ArcGIS® 9

ArcGIS 3D Analyst™ Tutorial

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DATA CREDITS

Exercise 1: Death Valley image data courtesy of National Aeronautics and Space Administration (NASA)/Jet Propulsion Laboratory (JPL)/Caltech.

Exercise 2: San Gabriel Basin data courtesy of the San Gabriel Basin Water Quality Authority.

Exercise 3: Belarus CS137 soil contamination and thyroid cancer data courtesy of the International Sakharov Environmental University.

Exercise 4: Hidden River Cave data courtesy of the American Cave Conservation Association.

Exercise 5: Elevation and image data courtesy of MassGIS, Commonwealth of Massachusetts Executive Office of Environmental Affairs.

Exercise 6: Las Vegas Millennium Mosaic (Year 2000 Landsat) and QuickBird images data courtesy of DigitalGlobe.

Exercise 7: Ozone concentration raster derived from data courtesy of the California Air Resources Board, Southern California Millennium Mosaic (Year 2000 Landsat) image courtesy of DigitalGlobe, Angelus Oaks imagery courtesy of AirPhoto USA, Southwestern U.S. elevation data derived from U.S. National Elevation Data courtesy of the U.S. Geological Survey.

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ArcGIS 3D Analyst Tutorial

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The best way to learn ESRI® ArcGIS® 3D Analyst™ is to use it. In the exercises in this tutorial, you will:

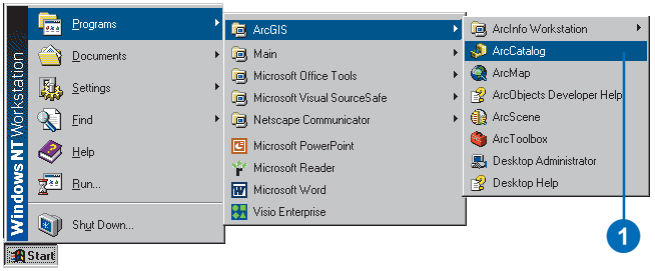
- Use ArcCatalog™ to find and preview 3D data.
- Add data to ArcScene™.
- Set 3D properties for viewing data.
- Create new 3D feature data from 2D features and surfaces.
- Create new raster surface data from point data.
- Build a TIN surface from existing feature data.
- Make animations.
- Learn how to use ArcGlobe™ and manage its data content.

In order to use this tutorial, you need to have the 3D Analyst extension and ArcGIS installed and have the tutorial data installed on a local or shared network drive on your system. Ask your system administrator for the correct path to the tutorial data if you do not find it at the default installation path specified in the tutorial.

Copying the tutorial data

First you will copy the tutorial data to a local drive. You will use ArcCatalog to browse to and copy the data.

1. Click Start, point to Programs, point to ArcGIS, and click ArcCatalog.

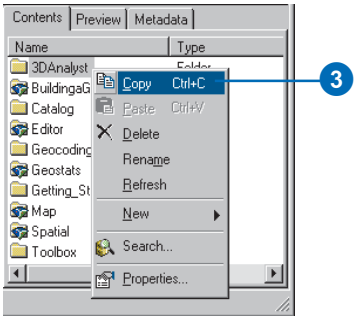


   ArcCatalog lets you find and manage your data. The left side of the ArcCatalog window is called the *Catalog tree*; it gives you a bird's-eye view of how your data is organized and provides a hierarchical view of the geographic data in your folders. The right side of the Catalog window shows the contents of the selected branch of the Catalog tree.

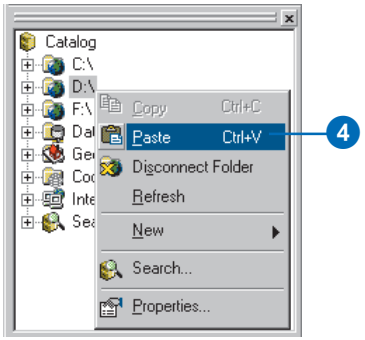
2. Click in the Location combo box and type the path to the \arcgis\ArcTutor folder on the drive where the tutorial data is installed. Press Enter.

   The ArcTutor folder is now the selected branch of the Catalog tree. You can see its contents in the Contents tab.

3. Right-click the 3DAnalyst folder and click Copy.

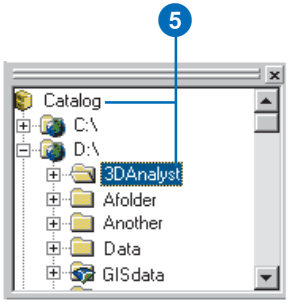


4. Right-click the local drive where you want to place the tutorial data and click Paste.



   The folder is copied to your local drive. Now you'll make a folder connection to the 3DAnalyst folder in the Catalog tree.

5. Click the 3DAnalyst folder on your local drive and drag it onto the top-level node, Catalog, of the Catalog tree.



   There is now a folder connection in the Catalog for your local copy of the tutorial data.

In the graphics illustrating this tutorial, the ArcCatalog option to use a special folder icon for folders containing GIS data is turned on. That is why the folder GISdata, in the graphic above, looks different from the other folders. You can turn this option on in ArcCatalog, in the Options dialog box, on the General tab. ArcCatalog works faster when this option is turned off, so it is off by default.

Exercise 1: Draping an image over a terrain surface

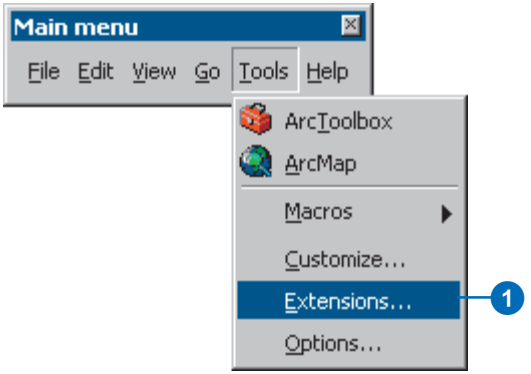
Viewing a remotely sensed image draped over a terrain surface can often lead to greater understanding of the patterns in the image and how they relate to the shape of the earth's surface.

Imagine that you're a geologist studying Death Valley, California. You have collected a TIN that shows the terrain and a satellite radar image that shows the roughness of the land surface. The image is highly informative, but you can add a dimension to your understanding by draping the image over the terrain surface. Death Valley image data was supplied courtesy of NASA/JPL/Caltech.

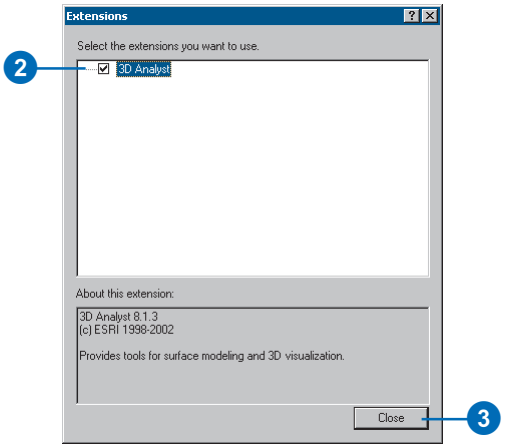
Turning on the 3D Analyst extension

You'll need to enable the 3D Analyst extension.

1. Click Tools and click Extensions.



2. Check 3D Analyst.
3. Click Close.

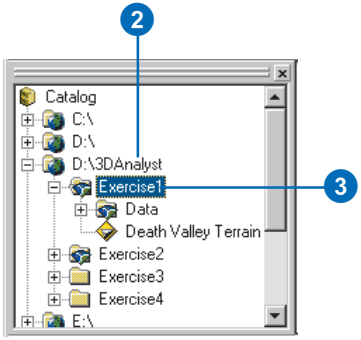


Previewing 3D data in ArcCatalog

Before you drape the image, you'll browse to the terrain data and preview it in ArcCatalog.

1. Navigate to the 3DAnalyst folder connection in the Catalog tree.

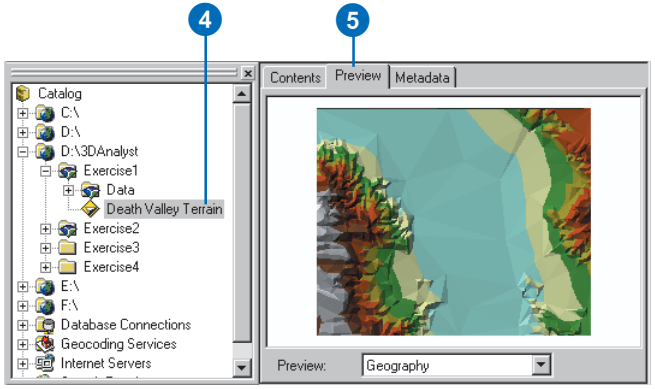
2. Double-click 3DAnalyst.
3. Double-click Exercise1.



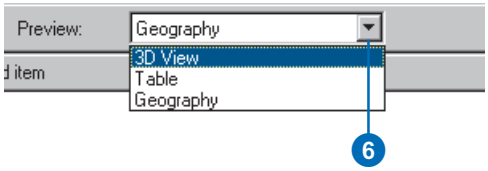
You see a folder called Data and a TIN layer called Death Valley Terrain.

A layer is a shortcut to geographic data. It also stores information about how the geographic data should be drawn on a map or in a 3D scene.

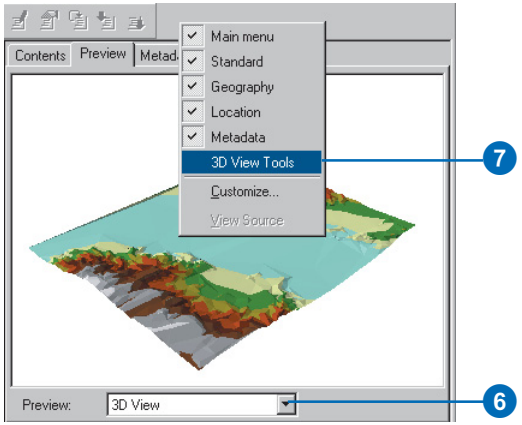
4. Click Death Valley Terrain.



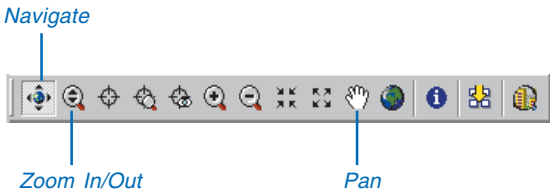
5. Click the Preview tab. You can preview your GIS data in ArcCatalog. With 3D Analyst installed, you can also preview some data in three dimensions.
6. Click the Preview dropdown arrow and click 3D View.



7. Right-click above the preview window and click 3D View Tools.



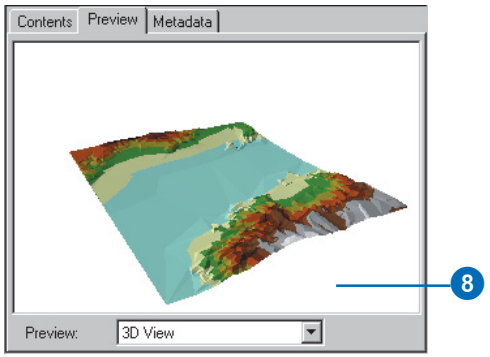
The preview becomes a 3D preview, and a new set of tools appears on the 3D View Tools toolbar.



The Navigate tool is active when you first preview data in 3D. You can see the names of tools by hovering the pointer over the tool.

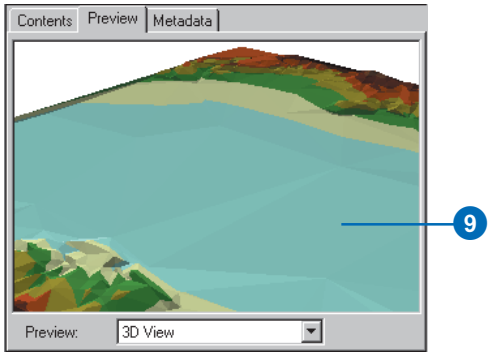
The Navigate tool allows you to rotate 3D data and change the apparent viewer height by clicking and dragging left and right and up and down, respectively, in the 3D preview.

8. Click on the 3D preview and drag to the right.



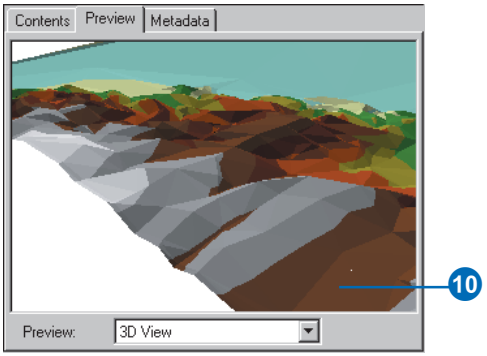
The data rotates around its center. The Navigate tool also allows you to zoom in and out and pan across the data, depending on the mouse button that you click while dragging in the 3D preview.

9. Right-click on the 3D preview and drag down.



The pointer changes to the Zoom In/Out pointer, and the view zooms in to the data.

10. Click the middle button—or both the right and left buttons if you have a two-button mouse—and drag to the right.

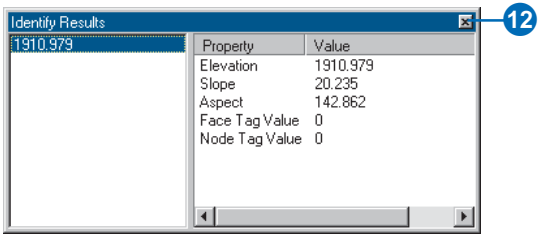


The pointer changes to the Pan pointer, and the view pans across the data.

11. Click the Identify button and click on the TIN.

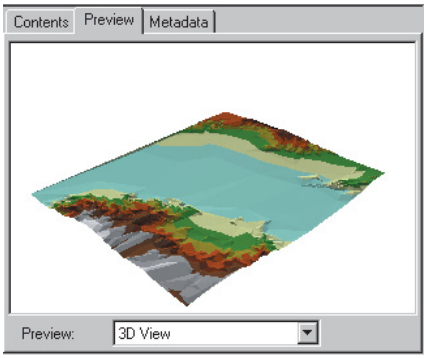
The Identify Results window shows you the elevation, slope, and aspect of the surface at the point you clicked.

12. Close the Identify Results window.



13. Click the Full Extent button.

The view returns to the full extent of the data.



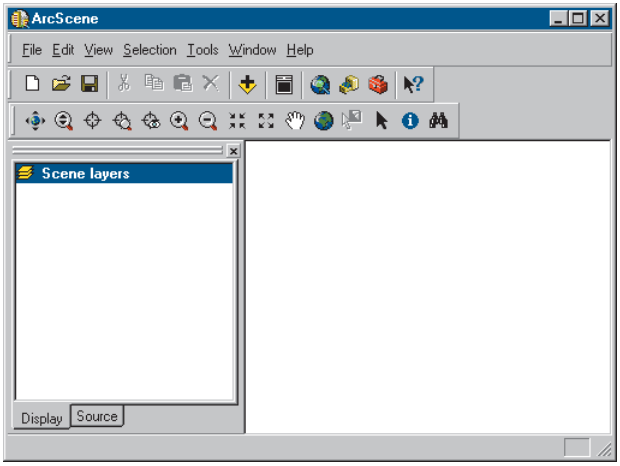
Now you've examined the surface data and begun to learn how to navigate in 3D. The next step is to start ArcScene and add your radar image to a new scene.

Starting ArcScene and adding data

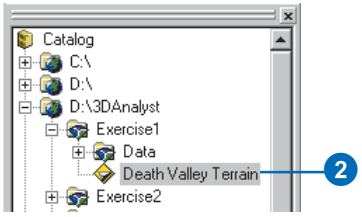
ArcScene is the 3D viewer for 3D Analyst. Although you can preview 3D data in ArcCatalog, ArcScene allows you to build up complex scenes with multiple sources of data.

1. Click the ArcScene button on the 3D View Tools toolbar.

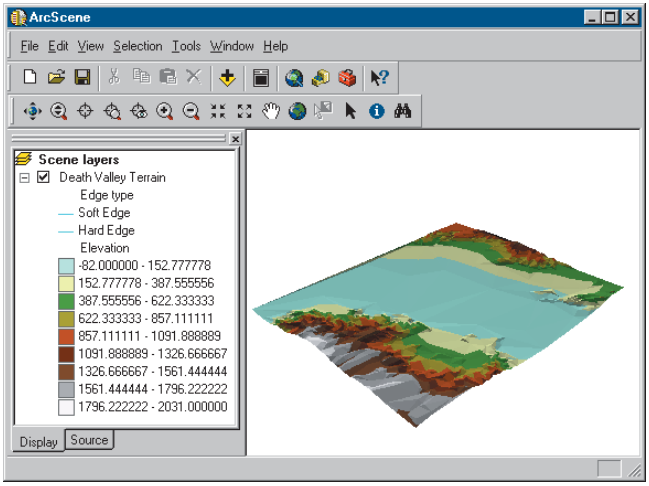
ArcScene starts. Note that many of the tools on the ArcScene Standard toolbar are the same as the 3D navigation tools that you see in ArcCatalog.



2. Click the Death Valley Terrain layer in the Catalog tree and drag it onto the right-hand side of the ArcScene window, then release the mouse button.

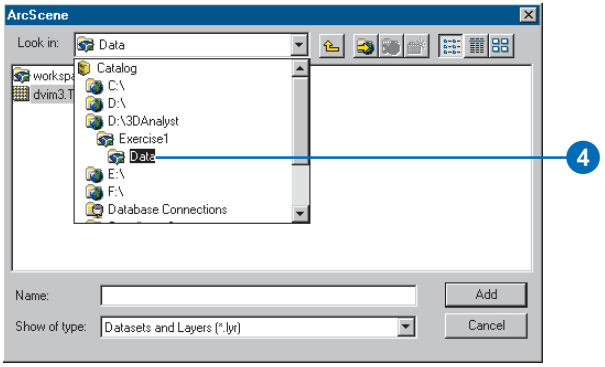


The TIN is drawn in the new scene.

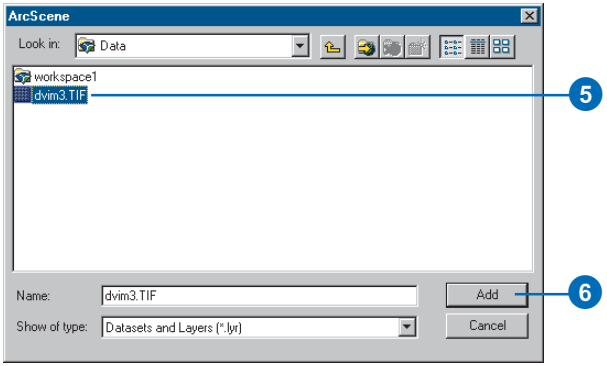


3. Click the Add Data button on the ArcScene Standard toolbar.

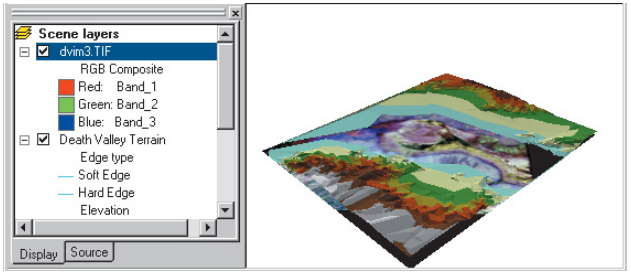
4. Navigate to the Data folder for Exercise1.



5. Click dvim3.TIF.
6. Click Add.

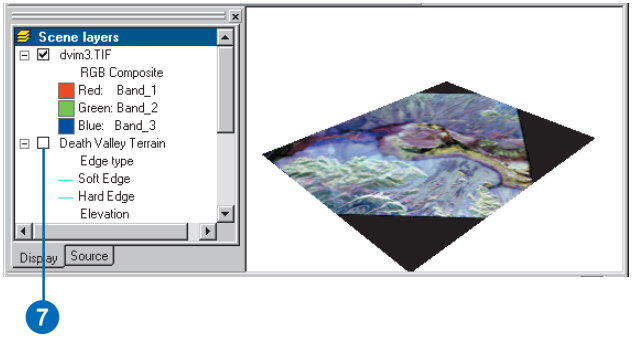


The image is added to the scene.



The image is drawn on a plane, with a base elevation value of zero. You can see it above the Death Valley terrain surface where the terrain is below 0 meters elevation (sea level); it is hidden by the terrain surface everywhere else.

7. Uncheck the Death Valley Terrain layer.



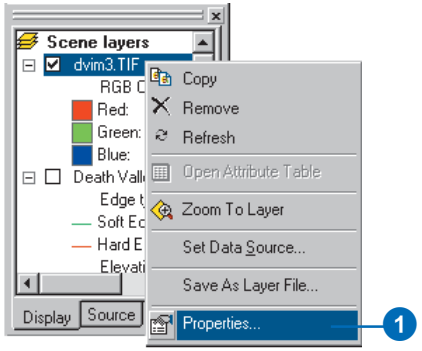
Now you can see the whole image. The black areas are parts of the image that contain no data and are a result of previous processing to fit the image to the terrain.

You have added the image to the scene. Now you will change the properties of the image layer so that the image will be draped over the terrain surface.

Draping the image

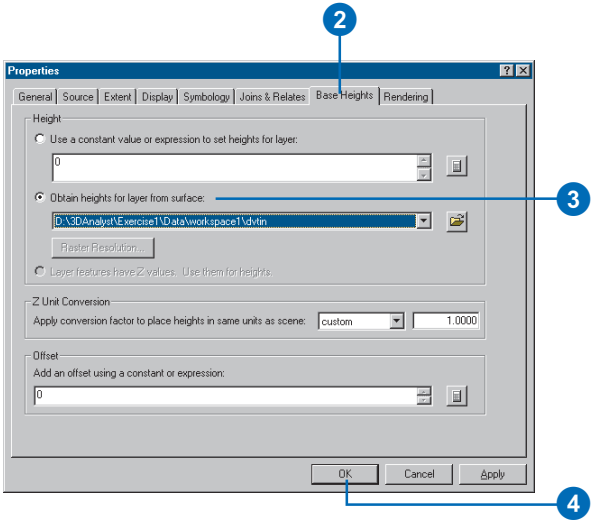
While the surface texture information shown in the image is a great source of information about the terrain, some relationships between the surface texture and the shape of the terrain will be apparent when you drape the image over the terrain surface. In ArcScene, you can drape a layer—containing a grid, image, or 2D features—over a surface (a grid or TIN) by assigning the base heights of the layer from the surface.

1. Right-click dvim3.TIF in the ArcScene table of contents and click Properties.



The layer Properties dialog box appears. You can change how a layer is drawn on a map or in a scene by setting its properties.

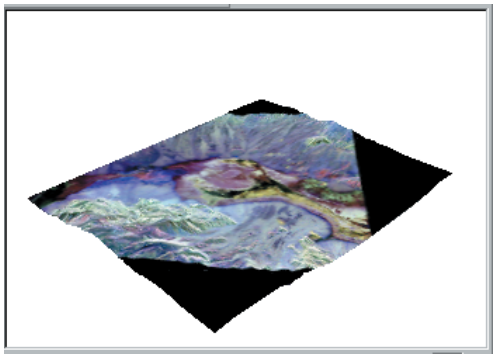
2. Click the Base Heights tab.



3. Click the option to Obtain heights for layer from surface.

   Because the TIN is the only surface model in the scene, it appears in the surface dropdown list.

4. Click OK.



The image is draped over the terrain surface.

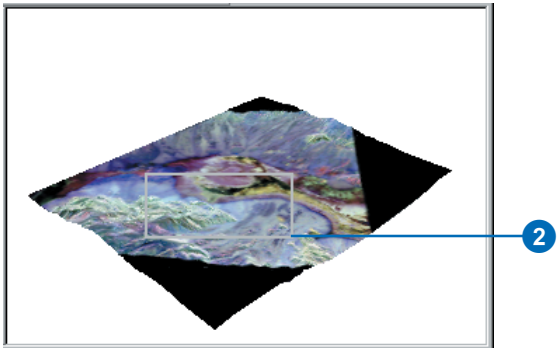
Now you will be able to navigate around the image and see the relationship between surface texture, as shown by the image colors, and the shape of the terrain.

Exploring the image

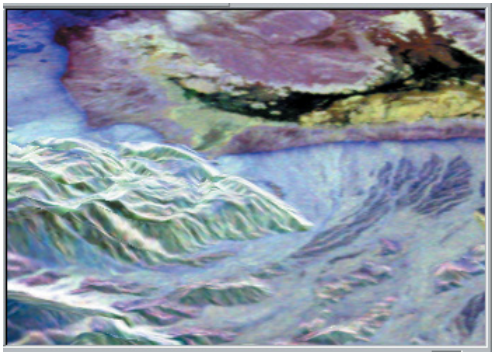
You will use the navigation tools on the ArcScene Tools toolbar to explore the draped image.

1. Click the Zoom in button.

2. Click and drag a rectangle around the middle of the image.

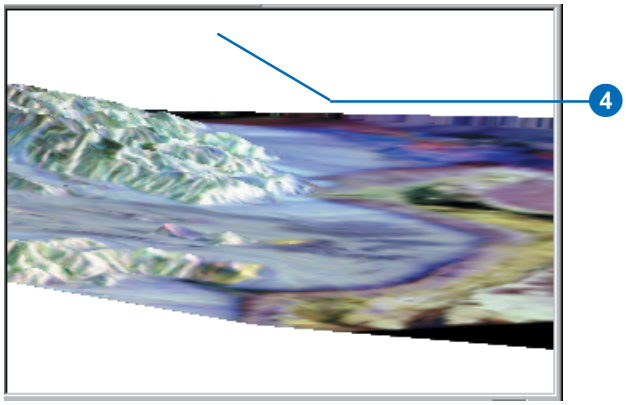


The scene zooms to the middle part of the image.

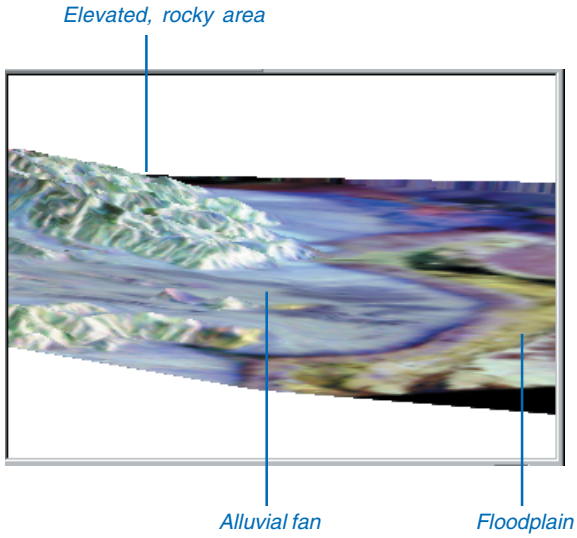


3. Click the Navigate button.

4. Click on the scene and slowly drag up and to the left.



The scene rotates, and the view angle lowers, so it looks as though you are looking down the valley, past the higher land on the left side of the scene.



The elevated land is visibly rougher terrain than the flat valley bottom. The surface texture—and therefore the color, in the radar image—of this rocky area is different than the fine sediment of the floodplain—the yellow and black region in the valley bottom. The rocky area is also a different texture from the gently sloping alluvial fan that runs past it, down onto the valley floor.

Draping the radar image over the terrain surface allows you to see the relationship between the general shape of the land surface and the texture of the rocks and sediment that make up the surface.

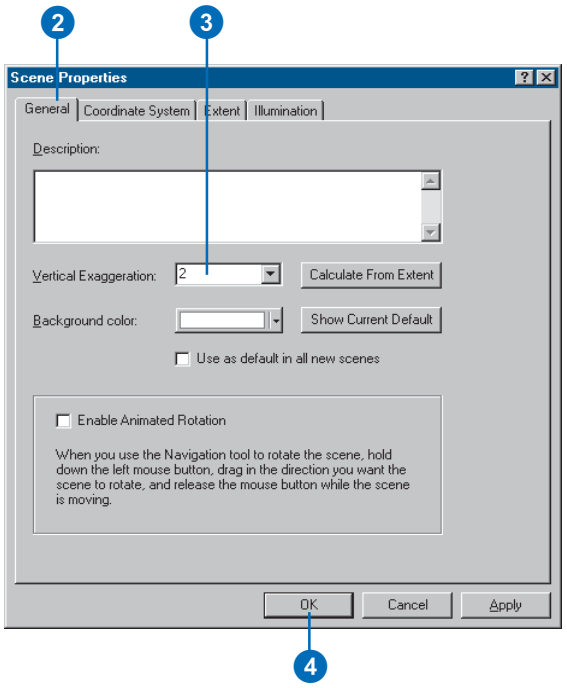
Exaggerating the terrain

The valley is a broad area, relative to the height of the terrain, even though the mountains at the edge of the scene are more than 2,000 meters above the valley floor. In order to enhance the sense of depth in the scene, and to bring out subtle features in the terrain, you will exaggerate the height of the terrain.

1. Right-click Scene layers in the table of contents and click Scene Properties.

   The Scene Properties dialog box lets you set properties that are shared by all of the layers in the scene. These include the vertical exaggeration, the background (sky) color, the coordinate system and extent of the data, and the way that the scene is illuminated (the position of the light source relative to the surface).

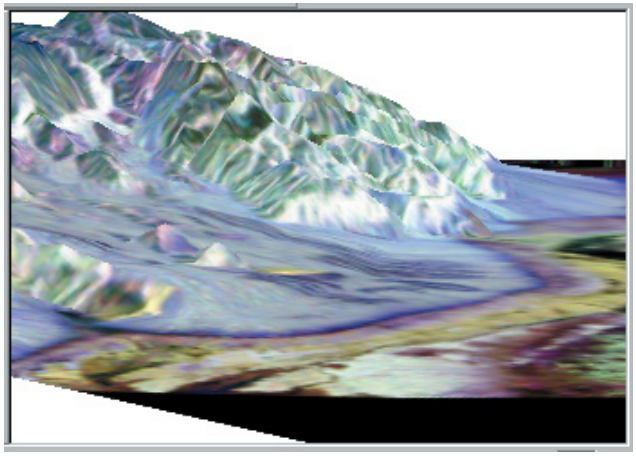
2. Click the General tab.



3. Type “2” in the Vertical Exaggeration combo box.
4. Click OK.

   The apparent height of the terrain is now doubled.

You can now clearly see how the alluvial fan spreads out onto the valley floor, between the larger rocky area at the center of the scene and the smaller rocky area in the foreground at the left side of the scene.

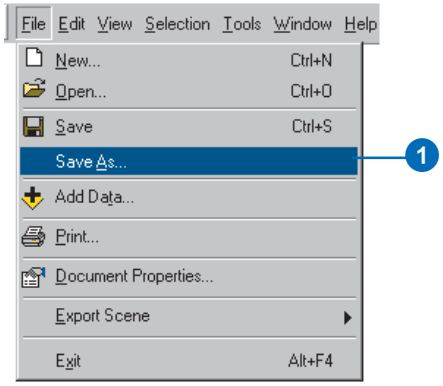


You have added depth to the radar image, explored the general relationship between the data in the image and the terrain data, and enhanced the scene so that you can perceive more subtle variations in the terrain.

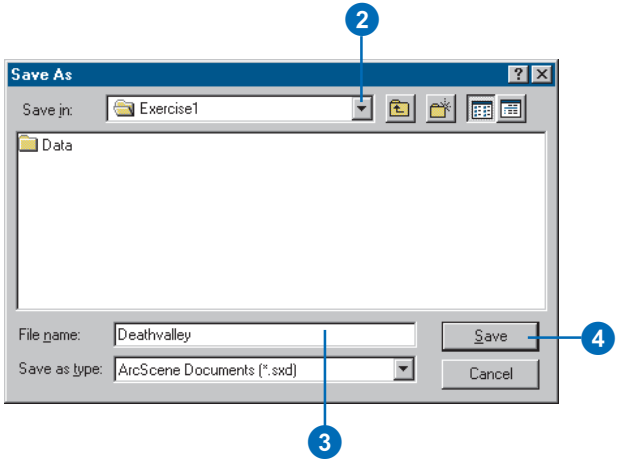
Now that you've built the scene, you will save it so that you can explore it later if you choose.

Saving the scene

Scenes, also called Scene Documents, are like maps. They contain information about how the layers that are in the scene should be rendered and where the data is located.



1. Click File and click Save As.



2. Navigate to the Exercise1 folder.
3. Type "Deathvalley".
4. Click Save.

The scene will now be available for you to open later.

Exercise 2: Visualizing contamination in an aquifer

Imagine that you work for a water district. The district is aware of some areas where volatile organic compounds (VOCs) have leaked over the years. Scientists from your department have mapped some plumes of VOCs in the aquifer, and you want to create a 3D scene to help officials and the public visualize the extent of the problem.

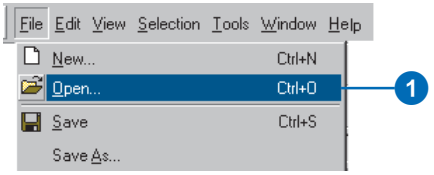
Some of the data for the scene has already been assembled in the Groundwater scene. You will modify the scene to better communicate the problem.

VOC data was supplied courtesy of the San Gabriel Basin Water Quality Authority.

Opening the Groundwater scene document

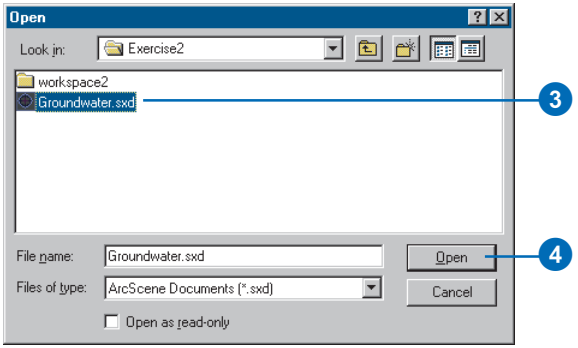
This scene document contains a TIN that shows the shape of the contaminant plume, a raster that shows the concentration of the contaminant, and two shapefiles that show the locations of parcels and wells. You will drape the concentration raster over the plume TIN, extrude the building features and change their color, and extrude the well features so that the wells that are most endangered by the contamination may be more easily recognized.

1. In ArcScene, click File, then click Open.



2. Navigate to the Exercise2 folder.

3. Click Groundwater.sxd.



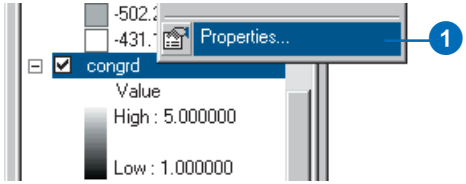
4. Click Open.

   The Groundwater scene opens. You can see the four layers in the table of contents.

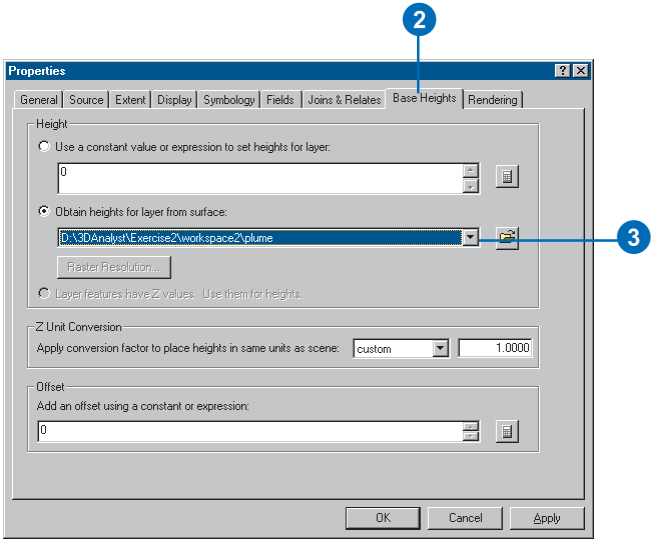
Showing the volume and intensity of contamination

You'll drape the raster of VOC concentration over the TIN of the contaminant plume surface to show the volume and intensity of contamination in the aquifer.

1. Right-click congrd and click Properties.



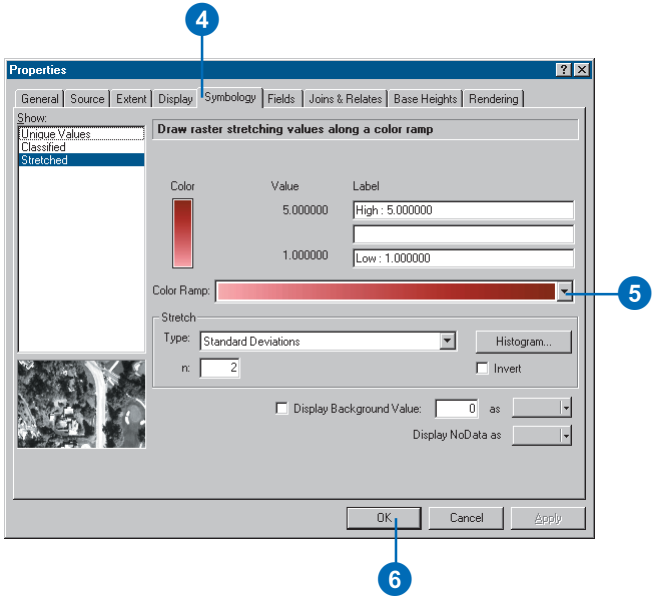
2. Click the Base Heights tab.



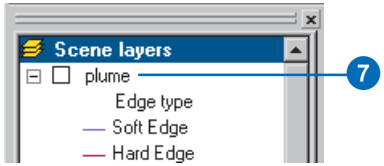
3. Click the dropdown arrow and click plume to get the heights from the plume TIN.

   Now you will change the symbology of the raster to show the intensity of the contamination.

4. Click the Symbology tab.



5. Click the Color Ramp dropdown arrow and click a red color ramp for the raster.
6. Click OK.



7. Uncheck plume in the table of contents.

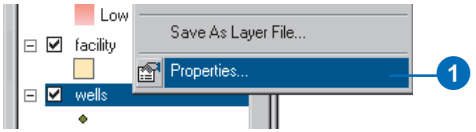
Now it is possible to see the shape of the plume and its intensity in 3D.

Showing the relationship of the plume to wells

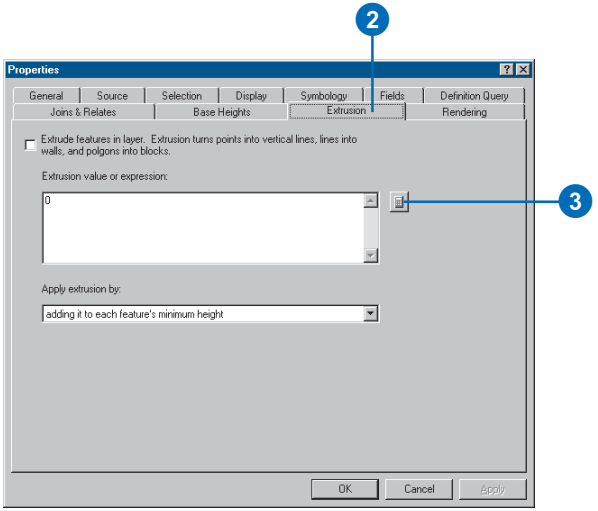
You can see that some of the wells are within the area of the plume. However, it is difficult to see which wells are most seriously affected because the contamination is more widespread but less concentrated at greater depths.

You will extrude the well features based on their depth attribute in order to see which wells intersect the plume.

1. Right-click wells and click Properties.



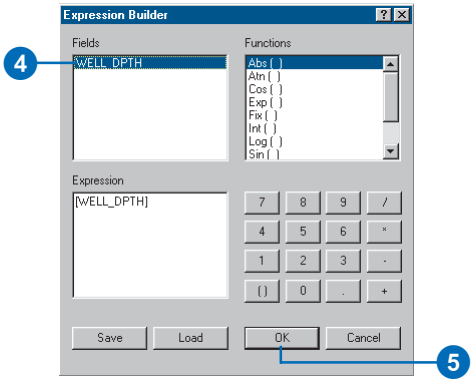
2. Click the Extrusion tab.



3. Click the Calculate Extrusion Expression button.

   You will display the well points as vertical lines equal to the depth of the well. This information is stored in the WELL_DPTH field.

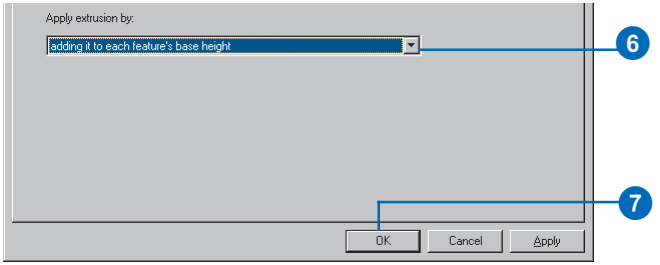
4. Click WELL_DPTH.



5. Click OK.

6. Click the dropdown arrow to apply the extrusion expression by adding it to each feature's base height. The well depths are expressed as negative values, so they'll be extruded downward.

7. Click OK.

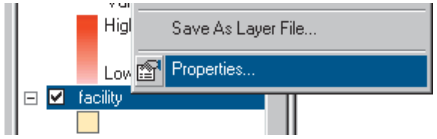


You can see the places where the wells intersect, or are close to, the plume. Now you will modify the scene to show the priority of various facilities that have been targeted for cleanup.

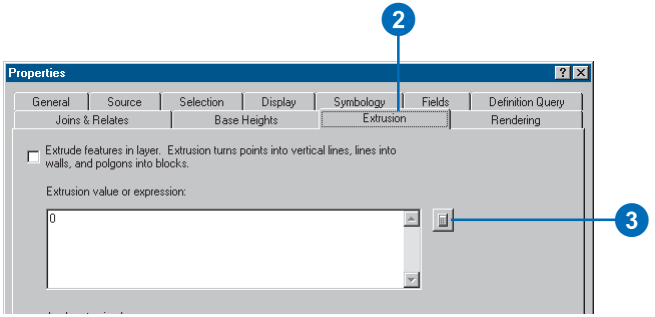
Showing the facilities with a high cleanup priority

Analysts in your department have ranked the facilities according to the urgency of a cleanup at each location. You'll extrude the facilities into 3D columns and color code them to emphasize those with a higher priority for cleanup.

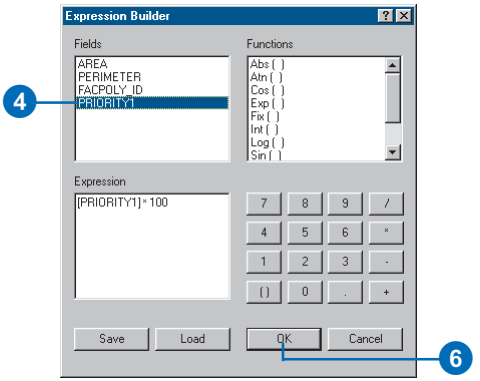
1. Right-click facility and click Properties.



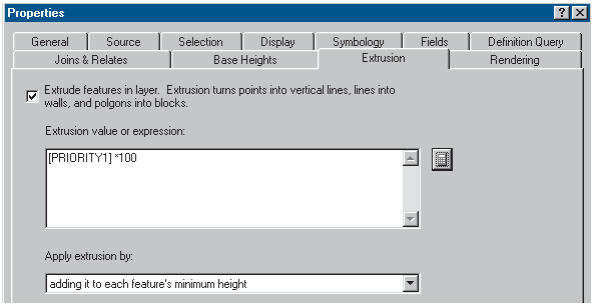
2. Click the Extrusion tab.
3. Click the Calculate Extrusion Expression button.



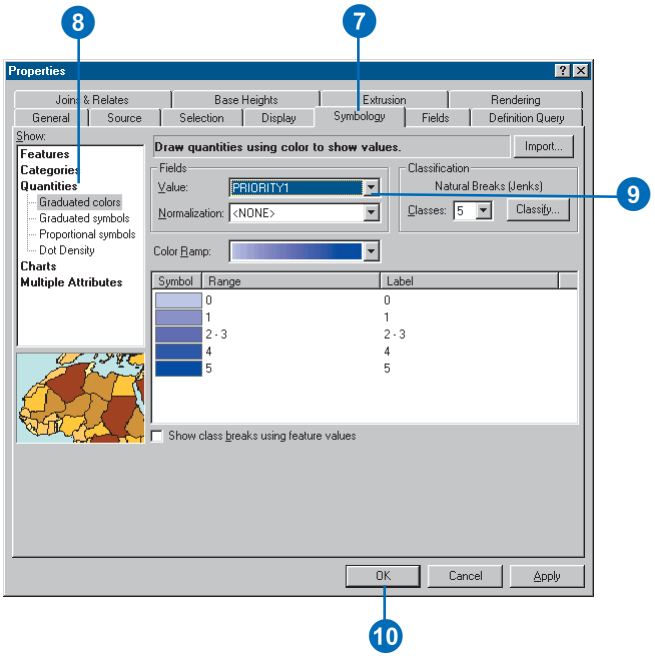
4. Click PRIORITY1.
5. Type "* 100".
6. Click OK.



The expression you created appears in the Extrusion value or expression box.



7. Click the Symbology tab.
8. Click Quantities.
9. Click the Value dropdown list and click PRIORITY1.



10. Click OK.

    The facilities are now extruded in proportion to their priority score. The scene now shows the shape and intensity of the contamination, the wells in relationship to the plume, and the facilities that need to be cleaned up in order to prevent further pollution of the groundwater.

    Now you'll save your changes to the scene.

11. Click the Save button.

Exercise 3: Visualizing soil contamination and thyroid cancer rates

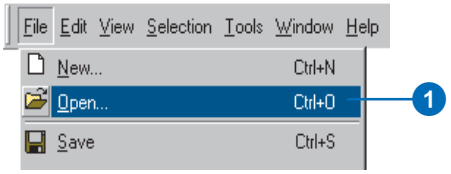
In 1986, after the catastrophic accident at the Chernobyl nuclear power plant in Ukraine, a large amount of radioactive dust fell on Belarus. Since then, scientists have studied the aftermath of the accident. One tool for exploring the data is 3D visualization. In this exercise, you will create two surfaces from point data collected in Belarus. One set of points contains measurements of soil CS137 concentrations. CS137 is one of several radioactive isotopes released by the accident. The other set of points shows the rates of thyroid cancer, aggregated by district, with the sample point placed near the district centers.

The CS137 contamination and thyroid cancer data was supplied courtesy of the International Sakharov Environmental University.

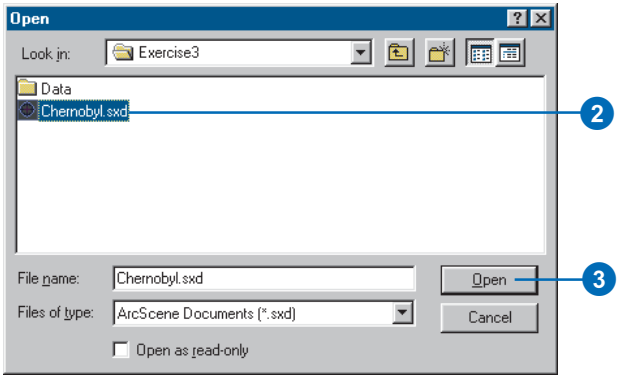
Viewing the point data

First, you will open the Chernobyl scene and view the point data.

1. Click File and click Open.



2. Navigate to Exercise3 and click Chernobyl.
3. Click Open.



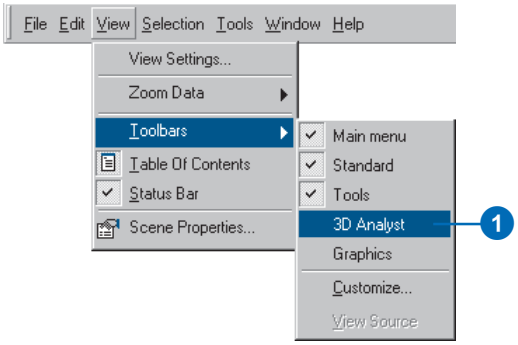
The CS137 soil measurements are shown with small point symbols, using a graduated color ramp to show the intensity of the contamination. The districts' thyroid cancer rates are shown with larger symbols, using a different color ramp.

Creating 3D point features

The soil CS137 samples are 2D points with some attributes. One way to view 2D points in 3D is by setting an extrusion expression, or a base height. You can also incorporate a z-value into a feature's geometry to allow it to be directly viewed in 3D without the need to set a base height from a surface or an attribute.

First, you'll add the 3D Analyst toolbar to ArcScene.

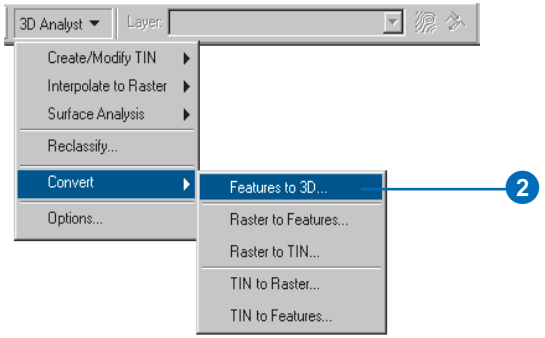
1. Click View, point to Toolbars, and click 3D Analyst.



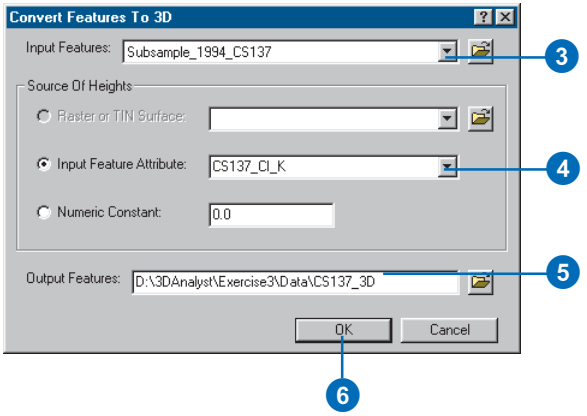
The 3D Analyst toolbar in ArcScene contains several 3D analysis and data conversion tools. The ArcMap™ 3D Analyst toolbar contains the same tools, plus several additional tools that you can use in ArcMap.

Now you will create 3D point features from the soil CS137 points.

2. Click 3D Analyst, point to Convert, and click Features to 3D.



3. Click the Input Features dropdown list and click Subsample_1994_CS137.



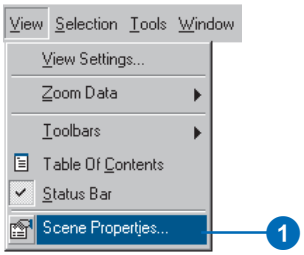
4. Click the Input Feature Attribute button, then click the Input Feature Attribute dropdown list and click CS137_CI_K.
5. Change the output feature name to CS137_3D.
6. Click OK.

The features are converted to 3D point features. However, they still seem to be resting on a flat plane because the CS137 concentration values range from 0 to 208.68, which is small, relative to the horizontal extent of the data.

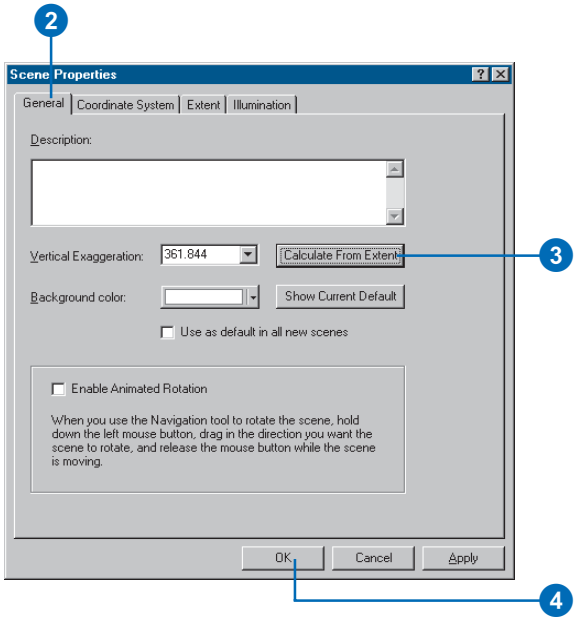
Increasing the vertical exaggeration

You will exaggerate the scene to show the new points with their height embedded in the feature geometry.

1. Click View and click Scene Properties.



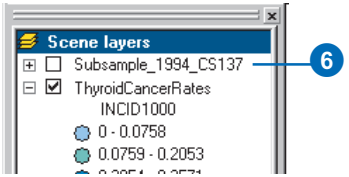
2. Click the General tab.



3. Click Calculate From Extent.
4. Click OK.
5. Click the Full Extent button.

Now that you can see the new 3D points in the scene, you can turn off the original CS137 sample point layer.

6. Uncheck the box in the table of contents beside Subsample_1994_CS137 and click the minus sign beside the box to hide the classification.

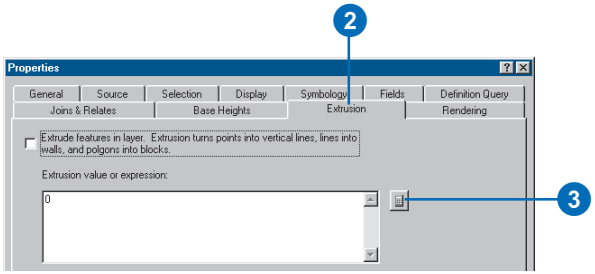


Extruding columns

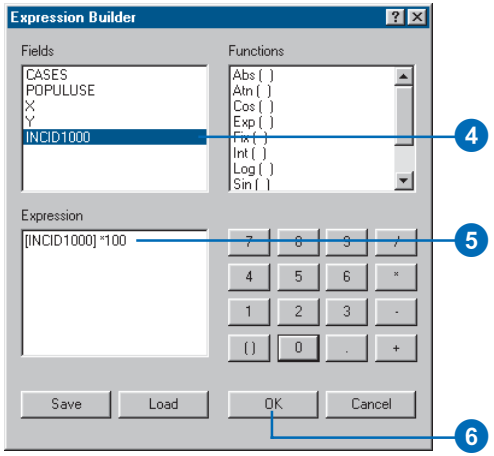
Viewing points in 3D space is one way to investigate data. Another way is to extrude points into columns. You will extrude the thyroid cancer points into columns to compare them to the contamination data.

1. Right-click ThyroidCancerRates and click Properties.

2. Click the Extrusion tab.



3. Click the Calculate Extrusion Expression button.
4. Click INCID1000 (the rate of cases per 1,000 persons).



Because the z-values of the phenomena that you are comparing have different ranges, you will multiply the cancer rate by 100 to bring the values into a range similar to that of the CS137 measurements.

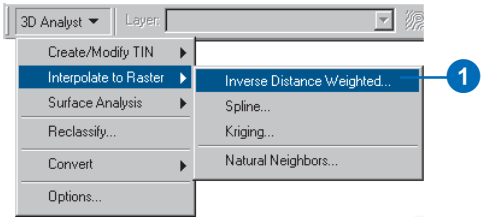
5. Type "* 100".
6. Click OK on the Expression Builder dialog box.
7. Click OK on the Layer Properties dialog box.

Now the district centroid points are shown with columns proportionate to the thyroid cancer rates. If you navigate the scene you will see that the areas with the highest contamination levels also tend to have high thyroid cancer rates, although there are areas with lower CS137 contamination levels that also have high cancer rates.

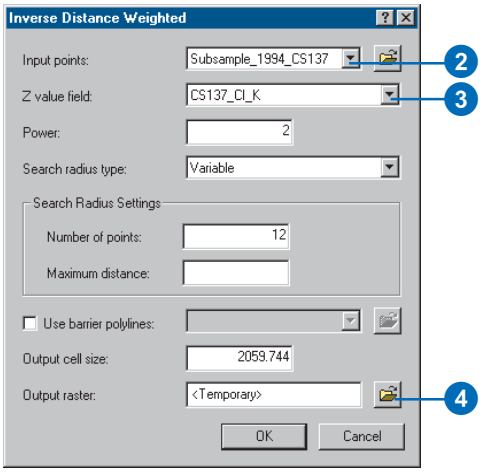
Creating a surface from point sample data

You know what the soil concentrations of CS137 are at the sample point locations, but you do not know what they are at the locations between sample points. One way to derive the information for locations between sample points is to interpolate a raster surface from the point data. There are many ways to interpolate such surfaces, which result in different models of varying accuracy. In this exercise you will interpolate a surface from the samples using the Inverse Distance Weighted (IDW) interpolation technique. IDW interpolation calculates a value for each cell in the output raster from the values of the data points, with closer points given more influence and distant points less influence.

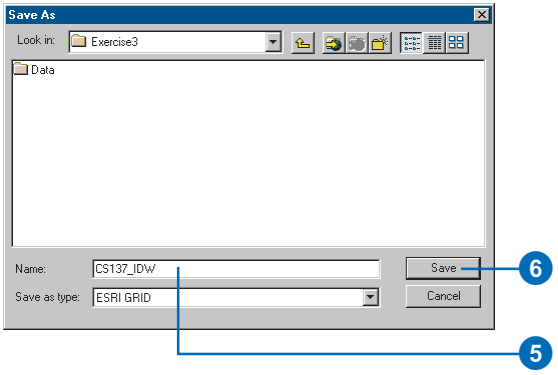
1. Click 3D Analyst, point to Interpolate to Raster, and click Inverse Distance Weighted.



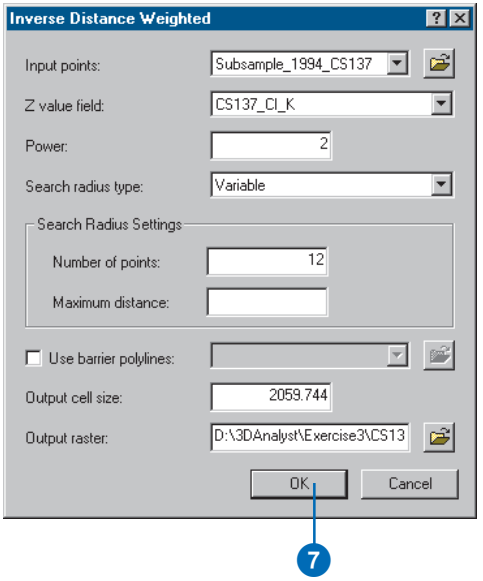
2. Click the Input points dropdown list and click Subsample_1994_CS137.



3. Click the Z value field dropdown list and click CS137_CI_K.
4. Click the Browse button.
5. Navigate to the Exercise3 folder and type "CS137_IDW" in the Name field.



6. Click Save.
7. Click OK.

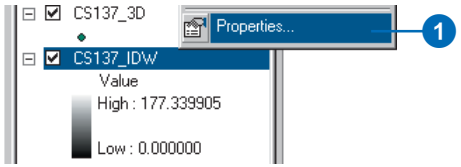


ArcScene interpolates the surface and adds it to the scene.

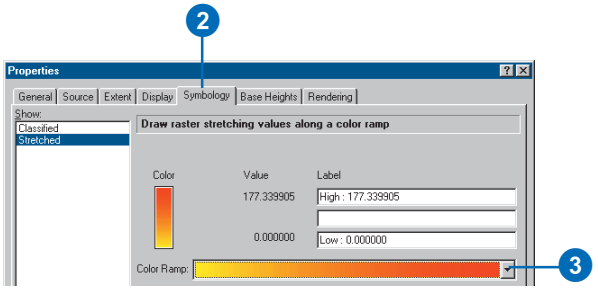
Viewing the interpolated surface

Now that the surface has been added to the scene, you can see that there are two areas with very high concentrations of CS137. You will view the surface in perspective, with a new color ramp, to better see its shape.

1. Right-click CS137_IDW and click Properties.

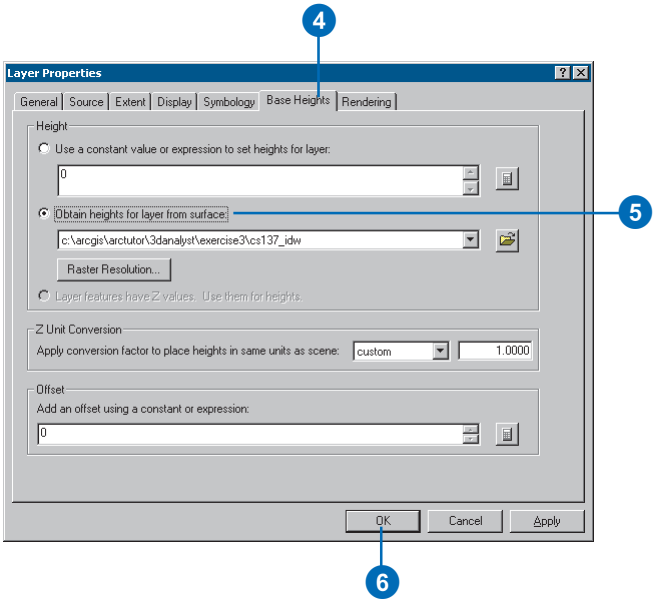


2. Click the Symbology tab.

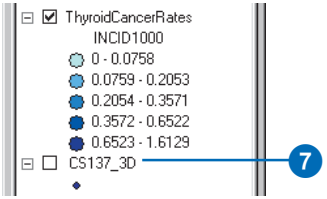


3. Click the Color Ramp dropdown arrow and click a new color ramp.

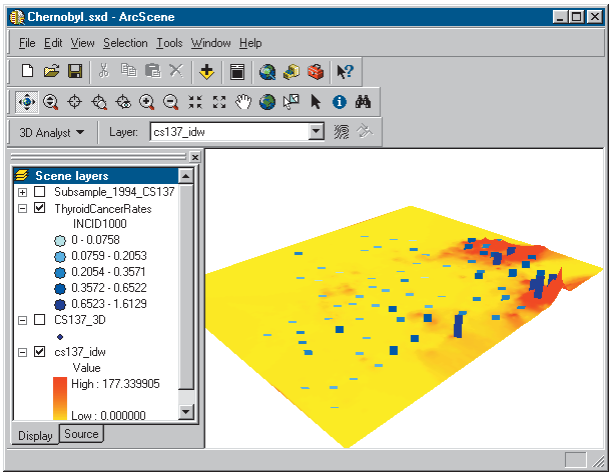
4. Click the Base Heights tab.



5. Click Obtain heights for layer from surface.
6. Click OK.
7. Uncheck CS137_3D in the table of contents.



Now you can see the interpolated surface of CS137 contamination, along with the thyroid cancer rate data.

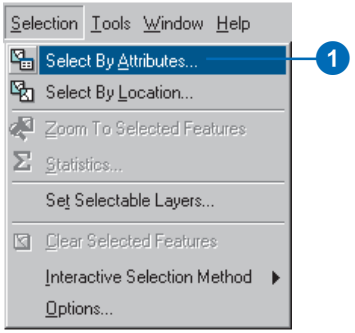


Next, you will select the province centers with the highest rates of thyroid cancer.

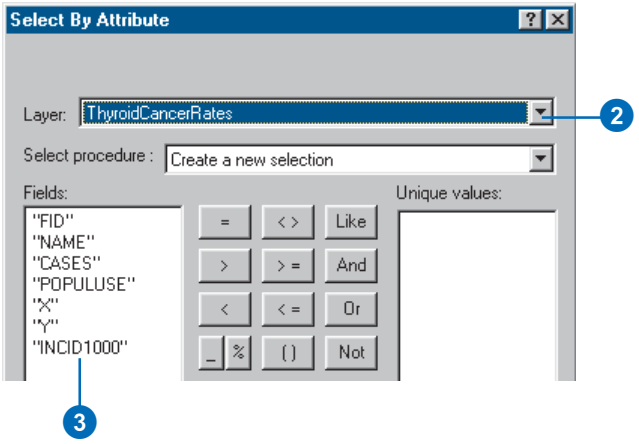
Selecting features by an attribute

Sometimes it is important to focus on a specific set of data or specific features. You can select features in a scene by their location, by their attributes, or by clicking them with the Select Features tool. You will select the province centers by attribute to find the locations with the highest rates.

1. Click Selection and click Select By Attributes.

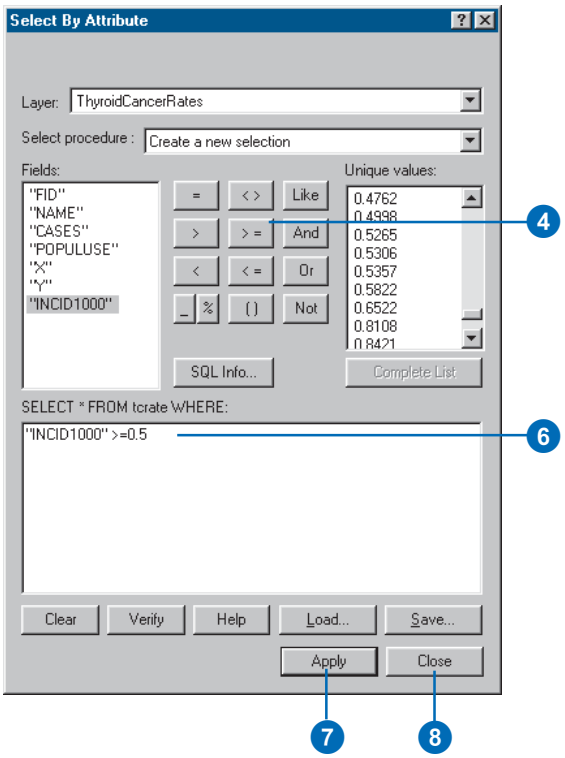


2. Click the Layer dropdown arrow and click ThyroidCancerRates.



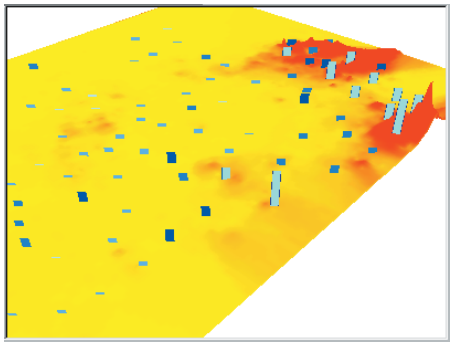
3. Double-click INCID1000 in the Fields list.

4. Click the >= button.



5. Type “0.5”.
6. Check the selection expression you’ve built.
7. Click Apply.
8. Click Close.

   The province centers with thyroid cancer rates greater than 0.5 cases per 1,000 are now selected in the scene.

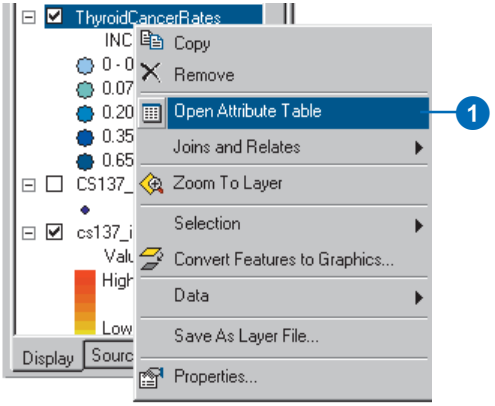


They are drawn in light blue to indicate that they are selected.

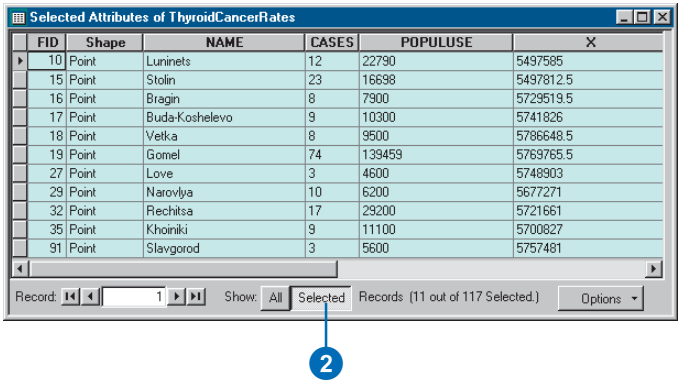
Viewing the attributes of features

You will investigate attributes of the selected locations and find out how many cases of thyroid cancer occurred in these districts.

1. Right-click ThyroidCancerRates and click Open Attribute Table.

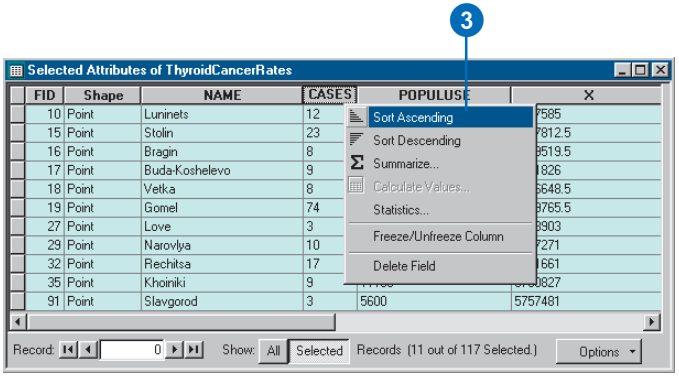


2. Click the Selected button.



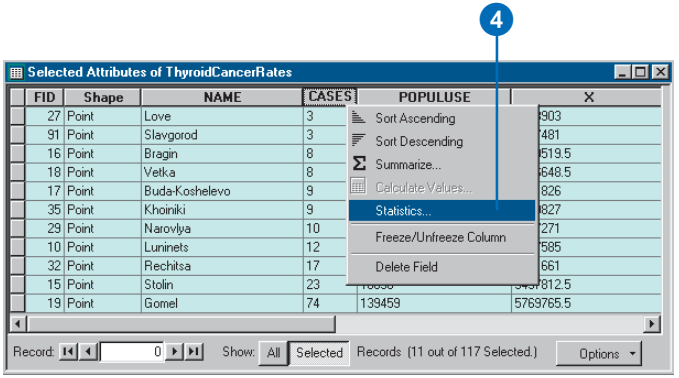
The table now shows only those features that you selected.

3. Right-click CASES and click Sort Ascending.



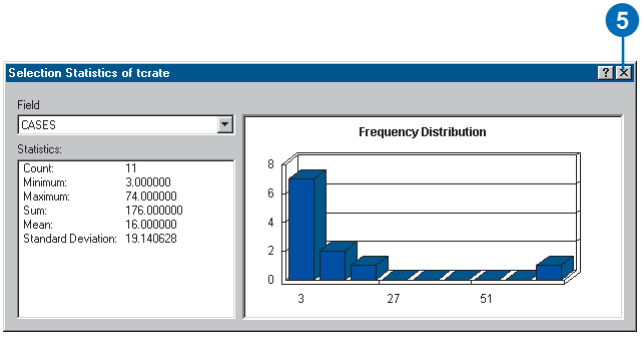
The selected province centers are sorted according to the number of cases.

4. Right-click CASES and click Statistics.

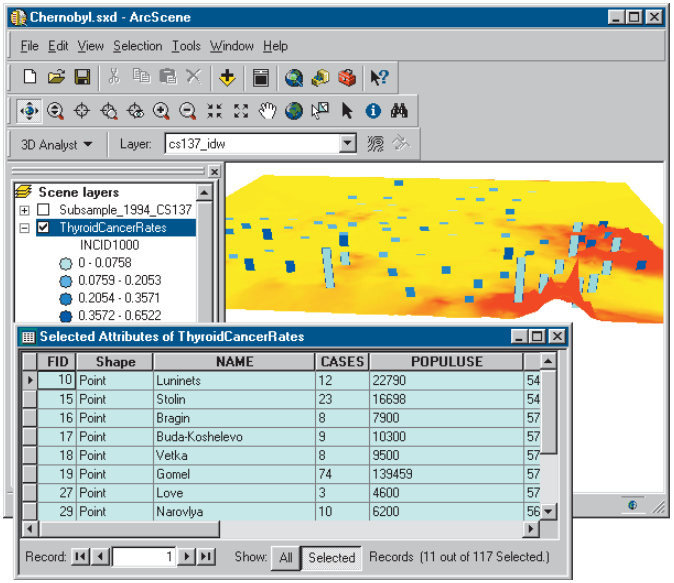


The total number of cases in the selected set of 11 province centers is 176.

5. Close the Selection Statistics dialog box.



6. Click the Navigate button and click on the scene.



You can work in ArcScene while the attribute table is open.

7. Click the Save button.

In this exercise you have created 3D features, extruded point features, and interpolated a raster surface from a set of data points. You've compared the extruded vector data to the surface data and explored the attributes of the vector data.

Exercise 4: Building a TIN to represent terrain

The town of Horse Cave, Kentucky, is situated above a cave that once served as the source of drinking water and hydroelectric power for the town. Unfortunately, the groundwater that flows in the cave was polluted by household and industrial waste dumped on the surface and washed into sinkholes. Dye tracing studies and a three-dimensional survey of the cave revealed the relationship between the cave passages and the town and demonstrated the connection between open surface dump sites and contamination of the groundwater in the cave below.

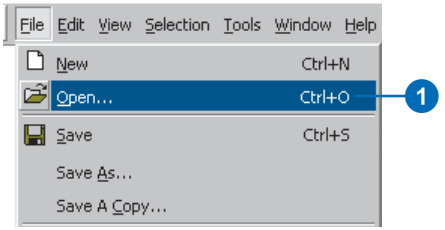
Thanks to the development in 1989 of a new regional sewage facility and the joint efforts of the Cave Research Foundation and the American Cave Conservation Association (ACCA), the groundwater is cleaner, and the cave has been restored. It is now operated as a tour cave and educational site by the ACCA.

Cave data was provided courtesy of the ACCA.

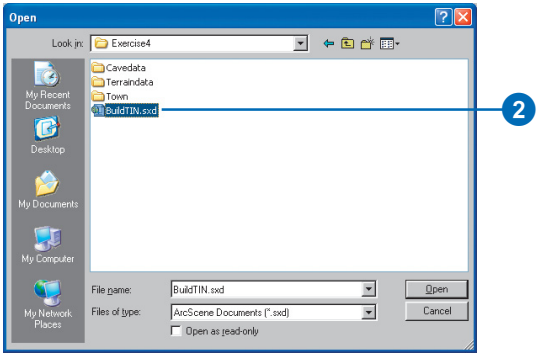
Viewing the cave and the landscape

First you will open the BuildTIN scene and view the cave survey and some terrain data layers. You'll use this terrain data to create a TIN and drape some other layers on it to visualize the relationship of the cave to the town.

1. Click File and click Open.

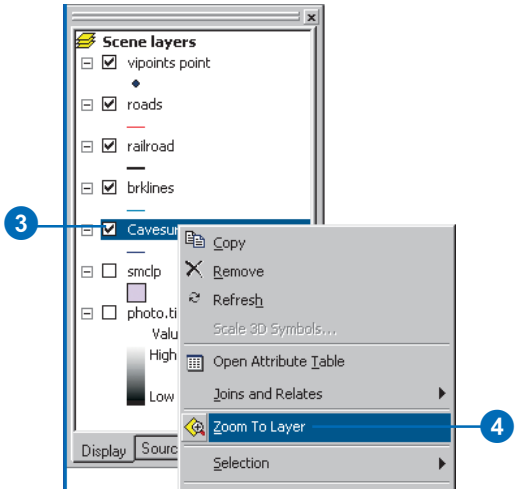


2. Navigate to the Exercise4 folder and double-click BuildTIN.sxd.



The scene opens, and you can see the location of roads and railroads, some sample elevation points, and a few significant contour lines. In the table of contents, you can see that some layers have been turned off.

3. Check the box to show the Cavesurvey layer.



4. Right-click Cavesurvey and click Zoom To Layer.

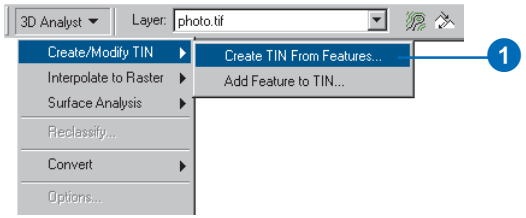
   The cave survey data consists of PolylineZ features, which are automatically drawn in 3D because they have z-values embedded in their geometry. They appear above the rest of the data because all of the other layers are drawn with the default elevation of 0.

   In the next steps you will build a TIN to provide the base heights for the streets and a photo of the town.

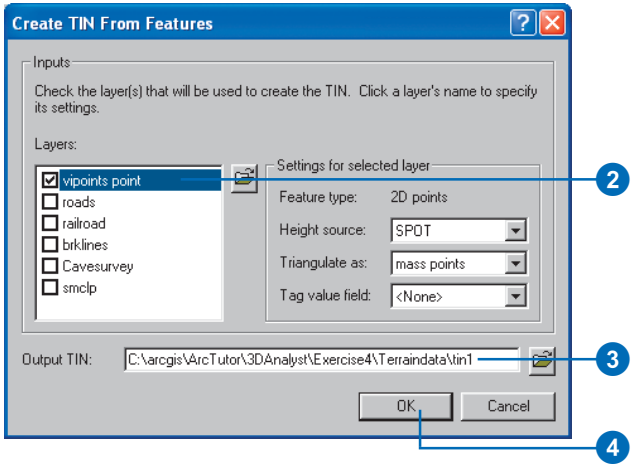
Creating a TIN from point data

You have a point layer called vipoints point. This coverage consists of points with an attribute called SPOT that contains elevation values taken at these points. You'll create the TIN surface model from these points.

1. Click 3D Analyst, point to Create/Modify TIN, and click Create TIN From Features.



2. Check vipoints point.

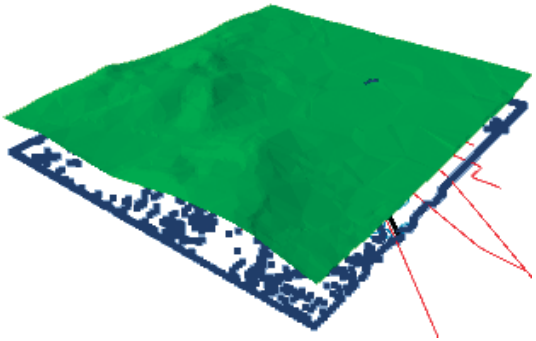


   The SPOT field name appears in the Height source dropdown list, and the layer will be triangulated as mass points.

3. Change the default path so that the new TIN will be created in the Exercise 4\Terraindata\ folder.

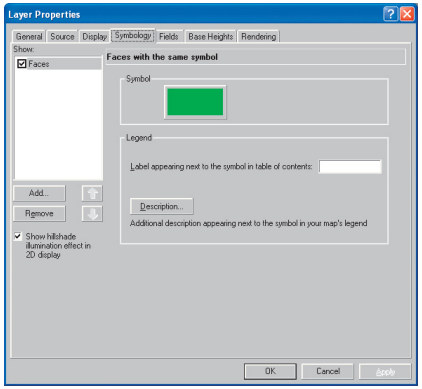
4. Click OK.

The TIN is created and added to the scene. Note that it is drawn above the Cavesurvey layer; the elevation values in the TIN define its base height.

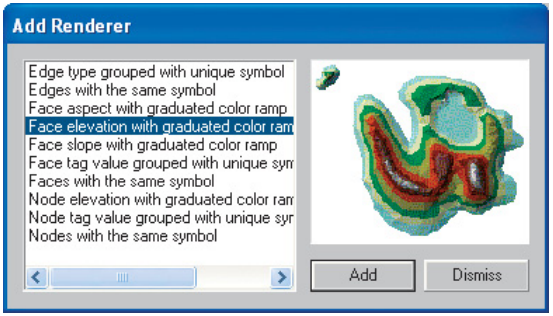


By default, the TIN is symbolized using a single color for every face.

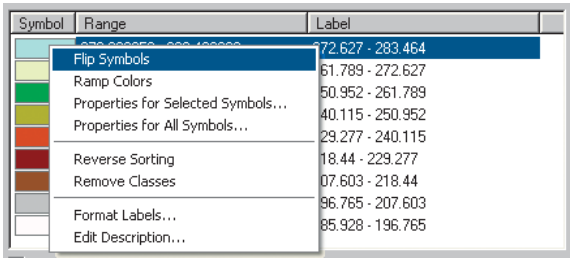
Right-click on the tin1 layer in the table of contents and click Properties, then click the Symbology tab. You can see there is a single renderer in place, titled Faces.



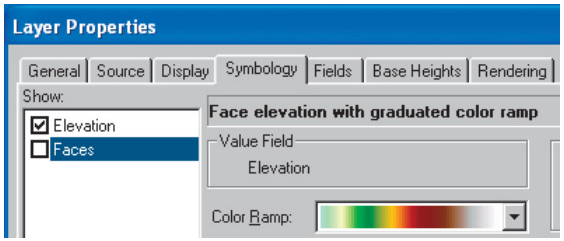
Click on the Add button to open up the Add Renderer dialog box. Click on the Face elevation with graduated color ramp option and click Add. Click Dismiss to close the Add Renderer dialog box and return to the Layer Properties dialog box.



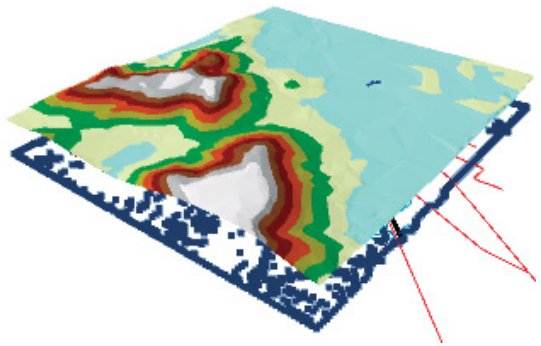
If the symbol for the highest elevation range is set to blue instead of white, then right-click on any of the symbols and click Flip Symbols. This will switch the order of the symbols and render the highest points of the TIN as snow capped peaks.



Switch off the old single color renderer by checking off the Faces checkbox in the list of renderers.



Click OK to close the Layer Properties dialog box.

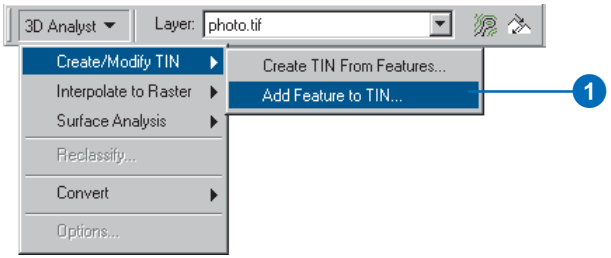


While this TIN is a fairly good model of the surface, you can make it more accurate by adding more features.

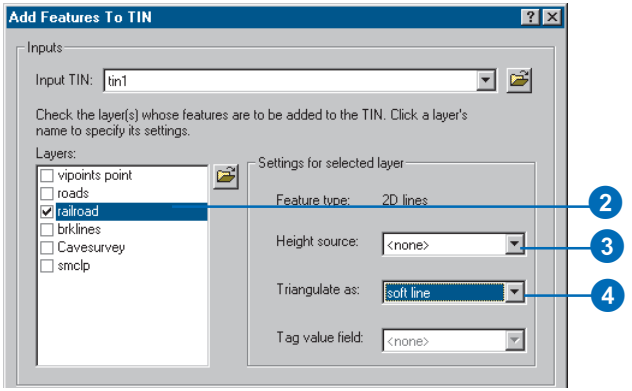
Adding features to a TIN

Now you will add hard and soft breaklines and a clip polygon to the TIN. You'll add the railroad features as soft breaklines, so they'll be represented on the surface but won't influence the shape of the surface. You'll add the brklines features as hard breaklines with elevation values to refine the shape of the surface in areas that you're most interested in. Finally, you will add the smclp polygon as a soft clip polygon to more smoothly define the edge of the TIN.

1. Click 3D Analyst, point to Create/Modify TIN, and click Add Feature to TIN.

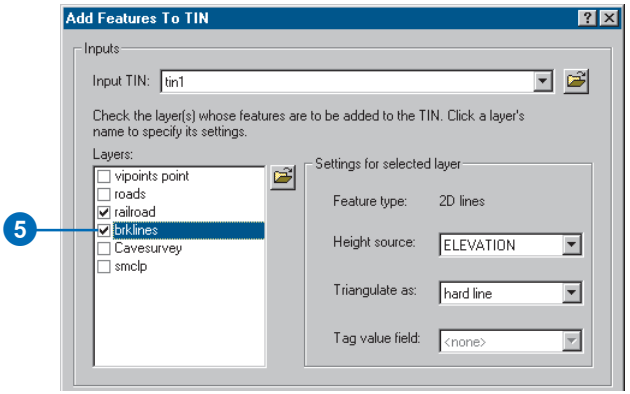


2. Check railroad.



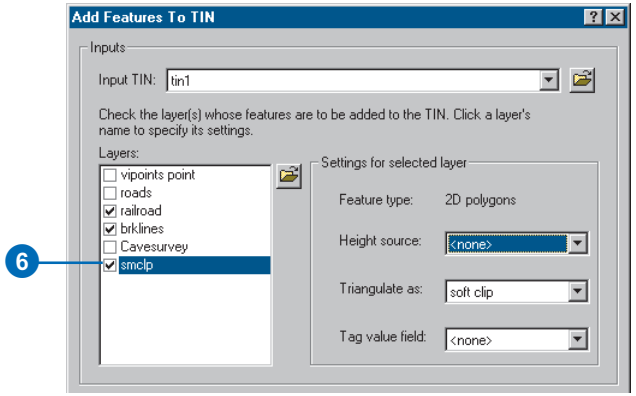
3. Click the Height source dropdown arrow and click <none>.
4. Click the Triangulate as dropdown arrow and click soft line.

5. Check brklines.



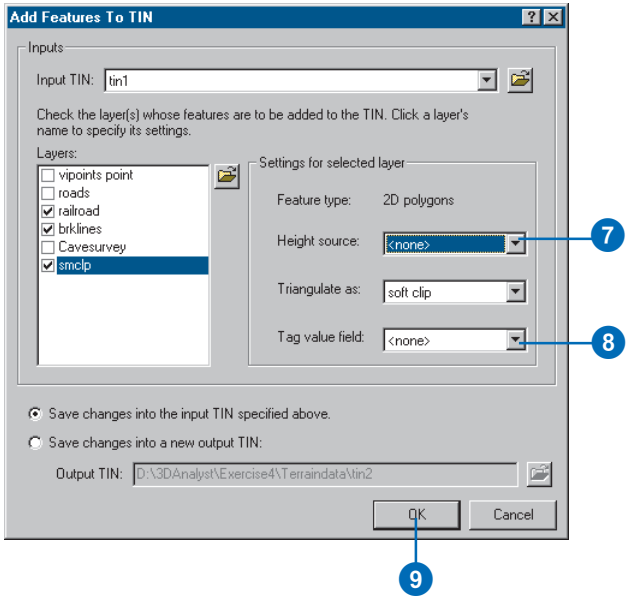
The Add Features To TIN tool detects that there is an ELEVATION field and uses it for the height source. You will accept the default and triangulate them as hard breaklines.

6. Check smclp.



7. Click the Height source dropdown arrow and click <none>.
8. Click the Tag value field dropdown arrow and click <none>.

   You have defined the feature layers that you want to add to your TIN and specified how they should be integrated into the triangulation.



9. Click OK.

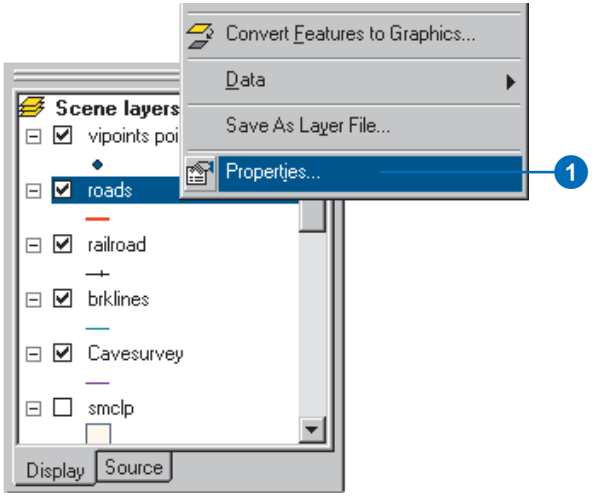
The new features are added to the TIN.

After the next step you will see that the railroad follows a bed that has been leveled somewhat relative to the surface.

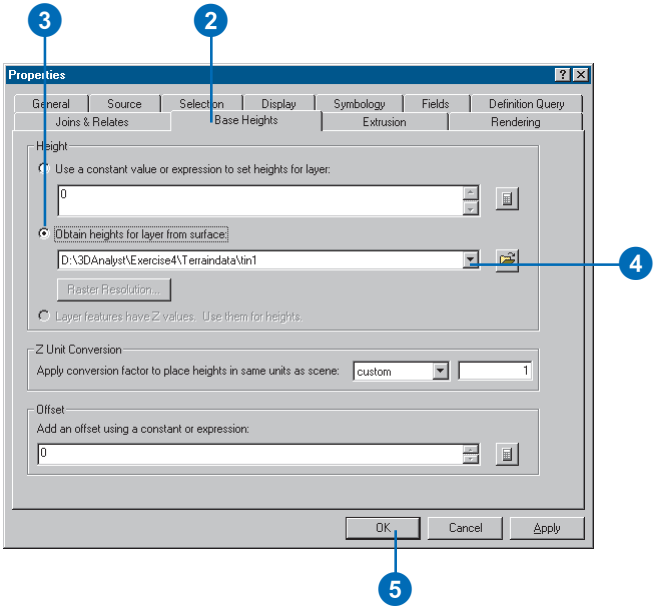
Setting feature base heights from the TIN

Now you will set the base heights for the road and railroad features from the new TIN.

1. Right-click roads and click Properties.



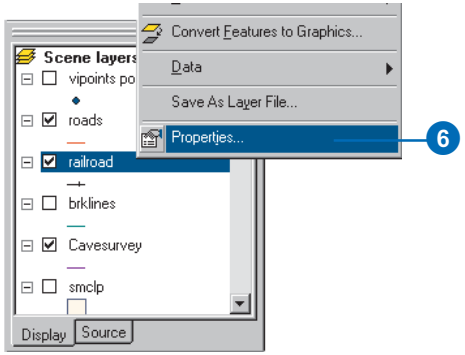
2. Click the Base Heights tab.



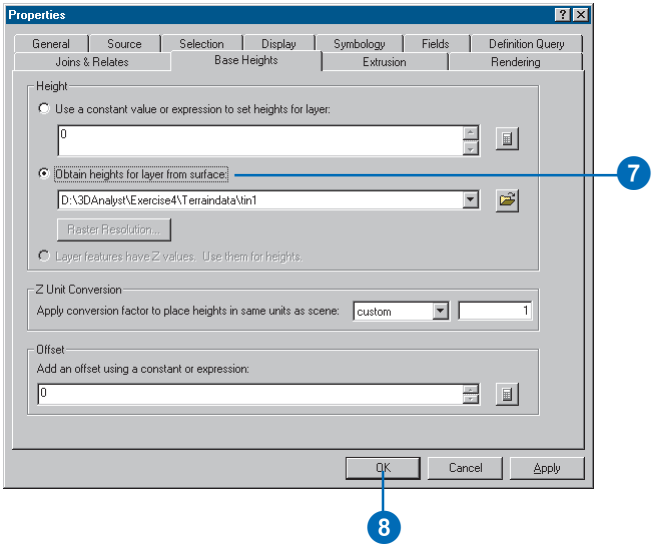
3. Click Obtain heights for layer from surface.
4. Click the dropdown arrow and click tin1.
5. Click OK.

   The road features are now draped over the TIN surface that you created. Now you will drape the railroad features over the surface.

6. Right-click railroad and click Properties.

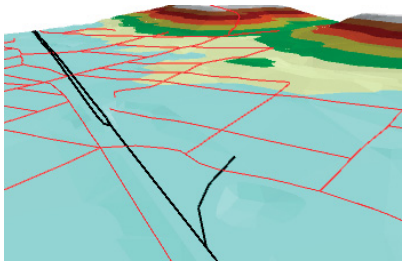


7. Click Obtain heights for layer from surface.



8. Click OK.

The railroad features are now draped over the TIN surface that you created.

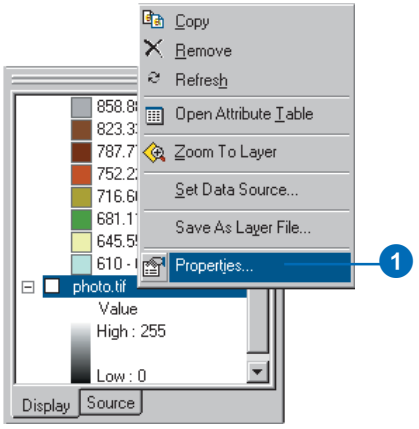


Next you'll drape the aerial photo over the TIN.

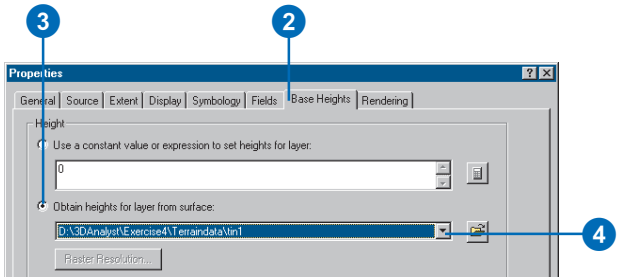
Setting raster base heights from the TIN

Including the aerial photo of the town in the scene makes the relationship between the cave and the town much more evident. You'll drape the raster over the TIN and make it partly transparent so that you'll be able to see the cave beneath the surface.

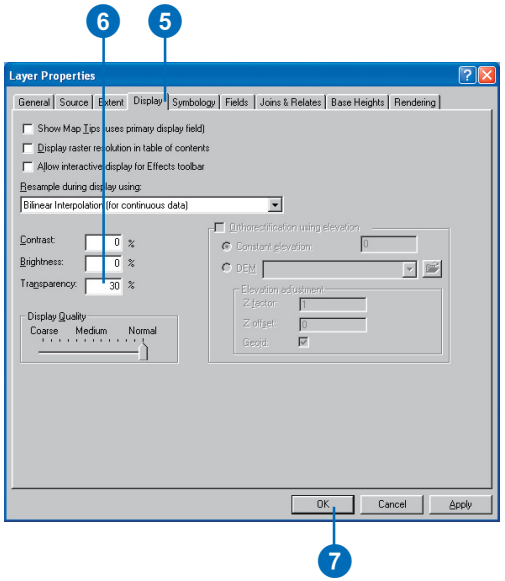
1. Right-click photo.tif and click Properties.



2. Click the Base Heights tab.
3. Click Obtain heights for layer from surface.
4. Click the dropdown arrow and click tin1.



5. Click the Display tab.
6. Type "30" in the Transparency text box.



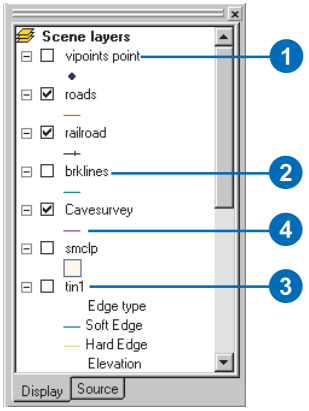
7. Click OK.
8. Check photo.tif.

Now the aerial photo is 30 percent transparent. You can see large patches of the TIN over the photo because the TIN and the photo have the same drawing priority. If you wanted the TIN to be visible below the photo, you could change its drawing priority to 10 (lowest) on the Rendering tab of the TIN's Layer Properties dialog box. You could also offset the base height of the TIN or the photo by a small amount.

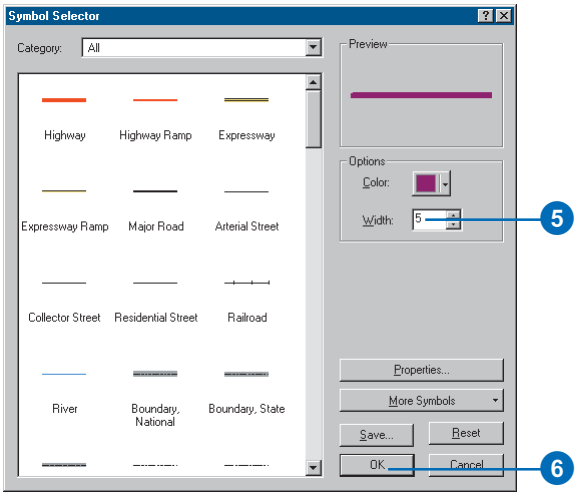
Cleaning up the scene

To clean up the scene you'll turn off some layers that are no longer needed and make the cave line symbol larger.

1. Uncheck vipoints point.
2. Uncheck brklines.
3. Uncheck tin1.
4. Double-click the line symbol for the Cavesurvey layer.

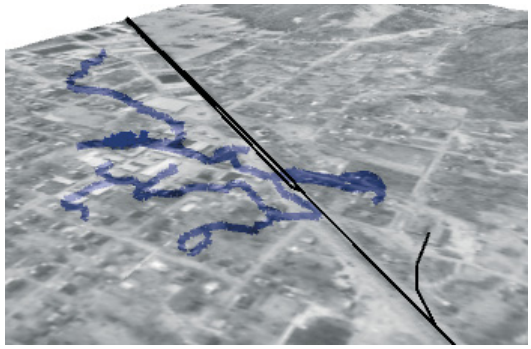


5. Type “5” in the Width box.



6. Click OK.

   Now you can see the three-dimensional passages of the cave, symbolized by thick lines. The surface features and the aerial photo provide context, so you can easily see the relationship of the cave to the town.



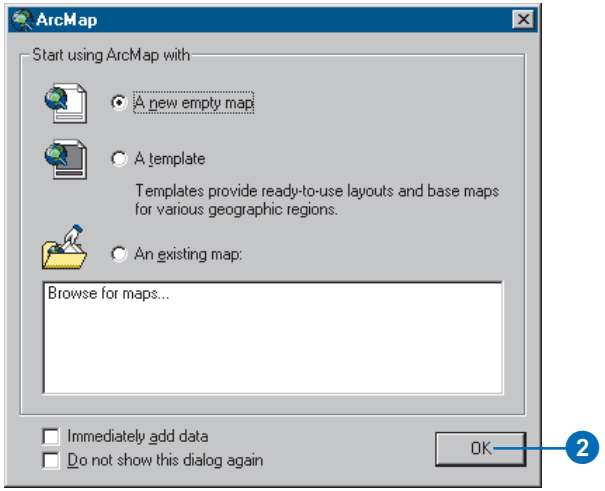
Creating a profile of the terrain

The cave follows the valley floor orientation. To get an understanding of the shape of the valley, you will create a profile across the TIN. In order to create a profile, you must first have a 3D line (feature or graphic). You will start ArcMap, copy the TIN to the map, and digitize a line to make your profile.

1. Click the Launch ArcMap button.

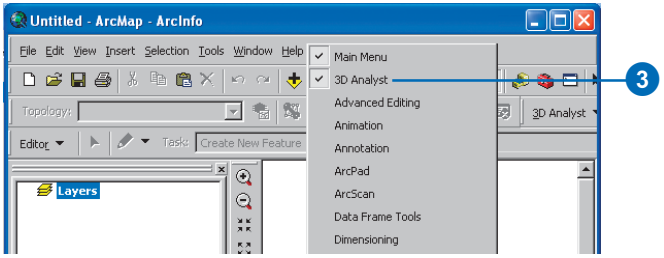
   ArcMap starts.

2. Click OK.



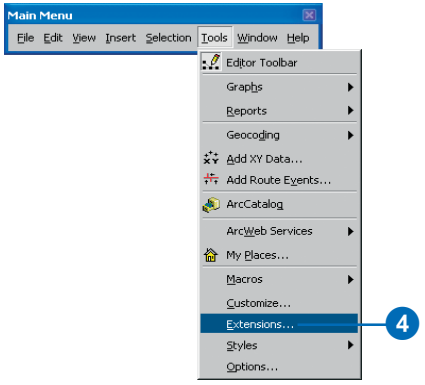
Now you will add the 3D Analyst toolbar to ArcMap. The ArcMap 3D Analyst toolbar contains a few tools that do not appear on the ArcScene 3D Analyst toolbar. Two of these are the Interpolate Line tool and the Create Profile Graph tool, which you will use to create your profile of the surface.

3. Right-click on one of the ArcMap toolbars and click 3D Analyst.

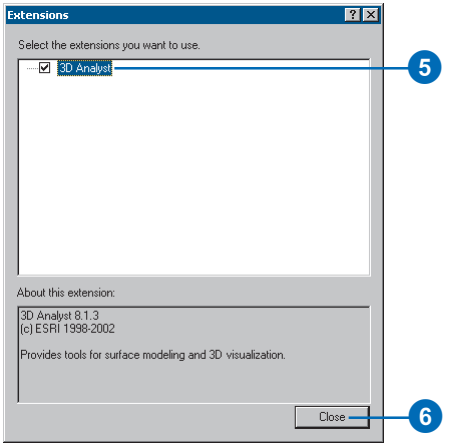


The 3D Analyst toolbar appears.

4. Click Tools and click Extensions.

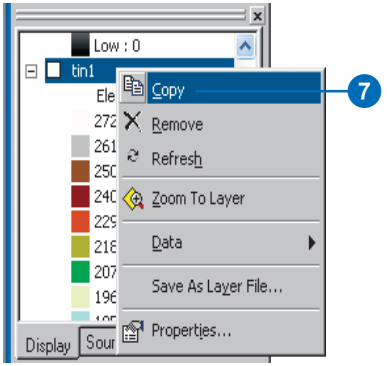


5. Check 3D Analyst.
6. Click Close.

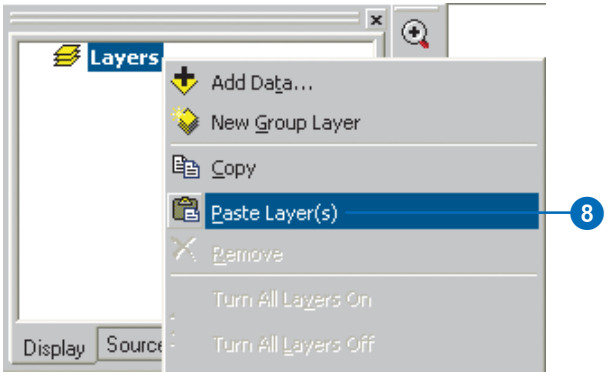


The 3D Analyst extension is enabled.

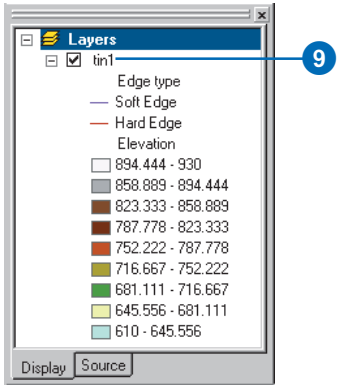
7. Right-click tin1 in the ArcScene table of contents and click Copy.



8. Right-click Layers in the ArcMap table of contents and click Paste Layer(s).

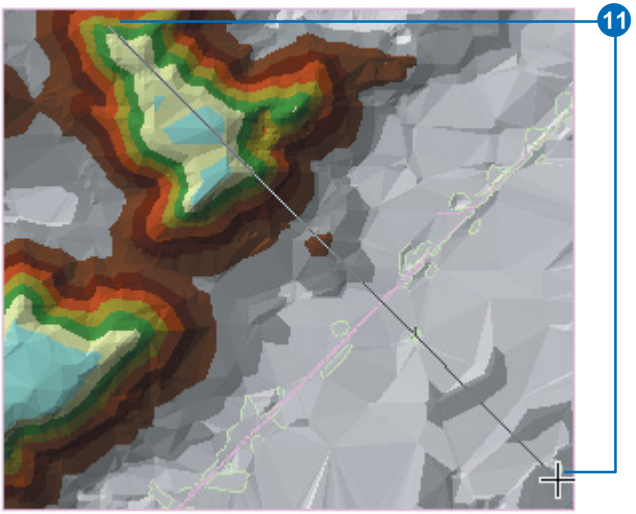


9. Check tin1 in the ArcMap table of contents to make the layer visible.



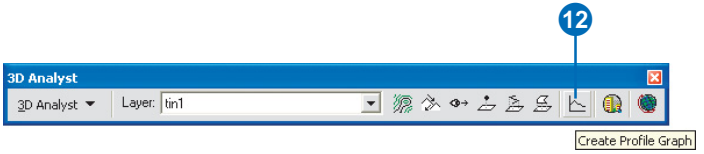
10. Click the Interpolate Line button.

11. Click the upper-left corner of the TIN, drag the line to the lower-right corner, and double-click to stop digitizing.

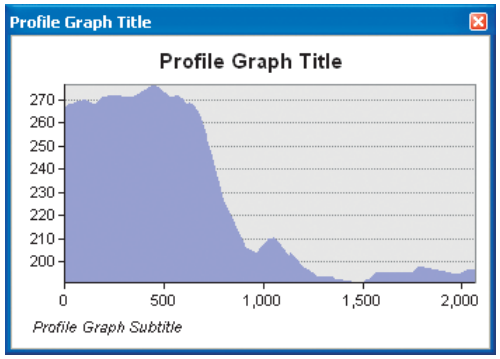


You can create a profile along a line with more than one segment, but in this case you'll just make one straight line.

12. Click the Create Profile Graph button.

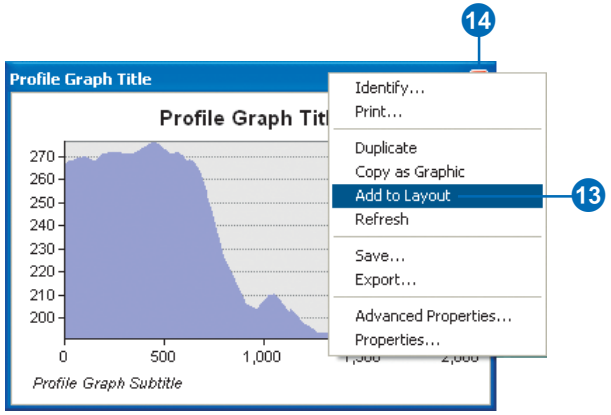


The profile graph is created.



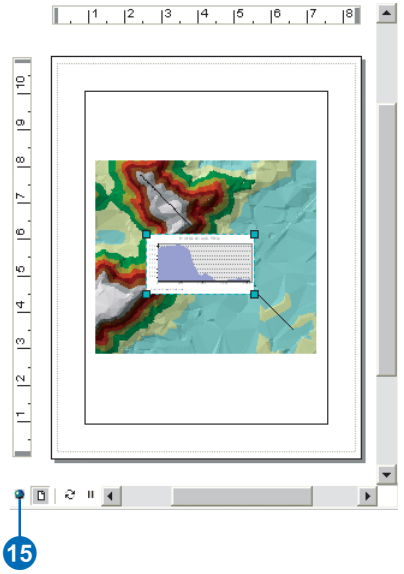
You can edit the title, subtitle, and other properties of the graph; you can save, print, or export the graph; you can copy it to the clipboard; and you can show the graph on the layout. You can also simply close the graph.

13. Right-click the Profile Graph Title bar and click Add to Layout.
14. Close the profile graph window.



You can see the graph on the layout of the map.

15. Click the Data View button to return to data view.

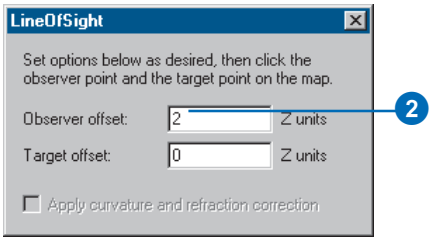


Creating a line of sight on the terrain

Another way of understanding the terrain is to create a line of sight. Lines of sight show what parts of a surface are visible and what parts are hidden along a line from an observer point to a target point.

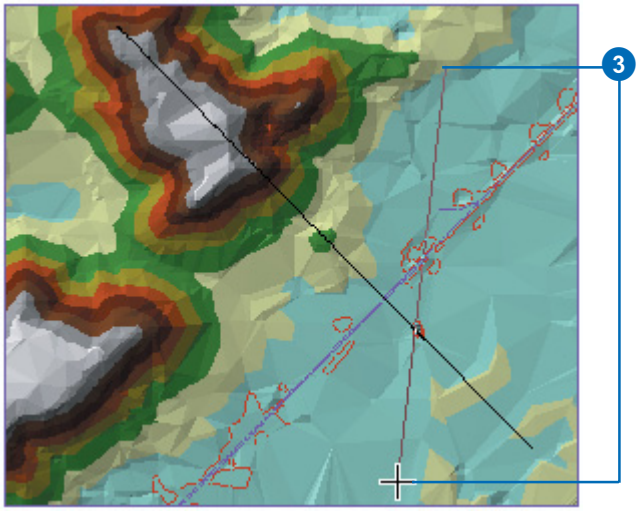
1. Click the Create Line of Sight button.

2. Type “2” in the Observer offset text box.

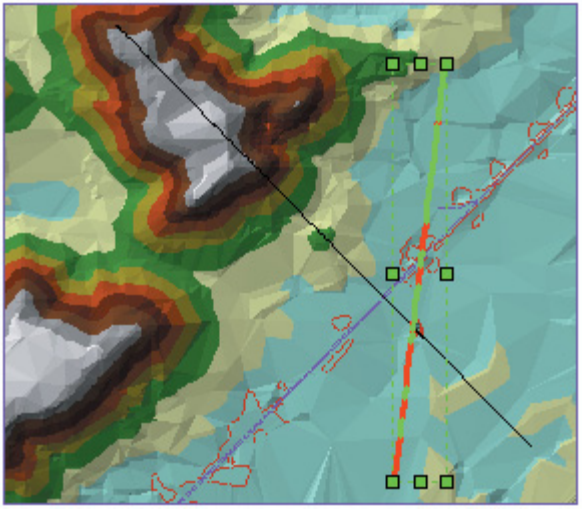


The line of sight will be calculated to show what is visible from the perspective of an observer two meters tall, as the z units for this scene are meters.

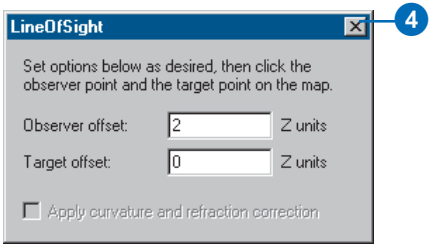
3. Click on the south slope of the higher land in the upper-right part of the TIN (the observer point), drag the line to the lower-right part, and release the mouse button (the target point).



The line of sight is calculated. The green segments show areas that are visible from the observer point; the red segments are hidden from the observer.

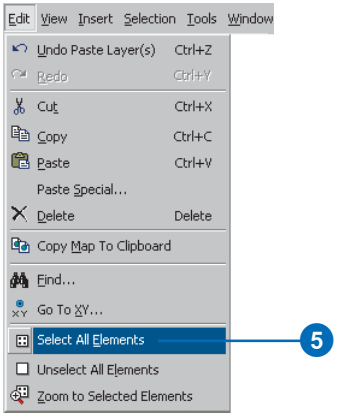


4. Close the LineOfSight dialog box.



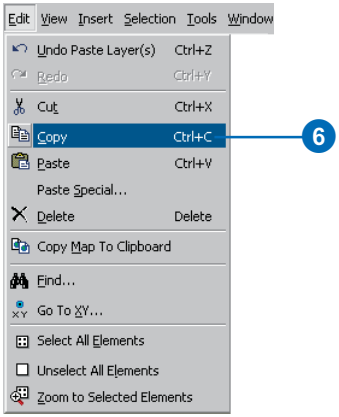
Lines of sight, like other graphic lines, can be copied from ArcMap to ArcScene. Now you will copy both the lines you've created into the scene.

5. Click Edit and click Select All Elements.

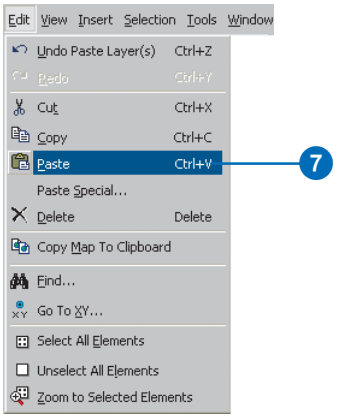


Both of the lines you created are selected.

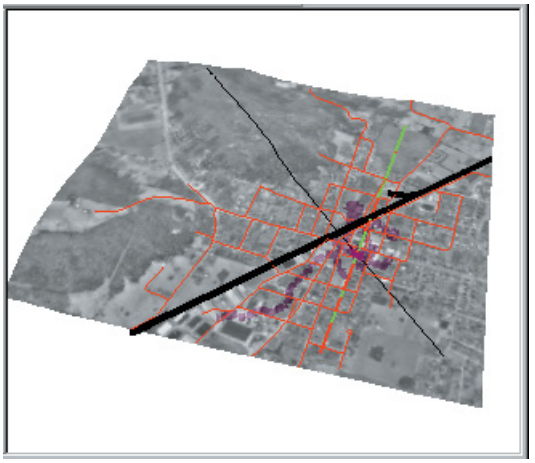
6. Click Edit and click Copy.



7. Click Edit in ArcScene and click Paste.

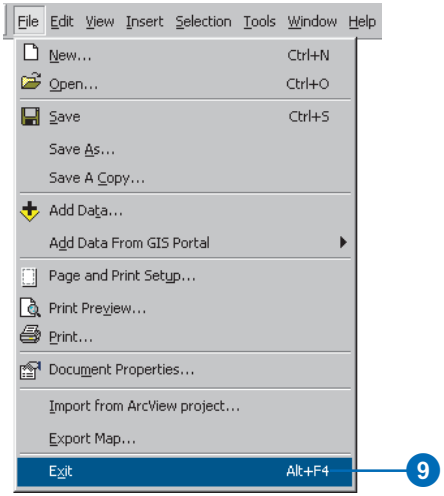


The lines are pasted into the scene.

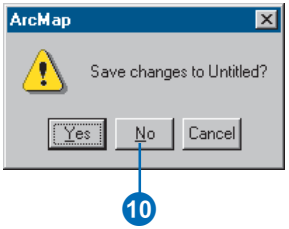


8. Click the Save button in ArcScene.

9. Click File in ArcMap and click Exit.



10. Click No.



Exercise 5: Working with animations in ArcScene

Imagine that you wish to create an animated sequence showing the flight of an object over a landscape. You've created a TIN and have draped images over it to show the area. You also have some data pertaining to a strange phenomenon that has been occurring in the region. You are interested in displaying all the data in a dynamic way, making an animation to tour points of interest, and showing how you made the surface. You would also like to model the phenomenon by moving a layer in the scene.

The tutorial data has already been assembled in the scene document named Animation.sxd. You will use ArcScene animation tools to effectively convey the points you want to show.

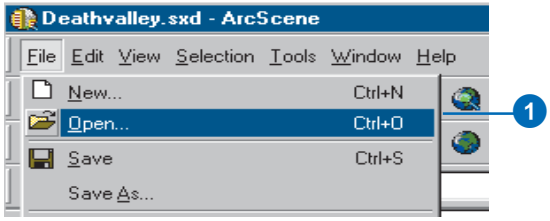
Data was supplied courtesy of MassGIS, Commonwealth of Massachusetts Executive Office of Environmental Affairs.

In this exercise, you will play an existing animation in the scene document, Final Animation_A.sxd, and perform the tasks typically used to create the animation.

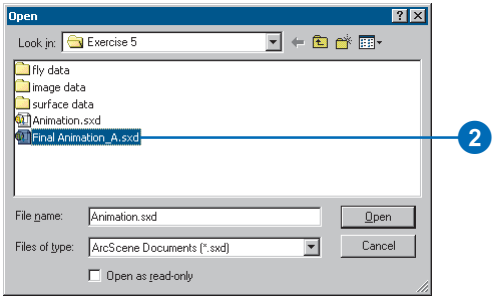
Opening the Final Animation_A scene document

In this section, you will play an animation that demonstrates some of the effects that you can create when you animate a scene.

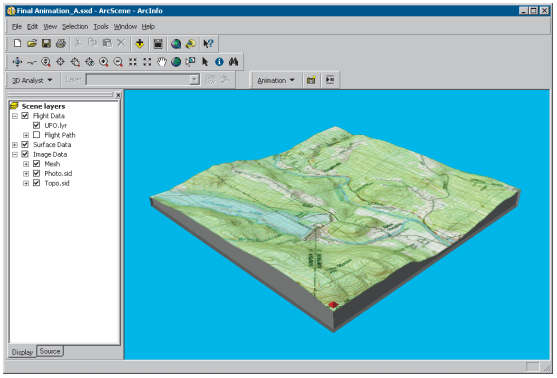
1. Click File in ArcScene and click Open.



2. Navigate to the Exercise5 folder and double-click Final Animation_A.sxd.



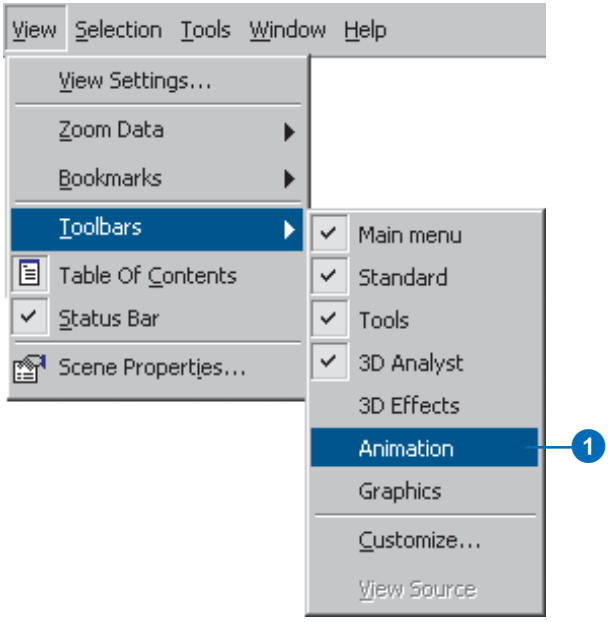
This scene contains geographic information and recorded special effects that have been combined to make an animation.



Playing the scene's animation

In order to view a scene's animation, you need to turn on the Animation toolbar.

1. Click View, point to Toolbars, and click Animation.



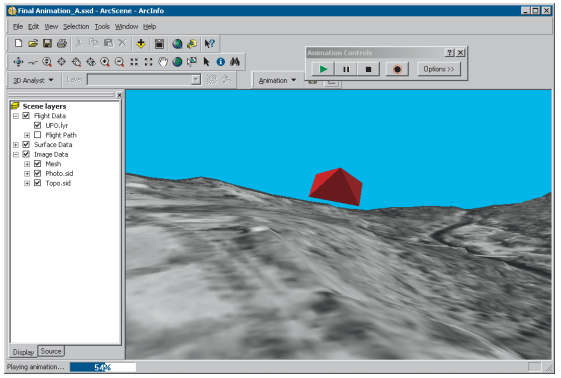
The Animation toolbar appears. Now you'll play the animation.

2. Click the Open Animation Controls button.

This animation shows the flight of a hypothetical unidentified flying object (UFO) over the terrain.

3. Click the Play button.

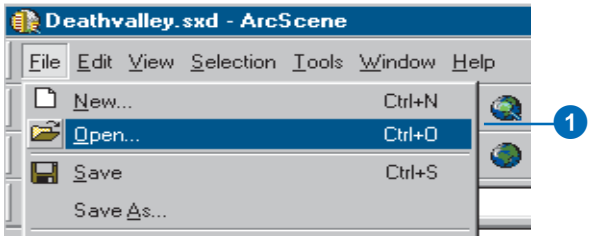
The animation plays, illustrating some of the effects you can use in an animated scene.



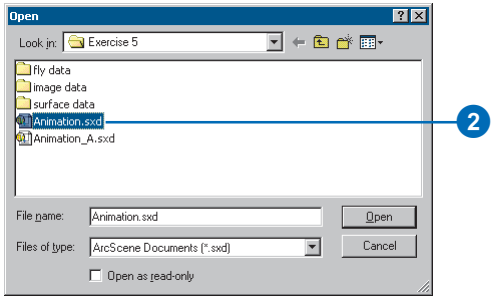
In the next section you will work through the steps used to make animations like this one.

Opening the Animation scene document

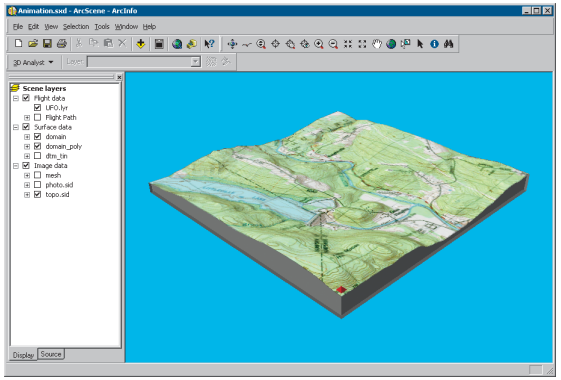
1. Click File in ArcScene and click Open.



2. Navigate to the Exercise 5 folder and double-click Animation.sxd.



The scene contains an ortho photo, a scanned topographic map, and other data you need to make your animation.



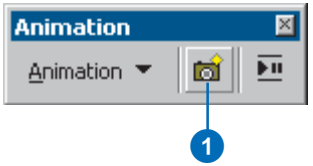
In this section, you'll use the animation tools to capture keyframes, import tracks, play back your animations, and save them to a scene document.

There are three types of keyframes that you can use to build animations. The first is a camera keyframe. A camera keyframe is a snapshot of the view you see in a scene. The second, a layer keyframe, is a snapshot of a layer's properties. The third type is a scene keyframe, which stores properties of a scene. In this section, you will create a simple animation from a set of camera keyframes.

Capturing Perspective views as keyframes to make an animation

The simplest way to make animations is by capturing views to be stored as keyframes. The captured views are snapshots of camera perspectives in a scene at a particular time. The most fundamental element of an animation is a keyframe. Keyframes are used as snapshots to interpolate between in a track. You'll create a set of keyframes to make a camera track that will show an animation between points of interest in your study area.

1. Click the Capture View button to create a camera keyframe showing the full extent of the scene.

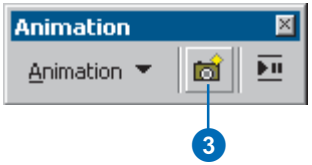


For a camera keyframe, the object is the virtual camera through which you view the scene. Navigating the scene changes camera properties that determine its position.

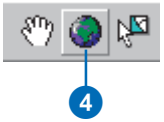
ArcScene interpolates a camera path between keyframes, so you'll need to capture more views to make a track that shows animation.

2. Right-click UFO.lyr and click Zoom To Layer.

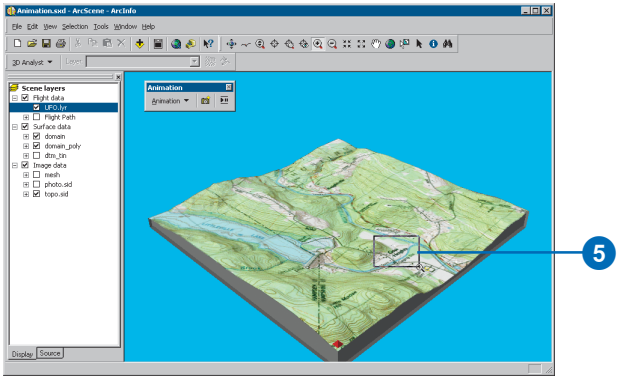
3. Click the Capture View button to create a camera keyframe showing the UFO layer.



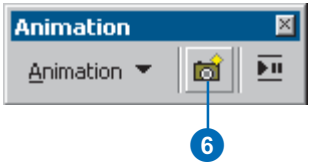
4. Click the Full Extent button to view all the data.



5. Click Zoom In on the Navigation toolbar and zoom to Goss Heights, located near the center of your view.

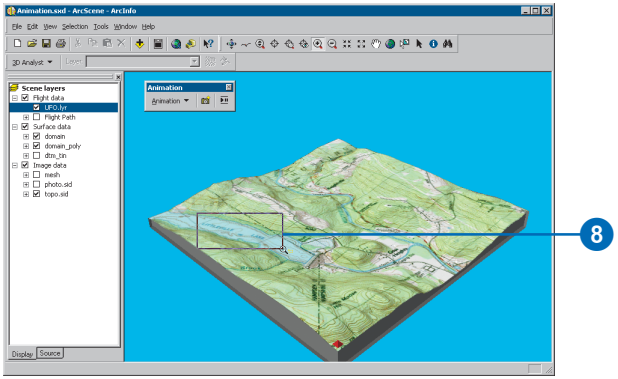


6. Click the Capture View button to create a camera keyframe of Goss Heights.

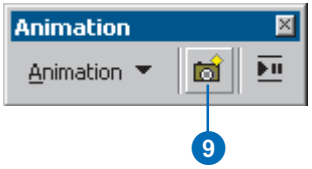


7. Click the Full Extent button.

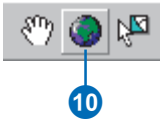
8. Zoom to Littleville Lake.



9. Click the Capture View button to capture a view of Littleville Lake.



10. Click the Full Extent button.



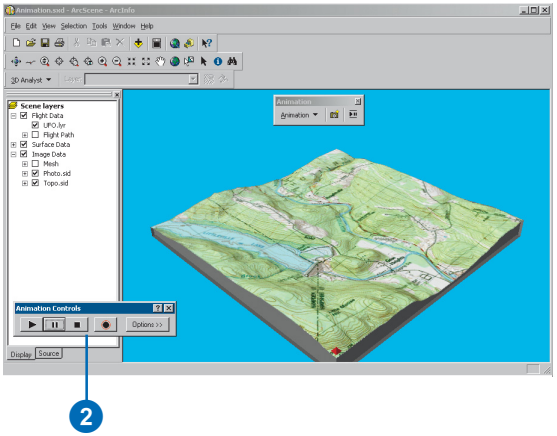
The captured views you just made are stored as a set of camera keyframes in a camera track. When the track is played, it shows a smooth animation between the keyframes. Next, you'll play your animation track.

Playing back your animation

You will play back animations using simple tools that resemble the controls of a video cassette recorder (VCR).

1. Click the Open Animation Controls button.

2. Click the Animation toolbar and drag it to the lower-left corner of the scene so it won't block your view of the tools or data.



3. Click the Play button.

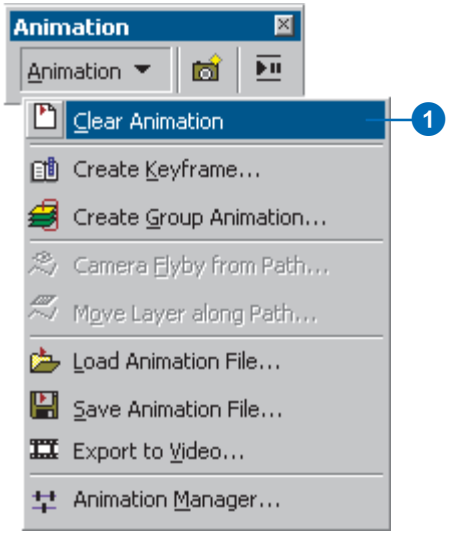
An animation is played back by interpolating the camera position between the keyframes in the track. In this case, the animation shows a virtual tour through the views you captured.

Clearing an animation

If you want to start over, you can erase all the tracks you created. In this section, you'll remove the tracks you just created so you can improve your animation.

1. Click Animation and click Clear Animation.

   All animation tracks are removed from the scene.

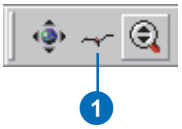


Recording navigation

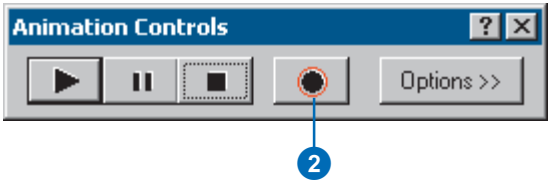
Another way to create a camera track for an animation is to record in real time while you navigate in a scene. In this section, you will record your view of the scene while you navigate using the Fly tool.

1. Click the Fly tool on the navigation toolbar.

   The Fly tool allows you to fly through your scenes.



2. Click the Record button to start recording your navigation.



   ArcScene begins recording as soon as you click the Record button. If you don't navigate right away, your track will reflect this.

Exercise 6: ArcGlobe basics

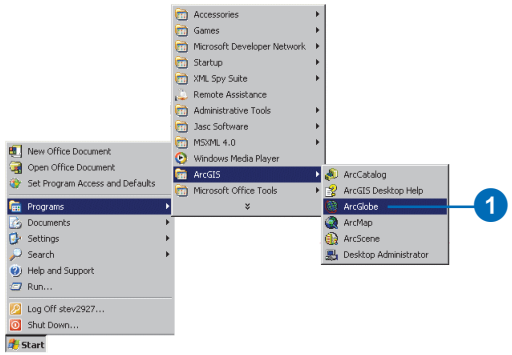
Navigating in ArcGlobe lets you explore your data and teaches you how to accomplish fundamental tasks that you'll use later.

In this exercise, you'll learn how to use the ArcGlobe navigation tools and set properties that enhance your viewing experience. This exercise assumes that you are using ESRI-supplied default layers.

Examining the default layers in ArcGlobe

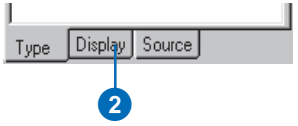
First, you'll start ArcGlobe and learn what kind of data is included by default.

1. Click the Start menu, point to Programs, then ArcGIS, and click ArcGlobe.



ArcGlobe starts and its default layers are loaded. Notice which layers are loaded in the globe by looking at the list in the table of contents.

2. Click the Type tab in the table of contents.



ArcGlobe categorizes layers according to their type. Layers are classified as elevation, draped, or floating. Elevation layers are raster sources with height information. They give the globe surface terrain. Draped layers are features or rasters that use the elevation layers as a source of their base heights. These layers appear draped over the globe surface. Floating layers are features or rasters that float independently of the terrain surface. They appear offset from other layers, either draped on discrete surfaces or set to some constant elevation. Note the way the default layers are categorized. Notice the default layers listed in the Type page of the ArcGlobe table of contents. Both layers are draped layers and, therefore, appear draped on the globe surface.

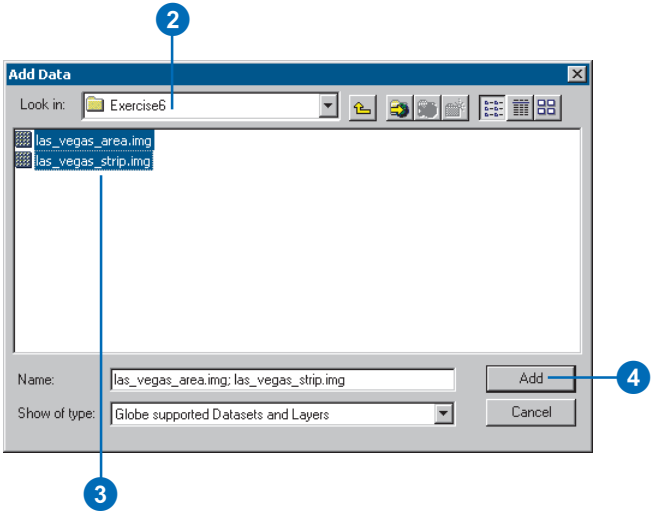
Adding more layers

Default layers serve as a background to any data that you want to add to ArcGlobe. Next you'll add some local data for the Las Vegas area.

1. Click the Add Data button.

2. Navigate to the location of the Exercise 6 tutorial data folder.
3. Click las_vegas_area.img, press Shift, and click las_vegas_strip.img.

   The multiple layers are selected.



4. Click Add.

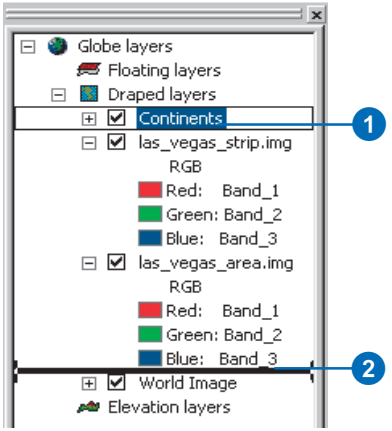
   The image layers are added to ArcGlobe as draped layers. You'll explore them later in this exercise.

Changing a layer's drawing priority in the table of contents

Draped layers that have overlapping extents need to have a drawing priority set so one layer gets drawn on top of the other. ArcGlobe makes some assumptions to accomplish this, using criteria such as the cell size of a raster layer. Occasionally, you'll need to override the ArcGlobe default drawing priorities. One way to do this is to change the order of draped layers as they appear in the Type page of the table of contents.

1. Click the Continents layer and drag it so it's just above the World Image layer.

   A black line indicates where the layer will be placed.



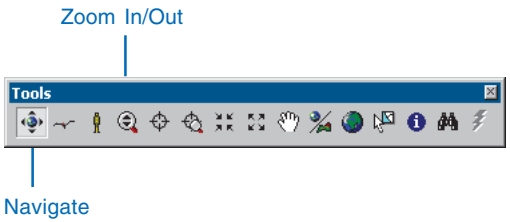
2. Release the mouse pointer to drop the layer in its new position.

   The drawing priority is now set so las_vegas_area.img and las_vegas_strip.img get drawn on top of the Continents layer.

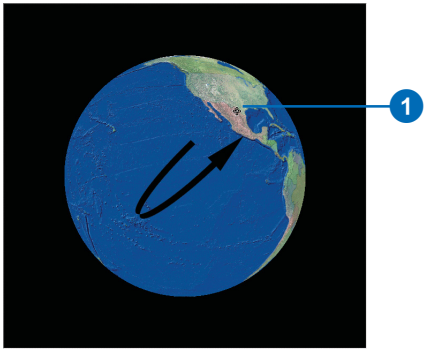
Navigating in Globe mode

ArcGlobe has two viewing modes: Globe and Surface. Globe mode allows you to navigate your data in the realm of the whole globe and sets the camera target to the center of the globe. Surface mode lets you work with your data at a lower elevation, allows additional perspective viewing characteristics, and sets the camera target on the surface of the globe. You'll learn how to navigate in Globe mode first, then in Surface mode.

The Navigate tool is active when you start ArcGlobe. You can see the names of other tools on the Tools toolbar by hovering the pointer over the tool.

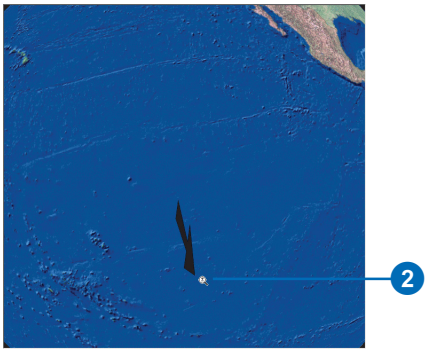


1. Click the globe, slowly drag up and to the right, then release the mouse pointer.



The globe rotates and the view angle lowers, so you gain a different vantage point.

2. Right-click and drag down.



The pointer changes to the Zoom In/Out pointer, and the view zooms in on the globe. To zoom out, right-click the globe and drag up.

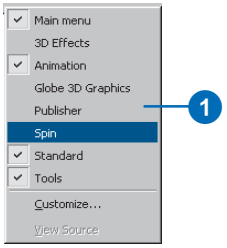
3. Click Full Extent.

The globe displays at full extent.

Turning on the Spin toolbar

You can use the Spin toolbar to automatically spin the globe clockwise or counterclockwise at any speed you wish.

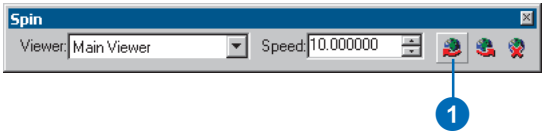
1. Right-click the menu area and click Spin.



The Spin toolbar appears as an undocked toolbar.

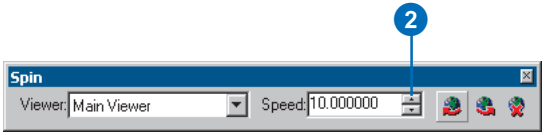
Using the Spin tools

1. Click the Spin Clockwise button.

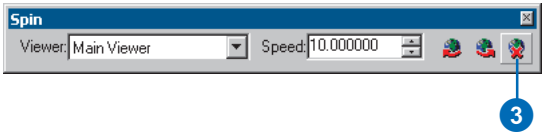


The globe continuously spins clockwise around the z-axis. You can change the speed at which it spins.

2. Click the Up arrow on the Speed text box to increase the rate at which the globe spins.



Continued clicks will incrementally increase the spin rate. You can also type in a value. Click the Down arrow to decrease the rate.



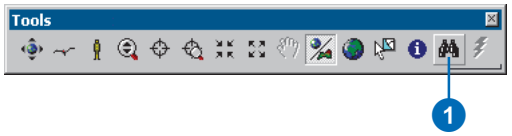
3. Click the Stop button to stop the globe from spinning.

   You can also press Esc to stop the globe from spinning.

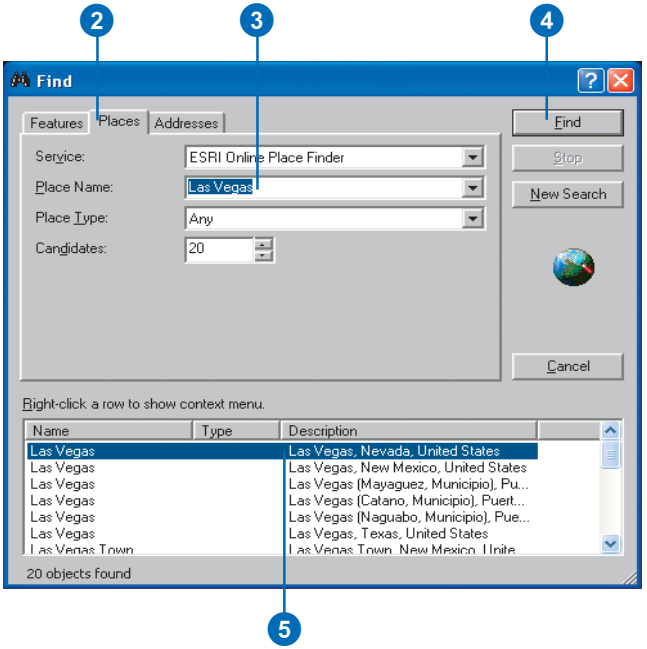
Finding places on the globe

If you have an Internet connection, you can find world locations by using the ESRI Online Place Finder in the Find dialog box.

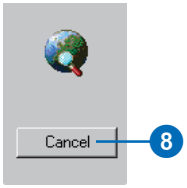
1. Click the Find button.



2. Click Places.
3. Type “Las Vegas” in the Place Name text box.
4. Click Find.
5. Right-click Las Vegas, Nevada, United States, and click Create Bookmark.
6. Right-click Las Vegas, Nevada, United States, and click Zoom To.



7. Click Cancel to close the Find dialog box.

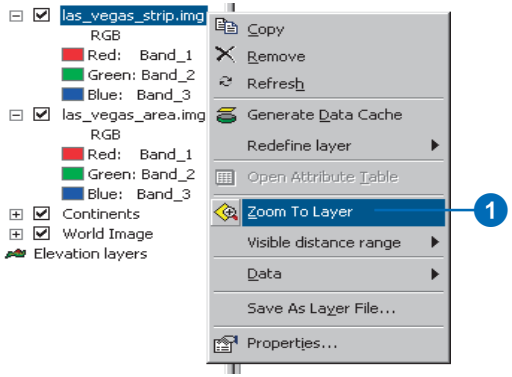


The Find tool is an easy way of locating almost any place in the world. Use it to locate points of interest, then use bookmarks to save perspectives of these places.

Now that you're zoomed close to the globe surface, you'll learn how to navigate in Surface mode.

Navigating in Surface mode

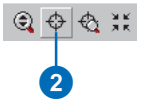
When you zoom in close to your data, you can switch to Surface mode to make your navigation apply more correctly to your new environment. Switching to Surface mode places the camera target on the globe surface and gives you a sense of 3D perspective while you navigate your data.



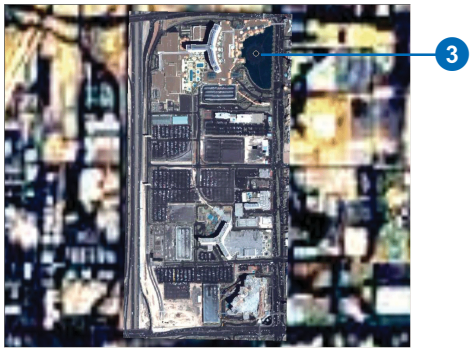
1. Right-click las_vegas_strip.img in the table of contents and click Zoom To Layer.

   The display zooms to the Strip area of Las Vegas.

2. Click the Center on Target button.

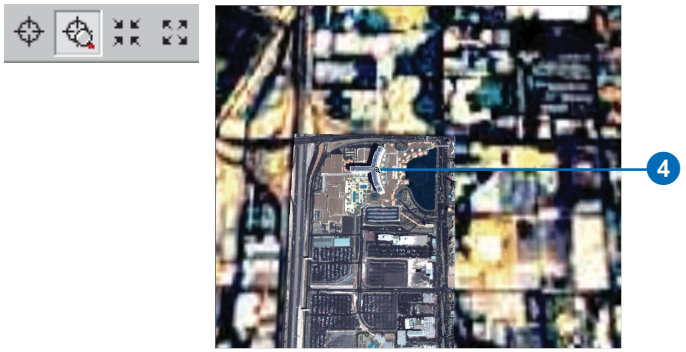


3. Click the center of the Fountains of Bellagio.



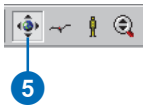
The point you clicked is moved to the center of the display. Centering on a target sets a target on the globe surface and switches to Surface mode.

4. Click Zoom to Target and click the central dome of the Bellagio.

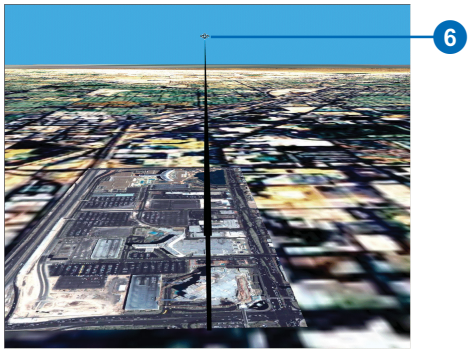


A new target is centered and the display is zoomed to it.

5. Click the Navigate button.



6. Click the bottom of the display and slowly drag up.



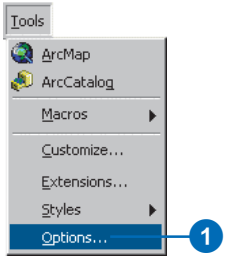
The globe rotates, and the viewing angle lowers. The horizon becomes visible with a light blue background, and you view the globe in a new perspective.

7. Click the Full Extent button to return the globe to its full extent position.

Setting some preferences

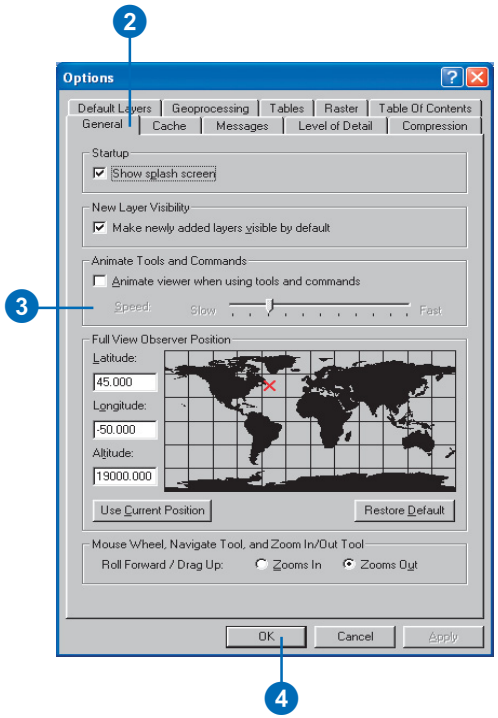
You can modify the way ArcGlobe functions at both the application and globe levels. First, you'll explore some application-level options.

1. Click Tools and click Options.



The Options dialog box is where you set application-level preferences. The settings will be preserved in all instances of ArcGlobe.

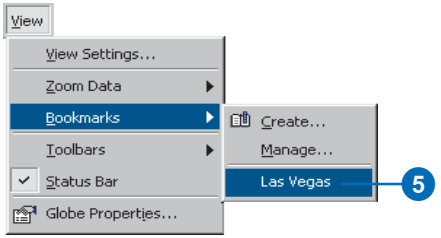
2. Click General.
3. Check Animate viewer when using tools and commands.



This option will show smooth transitions from one view to the next when you use tools that change your perspective. This will be the standard behavior every time you start ArcGlobe until you turn off the option.

4. Click OK.

5. Click View, click Bookmarks, and click Las Vegas.

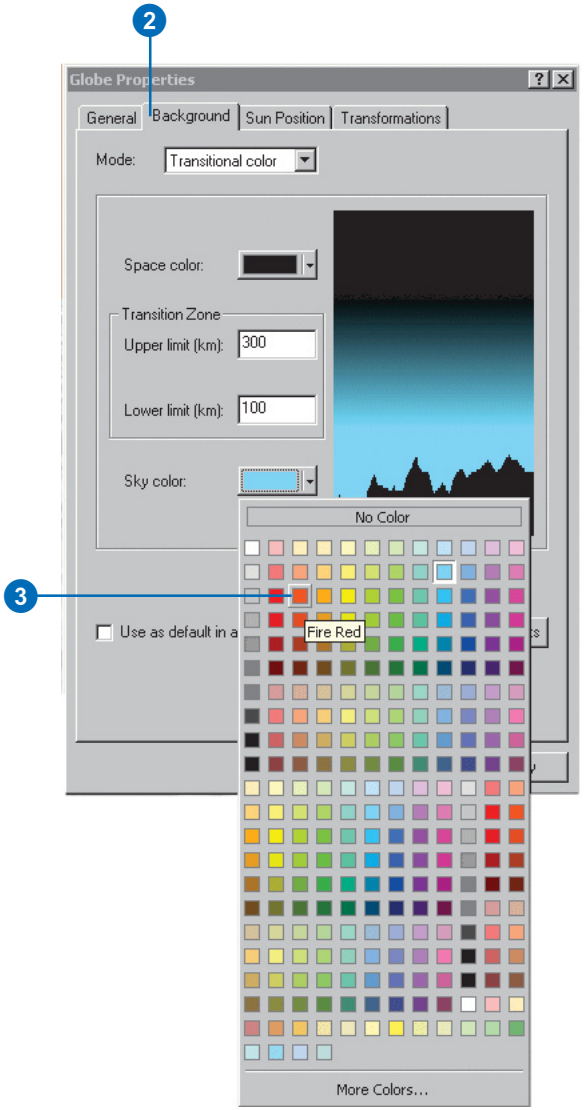


The display moves to the Las Vegas bookmark in a smooth, animated transition. Next, you'll examine a document-level option.

Setting a document-level option

1. Double-click Globe layers.

2. Click the Background tab.
3. Click the Sky color dropdown arrow and click a color of the morning or evening sky.



Sky color is the color of the background when you zoom in close to your globe as defined by the lower limit of the transition zone.

4. Click OK.

If you switch to Surface mode and lower the viewing angle, you'll notice the background color changing to the color you indicated.

In this exercise you learned how to differentiate between ArcGlobe layer types, navigate in Globe and Surface modes, find places, and set some application and globe properties. Now that you've learned some fundamentals, you can begin to explore other areas of ArcGlobe. In the next exercise, you'll learn how to use data as different layer categories.

Exercise 7: ArcGlobe layer classification

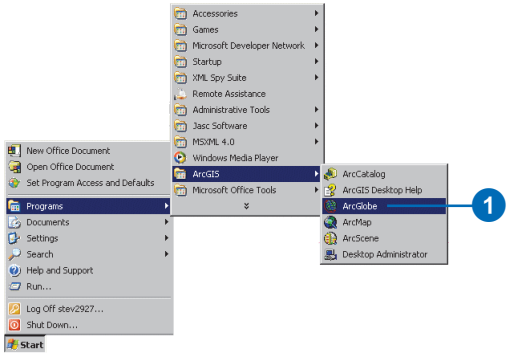
ArcGlobe classifies layers into three types to help you manage them: elevation, draped, and floating. In this exercise, you'll learn how to use the classifications to help layers provide the right information to your documents. This exercise assumes that you are using ESRI-supplied default layers.

Adding elevation layers

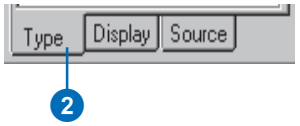
Elevation layers provide height information to the globe surface. You'll use rasters with height source information to provide topography to the globe surface, making it a globe terrain.

1. Click the Start menu, point to Programs, then ArcGIS, and click ArcGlobe.

   ArcGlobe starts, and its default layers are loaded.

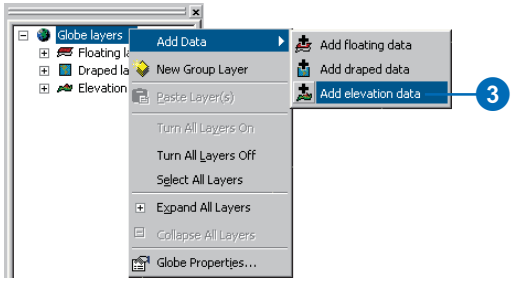


2. Click the Type tab in the table of contents to show the default layer classifications.

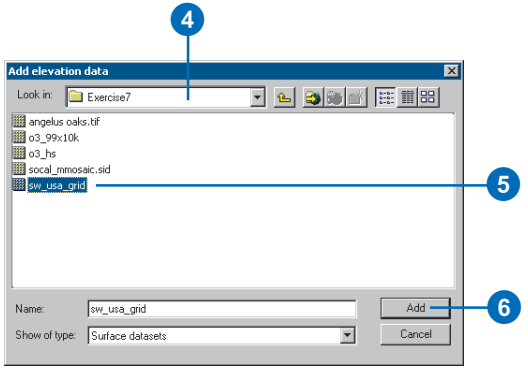


3. Right-click Globe layers, point to Add Data, and click Add elevation data.

   This indicates that you want to add a specific type of data to that layer category.



4. Navigate to the location of the Exercise7 folder.
5. Select sw_usa_grid.
6. Click Add.

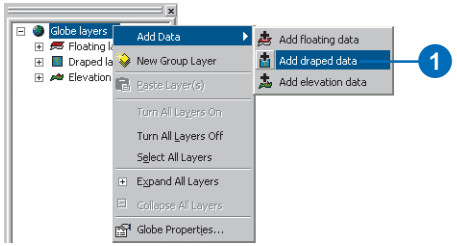


The raster is added to the elevation category and will be used as a source of elevation for the globe surface.

Adding draped layers

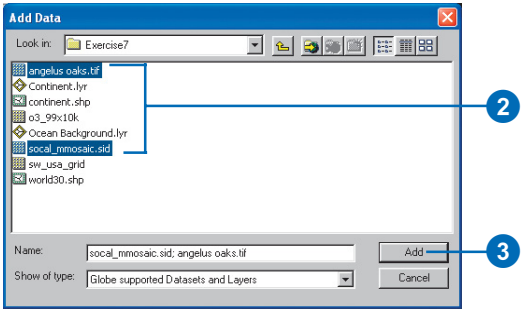
Draped layers are placed on the globe surface and use any elevation data present to show base heights. Next, you'll add images that will be draped on the globe terrain you created.

1. Right-click Globe layers, point to Add Data, and click Add draped data.



Layers you now add will be draped on the globe terrain.

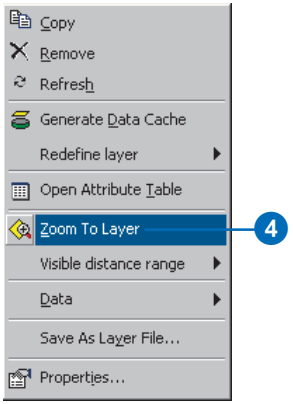
2. Click angelus oaks.tif, press Ctrl, and click socal_mmosaic.sid.



Both layers are selected.

3. Click Add.
4. Right-click angelus oaks.tif and click Zoom To Layer.

   The display zooms to the extent of the layer. A few moments will pass before the layer is shown at full resolution as the on-demand cache is built. Once the cache is built, you'll be able to revisit the area and display the layer quickly.



The Angelus Oaks imagery appears washed out due to the Continents layer being drawn with a higher drawing priority. Next, you'll learn how to change the drawing priority of a draped layer.

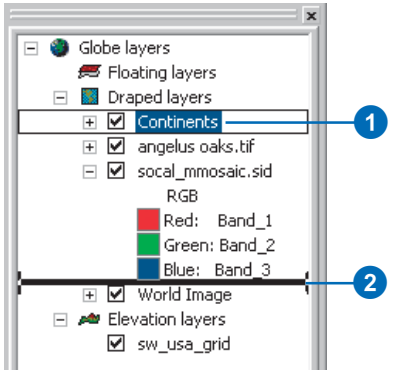
Changing the drawing priority of a layer in the table of contents

Draped layers that have overlapping extents need to have a drawing priority set so one layer gets drawn on top of the other. ArcGlobe makes some assumptions to accomplish this, using criteria such as the cell size of a raster layer. Occasionally, you'll need to override the ArcGlobe default drawing priorities. One way to do this is to change the order of draped layers as they appear in the Type page of the table of contents.

1. Click the Continents layer and drag it so it's just above the World Image layer.

   A black line indicates where the layer will be placed.

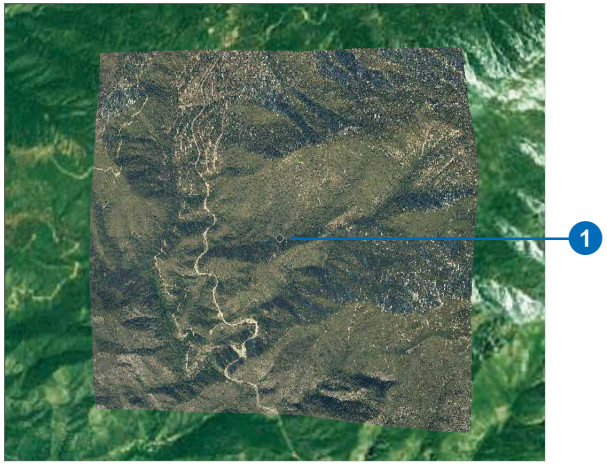
2. Release the mouse pointer to drop the layer in its new position.



The drawing priority is now set so angelus oaks.tif and socal_mmosaic.sid are drawn on top of the Continents layer.

Setting a target to initiate Surface mode

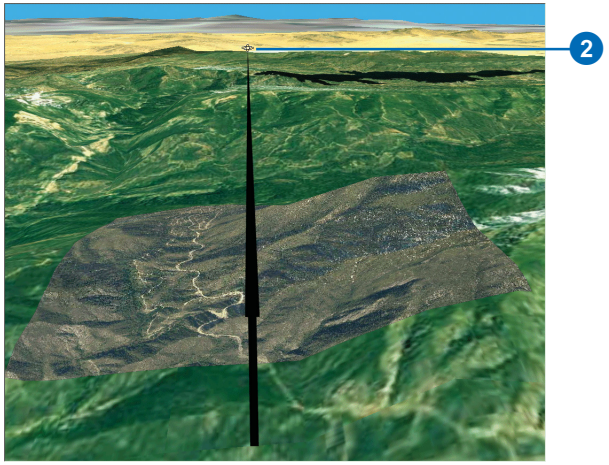
1. Press Ctrl and click the middle of the display.



You've initiated Surface mode and set a target at the location on the globe surface where you clicked.

2. Click the bottom of the display and slowly drag up.

   The globe terrain you created becomes discernible as you investigate the imagery you added.

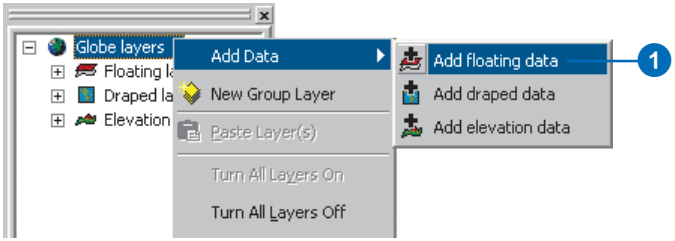


3. Click the Full Extent button to return the display to the original view.

Adding floating layers

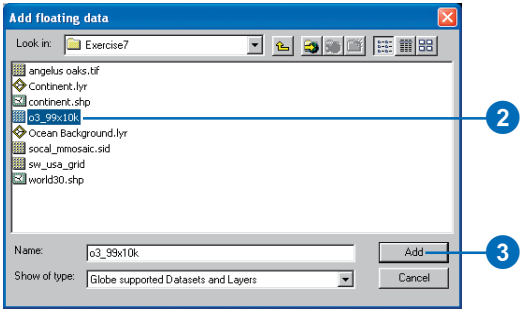
Floating layers are layers that float independently of the globe surface. Next, you'll add a raster as a floating layer and set it to elevations not connected with the globe surface.

1. Click Globe layers, point to Add Data, and click Add floating data.



2. Click o3_99x10k.

   o3_99x10k is a raster showing average annual ozone concentration for 1999 in California.

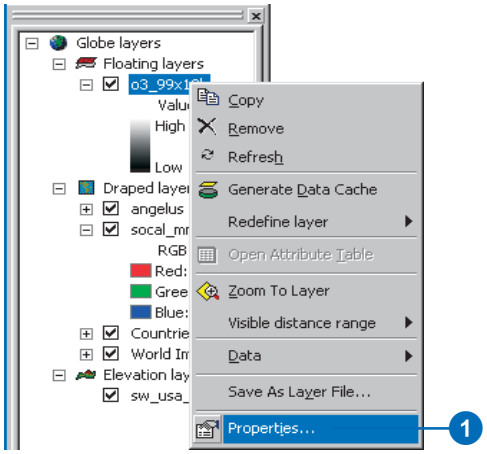


3. Click Add.

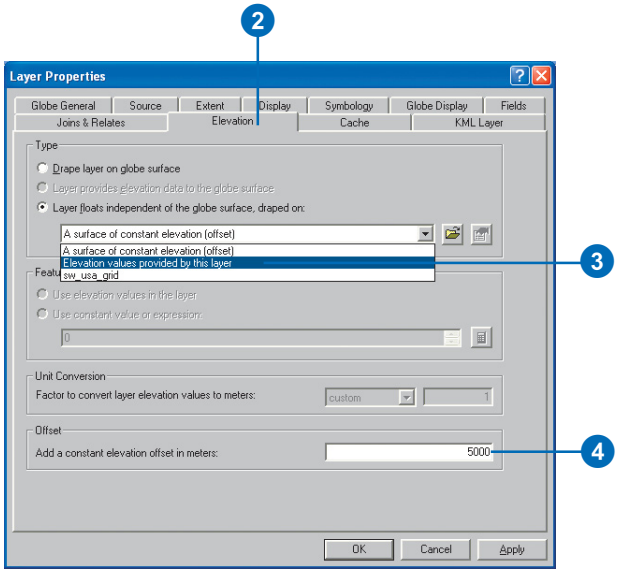
   The layer is added to the floating category.

Setting elevation properties of floating layers

1. Right-click o3_99x10k and click Properties.

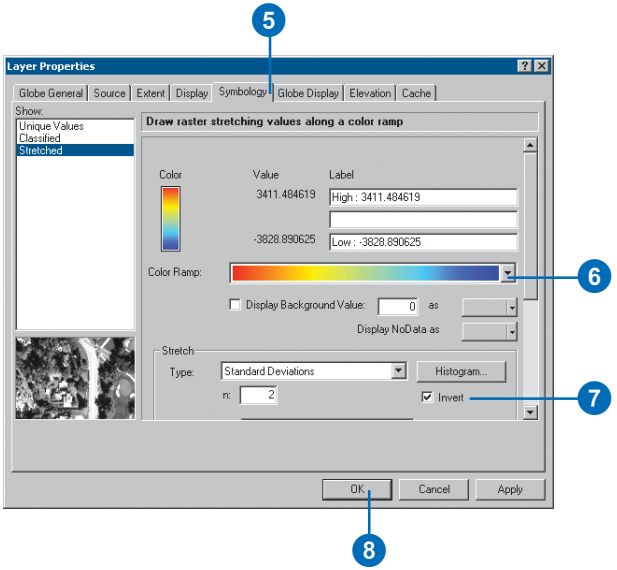


2. Click the Elevation tab.
3. Click Elevation values provided by this layer in the Layer floats independent of the globe surface, draped on dropdown menu.



4. Type “5000” in the Add a constant elevation offset in meters text box.
5. Click Symbology.
6. Select the red to blue color ramp in the Color Ramp dropdown menu.

7. Check Invert.



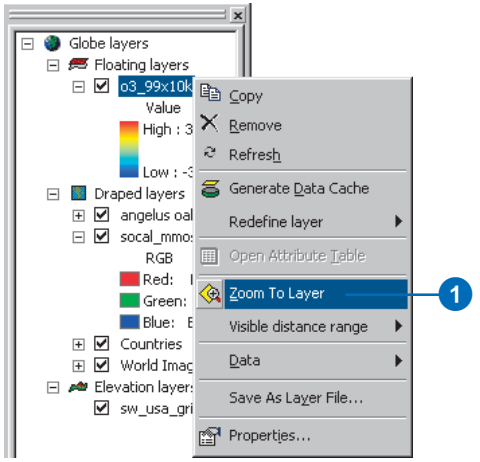
This inverts the color ramp so that high values will be displayed as red, low values as blue.

8. Click OK.

You've set the raster to use its own values as a source of base heights, offset those heights 5,000 meters from the globe surface, and symbolized the concentration values with color. Next you'll take a look at how this appears in the display and set a vertical exaggeration to accentuate the elevation.

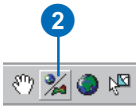
Setting a vertical exaggeration factor for floating layers

1. Right-click o3_99x10k and click Zoom To Layer.

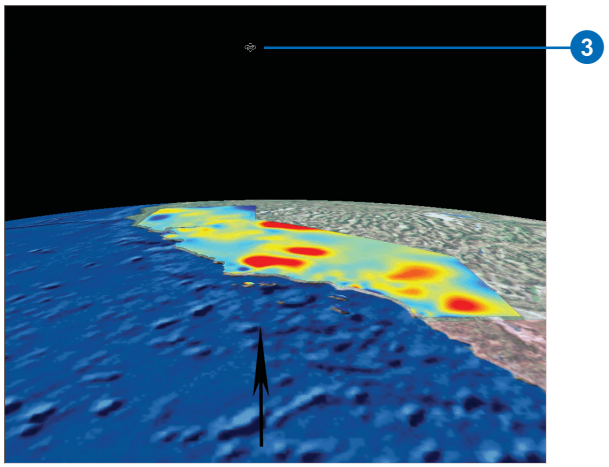


The layer is displayed in the view.

2. Click the Navigation Mode button to change the mode to Surface navigation.



3. Click the bottom of the display and slowly drag the mouse pointer up.

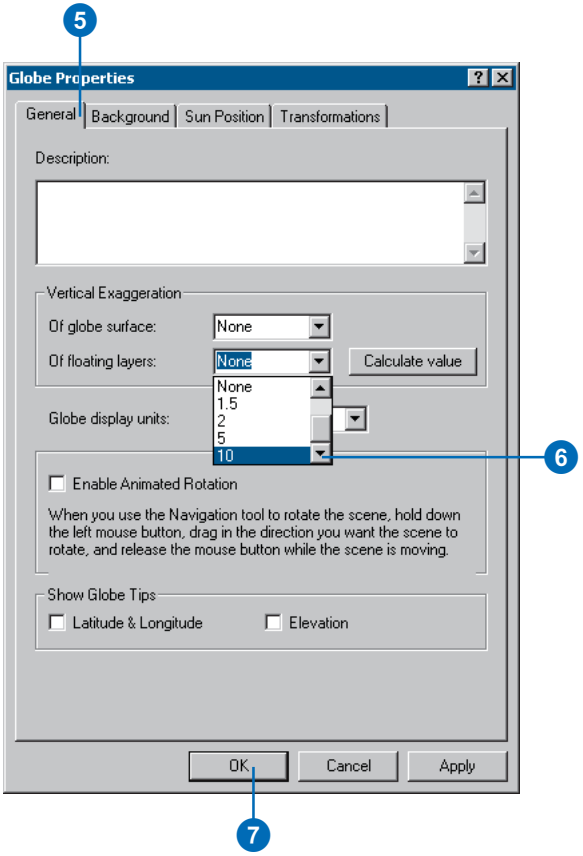


This allows you to see the effect of changing the vertical exaggeration.

4. Double-click Globe layers.

5. Click the General tab.

6. Select or type a value of "10" in the Vertical Exaggeration Of floating layers dropdown menu.



The floating layer will be exaggerated by a factor of 10.

7. Click OK.

Examine the floating layer you created. You'll see a 3D raster showing average ozone concentrations in California in 1999. The layer floats above the state of California and is a surface that is different from the terrain below.

In this exercise, you learned how to differentiate layer types in ArcGlobe, saw the effect they have on the globe, and set properties to improve their display. Explore Exercise7.3dd globe document in the Exercise7 folder to discover additional ways to enhance your globe documents. The document contains layers saved with custom settings, bookmarks, globe lighting, and animation tracks.

Exercise 8: Creating and using a terrain dataset

A terrain dataset is a multiresolution TIN-based surface derived from measurements stored in one or more feature classes in a geodatabase.

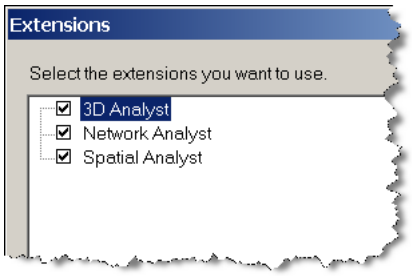
In this exercise, you will use geoprocessing tools to load surface data into a geodatabase, construct a terrain from them, and use the terrain inside ArcMap and ArcGlobe.

Loading surface feature data into a geodatabase

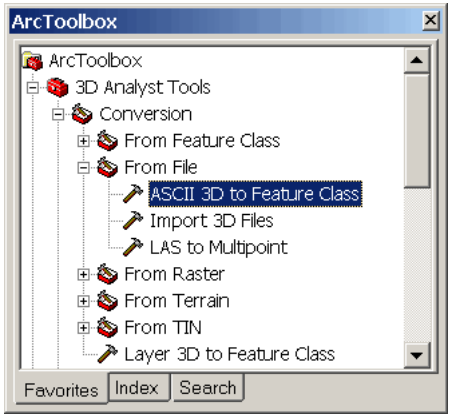
In this scenario, you have LIDAR points and photogrammetric breaklines stored in ASCII text files. You'll use them to construct a terrain. To accomplish this, you need to import them into feature classes that reside in a feature dataset. The terrain will be made at the same location, next to its source data.

You've been provided a file geodatabase with a feature dataset. It contains two polygon feature classes. One is for lakes, the other to delineate the study area. What you need to do first is import the ASCII points and lines.

1. Start ArcCatalog and make sure the 3D Analyst extension is enabled via the Tools>Extensions dialog box.

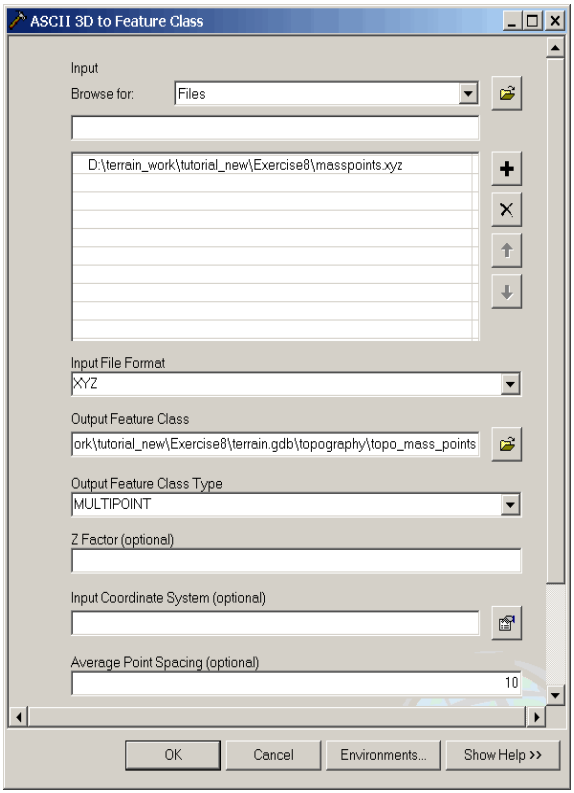


2. Browse to the terrain geodatabase and open the topography feature dataset.
3. In the ArcToolbox window, choose the 3D Analyst Tools >Conversion>From File> ASCII 3D to Feature Class tool.



Next you'll convert points from a simple text file in XYZ format into a multipoint feature class. These points only define surface geometry. All that's recorded for them are x, y, and z. There's one point per line, and the coordinates are separated by spaces. Since there is no attribution associated with these points, dedicating a database row for each is wasteful and inefficient. Instead, you'll combine them into multipoints. A multipoint can store many points per shape or row, saving storage space and improving read-write performance.

4. Open the ASCII 3D to Feature Class tool, make sure the Browse for drop down list is set to Files, click the Browse button, and choose the masspoints.xyz file as input. Set the Input File Format to XYZ, name the output feature class topo_mass_points and save it inside the topography feature dataset. Set the Output Feature Class Type to MULTIPOINT and the Average Point Spacing to 10 then click OK.

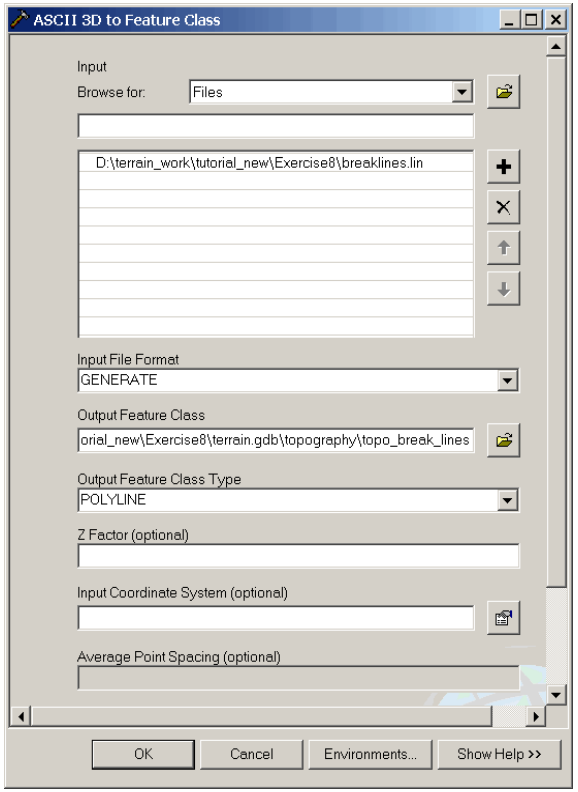


The point spacing represents the average distance between measurement points. Sometimes this is referred to as nominal point spacing. This is given in the xy units of the data.

The average point spacing option is only available when the Output Feature Class Type parameter is set to MULTIPOINT. It facilitates the clustering of points so that each output multipoint is made from points that are relatively close to one another.

In the next step, you'll use the same tool to import breaklines. Breaklines are linear features, such as roads and water body shorelines, that need to be represented on the surface. These are provided in the 3-D GENERATE format; an ASCII format similar to XYZ but more appropriate for line and polygon data. You can find a detailed description of the format in the help. To find it, click the Learn more about link located at the top of the help page for the ASCII 3D to Feature Class tool.

5. Open the ASCII 3D To Feature Class tool again. Choose breaklines.lin as input and set the Input File Format to GENERATE. Name the output feature class topo_break_lines and locate it inside the topography feature dataset. Set the Output Feature Class Type to POLYLINE and click OK.



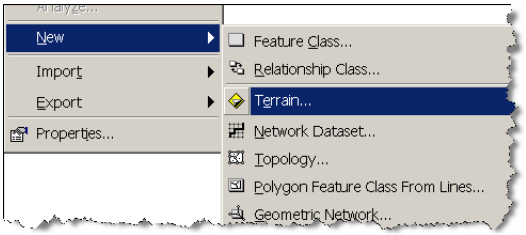
Now you've loaded the mass points and breaklines from which a terrain will be built. The points came in XYZ format, the lines in 3-D GENERATE format. Both are ASCII formats for simple 3-D data and are read using the same tool, ASCII 3D to Feature Class.

If you need to process a large collection of LIDAR points, consider using the LAS format instead of XYZ. LAS is an industry-standard format for LIDAR data. It's more efficient because it's binary. It also has more information stored in the file about the data. There's a separate tool to import LAS format files, LAS to Multipoint, that's located in the same toolset as the ASCII 3D to Feature Class tool.

Building a terrain from features

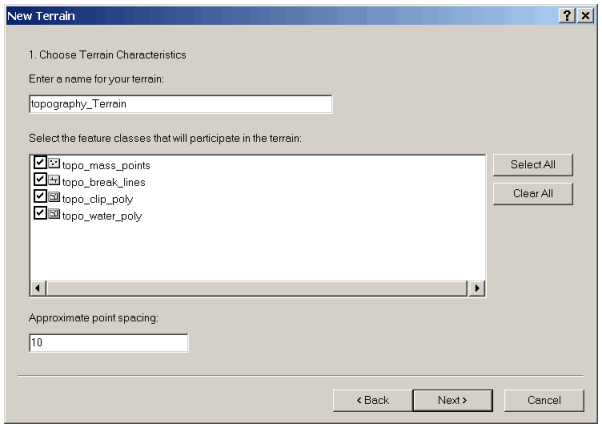
Use the Terrain wizard in ArcCatalog to define and build a terrain.

1. In ArcCatalog right-click the topography feature dataset and select New>Terrain from the context menu.

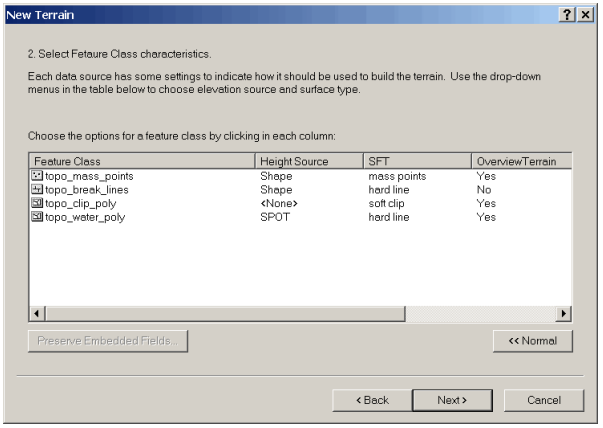


Terrains are located in feature datasets. Terrains, and the feature classes used to build them, must reside at the same location. One benefit of using the feature dataset as a container is that it ensures all the data used to build a terrain has the same spatial reference. In an SDE database, it's also the organizational level at which data gets registered as versioned for editing.

2. Accept the default name for the terrain. Click the Select All button to check on all the feature classes. Then set the Approximate point spacing to 10.



3. Click Next and indicate how each feature class will contribute to the terrain. Click the Advanced button to expand the column list. Use the same values as shown in the graphic below.



Since the mass points and breaklines have z-values, which will be used to define the terrain surface, the height source for them is set to Shape. This means that z comes from the shape geometry.

The topo_clip_poly feature class contains a 2D polygon. It defines the horizontal extent of the surface and minimizes interpolation artifacts around the surface perimeter. Clip polygons work best when they're smaller than the extent of the data that is being used to provide z-values.

The water polygons are represented by 2D geometry but have the height attribute SPOT. Each polygon can have its own height, but that height is constant. For lakes, this is fine, since they're flat. With this data, there are no measurements inside the lake boundaries that contradict the lake SPOT values, so you can add the boundaries as

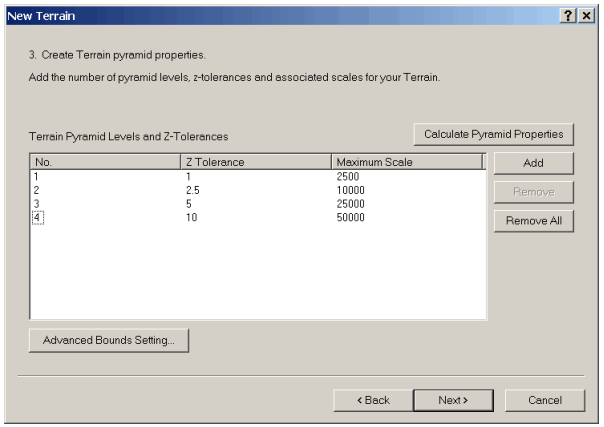
breaklines; otherwise, they'd be added as replace polygons to ensure their areas get flattened.

Everything but the breaklines are used for the terrain's overview representation. The overview is a generalized representation of the terrain, similar to a vector-based thumbnail. The breaklines are too detailed for this, but all the other information is needed to produce a reasonable looking overview.

On the next panel, you'll define the pyramid for the terrain. Terrain pyramids are used to create multi-resolution surfaces. They're similar to raster pyramids in concept (that is, coarser pyramids are used for display at smaller scales to improve display performance), but there are differences. The most significant are that they're composed of vector-based measurements, their construction is based on some measure of vertical accuracy, and they can be used for analysis as well as display.

Terrain pyramids are defined using two factors: z-tolerance and reference scale. The z-tolerance of an individual pyramid level represents its approximate vertical accuracy relative to the full resolution data. The reference scale of a pyramid level defines the display scale at which it becomes active.

4. Click Next to define the terrain pyramid levels. Click Add four times, then manually reset the values for Z Tolerance and Maximum Scale. Use the values specified in the following graphic.

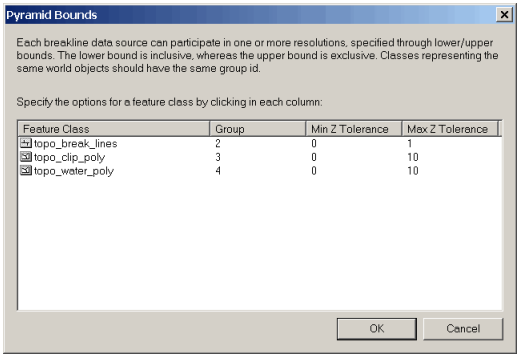


Using these settings, the full resolution data is used in map displays up to a scale of 1:2,500. Between display scales of 1:2,500 and 1:10,000, only the data necessary to achieve an approximate vertical tolerance of 1.0, relative to the full-resolution data, is used. Between 1:10,000 and 1:25,000, a tolerance of 2.5 is used. Between 1:25,000 and 1:50,000, a tolerance of 5 is used. For any scale smaller than that, a tolerance of 10 is used.

Tolerances and scales used to define a terrain pyramid need to be specified based on application requirements. One approach is to mimic the accuracy requirements of a contour map series. A generally accepted rule is that contours should be accurate to within one-half of their interval. For example, if a 1:24,000 scale map within your study area uses a 5-foot contour interval, then the vertical accuracy should be 2.5 units RMSE. Base the pyramid on the scales and contour intervals appropriate for a map series of the terrain.

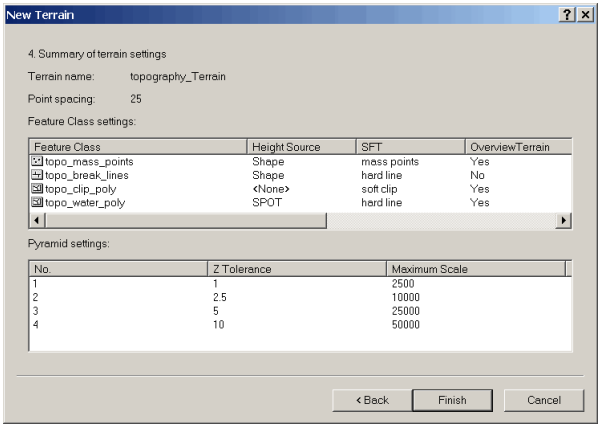
While breakline vertices are used where needed through all pyramid levels, the actual line enforcement can be restricted to occur in a subset of these levels. For example, road curbsides need not be enforced as triangle edges in a terrain at scales smaller than 1:24,000. You control enforcement via the Pyramid Bounds dialog box.

5. Click the Advanced Bounds Setting button to open the Pyramid Bounds dialog box.
6. Set the Max Z Tolerance for the topo_break_lines feature class to 1. Accept the defaults for the others.

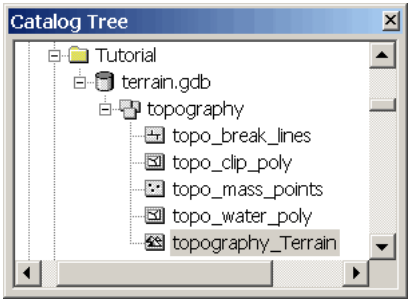


In the dialog box, z-tolerances indicate at which pyramid levels the enforcement is to take place. Using the given values, the breaklines will be enforced for pyramid levels with z-tolerances >= 0 and <= 1.0. This translates into the breaklines being enforced only at scales larger than 1:10,000. The water and clip polygons are enforced through all scales. This ensures the data boundary is always correct and water bodies remain flat.

7. Click OK to dismiss the Pyramid Bounds dialog.
8. Click Next to reach the summary panel. Review your settings. Click Finish to initiate the terrain build process. This will take less than five minutes.



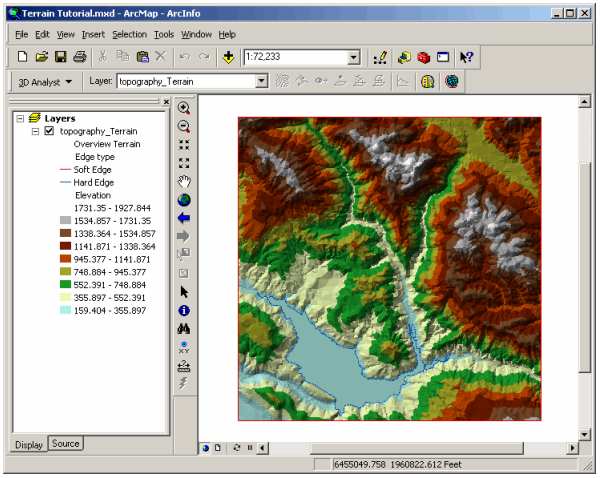
When the terrain build process is complete, the new terrain is added to the Catalog Tree inside the feature dataset. You can right-click this to get properties. You can also preview the terrain in ArcCatalog.



Viewing a terrain in ArcMap

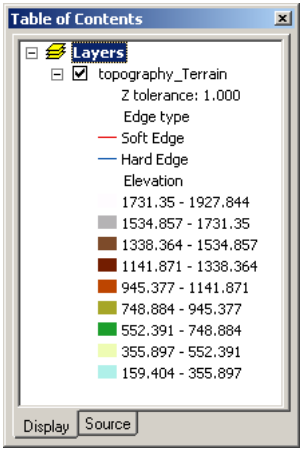
Viewing a terrain in ArcMap is similar to viewing other data types. There's a terrain layer that you can turn on and off in the table of contents (TOC). It has a Layer Properties dialog to control display parameters. The Symbology tab on this dialog is identical to TIN layers.

1. Start ArcMap.
2. Click the Add Data button.
3. Browse to topography_Terrain, add it to the map, then make sure its visibility is turned on.



The terrain will retrieve measurements from the database for the pyramid level associated with the current display scale. The measurements are triangulated on the fly and drawn to the screen. When going from a coarser pyramid levels to more detailed levels, only the additional measurements needed to get to the higher-detail pyramid level are retrieved and added to the triangulation.

4. Zoom in on the display. Note how the vertical tolerance associated with the current display is listed in the map's Table of Contents.



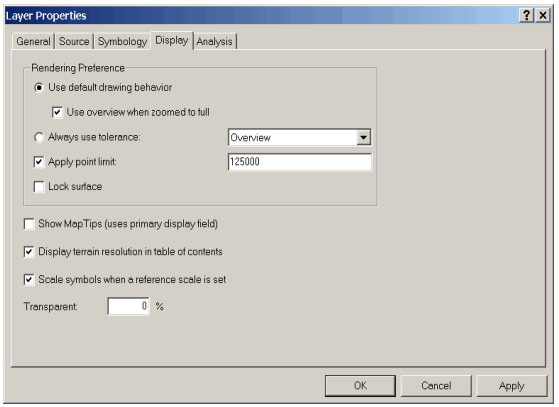
5. Zoom to the full extent of the layer. Note that Overview Terrain is listed in the Table of Contents.

The terrain overview is the coarsest representation of the terrain. It's coarser than the lowest level of detail (LOD) pyramid specified when the terrain was defined. The overview is used by default when the layer is zoomed out to full extent or beyond. This is used to speed up rendering. Use of the overview representation can be turned on and off from the Display tab of the terrain's Layer Properties dialog. You can also apply a point limit from this tab.

The use of a limit tells the terrain layer to downgrade its display resolution if the current environment (that is, display extent, scale, and pyramid definition) would require too many measurement points. This helps maintain display performance at the cost of not always honoring the terrain's

original pyramid display definition. When the resolution has been downgraded, an asterisk is displayed next to the terrain layer's name in the TOC. By default, a point limit of 800000 is used.

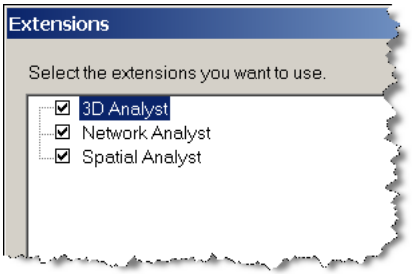
6. Open the terrain's Layer Properties dialog and click the Display tab.
7. Change the point limit from 800000 to 125000 and click OK.
8. From the map display, zoom in and out, then pan around.



The display should be consistently fast because the layer is adjusting which pyramid levels gets used to keep the point count below the 125000 limit.

Using the interactive surface analysis tools in ArcMap

1. Make sure the 3D Analyst extension is enabled by clicking its check box in the Tools>Extensions dialog.

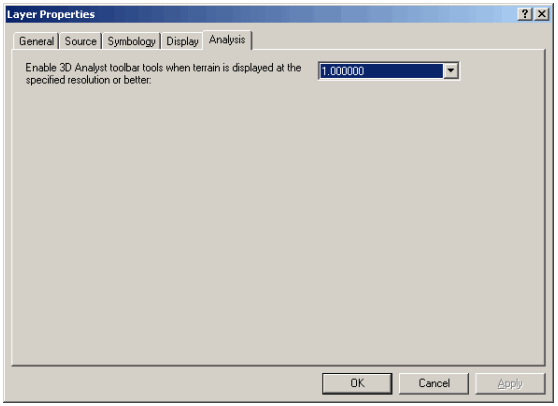


2. Add the 3D Analyst toolbar from the View>Tools menu if it's not already displayed. The terrain is displayed in the Layer combo box on the toolbar.

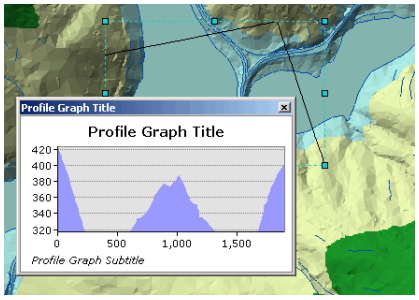
If you aren't zoomed in far enough, the tools on the toolbar are disabled. By default, they're only enabled when the terrain is displayed at full resolution. Based on how the terrain's pyramid was defined, this will occur at display scales of 1:2,500 or larger.

You can enable the tools at lower resolutions from the Analysis tab of the terrain's Layer Properties dialog. When you enable the tools at LODs lower than full resolution, the accuracy is also decreased. Interactive tools always operate at the current display resolution. This is useful if the full-resolution terrain is oversampled for the requirements of the analysis.

3. Open the terrain's Layer Properties dialog and, on the Analysis tab, set the enabling resolution to 1.0.



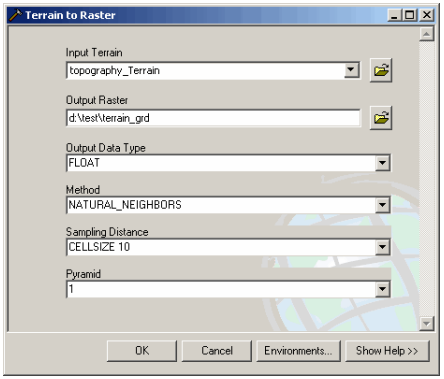
4. Zoom in on the terrain until the display scale is larger than 1:10,000. The tools should now be enabled.
5. Use the Create Line of Sight tool to see how it works on the terrain.
6. Use the Interpolate Line tool. The resulting graphic line will automatically be selected. A selected 3D polyline enables the Create Profile Graph tool.
7. Execute the Create Profile Graph tool to graph the 3D line.



Rasterize a terrain using a geoprocessing tool

Terrains can be rasterized based on any extent, cell size, and vertical tolerance. You can choose between linear and natural neighbor interpolators. The latter generally produces higher quality results but at the expense of processing time. Rasterization is performed using the Terrain to Raster geoprocessing tool.

1. Open the Terrain to Raster tool. It's located in the 3D Analyst Tools>Conversion>From Terrain toolset.
2. Choose the terrain in the Input Terrain combo box. Set the other values to match the graphic below.

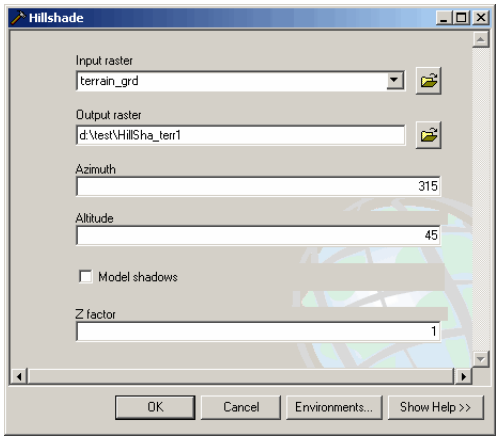


Keeping the Output Data Type as FLOAT will preserve vertical precision. Changing the interpolation Method to NATURAL_NEIGHBORS will take a little longer than LINEAR but it adds some smoothness everywhere except across hard breaklines where sharp discontinuities are supposed to occur. Setting an explicit Sampling Distance lets you know exactly what the output cell size will be. The pyramid resolution represents the z-tolerance of the desired pyramid level. In this terrain, the pyramid level with a resolution of 1.0 has the breaklines enabled. This surface will be somewhat generalized relative to the full-resolution data but not by much, and this process will run faster because it's using a thinned version of the data.

3. Click OK to execute the tool.

To see the morphology of the derived raster surface, generate a hillshade image:

1. Open the 3D Analyst Tools>Raster Surface>Hillshade tool.
2. Specify the raster created by the Terrain To Raster tool as input.
3. Click OK to execute the tool, and examine the resulting hillshade layer.

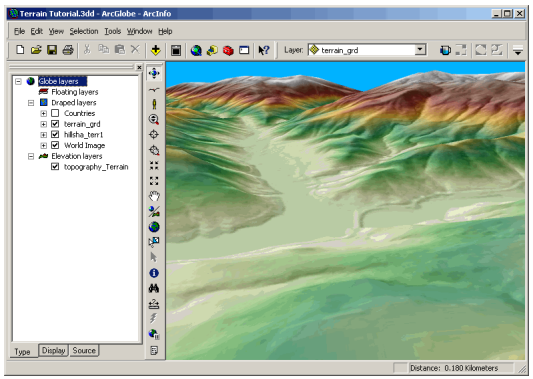


Using a terrain as an elevation layer in ArcGlobe

Terrains can be used in ArcGlobe as elevation layers, contributing to the definition of the globe surface.

1. Start ArcGlobe.
2. Add the terrain as an elevation layer.
3. Add the rasterized terrain and hillshade as draped layers.
4. Place the rasterized terrain on top of the hillshade on the Type tab of the TOC.

5. Symbolize the elevation raster using an elevation color ramp and assign about 50 percent transparency via the Effects toolbar.



For best quality display, you can do several things. Go to the Cache tab on the terrain's Layer Properties dialog and uncheck the option to compress to 16 bits. This will eliminate the possibility of the surface geometry looking stair stepped when zoomed in very close. You can also set both the draped layers to use bilinear renderers. These will draw a smoother picture. Also, the hillshade raster should not use any stretch. The default using standard deviations is not appropriate for this data.

As an alternative to viewing draped rasters derived from the terrain, you can add the terrain directly as a draped layer. To do this, open the TOC context menu, click Add Data>Add Draped Data, then choose the terrain.