Reviewer's comments appear in italics, **our responses appear in boldface blue text**.

The manuscript presents an additional analysis of a subset of the simulations conducted previously by the team and published in Rosencrans et al. (2024). The current analysis uses only the simulations that were conducted with 100% of the added TKE by the turbines available, which was the default value in the Fitch parameterization in older versions of the WRF. The default value in new versions of the WRF is 25%, not 100%. There is no justification in the paper as to why the value of 25% was not used.
By contrast, it is known that using 100% causes an overestimation of added TKE at the grid cells with the turbines. For example:

1. *Eriksson et al. (2015) report excessive TKE by about a factor of 2 (their Figures 15 and 19);*
2. *Abkar and Porté-Agel (2015) find that TKE is overestimated by 50%-200% using the 100% factor (their Figure 5);*
3. *Pan and Archer (2018) find that using the 100% value causes an overestimation of at least a factor of two in several WRF simulations of commercial-scale offshore wind farms (their Fig. 6);*
4. *Archer et al. (2022) propose the 25% value because using 100% causes an overestimation by up to 300% in TKE (their Figure 6, case 4).*

As the current manuscript uses the 100% value, which is unjustified and likely to cause incorrect distributions of heat and momentum fluxes, the manuscript as is should not be published. The team needs to rerun the simulations using the 25% value or, at the very least, rerun the simulations with the 25% value for selected months (say one per season) and present a sensitivity analysis of the results.

We thank the reviewer for their time and consideration in reviewing our manuscript. The issue of the correct amount of turbine-added TKE is an area of active research and scientific discussion, so we are surprised at the reviewer's stance that 25% is a settled issue, especially since the first three papers they cite predate the TKE bug fix which may have influenced the conclusions. The Archer et al. (2020) recommendation of 25% was based on large-eddy simulations of one turbine in neutrally-stratified conditions and is not likely to be representative of all circumstances in which wind farm parameterizations will be used.

Further, several papers (not from our research group) have recently concluded that the 25% value recommended by Archer et al. (2022) does not perform optimally:

1. **Ali et al. (2023) state that "Overall, wind speed and TKE magnitudes predicted by Fitch's parameterization were close to the measured values. This result does not necessarily contradict other studies that found excessive turbulence generation using Fitch's parameterization, because the current comparison is local to the FINO-1 mast and the transect flights over the Gode Wind farms. However, setting $\alpha = 0.25$ was not optimal in the conducted experiments."**

2. **Larsén and Fischereit (2021) state that "It also remains inconclusive which correction factor should be used in connection with the turbine-induced TKE generation in the Fitch scheme: we only tested two factors (1 and 0.25) here and we observe a better performance when using α = 1 than α = 0.25, which does not support the conclusion from Archer et al. (2020)."**

Further, other groups that have implemented versions of the Fitch wind farm parameterization into other mesoscale numerical weather prediction simulation codes (Akhtar et al., 2024; Chatterjee et al., 2016; van Stratum et al., 2022), and have also chosen to use 100%. Our approach is not an outlier in the scientific community and is justified.

Finally, the reviewer requests an expensive sensitivity study. A short sensitivity for a range of wind speeds was already conducted and presented in Rosencrans et al. (2024), Supplemental Figure 1, which showed subtle impacts on the heat and moisture fluxes. We reproduce that figure here for the reviewer's convenience:

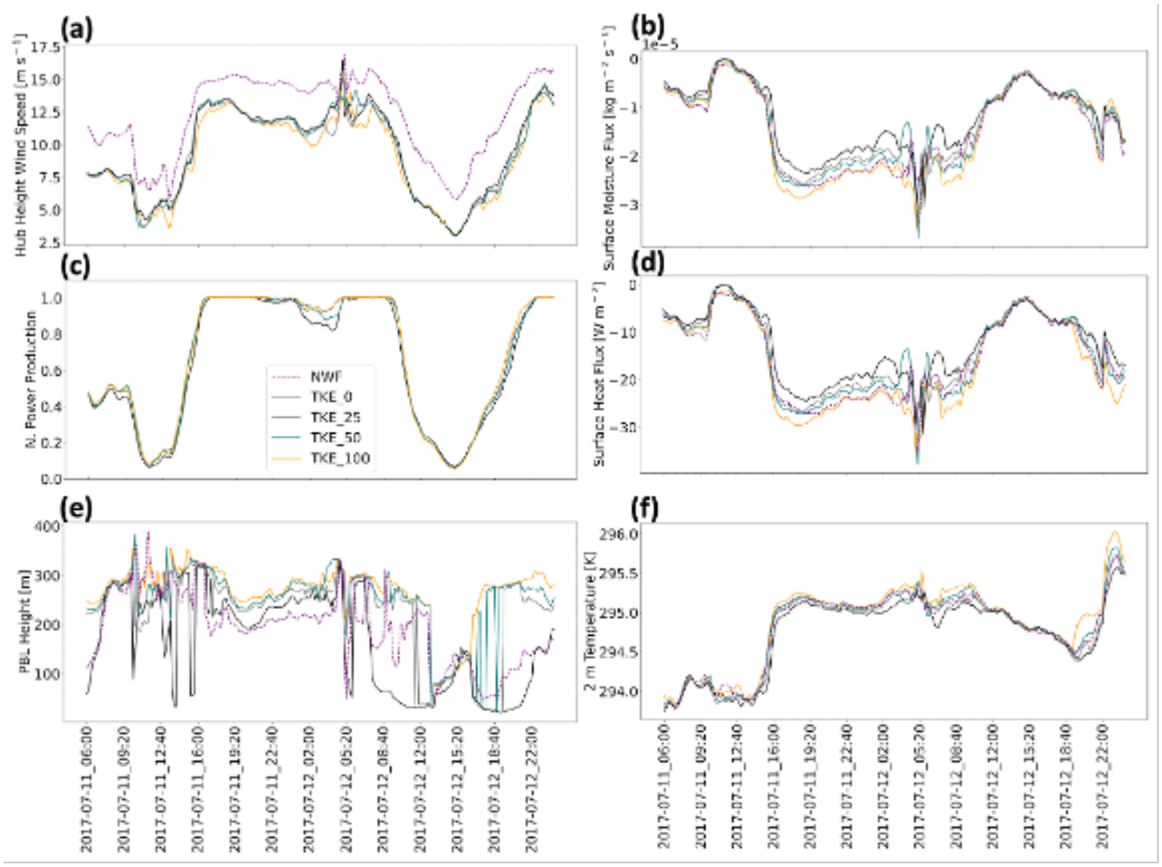

Figure A1 The effects of modifying the amount of turbulent kinetic energy (TKE) during test runs. Panels show (a) hub-height wind speed, (b) surface moisture flux, (c) normalized power productionv (d) surface heat flux, (e) planetary boundary layer (PBL) height, and (f) 2 m temperature. Values are collected from a point centered on the RIMA block. Power production is the sum of all cells containing wind turbines. TKE_100 is shown in orange, TKE_50 in blue, TKE_25 in gray, TKE_0 in black, and NWF in purple dashes.

Given these very small differences, we find the considerable computational expense of such a sensitivity study to be unjustified.

Regardless, we should have included some discussion of the fact that this topic is an active area of research. Therefore, we include the following text in the manuscript starting at the end of Section 2, just before Section 2.1:

> **The topic of how much turbine-generated turbulence to incorporate into mesoscale wind farm parameterizations is an active area of research. The initial default value recommended by Fitch et al. (2012) was 100%. In later work, Archer et al. (2020) recommended a value of 25% based on their large-eddy simulations of an individual turbine in neutrally-stratified conditions. More recent comparison with field observations, using the bug fix and corrected TKE advection (Larsén and Fischereit, 2021; Ali et al., 2023) both suggest that 100% added TKE yields better agreement with observations. Given this uncertainty in the literature and the experience of the sensitivity study of Rosencrans et al. (2024) (their Supplemental Figure A1b and d) that the amount of added TKE makes a very subtle impact on surface fluxes, we return to the standard default value of 100% added TKE for these simulations.**

Minor issues

1. *It is unclear why the runs named "d" were separated out and studied here. The wind speed (0-3 m/s) is below the cut-in wind speed of the turbines, thus there is no power extraction in these runs. The results should look identical to those of the NoWF, but they do not, possibly because some turbines may be experiencing wind speeds locally that are above the cut-in. Nonetheless, I do not see any value in the analysis of these results.*

In fact, the results for wind speeds between 0-3 m/s should not look identical to the NWF runs because there is a standing thrust coefficient included in the WRF wind farm parameterization that is still activated even at wind speeds below cut-in. See lines 304/305 of the WRF code at https://github.com/wrf-model/WRF/blob/master/phys/module_wind_fitch.F. The value of this analysis is in assessing the effect of the drag of the inactive blades as represented by the standing thrust coefficient.

2. *Figure 4: do not show QKE but TKE. QKE is only used inside the WRF model but TKE is the well-known, physically-meaningful variable of interest. Same for the discussion in Section 4.4, focus on the real variable TKE, not on the WRF-specific QKE.*

QKE and TKE differ by a factor of two as explained in section 2.1. Regardless, the revised version of the manuscript will modify the figures and discussion to correct for this factor of two to focus on TKE.

3. *Eq. 1: The flux should be the* ***virtual*** *heat flux, not just the heat flux, typo perhaps. Also, I assume this is calculated from the WRF output fields, but it is unclear which level(s) was chosen for the mean theta_v.*

We have corrected the equation and the text to note that we calculated the mean value of virtual potential temperature from the 2-m temperature, surface pressure, and surface water vapor mixing ratio. We use heat flux (which is available from WRF), not virtual heat flux (which is not available).

4. *Remove the sentence at line 225: your results are indeed the same as those of Rosencrans et al. (2024), you can't say that they are confirming them.*

The reviewer is correct, we have revised the sentence to:

> **During unstable conditions, wind speeds are replenished faster due to increased mixing from aloft, which reduces the extent of the wake, as also reported in Figure 12 of Rosencrans et al. (2024).**

5. *Explain why there is a slight increase in 10-m wind speed at the wind farms in stable conditions. What mechanism can cause this unusual finding? Is it possible that it has to do with the excessive TKE from the 100% coefficient?*

This increase in 10-m wind speed in stable conditions is not "unusual", but has been observed in long-term measurements of wake effects in stable conditions as reported in Bodini et al., (2021), their Figure 4 and in the measurements of Rajewski et al. (2013), their Table 2. It has also been seen in stably-stratified large-eddy simulations (Vanderwende et al., 2016). When stably-stratified flow encounters an obstacle (such as a wind turbine, which is a porous obstacle but an obstacle nonetheless), flow is diverted around the obstacle and accelerates to fulfill mass conservation. In this case, the flow is diverted not just around the obstacle of the wind turbine rotor disk but also under it.

6. *Line 294: is the downward heat flux is reduced, thus less heat comes down to the surface from the layer above it, how come "more heat is transferred to the surface"?*

Thank you for catching this typo and unclear statement. We have corrected the text to

> **"During stable conditions, heat flux is negative. When heat flux is moderately reduced within the wind plant, it becomes less negative implying that the cooling typical of stable conditions slows, as is also seen in the T2 changes of Figure 11. We also observe an increase in heat flux downwind of the wind plant of around 1.5 W m-2 during stable conditions, implying that the cooling typical of stable conditions accelerates. No downwind effect on heat flux occurs during neutral and unstable conditions."**

7. *Figure 13: the square patterns are concerning … if they are truly due to the fact that there are more turbines in the grid cells along the lines (line 321), then why are we not seeing a similar pattern in the wind speed deficits, only in the added TKE?*

The difference between the effect of TKE and the effect of the wind speed deficits is related to the magnitude of the changes. The added TKE at hub-height as seen in Figure 13 is more than a factor of two greater than the values of TKE in the NWF simulations, and so the addition (especially for cells with multiple turbines) is a factor of two larger than the ambient background values. In contrast, the wind speed deficit introduced by the wind farm effect is smaller than the ambient wind speed

background values, and so the grid pattern is not clearly visible. The grids are slightly visible in other quantities that have smaller ambient background values compared to the wind-farm-induced differences, like the heat flux in stable conditions for fast winds (Figure 12f).

8. *All figures: add units*

We have double-checked all figures for units and realized they were inadvertently omitted. The revised manuscript will add them to Figure 6 (within the wind roses), and to the color bars in Figures 9, 10, 11, 12, 13, 14, 15, and B1-B6.

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