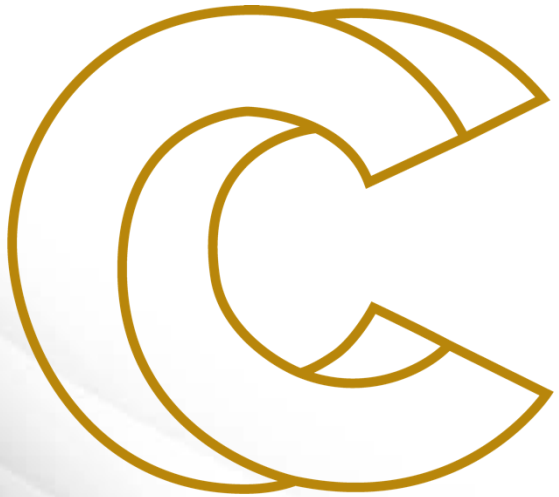

EURO^2

Introduction to Computational Fluid Dynamics

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The CFD process

Problem identification

- What do we want?
- What do we have?

Pre-processing

- Geometry
- Grid
- Physical model
- Turbulence

Solving

- Monitoring the simulation

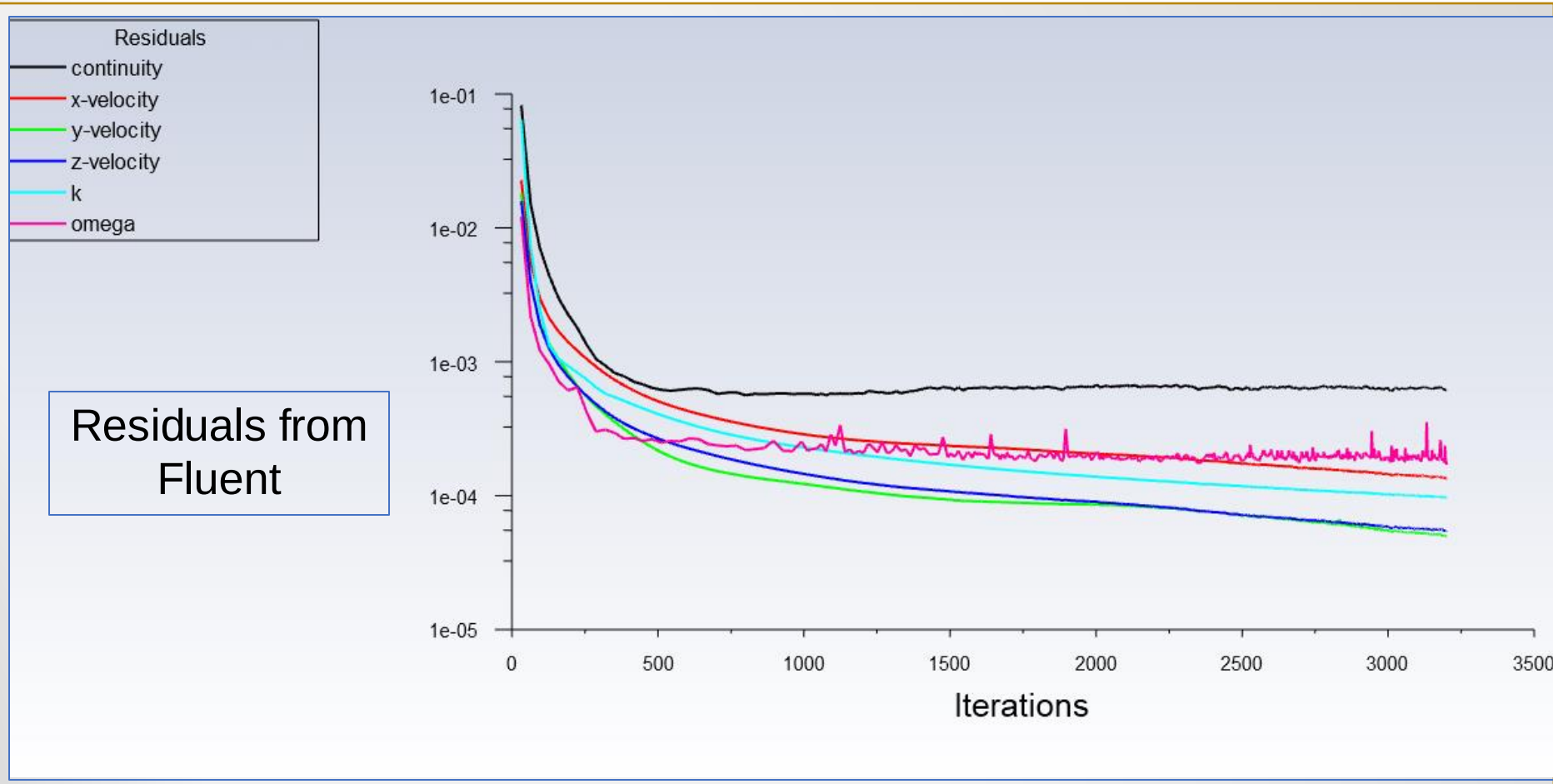
Post-processing

- Interpretation the results
- Report
- Update the model

Solving – Residuals

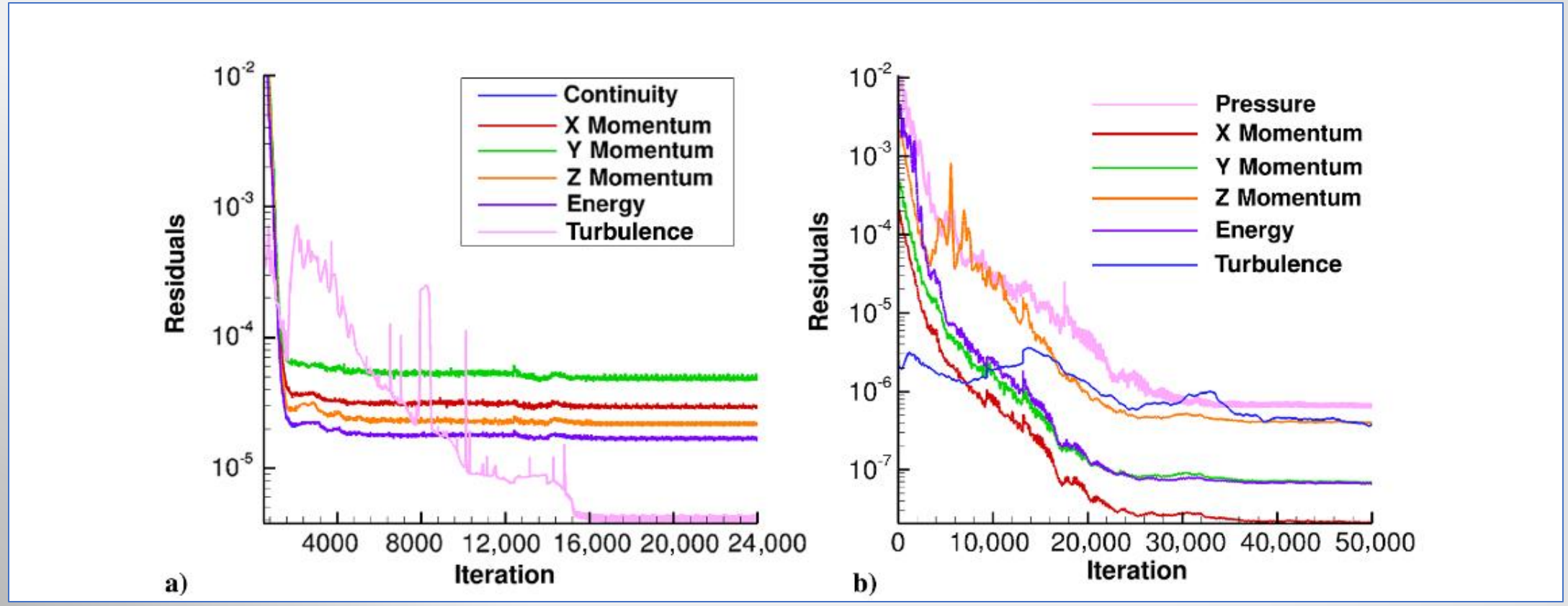
After completing the setup then we start the simulation

We need to decide when the simulation is converged



Residuals from Fluent

Solving – Residuals

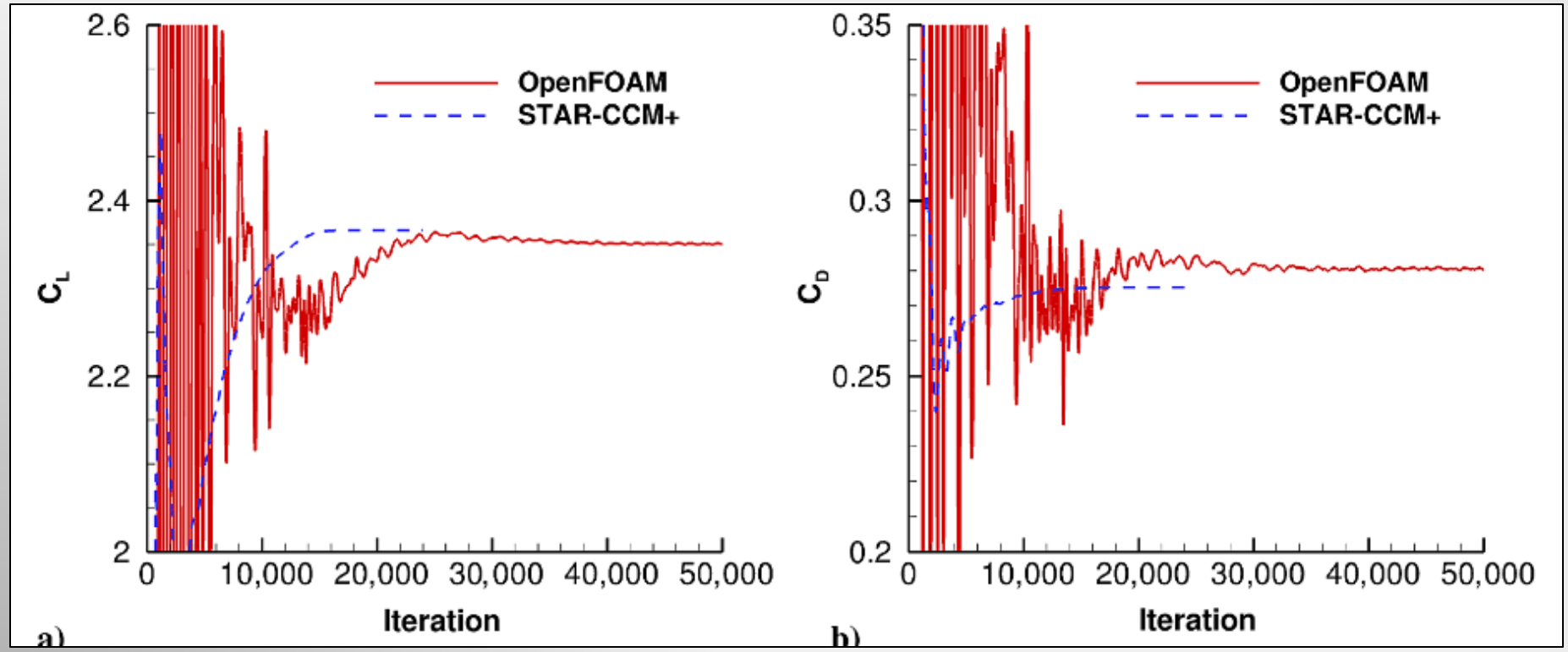


Residuals from STAR-CCM+

Residuals from openFOAM

Solving – Residuals

(Ashton, 2019)



Any quantity of interest should become constant too

Solving – CFL Number

CFL Number is a very important parameter for unsteady problems.

If it is high enough, then the solution blows up

$$CFL = \frac{u\,\Delta t}{\Delta x} = \frac{u}{\Delta x/\Delta t} = \frac{\text{speed of the PDE}}{\text{speed of the mesh}}$$

There is no magical number but it should be lower than 1.

If it is too low, then the computational time increases significantly

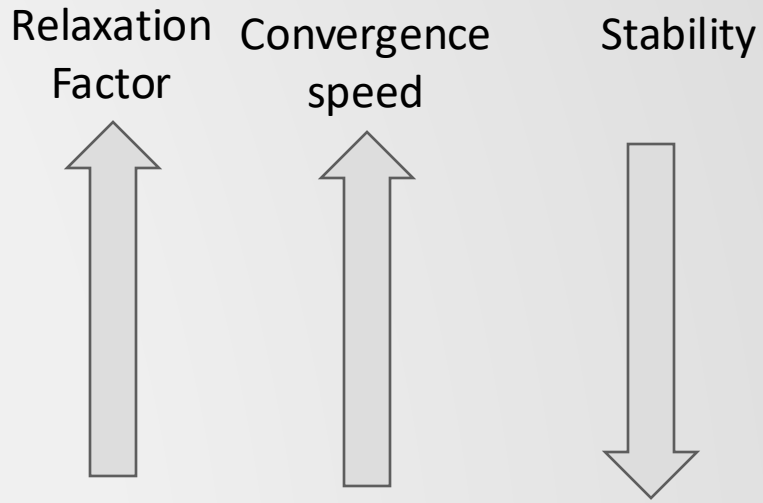
If the solver is implicit, then it is irrelevant.

Solving - Relaxation Factor

Under-relaxation is a technique that involves restricting the magnitude of a variable's alteration from the preceding iteration to the subsequent one.

< 0.15 it will slow down the solution too much.
> 0.7 can cause unstable solution.
> 0.9 can cause divergence.

The values between $0.3 < \alpha < 0.7$ are recommended.



Post-processing

Post-processing is the way you present your results. Your results' quality is irrelevant if you cannot present them properly.

How?

Tables or lists

X-Y plots

Contour plots

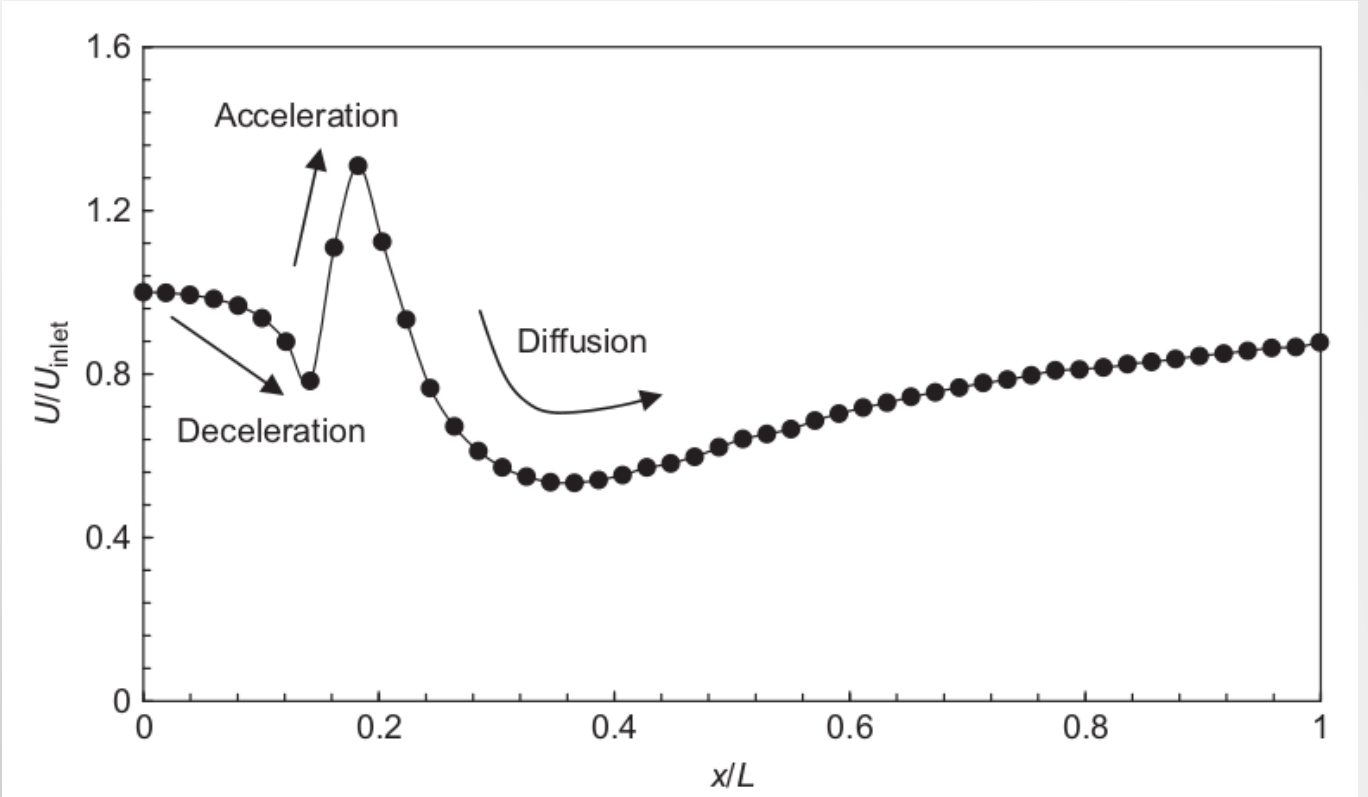
Animations

There are many post-processing software. Do not limit yourself with the built-in ones

- Paraview
- Tecplot
- Ensight

Post-processing

X-Y Plots

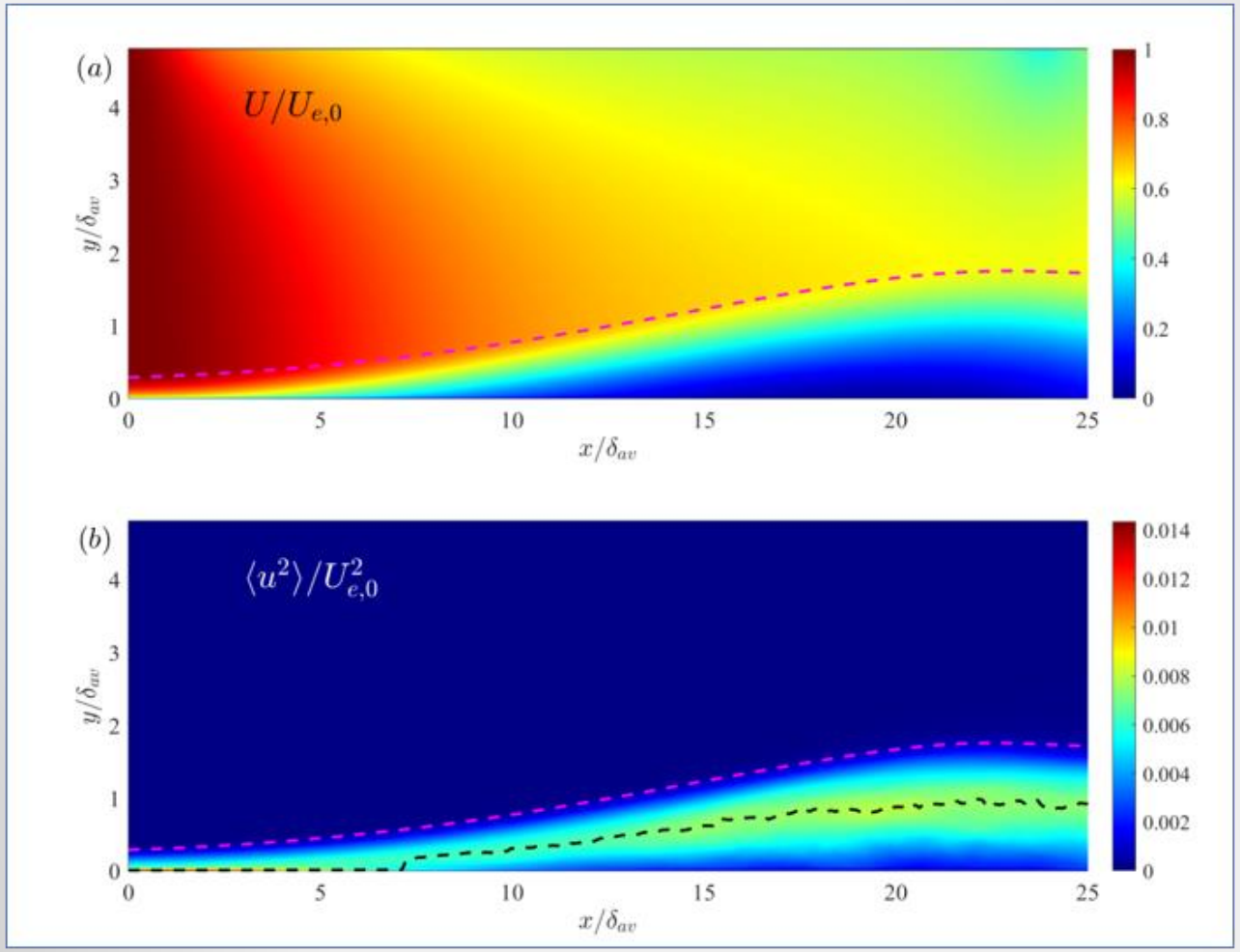


Change of the velocity as a function of x.

Post-processing

Contotur plots

They can provide global information about the flow

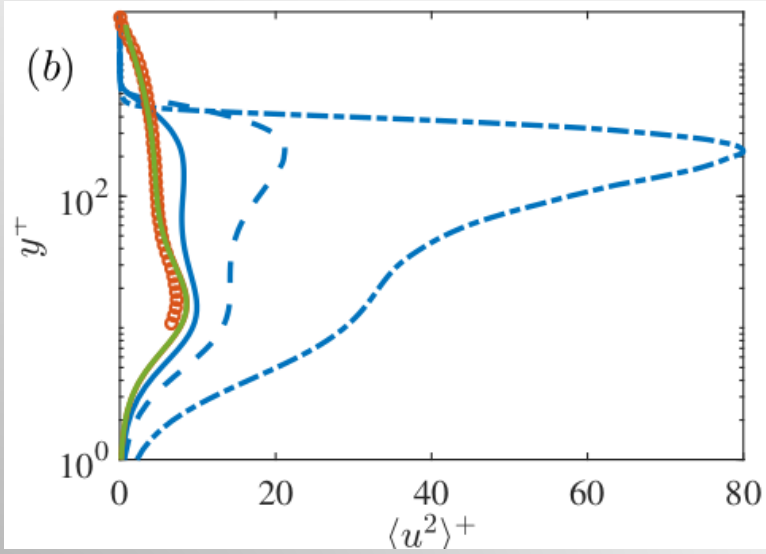


Mean velocity

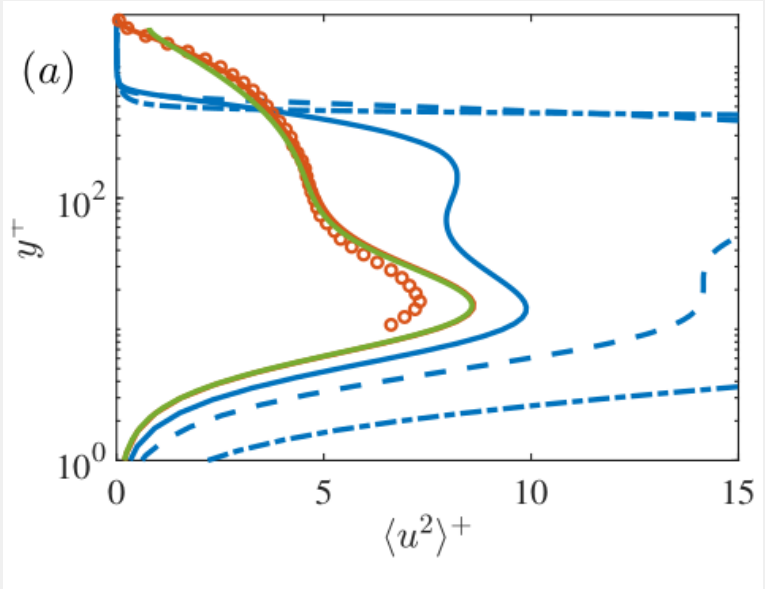
Reynolds stresses

Post-processing

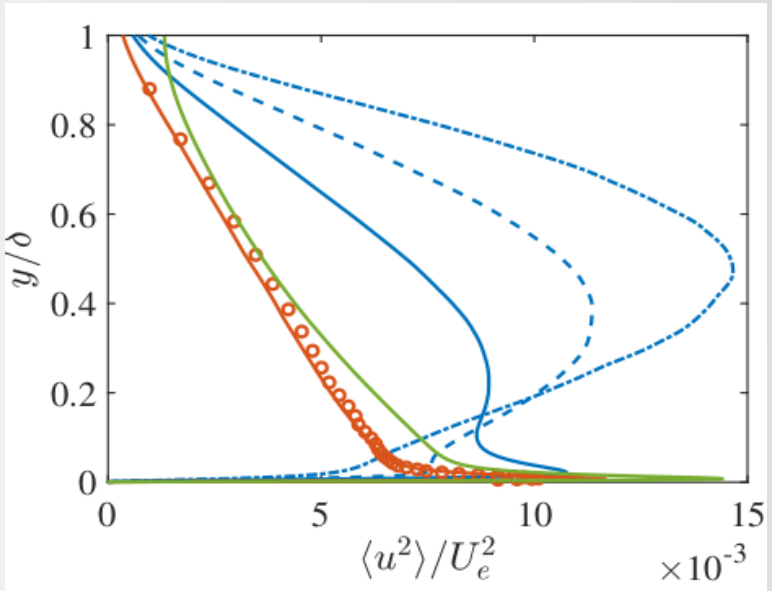
You need to plot the quantites in the best way to extract the maximum information from the results



Logarithmic y-axis with a zoom in the inner layer as a function of y+



Logarithmic y-axis without a zoom in the inner layer as a function of y+

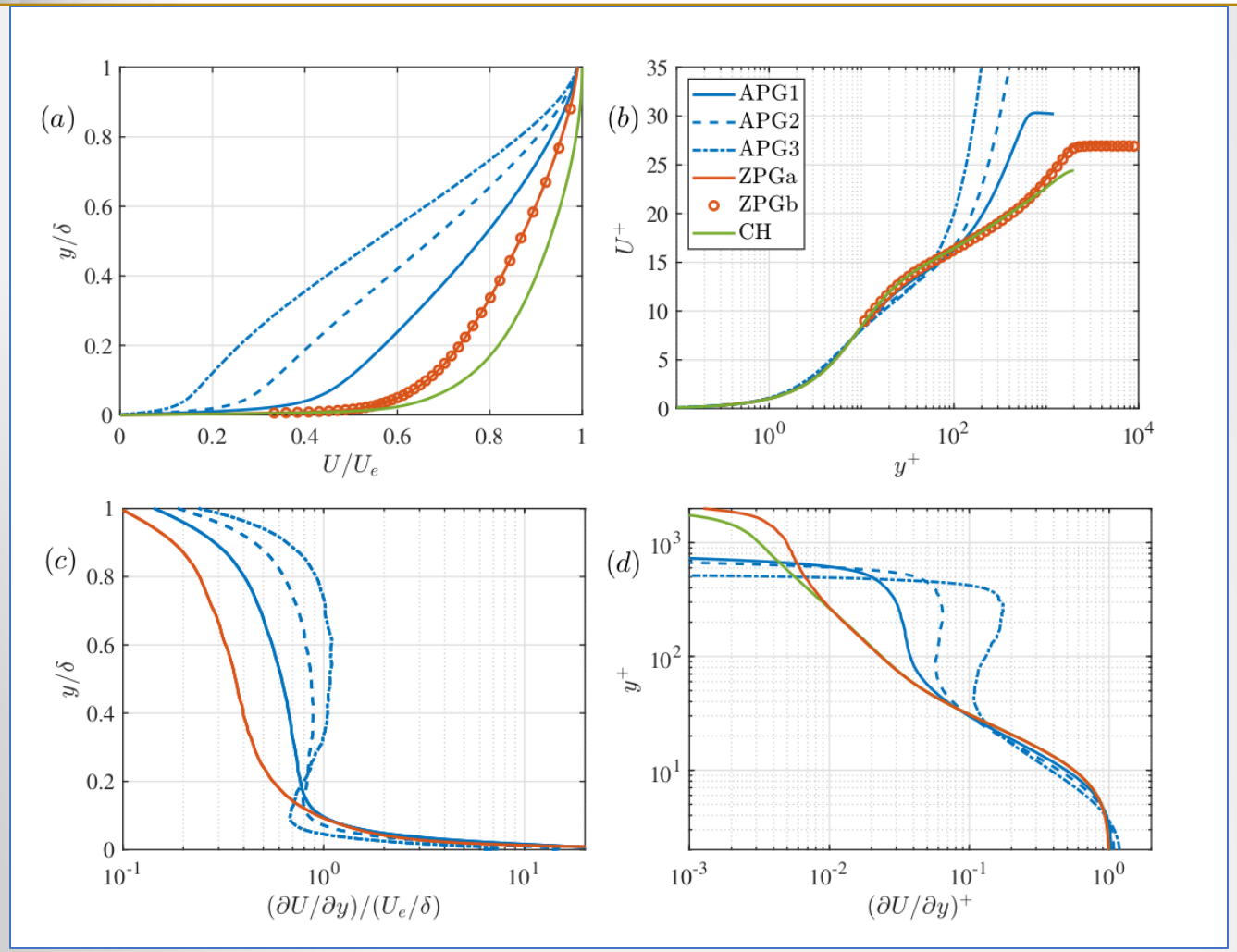


Linear y-axis as a function of y.

Post-processing

Mean velocity

Mean shear

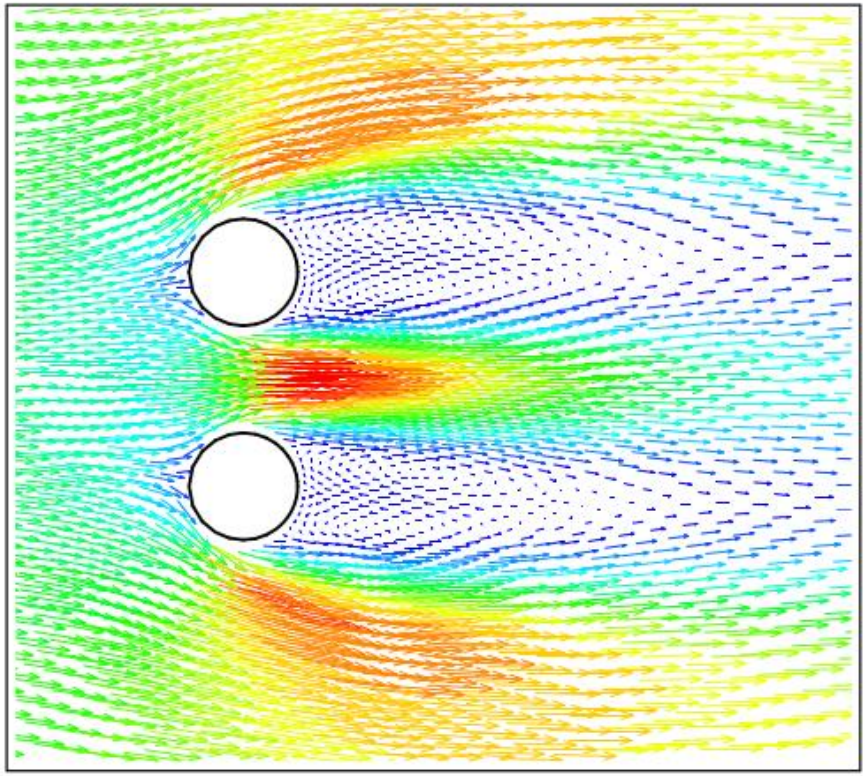


The profiles can be very important to understand the flow even though they are not that pretty.

Post-processing

Vector Plots

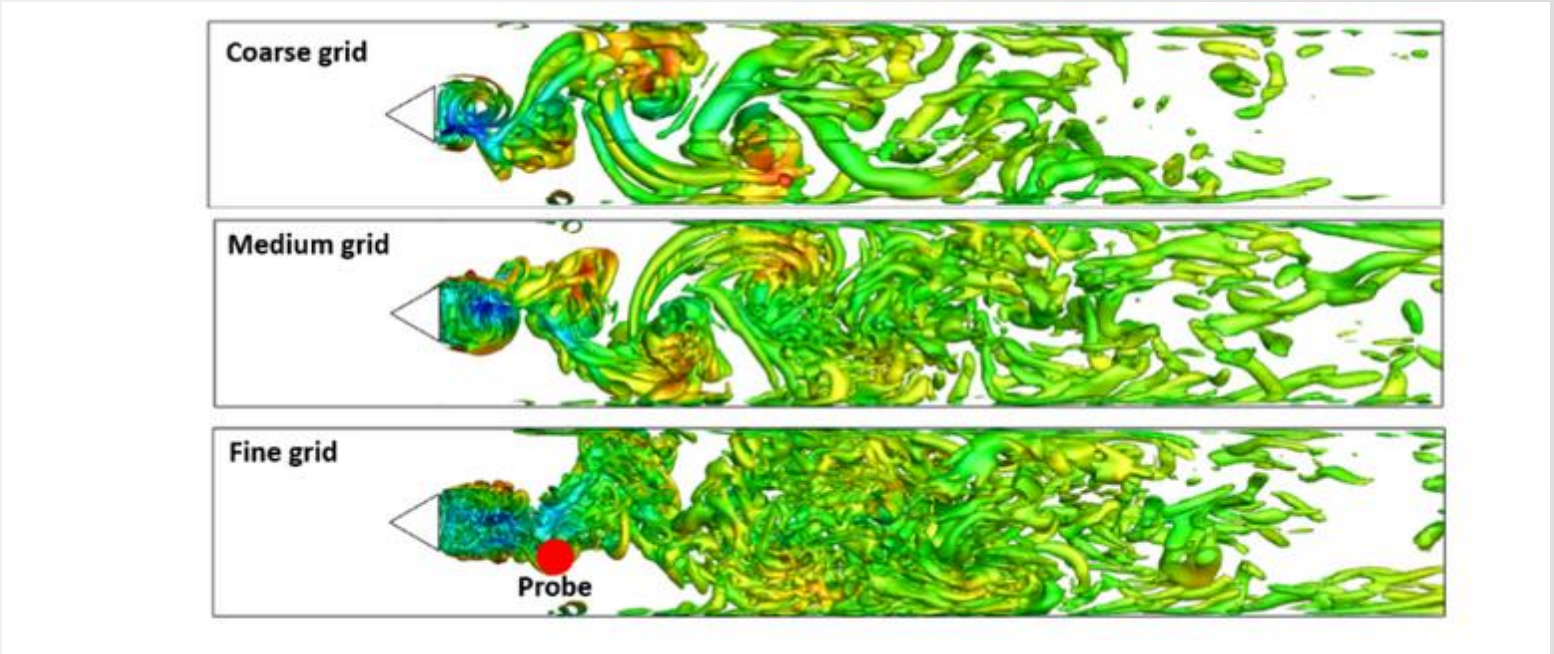
Velocity vectors flow between cylinders



Post-processing

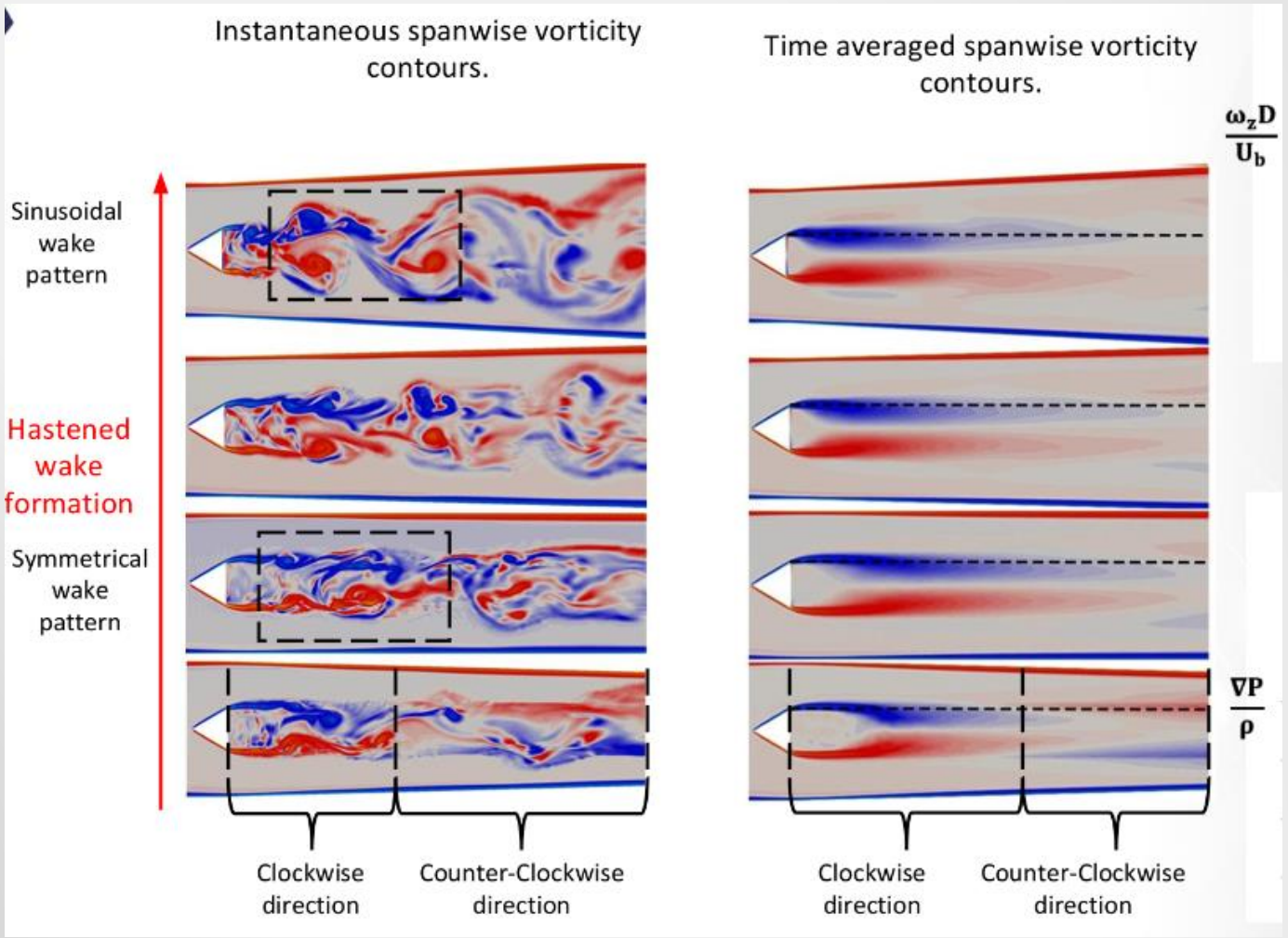
Instantaneous views

They are useful to see the flow at one instance



Post-processing

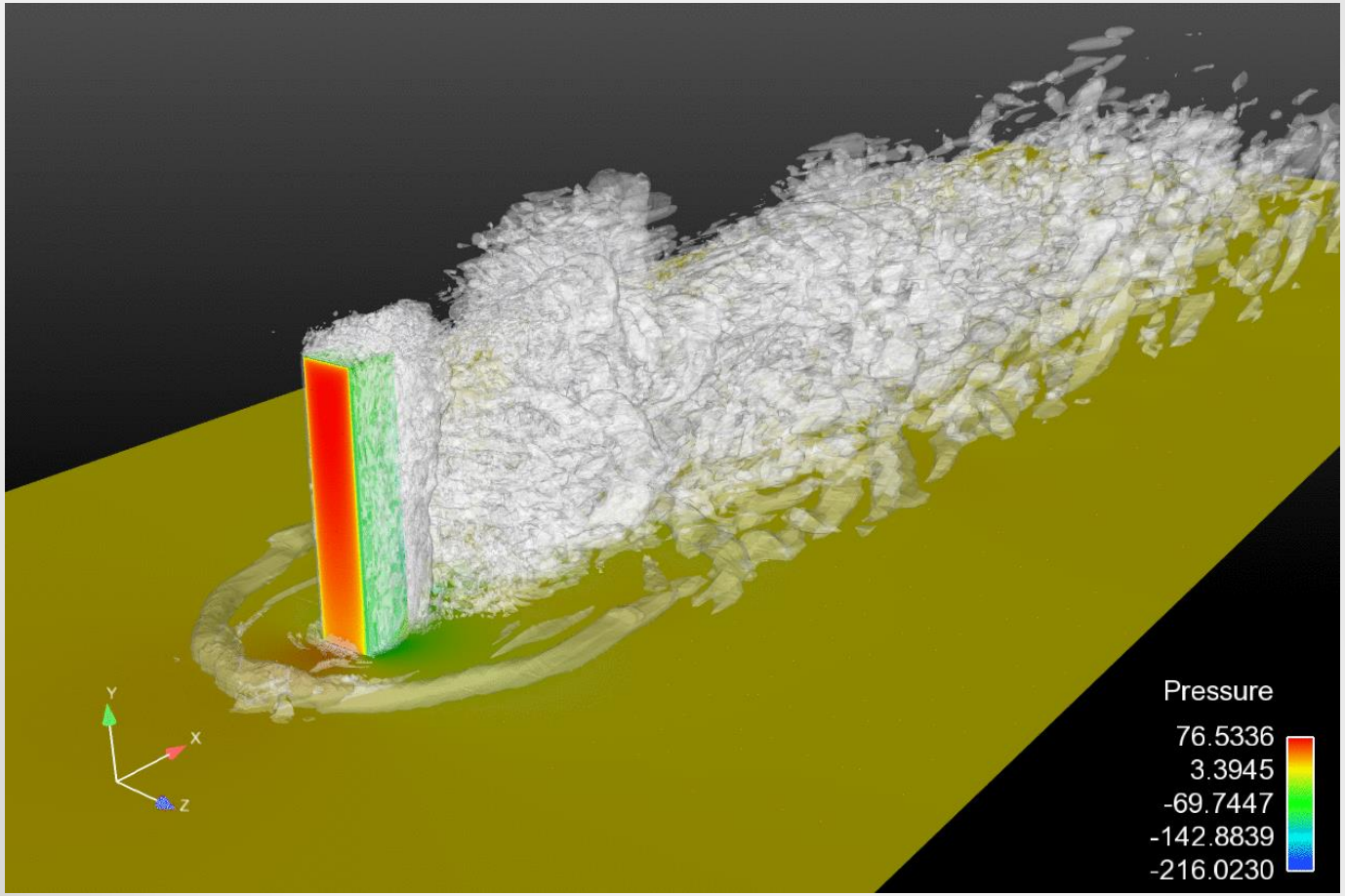
Contotur plots



Post-processing

Animations

Iso-surfaces of Q criterion. Walls colored by instantaneous pressure.



Thanks

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