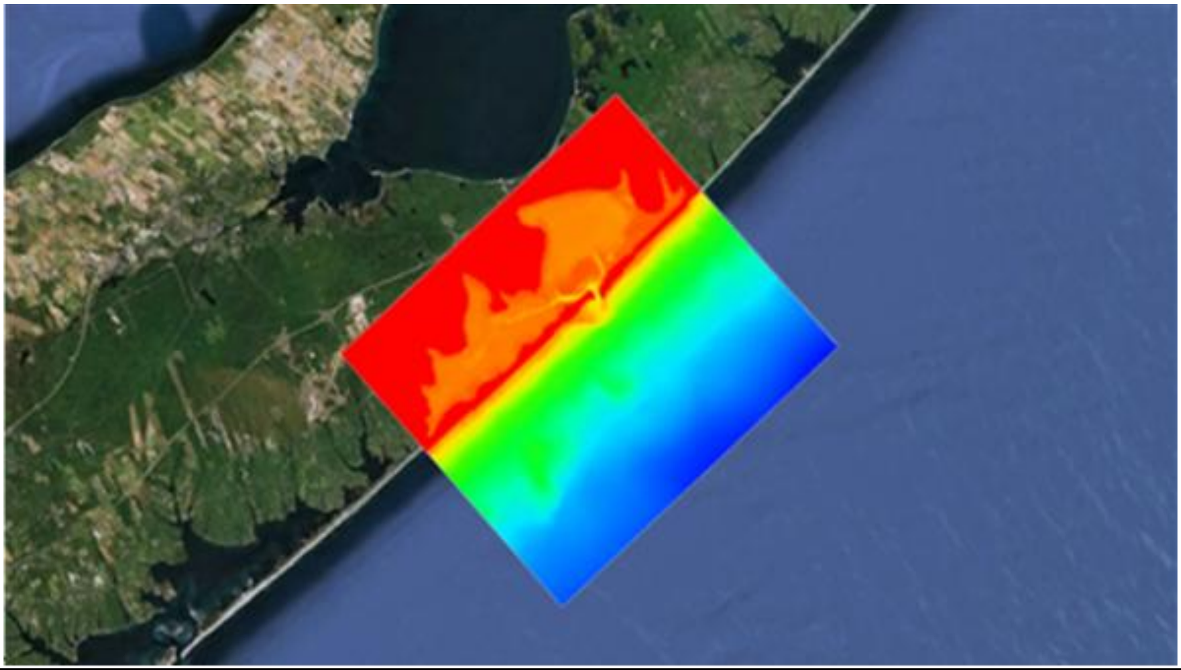
*SMS 14.0 Tutorial*

# *CMS-Wave Analysis*

## Creating a CMS-Wave model in SMS



## Objectives

This tutorial gives a brief introduction to the CMS-Wave interface and model. A previously-created grid will be used, CMS-WAVE will be run, and the results visualized.

### Prerequisite Tutorials

- Overview
- Map Module

### Required Components

- SMS Core
- CMS-Wave Model & Interface

### Time

- 15–30 minutes

# 1 Introduction

CMS-Wave is a part of the Coastal Modeling System which is maintained by the USACE. The model is a 2-D wave spectral transformation (phase-averaged). The term "phase-averaged" means that it neglects changes in the wave phase in calculating wave and other nearshore processes.

This model is similar to the STWAVE model which is also maintained by USACE. Differences include support for non-square and varying sized computation cells, inclusion of structures, treatment of a muddy bed, and a variety of other features.

This tutorial is based on data from the south shore of Shinnecock Inlet, Long Island, New York. For instructions on generating the cell centered grid refer to the tutorial “Creating a Cell-Centered Grid” and “Creating a Variable Resolution Cell-Centered Grid.

# 2 Getting Started

To open the project, do the following:

1. Launch SMS, select *File* | **Open...** to bring up the *Open* dialog.
2. Browse to the *data files* folder for this tutorial and select “shinnecock.sms”.
3. Click **Open** to import the project and exit the *Open* dialog.

The project should appear similar to Figure 1 (the color ramp of the contours may need to be reversed to more accurately match the figure). The project contains a 2D grid set to the CMS-WAVE model type. See the “Grid Generation” tutorial for information on how this grid was generated.

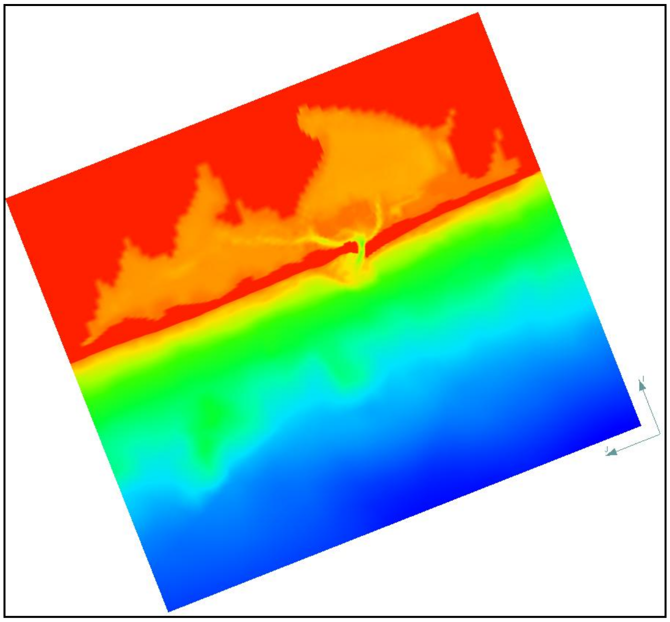


*Figure 1 Initial project appearance*

## 3 Generating Spectral Energy Distribution

To generate the spectral energy distribution by doing the following:

1. Right-click " Map Data" in the Project Explorer and select **New Coverage** to bring up the *New Coverage* dialog.
2. In the *Coverage Type* section, select *Generic* | **Spectral**.
3. Leave "Spectral" as the *Coverage Name* and click **OK** to close the *New Coverage* dialog.
4. Using the **Create Feature Point** tool, create a node near the middle of the bottom grid boundary (see arrow in Figure 2).

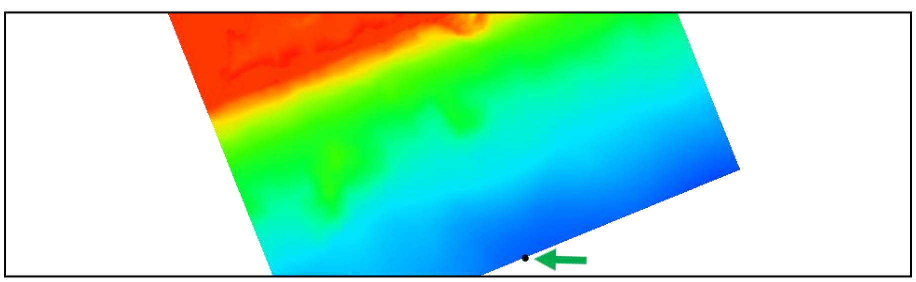


*Figure 2 Node near the middle of the bottom grid boundary*

5. Using the **Select Feature Point** tool, double-click on the node to bring up the *Spectral Energy* dialog.
6. Click on the **Update Reference Time…** button to make the *Time Settings* dialog appear. Enter "04/05/2018 12:00 AM" as the *Reference time*.
7. Click **OK** to close the *Time Settings* dialog.

8. In the *Spectral Manager* section, click **Create Grid** to bring up the *Spectral Grid Attributes* dialog.

Leave the *Grid angle (degrees)* as it is computed from the grid and “Local” as the *Spectral energy grid plane type.* This orients the spectra to the active grid.

9. Click **OK** to close the *Spectral Grid Attributes* dialog and open the *Create Spectral Energy Grid* dialog.
10. Click **OK** to create a new spectral energy grid and close the *Create Spectral Energy Grid* dialog.

The new spectral energy grid will appear in the *Spectral Manager* section below the four buttons at the top. This section is the spectral energy tree. The spectral grid just created is displayed in the *Spectral Viewer* section.

11. Click **Spectra** to bring up the *Generate Spectra* dialog.
12. In the *Spectral Parameters* section, enter the following parameters into the spreadsheet:

| Time Offset (hrs)/Index | Angle (deg) | Hs (m) | Tp (s) | Gamma | nn |
|---|---|---|---|---|---|
| 0.0 | 25.0 | 1.0 | 18.0 | 7.0 | 26 |
| 1.0 | 25.0 | 1.0 | 12.0 | 4.0 | 10 |
| 2.0 | 25.0 | 1.0 | 6.0 | 3.3 | 4 |

This set of wave conditions will evaluate three wave periods in the same direction as they approach the shore and inlet.

13. In the *Parameter Settings* section, select *Specify once for all spectra* under *Seaward Boundary Depth* and enter “32.0” (m) in the field below that.

This tutorial assumes that the wave gauge is approximately at the offshore edge of the grid. If the gauge was in deeper water, specify the actual depth of the gauge.

14. Click **Generate** to generate the spectrum and close the *Generate Spectra* dialog.

Three new spectrum timesteps should appear below the grid in the spectral energy tree. The "0.0000", “1.0000” and “2.0000” represent the time offset from the reference time in hours. The reference time is displayed below the tree control. This case illustrates how separate wave conditions can be illustrated as time steps.

15. Select each spectrum ("0.0000", “1.0000” and “2.0000”) in turn.

The contours show the energy distribution. The 18.0 second wave is quite focused and concentrated while the 6.0 second wave is much more distributed. Select cell corners to view/edit their energies. Feel free to experiment with rotating the spectra or viewing the frequency and/or direction distribution plots.

16. Click **Done** to exit the *Spectral Energy* dialog.

# 4 Assigning Observation Cells

CMS-Wave supports two methods for generating transformed spectra inside the domain. These include “Observation Cells” and “Nesting Points”. Functionally, these two options are almost identical. They are both supported to match historic functionality of the engine. This exercise will use “Observation Cells”. This requires that we define the location of the observation cells.

1. Right-click on " Map Data" in the project explorer and select **New Coverage** to open the *New Coverage* dialog.
2. Set the *Coverage Name* as "Observation Cells" and click **OK** to close the *New Coverage* dialog.

This coverage will be used for locations only, so the coverage type does not matter.

3. Using the **Create Feature Point** tool, create a point inside Shinnecock Bay as shown in the figure below.

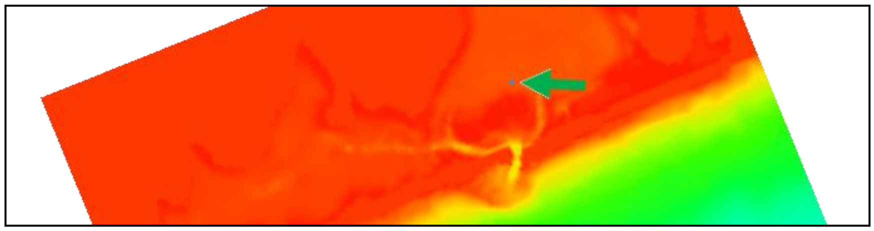


*Figure 3 The first selected cell (indicated by arrow)*

4. To illustrate putting this observation point at a specific location, such as at the location of a buoy, with the point still selected, change the X and Y coordinates in the Edit Window to "428397" for *X* and "77920" for *Y*.
5. Repeat steps 4–5 to add two more points with the coordinates (428501,76036) and (429701,71986). One of these is in the inlet and the other is offshore.

# 5 Setting up the CMS-Wave Simulation

Starting in SMS 13.2, the interface for CMS-Wave uses a simulation-based representation. The simulation-based approach allows for reuse of grids, spectral coverages and other model components. Multiple simulations can be created in a single SMS project file.

## 5.1 Creating the simulation

To create the simulation:

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

A new " CMS-Wave 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 "shin_half" for the simulation and press *Enter*.

## 5.2 Adding the Grid to the Simulation

A CMS-Wave simulation consists of a grid (basis of computations), spectra data, 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 " 20-200 meter Grid" object and select *Apply to* | **CMS-Wave Simulations→shin_half**.

Notice the " 20-200 meter Grid" grid item has been added under the " shin_half" simulation. The " 20-200 meter Grid" grid item creates a link between the simulation and the grid which tells the simulation to use the specified grid during the model run. If multiple simulations were in the project, the same grid can be linked to more than one simulation. Any changes to the grid will automatically be updated in every simulation using that grid.

# 6 Setting the Model Control

To edit the simulation parameters:

1. Right-click on the " shin_half" simulation and select **Model Control…** to bring up the *Model Control* dialog.

In the *Model Control* dialog, CMS-Wave inputs can be set for use in the model run. The dialog contains multiple tabs which will be discussed below.

## 6.1 Parameters

The *Parameters* tab contains general settings for the model run. Set the following options.

1. In the *Parameters* tab, change the *Source Terms* to "Propagation Only". (This means that you will not specify wind conditions to simulate wave generation in the domain.)
2. Leave the other settings at their default and continue to the next section.

## 6.2 Boundary control

The *Boundary control* tab contains options for assigning spectral data for the model run.

1. Select the *Boundary control* tab in the *Model Control* dialog.
2. Leave "Spectral coverage" in the *Source* combo box.
3. In the *Sides* section, next to "Specified spectrum" click **Select…** to open the *Select Spectral Coverage for Side 1* dialog.
4. Select the " Spectral" coverage and click **OK** to close the *Select Spectral Coverage for Side 1* dialog.
5. Click the **Populate** button to automatically enter case times associated with the spectra in the spectral coverage. (Note: this button also changes the reference time to match the time specified in the coverage.)

Note: while it is common for the computational spectrum grid and the times for the cases to match the spectral coverage, it is not required. SMS will redistribute the spectral energy and interpolate between spectral times if needed.

### 6.3 Output Control

The *Output Control* tab contains additional options for outputting results from the CMS-Wave model run.

1. Select the *Output control* tab in the *Model Control* dialog.
2. Turn on *Use observation cells*.

This instructs CMS-Wave to compute full spectra at the specified locations.

3. Click **Select** to open the *Select Monitoring Cell Coverage* dialog.
4. Select the "Observation Cells" coverage.
5. Click **OK** to close the *Select Monitoring Cell Coverage* dialog.

This defines the locations that will be passed to CMS-Wave.

### 6.4 Options

The *Options* tab contains options when running CMS-Wave. This simulation will use the default options.

1. Select **OK** to exit the *Model Control* dialog.

## 7 Running CMS-Wave

To run CMS-Wave:

1. Right-click on the " shin_half" simulation in the Project Explorer and select **Save Project, Simulation and Run**. The *Simulation Run Queue* dialog will appear.

   (Note: If a message such as "CMS-Wave.exe – not found" is given, click the file browser button to manually find the CMS-Wave executable. The default installation location for this executable is relative to the SMS installation folder ".\python36\Lib\site-packages\cmswave_exe".)

A *Simulation Run Queue* dialog will show the progress of the CMS-Wave run.

2. When CMS-Wave finishes, select **Load Solution**.

The solution will be loaded into SMS under the " 20-200 meter Grid" object in a folder named "shin_half (CMS-Wave)" and consists a datasets of wave height, wave period, wave direction and vector dataset to display the direction.

3. Select *Edit* | **Time Settings…** to bring up the *Time Settings* dialog.
4. Set *Display as* to "Absolute Date/Time".
5. Click **OK** to close the *Time Settings* dialog.

### 7.1 Visualizing the CMS-Wave Solution

To see the solution results:

1. Select *Display* | **Display Options** to bring up the *Display Options* dialog.
2. On the list on the left, select *Cartesian Grid*.

3. Turn on the *Contours* and *Vectors* options.
4. Select the *Contours* tab.
5. For the *Contour Method* select "Color fill" and set the *Transparency* to "20" percent.
6. Select the *Vectors* tab.
7. Under *Vector Display Placement and Filter,* change the *Display* to "on a grid." Leave the spacing at "30" pixels in each direction.
8. Set the *Origin* to be "Relative to max elevation".
9. Select **OK** to close the *Display Options* dialogs.

The " Wave Direction" scalar dataset under the " 20-200 meter Grid" grid was the last dataset loaded so it is active.

Note:

- The vectors display the direction of the waves. As the wave approaches the shore the wavelength shortens so the waves bend towards the shoreline.
- The scalar direction value is relative to the grid orientation as computed by CMS-Wave (0.0 are waves moving in the shore normal direction.)

10. Select the " Wave Height" scalar dataset under the " 20-200 meter Grid" grid. The first *Time step* (representing an 18.0 second wave) is active.

Note:

- Wave height is 1.0 meter on the offshore side of the grid as was specified in the input wave conditions.
- Wave height increases as the waves crest near the shore.
- A small amount of wave energy penetrates through the inlet into the bay.
- This simulation is not set up to simulate reflections so only forward dispersion of the wave into the bay is represented and the waves do not penetrate to the back corners of the bay.

The display should appear like Figure 4.

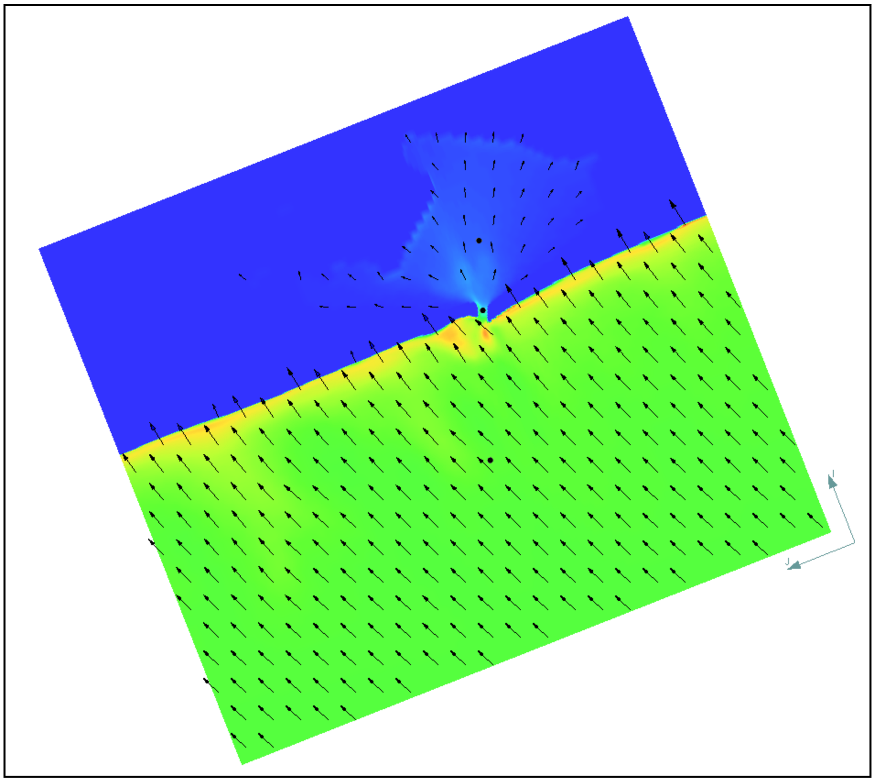


*Figure 4 CMS-Wave results*

11. Select each *Time step* in turn (the second represents a 12.0 second wave and the last represents a 6.0 second wave).

Note:

- As the wave energy is less concentrated, there is less of a build-up of waves as they approach the shore.
- The wave period also has some effect on the amount of energy that penetrates through the inlet.

## 7.2 Visualizing the Spectral Energy

The spectral energy is recorded at each observation cell (or nesting point) in the simulation and written by CMS-Wave to an observation file (*.obs) (or nesting (".nst") file for nesting points). These file is automatically read in at the end of a CMS-Wave run. The data in this file is put into a spectral coverage. In this case the coverage is named " shin_half – OBSE". To view the spectral energy:

1. Select the coverage " shin_half – OBSE" in the Project Explorer to make it the active coverage. (Note: it is in the (shin_half (CMS-Wave)" solution folder.)

Notice that there are nodes at each of the monitoring locations specified in the " Observation Cells" input coverage.

2. Double-click on the offshore observation node using the **Select Feature Point** tool to bring up the *Spectral Energy* dialog.

Notice the spectra at this location are very similar to the input spectra on the offshore boundary. It has not transformed much to this location in the grid. The energy is mostly coming from the right of shore normal and the energy density is up to 4.4. (Note: the peak energy in the input spectra was around 5.1. These values can be examined by selecting points on the spectral grid or going to the contour options for the spectral display.)

3. Click **Done** to close the *Spectral Energy* dialog.
4. Double-click on the observation node in the inlet using the **Select Feature Point** tool to bring up the *Spectral Energy* dialog.

Notice the spectra at this location has transformed. The energy is now to the left of shore normal, and the energy density has dissipated down to less than 1.0.

5. Click **Done** again to close the *Spectral Energy* dialog.
6. Double-click on the observation node in the bay using the **Select Feature Point** tool to bring up the *Spectral Energy* dialog.

Notice the spectra has spread out, changed direction and dissipated even more.

7. Click **Done** to exit the *Spectral Energy* dialog.

# 8 Conclusion

This concludes the initial "CMS-Wave Analysis" tutorial. The model contains many more features and capabilities that have not been explored in this document. Refer to the CMS-Wave User Manual and the SMS help file found in *Help* | **SMS Help…** for more information.