CFD Simulations using Feel++

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August 25, 2020

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The objectives of this work is to study different flows with Feel++

- Laminar Isotherme Backward Facing Steps Benchmark
- Numerical simulations of flow past three circular cylinders in equilateral-triangular arrangements
- Forces and flow around three side-by-side square cylinders
- Proximity Effects on Characteristics of Flow around Three Inline Square Cylinders

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The results obtained with Feel++ are compared with the results in the articles

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Introduction to Computational Fluid Dynamics

- CFD insight

- CFD prosses

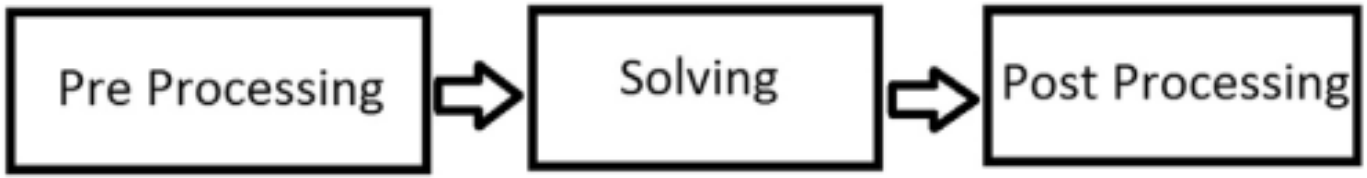

Figure 1.1 The computational fluid dynamics process.

- CFD governing equations
  In principle, all three parameters must be conserved:
  - Conservation of mass
  - Conservation of momentum
  - conservation of energy

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Presentation

The study was based on a laminar flow around a step laid in a flat channel for two different Reynolds number values: $Re = 389$ and $Re = 1095$ at different downstream locations.

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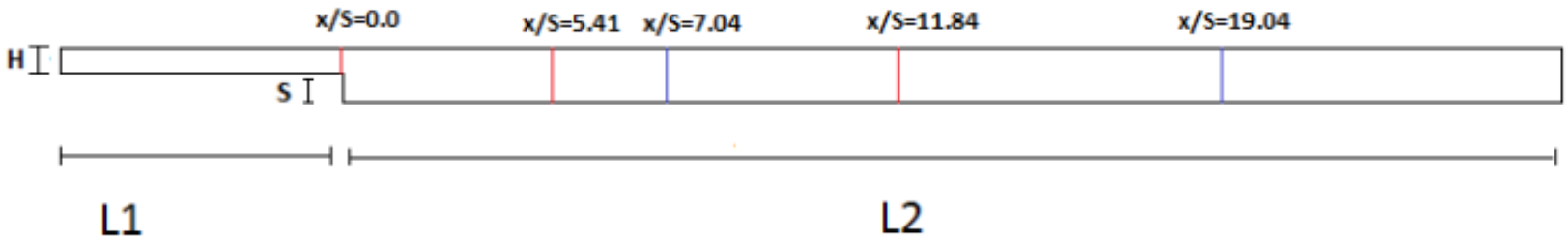

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The graph below show the comparison of the theorical solution with simulate flow solution for:

- $x/S = 0.0$

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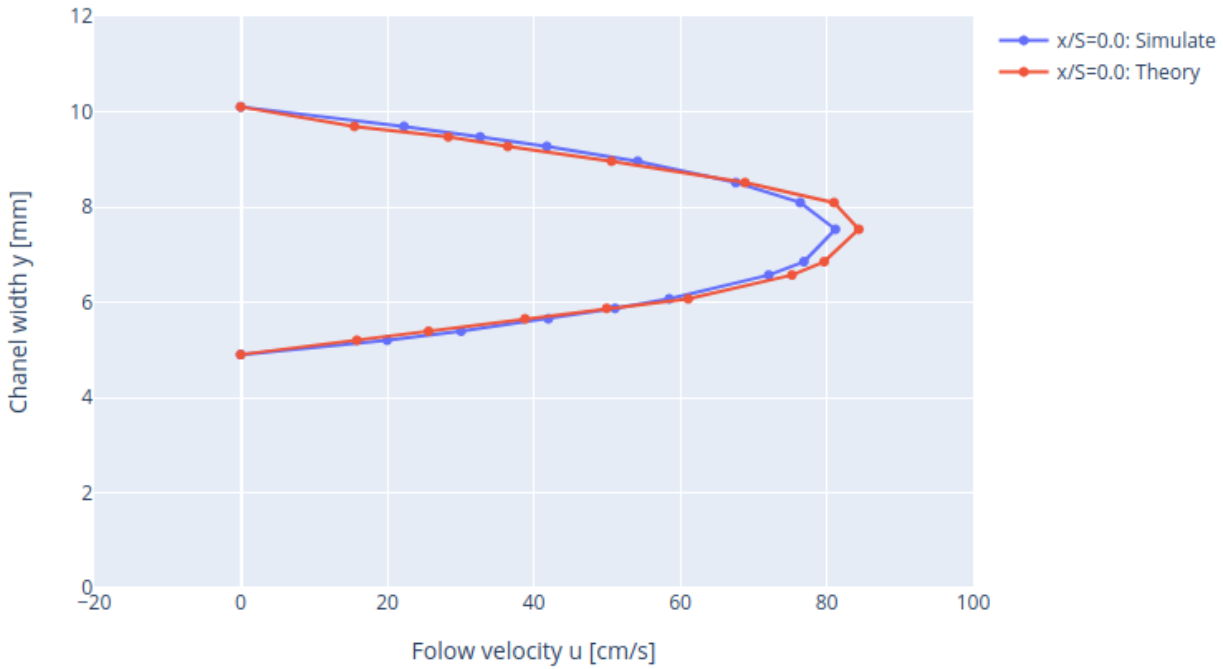
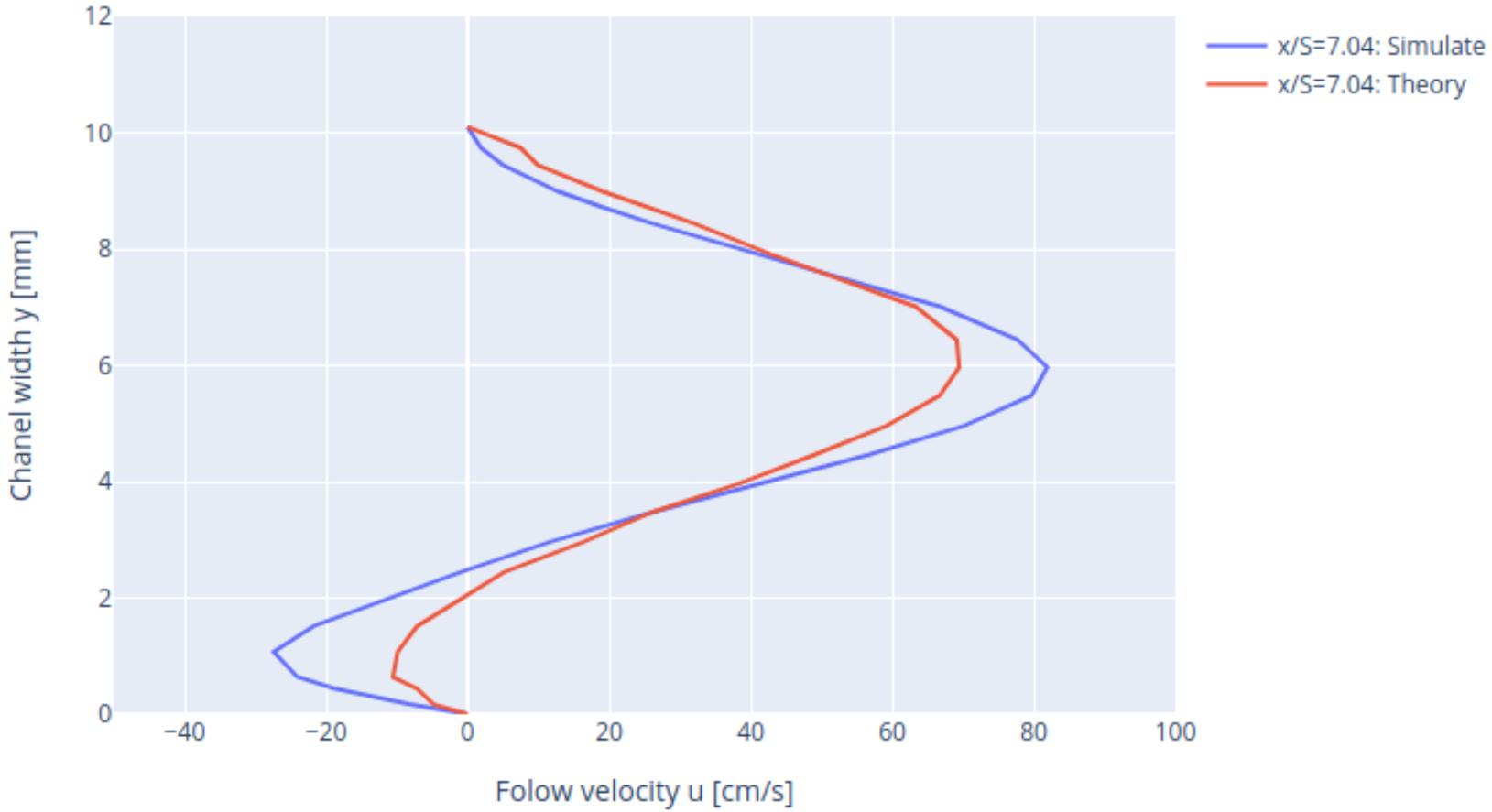
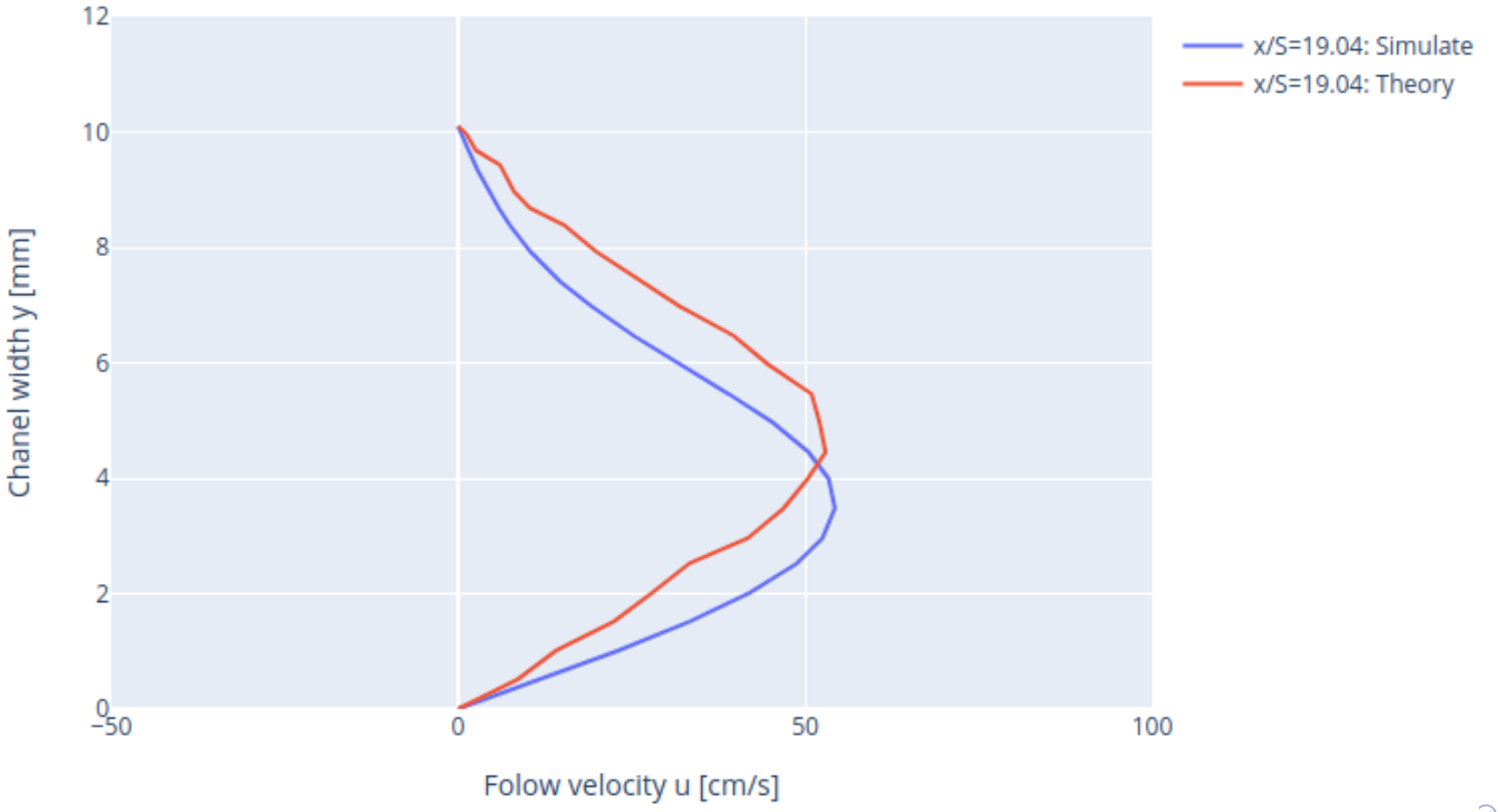


- $x/S = 5.41$


x/S=7.04: Simulate
x/S=7.04: Theory
Chanel width y [mm]
Folow velocity u [cm/s]
0
2
4
6
8
10
12
−40
−20
0
20
40
60
80
100

- $x/S = 11.84$

- $x/S = 11.84$


12
10
8
6
4
2
0
−50
0
50
100
Chanel width y [mm]
Folow velocity u [cm/s]
x/S=19.04: Simulate
x/S=19.04: Theory

Comparaison

According to the results the variance of the model for$x/S = 0.0$, $x/S = 5.41$ and $x/S = 11.84$ corresponds to only 8%,35, 05% and 35% of the mean of the observations respectively.

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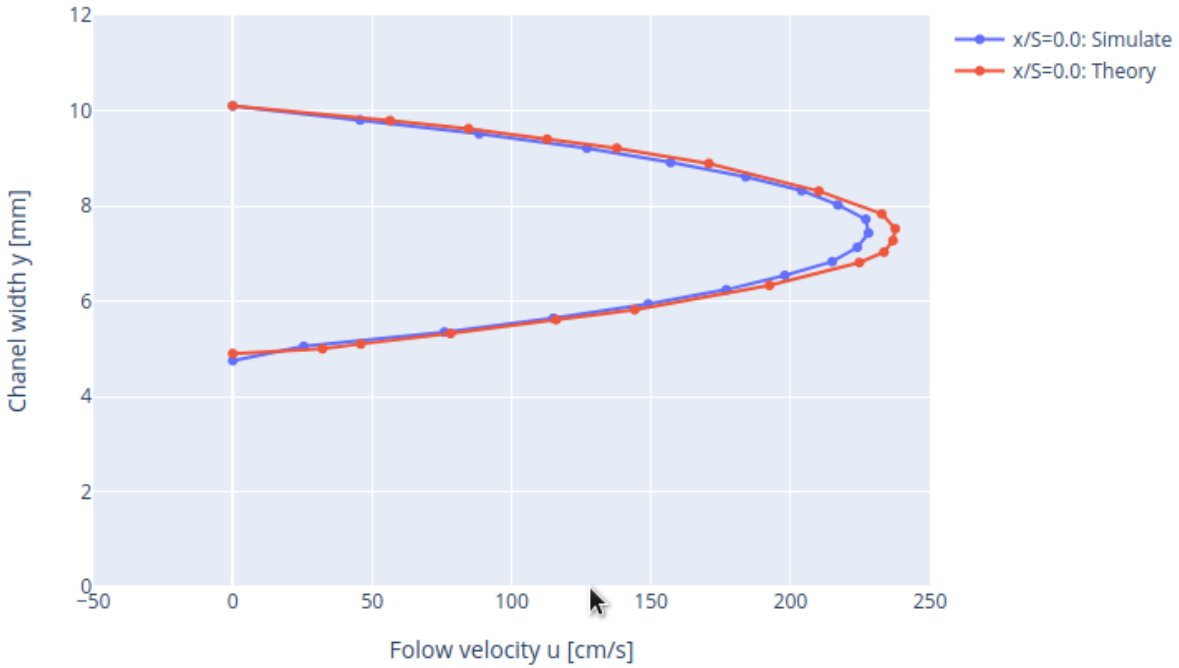
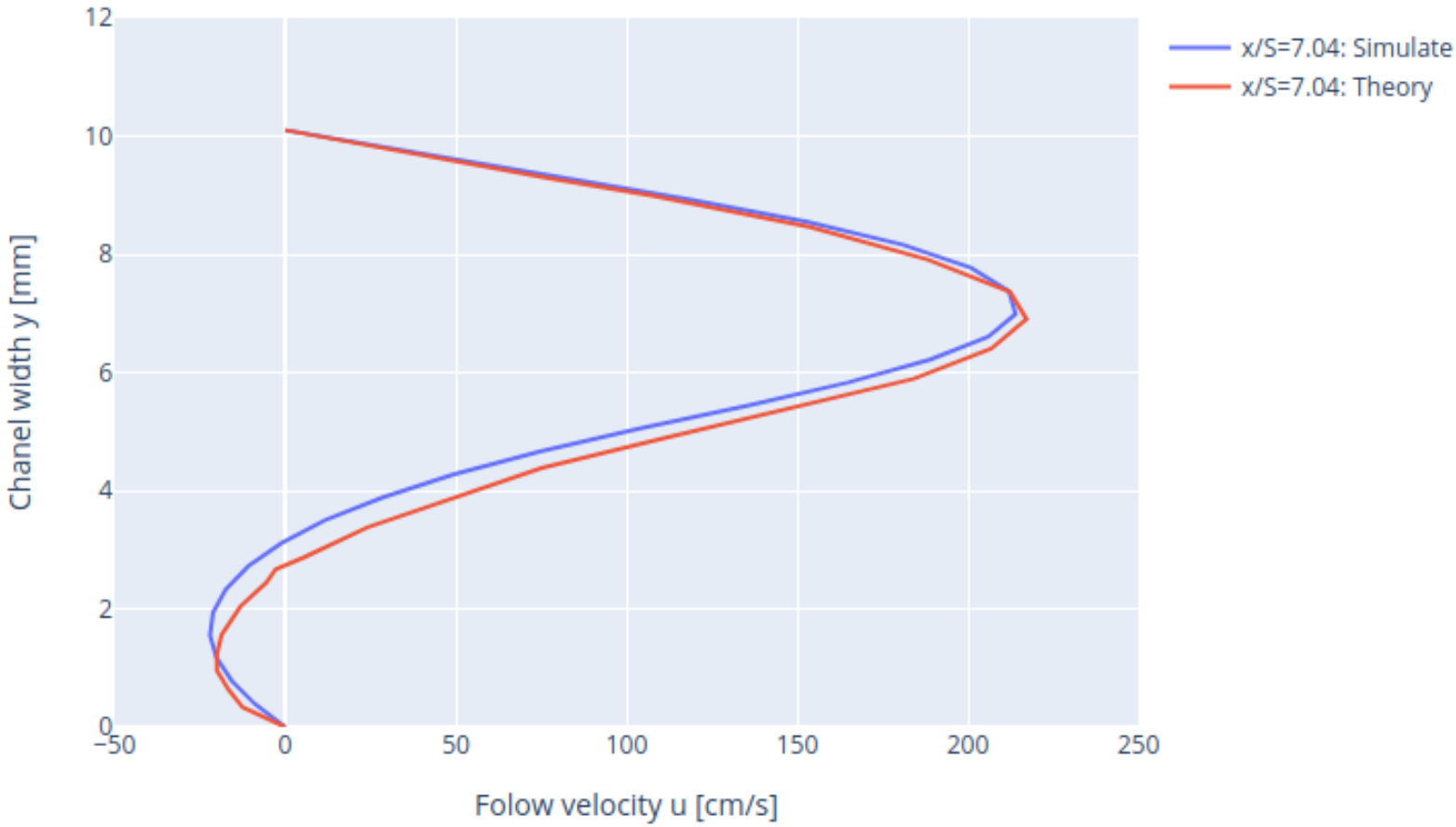
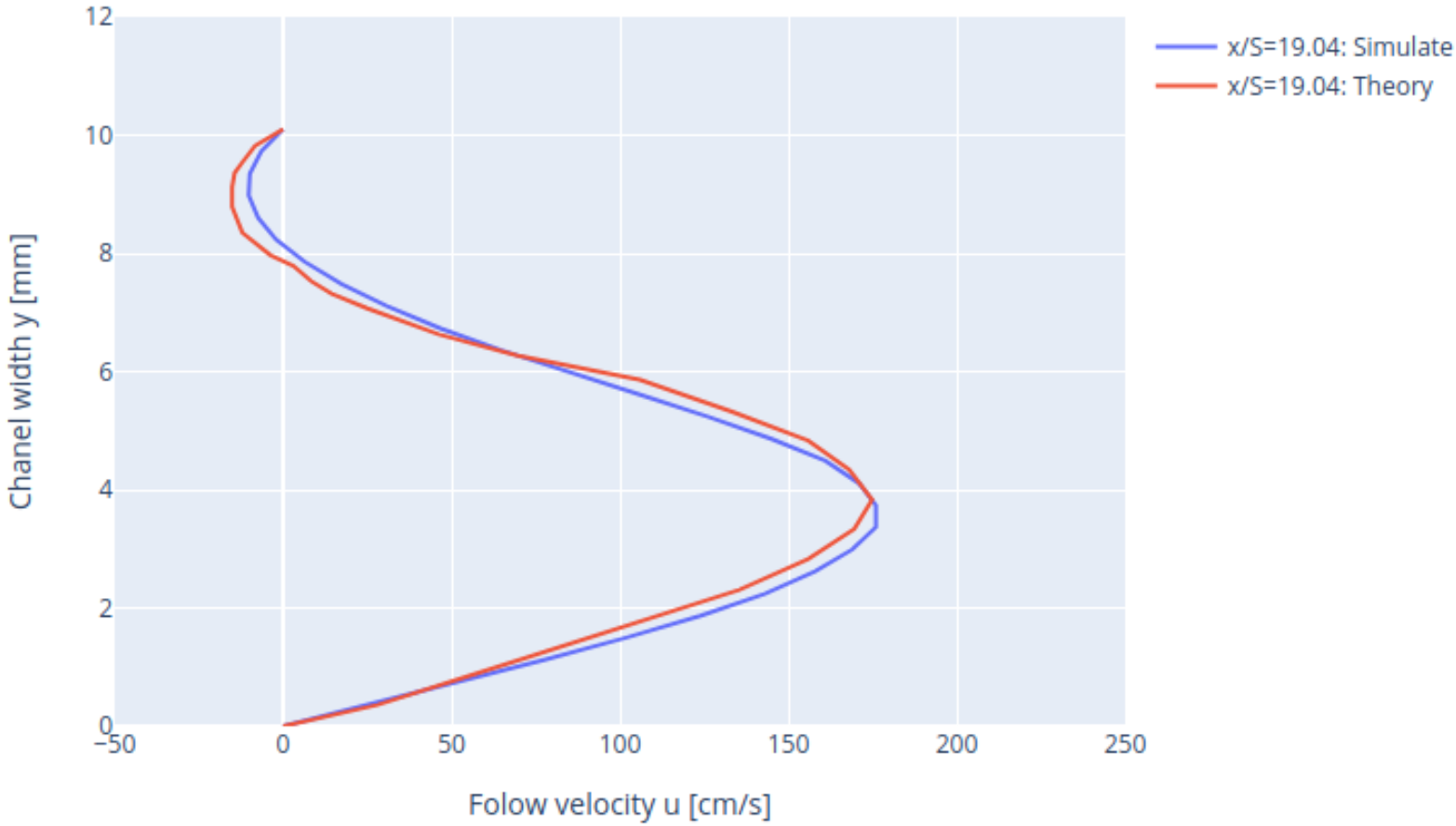


- $x/S = 7.04$


x/S=7.04: Simulate
x/S=7.04: Theory
Chanel width y [mm]
Folow velocity u [cm/s]
0
2
4
6
8
10
12
−50
0
50
100
150
200
250

- $x/S = 19.04$

- $x/S = 19.04$


x/S=19.04: Simulate
x/S=19.04: Theory
Chanel width y [mm]
Folow velocity u [cm/s]
0
2
4
6
8
10
12
−50
0
50
100
150
200
250

Comparaison

According to the results the variance of the model for$x/S = 0.0$, $x/S = 7.04$ and $x/S = 19.04$ corresponds to only 6.96%,14.80% and 20% of the mean of the observations respectively.

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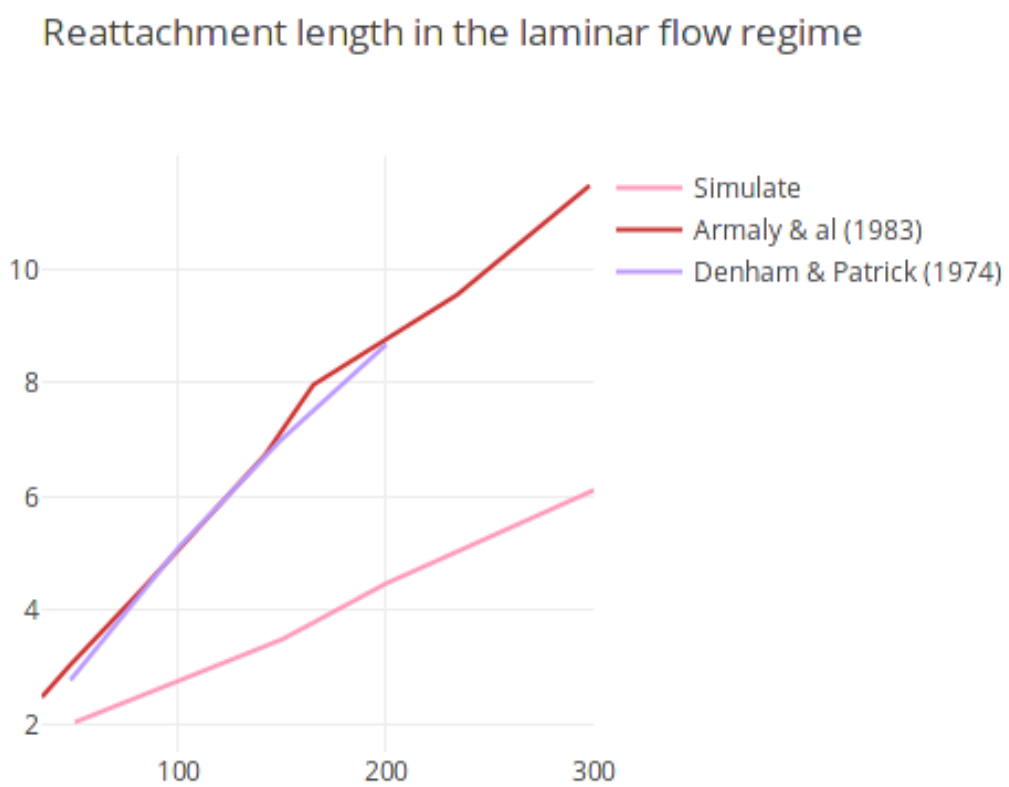
Reattachment length in the laminar flow regime
Simulate
Armaly & al (1983)
Denham & Patrick (1974)
10
8
6
4
2
100
200
300

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- This study is based on the flow of a fluid in front of 3 circular and identical cylinders.

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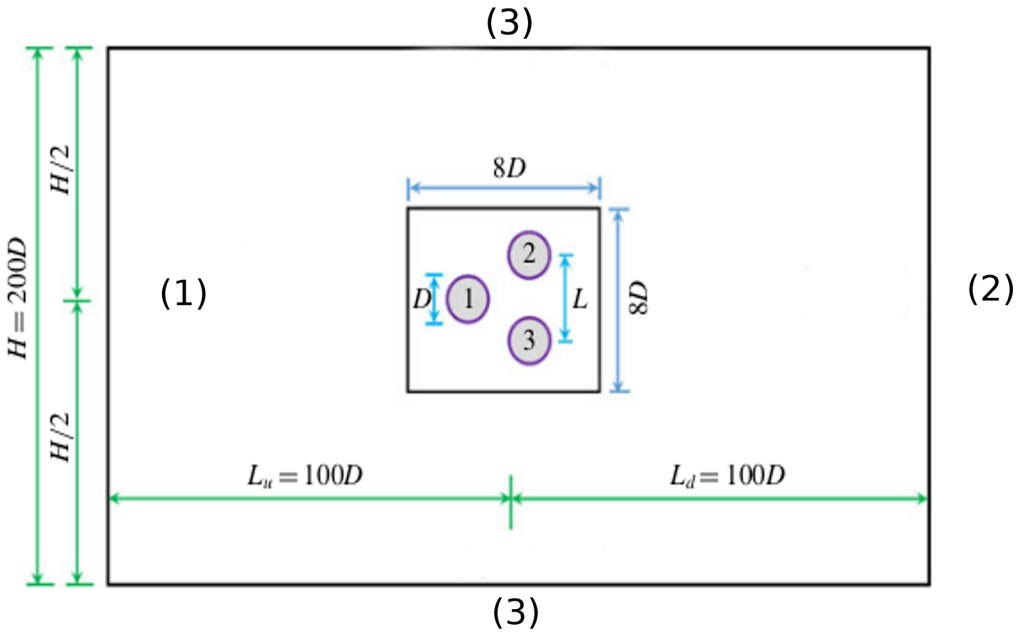

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The mesh has been developed with tighter meshes close to the cylinder and downstream of the cylinder in order to be able to finely detect the flow value fields.

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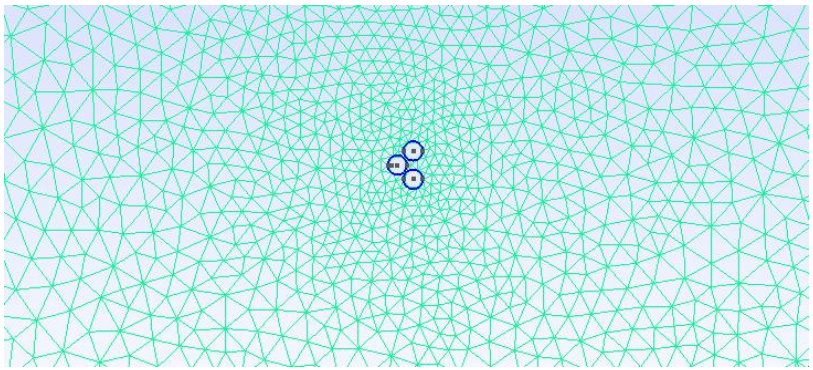
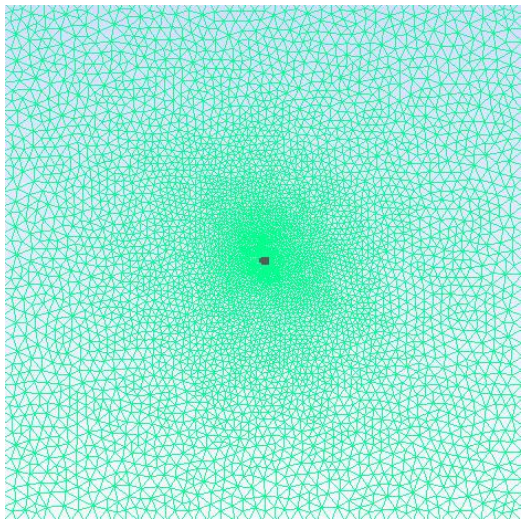


zoom-in view of the previous mesh



Generated mesh for case

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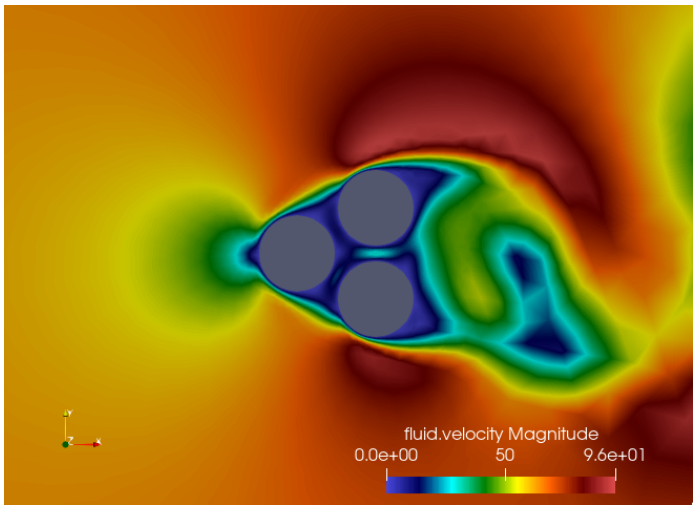
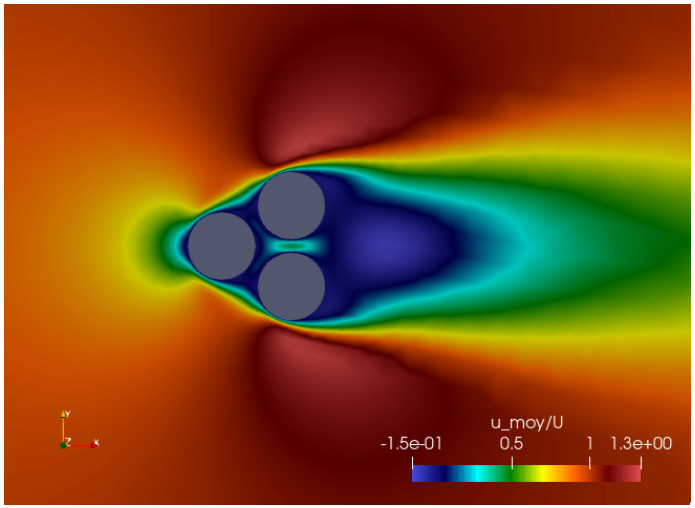
- $1.0 < L/D \leq 1.4$

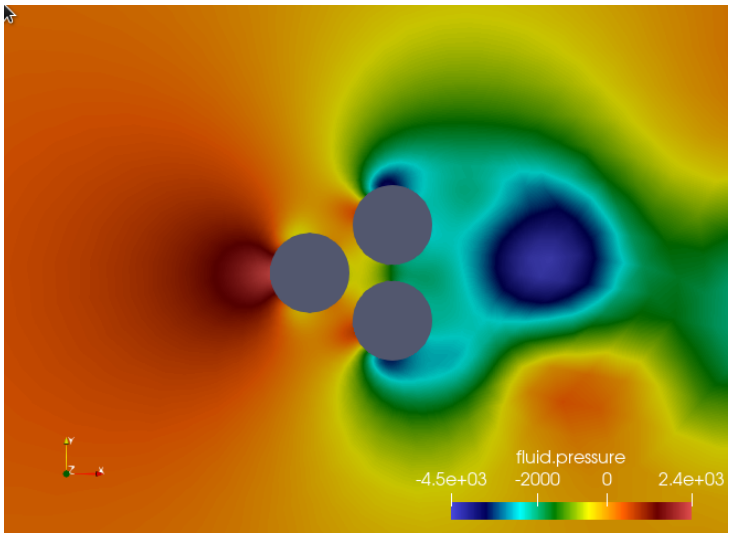
- $1.0 < L/D \leq 1.4$



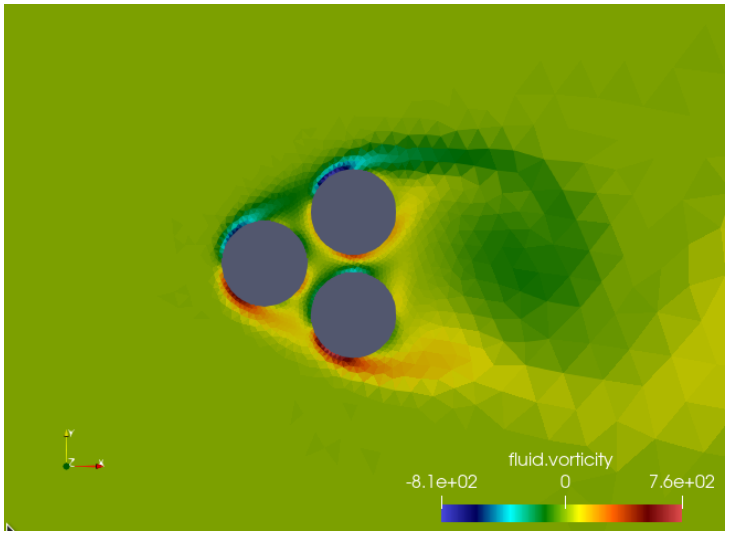
Velocity magnitude



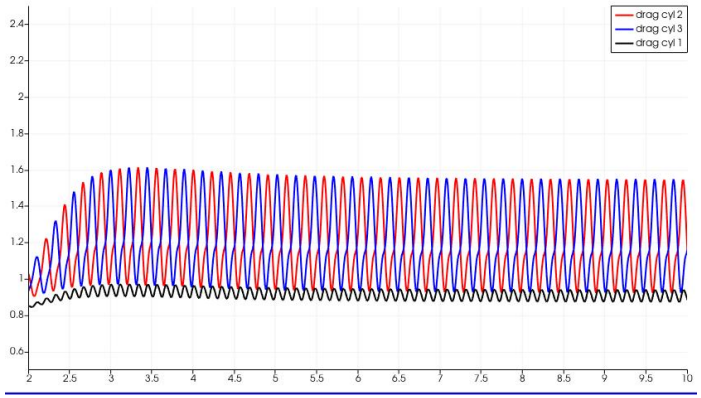
Time-averaged streamwise velocity



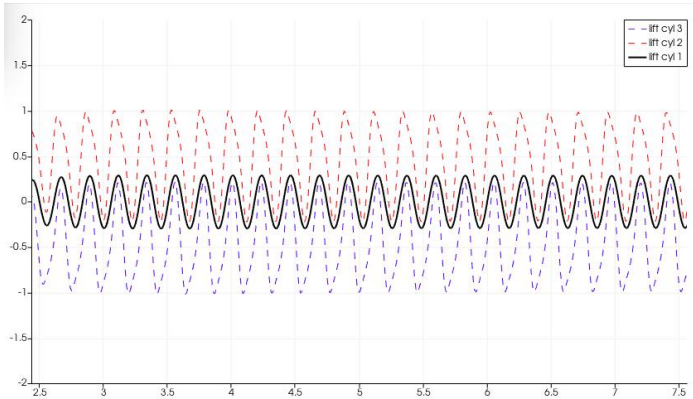
Pression



Vorticity



Time histories of drag coef



Time histories of lift coef

- $1.4 < L/D \leq 1.9$

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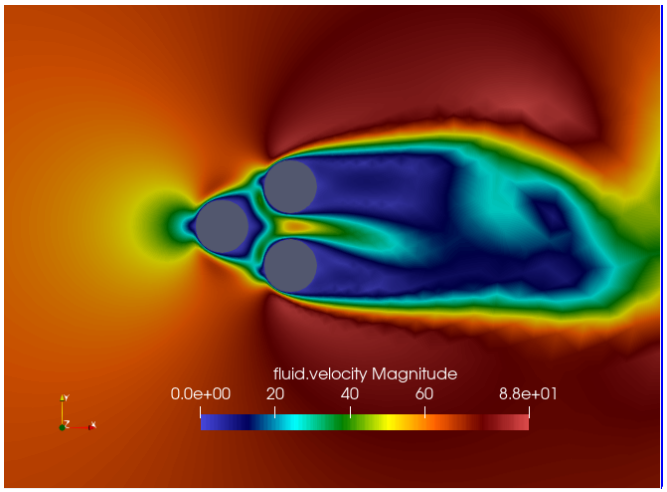
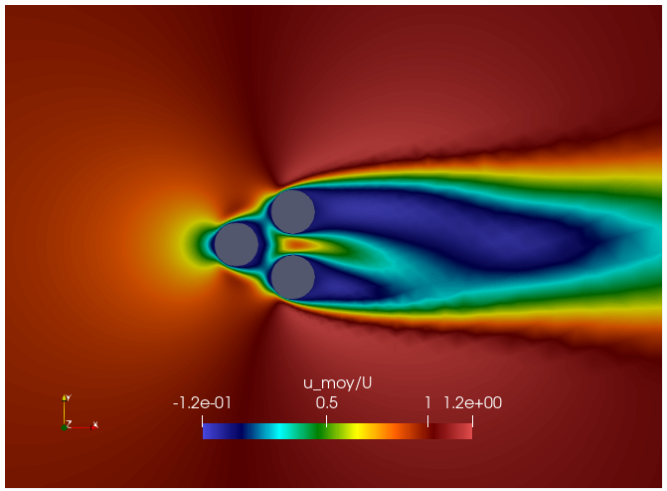
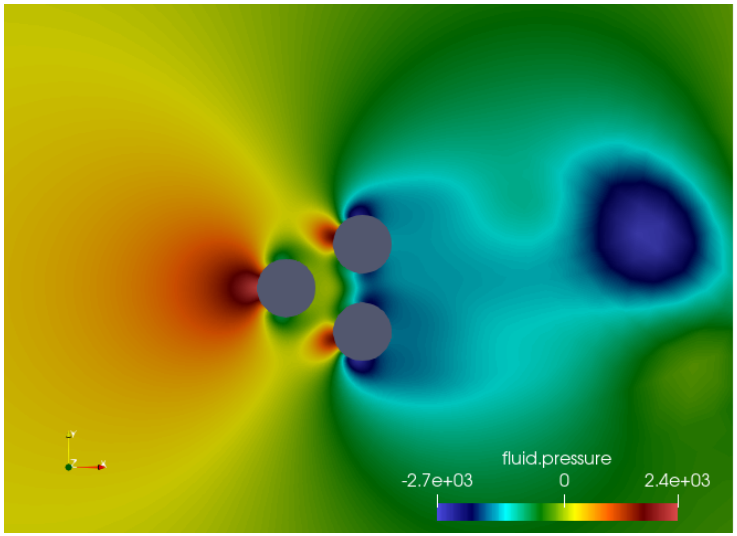


Velocity magnitude



Time-averaged streamwise velocity



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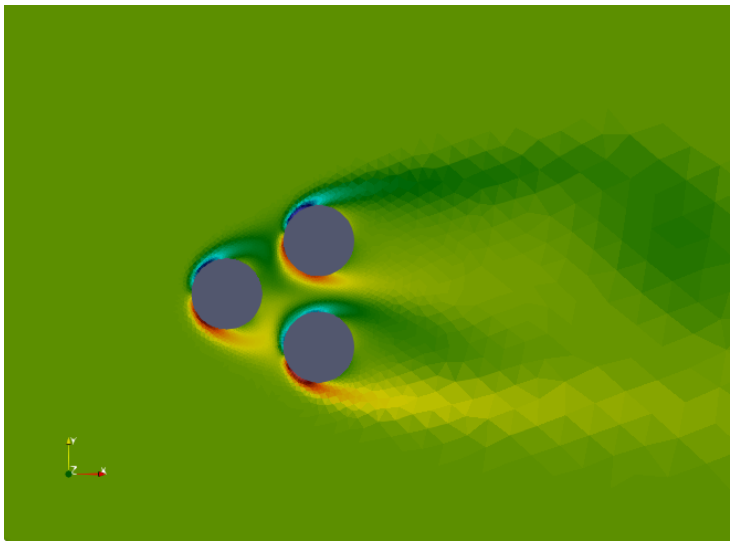
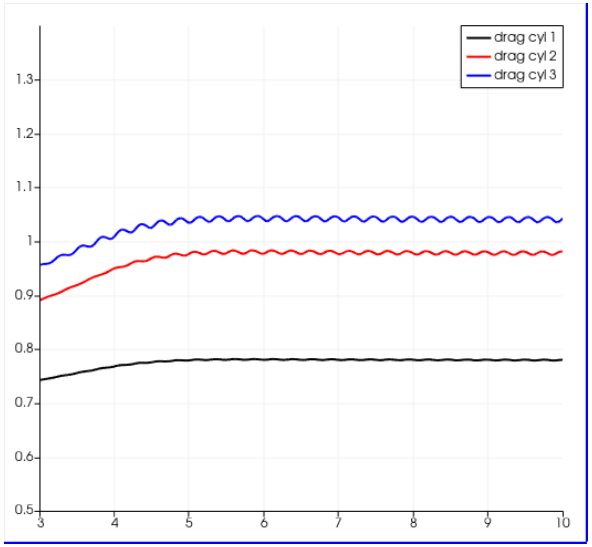
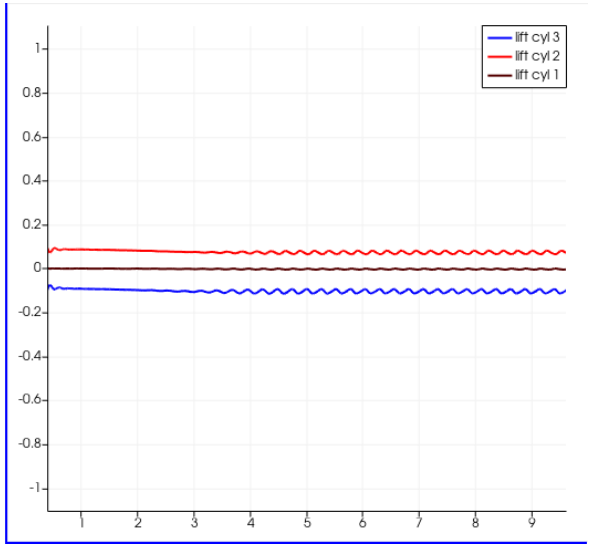


Vorticity



Time histories of drag coef



Time histories of lift coef

- $1.9 < L/D \leq 2.5$

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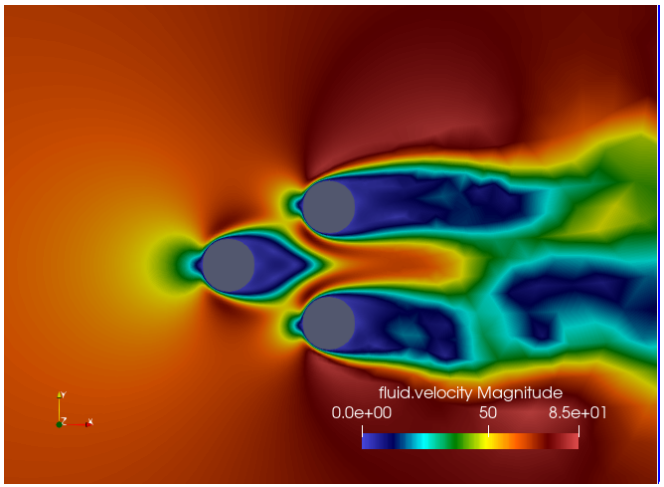
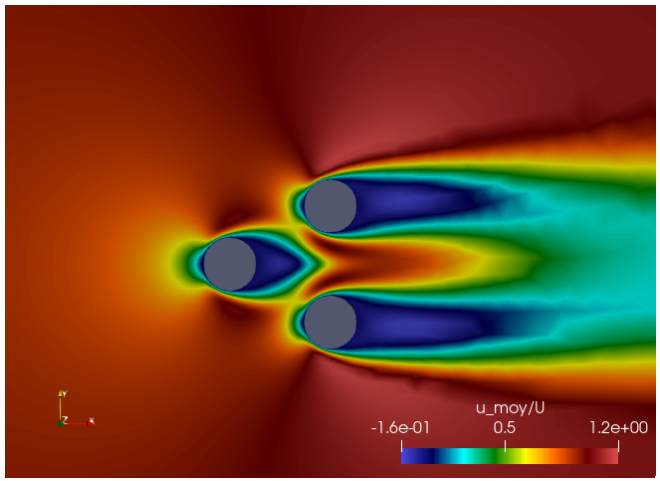
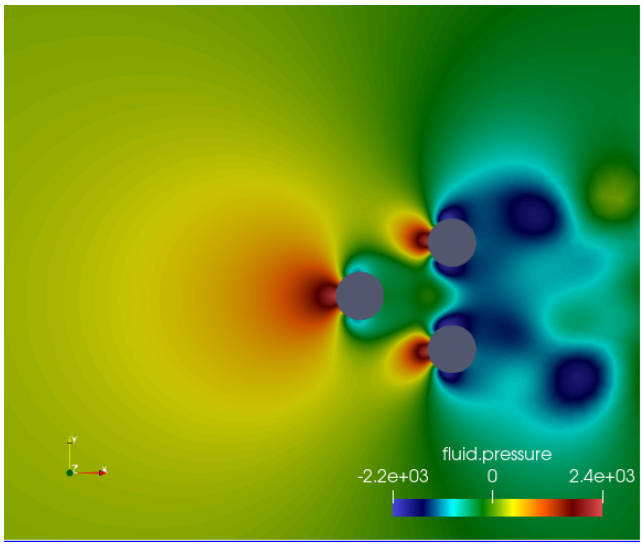


Velocity magnitude



Time-averaged streamwise velocity



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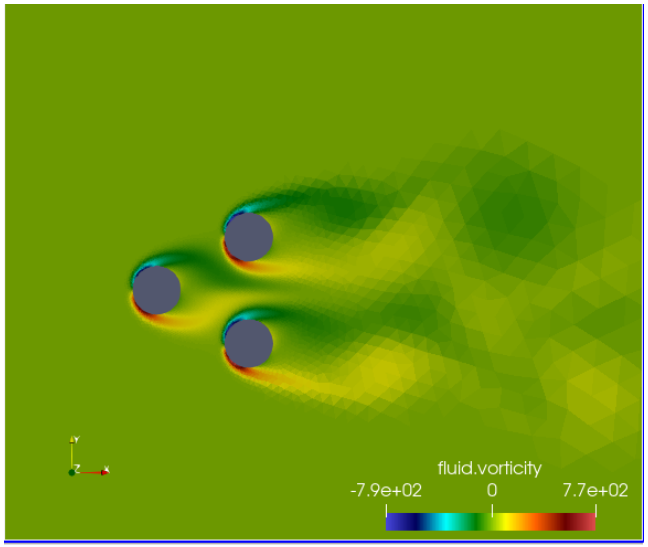
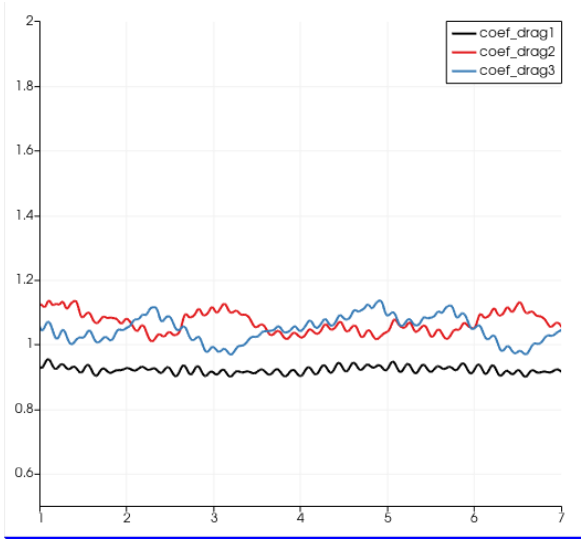
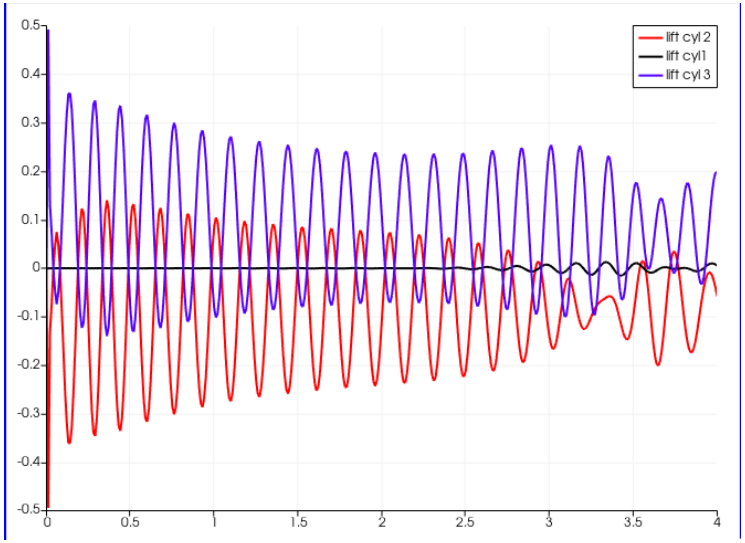


Vorticity



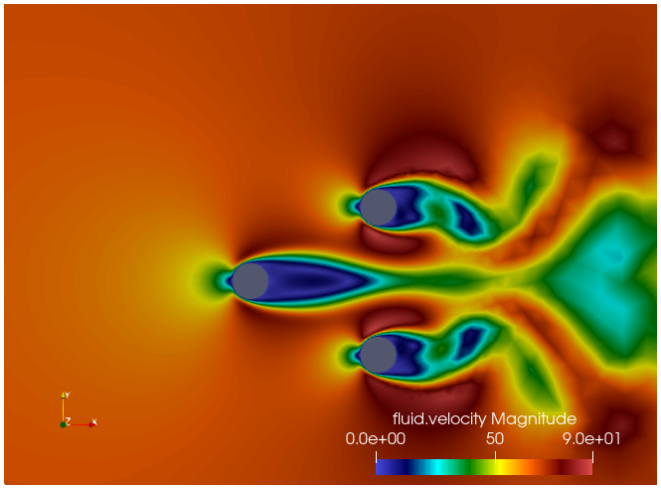
Time histories of drag coef



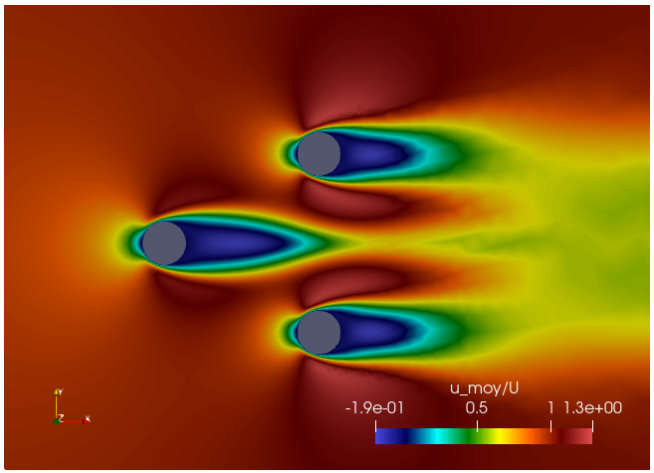
Time histories of lift coef

- $2.5 < L/D \leq 2.8$ and $3.4 < L/D \leq 4.1$

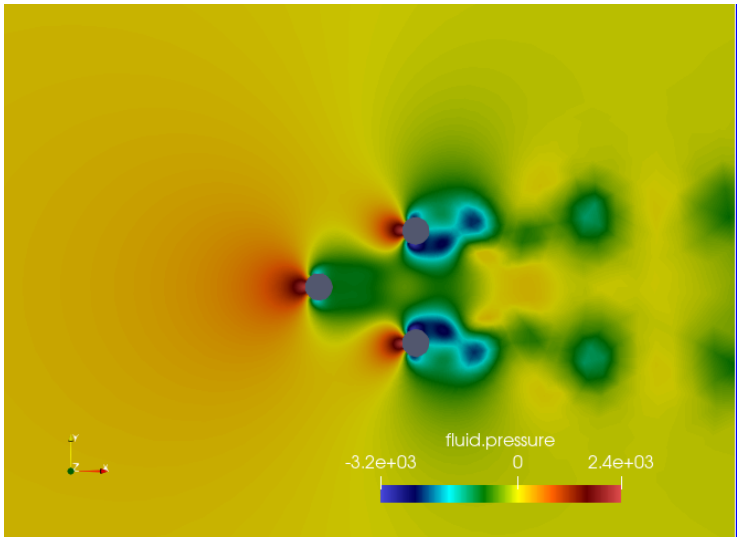
- $2.5 < L/D \leq 2.8$ and $3.4 < L/D \leq 4.1$



Velocity magnitude



Time-averaged streamwise velocity



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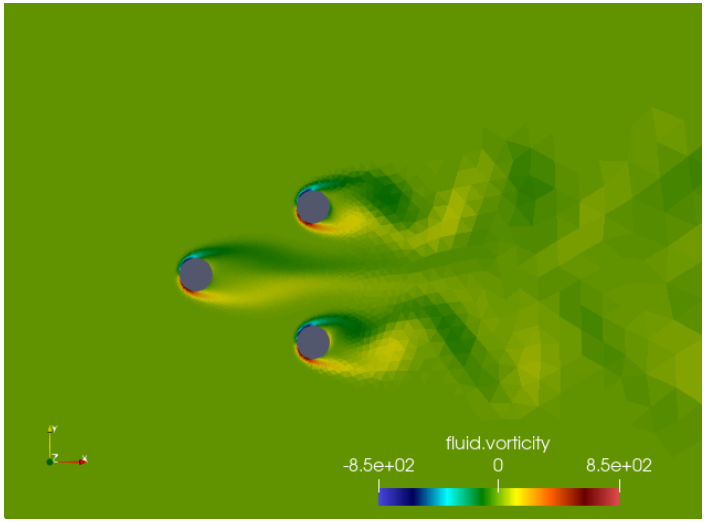
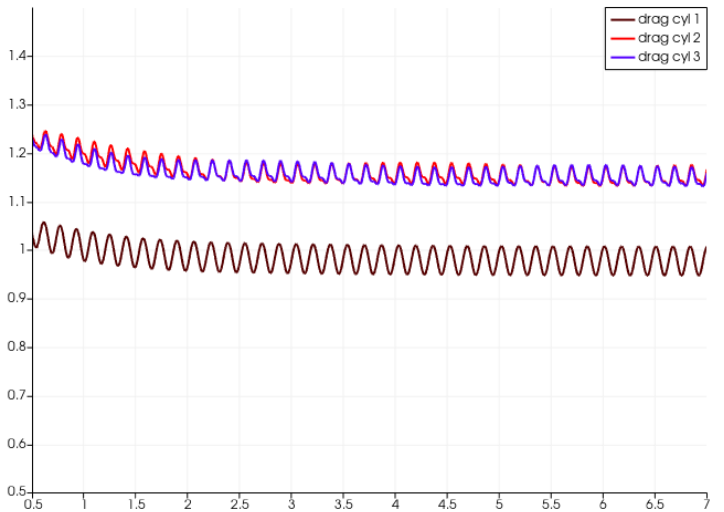
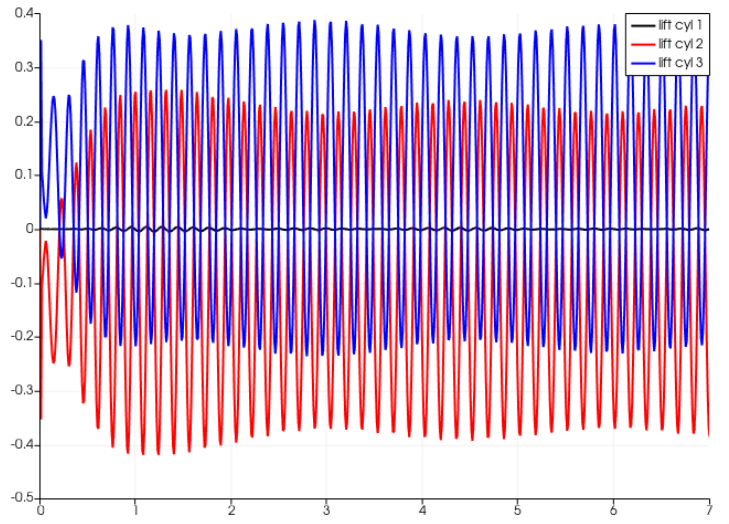


Vorticity



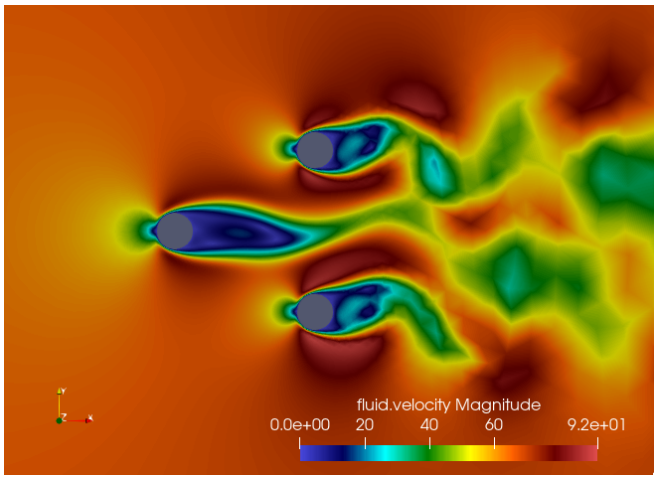
Time histories of drag coef



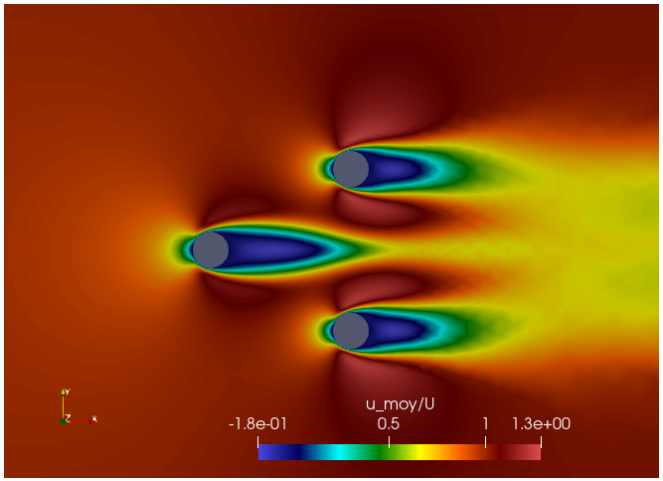
Time histories of lift coef

- $2.8 < L/D \leq 3.4$ and $4.1 < L/D \leq 4.5$

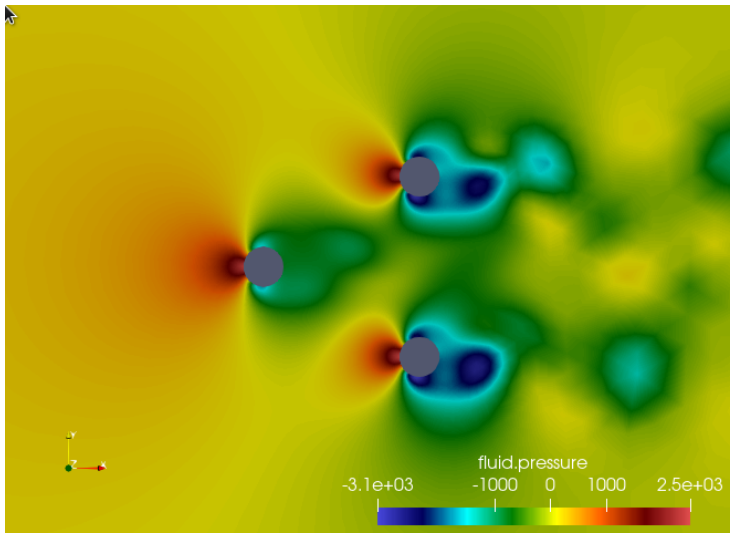
- $2.8 < L/D \leq 3.4$ and $4.1 < L/D \leq 4.5$



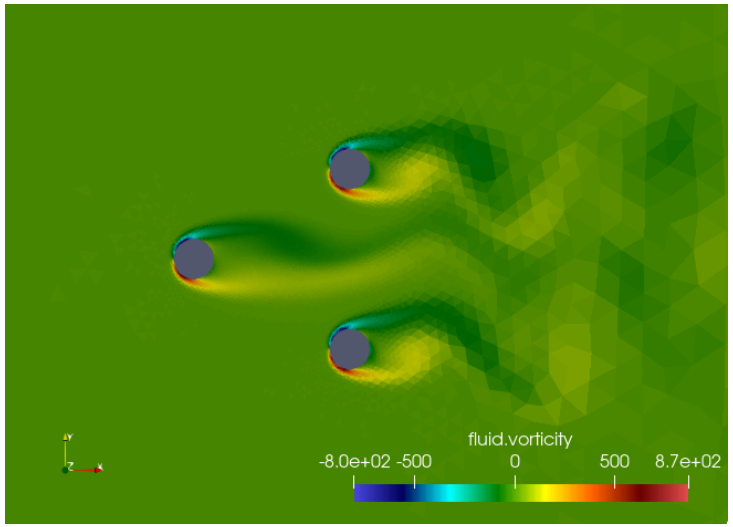
Velocity magnitude



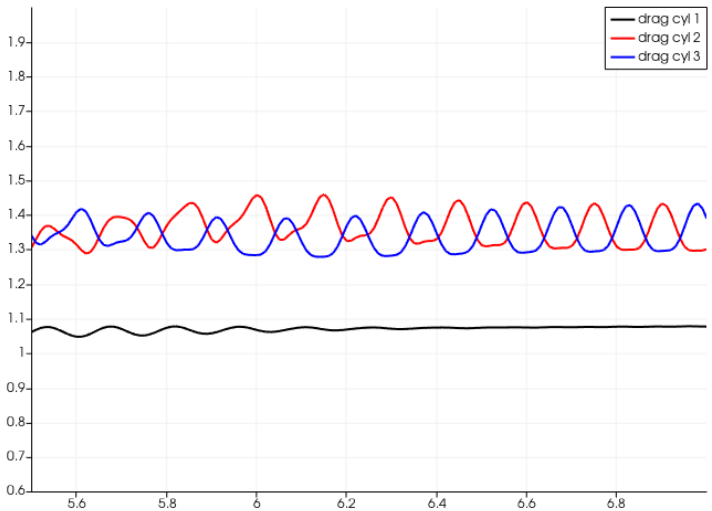
Time-averaged streamwise velocity



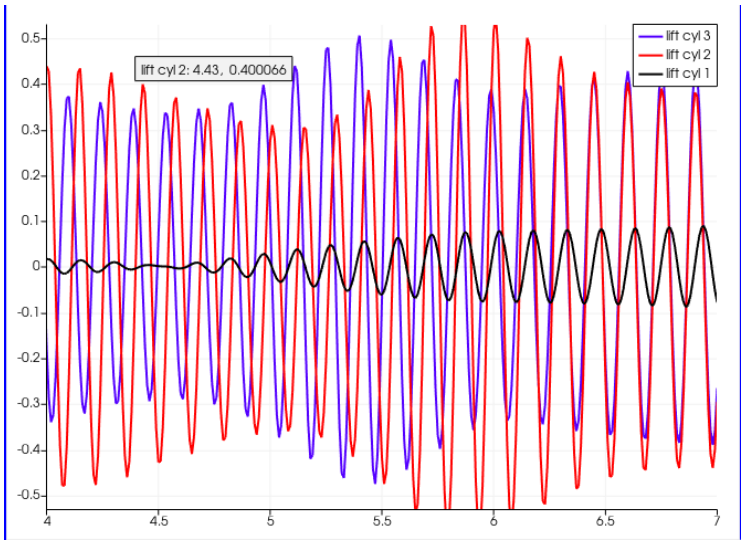
Pression



Vorticity



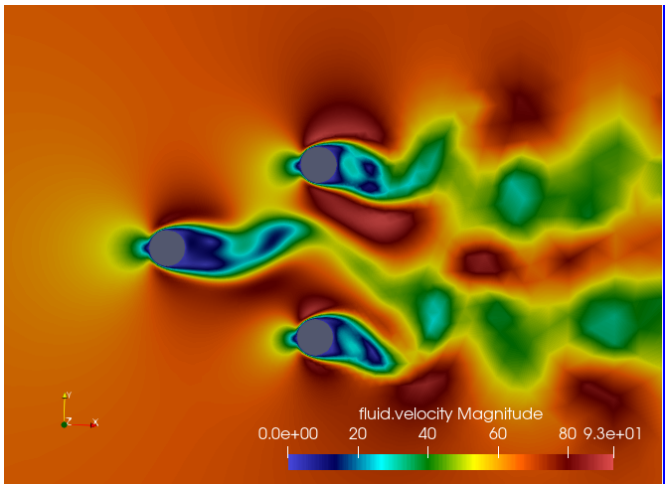
Time histories of drag coef



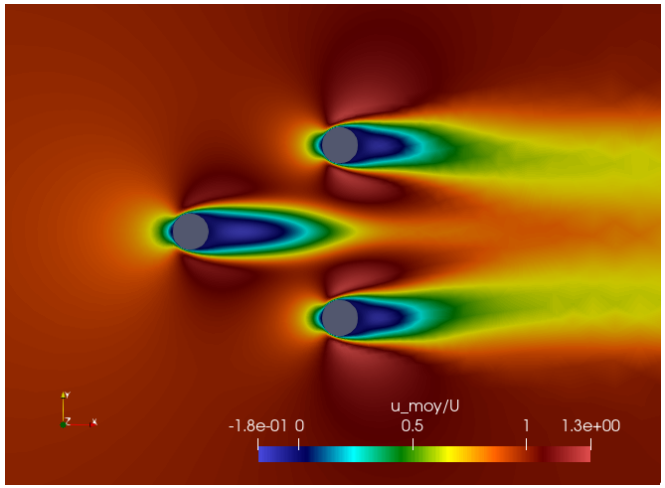
Time histories of lift coef

- $4.5 < L/D \leq 6$

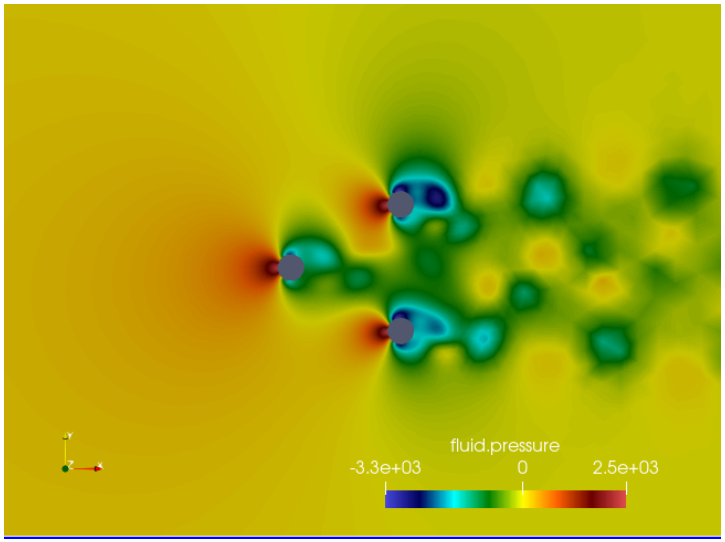
- $4.5 < L/D \leq 6$



Velocity magnitude



Time-averaged streamwise velocity



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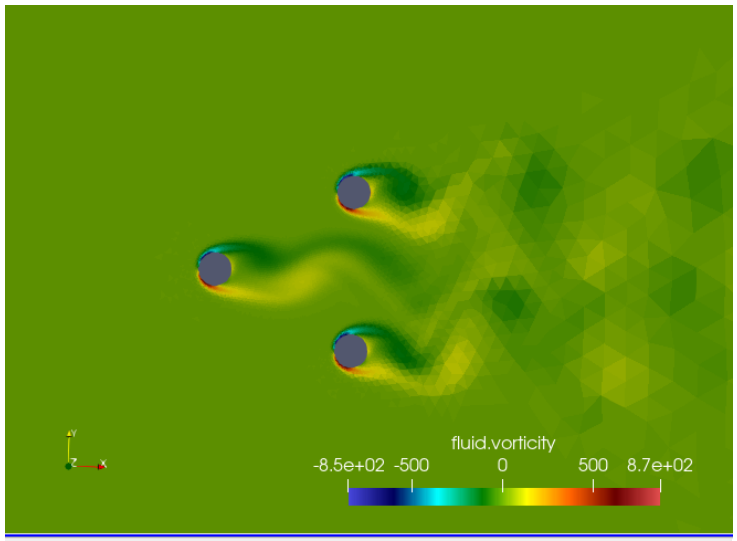
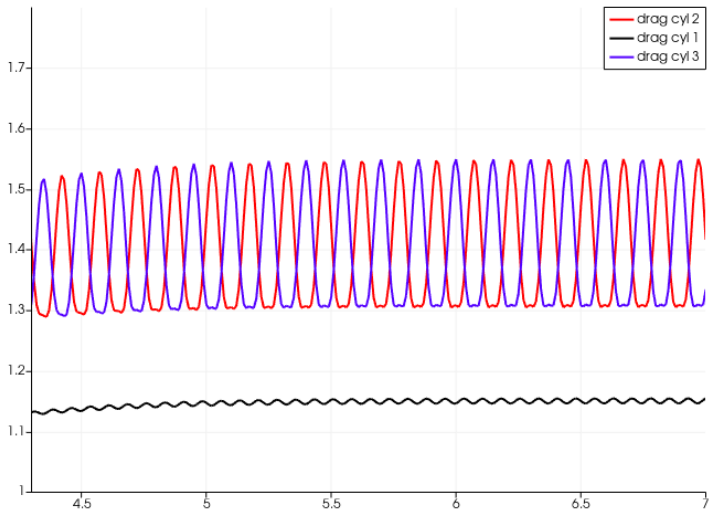
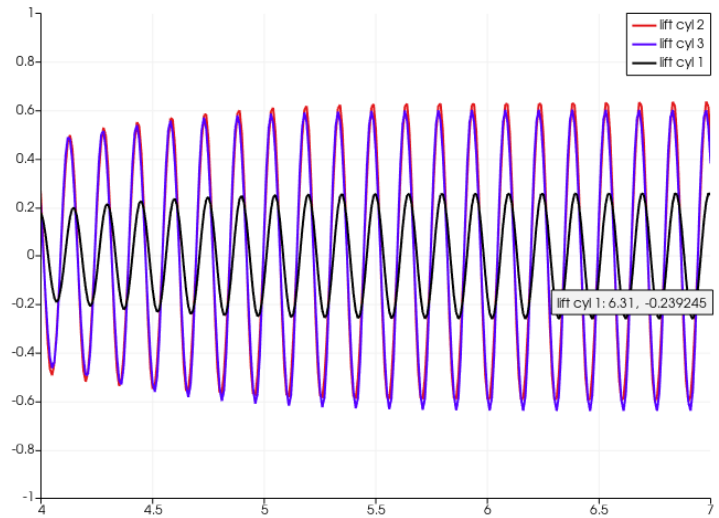


Vorticity



Time histories of drag coef



Time histories of lift coef

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- Velocity and stremwise velocity
- Pression
- Vorticity
- Drag and Lift coefficients

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[chen-2020] Numerical simulations of flow past three circular cylinders in equilateral-triangular arrangements Chen, Weilin, Ji, Chunning, Alam, Md. Mahbub, Williams, John, Xu, Dong, Journal of Fluid Mechanics2020/05 Vol. 891


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