

Answers to the comments of Referee #1, corresponding to the article “Observed and simulated turbulent kinetic energy (WRF 3.8.1) over large offshore wind farms”

First of all, we thank the referee for her/his comments. In this document the comments of the referee #1 are plotted in black the corresponding answers are printed in green.

Minor comments

1. Title: Is it necessary to show the WRF version in the caption (WRF 3.8.1)? I would let it out in the title.

According to the guidelines of GMD it is necessary to state the version number in the title of the manuscript

2. P1L11: I think „deficit“ is missing and it should be: „... which in turn causes an underestimation of the wind speed deficit above the wind farm“.

Great catch, thanks. (P1L11)

3. P2L8: „...the wind speed reduction caused by the wind turbines upwind can be only balanced by the vertical momentum flux.“ I would omit this sentence, as it repeats the info given in the sentence before.

We agree, thanks.

4. P2L22-L24: I think the two sentences are a little bit confusing. Can you rewrite them, maybe something like: „It is therefore necessary to evaluate TKE of mesoscale wind farm parameterizations with observed TKE over large offshore wind farms.“

We agree and omit the last sentence of the paragraph and write: “However, an accurate representation of observed TKE and the associated change in the vertical fluxes over a wind farm is difficult to evaluate but necessary.” (P2L21)

5. P2L29: Are you only interested in TKE above wind farms or also in TKE behind them?

In this case, only above offshore wind farms as we only have measurements there. To be more precise, we could write therefore: “How sensitive is the impact of the wind farm parameterization on the TKE to the horizontal and vertical grid of the driving mesoscale model **above offshore wind farm?**” However, that makes difficult to understand. (P2L31)

6. P3L2: I would omit „version 3.8.1“ and add this info to section 2.3.

We agree.

7. P3L5: „horizontal and vertical grid resolution“

Done. (P3L3)

8. P3L9 and P3L25: I think an article is missing: ...in the vicinity of the...

Done. (P3L7 and P3L23)

9. P5L9: Please add: Figure 4a) shows the 10m wind speed ...

Done. (P5L9-10)

10. P9 Table2: I don't understand the differences of the three control simulations CNTRa,

CNTRb, CNTRc. Is it right that the setup of these runs is the same and they only difference is the case study (I, II and III). For me it's a little bit confusing to have these three control simulations and I would suggest to have just one CNTR setup in Table 2.

Indeed, that can be confusing. We leave Table 2 untouched, but we added an extra paragraph: „We conducted three control simulations namely CNTRa, CNTRb and CNTRc corresponding to the three case studies. These three simulations are identical in terms of their numerical setup, they only simulate different days.“ (P5L20-24)

11. P10L4: I don't understand the explanation of „Warm air advection was associated with a stably stratified atmosphere according ...“ Normally, warm air advection is associated with an anticyclonic turning of the geostrophic wind with height (on the northern hemisphere turning to the right). Can you add one sentence here to explain in more detail where you can see that warm air advection occurred?

True. The wind is turning anticyclonic in Fig. 6g). However, the turning is not pronounced. Therefore we reformulated the sentence: “Weak warm air advection was associated with a stably stratified atmosphere according to the climb flight (Fig 6g, anticyclonic turning of the wind with height)” (P10L9-10)

12. P10L6: Can you explain where the FINO1 tower is located or add it maybe in Fig. 1?

Sure. We have added the location of the tower in Fig. 1.

13. P11L13: Can you replace „the airborne measured TKE“ by „the observed TKE“?

Done. (P12L2)

14. P11L13: The sentence „The TKE over the wind farms MSO and ONO...“ is a little bit long and difficult do understand. Can you please simplify this sentence?

True, this sentence is too long. We shortened this sentence and write now: “The TKE over the wind farms MSO and ONO was increased compared to the surrounding (Fig. 9a, Fig. 10a). More specifically, the research aircraft measured

a TKE of up to $2.0 \text{ m}^2 \text{ s}^{-2}$, but $0.2 \text{ m}^2 \text{ s}^{-2}$ within the undisturbed environment, meaning that the TKE over the wind farms is almost ten times higher 50~m over the rotor top compared to the surrounding environment. “ (P12L1-5)

15. P13L13: I don't understand the explanation with the warm air advection. My explanation for the slight disagreement between WRF and the observation is that for case study I we are close to an approaching trough advecting cold air from northwest. It might be that the location of the trough is slightly shifted in the model and that we are located already in colder and different airmasses compared to the observations. This is, however, just a guess...

Yes, I think we both mean the same think: The deviation between simulation and observation stems from the advection of different air, that in turn is caused by different wind directions. We like your explanation and adapted it:” This deviation could be rooted in a dislocation of the incoming trough, causing more westerly winds in the simulations than in the observations.” (P13L24-25)

16. P17L11: Fig. 11 should be mentioned in the text before Fig. 12. You could add a hint to Fig. 11 the sentence „A summary of all sensitivity tests...“.

A very helpful comment. We rearranged the order of the figures and added the following line to the captions of Figures 11, 12 and 13:” A summary of all sensitivity test is listed in Table 2”.

17. P18L1: Please add (see Fig. 12) at the end of the first sentence.

Done. (P18L4-7)

18. P20L3: Replace the number 80: „...the effect of the 80 vertical levels...“

Done. We write now: ”including a change in the number of vertical levels.“ (P21L1)

19. P24L5: Please simplify the sentence „Given the results of this study, ...“, as it is difficult to read.

True. We have split this sentence into two parts:“ Given the results of this study, previously published studies assessing the impact of offshore wind farms have possibly underestimated the impact on the marine boundary layer. Hence, we suggest regional climate simulations for offshore sites with a grid size of 5~km or finer.“ (P24L13-16)

20. P24L8: „... difficulty in parameterizing...“

Done.

Figure comments

1. Fig. 2: Please make a link to Table 2 in the caption in line 5: ... for the sensitivity studies: DX5, DX16, ... (see Table 2).

Done.

2. Fig. 8 and Fig. 10: I'm wondering, if it is possible to add an arrow in each panel, which indicates the mean wind direction along each flight leg. In leg AB the mean wind along the cross section is blowing from B to A, in leg CD from C to D and in leg EF from F to E (please correct me if this is not right). For leg CD it's maybe difficult as the leg seems to be nearly perpendicular to the approaching wind. I think such arrows could help to identify up- and downwind region of the wind farms. Anyway this is just a suggestion...

There is a misunderstanding. In Fig. 8 and Fig. 10 the mean wind is more or less perpendicular to the cross sections i.e. the mean wind points into the paper plane as it is indicated in Fig. 8. and Fig. 9. To avoid any confusion here, we added now a sentence to the caption of Fig. 8 and Fig. 9 stating that the flight legs are perpendicular to the mean wind speed. We apologize for this misunderstanding.

3. Fig. 7, 9, 11, 13: Is it possible to add the letters A, B, C, D, E, F which label the cross sections? I know that they are in Fig. 1, but it would help to see at a glance how the legs were oriented?

In principle that is possible. However, the close-ups shown in Fig. 7, 9, 11, 13 are so focused on the wind farms that the points A, B, C, D, E, and F are located outside of the Figure frame.