

We thank the reviewer for his/her time and efforts in carefully reading our manuscript. The feedback on our work is highly appreciated!

A point-by-point reply to the individual comments can be found below in blue (the original comments are included in black).

Comment on Investigating energy production and wake losses of multi-gigawatt offshore wind farms with atmospheric large-eddy simulation

January 27 2023

In this paper, by using large-eddy simulation (LES) with coarse grid, the authors examines the energy production and the wake losses of six different hypothetical wind farm, with consideration of atmospheric stability. The novelty of presented in this paper includes setting up boundary conditions by incorporating large scale tendencies from reliable reanalysis dataset and taking transport of moisture and latent heat into account, which make the study presented by the authors stands out among many similar LES studies considering dry ideal conditions only. Moreover, the authors have performed sensitivity analysis which makes their results robust. Thus I recommend publishing this paper.

Several minor or technical comments which I think may help:

- Line 33: typo: exampe -> example

Corrected

- Line 102-111, section 2.2.1: The authors have talked about how model fields from ERA5 are incorporated to the LES temporally. I was wondering how did the authors spatially incorporate the coarse ERA5 data (which I think have a resolution to the order of 10 km) to the LES run with 120 m resolution. Did the authors interpolate them?

Clarified by adding: 'Initial conditions and large-scale (*LS*) tendencies are extracted from ERA5 by means of spatial and temporal interpolation and prescribed to GRASP as a function of height only (i.e. homogeneous over the domain).'

- Line 134 - 137: It seems that the authors have incorporated a simple ADM without wind farm rotation. Maybe out of scope, but I was wondering if the results will be different if rotation has been accounted for. There are several ADMs that already considered rotation maybe the authors can check those.

We have no experience with ADMs that consider rotation. From that, it's hard to make any statement how using these models will impact the results. As the number of turbines is large in the simulated 4GW wind farms, the impact may be small, but this is mere speculation. We do have experience with (rotating) actuator line models, but this would require a totally different study in terms of resolution (in fact, simulation of the present domain with the then required resolution is computationally unfeasible). And, as such, a comparison with the present setup is hard to make.

No changes made.

- Line 139: typo: manufactorer -> manufacturer

Corrected

- Line 155-160: The resolution of the LES run:

- Could the authors provide more information about the vertical grid stretching thus the vertical resolution across the rotor?

Added: The number of vertical levels is already indicated: 48. Grid stretching was done by applying a uniform growth factor from the lowest model level upwards. Added: '(i.e. a uniform growth factor of 2.845 %)' (See also comment on line 156 RC2)

- The 120 m horizontal grid spacing (and the 60 m in the sensitivity test part later) is very interesting since it sits between the resolution of mesoscale models with wind turbine modeled (e.g. WRF with Fitch model where the resolution is in the order of 1 kilometer) and that of the wake-resolving LES (in the order of 1 meter). Since there is no resolving of the wake in this study, the coarse resolution makes sense. I was wondering apart from the observations and wind farm data, have the authors also considered comparing the results with those from mesoscale models and wake-resolving LES? This may be a worthy point in future studies.

Indeed, no comparison with other models has been made for the present study. For sure, it would be interesting to compare the present results with those from mesoscale models (requires careful alignment of scenarios and simulations though, to make meaningful comparison).

- Line 258: Why do the authors chose 270 m and 30 m to calculate the bulk Richardson number?

This these two heights correspond to the highest and lowest point of the rotor of the IEA15 turbine ( $z_{hub}=150m$ ,  $r=120m$ ). This is indicated in the text.

- Overall comment

- I think the authors should format the reference to the Figures in the text like Figure X a), b), c), etc. to be consistent with the sub figures in the paper. Currently they are in a format like Figure X a, b, c, ...

For now, we choose to stick with the original way of referring to the Figures

- Just curious, have the authors considered seasonal variations for this year-round LES study? No LES studies so far have done that but there are other large-scale studies that focuses on seasonal changes of wind farm wake losses and production (e.g. Pryor et al. 2018, Wan et al. 2012). Maybe it will be interesting to consider seasonal effects.

We have not checked this, but for practical purposes this is relevant indeed (although no clear conclusions on seasonal effects can be drawn from a single year). However, seasonal variations will be induced by variations in more physical properties like wind speed distribution and stability. So indirectly our results give an indication what will happen in windy seasons with unstable conditions versus maybe seasons with a lot of stably stratified conditions and calmer winds.