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SENSOR ASSISTED WIND FARM OPTIMISATION (SAWOP)

TOWARDS GENERATING MORE VALUE OUT OF MEASUREMENT DATA USING WIND FARM PERFORMANCE MONITORING METHODOLOGIES

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19TH JANUARY 2023 | EERA DEEP WIND CONFERENCE 2023 | TRONDHEIM, NORWAY

WHAT IS ON THE MENU TODAY ?

- LEARN ABOUT SAWOP AND THE CAMPAIGN
- SCOPE AND MAIN RESULTS TO SHARE TODAY
- SCADA DATA PROCESSING
- ASSESSMENT OF EXTERNAL CONDITIONS
- WAKE MODELLING FOR FARM FLOW CONTROL
- COMMENTS, REFLECTIONS AND DISCUSSION

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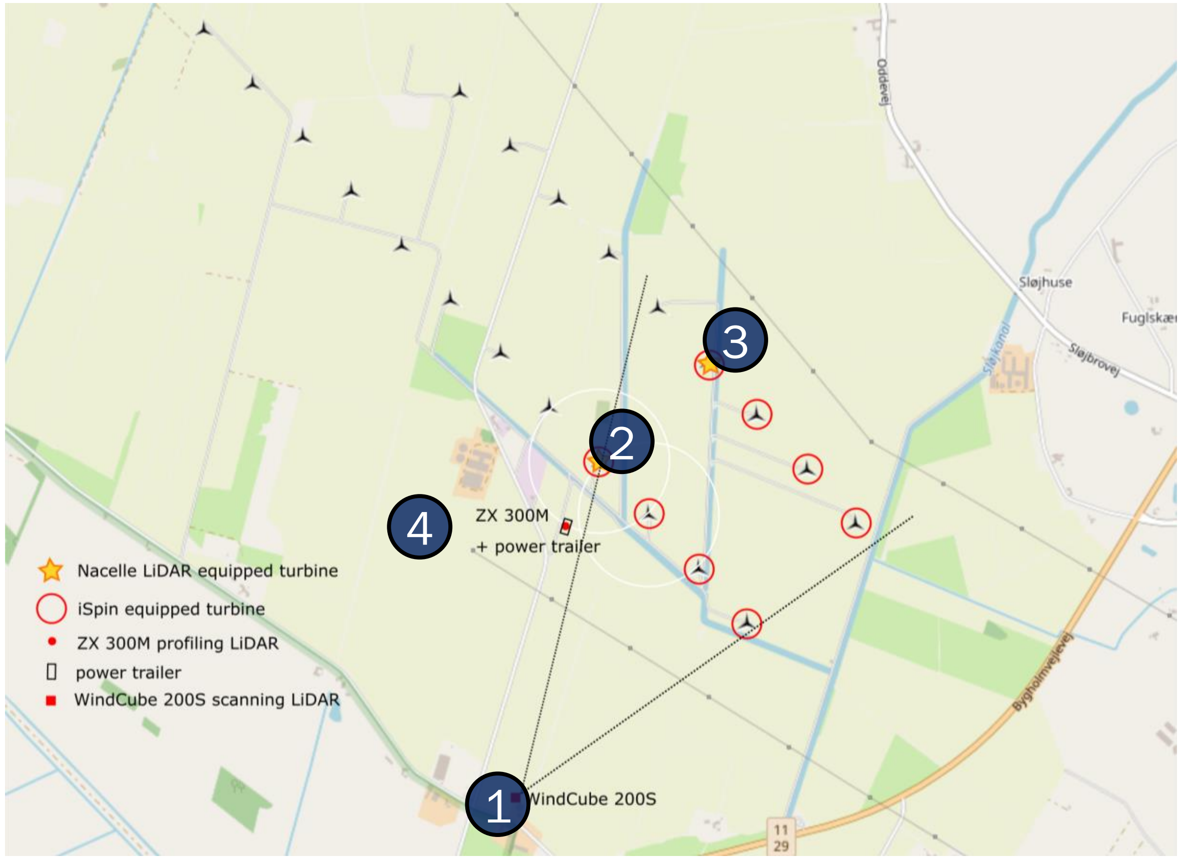
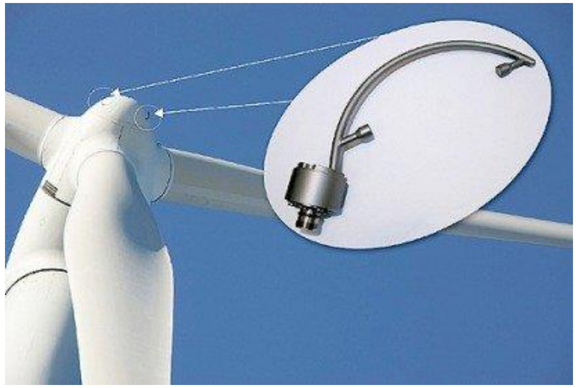
UNIQUE MEASUREMENT CAMPAIGN TAKING PLACE AT ONSHORE WIND FARM KLIM

Employment of dedicated sensors to improve individual turbine performance and farm level energy production.





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THREE MAIN RESULTS TO DEEP DIVE TODAY

The SAWOP project aims to improve wind turbine and farm performance by making use of additional sensors. Work Package 4 focuses specifically in developing power performance monitoring methodologies and investigating benefits from wind farm flow control. Three main results to be explored today are:

(1) FLORIS-based Analysis for SCADA data (FLASC) serves as a reliable tool for SCADA data processing.

- (1) Lack of tools/consensus on farm level data processing.
- (2) Allows for implementation of filters specially useful for this campaign.
- (3) Corrects offsets in wind direction measurements.

(2) Dedicated post processing can be used to quantify the external conditions in the inflow.

- (1) Follows the wind farm as a sensor approach.
- (2) Non uniform inflow can be quantified and used in simulations, increasing accuracy of turbines power production.

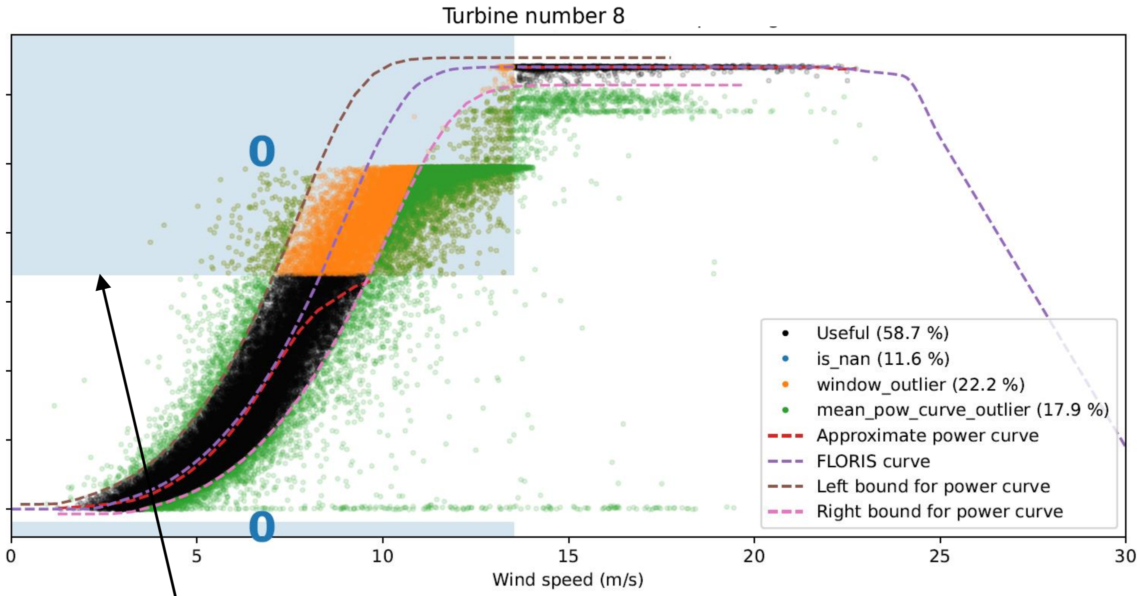
(3) Divergence between wake models for specific situations.

- (1) Models have different accuracies depending on the wake situation and atmospheric conditions for a given wind direction.

FLASC AS A CONSISTENT METHOD FOR DATA PROCESSING AND MEASUREMENT CORRECTION

FLASC allows to filter data based on different conditions and provides dedicated visualisations.

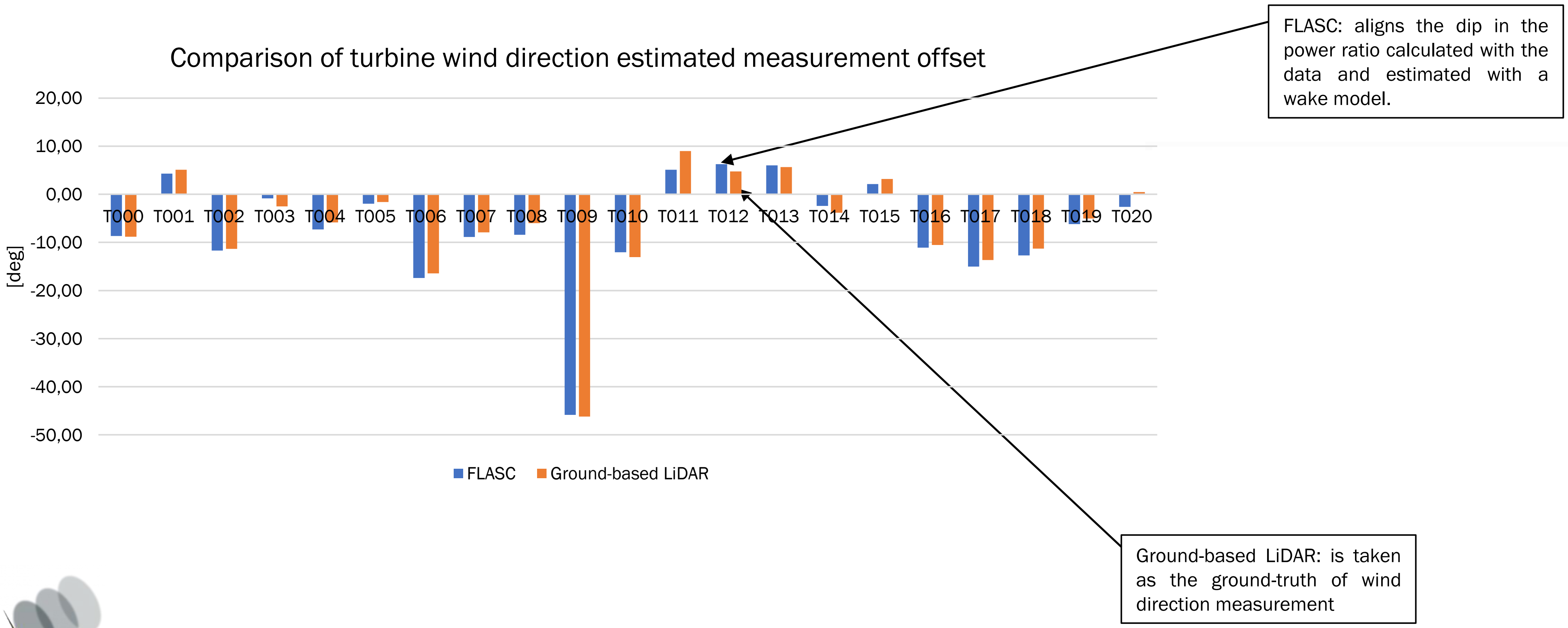
Windows can be added to remove points where turbine is operating in a noise reduction mode. This is specially useful for processing data from an onshore campaign.

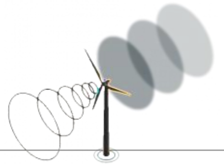


Adding specific window to remove measurements where turbine operates in noise reduction mode and deviates from other turbine power curves.

FLASC AS A CONSISTENT METHOD FOR MEASUREMENTS CORRECTION

Offsets in wind direction measurements exist and must be removed. FLASC implements a correction based on a wake model and the results are consistent with the ones using a ground-based LiDAR as ground truth.





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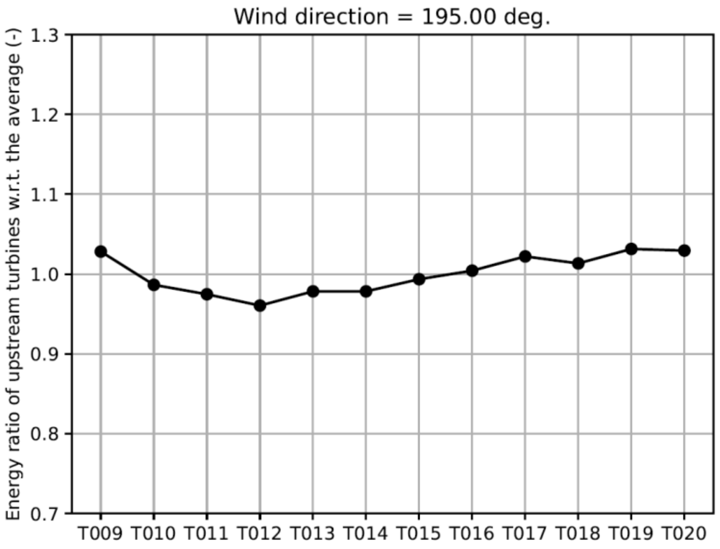
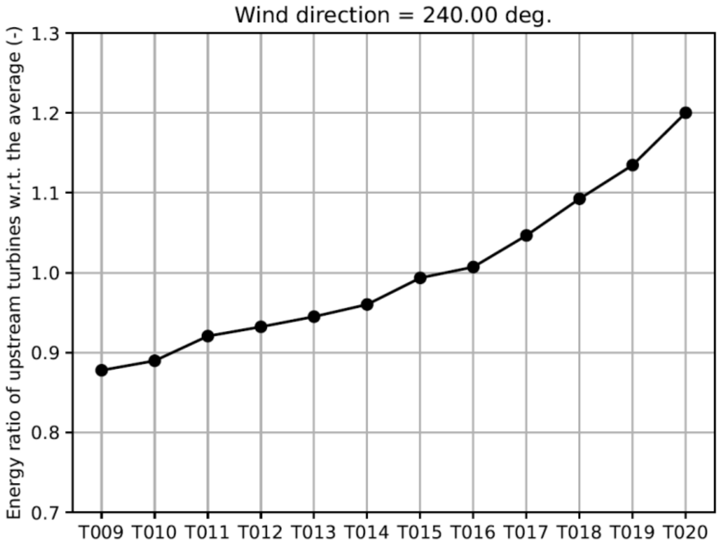
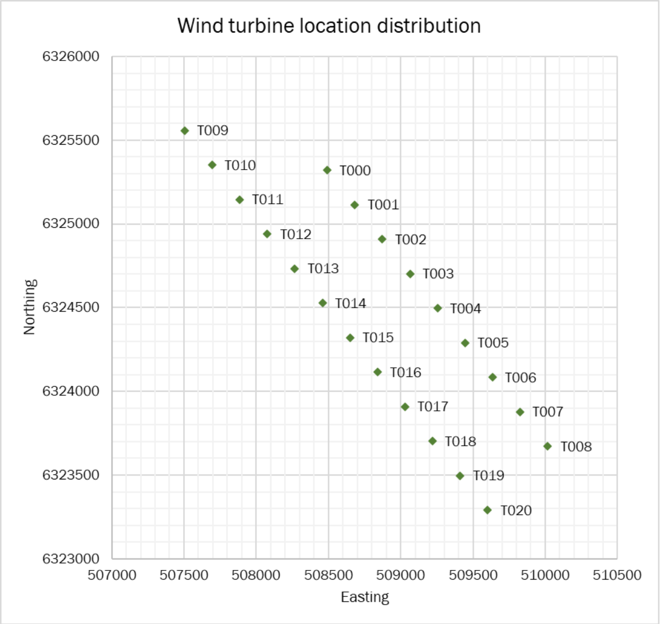
POST PROCESSING ALLOWS TO QUANTIFY NON UNIFORM INFLOW

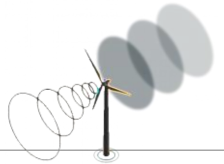
The energy ratio is quantified per turbine. The ratio of each turbine energy to the average energy over the leading row of turbines is assessed.

Particular sectors exhibit evidence of non uniform inflow, which is thought to be due to the existence of lakes and forests from that direction.









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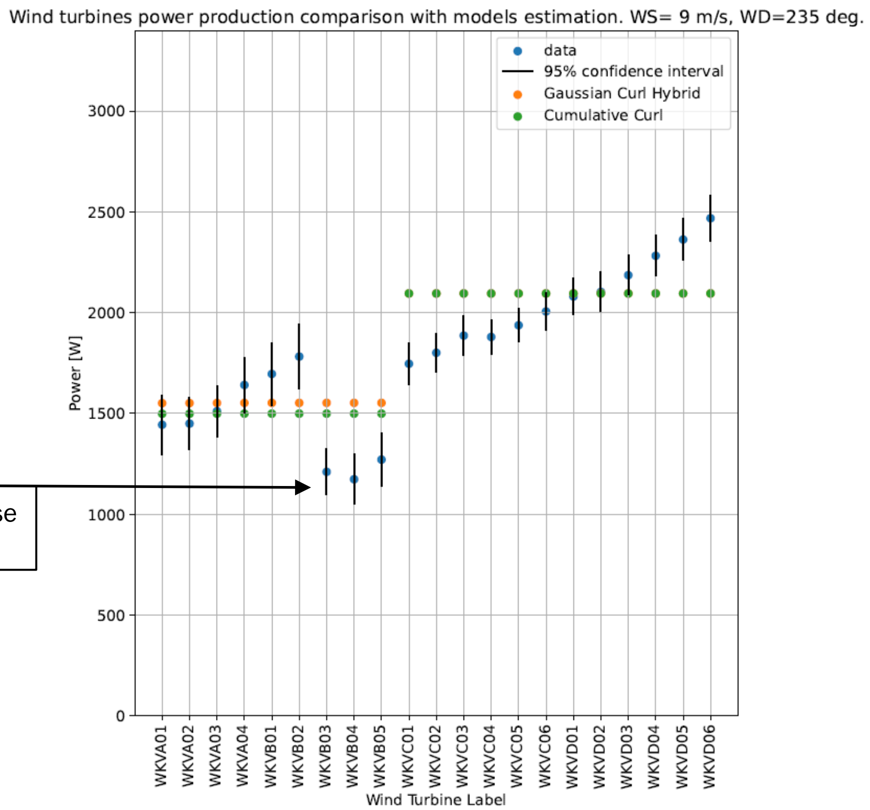
ACCOUNTING FOR NON-UNIFORM INFLOW IMPROVES ACCURACY OF PREDICTIONS

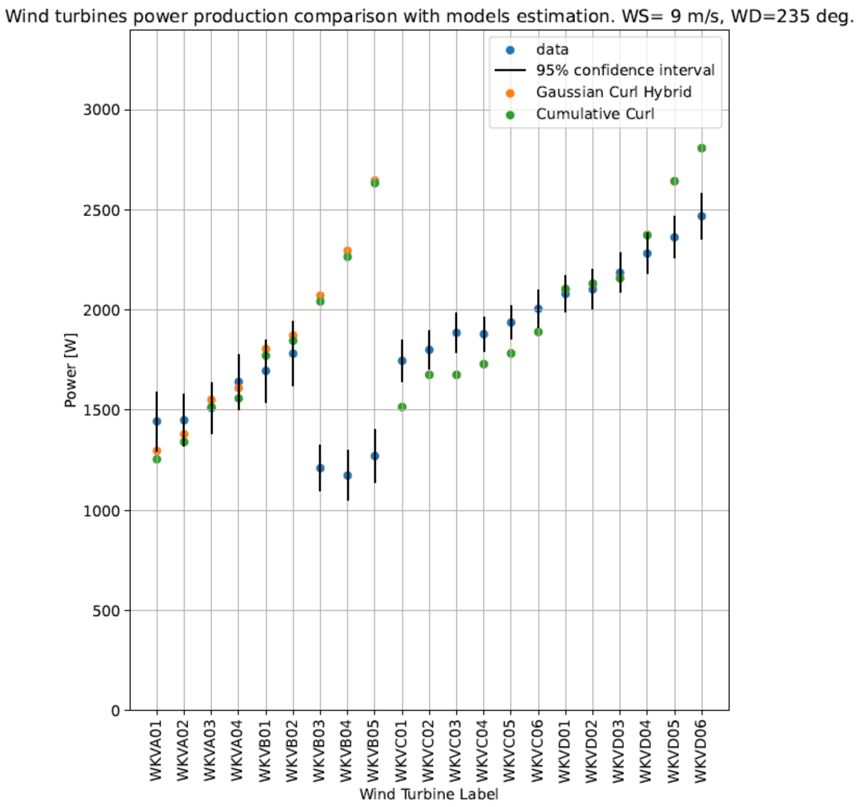
Accounting for non-uniform inflow reduces the average error from 8.7% to 6.9% (excluding turbines operating in noise reduction mode).

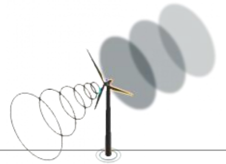
ASSUMPTION OF UNIFORM INFLOW



Turbines operating in noise reduction mode

MAKING USE OF NON UNIFORM INFLOW





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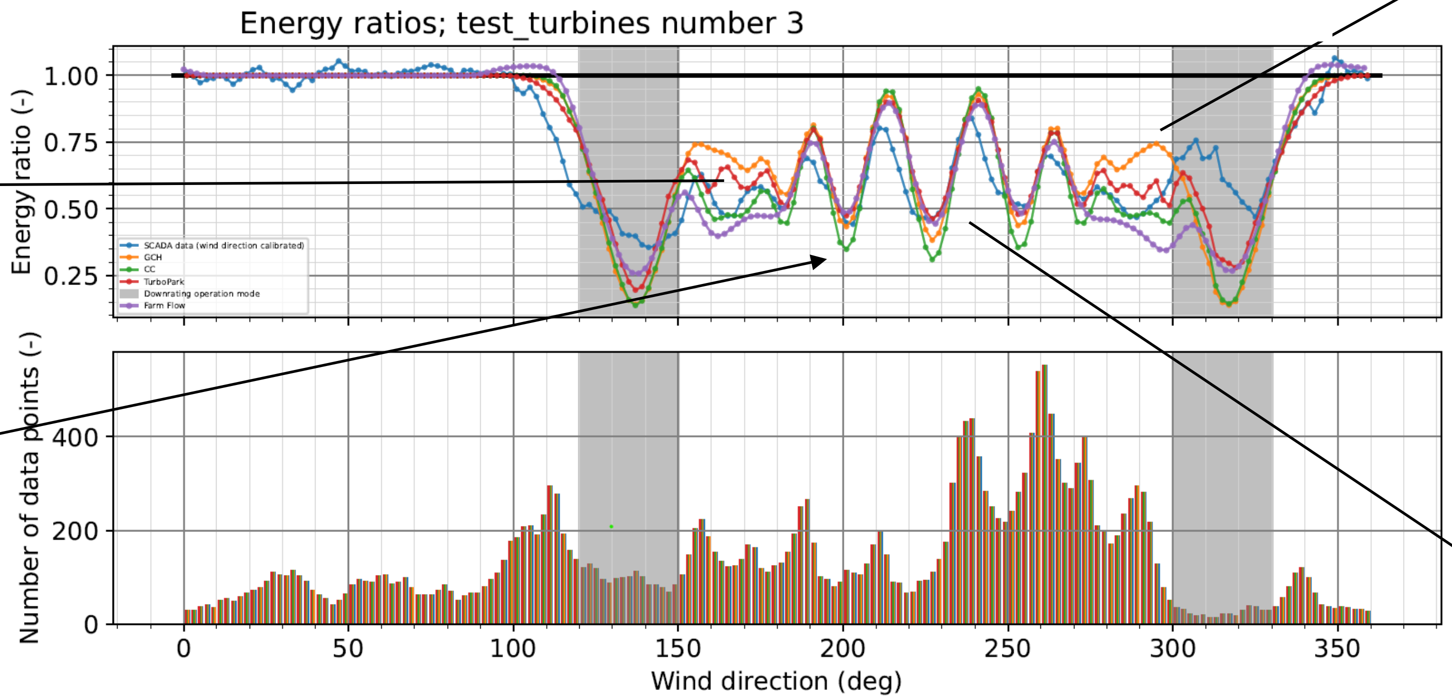
WAKE MODELS DIFFER IN THEIR ACCURACY DEPENDING ON SECTOR EVALUATED

Four wake models are compared across multiple turbines using the energy ratio metric.

Interesting insights can be taken from this comparison.

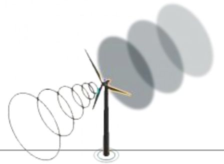


TurbOPark wake growth parameter set to 0.05 as opposed to the historical one of 0.04 used of offshore.

Overall, majority of wake models captures deficit in wake. Cumulative Curl model shows largest deviation.

For certain wind directions, it appears Gaussian Curl Hybrid model over estimates wake recovery. For these wind directions, combination of wakes is expected, perhaps not well taken into account by the GCH model.

Turbulence intensity may differ across wind directions, explaining model divergence across the rose



RESULTS AND INSIGHTS ARE READILY APPLICABLE FOR OFFSHORE WIND

Results, insights and methodologies developed in this work, based on a measurement campaign in an onshore wind farm, are readily applicable for offshore wind farms as well.

(1) FLORIS-based Analysis for SCADA data (FLASC) serves as a reliable tool for SCADA data processing.

  (1) Automatization of the processing of data for a large number of turbines, which will only grow in size in the future.

(2) Dedicated post processing can be used to quantify the external conditions in the inflow.

  (1) External conditions become complex as offshore wind farms grow larger and with more complex shapes. Coastal effects are also of interest to evaluate.

(3) Divergence between wake models for specific wind directions.

  (1) Due to deep array effects in offshore wind farms, models such as the cumulative curl may be more suited and yield more accurate predictions. Optimisations making use of this model may yield more accurate results.

  (2) Wind farm flow control can be applied at offshore wind farms, where turbulence intensity is lower and AEP increases may be higher.

QUESTIONS AND ANSWERS

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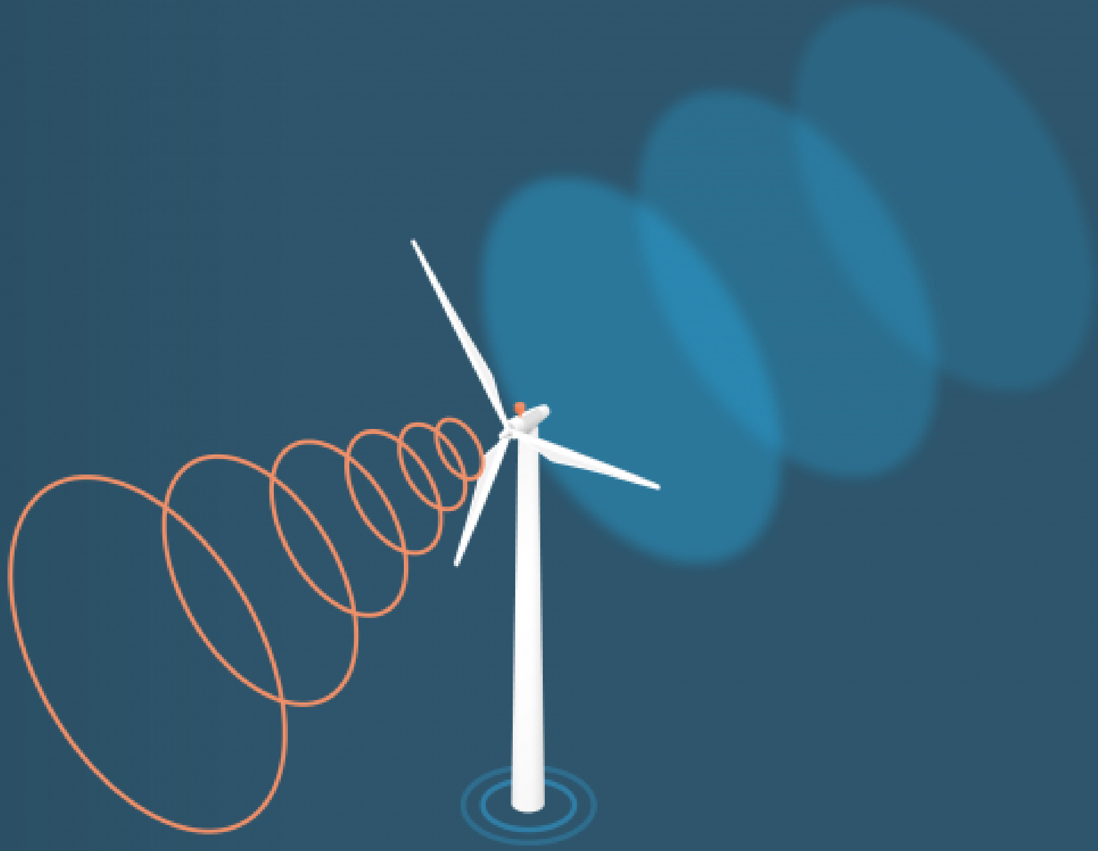
THIS PROJECT IS EXECUTED WITH SUBSIDY FROM THE MINISTRY OF ECONOMIC AFFAIRS AND CLIMATE, NATIONAL REGULATION EZ-SUBSIDIES, TOPSECTOR ENERGY EXECUTED BY THE NETHERLANDS ENTERPRISE AGENCY. RVO REFERENCE NUMBER TEHE118022.



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