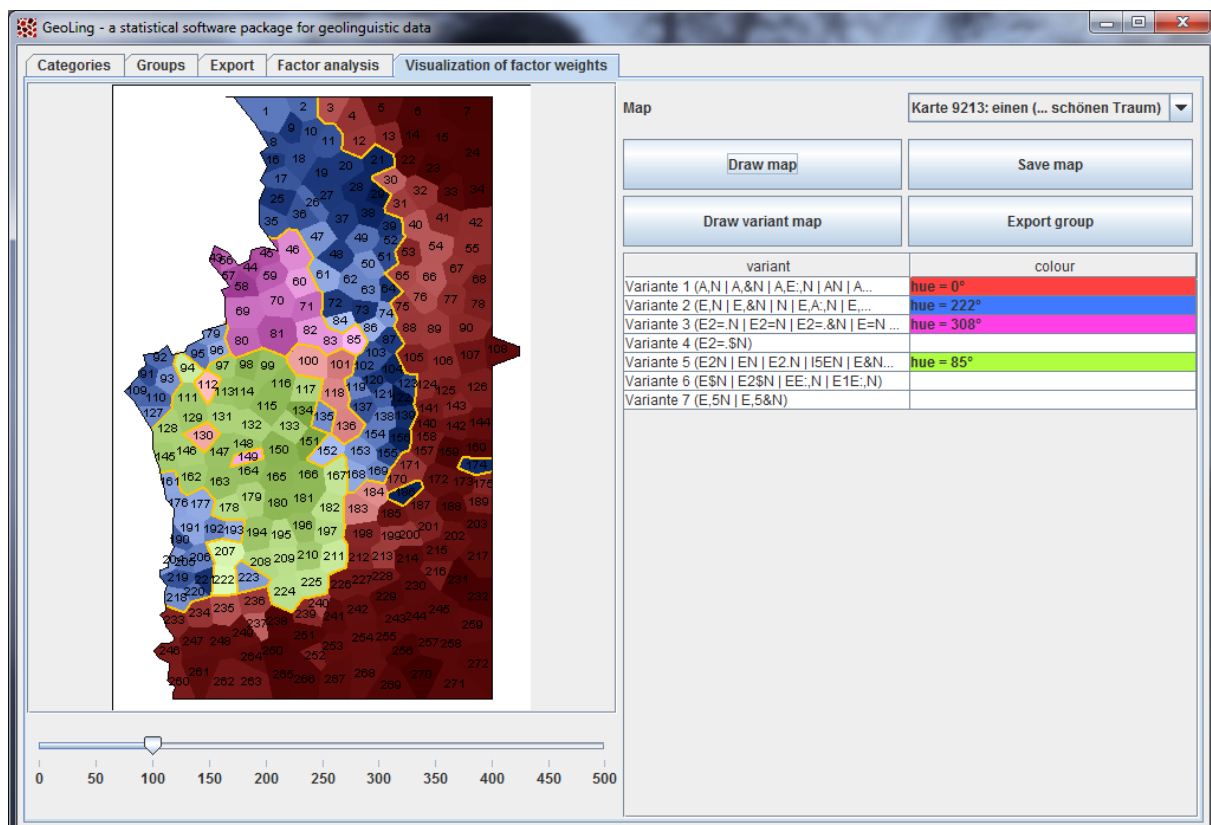


Figure 31: Reconstruction of an area class map using results of factor analysis.

## II.6 cluster analysis

This tab provides the means for clustering. While clustering in general long since has become a common technique in dialectometry, the way *GeoLing* uses cluster analysis is new: It does not cluster dialects/locations, it clusters maps. Thus, it becomes possible to find groups of maps that are spatially similar.

A short note on the theory of clustering: The human mind is able to find groups in data with astonishing precision, as long as the data satisfies certain psychological premises and is of manageable size. In order to identify which of, say, a thousand dialect maps are similar in terms of their spatial structure, neither of these preconditions are met; we need an “objective” way of identifying patterns in data using a machine. This is what clustering makes possible.

Clustering needs a) pairwise distances or similarities between maps and b) an algorithm to group the maps depending on their mutual similarities. By default, our program provides three different types of distances between maps:

1. distance vectors based on sectors
2. average differences in local dominances
3. distance vectors based on *covariance*

The algorithms that are available are *Hierarchical Agglomerative Clustering*, *K-Means* and *Fuzzy C-Means*.

Our publications on clustering dialect maps concentrate on two combinations of distances between maps and algorithm: One is based on sectors and dominance values and makes use of Hierarchical Agglomerative Clustering (RUMPF / PICKL / ELSPAß / KÖNIG / SCHMIDT 2010); the others feature fuzzy clustering (using the Fuzzy C-Means algorithm) of covariance values (MESCHENMOSER / PRÖLL 2012a; PRÖLL 2013a, b). However, the software allows employing all possible combinations of data representation and algorithm.

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