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# Assessment of a turbine model to predict cost effectively the far wake of a hydrokinetic farm

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## Context

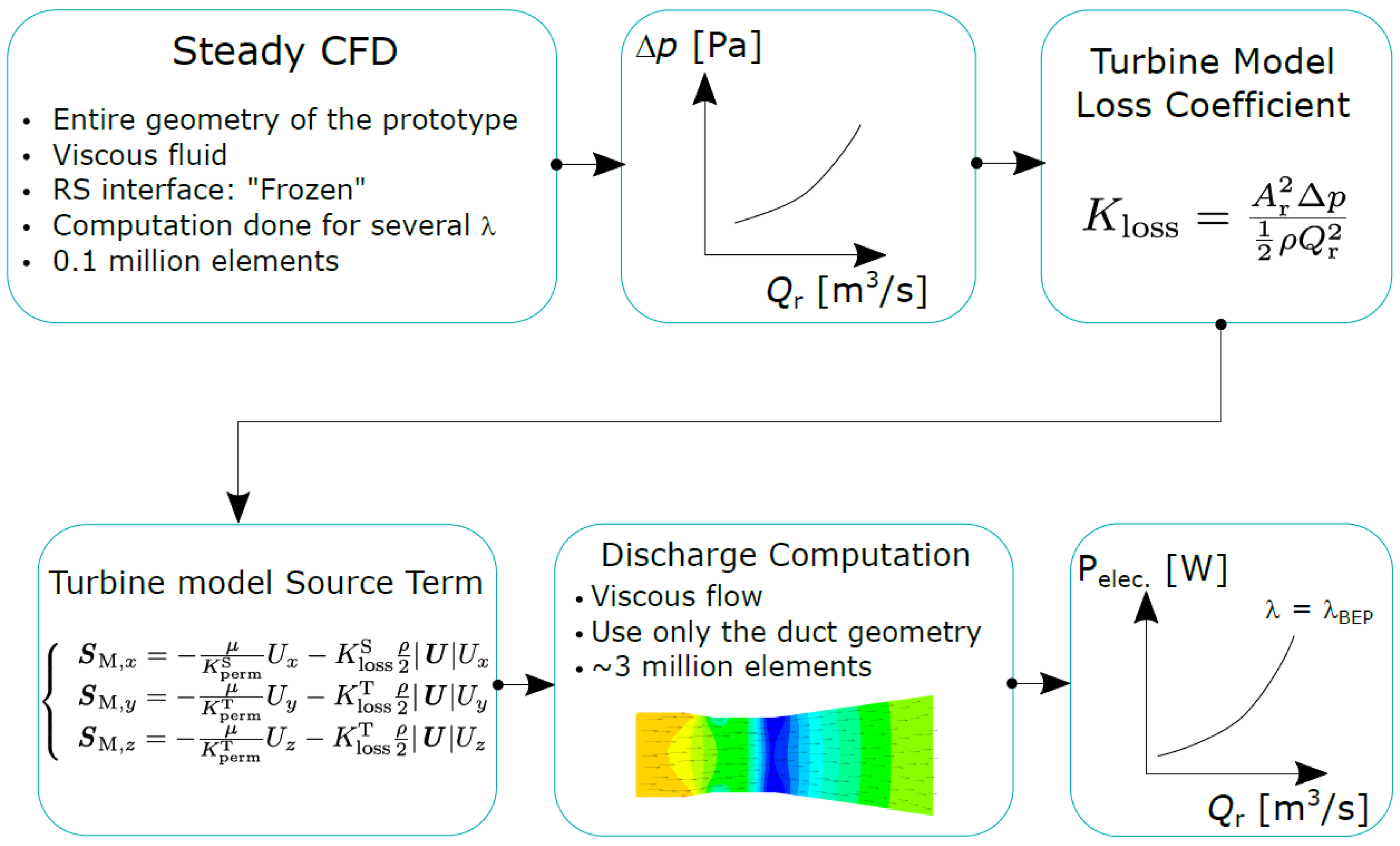
- To maximize the energy harvest from rivers, several hydrokinetic turbines [1,2] are assembled to form a farm, which requires to investigate the influence of the machines between each other and their influences on the local flow.
- To study theses influences, numerical simulations are used. However, it requires to compute the free surface flow and all the interfaces between the stationary and rotating parts, which is time and computational expensive.

### *Objective*

- To implement a simplified hydrokinetic model to save computational resources.

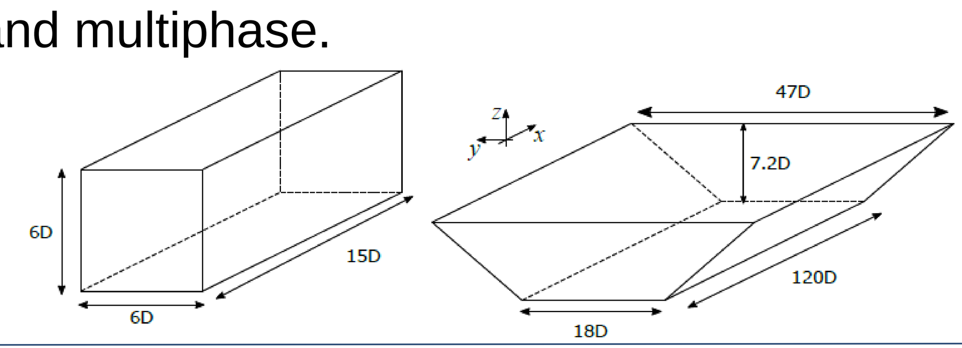
## Hydrokinetic Turbine Model

The hydrokinetic turbine model (similar to the actuator disk) mimics the pressure drops experienced by the fluid from the runner [3]. The model requires a loss coefficient as parameter, which is obtained numerically using steady state simulations with a simplified computational domain.



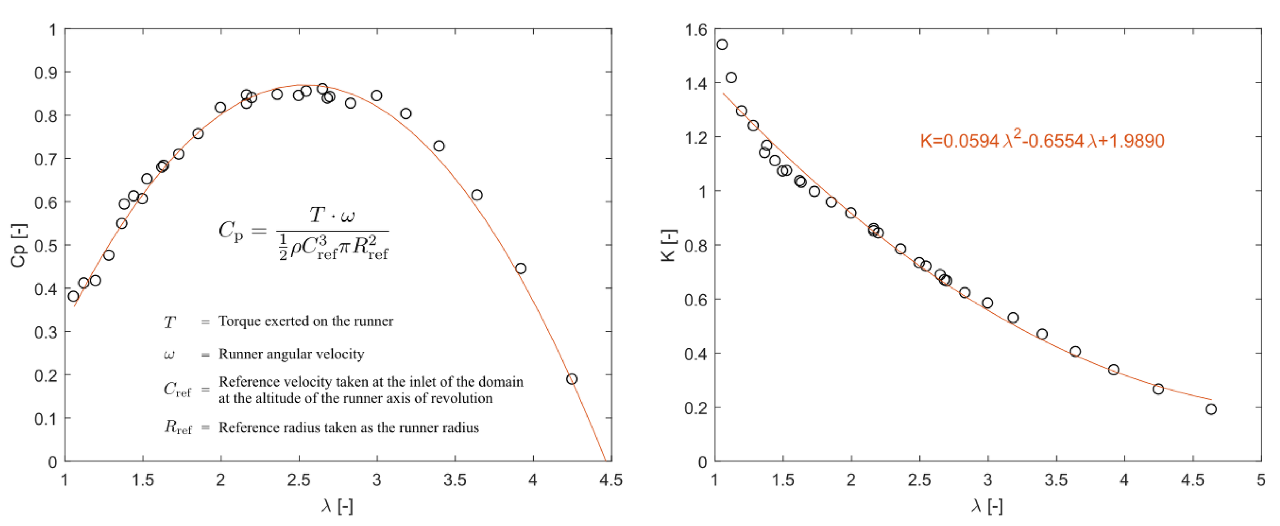

## Numerical setup

Two different computational domains were designed using ANSYS ICEM CFD. The first one (**case 1**) uses a rectangular domain and was used to define the turbine model by steady and single phase simulations. The second one uses a trapezoidal domain and was used to simulate the flow field through a farm using once the full geometry of the machine (**case 2**) and once the turbine model (**case 3**). These simulations were unsteady and multiphase.




## Computed performance and loss coefficient

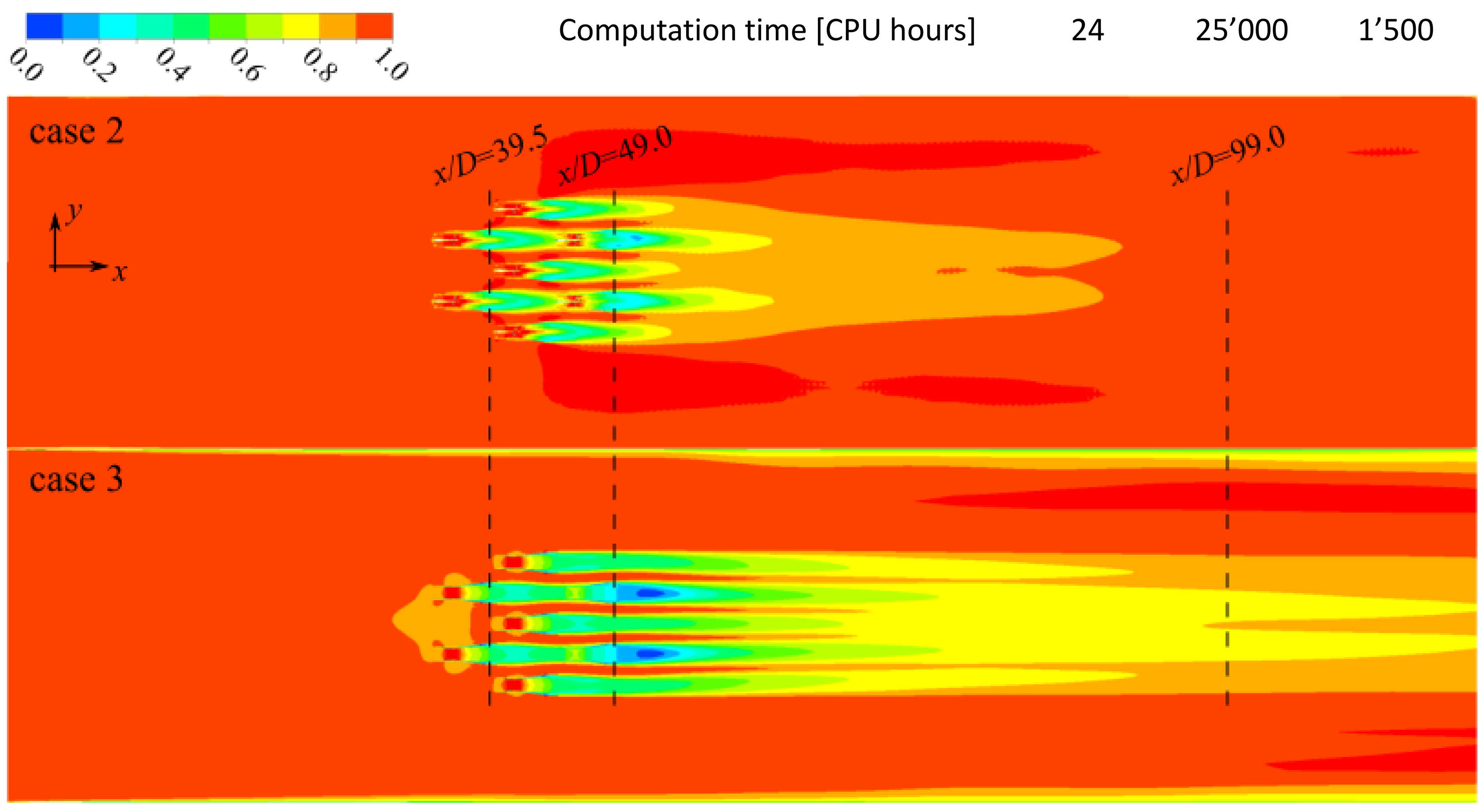
To establish the performance characteristic and the model parameter of the hydrokinetic turbine, several combination of the tip speed ration $\lambda$ were computed using ANSYS CFX R17.2. The Best Efficiency Point is reached for a *Cp*=0.87 [-] and a $\lambda$=2.54 [-]. Based on these simulations, the coefficient of resistance *K* can be computed and corresponds to 0.71 [-] at BEP [4].



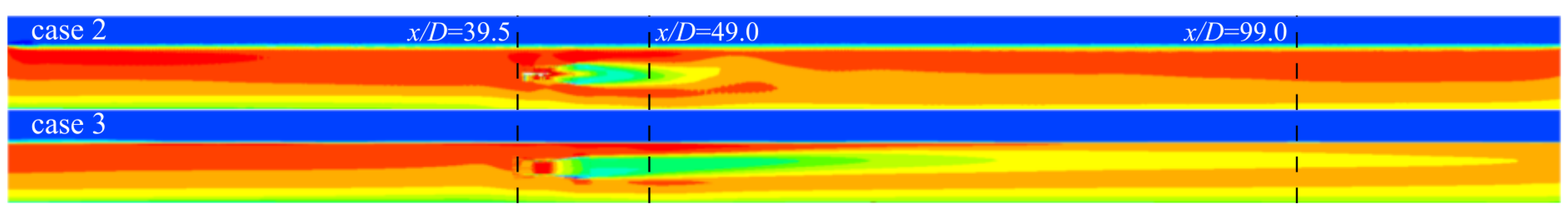

## Results

- Case 3 required approximately 15 time less CPU hours and mesh resources compared to case 2.
- Case 2 shows a qualitative faster wake recovery, which might be attributed to the difference of mesh type and the lack of flow rotation in case 3.
- However, the quantitative comparison between case 2 and 3 shows that the difference in the horizontal velocity profile at *x/D*=99.0 is only of -13%.

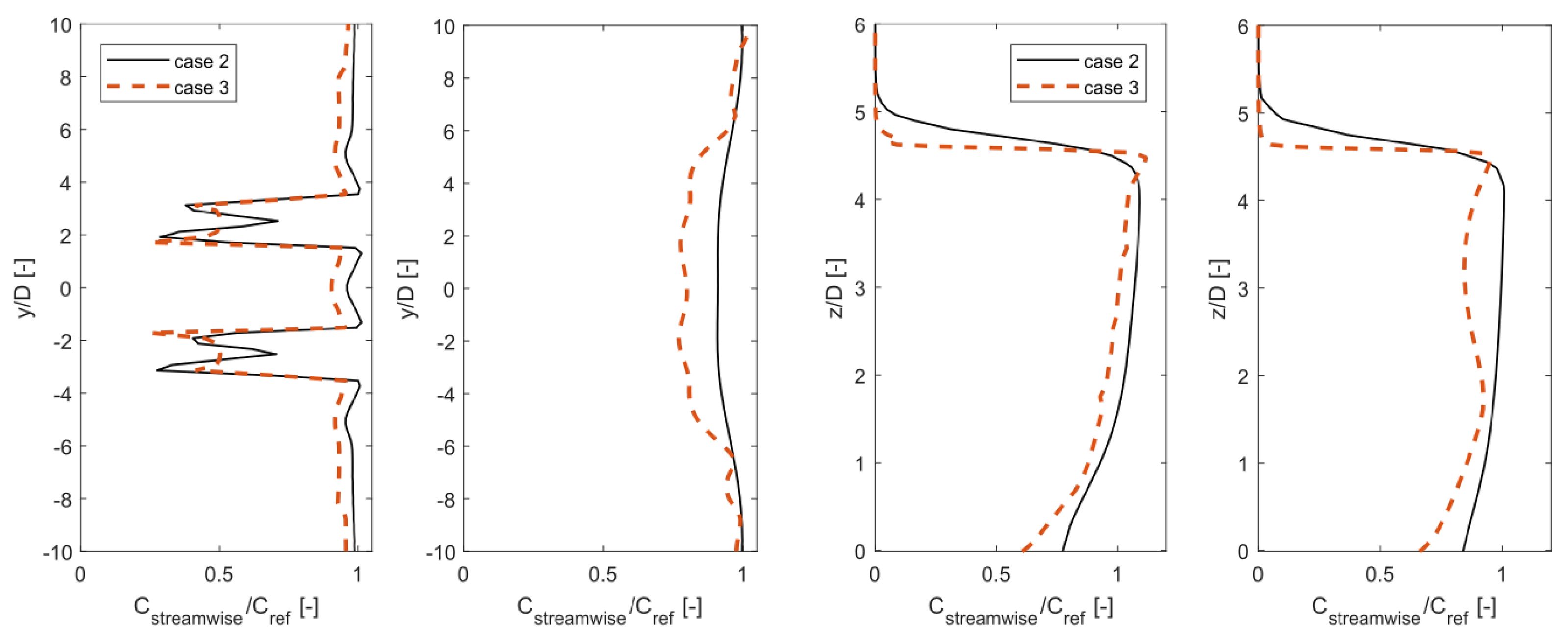
| Case | 1 | 2 | 3 |
|---|---|---|---|
| Mesh size [Millions of elements] | 0.1 | 45.6 | 2.9 |
| Computation time [CPU hours] | 24 | 25'000 | 1'500 |




Comparison of the instantaneous normalized streamwise velocity on the *Oxy* plane (z/D=2.6)




Comparison of the instantaneous normalized streamwise velocity on the *Ozx* plane (y/D=0.0)




Comparison of the instantaneous normalized velocity profiles. (a) horizontal profile at z/D=2.6. Left : x/D= 39.5. Right: x/D= 99.0. (b) vertical profile at y/D=0.0. Left : x/D= 39.5. Right: x/D= 99.0.

## Conclusions

- A methodology was proposed to investigate faster the flow field passing through a hydrokinetic turbine farm.
- The comparison between the high resolution simulation (case 2) with the simplified one (case 3) showed acceptable discrepancies but a significant gain in mesh size and computation time.
- This methodology is well suited for an initial investigation on where to place hydrokinetic turbines in a river to get the maximum power output.

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## References

[1] C. Münch, S. Richard, A. Gaspoz, V. Hasmatuchi, N. Brunner, "New Prototype of a Kinetic Turbine of Artificial Channels" Advances in Hydroinformatics, Springer, Singapore, 2018, pp. 981-996.

[2] C. Münch, J. Schmid, S. Richard, A. Gaspoz, N. Brunner, "Experimental Assessment of a New Kinetic Turbine Performance for Artificial Channels" Water 2018, Volume 10, Issue 3, 311.

[3] Batten W M J, Harrison M E and Bahaj A S 2013 *Phil Trans R Soc A* 371 20120293-20120293

[4] O. Pacot, D. Pettinaroli, J. Decaix and C. Münch, "Cost-effective CFD simulation to predict the performance of a hydrokinetic turbine farm". To be presented at the IAHRWG2019, 9-11 October 2019, Stuttgart, Germany.