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Windshear and Windveer Characterization for Resource Assessment Improvement

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Abstract

As rotor size increases, wind speed and wind direction measurements obtained at a single point are no longer representative of wind conditions in the whole area swept by the rotor.

Nowadays, windshear is calculated from wind speed measurements at two points located at different heights (usually hub height and lower blade-tip height) leading to errors in the wind speed characterization above hub height. On the other hand, windveer is rarely considered.

This work proposes new methods for characterizing windshear and windveer and analyses the benefits of using those in the resource assessment stage.

Objectives

- Understand constraints of current methods of characterizing windshear and windveer.
- Learn new methods for the characterization of windshear and windveer, its pros and cons with regards to current ones.
- Select the appropriate method or combination of methods according to the application.
- Improve resource assessment and wind farm design accounting for windshear and windveer.

Methods

Based on LiDAR measurements, new parameters are defined to better characterize windshear and windveer

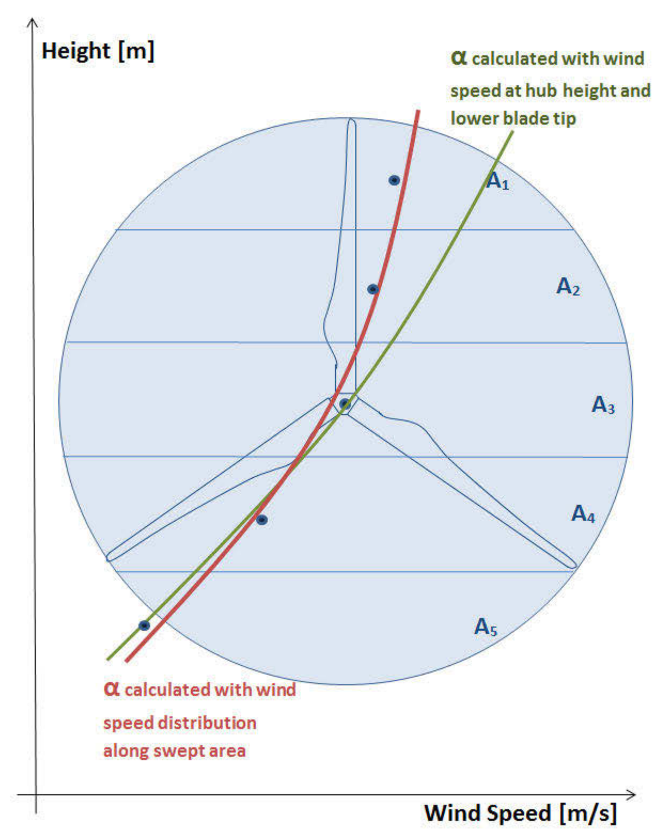
Wind Shear

Two new parameters are proposed for Wind Shear:

$$REWS_{norm} = \frac{REWS}{v_{hub\ height}} = \frac{\left(\sum_{i=1}^{n} v_i^{3} \cdot \frac{A_i}{A}\right)^{1/3}}{v_{hh}}$$

REWS: Rotor Equivalent Wind Speed

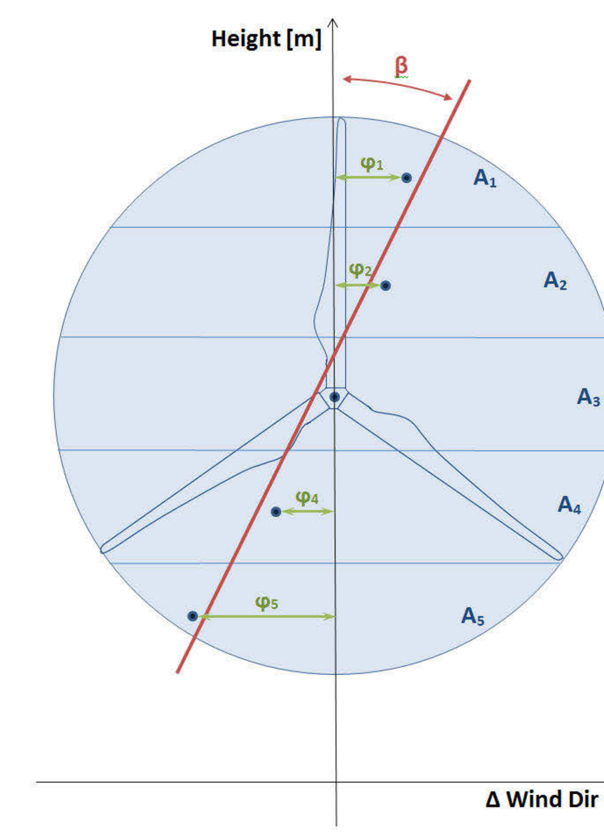
Assuming a power law shear profile, the shear exponent (α) is calculated by linear regression considering the wind speed distribution along the full rotor swept area.



$$v = v_{hh} \cdot \left(\frac{h}{h_{hh}}\right)^{\propto}$$

Wind Veer

Three parameters are defined for Wind Veer:



$$REWS_{ratio} = \frac{REWS_{Veer}}{REWS} = \frac{\left(\sum_{i=1}^{n} (v_i \cdot cos(\varphi_i))^{3} . \frac{A_i}{A}\right)^{1/3}}{\left(\sum_{i=1}^{n} v_i^{3} . \frac{A_i}{A}\right)^{1/3}}$$

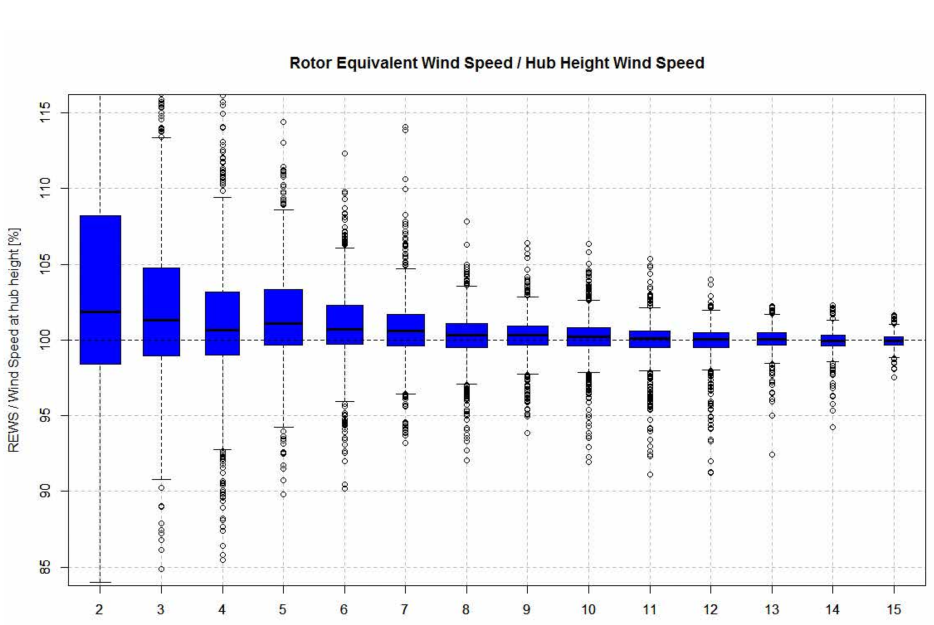
β = *Slope of linear regression of the points (Δdir,h)*

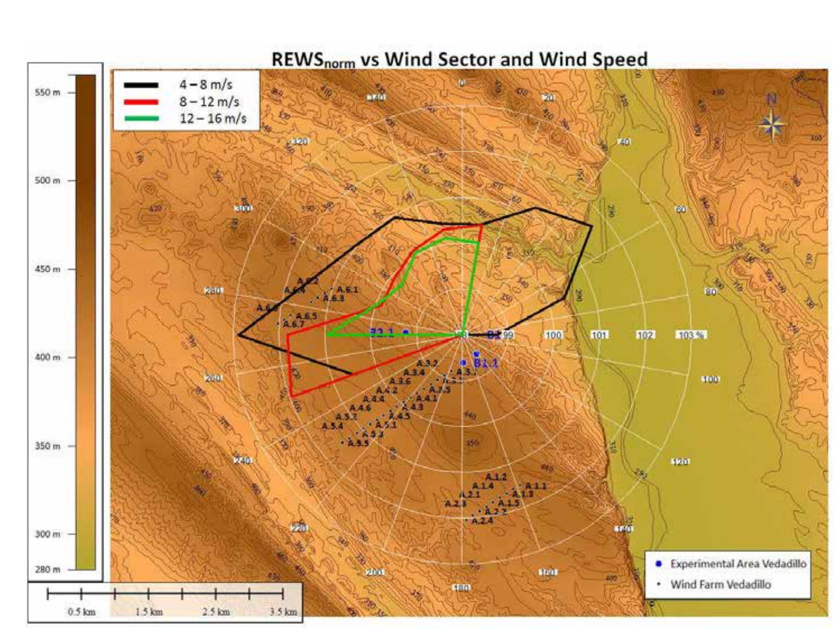
$$MeanDev = \frac{\sum_{i=1}^{n} |\varphi_i|}{n}$$

Results

Wind Shear

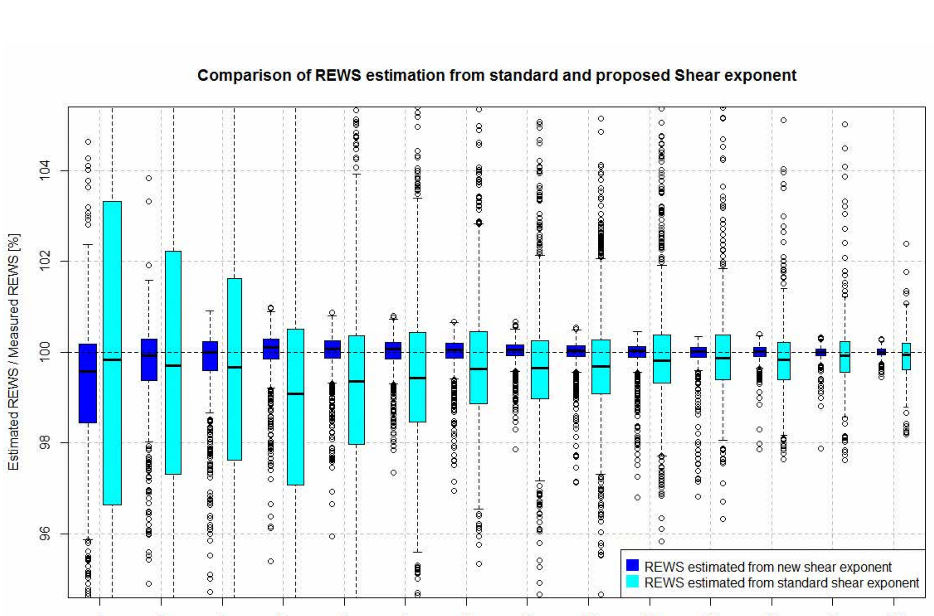
The parameter ***REWS$_{norm}$*** provides useful information of the impact of wind shear on the available wind power and how it depends on several factors such as wind speed, wind sector, day/night, …

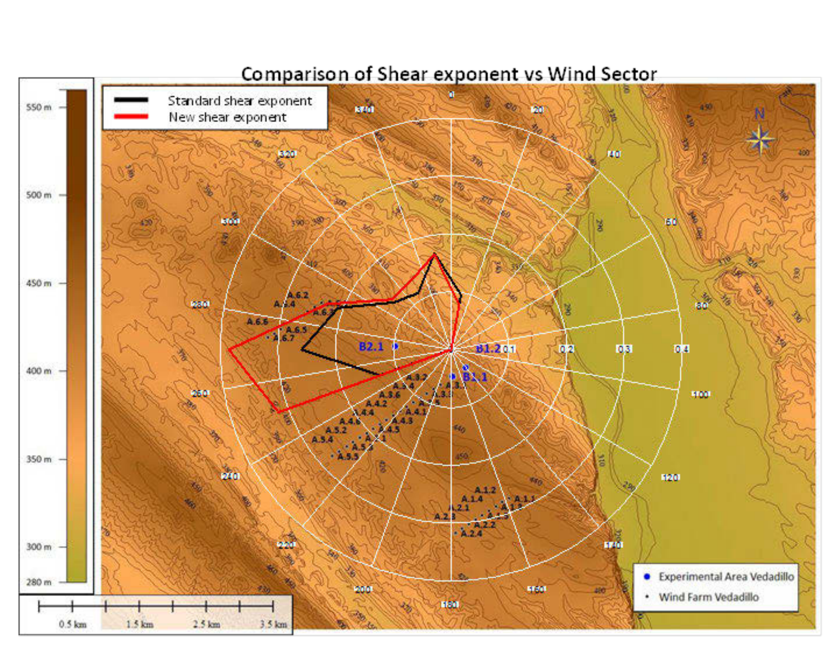




Nevertheless, ***REWS$_{norm}$*** does not provide information of wind speed variation with height and it is dependent on hub height, rotor size and wind speed.

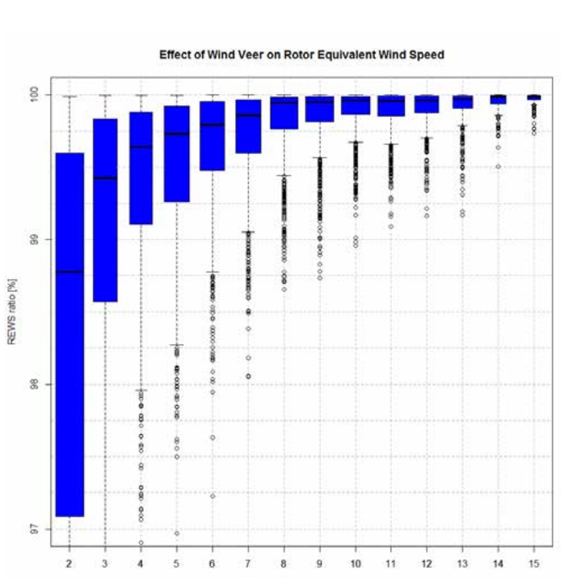
For characterizing wind shear at a site, the shear exponent α is more appropriate, but α calculated from wind speed at hub height and lower blade-tip leads to important misestimations above hub height. The proposed method for calculating α shows estimations much closer to measured values.

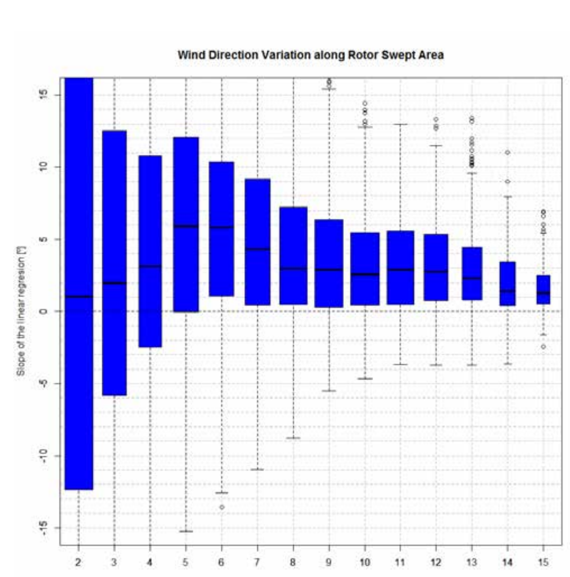


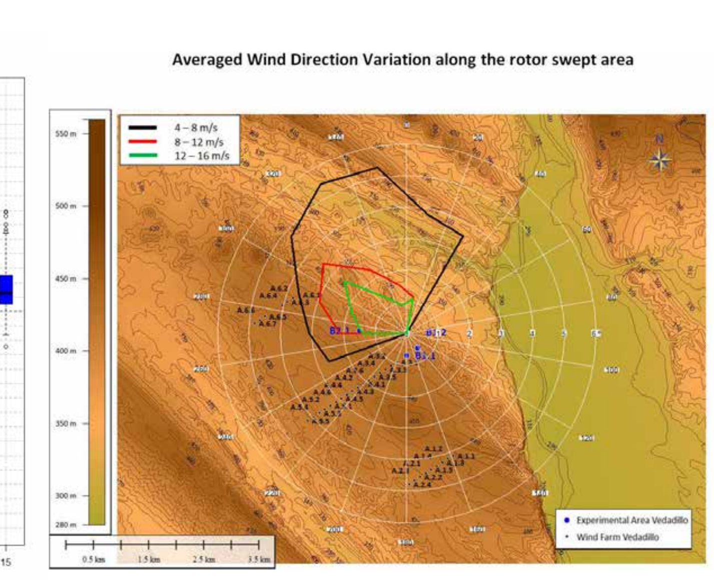


Wind Veer

Each of the parameters introduced for wind veer provides important information about wind direction variation with height and the impact it has on available wind power.







REWS$_{ratio}$ provides information about the impact of wind veer on available wind power.

β provides information about the orientation and distribution of the wind direction variation.

MeanDev gives an idea of the average variation (important for wind Turbine performance)

Conclusions

Accurate characterization of windshear and windveer is of growing importance for wind resource assessment, and affects wind farm design and energy production estimation.

Different methods for characterizing windshear and windveer have been proposed. Some of them are helpful for wind farm design while some others are useful for energy production estimation.

Each of the proposed parameters contains different information about wind speed and direction variation with height.

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