SURFACES

Getting Started

Surface Modeling

with

TNTmips®

Before Getting Started

This booklet introduces the powerful Surface Modeling process in TNTmips®. Surface modeling creates approximations of functional surfaces from the 3D information you provide. A functional surface combines spatial location with the value for some variable (such as elevation, chemical concentration, or population density) at that location. Functional surfaces are commonly represented as Digital Elevation Models (raster), isolines (vector contours), or Triangular Irregular Networks (TIN object). You can create any of these surface forms and convert between them in the Surface Modeling process. You can also create serial profiles of functional surfaces.

Prerequisite Skills This booklet assumes that you have completed the exercises in *Getting Started: Displaying Geospatial Data* and *Getting Started: Navigating*. Those exercises introduce essential skills and basic techniques that are not covered again here. Please consult those booklets and the TNTmips reference manual 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 SURFMODL data collection.

More Documentation This booklet is intended only as an introduction to Surface Modeling. Consult the TNTmips reference manual for more detailed information on the Surface Modeling process.

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 hardware key), TNTmips operates in TNTlite mode, which limits object size and does not allow export.

Surface Modeling is not available in TNTview, TNTedit, or TNTatlas. All the exercises can be completed in TNTlite using the sample geodata provided.

Randall B. Smith, Ph.D., 27 August 2001

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 Getting Started booklets on other topics. You can download an installation guide, sample data, and the latest version of TNTlite.

http://www.microimages.com

Welcome to Surface Modeling

The Surface Modeling process in TNTmips includes a set of operations that allow you to transform spatial data representing a three-dimensional surface from one form to another. The most familiar example of such data is probably the variation in elevation of the Earth's surface. However, any variable can be visualized and analyzed as a three-dimensional surface as long as it varies relatively smoothly at the chosen map scale, and has only a single value at each location. Examples include crop yield data, population density data, the concentration of dissolved chemicals in the ocean or groundwater, geophysical measurements such as gravity, and many others.

A three-dimensional surface can be approximated in a number of forms, including irregularly-spaced point observations, a regular grid of values, or contour lines of equal value (isolines). In TNTmips, irregularly-spaced point data can be stored as vector points, as a TIN (Triangulated Irregular Network), or in a database object containing *x* and *y* coordinates in addition to the value to be mapped. Gridded measurements are stored as a raster object, and contours as a vector object. Each of these data types can be used as input for one or more of the Surface Modeling operations.

Each Surface Modeling operation produces a specific type of object. The Surface Fitting operation produces a raster grid, Contouring produces vector contour lines, and Triangulation produces a TIN. The Profiling operation creates a series of parallel vertical profiles of a surface raster. Most operations provide a choice of several different methods for producing the desired surface. Your choice of method may depend on the type of input data, as well as the intended use for the output surface.

STEPS
- ☑ launch TNT
- ☑ select Process / Surface Modeling from the main menu

The exercises on pages 4-12 of this booklet show you how to create surface rasters with the **Surface Fitting** operation. Techniques for producing vector contours with the **Contouring** operation are introduced on pages 13-15. Pages 16-20 lead you through the creation of TIN objects with the **Triangulation** operation. Pages 21-22 show you how to create stacked vertical profiles of a surface raster with the **Profiling** operation. Page 23 presents graphical and tabular summaries of all Surface Modeling operations and methods.

Surface Fitting with Default Settings

STEPS

☑ select Surface Fitting from the Operation option menu

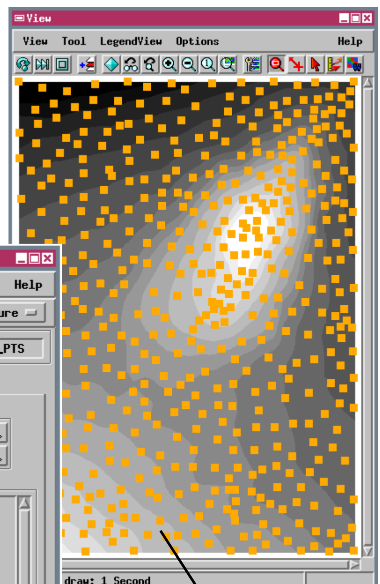
☑ click the Open icon button 

☑ select the ELEV_PTS vector object from the SURFACE Project File in the SURFMODL data collection

☑ click the Run icon button and name a new Project File SURFOUT 

☑ accept the default name provided for the output surface raster

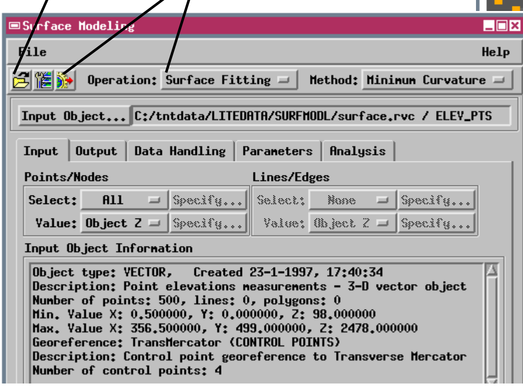
Let's start by running a sample Surface Fitting operation. **Surface Fitting** interpolates a regular grid of values from data in the input object and outputs the grid as a raster object. The input data can be in the form of points stored in a vector object or in a database that has X and Y coordinate fields for each record. You can also use vector contour lines or the nodes and/or edges in a TIN object as input. The input object used in this exercise is a 3D vector object containing 500 irregularly-spaced sample elevation points from a topographic surface. The elevation is stored as a Z-value for each point.



Select a Surface Modeling operation.

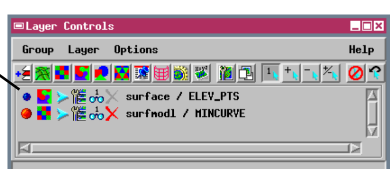
Click on the Open icon button to choose the input object.

Click the Run icon button to initiate the operation and name an output object.



Surface Modeling uses a standard View window to display input and output objects.

 To change display settings for any input or output objects, click the Layer Manager icon button on the Surface Modeling or View windows to open the standard Layer Controls window.



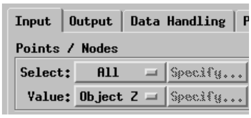
Keep the Surface Modeling window open with the current settings for the next exercise.

Set Input and Output Parameters

The Input and Output tabbed panels of the Surface Modeling window let you control the selection of data from the input object and the size and spatial resolution of the output surface raster. In this exercise you examine these controls and set a cell size for the next surface raster to be generated from the ELEV_PTS vector object.

The controls on the Input tabbed panel vary depending on the operation and input object type you have selected. Since the current input vector object contains points, the Points / Nodes subpanel is active. These controls determine which points are used to generate the surface raster values, and where to find the “elevation” value. In this case all of the points in the object are valid elevation measurements, so the default selection of All that appears on the Select: option button is appropriate. The default selection of Object Z on the Value: option button is also appropriate, as we are surface fitting the elevation value stored as the Z-value in the 3D (XYZ) vector object. A By Query option is also provided on each of these menus, allowing you to use a database query to select a subset of the points as input for the process and to use values stored in a database field as the Z value.

The Cell Size subpanel on the Output tabbed panel is used to set the size of the output raster cells in meters. The previous Surface Fitting operation calculated a cell size of 58.4822 meters from the geographic extents of the input object and the default output raster size. When you enter new cell size values in the Line and Column parameter text fields, the size of the output raster is calculated and the Raster Size parameter fields are updated.

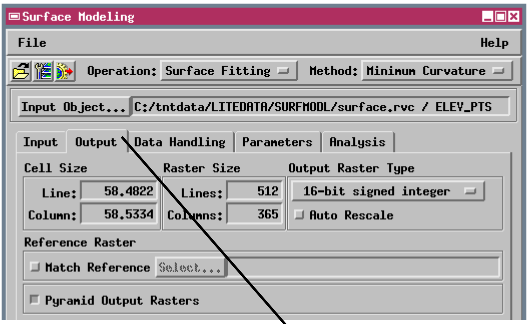


STEPS

☑ examine the Points / Nodes controls on the Input tabbed panel

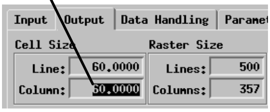
☑ click the Output tab to reveal the Output tabbed panel

☑ in the Cell Size subpanel, enter 60.0 in the Line and Column text fields



Click a tab to reveal its attached panel.

To change a parameter value, highlight the field with the mouse cursor and type in the desired value.



Keep the Surface Modeling window open with the current settings.

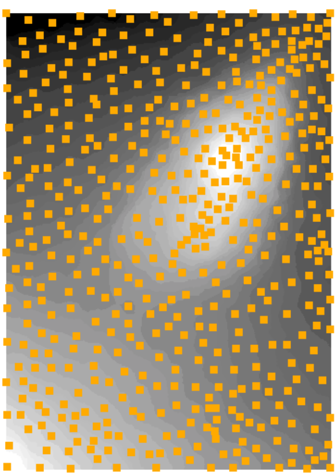
Surface Fitting by Inverse Distance

STEPS

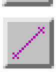
- ☑ click on the Method option button and select Inverse Distance
- ☑ click on the Parameters tab and choose Circle from the Search Area option menu
- ☑ set the Search Distance parameter value to 30
- ☑ click the Run icon button and direct the output raster to the SURFOUT Project File 
- ☑ accept the default name provided for the output surface raster

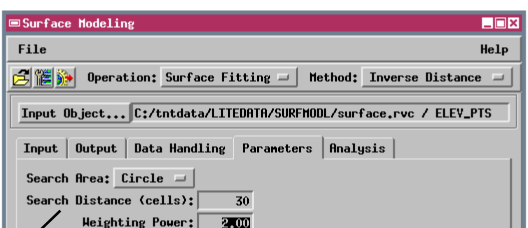
Surface Modeling offers a variety of surface fitting methods, each of which can be used with particular types of input objects. (Methods that cannot be used with the current input object are dimmed on the Method option menu).

The Inverse Distance method can be used with vector objects containing points or contours, or with database or TIN objects. The method chooses a set of nearby input points to interpolate a surface value for each cell in the output raster. The Search Area parameter determines the shape of the selection area, while the Search Distance parameter determines its size. The settings used here create a circular selection area with a 30-cell radius (1800 meters with the current output cell size of 60 meters). The spacing of adjacent points in this input object varies from 200 to about 2000 meters, so these settings should provide an adequate set of points for each raster cell location. The Z-value associated with each selected vector point is then multiplied by a weighting factor before averaging. The value of the weighting factor is largest for points closest to the current raster cell, and decreases exponentially with distance. The Weighting Power parameter determines the exponent used in the distance function. With the default setting of 2.00, the weights decrease in value by the square of the distance.



To measure the distances between points in an input object., click the GeoToolbox icon button on the View window and use the Ruler tool. For more information see the booklet *Getting Started: Sketching and Measuring*.





The Search Distance parameter controls the size of the area used to select input data values for interpolation.

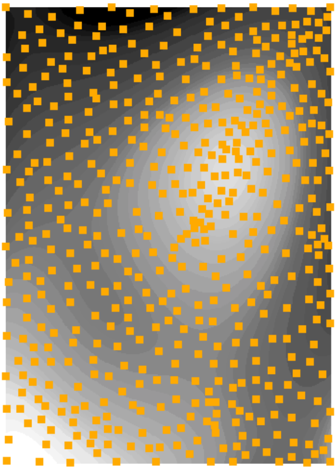
Keep the Surface Modeling window open with the current settings for the next exercise.

Polynomial Trend Analysis

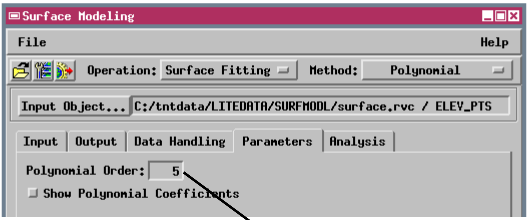
The Polynomial surface fitting method finds a best-fit surface defined by a polynomial equation that treats the mapped value as a mathematical function of geographic position. You can use vector point, TIN, and database objects as input with this method.

The polynomial method finds the best-fit surface by minimizing the sum of the squared deviations between the input values and the calculated surface. Because this is a best-fit for the *entire set* of input points, typically the output surface does not match the original value at each input point. This method is most useful for portraying generalized spatial trends for a "noisy" mapped value.

STEPS
- ☑ select Polynomial from the Method option menu
- ☑ click on the Parameters tab
- ☑ set the Polynomial Order parameter value to 5
- ☑ click the Run icon button and direct the output raster to the SURFOUT Project File 
- ☑ accept the default name provided for the output surface raster



The Polynomial Order parameter controls the form of the polynomial equation, which in turn defines the complexity of the computed surface. A second-order polynomial equation defines a parabolic curved surface with only one sense of curvature (concave or convex). A third-order (cubic) equation allows one change in sense of curvature in any cross-section. Higher-order equations allow for increasing complexity and more local detail. The fifth-order polynomial surface you generate here depicts the generalized trends in elevation in the input point object, but does not convey the detail present in the surface raster produced in the previous exercise by the Inverse Distance method.



The Polynomial Order parameter controls the complexity of the computed surface.

Keep the Surface Modeling window open with the current settings for the next exercise.

Surface Fitting by Triangulation

STEPS

☑ click the Open icon button and select the ELEV_TIN object from the SURFACE Project File

☑ click [Yes] in the Verify window

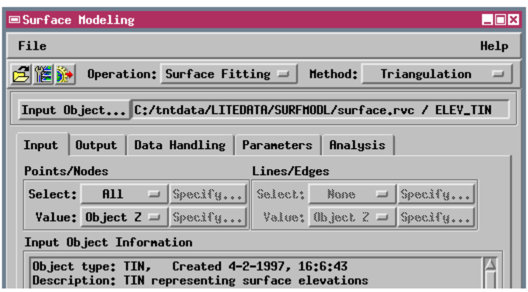
☑ select Triangulation from the Method option menu

☑ click the Output tab and set the Line and Column cell size to 60.0

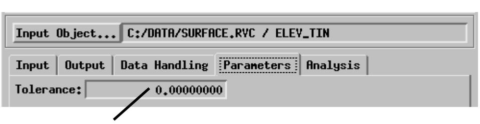
☑ click the Run icon button and direct the output raster to the SURFOUT Project File

The Triangulation method creates a surface raster from point data stored as vector points, TIN nodes, or in a database. The Triangulation method uses the input points to build a network of triangles meeting the Delaunay criterion: for each triangle, the circle that passes through all three vertices encloses no other input points. (The Delaunay criterion produces triangles that are as small and equilateral as possible, and is the rule used in creating TIN objects.) The process then fits a planar surface to each triangle, so that the overall surface is modeled as a collection of triangular planar facets.

The Tolerance parameter on the Parameters panel sets the minimum distance allowed between nodes in the network. (The distance units are in internal object coordinates, which may differ from distances derived from the object's georeferencing). By increasing the value of this parameter, you can eliminate closely-spaced and potentially redundant points as the network is created. To produce the maximum detail in the output surface raster, leave the Tolerance parameter at its default value (0).

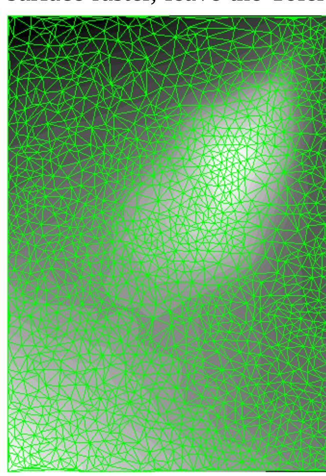


When you select a TIN object as input for other surface fitting methods, you can use either the nodes, edges, or both to interpolate the surface values.



The Tolerance parameter sets the minimum distance allowed between nodes in the triangular network created from the input points or TIN nodes.

Note: You can also select a new input object by pressing the Input Object button. Selecting a new input object resets any previous Output and Parameter settings to their default values.

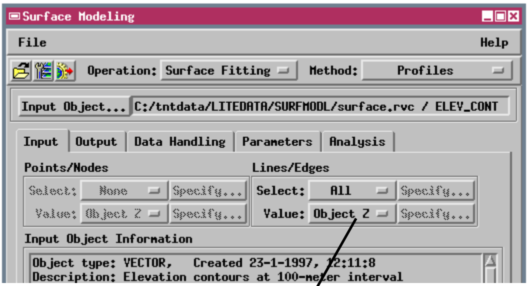


Surface Fitting by Profiles

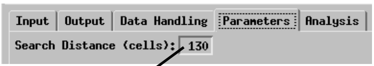
The Profiles surface fitting method is specially tailored to create a surface raster from contour lines. Only vector contours can be used as input with this method.

The Profiles method uses a multi-directional linear interpolation procedure to create a surface raster. The process searches for pairs of input elevation values on opposite sides of each output raster cell to use for interpolation. Edge cells are processed first, searching only parallel to the edge. For other cells, the process searches in eight different directions, and uses the closest pair of values (including edge cell values) to assign an interpolated output value. The Search Distance parameter determines the radius of the search (in raster cells). If the Search Distance is too small relative to the spacing and arrangement of the contour lines, the search may fail to find values in one or more directions to use for interpolation. The result will be "holes" in the output surface raster. Small holes can be repaired using other TNTmips processes.

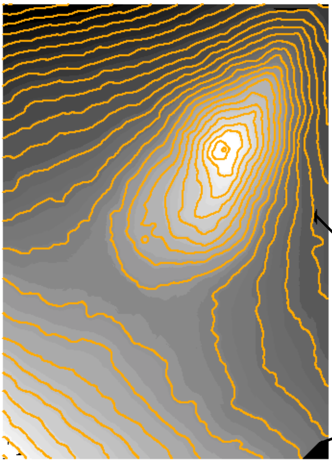
STEPS
- ☑ click on the Method: option button and select Profiles
- ☑ click the Open icon button and select the ELEV_CONT vector object from the SURFACE Project File 
- ☑ click the Output tab and set the Line and Column cell size to 60.0
- ☑ click the Parameters tab and set the Search Distance value to 130
- ☑ click the Run icon button and direct the output raster to the SURFOUT Project File 



When the input vector object contains elevation contours, the Lines / Edges subpanel is active. For 3-D input objects, use the default selection of Object Z on the Value option button.



Use the Search Distance parameter setting to control the spatial scope of the interpolation process.

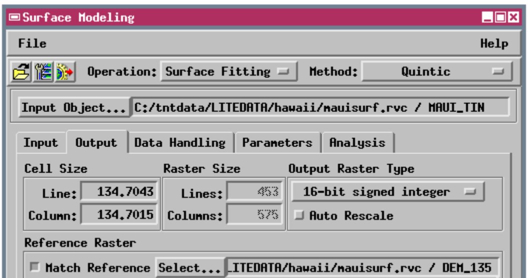


Black areas indicate "holes" (null areas) for which no surface value was calculated. Increasing the search distance helps fill holes, at the expense of longer processing times. (Edges and corners present special difficulties; increasing the search distance may not help in these cases.)

Surface Fitting by Quintic Method

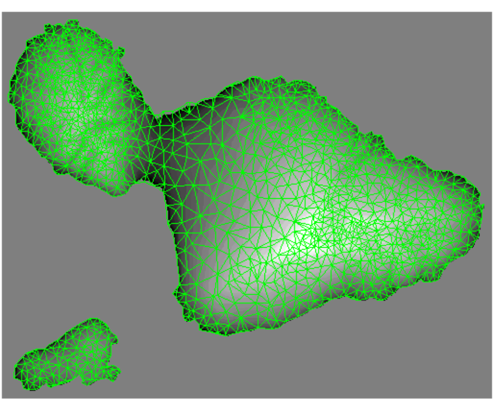
STEPS
- ☑ click the Open icon button and select the MAUI_TIN object from the MAUISURF Project File 
- ☑ select Quintic from the Method option menu

The Quintic method is optimized to create a surface raster from a TIN object. The elevation values at the nodes of the TIN triangles are used to compute a fifth-order polynomial surface for each triangular area. In computing each polynomial surface, the method also uses elevations from surrounding triangles to compute the slope and change of slope in different directions around each node. The slope data is used to define the shape of the individual polynomial surfaces to ensure that they join relatively smoothly along the triangle boundaries. This produces a smoother surface than the Triangulation method.



- ☑ click the Output tab and turn on the Match Reference toggle button
- ☑ on the same panel press [Select...] and choose the DEM_135 object from the MAUISURF Project File
- ☑ click the Run icon button and direct the output raster to the SURFOUT Project File 

The Quintic method interpolates elevations only within the confines of existing TIN triangles. "Holes" in the TIN are not filled, and separate TIN hulls generate separate elevation surfaces (as illustrated by the island surfaces created in this exercise). Raster areas outside the TIN hulls are assigned the default null value for the selected type of output raster. The Quintic method has no user-adjustable parameters, so its Parameters tabbed page is blank.



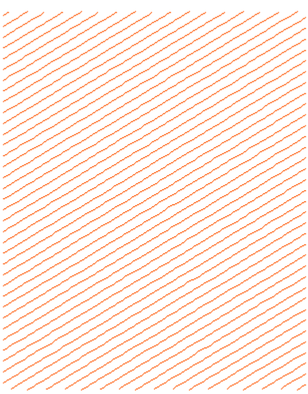
The Match Reference option on the Output tabbed panel enables you to match the dimensions, orientation, and cell size of your output surface raster to an existing georeferenced raster object that covers the same area as your input data. This option works with any Surface Fitting method except the Bidirectional method, which is discussed on the following page.

Bidirectional Surface Fitting

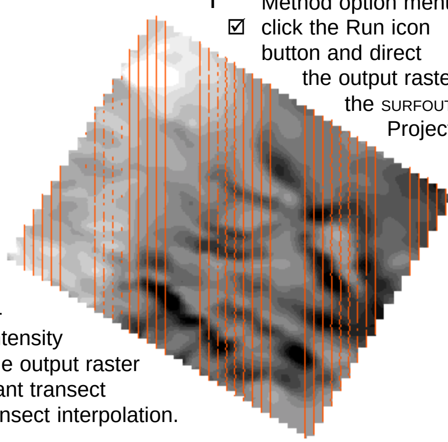
The Bidirectional surface fitting method is designed for use with aeromagnetic and other geophysical data that are collected along groups of nearly parallel transect lines. In most cases the distance between measurements along each transect is much less than the spacing between adjacent transects, so there is an inherent directional bias in the distribution of the observation points.

The Bidirectional method interpolates raster values in two steps: first along each transect line, then perpendicular to the dominant transect direction. With the Direction Type option set to Auto, the process automatically determines the predominant transect direction. Alternatively, you can set this option to Manual and enter an azimuth value to be used as the predominant direction.

Input data for the Bidirectional method must be in the form of 3D vector lines, with one line for each transect and line vertices representing measurement locations.

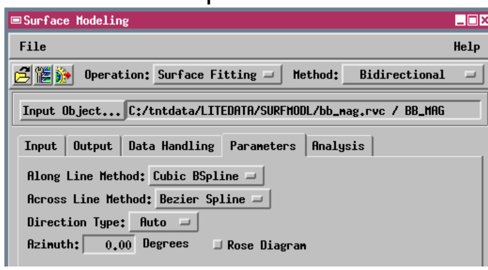


These transect lines are from an aeromagnetic survey of a single 7.5-minute quadrangle, with magnetic intensity values in nanoteslas. Columns in the output raster are aligned parallel to the predominant transect direction to allow efficient across-transect interpolation.



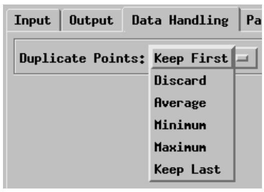
STEPS

- ☑ click the Open icon button and select the BB_MAG object from the BB_MAG Project File
- ☑ select Bidirectional from the Method option menu

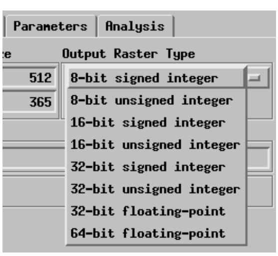


- ☑ on the Output panel, choose 32-bit floating-point from the Output Raster Type option menu and turn off the Match Reference toggle.
- ☑ click the Parameters tab and choose Cubic BSpline from the Along Line Method option menu
- ☑ select Bezier Spline from the Across Line Method option menu
- ☑ click the Run icon button and direct the output raster to the SURFOUT Project File

Other Surface Fitting Methods



Depending on your input data and the cell size of your output surface raster, more than one input data point may fall within the area of an output raster cell. Use the Duplicate Points option menu on the Data Handling tabbed panel to specify how such duplicate input values should be handled.



Use the Output Raster Type option menu on the Output tabbed panel to choose the appropriate data type for the computed surface raster. When the input represents elevations of the Earth's surface, the default setting of 16-bit signed integer is most appropriate, since its range is from -32,768 to +32,767.

The Surface Modeling process in TNTmips also includes several additional surface fitting methods that are not used in the exercises in this booklet. These methods are either similar to methods already covered, or are advanced methods with many parameter settings. Brief summaries of these methods are provided below. You can find additional information about them in the TNTmips reference manual section on Surface Modeling.

Minimum Curvature The Minimum Curvature method applies a two-dimensional cubic spline function to fit a smooth surface to the set of input elevation values. The computation requires a number of iterations to adjust the surface so that the final result has a minimum amount of curvature. The input object can be in the form of vector points, vector contours, a TIN, or a database.

Kriging Kriging interpolates an elevation value for each output raster cell by calculating a weighted average of the elevations at nearby points. Closer points are weighted more heavily than more distant points in the calculation. The Kriging procedure analyzes the statistical variation in values over different distances and in different directions to determine the shape and size of the point selection area, and the set of weighting factors that will produce the minimum error in the elevation estimate. Kriging can be used with input vector points, TINs, and database objects.

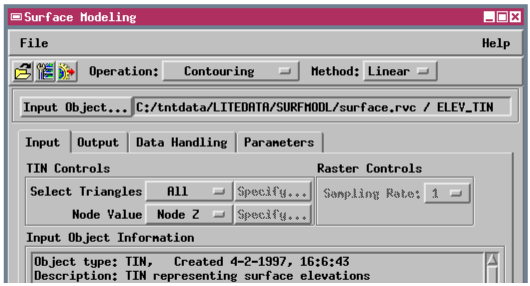
Linear The Linear method fits a planar surface to each triangle in an input TIN object. Unlike the Triangulation method, elevations are interpolated only within the confines of existing TIN triangles. "Holes" in the TIN are not filled, and separate TIN hulls generate separate elevation surfaces. The Linear method essentially reproduces the triangular-faceted TIN surface in raster form.

Contouring a TIN Object

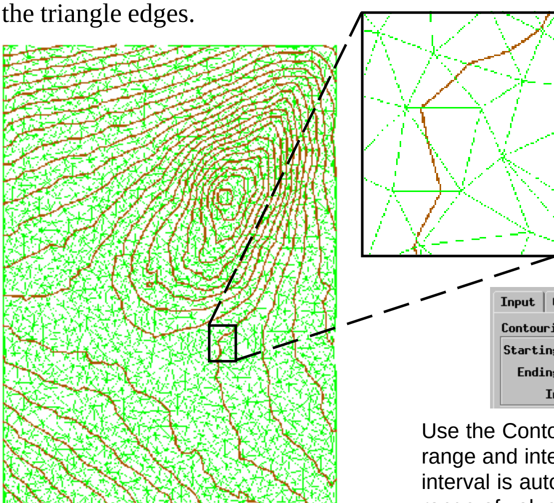
The next series of exercises explore the **Contouring** operation, which creates a 3D vector object with lines of equal value (contours or isolines) at a specified interval. TIN and raster objects can serve as input for contouring.

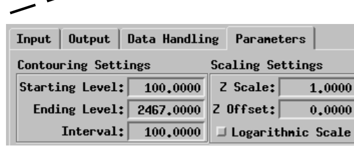
The Linear method is the only one available for contouring TIN objects. It treats each TIN triangle as a planar surface. When a contour is found to pass between two TIN nodes, the location of its intersection with the triangle edge is determined by linear interpolation from the node Z-values (or values you specify by a query). Each output contour line is made up of straight-line segments (one segment per triangle crossed), with direction changes occurring at the triangle edges.

STEPS
- ☑ choose Contouring from the Operation option menu
- ☑ click the Open icon button and select the ELEV_TIN object from the SURFACE Project File



- ☑ click the Parameters tab and set the Starting Level parameter value to 100
- ☑ set the Interval parameter value to 100
- ☑ click the Run icon button and direct the output vector object to the SURFOUT Project File

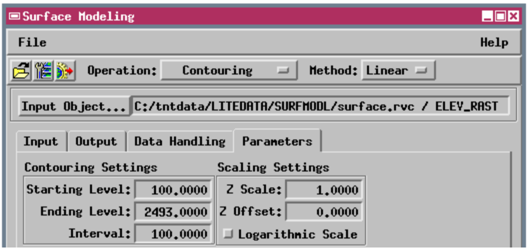




Use the Contouring Settings to control the range and interval of the contours. A default interval is automatically calculated from the range of values in the input object.

IMPORTANT: Choosing a new Surface Modeling operation clears the previous Input Object selection and resets all processing parameters to their default values. You are also asked to choose whether or not to remove previous result layers from the View window before beginning the new Surface Modeling operation.

Contouring a Raster: Linear Method



The Linear method is also available for contouring raster objects. It locates contours from the raster values by linear interpolation in the line and column directions.

When you contour a raster object you have the option of smoothing the input raster values prior to finding contours. The Smoothing Method options are found on the Data Handling tabbed panel. With no smoothing, contour lines may appear jagged. The Weighted Average smoothing method produces increasing smoothing as you increase the Filter Window Size.

STEPS

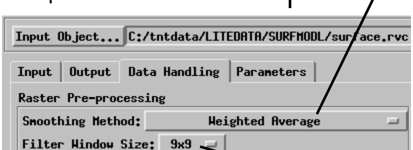
☑ click the Open icon button and select the ELEV_RAST object from the SURFACE Project File

☑ click the Parameters tab and set the Starting Level parameter to 100 and the Interval parameter to 100

☑ click the Run icon button and direct the output vector object to the SURFOUT Project File

☑ click the Data Handling tab and choose Weighted Average from the Smoothing Method option menu

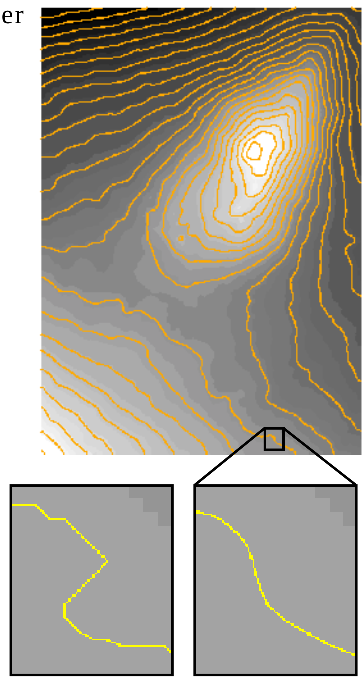
Choose raster smoothing options from the Smoothing Method option menu.



☑ select 9 x 9 from the Filter Window Size option menu

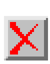
☑ click the Run icon button and direct the output vector object to the SURFOUT Project File

Increase the Filter Window Size to produce smoother, more generalized contours.



No smoothing

Weighted Average 9 x 9 Filter Size



Remove the contour object from the view window and keep the current contouring settings for the next exercise.

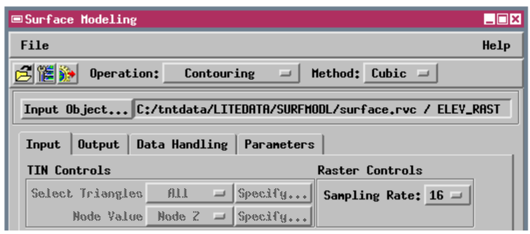
Contouring a Raster: Cubic Method

If fine detail is not required, you can also smooth contours and speed processing of a raster by increasing the Sampling Rate setting on the Input tabbed panel. This setting controls the sampling interval that determines the set of raster cells used to interpolate contour positions. With a Sampling Rate of 4, for example, sample cells are selected at intervals of four lines and four columns, so the sample set includes one-sixteenth of the input cells. With the default setting of 1, every raster cell is used.

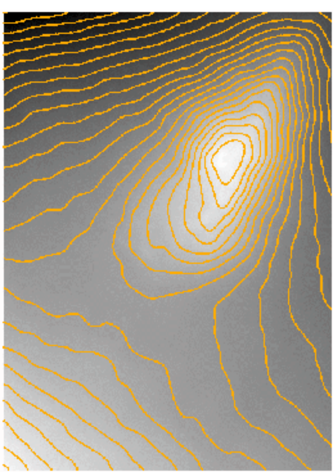
STEPS

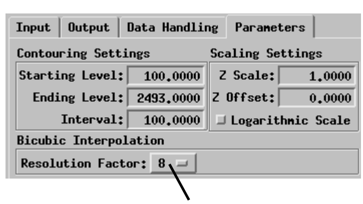
- ☑ click the Method button and choose Cubic
- ☑ click the Input tab and choose 16 from the Raster Controls Sampling Rate option menu
- ☑ click the Parameters tab and choose 8 from the Bicubic Interpolation Resolution Factor option menu

The Cubic contouring method interpolates a position for a contour line segment by fitting a cubic polynomial surface to the nearest surrounding four cells in the sample set. The Resolution Factor setting on the Parameters tabbed panel sets the number of subunits that this area is divided into during the interpolation process. Increasing the Resolution Factor increases the apparent spatial detail in the contour lines when the Sampling Rate is set to a value greater than 1.



- ☑ click the Data Handling tab and choose None from the Smoothing Method option menu
- ☑ click the Run icon button and direct the output vector object to the SURFOUT Project File





Increase the Resolution Factor setting to preserve apparent contour detail as you increase the Sampling Rate. The Resolution Factor setting should not exceed the Sampling Rate.

Triangulation from Point Data

STEPS

☑ choose Triangulation from the Operation option menu

☑ click the Open icon button and select the ELEV_PTS_2D object from the SURFACE Project File 

☑ click the Input tab, then press [Specify...] next to the Value option button

☑ in the Query Editor window, choose Field from the Insert Menu

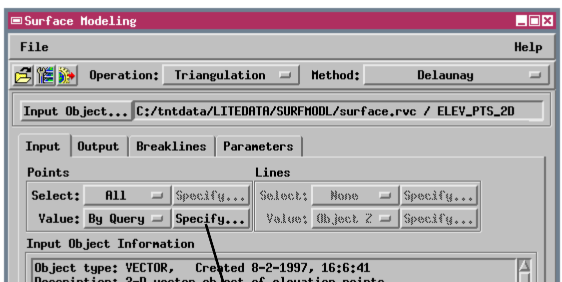
☑ in the Insert Field window, click on ELEV_PTS in the Table List, then Z_VAL in the Field list; click [Insert], then [Close]

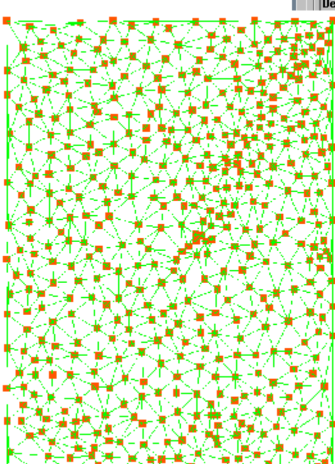
☑ click [OK] in the Query Editor window

☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File 

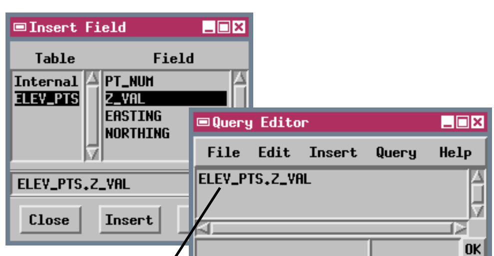
You have worked with TINs as input objects in previous exercises. To create a TIN object, use the Triangulation operation. **Triangulation** computes a TIN from points in a vector or database object, from vector contours, or from a raster object.

When the input object contains point data or contours, the Delaunay triangulation method is used. This method uses the input points (or contour line vertices) to create a triangular network meeting the Delaunay criterion (described in the exercise on Surface Fitting by Triangulation on page 8). For an input database object or 2D vector object, By Query is the active selection on the Value option button on the Input tabbed panel. You must use a query to specify a database table and field containing the values to use as Z-values for the output TIN nodes.





Press [Specify...] to open the Query Editor window and create a query that specifies the table and field containing the desired Z values.



A value query has the simple form TABLE.FIELD, specifying the field in the attached database table that contains the desired values.

Triangulation from a Raster

The Adaptive Densification method of Triangulation is used to create a TIN from a raster object. After placing initial TIN nodes at the corners of the input raster to form two large triangles, this method subdivides triangles in a number of iterations to create a denser TIN structure. A triangle is subdivided by placing a new node at the raster cell location with the highest deviation from the planar surface defined by the triangle.

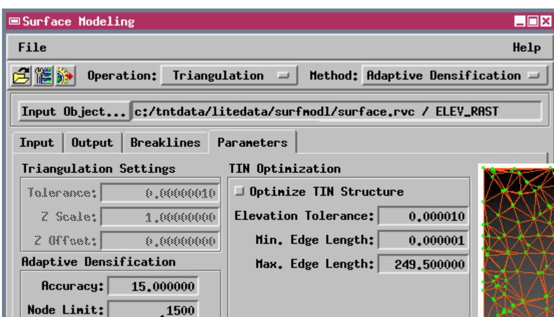
You can control the complexity and fidelity of the output TIN using the Accuracy and Node Limit parameters. The Accuracy parameter value sets the maximum Z-value deviation between a triangle and the raster surface it represents. If a triangle's deviation is less than this value, the triangle is not subdivided further. The Node Limit parameter sets a rough upper limit on the number of nodes in the final TIN object.

STEPS

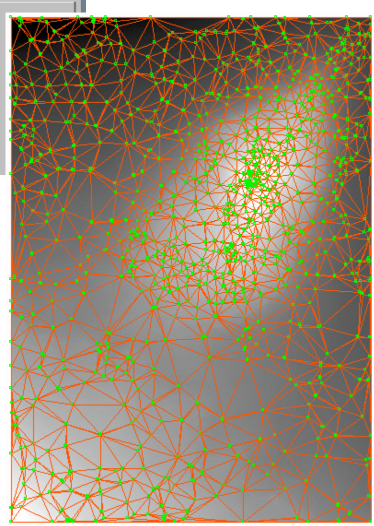
- ☑ click the Open icon button and select the ELEV_RAST object from the SURFACE Project File

- ☑ click the Parameters tab
- ☑ in the Adaptive Densification panel, change the Accuracy parameter value to 15 and the Node Limit value to 1500
- ☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File

The Adaptive Densification method is automatically selected when you choose a raster object as input for the Triangulation operation.



The number of nodes in the final TIN object may be less than the Node Limit if all triangles satisfy the current Accuracy parameter setting before the Node Limit is reached. For example, the TIN produced using the settings in this exercise contains 1384 nodes. By contrast, if the node limit is reached partway through a processing iteration, subdivision continues until all current triangles have been processed. In this case the final number of nodes will exceed the Node Limit value by a small amount, and some triangles may not satisfy the Accuracy parameter setting.

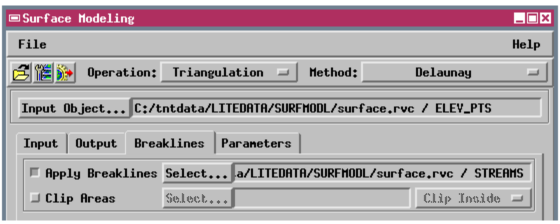


Triangulation with Breaklines

STEPS

- ☑ click the Open icon button and select the ELEV_PTS object from the SURFACE Project File
- ☑ click the Breaklines tab, turn on the Apply Breaklines toggle button, and press [Select]

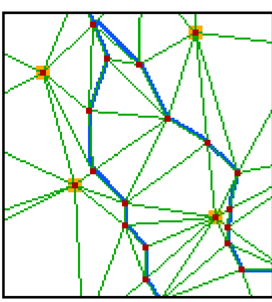
The Triangulation operation includes several processing options that are available for any input object type, including the use of breaklines. **Breaklines** are 3D vector lines or polygons that refine the structure of the resulting TIN object.

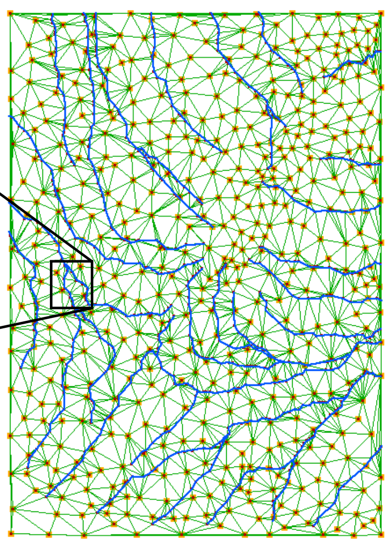


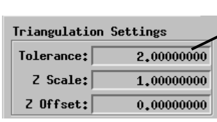
The Apply Breaklines option incorporates vector lines within the structure of the TIN as fixed elements or boundaries. Each breakline is represented in the TIN as a series of interconnected triangle edges. The breakline edges are treated as "hard edges" which cannot be removed during any subsequent retriangulation of the TIN.

- ☑ select object STREAMS from the SURFACE Project File
- ☑ click the Parameters tab and set the Tolerance value in the Triangulation Settings to 2.0
- ☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File

The breaklines used in this exercise represent a drainage network. In addition to providing supplemental elevation control, they also mark the change in slope direction at the bottom of valleys. As breaklines, they become boundaries that are appropriately preserved during any further change in the TIN structure.





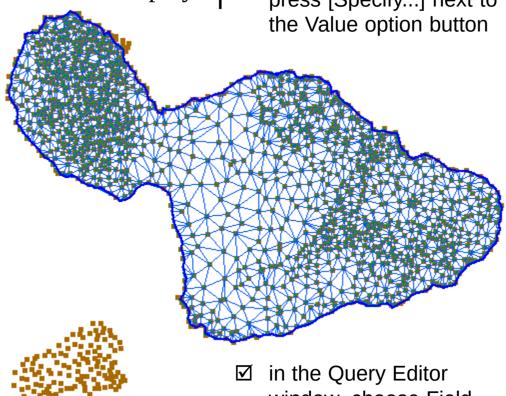


The Tolerance parameter has the same function as in the Triangulation method of Surface Fitting (see page 8).

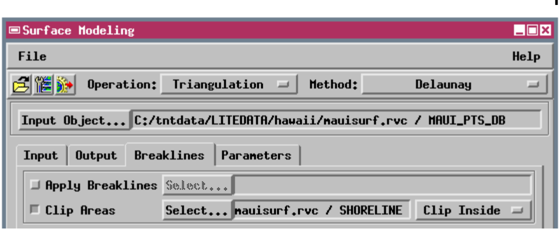
Triangulation Using Breaklines to Clip

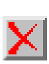
The Clip Areas option allows you to use one or more polygons in a vector object to limit the extent of the TIN produced by the Triangulation operation. The lines bounding the polygons also become “hard edges” in the TIN structure (see page 18).

The Clip Inside option is appropriate when the polygon represents the outer boundary of the area of interest. The TIN structure inside the breakline polygon is retained, while edges and nodes outside the polygon are eliminated. In the example in this exercise, the input elevation point database represents the island of Maui and a smaller outlying island, while the breakline polygon outlines the shoreline of the main island. Only the main island is covered by the resulting TIN object.



The Clip Outside option creates “holes” within the TIN: the TIN structure outside the polygon is preserved, and edges and nodes inside the polygon are eliminated. In a topographic example, this option might be used when the polygon represents the complex shoreline of a large, irregularly shaped lake. Without clipping, the lake surface would be represented by a large number of horizontal triangles.





Remove the TIN object from the view window and keep the current Triangulation settings for the next exercise.

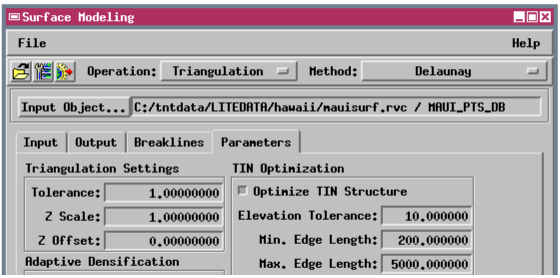
STEPS

- ☑ click the Open icon button and select the MAUI_PTS_DB object from the MAUISURF Project File
- ☑ click [OK] on the Database Pinmap Display Controls window
- ☑ click the Input tab, then press [Specify...] next to the Value option button
- ☑ in the Query Editor window, choose Field from the Insert Menu
- ☑ in the Insert Field window, click on MAUIPTS in the Table List, then ELEV in the Field list; click [Insert], then [Close]
- ☑ click [OK] in the Query Editor window
- ☑ on the Breaklines tabbed panel, turn on the Clip Areas toggle button
- ☑ press [Select] for Clip Areas, and choose object SHORELINE in the MAUISURF Project File
- ☑ on the Parameters panel, set the Tolerance value in the Triangulation settings to 450.0

- ☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File

Triangulation with Optimization

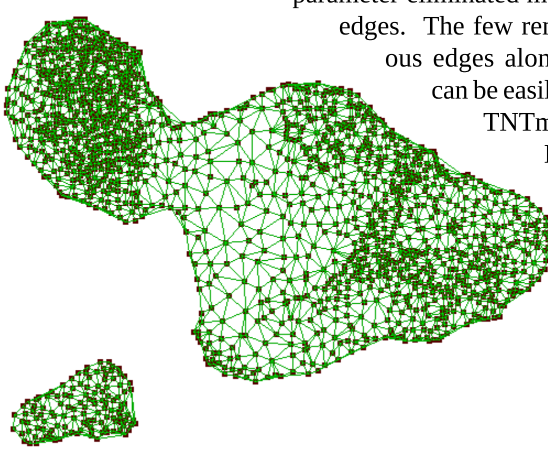
STEPS
- ☑ turn off the Clip Areas toggle button on the Breaklines tabbed panel
- ☑ click the Parameters tab and set the Tolerance value in the Triangulation Settings to 1.0
- ☑ turn on the Optimize TIN Structure toggle button



- ☑ set the Elevation Tolerance value to 10.0
- ☑ set the Min. Edge Length value to 200
- ☑ set the Max. Edge Length value to 5000
- ☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File 

TIN Optimization provides several functions to filter out redundant TIN nodes and control the geometry of the resulting TIN object. If a TIN node is too close to another node with a similar elevation, it is identified as redundant and eliminated. The Elevation Tolerance parameter defines the minimum elevation difference that is allowed for nearby nodes in the final TIN object. The Min. Edge Length parameter value quantifies "nearby": it sets the minimum triangle edge length allowed in the output TIN.

The Max. Edge Length parameter value sets an upper limit on the length of triangle edges in the TIN. This parameter can be useful when the set of input points has an irregular margin or includes two distinct clusters of points, and you don't have a suitable breakline polyon available for clipping. For the point database used in this exercise, triangulation without optimization would create a number of long edges that would span indentations in the coastlines and connect the two islands. The selected value of the Max. Edge Length parameter eliminated most of these long edges. The few remaining extraneous edges along the coastlines can be easily removed in the TNTmips Spatial Data Editor.



Profiling a Surface Raster

The **Profiling** operation creates a series of parallel ("stacked") vertical profiles of a surface raster. Stacked profiles provide a quick alternative means of visualizing a three-dimensional surface from different directions and with differing vertical scales. The profiles are stored as a CAD object.

You can use the Stack Profiles Settings on the Parameters tabbed panel to control the spacing between profile lines, vertical scaling, the profile line direction, and optional profile line smoothing.

STEPS

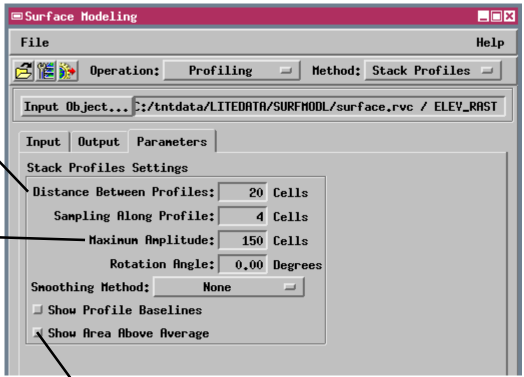
☑ select Profiling from the Operation option menu

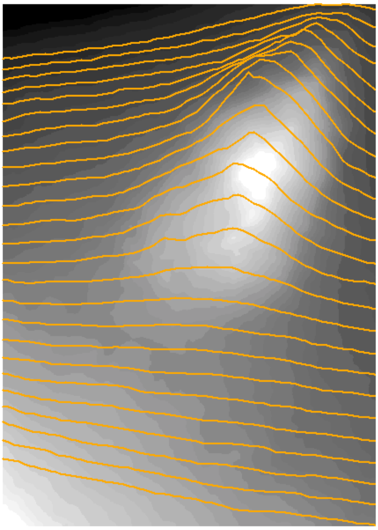
☑ click the Open icon button and select the ELEV_RAST object from the SURFACE Project File

☑ click the Parameters tab and set the Distance Between Profiles parameter value to 20 and the Maximum Amplitude to 150

The Distance Between Profiles parameter controls the profile spacing.

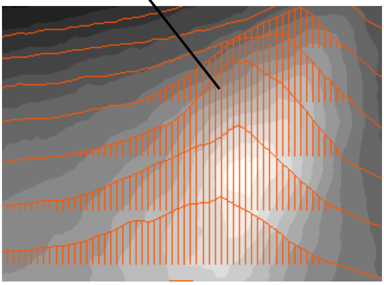
Set the maximum vertical dimension of a profile (in raster cells) with the Maximum Amplitude parameter value. You should adjust the profile spacing and amplitude in tandem to ensure that the profiles show sufficient detail without confusing overlap.





☑ click the Run icon button and direct the output CAD object to the SURFOUT Project File

With the Show Area Above Average toggle button turned on, the upper portion of each output profile is marked by a hatch fill.

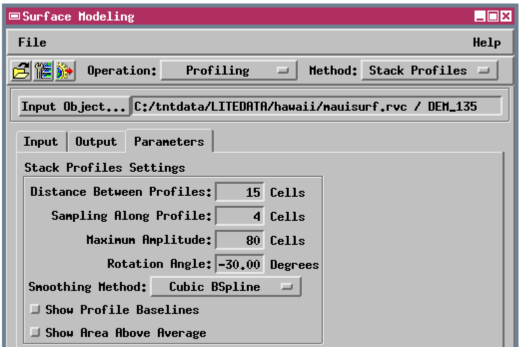


Creating Rotated Profiles

STEPS

☑ click the Open icon button and select the DEM_135 object from the MAUISURF Project File 

The default profiling direction is horizontal. To create profiles in other orientations, specify a rotation angle (positive degrees counterclockwise from horizontal, or negative degrees clockwise from horizontal).



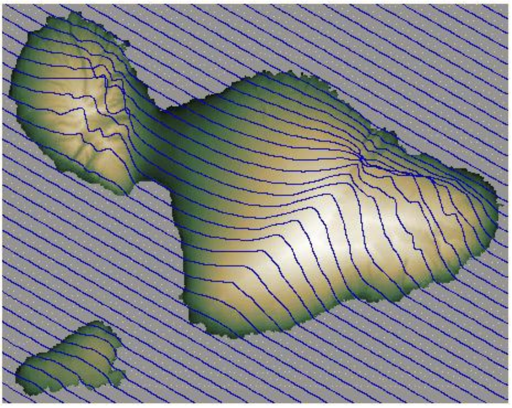
If profiles appear “noisy” (too detailed), you can either increase the value of the Sampling Along Profile parameter, or smooth the profile. The profile is smoothed by splining, with a choice of either Cubic (third order) B Spline, or Quadratic (second order) B Spline methods.

☑ click the Parameters tab and set the Distance Between Profiles parameter value to 15 and the Maximum Amplitude to 80

☑ set the Rotation Angle to -30.00

☑ choose Cubic BSpline from the Smoothing Method option menu

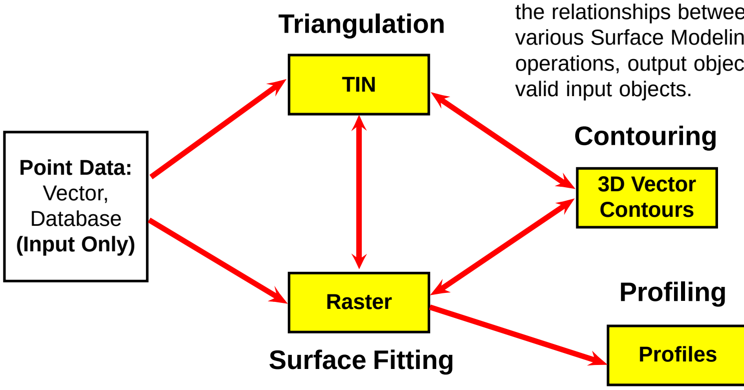
☑ click the Run icon button and direct the output TIN object to the SURFOUT Project File 



You can set up datatips to check the Z-Values quickly in the output objects you create in the Surface Modeling process. Click the object icon button for the relevant layer in the Layer Controls window to open the appropriate Object Display Controls window. Open the Datatip tabbed panel (for a raster) or the panel for the appropriate element type in a vector or TIN object. Turn on the Show Datatip toggle button. Press [Field] and choose the appropriate database table and field (for example, NODE.Z for TIN nodes). For further information, see *Getting Started: Displaying Geospatial Data* and *Getting Started: Navigating*.

Surface Modeling Summary

This diagram and chart summarize the relationships between the various Surface Modeling operations, output objects, and valid input objects.



Operation	Method	Input Objects					Output Object
		Raster	TIN	Vector Lines	Vector Points	Data-base	
Surface Fitting	Minimum Curvature		Yes	Contours	Yes	Yes	Raster
	Inverse Distance		Yes	Contours	Yes	Yes	
	Profiles			Contours			
	Polynomial		Yes		Yes	Yes	
	Triangulation		Yes		Yes	Yes	
	Kriging		Yes		Yes	Yes	
	Linear		Yes				
	Quintic		Yes				
	Bidirectional			Transects			
Contouring	Linear	Yes	Yes				Vector Contours
	Cubic	Yes					
	Iterative Thresholding	Yes					
Triangulation	Delaunay			Contours	Yes	Yes	TIN
	Adaptive Densification	Yes					
Profiling	Stack Profiles	Yes					CAD

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