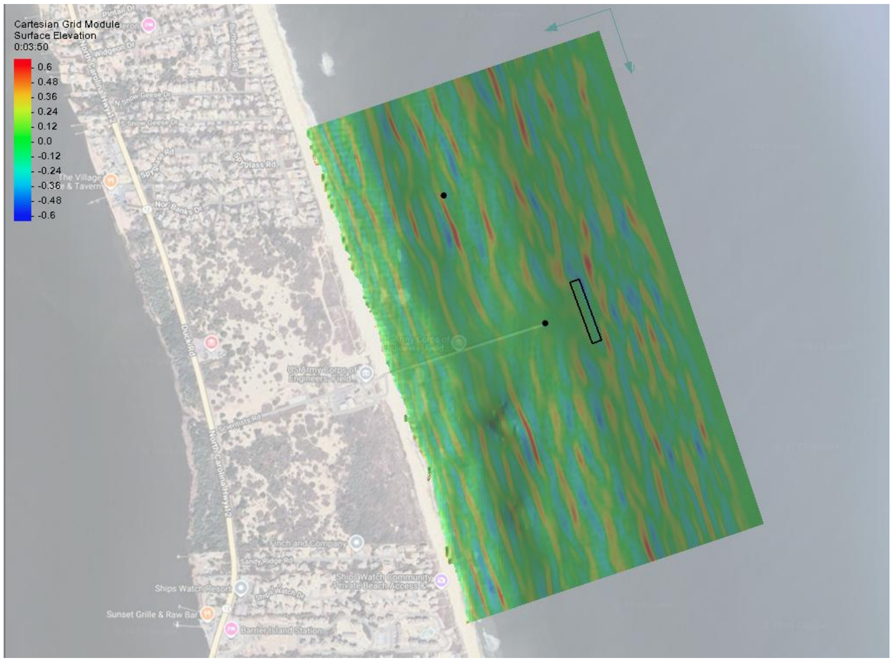
SMS 14.0 Tutorial

FUNWAVE Additional Features - Reef

Additional features of the FUNWAVE Interface in SMS



Objectives

Learn how to set up a FUNWAVE simulation with spatially variable friction and a breakwater structure.

Prerequisite Tutorials

- SMS Overview
- Grid Generation
- FUNWAVE Introduction

Required Components

- SMS Core

Time

- 35–45 minutes

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1 Introduction

This tutorial covers the steps of creating the data files for FUNWAVE-TVD® (FUNWAVE) simulations in the Surface-water Modeling System (SMS).

FUNWAVE is a fully nonlinear phase-resolving Boussinesq wave model for modeling of surf zone–scale optical properties in a Boussinesq model framework, and modeling of Tsunami waves in both a global/coastal scale for prediction of coastal inundation and a basin scale for wave propagation.

A FUNWAVE simulation consists of the following components:

- A Cartesian grid
- A coverage defining output stations
- Datasets as needed for spatial inputs
- A set of model parameters

The approach used for the definition of this tutorial includes using the WaterWorks On Demand (WWOD) platform. This requires an account on WWOD, which has an installation of FUNWAVE. Browse to https://taylorengineering.com/project/usace-model-modernization-waterworks-ondemand-platform/ for more information.

This tutorial begins with a bathy/topo DEM of the area around the USACE Field Research Facility (FRF) at Duck, North Carolina, a background image, and some annotation data.

2 Getting Started

Start by importing a project file containing background data:

1. Launch the SMS application.
2. From the *Menu* bar, select the *File* | **Open…** menu item to bring up the *Open* dialog.
3. From the *Files of type* drop-down, select “Project Files (*.sms)”.
4. Browse to the initial project folder for this tutorial and select “start.sms”.

5. Click the **Open** button to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1.

6. Click the *File* | **Save As…** menu command to bring up the *Save As* dialog.
7. For the *File Name*, enter “reef.sms”.
8. Click the **Save** button to save the file under the new name and close the *Save As* dialog.

Note that the project includes a display projection set to UTM Zone 18. FUNWAVE requires a Cartesian projection.

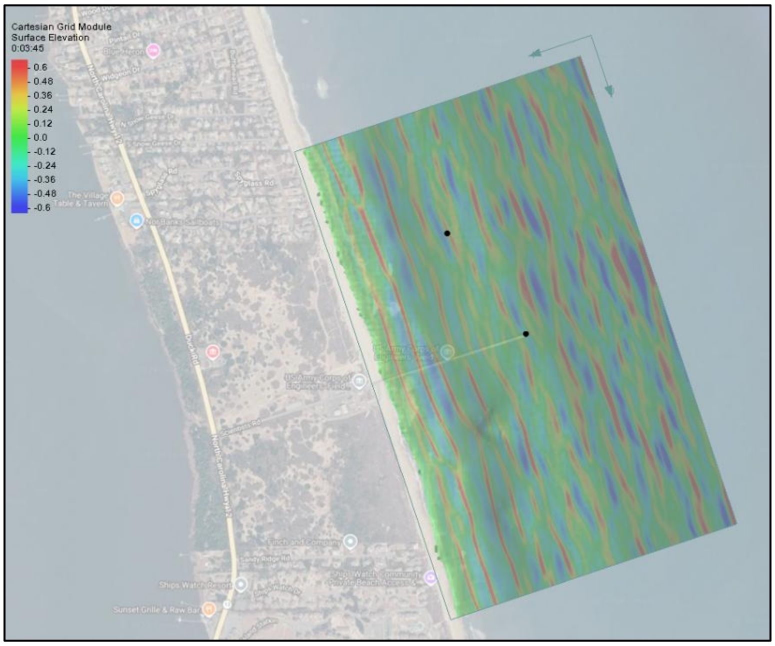

Figure 1 Initial project

3 Applying a Reef

We now want to create a modified simulation that includes a constructed reef in the domain. This is simulated specifying a region in the domain with high friction using a variable friction dataset on the grid and assigning that in the model parameters.

3.1 Create the Friction Dataset

To set up a spatially varied friction coefficient, or dataset:

1. Right-click on the “ Elevation” Cartesian grid dataset and select the **Duplicate** context menu command.
2. Right-click on the “ Elevation (2)” Cartesian grid dataset and select the **Rename** context menu command.
3. Enter “friction coef” and press the *Enter* key to set the new name.
4. From the *Modules* bar, select the “ Cartesian Grid Module” module.
5. Using the **Select Grid Cell** dynamic tool, right-click on the polygon and click on the **Select All** context menu command to select all the cells.

6. In the *Edit Window,* for the "S" value, enter "0.02" and press the *Enter* key to set the value. This assigns the default friction coefficient of 0.02.

3.2 Creating Area Property Coverage

1. In the Project Explorer, right-click on the " Map Data" folder and select the **New Coverage** context menu item to bring up the *New Coverage* dialog.
2. In the *Coverage Type* section, under the *Generic* section*,* select "Area Property".
3. For the name, enter "Reef".
4. Click the **OK** button to close the *New Coverage* dialog.

3.3 Importing Shapefile

1. Select the *File* | **Open** menu command to open the *Open* dialog.
2. Select the "Reef.shp" shapefile.
3. Click the **Open** button to import the shapefile into the *GIS Data* folder.
4. Right-click on the " Reef.shp" GIS data item and select the *Convert* | **Shapes** → **Feature Objects** context menu command to open the *GIS to Feature Objects Wizard – Step 1 of 2* dialog.
5. From the *Select a coverage for mapping* drop-down menu, select the "Reef" coverage
6. Click the **Next >** button to go to the *GIS to Feature Objects Wizard – Step 1 of 2* dialog.
7. Click the **Finish** button to accept the defaults and close the dialog.

The reef will appear similar to Figure 2.

Figure 2 Reef polygon

3.4 Applying Shapefile

1. In the Project Explorer, select the " Reef" map data coverage to make it active.
2. Using the **Select Feature Polygon** dynamic tool, select the polygon in the *Reef* coverage.
3. Right-click and select the **Select intersecting objects** context menu command to open the *Select Intersecting Objects* dialog.
4. In the *Choose Data to Select* section, select the "Cartesian grid" radio button.
5. On the right, in the tree chooser, select the "2m grid" dataset.
6. Click the **OK** button to close the *Select Intersecting Objects* dialog.
7. In the *Edit Window*, for the *S* value, enter "0.3" and press the **Enter** key to set the new friction coefficient.

3.5 Duplicating and Modifying the Simulation

We now need to apply this dataset to a new simulation by changing the model parameters.

1. In the Project Explorer, right-click on the " existing" simulation and select the **Duplicate** context menu item.
2. Right-click on the " existing (2)" simulation and select the **Rename** context menu command.
3. For the new name, enter "reef" and press the *Enter* key to set the name.
4. In the Project Explorer, right-click on the " reef" simulation and select the **Model Control...** context menu item. The *Model Control* dialog will open.
5. From the list on the left, select the *Project* entry. The associated parameters appear on the right.
6. For the *Project title (TITLE),* enter "FRF with man made reef".
7. From the list on the left, select the *Physics* entry. The associated parameters appear on the right.
8. Turn on the *Friction option (FRICTION_MATRIX)* checkbox.
9. Under *Friction (FRICTION_FILE),* click the **Select…** button that appears to open the *Select dataset for Friction (FRICTION_FILE)* dialog.
10. Turn on the *"friction coef"* dataset checkbox.
11. Click the **OK** button to close the *Select dataset for Friction (FRICTION_FILE)* dialog.
12. Click the **OK** button to close the *Model control* dialog.

4 Running the FUNWAVE Simulation

Export the simulation from SMS, upload to WWOD, execute FUNWAVE on WWOD, and import the FUNWAVE simulation results into SMS.

This tutorial includes a solution file that can be copied into SMS. Described in the *Loading the FUNWAVE Solution into SMS* section.

4.1 Exporting Simulation Files

SMS has now gathered all the information related to a FUNWAVE simulation. We now need to tell SMS to save the input files for the analysis. To do this and review the files:

1. From the *Menu* bar, select the *File* | **Save Project** menu item.
2. Right-click on the " reef" simulation and select the **Save Simulation** context menu item.
3. In the Project Explorer, right-click on the " Project" folder and select **Open Project Folder**. This will open an operating system *File Explorer* browser window in the location of the files, for this tutorial the "FUNWAVE_reef\data_files\" folder.

4.2 Renaming the Input File

1. In the *File Explorer*, opened in the previous step, browse to the "reef_models\FUNWAVE\reef" folder.
2. Right-click on the "input.funwave" file and select the **Copy** context menu command.
3. Right-click on a blank space in the File Explorer window and select the **Paste** context menu command.
4. Right-click on the "input – Copy.funwave" file and select the **Rename** context menu command.
5. Rename the file to "input.txt" and press the *Enter* key to set the new name. FUNWAVE requires the input file to be named like this.
6. In the rename confirmation dialog, click the **Yes** button.

4.3 Copying the Submit File

1. From the *data_files* folder for this tutorial, copy the "submit.pbs" file.
2. In the *data_files\reef_models\FUNWAVE\reef* folder, paste the "submit.pbs" file. This is a bash script that will be used to run the simulation.

4.4 Using WaterWorks On Demand (WWOD)

The approach used for this tutorial includes using the WaterWorks On Demand (WWOD) platform https://taylorengineering.com/project/usace-model-modernization-waterworks-ondemand-platform/. This requires an account on WWOD, which has an installation of FUNWAVE.

4.5 Upload Simulation Files to WWOD

Upload the simulation files created by SMS to WWOD.

1. Log into WWOD.
2. From the WWOD dashboard, click on the *Files* link at the top of the screen and select the **Home Directory** option.
3. Use the **New Directory** button to create a directory or select an existing directory to perform the FUNWAVE run.
4. Click on the **Upload** button to bring up the upload dialog.

5. Click on the **Browse folders** link. This will open a *windows file selector* dialog.
6. Navigate to the FUNWAVE simulation folder for the project on the local machine. For this tutorial, the “data_files\reef_models\FUNWAVE” directory.
7. Select the “reef” folder and click the **Upload** button.
8. Confirm the number of files to upload to the site, by clicking the **Upload** button**.**
9. Click the **Upload files** button to upload the files to WWOD.

4.6 Starting Linux Desktop on WWOD

This section describes how to execute FUNWAVE on the WWOD system.

1. In the WWOD dashboard, click on the *Apps* drop-down at the top of the screen and select **All Apps***.*
2. Scroll through the entries and select **Linux Desktop**. This will open the setup window.
3. In the setup window, for the *Session Target,* select “With GPU”.
4. For the *Maximum duration in hours of your remote session*, for the purposes of this tutorial enter “8”. For most simulations, this will need to be longer.
5. Click the **Launch** button.
6. WWOD will open a status list of interactive sessions with Linux Desktop app showing a status of *Queued.*
7. Wait for the notice to change from *Queued* to *Running.* When this happens click the **Launch Linux Desktop** button that appears. This will launch a new web browser tab for the virtual server.

4.7 Executing FUNWAVE on WWOD

1. From the dock at the bottom of the display, use the *Application Finder* to launch a new *Terminal Emulator*. This will bring up a terminal window.
2. Navigate to the directory containing the FUNWAVE input files. For example, enter “cd FUNWAVE/reef”.
3. Enter the command “qsub submit.pbs” and press the *Enter* key to run the script. This will launch the FUNWAVE simulation. This simulation will take a few minutes to run on WWOD. For this first simulation, WWOD may take a few minutes longer to launch the first process.
4. To monitor the progress of the simulation, use the “qstat” command. There will be a job with the name of “funwave” in the list. Rerun the “qstat” command from time to time. The simulation is done when the *funwave* job disappears from the list.

The *submit.pbs* script has a few parameters set for this tutorial that should be changed for other simulations. This includes the *max walltime* on line 6 and the *N_PROCS* variable on line 11.

On WWOD, *max walltime* refers to the maximum amount of real-world clock time that the job is allowed to run on the compute-node before termination. Since this tutorial is small and light this is set to 8 hours. A larger simulation may need a longer time period, though this may increase queue wait time.

On WWOD, *N_PROCS* refers to the number of processor cores that can be used in parallel to run the simulation. This is set in the Model Control dialog, by entering values for PX and PY. For this case, the values of PX (5) and PY (8) are determined to make approximately square subdomains and multiplying (5 * 8) = 40 them together while limiting the number of compute threads to less than 44, a single compute node on WWOD. Using more cores than a node has can slow performance due to communications overhead.

4.8 Copy Solution to Local Machine

After the FUNWAVE simulation is complete, the solution files will need to be copied back to the local machine. To do this:

1. From the WWOD dashboard, click on the *Files* drop-down menu at the top of the screen and select "Home Directory".
2. Browse to the directory the simulation was uploaded to. For this tutorial, "FUNWAVE".
3. To the left of the "reef" folder, turn on the checkbox.
4. Click the **Download** button at the top of the panel. This compresses the folder as a ZIP file and downloads the file.

4.9 Loading the FUNWAVE Solution Into SMS

To load the solution computed by FUNWAVE for review. This solution includes field data for grid as well as point data at the stations.

Copy the solution files to the simulation directory.

1. In the *File Explorer*, browse to the *Downloads* folder and locate the "reef.zip" file. If needed, an already completed solution file is available in the "FUNWAVE_reef\Solution" folder.
2. Right-click on the "reef.zip" file and click on the **Extract All…** context menu command.
3. Copy all of the contents from the solution folder and paste into the simulation folder created by SMS. For this tutorial, the "data_files\reef_models\FUNWAVE\reef" folder.

To load the solution:

4. In the Project Explorer, right-click on the "reef" simulation and select the **Read Solution** context menu item.
5. The *Loading FUNWAVE Solution Files* dialog appears as the files are read into SMS.
6. A *Solution* folder is created under the reef simulation.
7. The *Time steps* window also appears.

The solution consists of water surface elevations and wave velocities (directions) for 20 timesteps at the end of the simulation see Figure 3. These timesteps start at 225 seconds (3:45 minutes) into the simulation and are saved about every 1.5 seconds by FUNWAVE.

The solution also includes time series for the entire simulation at the output stations with a time interval of about 0.25 seconds.

5 Visualizing Field Datasets

The file data is visualized using contour options on the grid in SMS.

To examine the field data for this solution:

1. Select the *Display* | **Display Options…** menu command to open the *Display Options* dialog.
2. From the list on the left, select the *Cartesian Grid* option
3. On the *Cartesian Grid* tab, turn off the *Cells, Cell id, and Cell ij* checkboxes.
4. Turn on the *IJ triad* checkbox.
5. Turn on the *Contours* checkbox.
6. On the *Contours* tab, in the *Contour method* section, from the drop-down menu select *Color fill.*
7. For the *Transparency,* enter “60” %.
8. Click the **OK** button to close the *Display Options* dialog. The Graphics Window should look similar to Figure 3.
9. In the *Time Step* window, step through the timesteps.

Note the range of water elevations. If desired, experiment with different contour ranges in the *Display Options* dialog.

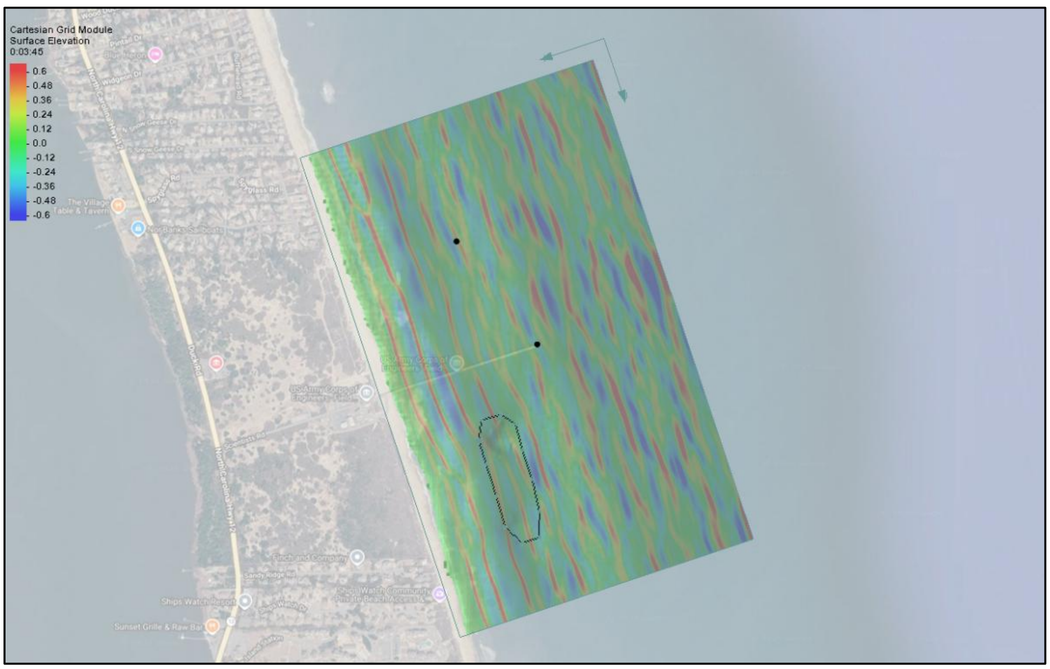

Figure 3 Reef simulation

5.1 Comparing Datasets

The two surface water elevations can be compared to view changes because of the increased roughness in the area labeled reef. Refer also to the Data Visualization tutorial.

Note that the timesteps created by the “reef” run are not exactly the same as those from the “existing” run. This is due to random variability in the computations in FUNWAVE. Similarly, the solution values will have random variability.

1. Select a time-step and switch between the *existing* and *reef* surface elevations.

Local edits in the reef area can be explored by creating additional simulations varying items such as:

- Duplicating the mesh and reducing the depth in the area of the reef.
- Varying the roughness to a greater degree in the area of the reef.

6 Conclusion

In this tutorial demonstrated the setup of a FUNWAVE simulation and exported the files for the analysis. The tutorial covered the following:

- Creation of datasets of the grid for input
- Creating datasets and using spatially varied input for a reef:
- Importing and Exporting the FUNWAVE files
- Reviewing FUNWAVE results

Documentation for the USACE version of FUNWAVE can be found at https://fengyanshi.github.io/build/html/index.html#.

Ideas for additional experiments with FUNWAVE:

- Look at plots for output point behind the breakwater
- Change wave height, period, direction
- Change damping behind the wave maker
- Average (mean) values
- Steps included below
- Including Hs, Hrms, and Ho variables