NIWE

FOWPI – COMPARISON BETWEEN LIDAR AND VORTEX DATA

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ADDRESS COWI A/S
Parallelvej 2
2800 Kongens Lyngby
Denmark

TEL +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.com

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1 Introduction

This note includes the results of a preliminary comparison between the Vortex hindcast data used for the initial FOWPI wind resource calculations and readily available wind data measured by the platform mounted offshore LiDAR at the vicinity of FOWPI site.

The LiDAR has been installed by Meteopole, under the FOWIND consortium, and it is noted that this report assumes that the installation and operation of the LiDAR, as well as handling of the LiDAR data, is according to best practice. At this stage COWI has not evaluated the data quality, besides visual inspection of the time series. Further evaluation is to be carried upon provision of quality documents such as installation, maintenance and data handling reports.

2 Executive Summary

A comparison between the VORTEX mesoscale data, used as basis for the initial FOWPI wind study, and the measurements from the offshore LiDAR installed in Zone B Gujarat has been made for the concurrent period from 23 January 2018 to 30 June 2018. The Vortex data was extracted at the same position as the LiDAR.

Based on the comparison it is seen that the Vortex data follows the same monthly variation as measured by the LiDAR however, the monthly mean wind speeds based on the Vortex data are generally lower than measured by the LiDAR. During the low wind months, the difference is larger than during the high wind months.

The Vortex data under-predicts the average wind speed by respectively 12.5% and 14.6% at 100 m and at 80 m AMSL compared with the average wind speed measured by the LiDAR during the considered period 23 January 2018 to 30 June 2018. This corresponds to a long-term average wind speed increase from 7.1 m/s to 8.0 m/s, at 100 m Above Sea Level (ASL).

With a wind speed to AEP sensitivity (dAEP/dWS %) of approx. 1.7, calculated based on a Vestas V136 4.2 MW and the estimated long-term wind distribution (see ref. 1), at the position of the LiDAR and Vortex data, the wind speed prediction by the Vortex data corresponds to an under-prediction of the AEP of approx. 21-25% in 100 m and 80 m respectively.

Furthermore, it is also found that there is a wind veer of approximately 20 degrees between the modelled Vortex data and the LiDAR measurements. This wind veer is also present when comparing with other reanalysis data sources such as MERRA2, CFSR and ERA5. It is recommended to verify the wind direction measured by the LiDAR e.g. by quality check of ongoing campaign and/or comparison with available nearby measurements.

3 LiDAR Data

At present, the wind data measured by the LiDAR has been made available from 1 November 2017 to 30 June 2018. Wind speed and wind direction are measured at the following heights:

LiDAR Measuring Heights [m]											
40	60	70	80	87	100	107	120	140	160	180	200

Table 3-1 LiDAR measuring heights

Furthermore, atmospheric pressure and relative humidity are measured as well.

The recovery of the LiDAR data has been low during the first period of the measuring campaign as shown in Table 3-2 below, presenting the number of 10 min data sets obtained within each day (N.B. 144 corresponds to 100%). Therefore, only LiDAR data from 23 January 2018 has been considered in the presented analyses. COWI is also informed that data is lacking from 24 July 2018 to 10 September 2018.

Day	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018
1	141	132	144	144	144	144	144	144
2	144	0	1	143	144	144	144	144
3	144	0	88	144	144	144	144	139
4	144	0	1	144	144	144	144	144
5	144	0	70	144	144	144	144	144
6	141	0	72	144	144	144	141	144
7	0	63	73	144	144	144	144	144
8	72	144	72	144	82	144	144	144
9	141	37	1	144	75	144	144	144
10	98	0	85	144	144	144	144	143
11	66	75	1	144	144	144	144	143
12	20	50	79	144	140	144	144	144
13	0	144	1	144	140	144	144	144
14	88	1	73	144	138	139	144	144
15	144	87	67	144	144	144	144	144
16	144	144	73	144	144	144	144	144
17	144	1	75	144	144	144	144	143
18	41	0	77	144	144	144	144	144
19	0	0	79	144	144	144	144	144
20	90	0	77	144	144	144	144	144
21	144	87	76	144	144	144	144	144
22	144	144	45	144	144	144	144	144
23	144	1	144	144	144	144	144	138
24	24	83	144	144	144	144	144	112
25	79	144	144	144	144	144	144	122
26	144	1	144	144	144	144	144	144
27	144	0	144	144	144	144	144	144
28	7	85	144	144	136	141	144	139
29	71	144	144		144	144	144	144
30	144	1	144		144	144	144	144
31		84	144		144		143	
Recovery	**68.3**	**37**	**58.8**	**100**	**96.6**	**99.8**	**99.9**	**98.3**

Table 3-2 Recovery of LiDAR data (100 m)

4 Vortex Data

For the initial wind study, a 20 years VORTEX time series (virtual mast) representing the wind at respectively 80 m and 100 m AMSL at the same position as the LiDAR has been applied covering the period:

- Vortex wind data period: 01 August 1997 to 31 July 2017

For this comparison, concurrent Vortex and LiDAR time series data up to 30 June 2018 has been analysed.

For more details regarding the Vortex data, see ref. 1.

5 Comparison of LiDAR and Vortex data

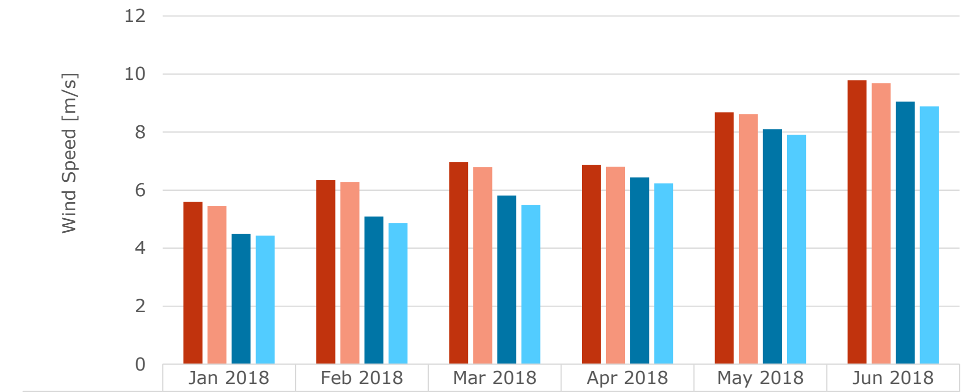
For the comparison between the LiDAR and the Vortex data, only data covering the following period has been included for both data sets:

- Comparison period: 23 January 2018 to 30 June 2018

The comparison period partially covers months from both the low and high wind season. Although a longer period of data would certainly be valuable for the analysis, it is assessed that the available data can contribute to the assessment of the validity of the Vortex data.

5.1 Wind Speed

Figure 5-1 shows the monthly mean wind speeds based on respectively the LiDAR and the Vortex data.



	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018
Lidar 100m	5.60	6.36	6.97	6.88	8.68	9.78
Lidar 80m	5.44	6.27	6.79	6.81	8.62	9.68
Vortex 100m	4.49	5.09	5.81	6.43	8.09	9.05
Vortex 80m	4.43	4.85	5.49	6.23	7.90	8.88

Figure 5-1 Monthly mean wind speed based on LiDAR and Vortex data. Note that Jan 2018 only covers 9 days of data.

It seen that the Vortex data follows the same monthly variation as measured by the LiDAR however, the monthly mean wind speeds based on the Vortex data are generally lower than measured by the LiDAR. During the low wind months, the difference is larger than during the high wind months.

Figure 5-2 shows the correlation between daily mean wind speeds based on respectively the LiDAR and the Vortex data. It is seen that the correlation coefficient, R^2 is 0.75, which is not a perfect correlation, though acceptable.

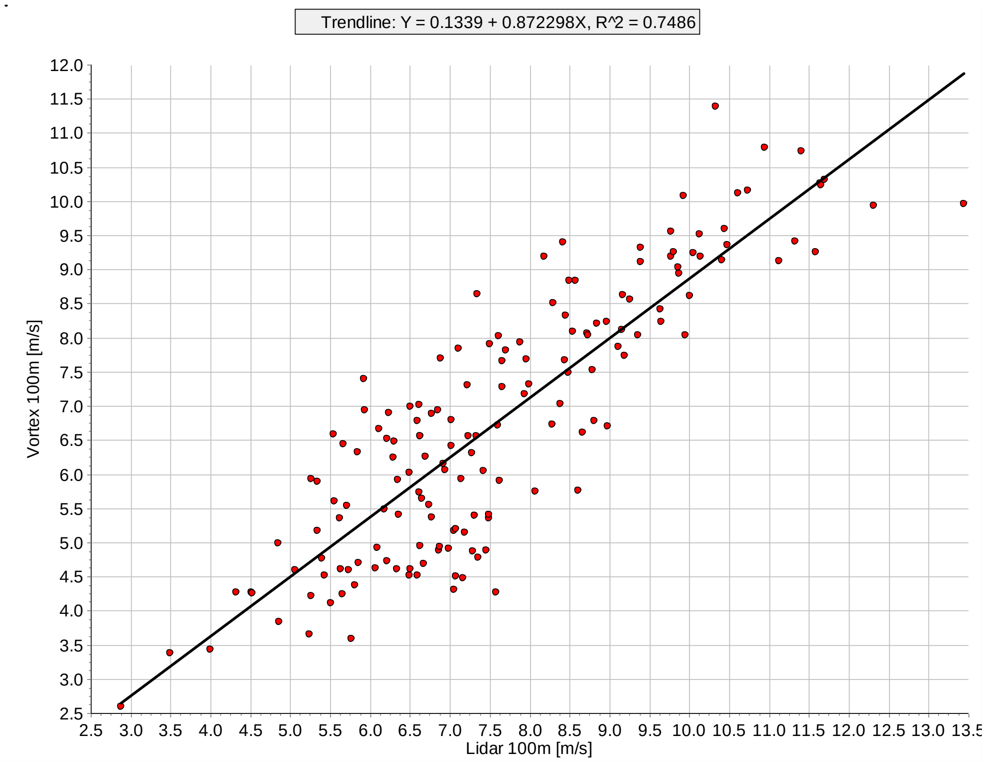


Figure 5-2 Correlation between daily mean wind speed based on Vortex and LiDAR data (100 m)

The average wind speeds for the considered period 23 January 2018 to 30 June 2018 based on respectively the LiDAR and the Vortex data are given by:

Height [m]	LiDAR [m/s]	Vortex [m/s]	Ratio LiDAR/Vortex
100	7.63	6.78	1.125
80	7.53	6.57	1.146

Table 5-1 Average wind speeds based on LiDAR and Vortex data during the period 23 January 2018 to 30 June 2018

It is seen that the Vortex data under-predicts the average wind speed by respectively 12.5% and 14.6% at 100 m and at 80 m ASL compared with the average wind speed measured by the LiDAR during the considered period 23 January 2018 to 30 June 2018.

With a wind speed to AEP sensitivity (dAEP/dWS %) of approx. 1.7, calculated based on a Vestas V136 4.2 MW and the estimated long-term wind distribution (see ref. 1), at the position of the LiDAR and Vortex data, the wind speed under-prediction by the Vortex data corresponds to an under-prediction of the AEP of approx. 21-25% in 100 m and 80 m respectively.

In ref. 1, the long-term Weibull mean wind speeds at respectively 100 m and 80 m ASL were, based on the Vortex data, estimated to:

- Mean wind speed at 100 m ASL (Vortex): 7.1 m/s
- Mean wind speed at 80 m ASL (Vortex): 6.9 m/s

Applying[1] the ratios between the LiDAR and Vortex average wind speeds in Table 5-1, the corrected long-term Weibull mean wind speeds at respectively 100 m and 80 m ASL become:

- Mean wind speed at 100 m ASL (LiDAR corrected): 8.0 m/s
- Mean wind speed at 80 m ASL (LiDAR corrected): 7.9 m/s

5.2 Wind direction

The wind direction distributions based on respectively the LiDAR and the Vortex data during the considered period 23 January 2018 to 30 June 2018 are shown in Figure 5-3.

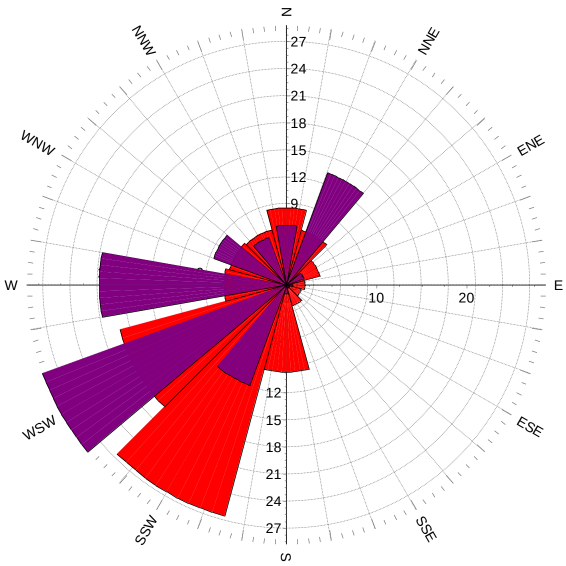


Figure 5-3 Wind roses (frequency), purple: Vortex and red: LiDAR (100 m)

[1] This is a simple approach. A more detailed MCP method must be applied upon completion of measurements and quality review of LiDAR installation, maintenance and data handling.

It is seen that the LiDAR data includes more wind in the SSW sector, and the difference between the Vortex and LiDAR wind directions corresponds to a wind veer of approximately -20 degrees.

The wind veer is also present when comparing the LiDAR data with reanalysis data sources such as MERRA2, CFSR and ERA5. It is recommended to verify the measured wind direction of the LiDAR e.g. by quality check of ongoing campaign and/or comparison with available nearby measurements.

6 References

1 COWI, FOWPI – Wind Turbine, Layout and AEP. Version 1, September 2018.