Integrated Landslide and Tsunami simulation software LS-Tsunami

Instruction manual

Table of Contents

1. Introduction

This chapter shows how to use Integrated Landslide-Tsunami simulation model (LS-Tsunami).
If this part can be clearly understood, simulations can be conducted successfully.
Common operations with Landslide simulation (LS-RAPID) are shown in its operation manual.

1-1. About this software

This LS-Tsunami software is designed to couple two computing simulations: the landslide simulation (LS-RAPID) and the tsunami computing simulation produced under the editorship of Kyoji Sassa (International Consortium on Landslides) and Hideaki Yanagisawa (Tohoku Gakuin University). This software can run on a Windows PC. The software has visual interfaces and produces 3D graphical computational results to help beginners to carry out an integrated landslide and tsunami simulation.

1-2. System requirements

・OS	Windows 7, Windows 8, Windows10
・Hardware	Computers supported with above OSs and a multicore CPU (ex. Intel Core2Duo) is required.
・Memory	More than 2 GB is recommended
・HDD	More than 1 GB of free space is required
・Drive	CD-ROM drive to install the software
・Display	More than 1280 x 800
・Mouse device	Mouse with wheel is required
・GPU	nVIDIA (GeForce series) or ATI Technologies (RADEON series) is recommended. Other GPUs may not work properly.
・Software	Landslide computing simulation, LS-RAPID Version 2.12 or newer version

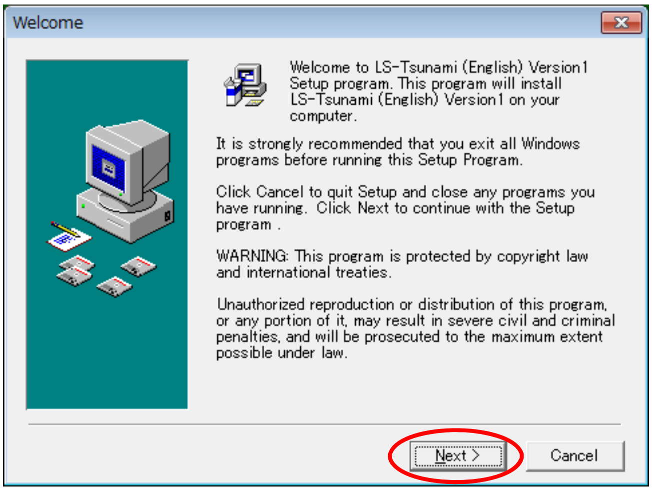
■ About a display error due to a GPU mismatch

If a screen display very slowly when you do not use above recommended GPUs, click [Display properties] - [Configurations] - [Details] - [Troubleshooting], and set “No” for Hardware Accelerator.

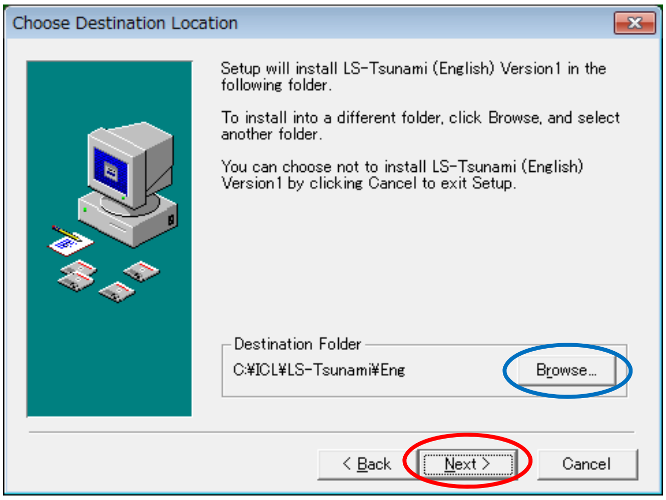
1-3. Installation

This chapter shows how to install LS-Tsunami. When you insert the CD-ROM and start to install the program, the installation window automatically appears.

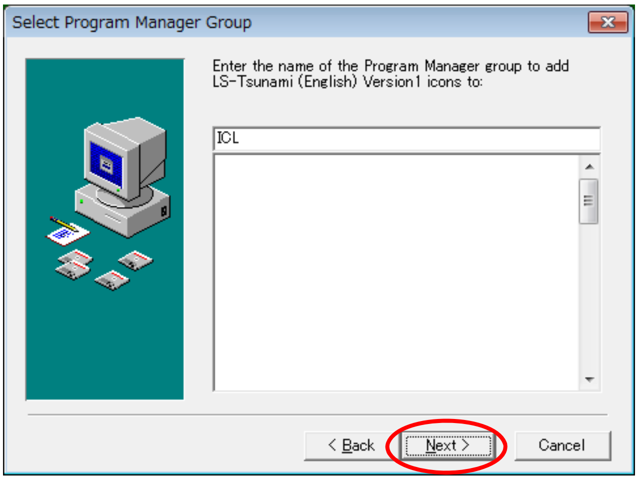
Click “Next” to start the installation.



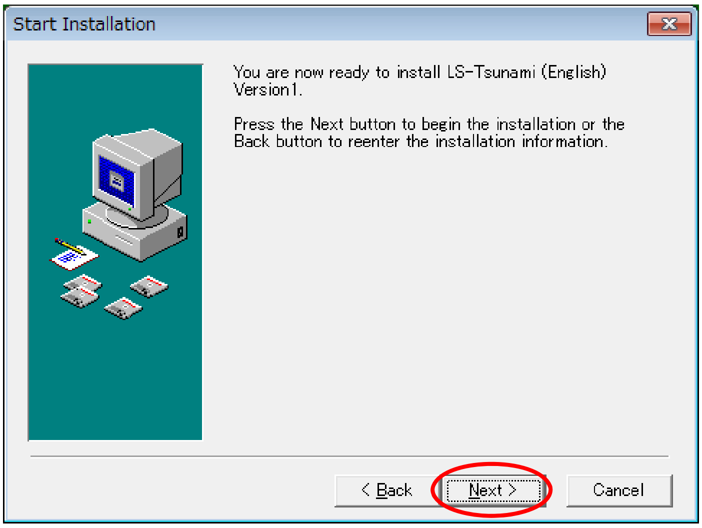
If you install the program on a drive other than C, choose another drive in the next window and click “Next” to proceed.



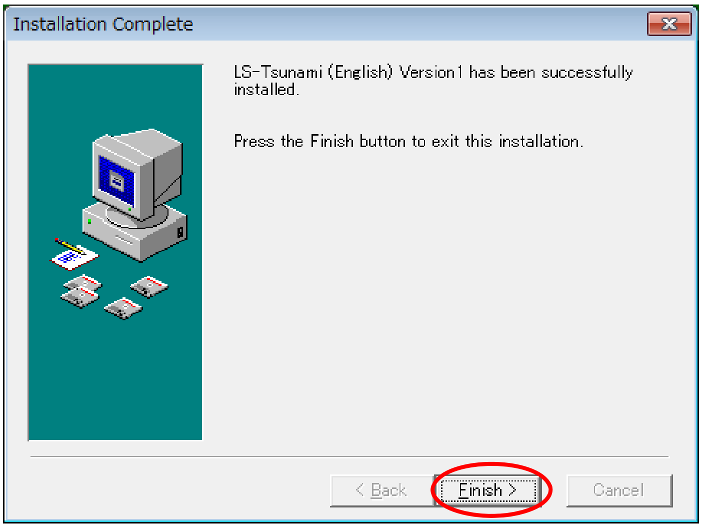
This window shows the group folder of LS-RAPID and LS-Tsunami software in the start menu. Click “Next” to proceeds in the next window.



Click “Next” to start installation.



When the next window appears, installation is done. Click “Finish >” to finish the installation and close the window.



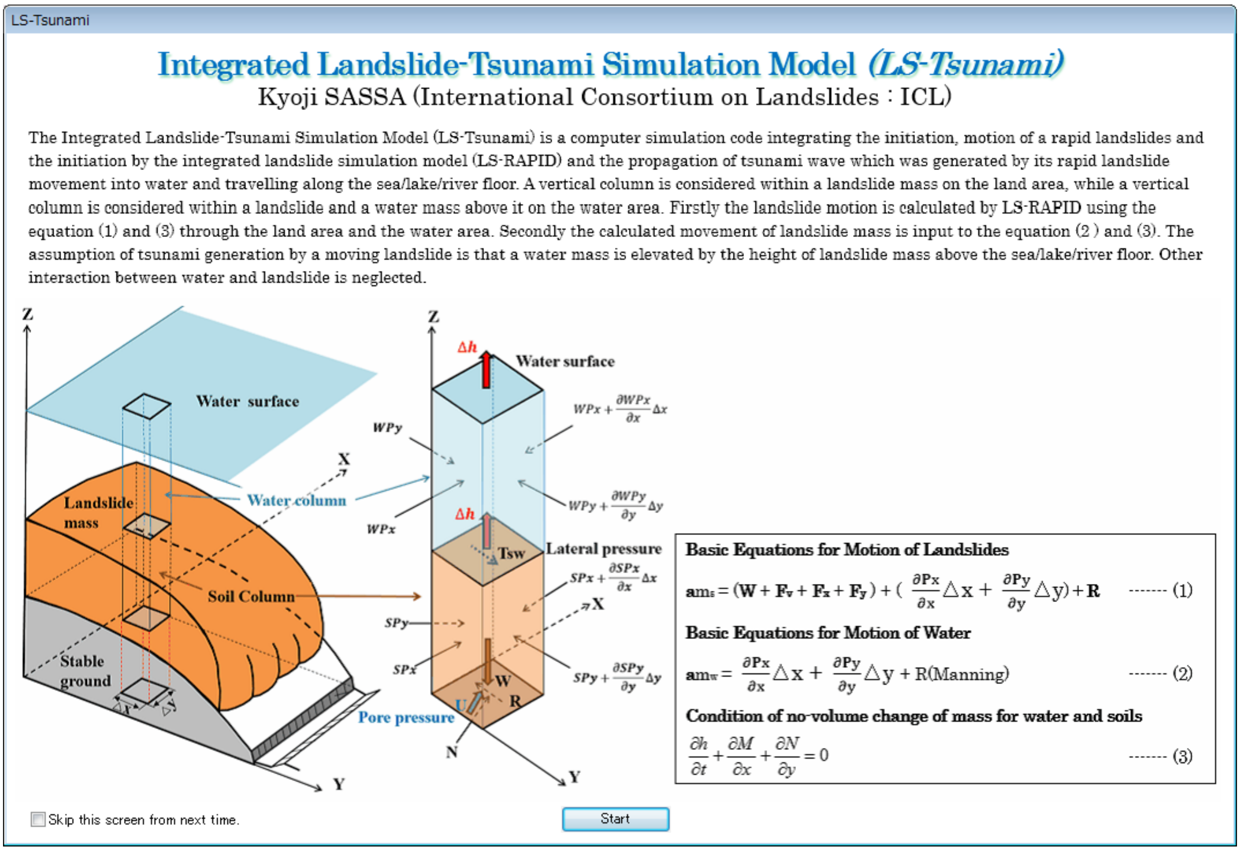
You need to install a “protector driver”, if you are not a user of the trial version and if you have already installed it. Details are in “manual/guide.pdf” in the CD-ROM.

To use the LS-Tsunami, you have to obtain the optional license code with LS-RAPID. Details are in “manual/licence.pdf” in the CD-ROM.

1-4. Starting up

For starting up, click [START] – [Show all programs] – [ICL] – [LS-Tsunami].

You will get to the next start window that shown below. Then click the ‘start’ button for the operational window.



2. Functions of this program

You can use two types of computing simulation with this program.

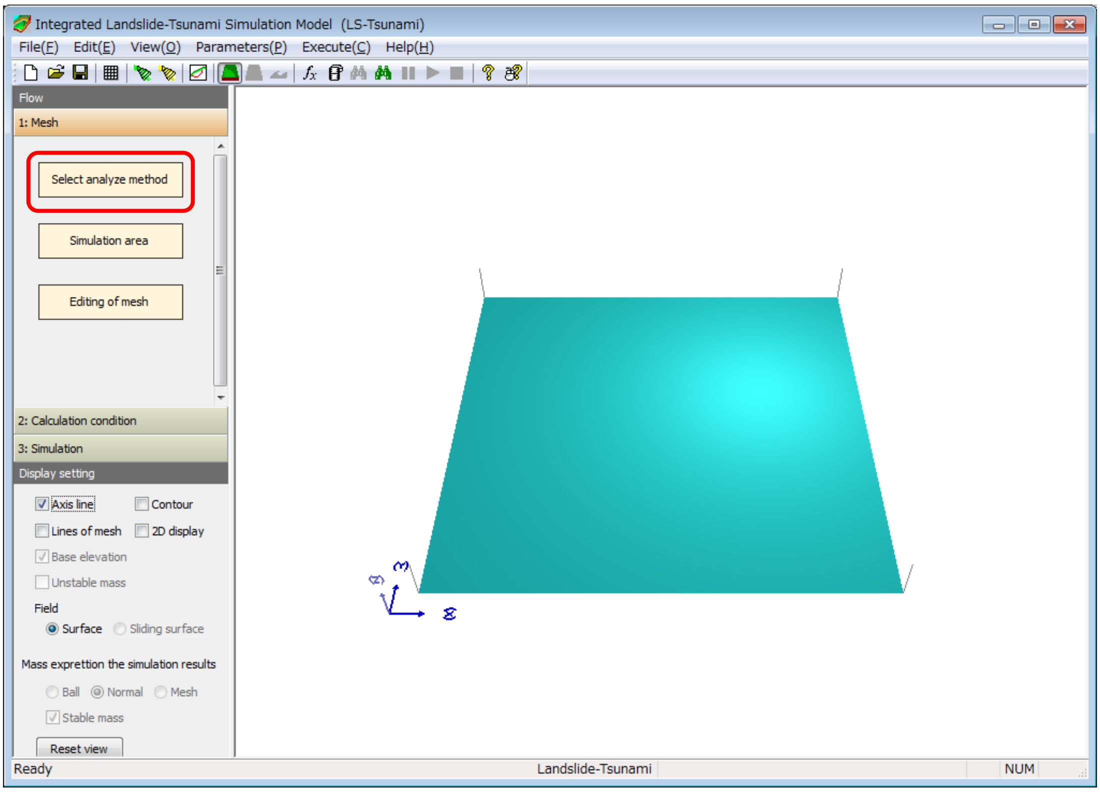
1) Landslide + Tsunami simulation

First the landslide simulation is carried out by LS-RAPID and then the tsunami simulation is carried out using those results. (Chapter. 3)

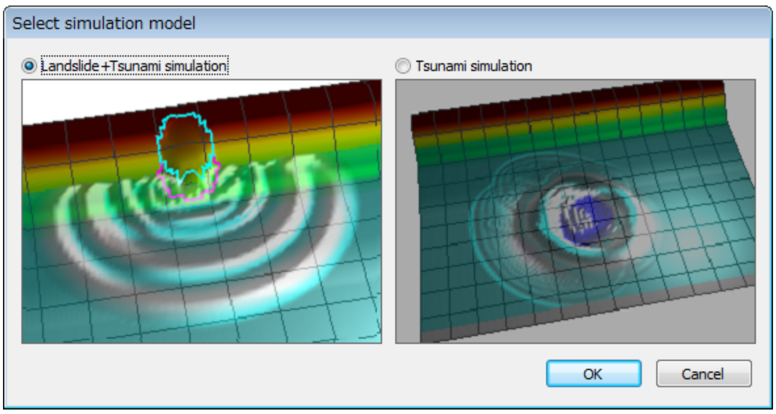
2) Tsunami simulation

Normal tsunami computing simulation that using crust deformation parameters. (Chapter. 4)

Click Flow [1: Mesh] - [Select analyze method]



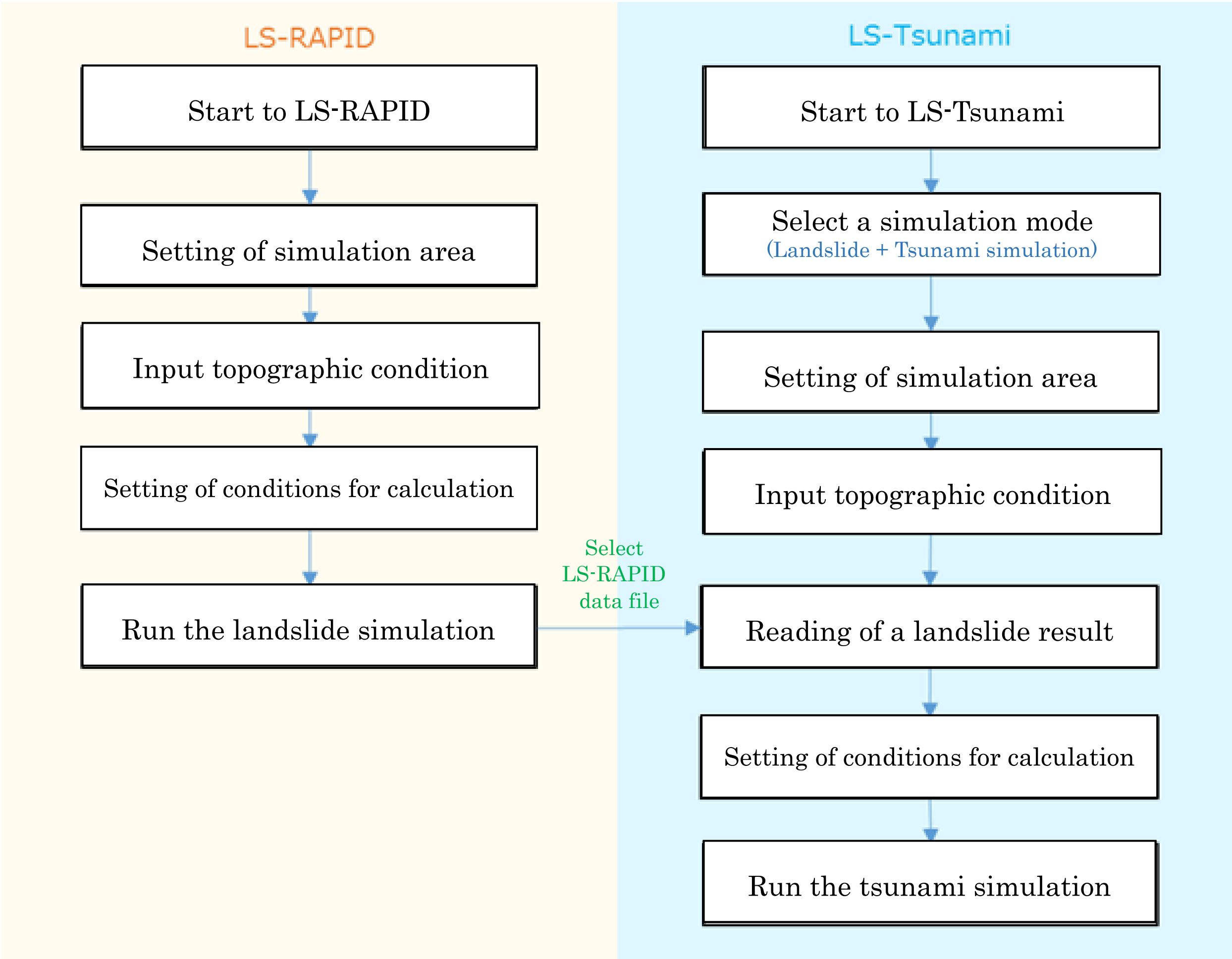
When the next window appears, you select the type of simulation you need and then click OK.
The left window shows the integrated landslide - tsunami simulation, and the right window shows a normal tsunami simulation.



3. Landslide + Tsunami simulation

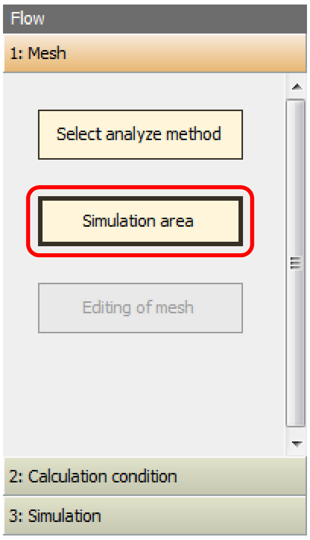
3-1. Simulation Steps

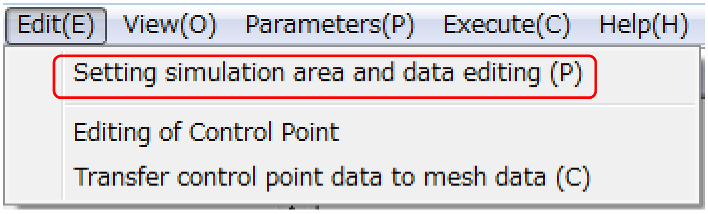
Figure below shows the flow diagram to carry out the LS-RAPID and LS-Tsunami simulation.

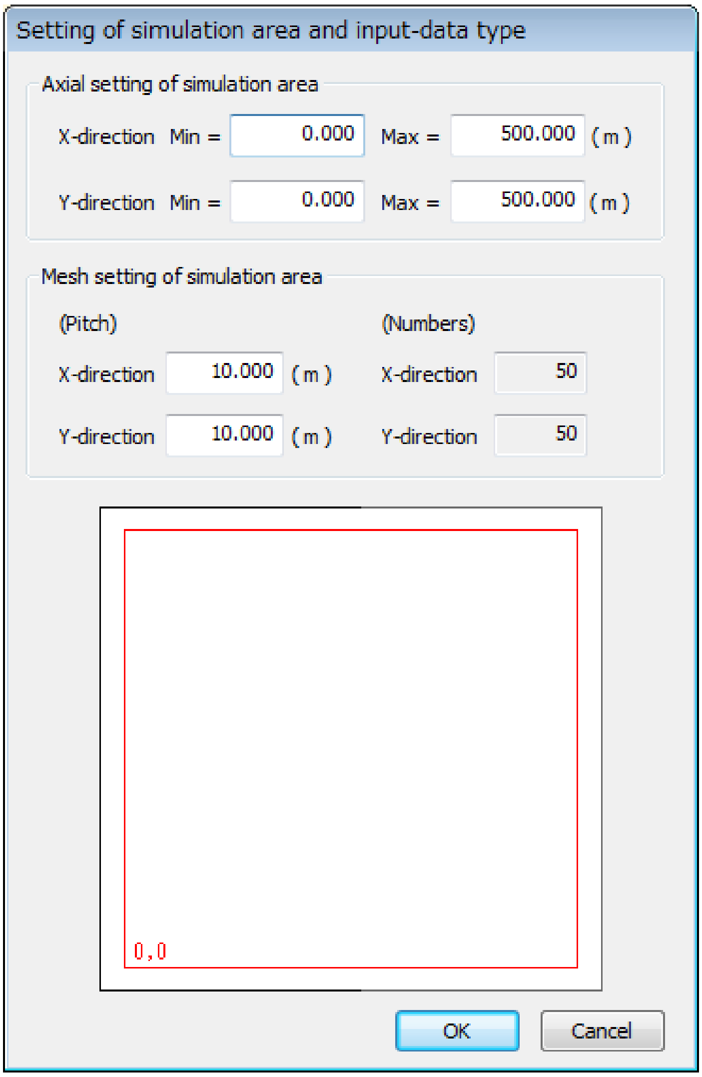


3-2. Setting of simulation area

Click flow [1: Mesh] – [Simulation area], or menu [Edit] - [Setting simulation area and data editing], and input the area of calculation. Setting procedure is similar to LS-RAPID.

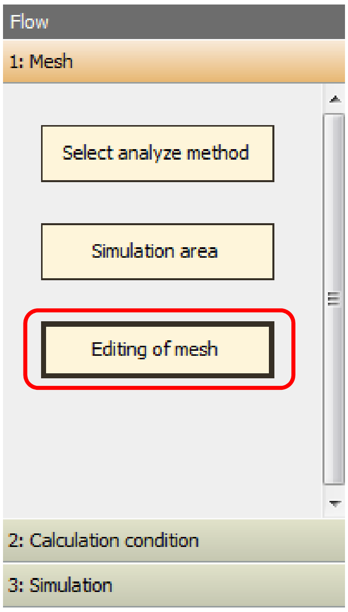


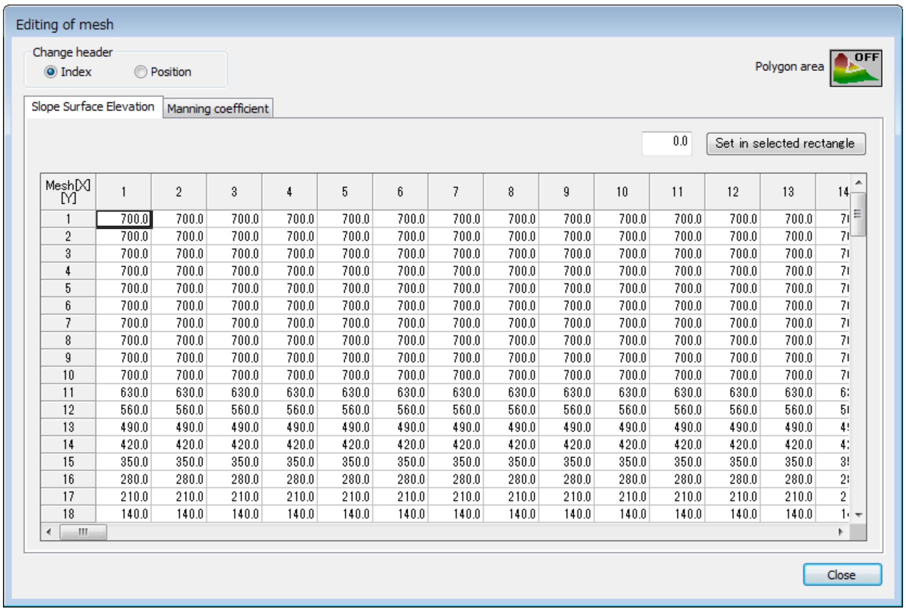




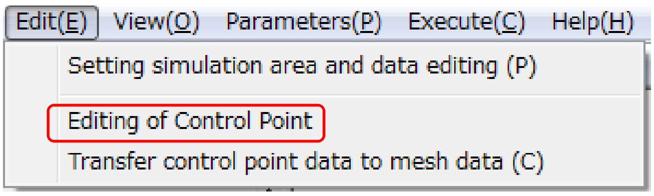
3-3. Editing topographic data

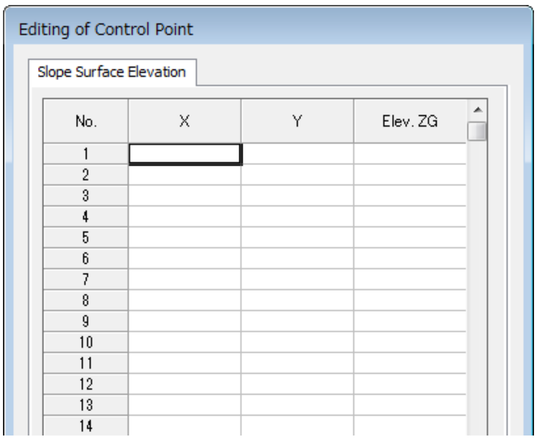
Click Flow [1: Mesh] – [Editing of mesh] for opening the window to input topographic data.





If there are some random elevation data other than meshed data, use the function [Transfer control point data to mesh data] to produce meshed data values.

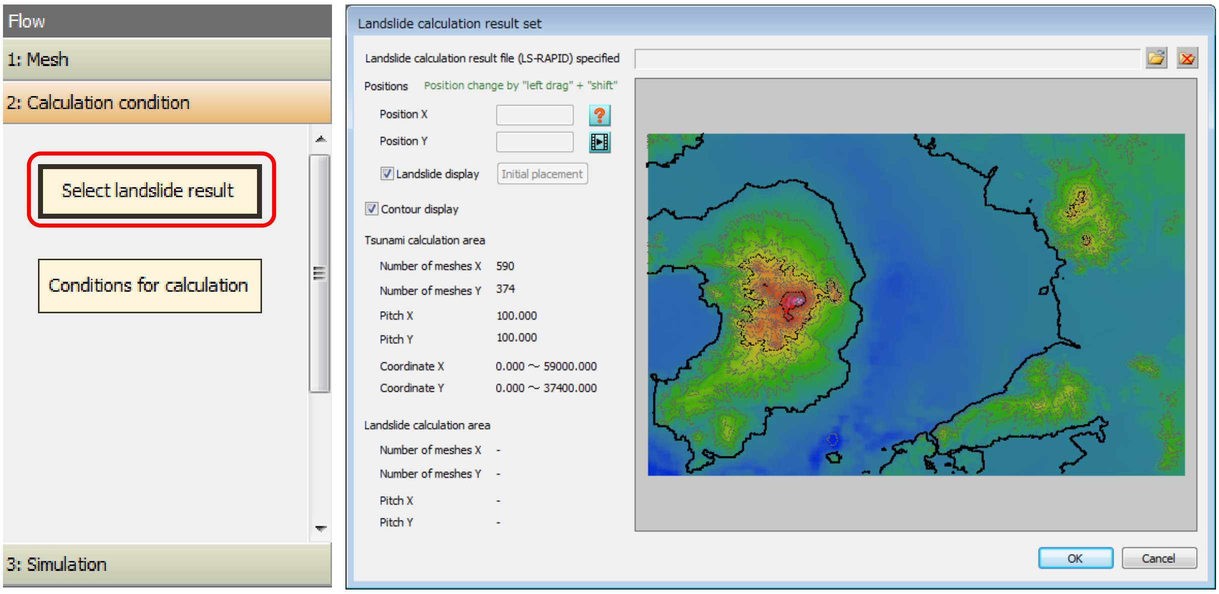




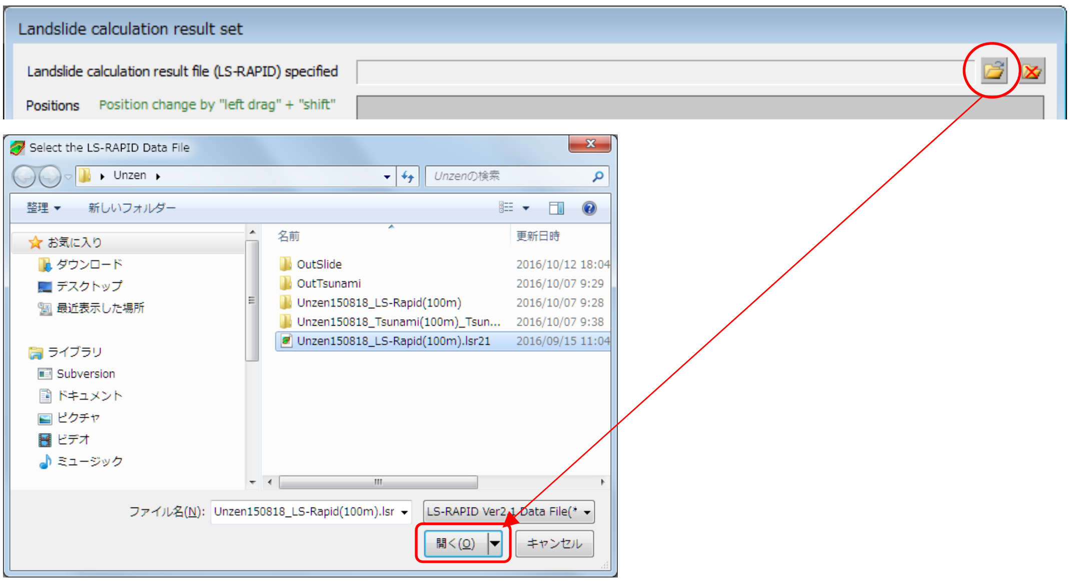
Making topographic data for simulation using LS-Tsunami is similar to the LS-RAPID. Please refer to Chapter 3 in the manual of LS-RAPID.

3-4. Reading of a landslide result (LS-RAPID data file)

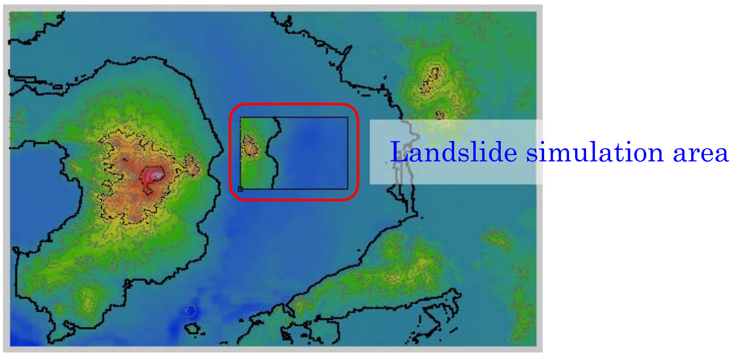
Click Flow [2: Calculation condition] – [Select landslide result] is to combine the topographic data for the landslide simulation and the data for tsunami simulation. Click  in the dialogue box to show how to combine both data.



Click folder to open the data file of LS-RAPID (the calculation result from LS-RAPID).

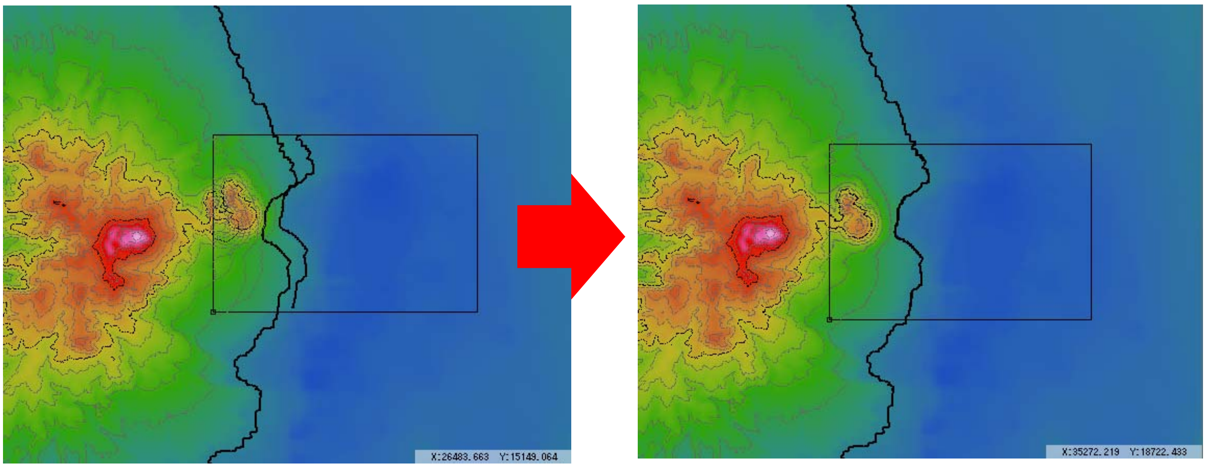


The next window shows the landslide simulation area on the tsunami simulation area.



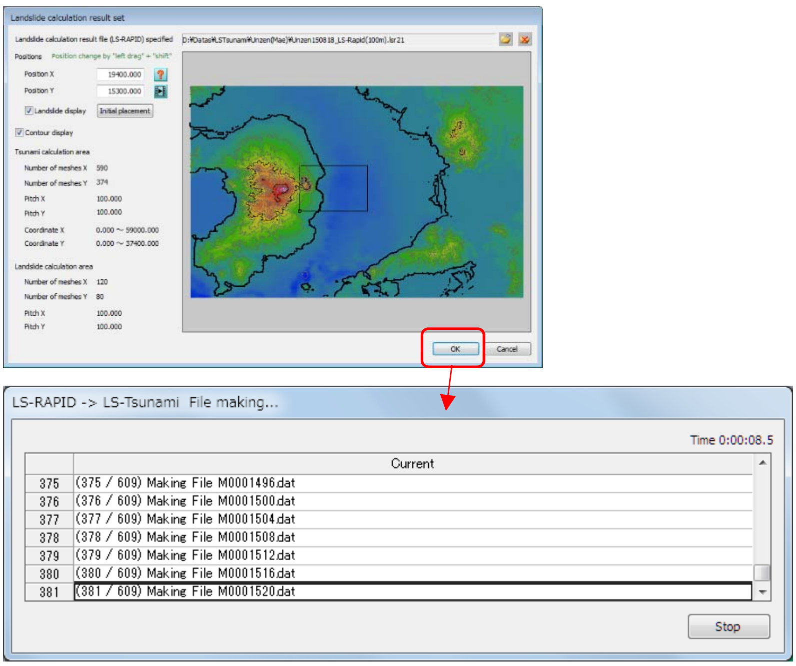
Emplace the landslide simulation area on the tsunami simulation area by mouse operation.

Click [?] to show how to operate this command.



Then click [OK] to load the result of the landslide simulation.

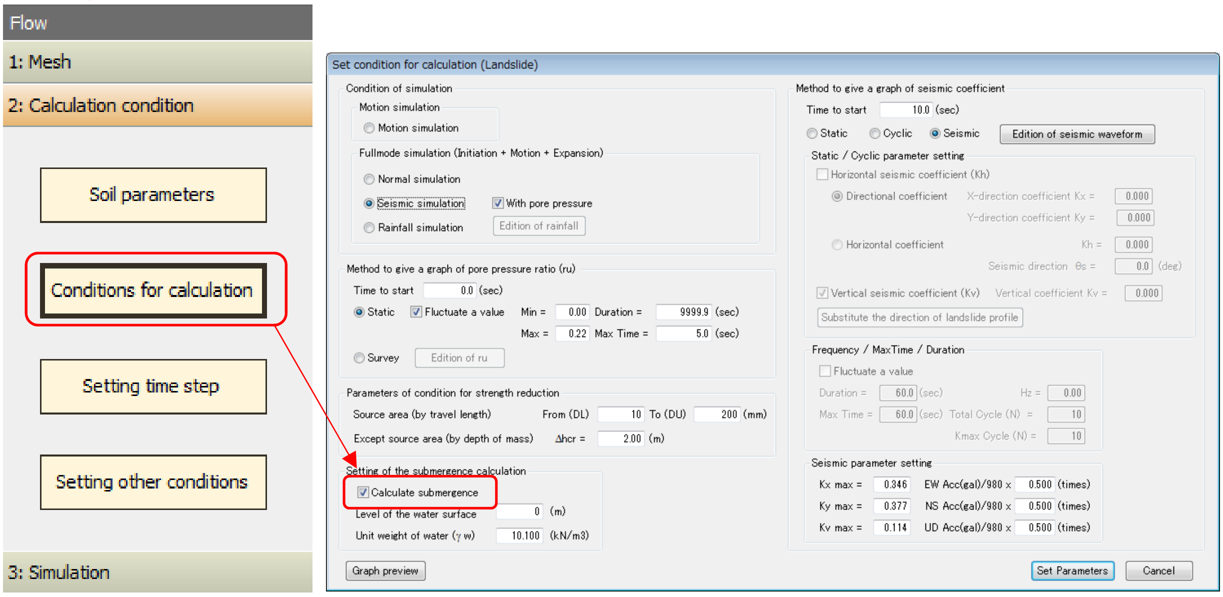
The following box will appear.



Notice: The landslide simulation using LS-RAPID should be carried out before doing the LS-Tsunami simulation. Therefore, the following 3 settings must be accomplished:

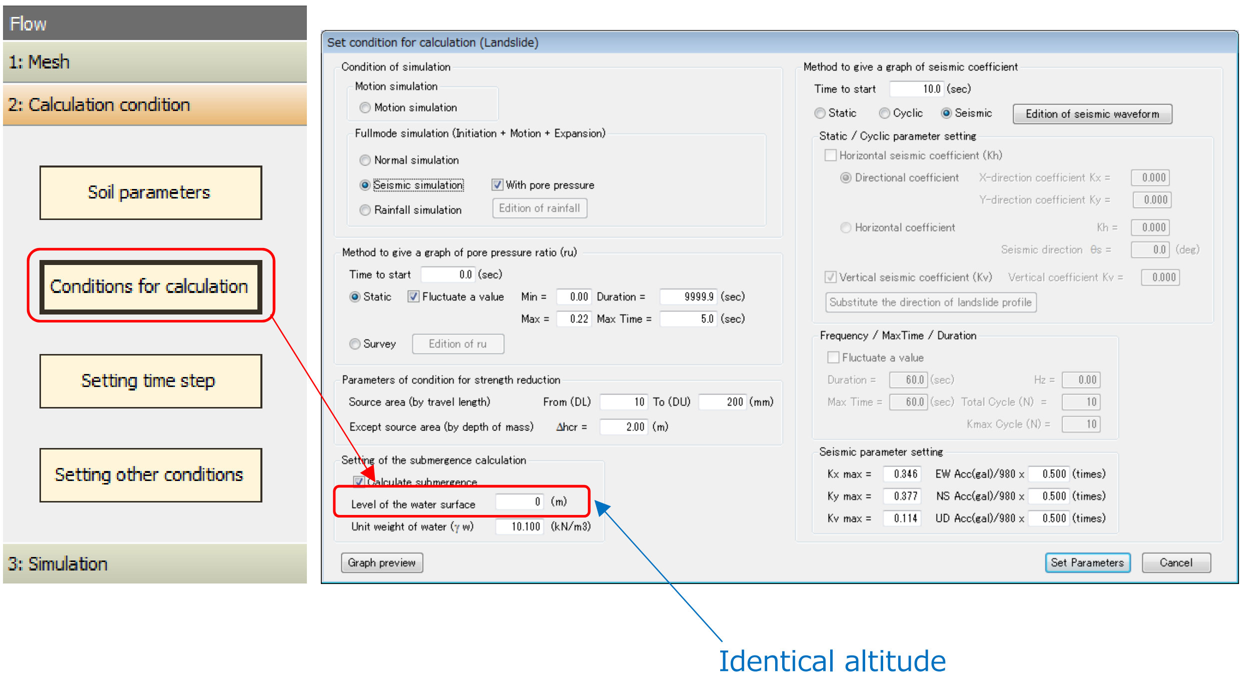
1. Tick the [Calculate submergence] option and set its parameters

Setting on the LS-RAPID application

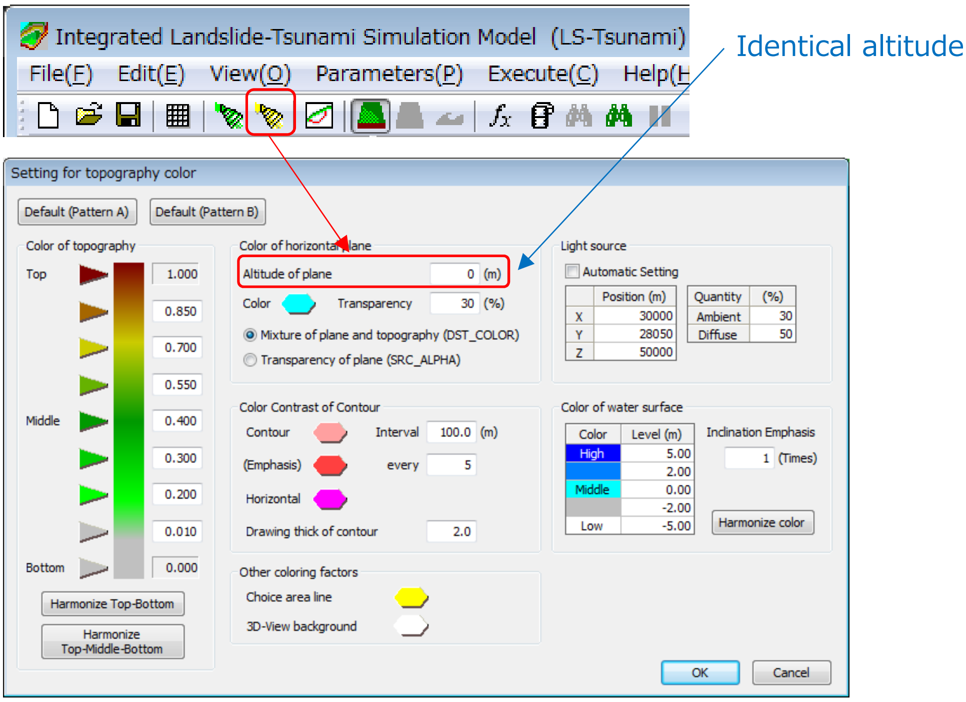


2. Set the [Level of the water surface] to conform with the tsunami simulation

Setting on the LS-RAPID application

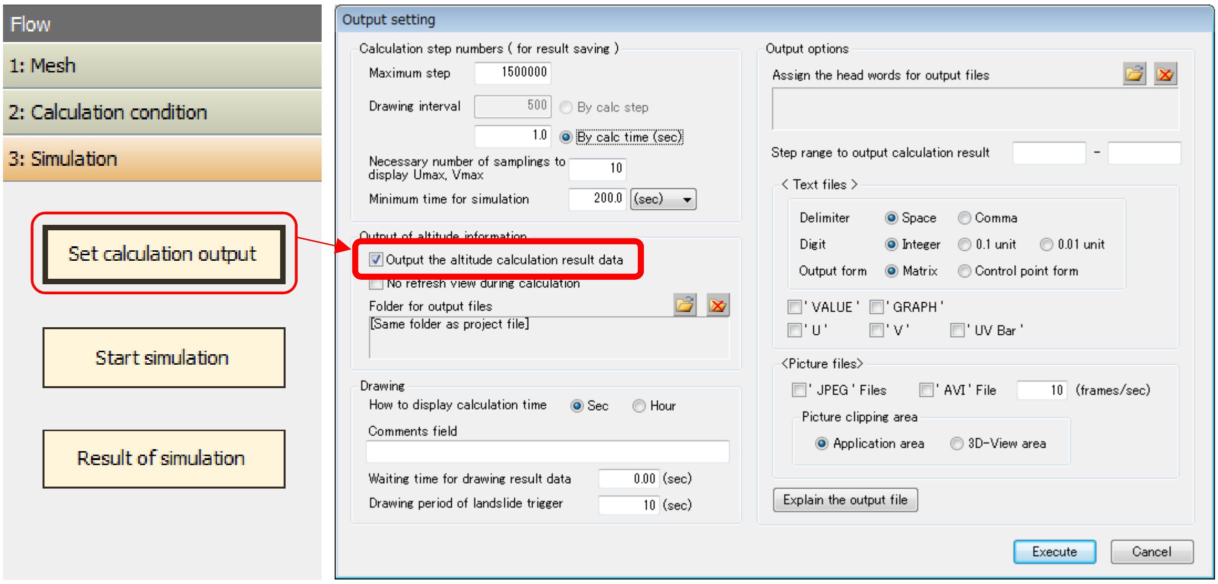


Setting on the LS-Tsunami application



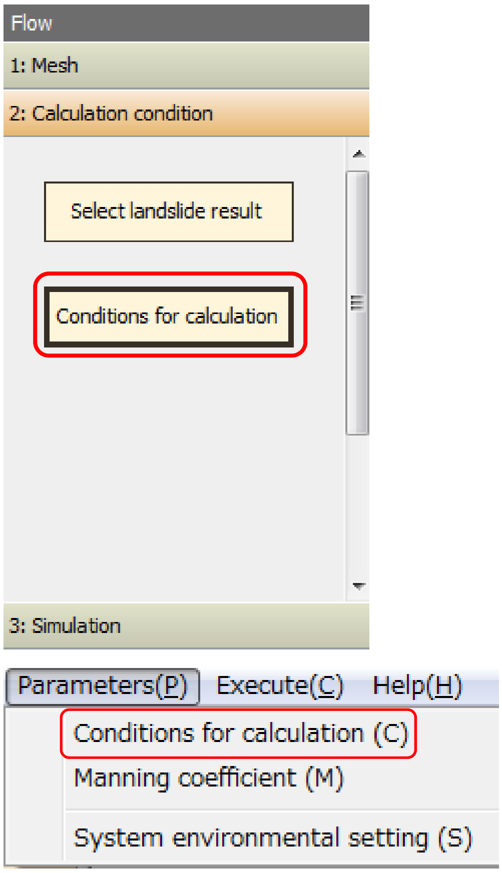
3. Tick the [Output the altitude calculation result data] option

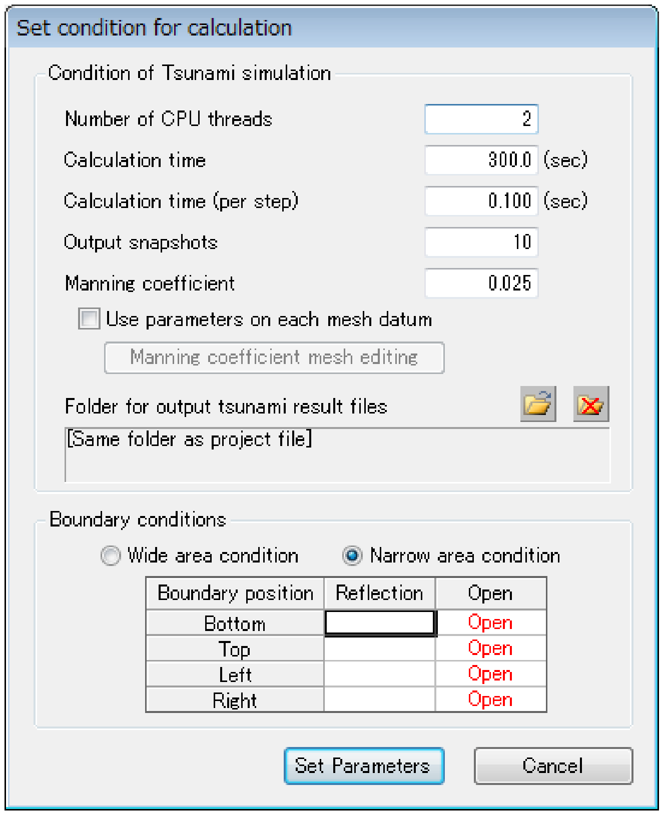
Setting on the LS-RAPID application



3-5. Setting of conditions for calculation

Click flow [2: Calculation for condition] – [Condition for calculation], or menu [Parameters] - [Conditions for calculation].





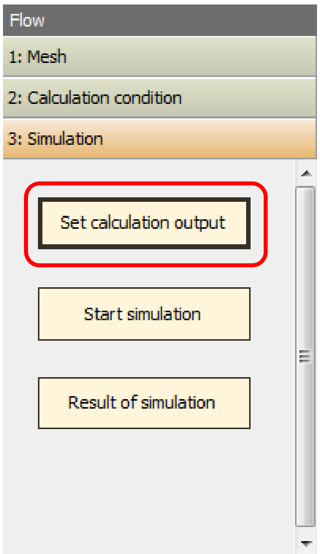
Contents	Explanations
Number of CPU threads	Set to the number of CPU cores. The number of CPU cores varies with each PC. If you use all cores for the simulation, it will hinder the performance of other tasks on your PC. Set this number based on your experience.
Calculation time	Set the duration. You need to set this by an area of simulation.
Calculation time (per step)	Set to the time for each calculation step. The number of calculation steps is calculated by the division of calculation time /time for each step. Normally, you set the time interval for the calculation of LS-LAPID.
Output snapshots	Set to output data interval for each step. You have to adjust this number depending on the duration. A value of about 100 is often used.

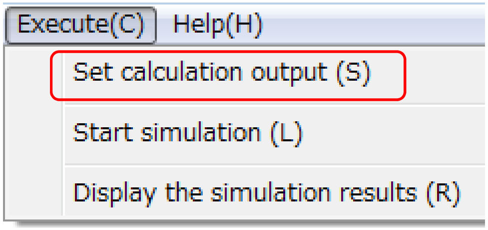
Contents	Explanations
Manning coefficient	Set to Manning's roughness coefficient. If you want to set this number for each mesh datum, tick [Use parameters on each mesh datum] and click [Manning coefficient mesh editing] to input the number for each mesh datum in a manner similar to inputting an elevation datum.
Folder for output tsunami result files	Designate to a folder for saving the output of the tsunami computing simulation. It is not necessary to change the default folder. All files in this output folder will be deleted after computing processes. **Do not designate a folder in which you have stored files that you need.**
Boundary conditions	You have to select [Wide area condition] or [Narrow area condition]. The wide area mode uses the conditions for linear progressive waves, and is effective for areas including deep water (for example, the total sea area of Japan). On the other hand, the narrow area mode uses the boundary condition of Sommerfeld type, and is effective for areas including shallow and coastal areas. Then, choose and set 'Reflection' or 'Open' to the squares. Boundary position means Bottom is Y (-) of the coordinate, Top is Y (+), Left is X (-) and Right is X (+) respectively.

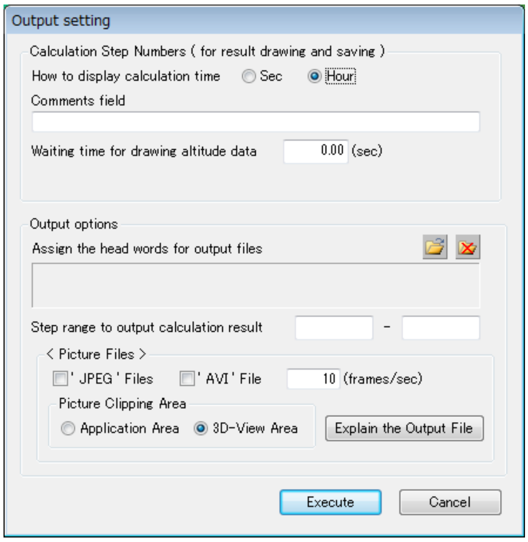
The process [2: Calculation condition] – [Condition for calculation] sets Calculation time and Calculation time per step for the tsunami simulation are same as the LS-RAPID calculation.

3-6. Settings for output and visualization

Click flow [3: Simulation] - [Set calculation output], or menu [Execute] - [Set calculation output]. A dialog box below will appears.







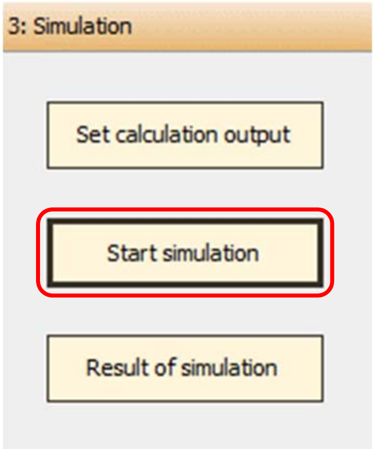
・Setting for output visualization

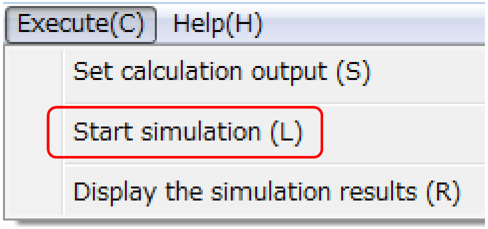
Contents	Explanations
How to display calculation time	○ Sec ○ Hour Set the format for displaying elapsed time.
Comment field	You can display some comments.
Waiting time for drawing altitude data	You can adjust imaging speed with this setting. The initial setting is 0.0. If you want a slower imaging speed, adjust this value.

・Options for output files

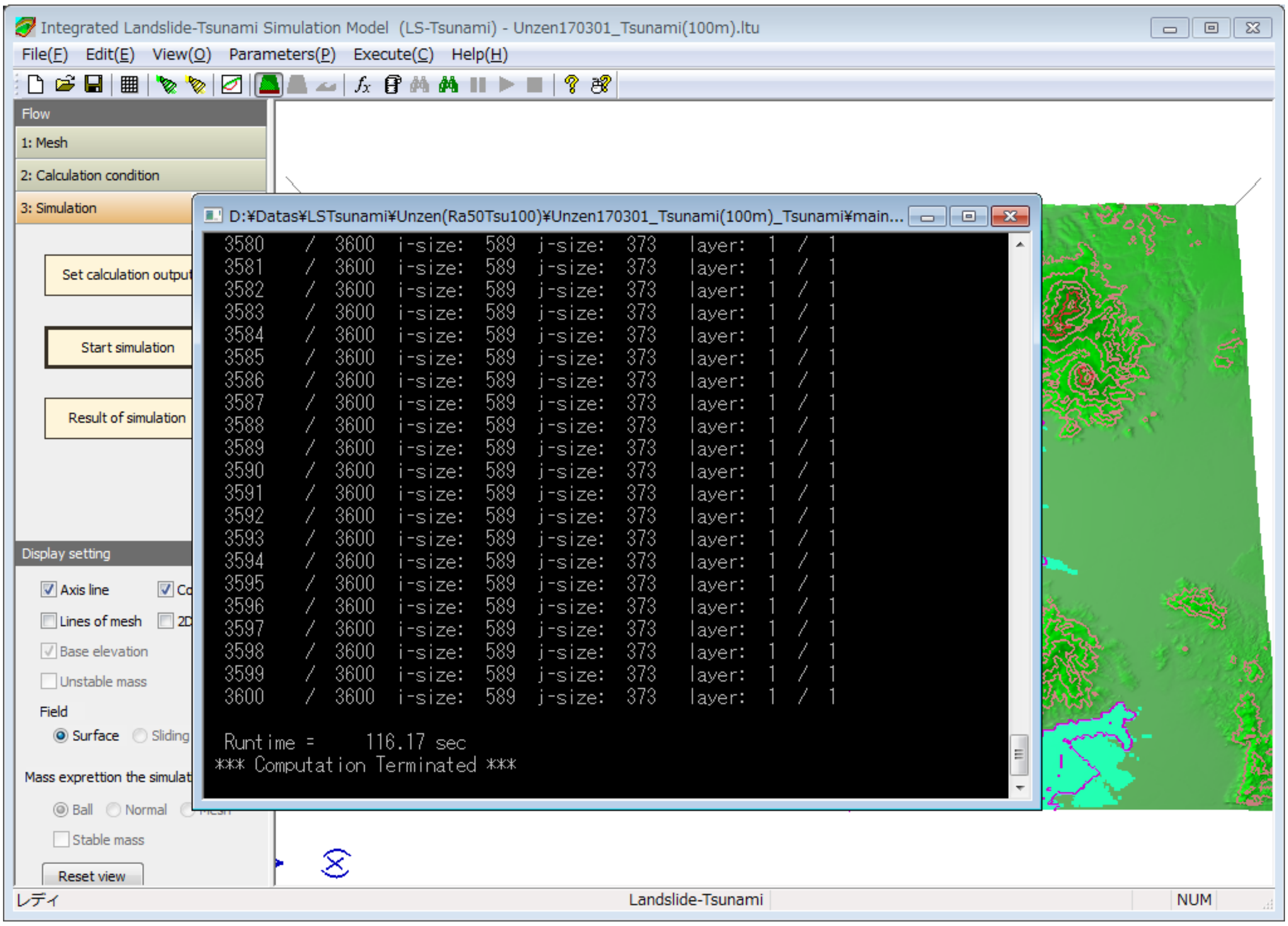
Contents	Explanations
Assign the head words for output files	You can designate the storage of output files and initials of file names.
Step range to output calculation result	If you input values, you will get output data that is between the two values. If you do not set any values, you get the complete output data.
Picture clipping area	○ Application area ○ 3D-View area Settings of the range when you save files as JPEG image or AVI movies. You can set ranges of all or only the 3D view area. If you could not get images properly, set 3D-View area.

3-7. Start the simulation



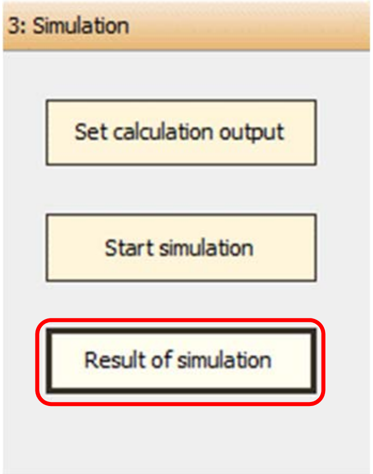


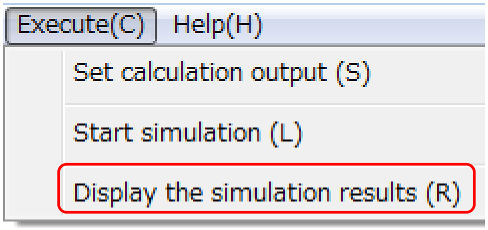
Click flow [3: Simulation] - [Start simulation], or Menu [Execute] - [Start simulation].
Next windows appear and the simulation starts to run.

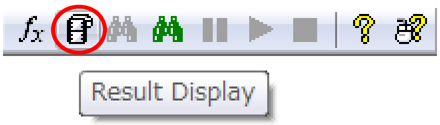


If the run finishes properly, the “Computation Terminated” note will appear.
Then, Close this calculation window.

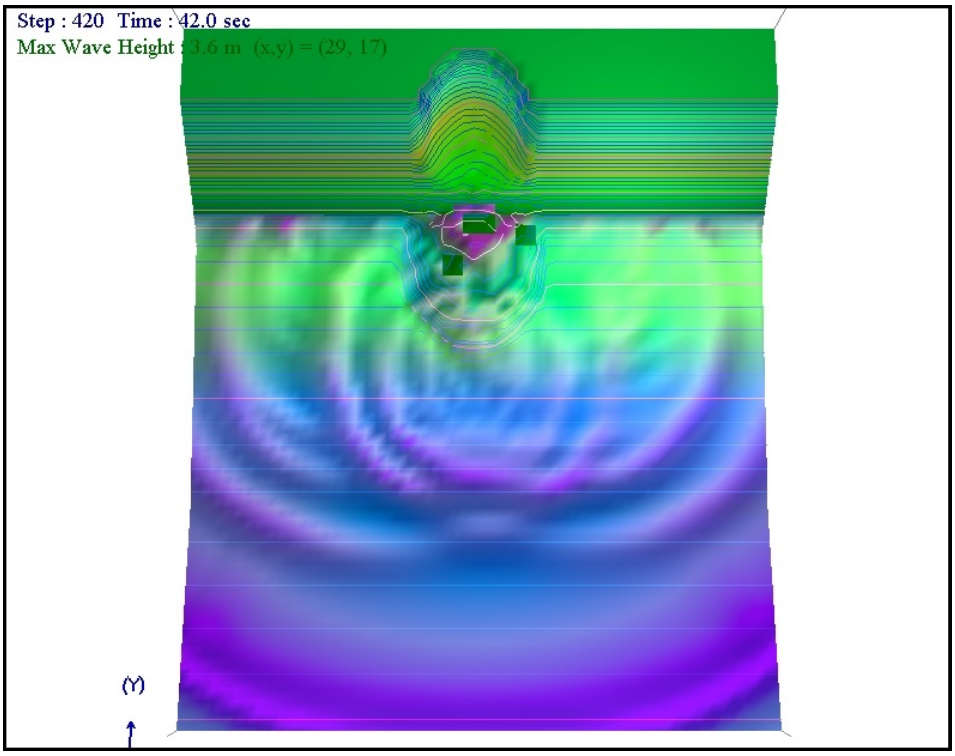
3-8. Display the results







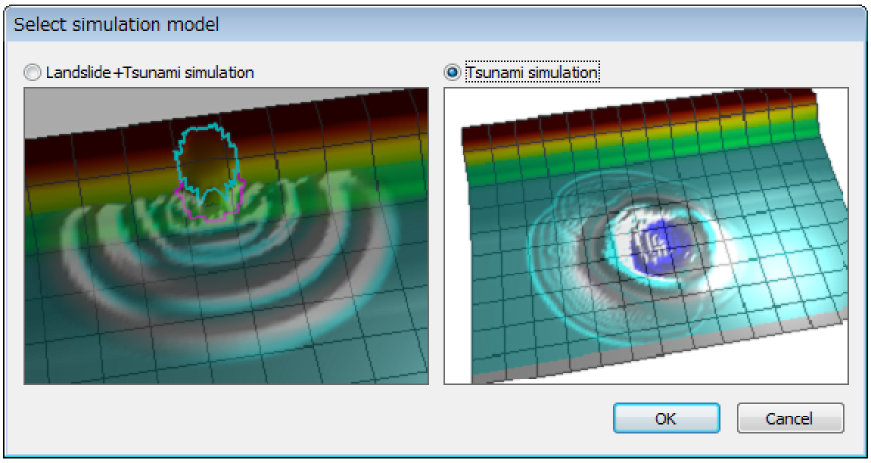
Click flow [3: Simulation] - [Result of simulation], or menu [Execute] - [Display the simulation results] to see the visualized results of the simulation.



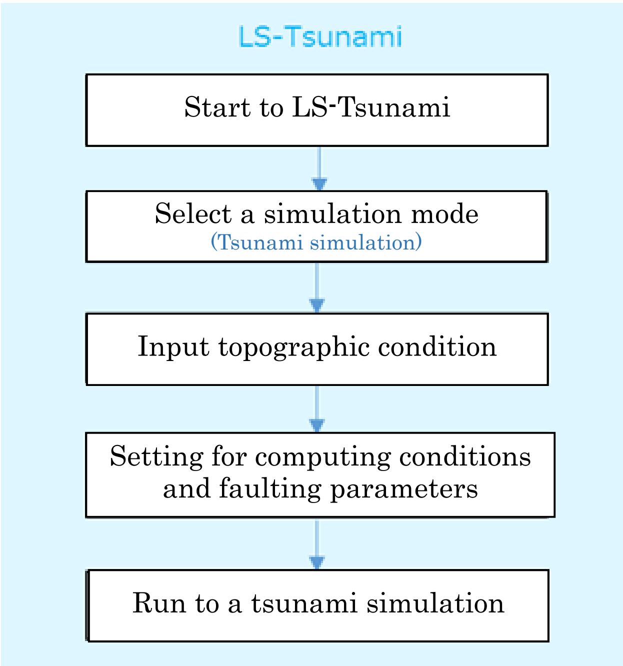
4. Tsunami simulation

4-1. Simulation Steps

If you want to simulate a tsunami by faulting and other seafloor deformations, select “Tsunami simulation”.

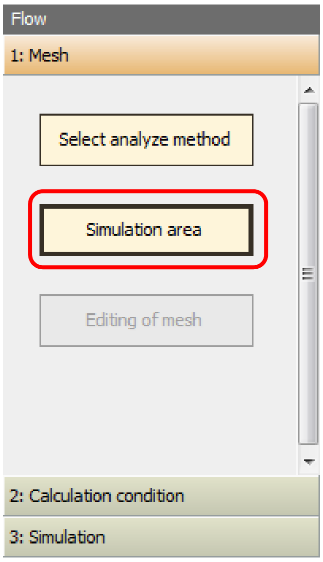


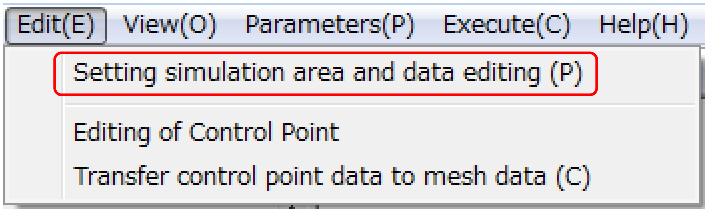
The figure below shows the flow diagram of LS-Tsunami simulation

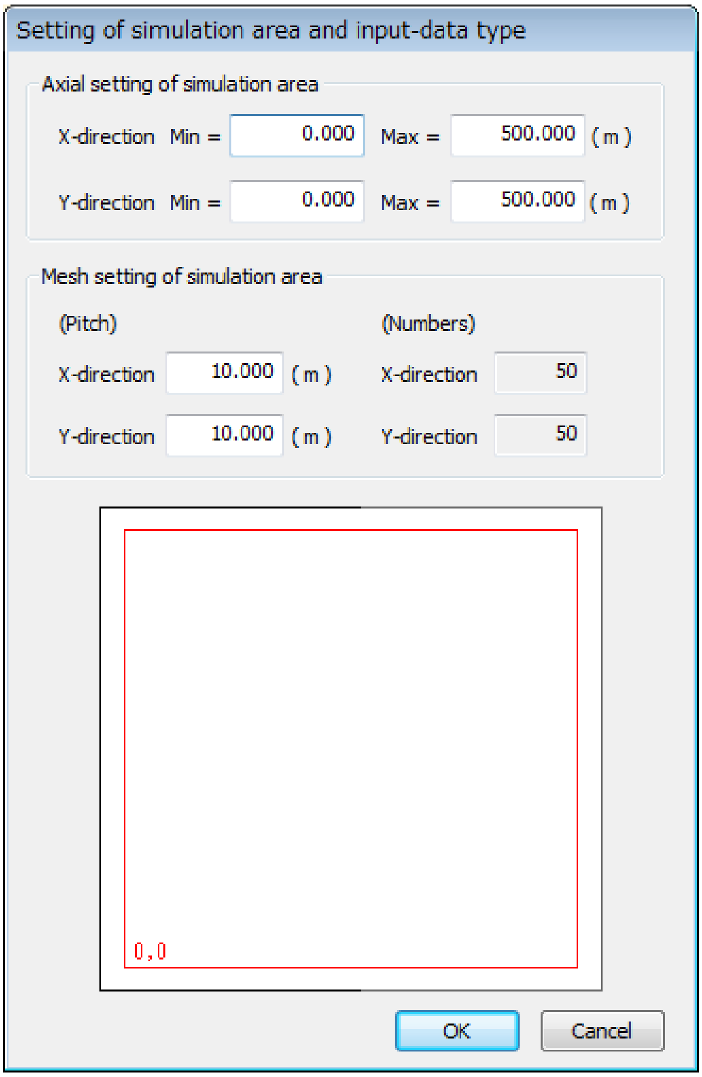


4-2. Setting of simulation area

Click flow [1: Mesh] - [Simulation area], or menu [Edit] - [Setting simulation area and data editing], and input the area of calculation. Setting procedure is similar to LS-RAPID.

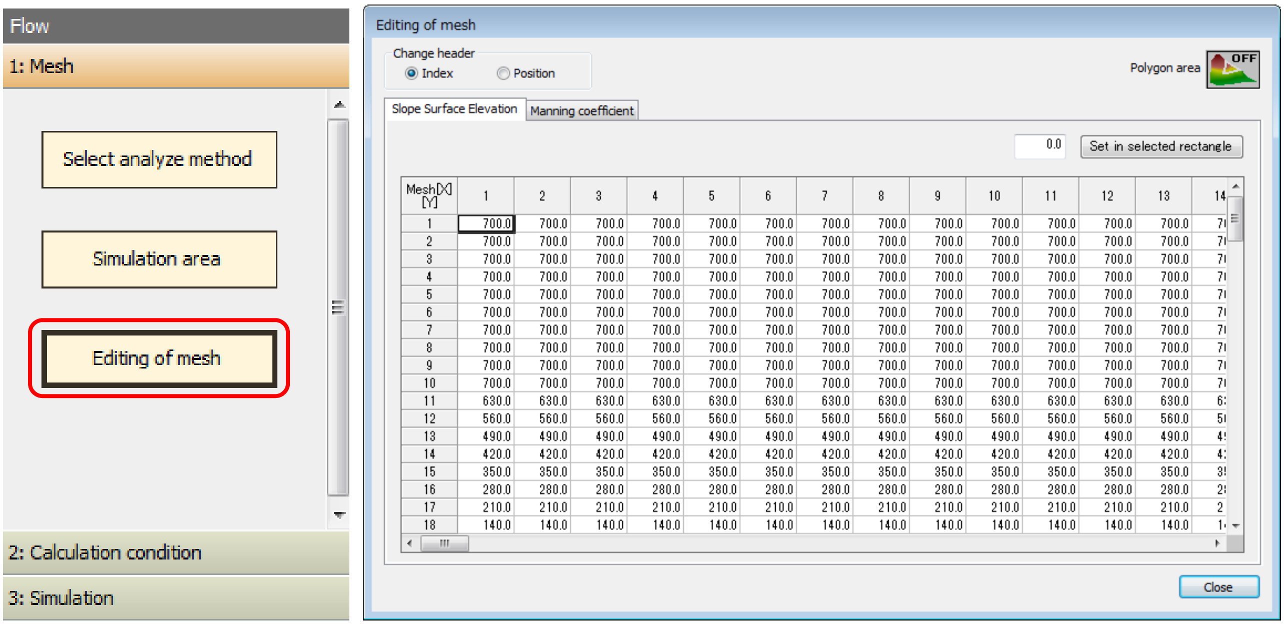




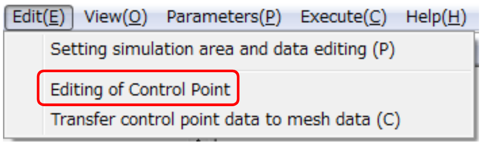


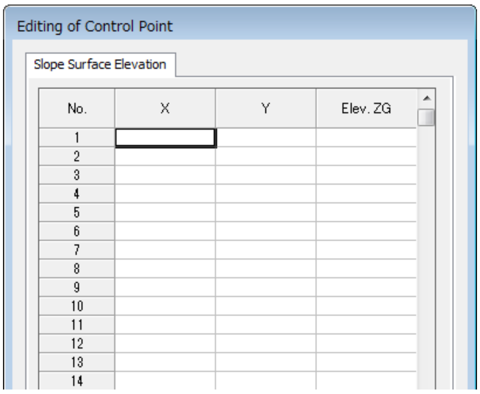
4-3. Editing topographic data

Click Flow [1: Mesh] – [Editing of mesh] to open the window to input topographic data.

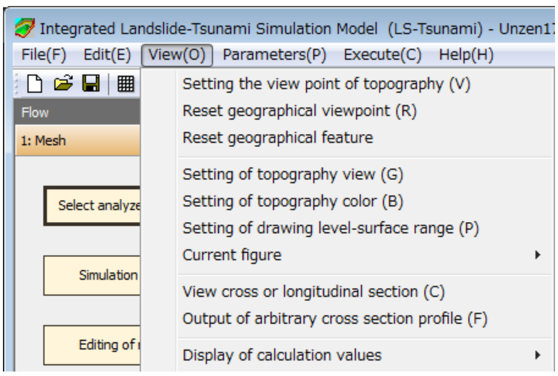


If there are some random elevation data other than meshed data, use the function [Transfer control point data to mesh data] to produce meshed data values.



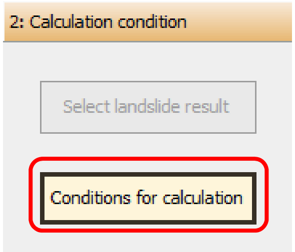


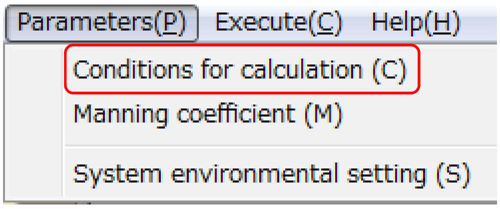
Setting to parameters for LS-Tsunami, which is similar with the LS-RAPID.

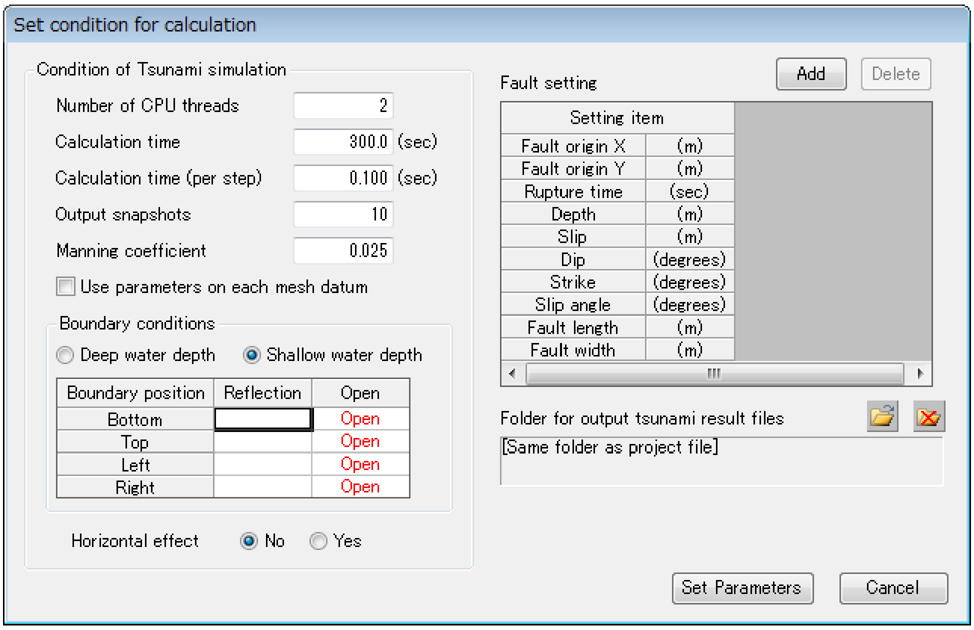


4-4. Setting of conditions for calculation

Click Flow [2: Calculation condition] - [Condition for calculation] option, or menu [Parameters] - [Conditions for calculation]. If the Manning's coefficient for each mesh is necessary, then click menu [Manning coefficient] to set it.





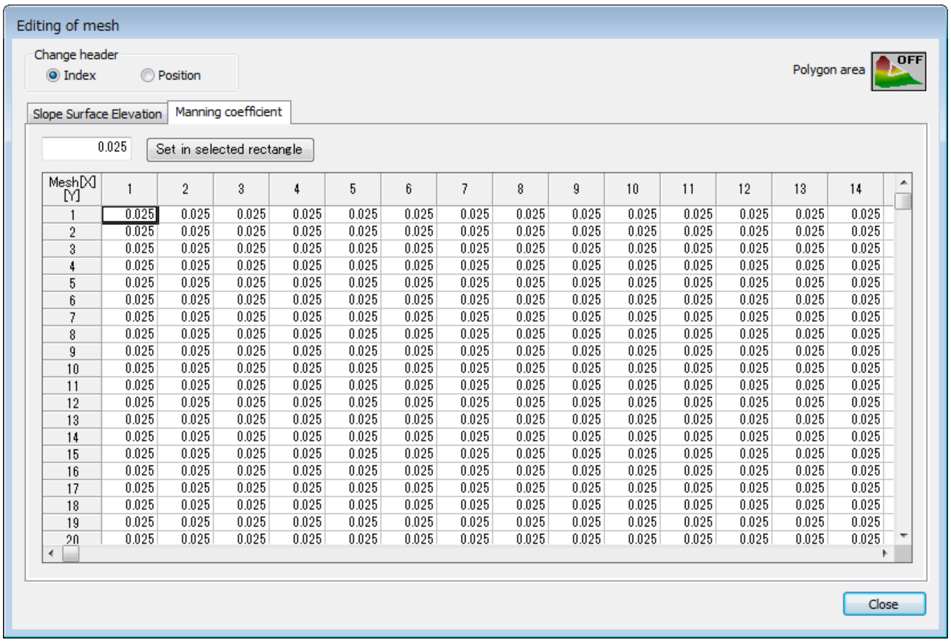


Contents	Explanations
Number of CPU threads	Set the number of CPU cores. The number of CPU cores varies with each PC. If you use all cores for the simulation, it will hinder other tasks running on your PC. Set this number based on your experience.
Calculation time	Set the duration. You will need to set this based on the area of the simulation.
Calculation time (per step)	Set to the time for one computing step. You have to adjust this depending on the area and duration of the simulation. A value of about 0.005 is often used here. The number of steps is the total duration / one time interval.
Output snapshots	Set the output data interval for each step. You have to adjust this number depending on the duration. A value of about 100 is often used.

Contents	Explanations
Manning coefficient	Set the Manning's roughness coefficient. If you want to set this number for each mesh datum, check [Use parameters on each mesh datum] and click menu [Parameters] – [Manning coefficient] to input the number for each mesh datum in a similar way of inputting an elevation datum.
Boundary conditions	You have to select [Deep water depth] or [Shallow water depth]. The wide area mode uses the conditions for a linear progressive wave, and is effective for areas including deep water (for example, the total sea area of Japan). On the other hand, the narrow area mode uses the boundary condition of Sommerfeld type, and is effective for areas that include shallow and coastal areas. Then, choose and set 'Reflection' or 'Open' to the squares. Boundary position means Bottom is Y (-) of the coordinate, Top is Y (+), Left is X (-) and Right is X (+) respectively.
Horizontal effect	If you click 'Yes' the program will incorporate the effect of a horizontal component for computing. If a fault occurs on a slope, the initial water surface of its generated tsunami is affected by a horizontal component.
Fault setting	The following parameters are for computation by faulting – crust deformation.
Fault origin X,Y(m)	Coordinates for the original position of the fault surface.
Rupture time (sec)	Time when faulting starts.
Depth (m)	Depth of the top of the fault surface.
Slip (m)	A slip distance on the fault surface.
Dip (degrees)	Maximum dipping angle of the fault surface.
Strike (degrees)	Strike angle of the fault surface. Give this value using North as 0˚ and increase the angle clockwise.
Slip angle (degrees)	Angle of slip direction on the slip surface. Give this value using the right side of the horizontal surface as 0˚ and increasing the values anti-clockwise.
Fault length (m)	Length of the fault.
Fault width (m)	Width of the fault.
Folder for output tsunami result files	Designate to a folder saving the output of the tsunami computing simulation. It is not necessary to change the default folder. All files in this output folder will be deleted after computing. **Do not designate a folder in which you have stored files that you need.**

If the Manning's roughness coefficient for each mesh datum is necessary to set, then click menu [Parameters] - [Manning coefficient] option.

The window below shows the table to set a Manning's roughness coefficient for each mesh datum.



Mesh[X] [Y]	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
2	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
3	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
4	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
5	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
6	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
7	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
8	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
9	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
10	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
11	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
12	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
13	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
14	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
15	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
16	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
17	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
18	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
19	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
20	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

Schematic sketches of a fault model and faulting parameters.

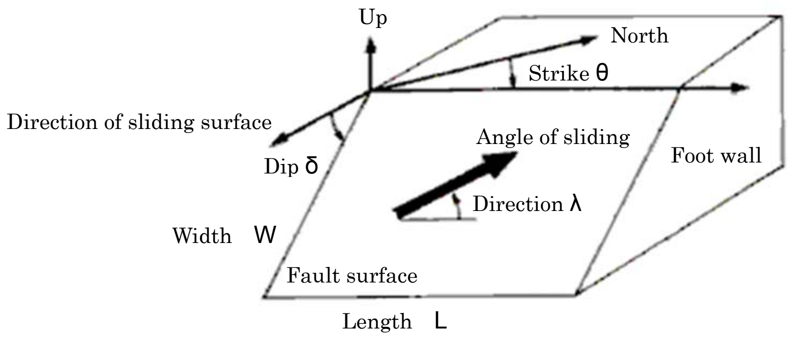


Figure1. Fault model and faulting parameters (bold arrow indicates the direction of movement of the hanging wall on the footwall)

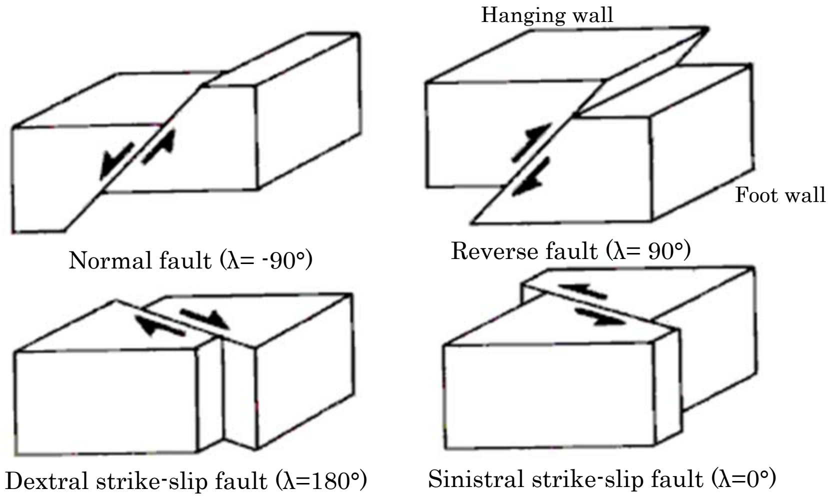
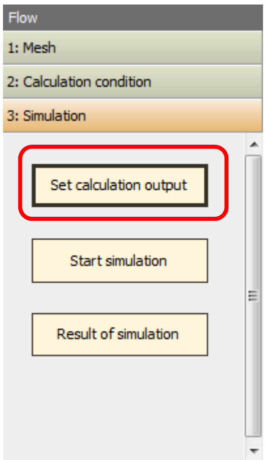
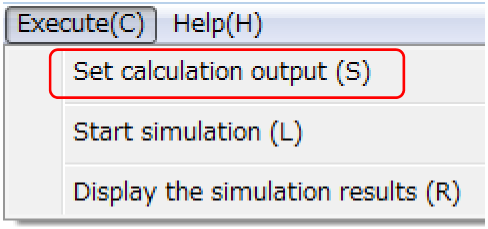


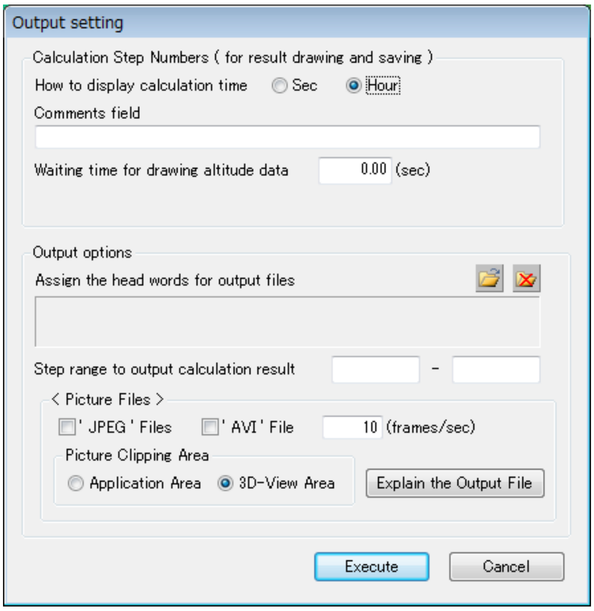
Figure2. Different form types of faults
(from Handbook of Fault Parameters pp.24-25 (In Japanese) Kajima Publishing, 1989)

4-5. Settings for output and visualization





Click flow [3: Simulation] - [Set calculation output] option, or menu [Execute] - [Set calculation output]. A dialog box below will appears.



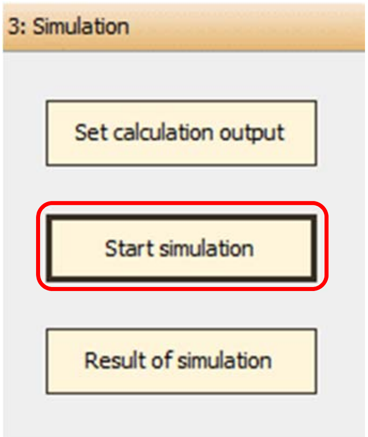
・Setting for output visualization

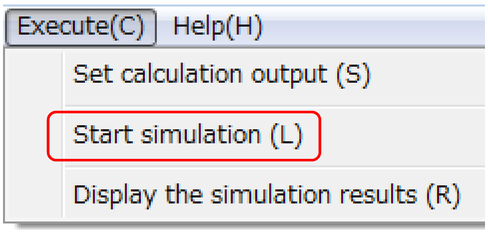
Contents	Explanations
How to display calculation time	○ Sec ○ Hour Set the format for displaying elapsed time.
Comment field	You can display some comments.
Waiting time for drawing altitude data	You can adjust imaging speed with this setting. The initial setting is 0.0. If you want a slower imaging speed, adjust this value.

・Options for output files

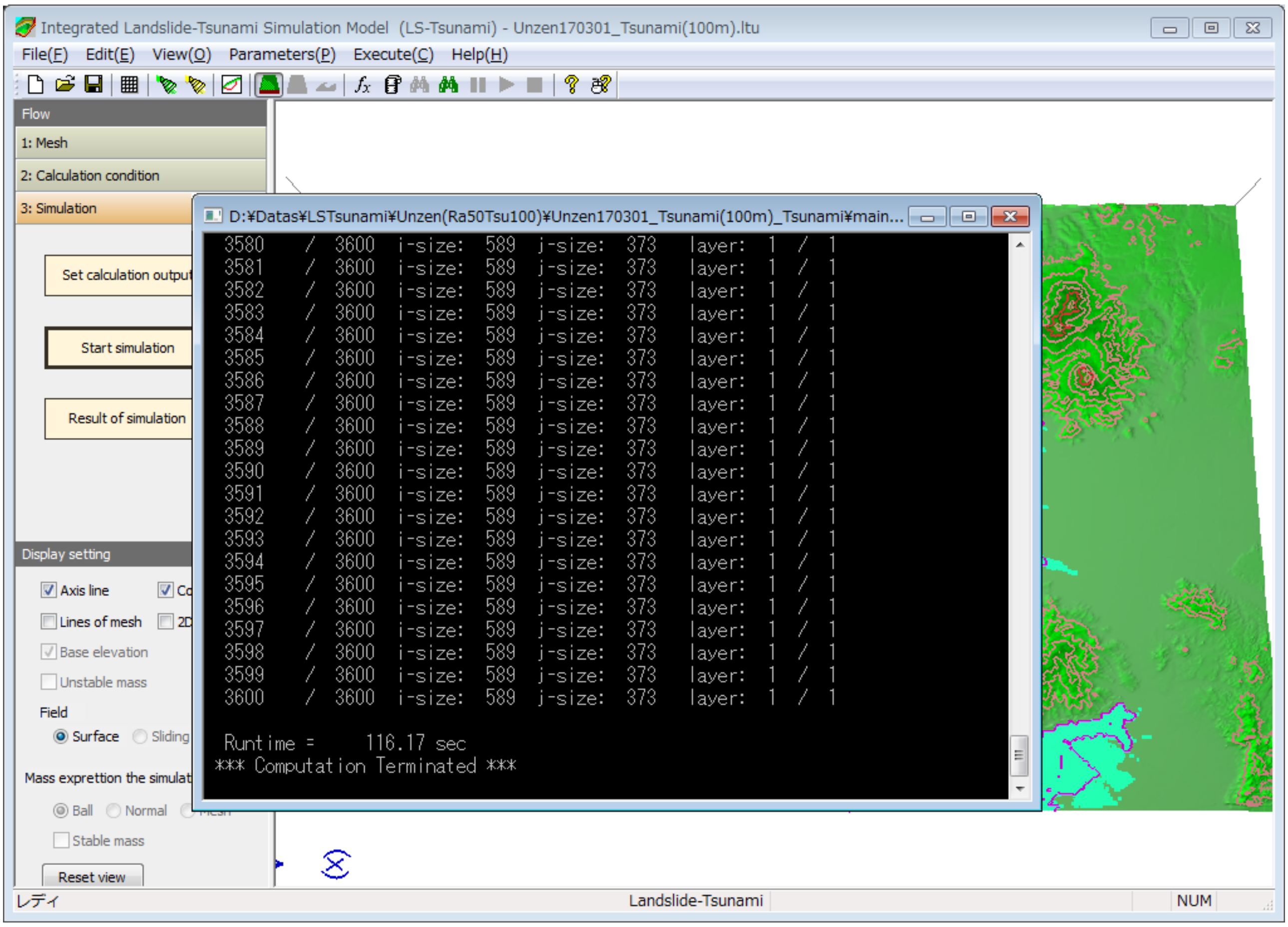
Contents	Explanations
Assign the head words for output files	You can designate the storage of output files and initials of file names.
Step range to output calculation result	If you input values, you will get output data that is between the two values. If you do not set any values, you get the complete output data.
Picture clipping area	○ Application area ○ 3D-View area Settings of the range when you save files as JPEG image or AVI movies. You can set ranges of all or only the 3D view area. If you could not get images properly, set 3D-View area.

4-6. Start the simulation



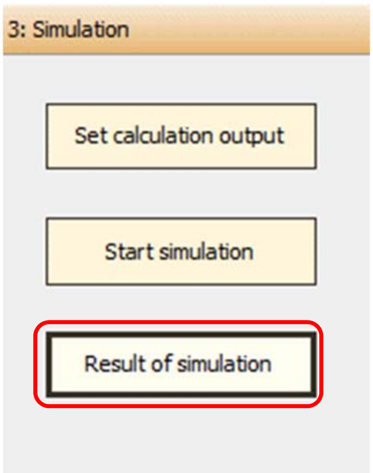


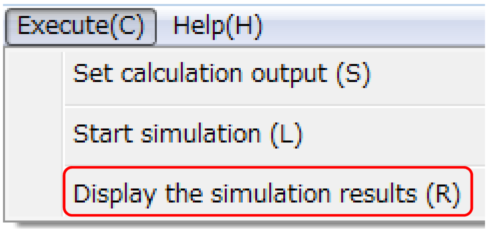
Click flow [3: Simulation] - [Start simulation] option, or menu [Execute] - [Start simulation]. Next following windows appear and the simulation starts to run.

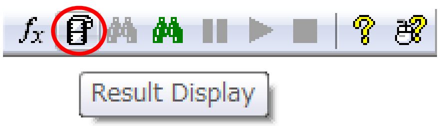


If the run finishes properly, “Computation terminated” note will appear.
Then, Close this window.

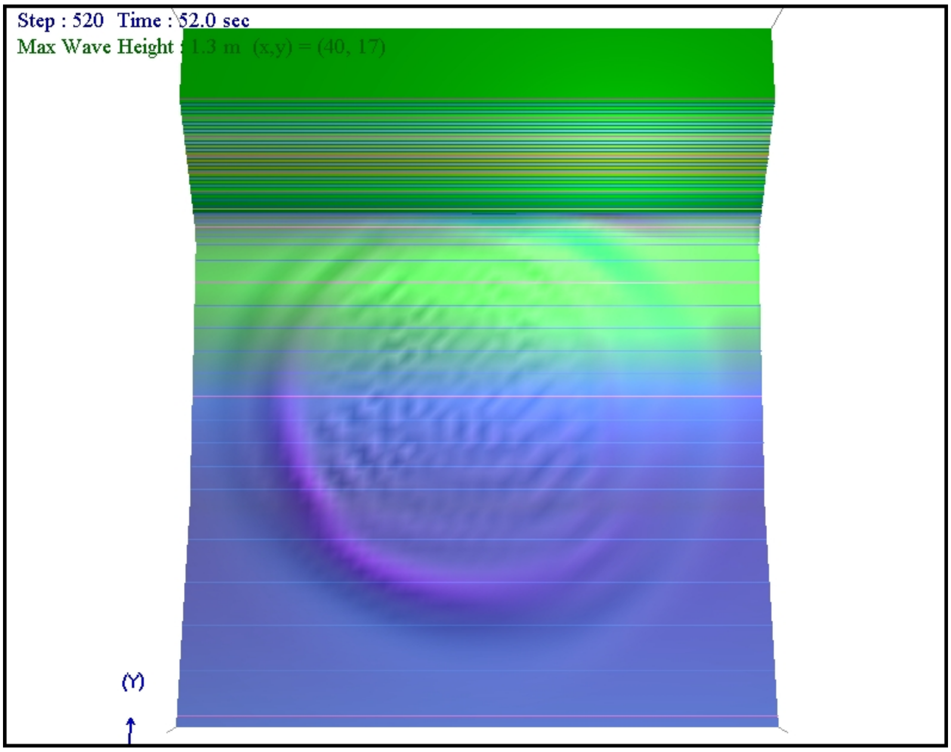
4-7. Display the results







Click flow [3: Simulation] - [Result of simulation] option, or menu [Execute] - [Display the simulation results] to see the visualized results of the simulation.



5. Base Study

The scientific use of LS-RAPID Landslide Simulation and LS-Tsunami Simulation could be observed from the paper below:
Sassa K, Dang K, Yanagisawa H, He B (2016) A new landslide-induced tsunami simulation model and its application to the 1792 Unzen-Mayuyama landslide-and-tsunami disaster, Landslides 13:1405-1419. DOI 10.1007/s10346-016-0691-9