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Interactive comment on "Does the wind turbine wake follow the topography? – A multi-lidar study in complex terrain" *by* Robert Menke et al.

Robert Menke et al.

rmen@dtu.dk

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Response to reviewer 1 (Michele Guala)

We thank Michele Guala for his critical feedback which helped us to improve this manuscript. Below we answer his specific comments in detail:

Comment 1

I have some reservation on the atmospheric stability assessment: |z/L| <0.01 is a very strict condition for the neutral regime, rarely observed from micrometeorological data from sonic anemometers. Based on Fig 6 it seems that it occurs quite frequently. I am wondering how accurate is the estimate of the turbulent heat flux and how far from the

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surface (the actual z) is the estimate referring to.

The |z/L| used in the stability assessment is derived from the RMOL variable in the WRF output, which is from the formulation in the MYNN2 PBL and surface layer scheme (Nakanishi and Niino 2006) and is computed at the model surface (10m). As mentioned in the manuscript, there is some evidence that the WRF model has shown good skill at simulating their climatology (see e.g. Fig 6 in Draxl et al, 2014). The limit of $|z/L| < 0.01$ is also used by Muñoz-Esparza et al. (2012) who suggests a limit of $|L| > 1000$.

Comment 2

More importantly the Monin Obukhov similarity assumes a logarithmic region where the mean velocity profile is distorted by the thermal stability effect. In complex terrain the contributions to mechanical production of turbulent kinetic energy may be more complicated as compared to the $u_\star^3/kz$ term that is likely employed here. The authors should provide the definition of L and discuss how they account for the non-flat topography and for the orientation of the reference system with respect to the mean incoming wind (likely non flat and to some extent following the terrain).

We are aware that the Monin Obukhov theory is meaningless when calculated for flow over complex terrain from mast measurements. However, the simulation results of the WRF model employed in this study are based on a 3 km x 3 km grid of the smallest domain. Terrain features which are small compared to the model resolution, like the Perdigão ridges, are thus not visible to the model and are only represented by an increased surface roughness. The model sees only a smoothed surface which makes it possible to derive the Obukhov length from the simulation. Confidence in the results is gained by a comparison of the WRF results with the diurnal cycle (Figure 1). The distribution shows a clear separation of the results in a day and night time regime. This distribution corresponds well with observations made by us in the field during the campaign. The period of the campaign was generally very hot and dry with maximum temperatures above 40°C.

Comment 3

Fig 7: the wake deficit depends on the turbine operating conditions: it would be relevant to provide the tip speed ratio and the power coefficient for the wake plotted in Fig 7b (at least the 10min corresponding averaged value).

We added the tip speed ratio and power coefficient based on the 10 minute averages from the SCADA system of the turbine to the manuscript.

Comment4

Despite of many hours of measurements, the most interesting figures show results from quasi-instantaneous measurements. I wonder if it is possible to use conditional averages or two point correlation to support the conclusion with statistics instead of single realization. Perhaps, the wind tunnel work by KB Howard, LP Chamorro, and M Guala "comparative analysis on the response of a wind-turbine model to atmospheric and terrain effects" Boundary-layer meteorology 158 (2), 229-255, 2015 may offer some ideas

We will consider employing the two-point correlation technique for further work that will be done also in combination with a new dataset that was measured during the Perdigão 2017 campaign at the same measurement site.

Comment 5

Fig 10b: how is the wake deflection angle estimated? within a range of x/D? based on the velocity contour, a velocity minima envelope? Please clarify

The length of the wake in the Diamond scan is estimated by the velocity contour. This information has been added to the manuscript.

Comment 6

For non LiDAR experts, perhaps the definition of radial velocity should be provided. Some of the velocity contour distribution with height presented in fig 9b are prone to be misinterpreted without a proper definition.

The definition of radial velocity has been included in the manuscript and the description of the RHI scanning trajectory has been advanced.

References

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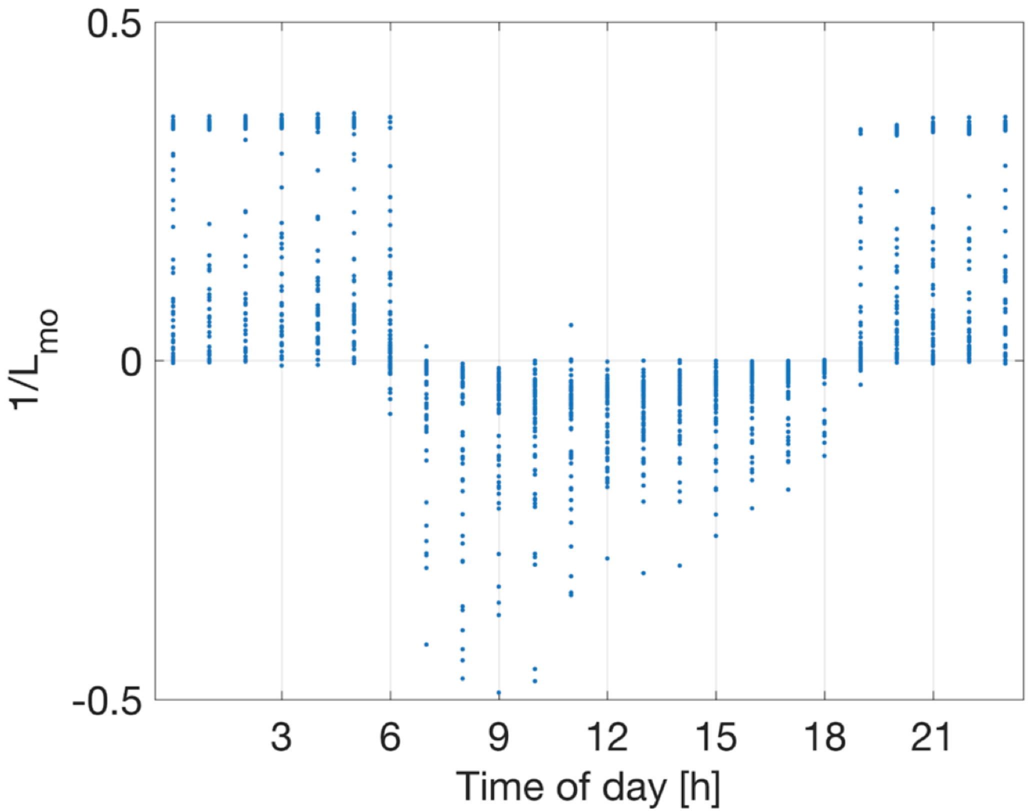

Fig. 1. Diurnal cycle of the Obukhov length for the period of the measurement campaign.

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