Response to Reviewer 1 comments:

General comments: This manuscript quantitatively (statistically) analyzes the influence of different stability classes and turbulence regimes (obtained through the bulk Richardson number, turbulence intensity, etc.) on the wind turbine nacelle transfer functions. The authors analyzed data from one wind turbine and two sets of data from an upwind position from the wind turbine (mast and wind scanner data). The paper is well written and within the scope of Wind Energy Science.

The authors thank the reviewer for their kind comments.

The manuscript addresses an interesting subject that might have both practical and scientific applications in wind energy sector. However, the manuscript requires a number of clarifications throughout the text. Most of my questions are regarding the methodology and data, but I don't ask additional analyses to be conducted at this point. Namely, it is not clear how the authors calculated some of the atmospheric quantities (e.g. bulk Richardson number). Interpretation of the results could also be better. Please see my specific comments below.

I recommend minor to moderate revisions for this manuscript before it can meet the publishing standards of Wind Energy Science.

Specific comments:

1. Anemometer and wind vane are not visible in Figure 1. The purpose of this figure (according to the text) is to show these instruments, but they are not visible. I advise the authors to add Figure 1b in which the anemometer and wind vane will be zoomed in (i.e. visible). The current Figure 1 can be Figure 1a.

We thank the reviewer for pointing this out, and we have found another picture in which the nacelle anemometer is more visible. We will replace the current Figure 1 with the following:

Figure 1. GE-1.5/77 sle turbine at the National Wind Technology Center. Photo credit: Dennis Schroeder/NREL (image gallery number 29611).

2. The last paragraph in Introduction contains too many "as well as" phrases. Please reformulate these sentences in order to increase the readability of the text.

We will change to the following (changes are represented by the bold text):

"In this study, we quantify the effect of NTF-corrected nacelle anemometer measurements on the AEP and investigate the influence of different atmospheric stability and turbulence regimes on these NTFs. In Sect. 2, we briefly summarize our data set, which includes upwind **and** nacelle-based measurements, **as well as** our data analysis methods which include filtering based on turbine operation, and definitions of the stability and turbulence regimes. We present results of AEP calculations **together with results of** separate NTFs for different stability and turbulence regimes in Sect. 3**. In** Sect. 4 we summarize conclusions about the effect of the NTF on the AEP **in addition to** the effects of atmospheric stability and inflow turbulence on the NTFs."

3. The last paragraph in Sect. 2.1 starts with "Further". I would suggest starting it with "Lastly."

We thank the reviewer for the suggestion and we will change to "Lastly."

4. Line 112. What do you mean by "simple, built-in transfer function" and how would this function modify the measured data? Please clarify as this might have importance for your results.

We agree that this statement is not clear, and will revised the paragraph as such:

"Lastly, the nacelle-reported wind speeds used in this analysis have been subjected to a simple, linear regression transfer function before the retrieval from the SCADA system of the DOE GE 1.5 sle turbine. This linear regression function, built into the SCADA system by the turbine manufacturer, effectively translates the raw signal from the cup anemometer to wind speed and is not unlike a transfer function provided by an anemometer manufacturer. We see the uncertainty of this built-in transfer function as an advantage to our analysis as a typical wind plant operator would only have access to similar data."

5. Lines 120-125. You estimated Weibull distribution parameters from the 2.5 months of data and then assumed that these parameters are representative for the whole year; am I right? Assuming that, you calculated the annual energy production. Can you please compare these calculated parameters against the parameters obtained from the data that actually cover one full year at that site, so we can see the uncertainty of your assumption and analysis?

Yes, we calculated Weibull parameters based on the 2.5 months of hub-height wind speed data, filtered by wind direction sector, wind speed, and curtailment. These Weibull parameters were then used to calculate sample wind distributions for the AEP estimates. We then extrapolate the AEP estimates to one year so the AEP values are more characteristic of typical AEP numbers at sites suitable for wind development. We have clarified this reasoning and will add the following in bold to the end of Sect. 2.2:

"A sample wind distribution using Weibull distribution parameters representative of the data set (scale parameter: $\lambda = 10.04$ m s^{-1}, shape parameter: $k = 2.63$, figure not shown) is used in these calculations as suggested by IEC 61400 12-1 (2015) for a site-specific AEP. **We note that these parameters, based on 2.5 months in the "high" wind season at this site, are not actually representative of the entire year. However, as noted in other analyses of this test site (Clifton and Lundquist, 2012; Clifton et al., 2013), this site would not be chosen for wind development given the long summer season with little or no wind. We emphasize that this approach is not meant to suggest actual AEPs for this site, but to explore the sensitivity of AEP calculations at sites reasonable for wind development.** "

Because of the additional text, the following references will be added:

Clifton,A.and Lundquist,J.K.:Data clustering reveals climate impacts on local phenomena, J. Appl. Meteorol. Clim., 51, 1547– 1557, doi:10.1175/JAMC-D-11-0227.1, 2012.

Clifton, A., Schreck, S., Scott, G., and Lundquist, J. K.: Turbine inflow characterization at the National Wind Technology Center, J. Sol. Energ.-T. ASME, 135, 031017, doi:10.1115/1.4024068, 2013.

6. Line 130. You are talking about near-surface flux measurements at 15 m and humidity measurements interpolated to 15m, but in Sect. 2.1 (Meteorological and turbine data) you didn't mention any flux and/or relative humidity measurements. How/from where did you obtain this data? Also, what kind of interpolation did you apply to get relative humidity at 15 m?

A 3-D sonic anemometer mounted at 15 m on the tower as described in Sect. 2.1 provides measurements of the vertical component of the wind as well as sonic temperature. To make this clear, we will add the following in bold:

"On the met tower, cup anemometers placed at 3, 10, 30, 38, 55, 80, 87, 105, 122, and 130 m measure wind speed and vanes placed at 3, 10, 38, 87, and 122 m measure wind direction. Three-dimensional (3-D) sonic anemometers placed at 15, 41, 61, 74, 100, and 119 m **measure all three components of the wind as well as sonic temperature which are used to calculate momentum and heat fluxes**."

As for humidity measurements, we will add the following in bold:

"Barometric pressure and precipitation amounts are measured at 3 m, temperature is measured at 3, 38, and 87 m **and dew point temperature is measured at 3, 38, 87, and 122 m**."

As well as:

Using near-surface flux measurements at 15 m (within the surface layer) as well as surface temperature and humidity measurements **linearly** interpolated to 15 m, we calculate 30-min values of L to estimate the height at which the buoyant production of turbulence dominates the mechanical production of turbulence."

We will also add the following table to make it easier to visualize the tower configuration:

Instrument	**Mounting heights (m)**
Cup anemometer	3, 10, 30, 38, 55, 80, 87, 105, 122, 130
Wind vane	3, 10, 38, 87, 122
3-D sonic anemometer	15, 41, 61, 74, 100, 119
Barometric pressure sensor	3
Precipitation sensor	3
Temperature sensor	3, 38, 87
Dew point temperature sensor	3, 38, 87, 122

7. Similar to the previous comment, how did you calculate the virtual temperatures (absolute and potential) in order to obtain the bulk Richardson number values? That is, did you measure/calculate specific humidity or the mixing ration or the wet-bulb temperature? Please clarify.

We thank the reviewer for pointing out that we did not explain in full our Bulk Richardson number calculations. We will add the following equation and reference to Stull (1988):

$$R_B = \frac{g \Delta T \Delta z}{\overline{T} \Delta U^2}$$

where g is the gravitational constant, ΔT is the change is temperature across Δz, $\bar{T}$ is the mean temperature across Δz, and ΔU is the change in horizontal wind speed across Δz. Humidity is not considered in this formulation of the bulk Richardson number.

8. I suggest you merge the last paragraph in Sect. 2.3 (Line 149) with the previous paragraph.

We thank the reviewer for this suggestion and will merge the last paragraph in Sect. 2.3 with the previous paragraph.

9. The caption for Fig. 3 can be simplified. You can say it's the same as Fig.2, but using second-order polynomial fit.

We will simplify the caption for Fig. 3 from:

"Comparison of upwind wind speeds with nacelle anemometer wind speeds. (a) Scatter is the upwind tower 80-m wind speed versus nacelle wind speed. Red line is the second-order polynomial fit and empirical transfer function between the tower 80-m observations and the nacelle-mounted anemometer observations; gray line is the fifth-order polynomial fit. Dashed line is 1:1. (b) Average deviation in the second-order polynomial NTF-corrected nacelle-mounted anemometer wind speed from tower 80-m wind speed versus tower 80-m wind speed is shown. Dashed line indicates a 0 m s^{-1} change. Includes data filtered for tower 80-m wind speeds between 3.5 and 25.0 m s^{-1}, 87-m wind directions between 235° and 315°, and for normal turbine operation."

to:

"Comparison of upwind wind speeds with nacelle anemometer wind speeds. The red line in (a) is the second-order polynomial fit and empirical transfer function between the tower 80-m observations and the nacelle-mounted anemometer observations and the gray line in (a) is the fifth-order polynomial fit."

10. Line 220. If the nacelle anemometer underestimates the upwind winds, how is it possible that AEP based on the data from this anemometer is higher than using the upwind data? You provided an explanation, but I do not understand it. Please clarify.

If the nacelle anemometer underestimates the wind speed, the power curve is essentially shifted upwards. This is because the turbine appears to produce more power at lower wind speeds. For example, if the turbine is producing 400 kW, the corresponding wind speed according to the manufacturer power curve is 7 m s^{-1}, however, the anemometer may be reading 6 m s^{-1}, so it seems like the turbine is producing more power at lower wind speeds, moving the power curve up and increasing the AEP. Additional text indicated by the bold font has been added to the following to make this more clear:

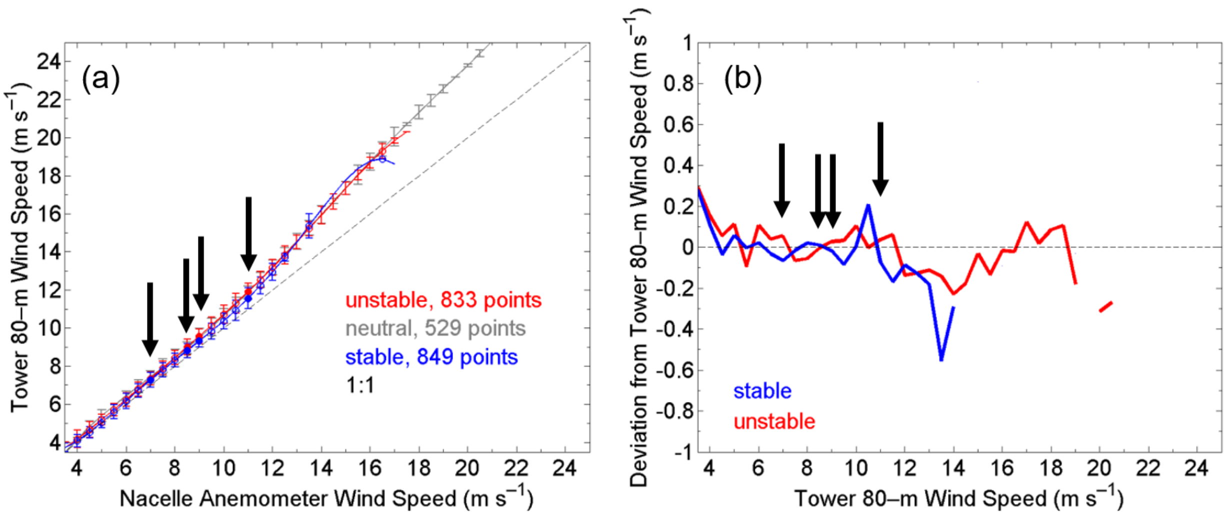
"This overestimation of AEP is expected as the nacelle anemometer consistently underestimates the upwind wind speed, which leads to the misrepresentation of higher power output at lower wind speeds**, effectively shifting the entire power curve upwards**, and therefore leading to a higher AEP."

11. The bottom row in Table 2 says "% difference from tower winds." If that's the name you choose, then the values are not accurately corresponding to that name. It indicates that AEP_upwind is 100% different from itself. Please simplify/rename and clarify.

Thank you for pointing this out, and we will correct the label to "% of tower winds".

12. The size of error bars and circles in Fig. 6 are not (very well) visible at 100% zoom. Please try to make these figures bigger as the interested reader is not able to actually estimate the errors from this graph.

Based on your comment, we have decided to split this figure up to enlarge the individual panels. So we will take Fig. 6 and show (a) and (d) as one figure, (b) and (e) as another, and (c) and (f) as a third figure. This way the reader will be able to more clearly see bins where regimes are statistically distinct from one another. Example:



13. The size and scaling of Fig 6. (bars, lines, points, etc.) are inadequate to develop the discussion that starts at Line 235 and ends at Line 247. Looking at Fig. 6a, I am not able to see any difference between the stable and unstable conditions and the arrows don't help much. Some discrepancies between the lines are visible at around 400% zoom.

Our answer to the above comment will make it easier for the reader to see these statistical differences. In addition, we will move the discussion starting at line 243 to a new section after showing turbulence results in an additional section 3.4 titled "Discussion", in which we will expand to include more explanation on a physical reasoning behind these results.

14. Line 244. You believe that unstable conditions amplify the blockage effect and you carefully used the words "we speculate", "might be", "could be", etc., which I like. However, can you provide some physical reasoning behind this speculation? Namely, why would the interaction between turbulent eddies and turbine augment the blockage effect and not diminish it? Your results show an augmentation (not very visible in Fig. 6 as it is now, but nevertheless show it), but what is the physics behind it?

We will add the following in bold and move to a new discussion section 3.4:

“We speculate that at wind speeds below rated, mixing in the atmosphere during more convective conditions, as well as the turbine interaction with these turbulent eddies, may result in additional motion that exaggerates blockage effects by the rotor and nacelle and causes underestimation by the nacelle-mounted anemometer.

We suspect that rotor response is lagging in more convective and turbulent conditions as the turbine responds more quickly to drops in wind speed. Therefore, during more turbulent conditions, it is possible that lower rotor efficiency influences flow induction and thus the wind speeds measured on the back of the nacelle. If turbine and rotor efficiencies are lower during periods with convective and more turbulent conditions, it may be surmised then, that less momentum passes through the rotor and along the nacelle. In addition, power curve results from the same dataset discussed here (St. Martin et al. 2016) show that during less stable and more turbulent conditions at wind speeds within the ramp-up region of the power curve, more power is produced than during periods of more stable and less turbulent conditions. Power production will also affect the flow induction (Frandsen et al., 2009) and thus the wind speed directly behind the rotor disk: if more energy is extracted by the rotor, the nacelle-mounted anemometer will likely measure lower winds.”

15. References. Sometimes you used abbreviations for journal names and sometimes full names. Please be consistent.

We thank the reviewer for pointing this out and will make sure we use journal abbreviations consistently throughout our reference list.