TERRAIN ANALYSIS

Tutorial

Analyzing Terrain and Surfaces

with

TNTmips®

Before Getting Started

Topography profoundly influences many physical and biological processes and provides the backdrop for human activities such as construction, transportation, communication, resource management, and recreation. Because of the varied ways in which natural or manmade systems interact with landscapes, computer analysis and modeling of terrain requires a number of specialized software tools. This booklet introduces a series of TNTmips® processes that allow you to analyze elevation rasters and to model various types of interaction with terrain.

Prerequisite Skills This booklet assumes that you have completed the exercises in the tutorials entitled *Displaying Geospatial Data* and *Navigating*. Those exercises introduce essential skills and basic techniques that are not covered again here. Please consult those booklets for any review you need.

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 CD, you can download the data from MicroImages' web site. In particular, this booklet uses sample files in the TERRAIN data collection. Be sure the sample data has been installed on your hard drive so changes can be saved as you use these objects in the following exercises.

More Documentation This booklet is intended only as an introduction to terrain and surface analysis. Details of the process can be found in a variety of tutorial booklets, color plates, and Quick Guides, which are all available from MicroImages' web site (go to http://www.microimages.com/search to quickly search all available materials, or you can narrow your search to include only tutorials or plates.

TNTmips and TNTlite® TNTmips comes in two versions: the professional version and the free TNTlite version. This booklet refers to both versions as "TNTmips." If you did not purchase the professional version (which requires a software license key), TNTmips operates in TNTlite mode, which limits the size of your objects and does not allow preparation of linked atlases. All the exercises can be completed in TNTlite using the sample geodata provided.

Randall B. Smith, Ph.D., 27 September 2007

It may be difficult to identify the important points in some illustrations without a color copy of this booklet. 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 TNTlite.

http://www.microimages.com

Welcome to Analyzing Terrain

TNTmips provides a number of tools for visualizing and analyzing Digital Elevation Models (DEMs). Appropriate contrast enhancement and use of color palettes can significantly aid in visualization of DEMs in a 2D display. A DEM can also be displayed with relief shading, which helps you visualize the surface by portraying it as if it were illuminated from a particular compass direction and elevation angle, both of which you can adjust interactively. These tools are also applicable to other rasters that represent 3D mathematical surfaces, such as gridded gravity or crop yield values.

The Topographic Properties process computes general terrain characteristics from a DEM: slope, aspect, plan and profile curvature, and shading. Slope and aspect refer to the magnitude and direction, respectively, of maximum downward slope. Slope, aspect, and curvature rasters can be used as components in more complex environmental models, such as predicting soil erosion or landslide hazards. The shading raster provides a fixed alternative to displaying the DEM with interactive relief shading.

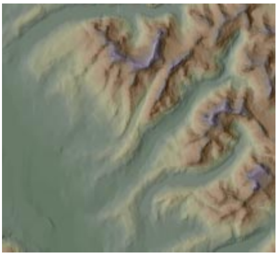
The Viewshed process performs line-of-sight analysis of a DEM to define a viewshed, the portion of the terrain that is visible from a given viewpoint on or above the ground. Viewshed analysis can be used to find optimal sites for communication facilities such as television or cell phone transmitters or for military observation posts or fire towers. It can also be used to assess the visual impact of activities such as mining and logging.

The Cut and Fill Analysis process compares two elevation rasters of the same area and identifies locations where their elevation values differ. These areas are traced to form polygons in an output vector object. The volume of material added or subtracted is calculated for each polygon and stored in an attached database table.

STEPS

☑ choose Main / Display from the TNTmips menu

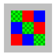
A companion tutorial booklet entitled *Modeling Watershed Geomorphology*, introduces the Watershed process, which computes stream networks, watersheds, and related properties from a DEM.



Techniques for creating consistent and effective displays of DEMs are introduced on pages 4-8. Pages 9-13 cover the products you can create in the Topographic Properties process. The Viewshed process is discussed on pages 14-18, followed by an introduction to the Cut and Fill process on page 19.

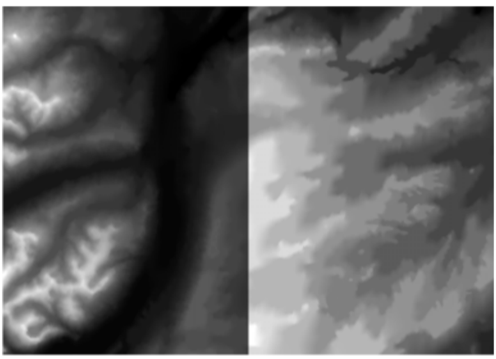
Set Consistent Contrast and Colors I

STEPS



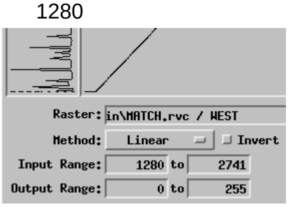
- ☑ press the Add Raster icon button in the Display Manager window and choose Single from the dropdown menu
- ☑ navigate to the MATCH Project File in the TERRAIN data collection and select rasters EAST and WEST

When you work with a set of adjacent DEM or other surface rasters, each raster will have a different range of values, but the same numerical value has the same meaning in each. To convey that meaning consistently when the rasters are displayed, a given range of surface values should be displayed with the same range of gray tones (or colors) in each raster. Achieving that consistency requires that you adjust the contrast enhancement for each raster.



The problem is illustrated by the two DEMs used in this exercise. Elevations in raster EAST range from 1280 to 1707 meters and in raster WEST from 1340 to 2741 meters. The default linear contrast table that has been saved with each raster stretches the full range of gray tones from each raster's minimum to its maximum value. As a result, the same gray tones correspond to different elevation ranges in each raster and the DEMs do not appear to match along their common boundary.

- ☑ right-click on the raster icon for the WEST layer in the Display Manager and select Enhance Contrast from the dropdown menu
- ☑ in the Raster Contrast Enhancement window, change the value in the left (minimum) Input Range box from 1340 to 1280



- ☑ choose Save from the Enhancement window's File menu, then choose Close

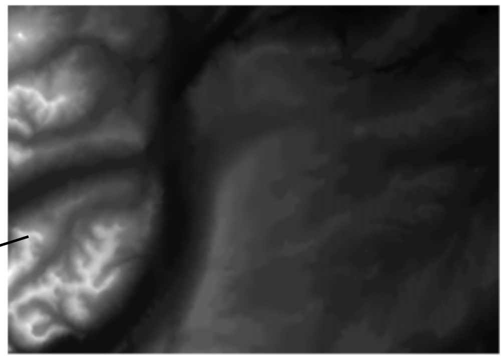
To properly adjust the contrast, you should first examine the histograms of all the rasters in the set to determine the overall minimum and maximum values. For rasters EAST and WEST the overall range is from 1280 to 2741. You can then open the Raster Contrast Enhancement window for each raster and set the Input Range values to match the overall range of the raster set rather than the raster's own particular range. (Alternatively, use the Project File Maintenance process to copy the first adjusted contrast subobject to all subsequent rasters.) Gray tones are then spread over this larger overall range for each raster, producing consistent gray tones for the corresponding elevation ranges in each (see illustration on the following page).

This exercise continues on the following page.

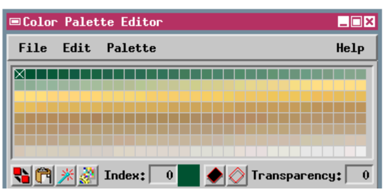
Set Consistent Contrast and Colors II

Color is usually more effective than gray tones in bringing out detail in a displayed DEM or surface raster. Once you have set up a consistent contrast table for each raster, you can use the Color Palette Editor to select a standard color palette or to design your own. (A linear contrast enhancement is recommended if you are going to use a color palette.) The palette should be saved as a subobject for each raster in the set. The same color is then assigned to the corresponding elevation range in each displayed raster.

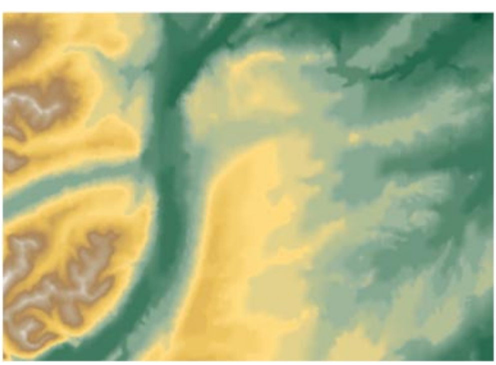
STEPS
- ☑ repeat the last three steps for the EAST layer, but change the right (maximum) Input Range value from 1707 to 2741
- ☑ redraw the View window



Rasters WEST and EAST displayed with gray tones in each raster spread linearly over the overall elevation range. Gray tones now match at the boundary.



The Earth-Tones color palette, one of many Standard Color Palettes available in TNTmips.



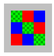
EarthTones palette applied to rasters EAST and WEST.

- ☑ right-click on the raster icon for the WEST layer and select Edit Colors from the dropdown menu
- ☑ click on the Palette menu in the Color Palette Editor window and select the Earth Tones palette
- ☑ if the Earth Tones palette is not shown on the initial menu, choose More Palettes and select it from the scrolling list in the Standard Color Palettes window and click [OK]
- ☑ choose Save As from the Color Palette Editor's File menu and save the palette as a subobject of raster WEST
- ☑ repeat the last step and save the palette as a subobject of raster EAST

When you have completed this exercise, right-click on Display Group 1 in the Display Manager and select Close Group from the dropdown menu.

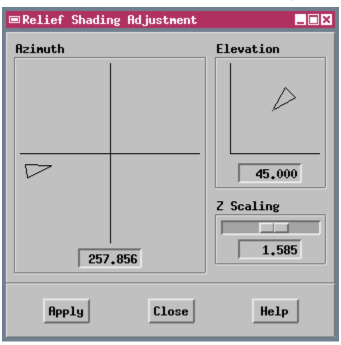
Display DEM with Relief Shading

STEPS



- ☑ press the Add Raster icon button in the Display Manager and choose Single
- ☑ select raster CLKDEM from the SHADE Project File
- ☑ right-click on the raster icon for the CLKDEM layer and select Relief Shading from the dropdown menu
- ☑ vary the Azimuth setting in the Relief Shading Adjustment window, click [Apply] and note the effect on the DEM

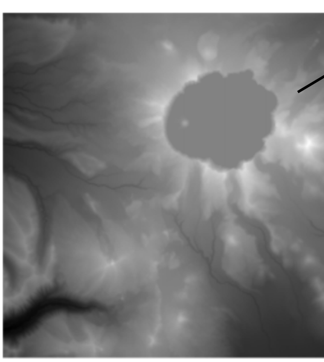
The Relief Shading tool shows how the surface would appear if illuminated by an infinitely distant light source (assuming that the surface represents a uniform material). The Relief Shading Adjustment window allows you to vary the azimuth (compass direction) and elevation angle of the light source and the Z-scaling (vertical exaggeration). The azimuth can vary from 0 to 360 degrees clockwise from north. Surface features perpendicular to the illumination direction are accentuated by shadowing, while those trending parallel to it are less visible. Decreasing the elevation angle generally darkens the shaded image and increases the contrast between shadowed and illuminated areas. To produce a brighter image that preserves shadow contrast, increase both the elevation angle and the z-scaling.



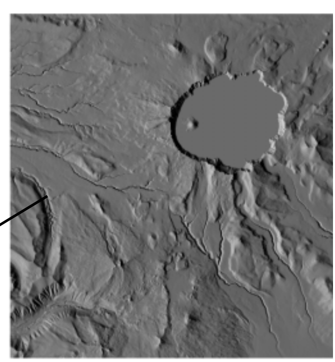
- ☑ vary the Elevation setting and note the effect
- ☑ vary the Z Scaling setting and note the effect

NOTE: you can change the display parameters for a raster so that it is automatically displayed with relief shading each time you add it to a group. To do so, open the Raster Layer Controls window and turn on the Relief Shading toggle button. The last-used (or default) shading settings will be used. Any changes in the shading settings that you make subsequently for the raster using the Relief Shading Adjustment window are not automatically saved. To force a save of the new settings, turn the Relief Shading toggle button off and then back on.

Close the Relief Shading Adjustment window and close Display Group 1 when you have completed this exercise.



DEM of Crater Lake area, Oregon in grayscale.



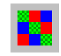
Crater Lake DEM displayed with relief shading settings shown in the illustration above.

Create a Color Shaded Relief Display

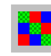
You can combine the effects of color-mapped elevation and relief shading to create color shaded relief displays. If you expect to use such a display repeatedly, it is best to work with two copies of the DEM, which can be set up to use different display parameters. Set up one copy of the DEM to display with relief shading, and the other to display with a color palette. Then display both DEMs in the same display group, with the color-mapped version on top partially transparent. The resulting view combines the textural information from the shaded layer with the color-coded elevation information from the overlying layer.

You can vary the brightness and contrast of the merged view by adjusting the relief shading settings for the lower DEM; a relatively bright shaded image produces brighter colors. Vary the transparency setting of the color-mapped DEM to control the relative contribution of the color and shaded versions. Increasing the transparency will subdue the colors and place more emphasis on the terrain shading.

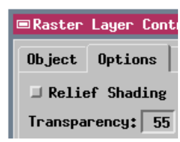
STEPS

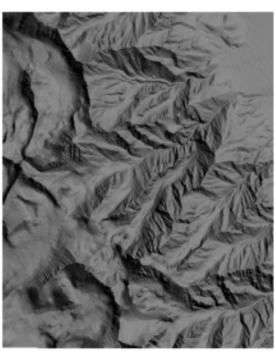


- ☑ in the Display Manager, add raster object MWDEM1 from the SHADE Project File
- ☑ note the relief-shaded view of the DEM

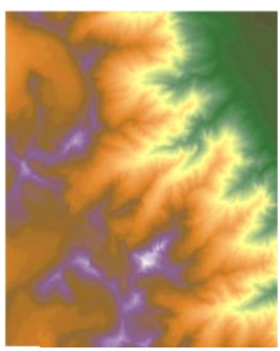


- ☑ add raster object MWDEM2 from the SHADE Project File
- ☑ note the color-mapped view of the DEM
- ☑ right click on the raster icon for the MWDEM2 layer and select Controls from the dropdown menu
- ☑ on the Options panel of the Raster Layer Controls window, change the value in the Transparency field to 55, then press [OK]

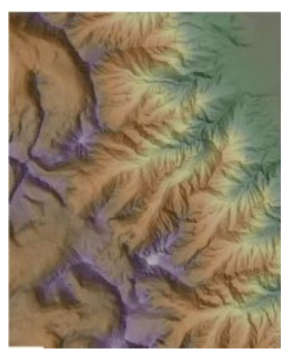




Relief-shaded view of MWDEM1.



Color-mapped view of WMDEM2.



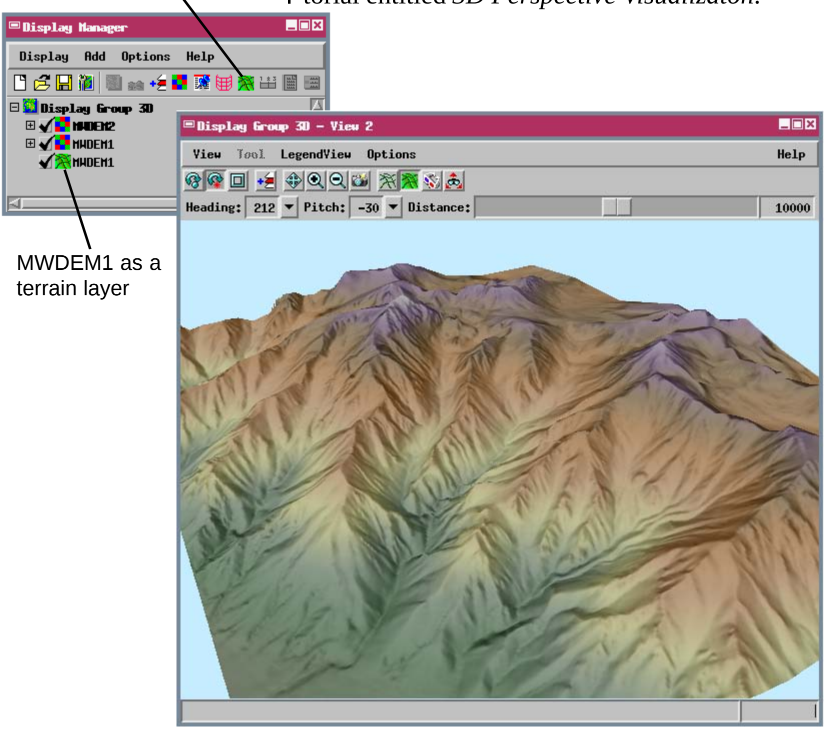
Color shaded relief view of the two versions of the DEM.

Close the display group when you have completed this exercise.

Display Terrain in 3D

STEPS
☑ choose Display / Open on the Display Manager
☑ select DISPLAY GROUP3D from the SHADE Project File

To enhance your visualization of the topography depicted by a DEM, you can create a 3D perspective rendering of the DEM in the Display process. In this exercise you open a saved display group that includes a perspective view of the data you worked with in the previous exercise (shown below). In this group one of the copies of the DEM raster has been added as a Terrain layer to provide a 3D surface upon which other layers can be draped. In this example the two DEM copies have been used as drape layers to again depict color shaded relief. Controls on the perspective view window allow you vary the 3D viewing geometry (heading, pitch, and distance). More details on 3D viewing can be found in the tutorial entitled *3D Perspective Visualizaton*.



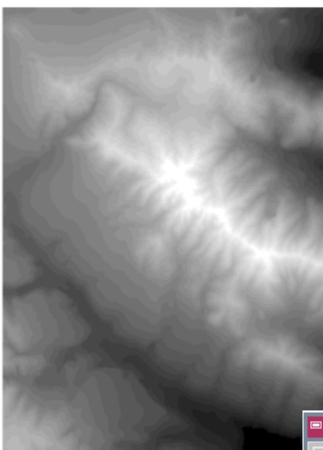
Close the display group when you have completed this exercise.

Compute Topographic Properties

The Topographic Properties process can be used to compute several fundamental topographic properties from the input DEM. You can measure the surface slope magnitude (slope) and its downward direction (aspect) at each cell location, and compute measures of terrain curvature for each cell. Together these properties define the spatially-varying shape and orientation of the terrain surface. You can also compute shaded-relief images from the DEM with varying illumination parameters. You can compute any combination of these products in a single run.

STEPS

- ☑ choose Raster / Elevation / Topographic Properties from the TNTmips menu
- ☑ click [Raster...]
- ☑ navigate to the SLOPE Project File and select object DEM_S1
- ☑ from the Surface-Fitting menu choose *Exact fit to 4 nearest neighbors and center cell*



A grayscale representation of DEM_S1 with normalized contrast enhancement. To accomodate the range of possible Earth surface elevations (in either meters or feet) without scaling, many DEM rasters use a signed 16-bit integer data range (-32,768 to +32,767). To preserve greater elevation precision, some DEMs are produced in decimal (floating point) meters. Elevations in all of the DEMs used in this booklet are in integer meters.

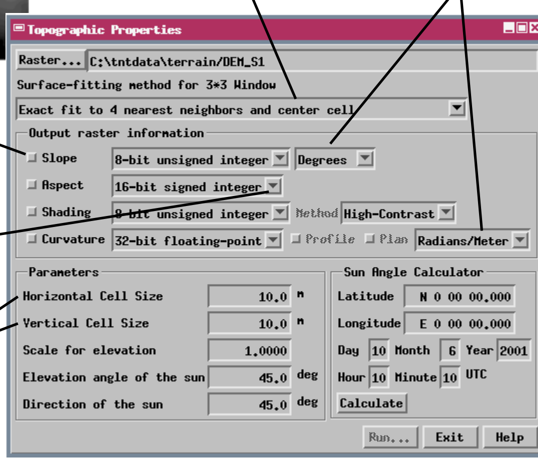
Choose the surface-fitting method to use for computing the topographic parameters for each cell.

Units menus for Slope and Curvature

Use toggles to indicate the topographic properties to compute.

Use menus to set the raster type for each selected output raster object.

Horizontal and Vertical Cell Size are read from the input raster and cannot be edited; all output rasters match the cell size and extents of the input DEM.

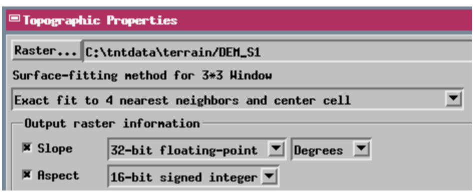


Keep the current settings and continue to the next page.

Compute Slope and Aspect

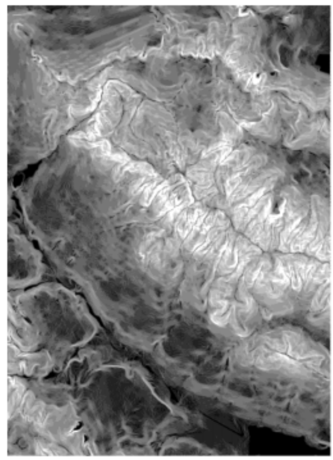
STEPS

- ☑ turn on the Slope and Aspect toggle buttons and make sure that the Shading and Curvature toggles are off.
- ☑ choose Degrees from the units menu for Slope
- ☑ choose *32-bit floating point* from the raster data type menu for the Slope raster, and *16-bit signed integer* for the Aspect raster

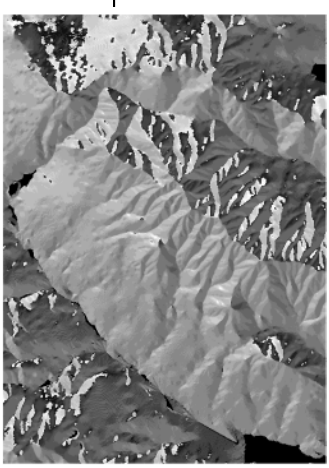


- ☑ press [Run...]
- ☑ use the standard Select Objects dialog window to name a new Project File and accept the default names for the output Slope and Aspect raster objects
- ☑ use the Display process to view the output Slope and Aspect raster objects
- ☑ close the Display group when you have completed the exercise

Slope can be expressed as either a vertical angle measured from the horizontal in degrees (0 to 90) or as percent slope [tangent(slope) x 100; a slope angle of 45 degrees is equal to a 100 percent slope]. Choose either Degrees or Percents from the option menu to make this selection. For maximum precision for the slope values, choose 32-bit floating-point for the raster data type. If you wish to quantize slope angles or percentages to the nearest integer, you can select 8-bit unsigned for the raster data type.



Slope raster with auto-normalized contrast.

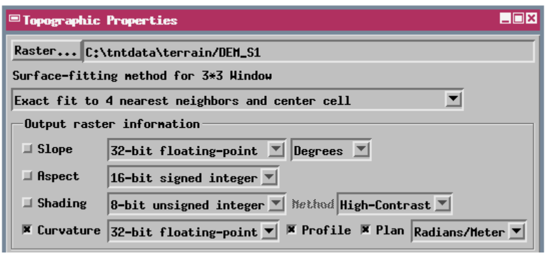


Aspect raster with auto-normalized contrast enhancement.

Aspect values are azimuth angles with the range 0 to 360 degrees, increasing clockwise from north. Flat areas are indicated by a value of -1. In a grayscale display, flat areas and north to northeast-facing slopes are darkest and northwest-facing slopes are brightest (the DEM is assumed to be oriented with north at the top). You can choose from either 16-bit signed integer or 32-bit floating point raster data types for the aspect raster.

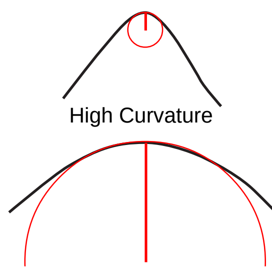
Compute Profile and Plan Curvature

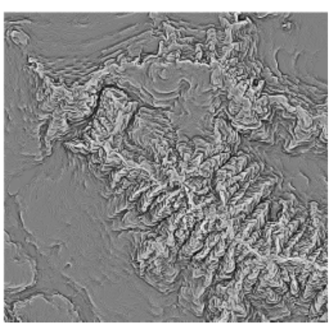
A terrain curvature for a particular cell represents the curvature of a line formed by intersecting a plane of some chosen orientation with the terrain surface. A curvature value is the reciprocal of the radius of curvature of the line, so a broad curve has a low curvature and a tight curve has a high curvature value. You can choose curvature units of radians per meter or radians per hundred meters.

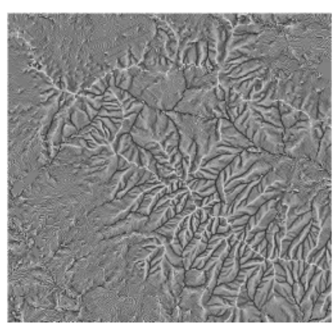


Profile curvature is the terrain curvature in the vertical plane parallel to the local slope direction. It measures the rate of change of slope and therefore influences the flow velocity of water draining the surface. Profile curvature is positive for a convex-upward surface and negative for one that is concave upward. Plan curvature (also called contour curvature) is the curvature of a hypothetical contour line passing through the cell (line formed by intersecting a horizontal plane with the terrain). Plan curvature is positive for convex-outward surfaces, negative for surfaces that are concave outward, and is undefined for flat areas. Plan curvature influences the convergence or divergence of water during downhill flow.

STEPS
- ☑ turn off the Slope and Aspect toggle buttons
- ☑ turn on the Curvature toggle and make sure that the Profile and Plan toggles are both turned on
- ☑ choose *32-bit floating point* from the raster data type menu for Curvature
- ☑ choose Radians/Meter from the units menu for Curvature
- ☑ press [Run...]
- ☑ accept the default names for the output curvature raster objects
- ☑ use the Display process to view the output raster objects

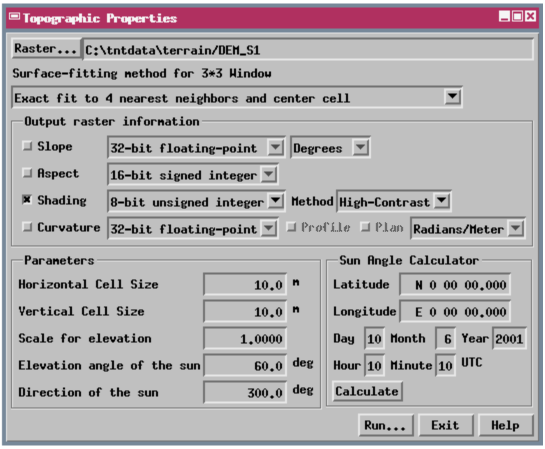



Portion of profile curvature raster with auto-normalized contrast.


Portion of plan curvature raster with auto-normalized contrast.

Compute Shading

STEPS
- ☑ turn off the Curvature toggle and turn on the Shading toggle
- ☑ set the value of the *Elevation angle of the sun* field to 60
- ☑ set the value of the *Direction of the sun* field to 300

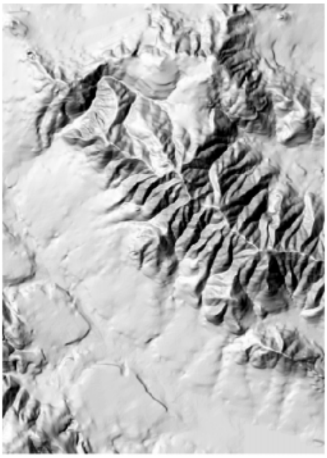


- ☑ press [Run...]
- ☑ accept the default names for the output shading raster object

The Shading option in the Topographic Properties process computes and saves a shaded-relief image of the input DEM. You can use this pre-computed shading image in place of a dynamic shaded-relief display of the original elevation raster in various display applications (see pages 6-7). Controls in the Parameters panel of the Topographic Properties window let you vary the elevation angle and direction of the sun illumination as well as the elevation scale. The shading image is automatically displayed in a Shading Result window that opens when the shading processing is complete.

The Method menu provides two options for computing shading: High-Contrast and Display. The High-Contrast method provides a wider range of output shading values than the Display method (which is identical to the one used to compute shading in the Display process). The appearance of the shading raster will also vary depending on the contrast enhancement method you use in displaying it.

The Sun Angle Calculator computes and sets sun direction and elevation angles for the ground position (latitude/longitude), date, and time that you enter. (Time is specified as Coordinated Universal Time, or UTC, also referred to as Zulu time or Greenwich Mean Time.) Use the sun calculator to compute a shading raster to match the illumination characteristics of a remote sensing image acquired at a known date at time.



Shading raster with auto-linear contrast enhancement.

Surface-Fitting Methods

STEPS

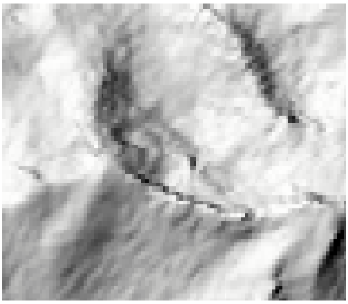
☑ open the Surface-fitting method menu on the Topographic Properties window

Surface-fitting methods

Exact fit to 4 nearest neighbors and center cell
Quadratic surface, least-squares fit
Quadratic surface, least-squares fit, weighted by 1/distance^2
Quadratic surface, least-squares fit, weighted by 1/distance
Quadratic surface, least squares fit, match central cell

Topographic properties are computed for each cell by using a moving 3 by 3 kernel of cells to compute first and second derivatives of the local surface in the line and column directions. The choice of cells within this kernel and the weighting factors applied can be varied to represent different mathematical approximations of the local surface. The five surface-fitting methods shown to the left are available.

The first listed method uses a cross-shaped kernel and fits the surface exactly to all five cell values; this method produces topographic parameters that are most faithful to the raw elevation values. However, most DEMs contain elevation errors to varying degrees. To mitigate the effects of such elevation "noise", the other four surface-fitting methods use elevations from all nine kernel cells to compute a curved surface that is a "best fit" approximation of the kernel values. As a result, these quadratic methods all introduce a degree of averaging and smoothing to the topographic parameters. The quadratic methods differ from each other in how the values of the more distant corner cells in the kernel are weighted relative to the middle cells along the kernel edges. In addition, only the last quadratic method in the list forces the quadratic surface to exactly match the elevation of the central cell in the kernel. Differences between the topographic parameters created using the four quadratic surface-fitting methods are slight, but may be locally significant.



Exact fit to 4 nearest neighbors

Quadratic surface, least-squares fit

Comparison of local areas of two shading rasters computed using different surface-fitting methods. The shading raster from the quadratic surface-fit method (bottom) is noticeably smoother than the one computed by exact fit to the 4 nearest neighbors (top).

☑ press [Exit] on the Topographic Properties window

Viewshed Analysis

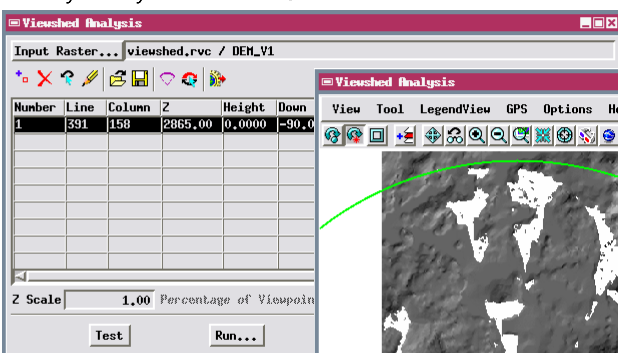
STEPS

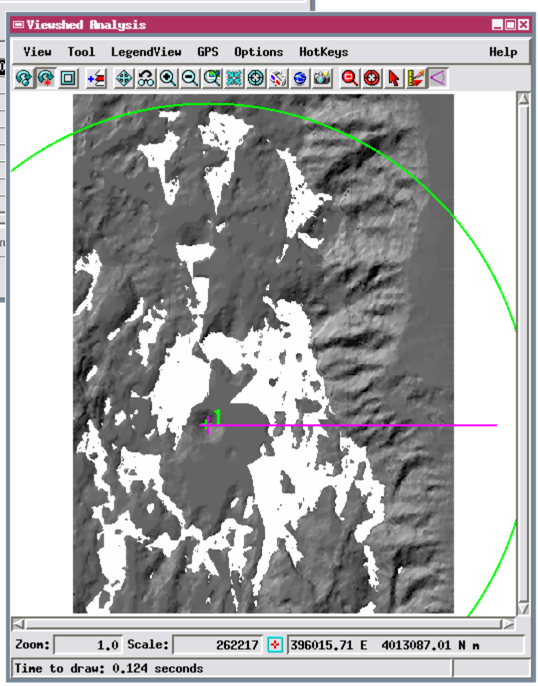
- ☑ choose Raster / Elevation / Viewshed from the TNTmips menu
- ☑ in the Select Object window, navigate to the VIEWSHED Project File and select object DEM_V1
- ☑ move the mouse over the center of the circle graphic in the View; the cursor should assume the four-point arrow shape
- ☑ drag the center of the circle graphic to the location shown in the illustration
- ☑ with the cursor over the View, use the arrow keys on your keyboard to move the viewpoint until the Line field in the Viewshed Analysis window reads 391 and the Column field reads 158
- ☑ click the Test button at the bottom of the Viewshed Analysis window

The results of a Viewshed analysis are encoded as a binary raster in which cells with a value of 1 (white) are visible from the selected viewpoints.

The Viewshed process allows you to compute a viewshed from one or more positions on or above the surface represented by the input elevation raster. This raster is displayed in a View window and an initial viewpoint location is automatically placed on the surface at the center of the raster, indicated by the number 1 next to the cross at the center of the circle graphic. You can reposition this point anywhere within the area of the elevation raster.

The Test option allows you to preview the results by computing a temporary viewshed raster that is displayed in the Viewshed Analysis window. The temporary viewshed raster is displayed with cells within the viewshed (visible areas) in white and the remaining cells (non-visible areas) transparent so that the input raster is not obscured.





Adjust Viewpoint Height

To identify cells that are visible from your selected viewpoints, the viewshed process analyzes the 3D lines connecting each viewpoint and each cell. If a sightline remains entirely above the ground surface between the viewpoint and cell, the cell is visible from that viewpoint.

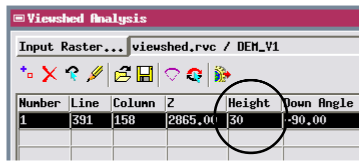
The viewpoint in the previous exercise is on the surface at the top of a conical hill rising near the edge of a flat-floored mountain basin. Although this is the highest elevation on the hill, the very low slopes on the hilltop block most of the sightlines to the lower areas immediately surrounding the hill. Viewshed extents computed from points directly on the surface can be very sensitive to small differences in elevation around the viewpoints. You can raise a viewpoint by entering the desired height above the surface (in meters) in that point's Height field in the Viewshed Analysis window. A height value of 1 or 2 meters usually gives a better representation of the area seen by a person standing at that location, or, conversely, the area from which a person or vehicle at that location would be visible.

For many viewshed applications the desired viewpoint is at the top of a tower or building some distance above the ground. In this exercise the viewpoint is placed 30 meters above the ground. As expected, the size of the viewshed is greatly increased by elevating the viewpoint. By running a number of viewshed tests with different heights you can determine the minimum structure height required to produce a desired viewshed.

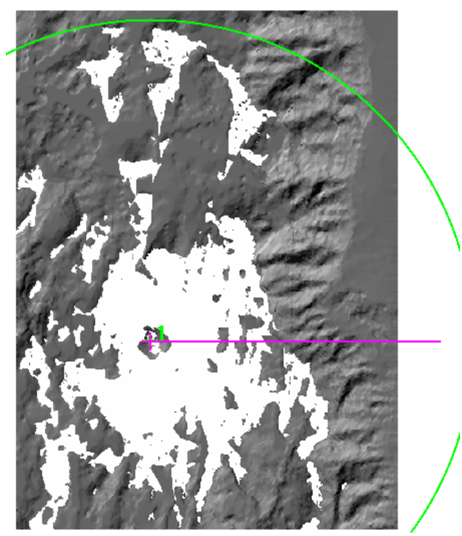
STEPS

☑ type 30 in the Height text box in the Viewshed Analysis window and press [Enter] or [Tab]

☑ press [Test]



This DEM has been set to display with shaded relief as described earlier in this booklet. Once set, these and other display parameters are stored with the DEM and used automatically by the display interface in any TNTmips process.



Viewshed for a viewpoint 30 meters above the ground surface.

Adjust Field of View

STEPS

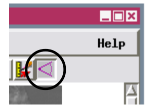
☑ scroll the pointlist in the Viewshed Analysis to the right to reveal the Sweep Angle and View Distance fields

☑ enter 150 in the View Distance field for Point 1

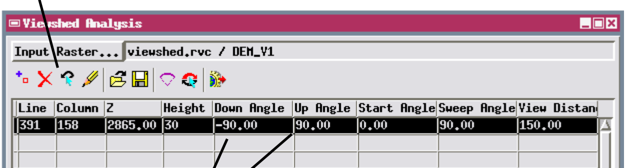
☑ enter 90 in the Sweep Angle field for Point 1

☑ press [Test]

Press the Restore Defaults icon button to restore the default field of view settings.



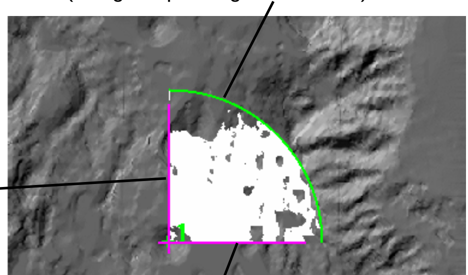
The Field of View tool, which is active by default when you start the Viewshed process, can be used to limit the horizontal field of view to be included in the viewshed analysis for any viewpoint. You can set the horizontal field of view values (Start Angle, Sweep Angle, and View Distance) by dragging elements of the circular tool graphic in the View or by entering values directly in the respective fields in the Viewshed Analysis pointlist. The two horizontal lines of the tool graphic define the Start Angle and Sweep angle; both are measured counter-clockwise in degrees, with the positive x-axis direction corresponding to a 0-degree start angle. The position of the arc of the circle defines the radial View Distance limit, which is measured in raster cells. The mouse cursor changes shape depending upon which of these graphic elements it is positioned closest to, as described in the figure captions below.



You can also set limits on the vertical field of view for a viewpoint using the Down Angle and Up Angle fields. Both angles are specified in degrees where 0 = horizontal. The Up Angle can range from 0 to 90 degrees, and the Down Angle from 0 to -90 degrees.

Drag the arc to change the View Distance (using the pointing hand cursor)

Sweep Angle (left-arrow cursor)



Start Angle (right-arrow cursor)

☑ press [Run]

☑ use the standard Select Objects dialog to name a new Project File and an output raster object

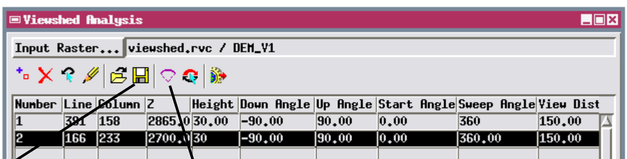
When you are ready to create a permanent output raster with the results of the viewshed analysis, press the Run button on the Viewshed Analysis window.

Viewshed from Multiple Viewpoints

You can add any number of viewpoints to the analysis using the Add icon button on the Viewshed Analysis window. Each new point is added to the viewpoint list and is initially placed in the center of the raster, ready for you to position it in the desired location. You can set viewshed parameters independently for each viewpoint by editing the settings in the viewpoint list or by highlighting the point's list entry and adjusting the point's Field of View tool graphic. A joint viewshed for all points is computed when you test or run the process.

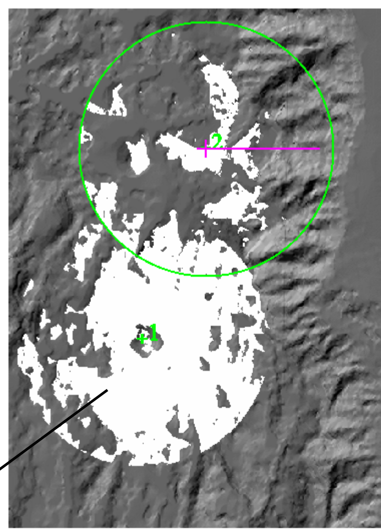
STEPS

- ☑ reset the Sweep Angle for Point 1 to 360
- ☑ press the Add icon button on the Viewshed Analysis window 
- ☑ drag the new Point 2 to a location in the northern half of the raster
- ☑ set the Height of Point 2 to 30
- ☑ set the View Distance for Point 2 to 150
- ☑ press [Test]



You can use the Save Viewpoints as Vector icon button to save the viewpoints for later reuse in the process.

In its default mode, the viewshed computation assumes a "flat-earth" geometry: the surface defined by a single elevation is a horizontal plane. This assumption is appropriate for local viewshed analysis. If the area you are analyzing is larger in extent (tens of kilometers across or greater), you will achieve more accurate results by turning on the Allow for Earth Curvature toggle button.



Viewshed for two viewpoints with view distances each set to 150 raster cells.

NOTE: When a new viewpoint is added at the raster center, its view distance is set just large enough to include all of the raster area. This ensures that at least parts of the field of view tool's view distance arc are visible at full view of the raster for ease of adjustment. However, when you drag the point to a new location, parts of the raster will lie outside the view distance circle. If you want all of the raster area included in the analysis, you need to increase the view distance appropriately for each new point.

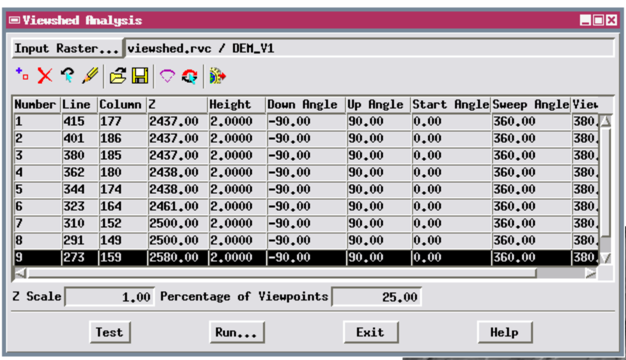
Load Saved Viewpoints

STEPS

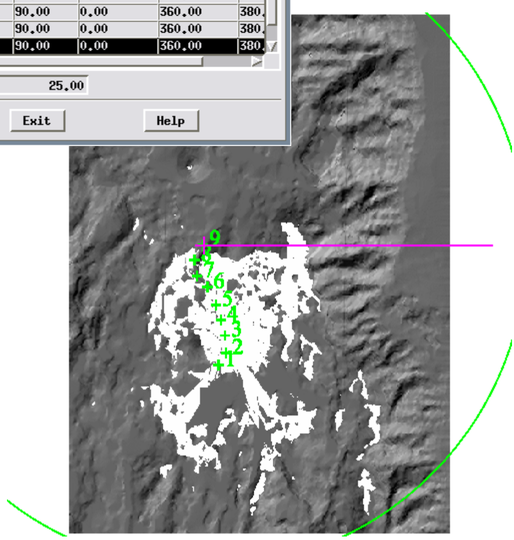
- ☑ press the Load Viewpoints icon button on the Viewshed Analysis window and choose Load from the dropdown menu
- ☑ select vector object VPTS from the VIEWSHED Project File
- ☑ enter 2.0 in the Height field for each of the 9 viewpoints
- ☑ enter 25 in the Percentage of Viewpoints field at the bottom of the Viewshed Analysis window

The Load Viewpoints icon button allows you to add viewpoints from any geometric object (vector, CAD, or Shape) that contains point elements. The button menu provides options to clear any existing viewpoints (Load) or add to any existing viewpoints (Append).

When a viewshed is computed from multiple viewpoints, in the default mode any raster cell that is visible from at least one of the viewpoints is included in the viewshed. You can set stricter guidelines for visibility by changing the value in the Percentage of Viewpoints field (default = 0). This field sets the threshold percentage of viewpoints that must be visible from any cell in order for that cell to be included in the viewshed.



- ☑ press [Test] on the Viewshed Analysis window



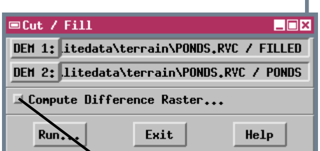
- ☑ *close the Viewshed process by pressing [Exit] when you have completed this exercise*

Cut and Fill Volumetric Analysis

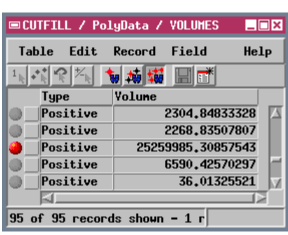
In the Cut and Fill Analysis process you select two elevation models that have the same size, geographic extents, and cell size. Elevations in the model selected as DEM2 are subtracted from those in DEM1. Polygons outlining the areas of net elevation difference are displayed automatically in the View window at the conclusion of processing.

The Cut and Fill process can be used to assess changes in landscapes through time due to erosion and deposition or landsliding. In this exercise we instead compare the DEM of an area with natural depressions, many of which contain ponds, with its depressionless equivalent (FILLED) produced by the Watershed process. Polygons with positive volumes identify depressions that have additional water storage capacity.

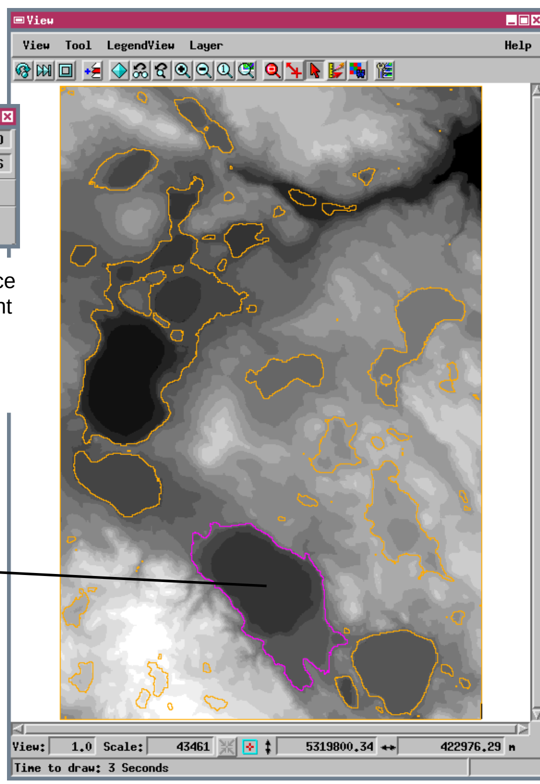
STEPS
- ☑ select Raster / Elevation / Cut and Fill Analysis from the TNTmips menu
- ☑ press [DEM1] on the Cut / Fill window and select raster FILLED from the PONDS Project File
- ☑ press [DEM2] and select raster PONDS from the same file
- ☑ press [Run] and create an output Project File
- ☑ accept the default names for the output vector object and attached database table



Turn on the Compute Difference Raster toggle button if you want to save the raster that records the difference in elevation for each cell location in the input



The VOLUMES table records the volume difference for each polygon, and whether the difference is positive or negative.



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