# Lesson 6:
DEM-Based Terrain Modeling

Lesson Goal: Lean how to output a grid theme that can be used to generate a thematic two-dimensional map, compute an attractive hillshaded map, and create a contour line theme and TIN, and produce a 3D scene.

What You Will Need: A Pentium class PC with 64 MB of RAM (minimum) and 100 MB of free hard drive space, ArcView GIS 3.1 or higher, the ArcView 3D Analyst and ArcView Spatial Analyst extensions, WinZip, and an Internet connection.

Data and/or Utilities: No utilites required. This lesson uses a conversion utility and sample extension that come with ArcView GIS. Get sample data from the Cornell University's Geospatial Information Repository.
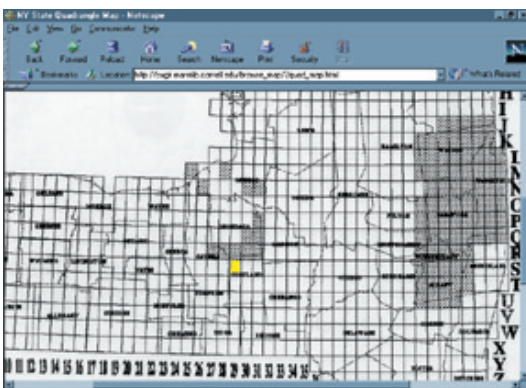
Select data for this project from the CUGIR site's clickable map.

This article describes how to use sample 1:24,000-scale 7.5' digital elevation model (DEM) data files to perform two-dimensional and three-dimensional modeling in ArcView GIS with the ArcView Spatial Analyst and ArcView 3D Analyst extensions.

USGS 7.5' DEM, a raster data set containing elevation information, has 10 x 10 meter data spacing. After converting the data, it can be easily imported into ArcView GIS. Terrain models constructed from elevation data can be used for a variety of purposes including line-of-sight forecasting, slope and aspect determination, surface runoff pattern analysis, and drainage basin delineation.

DEM data at this scale is particularly useful because each data set provides the same large-scale coverage as a standard USGS 1:24,000-scale quad map. Details regarding available coverages and procedures for ordering DEM data sets can be obtained at the USGS Web site. This project uses a DEM file downloaded from a source that provides converted 7.5' DEM coverages of New York State at no cost.

Downloading and Converting DEM Data

Locating and downloading the sample data set is the first step in this project.

1. Create a new folder named DEMWORK to hold downloaded data files.

2. Visit ArcUser Online for links to Cornell University's Geospatial Information Repository (CUGIR). Visitors to this site can select a 7.5' quad to download by graphically choosing it from a clickable map of New York State.

3. Use the map's reference grid to locate and click on quad S 29 (Homer), the northwest quad in Cortland County. This brings up a page showing the zipped USGS DEM files for this quad. Select and download 29elu.Z and S29hya.e00.Z to the DEMWORK folder. 29elu.Z is a UNIX-compressed USGS ASCII file that is 2,443 KB. S29hya.e00.Z is the hydrography file associated with this quad.

4. After closing the browser, go to My Computer and open the DEMWORK folder. This folder should now contain both downloaded files. Because 29elu.Z is a UNIX-compressed file, use the WinZip decompression utility with the Classic option to

extract the file. The decompressed file should be 9,225 KB. Rename it HOMER.dem.

5. Unzip s29hya.e00.Z, the hydrography coverage, and rename it s29hya.e00. Use the IMPORT71 utility that comes with ArcView GIS to format the file so it can be used. IMPORT71 is a stand-alone program that converts an ARC/INFO interchange file created on any other operating system into an ARC/INFO Version 7.x coverage or grid. IMPORT71 appears as a program item in the ArcView GIS program group. If it is not in the program group, it should be found with the ArcView GIS programs in the bin32 subdirectory. To run IMPORT71, double click the IMPORT71 program item in the ArcView GIS program group to display the dialog box.
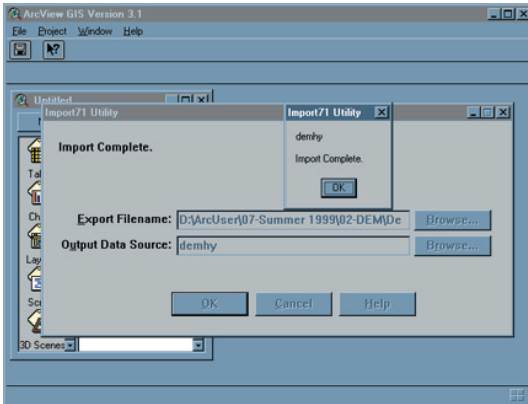
Create a Thematic Map in Two Dimensions

The downloaded and prepared data can now be used for two-dimensional modeling.

1. Start ArcView GIS, load ArcView Spatial Analyst, create a new project, and open a view.

2. Choose Import Data Source from the File menu. If Import Data Source is not available from the File menu, load the ArcView Spatial Analyst extension. Select USGS DEM as the file type and click on OK.

3. HOMER.dem should appear in the list of Import USGS DEM files. Select it and click on OK.

4. The Output Grid box appears with the default grid name imgrd1 (if this is the first output grid generated in this session). Rename the output grid HOMERS29. Allow the file to be placed in the Temp directory and click OK. Be patient while ArcView GIS calculates the new grid.

5. When the Import Data Source HOMERS29 box appears, click Yes to add the new theme to the view. Now save the project with the name HOMERDEM by choosing File, then Save Project As.

Maximize the view and make the HOMERS29 theme active and visible. Use the Open Theme Table button to open and examine the file structure. Select the column titled Value and click on the Sort Ascending button. The elevation values in this column should range between 329 and 587 meters.

Make the HOMERS29 theme active and double click its legend to open the Legend Editor. Select Graduated Color as the Legend Type and choose Value as the Classification Field. Click the Classify button, set the number of classes to 10, and click OK. Type in the elevation ranges in the Value column of the Legend Editor, beginning with 320–350. Each range should span 30 meters. The last range should be 590–620. There are several ways to enhance the HOMERS29 theme to better visualize the data. A hillshade theme and a contour map can be created, and finally, the hydrography coverage can be added to the view.

The Import71 utility converts ArcInfo interchange files (.e00) into a form ArcView GIS can use.

Performance Strategy

Steps for reducing the size of the area modeled by clipping the contour line theme are described in an appendix "What to Do if Your Computer Chokes," at the end of this tutorial. Learn how to create a custom theme that can speed navigation and improve refresh rates. Even if the computer used for modeling is sufficiently robust to render a large model, working with a smaller model while learning these techniques might be a good idea.

Creating a Hillshade

Choose Compute Hillshade from the Suface menu. In the Compute Hillshade dialog box, set the Azimuth at 95 and leave the Altitude at the default value, click OK, and wait while the Hillshade of HOMERS29 theme is created. Make it the only active theme and display it.

Generate a Contour Line Theme

The grid theme used to create the hillshade theme can also be used to create a contour line theme.
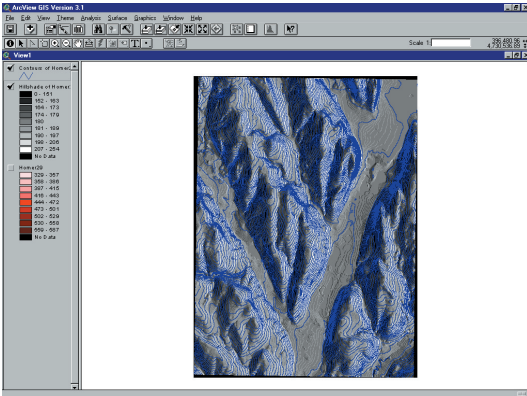
1. Make HOMERS29 the active theme and choose Create Contours from the Surface menu.

2. In the Contour Parameters dialog box, set the Contour Interval to 10, leave the Base Contour set to 0, and click OK. Display the Contours of HOMERS29 theme.

3. Add the hydrography coverage, 29hya, as a theme in the view and display it. The view should now look like Figure 2. Save the project again.

Now examine the model. Note the rounded hills and partially filled valleys. This is a glacially sculptured landscape. During the last Ice Age, valleys in this area were filled with glaciers more than 300 meters deep. At the end of this period, outwash conditions created an abundance of sand and gravel deposits. The quad northeast of the Homer quad, the Tully quad, maps an area that includes the Tully terminal moraine. Drainage from the area mapped by the Homer quad flows to the south, eventually joining the Susquehanna River. The Finger Lakes are located west of this area. The southern ends of these lakes are blocked by substantial moraines, and drainage from these lakes flows northward to Lake Ontario.
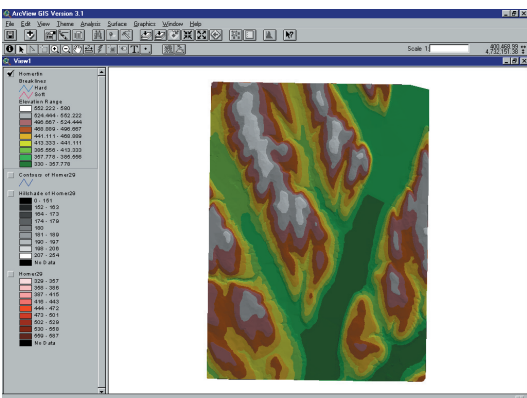
Creating a Topography TIN

The Contours of HOMERS29 theme created in the previous procedure can now be used to build a TIN. Consider limiting the size of this theme using the techiques described in the an appendix "What to Do if Your Computer Chokes," at the end of this tutorial.

1. Make the Contours of HOMERS29 theme active, choose Create TIN from Features from the Surface menu. Make sure ArcView 3D Analyst is loaded.

2. In the Create New TIN dialog box, set Height Source to Contour, Input As to Mass Points, leave Value set to <none>, and click OK. Additional information on TIN creation options is available by clicking on the Help button in the dialog box.

3. The Output TIN Name dialog box opens. Name the new theme HOMERTIN, allow it to be saved to the Temp directory, and click OK. The progress bar at the bottom of the view shows the rate of TIN creation. Be very patient. When the TIN is complete, its legend will appear in the view.

4. Modify the appearance of the TIN by double clicking on the legend for the TIN theme to invoke the TIN Legend Editor.
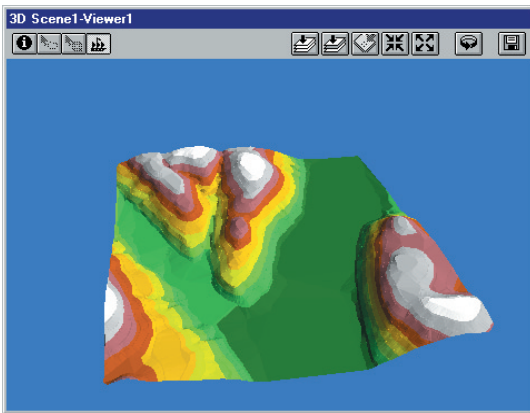

The grid theme used to create the hillshade theme can also be used to create a contour line theme.

The Contours of HOMERS29 theme created in the previous procedure can now be used to build a TIN.

5. In the TIN Legend Editor, click the Edit button in the Faces section to edit the elevation range. Use the Classify button to change the number of classes to 10, and set the ranges at 30-meter intervals to match HOMERS29.

6. Use Terrain Elevation #1 for the color ramp. Remember to click on Apply before closing each Legend Editor window.

7. Turn off the Contours of HOMERS29 theme. Make the HOMERTIN theme active and turn it on. Triangulated polygons will slowly build in the view until it looks like Figure 3.

Modeling Two-Dimensional Data in a 3D Scene

The TIN just constructed can be used in ArcView 3D Analyst to create a 3D Scene.

1. Make sure ArcView 3D Analyst is loaded and make the project window active.

2. Click on the 3D Scenes icon, located at the bottom of the project window below Scripts, then click the New button. Two windows open the 3D Scene-Viewer window and the 3D Legend window. Neither window can be minimized, but both can be resized and moved. Size and position both windows so that the two-dimensional view with the TIN theme is accessible.

3. From the 3D Scene menu choose Properties to open the 3D Scene Properties window. Set Map Units to meters, Vertical Exaggeration to 3, and the Background Color to light blue. Set Sun Azimuth to 95 and Sun Altitude to 45. Click on OK.

4. Make the two-dimensional view active and make HOMERTIN the only active theme. Turn it off. Choose Edit, then Copy Themes. Make the 3D Scene-Viewer the active window, and choose Paste from the Edit menu.

5. Use the same procedure to copy the hydrography theme to the 3D Scene-Viewer. To convert the hydrography theme to a 3D shapefile, make it active and select Convert to 3D Shapefile from the Theme menu. In the first dialog box select Surface for Get Z Values From, and in the second dialog box use HOMERTIN for Choose Theme to Use as Surface. Name the new theme s29hyd3D and add it to the view. Choose 3D Properties from the Theme menu to set the Offset Heights option to 5.

6. Before starting the 3D rendering process, set the theme drawing priorities to a simpler hydrography scene when navigating. Make the hydrography theme active, choose Theme, then 3D Properties to invoke the 3D Properties dialog box. Click the Advanced button to bring up the Advanced 3D Properties dialog box. Uncheck the second box next to Draw Theme When Not Interacting. Exit both dialog boxes by clicking OK.

7. Because the Homer 3D Scene is more detailed, use the opposite Advanced setting for it. Make Homer 3D the active theme, choose Theme, then 3D Properties, click on the Advanced button, check the Draw Theme When Not Interacting box, and uncheck the Draw Theme When Interacting box.

The TIN constructed in the previous step can be used in ArcView 3D Analyst to create a 3D Scene.

ArcView GIS Tip

Leave a small portion of the associated 2D View visible underneath the 3D legend window so that you can easily move between views. Use the Theme Clipboard to copy a theme from a 2D View to a 3D View.

8. Make both themes active and start the three-dimensional rendering process by turning on the hydrography theme. When it is displayed, turn on the HOMERTIN theme. The process will take several minutes. **Be patient.** After admiring this model, turn the 3D themes off and save the project.
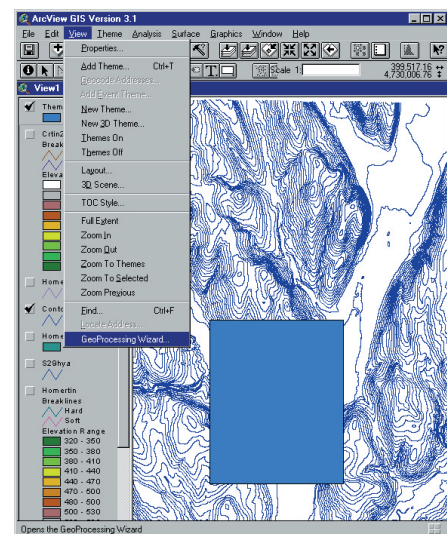
Summary

These steps show how to produce very attractive and highly detailed three-dimensional terrain models with minimum effort. The USGS 7.5' DEM data files used in this tutorial, available from the Cornell University Web site, provide a good start in working with DEM data for two- and three-dimensional

This lesson is based on an article written by Dr. David Miller of State University of New York College at Cortland. This article originally appeared in the July–September 1999 issue of *ArcUser* magazine.

Appendix: What to Do if Your Computer Chokes

Converting and rendering data in three dimensions seriously tests the graphic performance limits of most computers. Reboot the system and reload the project if the computer hangs up. If it proceeds at an excruciatingly slow rate, do not save the project after copying the TIN file to the 3D Scene. Close the project without saving the changes and then reload. Either of these actions will return the project to its status at the point just after the contour theme was created. To make this process manageable, reduce the size of the area modeled by clipping a portion of the contours theme.

1. Make the Contours of HOMERS29 theme active. Select New Theme from the View menu.

2. In the New Theme dialog box, specify Polygon for feature type and click OK.

3. Save the new theme to the DEMWORK directory with the name HOMERCUT.

4. Click on the Draw Rectangle button and create a rectangle near the center of the contours theme.

5. From the Theme menu choose Stop Editing. Select Yes in the Stop Editing dialog box. The HOMERCUT theme consists of one rectangular feature.

6. Click on the Clear Selected Features button and drag the Contours of HOMERS29 theme to the top of the legend.

7. In the File menu choose Extensions and turn on the GeoProcessing extension. In the View menu click on the GeoProcessing Wizard.

8. In the GeoProcessing window choose the Clip One Theme Based on Another option and click on Next.

9. In the dialog box use Contours of HOMERS29 for the input theme to clip and use HOMERCUT for the overlay theme. The output file should be named HOMERCLIP and placed in the DEMWORK directory.

10. Use the same procedure to clip the hydrology coverage. Now click on Finish.

Use the GeoProcessing extension, available under the View menu, to clip a portion of the contour theme.

    The reduced area HOMERCLIP theme appears in the legend and can be used to create a topography TIN as described in the main article. Use the name HOMER-CLIPTIN for this smaller theme, which can be used to complete the tasks necessary to open a 3D view.