

Wave-Model

Yakutat Case

Sam McWilliams
Craig Jones

Day 3

Wave energy converter modeling



Develop Yakutat Wave Model

- This tutorial will go over how to build a model for waves in Yakutat, Alaska

Building a Wave Model

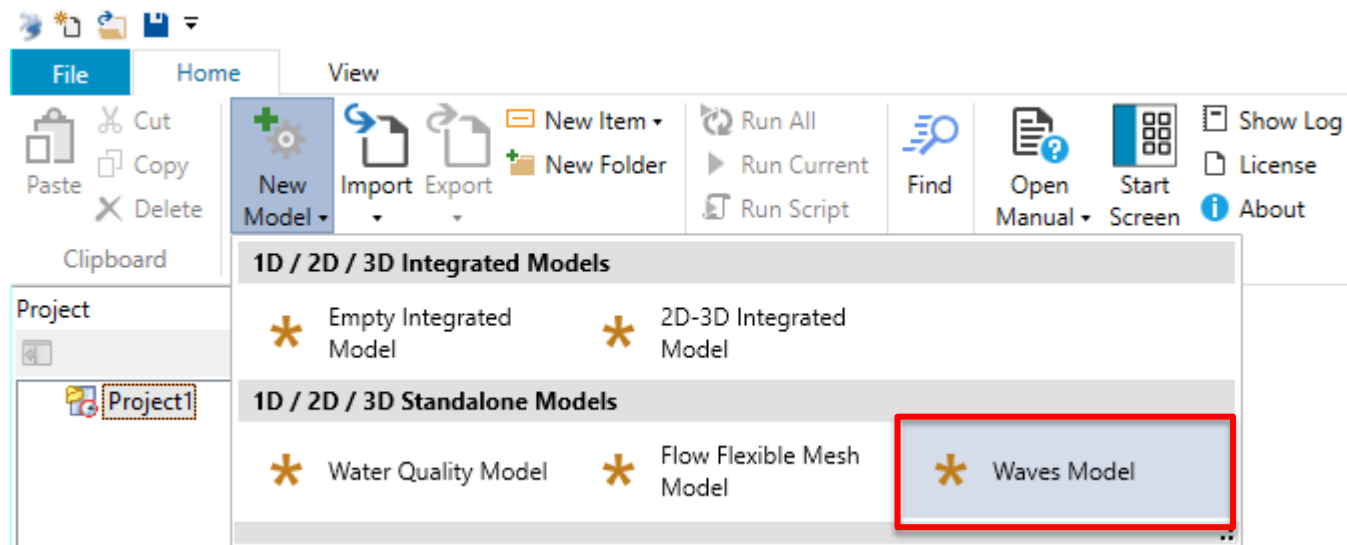


Setting up a simple model

- › Build the Grids
- › Add bathymetry
- › Display a Basemap
- › Set up boundary conditions and forcing
- › Set up processes and time parameters
- › Set up output
- › Run model
- › Visualize Results

Start a new model

- › Start a new waves model as shown on the right.
- › Click New Model → Waves Model



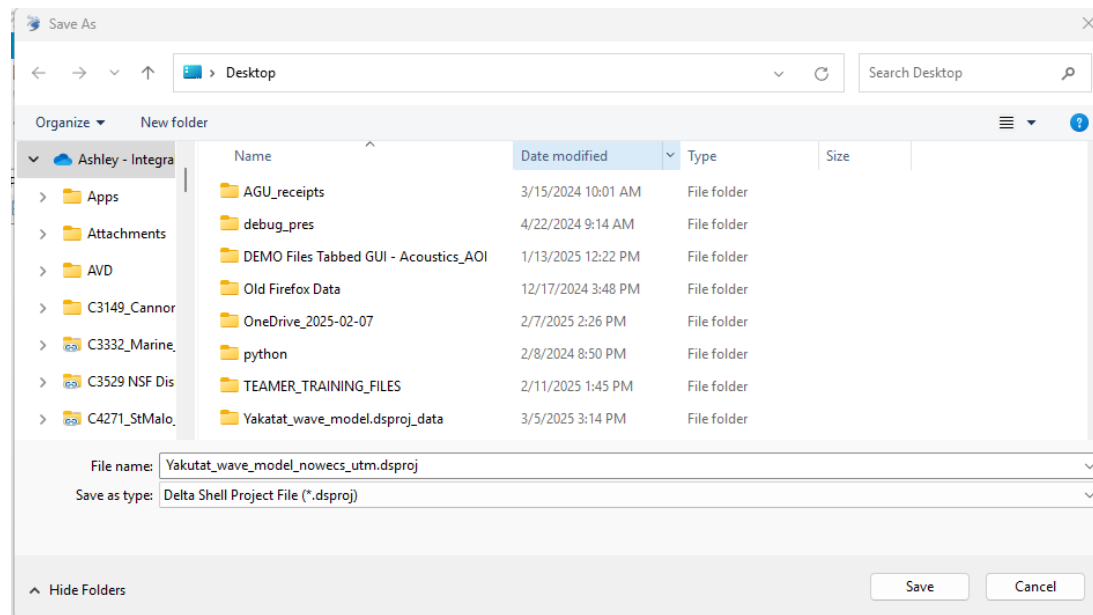
Save the model in a location

- › Click File → Save As
- › Save as a “yakutat_nowecs_utm.dsproj” directory in a location of your choice
- › File structure:

- .dsproj_data

— Waves

Inputs
Outputs



Build the Grids

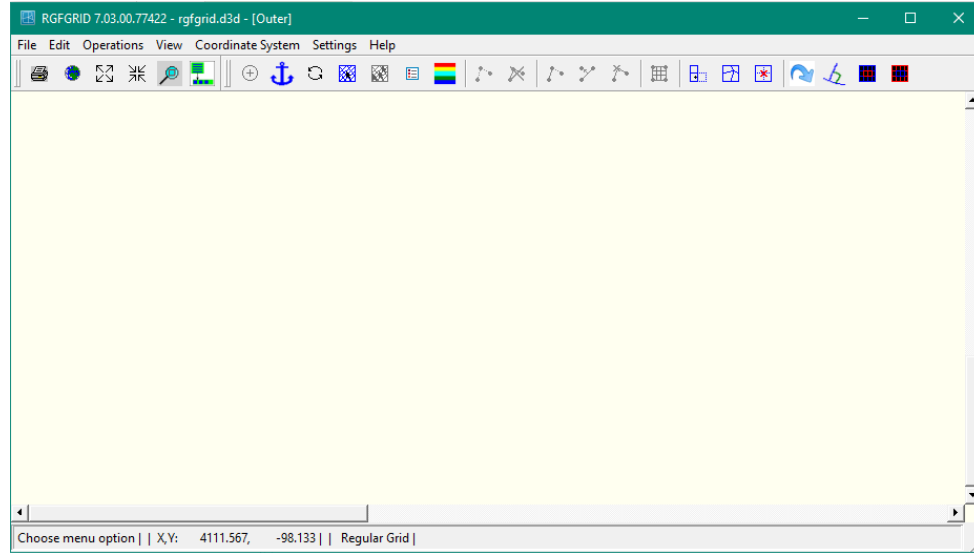


Open RGF Grid Separately

- › We will develop two grids outside of the Delft3D Program
- › Program is used to build rectilinear, curvilinear, and unstructured grids.
- › We will build two grids that will be imported into the model we just created.

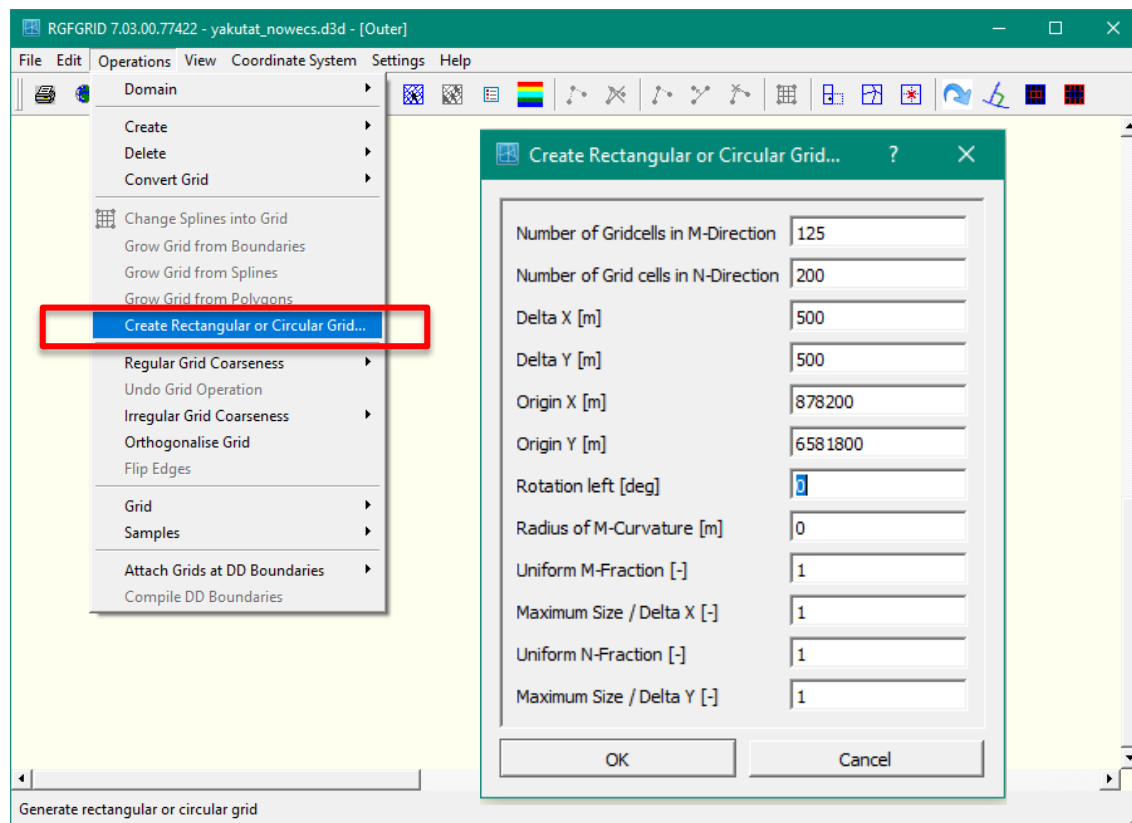
RGFGrid

- › Open the program



Generate the Grid

- Select Operations -> **Create Rectangular or Circular Grid.**
- Simple grids can be generated by defining the number and size of cells in the popup window.



Generate the Grid, continued

- › Enter values to the right to create the grid.
 - Note the units are in meters.
- › We will be working in real world coordinates, so provide an origin in UTM
 - Origin X : 878,200
 - Origin Y : 6,581,800

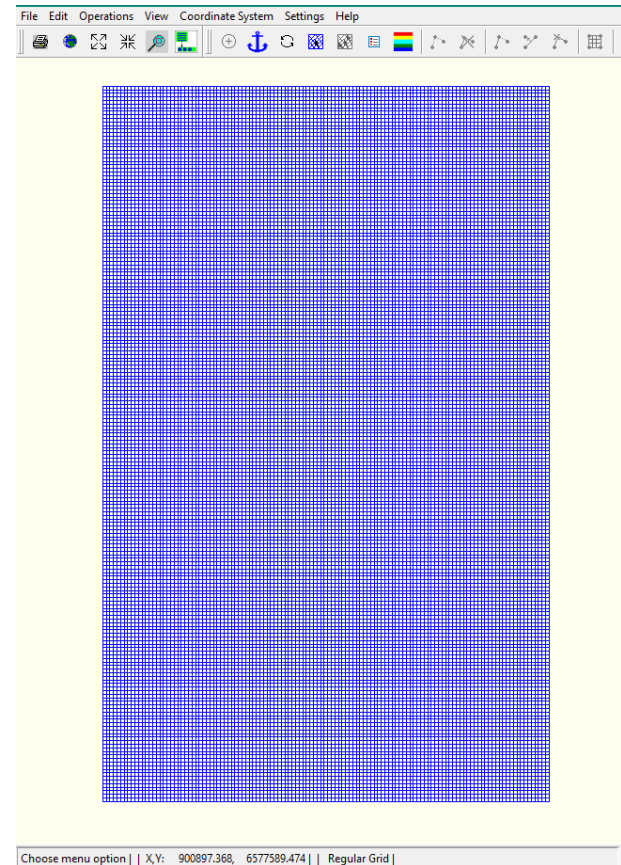
Create Rectangular or Circular Grid...

Number of Gridcells in M-Direction	125
Number of Grid cells in N-Direction	200
Delta X [m]	500
Delta Y [m]	500
Origin X [m]	878200
Origin Y [m]	6581800
Rotation left [deg]	0
Radius of M-Curvature [m]	0
Uniform M-Fraction [-]	1
Maximum Size / Delta X [-]	1
Uniform N-Fraction [-]	1
Maximum Size / Delta Y [-]	1

OK Cancel

Structured Grid

- › Basic Structured Grid is developed.

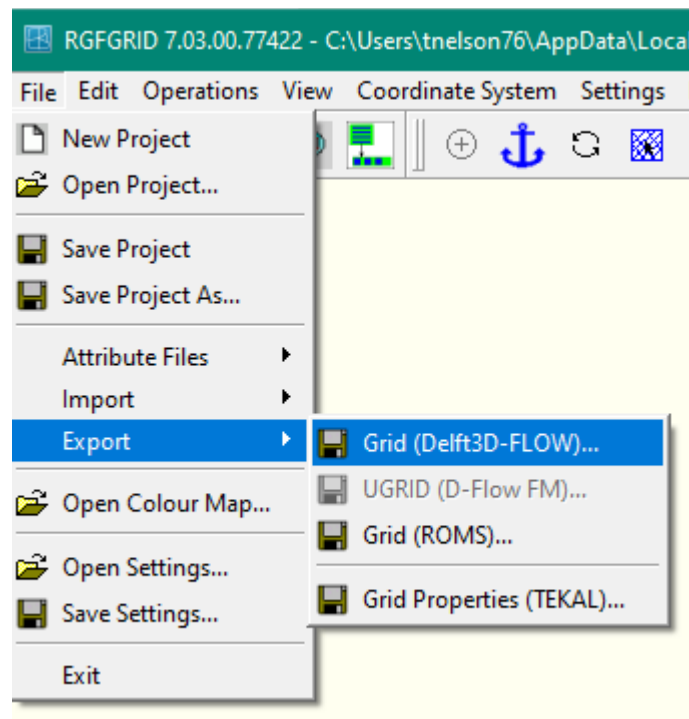


Save Grid

› File-> Export -> Grid

› Save as

*.dsproj_data/Waves/input
/outer.grd



Inner Grid



Inner Grid

- › The previous grid had a spacing of 500m. We need a grid on the scale of a WEC, but we do need that scale everywhere. High resolution will result in increased computation time.
- › SWAN allow for the placement of an inner grid which can be placed in the region of interest for WECs.
- › This uses the information from the outer grid to drive forcing within the inner grid.
- › The turbines will be placed within the inner grid.

Inner Grid

- › If the grid is not selected (if the grid is not blue), follow the steps:

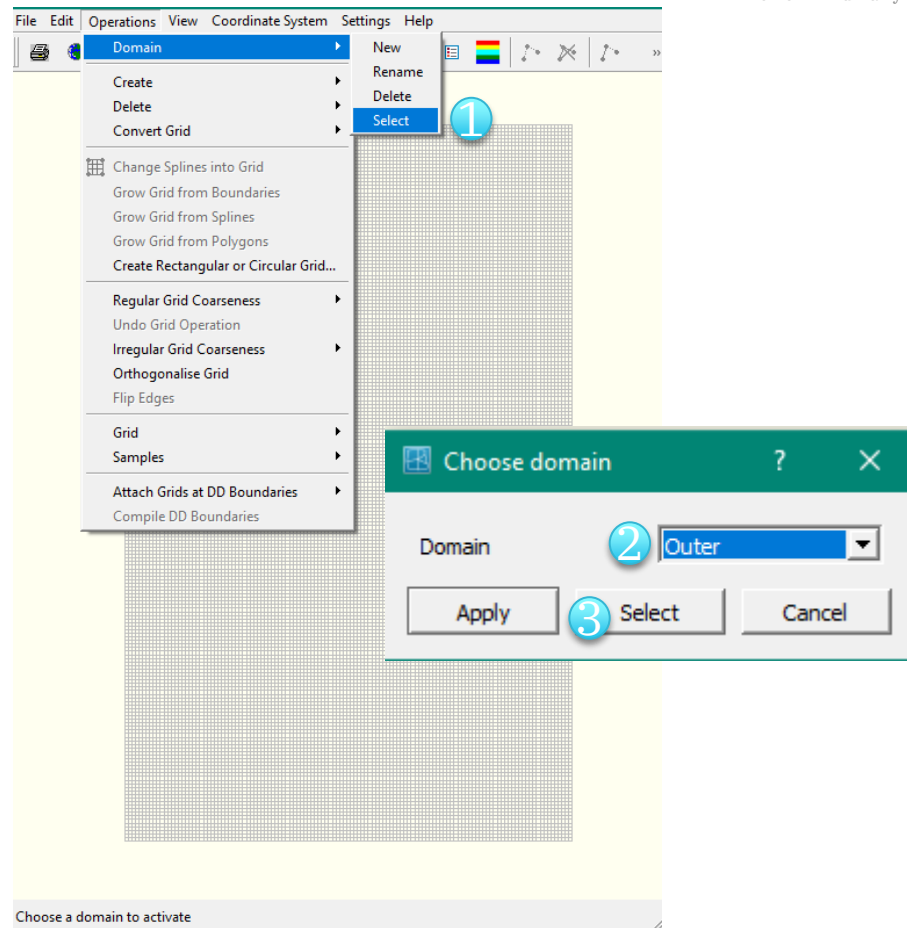
1. Click

- Operations ->
- Domain->
- Select

2. Select **Outer** from the dropdown box

3. Click Select

- › The grid will turn blue



Inner Grid

1. In the toolbar select the *Block Delete Exterior*
 - This will crop the grid to the region you select
2. Click 4 points close to these coordinates:

Upper Left = 905,400 | 6,618,800

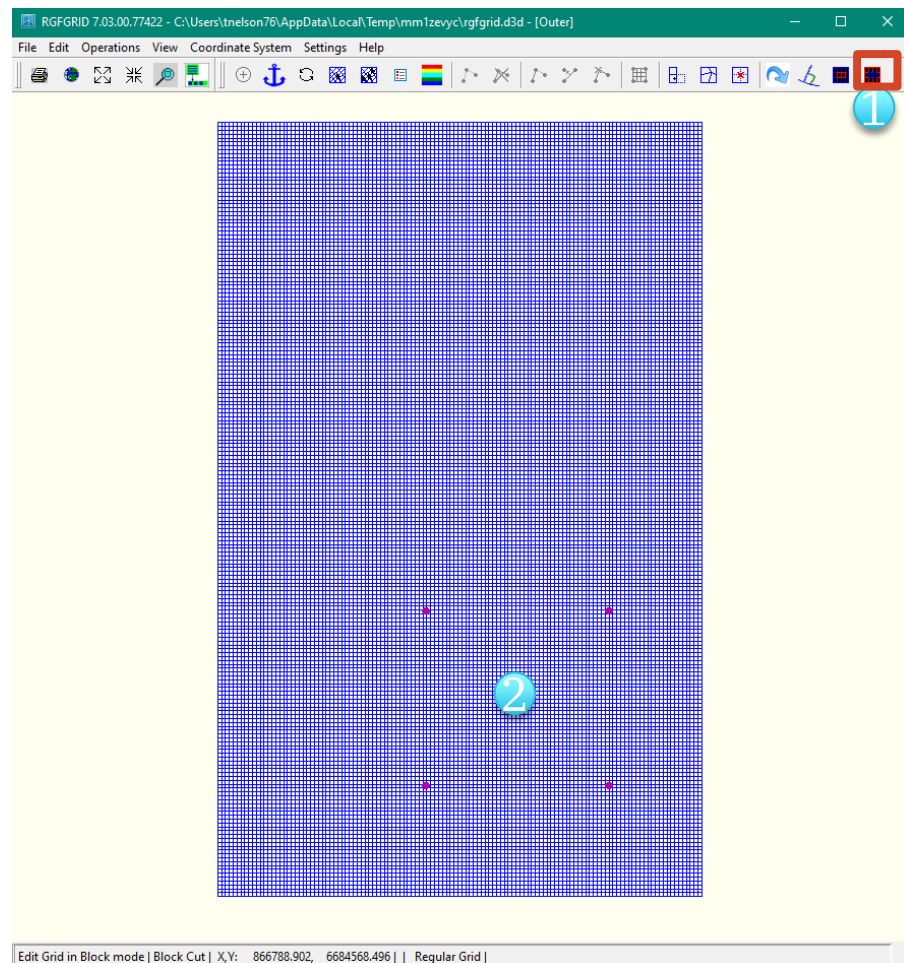
Upper Right = 928,750 | 6,618,800

Lower Left = 905,400 | 6,596,200

Lower Right = 928,750 | 6,596,200

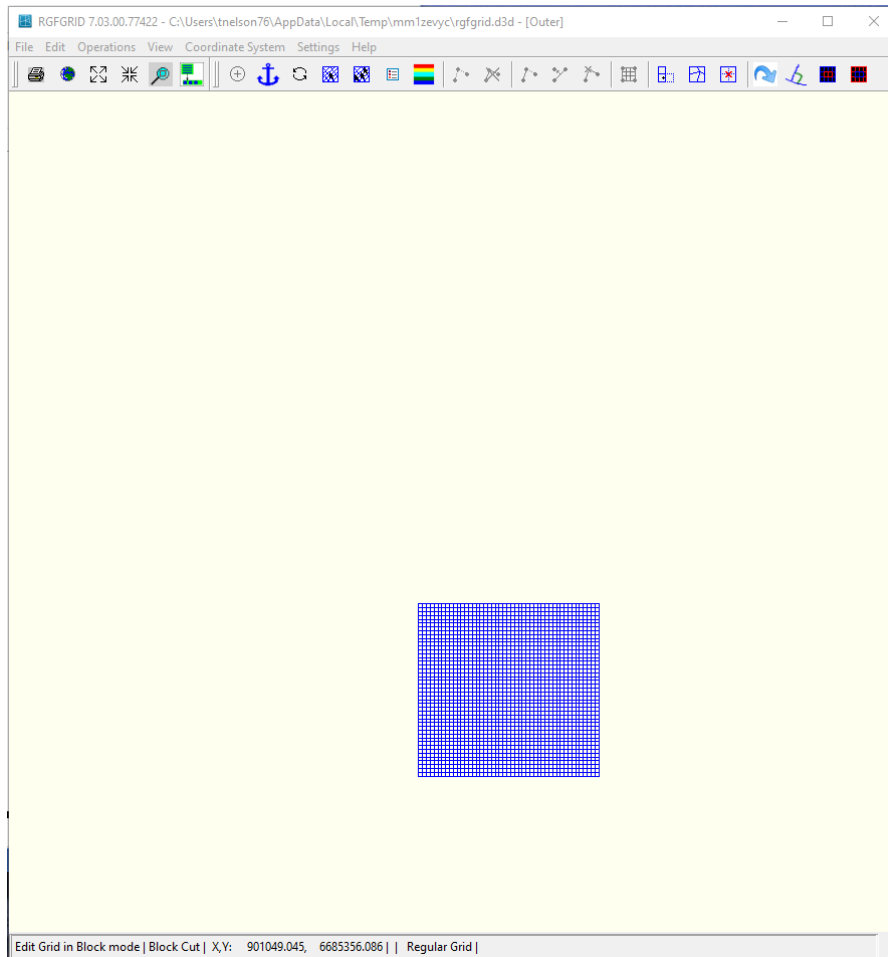
You can see the coordinate on the bottom status bar.

› Right click to end



Inner Grid

- › You now have a cropped grid the same resolution as the outer grid.
- › You can zoom in by using the scroll wheel on the mouse.



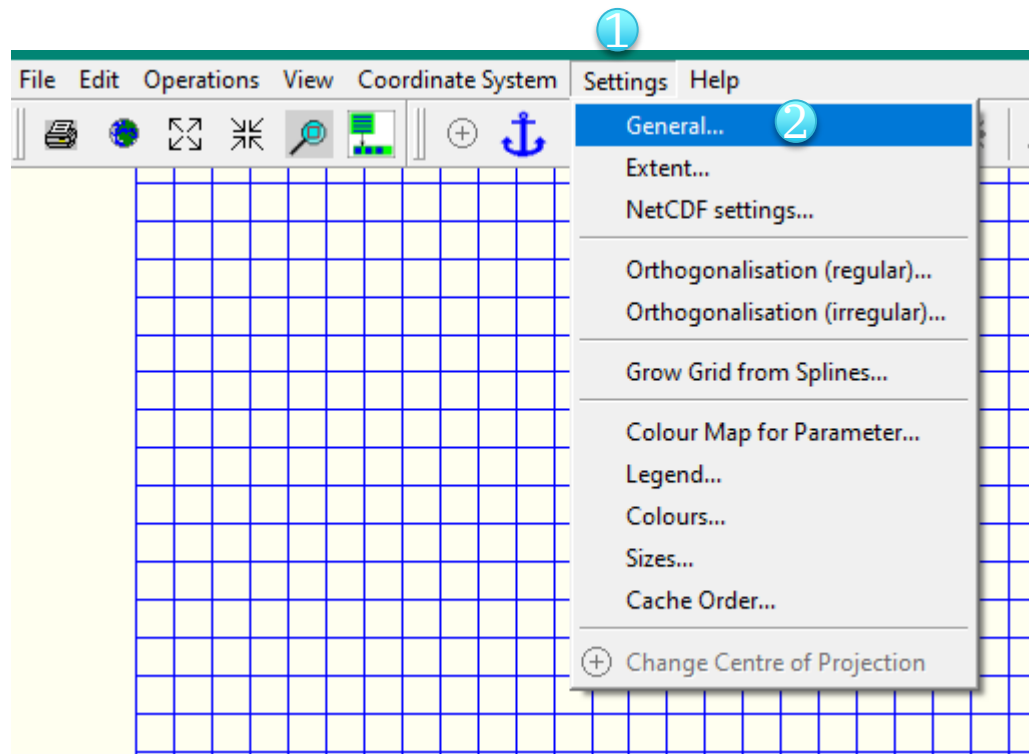
Inner Grid, Increase Resolution

- › We will now refine the grid 3 times. The following steps will have you set the settings in the refinement tool and then refine the grid

- › Select:

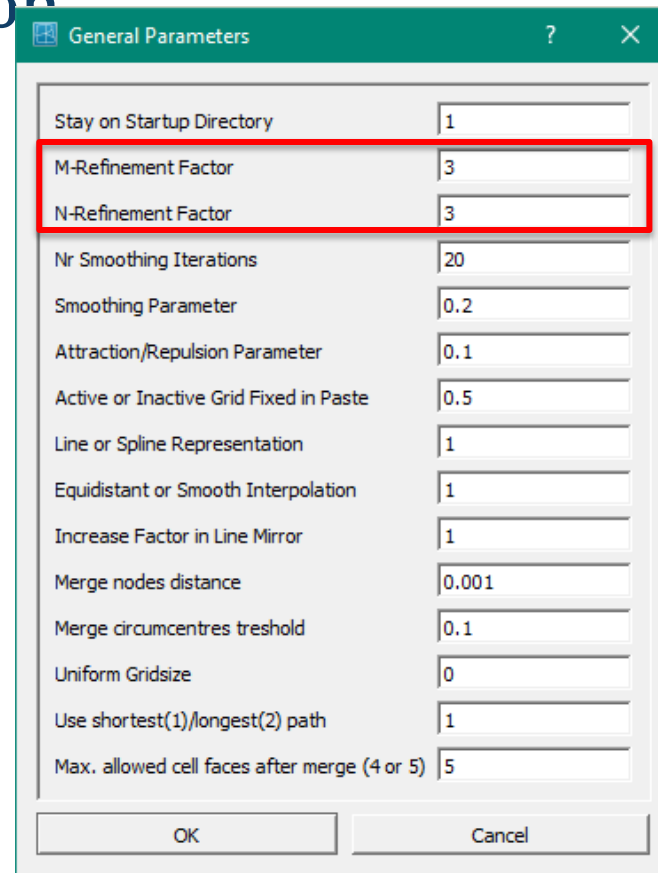
1. Settings

2. General



Inner Grid, Increase Resolution

- › Change the M and N-Refinement Factor to 3.
- › This is the number of times the grid will be refined.



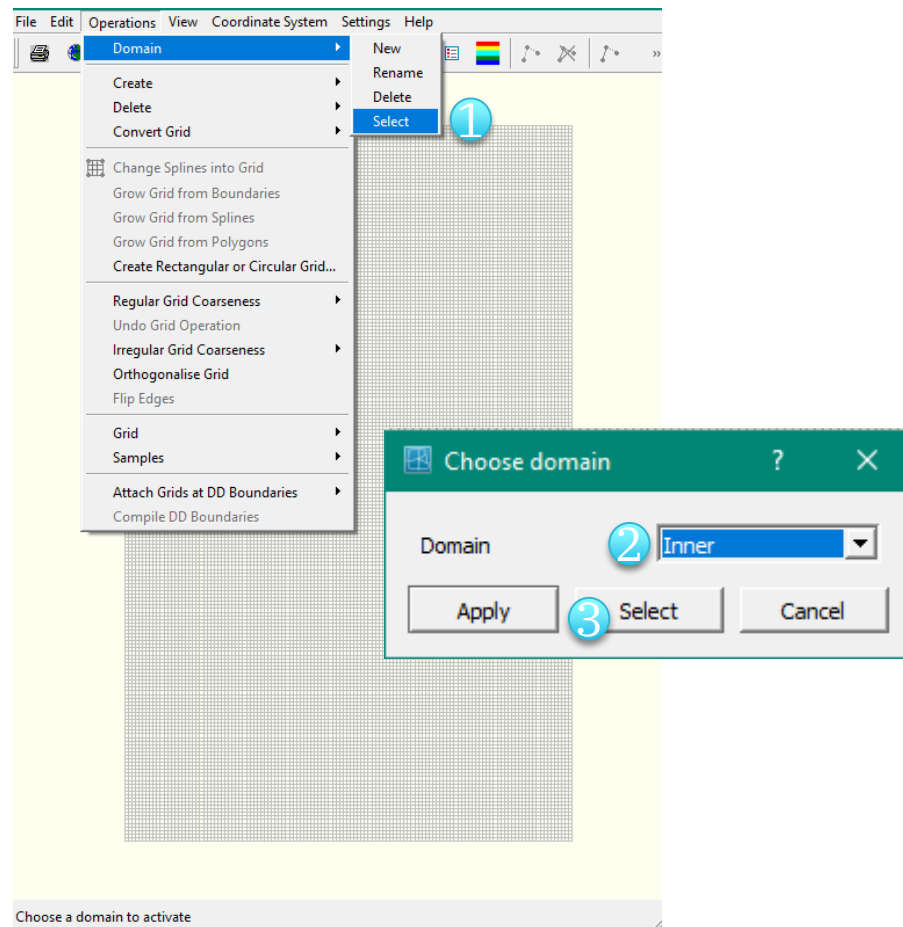
The screenshot shows a 'General Parameters' dialog box with a green title bar. The dialog contains a list of parameters and their values. A red rectangular box highlights the 'M-Refinement Factor' and 'N-Refinement Factor' fields, both of which are set to 3. The other parameters and their values are as follows:

Parameter	Value
Stay on Startup Directory	1
M-Refinement Factor	3
N-Refinement Factor	3
Nr Smoothing Iterations	20
Smoothing Parameter	0.2
Attraction/Repulsion Parameter	0.1
Active or Inactive Grid Fixed in Paste	0.5
Line or Spline Representation	1
Equidistant or Smooth Interpolation	1
Increase Factor in Line Mirror	1
Merge nodes distance	0.001
Merge circumcentres treshold	0.1
Uniform Gridsize	0
Use shortest(1)/longest(2) path	1
Max. allowed cell faces after merge (4 or 5)	5

At the bottom of the dialog are 'OK' and 'Cancel' buttons.

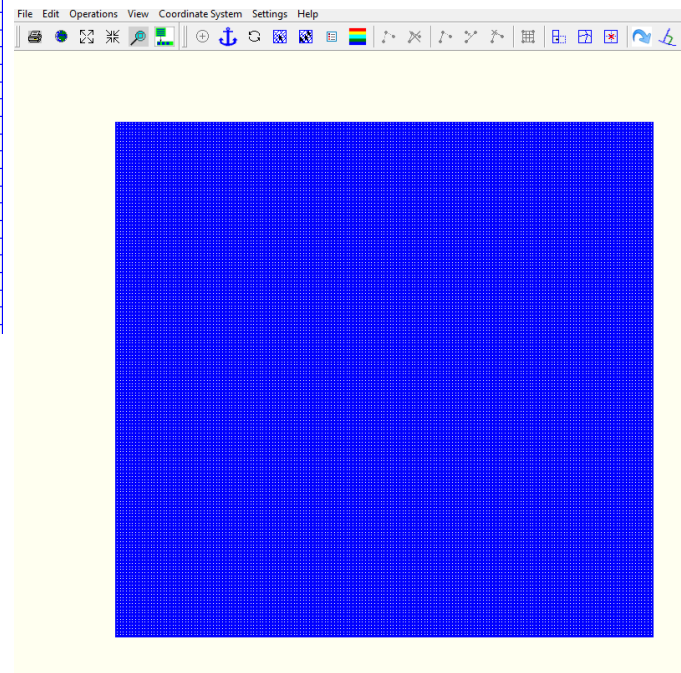
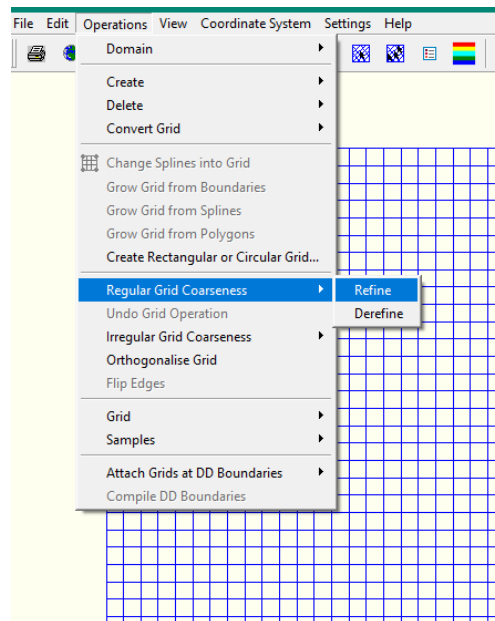
Inner Grid, Select Domain

- › If the grid is grayed out (unselected) follow the steps:
 - Select the Inner Grid Domain to apply changes.
 - Click Operations -> Select
 - Choose Inner and Select.



Inner Grid

- › Increase the grid resolution by selecting
- › Operations → Regular grid coarseness → refine

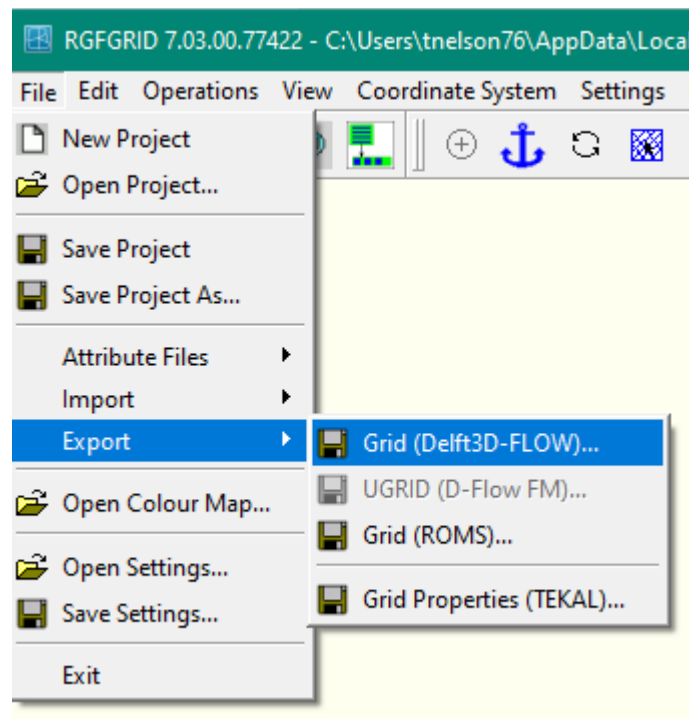


Save Grid

› File-> Export - > Grid

› Save as

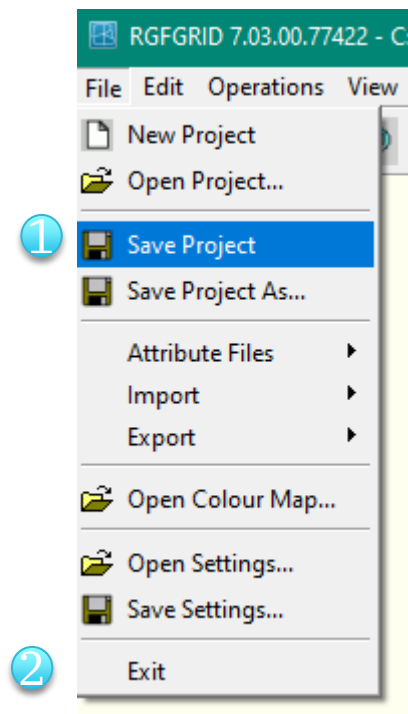
*.dsproj_data/Waves/input
/inner.grd



Save project and Exit

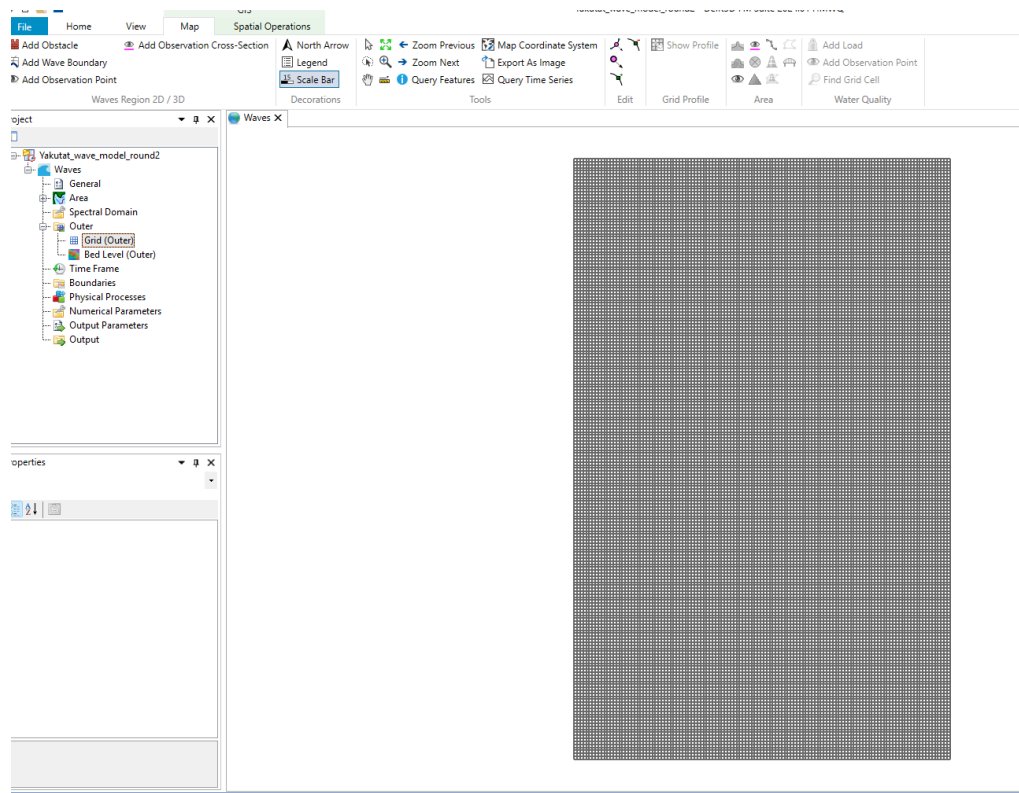
Now Save the project and return to the Model

1. File-> Save Project
2. File -> Exit



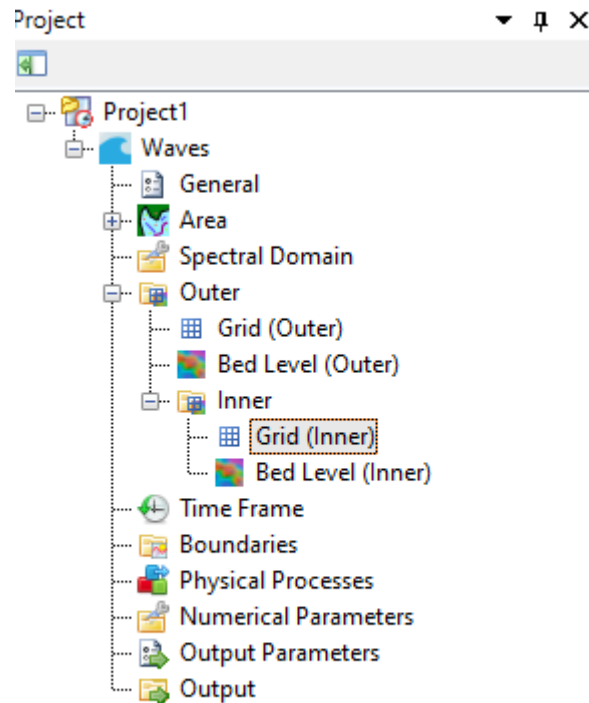
Import Outer Grid

- › Return to Delft3D
- › Expand the waves dropdown, and expand the Outer dropdown menu.
- › Right click on “Grid(Outer)” and select “Import”
- › Select
 - `.dsproj_data/Waves/Input/outer.grd`
- › A grayed out grid will appear



Import Inner Grid

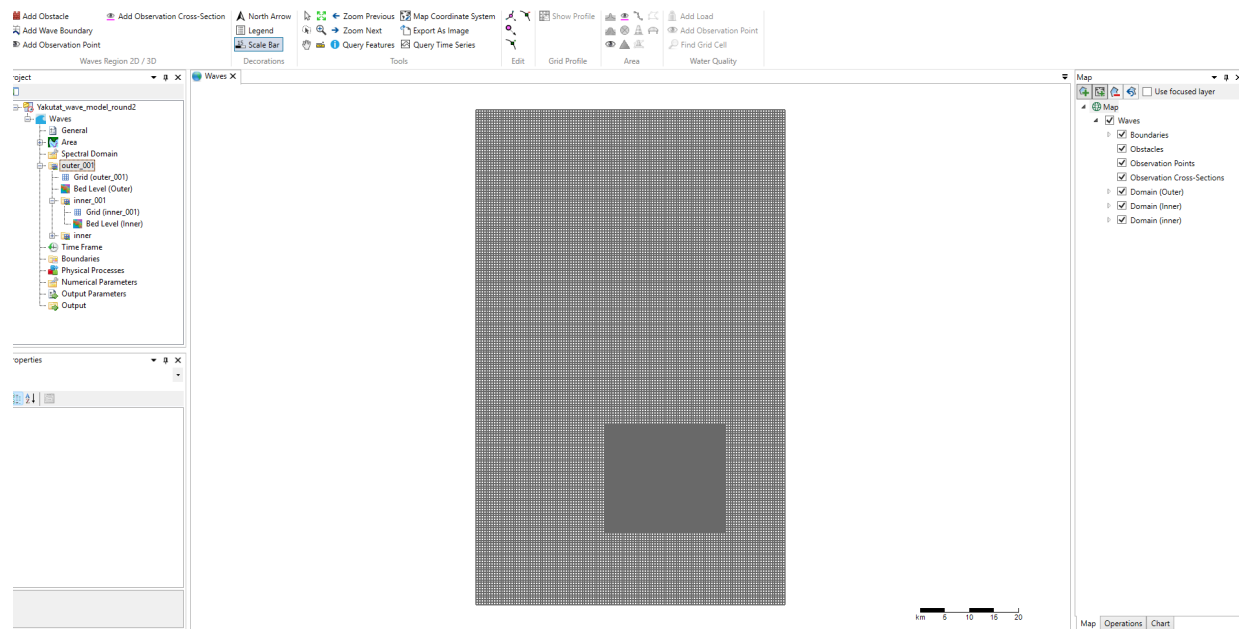
- Right Click on “Outer” and select “Add Interior Domain”
- You will see a pop up asking if you want to use the contents of inner.grd
 - Select “No”
- You will now see an “Inner” dropdown



Import Inner Grid

- › Open the Inner drop down
- › Right click on “Grid (Inner)”
- › Select “Import grid”
- › Navigate to

.dsproj_data/Waves
/Input/inner.grd



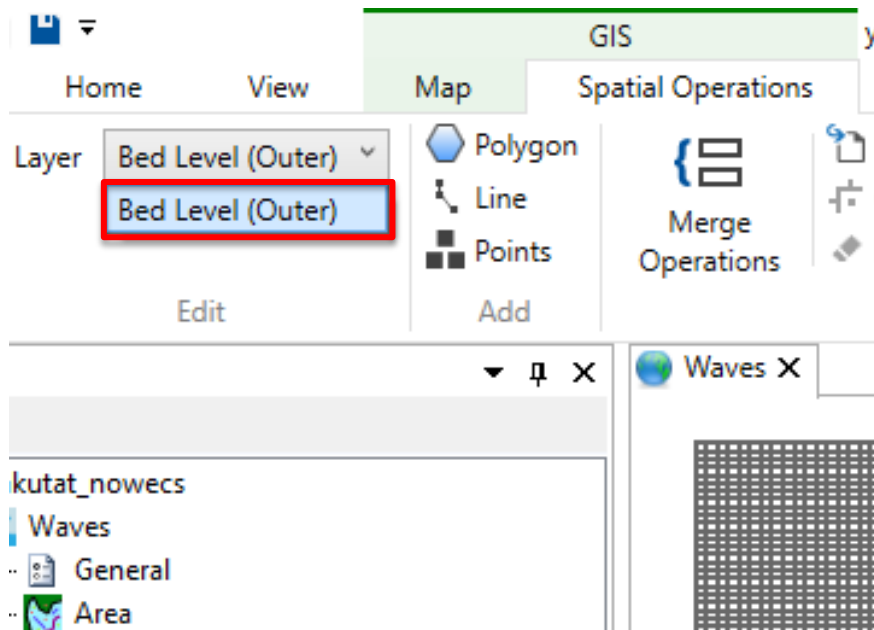
Bathymetry: Outer Grid



Bathymetry

- › Add bathy to the grid
- › Select the bed level layer in the spatial operations menu
- › This menu allows you to apply spatial data to grid from a .dep file or assign bulk values across regions.

Bathymetry is applied in the GIS Spatial Operations Menu!!!



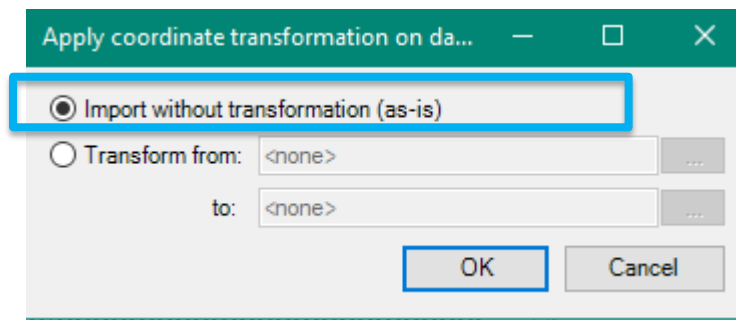
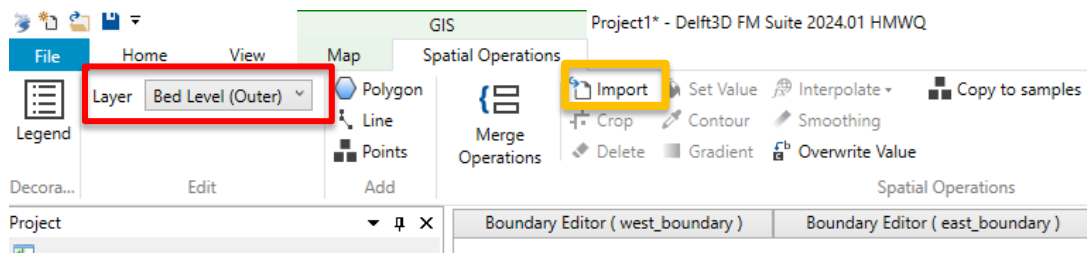
Bathymetry, continued

- › The bathy file is a tab delimited file with columns X, Y, Z.
- › For Cartesian coordinates units are in meters.
- › For spherical coordinates,
 - Longitude is from 0-360 degrees.
 - Latitude is from -90 to +90 degrees.
- › Depth is positive downward.

	Easting	Northing	Depth
bathy_waves_utm_32606.xyz			
1	229752.89760814287	6773110.29696589	-53.0
2	229667.84316594328	6771998.704133265	-30.0
3	229667.84316594328	6771998.704133265	-29.0
4	229582.79698615562	6770887.111707395	-29.0
5	229497.759071371	6769775.519688366	-29.0
6	229497.759071371	6769775.519688366	-28.0
7	229412.7294241797	6768663.928076258	-30.0
8	229327.7080471723	6767552.336871158	-36.0
9	229327.7080471723	6767552.336871158	-27.0
10	229242.69494293898	6766440.746073151	-25.0
11	229157.69011406938	6765329.155682318	-72.0
12	229157.69011406938	6765329.155682318	-85.0
13	229072.6935631531	6764217.565698746	-98.0
14	228987.7052927795	6763105.976122516	-116.0
15	228987.7052927795	6763105.976122516	-163.0
16	228902.72530553763	6761994.386953713	-183.0

Bathymetry. continued.

- › In the GIS-Spatial Operations tab, select the bed Level (Outer) Layer.
- › Click the import button.
- › Select the file bathy_waves_utm_32606.xyz file from /Inputs/bathy_waves_utm_32606.xyz
- › In the popup, select Import without transformation and OK



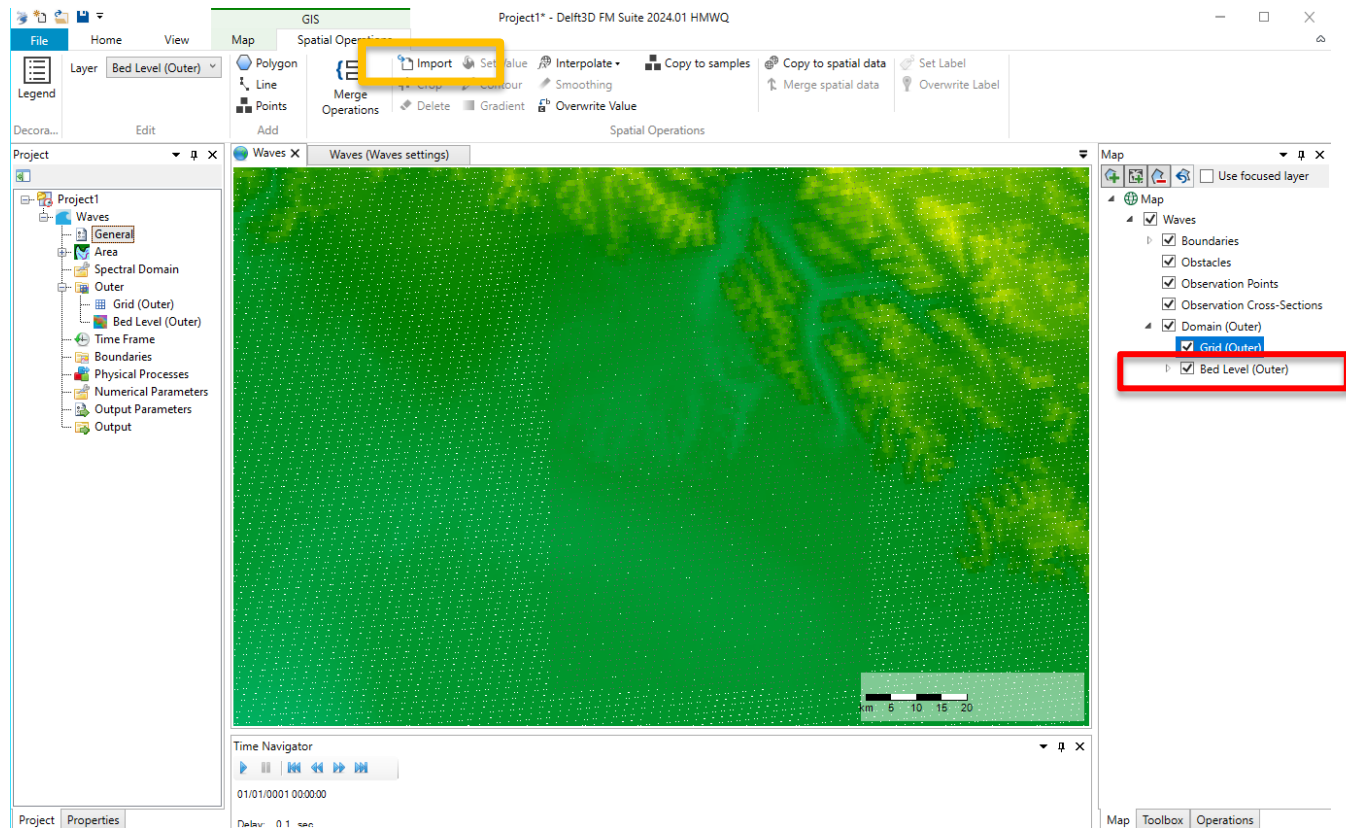
Bathymetry Ctd.

- › Toggle on the bathy layer in the Map panel

“Bed Level”

- › The points with bathymetry will appear on the map.

- › Click Interpolate in the GIS-Spatial Operations Tab and select Interpolate Selected Set.



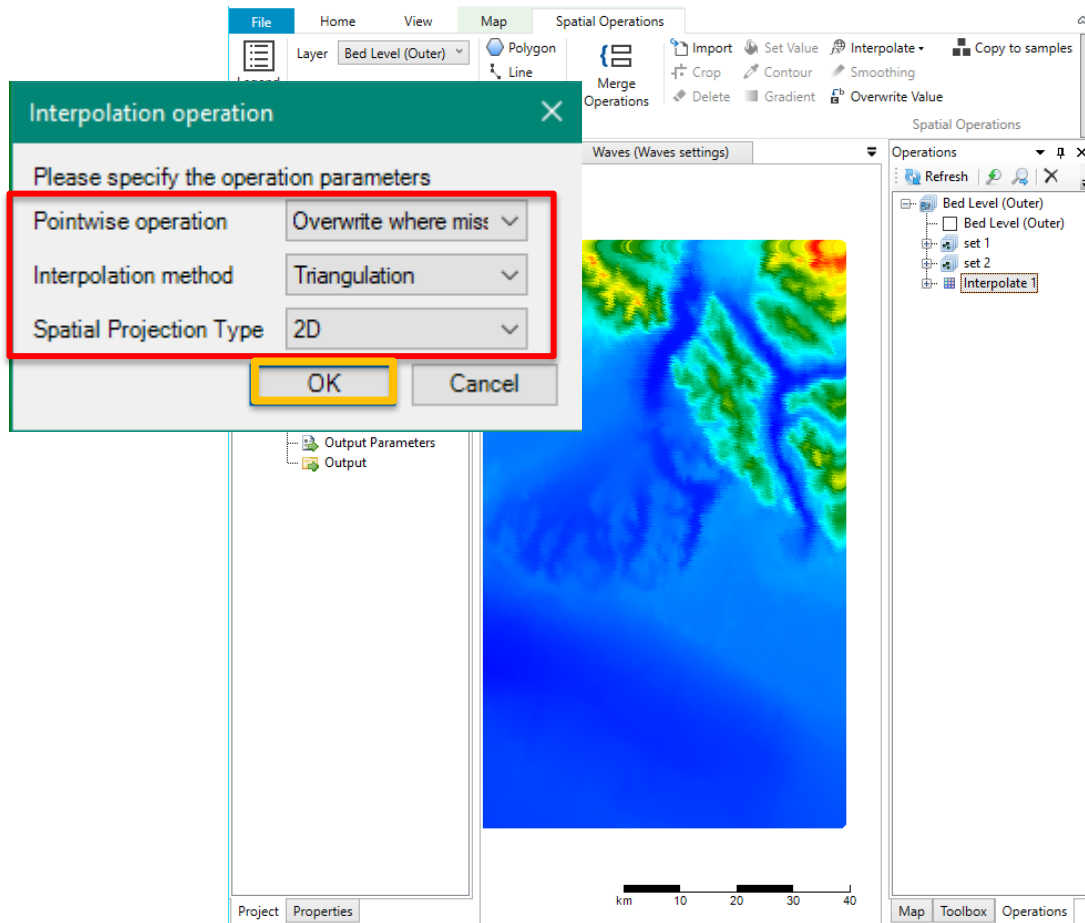
Bathymetry Ctd.

› In the popup select

- Overwrite where missing
- Triangulation
- 2D

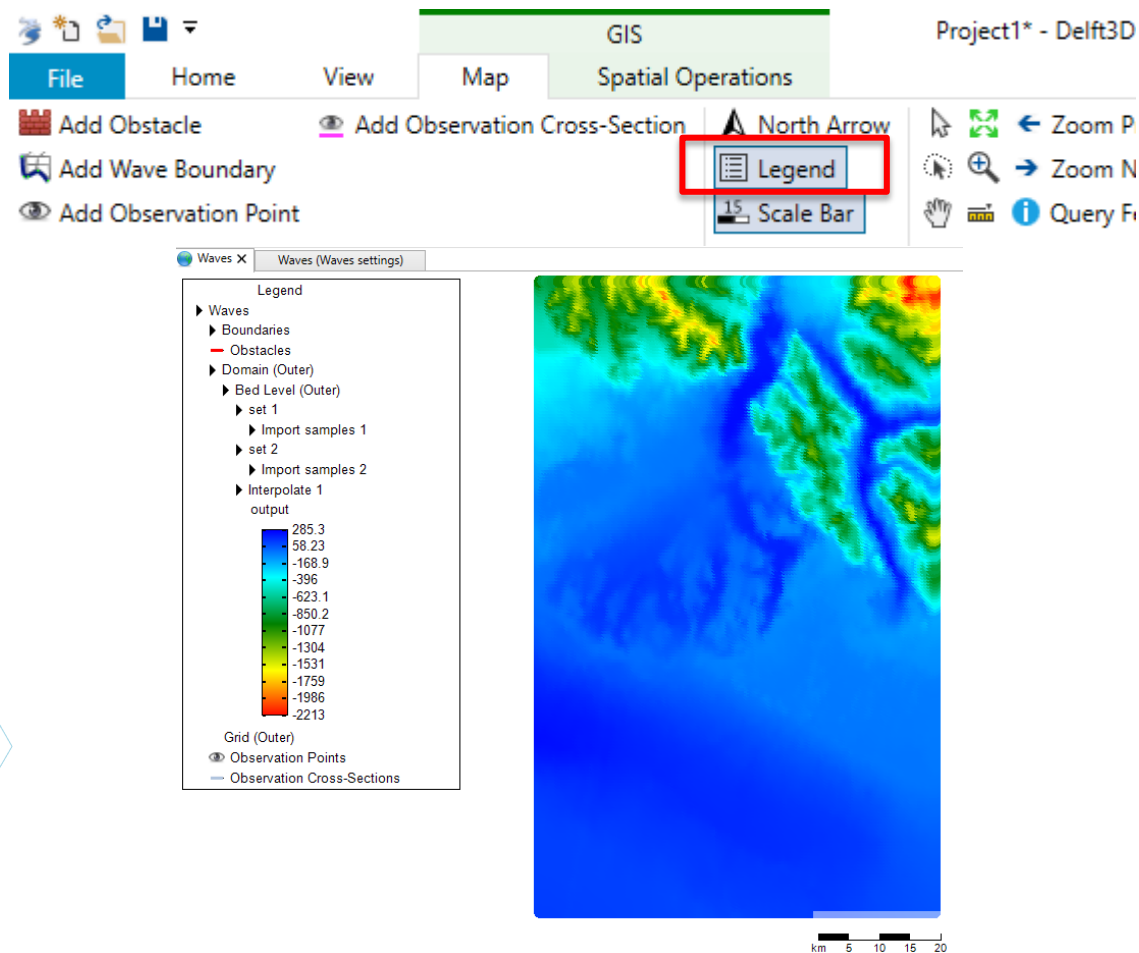
› Click **OK**

› An interpolated surface will appear on the map.



Bathymetry Ctd.

- › To view a legend, click **Legend** in the GIS-Map tab.



Bathymetry: Inner Grid

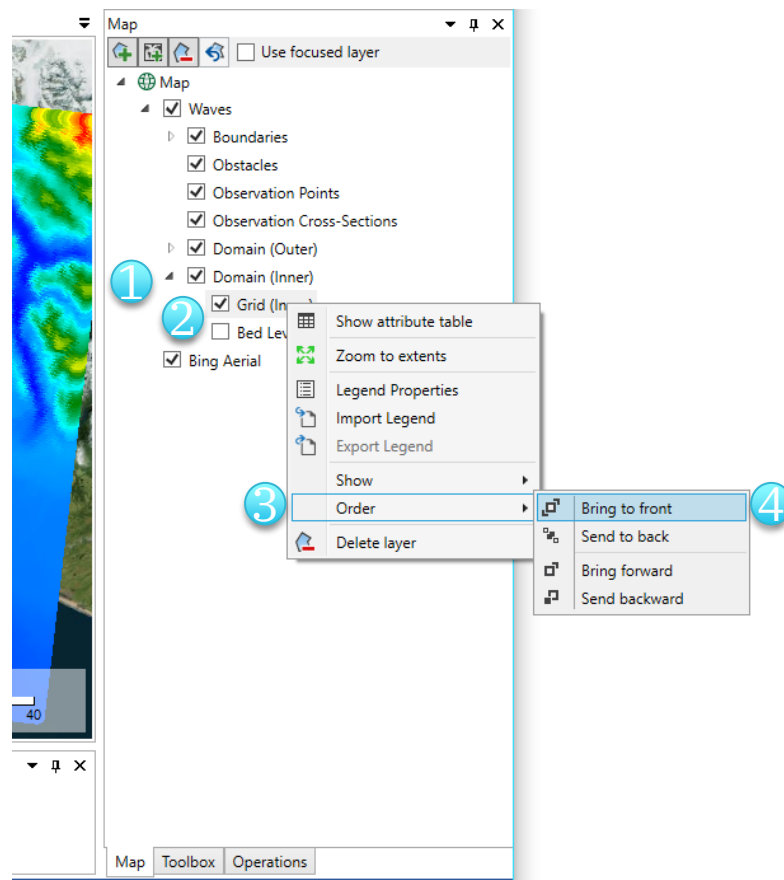


View Grid

- › The inner grid might display in a layer below the outer grid and the bathy. To bring it to the front:

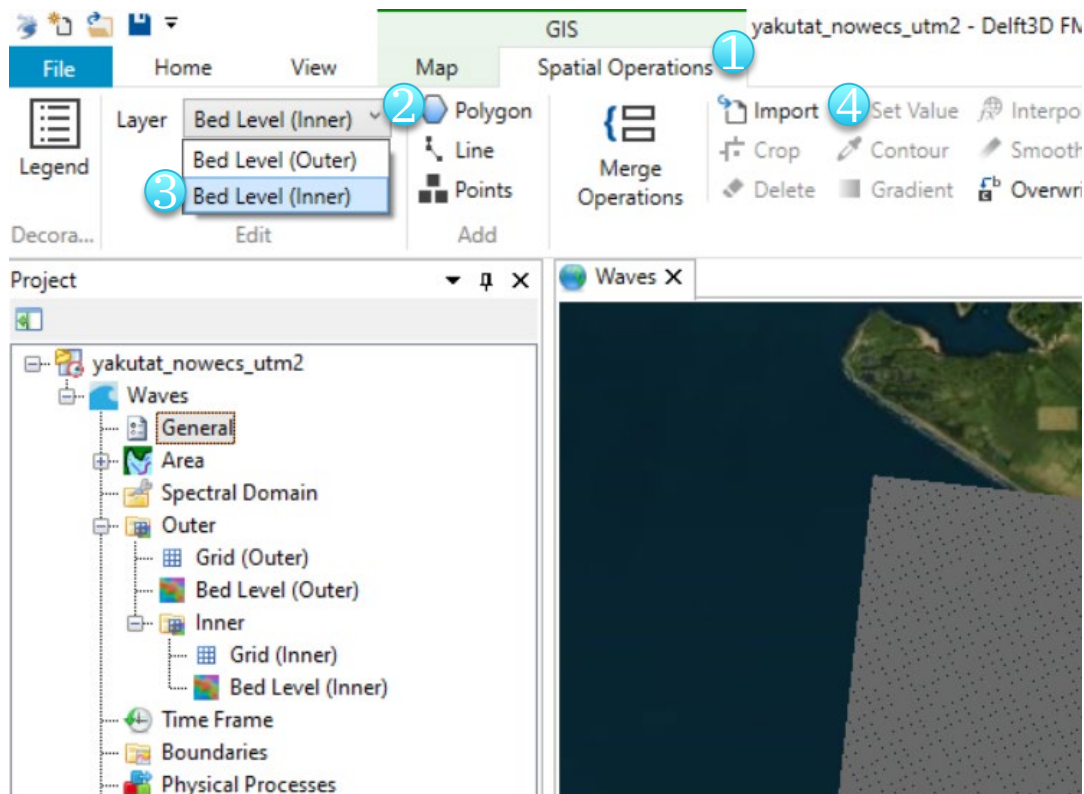
1. Expand Domain in the Map Panel
2. Right click on Domain (Inner)
3. Select Order
4. Select Bring to Front

- › Hide the outer grid by unchecking Domain (Outer)



Interpolate Bathy on Inner Grid

1. Select the Spatial Operations tab under GIS.
2. Click the dropdown menu by Layer in the Edit section.
3. Select Bed Level (Inner).
4. Then Click Import in the Add section.

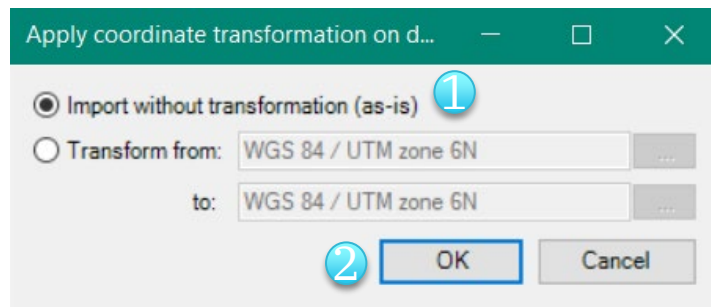


Interpolate Bathy on Inner Grid

Select

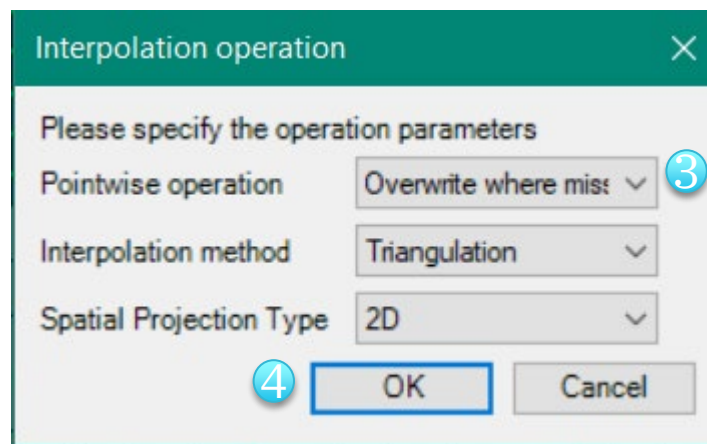
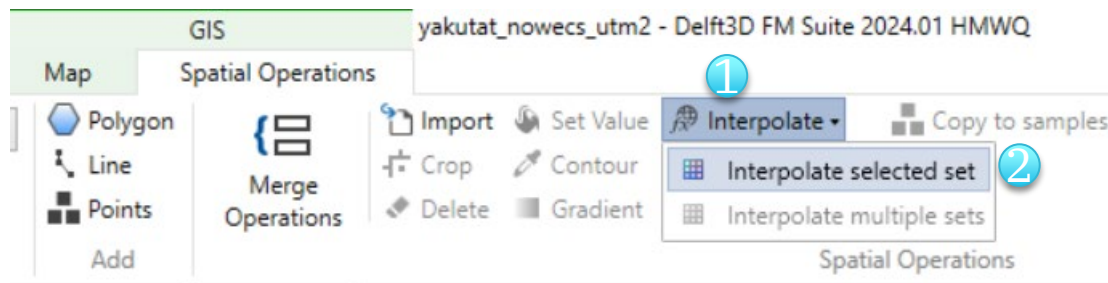
../Inputs/bathy_waves_utm
_32606.xyz

1. Import without transformation (as-is)
2. Click OK



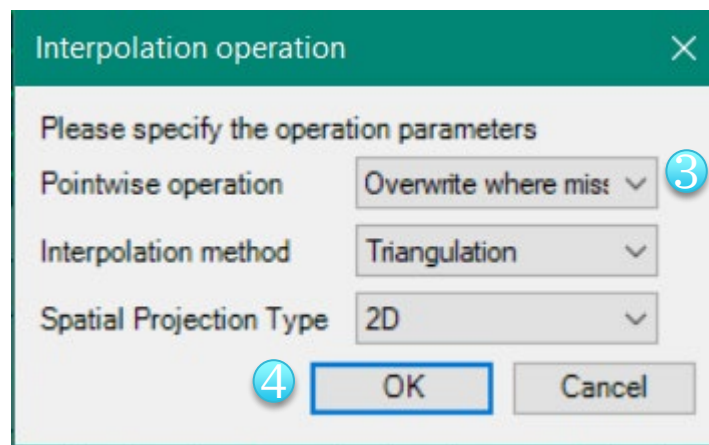
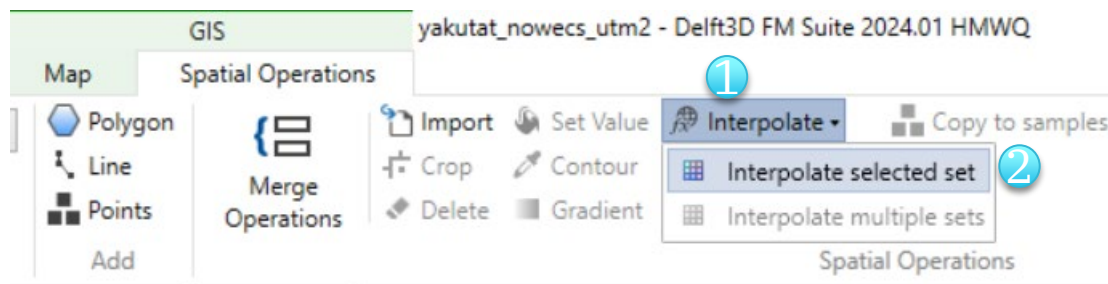
Interpolate Bathy on Inner Grid

1. Click Interpolate in the GIS Spatial Operations tab
2. Select Interpolate selected set
3. In the popup select Overwrite where missing
4. Click OK



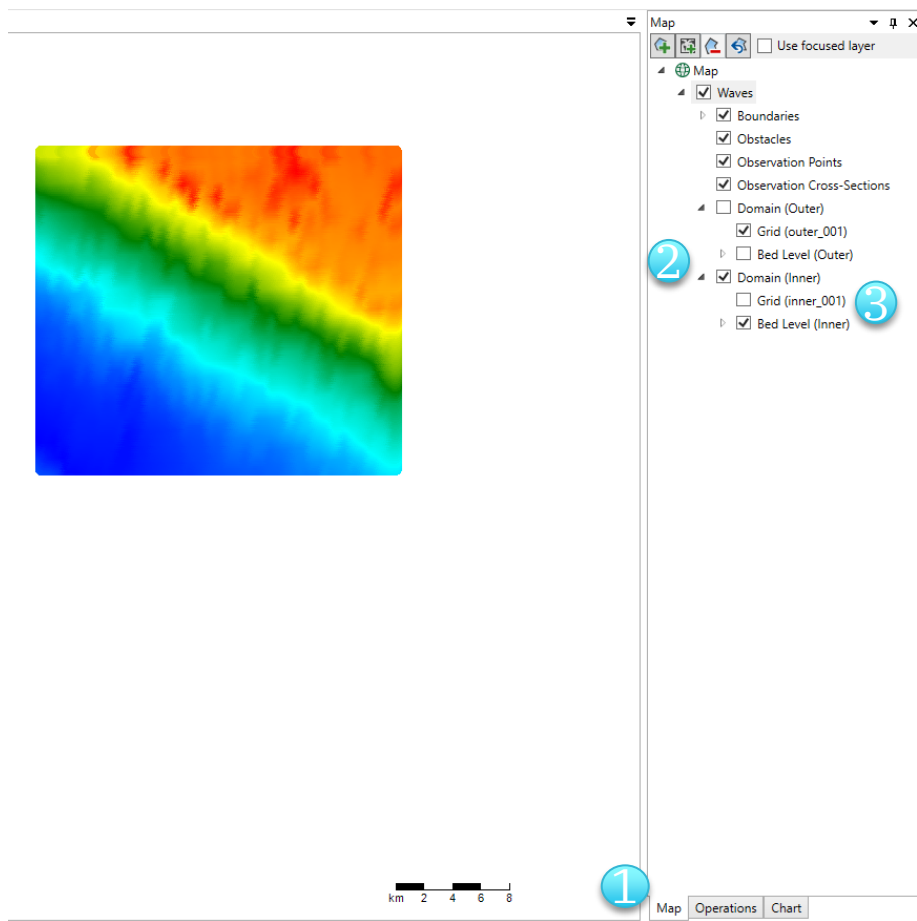
Interpolate Bathy on Inner Grid

1. Click Interpolate in the GIS Spatial Operations tab
2. Select Interpolate selected set
3. In the popup select Overwrite where missing
4. Click OK



View the bathymetry

1. Select the Map Pannel.
 2. Expand Domain (Inner)
 3. Uncheck Grid (Inner)
- › The bathy for the inner grid should now be visible.



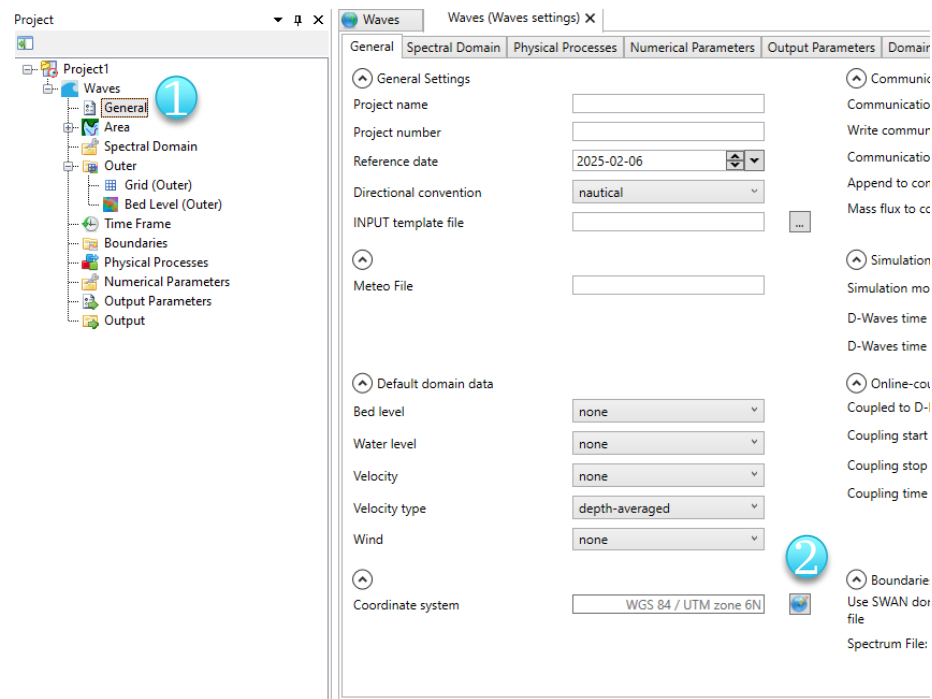
Add a Basemap



Define the Coordinate System

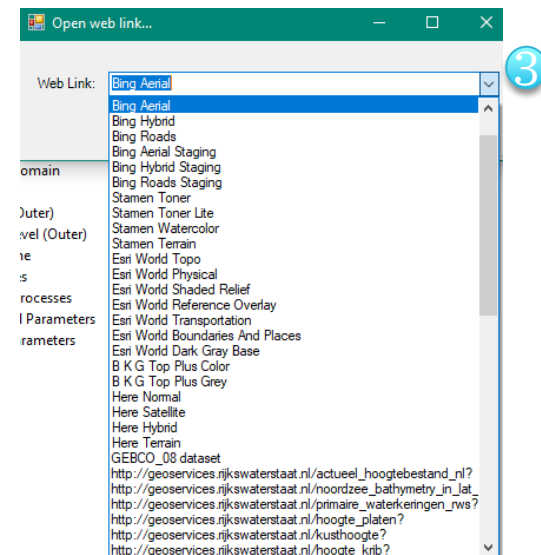
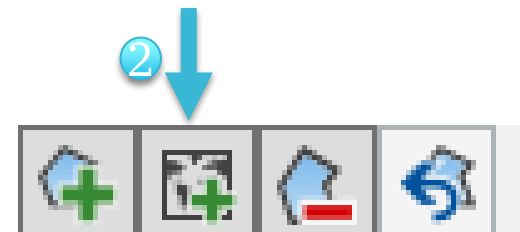
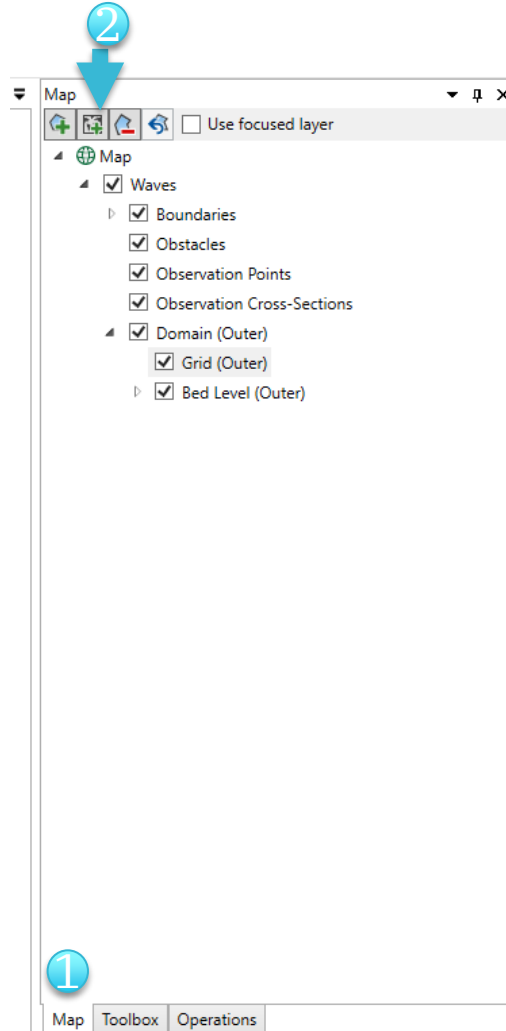
› The coordinate reference system will be defined to add a basemap

1. Double Click on General
2. Click on the world icon next to Coordinate System.
3. Enter **32606**



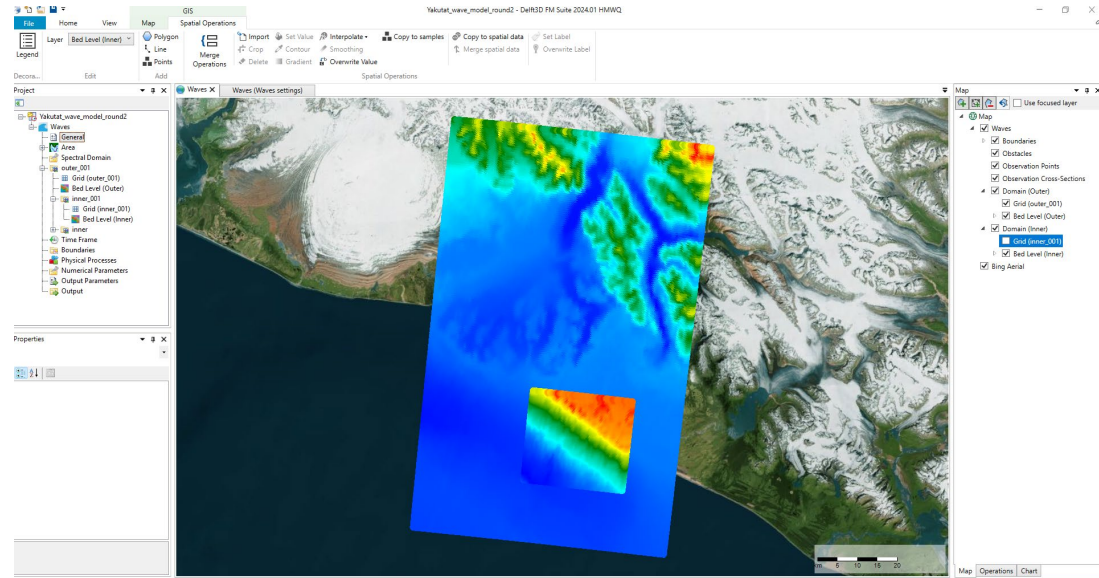
Basemap

1. Select the Maps Panel
2. Click on the add New WMS layer icon
3. Select a basemap (Bing Aerial)



Basemap

- › The grids and bathymetries will now appear with the basemap.



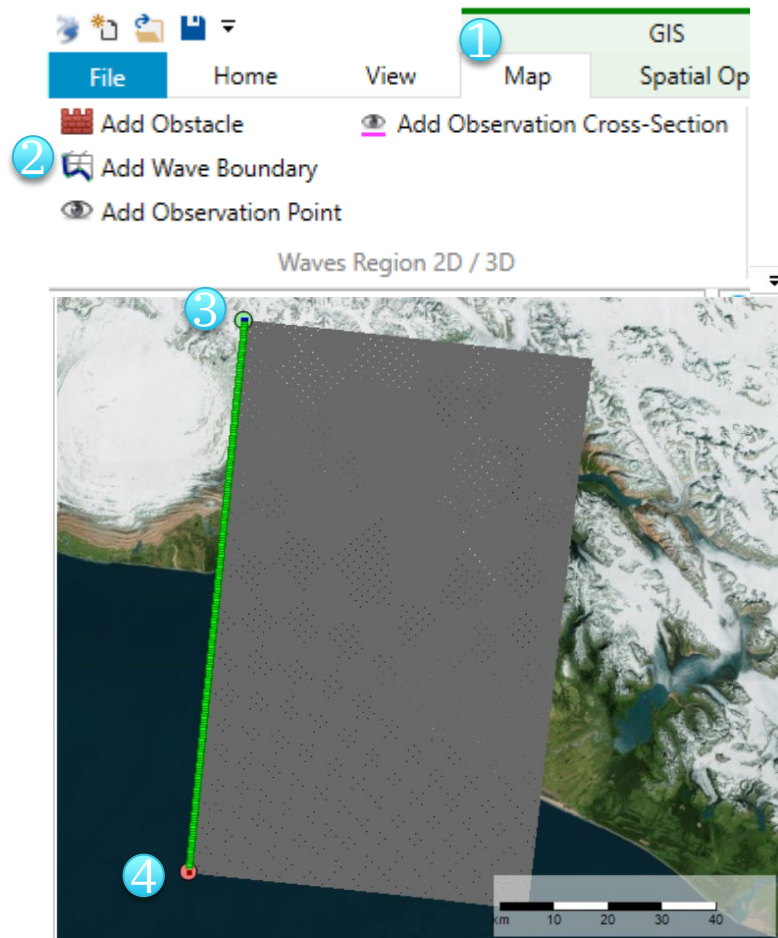
Add Boundary Conditions



Boundary Conditions

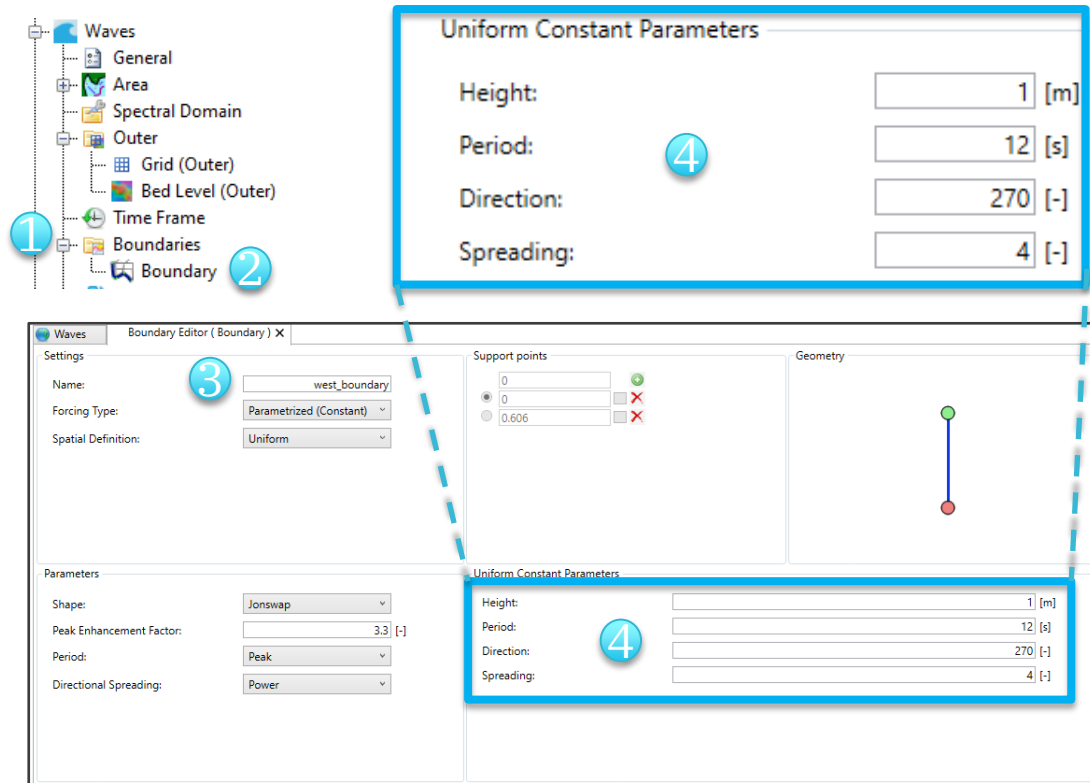
➤ Boundary Conditions are added to the outer grid.

1. Select the GIS-Map tab
2. Click Add Wave Boundary in the.
3. Single click near the top west side (left)
4. double click near the bottom west side (left).



Boundary Conditions Cnt.

1. Expand Boundaries in the Project Panel.
2. Double Click on Boundary
3. Rename the boundary name to *west_boundary*.
4. Update Uniform Constant Parameters to match those shown



Boundary Conditions Cnt.

1. Add a wave boundary along the south side.
2. Add a wave boundary along the east side
3. Update boundaries with the same parameters as the west boundary.

Uniform Constant Parameters	
Height:	<input type="text" value="1"/> [m]
Period:	<input type="text" value="12"/> [s]
Direction:	<input type="text" value="270"/> [-]
Spreading:	<input type="text" value="4"/> [-]

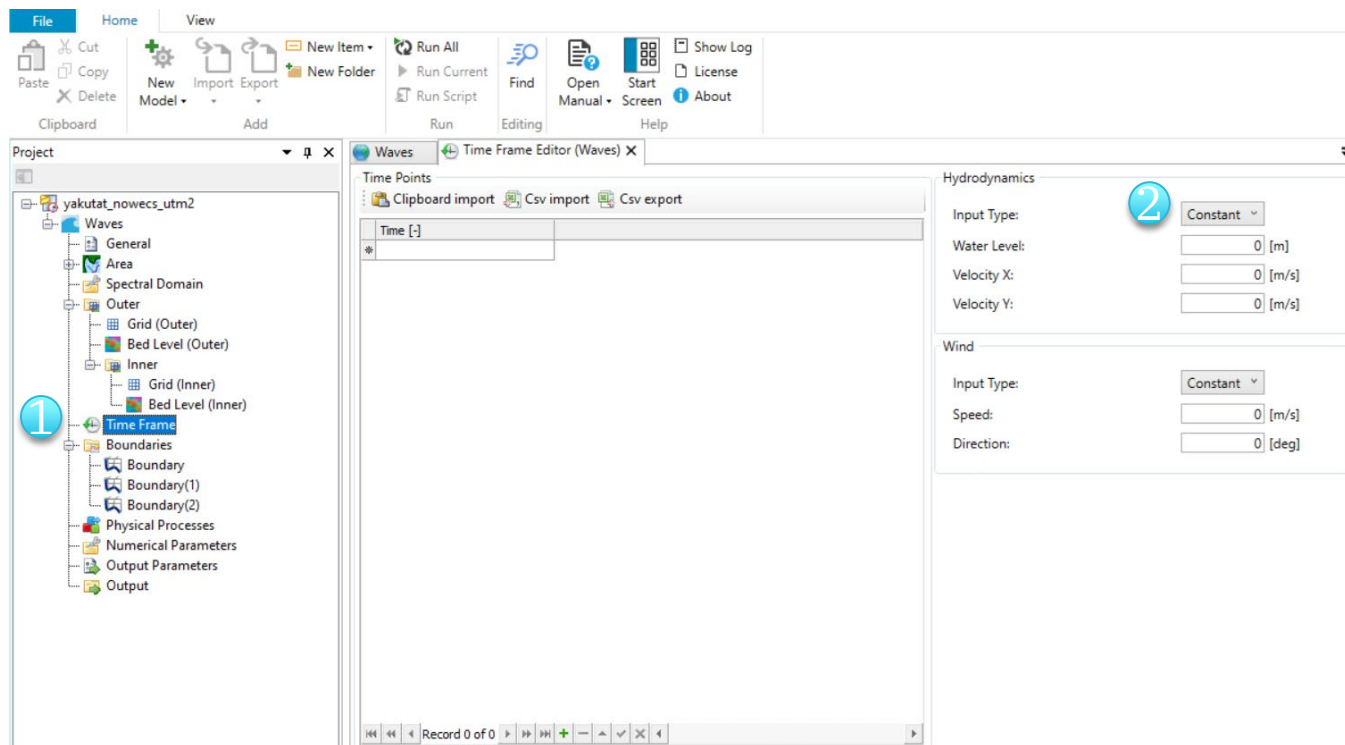


Model Settings



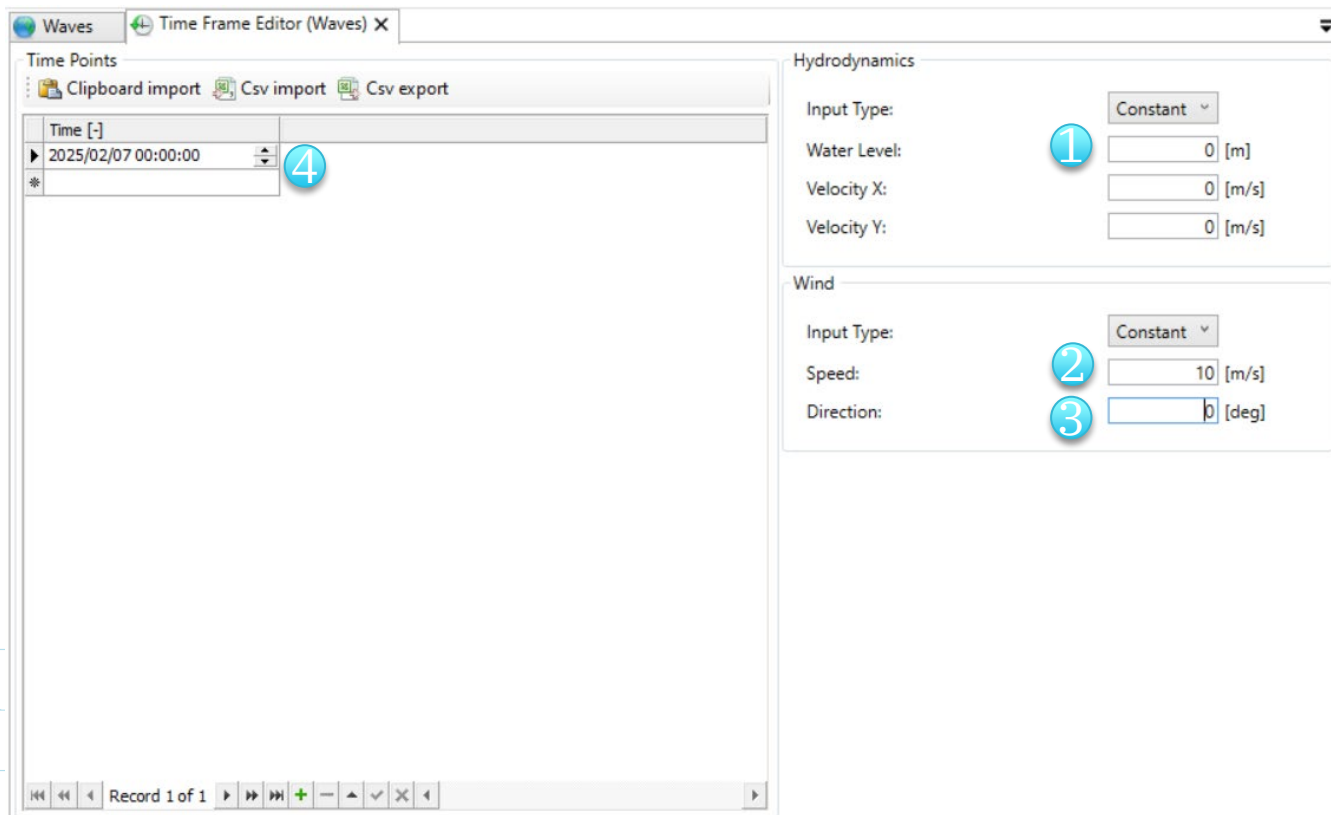
Set Time Frame

1. Double Click on Time Frame in the Project Panel
2. Select Constant from the Input Type dropdown menu.



Set Time Frame

1. Keep Water Level, and Velocity at 0.
2. Set the Wind Speed to 10 m/s
3. Set direction at 0 deg.
4. Add a single date
 - E.g. today's date



Physical Processes

- › Keep physical process at the default value, or match those here.

General	Spectral Domain	Physical Processes	Numerical Parameters	Output Parameters	Domain specific settings
<div> <div>⬆</div> <div>Constants</div> </div>					
Water level correction		<input type="text" value="0"/> [m]			
Gravitational acceleration		<input type="text" value="9.81"/> [m/s ²]			
Water density		<input type="text" value="1025"/> [kg/m ³]			
North direction w.r.t. x-axis		<input type="text" value="90"/> [deg]			
Minimum water depth		<input type="text" value="0.05"/> [m]			
<div> <div>⬆</div> <div>Breaking</div> </div>					
Depth induced breaking		<input checked="" type="checkbox"/>			
Alpha		<input type="text" value="1"/> [-]			
Gamma		<input type="text" value="0.73"/> [-]			
<div> <div>⬆</div> <div>Bed friction</div> </div>					
Bed friction		<input type="text" value="JONSWAP"/>			
Bed friction coef.		<input type="text" value="0.038"/> [m ² /s ³]			
<div> <div>⬆</div> <div>General</div> </div>					
Physics mode		<input type="text" value="third generation"/>			
Wave setup		<input type="checkbox"/>			
Wind growth		<input checked="" type="checkbox"/>			
Quadruplets		<input checked="" type="checkbox"/>			
White capping formulation		<input type="text" value="Komen"/>			
Refraction		<input checked="" type="checkbox"/>			
Frequency shifting		<input checked="" type="checkbox"/>			
Wave force computation		<input type="text" value="dissipation 3d"/>			
<div> <div>⬆</div> <div>Triads</div> </div>					
Triads		<input type="checkbox"/>			
<div> <div>⬆</div> <div>Diffraction</div> </div>					
Diffraction		<input type="checkbox"/>			

Domain specific settings

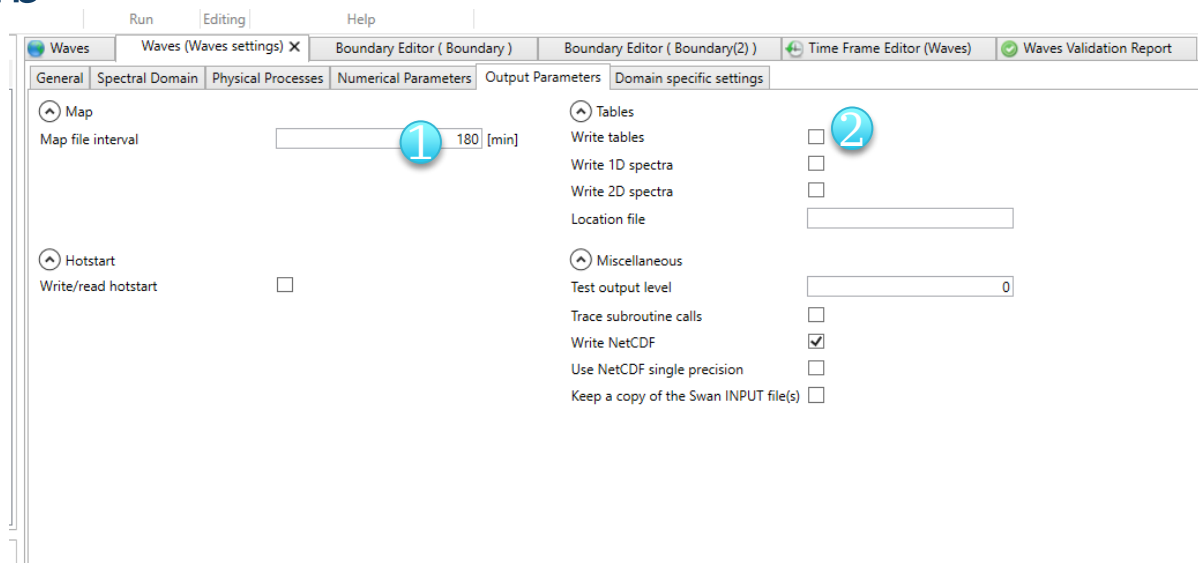
- › Keep the default value, or match those here.

General		Spectral Domain	Physical Processes
Numerical Parameters		Output Parameters	Domain specific settings
<div> <div> All Domains Outer </div> </div>			
Outer <div> <input type="checkbox"/> Use custom values Type Circle Nr. of directions 72 [-] Start direction 0 [deg] End direction 360 [deg] </div>		<div> <input type="checkbox"/> Use custom values Nr. of frequencies 24 [-] Start frequency 0.05 [Hz] End frequency 1 [Hz] </div>	
<div> <input type="checkbox"/> Use custom values Input type Wind vector Wind velocity ... Spider web ... </div>		<div> <input type="checkbox"/> Use custom values Bed level Do not use Water level Do not use Velocity Do not use Velocity type Depth averaged Wind Do not use </div>	

Output Parameters

› Outputs are in NetCDF format

1. Update Map file interval to 180 min
2. Uncheck Write tables



Model is now set up to run without turbines

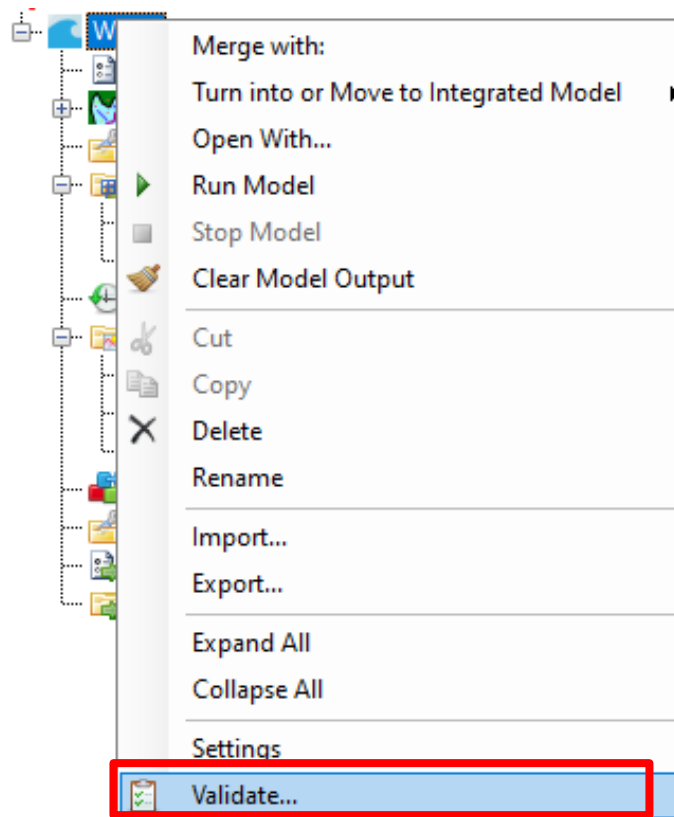
- › The steps outlined above get us to a base model with relevant components
 - Unstructured grid (Outer and Inner)
 - Basic bathymetry
 - Boundary conditions
- › Save model in File-> Save as
 - Select a save location and check to make sure it created
 - .dsproj file
 - Project folder and a subfolder called Waves and in that a subfolder called input

Run The Model



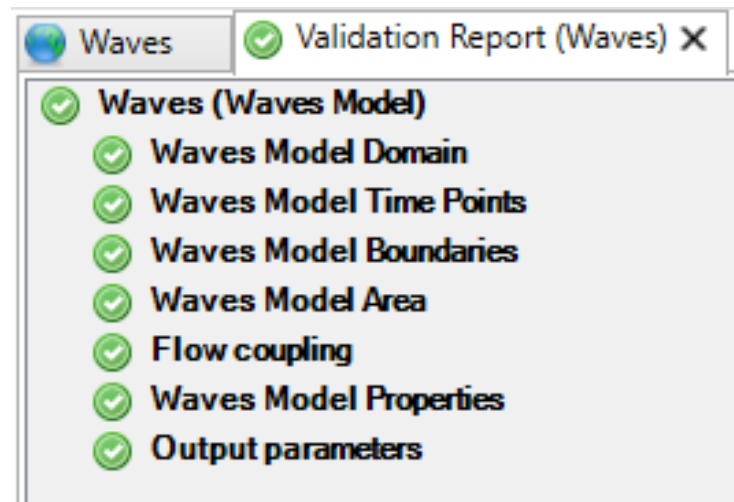
Check the Model

- › We're ready to run the model
- › A good check prior to executing is to “validate” first to make sure all settings are input
- › Right Click on Wave and select Validate



Results of Validation

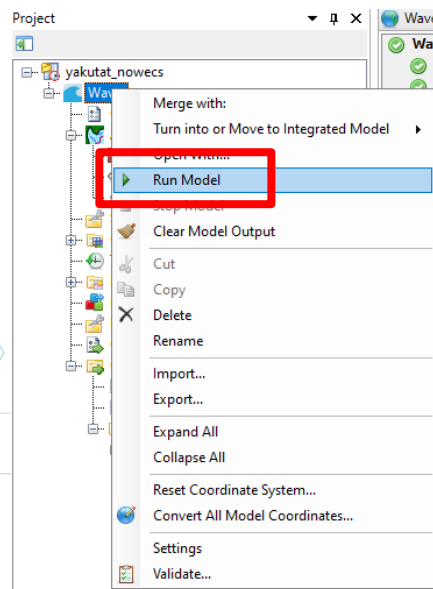
- › All check –boxes should be green
- › Some may show as red if something is not properly set up and it will tell you what those are.
 - Common issues may be inconsistent timing of start/stop and boundary conditions
- › Warnings with ! May also appear and you can select the item to evaluate why



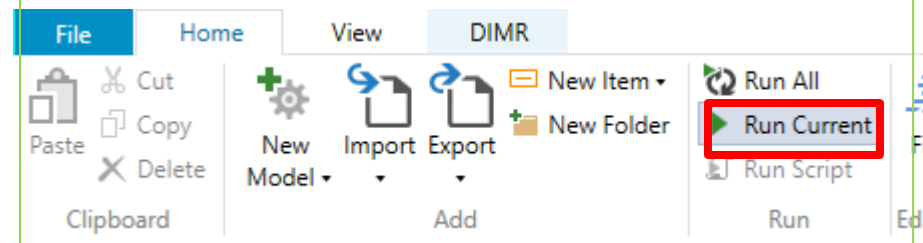
Run the model

› 2 Ways to execute

› Right Click Waves and select run

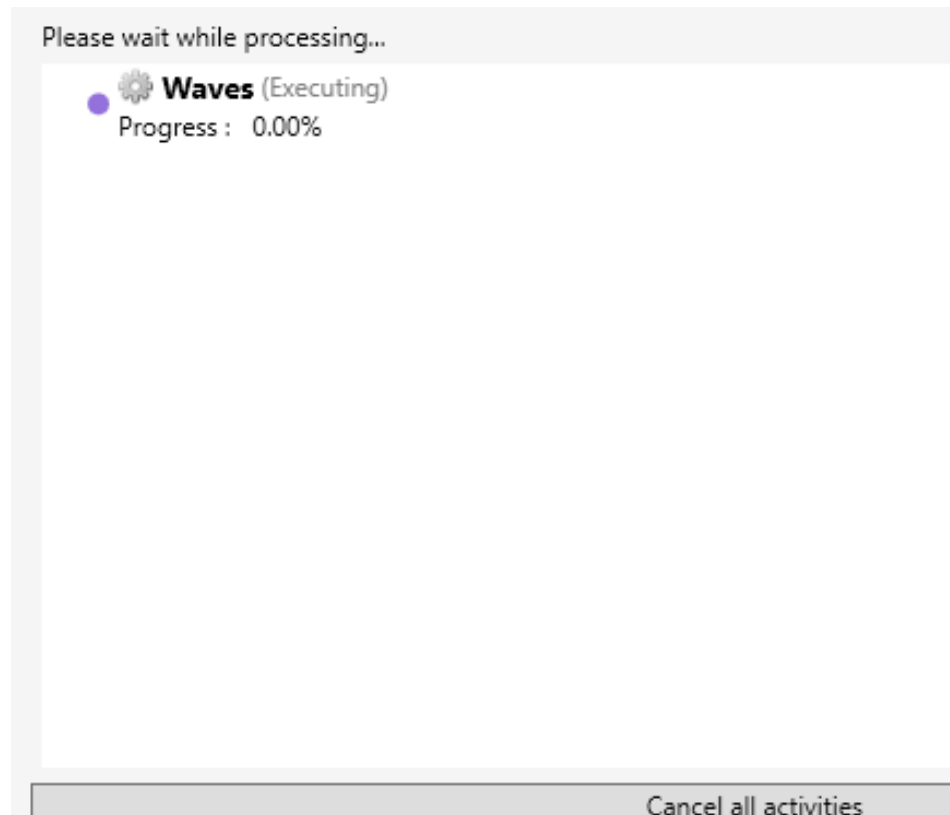


› In Home Menu select Run Current



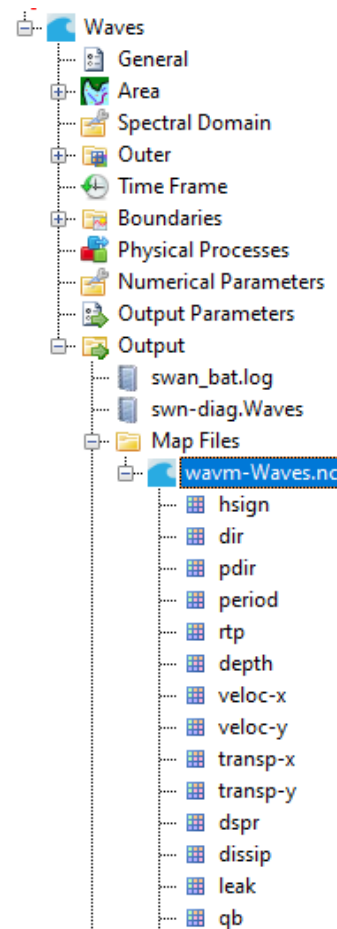
Model running

- › If model is run from the GUI a box will appear showing progress
- › NOTE: This is not the only way to run these models
- › Models can be run with bash scripts, on linux, or other means.



Success!!

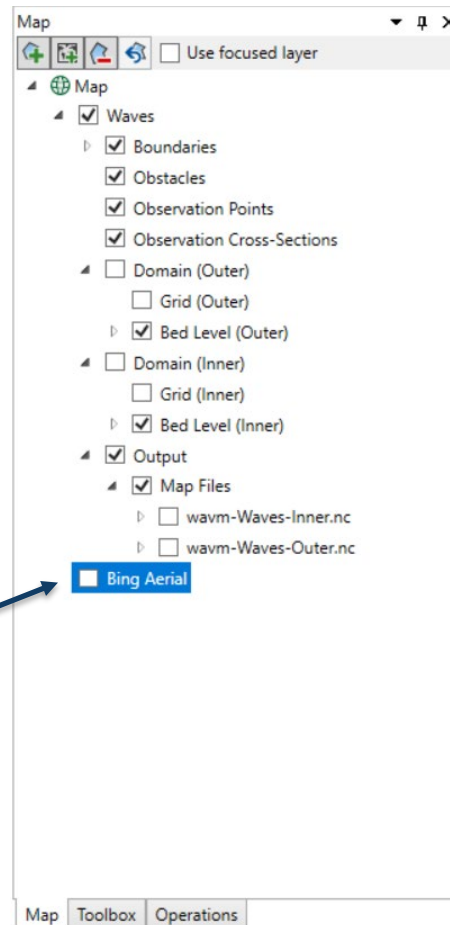
- › Model run was successful
- › Save model and results will be saved to an output folder in same location as the input folder
- › Model results appear in the Project Pannel. Expand the Output folder and wavm-Waves.nc under Map File to view a list of variables



View Results

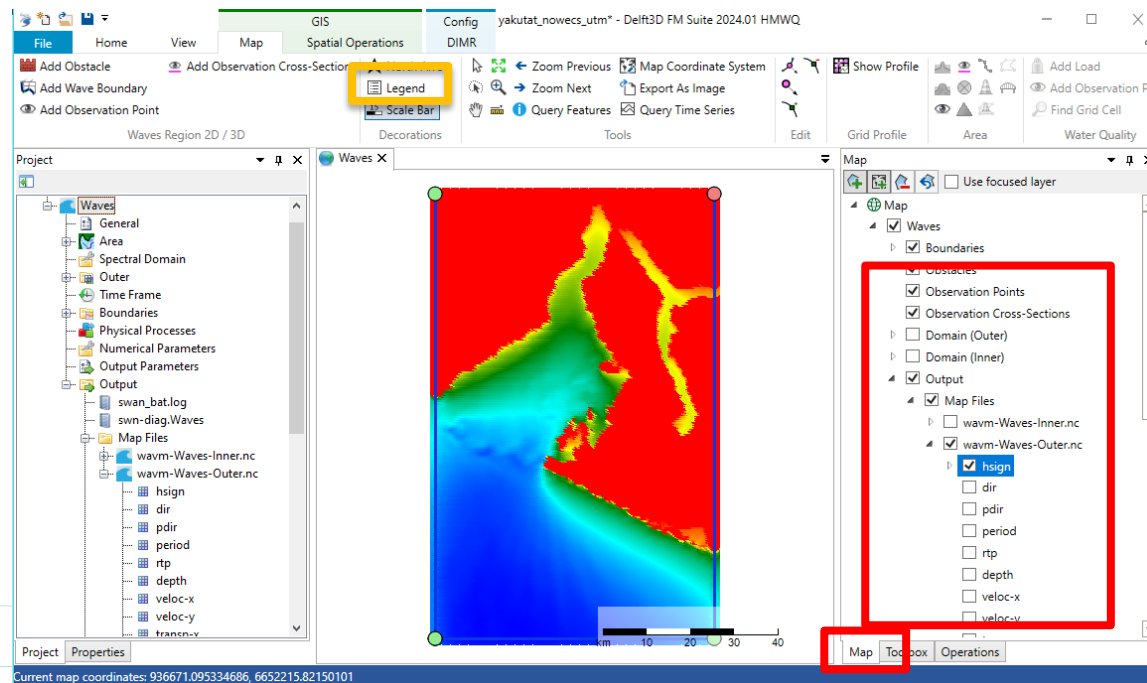
- › The output results will appear in the Project Panel.
- › Unfortunately, the coordinate reference system will not match the location (hopefully fixed in later version of Delft).

1. Unselect the Basemap from the Map Panel



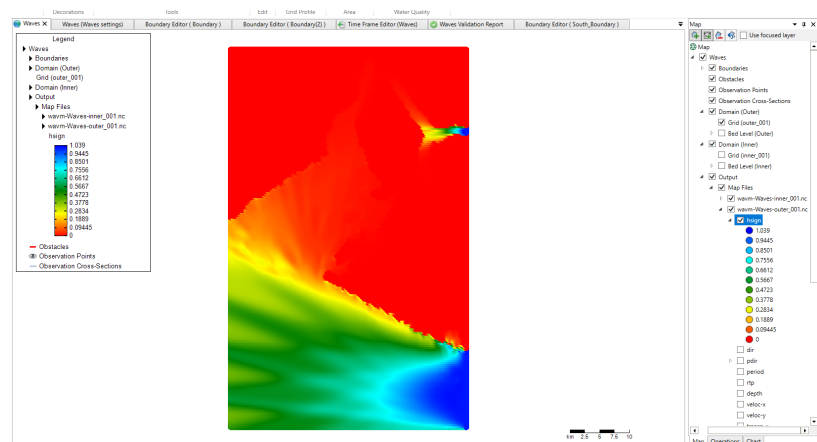
View Results

- The output results will appear in the Project Panel.
- Select the variable layer in the **Map** panel to display a variable.
- Add a **legend** to inspect values.

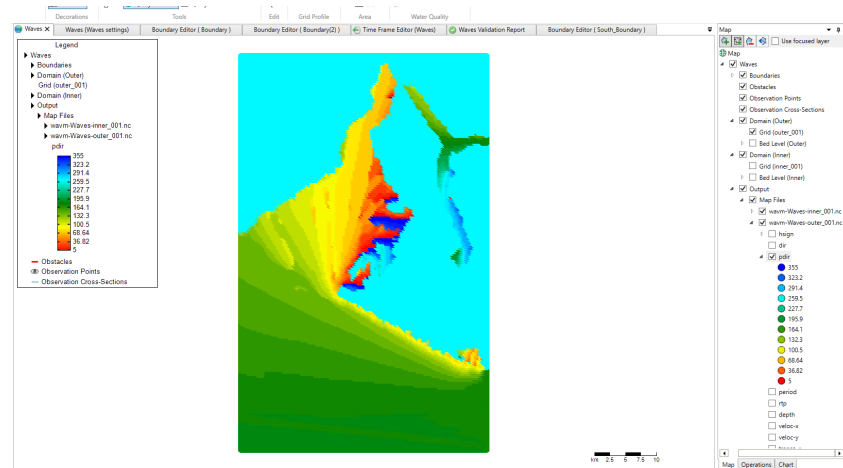


Directional Bug

- Note that while the boundary conditions specify wave direction in a nautical direction, SWAN outputs in a cartesian direction (i.e., direction waves are travelling TOWARDSs)



- For an example, see the following figure.
 - Boundary conditions were waves coming from 90degrees Nautical only on the eastern boundary, and outputs show direction as 180 degrees



Save the Model

- › Save the model to save the Output.
- › Save model in File-> Save as
 - Select a save location and check to make sure it created
 - .dsproj file
 - Project folder and a subfolder called Waves and in that a subfolder called input

The model output will be in the *yakutat_nowecs_utm.dsproj_data/Waves/output* directory.