

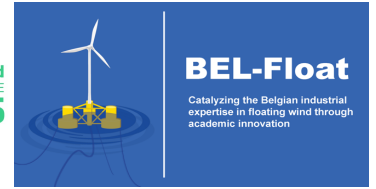
An assessment of the metocean conditions in the Belgian offshore zone: a comparison between reanalysis and in-situ data

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INTRODUCTION

Wind resource accounts for one of the conditions for energy production assessment [1]. This study is encompassed by three goals:

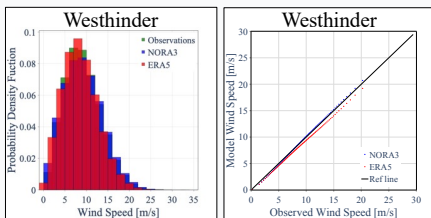
- To assess the accuracy of reanalysis data in the Belgian offshore zone by comparing NORA3 and ERA5 with in-situ measurements.
- To assess the impact of neighbouring wind farms on:
 - reanalysis model accuracy.
 - resource estimation.

One of the in-situ measurements is the reconstructed wind field from a nacelle-mounted LiDAR (pictured on the right).

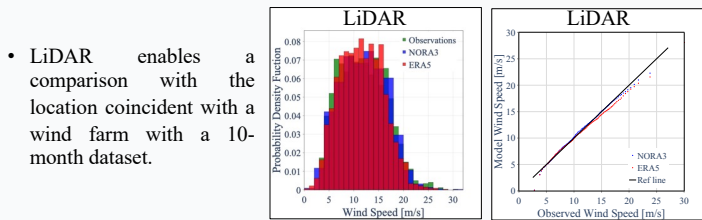


ACCURACY ASSESSMENT OF REANALYSIS DATA

- At both sites, reanalysis datasets - **ERA5** and **NORA3** - are evaluated against on-site measurements for accuracy and reliability.



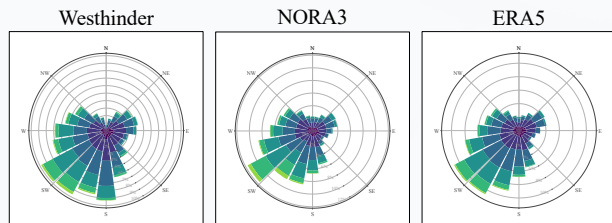
- Westhinder location has a 24-year dataset that enables long-term comparisons.



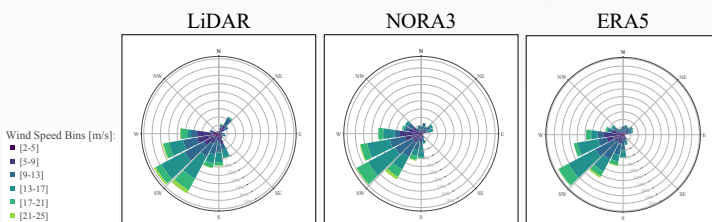
- LiDAR enables a comparison with the location coincident with a wind farm with a 10-month dataset.

SEASONAL ANALYSIS

- At Westhinder, NORA3 closely match measurement pile data:
 - Discrepancies no greater than $\pm 4.5\%$, with **-0.5% in Winter** (below)

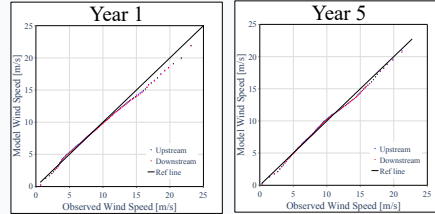


- At the LiDAR location, NORA3 is the reanalysis with better agreement:
 - Discrepancies no greater than $\pm 0.9\%$; with **0.21% in Winter** (below)



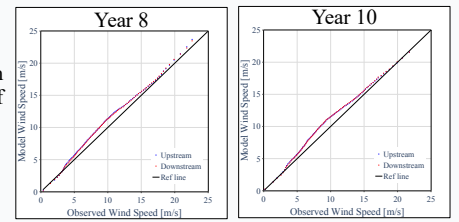
INFLUENCE OF NEIGHBOURING WIND FARMS

- Correlation between **SCADA** and **NORA3** over time, focusing on upstream and downstream conditions; Quantile plots reveal a decline in correlation after the new wind farm was added.



- Before the new wind farm introduction upstream of the analysed wind farm.

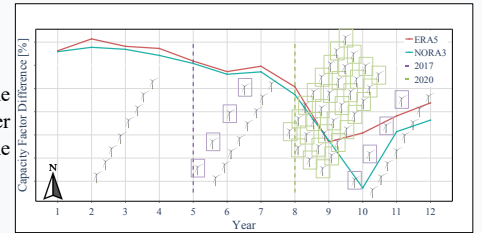
- After the new wind farm introduction upstream of the analysed wind farm.



- Introduction of new wind farm shows substantial effects in below-rated power conditions, highlighting the importance of external wake effects.

ACCURACY ASSESSMENT OF WIND RESOURCE

- Analysis of the differences between capacity factors calculated with SCADA and reanalysis data before and after the introduction of new wind farms upstream of the analysed wind farm; results exclusively from incoming wind of the wake dominant direction.



- Simplified representation of the evolution of the cluster of wind turbines in the region of this analysis.

- Introduction of a new wind farm in year 5 (purple dashed line) and another two farms from year 8 (green dashed line):
 - Post-2019, a sharp drop is observed in NORA3, which reaches a peak discrepancy of around 5x more estimated power in year 10 before improving.

CONCLUSIONS & FURTHER WORK

The current study can summarize three main conclusions:

- The consistency of ERA5 and NORA3 with measurement-based data highlights their reliability as tools for wind speed and direction assessment in the context of resource assessment studies [2].
- The correlation weakened after the new farm became operational, indicating reduced accuracy in the modelled wind speeds and potentially highlighting the impact of wake interactions [3]. This is expected to be due to important external wake effects.
- This is further shown with the capacity factor analysis, which emphasises the limitations of only reanalysis data for resource assessment without any correction. An update of correlations between reanalysis and field data is needed at changes in external wake effects or wakes to need to be explicitly modelled by means of physical models.

- For future work, it is relevant to investigate introducing corrections for the reanalysis data to be further reliable and robust for wind resource assessment.



[1] Lee, J. C., & Fields, M. J. (2020). *Wind Energy Science Discussions*, 2020, 1-82
 [2] Solbrekke, I. M., et al. (2021). *Wind Energy Science*, 6(6), 1501-1519.
 [3] Gualtieri, G. (2022). *Renewable and Sustainable Energy Reviews*, 167, 112741

