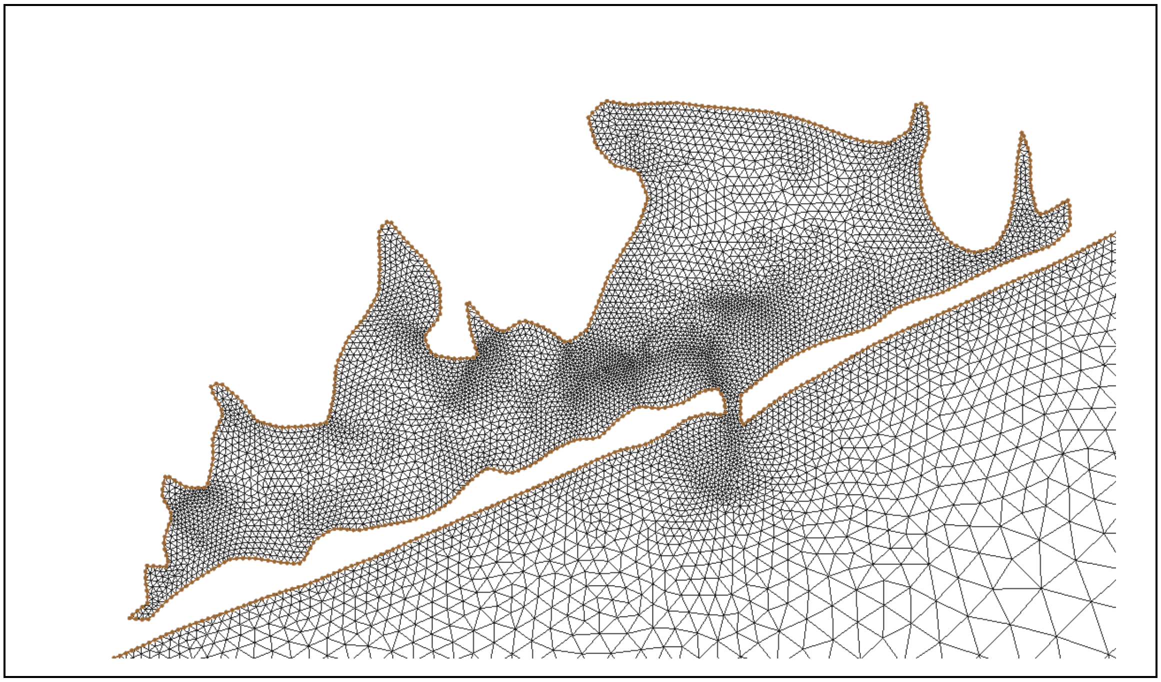
SMS

v. 12.1

SMS 12.1 Tutorial

ADCIRC LTEA



Objectives

LTEA stands for the "Local Truncation Error Analysis". The name refers to an analysis methodology for measuring local truncation error in a numerical analysis. The LTEA Toolbox incorporated into the Surface-water Modeling System uses the LTEA algorithm as the heart of a utility which creates finite element meshes of varying resolution for ADCIRC analysis.

Prerequisites

- ADCIRC Tutorial
- Overview Tutorial

Requirements

- ADCIRC
- Map Module
- Mesh Module
- Scatter Module

Time

- 30-45 minutes

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1 Before Using the Toolbox

Before the LTEA toolbox can be accessed, load the geometric definition for an ADCIRC simulation. This definition consists of a bathymetric survey of the area to be modeled and an ADCIRC coverage in the Map module with arcs describing the shape of the modeling domain.

An existing ADCIRC mesh can be used as the basis for the analysis since it defines both the bathymetry and a domain boundary.

This tutorial makes use of a bathymetric survey and a coastline arc. A modeler acquires this type of data from local surveys or from a data source such as those described in the *GeoSpatial Data Acquisition* page (http://xmswiki.com/xms/GSDA:GSDA) maintained by Aquaveo.

1.1 Loading Data

Two data files are provided for this exercise:

- “shin.cst” – a coastline definition in Geographic NAD 27 coordinates.
- “shin.pts” – a set of survey points in UTM NAD 27 coordinates.

To get ready to use LTEA:

1. Select *File* | **Open** to bring up the *Open* dialog.
2. Browse to the file “shin.cst” located in the data files folder for this tutorial. Click **Open**.
3. Right-click on *Area Property* and select **Rename**.
4. Change the name of coverage to “Shin Domain”.
5. Right-click on “Shin Domain” and select *Type* | *Models* | **ADCIRC**.
6. Select *Display* | **Projection** to bring up the *Display Projection* dialog.
7. Select *Global projection* to bring up the *Select Projection* dialog.
8. Set *Projection* to “Geographic (Latitude/Longitude)” and set the *Datum* to NAD 27. Leave the other settings at their defaults.
9. Click **OK** to close the *Select Projection* dialog.
10. Set *Projection* in the *Vertical* section to “Local” and set *Units* to “Meters”.

11. Click **OK** to close the *Display Projection* dialog.
12. Right-click on the *Shin Domain* coverage, and select **Projection...** to bring up the *Object Projection* dialog.
13. Select *Global projection* and check that it is set to “Geographic (Latitude/Longitude), Zone NAD27, arc degrees”.
14. Check that the vertical units are set to “Meters”.
15. Click **OK** to close the *Object Projection* dialog.

To define the boundary type and build polygons:

1. Select the **Select Feature Arc** tool.
2. Double-click on the arc to open the *ADCIRC Arc/Nodestring Attributes* dialog.
3. In the *Boundary Type* section, select *Mainland* and click **OK**.
4. Select *Feature Objects* | **Define Domain…** to bring up the *Domain Options* dialog.
5. Select *Semi-circular* and click **OK**.
6. Build polygons by using *Feature Object* | **Build Polygons**.

To set the attributes for the ocean arc:

1. Double-click on the newly created ocean arc to pull up the *ADCIRC Arc/Nodestring Attributes* dialog.
2. Select *Ocean* under *Boundary Type*.
3. Click **OK** to close the *ADCIRC Arc/Nodestring Attributes* dialog.
4. Right-click the “Shin Domain” coverage in the Project Explorer and select **Reproject**.

This converts the coordinate system to UTM. This is done for two reasons. First, the survey is in UTM and second, the LTEA toolbox requires that data start in a rectangular system.

5. Select **Yes** if a dialog appears advising that round-off errors may be introduced. This will bring up the *Reproject Object* dialog.
6. In the *New Projection* section, click the **Set Projection…** button.
7. Select “UTM” for the *Projection*, set *Zone* to “18 (78˚W - 72˚W – Northern Hemisphere)”, and set *Datum* to “NAD27”.
8. Click **OK** to close the *Select Projection* dialog and **OK** again to close the *Reproject Object* dialog.
9. Set the display projection by right-clicking on the *Shin Domain* coverage and selecting **Work in Object Projection**.

The scatter points need to be imported, and the projection needs to be set for them:

1. Select *File* | **Open** to bring up the *Open* dialog.
2. Select the file “shin.pts” and click **Open**. The *Open File Format* dialog will appear.

3. Select *Use Import Wizard* and click **OK** to bring up the *File Import Wizard – Step 1 of 2* dialog.
4. Check on *Space* under *Set the column delimiters*.
5. Click **Next**, then **Finish** to close the *File Import Wizard*. The scatter points will appear. If the scatter points do not appear, turn on *Points* on the *Scatter* section of the *Display Options* dialog.
6. Right-click on the new "shin" scatter set, and select **Projection** to bring up the *Object Projection* dialog
7. Select *Global projection* and check that it is set to "UTM, Zone: 18 (78˚W - 72˚W – Northern Hemisphere), NAD27, meters".
8. Make sure *Units* in the *Vertical* section is set to "Meters".
9. Click **OK** to close the *Object Projection* dialog.

For this tutorial, the coastline definition is less precise than the survey data. When using LTEA with real world data, define the level of detail for the coastline, keeping in mind the impact on numerical analysis.

2 Using the Toolbox

The LTEA toolbox consists of a wizard that guides through various steps in creating a mesh with varied resolution for an ADCIRC analysis.

2.1 Launching the Toolbox

To launch the toolbox:

1. Right-click on "Shin Domain" and select **Mesh Generation Toolbox**. This will bring up the *Mesh Generation Toolbox* dialog.
2. Select "Localized Truncation Error Analysis (LTEA)" and click **Run** to bring up the *LTEA Tool* dialog.

2.2 Specifying the Input

If a mesh already exists, the domain and bathymetry can be derived from it.

To generate a simple mesh in order to run ADCIRC do the following (Figure 1):

1. Set *Boundary* to "Shin Domain"
2. Click the **Select** button next to *Bathymetry* to bring up a *Select Dataset* dialog.
3. Select the "depth_bathymetry" dataset and click **Select** to close the *Select Dataset* dialog.
4. Select the *Create Linear Run Mesh* option.
5. Turn on the *Override Boundary Spacing* option.

By choosing this option, the toolbox will space boundaries varying from the coastline spacing to the deep water spacing shown in the edit fields below the checkbox. Currently, these boundary spacing options are set to “100” for the *Coastline spacing*, and “10000” for *Deep water spacing*. If great effort was put into spacing the boundary, leaving this unchecked will preserve that spacing.

6. Turn on *Save Linear Run Mesh*.
7. Click the **Browse** button below *Save Linear Run Mesh*. This will bring up a *Save* dialog.
8. Enter “ltea_lin_mesh” in the *File name* field and select “ADCIRC Files (*.grd)” in the *Save as type* field. Click **Save** to close the *Save* dialog.
9. Click the **Continue >** button.

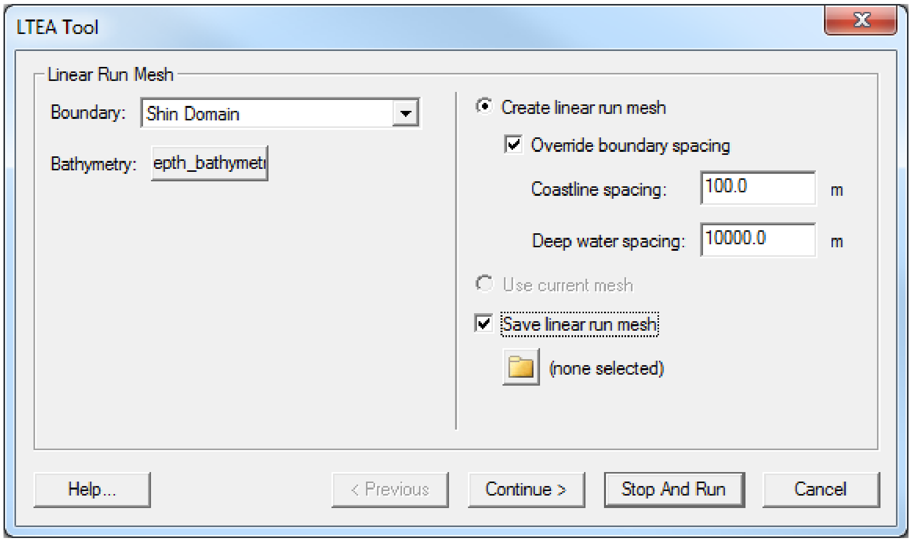

Figure 1 Initial mesh page of the LTEA toolbox

2.3 Getting the Harmonic Solution

LTEA analysis utilizes the harmonic solution data from an ADCIRC run. Normally, this solution comes from a linear run of the ADCIRC model on the linear mesh generated in the previous step.

The term “linear ADCIRC” is used because several of the non-linear terms in the ADCIRC solution schemes are turned off. Since no solution exists for a mesh in this test case, SMS has selected the *Run ADCIRC linear run* option and set the model parameters to standard defaults.

The LTEA toolbox uses the following settings (in the *ADCRIC Model Control*) for the ADCIRC linear run:

- *Finite Amplitude Terms*, *Advective Terms*, and *Time Derivative Terms* are off.
- *Coriolis Method* and *Lateral Viscosity* are set to a constant value of “0”.
- *Bottom Stress/Friction* is set to “Constant Linear”.
- Harmonic analysis is performed for the last 1.5 days of the simulation.

- A single M2 tidal forcing constituent is extracted from the LeProvost database along the ocean boundaries. The *Nodal Factor* and *Equilibrium Argument* are set to "0".
- *Minimum Water Depth* is set to "1.25" times the maximum extracted tidal forcing amplitude.
- A time step of 15 seconds is used; this greatly reduces the run time compared to a non-Linear ADCIRC run.

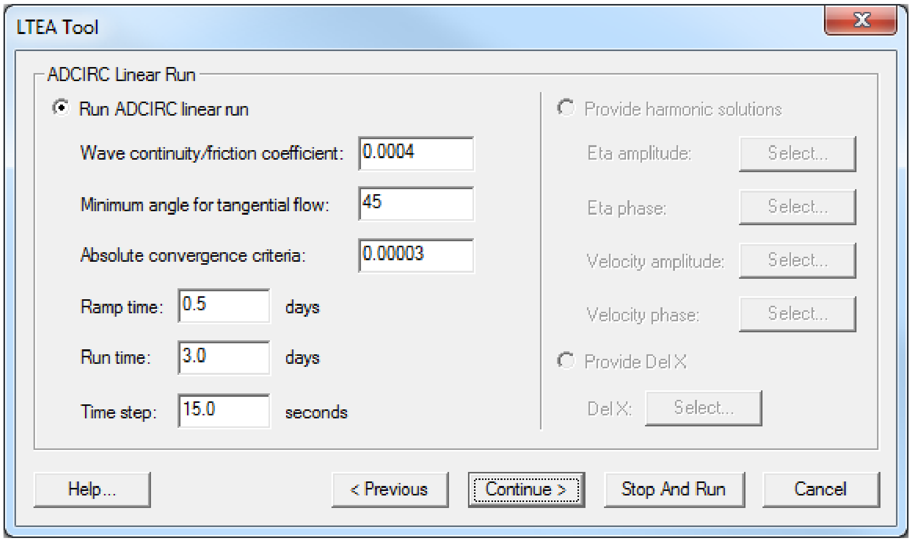

Figure 2 Linear ADCIRC run page of the toolbox

10. Leave all the setting on this page at the defaults (Figure 2) and click the **Continue >** button to move to the next step of the process.

If desired, using the **Stop and Run** button would instruct SMS to close the toolbox and perform the linear run. This may take a few minutes. When it is done, there will be several datasets loaded into SMS. The LTEA toolbox can then be restarted then skip through to the third step.

2.4 LTEA Analysis

The LTEA analysis can now use the harmonic datasets created from the ADCIRC run to create a size function called "DelX".

11. In order to get LTEA values close to the domain boundary, make sure that the *Use partial molecule* check box is selected (Figure 3).

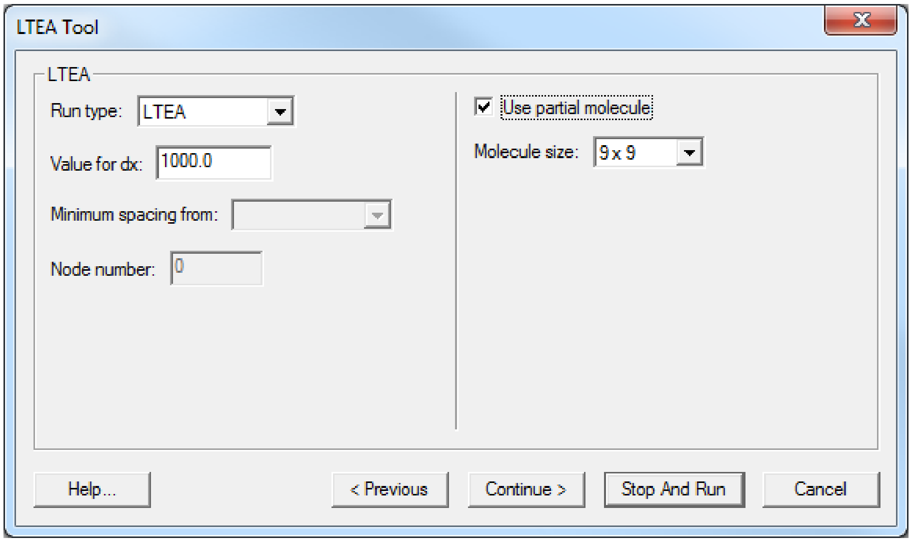

Figure 3 LTEA options page for the toolbox

The option for the molecule size should be left at “9 x 9”. This means that a small, equally-spaced grid of nine cells by nine cells is created around each node, and values from the ADCIRC solutions are interpolated for all 81 cells. These values are then used for the LTEA analysis.

Nodes on the edges of the domain will not have values for cells outside of the domain and normally LTEA will not give a value for these nodes with partial molecules. If partial molecules are not used, the boundary spacing from the domain boundary will be used to place nodes on the final mesh until a region where LTEA values are present and the process then uses LTEA values.

12. Click on the **Continue >** button to move onto the next step.

If desired, the **Stop and Run** button would cause SMS to close the toolbox and run the LTEA analysis. The analysis generates several datasets used as size functions in the mesh generation process.

2.5 Generating the Mesh

With the size function “DelX” created, a mesh can be generated that is influenced by LTEA.

1. In the *Generate Final Mesh* section, enter “10,000” in the box below *Target number of nodes*.
2. Enter “500” in the *plus/minus* field.
3. Leave the *Element area change limit* at “0.5”.
4. Check on *Redistribute Boundaries*.

This allows the mesh generation process to redistribute the domain spacing according to LTEA values to get more resolution in the body of the mesh rather than on the edges.

5. Click the **Run** button. Wait a few seconds and the model will begin to run. The *LTEA Tool* dialog might still be showing.

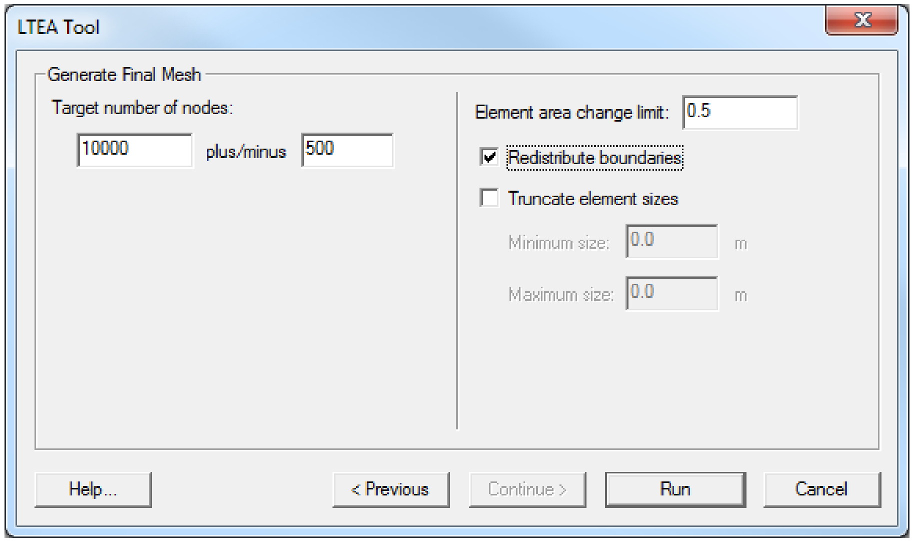

Figure 4 Final mesh page of the dialog

6. Enter "Shin Domain Initial Boundary Mesh" as the *Mesh name* when the *Mesh Name* dialog appears.
7. If a message appears stating the data must be saved, click **OK** to bring up a *Save* dialog.
8. Browse to a location to save the file. Give it a *File name* of "LTEArun.sms" and click **Save**. The *ADCRIC* model wrapper will start.
9. When *ADCIRC* model wrapper ends, a *Mesh Name* dialog will appear. Accept the default name and click **OK**.
10. Click **Done** on the *Mesh Generation Toolbox*.
11. Now save the project for later review, if desired.

If a message appears stating that the program could not find the file "M2.legi":

12. Go to *Aquaveo.com/downloads/SMS* and download the "ADCIRC Basic Utilities" under the *Database Files & Utilities* section.
13. Follow the directions in the "ReadMe.txt file" once the downloaded file has been unzipped. It explains where to place the files.
14. Once the above has been done, go back to SMS and click on **OK** to search for the files.
15. Browse to the folder where the files were placed and click on **Open** to tell SMS where to find the files.

With the final mesh being loaded, note the different scatter sets labeled "Scaled", with varying numbers that follow. In order to reach the correct target number of nodes, the original size function is scaled and a mesh is created.

The final number of nodes in that mesh is then checked to the target to see if it is within the tolerance. If the total number of nodes is not within tolerance, it is deleted and the size function is rescaled and the process is repeated until the target number of nodes is reached. The number after "Scaled" is the scaling factor used to create the different number of meshes.

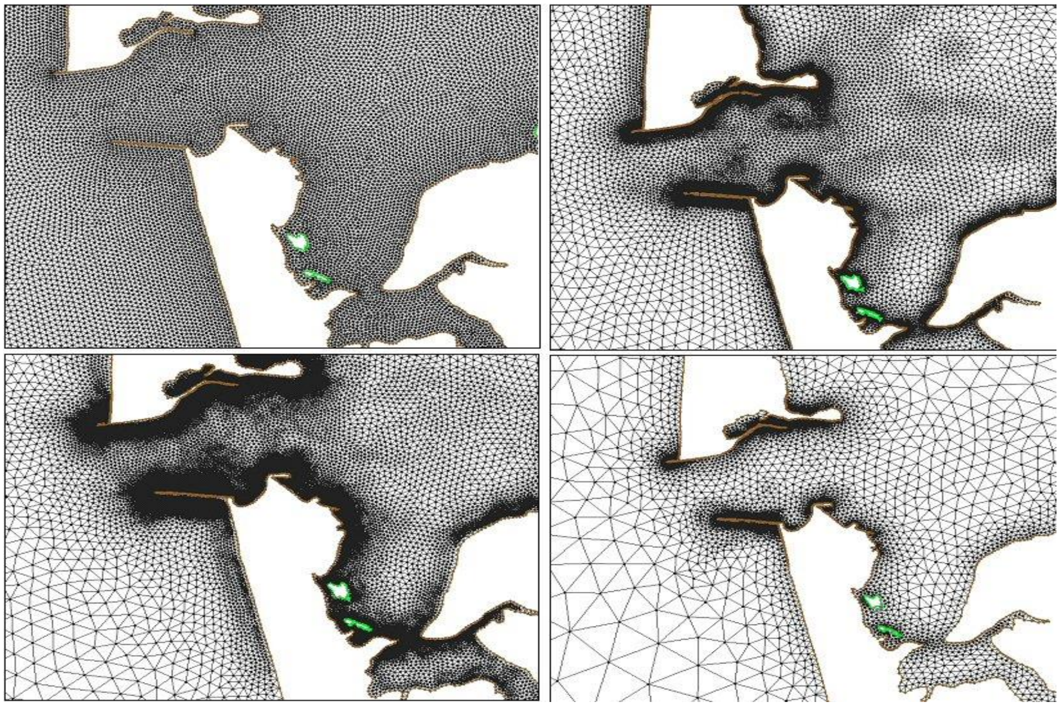

Figure 5 Various grid resolutions for a single domain

3 Conclusion

For this tutorial, the process was done step by step to explain the different options of each page. If desired, try running the toolbox straight through once by just filling in all of the required fields. The result will be the same. That is one of the most important parts of the toolbox. The process is repeatable: anyone can take those inputs and get the same result every time.

Finding the correct number of nodes for a mesh is an ambiguous task and depends on the research needs. With the toolbox, many different meshes can be created with varying target number of nodes. These meshes can then be tested to determine how many nodes are the most advantageous. Figure 5 shows a domain with several meshes created with varying number of nodes.

Exit SMS, or continue experimenting with different scenarios.

