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Sensitivity of Romo Wind Spinner Anemometer iSpin to Environmental Variables: First Experimental Results

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Abstract

To monitor the performance of wind turbines, spinner power curves (SPC) can be calculated using spinner anemometer measurements and a spinner transfer function (STF).

The Performance Transparency Project (www.ispin-ptp.com), funded by EUDP, aims to demonstrate the seasonal, terrain and operational wise robustness of the STF for a spinner anemometer of type iSpin (ROMO Wind).

The STF sensitivity to operational and environmental variables was tested at three sites covering flat, semi-complex and complex terrain. Each site was equipped with the same turbine type and a reference met mast.

The results indicate that (i) turbulence has a linear influence on the application of the STF and (ii) site topography and external variables have no effect on the SPCs. STFs measured in semi-complex and flat terrain have a mutual deviation up to 2% (4% in complex terrain).

Introduction

Spinner Transfer function (STF)

The STF of a spinner anemometer traces back the wind speed at the spinner to the undisturbed wind speed upstream of the rotor. A STF consists of a look-up table including wind speed measurements taken with an iSpin and a reference anemometer, both averaged over bins of 0.5 m/s (see Figure 1).

Objectives

This study aims to assess the STF and its sensitivity to operational and external variables, considering a spinner anemometer mounted on five turbines of the same type, but installed at different sites in flat and semi-complex terrain (see Table 1).

Methods

STF comparison

For each turbine, a STF was measured following the standard IEC-61400-12-2 using wind speed measurements from the iSpin and from the instrumented mast nearby, applying a site calibration to sites not in flat terrain.

The STFs measured at different WTs were interpolated on the centre of their wind speed bins. The STF correction, i.e. the difference of the bin centres from the corresponding iSpin wind speed, was used as term of comparison for the STFs.

The iSpin measurements corrected with the respective STF were compared to the corresponding measurements at the mast in relation to external variables to highlight any possible sensitivity of the STF (see Figure 2)

SPC assessment

For each turbine, five SPCs were measured with the iSpin applying the available STFs to calculate the free wind speed. To quantify the effects of differences in the STFs, the results were mutually compared.

Each SPC was also used to convert the measured power into a turbine equivalent wind speed. To test the influence of wakes and site topography on the STF, the quotient between the iSpin measurements and the turbine equivalent wind speed was analysed with respect to the wind direction in a self-consistency test including all wind directions. According to the standard IEC-61400-12-2, the quotient is supposed to be within the range 1±2% in the valid sectors.

Results

Between 3 m/s and 11 m/s, the STF corrections at different sites show a maximal absolute deviation from the average of ~4% of the iSpin wind speed (Figure 3, left); excluding site C, the deviations are mainly within ±2%.

The SPCs of WT 25 (site C) measured with these STFs (Figure 3, right) have a standard deviation of ~6% between 3 to 11 m/s; excluding STFs measured at site C, the deviations are reduced to ~3%.

Looking at the sensitivity to external variables in terms of bin averages, an agreement among WTs in all sites can be observed (Figure 4).

The rotor speed and the yaw offset have no influence on the STF correction, whilst a linear influence of turbulence was identified.

In the exemplary case of WT 25 (Figure 5), the self-consistency test on the SPC shows that the STF correction is not affected by site effects much. In fact, the quotient between the iSpin measurements and the turbine equivalent wind speed exceeds the recommended limits only in sectors affected by wakes and not in sectors excluded from the SPC measurements because of topographical differences with respect to the valid STF sectors.

Conclusions

Excluding complex terrain, a reasonable agreement was observed for STFs measured at different sites.

The STF has a linear dependence on turbulence, but it seems not to be affected much by operational variables nor site effects.

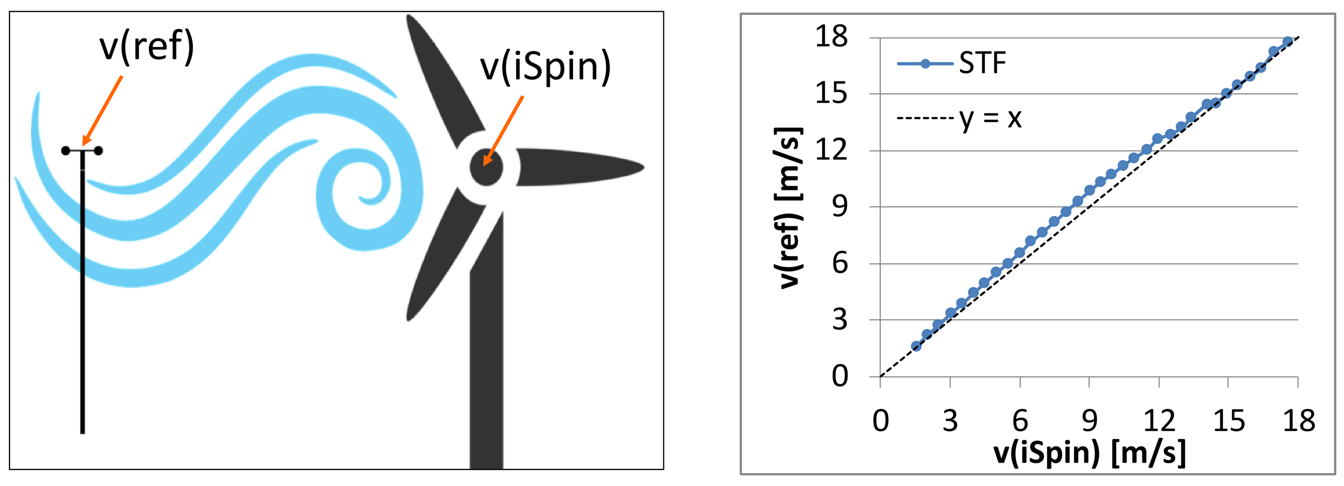

Figure 1: Illustration of STF measurements (left) and exemplary STF (right).

Site	Turbine ID	Terrain Class			
		Slope	RIX	Ridge	Final
A (Flat)	07	0.0	0.0	0.0	**0.0**
B (Semi-	04	2.0	1.0	0.0	**3.0**
complex)	05	2.0	1.0	0.0	**3.0**
C (Complex)	24	2.0	2.6	0.1	**4.8**
	25	2.5	3.0	0.0	**5.0**

Table 1: Details of sites and test cases addressed in this study.

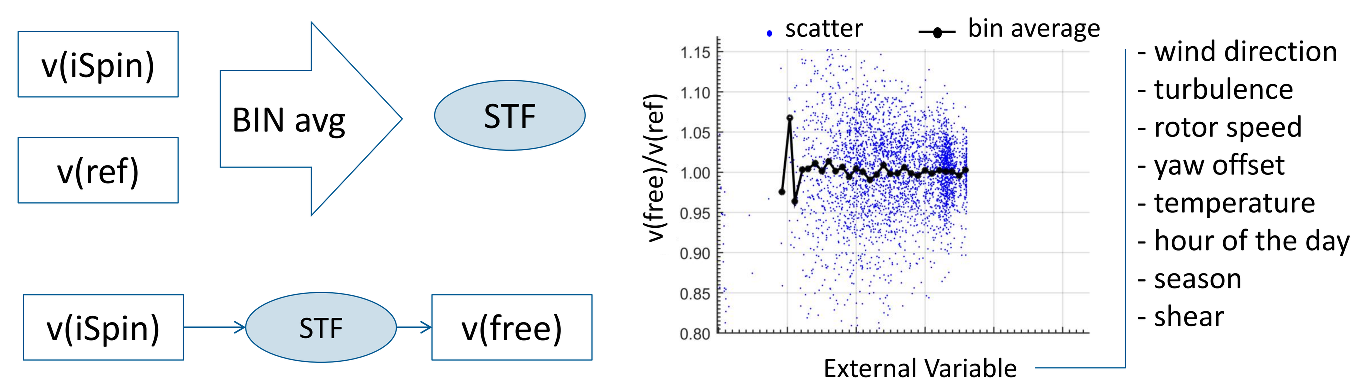

Figure 2: Schematic description of the STF sensitivity analysis. Ideally, the scatter and the bin average of v(free)/v(ref) lies around 1.

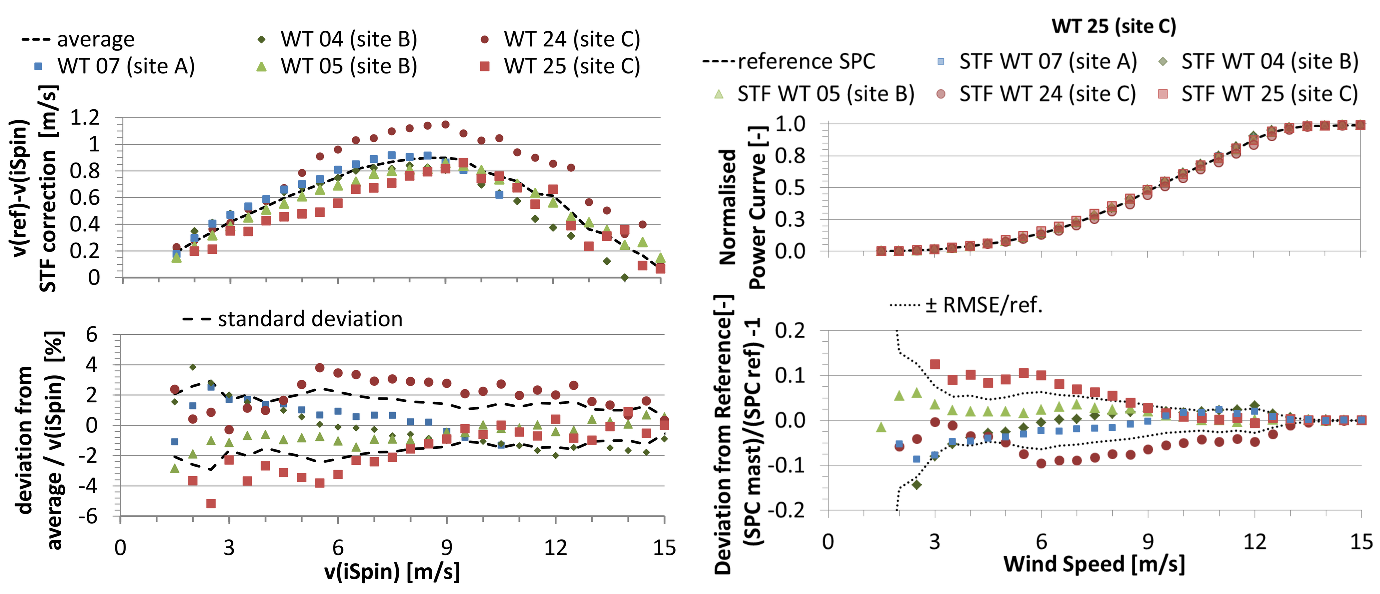

Figure 3: Comparison of STF correction measured for different turbine (left) and their application for SPC measurement of WT 25 at site C (right).

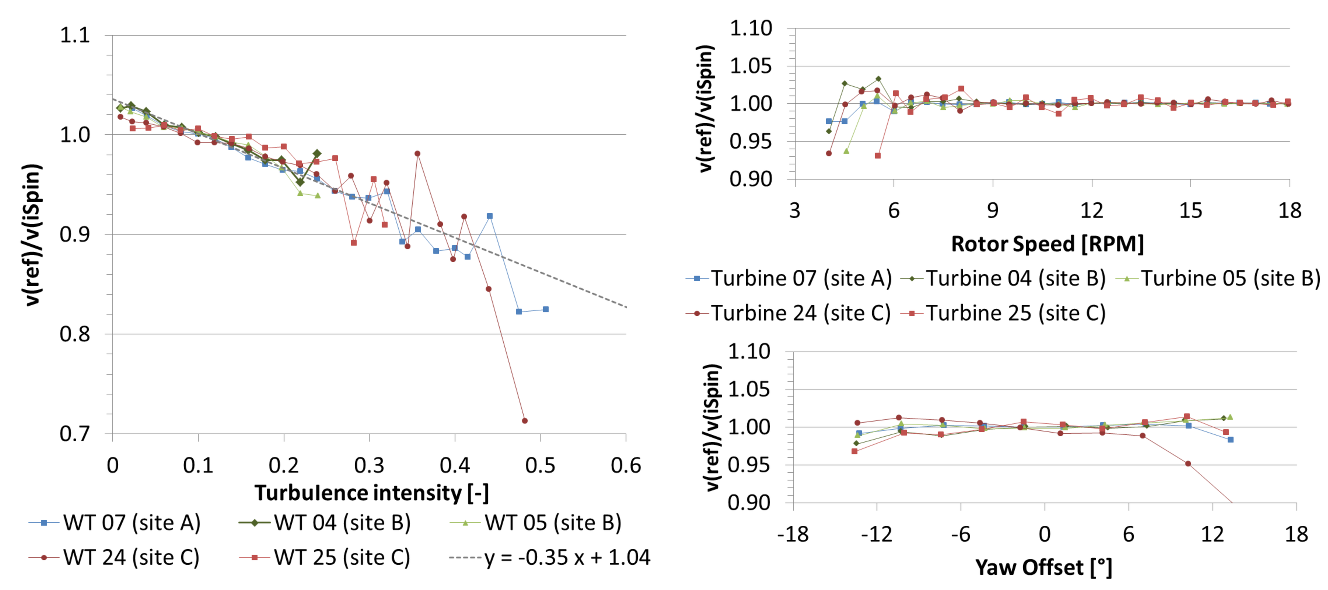

Figure 4: STF sensitivity to turbulence intensity (left) and operational variables (right).

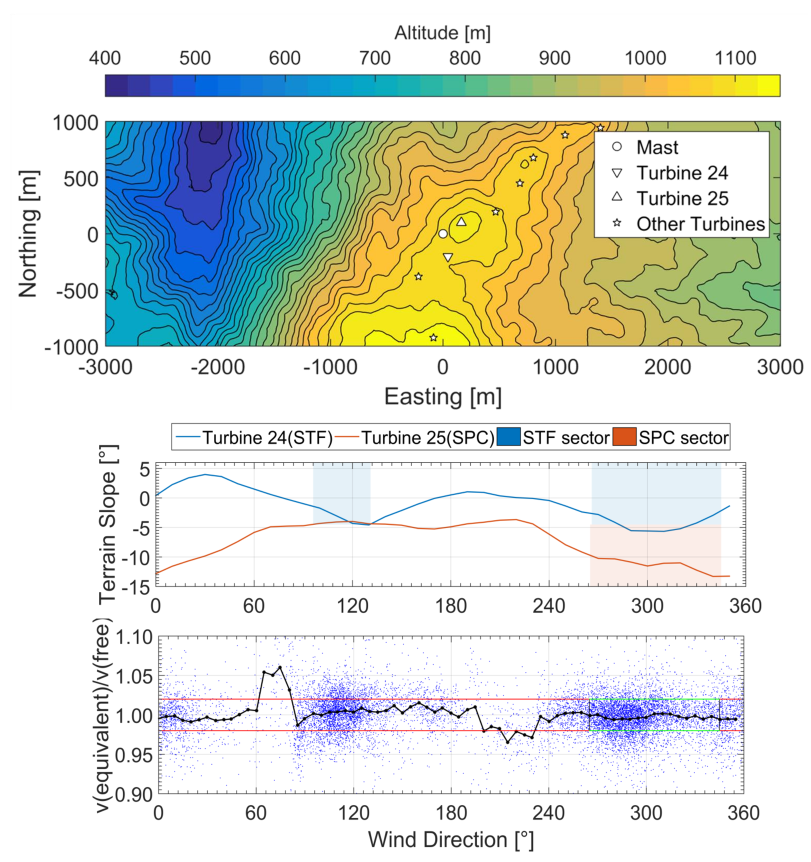

Figure 5: Topography at site C (top) and WT25 self-consistency test (bottom) using WT24 STF in relation to the terrain slope (middle).