

## 9.2 Geostatistics in ILWIS 2.2

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This is an introductory exercise using a case study on Carbon14 ( $C^{14}$ ) water measurements in Botswana, Southern Africa.

### 9.2.1 Point maps with a value domain

1. Start ILWIS and go to directory C:\ILWIS22\DATA\CARBON14.
2. A point map with  $C^{14}$  percentages is given and named C14; you can find it in the Catalog. Open point map C14. In the Display Options dialog box check *Attributes* ON, accept column C14 and all other defaults. Then click OK.
3. Move with your mouse pointer over the map window and keep the left mouse button pressed. Notice that the pixel values are displayed for each position of the mouse pointer:
  - next to the mouse pointer and
  - at the status line.
4. Select *Layers, Add Annotation, Grid Lines* from the menu. Accept the defaults Display Options.
  - Estimate the size of the map (X-extent and Y-extent) and verify this using the Distance tool: Press the right-most button in the button bar (the pair of compasses) and measure some distances.
  - Measure the length of both the shortest and the longest point-pair vector (zoom in if needed). Find also the angle and the  $C^{14}$  percentage difference for each point pair.
5. Select point map C14 in the Catalog. To view the properties of the map, use the right mouse button on the map in the Catalog, and select Properties from the context-sensitive menu. Then, use the right mouse button again on the point map in the Catalog and open the point map as a table.
  - How can you verify that the map is from an area in Botswana, Africa?
  - How many different point pairs can be made?
6. Open the table named C14. In the C14 column you will find the percentages of  $C^{14}$  content (p.m.c = percents 'modern carbon'), measured in well water at all locations appearing in the point map. Percentages are given with respect to a stabilized  $C^{14}/C^{12}$  ratio.

7. The other columns show the computed standard deviation and two outcomes of variance computations.
  - Can you explain the difference in the columns VAR and VAR52\_51 ?

### 9.2.2 Spatial correlation and empirical semi-variogram

1. Select the point map in the Catalog, press the right mouse button and select Spatial Correlation, or double-click the SpatCorr operation in the Operation-list. Specify a lag spacing of 10 km. Call the output table SPCORR10 and check Show ON. Type in the description box: 'Point pair statistics of C14 with lag-interval of 10km' (This text is optional and can always be changed later). Accept all other default values and click OK.
  2. Inspect the different columns and their properties. Double-click the column names to view details, i.e. the Column Properties.
    - What does 37 in the first field of the NRPAIRS column mean precisely?
    - How many point pair "vectors" are longer than 55 km?
    - Do the six longest vectors show the expected semi-variance
  3. Select *Options, Show Graph* and choose DISTANCE for the X-axis and SEMIVAR for the Y-axis.
    - In which units are these coordinates X and Y expressed respectively?
  4. Repeat steps 1, 2, and 3 for a lag-interval of 5 km (you can skip the questions). Use SPCORR5 for the output table name.
    - Explain the differences in the NRPAIRS column, even in records with equal lag.
  5. Make a bi-directional SPATCORR table with 10km lag interval. For the primary direction take an angle of 15° (clockwise from the map north), a tolerance of 30°, and no band limitation. Call this table B11530.
    - Inspect the columns of the table B11530 and explain the main differences between columns NRPAIRS1 and NRPAIRS2.
    - Why don't they sum up to  $52 \times 51 / 2$  point pairs? Where are the remaining ones?
    - Compare columns SEMIVAR1 and SEMIVAR2. Do you conclude a trend or anisotropy from these figures? Why?

Close all map windows and tables that are still open.

**9.2.3 Modeling the semi-variogram**

1. Open the table SPCORR10.  
Select *Option, Show Graph* and display a *point* graph of SEMIVAR against DISTANCE. This is the empirical (= physically measured) semi-variogram.
2. The ('theoretical' or 'estimated') Semi-variogram Model is now made as follows:  
In the graph window select *Graph, Add SemiVariogram Model*.  
Choose *Spherical*, 200, 650 and 40 km for the model parameters.
  - At which distance (X-coordinate) do you find the greatest discrepancy between the semi-variogram model and measured values?
  - To which PMC (percent modern Carbon) does this discrepancy correspond?
  - Make a list of all available semi-variogram models or functions (Spherical, Circular...), their numeric parameters and the units in which these parameters are measured.
3. Select *Graph, Add Semivariogram Model* and add a circular semi-variogram model with the same parameter values as above. Use a different color.

**9.2.4 Point map interpolation**

When you already familiar with point interpolation operations you can skip this part.

1. Select georeference C14 from the Catalog. View its properties by using the right mouse button.
  - Explain the term Georeference Corners.
  - How many pixels (RowCols) will make up a raster map based on this georeference?
  - Write down its coordinate boundaries and the pixel size. Do they fit?
2. Select the point map C14.  
Use the right mouse button and select *Interpolation, Nearest Point*.  
Check the *attribute box* ON, select column C14 and use C14 georeference C14.  
Call the output map C14NP. Let it show immediately (check the *Show box* ON).  
Accept all other default and click OK.
  - Do you know the name of the type of raster map you obtain?
3. In the catalog click the point map with the right mouse button and select *Interpolation, Moving Average*.  
Check the *Attribute box* ON, select column C14 and check the *Show box* ON.  
Call the output C14MA, use georeference C14 and accept other defaults.  
Click OK to execute the gridding operation by Moving Average.

**9.2.5 Kriging estimation and error map**

1. Select the point map C14.  
Use the right mouse button and select *Interpolation, Kriging*.
2. Accept the default Spherical Model and fill in Nugget, Sill and Range values as in 9.2.3.  
Specify a limiting distance of 25 km.  
For *Nr of points* fill in 4 for *Min* and 14 for *Max*.  
Call the output raster map KO25 and call the Error map FO25. Check *Show ON*.  
Accept all other defaults and click OK.  
The calculation can take a few minutes.
  - Which parameters influence the speed of calculation?
  - Explain the numbers in the *Tranquilizer*, i.e. the numbers above the increasing progress bar.
3. Use the right mouse button to view the properties of raster maps KO25 and FO25.
  - Find the range of output values in both maps. Which units?
  - Was the Kriging estimation 'simple' or 'ordinary'? What's the difference?
4. Perform another Kriging estimation from the C14 point map with a search radius (limiting distance) of 40 km, copy all other parameter values from KO25.  
Call the output maps KO40 and FO40 respectively.
5. Open both error maps FO25 and FO40 and close all other maps and tables.  
Drag the input point map C14 on top of each of the error maps. Use crosses as point- symbols.
  - Find the point with the best Kriging estimate and the point with the worst one in both estimation results.
6. Make a simple Kriging interpolation similar to the previous tasks.
  - List the parameters that don't enter into the process anymore compared to ordinary Kriging). Call the output raster maps KS and FS (estimate map and error variance map respectively).
7. Drag the input point map over raster map FS.
  - Find the point with minimum and the point with maximum error variance ('uncertainty').

