Lab 5 – Interpolation

Exercise 1: Explore Different Interpolation Methods
In this exercise, you will use a sample point layer that represents elevation points at specific locations on and around the Shivwits Plateau in Arizona. You will then use several interpolation methods available in ArcGIS Spatial Analyst to create terrain surfaces from the sample point layer and compare the results.

Step 1: Load in points.csv, set environments, and investigate data
Display XY Data. XY coordinates are measured in projected coordinate system NAD 1927 UTM Zone 12N. From the Geoprocessing menu set the Environments. Under the workspace option set the scratch to your data folder. Set the processing extent to same as layer points.csv Events. Set the raster analysis cell size to 30. In the Table of Contents, right-click the points layer and choose Open Attribute Table. The ELEV field contains an elevation value (z value) for each record. In this case, the elevation values are in meters.

Step 2: Use Natural Neighbor to interpolate a surface
From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then double-click Natural Neighbor. For your Input point features, select points. For the z value make sure to select ELEV. Change the name of your output raster to Neighbor, then click OK.

Step 3: Use Inverse Distance Weighted (IDW) to interpolate a surface
From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then double-click IDW. For your Input point features, select points. For the z value make sure to select ELEV. Change the name of your output raster to IDW, then click OK.

Step 4: Use Spline to interpolate a surface
From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then double-click Spline. For your Input point features, select points. For the z value make sure to select ELEV. Change the name of your output raster to Spline. In the Spline dialog, click in the Weight box, change the weight value to 2 and click OK.

Step 5: Use Kriging to interpolate a surface
From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then double-click Kriging. For your Input point features, select points. For the z value make sure to select ELEV. For Kriging method, choose Universal. Change the name of your output raster to UnivKriging and click OK.

Step 6: Compare the elevation ranges in the interpolated surfaces
At this point, you should have four group layers named Neighbor, IDW, Spline, and Krige. Expand the interpolated elevation layers within each group and notice that each interpolation method resulted in a different range of elevation values assigned to each elevation category. To visually compare the groups, toggle between the layers by turning them on and off. You may not see much difference between the layers. Based on the information you have so far, it is difficult to tell whether one interpolation method is better than the other. Although Kriging provides the most complex analysis, this doesn’t mean that it is the best method for your project. The
interpolation method you choose at any given time is mainly a matter of preference and depends mostly on your familiarity with the data. The purpose of this exercise was to introduce you to basic interpolation methods. You will explore them in more detail in the exercises that follow.

Key points
- Using default parameters, all the interpolation methods basically create similar surfaces. The differences between them are in the details.
- Your choice of an interpolation method is influenced by your knowledge of the surface you are modeling. You can use your knowledge of reality (or maybe the high-resolution aerial photos you have of it) to check how well the interpolators are doing.
- Your understanding of the methodology also influences your choice of method. Kriging is much more sophisticated than IDW (and, as a rule, creates more accurate surfaces), but IDW is conceptually easier to understand.

Exercise 2: Model elevation and snow depth
In this exercise, you will choose an interpolation method and to determine the relationship between quantitative variable elevation and snow depth. You have two point files that sampled snow depth and elevation at different places within the study area, so you will have to interpolate elevation at the samples where there are known snow depths throughout the Homewood quadrangle, which includes a portion of southwest Lake Tahoe, California.

Step 1: Load Elevation.csv, load SnowDepth.csv, set environments, and investigate data
Display XY Data. XY coordinates are measured in projected coordinate system NAD 1927 UTM Zone 10N. From the Geoprocessing menu set the Environments. Under the workspace option set the scratch to your data folder. Set the processing extent to same as layer SnowDepth.csv Events. Set the raster analysis cell size to 30.

Step 2: Create the mask
A portion of Lake Tahoe occupies the northeast corner of the quadrangle. You will create a mask to exclude Lake Tahoe from the analysis. Load in the landcover.tif raster. Open the attributes table and note the landcover code for water. Use raster calculator and the SetNull function to create a mask. If you need a reminder, see Exercise 6 from Lab 4. Name the output raster “mask”. Go to the Environments in the Geoprocessing menu. Under raster analysis select mask as your mask. Only the area where the analysis extent and the mask coincide will be included in the analysis.

Step 3: Create an elevation surface using two interpolation methods
Choose two interpolation methods you want to compare. Interpolate the points for elevation to create a surface of elevations. Now load in the HomewoodDEM.tif raster.

Step 4: Extract the interpolated and DEM values to the Snow Depth points
You will need to first save the Snow Depth points to a shape file by exporting data. Use Extraction in the Spatial Analyst Tools. Select Extract Multi Values to Points. The input point feature is the shape file you just created. The input rasters are the two interpolated surfaces and the HomewoodDEM. Select OK.
**Step 5: Geographically Weighted Regression with Spatial Statistics Tools**
To look at the relationship between interpolated layers, digital elevation model layers and snow depth, we will use the geographically weighted regression tool. Select the Spatial Statistics Tools in ArcToolbox. Expand the Modeling Spatial Relationships menu and select the Geographically Weighted Regression tool. For the input feature, select the snow depth shape file. First we will look at the relationship between the two interpolated elevations. It doesn’t matter which one you choose for the dependent or the independent variable, just put one in each and select OK. Your results are saved in a table in the table of contents, GeographicallyWeightedRegression_supp. Right click on that table and open to view results. The important statistic here is the $R^2$ (amount of explained variation), which ranges between 0 and 1. If it is 0, then there is no relationship between the two variables. If it is 1, then there is a perfect relationship between the variables (100% explained variation). $R^2$ should be 1 or near 1 for this analysis. Now look at the relationship between one of the interpolated elevations (dependent variable) and the DEM (independent variable). Notice that there is a value near zero. There appears to be little relationship between the interpolated elevations and the DEM. Finally, look at the relationship between snow depth (dependent variable) and the DEM (independent variable).

**Key points**
- When you have data for points at two different locations, you can interpolate one or both set of points to model data across your sampling sites.
- Be careful with the interpolation method you use and verify interpolation if data are available.
- Geographically weighted regression will allow you to determine the relationship between response (dependent) and predictor (independent) variables.

**Exercise 3: Model subsurface limestone formation near earthquake faults**
Folded rock structures, known as anticlines, form a subterranean architecture similar in shape to the barrel vaults of cathedrals. Given the right conditions, these structures can contain oil, gas, water, or a mixture of each. Geologists study rock deformations to determine the shape and size of oil and gas pockets that may be lying just beneath them. In this exercise, you are provided with a sample point layer that represents drill holes used to penetrate the top of a subsurface limestone formation. In this case, exploratory drilling has indicated the presence of oil, and the depths of the drill holes will be used to model the bending of the limestone surface. In order to visualize what is going on underground, you will use the Inverse Distance Weighted (IDW) interpolation method to create a surface from the sample point layer; first, without using the barrier option, then using the barrier option.

**Step 1: Load data**
Add three shapefiles to ArcMap (LisbonValley, DrillHoles, and Fault). You will notice a number of drill holes, as well as two fault lines cutting through a portion of the anticline. These faults are normal faults, meaning that the section of limestone between the fault lines is moving downward. Set the analysis environment with processing extent same as LisbonValley and raster analysis cell size as 50.

**Step 2: Create a surface of the limestone formation using the IDW interpolation method**
From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then
double-click IDW. For your input point features, choose Drill hole. Click the Z value field dropdown arrow and click ELEVTOPM. The ELEVTOPM field contains drill hole depth measurements in meters. Because the measurements represent depth (from the top of the drill hole to the top of a subterranean limestone formation), the numbers are negative. In the Power text box, set the power to 3. Click OK.

**Step 3: Create a hillshade of the limestone formation**
In this step, you will visualize the top surface of the limestone formation by creating a hillshade relief of the IDW surface. The hillshade will further emphasize the bending of the limestone formation over the oil pocket. You will notice that there are several sinks and rises in the surface. The bending of the limestone formation helps define the shape of the oil pocket. Use the Hillshade tool or raster calculator to make the hillshade.

**Step 4: Create another surface of the limestone formation using IDW with a barrier**
In this step, you will create another surface representing the limestone formation, but this time you will include two parallel fault lines in the analysis. Deep depressions in the previous surface indicate that the block of limestone between the fault lines is probably lower than the rest of the surface. The fault lines will serve as barriers that restrict calculations used by IDW. When the fault lines are used as barriers, they restrict the IDW function from using the depth values from drill holes on the other side of the fault. In a sense, they compartmentalize the IDW process. As a result, three compartments are created: the anticline compartment, the block between the fault lines, and the third compartment with only two sample points. From the Spatial Analyst Tools menu in ArcToolbox, expand the Interpolation menu, then double-click IDW. For your input point features, choose Drill hole. Click the Z value field dropdown arrow and click ELEVTOPM. In the Power text box, replace the existing number with 3. Select the Fault layer for your input barrier polyline features. Click OK.

**Step 5: Create a hillshade of the limestone formation with faults**
In order to visualize how the limestone formation and the anticline are affected by the parallel faults, you can create a hillshade relief of the IDW with barriers surface. The fault area has cut through a portion of the anticline. As the limestone between the fault lines slipped down, oil may have been forced from the fault area, helping deform the limestone formation further.

**Key points**
- You may be able to improve the accuracy of an IDW surface by using line layers as barriers.
- Barriers can represent abrupt changes (e.g., faults, cliffs, rivers, etc.).

**Assignment Questions**
1. Explain the differences you see in the visual comparison between the four interpolation results in Exercise 1.
2. From Exercise 2, what is the amount of explained variance ($R^2$) between snow depth and a) the DEM, b) one interpolation method you chose, and c) the other interpolation method you chose. Be sure to tell me which interpolation methods you used for b and c.
3. When should you use barriers in an interpolation analysis? How does the analysis work with barriers?