Supergen ORE Hub WS4: Response-conditioned short design events for floating ORE applications

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Aims and Objectives

- Are extreme responses from short design events comparable with traditional methods for floating ORE?
- Inform future best-practice guidelines for floating ORE.

What is a Short Design Event (SDE)?

A SDE is a **short duration** event that targets an **extreme response** from a device for given metocean conditions (Fig. 1).

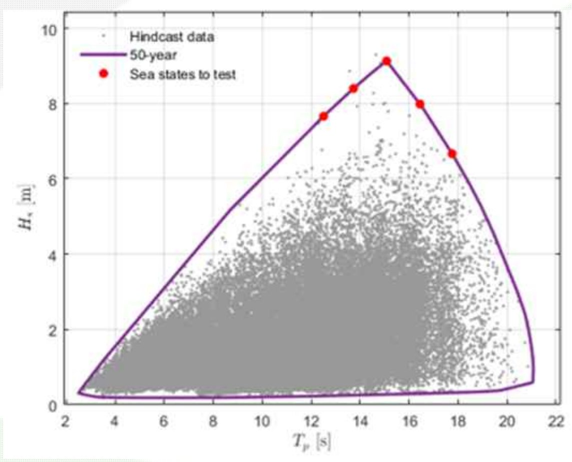

Figure 1: Metocean conditions example. Sea states are identified using a 50-year return period contour method[1].

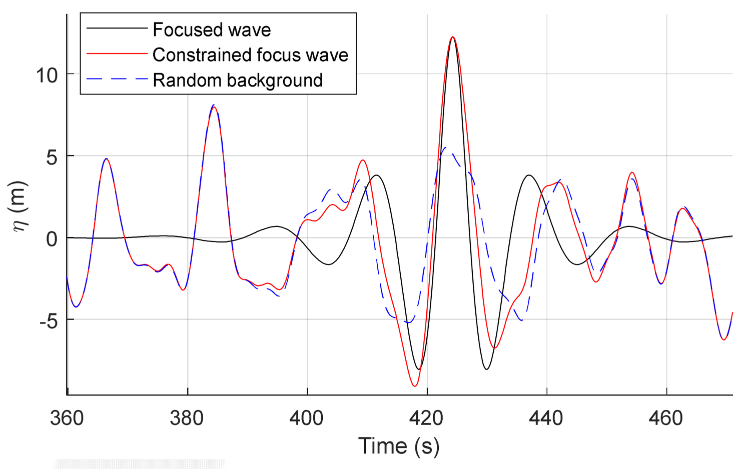

Figure 2: Example of a constrained SDE

SDEs may be either a wave, or a combined wind-wave profile. SDEs can be considered alone (**single** SDE) or embedded in a background wave (**constrained** SDE; see Fig. 2).

Supergen are developing "**response-conditioned**" SDE approaches (Fig. 3) where the profile is generated using an **RAO** to account for the **device's linear response**.

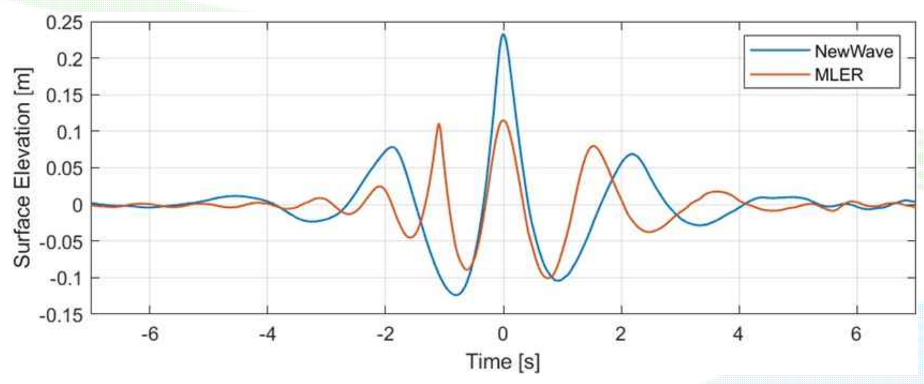

Figure 3: Comparison of a response-conditioned SDE (MLER) with a wave-height conditioned SDE (NewWave).

How does this differ from traditional design?

The traditional approach involves simulating **18-hours** (full scale) of irregular sea state (ISS) data. The data can be used to estimate exceedance probability, or the largest events averaged to provide a characteristic response.

This is relatively straightforward to implement but **time-consuming**. SDEs aim to provide an **efficient alternative.**

Methodology

We are primarily using scale physical modelling in the COAST Laboratory. Typical test plan:

1) Identify conditions that produce extreme response;
2) collect ISS and SDE data;
3) comparison of response for each method (Fig. 4).

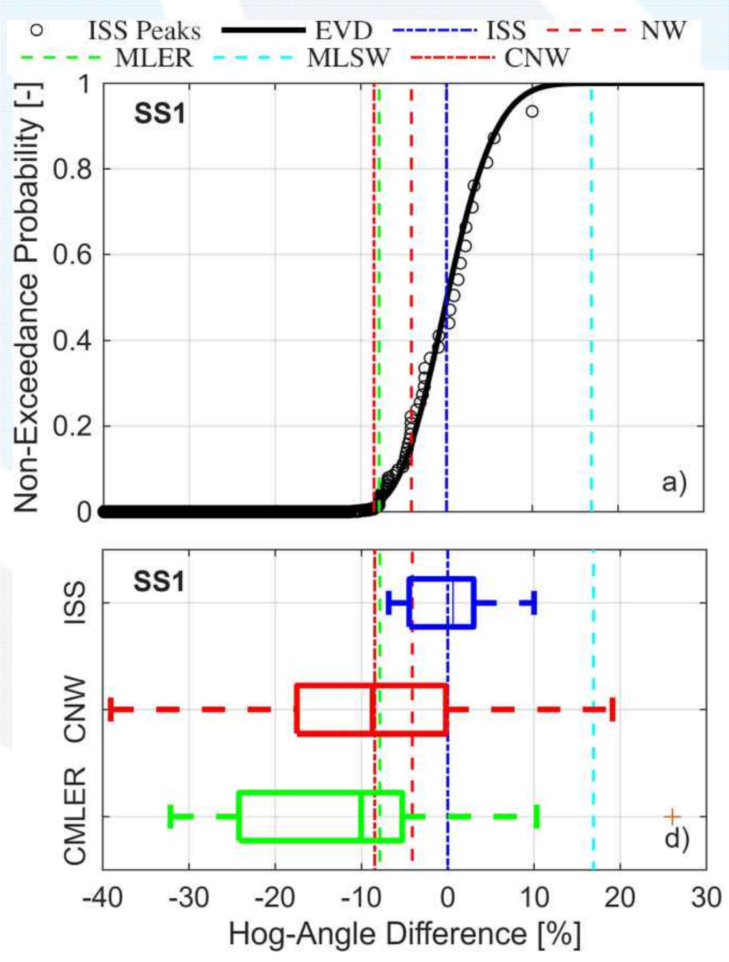

Figure 4: Example of a comparison of ISS and SDE methods for hog-angle of the Mocean Energy device (Fig. 5).

Wave Energy Update

Supergen have an ongoing collaboration with Mocean Energy. A 1:28 scale model of Mocean device (Fig. 5) has been used to evaluate SDEs for hog-angle and mooring load.

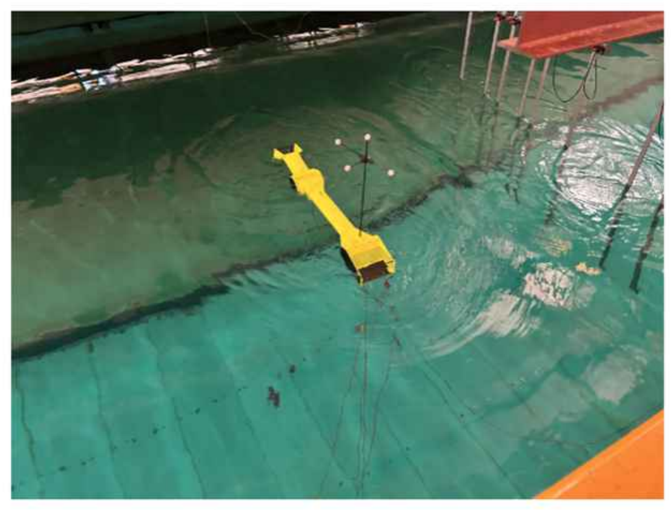

Figure 5: The Mocean Energy WEC model in the COAST Laboratory.

Observations

- Benefit of **response-conditioning limited** in this case
- Responses governed by **breaking waves**
- **Wave-steepness** conditioning performed best out of SDEs considered (with breaking point tuning)
- **Similar wave shapes** to hinged WECs tested previously.

Floating Offshore Wind Update

New physical models of the Windcrete spar for a 15MW turbine (Fig. 6) and a semi-sub for a 10MW turbine (Fig. 7) have been developed and used to assess SDEs. Responses have been extended to include tower base bending moment, with a flexible tower.

Figure 6: Scale model of the semi-sub in the COAST Laboratory.

Figure 7: Scale model of the Windcrete spar in the COAST Laboratory.

A real-time hybrid approach[2] (Fig. 7) is used where the aerodynamics are modelled using a thruster and an openfast-trained surrogate model. The aerodynamic system has been updated to improve communication time, and been expanded to a cut-out speed wind scenario.

Semi-sub Observations

- SDEs compare well with ISS data for **surge** and **mooring load**.
- **Pitch** agrees less than for VolturnUS[3]: needs further work.

Spar Observations

- Single SDEs perform well in **wind-driven** operational scenarios.
- **Constrained** SDEs required for tower base **moment** and **nacelle acceleration.**

References

[1] Tosdevin et al. (2025) On the development and application of short design events for the prediction of extreme responses of floating offshore wind turbines, Ocean Eng, 327, 120929.
[2] Ransley et al. (2023) Real-Time Hybrid Testing of a Floating Offshore Wind Turbine Using a Surrogate-Based Aerodynamic Emulator, ASME Open J. Engineering, 2, 021017.
[3] Brown et al. (2023) On the selection of design waves for predicting extreme motions of a floating offshore wind turbine, Ocean Eng., 290, 116400.

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