Wind Field Reconstruction from Data of Floating LiDARs
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Background

Currently, the worldwide installed capacity of offshore wind turbines is 64.3 GW (less than 10% of the total installed wind energy capacity) and it is expected to greatly expand, reaching 447 GW over the next decade [1]. According to GWEC, in the total offshore wind capacity, the Floating Offshore Wind Turbines (FOWTs) contribution forecast is only 10.9 GW in 2030. This is because this technology is still in its infancy and has a relatively high LCOE. Thus, reducing the costs involved in the installation of FOWTs is central for the sector.

Measuring wind resource and wind field characteristics (wind speed, shear, turbulence) is crucial for site assessment in the placement of wind turbines and prediction of loads and performance. It also represents a considerable part of a project capital cost. This is why wind turbine operators should investigate methods to precisely measure the wind at a low cost. For this reason, LiDARs are an interesting technology considering that their installation cost is usually ten times lower than traditional fixed met masts [2]. An illustration of how nacelle-mounted LiDARs scan the incoming wind field can be found in Figure 1. The problem for the floating wind energy field is that, when these LiDARs are installed on floating platforms, a significant uncertainty is induced by the motion of the instrument, particularly for turbulence measurements [3]. The purpose of this Master Thesis project is to derive a method to correct the LiDAR measurement to reduce the bias caused by the moving platform.

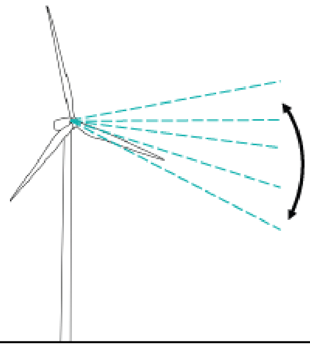

Figure 1 – Nacelle-mounted LiDAR setup and vertical profiling [4]

Objectives

My first objective will be to develop an algorithm to correct the LiDAR measurements. For instance, the wind velocity measurement is biased by the velocity of the instrument itself and the algorithm should account for that. For this, the mathematical relation between the measured Line-Of-Sight Velocity (Vlos), the wind velocity at the focus point of the LiDAR, and the LiDAR velocity will be established. As a first approximation, a point-wise approach will be used but an optional objective is to obtain a better calculation of the Vlos integral over the LiDAR measurement volume.

Then, from the corrected Vlos values, the wind field can be reconstructed. The second objective of the thesis is to test and validate the reconstruction of the wind field using prescribed/known wind fields. If time allows, the last aim of this study will be to use real data from the LiDARs on a TetraSpar floating platform in the North Sea to finally validate the model. This concrete application of the model can lead in the end to an actual power curve and load prediction.

References

[1] Global Wind Energy Council, *Global Offshore Wind report 2023*. URL: https://gwec.net/gwecs-global-offshore-wind-report-2023/

[2] Netherlands Enterprise Agency, *Assessment wind measurement program north sea*. 2014. URL: https://offshorewind.rvo.nl/file/download/31040402/Assessment+Wind+Measurement+Program+North+Sea+-+DNV-GL

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[3] Cool, G.A., *Floating LiDAR Technology: Oceanographic parameters influencing accuracy of wind vector reconstruction*. 2016. URL: http://resolver.tudelft.nl/uuid:ab02439b-749b-400d-b113-adaf49e00134

[4] Pelle, M., *Flow structure detection using a numerical lidar measurement model*. 2022. URL: http://resolver.tudelft.nl/uuid:ab55d015-e3e2-4075-8397-8a88132f13bd