

Variography - Introduction

The variogram (or semi-variogram) is a graph relating the variance of the difference in value of a variable at pairs of sample points to the separation distance between those pairs. This relationship can in addition be calculated for different directions. This manual assumes you are familiar with the theories of Geostatistics and the calculation and use of the semi-variogram.

For a background on variography and its place in Geostatistics, there are a number of classical texts:

Matheron, G, The Theory of Regionalised Variables and its Applications, 1971

David, M, Geostatistical Ore Reserve Estimation, 1977

Journel, AG and Huijbregts, C, Mining Geostatistics, 1978

Clarke, I, Practical Geostatistics, 1982

Version 2.11.0.7 of GeoAccess released in July 2009 has enhanced functionality in the modelling of variograms – see Variogram Modelling on Page 11.


Variography – Setting up the Parameters

When a data file has been loaded, and the Variography tab selected, the following screen will be displayed.

The screenshot shows the 'Variography' tab selected in a software window titled '140_MZ : 19276 recs'. The window has a menu bar with 'Stereoplot', 'Geotech Sections', 'Geotech Plans', 'Ternary Plot', and 'Tools'. Below the menu bar are tabs for 'Statistics', 'PPlot/Histo', 'Correlation', 'Variography' (selected), 'Multi Plot', and 'Oriented Core'. On the left side of the 'Variography' tab are three buttons: 'Re Load Data', 'Save Data', and 'View/Edit Data'. The main area contains a list of variables for variogram calculation. On the left, there are three dropdown boxes for 'Easting' (set to 'EASTING'), 'Northing' (set to 'NORTHING'), and 'RL' (set to 'RL'). To the right of these are eight 'Value' fields, each with a dropdown menu and a checkbox. The values are: Value 1: FE (checked), Value 2: AL203, Value 3: SiO2, Value 4: P, Value 5: LOI, Value 6: DENSITY, Value 7: DENSITY, and Value 8: DENSITY. To the right of these fields are two buttons: 'Set Up Indicators (Value Field 1)' and 'Set Up Directions'. At the bottom right is an 'OK' button. At the bottom of the window, a status bar indicates '19276 records in memory' and '14 variables loaded'.

GeoAccess will attempt to find fields with appropriate names for the Easting, Northing and RL variables. It will also suggest other fields for the likely variables for variogram calculation. Use the drop down boxes to change these variables as required.

By default variograms are calculated for the first field. Tick the appropriate boxes to calculate multiple variograms as required. A new results window will be displayed for each variable calculated.

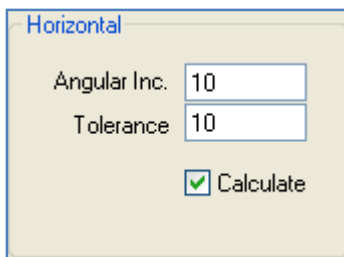
To set up the variogram parameters, click on the  button, which will display the following screen.

The screenshot shows the 'Variogram Parameters' dialog box. It has a title bar 'Variogram Parameters'. Inside, there are three main sections: 'Variogram Lags', 'Horizontal', and 'Vertical'. The 'Variogram Lags' section has two input fields: 'Variogram Lag' (set to 20) and 'No of Increments' (set to 12). There are 'Cancel' and 'OK' buttons. The 'Horizontal' section has 'Angular Inc.' (15) and 'Tolerance' (25) fields, and a 'Calculate' checkbox. The 'Vertical' section has 'Direction' (0), 'Angular Inc.' (15), and 'Tolerance' (25) fields, and a 'Calculate' checkbox. The 'Directional (or Downhole)' section has 'Direction (Azimuth)' (90), 'Dip' (60), 'Angular Tolerance' (15), and 'Lag' (1) fields, and a 'Calculate' checkbox. A note at the bottom says 'Note: Positive dip is down'.

The parameters required are:

The screenshot shows the 'Variogram Lags' section of the 'Variogram Parameters' dialog box. It has two input fields: 'Variogram Lag' (set to 20) and 'No of Increments' (set to 12).

The variogram will be grouped into bins where the lag is the distance between the bins. For example, with the above definition, data will be averaged for distances of 0m to 10m, 10m to 30m, 30m to 50m and so on.



Horizontal

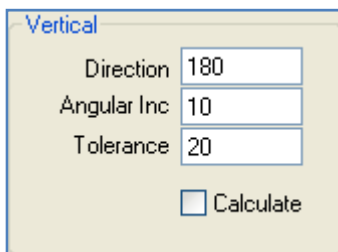
Angular Inc. 10

Tolerance 10

☒ Calculate

Horizontal variograms are calculated for a series of directions, starting at 0° (ie looking North), and increasing by the defined increment to 180°. In the above case variograms will be produced in directions 0°, 10°, 20°, 30° etc, to 180°. The Tolerance is an angle which defines a conical search area in which data will be considered. In the above case, for the 0° directional variogram, data will be used which falls between directions of 350° and 10°.

Normally the horizontal variogram is calculated first to give a indication of the strike orientation of the data. This direction can then be used to define the direction for the vertical variogram.



Vertical

Direction 180

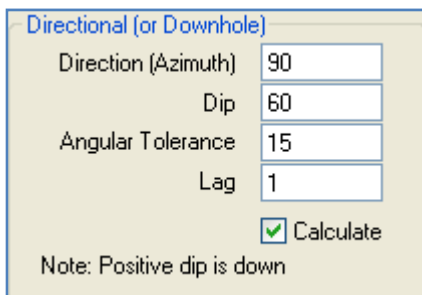
Angular Inc 10

Tolerance 20

☐ Calculate

In the case above a series of variograms will be calculated, starting with one looking to the South (180°) and horizontal, then to 180° at 10° dip, 20° dip etc. After the 180°, 90° dip (ie vertical), variograms will be calculated looking North (0°) at 80° dip, 70° dip etc. The Tolerance defines the search window.

Downhole or directional variograms can also be calculated.



Directional (or Downhole)

Direction (Azimuth) 90

Dip 60

Angular Tolerance 15

Lag 1

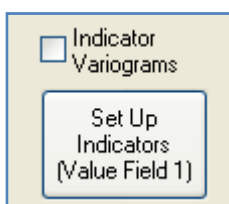
☒ Calculate

Note: Positive dip is down

In the downhole direction the sample spacing is usually quite different from the spacing in other directions, so a different lag distance may be specified.

Variography – Types of Variogram Calculated

By default, normal, log-normal and relative variograms are always calculated. Up to 12 Indicator variograms can also be calculated by ticking the Indicator Variograms box or clicking on the Set Up Indicators button.



☐ Indicator Variograms

Set Up Indicators (Value Field 1)

The following screen will be displayed.

Indicator Cutoffs


Indicator 1	
Indicator 2	
Indicator 3	
Indicator 4	
Indicator 5	
Indicator 6	
Indicator 7	
Indicator 8	
Indicator 9	
Indicator 10	
Indicator 11	
Indicator 12	

The indicator values are initially blank. You can enter up to 12 individual indicators, or use the **Fill by Percentiles** button to automatically fill by percentiles, as shown below.


Indicator Cutoffs

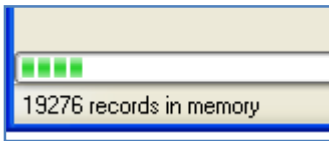
Indicator 1 - 10%	61.92
Indicator 2 - 20%	63.04
Indicator 3 - 30%	63.69
Indicator 4 - 40%	64.14
Indicator 5 - 50%	64.49
Indicator 6 - 60%	64.79
Indicator 7 - 70%	65.09
Indicator 8 - 80%	65.42
Indicator 9 - 90%	65.79
Indicator 10 - 95%	66.07
Indicator 11 - 97.5%	66.28
Indicator 12 - 99%	66.51

When the percentile option is selected, 95% 97.5% and 99% values are also calculated to allow better definition of the high grade tail of a distribution.

The  button makes a copy of the indicator table to the clipboard so that it can be pasted into a document or spreadsheet.

Variography – Run

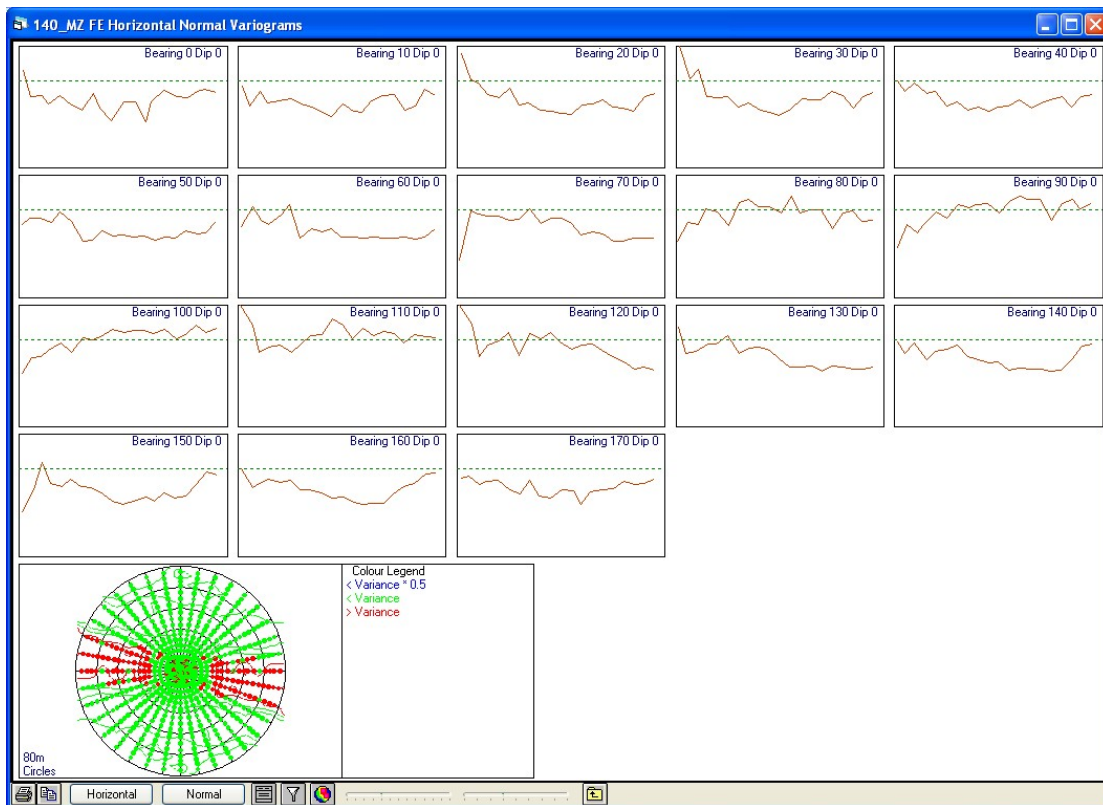
When all parameters have been defined, click the  button to generate the variograms. While the variograms are being generated (which may take some time for large data sets) a progress bar will be displayed at the lower left hand corner of the screen.



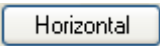
Depending on the speed with which it is moving, this may be a good time to get a cup of coffee or tea.

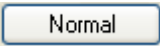
Variography – Initial Display


When the variography calculations are complete, the display will look similar to the one below. Initially the Normal (or untransformed) experimental variograms and variogram fan will be shown.



Several options are available at this stage.

 This button toggles the display from Horizontal to Vertical, Inclined and DownHole as defined when setting up the variography parameters.

 This button toggles the display between the Normal, Log and Relative modes.

 This option allows a title box to be added to the display as follows:

Titles	
Widenbar and Associates	
Deposit A	
Horizontal Normal Variograms	
Data Set : 140_MZ	
Variable : FE	
7/06/2006	

The title box will be displayed in the lower right corner, as shown below.

<table border="1"> <tr> <td>Widenbar and Associates</td> </tr> <tr> <td>Deposit A</td> </tr> <tr> <td>Horizontal Normal Variograms</td> </tr> <tr> <td>Data Set : 140_MZ</td> </tr> <tr> <td>Variable : FE</td> </tr> <tr> <td>7/06/2006</td> </tr> </table>	Widenbar and Associates	Deposit A	Horizontal Normal Variograms	Data Set : 140_MZ	Variable : FE	7/06/2006
Widenbar and Associates						
Deposit A						
Horizontal Normal Variograms						
Data Set : 140_MZ						
Variable : FE						
7/06/2006						



This option allows you to filter out points on all variogram displays with less than a specified number of data pairs.




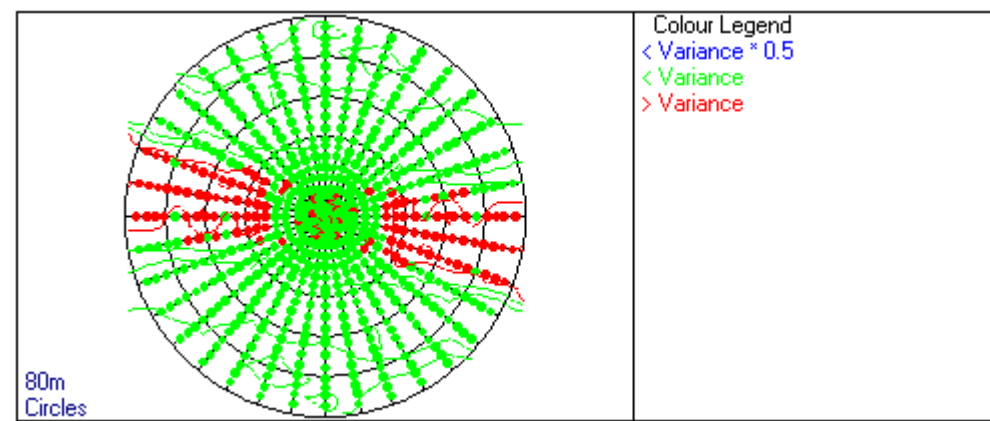
This copies the graphics display to the clipboard in a format that can be pasted into an application such as Word for production of reports.

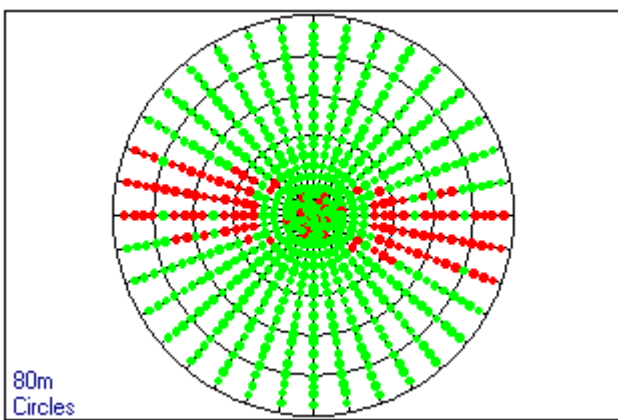
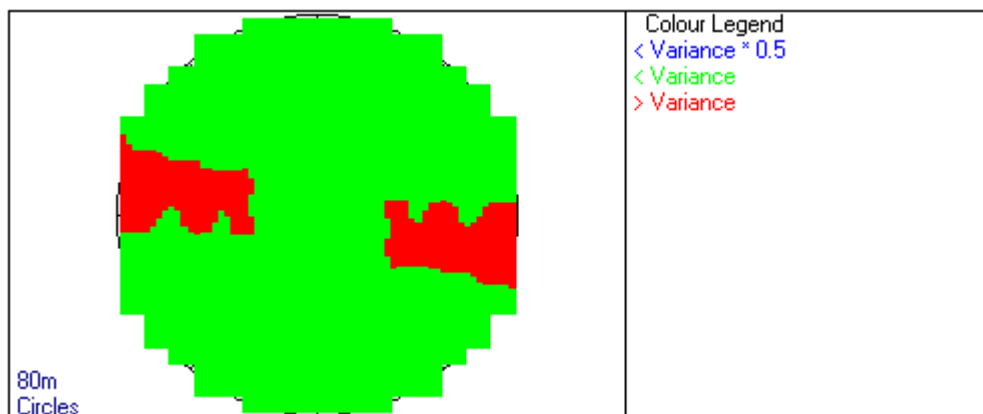


This opens the printer dialog window to produce a hard copy of the graphics display.

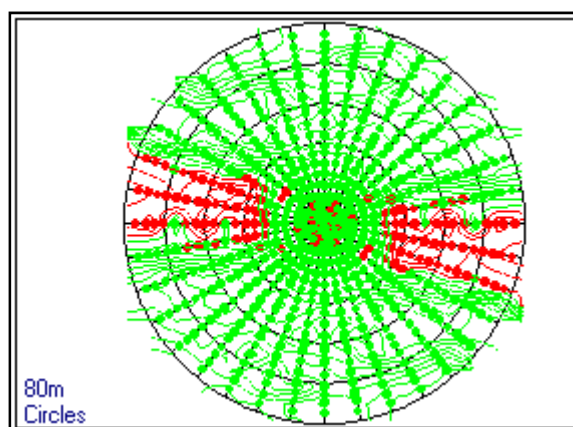
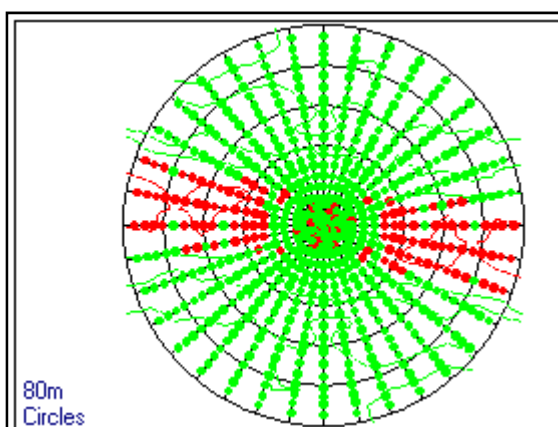


These three controls operate in conjunction with each other to control the mode of display of the variogram fan at the lower left of the screen. The  button toggles the display mode as shown below

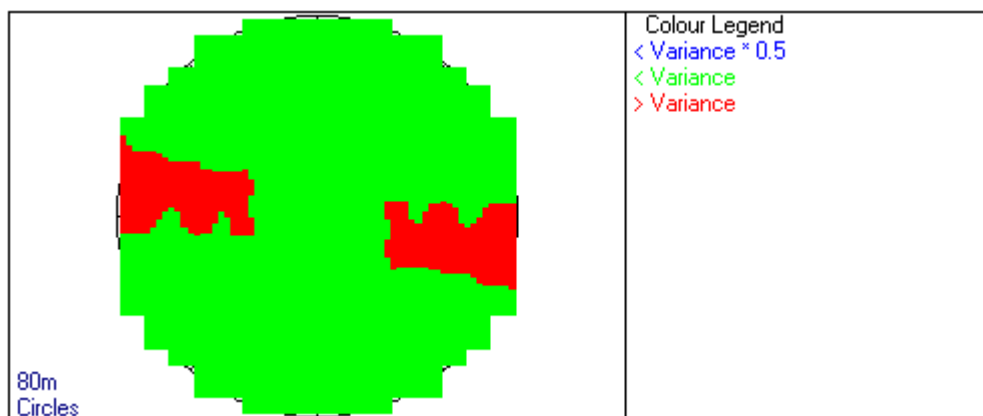


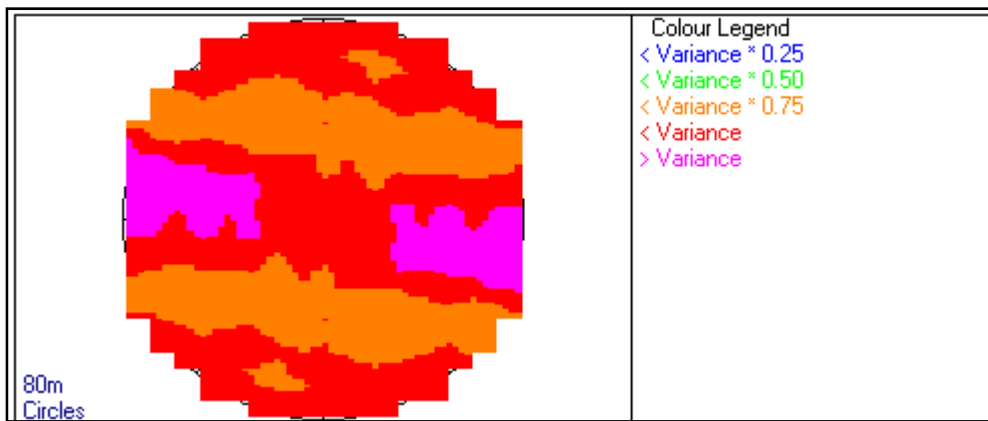


The left slider changes the contour density on the variogram fan as illustrated below.

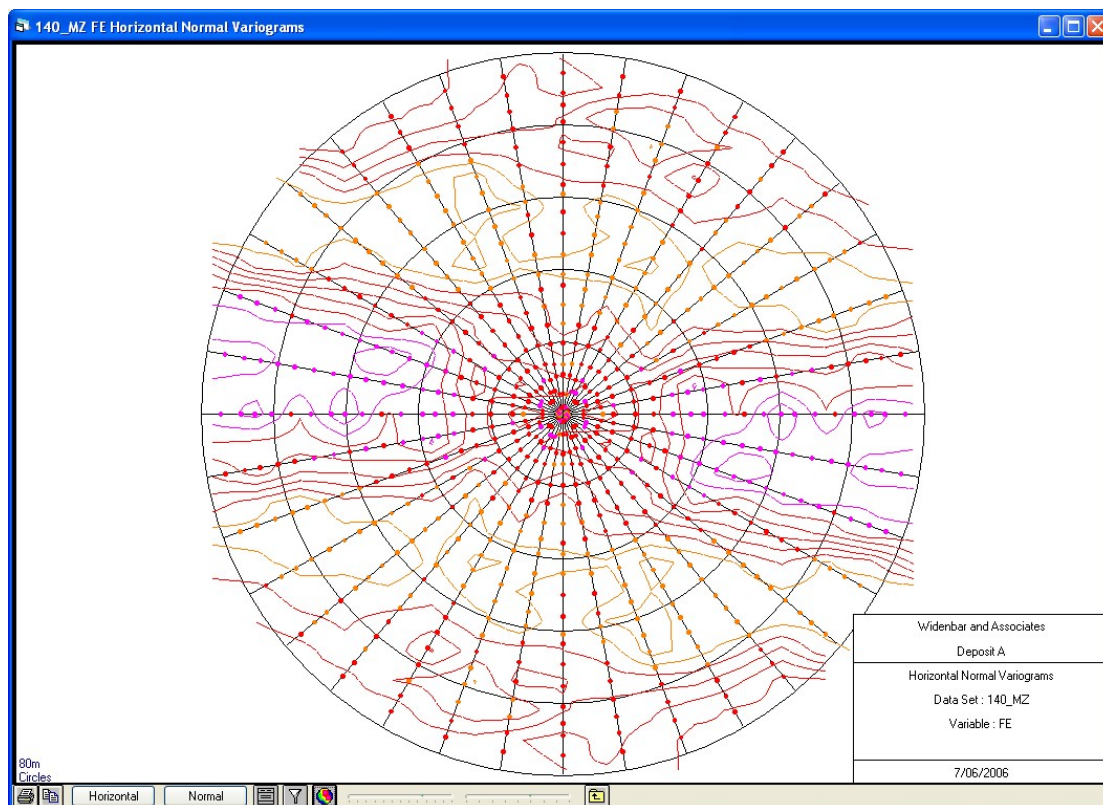



The right slider changes the contour colours:





Clicking on the variogram fan will expand the fan to fill the display screen, as shown

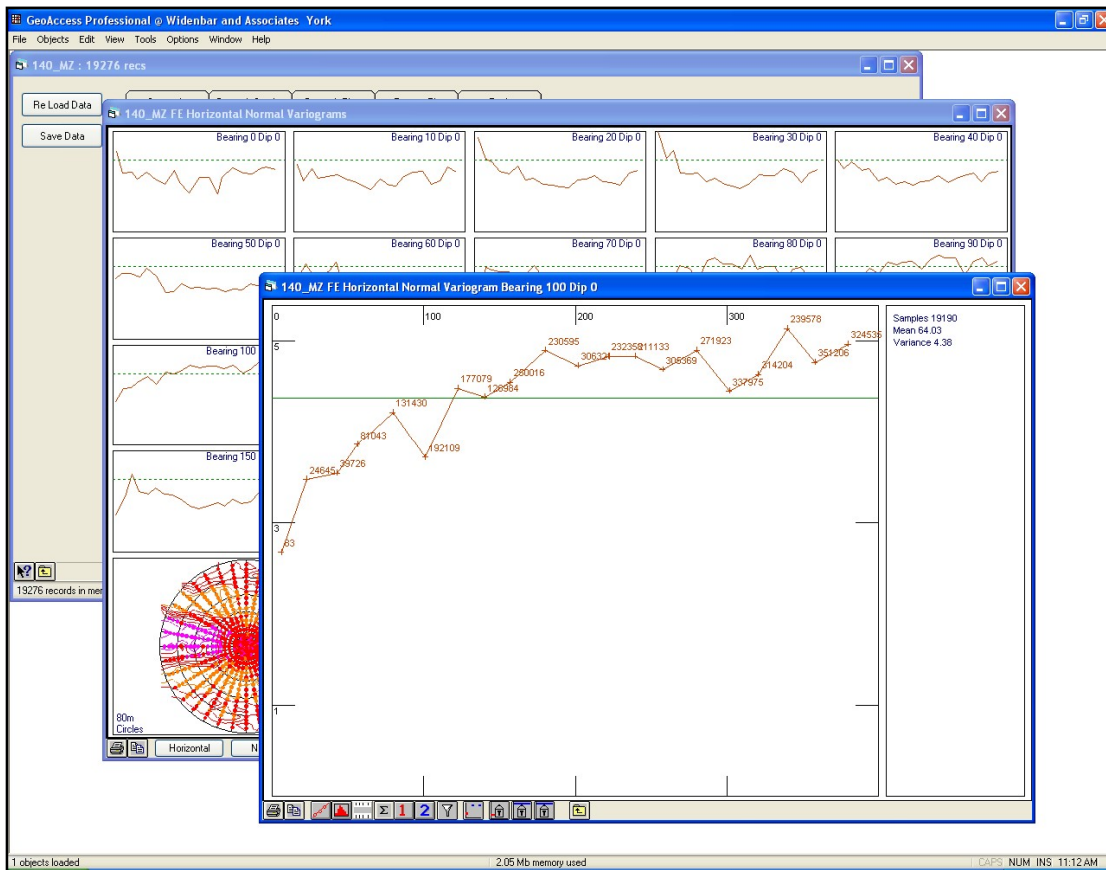


Use the  button to return to the complete display.

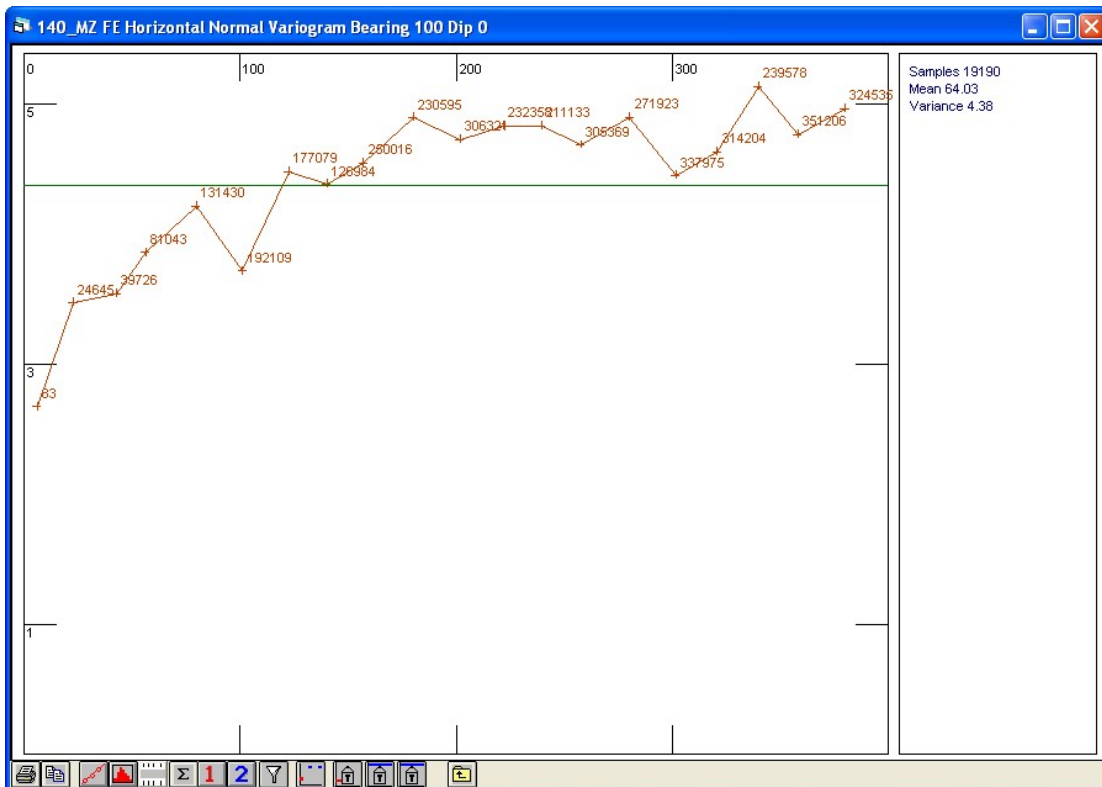
Variogram Display Options

There are two ways to open a new window with an individual variogram for display and/or modelling

Either click on the variogram in the main display, or click on the variogram direction line in the full fan display screen. Either method will open a new window, which will be overlaid over existing windows as shown below.



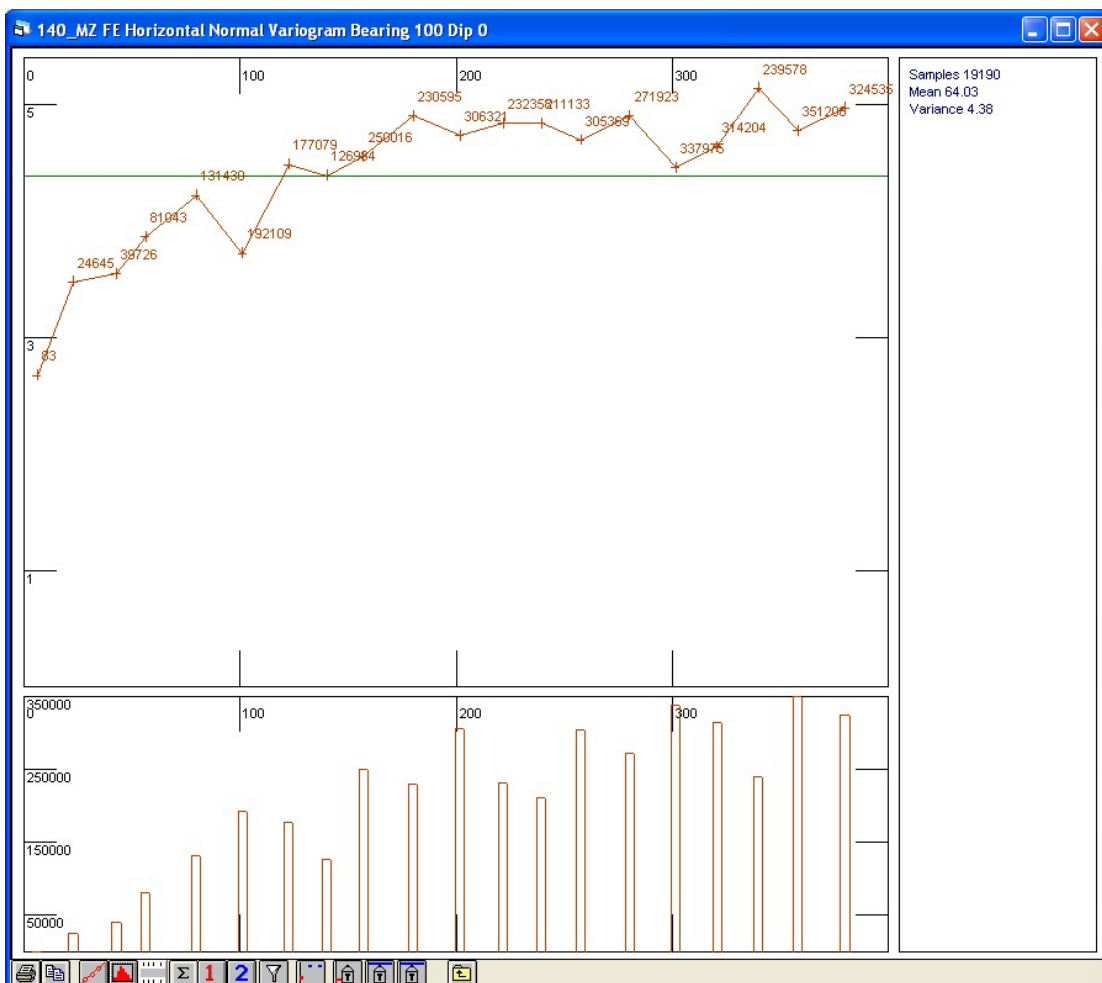
The default display shows the semi-variogram together with the number of pairs on each lag interval



This button toggles the display mode, for the purposes of clarity.



This option toggles a histogram display which graphically shows the number of sample pairs in each lag interval.





This option allows you to re-scale the x and y axes of the variogram plot.



This option toggles the display of the statistical data in the right screen pane.



This option allows you to filter out points on the variogram display with less than a specified number of data pairs.



This copies the graphics display to the clipboard in a format that can be pasted into an application such as Word for production of reports (using Paste|Special|Bitmap to do this). It also copies the variogram model parameters to the text portion of the clipboard so that it can be pasted (using Ctrl-V) into a spreadsheet.



This opens the printer dialog window to produce a hard copy of the graphics display.




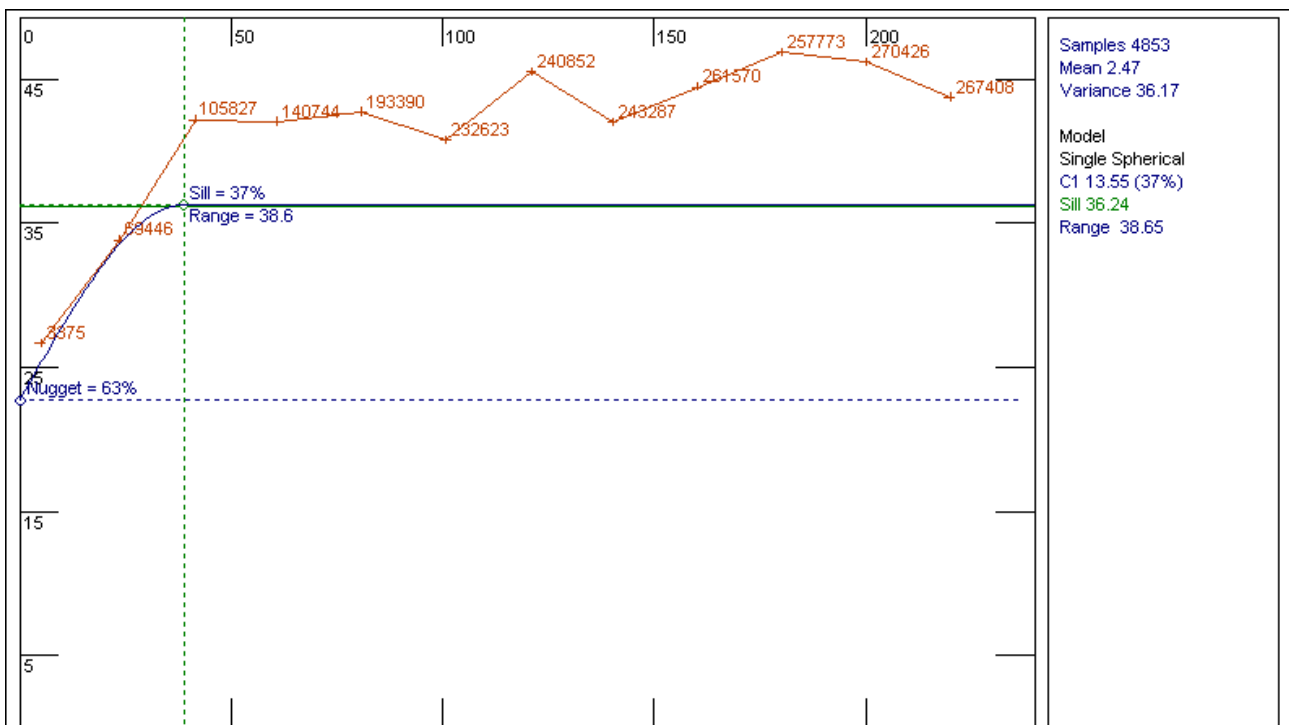
This closes the variogram window.

Variogram Modelling

Variogram modelling is controlled using the following options






This allows modelling of a single spherical scheme model. When selected the cross-hair cursor will change to a  when the left mouse button is held down. To change the nugget effect hold down the left mouse button while the cursor is at the left edge of the screen and move the cursor up and down. To change the sill/range move the mouse to near the sill and then hold down the left mouse button while moving the mouse. The variogram model line will be recalculated as the mouse is moved. Guide points are provided to help in the modelling.



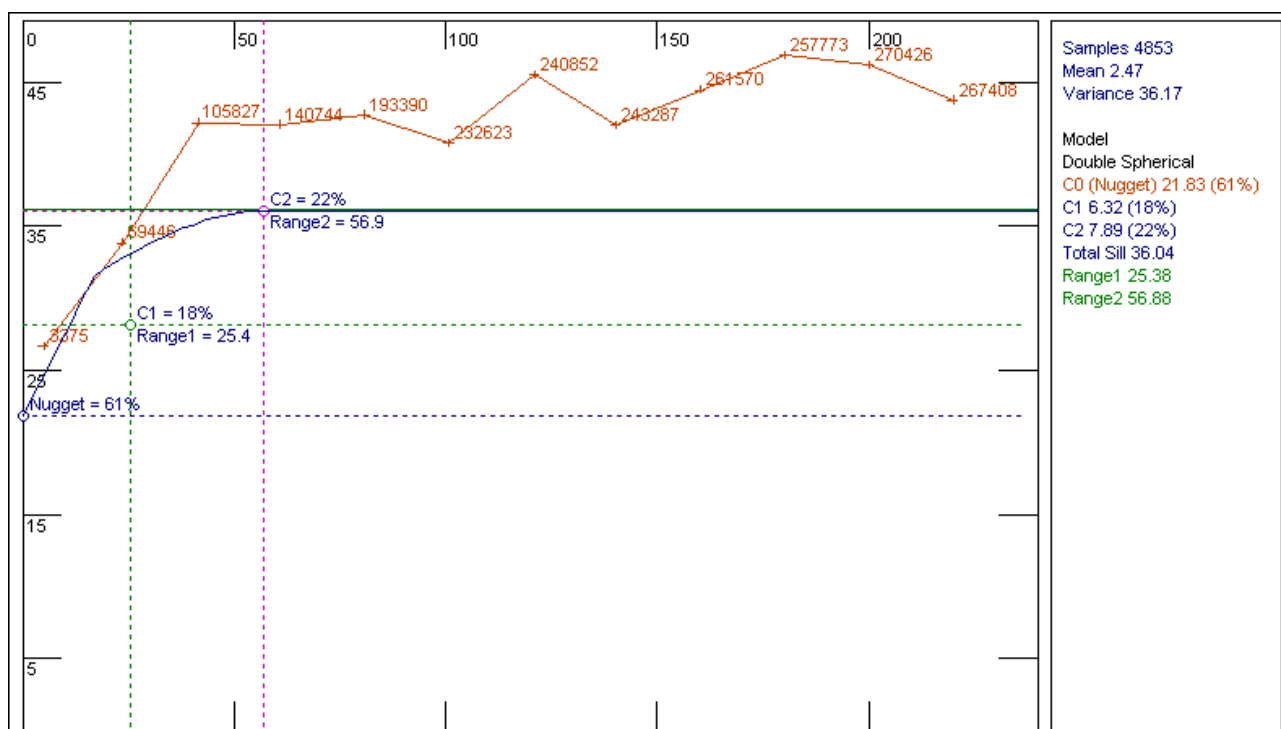
This option allows you to manually enter nugget, sill and range values. This can also be done by clicking on the Model data area in the right pane.







The    buttons allow various parameters of the model to be locked while others can be changed.

2 This allows modelling of a double spherical scheme model.

Guide points and guide lines are provided to help in controlling the model., as illustrated below.





 This option allows you to manually enter nugget, sill and range values. This can also be done by clicking on the Model data area in the right pane.

The    buttons allow various parameters of the model to be locked while others can be changed

Variogram Model Consolidation

To finalise the variogram models and use them as input to kriging, a set of three variograms needs to be defined. For most software packages these will need to have common nugget and variance values, but different ranges. You will usually have the three variograms (representing the Major, Semi-Major and Minor directions) on the screen together. GeoAccess now provides a mechanism to simply copy the model parameters from one window to another, which is particularly useful for double spherical scheme modelling, where the variance components need to be common to all variograms, but are difficult to model normally.

When a variogram is modelled use the Copy function  to place the parameters on the clipboard. Then in the target variogram window (with the model option enabled), use the paste function  to insert the parameters into the new variogram. At this point the variances are automatically locked, and the range(s) can be edited. To be able to change the variances if required, simply exit modelling and re-enter to enable full editing.

Variogram Save

On exiting the main variogram display screen you will be prompted to save the variogram.

Variograms can be recalled subsequently from the GeoAccess main menu using the File|Open|Variogram option. All modelled variograms are also saved and models can be viewed and edited after recall.