EvaTRiP Pro User's Manual

Release 1.0.0

Public Works Research Institute

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CONTENTS

CHAPTER

ONE

INTRODUCTION

EvaTRiP Pro is an analysis tool for calculation result of rive channgel flows, that is developed to provide a useful tool that can be used for wide variety of purposes, based on functions of EvaTRiP.

It can be used to analyse calculation results of arbitrary river channel solvers, including Nays2DH.

EvaTRiP Pro is the solver developed with Python, and the source code is available with license that allows users to modify it.

If users want to execute advanced analysis than in EvaTRiP Pro, users can edit source code of EvaTRiP pro, to add their own functions, and use them.

We hope that many users will use EvaTRiP Pro in their researches, educations, and businesses, and that will leads to the river designs considering for better environments.

Please refer to *License* (page 25) for the detail of license.

CHAPTER

TWO

WORKFLOW

The workflow to use EvaTRiP pro, to analyse calculation result is as follows:

1. Run a river channel flow solver, like Nays2DH, to get calculation result.
2. Create a project for EvaTRiP Pro, and setup setting for analysis, using Pre-processing window and Calculation Condition dialog.
3. Run EvaTRiP Pro, with menu [Simulation] –> [Run].
4. Visualize analysis result using [2D Post-processing Window] and [Graph Window].

Please refer to *Functions* (page 5) for detail about how to use each function.

CHAPTER

THREE

FUNCTIONS

The list of functions of EvaTRiP Pro is shown in Table 3.1.

Table 3.1: The functions EvaTRiP Pro

Function	Description
Riffle and pool analysis	Analyze the area of riffle, pool and rapid, based on depth, velocity and Froude number.
Region statistics analysis	Calculate statistics, like average, stddev etc for regions.
Threshold Classification	Classificate calculation result values with threshold values.
Composition tool	Calculate Froude number, move critical diameter etc.
Response function tool	General purpose analysis tool based on PHABSIM.

3.1 Common Operation

3.1.1 How to use

Importing grid

1. Select [File] –> [Import] –> [Grid] in menu.
2. Select the analysis target CGNS file, and click on [Open] button.

With the steps above, grid is imported from the selected CGNS file.

Figure 3.1 shows an example of [Pre-processing Window] just after importing a grid.

Editing calculation condition

On [Basic Setting] page of [Calculation Condition] dialog, setup setting like below:

- **CGNS File Name**: Select the CGNS file, that contains calculation result to analyze.
- **Result Setting Depth**: Select the calculation result that contains depth values.
- **Result Setting Water Surface Elevation**: Select the calculation result that contains water surface elevation values.
- **Result Setting Velocity(X)**: Select the calculation result that contains x component of velocity values.
- **Result Setting Velocity(Y)**: Select the calculation result that contains y component of velocity values.
- **Functions**: Check on checkbox next to the functions to use.

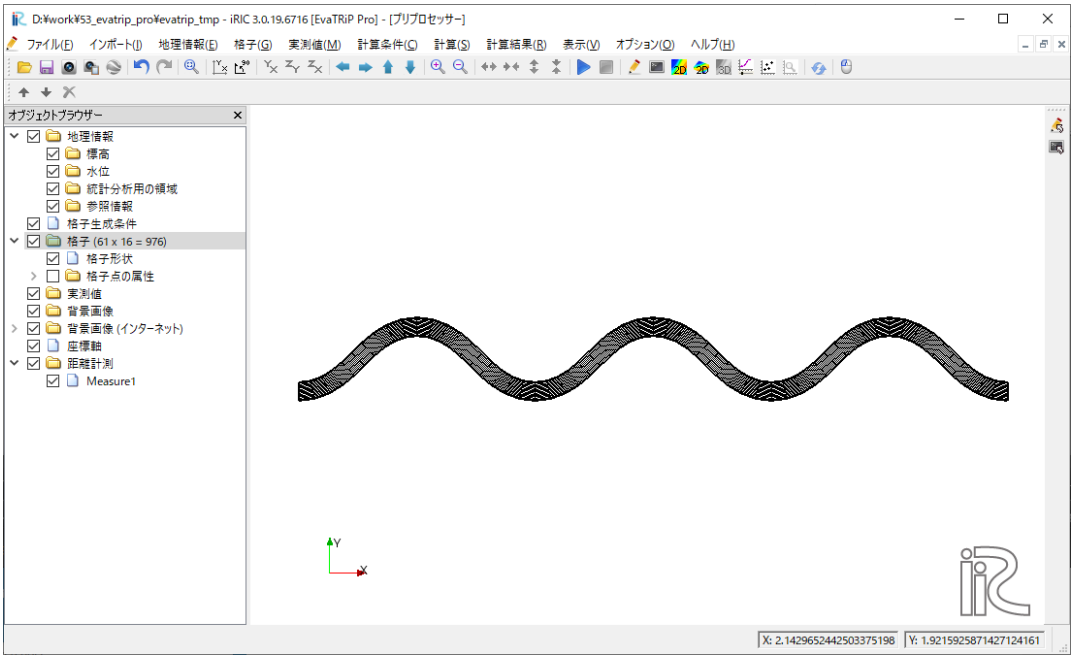

Figure 3.1: [Pre-processing Window] just after importing a grid

3.2 Riffle and pool analysis

Analyze the area of riffle, pool and rapid, based on depth, velocity and Froude number.

3.2.1 Description of functions

Riffle and pool analysis tool provides the two functions below:

- Classify area based on value of Froude number (Entwistle et al., 2018)
- Manual definition

Classify area based on value of Froude number (Entwistle et al., 2018)

Based on Froude number value calculated from depth and velocity, river channel area is classified to 5 types, including Pool, Glide etc. Detail is shown in Table 3.2.

Table 3.2: Classes based on Froude number

Class	Range of Froude number
Pool	$Fr < 0.04$
Glide	$0.04 \leqq Fr < 0.15$
Run	$0.15 \leqq Fr < 0.245$
Riffle	$0.245 \leqq Fr < 0.49$
Cascade / rapid	$0.49 \leqq Fr$

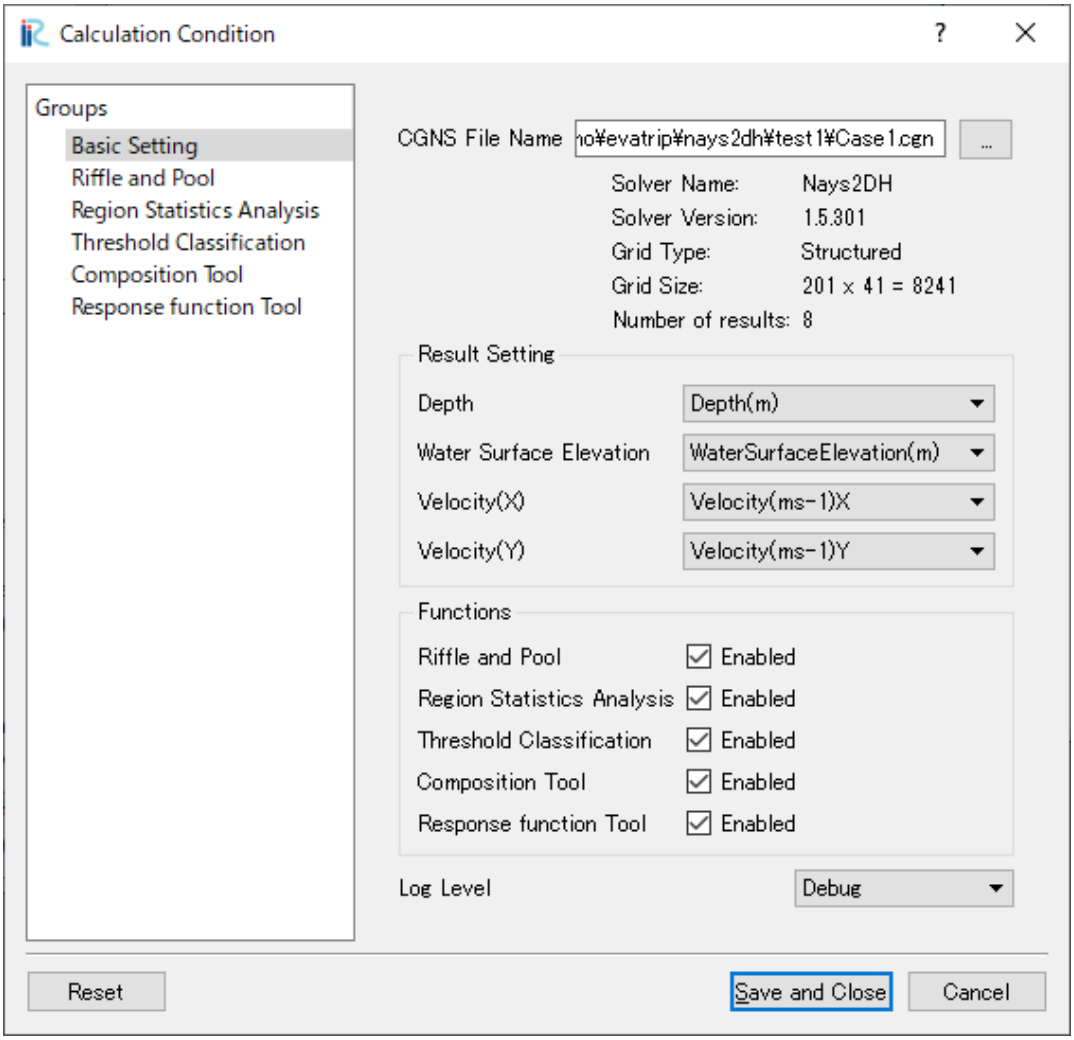

Figure 3.2: [Calculation Condition] dialog [Basic Setting] page

Manual definition

Classify area to pool, riffle, rapid using the threshold value of depth and velocity.

3.2.2 How to use

Editing calculation condition

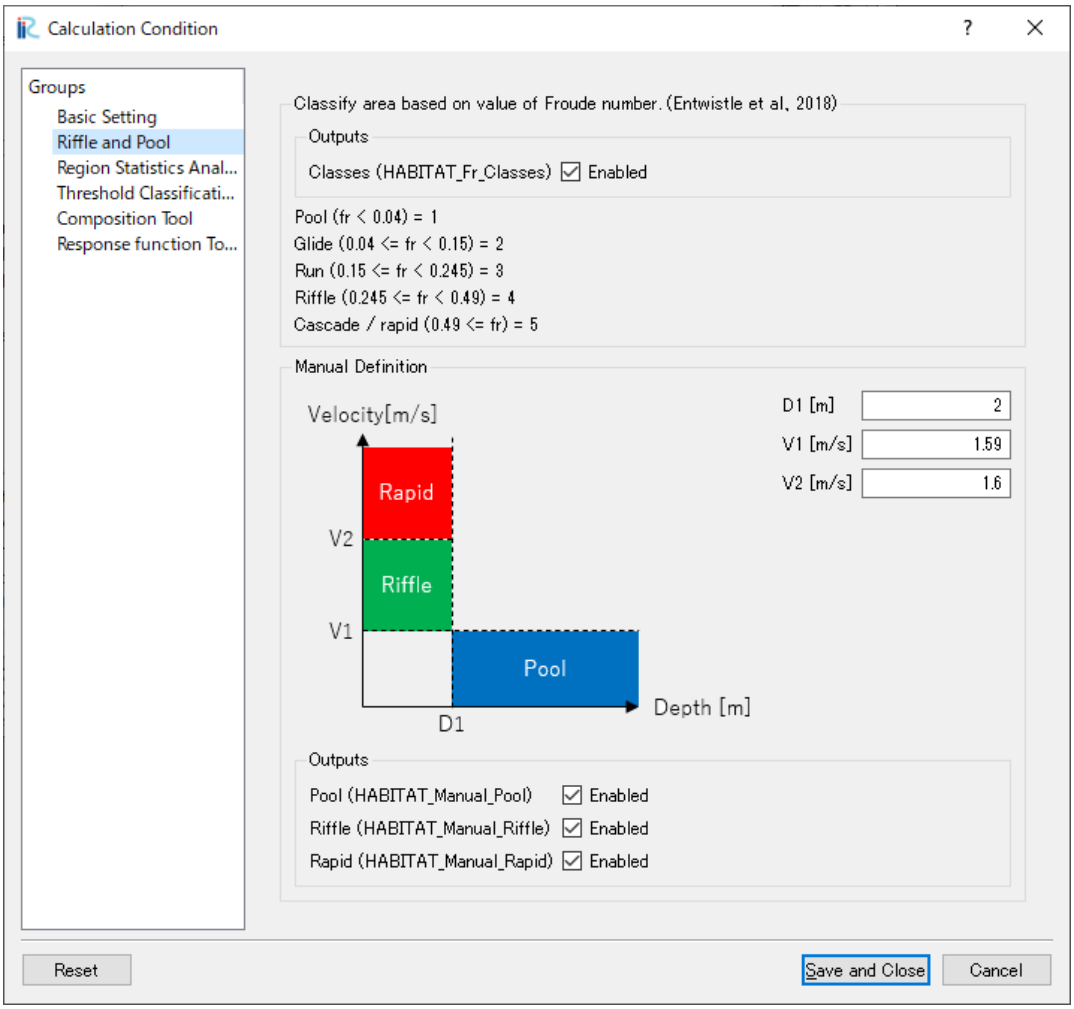

Figure 3.3: [Calculation Condition] dialog [Riffle and Pool Analysis] page

On [Riffle and Pool Analysis] page of [Calculation Condition] dialog, setup setting like below:

Classify area based on value of Froude number (Entwistle et al., 2018)

- **Classes (HABITAT_Fr_Classes)**: Check on to output results.

Manual Definition

- **D1 [m]**: Specify the threshold value of depth, refering the figure.
- **V1 [m/s]**: Specify the threshold value of velocity, refering the figure.
- **V2 [m/s]**: Specify the threshold value of velocity, refering the figure.
- **Outputs**: Check on to output results.

Visualization of analysis result

Visualize the analysis result that EvaTRiP pro outputs.

The list of output values are shown in Table 3.3.

Table 3.3: The list of output values

Name	Description
HABITAT_Fr_Classes	Pool = 1, Glide = 2, Run = 3, Riffle = 4, Cascade / rapid = 5
HABITAT_Manual_Pool	1 for Pool, 0 for others
HABITAT_Manual_Riffle	1 for Riffle, 0 for others
HABITAT_Manual_Rapid	1 for Rapid, 0 for others

3.3 Statistics Analysis

Calculate statistics, like average, stddev etc.

3.3.1 Description of functions

Calculate the statistics below:

- Maximum
- Minimum
- Average
- Standard deviation
- Coefficient of Variation

Statistics Analysis function provides the two functions below:

- Calculates statistics at each grid node
- Calculates statistics for regions

Calculates statistics at each grid node

Calculates statistics at each grid node, in the time range specified.

Calculates statistics for regions

If user defines [Areas for Statistics Analysis] in Pre-processing window, statistics for each region for each time step is output to CSV file.

If regions are not defined, statistics for whole region is calculated.

3.3.2 How to use

Define areas for Statistics Analysis

User needs to execute this step only when they wants to use [Calculates statistics for regions] multiple regions.

The steps are shown below:

1. Defining groups
2. Defining polygons
3. Mapping groups to grid

Defining groups

Select [Geographic Data] / [Area for Statistics Analysis], and Select [Edit Groups···] from right-clicking menu.

Dialog in Figure 3.4 is shown, so define the groups you need.

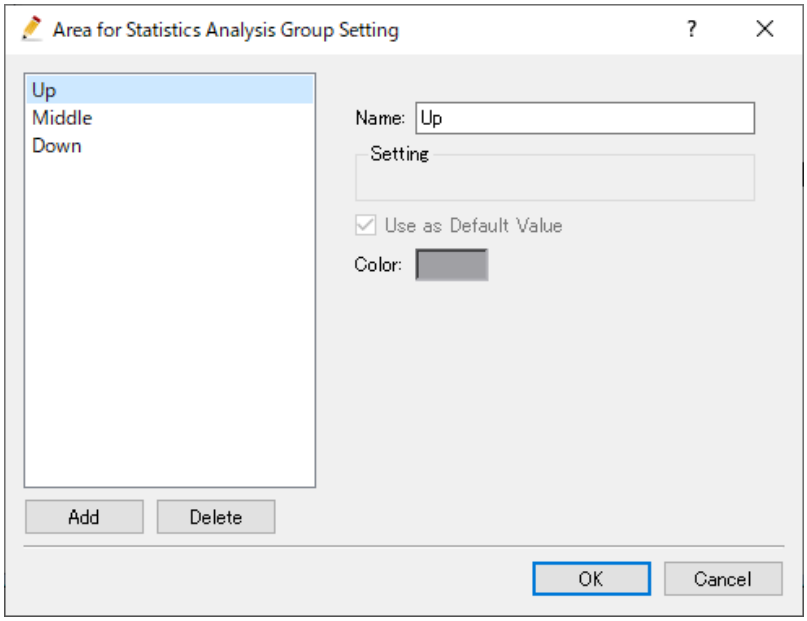

Figure 3.4: [Group Setting] dialog

Defining polygons

Select [Geographic Data] / [Area for Statistics Analysis], and Select [Add] –> [Polygons···] from right-clicking menu.

New polygon data is added, so define polygons, and link them to the groups. When you finish defining polygons by double-clicking, a dialog to select a group is shown.

Figure 3.5 shows an example of [Pre-processing Window] after defining polygons.

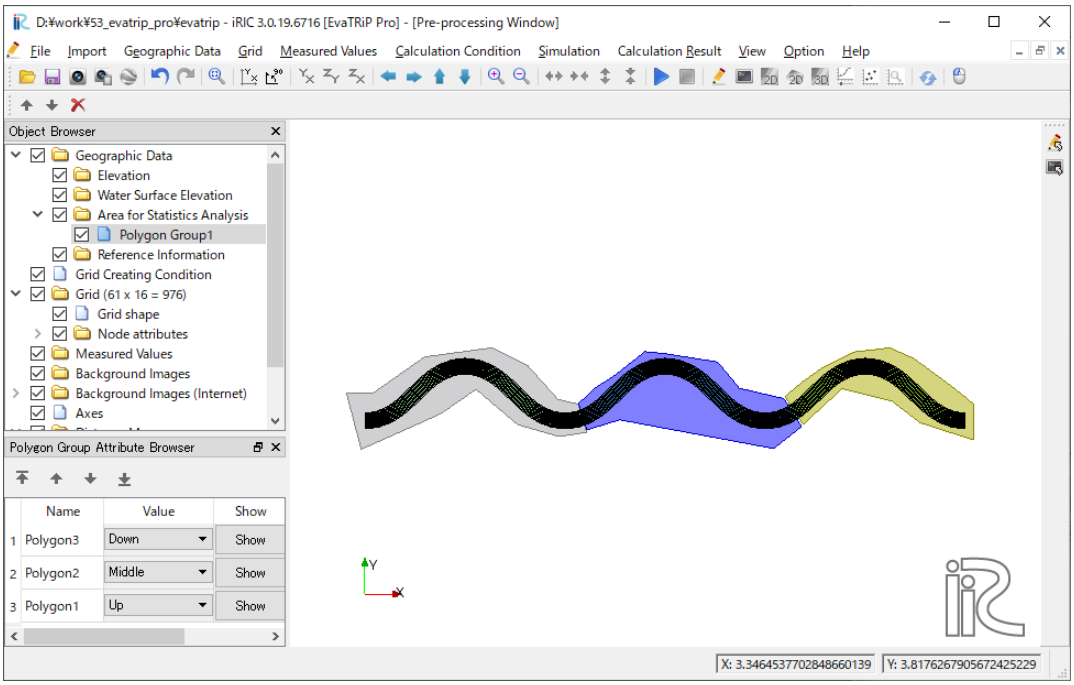

Figure 3.5: Example of defined polygons

Mapping groups to grid

Select [Grid] –> [Attribute Mapping] –> [Execute] from menu. [Attribute Mapping] dialog is shown, so check on [Area for Statistics Analysis] and click on [OK] button.

Note: When a grid node is included in multiple polygons, the group linked to the polygon on the top is mapped to the node.

Please note that it is not possible to map multiple groups to a grid node.

Note: Please note that you need to execute this step, even when you do not define groups, and calculates statistics for whole region.

Editing Calculation Condition

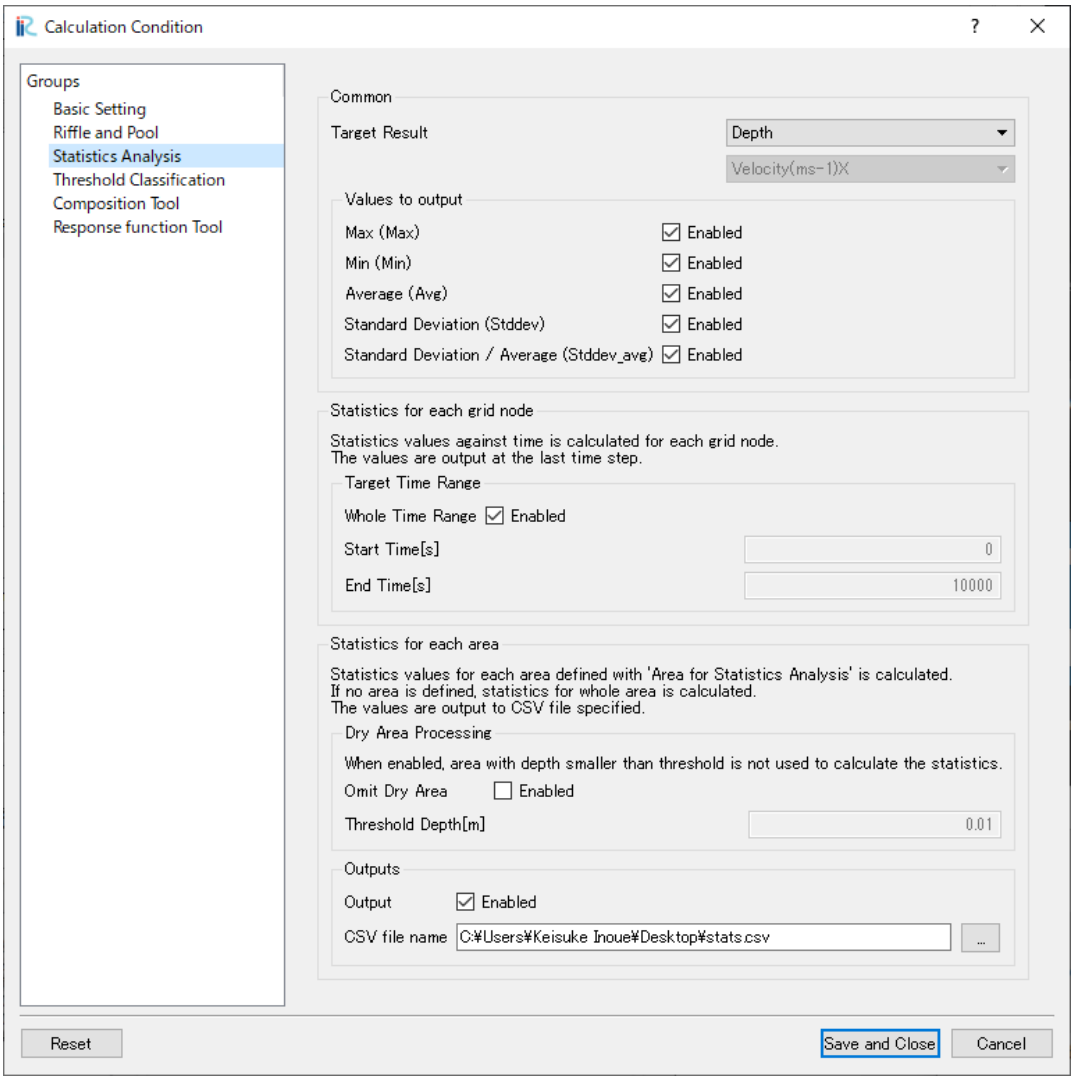

Figure 3.6: [Calculation Condition] dialog [Statistics Analysis] page

On [Statistics Analysis] page of [Calculation Condition] dialog, setup setting like below:

Common

- **Target Result**: Select the calculation result of which to calculate statistics.
- **Values to output**: Check on checkboxes that you want to output.

Statistics for each grid node

- **Target Time Range**: Specify the time range to calculate statistics.

Statics for each area

- **Dry Area Processing**: Specify setting about if the tool should use values at area with depth smaller than threshold, to calculate statistics.
- **Output**: Check on checkbox to output values.
- **CSV file name**: Specify the CSV file name to output.

Visualization of analysis result

Visualize the analysis result that EvaTRiP pro outputs.

The statistics for each grid node is output at the last time step.

The list of output values are shown in Table 3.4.

Table 3.4: The list of output values

Name	Description
STAT_Max	Maximum
STAT_Min	Minimum
STAT_Avg	Average
STAT_Stddev	Standard deviation
STAT_CV	Coefficient of variation

Checking the CSV file output

Statistics for each area is output to CSV file.

Table 3.5: The list of values output to CSV file

Name	Description
Count	The number of nodes included in the area
Max	Maximum
Min	Minimum
Avg	Average
Stddev	Standard deviation
CV	Coefficient of variation

3.4 Threshold Classification

Classificate calculation result values with threshold values.

3.4.1 How to use

Editing Calculation Condition

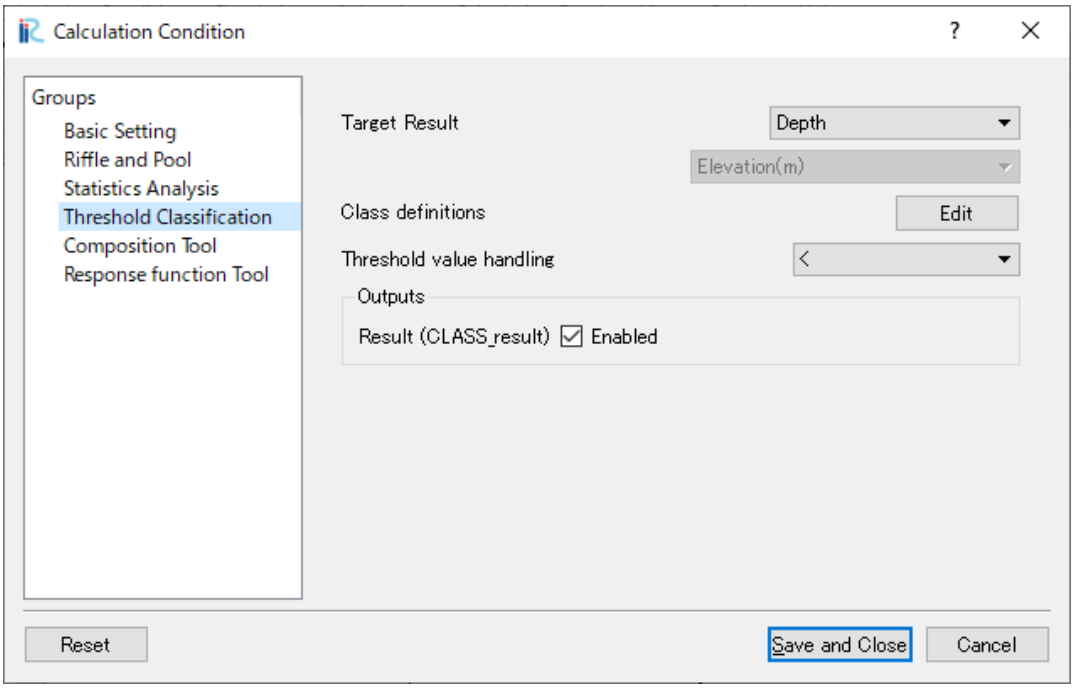

Figure 3.7: [Calculation Condition] dialog [Threshold Classification] page

On [Threshold Classification] page of [Calculation Condition] dialog, setup setting like below:

- **Target Result**: Select the calculation result to classify.
- **Class definitions**: Define the classification. Refer to Figure 3.8 for example.
- **Threshold value handling**: Select from if threshold value is included to left range or right range. if "<" is selected, threshold value is included to left range.
- **Result (CLASS_result)**: Check on the check box to output the analysis result.

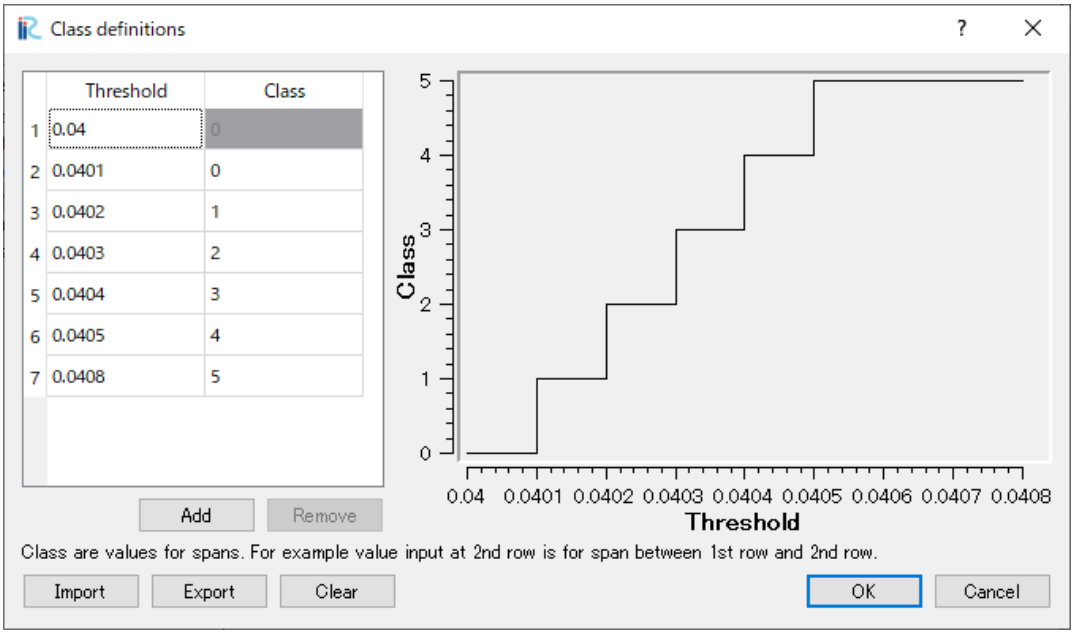

Figure 3.8: Example of classification definition

Visualization of analysis result

Visualize the analysis result that EvaTRiP pro outputs.

The list of output values are shown in Table 3.6.

Table 3.6: The list of output values

Name	Description
CLASS_result	Classification result

3.5 Composition tool

Calculate Froude number, move critical diameter etc.

3.5.1 Description of functions

Composition tool provides the following five functions:

- Froude number calculation
- Move critical diameter calculation
- Fluid force calculation
- Manual formula calculation

Froude number calculation

Calculates Froude number from depth h, velocity v. Froud number is calculated with the formula below. g is the gravitational acceleration.

$$Fr = \frac{v}{\sqrt{gh}}$$

Move critical diameter calculation

Calculates move critical diameter values with the following steps:

1. Calculates water level gradient I from water surface elevation. Calculate water level gradient for both I-direction and J-direction, and then use the maximum value of them as I for each grid node.

   Level gradient in I direction I_i is calculated with formula below. x, y are coordinates of grid.

   - $i = 1$

   $$I_1 = \frac{w_{(2,j)} - w_{(1,j)}}{\sqrt{(x_{(2,j)} - x_{(1,j)})^2 + (y_{(2,j)} - y_{(1,j)})^2}}$$

   - $i = i_{max}$

   $$I_{max} = \frac{w_{(i_{max},j)} - w_{(i_{max}-1,j)}}{\sqrt{(x_{(i_{max},j)} - x_{(i_{max}-1,j)})^2 + (y_{(i_{max},j)} - y_{(i_{max}-1,j)})^2}}$$

   - else

   $$I_i = \frac{1}{2}\left(\frac{w_{(i+1,j)} - w_{(i,j)}}{\sqrt{(x_{(i+1,j)} - x_{(i,j)})^2 + (y_{(i+1,j)} - y_{(i,j)})^2}} + \frac{w_{(i,j)} - w_{(i-1,j)}}{\sqrt{(x_{(i,j)} - x_{(i-1,j)})^2 + (y_{(i,j)} - y_{(i-1,j)})^2}}\right)$$

   Similar formulas are used to calculate level gradient in J direction.

2. Calculates friction speed u_* from depth h and water level gradient I. g is the gravitational acceleration.

$$u_* = \sqrt{ghI}$$

3. Calculates move critical diameter using Iwagaki ' s formula [Iwagaki], from u_*. The formulas are shown in Table 3.7. Please note that the unit of u_* is centimeter per second, and the unit of move critical diameter is centimeter. The unit of critical diameter values output is milimeter.

Table 3.7: Formulas to calculate move critical diameter

Condition	Formula
$24.5127 \leqq u_*^2$	$d_{max} = u_*^2/80.9$
$6.49 \leqq u_*^2 < 24.5127$	$d_{max} = (u_*^2/134.6)^{22/31}$
$3.1075 \leqq u_*^2 < 6.49$	$d_{max} = u_*^2/55.0$
$1.469 \leqq u_*^2 < 3.1075$	$d_{max} = (u_*^2/8.41)^{32/11}$
$u_*^2 < 1.469$	$d_{max} = u_*^2/226.0$

Note: Because water level gradient is needed, this function can be used for calculation results of solvers that uses structured grids.

Fluid force calculation

Calculates Fluid force F from depth h and velocity v, with the formula below:

$$F = hv^2$$

Manual formula calculation

Calculates value with formula manually defined.

You can describe formulas with Python notations. Refer to *Examples of [Manual Definition]* (page 19) for examples.

You can use the variables in Table 3.8 for Manual definition.

Table 3.8: The list of variables available in manual definition

Value	Variable name
Depth	depth
Water surface elevation	wse
Velocity (X)	vx
Velocity (Y)	vy
Velocity (magnitude)	v
Arbitrary Variable 1	val1
Arbitrary Variable 2	val2

3.5.2 How to use

Editing calculation condition

[Composition Tool] page of [Calculation Condition] dialog, setup setting like below:

- **Arbitrary Variable 1, 2**: Select the variable to use in [Manual Definition].
- **Manual Definition**: Define the manually defined formula
- **Outputs**: Check on values to output.

Visualization of analysis result

Visualize the analysis result that EvaTRiP pro outputs.

The list of output values are shown in Table 3.9.

Table 3.9: The list of output values

Name	Description
COMP_Froude	Froud number
COMP_CriticalDiameter	Move critical diameter
COMP_FluidForce	Fluid Force
COMP_Manual	Calculation result of manually defined formula

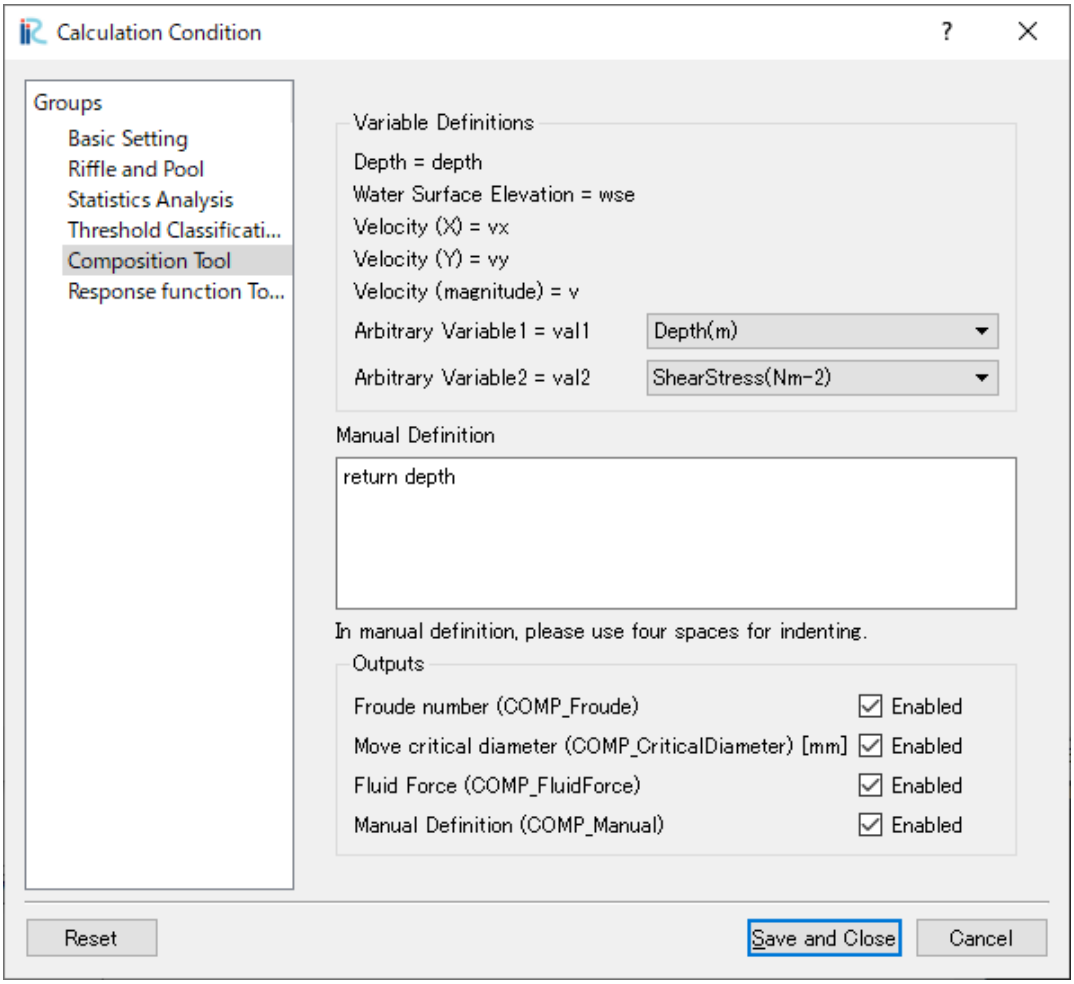

Figure 3.9: [Calculation Condition] dialog [Composition Tool] page

3.5.3 Examples of [Manual Definition]

Users can define formula with Python notations.

Please refer to the hints below:

- Variables like depth, wse are loaded as numpy.ndarray.
- Please use four spaces for indenting.
- numpy is already imported as np.
- You can use arbitrary modules, using import statement.
- You can use print() to output calculation result to [Solver Console Window].
- You can use only ASCII characters.

Examples of [Manual Definition] are shown below.

Extract region with threshold depth

Outputs 1 for region with depth bigger than 1, and 0 for others.

```
return np.where(depth >= 0.5, 1, 0)
```

Print the difference between max and min of depth

```
print('depth min - max = {0}'.format(np.max(depth) - np.min(depth)))

# depth output as dummy
return depth
```

3.6 Response function Tool

General purpose analysis tool based on PHABSIM.

3.6.1 How to use

Editing Calculation Condition

On [Response function Tool] page of [Calculation Condition] dialog, setup setting like below:

- **Function 1 Output (RESP_F1) etc.**: Check on the check box to output.
- **Function 1 Target Result etc.**: Select the calculation result to input to the function.
- **Function 1 Response Function etc.**: Define the fujnction. Refer to Figure 3.11 for example.
- **Sum (RESP_Sum)**: Check on check box to output the sum of functions.
- **Arighmetic mean (RESP_A_Mean)**: Check on check box to output the arighmetic mean of functions.
- **Geometric mean (RESP_G_Mean)**: Check on check box to output the geometric mean of functions.

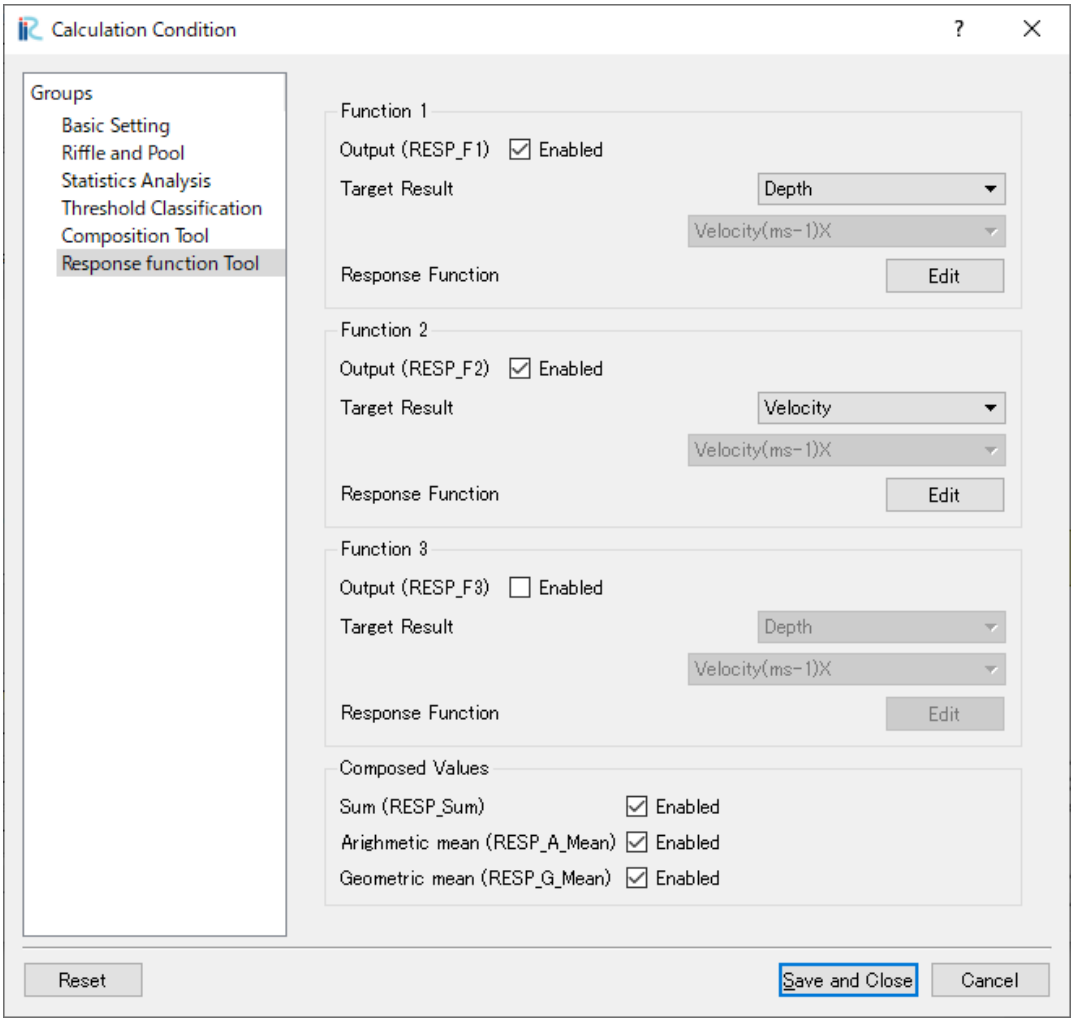

Figure 3.10: [Calculation Condition] dialog [Response function Tool] page

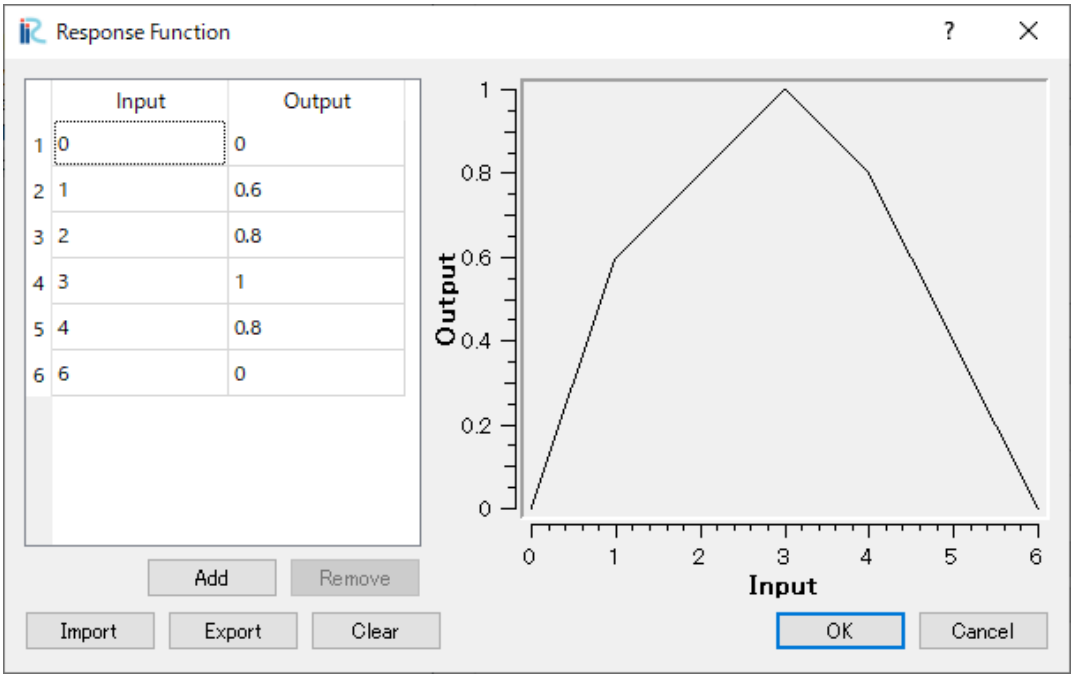

Figure 3.11: Example of function definition

Visualization of analysis result

Visualize the analysis result that EvaTRiP pro outputs.

The list of output values are shown in Table 3.10.

Table 3.10: The list of output values

Name	Description
RESP_F1	Function 1
RESP_F2	Function 2
RESP_F3	Function 3
RESP_Sum	Sum
RESP_A_Mean	Arighmetic mean
RESP_G_Mean	Geometric mean

CHAPTER

FOUR

EXAMPLES

A YouTube movie about how to use EvaTRiP is published. The movie is in Japanese.

The URL of the movie is as below.

https://youtu.be/i85tmbkFv70

CHAPTER

FIVE

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BIBLIOGRAPHY

[Iwagaki] Yuichi Iwagaki: Hydrodynamical study on critical tractive force, Trans. of JSCE, No. 41, pp 1-21, December, 1956