The authors thank the reviewer for his/her comments. The thorough review and suggested edits have resulted in an improved manuscript. Responses to each comment are provided below and are formatted in the following manner: comments have been placed in italics, along with normal text for the response. If the changes have been made to the manuscript, these are included in bold thereafter.

Comment : Introduction is a bit unfocused and writing can be improved. From the abstract and the introduction, the scientific goal of this manuscript is unclear and, frankly speaking, it is still unclear even at the end of the document. Maybe is the reconstruction of the Reynolds stress through POD modes and then highlighting difference among the different layouts? This should be explained clearly.

Response: The authors agree that this is an important point. The abstract and introduction are rewritten and improved to address the scientific goal of this manuscript.

The paragraphs below are added to the abstract and Introduction part in the revised version of the paper.

"**As wind farms become larger, the spacing between the turbines becomes a significant design element that can impose serious economic constraints. Therefore the investigation of the turbine spacing and its effect on the produced power and flow structure are crucial for future development of wind energy.**"

"The four cases are chosen with a spacing of 6D and 3D in the streamwise, and 3D and 1.5D in the spanwise direction"

" Thus, the upstream flow of each of the four cases converges faster than the flow downstream of the wind turbine in terms of the represented cumulative turbulent kinetic energy. The streamwise averaged profile of the Reynolds stress is reconstructed using a specific number of modes for each case; the case of 6D x 1:5D spacing displays the fastest reconstruction. Intermediate modes are also used to reconstruct the averaged profile and show that the intermediate scales are responsible for taking the shape of the original profile."

"As a result of wind farms becoming larger, the cost of the land-surface is considerable and becomes a critical factor in the overall value of the wind farm. The spacing between the turbines is an important design factor in terms of overall wind turbine performance and economic constraints. Therefore, the investigation of limited spacing is important as it affects the wind turbine-generated wakes as well as the power production. The current work statistically compares the turbulent flow in various configurations of the array, where the streamwise and spanwise spacing are varied. The performance of the arrays is illustrated by analyzing the mean velocity, Reynolds shear stress, mean kinetic energy flux and power measurement. In addition, the proper orthogonal decomposition (POD) analysis is employed to identify the coherent structure of the turbulent wake associated with variation in spacing. The reconstruction

algorithm of the POD is also applied to reconstruct the Reynolds shear stress and show the fast rebuilding based on the spacing variation.”

Comment : In Sect. 2, POD is briefly described, not always in a very rigorous manner (see detail comments below).

Response: The authors agree with the reviewer for this point. The authors expand the theory part by adding the intermediate equation as can show in modified version of the paper.

Comment: In Sect. 3 the experimental setup is described.

Response: The authors thank the reviewer.

Comment: In Sect. 4 power production for the different layouts and rotor angular velocities is reported. This section looks a bit disconnected with the remainder of the manuscript. No clear connections are made between power production and the wake velocity field.

Response: The authors agree with the reviewer for this point. This section is moved to the end of the paper and the authors make a connection with mean velocity profiles with a new paragraph

“ The trend of the power curves follows the same that observed in the averaged profiles of the streamwise velocity, see figure \ref{8} (a). Further, they verify the relationship between the power of the turbine with the deficit velocity. The maximum power and velocity are found in the case Π_{1} and the minimum quantities are noticed at Π_{4}. Finally, the smallest variations in the power measurement and main velocity are observed between cases Π_{2} and Π_{3}, whereas the largest difference is observed between cases Π_{1} and Π_{2}.”

Comment: In Sect. 5A, mean velocity field and Reynolds stress are reported for the different layouts. In Sect. 5B, streamwise averaging analysis is described. In Sect. 5C, the POD results are provided, while in Sect. 5D, reconstruction of the Reynolds stress through POD modes is presented.

Response: Thanks.

Comment: The main criticism on this manuscript is that the results presented do not provide a clear insight to improve understanding of wake turbulence for different wind farm layouts. I guess the main results should be better highlighted in the data analysis and conclusions. Furthermore, writing should be improved throughout the manuscript.

Response: The authors try in the modified version to highlight the difference between the four cases by addition a new paragraph especially in conclusion part and that will provide a better understanding for the main goal of this study. Also, the writing of the manuscript was approved grammatically and in terms of writing style.

“Insight into the behavior of the flow in a wind turbine array is useful in determining how to highlight the overall power extraction with the variation in spacing between the turbines. The main goal of the current study is to determine the effect of the tight spacings on the flow behavior and the findings of this study have a number of important implications, especially regarding the cost of a wind farm or when the large areas are not available. Stereographic PIV data are used to assess characteristic quantities of the flow field in a wind turbine array with varied streamwise and spanwise spacing. The flow fields are analyzed and compared statistically and by snapshot proper orthogonal decomposition.”

“Streamwise mean velocity, Reynolds shear stress and vertical energy flux are presented in upstream and downstream of the considered cases. In the inflow measurement window, higher velocities are observed in cases Π_{1} and Π_{4} comparing to the other two cases whose inflows are unrecovered wakes from leading rows. In contrast, case Π_{2} and Π_{3} show higher Reynolds shear stress and energy flux. The notable differences between the cases are found above the top tip and below the bottom tip downstream the turbines, whereas the core of the wakes shows fewer discrepancies. The streamwise and spanwise spacings form a unified effect on the flow, where the degree of the impact of one highly depends on the other. This relation is shown in all statistical quantities such as reducing 50\% of the streamwise spacing leads to increase the averaged Reynolds shear stress by 16\% and 2\% when $z=3D$ and $1.5D$, respectively. According to current statistical quantities, one can infer that the higher influence of streamwise spacing is shown when the spanwise spacing is $z=3D$, and the significant effect of the spanwise spacing is observed when the streamwise spacing is $x=3D$. In order to remove the streamwise dependence, streamwise average profiles of the statistical quantities are computed. Averaged profiles of the velocity follow the order of higher velocity seen in the contour plots in case Π_{1} and lowest velocity in case Π_{3}. The maximum and minimum difference are observed between cases Π_{1} with case Π_{3} and Π_{2} with case Π_{3}. The result also reveals that the streamwise spacing is more impactful than the spanwise spacing. Averaged profile of Reynolds shear stress and energy flux shows the same sequence where the maximum and minimum locate in case Π_{2} and case Π_{4}, respectively.”

“Based on the POD analysis, the upstream of the four cases converges faster than the downstream flow. Case Π_{1} and Π_{4} show the rapid convergence in cumulative energy content in upstream, in contrast, case $

\Pi_{1}$ remains behind case Π_{4} in the downstream. The first mode of the case Π_{4} carries the maximum turbulent kinetic energy content compared to the first mode of the other cases. No significant difference in energy content is observed after the mode 10 between the four cases. The streamwise-averaged profiles of the Reynolds shear stress are reconstructed by back-projecting coefficients onto the set of eigenfunctions. Low index modes are used individually to show the POD mode contributions. Cases Π_{4} and Π_{1} rebuild the average profile faster than other two cases and the discrepancy in reconstruction between them is mainly observed in profiles using only the first five modes. The same trend in reconstruction is observed in cases Π_{2} and Π_{3}. The reconstructed profiles display the effect of the spacing and the variation between the wind array, where the array of large streamwise spacing exceeds and reconstruct faster than the other cases due to carrying more coherent structure within the flow. “

“Power produced is measured directly using torque sensing system. The power curves exactly follow the trend of the velocity profiles. The maximum power extracted at the normalized angular velocity of 15.8 $\pm$ 1 and it is harvested in case Π_{1}. The small difference in harvested power is observed between cases Π_{2} and Π_{3}. Continued efforts are required to understand the impact of streamwise and spanwise spacing in infinite array flow with different stratification conditions. The current work demonstrates that the wake statistics and power produced by a wind turbine depend more on streamwise spacing than spanwise spacing. However, the results above pertain only to a fixed inflow direction. In the case where the bulk flow orientation changes, spacing in both the streamwise and spanwise directions will be important to the optimal power production in a wind turbine array.”

Detail comments

Comment: Abstract: possesses highest energy content, it sounds strange. Consider to rephrase it.

Response: The authors rephrase it as

“The case of spacing 6D x 1.5D possesses the maximum turbulent kinetic energy content in the first mode compared with other cases.”

Comment: line 9: increased coalesce dynamic load. Consider to rephrase it.

Response: The authors rephrase it as

“increased in the accumulated dynamic load"

Comment: line 13: Wake growth particularly depends on the shape and magnitude of the velocity deficit. What does it mean?

Response: The authors mean that the wake growth depends on the whether it is symmetric or not , which will effect on the interaction between the wakes of the turbines and accumulative dynamic load on the downstream turbines. Thus the magnitude of the velocity deficit determine the impact distance of the wake spread.

Comment: line 36: according to the Nested farm..Spacing within a real wind farm varies with wind direction. I suggest providing ranges of spacing according to the wind rose.

Response: The authors added the range as

“The optimal spacing according to the Nysted farm is 10.5 diameters (D) downstream by 5.8D spanwise at the exact row (ER). The wind direction at the ER is 278 and mean wind direction can be slightly offset from ER by ± 15° “

Comment: line 68: Maybe it is appropriate to write the mean kinetic energy budget?

Response: The authors have included to energy budget according to the review ’s suggestion

Comment: line 70: The Reynolds shear stress is the center of the energy flux. This is not clear, consider to rephrase it.

Response: The authors rephrase it as

“The Reynolds shear stress is responsible for the mean kinetic energy flux.”

Comment: lines 78-79: The snapshot method enables reducing POD computational cost when the space dimension of a single snapshot is larger than the total number of snapshots.

“The snapshot method enables reducing POD computational cost when the space dimension of a single snapshot is larger than the total number of snapshots”

Response: The authors added this paragraph to the theory part. Thanks

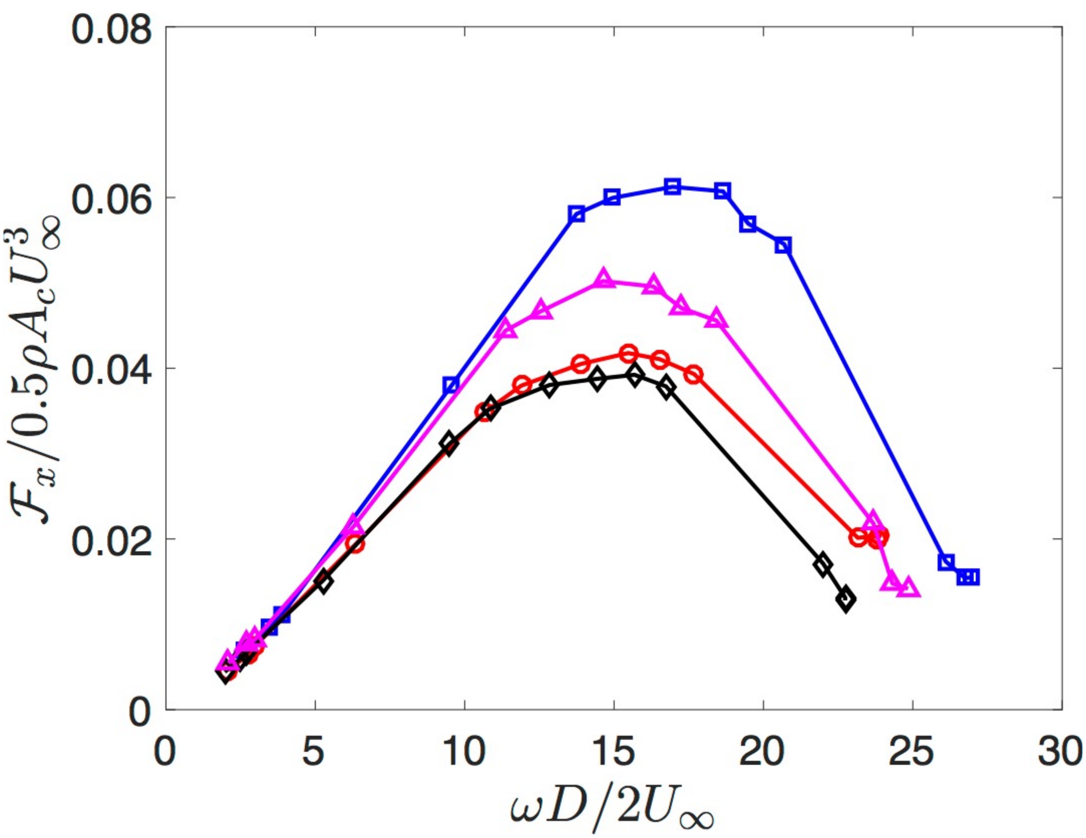
Comment: line 88: The optimal deterministic problem is solved numerically as the eigenvalue problem. Rephrase it.

Response: The authors modified this sentence as

" To acquire the optimal basis functions, the problem is reduced to the eigenvalue problem denoted"

Comment: Fig. 3: This is the power measured only for the turbine under examination or from the entire array? Is it possible to report the power in a non-dimensional form?

Response: The authors are correct, the power is only measured for the turbine under examination. The authors also presented the power in a non-dimensional form in the revised version of the paper.



Comment: Sect. 4: The power measurements seem to be disconnected from the rest of the manuscript. Try to bridge the power measurements with the wake velocity data.

Response: The authors added a paragraph to connect the velocity and power.

“ The trend of the power curves follows the same that observed in the averaged profiles of the streamwise velocity, see figure \ref{8} (a). Further, they verify the relationship between the power of the turbine with the deficit velocity. The maximum power and velocity are found in the case Π_{1} and the minimum quantities are noticed at Π_{4}. Finally, the smallest variations in the power measurement and main velocity are observed between cases Π_{2} and Π_{3}, whereas the largest difference is observed between cases Π_{1} and Π_{2}.”

Comment: line 161: do you mean upstream and downstream of the turbine under examination?

Response: Yes, the authors mean the upstream and downstream of the turbine under examination.

Comment: line 186: there is an extra space.

Response: The authors erase the extra space. Thanks

Comment: Fig. 4: why you do not show the other two velocities as well?

Response: The authors just presented the streamwise mean velocity because it is the most important component for this type of flow and it is also used to compute the energy flux. The other components of the mean velocity have not been included as they do not add much to the discussion at hand.

Comment: Sect. 5B: explain better the rationale in performing averaging in the streamwise direction even though streamwise gradients are significant.

Response: As the authors mention that in the manuscript, Spatial averaging makes it possible to compare the different cases while removing the streamwise dependence. The streamwise averaging will provide a complete picture of the wake behavior through the full domain and will provide the ability to fill in the missing data, especially for the large domain. For example, the upstream and downstream of the case 6D x 3D dos not capture the full domain as result of the limit size of the PIV plane, when we moved the upstream after the downstream plane, there are a missing data between the two planes, but the procedure of the streamwise averaging fixed this problem.

Comment: line 254: specify if POD was performed by analyzing snapshots of the Reynolds stress or velocity components.

Response: The POD was performed by analyzing snapshots of the velocity components. The author added that in revised version as

“Based on the velocity field, the spatially integrated turbulent kinetic energy is expressed by the eigenvalue of each POD mode.”