GY461 Applied GIS: Environmental GIS Programming Project

I. Introduction

Programming principles give the GIS analyst powerful tools to automate repetitive tasks. One example would be initialize a raster grid that is based on a mathematical equation. The example that we will use in this example will be a 3rd-order trend surface. The equation would have as independent variables a location in x,y coordinates with solution of the equation yielding a z elevation value that represents a best-fit trend surface through the actual x,y,z data. In this example the surface being modeled is the top of an Ordovician petroleum producing formation based on drilling data. The analysis that we are particularly interested in will be to subtract the trend surface from the z elevation of the data points to plot “residuals” - i.e. the wells that have the top of the Ordovician above the main trend. These would indicate “dome” structures that serve as petroleum traps (the overlying Silurian formation is an impermeable shale). The reason that we can’t simply look at the absolute elevation of the top of the Ordovician is that it dips along a regional trend. The trend surface in effect removes the regional dip so that we only have to deal with residuals above and below the regional trend. After determining the extend of the positive residuals you will be given some statistics on oil production from this unit so that you can estimate production from the field.

II. Step 1: Generate a Visual Basic Program in Excel to build the 3rd Order Trend Surface

Download the starting files from:

After extracting the files into a “TopOfOrdovician” folder under “C:\ArcGIS_Data\{Your Initials}\”, load the “TopOfOrdovician.xls” spreadsheet. In the sheet named “TopOfOrdo” you will find the raw data in x,y,z columns. Also in this sheet are the coefficients of a 3rd order trend surface polynomial in the form:

z(x,y) = c0 + x * c1 + y * c2 + x ^ 2 * c3 + x * y * c4 + y ^ 2 * c5 + x ^ 3 * c6 +
    x ^ 2 * y * c7 + x * y ^ 2 * c8 + y ^ 3 * c9

where x,y are the location coordinates, c1 through c9 are the coefficients given in the spreadsheet, and z(x,y) is the trend surface elevation as a function of x,y location coordinates.

Your instructor will go over programming principles related to building a Visual Basic program to calculate an ESRI ASCII raster file in the format:

```
ncols        {number of columns}
nrows        {number of rows}
xllcorner    {x coordinate of the lower left corner of the grid}
```

yllcorner {y coordinate of the lower left corner of the grid}
cellsize {spacing of grid nodes}
nodatavalue {value that represents missing data}
cell node (1,1) {z value at col=1, row=1}
cell node (2,1) {z value at col=2, row=1}
.
.
.
cell node (ncols,nrows) {zvalue at col=ncols, row=nrows}

Use the ctrl+{key} assignment used when the macro was created to run the program. The 2nd sheet named "ASCII_Grid" will contain the ESRI grid calculated by your program. Check the Z values to make sure they are reasonable. Save this file as an ASCII .TXT file to your folder.

III. Setup the ArcMap Project File

Start a new ArcMap project file and do the following:

1. Save the x,y,z data in the "TopOfOrdo" sheet to a DBF file. Use the "XY Data" plotting tool to add the well data to the project. Label each point with the Z elevation value of the top of the Ordovician.

2. Use the "ASCII to Raster" tool to add the calculated 3rd Order trend surface to the project. You should have a project similar in appearance to **Figure 1**.

3. Use the spatial analyst interpolate to raster "kriging" option to generate a best-fit surface raster through the raw data points. The setup will appear like **Figure 2**. The result should appear as in **Figure 3**.

4. Use the raster math "minus" option to subtract the trend surface grid from the kriging grid to produce a residuals grid. Pay attention to which grid is being subtracted - you should be subtracting the trend surface from the kriging grid to produce the residuals (see **Figure 4**). The result will appear similar to **Figure 5**.

5. Use the "re-classify" tool to re-classify the residuals into these classes:

Class	Value range
1	<=-600
2	-600 - -400
3	-400 - -200

4	-200 - 0
5	0 - 200
6	200 - 400
7	400 - 600
8	600 - 800
9	800 - 1000
10	1000 - 1200

See **Figure 6** for the reclassify tool window settings. Use the “Classify” button to manually define the class intervals as in **Figure 7**.

6. Use the conversion tool “Raster to Polygon” to convert the classified residuals into vector polygons. See the window setup for this tool in **Figure 8**. Use a symbology for the class polygons similar to **Figure 9**, then generate a map with the following:

a. North Arrow
b. Legend that includes the wells and class polygons. In the legend list the residual value range for each class (i.e. class 1 : <= -600; class 2 : -600 - -400, etc.)
c. Scale bar in miles. Note that the map units for x and y are inches measured from a 1:24,000 scale base map.
d. Title “Top of Ordovician Oil Production Project”
e. Place your name in the lower right corner in the layout

7. Create a geodatabase and add the class polygon shape topology to the geodatabase as a polygon feature. You are doing this so that you can access the area of each polygon. Answer the following questions

a. Create a new field in the polygon feature class named “acreage”. Using a calculation query fill this in with the acres represented by each polygon. Remember that the X,Y coordinates for the projects are simply inch units measured from a 1:24,000 scale topographic map. Note the following:

1 inch = 2000 feet = 0.3788 miles   (1:24,000 scale)
1 square mile = 640 acres

Sum the acreage of each polygon to calculate the total acreage of residual polygons that were positive (i.e. class 5 through 10). You will need to define a “definition query” for the feature to filter in just those polygons.

Total acreage of positive polygons = ___________________

b. Calculate the potential oil production of the field with the given:

1. Historically the Ordovician formation has produced 600 barrels of oil per acre of land per day. Currently the market price for crude oil is $85 per barrel.

How much money will the field make in a year assuming the above values? ________________________________

Historically fields developed in this Ordovician formation have produced at a constant annual rate for a decade. How many barrels of oil (reserves) are in this formation before production begins: ______________________

GY461 Applied GIS: Environmental GIS Programming Project

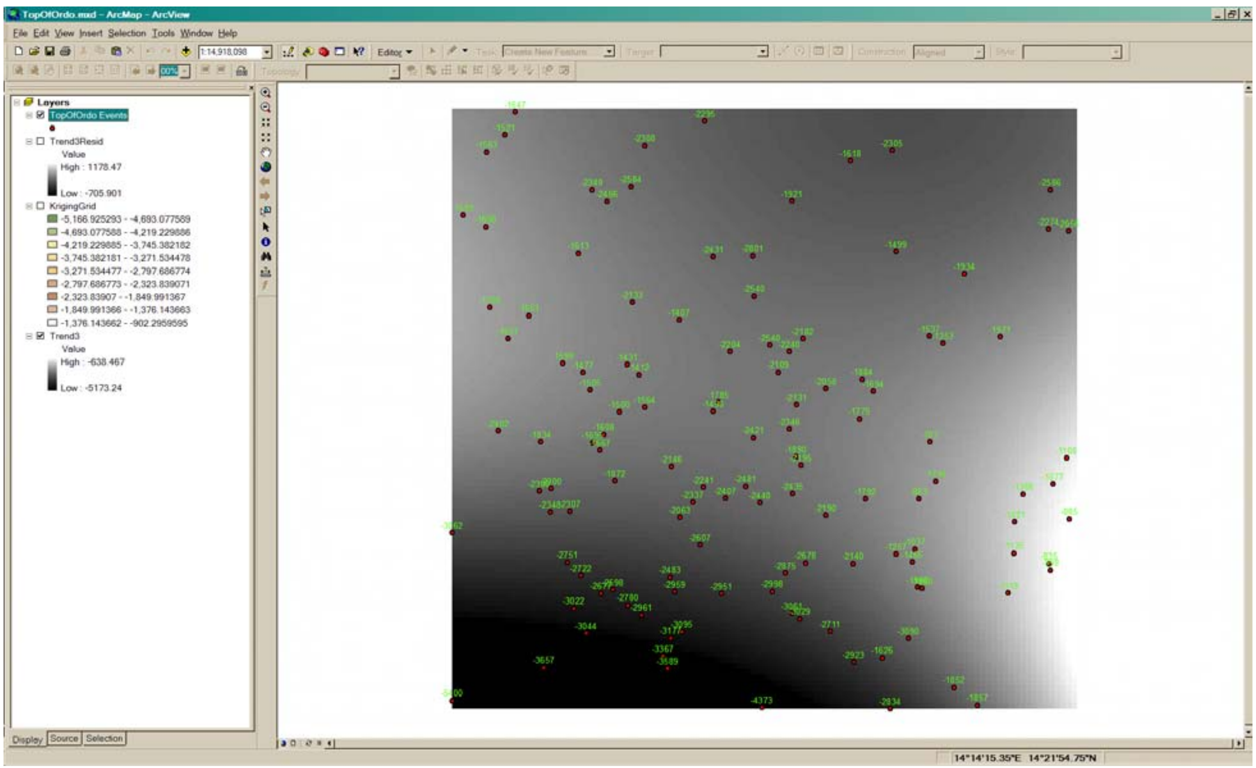

Figure 1: Results from importing the calculated 3rd order trend surface and the original well data points.

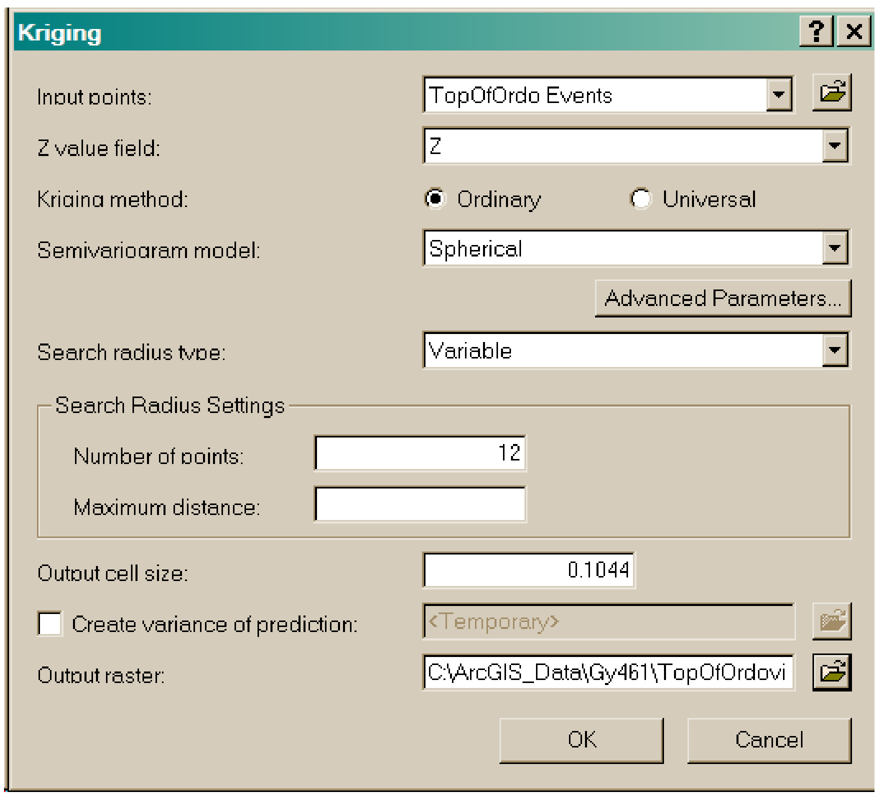

Figure 2: Setup of kriging option for well data.

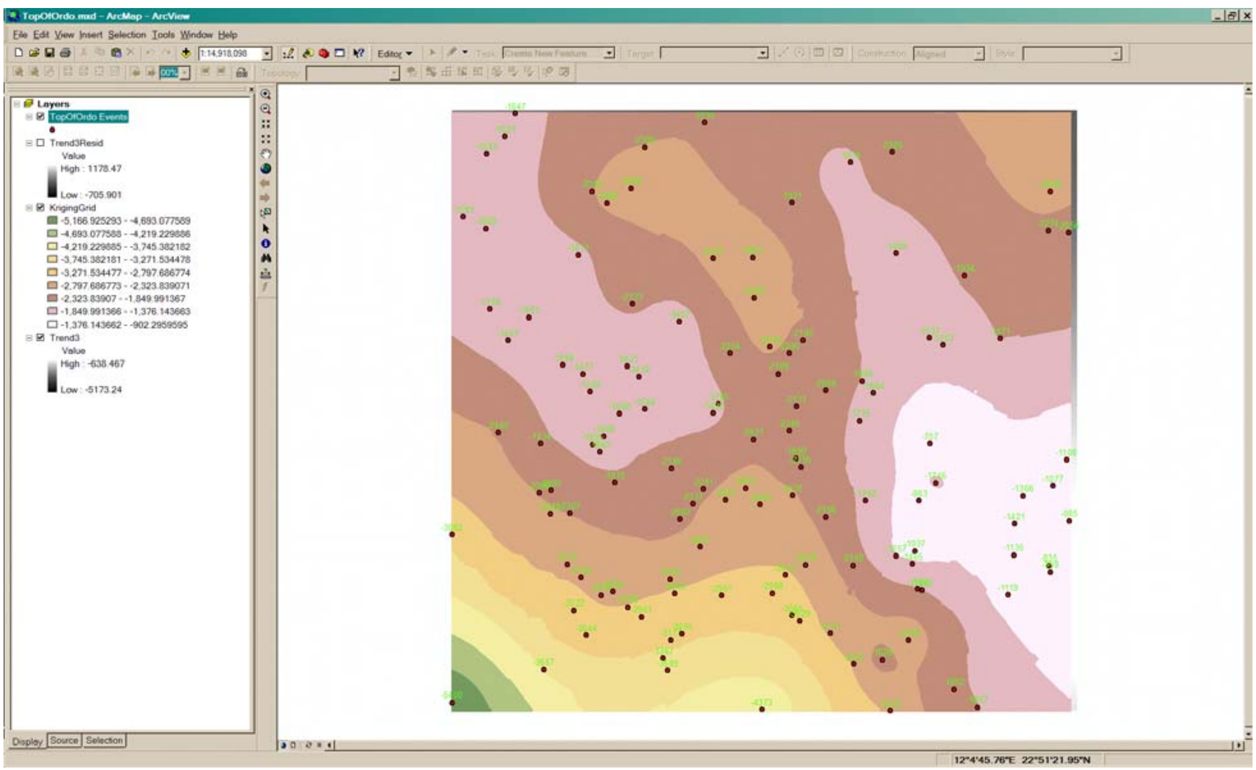

Figure 3: Results of importing kriging raster of well data.

GY461 Applied GIS: Environmental GIS Programming Project

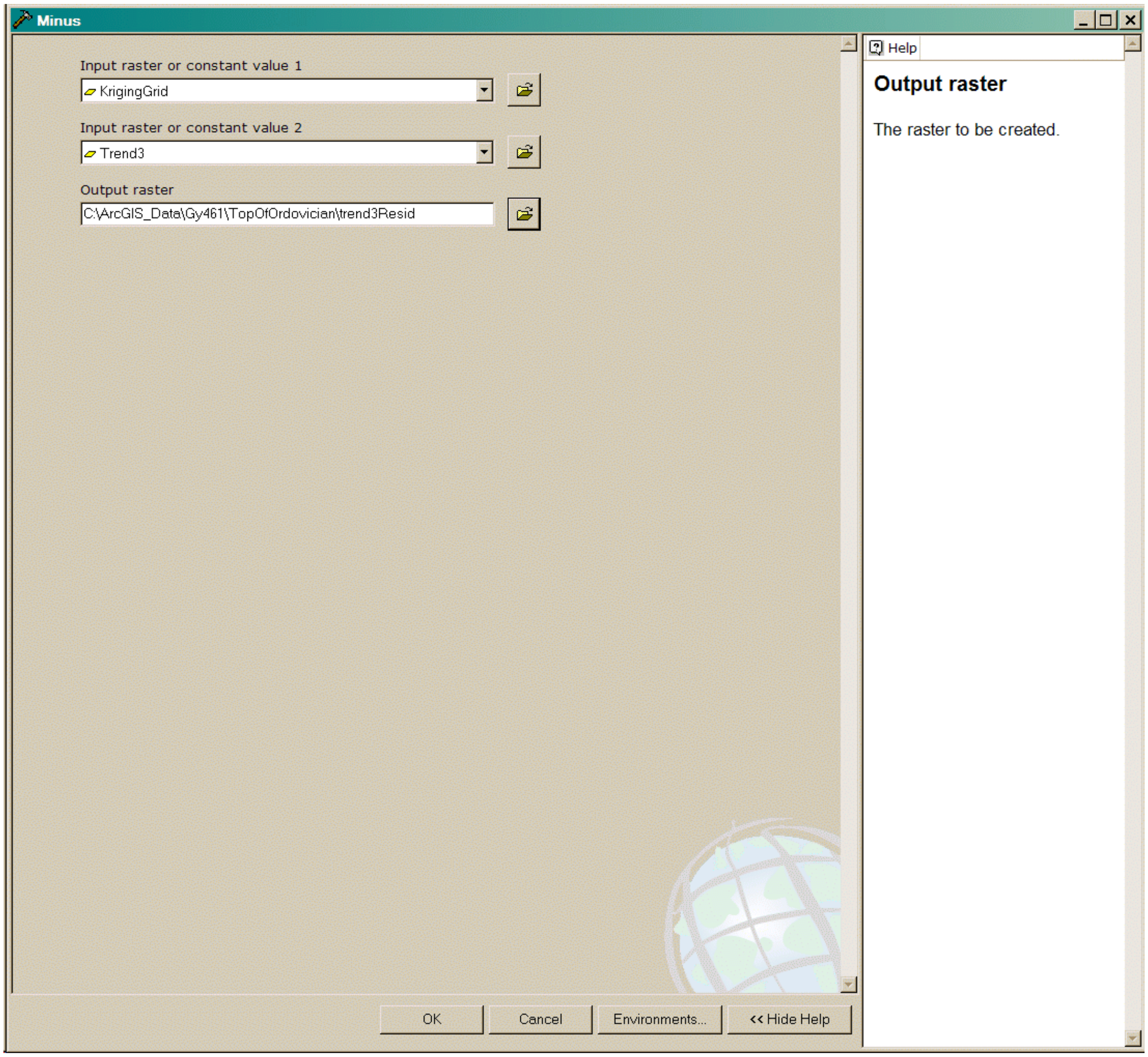

Figure 4: Creation of residuals grid from raster math "minus" function.

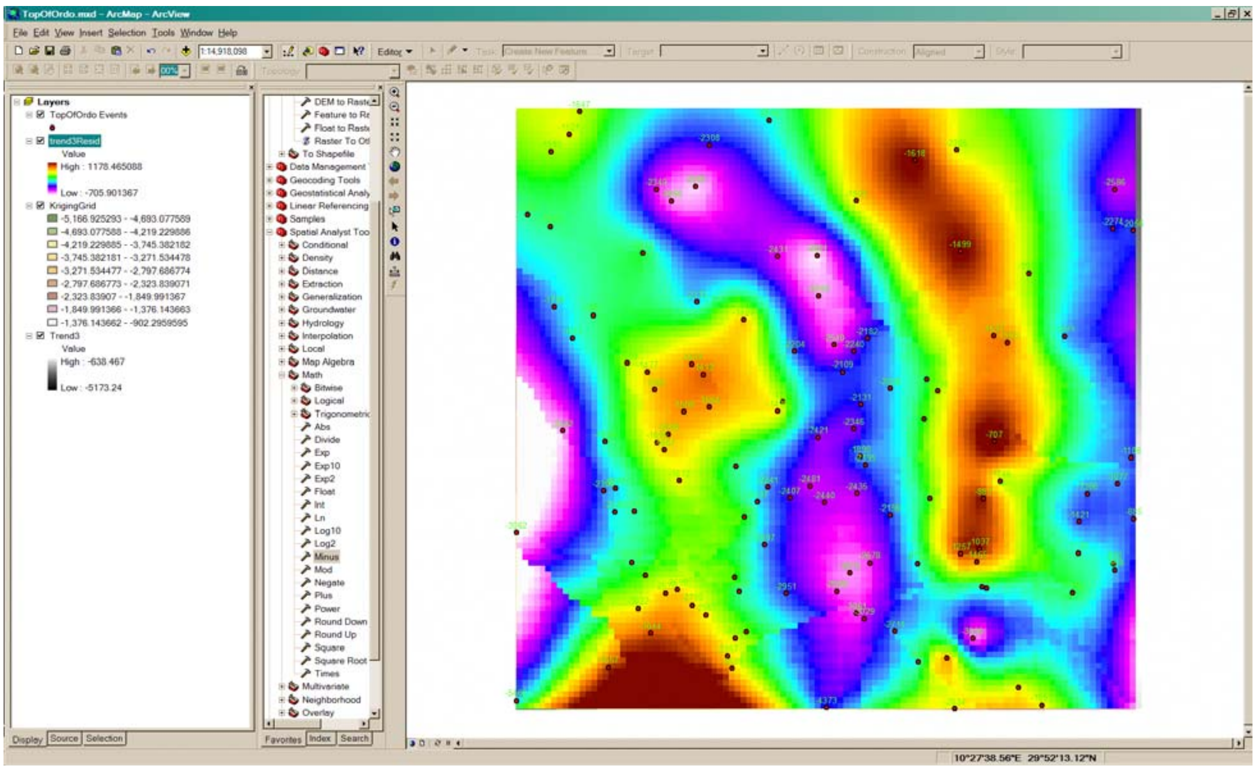

Figure 5: Appearance of residuals raster grid.

GY461 Applied GIS: Environmental
GIS Programming Project

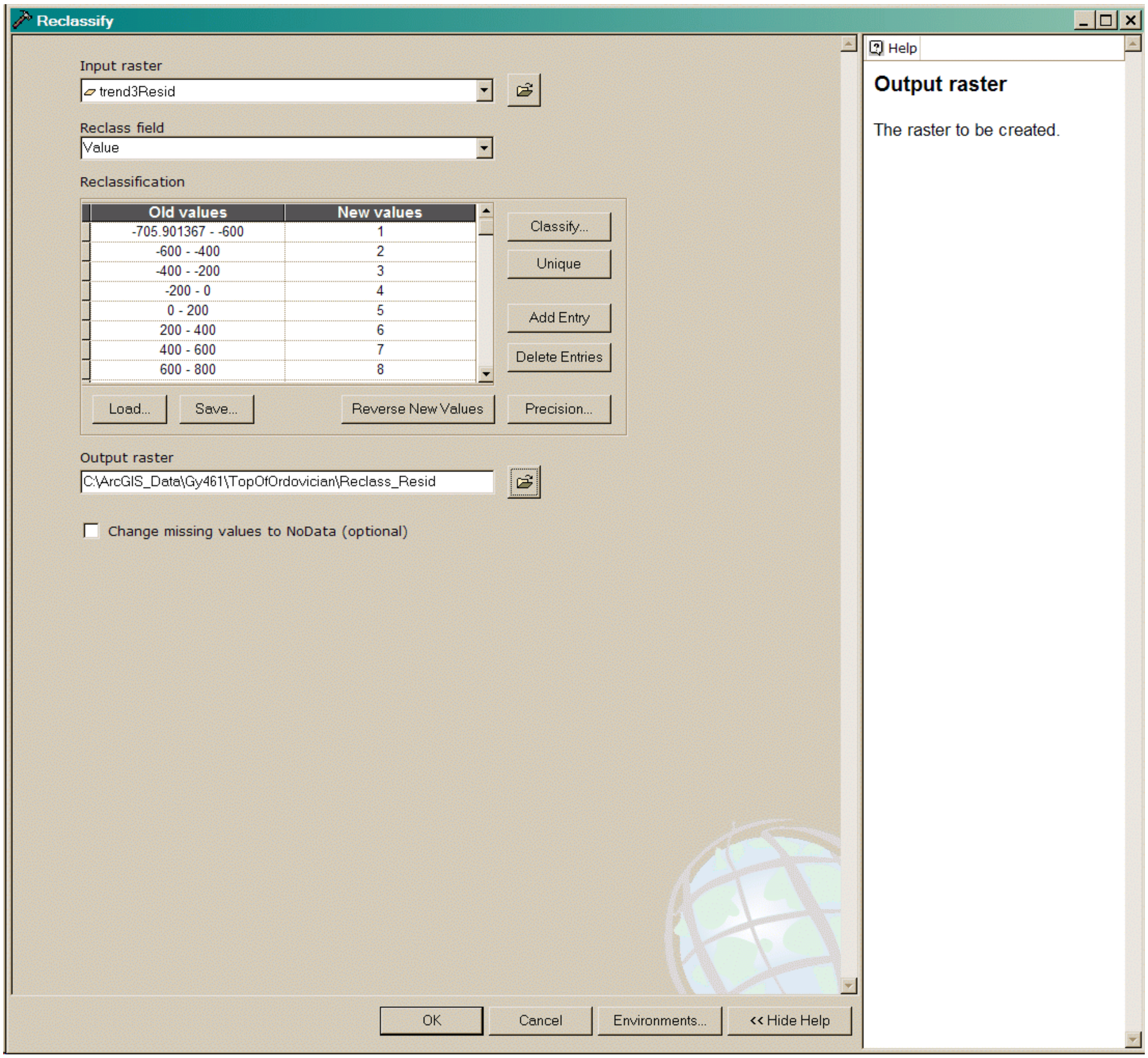

Figure 6: Reclassify tool window setup.

GY461 Applied GIS: Environmental GIS Programming Project

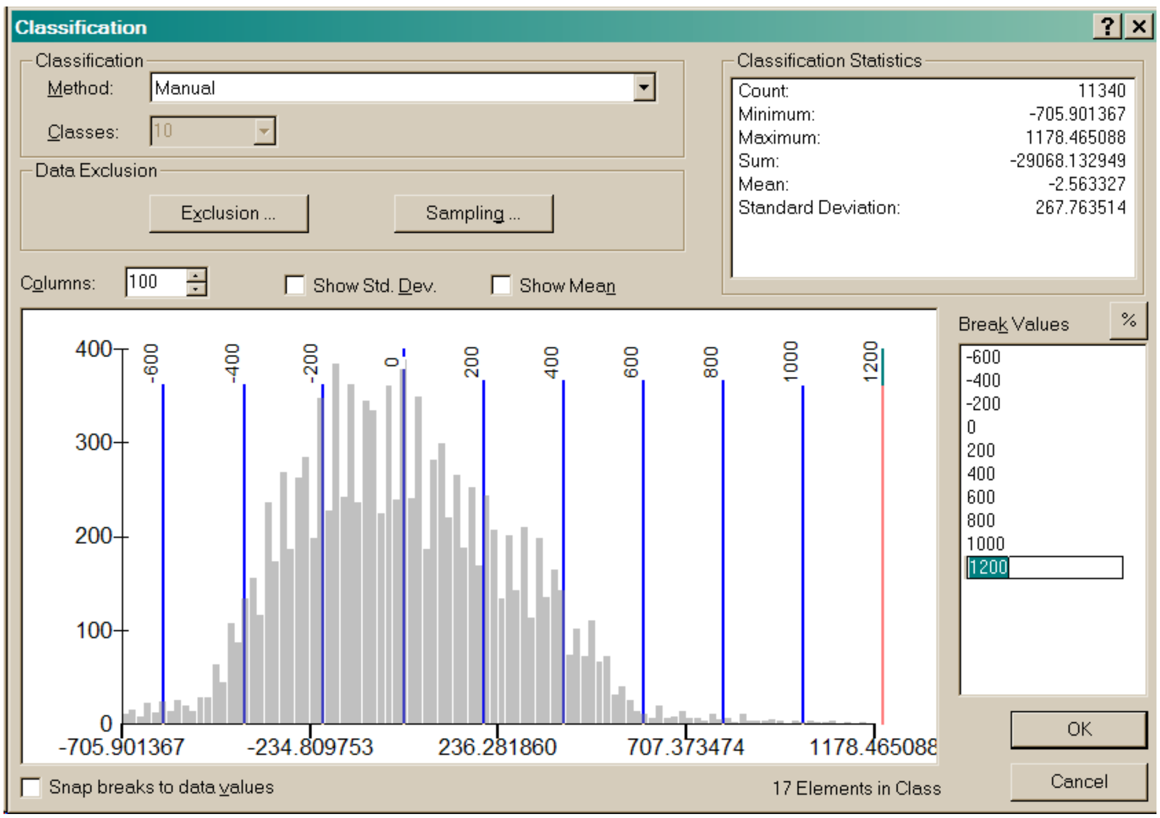

Figure 7: Defining the class intervals for the reclassify tool.

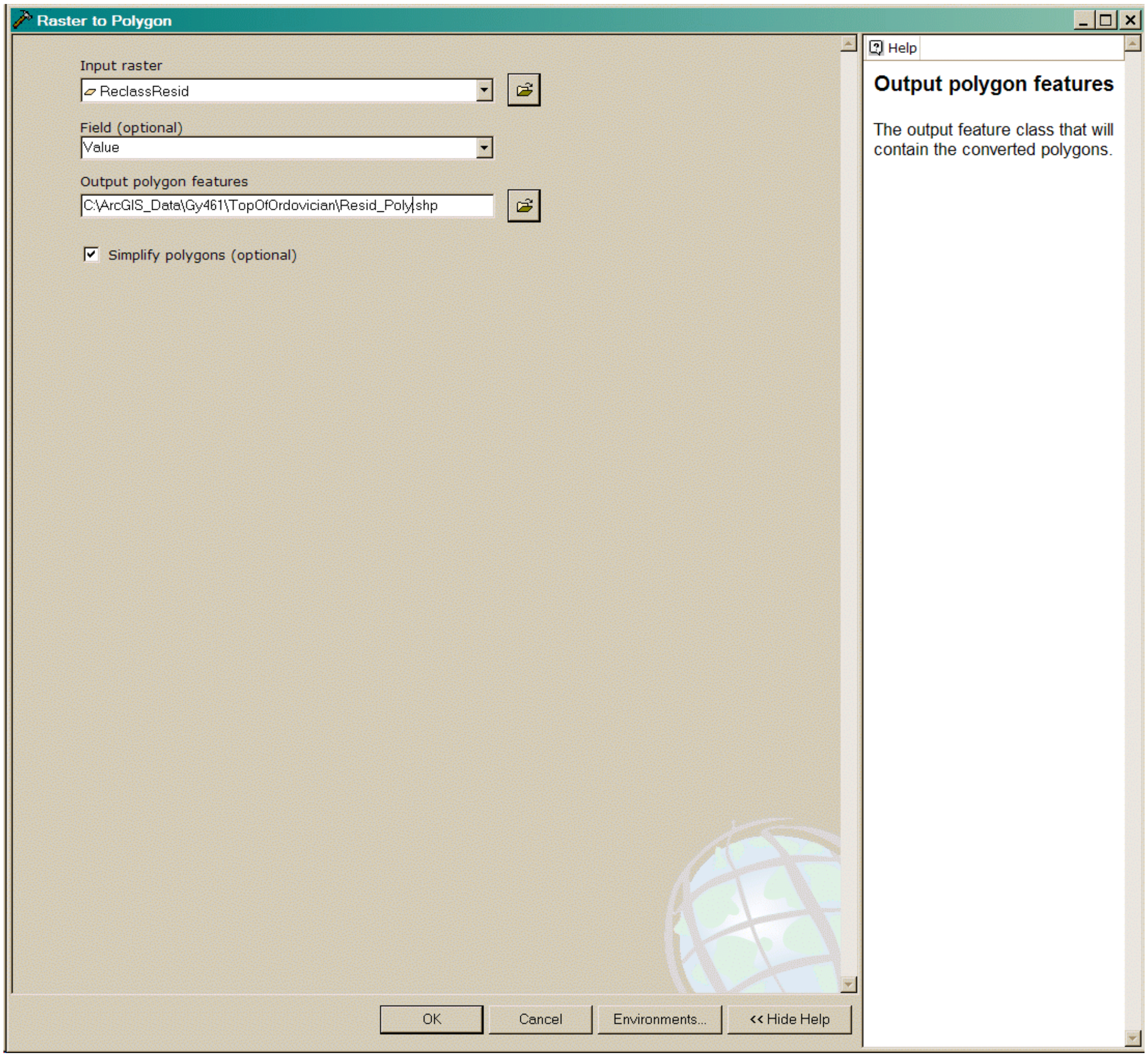

Figure 8: Window settings for the "raster to polygon" conversion tool.

GY461 Applied GIS: Environmental GIS Programming Project

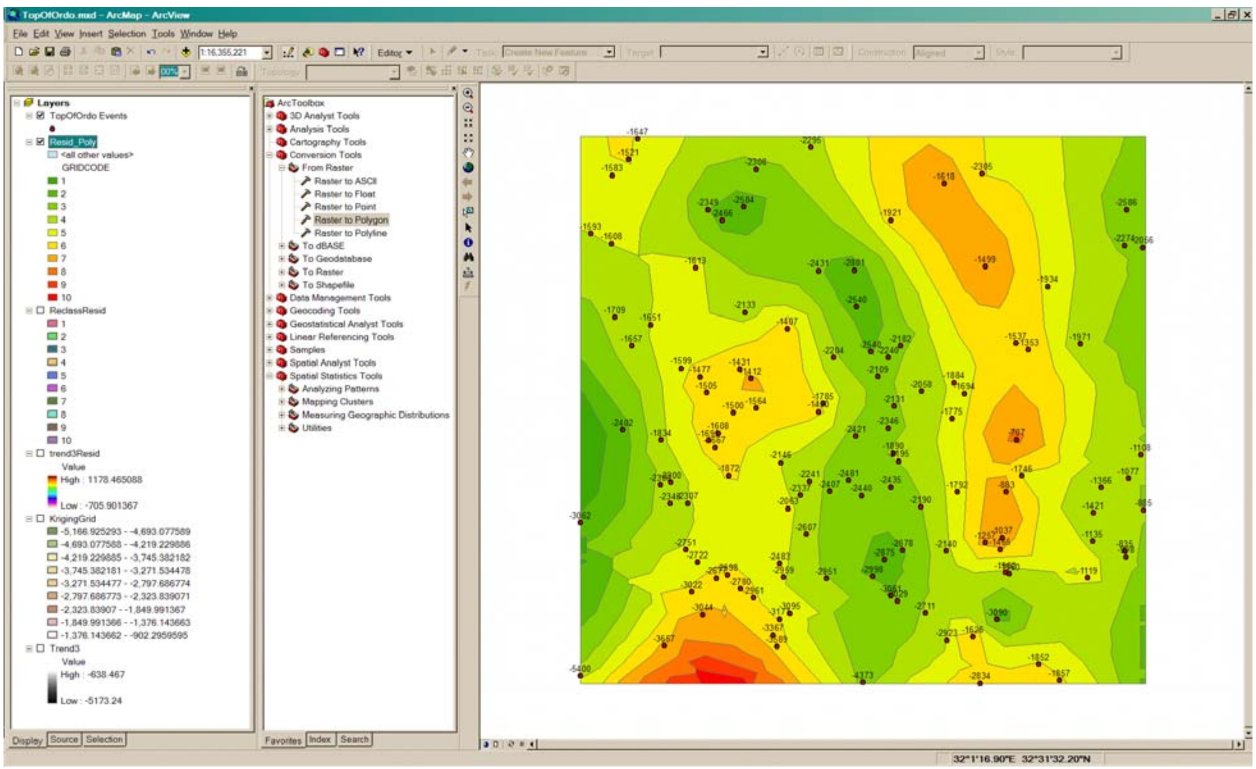

Figure 9: Map of residuals polygons- values 5 through 10 are positive.