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Early Career Researcher Posters and Abstracts Booklet

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Early Career Researcher Posters 2026

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Scale model testing of the WindCrete spar in extreme conditions

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Abstract

The design for a 1:69.3 scale model of the WindCrete spar device is presented along with results from physical model testing in extreme conditions. It is shown that for the responses studied that the short time series efficiently produced extreme responses within -5% to +7% of those from extended irregular waves and turbulent wind series (the traditional approach) for wind dominated responses. However, more work is needed to factor in the higher order wave loading for responses where the tower response is important.

Keywords: floating wind, focused waves, constrained focused waves, response conditioned wind, short design events, Spar.

2. Design of the 1:69.3 scale WindCrete Spar model

Numerical modelling work suggested short design events perform well for the spar when scaled to the 80th percentile response and so a physical model was produced with a Supergen ECR fund award to test in the Ocean basin at the University of Plymouth. Wind loading is applied using a real time hybrid testing method consisting of a surrogate model trained on OpenFAST data where a wind input time series is used in combination with measured platform motions to estimate aerodynamic thrust.

- 4, single axis piezoelectric load cells to measure tower base loads
- 8 pressure sensors to give breaking wave loads
- Main body made from acrylic tube
- Lead shot ballast
- 3D printed hemisphere and transition piece
- Aluminium tower to match period of 1st bending mode

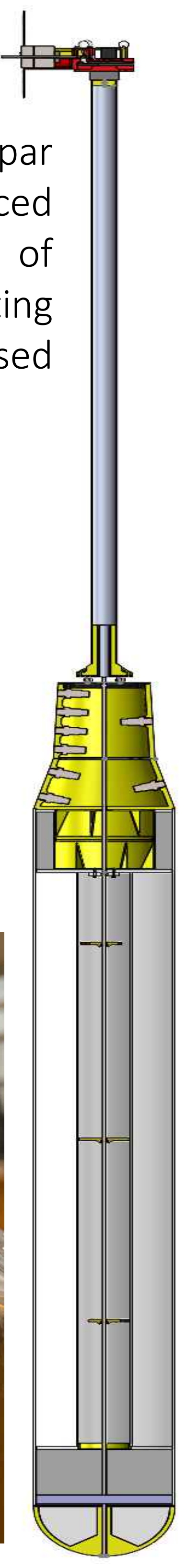


Fig.1 (left to right) Single axis load cell arrangement used to calculate tower base bending moments, deployed load cells at tower base, CAD model of fully assembled model.

3. Short sequence response conditioned approach

What are focused / constrained focused waves?

Focused waves use linear dispersion to produce the shape of an extreme wave. These waves can be constrained into short irregular wave time series. This process has here been expanded to a turbulent wind time series.

What is meant by response conditioned?

The shape of the wave or wind time series is conditioned on the linear response amplitude operators (RAOs) to give the shape of the wave/wind profile most likely to produce the extreme of the response of interest. The single focused wave/wind is termed the most likely extreme response wave/wind (MLER) and the constrained version the constrained MLER (CMLER). More information on the method applied to the waves can be found in [1] and on wind in [2] and [3].

What are the advantages of short design waves/wind over irregular waves?

Constrained events have the potential to reduce simulation times significantly compared with the traditional one-three hour long time series. They are also short enough (5-10 minutes) that they may be used in computationally expensive, high fidelity numerical modelling.

Fig.2 below illustrates the response conditioned wind and wave profiles (red and green) compared with the time series which lead to the extreme tower base response from 10, traditional one hour runs for the WindCrete device (black). The time step of the extreme response is aligned at 0s and the 19 background lines show the profile leading to the extreme for each of the three hour runs.

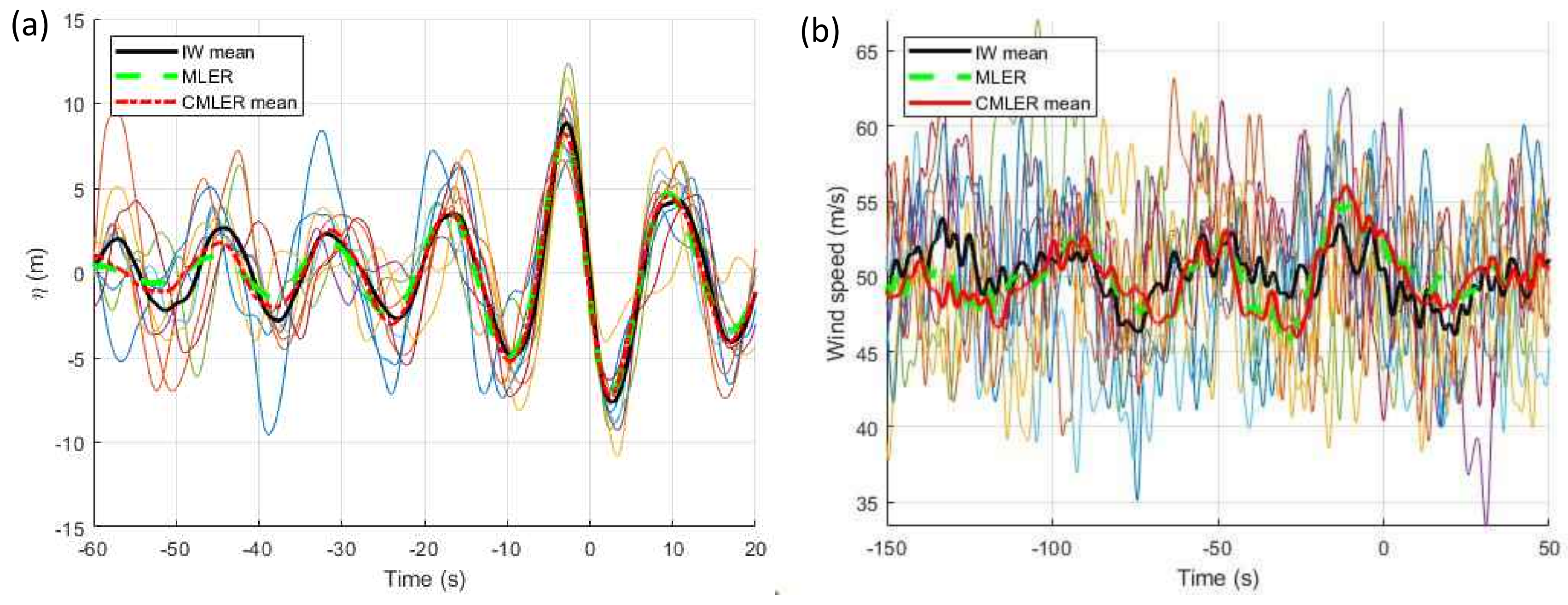


Fig.2 Empirical average wave (a) and wind (b) profile (Emp) comparison with MLER and the mean of 19 CMLERs

4. Extreme responses

The characteristic values of each response are determined by taking the mean of the maxima for the three-hour sea states and the single maxima for the 8 minute MLER event cases. Fig.3 shows the environmental conditions tested and previously estimated regions of applicability for different methods for predicting design values.

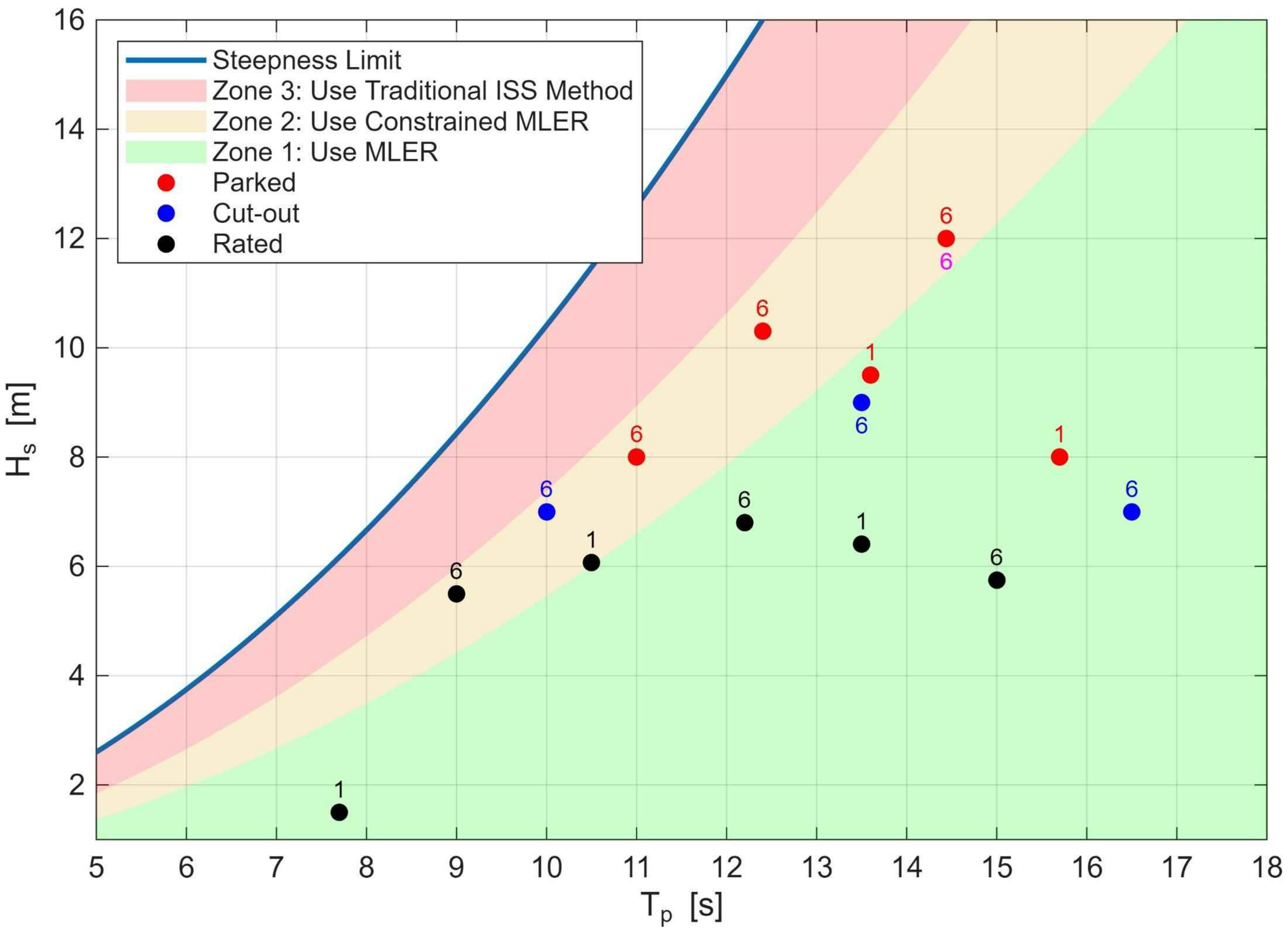
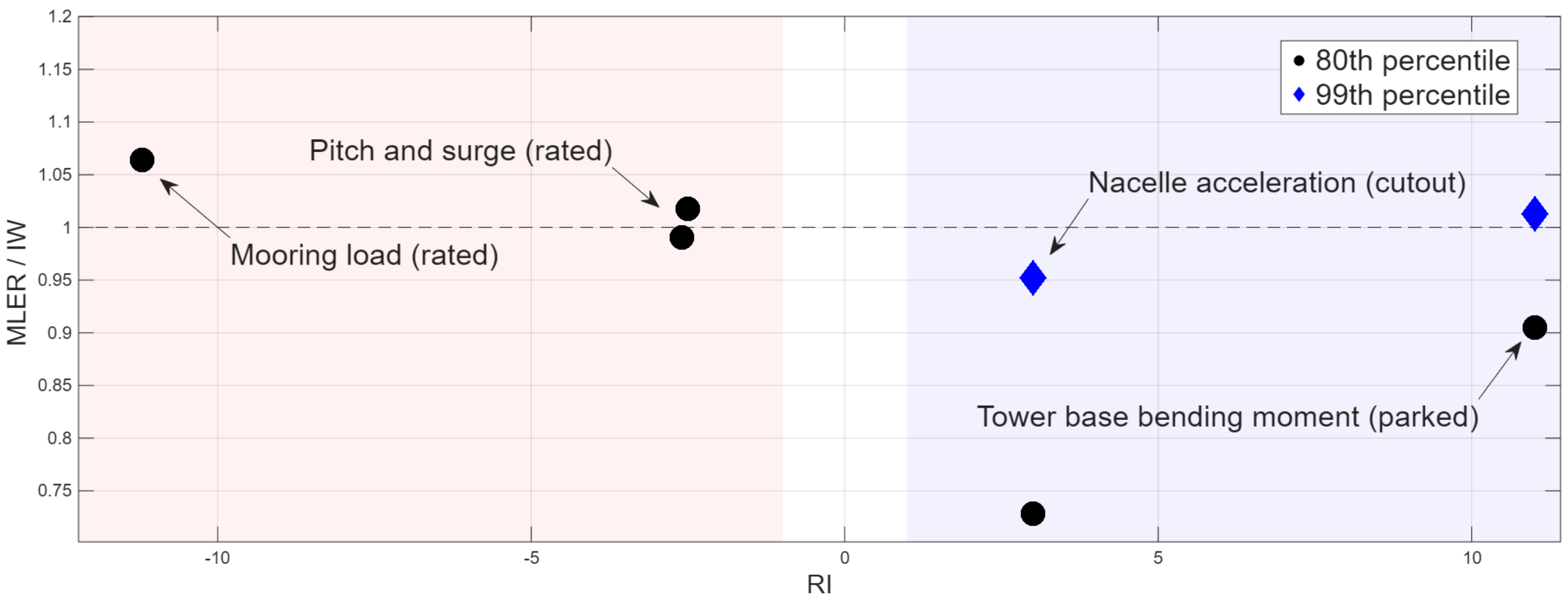


Fig.3 Sea states where short design events were tested based on 50 yr return period contours, numbers give number of 3 hour seeds tested. Zones are suggested applicability of different design waves.

Fig.4 compares the characteristic value estimates from the environmental conditions leading to the maximum observed responses for pitch, surge, mooring load, tower base bending moment and nacelle acceleration. The response from the single 8 minute design event is divided by the design value predicted from 18 hours of data. The x axis shows the relative importance (RI) of the response with the red region indicating that the wind loading is more important, and blue that the wave loading dominates. An RI value of 4 means the wave loading is expected to result in a response 4x larger than that due to the wind in that sea state. The short design event method performs well for the wind dominated responses but for the wave dominated responses where higher order wave loading is important to setting off the tower response, more work is needed as responses are underpredicted. This can be seen in the plot as a larger percentile scaling (larger wave amplitude) is required to produce a design value estimate in line with the traditional approach (a value closer to 1).

Fig.4 Comparison of characteristic values estimates between the traditional and single design event methods for the spar model across the 5 responses of interest. Blue indicates wave loading dominates, red indicates wind loading dominates.



Conclusions

The Response conditioned wind and wave profiles produced estimates for the design responses within -5% to +7% of the traditional method when wind loading dominated the response, and in a much shorter time. The response conditioned wind and wave time series were similar to those observed to lead to extreme responses in the traditional method. A more comprehensive analysis for different platform types is given in [2] and future work will seek to incorporate the impact of higher order wave loading on the tower response.

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[3] T. Tosdevin, E. Edwards, A. Holcombe, S. Brown, E. Ransley, M. Hann, D. Greaves. 'On the use of response conditioned focused wave and wind events for the prediction of design loads' IOWTC, 2023.

Structural Design and Integrity Assessment of FOWT Substructures

Supporting Cost Efficiency Across the Life Cycle

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Highlights

- Integrated global-local process enabling broader early-stage design exploration
- Fully coupled load-to-stress framework supporting life-cycle structural assessment

Background

Floating offshore wind turbines (FOWT) offer a promising solution for deep-water wind energy deployment, but their large-scale application remains constrained by high cost. Approximately 25% of capital expenditure is associated with substructures [1]. This motivates early-stage design and long-term integrity assessment to improve structural efficiency across the life cycle.

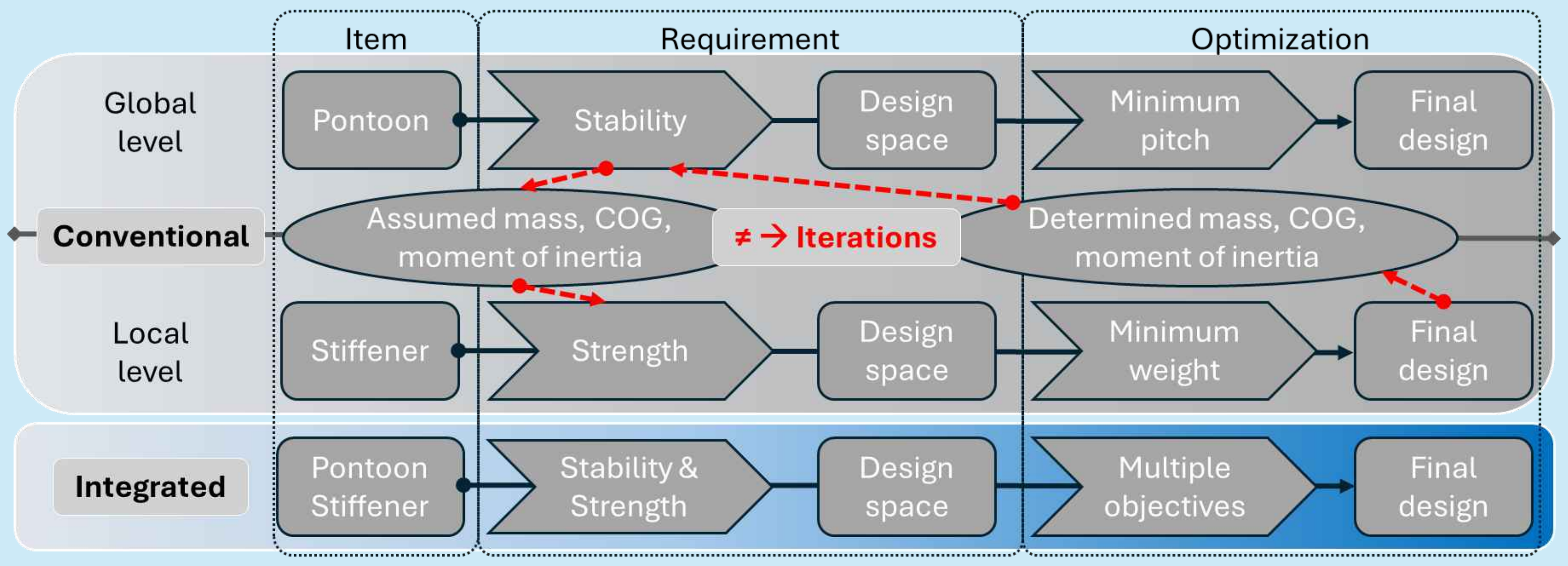
Pathway I: Integrated Early-Stage Design

Research Need

- Conventional design processes treat global and local levels sequentially, requiring repeated iteration between the two levels.
- This limits the efficient exploration of substructure design options in early-stage design.

Methodology: Integrated Design Process

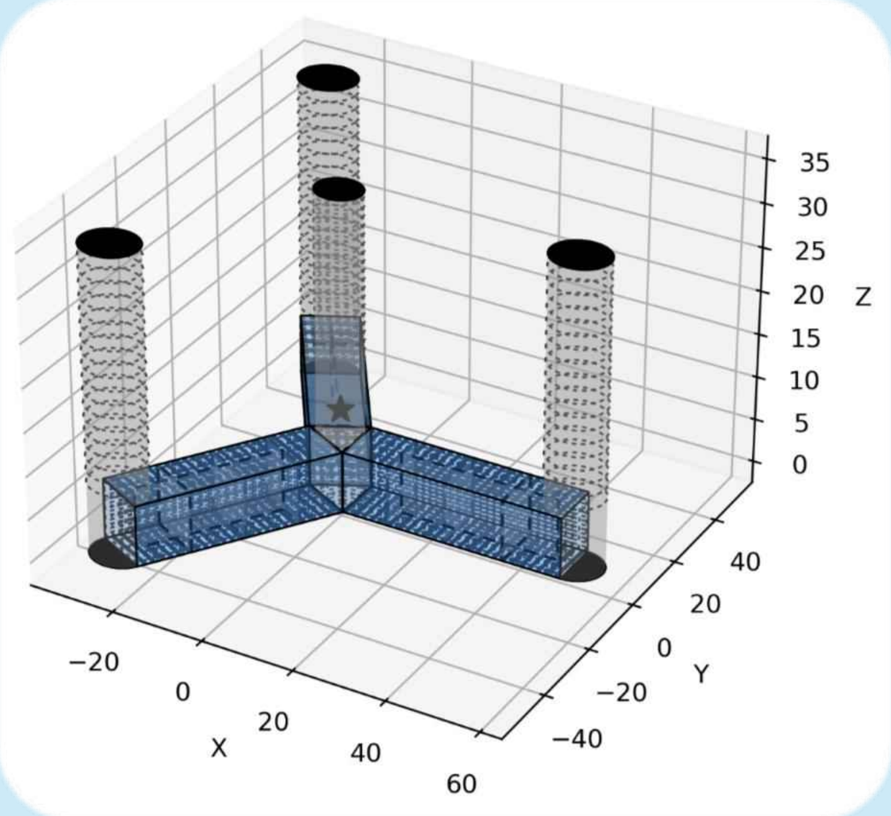
- Integrated process linking global responses with local structural design assessment



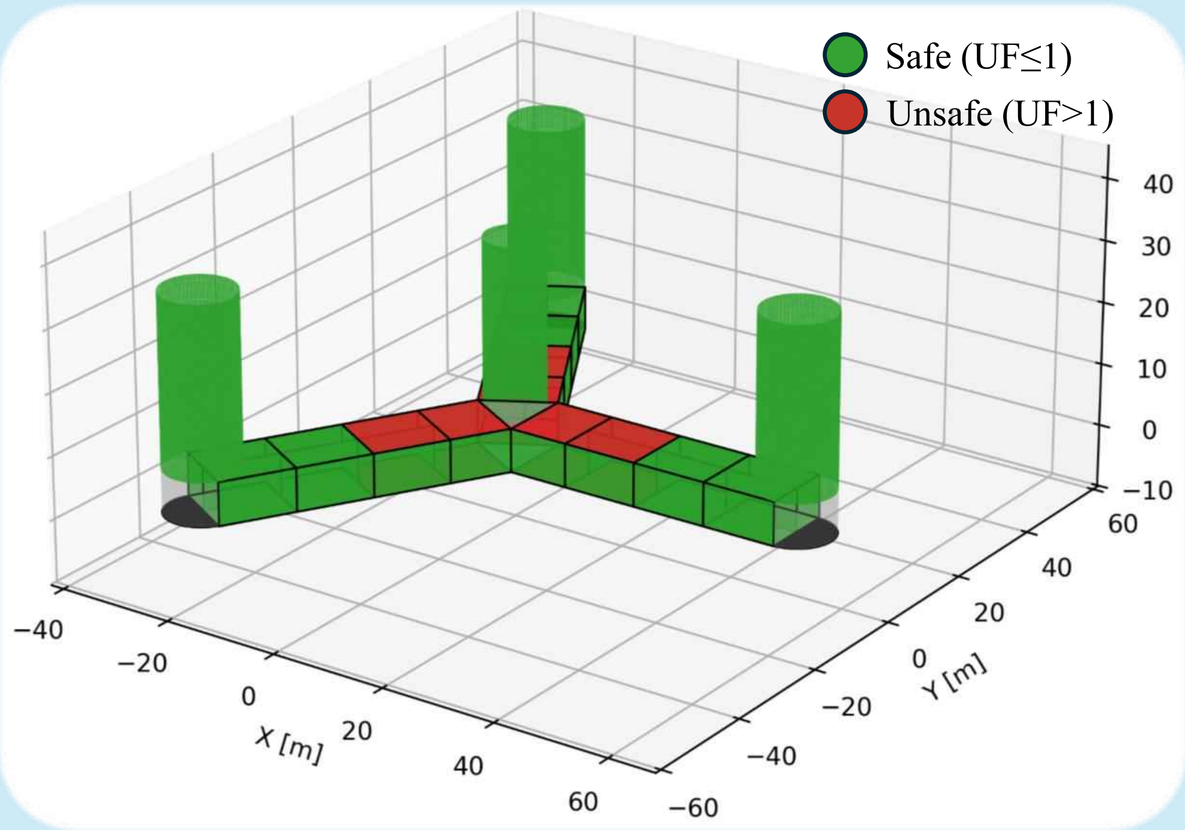
- Global level: Hydrostatics, hydrodynamics, and stability [2]
- Local level: Analytical plate-beam models for structural design checks

Example Results

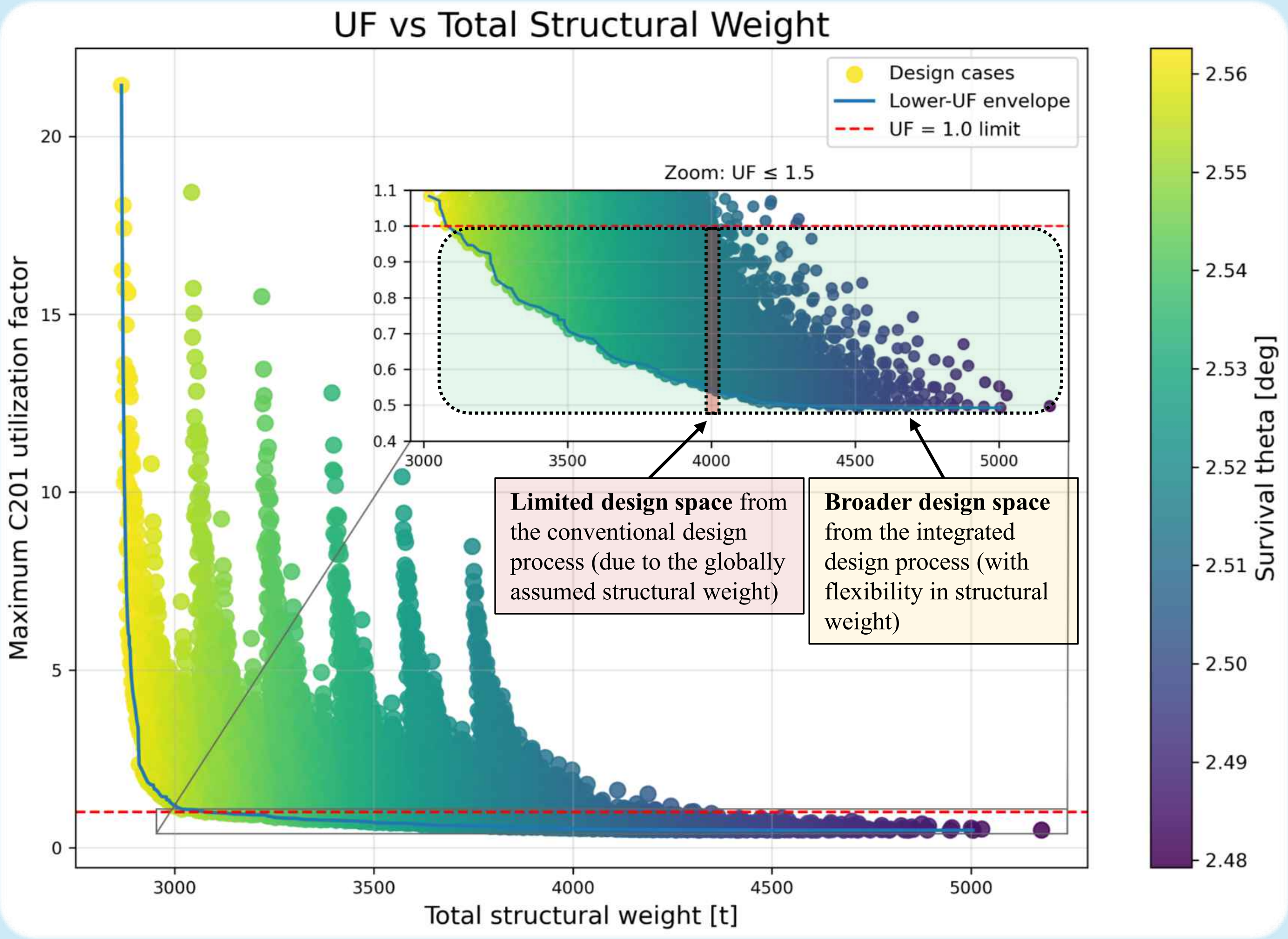
- Structural weight and utilization factor (UF) for alternative local substructure designs



Local arrangements including bulkheads, frames, and stiffeners



Sectional-level strength assessment under DNV-RP-C201&C202



Trade-off between the structural weight, utilization factor, and survival pitch response

Key Findings

- The integrated process enables broader exploration of feasible substructure designs than a conventional sequential workflow.
- Heavier configurations may provide safer local layouts, while lighter solutions may still satisfy design limits through improved arrangement.

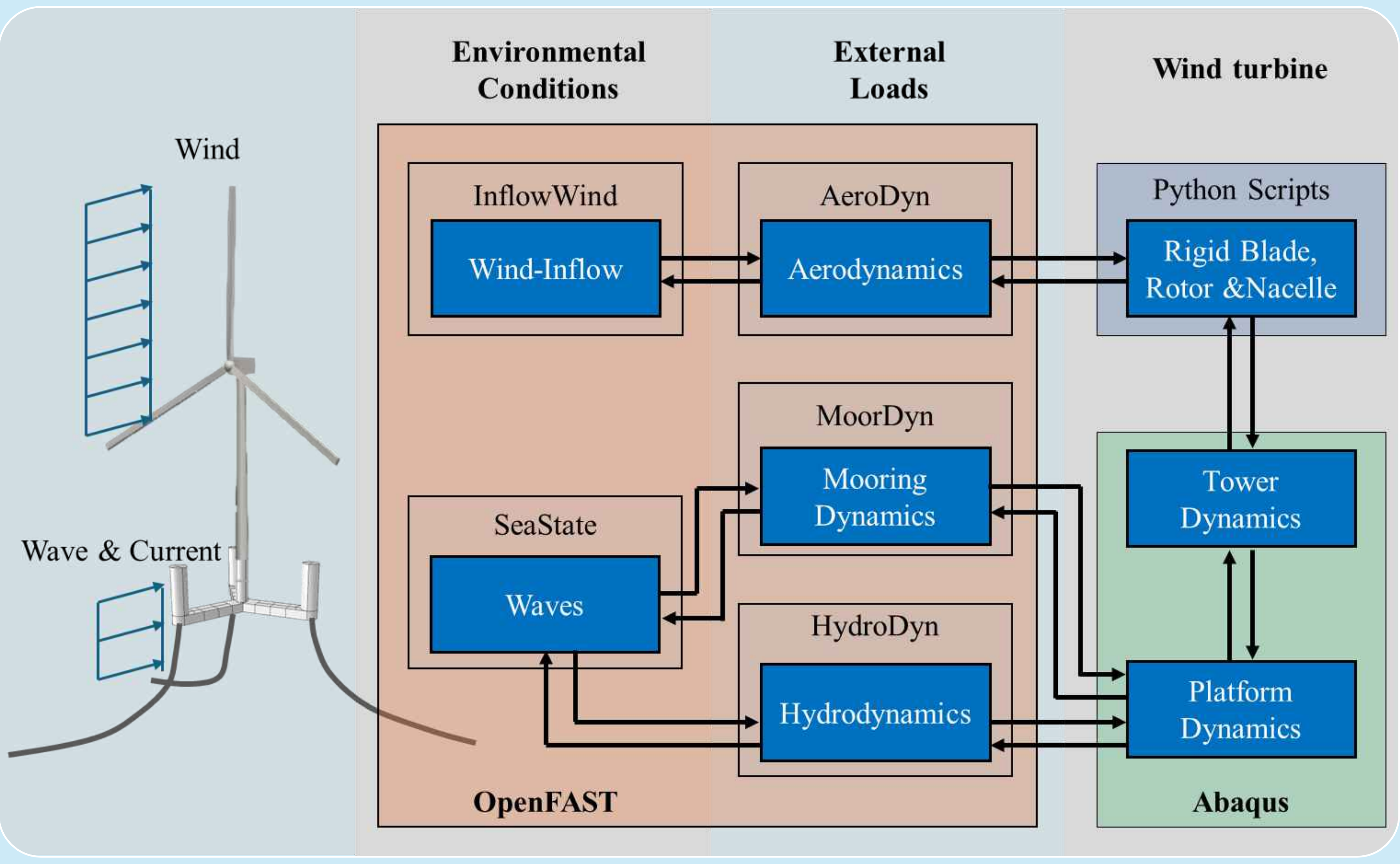
Pathway II: Life-cycle Integrity Assessment

Research Need

- Life-cycle integrity assessment requires stress-level predictions under complex loads.
- Existing workflows often rely on two-stage or one-way coupled analyses, limiting direct load-to-stress evaluation.

Methodology: Fully-Coupled Numerical Analysis

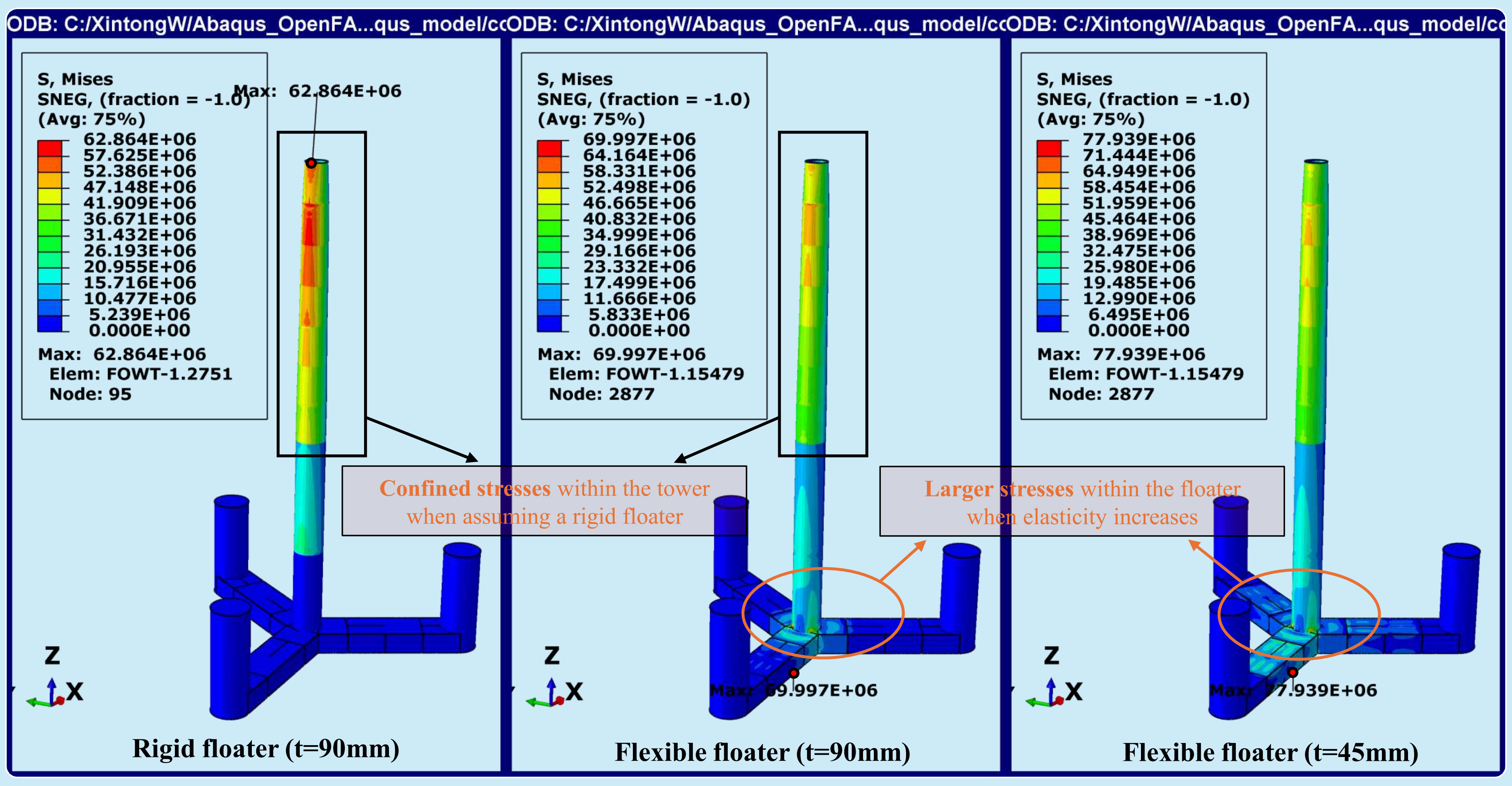
- Fully coupled aero-hydro-moor-elastic dynamic simulation using OpenFAST and Abaqus
- In a time-domain workflow, OpenFAST resolves the environment-system interactions, while Abaqus evaluates system responses and structural stresses



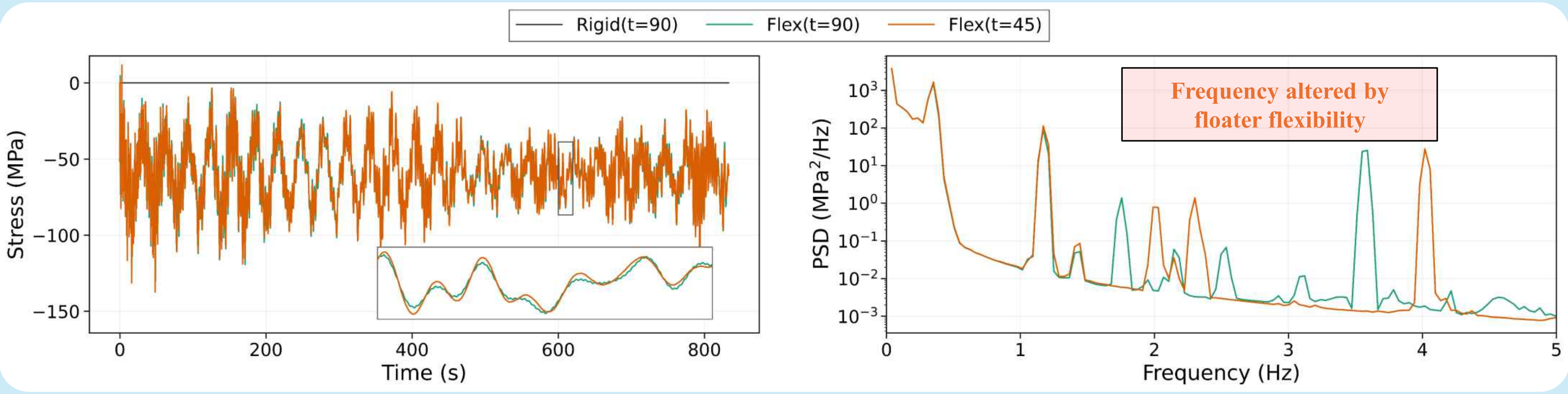
Two-way coupled framework for aero-hydro-mooring-elastic dynamic structural analysis of FOWTs

Example Results

- Influence of floater elasticity on structural responses



Von Mises stress for different floater models in the coupled analysis



Time history and power spectral density of in-plane stress at the floater-tower intersection

Key Findings

- Floater elasticity changes the natural frequencies of the coupled floater–tower system and modifies the system response.
- More flexible floaters can increase local stresses in the floater and at floater–tower intersections, while reducing tower stresses and platform motions.

Main conclusions

- The integrated early-stage design framework broadens the design space and supports more **cost-efficient substructure arrangements**.
- The coupled life-cycle framework supports structural integrity assessment and informs **long-term operation and maintenance planning**.

Future work

- Multi-objective optimisation for substructure concepts, balancing global and local responses
- Further investigation of floater elasticity effects to support robust and conservative design decisions

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*Presenting author

Acknowledgements

The research is supported by the UK Engineering and Physical Sciences Research Council (EPSRC) through the Ocean-REFuel (Ocean Renewable Energy Fuels) Programme Grant EP/W005212/1

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Decadal patterns of fronts and fishing in the Celtic Sea and its implications for offshore wind development

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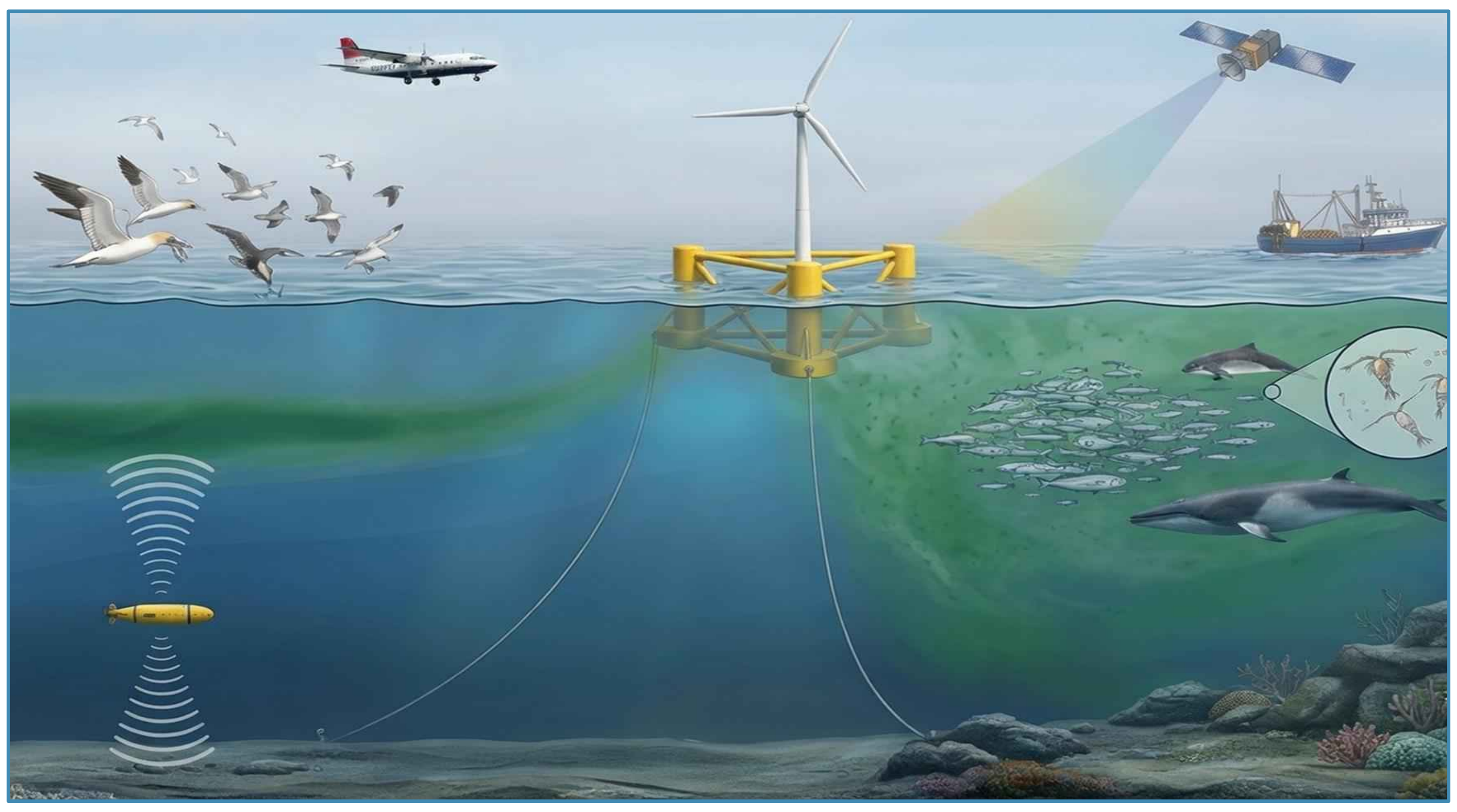
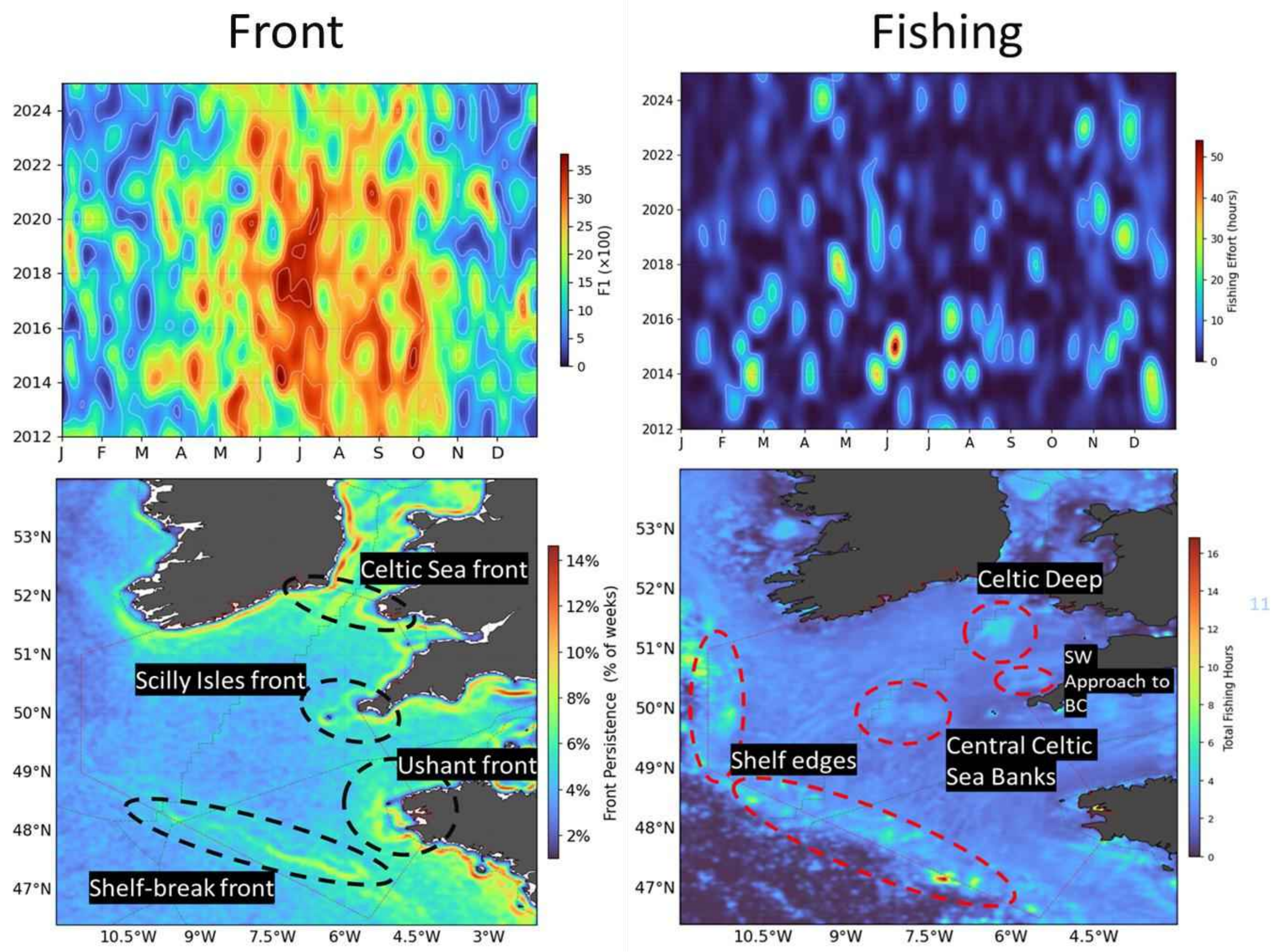
[a] University of Plymouth; [b] Plymouth Marine Laboratory; [c] Heriot-Watt University

BACKGROUND

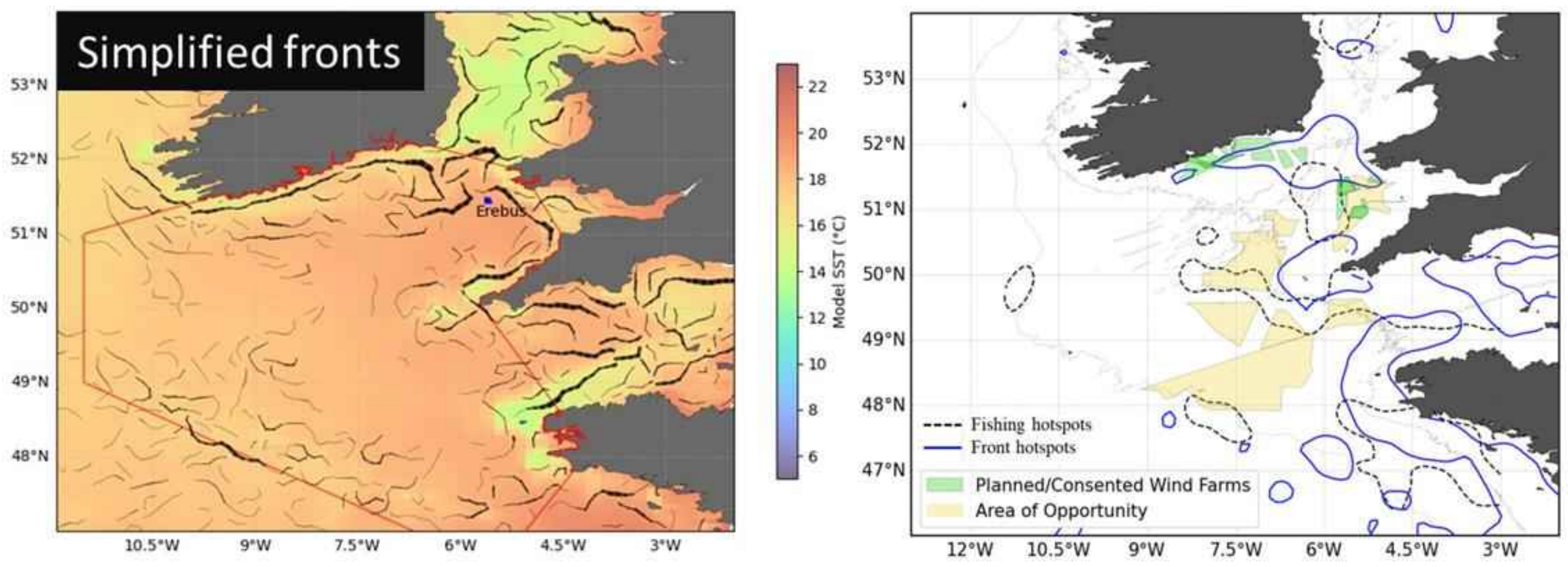
The Celtic Sea is a highly productive shelf sea ecosystem characterised by dynamic, seasonally persistent ocean fronts. This complex socio-ecological system supports valuable fisheries and is also a priority region for large-scale floating offshore wind (FLOW) development. Where FLOW developments overlap with existing fishing grounds, FLOW may directly displace fishing activity, while associated wake dynamics may modify frontal processes and productivity, with wider ecological knock-on effects on fisheries.



Fishing effort peaks around June and December, with several persistent hotspots (e.g. Celtic Deep and Shelf edges). Fronts also show marked seasonality, peaking in July and exhibiting interannual variability. Typical frontal hotspots are shown on the map (e.g. Celtic Sea front).



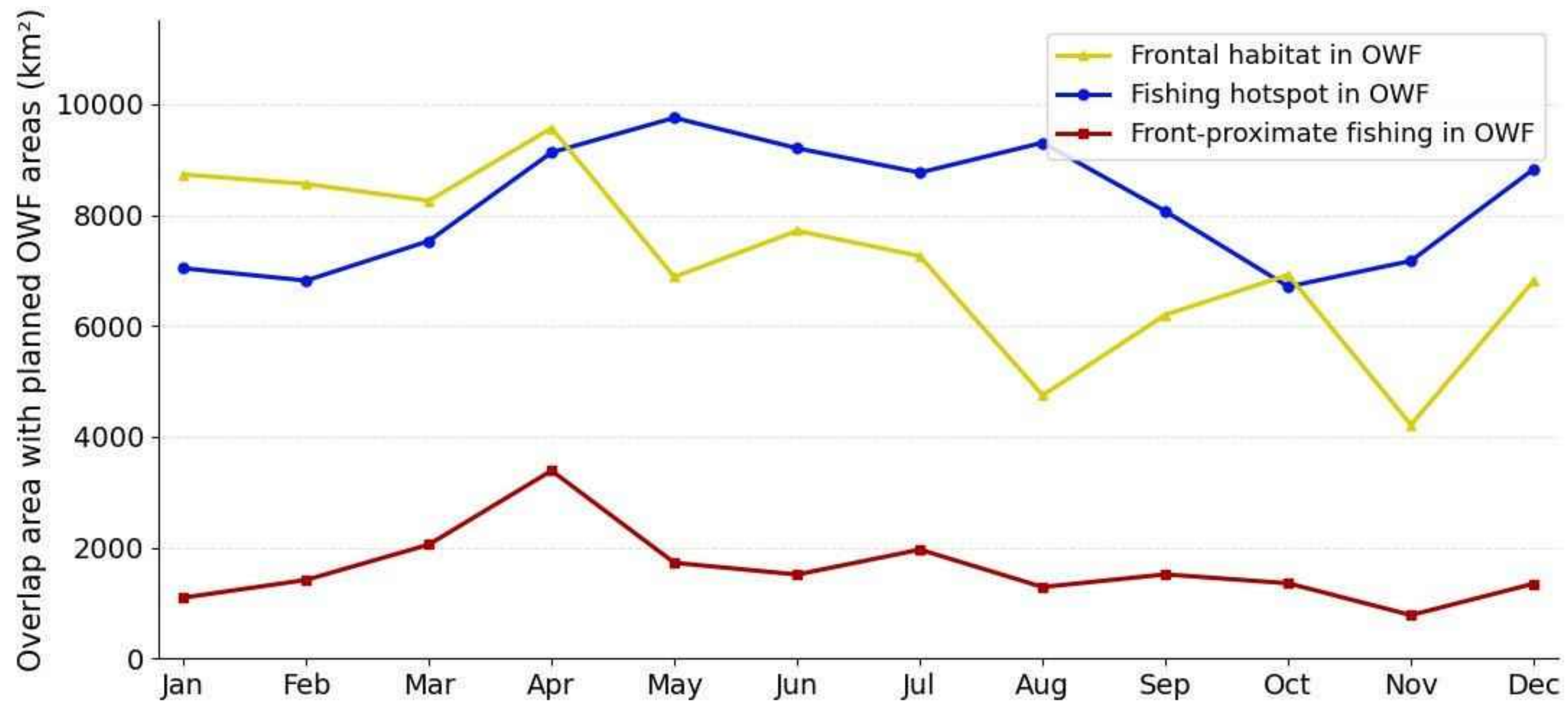
MATERIALS AND METHODS



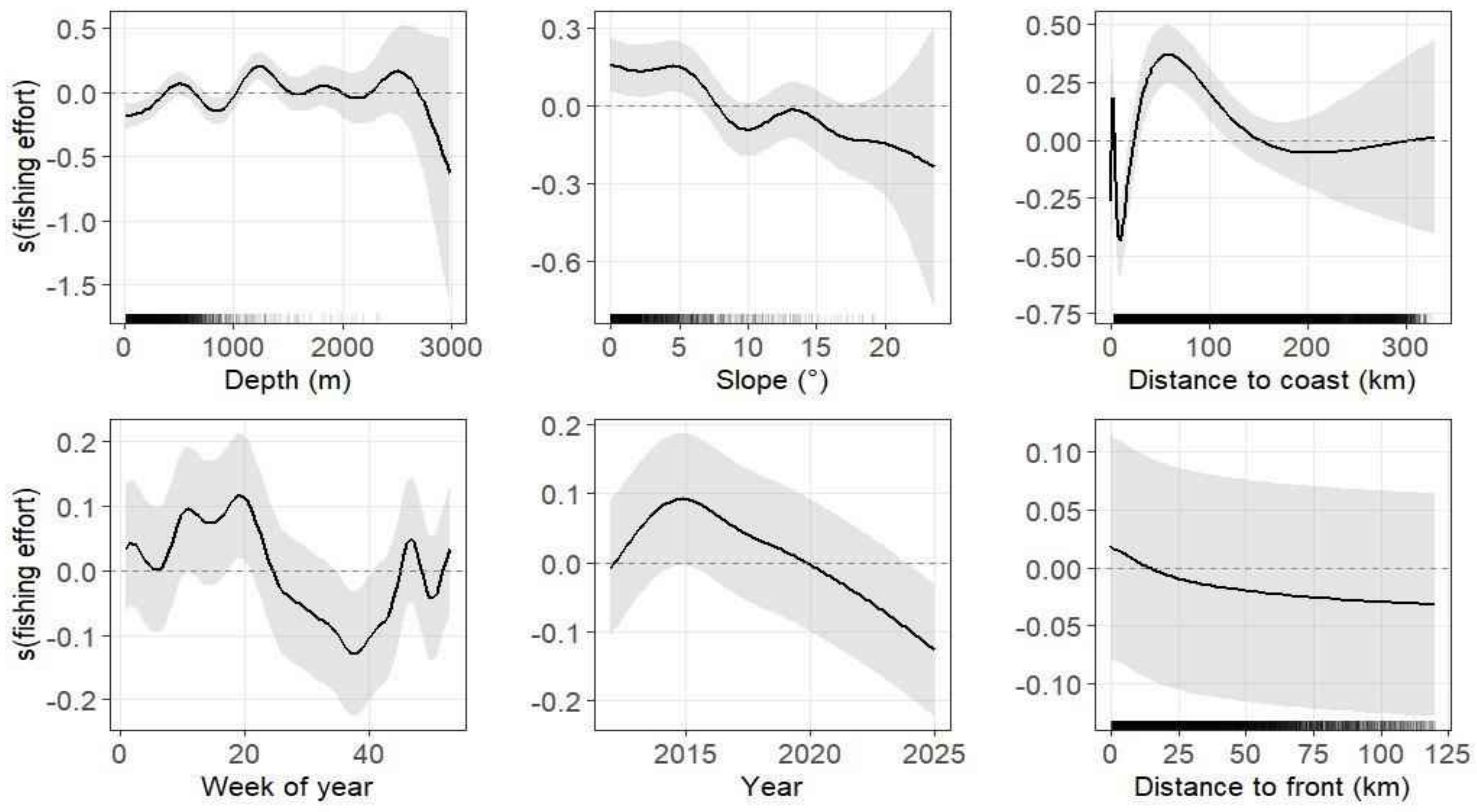
Decadal (2012–2015) fishing effort (Global Fish Watch) and ocean fronts (remote sensing) were used to characterise spatiotemporal distributions, while bathymetry and planned offshore wind farm (OWF) areas were used to assess spatial overlap with fishing and fronts. Generalised additive models (GAMs) were used to test fishing–front associations.

RESULTS

Fishing activity, ocean fronts, and front-proximate fishing show clear seasonal overlap, with the top 20% of front-proximate fishing effort occurring within planned OWF areas, accounting for 7–23% of hotspots.



Fishing activity is associated with ocean fronts, with trawlers tending to concentrate near frontal features.



Acknowledgements: We thank members of our *Frontline* consortium: Kelly McLeod (HiDef), Oliver Padget (University of Liverpool), Sarah Bond and Tim Guilford (University of Oxford).

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Enhancing Wave Energy Converter Performance in Confined Environments: The Role of Wall Proximity

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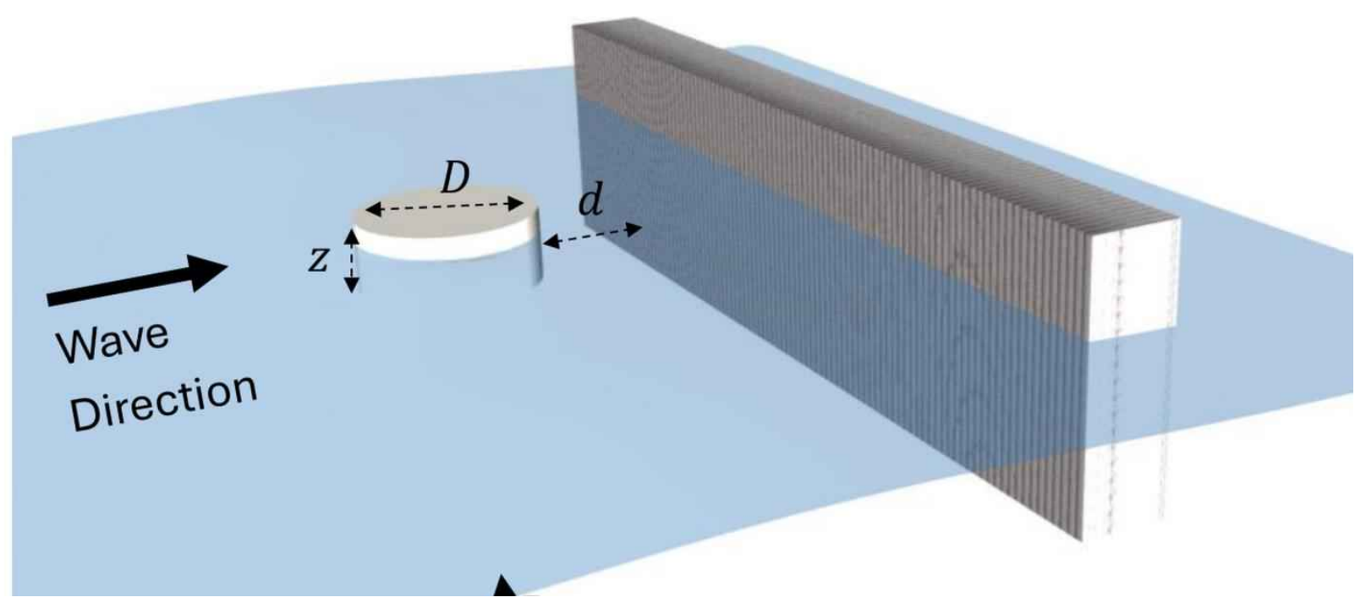
HIGHLIGHTS

- Marina-based WECs are investigated as a low-cost alternative to open-sea systems.
- A fully converged 3D CFD model captures turbulence and near-wall effects.
- Optimal buoy positioning can increase captured power by up to tenfold.



WEC setting next to a vertical wall

INTRODUCTION

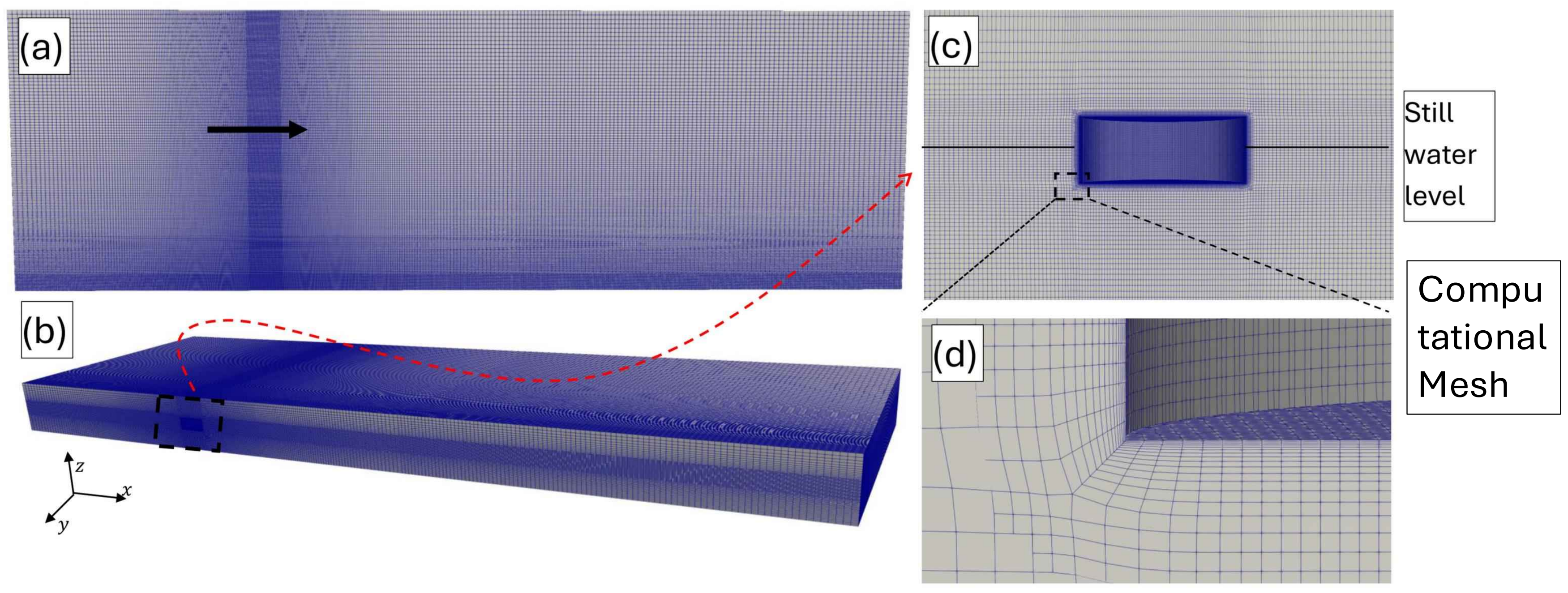
- Wave energy offers high power intensity, predictability, and availability compared to wind and solar, but adoption is limited by high costs and harsh offshore conditions (Arrosyid et al., 2025).
- Deploying wave energy converters (WECs) at sheltered marina environments can reduce survivability risks and significantly lower installation and cabling costs.
- This study focuses on a low-cost, low-power heaving buoy WEC with a direct-drive linear generator, designed for operation in reduced wave conditions at a marina.
- High-fidelity 3D Computational Fluid Dynamics (CFD) modelling is required to accurately capture complex flow interactions near marina walls, where turbulence and viscous effects strongly influence WEC performance (Windt et al., 2020).

AIMS

- Develop a fully converged 3D CFD model to simulate flow hydrodynamics around a cylindrical WEC device.
- Establish a methodology for grid convergence assessment based on turbulent flow quantities.
- Apply the model to quantify the effect of wall proximity on the WEC's power absorption performance.

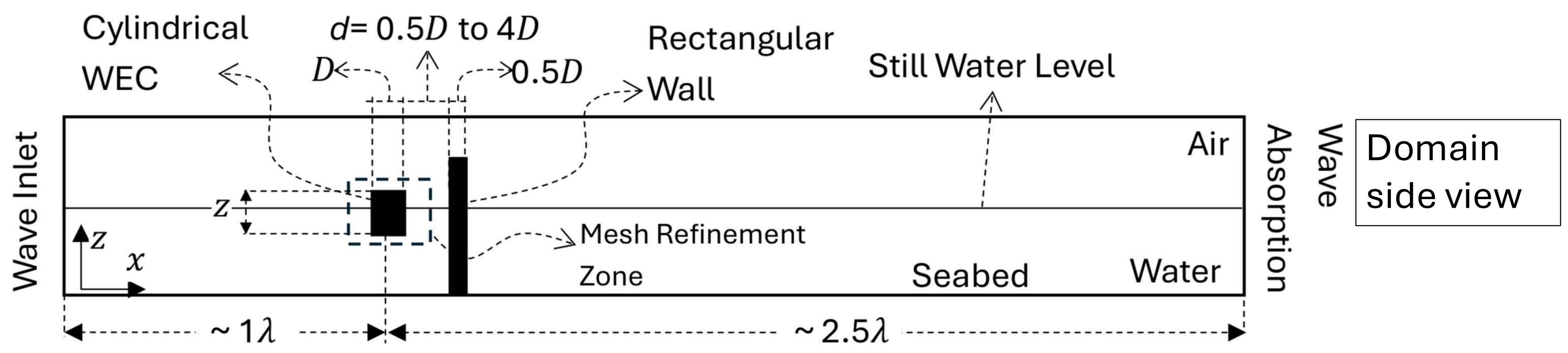
METHOD

- A 3D finite-volume CFD model was developed using the RANS framework with the k-ω SST turbulence model, implemented in OpenFOAM (Weller et al., 1998).
- Local mesh refinement was applied around the buoy.
- The motion of the buoy was represented by using mesh morphing approach, enabling dynamic fluid–structure interaction.



Still water level

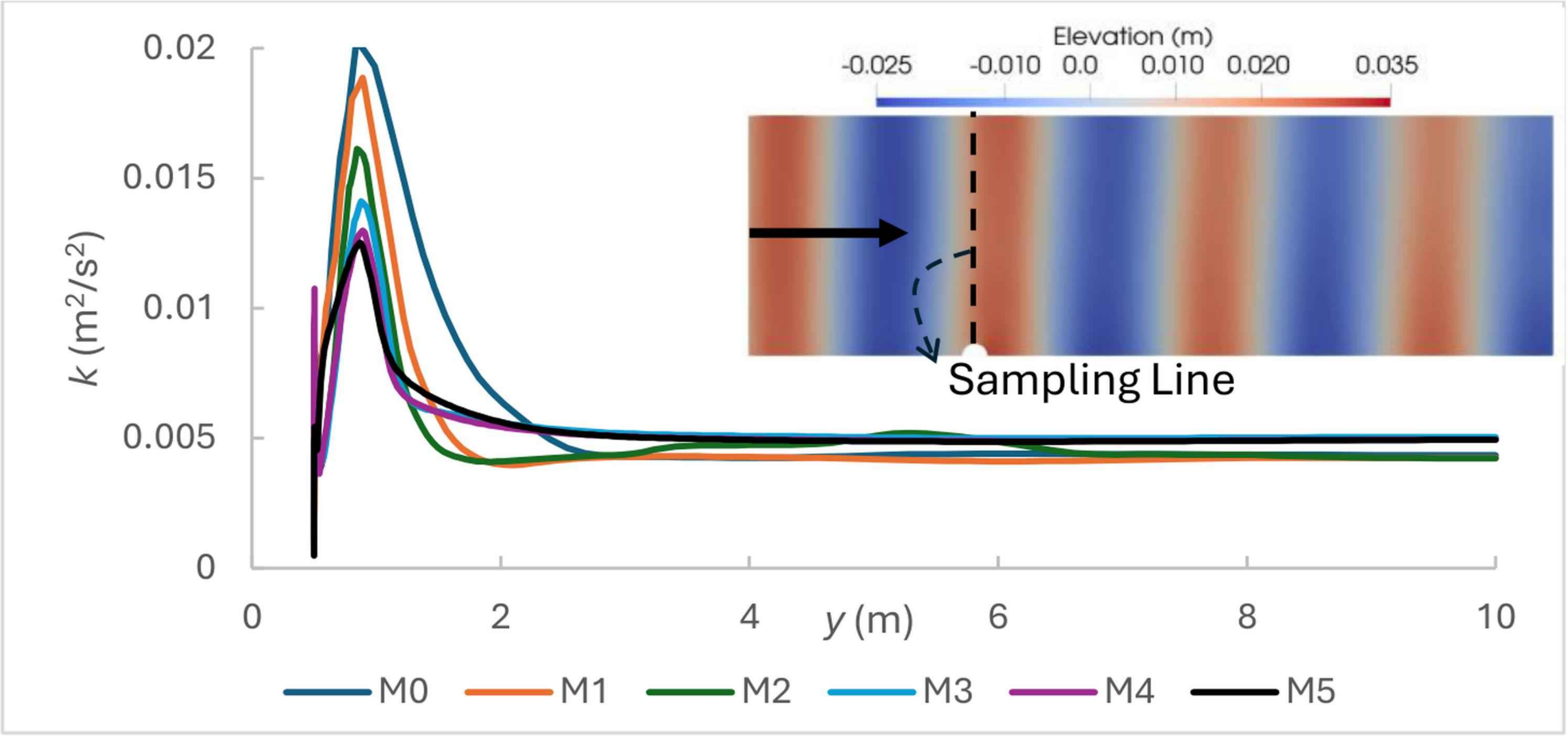
Computational Mesh



Domain side view

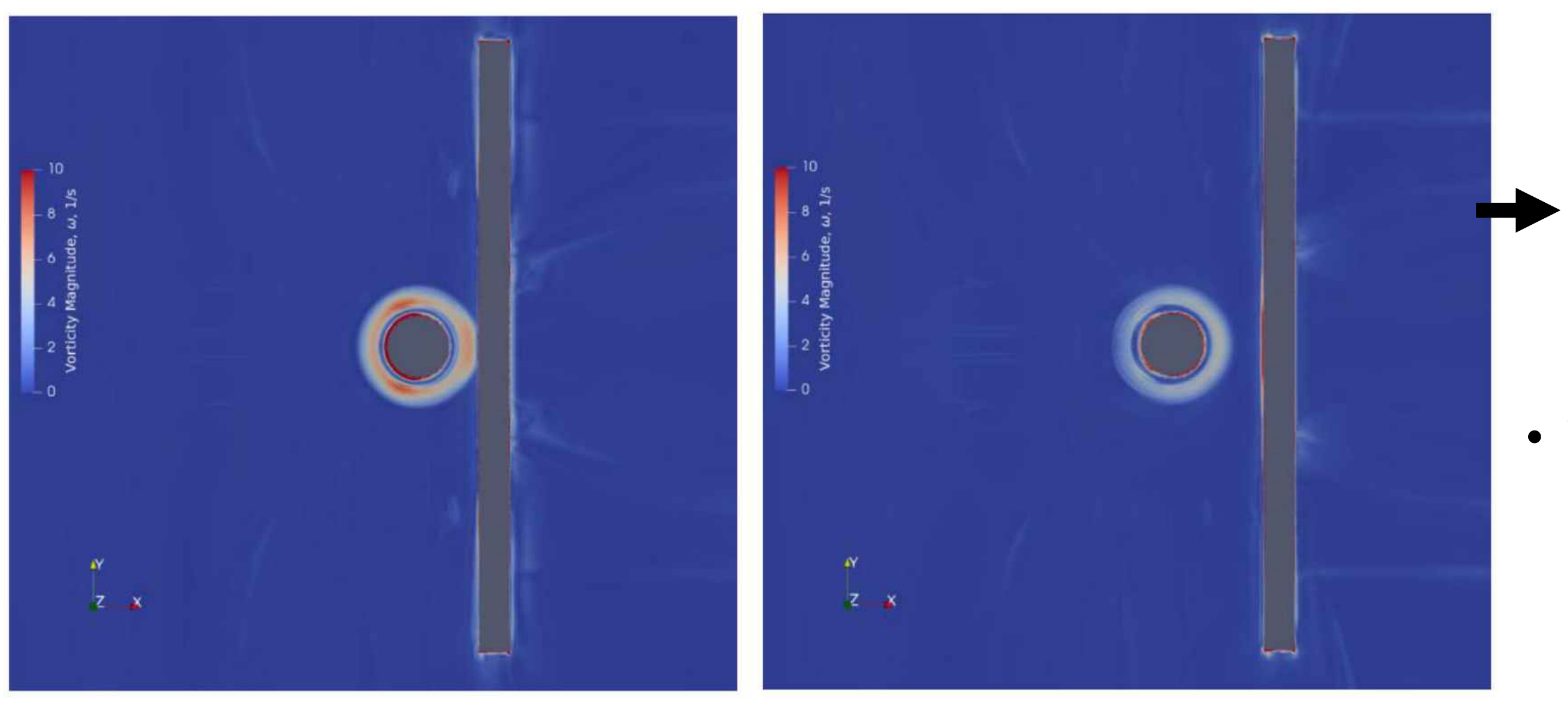
VERIFICATION OF THE MODEL

Mesh	Total Cell Count	Max y^+ around the WEC	Total run time (hrs.)
M0	371,374	9.1	0.8 (20 proc.)
M1	1,062,282	7.3	5.4 (80 proc.)
M2	2,300,400	6.4	25.5 (80 proc.)
M3	4,234,255	5.9	9.6 (160 proc.)
M4	**7,018,225**	**5**	**19.34 (160 proc.)**
M5	10,681,463	4.8	45.54 (160 proc.)



- Five mesh configurations were evaluated to assess grid sensitivity.
- Convergence was assessed based on the turbulent kinetic energy (k).

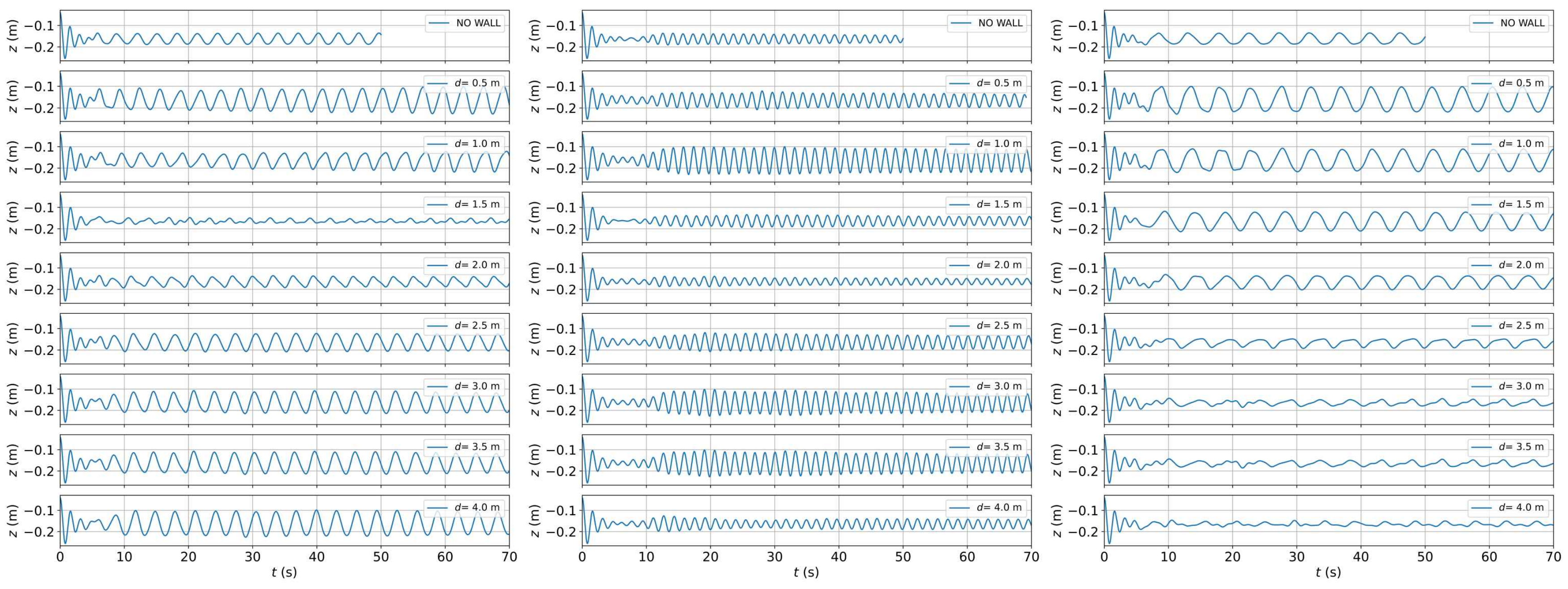
EFFECT OF WALL PROXIMITY ON FLOW DYNAMICS



Vorticity distributions plotted on the free surface.

- Vorticity magnitude increases when the buoy gets closer to the wall.

EFFECT OF WALL PROXIMITY ON WEC MOTION

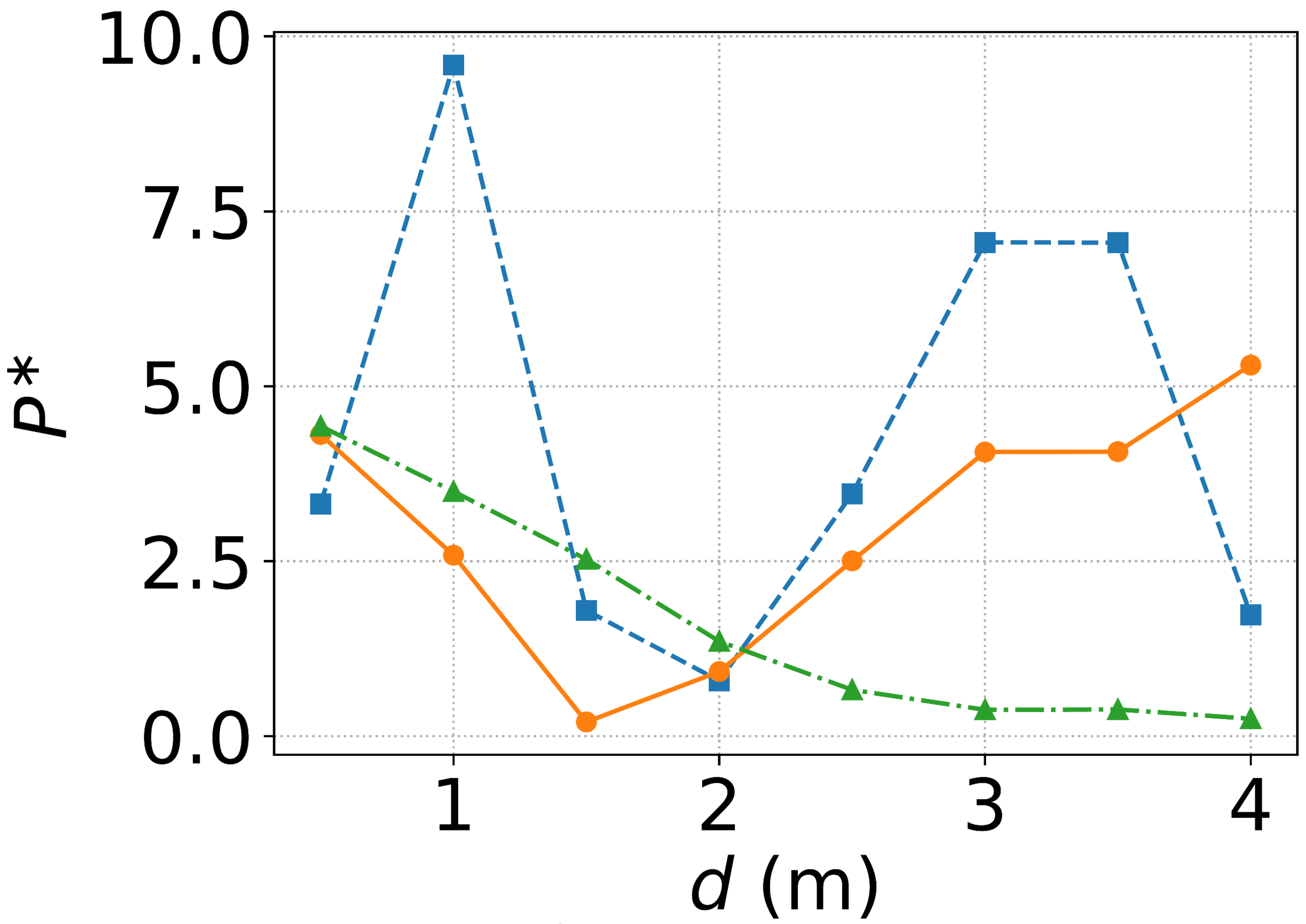


Wave period, T=3.14 s

T= 1.57 s

T= 4.71 s

- The oscillations of the buoy are different based on the wave settings.



Blue: T=1.57 s
Orange: T=3.14 s
Green: T=4.71 s

- The normalized power, $P^* = P_i/P_r$, was evaluated as a function of wall proximity under three different wave conditions.
- Here, P_i denotes the power generated for a given case, and P_r represents the reference power in the absence of a wall.

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