<u>Summary :</u>

The paper entitled "The impact of far-reaching offshore cluster wakes on wind turbine fatigue loads" investigates the impact in terms of loads of a cluster wake on wind turbines located from 15 to 21 km downstream. The authors utilize SCADA data and turbine-based measurements and derive a load proxy based on the available measurements to investigate the fatigue loads.

They found that the standard deviation of nacelle acceleration correlated well with certain DELs (blade flap-wise moment, tower top moments), and so used this proxy to investigate the loads for turbines affected by the cluster wake.

For this research work, they developed a methodology for quantifying loads on a turbine as a function of the incoming wind speed: while turbines in cluster wakes show a small decrease of loads compared to free wind turbines, separating the dependence of loads on the incoming wind speed leads to a small increase of fatigue loads for cluster wake turbines.

The also found that atmospheric stratification has no impact on the magnitude of loads within the cluster wake. There were also no additional blade mode excitations due to the presence of the cluster wake.

They conclude that wind turbines affected by cluster wakes have a marginal increase in loads when compared to turbines in freestream conditions (reference freestream conditions).

General comment

The paper is well written and pleasant to read. The research work is very interesting, as it investigates farm interactions based on measurements, which is always valuable for the wind community.

A large part of the paper is dedicated to the methodology and how to quantify cluster wakecaused loads: how "cluster wake" cases are determined from all available data, how the proxy is determined, how the stratification is estimated etc. It is Interesting and important because this helps the reader to understand the complexity of SCADA data processing and the limitations of the available data (compared to numerical investigations, where all the flow field is known). These two sections are dense, with a lot of information, and some explanations/details are sometimes missing (see Specific comments).

The analysis of the results is rigorous, and the discussion is critical, highlighting the limitations of the study. A comparison with numerical studies would be interesting, if such studies exist in the literature.

Please see below for more specific comments

Specific comments:

1. Page 3, lines 65-66, Introduction : "Our objective is to determine if far-reaching cluster wakes impact individual downstream wind turbine short -term fatigue loading dependent on the atmospheric stratification."

I would adapt/modify this sentence as the study of dependance on atmospheric stratification is only a small part of the analysis.

2. Page 4, line 94, Section 2.1 : "... data from the sister wind farms Albatros and Hohe See...".

The authors should also refer to Fig 2 to help to the reader locate wind farms of interest in the N8 cluster.

- Page 4, lines 103-104, Section 2.1 : "we chose turbines in free-wind (green) and innerfarm wake (red) as reference conditions..." At this stage of the reading, the meaning "reference conditions" is not clear. This will become clearer later, but for the sake of readability, this should be explained a little more here.
- 4. Page 4, line 105, Section 2.1 : "The wind direction was derived from the 10-min mean nacelle positions".

Which turbines were used to calculate the wind direction? All turbines?

5. Page 5, lines 114-115, Section 2.2 : the authors wrote that they filtered out situations where wind speed was higher that the rated speed. What is a situation with above rated wind speeds: is it when all upstream turbines are impacted by an above-rated wind speed? The authors should clarify this, especially as later in the article, they write that if turbines in free wind speed are in above rated conditions, that is not a problem (see comment 8)

And why do the authors discard situations where the wind speed is higher than the rated speed?

- 6. Page 7, Figure 4 (a): I guess the authors do not have a snapshot a little later, to really see the wake of the cluster that will impact the downstream wind farms. The snapshot should be explained a bit more, to be useful in the analysis/paper. Do we see in figure 4 (a) a part of the cluster wake that will have an impact on cluster N8?
- 7. Page 7, Figure 4 (b): Are these wind speed and direction for each wind turbine?
- Page 7, lines 124 to 127 : "The wind speed in the front row of turbines which are not affected by the cluster wake are also within 0.5 m/s of each other".
 Is it a condition for the selection of a cluster wake case? And I do not understand the

sentence that follows (same paragraph):

"There are four cluster wake cases (out of 96) where this does not hold true since the free-wind turbine are operating above the rated wind speed."

What does the term "this" refer to? Why does operating at a wind speed higher than the rated speed necessarily mean that the wind speeds of the free-wind turbines are not within 0.5 m/s of each other?

And final sentence:

"We did not discard these cases since the turbines within the cluster wake were still below-rated and satisfied all other conditions". Why do the authors keep these cases? (related to comment 5)

- 9. Page 7, lines 131-132 : the authors mention the power deficit caused by the cluster wake in the first line, but they do not detail how they calculate it. Is it calculated in the same way as the power deficit discussed in section 4.2? The definition of power deficit should be detailed here, and perhaps recalled later in the results.
- 10. Page 8, Section 2.3, second paragraph: If I understood correctly, the authors validated WRF simulations based on atmospheric measurements for another period, and they found a good match. So they use another WRF simulations for the considered period. Are there the results of Canadillas et al. ? I yes, the authors should write that it comes from this reference explicitly and maybe detail the reference in one sentence.
- 11. Page 9, lines 157-160, Section 3: This sentence is difficult to understand. Is this what you need to do for a complete fatigue analysis?

- 12. Page 9, lines 171-173, Section 3.1 : it is written that the nacelle accelerations have an approximately linear relationship with wind speed below the nominal value. What happens for wind speeds higher than the rated speed? (Because the authors wrote that they kept situations where the free wind turbines are higher than the rated speed).
- 13. Page 10, line 181 : for the Borssele wind farm, what period is used to compute the DELs? Do the authors compute correlations over a wide range of atmospheric conditions and stratifications? I assume that correlations are better for certain wind conditions... It would be useful to have more details about these calculations. Same comment for the numerical simulation. Further in the paper (Section 5.1, discussion), it is written that this is a numerical simulation for onshore turbine. It should be mentioned here.
- 14. For the DEL, do the authors correct the number of cycles based on the mean loads?
- 15. Page 10, Table 3 : How do the authors explain the difference in correlations between measurements and numerical simulations (for the tower top tilt moment)?
- 16. Page 11 : I do not understand the difference between u' and the anemometer-based TI. How are they computed respectively? The anemometer-based TI is computed based on u' no? Why is the correlation between a'_{fa} and u' good, but not between a'_{fa} and TI?
- 17. Page 12, Figure 7 : It would be interesting to add SL for inner farm effects even if it is not explained in detail. (but this would increase the size of the paper)
- 18. Page 14, lines 270 : "..., possibly due to the combined effects of increased wake recovery in very unstable stratification and lower wind speeds due to the cluster wake".
 I do not understand this sentence: the effects are opposite. Why would a combination of these effects lead to a decrease in loads?
- 19. Page 21, line 373 : the authors write that, for 56 out of 96 cases, spectra were available. What does this mean? Because the authors wrote on page 20 that they averaged the turbine spectra for all cases: so, "all cases" means 56 cases or 96?
- 20. Page 22, line 386 : "Pettas et al. (2021) found the maximum distance that the wakes from neighbouring wind farms impacted SCADA signals was 6.5 km". Whatever the size of the upstream wind farm? Or for one layout/situation?
- 21. Page 22, lines 388-389 : "... that showed increased values due to the cluster wake were the pitch and the generator speed. Firstly, we found a small increase in the nacelle TI..." I do not understand the link, and I think that "Firstly" is not the right term to begin this sentence. Do the authors mean that Pettas et al. found nothing at 6.5 km although they found impacts at 15 km ? It should be clearer. And next lines (lines 389-390) : the nacelle anemometer is located at the same position, whatever the turbine (in freewind or in cluster wake). So why might the increase of TI for cluster wake turbines be attributed to the location of the nacelle anemometer?
- 22. Page 24, discussion: are there any numerical studies of cluster wakes, which might help the authors to explain some of their results/measurements?

Technical comments

- Page 3, line 77, Introduction : "... Section 2 introduces the reference wind farms, the wind farm and the atmospheric data...".
 The sentence should be read again: what are the reference wind farms? What is the wind farm?
- Page 14, line 261 : "... in both figures are ..." Write explicitly in Figs 8 (a) and 8 (b).