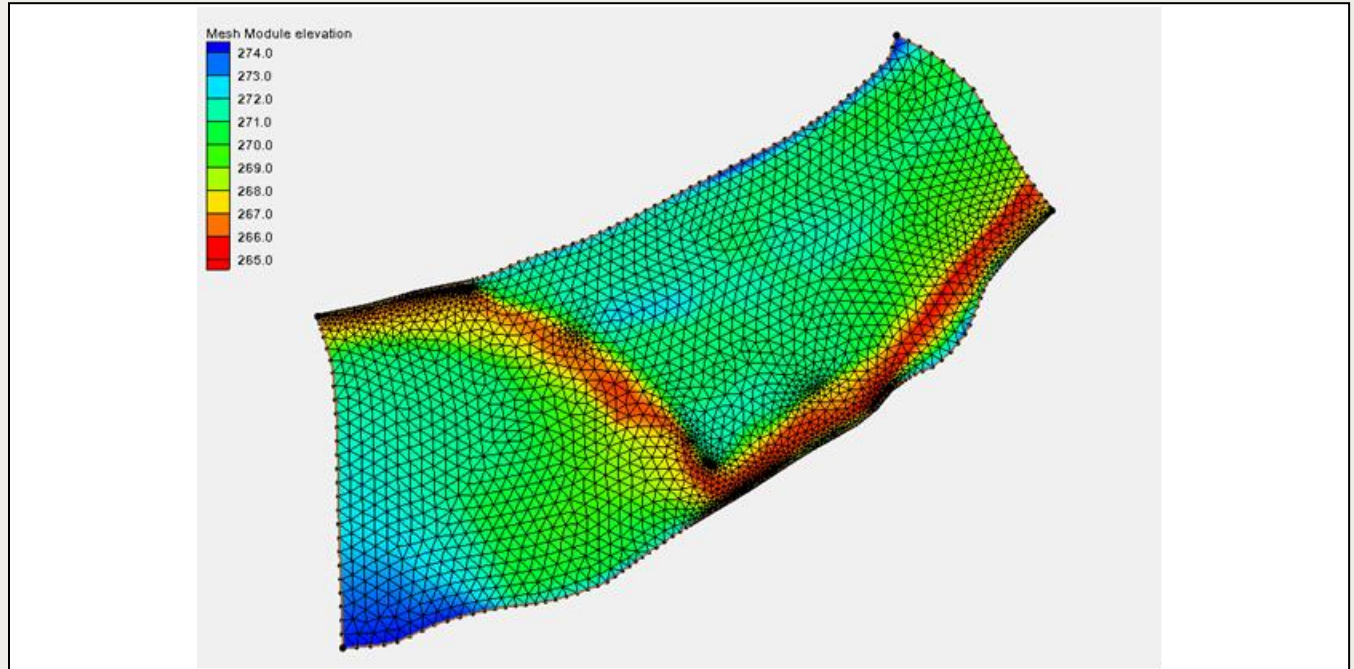




SMS 14.0 Tutorial

Creating a Size Function

Size functions in SMS



Objectives

This tutorial instructs 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 depth, slope, or curvature.

Prerequisite Tutorials

- Overview

Required Components

- SMS Core

Time

- 30–45 minutes

1	Introduction	2
1	Preprocessing	2
2	Creating the Mesh	3
3	Size Function Based on Depth	5
3.1	Reading in the Project	5
3.2	Setting Up the Mesh	5
3.3	Smoothing Data	6
4	Size Function Based on Slope	8
4.1	Preprocessing	8
4.2	Creating a Fixed Gradient Dataset	10
4.3	Creating the Size Function	12
4.4	Smoothing the Size Function	13
4.5	Creating the Mesh	14
5	Size Function Based on Curvature	15
5.1	Creating a Curvature Dataset	15
5.2	Creating the Size Function	16
5.3	Smoothing the Size Function	16
5.4	Creating the Mesh	16
6	Conclusion	17

1 Introduction

A size function determines the element size based on a dataset 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 on different criteria.

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

1 Preprocessing

First create the elements from a coverage and change the element size by doing the following:

1. Right-click on  "Area Property" in the Project Explorer and select *Type | Generic | Mesh Generator*.
2. Select  "Area Property" to make it active.
3. Using the **Create Feature Arc**  tool, click out four arcs forming a square.

The exact placement of the square doesn't matter as the coordinates for each corner will be adjusted later.

4. Using the **Select Feature Vertex**  tool, hold down the *Shift* key and select the three vertices.
5. Right-click and select **Nodes** ↔ **Vertices**.
6. Using the **Select Feature Point**  tool, select the lower left node and enter "0.0" for both X and Y coordinates in the Edit Window.
7. Repeat step 6 for the upper left node, entering "0.0" for X and "1000.0" for Y.
8. Repeat step 6 for the upper right node, entering "1000.0" for both X and Y.
9. Repeat step 6 for the lower right node, entering "1000.0" for X and "0.0" for Y.
10. **Frame**  the project.

This is now a square map layer of 1000 ft². Be sure not to have anything selected in the Graphics Window before moving on.

11. Right-click on “ Area Property” and select *Convert* | **Map** → **2D Scatter** to bring up the *Map* → *Scatter* dialog.
12. Click **OK** to accept the defaults and close the *Map* → *Scatter* dialog.
13. If advised there are no triangles to check, click **OK** to create the scatter set.
14. Right-click on “ elevation” and select **Rename**.
15. Enter “size” and press *Enter* to set the new name.
16. Select “ size” to make it active.
17. Using the **Select Scatter Point**  tool, right-click in the Graphics Window and click **Select All**.
18. Enter “50.0” in the Z edit field.

Keep in mind that this is an element size, not an elevation.

19. Click  **Display Options** to bring up the *Display Options* dialog.
20. Select “Scatter” from the list on the left.
21. On the *Scatter* tab, turn on *Points* and *Contours*.
22. On the *Contours* tab, in the *Contour method* section, select “Color Fill” from the first drop-down.
23. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 1.

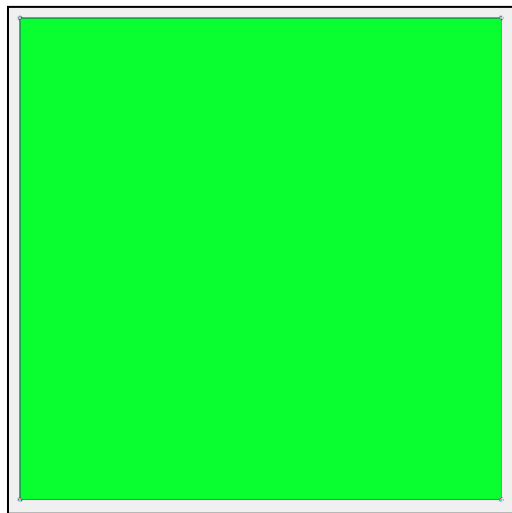


Figure 1 The initial project after adjusting element size and turning on contours

2 Creating the Mesh

Now create a mesh that illustrates the size of the elements by doing the following:

1. Select “ Area Property” to make it active.

2. Select *Feature Objects* | **Build Polygons**.
3. Using the **Select Feature Arc**  tool, select one of the arcs of the square.
4. Right-click in the Graphics Window and select **Redistribute Vertices...** to open the *Redistribute Vertices* dialog.
5. In the *Arc Redistribution* group, set the *Specify* combo box to “Number of segments”.
6. Set the *Number of segments* to “20” and select **OK** to exit the *Redistribute Vertices* dialog.

We need to redistribute the vertices for the other arcs. They can be done together.

7. Multi-select the remaining arcs by holding down the *Shift* key while clicking on the arcs.
8. Right-click and select **Redistribute Vertices...** to open the *Redistribute Vertices* dialog.
9. Follow steps 5 and 6 again to redistribute the vertices for the remaining arcs.
10. Using the **Select Feature Polygon**  tool, double-click in the square to bring up the *2D Mesh Polygon Properties* dialog.
11. In the *Mesh Type* section, select “Scalar Paving (triangles)” from the drop-down.
12. Click **Scatter Options...** to bring up the *Interpolation* dialog.
13. In the *Interpolation Options* section, enter “50.0” as the *Single Value*.
14. In the *Scatter Set to Interpolate From* section, select “size” from the tree list.
15. Click **OK** to close the *Interpolation* dialog.
16. In the *Elevation (bathy/topo) type* section, select “Scatter set” from the drop-down.
17. Click **Scatter Options...** to bring up the *Interpolation* dialog.
18. Repeat steps 13-15 in the *Elevation (bathy/topo) type* section.
19. Close the *2D Mesh Polygon Properties* dialog by clicking **OK**.
20. Right-click on “ Area Property” and select **Convert | Map→2D Mesh** to bring up the *Mesh Name* dialog.
21. Enter a name for the new mesh and select **OK** to exit the *Mesh Name* dialog.

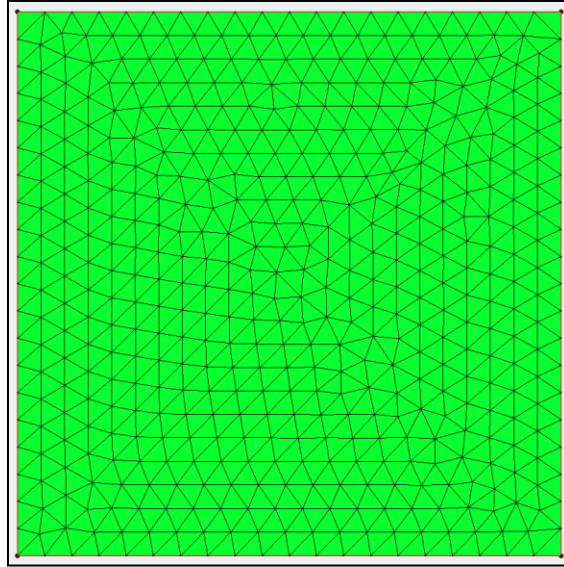


Figure 2 The new 2D mesh

3 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.

3.1 Reading in the Project

To import the scatter set, do the following:

1. Select *File* | **New**.
2. If asked to save the changes, select **Don't Save**.
3. Select *File* | **Open...** to bring up the *Open* dialog.
4. Browse to the *Data Files*\ folder for this tutorial and select "Shinnecock.sms".
5. Click **Open** to import the project and to exit the *Open* dialog.

3.2 Setting Up the Mesh

Do the following to import and set up the mesh:

1. Select "Domain" to make it active.
2. Using the **Select Feature Polygon** tool, double-click in the middle of the mesh polygon to bring up the *2D Mesh Polygon Properties* dialog.
3. In the *Mesh Type* section, select "Scalar Paving (triangles)" from the drop-down.
4. Click **Scatter Options...** to bring up the *Interpolation* dialog.
5. In the *Scatter Set To Interpolate From* section, select "size_3000_to_500" from the tree list.
6. Click **OK** to close the *Interpolation* dialog.

7. In the *Elevation (bathy/topo) type* section, select “Scatter set” from the drop-down.
8. Click **Scatter Options...** to bring up the *Interpolation* dialog.
9. In the *Scatter Set To Interpolate From* section, select “Positive Depth” from the tree list.
10. Click **OK** to close the *Interpolation* dialog.
11. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
12. Right-click on “ Domain” and select *Convert | Map → 2D Mesh* to bring up the *Mesh Name* dialog.
13. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.
14. Turn off “ Scatter Data” in the Project Explorer.
15. Click **Display Options**  to bring up the *Display Options* dialog.
16. Select “2D Mesh” from the list on the left.
17. On the *2D Mesh* tab, turn on *Contours*.
18. On the *Contours* tab, in the *Contour method* section, select “Color Fill” from the first drop-down.
19. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 3. Notice how element size decreases as depth decreases.

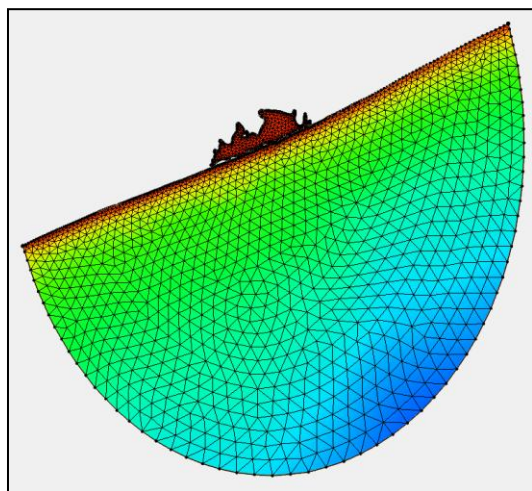


Figure 3 Mesh showing size function based on depth

3.3 Smoothing Data

Now that the project has a mesh, notice that the elements change size rather abruptly. To have the element size change more gradually, create a smoothing dataset.

1. Turn on “ Scatter Data” and select “ shin” to make it active.
2. Click the **Toolbox**  macro to open the *Toolbox* dialog.
3. In the *Tools* tab, expand the “ Datasets” folder.

4. Double-click on the **Smooth Datasets** tool to open the *Smooth Datasets* dialog
5. In the *Input elevation dataset* section, select “Scatter Data/shin/size_3000_to_500”.
6. For the *Anchor* option, select “Minimum value”.

A minimum value anchor will ensure that the smallest element will stay the same size, and the bigger elements will change.

7. In the *Smoothing Options* section, select “Element area change”.
8. Enter “0.5” as the *Smoothing area change limit*.
9. Enter “Smooth_0.5” as the *Output dataset*.
10. Click **OK** to close the *Smooth Dataset* dialog and run the tool.
11. When the tool finishes, click **OK** to close the *Smooth Dataset* tool.
12. Select “ Domain” to make it active.
13. Using the **Select Feature Polygon**  tool, double-click on the mesh polygon to bring up the *2D Mesh Polygon Properties* dialog.
14. Make sure that “Scalar Paving (triangles)” is selected from the drop-down in the *Mesh Type* section..
15. Click **Scatter Options...** to bring up the *Interpolation* dialog.
16. In the *Scatter Set To Interpolate From* section, select “Smooth_0.5” from the tree list.
17. Click **OK** to close the *Interpolation* dialog.
18. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
19. Right-click on “ Domain” and select *Convert | Map → 2D Mesh* to open the *Mesh Name* dialog.
20. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.
21. Turn off “ Scatter Data” in the Project Explorer.

Notice that the element size changes more gradually now (Figure 4).

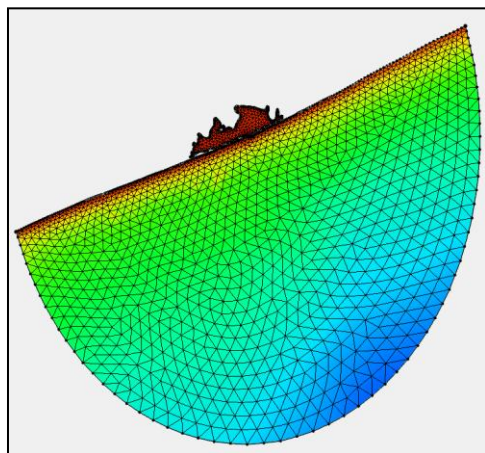


Figure 4 Mesh showing size function based on depth after smoothing

4 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. Survey data from the Cimarron River will be used here to create the size function.

4.1 Preprocessing

1. Select *File* | **New** and click **Don't Save** when asked if you want to save the project.
2. Click **Open**  to bring up the *Open* dialog.
3. Select "Cimarron_Survey 2005.h5" and click **Open** to import the file and exit the *Open* dialog.

The project should appear similar to Figure 5.

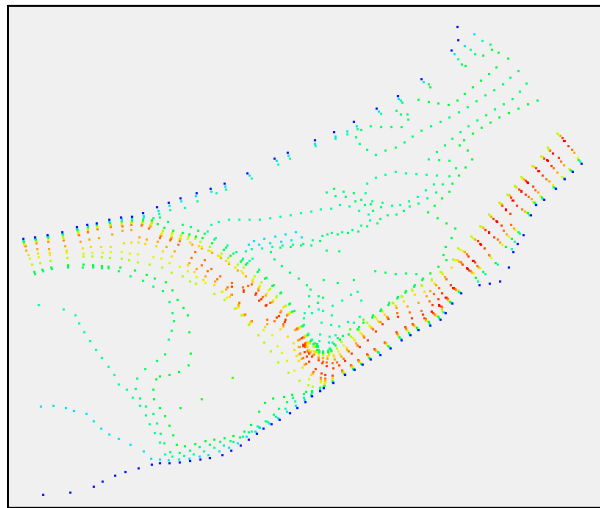


Figure 5 Imported "Cimarron Survey 2005.h5"

4. Click **Display Options**  to bring up the *Display Options* dialog.
5. Select "Scatter" from the list on the left.
6. On the *Scatter* tab, turn off *Points* and turn on *Contours*.
7. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
8. Click **OK** to close the *Display Options* dialog.

The project should appear similar to Figure 6.

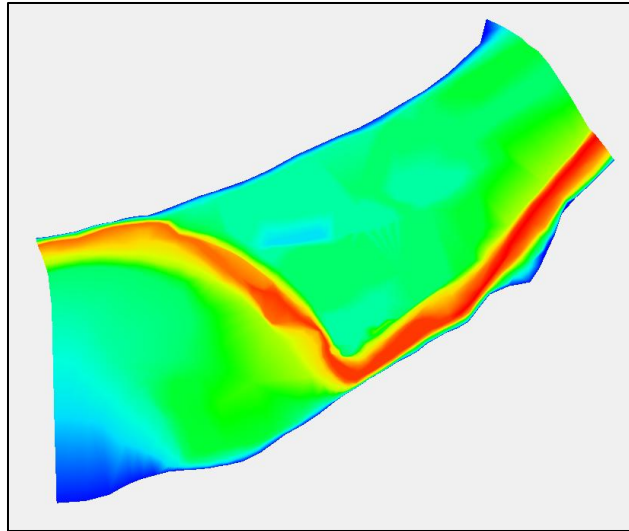


Figure 6 Scatter set using the contour color fill option

9. Right-click on  "Survey 2005" and select **Convert | Scatter Boundary → Map** to bring up the *Select Coverage* dialog.
10. Select *Use existing coverage* and click **Select...** to bring up the *Select Tree Item* dialog.
11. Select  "Area Property" from the tree list and click **OK** to close the *Select Tree Item* dialog.
12. Click **OK** to close the *Select Coverage* dialog.
13. Right-click on  "Area Property" and select **Rename**.
14. Enter "Cimarron River" and press *Enter* to set the new name.
15. Right-click on  "Cimarron River" and select **Type | Generic | Mesh Generator**.
16. Using the **Select Feature Vertex**  tool while holding down the *Shift* key, select the four corner vertices. **Zoom**  in if necessary.
17. Right-click and select **Nodes ↔ Vertices**.
18. Using the **Select Feature Point**  tool, select the node on the right side of the border (Figure 7) and right-click and select **Node ↔ Vertices**.
19. Using the **Select Feature Arcs**  tool with the *Shift* key held down, select each of the four arcs.
20. Right-click and select **Redistribute Vertices...** to bring up the *Redistribute Vertices* dialog.
21. In the *Arc Redistribution* section, select "Specified spacing" from the *Specify* drop-down.
22. Enter "200.0" as the *Average spacing*.
23. Click **OK** to close the *Redistribute Vertices* dialog.

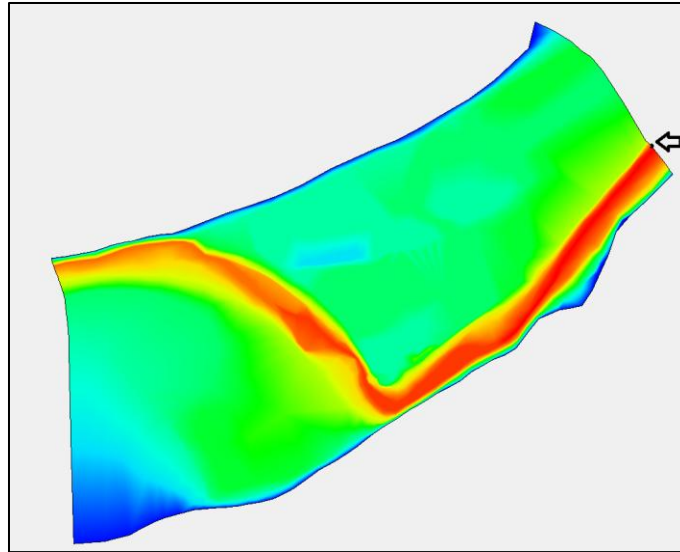


Figure 7 Node to convert to a vertex

Now to eliminate extrapolation values by making sure that all the vertices and nodes lie within the scatter data.

24. Using the **Select Feature Vertex**  tool, move each vertex along the edge of the scatter set to the inside of the scatter set so that SMS does not extrapolate any values outside of the scatter data.
25. Repeat step 24 using the **Select Feature Point**  tool, moving all four nodes within the scatter set.
26. Repeat steps 19–23, above, entering “90.0” as the *Average spacing*.
27. **Zoom**  in and verify that all arcs are within the scatter set. If not, repeat steps 24 and 19–23 until they are.

All of the vertices and nodes should be inside the scatter data. A close-up of the top left corner of the scatter set is shown in Figure 8.

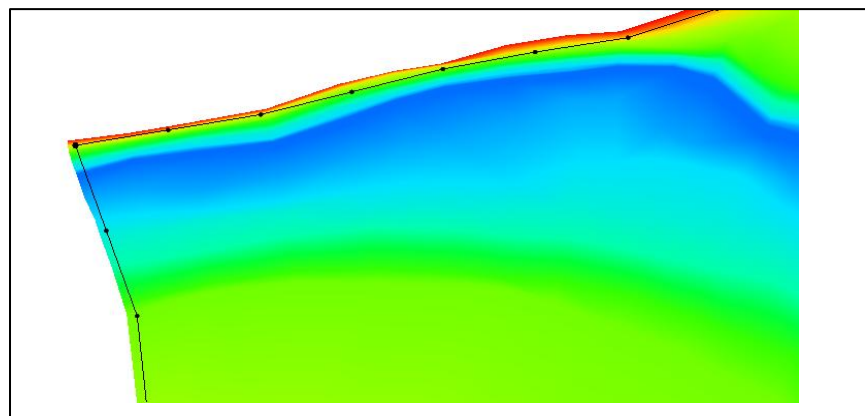


Figure 8 Vertices and nodes inside of the scatter data

4.2 Creating a Fixed Gradient Dataset

1. Select  “Survey 2005” to make it active.

2. Click the **Toolbox**  macro to open the *Toolbox* dialog.
3. In the *Tools* tab, expand the “ Datasets” folder.
4. Double-click on the **Geometry Gradient** tool to open the *Geometry Gradient* dialog
5. In the *Input dataset* section, select “Scatter Data/survey/elevation”.
6. Turn off the *Gradient vector* and *Gradient direction*.
7. Enter “Geom Gradient” as the *Output dataset*.
8. Click **OK** to close the *Geometry Gradient* and run the tool.
9. When the tool finishes, click **OK** to close the *Geometry Gradient* tool.

There is now a new “ Geom Gradient” dataset.

10. Right-click on “ Geom Gradient” and select **Dataset Contour Options...** to bring up the *Dataset Contour Options – Geom Gradient* dialog.
11. In the *Contour method* section, select “Color Fill” from the first drop-down.
12. In the *Data range* section, turn on *Specify a range* and enter “0.0” for the *Min* and “0.33” as the *Max*.
13. Click **OK** to close the *Dataset Contour Options – Geom Gradient* dialog.

Specifying this range for the contours helps better display the data.

14. Select “ Survey 2005” to make it active.
15. Click the **Toolbox**  macro to open the *Toolbox* dialog.
16. In the *Tools* tab, expand the “ Datasets” folder.
17. Double-click on the **Dataset Calculator** tool to open the *Dataset Calculator* dialog.
18. For *Grid source selection*, set to “Scatter Data/Survey 2005”.
19. For *Data location selection*, set to “Points”.
20. Under the *Dataset table*, click the **Add Row**  button.
21. In row 1, set the *Dataset* to “Geom Gradient”.
22. For the *Mathematical expression*, enter “where (d1 > 0.33, 0.33, d1)”.

The equation is a conditional statement where if the expression “d1 > 0.33” is true, the first value (0.33) is the result. If it is false, the second value (d1) is the result. This creates a dataset where “0.33” is the fixed maximum gradient.

23. For the *Output dataset name* enter “Geom Gradient Fixed”.
24. Click **OK** to run the tool.
25. When the tool finishes, click **OK** to close the *Dataset Calculator* window.

There should be a new “ Geom Gradient Fixed” dataset in the Project Explorer. The project should appear similar to Figure 9.

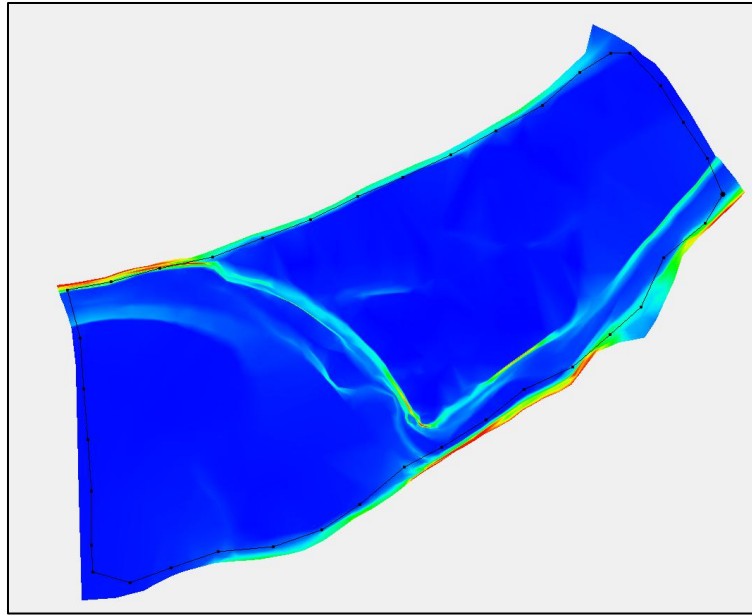


Figure 9 Fixed gradient

4.3 Creating the Size Function

Next, create a size function based on slope using this equation:

$$\text{max size} - \left(\frac{(\text{slope} - \text{min slope})}{(\text{max slope} - \text{min slope})} \right) * (\text{max size} - \text{min size})$$

1. Click the **Toolbox**  macro to open the *Toolbox* dialog.
2. In the *Tools* tab, expand the “ Datasets” folder.
3. Double-click on the **Dataset Calculator** tool to open the *Dataset Calculator* dialog.
4. For *Grid source selection*, set to “Scatter Data/Survey 2005”.
5. For *Data location selection*, set to “Points”.
6. Under the *Dataset table*, click the **Add Row**  button.
7. In row 1, set the *Dataset* to “Geom Gradient Fixed”.
8. For the *Mathematical expression*, enter “50-((d1-0)/(0.33-0))*(50-5)”.
9. For the *Output dataset name* enter “Gradient Size 5to50”.
10. Click **OK** to run the tool.
11. When the tool finishes, click **OK** to close the *Dataset Calculator* window.

There should be a new “ Gradient Size 5to50” dataset in the Project Explorer. The project should appear similar to Figure 10.

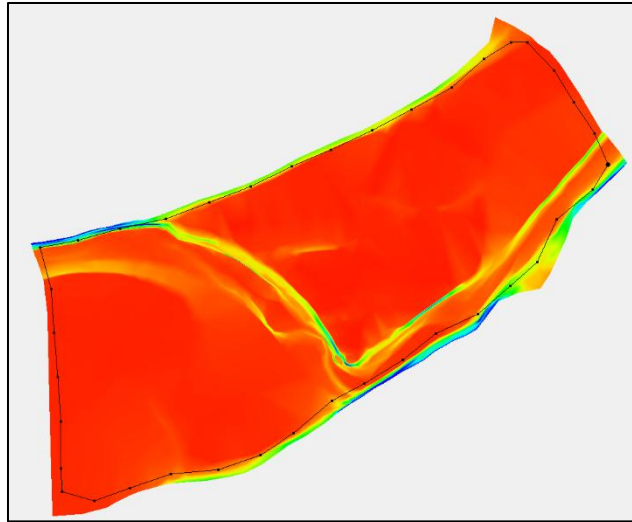


Figure 10 Gradient size 5 to 50

4.4 Smoothing the Size Function

One more dataset needs to be created before creating the mesh.

1. Click the **Toolbox**  macro to open the *Toolbox* dialog.
2. In the *Tools* tab, expand the “ Datasets” folder.
3. Double-click on the **Smooth Datasets** tool to open the *Smooth Datasets* dialog.
4. For *Input elevation dataset*, set to “Scatter Data/Survey 2005/Gradient Size 5to50”.
5. For the *Output dataset name* enter “Gradient Size 5to50 Smooth 0.5”.
6. Click **OK** to run the tool.
7. When the tool finishes, click **OK** to close the *Smooth Datasets* window.

There should be a new “ Gradient Size 5to50 Smooth 0.5” dataset in the Project Explorer. The project should appear similar to Figure 11.

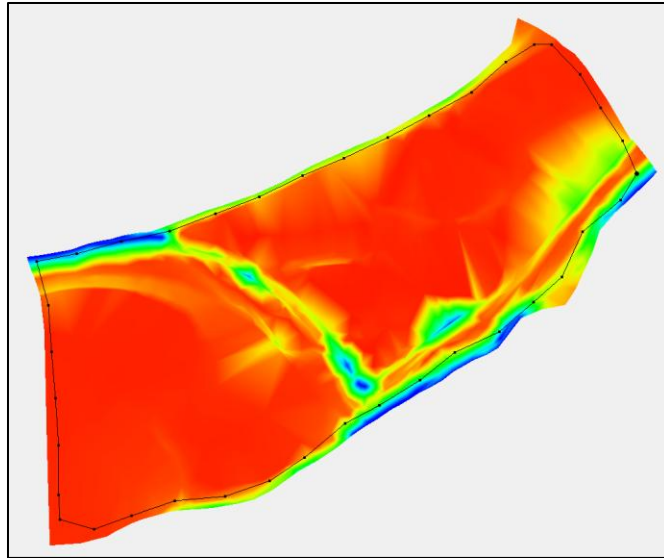


Figure 11 Smoothed size function based on slope

4.5 Creating the Mesh

1. Switch to the **Map**  module.
2. Select *Feature Objects* | **Build Polygons**.
3. Using the **Select Feature Polygon**  tool, double-click the map polygon to bring up the *2D Mesh Polygon Properties* dialog.
4. In the *Mesh Type* section, select “Scalar Paving (triangles)” from the drop-down.
5. Click **Scatter Options...** to bring up the *Interpolation* dialog.
6. In the *Scatter Set To Interpolate From* section, select “Gradient Size 5to50 Smooth 0.5” from the tree list and click **OK** to close the *Interpolation* dialog.
7. In the *Elevation (bathy/topo) type* section, select “Scatter set” from the drop-down.
8. Click **Scatter Options...** to bring up the *Interpolation* dialog.
9. In the *Scatter Set To Interpolate From* section, select “elevation” from the tree list and click **OK** to close the *Interpolation* dialog.
10. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
11. Right-click on “ Cimmaron River” and select *Convert* | **Map** → **2D Mesh** to bring up the *Mesh Name* dialog.
12. Click **OK** to accept the default *Mesh name* and close the *Mesh Name* dialog.

The project now has a mesh with finer elements to represent higher gradients (Figure 12).

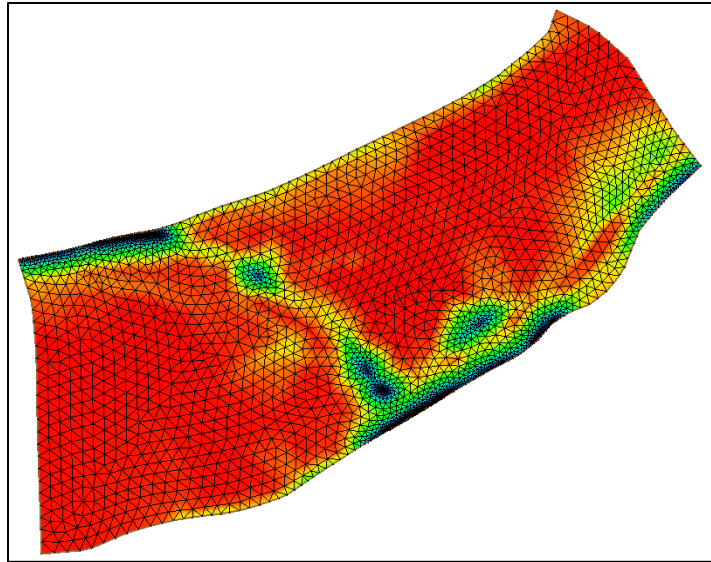


Figure 12 Mesh with finer elements to represent higher gradients

5 Size Function Based on Curvature

A curvature dataset is made by taking the slope of the slope (gradient) data. To create a size function based on the curvature build upon the data already entered.

5.1 Creating a Curvature Dataset

1. Select “ Survey 2005” to make it active.
2. Click the **Toolbox**  macro to open the *Toolbox* dialog.
3. In the *Tools* tab, expand the “ Datasets” folder.
4. Double-click on the **Geometry Gradient** tool to open the *Geometry Gradient* dialog
5. In the *Input dataset* section, select “Scatter Data/survey 2005/elevation”.
6. Turn off the *Gradient vector* and *Gradient direction*.
7. Enter “Curvature Gradient” as the *Output dataset*.
8. Click **OK** to close the *Geometry Gradient* and run the tool.
9. When the tool finishes, click **OK** to close the *Geometry Gradient* tool.
10. Right-click on “ Curvature Gradient” and select **Properties...** to bring up the *Properties* dialog.
11. Select value for *Maximum* in the *All time steps* section and press *Ctrl-C* to copy the value.

This value will be used for an equation in the next section.

12. Click **OK** to close the *Properties* dialog.

5.2 Creating the Size Function

1. Click the **Toolbox**  macro to open the *Toolbox* dialog.
2. In the *Tools* tab, expand the “ Datasets” folder.
3. Double-click on the **Dataset Calculator** tool to open the *Dataset Calculator* dialog.
4. For *Grid source selection*, set to “Scatter Data/Survey 2005”.
5. For *Data location selection*, set to “Points”.
6. Under the *Dataset table*, click the **Add Row**  button.
7. In row 1, set the *Dataset* to “Curvature Gradient”.
8. For the *Mathematical expression*, enter “50-((d1-0)/(copied value-0))*(50-5)” in the field, and enter the copied value by pressing Ctrl-V.
9. For the *Output dataset name* enter “Curvature size 5to50”.
10. Click **OK** to run the tool.
11. When the tool finishes, click **OK** to close the *Dataset Calculator* window.

5.3 Smoothing the Size Function

1. Click the **Toolbox**  macro to open the *Toolbox* dialog.
2. In the *Tools* tab, expand the “ Datasets” folder.
3. Double-click on the **Smooth Datasets** tool to open the *Smooth Datasets* dialog.
4. For *Input elevation dataset*, set to “Scatter Data/Survey 2005/ Curvature size 5to50”.
5. For the *Smoothing option*, set to “Elemental area change”.
6. For the *Output dataset name* enter “Curvature size 5to50 Smooth 0.5”.
7. Click **OK** to run the tool.
8. When the tool finishes, click **OK** to close the *Smooth Datasets* window.

5.4 Creating the Mesh

1. Select “ Cimmaron River” to make it active.
2. Using the **Select Feature Polygon**  tool, double-click the boundary polygon to bring up the *2D Mesh Polygon Properties* dialog.
3. In the *Mesh Type* section, select “Scalar Paving (triangles)” from the drop-down.
4. Click **Scatter Options...** to bring up the *Interpolation* dialog.
5. In the *Scatter Set To Interpolate From* section, select “Curvature Size 5to50 Smooth 0.5” from the tree list.
6. Click **OK** to close the *Interpolation* dialog.
7. In the *Elevation (bathy/topo) type* section, select “Scatter set” from the drop-down.

8. Click **Scatter Options...** to bring up the *Interpolation* dialog.
9. In the *Scatter Set To Interpolate From* section, select “elevation” from the tree list.
10. Click **OK** to close the *Interpolation* dialog.
11. Click **OK** to close the *2D Mesh Polygon Properties* dialog.
12. Right-click on “ Cimmaron River” and select *Convert | Map → 2D Mesh* to bring up the *Mesh Name* dialog.
13. Click **OK** to accept the default mesh name and close the *Mesh Name* dialog.

There is now a mesh with finer elements to represent greater curvature (Figure 13).

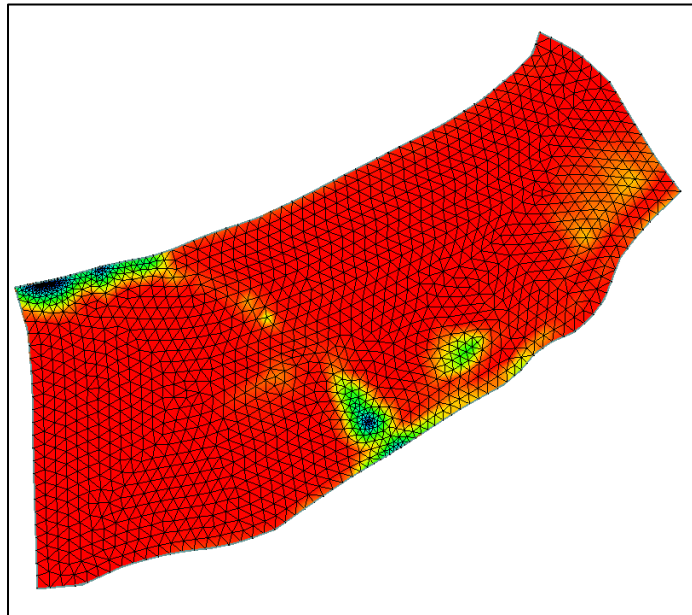


Figure 13 Mesh with finer elements to represent greater curvature

6 Conclusion

This concludes the “Size Functions” tutorial. Size functions can be created using many different types of datasets. Some datasets 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.

Feel free to continue experimenting in SMS or exit the program.