Referee's comments to first revision of wes-2024-79

General comments

Thanks to the authors for making changes to the manuscript. There are however still important aspects that were not addressed as many comments were disregarded.

First, in the manuscript it could be made clearer for the reader who is not familiar with the previous publications where a fully developed flow is assumed ($U_{T,i} = const$) or where the less strict assumption of $C_T' = const$ applies, as now they are kin of mixed. The source of confusion seems to be that ND20 was derived for fully-developed flow (aka, infinite layout), but then they hinted at a more general solution in section 3. Also, Kirby et al. 2020, simulates only infinite farms with actual LES, but then postprocesses the C_p for hypothetical finite-size farm (section 4.3).

Second, the main point, i.e. the physical interpretation of η_{FS} and η_{TS}, was not addressed. The major critical aspects still are:

- $\eta_{TS} = C_p/C_{p,Nishino}$ is the ratio of the "true" power coefficient (i.e. based on LES) and the prediction by ND20 that uses an averaged approach. Mathematically, this simply carries out the modeling error of ND20. It could be applied to every analytical model. The fact that $C_{p,Nishino}$ has a physical meaning for a real layout, other than something like "the efficiency that the farm would have if it was infinite" has not been proven. Calling it the "near-ideal" case in a "best-performing" sense, pointing to the fact the LES simulations of infinite farms (so already pretty idealized) rarely exceeded this value is not rigorous, unless we assume that the 50 LES represent a representative statistical set of all the possible wind farm configurations and atmospheric conditions (which clearly do not as they are infinite). Also, interpreting $\eta_{TS} > 1$ as due to flow confinement is admittedly not proven and it was kept in spite of the previous comments.

- The fact that $\eta_{FS} = C_{p,Nishino}/C_{p,Betz}$ is related "farm-atmosphere interaction" may be misleading. It reminds of calls to mind atmospheric flow features, like Coriolis, stability, mesoscale circulation, blockage, gravity waves, but it could be applied to any neutral flow past an obstacle, not necessarily an "atmospheric" one. Even more questionable are statements like:

  "In this study our LES results showed that, for a large staggered array of 160 turbines, the downstream power degradation was not due to turbine-wake interaction but entirely due to the farm-atmosphere interaction."

  Things could be simpler than that: η_{FS} mathematically is simply the prediction of efficiency by ND20, with all its limitations. And it does include wakes, because when averaging for instance velocity within the farm layer, wakes do contribute to reduce U_F.
  The example of the farm in channel where mass conservation creates speedups that cancel out with wakes is just a very special and realistic case of a pressure-drive flow or, $-\frac{\delta p}{\delta x}$. The momentum deficit in real farms is replenished by reduction in kinetic energy, $U\frac{\partial U}{\partial x}$ if the flow is not fully developed (most cases) and partly turbulence momentum transfer from above and

the sides, $-\frac{\partial \overline{uu_i}}{\partial x_i}$, whereas large scale pressure patterns are minimally changed. Therefore, wakes do contribute to make $\beta < 1$. In other words, saying that η_{FS} is not connected to turbine-wake interaction, it is like saying that wakes (and thus thrust) are not considered in ND20, which is a patent contradiction.

Long story short, there it is still not convincing that the η_{TS} includes "local effects" and η_{FS} quantifies the "farm-atmosphere interaction", which is also an elusive concept. The original idea of the scale separation of ND20 was to isolate on one side of the equations parameters that depend on the layout and wind direction (C_T^*, γ), and on the other side the large-scale momentum replenishment from above the farm by the enhanced momentum flux ($M(\zeta)$, and coupled then through β. This fact was nicely validated in this work. However, relating the prediction ND20, as a whole, to farm-atmosphere interaction and the difference to turbine-wake is not sound. ND20 do include local effects like wake in their modeling.

It is recommended to carefully rethink this definition and possibly remove or mitigate their physical interpretation and reduce the scope of the manuscript as a validation of the two-scale separation hypothesis.