Physics-informed machine learning for rapid fatigue assessments in offshore wind farms

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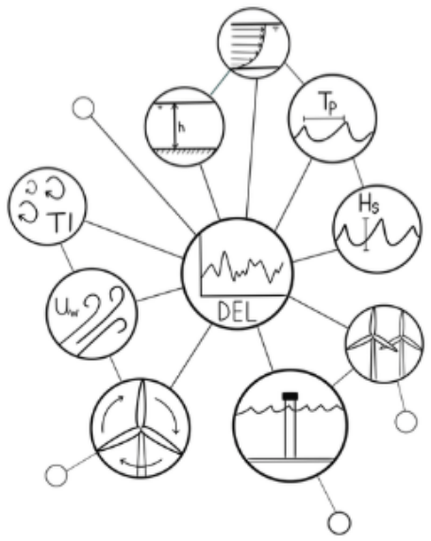
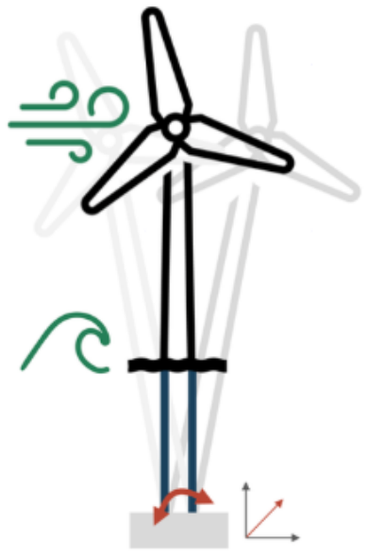
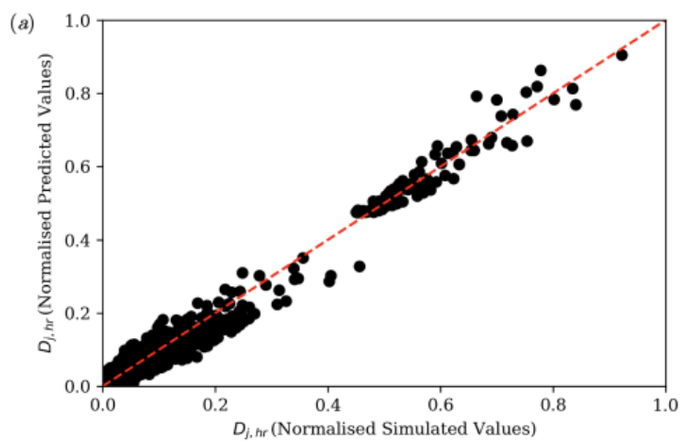
Structural Health Monitoring

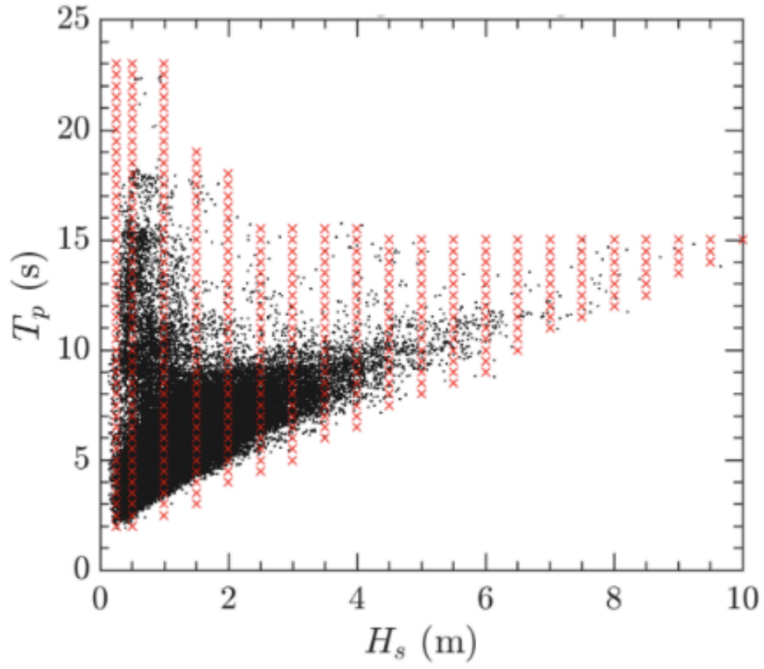




Physics-based modelling to complement AI systems to simulate missing data and provide *prior knowledge*.

Fatigue modelling - fully non-linear wave models and deep learning algorithms to model and predict RUL in monopile structures.





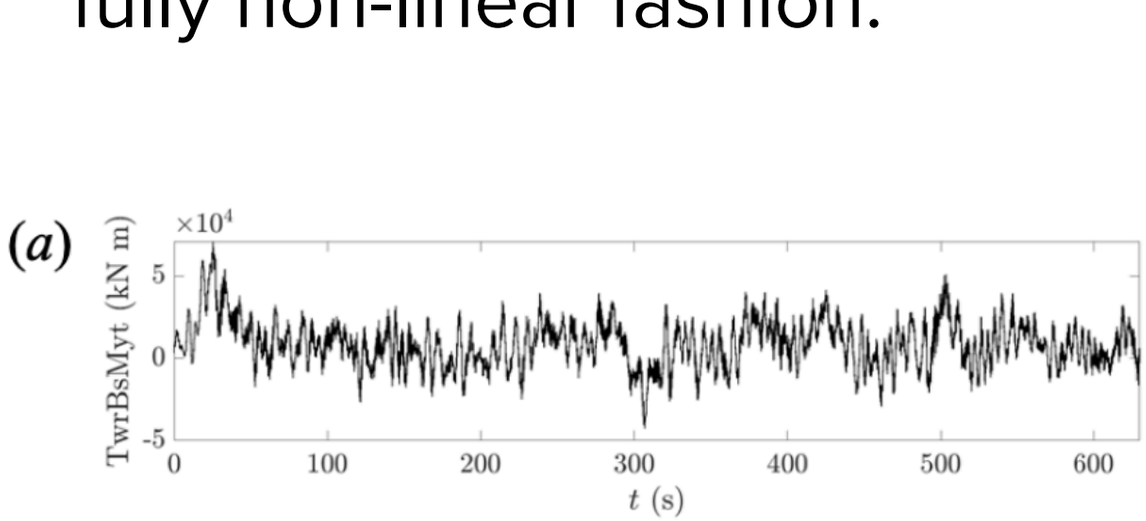
Houseago et al. (2022) EWSHM.

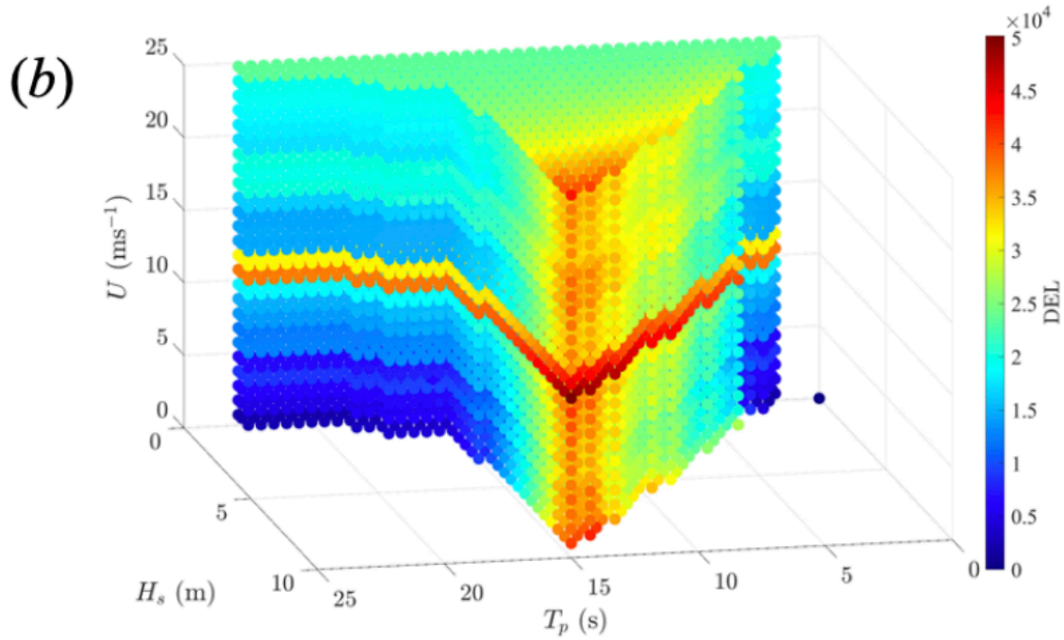
The University Of Sheffield.

Supergen Offshore Renewable Energy

Simulating Environmental Conditions

Non-linear wave kinematics — simulated 381 sea states with varying a heights and peak period in 30 meters deep water in a fully non-linear fashion.

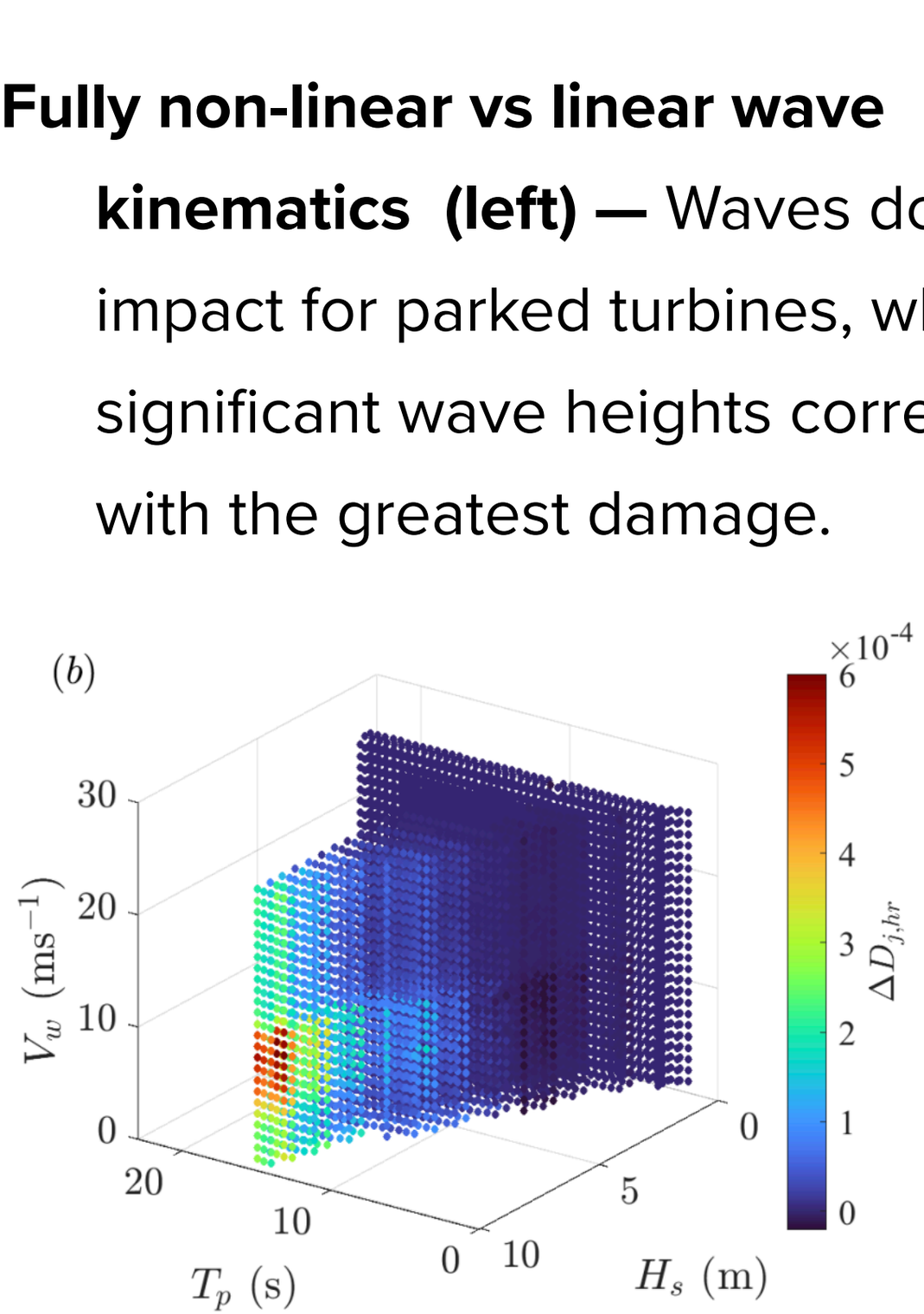


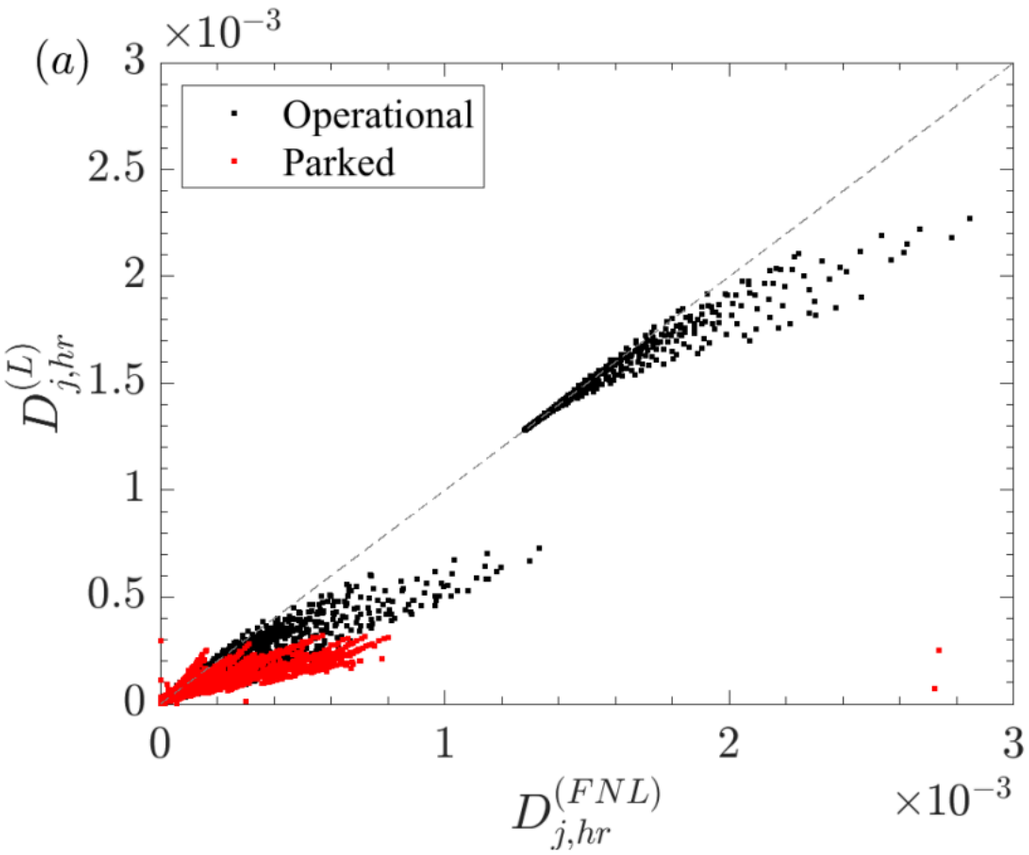


Fatigue Sensitivity— aero-hydro-elastic-servo simulation software FAST(v7) to obtain the monopile mudline fore-aft bending moment for NREL 5MW turbine in 30 m water depth. Resulting in output for **114,300 environmental conditions**.

Short-term damage

Fully non-linear vs linear wave kinematics (left) — Waves dominate impact for parked turbines, where significant wave heights correspond with the greatest damage.

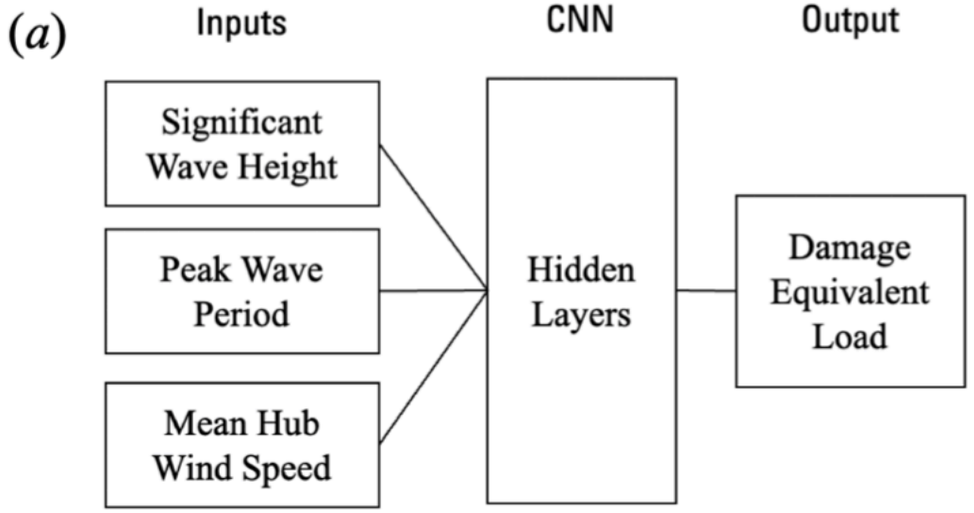


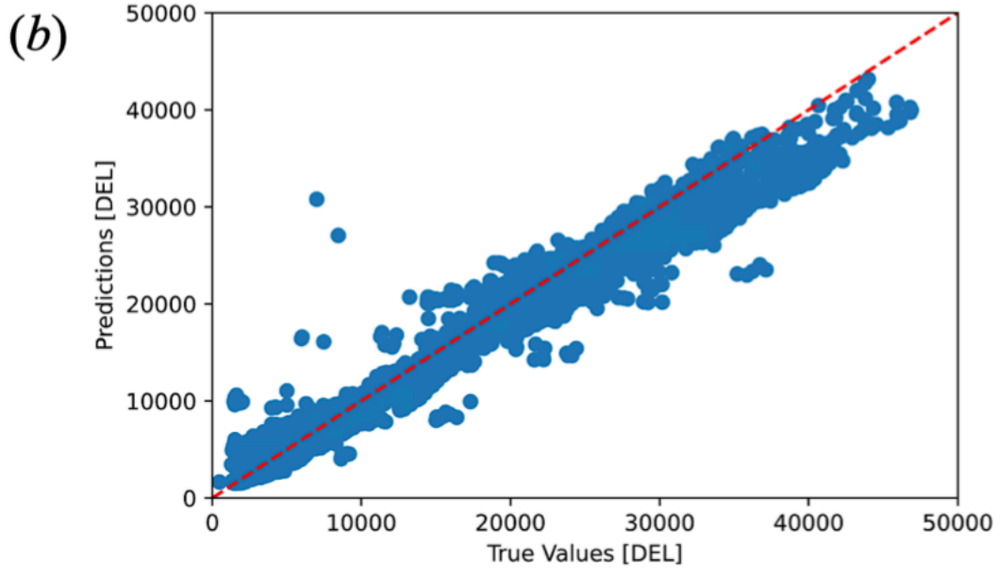


Hourly damage (right) — importance of wave nonlinearities increases at larger magnitude peak wave heights.

Machine Learning

Meta-model — a CNN to learn from generated (fatigue damage) datasets to predict damage equivalent load in *unseen environmental and operational conditions*.



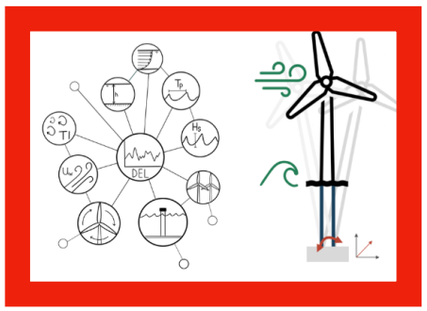


Result: Cumulative damage determined by the meta-model shows **good agreement** with the data lumping approach.

NERC Discipline Hopping

Hackathon on AI for Sustainability —

30+ participants working on 3 sustainability projects over a week.



This project.

Natural Environment Research Council

Outcomes: new networks, open-source code, a journal article, and lots of enthusiasm for applying AI to sustainability projects

Dissemination & Outputs

Two **stakeholder workshops**, including: Atkins, Eleven-I, Jesmond Engineering, OREC, TECOSIM Ltd

Sustained **conversation** with Eleven-I and TECOSIM.

Presentation at **Supergen 4th Annual Assembly**, with the project receiving **1st prize** in the poster competition.

Paper at the European Workshop on Structural Health Monitoring (EWSHM).

NERC Discipline Hopping **Hackathon** for AI in Sustainability.