PO.263

Retrieving wind speed at constant height above ground level in complex terrain with a Wind Iris 4-beam nacelle Lidar

P. Mazoyer, M. Boquet
Leosphere

Introduction

Using nacelle Lidars to verify and improve turbine performance is an increasingly common practice in the industry. The new Wind Iris 4-beam offers extended measurement capacity compared to the previous 2-beam version, allowing for 3 heights for each of the 10 measuring distances: top height, bottom height and a user selectable height (typically hub-height) between the two pairs of beams.

Principles of the Wind Iris 4-beam reconstruction are presented here, as well as a validation of a method developed by DNV-GL ([2]) to further tackle complex terrain challenges using orography information.

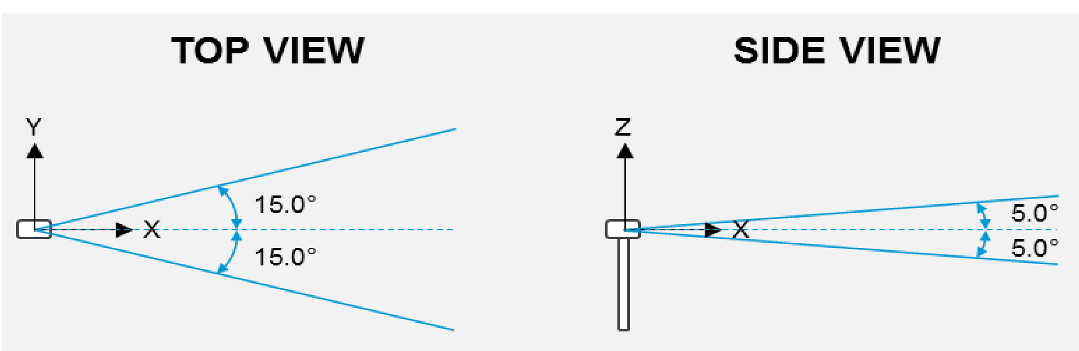


Figure 1: 4-beam Wind Iris beam configuration

Figure 2: A set up of Wind Iris

Standard wind reconstruction

Reconstruction is first made at bottom (Href1) and top (Href2) heights using the corresponding pair of beams and the proven reconstruction of the Wind Iris 2-beam. At each distance and for each height (bottom and top), wind speed, direction and turbulence intensity are measured.

Then, the Wind Iris 4-beam automatically retrieves wind for any height defined by the user (Huser) between the 2 measurement points, using real time onboard inclinometer information and the following assumptions:

- Huser Wind speed follows a power law profile (PLP)
- Huser Wind direction follows a linear profile
- Huser TI follows a log profile

This strategy ensures that Huser, generally Hub-height, is at a constant absolute height ahead of the turbine.

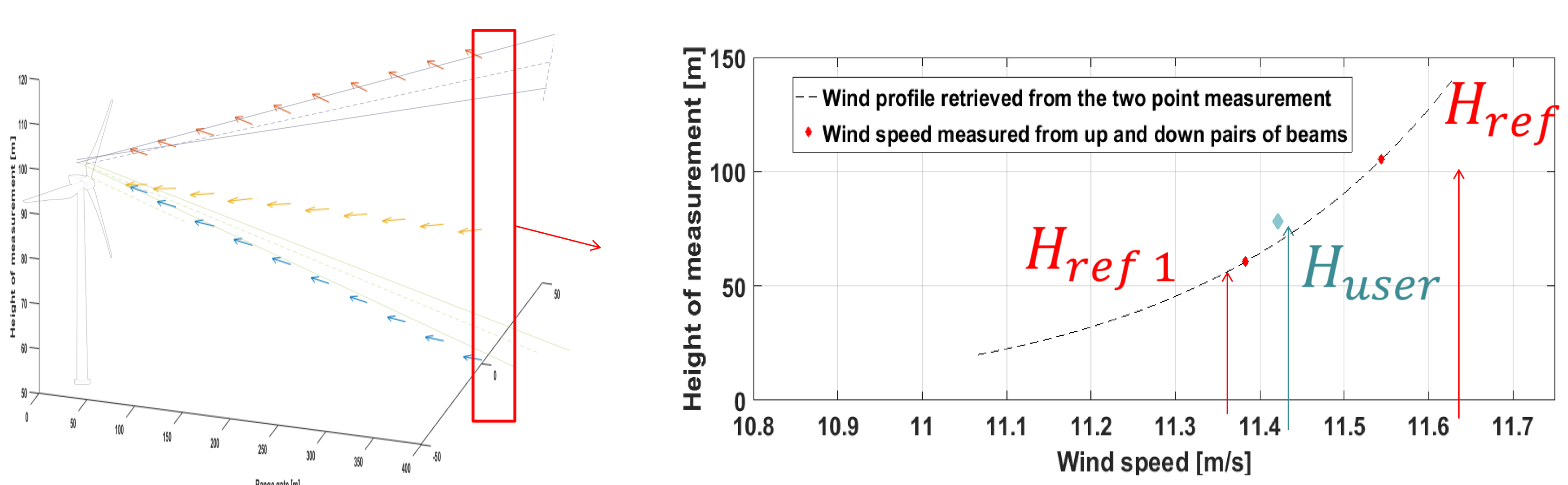
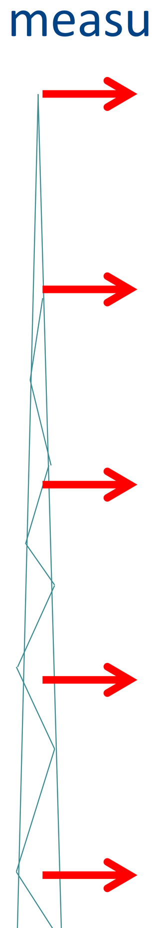


Figure 3 : Wind measurement example

Validation results in simple terrain

A 5-cups mast was used to compare extrapolated wind speed to measurements to challenge the PLP assumption:



- Figure 4 shows a profile of cup measurement with corresponding extrapolated wind speed profile: **profiles are very close to wind speed measurements.**
- Over three months of measurement mean deviation **due to extrapolation is maximum 0.1 m/s (see figure 5) confirming the log profile assumption**

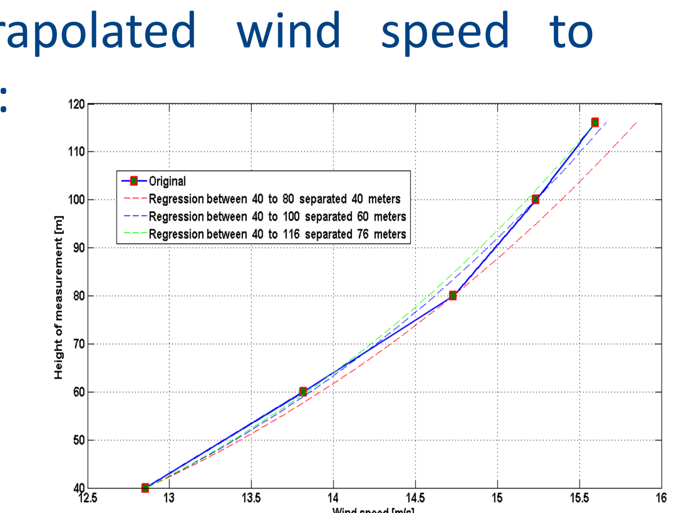


Figure 4 : wind speed profile

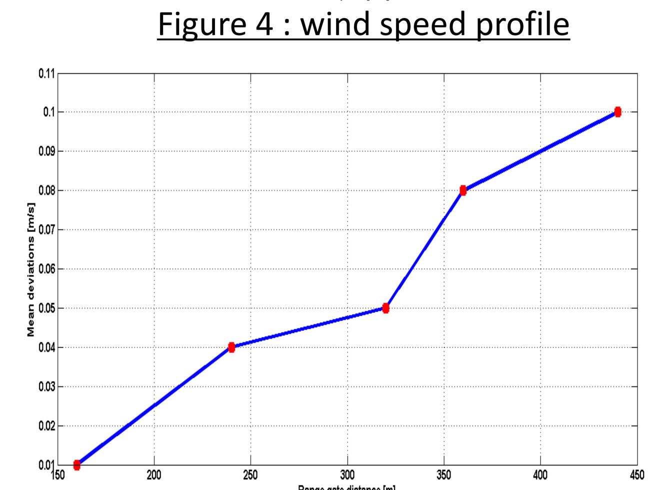


Figure 5 : mean deviations

This standard wind reconstruction is observed to provide accurate and precise measurement in accordance with industrial requirements ([3]). Low altitude variation assumption is broken in highly complex terrain and reconstruction requires terrain information to achieve equivalent accuracy and precision.

Complex terrain wind reconstruction

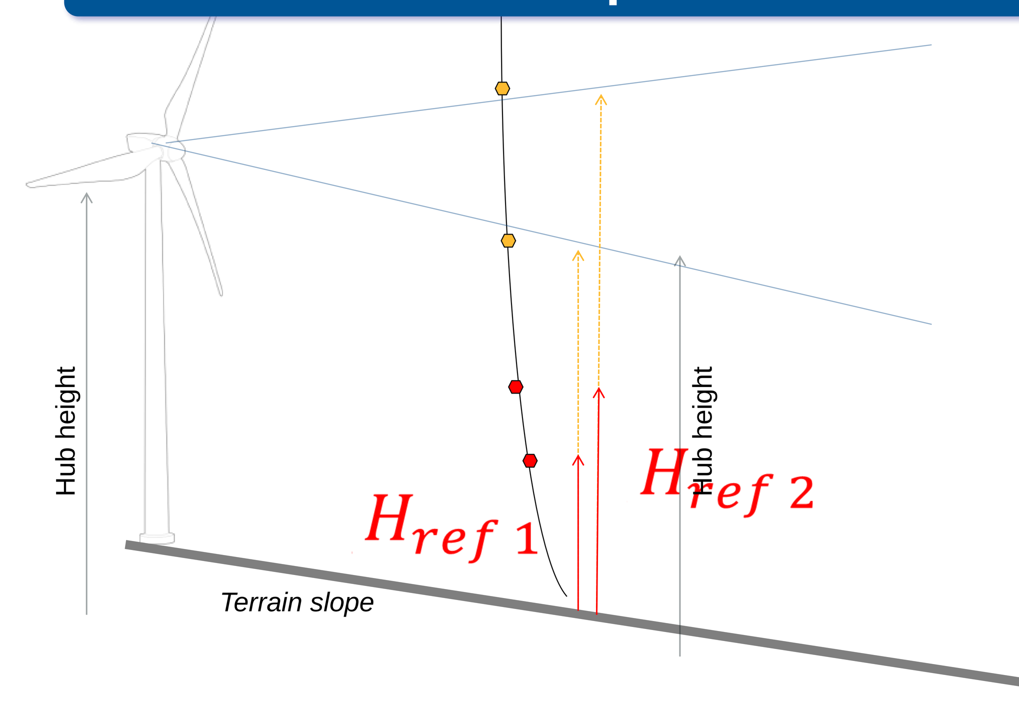
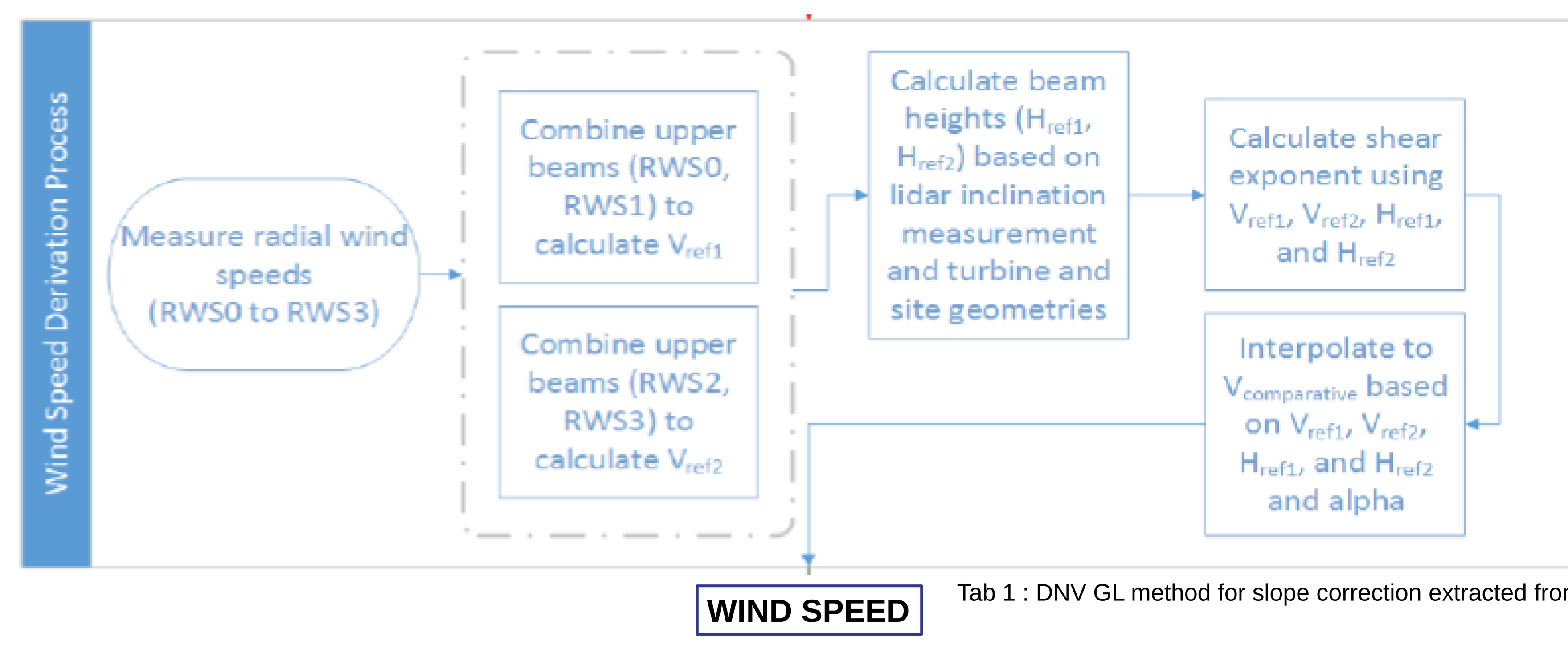


Figure 6 : Wind measurement example

In complex terrain, for standard wind reconstruction, a bias can appear in case of significant slopes. Indeed the heights at which the algorithm reconstructs (red height) do not match real heights above ground level.

This can lead to an overestimation or underestimation of the wind speed depending on terrain slope.

DNV-GL developed a method ([2]) based on standard wind reconstruction principles which computes the height of measurement for each location of measurement and the permits to better retrieve the wind speed :



Tab 1 : DNV GL method for slope correction extracted from [2]

Validation: a 4-beam Wind Iris measured in a moderately complex in France. Steep slopes are present in the South (see *figure 8*); Leosphere applied the above method and compared to standard wind speed reconstruction. Using slope correction method gives higher wind speed measurement for positive slope and lower wind speed for negative slope: **on real data, corrections behaves as expected (see figure 9).** Power curve is computed from both standard and slope corrected wind measurement and a significant change is observed **(see figure 10).**

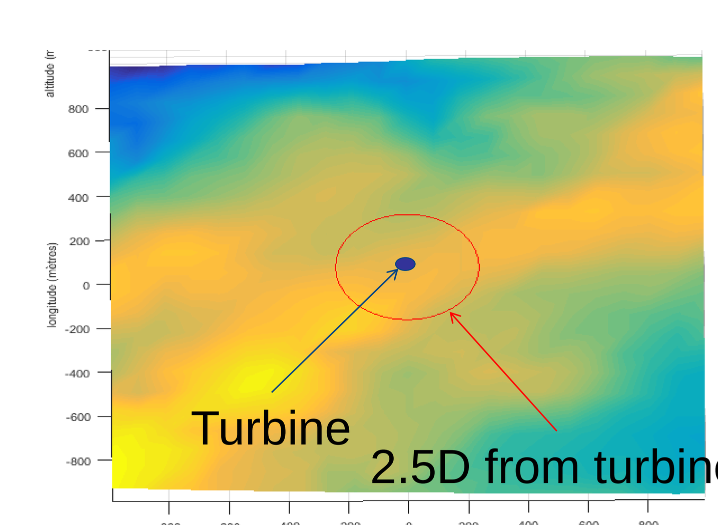


Figure 8 : Map of wind farm elevation

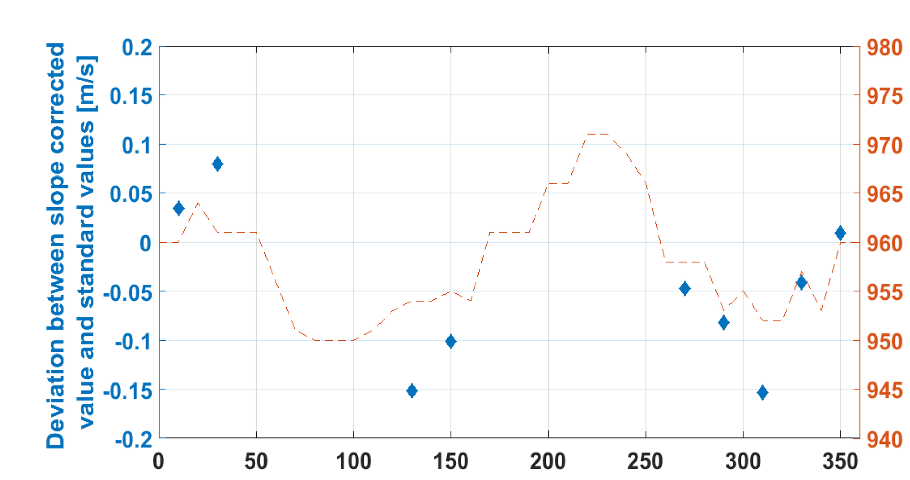


Figure 9: Deviation between slope-corrected wind speed and standard according to wind sectors

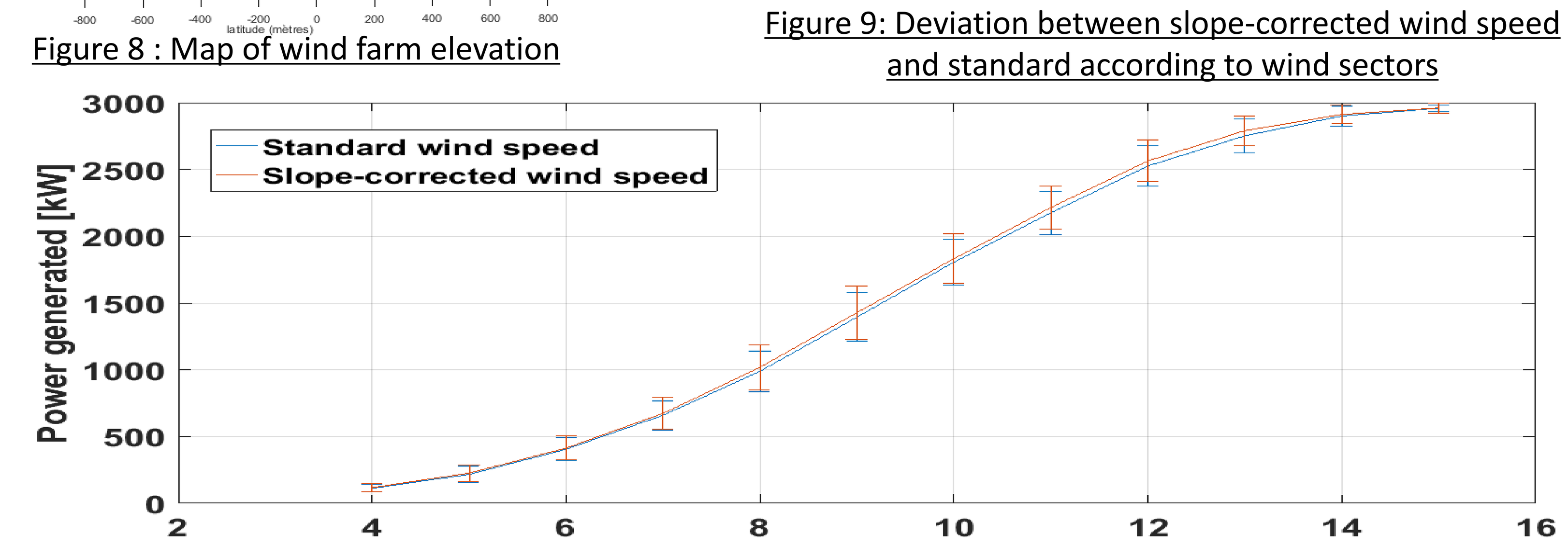


Figure 10: Power curve for standard wind speed and slode-corrected wind speed

Conclusion

- ✓ The standard wind reconstruction, embedded in the system, is accurate and precise in simple and moderately complex terrain
- ✓ As tilt is automatically taken into account, it removes the need for a precise pre-tilt at installation, simplifying further operations
- ✓ Uncertainty increases with terrain complexity, and correcting for slopes following DNV GL ([2]) method described in this poster is observed to provide accurate and precise wind measurements
- ✓ Leosphere can provide support to easily apply this advanced method

Reference

1. What makes a nacelle mounted lidar a suitable tool for power performance measurement, Rozen Wagner, DTU, EWEA 2014.
2. 3D Nacelle Mounted Lidar in Complex Terrain, Paul Lawson, DNV GL, Power Curve Working Group 2015
3. Metrological validation and operational assessment of a new 4-beam nacelle mounted lidar, Paul Mazoyer, Leosphere, EWEA TW 2016

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