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Total number of authors:
31

Publication date:
2024

Document Version
Publisher's PDF, also known as Version of record

PO.207

This project receives funding from the European Union Horizon 2020 research and innovation programme under grant agreement no. 861291.

Train²Wind - Lollex and other results

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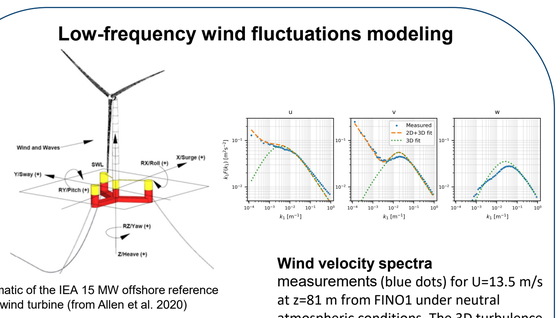
- *TRAIN²WIND* is a PhD TRAINing school analysing enTRAINment in offshore WIND farms
- The main aim is to investigate the inflow of new momentum into very large wind farms
- 13 PhD students and 6 short-term fellows since 2020 (project is closing July 2024)
- **Lollex** is the experiment at the Rødsand II wind farm in Lolland, Denmark (2 lidars on CTV Sept '22-Aug '23, plus a scanning lidar on the substation May-Aug '23)
- We also investigate farm-farm interaction, and wether vertical axis wind turbines would be advantageous for GW+ wind farms

Lollex

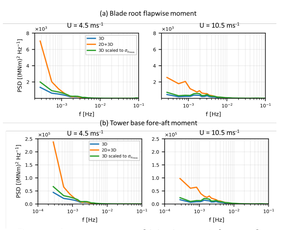
Abdul Haseeb Syed, DTU

Low-frequency wind fluctuations modeling



A schematic of the IEA 15 MW offshore reference floating wind turbine (from Allen et al. 2020)

Wind velocity spectra measurements (blue dots) for U=13.5 m/s at z=81 m from FINO1 under neutral atmospheric conditions. The 3D turbulence model (Mann spectral model) is fitted (green dotted lines) as well as the 2D+3D turbulence model (orange dashed lines) for u and v components



Dynamic response of blade root fore-aft and tower base fore-aft moments under low-frequency wind fluctuations. It can be observed that these moments show a heightened response under low-frequency wind turbulence

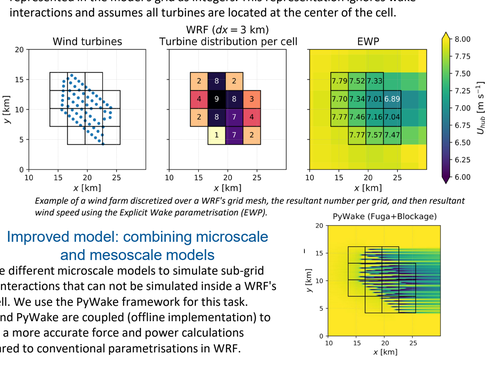
More details about the model and its implementation can be found here:
1. Abdul Haseeb Syed and Jakob Mann. A model for low-frequency, anisotropic wind fluctuations and coherences in the marine atmosphere. Boundary-Layer Meteorology, 190(1):1, Jan 2024.
2. Syed, A. H. and Mann, J.: Simulating low-frequency wind fluctuations, Wind Energ. Sci. Discuss. [preprint], https://doi.org/10.5194/wes-2023-142, in review, 2023.

Oscar Garcia, DTU

Mesoscale modelling of offshore wind farms

Wind turbine representation

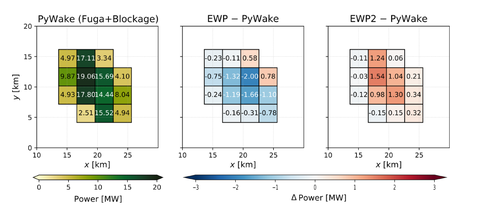
Wind turbines in the Weather Research and Forecasting (WRF) model, are represented in the model's grid as integers. This representation ignores wake interactions and assumes all turbines are located at the center of the cell.



Example of a wind farm discretized over a WRF's grid mesh, the resultant number per grid, and then resultant wind speed using the Explicit Wake parametrisation (EWP).

Improved model: combining microscale and mesoscale models

We use different microscale models to simulate sub-grid wake interactions that can not be simulated inside a WRF's grid cell. We use the PyWake framework for this task. WRF and PyWake are coupled (offline implementation) to obtain a more accurate force and power calculations compared to conventional parametrisations in WRF.



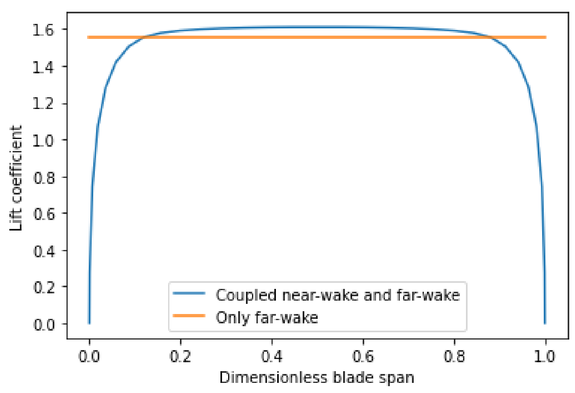
Comparison of output power from PyWake, WRF with no sub-grid wakes (EWP) and the coupled version (EWP2)

Grischa Fraumann, Uni Copenhagen

Collaboration is becoming more important in distributed research programs in data-intensive research. Collaboration has been studied in several academic disciplines and contexts, given the relevance of such interactions in different areas. However, the concrete setting of collaboration in data-intensive research networks coupled with PhD education has not been studied in detail. The present studies map the collaboration space in the context of Innovative Training Networks in the wind-energy research area that is affected heavily by digitalization. We conducted the following 47 semi-structured interviews concerning collaboration in data-intensive research networks from a diverse set of countries and organizational types structured within four related networks: (1) Expectations of collaboration at the beginning of a PhD with 23 PhD fellows; (2) collaboration support in data-intensive research networks with five PhD supervisors; (3) differences between collaboration in physical environments on campus and virtual environments during the COVID-19 pandemic with seven researchers; and (4) experiences of collaboration in data-intensive research networks with 12 PhD fellows. These interviews were conducted during the development of a data-intensive research network over 2.5 years. They were also enriched by participant observations during scientific experiments and project meetings. Preliminary findings suggest that collaboration within this empirical setting is shaped by research data and infrastructure. Practical implications of the results include the relevance of understanding research and development processes to support collaboration in sustainable energy research. More in-depth studies of such networks could provide a broader picture of collaboration within Innovative Training Networks.

Nicolau Conti Gost, DTU

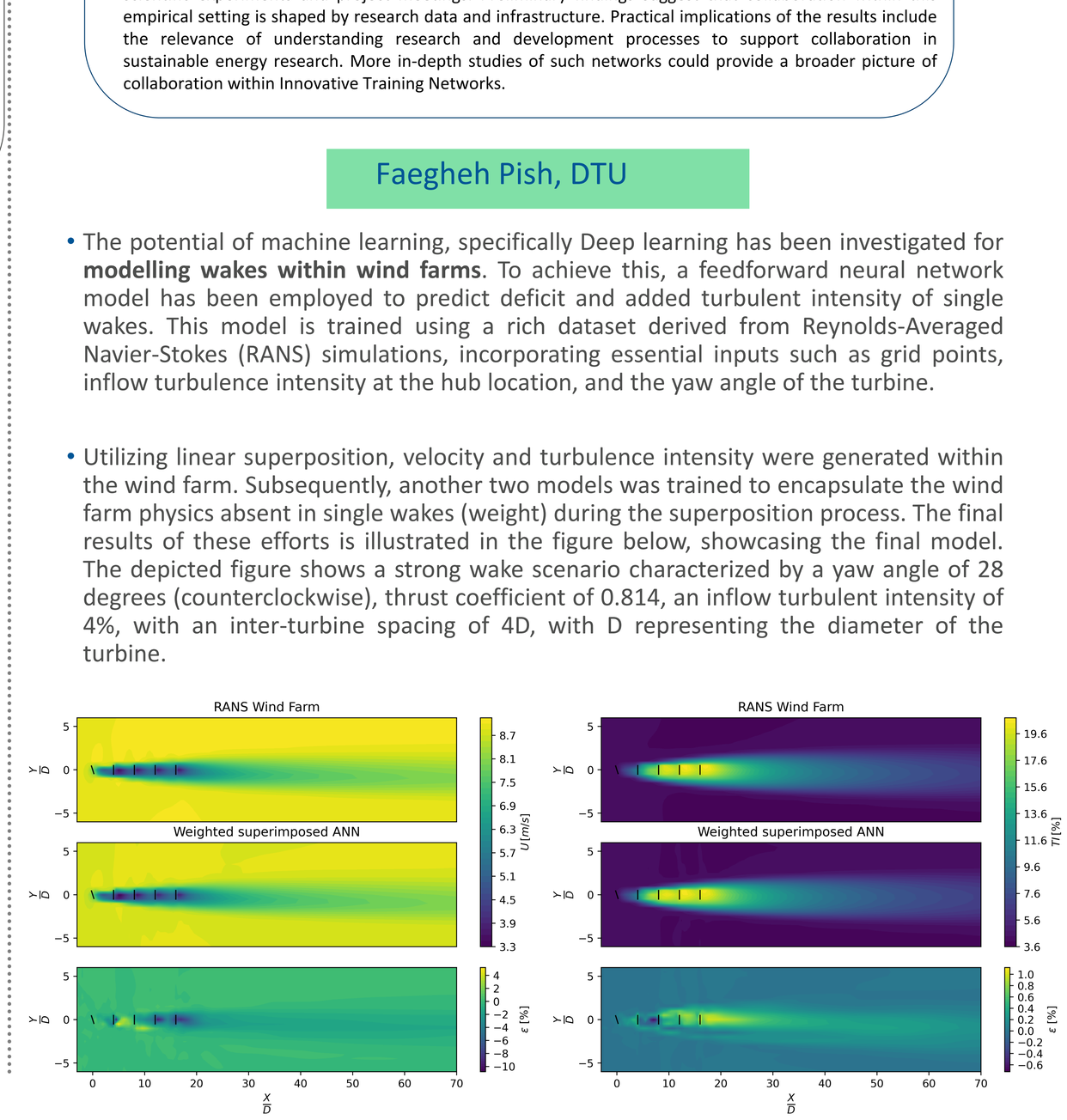
- **Vertical axis wind turbines** may offer crucial advantages in offshore wind thanks to their lower center of gravity and sea level placement of the generator and drivetrain, which lead to a great decrease of substructure and maintenance costs. Studies also suggest that VAWTs may facilitate a quicker wake recovery, thus increasing the total power production of wind farms
- Due to the great variation of inflow conditions during a revolution, VAWT blades are very susceptible to fatigue and therefore a proper aerodynamic model is necessary. A lifting-line near-wake model adapted to VAWT operation is coupled to a far-wake model to compute the total induction and blade loading. A comparison of maximum blade loading against the Actuator Cylinder far-wake model for a VAWT operating at V = 10 m/s and tip speed ratio TSR = 2.9 is shown in the figure below



- As can be seen above, the coupled model yields a more accurate loading along the blade which will have a huge impact on the blade lifetime assessment and on power production.

Faegheh Pish, DTU

- The potential of machine learning, specifically Deep learning has been investigated for **modelling wakes within wind farms**. To achieve this, a feedforward neural network model has been employed to predict deficit and added turbulent intensity of single wakes. This model is trained using a rich dataset derived from Reynolds-Averaged Navier-Stokes (RANS) simulations, incorporating essential inputs such as grid points, inflow turbulence intensity at the hub location, and the yaw angle of the turbine.
- Utilizing linear superposition, velocity and turbulence intensity were generated within the wind farm. Subsequently, another two models was trained to encapsulate the wind farm physics absent in single wakes (weight) during the superposition process. The final results of these efforts is illustrated in the figure below, showcasing the final model. The depicted figure shows a strong wake scenario characterized by a yaw angle of 28 degrees (counterclockwise), thrust coefficient of 0.814, an inflow turbulent intensity of 4%, with an inter-turbine spacing of 4D, with D representing the diameter of the turbine.



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