Lab Assignment 7 – 3D Visualization and Analysis

Due Date: 10/30/2020

Overview

3-D visualization can be a very important method of presenting data in ways that 2-D methods cannot. Draping and Extrusion are two techniques that are mostly often used to display data in 3 dimensions to create realistic visual effect. The power of 3-D is not limited to visualization. It can help perform many useful analyses as well. In ArcGIS, there are multiple environments for 3-D visualization and analysis: ArcScene, ArcGlobe, and ArcGIS Pro.

In this lab assignment, we will focus on ArcScene and ArcGlobe. Next week, we will learn more about 3D visualization in ArcGIS Pro.

Part I – Extrusion

Extrusion is a process of projecting features in a two-dimensional data source into a three-dimensional representation. Points can be extruded into vertical lines, polylines into vertical walls, and polygons into 3-D solids/blocks.

Start ArcScene and then add the layer – "PG_CensusTracts.shp".

Review lecture for how to do the extrusion process.

You need to use appropriate Symbology. Change the display method to Graduated Color.

You will use the field – "POP90_SQMI" (population density in 1990) as the display value.

To do the "Extrusion", you can type a constant number in the expression box. However, extrusion based on constant value usually is not useful. The most common extrusion is based on a variable, i.e. an attribute from the table associated with the data layer.

Try "[POP90_SQMI]/100000".

Why do we need to divide the value by 100,000? This is because the values of population density are very high compared to the map unit. In this case, the map unit is decimal degree. So, if you want to display the extruded blocks directly based on population density value, those blocks will be extremely "thick". In addition, the differences among blocks will be too dramatic.

By dividing the population density value by a factor (100,000 in this specific case), we can "even out" the differences among blocks and make the 3-D view less dramatic for better visualization.

[1] Make a screen shot of ArcScene displaying the 3-D map and include in report.

Your next task is to create a 3-D view based on “POP2000”. You need to decide an appropriate extrusion value.

[2] Make a screen shot of ArcScene displaying the 3-D map and include in report.

Now, open a new ArcScene window. Add the data layer – “PG_CensusTracts_Projected.shp”.

You can use the population density again to display it in 3-D.

This time, it is possible to use the population density value directly as the extrusion variable. You don’t have to divide the value with a factor because the population density values are appropriate compared to the map unit scale in this specific case. Of course, you can use a small factor if you want to “fine tune” the visual effect.

[3] Make a screen shot of ArcScene displaying the 3-D map and include in report.

Note:

- The lesson learned here is that the coordinate system of the input dataset will affect how you define the extrusion factor.

Part II – Draping

Draping is the most common 3-D effect for displaying landscape surfaces. It is a perspective or panoramic rendering of a two-dimensional image superimposed onto a three-dimensional surface. Any 2-D features can be displayed by draping over a 3-D surface.

Start a new window of ArcScene.

Add the data layers – “Ithaca_DEM”, “City_Trees”, and “Observation_Point”.

Because “Ithaca_DEM” is a surface itself, you can display it in 3-D directly.

Open the Layer Properties dialog of this dataset.

Click on Base Heights tab and then define the floating surface as the DEM.

The surface is displayed as a 3-D map now. However, because the range of elevation values is not large enough, the 3-D effect is not obvious. For better visual effect, we can exaggerate the variation of elevations. This will make the hills and valleys more dramatic.

Right-click on Scene Layers and open the **Scene Properties** dialog and set the Vertical Exaggeration as 5.

Now, you will see the terrain is more visually recognizable.
You might want to change the Color Ramp so that it has better contrast and also intuitive.

[4] Make a screen shot of ArcScene displaying the 3-D map and include in report.

Now, if you look at the data layer – "City_Trees", it is still displayed as a 2-D map under the 3-D terrain. And you can display this data layer in 3-D by "drape" it on the top of the 3-D terrain. You will need to figure out how to do it.

Modify the symbology of the data layer to make it easy to distinguish on the surface.

[5] Make a screen shot of ArcScene and include it in your report.

Part III – Extrusion + Draping

It is always helpful when you combine Extrusion and Draping in 3-D visualization as this will enhance the 3-D visual effect.

Continue from previous section.

Open the Layer Properties dialog of "City_Trees".

Click on Extrusion tab and then define extrusion value as "MAX_PDOP". Ideally, you should use the actual heights of tress if such information is available in the attribute table. However, we don't have this information. So, we can use the diameters of those trees to represent their heights (assuming these two values are correlated.)

You can be creative when displaying the result by selecting appropriate color and symbols.

The goal is to make the visualization realistic and intuitive.

[6] Make a screen shot of ArcScene and include it in your report.

Part IV – Viewshed Analysis

We have practiced Viewshed Analysis in the previous lab assignment. It was done within ArcMap. So, the result (a binary surface) was displayed as a 2-D map. The same analysis can be performed within ArcScene. However, the result can now be displayed in 3-D environment. You can rotate the map and compare to the terrain surface to get a better understanding about Viewshed Analysis.

First, you can drape the data layer – "Observation_Point" on the terrain.

Now, turn on 3-D Analyst extension. Make sure you also turn it on from Tools → Extensions.

Go to 3-D Analyst → Visibility → Viewshed …

The resulted viewshed is a binary grid. Modify the symbology for better color contrast.

Now, drape this new grid on top of the terrain. Turn off the DEM layer.

Note:

- Sometime the viewshed grid might be visually "interrupted" by the DEM surface. That's because these two surfaces have the same base heights and thus overlap with each other.

[7] Make a screen shot of ArcScene and include it in your report.

You can rotate this 3-D surface in various angles and perspectives so that you can see how the visibility of the target point is affected because of the terrain. This will help you get a better understanding how this viewshed was calculated.

Optional:

- If you have time and interest, you might want to add a few more observation points and conduct a viewshed analysis.
- Also, you might want to try to create an animation based on the viewshed analysis result.

Now, assume the height of the observation point is 30 meters, you will use the Visibility tool to create a new surface. (Hint: You may need to edit the attribute table.)

Modify the symbology for better color contrast.

Now, drape this new grid on top of the terrain. Turn off the DEM layer.

[8] Make a screen shot of ArcScene and include it in your report.

Compare this new visibility surface to the viewshed surface you created earlier, you will see noticeable difference.

Part V – Line of Sight Analysis

Line of Sight Analysis creates a line between two points that shows the parts of the surface along the line that are visible to or hidden from an observer. It helps determine whether a given point is visible from another point.

Suppose you want to take a walk along the famous fishing trial, you may be interested to find out which portion of the trail is visible from your starting location along the trail.

You can use either ArcMap or ArcScene through 3D Analyst to do this.

First, try ArcScene.

Add the data layer – "Fishing_Trail" and then drape it on the surface.

Go to ArcToolbox and find 3D Analyst Tools → Visibility → Line of Sight

You need to figure out the rest for this analysis.

Notice that the Line of Sight result is automatically drapped on top of the surface.

[9] Make a screen shot of ArcScene and include it in your report.

Note:

- The output – Line of Sight, is actually a 3D shapefile.
- The line of sight does not exactly "match" the fishing trail. The trail can be a line with any curves. However, the line of sight is always a straight line (linking the observation point and target point) on the surface. The line of sight is only curved following the surface.

Now, you should try to use the same tool from ArcMap. The result is displayed in 2D.

[10] Make a screen shot of ArcMap and include it in your report.

Then, you can add this result into ArcScene. You should notice that the two results from Line of Sight analysis exactly match.

Part VI – Profile Graph

Surface profiles show the change in elevation of a surface along a line. They are useful to combine with Line of Sight visibility analysis or Steepest Path surface analysis. They can help you assess the difficulty of a trail or evaluate the feasibility of placing a rail line along a given route.

The Profile Graph tools on the 3D Analyst interactive toolbar are used to derive a graphic representation of one or many profiles. Profiles can be generated from any 3D line feature(s) drawn over a surface. You can create profiles on either a raster, triangulated irregular network (TIN), or terrain dataset surface. Profile graphs can also be derived by drawing a 3D line over a set of points or multipoints.

Please note that the Profile Graph tools are only available within ArcMap.
In ArcMap, on the menu bar, right-click to check and enable 3D Analyst.

Make sure you choose the correct surface.

In the previous session, you have already created a Line of Sight.

Make sure that you select the lines on the map.

Then click on Profile Graph.

[11] Make a screen shot of the Profile Graph and include it in your report.

Part VII – Calculating Surface Volume

Surface Volume calculates the projected area (projected to the 2D Cartesian plane or the shadow of the 3D surface with the light source directly from above), surface area, and volume of a surface relative to a given base height, or reference plane. The input surface can be a raster, TIN, or terrain dataset. And the results are written to a comma-delimited text file.

Go to 3D Analyst Tools → Functional Surface → Surface Volume

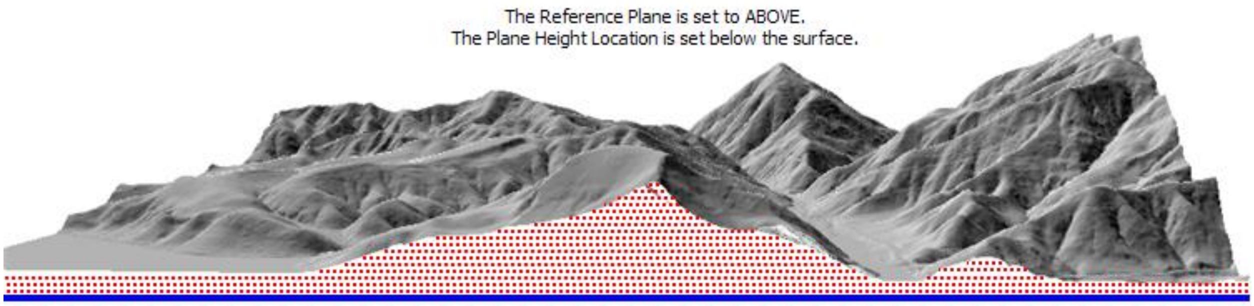
Notes:

- The area and volume are calculated between the reference plane and the surface.
- The Reference Plane determines whether these calculations are performed above or below the plane.
- The Plane Height represents the height of the horizontal reference plane from which calculations are derived.
    - The default Plane Height is determined by the option used for Reference Plane. If the Reference Plane is set to ABOVE then the Plane Height is set to the minimum height of the surface. If it is set to BELOW, the default Plane Height is set to the maximum height.

So, there are different combinations depending on how you set the Reference Plane and Plane Height.

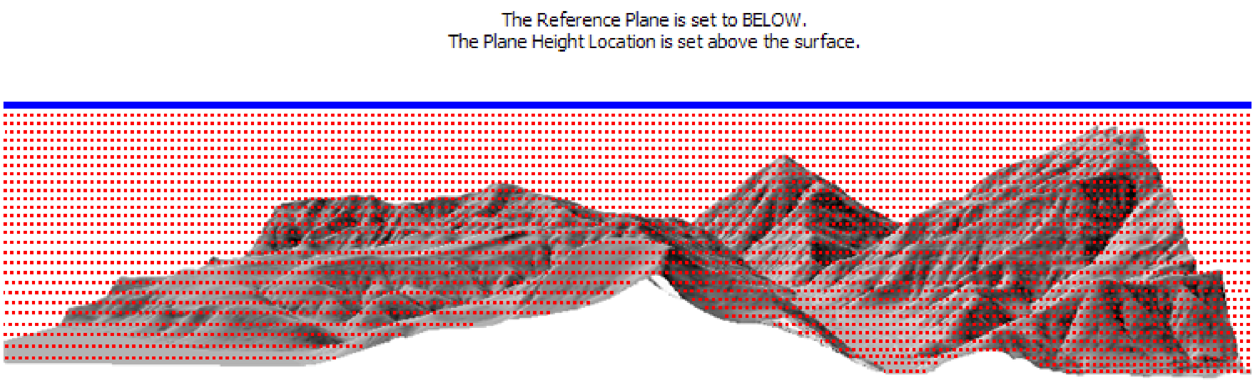
Scenario 1: Assume that all the volume under the surface is a coal mine. The question is to find out the total reserve.

In this case, you will set the Reference Plane as "ABOVE" while the Plane Height below the surface.



Scenario 2: Assume that the whole study area is submerged under water due to global warming. The question is to find out the total water volume.

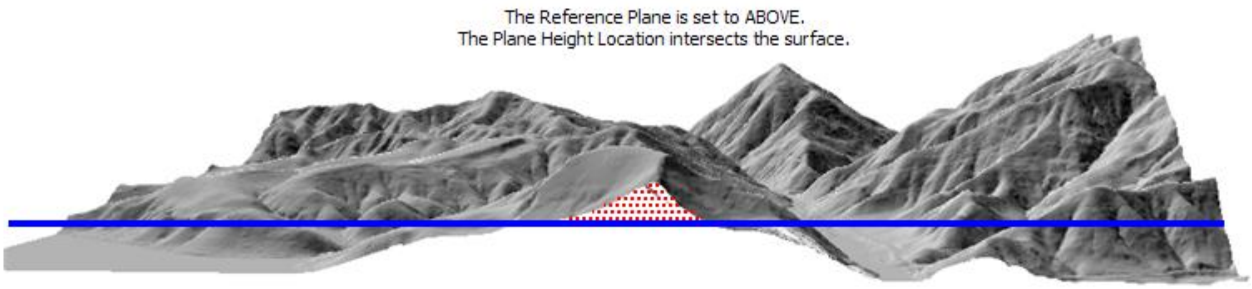
In this case, you will set the Reference Plane as "BELOW" while the Plane Height above the surface.



Scenario 3: Assume that part of the study area is submerged under water due to global warming. The question is to find out the total mine reserve above the water line.

In this case, you will set the Reference Plane as "ABOVE" while the Plane Height is set somewhere between the maximum and minimum elevation value, which means that it "intersect" with the surface.

Let's set the Plane Height as 195.



Now, use the Surface Volume tool (3D Analyst → Functional Surface) and carry out the analysis under each scenario.

Once you get the results (.txt files), find the information and fill the table below.

	Plane Height	Reference	Area_2D (m^2)	Area_3D (m^2)	Volume (m^3)
Scenario 1					
Scenario 2					
Scenario 3					

[12] Include this table in your report.

Note:

- You might want to carefully compare those numbers in different scenarios.
- You will see that, while the volume will change, some other numbers (e.g. Area_2D) may not change depending on the scenarios.

Part VIII – 3-D Visualization in ArcGlobe

So far, you have used tools or functions within ArcScene for 3-D visualization and analysis. While ArcScene is optimized for viewing and analysis of smaller datasets, such as a specific local area, ArcGlobe is designed to be used with very large datasets and allows for seamless visualization of both raster and feature data.

For this exercise, you will use the data – “States” and “US_Cities_half_mln” (major cities that have a population of at least 500,000).

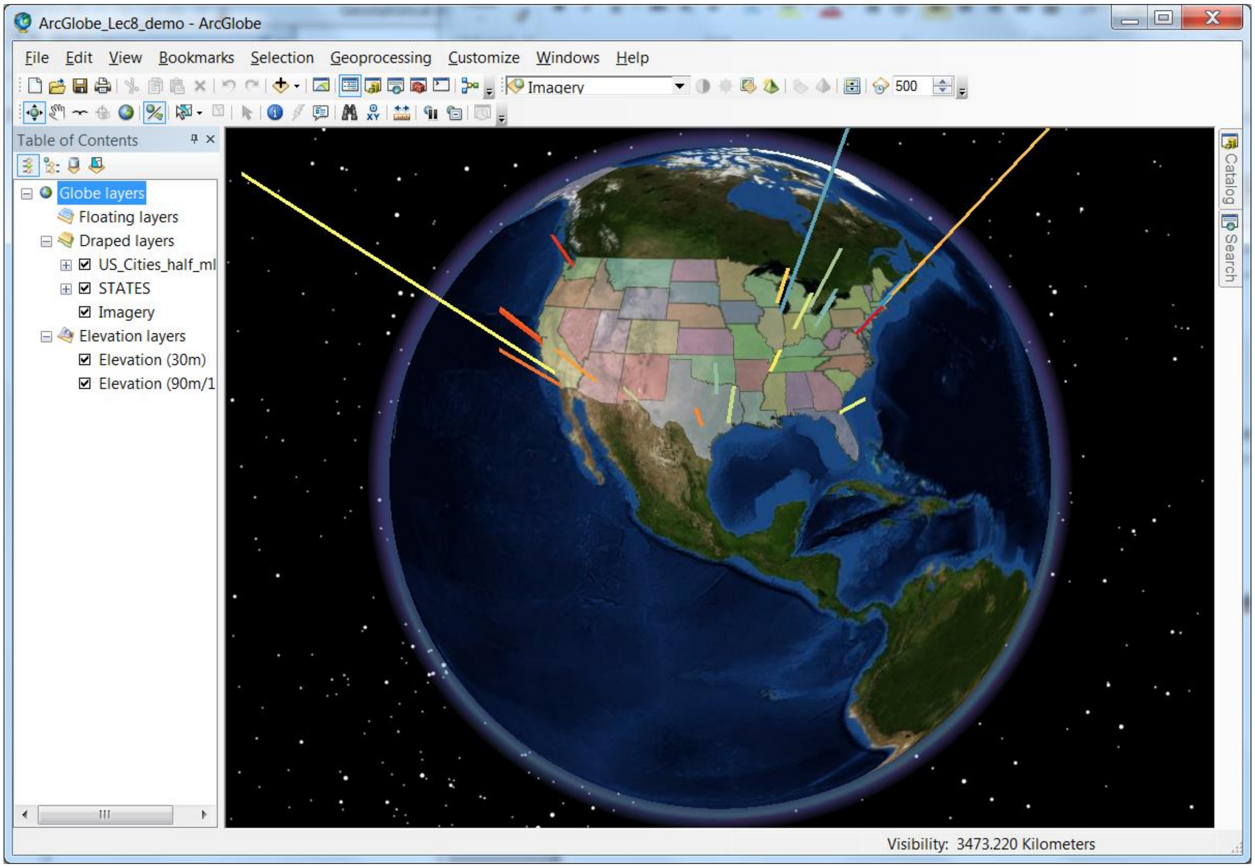
Note:

- ArcGlobe projects all data onto a globe-shaped surface using one particular coordinate system—Cube Projection. All data added to an empty ArcGlobe document is projected on the fly to this coordinate system.

- Data that miss projection information associated with it cannot be added into ArcGlobe. (You should test it by using the "Aerial_Photo" image data included in the lab dataset.)

Your tasks:

1. Add the two data layers
2. Extrude the cities based on the population
3. Extrude the states based on the population density
    - You will need to multiply the population density value with a factor. You can find the appropriate factor by doing various tests.
4. Modify the symbology to create a 3-D view similar to the one shown below. However, your ArcGlobe should also show the 3-D view of the state layer.
    - Be creative about how to create the best 3-D effect.



[13] Make a screen shot of the result and include it in your report.

Part IX – Animations

(This part is optional.)

Animations can be very useful and powerful means in communicating information to the audience. In ArcGIS, there are a variety of ways of creating animations, for example:

1. In ArcMap, you can easily create a time animation which will allow you to control the time of the display. The features, table rows, or rasters in your time-enabled data are displayed based on the current display time in the map. In creating a time animation, you'll first enable time on the datasets you want to visualize over time.
2. In ArcScene, there are at least five different options of creating animations.
    a. Capturing perspective views
    b. Recording camera or map view racks
    c. Creating keyframes of camera or map view properties
    d. Using bookmarks to create an animation
    e. Moving the camera or view along a predefined path (line)

3. In ArcGlobe, it is very similar to ArcScene in terms of creating animations.

In this exercise, you will focus on ArcScene and ArcGlobe. You can use the data from the "ArcScene" folder. I strongly encourage you to try these options by yourself. Once you have tried all of these options, you will get a better understanding which is better or more appropriate for different purposes.

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