CFB Erosion: Setup and Analysis

CPFD Software

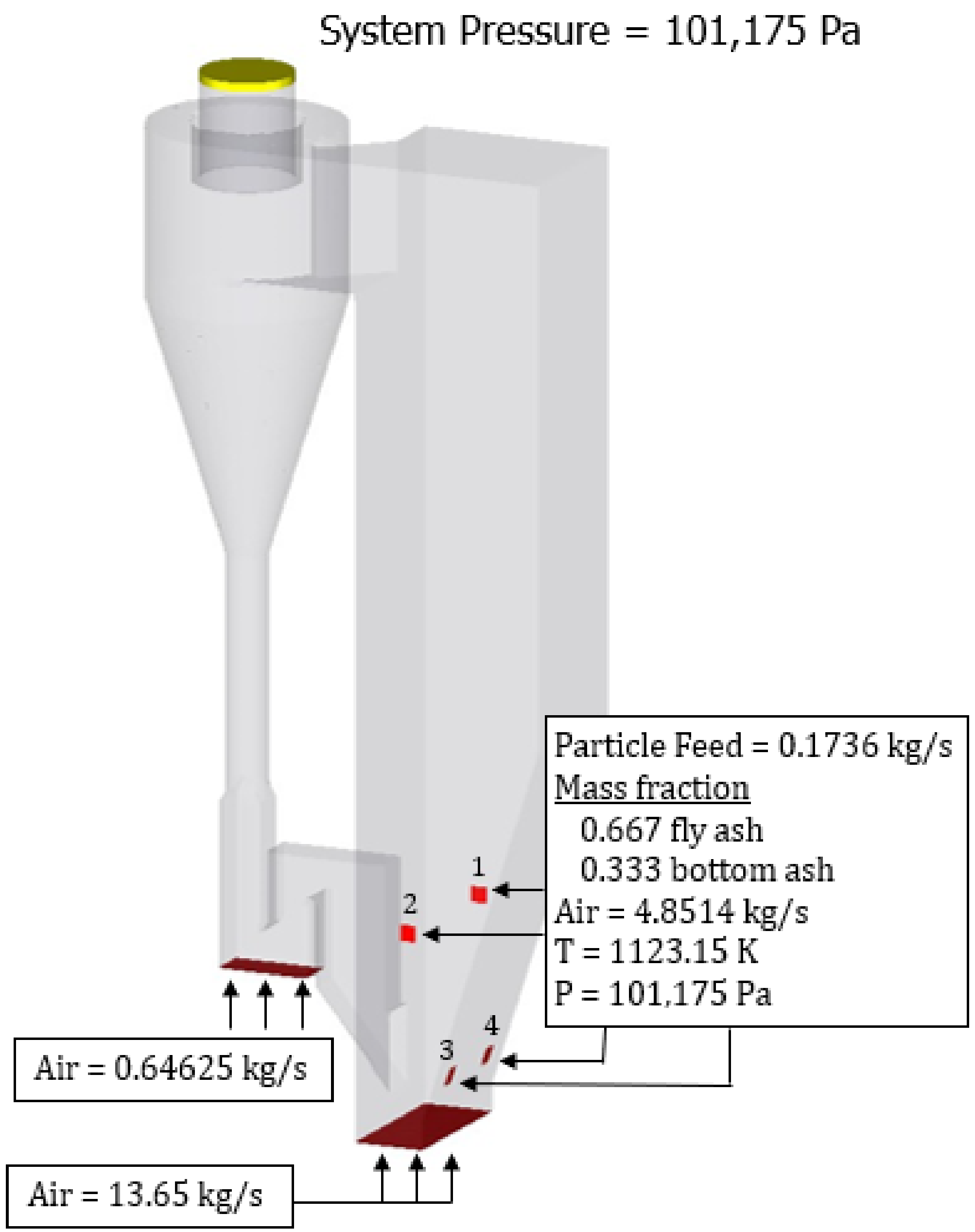
www.cpfd-software.com

Circulating Fluidized Bed (CFB)

Model of circulating fluidized bed (CFB) based on the system operating at the 40 MW Strongoli power plant in Italy.

Start with Case 1: Baseline

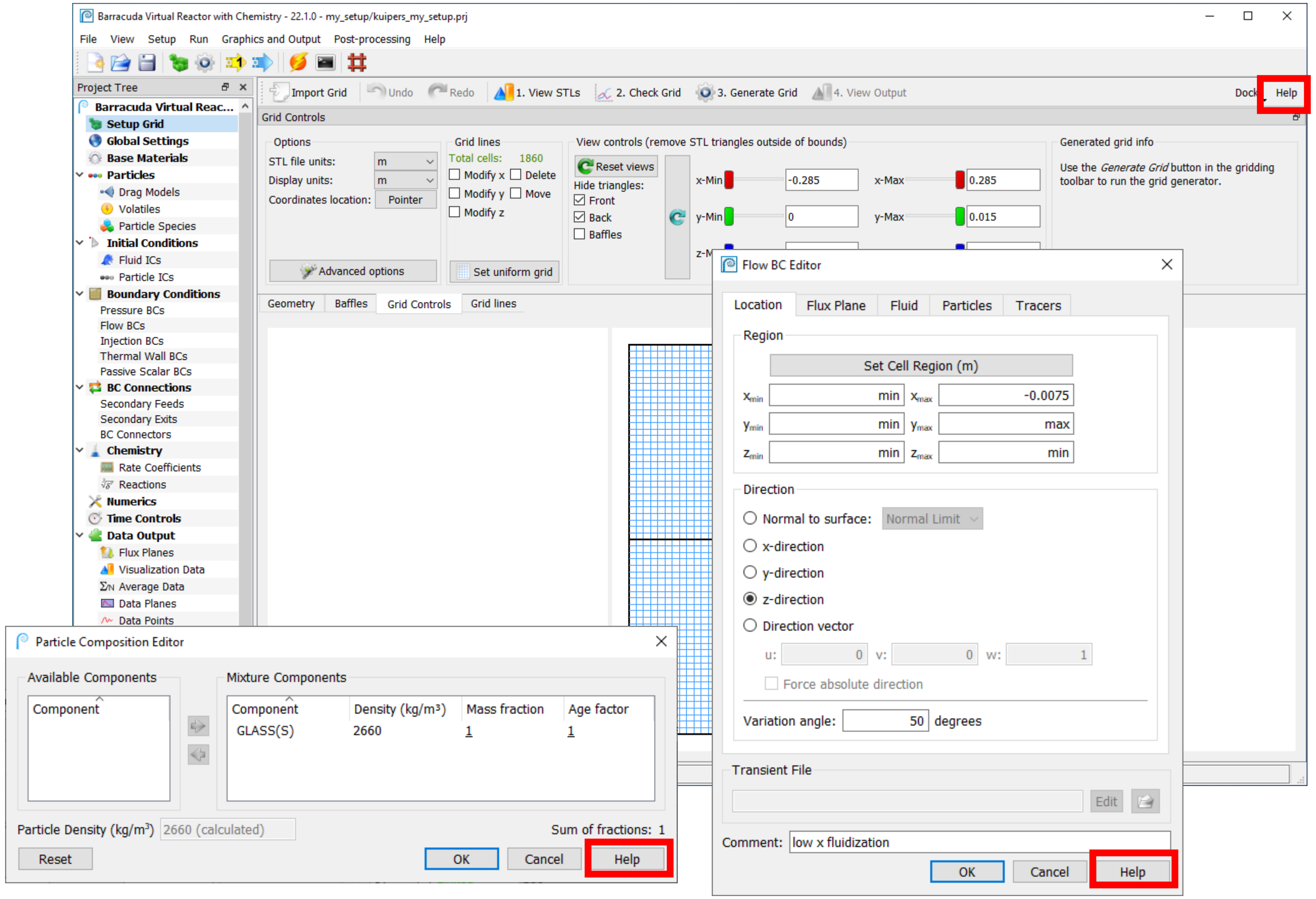
Case 2: Modified geometry with larger cyclone inlet width



How to Get More Information

All training materials have a limited amount of information about Barracuda and the GUI.

If you want to learn more, click on the Help button in the relevant dialog. This brings up the corresponding section of the User Manual.



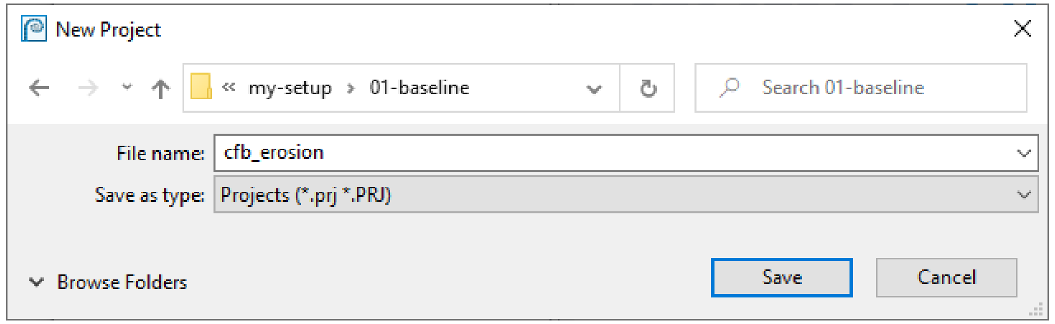
Project File

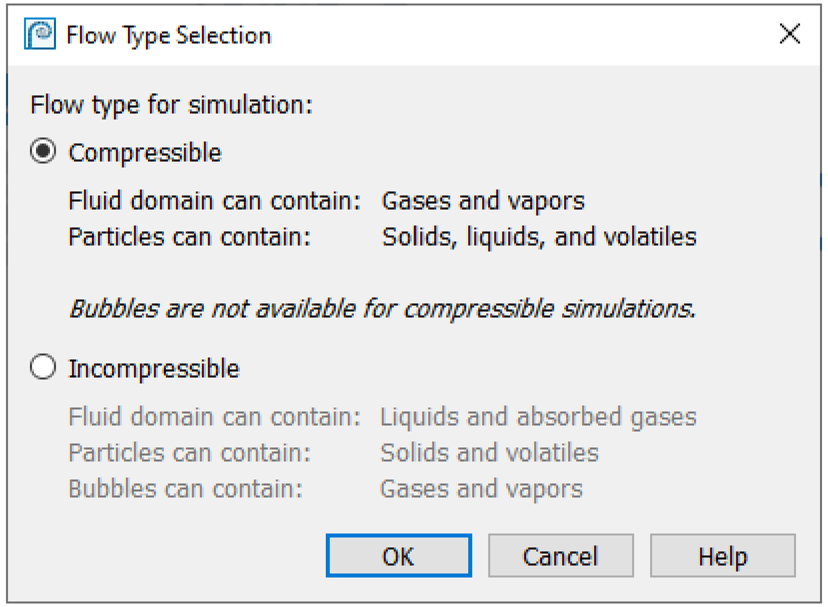
Make a new compressible project file in the supplemental training directory:

\cfb_erosion\my-setup\01-baseline

With the project name:

cfb_erosion.prj





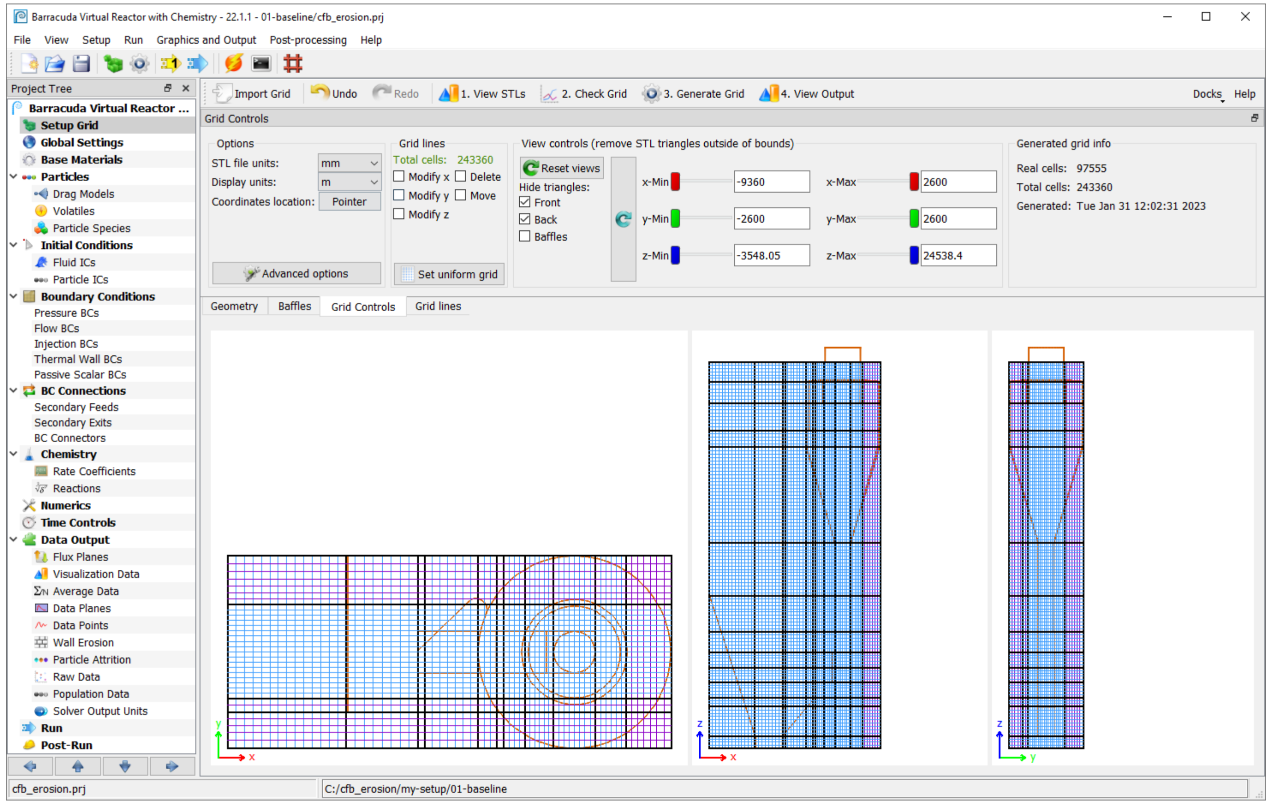
Setup Grid

Geometry tab:

- Add original_baseline_1150mm.stl

Grid Controls tab:

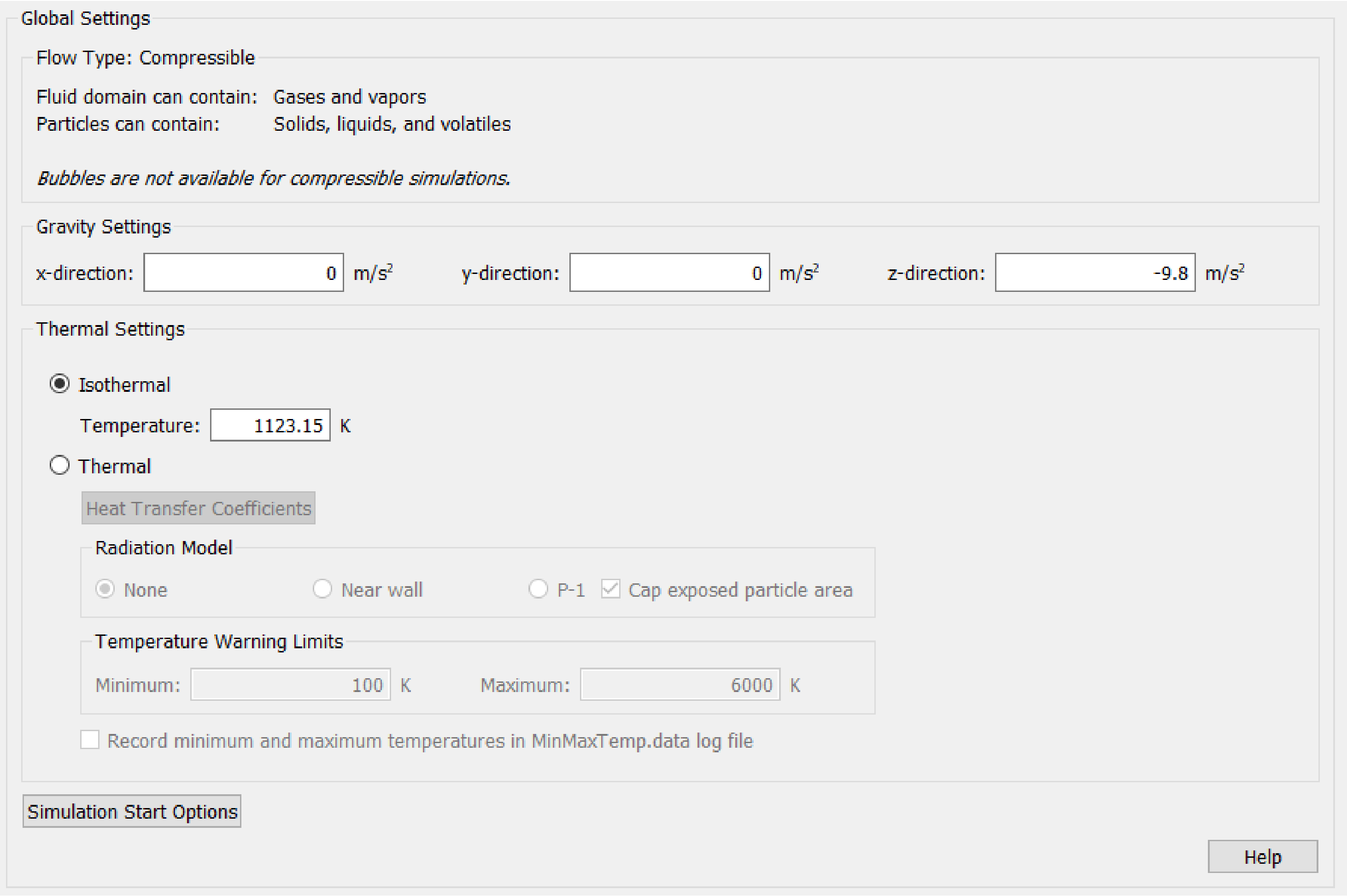
- Set STL file units to mm
- Follow along with Non-linear Gridding video: https://cpfd-software.com/non-linear_gridding_demo/



Global Settings

Set Gravity in the z-direction

Select Isothermal at 1123.15 K



Base Materials

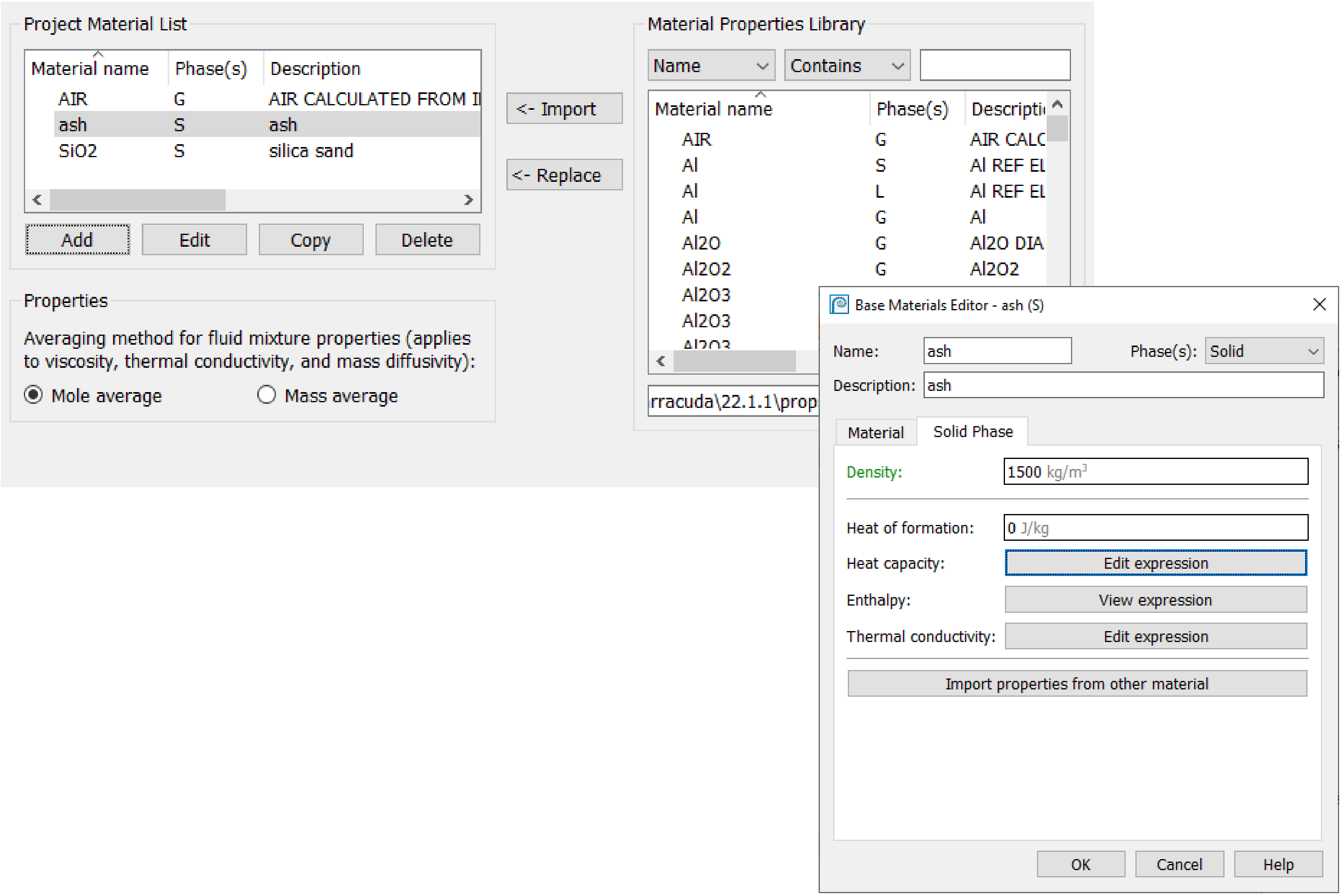
Import AIR

Add SiO2

- Phase: Solid
- MW = 1 g/mol
- Density = 2650 kg/m^3

Add Ash

- Phase: Solid
- MW = 1 g/mol
- Density = 1500 kg/m^3



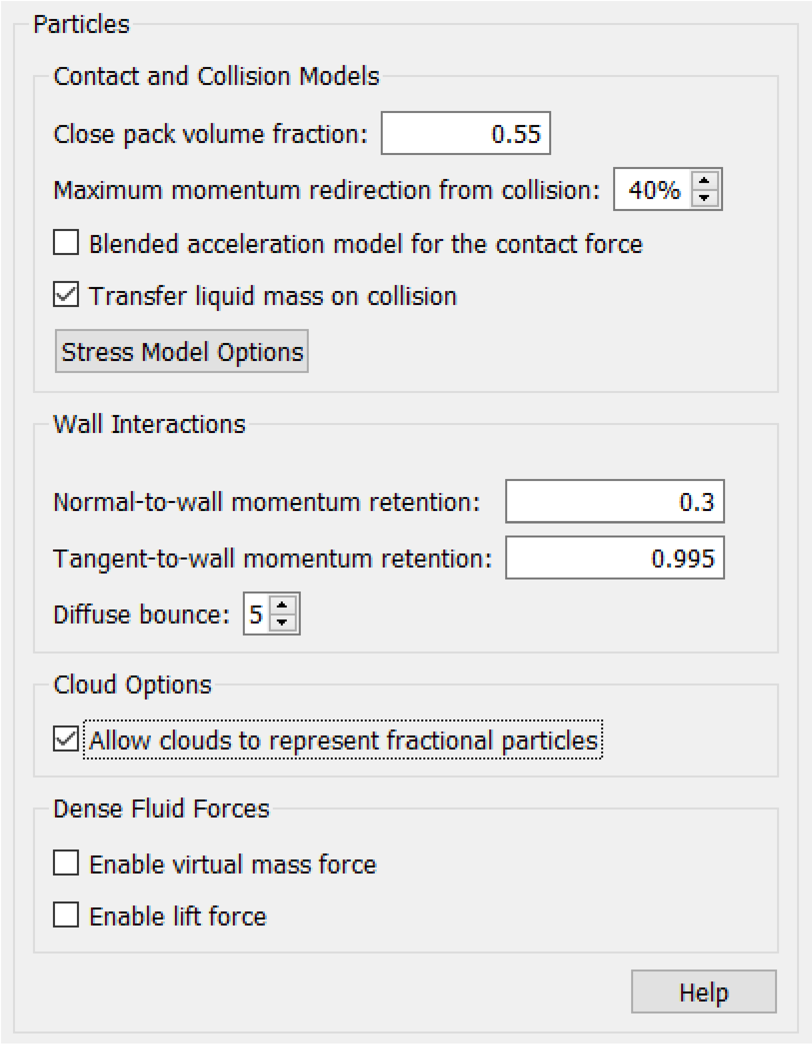
Particles

Set Close pack volume fraction: 0.55

Normal-to-wall momentum retention: 0.3

Tangent-to-wall momentum retention: 0.995

Diffuse bounce: 5

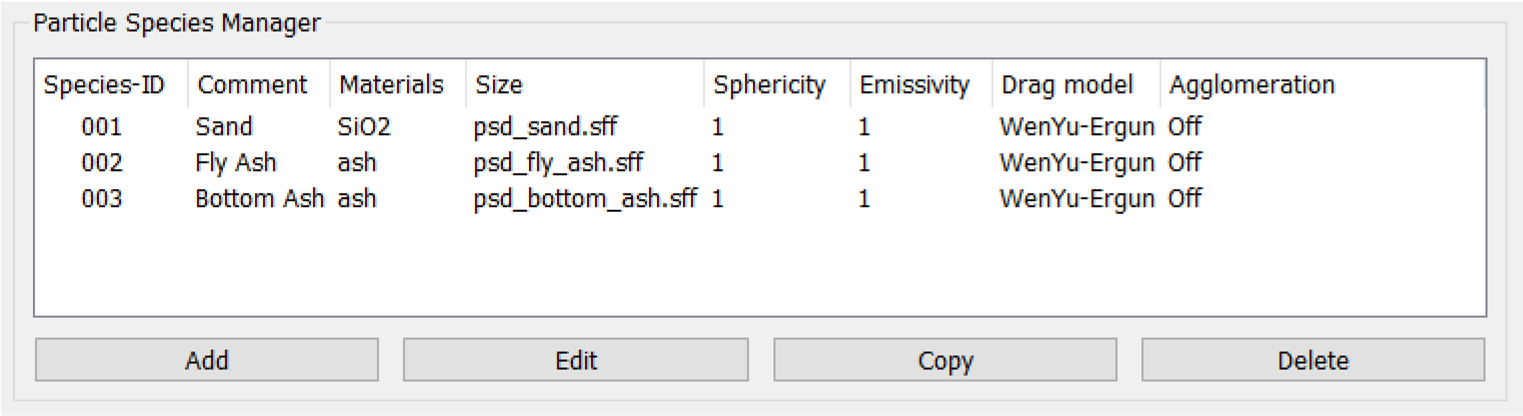


Particles Species

Create the following particle species:

- Sand, 100% SiO2, psd_sand.sff, WenYu-Ergun drag model
- Fly Ash, 100% ash, psd_fly_ash.sff, WenYu-Ergun drag model
- Bottom Ash, 100% ash, psd_bottom_ash.sff, WenYu-Ergun drag model

PSD files are included in the supplemental training directory.


Particle Species Manager

Species-ID	Comment	Materials	Size	Sphericity	Emissivity	Drag model	Agglomeration
001	Sand	SiO2	psd_sand.sff	1	1	WenYu-Ergun	Off
002	Fly Ash	ash	psd_fly_ash.sff	1	1	WenYu-Ergun	Off
003	Bottom Ash	ash	psd_bottom_ash.sff	1	1	WenYu-Ergun	Off

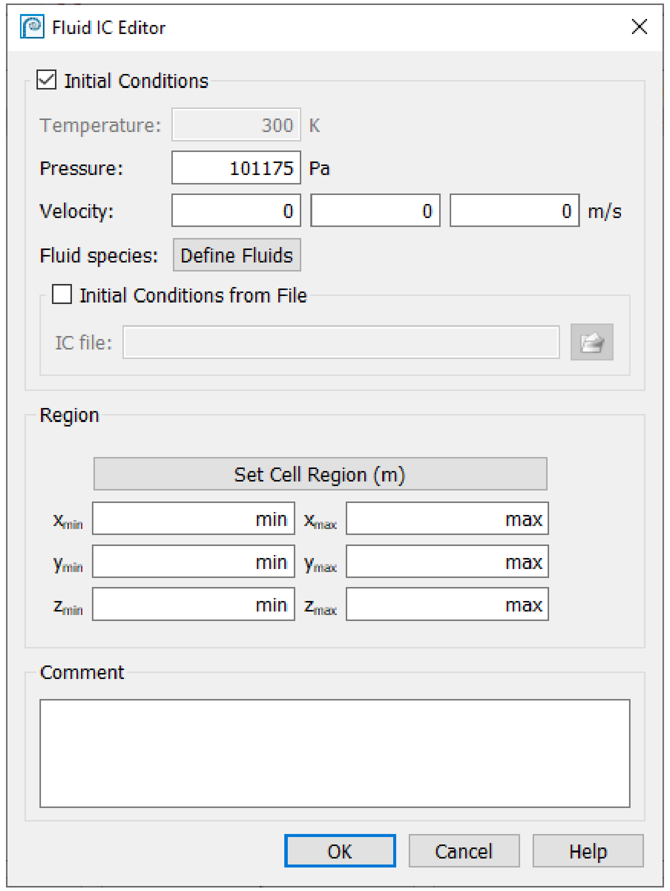
Fluid and Particle ICs

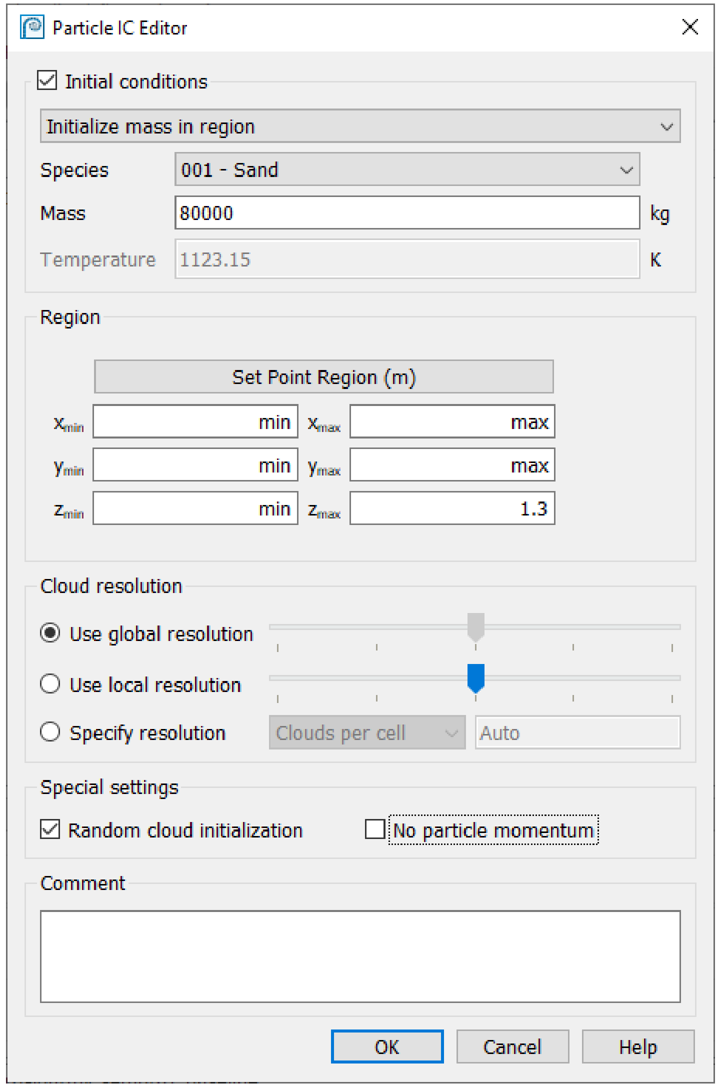
Fluid IC

- Pressure = 101175 Pa
- Fluid species = 100% AIR

Particle IC

- Initialize mass in region
- Species = Sand
- Mass = 80,000 kg
- Set region to min, max for x- and y-, and z-max to 1.3 m

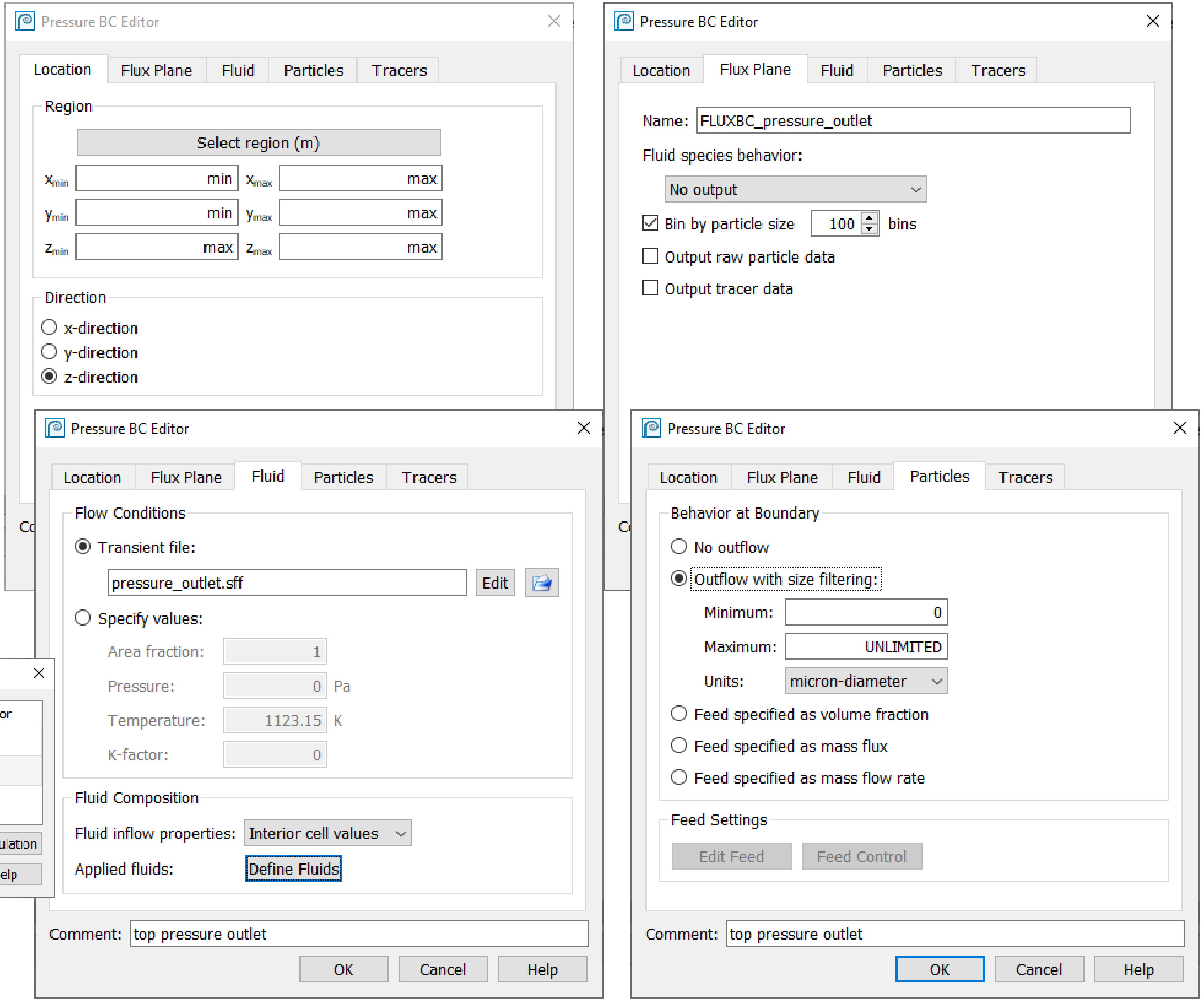


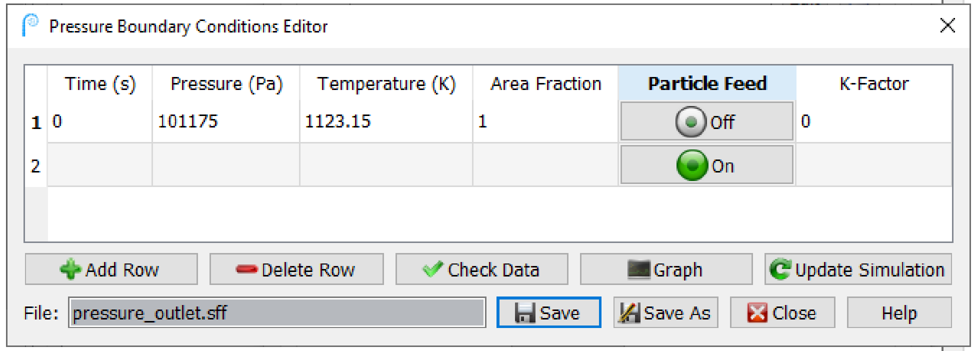


Pressure BC

Add a pressure BC with information shown here for cyclone outlet.

Use 100% AIR for Applied fluids

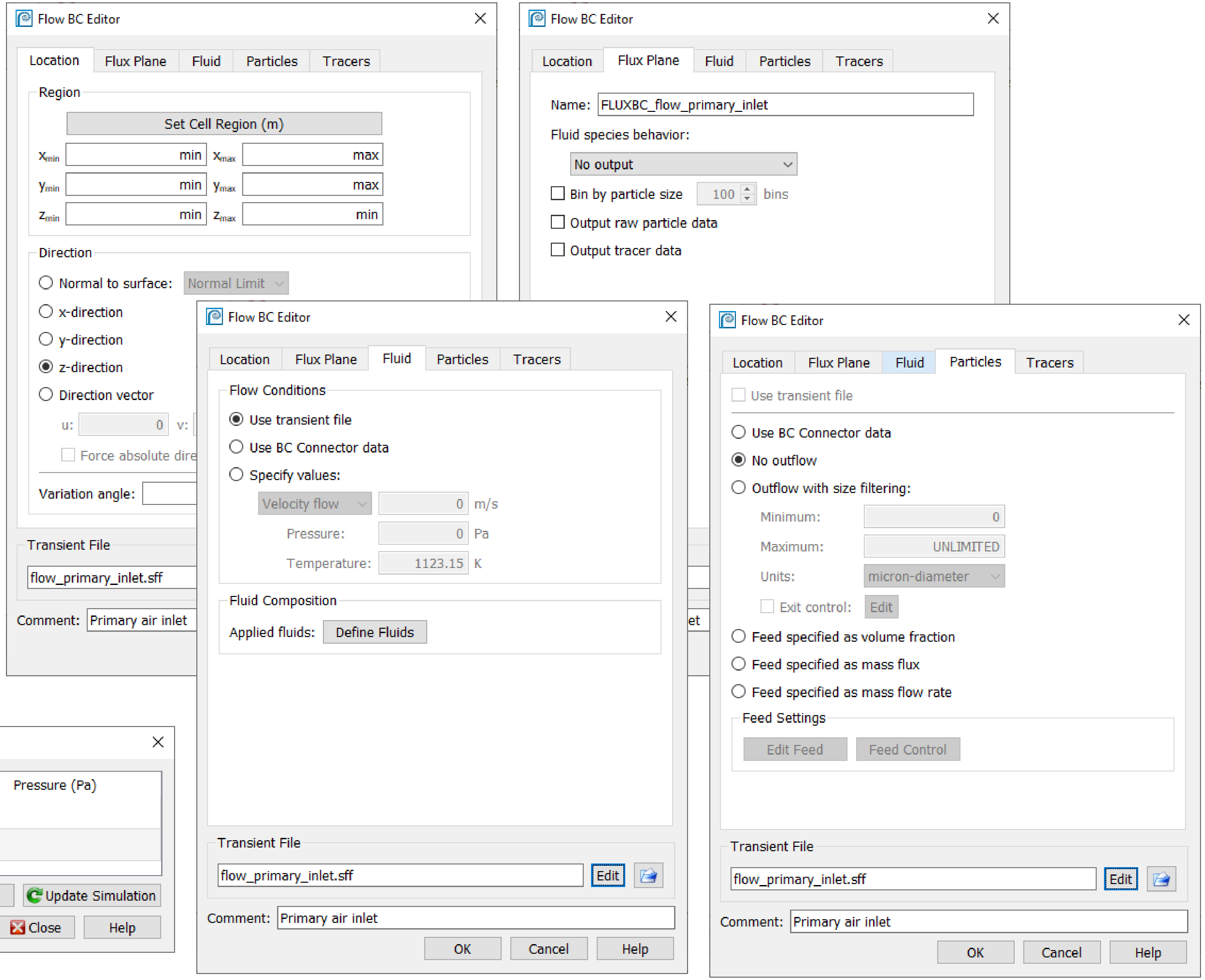


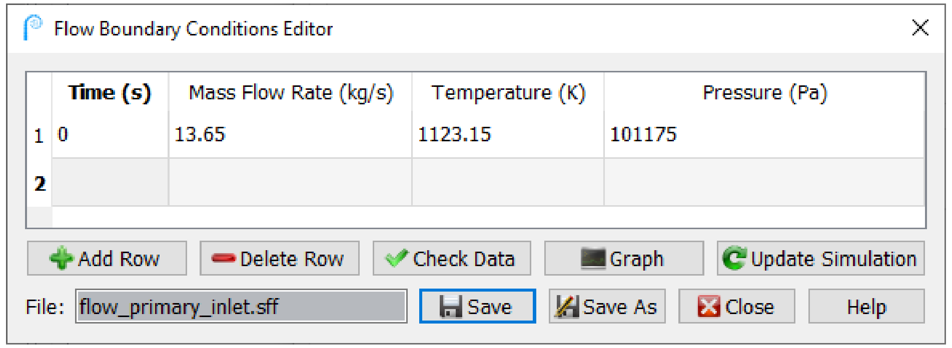


Flow BCs

Add flow BC with information shown here for primary air inlet.

Use 100% AIR for Applied fluids

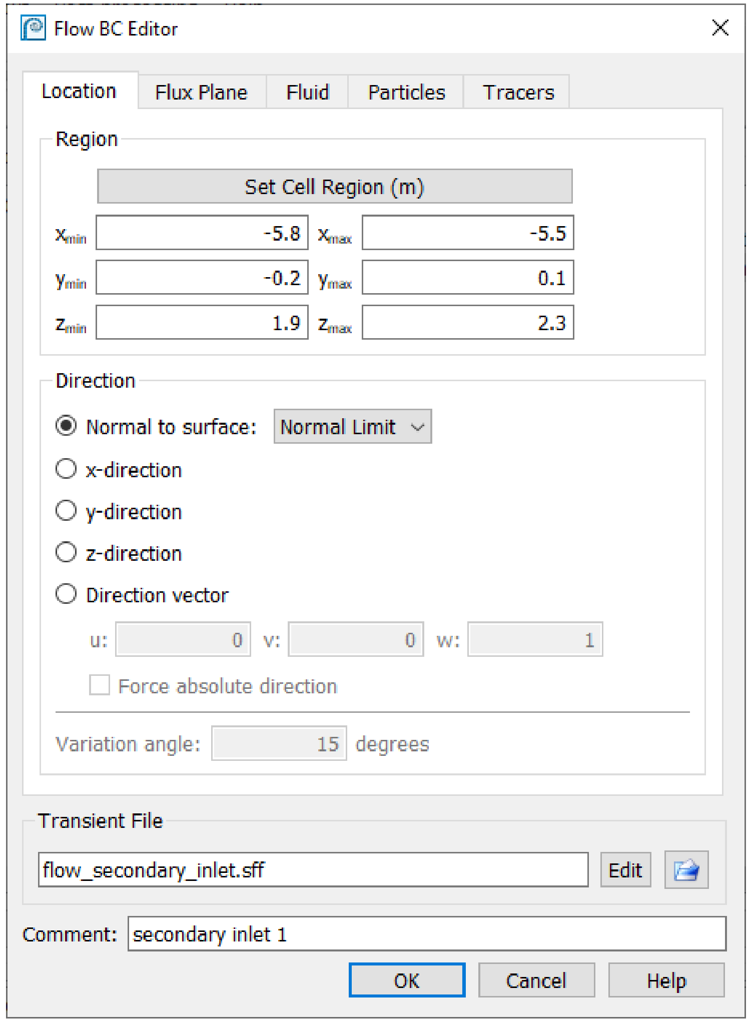


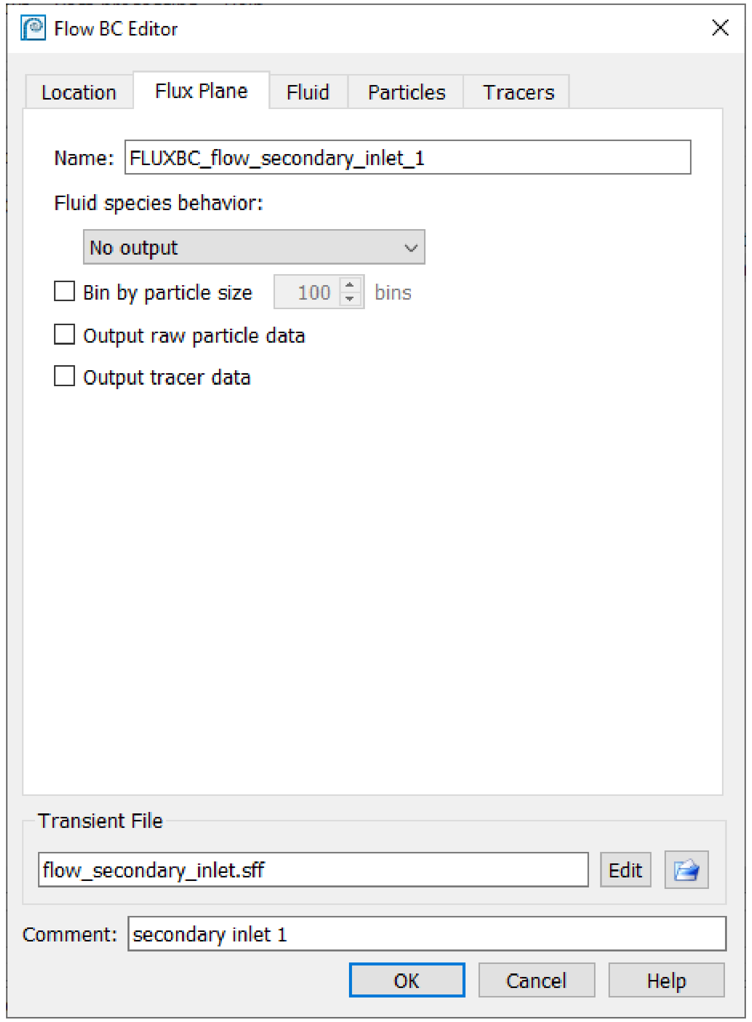


Flow BCs

Add flow BCs for 4 secondary air inlets.

Use information in the table to set the cell region and Flux Plane Name for each flow BC.





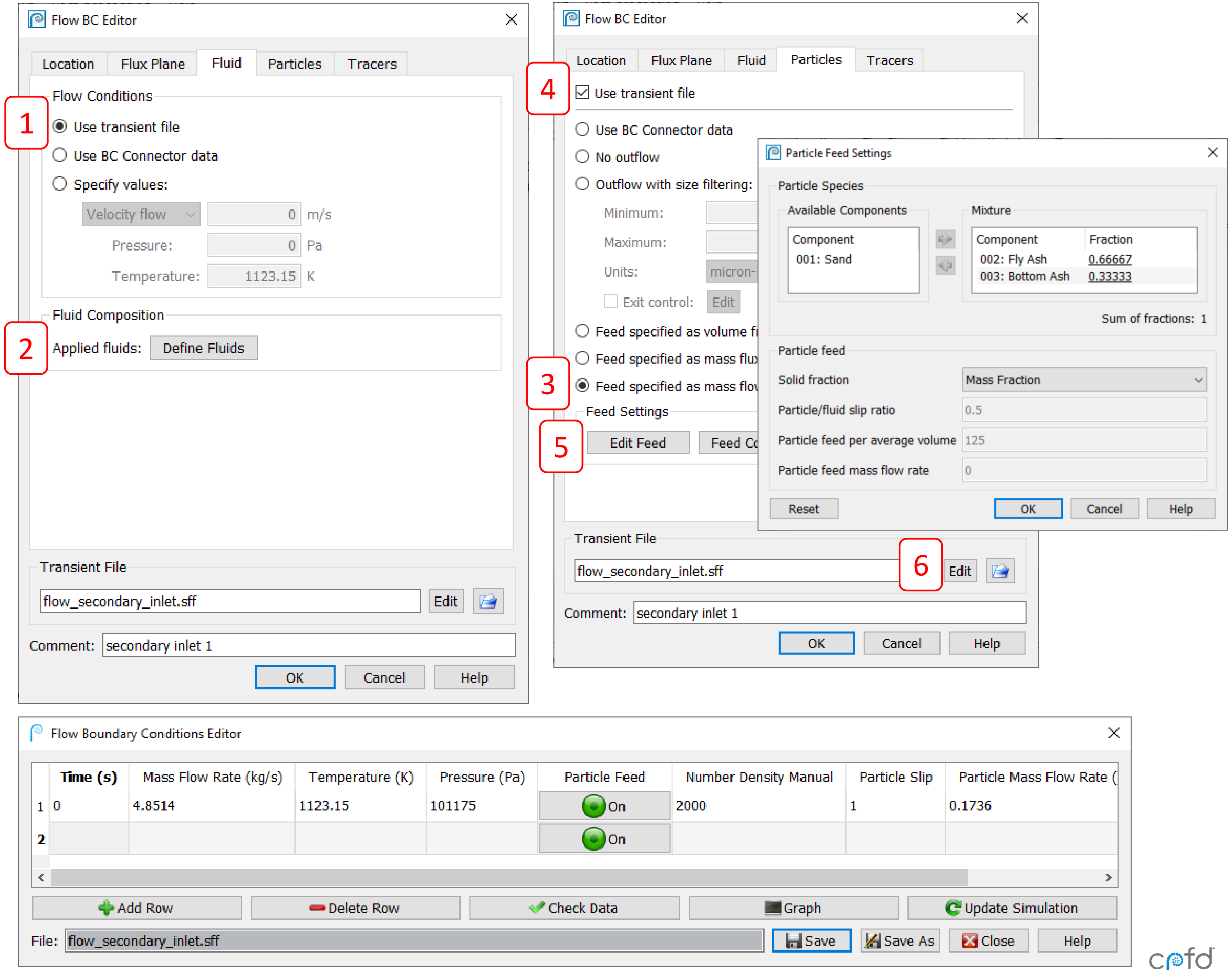
Secondary Inlet	xmin	xmax	ymin	ymax	zmin	zmax	Flux Plane Name
1	-5.95	-5.52	-1.63	-1.44	1.9	2.32	FLUXBC_flow_secondary_inlet_1
2	-5.95	-5.52	max	max	1.9	2.32	FLUXBC_flow_secondary_inlet_2
3	-6.57	-6.37	1.3	1.58	-2	-1.57	FLUXBC_flow_secondary_inlet_3
4	-6.57	-6.36	-0.53	-0.3	-2	-1.57	FLUXBC_flow_secondary_inlet_4

Flow BCs

Fill in the information in the numbered order shown here for the Fluid and Particles tabs.

Use 100% AIR for Applied fluids.

Use the same particle species mixture and flow_secondary_inlet.sff for all 4 BCs.

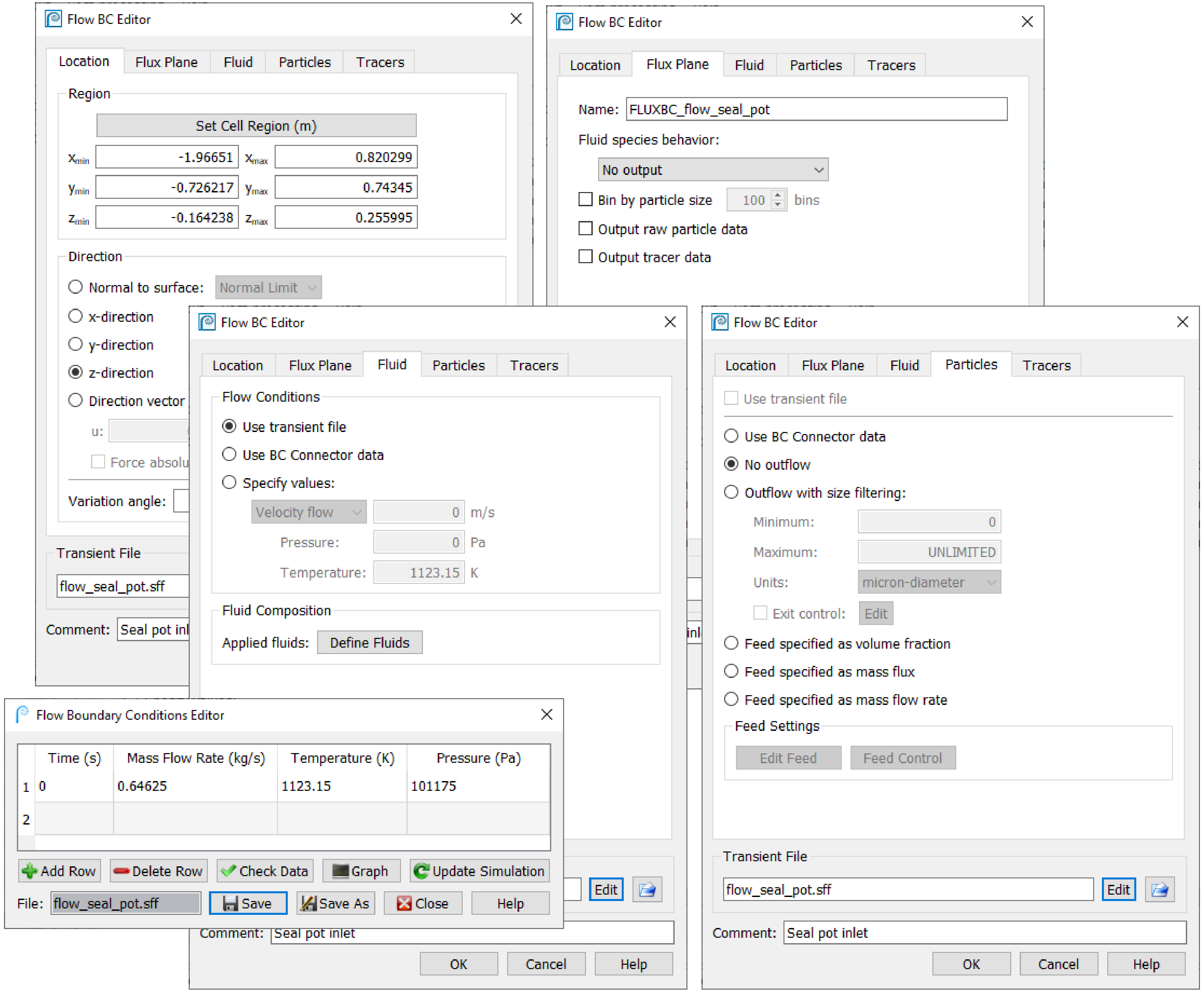


Flow BCs

Add flow BC with information shown here for seal pot air inlet.

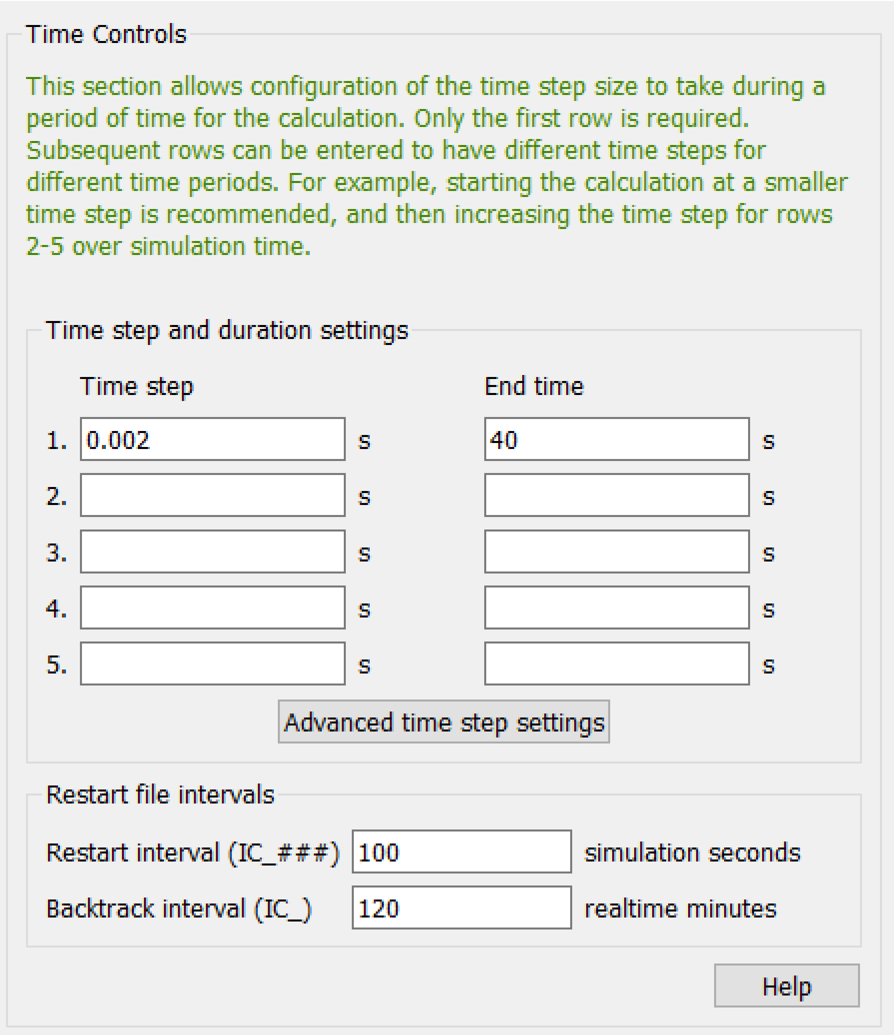
Use Set Cell Region to graphically select the bottom surface of the seal pot.

Use 100% AIR for Applied fluids



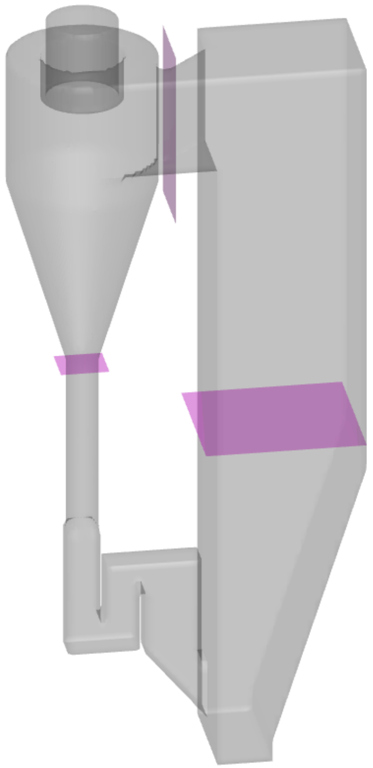
Time Controls

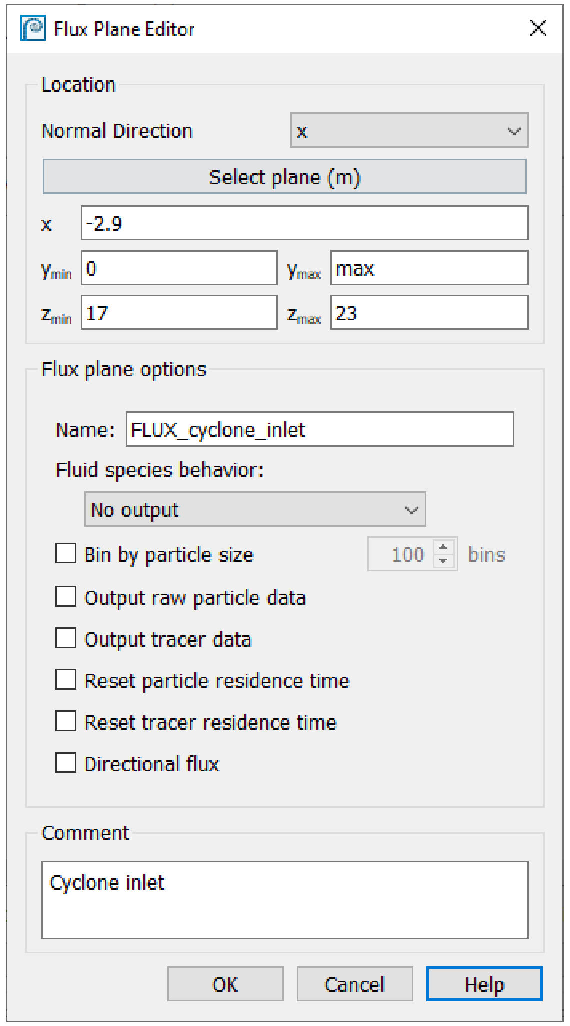
Set Time step and End time

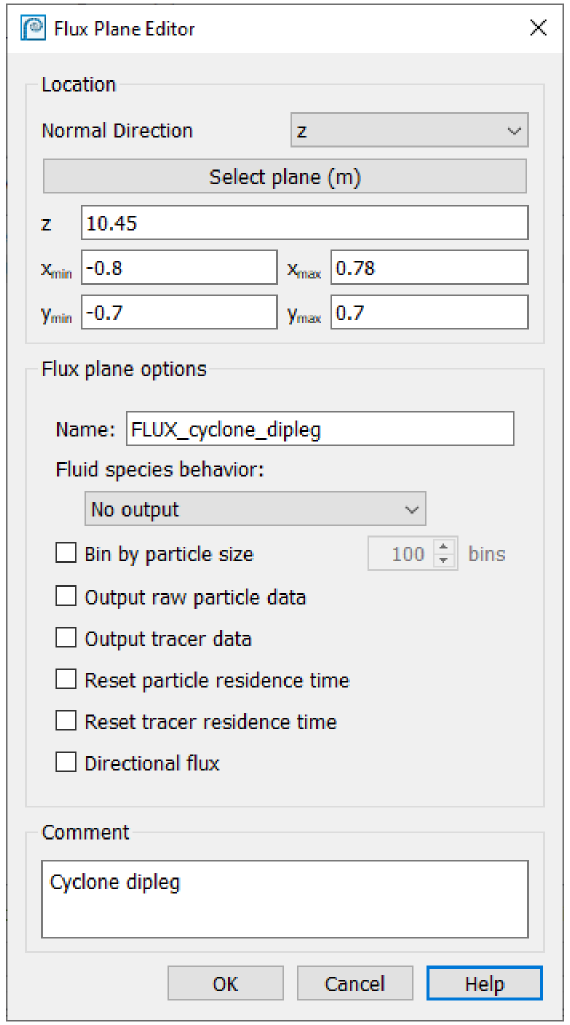


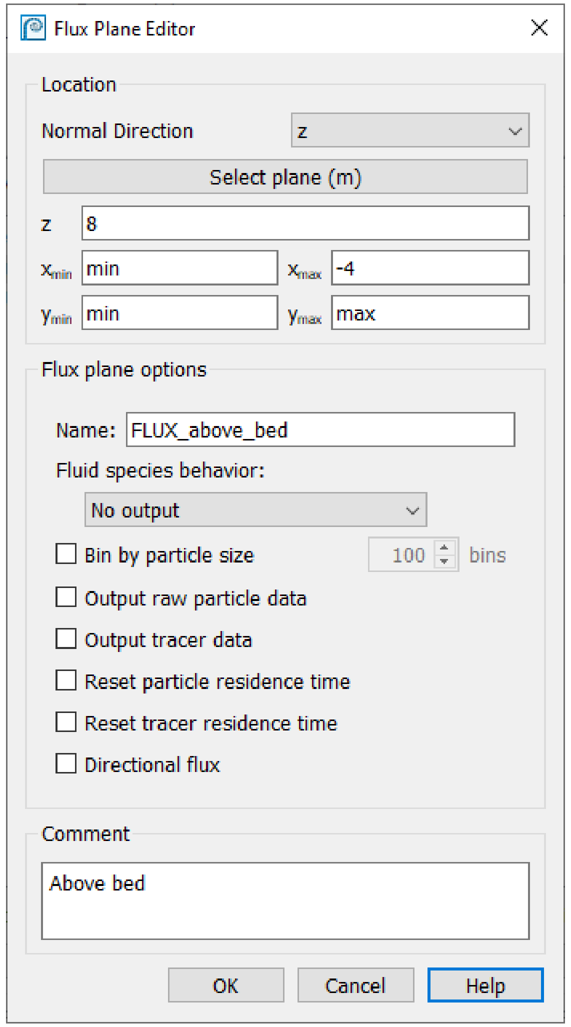
Flux Planes

Define 3 internal flux planes to track flow: cyclone inlet, dipleg, and above bed



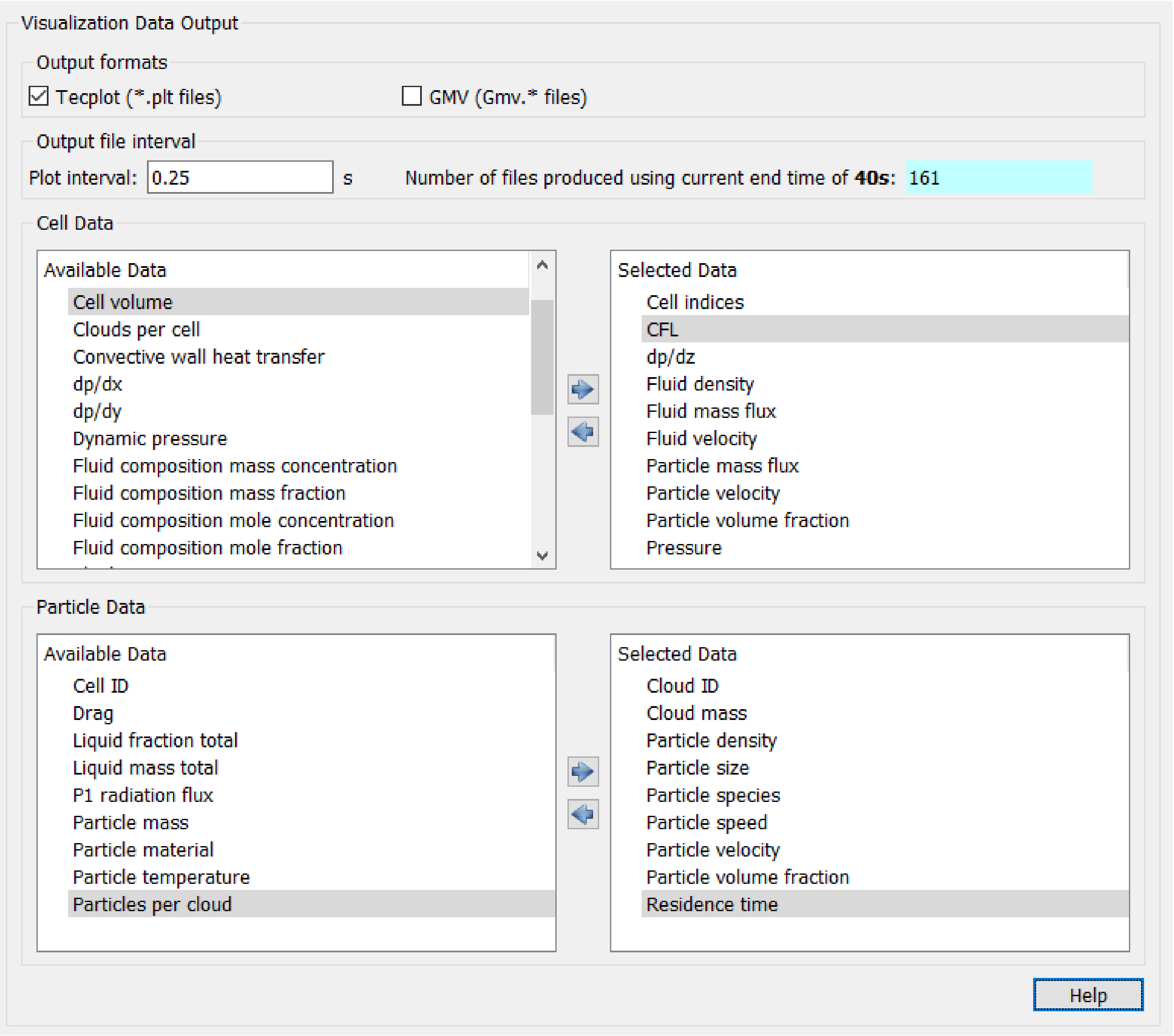






Visualization Data Output

Set Output file interval and select the options shown for Visualization Data Output.

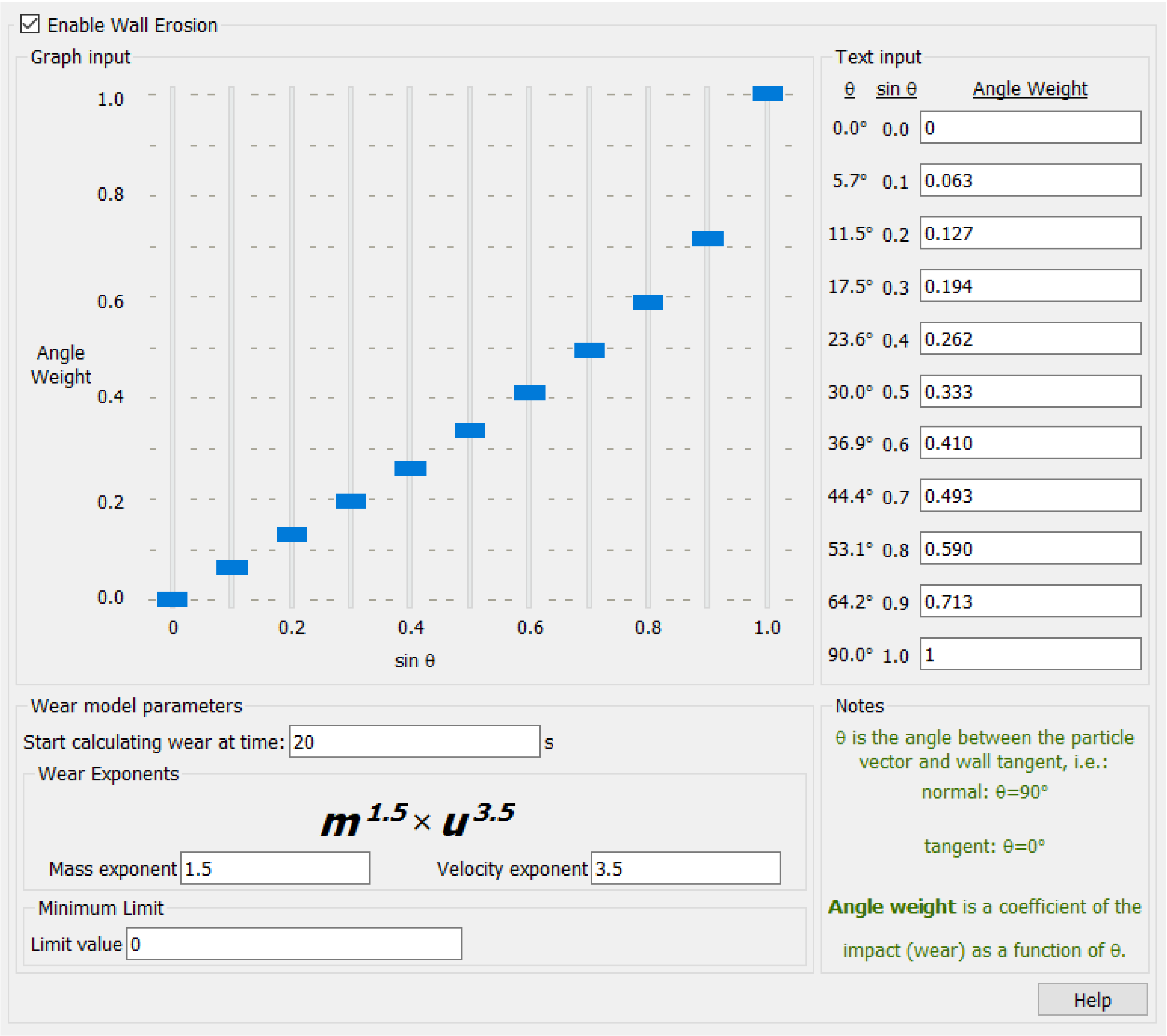


Wall Erosion

Select Enable Wall Erosion

Set the angular dependence for refractory based on this reference:

https://cpfd-software.com/how-do-i-set-wall-erosion-parameters-for-my-unit/

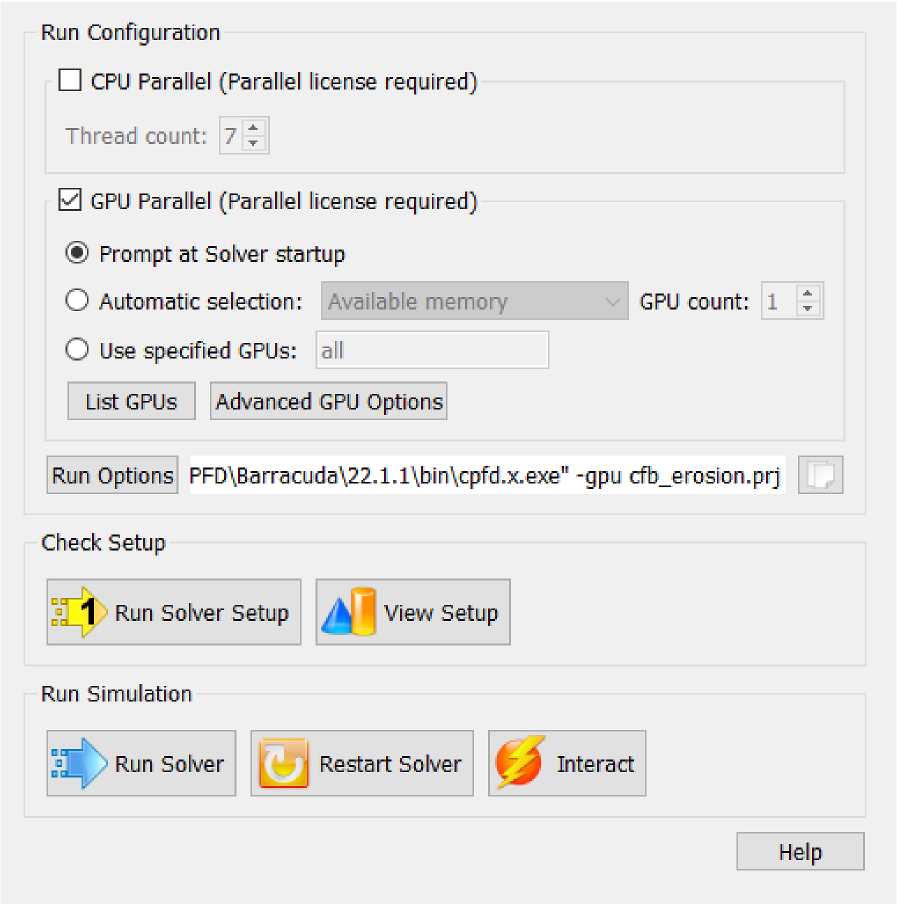


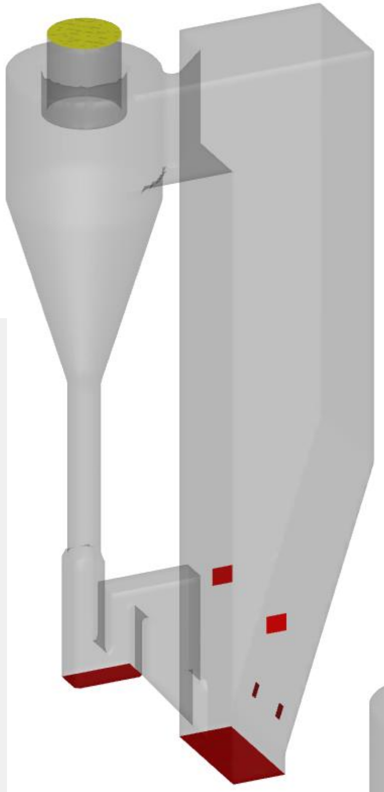
Run

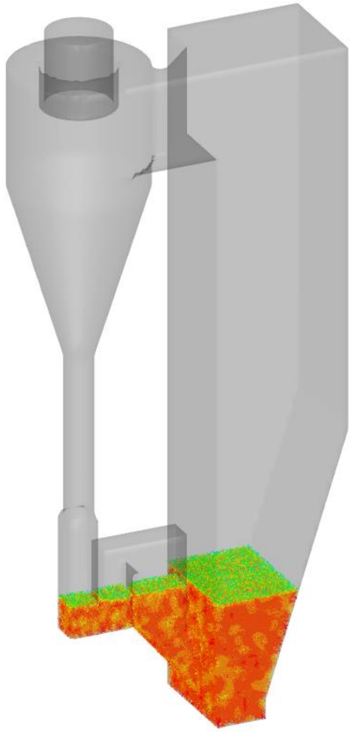
If NVIDIA GPU card is available, select GPU Parallel

Run Solver Setup and View Setup

Once you have checked the setup, Run Solver to start the simulation for Case 1





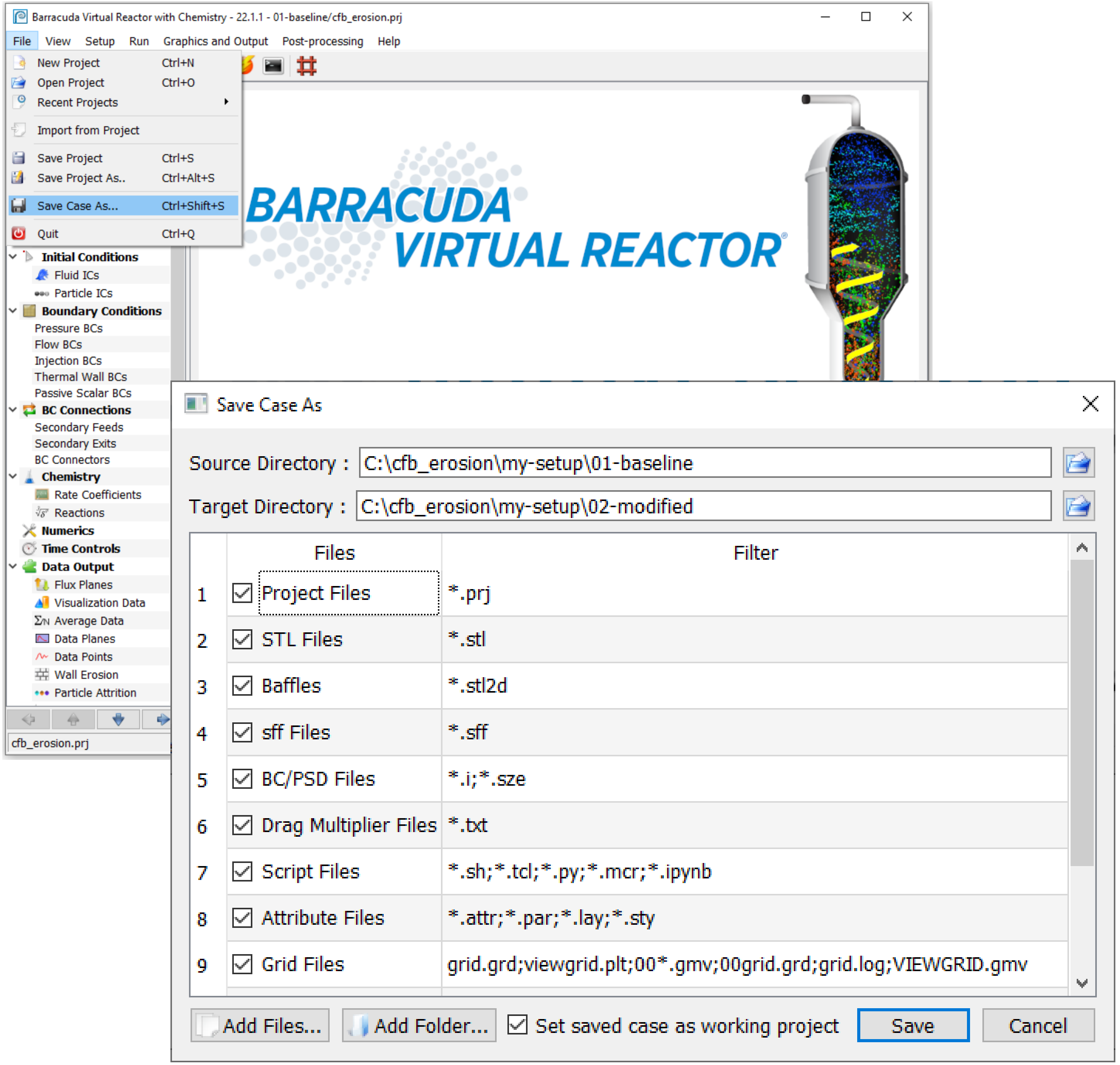


Save Case As...

The modified geometry project directory can be created from the existing project directory using Save Case As...

Select 02-modified as the target directory

Ensure Files 1-9 are selected and click Save



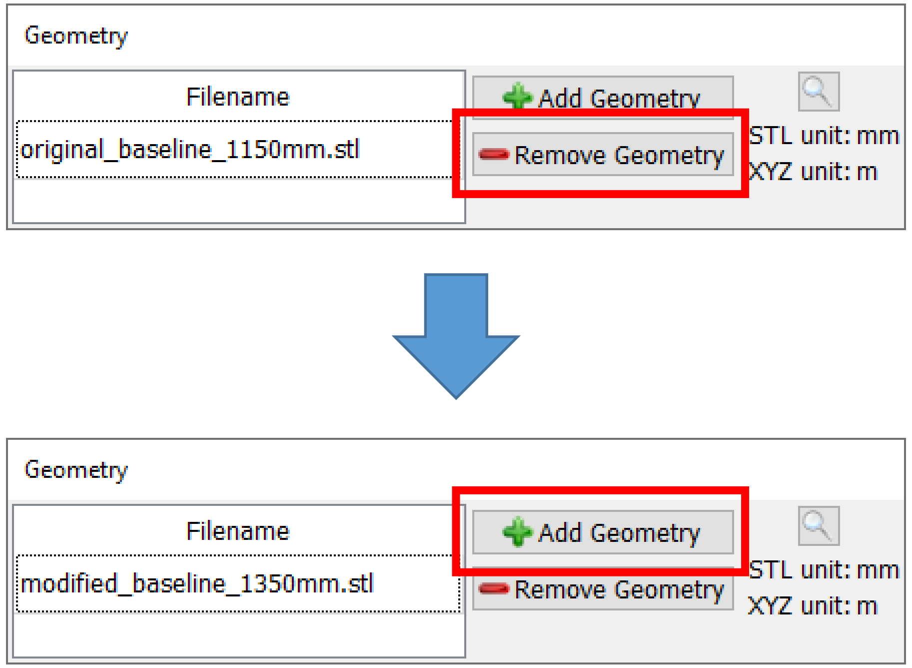
Case 2: Modified

In the 02-modified project, go to Geometry tab of Setup Grid

Highlight orginal_baseline_1150mm.stl and Remove Geometry

Add Geometry and select modified_baseline_1350mm.stl

Generate the grid

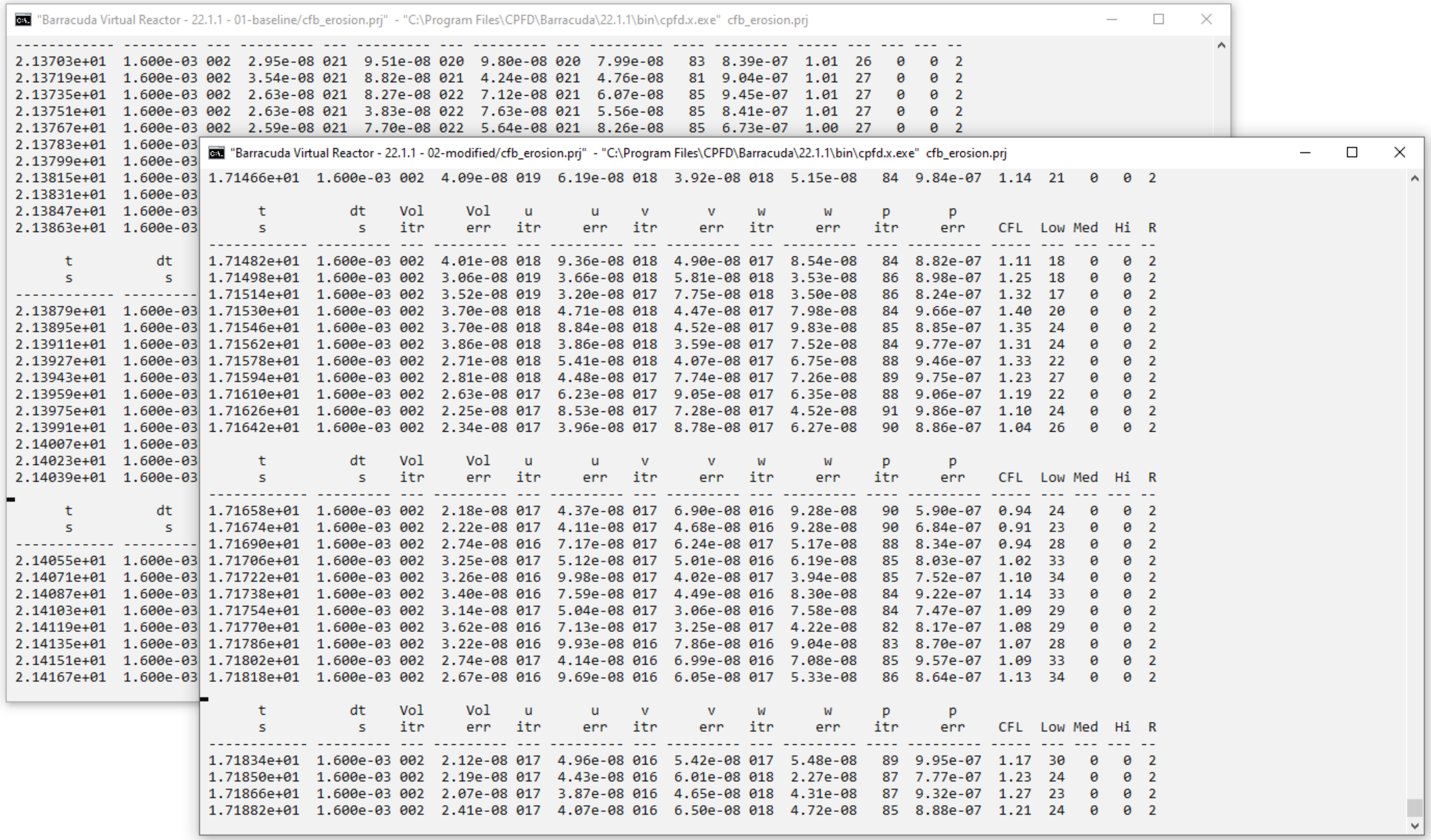


Case 2: Run

If you have access to two Barracuda licenses, you can run Case 1 and 2 at the same time

Run Solver on Case 2

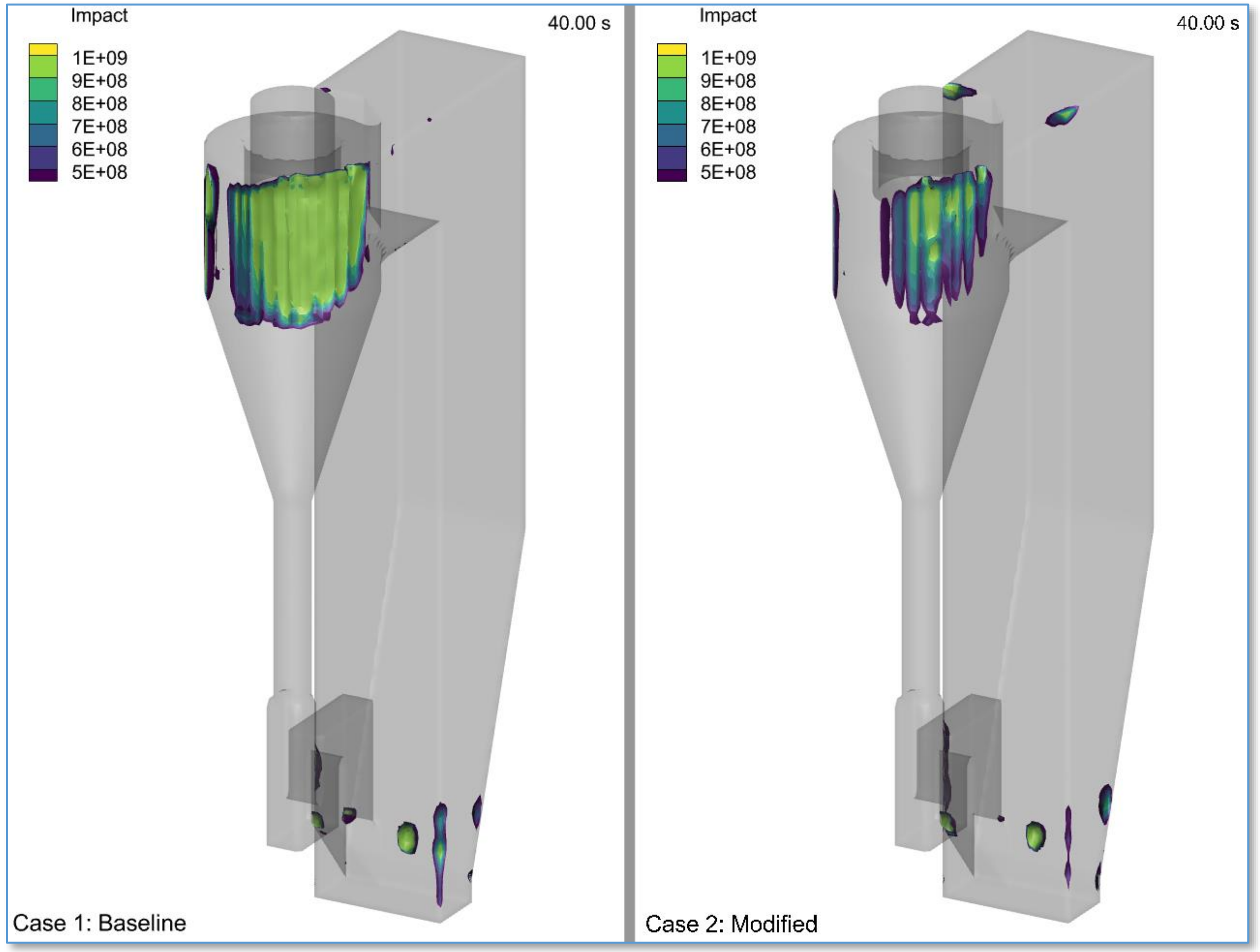
Allow both cases to finish running before starting on the post-processing



Post-Processing: Cyclone Erosion

Follow along with this video to create your own view of erosion. Compare the erosion in the cyclone in Case 1 with Case 2.

https://cpfd-software.com/tecplot-for-barracuda-using-isosurfaces-to-analyze-erosion-results/



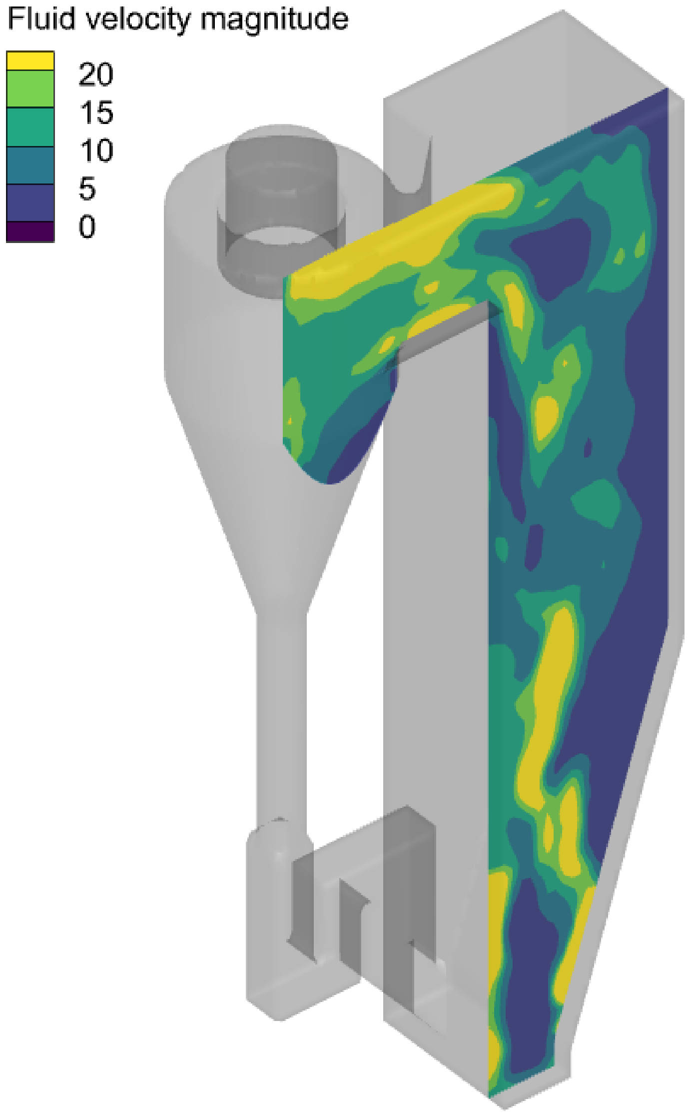
Post-Processing: Slices

Create a slice colored by fluid velocity magnitude through the center of the cyclone inlet

- Erosion is highly dependent on velocity so it is useful to visualize the velocity in the cyclone inlet tube in both cases

This video shows how to create slices:

https://cpfd-software.com/tecplot-for-barracuda-calculating-spatial-averages-on-slices/

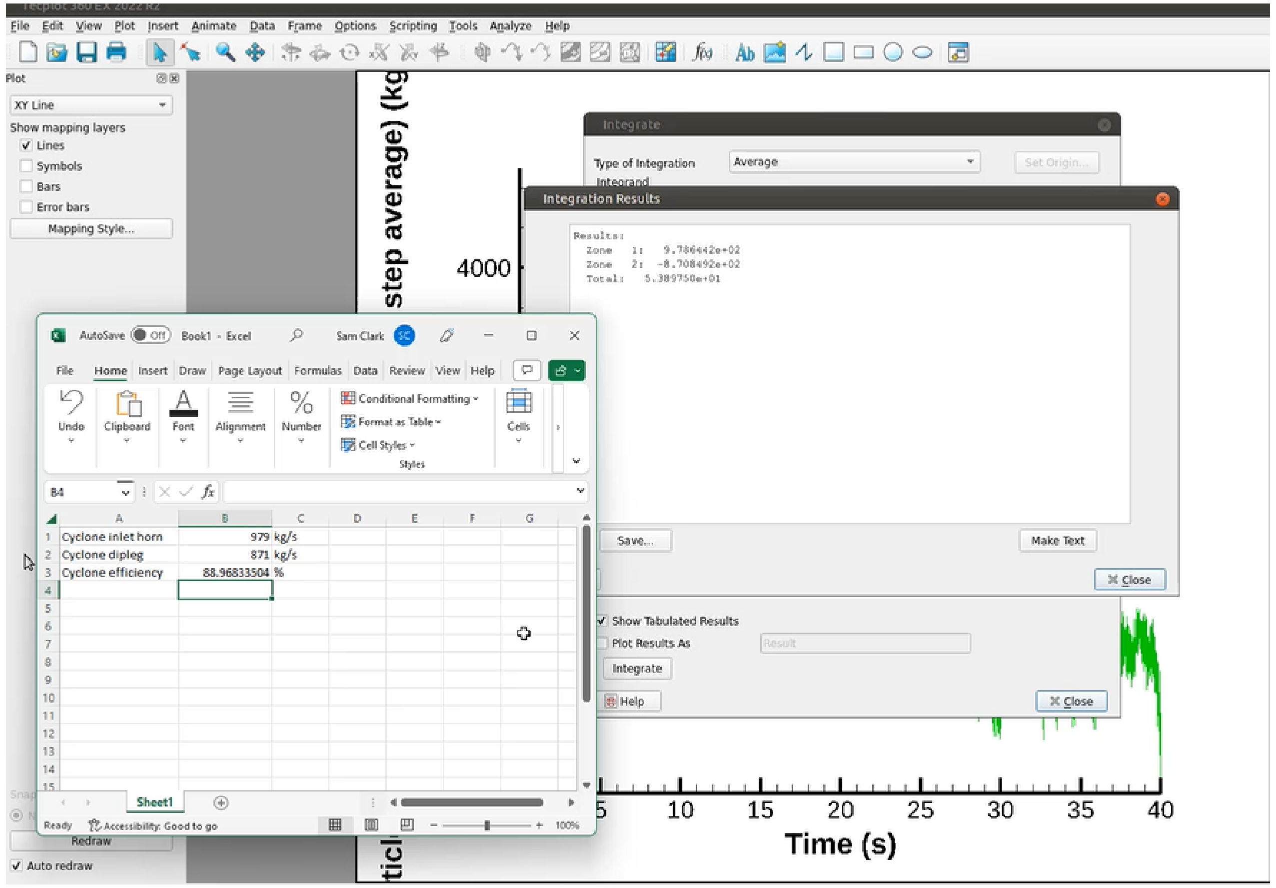


Post-Processing: Cyclone Efficiency

Follow along with this video to create an xy plot in Tecplot using flux plane data to calculate cyclone efficiency.

- Calculate the efficiency for both cases and compare

https://cpfd-software.com/tecplot-for-barracuda-calculating-cyclone-efficiency/



Summary

This model showed an example of a CFB loop simulation based on a real industrial application.

Post-processing techniques for viewing and comparing erosion and cyclone efficiency were shown.