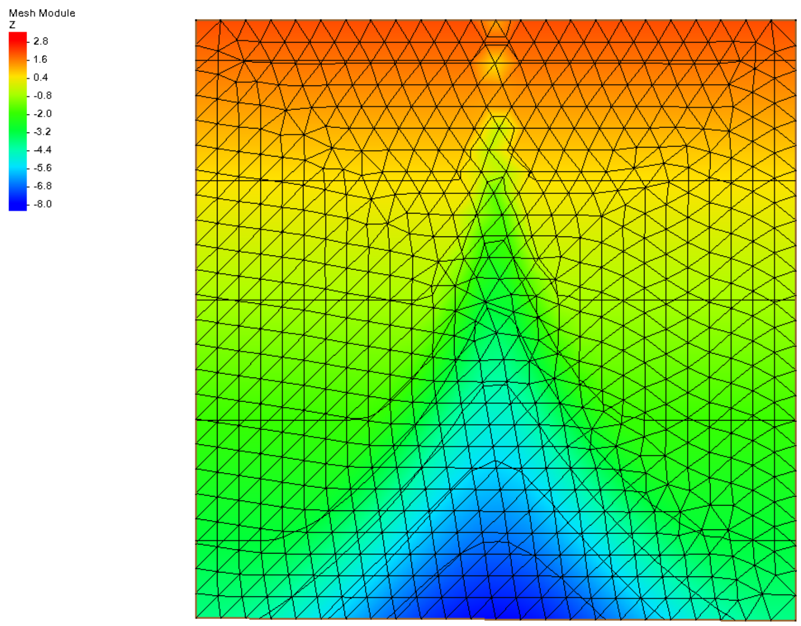
SMS 13.2 Tutorial

ADCIRC – Synthetic Channel Mesh Generation – Part 1

Introduction to creating an ADCIRC mesh



Objectives

This tutorial demonstrates the most basic method of creating a mesh for use in an ADCIRC simulation.

Prerequisite Tutorials

- Overview
- Map Module

Required Components

- SMS Core
- ADCIRC Interface

Time

- 10–20 minutes

1 Introduction

This tutorial demonstrates the process of creating a triangular mesh of a linear floodplain and synthetic channel for use in the ADCIRC (Advanced Circulation) engine. The mesh in this case will be generated with an approximate horizontal resolution of 500 m.

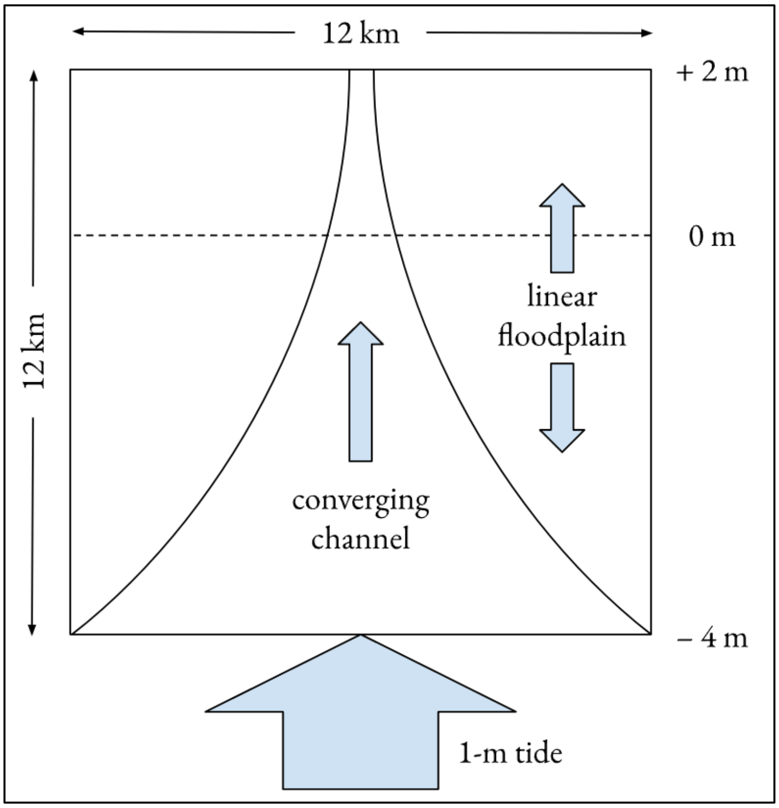


Figure 1 Domain overview

The domain is a 12 km by 12 km square. Most of the domain is a floodplain with a linear slope, with depths ranging from –4 m to +2 m. A converging channel will run from the bottom to the top of the domain, and its width will decrease as it goes inland. At the open ocean (y=0, bottom of the domain), the channel will be very wide (12 km). At the coastline (roughly y=8 km), the channel will be narrow (1 km). At the top of the domain (y=12 km), the channel will be tiny (200 m). The bathymetry is represented with a digital elevation map (provided) with a resolution of 10 m.

ADCIRC (https://adcirc.org/) is a finite element hydrodynamic model for coastal oceans, inlets, rivers, and floodplains.

2 Getting Started

Start with loading the digital elevation map (DEM) into SMS:

1. Launch the **SMS** application.
2. Select *File* **| Open…** to bring up the *Open* dialog.
3. Browse to the *Input* folder for this tutorial and select "SyntheticChannelGrid.tif."
4. Click **Open** to import the raster and exit the *Open* dialog.

The display of SMS will include the elevation raster as shown in Figure 2.

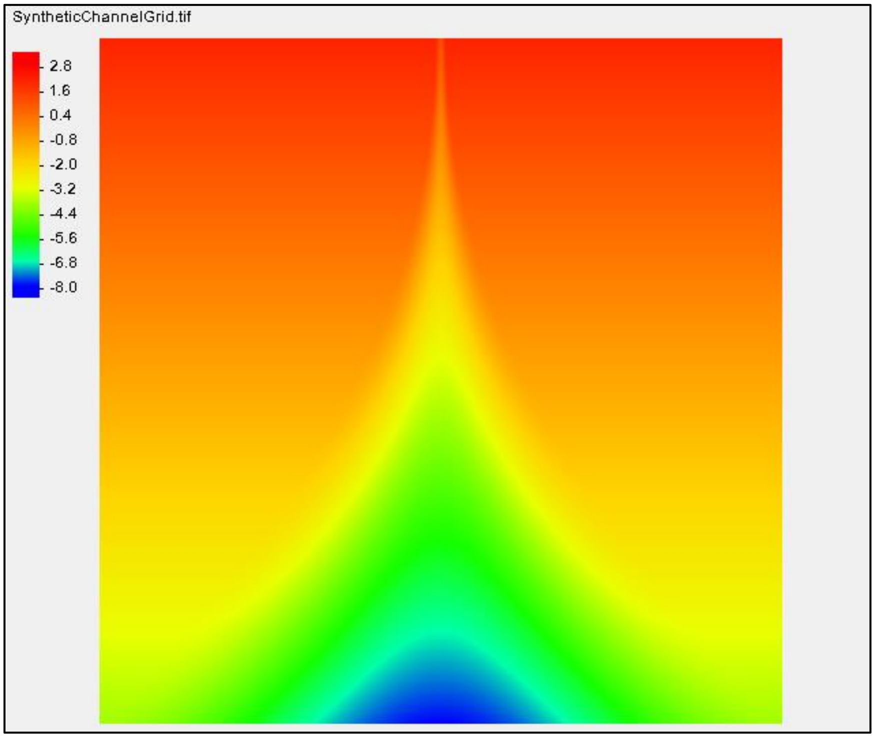


Figure 2 Elevation raster.

Notes:

- This tutorial uses a DEM instead of a scatter set because it is a more efficient method of storing gridded data.
- The DEM includes projection and unit data. In this case it sets the units to meters with a local projection. Scattered survey data does not set the projection. Refer to the Overview tutorial to review how to specify projection if needed.

3 Changing the DEM Display Options

The default display attribute for digital elevation maps is a continuously graded color to represent depths. SMS allows seeing a representation of specific depths. To do this:

1. In the Project Explorer, under " GIS Data", right-click on the " *SyntheticChannelGrid.tif*" DEM and select **Display Options…** to bring up the *Raster Display Options* dialog.

2. Click the **Contour Options** button bring up the *Raster Contour Options* dialog.
3. Uncheck the *Fill continuous color range* option to turn off enable discrete color bands.
4. Click **OK** to exit the *Raster Contour Options* dialog.
5. Click **OK** to exit the *Raster Display Options* dialog.

The display of SMS will now appear similar to Figure 3.

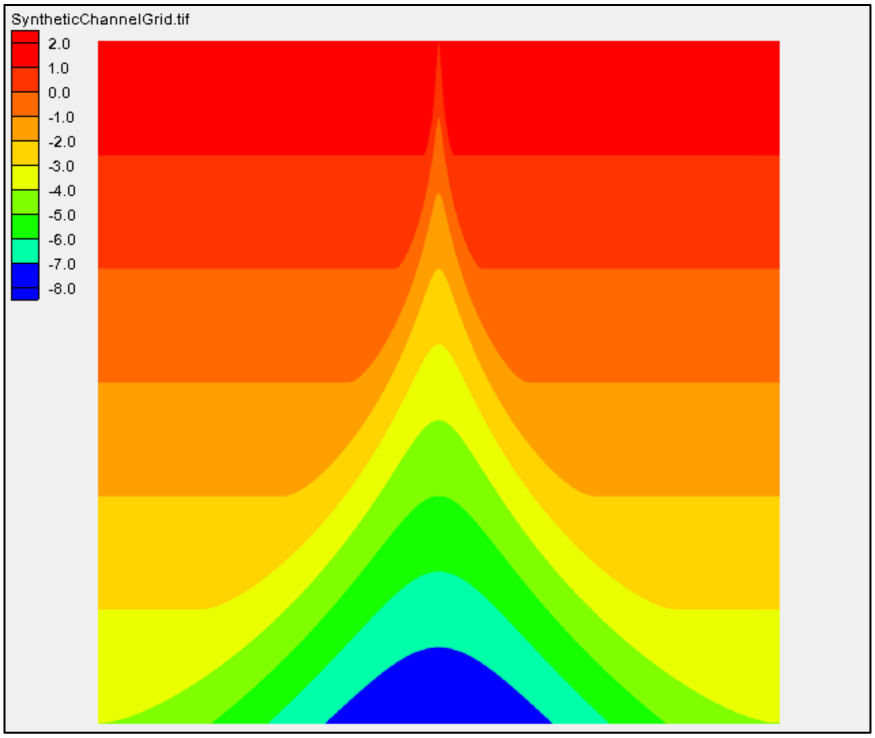


Figure 3 The SMS project

4 Defining the Mesh Extents

The next major step is to define the mesh domain. The *Map* module will be used to specify the domain in general terms. In this case, the domain is represented by the corners. Define the corners of the domain as follows:

1. In the Project Explorer (the left panel), right-click on the " Area Property" coverage and select *Type* | *Generic* | **Mesh Generator**.

This defines the current purpose of the coverage to be for generating a mesh. If desired, the name of the coverage can be changed to represent this purpose.

2. Using the **Create Feature Arc** tool, click in the Graphics Window at the upper left corner of the DEM.
3. Continue defining the arc by clicking the upper right corner, the lower right corner, the lower left corner and then finally on the upper left corner again to close the polygon as shown in Figure 4**Error! Reference source not found.**. Don't worry about exact locations at this point.

4. Using the **Select Objects** tool, click on the node at the upper left corner to select it.
5. Above the Graphics Window, for the *X:* field enter "0" and for the *Y:* field enter "12000" to specify the exact location for the node.
6. Using the **Select Objects** tool, click on the vertex the upper right corner to select it.
7. Right-click and select **Nodes <-> Vertices** to change this vertex to a node. This ensures that this location will be in the generated mesh.
8. For this node, enter (12000, 12000) in the *X:* and *Y:* edit fields.
9. Repeat steps 6–8 for the two vertices at the bottom of the DEM entering points (12000, 0) and (0, 0) for the locations.

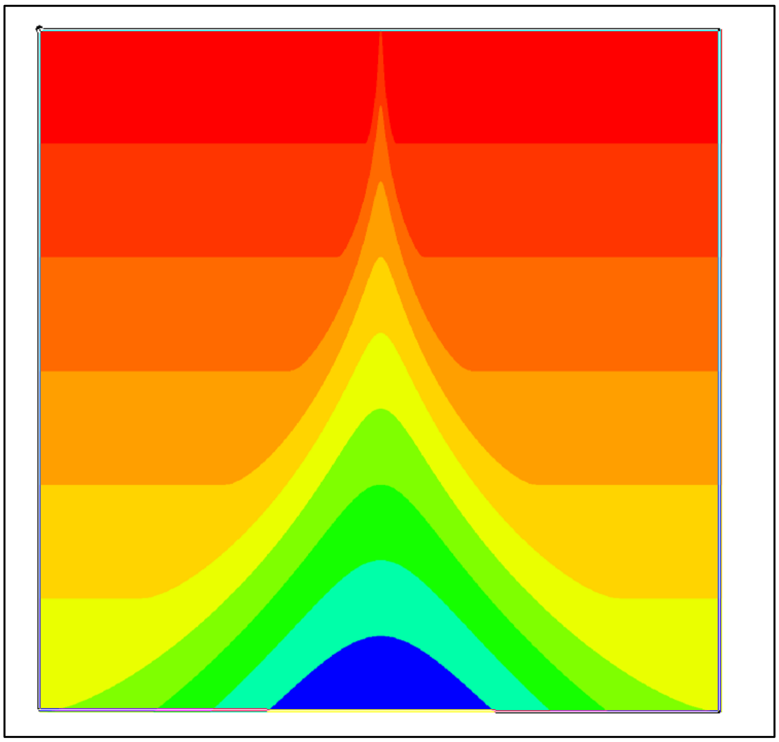


Figure 4 The arc around the domain.

The model domain is now defined as four arcs enclosing a 12 km square.

5 Defining the Mesh Resolution

The *Map* module is used to specify the size of the elements in the mesh. It is important to note that nodes and vertices on arcs in the *Map* module will become mesh nodes. Thus, adjusting the vertices and nodes controls the resolution of the mesh that will be created later. This tutorial specifies the desired resolution as 500 m along the outer boundaries of the domain. To do this:

1. Click the **Display Options** macro to bring up the *Display Options* dialog.
2. Select *Map* in the left pane of the dialog to ensure the Map module display options are displayed.
3. Turn on the *Vertex* option to display vertices (interior points) on arcs.

4. Click **OK** to exit the *Display Options* dialog.

This has no immediate effect because there currently should be no vertices in this layer.

5. Using the **Select Feature Arc** tool, right-click in the Graphics Window and select **Select All**. This selects all four arcs.
6. Right-click again and select **Redistribute Vertices…** to bring up the *Redistribute Vertices* dialog.
7. Make sure the *Specify* option is set to "Specified spacing" and enter "500" in the *Average spacing* field.
8. Click **OK** to close the *Redistribute Vertices* dialog.

This will change the distribution of the vertices on the arcs and close the dialog. The arcs now have vertices every 500 meters as shown in Figure 5.

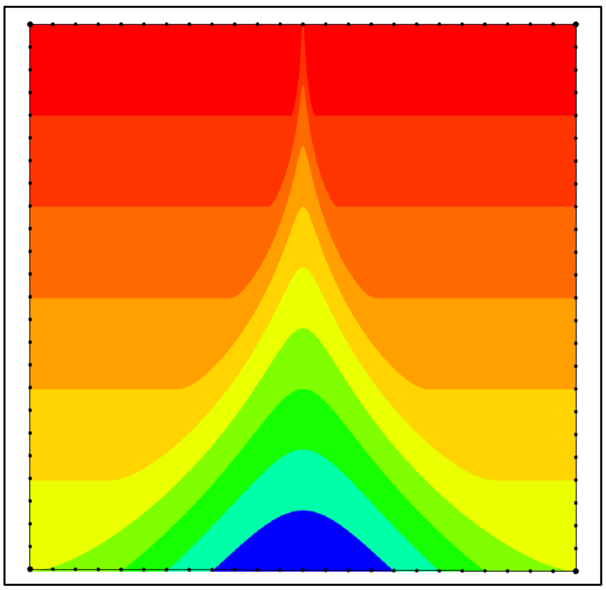


Figure 5 Arcs with vertices every 500 meters.

6 Assigning Polygon Attributes

The next step is to specify the meshing parameters. This tutorial will use a simple paving method (advancing front method). Additional tutorials will illustrate other mesh generation options.

1. Click the **Clean** macro on the horizontal toolbar below the menus to bring up the *Clean Options* dialog.

A clean layer means that there are no overlapping arcs or disconnected nodes. GIS data is notorious for being complicated and inconsistent so reviewing the data is a good idea. In this case, the layer is simple so it is probably not necessary

2. Turn on *Snap nodes and vertices*, *Intersect arcs,* and *Remove dangling arcs*.
3. In both *Tolerance* fields and the *Minimum length* field, enter "10.0" m.

The tolerances will define how close two nodes/vertices have to be in order to be merged, and how close an arc end point has to be to an arc in order to snap it to the arc. The minimum length is used to clean up arcs that extend past an intersection.

4. Click **OK** to close the *Clean Options* dialog. SMS will perform the clean operation.
5. Click the **Build Polygons** macro on the horizontal toolbar below the menus.
6. Using the **Select Feature Polygon** tool, double-click inside the polygon to bring up *2D Mesh Polygon Properties* dialog.

Notice the *Mesh Type* defaults to “Paving”. That is what will be used in this case, so leave that value.

7. For the *Elevation (bathy/topo) type***,** select “Raster” to indicate mesh elevations will be extracted from the DEM.
8. Click the **Raster Options…** button to bring up the *Raster Sets* dialog.
9. Select the “SyntheticChannelGrid.tif” and click **OK** to exit the *Raster Sets* dialog.
10. Click the **Preview Mesh** button to view a preview of what the generated mesh will look like.
11. Click **OK** to exit the *2D Mesh Polygon Properties* dialog.

The project is now ready to generate the mesh.

7 Generating the Mesh

In this section, change the display options and generate the mesh:

1. Click the **Display Options** macro to bring up the *Display Options* dialog.
2. Uncheck the *Show option pages for existing data only* option.
3. Select *2D Mesh* from the list on the left.
4. Turn on the *Contours* option.
5. Select the *Contours* tab at the top of the dialog.
6. Change the *Contour Method* to “Color Fill and Linear”.
7. Click on the **Color Ramp…** button to bring up the *Color Options* dialog.

The default color ramp for the mesh is the hue ramp option, but this project should have a maximum value of red instead of blue.

8. Click on the **Reverse** button to switch the color order.
9. Click **OK** to exit the *Color Options* dialog.
10. Click **OK** to exit the *Display Options* dialog.
11. Right-click on the “ Area Property” coverage and select *Convert* | **Map to 2D Mesh** to bring up the *Mesh Name* dialog.

SMS will generate a mesh for each selected polygon (or all polygons if none are selected). This could take some time for large complex meshes, but is fast for meshes with fewer than 1,000,000 elements.

12. In the *Mesh Name* dialog, enter “Paved ADCIRC Mesh” as the name.
13. Click **OK** to close the *Mesh Name* dialog.

An unstructured mesh will now appear as shown in Figure 6.

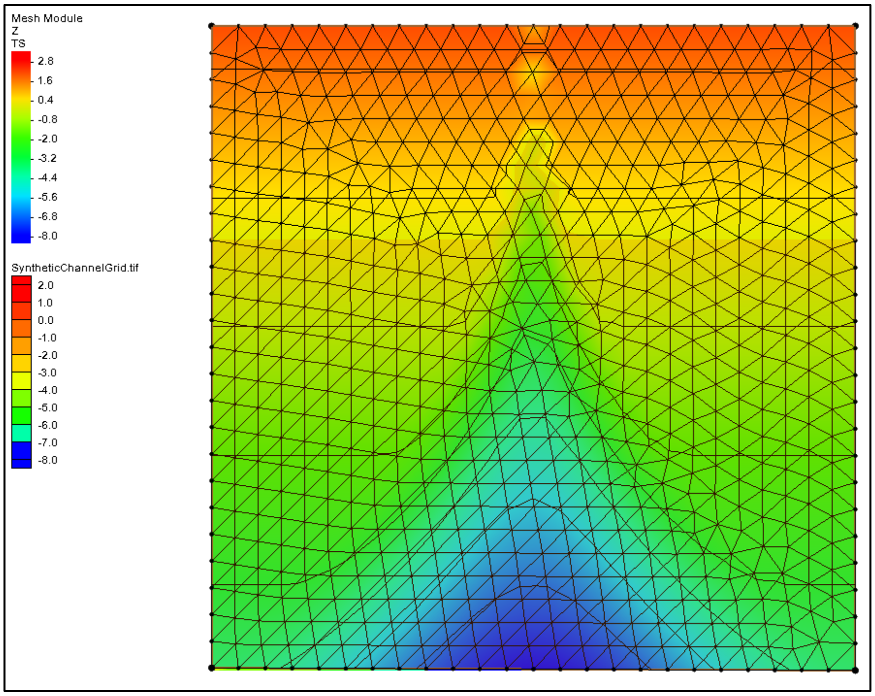


Figure 6 The mesh over the DEM.

8 Conclusion

This workflow assigned elevation data to the mesh as it was generated. Elevations can be updated for all or part of the mesh after the fact as well.

Note that the channel is poorly represented in this mesh. It does not extend to the top of the domain. The channel could be more accurately represented by reducing the 500 m spacing. However, that would increase resolution throughout the domain and would result in slower computations. Other tutorials illustrate how to selectively refine a domain to better represent features such as the channel without over resolving other areas in the domain.

This concludes the "ADCIRC – Synthetic Channel Mesh Generation-Part 1" tutorial. Topics covered in this tutorial included:

- Loading a DEM (raster) and using it as an elevation source.
- Creating a "Mesh Generator" coverage and digitizing arcs in that coverage.
- Converting feature vertices to nodes to split an arc into multiple arcs.
- Redistributing vertices on an arc to control mesh resolution.
- Creating a mesh from a mesh generator coverage.

The process is explored in more detail in part 2 of the tutorial. To use this mesh in an ADCIRC simulation, proceed to the "ADCIRC – Synthetic Channel Simulation Execution-Part 1" tutorial.

9 Notes

The geometry for this case comes from the following equations:

- For a given y-location (distance up the domain), the width of the channel is given by a quadratic function:

$$width = 59 / 720000 * y^2 - 59 / 30 * y + 12000$$

Thus, at the bottom of the domain (y=0), the channel spans the entire domain (width=12000 m), and at the top of the domain (y=12000 m), the channel shrinks to its minimum size (width=200m). This quadratic function allows the channel to be very wide in the bottom (wet) part of the domain, but it quickly becomes narrow in the middle and top (dry) parts of the domain.

- For floodplain locations outside the channel (i.e. to the left or right), the ground surface elevations follow a simple linear function:

```
linear_z = 6 / 12000 * y - 4
```

Thus, at the bottom of the domain (y=0), the floodplain elevation is –4 m (but deeper in the channel), and at the top of the domain, the floodplain elevation is +2 m. This is a representation of a linear floodplain, although spread over a large distance of 12 km.

- For locations inside the channel, the ground surface elevations follow a cosine function:

```
amplitude = 2.0 - 1.5 / 12000.0 * y

theta = x / width * PI

chan_z = -amplitude * cos(theta) – amplitude + linear_z
```

This cosine function may seem complicated, but the idea is simple. At the edges of the channel, the elevations should match the linear floodplain. Then the elevations should decrease (following a cosine shape) toward the center of the channel. At the center of the channel, the elevations should be lower than the surrounding floodplain. The lower centerline elevations will change; at the bottom of the domain (x=6000 m, y=0), the channel is 4 m lower than the floodplain, and at the top of the domain (x=6000 m, y=12000 m), the channel is only 1 m lower than the floodplain.

The data used in this tutorial does not correspond to any location in the real world – it is synthetic. This tutorial is a nice example of ADCIRC's wetting and drying, and it was used as a test case (at much higher resolution) in the publication *Environmental Modelling & Software*
https://www.sciencedirect.com/science/article/abs/pii/S1364815221000888?via%3Dihub

