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Can we trust turbulence models?

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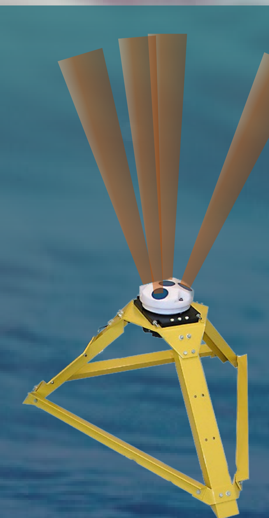
CONTEXT

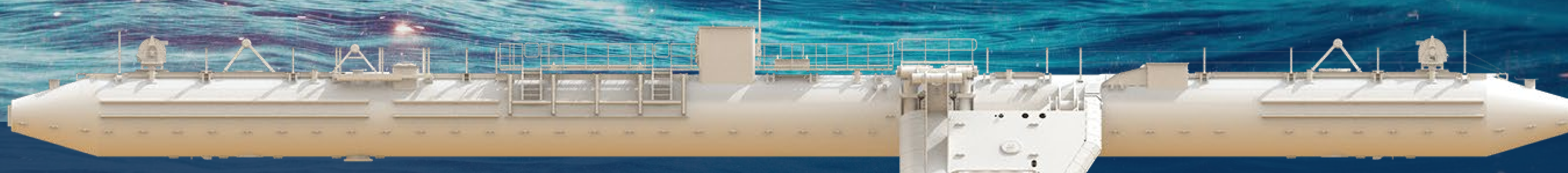
Understanding turbulence is crucial to the design of tidal energy converters as it influences loads, fatigue life and power production [1]. Developers use turbulence models to generate synthetic inflows for use in simulations of device performance. Such models are typically based on a combination of parameters derived from physical observations and theoretical models, often inherited from the wind industry and untested for tidal applications.

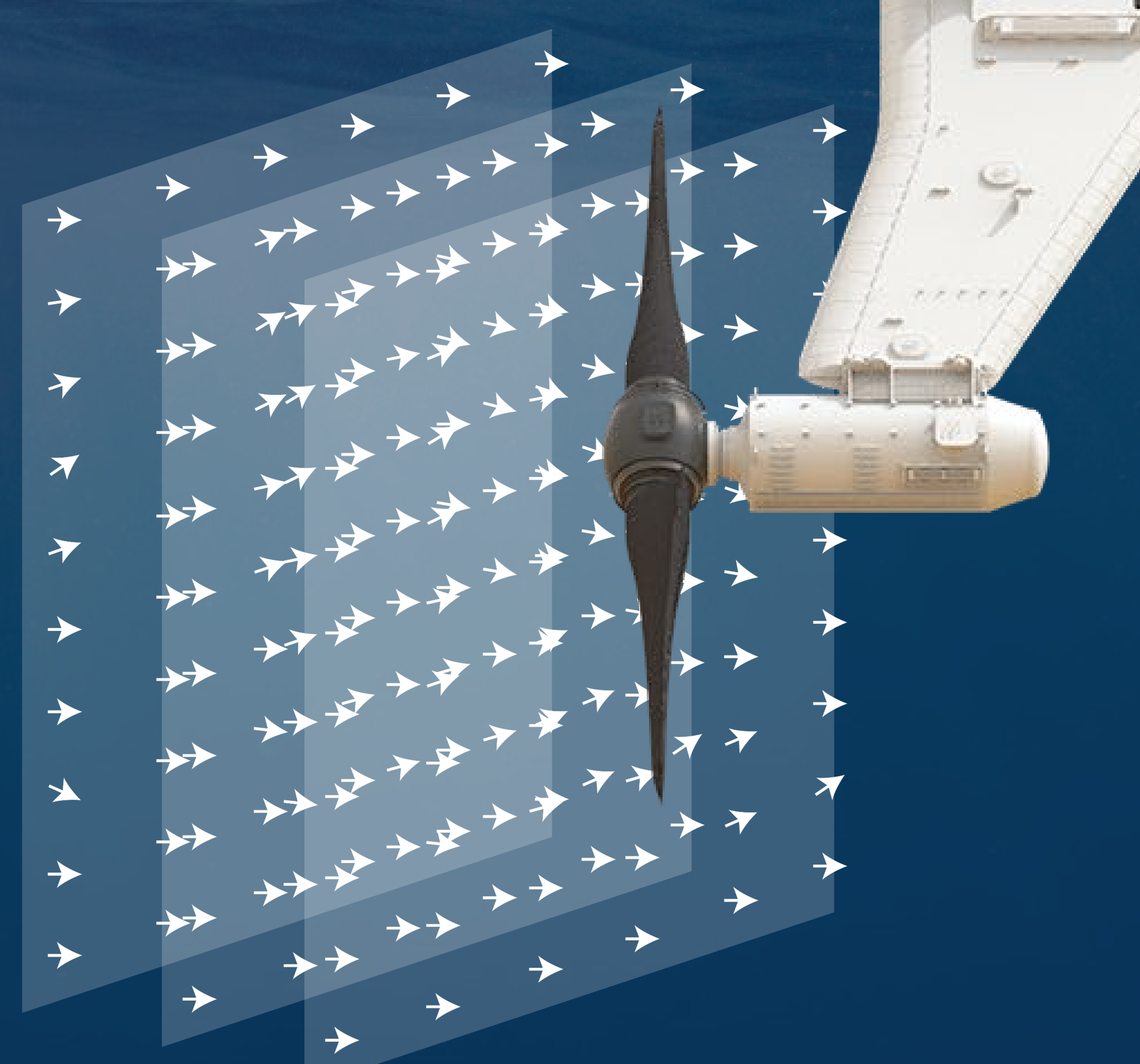
METHODS

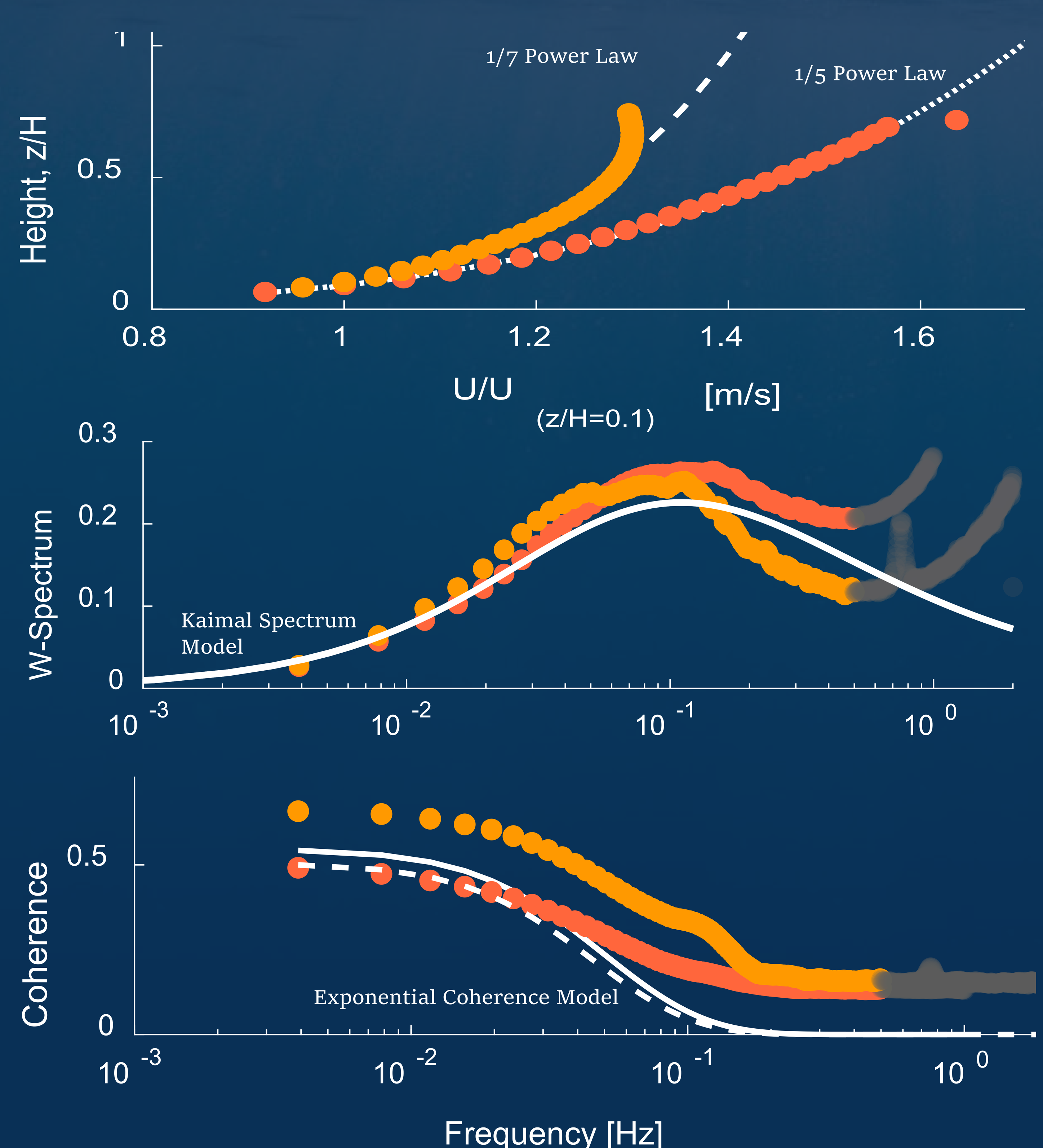


In this study, we compare turbulence theories and assumptions, typically used in the tidal energy industry, to turbulence observations derived from ADCP data from test berths at two energetic tidal sites. We analyse shear, spectral and spatial coherence models recommended by the DNVGL Tidal turbines standard [2] and IEC Technical Specifications [3], and which form the basis of flow generation by simulators such as Tidal Bladed [4].

RESULTS







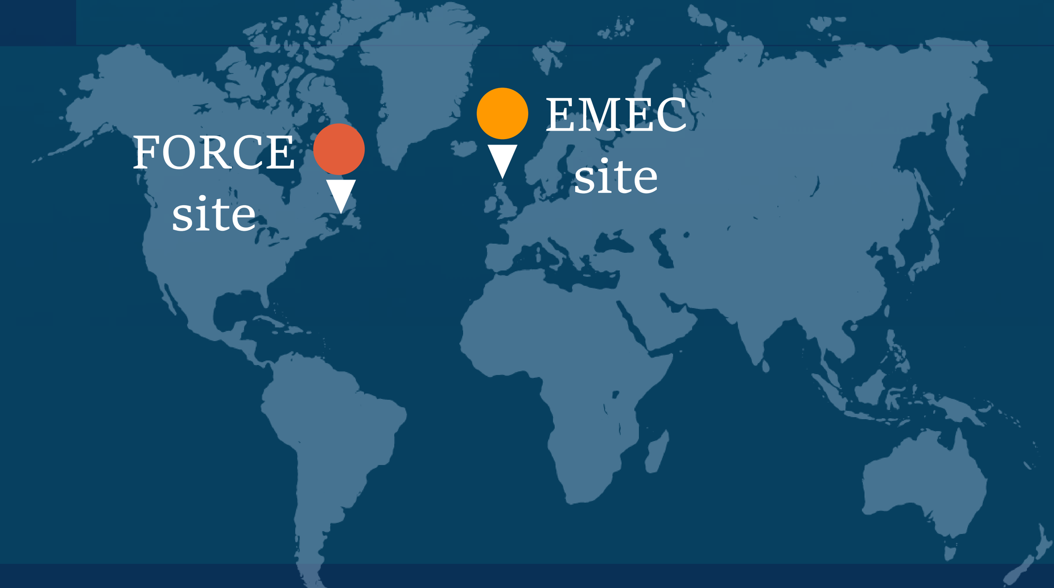
The shear profile at the EMEC test berth significantly deviates from the power law profile. The velocities at the test berth at FORCE follow a 1/5th power law profile.

In line with other studies [5], the Kaimal spectrum provides a better fit than the von Karman model for measurements at both sites, with better agreement near the seabed.

EMEC test berth measurements showed significantly higher spatial coherence than the exponential model, whereas FORCE site measurements matched the model well at low frequencies.

The two tidal sites show different levels of agreement with turbulence models, with FORCE showing more ‘canonical’ turbulence profiles.

Both sites showed higher discrepancies on the ebb cycles (as shown on charts), than the floods (not shown).



CONCLUSIONS

Our findings demonstrate that some of the assumptions and empirical models used in generating turbulent flows are not applicable to tidal flows. Moreover, the applicability of models varies within the same site depending on bathymetric features present, as well as by depth and tidal cycle. These findings are important because such discrepancies are likely to result in inaccuracies in load modelling.

CURRENT WORK

The next step is to quantify **what these discrepancies amount to in terms of simulated device loads?**

We are currently investigating the sensitivities of turbulence parameters in models using TurbSim and Tidal Bladed. This work will improve our understanding of the most critical turbulence parameters for modelling loads and the uncertainties related to using empirical models instead of measured parameters.

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1. T. Blackmore, L. E. Myers, A. S. Bahaj, B. Gaurier, L. Myers, and G. Germain, The effect of freestream turbulence on tidal turbines, in Proceedings of the 11th European Wave and Tidal Energy Conference, 2015
2. DNV-GL, Dnvgl-st-0.164: Tidal turbines, p. 230, 2015.
3. E. Comission, PD IEC / TS 62600-201: 2015 BSI Standards Publication Marine energy Wave , tidal and other water current converters. 2015
4. M. Q. Khairuzzaman, “Tidal Bladed Theory Manual,” 2016.
5. J. McMillan, “Turbulence Measurements in a High Reynolds Number Tidal Channel,” PhD Thesis, no. June, 2017.