PO.080

Evaluation on the vertical difference of wind field by wind shear and REWS using Nacelle-Mounted Lidar

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Abstract

NML (Nacelle-Mounted Lidar) is a natural and cost-efficient solution of wind measurement for wind turbines, due to the easy deployment and the accurate wind measurement. Currently, NML are widely uses for multiple applications, such as, Power Performance Testing (PPT), Lidar-Assist Control (LAC), and offshore floating turbine[1,2].

Wind shear is one of the key parameters in many applications to know the vertical information of wind field. Currently, HHWS (wind speed at hub height) is mainly used for **PPM** (Power Performance Measurement). For an accurate and thorough PPM, **REWS** (Rotor Equivalent Wind Speed) is recommended and defined by IEC standard[1].

In this study, the wind shear and REWS by NML (Nacelle-Mounted Lidar) is evaluated and the benefits of REWS for PPM has been studied.

Measurement

Measurements are taken at wind farm in flat terrain using WindCube Nacelle (formerly named Wind Iris), installed on the nacelle of 2.7 MW wind turbine. One GBL (Ground-Based Lidar) are located at 290m in front of wind turbine to vertically measure: (1)hub height wind speed (HHWS at 89m); (2)wind shear; (3)REWS. The wind sector from 140° to 210° fulfils the IEC requirement for the typical PPT test for a better measurement efficiency due the wind direction.

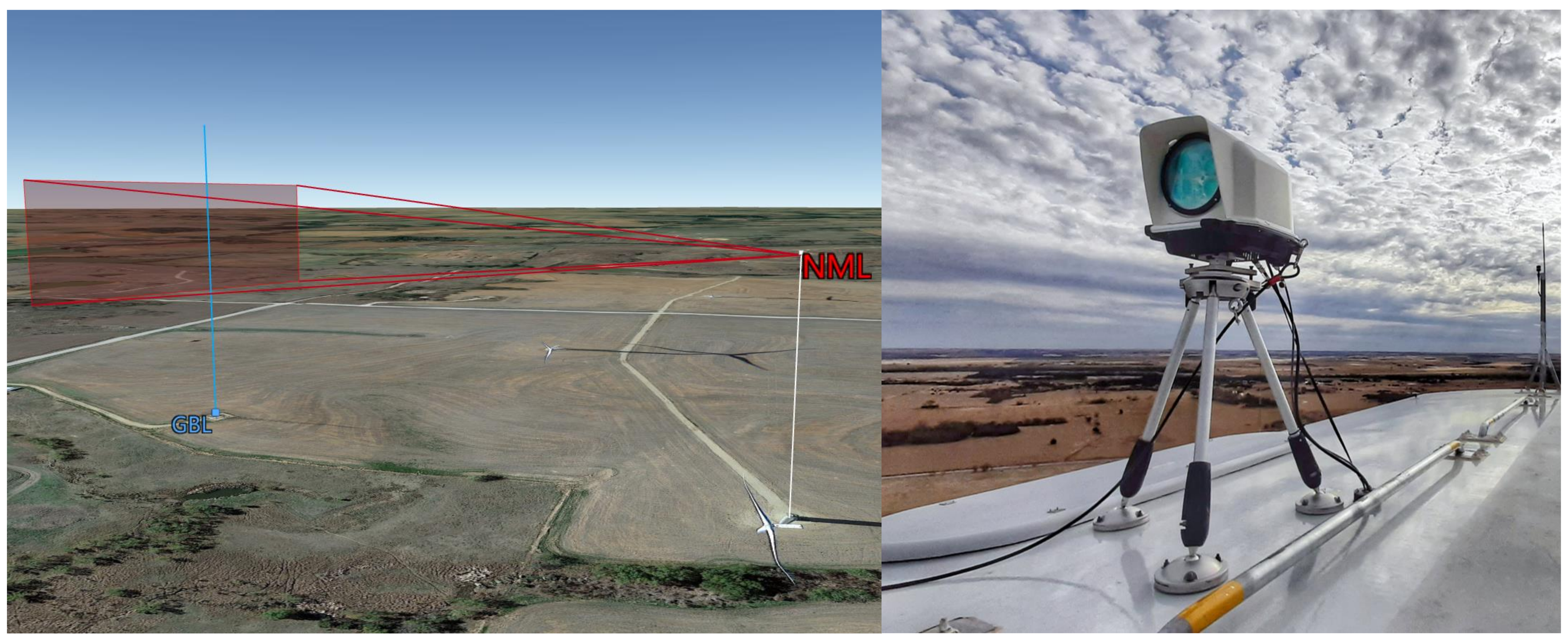

Fig.1 Measurement setup: (a) location; (b) NML installation Photo

Method: IEC definition of the REWS

As stated in the second edition of the standard[1] : “The rotor equivalent wind speed is the wind speed corresponding to the kinetic energy flux through the swept rotor area, when accounting for the vertical wind shear. Where the wind speed for at least three measurement heights are available, the rotor equivalent wind speed is defined as:

$$v_{eq} = \left(\sum_{i=1}^{n_h} v_i^3 \frac{A_i}{A}\right)^{1/3}$$

Where, n_h is the number of available measurement heights ($n_h \geq 3$); v_i is the wind speed measured at height i; A is the complete area swept by the rotor; A_i is the area of the i^{th} segment.

An algorithm was developed to fulfill this recommendation. The calculation at a given range gate uses the HWS within a configurable volume around this gate. This method is demonstrated by the below figures [3].

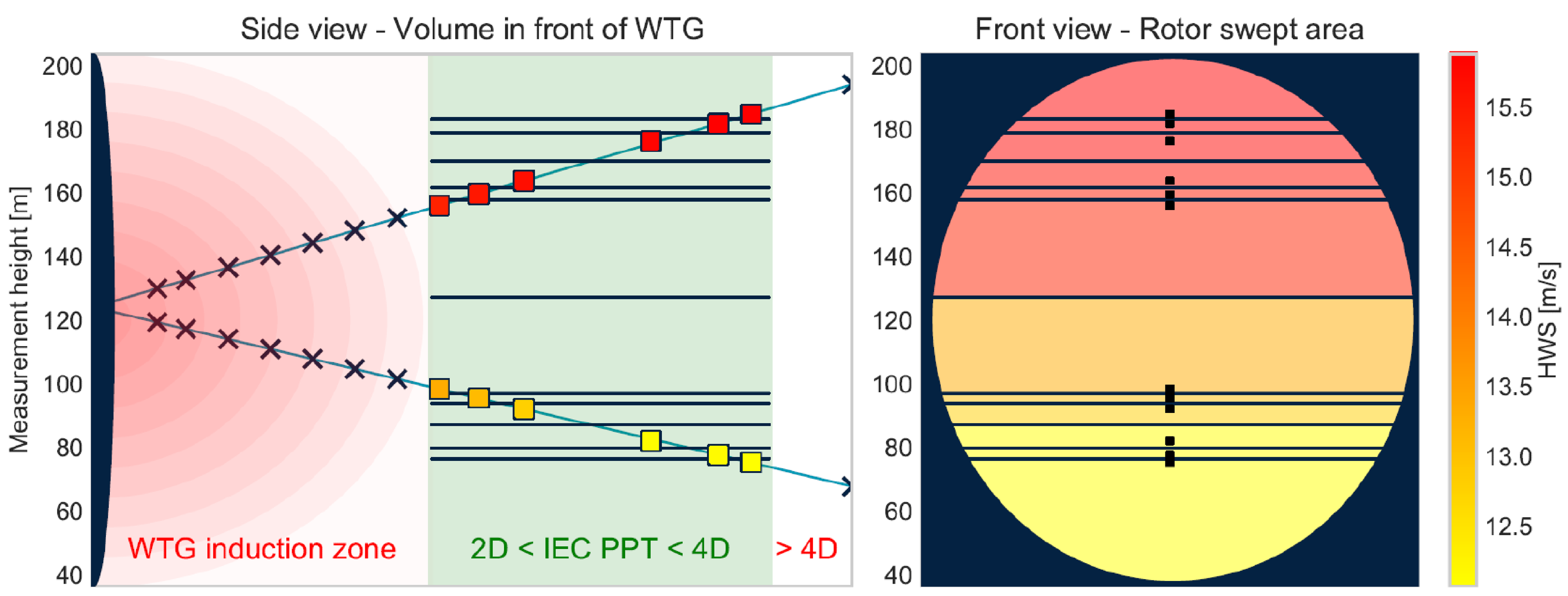

Fig.2 schematic diagram: (a) side view; (b) front view

Result(1): REWS and Wind Shear

The wind measurement by the NML is evaluated by the GBL. Fig.3 shows the good measurement accuracy for both devices.

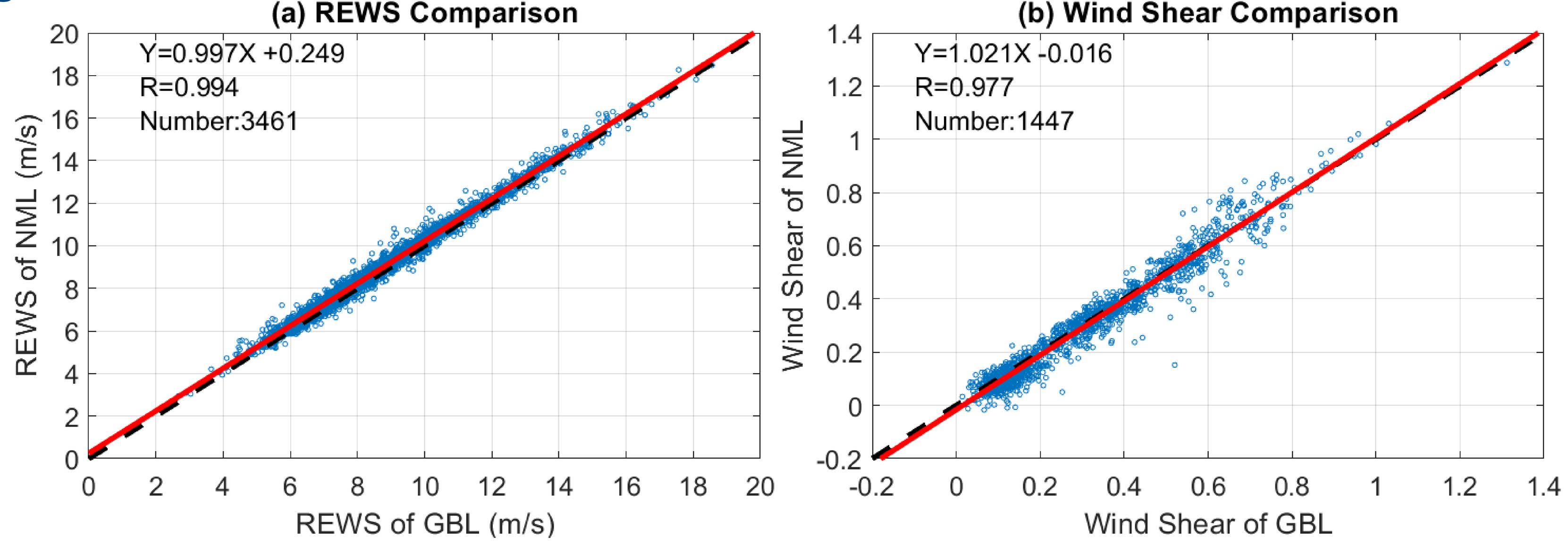

Fig.3 Wind measurement comparison: (a) REWS; (b) wind shear

Result(2): Power Performance Measurements

Fig.4 are the PPM by GBL and NML: the top figures are the results by GBL and the bottom figures are by NML. From Fig(a) to Fig(d), the scatter points become more concentrated, which indicates that the uncertainty of PPM becomes smaller.

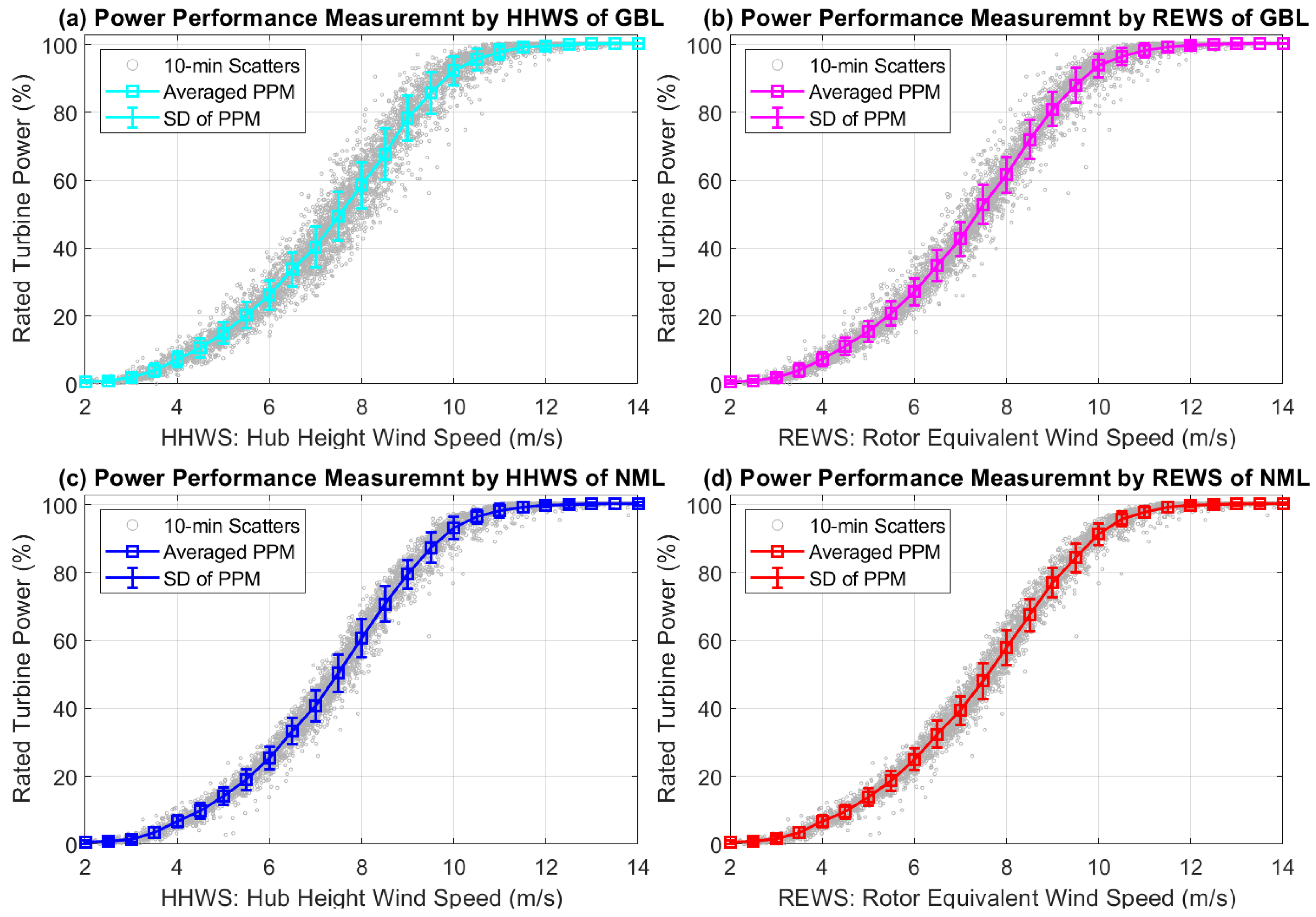

Fig.4 PPM (Power Performance Measurement) by Met Mast and NML

Fig.5 compares the results in Fig.4 and the line colors are compatible. Fig.5(b) is the differences to PPM by HHWS by Met Mast. The red line (from NML REWS) has the lowest uncertainty with concentration for 10-min scatters.

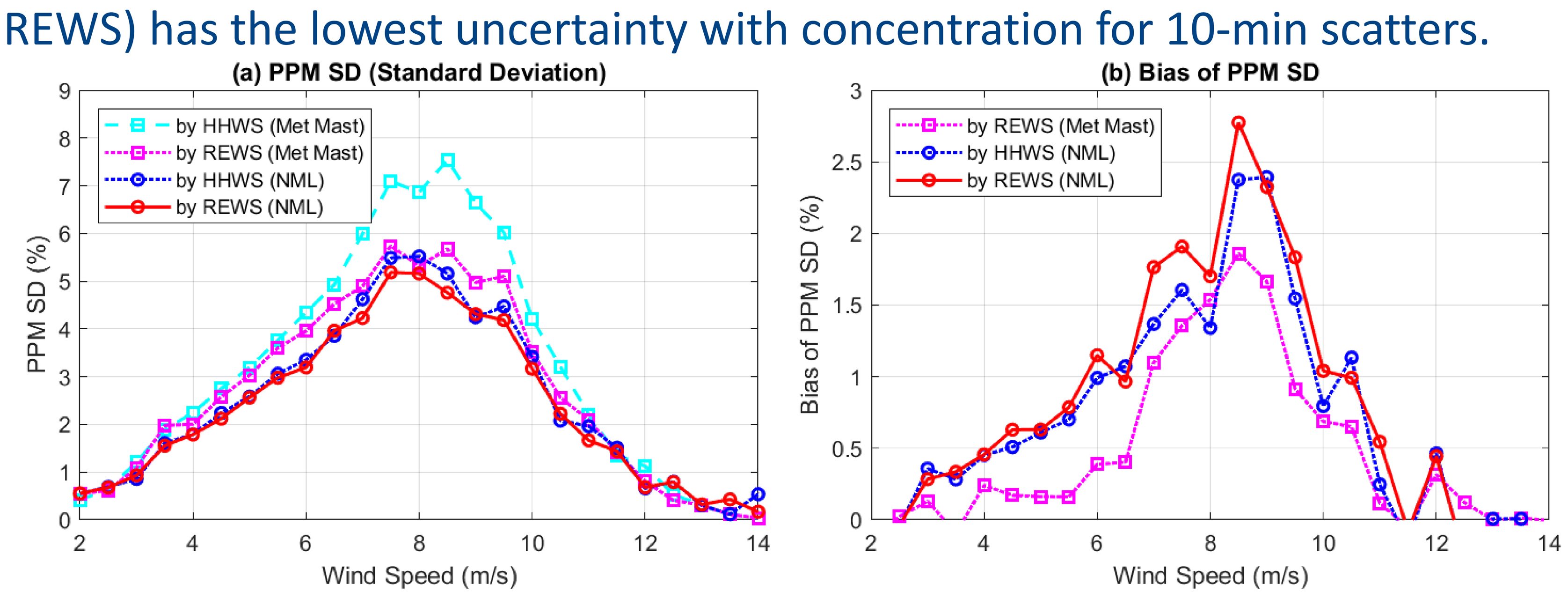

Fig.5 The comparison of PPM: (a) SD of PPM in Fig.4; (b) Differences to HHWS by Met Mast

Conclusions

This study shows the good accuracy for wind shear measurement and the high benefit of REWS for PPM.

1) The wind shear measurement by NML is accurate.
2) The REWS can reduce the uncertainty of PPM for GBL and NML.
3) PPM by REWS of NML has the lowest uncertainty, which shows the good potential application for the evaluation of the turbine power performance.

References

1. IEC 61400-12-1: Power Performance Measurements of Electricity Producing Wind Turbines, 2017
2. IEC 61400-50-3: Use of nacelle-mounted lidars for wind measurements, 2022
3. J Tissot. IEC REWS calculation with 4–beam nacelle lidar, WindTech2020, IEC-REWS-Calc-4Beam-Nacelle-Lidar (vaisala.com)