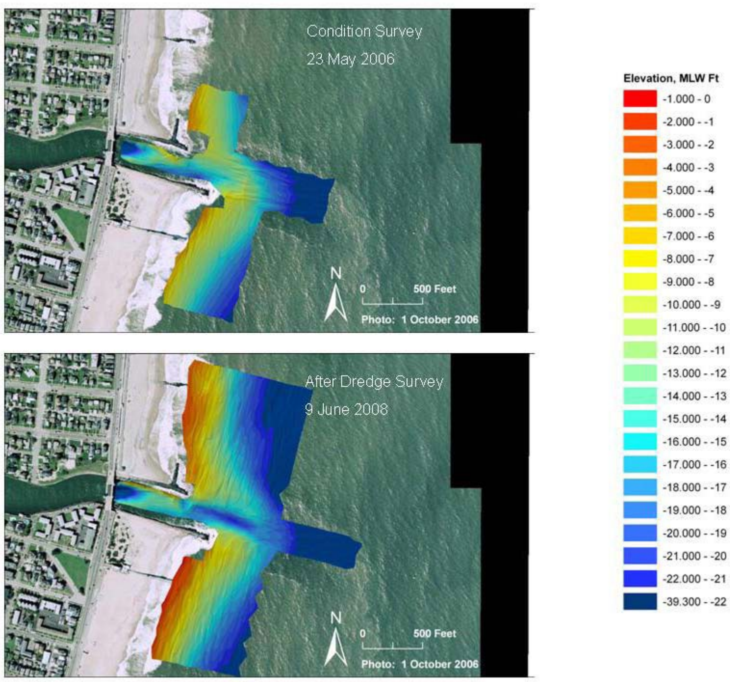
**19-23 September 2022**

# Setting up CMS-Wave




Shark River Inlet, NJ

The Shark River Inlet, NJ, is used as an example to demonstrate steps in creating the CMS-Wave grid using the SMS13.1.24. Look in folders for the last section for files to start from.

## 1. Importing the Scatter Set Data File(s)

To generate the necessary CMS-Wave grid we begin with uploading the existing scatter set data (topography and bathymetry) of the area around the Shark River Inlet to the SMS. The SMS screen appears in the **Scatter module** similar to Figure 1. It may be necessary to merge multiple scatter data sets before this step. (See training on bathymetry conversion to a merged final scatter dataset.)

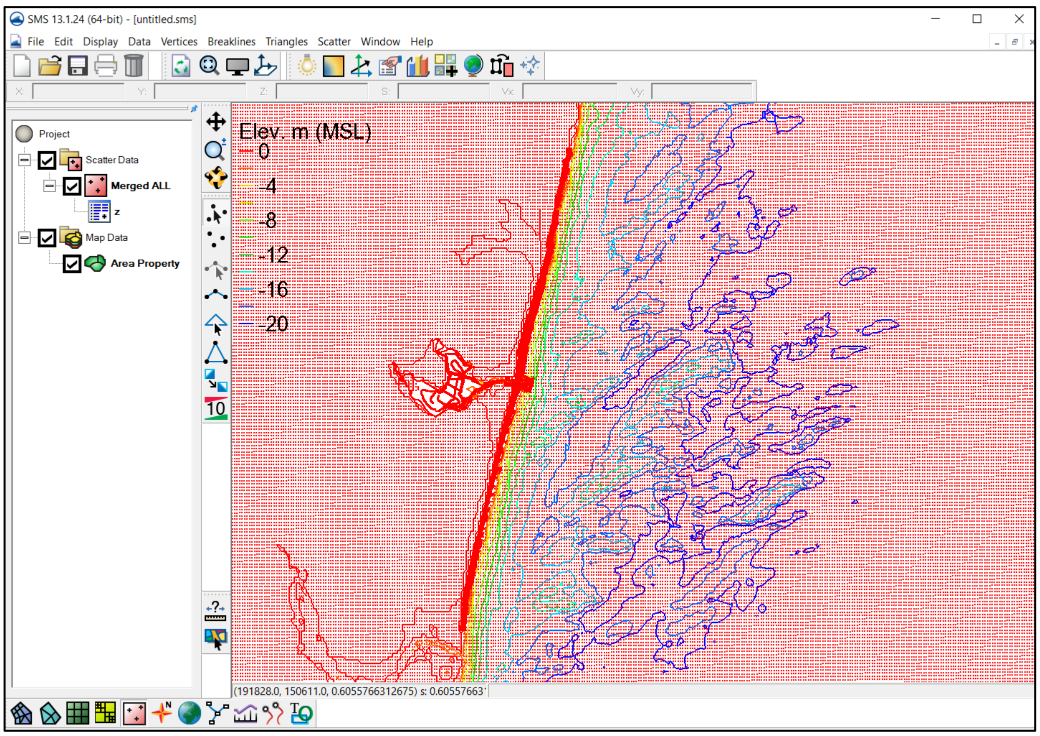



Figure 1. Scatter set appearance in the SMS screen.

It is optional to set the **Display Projection**, under the **Display** selection in the SMS, to a Global projection (e.g., Add projection from: State Plane Coordinate System under the *Library* option) or stay in the local system (No projection).

When generate a new CMS-Grid and project file in the SMS, it is important to check or set up the display projection to ensure that individual datasets and model grids are properly projected and aligned to the correct horizontal and vertical coordinates. Make sure to select the Units in “Meters” (metric system).

To check/change the coordinate selection for the Global projection:

- Select *Display* | **Display Projection**… Check *Global projection* and click *Set Projection* to open the *Horizontal Projection* dialog.
- If a horizontal coordinate system has been applied previously, it will be listed under *Recent Projections* which users can select (click to highlight the selection) in the list for the present model coordinates. The projection information is given in the same dialog under the *Add projection from* options.
- To specify a new horizontal coordinate system, users can use the *Add projection from* | Library option to open the *Select Projection* dialog.
- In this example with the *Select Projection dialog*, select "State Plane Coordinate System (NAD83)" from the *Projection* drop-down.
- Select "New Jersey (FIPS 2900)" from the *Zone* drop-down (Figure 2).
- Select "NAD83" from the *Datum* drop-down.
- Select "METERS" from the *Planar Units* drop-down.
- Click **OK** to close the *Select Projection* dialog. Click **OK** to close the *Horizontal Projection* dialog.
- In the *Vertical* section (under the *Display Projection*), select "Meters" from the *Units* drop-down.
- Click **OK** to close the *Display Projections* dialog.

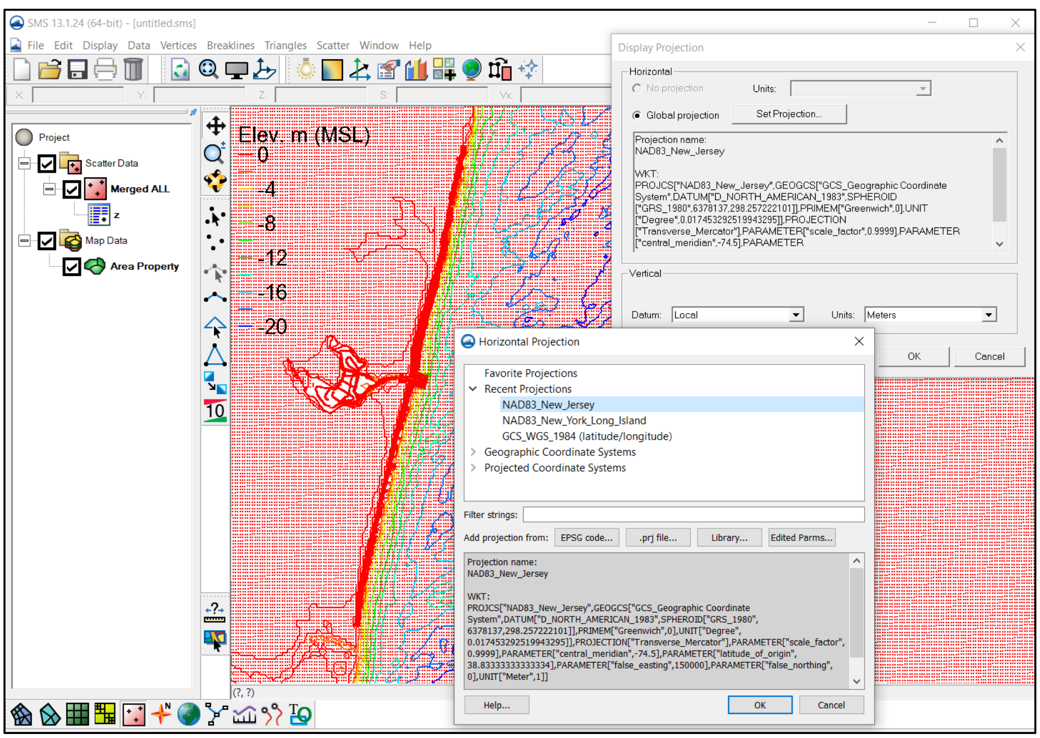


Figure 2. Display Projection dialog.

After the global coordinates are specified, it is necessary to check if the applied coordinates are correct by comparing with online aerial images or maps.

- Click the "**Add Online Maps**" tool icon, , to bring up *Get Online Maps* dialog. Click a map imagery to select (e.g., "World Imagery").
- Click **OK** to close the dialog and display the selected map image (Figure 3).

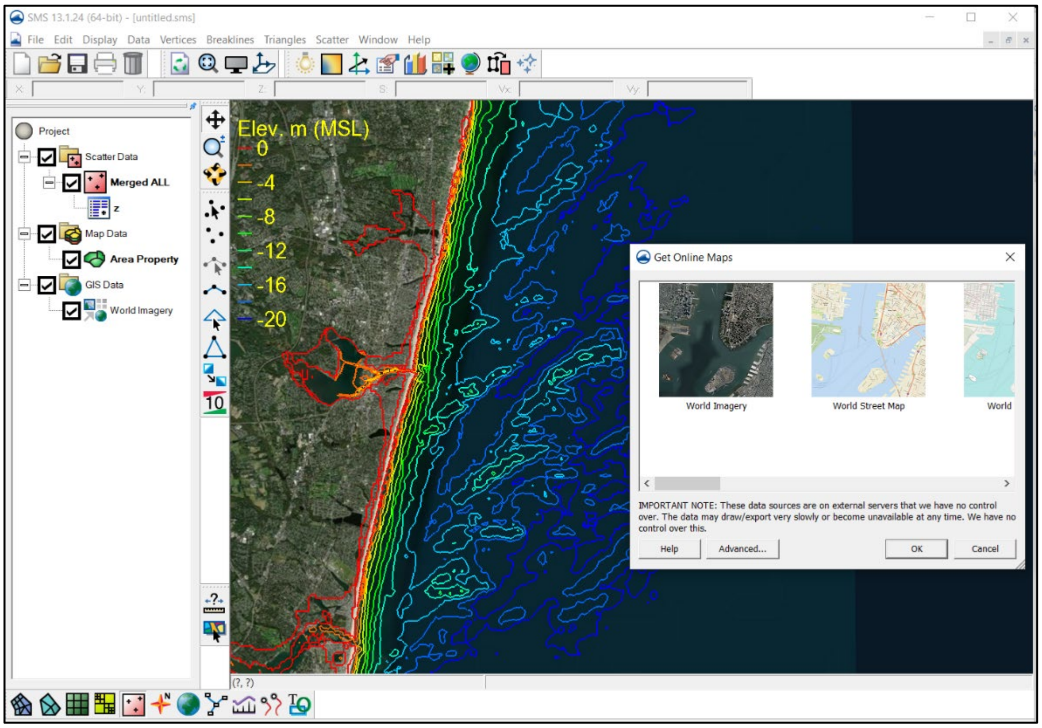



Figure 3. Map image appearance in the SMS screen.

## 2. Creating the Cartesian Grid for CMS-Wave

The Cartesian grid for CMS-Wave is created in the **Map module**.

- Switch to the "**Map module**".
- Right-click "**Area Property**" under the " Project" (in the Data-Tree box), select *Type* | **Models** | CMS-Wave.
- Right-click "**Area Properties**" and select *Rename*.
- Enter "CMS-Wave" and press *Enter* to set the "CMS-Wave" name.
- Using (click) the **Create 2-D Grid Frame** tool, click out three corners of the grid in the order shown in Figure 4 to create the grid frame. The first two points (Points 1 & 2) clicked define the local x-direction (point toward the land), which is the direction of the incoming waves (normal to the general shore orientation), and the last two points (Points 2 & 3) clicked are placed on the land.

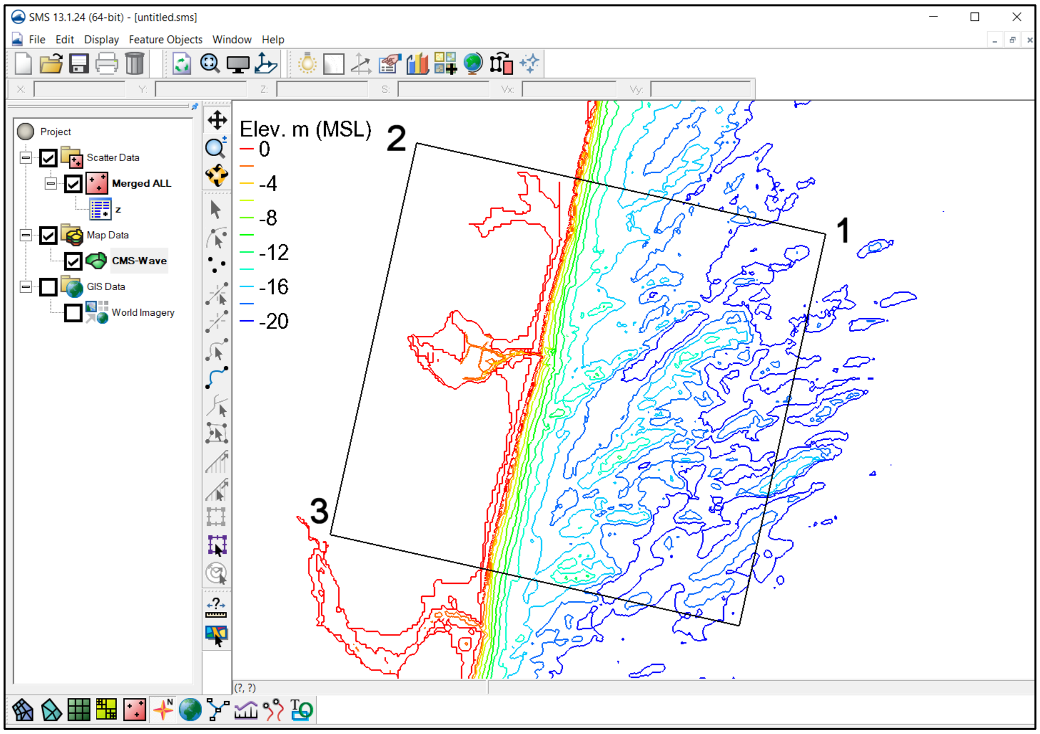



Figure 4. Creating the Cartesian grid frame.

- For CMS-Wave it is important to always start on the ocean side and then click on the landward side to tell CMS-Wave which direction to calculate values.
- Using (click) the **Select 2-D Grid Frame** tool, click on the selection box in the middle of the grid frame. In this example, the origin should be located in the top right corner of the grid, as indicated by the arrows (Figure 5).
- Resize the grid frame by dragging the edges until the grid frame fits properly over the desired area (CMS-Wave model domain). Dragging a corner or any side resizes the frame. Dragging the middle point moves the entire frame. Rotate the frame around the origin by holding and dragging the circle (handle) located at the top left corner just outside the grid.
- Right-Click on the middle point and click 'properties' to bring up the *Grid Frame Properties* dialog. The origin and grid angle (also the frame dimension) can be manually entered (adjusted) in this dialog. This dialog allows for greater precision in placement of the grid (Figure 6).
- In this example, the *Grid Frame Properties* dialog shows a constant cell size of 10 m x 10 m (default). There are 1350 and 1345 cells in the local I (local x) and J (local y) directions, respectively, with this grid frame. For CMS-Wave, users should keep the maximum cell numbers along each of the local x and y directions within 2500, which is specified in the model to avoid the overuse of the computer memory.

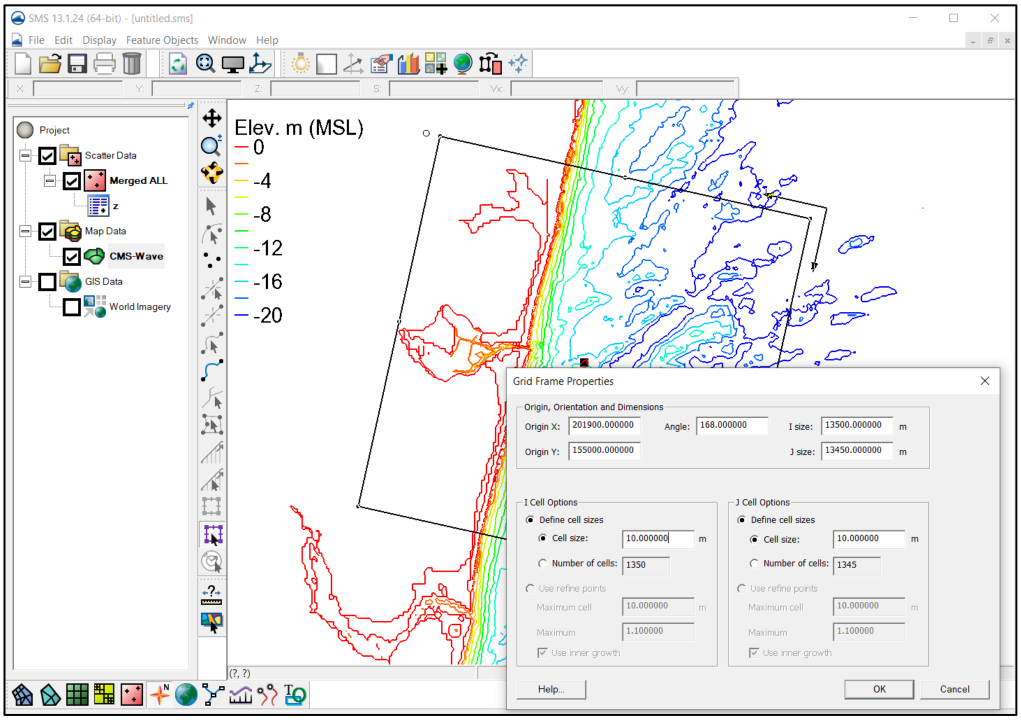



Figure 5. Selecting and adjusting Cartesian grid frame.

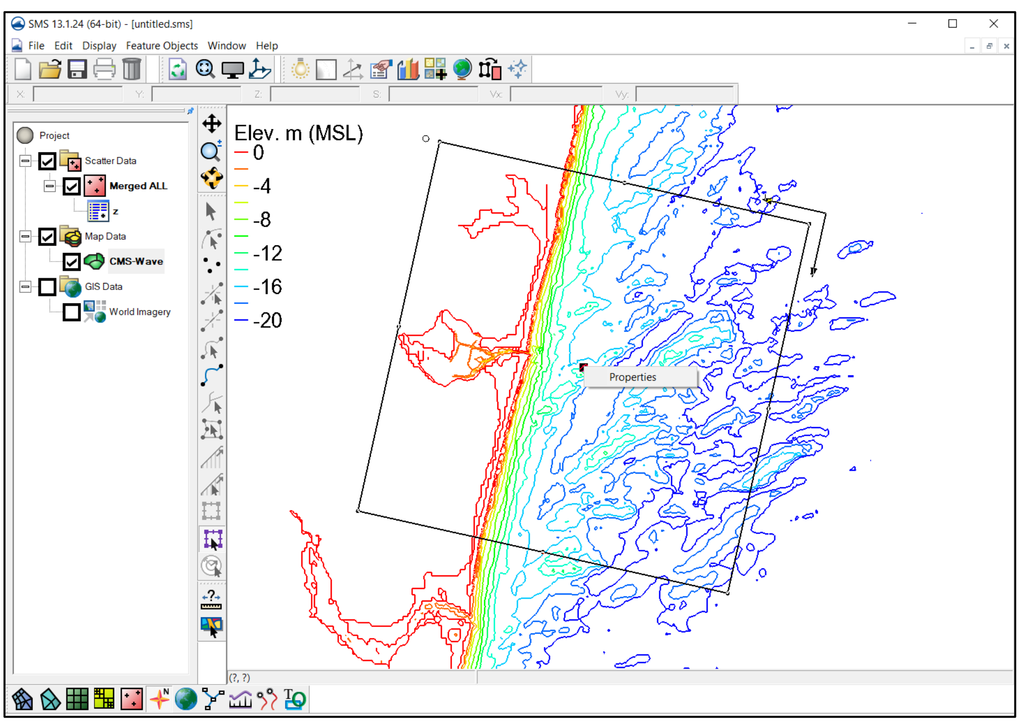



Figure 6. Display Grid Frame Properties dialog.

Users can reduce these cell numbers by using variable cell size in the model grid.

- In the **Map module**, use **Create Feature Point** tool to specify a pair of feature points or multiple pairs of feature points. Using (click) **Select Feature Point** tool, users can click and hold a feature point to move it to a different location. Select each pair of points (drag a box area to enclose each pair of points) and right-click to select the "Point Attributes…" in the drop-down menu (Figure 7). This will bring up *Refine Point* dialog (Figure 8).
- Select either I or J or both I J directions and provide the Base cell size (specifying finer cell size). In this example, a 10-m cell spacing was specified for both I and J directions. Click **OK** to close the dialog.

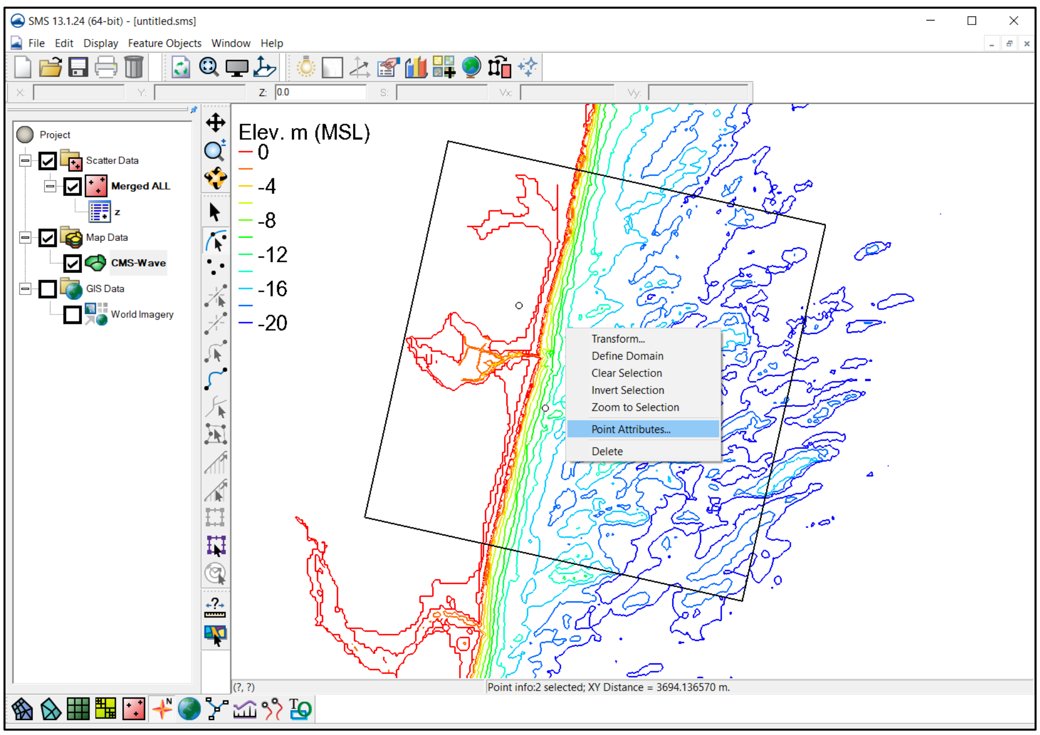



Figure 7. Display Feature Point properties menu.

- Once the refine feature points with the base cell size(s) were specified, return (click) to the *Grid Frame Properties* dialog . Select "Use refine points" to provide Maximum cell size and also Maximum (factor) for transition of fine cells (base cell size) to coarse cells (maximum cell size) as shown in Figure 9.
- In this example, specify 200 m for Maximum cell size and 1.05 for Maximum (growth factor) in both I and J directions.

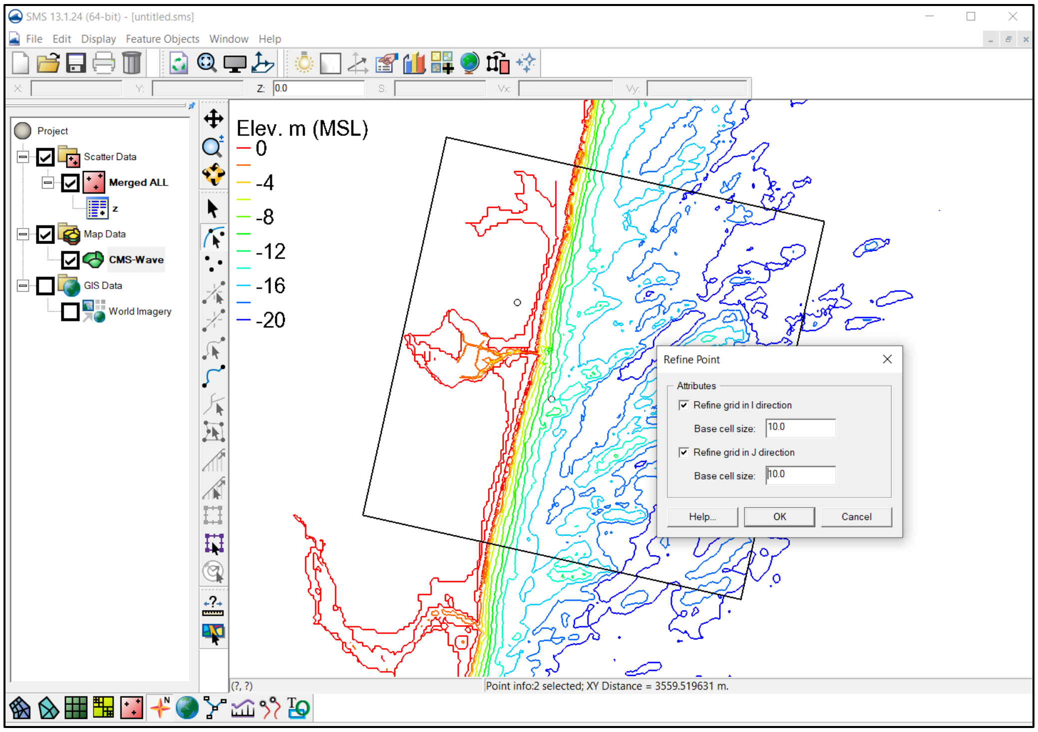



Figure 8. Specifying refine base cell size(s).

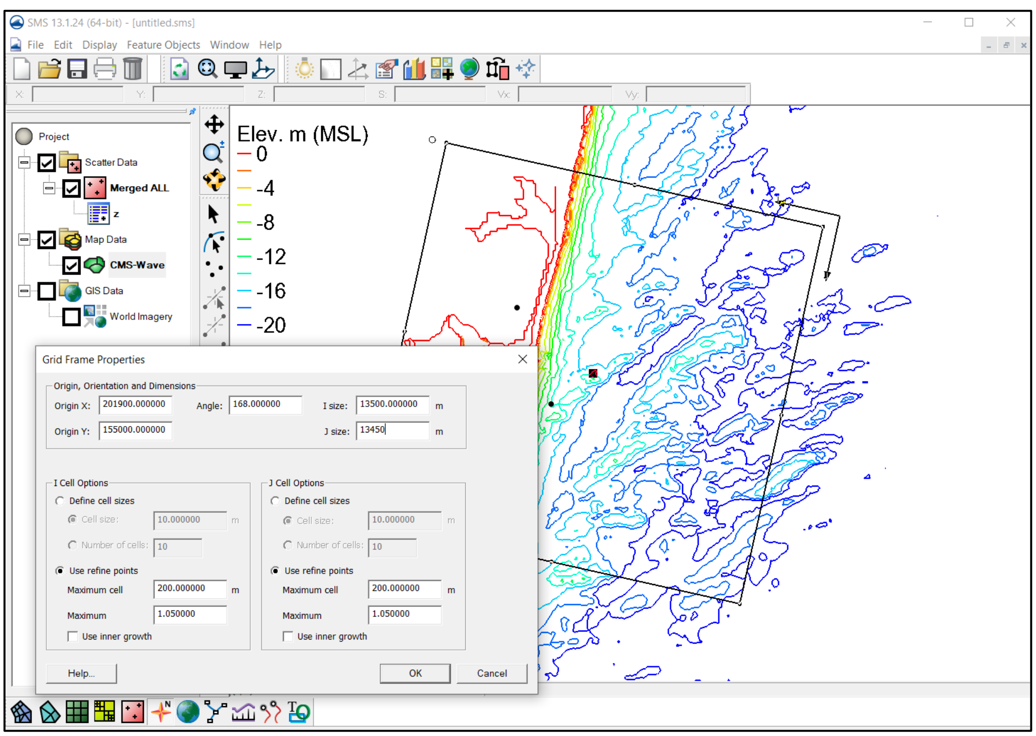



Figure 9. Specifying refine point maximum cell size(s) and maximum growth factor.

The information in the *Grid Frame Properties* dialog can be edited as desired in this stage. In the *Use refine points* feature, there is also choice to apply *Use inner* *growth* for each pair of refine feature points. This feature is not typically applied for most grid generations (Figure 9).

- Click **OK** to close the *Grid Frame Properties* dialog.
- Select *Feature Objects* | **Map→2D Grid** to bring up the *Map → 2D Grid* dialog (Figure 10).
- Verify values in the *Origin, Orientation and Dimensions* section. In the *Depth Options* section, select "Scatter Set" (the default is "Constant" with Depth: 0.0) from the *Source* drop-down (Figure 10).
- Then, click **Select…** to bring up the *Interpolation* dialog (Figure 11).
- In the *Scatter Set To Interpolate From* section, select (click to highlight) one scatter set from the list of available scatter set data.
- In the *Interpolation Options* section, select "Linear" (the default) from the *interpolation* drop-down and "Inverse Distance Weighted" from the *Extrapolation* drop-down (Figure 11).
- Click **OK** to exit *Interpolation Options* dialog.
- Click **OK** to exit the *Map → 2D Grid* dialog and create the CMS-Wave grid (Figure 12). The Cartesian Grid Data appears now with CMS-Wave Grid in the Data-Tree box.

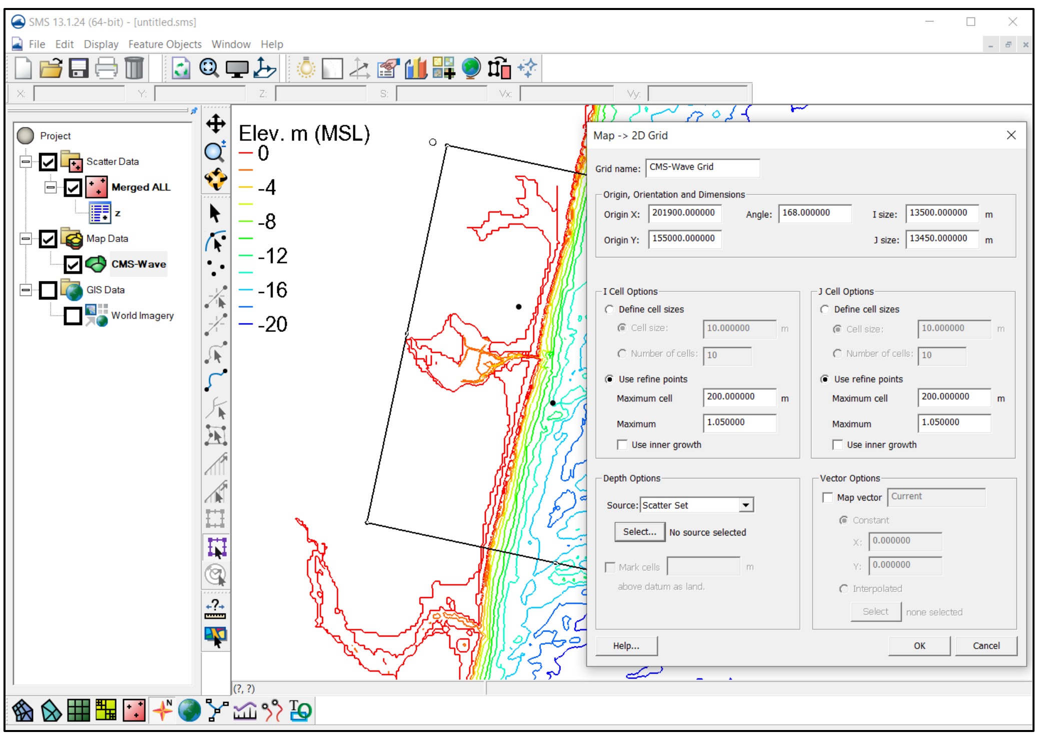



Figure 10. Display Map→2D dialog.

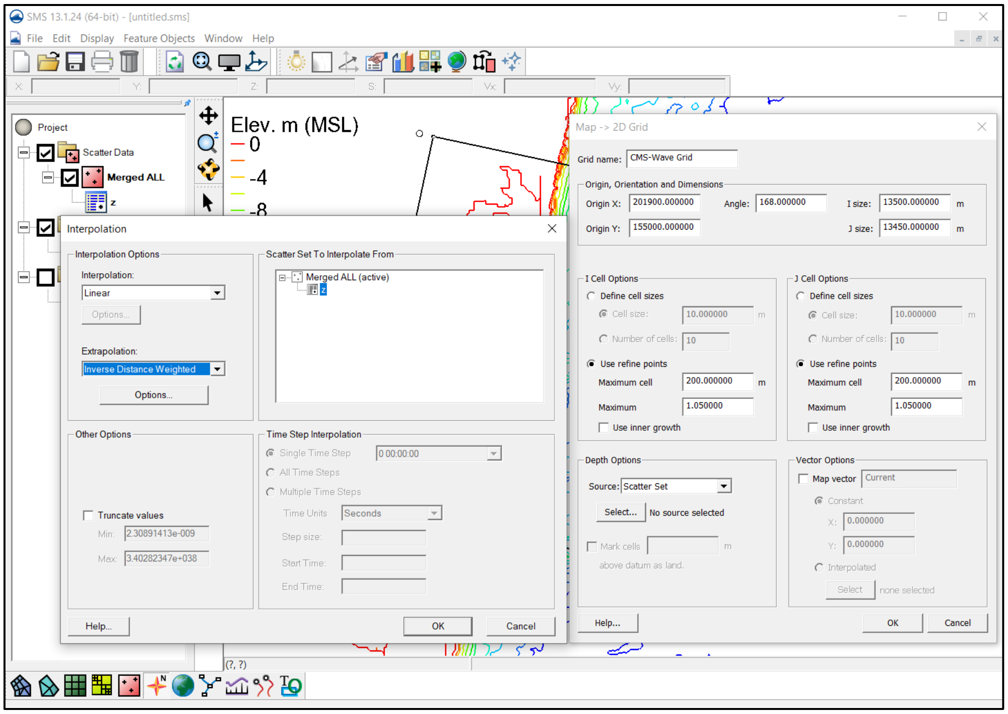



Figure 11. Display *Interpolation* dialog.

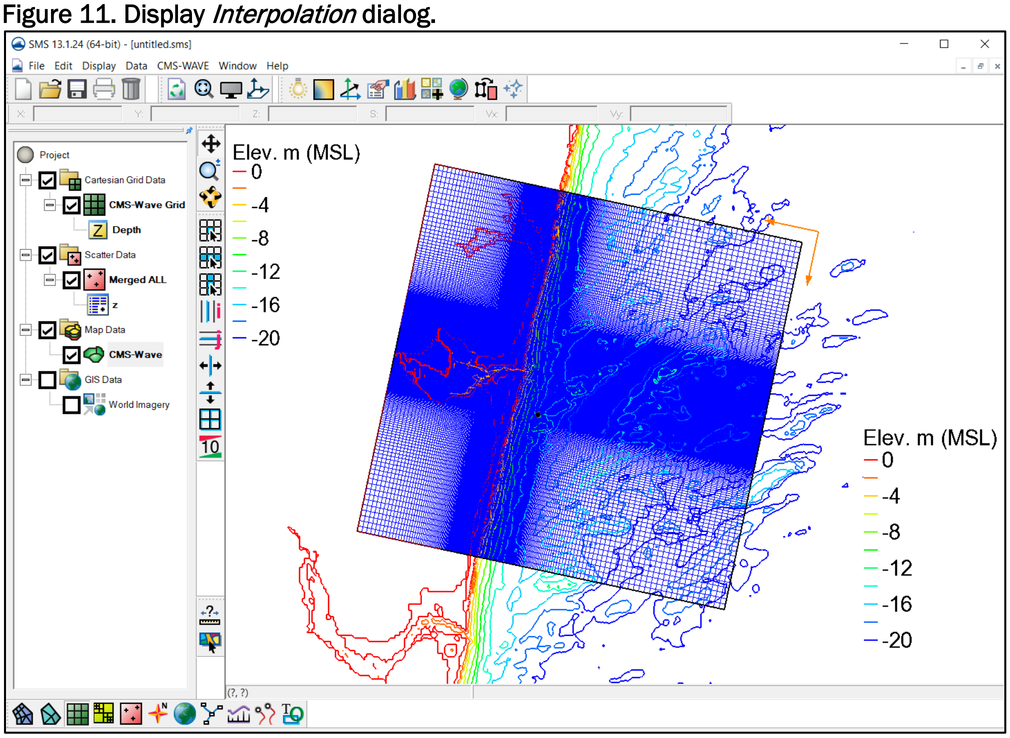



Figure 12. CMS-Wave grid with variable cell size.

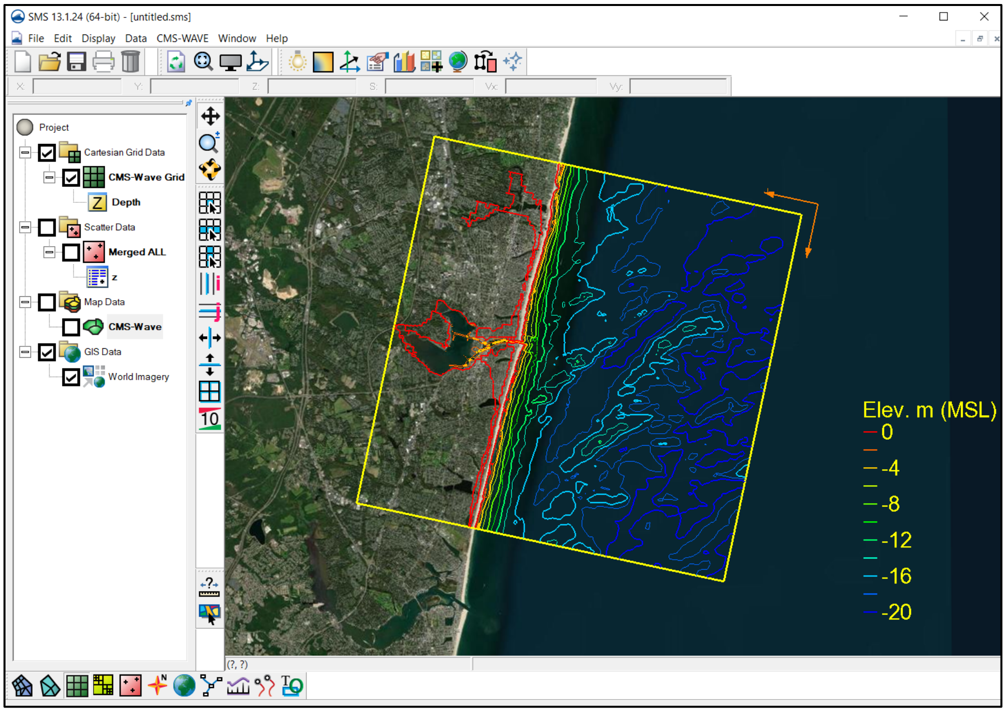



Figure 13. CMS-Wave grid with bathymetry contours.

Figure 13 shows the CMS-Wave domain with bathymetry contours. Use Get Info dialog box (under "File") to display the total number of cells in in the CMS-Wave grid domain, which is now 442 x 334 cells. If a constant cell size 10 m is applied, there will be 1350 x 1345 cells (Figure 6) in the same domain. Because the CMS-Wave runtime is approximately proportional to the total number of cells, it is more efficient to use the variable cells for CMS-Wave.

- Select *File* | **Get Info**… to open Display the *Information* dialog which provides the number of rows and columns in the **Cartesian module** (Figure 14).
- In the Cartesian module, Select *File* | **Save As** to bring up the *Save As* dialog.
- Select either "Project File (**.sms*)" or "CMS-Wave simulation (**.sim*)" from the *Save as type* drop-down and provide "File name:" (Figure 15).
- Click **OK** to exit *Save as type* dialog and saved CMS-Wave grid files (**.sim*, **.std*, **.dep*, and **.struct* or **grds.h5*).

The description of more details of CMS-Wave grid files can be found in the CMS-Wave Technical Reports (https://erdc-library.erdc.dren.mil/jspui/bitstream/11681/7653/8/CHL-TR-08-13.pdf).

It is important to check/review the created CMS-Wave grid for proper coverage and resolution of the modeling area. It may be necessary to use additional survey or shoreline data or registered aerial imagery data to improve/update the model grid bathymetry.

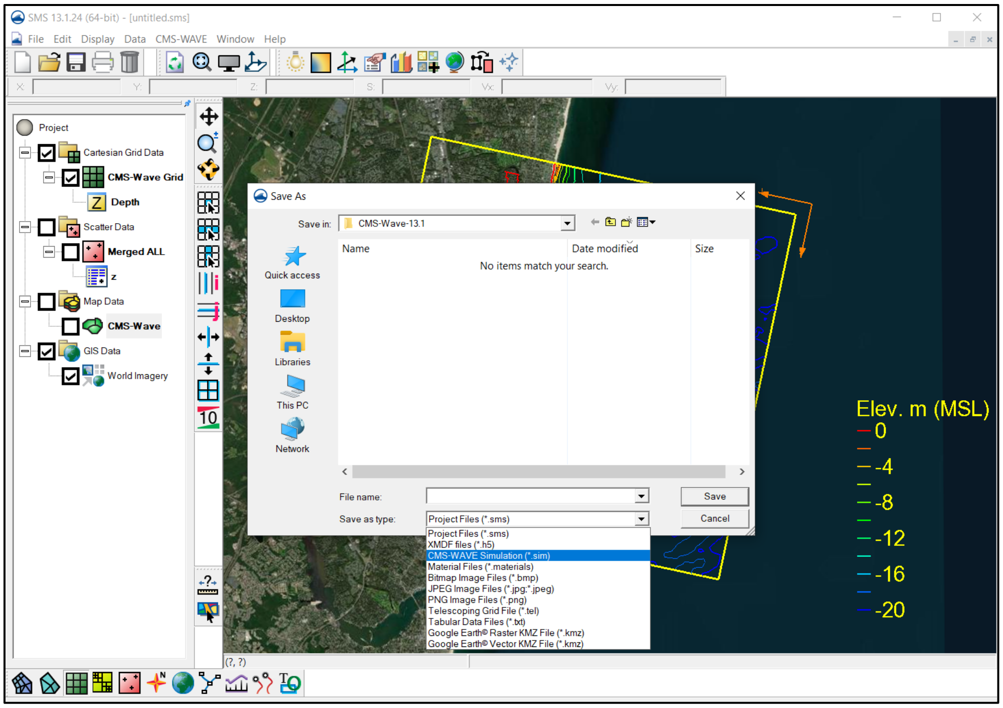



Figure 14. Display *Information* dialog.

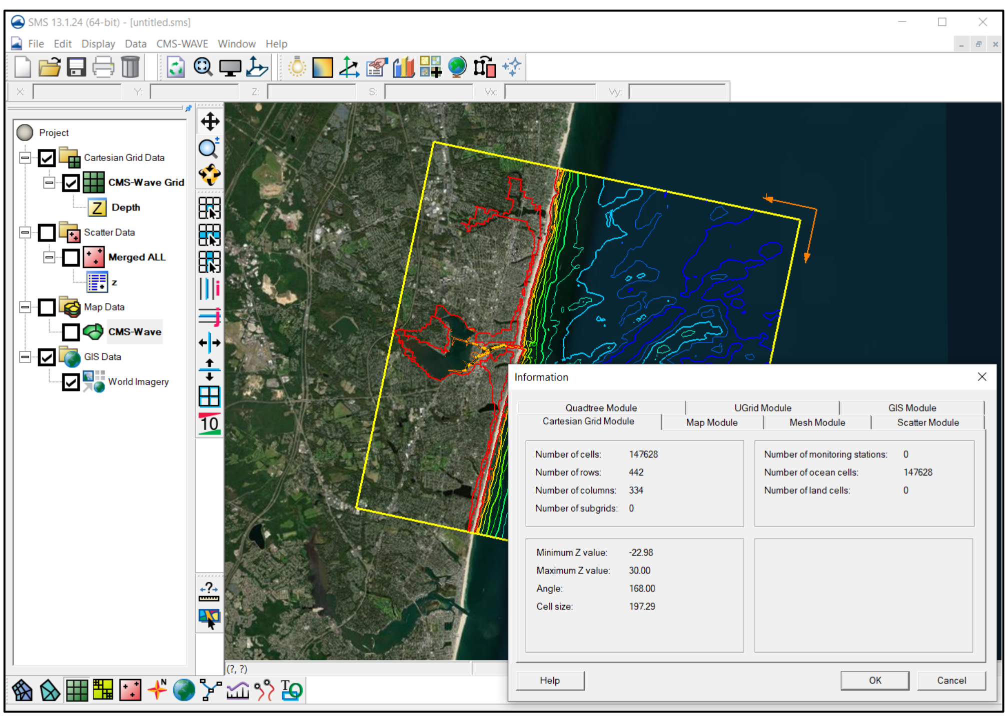



Figure 15. Display *Save as type* dialog.

# 3. Generating Wave Spectral Input for CMS-Wave

The basic application of CMS-Wave is typically for a linear coastline (with depth contours parallel to shoreline) where wave input (incoming or incident waves) may only be required along the seaward boundary. Because CMS-Wave is a steady-state model, the simplified wave input in this case would be a constant wave condition specified along the seaward boundary. The essential wave input to CMS-Wave is binned, directional wave spectral data. It can be the hypothetical or design wave condition(s), hindcast wave condition(s), or directional wave data collected in the field.

The SMS can generate the wave spectral input file for CMS-Wave.

- Upload CMS-Wave grid file (**.sim*) to the SMS.
- Right-click " Map Data" in the Project Explorer (Data-Tree window) and select **New Coverage** to bring up the *New Coverage* dialog.
- In the *Coverage Type* section, select *Generic* | **Spectral** (Figure 16).
- Click **OK** to close the *New Coverage* dialog.
- Using the **Create Feature Point** tool to create a node near the grid seaward boundary.
- Use **Select Feature Point** tool, double-click on the node to bring up the *Spectral Energy* dialog (Figure 17).
- In the *Spectral Manager* section, click **Create Grid** to bring up the *Spectral Grid Attributes* dialog (Figure 17).
- The *Grid angle* is the same as the grid orientation angle specified in Figure 6 or 9 (in this case, it is "168" deg). The Spectral energy grid plane type can be either "Global" or "Local", selected in the *Spectral energy grid plane type* drop-down menu. In this example, "Local" is specified.
- Click **OK** to close the Spectral Grid Attributes dialog and also open the *Create Spectral Energy Grid* dialog (Figure 18).
- In the *Frequency Distribution* section, enter "30" (default) in the example as the Number (the total number of frequency bins), "0.01" (default) Hz as the Delta (a constant frequency bin interval or increment), and "0.04" (default) Hz as the Minimum (the smallest frequency bin). In this case, the Maximum (the largest frequency bin) is "0.33" Hz. That is, the corresponding 30 wave period bins used in CMS-Wave will be ranging from 3 second (0.33 Hz) to 20 second (0.04 Hz).
- For coastal applications in the Gulf of Mexico, users may enter "40", "0.01", and "0.06" as the Number, Delta, and Minimum, respectively, which correspond to 40 frequency bins covering wave periods ranging from 2.2 second to 17 second (The sea basin of Gulf of Mexico is much smaller than the Atlantic and Pacific Oceans. Accordingly, spectral waves in the Gulf of Mexico are skewed more towards higher frequencies than waves in the Atlantic and Pacific Oceans).

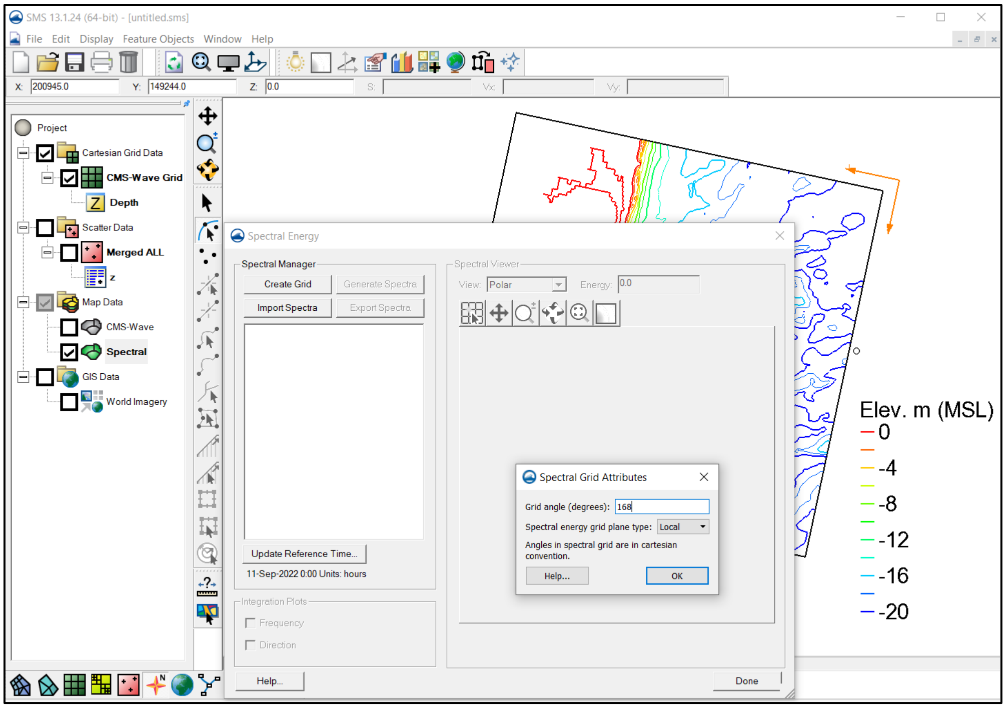



Figure 16. Display *New Coverage* dialog.

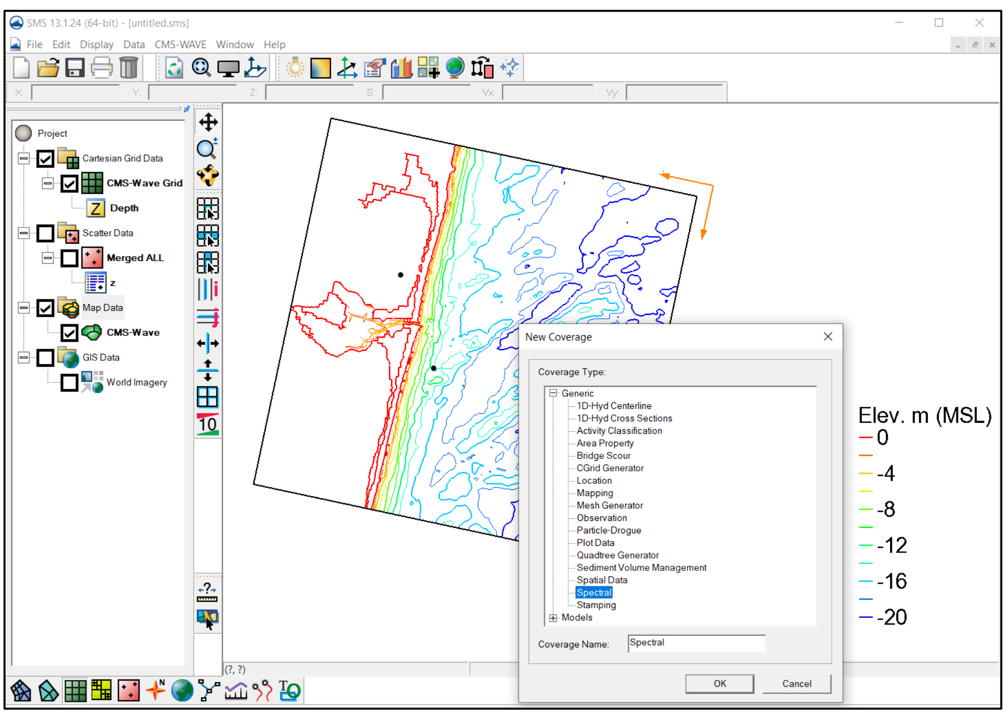



Figure 17. Display *Spectral Energy* dialog and Spectral Grid Attributes.

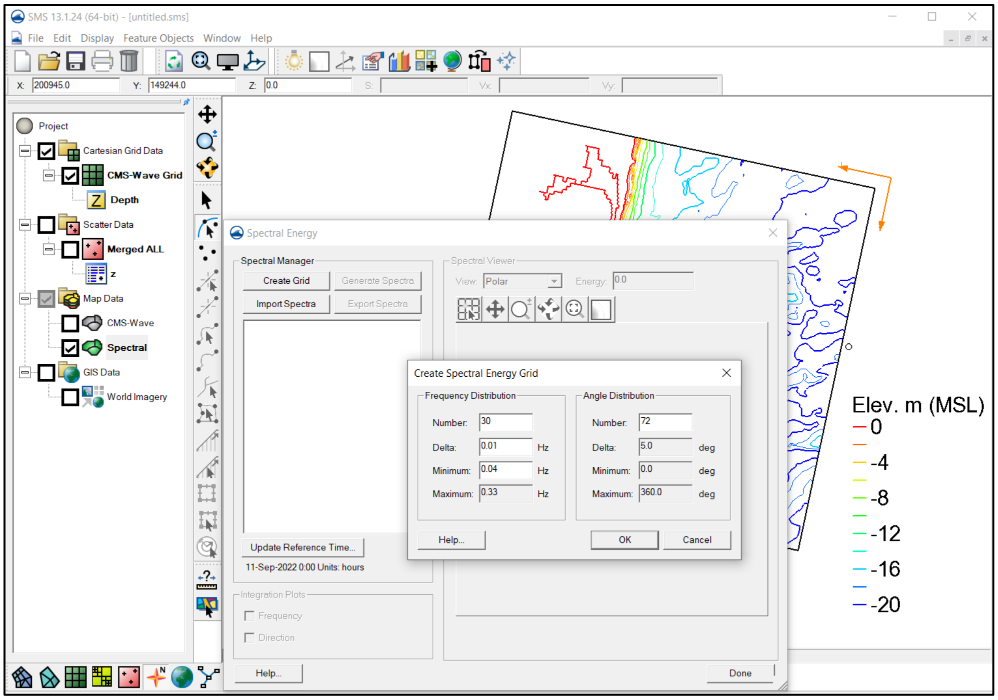


Figure 18. Display Create Spectral Energy Grid dialog.

- Click **OK** to close the *Create Spectral Energy Grid* dialog, and also create the specified spectral energy grid which covers 360-deg range (Figure 19). Note the bold radial line shown in the spectral energy grid corresponds to “0” degree of the “Local” plane in the Global (meteorological) coordinate system.
- Click **Generate Spectra** to bring up the *Generate Spectra* dialog. In the section of *Parameter Settings*, select (click) “TMA (shallow water)” spectrum in the *Generation Method* drop-down menu. In the *Angle Settings* section, select “Shore Normal” from the Projection drop-down menu (Figure 19).
- In the *Spectral Parameters* section, enter the following parameters in the given spreadsheet (Figure 20). The “Angle” is the mean wave direction (‘to’ direction in the mathematical and “Local” convention). The “Hs” and “Tp” are significant wave height (m) and spectral peak period (second), respectively. The “Gamma” is the peak enhancement parameter in the TMA or JONSWAP (deep water range) spectrum. The “nn” is the power (an even number) of a cosine-type function for distribution of wave energy with respect to the mean wave direction.

| Time (hr)/index | Angle (deg) | Hs (m) | Tp (s) | Gamma | nn |
|---|---|---|---|---|---|
| 0.0 | -20.0 | 2.0 | 8.0 | 3.3 | 50 |
| 3.0 | 0.0 | 2.0 | 8.0 | 3.3 | 50 |
| 6.0 | 20.0 | 2.0 | 8.0 | 3.3 | 50 |

- In the *Parameter Settings* section, select *Specify once for all spectra* under the *Seaward Boundary Depth* and enter the depth value in the box field below (it is "the average depth" along the grid seaward boundary).
- Enter "20.1" m for the *Seaward Boundary Depth* (Figure 19). Users can find this average depth by selecting (click) the first column using 'Select Grid Column' tool along the model grid seaward boundary in the " Cartesian module".
- Click **Generate** to generate the spectral data and close the *Generate Spectra* dialog.

Note that the reference of Angle (deg) is given in *Angle Settings* section. In this example, it is the "Shore Normal" from the *Projection* drop-down. For "Shore Normal", 0 angle indicates normal to shoreline, -20 deg angle is oblique from the right and 20 deg angle is oblique from the left side reference to shore normal.

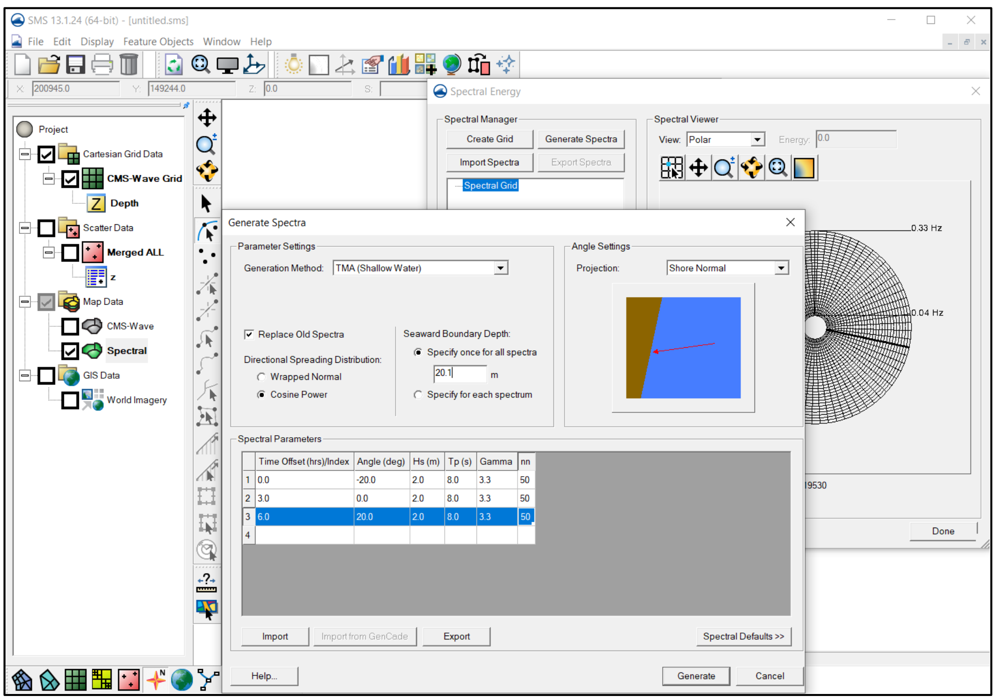


Figure 19. Display Spectral Energy and Generate Spectra dialogs.

A list of Time/index (numerical label) should appear below the *Spectral Grid* in the spectral energy tree box. Click (highlight) one of the Time/index to show (display) the spectral energy contours (energy distribution) in *Spectral Energy* section. Note spectral direction in the display is shown as the 'from' direction (Figure 20).

- Under the *Integration Plots* section, check 'Frequency' and/or 'Direction' for 'Energy vs Frequency' and/or 'Energy vs Direction' plots (Figure 20).
- Click **Done** to exit the *Spectral Energy* dialog.

- Switch to (click) the " Cartesian module" from the " Map module".
- Select *CMS-Wave* | **Model Control…** to bring up the *CMS-Wave Model Control* dialog (Figure 21).
- In the *Input Forcing* section, select "Half plane" from the *Plane type* drop-down.
- Click **Spectral Grid...** to bring up the *Spectral Grid Properties* dialog.
- In the *Frequency Distribution* section, enter "30" as the Number.
- Click **OK** to close the *Spectral Grid Properties* dialog.
- In the *Wind* section, select "Constant" from the *Source* drop-down (this selection is used only for specifying constant wind field over the entire model domain).
- At the bottom of the *Input Forcing* section, click **Define Cases…** to bring up the *Spectral Events* dialog (Figure 22).
- In the *Edge Boundary Type* section, click **(none selected)** to the right of Side 1 to bring up the *Select spectral coverage* dialog.
- Select " Spectral" (click to highlight) from the list (it was created in the ' Map module') and click **OK** to close the *Select spectral coverage* dialog (see Figure 23). This step assigns (interpolate) and links wave spectral data created in the " **Map module**" to CMS-Wave as boundary condition (**Spectral** appears now to the right of Side 1 in the *Edge Boundary Type* section.
- In the *Events* section, click **Populate From Coverage**. This creates an event for every time entry defined in the spectral coverage. In this case, there are three incident wave events (Figure 24). One can provide wind input data (magnitude and direction) for each event if desired.

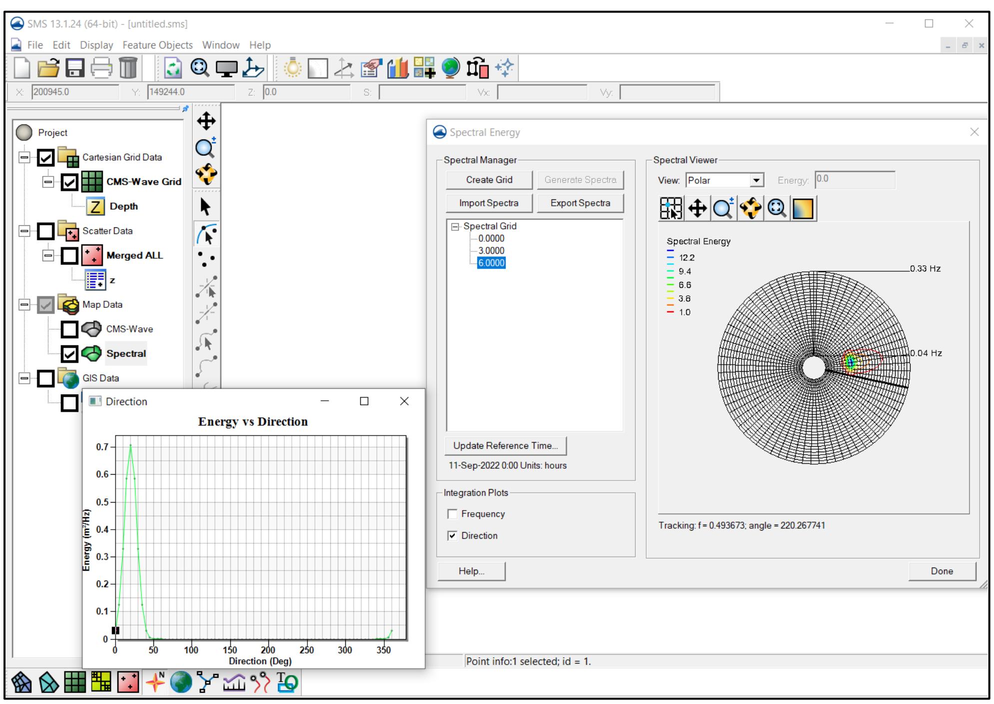


Figure 20. Display spectral contours in *Spectral Energy* dialog.

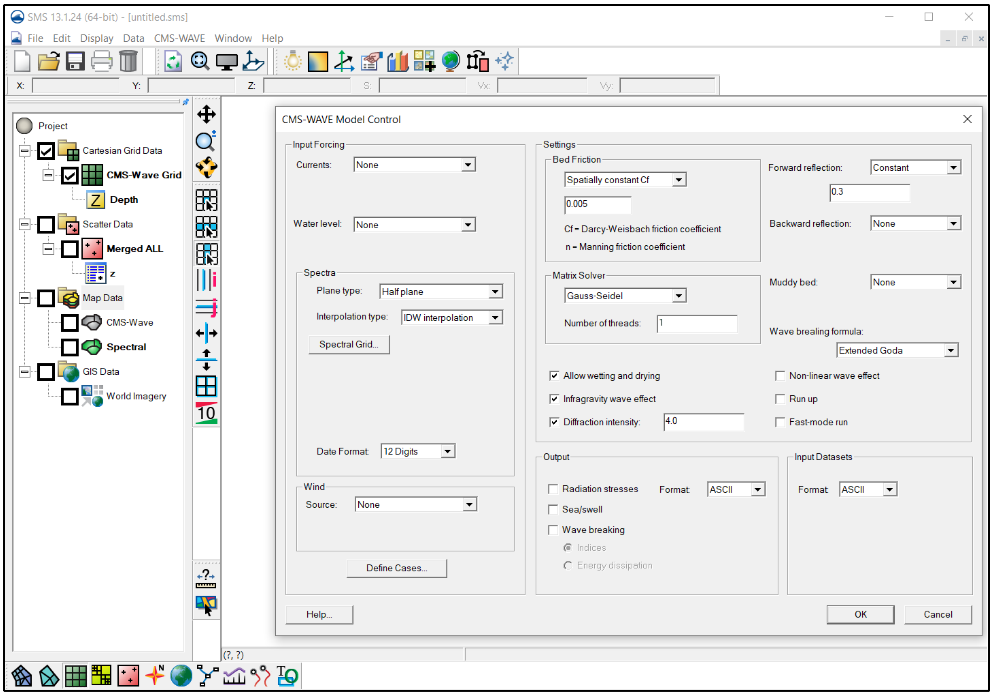



Figure 21. Display *CMS-Wave Model Control* dialog.

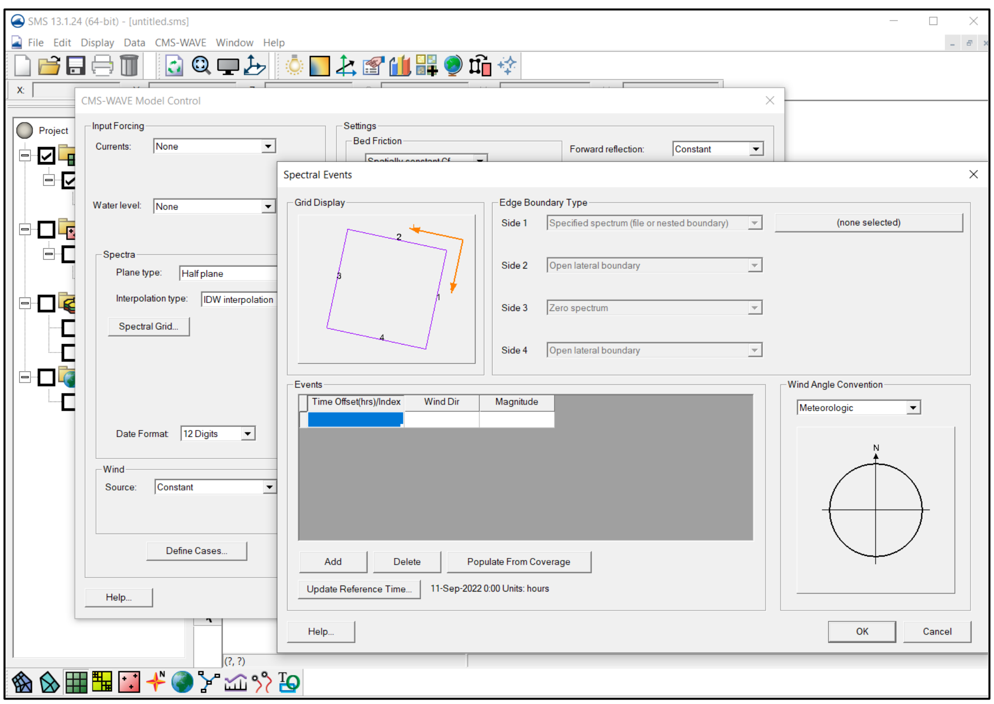



Figure 22. Display *Spectral Events* dialog.

- In this example, select "Shore normal" in the *Wind Angle Convention* drop-down. Add "5" m/sec and "-10" degree as constant speed and direction, respectively, of wind for the first incident wave event while no wind forcing for the second and third incident wave events.
- Click **OK** to exit the *Spectral Events* dialog.

- Click **OK** to close the CMS-Wave Model Control dialog.
- Users can also specify different structure features (e.g., jetty, groin, seawall, etc.) at selected cells. This can be done in the " Cartesian module" (see Figure 25).
- Select *File* | **Save As**… to save **.sim*. A **.spec* file (incident wind wave spectral file) and a corresponding **.txt* (incident wind wave parameter file) were created in addition to **.sim*, **.dep* (model bathymetry grid), **.std* (wave model control and setting factors/parameters), and **.struct* (structure feature and specification at specified cell locations), all text (ascii) files. When saving **.sim*, it is preferred to save to a filename without any empty space in the filename. This is to avoid the trouble to run the CMS-Wave model in the Command Window.
- Before exit a SMS session, it is recommended to also save a project (**.sms*) file which will save all scatter data, map data, and GIS data being applied/processed in addition to the CMS-Wave input files from the entire SMS session. It could be really useful and convenient if users would like to modify or recreate the model grid or input spectral files without from scratch. Select Select *File* | **Save As**… to save **.sms*.

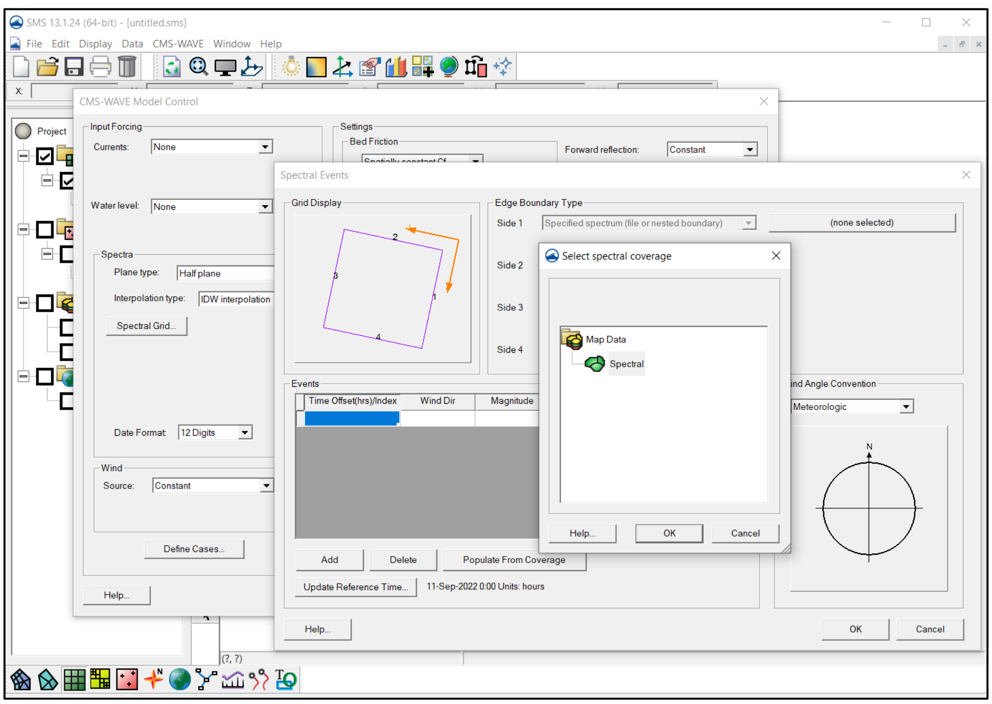



Figure 23. Display *Select spectral coverage* dialog.

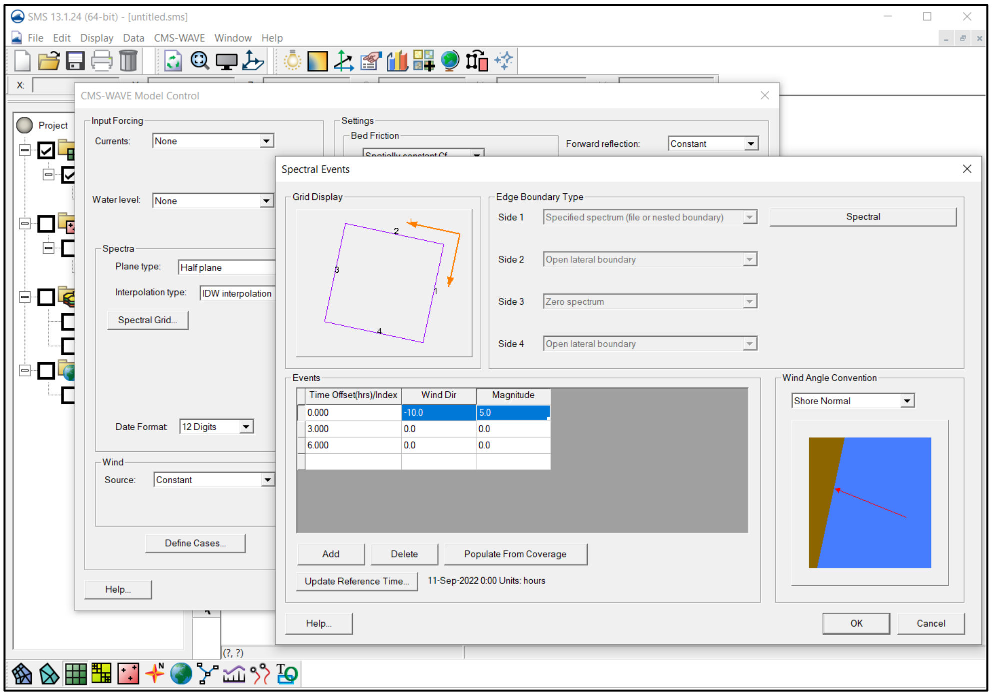


Figure 24. Assigned wind wave cases in *Spectral Events* dialog.

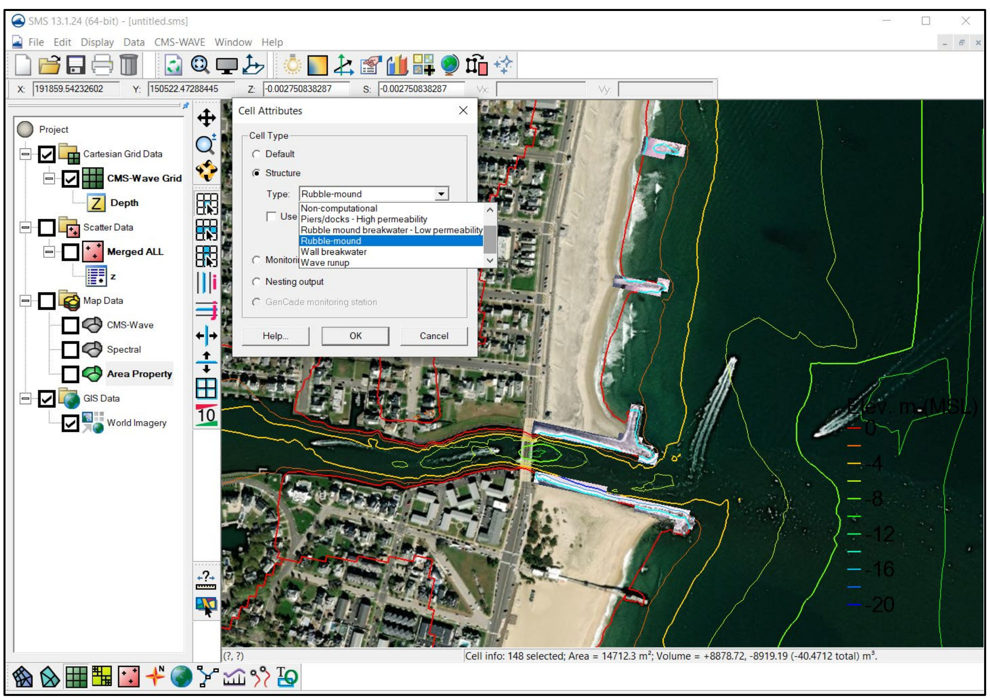


Figure 25. Specify rubble-mound structure cells (jetties and groins) in the model.

## 4. Selecting Special Output Stations

CMS-Wave will output **.wav* to save significant wave heights, peak period, and mean wave direction for all cells in the grid. Special output locations (monitoring stations) can be specified to save directional spectral output data (in *.*obs* file) and additional wave parameters (swell, local sea, associated current, flow rate, etc.) in the selhts.out (or *.*out*) file.

Specify special output locations in the SMS:

- In the "**Cartesian module**", select the **Select Grid Cell** tool.
- Click a grid cell of interest to select it. Right-click and select (click) the "**Cell Attributes…**" to bring up the *Cell Attributes* dialog. Select the "**Monitoring station**" to designate the cell as special output location.
- Click **OK** to close the Cell Attributes dialog.
- Repeat above steps to add more cells as special output locations. Or, hold the **Shift** key to select multiple cells and apply "**Cell Attributes…**" to designate as special output locations.
- Select *File* | **Save As**… to save *.*sim*. The special output location cells are saved in the *.*std* file.

The same steps described above can be used for assigning structure cells and grid nesting output cells. The structure cell type includes (1) Bathymetry modification, (2) Floating breakwater, (3) Non-computational block cells, (4) Piers/docks – highly permeability, (5) Rubble-mound breakwater – low permeability, (6) Rubble-mound – non-permeable, (7) Caisson – wall breakwater, and (7) wave runup. If structure cells are given (assigned), saving the *.*sim* will also save the structure cell information in the *.*struct* file.

More details of CMS-Wave structure cells can be found in the CMS-Wave Technical Reports (http://www.dtic.mil/dtic/tr/fulltext/u2/a486622.pdf)

The model output file *selhts.out* (or *.*out*) for the special output stations writes out 17 columns:

Column 1 - spectrum label (or timestamp)
2 - i index in Cartesian (i,j)
3 - j index in Cartesian (i,j)
4 - significant wave height (m)
5 - spectral peak wave period (sec)
6 - mean wave direction (deg, local coordinate system)
7 - swell height (m)
8 - swell wave period (sec)
9 - swell direction (deg)

10 - local-generated wave height (m)
11 - local-generated wave period (sec)
12 - local-generated wave direction (deg)
13 - wave breaking index (non-zero for breaking)
14 - water level mark (m) if calculated
15 - flow rate (m*m/sec) if calculated
16 - east-west flow velocity component if calculated
17 - north-south flow velocity component if calculated

## 5. Running CMS-Wave

CMS-Wave can be run in the Windows Command Prompt (DOS window) or in the SMS13.1.24.

To run CMS-Wave in the DOS window, place all CMS-Wave input files (e.g., *run1.sim, run1.std, run1.dep, run1.spec, run1.struct*, etc.) in the same folder (make sure no empty space in the folder's name, e.g., *C:\CCSC-Alt0*) with the CMS-Wave executable (e.g., *CMS-Wave.exe*) and a corresponding *libiomp5md.dll* file.

Running CMS-Wave for *run1.sim* in the DOS window command line:

- ***C:\CCSC-Alt0>CMS-Wave.exe run1.sim***

Running CMS-Wave in SMS13.1.24:

- Upload **.sim* (e.g., *run1.sim*) to the SMS.
- Select *CMS-Wave* | **Launch CMS-Wave** to open the *CMS-WAVE* model wrapper dialog and proceed model run.
- When CMS-Wave has finished running, turn on (check) *Load solution* and click **Exit** to close the *CMS-WAVE* model wrapper dialog.

Example Files for this section are in the folder *Workshop/CMS-Wave/SMS-files.*