Reviewer 2

In the manuscript, the authors present a model for the curled wake based on approximations to the Navier-Stokes equations. They compared the model predictions with the LES data of wind turbine wakes in uniform and turbulent inflow. The topic is interesting and useful for the wind-energy community, and the manuscript is well-written. However, there are some issues which are required to be addressed.
The authors appreciate the positive feedback from the referee. The comments have been addressed below. The responses are marked in blue in the manuscript.

1. The results obtained from the other models, in particular, the ones proposed by Shapiro et al. (2018) and Bastankhah and Porte-Agel (2016), could be added to the text (in Fig. 5 and 7). In the current format, it is not possible to compare the performance of the proposed model with the other ones.
Response:
We agree with the reviewer and the profiles suggested for the Gaussian model have been added. We noticed that in the cases with uniform inflow, it is difficult to compare the curled wake model to the Gaussian model. In these conditions the Gaussian model is only able to predict the wake profiles too far downstream. However, in the case of the atmospheric boundary layer, the Gaussian model works well. Section 4.2 has been re-written by adding the results from the Gaussian model.

2. Since the experimental data of wind turbine wakes in yawed conditions is available (e.g., Bastankhah and Porte-Agel, 2016), it would be more useful if the model is also compared with the experimental data.
Response:
We agree with the reviewer that comparisons to experiments are valuable. However, in order to keep the paper concise and focused on the derivation of the model and comparisons to LES, we will leave this suggestion as part of future work. This has been addressed in the conclusions:

"Future work consists of improving the curled wake model with emphasis on implementing a robust decay model for the vortices and comparing the model against experimental data."

3. In addition to Fig. 5 and 7, the vertical profiles of the wind velocity should be added to the manuscript to better compare the model with the simulations.
Response:
We agree that these figures would help to better compare the model and the LES. Both these figures have been added and the following text has been added to the manuscript:

"Figure 5 shows the axial velocity along a vertical that passes through the center of the rotor for different downstream locations from the simulations in Figures 2 and 3. Good agreement can be observed from the profiles between the model and LES. The general behavior of the profiles is well capture by the model. In the case of the ADM, differences in the near wake are present due to the inclusion of the tower model. The profiles from the model have sharper gradients near the edges, showing that a turbulence model should be present to incorporate the diffusion due to turbulent mixing.”

“Figure 8 presents velocity along a horizontal and vertical lines passing through the center of the rotor comparing the model presented, the Gaussian wake model from Bastankhah and Porté-Agel (2016) and large-eddy simulations. There are differences present in the proposed model, which we attribute to the simplifications of the proposed model and the turbulence model. However, there is good agreement in the curled wake model in terms of near wake predictions. As the wake moves downstream, the Gaussian model seems to better capture the general shape, but the location of the wake seems too far off in the negative y direction. From the vertical profiles, we can see that further downstream the agreement between the curled wake model and the LES deteriorates. This is because the turbulent diffusion from the model does not provide enough dissipation, and because the vortices do not decay nor are they convected to the side. This means that the vortices will convect the wake deficit providing unrealistic stronger wake deficits further downstream.”

4. A figure showing the lateral displacement of the wake with downwind distance could be added to the text, and it should be compared with the other existing models.
Response:
We have added the figure with the following discussion:

“It is difficult to track a wake centerline in the curled wake model and the LES. The curled wake is characterized by a complex three-dimensional structure and a wake center is not really descriptive of this mechanism, specially in the near wake. Figure 9 shows lateral displacement of the center of the wake. The curled wake and LES cases compute this displacement by averaging a collection of tracers around the center of the rotor inside a radius of 0:2D. It is interesting to note that both models underpredict the displacement in the far wake compared to the LES. We argue that the displacement is not a proper measure because it cannot track the non-symmetric and more complex shape of the curled wake. The tracer is not only displaced laterally, but also in the vertical direction. To properly represent the curled wake and its displacement, a more robust and three dimensional model, such as LES and/or the curled wake model, should be used.”

5. In Table 1 and the related text, it is not mentioned which method for the wake superposition is used in the Gaussian wake model (e.g., Katic, Lissaman, Voutsinas, or a different one). Please clarify this issue in the text.
Response:
The sum of squares method has been used to superpose the wakes. This has been added to the introduction:
“After computing the individual wakes, they are added using the sum of squares method (Katic et al., 1987).”

6. In Fig. 4 and 6, why the predictions from the proposed model is different in the laminar inflow for the ADM and ALM? Is there any difference in the simulation setup using different turbine models? Can the model differentiate between the ADM and ALM?

Response:

The difference between ADM and ALM in the model is the addition of rotation. This has been explained in the text:

"The difference between the model implementation in this case, and the case of the actuator disk model is that rotation of the wake has been added"

7. Regarding the eddy viscosity model, there is no wall in the simulation under laminar inflow condition. How the eddy viscosity is computed in that case? Is it zero? For the turbulent case, it would be useful if the authors could show the comparison between the eddy viscosity model in equation (15) and the LES.

Response:

In the case of uniform inflow, the turbulence model is not present. However, to stabilize the numerical solution a small viscous term has to be added. This has been explained in the manuscript:

"In the case of laminar inflow, an arbitrary viscosity needs to be added to stabilize the numerical solution. After experimenting with different values, an effective viscosity based on a Reynolds number Re = 10^4 proved to be sufficient to stabilize the solution."

8. It is not clear how the model includes the turbulence level in the incoming flow. Is it included in the model though the effective viscosity?

Response:

Yes, the turbulent viscosity is specified in terms of the atmospheric boundary layer profile. There is no direct dependency on turbulence intensity. The current model is only valid for neutral stability and improvements to the turbulence model which take into account stability is part of future work.

9. It is suggested that, in the ABL case, the authors consider another yaw angle (e.g. 30o) to make the model validation more complete.

Response:

Results in the manuscript are presented for a range of yaw angles between 20 and 30 degrees. We have notices similar behavior of the model for smaller angles but have focused on these angles because they show best the curled wake mechanism and its effect on the wake.

10. In the ABL case, it would be useful if the incoming wind characteristics (i.e., vertical profiles of the mean wind velocity (in the log scale) and the turbulence intensity) are added to the text.

Response:
We agree with the reviewer. We have added the inflow profiles and a description:

"Figure 6 shows the inflow wind vertical profile 3 diameters upstream of the rotor for the LES and the one specified from the model, and the resulting turbulent viscosity as a function of height. A power law with a shear exponent of alpha = 0.15 was chosen in the model to match the LES inflow condition."