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Comment on wes-2022-69

Anonymous Referee #1

Referee comment on "Turbulence structures and entrainment length scales in large offshore wind farms" by Abdul Haseeb Syed et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2022-69-RC1, 2022

The manuscript presents an analysis of mixing and turbulence in the wake of offshore wind farms. This is based on the WIPAFF campaign that took place the 2016-2017 winter. Relative to a number of simulations that have explored turbulence in the wakes of turbines, this study is based on a thorough analysis of dedicated airborne measurements. The analysis is sound, the measurements have great value for the wind energy sector and the understanding of the boundary layer in the vicinity of offshore wind farms. Some minor points and suggestions are made below (eg inclusion of error bars in figures providing estimates- of the length scales), but minor revision will be sufficient to address them and allow for publication.

Minor Concerns

l48 citation of Cortina: add parentheses

l70-75: clearly stated objectives; not completely clear how objective 1 and 4 relate to each other: 1 aims at turbulent length scales, while 4 aims at dominant scales of entrainment..
both concern different locations relative to a wind farm; objective 4 gives more emphasis to the horizontal organization (around the wind farm, not just linearly upstream, above and downstream, and objective 4 includes a focus on different stratifications (objective 2). In other words, objective 4 seems to combine objectives 1 and 2 and to be somewhat redundant.

Figure 1: it would be appropriate and useful to a concise description of the meteorological situation; at present, only the stability is discussed (figure 2..).
The direction of the dominant wind should at least be indicated in figure 1, possibly some isobars from reanalyses could be included to give a sense of the general direction

of the flow.

l108-109: the vertical potential temperature gradient is indeed a measure of the stability of the atmosphere; it constitutes the basis for the calculation of the buoyancy frequency, or Brunt Vaisala frequency. This should be calculated and also given (either the buoyancy frequency or the period..), cf Holton, An introduction to dynamic meteorology (2004).

figure 5: the estimates include uncertainty; could error bars be added to give some appreciation of the uncertainty on these estimates? This would be hlpful to identify which features of the figure calls for interpretation, and which is likely without meaning.

l150: missing 'as': '...are more dominant, as clearly shown...'
This is not clear: the contrast between the black curves of the four panels is not so striking. The black curve of panel a extends to larger scales than that of panel c. There is only panel d (flight 40) which really sticks out as significantly different, with clearly larger scales present. (This is consistent with figure 5)

l170-180: The introduction and explanations for the formulas used for the spectra are insufficient or placed too late; a key quantity is wavenumber component (k_2) which is intoruced before equation (4), but explained only after equation (5). References are given for more
information on the subject, but there should be some more explanations given here nonetheless: what are the assumptions? What do these spectra correspond to? Regarding direction: k_2 is the wavenumber along the flight path because, by construction, this is the only spatial information we have access to with airborne measurements. The flight strategy implies that it is the wavenumber across the mean wind direction. Is this understanding right? The phrasing in line 183 puts the two information on the same level, which can create confusion.

Figure 6: the choice is made to put the constant level (indicating dissipation rate) at the same height in the three panels; hence the reader must check the labels of the vertical axis to understand which is larger or weaker. It could be more visual and closer to expectations for such a figure to use the same vertical axis for the three panels. (Even if that leaves quite some space empty in the first panel..) However, the information is present in the following figure, so it may be fine to leave the figure as is.

l214: remove 'in': 'some momentum flux upstream..'

l250-255: again, one needs to know for sure what k_2 corresponds to? Is it defined as the wavenumber along the profile (flight path)? Or as the wavenumber in the direction perpendicular to the main flow? (My understanding is that the flight paths were chosen perpendicular to the dominant wind, so that both coincide

for this specific campaign; it may be stated in section 2, but I missed it. It is worth emphasizing. A modification to Figure 1, including a description of the large-scale flow, would be welcome)

l257: is the appropriate lengthscale to consider 1/k, or $2\pi / k$?

Figure 11: same remark as for Figure 1: helping the reader have an idea of the background flow for these newly introduced flows will be a significant improvement.

Figure 12: error bars are necessary; uncertainties are discussed in section 4.1, a result of these considerations should be included in the figures, even in anticipation; this concerns Figure 12 and the previous figures which present estimates of scalars.

l360-361: the influence of farm layout has large practical implications. The authors should develop a bit more this statement: if some recommendation for farm layout may be tentatively stated, it is of interest; if the current study only hints at this influence, without making any conclusive statement possible, the authors could mention it and point to directions for further research.

l363: 'inifitely large wind farm' conditions: the authors should either explain or point to an appropriate reference (or both), both here and in the introduction.

l370: providing perspectives for future research would be appropriate here; the study has the originality of using real observations, in contrast to many numerical studies. Is the way forward to carry out more detailed numerical simulations? Other observational campaigns (and then come other questions: what is missing from this one? Is it just necessary to sample more cases? Or should the measurements be different? Enhanced? More numerous, denser?)? Combinations of both?