Example application of the Cologne Protocol for the Early Neolithic of Central Europe using QGIS and SAGA

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Notation conventions:

Name of file, folder or directory
Column- or row heading
/Menu / 1st submenu / 2. submenu / etc.; button
Option, value entries
(exemplification)
<default value/>

Programs / Program Version:
- QGIS 3.10
- SAGA 2.3.1
- (R 3.6.2.)

This manual presents an example application of the **Cologne Protocol** using QGIS and SAGA. You can either execute the task stepwise by hand (chapter A “Manual”) or use the semi-automatic QGIS Python/R scripts (*.py/*.rsx) available at the GitHub Repository [https://github.com/C-C-A-A/CologneProtocol-QGIS] and described in chapter B (“Scripts”). The scripts are however experimental and manual and scripts come without any kind of guarantee, so please make sure to double-check your results. Regardless of what approach you choose, please read the manual and consult the publication and supplement (*Schmidt et al. 2020*).

The manual describes the first two parts of the Cologne Protocol, which are a GIS-analysis of site distribution and the identifying of so-called Core Areas. The construction of Voronoi diagrams and "Largest Empty Circles" are conducted in QGIS. Kriging and converting the kriging results into isolines is done in SAGA. The step of selecting the Optimally Describing Isoline is not explained in this manual and can be found in the R or the MapInfo manual. The aim of this manual is neither to explain the theoretical background nor the further steps of the Cologne Protocol. For these points please refer to the associated publication including the supplementary information.

Step 1-5 of the Cologne Protocol can be performed in QGIS (`Pre-Processing.py`), building the semivariogram is either done in SAGA or using an QGIS R-script

(`Variogram.rsx`). For kriging we use a SAGA function or call this function from QGIS (`Kriging.py`). Post-processing, e.g. creating contour lines and calculating the area and number of sites per isoline (Step 8-11) should be performed in SAGA as well or by using the `Post-Processing.py` from within QGIS. In short, the manual approach requires using QGIS and SAGA, is more flexible but can be tiring while the models and scripts can all be run from QGIS, do save time but require R to be installed as well.

Steps:

A) Manual

1) Shape-Layer with sites as points

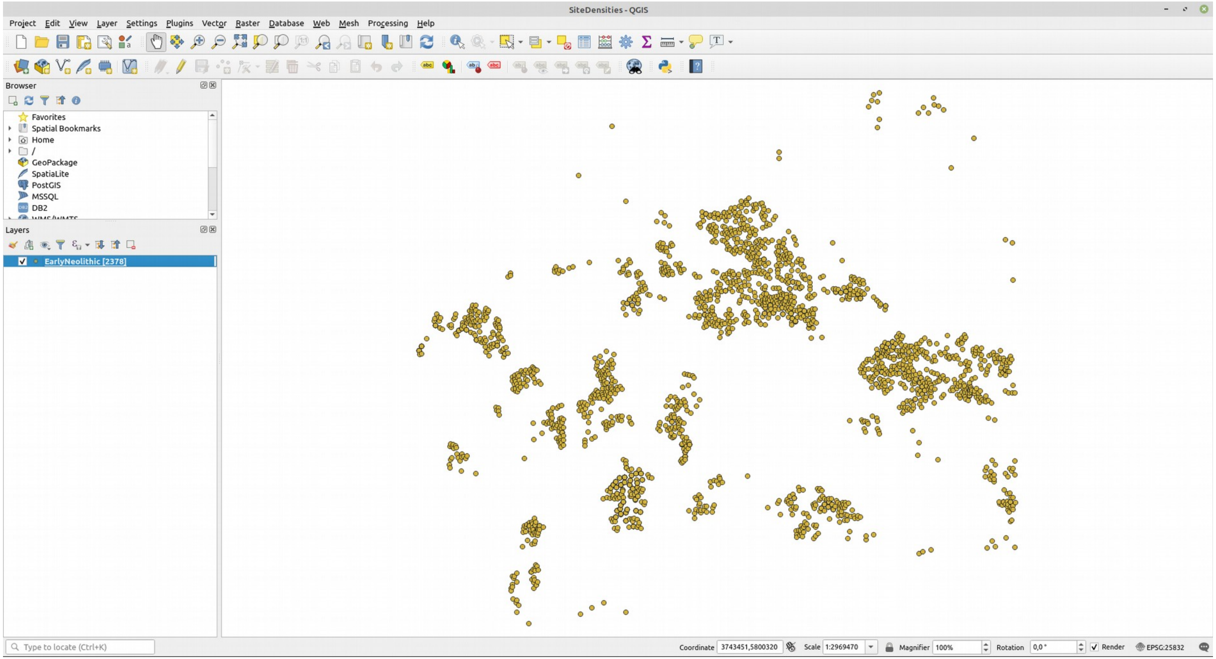
As case study we use part of a distribution map of Early Neolithic sites in Central Europe. The map is based on *Preuss (1998, Karte 1)* and available from the CRC 806 database (https://crc806db.uni-koeln.de/start/). Besides point symbols representing single sites the original map also included symbols for an agglomeration of five sites. The digital data set has been processed to resolve this issue.
Make sure to download the files in Gauss-Krüger projection not the WGS84 (Latitude/Longitude) files.

Start QGIS and load your or the example data set:

Layer / Add Layer / Add Vector Layer...

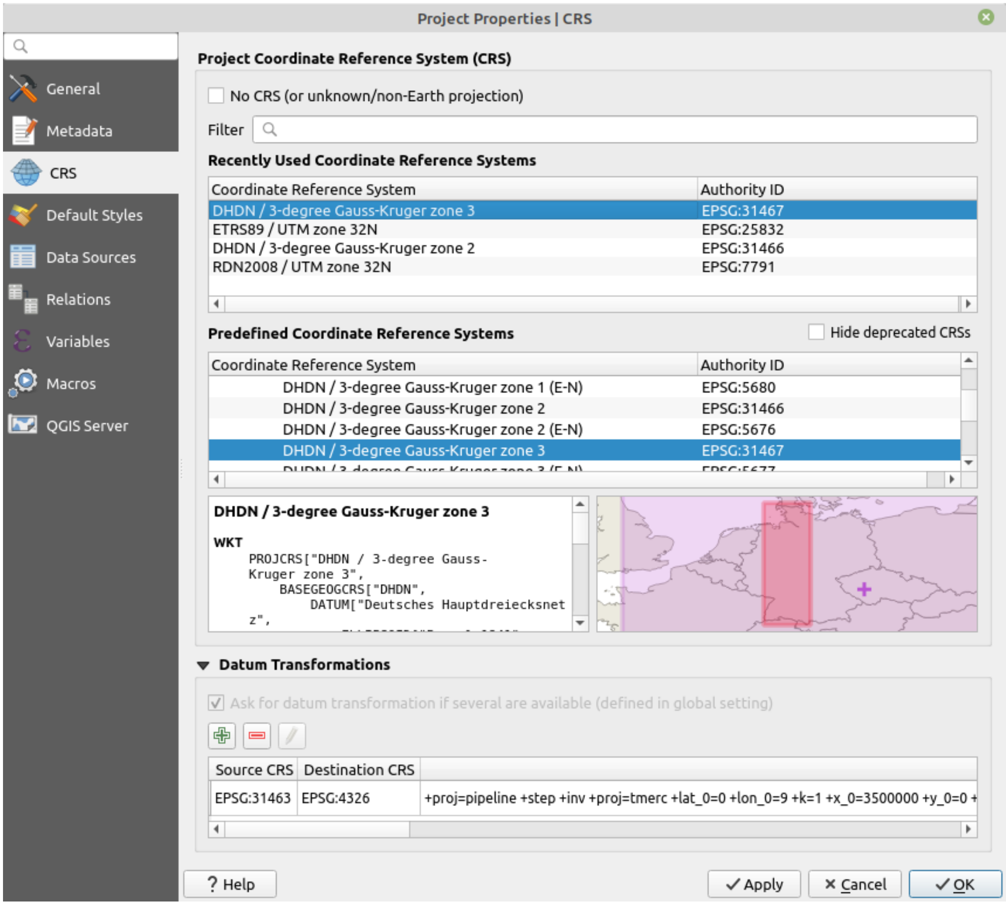
13_earlyNeolithic_FRG_sites_GK3.shp

Our example data set consists of 2378 early Neolithic sites.

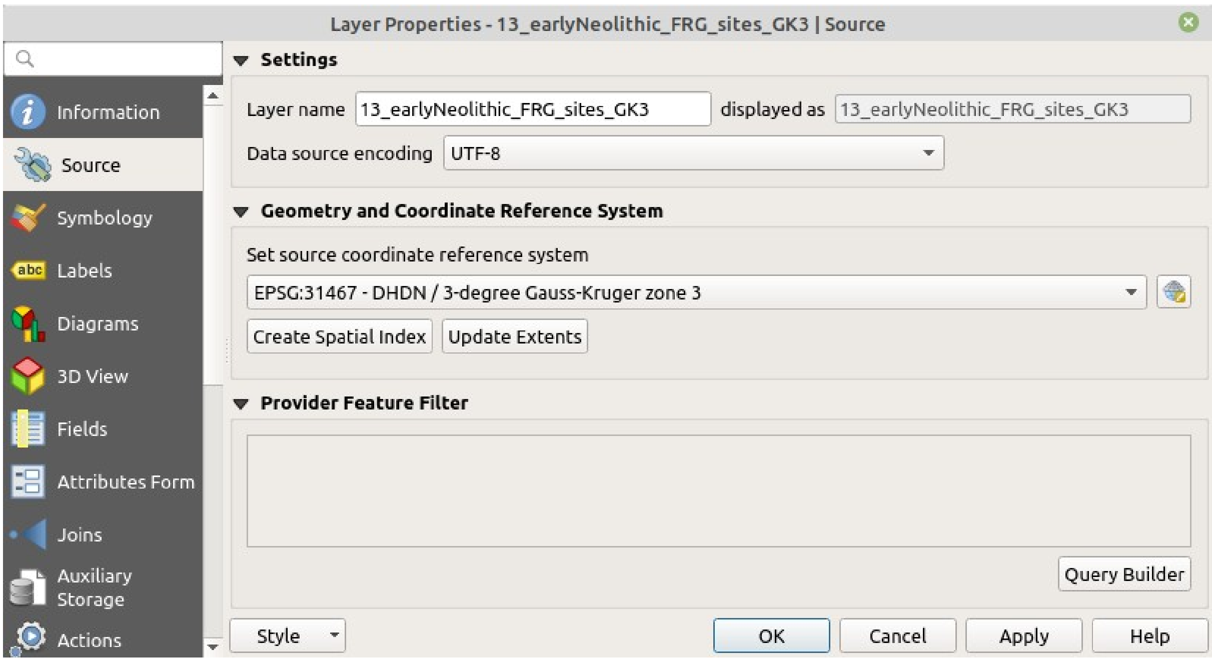


Check the projection system of your QGIS project and of the sites layer. Both should be EPSG 31467 (DHDN / 3-degree Gauss-Krüger zone 3). If they are not, change them accordingly.

Project / Properties / CRS...



Right Click on Layer / Properties / Source...



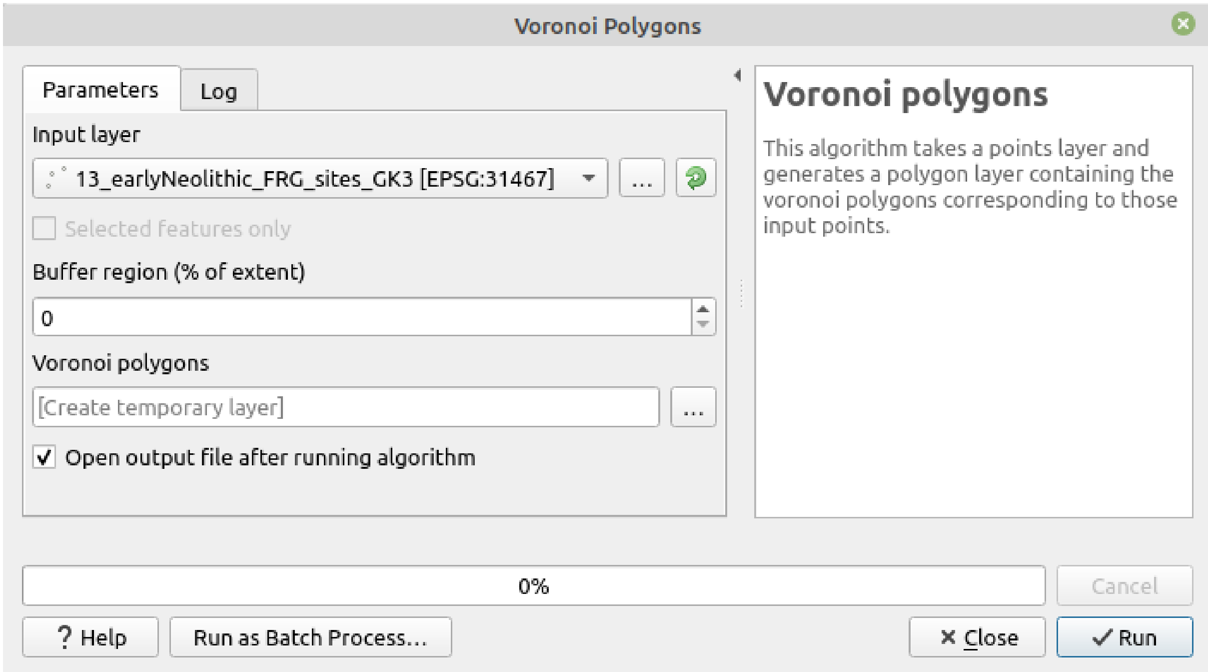
2) Creating Voronoi polygons

The Cologne Protocol uses the Largest Empty Circle (LEC) or more precisely the LEC radii to measure site distances. To locate the central points of the largest empty circles, voronoi diagrams are constructed and the voronoi vertices are extracted.

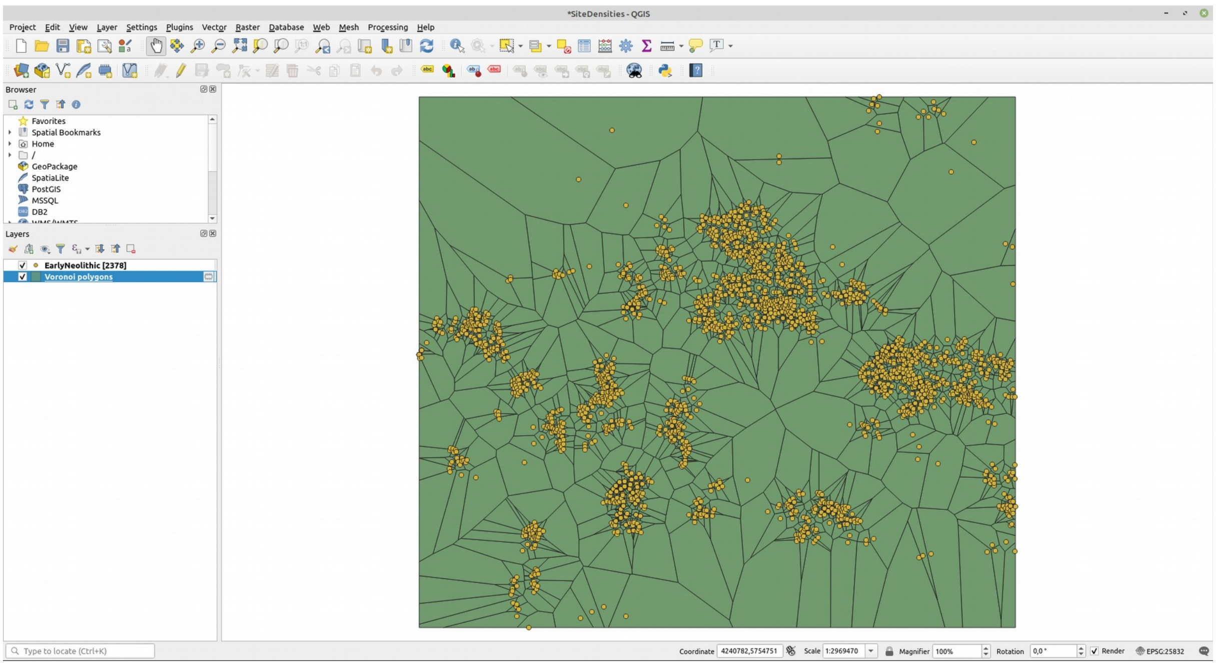
Vector / Geometry Tools / Voronoi Polygons…

Input Layer: 13_earlyNeolithic_FRG_sites_GK3.shp

Buffer region (% of extent): 0



Result: Voronoi polygons.shp

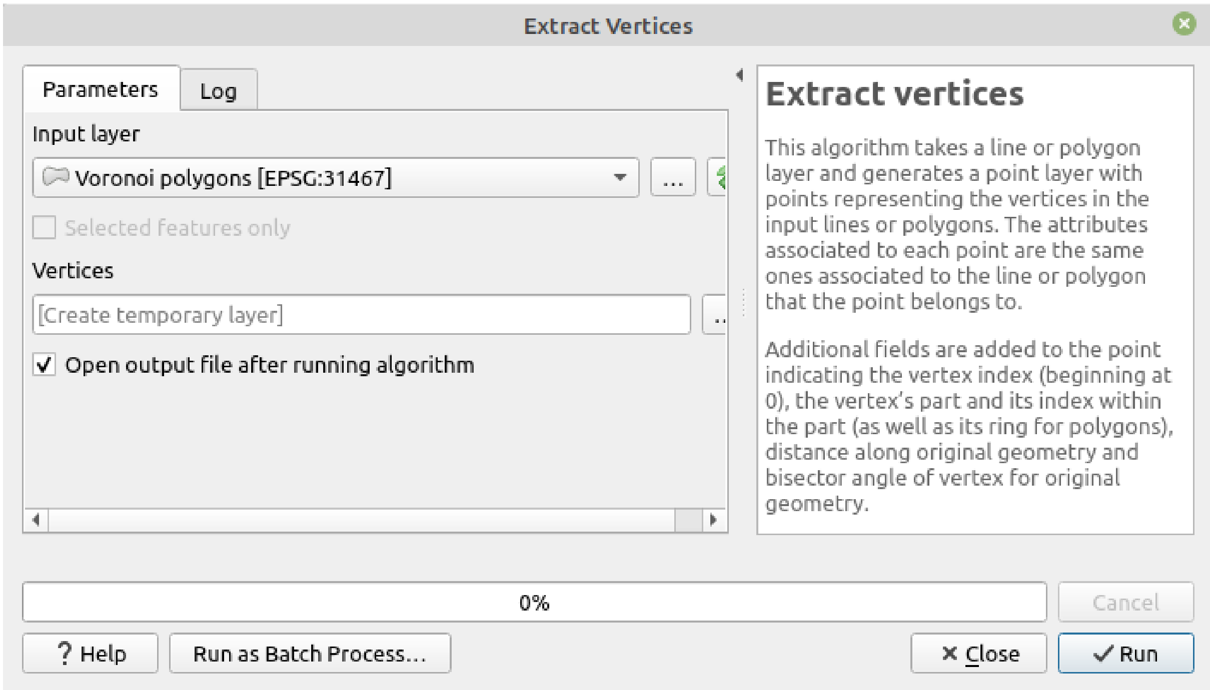


3) Extraction of vertices

Extract nodes/vertices of the voronoi diagrams.

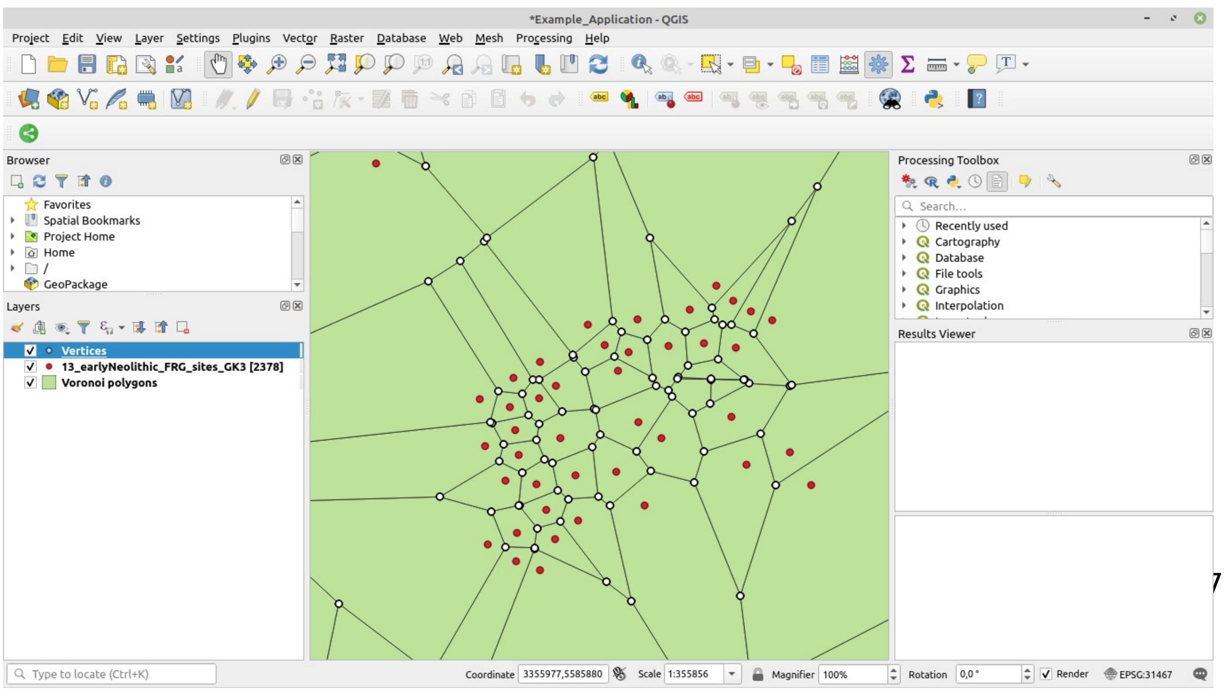
Vector / Geometry Tools / Extract Vertices

<u>Input layer:</u> Voronoi polygons



Result: Vertices.shp

Close-up with sites as red dots, voronoi diagrams as black lines and nodes/vertices as white dots. Exactly three sites are located on every circumference of a LEC.

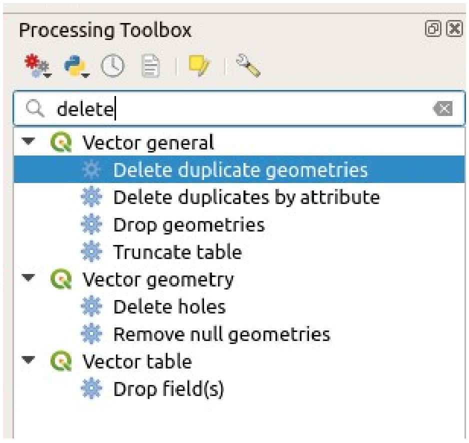


4) Aggregation of vertices

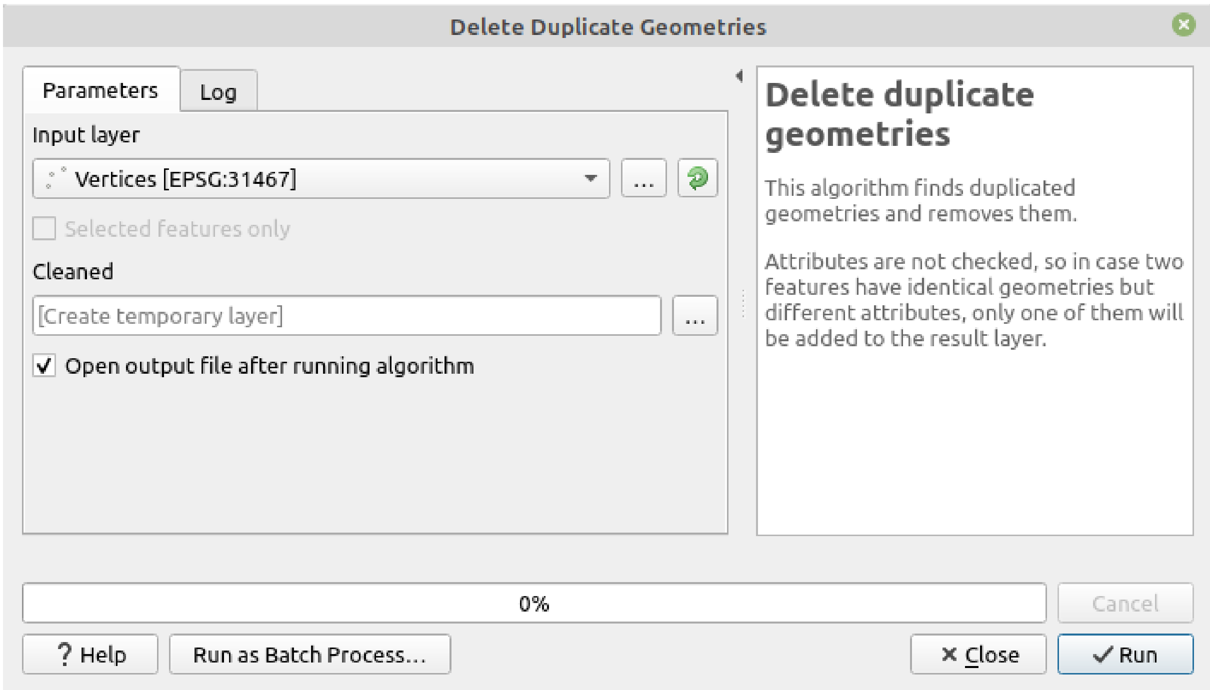
At the vertices/nodes several polygons meet, therefore extracting the nodes has led to duplicate vertices. Those have to be deleted. One possibility for deleting duplicates in QGIS is:

Open Processing Toolbox (Ctrl+Alt+T):

/Processing Toolbox / Vector general / Delete duplicate geometries...
Search for: *Delete duplicate geometries*

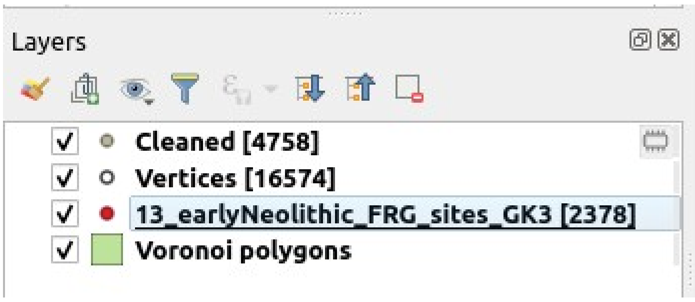


Input layer: Vertices



Result: Cleaned.shp

Using the example data you should end up with about 4758 vertices (duplicates deleted). You can add the number of features to the Layers panel by right clicking on the layer and selecting “Show feature count”.



5) Defining the radius of the „Largest Empty Circle“

The distance between vertex/node and the nearest measurement (site) is equal to the radius of the Largest Empty Circle (LEC). We will now measure the distance between vertices and sites (measurements/observations).

/ Processing Toolbox / Vector analysis / Distance to nearest hub (points)...

Source points layer: Shape-File with Vertices (Cleaned)

Destination hubs layer: Shape-File with sites (13_earlyNeolithic...)

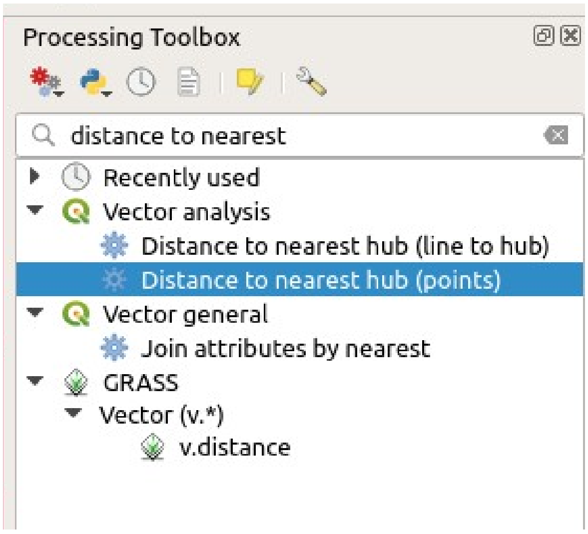
Hub layer name attribute: ID Column (_ID)

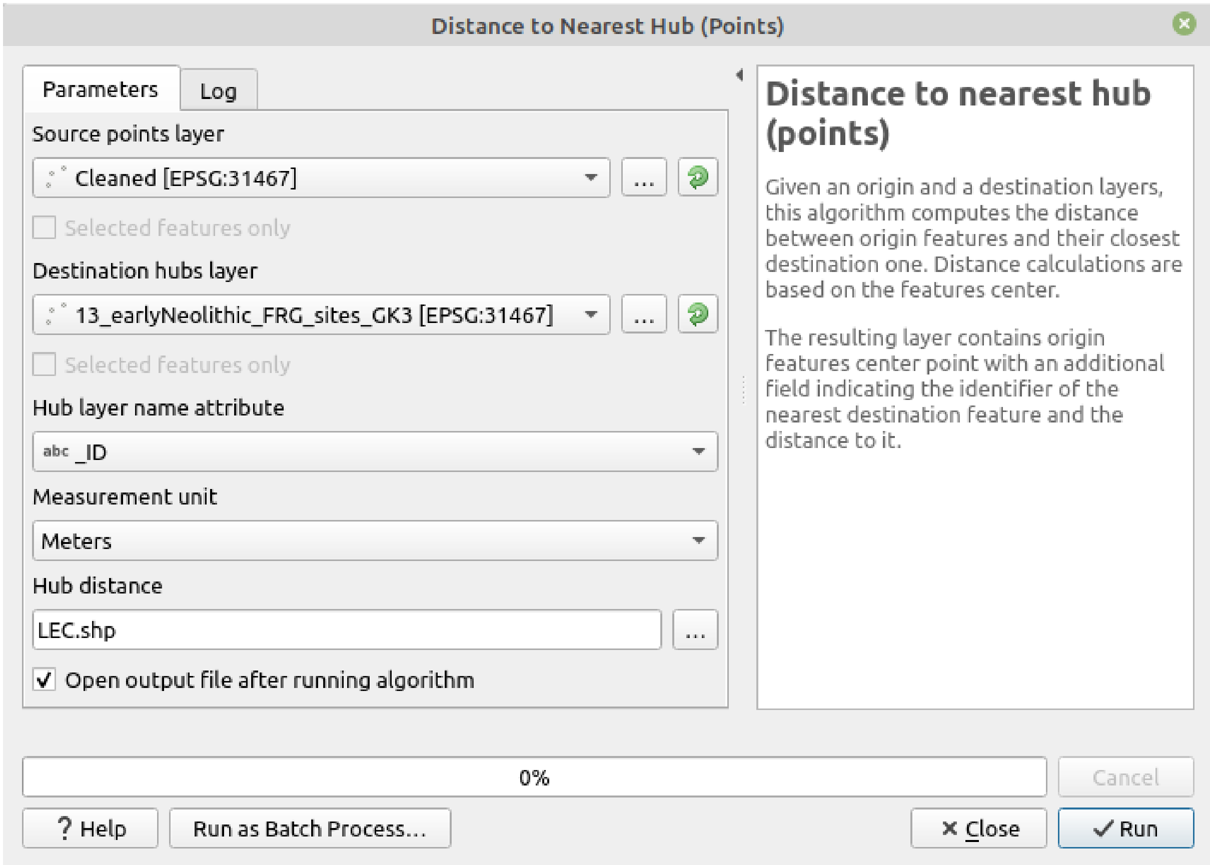
Measurement unit: Meters

Important: the unit of measurement has to be equal to the project unit of measurement (in our case meter).

This time it is vital to export the results, a temporary layer won’t do because we will be using the LEC shp-File in SAGA. Save results as:

LEC.shp



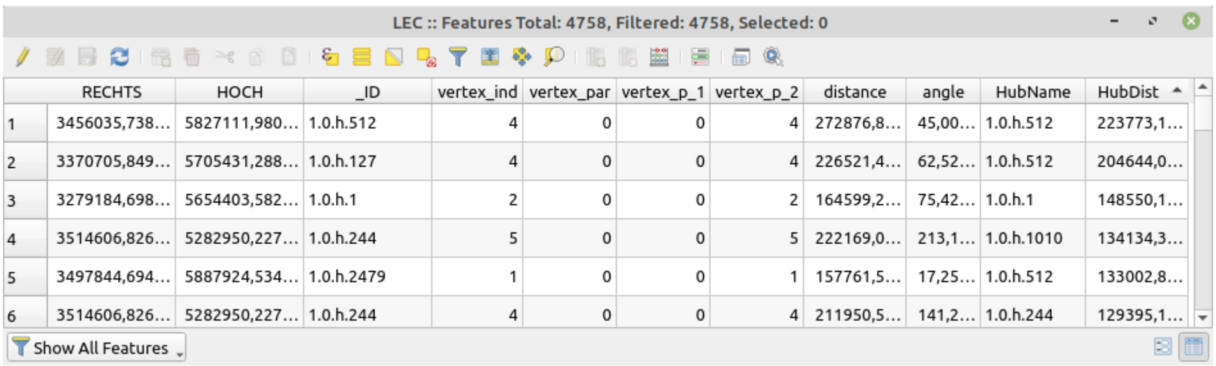


Have a look at the resulting Shape-File:

Choose Layer / Layer / Open Attribute Table...

Among others, you should find following columns:

HubName	ID of the nearest measurement (site)
HubDist	distance between node and measurement (LEC radius)



LEC :: Features Total: 4758, Filtered: 4758, Selected: 0

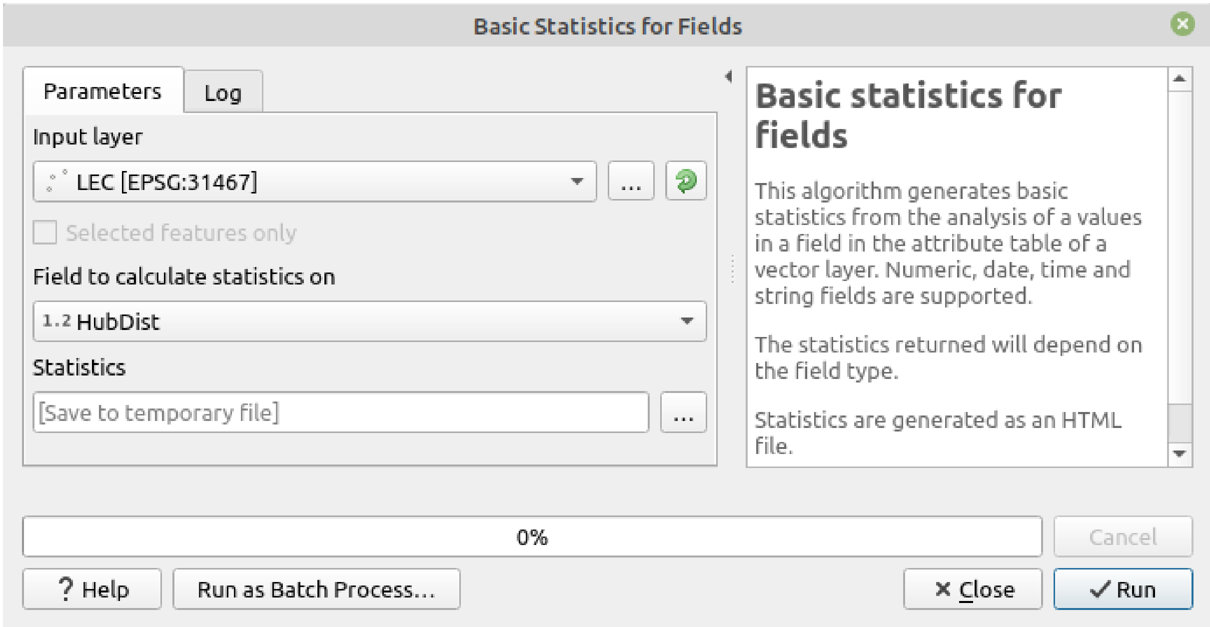
	RECHTS	HOCH	_ID	vertex_ind	vertex_par	vertex_p_1	vertex_p_2	distance	angle	HubName	HubDist
1	3456035,738...	5827111,980...	1.0.h.512	4	0	0	4	272876,8...	45,00...	1.0.h.512	223773,1...
2	3370705,849...	5705431,288...	1.0.h.127	4	0	0	4	226521,4...	62,52...	1.0.h.512	204644,0...
3	3279184,698...	5654403,582...	1.0.h.1	2	0	0	2	164599,2...	75,42...	1.0.h.1	148550,1...
4	3514606,826...	5282950,227...	1.0.h.244	5	0	0	5	222169,0...	213,1...	1.0.h.1010	134134,3...
5	3497844,694...	5887924,534...	1.0.h.2479	1	0	0	1	157761,5...	17,25...	1.0.h.512	133002,8...
6	3514606,826...	5282950,227...	1.0.h.244	4	0	0	4	211950,5...	141,2...	1.0.h.244	129395,1...

Show All Features

The maximum “HubDist” (LEC radius) for our dataset is ca. 223773 m.

To get basic Statistics for LEC-radii:

Vector / Analysis Tools / Basic Statistics for Fields...


Basic Statistics for Fields
Parameters
Log
Input layer
LEC [EPSG:31467]
Selected features only
Field to calculate statistics on
1.2 HubDist
Statistics
[Save to temporary file]
Basic statistics for fields
This algorithm generates basic statistics from the analysis of a values in a field in the attribute table of a vector layer. Numeric, date, time and string fields are supported.
The statistics returned will depend on the field type.
Statistics are generated as an HTML file.
0%
Cancel
Help
Run as Batch Process…
Close
Run

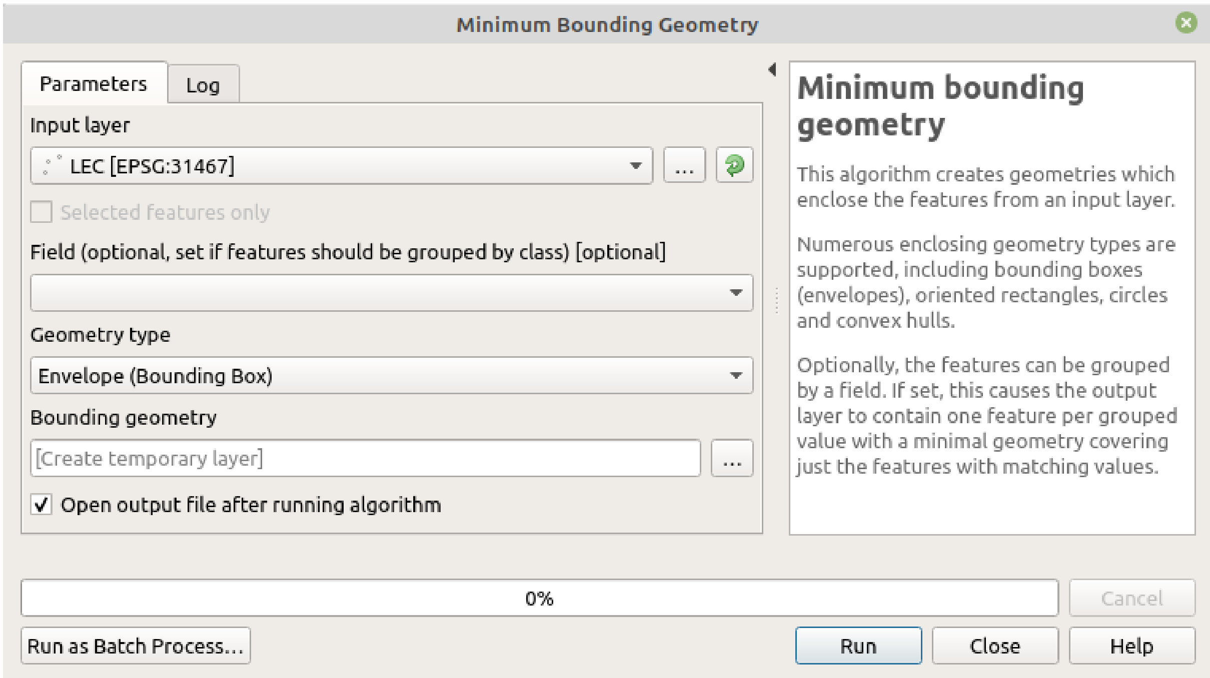
5a Calculate Statistics

The Kriging procedure requires the variables lag distance and maximum search distance. We will calculate these parameters in QGIS and then move on to SAGA to build a semivariogram and compute the interpolation. For the maximum search distance (MaxSearchDist) the diagonal of the LEC bounding box is divided by two. To estimate lag distance (LagDist) we divide the bounding box diagonal by 250. Both values will be used later in SAGA.

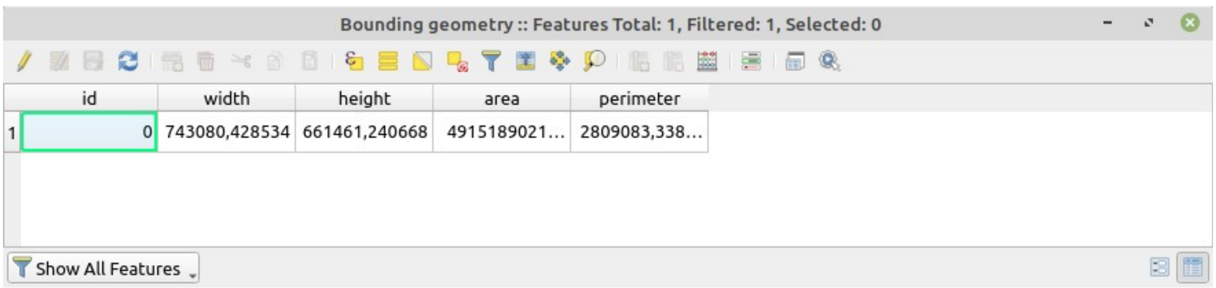
First, create the bounding box for the LEC/vertices:

Processing Toolbox / Vector Geometry / Minimum bounding geometry...

Input Layer:	LEC.shp
Field:	“”
Geometry Type:	Envelope (Bounding Box)

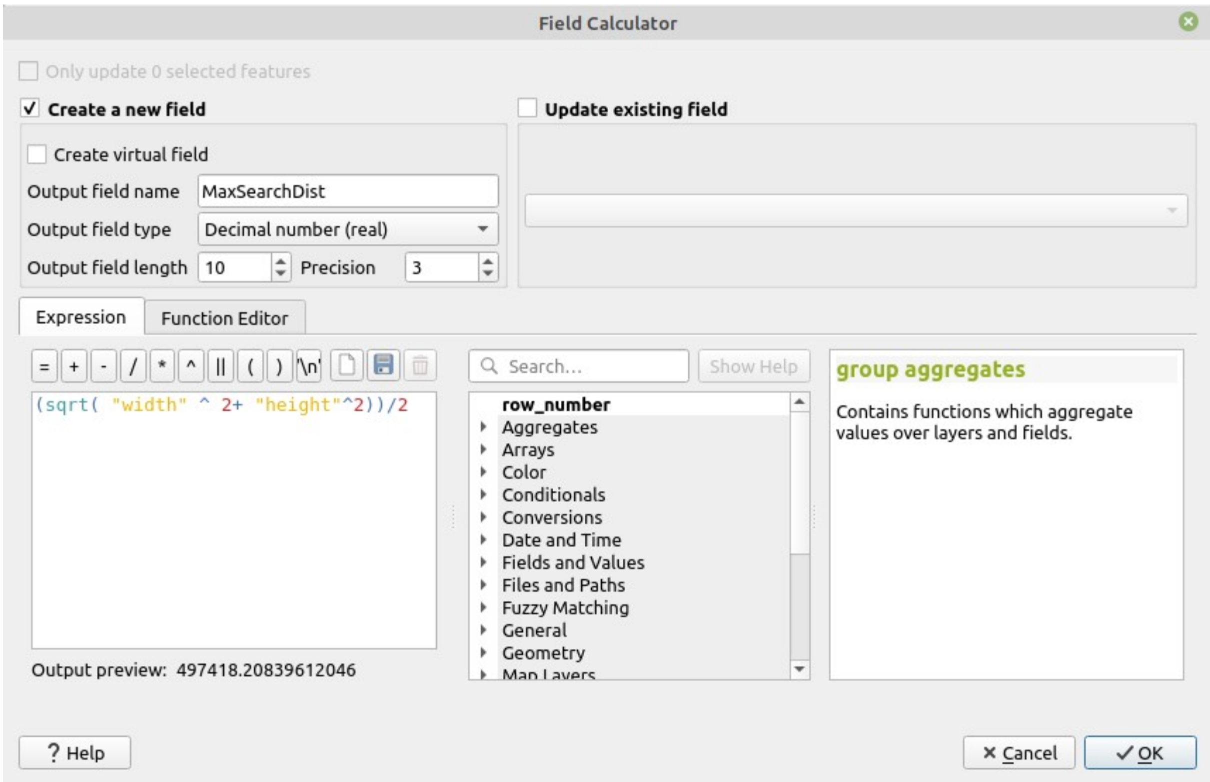


Open Attribute Table of new layer “Bounding geometry” (*Right Click on Layer / Open Attribute Table*) and open Field Calculator (Ctrl+*I*)



Check “Create a new field”

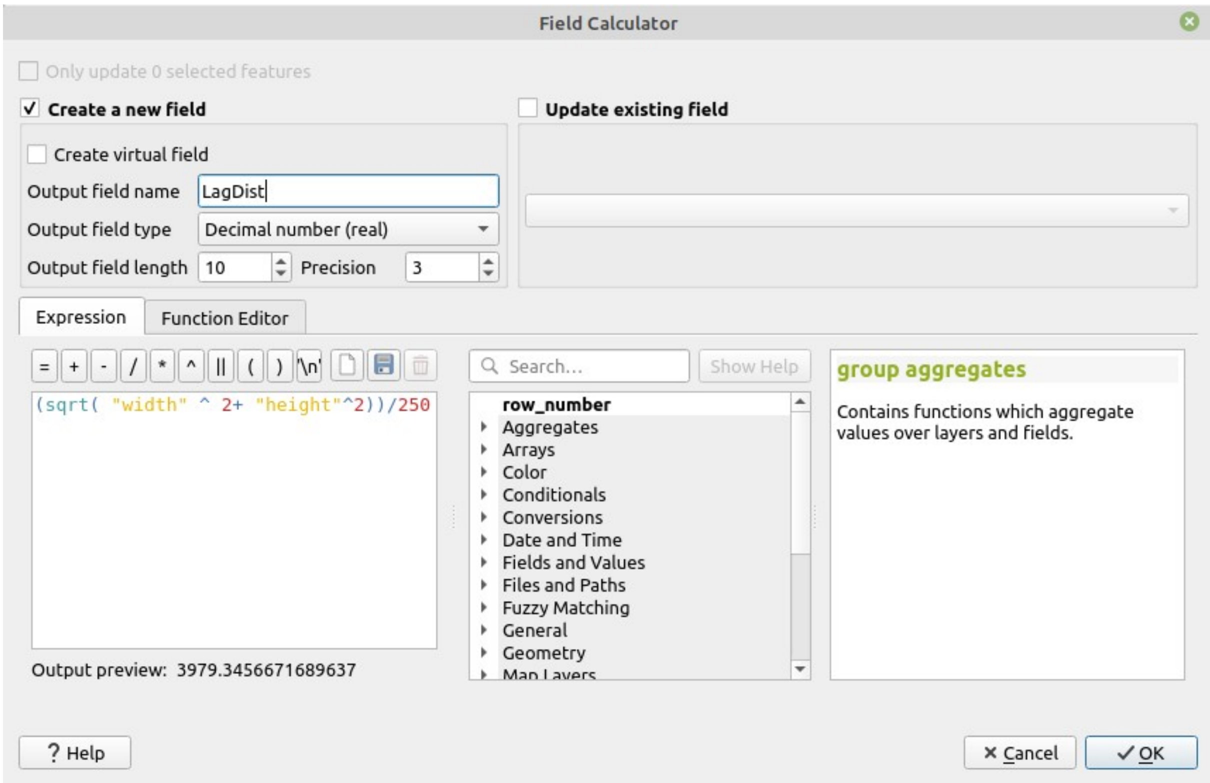
Output field name: MaxSearchDist
Output field type: Decimal number (real)
Output field length: 10
Precision: 3
Formula: sqrt("width" ^ 2+ "height"^2)/2

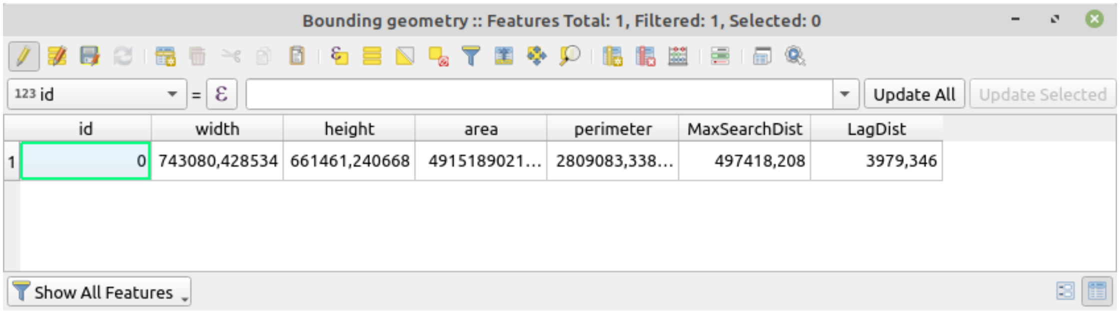


And you should also calculate the Lag Distance to be used in the Semivariogram:

Check "Create a new field"

Output field name: LagDist
Output field type: Decimal number (real)
Output field length: 10
Precision: 3
Formula: *sqrt("width" ^ 2+ "height"^2)/250*





	id	width	height	area	perimeter	MaxSearchDist	LagDist
1	0	743080,428534	661461,240668	4915189021...	2809083,338...	497418,208	3979,346

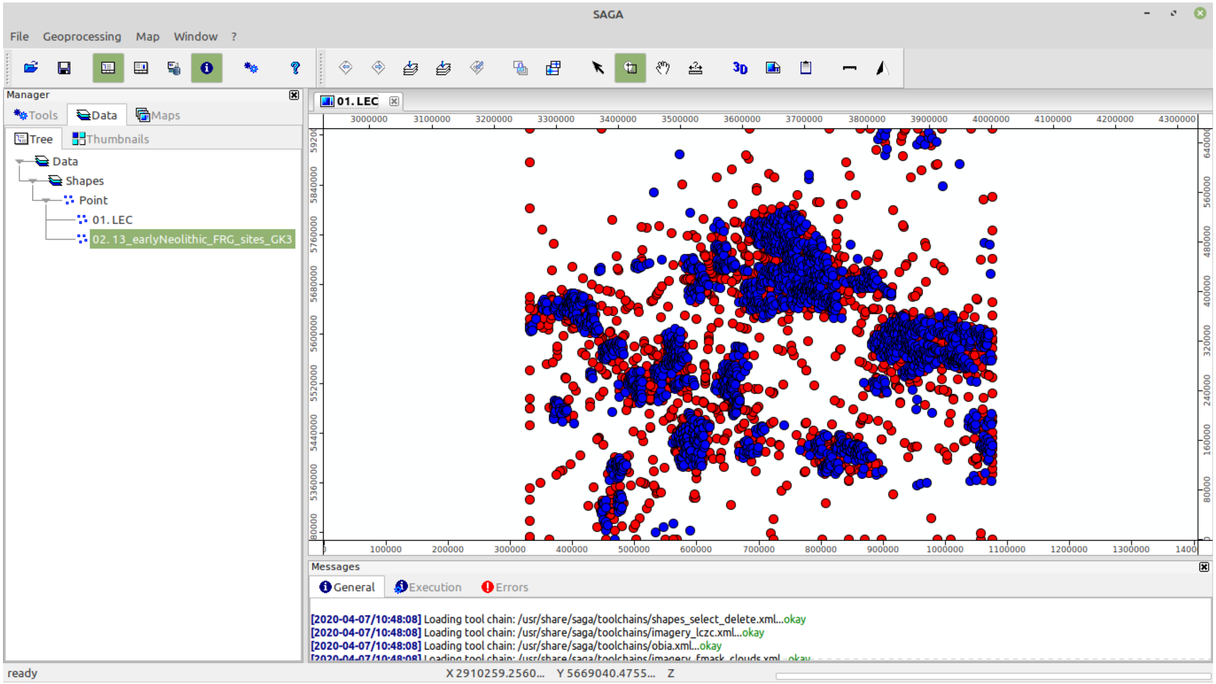
6) Kriging – Preparations and Grid

Save your results, close QGIS and start SAGA. Open the layers with the LEC-Radii and layer with initial measurements (sites):

File / Open...

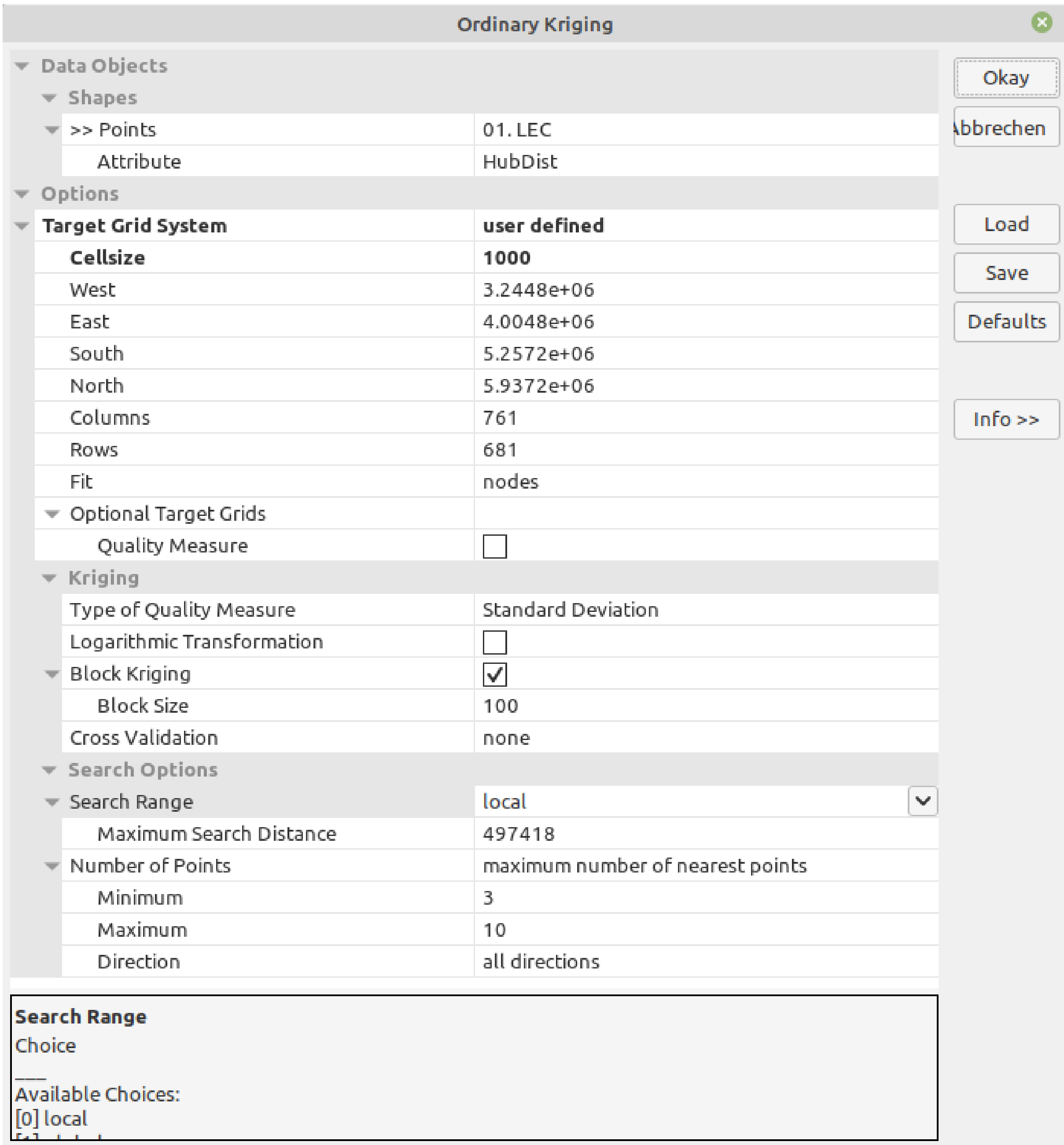
13_earlyNeolithic_FRG_sites_GK3.shp
LEC.shp

Double-clicking on the layer will add the points to a map.



For interpolation, we will be using the Ordinary Kriging Module from SAGA. The parameters for building the semivariogram and for Kriging have to be entered first. For kriging we need a grid of evenly distributed points. The interpolation algorithm will estimate the site distance (radius of LEC) at every point of the grid, based upon the available vertices and their values for the radius of the LEC. For the current example we will create a grid with a spacing of 1000 m between each point. That means a raster file with 1 × 1 km pixels is created.

Geoprocessing / Spatial and Geostatistics / Kriging / Ordinary Kriging...


Ordinary Kriging
Data Objects
Shapes
>> Points
01. LEC
Attribute
HubDist
Options
Target Grid System
user defined
Cellsize
1000
West
3.2448e+06
East
4.0048e+06
South
5.2572e+06
North
5.9372e+06
Columns
761
Rows
681
Fit
nodes
Optional Target Grids
Quality Measure
Kriging
Type of Quality Measure
Standard Deviation
Logarithmic Transformation
Block Kriging
Block Size
100
Cross Validation
none
Search Options
Search Range
local
Maximum Search Distance
497418
Number of Points
maximum number of nearest points
Minimum
3
Maximum
10
Direction
all directions
Search Range
Choice
Available Choices:
[0] local
Okay
Abbrechen
Load
Save
Defaults
Info >>

Points:	Layer we want to krige (LEC.shp)
Attribute:	HubDist
Target Grid system:	user defined
Cellsize:	1000
Search Range:	local
Maximum Search Distance:	497418
Number of Points Minimum:	3
Maximum:	10
Direction:	all directions

Check “Quality Measure” to get plot of the variance for checking the quality of the interpolation. You can also activate “Block Kriging” (Block Size: 100) for smoothing. Changing blocksize or not using block kriging won’t alter the results dramatically.

Press Okay to compute the sample semivariogram.

7) Kriging - Semivariogram

The kriging procedure requires a theoretical semivariogram, which is used to estimate the radii of the LEC at every point of the grid. To compute this theoretical semivariogram, we need to explore the experimental semivariogram first. The Semivariogram displays the ratio of distance between pairs of points to the similarity (difference) of points in distance classes (lags).

To adjust lag distance and enter a theoretical model (formula) click:

Settings / Variogram Settings...

Choose one of the following functions, either a

linear regression/exponential model:

a + b * x + c * x ^2

or as an alternative, the power model:

*a + b * x ^c*

Variables explained:
a= nugget
b = sill
c = range

`The spherical model doesn’t seem to work, at least using our data set.` Make sure to set nugget to zero (a = 0). For example in the exponential model:
“0 + b * x + c * x^2” or using the power model “0 + b * x ^c”. Or simply:

Linear regression/exponential model:

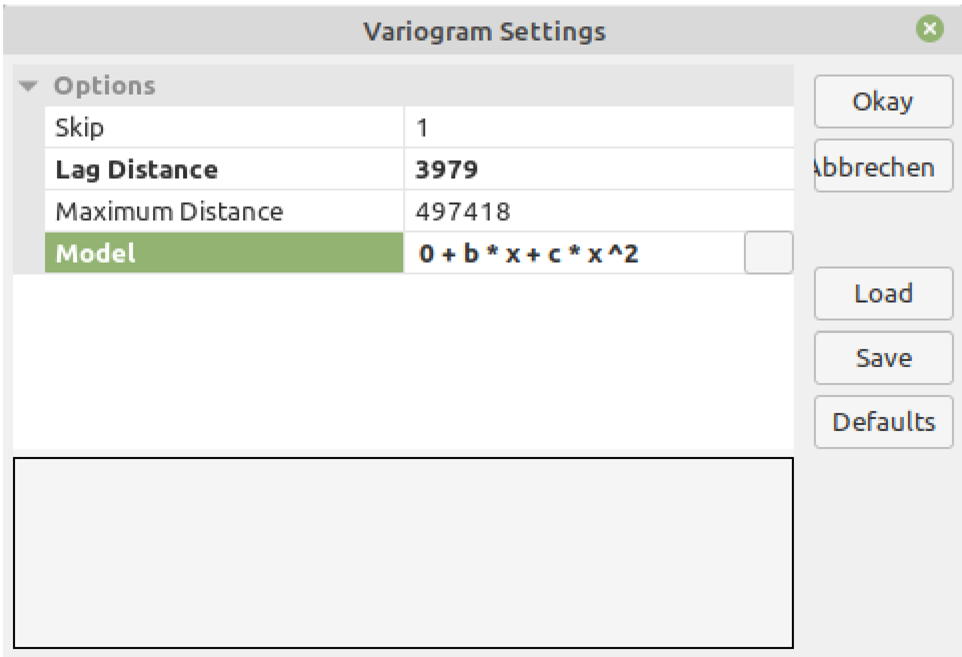
b * x + c * x ^2

or as an alternative, the power model:

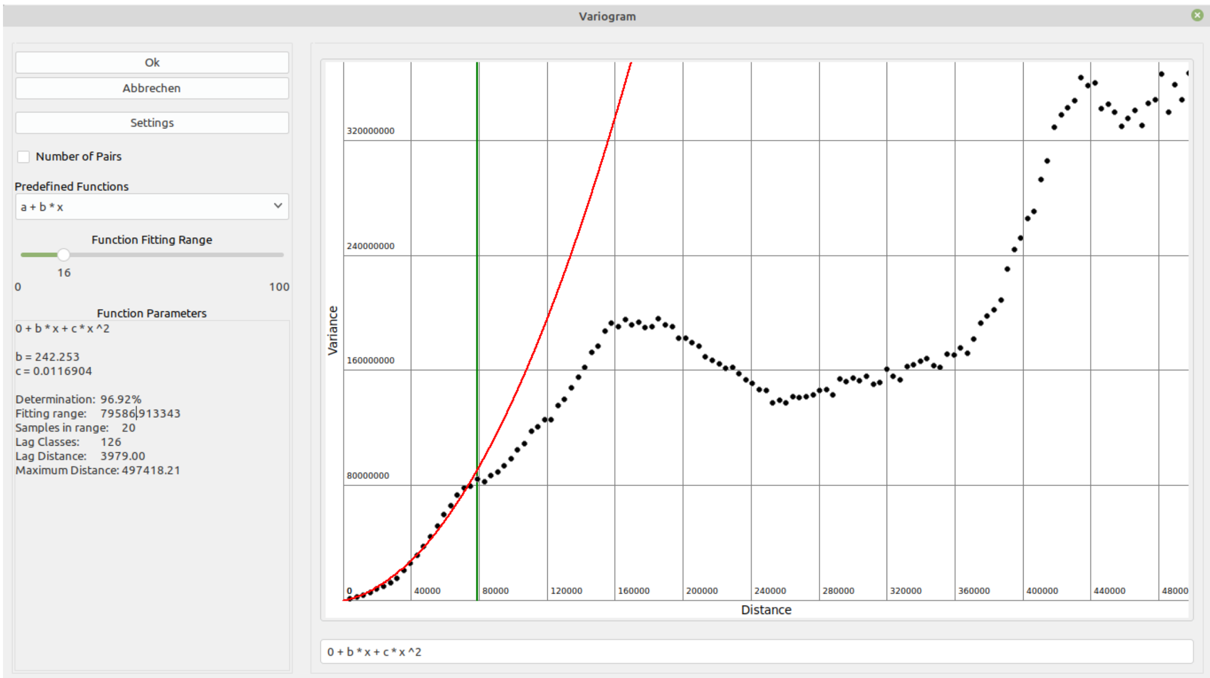
*b * x ^c*

Skip:	1	
Lag Distance:		3979 (calculated in QGIS)
Maximum Distance:		497418 (= MaxSearchDist, calculated in QGIS)
Model:		b * x ^c
		or
		b * x + c * x ^2

Enter the model of your choice in “Model” and click “Okay” to return to the semivariogram.



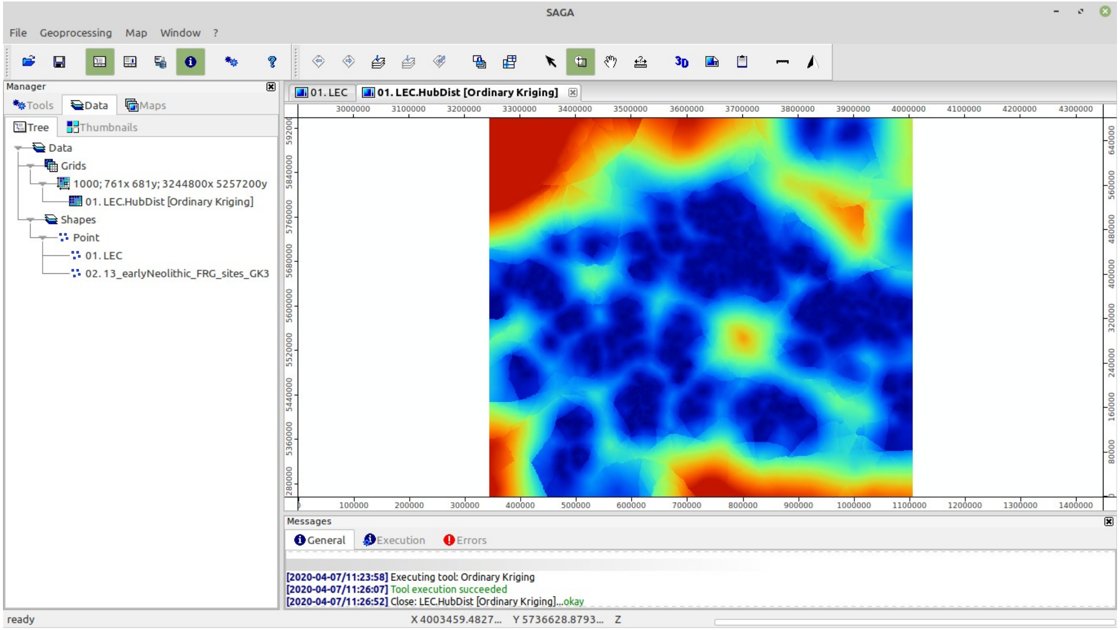
Adjust the fitting range to the first peak or plateau of the distribution by using the slider “Function Fitting Range” on the left side of the panel. In our case study it is at ca. 79586 on the x-axis (Fitting range = 79586.9). Of course, a decision has to be made on a case-by-case basis.



Click OK to start the Kriging process. Computing will take some while depending on your computer (processor, ram, hard disk).

8) Kriging - inspect and export raster output

The result of the kriging interpolation is a raster map of the prediction and, if you checked “Quality Measure”, the variance or standard deviation of the results. Double-click on the new grid to add it to a map.



You can export the raster as Surfer Grid so you can import it in QGIS later.

Geoprocessing / File / Grid / Export / Export Surfer Grid…

9) Creating contour lines (isolines)

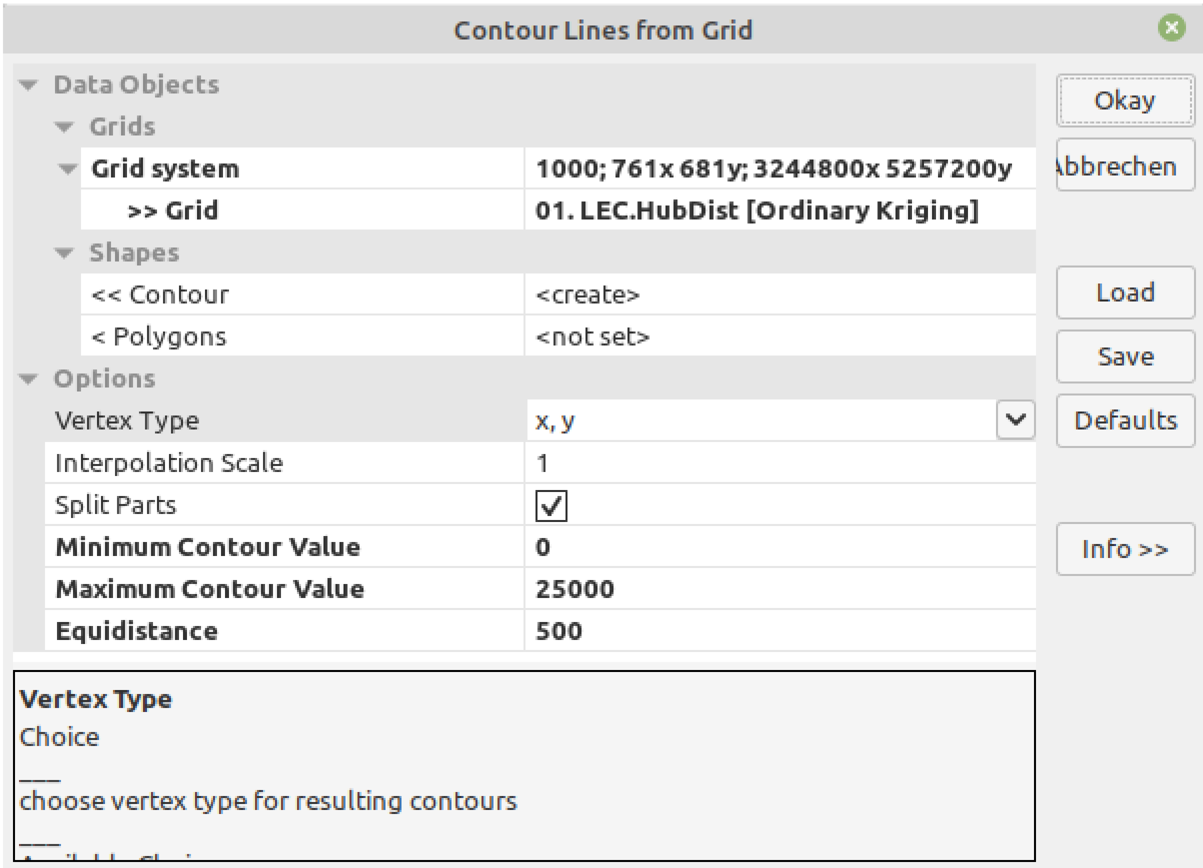
Using the kriging raster we will create isolines, convert them to polygons and compute the area and number of sites per isoline. Number of sites and isoline area are important for selecting the “Optimally Describing Isoline” (*Zimmermann et al. (2004, 53-55)*).

First we will extract the isolines or contour lines from the raster. The easiest way to find functions in SAGA is to search for them:

Geoprocessing / Find and run tool / Contour Lines from Grid...

or

Geoprocessing / Shapes / Grid / Vectorization / Contour Lines from Grid...

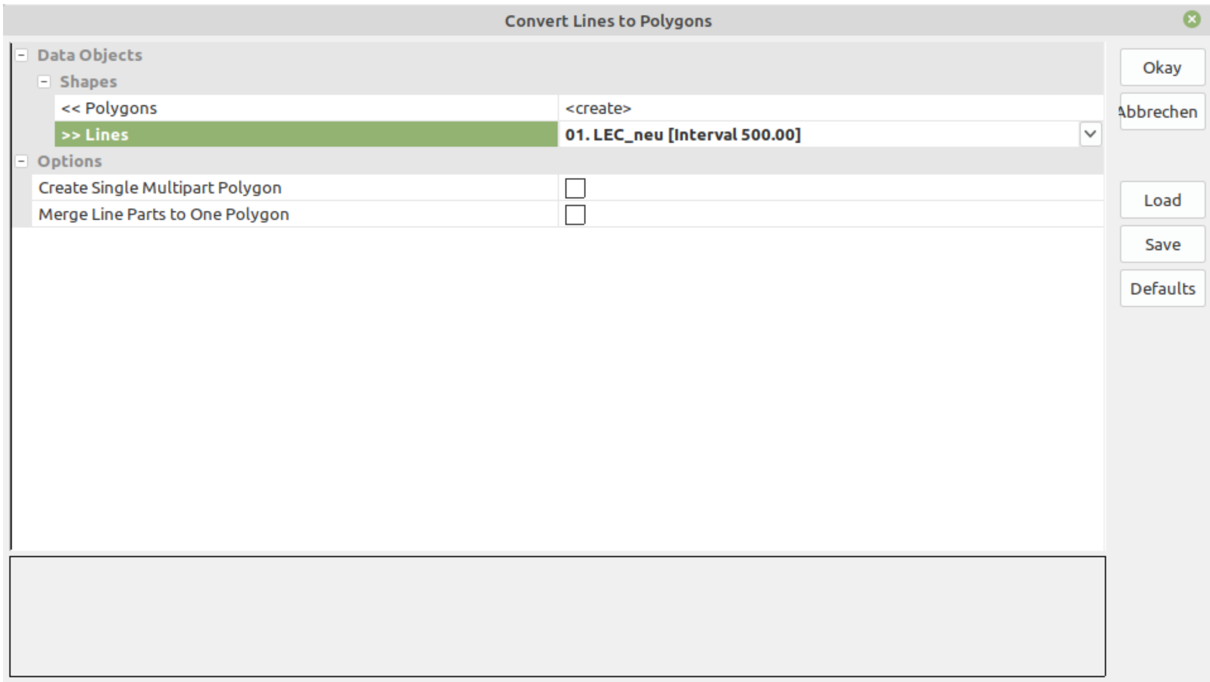


In our case study we need contour lines starting at 0 and ending at 25000 m with an equidistance of 500 m. It is advised to calculate as few isolines as possible.

Grid:	our new Kriging grid (the original not the export)
Contour:	<create>
Polygons:	<not set> (we want lines not polygons yet)
Vertex Type:	x, y
Interpolation Scale:	1
Split Parts:	checked
Minimum Contour Value:	0

Maximum Contour Value: 25000
Equidistance: 500

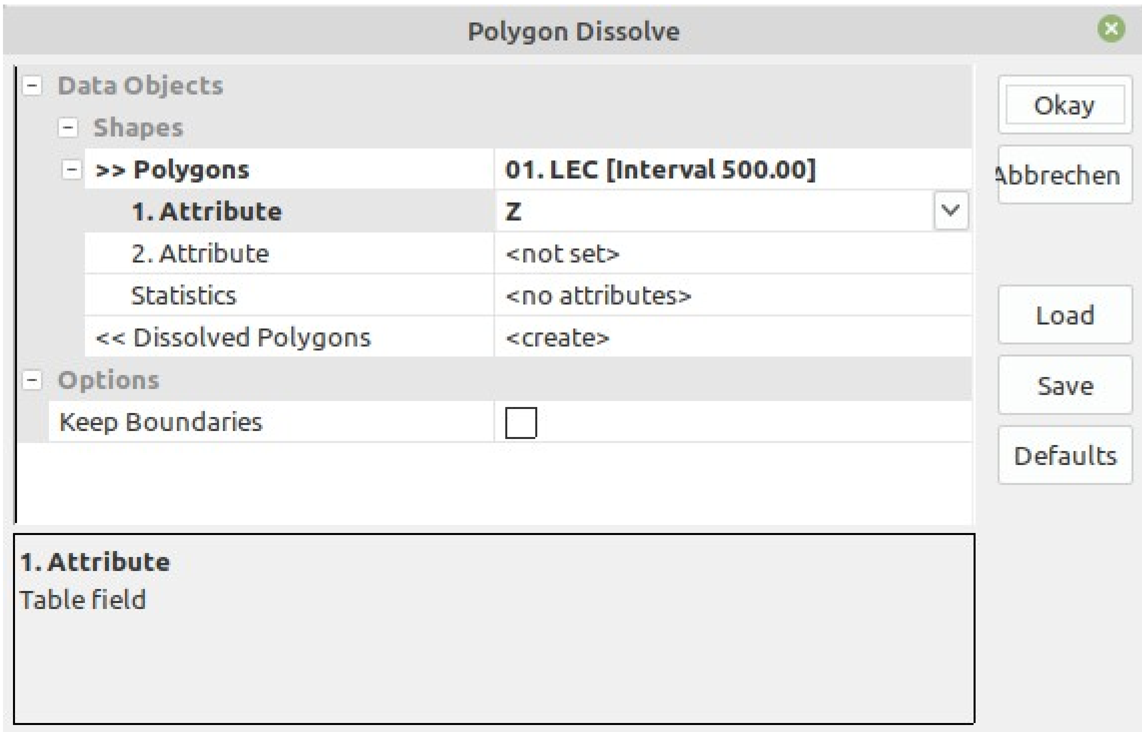
Geoprocessing / Shapes / Conversion / Convert Lines to Polygons...



Polygons: <create>
Lines: the contour line layer created above
Create Single Multipart Polygon: unchecked
Merge Line Parts to One Polygon: unchecked

Dissolve Polygons using the iso-value (Z):

Geoprocessing / Shapes / Polygons / Polygon Dissolve…

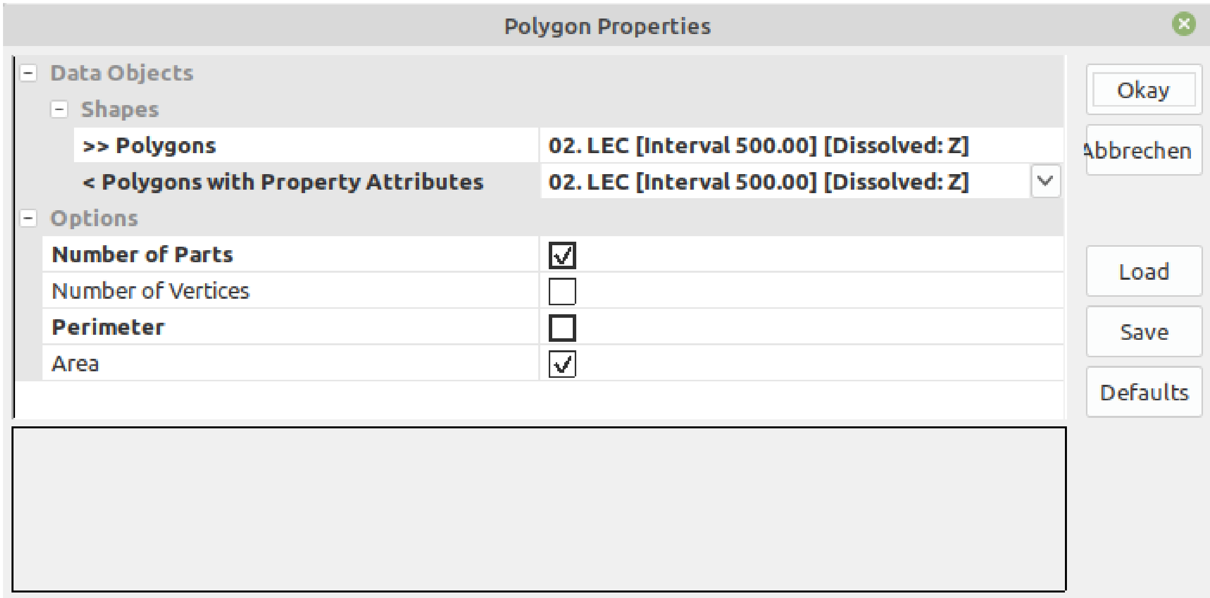


Polygons:	Polygon layer created above
1. Attribute:	Z
2. Attribute:	<not set>
Statistics:	<no attributes>
<<Dissolved Polygons:	<create>
Keep Boundaries:	unchecked

10) Calculating the area and the number of sites per isoline

Use the newly created dissolved isoline polygon layer and check the box “Area” and “Number of Parts”

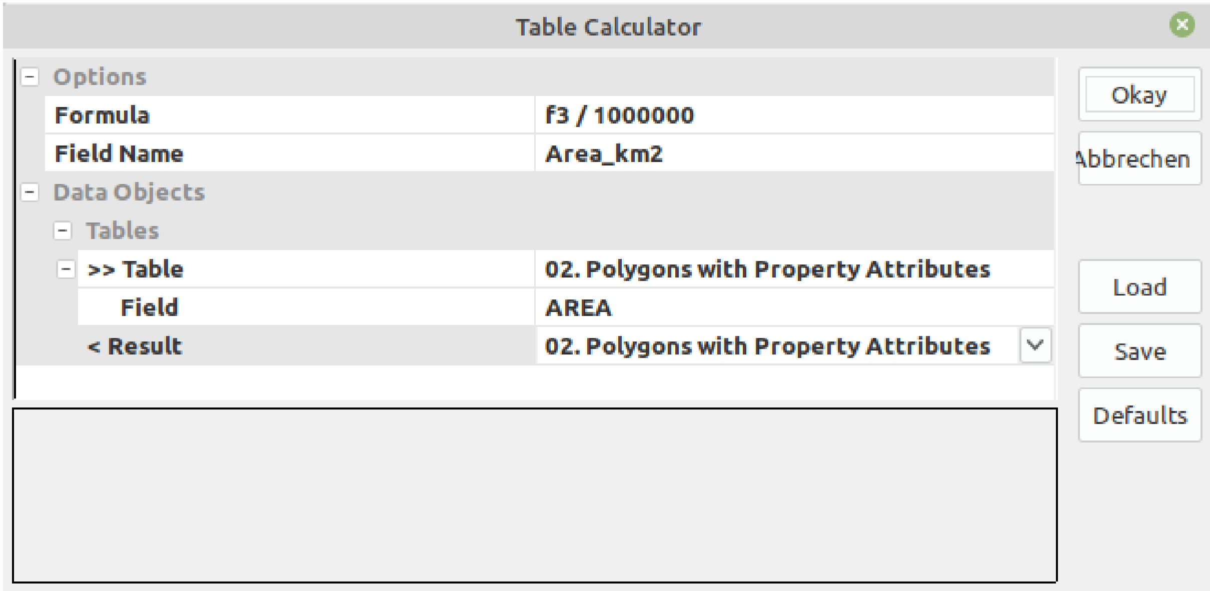
Geoprocessing / Shapes / Polygons / Polygon Properties…



Polygons:	Dissolved polygon layer created above
Polygons with Property Attributes:	Dissolved polygon layer created above
Number of Parts:	checked
Number of Vertices:	unchecked
Perimeter:	unchecked
Area:	checked

The calculated areas will be in your map unit (in our case study: m^2). If we want km^2 we have to:

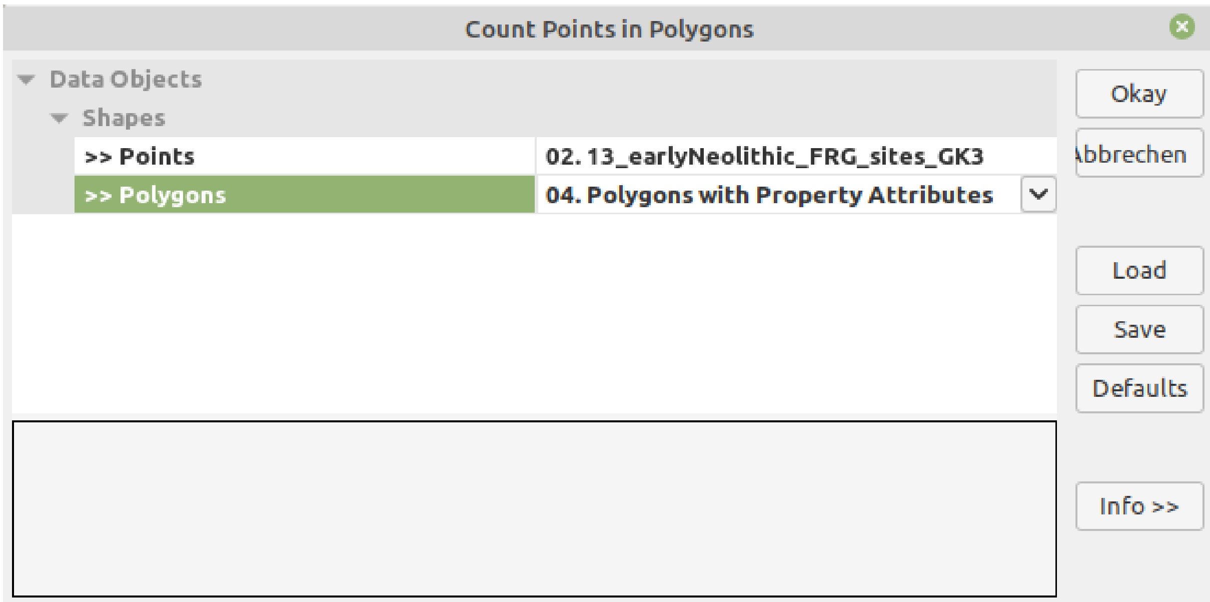
Processing / Table / Calculus / Table Calculator…



Formula: f3 / 1000000 (third field of the table)
Field Name: Area_km2 (name of field to be created)
>>Table: Polygon layer with attributes
Field: AREA (field to be divided)
<Result: Polygon layer with attributes (update layer)

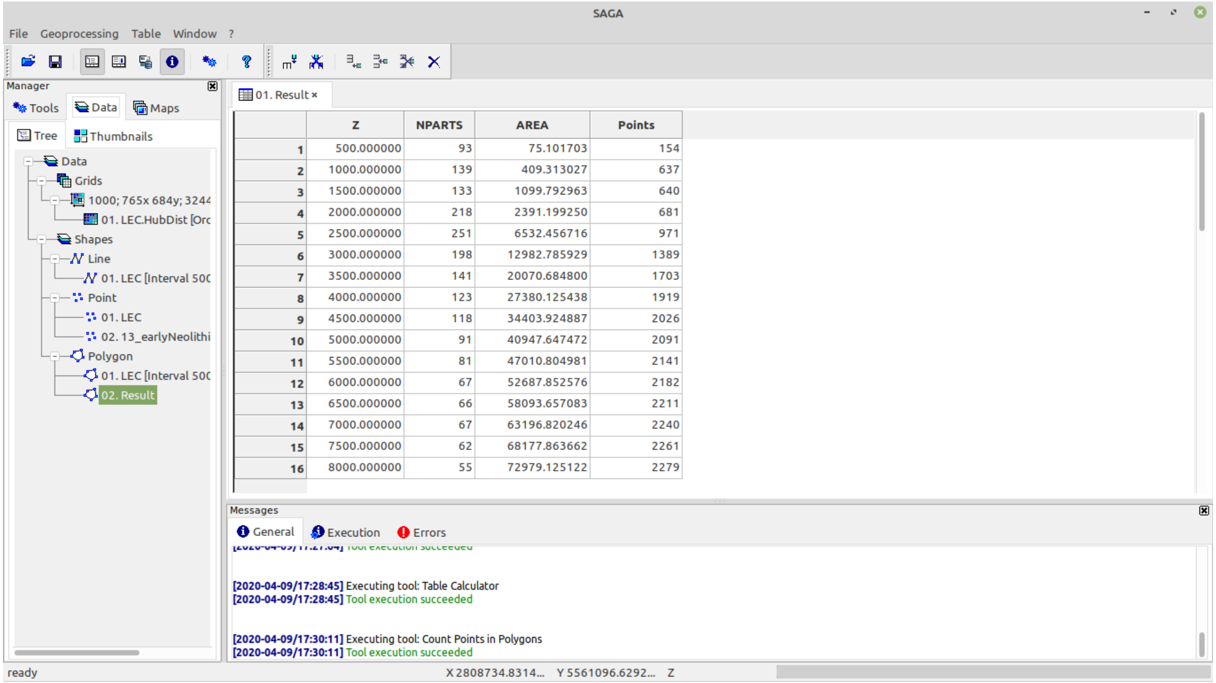
Geoprocessing / Shapes / Points / Points Count Points in Polygons

Now we count the number of sites within each isoline. “Points” is the original layer with measurements (sites) and “Polygons” is the dissolved Isoline polygon layer (might be called “Polygons with Property Attributes” or “Result”).



Have a look at the attributes

Right Click on Layer > Attributes > Show



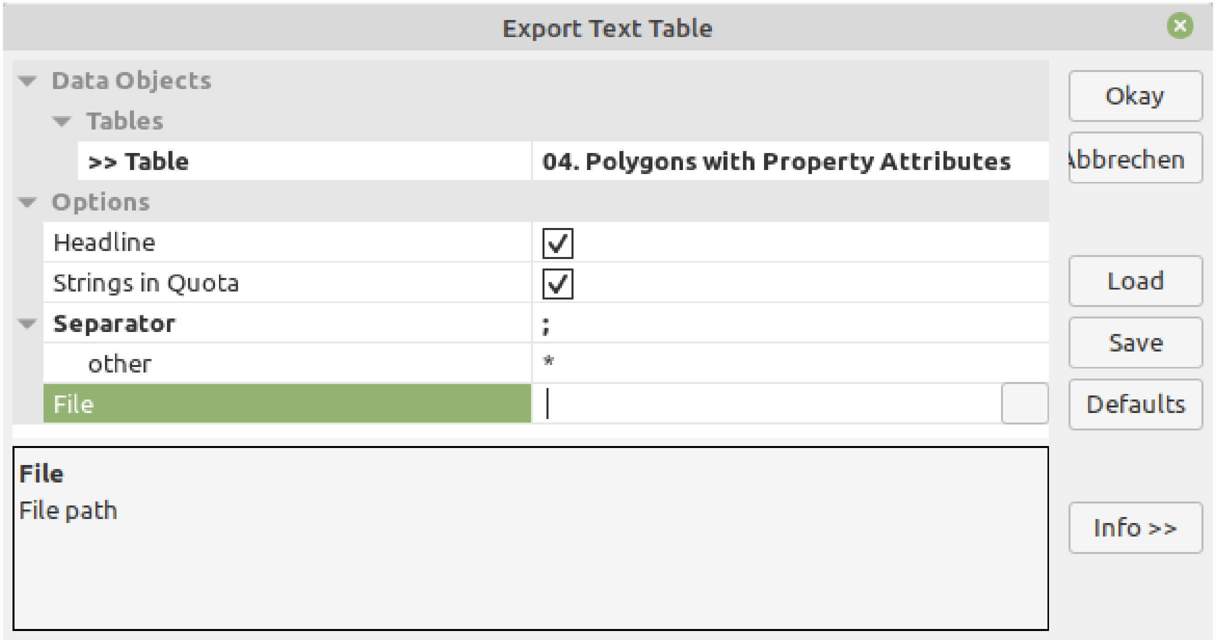
	Z	NPARTS	AREA	Points
1	500.000000	93	75.101703	154
2	1000.000000	139	409.313027	637
3	1500.000000	133	1099.792963	640
4	2000.000000	218	2391.199250	681
5	2500.000000	251	6532.456716	971
6	3000.000000	198	12982.785929	1389
7	3500.000000	141	20070.684800	1703
8	4000.000000	123	27380.125438	1919
9	4500.000000	118	34403.924887	2026
10	5000.000000	91	40947.647472	2091
11	5500.000000	81	47010.804981	2141
12	6000.000000	67	52687.852576	2182
13	6500.000000	66	58093.657083	2211
14	7000.000000	67	63196.820246	2240
15	7500.000000	62	68177.863662	2261
16	8000.000000	55	72979.125122	2279

You should end up with a shp-file of polygons and columns for each isoline value (Z), the number of part the isolines consist of (NPARTS), the area per isoline and the number of sites (Points) within each isoline. The figure above shows the results using the first formula (linear regression/exponential model).

11) Data export

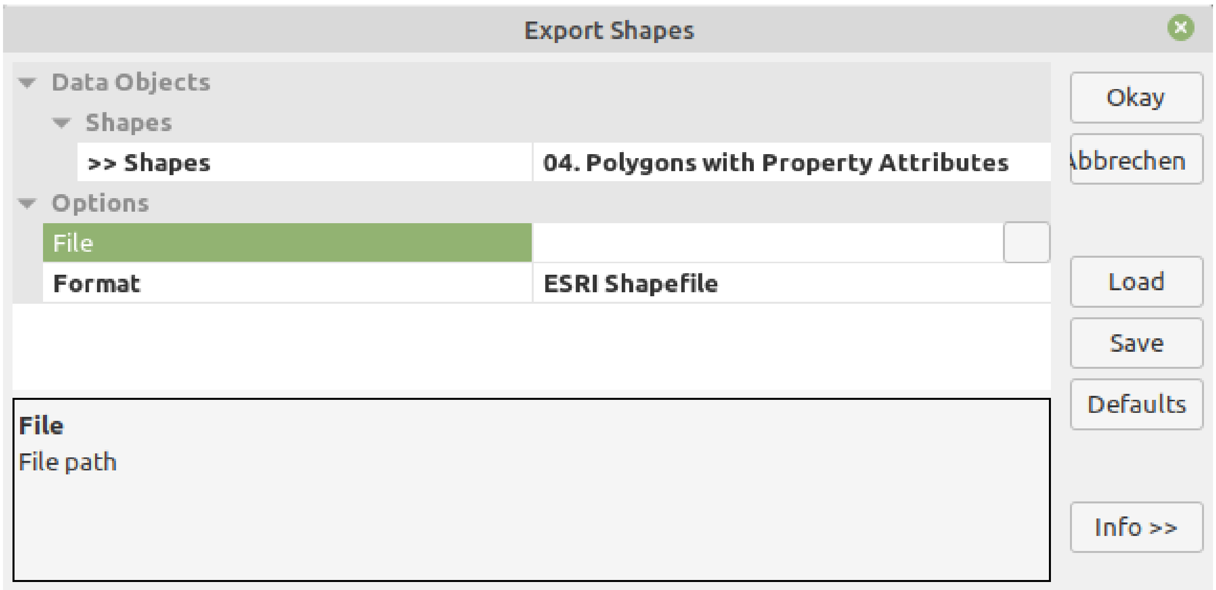
Export the results (might be called “Polygons with Property Attributes” or “Result”) as comma-separated values (*.csv):

Geoprocessing / File / Tables / Export / Export Text Table...



and as shape-File:

Geoprocessing / File / Shapes / Export / Export Shapes



12) Selecting the "Optimally Describing Isoline"

The step of selecting the Optimally Describing Isoline is not described in this manual. You can do this in a spreadsheet program (e.g. excel). Please refer to the R or the MapInfo manual.

B) Scripts

0. Preconditions

Precondition for using the Python and R scripts is having QGIS 3.10, SAGA 2.3.1 and R 3.6.2 installed. SAGA is usually installed as default during the QGIS setup, if you are working with Linux you might have to download and install SAGA on your own.

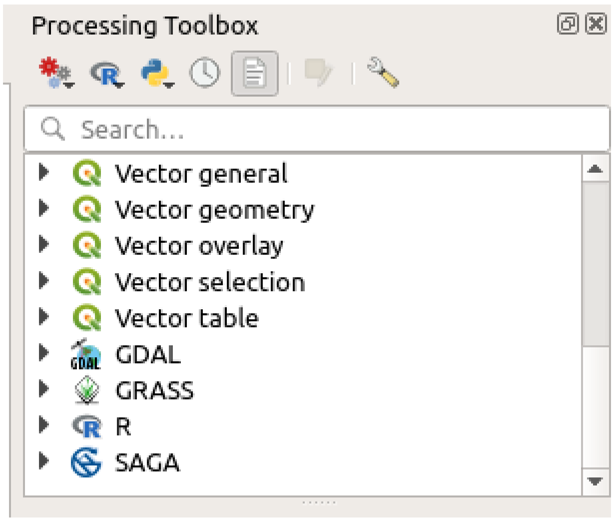
Download the four scripts from the GitHub Repository and unzip in a directory of your choice:

https://github.com/C-C-A-A/CologneProtocol-QGIS

Start QGIS and have a look at the Processing Toolbox:

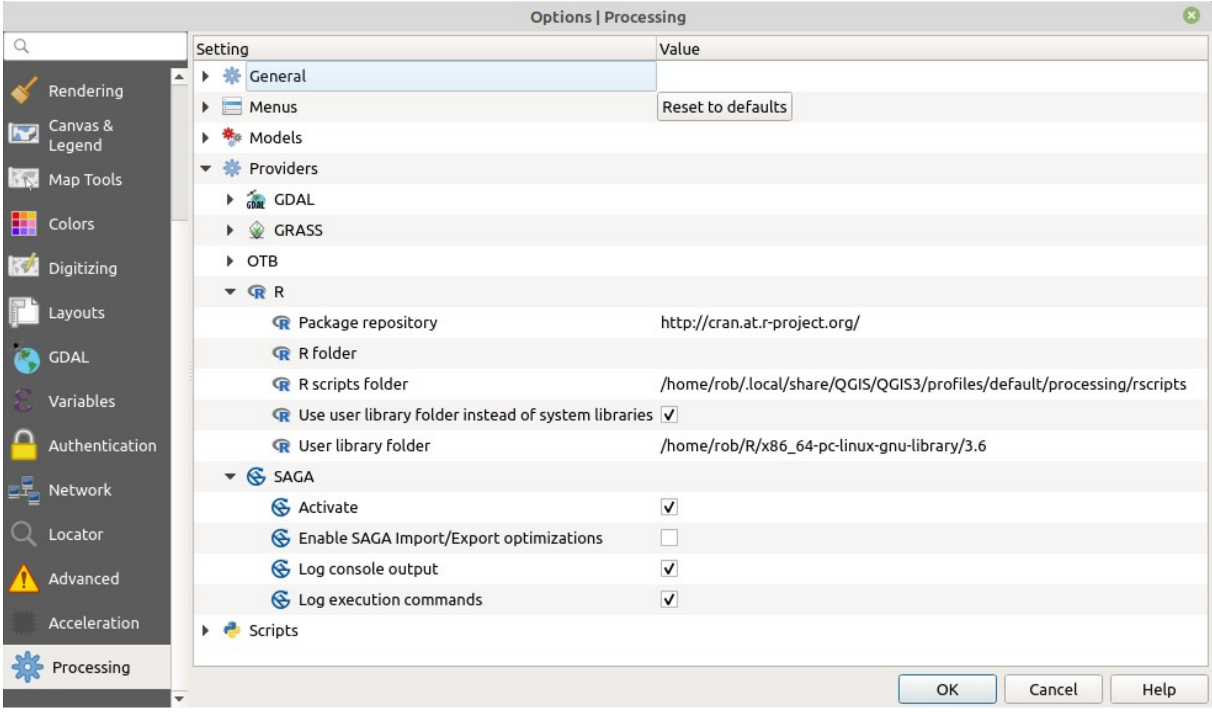
Processing / Toolbox...

There should be a R and SAGA icon in the box as well as a R and Python icon at the top of the panel:



If one of the icons is missing or a R or SAGA script or function cannot be run, check if R and SAGA is activated and if the program paths are right in :

Settings / Options / Processing / Providers....

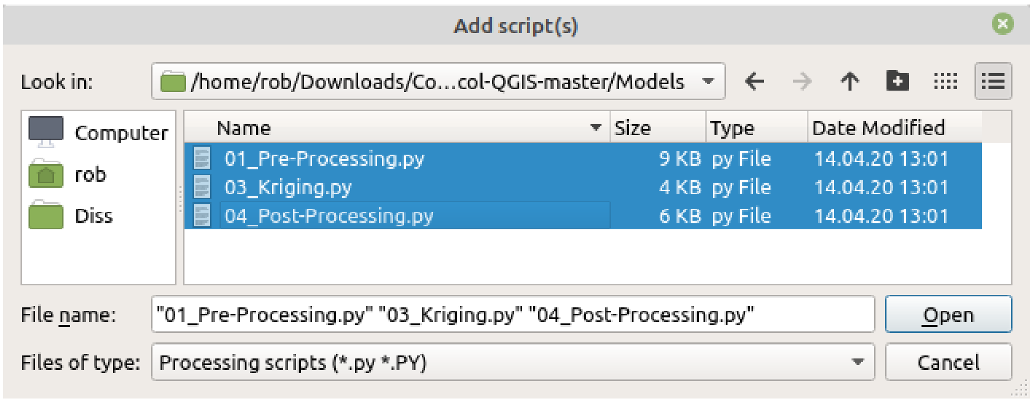


If it is still not working consult the QGIS User Guide:

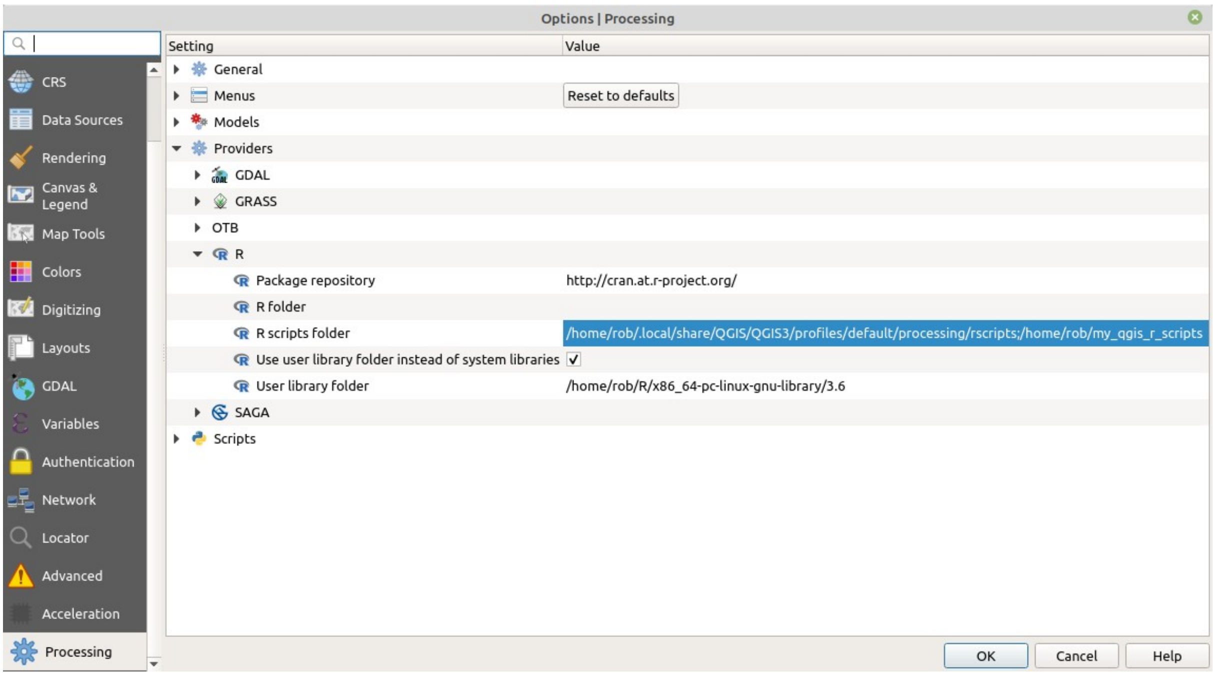
https://docs.qgis.org/3.10/en/docs/user_manual/processing/3rdParty.html

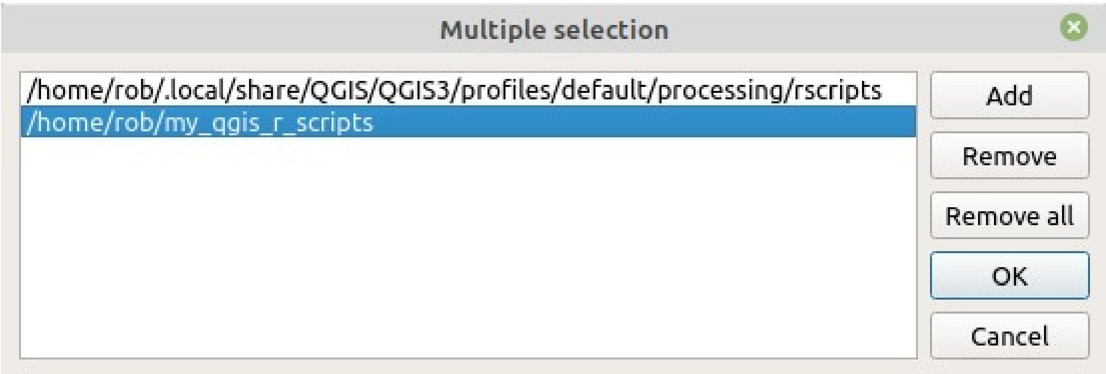
After configuring the external applications you can open the scripts. Click the Python icon at the head of the Processing Toolbox and choose “Add Script to Toolbox”. Add the three Python scripts (“01_Pre-Processsing.py”; “03_Kriging.py”; “04_Post-Processing.py”)

Processing Toolbox / Python Icon / Add Script to Toolbox...

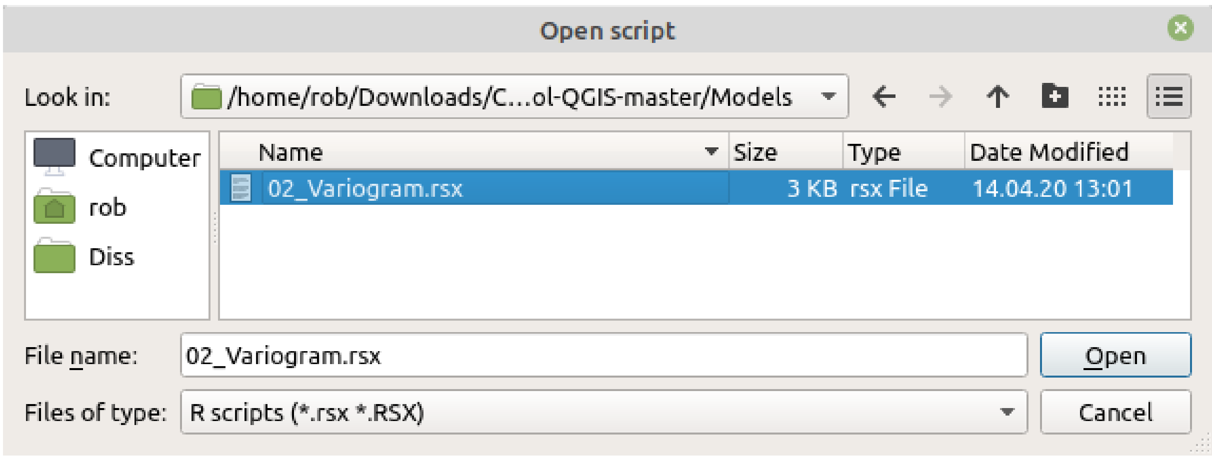


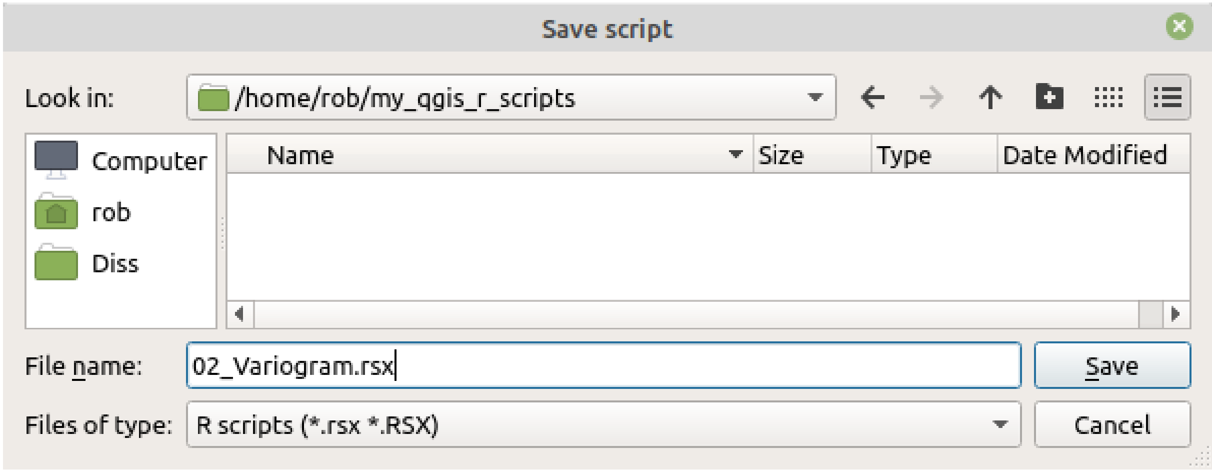
To open the R-script add your own or a new R scripts folder path to the processing options:



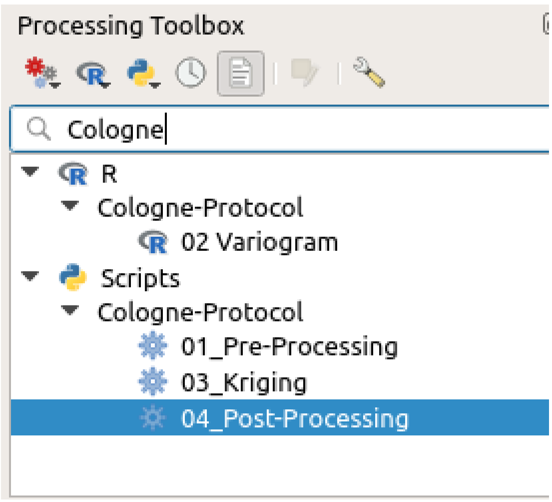


Then click the R icon in the Processing Toolbox header and choose “Create new R scrip” to add the*.rsx file. Open “02_Variogram.rsx” and save to the R scripts folder you just specified.



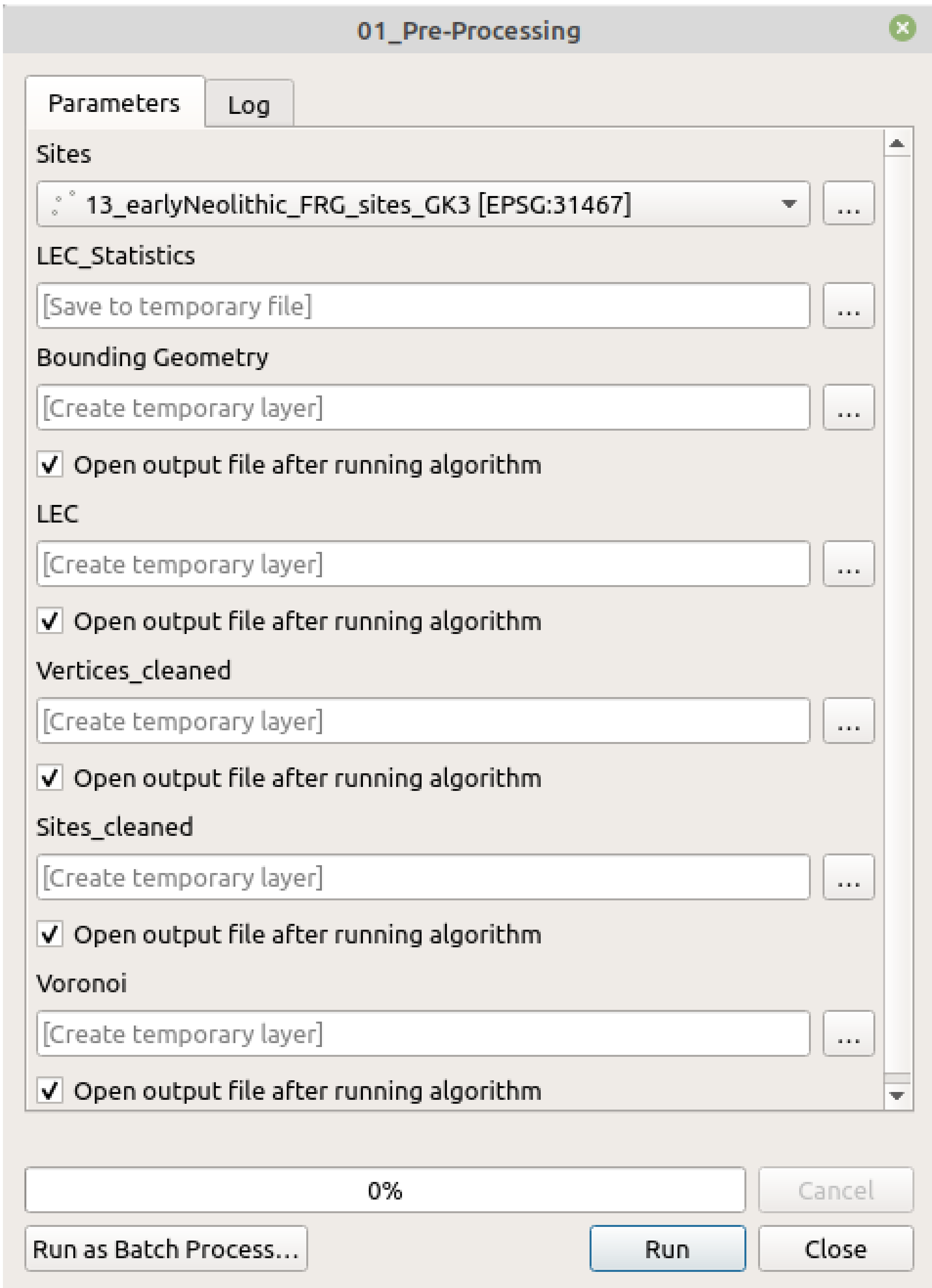


If you type “Cologne-Protocol” in the Processing Toolbox Search box you should be able to find all four scripts:



1. Pre-Processing

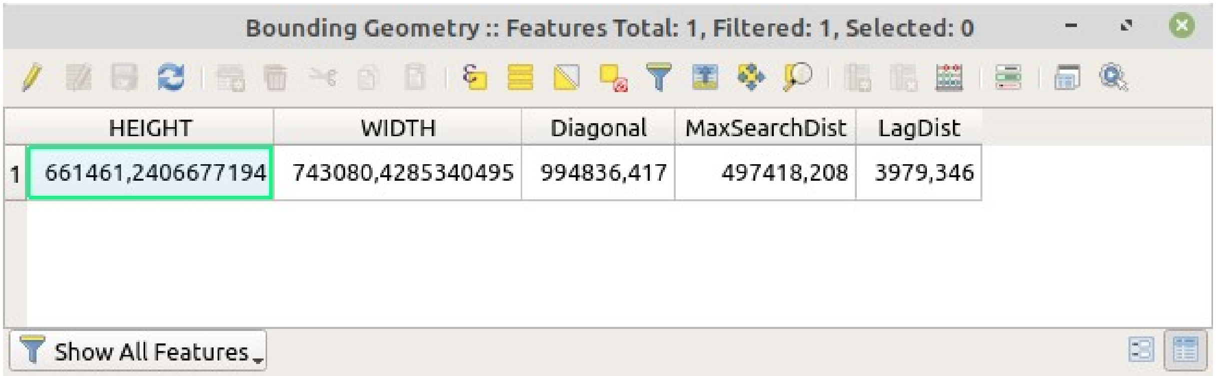
Double Click the “01_Pre-Processing”-Script and enter the sites layer you want to use.



Running the script will create the following layers:

Sites_clean	Input sites without duplicates
Voronoi	Voronoi diagrams
Vertices_cleaned	Vertices of the voronoi diagrams without duplicates
Bounding Geometry	Minimum Bounding Geometry of the vertices/LECs with

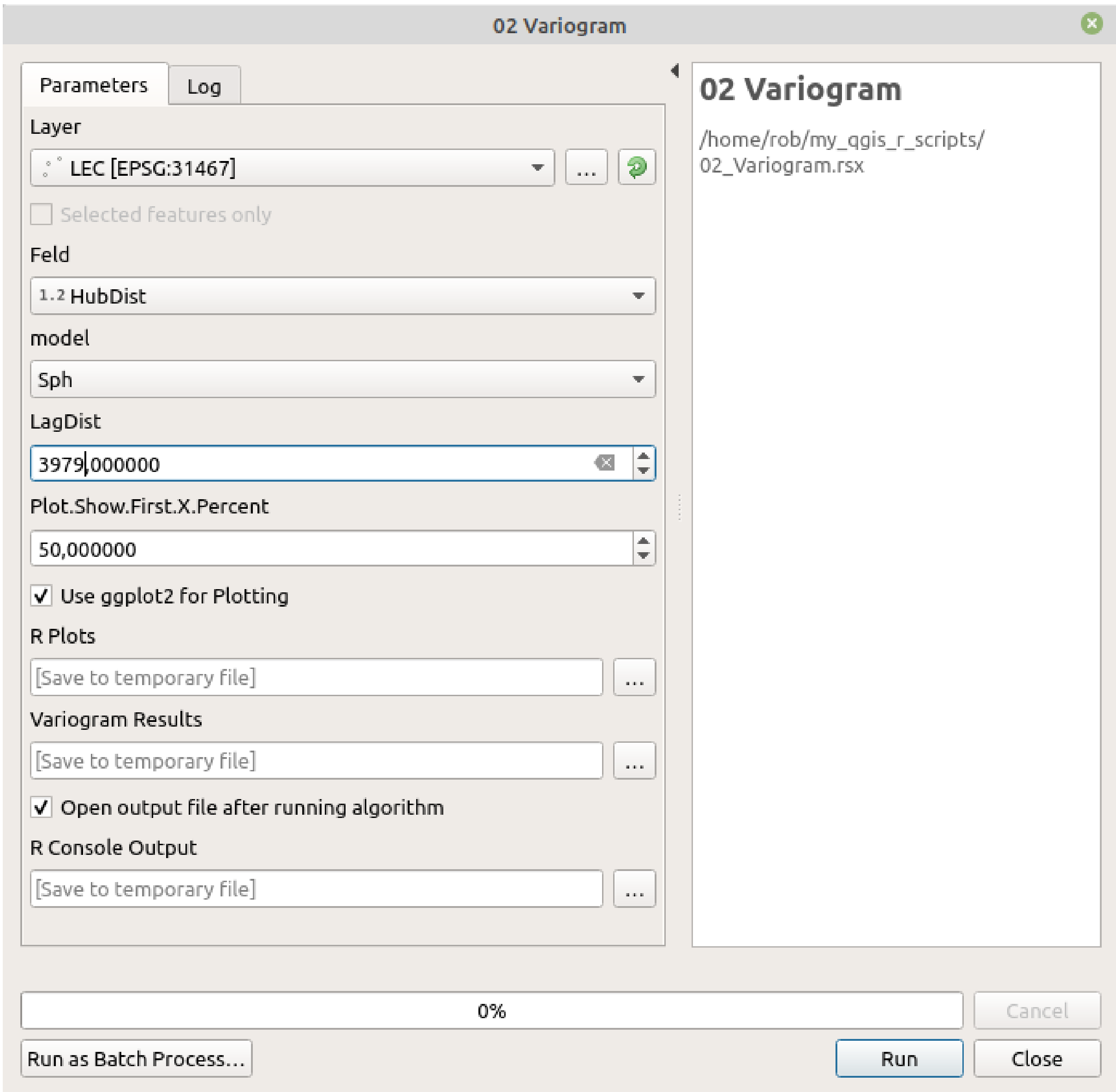
	Fields “Diagonal” (Bounding Box Diagonal), “MaxSearchDist” (Half of the Bounding Box Diagonal), “LagDist” (Lag Distance = Bounding Box Diagonal / 250)
LEC	Largest Empty Circles Centroids with Radius in the Field “HubDist”



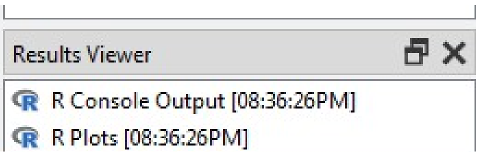
	HEIGHT	WIDTH	Diagonal	MaxSearchDist	LagDist
1	661461,2406677194	743080,4285340495	994836,417	497418,208	3979,346

2. Variogram

The R (*.rsx) Variogram script requires an input layer, the layer containing the LEC-Radii (LEC.shp) and the field with the LEC-Radii to be specified. You should also choose the theoretical model (spherical, exponential, Gaussian or Mat). Independent from your choice of model the script will compute a spherical, exponential and power model for your data. In the field LagDist you should enter the value calculated above (Layer „Bounding Geometry“, Field „LagDist“). The last two options specify if the frame of the plot should be zoomed to a certain percentage and whether the R base plot or ggplot2 is used for plotting.



The Variogram-Script will produce two html results in the "Results Viewer". The "R Console Output" which is a text based log and "R plots" with the semi-variogram.

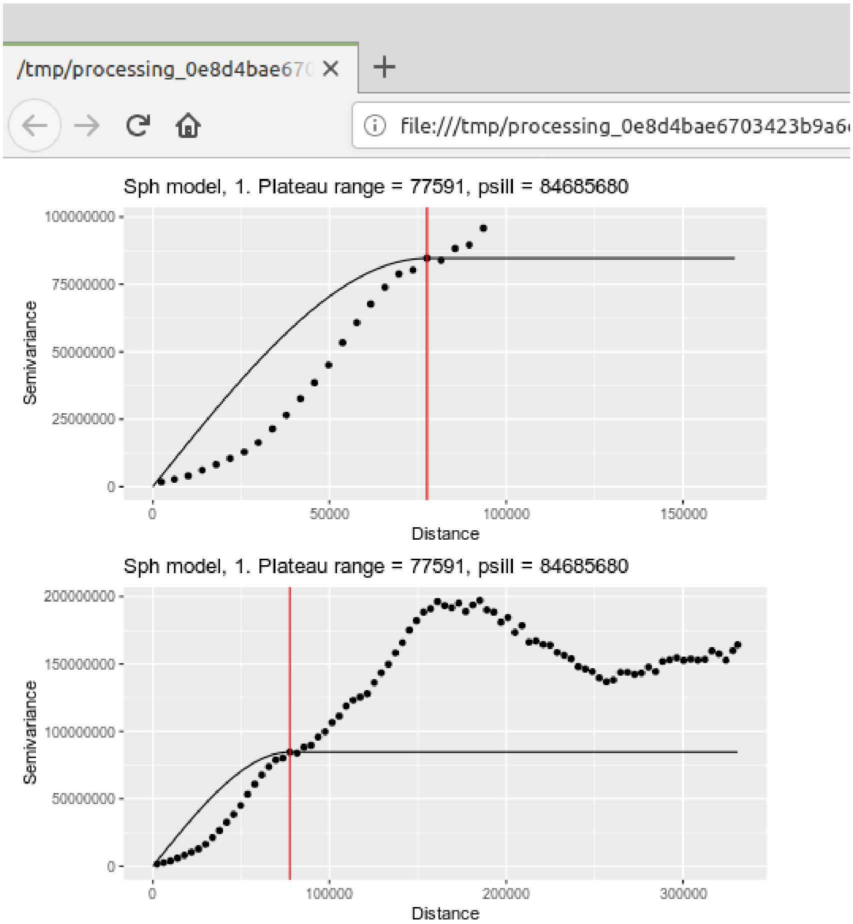


In the „R Console Output" you can look up the the nugget, psill and range of the computed variogram as well as the formulas of the different models you can use later on.

R Output

```
[1] "/home/rob/R/x86_64-pc-linux-gnu-library/3.6/gstat"
Registered S3 method overwritten by 'xts':
method from
as.zoo.xts zoo
[1] "/home/rob/R/x86_64-pc-linux-gnu-library/3.6/ggplot2"
[1] "/home/rob/R/x86_64-pc-linux-gnu-library/3.6/gridExtra"
[1] "/home/rob/R/x86_64-pc-linux-gnu-library/3.6/sf"
Linking to GEOS 3.8.0, GDAL 2.2.3, PROJ 4.9.3
WARNING: different compile-time and runtime versions for GEOS found:
Linked against: 3.8.0-CAPI-1.13.1 compiled against: 3.6.2-CAPI-1.10.2
It is probably a good idea to reinstall sf, and maybe rgeos and rgdal too
[1] "/home/rob/R/x86_64-pc-linux-gnu-library/3.6/raster"
Lade nötiges Paket: sp
[1] 20
Warnmeldungen:
1: Removed 100 rows containing missing values (geom_path).
2: Removed 60 rows containing missing values (geom_point).
[1] ""
[1] ""
[1] "**********************************************************************"
[1] ""
[1] "RESULTS:"
[1] ""
model psill range
1 Nug 0 0.00
2 Sph 84685680 77590.52
[1] ""
[1] "model = Sph"
[1] "nugget = 0"
[1] "psill = 84685680"
[1] "range = 77591"
[1] ""
[1] "Exponential Model:"
[1] "0+84685680*x+77591*x*x"
[1] "Power Model:"
[1] "0+84685680*x^77591"
[1] "Spherical Model:"
[1] "0+84685680* ifelse(x >77591, 1, 1.5 * x / 77591 - 0.5 * x*x*x / 77591*77591*77591"
[1] ""
[1] "***DONE***"
[1] ""
```

„R Plots“ consist of a overall plot (bottom) and the zoomed in version (top). The sample variogram is plotted as black points, the theoretical model as black line and the range at the 1st plateau signified as vertical red line.



All variogram results can be found in newly created „Variogram Results“ table:

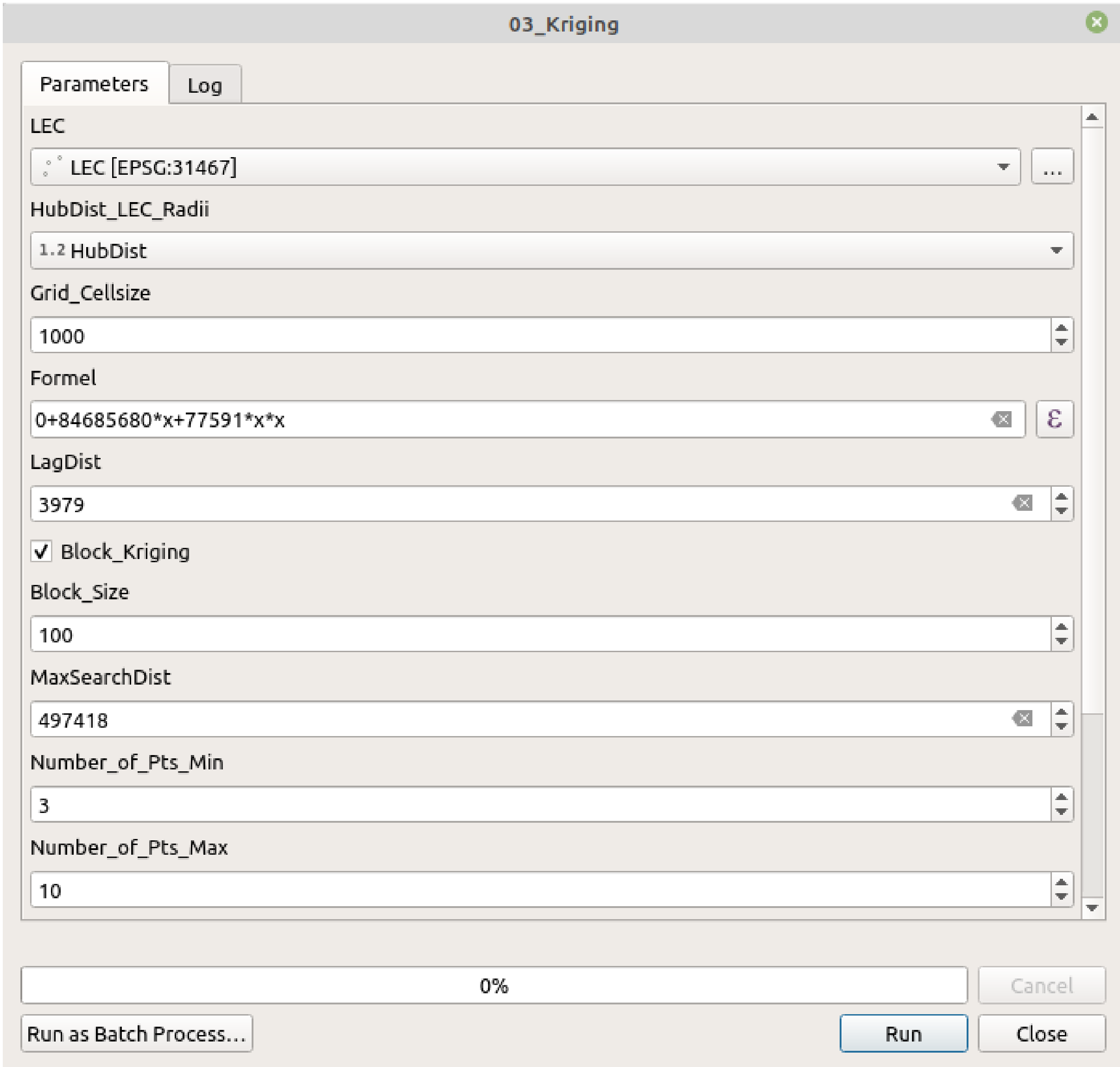
Variogram Results :: Features Total: 1, Filtered: 1, Selected: 0

	field_1	Model	Nugget	Range	Psill	exp	pwr	sph
1	1	Sph	0	77591	84685680	0+84685680*x+77591*x*x	0+84685680*x^77591	0+84685680* ifelse(x >77591, 1, 1.5 * x / 77591 - 0.5 * x*x*x / 77591*77591*77591

Show All Features

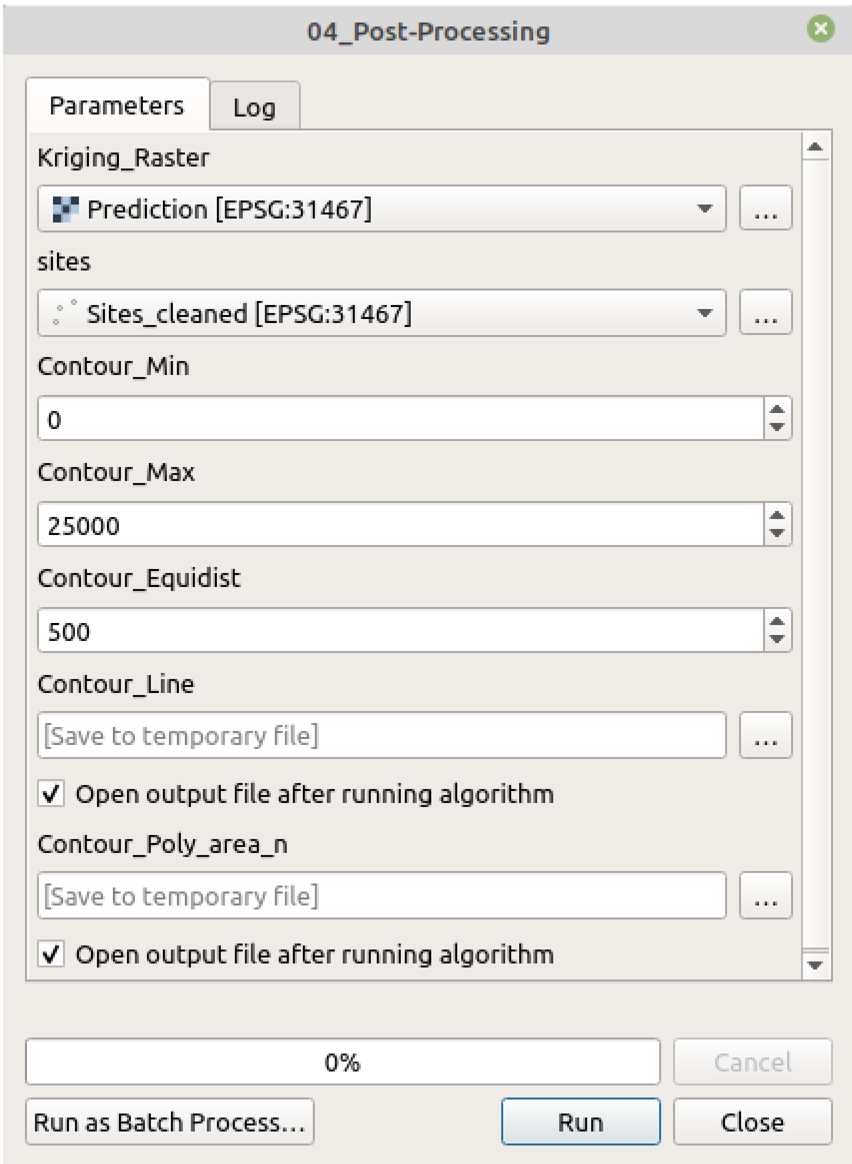
3. Kriging

The Kriging script requires again the layer and field with the LEC-radii (Layer: LEC.shp; Field: „HubDist“). You should also enter the cell size of the raster layer to be created, the formula of the theoretical variogram model you want to choose (look up in „Variogram Results“ table), the Lag Distance and Maximum Search Distance (look up in „Bounding Geometry“ layer). For testing try to use a coarse grid.


03_Kriging
Parameters
Log
LEC
LEC [EPSG:31467]
...
HubDist_LEC_Radii
1.2 HubDist
Grid_Cellsize
1000
Formel
0+84685680*x+77591*x*x
LagDist
3979
Block_Kriging
Block_Size
100
MaxSearchDist
497418
Number_of_Pts_Min
3
Number_of_Pts_Max
10
0%
Cancel
Run as Batch Process…
Run
Close

4. Post-Processing

Choose the just created Kriging raster and the “Sites_clean” layer (important, not your original layer) and enter minimum and maximum of the contour lines to be extracted as well as the distance between contour lines (equidistance) in meter.



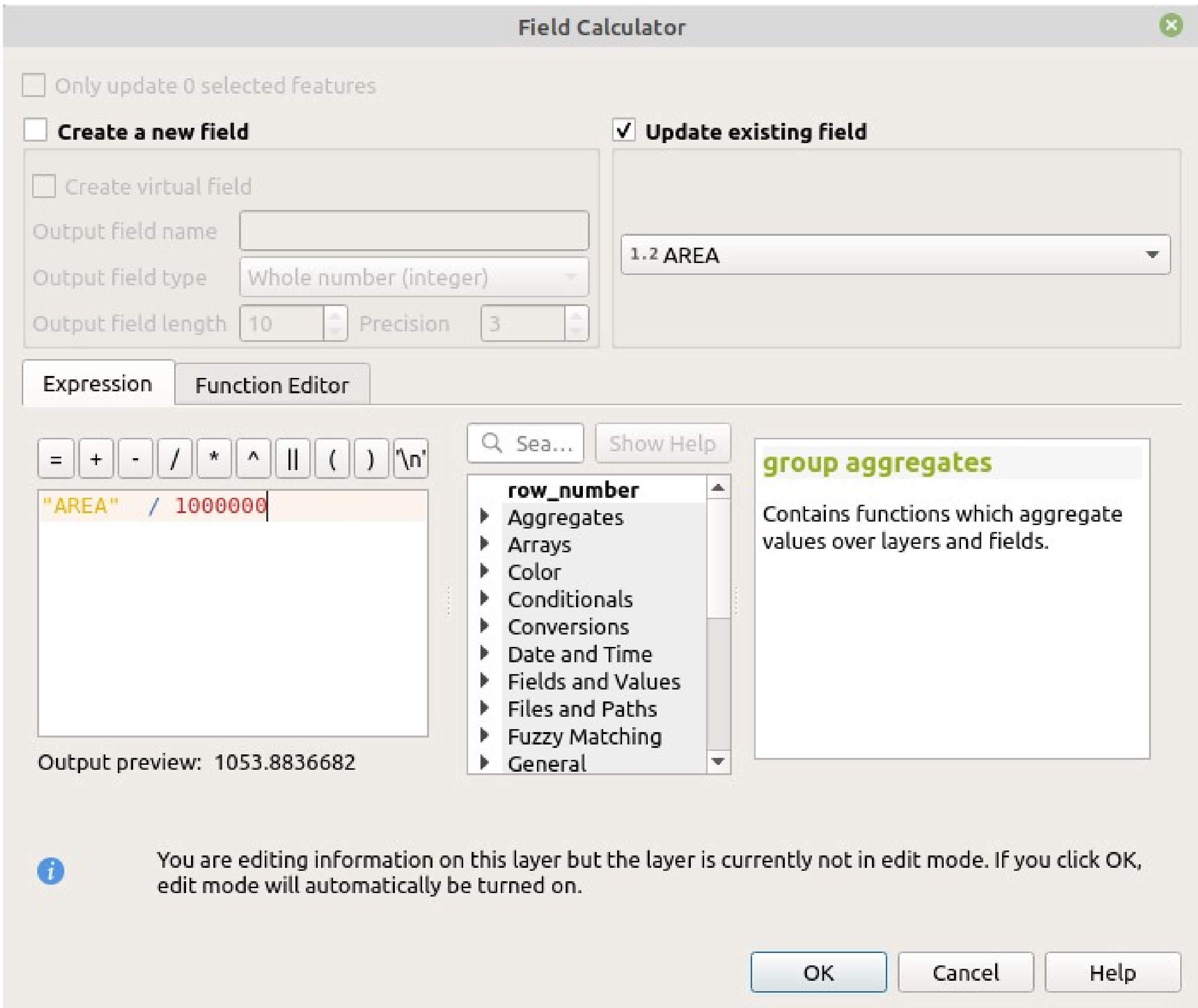
The most important results are saved in the Layer „Contour_Poly_Area_n“ with Fields containing the contour line value („Z“, e.g. 1000 = 1 km contour line), the number of polygon parts („NPARTS“), the area enclosed by the contour line („AREA“) and the number of sites within each contour line („NUM“).

The Area of Contour-Polygons is in m² and should be converted to km²:

Open Attribute Table of new layer (*Right Click on Layer / Open Attribute Table*) and open Field Calculator (Ctrl+*I*):

Check "Update existing field"

Output field name: AREA
Formula: "AREA" / 1000000



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