iRIC Software

Changing River Science

Nays2DH Examples

iRIC version 4.0

Introduction to Nays2DH

You can use Nays2DH in the iRIC for your calculations using the following procedures;

Launch Nays2DH
Prepare to use Nays2DH in iRIC

↓

Generating the computational grid
Generate the computational grid by using selected geographic data (river survey data, Digital Elevation Model,etc)

↓

Setting the computational conditions
Set initial and boundary conditions, etc

↓

Running a simulation
Calculate with Nays2DH

↓

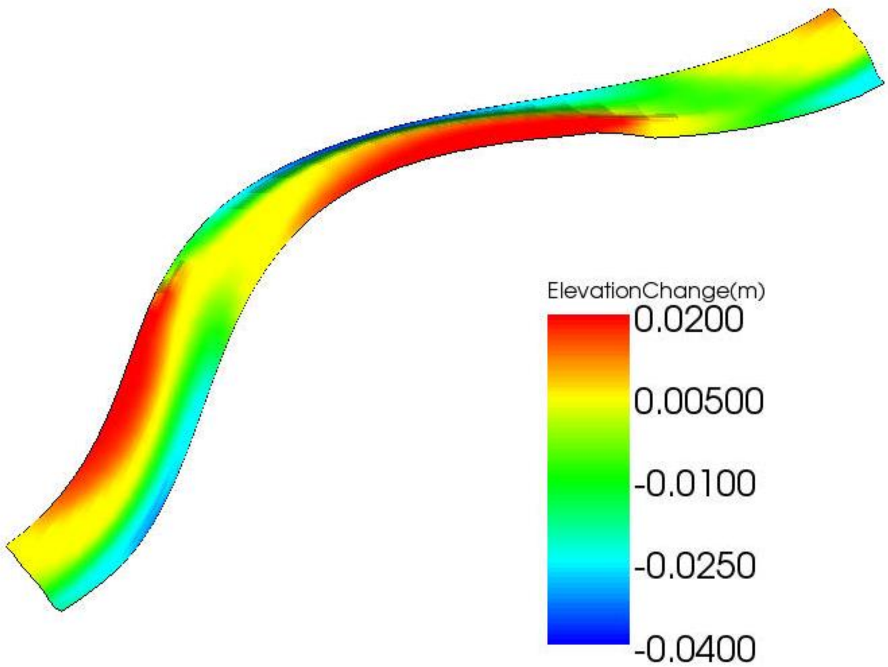
Visualizing the simulated results
Visualize the simulated results such as flow velocity, water depth, river bed elevation and more using contour maps, vectors, etc

Tutorial I.

Calculation of flow and morphological change of river bed in a meandering channel

● Purpose of this tutorial

You can understand the basic operation of Nays2DH in iRIC by calculating the flow and morphological change of the river bed in a meandering channel with simple bed geometry, and also understand the fundamental bed evolution phenomena in a meandering channel.

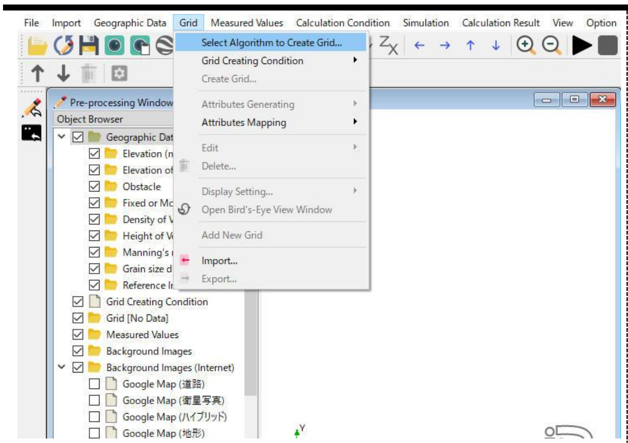


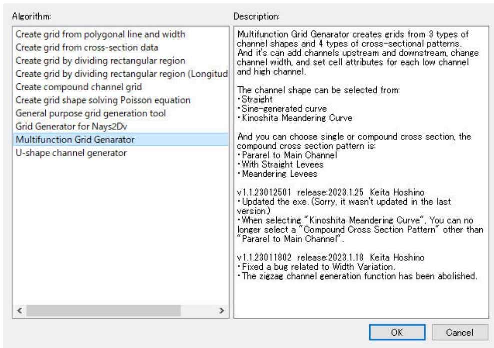
1. Generate a computational grid

Generate a computational grid of a meandering channel with a rectangular cross section using the [Multi-function Grid Generator] included in iRIC.

Select Menu bar → [Grid] → [Select Algorithm to Create Grid].

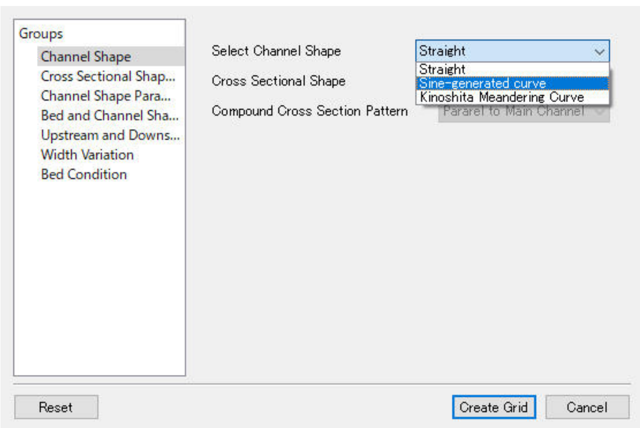
In the grid generation algorithm selection dialog, select [Multifunction Grid Generator] and press [OK].





The dialog for grid generation will be opened.

You can generate the computational grid by clicking on [Create Grid] after setting the conditions defined as follows.



[Channel Shape]

-Select Channel Shape

：Sine-generated curve

[Cross Sectional Shape Parameters]

- Width：0.3m
- Number of Grid in Lateral Direction：16

[Channel Shape Parameters]

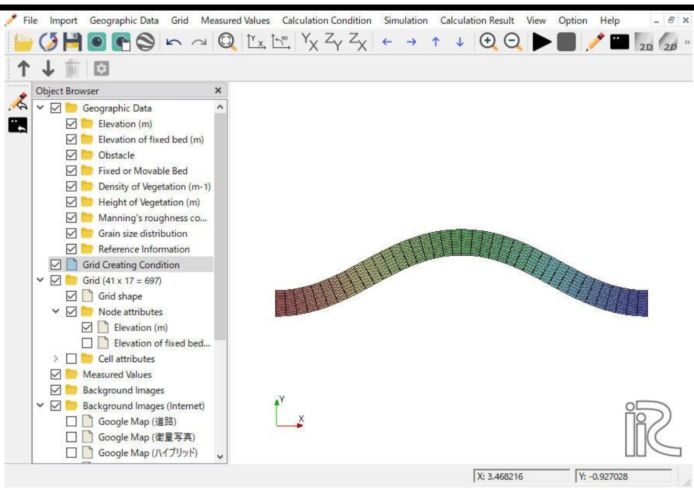
- Wave Length of Meander：4.7m
- Meander Angle ：28.6°
- Number of Grid in One Wave Length : 40

[Bed and Channel Shape]

- Channel Shape：0.004

The default values are used for the other parameters.

A confirmation dialog which asks you [Do you want to map geographic data to grid attributes now?] will appear. Click on [Yes], and the computational grid will be generated as follows.

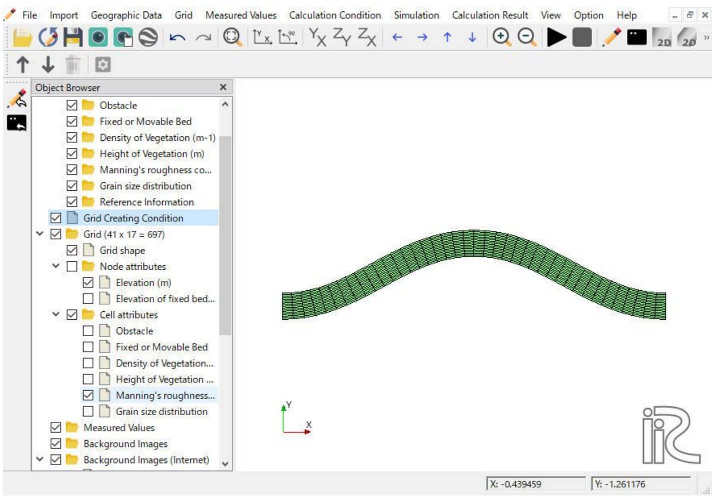


The computational grid will appear on the screen.

2. Set the cell conditions

The cell conditions can be set on the generated computational grid. Here, you set the Manning's roughness coefficient.

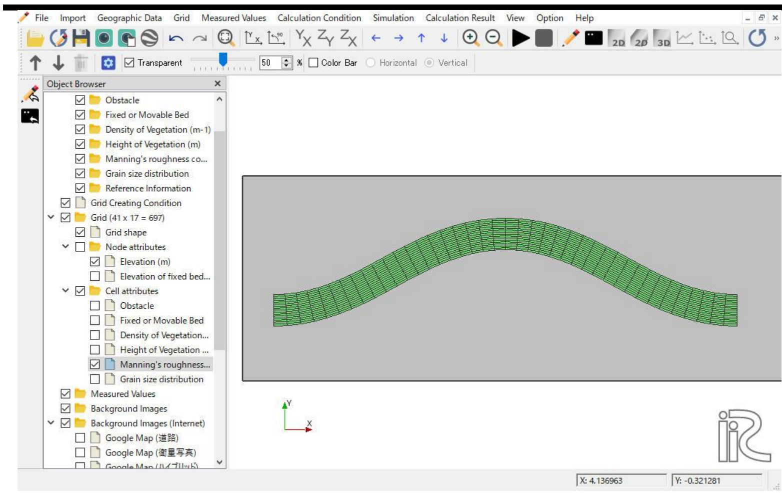
Click on [Cell attributes] in the object browser, and change the status of cell attributes to ☑. You can open the cell attributes by clicking on ▷ bottom on the left side of [Cell attributes], and then click on [Manning's roughness coefficient].



- The left side of the figure is the object browser, and the right side of the figure is the visualization screen.
- When you want to change something in the visualization screen, you need to click on the related item in the object browser. When you click on that item, the background color of the item changes to light blue. Such status is defined as 'active' here.
- While you keep the status of [Manning's roughness coefficient] as ☑, the contour on the grid indicates the value of [Manning's roughness coefficient].

Select all of computational grid by operating your mouse, and then right-click on the selected region.

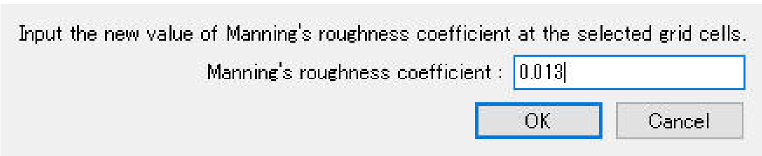
Then select [Edit value] on appeared menu.



- You can directly change the value of cell attributes of each cell.
- Hold down the Shift key and select cells continuously. You can select remote cells at the same time.

On the dialog [Edit Manning's roughness coefficient], you can specify the value of this coefficient in the region you selected.

By this procedure, Manning's roughness coefficient is set at all of cells in the grid.

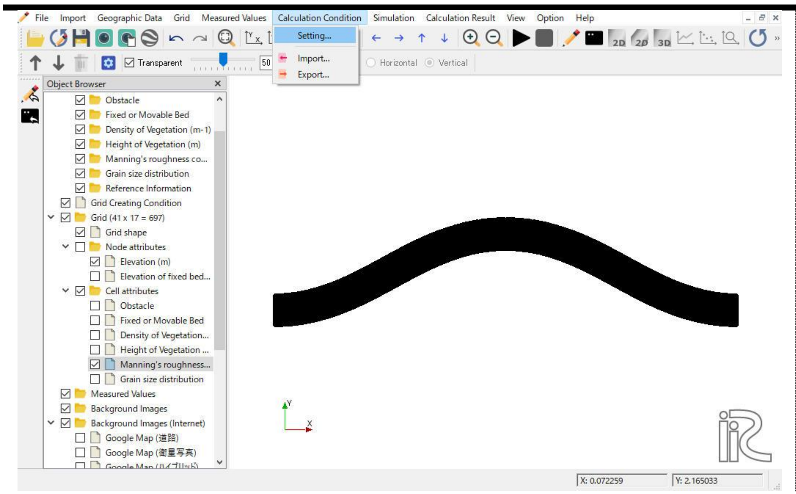


- Manning's roughness coefficient :0.013

3. Set the computational conditions

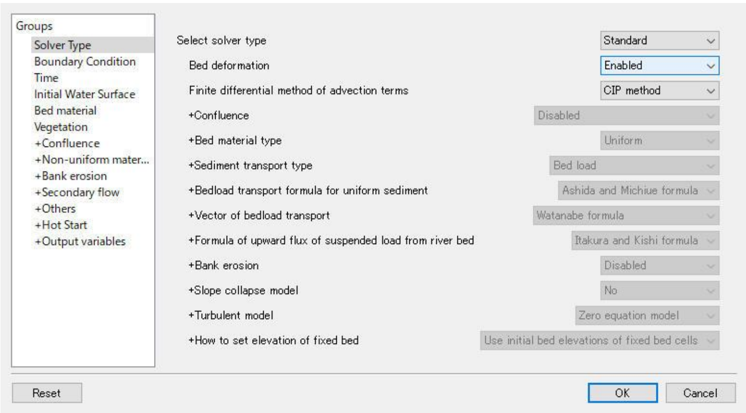
This section explains how to set the computational conditions for Nays2DH. The modified part of the dialog needed for this computation is only described below. For the rest of parameters, the default values are used.

Select [Calculation conditions] → [Setting] on menu bar.



- [Import]: iRIC reads the computational conditions from another iRIC project file which was created using Nays2DH.
- [Export]: You can output the computational conditions for other runs.

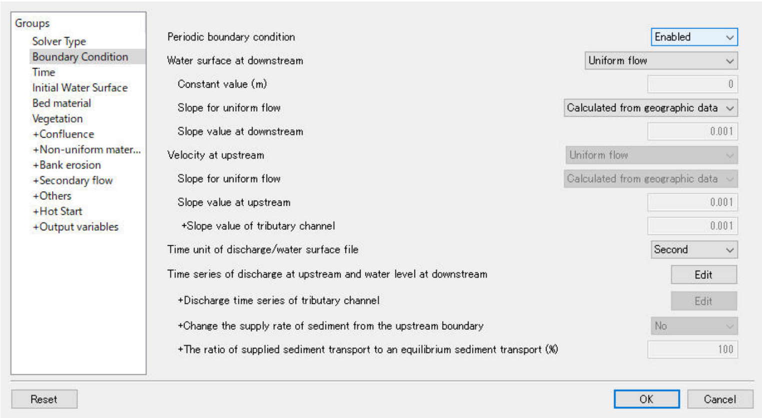
Set the computational conditions for this run as follows.



- Solver Type: setting the general settings of Nays2DH
  - Bed deformation: Enabled

Note: You can select the items with mark [+], if you select [Advanced] in [Select Solver Type].

Set the boundary conditions.

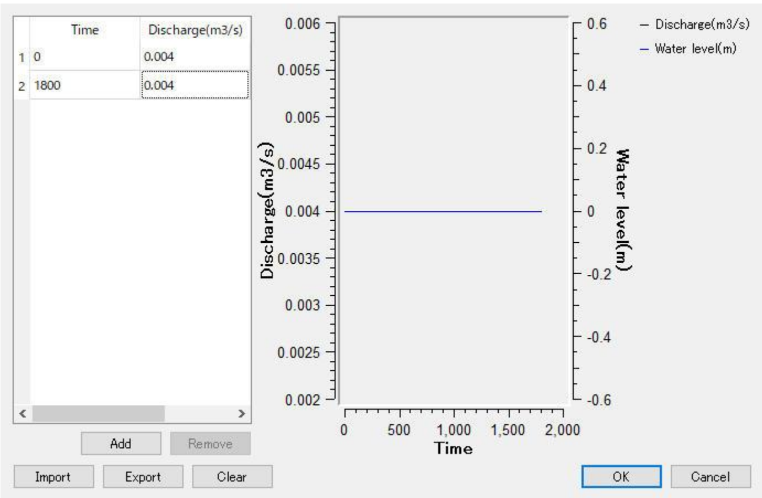


- Boundary conditions

  -Periodic boundary condition: Enabled
  -Time unit of discharge/water surface file: Second

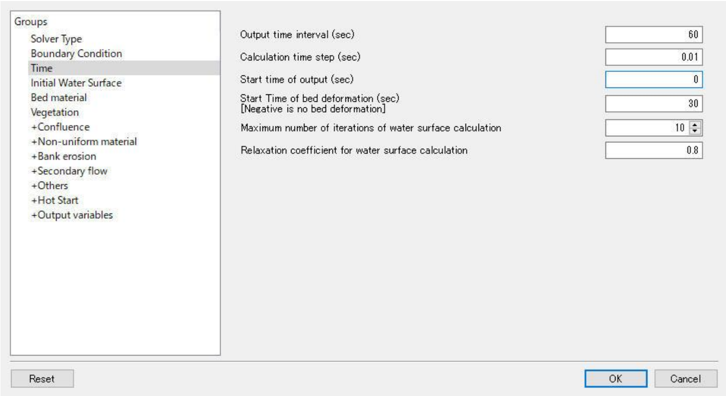
After setting the conditions as shown below, click [Edit] for [Time series of discharge at upstream and water level at downstream].

Set the discharge of upstream end.



- Clicking on [Add] makes new line.
- Time from 0 to 1800 (sec) with a constant discharge of 0.004 m^3/s, is given in this example.

Setting conditions related to Time.

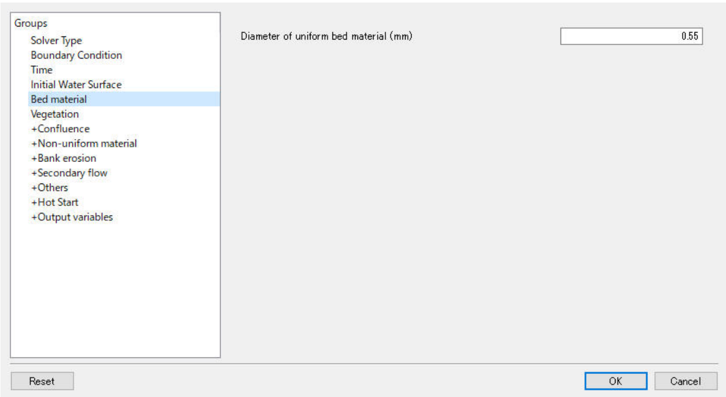


-Output time interval: 60 sec

-Calculation time step: 0.01 sec

-Start time of output: 0 sec

Setting conditions related to Bed material.

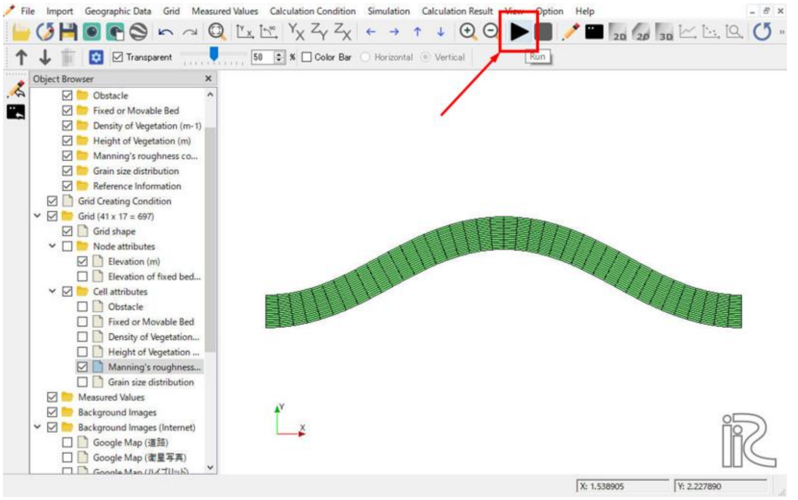


- Diameter of uniform bed material(mm): 0.55(mm)

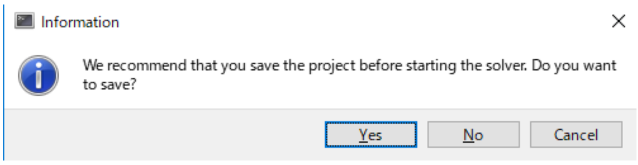
4. Run a simulation

After setting calculation conditions, run the computation.

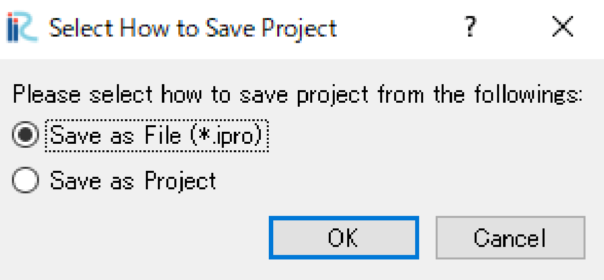
For running a simulation, select [Simulation] → [Run] in menu bar or select ▶ on menu tool bar.



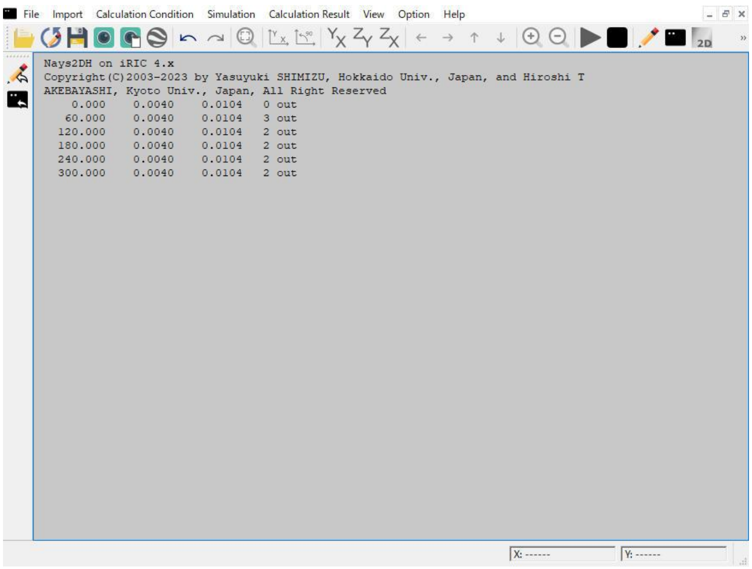
Before running the calculation, a message recommending that you save the current project is displayed, so click “Yes” to save the project.



There are two methods of saving the project, [Save as File (*.ipro)] and [Save as Project]. Here, select [Save as File (*.ipro)] and save it.

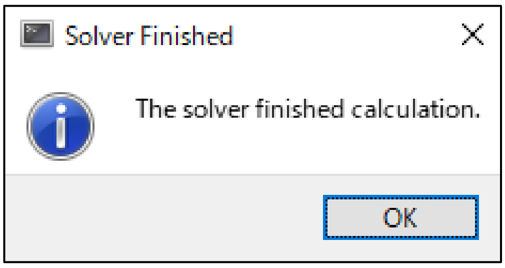


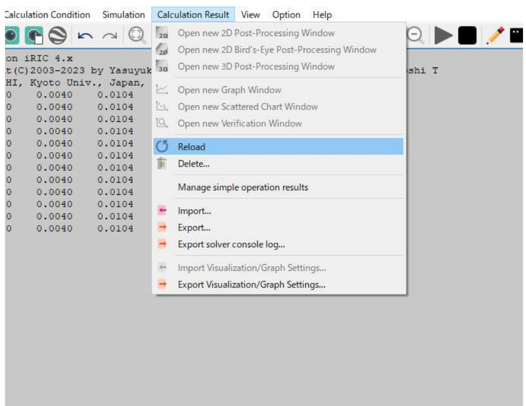
When saving the project is completed, the solver console starts up and the calculation begins.



- The numbers shown in solver console are time (sec), discharge (m^3/s) and downstream water level (m) (from left to right).
- The [out] shown on the right-hand side of the numbers means that iRIC has written the result to a file to be visualized.

You can visualize the result after getting a dialog which informs you [The solver finished calculation] (left figure), or by selecting [Calculation result] → [Reload] on the menu bar (right figure) during the calculation.

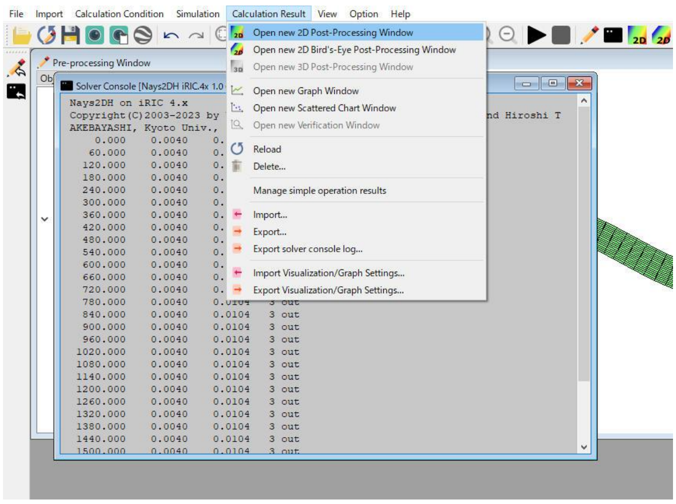




5. Visualize the results

By visualizing the output results, we confirm the calculation result.

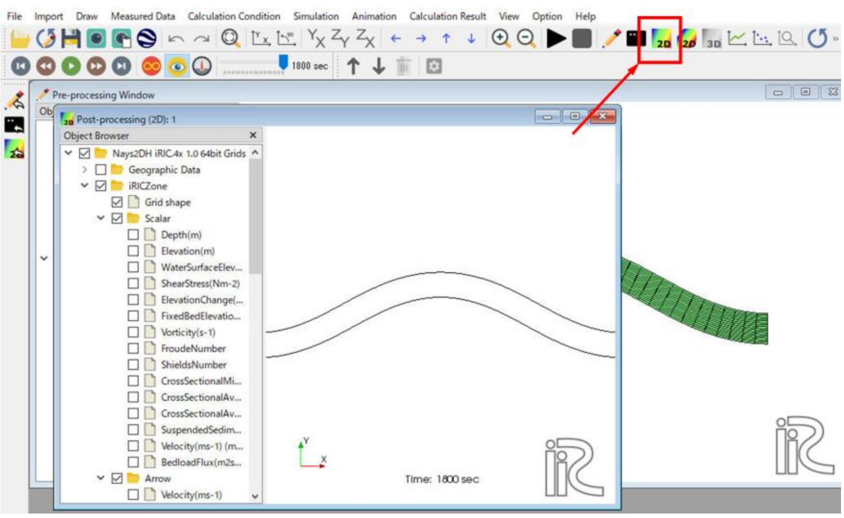
Select [Calculation result] → [Open new 2D post-processing window] in the menu bar, or click on the button shown in the following figure.



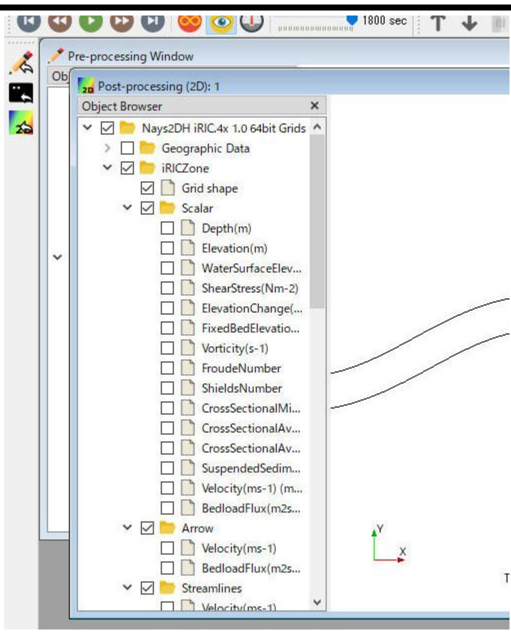
The buttons for visualization are from left to right:

- 2D Post-Processing window: for visualizing top or plan view of the result
- 2D Bird's-Eye Post-Processing window: for visualizing three dimensional view
- Graph window: for visualizing one dimensional graph of model variables

2D post-processing window will open.

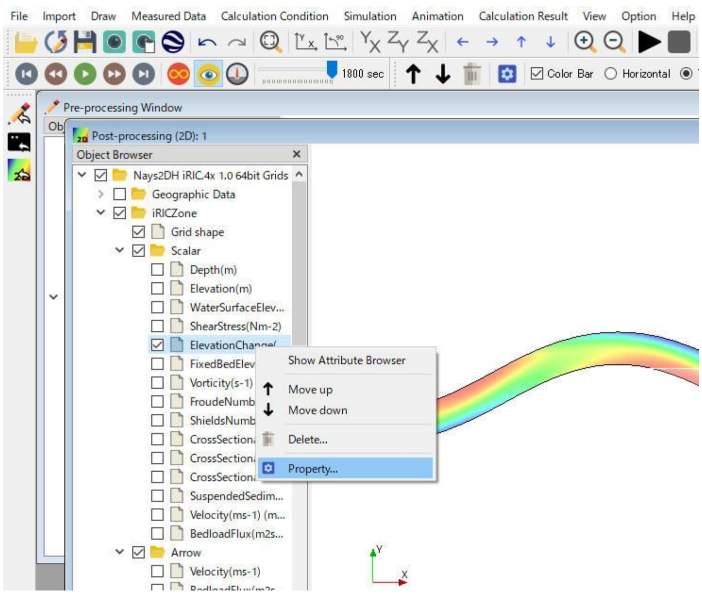


To display the physical quantity in a contour plot, left-click on the quantity you want to visualize. We choose “ElevationChange (m)” to visualize the calculation result of bed evolution.

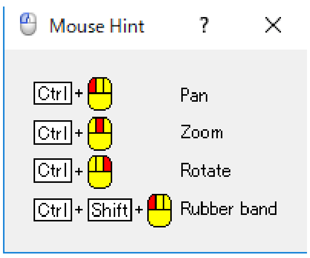


- [Scalar]: show a contour map of selected scalar data.
- [Arrow]: show a vector of selected vector data.
- [Particles]: visualize particle movement by selected vector data.
- [Particles]: visualize particle movement by selected vector data.
- [Cell attributes]: show the cell attributes you set in the cell conditions.
- [Measured values]: You can read the measured data such as experimental data.

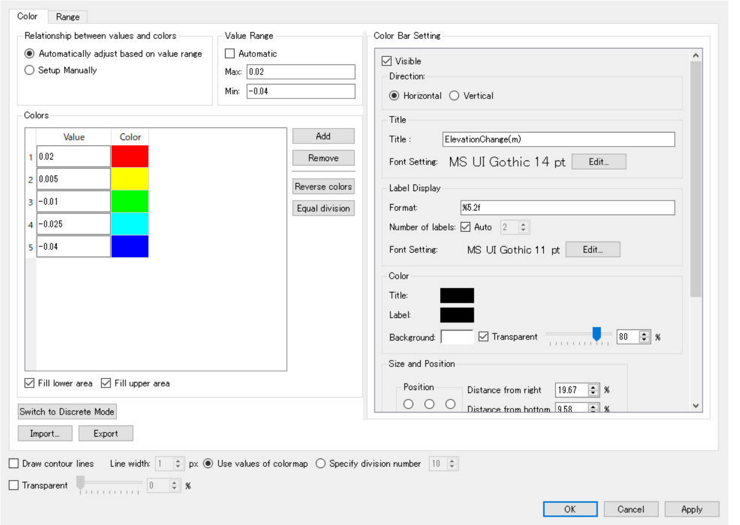
To change the range of color legend, right-click on [Scalar > ElevationChange (m)] and click [Property].



- You can grab the color bar with the mouse and move it. (Note that the scalar must be active.)
- You can pan / zoom / rotate the drawing screen using the following mouse operation.

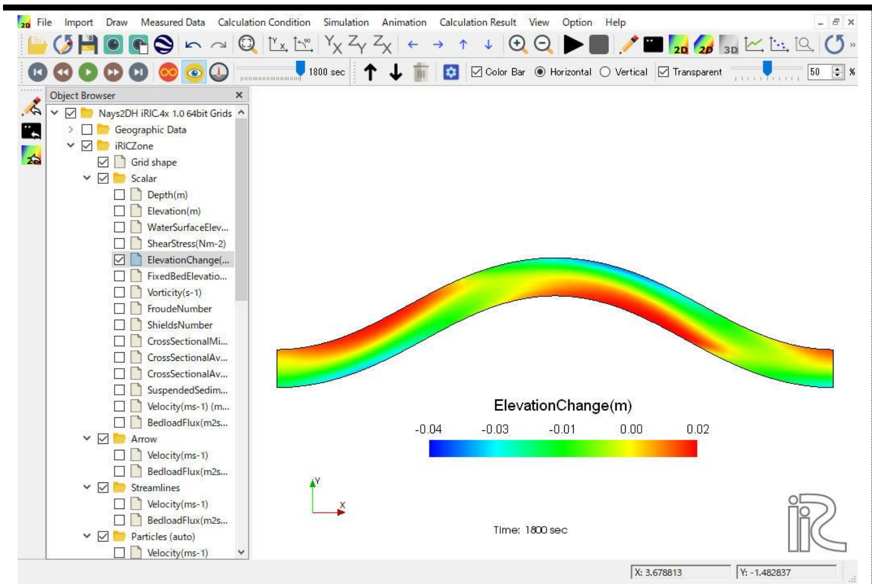


You can change the maximum value, minimum value, division number, etc. of the color bar.

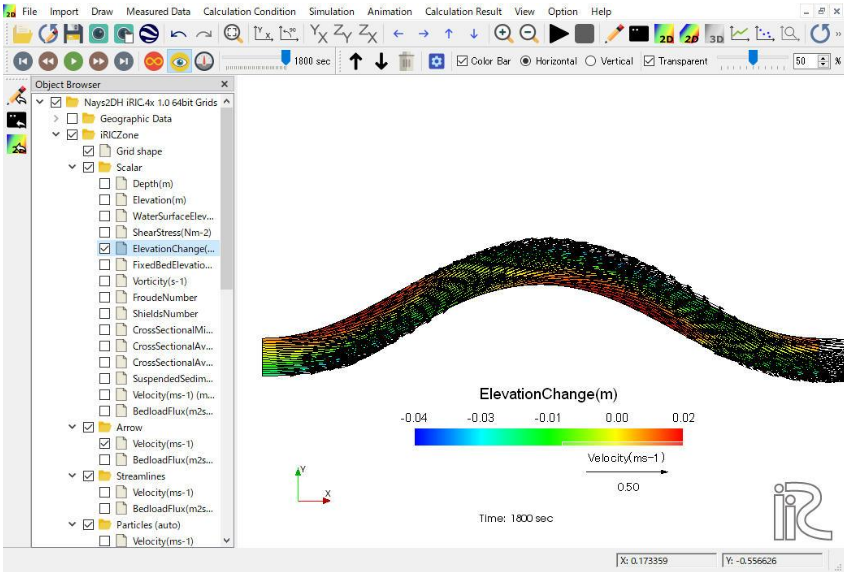


- Deselect [Automatic]
- Max: 0.02 (m)
- Min: -0.04(m)
- Deselect [Transparent] box
- Color bar setting:
  Direction > Horizontal

Now, you can clearly observe a point bar on the inner bend and the erosion in the outer bend.

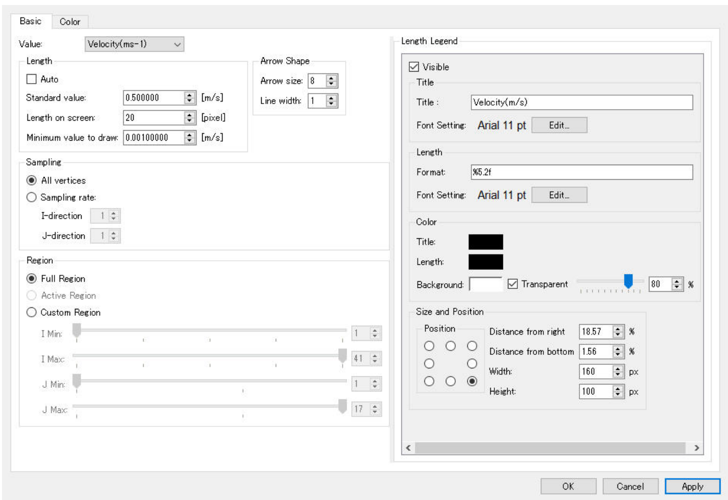


In the next step, the flow field is visualized by vectors. Click on the box of [Velocity] under [Arrow] in the object browser.



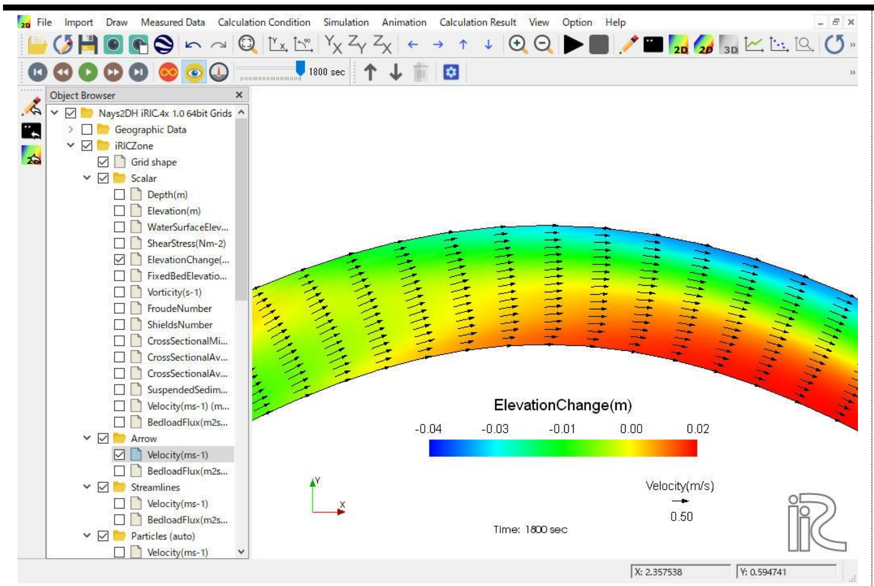
The flow in the computation is visualized by vectors. However, the length of vectors is not suitable for the visualization.

For setting the properties of vectors, right-click on [Arrow], and select [Property] on the pop-up menu that appears. The dialog for setting the vector scaling will open.

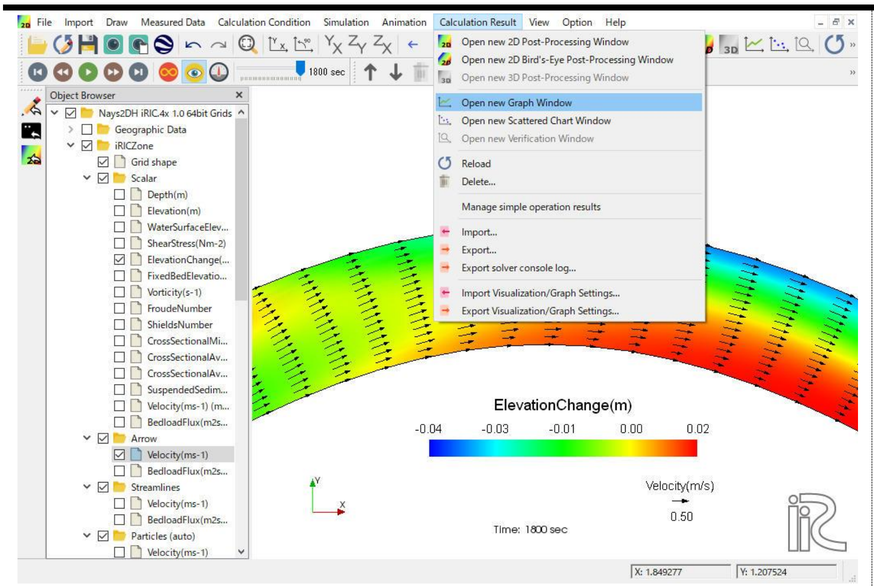


- Deselect [Auto] check box
- Length on screen: 20 pixel
- Legend title:
  Velocity (m/s)

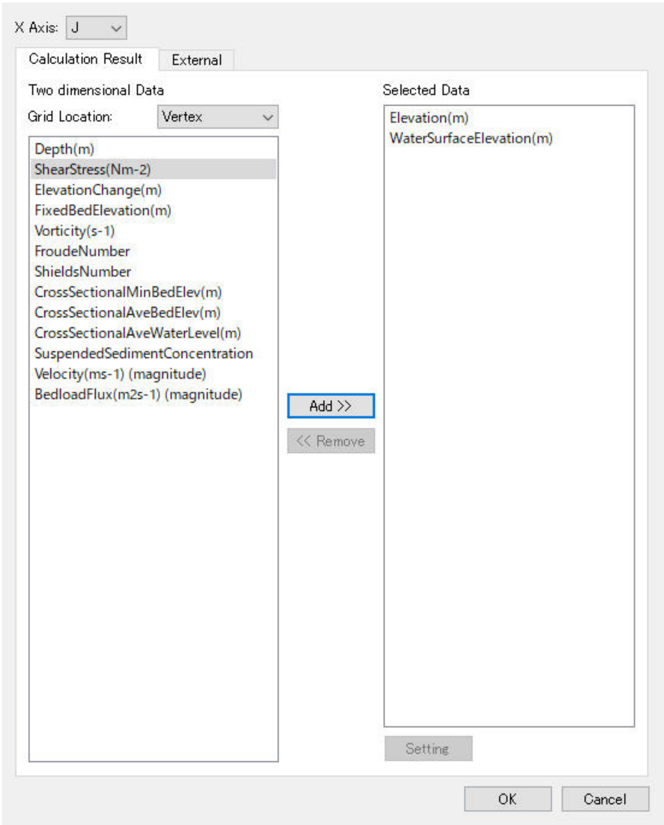
By adjusting the length of vectors, you now can see the flow field in the meandering channel.



Next, the one-dimensional graphic function is used for visualizing the water level and bed elevation in the cross section. Select [Calculation Result] → [Open new graph window] on the menu bar.



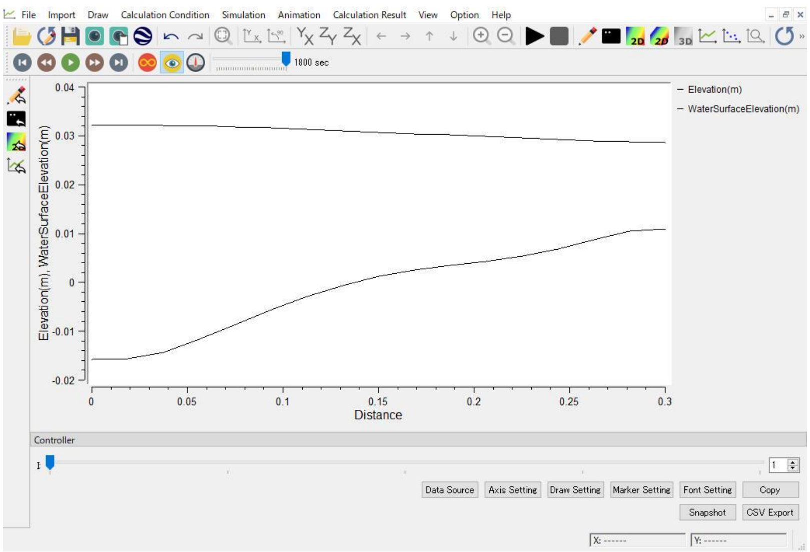
The dialog for setting the data of 1D graph will open. Select the X Axis as [J] and add [Elevation] and [WaterSurfaceElevation] from [Two dimensional data] to [Selected data].



- X Axis: J
- Two-dimensional Data: Select [Elevation], [WaterSurfaceElevation] and click on [Add].

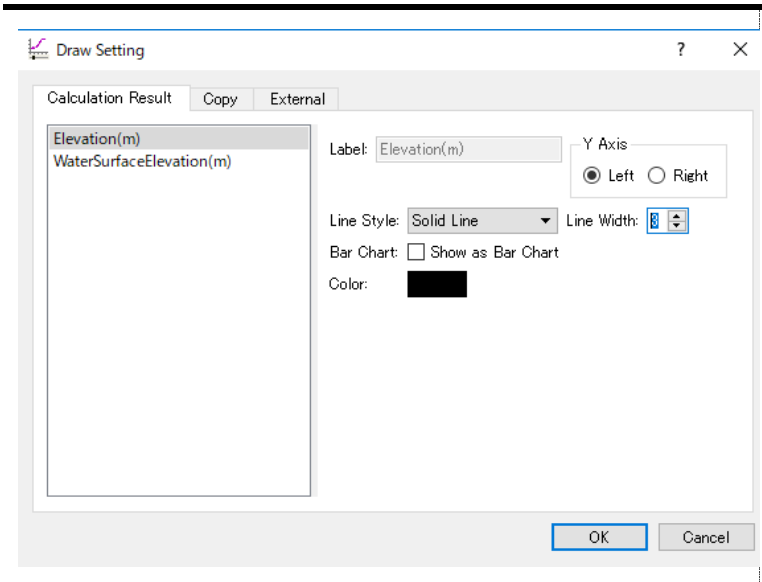
Note: I and J indicate the index of the longitudinal and transverse direction in the grid.

The water surface and bed in a cross section are visualized. Click on [Draw Setting] for changing the visualization properties of this graph.



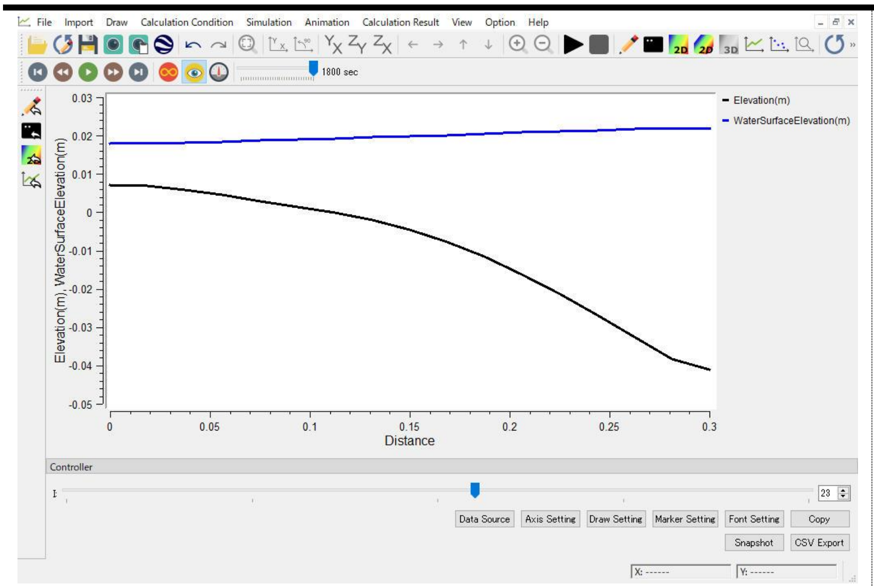
- By moving the location of I on Controller, you can change the position of the cross section.

You can change the style width and color of lines.

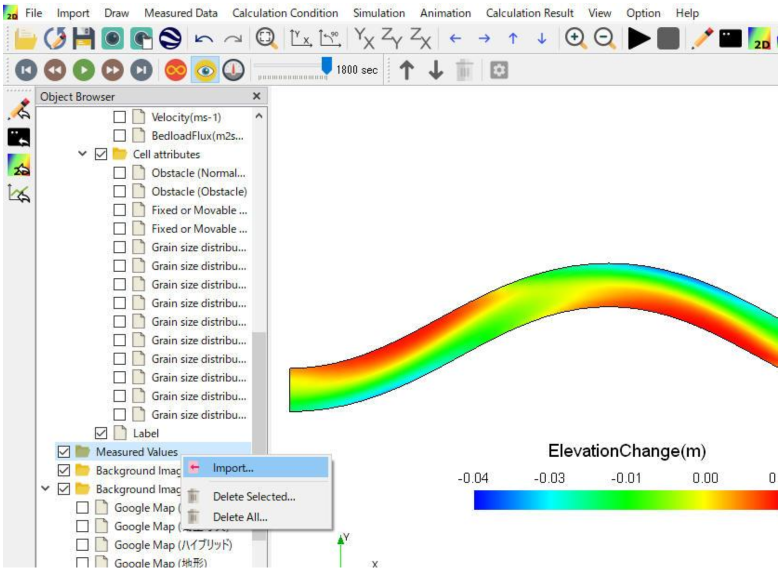


- Setting for Elevation(m)
  -Line style: Solid Line
  -Line Width: 3
  -Color: Black
- Setting for WaterSurfaceElevation(m)
  -Line style: Solid Line
  -Line Width: 3
  -Color: Blue

You can visually understand the line of water surface and river bed.

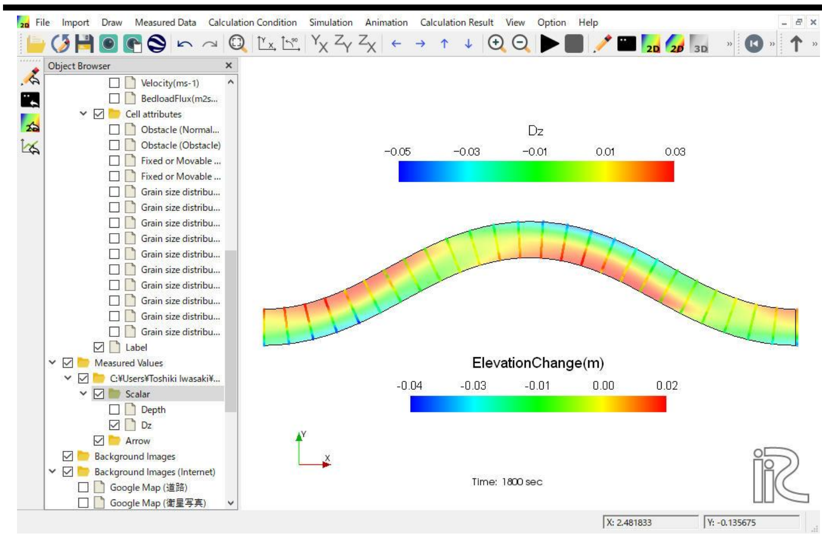


As the last step, the simulated bed elevation changes are compared with the experimental results. Right-click on [Measured Values], and select [Import] on the pop-up menu.



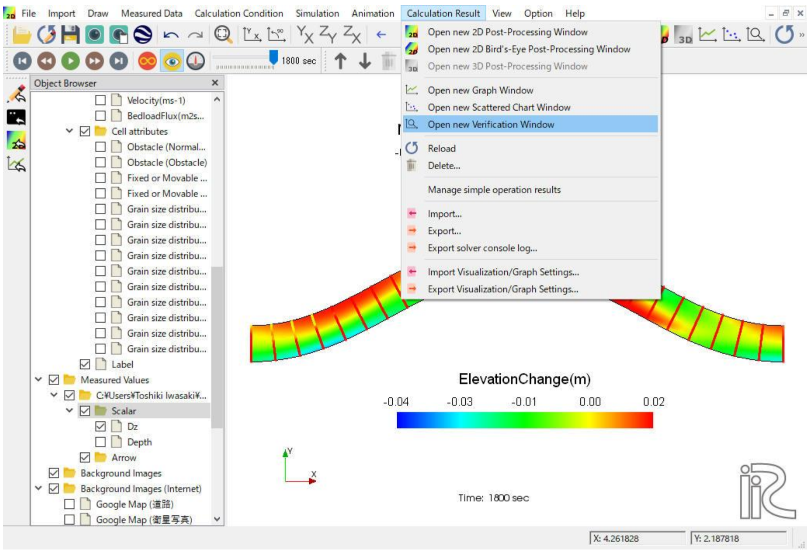
- "measured.txt" is specified as a [Measured values].

The measured data will be imported. Set the scalar and color bar ranges to be the same. You can change the range of color legend by right-clicking [Scalar] under [Measured Values] and selecting [property] on appeared pop-up menu.

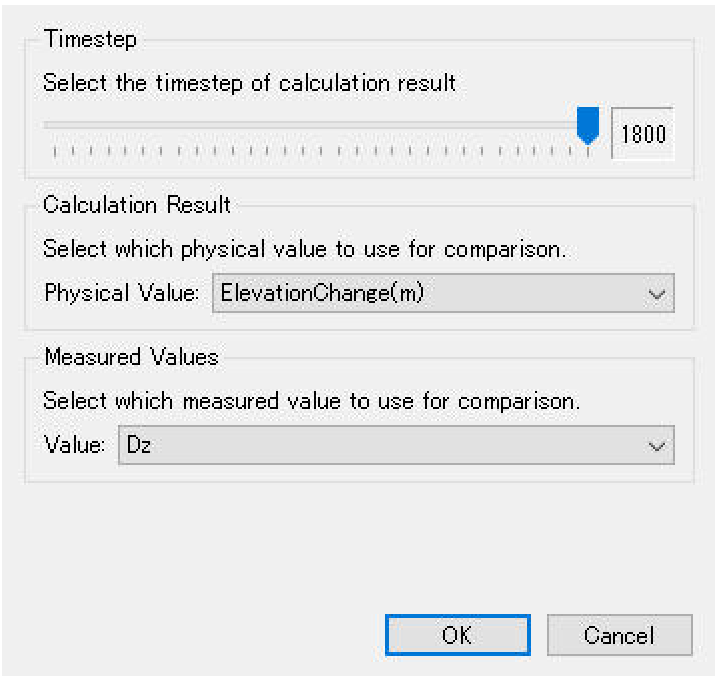


- The calculation result shows that the trend of measured values can be roughly reproduced.

You can do more qualitative comparison between simulated and measured bed topography. On the menu bar, select [Calculation Result] → [Open new verification window].

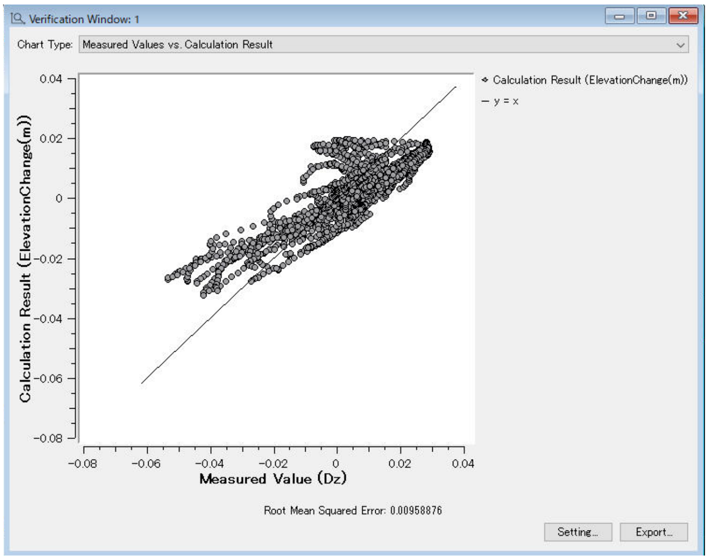


You will specify the time and quantity of simulated result for the comparison as well as the measured data. Here, the bed evolution is compared.



- [Timestep]: 1800, meaning you choose the simulation result at the end of computation.
- [Calculation Result]: ElevationChange(m)
- [Measured Value]: Dz

The dialog “Verification” will open. Select “Measured value vs. Calculation Result” for Chart type. The solid line in the figure means perfect agreement between simulated and measured bed evolution rate. The calculation result shows good agreement with the measured data. You can see how this agreement changes when you change the calculation condition (e.g., grid resolution, roughness, model parameters etc).

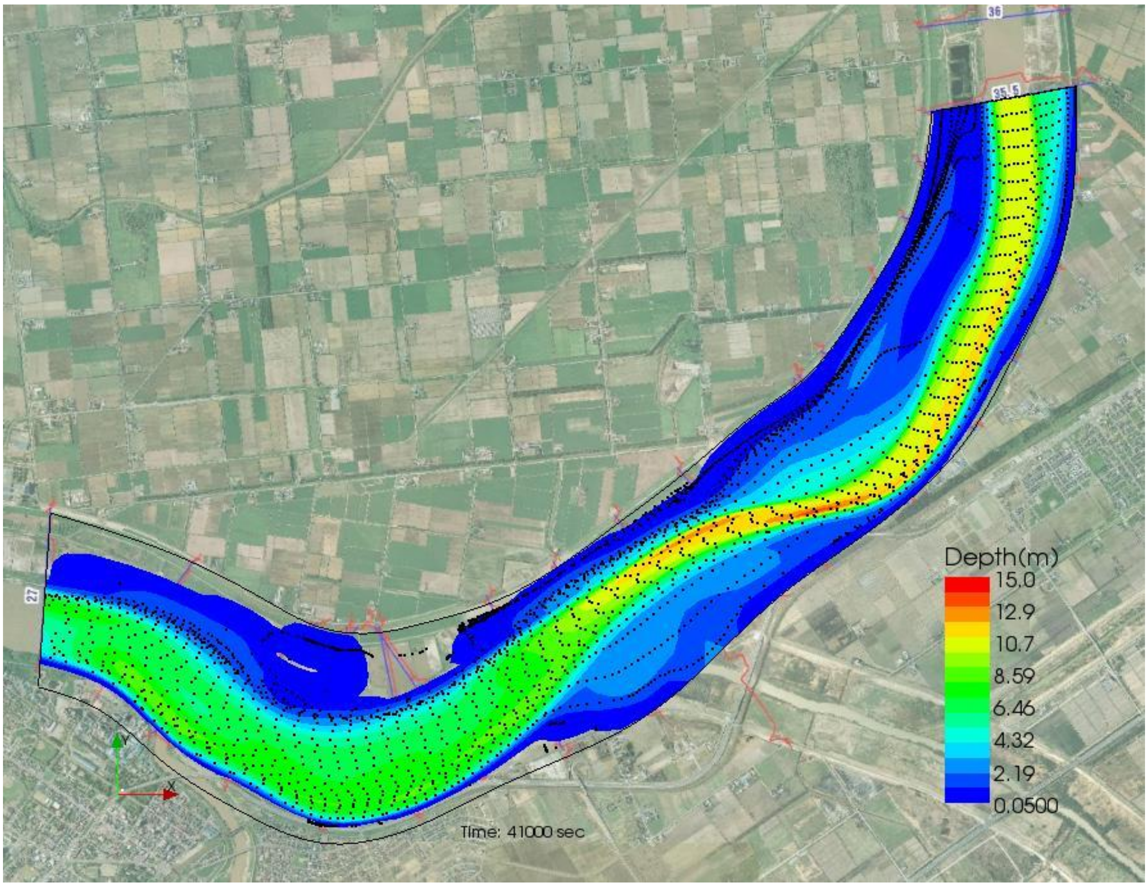


Tutorial Ⅱ.

Calculation of flow and bed morphological change of a real river

- **Purpose**

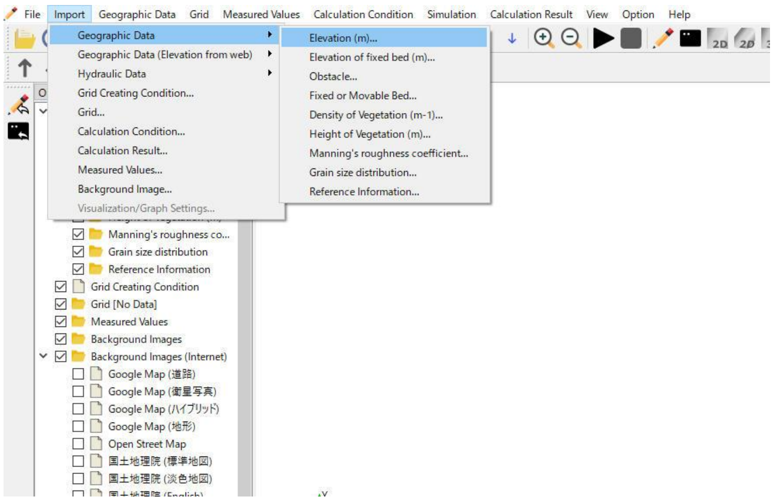
You will learn how to generate a computational grid from cross sectional river survey data, and set the computational conditions to calculate the flow and morphological changes in a real river. The computational results are visualized by the post-processing tools of iRIC. You will make a snapshot and animation of the computational results.



1. Generate a computational grid

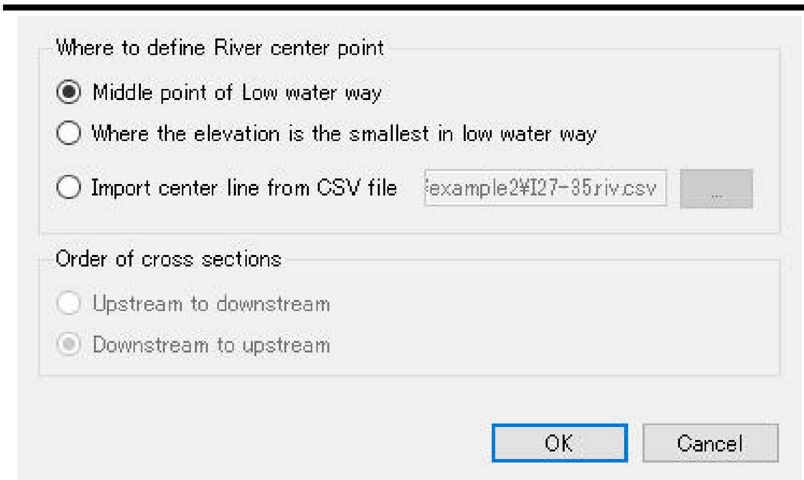
A computational grid will be generated by using river survey data which includes the cross-sectional geometry data for the river reach of interest.

You can import a river survey data by selecting Menu bar → [Geographic Data] → [Elevation(m)].



- You will specify [I27-35.riv] as a river survey data.

The dialog for setting the imported river survey data will open.

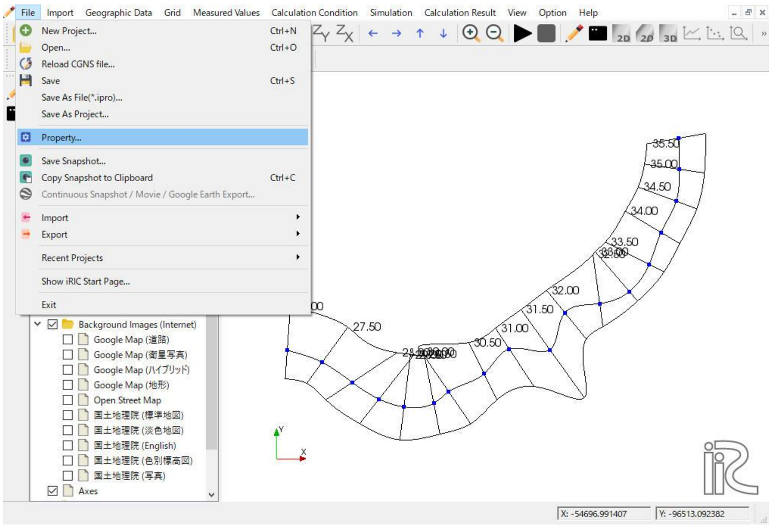


- Check on [Middle point of Low water way] for defining the location of centerline of the river survey data, and push [OK].

Note: you will see an error message when you open river survey data. You can just click “OK” to open the file.

When reading is successful, the transverse survey data is drawn.

Next, a background image can be imported. Click [File > Property] on the menu bar.

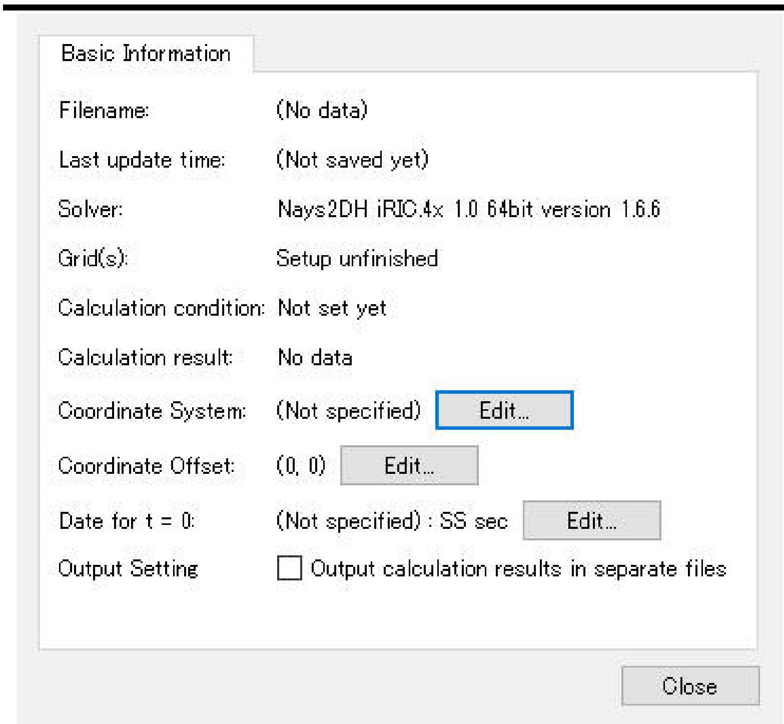


- Please specify [I27-35.jpg] as background image, or import the background images by following procedure.

Background Images

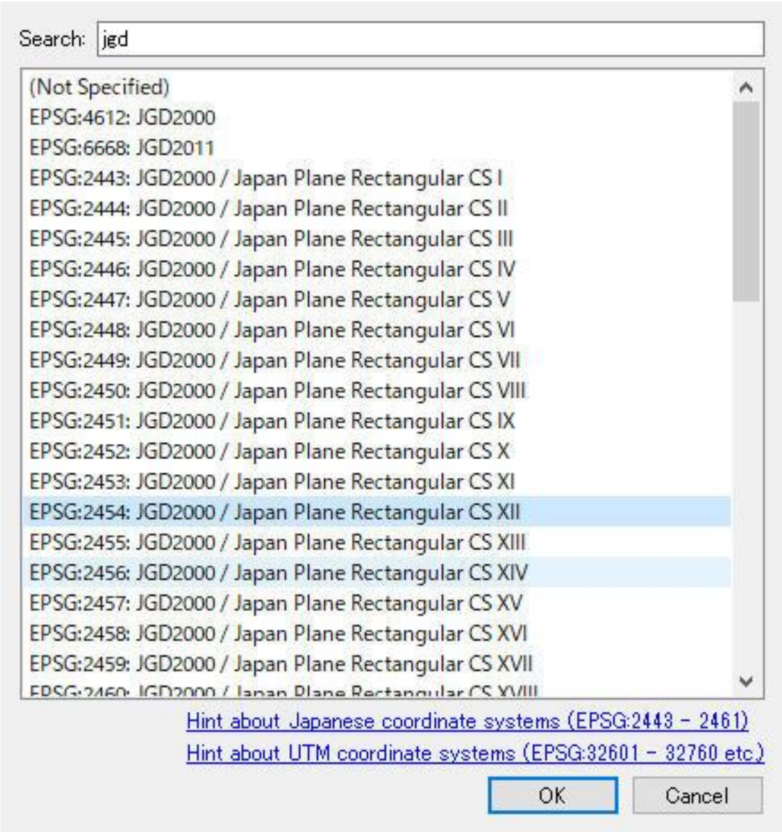
By importing background images such as maps and aerial photographs when creating a calculation grid or mesh, it is possible to create a calculation coordinate system that takes into consideration the levees, river banks, low waterways and high water reservoir boundaries. In addition, designation of vegetation cell, fixed bed cell, obstacle cell etc. can be set while referring to the background image, as is described below.

Set the coordinate system of the imported data. Click [Coordinate System > Edit].

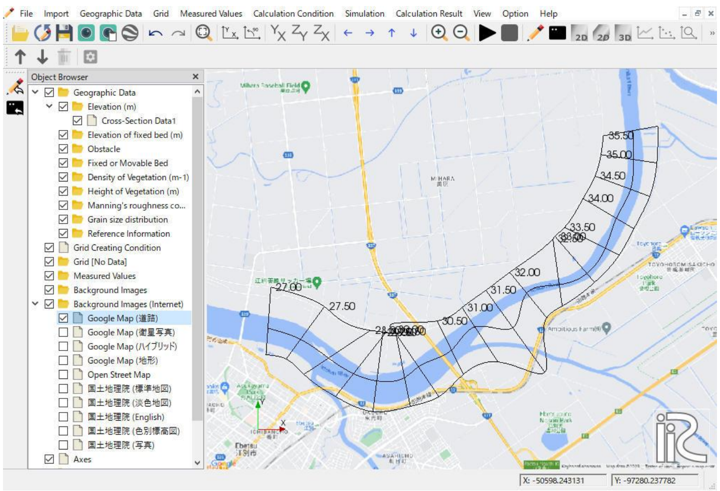


- The coordinate system of the data read this time is [Orthogonal coordinate system 12 series].

The selection screen for the coordinate system is displayed. Enter “jgd” in the search window. Select “EPSG:2454 JGD2000 / Japan Plane Rectangular CS XII“ and click “OK”.
Since you will return to the project property setting screen, please click “Close”.

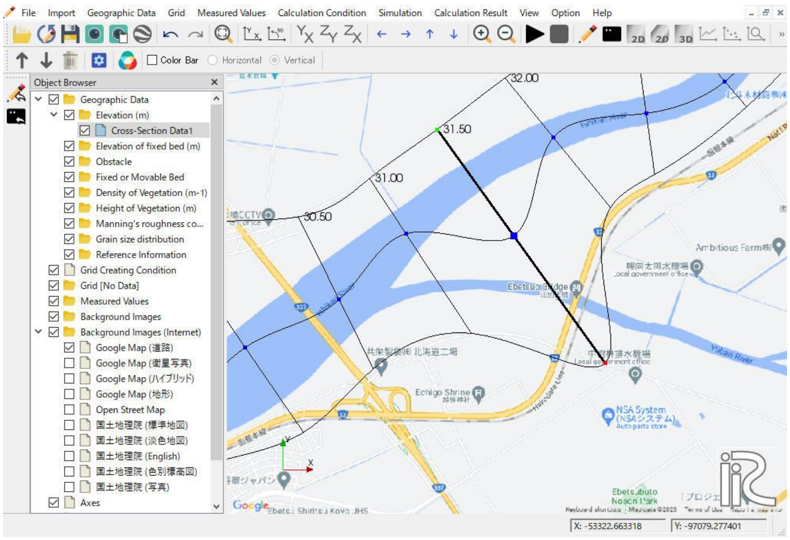


With the above settings, the coordinate system of the imported river survey data has been described. You can import background image from some sources like Google Map.



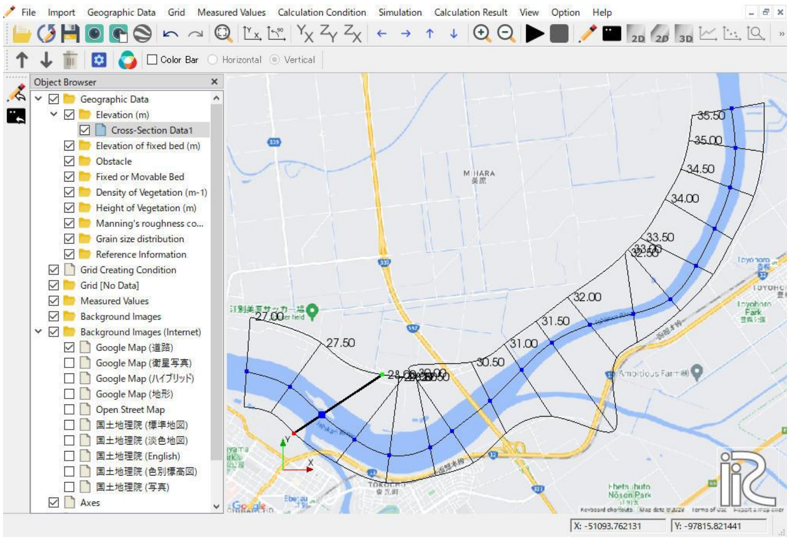
Note: To show Google Map image correctly, you will need Google API key and set it into Menu bar > Option > Background Images (Internet).

Align the channel center line with the main channel of background image.



- By selecting the survey line and holding down the Shift key, bring it closer to the blue circle at the channel center point, you can move the center point with the mouse.

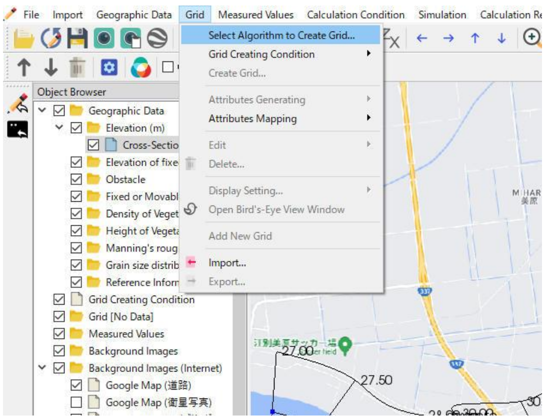
The channel center point was able to match the main channel center of background image.

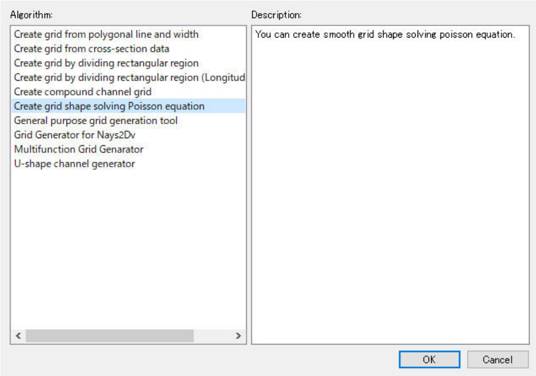


Set calculation grid generation conditions.

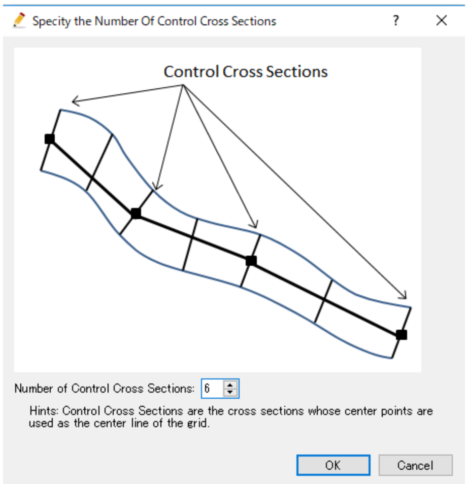
Select [Grid] → [Select Algorithm to Create Grid] on the menu bar as shown on the left.

On the screen on the right, select [Create grid shape solving Poisson equation].





Click [OK] as it is.

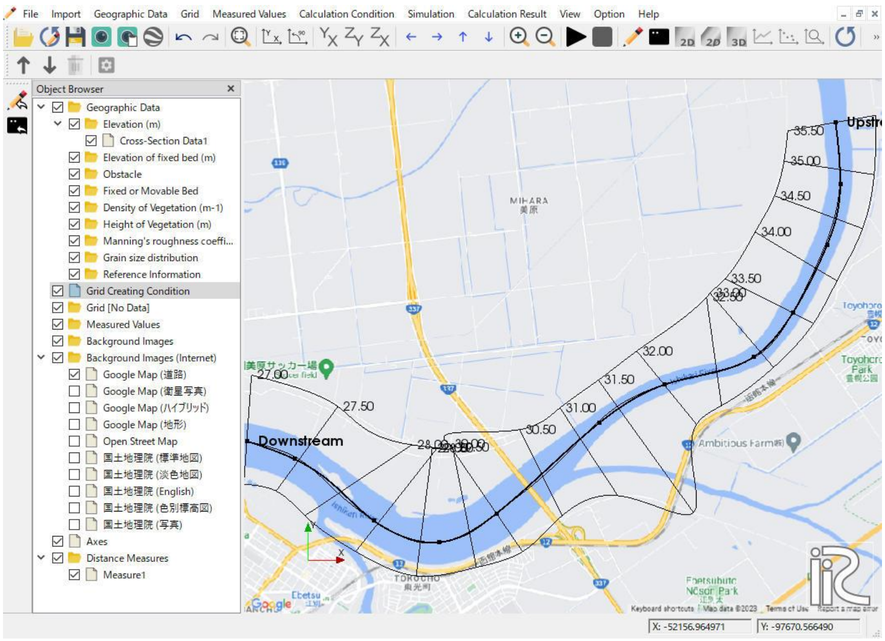


In this grid generation method, the calculation area is first set using the center line, the control section, and the left and right shoreline.

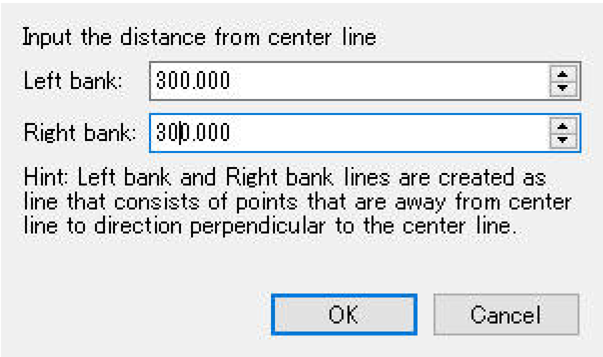
You can also add the number of control sections later.

First, edit the center line with the mouse so that the center line passes approximately through the center of the main channel.

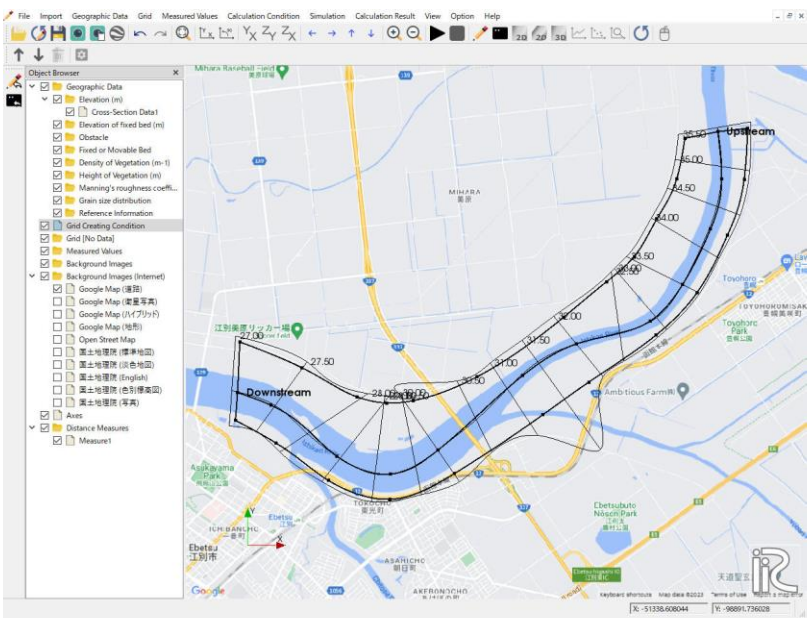
If the number of vertices is insufficient, you can add using right click.



Next, click [Build Left bank and Right bank line] from the right click menu. The screen for entering the distance from the center line is displayed. Please enter the approximate distance. For this case, both the left bank and the right bank are 300m.



There are some vertices on the left bank and right bank line. Move these vertices with the mouse to set the area to be calculated.

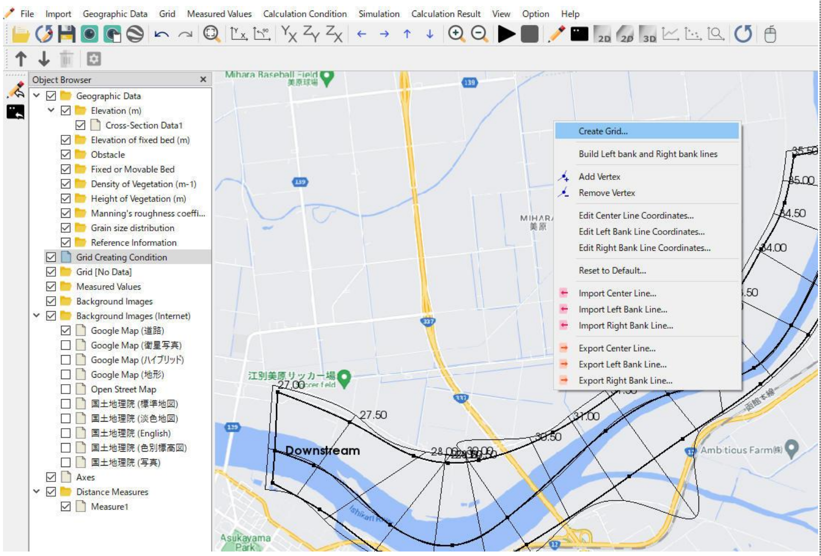


Attention Point:

The calculation area should be within the area of the imported river survey data. If you protrude from the area, the terrain data may not be mapped correctly to the calculation grid.

Please keep in mind that the center line, the left bank line, and the right bank line are roughly perpendicular to the cross section near the upstream and downstream ends of the reach- this will aid in setting boundary conditions.

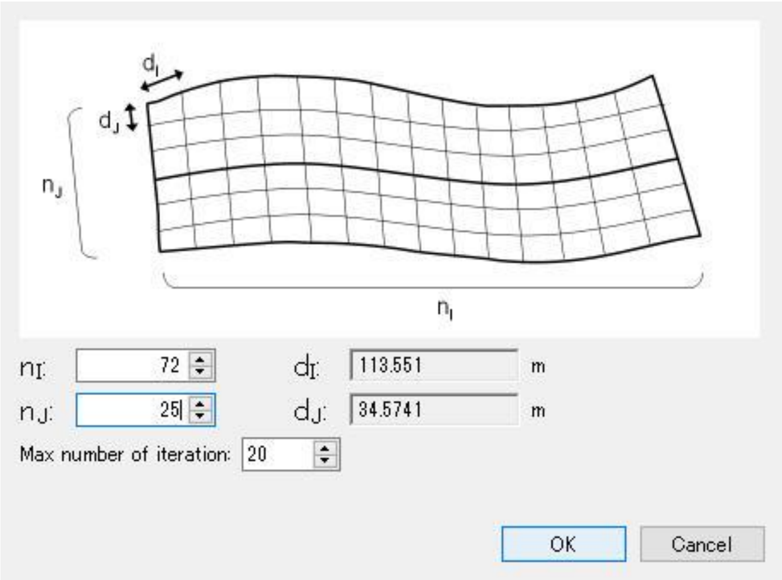
Once the calculation area is set, click [Create grid] from the right click menu.



The grid division number setting screen in the streamwise flow direction (ni) and transverse direction (nj) is displayed.

Please set these as follows and click [OK].

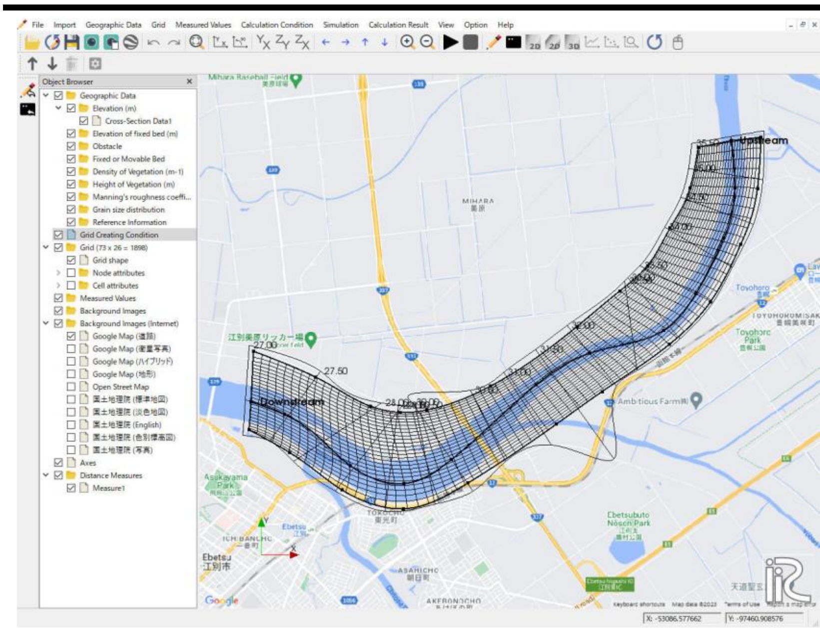
Next, in the confirmation dialog that comes up, click the [Yes].



Note: For workshops, please set as following as a guide according to the specifications of the calculator.

ni=50～
nj=20～

A calculation grid was created.



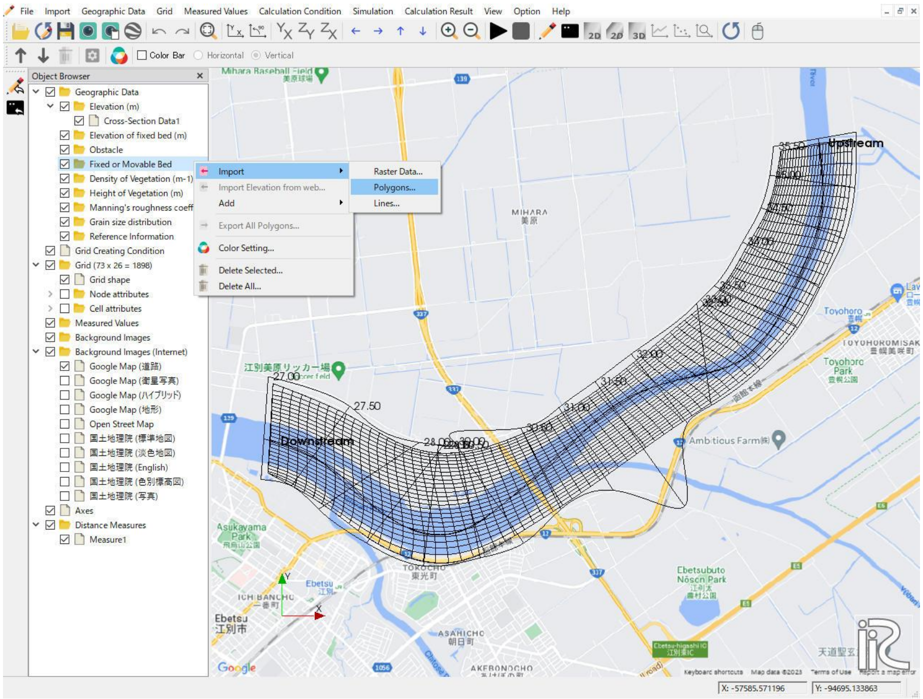
Please check the grid shape. In order to obtain better calculation results, it is important that grid lines are orthogonal as much as possible.

Are the edges collapsed and there is some grid like a triangle?
If so, check the points to be noted in the calculation area and correct the calculation area.

2. Setting cell attributes

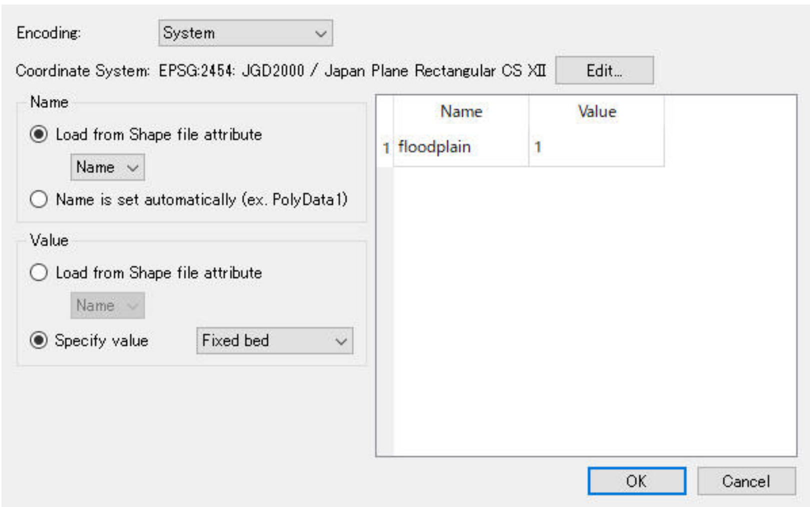
Set the roughness coefficients for the fixed and movable bed by choosing a value of Manning coefficient as attributes of the cell. The low water channel is treated as a movable bed and the high-water floodplain is a fixed bed; separate roughness coefficients are set for each.

Right-click [Geographic Data > Fixed or Movable Bed] of the object browser. Click [Import > Polygons] and load “floodplain.shp”.

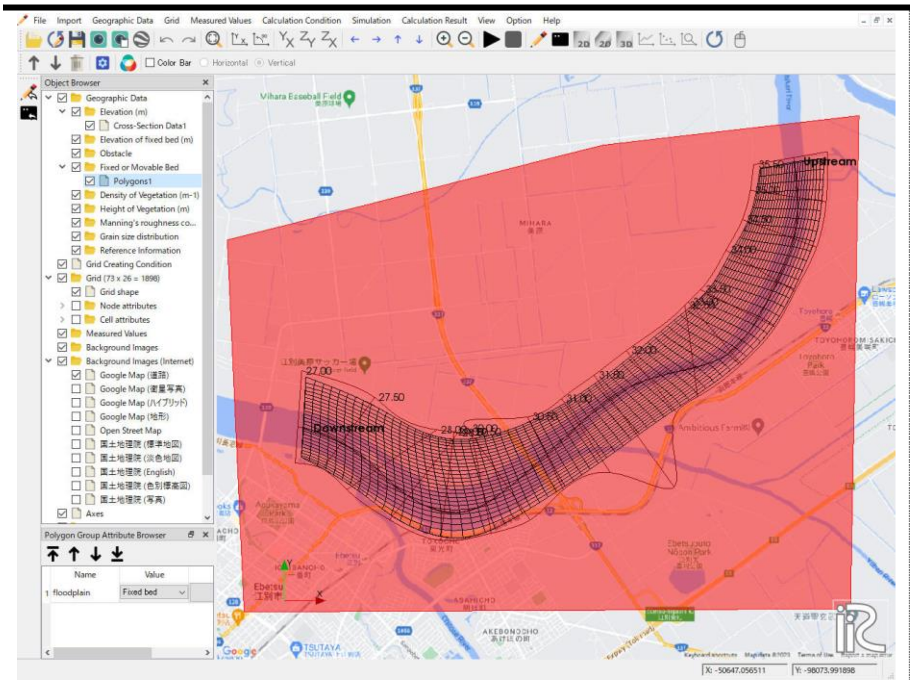


floodplain.shp

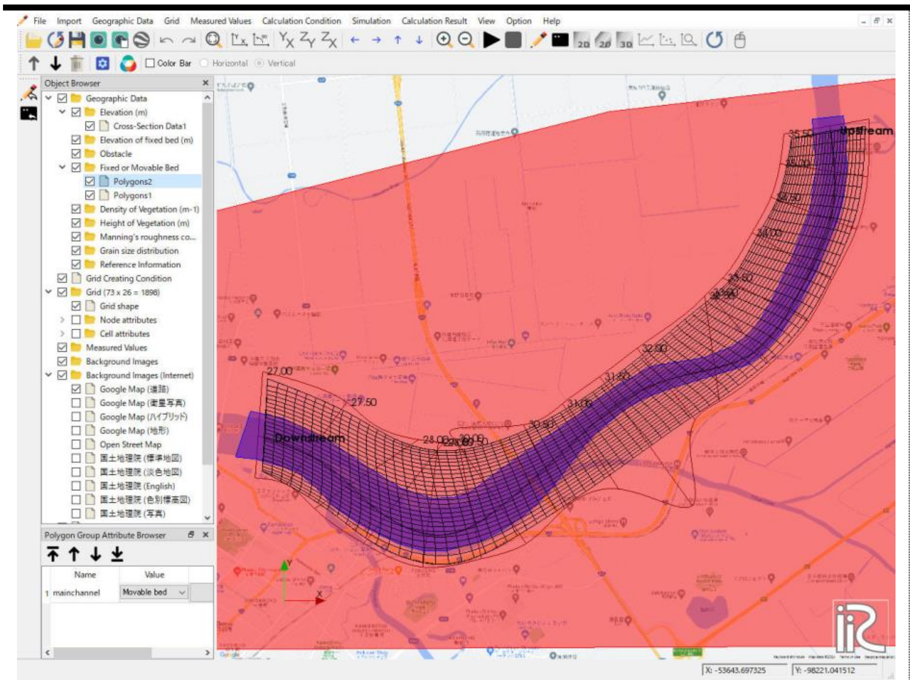
In the polygon import setting screen, set the value to [Fixed bed] and click [OK].



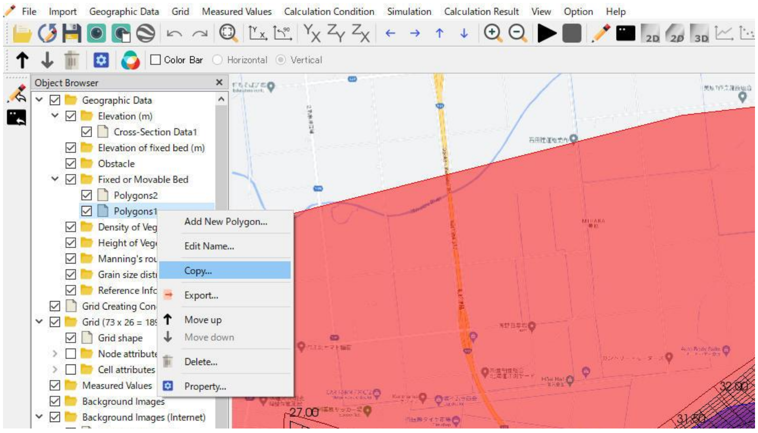
A polygon with “Fixed bed” attribute is loaded.



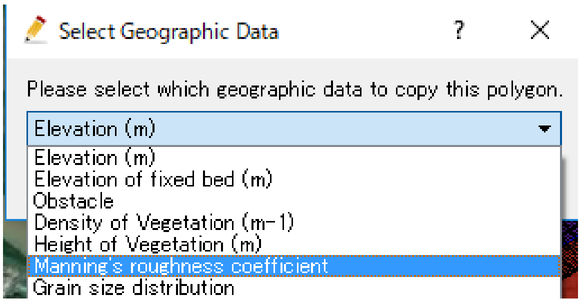
In the same operation, read the low waterway polygon “mainchannel.shp” as the value “Movable bed”.



Copy the polygon because the place you want to set Manning's roughness coefficient is the same as fixed bed and movable bed part. Right-click on the polygon you want to copy and select [Copy].



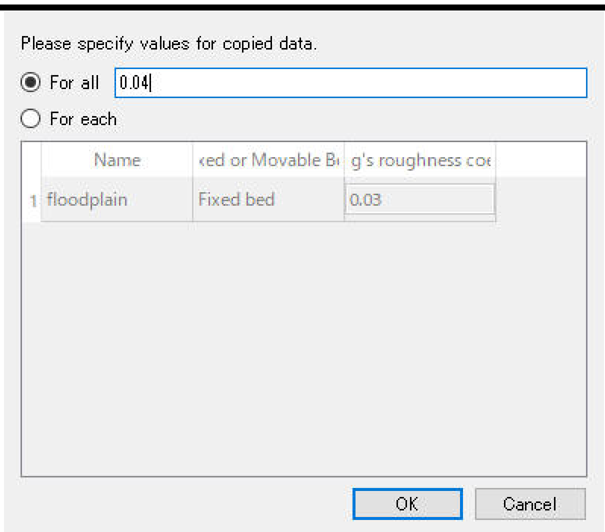
Select the geographic information to copy the selected polygon.



- Select [Manning's roughness coefficient]

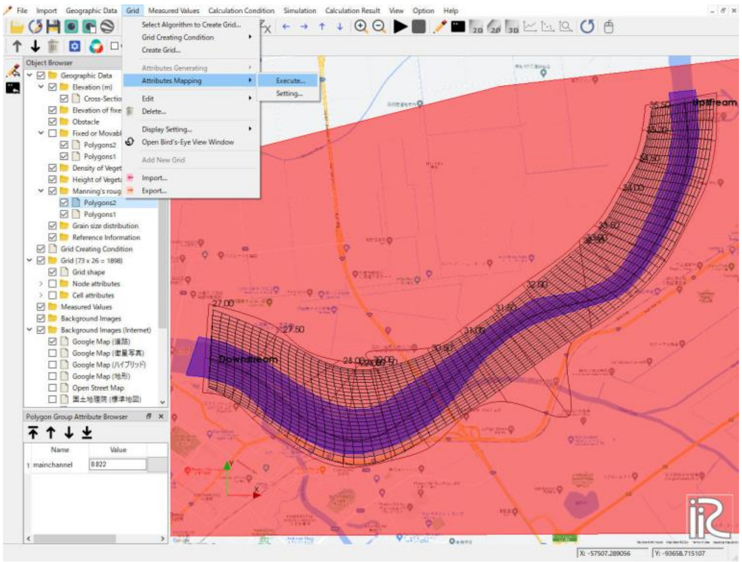
Set the value of the polygon to be copied.

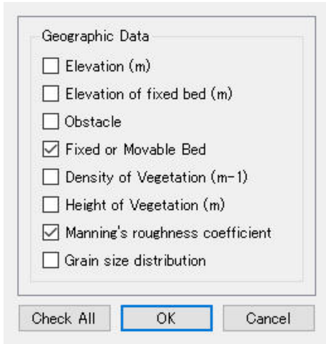
This operation is performed on both the high-water bed and low-water channel polygons.



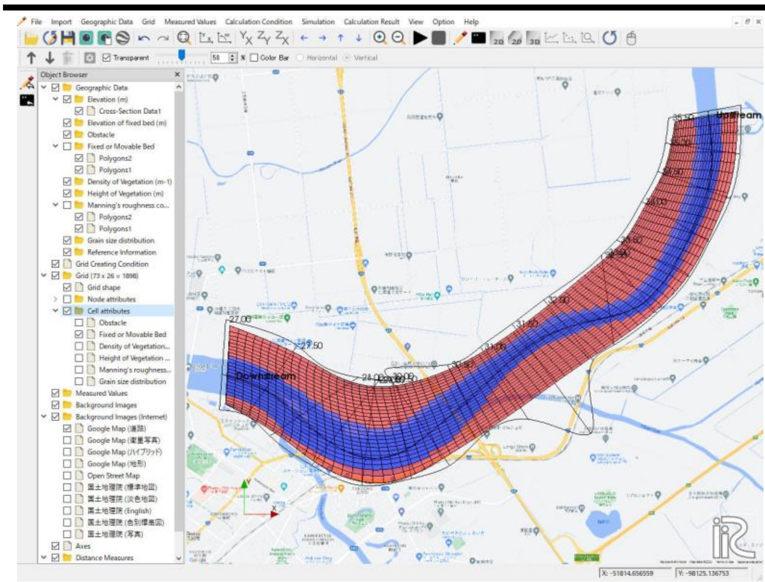
- Polygon with specified low waterway: roughness coefficient 0.022
- Polygon with specified a high waterbed: roughness coefficient 0.04

At this stage, the cell attribute has not yet been reflected in the calculation grid. To map a cell attribute to a calculation grid, select [Grid > Attributes Mapping > Execute] on the menu bar.





If you check the cell attributes of the grid, you can see that the cell attribute is mapped in the calculation grid.

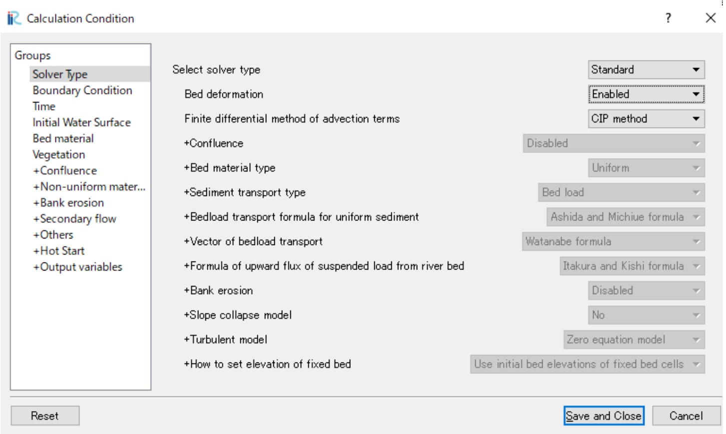


- If you want to fine-tune after mapping, you can change the value by specifying it in cell units.
- However, it is important to note that if you change the cell attributes directly on a cell-by-cell basis and then perform the mapping again, the directly modified part will disappear.

3. Setting calculation conditions

Set the calculation conditions. Since only the changes are described, you can infer the settings that are not explained here as the default values.

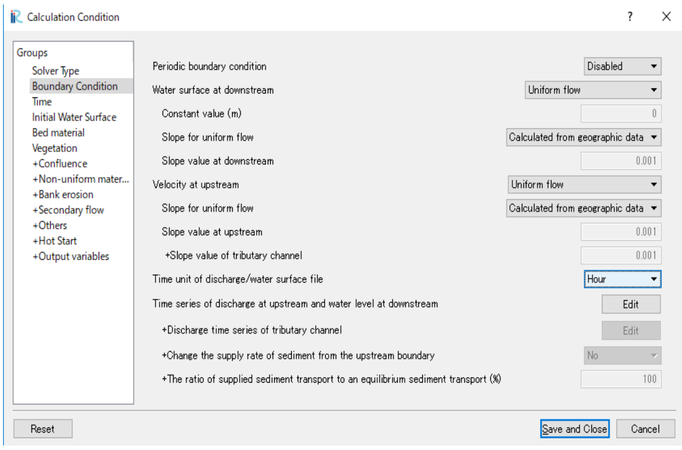
Set the necessary calculation conditions.



- Solver type: setting the general settings of Nays2DH

  -Bed deformation: Enabled

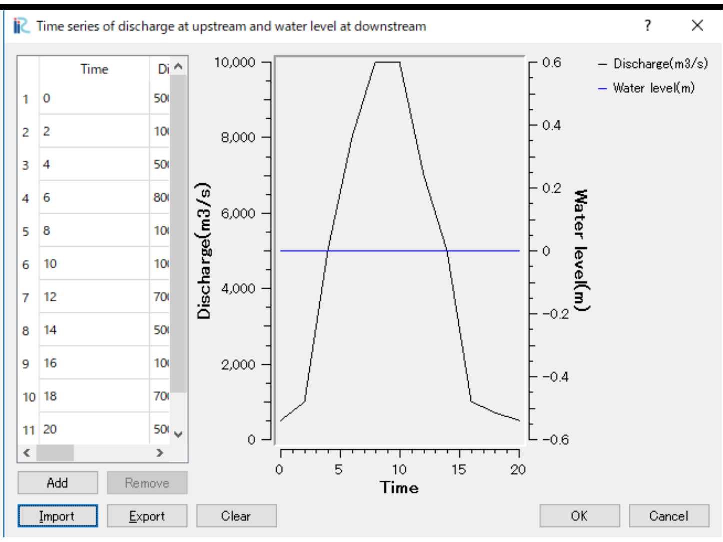
Set the boundary condition.



- Boundary Condition

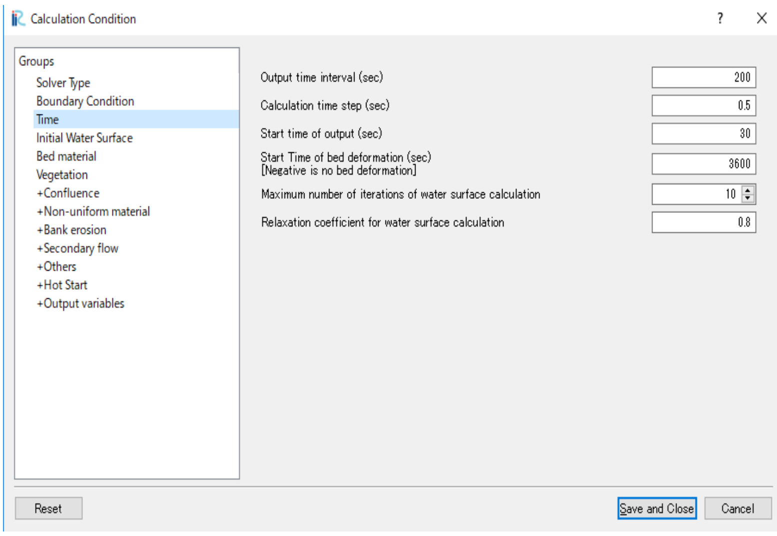
  - Time unit of discharge/water surface file: Hour

Set the discharge of upstream end.



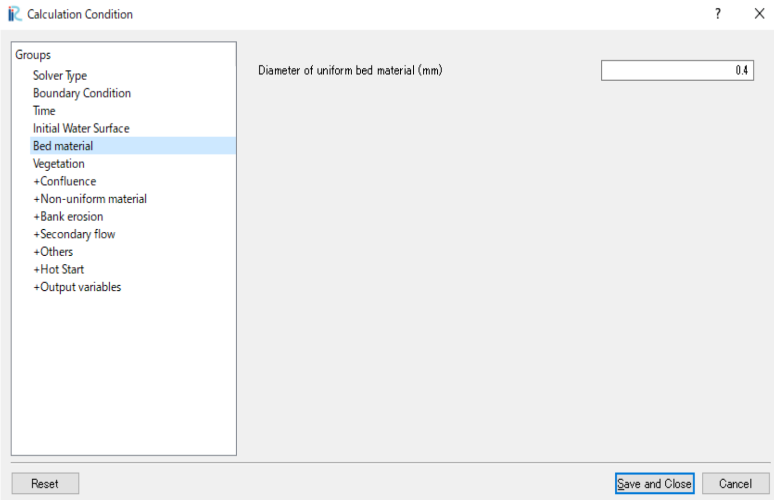
- For flow setting, click [Import] and load "qt.txt".

Setting conditions related to Time.



- Output time interval: 200 (sec)
- Calculation time step: 0.5 (sec)
- Start time of output: 0 (sec)
- Start Time of bed deformation: 3600 (sec)

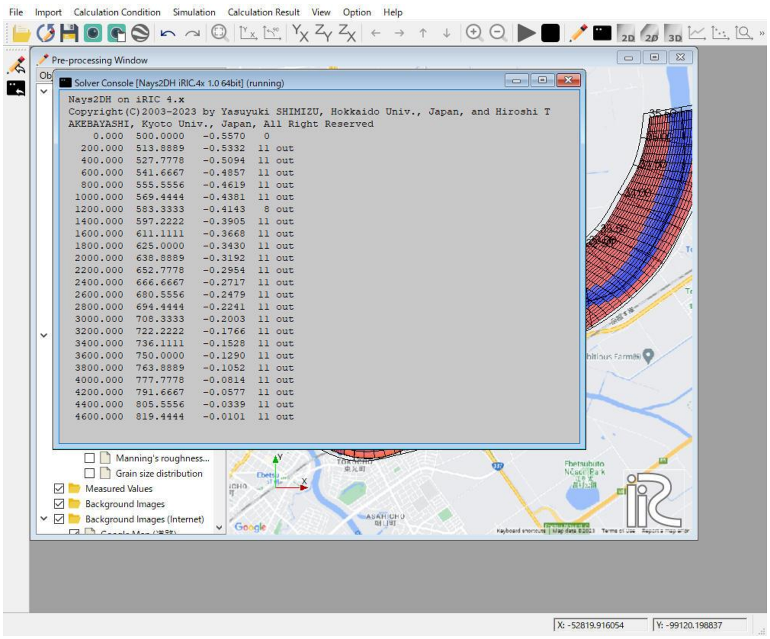
Setting conditions related to Bed material.



- Diameter of uniform bed material: 0.4 (mm)

4. Run a simulation

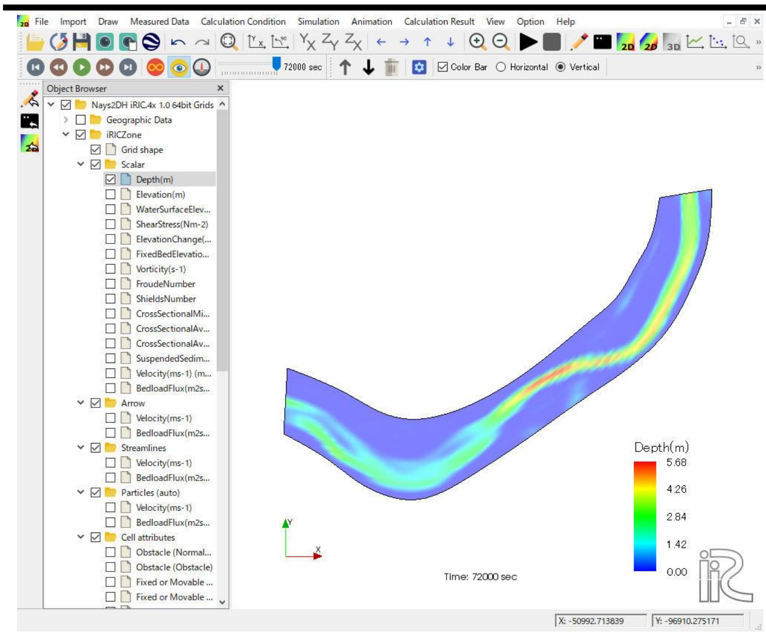
Select [Simulation] → [Run] in menu bar .



5. Visualization and out output of calculation results

Output the calculation result in iRIC and output the image.

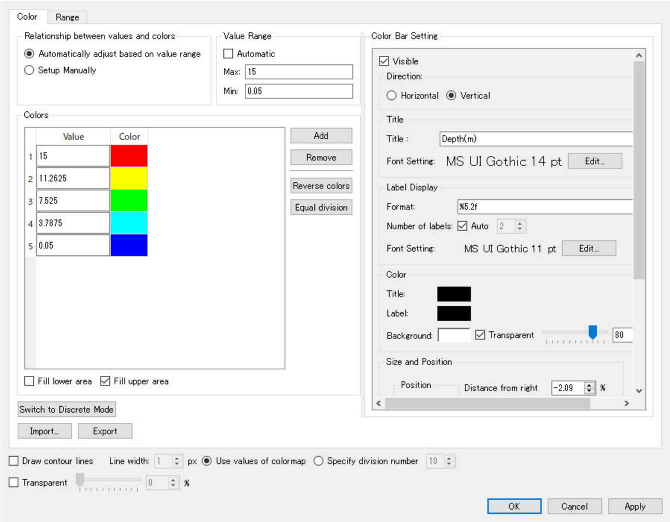
Select [Calculation result] → [Open new visualization window (2D)] on the menu bar.



- Output example displaying background image and water depth contours

Fix the color range of the contour so that it does not visualize low water depths.

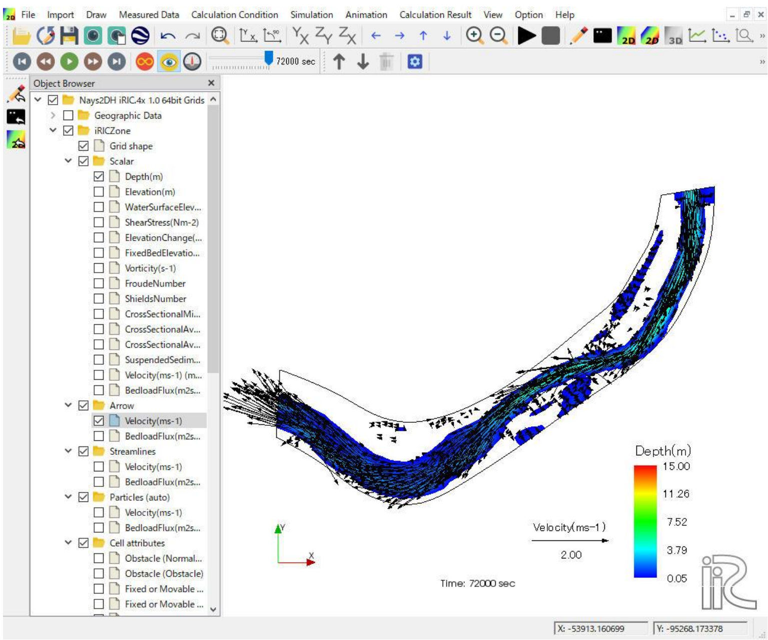
Right-click [Scalar > Depth (m)] in the object browser and select [Property].



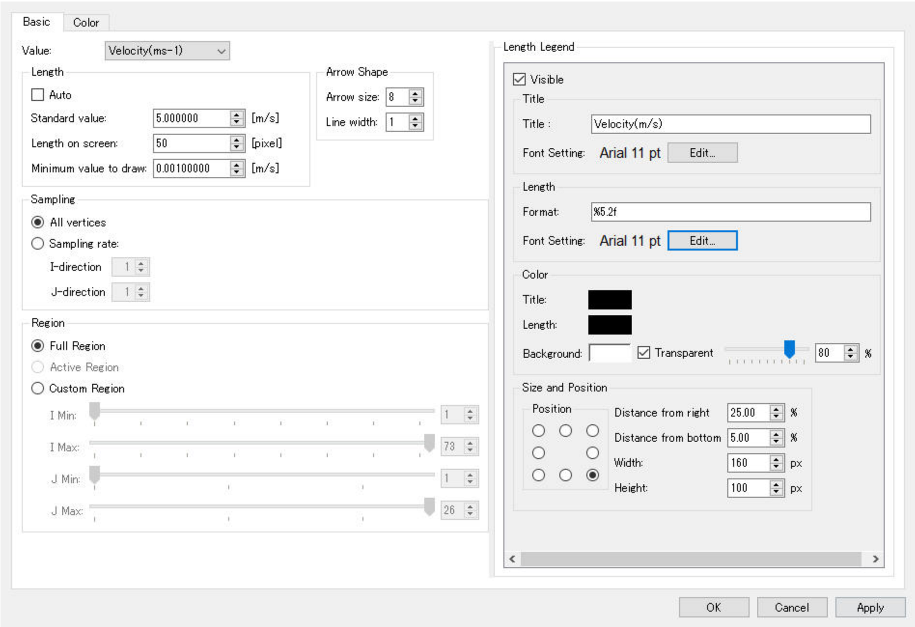
- Deselect [Automatic]
- Max: 15 m
- Min: 0.05 m
- Deselect [Fill lower area]
- Deselect [Transparent]

Next, visualize the arrow.

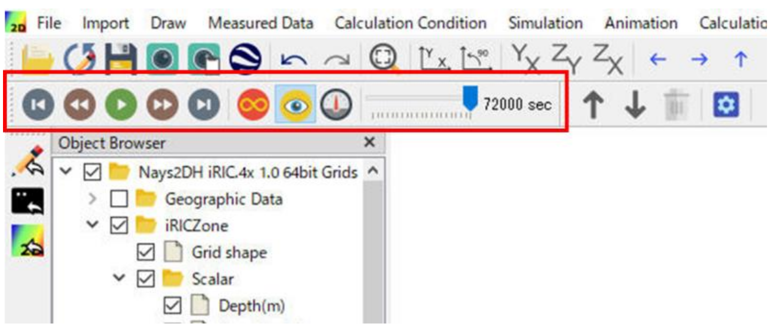
Select [Arrow > Velocity (ms-1)] in the object browser.



By right clicking on [Arrow > Velocity (ms-1)], you can set some parameters for visualizing the vector. Below is an example.

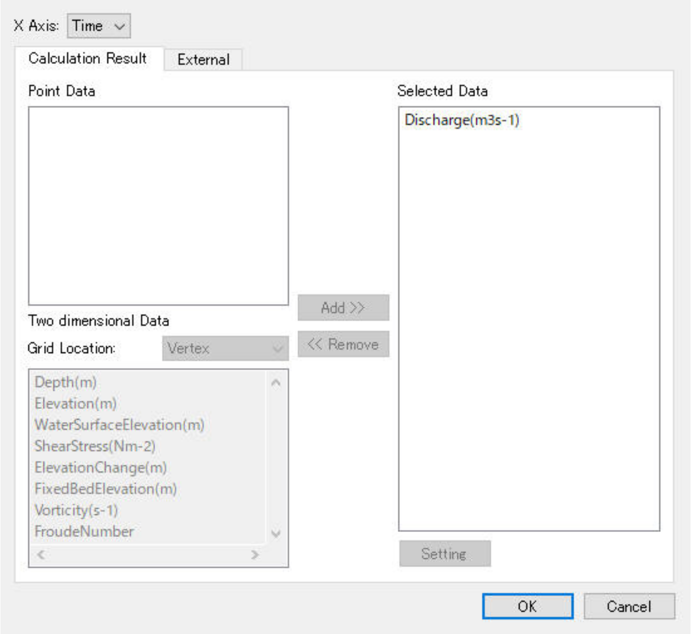


Use the animation tool bar to check the calculation result.



Also you can draw the hydrograph at the same time.

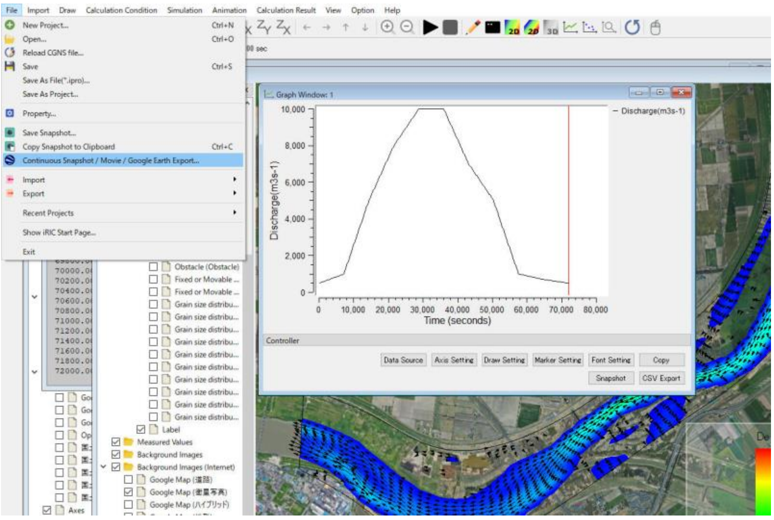
Select [Calculation Result > Open new Graph Window] in the menu bar.



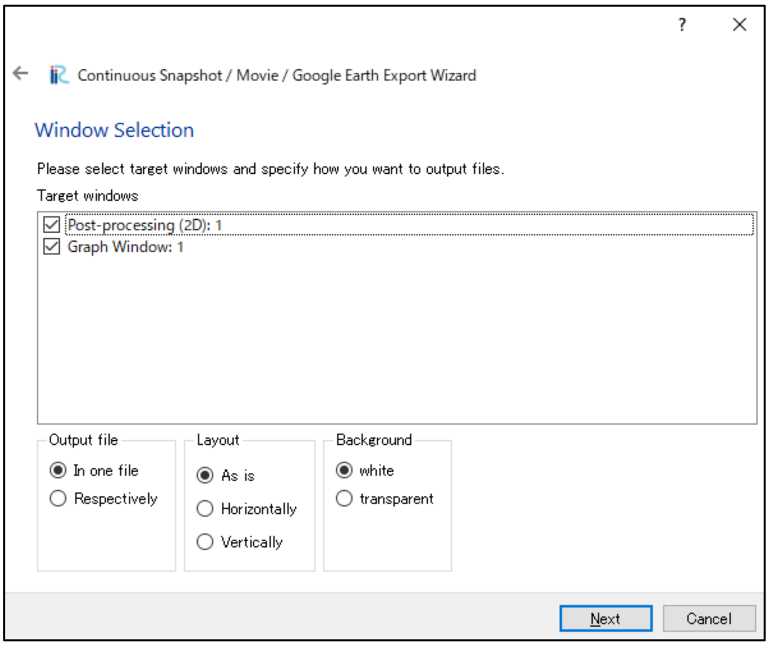
- X Axis: Time
- Select [Discharge (m3s-1)] in point data and select [Add].

You can draw a contour map and a hydrograph at the same time.

The computational results can be outputted as image file. Select [File > Continuous Snapshot /Movie/ Google Earth Export] on the menu bar.

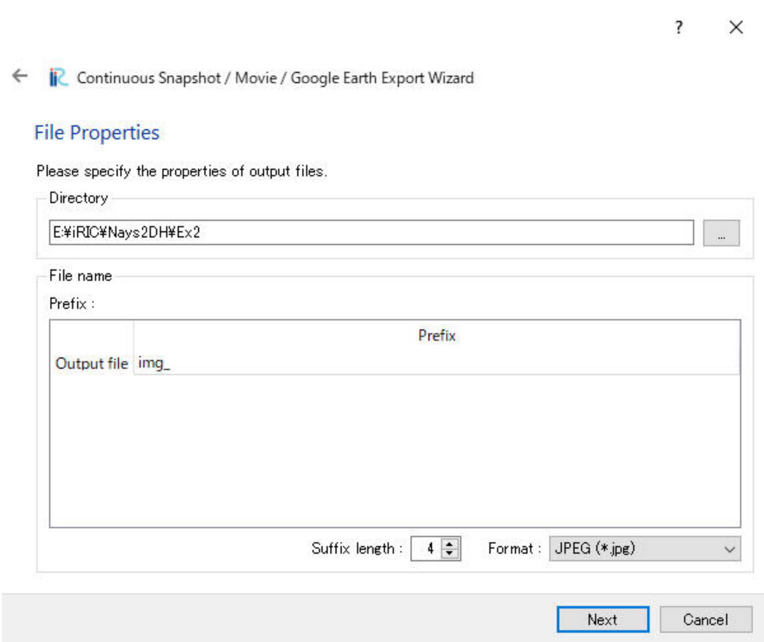


Make the necessary settings in the continuous snapshot wizard.



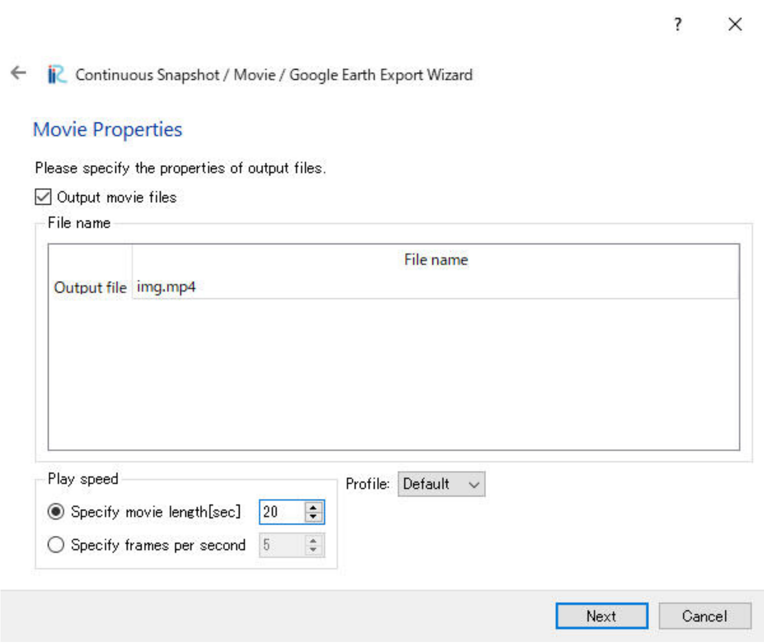
- Target windows: Select both
- Output file: In one file
- Layout: As is

Specify the file output location and image file format.



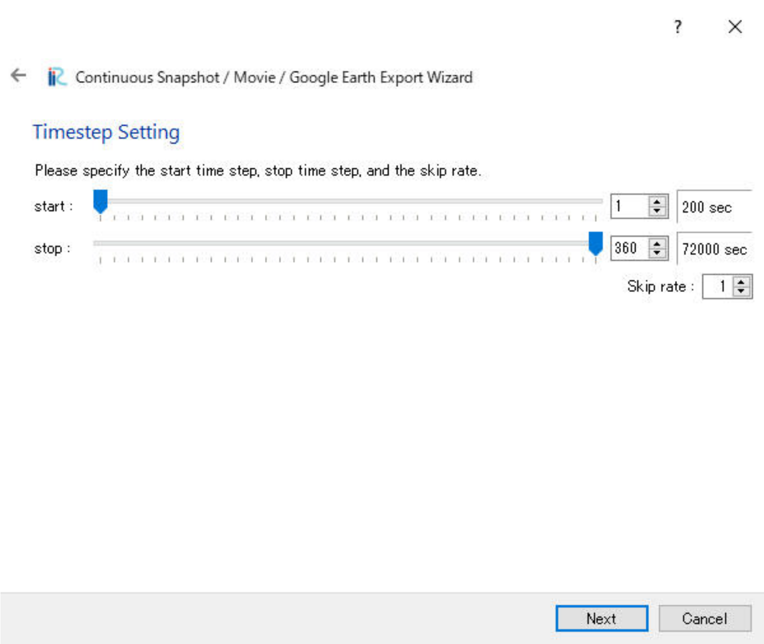
- Specify directory
- File Format: jpg

Specify whether to output movie.

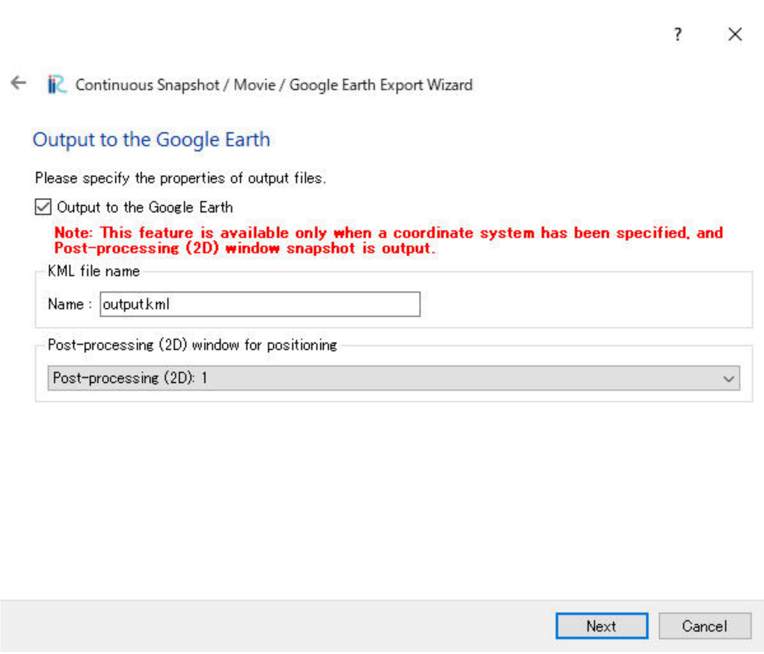


- Output the movie files

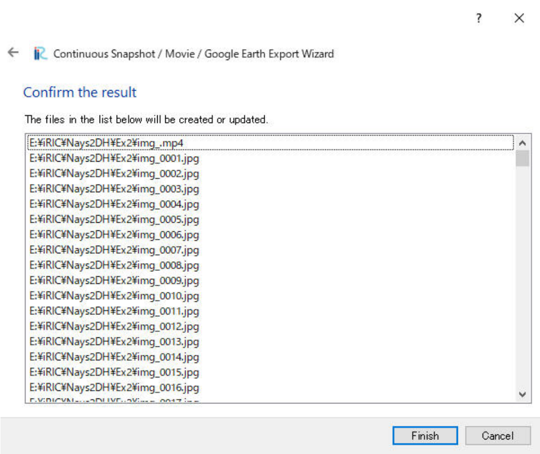
Specify the start and end time to output.



You can also export the image file into Google Earth



When the setting is completed, a confirmation screen (left figure) appears, so select [Finish]. The screen on the right is the output screen.



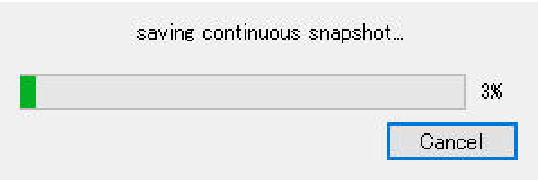
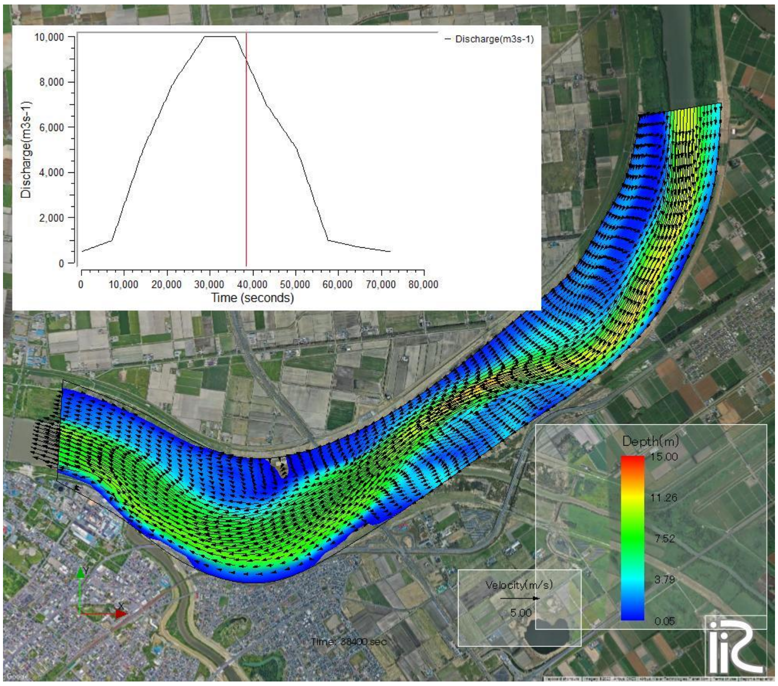


Image files grouped with a contour diagram and hydrograph in the movie are output.



An example of the Google Earth export of the computational result