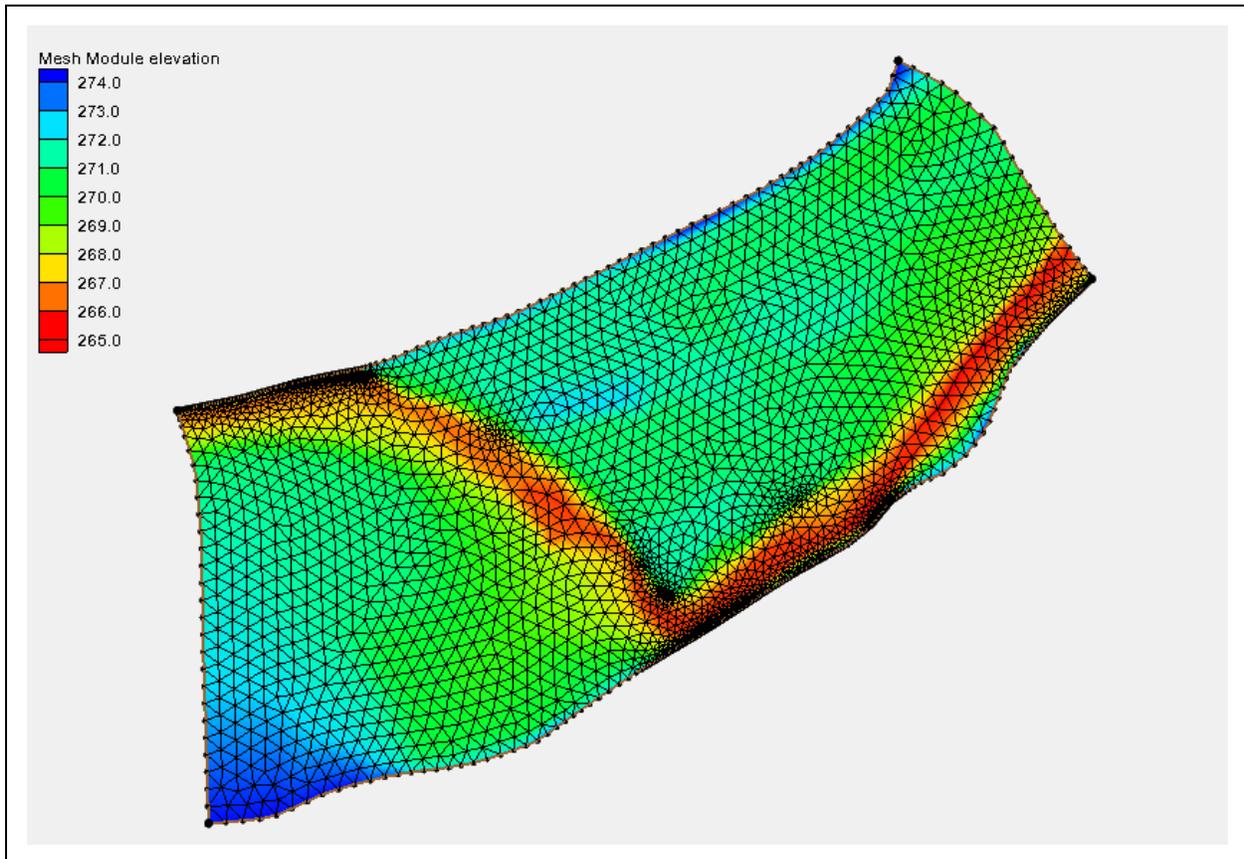


SMS 11.1 Tutorial

Creating a Size Function



Objectives

This lesson will teach you how to create and apply a size function to a 2d mesh model. Size functions can be created using various data. This tutorial will demonstrate how to create a size function based off of either depth, slope, or curvature.

Prerequisites

- None

Requirements

- Map Module
- Scatter Module
- Mesh Module

Time

- 30-45 minutes

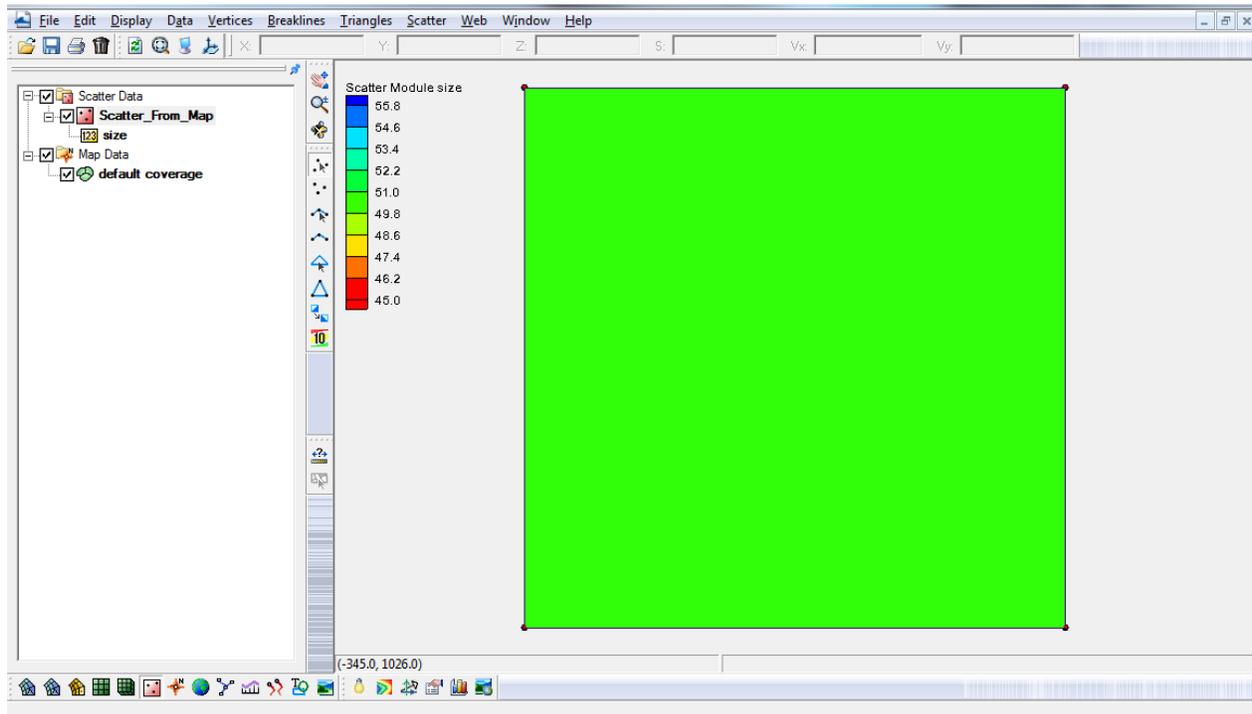
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1 Preprocessing

First we will show how to create and change element size from a coverage that we will create.

1. Right click on the Default Coverage in your project explorer and set the type to ADH.
2. Select the default coverage to make it active
3. Using the Create Feature Arc tool, click out four arcs forming a square. Select the *Select Feature Vertex* tool and highlight the three vertices. Right click and convert them all to *Nodes*.
4. Using the Select Feature Point tool, click on the bottom left point, and in the edit window put in the coordinates (0,0) for x and y. Now click on the upper left point and assign its coordinates to (0,1000) for x and y respectively. Click on the upper right and assign its coordinates as (1000,1000). Click on the lower right point and assign its coordinates to be (1000,0). You now have a square map layer of 1000 ft².
5. Frame the square by clicking the frame button.
6. Right click again on the Default Coverage and select Convert | Map-> 2d Scatter. Once the scatter set is created, rename the elevation data set to *size*.
7. Click on the newly created Scatter data in the project explorer to make it active. Select the Select Scatter Point tool and click in the graphic window. Right click and choose 'select all'. In the Z edit field put in 50. Keep in mind that this is not an elevation. It will be an element size. Figure 1 illustrates what it will look like.



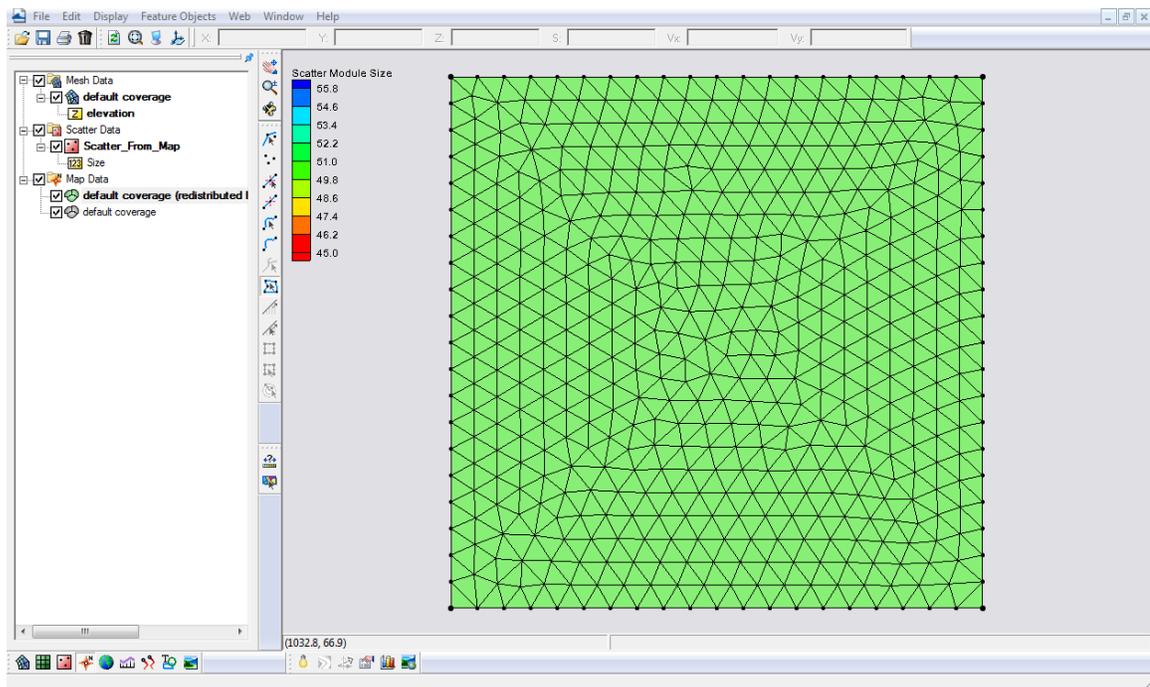
2 Creating the Mesh

Now we will create a mesh to illustrate the size of the elements.

1. Click on the default coverage to make it active. Click on the Feature Objects menu item and choose *Build Polygons*.
2. Choose the Select Feature Polygon tool and double click in the square. The 2D Mesh Polygon Properties dialog opens.
3. Change the Mesh Type to *Scalar Paving Density* and click on the Scatter Options button. This brings up the Interpolation dialog.
4. Set the extrapolation value to be 50.
5. Select *size* as the scatter set to interpolate from, then click OK.
6. Set the Bathymetry Type to *Scatter Set* and click on the Scatter Options button.

7. Set the extrapolation value to 50, and select *size* as the scatter set to interpolate from. Click OK twice. We will now convert the coverage to a mesh.
8. Right click on the default coverage and select *Convert / Map->2d Mesh*. A dialog will come up with the option to copy the coverage before meshing. Leave the option checked. The coverage will be redistributed during meshing to create a new coverage.

We now have a mesh that has 20 elements across. Each element's length in this case is 50 feet. Figure 2 illustrates this.



3 Size Functions

A size function determines the element size based off of a data set that will be created by SMS. Each point is assigned a size value. This size value is the approximate size of the elements to be created in the region where the point is located. The mesh will be denser where the size values are smaller. Size functions can be based off of different criteria. In

this tutorial we will show size functions based on either depth, slope, or curvature of the model.

3.1 Size Function Based on Depth

Many coastal models utilize a size function based on depth. As the depth gets shallower, the elements should get smaller. The model will become finer near areas of interest and coarser at deep water areas that are less significant.

1. Select *File | Delete All*
2. Open the *shin.pts* file
3. In the File Import Wizard, click Next, then Finish.
4. Select *Edit | Projection*.
5. Select the *Global projection* option. Set the Current Projection to UTM, NAD27, Meters, Zone 18 (78 W -72 W - Northern Hemisphere), now select OK. Set the Vertical units to Meters then click OK.
6. Click on the shin scatter data item in the project explorer to make it active. Right click the elevation data set underneath and rename it to *Positive Depth*. This is just to distinguish the fact that this is a depth data set rather than elevations.
7. With the shin scatter data still active, select *Data | Data Calculator*.

To create a size function based on depth, the following equation is used:

$$\frac{(((\text{positive depth} - \text{minimum depth}) / (\text{maximum depth} - \text{minimum depth})) * (\text{maximum size} - \text{minimum size}) + \text{minimum size})$$

8. In the data calculator, type in the following equation in the calculator edit field:
$$(d1-1) / (62.0077-1) * (3000-500) + 500$$

Put *size_3000_to_500* as the output dataset name, click *compute* and then *done*.
9. Open the *shin.grd* file
10. Right click on the Mesh in the Project Explorer and select *Reproject*. Click *Yes* to continue.

11. In the current projection portion of the dialog, select the Global projection option, click the *Set Projection* button and change the Projection to *Geographic (Latitude/Longitude)*, the Datum to *NAD83* with Planar Units of *ARC DEGREES* and click *OK*. Set the Vertical Units to Meters.
12. Verify that the New Projection is set the same coordinate system as your project and click *OK*. The mesh should now display on top of the scatter set.
13. Make sure the mesh module is active and right click on the mesh item in the project explorer. Select *Convert / Mesh to Map*.
14. Select the option to convert *Mesh Boundaries -> Polygons*
15. Click *Create New Coverage*, change the coverage type to *ADH*, change the coverage name to *ADH* and click *OK* twice to close both dialogs.
16. Select the *ADH* coverage to make it active, choose the *Select Feature Polygon* tool and double click in the middle of the polygon.
17. In the 2D Mesh Polygon Attributes dialog, set the mesh type to *Scalar Paving Density*, then click on the Scatter Options button.
18. Set the scatter set to interpolate from as *size_3000_to_500*. Click *OK*.
19. Set the Bathymetry type to *Scatter Set*, then click on the Scatter Options button and select *Positive Depth* as the scatter set to interpolate from. Click *OK*.
20. Right click on the *ADH* coverage and select *Convert / Map -> 2D Mesh*.
21. Click *OK* to the 2D Mesh Options dialog, and *OK* to an extrapolation warning and a mesh will appear. Be sure to turn off the scatter data so you can see your mesh. Figure 3 shows what it looks like. Notice how element size decreases as depth decreases.

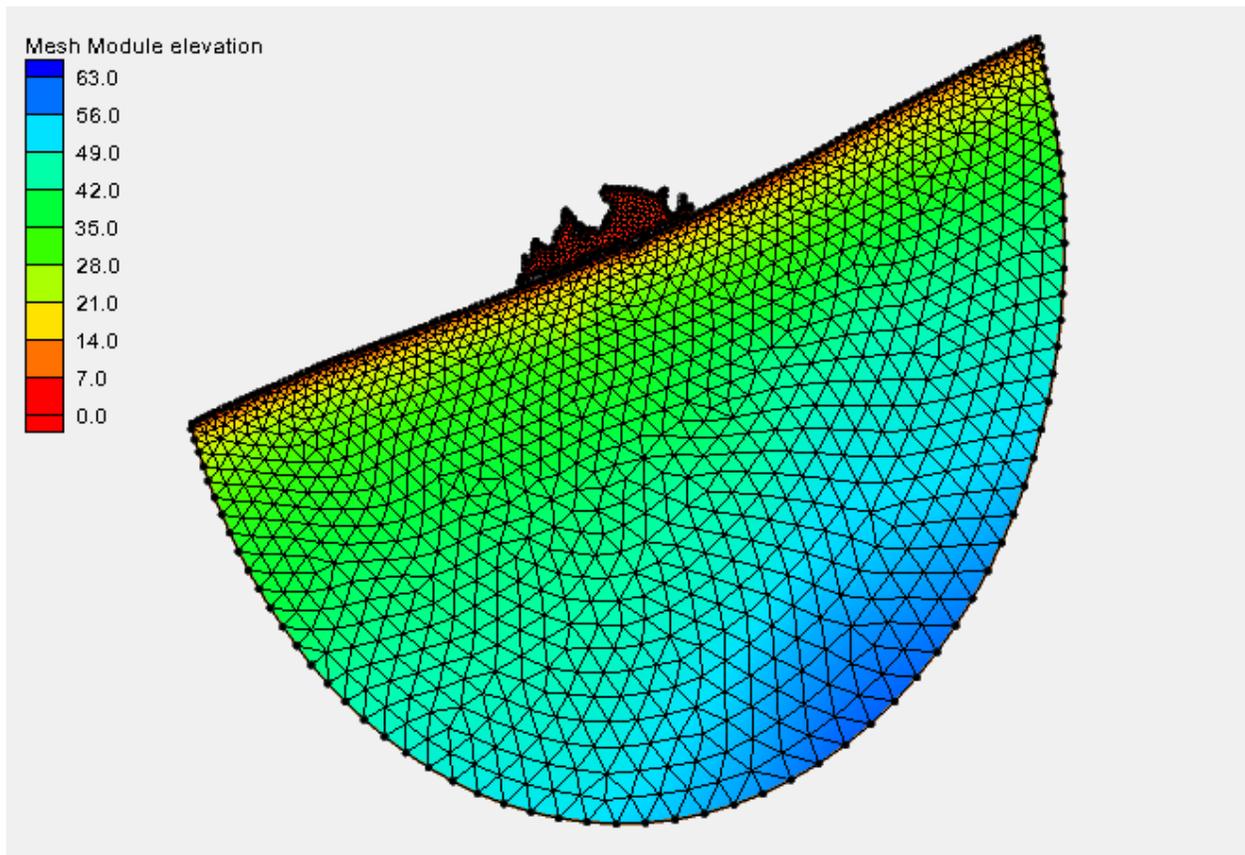


Figure 3

3.1.1 Smoothing Data

Now that we have our mesh, we can see that the elements change size rather abruptly. In order to have the element size change more gradually, we need to create a smoothing dataset.

1. Make sure the scatter module is active, and select *Data / Dataset Toolbox*. Switch the tool to the *Smooth dataset* tool, then choose *size_3000_to_500* as the dataset.
2. Set the area change limit to 0.5, and the anchor type to Minimum value. A minimum value anchor will ensure that the smallest element will stay the same size, and the bigger elements will change.

3. Set the Output dataset name to *Smooth_0.5*, then click *Compute* then *Done*.
4. Click on the *ADH* coverage to make it active, and with the *Select Feature Polygon* tool, double click in the polygon.
5. Make sure that the mesh type is still set to *Scalar Paving Density* and select the *Scatter Options* button. Change the scatter set to interpolate from to *Smooth_0.5* and then click OK twice.
6. Right click on the *ADH* coverage and select *Convert / Map ->2D mesh*. Click OK on the dialog box that gives you the option to make a copy of the coverage and delete the previous mesh. You can now see that the element size changes a bit more gradually than before as shown in figure 4.

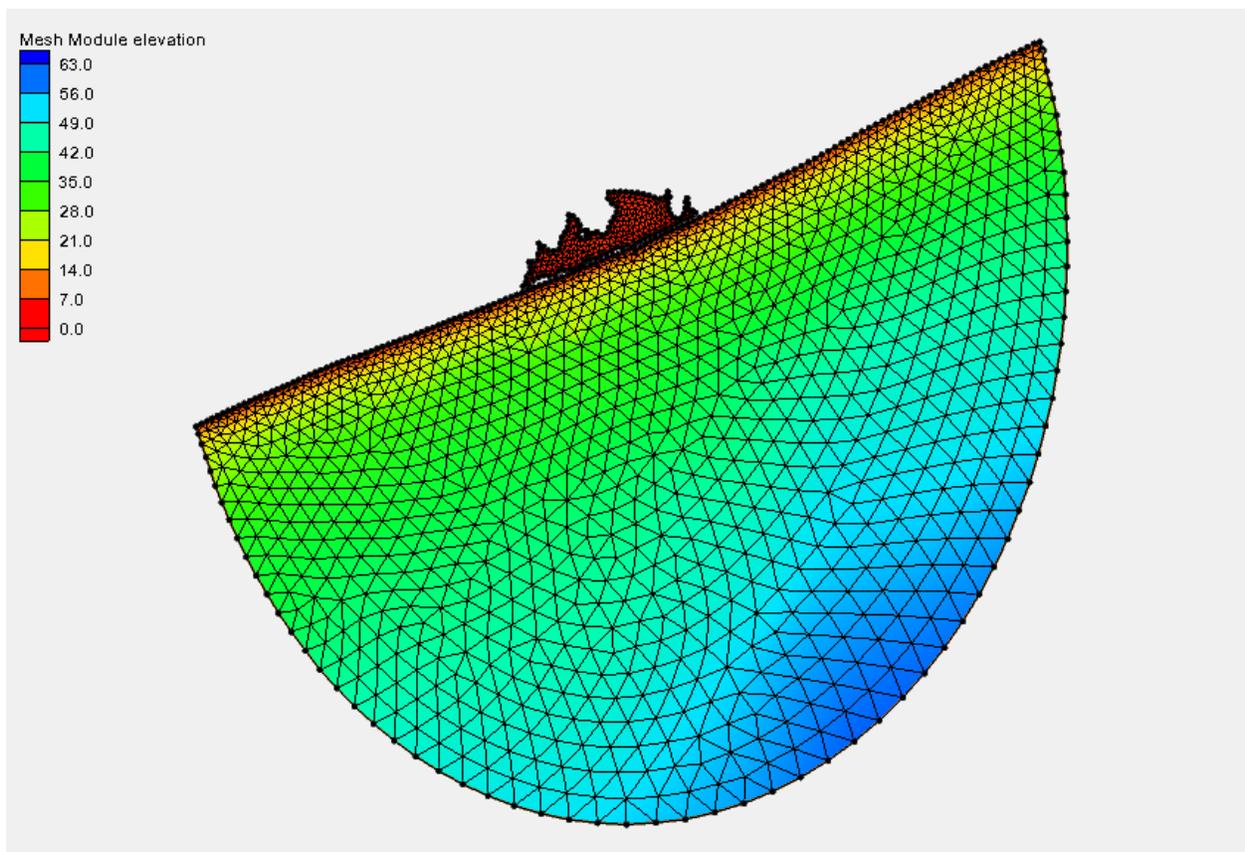


Figure 4

3.2 Size Function based on Slope

Size functions based on slope are helpful when analyzing slope data because as the rate of change of the gradient increases, the smaller the mesh element becomes. Size functions based on slope are mostly applied to river models. We will be using survey data from the Cimarron river to create our size function.

3.2.1 Preprocessing

1. Select *File / Delete All* to delete the shinnecock bay coastal model.
2. Select *File / Open* and open the *Cimarron Survey 2005.h5* file.
3. Select *Display / Display Options* and turn on the scatter set contours. In the Contour tab change the contour method *Color Fill*. The contours may already be turned on. Figure 5 shows the contoured data.

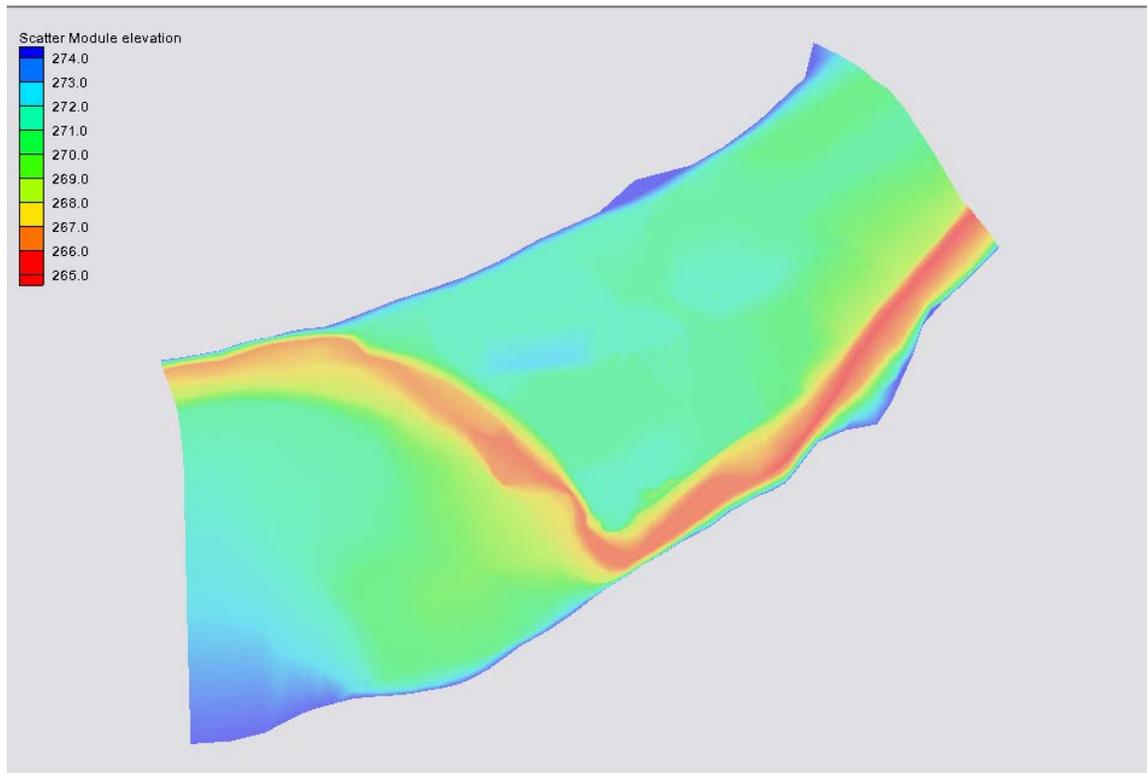


Figure 5

4. Right click on the Scatter data in the project explorer and select *Convert | Scatter Boundary ->Map*.
5. Rename the default coverage to *Cimmaron River*. Right click the coverage and set the type to *ADH*.
6. With the map coverage active, select the corner nodes with the *Select Feature Vertex* tool. When all four corners are selected, right click and choose *Convert to Nodes*. Figure 6 shows a node to the right of the lower left corner node. Select it with the *Select Feature Point* tool, then right click and choose *Convert to Vertex*.

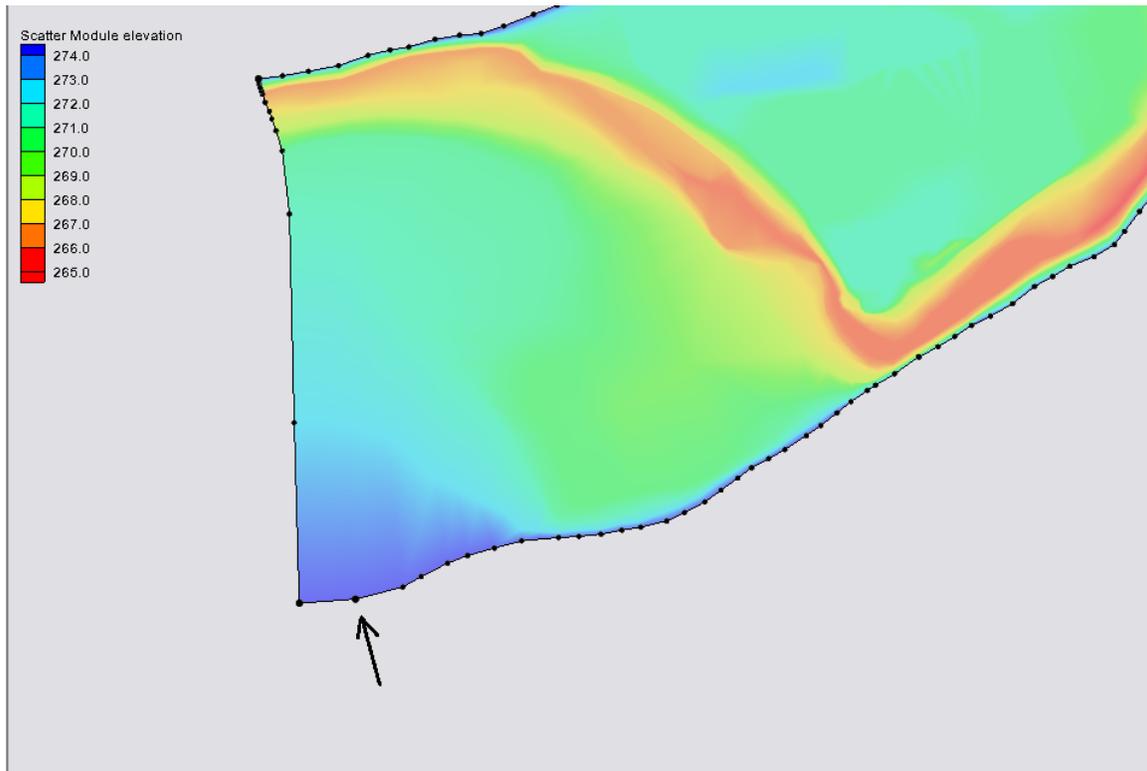


Figure 6

7. With the Cimmaron River coverage active, highlight the arcs using the *Select Feature Arcs* tool. Right click and select *Redistribute Vertices*. Make sure that *Specify* is set to *Specified spacing* and set the specified spacing to be 200 m.
8. In order to eliminate extrapolation values, make sure that the vertices lie within the scatter data. Move in each vertex so that SMS does not extrapolate any values outside of the scatter data.
9. Use the *Select Feature Arc* tool and select all 4 feature arcs. Right click and choose *Redistribute Vertices* again. Make sure that *Specify* is set to *Specified spacing* and set the specified spacing to be 90 m now. All of the vertices and nodes should be inside the scatter data. Figure 7 shows this.

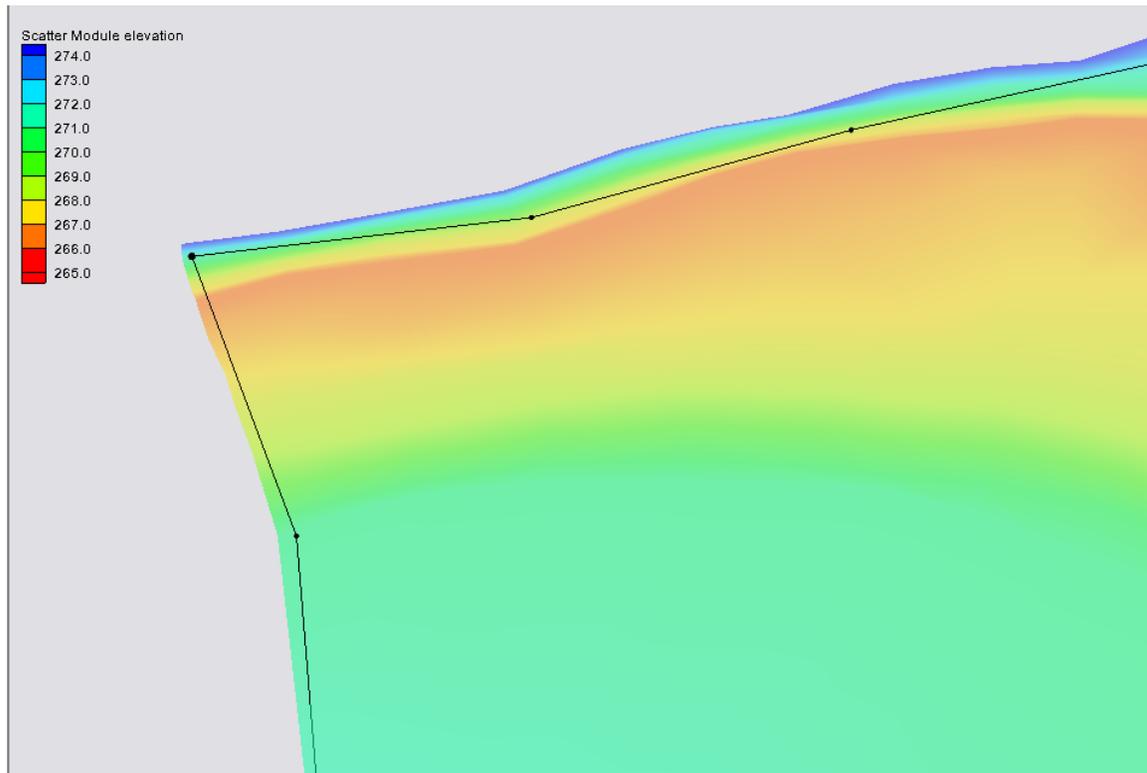


Figure 7

3.2.2 Creating a Fixed Gradient Data Set

1. Click on the scatter item in the project explorer to make sure it is activated. Select *Data / Dataset Toolbox*.
2. Select *Geometry* in the tools section. Choose *Elevation* as the data set and unselect *Gradient angle* and *Directional derivative*. Click *Compute* then *Done*. You now have a gradient data set.
3. Right click on the newly created data set and select *Data Set Contour Options*. Set the contour method to *Color Fill*. Toggle on *Specify a range* in the data range section and specify the *Max* as .33 and min as 0. Specifying this range for the contours helps us see the data we are interested in.
4. Make sure the Scatter data is active in the project explorer and go to *Data / Data Calculator*. In the calculator edit field, click on *min* then double click on the

Geom Gradient data set adding it to the expression, and then replace the remaining ?? with .33. This creates a data set where .33 is the fixed maximum gradient. Name this data set *Geom Gradient Fixed*. Click *Compute* then *Done*.

3.2.3 Creating the Size Function

1. Go to the Data Calculator again. We will now create our size function based on slope using this equation:

$$\text{max size} - ((\text{slope} - \text{min slope}) / (\text{max slope} - \text{min slope})) * (\text{max size} - \text{min size})$$

2. In the calculator edit field, put in this equation:

$$50 - ((d3-0) / (.33 - 0)) * (50 - 5)$$

3. Name the new data set *Gradient Size 5to50* then click *Compute* and *Done*. You now have a size function based on slope. However, there is still one more data set we need to create before we create our mesh.

3.2.4 Smoothing the Size Function

1. Go back to the Data Calculator and choose *Smooth Datasets* in the tools section. In the Data Sets section, make sure that *Gradient Size 5to50* is selected. Set the Output Data set name to be *Gradient Size 5to50 Smooth 0.5*. Then select *Compute* then *Done*.

3.2.5 Creating the Mesh

1. Make sure the Map module is active and select *Feature Objects / Build Polygons*. Then double click with the *Select Feature Polygon* tool.
2. Make sure that the Mesh type is set to *Scalar Paving Density*, and click on the *Scatter Options* button underneath. Choose *Gradient Size 5to50 smooth 0.5* for the scatter set to interpolate from, then click OK.

3. Make sure that Bathymetry type is set to Scatter Set then click Scatter Options and select Elevation.
4. Now, right click on the Cimmaron River coverage and select Convert | Map ->2D Mesh, then click OK. Now click OK again on the next two windows.

You now have a mesh with finer elements to represent higher gradients.

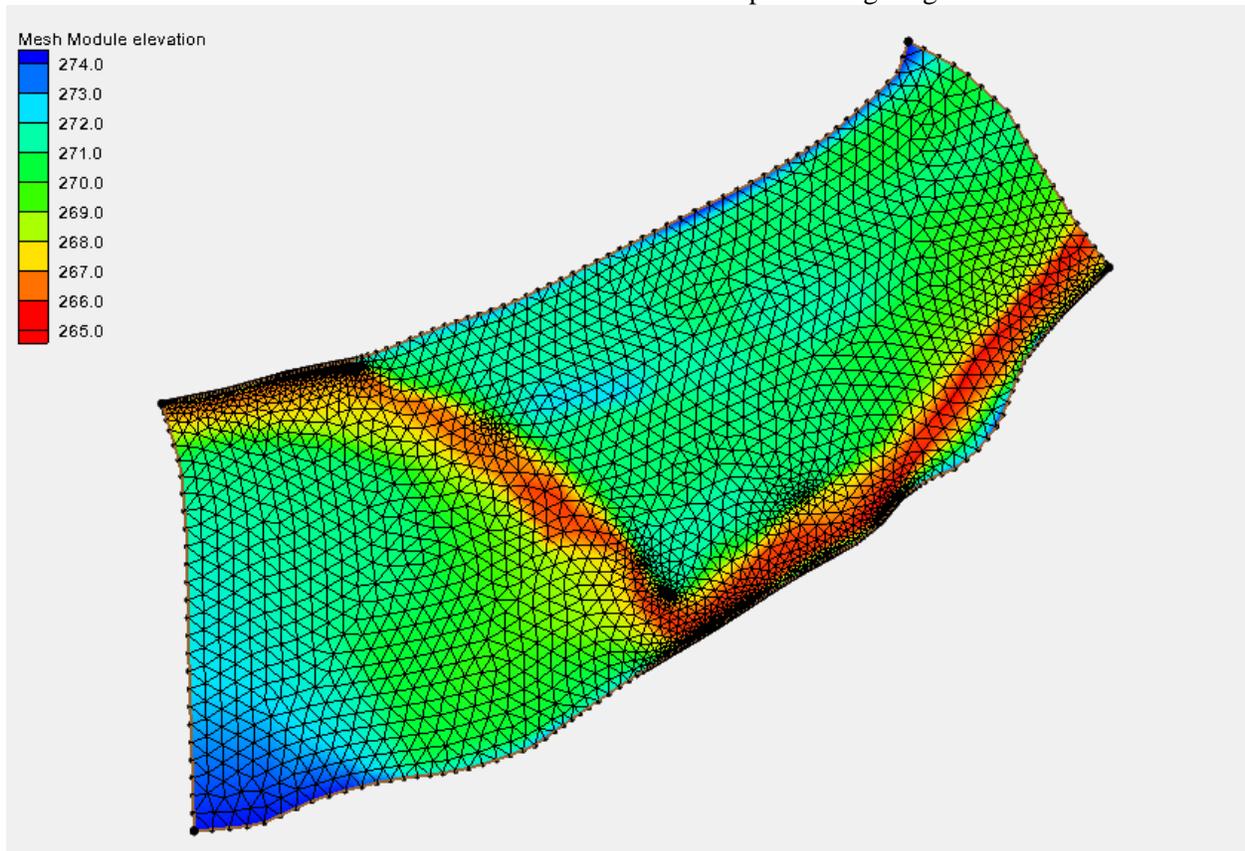


Figure 8

3.3 Size Function based on Curvature

A curvature data set is made by taking the slope of the slope (gradient) data. To create a size function based on the curvature we will build upon the data that we already have.

3.3.1 Creating a Curvature Data Set

1. With the scatter module active, select Data | Data Calculator
2. Select *Geometry* in the tools section. Select *Geom Gradient Fixed* as the data set to interpolate from. Uncheck *Gradient Angle* and *Directional derivative*, leaving only *Gradient* checked. Set the Output Dataset Name to be *Curvature*. Click *Compute* and *Done*.
3. Right click on the newly created dataset. Select *Info*. Copy the maximum, as we will use this for our equation later. We will use the same equation as previously used, found in step 1 of 5.2.3.

3.3.2 Creating the Size Function

1. Open the Data Calculator again, and in the calculator edit field, put in the following equation:

$$50 - ((d6-0) / (0.0488655 - 0)) * (50-5)$$

2. Set the name to *Curvature size 5to50* and click *Compute* then *Done*.

3.3.3 Smoothing the Size Function

1. Go back to the Data calculator. Select *Smooth Datasets* from the tools section and select *Curvature size 5to50*, then make sure the area change limit is set to 0.5 and the anchor type is set to Minimum Value. Set the data set name to *Curvature size 5to50 Smooth 0.5*. Click *Compute*, then *Done*.

3.3.4 Creating the Mesh

1. With the Cimmaron River coverage active, choose the *Select Feature Polygon* tool and double click the boundary polygon.
2. Make sure that the Mesh type is set to *Scalar Paving Density*, and click on the *Scatter Options* button underneath. Choose *Curvature Size 5to50 smooth 0.5* for the scatter set to interpolate from, then click *OK*.
3. Make sure that *Bathymetry* type is set to *Scatter Set* then click *Scatter Options* and select *Elevation*.

4. Now, right click on the Cimmaron River coverage and select Convert | Map ->2D Mesh, then Click OK. Now click OK for the remaining two windows.

You now have a mesh with finer elements to represent greater curvature.

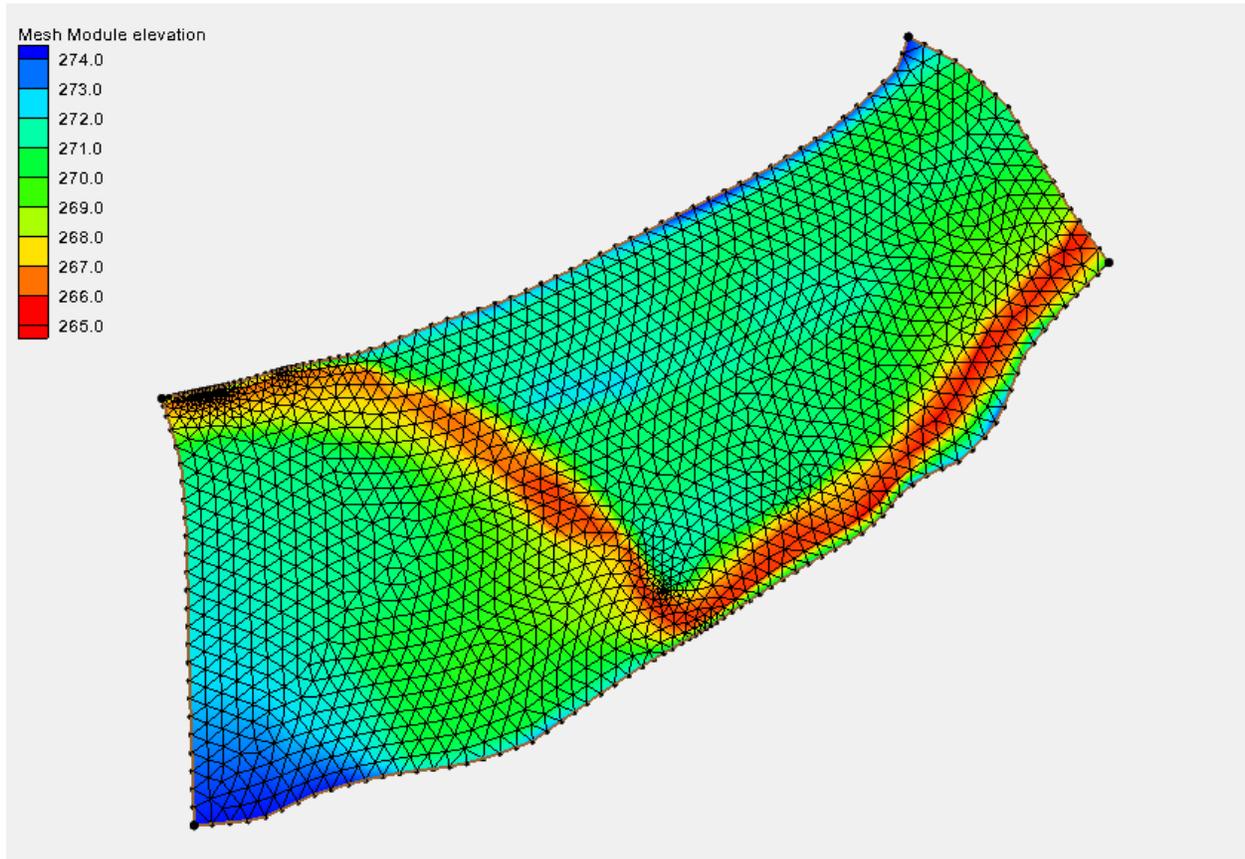


Figure 9

Conclusion

Size functions can be created using many different types of data sets. Some data sets work better for different models. A size function in a coastal model would most likely be based on depth, a size function in a riverine model might be based on slope, etc.