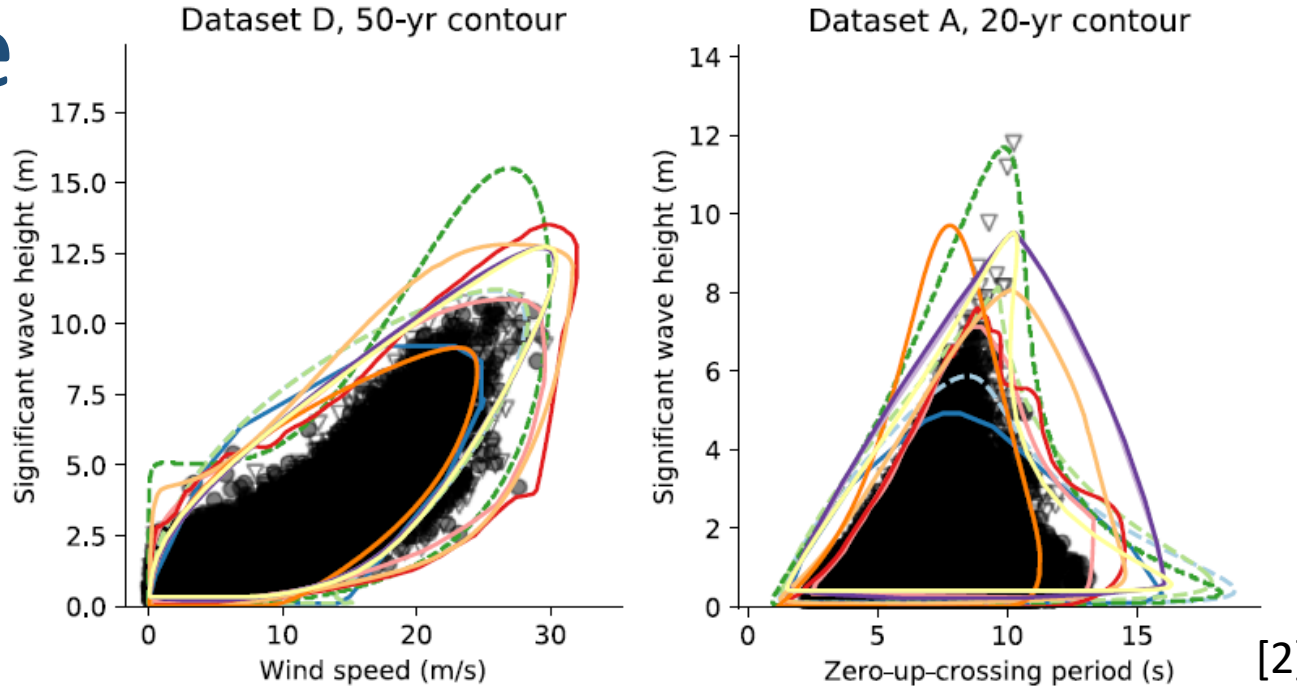
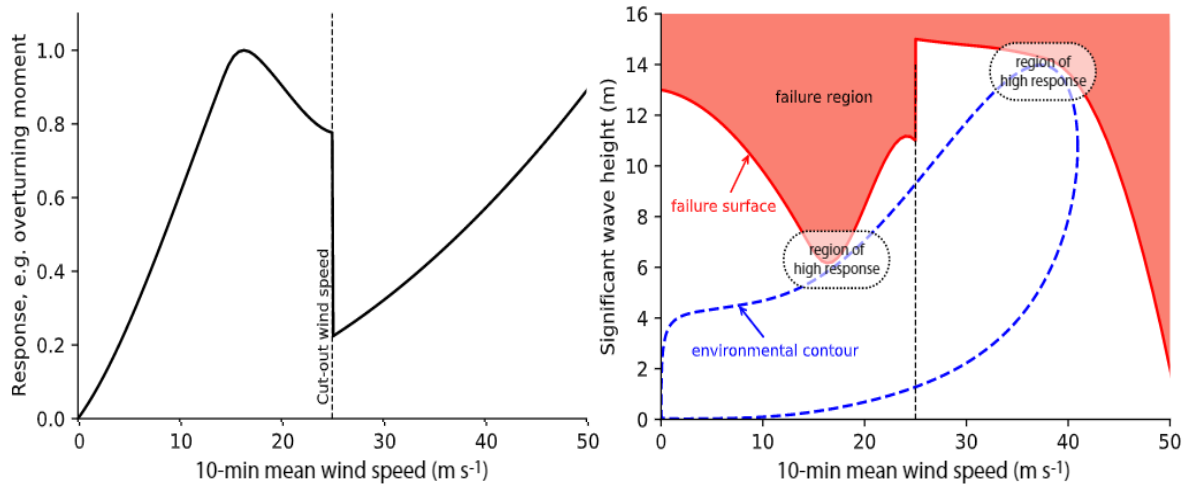
IMEX: research challenge

- Design of ORE structures requires estimates of **joint extremes** of winds, waves and tides
- Current design standards recommend models that make strong assumptions about form of joint distribution
- Statistical models can lead to errors in extreme response of the order of ±50% [1]
- **Reduced uncertainty** in environmental conditions leads to **more efficient and reliable designs**



[2]

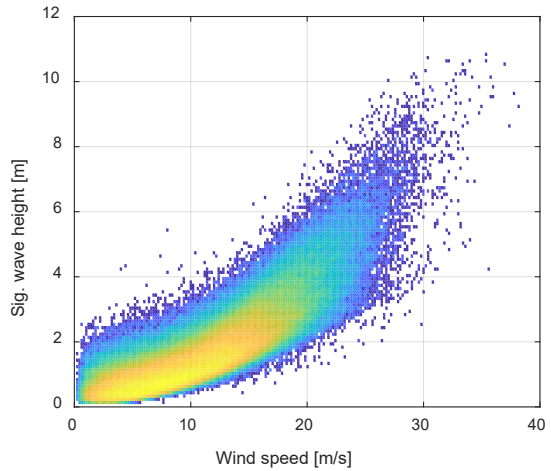


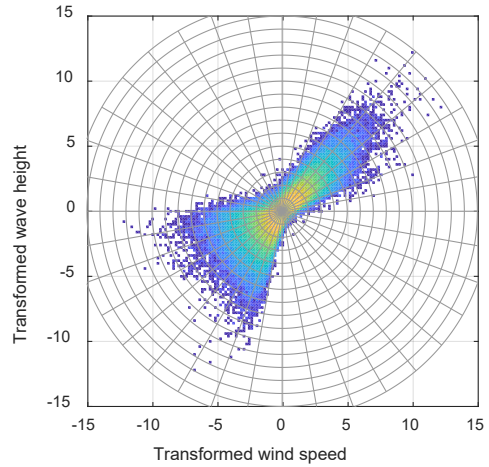
[3]

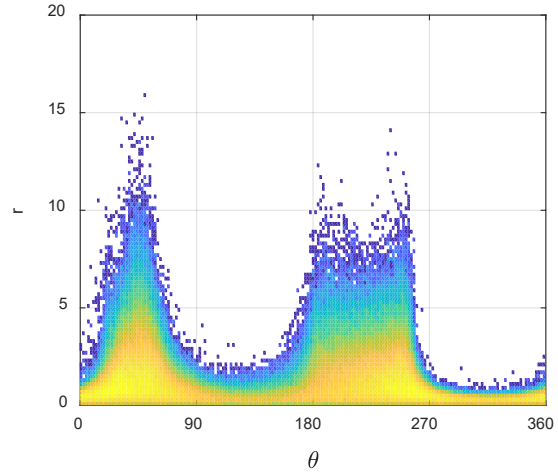
[1] de Hauteclocque et al. "Quantitative assessment of environmental contour approaches". Ocean Eng. 245 (2022)
[2] Haselsteiner et al. "A benchmarking exercise for environmental contours" Ocean Eng. 236 . (2021)
[3] Haselsteiner et al. "Long-term extreme response of an offshore turbine: How accurate are contour-based estimates?". Renew. Energy. 181 (2022)

IMEX objectives

- Develop new models for multivariate extremes
  - Based on **justifiable mathematical principles**
  - **Flexible** enough to represent observed datasets
  - **Simple** enough for routine engineering use
- Integrate models into open-source software: https://github.com/edmackay/PPL-model







Univariate extremes with covariate dependence

The SPAR model

- Semi-Parametric Angular-Radial (SPAR) model [4]
- Reframes multivariate extremes as an intuitive extension of univariate theory, with angular dependence
- More flexible than existing methods for multivariate extremes:
  - Can represent distributions both asymptotically independent and dependent distributions
- Inference is standard univariate problem with covariate dependence [5]
- Method is applicable for wide range of multivariate extremes problems

[4] Mackay, (2022). "Multivariate peaks-over-threshold with flexible dependence class". In preparation
[5] Barlow et al. (2022). "A penalised piecewise-linear model for non-stationary extreme value analysis of peaks over threshold". https://arxiv.org/abs/2201.03915v1