Using CFD for marine engineering applications

From the Wind to the Tide closing Workshop
3 February 2021

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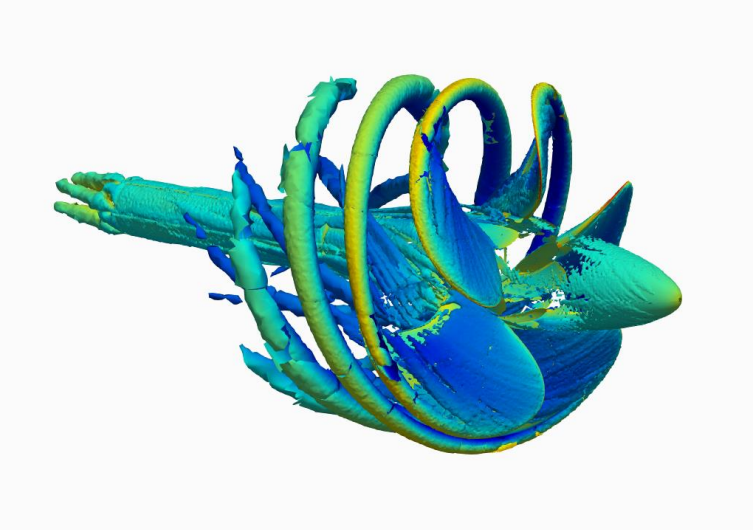
- *Computational Fluid Dynamics (CFD) is now an everyday tool for engineering applications.*

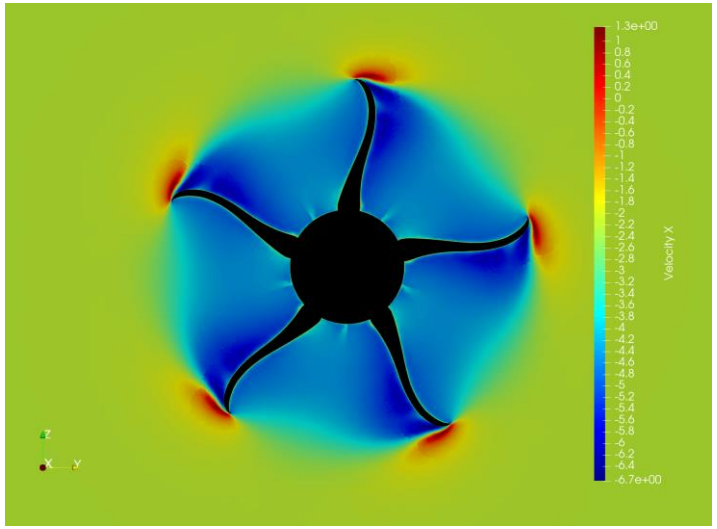
- *It widely used by industry in design-optimization-operation*

However…



- *There is still a lot of work to be done to account for as much physics as possible.*

- *This is a small presentation of our in house CFD code – MaPFlow and how we (at NTUA) handle these challenges.*

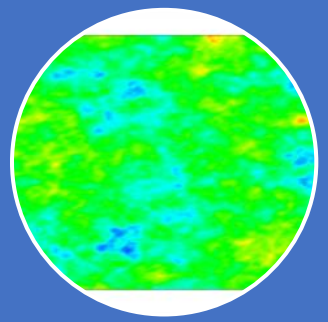


Pictures taken from Kalantzis DN"Numerical simulation of propeller open water characteristics using CFD." (2020)-Diploma Thesis

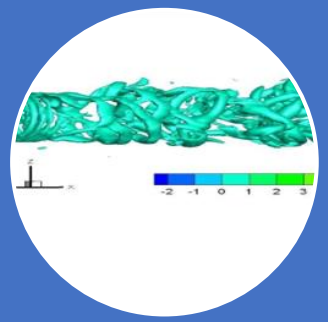
- Cell centered FV URANS flow solver
- Mixed grids
- Low Mach preconditioning
- Spalart Almaras, k-ω SST
- Multi-block MPI enabled
- 2^{nd} order in space & time

- Incompressible flows via the Artificial Compressibility Method
- Two-phase flows - Volume of Fluid Approach (VOF)
- 6-DOF rigid body dynamics
- Coupled with aeroelastic code - hGAST

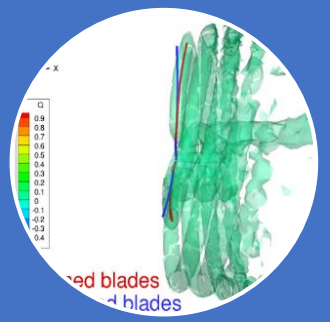
Towards more Realistic Simulations we pursue…



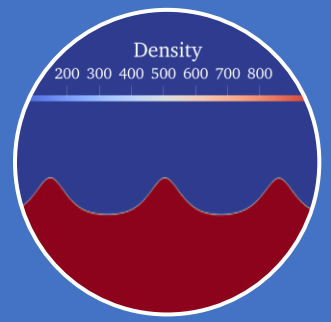
Complex Inflow



Wake Interaction



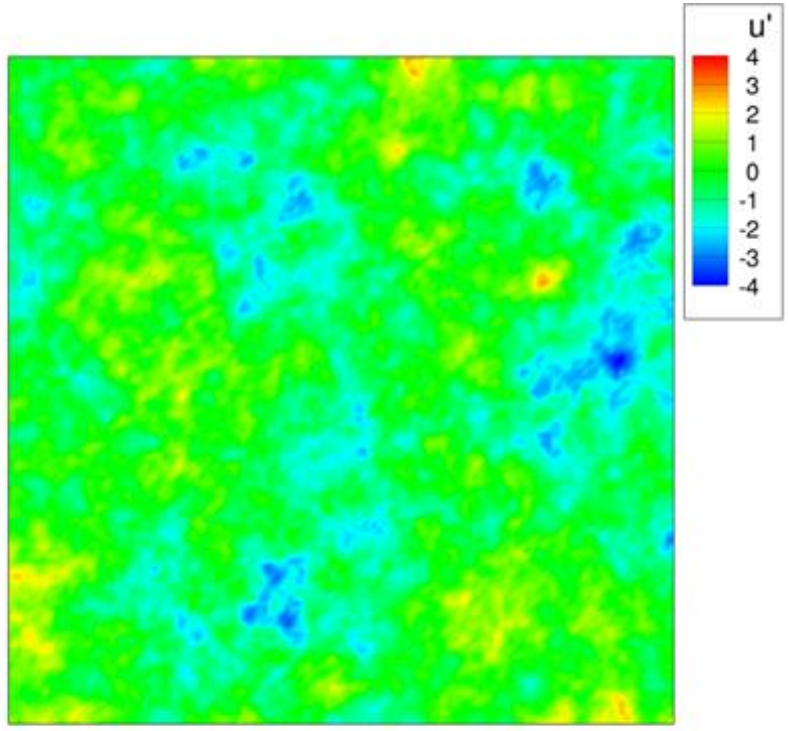
Aero/Hydro elasticity & Vibrations



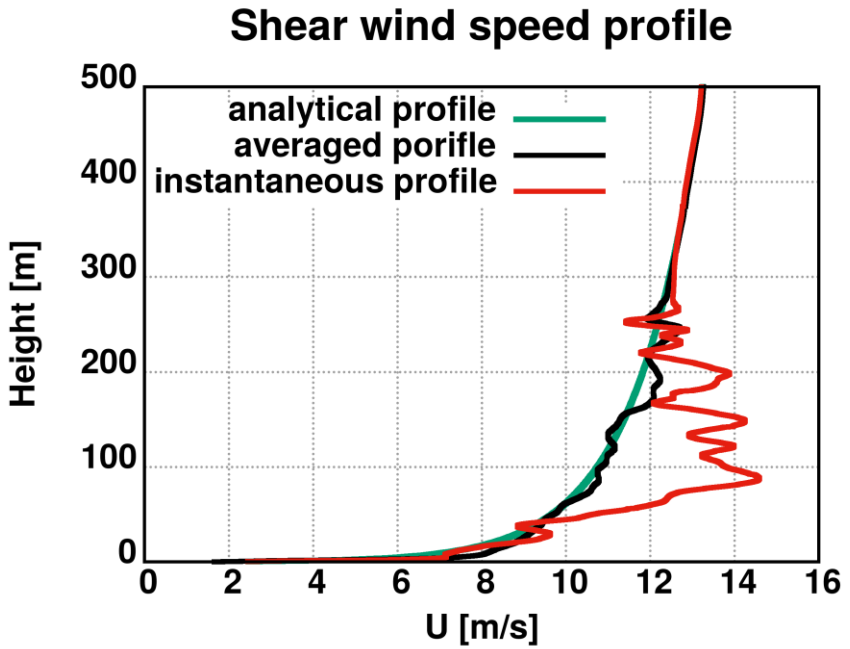
Free Surface effects

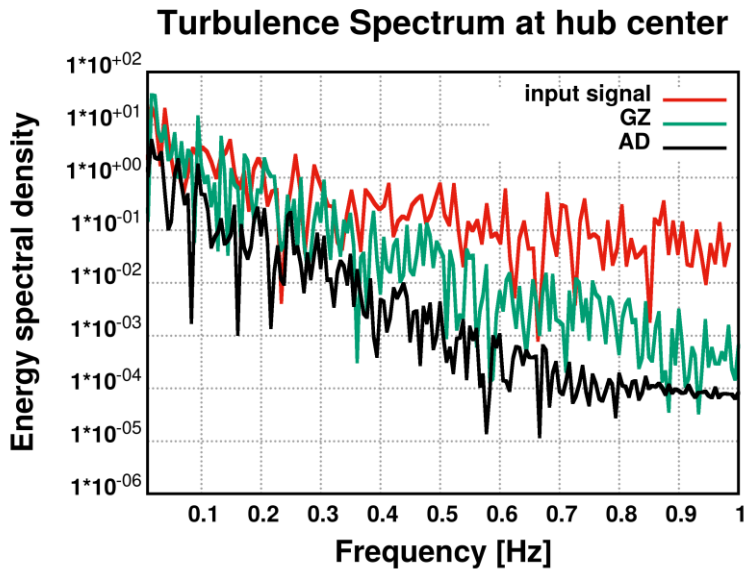
Complex Inflow

- *We use a Generation Zone (GZ) and the Mann box to generate Turbulence at Inflow*
- *We can also add a Shear Profile*
- *Shear and Incoming Turbulence interact*
- *Depending on the computational grid turbulence can decay quickly!*

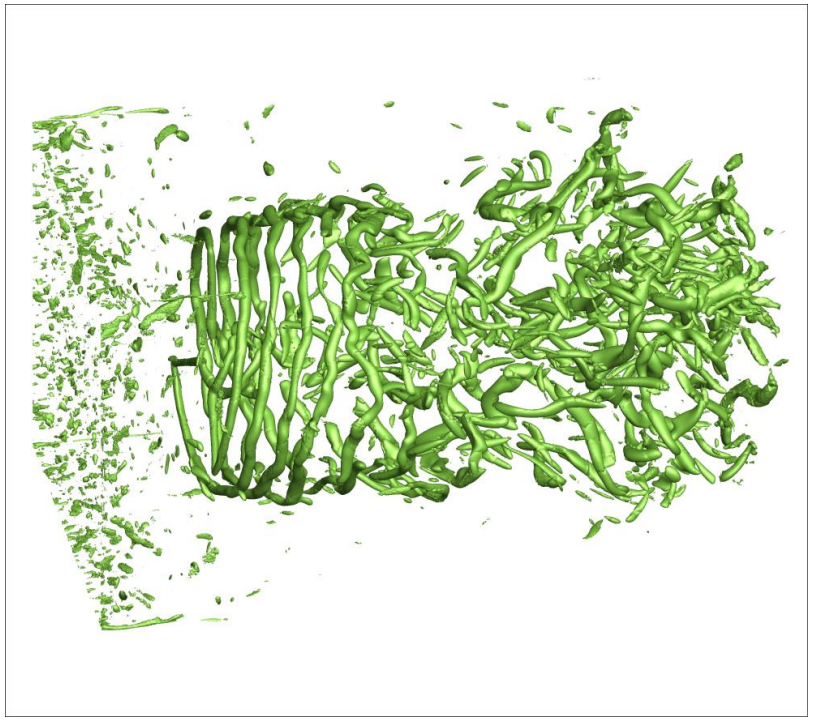


Inflow turbulence –Mann box

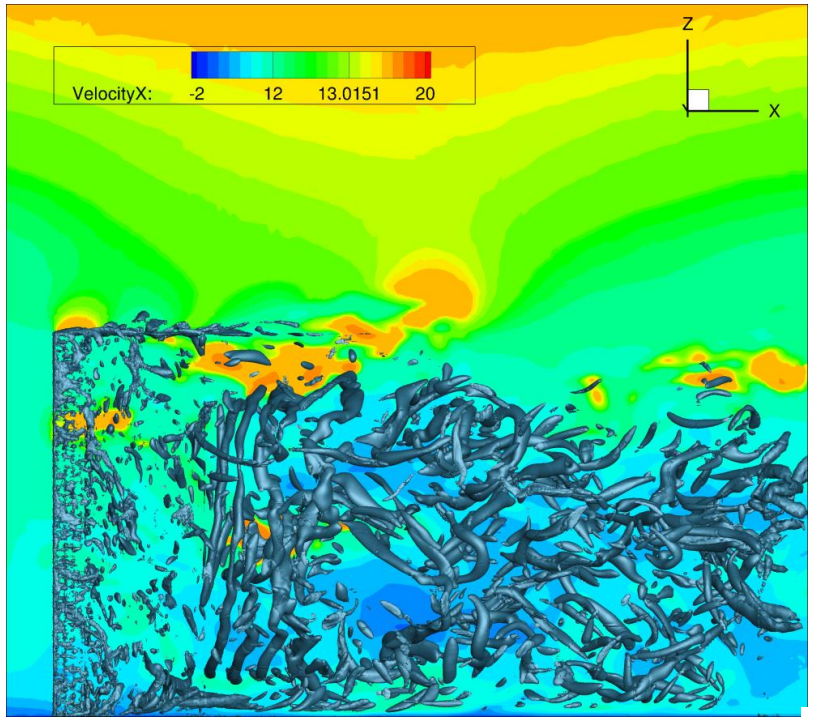




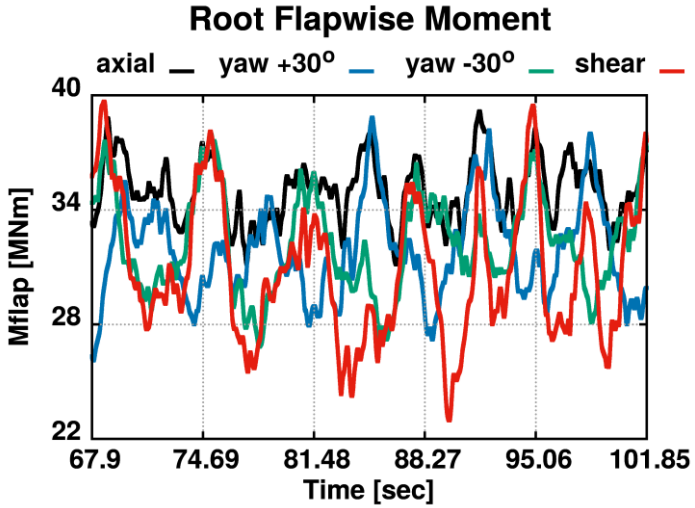
Applications: Complex Inflow-Aeroelasticity



Turbulent Inflow



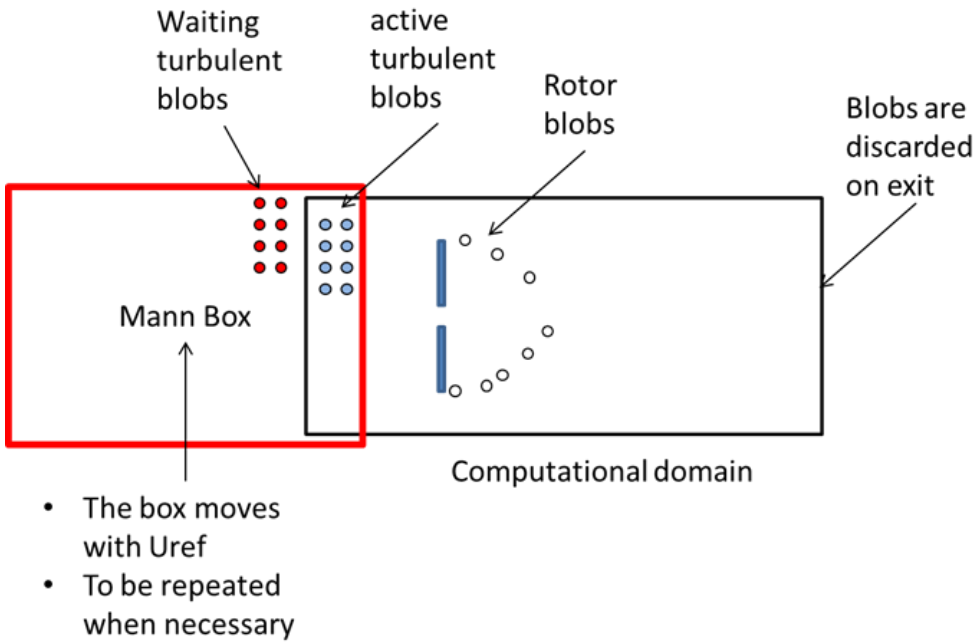
Shear + Turbulent Inflow

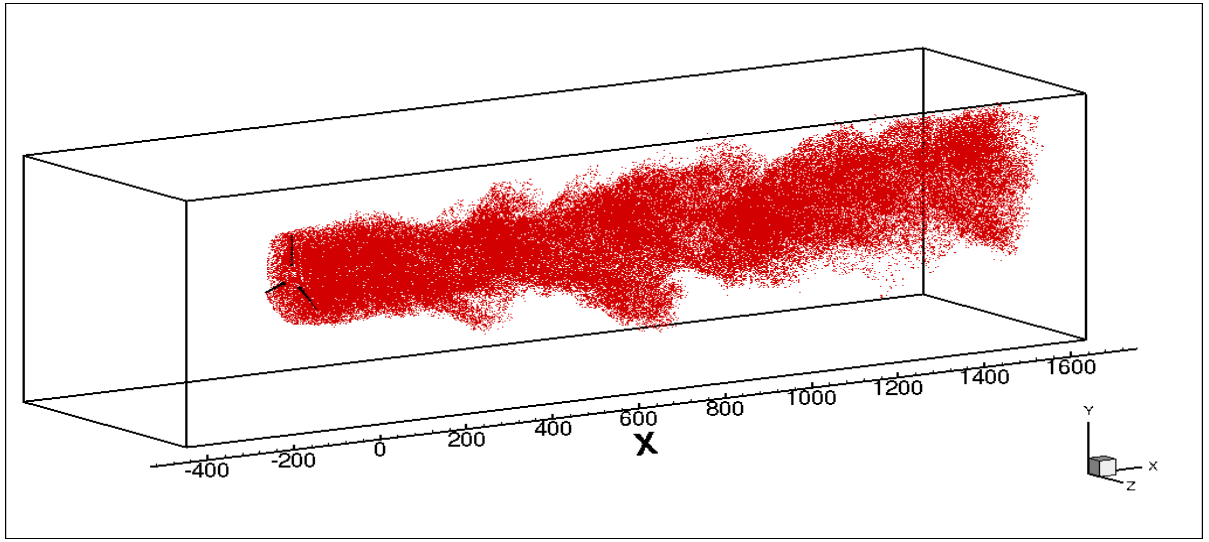


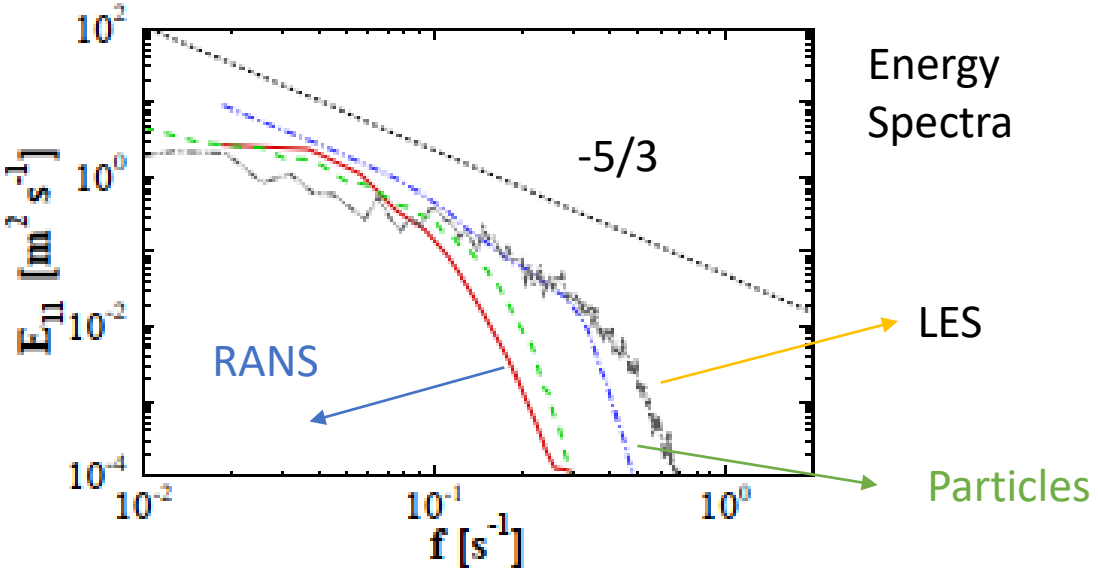
Spyropoulos N. et al – Work under publication

Hybrid Methods

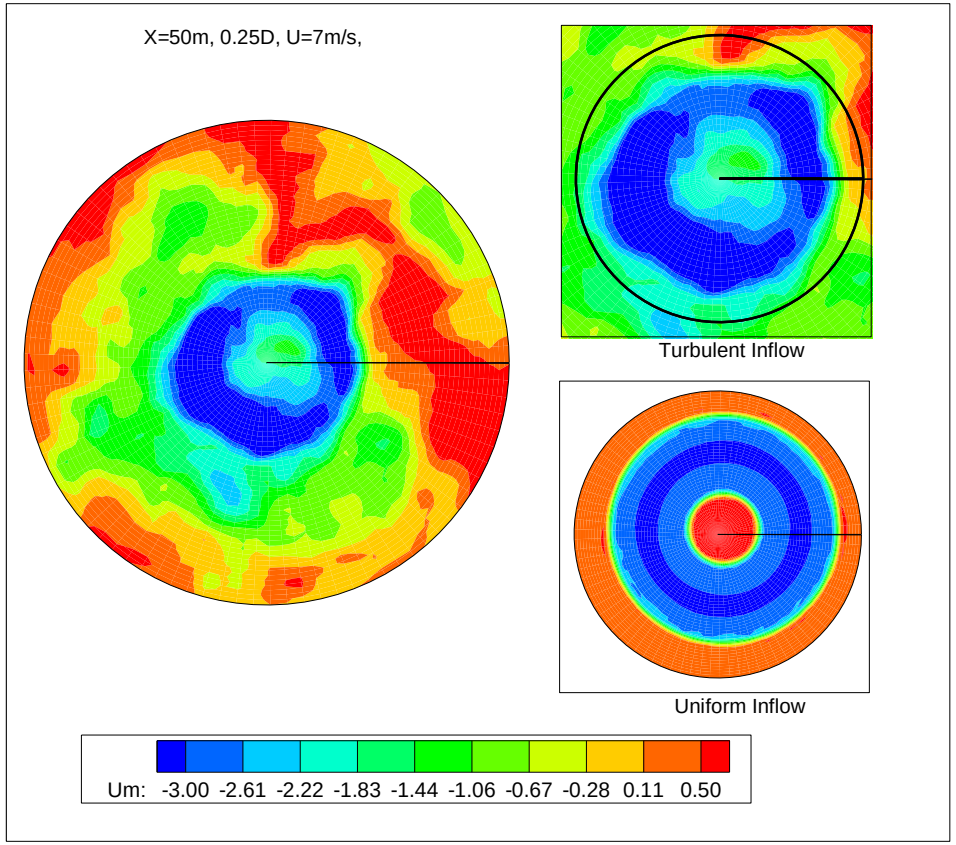
Vortex Particles + CFD

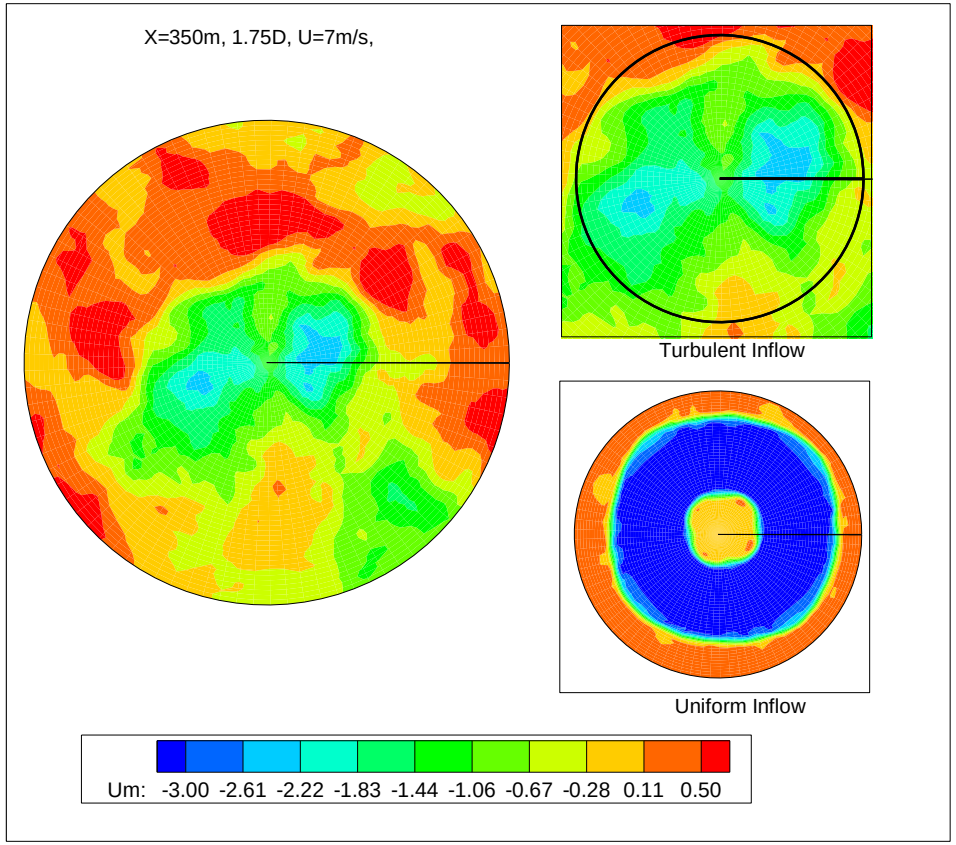






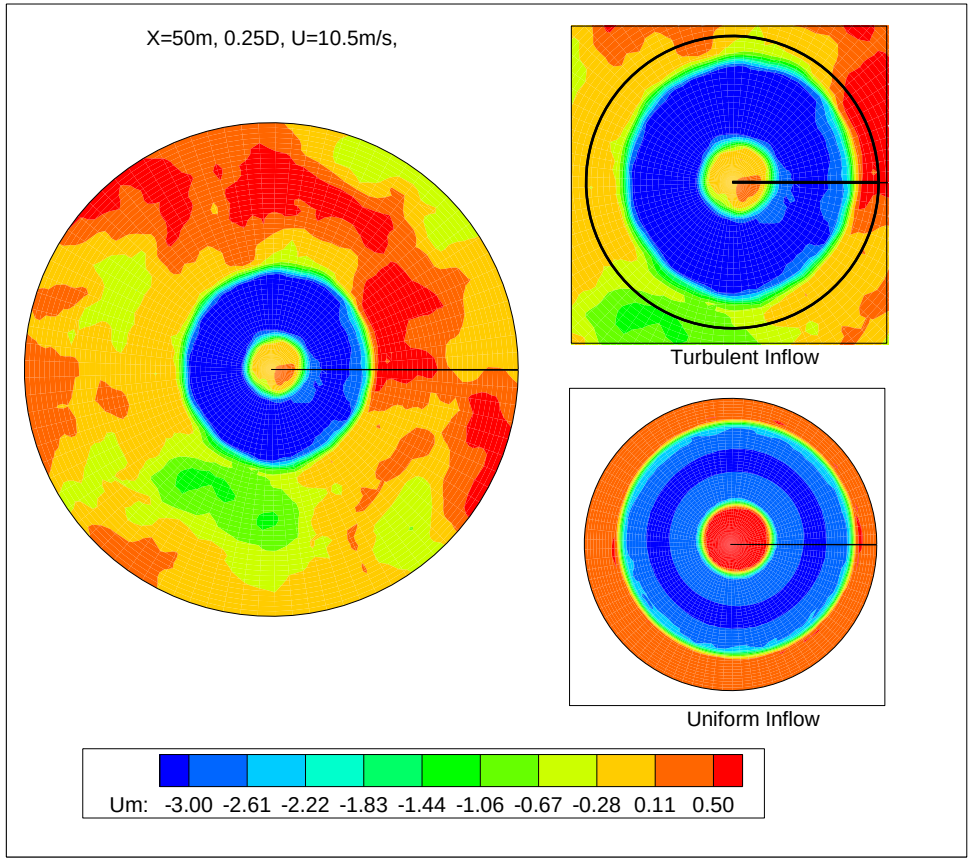
Energy Spectra

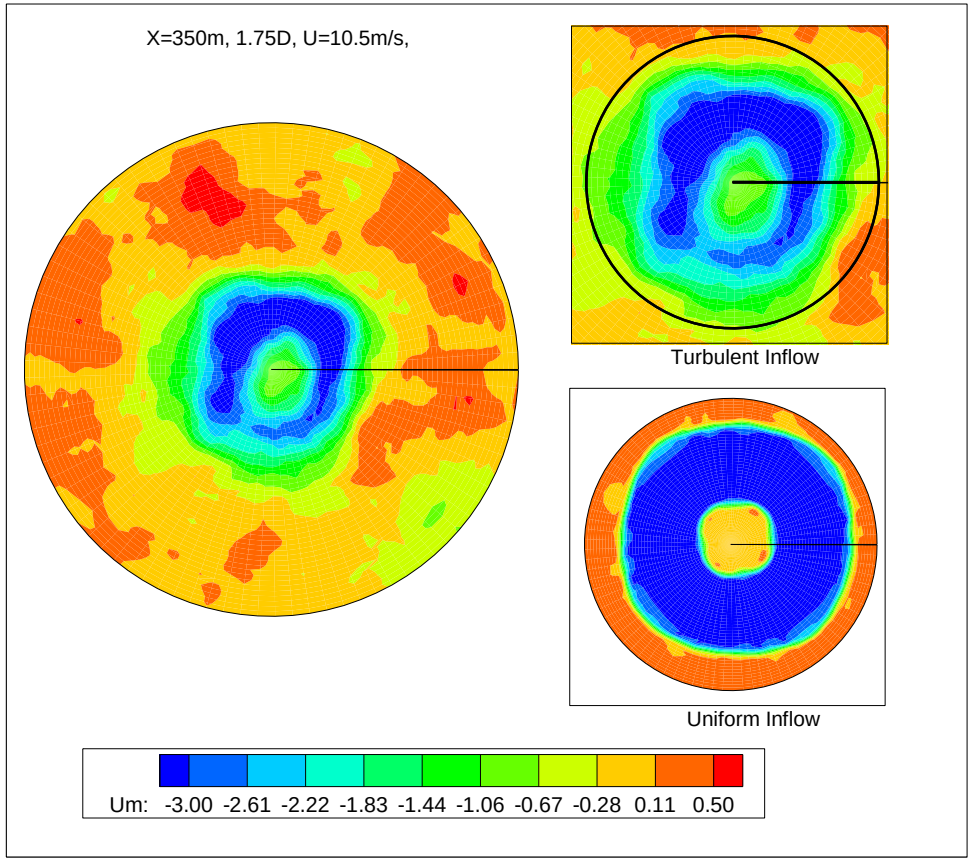




0.25 Diameters Downstream Tu=24.8%

1.75 Diameters Downstream Tu=24.8%



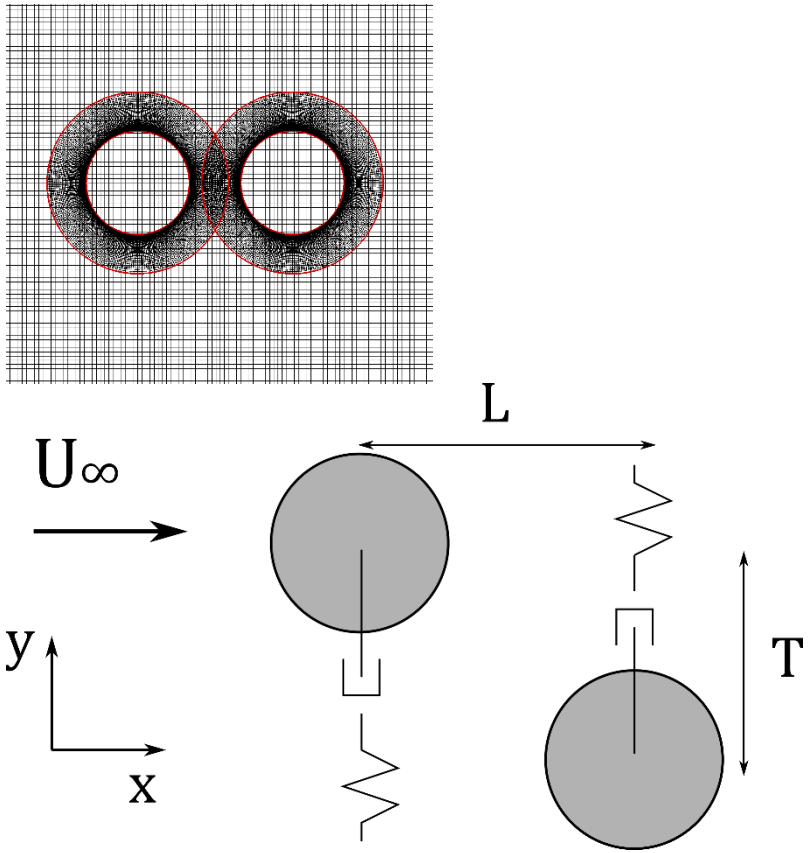


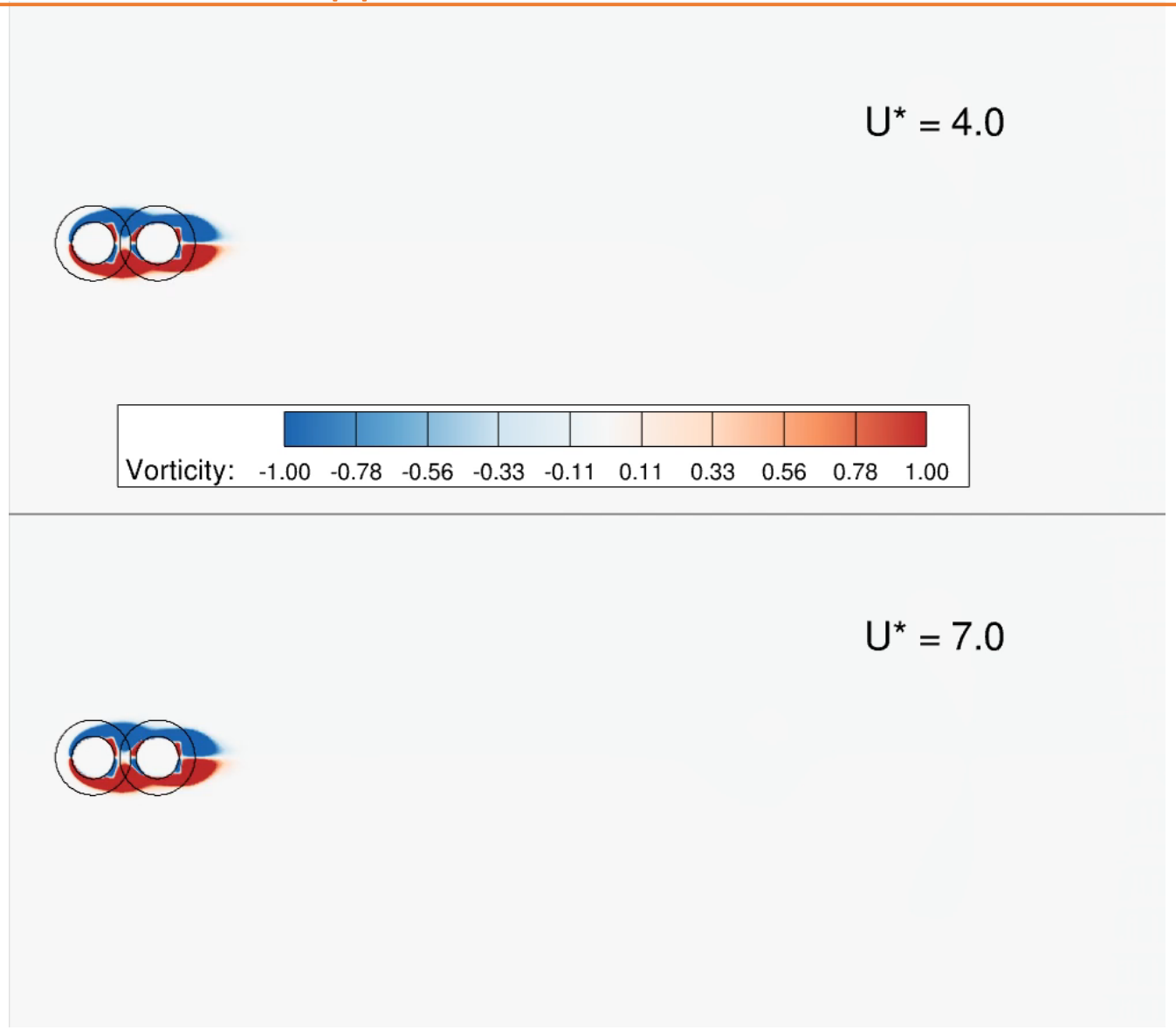
0.25 Diameters Downstream Tu=5%

1.75 Diameters Downstream Tu=5%

Vortex Induced Vibrations

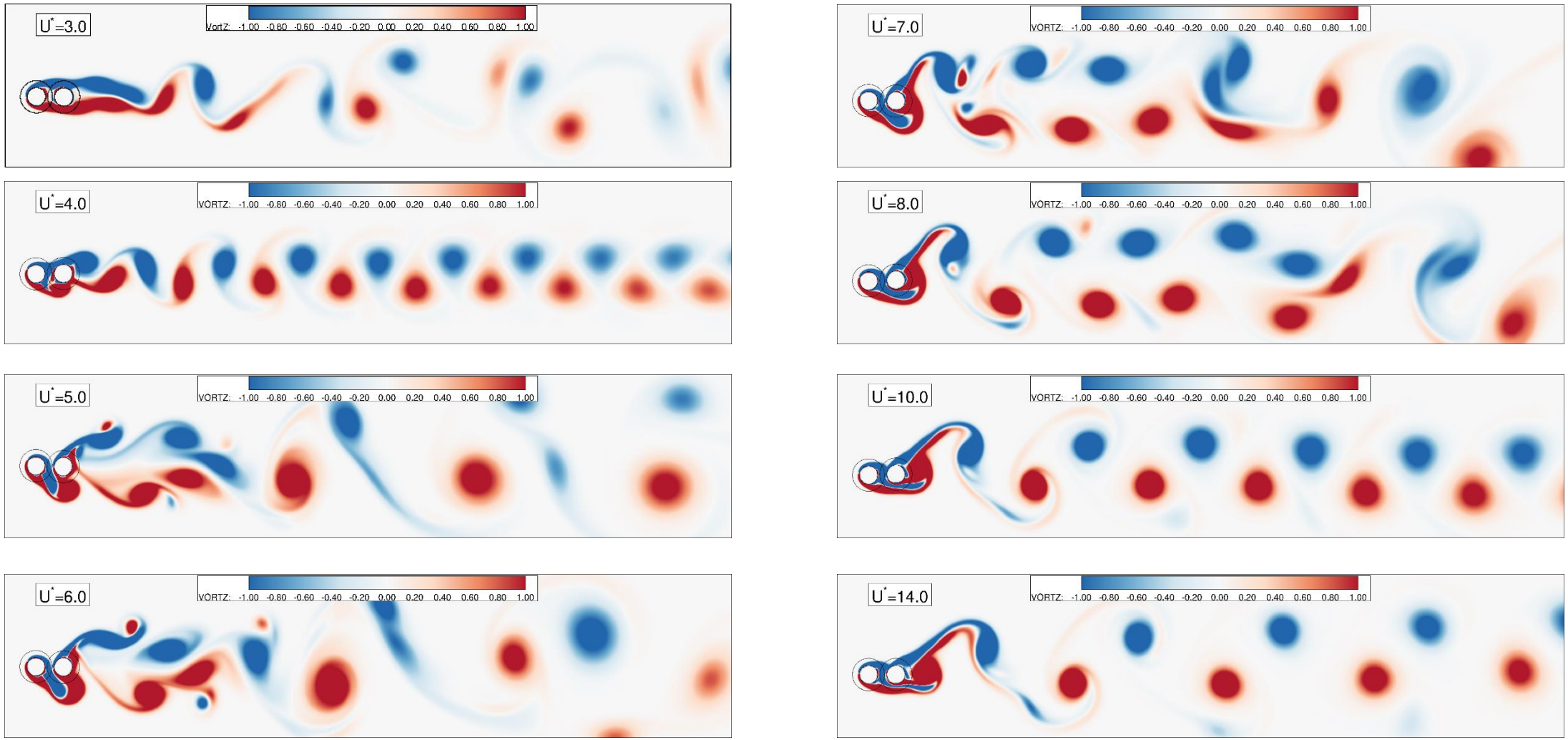
2D cylinders in tandem arrangement





Changing Spring Stiffness…

Applications: Vortex Induced Vibrations

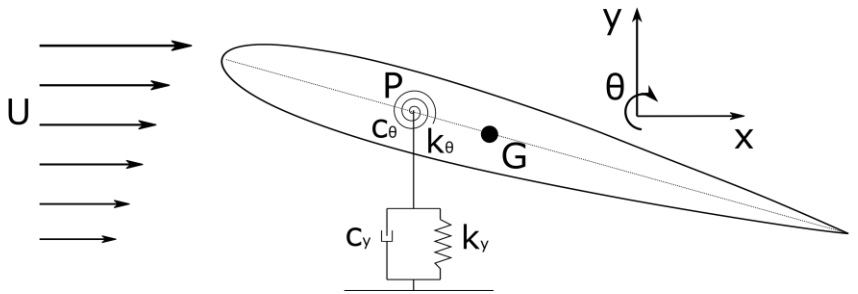


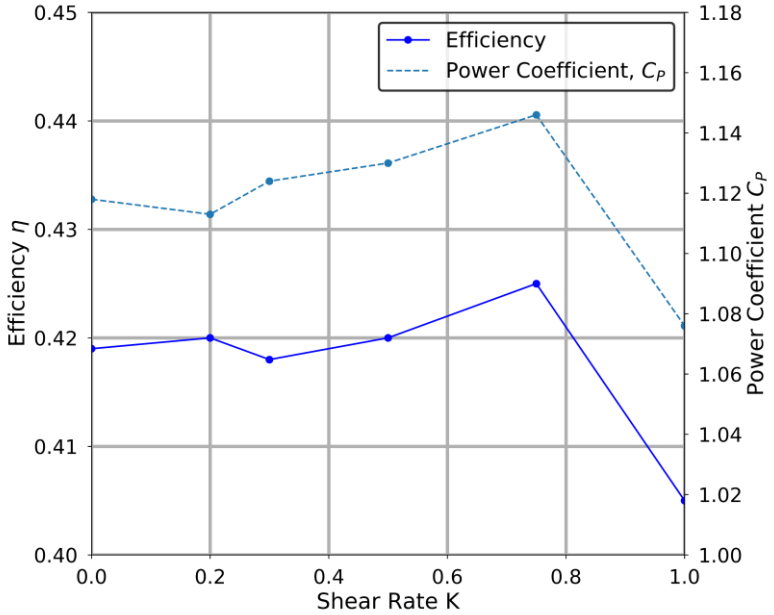
Effect of spring stiffness on the wake

Papadakis G.,Riziotis V. , and Voutsinas S. "A hybrid Lagrangian-Eulerian flow solver applied to cylinders in tandem arrangement." arXiv preprint arXiv:2112.09881 (2021).V

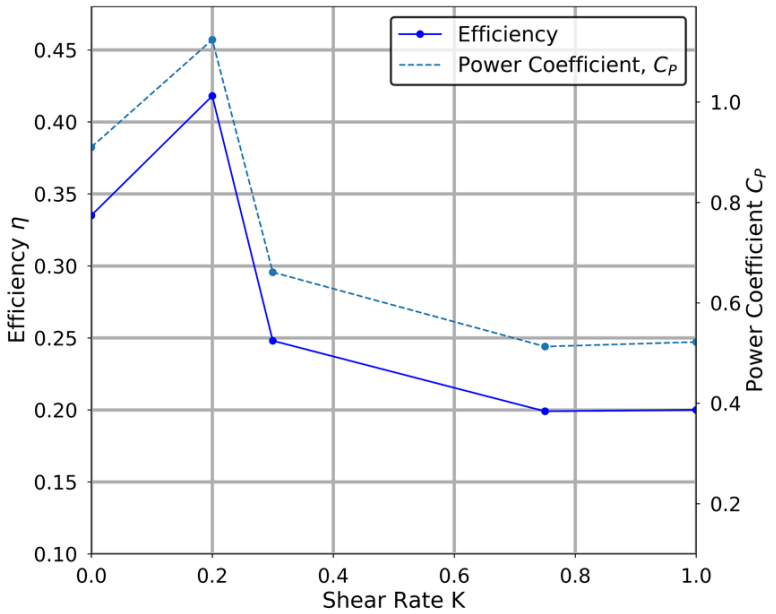
Shear & Free surface & Dynamics

Fully Passive Energy Extracting Flapping Foil
- Submerged
- Under Sheared Inflow



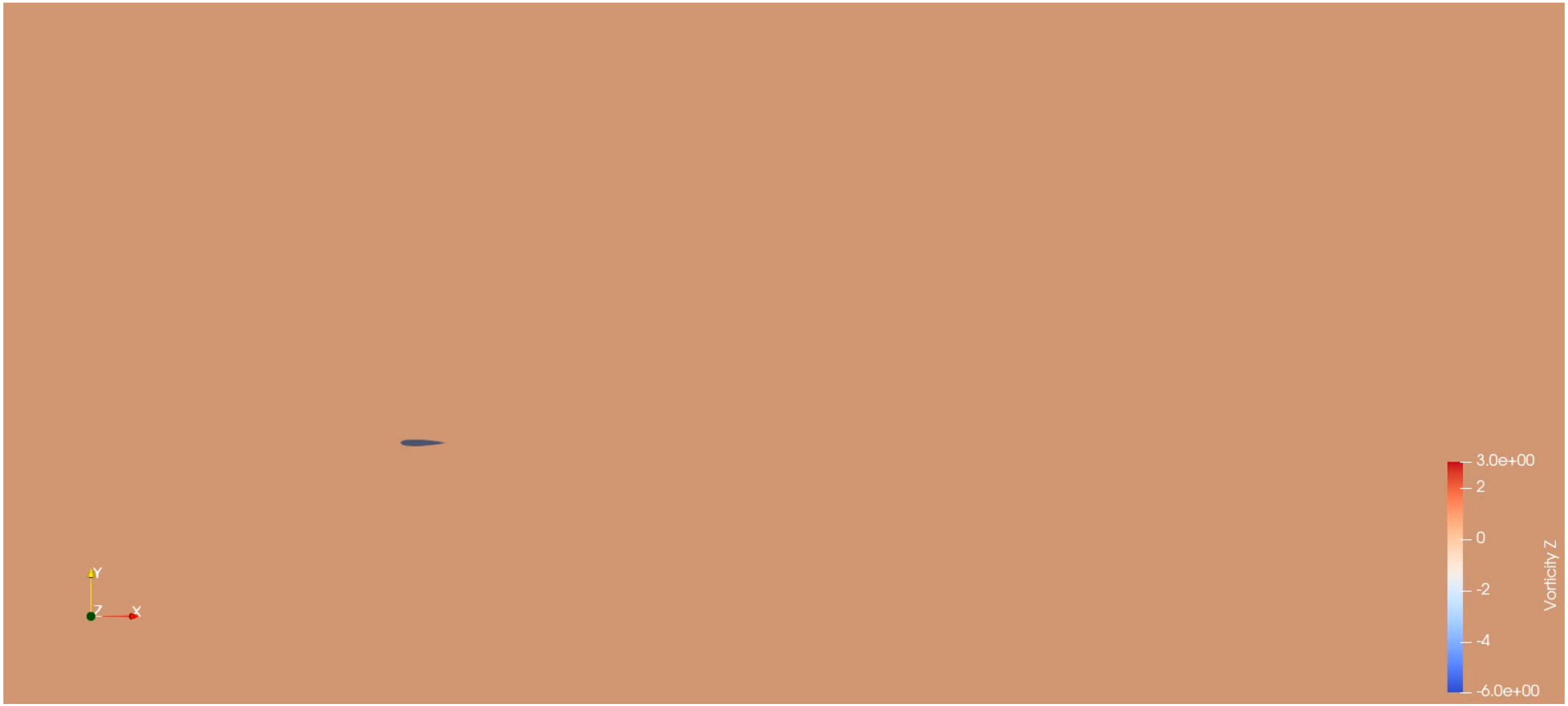


Without free surface



Operating under free-surface

Theodorakis K., Ntouras D., & Papadakis G. (2021). Investigation of a submerged fully passive energy-extracting flapping foil operating in sheared inflow. https://arxiv.org/abs/2112.11042v1

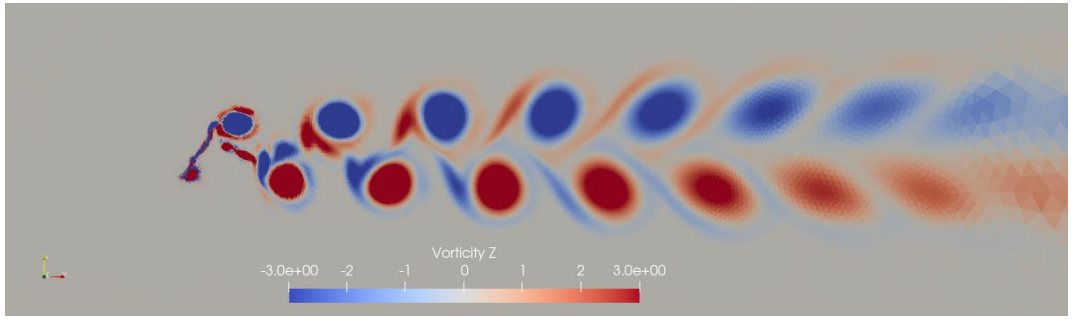

Y
Z
X
3.0e+00
2
0
-2
-4
-6.0e+00
Vorticity Z

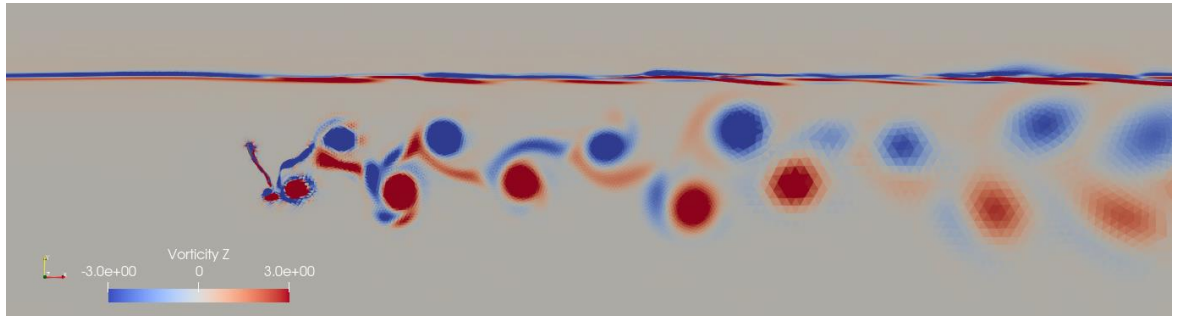
Shear rate

Without Free Surface

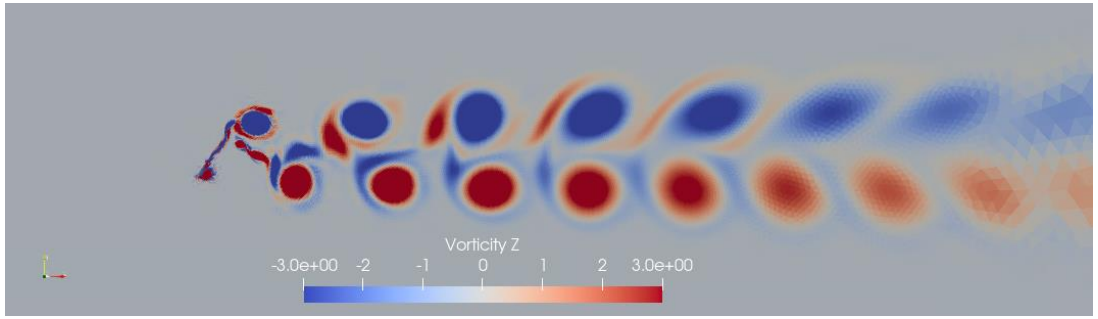
With Free Surface

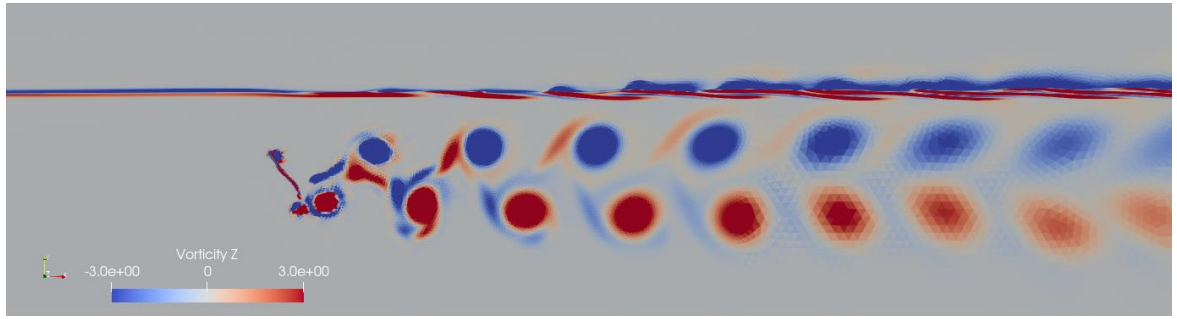
K=0



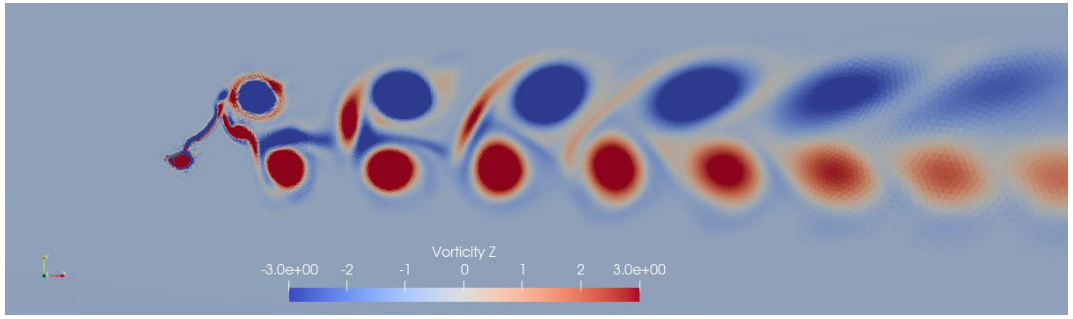


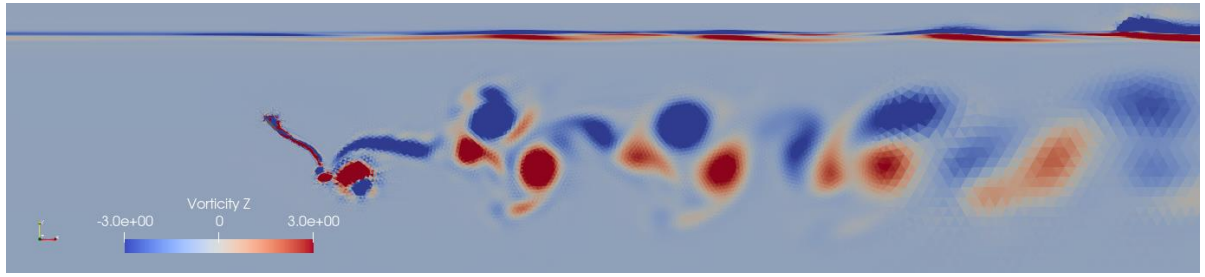
K=0.2



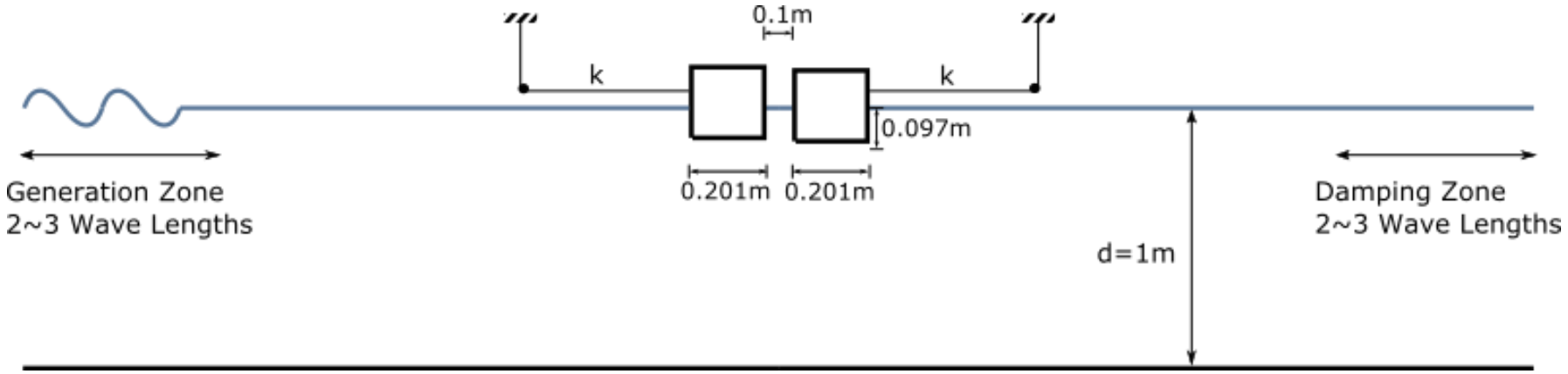


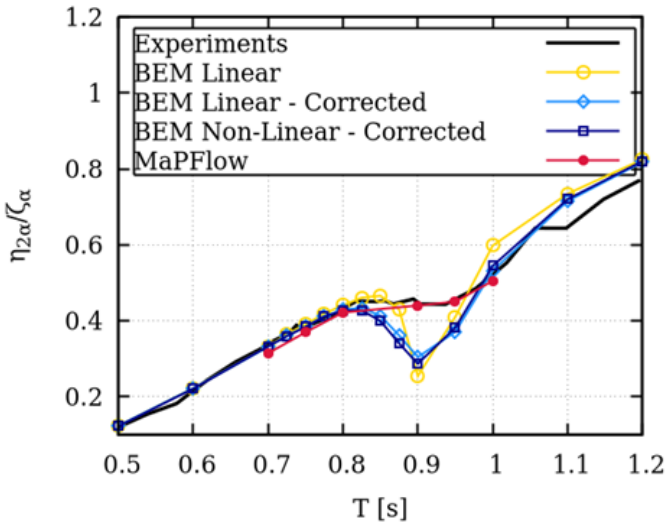
K=0.75



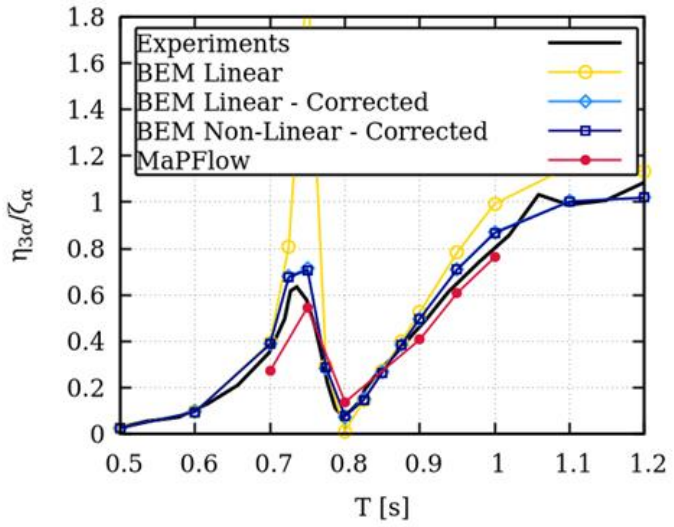


Two phase flows + Dynamics

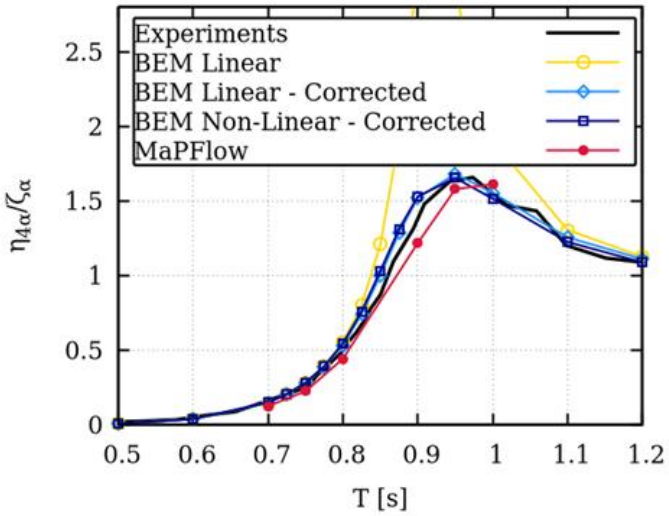




RAOs in sway direction



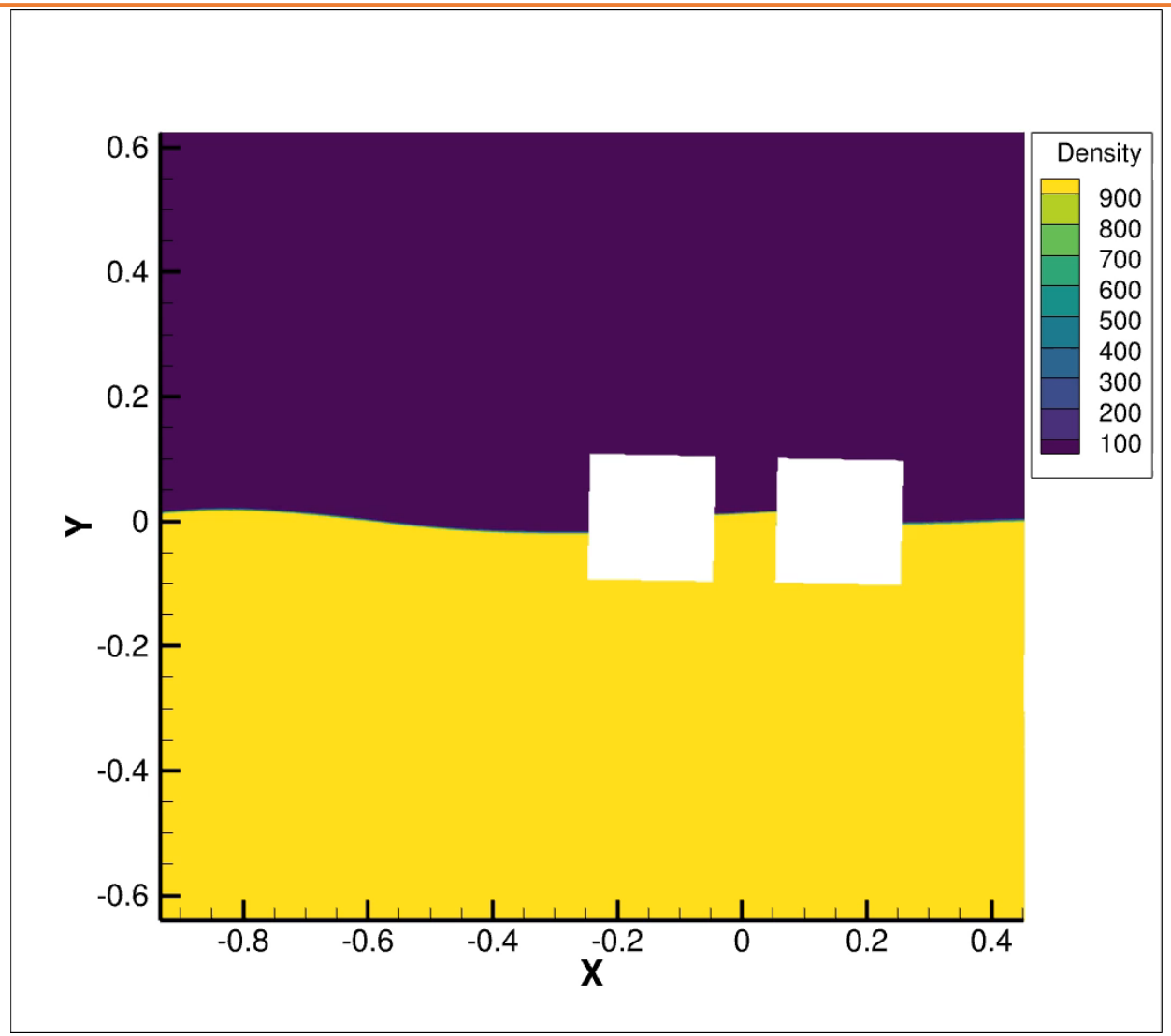
RAOs in heave direction

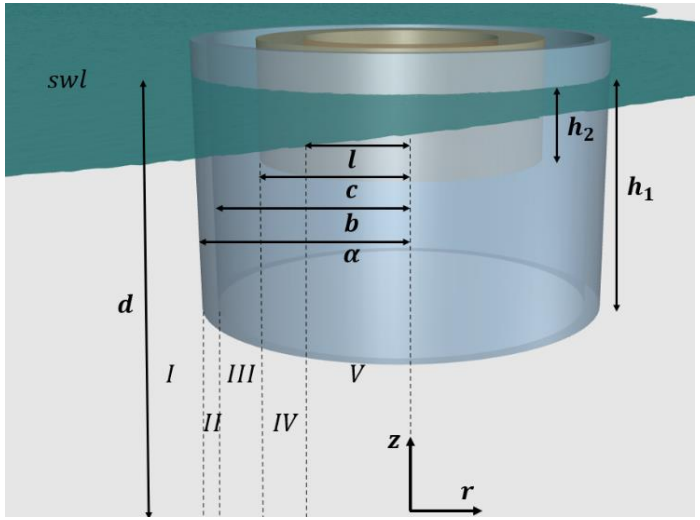


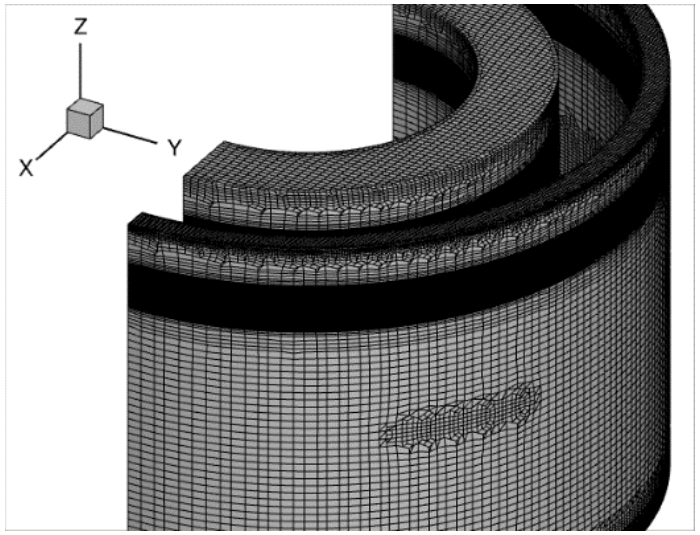
RAOs in roll direction

Ntouras D., Manolas D., Papadakis G. & Riziotis V. (2020). Exploiting the limit of BEM solvers in moonpool type floaters. Journal of Physics: Conference Series, 1618, 052059. https://doi.org/10.1088/1742-6596/1618/5/052059

Applications: Two-phase flows + Dynamics

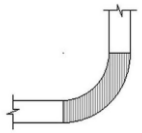


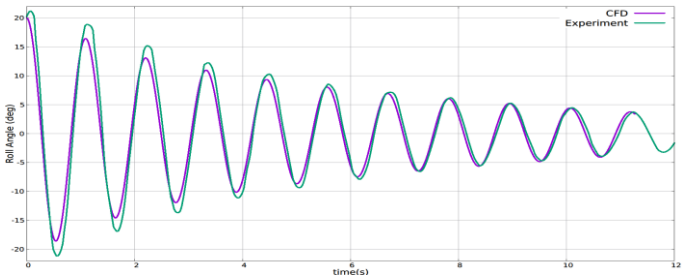


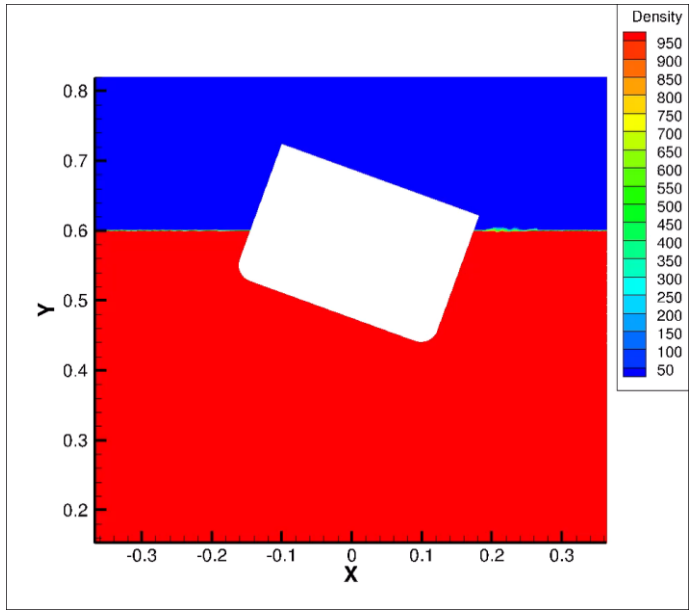


Mavrakos, Anargyros S., Dimitrios N. Konispoliatis, Dimitrios G. Ntouras, George P. Papadakis, and Spyros A. Mavrakos. "Hydrodynamics of Moonpool-Type Floaters: A Theoretical and a CFD Formulation." Energies 15, no. 2 (2022): 570.

BK00







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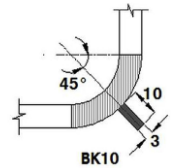
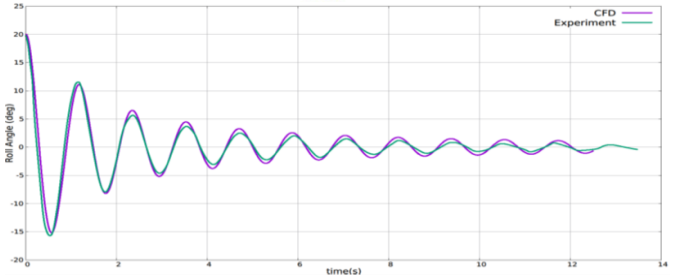
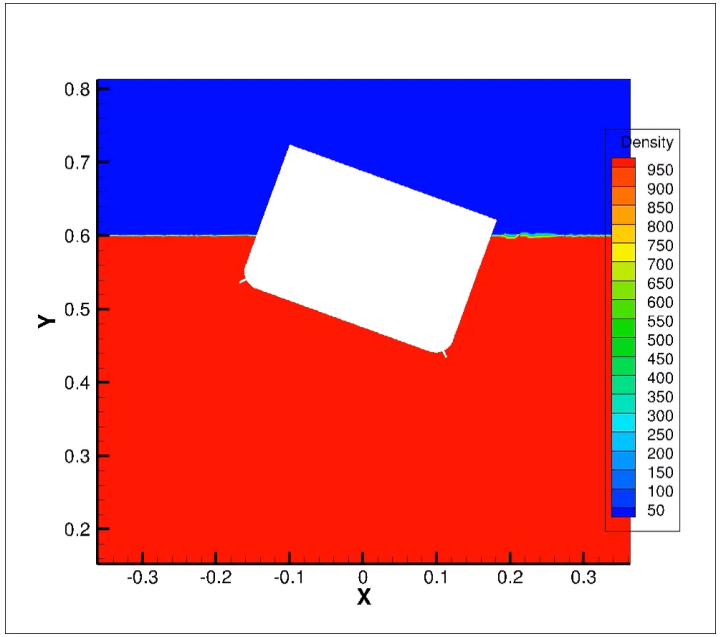
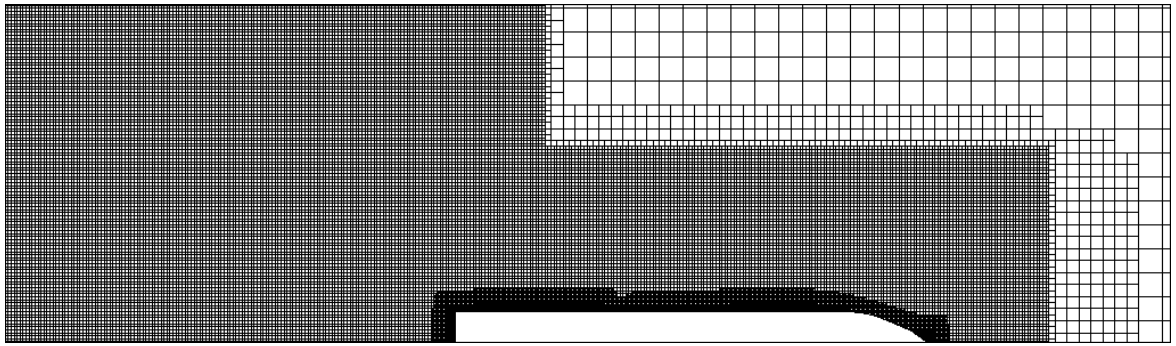


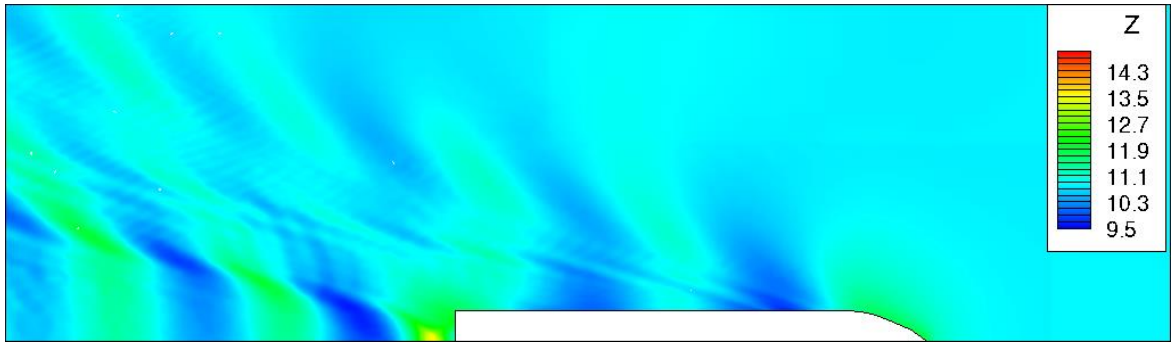


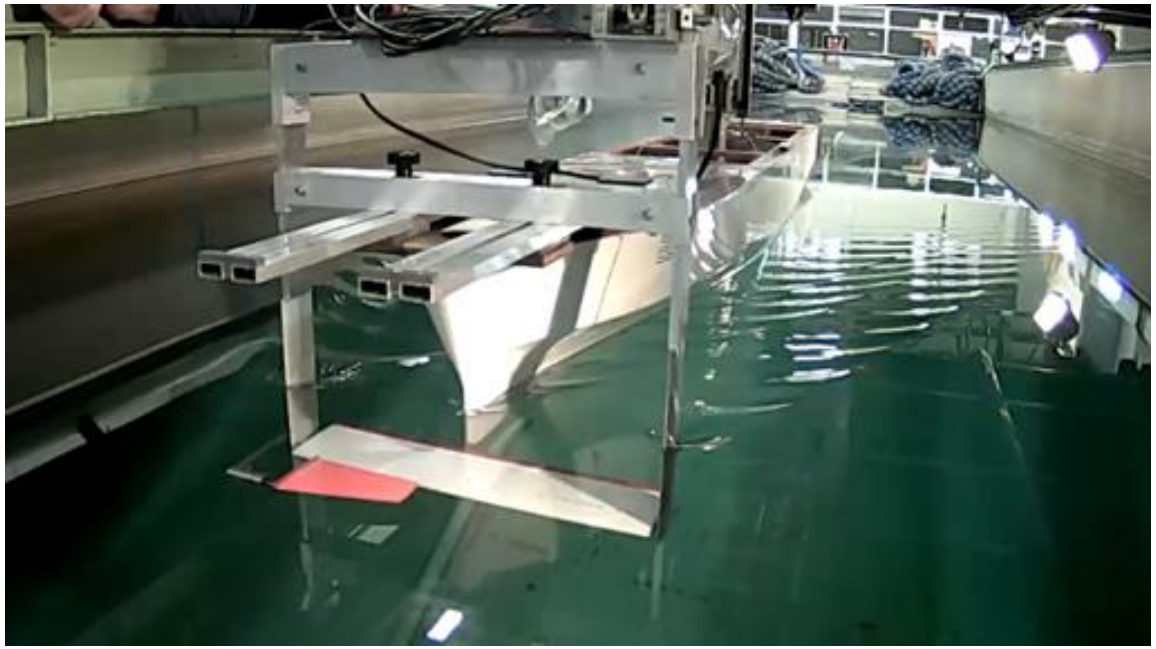


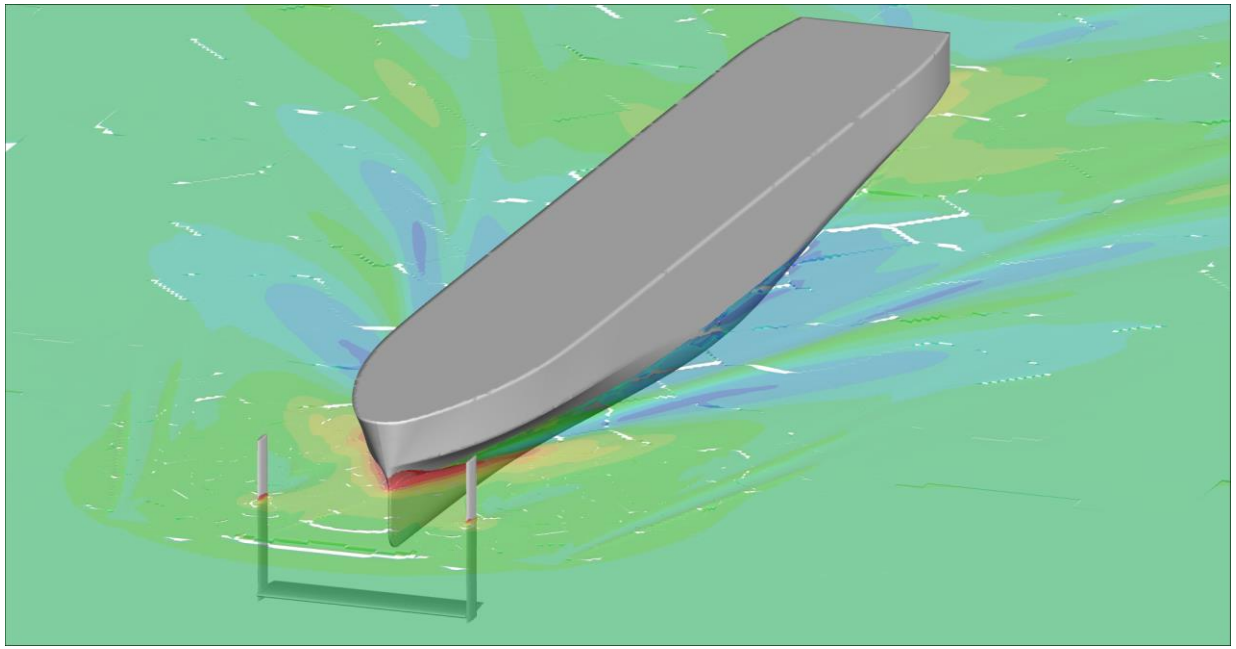
Spyrou, Ioannis Taro. "Numerical investigation on the effect of bilge keels in ship roll damping." (2020)-Diploma Thesis

Applications: Two-phase flows + Dynamics









Belibassakis K., Filippas E. and Papadakis G. "Numerical and Experimental Investigation of the Performance of Dynamic Wing for Augmenting Ship Propulsion in Head and Quartering Seas." Journal of Marine Science and Engineering 10.1 (2022): 24-SEATECH EU project

Thank you !