PERSPECTIVES

Tutorial

3D Perspective Visualization

with

TNTmips®

TNTedit™

TNTview®

Before Getting Started

This booklet introduces techniques for constructing and manipulating 3D views in TNTmips®, TNTedit™, and TNTview®. You can drape 2D objects over a terrain surface provided by a raster object with cells containing elevation values or display vector, CAD or TIN objects with full 3D coordinates. This booklet introduces you to the basic 3D visualization tools in the Display process.

Prerequisite Skills This booklet assumes that you have completed the exercises in the tutorials *Displaying Geospatial Data* and *TNT Product Concepts*. The exercises in those booklets present basic skills for selecting and viewing objects stored in Project Files and getting around in TNTmips. Please consult those booklets for any review you need. In addition, the exercises on using 3D Groups in display and page layouts require familiarity with the tutorial *Making Map Layouts.*

Sample Data The exercises presented in this booklet use sample data that is distributed with the TNT products. If you do not have access to a TNT products DVD, you can download the data from MicroImages' web site. In particular, this booklet uses objects in the VIEW3D, TERRAIN, and SANMATEO data collections. Make a read-write copy of these files on your hard drive; you may encounter problems if you work directly with the read-only sample data on the DVD.

More Documentation This booklet is intended only as an introduction to 3D visualization. Details of the processes described here can be found in a variety of tutorial booklets, Technical Guides, and Quick Guides, which are all available from MicroImages' web site.

TNTmips® Pro and TNTmips Free TNTmips (the Map and Image Processing System) comes in three versions: the professional version of TNTmips (TNTmips Pro), the low-cost TNTmips Basic version, and the TNTmips Free version. All versions run exactly the same code from the TNT products DVD and have nearly the same features. If you did not purchase the professional version (which requires a software license key) or TNTmips Basic, then TNTmips operates in TNTmips Free mode. The 3D perspective display features are also available in TNTedit and TNTview. All of the exercises in this tutorial can be completed in TNTmips Free using the sample data provided.

Randall B. Smith, Ph.D., and Keith Ghormley, 28 August 2013
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You can print or read this booklet in color from MicroImages' Web site. The Web site is also your source for the newest tutorial booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTmips Free.

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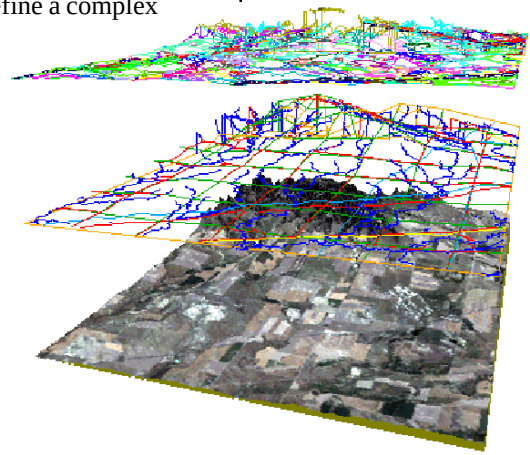
Welcome to 3D Visualization

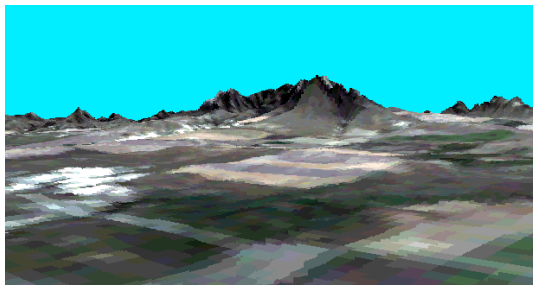
The Display process in TNTmips provides a number of flexible tools for 3D and stereo 3D visualization of many kinds of project materials. You can use the process with raster, vector, shape, CAD, and TIN objects. You can use a large array of drape objects over a wide-area surface to define a complex view.

☑ choose Main / Display from the TNTmips menu to start the display process

An essential concept underlies every feature in the process: the distinction between terrain layers and drape layers. A **terrain** or **surface** layer is a raster layer whose cell values are used as elevation values to define a surface viewable as a wireframe mesh. A **drape** layer contains a raster, vector, shape, or CAD object that takes its 3D shape from a surface object below it in the layer list in the Display Manager. One surface layer can also support any number of drape objects above it in the layer list. When multiple terrain and drape layers are used, each drape layer is rendered on the terrain layer closest below in the layer list.



Above: Crow Butte elevation with composite TM satellite image, DLG vector themes, and soil polygons.
Below: Crow Butte elevation with composite TM.



3D geometric objects that contain elevation values for their elements can be viewed directly in 3D views without the need for a raster terrain layer. Geometric objects include TIN objects, which always include 3D coordinates, and vector, CAD, and shape objects, which can be created or imported with 3D coordinates.

The exercises on pages 4-20 introduce setting up and adjusting 3D views. Special 3D effects with vector objects are discussed on pages 21-29. Pages 30-35 cover use of 3D groups in layouts, stereo viewing, and manifolds.

Create a New 3D Display

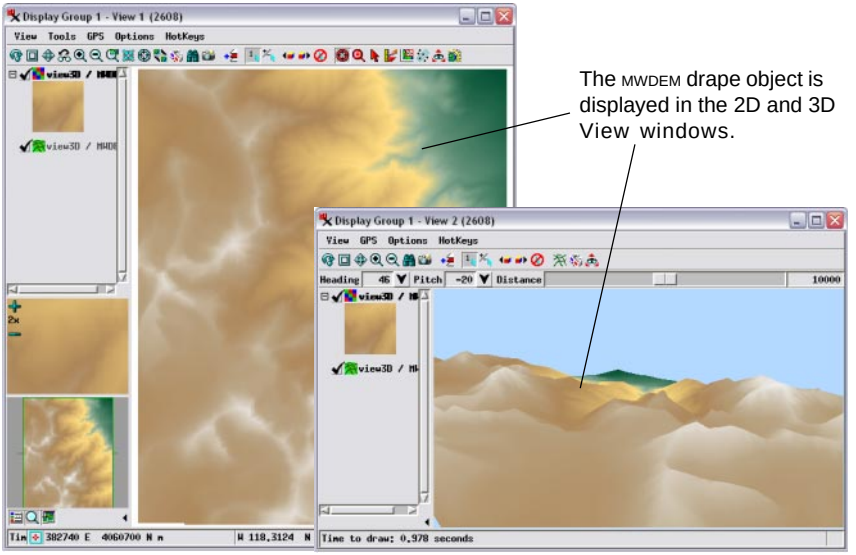
STEPS

- ☑ choose Display / New / 3D Display from the Display Manager window
- ☑ in the Select Object window navigate to the VIEW3D data directory and select MWDEM from the VIEW3D Project File as a terrain layer
- ☑ select VIEW3D / MWDEM again as a display layer (drape)
- ☑ keep this group open for the next exercise

The raster object you select as the terrain layer must be a grayscale raster. You cannot use color-composite raster objects as a terrain layer.

When you create a New 3D Display, you are automatically prompted to select a raster to serve as the terrain, then for one or more objects to display (drape) over that terrain. You can choose the terrain raster again to use as the drape layer if you wish. An elevation raster used as a drape raster is easier to visualize if it is displayed with relief shading or with a color palette, as in this exercise.

After you select the objects, the process opens two view windows. View 1 is the standard 2D View window that should be familiar to you from 2D Displays. View 2 is a perspective view window in which the data layers are rendered in 3D. Each View opens by default with a LegendView pane on the left side. You can use the Hide/Show checkbox in LegendView to control whether an individual layer is shown in that particular View, so the 2D and perspective views can show or hide different layers. The Hide/Show layer checkboxes in the Display Manager act globally across all Views.



Wireframe and Solid View

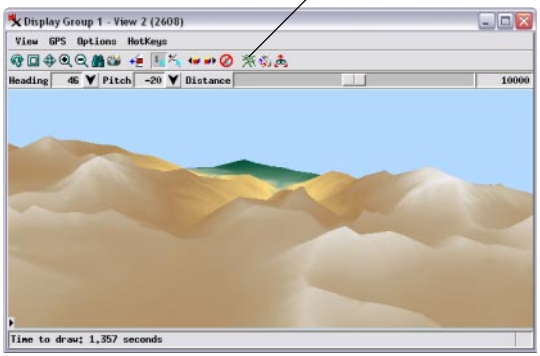
The 3D view window can show either a wireframe view of the surface or a solid view. The wireframe is a rectangular mesh of lines that shows the extents and general shape of the terrain layer and can be rendered into the view instantaneously. Solid view renders the drape layer onto the terrain layer and so requires a longer display time. The Wireframe View icon button on the 3D view toggles the window between these two states. The initial default mode is solid view, but after that the 3D view opens in whatever mode was last used in the previous session.

STEPS

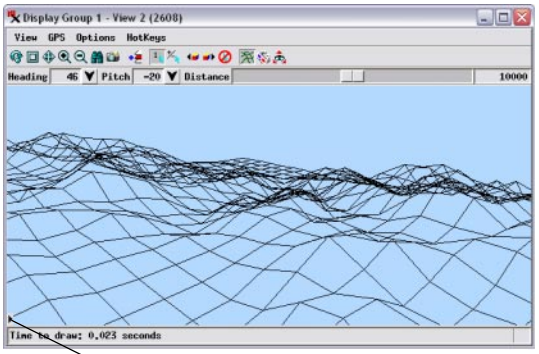
☑ (optional:) use the layer icon buttons on the Display Manager to open the drape and surface layers' Layer Controls windows and select wireframe colors

☑ turn on the Wireframe View icon button on View 2

You can change the window background color by choosing Color from the perspective view's Options menu. You can change the wireframe color for any raster drape layer in the Raster Layer Controls dialog that opens when you click the layer's object icon button in the layers list in the Display Manager (or select Controls from a layer's right mouse button menu in the Display Manager or the view sidebar). The wireframe color selection is on the Raster Layer Controls window's 3D tabbed panel. Note that each surface and drape layer has its own wireframe color. Since the topmost layer is the drape layer, its wireframe color is the one that shows in the 3D view.



The 3D perspective window shows either wireframe or solid renderings of the spatial data.



NOTE: to conserve space on the page, the sidebar has been turned off in the perspective view illustrations on this and subsequent pages using the Show / Hide Sidebar button (with black triangle icon).

Change Viewing Direction and Distance

Definitions:

Heading is the horizontal view direction in degrees clockwise from north.

Pitch is the vertical angle of the view direction relative to the horizontal; downward angles are negative.

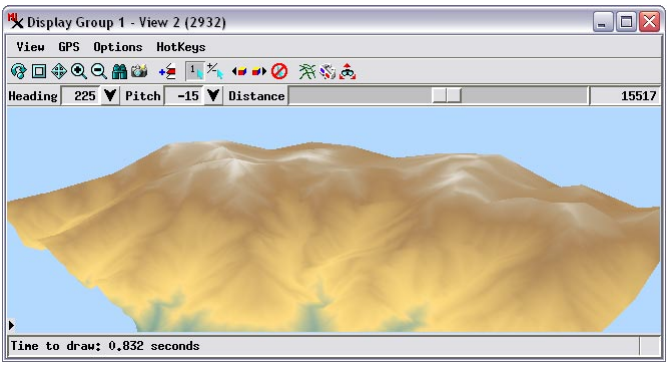
STEPS

- ☑ turn off the Wireframe View
- ☑ press the arrow icon button for Heading and choose Southwest from the dropdown menu
- ☑ choose Down 15 degrees from the Pitch menu
- ☑ move the Distance slider to the right until the value shown in the field to the right of the slider is around 15000

The 3D view opens with the group centered in the view. The view direction is toward the northeast from a point above the terrain. You can make simple adjustments to the viewing geometry using the controls below the icon buttons on the 3D view window.

You can enter a numeric value into the Heading field or press the downward arrow button and choose a cardinal direction (North, Northeast, and so on) from the menu. Likewise, you can enter a pitch value in the numeric field or use the menu to choose a pitch angle between 45 degrees up or down in 5-degree increments. Use the Distance slider to vary the distance (in meters) from the "viewer" to the center of the view. The default distance range of the slider is automatically extended when you drag the slider to one of its endpoints. The current distance is shown in the numeric field to the right of the slider; you can also type a desired distance into this field. With the perspective view in solid view mode, as you drag the Distance slider the view temporarily reverts to wireframe mode to provide a continuously-changing preview. When you release the slider, the perspective view redraws automatically in solid view.

Solid View with viewer position changed to show a view of the terrain toward the southwest and from a greater distance.



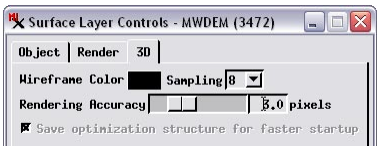
Surface Layer Controls

The Object settings on the Surface Layer Controls window allow you to modify the vertical scaling for a terrain layer. Setting the Scale value greater than 1.0 provides vertical exaggeration that can be useful in visualizing low-relief terrains. The Offset value is added uniformly to the entire terrain to shift all elevations up or down by the same amount. For example, you might want to use the same elevation raster as two different surface layers in the same group with different drape layers. You could then offset one of these terrains upward so that both can be seen at the same time in the perspective view.

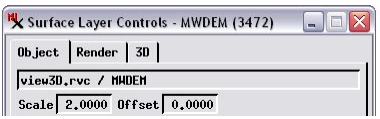
STEPS

- ☑ turn on the Wireframe View icon button on the perspective view window
- ☑ press the Layer Controls icon button for the terrain layer in the Display manager
- ☑ in the Surface Layer Controls window, click the 3D tab and choose 8 from the Wireframe Sampling menu

The sampling value for the wireframe determines how dense the wireframe appears. The MWDEM terrain layer in these exercises has a default sampling rate of 16. That means that the lines in the wireframe are derived from values in every 16th row and every 16th column of the raster object. To see more lines in the wireframe, change the sampling value to a smaller number. To see a sparser mesh, increase the sampling value. The denser the mesh, the more detail you can see in the surface in wireframe view.

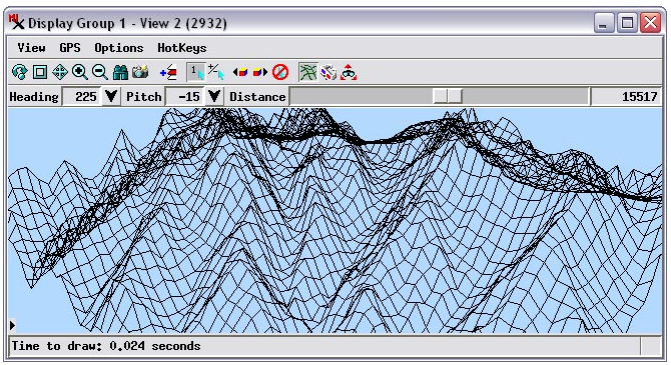


- ☑ on the Object tabbed panel change the Scale field to 2.0



Always change the wireframe sampling rate with the surface layer controls. The wireframes for drape layers use the same sampling rate as the surface layer.

- ☑ press [Apply] on the Surface Layer Controls window



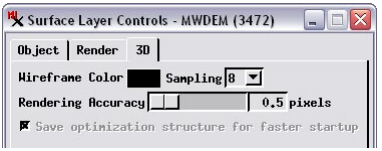
Wireframe view with vertical scale set to 2.0 to provide vertical exaggeration. The smaller wireframe sampling set here provides a denser representaion of the surface.

Setting Terrain Rendering Accuracy

STEPS

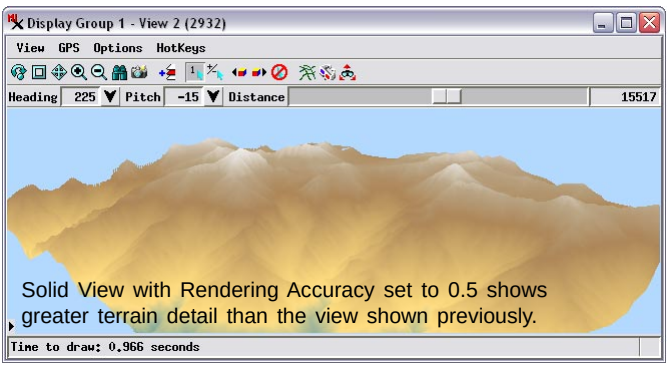
- ☑ in the Surface Layer Controls window Object panel, set the Scale to 1.0
- ☑ on the 3D panel, move the Rendering Accuracy slider all the way to the left; the numeric field should read 0.5

The terrain surface for solid 3D views is modeled as a variable-resolution triangular mesh of elevation values sampled from the terrain raster. Foreground and high-relief areas are represented by small triangles that can accurately represent terrain details. Background and low-relief areas that require less detail are modeled by larger triangles. This triangulation model is reconstructed each time the 3D viewpoint changes.



The elevation of each triangle vertex always equals the elevation in the corresponding terrain raster cell. The edges and faces of larger triangles, however, can deviate in elevation from the terrain raster cells they cross or span. The Rendering Accuracy value sets the maximum allowed vertical deviation between any triangle edge or face in the terrain model and the corresponding terrain raster cell value. These deviations translate directly to offsets up or down in the 3D view, so the accuracy value is measured in screen pixels. The range of this setting is from 0.5 to 10 screen pixels, with a default value of 3.0. Reducing the Rendering Accuracy setting provides a more accurate, detailed terrain rendering in Solid View by causing large triangles in the terrain model to be split into smaller, more accurate triangles. Because more triangles must be processed, rendering times are slower, though the difference should only be signficant for large terrain rasters.

- ☑ press [Apply] on the Surface Layer Controls window
- ☑ turn off Wireframe View mode on the perspective view window



Solid View with Rendering Accuracy set to 0.5 shows greater terrain detail than the view shown previously.

Stored Terrain Properties

Computation of the variable triangulation used for terrain rendering in the 3D view requires not only the raw elevation values in the terrain raster but also several additional neighborhood properties of each terrain raster cell, such as a measure of local relief. Because these terrain properties are independent of viewpoint, they can be computed once for the terrain raster, then used for each new viewpoint to quickly rebuild the variable triangulation.

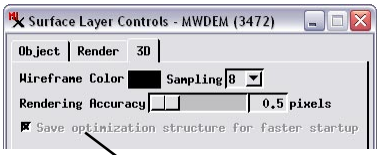
The Display process automatically computes surface properties for a raster the first time it is used as a terrain layer (in particular, the first time the terrain is rendered in solid view). The time required for this initial computation is directly related to the size of the terrain raster and can be several minutes for larger rasters. Terrain properties are saved with the raster object by default so that they do not need to be recomputed in later sessions. Saving the terrain properties increases the stored size of the terrain raster by 2 to 10 times (depending on the raster's size and data type), but in subsequent 3D viewing sessions the terrain properties are read automatically from the stored structure, so the first display of the 3D scene is not delayed.

A toggle button on the Surface Layer Controls window (*Save optimization structure for fast startup*) controls this storage behavior. This toggle is turned on by default, and is inactive if the current terrain raster already has stored surface properties (as in this exercise). If you turn the toggle off before rendering the 3D view with a new terrain raster (or if the terrain raster is on a read-only medium), the terrain properties are stored in a temporary file and used only for the duration of the current 3D viewing session. You should allow surface properties to be permanently stored for any raster that you expect to reuse as a terrain layer.

STEPS

☑ press [OK] on the Surface Layer Controls window

When you Import a raster file in TNTmips, the Import Parameters dialog for many file formats includes the option to Compute 3D Surface Properties. Turn this toggle button on to have the surface properties computed during the Import procedure. They will then be used automatically any time the raster is used as a terrain layer.



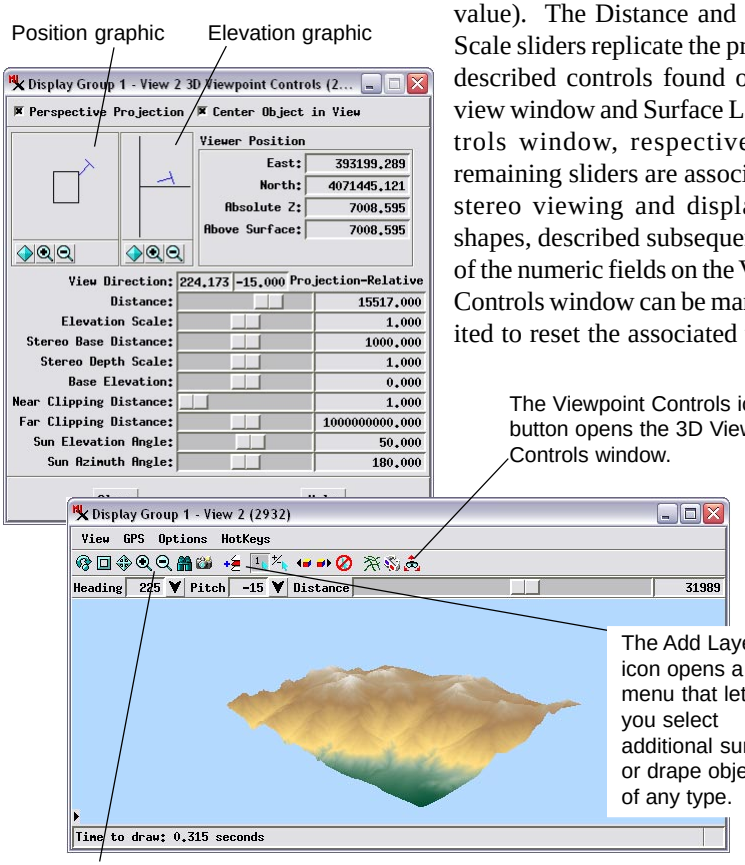
The toggle is inactive in this example because the MWDEM raster we are using for the terrain layer already has stored surface properties.

3D Viewpoint Controls

STEPS

- ☑ press the Viewpoint Controls icon button in the 3D view window
- ☑ in the 3D Viewpoint Controls window, drag the Distance slider to the right until the entire wireframe is visible in the 3D view and release

The Viewpoint Controls window provides a more comprehensive set of controls for changing the viewing geometry of the 3D view. The position and elevation graphics in the upper left corner of the window are controls (described on the next page) for changing heading and pitch angle. The Viewer Position fields show the current map coordinates, elevation, and height of the viewer. The View Direction fields (just above the bank of sliders) record the current heading (left value) and pitch (right value). The Distance and Elevation Scale sliders replicate the previously-described controls found on the 3D view window and Surface Layer Controls window, respectively. The remaining sliders are associated with stereo viewing and display of 3D shapes, described subsequently. Any of the numeric fields on the Viewpoint Controls window can be manually edited to reset the associated value.



Zoom In and Zoom Out actions differ from distance adjustments. The Distance sliders move the viewpoint and thus change the geometry of the perspective view. Zoom actions simply enlarge or reduce the view.

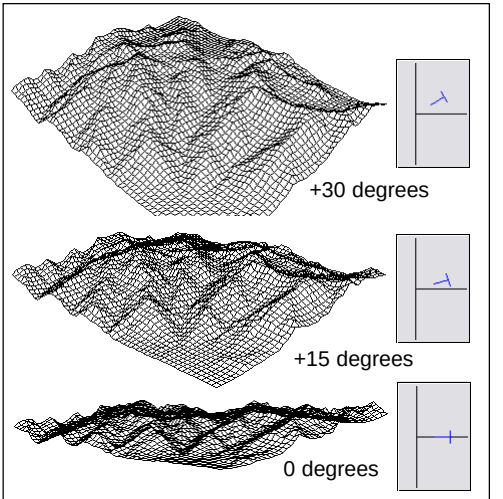
Position and Elevation Controls

The graphic controls in the 3D Viewpoint Controls window allow you to rotate the 3D model around vertical (position control) and horizontal (Elevation control) axes. The position control consists of a blue T-shaped graphic representing the viewer position and heading (long bar of the T) that you can rotate around a rectangle that represents the extents of the terrain raster layer. As you move the viewer indicator, the wireframe in the 3D View window rotates to show the change in viewer position and heading.

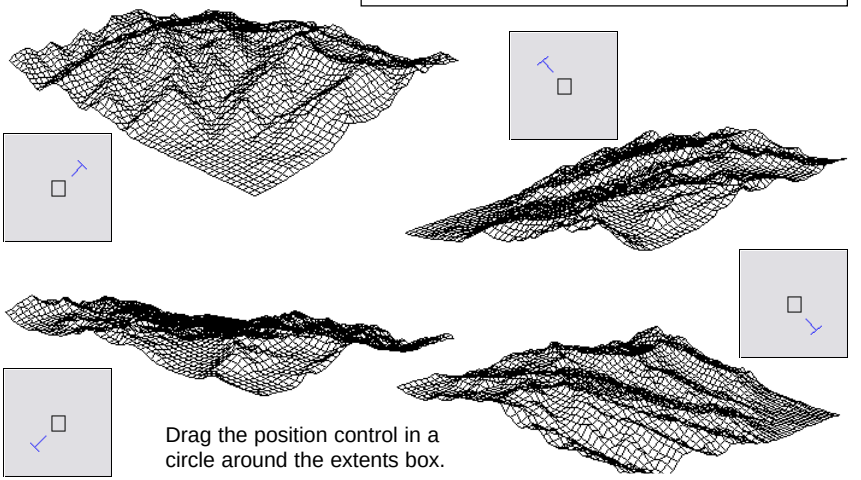
The vertical and horizontal lines of the elevation control depict a side view of the 3D space. You can swing the T-indicator through a semicircular arc and change the pitch angle from straight above (+90 degrees), to edge-on (0 degrees), to straight below the surface (-90 degrees).

STEPS

- ☑ drag the elevation control through its arc and observe the effect on the wireframe
- ☑ drag the position control around the extents box and observe the effect on the wireframe



Above: three positions of the elevation control.



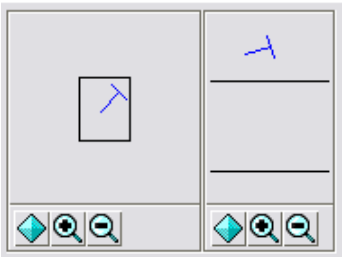
Drag the position control in a circle around the extents box.

Center Object in View Toggle

The Center Object in View toggle on the Viewpoint Controls window determines the mode of the position and elevation graphic controls. When the toggle is on (the default state), the 3D model stays centered in the 3D View window, and the controls rotate the viewer around this fixed center point. When the toggle is off the model is free to move in the 3D view, and the position and elevation graphics change from rotation to translation mode. You can drag the position graphic in this mode in any direction to reposition the viewer horizontally without changing the heading. Likewise, you can drag the elevation graphic up or down to change the viewer elevation without changing the pitch. Be careful when the Center Object in View toggle is off, because you can easily point the view away from the surface and see nothing but an empty 3D window. (You can always recover a "lost" terrain by turning on the Center Object in View toggle.)

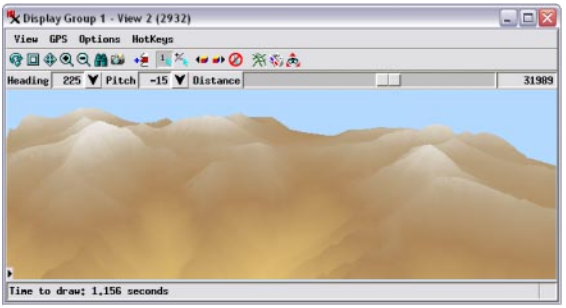
STEPS

- ☑ turn off the Center Object in View toggle in the Viewpoint Controls window
- ☑ drag the position graphic to shift the viewer position
- ☑ drag the elevation graphic up and down to change the viewer elevation
- ☑ hold down the shift key while dragging the position indicator to change the heading
- ☑ hold down the shift key while dragging the elevation graphic to change the pitch



The position and elevation graphic controls also have another mode when the Center Object in View toggle is off. If you hold down the shift key while dragging on the long bar of the T indicator, you can pivot either control graphic in place. In this way you can change the viewer heading and pitch without changing the horizontal position or elevation.

You can use the Zoom buttons to zoom either control graphic in or out.



NOTE: the Distance sliders have no effect when the Center Object in View toggle is turned off.

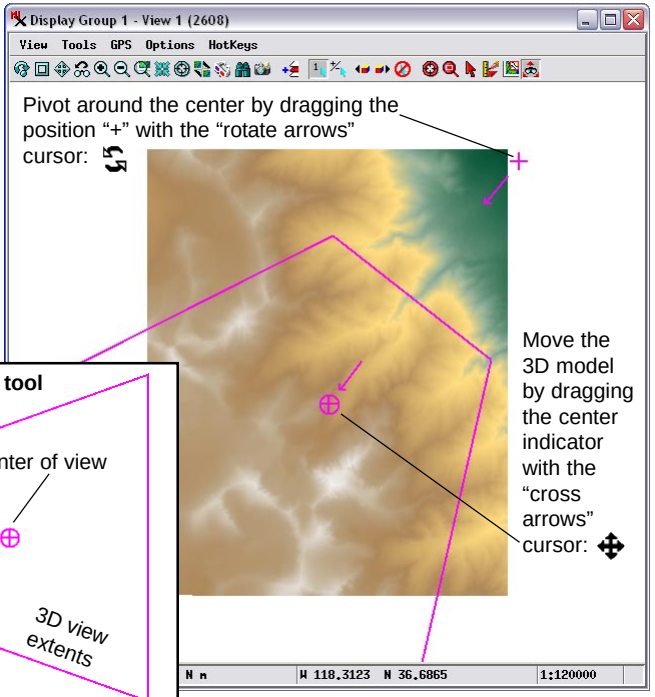
Adjust Viewpoint Tool

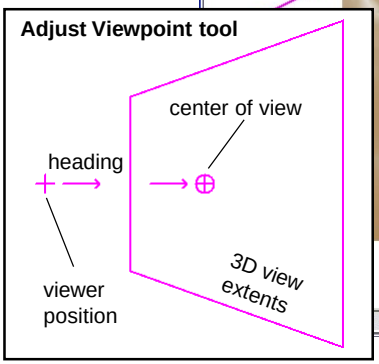
The 2D View window provides an additional means of changing the viewer position and viewing direction of the associated 3D view. Turning on the Adjust Viewpoint tool on the toolbar reveals a set of graphics in the 2D view: a four-sided polygon shows the general extents of the 3D view, a cross shows the viewer position, and a circled cross shows the location of the 3D view center. (The near and distant edges of the extents polygon may not be visible in some viewing geometries.) The mouse cursor assumes a "cross-arrows" shape over most of the 2D view; use the mouse in this mode to drag the view center indicator to a new location. When the mouse is close to the viewer position indicator, the cursor changes to the "rotate arrows" shape, and you can drag the indicator to pivot the viewer around the center.

STEPS

- ☑ turn the Center Object in View toggle on again
- ☑ in the 2D View window, choose Options / Hidden Features
- ☑ scroll down in the Customize window to the Tool Selection Toolbar group and turn on the Adjust Viewpoint checkbox, then press [OK]
- ☑ turn on the Adjust Viewpoint tool in the 2D view window
- ☑ drag and rotate the tool in the 2D view and observe the result in the 3D view

The Adjust Viewpoint tool, 3D Viewpoint Controls window, and the viewpoint controls on the 3D View window are all interlinked; each set updates when another control is changed.



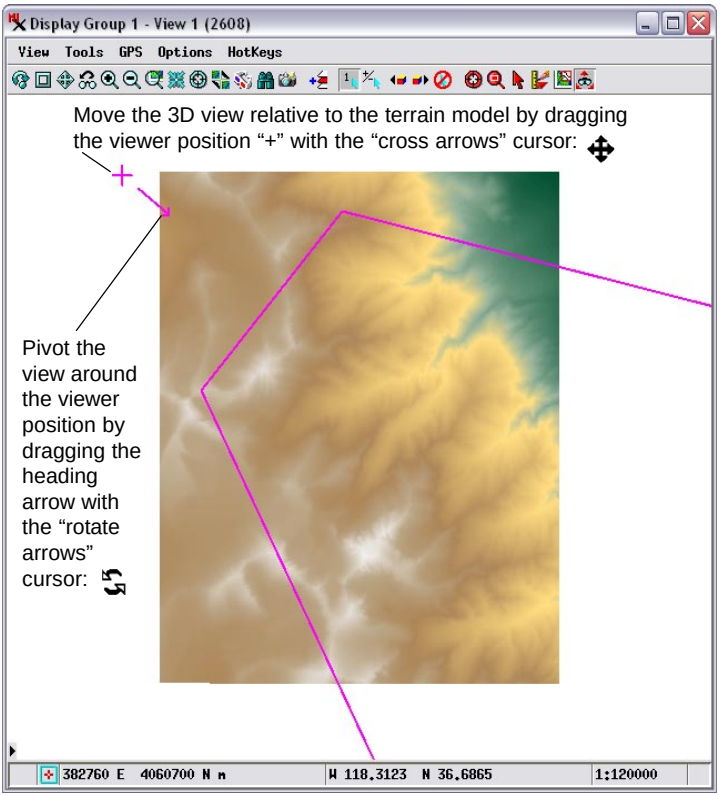


Adjust Viewpoint Tool Uncentered

STEPS

- ☑ turn off the Center Object in View toggle in the 3D Viewpoint Controls window
- ☑ note the changes in the Adjust Viewpoint tool graphics
- ☑ drag the viewer position indicator to reposition the view
- ☑ drag the heading arrow to rotate the view around the viewer position
- ☑ turn the Center Object in View toggle on again

When the Center Object in View toggle is turned off in the 3D Viewpoint Controls window, the view center indicator disappears in the 2D view and the behavior of the Adjust Viewpoint tool graphic changes. The cross arrow cursor now allows you to drag (rather than rotate) the viewer position indicator to reposition (translate) the view relative to the terrain model. Move the mouse close to the heading arrow; the cursor changes to the "rotate arrows" shape, allowing you to drag the heading arrow to rotate the view around the viewer position.



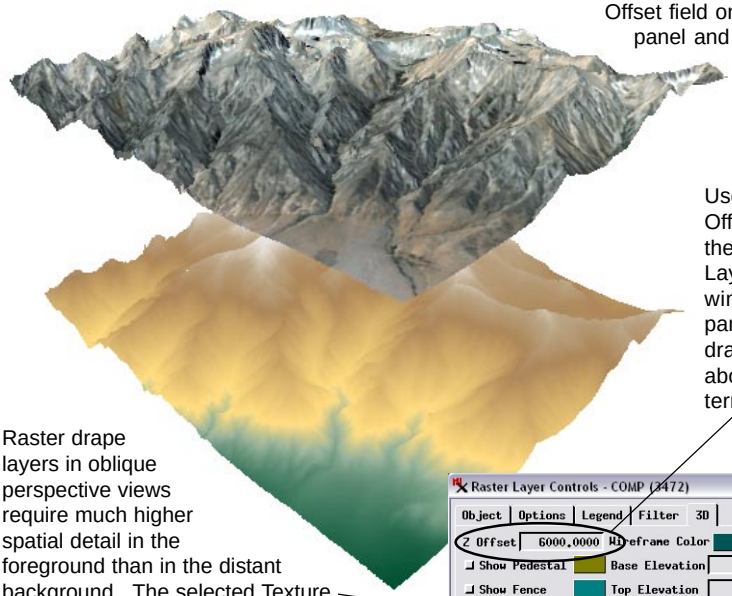
Floating Drape Layers

You can add any number of raster drape layers to a group with a 3D view. Each of these drape layers takes its shape from the underlying terrain layer. However, if all of the drape layers have the same spatial extents, the uppermost layer will obscure those underneath. There are several solutions to this problem in 3D viewing. One is to "float" the obscuring layer(s) above those below by setting a positive Z Offset for the layer in the Raster Layer Controls window.

In this exercise you add a composite raster layer (a natural-color Landsat satellite image) to the group and float it above the color-coded image of the elevation surface.

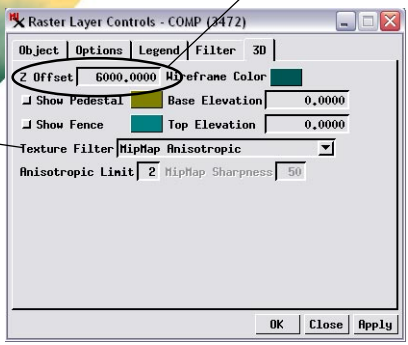
STEPS

- ☑ press the Add Objects icon button on the Display Manager window
- ☑ select raster object COMP from the VIEW3D Project File
- ☑ in the Display Manager, left-click on the Raster Controls icon button for the COMP drape layer
- ☑ in the Raster Layer Controls window for the comp layer, click on the 3D tab
- ☑ enter 6000 in the Z Offset field on the 3D panel and press [Apply]



Use the Z Offset field on the Raster Layer Controls window's 3D panel to float a drape layer above the terrain.

Raster drape layers in oblique perspective views require much higher spatial detail in the foreground than in the distant background. The selected Texture Filter determines how the drape raster and its pyramid tiers are sampled to produce different parts of the perspective view smoothly and efficiently. For more information see the Technical Guide entitled *Texture Filters for 3D Rendering.*

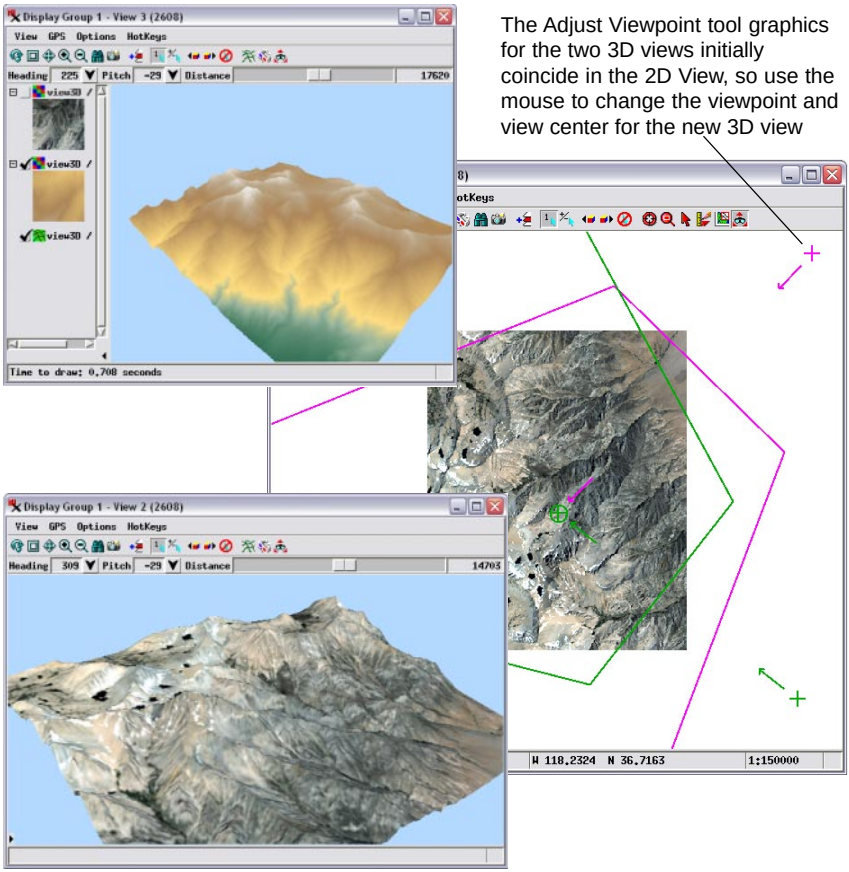


Multiple 3D Views

STEPS

- ☑ in the Raster Layer Controls window for the COMP raster layer, reset its Z Offset to 0 and press [OK]
- ☑ choose Display / Open 3D View from the Display Manager
- ☑ in the new 3D view, show the sidebar and turn off the Show / Hide checkbox for the COMP layer

You can also open multiple 3D views of the same group. The sidebar controls in each 3D view let you independently determine which drape layers are shown or hidden in that view, so you can see simultaneous 3D views with different drape layers turned on if you choose. You can also set different viewing geometries for each of the perspective views. Each 3D view is represented by its own Adjust Viewpoint tool graphic in the 2D view which can be manipulated independently as shown on a previous page. Each 3D view also has its own 3D Viewpoint Controls window.



Vector Drape Layers

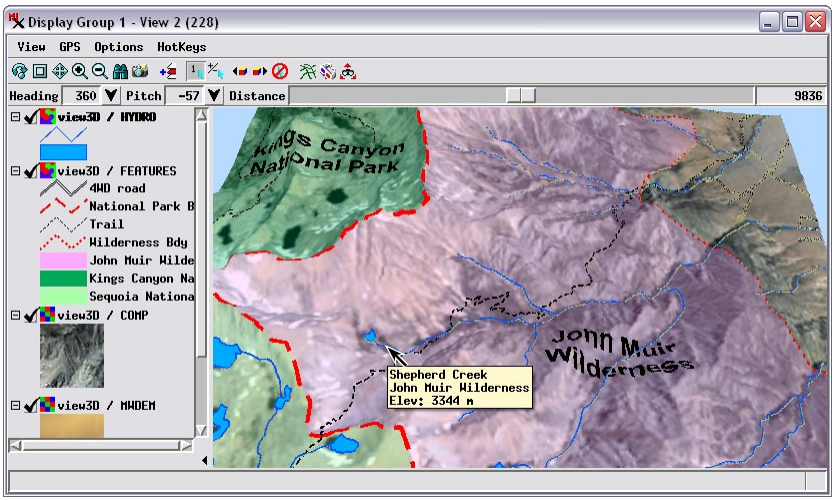
Geometric objects (vector, CAD, and shape objects) with 2D coordinates can also be used as drape layers in a 3D perspective view. Lines, polygons, and labels in these layers are rendered onto the underlying terrain surface just as raster drape layers are. Styles used for rendering the elements in the 2D view are also rendered in the 3D view, including transparent polygon fills. Bit-map and hatch fills for polygons can be rendered in the 3D view but are not optimal for perspective viewing. Solid color polygon fills (with or without partial transparency) work best for vector objects that will be viewed in 3D. DataTiip information for geometric elements and for raster cell values are also available when the mouse cursor is hovered over relevant locations in the 3D view.

Special 3D effects are available for point and polygon elements in 2D vector objects. Vector objects with 3D coordinates are also treated differently than 2D vector objects. These topics are discussed further on subsequent pages.

STEPS

- ☑ press the Add Objects icon button on the Display Manager window
- ☑ select vector objects FEATURES and HYDRO from the VIEW3D Project File
- ☑ pause the mouse cursor over features in the 3D view and note the DataTip

NOTE: display of fills for polygon elements in the 3D window requires appropriate settings in the layer's Vector Layer Controls window. Be sure that the Polygon Filling menu on the Polygons tabbed panel is set to *Enable for 2D and 3D.*



☑ choose Display / Close from the Display Manager when you have completed this exercise

Transparency and Relief Shading

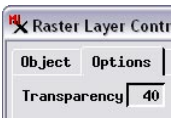
STEPS

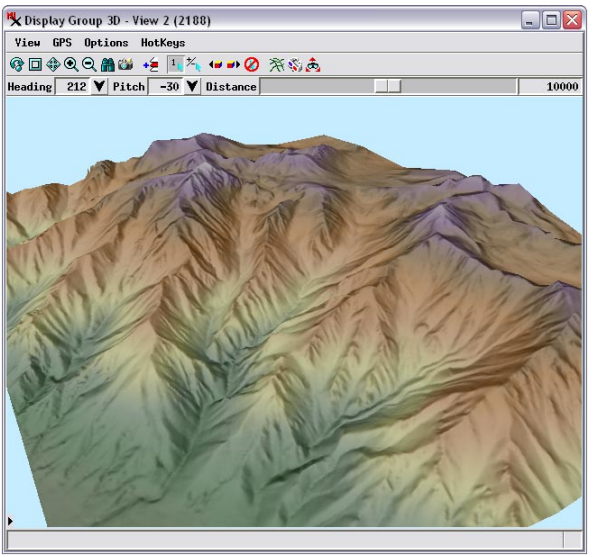
- ☑ choose Display / Open from the Display Manager window
- ☑ navigate to the TERRAIN data collection and choose Display Group 3D from the SHADE Project File
- ☑ in the Display Manager, left-click on the Raster Controls icon button for the upper drape layer (MWDEM2)
- ☑ on the Options panel of the Raster Layer Controls window for MWDEM2, note the Transparency field value, then press [OK]
- ☑ turn off the Show / Hide checkbox for the MWDEM2 layer
- ☑ open the Raster Controls window for the lower drape layer (MWDEM1)
- ☑ on the Shading panel of the Raster Layer Controls window for mwdem1, note that the Relief Shading toggle is turned on, then press [OK]
- ☑ turn on the Show / Hide checkbox for MWDEM2

- ☑ choose Display / Close from the Display Manager when you have completed this exercise

A group that incorporates a 3D view can be saved along with all 3D view settings using the Save As option from the Display menu in the Display Manager. In this exercise you open a saved 3D group with multiple raster drape layers illustrating the use of transparency and relief shading in 3D views.

Two raster drape layers are included in this group. The lower drape layer, which is the elevation raster that is also used as the terrain, has relief shading turned on for the raster. The upper drape layer is a copy of the elevation raster that is displayed with a color palette and with 40% transparency. The use of partial transparency for this upper raster layer allows the relief-shaded image and the color-mapped version to visually blend in both the 2D and 3D views to create a relief-shaded view with color-coded elevations. Both transparency levels and the relief shading option can be set in a drape layer's Raster Layer Controls window.





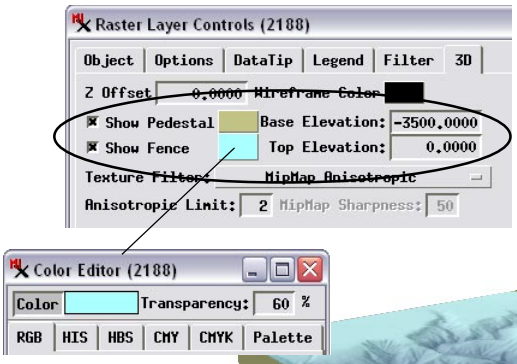
Pedestal and Fence

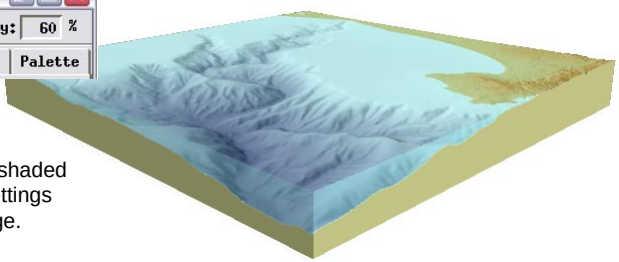
You can enclose any raster drape layer in a colored pedestal and/or fence using controls on the Raster Layer Controls window's Options tabbed panel. These vertical, curtain-like elements are drawn along the boundaries of the raster layer (excluding any cells designated as transparent by a null value, null mask, or display mask). A pedestal is drawn vertically downward from the terrain surface to the designated base elevation; a fence is drawn vertically upward from the surface to the designated top elevation. You can choose colors for the pedestal and fence and set a transparency value for either color in the standard Color Editor window.

The terrain surface in this example combines seafloor bathymetry and coastal topography for a portion of Monterey Bay, California (USA). A partially transparent blue fence extends upward from the seafloor surface to sea level (0 elevation) to suggest the presence of water yet enable submarine features behind the fence to remain visible.

STEPS

- ☑ choose Display / New / 3D Display from the Display Manager
- ☑ navigate to the VIEW3D directory and choose BATH_DEM from the MONBAY Project File as the terrain layer and COLORSHADE as the display layer
- ☑ move the Distance slider on the 3D view to the right until the entire terrain is visible
- ☑ open the Raster Layer Controls window for the COLORSHADE layer and click on the 3D tab
- ☑ turn on the Show Pedestal and Show Fence toggle buttons
- ☑ enter -3500 in the Base Elevation field
- ☑ press the color button to the right of the Show Fence Toggle
- ☑ note the Transparency field value in the Color Editor and press [OK]
- ☑ press [OK] on the Raster Layer Controls window





The pedestal and fence faces are automatically shaded using the illumination settings discussed on a later page.

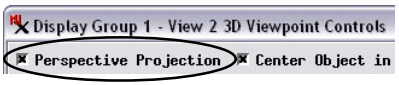
☑ choose Display / Close from the Display Manager when you have completed this exercise

Perspective and Parallel Projections

STEPS

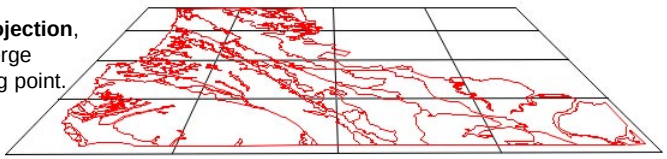
- ☑ press the Add Objects icon button on the Display Manager window
- ☑ navigate to the SANMATEO data directory and select objects TM_321 and GEOLMAP from the SANMATEO Project File
- ☑ choose Display / Open 3D View from the Display Manager
- ☑ choose Northwest from the Heading icon button menu in the 3D view

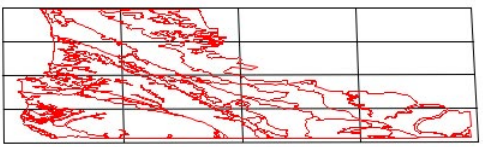
The 3D view can display layers in either perspective or parallel projection using the Perspective Projection toggle on the 3D Viewpoint controls window. The default perspective projection varies the scale of the scene to provide a realistic sense of depth and distance. Objects appear larger in the foreground than in the background, and sets of parallel lines converge toward a distant vanishing point. In a parallel projection, any sets of parallel lines remain parallel in the 3D view. Scale is constant throughout the view, so objects of the same size appear the same regardless of their position in the scene. This projection therefore conveys less sense of 3D depth in the view.



The Perspective Projection button on the 3D Viewpoint Controls window toggles the 3D view between perspective and parallel projections. This toggle is only active when the current group includes a terrain layer. 3D groups lacking a terrain surface are always shown in perspective projection.

In **Perspective Projection**, parallel lines converge towards a vanishing point.





In **Parallel Projection**, parallel lines remain parallel throughout the view.

A terrain surface is not required for 3D perspective views. Without a terrain surface, all display layers are projected onto a horizontal planar surface. A 3D view of a group with no terrain surface is useful for displays of a stack of floating layers or for other specialized 3D effects (see the following pages).

2D Points on Stalks

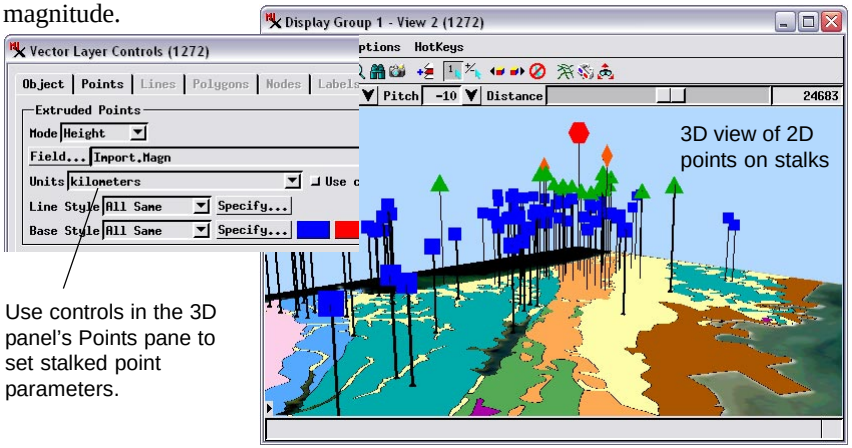
Special 3D effects are available for points and polygons in 2D vector objects. Both types of elements can be raised above the surface in 3D views using controls on the 3D tabbed panel of the Vector Layer Controls window.

2D point symbols can be rendered vertically (always facing toward the viewer) and elevated above (or below) the surface on a stalk (vertical line). The size of the stalk is determined by the value in a numeric field you designate in the vector object's point database and from the current selection on the Units menu. The Mode menu setting determines whether the stalk size is used as a height above the local surface or as an absolute elevation (height above the 0 elevation datum regardless of local surface elevation).

The QUAKES2 vector object in this example maps epicenter locations for earthquakes. The Richter magnitude of each earthquake is used as the height of the stalk in kilometers. (Since no surface is in use, there is no difference between Height and Elevation mode in this case.) The point symbols are set using a ThemeMap also based on the earthquake magnitude. The 3D display of the stalked points thus serves as a 3D bar graph of the earthquake magnitude.

STEPS

- ☑ add vector object QUAKES2 from the SANMATEO Project File
- ☑ press the Layer Controls icon button for the QUAKES2 layer in the Display Manager
- ☑ on the Vector Layer Controls window's 3D tabbed panel, choose Height from the Mode menu in the Extruded Points pane
- ☑ press [Field] in the Extruded Points pane
- ☑ in the Select Table/Field window, choose Import from the Table list and Magn from the Field list and press [OK]
- ☑ choose kilometers from the Units menu in the Extruded Points pane and press [OK] on the Vector Layer Controls window
- ☑ adjust the viewpoint in the 3D view



Use controls in the 3D panel's Points pane to set stalked point parameters.

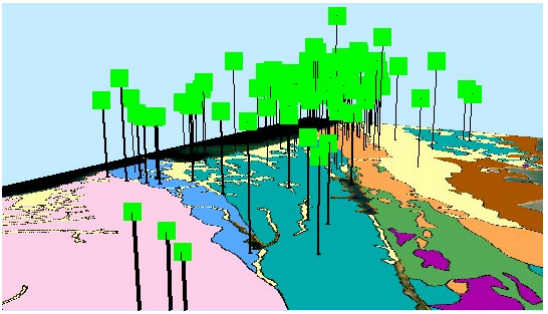
Style Point Symbols for 3D Perspective

STEPS

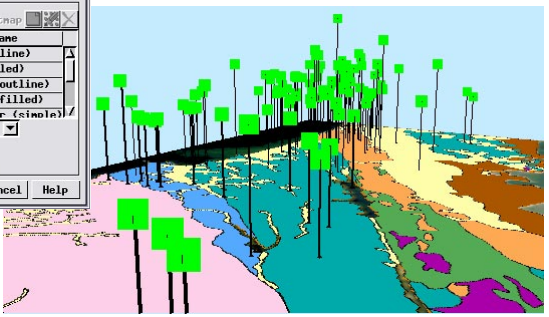
- ☑ open the Vector Layer Controls window for the QUAKES2 layer
- ☑ on the Points tabbed panel, choose All Same from the Style menu and press [Apply]
- ☑ note the uniform screen size of all of the point symbols
- ☑ on the Points tabbed panel, press [Edit] next to the Style menu
- ☑ in the Edit Styles window, choose User Defined on the At Scale: menu
- ☑ enter 100000 in the numeric field next to the At Scale: menu and press [OK] on the Style Editor
- ☑ press [OK] on the Vector Layer Controls window

The visual perspective effect in 3D views can be enhanced if you set proper style parameters for your vector elements. In this exercise we switch to All Same styling for point symbols to illustrate the effect of symbol scaling on perspective views.

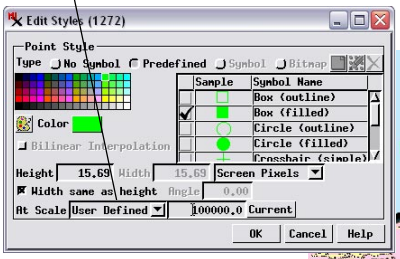
Point symbols (and line/border widths) can be set to have a constant size on the screen regardless of the map scale, or be sized relative to a particular map scale. In the 2D view, map-scaled symbols get larger in the view when you zoom in and smaller when you zoom out. These scaling effects also carry over into the 3D perspective view. Map-scaled symbols appear larger in the foreground of the 3D view and smaller in the background, contributing to the visual perspective effect. The same principle applies to the widths of line elements and polygon borders in vector drape layers.



Point symbols with fixed screen size (above) and scaled to a map scale (below).



Point symbols and line styles appear larger in the foreground when the element style definition uses a Design scale or User Defined scale.



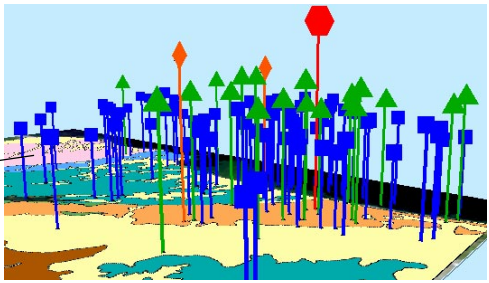
Style Point Stalks

Stalked points have three components: the elevated billboard symbol, the stalk line, and a base symbol on the surface. Point symbols are styled using controls on the Points tabbed panel on the Vector Layer Controls window. The stalk line and base are styled using controls on the 3D tabbed panel. Each of these components can be styled independently using the menu choices All Same, By Attribute, By Theme, or By Script. (For general information on styling vector elements, see the tutorial entitled *Creating and Using Styles*.)

In the previous exercises the stalk line and base were each styled All Same. In this exercise the stalk lines are styled By Theme (using a previously-prepared theme table) with colors assigned by earthquake magnitude ranges. In the initial display, each stalk is rendered with a single color. In the second display, with the Use Color Stack option turned on, all of the magnitude ranges through which a stalk passes are shown by their assigned colors on the stalk and thicker line widths are used for higher magnitudes.

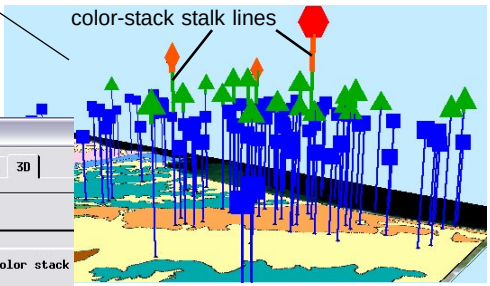
STEPS

- ☑ open the Vector Layer Controls window for the QUAKES2 layer
- ☑ in the Points tabbed panel choose Import_Magn from the Style menu
- ☑ in the Extruded Points pane of the 3D panel choose By Theme from the Line Style menu
- ☑ press [Apply] on the Vector Layer Controls window
- ☑ reopen the Vector Layer Controls window for the QUAKES2 layer
- ☑ in the Extruded Points pane of the 3D panel turn on the Use Color Stack toggle button and press [OK]

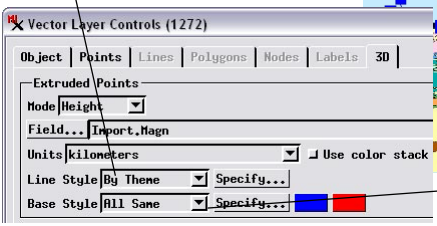


Points with stalk lines styled by theme.

Points with stalk lines styled by theme with the color stack option turned on.



Use the Line Style menus to set up styling for stalk lines.



Use the Base Style menus to set up styling for the base point symbols.

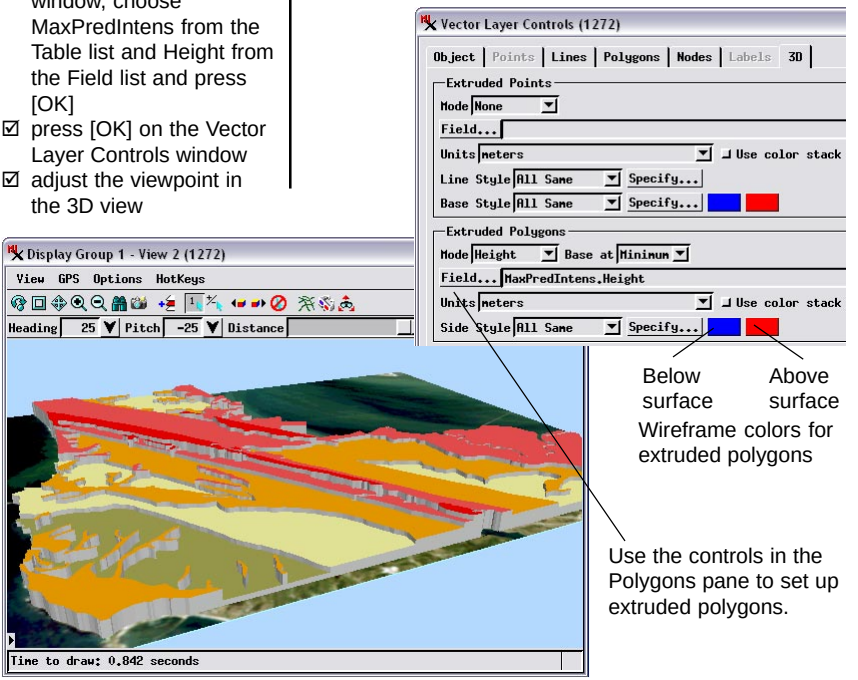
Extruded Solid Polygons

STEPS

- ☑ right-click on the QUAKES2 layer entry in the Display Manager and choose Remove Layer from the menu
- ☑ repeat for the GEOLMAP layer
- ☑ add vector object SEISMAP to the group
- ☑ open the Vector Layer Controls window for the SEISMAP layer
- ☑ in the Extruded Polygons pane of the 3D panel choose Height from the Mode menu
- ☑ press [Field] in the Extruded Polygons pane
- ☑ in the Select Table/Field window, choose MaxPredIntens from the Table list and Height from the Field list and press [OK]
- ☑ press [OK] on the Vector Layer Controls window
- ☑ adjust the viewpoint in the 3D view

You can also use the 3D panel on the Vector Layer Controls window to "extrude" vector polygons in the 3D view so they appear as solid objects extending above or below the terrain. Settings for extruded polygons are very similar to those for stalked points: set the Mode menu to Height or Elevation and select the numeric field and units to supply those values. If a terrain surface is used, a polygon may cover an area of varying surface elevation. When you use the Height mode, you can choose either the minimum or maximum elevation on the polygon boundary as the datum for the polygon height.

The vector object used in this exercise maps areas of varying maximum predicted seismic intensity for a model earthquake. The Height field in the MaxPredIntens table in the polygon database contains a height in meters for each intensity level.



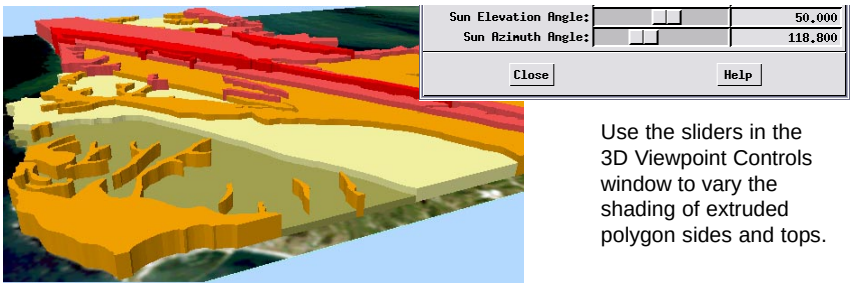
Polygon Side Style and Shading

The tops of extruded polygons are styled just like any vector polygon, using settings on the Polygon tabbed panel on the Vector Layer Controls window. The visual effect of a solid polygon is achieved by rendering the sides of the polygons as shaded vertical curtains. You can style the polygon sides All Same, By Attribute, By Theme, or By Script using the Side Style menu on the 3D tabbed panel. In the previous exercise the polygon sides were styled All Same using a gray color. In this exercise the polygon sides are styled By Attribute with the same styles used for the main polygon fill.

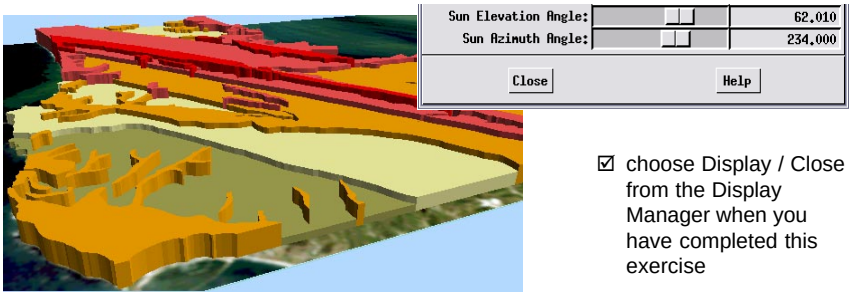
Two slider controls near the bottom of the 3D Viewpoint Controls window set the illumination parameters for the shading used for extruded polygon sides and tops, other 3D shapes, and for pedestal and fence elements around the boundary of the group. You can set both the Sun Elevation Angle above the horizontal and the Sun Azimuth Angle (the compass direction from the group to the sun position).

STEPS

- ☑ open the Vector Layer Controls window for the SEISMAP layer
- ☑ in the Extruded Polygons pane of the 3D panel, choose By Attribute from the Side Style menu
- ☑ press the Specify button next to the Side Style menu
- ☑ examine the style assignments and press [OK] on the Assign Styles by Attribute window
- ☑ press [OK] on the Vector Layer Controls window
- ☑ on the 3D Viewpoint Controls window, move the Sun Elevation Angle and Sun Azimuth Angle sliders



Use the sliders in the 3D Viewpoint Controls window to vary the shading of extruded polygon sides and tops.



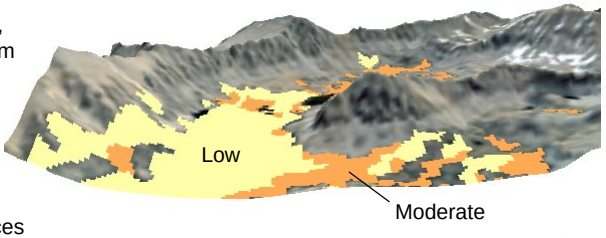
- ☑ choose Display / Close from the Display Manager when you have completed this exercise

Solid Polygons over Terrain

STEPS

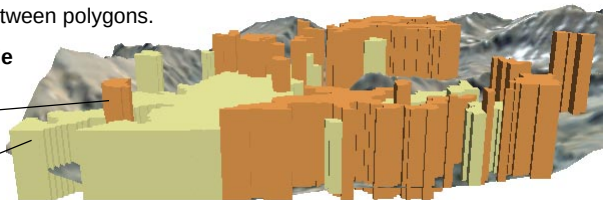
- ☑ choose Display / Open from the Display Manager window
- ☑ navigate to the VIEW3D data collection and select BURNGROUP from the VIEW3D Project File
- ☑ open the Vector Layer Controls window for the BURN_ND layer
- ☑ in the Extruded Polygons pane on the 3D panel, choose Height from the Mode menu
- ☑ press [Field] in the Extruded Polygons pane, select BURN.HEIGHT and press [OK] on the Select Table/Field window
- ☑ press [Apply] on the Vector Layer Controls window
- ☑ repeat the last 4 steps, choosing Elevation from the Mode menu and BURN.ELEV as the field

Polygon extrusion parameters must be chosen judiciously when the vector layer is draped over a terrain with considerable relief. In this example, vector polygons in a mountainous terrain delineate areas ranked in two categories of need for prescribed burning for wildfire suppression. When the polygons are extruded in Height mode, the difference in terrain elevation between some polygons in the same category causes their extruded tops to be at significantly different elevations. Changing to Elevation mode imposes a fixed elevation on the tops of all extruded polygons in each category. Polygon height and elevation values must be chosen according to the terrain characteristics to ensure that the top of each extruded polygon is higher than any point on its boundary. Polygons not meeting this restriction are not rendered as solid objects in the 3D view; only their boundaries are rendered on the terrain.

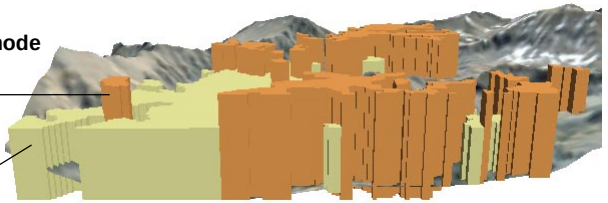


Burn Priority Polygons before extrusion. Note the considerable differences in elevation within and between polygons.

Extruded in Height mode



Extruded in Elevation mode



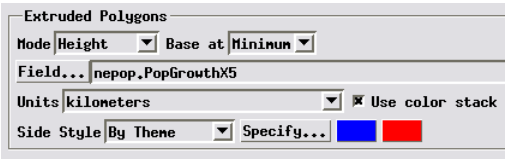
Solid Polygons with Color Stack

When solid polygon sides are styled By Attribute or By Theme, you have the option of turning on the Use Color Stack toggle. The polygons in this example are Nebraska counties with attached population statistics for 1990 and 2000, including population growth or loss (negative growth). Polygon extrusion is used to graphically depict the spatial variation in population growth and loss.

In the GrowthGroup, polygons with net population growth are selected by script for display and theme-mapped by 5% growth increments. A second computed database field with growth values multiplied by 5 was used to provide the polygon heights (in kilometers) and was also used for a side style theme map. In the LossGroup, counties with net population loss are selected and similarly styled. Since their growth values are negative, these solid polygons extend downward from the datum level. Separating growth and loss into separate displays makes it easier to see the details of each.

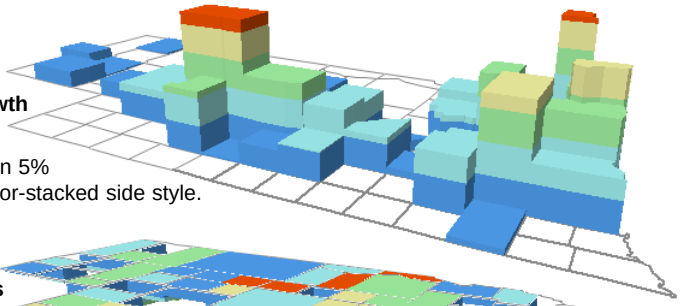
STEPS

- ☑ choose Display / Close from the Display Manager to close the previous group
- ☑ choose Display / Open and select GrowthGroup from the NEPOP Project File
- ☑ repeat the previous step, this time choosing LossGroup from the NEPOP Project File
- ☑ open the Vector Layer Controls window for the NEcounty layer in GrowthGroup
- ☑ examine the Extruded Polygon settings on the 3D panel, then press [OK]



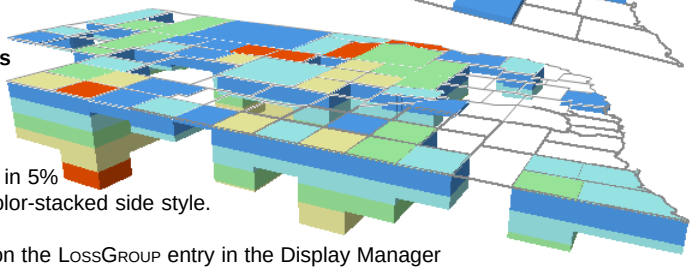
Counties with Population Growth 1990-2000

Theme-mapped in 5% increments in color-stacked side style.



Counties with Population Loss 1990-2000

Theme-mapped in 5% increments in color-stacked side style.



- ☑ right-click on the LossGroup entry in the Display Manager and choose Close Group; repeat for GrowthGroup

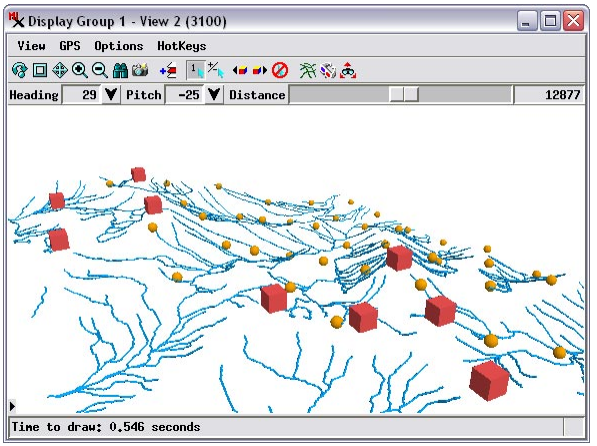
3D Vector Layers

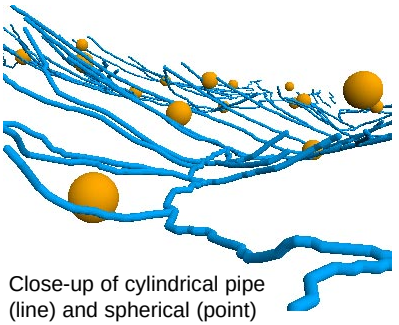
STEPS

- ☑ add vector objects STREAM3D, SEC3D, and PEAKS3D from the VIEW3D Project File in a new display group
- ☑ choose Display / Open 3D View

A 3D vector object (one that has z-coordinate values for its elements) can be displayed by itself in 3D perspective without requiring a separate terrain raster layer. The process uses the z-coordinate values for each element for elevations and renders the object in 3D independent from any other surface object. The objects used in this exercise include a set of 3D vector lines of stream courses (derived from the TNTmips Watershed process), points with 3D locations of section corners, and points with 3D positions of named mountain peaks.

In addition, point and line elements in 3D vector objects are automatically rendered as solid shapes in 3D views if they meet certain styling constraints. 3D points are rendered in 3D as solid spheres (if styled for 2D with a standard filled circle symbol) or as solid cubes (if styled for 2D with a standard square or other symbol). 3D lines styled for 2D with solid line styles are rendered in the 3D view as continuous cylindrical pipes.





Close-up of cylindrical pipe (line) and spherical (point) symbols in the 3D view.

The size and width criteria you have set up for these symbols are maintained in the 3D view. Setting sizes by map scale provides foreground-background size variation consistent with a perspective view. Shading effects for these 3D solid shapes can be adjusted using the Sun Angle sliders on the 3D Viewpoint Controls window.

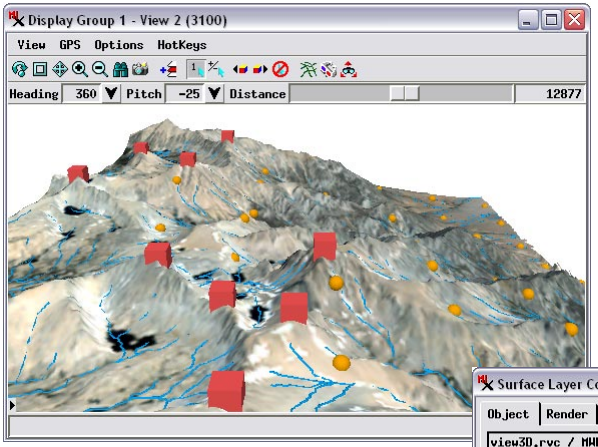
3D Vector Layers with Draped Terrain

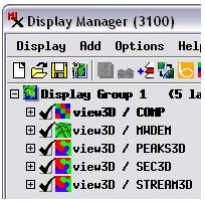
If 3D vector elements are displayed along with a draped terrain layer, the solid symbols for 3D points or lines that lie on or just above the terrain may intersect the terrain surface. These symbols are rendered accordingly: the portion of the symbol below the surface is hidden by any opaque layer draping that surface.

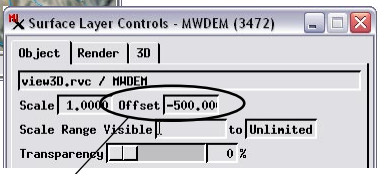
In this example, the elevations for all of the 3D vector elements coincide with those in the newly-added MWDEM terrain layer, so many of these symbols are partially hidden by the COMP drape layer. Setting a negative offset value for this terrain layer lowers it and its drape layer, allowing the 3D vector elements to float above the surface without intersecting it.

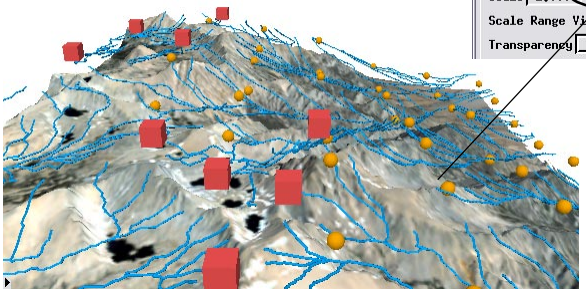
STEPS

- ☑ press the Add Terrain icon button on the Display Manager tool bar
- ☑ select raster MWDEM from the VIEW3D Project File
- ☑ press the Layer Controls icon button for the new terrain layer
- ☑ on the Object tabbed panel of the Surface Layer Controls window enter -500 in the Offset field and press [OK]
- ☑ add raster object COMP from the VIEW3D Project File to the group









- ☑ choose Display / Close from the Display Manager when you have completed this exercise

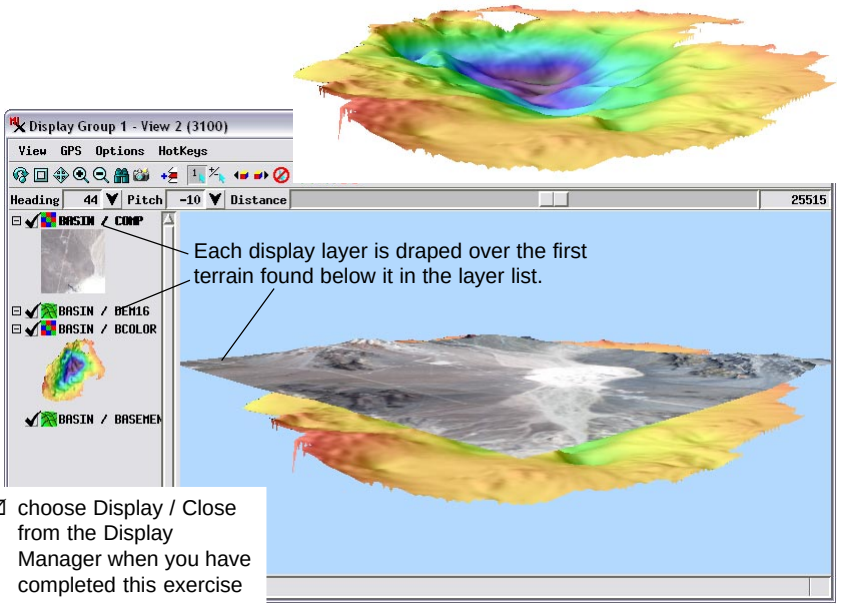
Multiple Terrains and Drape Objects

STEPS

- ☑ choose Display / New / 3D Display from the Display Manager
- ☑ from the BASIN Project File select BASEMENT as the TERRAIN layer and BCOLOR as the drape layer
- ☑ press the Add Terrain icon button on the Display Manager icon bar
- ☑ select raster DEM16 from the BASIN Project File
- ☑ add raster object COMP from the BASIN Project File to the group
- ☑ set the Pitch to -10 and move the distance slider to the right until the entire group is visible in the 3D view window

3D perspective views support the use of multiple terrain layers in a single group, each with one or more drape layers. Position in the layer list shown in the Display Manager and LegendView determines which display layer is draped over which terrain. Display layers are draped over the first terrain layer found below them in the layer list.

In this example, the lowest terrain in the list (BASEMENT) is the estimated surface of bedrock basement beneath a sediment-filled basin. The drape raster layer for this surface (BCOLOR) is a color shaded-relief image of this surface. Above these layers in the layer list is a digital elevation model of the ground surface (DEM16), which is draped by a natural-color satellite image (COMP). After all layers are added, you can hide the COMP layer to reveal the configuration of the bedrock basin. To see the ground surface and basin configuration at the same time, you could set a positive offset of several thousand meters for the DEM16 terrain layer.



- ☑ choose Display / Close from the Display Manager when you have completed this exercise

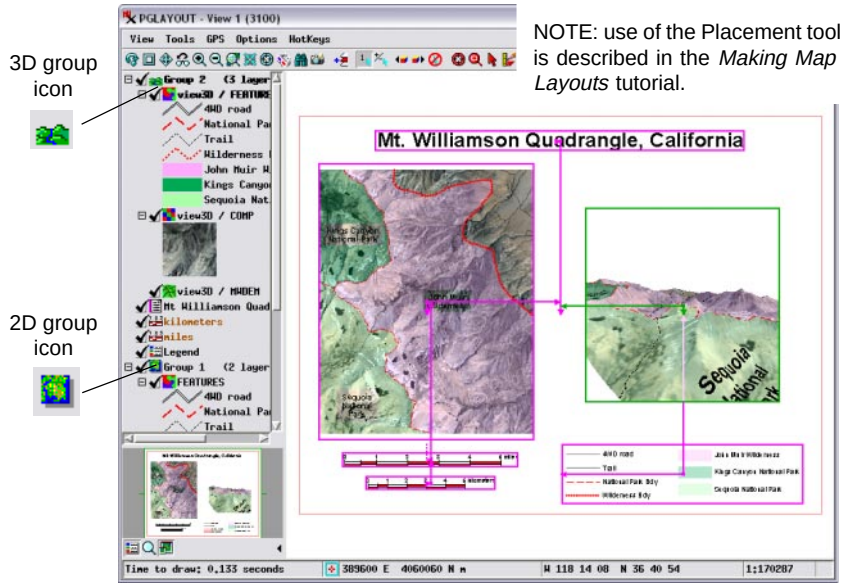
3D Groups in Layouts

You can incorporate 3D renderings into Display Layouts and Page Layouts as well. You can begin building a new 3D group in a Layout using the Add 3D Group icon button in the Display Manager, then add terrain and drape layers as you have before in display groups. You can also add a previously-saved 3D group to a layout using the Add / Saved Group menu option from the Display Manager. After selecting the saved group, you are prompted whether to add it to the layout as a 2D or 3D group. Choose 3D to place the saved 3D rendering of the group in the Layout.

The distinction between 2D and 3D groups is important in a layout, so these groups have different icons in the layer list in the Display Manager and in the sidebar, as shown below. Only a 3D group in a layout provides a 3D perspective rendering. Adding a terrain layer to a 2D group in a layout does not convert it to a 3D group and does not provide a perspective rendering.

STEPS

- ☑ press the Open Display icon button on the Display Manager
- ☑ select PGLAYOUT from the VIEW3D Project File
- ☑ press the Add 3D Group to Layout icon button on the Display Manager
- ☑ press the Add Terrain icon button on the Display Manager
- ☑ select MWDEM from the VIEW3D Project File and set the Offset field to 0 in the Surface Layer Controls
- ☑ add objects COMP and FEATURES to the new 3D group
- ☑ use the Layout Placement tool to move the new group to the right into the blank space in the layout



NOTE: use of the Placement tool is described in the *Making Map Layouts* tutorial.

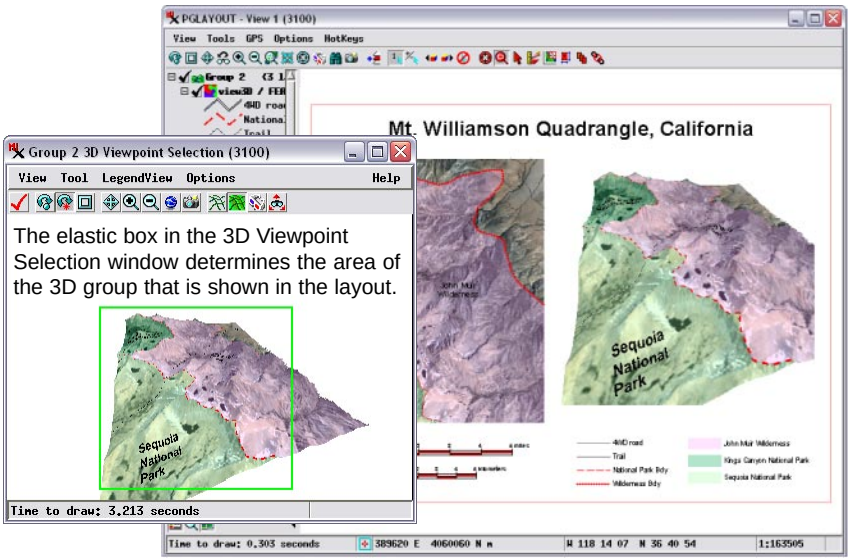
3D Viewpoint Selection Window

STEPS

- ☑ right-click on the Group 2 list entry in the Display Manager
- ☑ choose Viewpoint Controls from the right mouse button menu
- ☑ adjust the 3D Viewpoint Controls as desired
- ☑ press the Zoom Out icon button on the 3D Viewpoint Selection window or resize the window to show the entire 3D rendering
- ☑ drag and resize the elastic box in the Viewpoint Selection window to determine the group extents
- ☑ press the Apply Changes icon button in the 3D Viewpoint Selection window

Notice that the new 3D group you created is confined to a rectangular box that does not show the full extents of the perspective rendering. 3D groups in layouts have an associated 3D Viewpoint Selection window in addition to the 3D Viewpoint Controls. To open both windows, right-click on the group's list entry in either the Display Manager or LegendView, then choose Viewpoint Controls from the right mouse-button menu.

The 3D Viewpoint Selection window provides an elastic box that you can resize and reposition to indicate which rectangular portion of the perspective rendering you want to include in the layout. Drag the window border to resize it or use the zoom buttons if needed to assist in placing the rectangle. You can use the controls on the standard 3D Viewpoint Controls window to change the viewpoint for the 3D group as in previous exercises. After applying the changes you may need to use the Placement tool and Group Settings to change the placement and relative zoom of the 3D group.



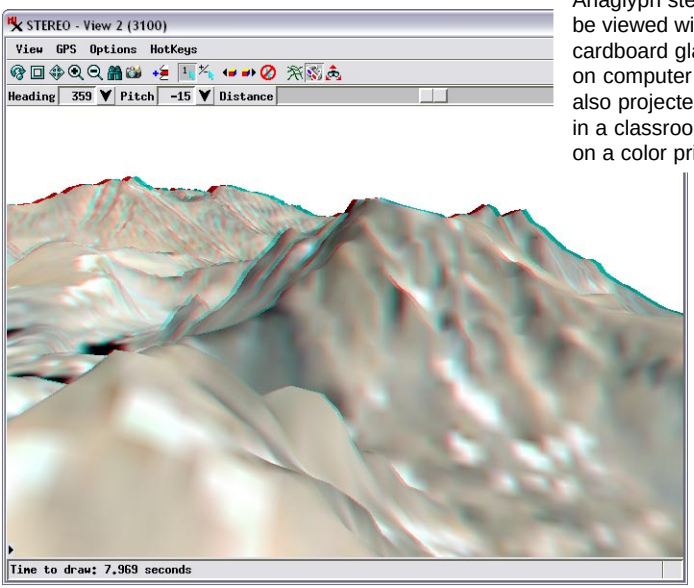
Stereo 3D Views

The 3D view can also provide stereo viewing of your 3D scenes. In stereo mode the 3D view generates offset left and right images of the scene that provide the illusion of depth when viewed with a stereo viewing device. These devices can include stereo monitors or electronically shuttered glasses (which use column-interlaced or line-interlaced images), a mirror stereoscope (images in separate frames), or two-color anaglyph glasses like those used for 3D movies. You can set stereo device options by choosing Options / Stereo Settings from the 3D view.

The group viewed in this exercise is a low oblique view of mountainous terrain set up for viewing with anaglyph glasses with a red left lens and cyan right lens. A mountain ridge extends from the lower left foreground toward the upper right, with another set of more distant peaks in the upper left. If you move your head slowly from side to side while viewing with anaglyph glasses, the distant parts of the scene should appear to move more than the foreground.

STEPS

- ☑ choose Display / Close on the Display Manager to close the previous layout, choosing No when asked whether to save changes
- ☑ open group STEREO from the VIEW3D Project File
- ☑ press the Stereo View icon button on the 3D view
- ☑ in the Stereo Device Settings window that appears, choose Anaglyph from the Stereo Mode menu and press [OK}



Anaglyph stereo images can be viewed with inexpensive cardboard glasses not only on computer monitors, but also projected on a screen in a classroom or meeting or on a color print.

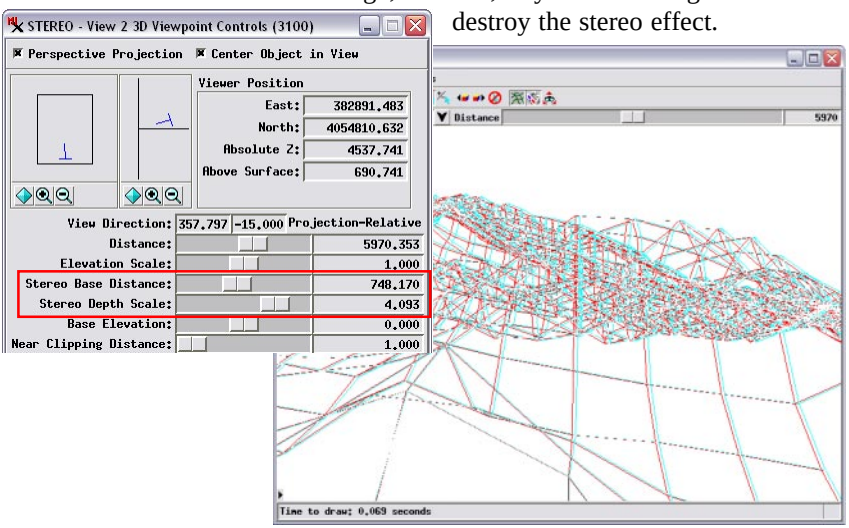
Stereo Viewing Settings

STEPS

- ☑ open the 3D Viewpoint Controls window
- ☑ switch to Wireframe View mode but keep the stereo mode turned on
- ☑ in the 3D Viewpoint Controls, move the Stereo Base Distance slider back and forth and note the effect on the stereo wireframes
- ☑ repeat with the Stereo Depth Scale slider
- ☑ choose Display / Close from the Display Manager when you have completed this exercise

In Wireframe View mode separate wireframes are rendered for the left and right stereo images. With the 3D view set for anaglyph viewing, each of these wireframes is rendered in the appropriate color (red and cyan in this case), so the wireframe can also be viewed in stereo. This makes anaglyph stereo and wireframe mode a good choice for setting up stereo viewing parameters, even when the final stereo view will be rendered for another stereo viewing device.

Controls for two important stereo viewing parameters are found on the 3D Viewpoint Controls window. The Stereo Base Distance is the distance from the viewer to the plane of zero offset between the left and right images. In wireframe mode this is the distance at which the different-colored wireframe lines merge. Typically the zero-offset plane should be in the foreground of or just in front of the view. The Stereo Depth Scale value determines the amount of stereo separation between left and right images. A scale value of 0 produces no separation and no stereo effect. As stereo separation increases, the sense of stereo depth also inceases. Setting the scale too high, however, may cause viewing discomfort or destroy the stereo effect.



Manifolds in 3D Views

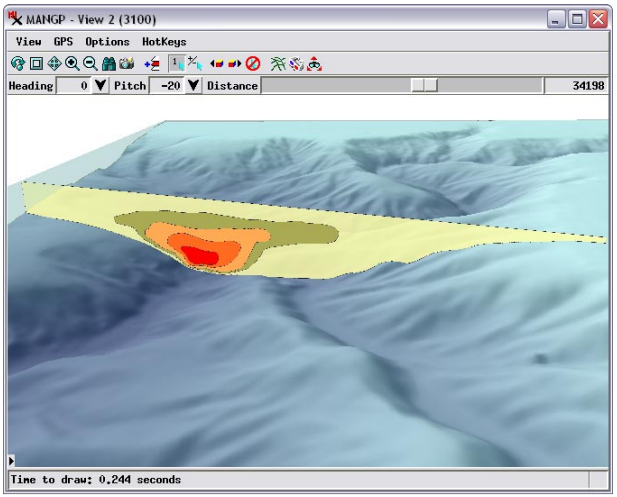
In addition to the terrain and drape layers you have worked with in previous exercises, 3D views can also include *manifolds*: raster or vector objects that contain their own shape and position information in the form of a set of 3D georeference control points. The 3D view uses these special control points (created using the 3D Piecewise Affine georeference model) to create a 3D triangular mesh representing the manifold surface on which the object is then projected. A manifold can be viewed by itself in the 3D view or in combination with a conventional terrain raster and its drape layer(s).

A manifold can be in the form of a simple vertical plane (such as a cross-section or profile), oblique plane, curving vertical curtain, or a more general 3D shape. The manifold in this group is a vector object representing a vertical water-column section across Monterey Submarine Canyon, offshore California. The colored areas in the manifold represent hypothetical zones of differing current velocity in the canyon. The outer, lowest-velocity zone has been styled with a partially transparent color to reveal the seafloor morphology behind it.

STEPS

- ☑ press the Open Display icon button on the Display Manager
- ☑ select group MANGP from the MONBAY Project File
- ☑ add vector object PROFILE from the same file to the 3D group
- ☑ use the Adjust Viewpoint tool to view the manifold from different viewing positions

Manifold objects are only displayed in 3D views. The Georeference and Spatial Data Editor 2D views display a "flat" view of the manifold object to allow editing operations.



You can set up a raster or a 2D vector object to display as a manifold using the Georeference process. Simply assign 3D control points using the 3D Piecewise Affine model. Refer to various Technical Guides at microimages.com for more information.

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