Wind Energ. Sci. Discuss., referee comment RC1
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Comment on wes-2021-116

Anonymous Referee #1

Referee comment on "FLOWERS: An integral approach to engineering wake models" by Michael LoCascio et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2021-116-RC1, 2021

GENERAL COMMENTS
This is a generally well written paper and presents an apparently new and interesting method for wind farm AEP calculations. I think that some of the content could be improved and my comments are below.

SPECIFIC COMMENTS

Abstract.
What does gradient-based mean? This doesn't seem to be explained anywhere within the article.
Perhaps consider replacing the sentence:
"The analytical integral and the use of a Fourier expansion to express the wind speed and wind direction frequency create a more smooth solution space for the gradient-based optimizer to excel compared with the discrete nature of the existing weighted-averaging power calculation."
with somethng like
"The analytical integral and the use of a Fourier expansion to express the wind speed and wind direction frequency create a relatively smooth solution space for the gradient-based optimizer in comparison to the existing weighted-averaging power calculation."
It is not clear why the "weighted-averaging power calculation" is discrete.

1. Introduction.
Should 'tophat' be 'top-hat'?
Line 30. What are gradient-free algorithms?
Line 46. The term "non-zero" before wind direction seems inappropriate. Perhaps remove the term altogether or replace with 'discrete'.

2. Mathematical formulation
Line 69. To "the streamwise and spanwise position" I think you should add "with respect to the wind direction theta', where theta' is the wind direction in the X,Y frame"
It seems that the following should be defined before equation (2)
x = r cos(theta-theta')
y = r sin(theta-theta')
Then y/x = tan(theta-theta')
However, on line 73 it is stated that y/x = tan(theta) which doesn't seem correct.

It would be worth putting this in a diagram for clarity, as in the attached figure.
Line 83. It should be clarified that the equation in this line comes directly from the equation in line 72, and represents the boundary of the wake velocity deficit. Again, this would benefit from a diagram.
Line 86 to 88. I don't think this sentence is really true. Surely the wake deficit is defined as the difference between the freestream velocity and the wake velocity.
Line 92 onwards at bottom of page 4. Does U_infinity(theta') imply there is only one inflow wind velocity for each direction? Where does the Weibull distribution fit into this scheme? Is there no integration over wind velocity in the integral?
Line 96. says "the product is a vector with length equal to the number of wind direction bins", however, this will have units of m/s so how can it be a number? Please clarify.
Line 100. for a given g(theta') and N.
Line 102. Taylor series to second order?
2.2 Annual Energy Production. It is not clear to me why the integral is intractable (line 121).

3. AEP Comparison
Could the authors briefly state how AEP is calculated? Typically this would be done with a wind rose/Weibull distribution and a wind turbine power curve? Is this the case here?
I think the various approaches need to be defined clearly and consistent terminology used throughout the paper. For example
Conventional Jensen approach = Jensen wake + numerical integration
FLOWERS = analytical formula
Conventional Gaussian approach = Gaussian wake + numerical integration
but it seems sometimes the first is referred to as 'Jensen integration' (line 183) or 'conventional numerical integration method' (line 192) or 'numerical integration' (line 198).
3.2 Generalised case. Line 170. Is the wind rose specified by f(theta') ?
Figure 2. caption says AEP comparison, but it seems that it is the wind velocity that is shown.
It is stated that "wind direction bins B used in (c) is B = 72", but this is for a single wind direction as shown in subfigure (a), is that right? Does this mean the single wind direction is split into 72?
Lines 183, 187, 192, 198. Again use consistent terminology instead of "Jensen integration", "conventional method" ... etc.
3.3 Improving computational efficiency
Can you give an indication of the absolute computational times? Minutes, hours, days?
Figure 5. Please state what they values are normalised with respect to. Is it with respect to the cases with maximum resolution?
Line 225. Perhaps replace "There is no reason to use the extended Fourier series if it only increases the computational cost of the FLOWERS solution"
with
"There is no reason to use the extended Fourier series if it increases the computational cost of the FLOWERS solution with no associated accuracy benefit."

4. Optimization Comparison
Lines 229 to 226. Again, please be consistent when stating optimizer names.
4.1 FLOWERS and Jensen
Figure 7. Are labels (a), (b) necessary?
Figure 7. It is a bit concerning that the two results are vastly different, but possibly due to fact that a top-hat wake is used instead of the more realistic gaussian wake. It is more reassuring that the layouts in Figure 10 are more similar.
Also, the initial positions are marked. Surely the final optimised layout should be independent of the initial positions?
Line 264. Please define AEP gain.
Figures 8 onwards. Are labels (a), (b) necessary if these labels are not referred to?

Perhaps put "B=, N=" in captions instead.

Conclusions. As future work it would be of interest to validate the AEPs of the various approaches against a real wind farm AEP.
Figures 8, 9, 11, 12 don't actually indicate which method is actually closest to the true AEP of a real wind farm.

Please also note the supplement to this comment:
https://wes.copernicus.org/preprints/wes-2021-116/wes-2021-116-RC1-supplement.pdf