Wind farm layout assessment in Sørlige Nordsjø II using engineering wake models and the NORA3 dataset

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ABSTRACT/MOTIVATION

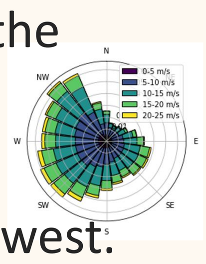
This study presents an overview and comparison of different engineering wake models and their ability to predict wake losses and the annual energy production (AEP) in the tender area for offshore wind farm Sørlige Nordsjø II (SN2). The poster compares the results from engineering wake models FLORIS and PyWake as well as Vind AI, which integrates PyWake in a user-friendly interface. The three wake models used in this study are the Jensen, GCH (Gauss Curl Hybrid), and TurbOPark models. The wake loss and AEP calculations were performed under varying turbulence intensity (TI), wind shear, and wind veer values. Additionally, the blockage effect will be included where possible. The necessity of the 5 km buffer zone between each of the three subareas and the recommended maximum capacity will be investigated. This study combines open-source software and the state-of-the-art wind atlas NORA3, which is valuable for both the wind energy industry and academic research. The engineering wake models have rarely been tested on wind farms of the magnitude of SN2. Therefore, it is interesting to observe their performances under such conditions and compare them with each other.

RESEARCH QUESTIONS

- Do Floris and other engineering wake models underpredict farm wake in large wind farms?
- Are Floris and PyWake similar when calculating AEP and farm wake? How do they compare to VIND AI?
- Which of the wake models Jensen, Gauss (GCH) and TurbOPark predicts wake losses in large wind farms most accurately?

METHOD & BACKGROUND

- This study utilised the NORA3 dataset, which has a spatial resolution of 3 km, an hourly resolution of 1 h and covers in its "simplified version" seven levels from 10 m to 750 m above the surface, and the FLORIS, PyWake, and VIND AI frameworks to calculate the wake loss and annual energy production of the offshore wind farm SN2.



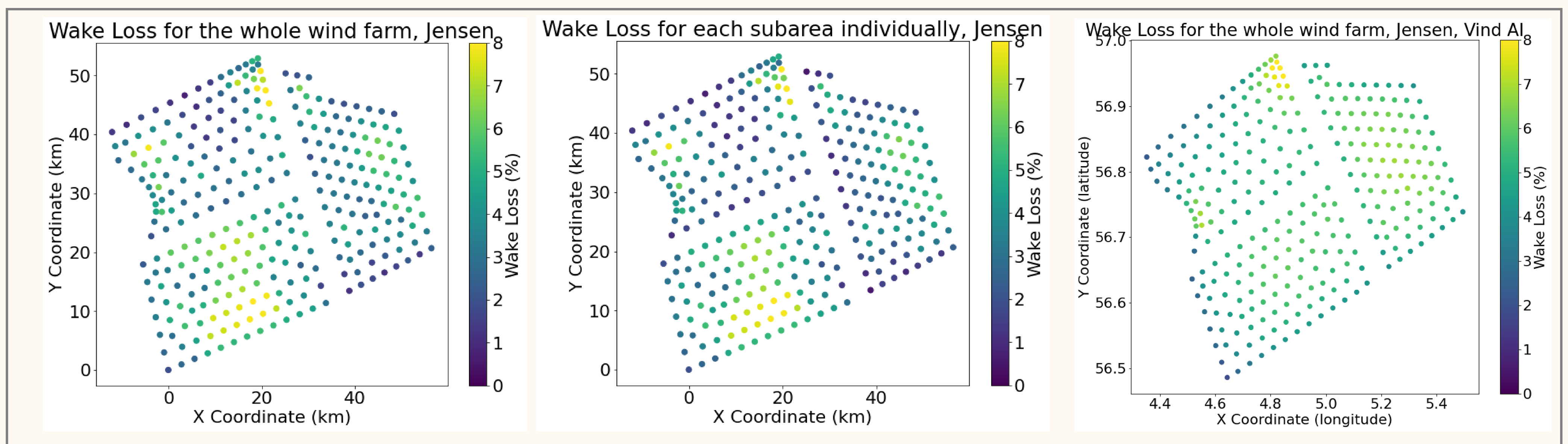
- The wind rose has most wind coming from the west.
- The distances between most neighbouring wind turbines are 10-13 diameters.

RESULTS/DISCUSSION

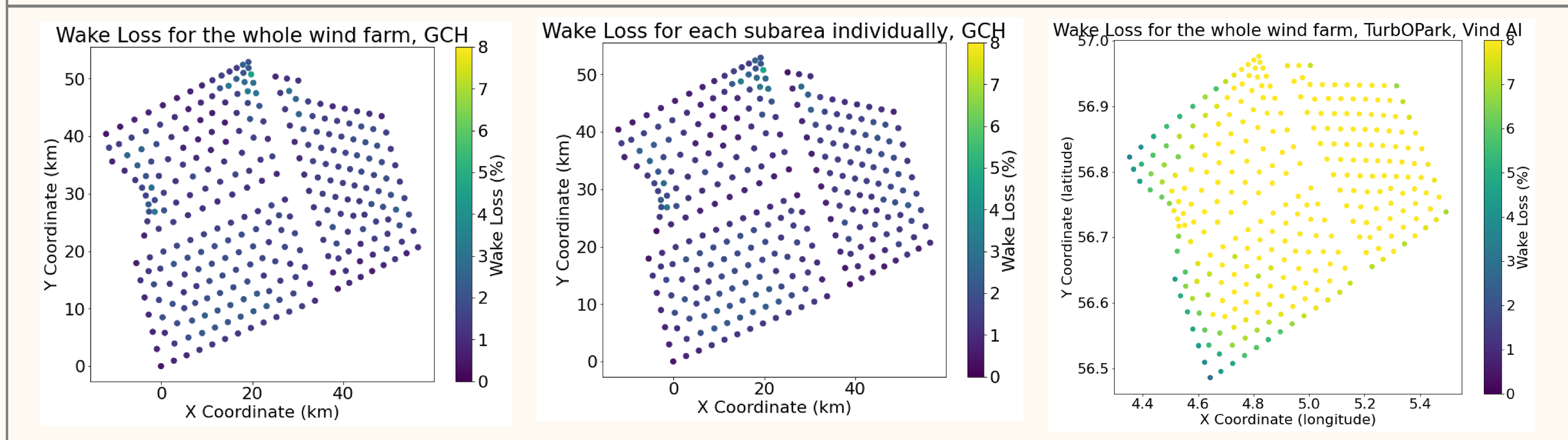
- The eastern subarea is more affected by wake than the other two subareas, despite the 5 km buffer zones.
- Both FLORIS and PyWake underpredict wake loss compared to the industry tool Vind AI.
- TurbOPark leads to the largest wake loss, with significantly larger values than for the Jensen and GCH models in PyWake and Vind AI. However, its implementation in FLORIS is still inadequate.
- Andersen & Løvseth's linear TI model improved the capacity factor (CF) when implemented in FLORIS.
- FLORIS is the most computationally expensive of the three models.
- The addition of the blockage effect increases total loss and represents a more realistic scenario.

CONCLUSION/ FUTURE WORK

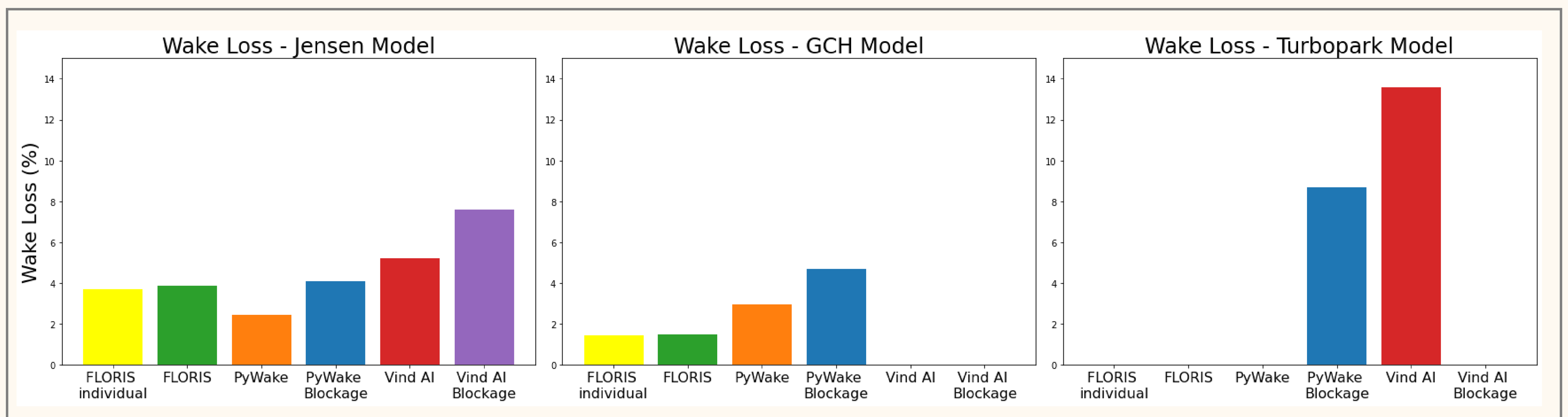
- The wake models used in engineering currently may underpredict the wake loss in the wind farm.
- Future research could investigate whether the capacity in SN2 should be increased, given the current predicted AEP. Additionally, incorporating the blockage effect in FLORIS could lead to better comparisons with PyWake and Vind AI.



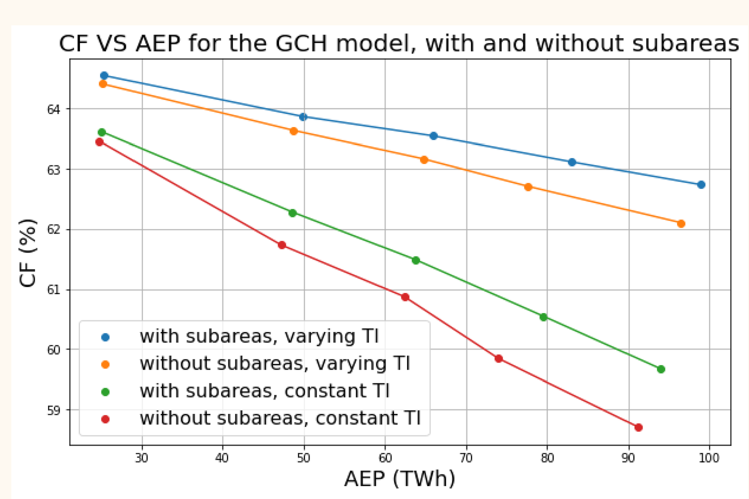
Wake loss at each turbine in SN2 using the Jensen model in FLORIS, calculated for the farm as a whole (left) and each subarea individually (middle), and Vind AI (right).



Wake loss at each turbine in SN2 using the GCH model in FLORIS for the whole farm (left) and each subarea individually (middle) and using the TurbOPark in Vind AI (right).



Wake loss for the Jensen (left), GCH (middle), and TurbOPark (right) models using both FLORIS, PyWake and Vind AI.



CF versus AEP in FLORIS for layouts with and without subareas, different maximum capacities and constant and varying TI.

REFERENCES

- The engineering wake models FLORIS, PyWake and Vind AI used in this study:
  - FLORIS: FLOw Redirection and Induction in Steady State | Wind Research | NREL
  - Welcome to PyWake — PyWake 2.5.0 documentation (dtu.dk)
  - Home | Vind AI
- Description of the wake models Jensen, GCH and TurbOPark used in FLORIS:
  - Wake Models — FLORIS (nrel.github.io)
- Andersen, O. J., & Løvseth, J. (2006). The Frøya database and maritime boundary layer wind description. Marine Structures, 19(2-3), 173-192.

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