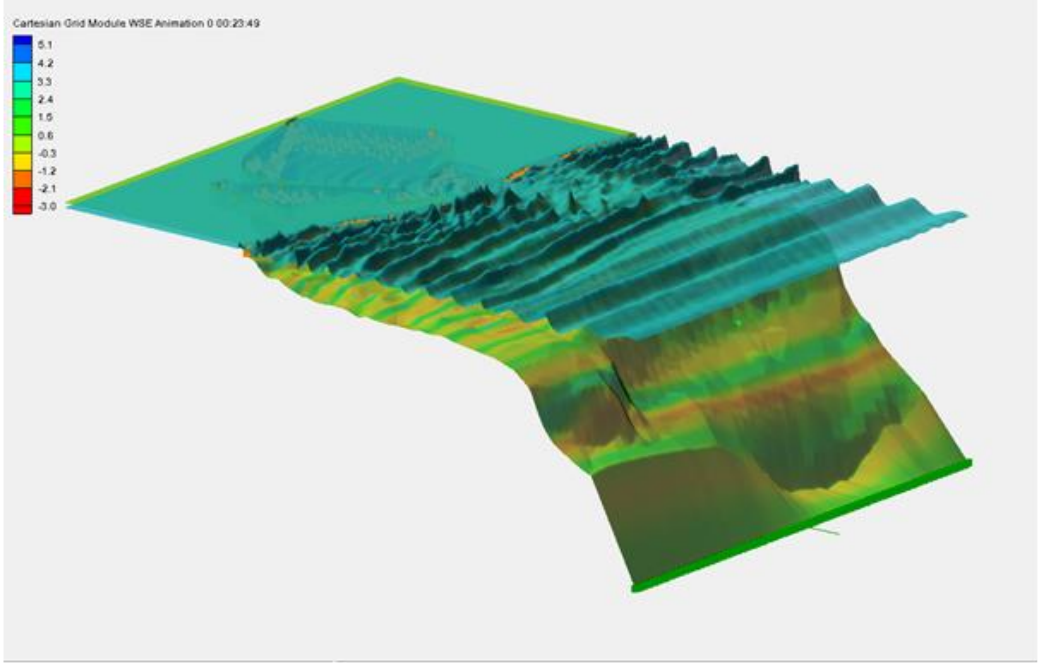
SMS 13.3 Tutorial

BOUSS-2D

Creating a BOUSS-2D Simulation in SMS



Objectives

This tutorial shows how to use the interface for BOUSS-2D and run the model for a sample application. This example steps through the process of setting up and running a simulation using data from the area around Kalaeloa Barbers Point Harbor in Hawaii.

Prerequisite Tutorials

- Overview

Required Components

- SMS Core
- BOUSS-2D Model & Interface

Time

- 15–25 minutes

1 Introduction

As a phase-resolving nonlinear wave model, BOUSS-2D can be used in the modeling of various wave phenomena including shoaling, refraction, diffraction, full/partial reflection and transmission, bottom friction, nonlinear wave-wave interactions, wave breaking and dissipation, wave runup and overtopping of structures, wave-current interaction, and wave-induced currents.

The data used for this tutorial includes images, bathymetry data, and coastline data for Kanaeloa Barbers Point Harbor, located on the southwest corner of the island of Oahu, Hawaii.

2 Getting Started

The cell-centered grid used for this tutorial was previously created. Open the background data for this project by doing the following:

1. If necessary, launch SMS.
2. If SMS is already running, select *File* | **New** to ensure that the program settings are restored to their default state.
3. If asked to save changes, click **Don't Save** to close the dialog and restore SMS to a default state.
4. Select *File* **| Open…** to bring up the *Open* dialog.
5. Browse to the *data files* folder for this tutorial and select "kanaeloa.sms".
6. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1. For more information on how the grid was generated, see the "Creating a Cell-Centered Grid" tutorial.

Before continuing, it is best to save the project under a new name in order to preserve the starting project for future use.

1. Select *File* **| Save As…** to bring up a *Save As* dialog.
2. Enter the *File name* "BarbersPoint.sms" and click **Save** to close the *Save As* dialog.

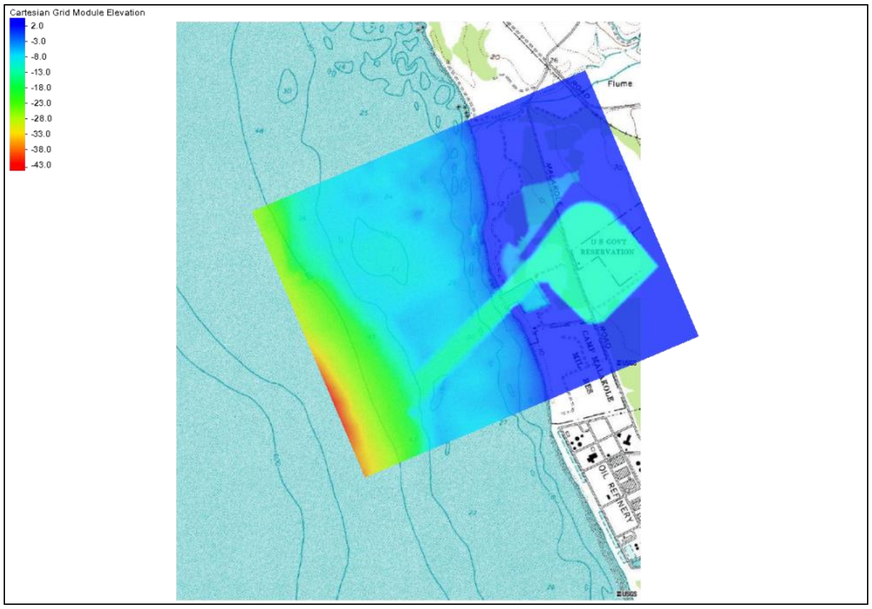


Figure 1 Initial project

3 Generate a Wave Maker

Wave makers are created through map coverages. To create a wave maker, follow these steps:

1. Right-click on " Map Data" in the Project Explorer and select **New Coverage** to open the *New Coverage* dialog.
2. In the *Coverage type* section, select *Models* **|** *BOUSS-2D* **| Wave Maker**.
3. Enter "Wave Maker" as the *Coverage Name.*
4. Click **OK** to close the *New Coverage* dialog.
5. Select " Wave Maker" to make it active.
6. Using the **Create Feature Point** tool, create a point in the new coverage as indicated in Figure 2 (roughly the location 589709.289, 2357770.534).

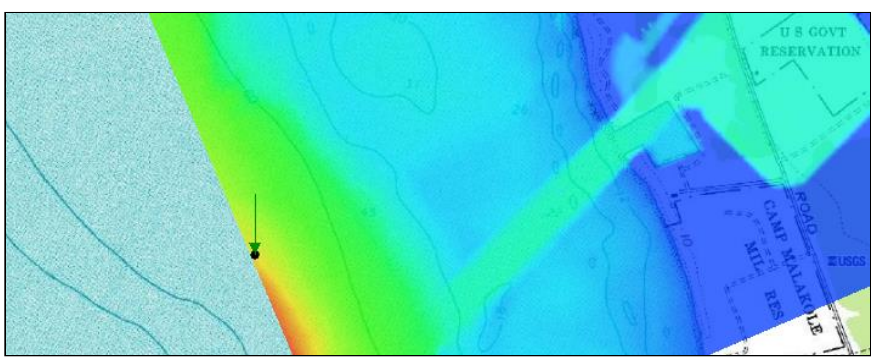


Figure 2 Wave Maker map coverage with feature point

4 Defining the Wave Maker

The BOUSS-2D wave maker must be positioned at a point in the grid. In SMS, create the wave maker on a point at a desired location.

To define a wave maker, follow these steps:

1. Using the **Select Feature Point** tool, select the newly created point.
2. Right-click and select **Point Attributes...** to bring up the *BOUSS-2D Wave Generator Properties* dialog.
3. In the *Wave Simulation Parameters* section, select “Irregular Unidirectional” from the *Type* drop-down.
4. Enter “750.0” (sec) as the *Series duration* and press the *Tab* key.
5. Click **OK** to acknowledge the message about changing the period for all wave makers.
6. In the *Spectral Parameters* section, select “JONSWAP Spectrum” from the *Type* drop-down.
7. Select “Specify hs and Tp” from the *Option* drop-down.

This allows the significant wave height and peak period values (H_s and T_p) to be set as follows:

8. In the spreadsheet, enter “3.0” as *Sig. Wave Height (m)*.
9. Enter “15.0” as *Peak Wave Period (s)*.
10. In the *Directional Parameters*, select “Meteorologic” from the *Projection* drop-down.
11. Enter “245.0” as the *Wave angle*.
12. Leave all other parameters at their defaults.
13. Click **OK** to close the *BOUSS-2D Wave Generator Properties* dialog.
14. If asked, click the **Yes** button to force a constant elevation.

As SMS generates the wave maker, this indicates that the offshore edge of the grid is not of constant depth. The wave maker should appear similar to Figure 3.

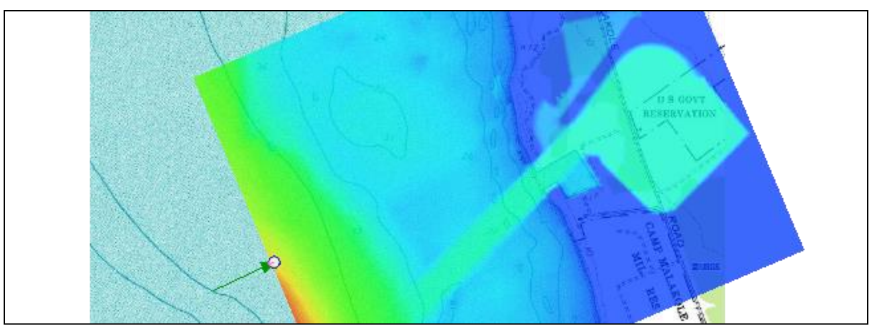


Figure 3 Arrow indicates direction of waves from the wave maker

5 Creating a BOUSS-2D Simulation

The next step in preparing a simulation is to specify model input parameters by first creating the BOUSS-2D simulation:

1. Right-click on an empty space in the Project Explorer and select *New Simulation* | **BOUSS-2D**.
2. Right-click on the newly created " Simulation" item and select **Rename**.
3. Enter "BarbersPoint" and press *Enter* to set the new name.
4. Drag both " 10m Grid" and " Wave Maker" under " BarbersPoint".

5.1 Setting the Model Parameters

With the initial setup for the simulation completed, it is now possible to define the model parameters.

1. Right-click on " BarbersPoint" and select **Model Control…** to bring up the *BOUSS-2D Model Control* dialog.
2. Enter "Barbers Point Sample Run" as the *Project title*.
3. In the *Time Control* section, enter "1500.0" (sec) as the *Duration*.

This value should be greater than the computed default (the number in the *Recommended* column) in that field.

4. Enter "0.25" (sec) as the *Timestep*.

The default time step is set to correspond with a *Courant* number of "0.6". Reducing the time step increases stability. The time step should not be increased.

5. In the *Parameters* section, turn off *Enable wave runup*.
6. In the *Output Options* section, turn on all options under *Time independent*.
7. Under *Animation Output*, turn on *Output WSE*, *Output Velocity* and *Override Defaults*.

For this case, first generate a series of solutions corresponding to the last five wave cycles (75 seconds) by changing the settings as follows:

8. Enter "1425.0" (sec) for *Begin output*.
9. Enter "1500.0" (sec) for *End output*.
10. Enter "1.0" (sec) as the *Step.*

The defaults for the above three parameters save the water level and velocity at even increments for the entire simulation. This generally results in either a huge output file or a discontinuous set of solution snap shots. An approximate size for the solution file is displayed to the left under *Required memory*.

11. Click **OK** to close the *BOUSS-2D Model Control* dialog.

6 Defining Damping Layers

If no damping is applied to the model, wave energy that is not dissipated along gradually sloping beaches will be bounced back into the domain. To calibrate to real world cases, or to prevent wave reflections from spreading back to the wave maker, it may be necessary to employ damping layers.

BOUSS-2D uses a dataset with a damping value at each cell to compute the damping of waves. A damping value of "0.0" indicates no damping and is the default. As the damping value increases (up to "1.0"), and the number of damping cells adjacent to each other increases, the energy that is reflected back from the edge of the computation domain decreases.

Damping layers are created in coverages by doing the following:

1. Turn on " Area Property" and select " Elevation" under " 10m Grid" in the Project Explorer.
2. Right-click on " BarbersPoint" and select **Generate Arcs Along Land Boundary…** to bring up the *Generate Arcs* dialog.
3. Select "Grid" from the *Generate from* drop-down.
4. Click **(none selected)** next to *Item* to bring up the *Select Tree Item* dialog.
5. Select " 10m Grid" and click **OK** to close the *Select Tree Item* dialog.
6. In the *Destination coverage* section, select *Create New Coverage*
7. Select "Damping" from the *Type* drop-down.
8. Enter "0" (m) as the *Elevation.*
9. Click **OK** to close the *Generate Arcs* dialog.

This builds a new coverage called "Damping" that contains an arc along the boundary (Figure 4).

10. Select " Damping" to make it active.
11. Using the **Select Feature Arc** tool, double-click on the arc to bring up the *Damping Properties* dialog.
12. Enter "20.0" as the *Width (m)* (the combined width of two cells).
13. Enter "0.2" as the *Coefficient*.
14. Click **OK** to close the *Damping Properties* dialog.

The width value for the damping depends on several factors including wave length and grid resolution. This small damping coefficient will reduce wave reflection inside the harbor.

15. Click anywhere outside of the damping boundary arc to deselect it.

Notice the " Damping" has been automatically linked to the simulation. This is because the coverage was generated from the simulation.

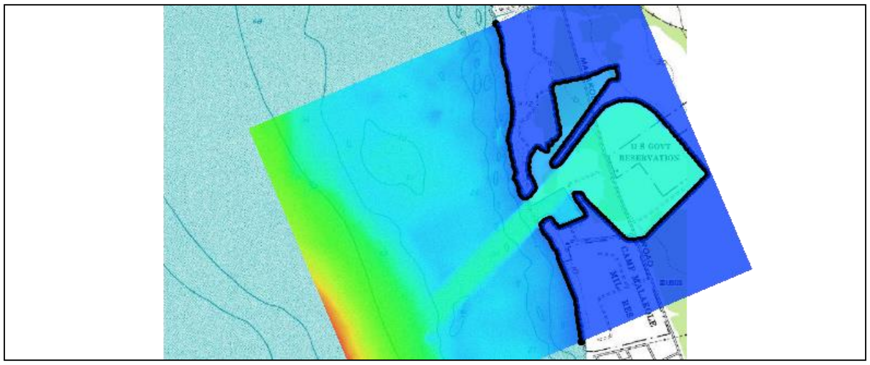


Figure 4 Boundary arc along the shoreline

7 Saving and Running the Simulation

The final step before running a simulation is to save the files for BOUSS-2D by doing the following:

1. Select **Save Project** .

This saves all the data files for execution.

2. Right-click on " BarbersPoint" and select **Export BOUSS-2D**.
3. Right-click on " BarbersPoint" and select **Run BOUSS-2D** to bring up the *BOUSS-2D* model wrapper dialog.
4. If a *Model Checker* dialog appears with a warning that the selected run time is longer than the recommended time, click **Run Model** to exit the *Model Checker* dialog.

If using a standard installation of SMS, the model should launch immediately. If SMS cannot find the BOUSS-2D executable, a message will be displayed asking to locate the desired executable.

This simulation may take several minutes to run with a 1.0 sec time step, depending on the speed of the computer being used. The model runtime increases or decreases linearly based on the number of computational cells.

5. After the model run is complete, turn on *Load solution* and click **Exit** to close the *BOUSS-2D* model wrapper dialog.
6. If the *Dataset Time Information* dialog appears, choose to use seconds for all datasets and click **OK** to exit the *Dataset Time Information* dialog.

8 Visualize Simulation Results

The model run created several solution datasets that include spatially varying results at the grid nodes. Some of these are scalar datasets:

- Wave breaking animation (Breaking Animation)
- Mean wave level (Mean Water Level)
- Mean wave directions (Mean Wave Direction)
- Significant wave height (Sig. Wave Height)

- Velocity magnitude animation (Velocity Animation Mag)
- Water surface elevation animation (WSE Animation)

The other two are vector datasets:

- Mean Velocity
- Velocity Animation

BOUSS-2D can save these results in two ways: in multiple separate files, or in a single binary file (HDF5 format). In this case, BOUSS-2D created the file "BarbersPoint_sol.h5" at the end of the run. SMS creates a folder in the Project Explorer containing all of the datasets (in this case, "barberspoint").

To display a functional surface of the water surface:

1. Select *Display* | **Display Options…** to open the *Display Options* dialog.
2. Select *Cartesian Grid* from the list on the left.
3. On the *Cartesian Grid* tab, turn off *Cells* and turn on *Contours* and *Functional surface*.
4. Click **Options…** right under the *Functional surface* option to bring up the *Functional Surface Options* dialog.
5. In the *Data Set* section, select *User defined dataset* to bring up the *Select Dataset* dialog
6. Select "WSE Animation" from the list of datasets and click **Select** to close the *Select Dataset* dialog.
7. In the *Z Offset* section, select "Display surface above geometry" from the drop-down.
8. In the *Z Magnification* section, turn on *Override global value* and enter "50.0" as the *Magnification value*.
9. In the *Display Attributes* section, select *Use solid color* and click the larger *Color* button to bring up the *Color* dialog.
10. Select **cyan** on the top row under *Basic colors* (fifth box from the left) and click **OK** to close the *Color* dialog.
11. Click **OK** to close the *Functional Surface Options* dialog.
12. On the *Contours* tab, in the *Contour method* section, select "Color Fill" from the first drop-down.
13. Select "General" from the list on the left.
14. On the *General* tab, turn off "Auto z-mag" in the *Drawing Options* section.
15. Enter "20.0" as the *Z magnification*.

This amplifies the variation in the Z-direction due to the very small wave heights compared to the size of the domain.

16. On the *Lighting* tab, turn on *Enable lights*.
17. Turn on *Smooth edges* in the *Surface attributes for all lights* section
18. Click and drag the sphere until the dot is in the upper-right quarter of the sphere, about a third of the way from the edge to the center of the sphere (see Figure 5). This will give good lighting contrast for the 3D view. If the dot is red, it is on the other side of the sphere, and will need to be further dragged to be on the correct side of the sphere.

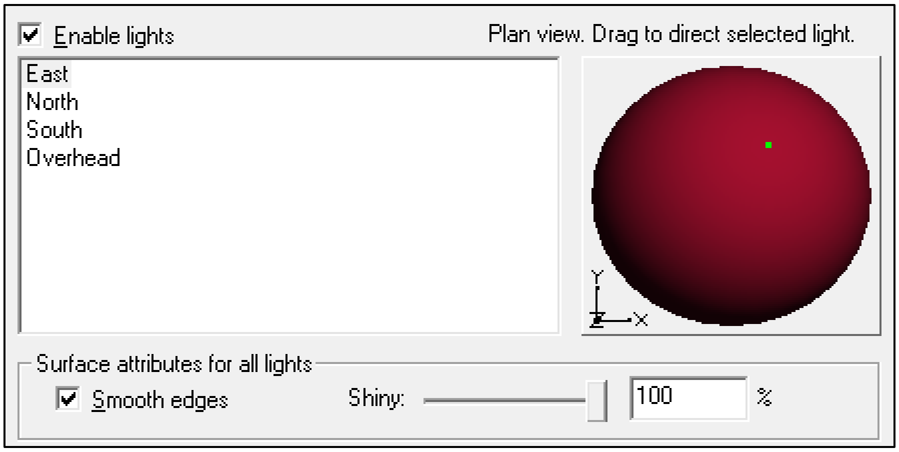


Figure 5 Lighting tab showing lighting direction

19. On the *View* tab, select *View angle* and enter "40.0" (degrees) as the *Bearing* and "25.0" (degrees) as the *Dip*.
20. Click **OK** to close the *Display Options* dialog.
21. Select the "Z Elevation" dataset in the Project Explorer to show the contour on the bottom of the ocean.

The system may take a several minutes to update the display, depending on the capabilities of the computer. Figure 6 shows this functional surface of the water surface over the bathymetric surface. The contour colors may vary. In this case, the contours are set to display a hue ramp with blue at the maximum end and the depth function active.

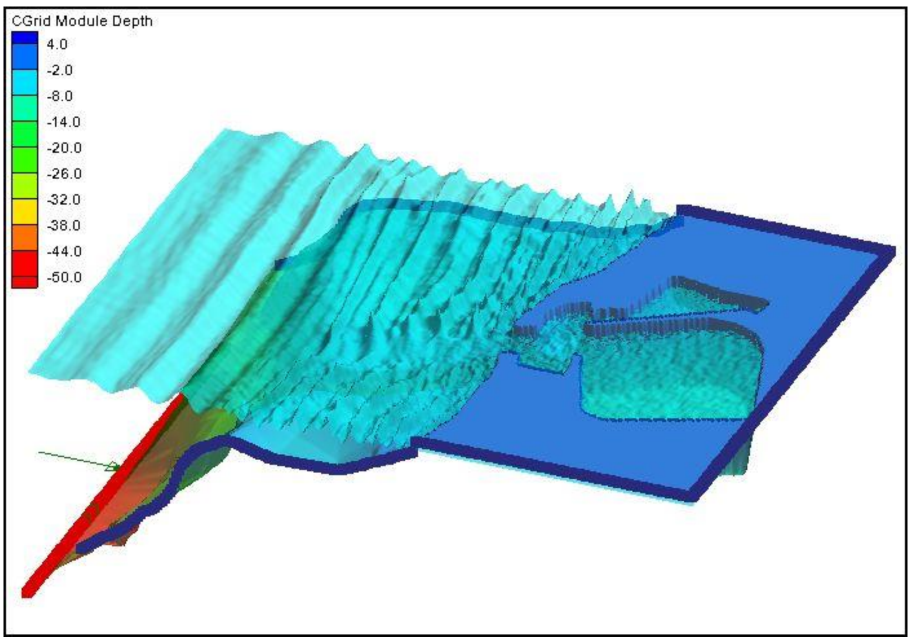


Figure 6 Water level functional surface over the bathymetry (magnified 20x)

All of the standard visualization methods described in the "Data Visualization" tutorial also work for the solutions generated by BOUSS-2D. Experiment with other options to view the solution.

9 Conclusion

This concludes the “BOUSS-2D” overview tutorial. Feel free to continue experimenting with the SMS interface, or exit the program.

