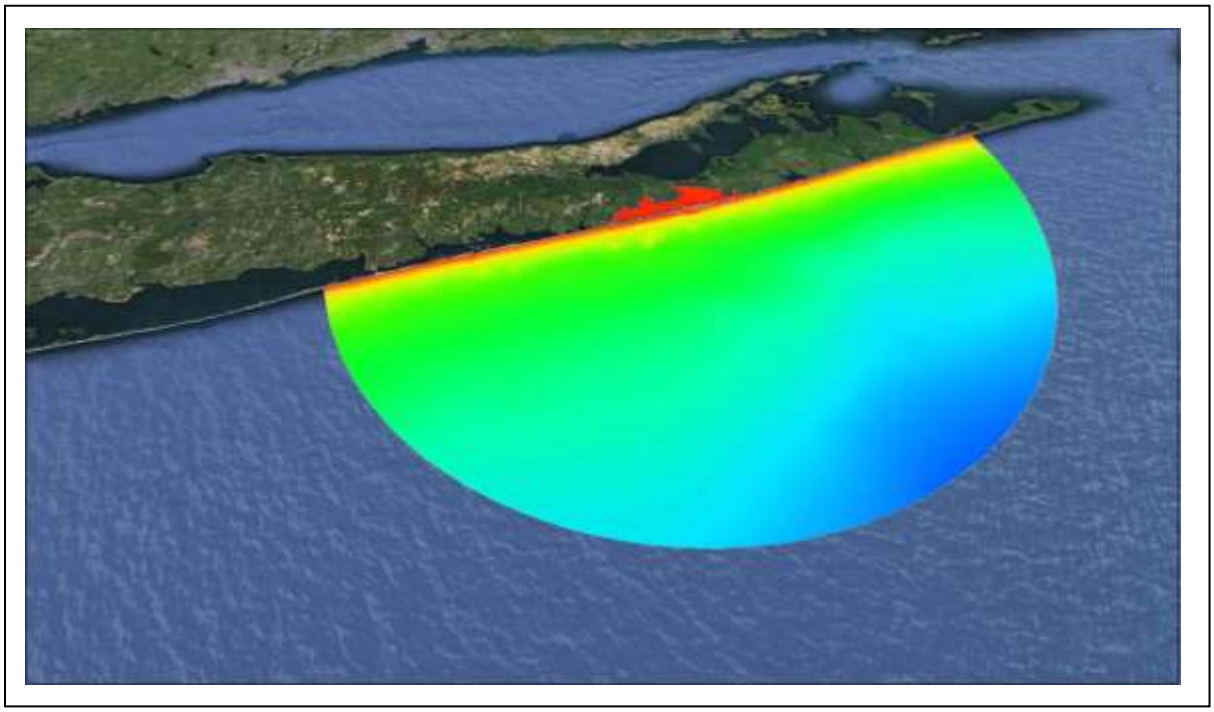
SMS

v. 13.1

SMS 13.1 Tutorial

ADCIRC Analysis



Objectives

This tutorial reviews how to setup and run an ADCIRC simulation. It will cover preparation of the necessary input files for the ADCIRC circulation model and visualization of the output.

Prerequisites

- Overview Tutorial
- Size Function
- Map Module
- Mesh Generation

Requirements

- ADCIRC
- Map Module
- Mesh Module
- Scatter Module
- LeProvost Tidal Database

Time

- 15–30 minutes

AQUAVEO™

1 Introduction

The ADCIRC (Advanced Circulation) model is a finite element hydrodynamic model for coastal oceans, inlets, rivers and floodplains. This tutorial will go over the process of creating an ADCIRC model using SMS. It will start by reading in a project with the mesh already generated. Review the "Size Function" and "Mesh Generation" tutorials to get to this point.

The data used for this tutorial are from Shinnecock Bay off of Long Island in New York. All files for this tutorial are found in ADCIRC data files directory.

2 Reading in the starting project

An initial project has been created containing a generated mesh and relevant data. For information on how this mesh was created, see the "Mesh Generation" tutorial. To open the project to start this tutorial, with SMS open:

1. Select *File* | **Open** to bring up the *Open* dialog.
2. Browse to the data files folder for this tutorial and select the file "shin.sms".
3. Click **Open** to import the project.

The project includes:

- A generic mesh of Shinnecock Bay on Long Island, New York and a small part the coastal region outside the bay.
- A scatter set representing bathymetric depths in the region.
- The display projection has been set to "GCS_North_American_1927" (geographic). The mesh is also relative to this datum.

The project should appear in the Graphics Window as show in Figure 1.

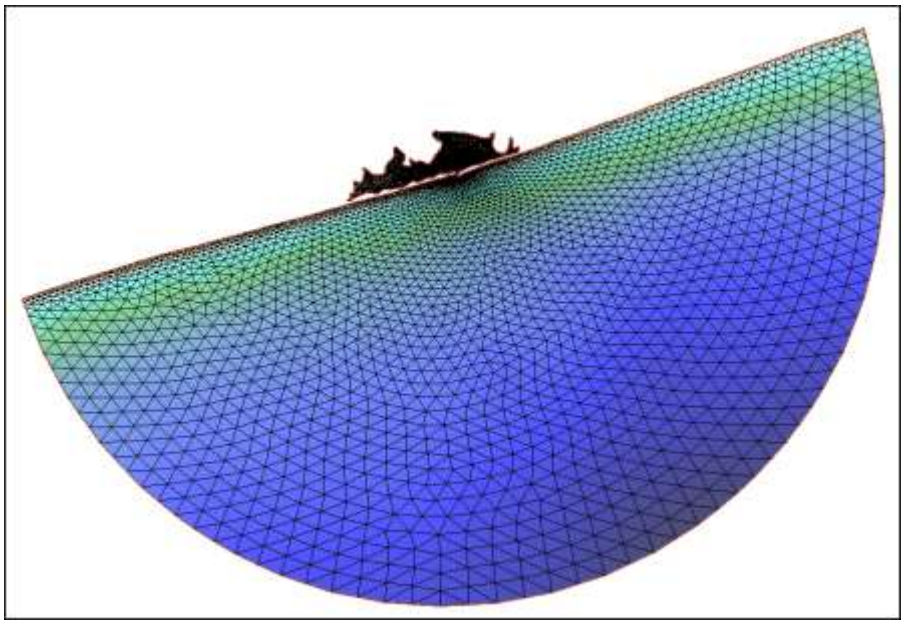


Figure 1 Initial mesh

3 Assigning Boundary Conditions

The ADCIRC model requires the user to define the boundary types for all edges of the domain. This is done by creating arcs around the domain and specifying the boundary type for each arc. The arcs need not be precisely located; they will be snapped to the mesh for each simulation being considered. They can be inside or outside of the domain, but it is often convenient to digitize just outside. If existing arcs exist they can be reused for this purpose.

3.1 Creating the Boundary Condition Coverage and Arcs

The boundary condition arcs must reside in an ADCIRC boundary condition coverage. To create a coverage and arcs for this simulation:

1. Right-click on "Map Data" and select **New Coverage** to open the *New Coverage* dialog.
2. For the *Coverage Type*, select *Boundary Condition* under *ADCIRC*.
3. Click **OK** to close the *New Coverage* and create a new coverage.
4. Select the "Boundary Conditions" coverage to make it active.
5. Using the **Create Feature Arc** tool, create an arc around the ocean portion with about 6–8 points. (Figure 2)
6. Using the **Create Feature Arc** tool, an arc along the coastline portion with 3–5 points. (Figure 2)

Note: refer to the "Map Module" tutorial to review the process of creating arcs. Remember that in this case, since the boundary condition arcs will be mapped (or snapped) to the mesh they do not need to be precise. They can be simple approximations of the boundaries.

(The arcs should appear similar to Figure 2)

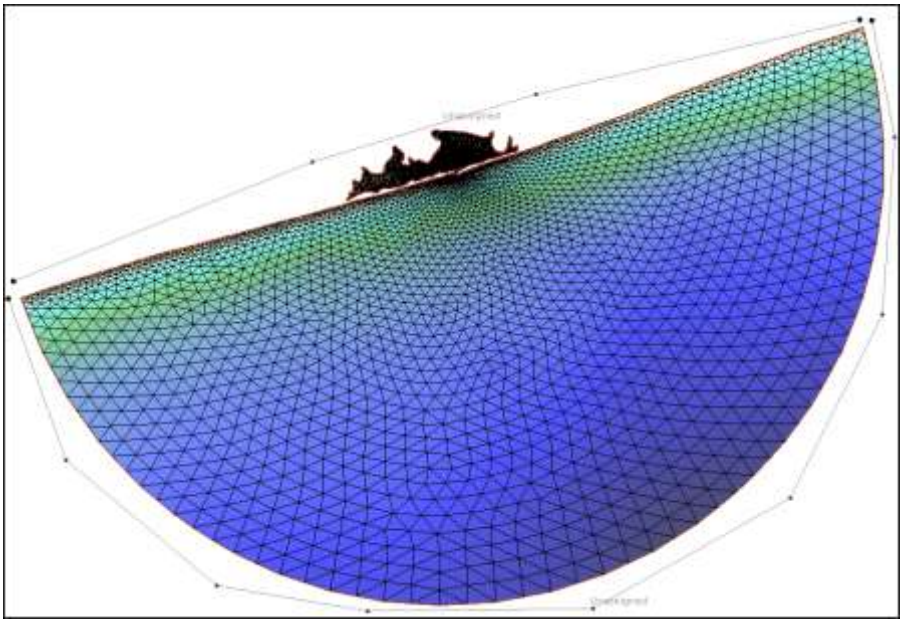


Figure 2 Digitized boundary condition arcs (lines). Labeled "Unassigned".

3.2 Setting the Boundary Condition Attributes

With the boundary condition coverage created, the arcs on the coverage need to be assigned attributes that define the boundary condition parameters for the simulation.

To set the boundary types:

1. Click on "Boundary Conditions" in the Project Explorer to make it active
2. Using the **Select Feature Arc** tool, double-click the arc representing the ocean boundary. The *Assign Linear BC* dialog will appear.
3. Select the "Ocean" option under the *Linear boundary condition options* section to assign this arc as an ocean boundary arc.

Later the tidal constituents to apply at this boundary will be specified.

4. Click **OK** to close the *Assign Linear BC* dialog.
5. Using the **Select Feature Arc** tool, double-click the arc representing the mainland boundary as shown in Figure 3 to open the *Assign Linear BC* dialog.
6. Select the "Mainland" option under the *Linear boundary condition options* section to assign this arc as a mainland boundary arc. Leave the *BC Options* set to "Natural".

Note: The natural boundary condition is much more numerically stable and is the recommended option.

7. Click the **OK** button to close the *Assign Linear BC* dialog.

With both arcs assigned the boundary condition coverage will be displayed as Figure 3.

Note: Right-clicking on the coverage will show a **Display Option** command which opens a dialog that allows specifying the display attributes of each boundary condition type.

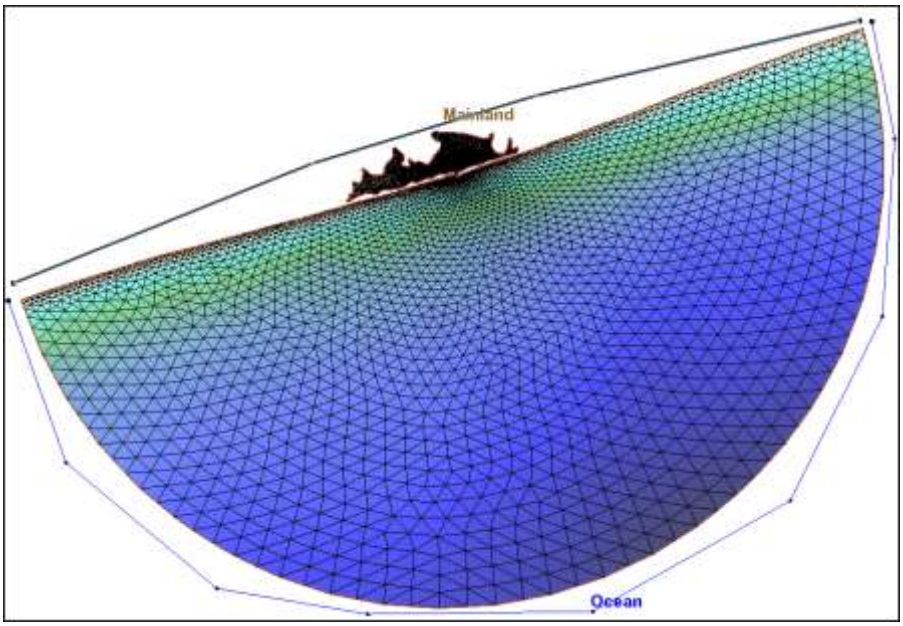


Figure 3 Feature arcs after boundary types have been assigned

4 Setting up the ADCIRC Simulation

The interface for ADCIRC uses a simulation based representation. The simulation based approach allows for the re-use of meshes, boundary condition coverages and other model components for multiple simulations. Multiple simulations can be created in a single SMS project file.

4.1 Creating the Simulation

To create the simulation:

1. Right-click in empty area of the Project Explorer and select *New Simulation* | **ADCIRC**.

A new "ADCIRC Simulations" group will appear in the Project Explorer along with a new simulation named "Sim".

2. Right-click on the "Sim" simulation and select **Rename**.

3. Enter the name "Tide-Run1" for the simulation and press *Enter*.

4.2 Adding Components to the Simulation

An ADCIRC simulation consists of a mesh (basis of computations), boundary conditions, and model parameters. The components already exist in the Project Explorer, now they must be linked to the new simulation. Two methods exist to link the components. This section illustrates both.

To add the components:

1. In the Project Explorer, right-click on the "ADIRC Mesh" object and select *Apply to* | **ADCIRC Simulations→Tide-Run1**.

Notice an "ADCIRC Mesh" item has been added under the "Tide-Run1" simulation. The "ADCIRC Mesh" item creates a link between the simulation and the mesh which tells the simulation to use the specified mesh during the model run. If multiple simulations were in the project, the same mesh can be linked to more than one simulation. Any changes to the mesh will automatically be updated in every simulation using that mesh.

Now to add a map coverage to the simulation.

2. Click-and-drag the "Boundary Conditions" coverage down to the "Tide-Run 1" simulation. As the cursor moves below the simulation name, a black line appears indicating this object can be added to this simulation. Let go of the mouse button to drop the "Boundary Conditions" coverage into the simulation.

Notice that the simulation is not simply linked into the simulation as the mesh was. Instead, the boundary conditions were snapped to the mesh boundary and associated with the nodes of that boundary. This appears in the project explorer as a mapped simulation element or component as "Boundary Conditions (applied)". These applied boundary conditions are displayed independent of the coverage as can be noted by the separate labels (2 labels for "Ocean" and 2 for "Mainland").

Check off the check box next to the "Boundary Conditions" coverage and the "ADIRC Mesh". The display now only shows the snapped/mapped boundary conditions. If the snapping is not consistent with the desired location of ocean and mainland, the arcs should be edited and the application of the boundary conditions to the simulation repeated.

4.3 Setting Model Parameters

To set up the ADCIRC simulation parameters:

1. Right-click on the "Tide-Run1" simulation and select **Model Control…** to open the *ADCIRC Model Control* dialog.
2. Select the *General parameters* tab:
    a. Specify the *Project title* to be "Shinnecock sample".

b. Specify the *Run ID* to be "ADCIRC v53".

c. In the *Coordinates* section, change the *Coriolis option:* to "Variable". This instructs ADCIRC to use the coordinates of the mesh to compute the influence of Coriolis forces.

d. Leave all the other general parameters as the default settings. Refer to the ADCIRC documentation for descriptions of each parameter.

3. Select the *Model formulation* tab:

   a. In the *Nonlinear terms* section, set the *Finite amplitude terms* to be "No wetting/drying". This mesh does not include beach area (it is cut off before that point so wetting/drying would not be useful. However the nonlinear finite amplitude terms are enabled.

   b. Specify the *Minimum depth* to be "0.05".

   c. Leave the *Advective terms – NOLICA* option off. This is a very small domain and the advective terms would create instabilities in the solution due to slight variations in the boundary conditions.

   d. In the *Generalized wave continuity equation – GWCE* section, set the *Weighting factor – TAU0* to be "Pure primitive equation: TAU0 specified".

   e. Set *Tau0* to "0.005".

   f. Set the *Solver message level* to be "Fatal". This keeps messages printed by the numeric solver to a minimum.

4. Select the *Timing* tab:

   a. Set the *Interpolation reference date* to "10/17/2012 12:00:00 AM". This date is used by the interface to extract tidal or meteorological values from other data sources for use in a simulation. It may be arbitrary or it may coincide with a specific event such as a hurricane.

   b. In the *Timing* section, set the *Time step (seconds)* to be "2.0".

   c. Set the *Length of run (days)* to be "1.5". Normal simulations last for several days up to a full lunar month. This is set to 36 hours just to get past the ramp time and show a tidal cycle.

   d. In the *Ramp Options – NRAMP* section set the *Number of hyperpbolic tangent spin up ramps* to be "1".

   e. Set the *General ramp* duration to be "1.0" days.

5. Select the *Output* tab:

   a. In the *Default* row of the table set the *Start (days)* to be "1.0" (to be after the ramp) and the *End (days)* to be "30.0" (this could be any number greater than the duration of the simulation. Since this simulation could be an initial spin up for a longer run it is common to put in a larger

value.) Set the *Increment (min)* to be "60.0"

6. Click **OK** to exit the *ADCIRC Model Control* dialog.

4.4 Tidal Forces

For this run of ADCIRC tidal forcing will be used. To define the tidal constituents that ADCIRC will apply at the ocean boundaries:

1. Right-click in empty area of the Project Explorer and select *New Simulation* | **Tidal Constituents**.
2. Right-click on the "Sim" and select **Rename**.
3. Specify the name to be "ADCIC Major" indicating that this will include the major tidal constituents from the ADCIRC database.
4. Right-click on "ADCIRC Major" simulation and select **Edit Constituents…** to open the *Tidal Constituents* dialog.
5. For the *Source*, specify "ADCIRC2015".

Note that the tool will support several different tidal databases. (*Note*: The xmswiki (https://www.xmswiki.com/wiki) article (SMS:ADCIRC_Tidal_Constituents) which can be accessed using the **Help** button includes instructions for installing the TPXO and FES databases if desired.

6. Change the *Reference time* to "10/17/2012 12.00 AM" to match the time specified for the simulation.
7. Click the **Select Major** button to select the *N2*, *S2*, *K1*, *O1*, and *M2* constituents.
8. Click **OK** to close the *Tidal Constituents* dialog.
9. In the Project Explorer, right-click on the "ADCIRC Major" simulation and select *Apply to* | **ADCIRC Simulations→Tide-Run1**.

SMS launches a script to generate the tidal constituent values. The progress of the script is displayed in a dialog that closes upon successful extraction. The "ADCIRC Major (applied)" component is added to the simulation.

10. Right-click on the "ADCIRC Major (applied)" component and select **Tidal Constituents** to view the mapped constituents consisting of an amplitude and phase for each ocean node fo0r each constituent.
11. Click **OK** to close the dialog.

5 Running ADCIRC

The simulation is now ready to be run. To invoke the run:

1. Right-click on the " Tide-Run 1" simulation and select **Save Simulation.**

This saves the ADCIRC specific input files (fort.14 and fort.15) in the simulation folder ("shin/ADCIRC/Tide-Run 1" below the folder containing the SMS project).

2. Right-click on the "  Tide-Run 1" simulation and select **Run Simulation** to launch the ADCIRC engine.

This process can be monitored in the *Simulation Run Queue.* This is a separate process so work can continue in SMS while the simulation run.

This run will simulate 1.5 days (36 hours) of simulation with a 1.0 day (24 hour) ramp. The time step was specified as 2.0 seconds, so the simulation will include 64,800 time steps (1.5 days * 24 hours/day * 3600 seconds/hour * 0.5 time steps/second). Output will be saved for each point on the mesh every 60 minutes of simulation time from 24 hours to 36 hours (25 total output periods).

5.1 Aborting the Run (optional)

On a moderate personal computer, running on a single core, this simulation of ADCIRC takes around three minutes. A finished solution is provided to avoid waiting for the simulation to complete if desired. To abort the run:

1. Click on the **Abort** button in the *Simulation Run Queue.* This will terminate the simulation.
2. Click on the **Remove** button in the *Run Queue*. This will remove the simulation from the queue, meaning it is fully released for additional edits and manipulation in SMS.
3. The precomputed solution file(s) (fort.63.nc, fort.64.nc, maxele.63.nc, maxvel.63.nc…) are in the simulation folder in the output directory. To open these:
    a. Select *File* | **Open** to bring up the *Open* dialog.
    b. Browse to the output folder for the model run which will be called "shinfinal". Hold the *Shift* key down and select the desired solution files.
    c. Click the **Open** button to import the selected files

Alternately, a drag/drop process can be used to load the selected files. In either case, the datasets will be loaded into a simulation folder under the mesh. Each output file from ADCIRC is imported into SMS as a dataset.

5.2 Loading the Solution

Once the simulation runs to completion, do the following to load the solution:

1. Click on the **Load** button in the *Simulation Run Queue.* (This appeared in the place of the abort button when the simulation completed.)

This operation removes the simulation from the *Simulation Run Queue* and dismisses (closes) the *Simulation Run Queue*.

The solution datasets ("  Elevation", "  Velocity", "  Maximum Elevation", "  Maximum Velocity"…) appear in a folder named for the simulation under the mesh. The number of datasets depends on the specified output options for the simulation.

6 Conclusion

Refer to the visualization tutorial to review/learn the methods used to generate images, curves and animations for the solution data generated by ADCIRC.

This concludes the "ADCIRC Analysis" tutorial. Continue exploring the ADCRIC model in SMS or exit the program.