CFD code comparison, verification and validation for a floating wind semi-submersible platform

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Objectives

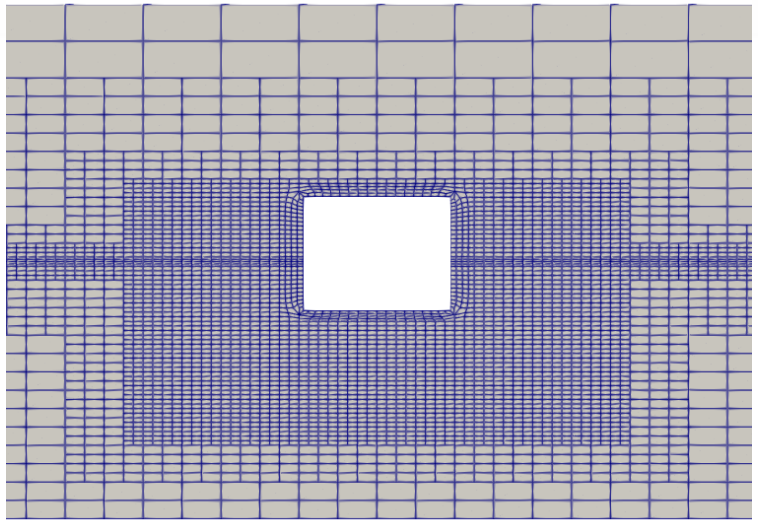
- Collaborative CFD research on hydrodynamics of FOWT
- Verification & validation
- Code comparison
  - ReFRESCO, OpenFOAM
  - Numerical setup as similar as possible
  - Freely available inputs and results: https://github.com/WavEC-Offshore-Renewables/Tokyo-Wavec-FOWT
- Decay tests
  - Floating cylinder
  - OC4 Phase II semi-submersible model

Verification & validation

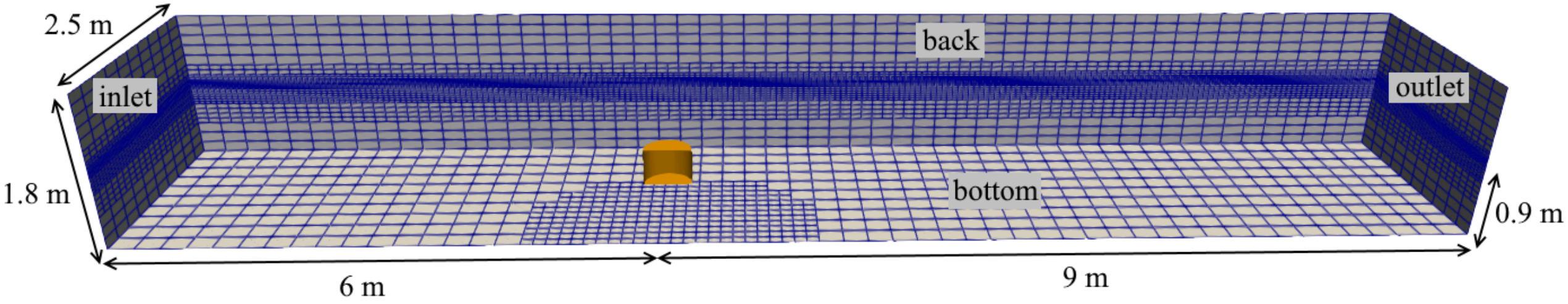
- Validation
  - Engineering task
  - Proving that the numerical model is an adequate representation of “reality”
  - E.g. comparison with experiment

- Verification
  - Mathematical task
  - Estimating uncertainty of simulation result while the exact solution is unknown
  - Numerical error = Round-off error + Iterative error + Discretisation error
  - E.g. grid & time step refinement study [1]

Setup 1: Free floating cylinder

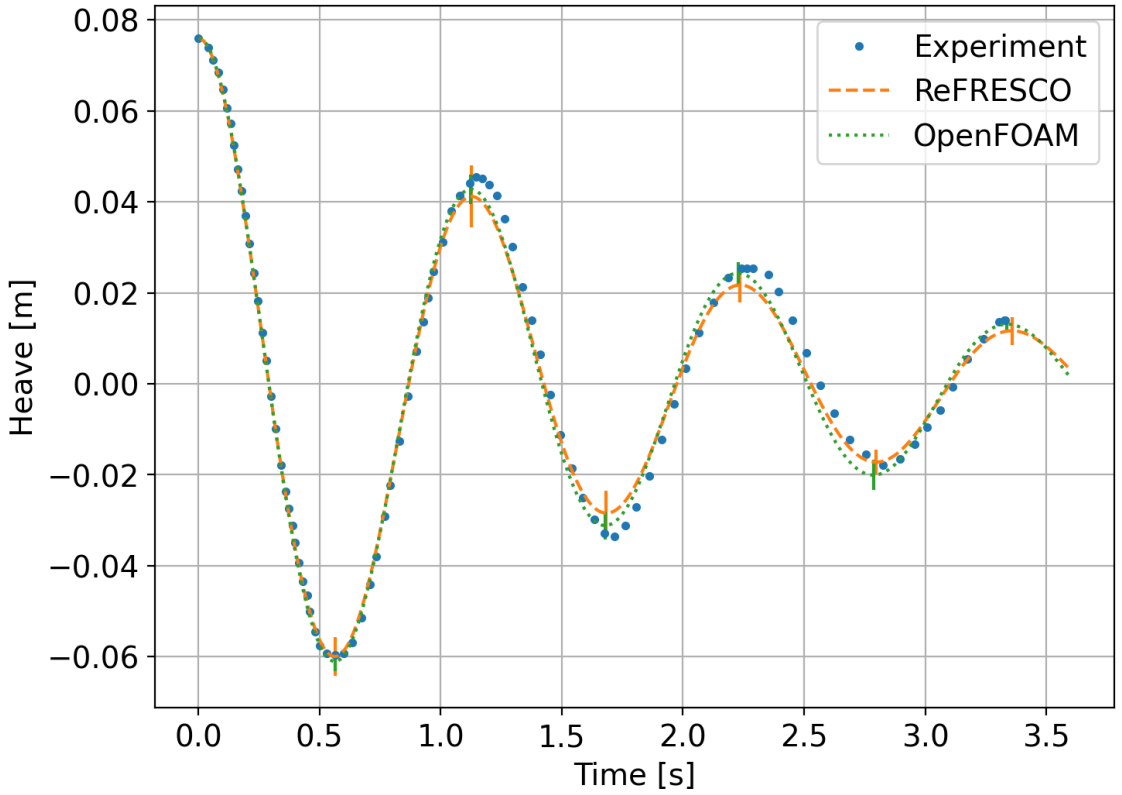


- Heave (& pitch) decay, 3 DoF
- Verification: Grid & time step refinement study
  - 4 meshes: 63k – 900k cells
  - 3 time steps
- Validation: Experimental [2] & numerical [2,3] data available



Cylinder: Heave decay

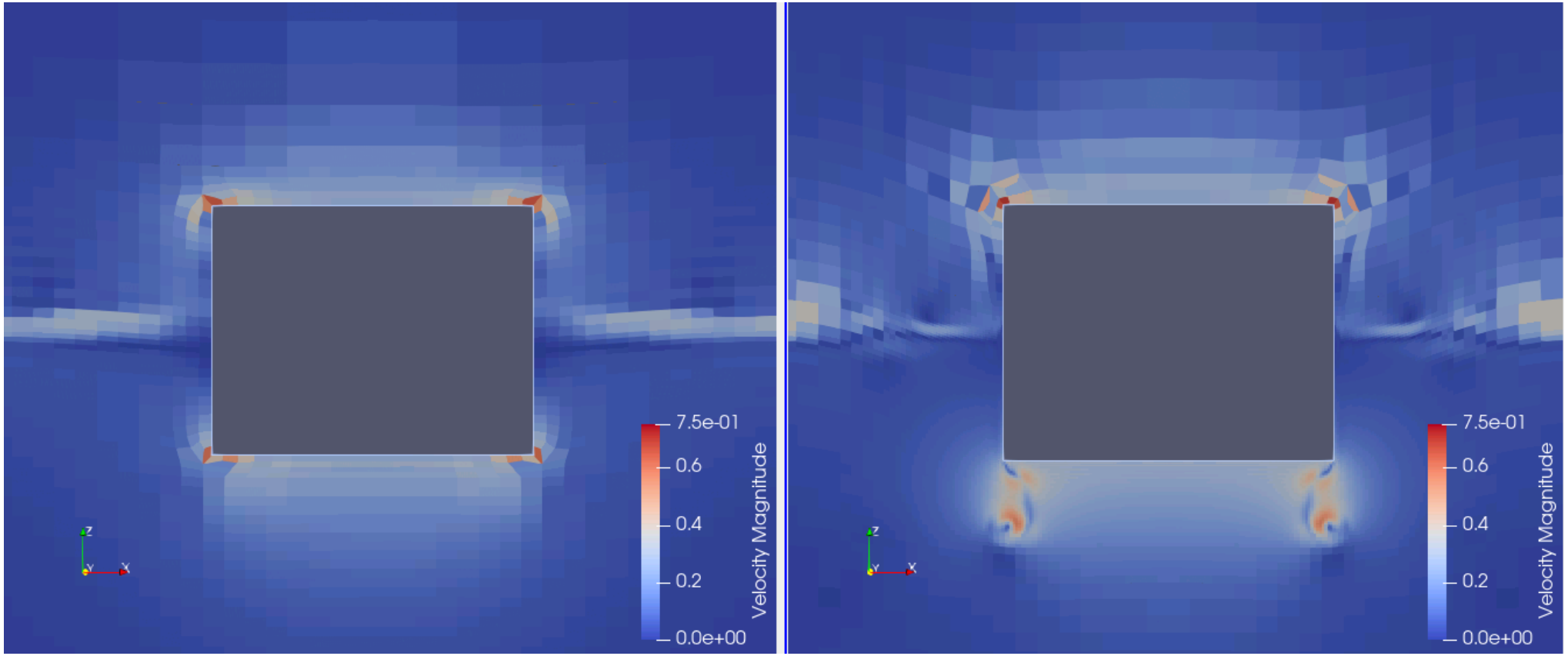
- Uncertainty levels achieved
  - For natural period:
    < 2 % for finer discretisations
  - For linear damping coefficient:
    ≈ 10 %
  - For peaks even larger…
- Deviations from experiment acceptable



	ReFRESCO (RF)		OpenFOAM (OF)		Experiment
T [s]	1.119	+1%	1.113	+0%	1.112
θ [-]	0.560	+9%	0.518	+0%	0.516

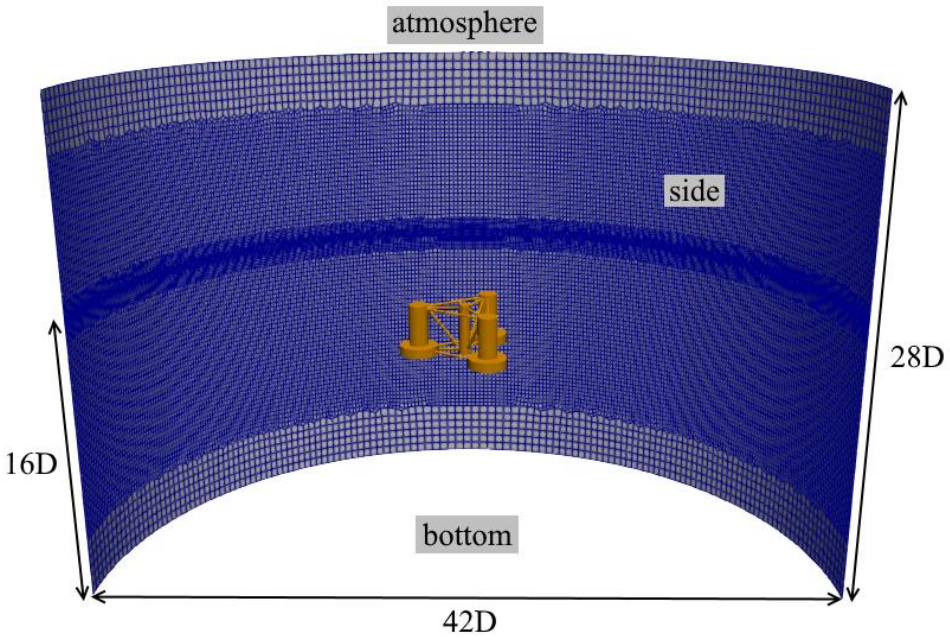
Cylinder: Heave decay

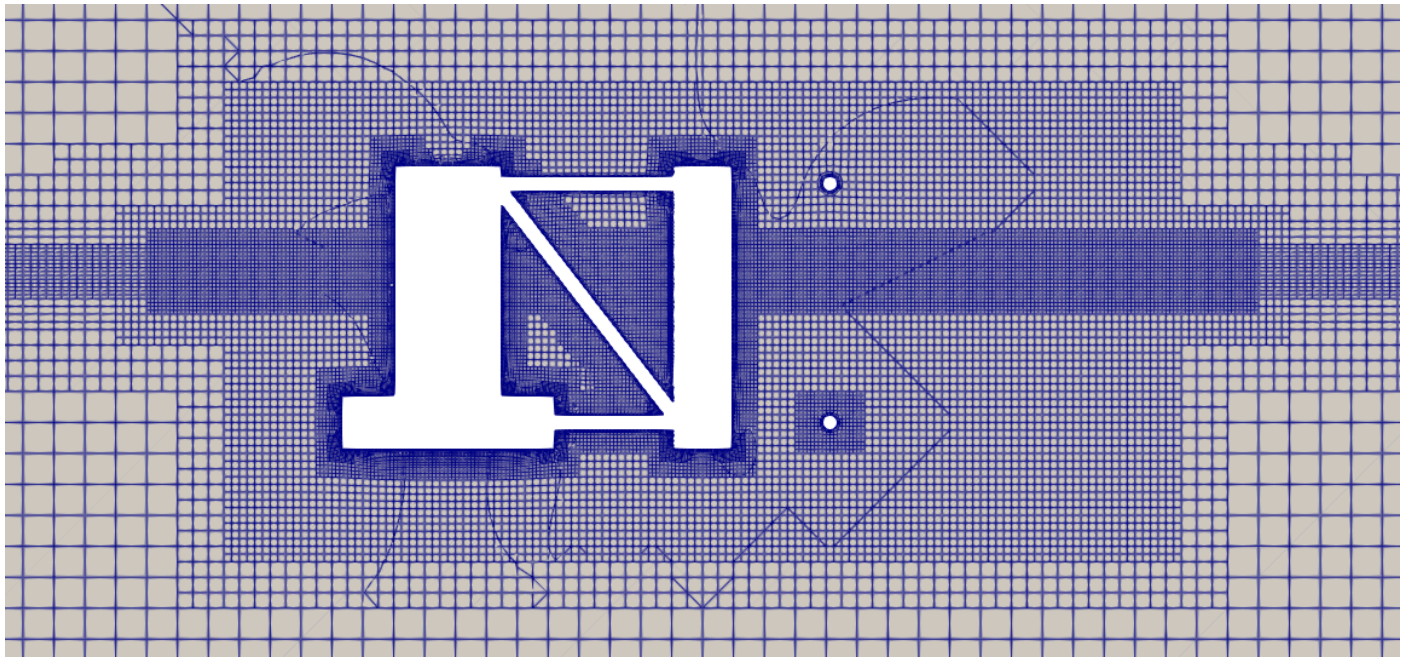
- Vortices around submerged edge only appear in higher resolutions!



Setup 2: OC4 semi-submersible

- Sway (& surge & yaw) decay, linear spring moorings, 1 & 6 DoF
- 11.5M cells, extra refinement around edges & viscous layer insertion
- Experimental data from 1:73 model-scale tank test by OSPL, UTokyo [4]

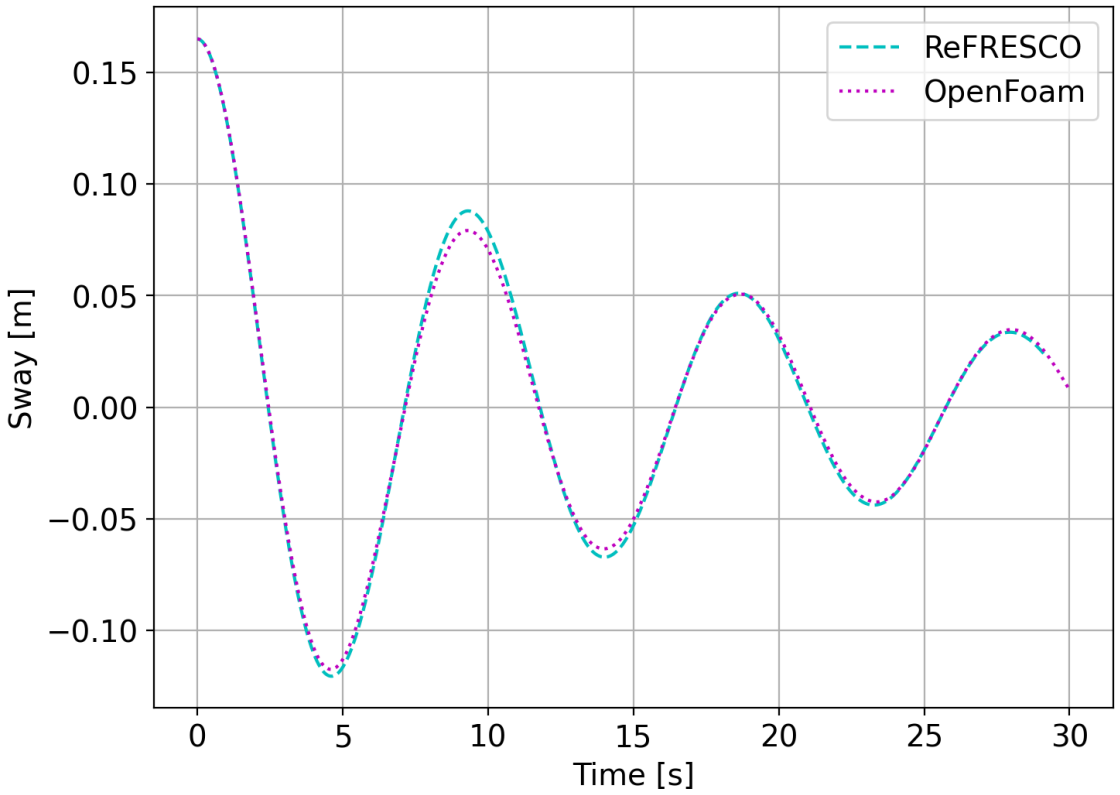




OC4: Sway decay 1/2

- Influence of damping coefficient calculation method
  1) All extrema
  2) Neglecting first 2 extrema

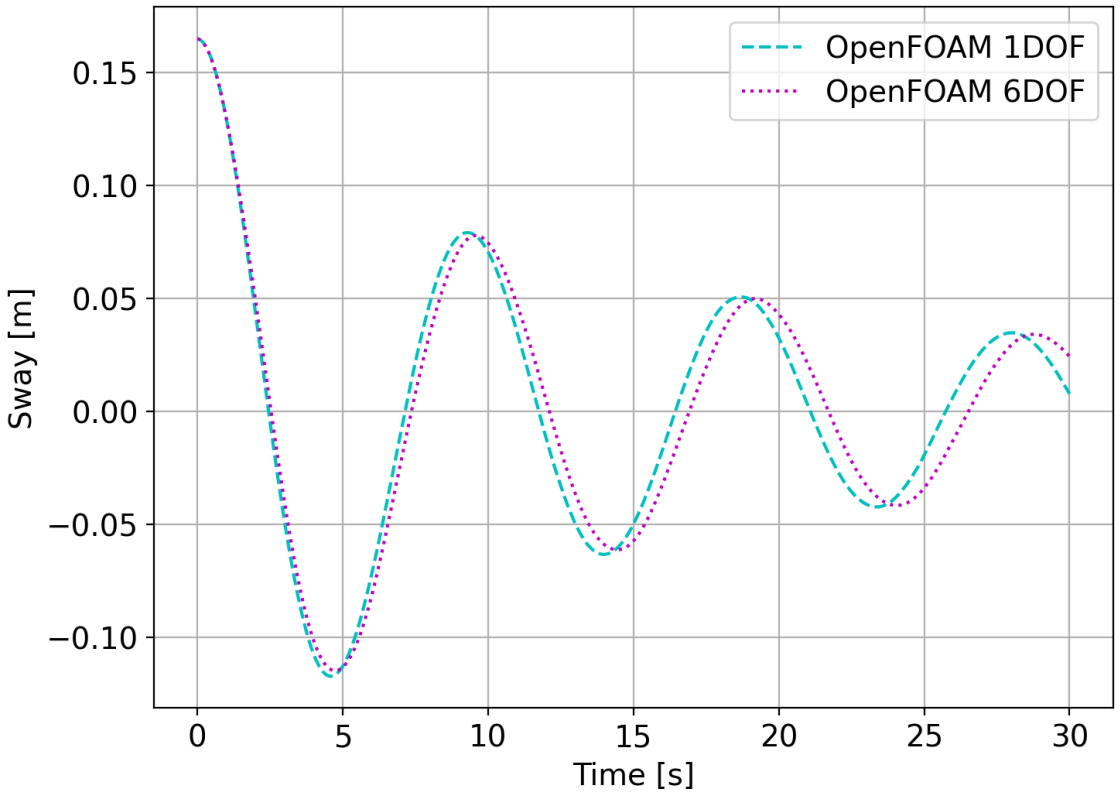
	ReFRESCO 1DoF		OpenFOAM 1DoF		Exp.
T [s]	9.32	-3%	9.33	-3%	9.6
θ_1 [-]	0.056	+47%	0.055	+45%	0.038
θ_2 [-]	0.051	+34%	0.044	+16%	0.038



OC4: Sway decay 2/2

- Influence of damping coefficient calculation method
  1) All extrema
  2) Neglecting first 2 extrema
- Impact of allowed degrees of freedom

	OpenFOAM 1DoF		OpenFOAM 6DoF		Exp.
T [s]	9.33	-3%	9.59	-0%	9.6
θ_1 [-]	0.055	+45%	0.054	+42%	0.038
θ_2 [-]	0.044	+16%	0.042	+11%	0.038



Conclusions & future work

- Code comparison only with thorough verification & validation
  - Quantitative assessment of all numerical AND experimental uncertainties!
- Decay modelling: Natural period rather easy, damping more challenging

- Cylinder: Revision of heave & pitch decay
- OC4: ReFRESCO 6DoF simulations, compare with experiment time series, review damping coefficient calculation methods [5], verification [6]

- More codes! Help us: https://github.com/WavEC-Offshore-Renewables/Tokyo-Wavec-FOWT

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