# IFAS Calibrator Version 2.0
# User Manual

ICHARM
(The International Centre for Water Hazard and Risk Management)

Public Works Research Institute

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# 1. Introduction

## 1.1 About IFAS Calibrator

IFAS Calibrator is a tool that optimizes parameters of the IFAS (Integrated Flood Analysis System) using the observed flow rate. The simulation can be run once an IFAS project is created.

The optimization of an IFAS project is limited to a two-layer tank model.

## 1.2 Operating System Requirements

OS：Windows7/8.1/10 (32bit/64bit)

CPU：at least 2GHz

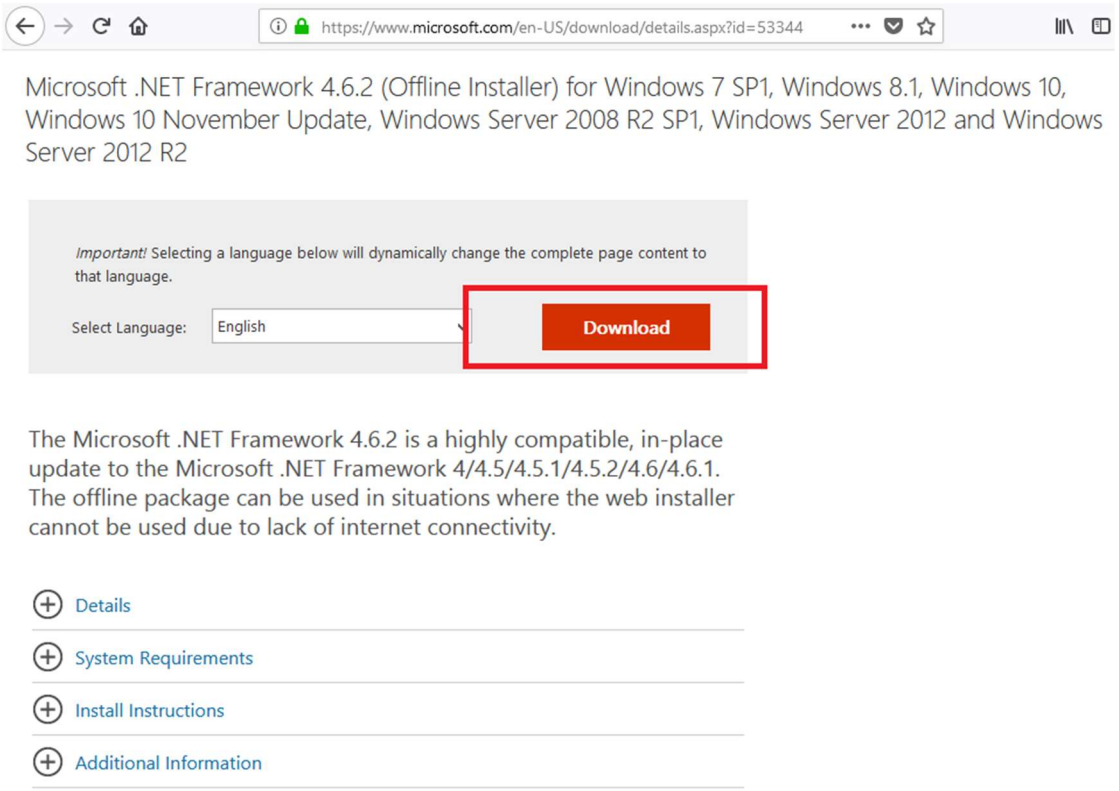
Memory： at least 2GB of RAM

Required software：.NET Framework 4.6 or greater

## 1.3 Installation of Microsoft .NET Framework

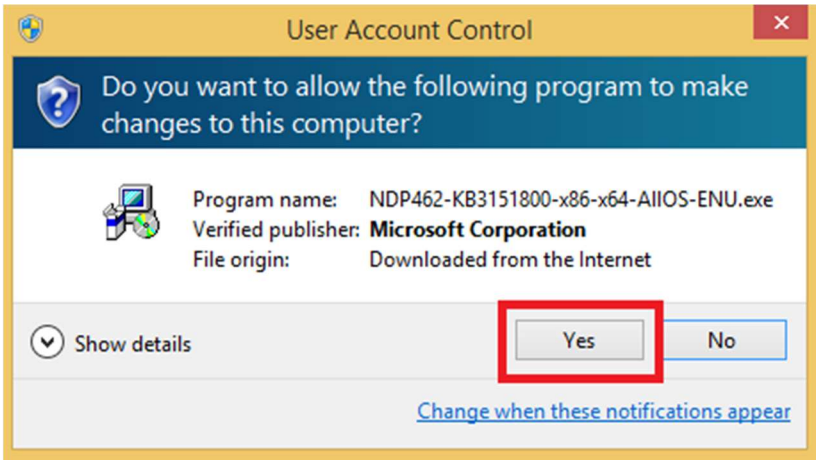
IFAS Calibrator requires .Net Framework to operate, installation instructions are provided below:

① Download .Net Framework from Microsoft's software download portal.



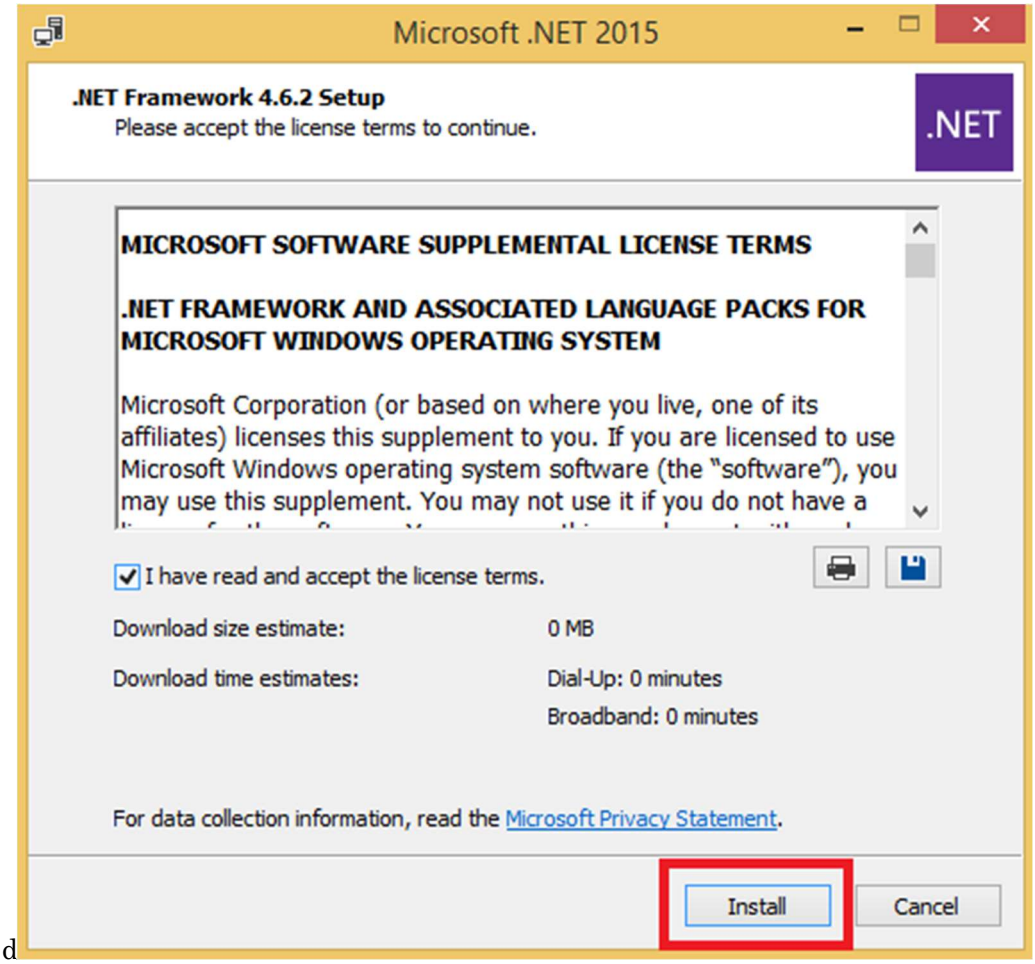
② Execute the downloaded file.

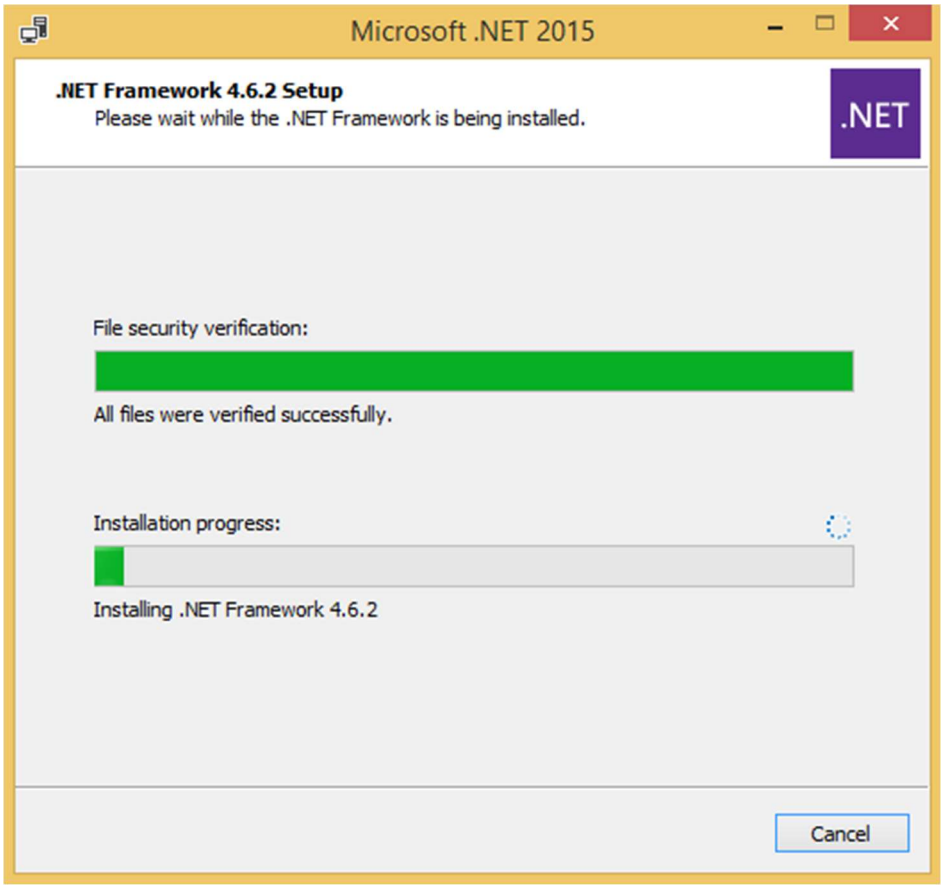
Depending on the security settings in place, a dialog similar to that shown below may appear. If this dialog appears, press “Yes”.

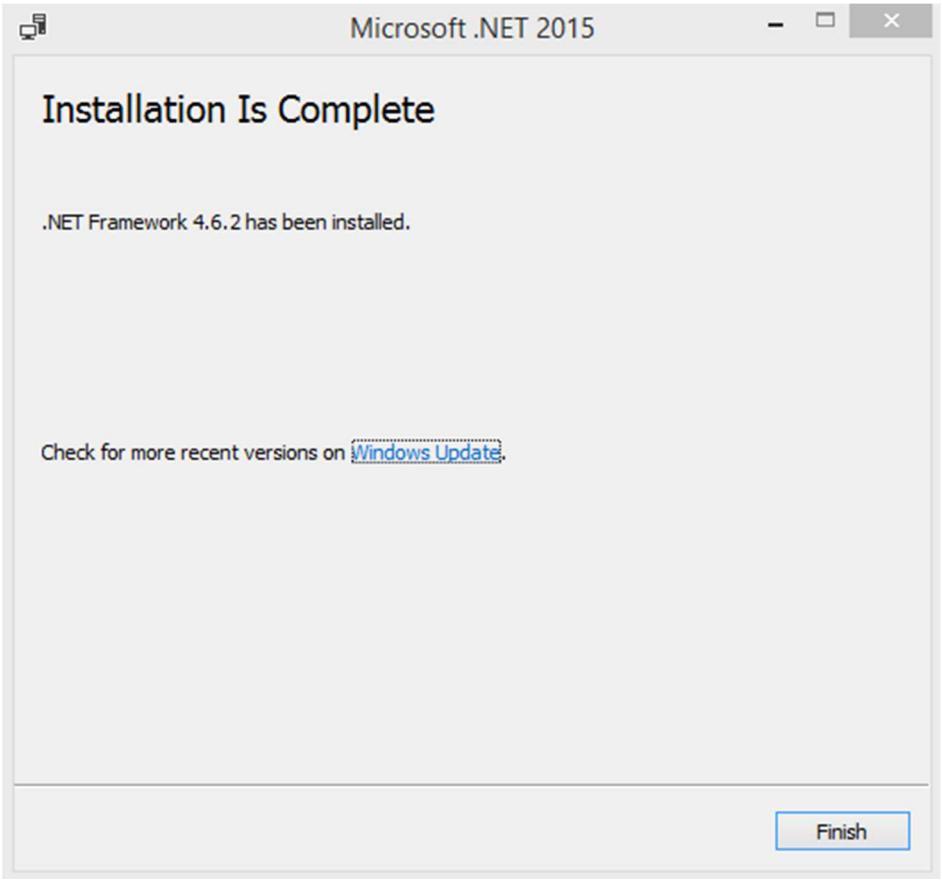



③ Execute the installer and follow the provided prompts.

d

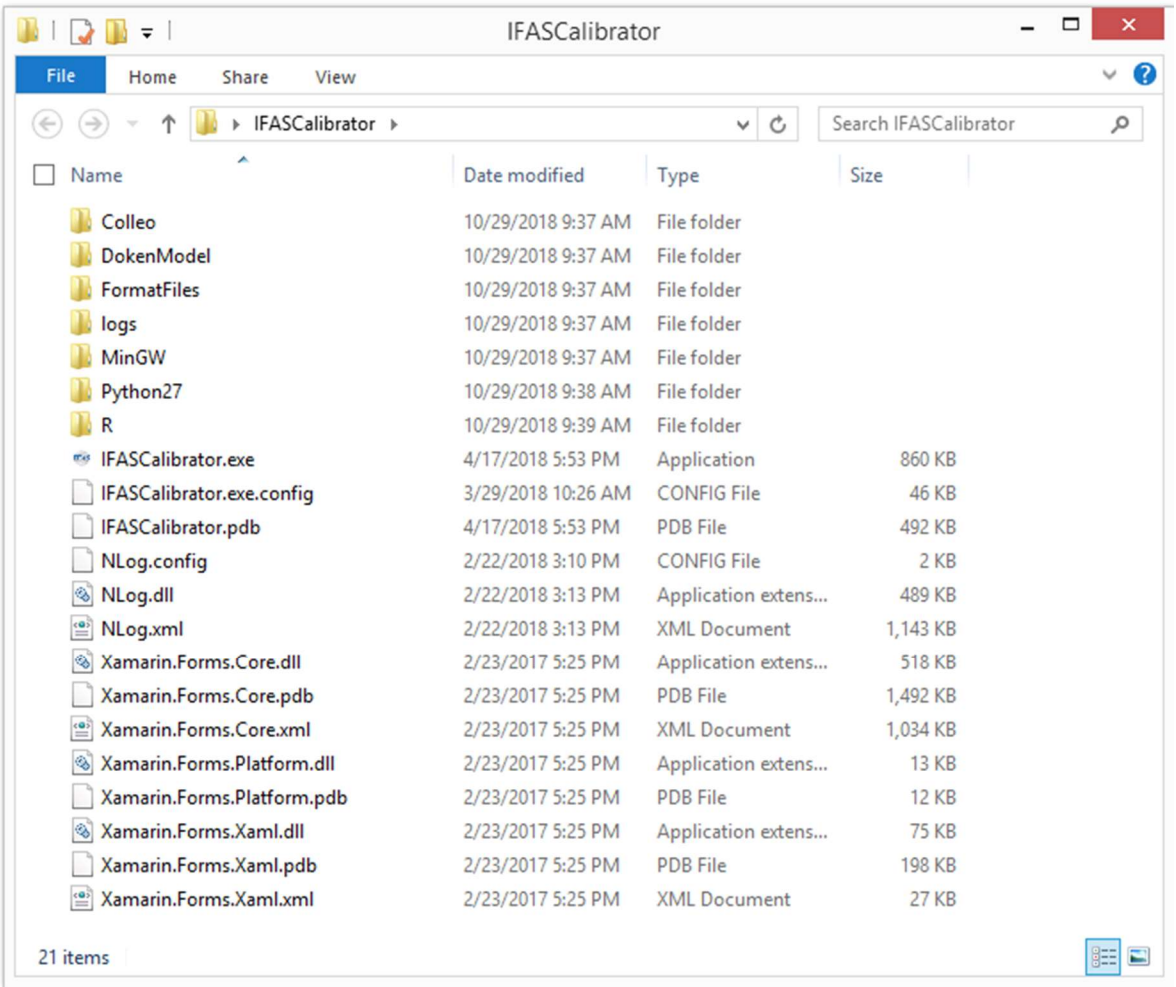



Microsoft .NET 2015
.NET Framework 4.6.2 Setup
Please wait while the .NET Framework is being installed.
.NET
File security verification:
All files were verified successfully.
Installation progress:
Installing .NET Framework 4.6.2
Cancel


Microsoft .NET 2015
Installation Is Complete
.NET Framework 4.6.2 has been installed.
Check for more recent versions on Windows Update.
Finish

# 2. IFAS Calibrator Installation

Do not use the IFAS Calibrator installer. Installation involves uncompressing the IFAS Calibrator archive into any location. The path of where IFAS Calibrator was uncompressed must not contain Japanese characters (ex. C:\).

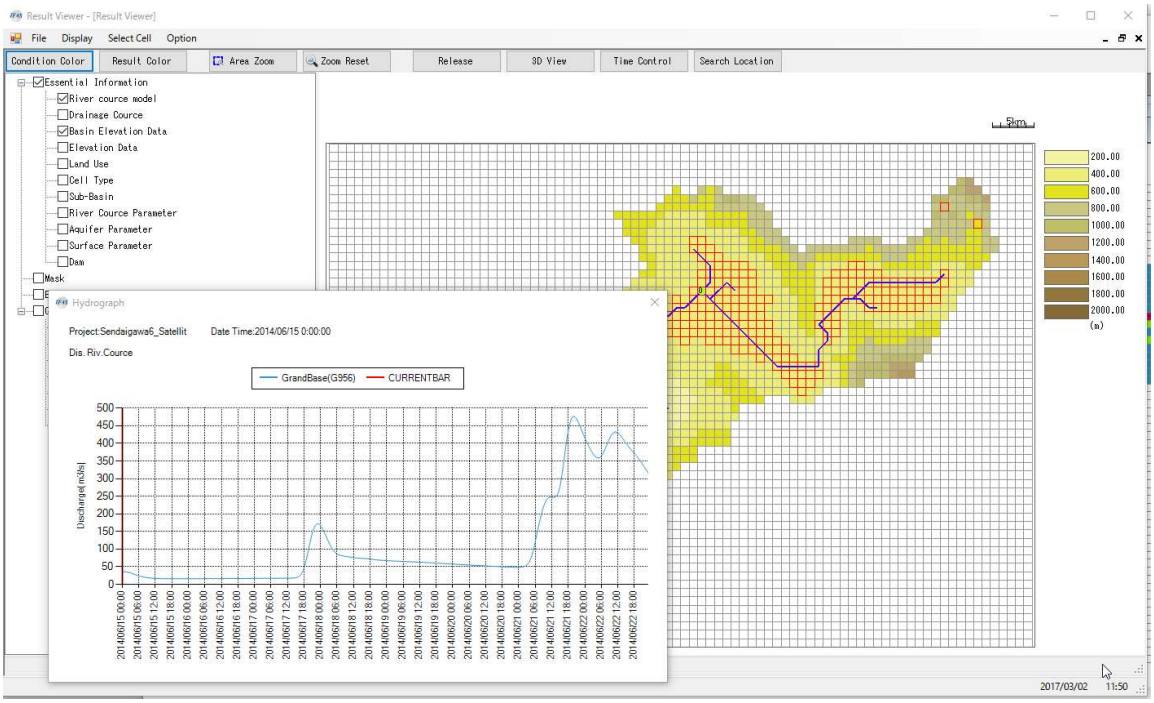


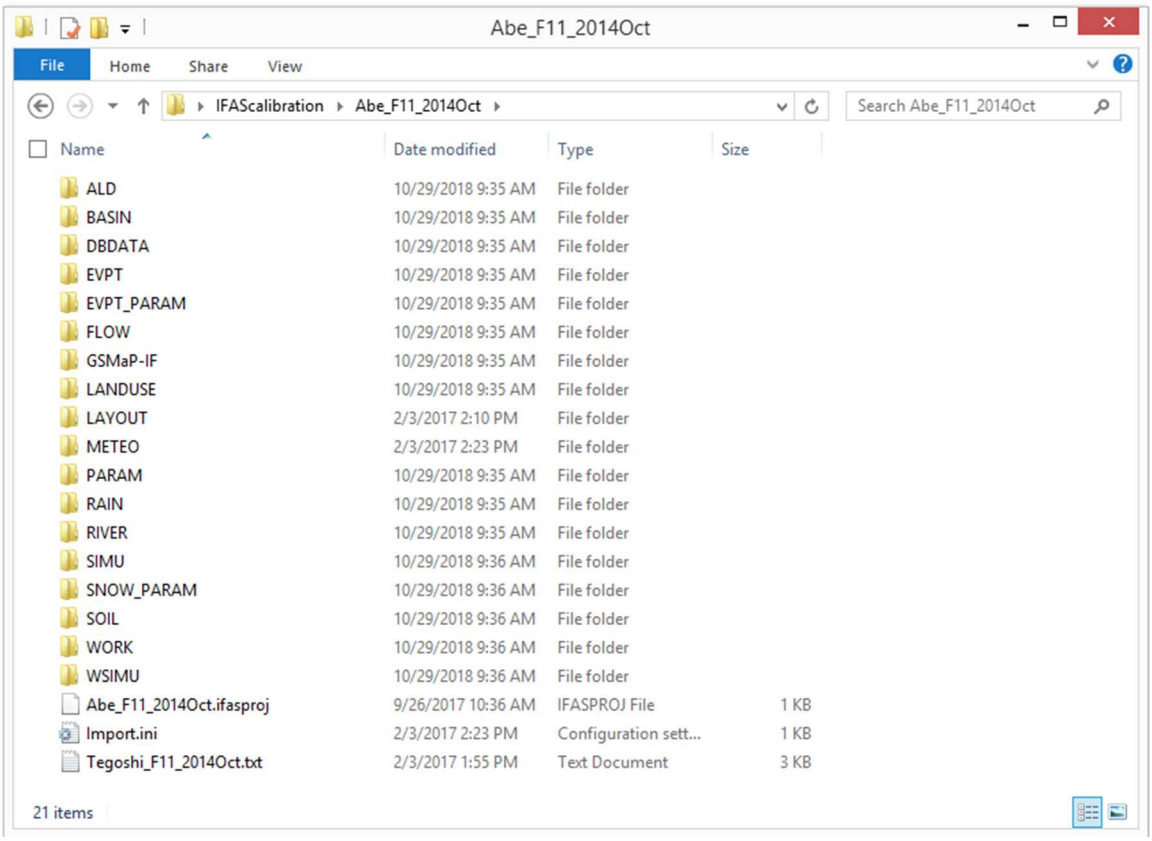
# 3. Parameter Optimization Settings

## 3.1 Setup

Load a simulation from an IFAS project file.

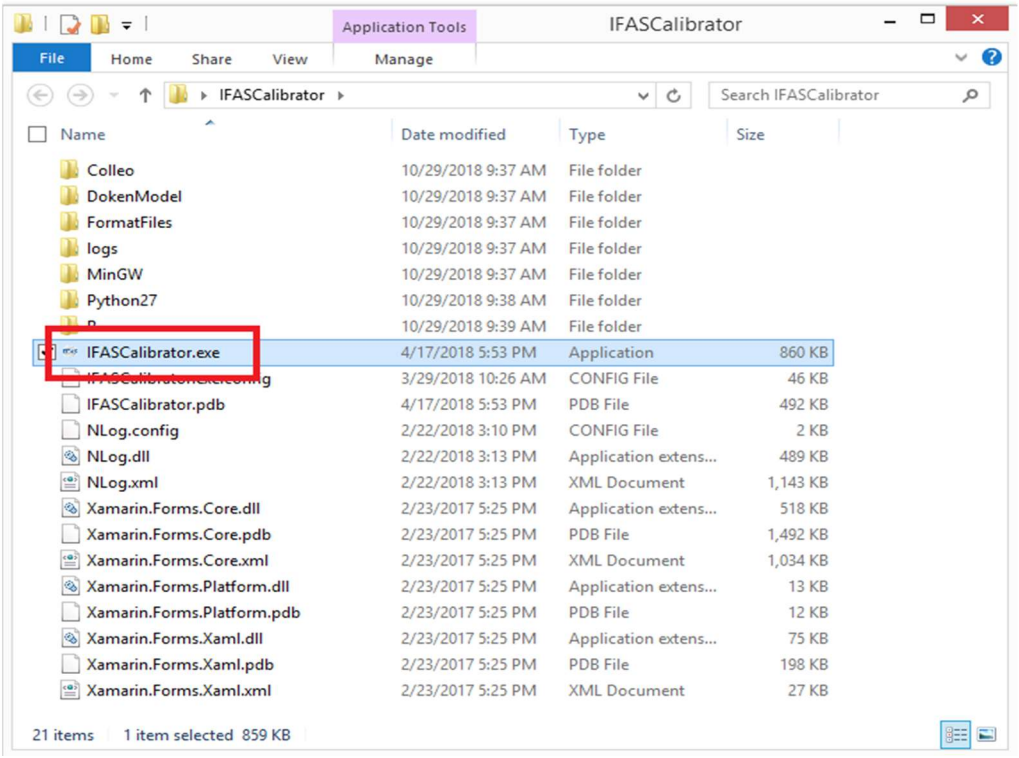
NOTE: An optimized IFAS project is limited to a two-layer tank model.



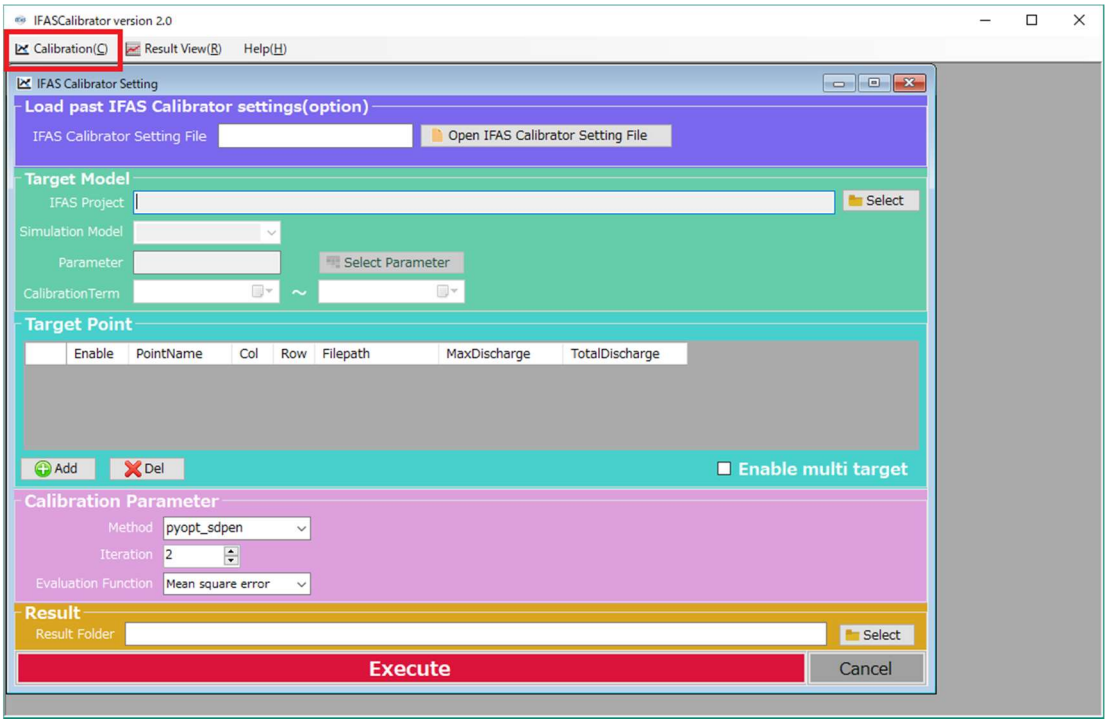



## 3.2 IFAS Calibrator Startup

Double click on “IFASCalibrator.exe” in the location of the extracted archive file.

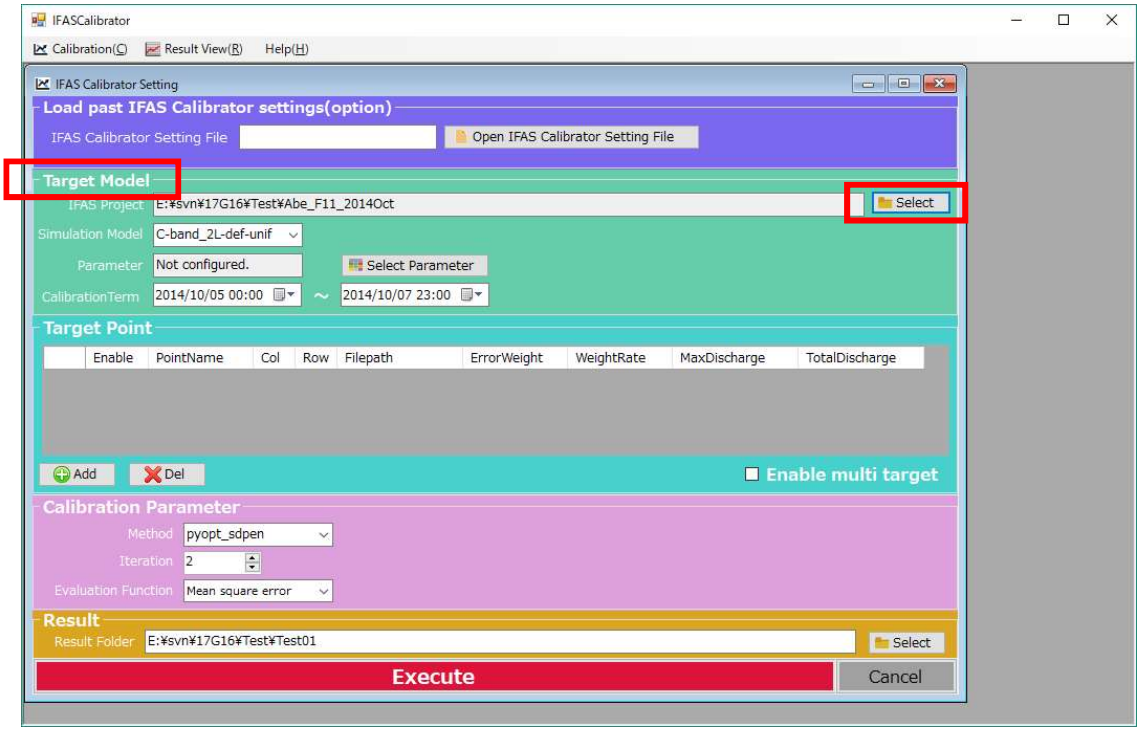



After the program opens, click “Calibration(C)” from the menu bar, and the interface for choosing settings will appear.

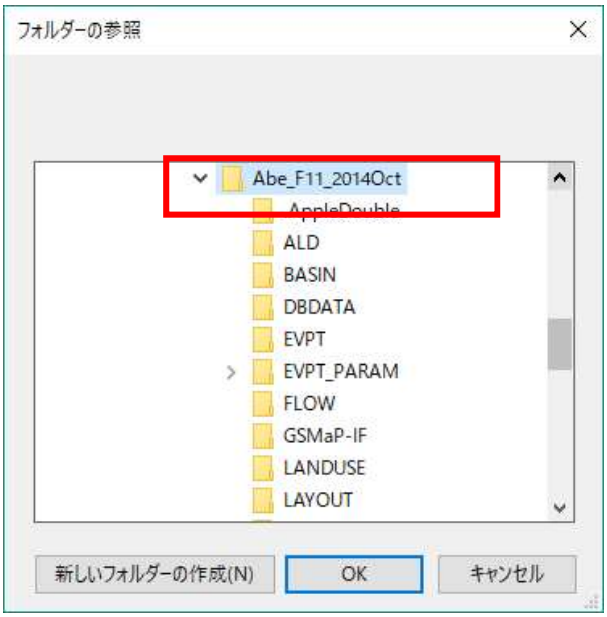


## 3.3 Opening an Optimized Target Model from IFAS Projects

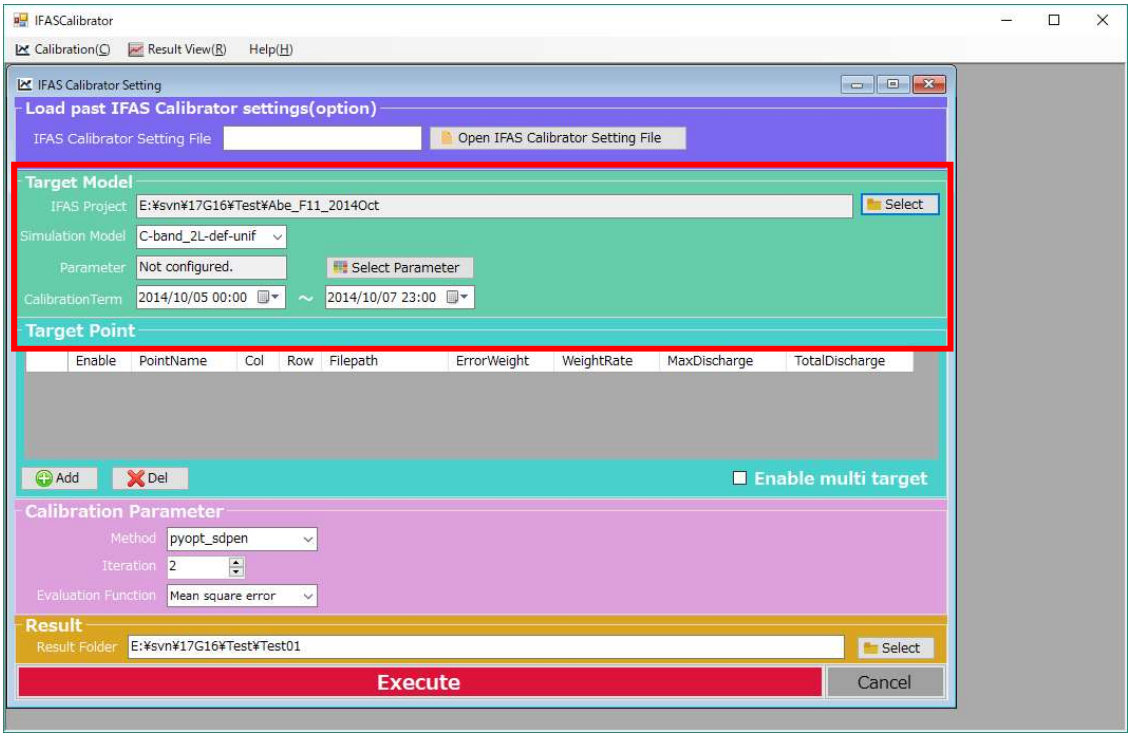
In the “Target Model” section, from the IFAS Project field, clicking the “Select” button will display a folder selection dialog.



After the folder selection dialog is displayed, select the desired IFAS project folder by clicking on it.

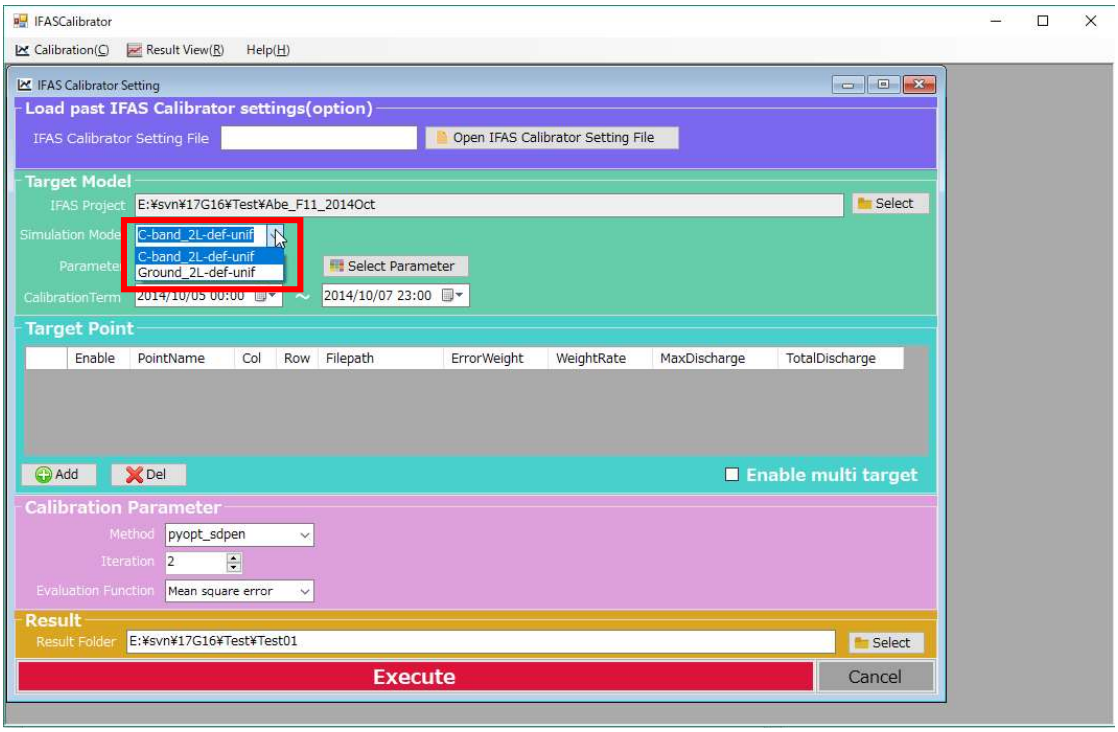



After selecting an IFAS project folder and pressing the “OK” button, project details, such as the Simulation Model name and Simulation period, will be displayed.



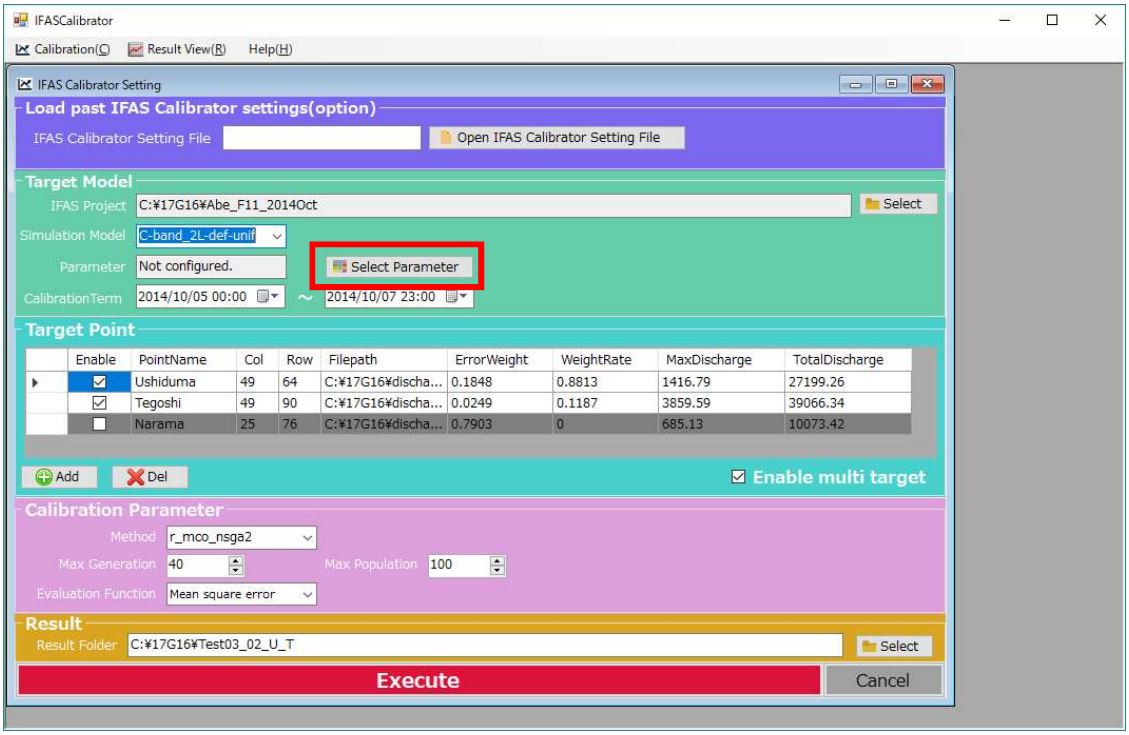
## 3.4 Optimized Target Simulation Selection

If there are multiple Simulation Models in the imported IFAS project, select the desired optimization target from the dropdown menu in the Simulation Model field.



## 3.5 Setting the Optimization Scope

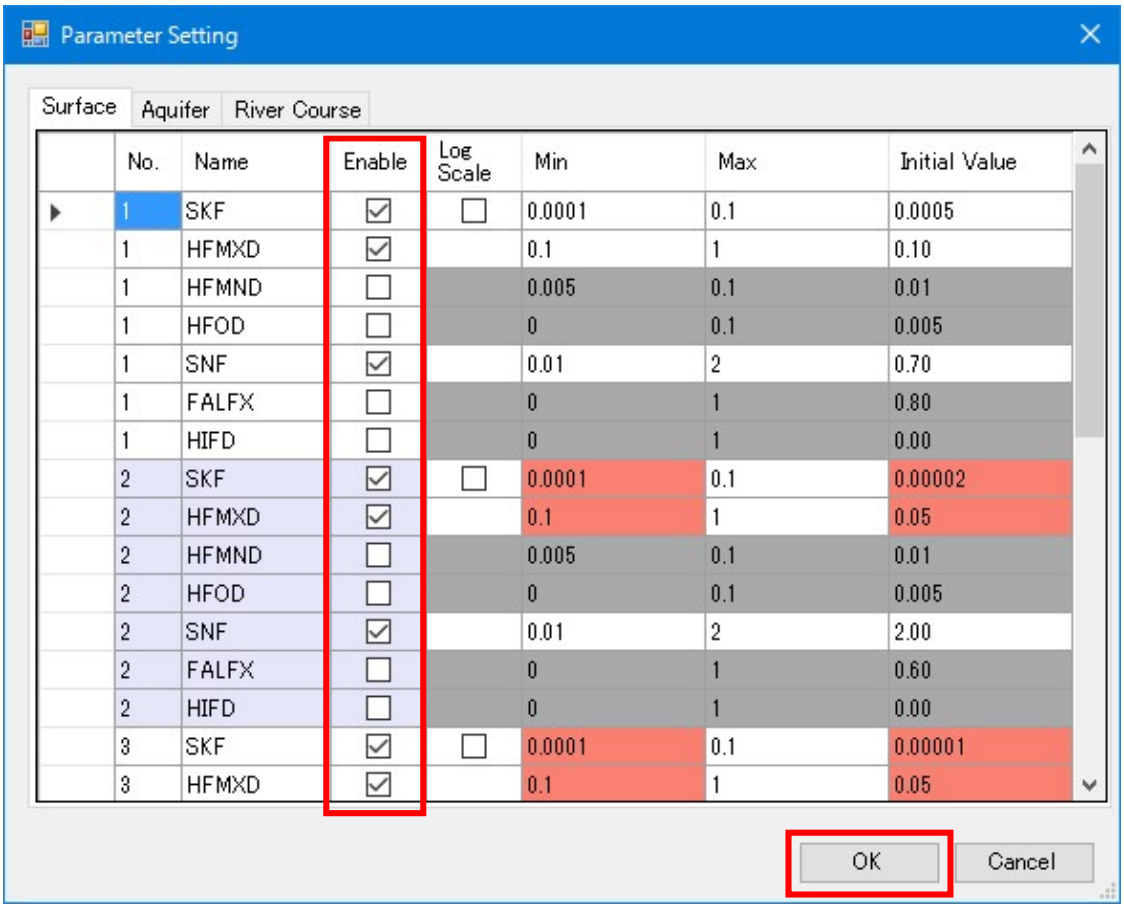
Click the “Select Parameter” button from the Parameter field.



IFAS parameters are enabled by clicking the respective check box in the “Enable” field. Minimum, maximum, and initial values can also be set for the optimization target. Click the “OK” button to set parameters.

“Enable”, “Min”, and “Max” are automatically set to default values, verify if any changes are necessary. “Initial Value” contains the values used in the selected IFAS simulation. Change values as necessary.

An error check will be performed for the values that you set, and an error message will be displayed for cells in error. Cells in red indicate an error. For an overview of error checking, see P12. Error checking is performed when the screen is opened. Therefore, when opening the screen for the first time, Min and Max may show error with the default values and the values used in the IFAS simulation.



＜Error checking outline＞

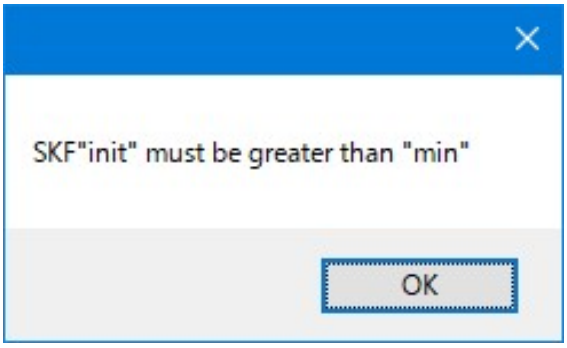
・All parameters must have *Min<=Initial Value＜Max.*

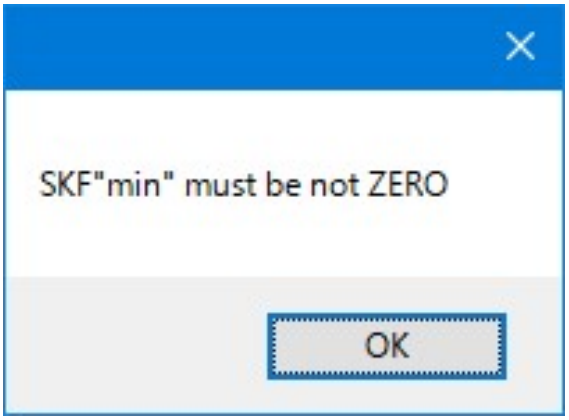
・Part one parameters must not be 0 (To prevent division by 0 errors)

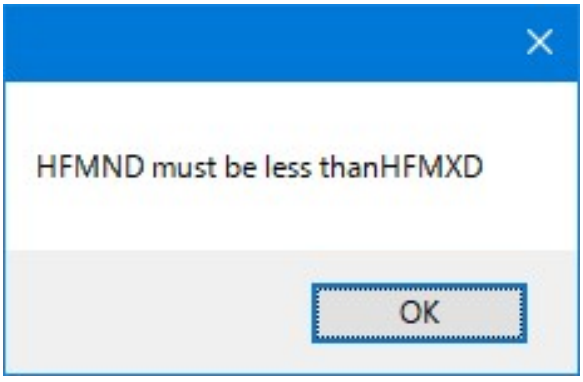
・Part one parameters that must be greater or smaller than related variable must have appropriate values.

NOTE: The error message does not change any values. All values must be changed and confirmed by the user.

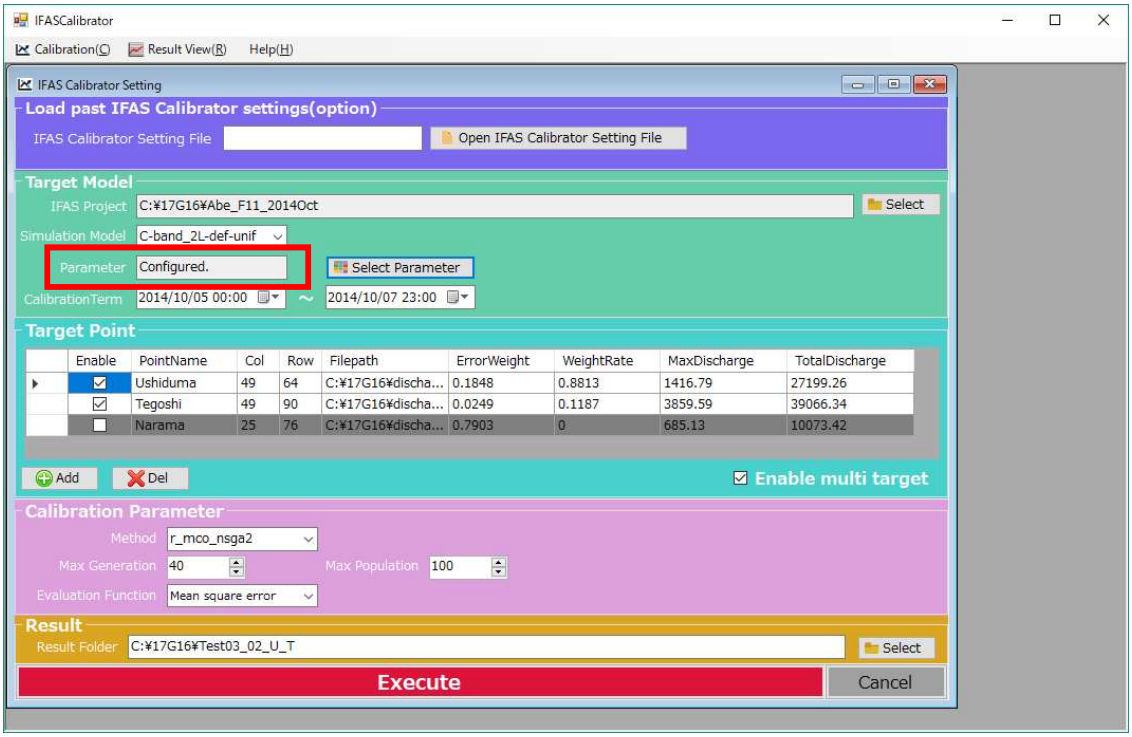
Examples of error messages.



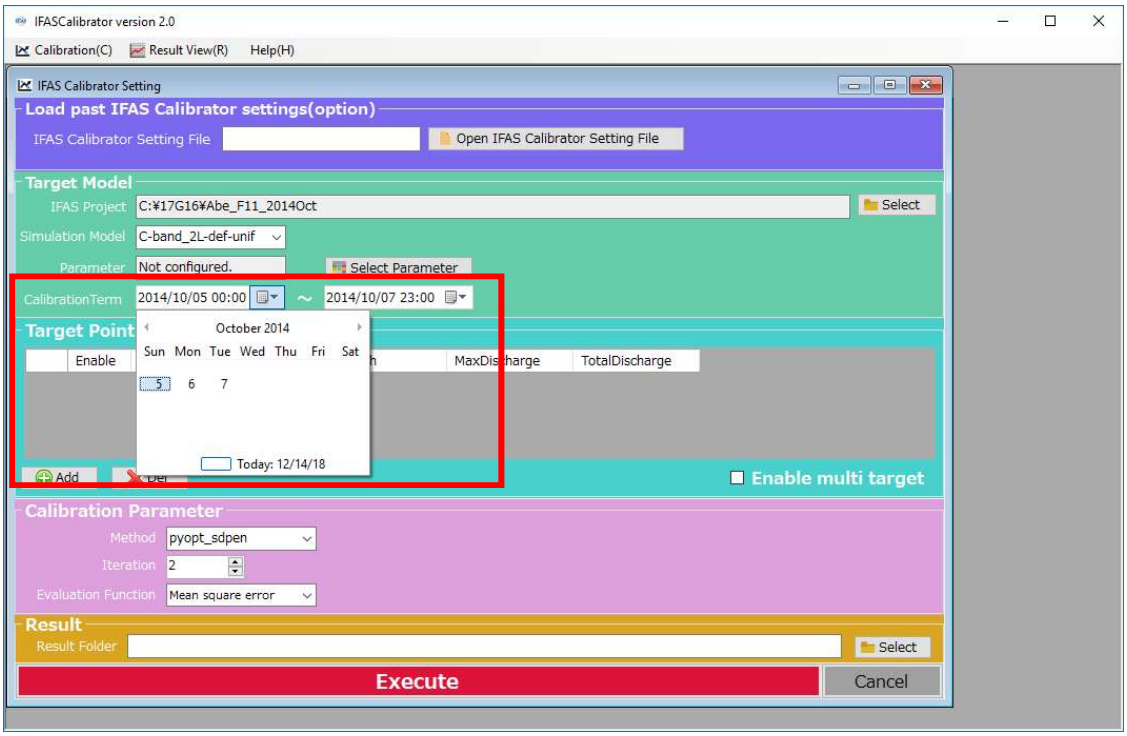
The “Parameter” field will change to “Configured.” when settings are properly set.



## 3.6 Setting the Optimization Evaluation Period

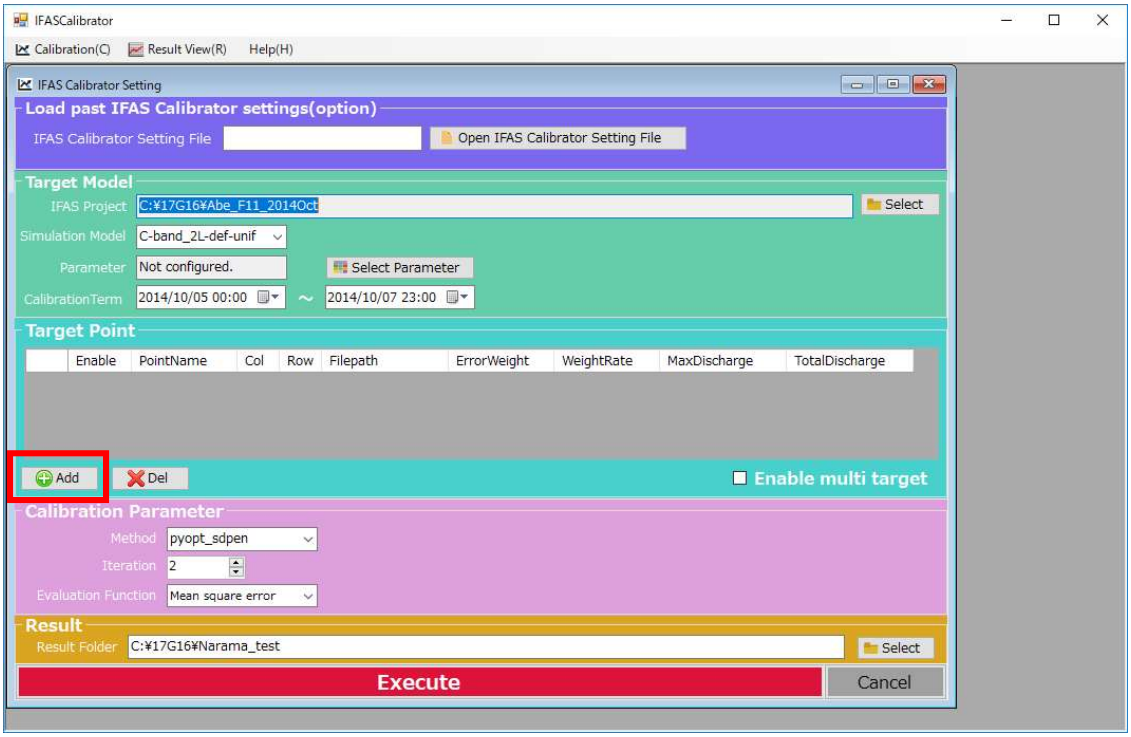
The optimization evaluation run duration can be shortened.

The dates can be chosen from a drop-down calendar, but time must be directly entered.

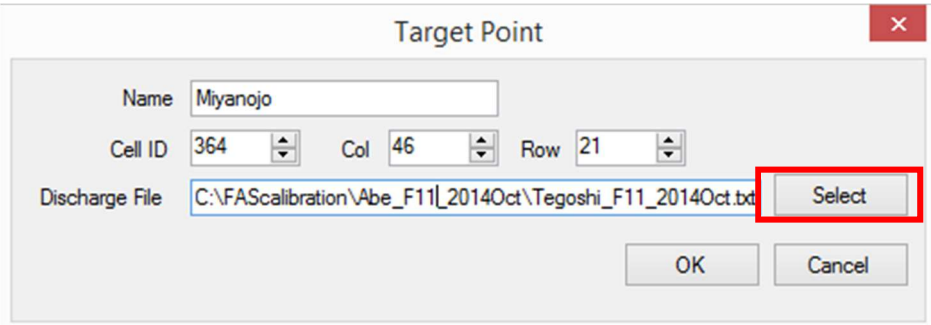


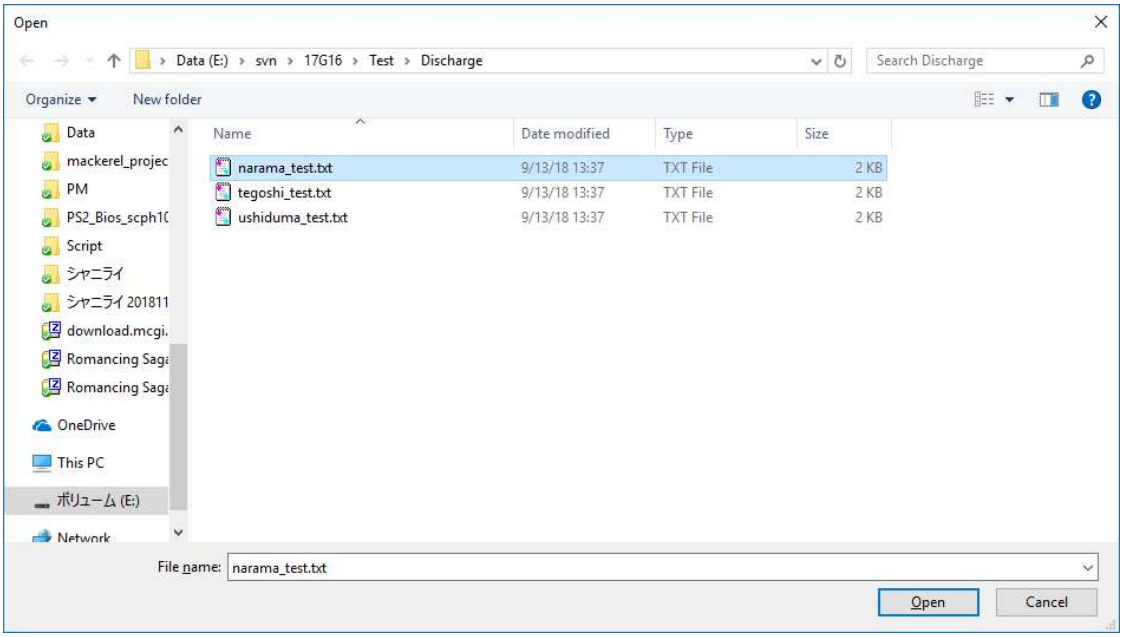
## 3.7 Setting the Observation Point

Click the “Add” button in the “Target Point” section to set the observation point for the optimal flow rate to be used for optimization.




Enter the observation Name, then Cell ID, or the Col and Row of the desired observation point of the corresponding IFAS project. Click the “Select” button to select the observation flow data file.





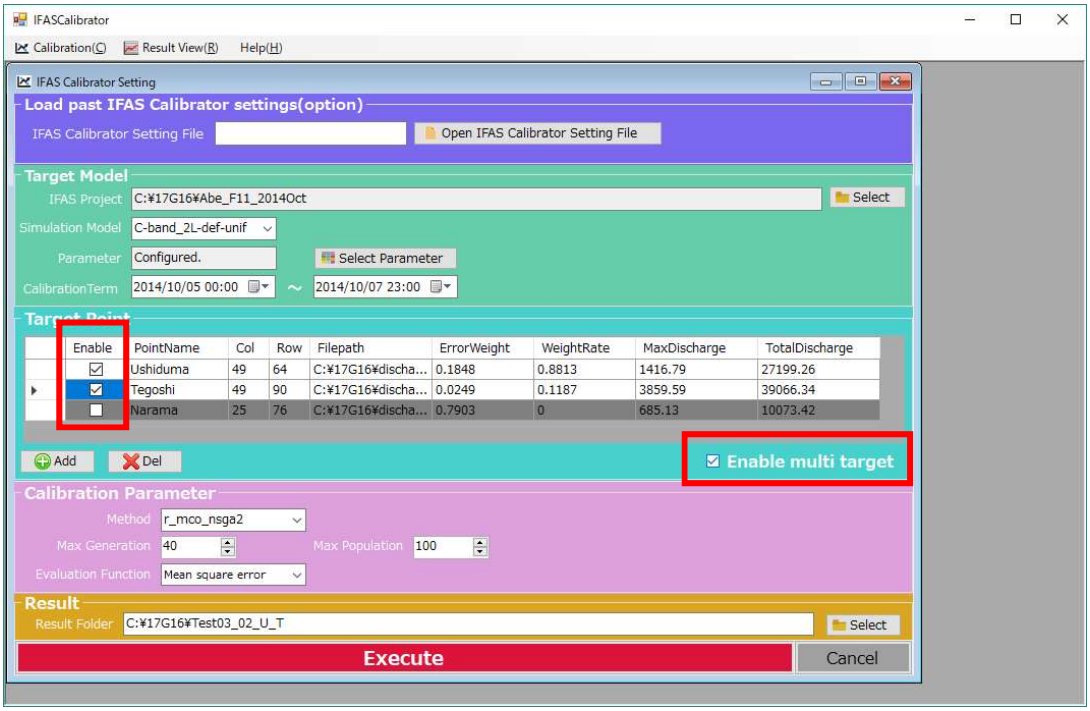

The observation flow data file must be in the format as shown below.
NOTE: each line must be “YYYYMMDDhhmm(space or tab)<flowrate>”

```
201406150000 49.21
201406150100 45.03
201406150200 42.34
201406150300 41.03
201406150400 39.74
201406150500 38.46
201406150600 38.46
```

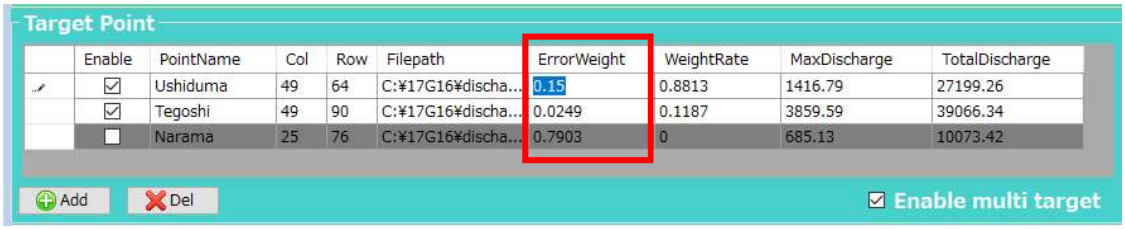
Make sure the observed flow files are always in the same interval as the IFAS project calculation interval for the entire period of the IFAS project to be optimized. The entire duration of the IFAS project is required, not only the optimization evaluation period. Also, each line must contain data, there must not be missing data within the time frame. For example, if the duration of the project is 6/15/2014 00:00 to 6/17/2014 23:00, with a calculation interval of 60 minutes, there must be 24 x 3 = 72 rows all containing data (no missing values).

## 3.8 Multiple Target Optimization Settings

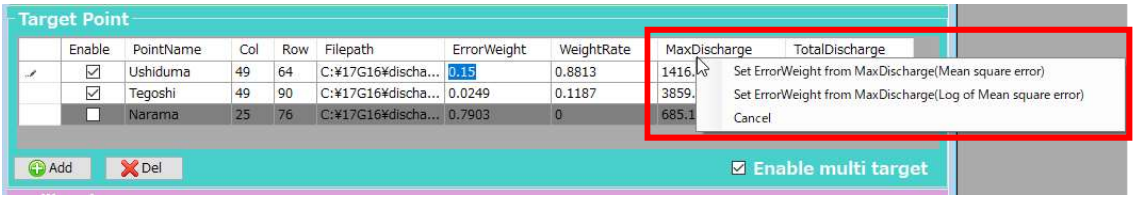
If multi-point multi-objective observation is desired, click the “Enable multi target” box to allow multiple points to be enabled. Click the check box in the “Enable” field to enable the target point.




The weight of error evaluation function for each point that have “Enable” checked can be set in the field “ErrorWeight”.

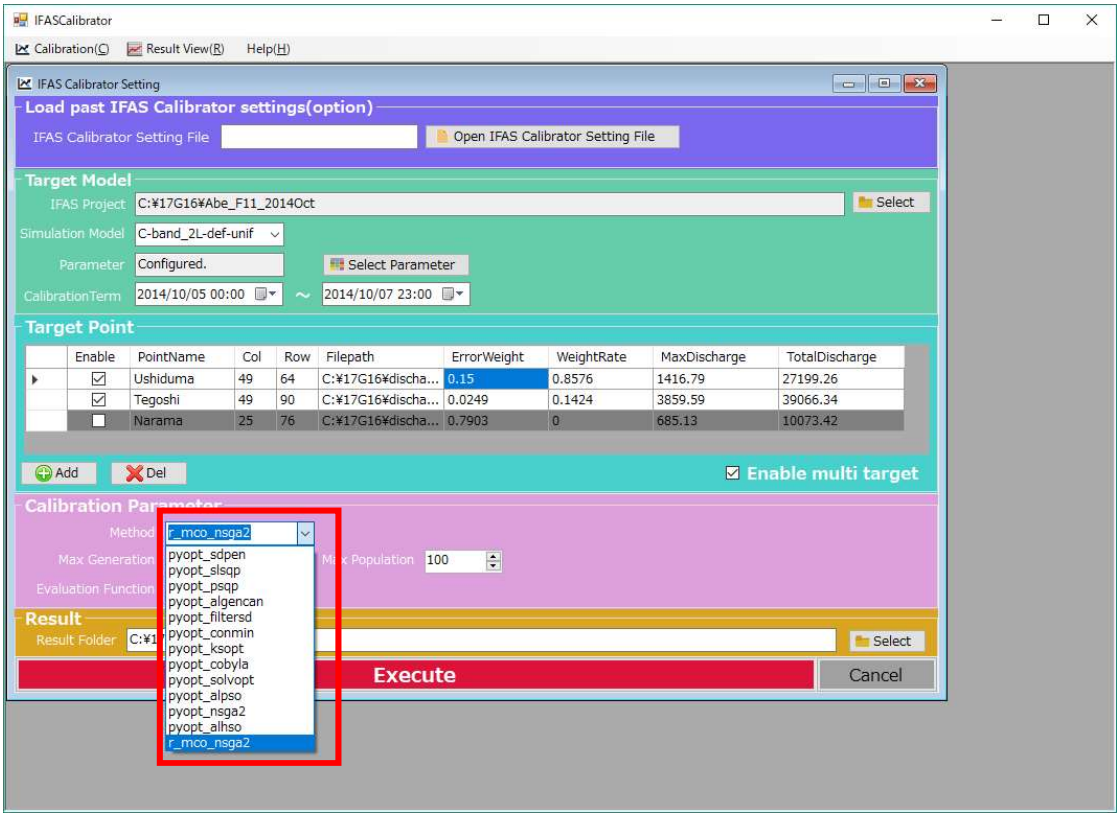



Right-clicking the header of the maximum flow rate (MaxDischarge) or the total flow rate (TotalDischarge) displays a menu where the error weight can be automatically set based on the maximum flow rate or the total flow rate.



## 3.9 Configuring Optimization Algorithms

Select the desired optimization method.



The algorithms to choose from are listed below.

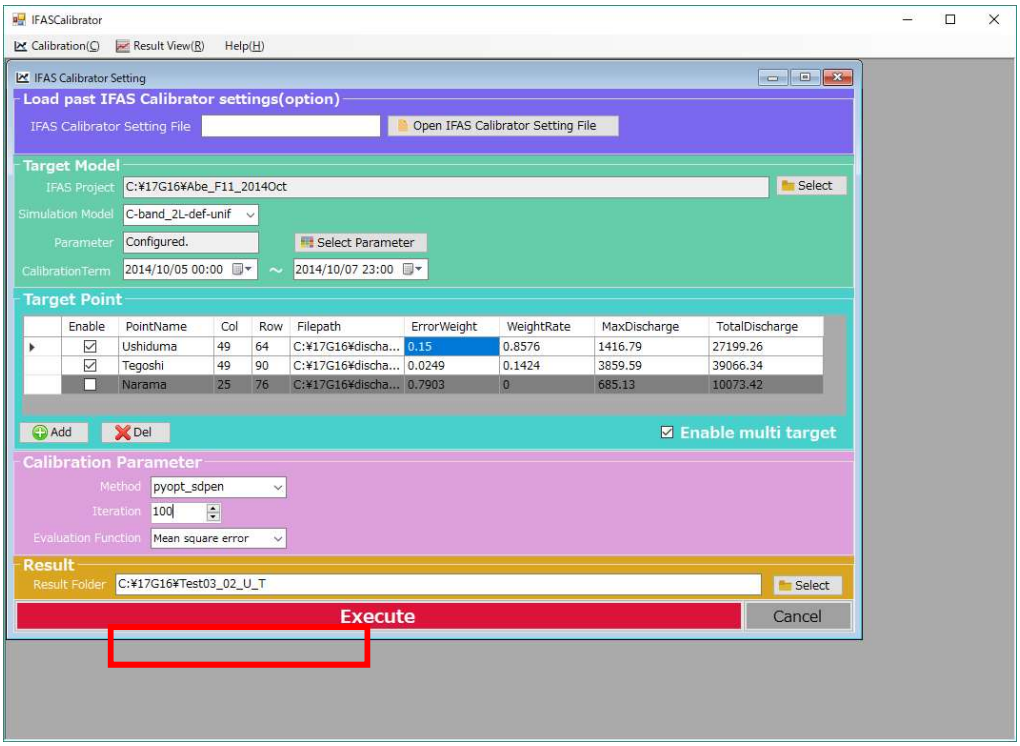
| Solver | Algorithm |
|---|---|
| pyopt_sdpen | Sequential Penalty Derivative-free method for Nonlinear constrained optimization |
| pyopt_slsqp | Sequential Least Squares Programming |
| pyopt_psqp | Preconditioned Sequential Quadratic Programming |
| pyopt_algencan | Augmented Lagrangian with GENCAN |
| pyopt_filtersd | FILTERSD uses a generalization of Robinson's method, globalised by using a filter and trust region. |
| pyopt_conmin | CONstrained function MINimization |
| pyopt_ksopt | Kreisselmeier–Steinhauser Optimizer |
| pyopt_cobyla | Constrained Optimization BY Linear Approximation |
| pyopt_solvopt | SOLver for local OPTimization problems |
| pyopt_alpso* | Augmented Lagrangian Particle Swarm Optimizer |
| pyopt_nsga2* | Non Sorting Genetic Algorithm II(pyopt) |
| pyopt_alhso | Augmented Lagrangian Harmony Search Optimizer |
| r_mco_nsga2* | Non-Sorting Genetic Algorithm II(R) |

*Requires a setting other than the number of calculations.

Detailed descriptions of each pyopt algorithm can be found at the following site:
http://www.pyopt.org/reference/optimizers.html

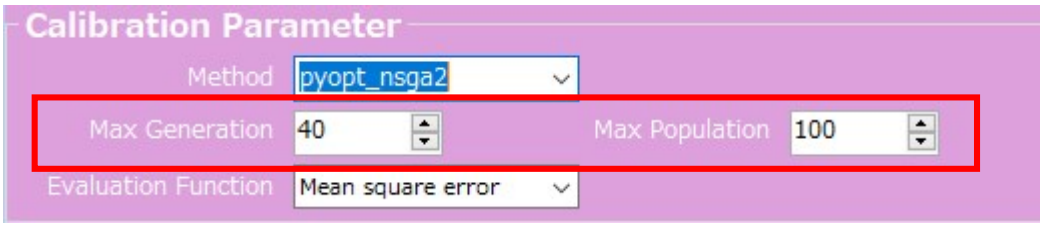
Detailed description of r_mco_nsga2 can be found at the following site:
https://www.rdocumentation.org/packages/mco/versions/1.0-15.1/topics/nsga2

Once the algorithm is selected, set the calculation count (Iteration).



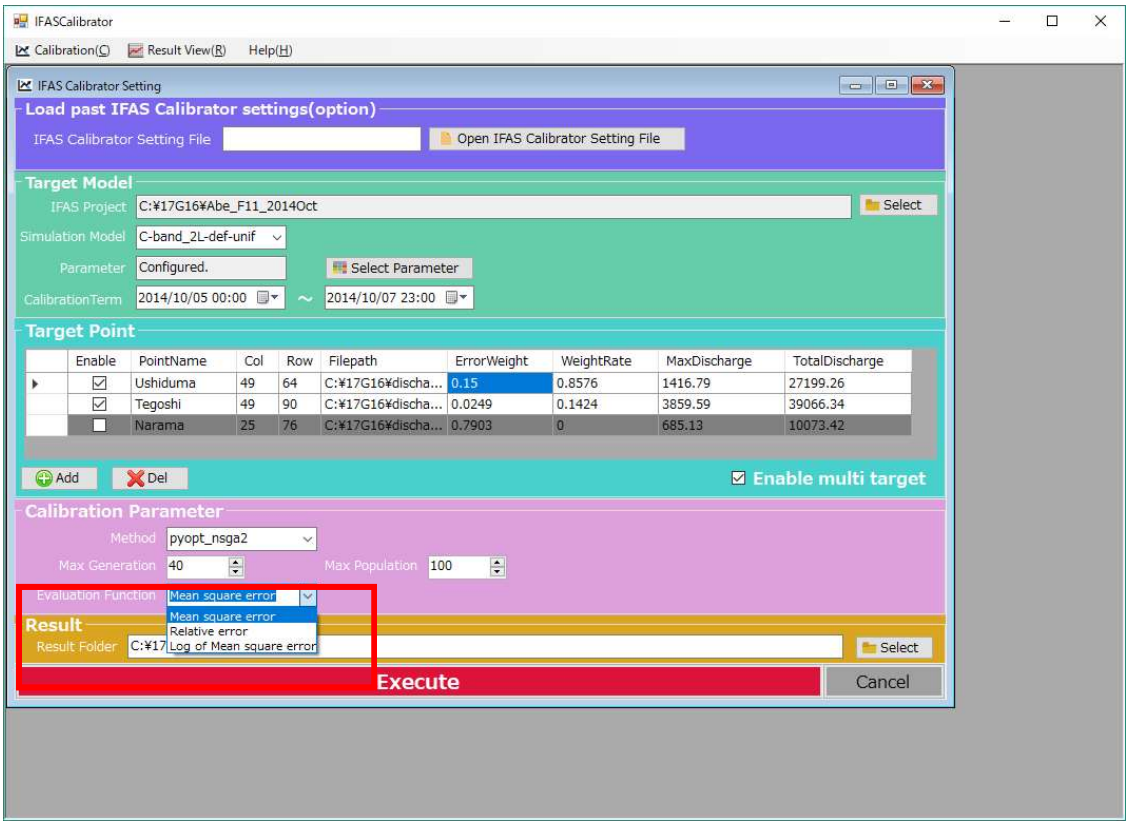

If you select a Solver (see P19) that requires a setting other than the number of calculations, it will appear as follows:

For pyopt_nsga2 or r_mco_nsga2, set the maximum number of individuals (Max Population) and the maximum number of generations (Max Generation). The maximum number of individuals can only be a multiple of 4. The number of calculations will be “Max Population” and “Max Generation”.




For pyopt_alpso, set the number of particles in “SwarmSize” and the number of external loops in “MaxOuterIter”

Set the error evaluation function to use as shown in the figure below.




The three error evaluation function choices are listed below.

$n$ is the number of calculation steps of the IFAS project to be optimized, $x_t$ is the calculated flow rate of IFAS in the calculation step $t$, $o_t$ is the observation flow rate in the calculation step $t$.

・Mean square error

$$E_m = \sum_{t=0}^{n} \frac{(x_t - o_t)^2}{n}$$

・Relative error

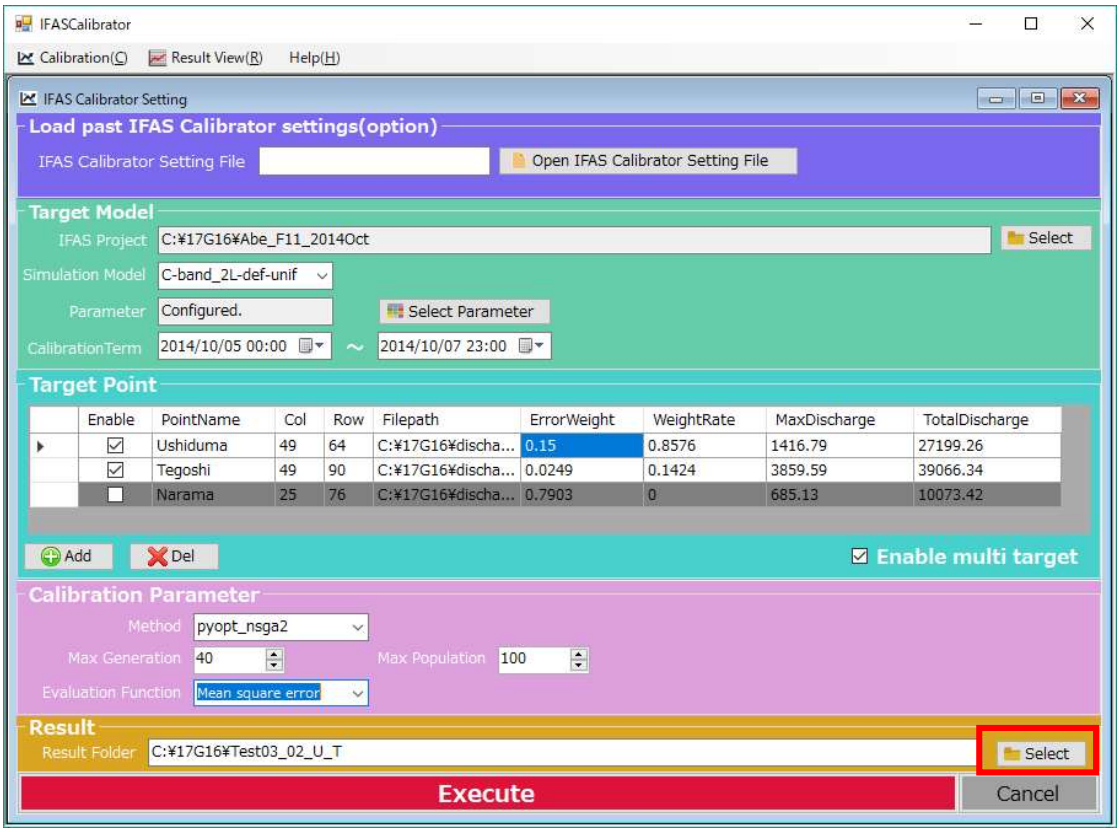
$$E_r = \sum_{t=0}^{n} \left| \frac{x_t}{o_t} - 1 \right|$$

・Log of Mean square error

$$E_l = \log\left( \sum_{t=0}^{n} \frac{(x_t - o_t)^2}{n} \right)$$

## 3.10 Setting the Result Folder

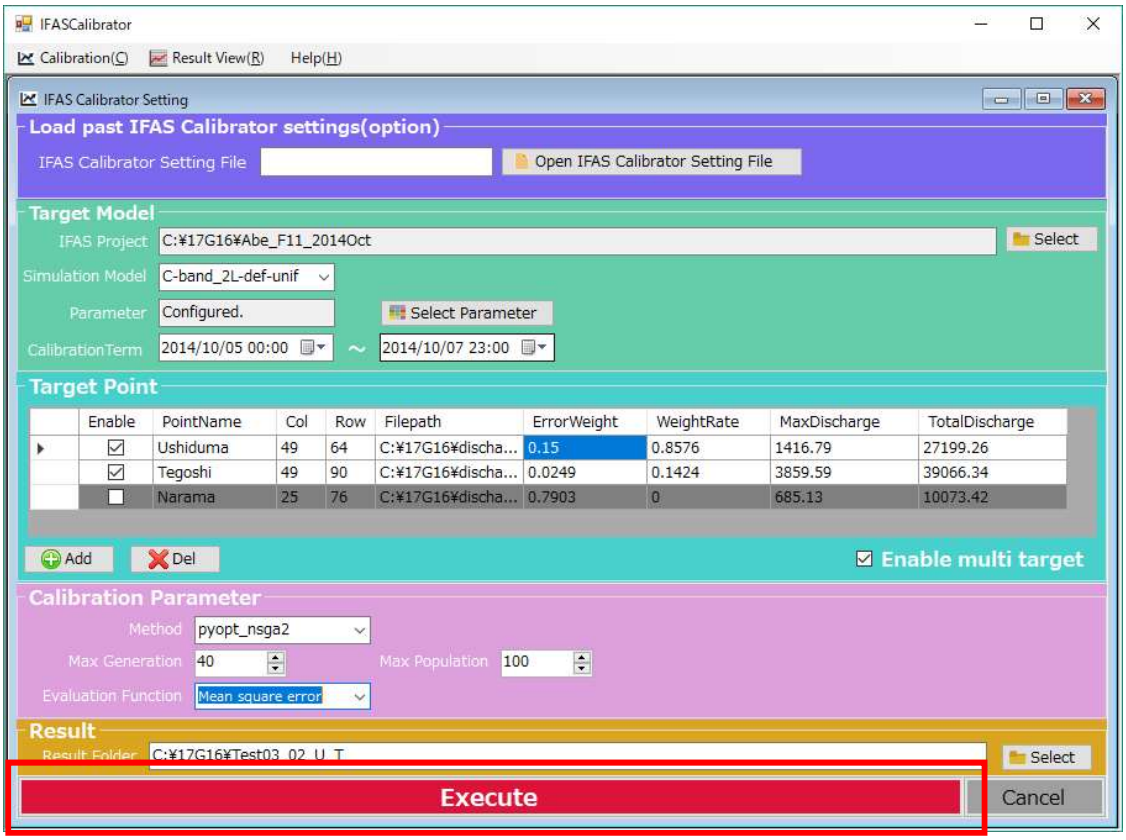
Click the “Select” button beside the Result Folder field and the save location for results will be set.




NOTE: Multi-byte characters must not be used in the path and Result Folder.

# 4. Optimization Execution

Click the “Execute” button to run the optimization.

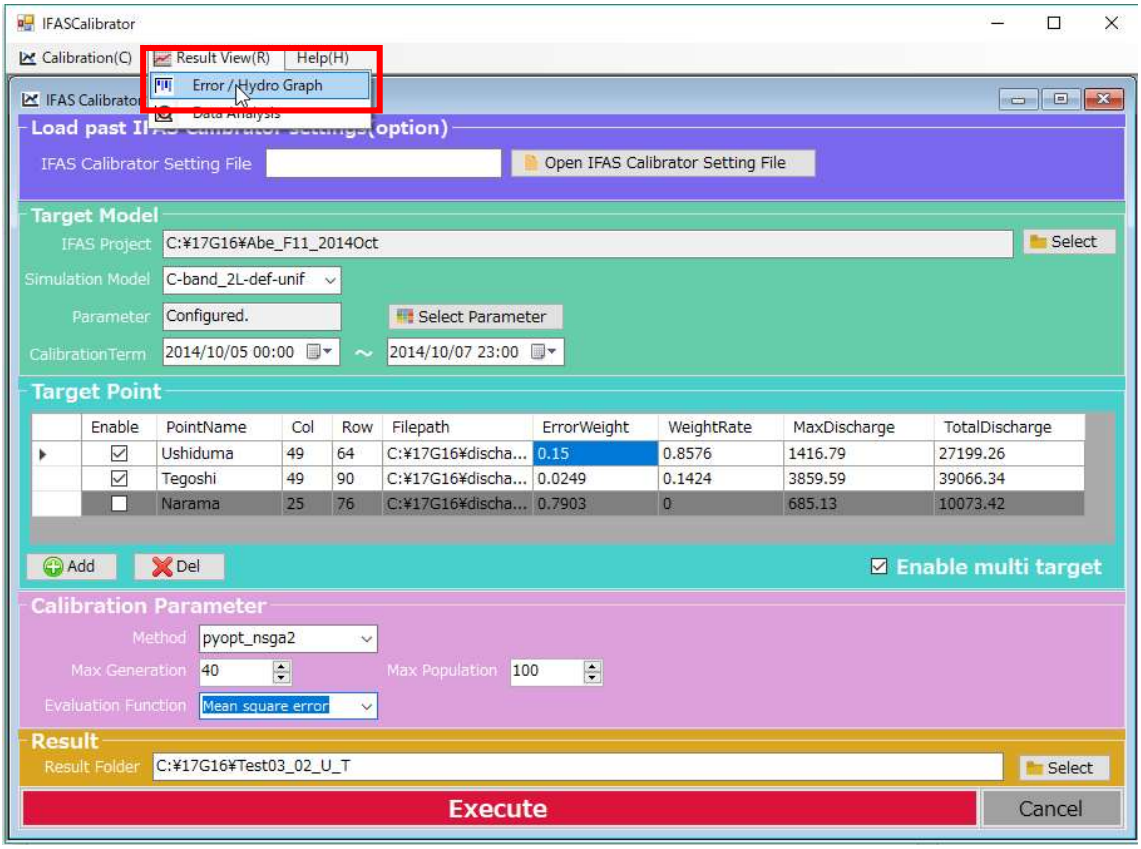



After the calculations are saved, the below message will appear.

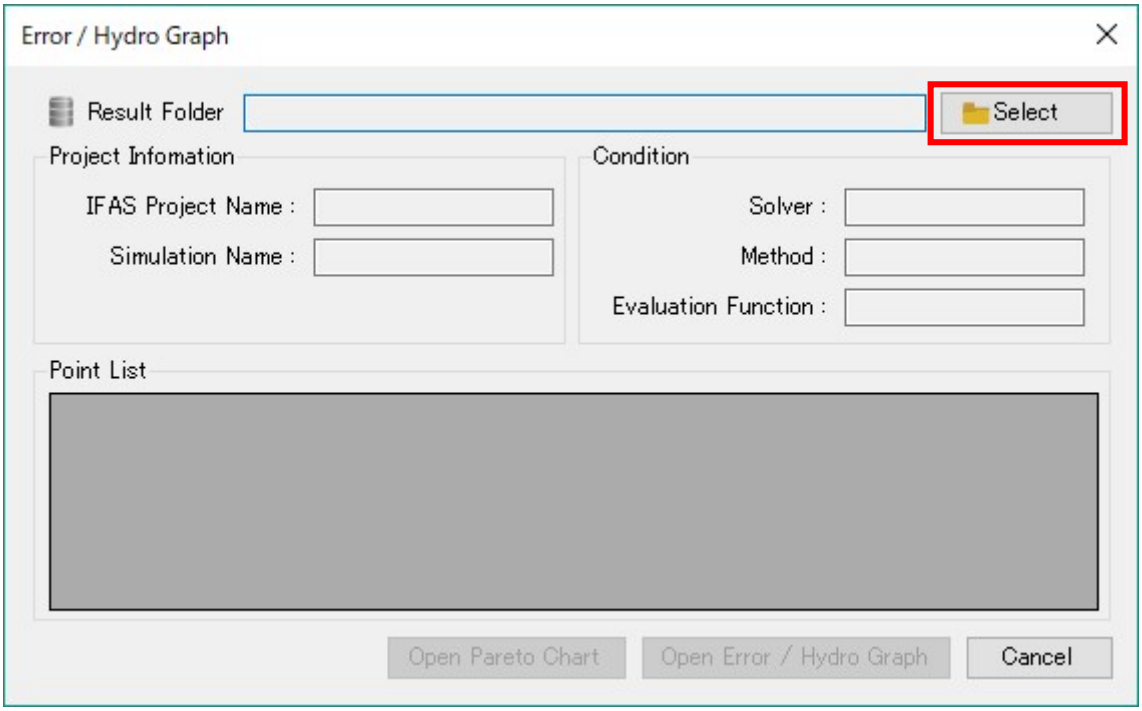
# 5. Verification of Optimization Results

## 5.1 Loading the Optimized Results

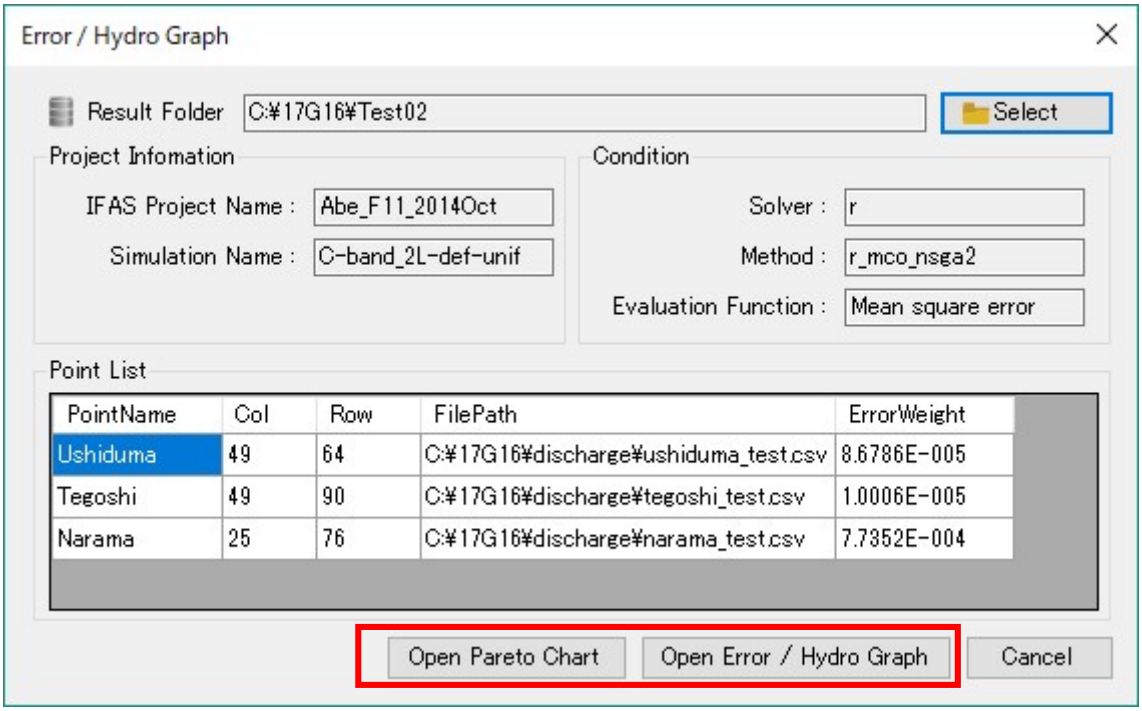
From “Result View” in the menu bar, click “Error/Hydro Graph”.



Click the “Select” button and choose the desired Result Folder.




After a folder is selected, “Open Error/ Hydro Graph” button will be displayed on the screen. If multi target optimization is enabled, the “Open Pareto Chart” button will also be displayed.

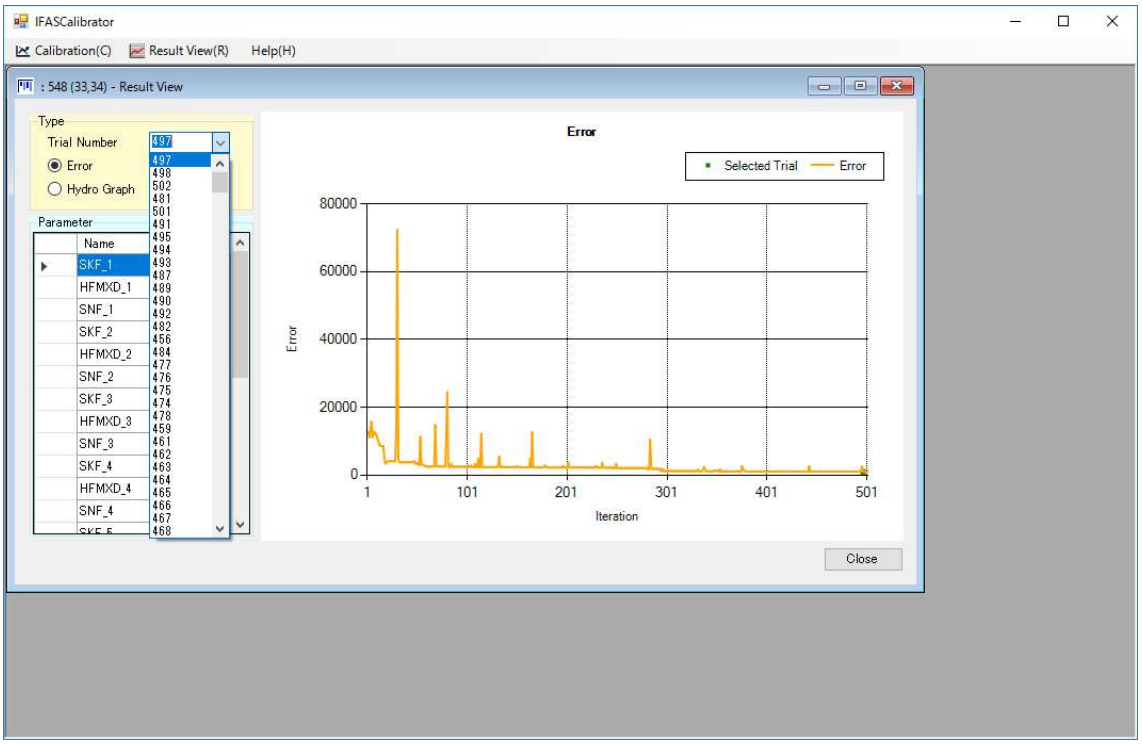


## 5.2 Verification of Error Graph and Hydrograph

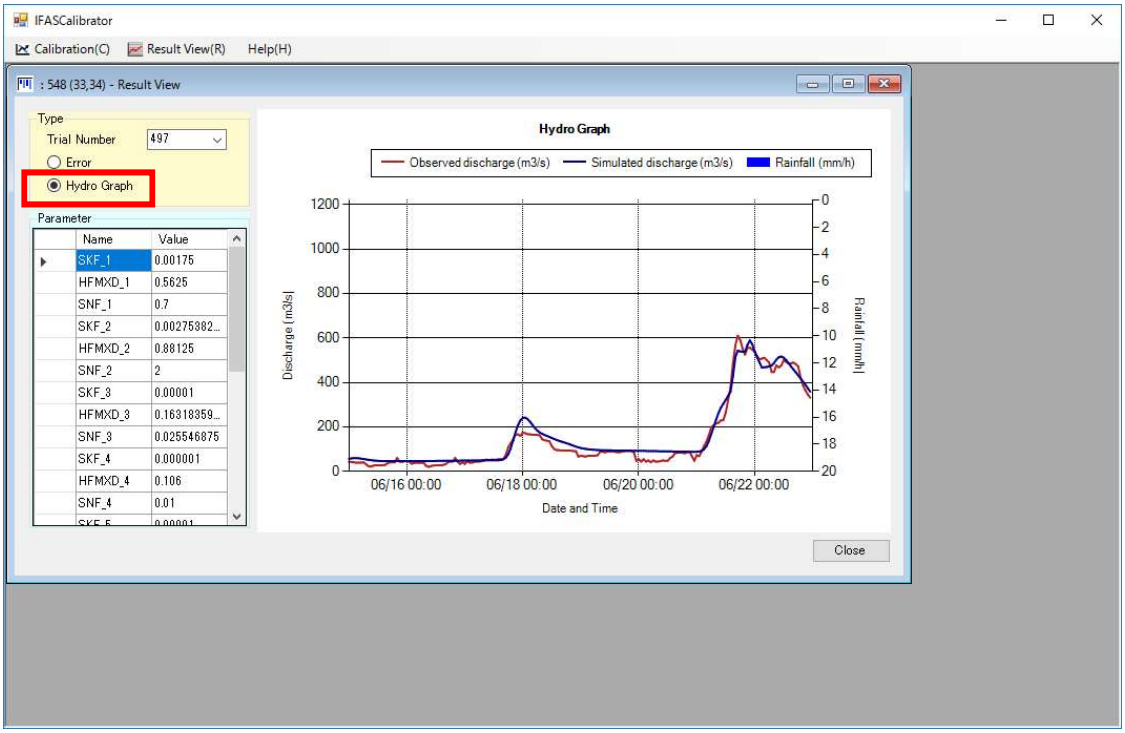
Click the “Open Error / Hydro Graph” button to display a graph of the error values for each trial.

The “Trial Number” list box is sorted in descending order of error value.

By default, the trial number with the smallest error is selected.



Click the “Hydro Graph” radio button to display a hydrograph of the flow rate in the trial.



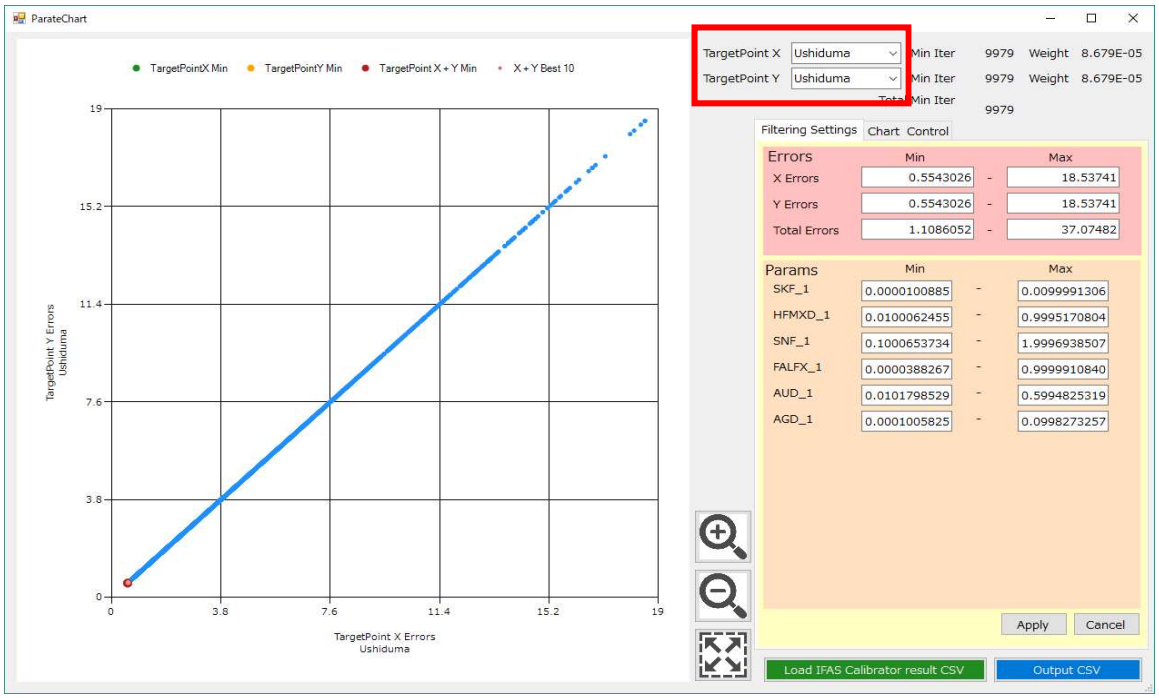
## 5.3 Confirmation of Pareto chart

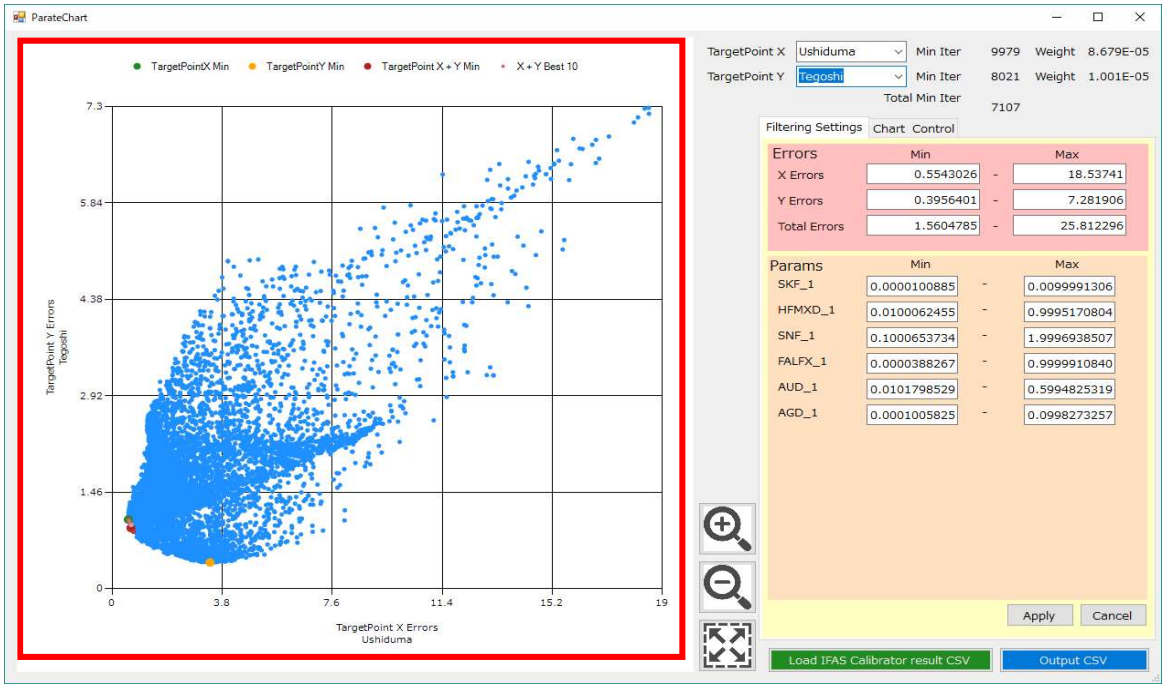
### 5.3.1 Display Pareto Charts

Click the “Open Pareto Chart” button to display the Pareto chart.

By default, the X and Y axes display the same target points (TargetPoint).

Different target points can be selected from the “TargetPoint” dropdown menu.

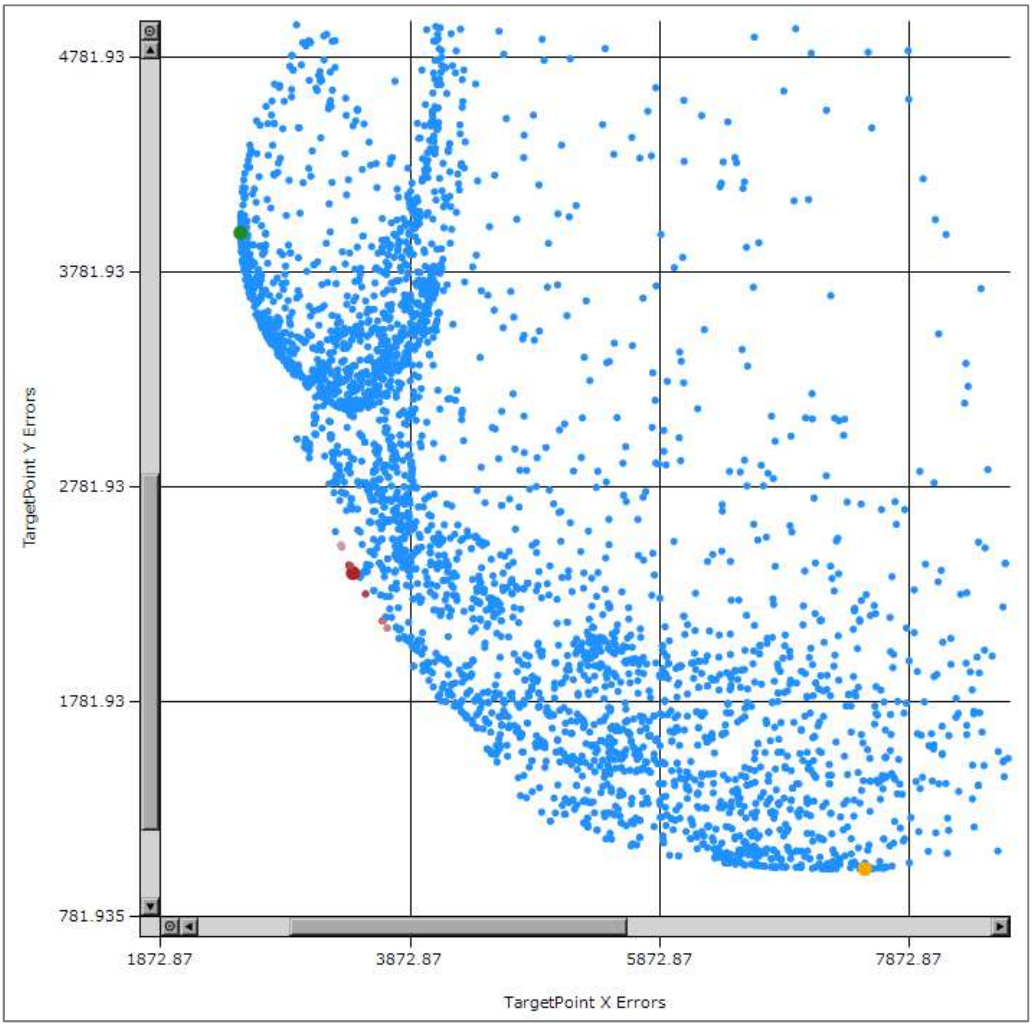


### 5.3.2 Pareto Chart Zoom

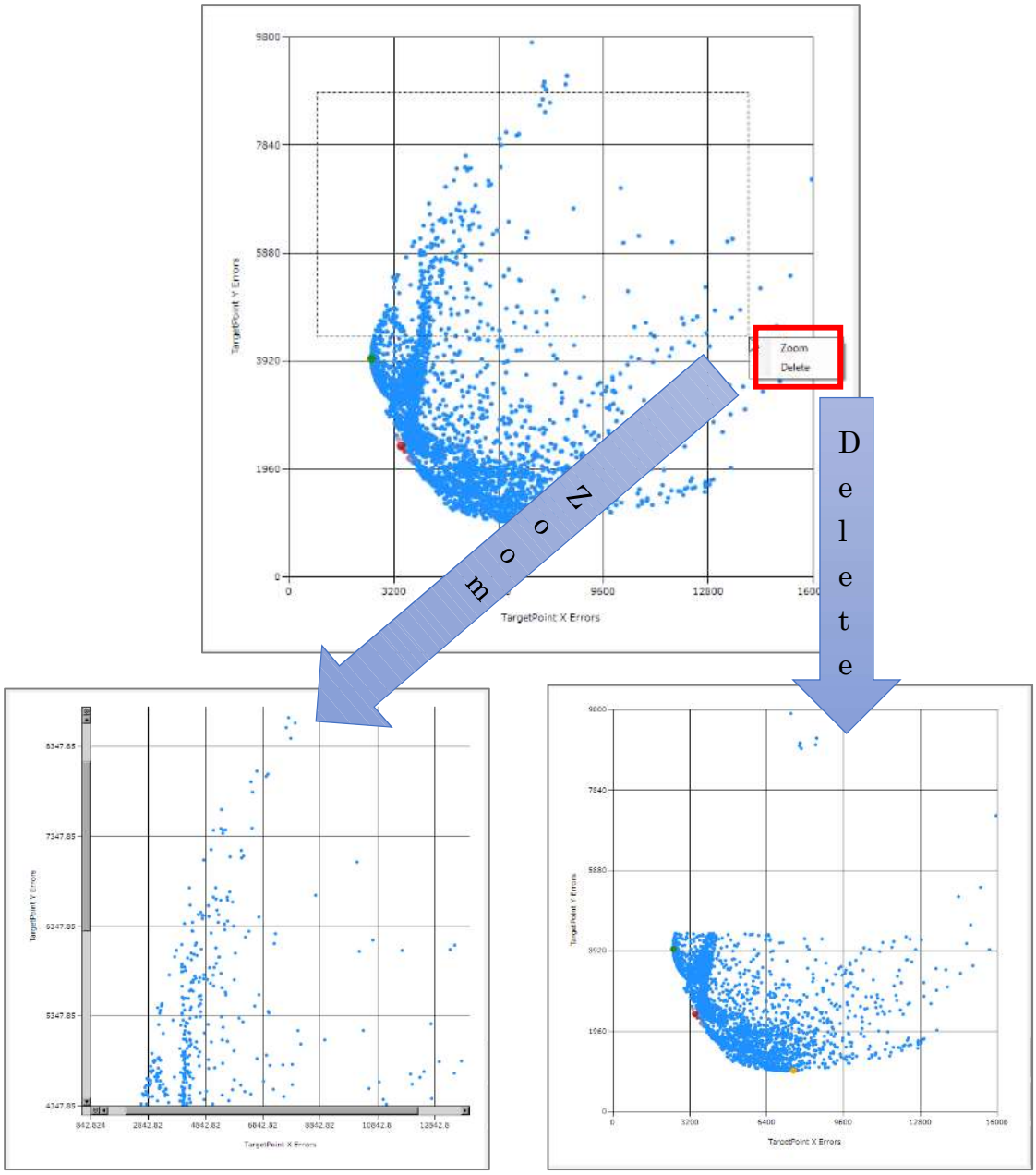
The mouse wheel can be used to zoom in and out of the Pareto chart.

In the figure below, the green point is the minimum error of the “TargetPoint X”. The yellow point is the minimum error of the “TargetPoint Y”. The red point is the minimum error when considering the sum of both target points. The pink points are the 10 best points when considering the sum of both target points.



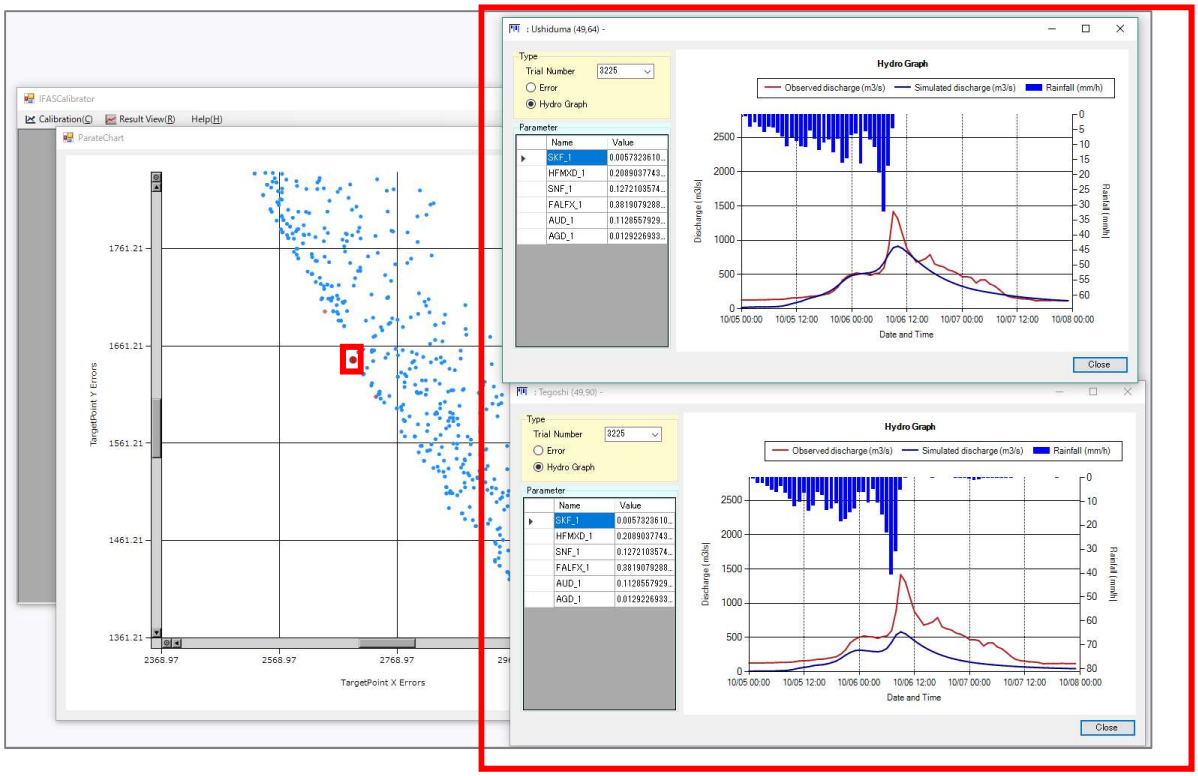
### 5.3.3 Pareto Chart Rectangle Selection

A rectangular area of the Pareto chart can be selected by dragging the mouse. The selected area can be zoomed into or deleted.



### 5.3.4 Hydrograph Display

Double-clicking a point on the plot will display the hydrograph of the trial times for both "TargetPoint X", and "TargetPoint Y".



### 5.3.5 Plot Filtering

The box on the right side of the screen are parameters for plot filtering.

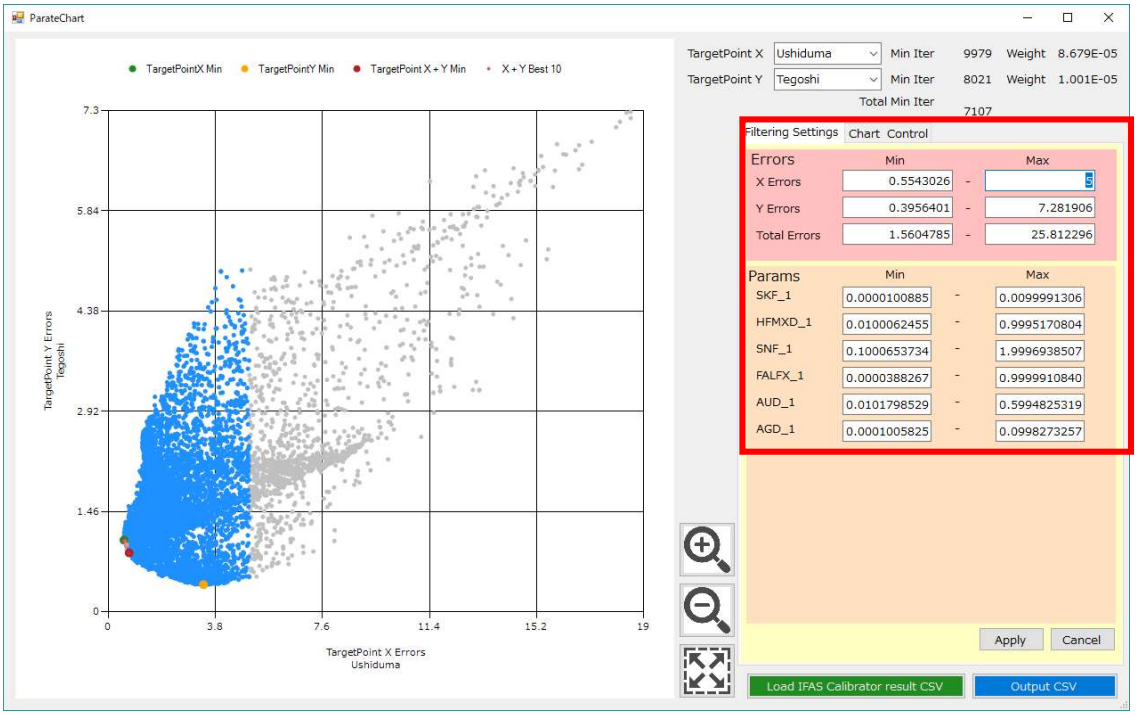
Plots can be refined and will be displayed in the graph on the left. Plots can be filtered by either evaluation values or parameter range.

The plot points to be deleted will appear in grey.

Entering range values then removing focus of the text box will grey points outside if the range.

Clicking the “Apply” button will delete the points in grey. Clicking “Cancel” will restore the graph to its original appearance.

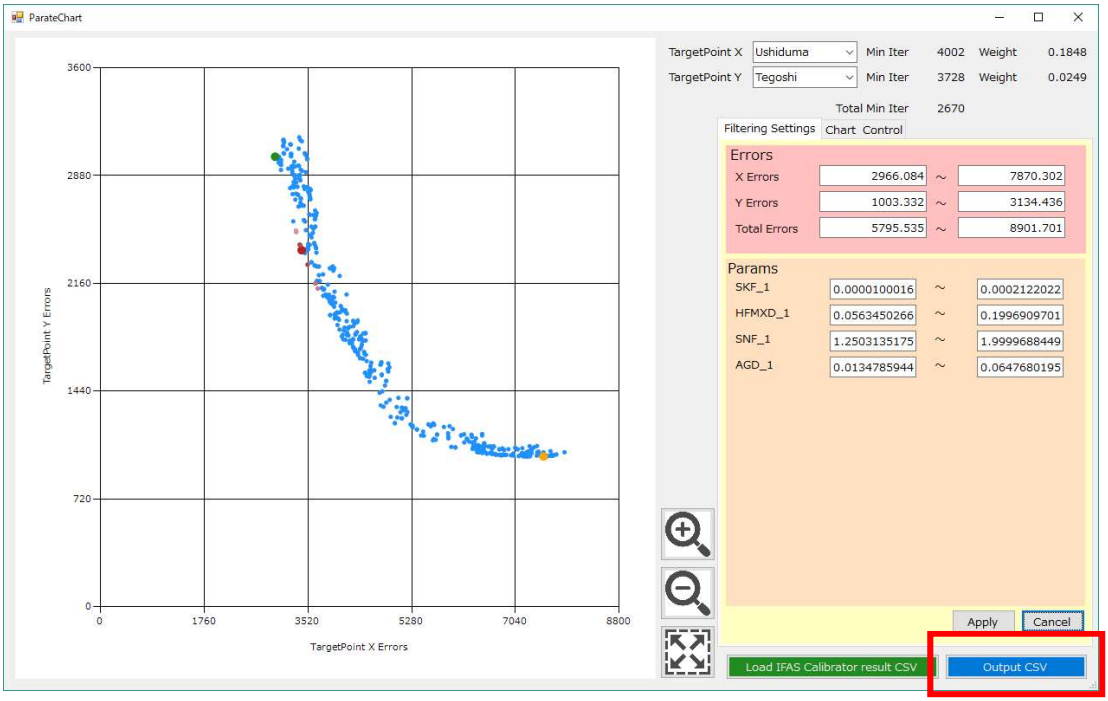
Once a deletion is performed by clicking the “Apply” button, the graph cannot be restored to its original form.



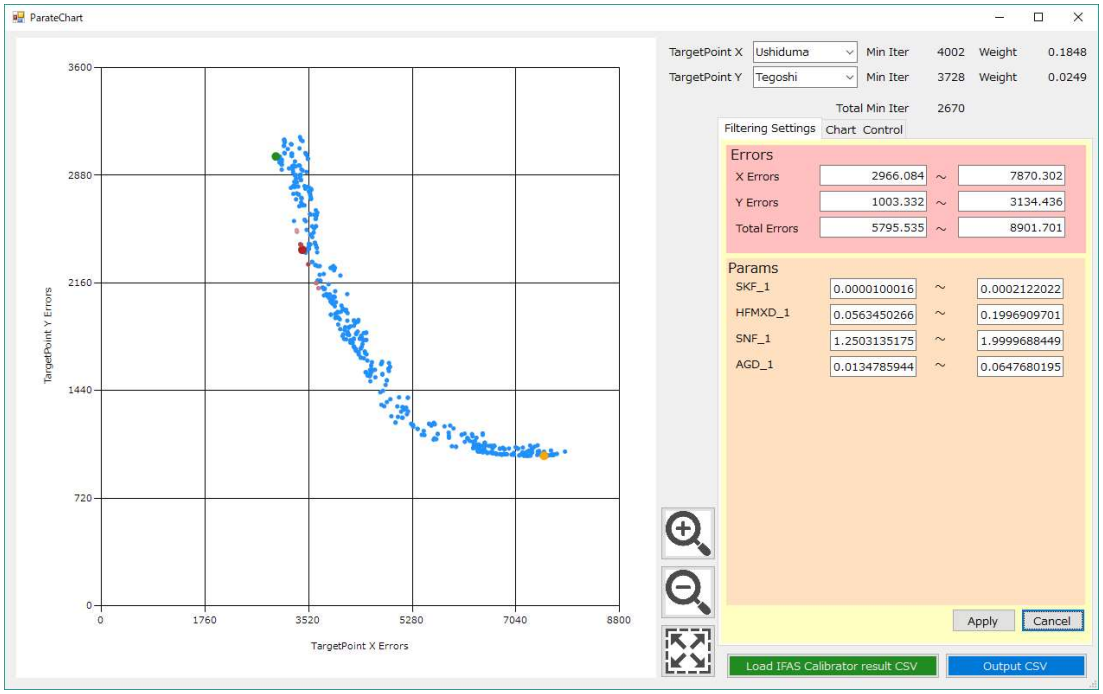
### 5.3.6 Output

After finding the Pareto boundary, by using the filtering and rectangular deletion functions, click the “Output CSV” button to save the parameter set, that describes the Pareto boundary, to file.

After finding the Pareto boundary, the filtering and rectangular deletion functions can be used to save the parameter set to a file by clicking the “Output CSV” button.




The Pareto boundary can be reproduced by reading in the output file.



NOTE: Any file in CSV format, where first line is a header and first column contain the trial count, can be loaded. Keep the plot containing trial numbers that match the loaded file and delete all other plots.

(The first line is treated as a header line and is ignored.)
879,・・・(The second column is ignored and its contents can be anything.)
902,・・・
909,・・・
957,・・・
989,・・・
1002,・・・

### 5.3.7 Support Features

Additionally, the following support functions are provided:

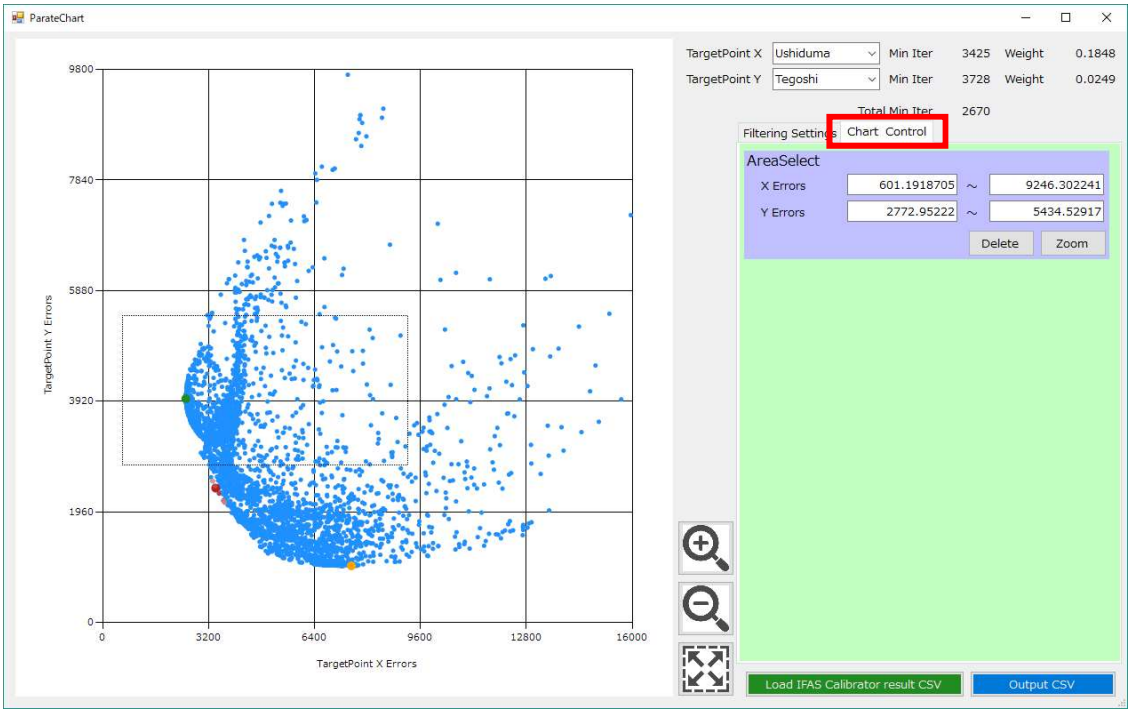
Buttons can be used operate the Pareto Chart when the mouse wheel is unavailable.

 : Zoom in

 : Zoom out

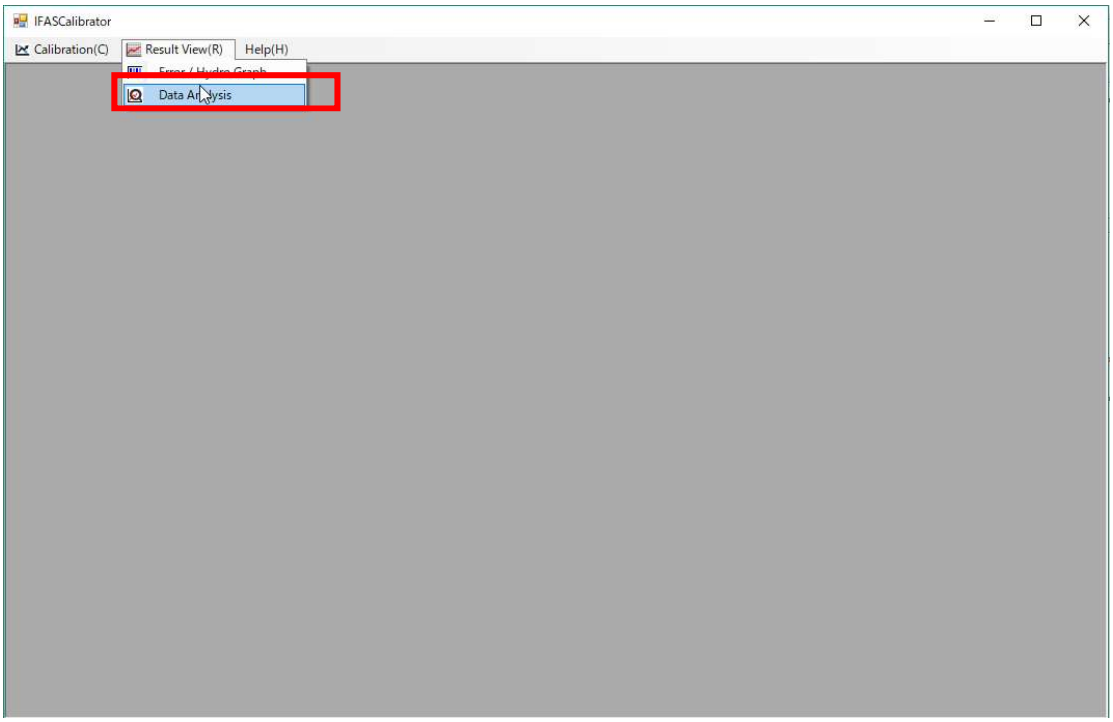
 : Display all (return to initial display)

Rectangular areas can be selected by entering text into the following ranges when the mouse drag is unavailable.

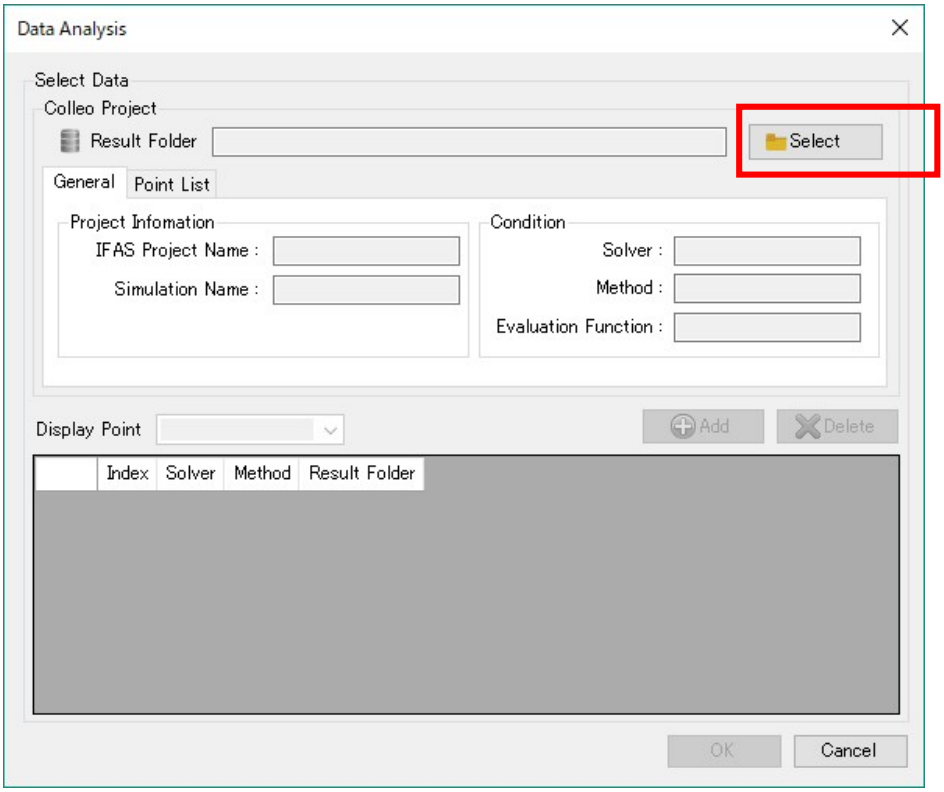


## 5.4 Analysis of Optimization Results

From “Result View” in the menu bar, click “Data Analysis” in the drop-down menu.

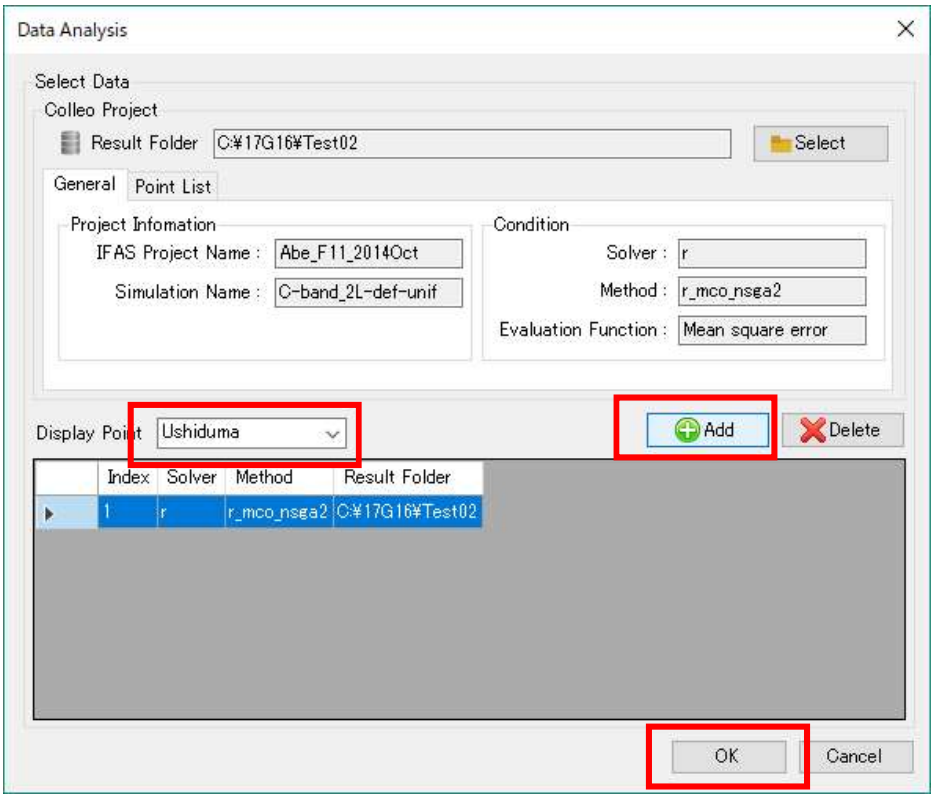



Click the “Select” button and choose the desired “Result Folder”.

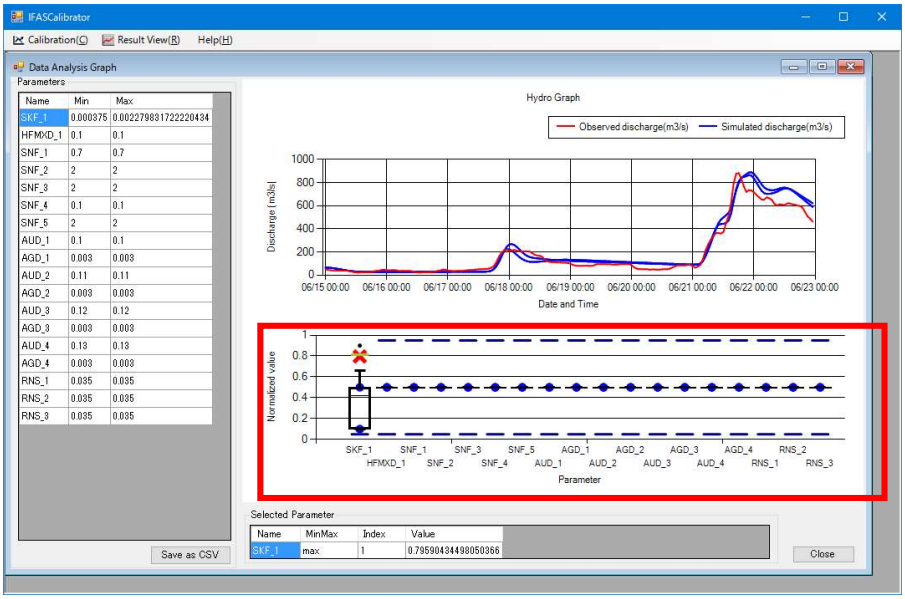


Click the “Add” button to add the selected folder to the list.

Also, if multiple points have been optimized, the point to be analyzed can be selected from the “Display Point” dropdown menu.

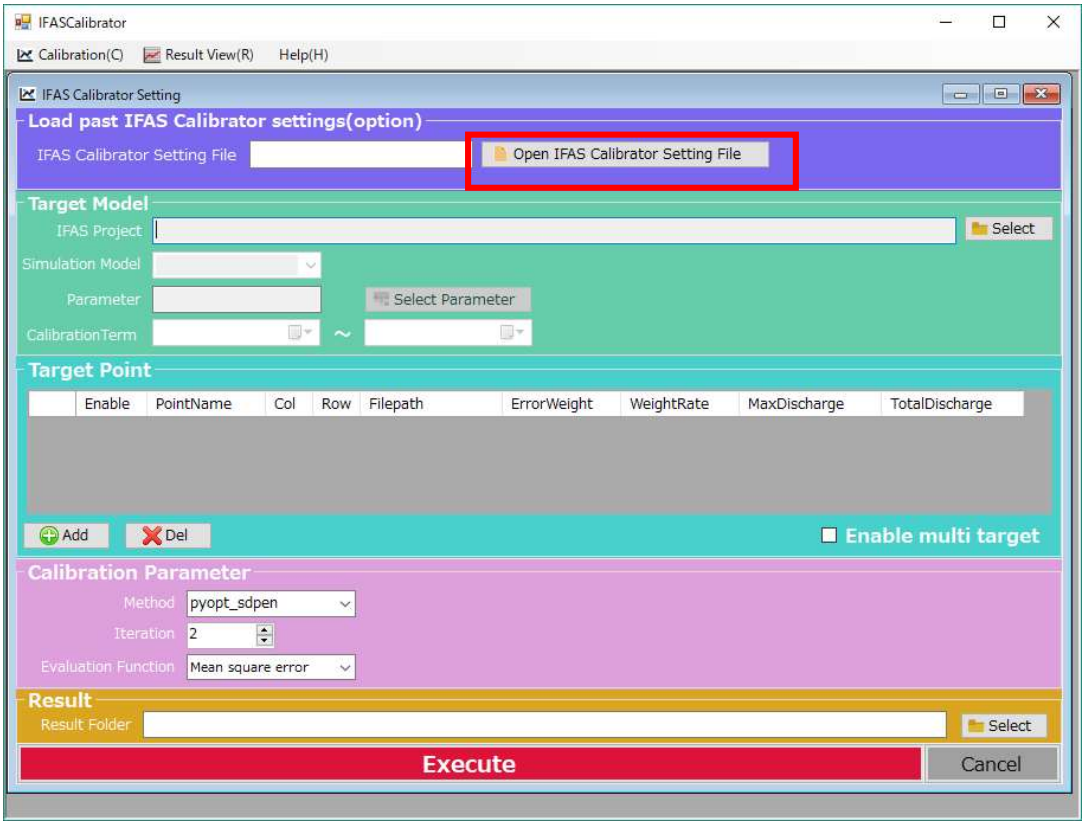


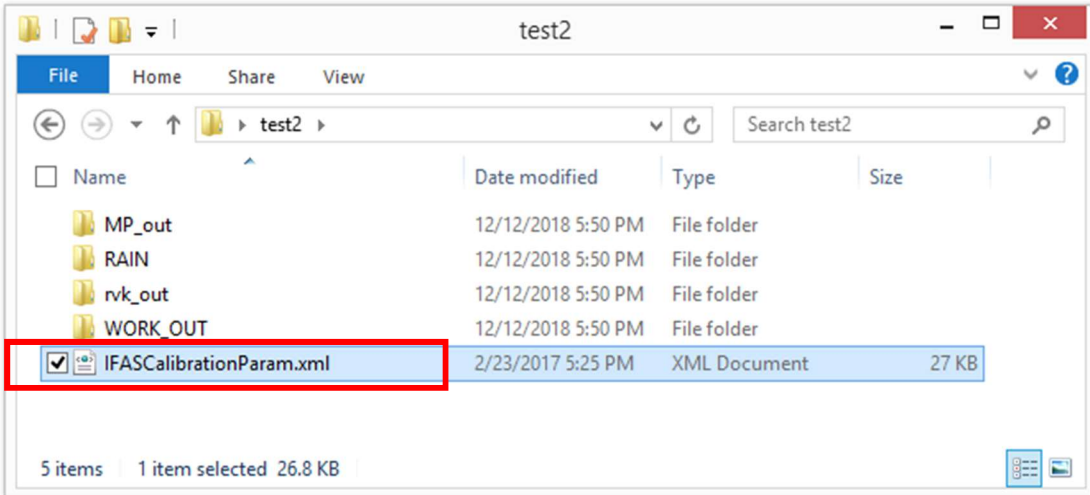

In the optimization analysis screen, the observed flow rate and the calculated flow rate of all trials of optimization calculation are displayed. Manipulating the grid below the graph will narrow down the range of parameters and calculated flow to be displayed. This is done for further refinement of the optimization.



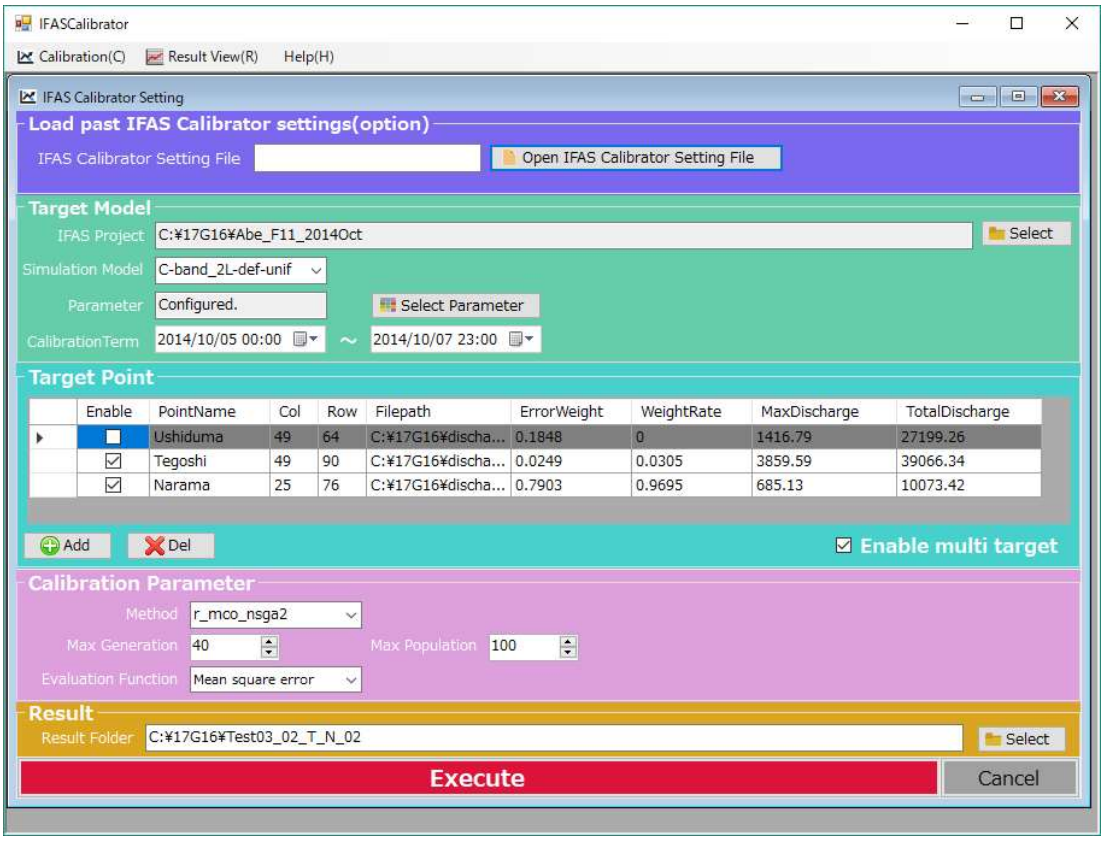
# 6. Loading Previous Optimization Settings

To load previous optimization settings to continue calculations, click the “Open IFAS Calibrator Setting File” button and select the “IFASCalibrationParam.xml” in the optimization result folder.



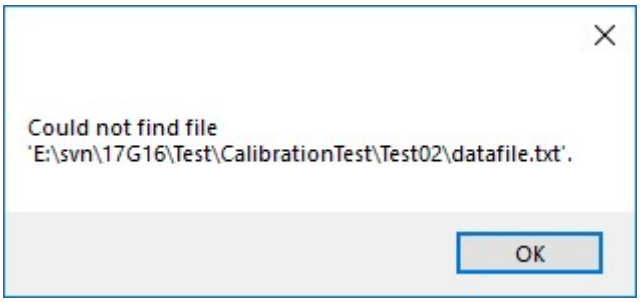



The previous optimization settings are loaded.



# 7. Troubleshooting

If the following error occurs when performing steps in sections “5.1 Verification of Error/Hydro Graph” and “5.3 Analysis of Optimization Results”, it indicates that the specified optimization output file cannot be read.




If the file “datafile.txt” exist in the location specified by the message, the following causes of error may exist:

### A) Data of the observation flow rate mismatch

Ensure that the observed flow file has the same interval as the IFAS project calculation interval for the entire period of the IFAS project that is being optimized. Please note the entire duration of the IFAS project is required rather than the optimization evaluation range.

### B) Divergence of IFAS

The calculation results diverge, and the optimization process may have ended prematurely. In this case, one of the files under the “WORK_OUT” folder in the optimization results folder contain “nan” values. Review the search scope of the parameters and perform the optimization again.

### C) Divergence of error value evaluation of optimization

For multi-objective optimization, if the weight is large, the evaluation function may diverge, and the optimization process may have prematurely ended. In this case, reduce the weighting and perform the optimization again.